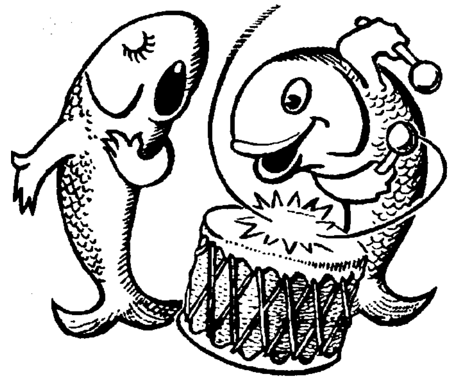
DRUM *and* CROAKER



A Highly Irregular Journal for the Public Aquarist

Volume 43 *Jan. 2012*

TABLE OF CONTENTS
Volume 43, 2012

Cover Photo: Jay Hemdal.

DRUM AND CROAKER 30 YEARS AGO

(Excerpts from the 1982 issue)

Richard M. Segedi

From the Drum and Croaker Editor

Stefani Hewlett, Vancouver Public Aquarium

Dear Fellow Aquarists,

The dubious honor of producing the Drum and Croaker has worked its way across North America and come to rest, for a year or two, at the Vancouver Aquarium. As the Drum and Croaker is now in its 25th year, and I, the present editor, have not been a member of this exalted profession for more than ten years, I searched dog-eared and tattered issues looking for direction, inspiration and enlightenment. Among the yellowing pages, I found pressed cockroaches, cartoons of middling quality and many gems of information. What I searched for was finally unearthed in the July, l957 issue. There is stated the original mandate of the Drum and Croaker: "A Piscatorial Provoker, a Revolving Poop Sheet, an irresponsible journal published at erratic intervals by undedicated Aquarists." With the above as guide, gospel and director, the Drum and Croaker now flames into print once again.

COPPER TREATMENT: THE DARK SIDE OF THE STORY

Carol E. Bower, Sea Research Foundation Institute for Aquarium Studies, Hartford, Connecticut

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

NEW PUBLICATIONS ON KEEPING MARINE INVERTEBRATES

James N. Atz Curator Emeritus, Dept. of Ichthyology, American Museum of Natural History, New York

The ever-multiplying publications on the aquaculture of bivalves and decapods (shrimp, lobsters, and crabs) now can provide a modicum of pertinent data on maintaining these creatures in aquaria. In addition, there are a couple of potentially useful scientific periodicals devoted to diseases (Journal of Invertebrate Pathology) and reproduction (International Journal of Invertebrate Reproduction). Otto Kinne's magnum opus on " Marine Ecology" (John Wiley, publisher) includes one volume of water management and the culture of seaweeds and other algae, a second one on animal culture from protozoans to mammals, and a third on special kinds of commercial and laboratory culture. These will be followed by a four-volume treatise on "Diseases of Marine Animals," the first of which has already appeared. These two comprehensive works ought to be on the shelves of all up-and-coming professional aquarists, but they are prohibitively expensive for all but a few.

JEFF MOORE, SUPERINTENDENT OF THE DALLAS AQUARIUM RETIRES

A colorful and varied career preceded the retirement of Jeffrey Moore in January of this year. From 1936 to 1939 Jeff worked as a tropical aquarist at the Dallas Aquarium. Then, because he was a single and the most junior employee, he was fired when the depression years hit. In the war years he saw duty as a naval yeoman and photographer. This latter experience led to further photographic studies at the end of the decade and two years working in a camera shop. The Aquarium world still held a real fascination and Jeff Moore returned to the Dallas Aquarium, and stayed for 25 years. The Aquarium community wishes Jeff Moore and his wife Martha good luck on a new career devoted to travel, friends and hobbies.

THE USE OF SEQUENTIAL CODED WIRE TAGS™ IN A PUBLIC AQUARIUM

Todd Harmon & Magan Celt, Todd.S.Harmon@disney.com

Walt Disney World® Resort, Disney's Animals, Science and Environment
Lake Buena Vista, FL 32830

Many larger species of fish in public aquariums are often individually identified using PIT (passive integrated transponder) tags. This technique allows the aquarium staff to positively identify each tagged fish, making it possible to track the health records of the animal as well as determine life span in captivity. However, the majority of fish in large marine aquaria are usually composed of smaller marine reef fishes that are not tagged because they are managed as a population and not individually. Individual tagging can also become labor intensive as well as expensive.

Life spans of fishes are often determined by studying fish in public aquaria and examining annular rings on otoliths (Randall and Delbeek, 2009). Minimized predation, reduced risk of pathogens (if correctly maintained), and readily available food are all contributing factors leading to increased life spans within a controlled environment. To collect longevity data, one must be able to track the age of a certain fish. This proves very labor intensive, whether using fish scales or otoliths as aging methods. However, tagging fish prior to entering the aquarium can give longevity data within the aquarium and is typically much less demanding of labor.

Most public aquariums add fish to their system on a continual basis to counter the natural mortality and predation that may occur within the system. With many of the same species being added on a regular basis, there is no way to determine how long a fish has been in the aquarium unless it is tagged or otherwise uniquely identified. This is especially true if it is an abundant species in the aquarium that has been continually stocked over the years.

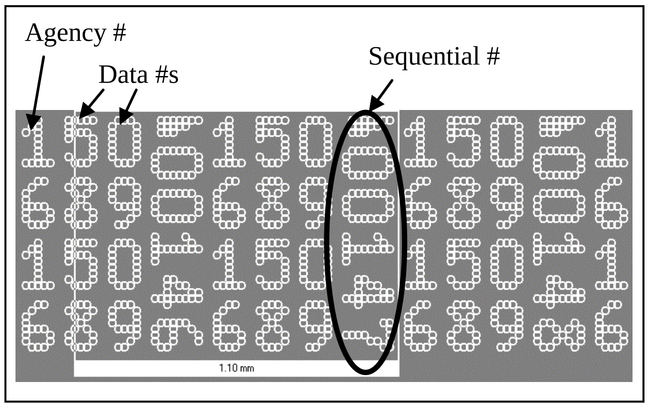
Our tagging program was designed to answer the question, "When was that individual fish added to the aquarium?" Each of our fish that is not PIT tagged instead receives a coded wire tag (CWT). The tag numbers are archived in an Excel spreadsheet with information such as quarantine group and date the animal was tagged. .

Tagging System

We chose to use Sequential Coded Wire Tags™ (CWT) (Northwest Marine Technology Inc., Shaw Island, Washington). Each tag is 1.1 mm in length by 0.25 mm diameter stainless steel wire with a batch code and individual number encoded on it (NWMT Application note APC05) (Figure 1). With this type of tagging system we can use "batch identification" that allows us to identify when a certain "batch" of fish entered the system.

These tags were selected for five main reasons: 1.) The tagging procedure is a fairly non-invasive event if done correctly. Bergman et al (1992) reported little damage to muscle tissue (histopathically) using CWT in largemouth bass, *Micropterus salmoides* compared with external tags in Pacific cod, *Gadus macrocephalus*. Fletcher et al (1987) also performed a histological analysis and reported normal healing in largemouth bass that were tagged in the cheek with CWT. 2.) These tags are entirely internal with no exposed portion visible for other animals to “pick at” or to become entangled in cracks and crevices within coral habitats found in the aquarium. 3.) In a public aquarium setting it would provide unpleasant viewing for guests if fish had external tags, especially ones dangling from the fish. 4.) Very small animals could be tagged. Buckmeier (2001) reported tagging small (32-54 mm) black bass in the nape musculature with good tag retention and little mortality. CWT are much smaller (1.1 mm x 0.25 mm) than other traditional tags such as: dart tags, opercular tags, T-bar tags, internal anchor, Petersen tags, and PIT tags. 5.) The ease and limited time it takes to tag 200-300 fish in a single tagging event.

Figure 1: Illustration of a CWT tag “2-Dimensional unrolled”. Photo of tag provided by Northwest Marine Technologies. (http://www.nmt-inc.com/).



One disadvantage to using these tags is that they can only be retrieved after the fish is deceased. Once the tag is retrieved it is “read” using a dissecting microscope. The data is then recorded into a database where initial stocking data is also archived. The data is matched to a specific date in which the fish was stocked. A second disadvantage is that they are so small that there are the extra steps of retrieving them from the flesh and using a microscope to read them.

Tagging Location

We chose the musculature just anterior to the dorsal midline on the left side for a tagging location (Figure 2). We chose this location because it was suitable for a wide range of species as well as different sizes of fish. Secondly, CWT had good tag retention data. Good retention in this general tagging location was reported by Hale and Gray (1998) with >97% tag retention in rainbow trout, *Oncorhynchus mykiss*, Peterson and Key (1992) with 92% retention in walleye, *Stizostedion vitreum*, and Munro et al (2003) that reported 100% retention in rainbow trout. Third, we wanted to keep the tags in similar locations for all fish which included many species with varying shapes and sizes. Consistent location made for easy detection and extraction by the pathologist and/or aquarist when retrieving the tag from deceased fish. Lastly, this location allowed us to lay the fish on its side, providing a stable surface when tagging with the handheld multi-shot injector (Figure 3). The tagging needle was inserted beneath the scales at about a 30 degree angle pointed towards the anterior of the fish. We also used a needle guard to regulate the needle depth.

Figure 2: Tagging location used on a typical spiny-rayed marine species.

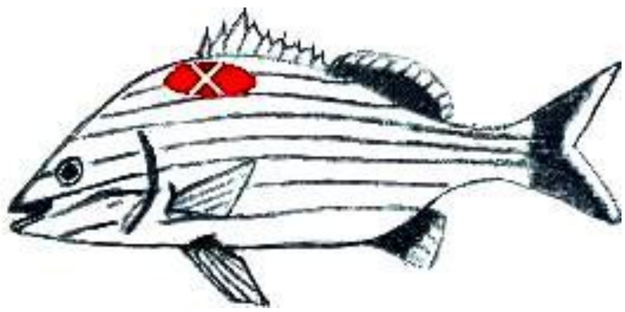
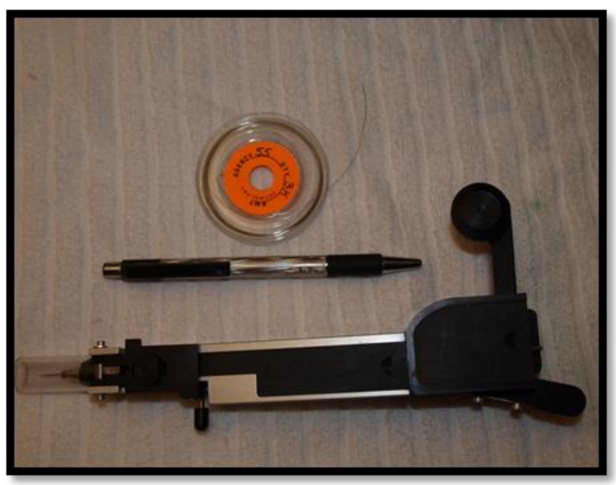


Figure 3: Handheld multi-shot tagger for coded wire tags with a spool of sequential tags.



Tagging Process

Fish were anesthetized in a buffered solution of 70 mgL^{-1} tricaine methanesulfonate (Finquel®, MS-222) (Redmond, WA). Approximately 10-30 fish were anesthetized at one time in a 40 L cooler. After a fish showed a loss of equilibrium, it was removed from the anesthetic water and placed onto a wetted cloth to be tagged. A tag was inserted using a handheld multi-shot injector (Northwest Marine Technology Inc., Shaw Island, Washington). The fish were then checked for tag retention using a handheld wand detector (Northwest Marine Technology Inc., Shaw Island, Washington) and then released into a temporary holding tank supplied with pure oxygen (Figure 4). The needle of the tagger was wiped with 10% Povidone iodine for disinfection after each tagging procedure. After all fish from a particular holding tank (typically 30-50) were tagged and completely recovered from the anesthetic, they were moved back into their original holding tank (Figure 4.0).

Recording and Reading Tags

At the beginning of each tagging event a tag was taken as a "beginning tag" and at the completion another was taken as the "end tag". These tags were read using a low power dissecting microscope (50 X) and the numbers were then entered into a spreadsheet including the date, number of fish, and accession numbers. Group accession numbers were assigned to all fish coming into quarantine. Group accession numbers were used to keep track of date of arrival, vendor and quarantine regime. With the beginning and ending number known for each group, each retrieved tag could be dated to a certain group of fish that entered the aquarium.

Figure 4: Tagging set-up and procedure. (1) fish holding tank, (2) anesthesia, (3) tagging bench, (4) temporary fish holding tank (just after tagging).

Tags were removed from deceased fish by scanning (handheld scanner) the fish for a tag and if positive, cutting a small portion of the flesh in the suspect area and scanning the piece taken. If the small piece scans positive, it is then placed in a plastic bag with necropsy number and species listed and placed in a freezer. The tag is eventually teased out of the piece of flesh then "read" using a dissecting microscope (50 X) (Figure 5). If the tag number was obscured by dried flesh, the tag was then soaked in hydrogen peroxide and rolled between gloved fingers to remove the flesh. The batch number was referenced into the tagging database and found where it fell between a beginning and end tag of a specific accessioned group (Figure 6).

Discussion

Tagging times for bluestriped grunts (*Haemulon sciurus*) ranged from 9.75 – 14.85 (seven trials) sec/fish and averaged 11.48 sec/fish. This time included taking the fish out of anesthetic, tagging and verifying for a retained tag. Tagging time depends largely upon the type of tag injector used. Peterson et al. (1994) recorded similar tagging times (5-15 sec/tag) between CWT and PIT tags both using a single tag injector. Buckley et al. (1994) tagged juvenile reef fishes at a rate of 10-15 sec. per fish using a handheld injector. Buckmeirer (2001) recorded tagging rates on juvenile largemouth bass, *Micropterus salmoides* to average 457 fish/h/machine using an automatic Mark IV injector (Northwest Marine Technology Inc., Shaw Island, Washington). The automatic injector is intended for tagging thousands of fish while the handheld injectors are designed for smaller numbers at a given time.

With the use of this tagging program, all fish that were tagged could be traced to when they were stocked into the aquarium. This can provide useful data on some of the history of the animal in the enclosure and whether it was recently stocked or possibly an "older" animal. It may not give exact age, but it provides the husbandry team valuable information on captive fishes and longevity within a certain aquatic system. Certain pathological findings such as Head and Lateral Line erosion (HLLE), granulomas and tumors may also be linked to a fish being an older resident or newer resident in the display and quite possibly link some pathological findings to "environmental events" within the aquaria.

Figure 5: Microscope view (50 X) of sequential coded wire tag as seen under a microscope for identification. The identification number of interest to us is composed of 5 numbers (sequential number) around the circumference of the tag. The tag is "rolled" to be read. The starting number is designated from a symbol. Pictures below show 2 of 5 numbers.

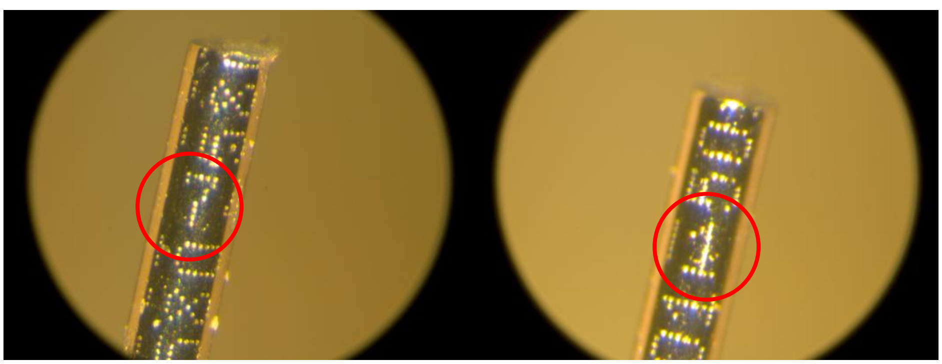
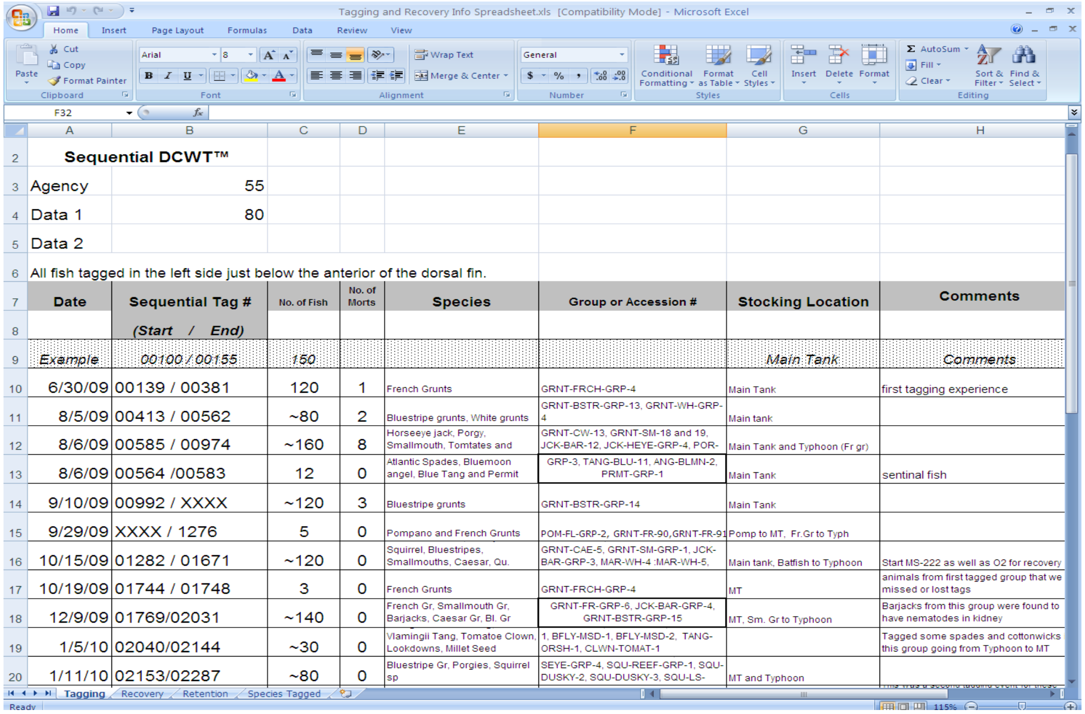


Figure 6: A view of the Microsoft Excel database used to track all tagging information.



Sequential DCWT™

Agency	55
Data 1	80
Data 2	

All fish tagged in the left side just below the anterior of the dorsal fin.

Date	Sequential Tag # (Start / End)	No. of Fish	No. of Morts	Species	Group or Accession #	Stocking Location	Comments
Example	*00100 / 00155*	*150*				*Main Tank*	*Comments*
6/30/09	00139 / 00381	120	1	French Grunts	GRNT-FRCH-GRP-4	Main Tank	first tagging experience
8/5/09	00413 / 00562	~80	2	Bluestripe grunts, White grunts	GRNT-BSTR-GRP-13, GRNT-WH-GRP-4	Main tank	
8/6/09	00585 / 00974	~160	8	Horseeye jack, Porgy, Smallmouth, Tomtates and	GRNT-CW-13, GRNT-SM-18 and 19, JCK-BAR-12, JCK-HEYE-GRP-4, POR-	Main Tank and Typhoon (Fr gr)	
8/6/09	00564 /00583	12	0	Atlantic Spades, Bluemoon angel, Blue Tang and Permit	GRP-3, TANG-BLU-11, ANG-BLMN-2, PRMT-GRP-1	Main Tank	sentinal fish
9/10/09	00992 / XXXX	~120	3	Bluestripe grunts	GRNT-BSTR-GRP-14	Main Tank	
9/29/09	XXXX / 1276	5	0	Pompano and French Grunts	POM-FL-GRP-2, GRNT-FR-90,GRNT-FR-91	Pomp to MT, Fr.Gr to Typh	
10/15/09	01282 / 01671	~120	0	Squirrel, Bluestripes, Smallmouths, Caesar, Qu.	GRNT-CAE-5, GRNT-SM-GRP-1, JCK-BAR-GRP-3, MAR-WH-4 :MAR-WH-5,	Main tank, Batfish to Typhoon	Start MS-222 as well as O2 for recovery
10/19/09	01744 / 01748	3	0	French Grunts	GRNT-FRCH-GRP-4	MT	animals from first tagged group that we missed or lost tags
12/9/09	01769/02031	~140	0	French Gr, Smallmouth Gr, Barjacks, Caesar Gr, Bl. Gr	GRNT-FR-GRP-6, JCK-BAR-GRP-4, GRNT-BSTR-GRP-15	MT, Sm. Gr to Typhoon	Barjacks from this group were found to have nematodes in kidney
1/5/10	02040/02144	~30	0	Vlamingii Tang, Tomatoe Clown, Lookdowns, Millet Seed	1, BFLY-MSD-1, BFLY-MSD-2, TANG-ORSH-1, CLWN-TOMAT-1		Tagged some spades and cottonwicks this group going from Typhoon to MT
1/11/10	02153/02287	~80	0	Bluestripe Gr, Porgies, Squirrel sp	SEYE-GRP-4, SQU-REEF-GRP-1, SQU-DUSKY-2, SQU-DUSKY-3, SQU-LS-	MT and Typhoon	

Over a 13 month period a total of 1273 fish were tagged with 25 return tags read. A majority of these returned tags were from an experiment of sentinel fish. Of these, two tags (8%) could not be read because of scratching or debris on the surface of the tag. The data retrieved has been valuable in diagnosing mortality trends in one of our large aquarium systems. With the tagging system in place for two years we were able to evaluate whether the losses are a mix of recently stocked fish or from the older population. The "age" was always a discussion point among Aquarists when we would lose fish in our large system. With the new tagging system we have the benefit of being able to determine exactly when the fish was stocked into the aquarium.

References

Bergman, P.K., F. Haw, H.L. Blankenship, and R.M. Buckley. 1992. Perspectives on design, use, and misuse of fish tags. Fisheries, 17(4): 20-24.

Buckley, R.M., J.E. West, and D.C. Doty. 1994. Internal Micro-tag system for marking juvenile reef fishes. Bulletin of Marine Science, 55(2-3): 848-857.

Buckmeier, D.L. 2001. Coded wire tag insertion sites for small fingerling black bass. North American Journal of Fisheries Management, 21: 696-698.

Fletcher, D.H., F. Haw, and P.K. Bergman. 1987. Retention of coded wire tags implanted into cheek musculature of largemouth bass. North American Journal of Fisheries Management, 7: 436-439.

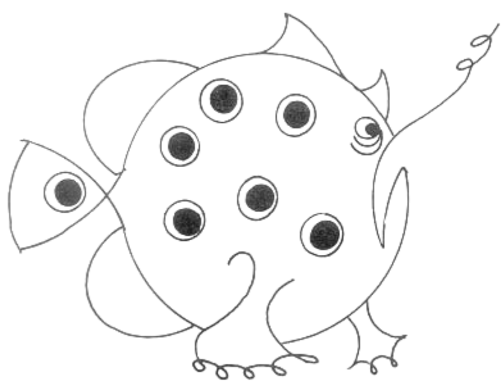
Hale, R.C., and J.H. Gray. 1998. Retention and detection of coded wire tags and elastomer tags in trout. North American Journal of Fisheries Management, 18:197-201.

Munro, A.R., T.E. McMahon, S.A. Leathe, and G. Liknes. 2003. Evaluation of batch marking small rainbow trout with coded wire tags. North American Journal of Fisheries Management, 23: 600-604.

Peterson, M.S. and J.P. Key. 1992. Evaluation of hand-tagging juvenile Walleye with Binary coded wire microtags. North American Journal of Fisheries Management, 12: 814-818.

Peterson, N.P., E.F. Prentice, and T.P. Quinn. 1994. Comparison of sequential coded wire and passive integrated tags for assessing overwinter growth and survival of juvenile coho salmon. North American Journal of Fisheries Management, 14: 870-873.

Randall, J.E. and J.C. Delbeek. 2009. Comments on the Extremes in Longevity in fishes, with special reference to the Gobiidae. Proceedings of the Academy of Sciences, Series 4, Vol. 60, No. 13, pp 447-454.



Craig Phillip, Drum and Croaker, 1968

ANIMAL CARE PRACTICES AND OBSERVATONS OF GROWTH IN CAPTIVE-BORN PACIFIC ANGEL SHARKS, *Squatina californica*, AT AQUARIUM OF THE BAY

Michael Grassmann, Aquarist II, michaelg@bay.org
Christina J. Slager, Director of Animal Care, christina@bay.org
Keith Herbert, Assistant Curator, keith@bay.org

Aquarium of the Bay, Embarcadero at Beach St, Pier 39, San Francisco, CA 94133, USA

Abstract

The Pacific angel shark, *Squatina californica*, is a species of flattened, ray-like shark found off the continental shelves of the eastern Pacific Ocean. The Aquarium of the Bay in San Francisco, California is the only institution that has reported successful captive-breeding of Pacific angel sharks. Between May and July of 2009, seven angel shark pups were born in the Near-shore Tunnel exhibit of the aquarium and promptly moved into an isolated holding system. Over a 30-month time period, careful records have been maintained documenting the pups' growth, feeding, and behavior. Though the life history traits of Pacific angel sharks are well documented, pups born in a captive and environment offer a unique opportunity to collect information about growth and successful animal care practices for this species. Comparing data from this group of angel sharks with others in different locations along the California coast also represents a chance to assess genetic divergence within isolated populations of this species.

Introduction

Pacific angel sharks, *Squatina californica*, are typically located in shallow bays, estuaries, at the head of submarine canyons, and on the edge of rocky reef or kelp forests between the depths of 3-100 m, but can occasionally be found at depth of almost 200 meters (Compagno et *al.*, 2005; Ebert, 2003). This species ranges from southeastern Alaska to the Gulf of California in North America, and off the coasts of Ecuador, Peru, and Chile in South America. It is a cryptically-colored bottom dweller that partially buries itself in soft mud or sand to ambush prey (Compagno et *al.*, 2005; Ebert, 2003).

The Aquarium of the Bay, located at Pier 39 in San Francisco, California, is one of the few institutions in the United States that has had long-term success keeping Pacific angel sharks and was the first aquarium to report captive breeding of Pacific angel sharks in 2007. Adult angel sharks collected by divers on SCUBA in Bodega Bay, California. They are transported to the aquarium in oxygenated holding containers and are quarantined for thirty days before being placed in the 350,000 gallon Near-shore Tunnel exhibit, depicting a Northern California coastal ecosystem. On May 21, 2009, during routine maintenance, divers in the exhibit discovered five newly-born angel shark pups, one of which was stillborn. On July 6, 2009, two more pups were found. On July 11, 2009 a seventh final pup was discovered, making the total litter three male and four female neonates (Figure 1). Three adult angel sharks were on exhibit during the time each neonate was found, one male and two females. On each occasion when a pup was discovered, the condition of the cloaca in each adult female was assessed. The same female

Figure 1: Image of a *S. californica* pup the day it was discoverd (with ruler for scale).

showed signs of redness and swelling during each observation so it was determined all of the pups were from the same litter. At the time of the pups' birth, the two females had been on exhibit since 2005 and 2007, and the male had been in the Near-shore Tunnel exhibit since September 2003. Base on the length and estimated ages of these sharks, in combination with well-established information about the size at maturity and a 9-10 month gestation time for the species, reproduction and parturition occurred while in the exhibit. This marks the second known case of successful captive-breeding demonstrated by this species (Cailliet et *al*., 1992; Compagno et *al*., 2005; Ebert, 2003; Richards, 2001; Schaadt and Landesman, 1997).

Life history traits for this species are fairly well-known due to a productive commercial fishery that existed off the California coast throughout much of the 1980s and collapsed in the early 1990s (Richards, 2001). Although neonates have been held for long periods of time in laboratory settings, pups born in a controlled captive environment offer a unique opportunity to gather information about growth and developmental behavior of the Pacific angel shark (Cailliet et *al*., 1992; Schaadt and Landesman, 1997). Additionally, because these sharks are not believed to migrate long a distance, speculation exists regarding the possibility of isolated populations that may be so genetically divergent that they constitute a different species (Cailliet et *al*., 1992; Ebert, 2003; Gaida, 1995; Gaida, 1997). The majority of genetic information previously collected on Pacific angel sharks was from individuals caught near the Channel Islands in southern California; however, the pups born at Aquarium of the Bay are the offspring of sharks collected from Bodega Bay in the northern portion of the state, raising the possibility these sharks may differ genetically from other populations (Cailliet et *al*.1992; Carter et *al*., 2010; Fouts and Nelson, 1999; Gaida, 1995; Gaida, 1997; Natanson et *al*., 1984; Natanson and Cailliet, 1986; Natanson and Cailliet, 1990; Richards, 2001). Comparing the data gathered from these pups to other Pacific angel shark populations found in various locations along the coast also offers a chance to assess intraspecific life history variation within this species (Cope, 2006).

Materials and Methods

Upon discovering the newborn pups in the Near-shore Tunnel exhibit each neonate was removed and placed in an isolated holding tank that contained no other fish or invertebrate species. Initial weights and measurements were also taken of each individual when they were found. To date, all of the pups are located in the same holding tank which receives filtered circulated water from the San Francisco Bay and has a fine sand substrate, approximately 25 cm thick. Although each individual was initially identified through a unique pattern of spots, color, and overall size, each shark eventually received a unique identification number in order to keep meticulous track of consumption rates, growth, and animal health.

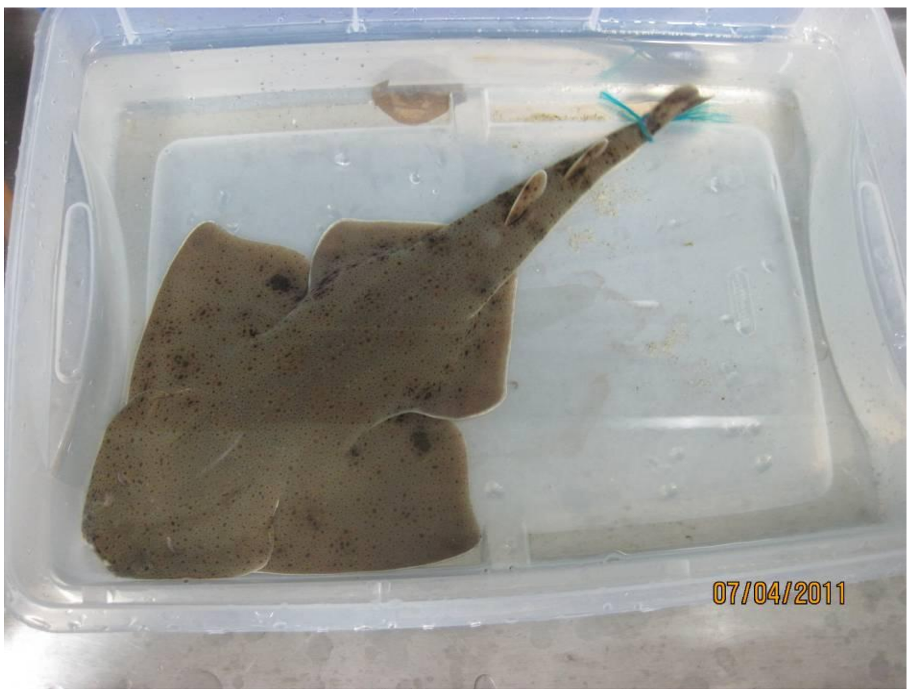


Figure 2: *S. californica* pup with colored yarn tag in a container for weights and measurements.

Originally plastic zip-ties were secured around the peduncle area of each shark for identification purposes. However, the plastic caused abrasive damage to the pre-caudal pit area and rapid growth required frequent tag changes. Attempts to use colored yarn or loose rubber bands as alternative tags resulted in similar problems (Figure 2). Eventually the use of personalized disc tags designed by FLOY tags was employed. Each pup was anesthetized in an MS-222 bath prior to the procedure, kept on RAM ventilation as the disc tag was secured and a coded PIT tag was implanted, and then given a prophylactic injection of antibiotics before being placed in recovery bath. Originally the discs were fastened to the first dorsal fin of each pup but this placement resulted in several of the pups receiving abrasions from the tag while the dorsal fin was folded over the body. The tags were subsequently loosely reapplied to the upper lobe of the caudal fin (Figure 3) to accommodate future growth and ensure no further wounds could occur. However, based on the atypical behavior of the sharks the placement of these tags caused further irritation; many of the pups fasted for nearly three weeks after the tags were applied, did not fully bury themselves in the substrate, and were easily disturbed resulting in rapid bursts of prolonged swimming. Through repeated swimming, four of the pups shook the disc tags off of their caudal fin without assistance while the remaining three had their tags removed by aquarium staff. Approximately one week after all of the tags were removed, six of the seven pups began regularly eating again and displayed characteristic cryptic behavior. Because the application of various external tags proved detrimental to the pups during the early stages of their development, the aquarium veterinarian and staff ultimately decided to use an underwater PIT tag scanner as the primary means to differentiate between individuals.

Figure 3: Custom FLOY tag used to identify angel shark pups.

Throughout the course of this study careful feeding records have been maintained to calculate average weekly food consumption and the percentage of body weight consumed by each pup per week. The sharks were originally offered a variety of food items six-days-a-week and deliberately fasted one day; however, as the pups continued to develop the feeding schedule shifted to two obligatory fast days weekly. Regular food items offered include: capelin

(*Mallotus villosus*), Pacific sardine (*Sardinops sagax*), Alaskan herring (*Clupea pallasii*), and chub mackerel (*Scomber japonicas)*. Each food item was weighed to the nearest tenth of a gram prior to being offered. Food was presented to the sharks through the use of a rigid PVC stick with attached monofilament line. The feeding technique used was similar to the one described by Fouts and Nelson (1999), where depending on the position of the shark, the anterior or posterior section of the animal was approached with the feeding stick and the food item was slowly waved laterally about 5-10 cm above its head. Originally the pups were given 120 attempts or approximately two-minutes time to strike at a food item. The number of attempts and subsequent time allotted for each individual to feed decreased with a consistent response to offerings and steady growth/weight gain. As of January 2011, sharks were given approximately 60 chances to strike at food over the course of a minute, although most individuals responded immediately or within 15-20 seconds after initial food offering. During each feeding session the sharks' reaction to the introduction of food, body morphology during strike, and post attack behavior were carefully observed.

On several occasions, schools of 10-20 juvenile northern anchovies (*Engraulis mordax*) were placed in the holding tank with the angel shark pups to see if the sharks would actively hunt live fish. During the first three offerings of live food, no direct observations of predation were made, however every time live fish were introduced into the tank with the sharks the school would slowly diminish in size until no anchovies remained. No anchovy mortalities were removed from the tank and several of pups would correspondingly refuse stick-fed items while live fish were present. In May of 2011 a large school of anchovies was introduced to the Near-shore Tunnel exhibit; approximately 20 fish were put in with the angel shark pups. On this particular occasion, five of the seven pups exhibited predatory behavior and two of the sharks consumed multiple fish within the first few minutes of their introduction into the holding tank.

Throughout their first year of development, each shark was removed from the holding tank on a weekly basis and placed in a clear plastic container for weights and measurements. A routine visual exam for any external parasites, wounds, or growth abnormalities was also conducted at this time. The pre-caudal length (PCL), total length (TL), disc width (DW) was recorded to the nearest 0.2 cm and initially weight was taken to the nearest gram. As the pups approached the age of six months, it became necessary to switch both the size of the container used for measurements and the scale used to obtain weights. The change in instruments resulted in weights being approximated to the nearest five grams. Upon reaching a year old, weights and measures shifted from weekly to bi-weekly increments. Finally, when the sharks became two-years-old, visual exams and measurements were conducted on a monthly basis because of logistical complications and increased stress on the animals during the procedure. These monthly measurements employed a long-term methodology to gather data that utilized a different scale with higher weight capacity and a four-foot-long stretcher that should accommodate the sharks' growth for the next several years.

Results

The percent body weight consumed was calculated based on average weekly consumption (g)/weekly body weight (g). Graphs comparing the total length (TL) grown (cm) to weight gain (g) (Table 1.1-1.7) were plotted for each pup using the data collected on weekly, bi-weekly, and monthly intervals. Graphs depicting TL over time (Table 2.1-2.7), weight gain over time (Table 3.1-3.7), average weekly consumption over time (Table 4.1-4.7), and percent body weight consumed over time (Table 5.1-5.7) were also plotted for each pup over a 30-month-period. Regression analysis was performed on all graphs and comparisons of TL and weight gain over time between the entire population were also plotted (Table 6.1-6.2). The instantaneous growth rate coefficient (G) for each pup was calculated using the formula: $G = (\ln Wt - \ln Wi)/t$, where Wt represents the weight in grams at the end of the time interval, Wi represents initial weight in grams, and t is the time in number of days between the two measurements. The instantaneous growth rate was then multiplied by 100 and expressed as specific growth rate (SGR) in percent per day. SGRs were calculated for all seven pups over a 28-30 month time period depending on date of date birth (Table 7). Monthly and annual growth rates were determined based on average weekly consumption and weekly percent body weight consumed (Table 7).

Growth and weight gain during the first year were extremely rapid, with every pup nearly doubling in length and gaining between approximately 400-600 grams. In every instance a nearly linear relationship was observed between TL grown and weight gain, with R2 values ranging from .90-.97. When comparing length to weight as an indicator of overall growth, more than half the population showed more linear slopes and higher correlations in weight gain over time compared to total length grown; however it has been speculated that using the parameters of disc width or girth may be more accurate when assessing overall growth in this species (Cailliet et *al.*, 2006). The percentage of body weight consumed peaked within the first two months, decreased noticeably between three and eight months, and continued to slowly decrease for each pup over the next year before stabilizing. Two females displayed the highest daily SGR based on weight, but no significant differences in SGRs were witnessed between males and females. Conversely, one of the males showed the highest overall monthly and yearly growth rate based on length. When comparing the entire population, no appreciable difference was found in the annual growth rates between male and female angel shark pups, nor has the initial size at birth currently been an indicator of a specific shark's overall growth rate.

All of the angel shark pups began pole-feeding within two days of being moved from the Near-shore Tunnel exhibit to the holding tank, and proved to have voracious appetites. Unlike some mature sharks that display a "feast and fast" method feeding, these developing newborns consumed approximately one percent of their body in a single feed and did not fast for any significant amount of time (Motta and Wilga, 2001). Short-term fasts of one or two days usually followed events when the pups were handled for weights and measurements. A few individuals fasted for two-three weeks after sustaining slight PCP or fin damage due to complications with their tags. Since the holding tanks are part of an open system and subject to periodic temperature fluctuations depending on the conditions in the surrounding San Francisco Bay water, average consumption rates dipped slightly in the winter months and peaked with the warmest water temperatures in early autumn (Table 5.1-5.7).

The feeding mechanics of the Pacific angel shark were well documented by Fouts and Nelson (1999) and categorized by four components: body lunge and acute cranial elevation, mouth protrusion, extreme protrusion of the upper jaw, and jaw closure. During their study Fouts and Nelson (1999) also reported attack times were recorded to range between 30 and 100 msec, and visual cues were determined to play a primary role in predation for Pacific angel sharks when compared to the other senses. When food is offered, the pups remain completely still, except for their eyes which lock onto the food item immediately and continually follow it until attack. An observation of note is that while cranial elevation and upper jaw protrusion have appeared to be the primary factors involved for rapid strike, suction force may also have a significant role in prey capture, a phenomenon witnessed in multiple other species (Motta and Wilga, 2001). Additionally, it has been consistently observed in this population that vision ceases to be a factor in the final moments of attack since the eyes of the angel shark roll back into the head due to expansion of the upper jaw and adjustment of chondrocranium (Motta and Wilga, 2001). All sharks immediately buried themselves back into the sand following an attack and often remained in the same exact position for days at time. Due to their sedentary nature, as the sharks have gained weight keeping an adequate substrate depth became critical to maintaining animal health since sores rapidly developed around the pectoral girdle if exposed to the tank's fiberglass bottom for any length of time.

This group of sharks generally fits into the described life history parameters for the species in terms of litter size, parturition time, and observed behavior. The litter size of eight pups, including the still-born individual, is within average litter range of 6-11; however, all pups born at Aquarium of the Bay were below the reported average of 25-26 cm TL and ranged from 21.9-23 cm TL (Compagno et *al.*, 2005; Natanson et *al.*, 1984 Natanson and Cailliet, 1986). All pups weighed between 116 and 123 grams at the time of birth. Parturition in wild Pacific angel sharks usually takes place between the months of March and June after a 10-month gestation period; reproduction is ovoviviparous with developing young being nourished by an external yolk sac (Capape et *al.*, 1990; Gaida, 1997; Natanson et *al.*, 1984; Natanson and Cailliet, 1986). The litter consisted of three males and four females; no significant difference in the size at birth was observed between the sexes. It was also unusual that three separate instances of parturition from the same adult female were observed, suggesting differing embryonic growth rates. The pups were fully developed when discovered, in contrast to a previous litter in 2007 where the young were found with attached yolk sacs that were not yet fully absorbed and consequently did not survive their first year. The bulge in each of the pups' abdomens indicated that while the yolk sac had been recently absorbed into the stomach, some yolk supply still remained for digestion after parturition.

It is well-documented that the growth rates in laboratory raised sharks are largely different than those found in wild populations; these same differences have been observed with the litter of angel shark pups born and raised at Aquarium of the Bay (Cailliet et *al.*, 1992; Van Dykhuizen and Mollet, 1992). The measured growth rates of these pups are slightly lower but comparable to other lab-raised specimens (Cailliet et *al*., 1992; Schaadt and Landesman, 1997). These differences could be due primarily to the smaller size at birth of this group. Additionally, methods used in tagging shark populations have been shown to usually have a negative impact on growth rates (Cailliet et *al*., 2006). Since this group displayed adverse behavior that correlated to tagging events, it is reasonable to infer that their growth rates may have been altered in some way by the tagging. When compared to wild specimens, the accelerated growth rate in these sharks has also been affected by the idealized conditions of a captive environment where limiting factors such as inter-and intra-specific competition, prey availability, and predation are not present.

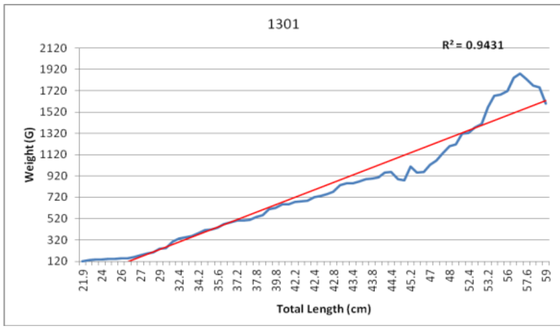
Discussion

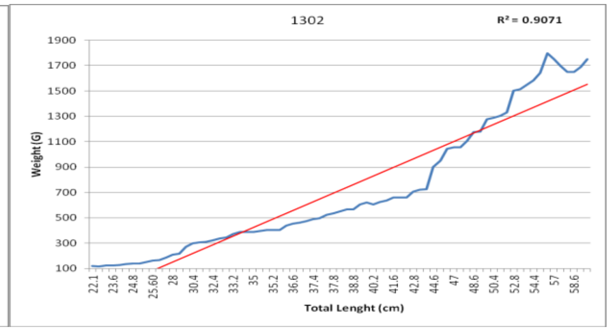
At the height of the local commercial fishery in 1985, the Pacific angel shark was the most landed shark species in California waters, with over one million pounds harvested. The following year a minimum size statue was put into effect. In 1991, gill and trammel nets were banned in California state waters and within one mile of the Channel Islands coast by a voter initiative, effectively ending the commercial fishery for this species in California (Richards, 2001). Despite the ban of gill net fishery in the early 1990s, the International Union for the Conservation of Nature Shark Specialist Group still listed *Squatina californica* as "Near Threatened" during its last species assessment in 2005 (Compagno et *al.*, 2005). Both males and females do not exhibit any appreciable difference in nearly all life history traits and take approximately a decade to become sexually mature; the maximum fecundity of 13 pups also does not increase with increasing age or size, as in some other ovoviviparous shark species (Cailliet et *al.*, 1992). Furthermore, although validated ageing techniques for this species of shark are under debate, longevity has been estimated at approximately thirty-five years. The combination of these characteristics makes *S. californica* highly susceptible to over-exploitation in response to any sustained fishing effort (Natanson and Cailliet, 1990).

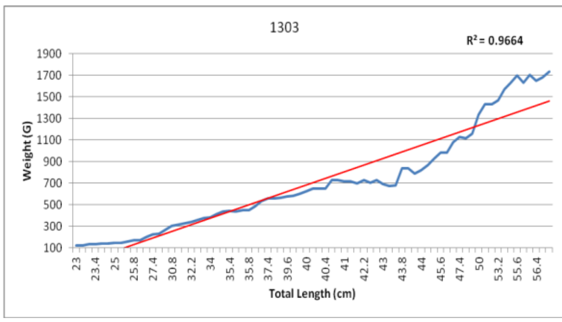
Despite regulations such as minimum size limits, once overfished, many shark populations may potentially take decades to recover. Research focused on the elasticity of the shark populations has suggested the highly *K* selected nature of *S. californica* results in a low rebound potential and long doubling time for species (Cortes, 2002; Steven et *al.*, 2000). Although the US commercial fishery for Pacific angel sharks ended over 15 years ago the species is still targeted in Mexican waters, is taken as incidental by-catch in some bottom trawl fisheries, and is subject to fishing pressure from recreational and spear fishermen in the United States (Richards, 2001). Additionally, even though sonic tagging and tracking studies have taken place on populations in Bodega Bay and Santa Catalina Island, no exhaustive population study has been conducted since 1994 (Carter et *al.*; Richards, 2001).

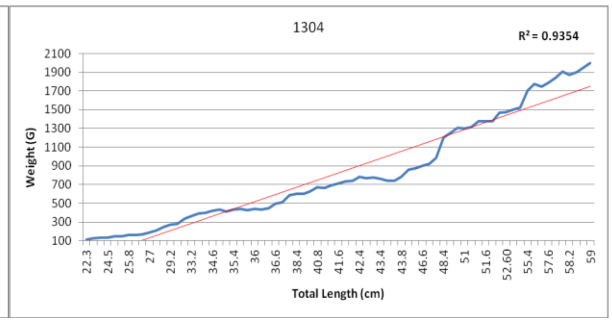
Continued observation and data collection of the angel shark pups kept at the Aquarium of the Bay can offer in-depth information pertaining to this species which could be applied to future management decisions. The data collected from these sharks will also undergo further statistical analysis in order to establish growth curves that can be compared to previously generated models for similarities and differences in overall growth trends. Currently, all the demographic and life history information for this group fall into existing parameters for *S. californica* except size at birth, and as the sharks grow this may continue to influence characteristics such as size at maturity or even fecundity. Also, it is believed that genetically isolated populations of Pacific angel sharks may exist in certain areas off the California coast, and that angel sharks may exhibit philopatric behavior (Gaida, 1995; Gaida 1997; Carter, et *al.*, 2010). Running genetic tests on these sharks and comparing the results to samples taken from wild individuals in different areas along the coast may help reinforce the validity of genetic divergence within the species and the existence of numerous regional sub-populations (Gaida, 1995; Gaida, 1997). Continuing research may also include outfitting one or more individuals

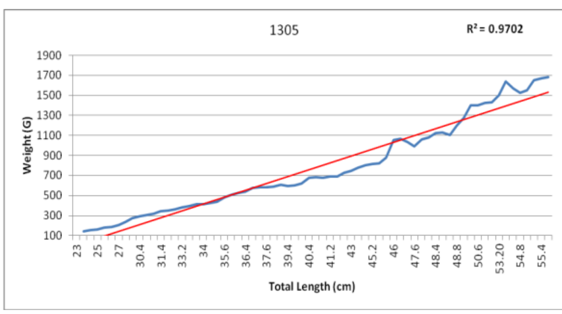
Tables 1.1-1.7: Weight Gain (grams) vs. Total Length (cm) for *S. californica* pups born at Aquarium of the Bay.

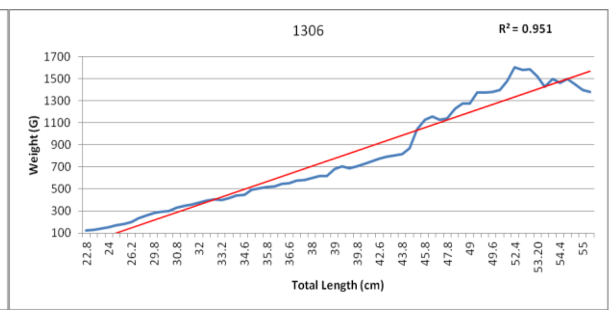












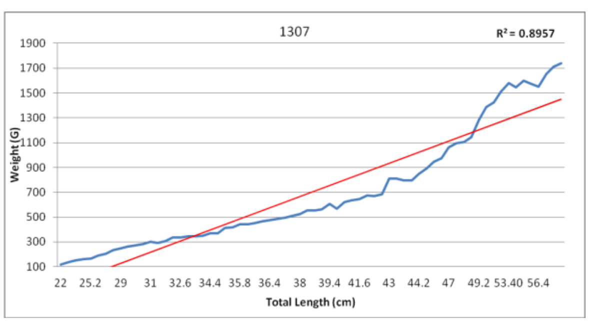
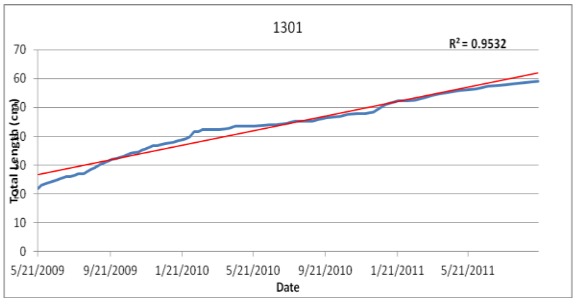
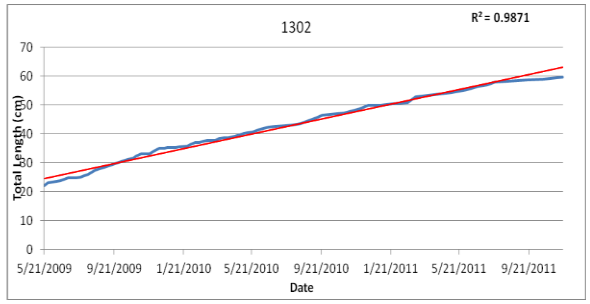
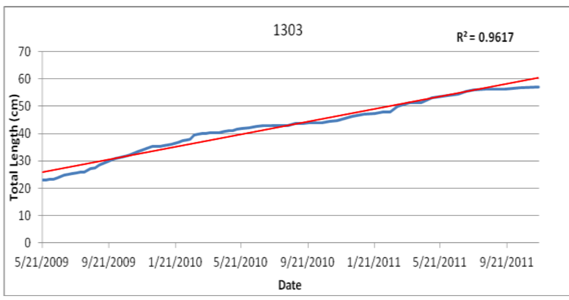
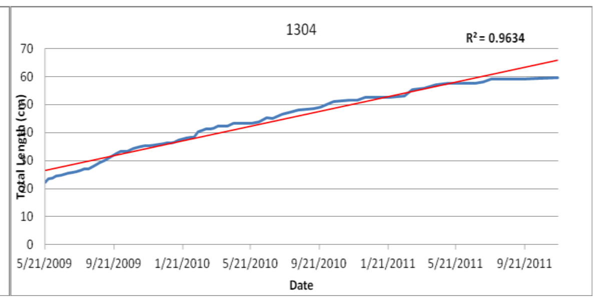


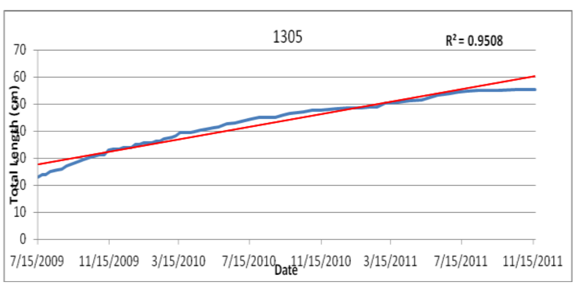
Table 2.1-2.7: Total Length Grown over Time for *S. californica* pups born at Aquarium of the Bay (with regression analysis).

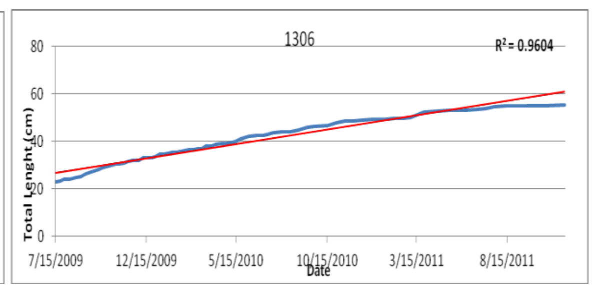












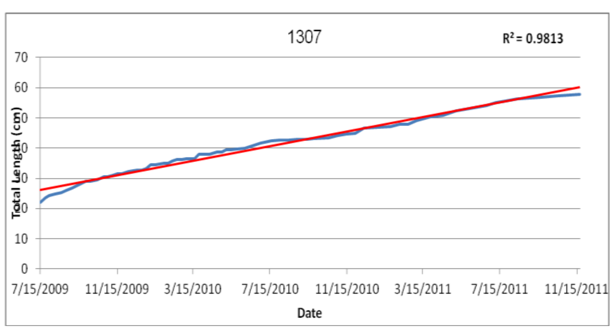
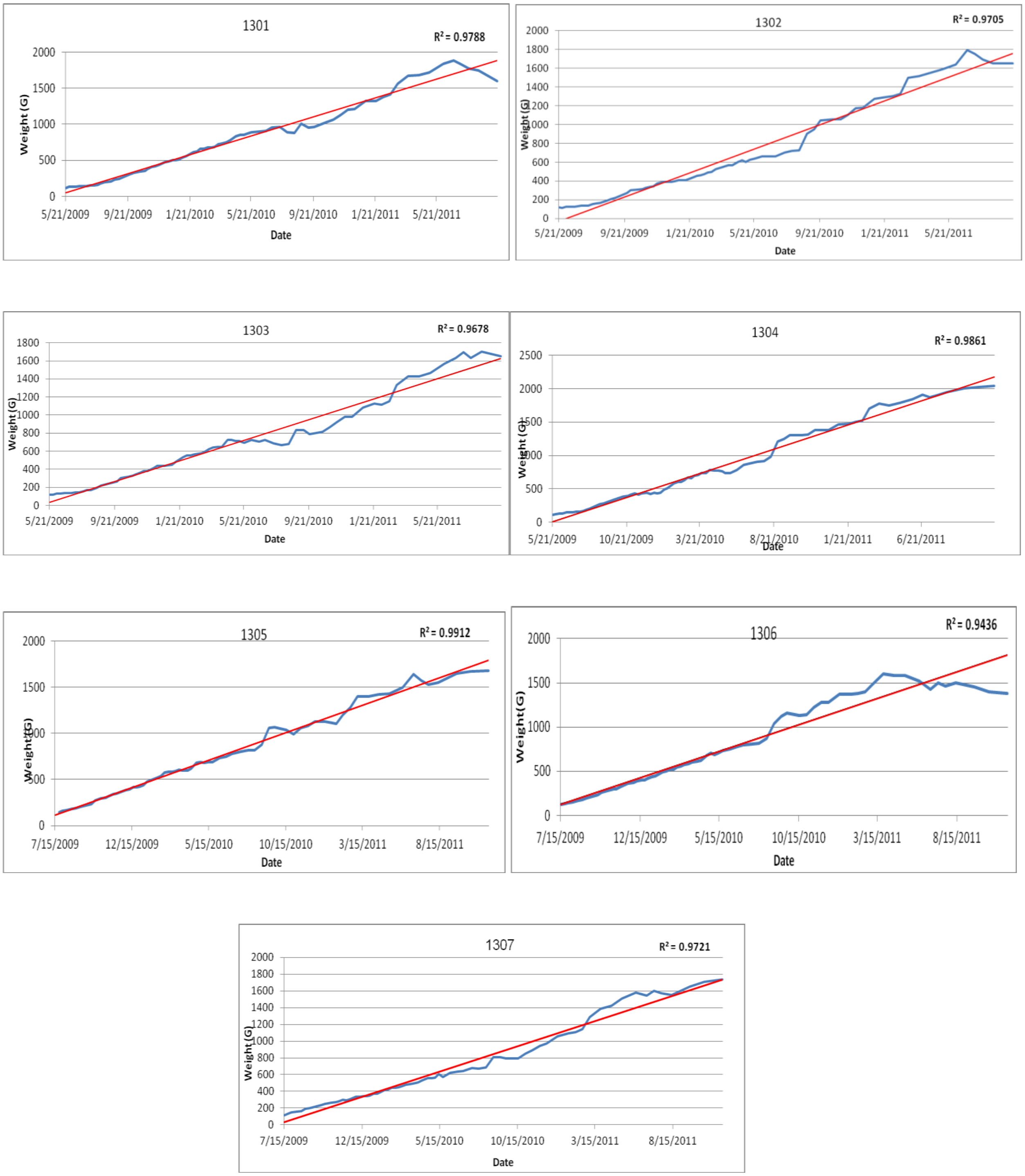
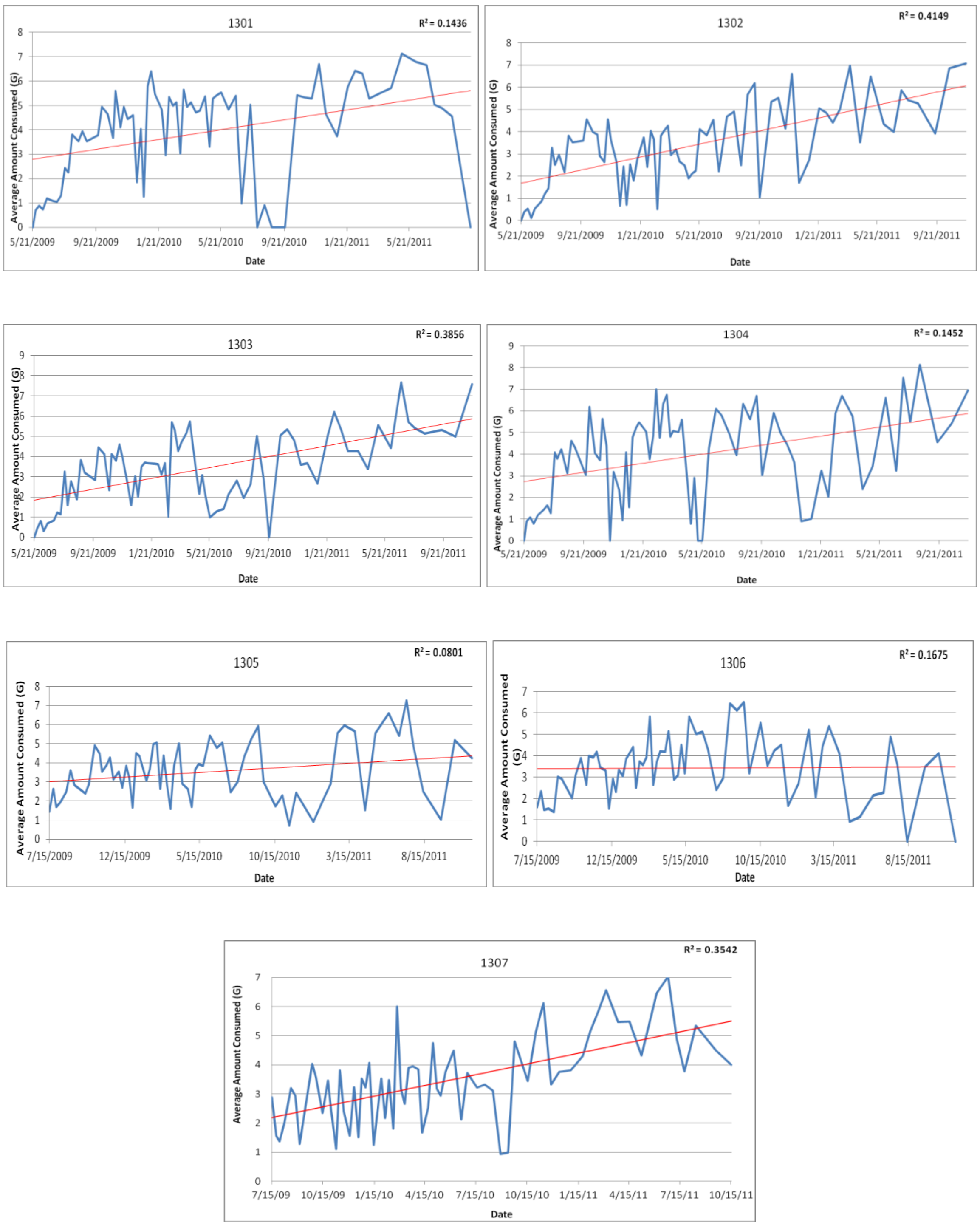


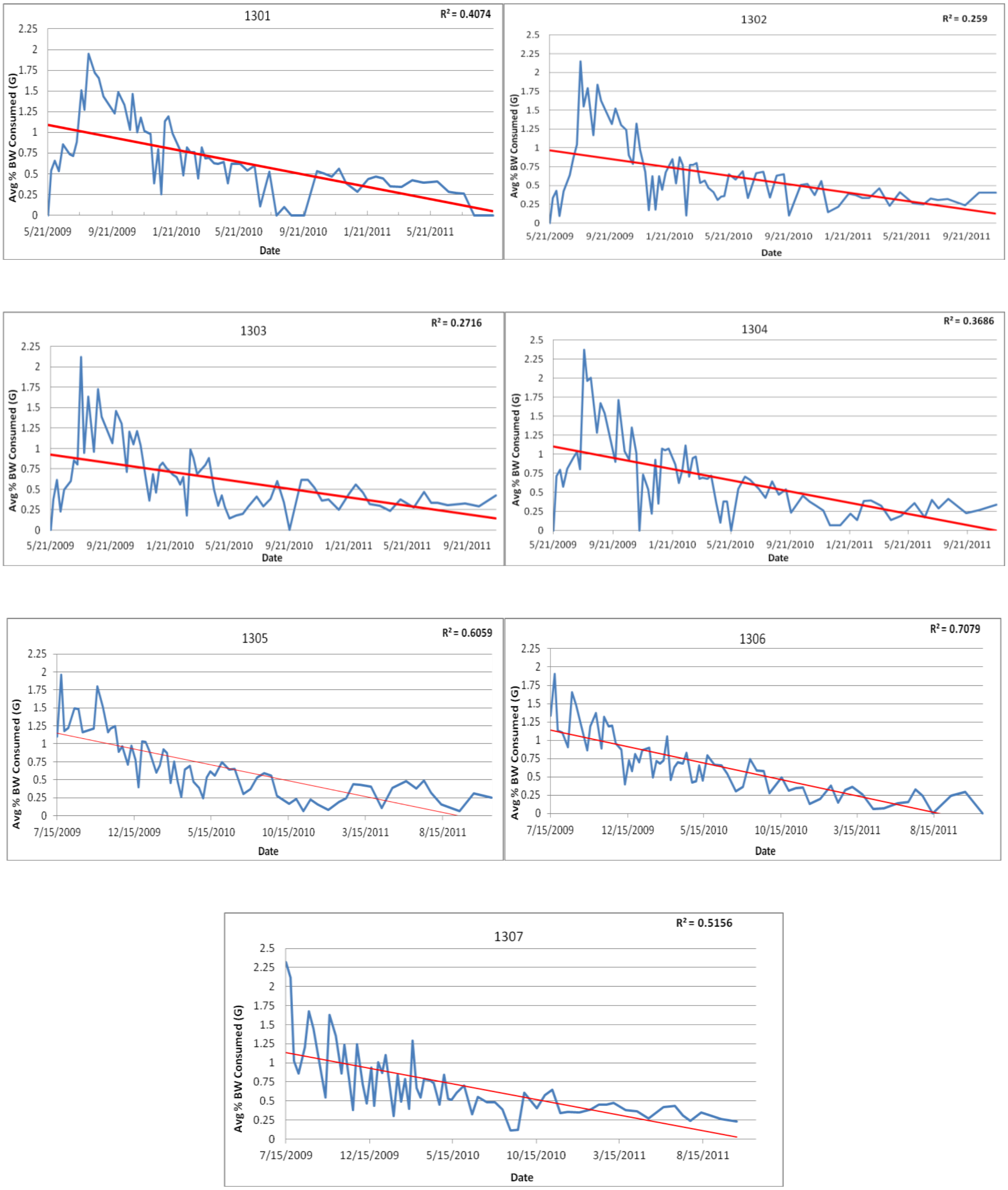
Table 3.1-3.7: Total Weight (Grams) Gained over Time for *S. californica* pups born at Aquarium of the Bay (with regression analysis).



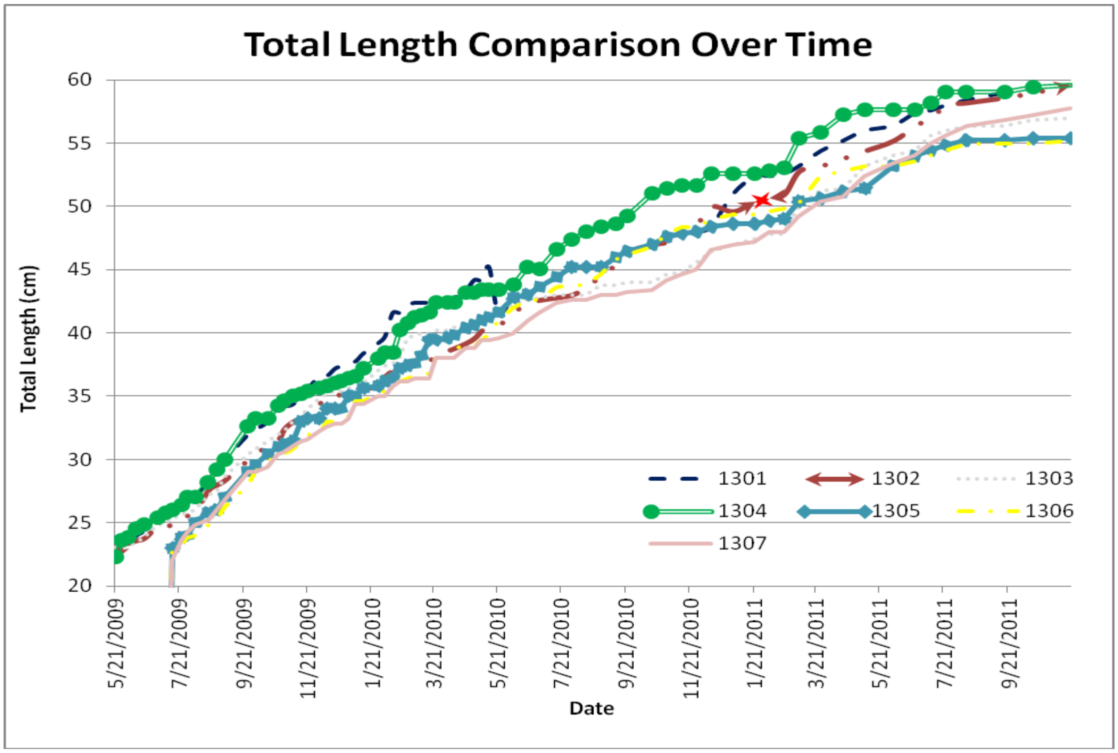
Tables 4.1-4.7: Average Consumption Rate (grams) of *S. californica* pups born at Aquarium of the Bay (with regression analysis).

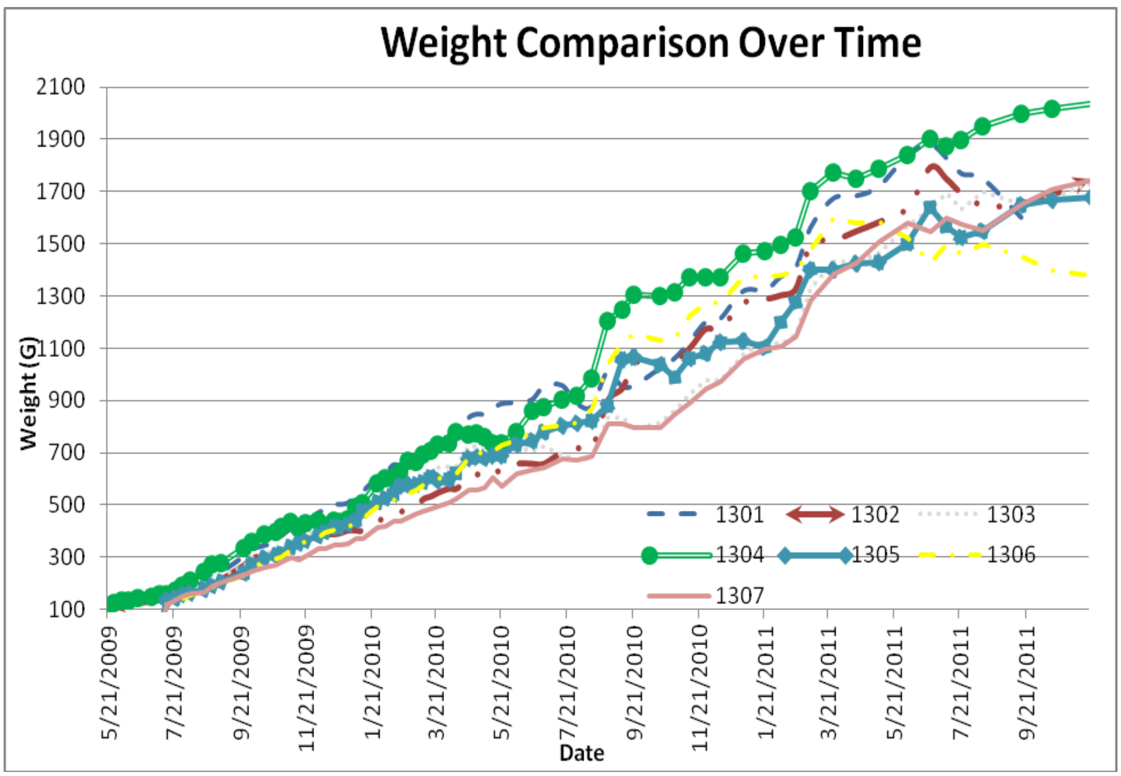


Tables 5.1-5.7: Average Percent Body Weight Consumed over Time by *S. californica* pups born at Aquarium of the Bay (with regression analysis).



Tables 6.1-6.2: Comparison of TL (cm) and Weight (G) between *S. californica* pups.





with acoustic tags and releasing them in the same vicinity where the parents were collected in order to test inherent migratory ability. As the pups mature and some are placed in the Near-shore Tunnel exhibit, they will be intermingled with wild specimens to promote a sustained and genetically varied in house-breeding program.

Table 7: Specific Growth Rate (percent daily), Monthly and Annual Growth Rates of *S. californica* pups born at Aquarium of the Bay.

ID Number	**1301**	**1302**	**1303**	**1304**	**1305**	**1306**	**1307**
Tag Color	**Dark Blue**	**Red**	**White**	**Green**	**Light Blue**	**Yellow**	**Pink**
Sex	**Male**	**Male**	**Female**	**Female**	**Male**	**Female**	**Female**
SGR%/day	**0.305**	**0.294**	**0.293**	**0.315**	**0.287**	**0.289**	**0.316**
G-rate cm/mo	**1.32**	**1.17**	**1.06**	**1.17**	**1.12**	**1.12**	**1.21**
G-rate cm/yr	**15.9**	**14.06**	**12.75**	**13.99**	**13.41**	**13.41**	**14.48**

Acknowledgments

The author would like to give special thanks to the Animal Care and Facilities staff at Aquarium of the Bay, as well as the resident vet Dr. Jill Spangenberg for all of the time and energy that continues to be invested in collecting data and maintaining the health of these animals; an additional thanks to Pamela Montbach, Senior Aquarist from Steinhart Aquarium at the California Academy of Science for her assistance with locating and obtaining many of the reference materials used in paper.

References

Cailliet, G. M., Mollet, H. F., Pittenger, G.G., Bedord, D., and Natanson, L.J. 1992. Growth and demography of the Pacific angel shark (*Squatina californica*), based upon tag returns off California. Australian Journal of Marine and Freshwater Research, 43: 1313-1330.

Cailliet, G.M., Smith, W.D., Mollet, H.F., Goldman, K.J. (2006). Age and growth studies of chondrichthyan fishes: the need for consistency in terminology, verification, validation, and growth fitting. Environmental Biology of Fishes, 77: 211-228.

Capa, C., Quingnard, J.P., and Mellinger, J. (1990). Reproduction and development of two angel sharks, *Squatina squatina* and *S. oculata* (Pisces: Squantinidae), off Tunisian coasts: semi-delayed vitellogenesis, lack of egg capsules, and lecithotrophy. Journal of Fish Biology, 37: 347-356.

Carter, E.H, Slager, C.J.S., Spangenberg, J.V., Hebert, K., and Sandstrom, P.T. (2010). Movements of Pacific Angel Sharks, *Squatina californica*, in Bodega Bay Channel: Tagging Project Preliminary Results. Drum and Croaker, 41: 39-49.

Compagno, L., Dando, M., Fowler, S. (2005) *Sharks of the World*. Princeton: Princeton University Press, 140-141.

Cope, J.M. (2006). Exploring intraspecific life history patterns in sharks. Fishery Bulletin, 104, (2): 311-321.

Cortes, E. (2000). Life history patterns and correlations in sharks. Rev. Fish. Sci., 8, (4): 299-344.

Cortes, E. (2002). Incorporating uncertainty into demographic modeling: application to shark populations and their conservation. Conservation Biology, 16, (4):1048-1062.

Ebert, D. A. (2003). *Sharks, Rays, and Chimeras of California*. Berkley: University of California Press, 76-80.

Fouts, W.R., Nelson, D.R. 1999. Prey Capture by the Pacific Angel Shark, *Squatina californica*: Visually

Mediated Strikes and Ambush-site Characterisitics. Copeia 1999, (2) 304-312.

Frisk, M. G., T. J. Miller, Fogarty, M.J. (2001). Estimation and analysis of biological parameters in elasmobranch fishes: a comparative life history study. Can. J. Fish. Aquatic. Sci., 58: 969−981.

Gaida, I.H. 1995. Evolutionary Aspects of Gene Expression in the Pacific Angel Shark, *Squatina california* (Squatiniformes: Squatinidae). Copeia 1995, (3): 532-554.

Gaida, I. H. 1997. Population Structure of the Pacific Angel Shark, *Squatina californica* (Squatiniformes: Squatinidae), around the California Channel Islands. Copeia 1995, (4): 738-744.

Hoenig, J.M., Gruber, S.M. (1990). Life history patterns in elasmobranchs: implications for fisheries management. *Elasmobranchs as Living Resources: Advances in the Biology, Ecology, Systematics, and the Status of the Fisheries*. NOAA Technical Report NMFS 90, U.S. Department of Commerce: 1-16.

Motta, P.J., Wilga, C.D. (2001). Advances in the feeding behaviors, mechanisms, and mechanics of sharks. Environmental Biology of Fishes, 60: 131-156.

Natanson, L.J., Cailliet, G.M., Welden, B.A. 1984. Age, growth and reproduction of the Pacific angel shark (*Squatina californica*) from Santa Barbara, California. Am. Zool., 24 (3):130A.

Natanson, L.J., Cailliet, G.M. 1986. Reproduction and development of the Pacific angel shark, *Squatina californica*, off Santa Barbara, California. Copeia 1986, (4): 987-994.

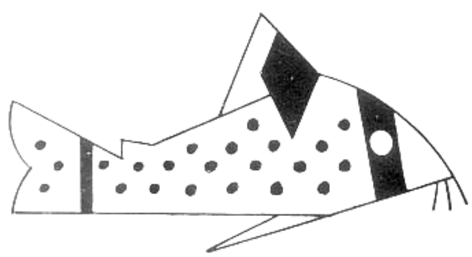
Natanson, L.J., Cailliet, G.M. 1990. Vertebral Growth Zone Deposition in Pacific Angel Sharks. Copeia 1990, (4): 1133-1145.

Richards, J.B. 2001. Pacific Angel Shark: History of the Fishery. California's Marine Living Resources: A Status Report. California Department of Fish and Game, 248-251.

Schaadt, M., Landesman, J.L. (1997). Husbandry of Pacific Angel Sharks at Cabrillo Aquarium. Drum and Croaker, 26: 3-5.

Stevens, J.D., Bonfil, R., Dulvy, N.K., Walker, P.A. (2000). The effects of fishing on sharks, rays, and chimaeras (chondrichthyans), and the implications for marine ecosystems. ICES Journal of Marine Science, 57, (3): 476-494.

Van Dykhuizen, G., Mollet, H. (1992). Growth, Age Estimation and Feeding of Captive Sevengill Sharks, *Notorynchus cepedianus*, at the Monterey Bay Aquarium. Australian Journal of Marine and Freshwater Research, 43: 297-318.



Craig Phillip, Drum and Croaker, 1968

HLLE RESEARCH AT SHARK REEF AQUARIUM

Jack Jewell, General Curator, jjewell@mandalaybay.com

Shark Reef Aquarium at Mandalay Bay
3950 Las Vegas Blvd South, Las Vegas, NV 89119

Description

The use of Regranex in the treatment of Head and Later Line Erosion (HLLE) has been well documented and is a proven success. We recently performed an experiment that suggests other factors may be important in the treatment of HLLE and call for a more systematic and controlled experimental approach.

Background

HLLE has been treated with Regranex with good results, Boerner, Dube et al Zoo Vet (2003), Adams, IAAAM (2005). This included an earlier experiment at Shark Reef (unpublished). Based on information from presentations by Dr. Lance Adams (AOP) and Dr. Andy Stamper (Living Seas) there is reason to believe that there may be other factors at work. At minimum, results suggest the very economical use of Regranex may provide similar outcomes to more extensive and expensive use of the drug.

Materials and Methods

Eight fish were used: four-purple tangs (*Zebrasoma xanthurus*), two regal blue tangs (*Paracanthurus hepatus*), and two *Ctenochaetus spp.* These fish were approximately three to four inches long and affected with HLLE. The fish were isolated in a large (760 Liter) tank – composed of 9 individual 76 Liter cubicles. Four fish had the entire affected areas debrided as described below. These fish received no other treatment and were immediately placed back in the water. The remaining fish received no debridement or treatment of any kind. Disease progression was photo documented at the beginning and end of the experimental period.

On May 21, 2010, all fish including controls were captured using "dip nets" and placed in 100 ppm MS-222 solution (8.5 g/85 L) for sedation/anesthesia. Fish that were debrided were placed in lateral recumbancy on a plastic tray, photographed; the head area was debrided using a scalpel and gauze. The process was repeated on August 31, 2010 and again on November 25, 2010.

Results

The photographs from the first session were unfortunately of poor quality and made later analysis difficult with some skewing of the % area affected due to the composition of the shot. Subsequent photos were excellent and allowed for good analysis. Adobe Photoshop was utilized by using the "threshold" process at level 128 for each image to determine the % area affected. There was a significant reduction in the visible symptoms of HLLE in all fish with no significant difference in the fish that were debrided and the control group. One of the debrided fish developed a seemingly unrelated growth on the dorsal aspect of its head and was lost.

Dissolved Organic Carbon (DOC) samples were sent out at the beginning of the experiment, after 12-weeks, and at the end of the experiment. We note the second DOC sample* was collected following the regular water change on August 25, 2010. The value likely reflects the dilution effect caused by the ~ 50% water change prior to sample collection. Typical DOC levels of systems tested at Shark Reef are in the 0.5 to 1.0 ppm range. The levels measured during the course of the experiment were:

May 24, 2010	2.1 ppm
August 31, 2010	ND*
December 29, 2010	1.7 ppm

Conclusion

Our experiment mirrors the results that have been observed by many others in the field i.e. that fish isolated in a system away from others fish and with independent filtration heal "spontaneously." As suggested by Drs. Lance Adams (AOP) and Andy Stamper (Living Seas), we hypothesize that the availability of this DOC may play an important role in affecting the disease progression. A more robust and controlled experiment is necessary before any hard conclusions may be drawn.

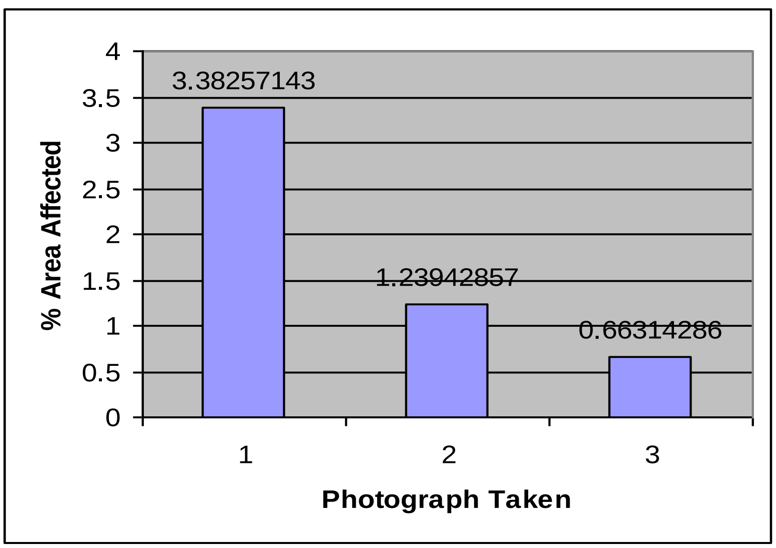


Figure 1: Percent area affected by HLLE over the course of the 24-week experiment (all experimental and control fish combined). The Photograph Taken legend indicates: initial photos (1), 12-week photos (2), and 24-week photos (3).

UNDERWATER PHOTOGRAPHY IN AQUARIUMS

Jay Hemdal, Curator of Fishes jay.hemdal@toledozoo.org

The Toledo Zoo, 2700 Broadway, Toledo Ohio USA 43609

Public aquarists often have difficulty photographing animals in their collections. Not only do they have the same problems as home aquarists (flash reflection off the glass, issues with white balance, fast moving fish, etc.) they have the added difficulty of distortion caused by much thicker viewing panels (often with fingerprints or scratches on the surface). In some cases, the answer is to photograph the subject animal in a special photo tank (Axelrod 1970). I have used photo tanks “from-the-side” as well as "top down". However, they only work for small specimens and anesthesia to keep the fish calm is often required. Additionally, there are still problems with surface glare from the flash (Hemdal 2006).

Another method that should be explored is the use of underwater cameras inside aquariums. While this technique has the obvious benefits of no issues with glare from the exhibit glazing, and closer proximity to the subject, it also has a different drawback; backscatter (when the flash hits particles in the water) can be worsened in underwater photos. This can be minimized by avoiding disturbing any detritus and by not feeding the tank before taking underwater shots. Image editing software can be used to remove any particle "flares" that might remain. One other problem with in-tank underwater photography is the vantage point – often obliquely from above the subject. While this can be used for its novel effect, you wouldn't want to have every image shot from this angle.

In my constant attempt to produce better images through technology, (as opposed to trying to improve any possible artistic talent I might have!) I’ve purchased a succession of underwater cameras over the years:

Early attempts

My first attempts at in-tank underwater photography relied on small film cameras; first the Minolta Weathermatic 110 and later the SeaLife 35mm. The minimum focus distance on both of these cameras was too long to be of any real use inside most aquariums. Later, I purchased a 3.2 megapixel Canon ELPH in a waterproof case. This allowed for barely tolerable results as the housing was bulky and the camera had relatively low resolution.

10 megapixel Pentax Optio W60

This camera is water resistant to 14 feet without a special housing. Costing only $100 used on EBay, it gives fairly good results, and doubles as a good small camera for above water snapshots. The water resistant latch for the battery and memory card is not very strong or secure. Be careful not to bump it while underwater, to avoid a possible leak. Pentax has come out with newer, improved versions of this camera.

Cryptic sponges photographed by placing an Optio W60 under some live rock in a sump and blindly pressing the shutter.

Portrait of a longnose hawkfish cropped from a larger image taken with a Optio W60.

Nikon AW100 Coolpix camera

The Nikon is a $320 camera that is waterproof to 10 meters and shock-proof from 1.5 m. Its 16 megapixel sensor and image stabilization holds some promise towards my meeting my goal of "better images through better equipment". The AW100 took a little bit of getting used to - having the lens opening in the upper left corner of the camera meant that my finger sometimes strayed into the shot. The close proximity of the flash and the lens (common to many pocket cameras) means that red-eye and backscatter can be more of an issue than with a camera having a remote strobe. This camera can focus as close as 1 cm from the lens in Macro mode – but because the flash is off to one side, extreme close-ups may not be lighted properly, and may show strong shadows. The GPS function of this camera is just a novelty for me now - but who knows, it may have some use while on collecting trips or other outdoor excursions. The Nikon AW100 can also take 1080p hd video, here is a short underwater video of flashlight fish in a public aquarium exhibit: http://www.youtube.com/watch?v=AkqlzycFJ5k

Boarfish photographed in its exhibit with a Nikon AW100

Nikonos

Seeing the glut of reasonably priced Nikonos film cameras for sale on EBay, I succumbed to temptation and through a series of purchases, amassed a full set of working set of gear including two cameras, three lenses and a strobe. My presumption was that the outstanding quality of this equipment would off-set the drawback of using non-digital camera equipment. This turned out to be false, the results I could obtain with the Nikonos equipment was better than the Pentax Optio, but not nearly as good as the Nikon AW100. The cost and delay in film processing has relegated my Nikonos gear into storage and probable future sale back on EBay.

Left: Nikonos V film camera and strobe. Right: Top-down image of a reef tank taken with a Nikonos V film camera.

Other cameras

There are many other cameras available that can be used for in-tank underwater photography. The following is a list of some that may be suitable, (based on their specifications) but that I have not tried for myself:

Camera Model	**Features**	**2011 street price**
Sea & Sea DX-1G	10mp Digital Camera w/housing	$995
SeaLife SL708 DC1200	Digital Camera and strobe 200’ rating	$740
Panasonic DMC-TS3	12.1 MP Digital Camera 40’ rating	$289
SeaLife Mini II SL330	9MP Digital Camera, 130’ rating	$230
Pentax Optio WG-1	14mp Digital camera 33’ rating	$198
Intova IC-12	12mp Digital Camera 180’ rated housing	$170
Vivitar 8400	8.1 MP 2.4" LCD Digital Camera 33’ rating	$92
Bell & Howell Splash WP5	12mp Digital Camera 10’ rating	$59

Hints and tips

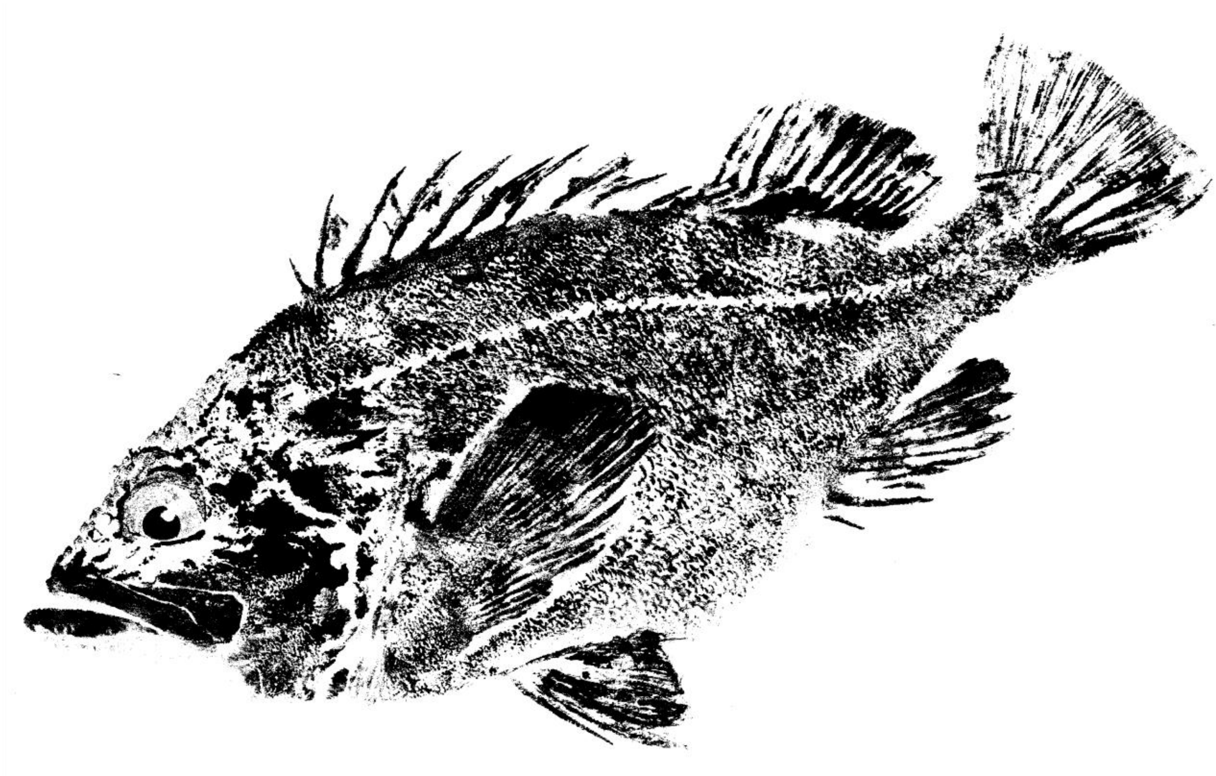
- In-tank photography can often best be done while diving (in large tanks). Beware that there is sometimes a time rating and well as a depth rating for underwater cameras; such as: “15 feet for 1 hour”. You might exceed this time during long dives.
- When first submerging a camera, brush off any air bubbles that might be adhering to the outside of the lens.
- Actinic lights and blue LEDs can cause severe fringing in the image. I usually turn these lights off before filming; although Photoshop can partially correct this (see sample images below).
- In-tank shots taken while standing next to the tank make it very difficult to frame your image. One solution is to “shoot from the hip” and just take a picture in the general direction of the subject. Then, in post-processing, you can crop the image to align the subject where you want it to be.
- Setting the flash on partial power will illuminate the subject, while causing the background to become dark – a good technique for highlighting a fish (as in the boarfish image above).
- After use, soak the camera in deionized water, then air dry. Never let saltwater dry on a camera, it can damage the O-rings. Do not rinse the camera under a faucet; the force of the water can unseat the O-rings, causing a flood.
- Post-processing is important. People sometimes feel that retouching a photo is akin to lying, and that may be the case if you’re a newspaper photographer. However, if your goal is to create a better image of an animal for a specific use and editing the image helps accomplish that, then post-processing is a valid tool.
- Don't be afraid to think outside the box. In one shot, I wasn't able to hold the camera at the proper angle, so I made the shot with the camera upside-down and then just flipped the image in Photoshop.

Left: Blue chromatic aberration on *Acropora* caused by blue LED lighting – close up.
Right: Blue tinged edge mostly removed in Photoshop

References

Axelrod, H.R. 1970. **Photography for Aquarists.** TFH Publications, Neptune, New Jersey.

Hemdal, J.F. 2006. **Advanced Marine Aquarium Techniques**. TFH Publications, Neptune, New Jersey.



Rockfish gyotaku by Bruce Koike.

RAISING BABY OCTOPUSES

Roland C. Anderson, Seattle Aquarium (emeritus), geoduck46@gmail.com

James B. Wood, Hawaii Institute of Marine Biology, jamesbwood2000@gmail.com

Octopuses have short life spans; many species only live for a year. To the surprise of many aquarists, female octopuses often lay fertile eggs in captivity. Both authors receive many questions, from public aquarists and hobbyists about rearing octopus eggs laid in captivity. This article is written to provide aquarists with a guide on the challenging task of raising octopuses from eggs.

It is important to know what species of octopus you have. For rearing purposes octopuses can be divided into two groups, small egged and large egged. Both types of eggs are typically laid by the mother in festoons, strings of eggs hanging down from the ceiling of her maternal den. Large-egged females typically lay hundreds to thousands of eggs, while small-egged species lay thousands to hundreds of thousands of eggs. A few Indo-Pacific species which may show up occasionally in pet shops carry their eggs rather than attaching them.

Table 1: Eight octopuses and the number and size of their eggs. Data from Sweeney et al 1992.

Species	Egg size in mm	Number of eggs
Small Egged (Planktonic)		
O. bimaculatus	2.5 - 4	20,000
O. rubescens	3 - 4	4000 - 45,000
O. vulgaris	1.5 - 2.7	100,000 - 500,000
O. cyanea	2 - 3	110,000 - 700,000
Enteroctopus dofleini	6 - 8	30,000 - 180,000
Large Egged (Benthic)		
O. mercatoris	6 - 10	25 - 300
O. bimaculoides	12 - 17	200 - 750
O. briareus	10 - 14	150 - 950

The names used to identify octopuses by commercial suppliers are often inaccurate. Octopuses that are typically commercially available in the USA include pygmy octopuses *Octopus joubini* and *Octopus mercatoris*, common octopus *Octopus vulgaris*, two-spot octopuses *Octopus bimaculoides* and *Octopus bimaculatus*, Caribbean reef octopuses (CROs) *Octopus briareus*, red octopuses *Octopus rubescens* and giant Pacific octopuses (GPOs) *Enteroctopus* *dofleini*. Several other species are occasionally encountered; this guide will also apply to raising their young. It will help with identification to know where your octopus came from, most are collected from either the east coast (probably Florida) or west coast (probably California).

After the eggs are laid, the female octopus tends the eggs. She will blow water and move her arms through them to clean and oxygenate them. She usually does not eat (not a hard-and-fast rule; she may eat some while tending her eggs). Some biologists posit that brooding female octopuses stop eating to prevent food wastes from attracting predators or fouling the water around the eggs. Some species block up the entrance to the den with rocks or whatever else is readily available; this camouflages the den so that the eggs are not visible.

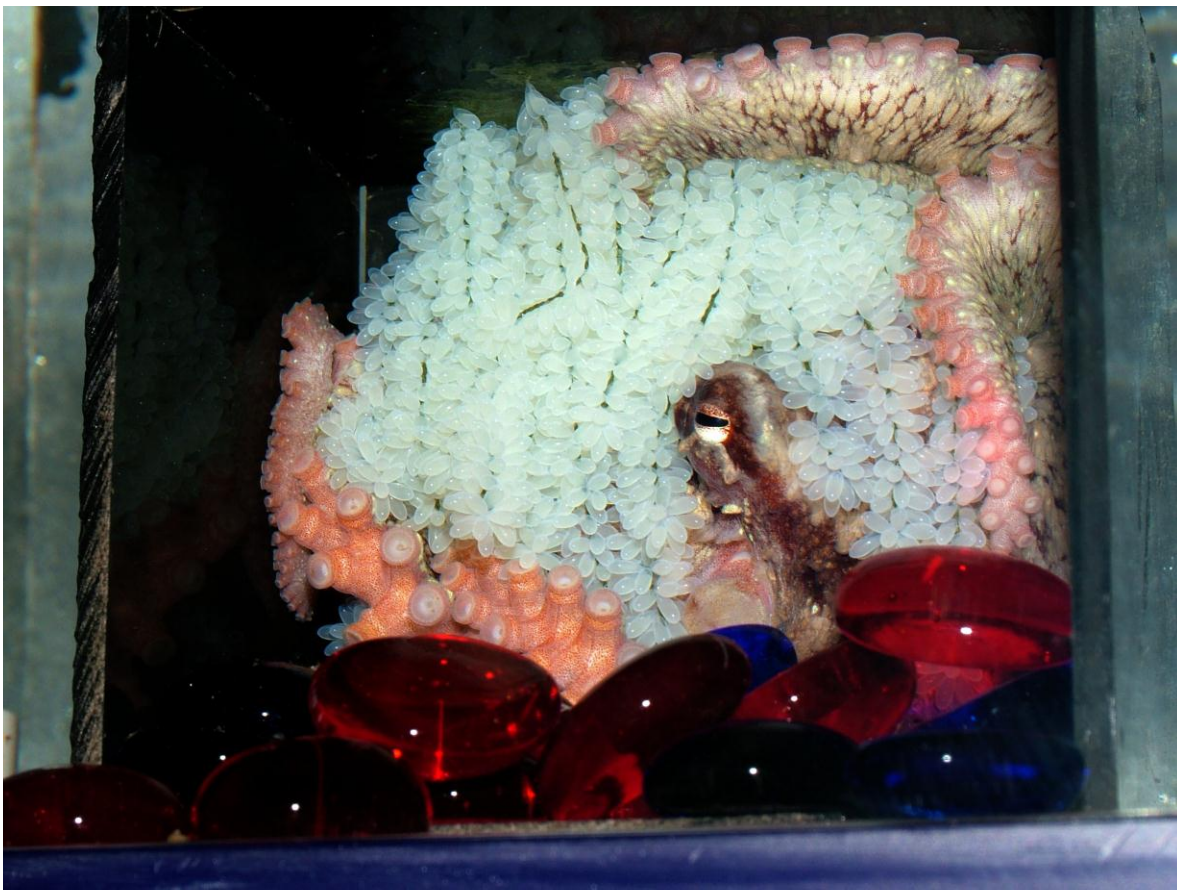


Figure 1: A red octopus female guarding her eggs. Photo: Seattle Aquarium.

There are two pygmy octopus species from Florida that are extremely difficult to distinguish. One of the characteristics used to distinguish them is that one species has small eggs and planktonic paralarvae. Paralarvae is the term used for cephalopod planktonic hatchlings (Young and Harman 1988). They are paralarvae because they don't go through a true metamorphosis like insects do. Large-egged species are direct developers, they skip the planktonic stage and have benthic hatchlings that spend their time crawling or hiding on the bottom rather than swimming in the water column. Since they are larger and behave more like their adult counterparts, benthic hatchings are relatively easier to raise. Another common east coast octopus sometimes found in pet stores is the Caribbean reef octopus. This species has long arms and is nocturnal in the wild but may become day active in captivity. It can grow to over two feet across its out-stretched arms while the two east coast pygmy species only reach a maximum of four inches arm tip to arm tip. Therefore, size can be a major distinguishing feature. The common octopus of Florida, the Gulf and the Caribbean may also show up in pet stores. It is stockier with shorter arms and is day-active. Adults are much larger than the pygmies or Caribbean reef octopus. The common octopus has tiny eggs and planktonic paralarvae. Its paralarvae have only been raised in Europe by a few scientists.

On the American west coast, there are two sister species of two-spot octopuses in southern California. An additional west coast species, the red octopus, is more common in colder water from California to Alaska. A chiller may be needed for west coast species and is required for red octopus. Red octopuses may be distinguished by their size, geographic region, typical muddy brown color, and two white spots in front of the eyes. Red octopuses have tiny eggs and their paralarvae have never been raised.

The two sister species of two spot octopuses can be mislabeled as pygmy octopuses. One species has black ink (*O. bimaculoides*) and one (*O. bimaculatus*) has brown ink. They both have false eyespots in the webbing in front of the eyes with a blue iridescent ring on the outside. The octopuses flash their "ocelli" at potential predators, making them look like eyes of a much larger animal. Young of the small-egged species, *O. bimaculatus,* have never been raised as they are planktonic and very small.

Small egged octopuses are especially difficult to rear. There are <u>only</u> <u>two</u> species of small-egged octopuses that have ever been raised from eggs: the giant Pacific octopus and the common octopus (*Octopus vulgaris*). If you have a small-egged species you probably will not be able to raise them. Of course you might get lucky, and if you do, please let us know.

The odds are even more greatly against you if your female octopus dies before the eggs hatch. Jim Cosgrove, a scientist who studies giant Pacific octopuses in Canada, has never witnessed a successful hatching in the wild if the female dies before the eggs hatch. Egg predators are lurking in the wild but even if there are no predators in an aquarium, without the female to clean and oxygenate the eggs they will often become fouled.

Octopuses are semelparous (terminal spawners) which means they reproduce at the ends of their lives like salmon and century plants, dying after reproducing. A female octopus laying eggs is a clear sign that she is near the end of her life cycle. Males typically have a similar life span to females. However, the end of their life cycle is not marked with an event as easy to observe as egg laying, males often mate with multiple females and then go into "senescence," a state similar to human dementia. They stop eating, crawl about aimlessly, and begin to waste away from starvation, and eventually die (Anderson et. al 2002).

After mating, the female returns to her den, lays her eggs, stops eating, wastes away to half her size, and dies just after the eggs hatch. Guarding the eggs is a closely–timed process. If she dies of starvation too soon the eggs will likely be eaten by predators, smothered by algae, or parasitized by tiny organisms. If she dies too late after the eggs hatch, she could have put more of her resources into egg production. Evolution has thusly timed the sequence of mating, laying and guarding the eggs, helping the babies hatch and then dying. This sequence is hard-wired into the female.

Once the eggs have been laid the next step is to determine if the eggs are fertile. If the female came from the wild in the prior three months, the chances are good that the eggs are fertile. Unmated female octopuses may still lay eggs. Sometimes infertile eggs will be laid normally but other times they are laid haphazardly, spread around the tank, rather than in a tight cluster of festoons. In at least one case a female giant Pacific octopus laid normal-looking eggs and tended them to hatching, but she developed a huge lump inside her that was determined by necropsy to be rotting unfertilized eggs. We hypothesized she mated only once in only one of her two oviducts, leaving half her eggs unfertilized. In another case a female Caribbean reef octopus laid unfertile eggs normally but ate them after a few weeks. In another example of a giant Pacific octopus female, the female laid normal looking eggs in a tank and tended them, but almost all were infertile; only a couple showed normal development inside. She may have waited too long to lay her eggs, storing sperm all the while, and perhaps the sperm went bad.

During the development of fertilized eggs the embryos become visible. The eggs are opaque when they are laid but the outer egg membrane becomes transparent later in the development so it can be visually determined what stage the embryos are at. Seeing eyespots on the developing embryo is a big first step and indicates that the eggs are fertile. At this stage in development, there is a yolk sac attached at the mouth (anteriorly) and the arms develop as though clutching the yolk. At first, the yolk sac is at the proximal end of the egg (toward the attachment). Later in development, the embryo has the typical octopoid shape, complete with a few suckers and large chormatophores on each arm, and even a functioning ink gland with an ink sac. When these embryos are disturbed, they can release ink within the eggs.

The octopus embryos go through two orientation reversals inside the egg. They begin with their mantle at the distal end (away from the attachment) and end up in that position. Gabe (1975) speculated that these reversals allowed for more room inside the egg for the developing embryo. It seems more likely that the last reversal just before hatching positions the mantle for contact with the emergence point of the egg, so the organ of Hoyle can be pressed there. This embryonic organ produces enzymes that dissolve the egg coating and are stored in cells at the end of the mantle. This final reversal occurs toward the latter part of the incubation period. Gabe documented that it occurred two weeks before hatching in a giant Pacific octopus with an incubation period of 160 days. Wood (1995) observed that Caribbean reef octopuses final reversal occurred between 12 and 20 days before hatching. Thus this final reversal within the egg and swelling of the egg is an indicator that hatching is eminent.

Hatching occurs accompanied with the rupture of the enzyme cells on the mantle that help dissolve the egg shell, along with expansions and contractions of the octopuses mantle. The hatchling octopus breaks through the distal end of the eggs mantle first, the normal swimming posture of a jetting octopus. There may be a remnant of a yolk sac still attached that the octopus lives on for the first few days but that is eventually absorbed and it must soon hunt for itself. Some species octopuses may hatch with a yolk sac attached if the eggs have been disturbed and hatched prematurely. Depending on what size the hatchlings are they either crawl away or swim into the water column.

Figure 2: A GPO paralarva ready to hatch. Note the arms clutching the reduced yolk sac and the individual chromatophores on the mantle. Photo: Jim Cosgrove

Small egged species have only been raised in *planktonkreisels* – circular upright tanks with smooth sides and micron screen keeping the octopuses and their food inside the tank. Sometimes a checkerboard pattern is used on the sides of the tank to keep the octopuses from running into the sides. There must be a circular current regime in the tank that keeps the hatch lings in the middle, preventing them from being sucked into a filter and also keeping them away from the tank walls. When transferring the hatchling octopuses into the rearing tank, they will be injured or killed if caught in a net. The best way to move them is to dip a container into the water and scoop them up. The hatchlings' tank must be either a flow through system or a closed system that has been cycled. All potential fish and invertebrate predators should be removed. Tropical or sub-tropical species only take 1-3 months to hatch, but giant Pacific octopus and red octopus take 4-10 months, depending on water temperature. The longest known development period is over 400 days for the deep sea octopus *Bathypolypus arcticus* (Wood et. al 1998).

Methods of feeding will be different between large and small egged species. Large egged species can be fed live mysid shrimp, amphipods, and shrimp or crab larvae close to their own size. They must be fed multiple times a day and all decaying food must be removed. Feeding and cleaning is intense and can take several hours daily.

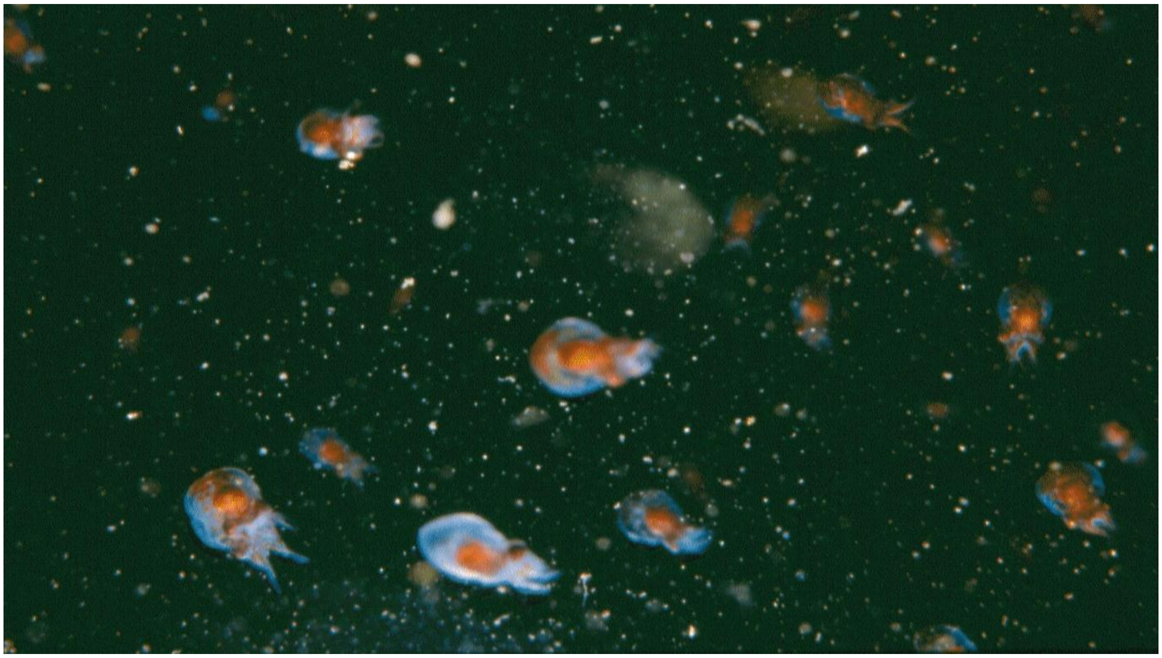


Figure 3: GPO paralarvae just-hatched. Note the yolk sac has been totally absorbed. Photo: Barry Shuman

Small egged species hatch into planktonic paralarvae. A planktonkreisel must be used to house them. Feeding is a distinct challenge. Good first foods to try are appropriate sized copepods or shrimp or crab larvae. Brine shimp are often used as a food source but they are like Twinkies, readily consumed but low in nutritional value. After a few weeks, individuals can also be fed pieces of raw seafood on feeder sticks. The tank needs to be kept even cleaner than for larger hatchlings. The fine micron screen may need to be cleaned of debris daily or it will clog. Once planktonic hatchlings settle to the bottom, they can be fed like large-egged benthic hatchlings.

Octopuses, especially juvenile octopuses are highly cannibalistic. Ideally, you should have one tank per octopus. In a large tank with lots of habitat and hiding places you might be able to rear a dozen or two benthic hatchlings. Wood and Wood (1998) published a "how-to" article about creating multiple rearing chambers for large egged octopuses. This technique separates the octopuses, reducing cannibalism and disease. You might be able to raise a hundred planktonic hatchlings in a single tank to settlement. Frankly, you should consider yourself lucky to raise a couple benthic hatchlings and extremely lucky to raise any planktonic hatchlings.

Remember, only two species of planktonic hatchlings have ever been reared. Prepare yourself for lots and lots of time spent on the project. The first author worked with Snyder (1986) and she spent 6-8 hours a day, seven days a week raising small egged giant Pacific octopuses. The second author has raised the large egged species *Bathypolypus arcticus, Octopus mercatoris, Octopus bimaculoides,* and *Octopus briareus.*

Track down and get the references suggested. The book is available through Amazon.com, the Snyder reference is available at many AZA institutions, and the Villanueva reference is either available at a good university library or available for purchase as a PDF online.

Good luck! You will really need it!

References:

Anderson R.C., Wood J.B. and Byrne R.A. 2002 Octopus senescence: the beginning of the end. Journal of Applied Animal Welfare Science. 5(4): 275-283.

Gabe, S.H. 1975. Reproduction in the giant octopus of the north Pacific, *Octopus dofleini martini*. Veliger. 18(2):146-150.

Mather, J.A., R.C. Anderson & J.B.Wood. 2010. Octopus – the Ocean's Intelligent Invertebrate. Timber Press (Portland, OR).

Snyder, S. 1986. Successful rearing of *Octopus dofleini* from hatching to settlement. AAZPA 1986 Annual Proceedings. 781-784.

Sweeney, M.J., Roper C.F.E., Mangold K.M., and Boletzky S.V. 1992 "Larval" and juvenile cephalopods: a manual for their identification. Smithsonian Contributions to Zoology. No. 513.

Villanueva, R., C. Nozals, & S.v. Boletzky. 1996. Swimming behaviour and food searching in planktonic *Octopus vulgaris* Cuvier from hatching to settlement. Journal of Experimental Marine Biology and Ecology 208: 169-184.

Villanueva, R 1995 Experimental rearing and growth of planktonic *Octopus vulgaris* from hatching to settlement. Canadian Journal of Fisheries and Aquatic Sciences. Vol. 52, no. 12, pp. 2639-2650.

Wood, J.B. 1995. Raising and Rearing *Octopus briarieus* In: The Journal of Maquaculture (The Breeder's Registry) . vol. 3, no. 2.

Wood, J.B. Kenchington, E. and O'Dor, R.K. 1998. Reproduction and embryonic development time of *Bathypolypus arcticus*, a deep-sea octopod (Cephalopoda: Octopoda). Malacologia 39(1-2): 11-19.

Wood, J.B. and Wood, D.A. 1998 James's Rearing Chambers. Freshwater and Marine Aquarium Magazine. vol. 21, no. 12.

Young, RE and Harman RF. 1988 "Larva," "paralarva" and "subadult" in cephalopod terminology. Malacologia. Vol 29: 201-207

A **SIMPLE D.I.Y. ELECTRIC EEL DETECTOR**

Markus Dernjatin, Displays Curator
markus.dernjatin@sealife.fi

SEA LIFE Center Helsinki, Finland

Introduction

What I describe here is a rather simple D.I.Y. "Electric eel detector." Building such an instrument is not rocket science, but getting started without exact details of existing devices can be frustrating. Before going any further I wish to emphasize that I am not an electrician of any degree, so my apologies if some details do not translate as they should. Please send me an email if you need more information.

We had a vision of something hi-tech when we first got an idea for the "Electric eel detector" some years ago. However, we soon found out that such a device was impossible to purchase, at least around here in Finland, because no one sells them and even finding some useful data to build one turned out to be quite difficult. Fixing electric devices is not the specialty of any in our small displays team and in case of problems we often rely on the electrician in the nearby amusement park. And so we did this time as well: with the kind help of Patrick Walsh we managed to put together something that turned out to be an eel detector enough for our purpose.

This device, as described below, displays blinking lights and produces sound, which have at least something to do with the electrical activity of the animals on display. Naturally, there is not enough current in the water to turn on any lights really, so this device is simply picking up "signals" and controlling lights in the panel by a simple ON-OFF method. Lights themselves get their power from the mains, not from the electric eel. This is something that needs to be explained to the visitors as well.

This device does not measure nor does it have any visual indicator for the strength of the current in the water. However the lights flash more often for example during the feeding, providing a good indication for the electric activity of the animals. The sound volume becomes remarkably louder in such situations as well. The overall effect has been great and it truly adds value to our quests' experience. Our device was built by using abandoned bits and pieces found from the shelves of the amusement parks warehouse, but there shouldn't be anything that one couldn't easily find from a store.

Electric Eel Display

Annually changing exhibitions, or "Mobile features" as we call them, are an important part of the SEA LIFE strategy and at least here in Finland many of our regular guests look forward to see what's coming next. In 2009 we had already gone through all the different mobile features available at SEA LIFE that time. Therefore we ended up designing a whole new feature by ourselves. This feature is called "Sea Senses" and it is about unique senses of the aquatic animals: for example trout that find back to their birth brook by the sense of smell, four-eyed fish and mantis shrimps with their extraordinary eyes, fish like drumfish, porkfish or sweetlips, which communicate with sound, and naturally the star of the show, an electric eel.

Sea Senses has a total of five displays. The biggest tank, which is for the electric eels, is a GRP (glass reinforced plastic) cylinder with 180 degree curved view panel. It has a diameter of 2 meters, height of one meter and a volume of approximately 3000 liters. The backdrop is a GRP replica of a muddy riverbank, with some free water space behind it to hide pipes and other equipment. Very fine sand was placed on the bottom and few XL-mangrove roots for the eels to hide among. The LSS consists of a 500-liter reservoir with a trickle tower bio-filter and a heater. The bio-filter is gravity fed via 63 mm overflow from the tank and water trickles through it to the reservoir. Water from the reservoir is pumped back to the tank with an AquaMedic OR6500 via 3 kW Elecro inline heater. There is also a small pressure sand filter and an $8m^3/h$ Badu pump circulating water from tank-to-tank. This setup gave us good water quality throughout the whole 12 months period we had the feature in Helsinki. We kept two specimens of *Electrophorus* in the tank. The bigger one was one meter long, while the smaller fish was 80 cm long. We had no problems keeping two individuals in the same display. Currently the Sea Senses-feature is in SEA LIFE Jesolo, Italy.

Eel Detectors Are Difficult To Find

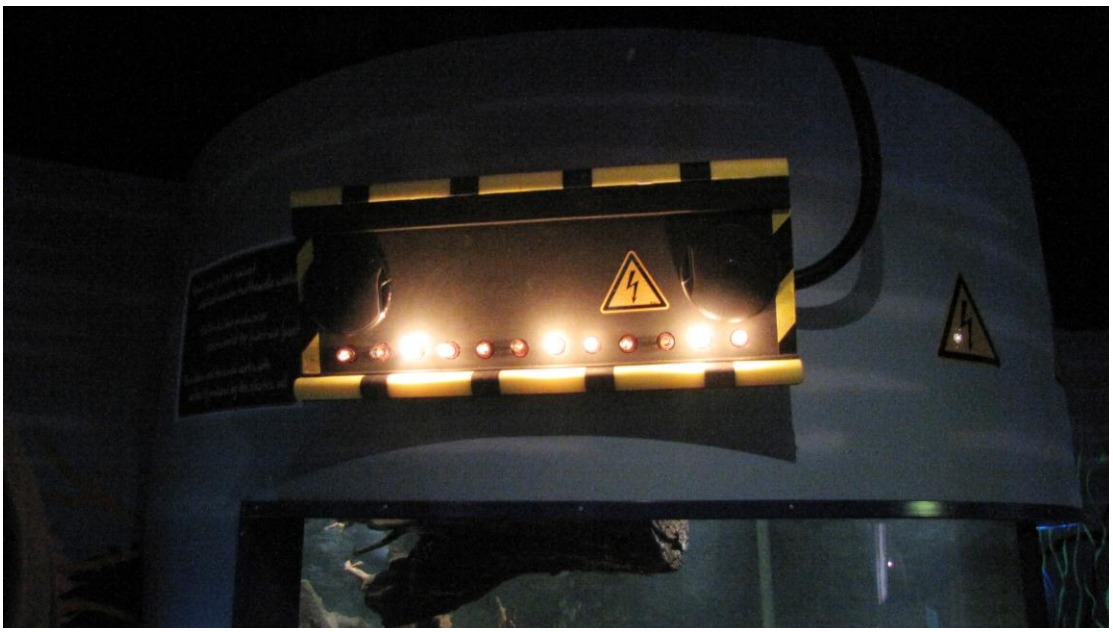
Naturally such display should have an electric eel detector. Since I had seen some in the past we thought that ordering one wouldn't be a problem. Also the manufacturer of our mobile feature and all of its interactive elements took our order for the detector. But as time passed by we started to get signals that most likely the feature would arrive without such a complicated device. Thus we had no chance but to try to find a solution to this problem on our own. After all, we still had one week for the launch of the feature…

I had seen one device in a public aquarium in the city of Tampere in Finland when I was a kid and I could still remember it clearly. It must have been something like 25-30 years ago. There is also one in Artis Royal Zoo aquarium, Amsterdam – I had seen it as well. Therefore I thought that it must be something you simply ask from your colleague who will send you D.I.Y. instructions right away into your mailbox. A quick call to Tampere: no one had any idea what had happened to the device, nor who had built it or how was it built. The device didn't exist anymore so they could not help me. Second call, this time to Amsterdam, was more useful thanks to our colleague Anton Dral. However their device was also from medieval times and Anton did not have drawings or any schematics of the system. The situation seemed to be impossible, yet we didn't give up and after a couple of teleconferences between Anton and Patrick we finally had at least some ideas to work with.

Basics for a D.I.Y. Aquarist

Pure water is a poor conductor of electricity – in aquarium this is seldom a problem. Even small amounts of impurities or minerals, especially salts, greatly increase the conductivity of water. Electric eels have two opposite electric poles - head and tail. They are analogous to battery (+) and (-) poles. The maximum voltage generated is proportional to the length of the animal: a short eel will generate a lower voltage than a longer one. It’s been described that juvenile *Electrophorus* can produce voltages of 100 volts whilst an adult specimen can produce voltages up to 600 volts. This is enough to kill a human, so there is no reason to play with these animals.

Electrical charges from the eel are generated in the form of pulses with lower energy charges used for navigation and communication purposes and higher energy charges used to stun and sometimes to kill the prey. These high-energy charges are also used as protection against predators. Each discharge is of duration of about 2 milliseconds. If the discharge is of a rapid succession the perceived duration of an electric shock is 2 millisecond times the frequency of the discharge. The eel is able to sustain this rapid discharge for as much as one hour. In normal operation your eel unlikely runs out of battery…



Picture 1: “Eel detector.”

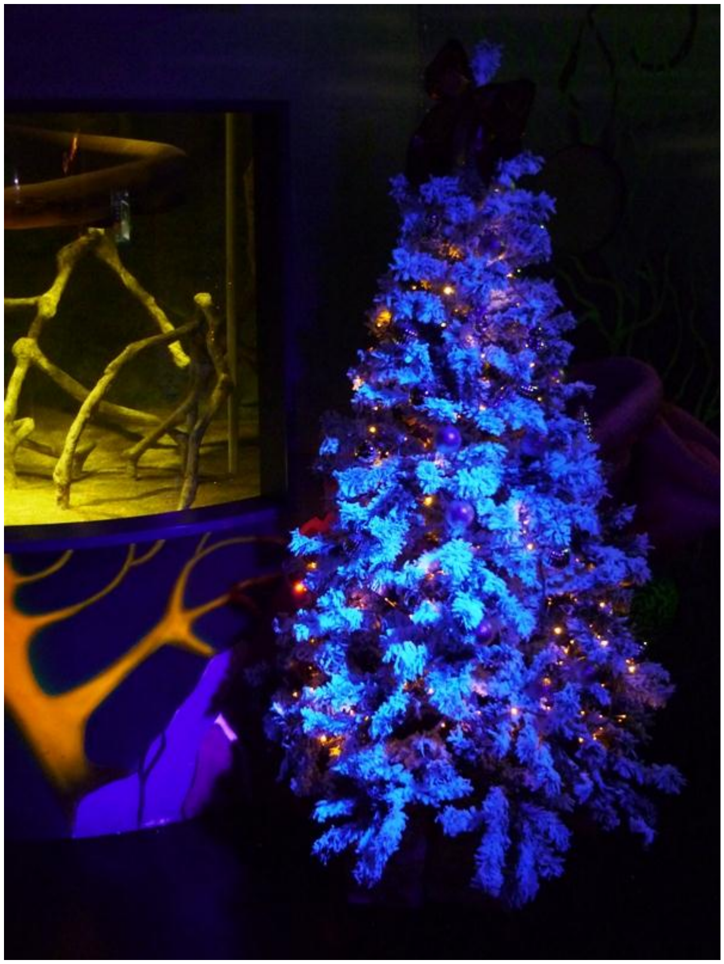
Eel Device And Xmas Tree

Four sensors, each one-meter long and made of a 6 mm diameter steel bar were placed into the aquarium (Diagram 1). Two went behind the backdrop, and two on both sides of the view panel. Latter ones were covered with thin plastic pipes to prevent the eel touching the metal itself. We do not know how many probes would be ideal and how they should be placed, but at least this worked well in our tank. These sensors were then connected, via simple electrical circuit, to the audio amplifier (Picture 2) as shown in the Diagram 2. The discharges are amplified and heard as a series of “pops”. The amplitude (volume/intensity) of the sound is dependent on the frequency of the discharge. It gets very noisy for example during the feeding or tank maintenance. Keep the volume down or you might make your smallest visitors cry… Before public feedings we always warned people about such sudden noises.

Picture 2: Audio amplifier.

The audio amplifier was connected to a Mode Electronics U40 light control unit's (Picture 3) audio input. This equipment was a remnant of the amusement parks old disco-set up. The lights control unit receives signals from the amplifier and then blinks lights respectively. If discharges are rapid the lights are blinking with shorter intervals, but they are always blinking with same intensity. We had a row of 12 small light bulbs and one loudspeaker placed in a front panel of a black wooden box decorated with some Danger - High voltage warnings and fake cables. This was the actual "device" visible to our guests. Unfortunately we didn't have time to figure out how to connect some kind of a current meter into the device. It is however possible to connect other lights to the device and this is exactly what we did: electric eels "lighting up" the Christmas tree lights (picture 4) turned out to be a great PR-story!

Picture 3: Lights control unit.



Picture 4: Christmas tree connected to the eel device. Trust me, it works!

Acknowledgements

Thanks to Patrick Walsh for the schematic drawings and patience with us. Thanks to Anton Dral for general advice with the device, thanks to Valerio Pacetti from Jesolo SEA LIFE (Italy) for the pictures and thanks to Essi Havula for valuable comments regarding this article.

Demonstration

There is a short video of the Sea Senses feature and you can see the device in operation. It is in Finnish so do not try to repeat what you hear:

http://www.youtube.com/watch?v=zuPvh_lM07A

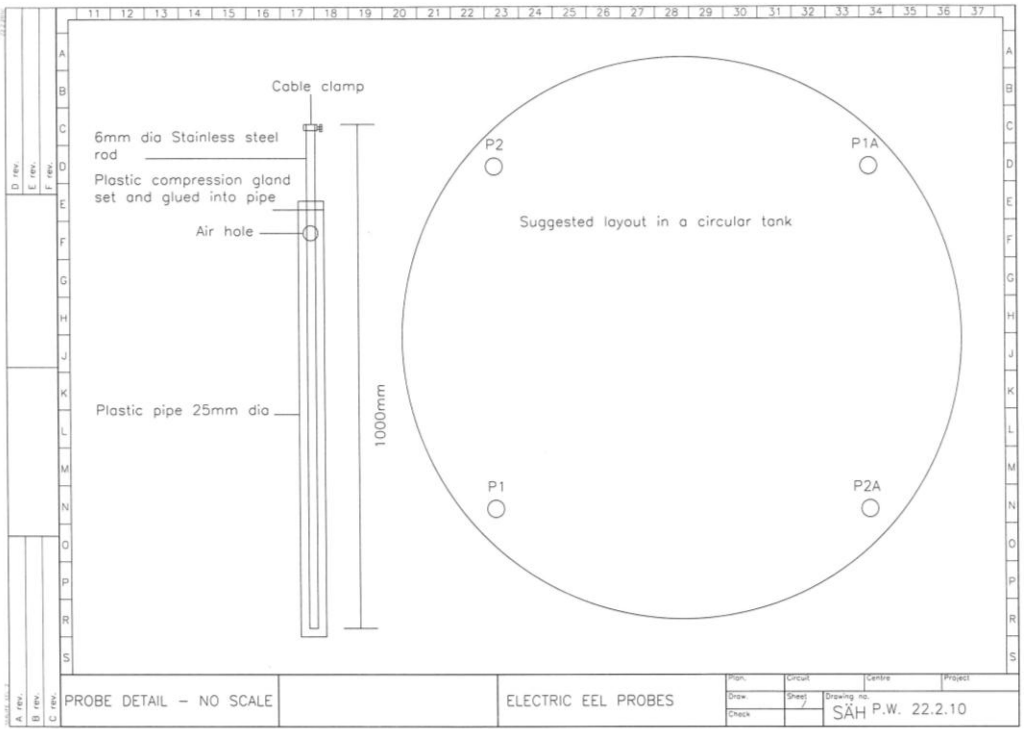


Diagram 1: Four metal probes were placed symmetrically in the tank.

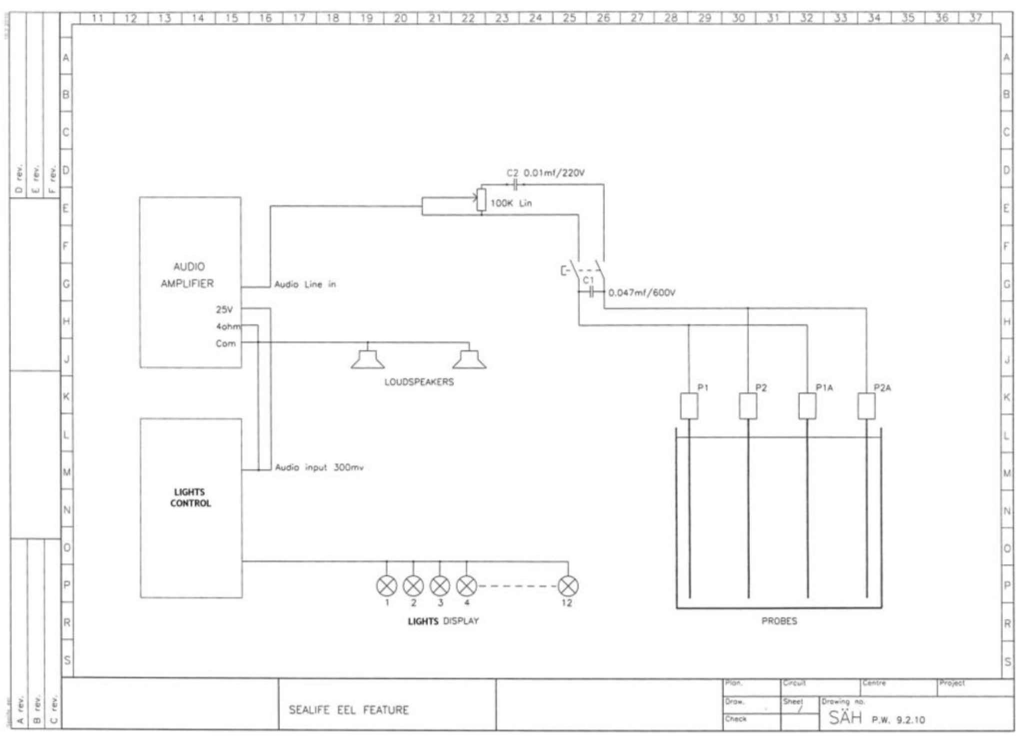


Diagram 2. Schematic drawing of the eel detector set up. "Lights display" and "loudspeakers" were placed in the actual "device" visible to the visitors. All the rest is behind the scenes.

SOLAR DERMATITIS WITH SECONDARY BACTERIAL INFECTIONS IN SWELL SHARKS (*Cephaloscyllium ventriosum*)

Megan Olhasso, Senior Aquarist, molhasso@cscmail.org
Janna Wynne, D.V.M., jwynne@cscmail.org

California Science Center, 700 Exposition Park Drive, Los Angeles, CA, USA

Introduction

This paper discusses a novel treatment for solar dermatitis and secondary bacterial infections in swell sharks (*Cephaloscyllium ventriosum*). Being unable to find documented treatment options, we found this approach was effective in resolving the case and returning the swell sharks to good health.

History

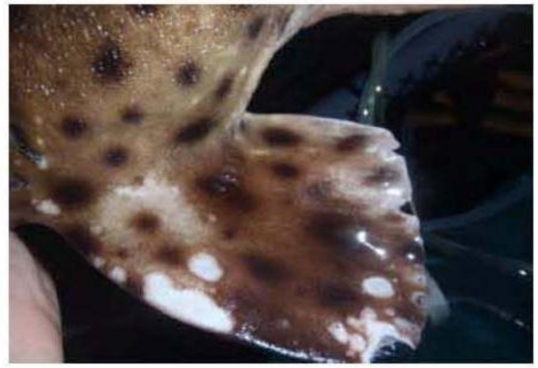
From September 2008 through June 2011, seven (2.5.0) swell sharks were housed in various indoor systems at the California Science Center. Although their environment varied slightly from system to system (depth, cohabitants, temperature, salinity etc.), they continued to eat well, maintain weight and mate. In June 2011, these sharks were moved to an outdoor system: a 20 foot round, 5 ½ feet deep, with a shade structure designed to block 70% of incoming sunlight. This shade cover, in addition to structural surroundings providing more shade at various times throughout the day, was thought to be ample coverage.

Four weeks after being moved outdoors, two of the swell sharks presented with multiple small areas of depigmentation on the dorsum of the body. Concurrently, all seven swell sharks stopped eating. The areas of depigmentation did not improve and two weeks later, were observed in five of the swell sharks.

Large PVC parts were added to the system for additional shade options as well as the placement of a tarp directly over 1/8th of the tank to provide a significant sunlight blockage area. Husbandry staff noted that all the swell sharks could usually be found under the second shade tarp.

Diagnosis and Treatment

Two months after being moved outdoors, erosions started to develop at the sites of depigmentation: loss of dermal denticles with erosion through the epidermis and into the dermis. A biopsy was taken from the left pectoral fin of one swell shark. Biopsy results showed severe necroulcerative dermatitis with some surfaces colonized by large numbers of bacteria suggesting sepsis. Solar dermatitis was considered a differential. At this time, it was noted that despite efforts to keep them well shaded, all seven sharks now had areas of depigmentation and dermal erosion.

Figures 1 & 2: Erosion Examples. For higher resolution images, please contact the authors.

Within twenty-four hours of receiving biopsy results, all seven sharks were moved indoors and placed in a pen (elevated in the water column) to minimize contact with fecal bacteria and facilitate treatment. All seven sharks were micro-chipped, weighed, and put on a regimen of ceftazidime: 25mg/kg, every 72 hours for five intramuscular injections. Microchip placement and intramuscular injections were done with hand or net restraint. At day nine, no improvement was observed. A second biopsy was collected to confirm the diagnosis. The histopathologic diagnosis was ulcerative dermatitis with intralesional bacteria. Two cultures were submitted, including a portion of the second skin biopsy. No growth was reported on either culture. Ceftazidime was continued based on the usual spectrum of gram negative bacteria we see affecting fish.

Fifteen days into treatment there were still no visible improvements in the skin lesions, however the sharks were starting to show interest in food. It was still several weeks later before the sharks showed consistent and enthusiastic eating habits.

At day thirty, two of the sharks showed significant healing of dermal ulcers and ceftazidime treatment was discontinued for those two sharks. Eating behaviors continued to improve with each shark eating at least one piece of fish per week. At day thirty-six, two more sharks were ready to be taken off of ceftazidime. The remaining three swell sharks completed fifty-one days of treatment. At this time, all seven swell sharks are eating well and skin lesions continue resolved.

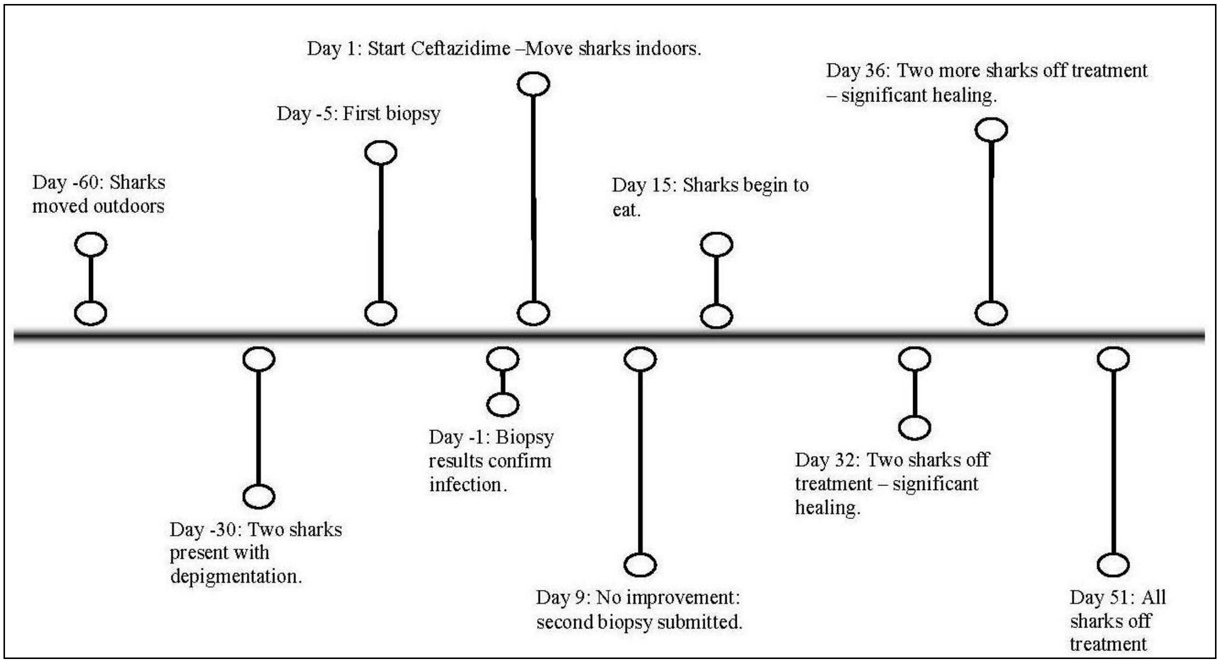
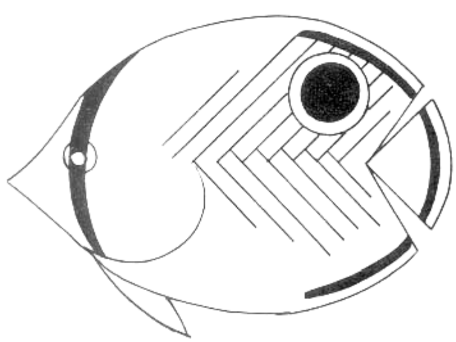


Figure 3: Treatment timeline.

Conclusion

In our clinical judgment, exposure to sunlight has the potential to cause depigmentation, providing opportunity for solar irritations that can lead to secondary bacterial infections. Lesions developed only after the sharks were moved outside and all lesions were on the dorsal body areas exposed to sun. Once physical signs have manifested, halting the deterioration can be difficult and may require a lengthy course of antibiotics. The use of ceftazidime, in combination with removal from sunlight exposure, can be effective and successful in healing swell sharks of solar dermatitis and erosive bacterial ulcers.



Craig Phillip, Drum and Croaker, 1968

RAW IN THE WINDY CITY chicago 2012

General information for the Regional Aquatic Workshop 2012

Host institution: John G. Shedd Aquarium

When:

April 10th-13th (AZA TAG meetings April 9th)

Where:

Swissôtel
323 East Wacker Dr
Chicago, IL 60601
312-565-0565
https://resweb.passkey.com/go/regionalaquaticworkshop

Mention the Regional Aquatic Workshop when registering

TENTATIVE SCHEDULE:

TAG, AQIG meetings (April 9th)

RAW First-Timer Mixer (April 9th evening)

General Paper Sessions (April 10th-12th)

Shedd Icebreaker/ Open House (April 10th)

River Cruise (April 11th)

Quarantine Workshop (April 13th morning)

Whirly Ball (April 13th afternoon)

Registration Fee:

Before Feb 1st

$75 Public aquarium or non-profit affiliate

$150 Commercial affiliate

After Feb 1st

$100 Public aquarium or non-profit affiliate

$175 Commercial affiliate

Room rates:

Single and Double occupancy	**$149/night**
Triple Occupancy	**$179/night**
Quad occupancy	**$209/night**

Rates are good 3 days pre and post conference if you want to see a little more of Chicago. You must call to get this rate on non-conference days.

Getting here:

The closest airports, O'Hare and Midway, both have train service ($2.25) that drops off a few blocks from the hotel.

Taxi will cost about $40 from Midway or O'Hare.

Shuttle services from the airports are around $15/person.

Parking at the hotel is $50/day.

Visit www.rawconference.org

or like us on facebook for more information

RAW 2011 ABSTRACTS
Virginia Aquarium and Marine Science Center, May 2 - 6
Virginia Beach, VA, USA

Abstracts compiled by Beth Firchau (Host); edited by Pete Mohan (D&C Editor).

Monday, May 2
Pre-RAW AZA Conservation Group Working Meetings

Freshwater Fishes TAG
Aquatic Invertebrate TAG
Coral Reef CAP
Aquatic Interest Group (AQIG)
Marine Fishes TAG

Tuesday, May 3, Session 1
Life Support and Water Quality

Sponsor Presentation – Aqua Logic

Nutrient Control in a 20,000 Gallon Reef Tank, 10 Years and Counting…

Joe Yaiullo
Joecorals@gmail.com
Atlantis Marine World Aquarium (Long Island Aquarium and Exhibition Center)

Maintaining a heavily stocked 20,000 gallon reef tank has proven to be a challenge on many fronts. "Nutrient issues" have surfaced through the past 10+ years, and these "issues" will be identified and subsequent attempts to control those situations discussed.

Hydrowizard: A Revolutionary Pump Will Have You Rethinking Your Entire Filtration System

Joe Yaiullo
Joecorals@gmail.com
Atlantis Marine World Aquarium

The Hydrowizard propeller driven unit is unlike no other. Given the design and flexibility of this prop unit, it is easy to install and you can achieve infinite flow patterns and tremendous flow rates in large systems while using very little electricity. A variety of uses will be examined, including investigating the concept of redesigning the accepted norm of mechanical and biological filtration systems.

Denitrifying System – Nitrate Removal at Oceanário de Lisboa Large Aquariums

Margarida Fernandes
mfernandes@oceanario.pt
Oceanario de Lisboa (Lisbon Aquarium

Nitrates build up may be one of the challenges to deal with in closed system aquariums. In 2003 a denitrifying system was installed at Oceanário de Lisboa as part of its water recovery treatment. Not being connected to an individual aquarium allowed the use of denitrified water in different aquariums. Due to operational problems it had to be turned off in 2007.

After introducing some changes to improve its efficiency the system was restarted in 2009. The methanol based system, with a flow through of approximately 1m3/h and a daily removal of 1,350kg of N-NO3, consists of one reactor, one protein skimmer and one ozone contact chamber. One of the changes in relation to the original system is the use of polystyrene foam as the biological support for the bacteria. The impact in the nitrate levels of the bigger aquariums, after one year of operation, is already substantial.

Aquatic Life Support Systems (LSS) and Control of Diseases

Dennis Thoney
Dennis.Thoney@vanaqua.org
Vancouver Aquarium

All species are hosts for parasites and under natural conditions most of these potential pathogens are not a health issue. However, in crowded, nutrient rich conditions associated with aquaculture and public aquariums many viruses, bacteria, protozoans, and helminthes that normally exist as commensals or associated with detritus can be pathogenic. In addition, many of these pathogens are capable of infecting other host species that would not be associated in the wild. It is critical that life support systems be designed to help prevent disease outbreaks and control diseases that do occur. In order to design LSS properly one must understand the life cycles and biology of potential pathogens. One also must understand the ability of each LSS component (mechanical filters, foam fractionators, ozone systems, UV irradiation systems) in regulating a specific pathogen. Except during chemical treatment regimes for fish, marine mammal and bird systems where oxidant or other toxicant concentrations can be maintained in tank water, pathogen control is usually conducted during the filtration process outside of the tank where the animals reside. Therefore, properly designed and operated LSS can contribute to pathogen control, but will not eliminate the need to manage and treat diseases through good husbandry and veterinary practices, respectively.

Autotrophic Denitrification in Aquarium Life Support Systems

Andy Aiken
aaiken@aqua.org
National Aquarium

Nitrates accumulate in aquarium exhibits and life support systems unless physically removed via water changes or reduced via biological processes. *Thiobacillus denitrificans*, an autotrophic facultative (optionally aerobic or anoxic) bacteria, will reduce nitrates to gaseous nitrogen. Oxidation of sulfur produces the required energy for bacterial life processes as nitrate is consumed. Unlike heterotrophic denitrification systems, an organic carbon-based food source (such as methanol) with a constant feed system is not required. Process use of sulfur produces sulphate, however not at toxic levels. Optimal pH for the reaction to occur is between 6.2 and 7.4. Hydronium is created during the reaction, causing a drop in pH. CaCO3 or other buffering material should be applied to raise pH back to match pH of the system. Maintaining dissolved oxygen levels of 1 mg/L or less does not significantly increase nor decrease effectiveness. Ordinary filter vessels can be used to contain the sulfur and/or CaCO3. The autotrophic denitrification system at the National Aquarium removes between 1.5 and 2.6 kg NO3 nitrate per day per m3 of Sulfur. Operating variables and outcomes are also discussed.

Tuesday, May 3, Session 2
Fee-Based and Animal Interactive Programs

Sponsor Presentation - Water Life Designs

Swim, Dive and Touch: Creating Mile High Guest Experiences

Ken Yates
kyates@ldry.com
Landry's Colorado Ocean Journey

Creating engaging guest experiences has been the explicit or implicit focus of our exhibits and husbandry efforts since public aquariums were created. In a relatively recent approach, many facilities have modified attitudes, policies and exhibits to provide even more personal and interactive guest experiences. The guest experience has been taken to the next level, through actual immersion in our miniature oceans or through direct interaction with our animals by touching and feeding. This direct experience is both a powerful tool in creating caring attitudes and a source of new revenue.

Initial discussions about these potential programs often raised many concerns about animal health, water quality issues, disruption of operations, etc. There was a fear about what might happen. Once aquarium professionals decided to use their expertise to prevent potential problems, in most cases the problems simply never materialized.

This presentation will summarize the immersive and interactive programs at Downtown Aquarium Denver and how we treated challenges as opportunities to make the programs happen and thrive.
Specifically, our public dive programs and Stingray Reef interactive touch and feeding programs will be described, along with our solutions to potential challenges. We found that we can have our animal health, good water quality, husbandry operations, exhibit maintenance alongside a fantastic and life-changing guest experience. We touch guest lives and attitudes in ways we never could before, and hopefully are creating conservation attitudes through caring about animals and habitats. In addition, and this is no small accomplishment in the eyes of our management, we have created new revenue engines. These programs can be a win-win for our aquariums, promoting both conservation and revenue.

A Stingray Touch Exhibit from Start to Finish (Or How to Lose a Lot of Money in the First Year and Pray that You'll Make it Up the Second Year

Jeff Mitchell
jeff.mitchell@czs.org
Chicago Zoological Society/ Brookfield Zoo

In 2010, the Brookfield Zoo restarted their 'Stingray Bay' exhibit. The pool was already on site but there was no filtration, electrical or other infrastructure. This presentation will look at the costs, the issues, the problems and the solutions to creating a successful stingray touch pool. It will focus on the initial startup costs and the revenues/expenses to staff and run the exhibit for an entire year. The zoo is committed to running this exhibit for 3 years so a long term perspective will be presented to showcase how a money loser in the first year becomes a money winner by the second year.

Building Guest Diving Experience Programs from the Ground Up

Mike Terrell (for Casey Coy)
ccoy@flaquarium.org
Florida Aquarium

The Florida Aquarium was the first not-for-profit aquarium in the nation to offer two unique and distinct guest immersion dive programs. The encounters not only serve as an additional revenue source, more importantly they further our mission to create experiences between visitors and the aquatic realm that inspire an attitude of stewardship. In order to build a successful program, the critical issues of captive animal ethics, diving risk management, staffing, ROI/budget, animal health and educational content must be addressed. Then, a foundation exists to expand other aspects of the facility, such as volunteer and staff recruitment, open water conservation research, exhibit maintenance and interactive dive shows. Done carefully and correctly, guest immersion dive programs are a win-win-win for the aquarium guest, the aquarium and the aquatic environment.

Close Encounters of the Toothy Kind

Jessica Miller
jmiller@lbaop.org
Aquarium of the Pacific

Many aquariums are now offering interactive programs that allow guests the chance to get closer to animals. At the Aquarium of the Pacific in Long Beach, we offer encounters with our pinnipeds, otters and sharks. Our Shark Encounter is a two hour experience that allows guests an interactive look at the care required for our toothy friends. The success of the animal encounter program relies on teamwork between 3 different departments: Husbandry, Education and Guest Services. In this presentation I will discuss the main aspects of our Shark Encounters which are: a behind-the-scenes tour, food preparation and introduction to the animals they are going to meet, and participation in our Shark Lagoon feeding. With creative problem solving and planning, we deal with challenges and issues in an appropriate manner to ensure a positive experience for both our guests and our animals

Safari Tours at the Columbus Zoo and Aquarium

Carrie Pratt
carrie.pratt@columbuszoo.org
Columbus Zoo and Aquarium

During the winter of 2010 the Columbus Zoo and Aquarium undertook a pilot program of fee-based interactive programs. In total we offered 6 different experiences guests could choose to participate in. This talk will focus on 2 of these programs, “Munch at Manatees” and “Dive in Discovery Reef”. All participants were given an introduction to our Zoo and our conservation programs followed by up to a two hour immersive experience in the area of their choice. Topics covered will include the development of the program, liability considerations, fees charged, necessary equipment, staff needs, and a typical schedule of events. A review of our successes and our challenges will also be included.

Adventure Aquarium’s Animal Interactive Programs

Elizabeth Hann
ehann@adventureaquarium.com
Adventure Aquarium

In May 2005, Adventure Aquarium opened its doors to the public and launched the Swim with the Sharks Adventure Program. This program allows guests to snorkel in our 550,000 gallon Shark Realm exhibit with three species of sharks and hand feed four species of stingrays. Since the program began we have booked over 6,500 guests and grossed over $883,000. With this success, Adventure Aquarium decided to launch two more programs: Feeding Fury and Sea Turtles Up-Close. The Feeding Fury allows guests to learn about our 27 sharks in our Shark Realm exhibit and assist an Adventure Aquarium biologist in pole feeding these animals. The Sea Turtles Up-close gives guest the unique opportunity to accompany an Adventure Aquarium biologist in station training our three sea turtles. All of our Adventure Programs have evolved over the past six years. We have been able to improve each program through guest surveys and trial and error.

Is Swimming with Gentle Giants Worth all the Trouble? You Bet It Is

Chris Coco
ccoco@georgiaaquarium.org
Georgia Aquarium

At a time when 'engaging' or 'interactive' guest experiences at aquarium institutions are coupled with a desire to generate new revenue streams, many of us are challenged to scrutinize our exhibits and living collections through a different lens. No longer are we able to simply present what we believe to be realistic and accurate renditions of a particular ecosystem, then stand back and watch guests come through the door. We have historically done so, assuming guests became inspired by what they viewed, resulting in return visits. Over the years we aquarists have become rather creative with new exhibit designs and have offered temporary shows to help to showcase fragile species and drive seasonal attendance. More recently, the challenging economic climate faced by our institutions or a growing need to create excess revenue for capital projects has compelled us to again look to our exhibits for fiscal help. In the wake of Georgia Aquarium's opening in 2005, a review of projected annual expenditures and capital improvements led to efforts to create revenue sources from new guest experiences. In addition to the usual variety of behind the scenes tours, evening events, etc., a new program was created to enable guests to immerse themselves in the popular Ocean Voyager exhibit. At 6.3 million gal (23.8 million L), Ocean Voyager is home to thousands of fish including several large species. A guest pay-to-dive / pay-to-swim program was assumed by the Aquarium to be a lucrative source of revenue. That assumption proved correct and thousands of guests have since taken advantage of a unique opportunity to be in close proximity to sharks and manta since the program commenced in 2008. A review of program creation, its current structure, our experiences and results is offered in this presentation.

Tuesday, May 3, Session 3
Fish Propagation 101

Sponsor Presentation - Piscine Energetics

Egg Incubation, Parturition, Breeding Paradigms, and Broodstock Management for Captive Propagation of Coldwater Marine Fishes

Jeff Marliave
jeff.marliave@vanaqua.org
Vancouver Aquarium

Public aquariums are not commercial aquaculture installations, so space and work hours are typically inadequate to allow ideal levels of effort. Nonetheless, if aquariums are to be producers rather than consumers of wildlife, it is essential to attempt to rear the offspring of fish that successfully breed in captive conditions. For some species there are emerging constraints on wild collection because of fisheries management concerns. Northern, coldwater marine fishes tend to produce larger larvae that hatch at advanced stages of development so that captive propagation proves practical.

Eggs for captive propagation can be collected wild or bred in captivity. Since eggs transport easily after gastrulation, wild collection usually presents no problem until the eggs are set up for prolonged incubation. The Vancouver Aquarium typically deals with benthic egg masses or pregnant, live-bearing female parents. With egg masses, the larger the mass, the more the tendency for point flows to travel around rather than through the egg mass, resulting in necrosis inside the mass. Pipe and venturi methods are used to force flows through an egg mass.

Methods of Feeding Marine Fish Larvae

Jeff Marliave
jeff.marliave@vanaqua.org
Vancouver Aquarium

No regime of live food in an aquarium can duplicate the dietary diversity in a wild plankton community, so a baseline assumption of larval malnutrition needs to be presumed. Additionally, most fishes lack any capacity for dealing with nutritional rancidity comparable to warm-blooded vertebrates. Therefore, a further assumption of nutritionally-induced immunodeficiency, based on impacts of nutritional rancidity, needs to be incorporated in diet planning in larval rearing. Finally, cultivated marine animals like rotifers and brine shrimp lack complete fatty acid profiles and contain relatively indigestible body parts, so nutritional supplementation must accommodate all of these above considerations. The Vancouver Aquarium has increasingly relied on innovations in the commercial aquaculture sector for purchase of live food organisms and diet supplements rather than on traditional methods of culturing algae and live foods, owing to space and budgetary constraints.

A parturition impeller device has been observed to cause ingestion of inert food particles by rockfish larvae. Turbulence can be a required stimulus for initial ingestion of inanimate food. Weaning from live to inanimate diets as early as possible is increasingly a goal as relevance of laboratory methods to potential aquaculture application is considered. Historically, captive propagation at the Vancouver Aquarium relied on feeding live, wild foods to fish larvae to maximize survival and growth, but such methods are not practical for aquaculture. Furthermore, the smallest larvae, as with rockfish, require very small prey items not easily collected. Strategies for feeding wolf-eels versus rockfish provide good contrast in requirements for successful propagation.

The culture system design must accommodate larval swimming behavior, but more importantly it must maximize encounters of food items and conditions favoring ingestion. Since malnutrition rather than starvation is of concern, captive larvae often must be induced to feed continuously and heavily. Black tanks and u.v.-shifted lighting, together with gentle turbulence, helps induce feeding. Since food tends to be cleared with tank seawater turnover, minimized makeup inflow has to be balanced with maintaining seawater quality, including oxygen and pH balance. Compromise is necessary with aeration, since violent turbulence disrupts normal feeding in small larvae. Mortality documentation and microscopic examination are necessary monitoring regimes. Successful propagation can reveal various aspects of natural history.

Feeding conditions can be affected by exigencies of culture viability or availability of fresh shipments of commercial foods, and it is necessary to respond within hours to signs of larvae needing additional or acceptable food. For this reason, along with measures to alter deterioration in water quality, it is typically impossible to precisely replicate rearing trial conditions. Simultaneous replication of trials is often precluded by space availability and competing demands for accommodating different species, so that serial replication through time becomes a problematic but necessary surrogate for synchronous replication. Clear judgment and good luck are needed to understand just what was involved in a breakthrough.

Sponsor Presentation - Reed Mariculture

Bartletts' Anthias: A Model for Examining the Production of Pelagic Spawning Tropical Marine Ornamental Fish

Eric Cassiano
ericcass@ufl.edu
University of Florida - Tropical Aquaculture Laboratory

Aquaculture technology and protocols promise to revolutionize the way we address our harvest of the oceans, providing a sustainable alternative to wild fisheries. In certain cases there is little opportunity for improving the sustainability of fisheries. The majority of marine ornamental fish species found in both public and private display aquariums are wild-caught. The development of captive breeding programs for the production of these marine ornamental fish species could benefit both commercial producers and AZA institutions while lessening the dependence on wild fisheries.

Bartletts' anthias *(Pseudanthias bartlettorum)* is a high-value marine ornamental fish species found throughout the Indo-Pacific region. They are gregarious serranids often found in shoals just above coral reefs grazing on zooplankton. Due to their aggressive nature they are best kept in small groups consisting of one male and 3-5 females. Bartletts' anthias are protogynous hermaphrodites, with the dominant female switching to male when the male is removed. Volitional spawning occurs daily at sunset without hormonal induction. Currently, no captive breeding program exists for Bartletts' anthias.

At the University of Florida's Tropical Aquaculture Laboratory, Bartletts' anthias broodstock were obtained from Christmas Island (Kiritimati) in the Line Islands. We are examining egg production and percent hatch within two different tank designs; 29 gallon glass aquaria and 38 gallon tall, slender fiberglass tanks. Within each design we are also comparing performance of spawning pairs and spawning colonies (1 male : 5 females). Two different forms of egg collection are also being evaluated; surface skimming and overflow into a collection device. Brood diet and other factors that affect egg production and performance are also being addressed.

Once the eggs are harvested, optimal incubation parameters and techniques (hatching jars or directly in the larval rearing system) are examined. Information pertaining to size at hatch, size at first feeding, gape size, and overall ontogeny aid in developing an advantageous larval feeding regime. Once a first feeding regime is developed, culture characteristics are examined to determine the correct environment for larval rearing. At this point, appropriate culture conditions and larval feeding protocols can be optimized. These techniques for examining appropriate larval rearing can also be applied through the juvenile and growout phases; examining diets and culture conditions while identifying critical stages of production.

Copepod Production and Other 'Alternative' Live Feeds Used in Tropical Marine Fish Larviculture

Eric Cassiano
ericcass@ufl.edu
University of Florida - Tropical Aquaculture Laboratory

The trade in tropical marine ornamental fishes relies almost exclusively on wild-caught specimens to supply both public and private display aquariums. Aquaculture success has been limited to a few species exhibiting a high degree of parental care, with low fecundity and large larval size. Success with many important, but primarily pelagic spawning species, has been limited. A major bottleneck limiting the expansion of the marine ornamental aquaculture sector has been the first feeding stage, when larvae switch from relying on endogenous yolk reserves to feeding exogenously. Recent advances in marine aquaculture technologies and strategies, especially within the area of larval feeding and production of live feeds, presents a unique opportunity for expanding the species list in marine ornamental production.

Traditional live feeds such as rotifers *(Brachionus spp.)* and brine shrimp *(Artemia spp.)* are often not utilized successfully in rearing marine fish larvae through the first feeding stage. Inadequate nutritional composition, large size, and/or the lack of feeding stimulus are among the factors limiting the efficacy of these 'traditional' live feeds. Copepods are the predominant prey item for a vast majority of wild marine fish larvae. Furthermore, copepods constitute the appropriate nutritional composition required for growth and development of marine fish larvae. Establishing larviculture protocols that include copepods may be necessary to optimize production of many marine fish species. Advances in copepod production have occurred and copepod nauplii have been successfully used as a live feed. Advantages of feeding copepods as a primary or supplemental diet have been repeatedly demonstrated. Currently, sufficient quantities of copepod nauplii are not readily available to satisfy the live feed demand of most commercial facilities. However, the limited production of high-value marine ornamental fish species is feasible for small-scale producers.

Copepods are one of the most ubiquitous groups of marine organisms, with over 24,000 species currently described, and are a major component of the marine zooplankton community. Even within taxonomic orders, the level of diversity between species can be high. Therefore, differences in culture techniques, parameters, and use as a live feed can vary greatly. Often times the culture parameters for one species of copepod will not be optimal for another. Furthermore, acceptance by marine fish larvae of certain copepod species can also vary between fish species. Therefore, many species of copepods should be evaluated to define their culture methods and optimal feeding protocols for various species of marine fish larvae.

Wednesday, May 4, Session 4
Sustainability

Welcoming Addresses

Sponsor Presentation - Dynasty Marine Associates

Captive Rearing of Candy Stripe Shrimp *(Lebbeus grandimanus)* Zoea

Dave Smith
dave.smith@pdza.org
Point Defiance Zoo and Aquarium

The candy stripe shrimp *(Lebbeus grandimanus)* is a highly desirable species in the aquarium trade due to its brilliant coloration and symbiotic relationship with the crimson anemone *(Cribrinopsis fernaldi)*. These unique characteristics and its limited distribution explain the high costs ($80/specimen) to obtain one of these animals for an aquarium display. However, recent events have demonstrated that this animal can be successfully reared in captivity. In April 2010, a gravid female candy stripe shrimp was observed releasing zoea in a display tank. Upon this discovery, the female shrimp and as many zoea that could be located were moved to a holding tank for rearing. This was a first time event for the staff at the Point Defiance Zoo and Aquarium and the resulting learning curve for raising these specimens was quite steep, however once identified, the solutions to threes problems were quite simple. This presentation will outline the life history of this species, and identify key aspects of its natural biology that may make this species an excellent candidate for captive rearing. Rearing equipment, methods, and food items will be explained along with growth charts and mortality trends.

Experience Raising Peppermint Shrimp

Ramon Villaverde
Ramon.Villaverde@columbuszoo.org
Columbus Zoo and Aquarium

Ornamental invertebrates are popular display animals as well as some being beneficial natural maintenance in a closed system. Peppermint shrimp are small attractive tropical shrimp used in aquariums for *Aptasia* control. Columbus Zoo and Aquarium breeding efforts of peppermint shrimp *(Lysmata wurdemanni)* started as a senior high school student science project. The goal for the project was to teach high school students basic aquarium husbandry and breeding skills who were interested in a career in the aquarium field. The added benefit of the project was a natural source for *Aptasia* control in various aquatic systems at the Zoo. Future use of the larvae could be utilized as a sustainable source for a plankton display system, and a food source for marine fish rearing. The presentation will go over the challenges of working with high school students, limited budget and resources, tracking of larvae development and potential future spin off projects.

Closed System Culture of Abalone for Future Outplanting in a Public Aquarium Setting

Aaron Hovis
ahovis@lbaop.org
Aquarium of the Pacific

This presentation will discuss the potential for closed system culture of abalone at the Aquarium of the Pacific. Also discussed will be the worldwide importance of members of the genus Haliotis, possibilities for conservation and education in a public aquarium setting.

I will focus on two species for this talk; the Red Abalone *(Haliotis rufescens)* and the White Abalone *(Haliotis sorenseni)*. I will discuss the natural history of these invertebrates and the theory behind their conservation. Included will be the strict protocol for quarantine of these animals to ensure that out-planted specimen are not a vector for the spread of fatal disease in wild populations. I will also discuss the culture system that was built at the Aquarium of the Pacific, how it functions and our recent spawn attempts of *H. rufescens.*

Spawn evaluation of a shark species, *Poroderma africanum* (Gmelin, 1789), at the Oceanário de Lisboa

Hugo Batista
hbatista@oceanario.pt
Oceanario de Lisboa

In order to have a better understanding of the pajama shark *(Poroderma africanum)* reproduction at Oceanário de Lisboa and to try to manage this shark population, all the eggs produced by the females were caught throughout one year.

These eggs were monitored until hatching. The goals of this study were: 1) to determine whether there is seasonality associated with the eggs viability; 2) to know the average number of eggs per female per year; 3) to determine if there is a "breeding season" or annual reproductive cycle.

Be Picky, Be Choosy: How to Select a Sustainable Aquarium Animal Supplier

Laura Simmons
laura@cairnsmarine.com
Cairns Marine

There are many animal collectors, trans-shippers and suppliers throughout the world. But in this "information age" it also seems difficult to really know where our animals are coming from and how. We all want to "do the right thing" and choose aquarium animal suppliers that can provide excellent specimens; unique stock that has be collected, handled and shipped in a way that had minimal impact on the wild environment and wild populations.

This presentation will use criteria being outlined within the public aquarium community to explore the concept of sustainability in relation to aquarium animal supplies and how we can work within these parameters.
How can we make informed decisions? There are several questions we should ask of our suppliers because as the client/customer we have a right to know where our products come from and how they are husbanded prior to arriving at our facilities. This talk will propose a questionnaire that can assist aquariums in selecting their stock providers, not only the questions to ask but how the answers might lead to higher quality products. Specific questions like "who collected these specimens?", "what method was used for collection?", "were chemicals used, if so what types", "what has the chain of custody been from the day of collection to the present?" and many more can be posed. Any supplier should be willing and able to answer these questions. Full disclosure is what aquariums should demand in order to know if we are receiving sustainably supplied specimens.

The criteria to be met will vary from facility to facility so each questionnaire can be tailored to the institution's goals and the expectations of their guests. In the end a healthy, quality product that has been sustainably supplied is the goal for responsible consumers and being picky and choosy is our right.

Wednesday, May 4, Session 5
Conservation

Sponsor Presention - CaribSea

Marine Exotic Species Removal Program

Ashleigh Clews
aclews@aqua.org
National Aquarium, Washington DC

The National Aquarium has developed a program to respond to and remove marine non-native species from Florida waters. Introduced (exotic) species are species that live outside their native distributional range and arrived there through human activities. Invasive species are introduced species that have managed to reproduce and multiply in an ecosystem. Invasive species typically have a negative impact on the environment.

For the past five years the National Aquarium, Washington, DC has partnered with the Reef Environmental Education Foundation (REEF) and NOAA in a study of the invasive red lionfish *(Pterois volitans)*. Red lionfish, which are native to the Indian and West Pacific Oceans, are considered the first invasive marine species in the Atlantic and are causing one of the largest ecological disasters of our time. There is little doubt from the work completed to date that this invasion began with the release of "pet" animals.

Roughly 25 other non-native ornamental fish species have been sighted in Florida waters. While they are currently introduced (exotic) species by definition, the National Aquarium hopes to address this threat before these species have a chance to become invasive. The National Aquarium is again partnering with REEF, which engages recreational divers to conduct fish diversity and abundance surveys. Once a sighting is reported and verified by divers, the Aquarium will mobilize a team to collect the animal. It will be shipped to the National Aquarium either for its collection or placed into holding while a final destination is determined. Animals not appropriate for the National Aquarium's collection will be posted on the AquaticInfo Listserve and AZA surplus lists. The efforts of the National Aquarium will be promoted through media events aimed at raising public awareness of the dangers of releasing pets into the wild.

Efforts in Rockfish Conservation in Puget Sound

Dave Smith and Tim Carpenter
dave.smith@pdza.org, t.carpenter@seattleaquarium.org
Seattle Aquarium

Rockfish population levels have been drastically reduced in Puget Sound due to a variety of fishing activities. Once considered "junk fish," these animals were targeted by commercial and recreational fisheries after other species were depleted. Due to their long life-span and slow rate of maturity many species are highly susceptible to environmental stress and fishing pressure.

The stock status of several species was evaluated for both regions of Puget Sound by Washington Department of Fish and Wildlife (WDFW). The majority of rockfish stocks or populations in Puget Sound are in the Precautionary status, and several species once important to recreational fisheries are in the Vulnerable or Depleted status. Fewer than 20% of the populations present in either North or South Sound are in Healthy status. It should be noted that these status levels indicate a significant lack of baseline data upon which to make firmer, more protective rulings.

As a result, the Seattle Aquarium, in conjunction with three other facilities (Point Defiance, Oregon Zoo, and Oregon Coast Aquarium), is embarking on a monitoring project to document and understand shifting baselines of rockfish diversity and distribution in Northwest marine ecosystems from Puget Sound and the Strait of Juan de Fuca to the Oregon Coast. Data on rockfish populations are gathered by divers using specialized underwater communication systems and underwater video. After the video data is analyzed, the compiled data on relative fish density data may then be compared to other data such as predator densities (marine mammals) or changes in environmental conditions such as water temperature, dissolved oxygen, salinity or other parameters collected by the state and federal agencies. Potential significant correlations between fish densities and other conditions can then be determined and may assist in the effective management and conservation of these ecosystems.

The resulting population status of various rockfish species in Washington State waters specifically have produced challenges to public aquaria hoping to collect and display these animals, in the hopes of using them to further their conservation messages. Exhibit design, specifically regarding species selection, needs to take these conservation issues into account; also, investigation into viable larval rearing techniques may be necessary to retain many of these species as display animals in public aquaria.

Coral Reef Restoration in the Bahamas: A Model for Comprehensive and Adaptive Conservation

Tanya Kamerman
Tanya.Y.Kamerman@email.disney.com
The Seas with Nemo and Friends, Walt Disney World

The coral reefs around southern Abaco, Bahamas have been affected by a number of natural and anthropogenic stressors that have led to their decline. This decline is evident in their low coral cover, scarcity or absence of key reef building corals and other ecologically and economically important species. This project uses an ecosystem approach and incorporates adaptive restoration methods aimed to rectify the situation. This includes the translocation of key grazers on coral reefs, the long-spine black sea urchin *Diadema antillarum*, and maximizing reef recovery through transplantation of healthy reef-building coral fragments, such as *Acropora palmata* and *Acropora cervicornis*, collected opportunistically from broken colonies. Yearly monitoring of reef sites from 2008-2010 showed that fish and benthic communities remained fairly stable. Throughout the study, *D. antillarum* has been increased by 30% and over 70% of transplanted corals are healthy and showing positive growth. Increasing the baseline knowledge, encouraging eco-friendly actions and changing the way Abaco communities view their environment is critically important for protecting and restoring coral reefs. Activity booklets, environmental summer camps, restoration workshops and opportunistic community education have been implemented as successful community outreach programs and have raised awareness of the importance of coral reef ecosystems. Regular evaluation of current management strategies (both biological and education) is critical to coral reef ecosystem restoration

Effecting Strict Quarantine of Sand Tiger sharks, *Carcharias taurus*, to Meet a Specific Set of Importation Criteria

Forrest A. Young M.S., C. Ben Daughtry and Juan Bernal, M.B.A
Forrest@DynastyMarine.net
Dynasty Marine Associates, Inc.

Many insular regulatory authorities enforce strict standards for importation of non-native species into their jurisdiction. Hawaii, Guam, Australia and New Zealand all have very exacting standards for non-native wildlife importation. The authors caught and provided quarantine for five sand tiger sharks, *Carcharias (Odontaspis) taurus*, 1.6 to 2.2m, under the auspices and supervision of the USDA and the New Zealand Ministry of Forestry and Agriculture. Prior to shipment, the five individuals were given a complete veterinary work up including oral and buccal examinations on two separate occasions, to remove ecto parasites. Prior to shipment, blood samples were analyzed by a pathologist to prevent passage of non-native hemo-parasites that could infect local NZ populations. The five sharks also underwent chemical treatments that will be described in detail to further remove any parasites that may have been missed by the exams. Incoming water for additions following backwashes and maintenance were treated with high dose chlorination that will also be described to maintain strict quarantine conditions throughout. All five sharks were safely transported to New Zealand by a proprietary closed container shipping method.

Wednesday, May 4, Session 6
Husbandry/Innovation/Care - Part 1

Sponsor Presentation - New Era

The Use of Sequential Coded Wire Tags™ in a Public Aquarium

Todd Harmon
Todd.S.Harmon@disney.com
Living Seas

A tagging program was designed to answer the question of "When was that fish added to the aquaria". Each fish that did not receive a Passive Integrated Transponder (PIT) tag would receive a coded wire tagged (CWT). This includes all fish other than sharks, rays, groupers, and cobia. The tags are a 1.1 mm in length by 0.25 mm diameter stainless steel wire with a batch code and individual number encoded on them. Tag information is recorded at time of tagging and then when a fish dies it is removed and read using a low-power dissecting microscope. The information is compared with information in a database with all the initial tagging information. It can then be traced to a specific date of when the fish was added into the aquaria collection. This information does not give exact age of the fish, but it does provide the husbandry team with valuable information on captive fishes and longevity within captive aquatic systems. This can provide useful data on some of the history of the animal in the enclosure and whether it was recently added or is possibly an "older" animal.

Over a 13 month trial a total of 1273 fish were tagged of 35 different species. Of these, 25 return tags were read. Tag placement was in the musculature on the left side near the anterior portion of the dorsal spine. Most returned tags were from sentinel fish located within a confined area of the main aquaria. Tagging times for blue striped grunts *(Haemulon sciurus)* ranged from 9.75 – 14.85 sec/fish and averaged 11.48 sec/fish. Tag retention in french grunts *(Haemulon flavolineatum)* was 97.4% for 93 days (N=118), and tag retention in white grunts *(Haemulon plumier)* was 100% for 111 days (N=35). No mortalities were attributed to tag placement. However, some mortalities occurred after a tagging event of compromised (open lesions) fish.

Successful Treatment of Infection in *Nautilus pompilius*

Greg Barord
gjbarord@gmail.com
City University of New York

The successful husbandry of Nautilus not only requires excellent water quality and system design but also acute observation. Early diagnosis and treatment of Nautilus disease is essential to ensure a positive outcome. This case study exemplifies these actions. A minor amount of mucus was noticeable shortly after the specimen was shipped. The specimen was moved to a hospital tank for further observation and treatment. This mucus accumulation was treated with iodine baths but the mucus continued to come back. Oxytetracycline was then used on the specimen 3 times over the course of a week through bath treatments. The mucus did not return after this treatment and the specimen was moved back to the original system after 30 days. The specimen continued to behave normally and no other problems have been observed. In many cases, once the mucus begins to cover the tentacles then the specimen is terminal. In this case, the mucus was around the eye and minimally on the tentacles. Caring for an animal that is so delicate but also threatened in the wild requires the best care. Early treatment of these infections can successfully help the specimen fight off the disease and live a normal captive life.

Predicting Egg Laying Behavior Based on Breeding in *Euprymna scolopes*

Nell Bekiares
bekiares@wisc.edu
University Wisconsin- Madison

The McFall-Ngai and Ruby labs have been studying the symbiotic relationship of the Hawaiian bobtail squid *(Euprymna scolopes)* and the bacterium Vibrio fischeri for more than 20 years. Thousands of hatchlings are produced from each adult collection and are used for study by the graduate students and post-docs in the lab.

Adult squid are collected on Oahu 3-4 times annually and brought back to the University of Wisconsin, where they are individually maintained in 100 gallon recirculating artificial seawater tanks. For the past 3 years, close observation and monitoring of variables such as size of collected individuals, group housing, sex ratio, and breeding pairs have optimized the process of producing hatchlings for study.

Although we produce many clutches weekly, we often have boom and bust scenarios with several clutches on one day, and none the next. This can produce wild fluctuations in the number of hatchlings available on any given day. Knowing exactly when to expect a clutch given the date of breeding has not yet been explored. As a case study, we observed a fertilized female over time to determine just how long a female might be able to store spermatophores from the previous breeding. For the main focus of this study, 2 cohorts of animals (approximately 32 females and 16 males) were mated semimonthly, and dates of egg deposition were compared to breeding dates. In addition, the relative size of clutch was noted to answer the question, “are more eggs deposited immediately after a breeding than in the following days?”

We anticipate that this information will help us further the production of hatchlings and increase lab efficiency through consistent fertile clutch production.

The Culturing of *Euprymna scolopes* in the McFall-Ngai and Ruby Laboratories

Eric Koch
ekoch2@wisc.edu
University Wisconsin- Madison

The Hawaiian bobtail squid *(Euprymna scolopes)* is best known for its unique symbiotic relationship with the bacterium *Vibrio fischeri*. At the University of Wisconsin-Madison, Drs. Margaret McFall-Ngai and Edward Ruby have developed a system in which to study the host-symbiont association.

Until recently, the McFall-Ngai and Ruby labs have been limited to studying either hatchlings less than 96 hours old, or fully mature squid. Within the last year, *Euprymna scolopes* has successfully been cultured from newborn hatchling to mature adult in multiple trials.

Raising Hawaiian bobtail squid from hatchling to mature adult is a labor intensive task that is still being improved. Factors such as a stable marine environment, appropriate prey at different stages, and a confined area to instigate feeding are critical in the survival of the squid.

By culturing *Euprymna scolopes,* long-term, new studies for the genetic basis for symbiotic persistence can be performed. A current study underway is the simultaneous rearing of aposymbiotic squid (without *V. fischeri*), and symbiotic squid colonized with a genetically marked, red fluorescent strain of *V. fischeri.*

Future directions of the study include creating a self-sustaining breeding colony of bobtail squid.

Strange Movements: Transport Logistics and the Tyranny of Distance

(Julian Baggio
julian@cairnsmarine.com
Cairns Marine

What is actually involved in the trans-continental movement of iconic reef species such as Great Hammerheads, Silvertip Sharks and Napoleon Wrasse?

The world-wide demand for public aquarium animals of all shapes and sizes has driven the development and evolution of tanks designed expressly for this purpose. Getting them "across the pond" from the splendid isolation of Northern Australia in commercial passenger aircraft means satisfying a range of engineering checks and balances. Equipment failure in these types of transports has the potential for catastrophic consequences and there is no room for error.

But it is not all about sticking big fish tanks on a plane. Airline rules and regulations, unit configurations and flight scheduling are but a few of the multiple constraints that must be managed and overcome on a case by case basis. Added to this, all manner of permits, certificates and official paperwork are required to make these shipments fly helping to create a logistical challenge of considerable proportions.

A greater appreciation and understanding of the transport process is invaluable for those involved in the high pressure game of livestock acquisition and insights gained can only serve to improve the success of these specialized shipments into the future.

Scales of Management and the Privilege of Having Fish

Lyle Squire Jr.
lyle.jnr@cairnsmarine.com
Cairns Marine

Consumers increasingly demand to know where their products come from and where they were produced. Questions of ethics, sustainability and exploitation are also brought about regarding products. These demands, concerns and questions extend to animals on display in aquaria as well.

This presentation addresses these questions as related to the Australian supply environment. I will include information about the physical scale of the fishery and how collecting is managed. It will shed light on the reality of collecting on the Great Barrier Reef and Coral Sea.

Our fishery area is enormous. The Great Barrier Reef is 540,000 km², two thirds of which is in a World Heritage listed Marine Park. The GBR is a national treasure where biodiversity conservation is king. One third of it is no-take refugia. About 30 aquarium suppliers operate in this fishery; Cairns Marine is the only one that regularly supplies public aquaria.

The Coral Sea Fishery to the east of the GBR is about one million km². We are one of only two permitted operators in this fishery region. In this vast, pristine aquatic wilderness, which takes several days to traverse, 80% of the coral reefs are included in no-take refugia.

Fisheries management in these environments is subject to rigorous scrutiny, political and scientific; it is designed to meet community expectation for sustainability. We choose to exceed these management regulations through world's best practices and stewardship initiatives. Understanding the scale and management of the fisheries is the goal of this presentation, but appreciating that it is a privilege not a right to have wildlife from these areas is paramount.

Bringing Collections, R&D and "Fair Trade" Together:
Behind Every Great Challenge There's a World of Opportunity

Joao Corriea
info@flyingsharks.eu
FlyingSharks

Collection operations involve capturing live animals from the wild, keeping them in a controlled environment, complex logistics and impressive sums of money. All these factors combined conspire to create a multitude of opportunities that don't often come to existence, especially in the habitually "spartan" field of Natural Sciences. This paper reports on a string of such opportunities created around Flying Sharks' activity since its debut in 2006:

1) R & D – Most researchers are frequently plagued with three issues that hinder their activities: specimen availability, space for conducting trials with live animals and, of course, funding. Collection companies are in a privileged position to provide solutions to these three needs, and this paper reports on multiple case studies where we have done so, whether by conducting R & D in-house or by providing the means for other researchers to do so as well.

2) Internships – Young undergrad, and graduate, students are often faced with the typical conundrum of not finding an institution that's willing to accommodate the required field work for their senior B.Sc. / M.Sc. / Ph.D. thesis. Again, collection companies may come to the rescue and provide almost infinite possibilities for students to conduct their work, whether it be in the common fields of ethology, stress physiology, husbandry techniques, or in the less common areas (while dwelling in the realm of Natural Sciences, at least) of marketing and business management.

3) Fair Trade – In a Globalized World, such as today's, supplies are but a click away through the use of the Internet and a credit card. That, however, comes with two issues that don't necessarily act in favor of the environment, nor of the company's best interests: (i) having materials shipped from abroad comes with a heavy carbon foot-print and (ii) that will most likely not sit well with local suppliers. As such, collection companies – notoriously famous for moving very substantial sums of money – are, again, in a privileged position to make a very positive impact on local suppliers, inputting serious funds on often marginal "by the sea" economies while, at the same time, saving generously on carbon emissions by recruiting local services, acquiring local products and rewarding them appropriately.

4) First employment – Young graduate Biologists, or Marine Biologists, are haunted with the traditional difficulty of finding their first job. Collection companies can certainly use the extra help of multiple volunteers, who are more than willing to assist in the "fun" jobs of collections per se and husbandry. Often such volunteering positions bring out a selection of dedicated young individuals who therefore find themselves bridging the not-so-thin gap that separates "volunteers" from "employees".

Thursday, May 5, Session 7
Husbandry/Innovation/Care - Part 2

Sponsor Presentation - Cairns Marine

Collection, Transport, and Shipping of the Portuguese Man-of-War, *Physalia physalis* to an Inland Aquarium

James Clark and Erika Lorenz
jclark@sheddaquarium.org
Shedd Aquarium

On February 15, 2011 we successfully located and collected *Physalia physalis* specimens off the coast of Marathon, FL for the purpose of shipping them to the John G Shedd Aquarium in Chicago, IL. Once the animals were found we captured them using an improvised netting technique. Animals were then transported back to shore using several different methods to ascertain which would be less destructive to the animals. The next step was to devise several different methods to pack the animals for shipping back to Chicago. In this talk we will show the different methods used to transport and ship the animals and report on the success of each method.

Food First Then Fish

Jim Prappas
jprappas@ldry.com
Landry's Restaurants

This paper compares the differences in a traditional Aquarium facility that is set up primarily as an attraction (which incorporates food services), and has staff /management geared towards the Aquarium product versus a very successful Restaurant company (Landry's Restaurants Inc. with over 200 restaurants) that is operating aquarium facilities (including 2 AZA facilities) within a restaurant business model.

The paper discusses the pros and cons of the management differences i.e., training philosophies, management development, and culture development.

Planning for New Research Initiatives: Stress and Mortality in Public Aquaria

Mike Tlusty
mtlusty@neaq.org
New England Aquarium

Research at public aquaria is an important tool for improvement of husbandry management practices. To be effective, open lines of communication must be established between husbandry and research departments in order to 1) identify critical issues in need of research, and 2) develop working plans. The New England Aquarium presents two collaborative research initiatives as models for this relationship. In these initiatives, we seek participation and feedback from our industry peers.

Stress: While stress triggers, responses, and downstream effects have received some scientific attention in aquatic animals in wild or aquaculture settings, the experience of stress as experienced by captive animals in public aquaria is poorly understood. Yet, it is a topic important of consideration, given public and industry scrutiny of animal welfare in zoos and aquaria. Understanding environmental and/or husbandry conditions that may trigger stress in aquarium animals will ultimately provide aquarists with informational tools needed to optimize the long-term welfare of exhibit animals. In response to this need, the New England Aquarium, in partnership with The Florida Aquarium Center for Conservation, have submitted a proposal to host a workshop to bring together researchers and aquarists to develop a research strategy to address this topic.

Mortality: Public aquaria are inextricably linked to the ornamental fish hobby. With public aquaria and the AZA community placing greater emphasis on institutional and environmental sustainability, we thus have a commitment to encourage the sustainability of the hobby on which we depend, and which we promote. However, the sustainability of the hobby is a topic which is data poor and largely unknown. Given the overlap of the two industries, can we apply data collected from the management of aquarium animals to better frame questions to address in the ornamental fish trade? Assessing sources and fates of our animals can help us understand our own working environment better, and, we suggest, can recommend sustainable practices for the ornamental fish trade.

Quarantine Protocols at the Tennessee Aquarium…20 Years in the Making

Carol Haley
clh@tnaqua.org
Tennessee Aquarium

In 1991, the Tennessee Aquarium completed their fish quarantine room and acquired the first fish for the facility that would open a year later. This was integral to providing adequate quarantine for all fish prior to stocking exhibits. Quarantine procedures were adopted from other large aquariums and were status quo for that time.

Over the past 20 years, quarantine protocols have been modified as new diseases have been encountered, pathogens have developed drug resistance and certain species have sensitivities to traditional chemotherapeutics. Quarantine procedures are now in place for freshwater and marine teleosts, Syngnathids, freshwater and marine elasmosbranchs and marine invertebrates. All protocols are working documents and are modified as needed.

Thursday, May 5, Session 8

Enrichment/Behavioral Conditioning

Sponsor Presentation - Flying Sharks

Good Husbandry is Enrichment

Bryan McNeil
b.mcneil@seattleaquarium.org
Seattle Aquarium

During the Seattle Aquarium's Association of Zoos and Aquariums (AZA) accreditation process, the husbandry team was tasked to meet/exceed the published standards of animal enrichment. However, the guidelines towards fish and aquatic invertebrates are unclear. Enrichment standards are historically based upon the zoo and marine mammal model (terrestrial enrichment) and these standards are difficult to apply to aquatic vertebrates and invertebrates (aquatic enrichment). The differences between terrestrial and aquatic enrichment and the concept that normal aquarist activities and procedures (i.e. husbandry and exhibit design) are normally sufficient to fulfill the needs of most taxa are discussed. The Seattle Aquarium's enrichment philosophy and how the staff practices, documents, and quantifies fish and aquatic invertebrate enrichment on a daily basis are discussed with three years of results. The Seattle Aquariums technique shows that a given aquarium upholds enrichment standards and practices with ease of recording and can be used to quantify enrichment.

Fish Training at the Albuquerque Aquarium

Melissa Levison (for Holly Casman)
Mel7201@aol.com
Albuquerque BioPark Aquarium

Visitors to the Albuquerque BioPark's Aquarium often ask if we have a dolphin show. To our great relief…we don't. However we aquarists know that fish are smarter than those brainy mammals anyway. We wanted to erase the popular misconception that fish have only a two second memory and make our visitors think twice before downing that fish fillet sandwich.

We started with a juvenile gray triggerfish and an off the shelf fish training kit. One of our Aquarists was a trainer for the Zoo's bird show so when she transferred to the Aquarium she applied her knowledge and experience to training our small trigger. To everyone's amazement the fish quickly mastered several behaviors and became so consistent and adept that we tried several more species with the intent of having (the first?) trained fish show at a public aquarium. The show will be conservation oriented and educational while still providing entertainment for our visitors. We want everyone to know that certain fish are as trainable as birds, dogs and certainly dolphins.

Implementing a Husbandry Training Program for the Giant Pacific Octopus *(Enteroctopus dofleini)* at the John G. Shedd Aquarium

Eileen Cicotello
emcicotello@gmail.com
John G Shedd Aquarium

The octopus is considered to be the most intelligent marine invertebrate and previous research indicates they have impressive learning capabilities, demonstrate play behavior, and also show individual characteristics similar to personalities. The giant Pacific octopus *(Enteroctopus dofleini)* is the largest and longest living species of octopus with a lifespan of only a few years, and it has been a popular animal displayed at the John G. Shedd Aquarium for nearly three decades. In August 2006 a formal octopus training and enrichment program was implemented with the objective to condition husbandry behaviors as well as provide enriching stimuli for optimal management and daily care of this species.

Classical and operant conditioning techniques in addition to strong relationship-building were used to train basic and advanced behaviors for 1.2 giant Pacific octopuses. Once a baseline diet was determined, a start of session signal and a shape as a station marker were conditioned to call the animal to station. After the octopus consistently stationed, more behaviors were trained including simple targeting with a target pole, A to Bs, tactile desensitization of the mantle and arms for routine physical evaluation, and crating into a basket for voluntary removal from the water to obtain a body weight.

The successful results of this program demonstrated that the giant Pacific octopus is readily trainable and able to learn and maintain a variety of behaviors within their short lifespan. Many training goals have been accomplished over the past four years, and the team continues to make marked progress on conditioning new behaviors. It is hoped that the unique challenges and training methods described in this paper will provide information to assist other institutions with implementing an octopus behavioral management program as well as advance cephalopod husbandry practices.

Raiding the Mammals' Toybox: Applying Enrichment Intended for Mammals to Various Sea Turtle Species

Mary McCarthy and Jessica Robinson
Mmccarth@virginiaaquarium.com, JJRobins@virginia aquarium.com
Virginia Aquarium

Creating an enrichment program can seem a daunting task, especially in an aquarium setting where enrichment is still somewhat novel. Time, energy, and money are often in short supply, but objects and concepts commonly used for mammals can also be applied to non-mammalian taxa. This presentation is two-fold: enrichment protocols for North American river otters *(Lontra canadensis)* and harbor seals *(Phoca vitulina)* will be examined. Then, the results of using the same methods on three different species of sea turtle will be presented. Criteria for evaluating the efficacy (or inefficacy) of the objects with both taxa will be discussed, as will special concerns that must be considered when dealing with captive aquatic environments and the inhabitants.

Behavioral Modification in Large White Seabass *(Atractoscion nobilis)* to Facilitate Transfer Between Tanks

Chris Mirabal
cmirabal@cscmail.org
California Science Center

Removing large, fast swimming fish from their exhibit or holding tanks can be difficult. Even if one has a net large and strong enough, they can be tough to catch and often damage themselves struggling before they can be sedated. In an effort to ease the movement of 6 large (3-4 ft, 15- 20kg) White Seabass *(Atractoscion nobilis)* from their holding tank, the fish were conditioned to allow an intramuscular injection of sedatives (Ketamine and Medetomine) so they could be removed easily and without damage to themselves or their handlers. Their preparation followed a rudimentary target-training format during regular feeds, with increasingly heavy-handed touching along the dorsal sides of the animals near the end of the regimen. The fish responded quickly to the target-training and although reaction to the touching varied among individual fish, all accepted the contact as a condition of the feed and continued to eat normally. The result was two-fold: First, the animals were able to be sedated with minimal effort or danger to themselves or their handler. Secondly, the large piscivores were trained to feed on a visual command that can be utilized within their exhibit tank to separate them from their smaller tankmates and SCUBA divers during regular, simultaneous feedings. This presentation outlines step-by-step how we achieved these results and how this may be used with similar species or conditions to avoid the classic “net, manhandle and struggle” techniques used to transfer many fish.

Can Spotted Eagle Rays Be the Next “Flipper”?

Tracy Heard
tmheard@virginiaaquarium.com
Virginia Aquarium

Getting larger tasks accomplished such as physicals on larger animals can be stressful for all involved. We needed to develop a plan to manage six spotted eagle rays in a 101,000 gallon aquarium for ease on staff and animals. We minimized stress on the animals by getting them onto an operant conditioning regime. They would need to be comfortable with hand feeding and tactile stimulus during feedings sessions. Many steps were taken to get from scatter feeding the entire collection as a whole to individualizing each ray, including introduction of targets and a bridge to accomplish this goal. Since physicals took place in the hospital tank, we had to get them all comfortable being in there and having us in the tank with them. We also introduced a door that isolates them and a net that was used to lift them out of the water. All rays responded well to target, bridge, stations, tactile, separations, and moving in and out of hospital tank with the door and net. Most adjustments took less than a week for the rays to show good responses. In conclusion the spotted eagle ray collection was managed with very little stress and all aspects of good husbandry were achieved using operant conditioning.

Thursday, May 5, Session 9
Exhibit Design

Sponsor Presentation - Living Color

Making Mussels

Jeff Landesman
Jeff.Landesman@Lacity.org
Cabrillo Aquarium

At the Cabrillo Marine Aquarium, zonation is an important educational concept that we chose to incorporate into two exhibits, an intertidal habitat and pier piling display. After several failed attempts to keep both live and ""prepared"" mussels and barnacles and considering prefabricated mussels we developed a technique for displaying ""real"" specimens. The actual shells are prepared in a series of inexpensive steps yielding an authentic, durable exhibit.

I'm All Aglow: An Interactive Crystal Jelly Display

Chris Okamato
Chris.Okamoto@lacity.org
Cabrillo Aquarium

Crystal jellies *(Aequorea victoria)* have been displayed in many aquariums around the world due to their ease of propagation and attractive attributes. We will use the crystal jelly as an example of a process which is the basis of the 2008 Nobel Prize in Chemistry. The crystal jelly contains GFP, Green Fluorescent Protein, which glows under U.V. light. This protein can be used as a biological marker, to bond to cancer cells which will fluoresce under U.V. light enabling doctors to locate cancer cells throughout the body. We will allow visitors to turn on a bank of U.V. lights, exciting this protein in the jelly, resulting in the GFP fluorescing.

Mangrove Bay – A New Elasmobranch Touch Experience at the New England Aquarium

Dan Laughlin
dlaughlin@neaq.org
New England Aquarium

Recent exhibit development work consisting of: design and construction, exhibit prototyping, animal acquisition (including field collections), animal quarantine, habitat fabrication and installation, will be presented. An opening of April ‘11 at the Aquarium’s Central Wharf location is planned.

Glimpses of three NEAq satellite facilities: Duxbury Harbor Porpoise Rehabilitation Facility, Charlestown Habitat Fabrication Shop, and the Quincy Shipyard Animal Holding Facility, and their critical roles, will be provided.

In early 2008 the Aquarium began planning a large elasmobranch touch exhibit for the Changing Exhibit Gallery. A small prototype was produced for the ’08 summer season to gauge visitor reaction, assess new species choices, explore interpretation strategies, and reintroduce staff to the challenges of managing this type of experience, the last NEAq iteration being presented in ’92. This ’08 prototype was followed by a thorough planning process to launch the ’11 uber-version. The execution would include: production coordination of a 14-section organically shaped bi-level tank, collection and transport of Chesapeake cownose rays, repurposing the Duxbury porpoise rehab facility, completing the fitting-out of the new Quincy shipyard facility, solving habitat design and fabrication challenges, deconstruction of the prior jellies changing exhibit, and creating sufficient LSS in limited footprint.

Rainforests Around the World

Greg Whittaker
gwhittaker@moodygardens.com
Moody Gardens

Hurricane Ike crossed Galveston Island on September 13th, 2008, inundating the Moody Gardens’ complex with a 14 foot storm surge. Catastrophic damage to facilities totaled over $50M, with nearly complete devastation of the tropical Rainforest exhibit’s electrical, HVAC and LSS infrastructure.

A comprehensive exhibit repair and renovation plan was funded by the Moody Foundation and implemented in a three stage process allowing for schedule gaps in construction phases to coincide with partial exhibit openings through the 2009 and 2010 peak tourism seasons.

The $25M enhancement project is nearly complete and the exhibit will reopen to the public on May 28th, 2011. Significant changes include an expanded exhibit path nearly doubling the previous guest experience, with an elevated canopy walkway showcasing butterflies, fruit bats and up close viewing of free-ranging reptiles, birds and mammals.

Behind the scenes, we gained a complete design and installation of aquatic life support systems that are a dramatic improvement over the previous operational retrofits of decorative water feature filtration systems to accommodate living collections. The current overall exhibit design includes features that will allow future enhancement plans to fall into place seamlessly and give us a chance to provide a changing guest experience to energize attendance every few years.

RAW Business Meeting

Friday, May 6, Session 10
Sea Turtles

Sponsor Presentation - YSI, Inc.

2010 Sea Turtle Census Survey- Preliminary Results

Joanne Harcke and W. Mark Swingle
joanne.harcke@ncaquariums.com
North Carolina Aquarium at Fort Fisher

In 2010, the Sea Turtle Working Group (STWG), which meets in conjunction with the Association of Zoos & Aquariums (AZA), developed a survey to produce a census of sea turtles in aquariums, zoological parks and science centers that have public display. Previous surveys were conducted in 1996 and 2002 by the Virginia Marine Science Museum Foundation in conjunction with the STWG. The 2010 survey was made available on Survey Monkey and announced to the STWG and others through AZA supported listservs. Preliminary results follow.

Thirty-seven zoological parks and aquariums reported having sea turtles at their facilities. All reported having sea turtles on public display or for public education programs. The survey was divided into two sections: permanent animal collections and rehabilitation or research.

There were a total of 213 turtles in permanent collections: 86 *Caretta caretta*, 95 *Chelonia mydas*, 8 *Chelonia agassizii*, 9 *Eretmochelys imbricata* and 15 *Lepidochelys kempii*. The number of sea turtles less than 1 year of age in permanent collections at a facility ranged from 1 to 31 with a mean of 7.7. The number of juvenile and adult sea turtles in permanent collections ranged from 1 to 15 with a mean of 3.9.

There were a total of 409 sea turtles being held for rehabilitation or research: 84 *Caretta caretta*, 284 *Chelonia mydas*, 5 *Eretmochelys imbricata* and 36 *Lepidochelys kempii.* The number of sea turtles less than 1 year of age being held for rehabilitation or research ranged from 1 to 31 with a mean of 9.7. The number of juvenile and adult sea turtles being held for rehabilitation or research ranged from 1 to 264 with a mean of 29.3.

Results will be used to facilitate increased communication and cooperation among organizations caring for sea turtles, with the goal of improving husbandry and conservation efforts.

Working with Captive-Reared Green Sea Turtle *(Chelonia mydas)* Hatchlings as Ambassadors for Education, Conservation and Research

Bryan Andryszak and Miriam Vadillo
Bryszak@gmail.com
Albuquerque Biopark Aquarium

From June 2007 through July 2010, biologists at Boatswain’s Beach / Cayman Turtle Farm, Ltd., developed a method for working with Green Sea Turtle *(Chelonia mydas)* hatchlings as an interactive tool for educating visiting park guests about general sea turtle biology and conservation while preparing the turtles for ultimate release to the ocean as part of the Cayman Turtle Farm’s ongoing turtle release program, referred to as ‘Headstarting’. The 1.3 million gallon “Boatswain’s Beach” public snorkeling lagoon provided a suitable environment for this study. Insights were gained concerning the behavior of green sea turtles at an early age. Through the process, referred to as ‘Transitioned Release’, more was learned about the ability of young green sea turtles to respond to training, their apparent ability to recognize color, their social compatibility with captive lagoon fish and snorkelers, and their transition of natural diet from animal to plant protein. It was determined that: turtles aged 3-6 months were best suited to enter the Transitioned Release process based on the earliest observable threshold for retaining trained responses; small turtles were better suited for public interactive displays; turtles that were too large posed a potential threat to fish tank mates; turtles responded to both visual and audible queues, with audible queues proving to be preferable in a public interactive display; retention of learned behaviors was not long-term; lagoon turtles transitioned on their own from fresh-cut animal protein to plant (algae) sources that grew naturally in the lagoon; turtles transitioned for 6-12 months in the lagoon (aged 18-24 months) successfully ‘Headstarted’.

Sea Turtles. The Journey- New Temporary Exhibit at Oceanario de Lisboa

Nuria Baylina
nbaylina@oceanario.pt
Oceanrio de Lisboa

Oceanário de Lisboa opened its doors in 1998 as part of the Expo 98. In 2011 an expansion is being built. This new building includes a temporary exhibit room with 600 m2 that will allow Oceanário to have new attractions every 2 or 3 years.

The first temporary exhibit is called “Sea Turtles. The Journey.” This exhibit pretends to show several aspects of the life of these wonderful animals with a special focus on the natural history, behavior, cultural importance and conservation issues.

The exhibit includes a 250m3 tank that represents the sea turtle journey through the North Atlantic Ocean focusing on some of the different habitats that these animals pass by during their lives.

Using Juvenile Sea Turtles to Expand Education Here, There, and Everywhere

Michele Lamping
Michele.lamping@ncaquariums.com
North Carolina Aquarium at Pine Knoll Shores

Each year the North Carolina Aquarium at Pine Knoll Shores receives dozens of debilitated sea turtle hatchlings from beaches all over North Carolina. The loggerhead and green hatchlings are rehabilitated and once deemed releasable by our veterinary staff, are released offshore into the Gulf Stream. Some hatchlings are held back for 1-3 years to be used as educational display and/or education outreach animals here or at other facilities. The Aquarium’s exhibit, ‘Loggerhead Odyssey,’ displays hatchlings from ages 2 months to about a year. The exhibit showcases life support, daily husbandry, and medical procedures. In front of the exhibit there is an adult loggerhead skeleton, a nest cross section, a video of our conservations efforts, and graphic panels with general sea turtle information. Along with these educational tools, volunteers use various sea turtle artifacts in front of the exhibit to engage and educate the public. After a year, selected sea turtles are put in tanks behind the scenes as points of interest for behind the scenes tours, for daily public programs about sea turtle conservation, or for outreach programs to local schools and festivals. To expand conservation efforts beyond the three North Carolina Aquariums, we have entered into partnerships with several organizations. Some of the turtles in the collection may be used in animal handling training sessions for NOAA observers or research subjects for graduate students from schools Including Duke University and UNC Chapel Hill. The NC aquariums are permitted to loan out a limited number of sea turtle hatchlings to out-of-state zoos and aquariums including facilities in Kentucky, Connecticut, Virginia, and Pennsylvania. This allows our program and sea turtle conservation efforts to expand beyond North Carolina.

Mystic Aquarium's Role in Loggerhead Sea Turtle Conservation, Education and Outreach

Aisnley Smith
asmith@searesearch.org
Mystic Aquarium & Institute for Exploration

All seven species of Sea Turtles are either threatened or endangered. The prolonged time required to reach sexual maturity as well as the high mortality rate of eggs and young turtles make loggerheads a species of specific concern. As a result, North Carolina Aquarium at Pine Knoll Shores (NCPKS) has instituted a head start program for rescued and rehabilitated hatchlings. For the past three years, Mystic Aquarium, a division of Sea Research Foundation Inc., has partnered with NCPKS to raise seven loggerhead hatchlings to approximately one year of age, for release back into the wild. This head-start program which enables the release of turtles at a larger size increases the loggerheads' odds of survival. NCPKS rescues distressed hatchlings from local beaches, and begins the rehabilitation and care in their facility. Once the hatchings are stable, they are transported from North Carolina to other facilities including the Mystic Aquarium in Connecticut, where for the next eleven months the turtles are closely monitored to ensure proper diet, care, and environment. There is close communication and coordination with veterinary staff, ensuring that the turtles receive the correct proportion and type of food based on their weight, to promote healthy growth. Morphometrics are taken on a regular basis, and the exhibit water chemistry and temperature are checked daily. While at Mystic Aquarium, the turtles are displayed on the main floor providing a unique educational experience for the guests. Visitors viewing the exhibit are presented with information on threats facing sea turtles, facts about their natural history, and a video about the impact of the recent oil spill on sea turtle populations. The following fall, the juvenile turtles are transported back to North Carolina, where they are cleared and released into the ocean. This head-start program and the collaboration between NCPKS and the Mystic Aquarium contributes to sea turtle conservation, education and outreach.

A Long-term Study (2000-2010) on the Biology of Nesting Loggerhead Sea Turtles *(Caretta caretta)* in the Northern Subpopulation: Fecundity, Nets, Temperatures, Sex Ratios, and Yolk Steroids

David Rostal
rostak@georgiasouthern.edu
Georgia Southern University

In 2000, we began a long-term study of nesting females on two Georgia barrier islands to address both basic scientific questions as well as applied questions. These questions were: 1) What is the true fecundity of nesting females in the northern subpopulation, 2) what temperatures are nest experience and what sex ratios are produced, 3) does nest relocation affect nest temperatures and sex ratios, 4) what is the yearly nesting population size structure, and 5) do yolk hormones vary in eggs across the season. Nesting females were monitored from 2000 to 2010 on Wassaw and Blackbeard Islands. Females were tagged, measured and nest location was recorded. Nest temperature was recorded for a subset of nests each year. A subset of eggs and hatchlings from these nests were measured to determine the amount of variation. Hatchling sex ratios were either estimated based on nest temperature or histology. In all years, hatchlings found dead in nests were preserved for sex identification. In 2003 and 2004, a pre-determined number of hatchlings were sacrificed to validate the use of dead hatchlings as well as temperature estimates. In 2006, eggs were collected to determine if yolk steroids varied across the season. Results from this study show that female loggerheads in the northern subpopulation are producing 5+ nests preseason. Hatchling sex ratios do vary during the season during a nesting season with males produced mostly early nests. The percent of males produced varied from 15% to 48% male by year. Female size also varied between years with increased numbers of smaller females arriving in the later years suggesting possible recruitment to the adult population. Finally, yolk steroid levels were observed to increase significantly as the nesting season progressed. The role of these steroids is not known but may influence sex determination, hatchling size and immune response.

Seasonal Variation in Egg Size in the Loggerhead Sea Turtle: Resource Partitioning in the Nesting Female

Ketan Patel
ketan_v_patel@georgiasouthern.edu
Georgia Southern University

Recruitment plays a major part in the survival of a species by focusing on the process of hatchlings surviving to reproductive age. Maternal investment studies focus on of resources allocated by the mother to hatchlings and its relationship to offspring survivorship. Understanding maternal contributions and strategies in reproduction can reflect how resources are allocated in response to resource availability and physiological constraints by the mother. Sea turtles have the highest egg yields of any oviparous non-avian reptiles, laying between 50 and 130 eggs (1-10% of female total body mass) multiple times in a nesting season. Caretta caretta have high seasonal fecundity and display little variation in egg size, and instead maximize clutch size. This study was conducted on Wassaw Island National Wildlife Refuge during the 2008 to 2010 nesting seasons. In order to assess the direct maternal effects, analysis of maternal condition, egg mass, clutch size, as well as comparisons of wet mass, dry mass of eggs, hatchling size and residual yolk mass were made. Egg mass decreases across the season while yolk mass and hatchling size remain relatively constant. Dry component analysis shows that pure yolk and albumen stays constant across periods and the decrease in egg mass is due to lower water content in the eggs. Ash-free dry mass studies were also carried out to discern and compare between organic (energy) and inorganic material (building components) in the yolk and albumen allocated to hatchlings. Bomb calorimitry studies were also carried out in order to quantify caloric content in the yolk and albumen. With the compilations of these studies, conservationists can better understand the mechanisms of resource partitioning and relate it to the relative survivorship of hatchlings throughout the nesting season.

Multiple Paternity in the Northern Subpopulation of Loggerhead Sea Turtle *(Caretta caretta)*

Jacob Lasala
jl02621@georgiasouthern.edu
Georgia Southern University

As researchers, most of our information comes from observing the organisms we study and determining their behavior. Mating systems are essential in shaping life history evolution and population dynamics of a species and should be considered when planning conservation efforts. If a species cannot be readily observed we can use molecular tools to reveal the mating systems that were previously obscured. For example, multiple paternity (MP) in sea turtles occurs when more than one male contributes his genes to the hatchlings within a nest. MP can influence genetic effective population size: the number of individuals who contribute genes to the next generation. MP can influence the genetic variation within a population, if nests are genetically diverse, the more likely a variety of genes will be passed on. However, within Testudines, MP can vary (0-100% of nests) and the cause is questionable (Uller & Olsson 2008), leading to more interesting questions: Previous studies on the loggerhead turtle *(Caretta caretta)* have shown that within large rookeries to the South (FL), 1/3 of the nests display MP. If nests from a Northern and smaller rookery were examined, would there be a difference of MP between the two sites? Goals of this study are to 1) determine if MP exists in Georgia's smaller nesting population and 2) determine if the percentage of nests with multiple fathers differs significantly from previous studies. Mothers and offspring were sampled from 30 nests in 2009 on Wassaw Island, GA, samples were genotyped and parental contributions were determined. MP was detected in greater than 30% of the nests, suggesting a difference between the two subpopulations. Finally, two other previously unasked questions will be addressed: does MP vary over the course of the nesting season and how many individual fathers are actively contributing to this Northern nesting population?

Managing the Cold-Stunning Season of 2009-2010 and Planning for the Future

Christian Legner
christian.legner@ncaquariums.com
North Carolina Aquarium at Roanoke Island

During the winter of 2009-2010, the Network for Endangered Sea Turtles (N.E.S.T.) and the North Carolina Aquarium on Roanoke Island (NCARI) were contacted to rehabilitate 75 cold-stunned sea turtles. Due to the small size of the rehabilitation facility, managing this number of animals required excellent communication among the state coordinators, veterinarians, other rehabilitation facilities, and other aquariums.

The number of cold-stunned sea turtles in previous years had been much lower; therefore our facility did not have an action plan in place for dealing with such large numbers. The season required us to re-evaluate holding and release criteria as well as expanding our range of contacts with facilities willing to hold rehabilitating turtles. Facilities as far away as Sea World Orlando and the Georgia Aquarium came to our aid.

At the end of the hectic season, we had a chance to evaluate causes for the large standing events and to begin planning for the future. Factors such as weather and sea surface temperature patterns will continue to fluctuate throughout the years. However, one human factor did surface; a great increase of staff and volunteer patrolling of local beaches during the fall and winter has led to finding many more turtles before they succumb to the cold. New plans implemented in the 2010-2011 cold-stun season resulted in better management of individual animal records, increased ease of transport between facilities, and a more organized response from our facility.

Cold Case Files: The Case of the Disappearing Carapace

Magan Celt
magan.f.ratte@disney.com
Walt Disney World

January 2010 presented itself as one of the worst cold stun events for sea turtles in Florida in most recent history. Over 5,000 animals were rescued in this cold stun event by various agencies in the state of Florida. This is a case study of a green sea turtle, *Chelonia mydas*, that stranded at Port St. Joe on January 7, 2010. This animal has lost a large portion of the top of its carapace and has now begun the process of rebuilding the shell. We have documented this process through the use of various media including photography, radiography, MRI, CAT scans and bone scans.

Sea Turtle Husbandry in the Wake of the Deepwater Horizon Disaster

Dee Murphy
Dmurphy@auduboninstitute.org
Audubon Aquarium of the Americas

When the Deepwater Horizon oilrig exploded of the coast of Louisiana, the Audubon Aquarium of the Americas was thrust into uncharted territory. In the months that followed the Aquarium, the Louisiana Marine Mammal and Sea Turtle Rescue Program and Louisiana Department of Wildlife and Fisheries worked tirelessly to clean over two hundred sea turtles and two dolphins. We were also inundated with numerous mortalities.

Our offsite holding facility turned into a M*A*S*H unit for sea turtles as the summer progressed. Now that the triage has died down we have examined what worked, what didn't, and what we can teach our peers so they will be better prepared in the event that this ever happens again.

POSTER ABSTRACTS

Hyperbaric Chambers for Rockfish at the Monterey Bay Aquarium

Joe Welsh
jwelsh@mbayaq.org
Monterey Bay Aquarium

The Monterey Bay has diverse and numerous rockfish *(Sebastes spp.)* communities living between 30 and 200M deep. These fishes and their habitats have been under-represented in the Monterey Bay Aquarium's exhibits partly because of the difficulty in collecting and holding healthy animals from these depths. In the past, aquarium collectors have positioned themselves using SCUBA gear at 20 meters under a fishing boat to receive rockfishes being reeled up. Here the fishes' airbladders were relieved with hypodermic needles before passing the fish up to the surface. This was a successful collecting method though it was logistically challenging. More recently, Jeff Smiley (Hubbs-Sea World) brought large rockfish straight to the surface from over 100 meters. These fish were quickly moved into pressure vessels and successfully recompressed and decompressed for eventual acclimatization to surface pressure. Inspired by Smiley's efforts, and also by some smaller chambers developed by Jeff Landesman (Cabrillo Marine Museum), we have developed and employed two types of pressure vessels: One is stainless steel and is pressurized with oxygen gas; the other is built of PVC pipe components, has a "two stage" function, and is pressurized with a water pump. These vessels work well for small to medium-sized rockfish, are transportable, easy to build and operate, and inexpensive. We have collected rockfish with hook and line, trawls, or traps from up to 150 meters depth. Rockfish that have been successfully acclimated to the surface in these vessels include Bocaccio, Canary, Chilipepper, Cow Cod, Greenstriped, Greenspotted, Halfbanded, Rosy, Starry, and Widow. We are helping supply live fish for research, including post-barotrauma rockfish vision investigations done by Bonnie Rogers (CSU Long Beach). We are also using recompression for routine hook and line or scuba collection of nearshore species.

Treatment of Trematodes

Megan Olhasso
molhasso@cscmail.org
California Science Center

While performing routine exit exams, nematodes within the gills were identified on three finescale triggerfish *(Balistes polylepis)*. A cabezon *(Scorpaenichthys marmoratus)* housed with them and examined at the same time did not have evidence of nematodes. Because they were housed in the same system, all four fish were held back in quarantine together. At a later exam nematodes were also found in the gills of the cabezon. It seemed likely that the gill nematodes had been transmitted from the triggerfish to the cabezon. All four fish were treated with fenbendazole given via tube feeding (50mg/kg) and fenbendazole immersion (.58ml/L or .15ml/gal). Gill nematodes were present post treatment. Levamisole was used as an immersion bath at 7.57mg/L (2mg/gal). After the immersion treatment there were significantly fewer nematodes. Levamisole was then given by intramuscular injection at 2mg/kg to both triggerfish and the cabezon – once a week for three treatments. Post treatment exams showed no visible nematodes.

Levamisole was the most effective treatment in resolving the gill nematodes. We were unable to find any references for the use of intramuscular injections of levamisole in fish. In this limited report intramuscular levamisole was safe, effective, and also easier and less expensive than levamisole immersion.

Seattle Aquarium Giant Pacific Octopus Census

Kathryn Kegel
k.kegel@seattleaquarium.org
Seattle Aquarium

In February 2000 the Seattle Aquarium started its annual Giant Pacific Octopus *(Enteroctopus dofleini)* census in the Puget Sound (Washington State, USA). This SCUBA diving survey was establish to help determine a baseline of how many Giant Pacific Octopuses there were in the area and to determine if the population was healthy. This was also an effective outreach to the local dive community. Over a three day period every year, volunteers are ask to dive in the Puget Sound area and report back on the location, depth, time, description of dens, and an estimate of size for each Giant Pacific Octopus seen. In 2010 we moved the census to January and sent teams to the several local beaches to meet with divers and the public to talk about the census and the aquariums upcoming weeklong event dedicated to octopuses, Octopus Week. Over the last 11 years we have tracked the fluctuation in Giant Pacific Octopus numbers in the Puget Sound area. Besides octopus numbers, the census has also given us more insight into the behavior, life history, and biology, of this amazing animal.

END