DRUM and CROAKER

A Highly Irregular Journal for the Public Aquarist

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Cover Photo: Pete Mohan, RAWdemic 2022, Moody Gardens, Galveston, TX
Interior Gyotaku: Bruce Koike
Interior Line Art: Craig Phillips, D&C Archives

DRUM AND CROAKER 50 YEARS AGO
Excerpts from the 1972 Issues

Selected by Pete Mohan

Rick Segedi has abstracted past issues for this column since 1994. At 88, he has decided to "retire from retirement," so last year's installment was his last contribution to this feature. Rick, thanks for shouldering this task for nearly 3 decades!

Rick was present at the birth of Drum and Croaker in the spring of 1957 and later penned many technical articles, as well as a humorous history of this occasion (Drum and Croaker, April 1977). He was prominent in the public aquarium field during his tenures at the old Cleveland Aquarium, the Pittsburgh Aquazoo, and the Mystic Aquarium. He later returned to his roots in Cleveland and retired from the Cleveland Metroparks Zoo, where the staff and animals from the old aquarium had found a new home years earlier. Rick is perhaps best known to our community for his involvement in the development of artificial seawater formulas (Drum and Croaker, April 1962). He was sent to the old Dallas Aquarium in 1963 to help mix their first batch (Drum and Croaker, 2021).

Steve Bailey (aka "Bailey") has offered to take over this column in 2023. Steve is a well-known team captain and cheerleader for all things "public aquarium." Hi is also a major contributor to Lake Victoria cichlid conservation (and many other SW and FW industry efforts), and is a two-time host of RAW. Welcome!

February 1972 Issue

TO ALL AQUARISTS

At the AAZPA *(now AZA)* meeting held in Salt Lake City during September, 1971, 19 aquarists from the United States and Canada met and discussed the problem of an annual meeting for aquarists. After considering the possibilities of affiliating with ASIH, AAM, and AAZPA, or going it alone, those present voted unanimously in favor of AAZPA. They also decided that a program committee should be elected annually to plan the yearly symposium, and that this committee should endeavor to survey the aquarists of the USA and Canada each year in order to determine the type of program that the majority prefer and to increase the unity and communication between aquarists. The program committee for the 1972 meeting is: Don Wilkie - Chairman Gil Hewlett - Vancouver Public Aquarium Lou Garibaldi - New England Aquarium Don Wilkie was subsequently appointed to the overall AAZPA program committee which is chaired by Mr. Ron Reuther, director of the San Francisco Zoological Gardens. Gil Hewlett has been appointed to the AAZPA liaison committee. It is hoped that in the future the aquarium member can be chosen by the aquarists rather than appointed by the AAZPA president.

This year's committee suggests a three-part program: 1. A workshop (probably in the evening) on some particular aspect of aquariology, e.g., Nutrition, disease, water treatments. Since the Western Fish Nutrition Lab is near Portland, nutrition might be a suitable topic. 2. A keynote speaker from outside the public aquarium field, who works in a closely related field, e.g., Dr. John Halver, the director of the Western Fish Nutrition Lab. 3. Papers on aquarium topics.

THE DEPLETION OF COPPER IN MARINE AND FRESHWATER ENVIRONMENTS BY ACTIVATED CARBON FILTRATION

Brad Latvaitis Assistant Curator of Fishes, Shedd Aquarium

Copper is being used at the John G. Shedd Aquarium for the control of algae, prophylactic disease control and specific disease treatment. When using cupric sulphate pentahydrate, it is important to make daily water quality analysis determinations so the copper level can be maintained. The copper level is determined through the diethydithiocarbamate treatment as described in Strickland and Parsons (1960).

The following general conclusions can be suggested. Water receiving no filtration will lose approximately 50% of its copper level within 24 hours. With filtration approximating the passing of 30 ml H_2O/sec over 390 grams of activated carbon an 80% depletion occurs within four hours. A 50% depletion occurs within four hours when 100 grams of activated carbon are exposed to water with a flow rate of 20 ml/sec. Water receiving carbon filtration lost 80%+ copper within 24 hours, while no filtration resulted in a 50% loss.

ARAPAIMA DEATHS CAUSED BY PLASTIC PLANTS

Elmer H. Taylor Curator, New England Aquarium

It would seem to be more than coincidence for two nice large arapaima, in two distant aquariums, (New England Aquarium and the Pittsburgh Aquazoo) to die from what appeared to be a related cause. The arapaima at the Pittsburgh Aquazoo was found dead from no apparent injury or malady. A plastic multi-fingered base from an artificial plant was found lodged in the esophagus, blocking open the pneumatic duct leading to the air bladder.

July 1972 Issue

EUROPEAN UNION OF AQUARIUM CURATORS FORMED

Frank de Graaf, Curator, Aquarium and Reptile House, Royal Zool. Soc., Natura Artis Magistra

During a symposium held in the Basel Zoo May 24-25,1972, the participating aquarium curators decided to form a European Union of Aquarium Curators to ensure a closer contact between them in the future. The main objective of this Union will be to organize regular symposia during which topics and problems of general interest will be discussed. During these symposia ample time will be allotted for personal contact between the participants. As far as possible working parties will be formed well ahead of each symposium to prepare reviews or other basic material for the topics under discussion

DIETARY DEFICIENCY IN LION FISH

Sylvan Cohen, M.D.

In February, 1961, Mr. John Prescott, Curator of Marineland of the Pacific, received a group of nine Lion fish (*Pterois volitans*) from the Philippine islands. The fish had been caught by hand nets and were about 3 inches long when admitted to the holding tank. They were in good condition and were placed in display tanks a month later. They were fed exclusively on frozen white bait smelt (*Allosmerus elongatus*), and grew well, reaching a length of about 5 inches in a year. About nine months after their receipt, however, they began exhibiting erratic behavior with loss of equilibrium and often swam in spirals and upside down. The fish were all affected to varying degrees of severity, with three deaths. An additional obviously dying fish was placed in formalin solution and was examined grossly and microscopically. The gross examination revealed nothing remarkable, but the microscopic examination showed significant findings. The liver was very fatty, but the most striking finding was in the brain where sections revealed marked degenerative changes in the parenchyma with prominent histiocytic infiltrates mixed with the degenerating brain substance. Without knowledge of the dietary history, a Vitamin B Complex deficiency was suspected based on the microscopic findings. This belief was reinforced when the history was obtained, and the diet was altered, but unfortunately no controlled experiment was done, partly because of the small number of fish remaining (5), and partly because of the strong desire to preserve as many of the specimens as possible. No individual substitution feeding was done but the diets of all the fish were changed to 50% frozen food (*Allosmerus elongatus*), 25% live gold fish, and 25% live *Fundulus*. Only one additional fish died after the dietary change, while the remainder rapidly improved and lived for several years.

Starry Flounder – Bruce Koike

CULTURE AND DISPLAY OF THE CTENOPHORE *Beroe cucumis*

Josh Wagner, Senior Aquarist, jwagner@lbaop.org

Aquarium of the Pacific

Introduction

Ctenophores, also known as comb jellies, are a very successful phylum of animals making up around 200 species (Mills, 2018). Characterized by comb plates for locomotion and colloblast for prey capture, ctenophores have successfully colonized nearly every marine environment. All ctenophores are predatory with prey capture differing with body morphology. A few examples of body morphology include the cydippid body plan in which the ctenophores utilize a web of sticky tentacles to capture small prey. The body morphology of the lobate ctenophore involves using large oral lobes covered in sticky colloblast cells to capture its food. The beroid body plan lacks both tentacles and lobes. Instead, they swallow other ctenophores whole, which makes up the entirety of their diet. Ctenophores make attractive exhibit displays, but among the nearly 200 species described, diversity at public aquariums is poor. The Monterey Bay Aquarium in the past several years has made huge strides in the culture and display of these sensitive organisms (Bubel, Kowles, Patry, et al., 2018). However, beroid ctenophores, due to their specialized diet of comb jellies, have not been displayed or cultured with any regular success outside of Japan. Using cultured *Mnemiopsis ledyi* as a consistent food source, the Aquarium of the Pacific has been able to display and culture the beroid ctenophore, *Beroe cucumis*.

Prey Selection

Before beginning research and development on *Beroe cucumis*, it was important to establish what the organisms were going to prey on in a captive setting. Species from the genus *Beroe* only consume other ctenophores, responding chemokinetically to the presence of its prey (Swanberg, 1974). At the Aquarium of the Pacific, using the techniques for mass ctenophore culture established by the Monterey Bay Aquarium (Bubel, Kowles, Patry, et al. 2019), the ctenophore *Mnemiopsis ledyi* is cultured consistently for display. Conveniently, *Beroe cucumis* have been reported to prey on this species in the wild (Galil, 2013). It was difficult to anticipate just how many *Mnemiopsis* a single *Beroe* could eat. Specimens were commonly seen with 3 individuals in their gut at one time (Figure 1). Initially, 5-6 *Mnemiopsis* were spawned once a month, resulting in the production of 100-200 individuals. Anecdotally, it took approximately 45 days before the *Mnemiopsis* were large enough to be fed out. Long term, this did not create enough food to sustain our collection as they grew.

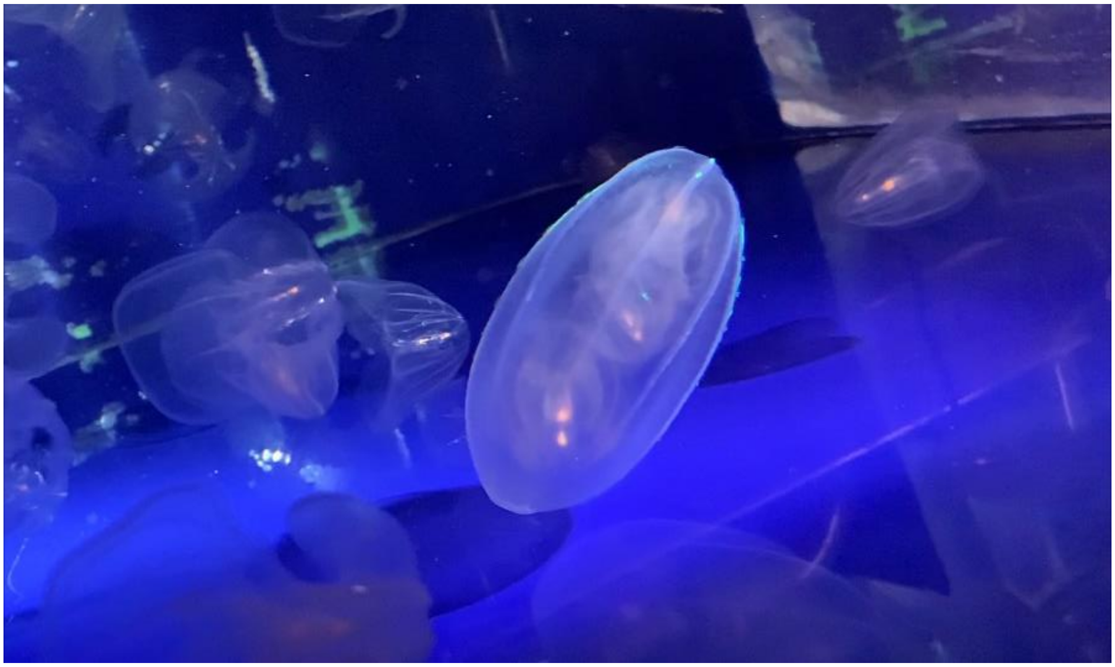

Figure 1. *Beroe cucumis* with 3 *Mnemiopsis ledyi* in its gut.

Animal Acquisition and Housing

Beroe cucumis were purchased through the Japanese wholesaler Blue Corner. Once acclimated, 5 animals were kept in a pseudo-kreisel (61 cm x 30 cm x 91 cm, 151 liters) at 14°C with a salinity of 33 ppt. Over the next week, each *Beroe* was offered half a *Mnemiopsis* daily, using a small pipette to target each individual. Once it was determined which specimens had the best appetite, the two top feeders were moved into a separate pseudo-kreisel and the temperature was increased to 19°C to increase metabolism. This new pseudo-kreisel was stocked with 20 adult *Mnemiopsis* which were consistently replaced, keeping a minimum 7 to 1 ratio of predator to prey.

Sexual Maturity and Spawning

Within a week of allowing the top feeders to free feed on adult *Mnemiopsis*, both specimens grew significantly and approximately doubled in size. Within two weeks, one of the specimens reached sexual maturity. Sexually mature *Beroe cucumis* are noticeable because the meridional canal underneath the comb rows will become cream colored, signaling the appearance of sperm and egg (Figure 2). One of the two *Beroe* began releasing eggs and sperm at this point and would do so daily. Unlike *Mnemiopsis*, which uses light to cue gamete release (Pang, 2008), the *Beroe* released gametes at different times of the day. The release seemingly corresponded with a large meal. Each spawning event came 1-7 hours after a large feed. Eggs were initially removed from the pseudo-kreisel with a pipette and placed in a 2 Liter glass beaker. The beaker was filled to the

2 Liter mark with sea water filtered through a 5-micron filter matching the water parameters of the pseudo-kreisel. After moving a large quantity of eggs over to the beaker for feeding trials, the sexually mature *Beroe* was placed in a diffusion tube for 24 hours to isolate another spawning event.

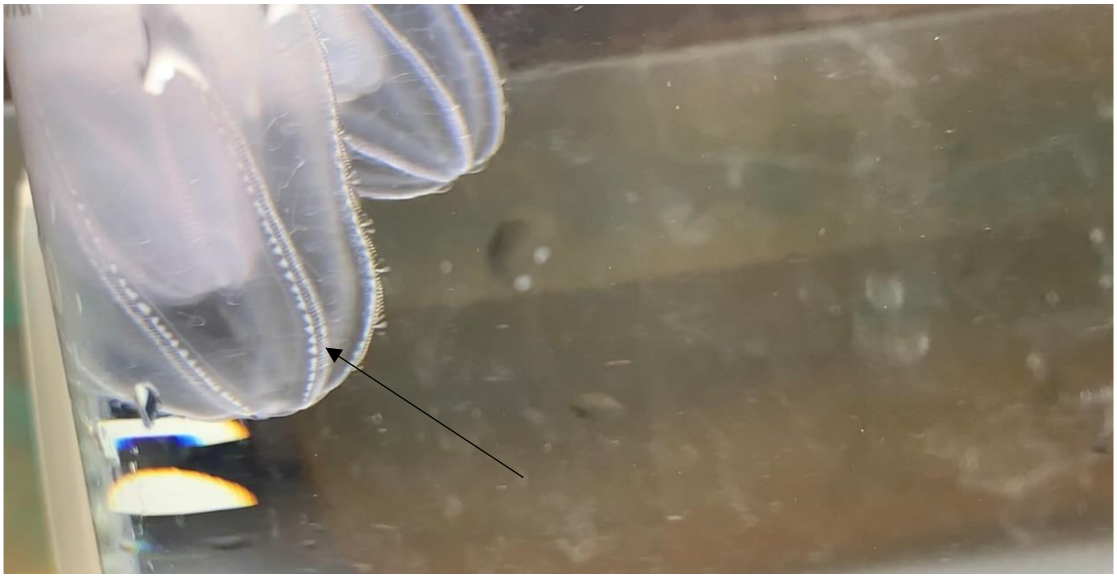

Figure 2. The meridional canal full of eggs and sperm.

Experiment

With a lack of information regarding the feeding habits of larval *Beroe cucumis*, multiple feeding trials were attempted. Ranging from 24-48 hours, fertilized eggs began to develop into larval *Beroe* inside the 2 Liter beaker. Specimens fertilized in the beaker were separated into a new beaker with identical water quality parameters: temperature of 20°C and salinity of 33 ppt. This was done until 3 identical beakers contained 20 *Beroe* each. Each beaker was then fed a different diet. Beaker #1 was fed pieces of *Mnemiopsis* that had been blended into a small particle size. Beaker #2 was fed approximately 20 larval *Mnemiopsis* three times a week. Beaker #3 was given 3 adult *Mnemiopsis*. Each beaker received a 100 percent water change twice weekly and was covered to prevent evaporation. The *Beroe* fertilized in the diffusion tube were fed larval *Mnemiopsis*, ranging from 10-20 larvae being fed 5 times a week.

Results

Beroe fertilized in the diffusion tube showed a faster rate of development initially, with development from egg to free swimming larvae within 15-36 hours. Seven days into the feeding trial, there was no noticeable feeding behavior from any of the larvae, but the specimens being fed larval *Mnemiopsis* were slightly larger in size. At 9 days post development, the first feeding behavior was physically observed. In the beaker being fed adult *Mnemiopsis*, one of the *Beroe* attached onto the lobe of the *Mnemiopsis* and began feeding on it (Figure 3). The *Beroe* stayed attached to the lobe for several minutes before letting go and swimming away. Since it was proven that the larvae were able to eat adult *Mnemiopsis* at this point, it was decided to stop the feeding trials and combine the remaining *Beroe* into one beaker and only offer adults as prey. Specimens

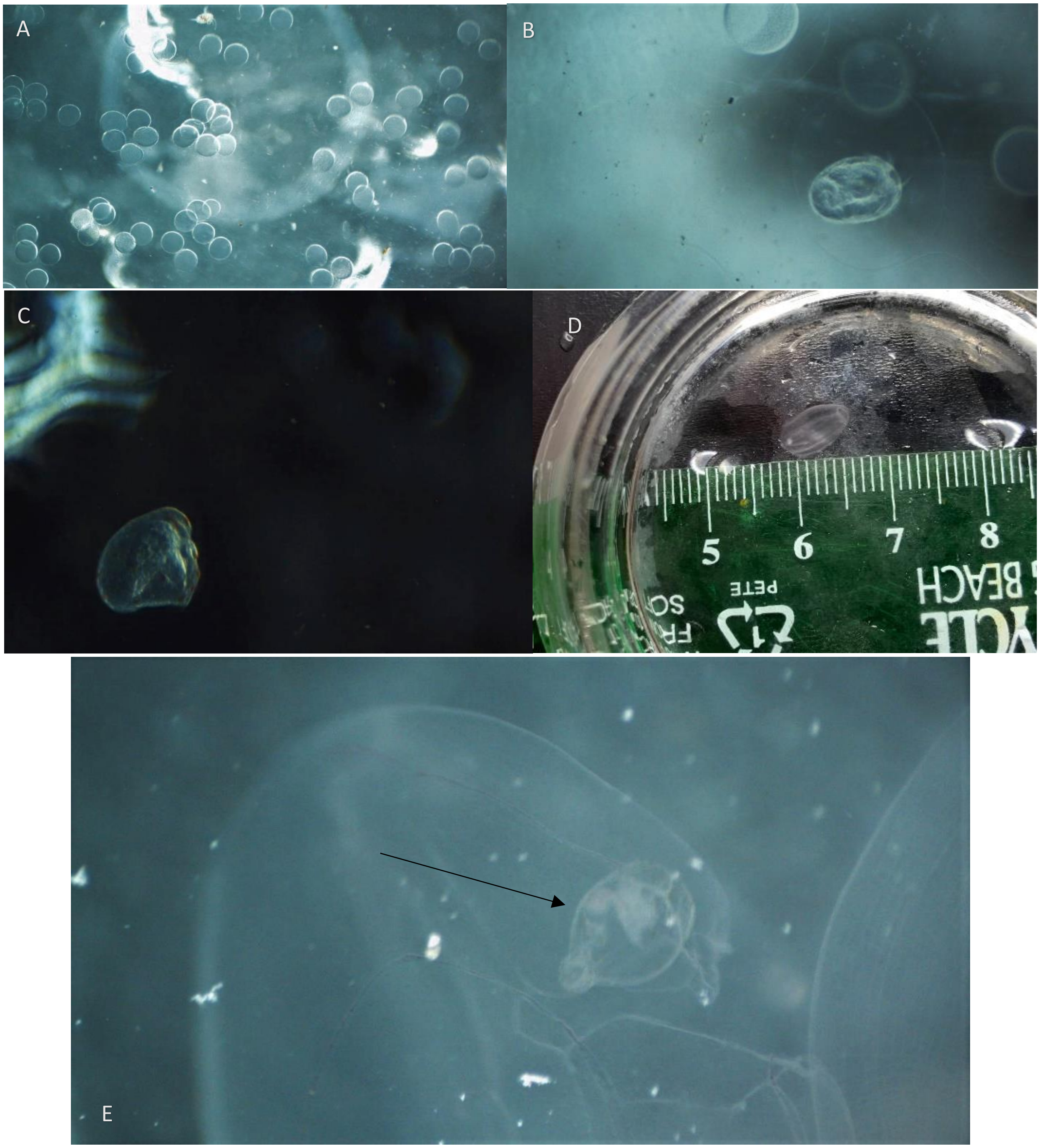

Figure 3. A. Newly released eggs. B. Egg at 12 hours. C. Larvae at 24 hours. D. 20 days post development. E. Larval *Beroe 8ucumis* attaching onto the lobe of an adult *Mnemiopsis ledyi.*

in the diffusion tube were also offered adults as food at this point. Though the specimens in the diffusion tube were larger than the specimens in the beakers, an interaction where a *Beroe* consumed a cydippid *Mnemiopsis* larvae was never actually observed. Even if they were being sustained on cydippid larvae, spawning enough *Mnemiopsis* to feed to the young *Beroe* seemed outside of the realm of what could be conceivably done**.** Once the feeding regime was established, all the *Beroe* housed in the2 Liter beaker received a 100 percent water change 3 times a week. Adult *Mnemiopsis* (3-4) were constantly kept in the beaker and replaced as needed. The same number of *Mnemiopsis* were kept in the diffusion tube and replaced as needed.

Specimens being kept in the diffusion tube continued to develop more quickly than those in the beaker. However, after day 16, a significant decline in the diffusion tube population was observed. Initially, the density was not quantified but estimated around 70-80 specimens. This quickly decreased to less than 20 individuals. No obvious reason for this decrease was noted, but food density could have been a contributing factor, as the food density per individual in the beaker was greater. With the *Mnemiopsis* being replaced as needed in both rearing vessels, this should not have been a problem. Another variable could had been the swimming and "resting" behavior of the *Beroe*. Unlike larval *Mnemiopsis*, which can stay suspended in the portion of the diffusion tube with very little movement, the *Beroe* are stronger swimmers and can move around the tube freely. Most of the smaller specimens spent the majority of their time at the top of the diffusion tube, but as they grew, they would tend to sit on the screen where passive water diffusion would occur. Though the water exchange through the screen is minute, this could have been detrimental as the screen can be a target for detritus and bacteria.

All of the *Beroe* were moved into a small pseudo-kreisel (25 cm x 30 cm x 61 cm, 45 liters) at 22 days post hatch. At this point, 27 individuals made the move, with an average size of 7 mm. Multiple feeding strategies were observed at this stage, including parasitism, tearing pieces off, and engulfing specimens whole. The parasitism behavior was only observed until the population of *Beroe* were large enough that the prey was approximately half their size.

Once specimens reached a size of 5-10 cm, they were placed on display in the Northern Pacific Jellies exhibit. The ctenophores were acclimated from an initial temperature of 20°C to the display temperature of 11°C over the span of a few days. At 11°C, individuals still consumed prey consistently and did not differ in their feeding behavior. The display of this species was fairly straightforward and followed the cleaning and sterilization protocols already in place for jellies displayed at the Aquarium of the Pacific. Providing enough food for each specimen was the limiting factor in a long-term display. Before placing the *Beroe* on display, two diffusion tubes were being used to spawn 5 *Mnemiopsis* twice monthly to fulfill the feeding needs. This spawning frequency was effective in the research and development period when working with 5 adult *Beroe*. However, working with 27 adult *Beroe*, this spawning frequency could not support the display. Two more diffusion tubes were purchased and immediately implemented, which allowed for twice the amount of food production. Initial feeding to the display was every other day, by cutting 3 adult *Mnemiopsis* into 4 pieces and broadcast feeding them. This sustained the exhibit for 80 days until the population declined and was replaced with another species.

Conclusion

Displaying the ctenophore *Beroe cucumis* is certainly achievable but is constrained by food availability. When given ample food, individuals can grow up to 10 cm and live for many months. Food availability also plays the most important role for creating gravid *Beroe cucumis*. Specimens can become gravid solely on a diet of *Mnemiopsis* if allowed to freely feed. An individual can also fertilize their own eggs despite reports that this is unlikely in a captive setting (Carré, Rouviere, Sardet, et al. 1984). Larvae given constant access to adult *Mnemiopsis* will grow quickly, attaching onto the lobes in a parasitic fashion. The larval rearing vessel is an area that can certainly be improved upon. The diffusion tube was not as successful as the beaker method in this trial. However, if multiple tubes were used, the variables limiting success could have been rectified. Beakers with no flow worked well in the initial trial, but a rearing vessel with consistent water quality and temperature control could be an improvement. Moving forward, the goal is to apply the information learned to culture this species, as well as other *Beroe* ctenophores, consistently and make them a permanent display animal at the Aquarium of the Pacific.

Acknowledgments

The author would like to thank his Assistant Curator Jennifer Anstey and Curator Nate Jaros for their endless support and positivity. He would also like to thank the Monterey Bay Aquarium's jelly team, specifically Thomas Knowles, MacKenzie Bubel, Wyatt Patry, Evan Firl, and Michael Howard for their innovative jelly husbandry and willingness to share information and techniques through programs like Jelly School.

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DEVELOPMENTAL PROGRESSION OF CAPTIVE REARED *Phyllobates vittatus* TADPOLES UNDER DIFFERING WATER SOURCES

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Abstract

Captive rearing of amphibian larval stages in captivity has been utilized for the conservation of several species. To determine the appropriate rearing conditions for a captive population of tadpoles, water quality conditions were taken into consideration. By determining the water source that is most beneficial for tadpole development, steps can be taken to develop an effective rearing method (Odum *et al.,* 2008). Increased success of rearing has the potential to develop a sustainable source of a commonly kept zoo and aquarium animal, the dart frog, *Phyllobates vittatus*. *P. vittatus* tadpoles of the same clutch were divided and reared in three different types of water: Reverse Osmosis (RO), Non-chlorinated (NCW), and filtered RO water naturally reconstituted (collected from dart frog exhibit; Exhibit) to determine the water type that gives the best chance for metamorphosis. Water changes were conducted once per week, with daily spot cleaning; temperature, pH, and tadpole stage recorded daily. Feeding was done 3 times weekly, spirulina for tadpoles and springtails for froglets post metamorphosis, and photos were taken twice weekly to record development progression.

Introduction

As sustainable sourcing and sourcing difficulties becomes a larger part of the zoo and aquarium industry, the need for effective rearing practices also rises. While various hobbyist platforms give different suggestions for dart frog tadpole care, little information is available regarding standardized best rearing practices (Kopp, 2007). Opinions regarding water source vary from strictly spring water or dechlorinated water steeped with an Indian almond leaf for a day (Burke, 2020), to RO steeped with green moss for a week (Amphibian Life, 2021), to steeped water that is replaced with RO over time (Josh's Frogs, 2011).

The objective of the research project is to determine the water type that is most beneficial for tadpole development, so steps can be taken to develop an effective rearing method. Increased success of rearing has the potential to develop a sustainable source of a commonly kept zoo and aquarium species.

Hypothesis

It is hypothesized that the Naturally Reconstituted Reverse Osmosis (RO) water collected from the exhibit will provide the *P. vittatus* tadpoles with the most rapid metamorphosis response because the water collected from the exhibit is the closest to that of natural occurring for the species in the wild. The Naturally Reconstituted RO water will be compared to Non-Chlorinated Water (NCW), and pure Reverse Osmosis water (Stoughton *et al.*, 2013). RO water is typically used for adult amphibian care, however given the lack of nutrients and minerals, we hypothesize a lower success rate of metamorphosis from the tadpole stage (Fabrezi *et al.*, 2008). NCW in our facility is considered regular tap water when compared to purified RO water.

Methods

A clutch of eight *P. vittatus* dart frog eggs, laid in a petri dish, were removed from the Poison Dart Frog exhibit, and transferred to a container back of house. As the eggs hatched, the released tadpoles were randomly separated into individual deli cups filled with 120 mL of water from one of three types: RO, NCW, and Exhibit. The successful hatching of all eight eggs resulted in three tadpoles each exposed to NCW and Exhibit water and two tadpoles exposed to RO water. All subject containers and plastic bottles containing each water type were kept in the same location; exposed to ambient temperature and artificial lighting provided by the main exhibit display as well as back of house overhead lighting.

Water Collection

Water was collected from each source at least 1 day prior to usage to ensure new water was able to reach ambient temperature and match that of the sample cups. During collection, a Penn Plax Brine Shrimp Aquarium Net was used to remove large particulate matter from the Exhibit water as it was drained from the exhibit. Collected water was then stored in the wash bottle corresponding to the source water.

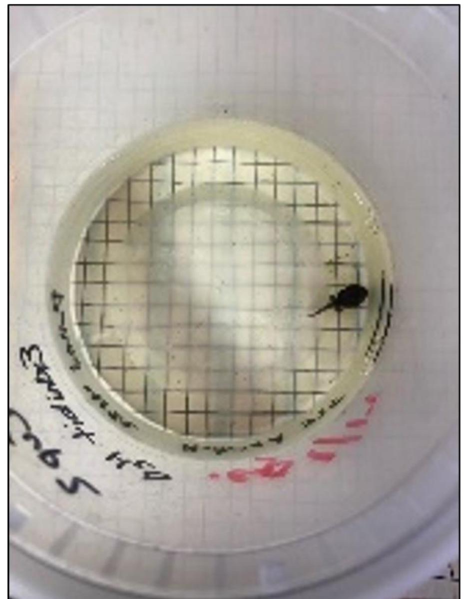

FIGURE 1: Setup for tadpoles with graph paper for scale; Exhibit2 Day 71

Daily Care

Each day an Apera Instruments AI209 Value Series PH20 pen was used to test the temperature and pH of each cup and spot cleaning was conducted using a 5 mL pipette that correlated to the water type in the deli cup. Cups were then topped off to 120mL using water collected from the source assigned to that cup.

Feeding

Individuals were offered food three times per week, until metamorphosis was complete. As tadpoles, a light dusting of spirulina powder, was tapped into each container. After full metamorphosis occurred, froglets received a small scoop of springtails instead of spirulina, continuing the same schedule as the spirulina powder.

Water Changes

Once per week, a 60mL baster corresponding to the water source type of each container, was used to remove 50% of the water and all organic matter. After the 50% water removal, water levels were returned to full depth with clean water of each corresponding type.

Development Tracking

Tadpoles were observed daily with noticeable developmental changes being recorded as milestones were met. To track overall growth, photographs were taken twice weekly, with a graph paper background. This allowed comparison of growth rate between milestones.

Results

Data collection began May 5, 2021 and concluded August 31, 2021, 118 days later. By this time all the individuals had either undergone metamorphosis or died. Overall, treatment, and cup water quality parameters are presented in Figures 2 through 5. As predicted, tadpoles exposed to the reverse osmosis water were the least successful with both individuals passing prior to achieving complete metamorphosis. While both developed rear legs, only one developed front legs and died prior to complete absorption of its tail. Development of tadpoles exposed to NCW and Exhibit water remained comparable with average developmental milestone timeframes of 56.33 days for arm leg development, 84 days for arms, and 88.33 days to complete metamorphosis for the NCW exposed individuals. Exhibit water exposed individuals averaged 64 days to develop legs, 82 days for arms, and 86 days to complete development. Progressive growth patterns for each cup are presented in Figure 6.

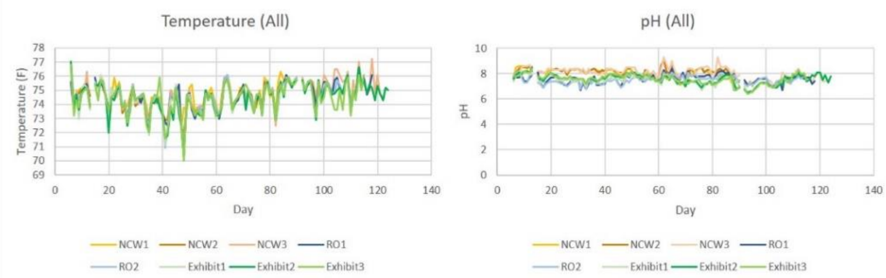

FIGURE 2: Graphs showing Temperature (F) and pH data for all tadpole cups (NCW1-3, RO 1-2, and Exhibit 1-3)

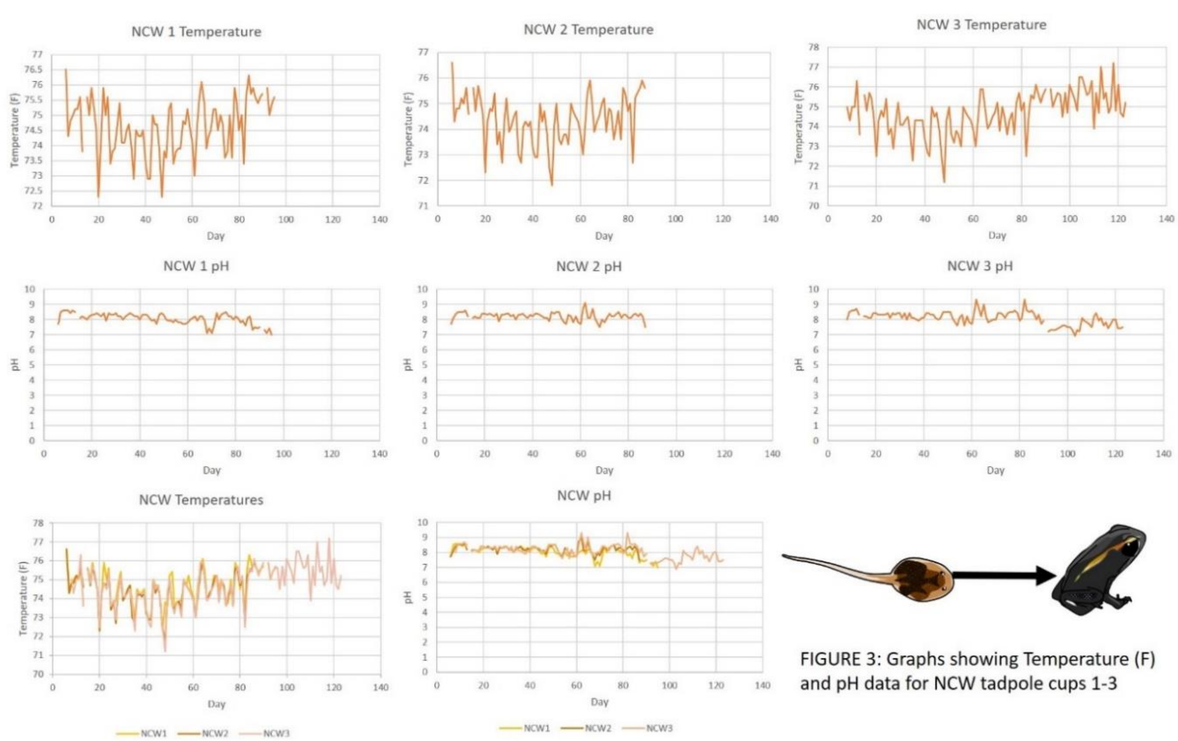

FIGURE 3: Graphs showing Temperature (F) and pH data for NCW tadpole cups 1-3

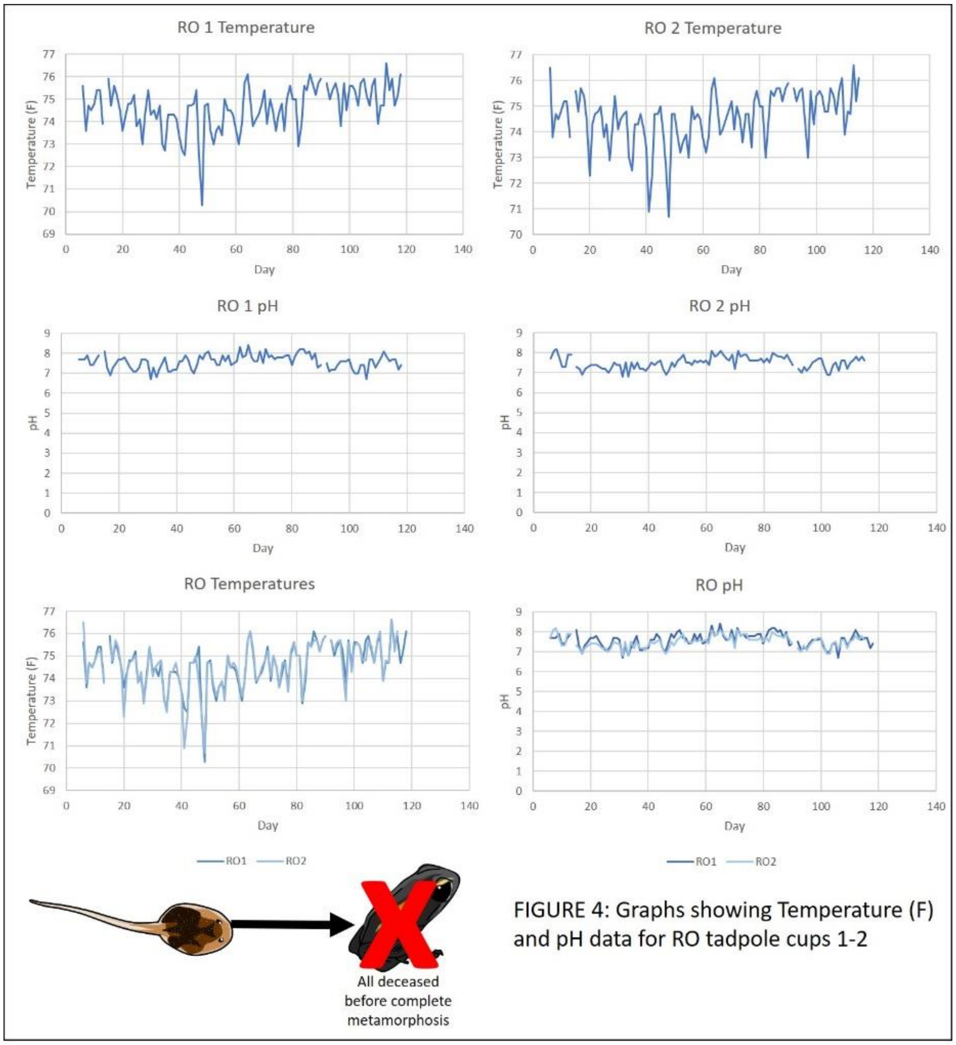

FIGURE 4: Graphs showing Temperature (F) and pH data for RO tadpole cups 1-2

Conclusion

According to our findings, we were able to reinforce our hypothesis to an extent. We found that the RO water tadpoles had the slowest rate of metamorphosis and neither of the test subjects completed metamorphosis, being found deceased prior to or during the metamorphosis processes. While exhibit water tadpoles took the longest to metamorphosize overall they had the highest rate of survival post metamorphosis. In developing a rearing program feeding alone is not sufficient for providing the necessary nutrients required by the developing tadpoles and nutrients provided by the water source must be taken into account. Based on these findings, we believe that using naturally reconstituted reverse osmosis water for tadpole rearing will result in the most successful metamorphosis and survival rate in captive bred *P. viattus* dart frogs. These findings will be used to implement an effective rearing program at our institution for a sustainable growth in our *P. viattus* population and surplusing purposes. Additional information can be obtained with regard to ideal food type and frequency as well as rate of occurrence for water changes to further increase the effectiveness of the tadpole rearing program. This information can also be used as a starting point for the rearing of other kept species of poison dart frog at our institution.

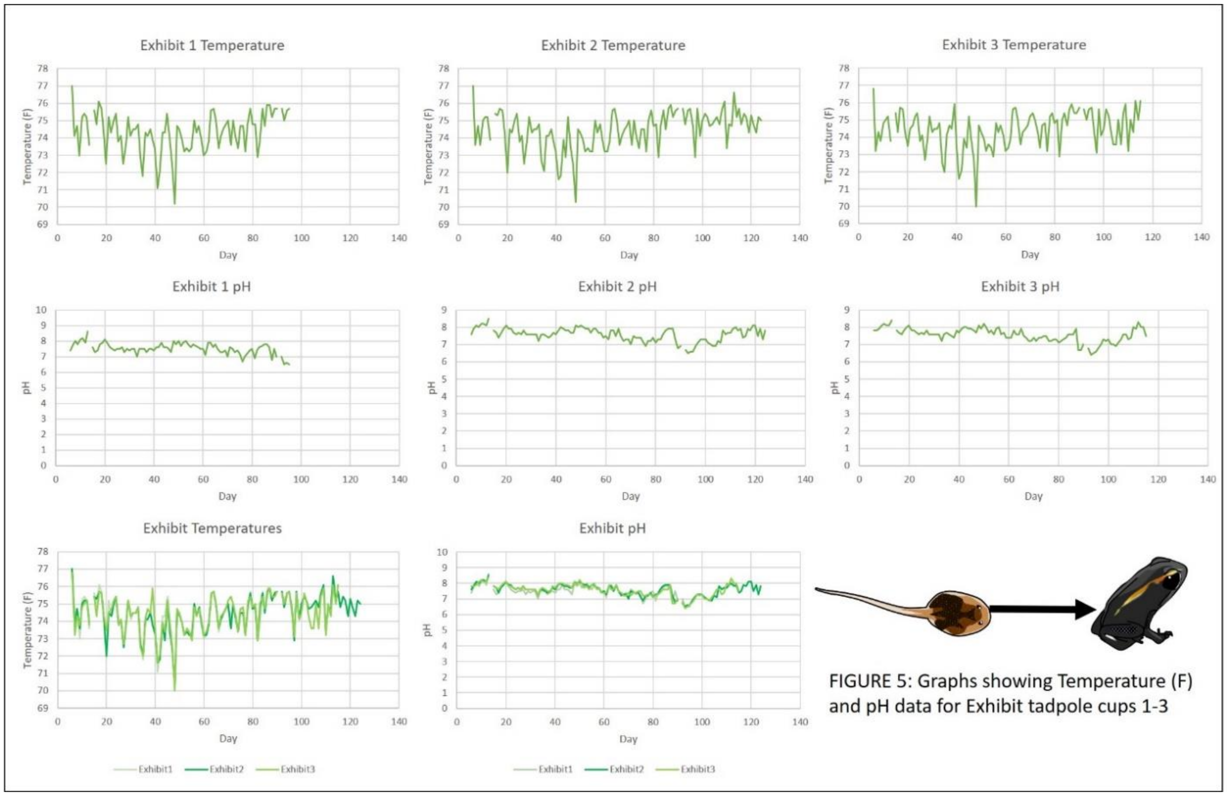

FIGURE 5: Graphs showing Temperature (F) and pH data for Exhibit tadpole cups 1-3

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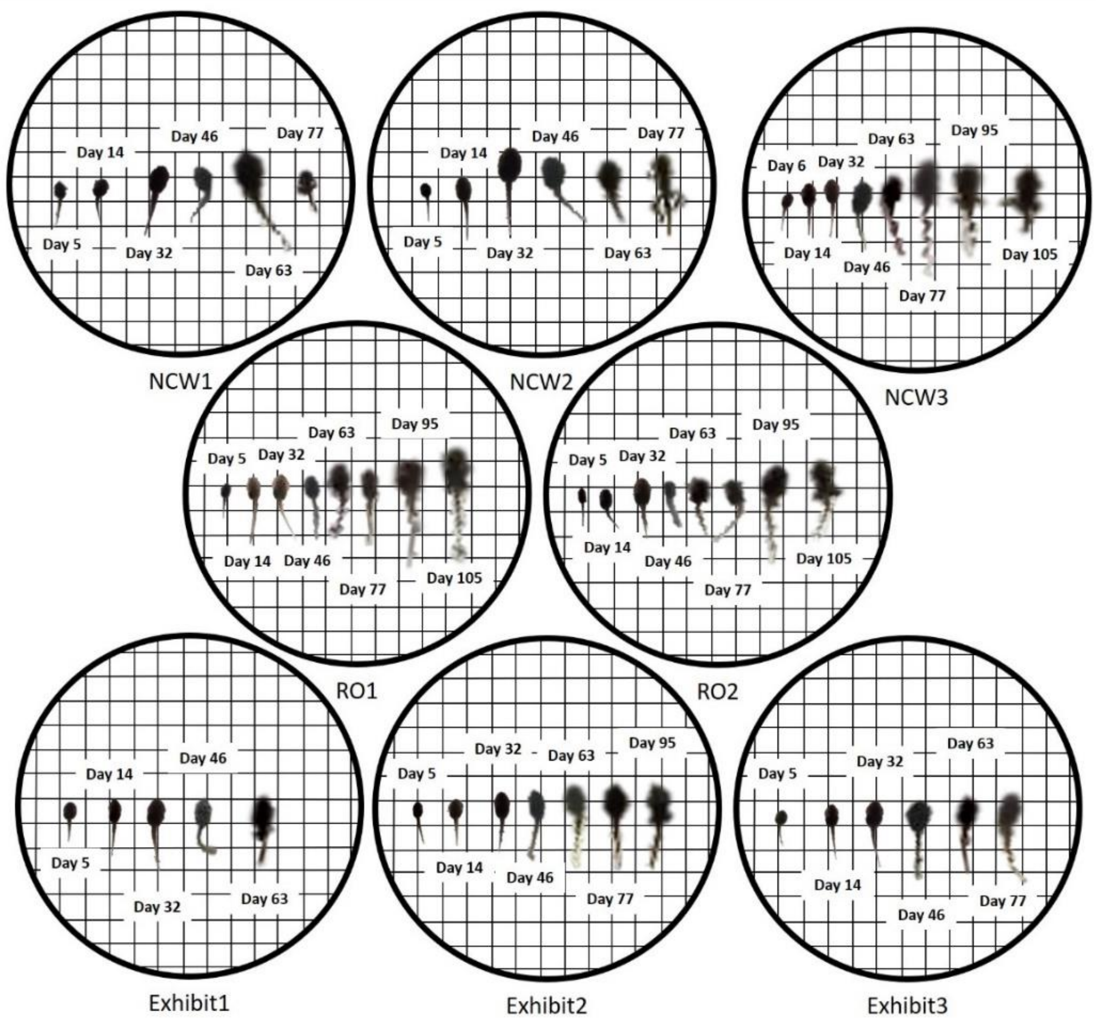

FIGURE 6: Progressive growth of each experiment tadpole; photo sample taken (up till death or metamorphosis of tadpole) on days 5/6, 14, 32, 46, 63, 77, 95, and 105

SUCESSFULLY BREEDING *Phyllopteryx taeniolatus* AT POEMA DEL MAR AQUARIUM

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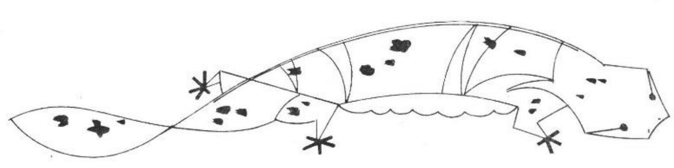
The weedy seadragon, *Phyllopteryx taeniolatus*, is a species belonging to the Syngnathidae family, of which seahorses are also a part. They are only found on the coasts of southern Australia, from Sydney to Perth, and southern Tasmania (Kuiter 2009), where they live between 3-50 meters deep, in Kelp forests and rocky reefs. Adults reach a maximum size of 30-40 centimeters. They have a brownish color with white spots in certain areas, and purple and blue lines that decorate their body. They have an elongated shape with a series of appendages that protrude from their body, helping them camouflage themselves among the algae, which are abundant in their natural habitat (Lourie 2016).

Wild individuals have an estimated lifespan of around 5-7 years, although this is not exactly known, while in aquariums they can reach almost 10 years. They are usually solitary most of the time, although small groups can be seen, especially during breeding seasons (Jones et al., 2020).

Despite having Least Concern status on the IUCN red list, it is listed as Near Threatened (Lourie 2016) due to the peculiarities and restrictions of its wild habitat.

The Syngnathidae family presents a special feature in all its members, in that the males incubate the eggs (Lourie 2016). In this case, opposite to what happens with Sea horses where the male incubates the eggs inside, the male of the weedy seadragon incubates the eggs attached to his tail. An egg transfer takes just seconds, but occurs only after mating sea dragons participate in a sort of courtship dance. The male and female mirror each other, often with their tails curled away from their mate, and dance around one another as they move up the water column. During the breeding season (which is usually in the spring and summer months), the males darken and their tail thickens a little more to be able to accommodate a completed laying of around 200-250 eggs. (Jones et al., 2020). The tail is one of the key points distinguishing females from males. After around 12 months, the differences between them can be observed. Females have a greater dorso-ventral distance from a lateral view than males. Males have a more elongated and stylized body with a longer and larger tail, specifically oriented to the type of reproduction that this species presents.



Display

At Poema del Mar the Weedy Sea dragon exhibit consists of a cylindrical, 12 m3 *(3,170 gallons)* display aquarium 3.75 meters in height and 1.87 in diameter. Coral gravel (0.5-1.5 cm) and artificial algae anchored to silica stones are used as substrate.

It is a closed system with at least 20% weekly water changes. The filtration is in the form of a compact filter (MAT compact F10) where biological filtration and the protein skimmer are integrated. In addition, there are two mechanical filters, ultraviolet lamps, and an ozone generator connected to the protein skimmer, although the ozone remains switched off for safety due to the high susceptibility of this species to small uncontrolled ozone variations. The total flow of the filtration is 10 m3 *(2,642 gallons)* per hour. The temperature is maintained between 15 and 16 ºC all year round thanks to a plate heat exchanger. The lighting is a 135-watt LED fixture (AI HYDRA 64 HD), adjustable via Wi-Fi.

As for the daily routines, the seadragons are fed twice per day (1 AM and 1 PM) with live mysis. Cleaning is done by diving twice a week, vacuuming the entire substrate completely on each dive. The algae that decorate the tank are removed monthly to freshen them and remove the diatom growth that is created due to the lighting.

Reproduction

All individuals arrived at our facility at the end of 2017. It was not until 2 years later that we started observing intense reproductive behaviors. These consist of dances where both individuals are arranged next to each other with their tails bent outwards. When the dances are very intense, the male puts his head under that of the female and shakes it repeatedly.

We have a sex ratio of 2.6.0. which we confirmed after morphological analysis of our individuals, based on the differences mentioned above.

Since the individuals arrived, they have always been held at the same temperature and light cycles, without any variation. In early 2020, a few months after starting to see these reproductive behaviors, the aquarium had to close due to the COVID pandemic. These behaviors were increasing, and shortly after 1 month and a half after closing the facilities, we had the first laying on April 28, 2020. It was not expected, and our surprise was greater when on May 1, just 3 days later, another male with eggs appeared. In the first of the clutches, we observed that the male had the entire tail almost completely covered with approximately 200 eggs. In contrast, the male holding the second clutch only had a small portion of the tail covered with approximately 75 eggs, with most of the eggs appearing on the bottom. In both cases, the spawning occurred at night, since at early morning rounds we observed the males with the eggs already attached to their tails.

After these two spawns, we observed a decrease in reproductive behaviors, but after a few weeks they increased again, equaling the previous level, and a third spawning occurred on July 21, 2020. In this case the spawning took place in the morning, after early rounds and before noon. Unfortunately, no one on the team was able to observe the upward egg transfer dance. In this case, the laying was approximately 100 eggs. The reproductive activity did not decrease and after 5 days we found a loose eggs on the bottom, from a presumably failed reproduction, and after 2 days, while a diver was carrying out the cleaning tasks, it was observed that a female also released around 50 eggs at the bottom.

Despite this great reproductive activity, the dances continued, and on October 29, 2020 we had another laying of approximately 100 eggs. This time the setting was made at night. It is important to note that we put protection on our surface skimmer to prevent our specimens from entrapment when performing the dance near the surface.

Throughout the year 2020 and until mid-2021, the park remained closed due to COVID, which made us think that one of the factors that could have favored the successful mating of this species is the absence of public.

In May 2021 the park opened to the public and a decrease in courtship behavior was observed. We came to think that the influx of public was going to cut the reproductive success in our dragon sea. But at the beginning of July, we noticed that one of the females began to have a somewhat inflamed oviduct, increasing in size every day, until on July 15 an ovate male with approximately 75 eggs on its abdomen appeared again. On July 25, 10 days after the first clutch of 2021, another Sea dragon appeared with approximately 180 eggs on its abdomen.

Hatching Figures

In our facility, the males incubate the eggs for an average of 40 days from the day the eggs are laid. Before an egg hatches, it is normal to see only the tail of the hatchling on the outside, and it can be like that for up to several days. After hatching, a miniature replica of the adult is born (just millimeters in length) and is swimming perfectly. In all the clutches, we have observed that the first young are born with a lot of yolk still. This prevents them from swimming correctly due to their weight and they can spend several days lying down until they reabsorb all that yolk and are able to swim correctly. Unfortunately, all of these hatchlings that were born with a lot of yolk (which we will call premature) died within the next 10 days.

After testing various instruments, we found that a plastic jar is the most useful tool to capture and move them from the main tank and transfer them to the quarantine tank. We tested rubber basins, bags, and other instruments, but the jug was by far the most effective.

In table 1, we will summarize the data obtained on hatchlings, deaths and final survival per clutch. In the births and survivals data, we will combine the first 2 clutches, since they were collected simultaneously and cannot be differentiated.

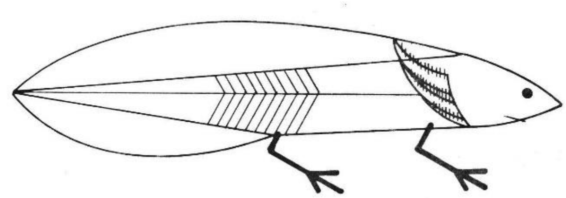


Table 1. Summary of Sea dragon hatchlings born in 2020.

Lay Date	Date of First Birth	Date of Last Birth	Total Number of Babies	Prematures	Sub-Adult Survival	Final Survival
28 April 2020	10 June 2020	03 July 2020	136	27	14	7
1 May 2020	22 June 2020	08 July 2020				
21 July 2020	26 August 2020	28 September 2020	25	11	12	7
29 October 2020	16 December 2020	6 January 2021	31	10	18	9
15 July 2021	02 September 2021	18 September 2021	4	1	1	1

Life Support System

As the first clutch caught us without much experience in this regard, we did not know what an ideal quarantine for the young was like. So, we used a homemade jellyfish kreisel (approximately 20 liters) for the first spawn. At first, we believed that it was the best option, since as the first hatchlings did not swim by themselves, they would move with the circulation of the tank. Also, the first hatchlings to swim properly seemed to stay perfectly in the water column.

However, after the first weeks we observed a high mortality rate. Reading articles and talking with people specialized in the subject, we came to the conclusion that a pseudo-kreisel is better for the growth of the young, where they could swim more freely than in a cyclical circulation type kreisel. Thus, with the last surviving hatchlings, and with a little more time, the Sea dragon quarantine was improved to achieve an ideal quarantine, using a first battery of three 28L, 35 x 25 x 26 cm pseudokreisel aquariums where the first two months of life are spent. Subsequently, they are transferred to another battery of two 56L aquariums of 50 x 35 x 32 cm where they will spend approximately three months. That duration depends on the growth rate of the individuals, but transfers to larger aquaria occur when we observe some stress in the animals, swimming close to the glass, zigzagging from the bottom to the surface and vice versa. These aquariums are connected with the main filtration system, so the quality and parametrics of the water from the quarantine and the exhibition where they were collected are exactly the same.

The final growth tank (150 x 70 x 55 cm, 575 L), is where the last 14 young are currently growing, since 9 of them have been transferred to the exhibition tank with the adult individuals. This tank has independent filtration, with its own chiller and UV equipment. Even so, water additions come from the main tank, so that there are no sudden changes in temperature and the water is as close to the main exhibition as possible.

Figure 1. baby Sea Dragon Growing tanks. During the first 2 months they were housed in the lower tanks. During the next 3 months they lived in the upper tanks.

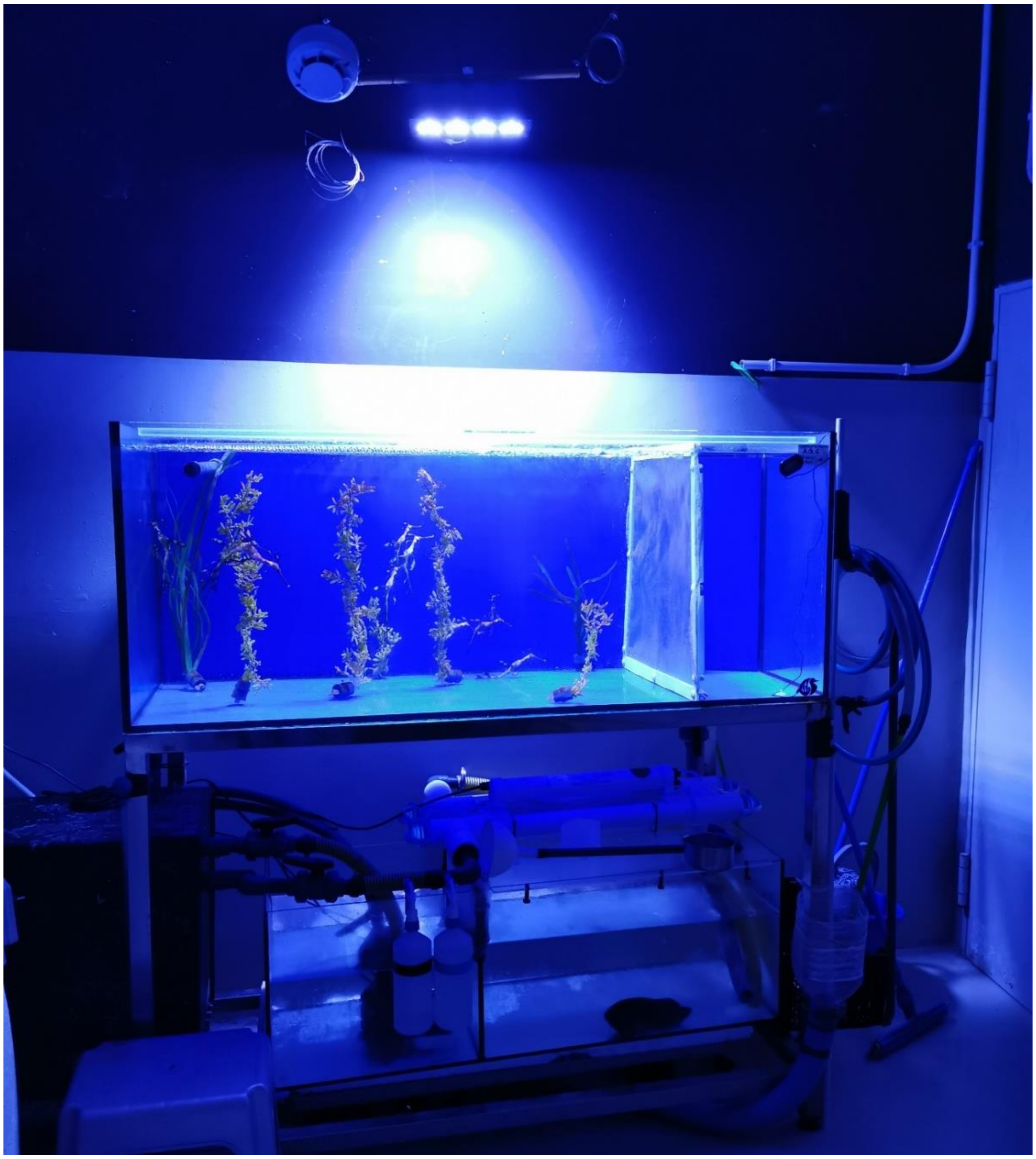


Figure 2. baby Sea Dragon Growing tanks. During the next 6 months.

Feeding and Cleaning Routines

These are for us, among the most important and sensitive issues in Sea dragon breeding.

Newborn fry eat 24-hour nauplii enriched with SELCO. Due to the rapid growth rate of this species, the size of the food must grow with the fry. Thus, at 5-7 days they are already mixed with metanauplius (increasingly larger) and at 10 days they begin to eat live newborn mysis. This is a critical point and where a large number of casualties occur. The naupli / metanauplius quickly become nutritionally insufficient for the young and need to eat mysis as soon as possible. The problem is the size and availability of newborn mysis. In addition, we observed that many hatchlings find it difficult to hunt the first mysis and if they fail to take that step, they end up dying from just eating metanauplius.

In our case, we combine our own mysis culture with the capture of wild organisms in the sea and some extra help from mysis donations from entities such as Loro Parque and Oceanográfic de Valencia. It is a key and determining factor to have enough mysis and the right size for the young to grow and develop correctly. Otherwise, they will grow too slowly or end up slowly losing weight and dying.

Another important detail in feeding is the correct disinfection of the food before supplying it. All the food that is administered is live, whether cultivated or wild, and sea dragons are extremely sensitive to all kinds of diseases, especially protozoa, which can be attacked by other organisms. Therefore, any live food administered follows a strict disinfection protocol that consists of a 1-minute Costapour SERA© bath and a subsequent 1-minute fresh water bath. After this process, the live food is returned to normal salty water and is ready to be administered.

Proper cleaning of the quarantine aquariums is the other key point. Sea dragons are very demanding in terms of water quality and if this is not carried out strictly, the appearance of scuticociliates is assured and can cause great mortality. The only solution to this is prevention, by thoroughly cleaning the tank on a daily basis. To do this, we recommend siphoning each tank between 6 and 10 times a day. Demanding preventative cleaning includes siphoning all surfaces of the tank each time, not only where we see food remains or animal feces.

Additionally, it must be taken into account that a pseudo-kreissel creates a cyclical circulation in the tank. As a result, any live food that is administered, especially nauplii and metanauplius, will remain turning in the water column. For this reason, it is necessary to remove all that excess in the daily siphons, both because remaining nauplii will end up dying and dirtying the water, and also quickly become nutritionally null. For this reason, we are not interested in our young eating that old nauplii and it is better to remove them, even if alive, and administer a new batch that have been freshly enriched and fed. The situation with mysis is different, since they stick to the walls (they do not stay swimming in the column) and when they die, they stay on the bottom, being much easier to withdraw.

Veterinary Treatments

As we have already mentioned, the main problem for Sea dragons (both hatchlings and adults) are scuticociliates. Cleaning is the best treatment to combat them, but if they still appear, formalin baths are very effective.

It is advisable to look at both the stool and the recently dead individuals with a magnifying glass to see if they have scuticociliates. In case of high density, a 40% formalin bath for 1 hour at a concentration of 0.1 - 0.15 ml / L removes them.

Even when ciliates are not observed, we take the opportunity to do a formalin bath at each change of tank, every 2-3 months. If we observe that large amounts of scuticociliates appear in the routine samplings of the siphoned matter, we carry out an extra bath. Of course, we never repeat baths at an interval of less than 1 month.

Furthermore, in certain individuals we have observed a tendency to loop and present erratic swimming in the tank. We observe this more in well-developed individuals with several weeks of life. In this case we also apply a preventive formalin bath. In some cases, the evolution was positive and they ended up recovering a correct swimming, and in other cases the individuals ended up dying. In these cases, apart from the bath, moving them to a larger tank in our case helped in the recovery of the animal. Based on our experience, of the 4 individuals who presented these behaviors, only 1 of them died after performing these steps, so we consider a good guideline to correct this problem.

Conclusions

Several factors have been determining factors in the reproduction of *P. taeniolatus* in our facilities.

First of all, we have not modified any physico-chemical parameters of the water, or any other environmental factors, such as lighting or diet, to induce mating. So, we determined that, although they are an important factor and that changes can trigger greater reproductive activity, it is not a determining and mandatory factor for successful reproduction.

Another factor to take into account is our aquarium's great volume and especially tall height. This is a very important factor when it comes to transfusing the eggs from the female to the male in a dance that travels through the water column (Melbourne Aquarium Sea Dragon Husbandry Manual).

Our first hypothesis that the reproduction of our seadragons was due to being in a calmer environment, without an audience around the exhibit, was discarded with the last egg setting occurring with the park open and with a volume of public even above average.

After having 6 successful layings in a period of approximately one year, our definitive protocol is summarized in the following essential points:

We leave the ovate male in the main aquarium; we do not remove it to another aquarium since we will avoid stressing it and the possible loss of eggs.

Cleaning tasks by a diver will remain the same, thus ensuring that there are no water quality problems or parasites.

In an average of 44.5 days at 16 ºC, 8 pH and 35% salinity our first offspring are hatched. These, with the help of a jug, and never taking them out of the water, are introduced into a pseudokreisel sharing water with the main aquarium specially designed to house them.

As they grow, they move to larger pseudokreisel until they end up in a 550-liter aquarium with independent filtration, importantly including an oversized ultraviolet sterilizer (for the size of the aquarium), thus eliminating a large part of possible pathogens that may affect juvenile seadragons.

Feeding in the first weeks of life will be based on brine shrimp nauplii enriched with DHA + SELCO INVE®. Buoyancy problems have been observed in baby seahorses when supplying selco in live food. So, we are very conservative when applying it (Palma et al, 2014).

After two weeks the main diet will be juvenile mysis. Despite having a specific culture of this species of decapod in our facilities, the high demand for food by the young is going to be the fundamental factor that will limit their survival during the third week of life.

As the month of life passes, the requirement of food size is expanded to larger ranges. Apart from the diet, other problems that we find when raising seadragons, they are exposed to ciliated protozoa. That is why we include protocol baths every 2 months using 40% formalin at 0.1 - 0.15 ppm for 1 hour. Additionally, we monitored the presence of ciliates in the siphoned material with the help of a microscope. Thorough cleaning of the quarantines at least 4 times a day is essential to avoid these cases.

Finally, after x time, part of our offspring are being introduced little by little to the main adult aquarium. For this, a formalin bath is previously carried out for one hour in a closed bag saturated with 180% oxygen, thus avoiding that due to the stress of handling they can access the surface air by absorbing air. When the treatment is complete, a water change will be made in the bag itself to avoid introducing drugs into the system, and it will be released in the lower area of the aquarium by a diver.

Thus, we complete the cycle of these wonderful animals that captivate us with their shape and swimming. Currently in our exhibit, our 8 adult weedies coexist with 9 offspring that belong to individuals from the first 2 clutches, where 7 of them, from the 1st clutch, have already completed one year of life in our facilities and the other 2 that belong to the 2nd setting, they are a few days away from fulfilling it

Future Directions

For Poema del Mar and the Loro Parque group it is essential to develop breeding programs for a large part of the organisms that inhabit our facilities.

For this reason, and due to the successful reproduction of this species in the aquarium, a project dedicated to the construction of an aquarium outside of public view in a controlled environment was born. In this way we will be able to count on a stock of reproductive animals that can continue the success achieved during this last year.

In this way we could also initiate a process of transferring these animals to other institutions, reducing the fishing pressure of this species whose population trend is decreasing. (IUCN red list).

Acknowledgements

From our aquarium we would like to thank the entire biology team, especially Bruno González, Adriana Sosa, Iván Rodríguez, Josué Pérez, Rubén Andrade, David Simón and Daniel Sánchez, as well as the LSS and veterinary team whose role has been fundamental in the whole process.

Additionally, we would like to thank the Loro Parque and L´Oceanográfic aquarium team for their support in supplying misidaceans of different sizes to feed the different phases of the Sea Dragons development.

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Black Skate – Bruce Koike

LOW VOLTAGE SIMPLE DIY ELECTRIC EEL DETECTOR

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Introduction

In 2012 Markus Dernjatin described a simple electric eel detector for Drum and Croaker that was later expanded on by Stephen Walker in 2017. Now, I am hoping to shed some light on a detector for those who have less active electrical residents.

When starting up the DIY voltage meter to add to an electric eel tank display, we ran into several challenges that may have been encountered by others in the field looking to build a probe for their electric eel displays. The primary challenge being our resident electric eel rarely shocks and only emits low voltage shocks when they do occur.

When initially reaching out to others in the field, it had been mentioned that others had attempted their own DIY voltage meters with little success. It was theorized that as electric eels age under human care, they are less likely to emit shocks at all, especially high voltage shocks. While we do not have an exact age on our resident electric eel, we do know it was acquired as an adult in 2014, making this scenario a possibility in our case as well.

Given this challenge, we set out to adapt the DIY voltage meter to something that would be a better fit for our situation. As we were only receiving shocks from our eel under 24 volts it was decided to attempt to change the display from a light bar that would allow the amount of light to vary based on the strength of the shock to a single all on or all off device controlled any time the eel shocked.

Build

In order to have ease of flexibility in the system, it was decided to have the 120V power generated by the adapter go directly to an outlet (Figure 1). This would allow us to plug anything into that outlet and have it controlled by the shock of the eel. First, two submerged ifm efector E43207 stainless steel probes from Automation24 were connected to an AEDIKO 4pcs DC 5V Relay Module 1 Channel Relay Board with Optocoupler Isolation Support High or Low Level Trigger adapter that would convert the DC current to AC (Figure 1). 16-gauge Speaker wire cable is used for this connection. The adapter is able to handle a maximum of 10 Amps, well below the 1 Amp Electric eels are able to produce. However, the electric eel does still need to produce a minimum of 9 Volts to activate the adapter and power the eel-controlled 120V outlet.

While the eel is able to power the outlet with lower voltage shocks, the amount it shocks is still very low and can be infrequent. To compensate for this lack of observable activity, a normal 120V outlet is provided to run other lighting that operates normally (no trigger by the eel). To accommodate both the eel-driven and normal circuits in a compact unit, a standard duplex outlet was split by removing the connecting tabs, and the 120V circuit not controlled by the eel was wired to the top half of the duplex (Figure 2), and can be used to plug in various decorations in that space without the area being left dark due to the low activity of the eel. For instance, a pre-lit Christmas

Tree can be plugged in at the regular outlet (Figure 3). An additional strand of lights can be added to the tree and plugged into the eel-controlled lower outlet (Figure 4).

Future usage of this design could include additional festive decorations when appropriate as well as a standard application, most likely a light of some sort, for between holidays. Being the adapter is able to withstand up to 10 Amps, this design can still be used with a more electrically active individual in the future if desired.

Acknowledgements

Thank you to all the Aquatic Info Listserv Members who reached out with design descriptions and prior challenges as well as the incredible maintenance team who put the pieces together

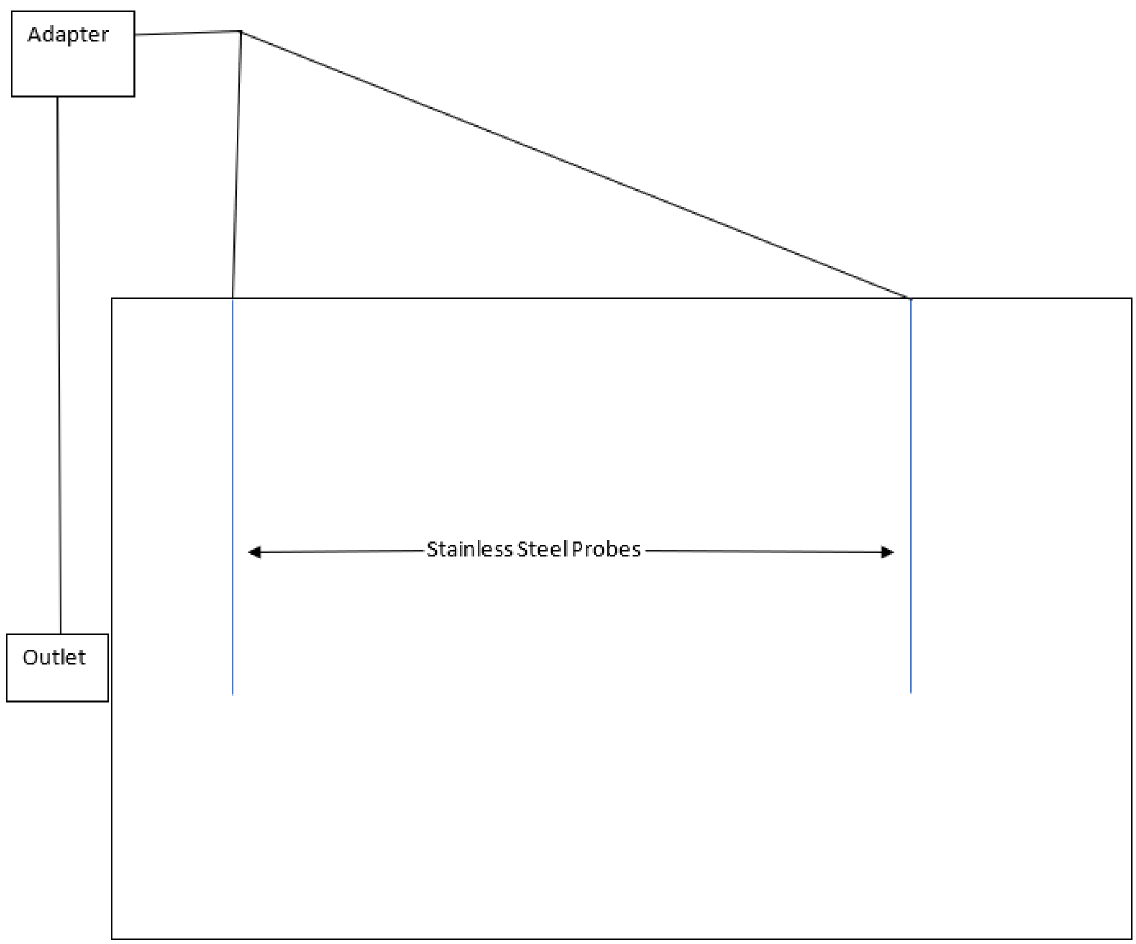

Figure 1. Schematic Drawing of Detector Set Up. Probes were hidden behind exhibit décor. All wiring and adapter were kept back of house. Only the outlet appears on the viewing side of the exhibit.

Figure 2. Divided outlet. 120V plug on top, Eel powered plug on the bottom.

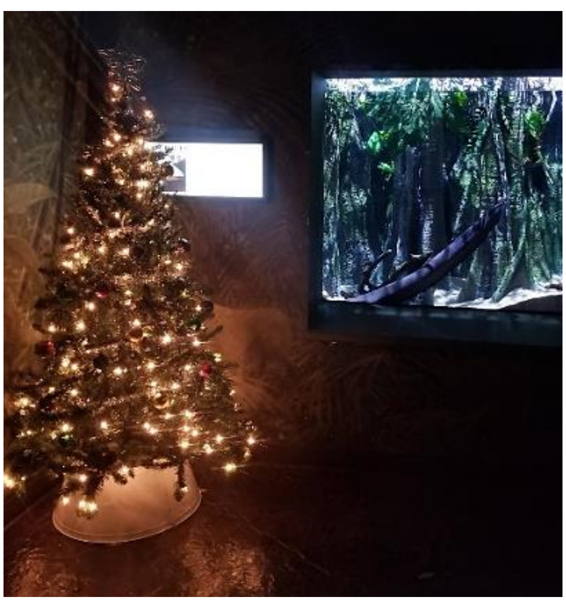

Figure 3. Christmas Tree plugged into outlet.

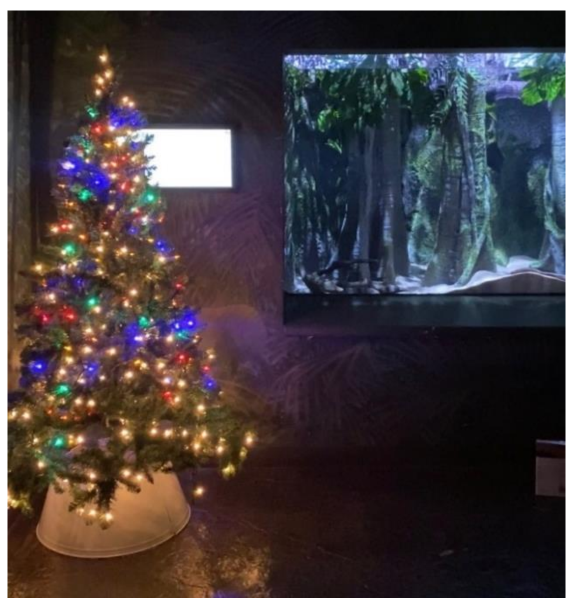

Figure 4. Christmas Tree colored lights lit by Eel.

EGG RETENTION AND ASSISTED EXPULSION IN THE STRIPED EEL CATFISH, *Plotosus lineatus* (SILURIFORMES: PLOTOSIDAE)

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Introduction

Retention of ova by fishes can be especially problematic in captivity, non-viable eggs retained by gravid fishes can result in septicemia as putrefaction occurs. Eggs retained may also harden by a process of calcification, rendering the fish unable to expel them.

A number of remedies are common across many fishes to encourage egg expulsion, hormonal therapies derived from research on human chorionic gonaotrophin (hCG) interactions have led to the development of spawning aids specific to fishes such as Ovaprim™ which utilize salmon gonadotrophic releasing hormone (sGnRHa) in combination with domperidone, a dopamine receptor antagonist. These products were developed for the aquaculture industry and has been used extensively in salmonid fishes, catfishes, and carps (Mikolajczyk et al., 2006; Svinger et al.2013; Chatakondi, 2017), and even in some invertebrates (Laining, 2016), and extra-label use is common in aquaria in a variety of fishes.

The extra-label use of sGnRHa products on tropical/exotic fishes in aquaria is common, but has had mixed results, with some species reacting positively and some failing to respond. Other common medications used as spawning aids include administration of human chorionic gonadotrophin (hCG), which is usually combined with carp pituitary extract (Lewbart, 2013). Synthetic luteinizing hormone analog (LRH-A) is also a common therapy, often administered with haloperidol or reserpine to block dopamine receptors (Lewbart, 2013). One commonality with many of these therapies is that the hormone-based medications do not cause ova to mature (Lewbart, 2013), so administration should only be performed when eggs are fully formed and the animal is ready for spawning. In extra-label use of spawning aids, the natural history of the species should be taken into consideration (in addition to assessment of gross body condition) to gauge when animals are mature and such therapies may have higher chances of success.

Methods: Statement of the Problem

In May of 2019 a group of 0.0.21 *Plotosus lineatus* (Thunberg, 1787) was acquired from Cairns Marine in Queensland Australia and shipped to the Maritime Aquarium (TMA) in Connecticut. The specimens were subadult, between 60-90mm TL. Sexual maturity in this species is known, females are mature at a size of 159-185cm TL (Vijayakumaran, 1997) with a fecundity of 1730±390 ova per female, per season at that size (Asriyana and Halili, 2021). In studies of wild fishes in Indonesian waters, the spawning season has been found to be June-August (Asriyana and Halili, 2021).

The female specimens housed at TMA began to show signs of coelomic distension in September 2019 (Fig. 1.), this condition persisted for several months with no deposition of eggs until January 2020 when animals were grossly distended and began to show abnormal behaviors such as laying on the bottom and ataxia. Dermal lesions began to form on the ventral surface where animals were resting, and after several months without egg deposition and skin lesions worsening it was decided by veterinarians and husbandry staff that intervention was warranted.

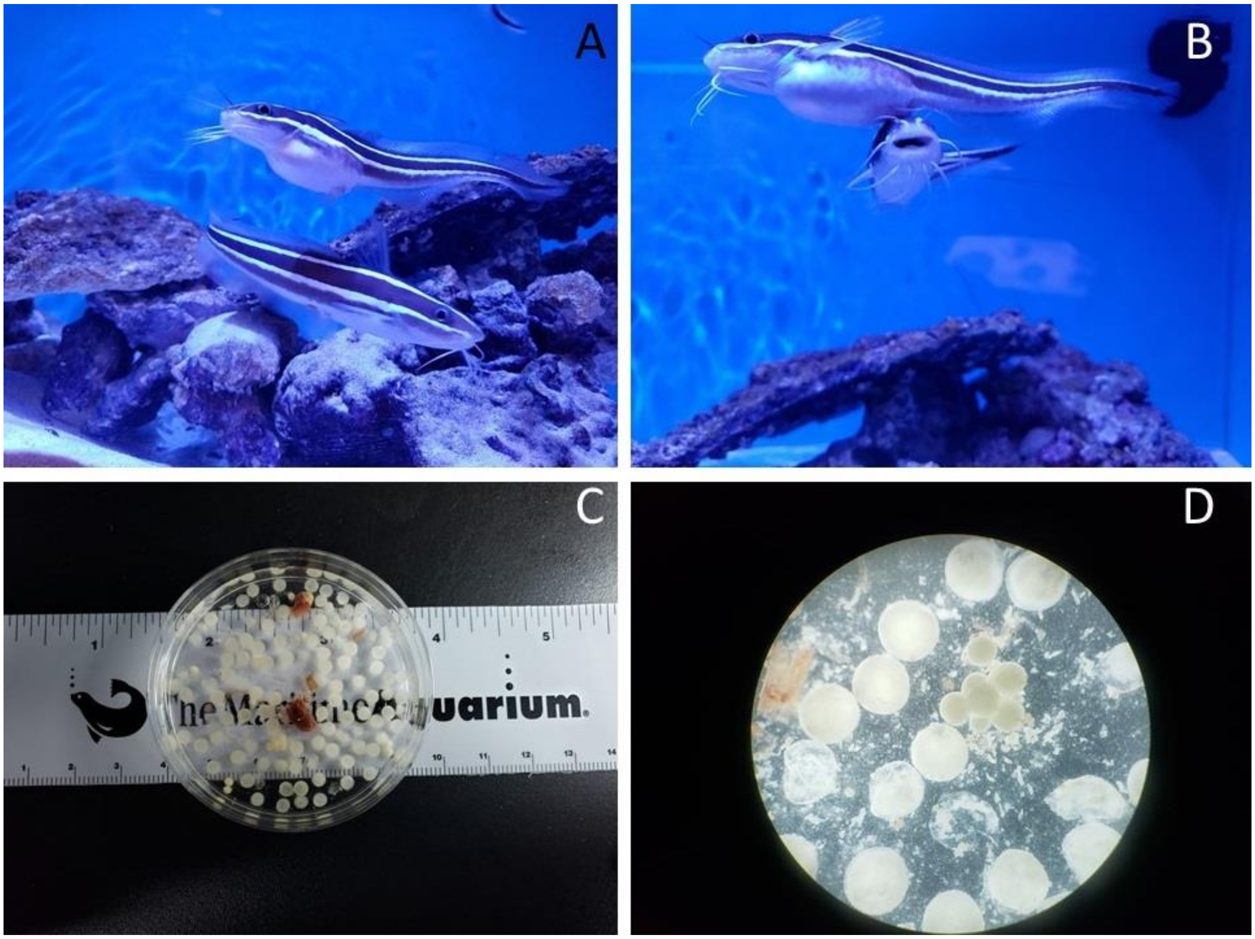

Figure 1. Gravid *Plotosus lineatus* showing marked distension of the coelom (A&B), note the male specimen nosing the cloaca of the gravid female (B). Eggs from a stripped specimen (C) numbered 123, 19 of which (15.4%) were underdeveloped, as seen in the fourth image (D). Photos: S. Schaefer-Padgett and R. Sadler, Maritime Aquarium.

Methods: Intervention

Extra-label use of Ovaprim™ by Syndel Laboratories was attempted. The animals were given an intramuscular (I.M.) injection at a rate of 10μg/kg on 04 Jan 2020. A second administration of Ovaprim™ was given on 09 Jan 2020 as a split dose (one I.P. injection followed by a second 6h later). After 28 days the sGnRHa injections had yet to yield any meaningful results.

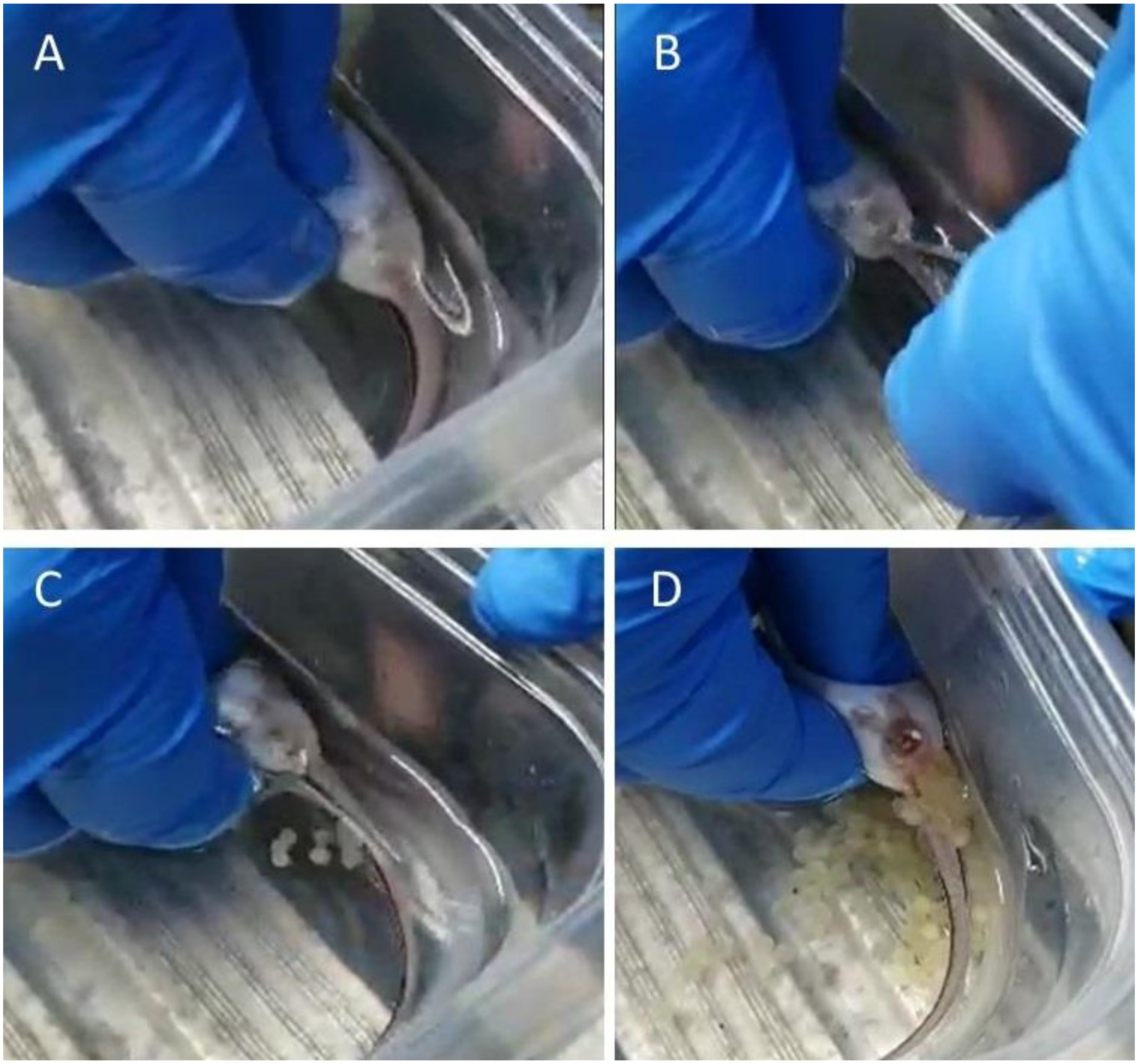

Figure 2. Manual stripping of eggs from *Plotosus lineatus*. Gentle pressure is applied to an anesthetized specimen with grossly distended coelom (A), if no egg expulsion occurs, the oviduct is gently opened, and eggs dislodged with an 18g. IV catheter inserted through the cloaca (B). As gentle anterior-to-posterior pressure is applied again the egg expulsion occurs (C&D). Photos S. Schaefer-Padgett and R. Sadler, Maritime Aquarium.

During this time period aquarium professionals were informally surveyed via the AquaticInfo listserver, and six institutions responded stating that they had experienced issues with this species becoming egg-bound. Three of these commented that they had never experienced success with the use of commercially available injectable spawning aids or been able to accomplish manual stripping of the eggs, and further noted that the condition was usually fatal for female *P. lineatus* who failed to deposit eggs.

On 06 Feb 2020 it was decided to try manual stripping of the egg mass (Fig. 2). Animals were sedated with 50mg/l tricaine methanesulfonate (MS-222) in buffered seawater. The animal was held in seawater ventral side up, and standard egg stripping techniques were utilized: applying gentle but firm pressure to the coelom in a firm posterior-to-anterior direction. This first attempt was not successful, and was discontinued as animals were too active. The MS-222 concentration was increased to 75mg/l and the stripping process repeated. At 75mg/l of MS-222 eggs were expelled from the specimens successfully. This process was repeated successfully on several other gravid females (n=8) from the group over the following 120d.

Several females that had been stripped of eggs later presented with ascites as evidenced by a swollen coelom approximately 60d after stripping, and a milky white fluid was aspirated from the ovary. Management of secondary infections following this procedure was done with waterborne nitrofurazone at 4mg/l and oral enrofloxacin (Baytril™) at 5mg/kg P.O. in gel diet per veterinarians' directions.

Results and Discussion

This group of animals was approximately 60-90 mm TL when acquired, and the animals had grown to approximately 140-175 mm TL when problems arose. From the eggs that were recovered in one case a total of 123 ova were recovered from a single specimen, 19 of which (15.4%) were underdeveloped (Fig. 1). It has been noted in the literature that 50% of wild specimens will be mature at a size of 159mm TL, and 100% will be mature at a size of 185mm TL (Vijayakumaran, 1997). Vijayakumaran (1997) also notes that average longevity for this species is 2.19 years in the wild. Other studies have predicted the species will attain maximum size at 28 months (Asriyana et al. 2020), and they regularly live up to seven years or more in aquaria (Thresher, 1984). From these longevity data it can be assumed that most specimens of wild *P. lineatus* will only have two or three breeding seasons in a lifetime, though possibly several more in captivity. It can be further extrapolated from the size of these captive specimens that this was their first breeding season, which could be a factor in reproductive complications.

The reproductive behavior of this species is somewhat known, they like to deposit eggs in substrate nests under rock ledges (Thresher, 1984), and they also occur in the wild in very large swarms of up to several hundred individuals (Clark et al., 2011). In this case sand substrate and rockwork were present in the exhibit, though it is possible that additional surface area for nest-building or a larger school of animals may have led to more successful egg deposition.

The use of sGnRHa in tropical species requires some careful extrapolation of the natural history of the species given that eggs must be fully mature to be expelled. In this case sGnRHa failed to produce results, though most ova did appear to be fully mature when manually stripped as evidenced by their size and the presence of a visible oil droplet in many. Eggs from one clutch were measured using ImageJ 1.52 (National Institutes of Health, Bethesda Maryland) from a photograph. Of 123 ova, 20 were measured and the diameter was found to be 2.14-4.23mm, with a mean diameter of 3.68mm. This is very much larger than previously recorded studies of wild *P. lineatus* which found ova to range in size from 0.11-1.35mm (Asriyana and Halili, 2021). This discrepancy (300-1900% increase in size) raises several questions; is there a difference in maturity between captive and wild specimens? Are egg-bound animals harboring ova that continue to grow well beyond a normal size? Did the substantially larger size of eggs lead to complications with egg laying? Are there significant differences between *P. lineatus* populations in the Indian Ocean versus the Pacific? Does diet in captivity affect egg production? Further studies will be needed to better elucidate the natural history of the species with regard to fecundity and reproductive cycles.

A Note on Occupational Safety

In this case a waterborne anesthetic was used to sedate the animals before handling, both for the benefit of the animal, and also for safety of the handler. A large variety of catfishes, including the marine catfishes are venomous (Wright, 2009), and *P. lineatus* is known to have a venom that can cause severe and lasting pain, edema of the entire affected limb, cardiac effects, and in rare cases fatalities have occurred following envenomation (Bergbauer et al., 2009). In any case, extreme caution is warranted when handling this species for husbandry or veterinary procedures.

Stripping ova from egg-bound fishes is certainly not groundbreaking, though *P. lineatus* has been a species that commonly presents with reproductive complications that seldom are resolved successfully. Due to the lack of available information on assisted egg expulsion in this species and the commonplace nature of health problems related to egg-bound *P. lineatus* the authors thought this account noteworthy to help guide other aquarists, veterinarians, or researchers working with the species.

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Yellowtail Rockfish – Bruce Koike

RIDE THE LIGHTNING: FEASIBILITY OF ELECTROSTERILIZATION OF AQUARIUM SEAWATER

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Introduction

The disinfection of seawater by conventional means is well known in aquaria; ultraviolet sterilization and ozone injection are two common methods used in most public aquaria today. In mammal tanks, chemical sterilants such as chlorine are also still used under carefully controlled dosages to minimize both algae and levels of coliform bacteria. Recent new technologies for water disinfection that have appeared in the literature include the use of carbon nanotubes, photocatalytic disinfection, and applications of superenergized non-thermal plasma, however there has been a growing volume of both laboratory and practical studies on the use of electricity or electrolysis to disinfect water.

Electrosterilization was first conceived in the early 1980's, and an early study (Kondo and Sakurauchi, 1982) demonstrated that 1J of energy could be applied to aqueous solutions containing *E. coli* with resulting effect on bacterial viability. These theoretical techniques have already found limited practical application in the electrosterilization of food products and fruit juices (Jayaram, 2000; Lee, 2012). Electrosterilization of wastewater and aquaculture water with extremely high levels of bacteria and organics has also been promising (Wijesekara et al., 2005, Oh et al., 2010). Electron microscopy of *Vibrio* cells that have been exposed to 2A currents for mere milliseconds show a complete rupture of cell membranes and loss of the intercellular matrix (Park et al., 2003). This same study (Park et al., 2003) found *Vibrio* populations to be reduced by an order of magnitude or more with exposure to a 2A (20J) current for 1-5 milliseconds, and showed that increasing amperage increased sterilization efficacy. The electrolysis of water also has secondary benefits of converting ammonia directly to nitrogen gas, and reducing COD (and therefore dissolved organics); Wijesekara et al. (2005) found 5V 0.1A (1J) could remove ammonia and COD from aquaculture effluent water, though only with an exposure of 80-140 min.

There are, however, several significant downsides to consider when applying electricity to water. First and foremost is the production of chlorine gas from application of electrical current to seawater, a well-known hazard. Studies on electrosterilization have found that chlorine production is dependent on the chloride content of the water, as would be predicted, and that a 2A (20J) current can raise free chlorine levels shockingly fast, as much as 50mg/l Cl^- in 1 min. (Oh et al., 2010). Application of electricity to water fosters a wide array of half-reactions to occur, including the formation of hypobromous acid (HOBr), chlorine dioxide (ClO_2), chlorate (ClO_3), perchlorate (ClO_4), hydrogen peroxide (H_2O_2), hydroxide ions (OH^-), hydroperoxyl (HO_2), ozone (O_3), and others (Malik et al., 2001; Wijesekara et al, 2005; Oh et al., 2010). Ultraviolet radiation (UV-C) is also produced by the arc of electrical discharge (Malik et al., 2001), and alkalinity may be depressed in the treated water (Wijesekara et al., 2005). In a wastewater or batch-treatment scenario the production of these disinfection byproducts may be advantageous, as they will increase sterilizing power of the apparatus, though in an aquarium setting generation of the above compounds could be extremely hazardous to animal health.

The litany of unintended disinfection byproducts formed with these methods have likely kept electrosterilization from gaining greater research interest for aquaculture and aquarium purposes; not to mention the disadvantages of purposefully allowing electrical current to contact water with living organisms! In 2004, a novel approach was published (Park et al.) utilizing alternating current to mitigate these risks. Park et al. (2004) found that alternating (AC) current reversed many of the half-reactions occurring in seawater with each cycle, and greatly minimized chlorine formation, especially at higher frequencies (50Hz). This paper captivated the author's interest, and the following investigation was undertaken as a cursory exploration of the feasibility of electrosterilization in aquarium waters.

Methods

Experiments were carried out and prototypes built at the Dallas Aquarium at Fair Park from 2015-2016. An initial validation trial was conducted as proof-of-concept for a method modified from Park et al. (2004) (Experiment 1), followed by construction and testing of a small-scale prototype (Experiment 2) to assess seawater disinfection performance and feasibility of electrosterilization.

Experiment 1: Validation Trial

A 25cm piece of 2" ID clear PVC was fitted to an end cap, two holes were drilled and tapped for 1/2" NPT threads and cable glands with 3/8" graphite electrodes were installed. One electrode (the cathode) was attached via test leads to the positive output, and one (the anode) was attached to the neutral lead of a 0-130 VAC Variac® 60Hz 10A variable transformer. 200ml of newly-mixed artificial seawater was added and the seawater matrix was exposed to 30, 100, & 130 VAC of current at electrode spacings of 5-45mm (in 5mm increments) to determine effective conduction distance in the seawater matrix. The temperature of the water was also measured via laser guided infrared thermometry (i.e. a temperature gun) to approximate the efficiency of the electrical transfer between electrodes.

Experiment 2: Sterilization Trials

A pilot-scale electrosterilization chamber was constructed using a 1m length of 2" clear PVC, with SCHD40 'T' fittings on each end facing opposite directions (bottom inlet, top outlet). Eight SCHD80 PVC Saddles were cut from pipe and cemented in place on opposite sides of the clear body of the sterilizer to create four (equidistant) points for electrodes along the path of water flow. Holes were drilled and tapped for 1/2" NPT threads, and threaded cable glands used to house the electrode. The general configuration followed the apparatus built by Park et al. (2004), though the electrode array was reconfigured to include a (more effective) multi-spark setup following Anpilov et al. (2004).

Two 100ml solutions of tryptic soy broth with peptone and 3% salt (1:1:1 NaCl: $CaCl_2$: KCl) were prepared and autoclaved. These were inoculated with a standard indicator culture of *Escherichia coli* (Carolina Biological Supply). Following inoculation, the media were incubated for 24h at 37°C to substantially amplify microbial densities and the cultures were each added to 20L of newly-mixed seawater in buckets that had been sanitized with a 250mg/l sodium hypochlorite solution. Two other sanitized 20L buckets were filled with seawater directly from a sea turtle exhibit with average total coliform levels of 600-750 CFU 100ml^{-1}. The four solutions were pumped through the apparatus energized with 30VAC and 100VAC (10A, 60 Hz) from bottom to top by a powerhead at 4000ml/min and tubing that had also been chlorine-sanitized. The influent (pre-bzzzzt) and effluent (post-bzzzzt) water were sampled and 100ml was run through a 0.45µm 45mm filter disc in a sterile filter flask and the disc was placed on coliform selective agar medium (Hach M-ColiBlu24 47mm prepared plates) and incubated for 24h at 37oC. After incubation total and fecal coliforms were enumerated by colony counts (red+blue=total CFU/100ml; blue=fecal CFU/100ml). Free and total chlorine were measured via the DPD method on a Hach DR3900 spectrophotometer and recorded pre- and post-zappification.

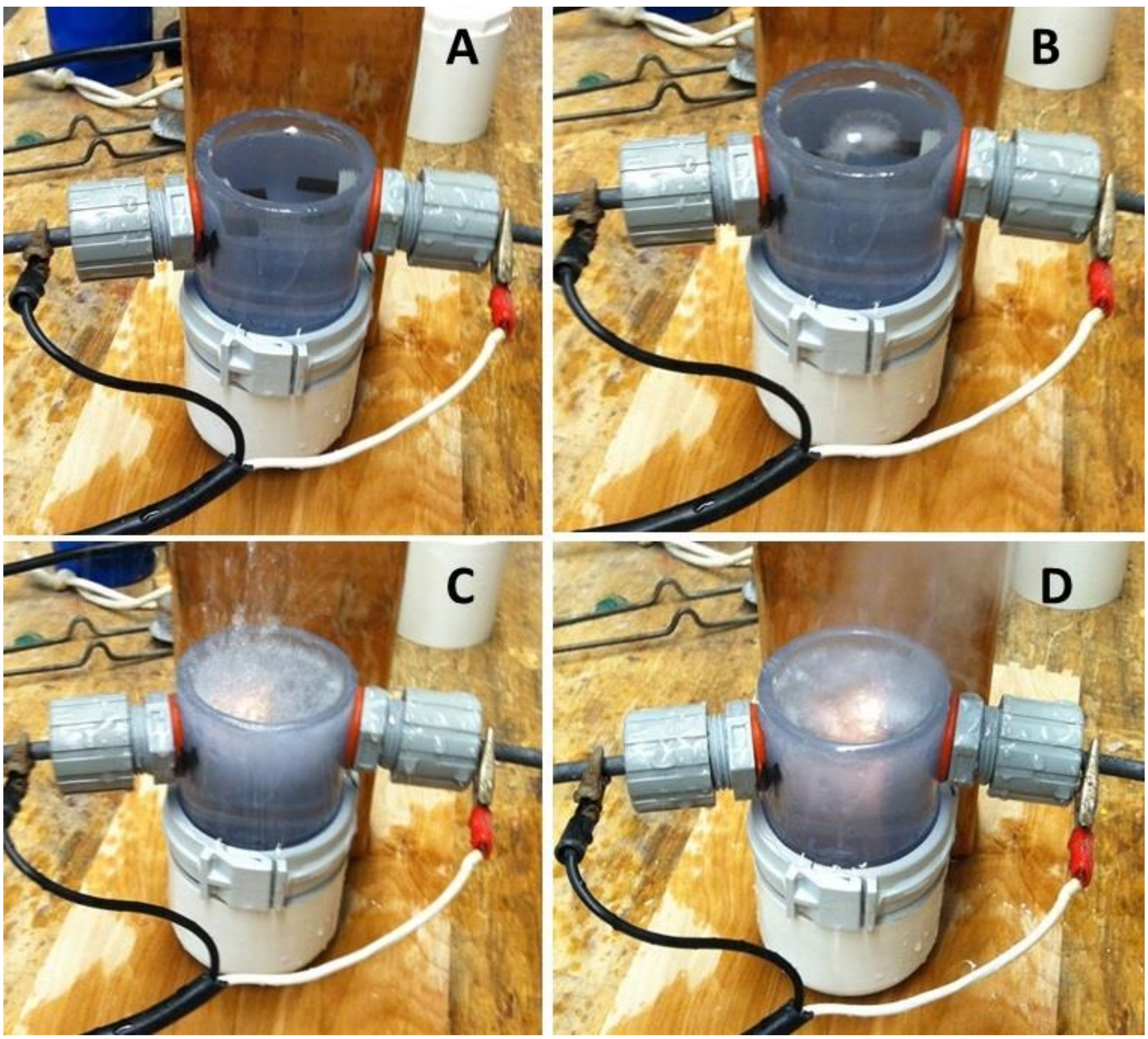

Figure 1. Test apparatus used in Experiment 1 to determine gap spacing of graphite electrodes to sustain 10A AC transmission through seawater without triggering overcurrent protection via the fuse in the Variac® power supply or GFCI outlet. Electrode gap distances of <35mm were able to sustain power transmission in 30ppt seawater, though with significant inefficiency as indicated by heat gain of the water. Stages in test A shows no power, B first 30 seconds at 100VAC 10A 60Hz note bubble formation from electrolysis of seawater, C explosive boiling of water, D rolling boil from power transmission.

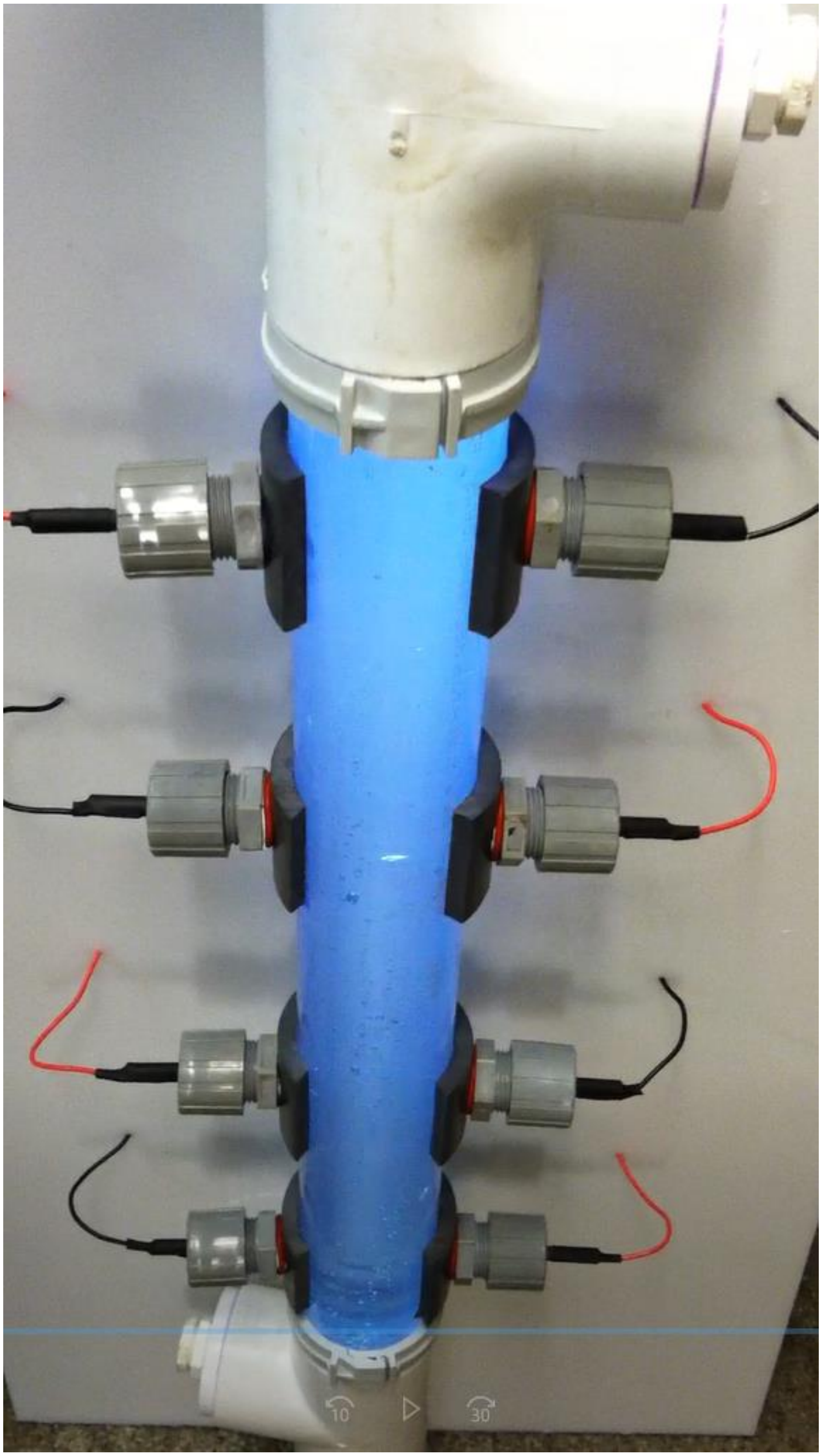

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Figure 2. The ‘Warp Core’, a 1m clear PVC tube with four pairs of electrodes constructed as a pilot-scale water electrosterilization apparatus in operation at a 30V 10A 60Hz AC discharge, note the bubbles rising in the chamber.

Results

Experiment 1

When seawater in the test apparatus was exposed to 130VAC, overcurrent protection was triggered at the power supply and a fuse was blown. Following the methods established by Wile-E-Coyote in his investigations of capture methods for *Geococcyx californianus*, the fuse was replaced by a solid copper rod of equivalent diameter (Acme Brand). This caused the Variac® transformer to burst into flames. The experiment was continued when a second power supply was obtained that had not been on fire. Voltages of 30 and 100VAC did not engage overcurrent protection safeguards and power could be sustained at electrode gap distances of <35mm. 100VAC caused the water to boil (from 23 to 100°C) within 2 minutes, 30VAC resulted in a rise in temperature to 73°C in the same time period.

"Plugged in and turned on, it's sparkin' and…High voltage rock and roll"
-AC/DC

Experiment 2

Once electrode gap spacing was established the larger pilot scale electrosterilizer test apparatus was built and four pairs of (noncorrosive) graphite electrodes were installed with 35mm gap spacing. Test runs were done with a static volume of seawater and current was sustained for up to 30 minutes at 30VAC (10A 60Hz), but voltage of 100VAC (10A 60Hz) could only be sustained for a few minutes before overcurrent protection engaged. Following this the unit was connected to a small sump pump and 3/8" ID tubing and seawater inoculated with microbial cultures as described above. Water that had flowed through the unit with active electrical current transmission had an overall heat gain of 3-5°C across these trials. Bacterial loads were reduced significantly in a single pass across the array of four electrodes, with 98-99% kill rates for *E. coli* and 95-97% kill rates for mixed coliforms (Table 1). Chlorine levels rose significantly in all post-electrified samples, with levels rising from near-zero to 0.08-0.26mg/l (mean 0.15mg/l free Cl_2).

"It's electric, boogie woogie, woogie, woogie"
-Griffiths & Wailer

Table 1. Reduction of Coliform Bacteria and Chlorine Generation of Seawater Following Electrosterilization

Microbe(s)	Volts	Pre-Zap				Post-Zap			
		Coliform Bacteria		Chlorine		Coliform Bacteria		Chlorine	
		Total	Fecal	Free	Total	Total	Fecal	Free	Total
	(VAC)	(CFU/100ml)	(CFU/100ml)	(mg/l)	(mg/l)	(CFU/100ml)	(CFU/100ml)	(mg/l)	(mg/l)
E. coli	30	$1.17x10^4$	$1.17x10^4$	0.00	0.01	236	236	0.08	0.08
Mixed	30	675	43	0.00	0.00	23	4	0.16	0.19
E. coli	100	$1.43x10^4$	$1.43x10^4$	0.01	0.03	118	118	0.26	0.25
Mixed	100	712	66	0.01	0.01	44	7	0.11	0.09

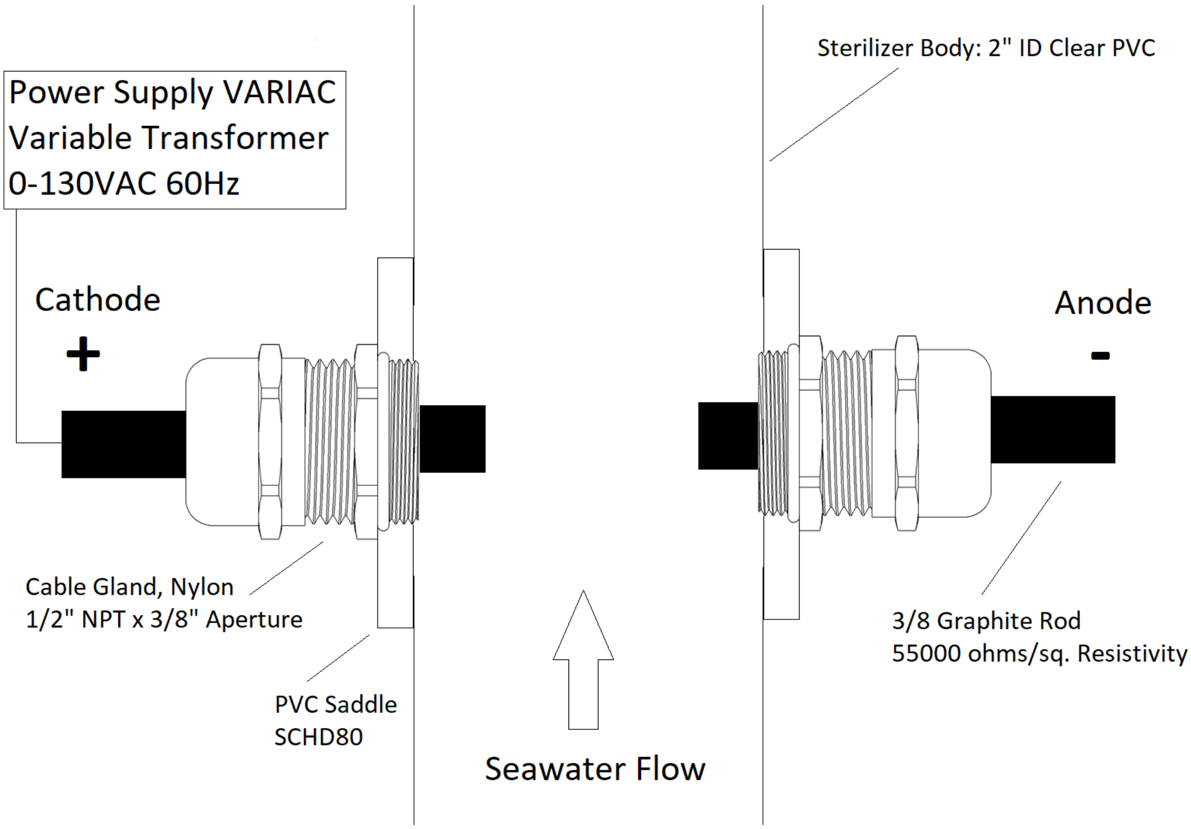

Figure3. Schematic representation of the electrode mounting configuration of the pilot-scale electrosterilization apparatus shown in Fig. 2 and used in Experiment 2. Graphite rods were used because of their high conductivity and lack of corrosivity as would be found in metallic electrodes. Cable glands were used to seal the electrode penetration through the vessel wall.

Discussion

The study that was the impetus for this dangerous and insane experiment (Park et al., 2004) cited minimal chlorine formation at higher frequencies (50Hz), and also suggested that amperages greater than 3A (30J) would be more effective at inactivating *Vibrio spp.*, so this experiment was conducted with 60Hz frequencies and 10A (100J). In every trial, at both 30VAC and 100VAC, *E. coli* and mixed 'natural' coliforms were significantly reduced (>90% inactivation rate), showing the method does indeed have some potential for sterilizing seawater.

"Oh we gonna rock down to, electric avenue"
-Eddy Grant

Chlorine production was minimal compared to studies conducted with DC current, however it was not zero. Free chlorine rose an average of 0.152mg/l in a single pass in this study (range 0.08-0.26mg/l) as a result of chlorine gas produced. The proposed methodology of using AC current does appear to significantly reduce the amount of chlorine formed, though these levels would still be unsuitable for most systems housing aquatic life. It is unknown how many other disinfection byproducts may have been produced, and in what concentrations, though given the formation of some chlorine gas it is likely that other reactive compounds were formed (albeit in low numbers).

"Expert on electricity must devise the destruction"
-Wu Tang Clan

Ultimately, this technology may hold some promise for an aquarium application if further developed to fully understand reactive byproduct formation, and what optimal energy input is needed for bacterial reduction. It is known that the specific waveform and pulse mechanics of electrical current is key to sterilization efficiency (Lee et al., 1997), and that longer wavelengths achieved by lower frequencies may be more effective at disinfection despite producing higher levels of chlorine (Park et al., 2004). Perhaps further experimentation could result in an optimal, higher-amperage, lower voltage current of a sufficient frequency and pulse application that could result in effective sterilization with minimal byproduct formation. If such an optimal combination of voltage, amperage, and frequency could be determined it is possible that use of a degassing tower as is common in ozone applications could be employed to strip disinfection byproducts from the water after treatment. Safeguards to prevent voltage from coming into contact with water housing animals (air gaps, grounding probes) are another major obstacle to the practical implementation of electrosterilization of aquarium water, as is development of effective and dependable occupational safety protocols for staff working with such apparatuses. Perhaps there is some niche application where this technology might be optimal, or maybe not, but at the very least exploration of unconventional ideas is always thought provoking.

Acknowledgements

Thanks to Stephen D. Walker, Retired Zoo Director and now Woodworker, for assistance with the design of this insane apparatus and for authorizing the purchase of a second variable transformer after the author destroyed the first (this is why we can't have nice things). Thanks to P. Zelda Montoya and John W. Foster IV for assistance constructing the device. Thanks are due to Nikola Tesla for alternating current; Tesla > Edison. A HUGE thank you to Charles Dalziel who invented the ground fault current interrupter in 1965; which has prevented the deaths of probably everyone reading this article during their time working in public aquaria.

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California Sheephead (Transitional Male) – Bruce Koike

THE AQUARIUM SYMPOSIA FROM THE 1956 AND 1957 MEETINGS OF THE AMERICAN SOCIETY OF ICHTHYOLOGISTS AND HERPETOLOGISTS

Editor's Note:

For sixteen years (1955-1970), the North American public aquarium community held its "Annual Aquarium Symposium" in conjunction with the annual meeting of the American Association of Ichthyologists and Herpetologists (ASIH). These symposia are the earliest regular meetings of public aquarium professionals from this part of the world of which I am currently aware. This is the second installment of papers from those years. As noted in the 2021 issue's "Drum and Croaker 50 Years Ago," these annual aquarium presentations moved to AAZPA (now AZA) in 1971. Many of the early founders and contributors to Drum and Croaker (D&C) were presenters at these conferences. The similarity in content to modern RAW presentations is remarkable.

Much of the content below was copied directly from the issues of Copeia in which it was recorded. Quotation marks are omitted. Photographs of the relevant pages were initially provided by Tony McEwan from uShaka Sea World. I later found additional access through the https://www.jstor.org/ site, where limited, free, read-only subscriptions are available. These summaries appear in the 4th issue each year.

Editorial Notes and News. Copeia Vol. 1956, No. 4 (Dec. 31, 1956), pp. 270-277.

The thirty-sixth annual meeting of the ASIH was held at the Conservation Training School, Higgins Lake Michigan, June 20-24, 1956. Hosts for meeting were the Michigan Department of Conservation, the U. S. Fish & Wildlife Service, and the University of Michigan. The Ichthyological Section consisted of a Symposium on Aquaria which was under the Chairmanship of L. C. Finneran. It consisted of the following contributions.

- Maintenance Mechanics. Christopher W. Coates. New York Aquarium.
- A Filtering System for Individual Tanks. William E. Kelley, Cleveland Museum of Natural History.
- A Portable Diatomaceous Filter for Aquarium Use. L. C. Finneran, Belle Isle Aquarium, Detroit.
- Transportation Water. Leonard N. Allison, Michigan Conservation Department.
- Artificial Sea-water. James R. Skelley, Cleveland Aquarium.
- Natural Sea-water in a Closed System, with Special Reference to Refrigeration for Octopi. Earl S. Herald, Steinhart Aquarium, California Academy of Sciences.
- The Proposed Milwaukee Aquarium. Leonard F. Pampel, Milwaukee Co. Park Commission.

Editorial Notes and News. Copeia Vol. 1957, No. 4 (Dec. 19, 1957), pp. 317-332.

The thirty-seventh annual meeting of the ASIH was held at the Jung Hotel, New Orleans, Louisiana, April 18-21,1957. The hosts were primarily recruited from the Department of Zoology of Tulane University. The Aquarium Symposium was held as a concurrent session on April 20th at 9:00 AM. The program was as follows:

1. Collecting
   - Collecting Techniques: Caribbean. W. B. Gray of Miami Seaquarium.
   - Collecting Techniques: Pacific Coast. Kenneth S. Norris, Marineland of the Pacific.
2. Food and Feeding
   - Food and Feeding Problems: Marine and Freshwater Fishes. Lawrence Curtis, Fort Worth Zoo and Aquarium.
3. Display
   - A Hypothetical Approach to Planning a Trout Stream Aquarium and a Lake Aquarium, Incorporating a Biotic Community Concept. Leonard Pampel, Washington Park Zoological Gardens, Milwaukee.
   - Plants in the Marine Aquarium. Craig Phillips, Miami Seaquarium.
   - Special Exhibits and Exhibition Techniques. Earl S. Herald, Steinhart Aquarium, California Academy of Sciences.
4. Special Reports
   - The Vancouver Public Aquarium. Murray A. Newman, Vancouver Public Aquarium Association.
   - The Oceanarium as a Research Facility, Kenneth S. Norris, Marineland of the Pacific.

Lance Lizardfish (ventral view) – Bruce Koike

Jennie Janssen and Meghan Holst

Minorities In Aquarium and Zoo Science, Inc.
https://www.miazs.org/

Who Are We?

MIAZS was founded by two women who are professional aquarists and researchers. We aim to promote diversity and inclusion in the aquarium and zoo sciences by countering the financial and social barriers that disproportionately prevent racial and ethnic minorities from entering and flourishing in these fields.

By partnering with colleagues throughout the industry, we strive to cultivate BIPOC-friendly work environments with inclusive hiring and retention practices, while ensuring minority professionals have access to professional development resources and mentor-matching opportunities to support their professional growth.

Given the non-traditional nature of this field, we are also committed to centralizing aquarium and zoo science resources for youth in underserved communities and making opportunities to gain pre-professional job training more accessible and equitable.


Jennie Janssen (L, *Photo by Theresa Kiel*) and Meghan Holst (R)

MIAZS Mission

Our mission is to advance aquarium and zoo science by diversifying the professionals and perspectives within it.

Goals

1. Our primary goal is to bring more people of color into aquarium and zoo fields
2. Our secondary goal, in parallel with the first, is to support and retain the existing minorities that work in these fields and those that will follow after them

Our Reach

While our focus is on racial and ethnic minorities - and our success metrics will be based on the increase and retention of those minorities - the practices we encourage and the tools we put in place will be made accessible so all the aquarium and zoo sciences can be more equitable and financially accessible for all.

Our Action Plan:

1) To bring more people of color into aquarium and zoo fields:
    a) Provide educators in under-served communities with resources to bring awareness of these professions to their students
    b) Provide aspiring professionals with resources to prepare them to be the best candidates for hire
    c) Work with hiring professionals and their home institutions to remove inequities in recruitment and hiring practices
    d) Increase the visibility of existing minority professionals to inspire the next generation
2) To support and retain existing aquarium and zoo minority professionals:
    a) Work with industry professionals and organizations to ensure BIPOC-friendly work environments
    b) Create specialized professional development and networking tools
    c) Provide centralized access to professional networks, resources, and professional growth opportunities

How You Can Help

You can support MIAZS efforts by following us on Twitter and Instagram @MIAZS_Now and visiting MIAZS.org. Check out our Membership options, or don't hesitate to reach out to us at contactMIAZS@gmail.com for further inquiries!

MONITORING, TRAINING AND DIET OF THE ZEBRA SHARK (*Stegostoma fasciatum*) AT THE AQUARIUM OF LORO PARQUE

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Abstract

Loro Parque aquarium contributes to the conservation of the zebra shark (*Stegostoma fasciatum*) through captive breeding programs. Within these programs, food plays a very important role in animal welfare and must be adapted to the requirements of the specimens at every moment of their life. The diet developed varies from 4% BW/day, 7 days/week, 28% BW/week in the first months of life to 2.5% BW/day, 3 days/week, 7.5% BW/week as a diet of adults. The development of medical training has allowed us to perform blood tests, ultrasounds and biometrics on a regular basis with the least possible stress, allowing us to improve the welfare of the animals and learn more about this species. The data obtained over time have allowed us to structure an annual calendar year within the aquarium, establishing an average temporality for pre-copulation, copulation, egg laying and birth.

Keywords: *Stegostoma fasciatum*, diet, medical training, monitoring

Introduction

The zebra shark, *Stegostoma fasciatum*, is a benthic shark of the order Orectolobiformes and the only species of the genus Stegostoma. It has a distribution in the Indian Ocean, western Pacific, Red Sea, East Africa, Japan and New South Wales (Australia) (Compagno, 2001). Genetic studies have revealed the existence of two different subpopulations; Indian-Southeast Asia and Eastern Indonesian-Oceania (Dudgeon *et al.*, 2009). This is probably due to the fidelity they show towards their place of residence, although it has been seen that *S. fasciatum* individuals migrate seasonally within a limited range (Dudgeon *et al*., 2013). It is a species that inhabits tropical and subtropical coastal areas, occuring on sandy, rocky bottoms and coral reefs on continental and insular platforms between 0-62 m deep (Compagno, 1984, Ebert *et al*., 2013).

Stegostoma fasciatum specimens have a typically cylindrical body with a maximum known length of 246 cm (Dudgeon *et al.*, 2008). Along the body they have five longitudinal ridges. The head has a rounded shape with a flattened snout that has two short barbels that serve as a sensory organ. Along the body we find two dorsal fins, rounded pectoral fins and a very long tail fin, almost as long as the rest of the body (Compagno, 2001). The coloration in adults is yellow-brown with dark brown spots along the entire body, except in the ventral area, which is pale in color (Bass, 1986). Males reach sexual maturity around 150-180 cm in size and females around 170 cm in size (Ebert *et al.*, 2013). Their life expectancy is estimated at 25-30 years (Compagno, 2001). The newborns have a drastically different coloration from that of the adult, their body is black with white-yellow transverse stripes (Compagno *et al*., 1989) that give rise to their name, zebra shark.

Stegostoma fasciatum is an oviparous species, it lays eggs on the seabed and anchors them to the substrate by special fibers. These eggs are rectangular in shape, dark brown or black in color with longitudinal striations and a size of around 17x8x5 cm. In captivity, annual egg-laying cycles lasting up to five months have been studied during which between 18 and 54 eggs are laid each year (Kunze & Simmons, 2004; Robinson *et al*., 2011; Dudgeon *et al*., 2017; Toledo & Alonso, 2021). In some isolated cases, *S. fasciatum* have exhibited parthenogenesis (Robinson *et al*., 2011; Dudgeon *et al*., 2017).

The zebra shark is rated on the IUCN Red List as "endangered" due to continued population decline, especially in the Southeast Indian Ocean region (Dudgeon *et al*., 2019a, White, et al., 2006). Despite all this, *S. fasciatum* is a very popular species in aquariums around the world. In this way, many of them have contributed to the conservation of this and other elasmobranch species through captive breeding programs (Uchida *et al*., 1990). However, specific breeding strategies have not been established, leaving mating success to chance, as males and females are simply kept together in the tank. Furthermore, as in the case of large elasmobranchs, the number of individuals present in aquariums is limited, the facilities are not always adequate and the costs are very high. Therefore, successful captive breeding programs require the development of optimal conditions and special attention.

Diet

Diet is one of the most important parts of animal welfare, health and proper growth. In addition, it is one of the key elements to close the biological cycle of animals, the central purpose of breeding programs. Consequently, the development of a correct diet, adjusted to the needs of each of the vital stages, is a constant priority for the aquarium.

Material and Methods

At the Loro Parque Aquarium, newborn *S. fasciatum* are offered food from the first day of their birth and in many cases with satisfactory results. Even those individuals which are born with remains of yolk, accept the food that is offered to them. This early first intake has become customary in newborn individuals (Christopher & Thomas, 2009).

The diet of a newborn is based on: prawns, cephalopods and mussels (Watson & Jansen, 2017). "White fish" (gadidae and similar) and "blue fish" (clupeidae and similar) are not incorporated into the diet until the third month following the recommendation of Silvia Lavorano (MON-P/ESB program coordinator of *S. fasciatum*) to prevent intestinal problems. Loss of appetite is common in newborn sharks. In these cases, daily controls are carried out while food is offered and only in extreme cases is force-feeding through a cannula used to feed liquefied fish.

The first two weeks the feeding is *ad libitum*, always controlling the level of swelling of the abdomen and predisposition to eat. After this period regular biometrics are taken every 15 days during the first months, and monthly after 4 months, allowing us to establish an intake based on their percentage of body weight (BW).

After the *ad libitum* weeks, they begin to feed at a rate of 4% of their BW each day of the week, divided into 4 different intakes per day during the first two weeks (28% BW/week). When intakes stabilize, it is reduced to 2 intakes per day while maintaining the same percentages (4% BW/day, 7 days/week, 28% BW/week), increasing the amount of food per intake but maintaining the daily amounts.

Towards 6 months of age, one day of fasting a week is established (4% BW/ day, 6 days/week, 24% BW/week). This age is usually accompanied by a decrease in the appetite of the animals, so food intake is decreased. At 8 months of age, we reduce the intakes to a single feeding per day but maintain the percentages. At 10 months we add one more day of fasting (4% BW/day, 5 days/week, 20% BW/week) following the same logic as in the previous months, and in addition, we begin to provide a diet based on two types of food every day, one of them always being white fish with the second food varying each day of intake. Following this pattern, at 12 months of life we provide three feedings a week (4% BW/day, 3 days/week, 12% BW/week), one of them composed entirely of white fish, another with 50% white fish and 50% cephalopod and the last one with 50% white fish and 50% blue fish.

When individuals reach a year and a half of life, their diet is based on 12% BW divided into three weekly intakes, 4% each day (4% BW/day, 3 days/week, 12% BW/week). In the case of adult *S. fasciatum*, their diet is based on 7.5% BW each week divided into three different intakes, 2.5% BW each day. (2.5% BW/day, 3 days/week, 7.5% BW/week). For these two age ranges, each day a single different type of food is offered in its entirety: white fish, cephalopod or blue fish. In addition, vitamin and mineral supplementation is carried out in a ratio of 0.1 tablet per kg of food (Aquavit®, International Zoo Veterinary Group, EU).

Results and Discussion

We must emphasize that the percentages refer at all times to the amount of food offered. The intake of that amount offered varies but in general terms it is largely adjusted to what is ingested by the specimens. In addition, on certain occasions the amounts or percentages are adjusted to the peculiarities of some specimens. The times and percentages have been established according to the appetite of the specimens, the results of the biometrics, the large amount of bibliography analyzed, the consultations with other entities, the experience of the workers and always with the support of the results of blood tests that are done on a regular basis.

Diet is one of the central elements of animal welfare. Although animal welfare and health have a multifactorial origin, a correct diet leads directly to a good state of health, correct blood values, adequate growth and good aesthetic appearance, among many other results. In the aquarium we dedicate a lot of time and effort to the study of the correct diet, the analysis of the diets developed, and the preparation of the intakes and the feeding of the specimens, thereby trying to achieve the highest possible levels of animal welfare.

Medical Training

The need to develop medical training arises with the aim of improving animal welfare in the aquarium. Training the animals allows a greater approach, observation and contact with them, minimizing the stress of handling and allowing us to complete numerous procedures that would otherwise be very complicated, very stressful or impossible to perform. Among these procedures, biometrics, blood extractions and the development of ultrasounds stand out, and allow us to guarantee the good health of the specimens.

The procedure presented below began to be developed in 2014 and has been adapted based on the experience developed, the bibliography studied, the consultations carried out and the results obtained.

Material and Methods

The first step is to establish a target or goal of the training. A level blue stretcher in the shape of a half cylinder is used for the development of the medical training and placed, during the last phases of the training, at the surface (Figure 1). The size of the stretcher is adapted to the size of the specimens on which training is being developed. The use of this stretcher is based on the capacity for visual discrimination of color and shape (Dudgeon, *et a*l., 2019b; Fuss, *et al*, 2013) that sharks possess. To check this fidelity and the discriminatory capacity of the specimens by the stretcher, each feeding day the stretcher is placed in a different place in the tank. In addition, during the feeding of the adults, other stretchers with different patterns are placed in the tank, oriented to the training of other species such as nurse shark (*Ginglymostoma cirratum*) and sandbar grey shark (*Carcharhinus plumbeus*), and we observe how this discriminatory capacity is maintained.

Stegostoma fasciatum training starts very early. Through the use of operant conditioning, food is used as an appetitive stimulus to lead the newborns to the stretcher located at the bottom of the tank. The use of bait to lead the specimens results in them associating the stretcher with feeding, establishing a responsive behavior and allowing the development of medical training. Once the association with the stretcher is established, we begin, in successive phases, to raise it to the surface. Finally, the stretcher is placed on the surface of the water, where the trainer will begin the next phase of training.

The training steps begin with hand contact. The duration of the contact will be gradually longer. After contact, food is used as a reward. Little by little, the trainer-shark contact will last longer, until it allows us some manipulation of each animal including holding its tail, lifting it by the dorsal fin, putting a hand on its belly, etc. Finally, we can turn the animal over and induce "tonic immobility" (Figure 1). The duration of each of the phases will be determined by the evolution of the animal's training. When the trainer deems it appropriate, we will proceed to the next phase of training. The time that tonic immobility is maintained is used when necessary for blood draws, ultrasound, or other tests. After immobility, the shark is returned to its natural position and rewarded. Between the return to normality and the award, a delay of reinforcement is established to ensure that the shark is ready for food intake.

Results and Discussion

The development of this chain of behaviors, their discriminating capacity with regards to the pattern of the stretcher, and their learning aptitude all demonstrate that some level of intelligence is presented by *S. fasciatum*. The medical training has allowed us to perform blood tests, ultrasounds and biometrics on a regular basis with the least possible stress, which have allowed us to improve the welfare of the animals and has made possible to learn more about this species.

Figure 1. In this image we can see a trainer developing a tonic immobility in a zebra shark, *Stegostoma fasciatum,* at Loro Parque Aquarium. Note the typical stretcher configuration.

Monitoring

The observation and monitoring of animals are a crucial part of the daily routine of any institution. Medical training, already described, and being able to dive with the specimens, allows regular direct observations of the animals.

Material and Methods

The recording of all observations is a fundamental step in being able to control the long-term evolution of different processes, to see their temporal continuity and to see if these phenomena repeat themselves over time. Data collection is focused on intakes, pre-copulation, copulation and egg laying phenomena, and these observations are recorded in MS Excel® databases.

The intakes are recorded individually ensuring that each specimen consumes the percentage of body weight (% BW) that corresponds to it. The pre-copulation, copulation and egg laying events (described in Toledo & Alonso, 2021) are recorded taking into account number of repetitions, date and the specimens involved.

Results and Discussion

The data obtained over time have allowed us to structure an annual calendar within the aquarium (Figure 2). As shown in the graph, the first pre-copulation events begin to be observed in the month of January and last until June, the end of the copulation season. Starting in February, pre-copulation events begin to be successful and copulation events are observed. Copulation events are recorded from February to June, April being the month with the highest record. The laying season runs from March to September, with May as the month where the highest concentration is observed. Registered hatchings are concentrated between September and December, with October being the month with the highest number of births (Toledo & Alonso, 2021). These results allow us to corroborate that the annual reproductive cycle of *S. fasciatum* in the Loro Parque aquarium corresponds to the natural year observed in this species in the wild.

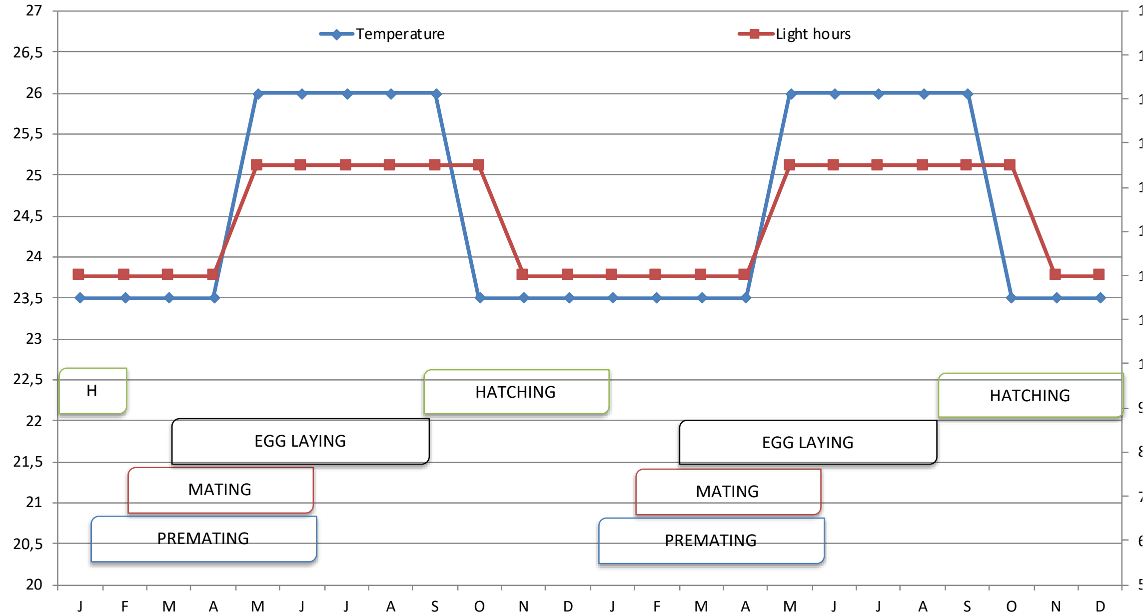

Figure 2. The graph shows variations in temperature and hours of light that occur over two years in the shark tank. In addition, it presents the annual reproductive cycle of the Zebra Shark (*Stegostoma fasciatum*) in the tank at the aquarium of Loro Parque.

It's important to be aware that the conditions generated in the aquarium, although they try to create a natural environment and copy many of the fluctuations that occur in it, are artificial and controlled (Henningsen, et al. 2004).

We must add that, although monitoring by the aquarium staff is constant, in most cases it is impossible to know which shark has laid a particular egg, due to night-time occurrence in the majority of cases. Future genetic analysis will allow us to know which animals are the parents of each offspring, and allow us to establish a genetic line that favors the possible introduction of the offspring into nature or for exchange with other aquariums.

Future Perspectives and Final Discussion

Elasmobranch populations play a critical role in the health of the oceans. Elasmobranchs are essential for maintaining marine balance. Without them, the trophic imbalance could lead to a population overgrowth of their prey, which would require more resources. These resources would decrease due to the increase in their demand and would lead to a cascade reaction that would endanger ecological balance and the structure of ecosystems. Therefore, the need arises to preserve and protect the existing populations of elasmobranchs and, in addition, to help recover their natural stocks and the habitats they once occupied. Furthermore, the protection of elasmobranchs generates umbrella species that help protect entire ecosystems. We must not forget that wherever we restore the wild, it will help us bring balance to the planet.

Acknowledgments

Thanks to everyone at the aquarium: Mina Herrera, Nestor Rocío, Jonathan González, and the rest of the team for the endless effort and the infinite hours dedicated to the animals and the breeding program. We also want to thank the veterinary team, Nuhacet Fernández, as head veterinarian, Francesco Grande and Richard Heidrich, for the enormous dedication in this program and all the knowledge and ability put into it.

The development of the study and the article presented here would not be possible without the involvement of Loro Parque (LP) and the Loro Parque Foundation (LPF). The Loro Parque Foundation supports animal welfare and biodiversity conservation, through research and education. Loro Parque, as a modern zoo, dedicates a great amount of effort and resources for the development of breeding programs, recognizing the importance of learning more about animals in order to improve their protection.

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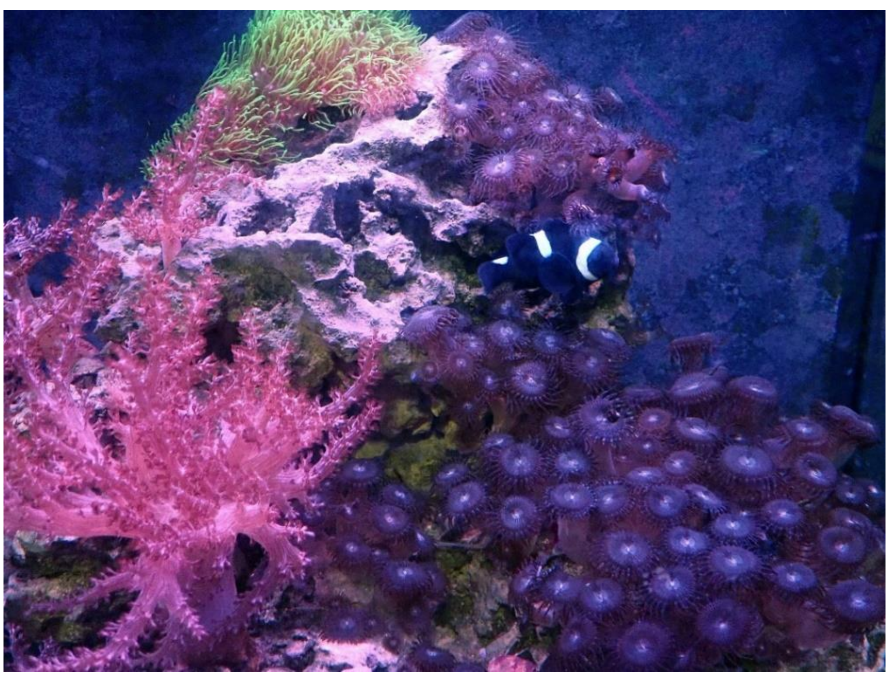
HOW HOME BREWING SAVED MY FISH

Jay Hemdal

Toledo Zoo and Aquarium

I've been a home brewer for over 25 years, and I generally brew 15 to 20 gallons a year. I'm ashamed to admit that I am just an extract brewer – one can of extract and 3 pounds of DME and three weeks later I have five gallons of good cheap stout. Indeed, my primary fermenter for all this time has been a six-gallon plastic "Mr. Beer" carboy. Just once, about ten years ago, did I try an all-grain recipe. I over-hopped it and had to pour it out. However, that one instance is how home brewing saved my fish today….

The second thing I have to be ashamed of is my 16-gallon Bio-Cube that I set up just before the Covid lock-down. This is the first home aquarium I've had in over twenty years. Since I set it up, I've discovered that with Zoo work, a new grandson at home and sailing, I just didn't have time to maintain it properly. Although it has one really nice Darwin clownfish, all of the rockwork is now covered, nay, completely hidden by hair algae and *Valonia*. So, I took the day off work and spent the morning plucking hair algae and washing rockwork. Trying to take a shortcut (as I am prone to do) I then drained 10 gallons out of the tank for a huge water change. I grabbed my mixing bucket, salt and the … whups; my hydrometer was nowhere to be found! The nearest LFS is 1 ½ hours roundtrip. Although I've been mixing seawater for fifty years, my confidence was low that I could just eyeball the mix. As the clownfish eyed me disapprovingly from the murky five gallons of water left in his tank – I remembered my one foray into all-grain brewing; I had purchased a glass hydrometer! And using that, is how home brewing saved my fish today.



Jay's home aquarium after being salvaged, but still kind of rocking an 80's vibe.

RAWdemic 2022 ABSTRACTS
The Regional Aquatics Workshop, February 20-24.
Moody Gardens, Galveston, TX, USA.

RAW returned after a two-year absence due to the pandemic. 200+ attendees and sponsors made their way to Galveston and there was collective joy at seeing "our people" in person. A number of virtual presentations reminded us of the waning but ongoing impacts of COVID. Special thanks to Greg Whittaker and Moody Gardens' management for their confidence, fortitude and faith.

February 20th
AZA Aquatic TAG Steering Committee Meetings

Monday, February 21st
Welcome and TAG Meetings

RAW Welcome, Ground Rules, etc.

State of the Industry, TIDE Talks, etc.
Short Presentations:
Pandemic-related challenges and opportunities that influenced our thinking or actions.

Moderators: Beth Firchau, Greg Whittaker, Allan Marshall
Kathleen Balogh and Pete Mohan, Kelli Cadenas, Chris Coco, Sandy Trautwein, Barrett Christie, and Lindsey Condray.

MFTAG Reporting Meeting
Paula Carlson et al.

FFTAG Reporting Meeting
George Brandy et al.

AITAG Meeting
Brian Nelson et al.

Icebreaker at the Aquarium Pyramid

Tuesday, February 22nd
Session 1: Health Management

Talks recorded by:
AnimalProfessional.com

Sponsor Presentation:
Aqua Logic

An Oldie but a Goodie – Phenoxyethanol in Elasmobranchs

Dr Robert Jones, rob@theaquariumvet.com
The Aquarium Vet, PO Box 2327, Moorabbin, Victoria, Australia.
(Virtual Presentation)

Phenoxyethanol has been used as a fish anesthetic for many years. In the past three to four years, The Aquarium Vet team have used it in multiple elasmobranch species, including some large animals up to 300 kilograms. We have used it to assist with handling and preparation for transports, as well as for sedation for minor procedures and surgery. The results have been excellent with a very smooth induction as well as recovery. Doses range from 0.15 ml/L up to 0.30 ml/L and our protocol will be presented.

Stella the Sand Tiger: No Bones About It

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Maryann R. Meadows, mmeadows@msaquarium.org.org
Mississippi Aquarium

A sub-adult female sand tiger shark (*Carcharias taurus*), housed at Mississippi Aquarium, presented with scoliosis and kyphosis shortly after being introduced to the main 300,000-gallon habitat. The curvature, partnered with a severe decrease in appetite, resulted in a veterinary examination that indicated that the individual had a vertebral luxation. In a groundbreaking surgery, the luxation was stabilized by placing bilateral plates and screws.

After the surgery, aquarists used physical therapy, environmental obstacles, and a curated training plan, with the goal of improving the chances of a successful reintroduction to the main habitat with varying success. Aquarists were able to determine that tracking the trends of her consumption rate combined with changes to her swim pattern showed a correlation between the shark’s assumed level of comfort/discomfort pre- and post-surgery.

Unfortunately, one month after reintroduction, the sand tiger shark presented with worsened spinal curvature, leading to a second spinal surgery. The second surgery required more invasive procedures including removing a piece of cartilage and placing larger plates. Post operatively the shark rested on the bottom with intermittent periods of swimming short distances. She became severely acidotic and was euthanized due to lack of response to emergency therapy.

Despite the outcome, the knowledge gained from both surgeries and the specific care required afterward provided information that may be useful to veterinarians and aquarists caring for elasmobranchs in other zoos and aquariums.

Investigation into Lymphoid Neoplasia in the Southern Stingray, *Hypanus americanus.*

Melissa C. Morrow, mmorrow@mysticaquarium.org
Mystic Aquarium

The presence of Lymphoid Neoplasia in elasmobranchs is a rare occurrence with a varied range of symptoms, making the diagnosis of this disease hard to confirm. At Wonders of Wildlife National Museum and Aquarium in Springfield, MO there is a 7-year-old Southern Stingray "Wilma" that has been diagnosed with Lymphoid Neoplasia with vascular invasion.

Symptoms first arose on May 19, 2019 as a small strip of tumors along the left side of her midline. Over the course of 6 months her symptoms progressed to large tumors covering the majority of her dorsal side and the ventral side of her tail. Following the progression of her symptoms, a skin scrape and abscess swab culture were performed leading to the diagnosis and treatment for *Vibrio alginolyticus* and *Photobacterium damselae* infections. Upon the seemingly ineffectiveness of that treatment, a skin biopsy was administered and submitted to Fishhead Labs, LLC who confirmed the diagnosis of Lymphoid Neoplasia with vascular invasion on September 27, 2019. With this diagnosis, The Wonders of Wildlife facility decided to perform a trial treatment of Prednisone and Lomustine Chemotherapy. The treatment was administered for 4 months, and ostensibly had success. The external tumors presumably went into remission and the stingray was placed back on exhibit June 23, 2020.

Hilo's Story: Providing Intensive Neonatal Care to a Spotted Eagle Ray Pup

Amanda Vaughan, Amanda.M.Crook@Disney.com
Epcot's *The Seas with Nemo and Friends*, Walt Disney World Resort

In December of 2019, a spotted eagle ray pup was born into the 5.7-million-gallon Main Environment at Disney's The Seas. Upon initial examination, the pup appeared externally healthy, in great body condition, and was displaying expected behaviors for growth and development. It was isolated to a pup habitat for one-on-one feeding opportunities, where aquarists observed positive signs of foraging behavior begin. After a few days of witnessing small amounts of consumption from the pup, all foraging behavior unexpectedly ceased. A plan for intervention was made between Animal Husbandry, Management, and Health teams. Bloodwork revealed a high white blood cell count, so twice-a-day tube feedings were administered, in addition to antibiotic therapy. Despite our team's best efforts to sustain the pup, visible loss of body condition continued, prompting modification of the current strategy. Because the ray's health had reached a point of extreme delicacy and our treatment plan needed to be highly aggressive, several factors to balance animal handling with animal health were required. A careful approach that took into account the animal's caloric needs, repetitive exposure to capture and anesthesia, necessary medical treatments, and overall neonate development was designed. After a month of intensive intervention, the pup began to eat without assistance and a training plan was devised. Throughout the process, our team gained several invaluable learnings for critical neonate care, including a greater understanding of digestive time and nutritional needs, best-practices for repetitive handling and anesthesia exposure, lesser-used treatment methods, and highlighting of inter-team communication and camaraderie.

Sponsor Presentation:
McRoberts Sales Company, Inc.

Completion of a Successful CT Scan on a Cownose Ray (*Rhinoptera bonasus*)

Amanda Vaughan, Amanda.M.Crook@Disney.com
Epcot's *The Seas with Nemo and Friends,* Walt Disney World Resort

At Disney's The Seas, a CT scan was planned for a cownose ray (*Rhinoptera bonasus*) who exhibited chronic spinning behavior. Several previous diagnostics and treatments had been administered, but were unremarkable in findings and behavioral improvement from the animal, hence the decision to proceed with a more invasive procedure. To complete the scan successfully, several caveats would need to be problem-solved, including: transport to an alternate facility, minimization of stressors on the animal, appropriate maintenance of all blood parameters during extended dry-dock time, design of equipment to adequately ventilate the ray while dry-docked, methodology to keep hospital equipment dry and free of salt, and collaboration of care efforts between teams that were unfamiliar working together. In order to best prepare, the Animal Husbandry Team spent time at the hospital facility to understand the building layout and transport path, space restrictions for storage of seawater and aquatic holding tanks, and dimension requirements to fit the animal into the CT machine. In turn, the Animal Health Team familiarized themselves with necessary husbandry equipment and ran through multiple practice runs with aquarium staff to mitigate unforeseen kinks in the plan. After the conclusion of extensive preparatory efforts, the scan was scheduled and all pre-established goals were completed, resulting in a successful procedure. Veterinarians were able to obtain quality images of the ray's brain, spine, and tail base, and we have opened up the door to use CT imagery as a diagnostic tool for our elasmobranch collection in the future, thus increasing animal welfare.

New Methods for Restraint and Treatment of *Uronema marinum* in Red Lionfish *(Pterois volitans*)

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The Aquarium at Moody Gardens

A new method was needed to treat a systemic Uronema infection in Lionfish (*Pterois volitans)*. Late diagnoses due to an atypical presentation commanded a radical treatment protocol. A drug cocktail of Panacur, Praziquantel, Enrofloxacin, Ponazuril and Vitamin B12, given orally with food was used to combat the infection. To facilitate this new treatment protocol, a new method of restraint needed to be created as well. A woven neoprene mat was used to wrap the fish and keep the venomous spines contained. Combined with neoprene glove, the method was effective and safe. This approach provided for keeper and fish safety while minimizing stress and sedation time. We believe that this method can be used by other institutions to facilitate animals handling safety.

Towards Understanding Microbial Degradation of Chloroquine in Large Saltwater Systems

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Circulating saltwater aquariums hosting marine animals contain a wide range of microorganisms, which have strong implications on promoting animal health. In this study, we investigated the degradation of chloroquine phosphate, an anti-parasitic bath pharmaceutical used in saltwater quarantine and exhibition systems, and attributed the reduction in drug concentration to microbial degradation of chloroquine associated with pipeline microbial communities. To advance our knowledge on chloroquine degradation in aquatic systems, we conducted microbial and chemical analyses on three tropical saltwater systems. Our findings show that aquarium microbiome composition is shaped by sampling location (i.e., tank water and pipeline; PERMANOVA $R^2 = 0.09992$, $p = 0.0134$), chloroquine dosing (PERMANOVA $R^2 = 0.05700$, $p = 0.0030$), and whether the aquarium is occupied by marine animals (PERMANOVA $R^2 = 0.07019$, $p = 0.0009$). Several microbial taxa belonging to the phyla *Actinobacteria*, *Bacteroidetes*, *Chloroflexi*, and *Proteobacteria*, along with functional genes related to pathways such as phenylethylamine degradation and denitrification, appeared to have differential (relative) abundance between samples where chloroquine degradation was observed and those without degradation (Benjamini-Hochberg adjusted p-value <0.05). Together, these results provide practical mitigation options to prevent or delay the development of chloroquine-degrading microbial communities in saltwater aquariums. Our results further demonstrate the need to improve our understanding of the interactions between nitrogen availability and microbial activity in saltwater systems.

Quarantining Before It Was Cool: Ecological Approaches in Coral Health Management

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Investigation into successful methods in coral restoration has become a progressively important area of focus in the aquatic community. Disruptions to the natural reef system, caused by climate change and anthropogenic activity, has led to increased bleaching events and susceptibility of coral to global large-scale die-off. Subsequently, growing numbers of government-funded agencies, public aquariums, and NGOs are attempting to mitigate this loss through coral restoration. In Hawaii specifically, restoration poses unique challenges due to high levels of endemism and the growth rate of Hawaiian corals—the slowest worldwide. At the Hawaii Division of Aquatic Resources' Coral Restoration Nursery, staff is continually exploring different methods of treatment for various coral maladies. Unlike disease treatment in aquariums, the team must consider the long-term effects that a medication (such as an antibiotic) could have on the ecosystem post-outplant. As all corals coming into the nursery are intended for re-introduction into the wild, treatment regiments must be selected based on a risk assessment for both the facility and future reef outplant site. Following a pervasive cyanobacterial outbreak at the nursery, staff qualitatively determined the treatment success rate for several colonies of *Porites lobata* with hydrogen peroxide. Treatment efficacy varied by colony genotype, tank conditions, severity of initial outbreak, treatment concentrations, and time exposed to the hydrogen peroxide. Within the scope of coral conservation and ecology, this technique, as well as other less-invasive methods that utilize simple tools to address coral health concerns, are further presented and discussed.

Tuesday, February 22nd
Session 3: Husbandry Techniques

Sponsor Presentation:
Dynasty Marine Associates, Inc.

Was this Swamp Always Here?
Or
Shouldn't that Water be in a Tank?

J. Chris Emmet, jemmet@ucsd.edu
Birch Aquarium
(Virtual Presentation)

Around 1:30am on November 26, 2021, one of the primary supply lines at Birch Aquarium catastrophically failed. Approximately 30,000 gallons of seawater were then pumped out of the system, before pumps shut down, leaving roughly one third of the facility's systems without flow, including the 70,000-gallon Kelp Forest tank. Once the reservoir was emptied, the Kelp Forest tank began to backsiphon, losing an additional 30,000 gallons. Staff were onsite within 30 minutes of the failure being discovered, and began responding to the situation, including emergency replumbs & rerouting of water, as well as isolating & identifying where the failure occurred.

Through coordination & teamwork between Birch Aquarium husbandry and facilities staff, as well as support from Scripps Institute of Oceanography facilities, systems were stabilized & bypassed, contractors were brought in, and the line was repaired and the system successfully recommissioned 20 hours from the initial response. Despite interruptions in flow, there was not a single fish mortality, highlighting the importance of a prompt response.

This presentation will discuss how the response proceeded, and how the lessons learned and steps taken can be generalized and applied to other facilities. A major line failure is a "worst case scenario," and staff being prepared for such an event can streamline and smooth the response to such a stressful and time-critical situation.

Population Management and Introduction Techniques of Aquacultured Fishes in the New England Aquarium's Giant Ocean Tank

Lindsay M. Phenix, lphenix@neaq.org
New England Aquarium, Boston, MA
(Virtual Presentation)

Since 2008, the New England Aquarium has been developing an expansive larval fishes program that has successfully reared 13 different teleost species to adulthood. This program has helped to advance self-sustaining animal populations and has allowed schooling species to reach great abundance within exhibits. One benefactor of these achievements in aquaculture has been the 200,000-gallon multi-taxa Giant Ocean Tank (GOT), with a total population comprised of more than 50% aquacultured individuals. While many challenges can be faced during the larval rearing process, special considerations must be taken into account once these animals reach exhibits. Introduction, and furthermore population management, have presented their own unique trials and tribulations, often due to behavioral and developmental difference from their wild counterparts. Here we will examine the introduction and management techniques used for the smallmouth grunt (*Haemulon chrysargyreum*) and lookdown (*Selene vomer*) populations within the GOT.

Holistic Husbandry Management of a Population of 0.5 Blackblotched Rays *(Taeniura meyeni)*

Amanda Vaughan, Amanda.M.Crook@Disney.com
Epcot's *The Seas with Nemo and Friends,* Walt Disney World Resort

Epcot's *The Seas* 5.7-million-gallon Main Environment is home to five female Blackblotch rays *(T. meyeni).* As our Blackblotched population has increased due to in-house reproduction, we have witnessed the establishment of a perceived 'social hierarchy', as well a variety of social interactions, both aggressive and passive in nature. For this reason, as well as the species' demanding needs for appropriate behavioral training, aquarist experience, tight diet management, and adequate housing, our team continues to evolve our strategy for overall Blackblotched ray husbandry. As of 2021, all five rays consistently participate in surface stretcher training, have a strategy for appropriate social groupings within sessions, take place in a 'behavioral wellness' monitoring tool that assesses their welfare on a daily basis, and have recently completed voluntary captures for physical examinations and barb grooming. As we work to achieve unprecedented animal welfare and staff safety while managing such large elasmobranchs, aquarists make ongoing assessments to streamline feeding and management procedures that uphold 'manners' in a species that can easily become overbearing due to their overall size and outgoing behavior. Through these changes, our team has accomplished more consistent feeding participation from all animals, better understanding of their expected behavior during times of high social aggression, and improved techniques in handling 250+ kilogram animals. We continue to strive for more, with the population currently progressing on voluntary blood and ultrasound behaviors and our team continuing to discern patterns in socialization and feeding trends and how they may relate to overall animal health.

Sponsor Presentation:
RK2 Systems

Hammering out Hammerhead Husbandry:
Lessons Learned in the Husbandry of *Sphryna lewini*, and Designing a New Exhibit to Specifically Meet Their Unique Requirements

Melissa Bishop and Tyler Rankin
Point Defiance Zoo and Aquarium, 5400 N Pearl St, Tacoma, WA, 98407, USA

In 2018 the Point Defiance Zoo and Aquarium opened the new Pacific Seas Aquarium with the largest display being a 280,000-gallon Sea of Cortez exhibit specifically designed to showcase Scalloped Hammerhead sharks (*Sphyrna lewini*). After one year of growing the animals out, that exhibit successfully opened in 2018 with 0.4.0 animals on display for the public. Scalloped hammerheads are known to be a more difficult species to keep in public aquariums. Many challenges were met and much was learned through the process that will be shared. Also, to be shared is compiled husbandry information acquired through the years by facilities that have previously tried to keep this species, as well as others who are currently successful. Some of our challenges included managing the complex social dynamics of female scalloped hammerhead sharks. This contributed to two mortalities while still in holding. Those social dynamics continue to be a challenge today. Also, to be shared are transport techniques, feeding strategies, and prophylactic quarantine treatments.

Bonnethead Shark (*Sphyrna tiburo*) Rearing, Days 1 – 425

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Species that were commonly wild caught can no longer be relied upon for collections that aim to be more sustainable in the future. Bonnethead Sharks (*Sphyrna tiburo*), which in 2019 changed in IUCN status from Least Concern to Endangered due to decreasing population size, are notoriously difficult to rear and care for when born in captivity. In February 2020, 6 bonnethead sharks were born at Shedd Aquarium creating an ideal case study of how to successfully rear this species in captivity. Not only were all 6 bonnethead sharks able to survive well past their 1st birthday, they were also handled every other week (27 catchup days) for checkups using tonic immobility (4-minute mean handling time) giving the aquatic community a large data set of biometrics on this species and an example of how this once thought 'delicate' species can in fact be handled in a manner congruent with practices of modern aquarium husbandry. Data collected includes weights, lengths, daily food intake including supplements and plant fiber to mimic recent indications of omniovry in this species, liver size, and bloodwork including lactate levels (lactate mean = 1.93mmol/L +/-0.88mmol/L; 125 samples) which we believe to be a key aspect of success.

The data collected can be disseminated to other facilities for future rearing of this endangered species and limit the need for wild collection.

Use of Animal Training in the Capture and Transport of Great Hammerhead Sharks, *Sphyrna mokarran*

Melissa Paynter
Georgia Aquarium

This presentation discusses the ongoing training of Great Hammerhead Sharks, *Sphyrna mokarran*, and the use of this training in the capture and transport of this species. Using a moving target, aquarists were able to guide the sharks throughout the habitat, and ultimately allow them to participate in their own husbandry by voluntarily swimming into their transport stretcher. In addition to this, this training program was able to provide mental and physical stimulation, customized nutrition, administration of oral medications and supplements, and reduction of handling stress. These behaviors transferred with the sharks when they were moved throughout the different systems they have been housed in and the training program continues to this day.

Large Elasmobranch Management: A Collaboration

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New public aquarium facilities have opened over the last several decades specifically designed to showcase large elasmobranchs. Guest feedback indicates an expectation to be engaged with larger and in some cases unique megafauna in larger, complex habitats. The focus on guest experience has influenced design parameters and challenged zoological professionals to achieve a higher level of successful care with large sharks and rays.

A partnership commenced in 2017 between Georgia Aquarium and Dynasty Marine Associates to successfully collect, acclimate, and transport several species of larger elasmobranchs for a new, conservation-oriented shark habitat that opened in 2020. A fundamental goal of the new presentation was to transform the mindset of the guest. Many people have a fear of sharks, but once they conclude their experience that fear is transformed into a feeling of appreciation and advocacy. Though several different species were procured for this display, notable advances in husbandry techniques were developed for *Sphyrna mokarran* and *Galeocerdo cuvier*. The three years of research and development throughout this process has led to a better understanding of the initial and long-term care needed for these species. Some of these advances were achieved in relatively brief periods of time while others required a longer, more detailed process. As other facilities around the world consider displaying these particular species, our shared experiences might prove beneficial as we continue to work to advance the best practices of husbandry care for these sharks.

Wednesday, February 23rd
Session 5: Welfare General Session

Sponsor Presentation:
Piscine Energetics

On The Use of Statistical Modeling in Making Data Informed Husbandry Decisions R You Ready!?

Chad L. Widmer, PhD, chad.widmer@pdza.org
Point Defiance Zoo and Aquarium

In 2018 the new Pacific Seas Aquarium at Point Defiance Zoo and Aquarium opened which includes a 280,000-gallon exhibit featuring scalloped hammerhead sharks, green sea turtles and spotted eagle rays. Soon after opening the Elasmobranch team began noticing negative behavioral issues in the shark collection that were on track to lead to poor husbandry outcomes. One hammerhead shark was chronically rubbing against the front window causing mechanical damage to its cephalofoil whilst another had developed a *Fusarium* sp. fungal infection which is very often fatal. Before the situation worsened, the team wanted to better understand and mitigate the factors driving these negative outcomes. Fortunately, the team had been collecting behavioral data from the time the sharks were introduced which enabled robust statistical analysis. Significant factors affecting shark behavior were identified using generalized linear models. Based on model predictions changes were made that led to positive behavioral outcomes for the collection of hammerhead sharks. Ongoing data collection has enabled the team to statistically address and make data informed husbandry decisions as new issues have arisen.

Don't Blow It Up: Improving Welfare Through Small-Scale, In-House Actions

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North Carolina Aquarium on Roanoke Island,

Aquatic animal welfare is an increasingly vital aspect of aquarium science, but significant challenges may occur in modifying existing habitats and infrastructure in the name of animal welfare. These modifications can be both time consuming and cost prohibitive. The need for upgrades and improvements is a never-ceasing reality of modern public aquariums. However, small and seemingly insignificant changes within an environment can provide perceptible improvement, without breaking the bank, when executed thoughtfully and purposefully.

The Stingray Touch Habitat at the North Carolina Aquarium on Roanoke Island, constructed in 2000, was increasingly displaying the need for improvement based on documented animal welfare assessments. Although no immediate welfare concerns were identified, the scores were steadily presenting lower values than other similar habitats. At the end of 2019 and into the beginning of the COVID-19 pandemic of 2020, monetary resources were limited. Creativity and resourcefulness became key to addressing these animal welfare problems within the given financial and labor limitations. By making several changes over the span of 12-18 months, we were able to measurably improve animal welfare, aesthetics, and functionality within one of our most popular attractions.

Behavioral and Physiological Metrics of Sensory Decline and Welfare in Senescent Giant Pacific Octopus, *Enteroctopus dofleini*

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Senescent octopuses experience extreme physical decline over a period of days, weeks, or months before eventual death. Despite widely known, predictable declines in octopus health in the post-reproductive stage, evaluations of welfare and humane endpoints are not standardized, in part because little is known about sensory and neural degeneration in the terminal phase. This study measured changes in behavioral response to nociceptive stimuli over the course of senescence in giant Pacific octopus (GPO), *Enteroctopus dofleini*, held in public aquariums in the USA (N=9) using von Frey filaments. Post-euthanasia, tissue was collected from arm tips (N=8), neural and epithelial cell death was quantified and compared with arm biopsies of healthy, pre-reproductive (n=2) GPOs. Behavioral data showed a significant difference in threshold mechanosensory and nociceptive response between pre- and post-senescent stages (significant values $p < 0.05$). Cell density declined significantly between healthy and senescent GPOSs for axial ganglion neurons ($p < 0.0001$) and epithelial cells at the sucker edge ($p = 0.0016$) tissues. There was a non-significant but clear trend in epithelial tissue death on the dorsal arm ($p = 0.0657$). Our results indicate a pronounced increase in sensitivity to touch at the early stages of senescence, followed by a precipitous decline as GPOs near death. Additionally, declines in cellular density between healthy and perimortem GPOs suggests the loss of sensitivity seen in peri-mortem behavioral assays may be explained by overall loss of neural and epithelial sensory cells. Our data provide new insight into the physiology underlying senescence-induced behavioral changes in octopuses.

Sponsor Acknowledgement:
TJP
Provided flash drives to RAW 2022 attendees. These contain sponsoring vendors' materials, the conference schedule and an attendee list.

Panel Discussion: Animal Welfare
Moderator: Allen McDowell

Wednesday, February 23rd
Session 6: Staff Diversity

Sponsor Presentation:
TheAquariumVet.com

Panel Discussion: Increasing and Retaining Minority Professionals in Aquarium Careers
Moderators: Jennie Janssen, Meghan Holst, and George Brandy
Also see the article on MIAZS in this issue.

ALLY Workshop *(during lunch break)*
Jennie Janssen and Meghan Holst

Wednesday, February 23rd
Session 7: Corals

Sponsor Presentation:
Species360

Florida Coral Rescue

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Since 2014, the Florida Reef Tract (FRT) has been battling a disease called Stoney Coral Tissue Loss Disease (SCTLD). Over 20 species of reef building corals, including Endangered Species Act listed corals, are susceptible to the disease, often resulting in whole colony loss. Some species experience up to 100% mortality at individual sites. Since November 2018, the Association of Zoos and Aquariums (AZA) has partnered with the Florida Fish and Wildlife Conservation Commission and other agencies to create land-based nurseries for FRT corals in need of rescue from the advancing disease. To date nearly 2000 corals have been removed from the FRT and are being maintained at AZA facilities. Some of the coral species never been held in human care and much is being learned through the work of AZA coral aquarists. New relationships and networks have been created impacting how zoos and aquariums are viewed as partners for conservation.

Partnering in Coral Restoration

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Aquarium Encounters of the Florida Keys and its sister company, Dynasty Marine Associates, have recently begun working with a local not-for-profit company called Reef Renewal USA to help them develop a community-based coral reef restoration program in the Florida Keys. Although the Reef Renewal USA "brand" is relatively new, the management team are some of the key people who pioneered coral reef restoration in Florida. This new endeavor is blending the talents and resources of a passionate team of people from all three companies to launch a bold and

innovative approach to coral reef restoration. A key component of this new approach is to fully train and engage the local community in the program so that a sense of ownership is developed. Local and out of town volunteers will be able to participate in everything from land based coral fragging programs to outplanting and reef maintenance programs taking place throughout the Florida Keys.

This program is working with over twenty species of corals, many of which have never been grown commercially or used for reef restoration programs. New, cutting-edge techniques for growing and outplanting these corals are being developed and implemented by this group of entrepreneurs, with the goal of being able to restore more reefs with more corals at a substantially better value than today's current average.

Expedition Colombia: Coral Reef Restoration in South America

Barrett L. Christie and David M. Hudson, Ph.D.
The Maritime Aquarium at Norwalk

The reefs of Colombia are among the most degraded in the occidental world, with an estimated 1% of historical coral cover left intact amid warming seas, sedimentation, dynamite fishing, freshwater influx, and improper wastewater discharge. In 2019 the Maritime Aquarium undertook a 6-week expedition to Colombia to engage local stakeholders in jellyfish propagation, sea turtle conservation, and coral reef restoration. Alongside staff from the Parque Nacional Natural Corales del Rosario y San Bernardo, the Oceanario Islas del Rosario, Acquario de Rodadero, and the Universidad del Magdalena, Maritime biologists documented the first-ever recorded wild spawning of two *Acropora* species within the Marine Protected Area, and likely the first for the country. Over 100,000 eggs were collected from staghorn coral, *Acropora cervicornis*, and larviculture techniques were taught to locals to improve their understanding of sexual coral propagation techniques, resulting in thousands of coral recruits being generated for reef restoration and ongoing research projects intended to raise the standard of reef restoration in the region. Doing conservation work in remote locations such as South America has many inherent challenges to overcome, but also great potential for high-impact conservancy.

Wednesday, February 23rd

Session 8: Conservation

Sponsor Presentation:
Tracks Software

Nautilus Conservation In the 22nd Century: Where Do We Go from Here?

Gregory J. Barord[1,2]
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In November 2021, the Save the Nautilus organization celebrated its 10th anniversary! Over that decade, we have collaborated with universities, governments, communities, and nongovernmental organizations to address some big knowledge gaps in our understanding of nautiluses to support conservation efforts. That led to local, national, and international regulations of nautiluses to curb their population decline because of unregulated fishing practices. However, there are plenty of examples of species that have been regulated under various agreements, but conservation efforts are not successful. The best/worst example of this is *Phocoena sinus*, the vaquita, and *Totoaba macdonaldi*, the totoaba, whose populations are still in decline even though both species have been listed on Appendix I of the Convention on International Trade in Endangered Species since the 1970's. With these stopgap measures now in place, we can continue investigating aspects of the natural history of nautiluses that remain a mystery, such as reproduction, diet, sedimentation, life span, species relatedness, and the role nautiluses play in their deep-sea habitat. Successful conservation does not happen on paper. Successful conservation is a result of collaboration of a diverse group of stakeholders, education and opportunity at all levels, and a commitment to improving outcomes that benefit the species and people. As the 22nd Century creeps closer and closer, the goal should be to see nautiluses disappear, not from the wild, but from endangered species lists and that is what we aim to work towards.

A New Species of Nautilus from Fiji: Collection, Husbandry and Education (2020)

Gregory J. Barord[1,2]
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The Fijian Islands are home to a population of nautiluses that are geographically isolated from all other nautiluses. This geographic isolation suggests, then, that the nautiluses of Fiji may also be genetically distinct from other nautiluses and represent a new species. After the 2017 CITES legislation to regulate nautilus exports, a five-year project was started in Fiji to support in situ and ex situ conservation efforts. As part of this plan, additional partners and stakeholders were brought to the table to continue population surveys, provide training/education to local students, and refine nautilus husbandry. With the strong likelihood of the Fijian nautiluses being their own distinct species, it is imperative to have a management plan in place to ensure they receive effective stewardship. The successful use of this model in Fiji can also then be applied to other nautilus range states throughout the Pacific to promote education and conservation. These initial efforts have already led to the description of new species of nautiluses in Vanuatu and American Samoa leading to additional questions surrounding the differences of their nautral history, husbandry considerations, and outreach possibilities.

Making the Stars Align: Why Aquariums Are Key Players in the Recovery of the Critically Endangered Sunflower Sea Star (*Pycnopodia helianthoides*).

Ashley B. Kidd, ashleykidd@ufl.edu
University of Florida

The sunflower star, *Pycnopodia helianthoides,* is a keystone predator of sub-tidal kelp and rocky reef ecosystems from Alaska, USA to Baja, Mexico. They shape the benthic communities they inhabit, preying primarily on bivalves and other echinoderms. Starting in 2013, a sea star wasting event (SSW) was observed in twenty-two Asteroidea species along the Pacific coast, acutely affecting *P. helianthoides*, reducing the population by ninety percent. The most extreme loss was seen in the southern portion of their range, and *Pycnopodia* are now considered extirpated from California and Oregon. *P. helianthoides* was listed as critically endangered across its entire range by the International Union of Concerned Scientists (IUCN) in August, 2020. One of the IUCN action items listed starting a captive rearing program for *P. helianthoides* reintroduction, as it is unlikely sea stars will be able to naturally recruit to coastal waters where population densities are too low. Researchers at the University of Washington Friday Harbor Labs have shown initial success for the closed loop aquaculture of this species. Reintroducing *P. helianthoides* could provide one solution to maintaining resilient kelp ecosystems by reestablishing this keystone predator. Results from a survey sent through the aquatic info listserv in September 2021, identified aquariums that are uniquely poised as collaborators in this new conservation initiative, with four Aquariums holding valuable genetic broodstock from wild populations that no longer exist. Further investigation identified facilities with appropriate aquaculture resources and staff expertise to begin formal discussions to promote this species as an AZA SAFE candidate.

RAW Business Meeting

Committee updates and voting for future hosts.
2023 Host: Virginia Aquarium, "RAW is for Lovers"
2024 Host: Point Defiance Zoo and Aquarium, "TacomRAW"

Thursday, February 24th

Session 9: Morning Buzz (short presentations)

The Kraken Curriculum – A New Professional Development Tool

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Professional development for aquarists, LSS operators, divers, and water quality technicians doesn't just have to happen once a year at RAW; it can happen every day right at your home institution. Professional development (PD) can require substantial investments of time, but as staff become more knowledgeable and proficient, such investments in time pay large dividends. Surveys of continuing education among aquarium professionals (n=150) indicate that 28% complete no PD on an annual basis, and the majority (>50%) do less than 10h/y (mean 13h/y), though time spent pursuing PD on personal time was significantly higher (32h/y). The first-year costs of onboarding, training, and inefficiencies associated with bringing on a new employee are significant, and at Maritime Aquarium that has been calculated to reach nearly $14,000 per staff member. Given these costs of training and developing new staff, efforts spent on in-house professional development can actually save resources and time if they lead to better staff retention and proficiency. Adding to the variety of resources available to managers to build an in-house professional development program, the Kraken Curriculum has been created from existing content on AnimalProfessional.com with links to supplemental materials, all curated by topic to lead individuals or groups through industry knowledge on animal husbandry, life support systems, water quality, veterinary care, collection planning, and more. Organizing existing content in this way allows for learning to occur from a breadth of perspectives, while also allowing industry knowledge gaps to be elucidated and filled through future presentations.

Different Brains Different Voices

David W. Sanchez, dsanchez@moodygardens.org
The Aquarium at Moody Gardens

With a staff with wide ranging experiences, the differing personalities and backgrounds communication can be a challenge. How can staff leaders effectively convey information to staff in the most effective manner? Moody Gardens has begun a pilot program using the on-line personality test "16 Personalities" to identify different personality types and to teach staff what make their coworkers "tick". This allows the staff to understand their coworkers better and avoid conflict that comes with miscommunication.

Sharing the Wealth: Senior Biologist Presentations at Moody Gardens

Jennifer Randolph, jlrandolph@moodygardens.org
The Aquarium at Moody Gardens

At the Aquarium at Moody Gardens, the aquarium husbandry staff has a variety of backgrounds and experience. Senior biologist staff are given the opportunity to give short presentations on a husbandry topic of their choice during weekly fish staff meetings. This not only makes sure that industry and institutional-specific information is communicated clearly and standardized for all aquarium staff, but also allows senior staff a way to deepen their knowledge and pass on their experience. In this talk I will highlight some of the presentations senior staff have given and future plans for this initiative.

ChondroCensus 2022: Building and Streamlining Collaborative Capacity

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The AZA SAFE Sharks and Rays International Census of Chondrichthyans in Human Care (aka the ChondroCensus), which launched in 2019 at www.sharksandraysproject.com as a reboot of the American Elasmobranch Society's International Elasmobranch Census, has grown to contain 274 unique species from 235 facilities across 54 countries world-wide as of November 2021. To make this collection of data a truly useful tool for engaging in meaningful, strategic, and collaborative chondrichthyan conservation, stakeholder Teams can complete a survey providing basic husbandry info and add their organizational accrediting body. These data can then be searched by region, organizational accrediting body, genus or species, sex, and the surveyed husbandry criteria. In addition to streamlining periodic reporting required by organizational accrediting bodies, these new features will also anonymously connect stakeholders with each other and with the research community to advance husbandry practices and facilitate collaborative chondrichthyan conservation efforts. Teams always remain anonymous and thus maintain control over their data, as search results are only shown as the number of Teams per ChondroCensus Region. Thus, each stakeholder facility's Team Coordinator holds the critical role of whether their Team chooses to respond to any requests for connection or information, thereby identifying themselves as stakeholders of the species a search query pertains to.

A Sea Turtle Wetsuit as a Therapeutic for Buoyancy Issues

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The Living Coast Discovery Center

A short time after closing our doors due to COVID, our rescued Loggerhead Sea Turtle experienced sudden changes in her buoyancy negatively impacting her quality of life. With limited resources, funding and time, our team quickly exhausted traditional medical options to remedy the issue. We began to explore other methods to manually achieve neutral buoyancy and in a collaborative effort with O'Neill Wetsuits, a custom wetsuit was developed to allow for targeted weight adjustments. With all in person meetings restricted by the pandemic, measurements, prototypes and data were all exchanged back and forth virtually and through the post with a final product developed at the end of 2020. After several trials, the novel use of weighted wetsuit therapy was used to correct the problem, improving the sea turtles long term ability to swim, eat, and breathe.

Sponsor Presentation:
U. S. Mysids, Inc.

Thursday, February 24th
Session 10: Husbandry Techniques 2

Thrash of the Titans: Stretcher Training *Arapaima gigas*

Evan Kinn, ekinn@sheddaquarium.org, 414-531-3781
John G. Shedd Aquarium

Back in 2019, the question was posed: "How can we move three 6-foot-long Arapaima gigas out of a 16,500-gallon exhibit?" The best place to start was with stretcher training using a 121 Animal Handling Flexible Shark Sling. However, these animals had never before had any type of training.

I began to station train all three arapaima by offering food only when they came up to a certain spot. They picked up on the station quickly, so I introduced a target, which two of the three took to immediately. At this point I decided to bring in a second person to help with training sessions, separating them into groups – the two that followed a target, the one that didn't. Once this was accomplished, the stretcher was introduced.

The stretcher was largely met with hesitation, but after several months of training, I had success and got one of them to regularly swim into the it! However, multiple instances of the arapaima panicking while in the stretcher caused them to lose all of their momentum.

Then the pandemic hit, forcing us to take a step back in the stretcher training due to staffing. I reassessed our strategy, had one trainer per arapaima, and introduced a light as a "bridge" during training, all without the stretcher. I redesigned the stretcher and have been working at getting one of them to swim into the stretcher, with the plan to slowly work on getting them comfortable enough to lift them safely out of the exhibit.

Stickin' It to the Sturgeon: Training for Diver Safety and Animal Welfare

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Melinda D. Robins, MDRobins@wondersofwildlife.org
Wonders of Wildlife

Being both primitive and endangered, sturgeon of all species have long been a popular choice for freshwater exhibit displays. An often large-bodied animal that is not known for its shyness around human divers, this leads to concerns of safety during routine maintenance as well as questioning what is the best method to administer nutrition and supplementation on the individual level. The industry's rotation of primary care takers turns old training plans into over conditioning and a new approach must be developed to attain appropriate behavioral goals.

At Wonders of Wildlife (WOW), a training plan was implemented in our 100,000-gallon native community exhibit. The species involved with the training are White Sturgeon (*Acipenser transmontanus*) and Lake Sturgeon (*Acipenser fulvescens*). Two divers enter the exhibit with a long PVC Tee, soft pouch, and an aqua maraca (audible bridge). This method uses operant conditioning as well as synchronized teamwork to ensure diver safety while not compromising animal welfare and providing appropriate enrichment. Animals are gently diverted from performing previous unwanted behaviors and are rewarded at the execution of safe practices. The result of this operant style training has led to less frenzied animals, correctly managed nutrient intake, and a routine enrichment program.

Culturing the Flower Hat Jelly

Matt Wade, mwade@mote.org
Mote Marine Laboratory

The flower hat jelly, *Olindias formosus* (Hydrozoa: Olindiidae), is a popular display species in public aquariums. Advancements in reproducing this species are highly sought after due to limited availability of wild specimens and limited culturing success. At the National Aquarium, several colonies of *O. formosus* hydroids were successfully settled in static bins at 16-24℃ 4 weeks post-in vitro fertilization. Optimal temperature for hydroid growth was found to be 24℃, and medusae development was induced at 16℃. Initial attempts at rearing newly liberated medusae in flow-through bins on a diet of *Artemia* nauplii and rotifers yielded behaviors of food capture and active rejection of food. Observation of a novel luring behavior led to the realization that larval fish are a key food source for this species. Newly liberated medusae were housed in flow-through bins and fed larval fish from a 500,000 gallon Caribbean exhibit. As the medusa grew, larger fish were introduced to their diet increasing their growth exponentially. Using these techniques National Aquarium was able to complete the life cycle of *O. formosus* for the first time in captivity.

Culturing Live *Americamysis bahia* in an Existing System: Saving Money One Shrimp at a Time

Morgan Lindemayer, mlindemayer@neaq.org (617)226-2188
New England Aquarium, 1 Central Wharf, Boston, MA 02110
(Virtual Presentation)

Mysid shrimp, *Americamysis bahia*, are small crustaceans used in the aquarium industry as a specialized food item for sea dragons, seahorses, pipefish and cephalopods. They provide a high protein diet that has led to increased growth rates in several aquaculture species. Many institutions dedicate financial resources to ordering live mysids to support high maintenance and specialized species. The New England Aquarium has directed this expense into trialing and developing an in-house culture using a low-cost, low-maintenance, small foot print design utilizing an existing system. This culture will serve to put money back into the aquarium and increase our sustainability. Controlling the culture conditions of our live foods gives us more control over what we are adding to our tanks and feeding our fishes, leading to a more successful and viable collection.

Thursday, February 24th
Session 11: Husbandry Techniques 2 (continued)

Sponsor Presentation:
Fritz Industries

Something to Shellibrate: Refining Husbandry for Successful Springsnail Propagation

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Arizona Center for Nature Conservation/Phoenix Zoo

Hydrobiid snails are very small, gill-breathing mollusks inhabiting freshwater seeps, streams, and springs. Twelve species of Hydrobiid springsnails in the genus *Pyrgulopsis* are native to Arizona, with all considered Species of Greatest Conservation Need. At the Arizona Center for Nature Conservation/ Phoenix Zoo (ACNC), we work in partnership with Arizona Game and Fish Department (AZGFD) and U.S. Fish and Wildlife Service (USFWS) to establish *ex situ* conservation programs. The goal of these programs is to successfully create breeding populations of springsnails that will produce offspring for future augmentation and repatriation of wild sites. We have housed four different *Pyrgulopsis* species since 2008, including one endangered and one threatened species under the ESA. Over the years we have refined tank design, life support, and water chemistry to improve our husbandry, which has led to increased reproductive success.

Recently, we have successfully reproduced Huachuca springsnails (*P. thompsoni*) and observed emergence of juveniles year-round. In this species, we have also observed exponential population growth, temporal activity patterns, and habitat preferences. We aim to apply the knowledge gained from our success with *P. thompsoni* to the recently acquired, threatened San Bernardino springsnail (*P. bernardina*), which is known to exist at a single spring in the U.S and two sites in Mexico.

Nurse Sharks Anyone? D.I.Y. Long Distance Shark Transport

Chris Spaulding, Chris.Spaulding@pdza.org
Point Defiance Zoo & Aquarium

The transportation of sharks across multiple states in excess of 2300 miles is not groundbreaking. However, executing the coordination, fabrication, and transportation itself completely from within an organization can be a significant and sometimes impossible undertaking for many facilities. In the fall of 2021, Point Defiance Zoo & Aquarium completed a sixty hour transport of six adult nurse sharks across six states, all supported by in-house efforts and expertise. Information regarding the construction of transport containers out of plywood, coordination of mobilization logistics, including emergency support from aquarium colleagues, and remote water quality monitoring will be among the items discussed. Not to mention, in the midst of a global pandemic, why would anyone do such a thing, and who in the world would be willing to take one, no six, for the team? All that and more will be discussed in an effort to share knowledge, lessons learned, and a good old fashioned shark transport story for the industry archives.

Growth and Feeding Strategies in the Husbandry of *Mola mola*

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The Ocean sunfish *(Mola mola*) is an enigmatic species, with many aspects of its biology and life cycle still requiring further investigation and understanding. Its nutritional requirements are a central topic of interest, as feeding strategies are key to ensure good husbandry practices. Fine tuning their diet regime should promote captive specimens' overall condition and growth. There are different management methods being applied from various institutions over the world and while some maintain a consistent percent BW per day ration, others apply an adjusted percentage according to the animal's development. Across institutions, BW percentages offered daily, vary from 5-6% at early stages to less than 1% for over 100Kg animals, distributed in one to six meals per day. Combining data from wild sunfish diet research and food consumption rates collected from captive animals we present key factors to define a feeding regime specific for this species. Institutions must not assume that one rule fits it all as there are important factors to consider. Aquarium systems, rearing parameters, animal's condition, and metabolism also impact the feeding regime and thus, must be evaluated continuously to apply the best practices to enhance longevity of these spectacular animals on display.

Culture and Display of the Ctenophore, *Beroe cucumis*

Josh Wagner, jwagner@lbaop.org
Aquarium of the Pacific
(Virtual Presentation)
Full article appears in this issue

With approximately 200 described species of ctenophores, representation at public aquariums in the United States is usually contained to one or two species. With their light reflecting comb rows and alien like bodies, ctenophores make for dramatic jelly displays. Ctenophores from the genus *Beroe* are particularly fascinating specimens. With a large mouth and ovoid shape, they look like nothing else normally displayed as a "jelly". Due to their specialized diet of other ctenophores, they are a challenging species to work with and not very common. The species *Beroe cucumis* has a global distribution and specializes on cydippid and lobate ctenophores as prey. Using cultured *Mnemiopsis leidyi* as a food source, the Aquarium of the Pacific has been able to learn techniques for the successful culture and display of this species. *B. ovata* was also discussed.

Thursday, February 24th
Session 12: Sustainable Collections

Aquatic Sustainability the Next Steps

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[1]Walt Disney World, Living Seas Animal Care, [2]John G. Shedd Aquarium, [3]Shark Reef Aquarium at Mandalay Bay

The AZA Aquatic Collections Sustainability Committee has been actively developing new tools, resources and recommendations for how we can improve the sustainability of our aquatic exhibits. Each facility is unique and have different needs and access to resources. Decision management is the first step to ensuring animal populations are not only sourced appropriately, but that welfare, longevity, reproduction potential and facility expertise are considered.

The focus of this talk will be on collection planning with an emphasis on options to increase sustainability in our aquariums and zoos though the Larval Programs Distribution Model with supporting Sustainability Fund. This presentation will overview the teams within the ACSC, the areas of work, and how these efforts need the input and support of the RAW community.

Endangered Fish, on Sale Cheap in the Back of a Denny's

Steve Bitter, steve@aquariumattheboardwalk.com
Aquarium at the Boardwalk

Lots of interesting and aquarium-suitable species have been collected and bred by dedicated aquarium hobbyists. As a freshwater fish extinction crisis looms, many of these species have become endangered or extinct in the wild, and now only exist in the hands of private breeders, often far from their native range. While many species are commercially viable and can be found at big box pet stores, many more are not, and have been remarkably well curated for decades in the hands of relatively few hobbyists. These hobbyists are loosely organized into breeding groups and clubs that focus on killifish, livebearers, and cichlids. However, in recent years these clubs are mostly trending downward. Their leaders and members are aging, and the fish they curate are at risk of becoming extinct in the hobby. Public aquariums don't historically engage this group very well, despite our missions of preserving species, and the low difficulty level of propagating many of these fish. I'll provide my recent experiences with learning about and raising some of these fish, and how rewarding it's been engaging killifish and livebearer clubs.

Using Data for Sustainable Collection Planning and Conservation

Sandy Trautwein, Ph.D., Director of Aquatic Conservation and Product Management
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Species360

Recent data on the most financially successful aquariums indicates that being good at your mission is more important than ever[2]. As the role of public aquariums continues to evolve, aquariums are seeking mission-based opportunities to promote their contributions to sustainability, animal rescue, and conservation. This presentation will review how data can help the aquarium community transform animal records into powerful tools to help promote our collective achievements and positive impact on the world.

[2] *"Future Aquarium Trends" webinar hosted by Species360; data provided by Impacts Experience.*

The Coral Reef Aquarium Fisheries Campaign: Year in Review

Paul A. Anderson, paul@aquariumfisheries.com
The Coral Reef Aquarium Fisheries Campaign

In 2021, The Coral Reef Aquarium Fisheries Campaign took a comprehensive approach toward its goal of empowering sustainable coral reef aquarium fisheries that support biodiversity conservation, healthy coral reefs, and the livelihoods of fishers, traders, and others who depend on them across the global value chain. On advancing policy, the Campaign completed an analysis of the regulatory landscape for marine aquarium fish fisheries in the State of Florida, outlining a comparatively robust regulatory framework. Accordingly, trends in catch data have remained largely stable or on the incline over time. The Campaign also works to upgrade the value chain of aquarium fishes. On this front, we've identified genes in fishes that respond to cyanide exposure in clownfish, guiding us to target the enzymes they produce in developing a field test. Meanwhile, Mystic Aquarium volunteers completed a nationwide canvass of ~3,200 marine aquarium businesses that we can engage to understand the U.S. trade and help them achieve environmental and economic sustainability in business operations. The Marine Science Magnet High School innovated a new educational experience for their kids while they pivoted to a hybrid model in the midst of the pandemic, sending lab kits...that is, aquarium kits...to students' homes to learn aquarium & aquaculture science. And finally, on the aquaculture R&D front, we've published a peer-reviewed research article to help aquaculturists increase aquaculture capacity for the royal gramma, one of the most popular marine aquarium fishes in the U.S. Come see us and find out what's in store for 2022!

Black Skates – Bruce Koike

A BRIEF GUIDE TO AUTHORS

Updated 2021

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

The approximate deadline for submissions is December 21st.

As always, typical Drum & Croaker articles are not peer-reviewed and content will not be edited, other than to correct obvious errors, clarify translations into English, modify incorrect or cumbersome formatting, or delete superfluous material. Other types of contributions (announcements, etc.) may be edited to meet space limitations.

As has always been the case, materials in *Drum and Croaker* may be reproduced unless otherwise specified. Occasionally articles appear in D&C that originated elsewhere. These must be obtained with approval from the original authors and publisher. Special instructions on the reuse of these papers and how they should be properly cited may be provided.

I expect and assume that all submissions to D&C (papers, photographs, etc.) have been authorized by all original authors or co-authors, do not infringe on any copyright or prior publication agreements, and have successfully completed any internal review process required by your institution.

Submit articles via email as a Microsoft Word document (or a file that can be opened in Word). **My E-mail address is petemohan55@gmail.com.**

All Articles Must Adhere to the Following Basic Format:

- Use justified, single-spaced, Times New Roman 12-point font throughout (except for the title section, and figure and table legends as noted below).
- A4 users please reformat to 8 ½ x 11-inch documents (North American "letter" size).
- Keep the resolution of photographs LOW. High resolution photos make the final PDF file huge and I always compress them anyway.
- **Format the title section with the line spacing set on 1.5 lines (not another method) and using centered, boldface font. Only the title should be CAPITALIZED (except italicized *Scientific namesii*)**. When using MS Word, go to the "Home" tab, open the detail on the "Paragraph" section, and choose "1.5 lines" under spacing and make sure the before and after spacing settings are at "zero". For these settings, see "Other Things I Whine About" below.
- Double-space after your "institution name" to begin the body of your text. When correct, the title and headings formatting should look like this:

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

Jill Fishhead, Senior Aquarist jfishhead@fishstinking.com

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

Text and Heading Format

Headings and text should look like the above heading and this paragraph. Use single spacing with 1" (2.54 cm) margins on ALL sides. Please indent/tab 0.5 inch (1.3 cm) at the beginning of each paragraph (not using the space bar!) and leave a single space between paragraphs. Justify the text (see toolbar options and note how pretty the right margin of this paragraph lines up!). Section headings should be in bold (as above) at the left margin.

Please use the following format for figure legends:

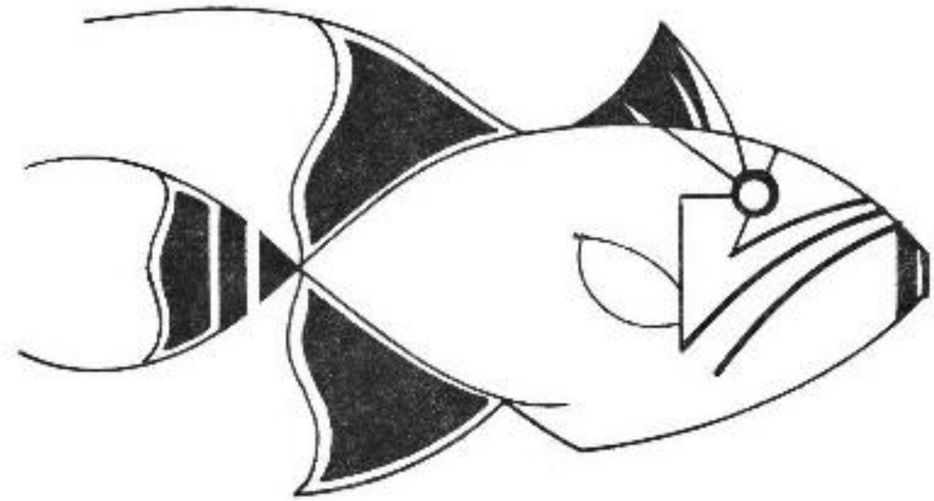


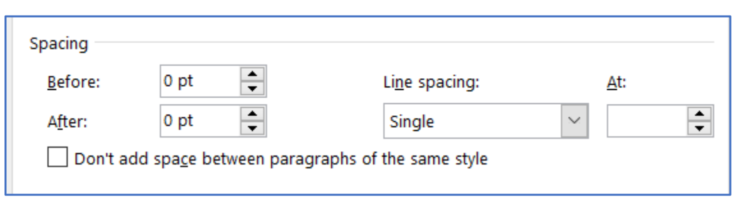
Figure 1. Legends should appear under the photo (such as this drawing by Craig Phillips) or graph in this format in 10-point font, aligned with the sides of the image or figure (center or justify). Very short legends can be centered. Photographs should be pasted into the document in the proper location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

Table Legends

Table legends go above the table. Otherwise, formatting is as above for figures.

Other Things I Whine About

- Please don't use Paragraph formatting to add spacing above or below lines. I have to remove all of these. Start with a single-spaced Word template, with NO before or after spacing. You will likely need to select this from the paragraph section on the home tab of Word, as the normal default template may contain unwanted 'before' or 'after' spacing.



- Use the "enter" key for all line spacings ("carriage return" for those who remember typewriters with a slidey thing on top).

- If you submit a table, put the data IN an actual table. Don't use the space bar or tabs to "line up stuff." This formatting can be lost if I have to change margins or otherwise reformat.
- Use the "tab" key to set your 0.5" indent at the start of each paragraph. It's likely your default. Don't use the space bar.
- Use bullets or numbers to make lists. It is easier to reformat these later if needed.

Short Contributions ("Ichthyological Notes")

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

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

Literature Cited

In the body of the paper, use this method to cite authors: (Phishmonger et al., 2008; Laurel and Hardy, 2009; Frazma, 1992).

When providing full references/citations at the end of a paper, use the citation style found in Copeia: https://asih.org/copeia/instructions-to-authors