An Automated Dwarf Seahorse Aquarium

This presentation details the development and construction of an automatic aquarium for simplified keeping of *Hippocampus zosterae* (Dwarf Seahorses). Dwarf Seahorses are considered difficult to keep due to their dependence upon needing to be fed enriched live food multiple times a day. An unattended aquarium which can continually hatch, enrich and feed *Artemia* (brine shrimp) for 7-10 days would enable many more hobbyists to successfully keep this species of seahorse. The basic concept is to divide a 76 liter (20 USG) tall aquarium into two separate compartments, the front compartment being a seahorse display/living area and the rear compartment where Artemnia are hatched and enriched. A mechanism is described and built which transfers the Artemia from the rear to the front compartment in a controlled manner. Water quality assurance systems are also provided.

9 Day Unattended Test Results

Frequently Asked Questions

Goal of this project: To develop a Dwarf Seahorse aquarium capable of 7-10 days of unattended automatic operation.

Completed aquarium setup *View of Interior* *Doors open*

Problems which needed to be solved

1. Transferring Artemia from the back compartment to the front in a controlled manner
2. Avoiding excessive bacterial growth in the rear compartment
3. Hatching/feeding/enriching the Artemia in the rear compartment and avoiding over feeding which causes water quality problems
4. Making daily partial seawater changes to keep the water quality acceptable
5. Biological filter to remove ammonia, nitrites and nitrates
6. Adequate water aeration and easily controllable circulation velocity
7. Easy to clean systems
8. pH control
9. Keeping Artemia food/enrichment from spoiling at room temperature
10. Lighting control
11. Returning uneaten live Artemia from the display/living compartment to the rear enrichment compartment where they can be grown and re-enriched
12. Replenishment of newly hatched Artemia into the system
13. Limit water volume of the display compartment to around 19-27 Liters (5-7 USG) to keep the Artemia density high
14. Design the aquarium to be aesthetically pleasing
15. Provide rear compartment biological filtration
16. Maintaining a salinity of 50-60 ppt the the rear compartment

Solutions

1. A moving sieve was designed using an Arduino microcontroller and a small servo motor.
2. The rear compartment is kept at room temperature (20-22 C or 68-72 F) degrees and at a salinity around 55 ppt. Artemia easily tolerate this high salinity level whereas pathogenic bacteria have significant growth problems in high salinity water.
3. Artemia nourishment/enrichment is provided by pumping small amounts of food multiple times per day into the rear compartment using a programmable peristaltic pump and magnetic stirrer controlled by a laser turbidity sensor and timer.
4. 400ml of fresh saltwater (Instant Ocean with RO/DI water) at a salinity of 30-35 ppt is pumped into the front display compartment 4 times per day by a programmable peristaltic pump. The excess water overflows the compartment divider into the rear compartment. The rear compartment has an overflow which drains into a 19 liter (5 USG) bucket providing about 15 liters (4 USG) of capacity (9 days). The flow rate could be temporarily reduced to obtain longer periods of no maintenance.
5. A small plastic HOB (Hang on back) filter containing Seachem Matrix is hung on the divider inside the rear compartment. 10-12 liters/hour of water from the front compartment is pumped through the filter and overflows back into the front compartment. This filter effectively removes ammonia, nitrites and (amazingly) nitrates from the seawater after a 2 month initial biological cycle.
6. A PVC pipe bubble riser tube is integrated with the PVC divider and protrudes into the rear compartment. The screened water intake is near the bottom of the front compartment. Air is bubbled up the riser tube and water flows back into the front compartment. The current flow in the front compartment can be optimally adjusted by varying the amount of air introduced into the riser tube. This design has a bubble capture chamber so that almost no bubbles reach the display compartment.

7. The moving sieve and bio-filter are easy to remove and replace facilitating easy cleaning. The aquarium is bare bottom with plastic grass plants.
8. A peristaltic doser pumps a small amount of Seachem Marine Buffer into the rear compartment to maintain a pH of 7.8 to 8.0. Due to the frequent water replacement, the front compartment does not need any buffer added after the compartment has been fully cycled.
9. The Artemia enrichment food is made with saturated brine water and does not spoil over a ten day period, even at room temperature. A peristaltic doser pump is used to pump food into the rear compartment. A magnetic stirrer is used to mix up the food in the container and is activated only when the doser pump is active.
10. An LED multi-color lighting panel has been glued to the plastic aquarium lid. An internet powerstrip timer is used to set the day/night cycle times.
11. A sieve is used to collect uneaten artemia from the water entering the filter. Every four hours a small pump is activated. The Artemia are pumped back into the rear compartment where they can be re-enriched and grown out so multiple sizes of enriched Artemia are produced to feed the seahorses.
12. Decapped Artemia cysts are added to the enrichment food and pumped together with the food into the rear compartment. The Artemia hatch in about 48-72 hours in the high salinity water.
13. The aquarium is filled only 60% full of seawater, which allows space for the feeding sieve to operate.
14. Blackout film is used to cover the glass at the waterline to hide the feeding apparatus. The back, bottom, and sides are also covered with blackout film. The system was placed on a small bachelor's chest with a lower space large enough to contain a 19 liter (5 USG) wastewater bucket, a 19 liter (5 USG) replacement seawater aquarium, timers, air pump, artemia enrichment/food jar, magnetic stirrer and the pH buffer solution container.
15. Biological filtration is accomplished using a mesh bag filled with Seachem Matrix which is hung inside the rear compartment.
16. Brine is dosed daily into the rear compartment by the dosing pump to maintain 60 ppt salinity.

Comments:

1. The aquarium has been in continuous operation since August 2019 following a 2 month cycle. Saltwater Mollies were added to prove and refine the aquarium operational characteristics. The Mollies were removed and eleven adult seahorses were added in October 2019.
2. The seahorses have done well. One died in December 2019 and was observed to have no visual or microscopic problems. Dwarves have a short lifespan of 1.5 years so it may have succumbed to old age. All others have done well. Several batches of fry have been birthed. I made little attempt to rear the fry and just left them in the aquarium. Seven have survived and grown to juveniles and adults.
3. The servo motor's action became jerky. The servo was removed and replaced. It is not known why the motor failed after a few months. I plan to disassemble the motor to determine the cause of failure.
4. I have investigated the best method to replenish Artemia into the system. I have tried mixing decapped cysts into the enrichment food, adding decapped cysts directly to the rear compartment and adding decapped cysts to a tray in the front compartment filter. All methods seem to work. I have chosen to mix decapped Artemia into the enrichment container so new decapped Artemia cysts are added daily to the rear compartment. They continually hatch and replenish the supply of Artemia.
5. A water level float switch was added to ensure the Artemia reclamation system does not reduce the seawater level in the front compartment to a very low level (in the case of a malfunction of the internet power switch).
6. The biggest issue I have had is adding the correct amount of Artemia enrichment/food into the rear compartment. As the Artemia grow, they eat more than when they are small. Therefore an increasing amount needs to be added to insure proper enrichment. To resolve this issue, I have designed and built a laser turbidity sensor which automatically adjusts the amount of enrichment/food added.

Cleaning Duties
I perform one or two of these tasks daily to spread out the work. But all can be performed on the same day if you are going on vacation for 7-10 days.

Restocking supplies (weekly)
Empty the overflow bucket. (2 minutes)
Fill the new seawater tank. (5 minutes)
Fill the buffer comatiner. (2 minutes)
Clean and fIll the enrichment container (2 minutes)
FIll the salt brine container (2 minutes)

Cleaning the front compartment (weekly)
A wand type cleaner was constructed out of expanded PCV and a non-abrasive pad to clean the painted divider.
Clean the painted divider. (3 minutes)
Clean the water intake screen with the wand cleaner. (1 minute)
Clean the interior glass surfaces with a magnetic glass cleaner. (3 minutes)
Remove and clean the plastic plants. (10 minutes, takes a while to get the seahorses off the plants)
Siphon the waste off the bottom and add replacement water. (5 minutes)
Clean the exterior glass surfaces. (3 minutes)

Cleaning the rear compartment (weekly)

Clean the glass area where the laser shines through the aquarium glass. (1 minute)
Remove the feeder mechanism and bio-filter. (2 minutes)
Clean the outside bottom of the bio-filter with paper towels to remove any waste. (2 minutes)
Use a pipe cleaner to clean the Artemia recovery water line. (2 minutes)
Siphon the waste off the bottom of the rear compartment and add some replacement water. (5 minutes)
Replace the feeder mechanism and bio-filter. (2 minutes)
Clean the overflow screen with a jet of water from a wash-bottle. (1 minute)

Monthly Cleaning
Clean the two air-stones and Artemia reclamation pump inlet (6 minutes)

Frequently Asked Questions

Q. Dwarf seahorses need other live food such as mysis shrimp and copepods as well as BB.

A. Dwarf seahorses will do very well when fed highly enriched brine shrimp gut loaded with DHA, EPA and various algae and diatoms. The brine shrimp are not BB (baby brine), they are 3-21 day old brine shrimp which have a gut and are loaded with the enrichment before being fed to the seahorses. The sieve size selects only brine shrimp which have developed a gut and are larger than BB shrimp. Also, I regularly add tisbe and tigriopus californicus copepods to the front compartment. Both types of copepods mentioned grow in the rear compartment and larger copepods get moved by the sieve automatically to the front compartment. This system does not replace good dwarf seahorse management, It does, however, make it possible to feed dwarfs several times a day without manually doing anything for 7-10 days. The system is easily programmable to feed the Dwarf seahorses multiple times per day ensuring they stay well fed with nutritious food. I now have much more free time to enjoy watching the seahorses instead of hatching food and feeding them.

Q. What is the Volume of the front seahorse compartment?

A. Internal dimensions are 23.5” X 5.75” X 8.875” = 1199 cubic inches = 19.65 L = 5.2 USG

Q. How does the automatic feeder work?

A. There is a 300 micron sieve mounted on an arm which is connected to a small servo motor. The arm can swing through an arc of 300 degrees. This allows the sieve to dip into the rear compartment and submerge completely. It then stops for 2 seconds and then swings up out of the water and continues in an arc into the front compartment where it completely submerges, waits 2 seconds and then returns to the vertical start position. An Arduino microcontroller powers and controls the movement of the servo motor. The Arduino is programmed to repeat the feeding cycle for 10 repetitions. It then stops and waits for power to be removed by a timer. At feeding time, power is applied to the Arduino controller and the feeding cycle starts again. Many cycles can be programmed each day depending upon the number of seahorses in the aquarium. The Arduino and servo motor are enclosed in a waterproof plastic box and suspended above the aquarium divider by an aluminum hanger that does not contact any seawater. The sieve size was chosen to only collect the slightly larger Artemia that have developed a gut. Most all newly hatched (smaller) Artemia flow through the sieve and remain in the enrichment compartment for further growth and enrichment..

Q. How does the turbidity sensor in the rear compartment work and why is it necessary?

A. The turbidity sensor regulates the amount of Artemia enrichment pumped into the rear compartment. I have found this is necessary because the number of Artemia and their size determines how much food needs to be delivered to the compartment. If too much uneaten food is present, then bacteria will grow and kill the Artemia. If there is not enough food, they will starve and be under-enriched. A red laser is fired through the rear compartment when a feeding cycle is initiated by the aquarium timer. A phototransistor detects the amount of light it receives and will cut the feeding short if the seawater is too cloudy (turbid). This will keep from overfeeding the Artemia. It also allows the doser pump to continue feeding if the seawater is too clear (not enough food). This simple circuit maintains an appropriate amount of Artemia food in the rear compartment. When I manually put enrichment into the rear compartment, I most always ended up putting too much enrichment into the compartment which caused problems.

Q. What is the Artemia recycler and how does it work?

A. As any dwarf seahorse aquarium owner knows, most of the Artemia we add to our aquariums as food for the seahorses are not eaten and then go to decomposable waste on the bottom of the aquarium or caught in the filter. A way to recycle these uneaten Artemia has been devised and implemented in this system. A small water pump at the bottom of the riser tube diverts a small amount of seawater through a small water line into the bio-filter. This filter has a sieve which collects the uneaten Artemia and holds them. A few times each day, a small pump in the sieve activates and pumps the Artmia back into the rear Artemia enrichment compartment where they can feed on enrichment and be eventually picked up by the automatic feeder sieve and offered again as food to the seahorses.

Q. What Artemia enrichment should be used in the rear Artemia compartment?

A. I have tested my homemade enrichment which did not work well. Alyssa's Seahorse Savvy Brine Shrimp Enrichment has worked well. Others feeds may work equally well but have not been tested.

Q. What is a bubble riser tube and where is it?

A. The bubble riser tube is integrated into the ½" sheet PVC divider. The intake is low on the divider and the output is at the front compartment water line. A constant flow of water is drawn through the tube by the rising air bubbles and forced back into the front compartment. It is easy to control the water circulation force in the front compartment by varying the airflow to the airstone at the bottom of the riser tube. This makes adjusting the water circulation velocity easy so the Dwarfs can catch their food. The riser tube also has an air trap that collects most bubbles so they are not forced into the front compartment. The riser tube also efficiently assists O_2 and CO_2 gas exchange.

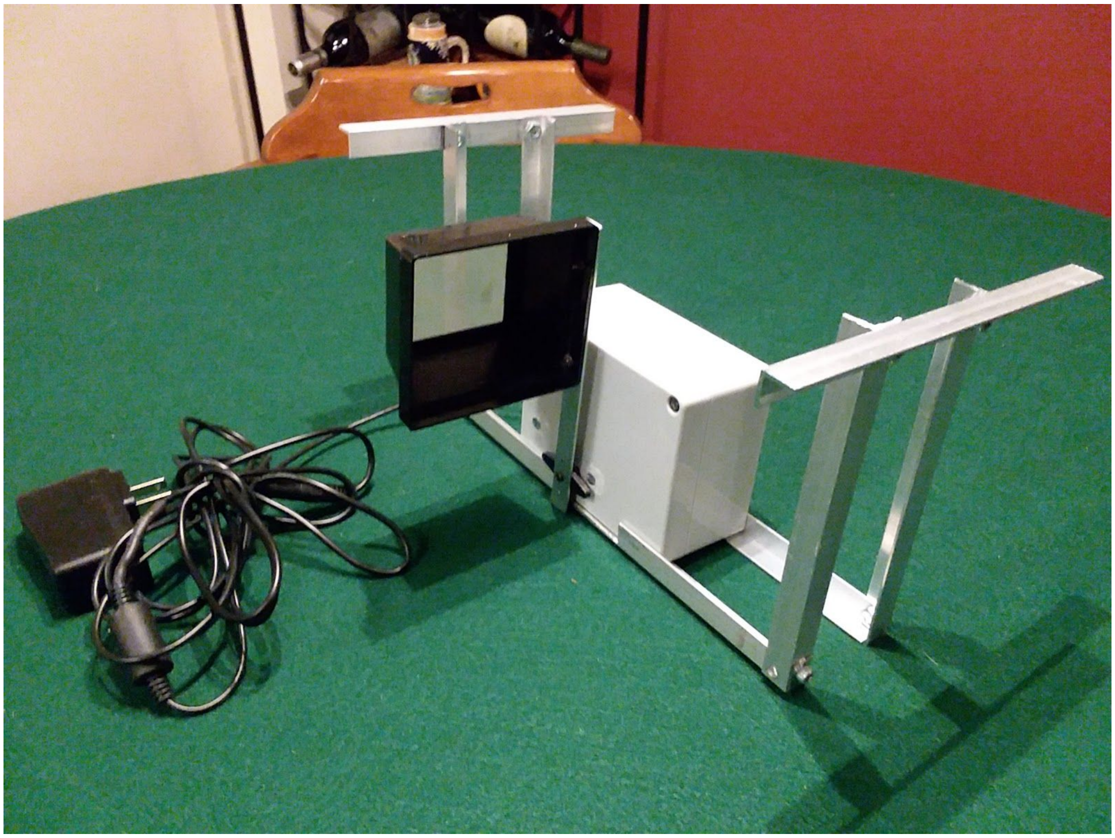
Q. Is there a way to separate the brine from their shells? Dwarfs can choke on the shells?

A. The brine shrimp cysts are decapped, so there are no shells. The decapped cysts are added to the enrichment container and get stocked into the rear compartment multiple times per day, sink to the bottom and hatch out continuously. The newly hatched shrimp are not picked up by the moving sieve since the holes are too large. They pass right through the sieve until they grow a bit and get enriched. So only shrimp that have been enriched get moved to the front seahorse compartment.

Aquarium and Equipment Cabinet with doors open

[Return to top](#)

Feeder Servo design



Return to Top

Click for video of Sieve in operation

Click for video of artemia in rear compartment

Click for image of artemia in rear compartment

The smart power strip turns the Arduino on and off. The Arduino program executes just once, then the power is removed. When power is again applied, the program executes and activates the servo. The Arduino microcontroller and servo are contained in the waterproof gray box.

Small Plastic HOB filter containing Seachem Matrix and Artemia Recycle Sieve

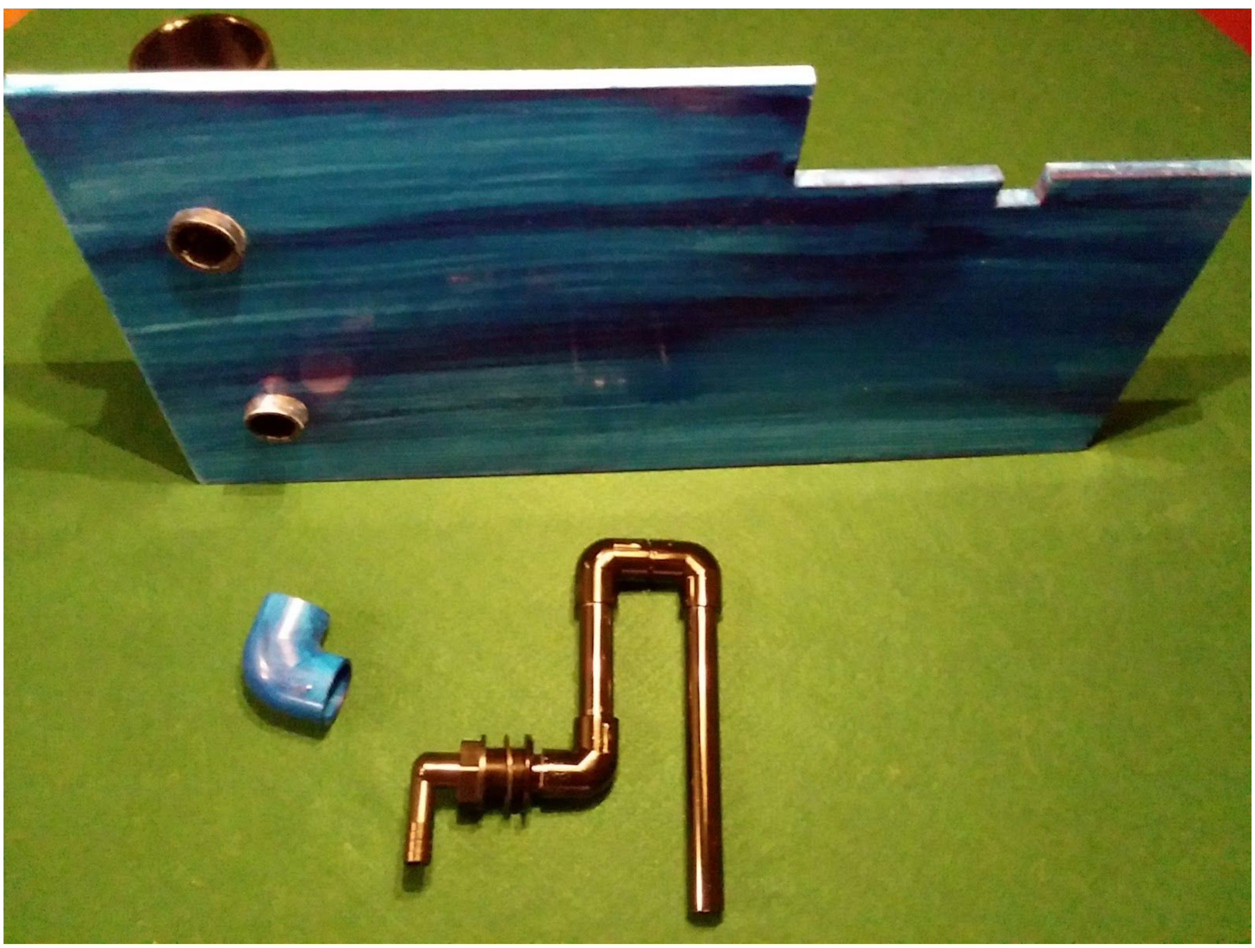
Return to Top

PVC pipe riser tube

A

Return to Top

Aquarium divider and overflow



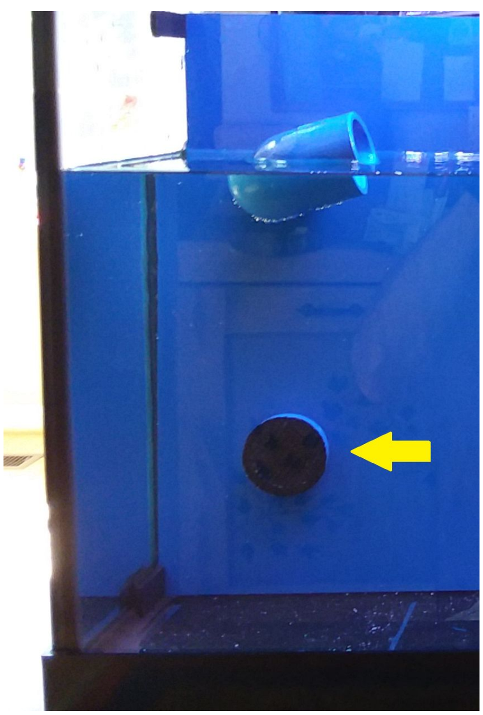
Return to Top

Rear compartment overflow

[Return to Top](#)

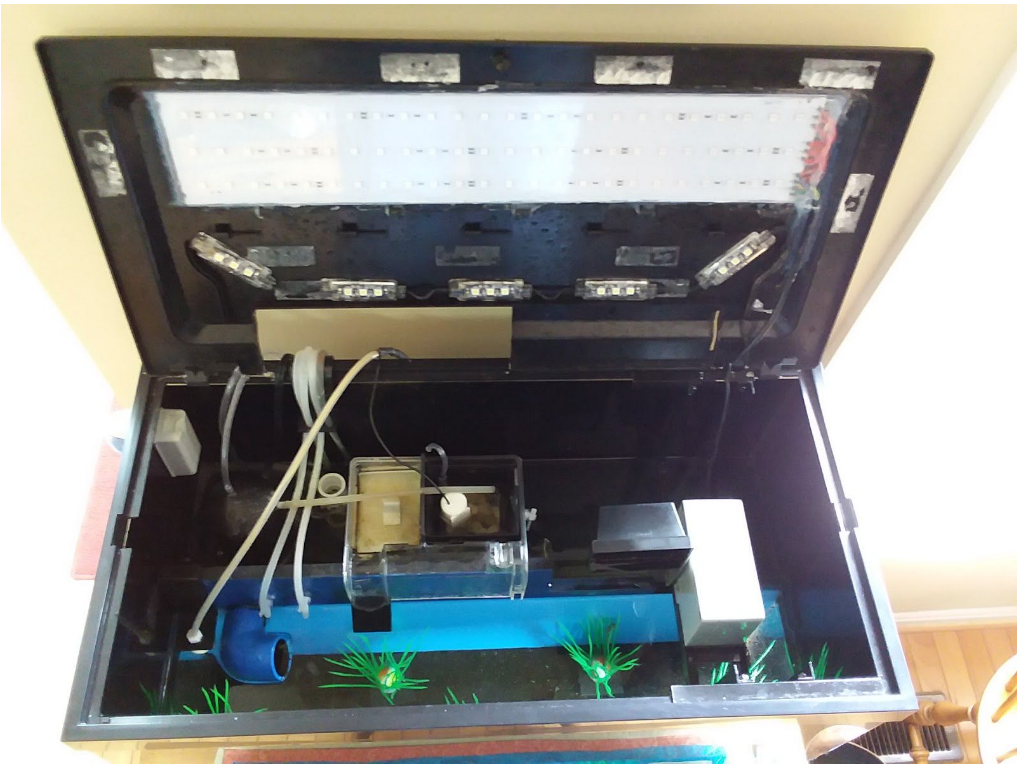
The non-tempered glass aquarium from Aquarium Masters was drilled and the overflow was installed. The white PVC was spray painted black before final assembly.

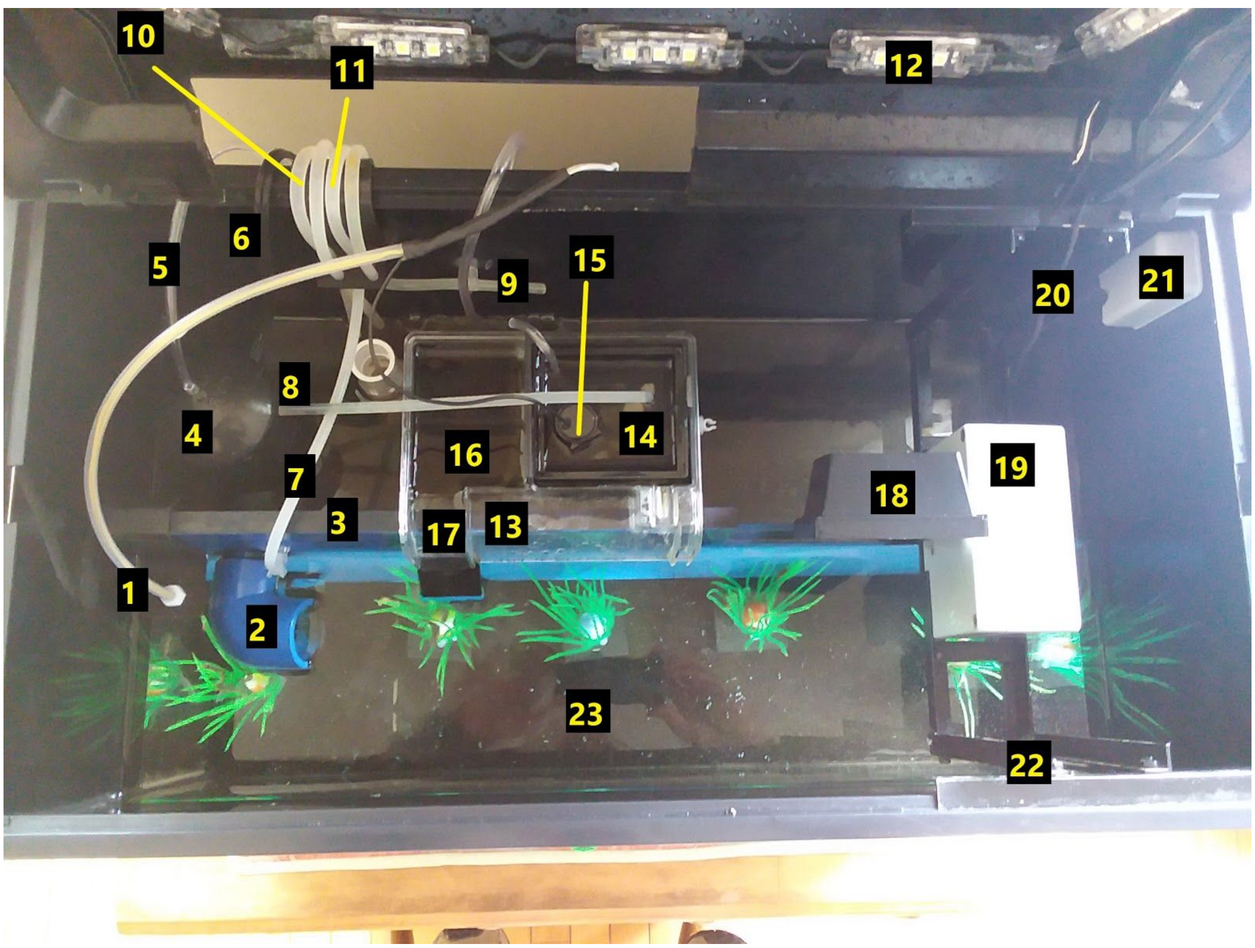
.Screened water intake



[Return to Top](#)

View of Interior





[Return to Top](#)

1. Level safety switch to assure Artemia recycle pump does not malfunction and slowly empty the front compartment into the rear compartment.
2. Outflow from bubble riser tube.
3. Divider made of ½” PVC sheet
4. Riser tube made of 2” PVC with cap
5. Airline from air pump
6. Power cord for the Artemia recycler pump
7. Fresh seawater line from doser pump
8. Small waterline from Artemia recycle pump
9. Artemia enrichment line from doser pump
10. Buffer line from doser pump
11. Brine line from doser pump
12. LED lights for rear compartment (not used)
13. Hang on filter for Artemia recycling and bio-filtration (SeaChem Matrix). Filter drains into the front compartment.
14. Artemia recycle sieve.
15. Small pump to move the Artemia from the recycle sieve to the rear compartment.
16. SeaChem Matrix compartment.
17. Return water flow from bio-filter
18. Artemia feeder sieve
19. Sieve servo motor and Arduino controller in waterproof box.
20. Power cord for sieve servo.
21. Magnetic glass cleaner.
22. Feeder sieve/servo support hanger.
23. Bare front compartment bottom.
24. Rear compartment overflow.

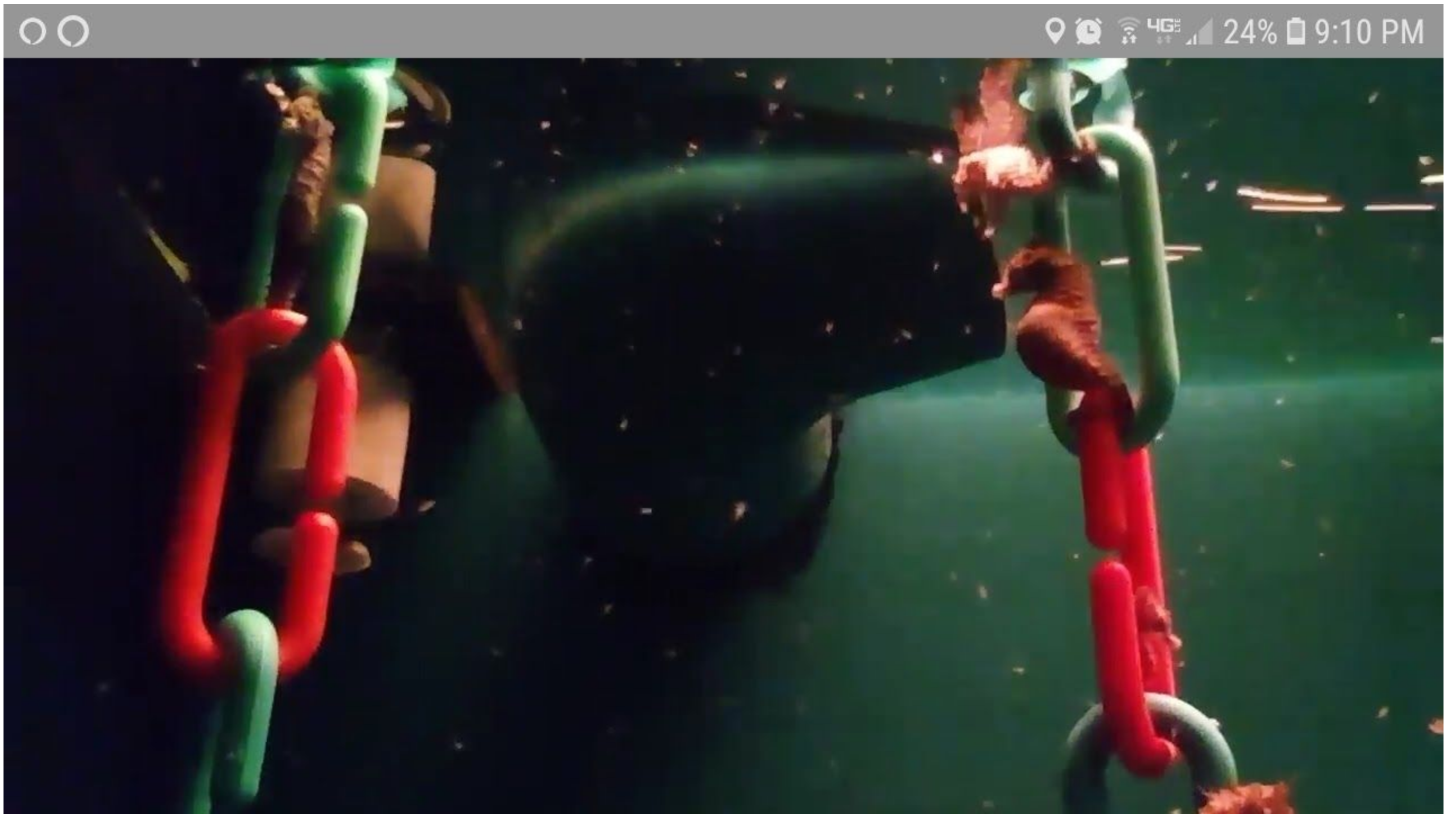
9 Day Unattended Test

The Automated Dwarf Seahorse Aquarium was left unattended while I was on vacation over the period of June 26, 2020 to July 5, 2020, a period of 9 days. I was able to use an Echo Show to drop in on the Aquarium each day to monitor the aquarium and perform a screen capture to get still pictures (available at the end of the linked document). The seahorses were well fed each day and there were no problems with the system. There was no algae growth visible. The bottom of the aquarium was no more dirty than normal. I usually siphon the bottom weekly, both front and back compartments. The Dwarf Seahorses were healthy and happy.

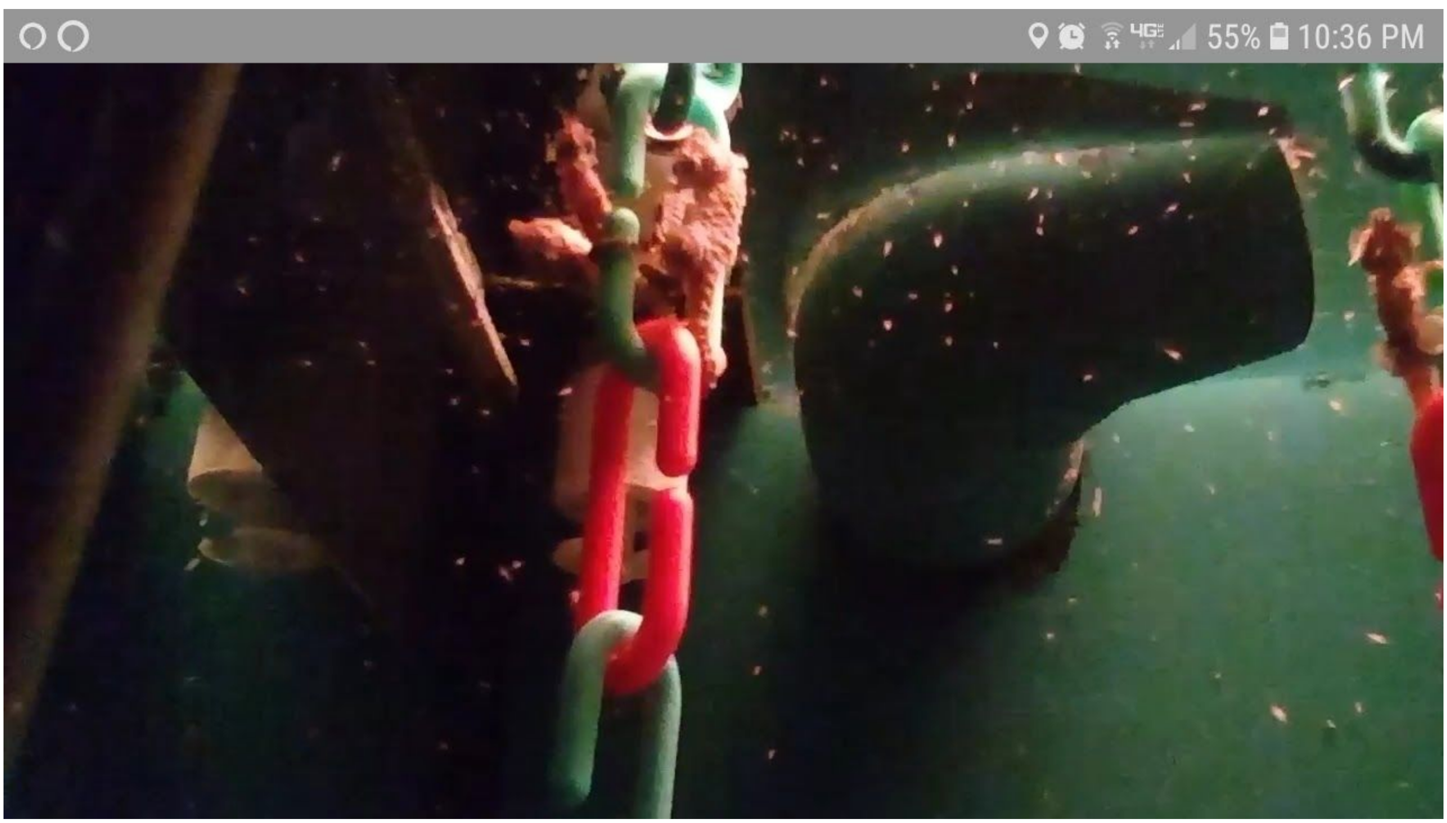
Doser pump schedule:

Saturated brine solution 50ml 4 times daily into rear brine shrimp compartment
167 ml of fresh seawater added to the front compartment 12 times daily
15 ml pH buffer added to rear compartment 4 times daily
20ml Brine Shrimp enrichment added to rear compartment 5 times daily
Automatic seahorse sieve feeder was set to operate 4 times daily.

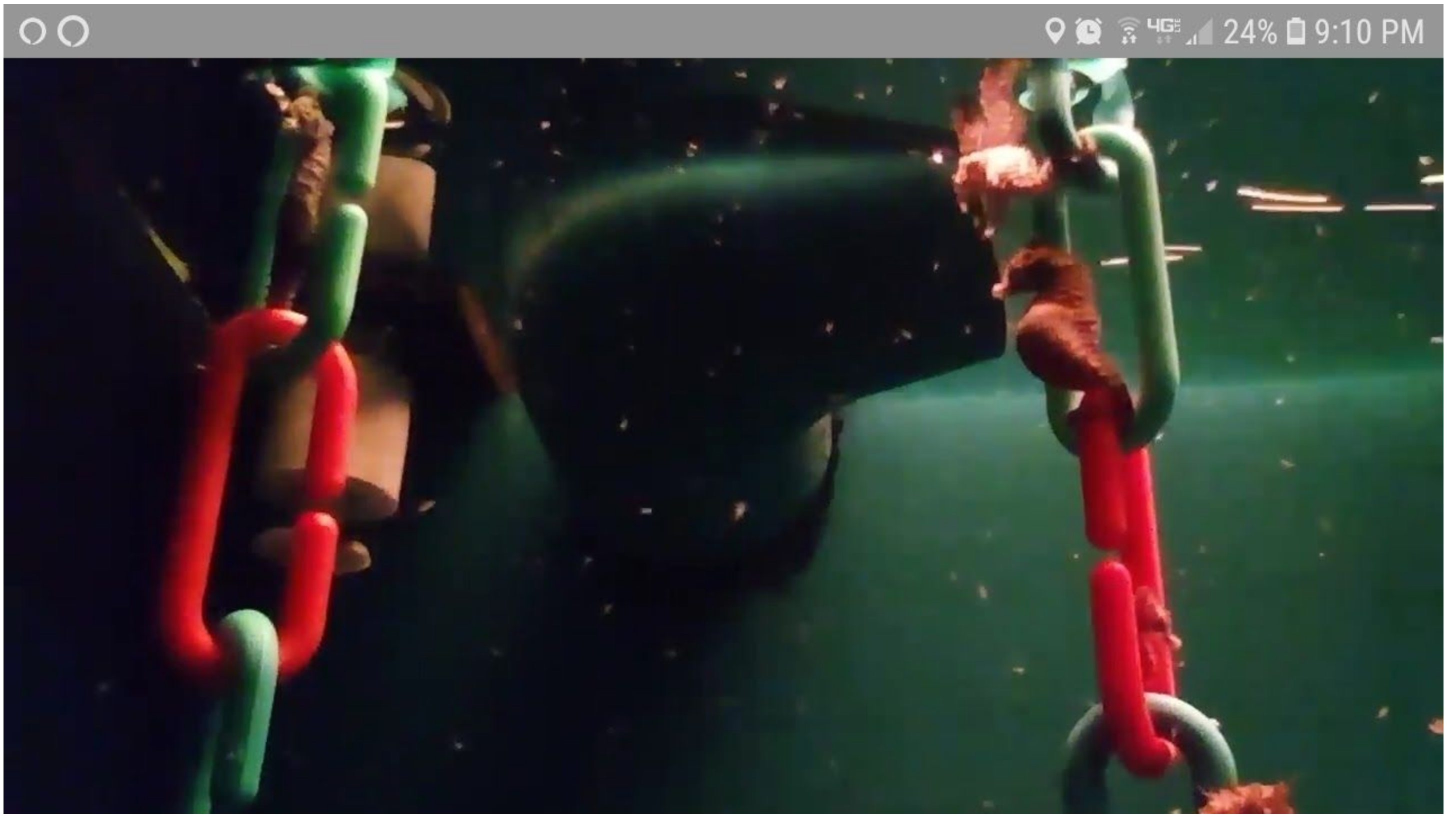
June26, 2020



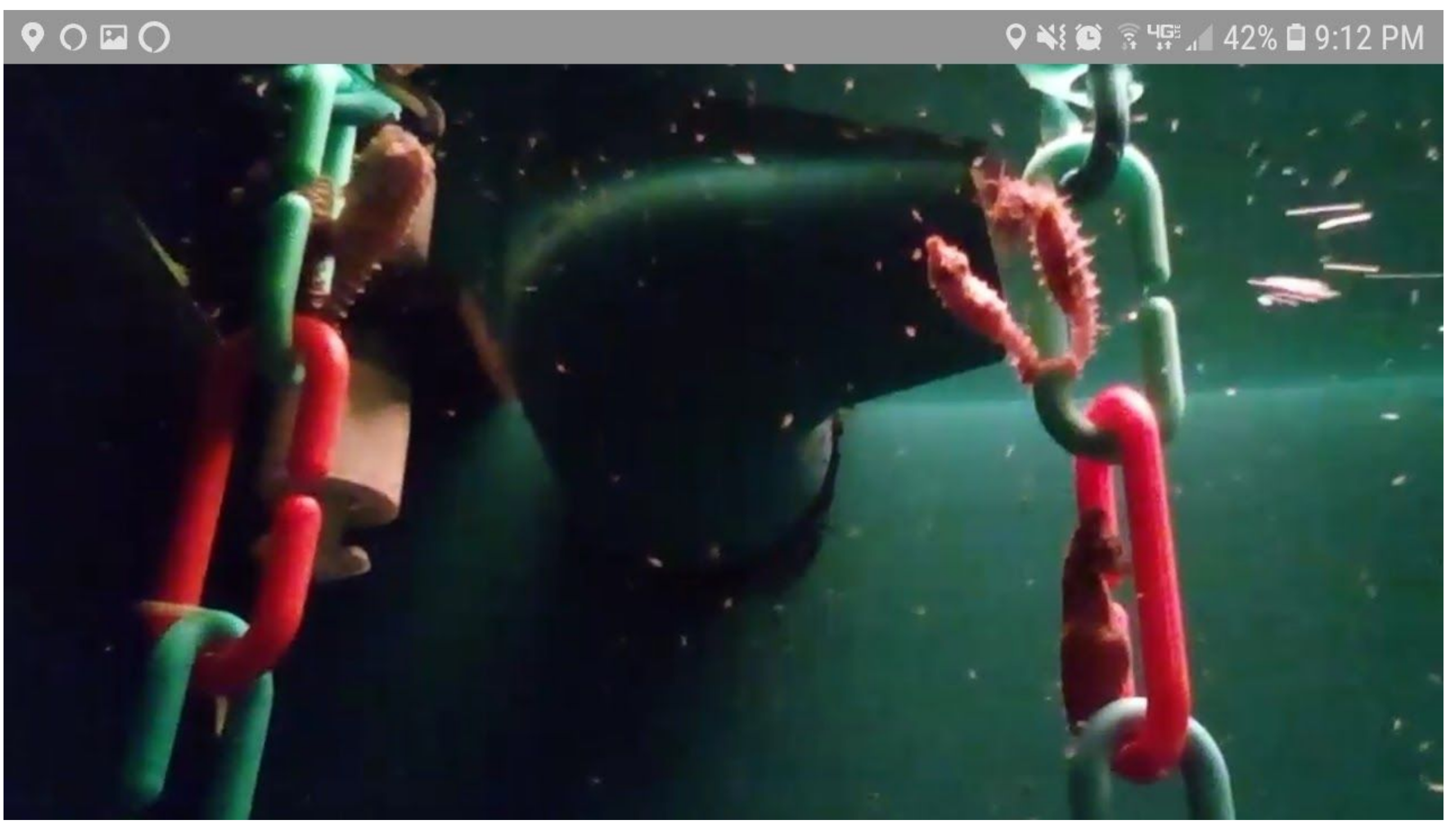
June 27, 2020



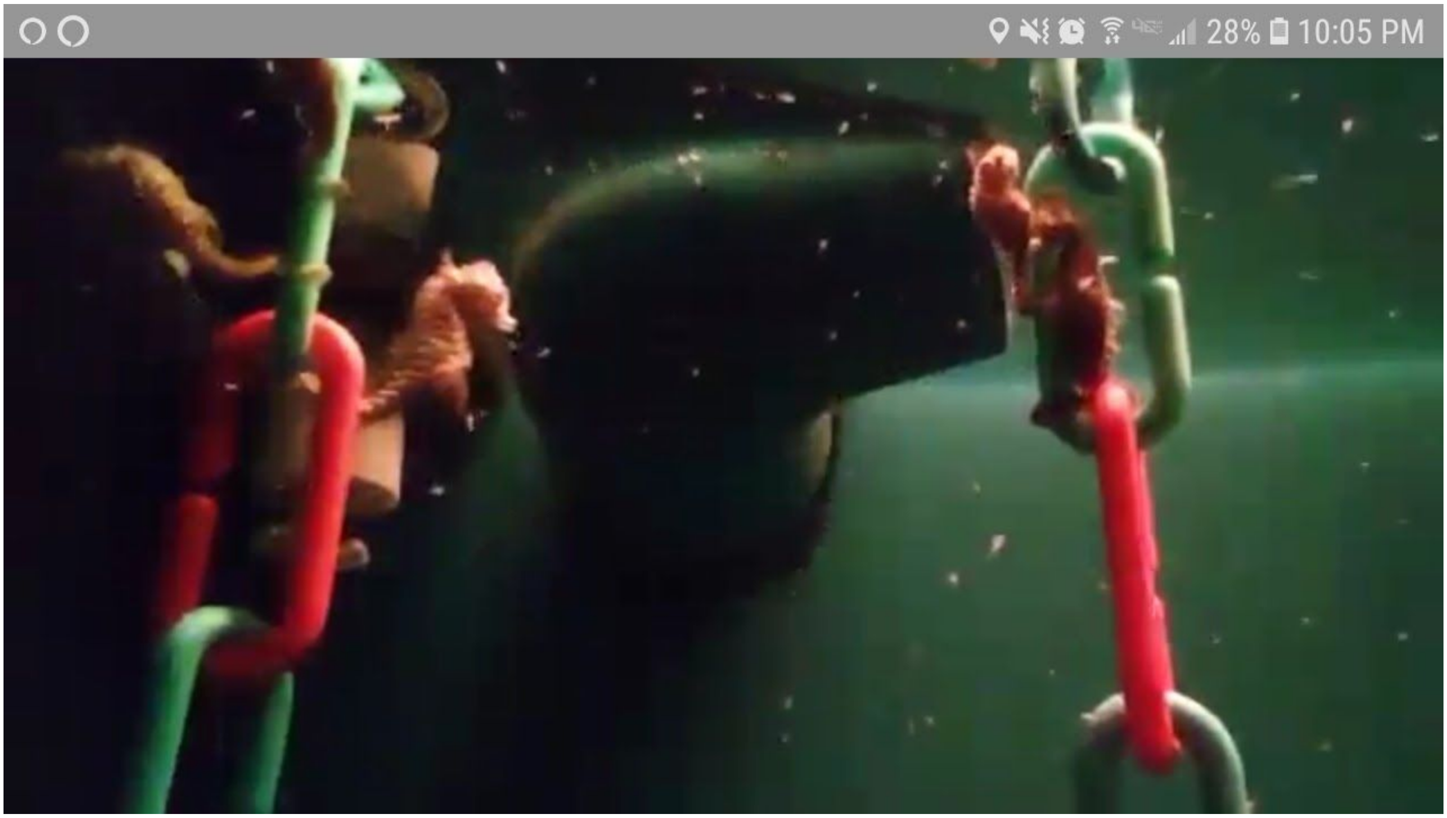
June 28, 2020



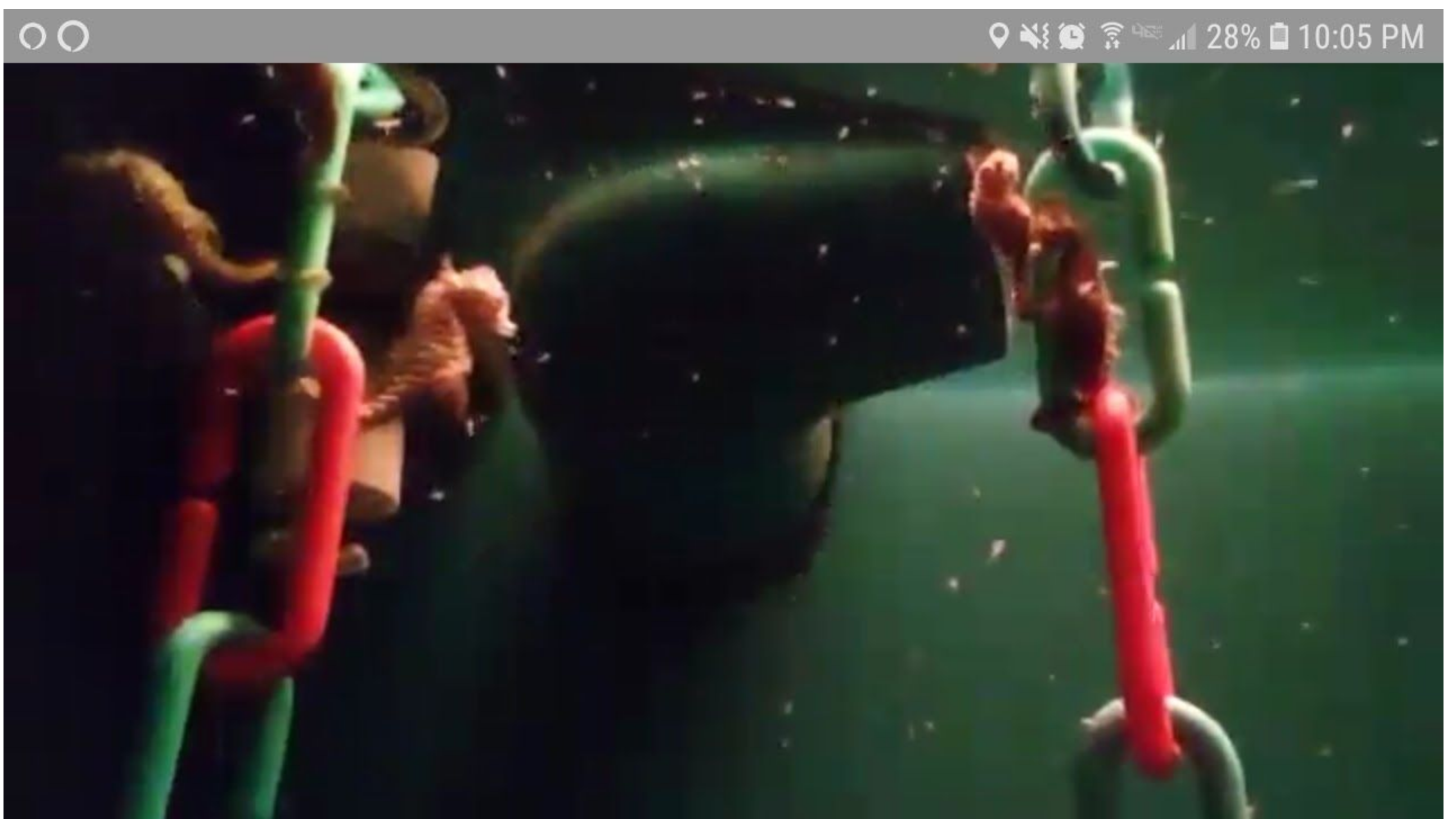
June 29, 2020



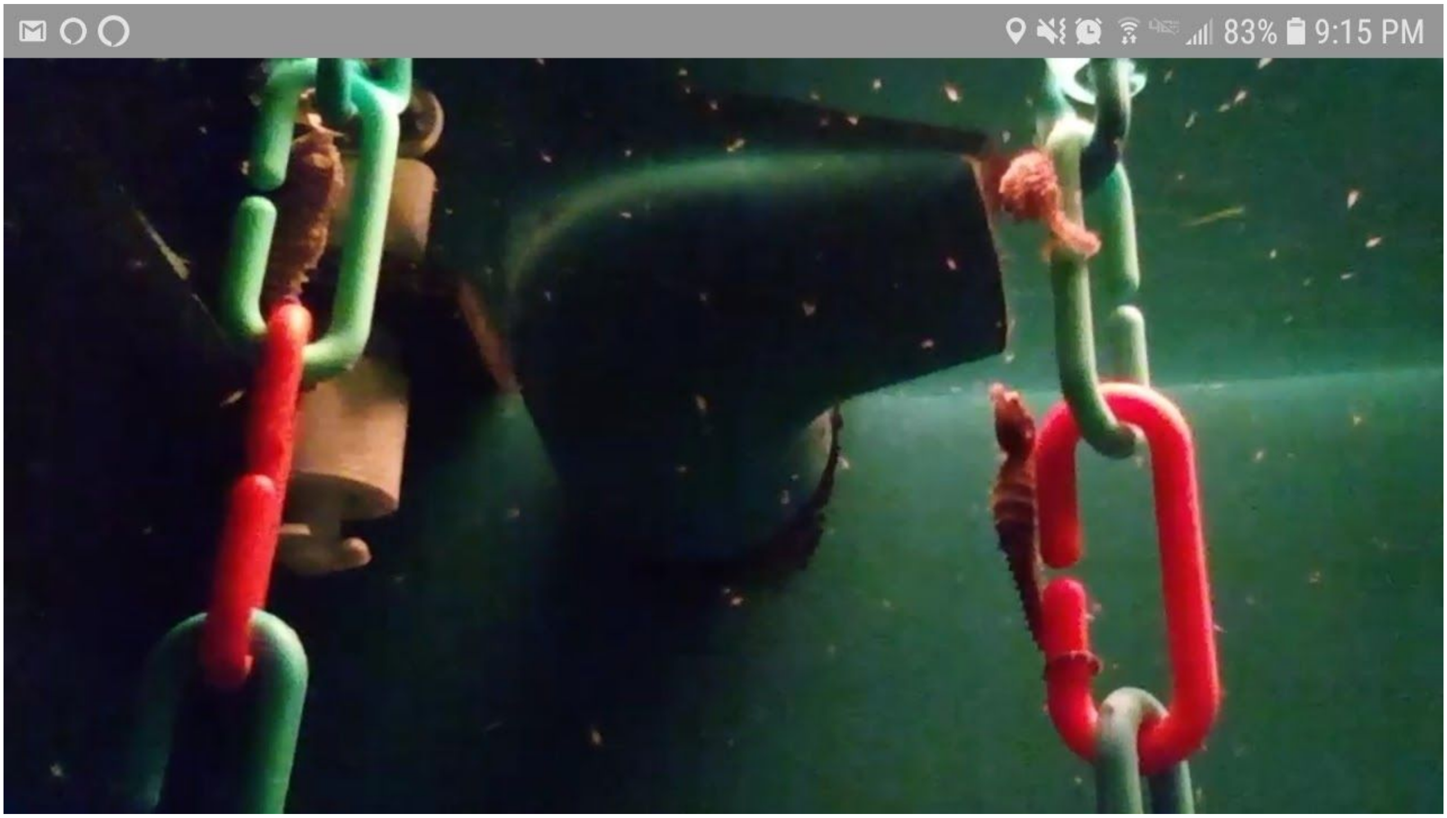
June 30, 2020



July 1, 2020



July 2, 2020



July 3, 2020