Applying Machine Learning to Oyster Reef Monitoring in the Chesapeake

CHESAPEAKE BAY FOUNDATION
Saving a National Treasure

Doug Myers, MD Senior Scientist
dmyers@cbf.org

Remote setting of Spat on Shell at CBF's Maryland Oyster Restoration Center in Shadyside

Spat on Shell loaded onto CBF's custom oyster restoration vessel Patricia Campbell

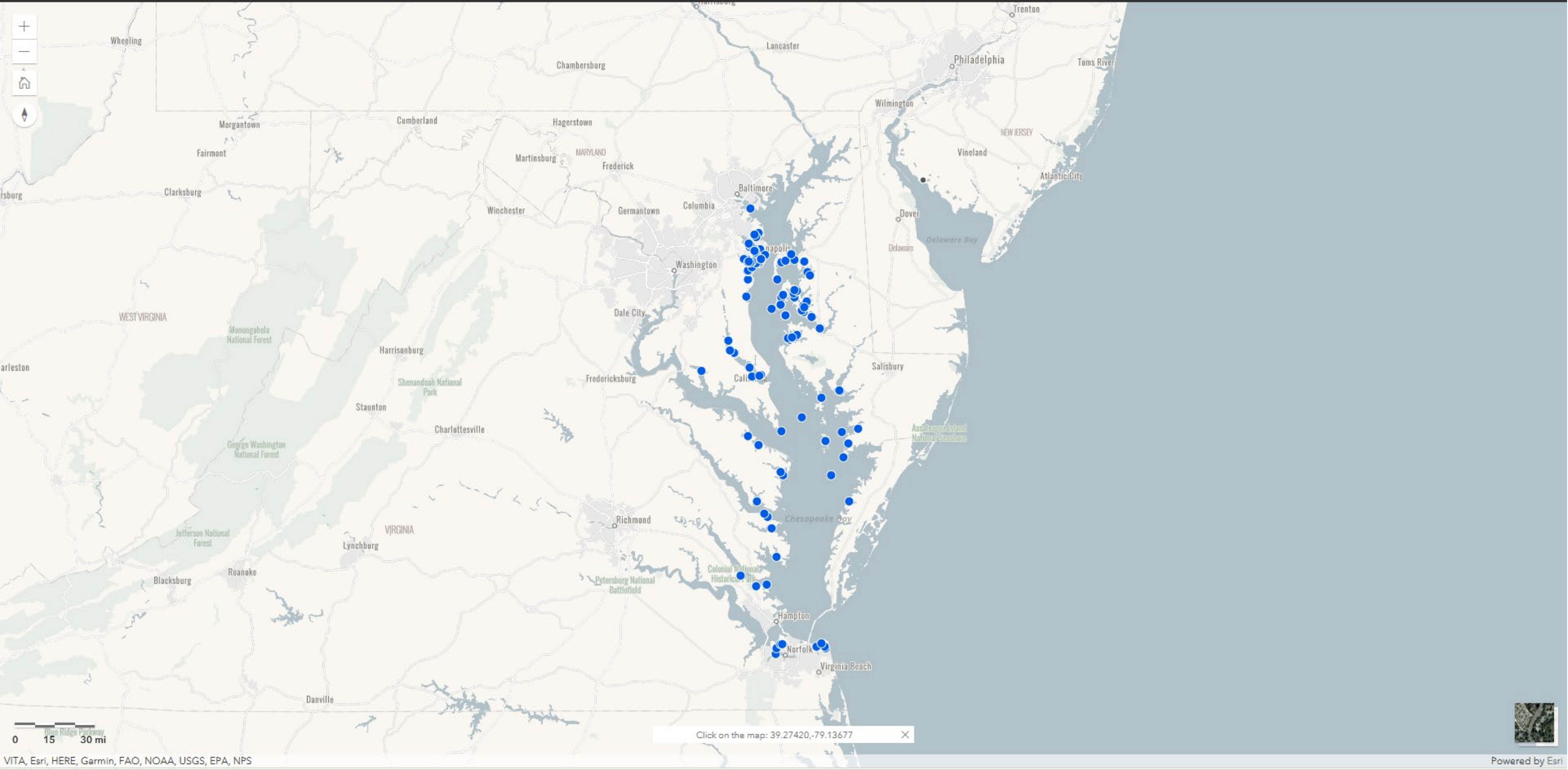
Oyster Gardening Program

Chesapeake Bay Foundation Oyster Restoration - Internet Explorer

http://cbforg.maps.arcgis.com/apps/Styler/index.html?appid=b17a4483c7334a719ae0cb19c944c094

Chesapeake Bay Foundation | Chesapeake Bay Foundation...

Chesapeake Bay Foundation Oyster Restoration



VITA, Esri, HERE, Garmin, FAO, NOAA, USGS, EPA, NPS

Powered by Esri

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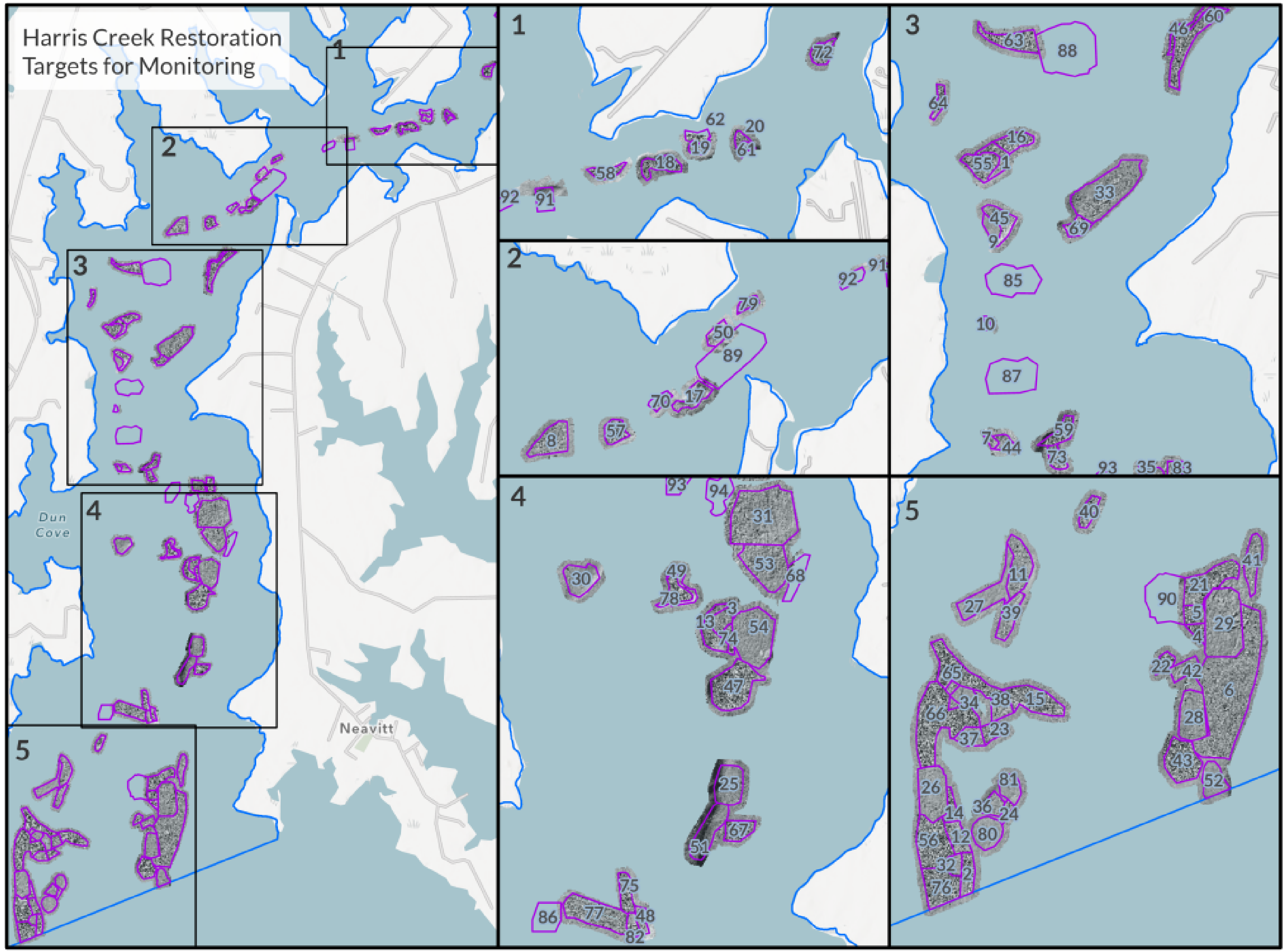


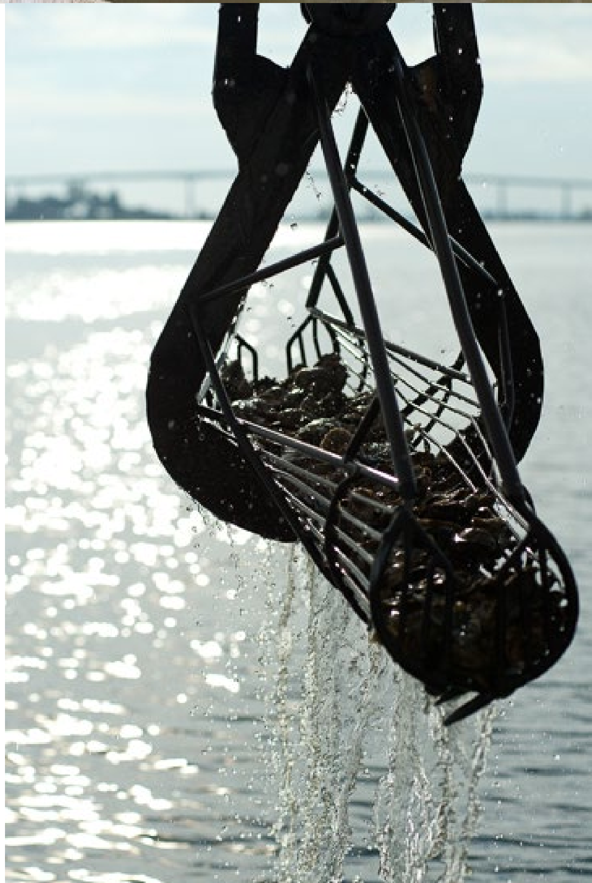
Map Created by: K. Leaverton | CBF Staff |3.18.2021

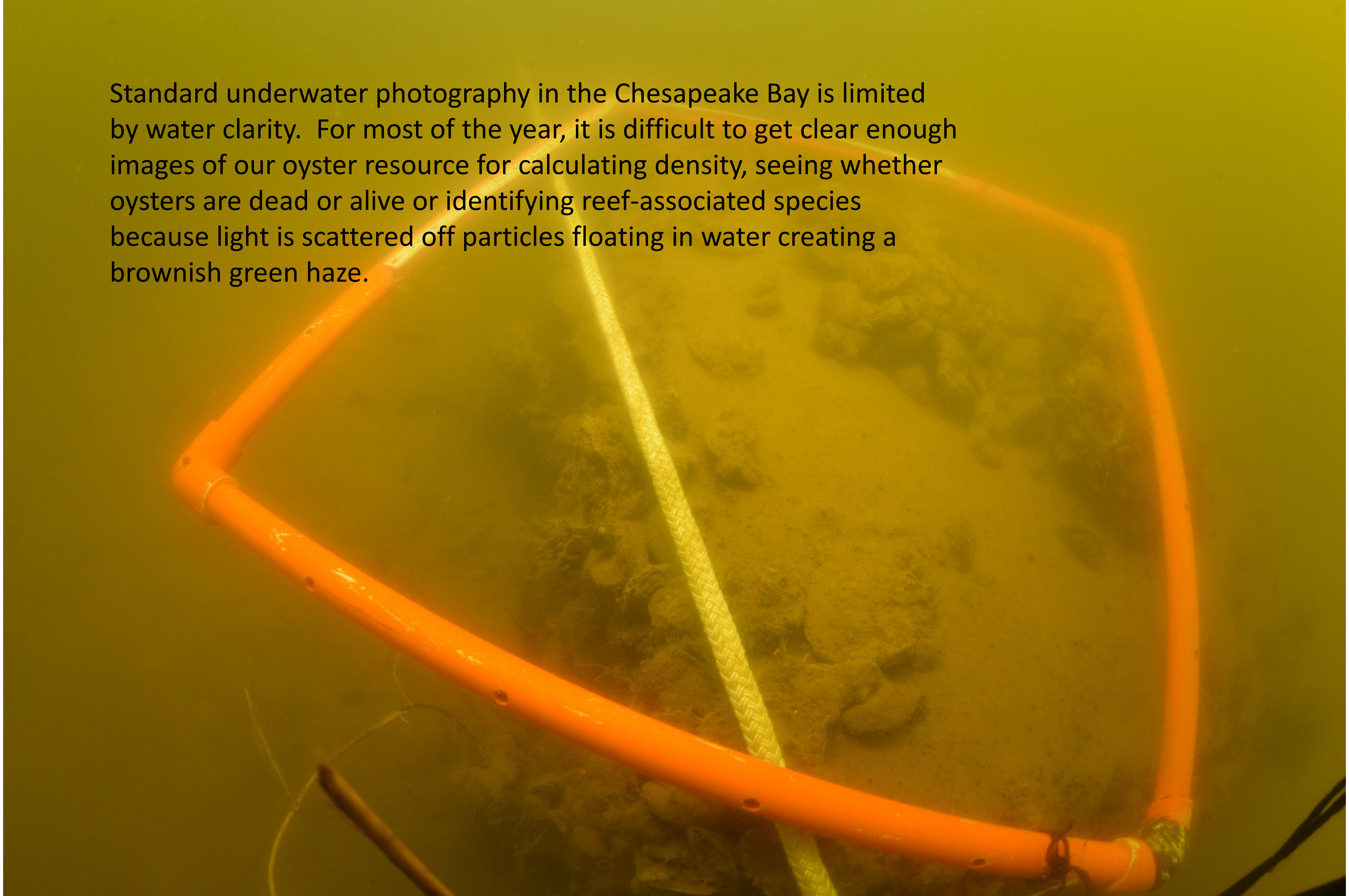
Where we were

Standard Destructive Sampling

Pros –
- Comprehensive metrics of density per square meter of bay bottom
- Comprehensive length frequency of measured oysters
- Ability to sample meat for biomass estimates

Cons –
- Small geographic coverage in a single field day
- Destroys reef structure
- Focuses on oyster production and not reef dynamics
- Long on-board or separate lab analysis required




Standard underwater photography in the Chesapeake Bay is limited by water clarity. For most of the year, it is difficult to get clear enough images of our oyster resource for calculating density, seeing whether oysters are dead or alive or identifying reef-associated species because light is scattered off particles floating in water creating a brownish green haze.

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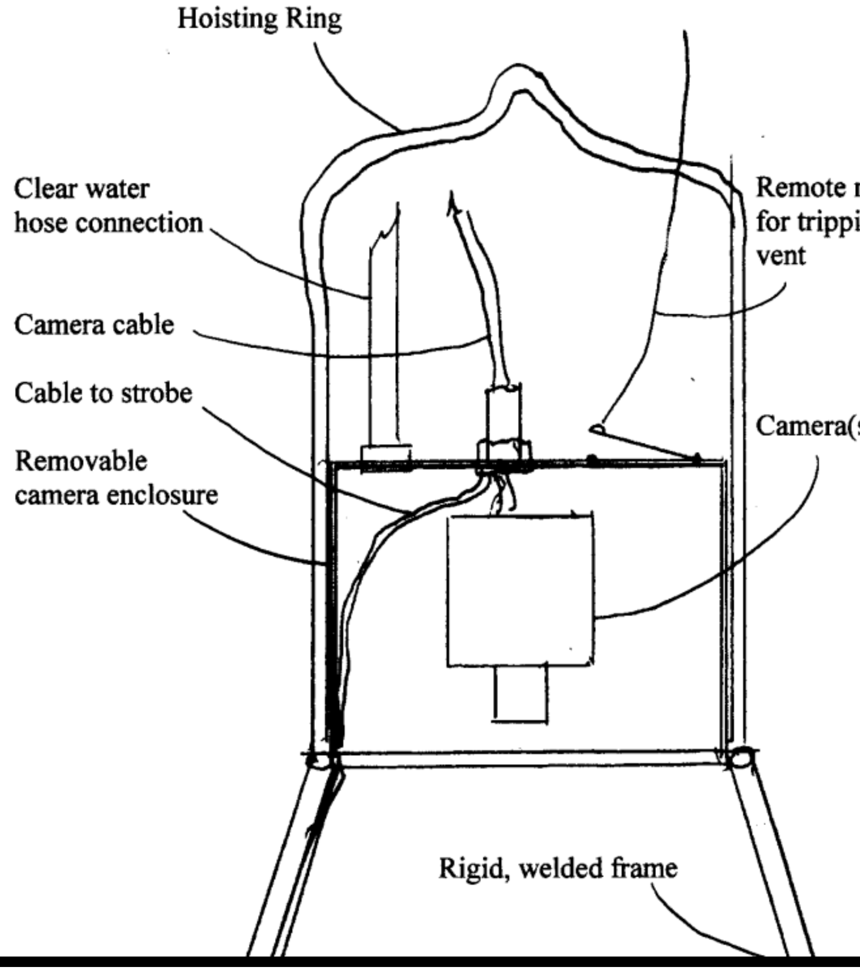
Suggested Sampling Apparatus for Non-invasive Oyster Bed Monitoring

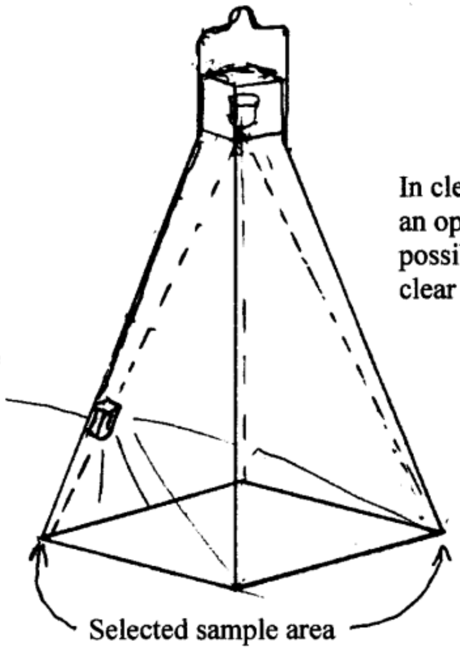
Robert P. Mason
January 1, 2014



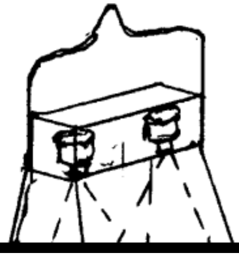
In murky water, the rigid frame is enclosed by water-proof sheets to isolate the interior volume. It is preferably left open at the bottom.

Once immersed, the pyramid is then flushed with clear water. The vent is opened to insert or lift the apparatus from the water.

Lighting can be mounted to one side for better modeling



In clear water, this can be an open frame of metal rod, possibly re-bar. No need for clear water or vent.



A pair of cameras arranged to simultaneously photograph the same sample area can record height and shape information.

Photo pairs are interpreted stereoscopically.

Monitoring Substrate placement and oyster reef development with Clearwater Box

FIG. 1:
Clearwater Imaging Box setup without two u/w lights.

©2016NickCaloyianisProductions,Inc.

FIG. 2:
TOP view: Clearwater Imaging Box

The Clearwater Box was developed by CBF in conjunction with Nick Caloyianis and Clarita Burger, a professional underwater photography team from Baltimore with experience diving all over the world and developing photography systems

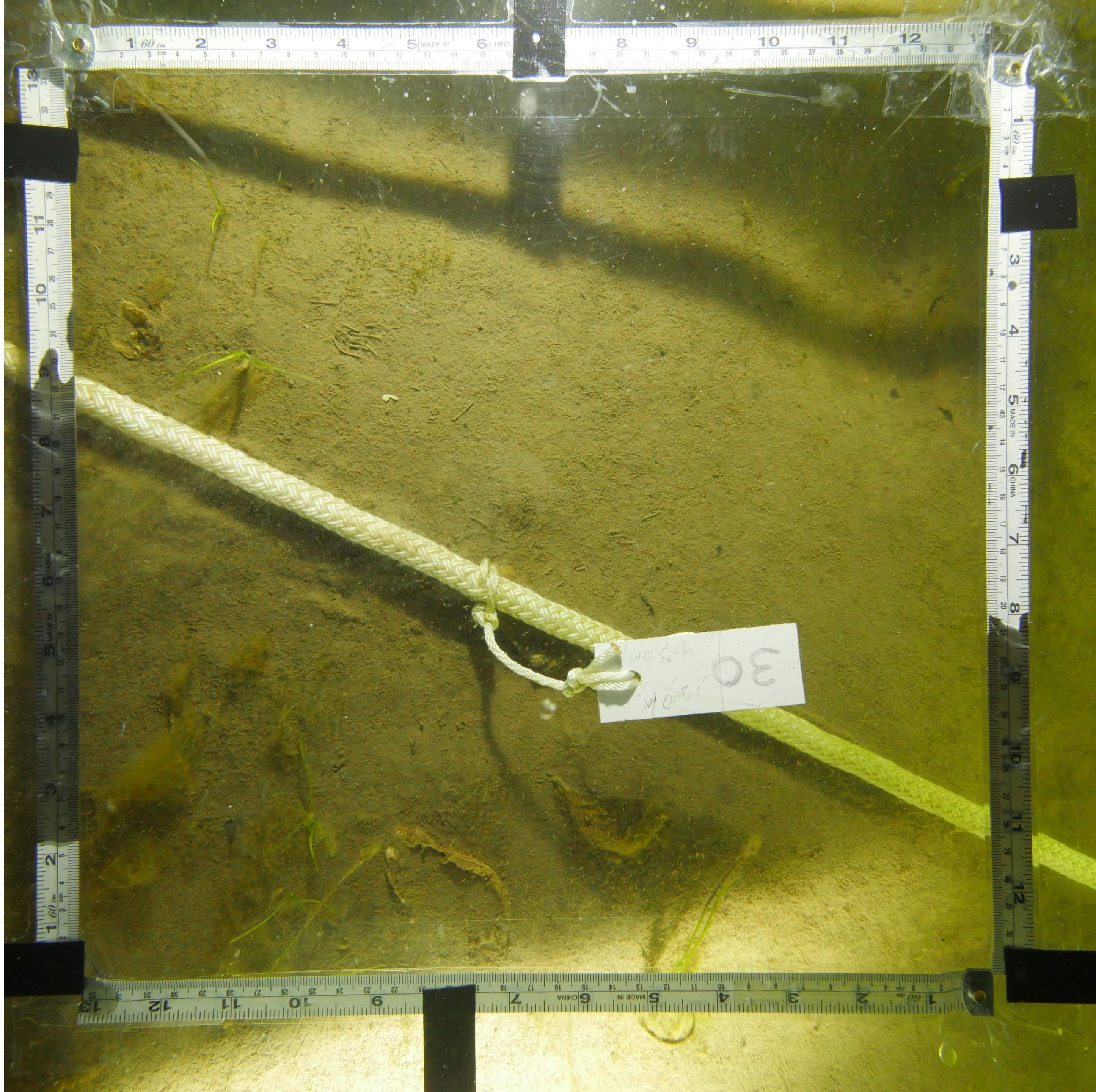
Clearwater Box is designed to be deployed by a single diver tended from a dive boat. 100 meter transects are laid across a reef target using side-scan SONAR to locate suitable bottom.

Video is taken first with movie lights and then the transect is filmed with stills taken at 10 meter intervals to characterize all reef targets consistently.

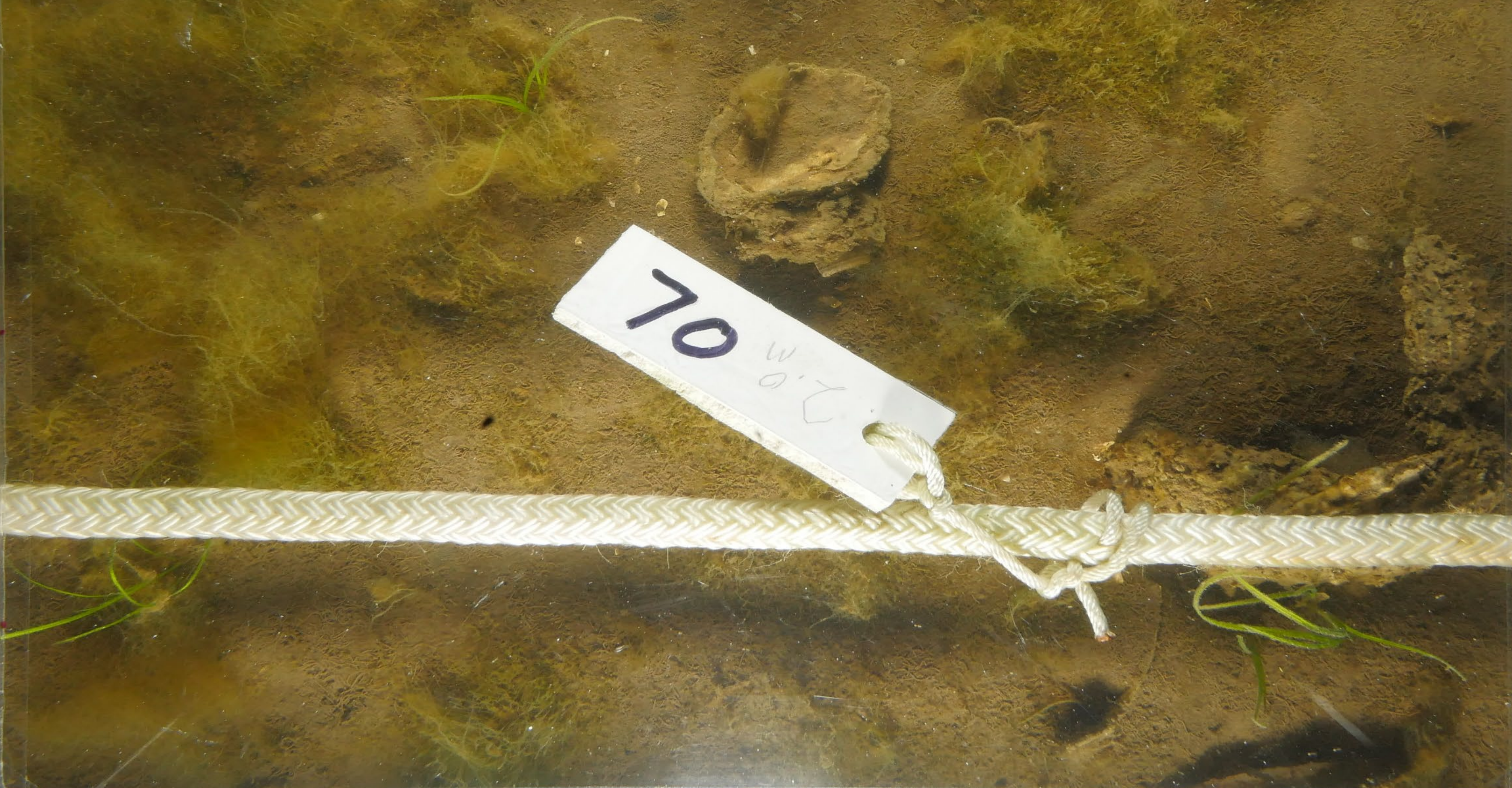
Substrate Preparation

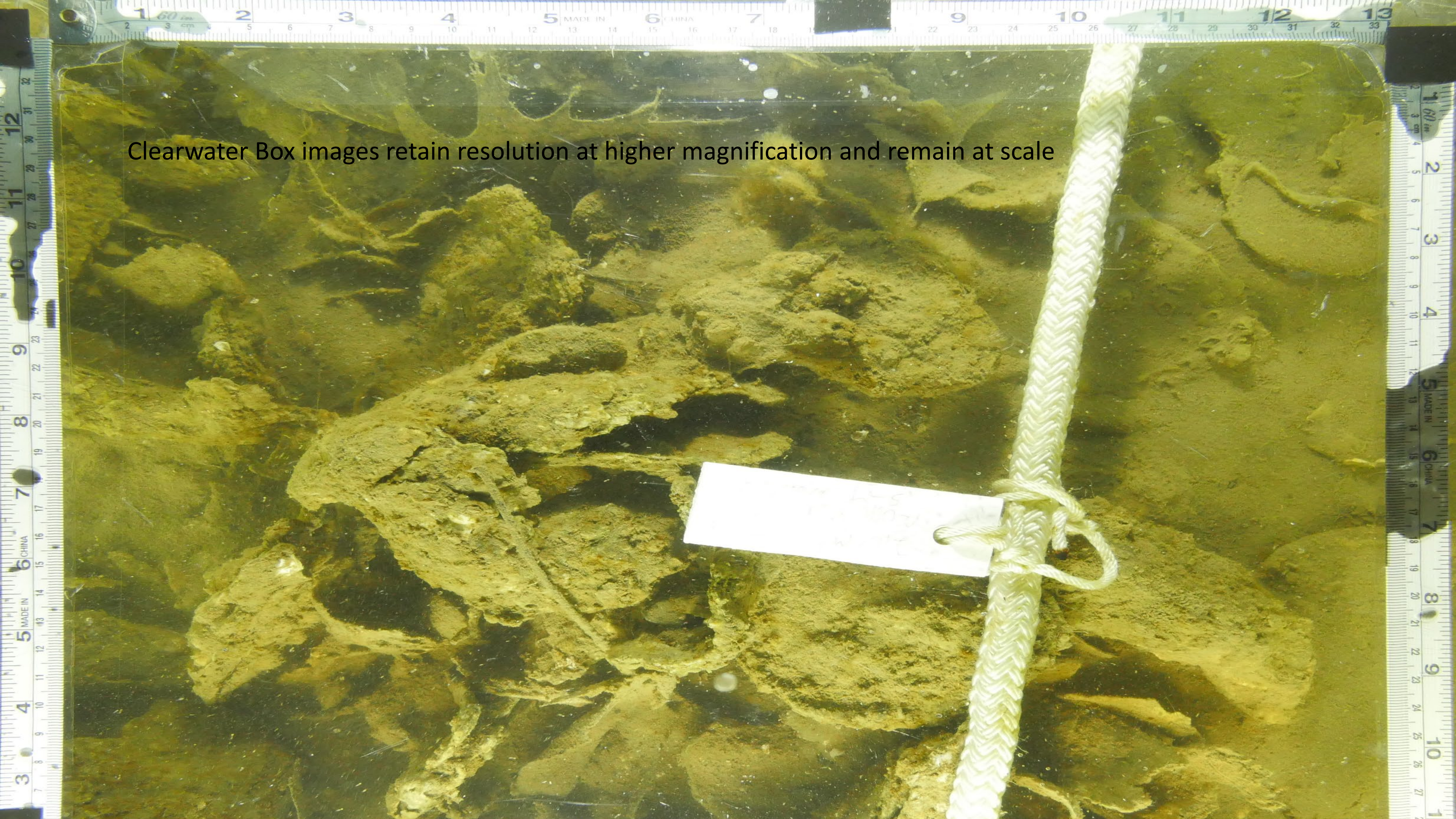
With Clearwater Box – Oysters and associated fauna appear clearly from a “bird’s-eye” view allowing measurements to be taken from photographs because buoyancy is stabilized to look straight down and a clear lens of distilled water separates the camera’s lens from the objective.

Clearwater Box also allows identification of other bottom types like this sparse SAV bed visible in the middle of winter. You can even see the castings of small worms that live buried in the mud.



Clearwater Box allows identification of reef-associated species without destructively sampling the reef.

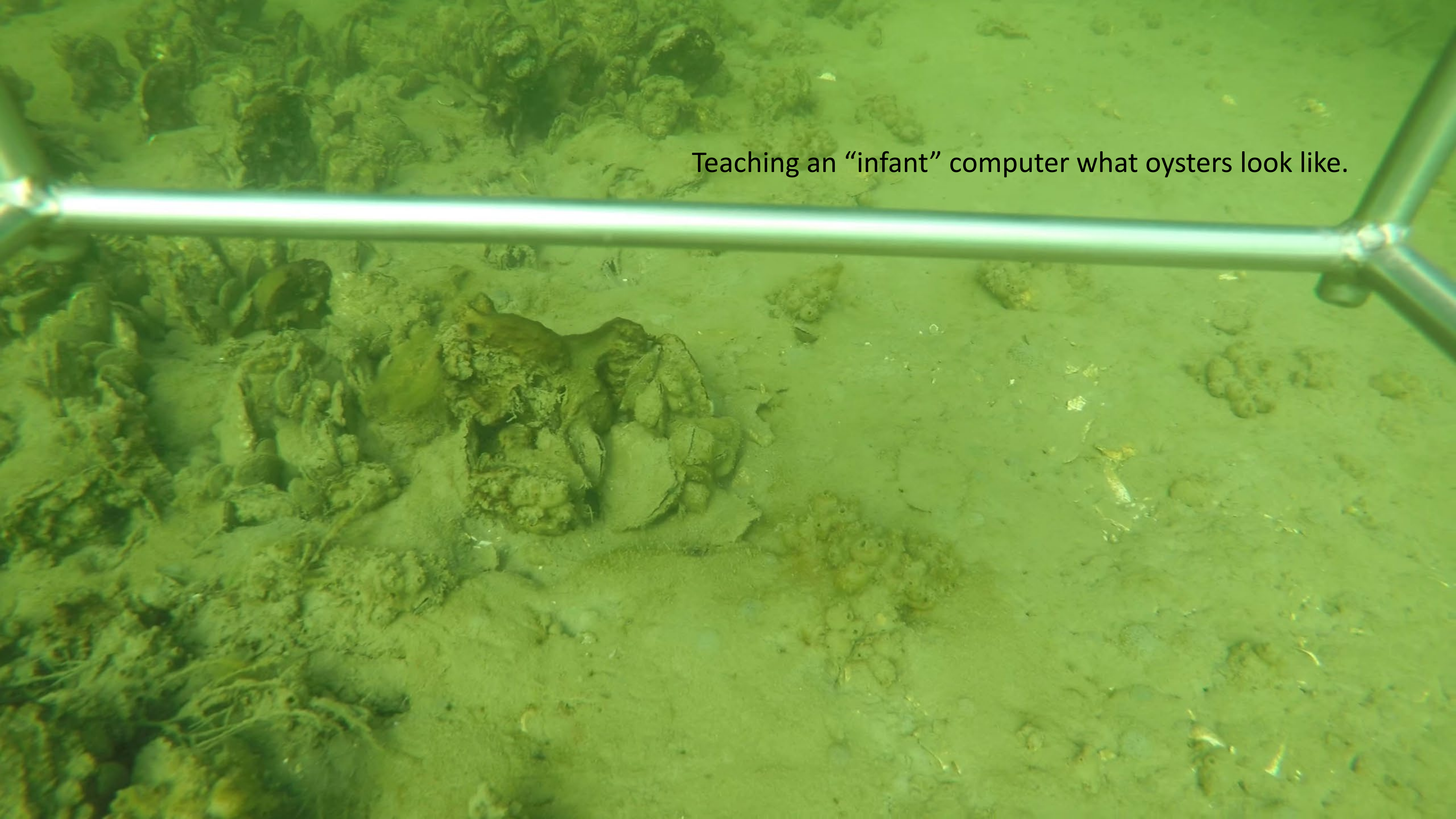



Clearwater Box images retain resolution at higher magnification and remain at scale

Fort Carroll Oyster Gardening Reef shows good signs of survival and growth

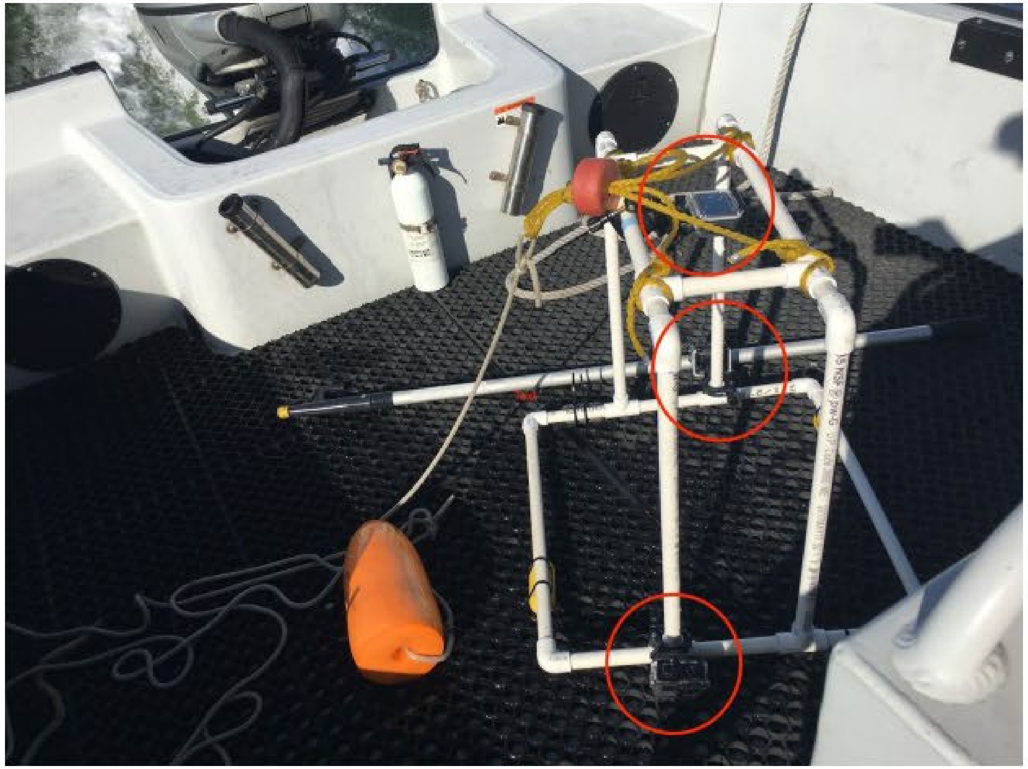
Worms, barnacles, anemones and sponges co-habitate with Fort Carroll Oysters

Fort Carroll's reef will help to filter water and improve biodiversity throughout Baltimore Harbor


Teaching an “infant” computer what oysters look like.

Additional Specifications for Northrup Grumman Oyster Reef Monitoring Challenge
PLATFORM – Prototype Littoral Aquatic Trainer for Oyster Restoration Monitoring

Category	Criteria	Weighting	Description
Area Coverage	Total area coverage: 1.0-5.0 sq km Average size of oyster reef: 6,100 sq m Number of reefs to sample per year: 50 Frequency: once per year	10%	Individual oyster reefs average approximately 6,000 sq m, but a much larger area might need to be searched to find and identify reefs and other biological features of interest. Once these are located, additional mapping and biochemical sampling would occur. Individual reefs do not need to be monitored any more frequently than 1-2 times per year. Instrument location should be tracked and all data should be georeferenced.
Depth	1.5.-15.0 m	10%	Current bottom mapping for oyster restoration is constrained by water depth as the survey vessels are too large to enter small creeks that may contain oyster reefs. Shallow water functionality is critical for both oyster reefs and seagrass beds as these areas are where both habitats are traditionally found.
Bathymetry	Resolution: X/Y – 0.3 m Z (minimum) – 0.5 m Z (maximum) – 0.01 m	15%	Many oyster reefs in Chesapeake Bay have been severely degraded and have only a few centimeters of vertical relief. In order to distinguish oyster beds from the surrounding soft sediment habitat, vertical resolution is very important. Additionally, oyster reefs grow slowly, on the order of mm per year. To ascertain whether oyster reefs are growing, we must be able to resolve Z-bathymetry accurately. This resolution could also help with the challenge of trying to quantify surface complexity on oyster reefs.
Bottom mapping	Ability to resolve the following bottom types: Mud Sand Surface shell deposits Buried shell deposits (up to 0.15 m depth) Live reef	15%	'Hard bottom' that can support the weight of an oyster reef is one of the most important considerations when identifying an area to construct an oyster reef. Hard bottom signatures are also an important indicator of the presence of live oyster bottom or shell deposits. Given the degraded state of oyster reefs in the Bay, many shell deposits are now buried beneath several cm of silt. Identifying these buried deposits would allow for the recovery and reuse of that shell for restoration.



Photos from Different Camera Positions

SERC Go Pro Classification slides.pptx - Work - Microsoft Edge
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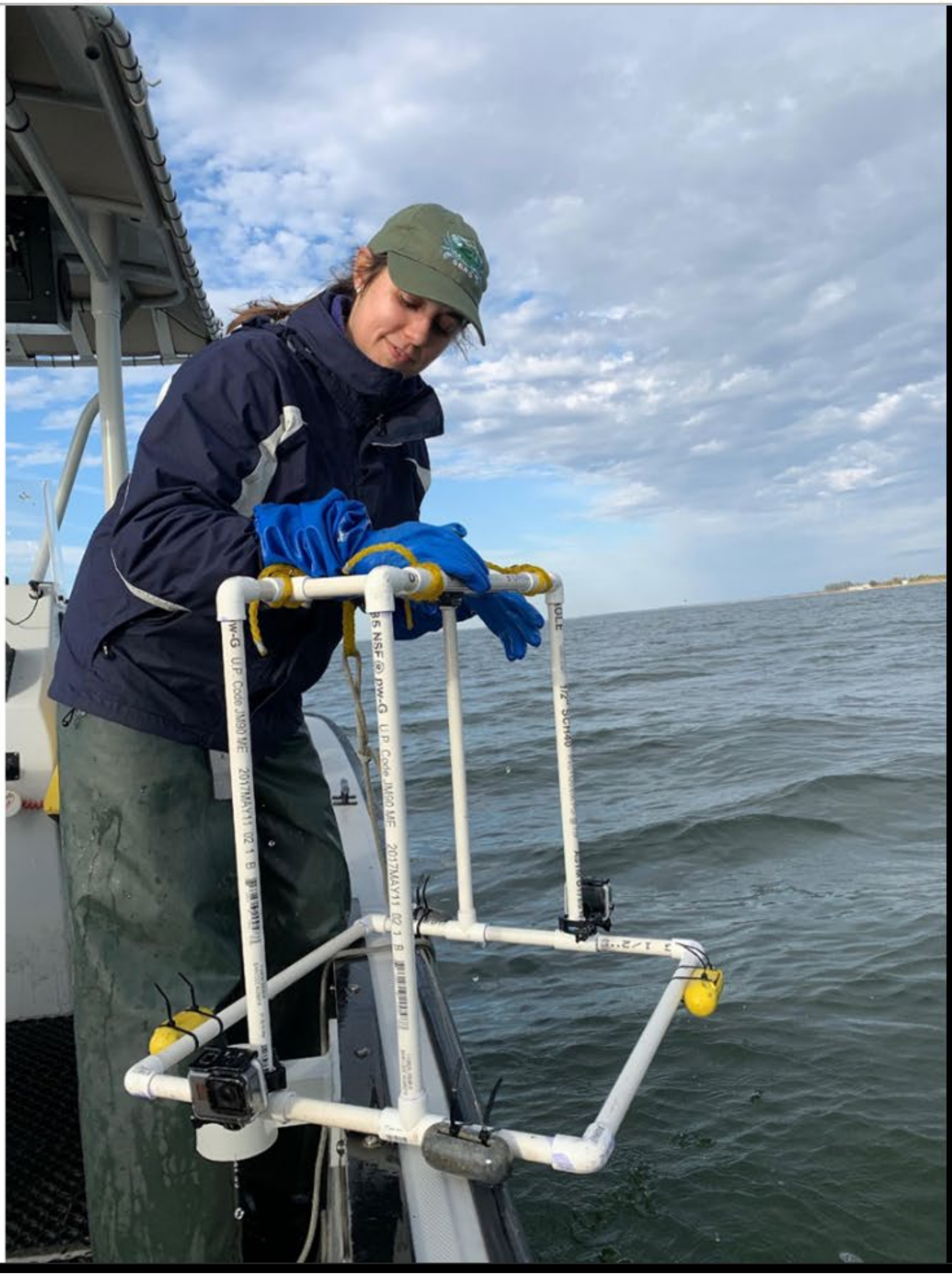
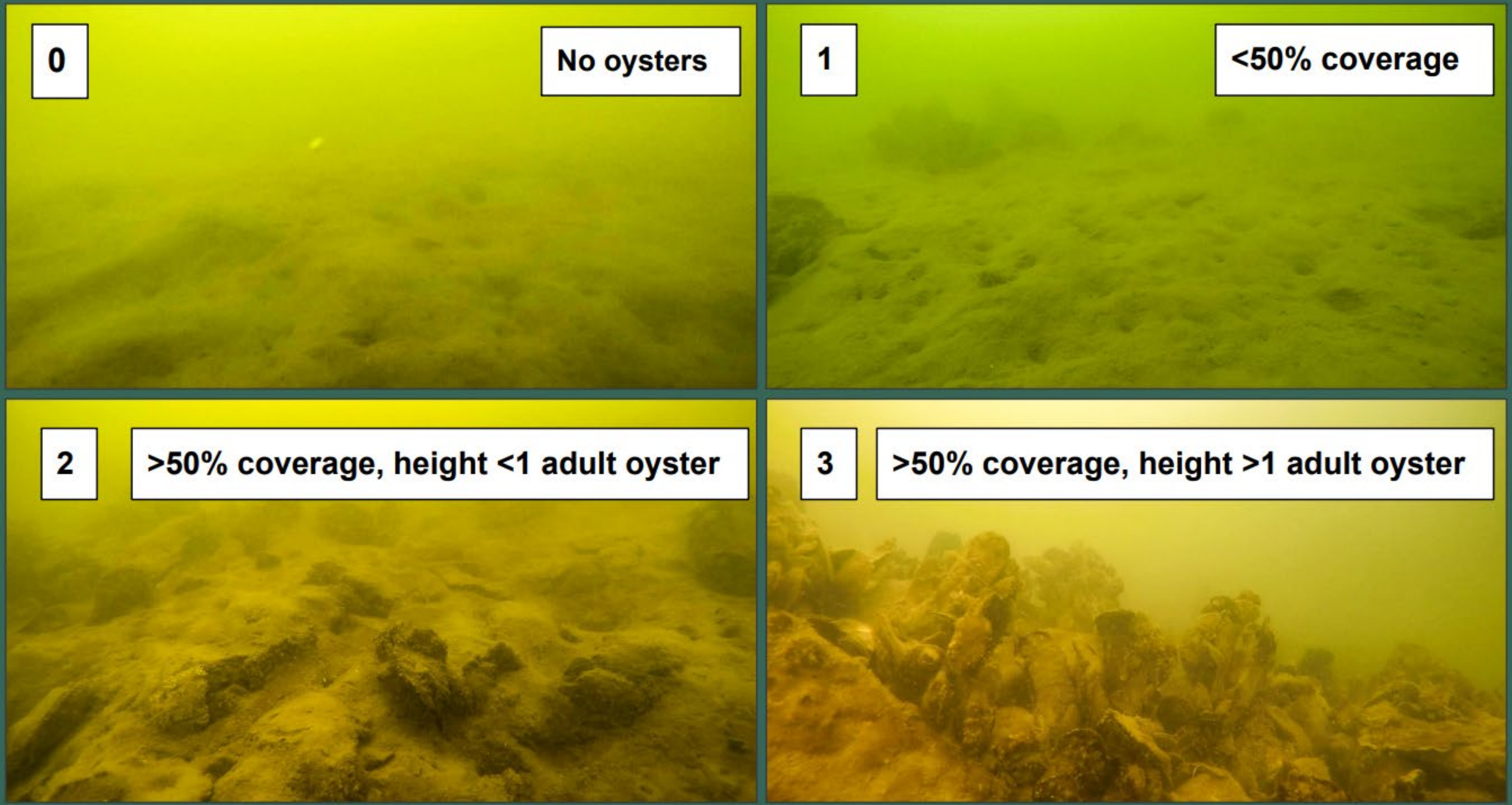
Training each sensor based on 0-3 scale of reef complexity developed by Smithsonian Environmental Research Center (SERC) using simple GoPro bottom imaging.

SERC scale tied back to physical sampling data from performing GoPro surveys of previously monitored reef locations.




0
No oysters
1
<50% coverage
2
>50% coverage, height <1 adult oyster
3
>50% coverage, height >1 adult oyster

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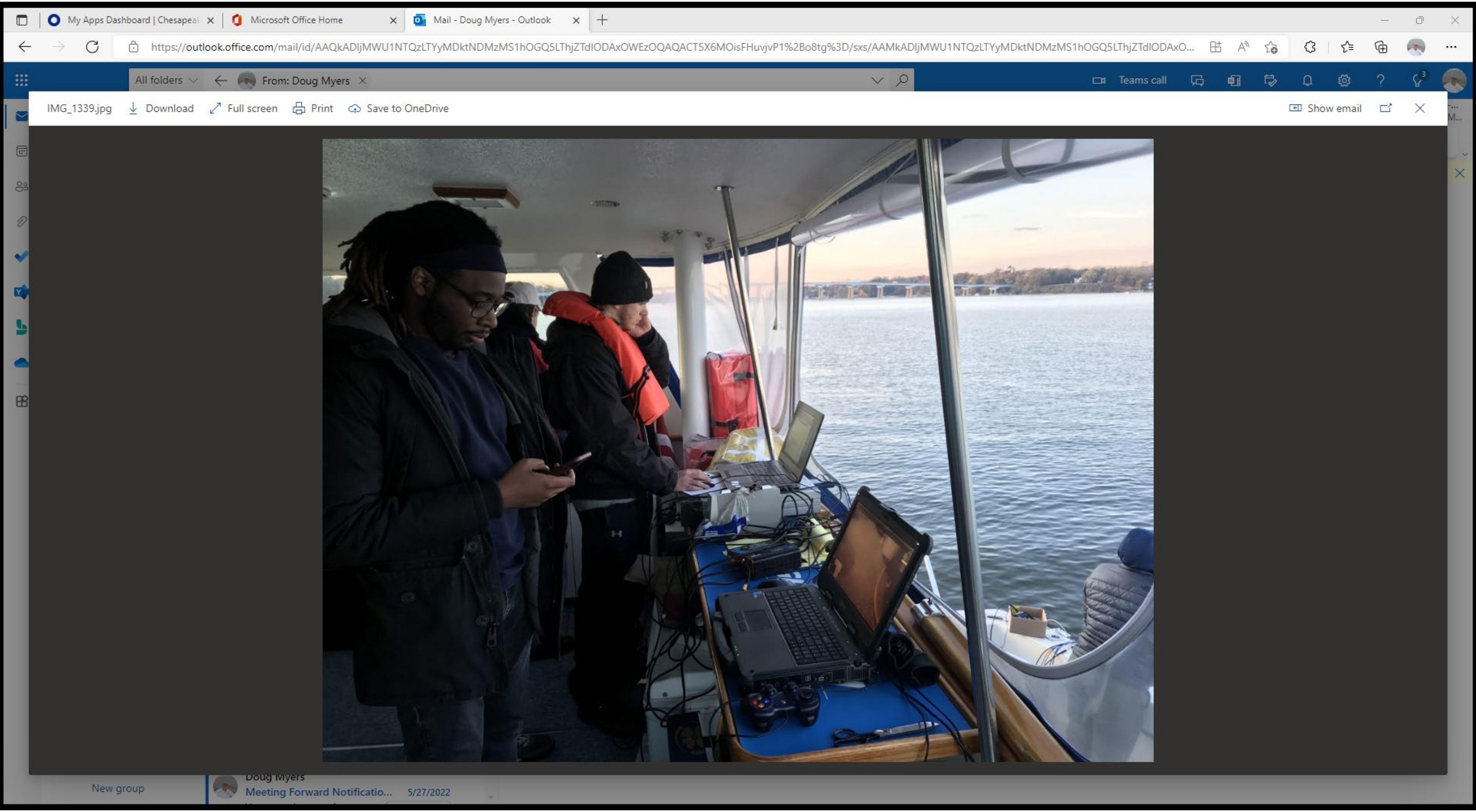
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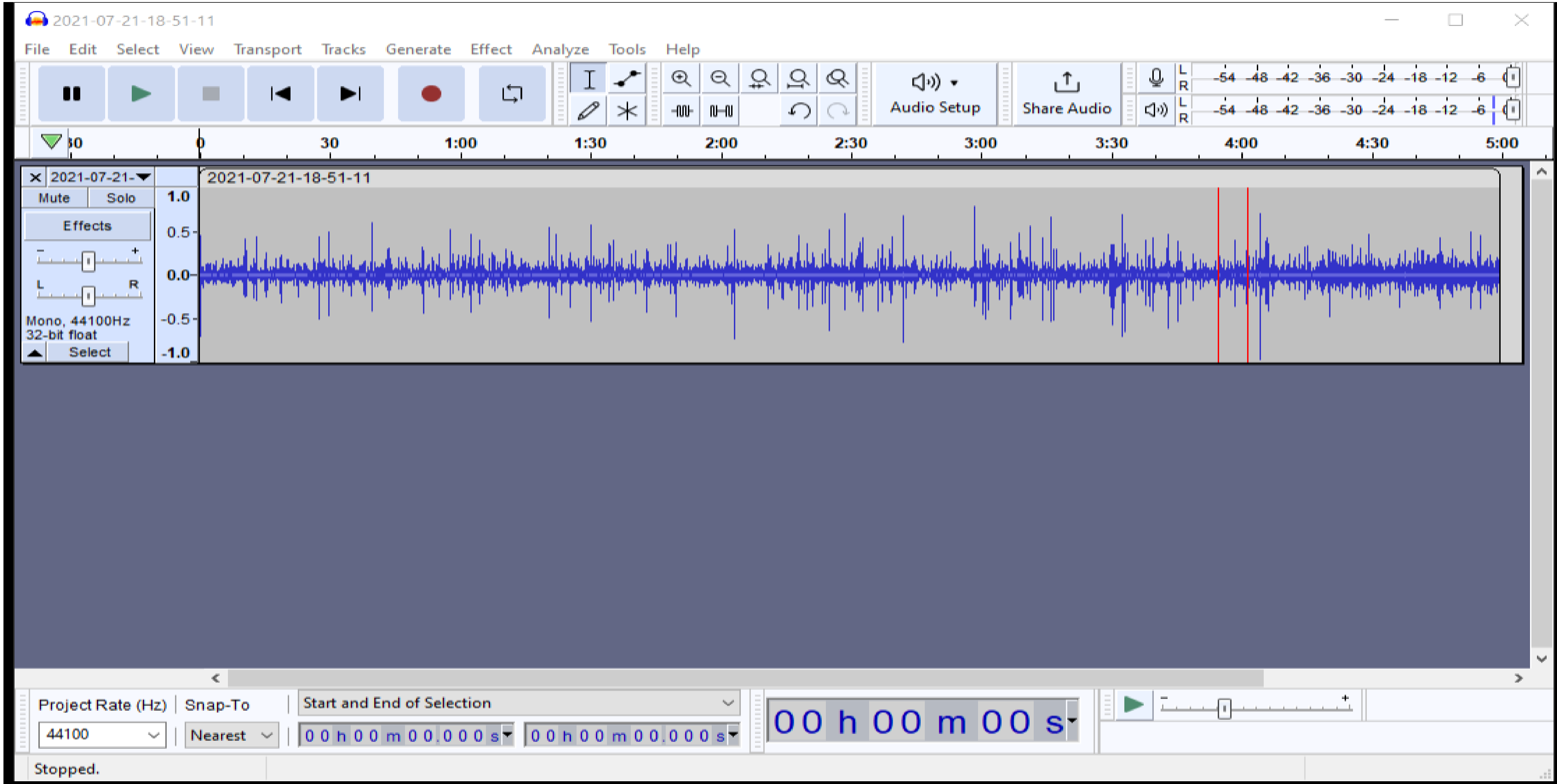
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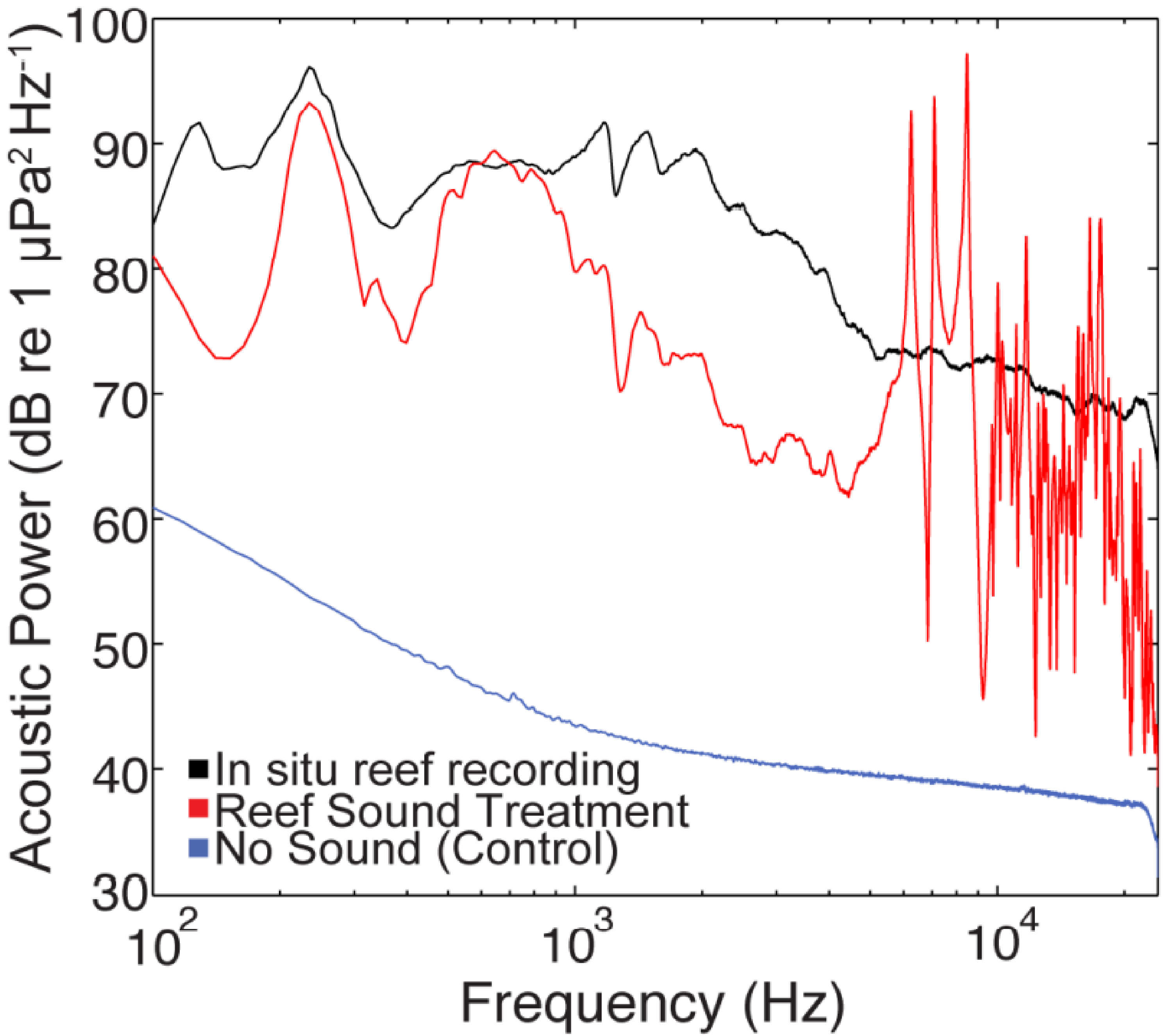

Lillis,et al 2013

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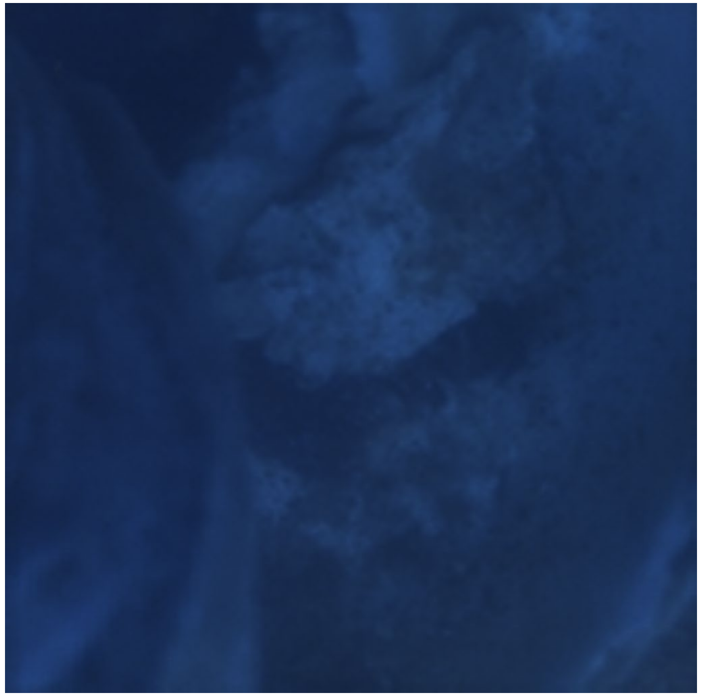
Dehazing Closeup – Medium Turbidity Tank

Original Image



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Dehazing Closeup – High Turbidity Tank

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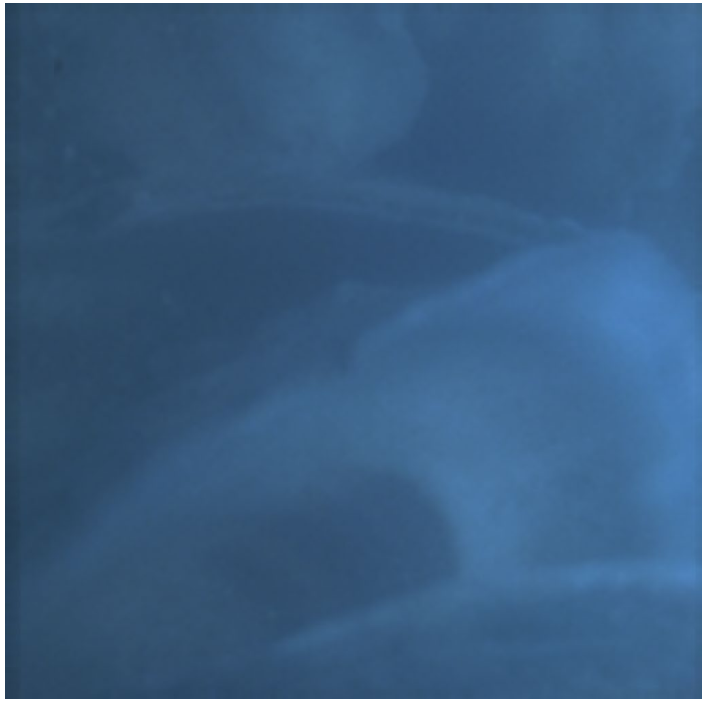

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