



Oyster Growth and Survival on an Artificial Reef in New Haven Harbor

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Introduction

The ecosystems that exist within the New Haven Harbor and the greater Long Island Sound have—and continue to—experience substantial degradation due to high levels of industrialization along the coast which brings increased nutrient loads, pollution, and sewage inputs, as well as the detrimental effects of global climate change including warmer waters and increased acidification. Oyster reefs, in particular, have experienced large amounts of stress, with the added pressure of intense overfishing (Beck et al., 2011). This degradation is harmful to both the oyster reefs and the coastal communities that rely on them. Oyster reefs support a number of critical ecosystem functions and services including the provision of habitat and food for a diversity of species, water filtration, and shoreline stabilization and coastal defense (Grabowski and Peterson, 2007). Without them, water quality and clarity are reduced, shorelines erode, species diversity decreases, and protection against storm damage is weakened. This remains true for the reefs in New Haven Harbor, which historically supported a thriving oyster industry. Successful restoration efforts have further demonstrated the value of oyster reefs to coastal ecosystems and communities (NOAA, 2017). As coastal communities continue to grow and local ecosystems continue to endure increasing stress, it is important to develop innovative ideas into projects that can effectively address habitat restoration and provide a healthy and resilient Sound for generations to come.

Reef Ball™ Modules (RBM's) are designed to mimic natural bottom structure and are being used to address a variety of environmental concerns. Initial investigations suggest that these artificial forms may have far reaching effects in habitat and species restoration efforts including: designing and growing artificial reefs, coral propagation and planting systems, estuary restoration, mangrove plantings, erosion control, and oyster reef restoration.

Students and faculty at the Sound School built five Mini-Bay RBM's (width: 0.76m, height: 0.53m, weight: 91kg) using oyster shells as a cement additive (see Figure 1). In May of 2018 the aquaculture laboratory at the school successfully spawned oysters, *Crassostrea virginica*. After the spawn three RBM's were placed in a set-tank with 200 micron spat. The RBM's soaked for ten days. In June 2018 the RBM's, three with set and two unseeded, were deployed in nearshore waters by the school campus for the creation of an artificial oyster reef (see Figure 3).



Figure 1: Each Mini-Bay Ball RBM weighs 90kg and provides 2.9m² of surface area and was constructed using materials and guidelines provided by the Reef Ball Foundation.



Figure 2: 3 RBM's were placed in a set tank, conditioned, and inoculated with larvae for 10 days. Oyster spat successfully set on the exterior, interior and within the holes in each RBM creating nearly complete coverage.

Objective

When the RBM's were first deployed in New Haven Harbor, there was no established monitoring protocol in place. This study focused on developing and enacting monitoring protocols for the newly formed artificial oyster reef to examine oyster growth and survival. The main objective of this project was not just to measure the oysters and document mortality thus far, but to lay the groundwork for more extensive and thorough future monitoring effort including pairing with environmental data and documenting species use by creating a step by step plan for future students conducting underwater research. The results of this study will be used to inform long term monitoring efforts and creation of additional student research projects as this pilot project is expanded into a larger-scale living shoreline and coastal restoration effort.

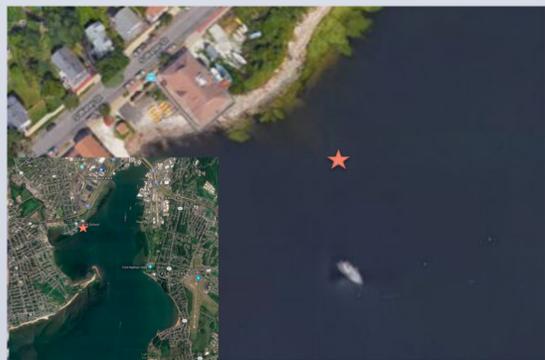


Figure 3: Current location of RBM's, approximately 40m offshore. This spot was selected to avoid creating any additional navigational hazards, accessibility, and firmness of the substrate.

Methods

First, a literature review was conducted to examine methodologies used in studies with similar objectives and conditions. Many different methods for measuring oyster growth and mortality were found that were applicable for the monitoring of this artificial reef. Method 1 involved the use of ImageJ software. ImageJ is an image processing program that can be used to measure organisms that are difficult to measure by hand by using an object in a photo of known size to provide scale. The materials needed for this method included a GoPro, ruler, and ImageJ software to analyze the pictures. This method was attempted on October 24, 2018 on the RBM's at high tide. RBM's were numbered and tagged to ensure continuity (see Figure 6). Ten photos of oysters on each RBM were taken with a ruler in each photo (see Figures 4 and 5). ImageJ was then used to analyze the length of each living oyster. Blank photos were taken between each RBM to easily distinguish them during analysis.

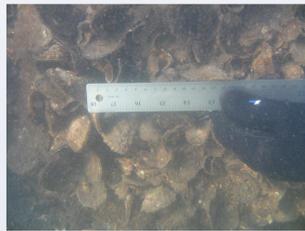


Figure 4: Photo taken on 10/24/2018 during trial of Method 1. A ruler next to a group of oysters was used as a scale to measure the oyster length using the photo processing program ImageJ.



Figure 5: Picture taken on 10/24/18 of RBM 1 that had been seeded with oysters. Oyster coverage was almost 100%.

For Method 2, 25cm² quadrats were used to isolate units of area on the RBM's for direct measurement in order to get an average size of oysters more efficiently. This method was based on heavily on those employed by Paul & Tanner (2012). A team of two divers was used to measure length of living oysters and record any dead oysters in two quadrats on each RBM. Gaping oysters were considered dead while closed oysters were identified as living. Quadrat A was located between the two top holes on the outward face of the RBM and Quadrat B was located between the two holes along the lower half of the RBM adjacent to the substrate (see Figure 8). This method was attempted on two occasions March 21 and 28, 2019.

During the trial on March 21, a HOBO MX2501 pH and Temperature logger was attached to RBM 2 with zip ties to record data over the course of the next week (see Figure 9). The successful deployment and recovery of the logger will guide future monitoring efforts that will seek to pair environmental data with growth, mortality, spawning, and recruitment.

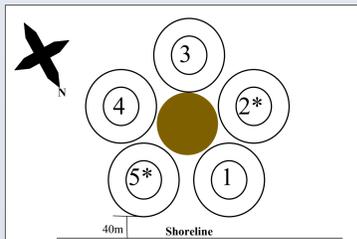


Figure 6: RBM's are located in a ring around an old wooden dock piling. The RBM's were numbered counter-clockwise starting with the module closest to shore as depicted here from above. *Denotes unseeded control RBM



Figure 7: Pictured above is all the materials needed for Method 2. This includes: 1 Quadrat, 1 Ruler with 4 paper clips attached, 1 Write in the rain booklet, 1 GoPro in a waterproof casing, 5 zip ties with numbers attached, 1 retractable spool to attach diving flag to, 1 pair of shears, and 2 dive slates.



Figure 8: Photo taken on 3/28/2019 of diver 1 measuring the length of living oysters on RBM1 Quadrat A while diver 2 takes photos and hold quadrat steady.



Figure 9: HOBO MX2501 pH and Temperature logger by Onset was placed on the RBM on 3/21/19 and picked up on 3/28/19. The logger collected data in 15 minute intervals for one week.

Results

During a trial of Method 1 the underwater work went smoothly, but use of ImageJ to determine oyster length proved ineffective due to the varying orientations and angles of oysters. The program was difficult to use and even after many attempts, did not give produce accurate measurements. Also, it was impossible to measure the oysters that were growing closely to other oysters because there was no way of identifying the hing of the oyster because it was not visible in the photos. The only collected data that could be analyzed from Method 1 came from pictures of the oysters directly lined up with the ruler.

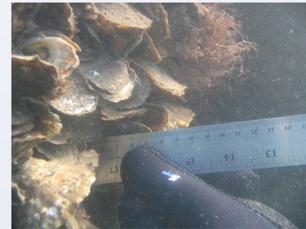


Figure 10: Once it was determined that imageJ was not an accurate tool to use for measuring oyster length, the photos that were taken on 10/24/2018 holding the ruler up to the oysters was the only data that was accurate. According to the photos took measuring the oysters, the average size during that time was 5.8cm from a random sampling.

During the first trial of Method 2, dive conditions were not ideal with low visibility, high winds, and tidal currents. These conditions prevented any measurements, but divers were able to attach the data logger to RBM 2 to record the pH and the temperature of the water over the next week.

Method 2 was tested again on 3/28/19. The weather for the week had been very mild so visibility was very good. Because of the previous week and the difficulty the divers had when trying to stay still, PVC poles were added to provide an anchor point for the divers to improve stability. Length and mortality data was successfully collected on all three RBM's. However, mortality data proved to be insufficient since scarring from oysters that had been lost or detached from the structures were not quantified.

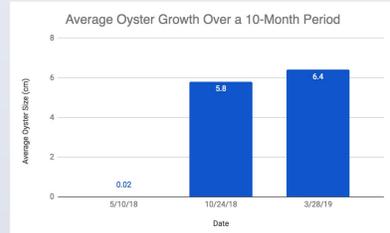


Figure 11: Average oyster growth measured over 3 dives from May 2018 to March 2019. Averages for oyster length were taken from measurements across all three RBM's.

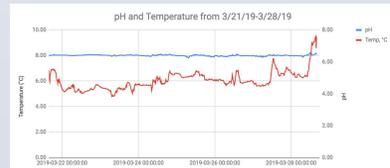


Figure 12: A HOBO MX2501 pH and Temperature logger was attached to RBM2 on 3/21/19 and was picked up on 3/28/19. pH remained consistent throughout the week. Higher temperature values occurred during time of deployment and recovery.

Divers observed oysters had higher survival rates when on more sheltered aspects of the RBM's including sides facing the interior of the ring and in the holes in the structure. Mortality rate for the exterior of the RBM's exceeded 50% on all modules. RBM1, the most sheltered structure, demonstrated highest survival rate with the most uniform coverage. There was extensive algae growth on the unseeded RBM's recorded in the fall dives and in the recent spring dives. RBM5 was documented to have the most algae growth on and around living oysters. RBM's facing the sound, only had algae growth along the base. Divers also noticed scarring from oysters that had grown and fallen off the RBM's as well as living oysters resting in the sediment that had detached from structures. During these three trials divers also observed the following species on the reef: *Callinectes sapidus*, *Hemigrapsus sanguineus*, *Urosalpinx cinerea*, *Tautoga onitis*, *Libinia emarginata*, *Busycotopus cancellatus*.



Figure 13: Picture taken on 10/24/19 of a *Busycotopus cancellatus*, consuming a *Callinectes sapidus* found adjacent to the reef.



Figure 14: In the spring divers noticed evidence of previous oyster growth through scarring on unseeded RBM's indicating natural recruitment that had not been previously observed in the fall due to algae coverage.

Conclusion

Method 2 was determined to be a more practical and accurate approach for the collection of oyster length and mortality data on the RBM's. It's effectiveness was further supported by trials performed in similar studies. Method 1 had flaws making it impossible to provide accurate and relevant data. Method 1 was created with little to no background or support from other projects unlike Method 2 which had already been tested and used by another group. ImageJ was not a reliable source to use for measuring the oysters due to the fact that the hing of oysters cannot be seen in a photo. Method 2 was successful because more thought, time, and research was put into it and multiple days were spent working on it and perfecting it. Divers were also able to refine the method by going out and testing the method first before using it. Recommended modifications for method two include use of a team of three divers. With so many different tasks and equipment, divers faced difficulty trying to handle everything between two people. A third diver should be sent to support the divers collecting data and capture images of the process. Lack of equipment and resources prevented divers from monitoring the RBM's throughout the winter. Testing of these methods had to be put on hold until the water was safe enough to dive in a wetsuit. Drysuits are needed to improve continuity in the data set. Method 2 only includes counting the amount of oysters that were still attached to the RBM and gaping. However, mortality also includes all of the oysters that once existed on the reef balls so divers will also need to record all of the scarring that was left on the reef. Further ways of quantifying oyster mortality and coverage of the RBM's should be investigated. Overall Method 2 was determined to be a successful means of measuring oyster growth on deployed habitat structures and can be utilized in long term monitoring of the artificial reef in New Haven Harbor.



Figure 15: Picture taken on 3/28/19 of diver employing Method 2 to record lengths of oysters on RBM1.



Figure 16: Gaping oysters as seen above were counted as dead. These oysters also have scarring from *Urosalpinx cinerea* predation.

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Reef Ball Foundation, <http://www.reefball.org>

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