

Massachusetts Department of Fish and Game
In-Lieu Fee Program

Eelgrass Restoration Project 2017 Annual Report

Implemented by the Division of Marine Fisheries

Prepared By

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Submitted to

The Massachusetts In Lieu Fee Program

Administered by the Department of Fish and Game



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Director

Project Overview

Summary

The Massachusetts In-Lieu Fee Program (ILFP) in the Department of Fish and Game (DFG) funded the DFG's Division of Marine Fisheries (MA DMF) to restore $\frac{1}{2}$ acre (2,023.4 m²) of eelgrass in the North Coastal Service Area beginning in 2017, to be monitored for a duration of five years. This report is for the first year of our project, the calendar year 2017. Based on site selection results, DMF chose Middle Ground in Salem Sound to plant two $\frac{1}{4}$ acre (1,011.7 m²) sites. The restoration effort was split over two seasons, the West $\frac{1}{4}$ acre site (MGW) was planted in April and May 2017, while the East $\frac{1}{4}$ acre site (MGE) was planted in the end of August and September 2017 (Table 1). Monitoring was performed at 1- and 6-month post-planting at MGW and 1-month post-planting at MGE, the 6-month monitoring of MGE is scheduled for March 2018 (Table 2). After the first month, 84% of the planting units at MGW had survived. At 6-months planting unit survival was 74%. At MGE 82% of the planting units had survived after the first month. This survival rate is expected and is similar to what we found in our previous restoration at Middle Ground (Evans et al. 2012). Next season we will continue monitoring as well as further planting to augment the developing plots.

Background

MA DMF was funded through the ILFP to restore $\frac{1}{2}$ acre (2,023.4 m²) of eelgrass in a five-year project beginning in 2017. The eelgrass restoration was permitted in 2017 under the Corps' General Permit, permit number NAE-2017-00754. The originally submitted proposal was to restore $\frac{1}{4}$ acre (1,011.7 m²) of eelgrass at two locations contiguous to sites that were successful in previous restoration efforts by DMF: Governor's Island Flats (GIF) in Boston Harbor and Middle Ground (MG) in Salem Sound. A potential site at Great Brewster Island, Boston Harbor, was also proposed. Due to concerns raised by the Federal Aviation Administration and their policy restricting habitat enhancement near the airport, GIF was dropped as a potential restoration site. Instead, DMF selected a second $\frac{1}{4}$ acre site at Middle Ground adjacent to the originally proposed site, bringing the total area of eelgrass to be restored at Middle Ground to $\frac{1}{2}$ acre. The proposal and permits were revised to reflect this change.

Middle Ground is the shoal northeast of the mouth of Salem Harbor situated between a rocky area known as Great Aquavitae and Great Haste Island (Figure 1). The shoal is approximately 6-12 feet deep at mean low water for nearly 125 continuous acres. There are anecdotal reports by local harbormasters of this area historically supporting abundant eelgrass, which was also indicated in NOAA nautical charts. MA DMF first investigated the central and eastern sections of Middle Ground in 2011 and found very few small scattered eelgrass patches. Light measurements indicated adequate light required for eelgrass growth (Evans et. al 2012) and there is extensive area of suitable depth for additional planting. Under MA DMF's Hubline mitigation program, DMF successfully planted a 0.8 acre (3,237.5m²) eelgrass restoration site at Middle Ground from 2012-2015 in the center of the shoal where depth is the shallowest. Monitoring in 2016 showed plant growth and plot enlargement through lateral expansion

(Evans et al. *in prep*). The ILFP site was selected along the same depth contour at the previous restoration site but in an area devoid of vegetation.

In addition to the requirements of the ILFP to restore ½ acre of eelgrass at Middle Ground, MA DMF also conducted site selection surveys (including acoustic mapping, video groundtruthing and diver surveys) in Boston Harbor, at Great Brewster Island and Hingham White Head Flats. Follow up work is needed before we determine if there is a promising potential restoration site in those locations.

Methods

Transplanting

Approximately 10,800 eelgrass shoots were collected from donor beds in Lynn (Broad Sound), Nahant (Nahant Cove), Salem (Aquavitae), Beverly (West Beach) and Gloucester (Niles Beach) to complete the combined ½ acre restoration effort utilizing a low impact collection method (Figure 2). This low impact method entailed SCUBA divers swimming at a predetermined compass heading along an area approximately 100 meters long by 10 meters wide to collect the 600 shoots required to plant two replicate plots. Divers gathered shoots by hand in a dispersed manner so that no more than 10% were harvested from any square-meter area. A typical shoot density at the donor sites was approximately 200-300 shoots/m². Therefore, a maximum of 20 shoots were collected by divers before moving to another area. Coordinates were recorded and plotted to ensure that the same area and heading were not overharvested. The relatively small number of shoots collected each season at each site will have no measurable impact on the donor site.

At each of the two ¼ acre sites, a total of 5,400 transplanted shoots were arranged in a checkered pattern of 18 three-meter by four-meter plots of planted and unplanted 1m² squares, for a total of 108 planted squares per site (Figure 3). Each site consisted of three transects, each containing six plots evenly spaced along the transect. Each square was planted at a density of 50 shoots/m² (Figure 4). The Burlap Disc (BD) method (Pickerell, pers. com.) was used exclusively for this restoration effort. The method involved weaving ten eelgrass shoots by their rhizomes into a 20 cm diameter, circular burlap disc. Each burlap disc with ten shoots is considered a planting unit (PU). Each PU is buried in an approximately 3-5 cm deep hole backfilled with sediment (Figures 5a and 5b). Harvested plants were stored in seawater for no more than 48 hours before being woven into the discs. To mitigate for seasonal effects (storms, algae blooms, crabs), the restoration effort was split over spring and fall seasons. The West ¼ acre site (MGW) was planted in April and May 2017, and the East ¼ acre (MGE) was planted in the end of August and September 2017.

In an effort to increase the success rate of both restoration sites, DMF partnered with Northeastern University to test the utility of using multiple source sites as a proxy for genetic diversity. To accomplish this, each site consisted of 10 plots with plants from a single donor site (monoculture) and eight plots with plants from multiple donor sites (polyculture) using two

different diversity treatments (three donor sites and five donor sites) (Figure 2). Polyculture plots were created utilizing the Burlap Disc method by weaving plants from multiple donor sites (either three or five) into the same disc. Plots that received the three donor site treatment always consisted of plants from West Beach, Niles Beach, and Broad Sound. Plots that received the five donor site treatment consisted of a mixture of all five donor sites: Broad Sound, Nahant Cove, Aquavita, West Beach, and Niles Beach.

Monitoring

Divers monitored the planted plots at one and six-months after transplanting at the MGW site (planted in April and May 2017) and at one-month at the MGE site (planted in August and September). Six month monitoring for the MGE site is scheduled for March 2018 (Table 1). Our initial one-month monitoring at MGW followed our proposed monitoring methods and included counting the number of plots present within the site, the number of squares within each plot, the number of shoots in a square (shoot density), and number of planting units in three of the six squares within each of the 18 plots, as well as measuring canopy height, making general observations and collecting video and still pictures. For the remaining monitoring events, the monitoring plan was expanded to also include estimating the percent cover at three of the six planted squares within each of the 18 plots, counting the number of planting units within each planted square and measuring the length and width of one planted square within each of the planted 18 plots to quantify expansion of the planting unit. Additional observations will be added to the methodology for future monitoring events including recording prevalence of wasting disease, grazing impacts, and epiphytes on the plants.

Annual monitoring during the peak biomass in July will continue for five years using the expanded methods with variation of the square aerial coverage measurements as the plantings begin to coalesce.

Divers monitored two of the three reference sites (West Beach and Peachs Point) once in 2017 by delineating a pre-determined transect with twelve 1m² quadrats selected in a repeated random design. Reference sites were monitored for shoot density, canopy height, and percent cover. Observations included prevalence of wasting disease (on a scale of none, trace >0-1% , low 2-10%, moderate 11-30% and high 31-100%). West Beach reference site was monitored on July 18, 2017 and Peachs Point reference site was monitored on August 9, 2017. We will continue to monitor both sites, along with a third (Aquavita) once annually during the peak growing season for comparison with restored sites.

Acoustic mapping was completed twice in 2017 to capture post-planting conditions: MGW was surveyed on June 8, 2017 and both restoration sites were surveyed on September 26, 2017. Restored and reference meadows will be mapped using hydroacoustic methods in the two planting years and again at the conclusion of the five year monitoring period, using a Humminbird 999CI HD SI unit, or a Humminbird HELIX 9 CHIRP MEGA SI GPS G2N, each with an 800 kHz high resolution transducer. Surveys are conducted with overlapping lines for 150% sonar coverage. The resulting sonar files have the water column removed and then are slant

range and beam angle corrected in SonarTRX Pro release 15. The resulting lines are exported and mosaicked in ArcGIS 10.4. In ArcGIS, areas within the mosaic that have the signature appearance of eelgrass will be delineated. The area of the meadow will then be quantified and compared to the mapped area from previous years.

Success criteria

Transplant success will be determined by the persistence and expansion of the restored meadow over five years. Restoration targets are the desired acreage of ½ acre with a shoot density, % cover and canopy height statistically equivalent to reference levels after 5 years.

Results

During the spring and fall of 2017, MA DMF successfully transplanted 10,800 shoots over two ¼ acre (1,011.7 m²) sites totalling ½ acre (2,023.4 m²) at Middle Ground in Salem Sound (Table 1). Monitoring was performed as scheduled at 1-month at both MGW and MGE. We also added an additional 6-month monitoring event which was completed at MGW and is planned for MGE in March 2018 (Table 2).

Middle Ground West

In April 2017, divers noted heterogeneity of the sediment surface with a mix of cobble, gravel and sand patches. Algae (*Laminaria* sp., *chondrus crispus*, green and red drift species) was also present in small patches. The same was noted during planting. During the 1-month monitoring of MGW, divers observed an increase in algae (*Ulva lactuca* and *Laminaria* sp.) at the site and noted that some eelgrass shoots had become entangled and twisted around the algae (Figure 6a). Divers removed the algae but the plants showed signs of damage (Figure 6b). Divers also noted crabs (Figure 6c) and some clipped eelgrass blades (Figure 6d). During the 6-month monitoring event divers noted sand waves and some burial of plants.

The 1-month monitoring of plots at MGW was conducted on June 28th, 2017. All plots were present and every square within each plot contained eelgrass. The mean PU survival was 84% across the site after 1-month. The site had a mean shoot density of 42.8 shoots/m² within planted squares (Table 3). There were no substantial differences between the three transects. The mean canopy height across all plots was 51.1cm, with values ranging from 30.8 to 77cm. We did not estimate percent cover at the 1-month monitoring event at MGW.

The 6-mo monitoring of MGW was done on November 14th, 2017. All plots were present and 12 of the 18 plots had eelgrass in every planted square. The other plots had between 2 to 5 of the six squares remaining. Mean PU survival was 74% across the site. Mean shoot density was 49.1 shoots/m² within planted squares (Table 4). By 6-months there were substantial differences between the transects. The middle transect showed the lowest PU survival at 60% while the south transect has the highest at 82%. The mean canopy height of the site was 42.4 cm with site-wide values ranging from 27 to 66cm. The mean percent cover of the planted squares was 28% with site-wide values ranging from 5 to 55%.

Middle Ground East

In August 2017, divers noted that the MGE site was composed of gravelly sand with some large boulders. There was also algae present, similar to MGW. Dense algae was also present during planting days. Divers noted a decrease in algae at the site during the MGE 1-month monitoring but some twisting of the eelgrass occurred as with the MGW site.

The 1-month monitoring of MGE was conducted on October 12th, 2017. Each of the 18 plots contained eelgrass and 1 plot was missing an entire planted square (5 PUs). PU survival was 82% with a range from 54% to 96%. The site had a mean shoot density of 38.9 shoots/m² (Table 5). Mean shoot density ranged across transects from 37.4 shoots/m² at the south transect to 40.6 shoots/m² at the mid transect. The mean canopy height at the site was 52.2cm with site-wide values ranging from 38.3 to 70.33cm. The mean percent cover was 33.7% with site-wide values ranging from 15 to 45%.

Reference Sites

Peachs Point

Divers monitored Peachs Point on August 9th, 2017. The mean shoot density was 244 shoots/m² with density values ranging between 80 to 576 shoots/m² in the 12 quadrats sampled (Table 6). The mean canopy height was 100.9 cm and mean percent cover was 71.3%. Wasting disease and grazing were observed in low quantities on plants.

West Beach

Divers monitored West Beach on July 26th, 2017. The mean shoot density was 244 shoots/m² with density values ranging between 176 to 336 shoots/m² in the 12 quadrats sampled (Table 6). The mean canopy height was 99.3 cm and the mean percent cover was 67.5%. Wasting disease was seen at moderate levels, with grazing evident on many plants. Signs of erosion existed and clay had become exposed from the sand at some quadrats.

Aquavitae

This site has not yet been monitored. Eelgrass at Aquavitae was first detected during a DMF acoustic survey in 2016 when we mapped a 5-acre meadow. We selected the site to be the third reference site against which to compare the success of the MGW and MGE sites, given it's similar depth, sediment and exposure characteristics. The acoustic imagery will be used, along with diver surveys, to establish a reference monitoring transect location in the summer of 2018. In the acoustic imagery, this bed is comprised of dense patches interspersed with bare areas, all atop a shoal area and limited by suitable depth (3-10 ft MLW).

Acoustic Mapping

Post-planting acoustic mapping detected the planted plots at both MGW and MGE at their approximate planted density of 50 shoots/m² (Figures 7 and 8).

Both the Peachs Point and West Beach beds were mapped in August 2016 and September 2017, which established two years of baseline extent and density information. We will continue to map Peachs Point, West Beach and Aquavitae as reference beds.

Requirements/Performance Standards

Status of Progress Towards Attainment of Success Criteria (performance standards):

The goal of the project is the restoration of ½ acre of eelgrass. Success is determined by the persistence and expansion of the planted eelgrass over five years. Both ¼ acre restoration sites at Middle Ground were planted less than one year ago, and therefore have yet to be evaluated for overall success. The initial transplants did well with similar PU survival as was found in previous planting efforts in Salem Sound (Evans et al. 2018) and other restoration projects (Kopp and Short 2001).

Budget Update

The budget for this project was organized into two main categories; 1) Equipment and supplies and 2) Personnel. Of the total project budget of \$262,092, we spent \$44,619.01 in calendar year 2017; including \$3,477.33 on equipment and supplies and \$41,141.68 on personnel. In most subcategories we ended the calendar year with a surplus. However, the Licor sensor was more expensive than we had initially calculated. Permitting also went over budget in calendar year 2017 but is also included in the calendar year 2018 budget; however, we do not expect to need additional permitting going forward. We end this year with a remaining balance of \$52,886.99 which will be rolled into our budget for 2018. The CY 2017 budget line items for this project, with associated charges and remaining balance, are listed below.

Calendar year 2017 budget and charges:

| Line Item | Approved Budget | Cumulative Charges (CY2017) | Remaining Balance |
|--------------------------------------|------------------------|------------------------------------|--------------------------|
| <i>Equipment and supplies</i> | | | |
| SCUBA Air fills | \$3,348.00 | \$641.50 | \$2,706.50 |
| Field Supplies | \$1,200.00 | \$552.80 | \$647.20 |
| Licor Sensor | \$560.00 | \$912.76 | -\$352.76 |
| Boat Fuel& Maintenance | \$7,750.00 | \$683.06 | \$7,066.94 |
| Dive Gear | \$1,000.00 | \$30.59 | \$969.41 |
| Hummingbird Software | \$1,200.00 | \$0.00 | \$1,200.00 |
| Lab Work | \$5,000.00 | \$0.00 | \$5,000.00 |
| Permitting | \$440.00 | \$656.62 | -\$216.62 |
| <i>Personnel</i> | | | |
| Personnel Carr | \$5,193.00 | \$5,193.00 | \$0.00 |
| Personnel Ostrikis | \$5,063.00 | \$5,063.00 | \$0.00 |
| Dive Pay | \$13,950.00 | \$2,295.00 | \$11,655.00 |
| Contract Employee | \$33,280.00 | \$16,864.00 | \$16,416.00 |
| Travel | \$250.00 | \$114.37 | \$135.63 |
| Indirect | \$14,889.00 | \$7,618.49 | \$7,270.51 |
| Payroll tax | \$948.00 | \$418.58 | \$529.42 |
| Fringe Benefits | \$3,436.00 | \$3,575.24 | -\$139.24 |
| TOTAL CY2017 | \$97,507.00 | \$44,619.01 | \$52,887.99 |

| | |
|--------------------|---------------------|
| Total grant amount | \$262,092 |
| Total remaining | \$217,472.67 |

Conclusion

The first ILF funded project in Massachusetts is underway with a successful initial planting in 2017. One half acre was planted with eelgrass throughout the spring and fall of 2017. At the last monitoring event in November, survival over the whole ½ acre was 78% of the planting units. We are planning additional planting in the summer of 2018 to augment the existing plots where needed and based on spring monitoring results.

Acknowledgements

Thanks to all who worked on this project from the initial planning and permitting, the field work, data analysis, and report preparation. Our project team includes Mark Rousseau, Tay Evans, Jill Carr, Kate Frew, Alex Boeri, with help from Vin Malkoski of DMF, Randall Hughes, Forest Schenck, Mallarie Yeager, and Lauren Puishys of Northeastern University (Figure 5d), and Phil Colarusso of EPA. Thanks also to Josh Helms of the Army Corps of Engineers for coordinating the funding and permitting for this project and to Aisling O’Shea, the DFG ILF coordinator.

References

- Evans NT and FT Short (2005) Functional trajectory models for assessment of transplanted eelgrass, *Zostera marina* L., in the Great Bay Estuary, New Hampshire. *Estuaries* 28: 936-947.
- Evans NT, WT Dukes and JL Carr (2012) Division of Marine Fisheries HubLine Eelgrass Restoration Mid-project Progress Report. June 2012. Submitted to The Department of Environmental Protection.
- Evans NT, JL Carr, K Frew, and A Boeri (2018) Division of Marine Fisheries HubLine Eelgrass Restoration Final Report. *In prep February 2018*.
- Kopp BS and FT Short (2001) Status report for the New Bedford harbor eelgrass habitat restoration project, 1998-2001. Submitted to the New Bedford Harbor Trustee Council and the NOAA Damage Assessment and Restoration Program: 1-64.
- Pickerell C (2011) Cornell Cooperative Extension, pers. com.

Appendix

Figures

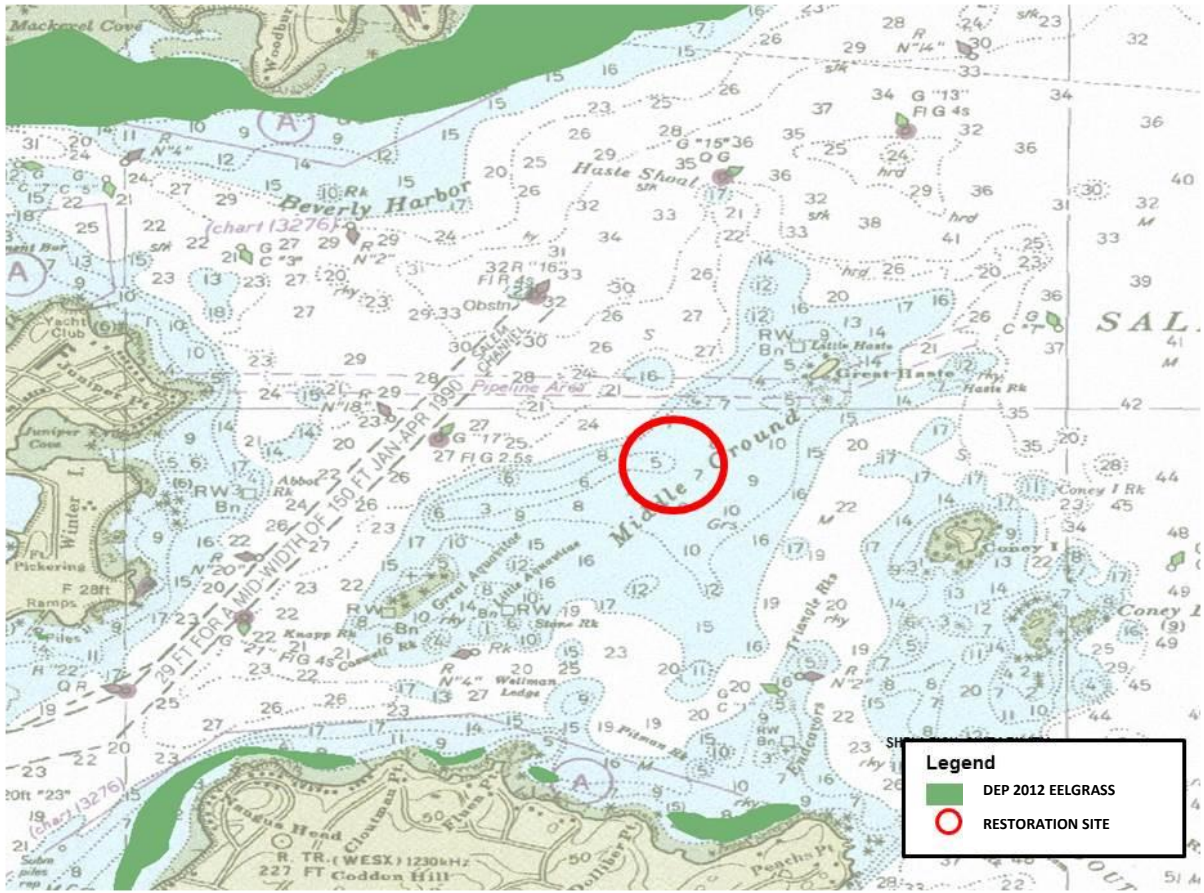


Figure 1: 1/2 acre restoration site at Middle Ground, Salem Sound.

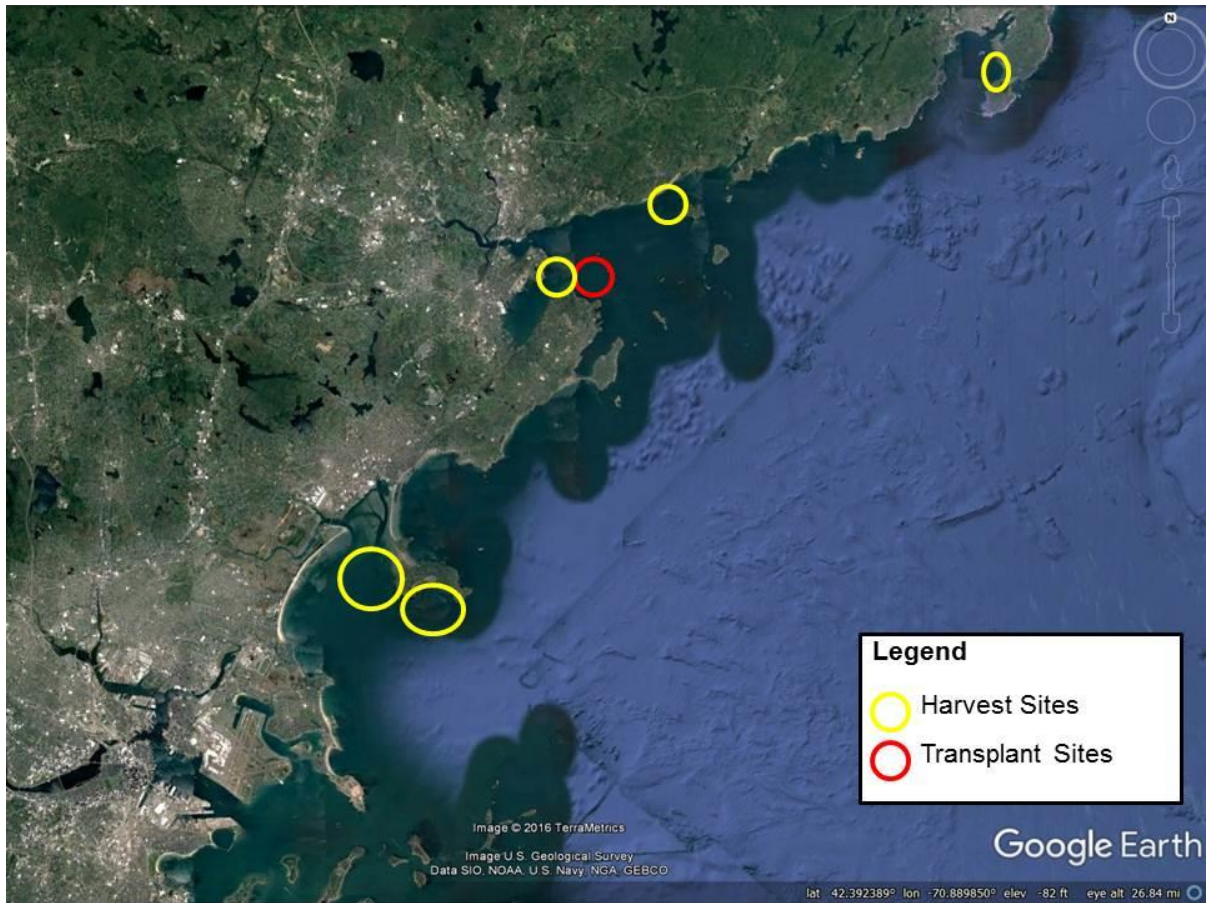


Figure 2: Eelgrass donor sites.

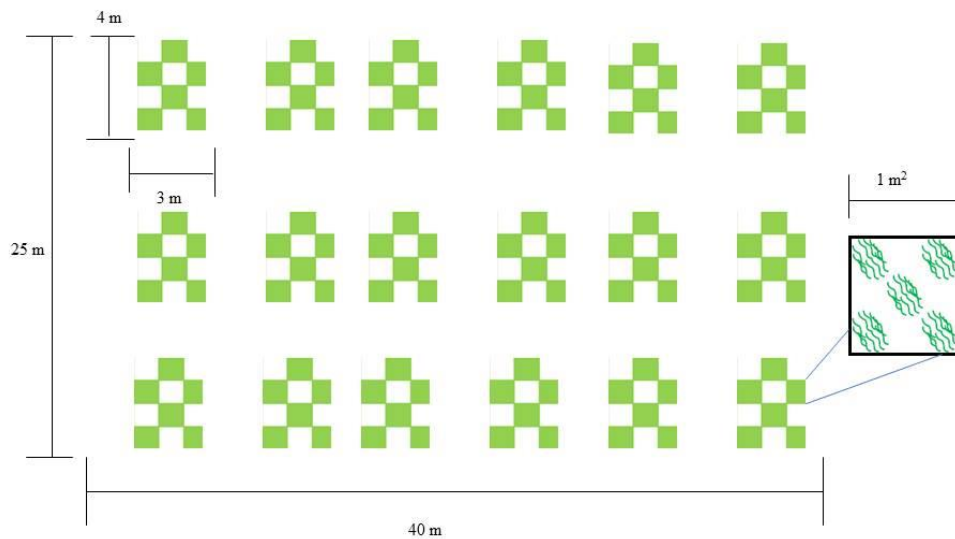


Figure 3: Layout for each site, approximately 1/4 acre area. 18 plots each in a checkerboard pattern of 6 planted and unplanted 1 m² squares for a total of 5,400 shoots. Two sites planted adjacent to each other at Middle Ground.

Middle Ground Site Layout

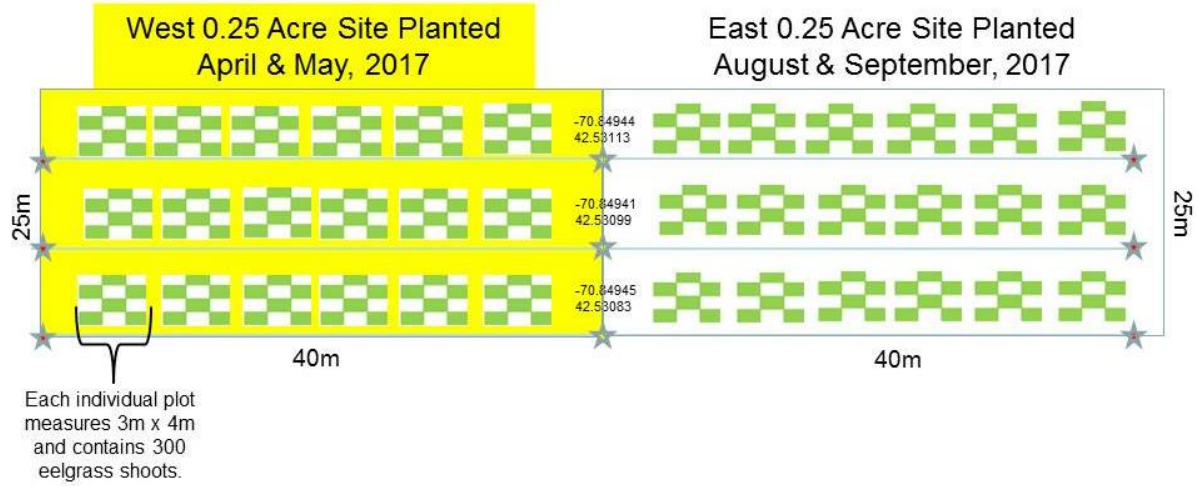


Figure 4: Middle Ground site layout.

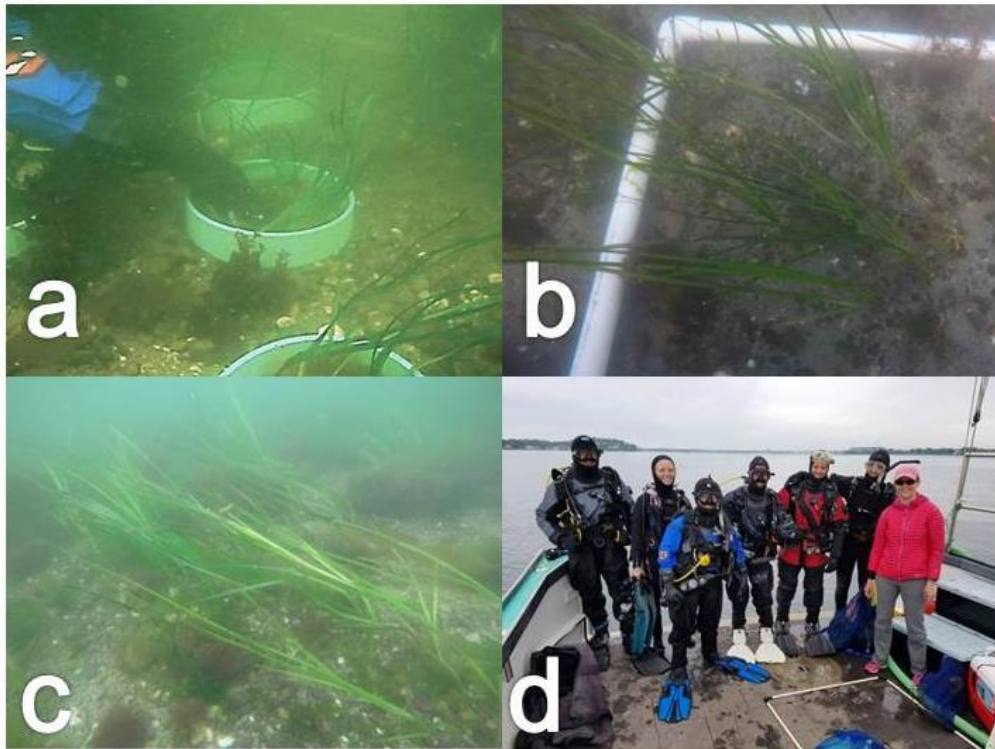


Figure 5: Diver planting a burlap disc of ten shoots (PU) (a), the planted disc (b), 1-month monitoring of MGW (c) and DMF and NEU divers (d).

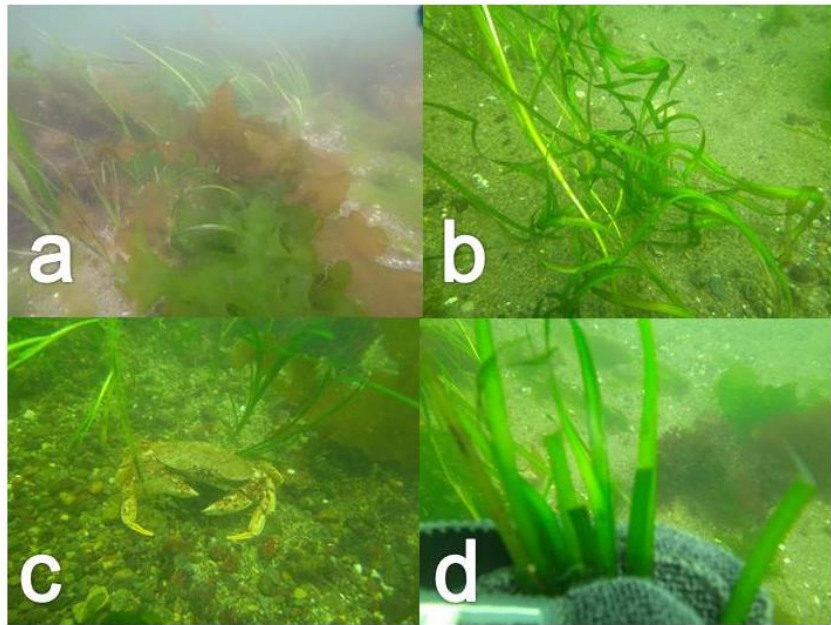


Figure 6: Middle Ground West 1-month monitoring: Algae entangling eelgrass (a), twisted damage to shoots (b), Rock crab along south transect (c), Evidence of crab clipped shoots (d).

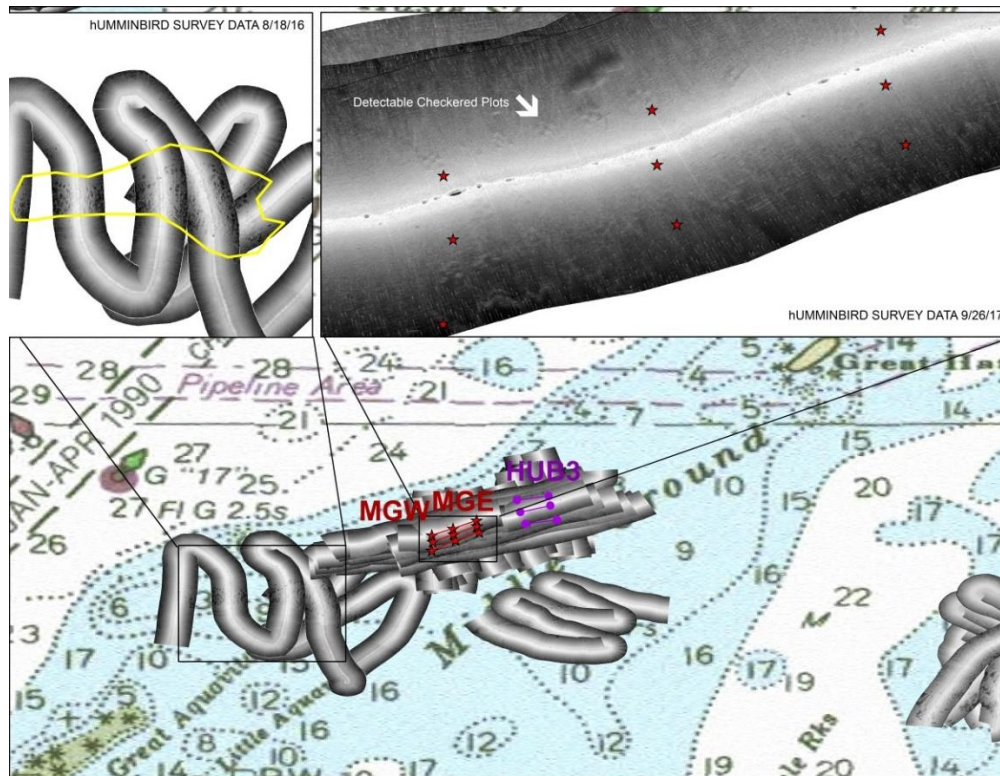


Figure 7: Middle Ground Acoustic Survey Scans.

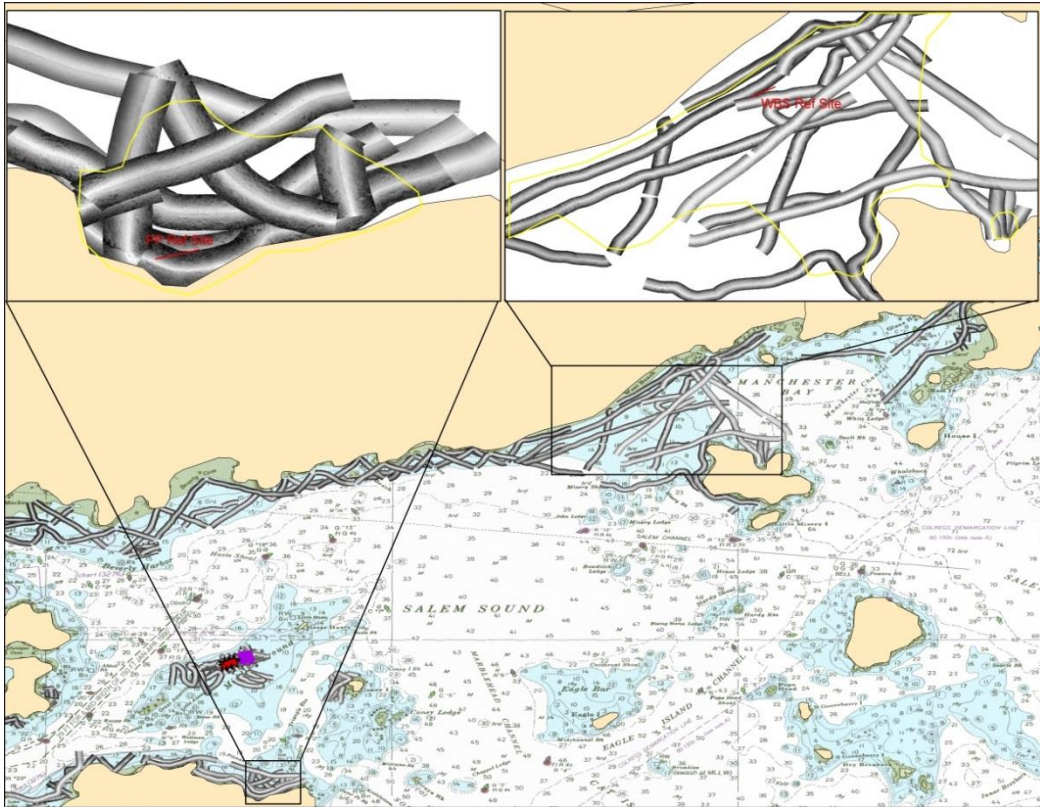


Figure 8: Reference Site Acoustic Survey Scan.

Tables

| Event | Date | Notes |
|--------------------|-----------|------------------|
| Spring Monoculture | 4/20/2017 | 2 plots planted |
| Spring Monoculture | 5/4/2017 | 2 plots planted |
| Spring Monoculture | 5/10/2017 | 2 plots planted |
| Spring Monoculture | 5/12/2017 | 2 plots planted |
| Spring Monoculture | 5/19/2017 | 2 plots planted |
| Spring Polyculture | 5/24/2017 | 8 plots planted |
| Fall Monoculture | 8/31/2017 | 10 plots planted |
| Fall Polyculture | 9/7/2017 | 8 plots planted |

| Site | 1 month | 6 month | 1 year |
|------------------------|------------|------------|--------|
| Spring 2017 Planting | 6/12/2017 | 11/14/2017 | 7/2018 |
| Fall 2017 Planting | 10/12/2017 | 3/15/2018 | 7/2018 |
| West Beach Reference | 7/18/2017 | NA | 7/2018 |
| Peachs Point Reference | 8/9/2017 | NA | 7/2018 |
| Aquavitae Reference | NA | NA | 7/2018 |

| Transect | Mean Planting Unit Survival | Mean Density [shoots/m ²] | Mean Shoot Survival | Mean Canopy Height [cm] |
|-------------|-----------------------------|---------------------------------------|---------------------|-------------------------|
| North | 78% | 41.4 | 82.80% | 55.9 |
| Mid | 86% | 42.1 | 84.20% | 44 |
| South | 90% | 44.9 | 89.80% | 52.9 |
| ENTIRE SITE | 84% | 42.8 | 85.50% | 51.1 |

Table 4: MGW 6-mo Monitoring results

| Transect | Mean Planting Unit Survival | Mean Density [shoots/m ²] | Mean Shoot Survival | Mean Canopy Height [cm] | Mean % Cover |
|--------------------|-----------------------------|---------------------------------------|---------------------|-------------------------|--------------|
| North | 74% | 35.9 | 71.80% | 45.6 | 32.8 |
| Mid | 60% | 48.4 | 96.90% | 37.2 | 24.4 |
| South | 82% | 63.1 | 126.10% | 44.4 | 27.5 |
| ENTIRE SITE | 74% | 49.1 | 98.30% | 42.4 | 28.2 |

Table 5: MGE 1-mo Monitoring results

| Transect | Mean Planting Unit Survival | Mean Density [shoots/m ²] | Mean Shoot Survival | Mean Canopy Height [cm] | Mean % Cover |
|--------------------|-----------------------------|---------------------------------------|---------------------|-------------------------|--------------|
| North | 86% | 38.6 | 77.10% | 56.8 | 29.2 |
| Mid | 86% | 40.6 | 81.20% | 47.2 | 38.9 |
| South | 74% | 37.4 | 74.80% | 52.5 | 33.1 |
| ENTIRE SITE | 82% | 38.9 | 77.70% | 52.2 | 33.7 |

Table 6: 2017 Reference bed monitoring results

| | Mean Density [shoots/m ²] | Mean Canopy Height [cm] |
|--------------|---------------------------------------|-------------------------|
| Peachs Point | 244 | 100.9 |
| West Beach | 244 | 99.3 |