Massachusetts Department of Fish and Game

In-Lieu Fee Program

Eelgrass Restoration Project 2019 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

Dan McKiernan, Acting Director

Submitted on

March 13, 2020

Project Overview

The Massachusetts In-Lieu Fee Program (ILFP) funded The Division of Marine Fisheries (DMF) to restore and monitor ½ acre (2,023.4 m^2) of eelgrass in the North Coastal Service Area beginning in 2017, for a duration of five years, to end in 2021, as agreed in the Project Proposal, finalized March 2, 2017. The eelgrass restoration was permitted in 2017 under the Corps General Permit number NAE-2017-00754. This report is for the third year of this project; the calendar year 2019.

Based on site selection results, DMF chose Middle Ground in Salem Sound to plant two ¼ acre (1,011.7 m^2) sets of three transects (formerly referred to as a site and now referred to as a set) in 2017 (Figure 1 and 2). To avoid adverse impacts of seasonal effects (storms, algae blooms, crabs), the restoration effort was split over two seasons; the West ¼ acre set (MGW) was planted in April and May 2017, while the East ¼ acre set (MGE) was planted in the end of August and September 2017 (Table 1). Due to a series of three consecutive nor'easter storm events in February and March, post-storm monitoring was conducted in April 2018 (Table 2). Storm impacts were clearly evident at both sets and most severe at MGE where six of 18 plots were completely missing and many more were partially damaged. At the time of this post-storm monitoring, 43% of the planting units had survived at MGW, while 16% of the planting units had survived at MGE. Because of these impacts, a new, identical ¼ acre set (MGS) was planted directly South of MGW in May of 2018. One-month monitoring of MGS was completed in June, showing survival of 99% of the planting units, which is an even better survival rate than that observed at both MGW and MGE sets in 2017 (Frew at al. 2017, Appendix A). Additionally, 5 plots missing from MGW were replaced in May 2018. Further planting at MGE was not conducted due to low survival; however, the remaining plots may expand unassisted, and we will continue to monitor them periodically. Annual monitoring was performed one year post-planting at MGE and MGW as scheduled in July 2018.

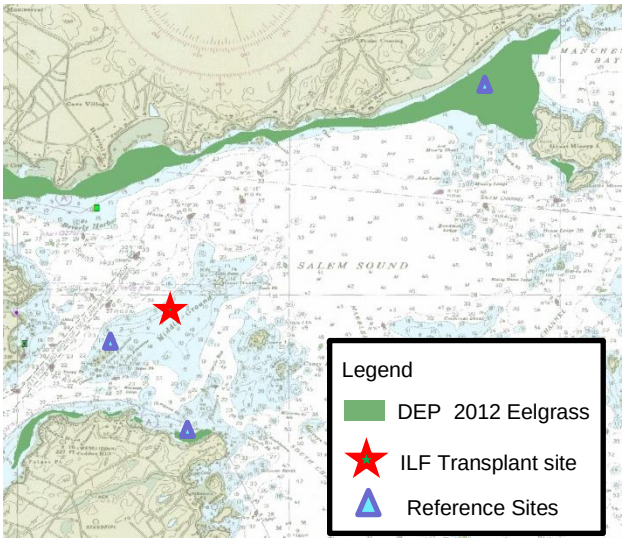


Figure 1. Middle Ground eelgrass restoration site and reference meadows (Aquavitte, Peachs point and West Beach) in Salem Sound

This report focuses on monitoring completed in 2019. In July 2019, monitoring was conducted at MGW two years post-planting for the 13 plots planted in 2017 and one year post-planting for the 5 supplementary plots planted in 2018 (Table 2). MGE, which was severely impacted by nor'easter storm events in the winter of 2018, resulting in an 84% loss of planting units, was not monitored in 2019. One year post-planting monitoring was conducted at MGS (Tables 1&2). Methods and results of the monitoring are detailed below.

Methods

Detailed planting methods are outlined in the Eelgrass Restoration Project Proposal and the 2017 and 2018 annual reports (Appendix A). This report focuses on work conducted in 2019, which consisted of monitoring at all planted plots within MGW and MGS.

Monitoring

On June 19, 2019, divers monitored the 2018 experimental seeding plot at MGW by swimming over the planted areas, inspecting the substrate at each plot and counting any shoots.

In July, divers monitored MGW two years post-planting for the 13 successful plots planted in 2017 and one year post-planting for the 5 plots planted in 2018 (Table 2). Also in July, one year monitoring was conducted at MGS, which was planted in May 2018. Monitoring in 2019 was conducted following the methods outlined in the Eelgrass Restoration Project Proposal (Evans and Carr 2017, Appendix A). However, the two-year-old planted disks (the planting units, or Pus) had developed into coalesced squares necessitating use of the Stage 2 of monitoring, where individual discs are no longer counted as they are indistinguishable. Instead, divers counted the number of squares within each plot (one square contained the original five disks that had coalesced). The squares then become the new unit of measure for survival. Divers also measured the length and width of one planted square within each of the 18 plots as well as the length and width of the entire plot, to quantify expansion. Divers measured the shoot density, canopy height and percent cover in a 1 m^2 area at three randomly-chosen places within each of the 18 plots. Finally, divers made general observations and took video and still pictures.

Three reference, natural eelgrass meadows were monitored to obtain a mean reference value for comparison with values measured at the the restoration site. Divers monitored all three reference beds (West Beach, Peachs Point, and Aquavitae, Figure 1) in July and August 2019 (Table 2) using methods detailed in the Project Proposal and the 2017 and 2018 annual reports (Appendix A) to obtain a mean reference value for all metrics measured at the transplanted sites (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%). All three reference sites will continue to be monitored once annually during the peak growing season (July) for comparison with restored sites.

Results

Middle Ground West (MGW)

In July 2019, two years post-planting at MGW, 75.6% of the originally planted squares were still vegetated and were growing and expanding (Figure 3). Eelgrass metrics had increased across all three transects compared to the same measurements made in 2018 (Figure 4). Mean shoot density of the plots was 148.6 shoots/m^2, mean canopy height was 69.0 cm, and mean percent cover was 63.3%. (Figure 4, Table 3) .Between 2018 and 2019, mean canopy height and percent cover also increased at reference sites, while shoot density decreased (Figure 4, Table 3). Mean area of a square within the plot was 2.23 m^2, a 113.6% increase from 2018 (Table 3, Figure 5). Divers noted abundant hydroid and algal epiphytes on and around the plants, particularly at the middle transect.

In 2019, one year post-planting at the 5 replacement plots, we measured 86.6% survival of the squares were present (26 of the 30). All measured eelgrass metrics increased across all five plots compared to the one-month monitoring results from 2018 (Table 4). Mean density was 94.4 shoots/m^2, mean canopy

height was 48.5 cm, and mean percent cover was 42.0%. The mean area of the vegetated squares within plots was 0.93 m^2, which is a 32.6% increase from 2018.

The seed plots planted off of the southwestern corner of MGW were monitored in July 2019; no plants were found.

Middle Ground South (MGS)

In July 2019, one year post-planting at MGS, all plots were still present, but four squares were missing in the middle and southern transects, yielding 96.3% survival of planted squares (Figure 6). Mean shoot density of the plots was 93.6 shoots/m^2, mean canopy height was 54.7 cm, and mean percent cover was 45.5% (Table 5). Mean area of a square within a plot was 1.56 m^2, a 167.3% increase from 2018.

Reference Sites

The mean shoot density measured at the three reference sites declined by approximately 20% from 2018 to 2019, while mean reference canopy height and percent cover increased (Figure 4). In 2019, all metrics were still higher at the refrence sites than at the transplant site.

Peachs Point

Eelgrass mean shoot density measured at the Peachs point reference meadow declined by approximately 18% compared to 2018, at 168 shoots/m^2 (Table 6.) Mean canopy height was 96.1 cm, and mean percent cover was 65.8% (Table 6).

West Beach

The West Beach reference site has been monitored by MA DMF since 2008, and the results in 2019 were consistent with past years. Mean shoot density in 2019 was 210.7 shoots/m^2. Mean canopy height was measured at 129.8 cm and mean percent cover was 92.1% (Table 6).

Aquavitae

Mean shoot density at Aquavitae increased by approximately 36% compared to 2018, at 189.7 shoots/m^2. Mean canopy height was 65.3 cm, and average percent cover was 78.3%.

Requirements/Performance Standards

Success Criteria (performance standards):

The goal of the project is the restoration of ½ acre of eelgrass by 2021. Success is determined by the persistance and expansion of the planted eelgrass over five years, from 2017 to 2021. The initial transplants had successful survival rates, and where they did not, they have been replanted. Current plant metrics are on the expected restoration trajectory (Figure 4). That is, they have continued to show planting unit survival greater than 50% (75.6% MGW, 86.6% MGW supplemental and 96.3% MGS), and an annual increase in density and plot expansion overall.

Summary and Conclusions

MA DMF has successfully completed the third year of the 5-year ILF eelgrass restoration project. A half-acre of eelgrass was planted at Middle Ground in Salem Sound over two seasons in 2017. After losses due to storms, the plantings were supplemented at MGW in the spring of 2018 by filling in lost planting

units and planting a new ¼ acre set of transects, called MGS. MGE was not replanted, because there was a >50% loss. Site characteristics, in addition to storm impacts and planting season, may have driven the decline. Therefore, the best course of adaptive management was to establish a new site on the same depth contour as the successful MGW site. In 2019, both MGW and MGS showed increases across most metrics.

Two more seasons of monitoring are planned in July of 2020 and 2021.

CY2019 Budget Update

In Calender year 2019 the ILF eelgrass project charged a total of $45,920 on all field, office and personel expenses. Please see below for a breakdown of the expenses from CY2019 compared to our approved 5-year budget, and the CY2018 expenses. The total cumulative charges to the account for both CY2017 CY2018 and CY2019 is $151,486. Also reported is the remaining balance in each category and total remaining of $110,606

Line Item	Approved 5-Year Budget	CY2017 Expenses	CY2018 Expenses	CY2019 Expenses	Cumulative Charges	Remaining Balance
SCUBA Air fills	$11,556	$642	$2,443	$1,034	$4,118	$7,438
Field Supplies	$3,200	$553	$476	$1,339	$2,368	$832
Licor Sensors	$560	$913		$0	$913	-$353
Boat Fuel& Maintenance	$26,750	$683	$6,644	$3,904	$11,231	$15,519
Dive Gear	$5,000	$31	$1,085	$1,651	$2,766	$2,234
Hummingbird Software	$1,200	$0		$0	$0	$1,200
Lab Work	$10,000	$0	$3,193	$0	$3,193	$6,807
Permitting	$880	$657		$0	$657	$223
Personnel Carr	$18,121	$5,193		$5,387	$10,580	$7,541
Personnel Ostrikis	$14,649	$5,063		$5,387	$10,450	$4,199
Dive Pay	$48,150	$4,605	$2,220	$0	$6,825	$41,325
Contract Employee	$66,560	$16,864	$31,332	$16,368	$64,564	$1,996
Travel	$1,250	$114			$114	$1,136
Indirect	$40,798	$7,761	$8,173	$6,618	$22,552	$18,246
Payroll tax	$2,440	$453	$523	$474	$1,450	$990
Fringe Benefits	$10,978	$5,173	$774	$3,759	$9,706	$1,272
TOTAL	**$262,092**	**$48,703**	**$56,863**	**$45,920**	**$151,486**	**$110,606**

Acknowledgements

We appreciate all those who assisted in the field and in project planning, especially Mark Rousseau, Kevin Creignton and Alex Boeri of DMF and, Forest Schenck, Randall Hughes, Iris Seto and Simonetta Harrison of Northeastern University Marine Science Center. Thanks to Aisling O'Shea and Elizabeth Cianciola of DFG for edits to our drafts and help with the budget.

Figures

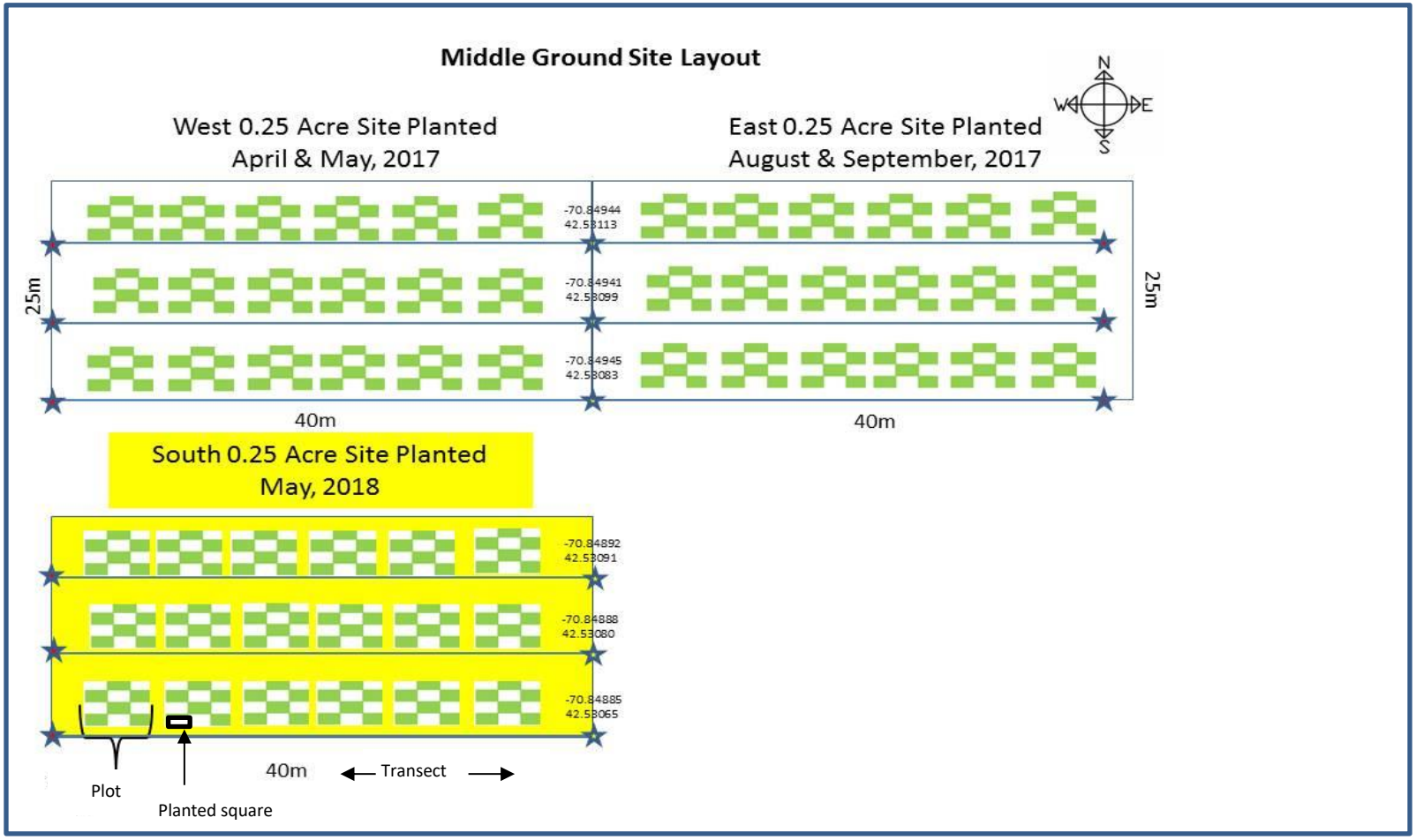
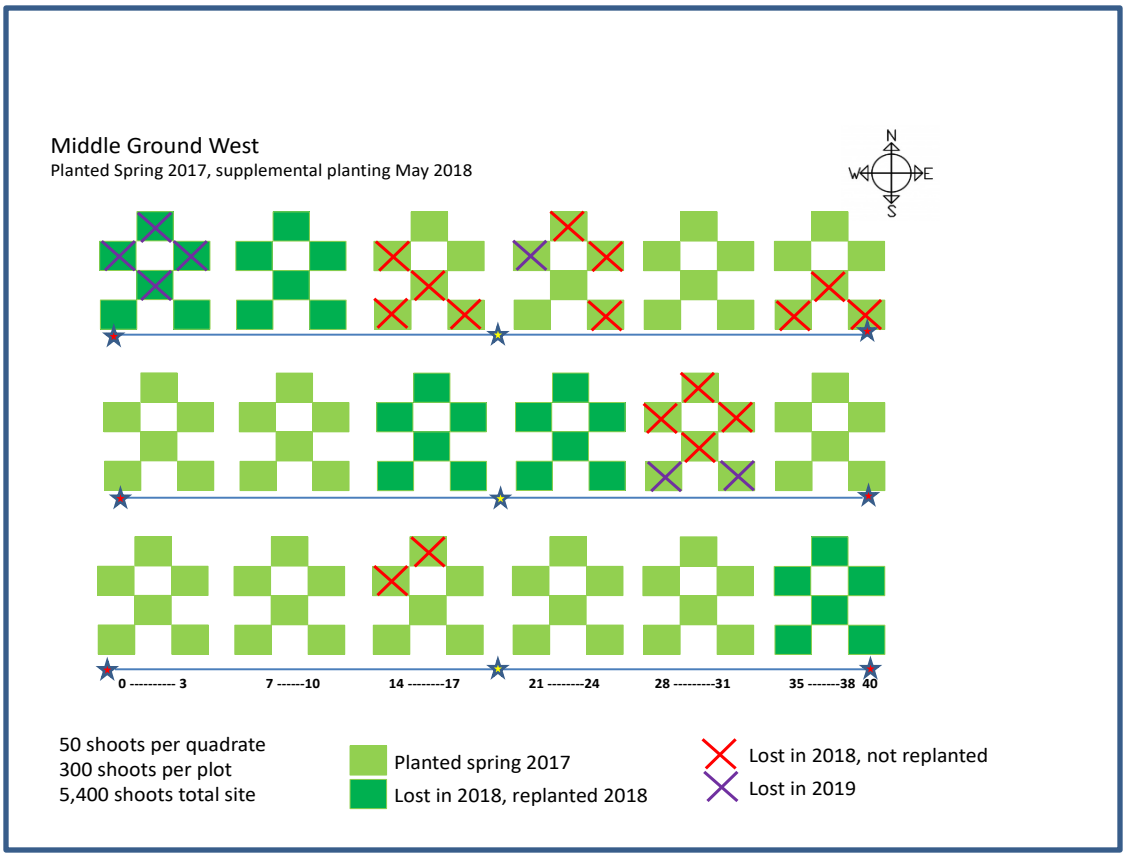


Figure 2: Middle Ground transplant site layout. Each **set** of three transects (formerly referred to as a site) spans approximately ¼ acre area. Middle Ground has three **sets** planted adjacent to each other for a total of 0.75 acre area. Each set consist of 18 **plots** in a checkerboard pattern of 6 planted and unplanted 1 m^2 **squares** for a total of 5,400 shoots.



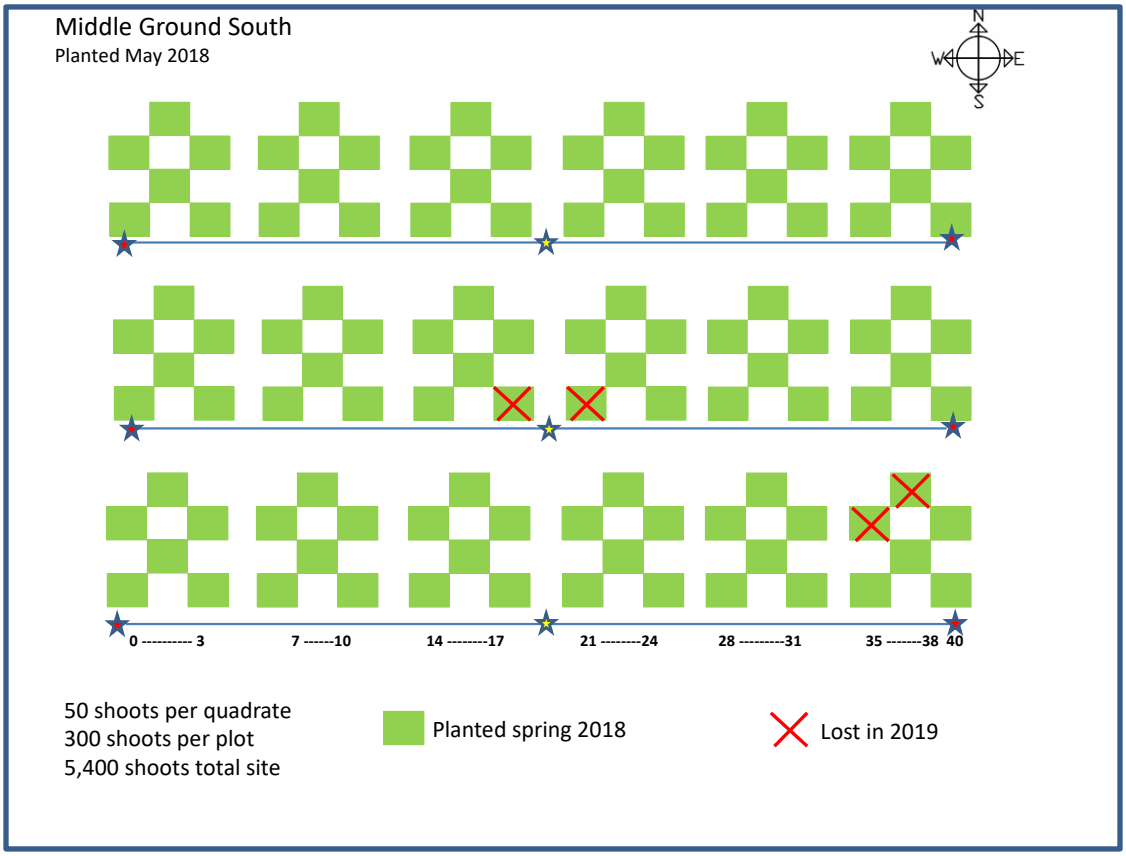


Figure 3: MGW and MGS 2019 square survival.

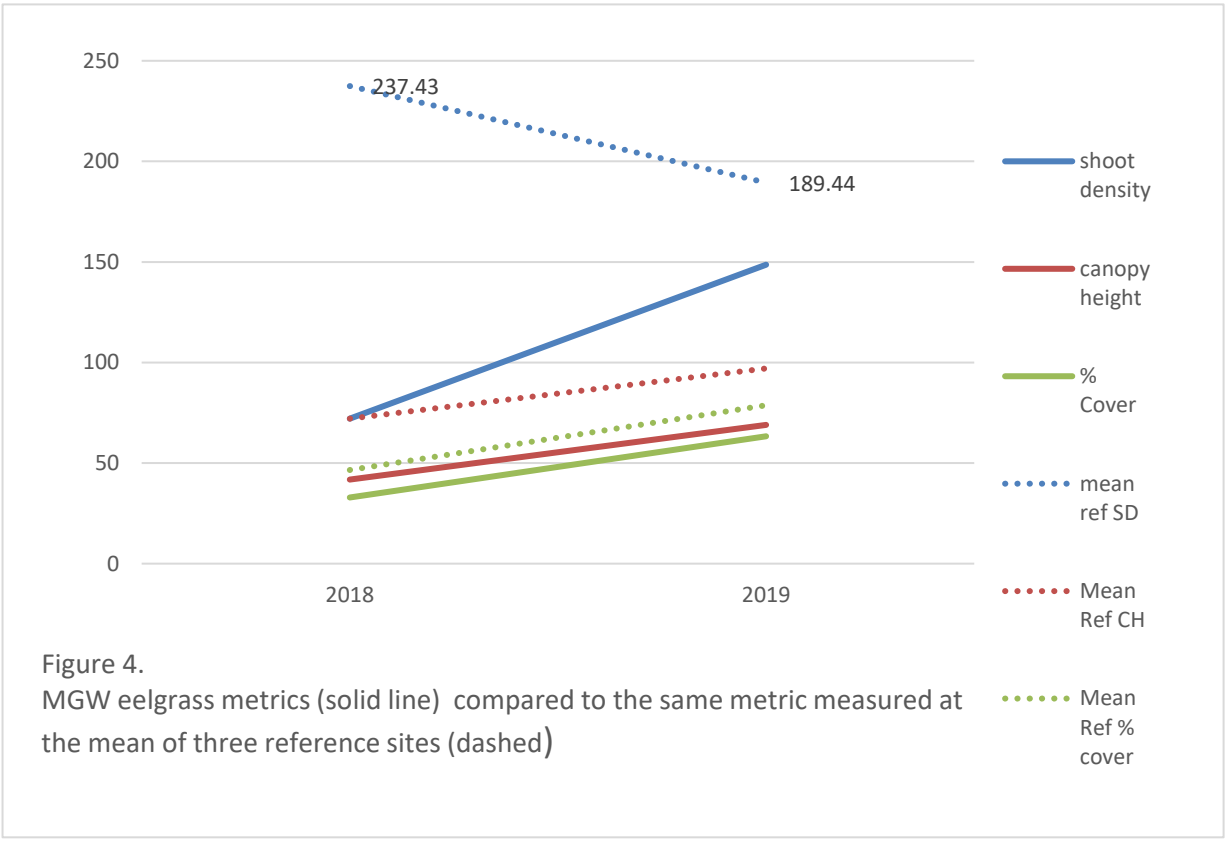


Figure 4.
MGW eelgrass metrics (solid line) compared to the same metric measured at the mean of three reference sites (dashed)

Tables

Table 1: Planting Dates (1 plot=6 planted m^2). Original sets were MGW and MGE. MGS and some plots in MGW are supplemental/ adaptive management shown in red. Note: Mono indicated donor plants are from one site and Poly indicates donor plants are from multiple sites		
Event	**Date**	**Notes**
MGW Mono	4/20/2017	2 plots planted
MGW Mono	5/4/2017	2 plots planted
MGW Mono	5/10/2017	2 plots planted
MGW Mono	5/12/2017	2 plots planted
MGW Mono	5/19/2017	2 plots planted
MGW Poly	5/24/2017	8 plots planted
MGE Mono	8/31/2017	10 plots planted
MGE Poly	9/7/2017	8 plots planted
MGW Mono	5/2/2018	4 plots planted
MGS Mono/Poly	5/10/2018	6 plots planted
MGS Mono/Poly	5/17/2018	6 plots planted
MGW Mono	5/23/2018	1 plot planted
MGS Mono/Poly	5/23/2018	6 plots planted
MGW seeding test plots	10/12/2018	1 seed plot planted

Table 2: Monitoring Dates. Dates in red represent anticipated monitoring events. Contract ends in 2021.

Site	1 month	6 month	1 year	2 year	3 year (anticipated)	4 year (anticipated)
MGW	6/12/17	11/14/17	4/9/18 post-storm 7/11/18	7/18/19	7/20	7/21
MGW (2018 supplemental)	7/11/18	NA	7/18/19	7/20	7/21	---
MGE	10/12/17	4/2/18	7/11/18	—	7/20	7/21
MGS	6/14/18	NA	7/10/19	7/20	7/21	---
West Beach	NA	NA	7/18/17, 7/24/18	8/6/19	7/20	7/21
Peachs Point	NA	NA	8/9/17, 7/3/18	7/24/19	7/20	7/21
Aquavitae	NA	NA	7/3/18	7/24/19	7/20	7/21

Table 3: MGW 2-year Monitoring Results (13 plots planted in 2017)

Transect	Mean Density [shoots/m^2]	Mean Canopy Height [cm]	Mean % Cover	Quadrat Area [m^2]
North	114.0	73.8	47.3%	2.45
Mid	94.3	48.9	56.1%	2.27
South	219.7	77.2	80.5%	1.96
ENTIRE SITE	**148.6**	**69.0**	**63.3%**	**2.23**

Table 4: MGW 1-year Monitoring Results (5 plots planted in 2018)				
Transect	**Mean Density [shoots/m^2]**	**Mean Canopy Height [cm]**	**Mean % Cover**	**Quadrat Area [m^2]**
North	46.3	40.3	28.4%	0.28
Mid	128.7	50.2	50.0%	1.42
South	122.0	53.3	53.3%	1.38
ENTIRE SITE	**94.4**	**48.5**	**42.0%**	**0.93**

Table 5: MGS 1-year Monitoring Results (18 plots planted in 2018)				
Transect	**Mean Density [shoots/m^2]**	**Mean Canopy Height [cm]**	**Mean % Cover**	**Quadrat Area [m^2]**
North	115.4	66.0	55.0%	1.51
Mid	106.1	54.5	53.1%	2.04
South	59.4	43.4	30.0%	1.17
ENTIRE SITE	**93.6**	**54.6**	**46.0%**	**1.56**

Table 6: 2019 Reference Bed Monitoring Results						
Site	**Mean Density [shoots/m^2]**		**Mean Canopy Height [cm]**		**Mean % Cover**	
	2018	*2019*	*2018*	*2019*	*2018*	*2019*
Peachs Point	366.7	168.0	106.3	96.1	67.1%	65.8%
West Beach	206.3	210.7	84.1	129.8	43.8	92.1%
Aquavitae	139.3	189.7	25.9	65.3	28.8%	78.3%

Appendix A

1) Eelgrass Restoration Project Proposal, 2017
2) 2017 Annual report
3) 2018 Annual Report

Massachusetts Department of Fish and Game

In-Lieu Fee Program

Eelgrass Restoration Project Proposal

and project change

To be implemented by the Division of Marine Fisheries

Prepared By

T. Evans and J. Carr

Submitted to

The Massachusetts In Lieu Fee Program

Administered by the Department of Fish and Game

MarineFisheries
Commonwealth of Massachusetts

David E. Pierce

Director

Revised November 21, 2016

Budget revision March2, 2017

Project change addition June 19, 2017

Introduction

In 2014 the Corps approved DFG to be the sponsor of a state-wide program that would provide in-lieu fee compensatory mitigation associated with Corps permits under §404 of the Clean Water Act and/or §§9 or 10 of the Rivers and Harbors Act of 1899 and related federal rule at 33 C.F.R. Part 332 (the federal Mitigation Rule). Specifically, on May 23, 2014 the Corps and DFG signed an Instrument developed by DFG that set forth a comprehensive description of how DFG will administer its in-lieu fee program ("ILFP") in Massachusetts.

The availability of DFG's ILFP allows permittees, with the Corps' approval, to make a monetary payment in compensation for project impacts to aquatic resources of the U.S. in Massachusetts, *in-lieu of* on-site mitigation. When these in-lieu fee payments are made to the ILFP, DFG assumes legal responsibility for implementing the required mitigation, which it does by aggregating and expending the in-lieu payments on mitigation projects.

DFG's ILFP is being administered by its three divisions – the Division of Marine Fisheries ("DMF"), the Division of Fisheries and Wildlife ("DFW") and the Division of Ecological Restoration ("DER") - and will implement mitigation projects that permanently protect aquatic resources and upland buffers and/or restore impacted aquatic resources within four (4) service areas. DFG selects ILFP mitigation projects through its application of detailed prioritization criteria in the ILFP Instrument, which includes consideration of a potential project's ability to achieve multiple mitigation objectives and its support or compatibility with broader conservation or management initiatives.

Since the establishment of DFG's ILFP, eight (8) U.S. Army Corps of Engineers ("Corps") permittees have made an in-lieu fee ("ILF") payment to the program totaling $298,670.84. Of this total amount, $274,670.84 of the ILF payments are derived from Corps-permitted impacts to subtidal, intertidal and estuarine marine resources in the Coastal Service Area. At the end of 2015 DFG determined that it had received a sufficient amount of ILF payments to fund and select one or more mitigation projects to be implemented beginning in 2016.

DFG's Evaluation of Potential Mitigation Projects

Representatives of DFG's Commissioner Office and DFG's Divisions met to identify, discuss and evaluate potential ILFP mitigation projects. In view of the type, location and scope of the Corps-permitted impacts underlying the great majority of ILF payments made to date, DFG determined at the outset that its first proposed mitigation project using ILFP funds should be to restore marine aquatic resources in the Coastal Service Area. DFG focused its attention

on two potential mitigation projects in the Coastal Service, specifically the North Subarea, discussed below.

- ***Key Marsh salt marsh restoration in Belle Isle State Reservation in Revere, MA.***

  This site, which is owned by the MA Department of Conservation and Recreation (DCR), contains about seven (7) acres of tide-restricted salt marsh and two (2) acres of filled salt marsh. The latter area has remnants of an abandoned radio tower facility built on the marsh and that is surrounded by an earthen dike designed to keep the tides out. To date, DER has only completed some preliminary assessment and design of restoration options.

  The big picture restoration goal is to restore tidal hydrology at this site. More specifically, on the northern portion of the site, the existing remnant berm would be removed to facilitate tidal exchange across the marsh surface. On the southern portion of the site, the berm would be breached at the location of the existing water control structure to restore tidal hydrology, and the breach area would be graded to mimic the channel profile of the historic tidal creek. A potential subsequent phase of the project would involve the removal of 2.2 acres of fill from to restore wetlands. At present, there are only a ballpark cost estimates in the range of $200,000 to $400,000, depending on scope of the dike and fill removal scope and the option selected to dispose of the materials. Current project partners include DCR, MassBays Program, Essex Co. Mosquito Control, Mystic River Watershed Association, and Friends of Belle Isle Marsh.

  DER does not have the staff resources to take the lead on project management, design, permitting, and construction. DCR, the land owner, has no intention of becoming the project lead either. Realistically, none of the other project partners has the capability and resources to assume the role of an effective project proponent. Thus, the absence of a capable and committed project lead is a key weakness in terms of both timely implementation and likelihood of success. Additionally, important aspects of the project have not yet been sufficiently developed (e.g., disposal approach; project costs; timeframe for implementation). Finally, DFG's proposed mitigation project – eelgrass restoration in Salem Harbor and Boston Harbor – has a closer nexus to the Corps-permitted impacts underlying the ILF payments.

- ***Eelgrass Restoration Project to be implemented by DMF***

  The second potential mitigation project considered by DFG was a proposal for DMF to use ILFP funds to restore approximately ½ acre of eelgrass to sites in Salem Sound and Boston Harbor, within the Coastal Service Area, Northern Subarea. By way of background, DMF has

a long-standing, ongoing and successful eelgrass restoration program, and so is uniquely qualified to conduct this restoration and fulfill the mitigation requirements of the ILFP. Beginning in 2005, DMF planted approximately five acres of eelgrass at sites in Boston Harbor as part of the Algonquin Hubline mitigation requirement (Hubline). Since that time the grass has more than doubled at the Long Island and Peddocks Island sites, to approximately 8.5 acres of eelgrass meadow. DMF recently completed the planting of two more acres of eelgrass in Massachusetts Bay, as part of a second mitigation requirement for Hubline (HUB3).

Site selection is a critical part of the restoration process. DMF has been working to refine site selection criteria throughout Massachusetts Bay and we are familiar with the best places to continue to restore eelgrass at this time. DMF proposed to restore eelgrass at two sites contiguous to sites that were successful in previous restoration efforts: Governor's Island Flats in Boston Harbor and Middle Ground in Salem Sound. DMF would plant ¼ acre at each site in the first year spread over two seasons. To ensure success, DMF would also augment plantings in the second year (third season) at previously planted sites and additional sites that have rated well in our site selection process. Finally, DMF has the requisite personnel with expertise that are available to complete the restoration within the above timeframes.

As between the Belle Isle Reservation tidelands restoration project and the eelgrass restoration project, DFG determined that the latter mitigation proposal by DMF is by far the strongest, most viable and timely ILFP mitigation project.

DFG's Selection of DMF's Proposed Eelgrass Restoration Project

For the reasons discussed in more detail below, DMF proposed and the DFG team selected, consistent with the ILFP project selection criteria in the Instrument, the specific eelgrass restoration project set forth in this proposal for review and approval by the Corps in consultation with the IRT.

Restoration Sites

***Site** Selection*

DMF relied on its extensive in-water experience to select sites for this project. Due to degraded water quality, available sites for restoration are increasingly limited in Massachusetts. We selected sites adjacent to sites where we have had previous restoration success. We propose two primary sites at Governors Island Flats, Boston and Middle Ground, Salem. We also propose Great Brewster Island as a secondary site. It is prudent to plant over several seasons

to ensure uncontrollable events such as storms or bioturbators (e.g., crabs) do not eliminate an entire planting. For this reason we have proposed three seasons of planting.

Donor sites for the Hubline restoration were previously selected based on the physical characteristics of the site and the proximity to the transplant site, with consideration of the size and longevity of the donor meadow. For the proposed project we will begin with our established donor sites in Nahant and Beverly, while continuing to assess the most effective use of these and other possible donor meadows for optimal transplant success.

Project change 6.19.17

In the early spring of 2017, DMF learned from the Army Corps of Engineers Regulatory Division that our proposal to plant eelgrass at the Governor's Island flat site in Boston Harbor will not receive Corps approval due to the site's close proximity to the airport and objection from the FAA pertaining to safety concerns with wildlife enhancement.

In light of this development, we were approved to plant the full ½ acre at Middle Ground in Salem Sound, meeting the ILF project requirements at one site rather than two. We will plant half of the area this spring and half in the fall. If we have time we will plant test plots at sites in greater Boston Harbor, outside of the airport wildlife exclusion zone. In 2018 we will augment any planting needed at Middle Ground and consider planting further at sites in Greater Boston Harbor, depending on the results of our test plots. Monitoring of the Middle Ground site, and possibly a Boston Harbor site, will continue for five years, until 2022.

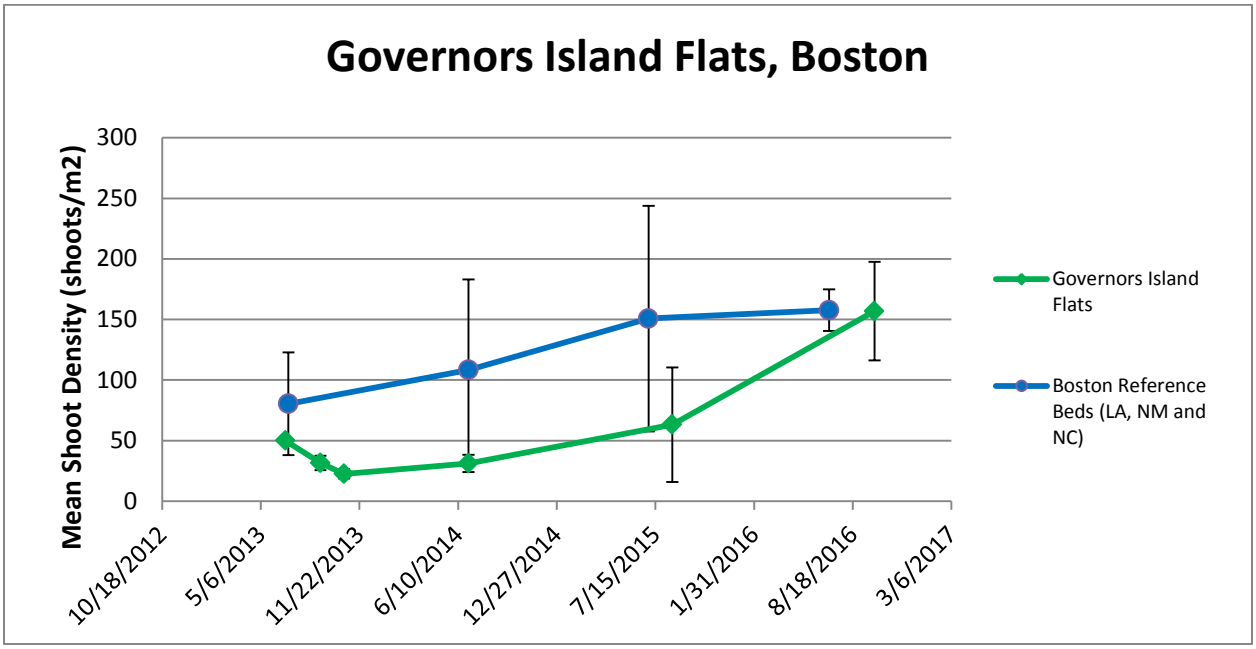
Success Criteria (performance standards)

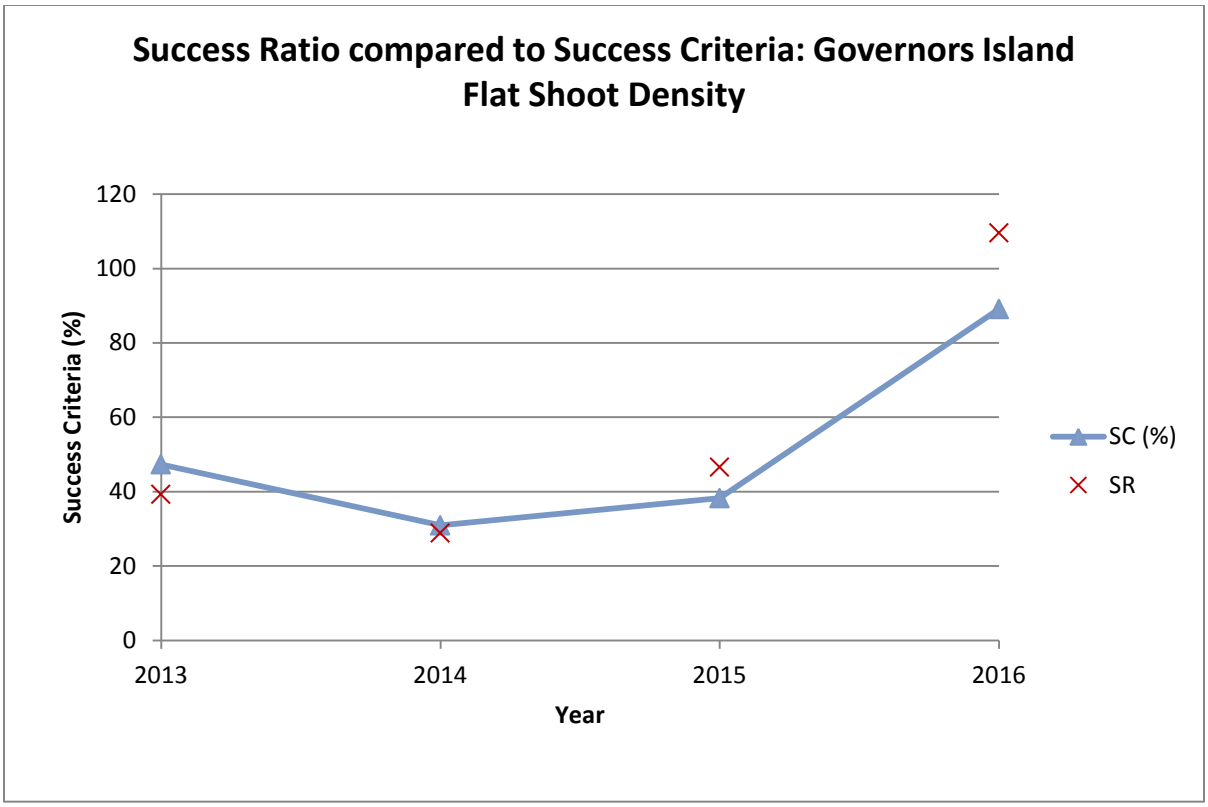
Transplant success will be determined by the persistence and expansion of the restored meadow over five years. Each year the restoration sites will be monitored and compared to values measured at reference sites. Within three years the plantings should be on a trajectory to reach the restoration targets, and after five years the targets should be met or the mitigation will not have successfully replaced the lost habitat (Evans and Short 2005). Restoration targets are defined as the desired acreage of ½ acre with a shoot density, % cover and canopy height statistically equivalent to reference levels. To determine if targets are met, we will compare a success ratio (SR) for each indicator at our restoration sites to Success Criteria (SC) calculated from local and representative reference sites. When the SR reaches the SC, that parameter is deemed a success. This method is described in Short et al (2000) with the following equations:

SC = 100*reference sites mean-1 Standard Deviation (SD)/ Reference sites mean

SR =100* Restoration site mean/Reference sites mean

The success criteria (SC) is calculated based on the mean and standard deviation (SD) for all the reference sites combined. This means that the threshold of success (the SC) is within one SD of the mean of the reference sites. The success ratio is the proportion of the mean at the restoration site compared to the mean at the reference site. The success ratio approaches 100 as the restoration site mean gets closer to the reference site mean. Below is a graph from our Governor's Island Flat restoration site showing shoot density at the restoration site compared to the reference sites. The second graph illustrates the SC and SR, showing that our restoration was successful for the shoot density parameter after three years (2015) and it exceeded the reference sites in 2016.





Governors Island Flats

Governors Island Flats (Figure 1) is a shallow bank within Boston Harbor. It is 5– 6 ft MLW, characterized by silty sediments. Historically, Governors Island flats had abundant eelgrass meadows.

DMF successfully planted a 1/3 acre area in 2013 at Governors Island Flats. Monitoring in 2015 showed plant growth and plot enlargement both through seeding and lateral expansion. Mean shoot density increased over the two years since transplanting and it is within one standard

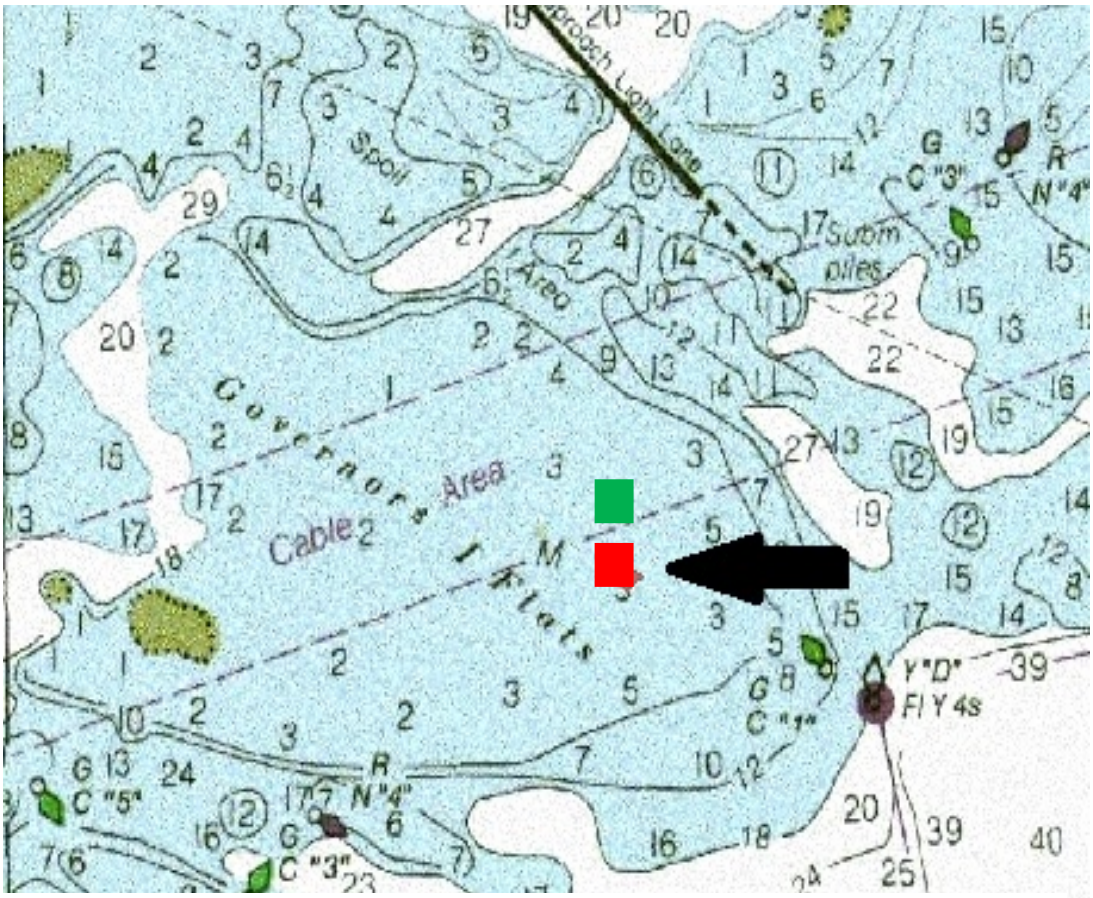


Figure 1. Proposed location of ¼ acre Restoration site at Governor's Island Flats (green) and hubline restoration site (red)

deviation of the mean of all the reference sites. There is additional area suitable for eelgrass restoration at the site and we propose the addition of ¼ acre shoreward of the existing restoration site (Figure 1). The exact location will be determined in the field based on suitable substrate. GPS locations will be obtained and included in all reporting. In the first season, a 1/8 acre site will be planted with eelgrass in a checkered pattern as shown in Figure 6. The following season an additional 1/8 acre will be planted at each site. We will augment the plantings as needed in the second year.

<u>Project change</u>

We will not utilize the Governor's Island Flat site as it did not meet permit requirements.

Middle Ground

Middle Ground, also known as Aqua Vite, is the shoal northeast of the mouth of Salem Harbor with depths of 6- 12 feet at MLW (Figure 3). There are anecdotal reports of this area having abundant eelgrass in past decades. We first investigated it in 2011 and found only a few small, scattered eelgrass patches. Light measurements indicated adequate light for eelgrass growth (Evans et. al 2013) and there is extensive area suitable for additional planting.

DMF successfully planted a 1/3 acre area at Middle Ground in 2012. Monitoring in 2015 showed plant growth and plot enlargement both through seeding and lateral expansion. Mean shoot density increased over the two years since transplanting and it is within one standard deviation of the mean of all the reference sites (Evans et. al 2013). A 1/8 acre site will be planted with eelgrass in the first season (e.g., spring) ,

Figure 2. Proposed location of ¼ acre Restoration site at Middle Ground (green) and hubline restoration site (red)

1/8 acre in the second season (e.g., fall of the same year), and will be augmented as needed in the third season (e.g. spring of the following year).

Project change

The update to our plan includes planting the full restoration area of ½ acre at the middle ground site. In the spring of 2017 we will plant 1/4 acre at Middle ground A and in the fall we will plant the other1/4 acre at Middle Ground B.

Methods

Permitting

DMF obtained all required local, state and federal permits and authorizations for the above restoration and donor sites in 2005, as part of the Hubline restoration. The Boston Conservation Commission has determined that we will require a new NOI, filed as an Ecological Restoration Project, for the additional plantings. We are currently discussing the proposed project with the Commissions in the other towns and with the Army Corps of Engineers to determine if any other permits are needed.

As of June 2017, we have the Orders of Conditions from Salem, Beverly, Nahant and Gloucester (DEP file number for Gloucester 028-2545).

Transplanting

Eelgrass shoots will be collected from donor beds in Nahant and Beverly using a low impact collection method where shoots are gathered by hand in a dispersed manner and no more than 1% are harvested from a m^2 area.

Eelgrass shoots will be collected from five different donor beds in Nahant, Salem, Beverly and Gloucester.

At Middle Ground we propose to plant approximately 1/2 acre of eelgrass in the first year, in two separate ¼ acre sites adjacent to each other. Each site will have 5,400 transplanted shoots arranged in a checkered pattern of 18 $12m^2$ plots of 6 planted and 6 unplanted 1 m^2 squares, for a total of 108 planted squares spread across each ¼ acre site (Figure 6). We will use the Burlap Disc method (Pickerell, pers. com.) or a seeding method. When using the burlap disc method, ten shoots are woven into a burlap disk by their rhizomes (Evans et al 2013). The discs are then planted in a shallow hole at five locations within a $1m^2$ quadrat.

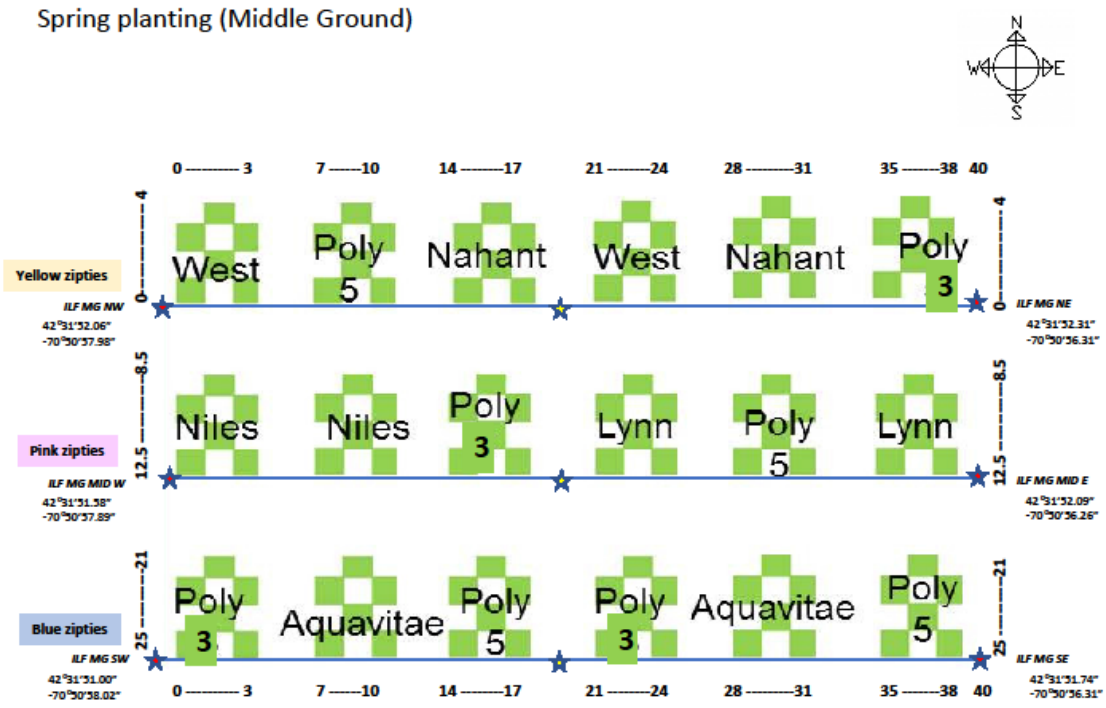


Figure 6. Layout for 1 site, approximately ¼ acre area. Eighteen plots each in a checkerboard pattern of 6 planted and unplanted 1 m2 squares for a total of 5,400 shoots. Two sites will be planted adjacent to each other at Middle Ground in Salem

Monitoring

We propose initial monitoring of the planted plots by divers one month after transplanting, and then both diver monitoring and acoustic mapping annually for five years. We will also monitor reference meadows for comparison.

Transplant Site

At the one month and annual monitoring events, divers will swim over each planted 12m^2 plot and note the presence/absence of originally planted squares for the entire restoration area. This will provide an initial percent survival of the transplant. In addition, three planted squares in each plot, for a total of 54 squares per site, will be randomly selected for collection of shoot

density, canopy height and percent cover measurements. The plot's length and width will be measured to quantify areal expansion. This monitoring method will continue for five years at all planted sites to determine the overall expansion of the plantings through lateral growth and seeding, and finally to calculate the area successfully restored.

Reference Site

We have six reference beds, three in Salem Sound and three in Boston Harbor, which we plan to monitor for comparison with our transplanted sites in order to calculate restoration success according to a method described in Short et al (2000). Reference beds have similar depth, bottom type, and water conditions as the restoration sites.
At each reference site a transect tape will be set within a pre-established location. Shoot density, canopy height and percent cover will be measured at 12 1 m^2 quadrats assigned in a repeated random design at locations along the transect.

Acoustic mapping

Both 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 with an 800 kHz high resolution transducer. The meadow area will be surveyed with overlapping lines for 150% sonar coverage. The resulting sonar files will have the water column removed and then be slant range and beam angle corrected in SonarTRX Pro release 15. The resulting lines will be exported and mosaiced in ArcGIS 10.2. In ArcGIS, areas within the mosaic that have eelgrass will be delineated. The area of the meadow will then be quantified and in the final years will be compared to mapped area from the previous years.

Budget

A detailed budget for DMF's eelgrass restoration project is set forth in **Attachment A** and addresses personnel costs (as well as the in-kind match being provided by certain DMF staff), costs for equipment and supplies, and costs for permitting.

ILF Prioritization Criteria

The Department of Fish and Game's (DFG) In Lieu Fee Program (ILFP) has developed prioritization criteria used to select mitigation projects. Below we outline our project's merits addressing each of the five criteria:

Criterion 1) The Project's Ability to Achieve Multiple Mitigation Objectives

The following seven mitigation objectives are identified in the ILFP instrument (p. 42). This project meets the five objectives in bold, each of which is described in detail below.

a. **Restores or improves more than one ecological function or system;**
b. Protects high quality resources/habitats for state-listed species protected under MESA;
c. **Protects important wildlife habitats identified by MassDEP's or other entities important habitat maps;**
d. Targets a high quality riparian habitat area;
e. Targets resources that are under threat of destruction or degradation;
f. Furthers the habitat protection climate change adaptation strategies described in the 2011 Massachusetts Climate Change Adaptation Report
g. Falls within one or more management and restoration climate change adaptation strategies.

a. *Restores or improves more than one ecological function or system*: The primary resource that will benefit from the proposed project will be eelgrass (*Zostera marina*). Eelgrass itself is an important habitat protected by the Massachusetts Wetlands Protection Act and the federal Clean Water Act and through NMFS Essential Fish Habitat provisions (discussed in greater detail below). It provides habitat for various life stages of commercial and recreational fishery resources such as winter flounder (*Pseudopleuronectes americanus*), American lobster (*Homerus americanus*), Atlantic cod (*Gadus morhua*), Pollock (*Pollachius virens*), white hake (*Urophycis tenius*),red hake (*Urophycis chuss*), tomcod (*Microcadus tomcod*), American eel (*Anguila rostrata*), striped bass (*Morone saxatilis*), bay scallop (*Argopecten irradians*) and juvenile stages of fish and invertebrates that serve as forage for the above mentioned species. Eelgrass is also important to ecological function as it enhances the physical quality of the subtidal habitat, improves water quality through biogeochemical enhancements and sediment trapping, attenuates wave and storm energy, and sequesters carbon.

One of the challenges of habitat restoration in the subtidal zone is the limitation of appropriate project types. Projects could include removal of fill or debris (physical restoration) or creation of fisheries habitat or ecosystem services (physical plus ecosystem restoration). This project proposes the latter.

c. *Protects important wildlife habitats identified by MassDEP's or other entities important habitat maps*: This project will restore critical habitat identified by the Wetlands Protection Act, the Mid-Atlantic Fishery Management Council (MAFMC) and

NMFS. MAFMC and NMFS have designated eelgrass as an Essential Fish Habitat (EFH) for cod, pollock, white and red hake, winter and summer flounder, as well as additional designation as a Habitat Area of Particular Concern (HAPC) for a subset of these species.

e. *Targets resources that are under threat of destruction or degradation*: Seagrasses are in decline worldwide (Short et al 2006, Short et al 2014), and declines have been observed statewide in Massachusetts (Costello and Kenworthy 2011) as well as in specific embayments (Costa 1988, DMF unpub. data). As an estuarine plant, seagrasses are useful indicators of estuarine health as they are subject to numerous threats of anthropogenic and environmental stresses. Such threats include nutrient loading, pollution, development-related habitat loss, impacts from boating and fishing activity, and shifting environmental conditions.

f. *Furthers the habitat protection climate change adaptation strategies described in the 2011 Massachusetts Climate Change Adaptation Report*: This project specifically addresses two adaptation strategies listed in the Coastal, Estuarine and Marine Habitats, Resources and Ecosystem Services section (pg114) of the report: Strategy 2, which focuses on improving resiliency of natural habitats through habitat restoration and other means; and Strategy 6 which calls for increased monitoring, observations and assessments to better manage resources and respond to critical shifts in benthic flora communities and areas of high trophic support. Monitoring at the restored and reference sites will include diver and acoustic monitoring and mapping for five years, which will be used to determine restoration success, but will also contribute to the body of knowledge from monitored sites in Massachusetts and New England, providing observation that can be used in a broader context as an early warning system to better manage and interpret change in eelgrass in the region.

g. *Falls within one or more management and restoration climate change adaptation strategies*: In addition to the strategies above, this project also addresses strategy g(iv) from the ILFP instrument (pg 43): Identify and assess potential restoration of coastal wetlands.

Criterion 2) The Project's Support of or Compatibility with Broader Conservation or Management Initiatives and Surrounding Landscape

The proposed project furthers the broader DFG management initiative of preserving the state's natural resources and people's right to conservation of those resources, as well as DMF's mission to manage the Commonwealth's living marine resources in balance with the

environment. In DMF's Strategic Plan, improving and restoring fisheries habitat is a key strategy to achieving one of our primary goals: to improve fisheries sustainability, promote responsible harvest and optimize production of our living marine resources. There are also many other conservation and management initiatives focused on eelgrass and estuarine water quality protection and improvement, such as DEP's Eelgrass Mapping and Monitoring Program, the Massachusetts Estuaries Project and EPA's Estuarine Protection Program.

This project supports broader conservation initiatives within Salem Sound and Boston Harbor by supplementing previous restoration efforts and by complementing ongoing monitoring efforts in these embayments. In both embayments, many estuarine health studies are being conducted by local watershed, academic and government organizations such as MWRA, Salem Sound Coastwatch, Northeastern University, Salem State University, EPA, and others.

Criterion 3) The Project's Likelihood of Success

Eelgrass restoration is inherently risky as unpredictable factors including storms and algae blooms may impact newly planted areas. Many groups have attempted eelgrass restoration in Massachusetts with mixed results. DMF has had the most successful track record with eelgrass restoration over the past decade and has met the restoration goals for all projects undertaken. To date three of six sites that DMF fully planted are continuing to grow and expand.

Site selection is an important step in eelgrass restoration. Sites that are not well chosen may lack the conditions needed for growth and expansion resulting in a high probability of transplant failure. Our institutional knowledge of habitat suitability, along with our use of several different site selection models, and experience with planting dozens of test plot and full-scale restoration locations throughout Salem Sound and Boston Harbor gives us the necessary foundation for making sound site selection decisions for this project.

Criterion 4) Whether the Project will Result in Mitigation in the same Service Area

The draft 2015 ILF Program Annual Report states that 87% of the total impacts to the Coastal Service Area occurred in Subtidal habitat in Salem Sound. The second most impacted habitat was Salt Marsh in Scituate (11% of total impacts). The third most impacted habitat was Subtidal/Intertidal impacts in Boston Harbor (2% of total impacts). The proposed project will create 0.5 or more acres of Essential Fish Habitat (EFH) in the Subtidal habitat in Salem Sound and Boston Harbor, both of which are within the Coastal Service Area.

The benefits of creating new eelgrass beds can be realized beyond these areas due to the reproductive physiology of the plant. Typically in the plant's second growing season, eelgrass

shoots become reproductive when temperature conditions are suitable (early to mid-summer). The reproductive shoot, holding dozens of seeds, is released and floats for a month or more before dropping its seeds (Källström et al 2008), which sink to the bottom. If seeds are transported to suitable habitats, new beds can form.

Criterion 5) Cost of Implementing and Maintaining the Project

DMF has provided a detailed budget for this proposal to demonstrate that we will accomplish the required acreage in the first year, with plantings to augment and fill in any losses in the second year. Our budget includes five years of monitoring, beginning in the first year. Although eelgrass restoration is relatively expensive when compared to terrestrial projects, DMFs experience and in-house capabilities maximize efficiency. Furthermore, planting eelgrass is one of the best options for restoring and improving subtidal habitat.

All proposed eelgrass restoration sites are located in shallow subtidal waters that are tidelands owned by and subject to the regulatory jurisdiction of the Commonwealth. Where, as here, a Commonwealth agency is restoring habitat on Commonwealth tidelands, there are no available and appropriate legal instruments to preserve such tidelands from further development. For example, DMF obtaining a Chapter 91 License would not be appropriate because the proposed eelgrass restoration activity does not involving the filling or placement of structures in Commonwealth tidelands. However, to put this situation in context and perspective, because the distances of the proposed restoration sites from shoreline, navigation channels, and other regulated uses (pipelines, cable crossings, etc.), there is a low risk of site use for future development at these locations. All commercial fishing activity utilizing mobile gear (trawls, seines, or other similar devises including scallop dredging) is closed by regulation in both the Boston Harbor and Salem Sound embayments. The activity with the greatest potential for development in the proposed restoration area is bottom-oriented shellfish aquaculture. Any proposed aquaculture activity requires a permit from DMF. Moreover, both of DMF's proposed eelgrass restoration sites are located in Designated Shellfish Growing Areas (DSGAs) classified by DMF as "Prohibited" for shellfish harvest in accordance with National Shellfish Sanitation Program (NSSP) water quality standards. As stated in DMF's *Shellfish Planting Guidelines, 3rd Edition* (footnote 1, p.7), DMF "does not support shellfish planting activities that create new, self-sustaining populations in Prohibited or Restricted waters due to the risk of attractive nuisance and other enforcement and public health concerns." In short, absent a municipal contaminated shellfish area management plan approved by DMF's Director, no such aquaculture would be allowed within DMF's proposed eelgrass restoration areas in Boston Harbor and Salem Sound. As a practical matter, the likelihood that either the City of Boston or the City of Salem would propose such a contaminated shellfish area management plan or that

DMF would approve them is highly unlikely for the foreseeable future. Finally, in the unlikely event that a project proponent proposed activities that had an adverse impact to DMF's proposed eelgrass restoration sites, mitigation would be required through the applicable federal and state permitting processes.

The ongoing restoration and protection of important marine habitats is an integral part of DMF's mission, as highlighted in multiple strategies of DMF's Strategic Plan (see Goal 1, Goal 3, Goal 4, Goal 5, Goal 6). Over the past decade, DMF has developed an eelgrass program that includes its own restoration, monitoring, management efforts, providing review and comment during the federal and state environmental review processes on projects that may affect eelgrass habitat, and establishing partnerships with other academic, non-profit, and government agencies interested in advancing eelgrass research and restoration.

Thus, this proposed eelgrass restoration project arises out of DMF's larger eelgrass program and reflects DMF's commitment to continue to further its long-term stewardship of eelgrass in the Commonwealth. Consequently, DMF's restoration, monitoring, management efforts are expected to continue beyond the proposed eelgrass plantings and minimum 5 year follow-up monitoring timeframe for this project. The progression and long term health of these proposed eelgrass restoration sites will inform future eelgrass protection and restoration efforts in the Commonwealth. In conclusion, DMF is making a long term commitment to the success of all of its eelgrass program efforts, including this eelgrass restoration project to be funded by ILF payments.

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ATTACHMENT A BUDGET FOR DMF ILFP EELGRASS RESTORATION PROJECT					
Equipment and Supplies					
Calendar Year:	**2017**	**2018**	**2019**	**2020**	**2021**
SCUBA air tank fills (with SeagrassNet)	$3,348	$3,348	$1,620	$1,620	$1,620
Field Supplies (screw anchors, transect tapes, floats, line, burlap)	$1,200	$500	$500	$500	$500
Licor sensors	$560				
Boat fuel and maintenance	$7,750	$7,750	$3,750	$3,750	$3,750
Dive Gear and maintenance as needed	$1,000	$1,000	$1,000	$1,000	$1,000
Humminbird acoustic instrument and Sonar TRX software	$1,200				
Lab work (eelgrass genetics)	$5,000	$5,000			
Permitting	$440	$440			
Personnel					
Dive pay 3 divers (including SeagrassNet)	$13,950	$13,950	$6,750	$6,750	$6,750
payroll on dive pay	$232	$232	$112	$112	$112
indirect on dive pay	$3,613	$4,673	$2,261	$2,261	$2,261
Fisheries Supervisor (Jill) (field and office)	$5,193	$5,387	$2,514	$2,514	$2,514
Indirect	$1,345	$1,395	$651	$651	$651
fringe	$1,740	$1,805	$842	$842	$842
payroll	$86	$89	$42	$42	$42
Fisheries Supervisor (Kate) (field and office first two years)	$5,062	$5,387	$1,400	$1,400	$1,400
Indirect	$1,311	$1,395	$363	$363	$363
fringe	$1,696	$1,805	$469	$469	$469
payroll	$84	$89	$23	$23	$23
Contract Seasonal (full time@ $16/hr x52 weeks, first two years)	$33,280	$33,280			
Indirect	$8,620	$8,620			$
payroll	$549	$549			
Travel (mileage reimbursement)	$250	$250	$250	$250	$250
Sub-total:	$74,346	$73,782	$41,834	$41,834	$41,834
Total Project Cost:	**$262,092**				
DMF Match					
Personnel - (total of 20 days each year of 2 EA II's time)	$5,610	$5,610	$5,610	$5,610	$5,610
Indirect	$1,453	$1,453	$1,453	$1,453	$1,453
fringe	$1,880	$1,880	$1,880	$1,880	$1,880
payroll	$93	$93	$93	$93	$93
Acoustic mapping (equipment use, technician time)	$800	$800	$800	$800	$800
SD Card and external hard drive for data management	$300				
Match Sub-total:	$10,136	$9,836	$9,836	$9,836	$9,836
Total Match:	**$49,481**				

MA DFG In-Lieu Fee Program

Division of Marine Fisheries (DMF) Eelgrass Restoration Project

Credit Release Schedule

40% of the credits will be released upon the completion of project plantings

As proposed by DMF, eelgrass will be planted at two 1/4 acre sites at Middle Ground in Salem Sound over a two (2) year period. While DMF's plan is to plan a 1/4 acre of eelgrass at each site, an outcome may be that DMF is unsuccessful at planting a full ¼ acre at one site, but has planted more than ¼ acre at the other site. For the purposes of this Schedule milestone, the release of 40% of the credits will occur upon DMF's successful planting of a total of ½ acre across the two sites, with the % credits attributable to each site shown in RIBITS as two separate entries.

10% of the credits will be released at the completion of each year of a five year monitoring program once each monitoring report has been reviewed and approved by the Corps in consultation with the IRT

Following the completion of the eelgrass plantings at the above two locations, DMF will monitor these restoration sites for a five (5) year period. As discussed in more detail in DMF's project description, the restoration sites will compared to measureable values (shoot density, % cover, canopy height) at reference sites. 10% of the credits will be released at the completion of each year of monitoring, as documented by DMF's monitoring report for that year.

The final 10% of the credits will be released after DMF determines, with the approval of the Corps in consultation with the IRT, that the project has successful met the performance standards.

DMF expects that within three years of the completion of the plantings, the restoration sites are expected to be on a trajectory to reach restoration targets, and after five years the restoration target should be met. Restoration target is ½ acre transplanted across two sites, with a shoot density, % cover and canopy height statistically equivalent to reference levels as discussed in more detail in DMF's project description.

If, at the time of the final 10% sign-off, DMF has successfully restored more than the required ½ acre in total across two sites in accordance with the success criteria in DMF's project description, DMF may request to be granted additional credit(s) for the larger area restored, subject to the approval of the Corps in consultation with the IRT.

Credit Release Schedule		
	Credit release (%)	**Completed activity/deliverable**
Project planting (years 1 & 2)	40%	½ acre transplanted eelgrass (as proposed, across two sites) – progress report and maps
Monitoring year 1	10%	Year 1 monitoring report
Monitoring year 2	10%	Year 2 monitoring report
Monitoring year 3	10%	Year 3 monitoring report
Monitoring year 4	10%	Year 4 monitoring report
Monitoring year 5	10%	Year 5 monitoring/Final Report – including proposed hydroacoustic mapping results
Final sign off	10%	DMF and the Corps agreed that project performance standards have been met

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

K. Frew, A. Boeri, J. Carr, and T. Evans

Submitted to

The Massachusetts In Lieu Fee Program

Administered by the Department of Fish and Game

David E. Pierce, Ph.D.

Director

Project Overview

Summary

The Massachusetts In-Lieu Fee Program (ILFP) funded The Division of Marine Fisheries (MA DMF) to restore ½ acre (2,023.4 m^2) of eelgrass in the North Coastal Service Area beginning in 2017, 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 ¼ acre (1,011.7 m^2) sites. The restoration effort was split over two seasons, the West ¼ acre site (MGW) was planted in April and May 2017, while the East ¼ 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 ½ acre (2,023.4 m^2) 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 ¼ acre (1,011.7 m^2) 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 ¼ acre site at Middle Ground adjacent to the originally proposed site, bringing the total area of eelgrass to be restored at Middle Ground to ½ 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 (3,237.5m^2) 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/m^2. 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 $1m^2$ 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/m^2 (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, Aquavitae, 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 $1m^2$ 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 (Aquavitae) 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 m^2) sites totalling ½ acre (2,023.4 m^2) 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/m^2 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/m^2 within planted squares (Table 4). By 6-months there was substantial differences between the transects. The mid 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 42.4cm 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/m^2 (Table 5). Mean shoot density ranged across transects from 37.4 shoots/m^2 at the south transect to 40.6 shoots/m^2 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/m^2 with density values ranging between 80 to 576 shoots/m^2 in the 12 quadrats sampled (Table 6). The mean canopy height was 100.9cm 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/m^2 with density values ranging between 176 to 336 shoots/m^2 in the 12 quadrats sampled (Table 6). The mean canopy height was 99.3cm 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 by 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/m^2 (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

Success Criteria (performance standards):

The goal of the project is the restoration of ½ acre of eelgrass. Success is determined by the persistance 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 but 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.

Calendar year 2017 budget and charges:

Line Item	Approved Budget	Cumulative Charges (CY2017)	Remaining Balance
Equipment and supplies			
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
Personnel			
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 thoughout 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 this summer 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.

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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 Extenstion, pers. com.

Appendix

Figures

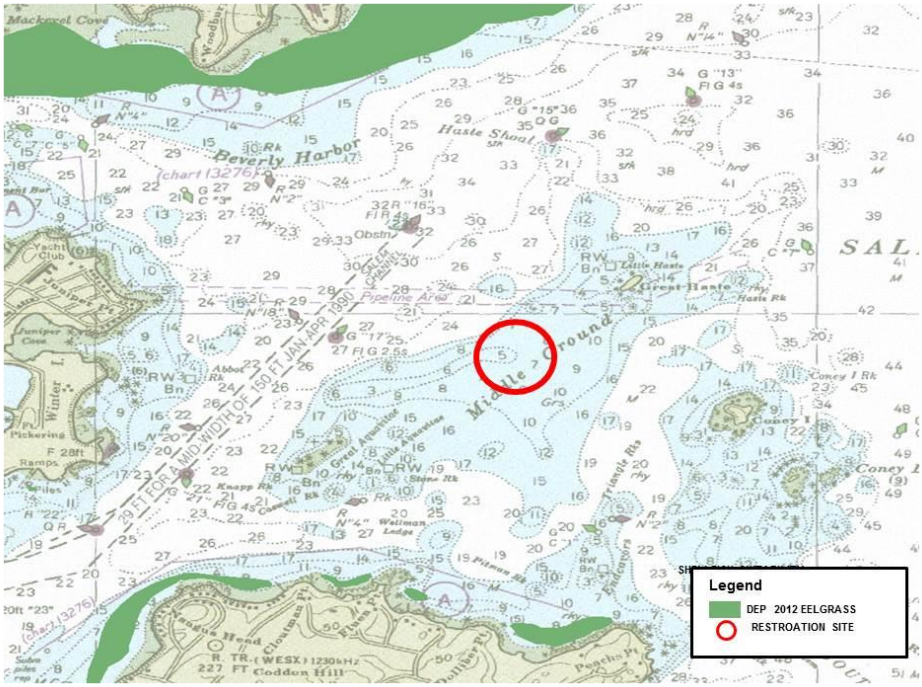

Figure 1: ½ acre restoration site at Middle Ground, Salem Sound.

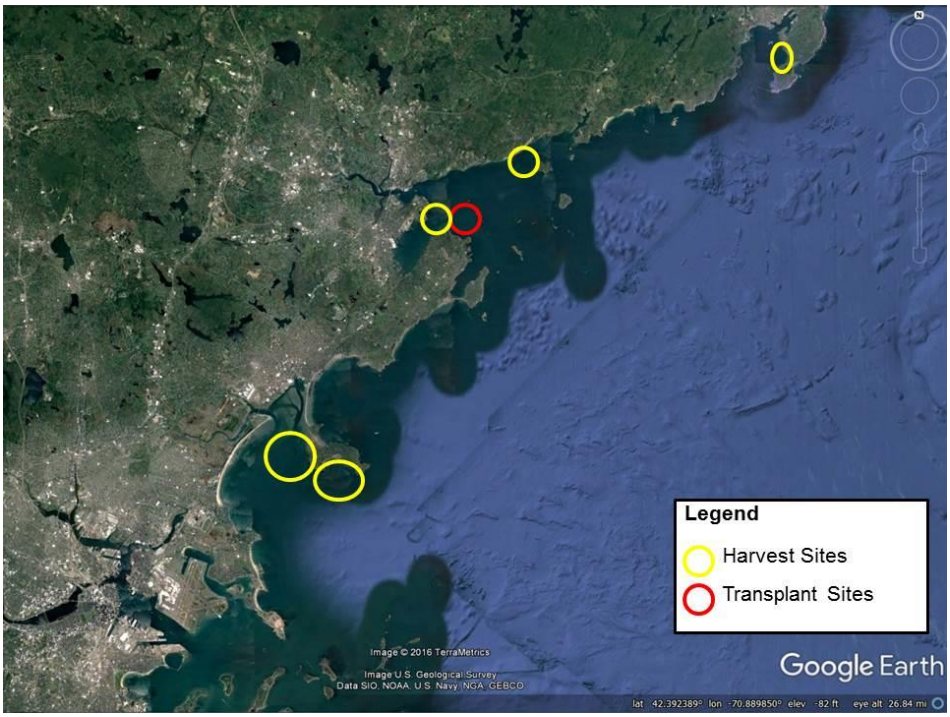

Figure 2: Eelgrass donor sites.

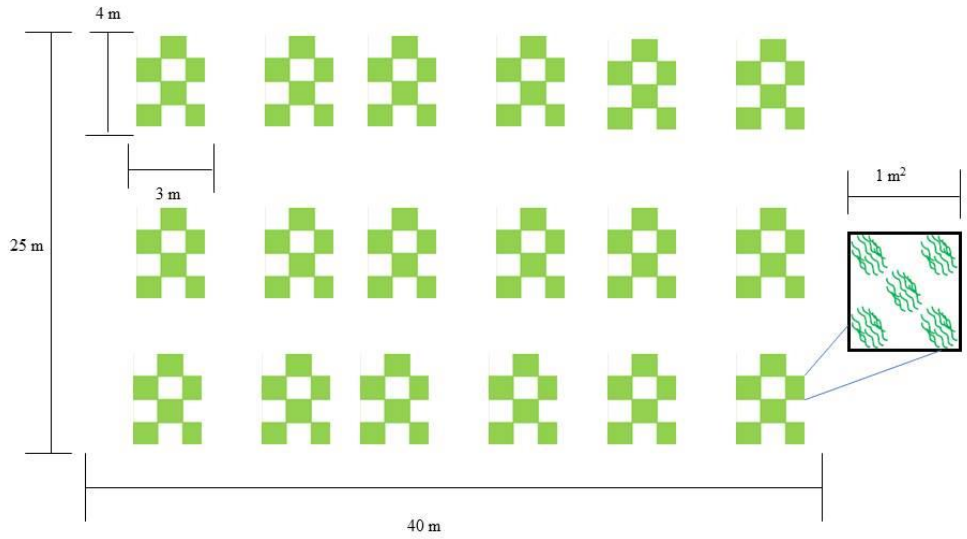

Figure 3: Layout for each site, approximately ¼ acre area. 18 plots each in a checkerboard pattern of 6 planted and unplanted 1 m^2 squares for a total of 5,400 shoots. Two sites planted adjacent to each other at Middle Ground.

Figure 4: Middle Ground site layout.

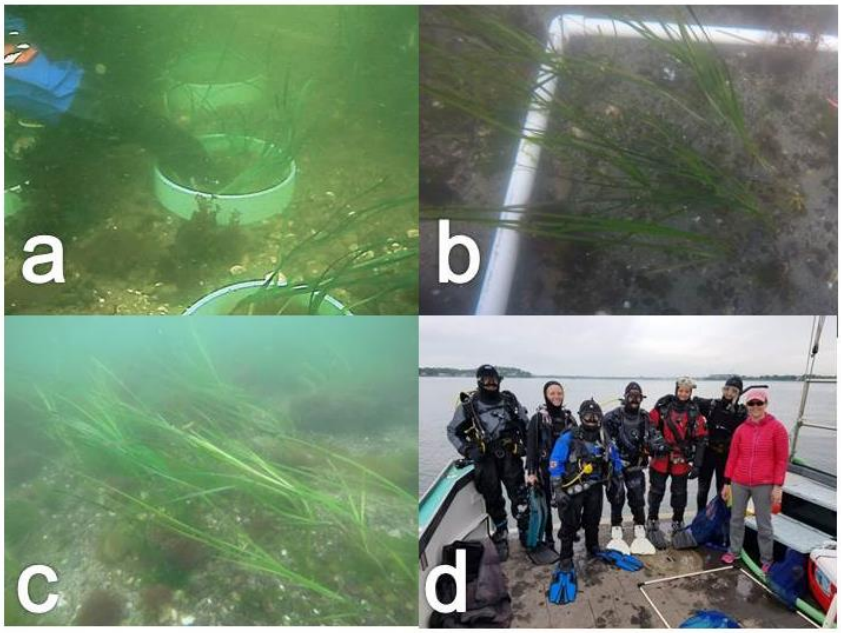

Figure 5: Diver planting a burlap disc of ten shoots (PU) (a), the planted disc (b), 1-month monitoring of MGW (c) and DMF and NEU divers (d).

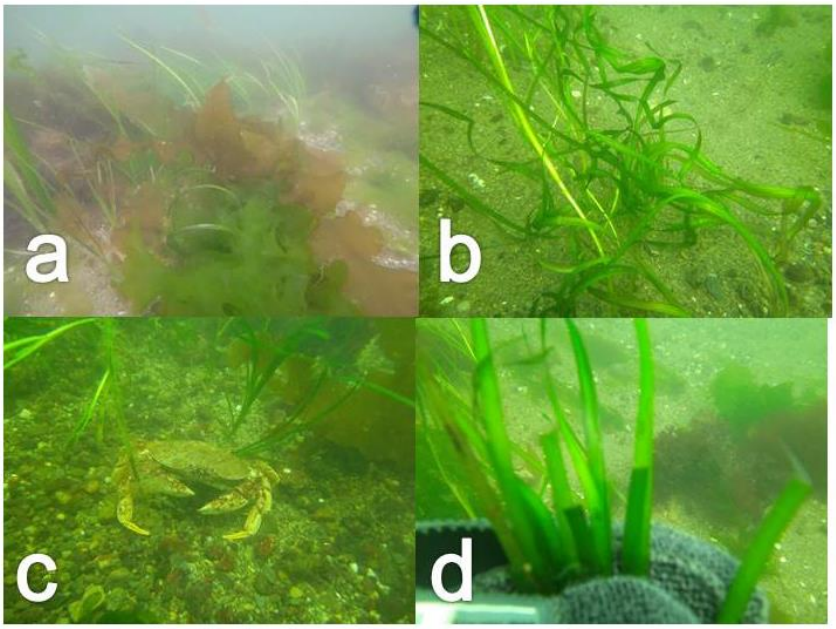

Figure 6: Middle Ground West 1-month monitoring: Algae entangling eelgrass (a), twisted damage to shoots (b), Rock crab along south transect (c), Evidence of crab clipped shoots (d).

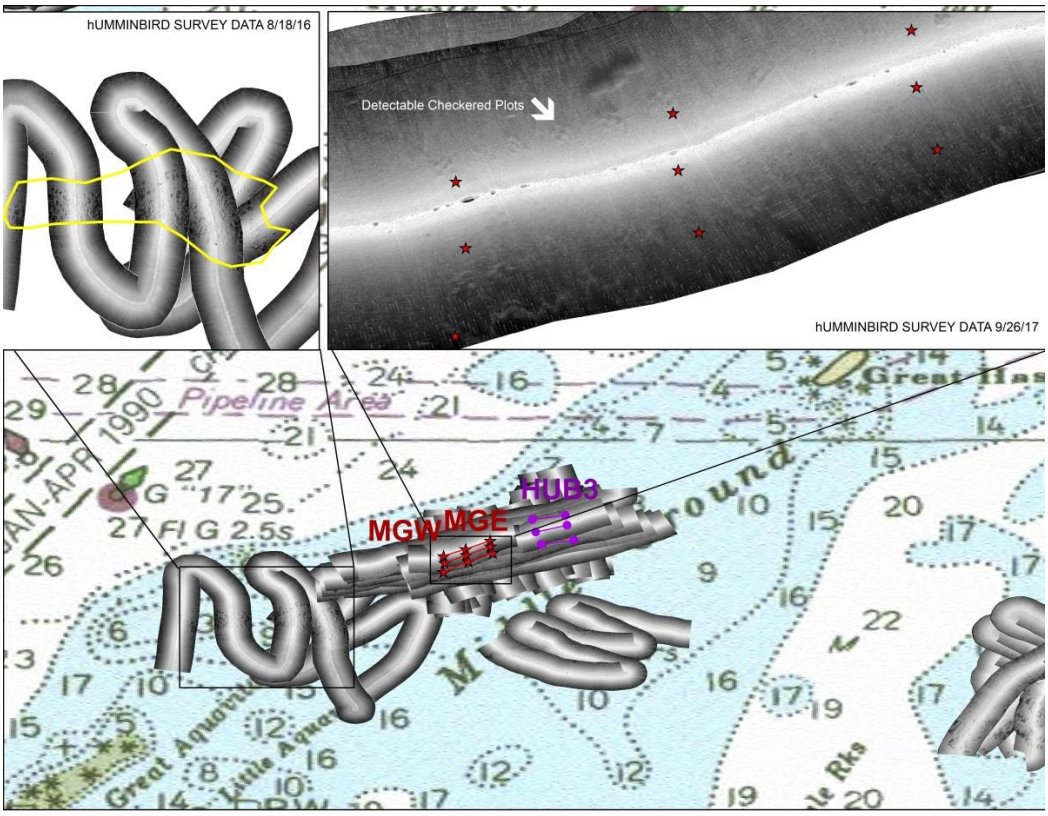

Figure 7: Middle Ground Acoustic Survey Scans.

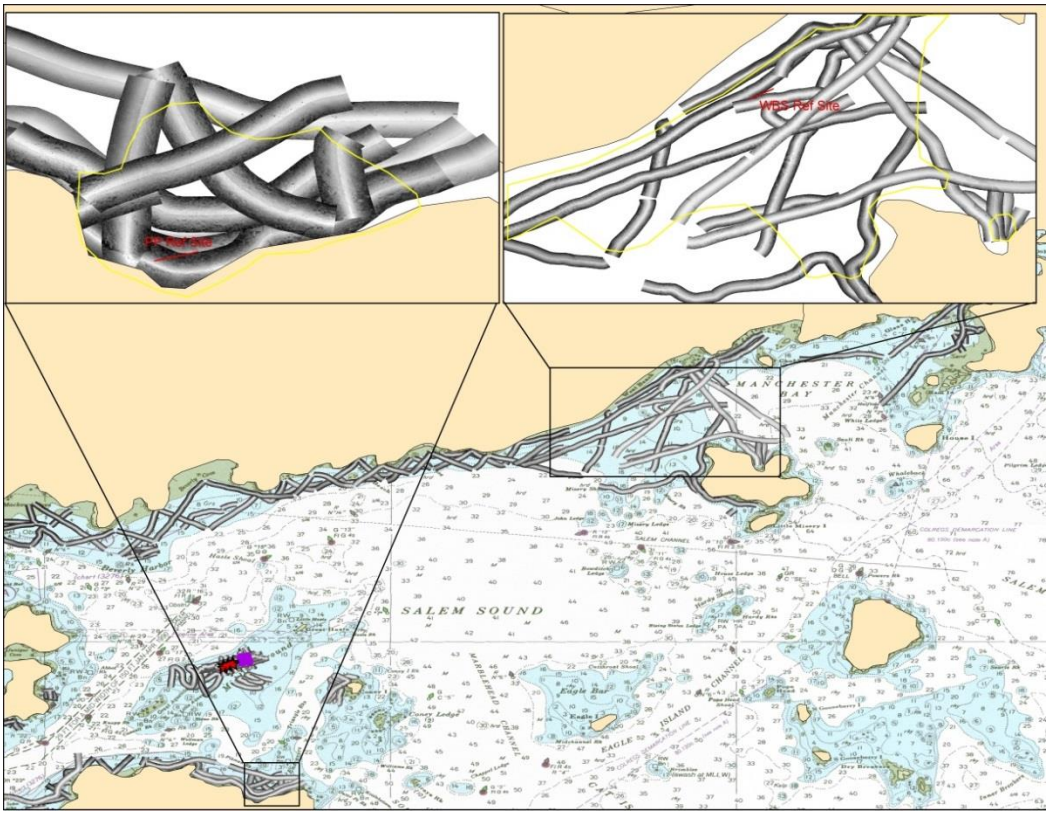

Figure 8: Reference Site Acoustic Survey Scan.

Tables

Table 1: Planting Dates		
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

Table 2: Monitoring Dates. Dates in red represent anticipated monitoring events			
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

Table 3: MGW 1-mo Monitoring results				
Transect	**Mean Planting Unit Survival**	**Mean Density [shoots/m2]**	**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/m2]**	**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/m2]**	**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

Massachusetts Department of Fish and Game

In-Lieu Fee Program

Eelgrass Restoration Project 2018 Annual Report

Implemented by the Division of Marine Fisheries

Prepared by: T. Evans , A. Boeri, J. Carr, K. Frew

Submitted to

The Massachusetts In Lieu Fee Program

Administered by the Department of Fish and Game

David E. Pierce, Ph.D.

Director

Submitted in March 2019 and finalized on May 22, 2019

Project Overview

The Massachusetts In-Lieu Fee Program (ILFP) funded The Division of Marine Fisheries (DMF) to restore and monitor ½ acre (2,023.4 m^2) of eelgrass in the North Coastal Service Area beginning in 2017, for a duration of five years. The eelgrass restoration was permitted in 2017 under the Corps General Permit number NAE-2017-00754. This report is for the second year of this project; the calendar year 2018.

Based on site selection results, DMF chose Middle Ground in Salem Sound to plant two ¼ acre (1,011.7 m^2) sites in 2017 (Figure 1). The restoration effort was split over two seasons, the West ¼ acre site (MGW) was planted in April and May 2017, while the East ¼ acre site (MGE) was planted in the end of August and September 2017 (Table 1). Monitoring was performed one year post-planting at both sites as scheduled in July 2018, and due to a series of three consecutive nor'easter storm events in February and March, additional post-storm monitoring was conducted in April (Table 2). Storm impacts were clearly evident at both sites and most severe at MGE where six of 18 plots were completely missing and many more were partially damaged. At the time of this post-storm monitoring, 43% of the planting units had survived at MGW, while 16% of the planting units had survived at MGE.

Because of these impacts, a new, identical ¼ acre site (MGS) was planted directly South of MGW in May of 2018. One-month monitoring of MGS was completed in June, showing survival of 99% of the planting units, which is an even better survival rate than that observed at both Middle Ground restoration sites in 2017 (Frew at al. 2017). Additionally, 5 plots missing from MGW were replaced in May 2018. Further planting at MGE was not conducted due to low survival, however the remaining plots may expand unassisted and we will continue to monitor them.

Methods

Transplanting

Plants were collected from donor meadows (Figure 2) using a low impact collection method detailed in our project proposal and 2017 final report. Harvested plants were stored in seawater for no more than 48 hours before being woven into the planting units (PUs). The method involved weaving ten eelgrass shoots by their rhizomes into a 20 cm diameter, circular burlap disc PU (Pickerell, pers. Com), dubbed the Pickerell Burlap Disc Method.

Each site consisted of three transects, with six evenly spaced plots. A plot had 6, 1m^2 squares, each planted with five PUs for a total density of 50 shoots/m^2 (Figures 3 and 4). Each PU is buried in an approximately 3-5 cm deep hole backfilled with sediment. 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.

To supplement the restoration, In 2018 approximately 5,400 shoots were collected from the three most promising donor beds, Nahant (Nahant Cove), Salem (Aquavitae), and Gloucester (Niles Beach) using the low impact collection method detailed in the 2017 annual report and project proposal. Plants from these three donor beds were associated with the more successful plots monitored in 2018 after the storm impact. The burlap disc PUs were planted in the new ¼ acre supplemental site (MGS) at Middle Ground in Salem on May 2, 2018 (Figure 2). An additional 1,500 shoots were collected from the donor

bed in Salem (Aquavitae) to complete supplemental replacement plots at MGW for five plots that had been destroyed due to winter storm damage.

All adult-plant transplanting utilized the same methods from 2017, i.e. the Pcikerell Burlap Disc Method. A final plot was planted at MGW using a new method, seeding. To test the use of seeds for restoration, we collected approximately 950 reproductive shoots from the West Beach and Manchester meadows in July and August 2018 and stored them in flow-through seawater tanks until they dropped their negatively buoyant seeds. Seeds were siphoned from the tank and planted in mid-October, 2018. Divers planted six, $1m^2$ quadrats, each containing approximately 1,000 seeds, off the Southwest corner of MGW. At each quadrat approximately 1,000 seeds were smoothed into furrows in the sand. The seeded quadrats alternated along a transect and were then surrounded by a single row of adult shoots woven into discs. The adult shoots were planted to protect the seeds from current and sediment movement.

Monitoring

Divers monitored MGE six months after planting in April (post-storm monitoring was also completed at MGW in April to see the impacts of major winter storm events) (Table 2). Additionally, monitoring was completed at both MGE and MGW for the first year of annual monitoring in July. One month monitoring was also completed for the newly planted MGS (planted in June). All monitoring in 2018 used the methods detailed in the 2017 annual report (Frew et al. 2017).

Divers monitored all three reference beds in July 2018 (West Beach, Peachs Point, and Aquavitae) (Table 2) using methods detailed in the 2017 annual report. All 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%). All three reference sites will continue to be monitored once annually during the peak growing season (July) for comparison with restored sites.

Acoustic mapping was completed at all three restoration sites at Middle Ground on August 10, 2018. Additionally, reference sites (Aquavitae and Peachs Point) were mapped on August 10 and October 12, 2018 respectively, to detect any changes in size and/or density of these beds. West Beach was not acoustically mapped due to weather constraints, but will be mapped in 2019. Acoustic surveys were conducted with a Humminbird HELIX 9 CHIRP MEGA SI GPS G2N, each with an 800 kHz high resolution transducer, following overlapping lines for 150% sonar coverage for the restoration sites, and less or no overlap for the reference sites. The resulting sonar files have the water column removed and then are slant range and beam angle corrected in SonarTRX Pro release 15, and the mosaicked tracks are inported into ArcGIS 10.4. In ArcGIS, areas within the mosaic that have the signature appearance of eelgrass are delineated. The area of the meadow is then quantified and compared to the mapped area from previous years. Restored and reference meadows were mapped in planting years and will be mapped again at the conclusion of the five year monitoring period.

Results

Middle Ground West (MGW)

Post-storm monitoring revealed losses at MGW. In some cases entire plots were eroded or buried and shoots were gone and in other cases some PUs were missing but the plots were still identifiable. The Five plots at MGW impacted by winter storms were re-planted in place in April 2018. The remaining 13 plots had a PU survival of 58.7% with mean shoot density of 72.1 shoots/m^2 within planted squares at

the annual monitoring on July 11, 2018 (Table 3). Despite losses of planting units believed to be from winter storm impacts, mean shoot density in the remaining plots increased by 40.6%. Canopy height at MGW averaged 41.8 cm, while the mean percent cover observed was 32.9%. Divers noted encrusting epiphytes, *Bugula* sp.and *Membranipora* sp. growing on eelgrass shoots. Bottom characteristics appeared to have changed since 6 month monitoring, as sand waves were no longer observed and gravel was present. Algae (*Laminaria* sp., green and red drift species) was also present in small patches.

The five replacement plots re-planted in April 2018 were monitored on July 11, 2018 (Table 4). Mean Planting unit survival was 99.3%, and four of the five plots had 100% PU survival. Mean shoot density was 61.7 shoots/m^2 an increase from the 50 shoots/m^2 planted one month before. Mean canopy height was 35.0 cm, and percent cover was 25.5%.

The increase in shoot density at the plots not impacts by storm driven erosion and burial, indicates that eelgrass is growing and expanding and the site is conducive to restoration. Several of the plots contained quadrats that had begun to coalesce and could no longer be distinguished from one another.

Middle Ground East (MGE)

Six month annual monitoring at MGE revealed that seven plots no longer contained any eelgrass/planting units (Table 5). The mean planting unit survival was 15.7% site-wide, with the middle and south transects at 22.8% and 21.7% respectively. The north transect was the most impacted with 2.8% planting unit survival. Mean shoot density was 6.1 shoots/m^2, mean canopy height was 18.9 cm, and the mean percent cover was 1.9% (Table 5).

Annual monitoring at MGE on July 11, 2018, showed further loss (Table 6); nine plots were completely gone and nine remained with only 20.7% PU survival, 17.1 shoots/m^2, 19.5 cm canopy height 10.3% cover .

In contrast to MGW, MGE had not recovered from the winter storms. The remaining eelgrass was not expanding. Because of the decrease in PU survival and the number of total plots lost, no supplemental planting was completed at MGE. We postulate that there may be two factors contributing to the substantial overall loss in eelgrass: planting in the fall did not allow the shoots enough time to root properly before winter storms impacted them, and the east location of the planting may have been more exposed to the winter storms than the west side (MGW).

Middle Ground South (MGS)

On June 14, 2018 divers completed 1 month monitoring at MGS. The mean planting unit survival was 99.4% and mean shoot density was 50.4 shoots/m^2 (Table 7). These numbers are similar to or better than those observed at MGW and MGE during 1 month monitoring in 2017. The mean canopy height at MGS was 43.3 cm and the average percent cover site wide was 30.9%.

Reference Sites

Peachs Point

Divers monitored Peachs Point reference site on July 3, 2018. The mean shoot density was 366.7 shoots/m^2, the mean canopy height was 106.3 cm, and the average percent cover was 67.1% (Table 8). Overall these results are similar to what was found at Peachs Point in 2017.

West Beach

On July 24, 2018 divers monitored the West Beach reference site in Beverly as part of the quarterly SeagrassNet monitoring. The mean shoot density was 206.3 shoots/m^2. The mean canopy height was 84.1 cm and the average percent cover was 43.8% (Table 8). This bed has been monitored by DMF since 2008, and the results found in 2018 are in line with normal observations at that site.

Aquavitae

In 2018, Aquavitae was established as a reference site for this restoration project due to its proximity to the restoration site and characteristic similarities. Divers monitored Aquavitae on July 3, 2017. The mean shoot density was 139.3 shoots/m^2 with density values ranging between 0 and 352 shoots/m^2. The mean canopy height was 25.9 cm, while the mean percent cover was 28.8% (Table 8).

Acoustic Mapping

Acoustic mapping of MGW and MGE (as well as post-planting at MGS) was completed on August 10, 2018. Individual plots could be detected at densities as low as the planting density of 50 shoots/m^2 (Fig 5).

Peachs Point and Aquavitae reference beds were mapped in August and October 2018. West Beach reference bed was not mapped in 2018 due to weather constraints, but will be mapped in 2019. Each of these sites will mapped again in the fifth year of the project in accordance with the project proposal.

Requirements/Performance Standards

Success Criteria (performance standards):

The goal of the project is the restoration of ½ acre of eelgrass. Success is determined by the persistance and expansion of the planted eelgrass over five years, from 2017 to 2021. The initial transplants had successful survival rates, and where they did not, they have been replanted. Current plant metrics are on the expected restoration trajectory. That is, they have shown initial PU survival greater than 50% and an annual increase in density and plot expansion overall.

Summary and Conclusions

MA DMF has successfully completed the second year of the 5-year ILF eelgrass restoration project. We planted ½ acre of eelgrass at Middle Ground in Salem Sound over two seasons in 2017. After losses due to storms we augmented the plantings at Middleground in the spring of 2018 by filling in lost planting units at MGW and planting a new ¼ acre site, called MGS. We did not re-plant the MGE site because there was a >50% loss. Site characteristics, in addition to storm impacts and planting season, may have driven the decline. Therefore, the best course of adaptive management was to establish a new site on the same depth contour as the successful MGW site. We chose to plant the new site in the spring of 2018 because we have found spring to be the most successful planting season. We will continue to monitor MGE as plants could rebound in the future at that site. We plan to do a site check in early spring 2019 to determine if additional planting will be needed in April or May of 2019.

Three more seasons of monitoring are planned in July of 2019, 2020 and 2021.

CY2018 Budget Update

In Calender year 2018 the ILF eelgrass project charged a total of $56,863 on all field, office and personel expenses. Please see below for a breakdown of the expenses from CY2018 compared to our approved 5-year budget, and the CY2017 expenses. The total cumulative charges to the account for both CY2017 and CY2018 are also reported as is the remaining balance in each category and total remaining of $158,134.

Line Item	Approved 5-Year Budget	CY2017 Expenses	CY2018 Expenses	Cumulative Charges	Remaining Balance
SCUBA Air fills	$11,556	$642	$2,443	$3,085	$8,472
Field Supplies	$3,200	$553	$476	$1,029	$2,171
Licor Sensors	$560	$913		$913	-$353
Boat Fuel& Maintenance	$26,750	$683	$6,644	$7,327	$19,423
Dive Gear	$5,000	$31	$1,085	$1,115	$3,885
Hummingbird Software	$1,200	$0		$0	$1,200
Lab Work	$10,000	$0	$3,193	$3,193	$6,807
Permitting	$880	$657		$657	$223
Personnel Carr	$18,121	$5,193		$5,193	$12,928
Personnel Ostrikis	$14,649	$5,063		$5,063	$9,586
Dive Pay	$48,150	$4,605	$2,220	$6,825	$41,325
Contract Employee	$66,560	$16,864	$31,332	$48,196	$18,364
Travel	$1,250	$114		$114	$1,136
Indirect	$40,798	$7,752	$8,173	$15,925	$24,873
Payroll tax	$2,440	$451	$523	$975	$1,465
Fringe Benefits	$10,978	$3,575	$774	$4,349	$6,629
TOTAL	**$262,092**	**$47,095**	**$56,863**	**$103,958**	**$158,134**

Acknowledgements

We appreciate all those who assisted in this project by helping topside on the dive boat, weave burlap discs, or join us as divers; including Mark Rousseau, Kristen Schmicker, Wendy Mainard of DMF and , Forest Schenck, Randall Hughes and Torrie Hanley of Northeastern University Marine Science Center, Aisling O'Shea of DFG and Alyssa Novak of Boston University.

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Evans, T., W. Dukes and J. Carr (2012) Division of Marine Fisheries HubLine Eelgrass Restoration Mid-project Progress Report. Submitted to The Department of Environmental Protection, dated June 2012.

Evans, T., J. Carr, K. Frew, M. Rousseau, K. Ford and A. Boeri (2018) Massachusetts Division of Marine Fisheries 2010 to 2016 HubLine Eelgrass Restoration Final Report. Submitted to the Department of Environmental Protection, dated March 2018.

Frew, K., A. Boeri, J. Carr, and T. Evans (2017) Division of Marine Fisheries In-Lieu Fee Eelgrass Restoration Project 2017 Annual Report. Submitted to The Massachusetts In Lieu Fee Program.

Appendix

Figures

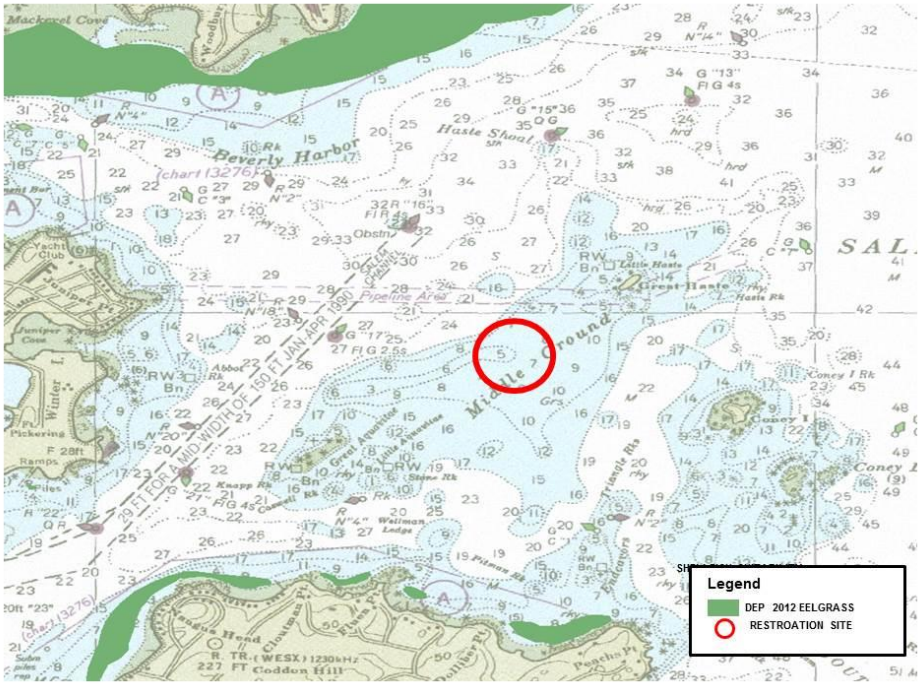

Figure 1: ½ acre restoration site at Middle Ground, Salem Sound.

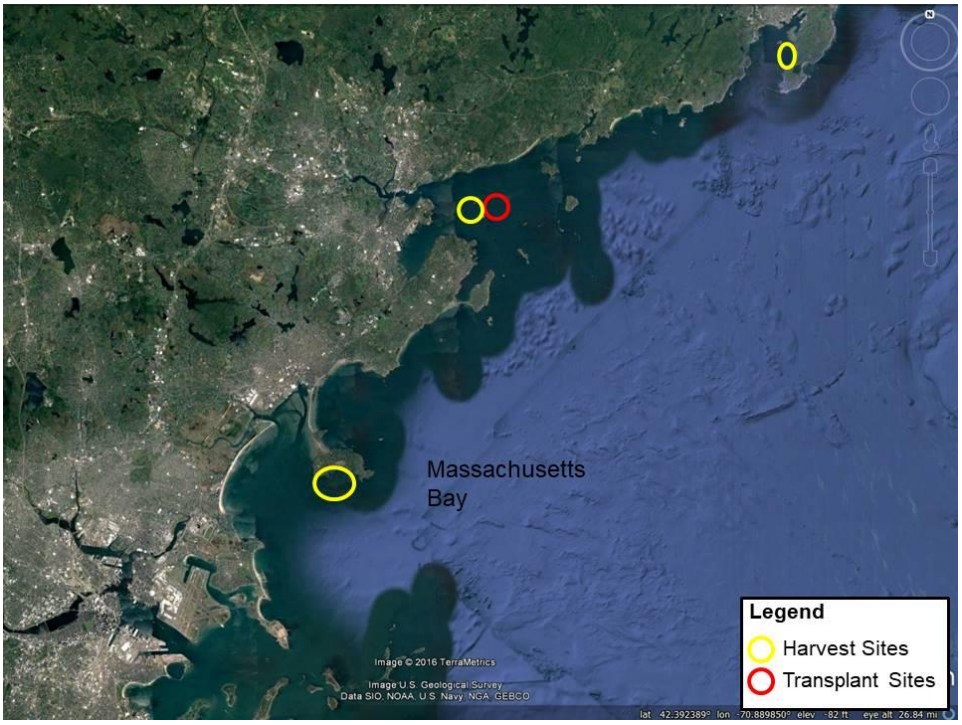

Figure 2: 2018 eelgrass donor sites.

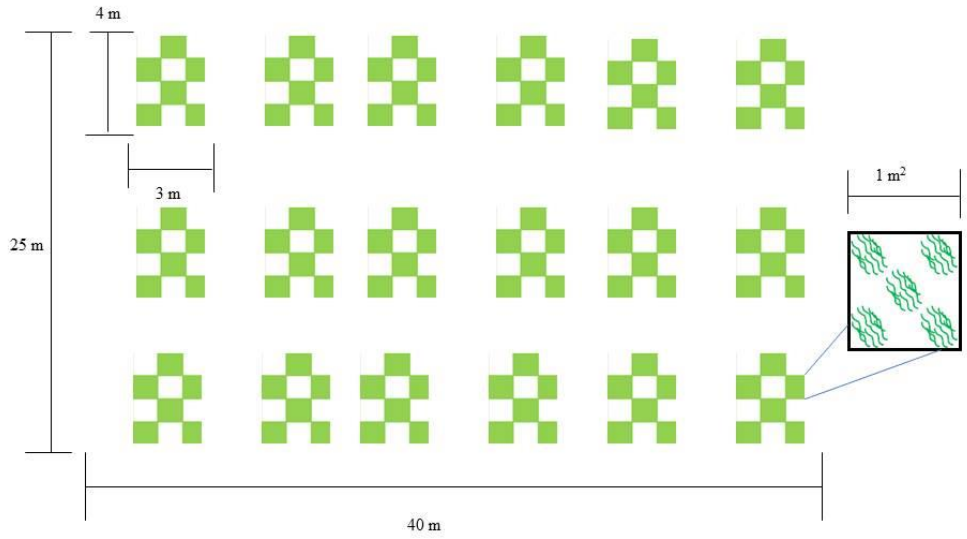

Figure 3: Layout for each site, approximately ¼ acre area. 18 plots each in a checkerboard pattern of 6 planted and unplanted 1 m^2 squares for a total of 5,400 shoots. Three sites planted adjacent to each other at Middle Ground.

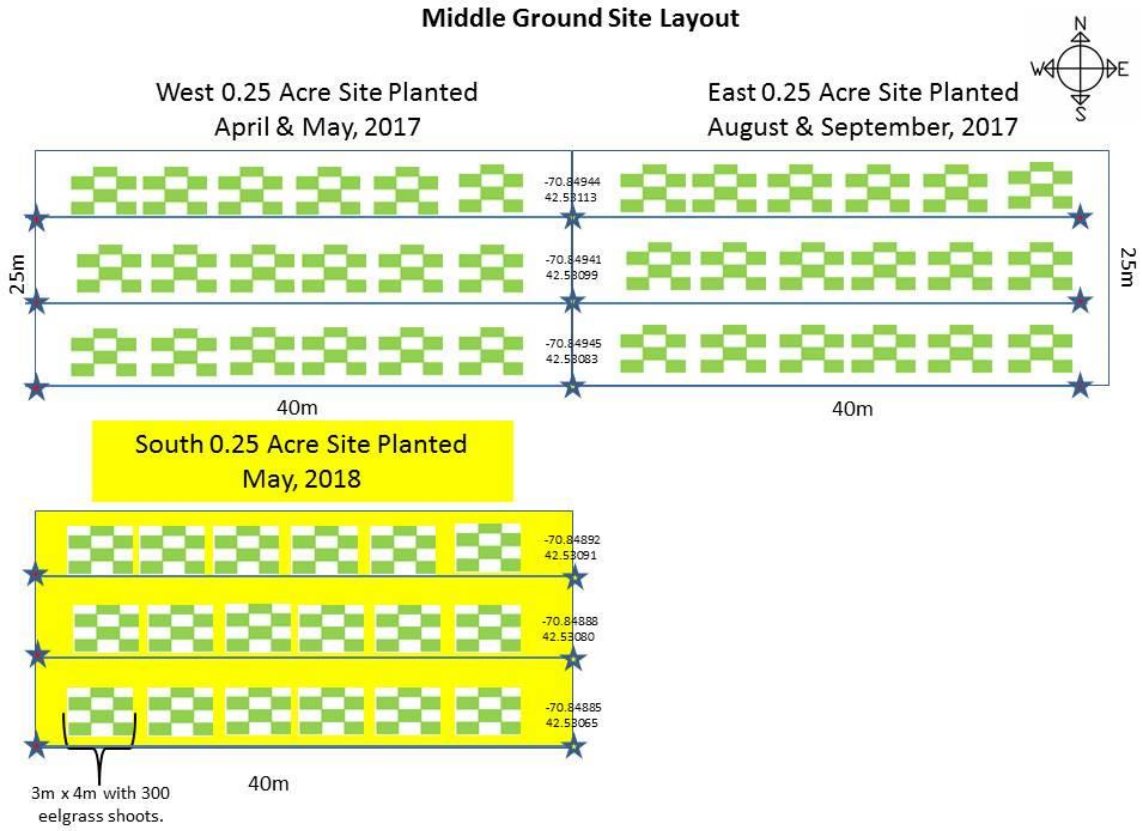

Figure 4: Middle Ground transplant site layout.

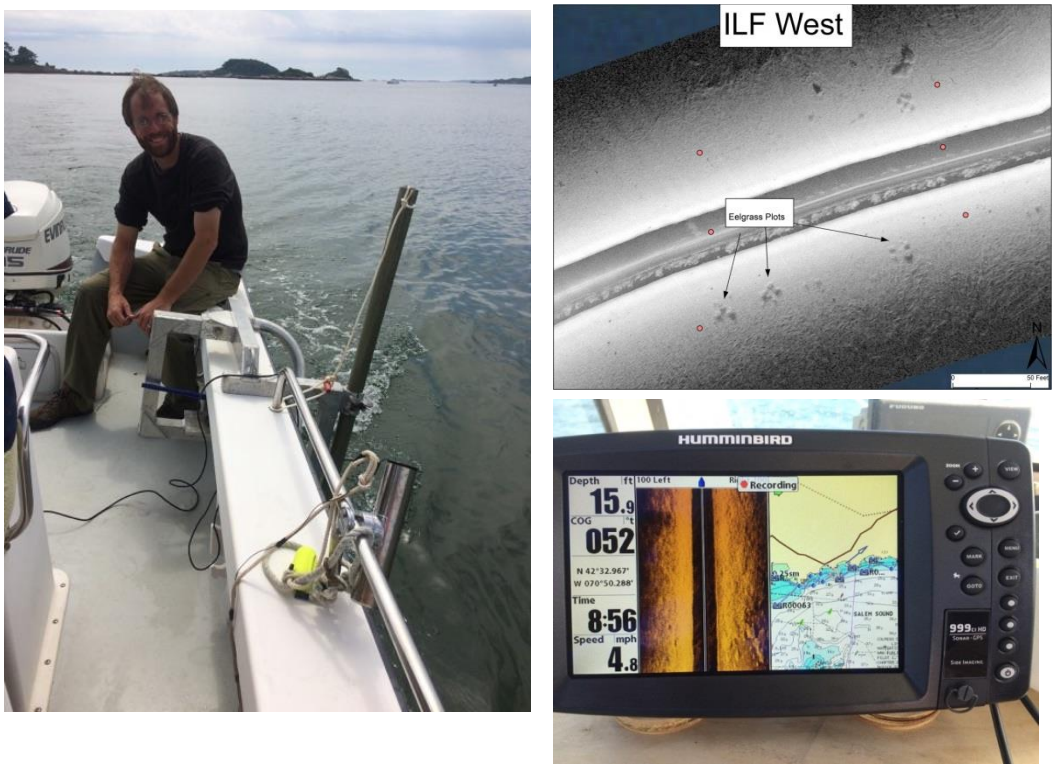

Figure 5: (clockwisw from left): Humminbird acoustic transponder mounted to the side of DMF's Maritime skiff; Planted eelgrass plots visible on acoustic survey at ILF West (red dots mark the boundaries of the site, the track in the middle is the disturbance from the boat and does not include useable acoustic data); the Humminbird display screen showing the acoustic return on the left (note light puffy looking areas are eelgrass) and location on a chart on the right.

Tables

Table 1: Planting Dates (1plot=6 planted m^2)		
Event	**Date**	**Notes**
West Monoculture	4/20/2017	2 plots planted
West Monoculture	5/4/2017	2 plots planted
West Monoculture	5/10/2017	2 plots planted
West Monoculture	5/12/2017	2 plots planted
West Monoculture	5/19/2017	2 plots planted
West Polyculture	5/24/2017	8 plots planted
East Monoculture	8/31/2017	10 plots planted
East Polyculture	9/7/2017	8 plots planted
West Monoculture	5/2/2018	4 plots planted
South Mono/Polyculture	5/10/2018	6 plots planted
South Mono/Polyculture	5/17/2018	6 plots planted
West Monoculture	5/23/2018	1 plot planted
South Mono/Polyculture	5/23/2018	6 plots planted
Hingham Test plot	5/11/18	1 pot planted
PIS seeding test plot	10/10/2018	1 seed plot planted
MG seeding test plots	10/12/19	1 seed plot planted
Essex seeding test plot	10/23/18	1 seed plot planted

Table 2: Monitoring Dates. Dates in red represent anticipated monitoring events				
Site	**1 month**	**6 month**	**1 year**	**2 year (anticipated)**
West 2017 Planting*	6/12/2017	11/14/2017	7/11/2018	7/2019
West 2018 Supplemental Planting	7/11/2018	NA	7/2019	7/2020
East 2017 Planting	10/12/2017	4/2/2018	7/11/2018	7/2019
South 2018 Planting	6/14/2018	NA	7/2019	7/2020
West Beach Reference	NA	NA	7/18/2017, 7/24/2018	7/2019
Peachs Point Reference	NA	NA	8/9/2017, 7/3/2018	7/2019
Aquavitae Reference	NA	NA	7/3/2018	7/2019

*Additional post-storm monitoring conducted on April 9, 2018

Table 3: MGW 1-year Monitoring results (13 plots planted in 2017)					
Transect	**Mean Planting Unit Survival**	**Mean Density [shoots/m^2]**	**Mean Shoot Survival**	**Mean Canopy Height [cm]**	**Mean % Cover**
North	42.3%	60.4	120.8%	41.4	27.7%
Mid	62.5%	61.6	123.2%	34.7	30.3%
South	68.5%	89.9	179.8%	47.9	39.3%
ENTIRE SITE	**58.7%**	**72.1**	**144.2%**	**41.8**	**32.9%**

Table 4: MGW 1-mo Monitoring results (5 plots planted in 2018)					
Transect	**Mean Planting Unit Survival**	**Mean Density [shoots/m^2]**	**Mean Shoot Survival**	**Mean Canopy Height [cm]**	**Mean % Cover**
North	98.3%	66.5	133%	37.5	16.3%
Mid	100%	63.3	126.7%	32.8	32.5%
South	100%	49.0	98%	34.3	30.0%
ENTIRE SITE	**99.3%**	**61.7**	**123.5%**	**35.0**	**25.5%**

Table 5: MGE 6-mo Monitoring results (18 plots planted in 2017)					
Transect	**Mean Planting Unit Survival**	**Mean Density [shoots/m^2]**	**Mean Shoot Survival**	**Mean Canopy Height [cm]**	**Mean % Cover**
North	2.8%	0.04	0.08%	8	0.04%
Mid	22.8%	10.1	20.2%	16.6	3%
South	21.7%	8.3	16.6%	22.9	2.8%
ENTIRE SITE	**15.7%**	**6.1**	**12.2%**	**18.9**	**1.9%**

Table 6: MGE 1-year Monitoring results (18 plots planted in 2017)					
Transect	**Mean Planting Unit Survival**	**Mean Density [shoots/m^2]**	**Mean Shoot Survival**	**Mean Canopy Height [cm]**	**Mean % Cover**
North	8.9%	4.5	9%	34.0	3.8%
Mid	15%	13.9	27.8%	33.5	6.9%
South	7.2%	7.2	14.4%	63.3	4.7%
ENTIRE SITE	**10.4%**	**8.5**	**17%**	**39.7**	**5.1%**

Table 7: MGS 1-mo Monitoring results (18 plots planted in 2018)					
Transect	**Mean Planting Unit Survival**	**Mean Density [shoots/m^2]**	**Mean Shoot Survival**	**Mean Canopy Height [cm]**	**Mean % Cover**
North	100%	50.3	100.6%	44.6	29.7%
Mid	98.9%	51.1	102.2%	39.0	30.6%
South	99.4%	49.8	99.6%	46.4	32.5%
ENTIRE SITE	**99.4%**	**50.4**	**100.8%**	**43.3**	**30.9%**

Table 8: 2018 Reference bed monitoring results			
Site	**Mean Density [shoots/m^2]**	**Mean Canopy Height [cm]**	**Mean % Cover**
Peachs Point	366.7	106.3	67.1%
West Beach	206.3	84.1	43.8%
Aquavitae	139.3	25.9	28.8%