

A Study of Factors Influencing Eelgrass (*Zostera marina*) around Mount Desert Island, Maine

Ashley R. Taylor, Anna E. Farrell, & Jane E. Disney

MDI Biological Laboratory

Community Laboratory

PO Box 35, Salisbury Cove, ME 04672

INTRODUCTION

For the past decade, staff, students, and volunteers of the Community Lab at MDI Biological Laboratory have been mapping eelgrass (*Zostera marina*) populations around Mount Desert Island (MDI), Maine as part of the mission of the Community Lab to monitor, study, and conserve these essential habitats, with a focus on nine study sites around MDI (Figure 1).

Eelgrass has declined statewide, and knowing where populations are and how they are changing are important factors in conservation efforts. The Department of Marine Resources and Maine Office of GIS previously mapped and published two statewide datasets of eelgrass distribution, one in 1997 and one in 2010 (MeDMR). Each dataset took multiple years to compile and complete. In the 2010 dataset, the Mount Desert Island region was mapped in 2008, which was the last formal state-led assessment of eelgrass in the region. Aside from anecdotal observations, there have not been



Figure 1. Community Lab eelgrass study sites around Mount Desert Island.

formalized calculations of the distribution of the remaining eelgrass populations in the region since then. Recognizing the need to maximize efficiency and utilize advancing technologies, the Community Lab began using new mobile tools to map eelgrass with updated and improved mapping systems, resulting in highly accurate maps of eelgrass in several of the nine study sites, which could then be compared to historic eelgrass beds.

Sampling Sites

During our field season in the summer of 2018, we monitored nine sites around Mount Desert Island,

Maine (Table 1). Five sites, Ship Harbor, Wonderland, and the three sites at Bar Island are part of Acadia National Park. Three sites, Hadley Point East, Hadley Point West and Berry Cove, are located in upper Frenchman Bay. Stave Island is near Gouldsboro, Maine in the eastern area of Frenchman Bay. Our study areas' extents are defined by red rectangles in the map books attached in *Appendix 1*. The beds in each of these areas exhibit different rates of growth and decline. Data collected at Hadley Point, Berry Cove, and Stave Island are included to provide comparison studies.

Site	Water Quality	Eelgrass Density	Green Crab Abundance
Bar Island East		X	
Bar Island West		X	
Bar Island Tide Pool		X	
Berry Cove	X	X	
Hadley Point East	X	X	X
Hadley Point West	X	X	X
Ship Harbor	X	X	X
Stave Island		X	
Wonderland	X	X	X

Table 1. Community Lab sampling sites and monitoring activity in 2018.

METHODS

Water Quality

Between June and August of 2018, 22 water samples were collected to see if there is a relationship between nutrient levels and eelgrass decline. Nutrient samples were collected by attaching a Millipore 0.45- μ m HA FM ® membrane filter to a filter housing tip, which was connected to a 2oz syringe after the syringe was rinsed three times with seawater. Next, the sample was filtered into the vial. Samples were analyzed at the University of Maine using a Bran & Luebbe Autoanalyzer III for nitrates and nitrites (NO_3+NO_2), silicic acid ($\text{Si}(\text{OH})_4$), and phosphates (PO_4).

Eelgrass Area and Density

Eelgrass bed coverage was mapped at all sites in 2018 using a Trimble R1 GNSS receiver paired with the ArcCollector smartphone app via Bluetooth technology. We referred to this as a 'mobile GIS solution'. In the field we used ArcCollector's streaming function to track our movements as we walked the perimeter of eelgrass beds in our study areas. The eelgrass bed polygons' associated attribute table was then populated using a custom field data collection form that had prepopulated dropdown menus for site name and automatically generated date and polygon acreage. Upon saving the polygon in the app, the data were synced with our Esri account and automatically appeared in our ArcOnline eelgrass map (Figure 2). This new method saved staff 3 hours of time collecting and processing data per site.

Eelgrass bed density was determined using 25cm² quadrats. At each site, quadrats were randomly thrown 20 times by each surveyor. If the quadrat landed outside of an eelgrass patch, it received a value of zero. In each quadrat that fell within an eelgrass area, the following data were recorded: number of shoots (differentiating

between flowering and vegetative), percent eelgrass coverage within the quadrat, and average plant height (three random blades selected).

Green Crab Abundance

Green crabs are known to be detrimental to eelgrass (Neckles, 2015). Green crab traps were baited with hot dogs, set and checked over four consecutive days in

late August, from August 21st through August 24th in Upper Frenchman Bay. They were also set and checked in June, from June 19th to the 22nd at Ship Harbor and Wonderland. At roughly the same time each day, the rectangular traps were hauled up, emptied of crabs, baited again, and re-set. Native crab species were released. Back in the lab, green crabs were measured, sexed, and counted. Crabs were collected using semi-circular traps at the Acadia National Park sites instead of our typical rectangular traps due to limitations in site accessibility. Data are available on Anecdata.org as part of the green crab project titled, Green Crab Studies.

RESULTS

Water Quality

Both nitrogen and silicate are at low levels compared to a decade ago, but nearly doubled between 2017 to 2018 (Figure 3). Eelgrass has been shown to wax and wane with silicate levels, which may also explain eelgrass loss (Herman et al, 1996). We have observed this correlation in Frenchman Bay.



Figure 2. Screen capture of the Community Lab's ArcOnline eelgrass map.

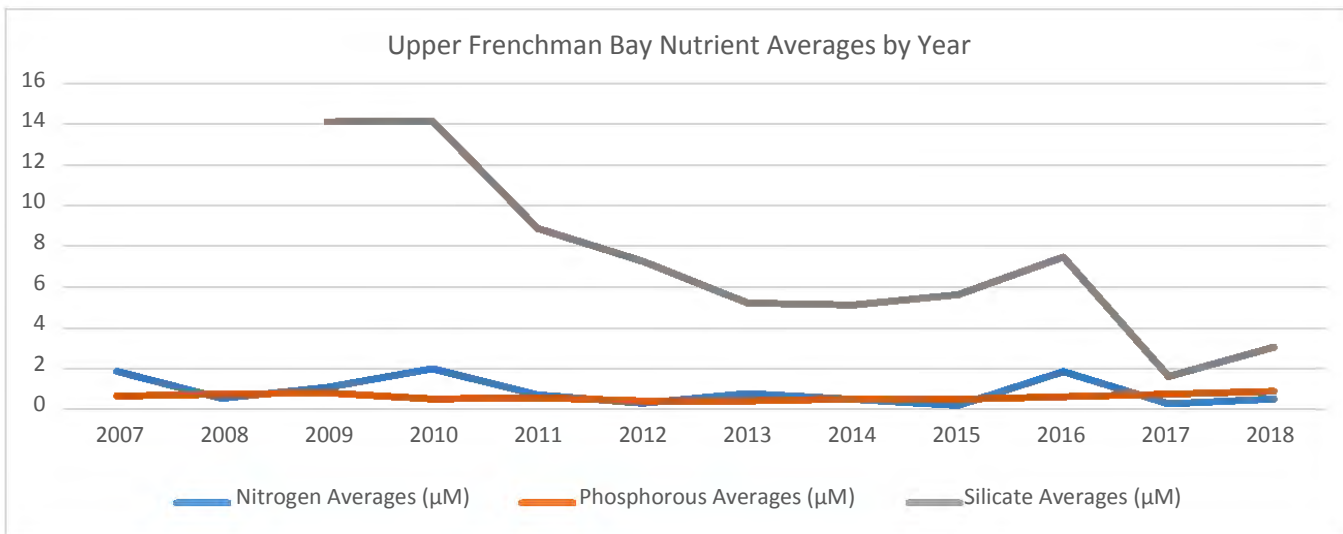


Figure 3. Upper Frenchman Bay nutrient averages from 2007-2018.

Eelgrass Density

Between 2017 and 2018, eelgrass shoot density increased at Bar Tide Pool, Stave Island, and Wonderland and decreased at Bar East, Hadley Point East, and Ship Harbor (Table 2 and Figure 4). There is a statistically significant difference in eelgrass density across sites with a *P*-value of 0.000822 based on a two-way ANOVA test (Figure 5).

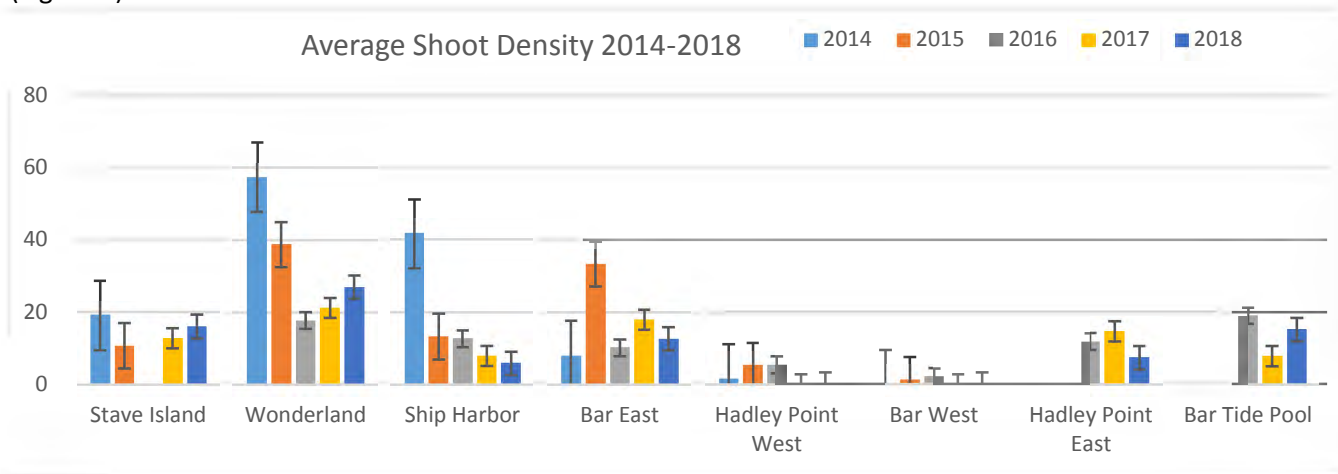


Figure 4. Average eelgrass shoot density 2014-2018.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	3306.162	4	826.5405	8.256597	0.000822	3.006917
Columns	705.6539	4	176.4135	1.762255	0.185838	3.006917
Error	1601.707	16	100.1067			
Total	5613.523	24				

Figure 5. Two-way ANOVA of eelgrass density between 2014-2018 across five sites.

Site	2014	2015	2016	2017	2018
Bar East	8	33.22	10.25	17.93	12.6
Bar Tide Pool	N/A	N/A	18.86	7.83	15
Bar West	0	1.29	2.06	0	0
Hadley Point East	N/A	N/A	11.74	14.48	7.4
Hadley Point West	1.5	5.22	5.33	0	0
Ship Harbor	41.6	13.25	12.74	8	5.95
Stave Island	19.09	10.69	N/A	12.73	15.95
Wonderland	57.3	38.75	17.78	21.2	27
Average of All Sites	21.25	17.07	11.25	10.27	10.49

Table 2. Eelgrass density averages by site from 2014-2018.

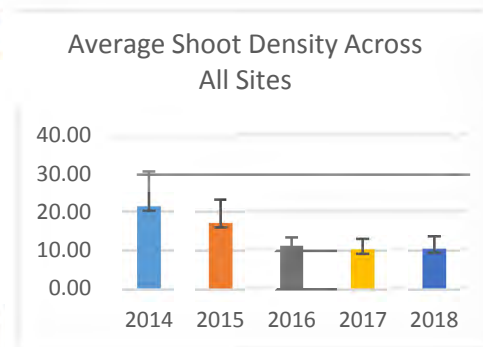


Figure 6. Average shoot density 2014-2018.

Eelgrass Area

Our 2018 mapping efforts and ArcGIS analyses revealed eelgrass acreage declines at nearly all sites except for Stave Island and Bar East. It is difficult to parse out if the increases at those sites were actually due to new growth or the new mapping technology that improved accuracy and accessibility. The average eelgrass acreage across all sites increased from 0.49 in 2017 to 0.53 in 2018 (Figure 7), which was a result of the increases at those two sites.

Looking at eelgrass change historically, *Table 3* shows eelgrass acreages change by site between two time periods: 1997-2008 and 2008-2018. In the last decade at our eelgrass study sites in Acadia National Park, one site completely disappeared (Bar Island West), one site has declined by 96% (Ship Harbor). One site has declined by 60% (Wonderland) and 39% (Bar Island East). In 2008 the Bar Island Tide Pool site was completely gone, but has reestablished 0.23 acres as of 2018.

Invasive Green Crab Abundance

Our results show a lower average number of green crabs per trap in 2018 compared to 2017 numbers (Figure 8). It is possible that green crabs have been contributing to eelgrass loss in upper Frenchman Bay. Green crabs were surveyed at Acadia National Park sites, Wonderland and Ship Harbor for three consecutive days in June of 2018. Over those three days, only four crabs were captured at Wonderland and 19 at Ship Harbor.

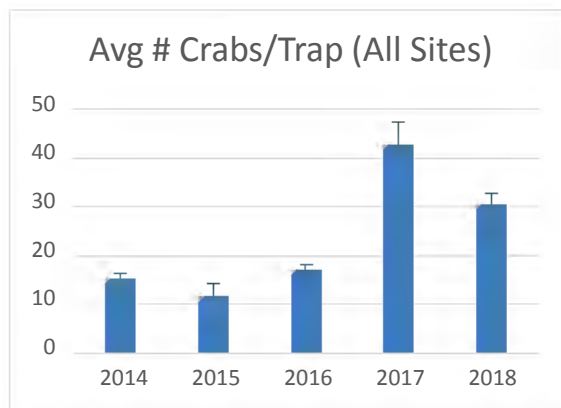


Figure 8. Average number of crabs per trap across all sites between 2014-2018.

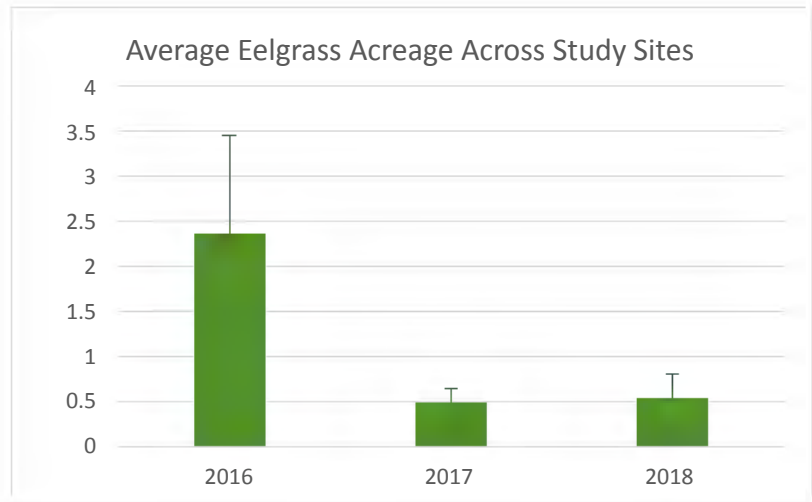


Figure 7. Average eelgrass acreage 2016-2018.

Site	1997-2008 Study Site Change	2008-2018 Study Site Change
Bar Island East	81% decrease	39% decrease
Bar Island West	57% decrease	100% decrease
Bar Tide Pool	100% decrease	100% increase
Berry Cove	99% decrease	85% decrease
Hadley Point East	53% decrease	93% decrease
Hadley Point West	83% decrease	100% decrease
Ship Harbor	21% increase	96% decrease
Stave Island	4% decrease	59% decrease
Wonderland	58% decrease	60% decrease

Table 3. Historic eelgrass comparisons between 1997-2008 and 2008-2018.

SUMMARY

In summer 2018, we used an interdisciplinary approach to investigate the causes of eelgrass loss in Frenchman Bay, Maine. By looking at multiple environmental variables known to affect eelgrass, such as water column nutrients and green crabs, we were able to gain a better understanding of the status of eelgrass populations at sites in upper and Eastern Frenchman Bay and in Acadia National Park.

Water quality was assessed at each site throughout the summer and early fall with samples analyzed for nutrients. Silicate, although found at higher levels than 2017, is still significantly lower than 2009-2016 averages. It is possible that this is contributing to major declines of eelgrass populations in upper Frenchman Bay.

Average eelgrass bed density decreased at half of our study sites and increased at the other half. Of the Acadia National Park sites, Ship Harbor and Bar Island East saw declining density while Wonderland and Bar Island Tide Pool increased. Eelgrass bed area decreased across all but three sites, two being Acadia National Park Sites Wonderland and Ship Harbor.

Our yearly green crab population study results show higher than average numbers compared to 2014-2016 averages, but lower than 2017 averages. Hadley Point West lost all eelgrass in 2017 and had high green crab numbers, which were likely a main stressor contributing to the loss of eelgrass. Although green crab numbers in that area are down from 2017, there was still a decline in eelgrass acreage and density at the corresponding study site (Hadley Point East), which did have the highest green crab per trap average of the three upper Frenchman Bay study sites.

It is clear there are still many variables at play that are affecting eelgrass populations around Mount Desert Island. We will monitor these factors to continue to build up long-term datasets that provide insight into eelgrass population health and the health of other marine habitats in Frenchman Bay. We hope to expand our green crab research efforts in 2019 as this seems to be a contributing factor to eelgrass loss.

Literature Cited

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Figure 9. Community Lab staff prepares crab traps for deployment.

Appendix 1: Historic Eelgrass Comparison Map Book 1997-2008 and 2008 and 2018.

