Eelgrass (*Zostera marina*) Distribution and Water Quality in Edgartown Great Pond

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Abstract

Estuaries are a vital part of nutrient cycling globally. They contribute to biodiversity and sustain tremendous fisheries and shellfisheries. Eelgrass (Zostera marina L.) helps maintain the health of estuaries, and also acts as a sign of their condition. Various factors control eelgrass density and distribution. I investigated the distribution of eelgrass (Zostera marina), in connection with water quality, in Edgartown Great Pond (EGP). In addition to evaluating the range and limits of eelgrass beds in EGP, I took sediment cores to assess distribution of eelgrass seeds over time. I compared these results with dissolved inorganic nitrogen concentrations and salinity values. Relational analyses were inconclusive, but the change in salinity before and after a dredging that opened the pond to the Atlantic Ocean was striking. Additional, and more focused, research on the status of eelgrass and other submerged aquatic vegetation (SAV) and the environmental factors that affect them in Edgartown Great Pond would be beneficial for the pond’s management.

Key words: Eelgrass, Zostera marina, SAV, submerged aquatic vegetation, seeds, salinity, nitrogen, coastal pond, estuary, sediment core

Introduction

An estuary is an aquatic system where fresh and saline water mix. Estuaries tend to be nutrient rich and highly productive. They are ecologically valuable, providing habitat and food sources for juveniles and adults of numerous species. Estuaries are also commercially viable, supporting shellfisheries, fisheries, and recreation.
Eelgrass (*Zostera marina*), a seagrass, is vital to the health of estuaries’ and a well-known indicator of their condition. It is widespread in the northern hemisphere. Eelgrass contributes to the maintenance of healthy marine ecosystems. Eelgrass provides habitat and a food source for various aquatic fauna, like fish, shellfish, and birds. Eelgrass improves water quality, in part by stabilizing sediment, and acts as a carbon sink (Short et al. 1996).

Anthropogenically-driven environmental changes have caused declines in eelgrass populations and geographical extent over the last century (Short et al. 1996). Development in watersheds increases the nutrient loading to estuaries through runoff and groundwater seepage polluted with wastewater (Pinckney et al. 2001).

I focused this study on the eelgrass population in Edgartown Great Pond (EGP). It is an 890-acre coastal pond on the south shore of Martha’s Vineyard, an island off the southeast coast of Massachusetts. EGP is brackish, and only receives occasional saltwater inputs from the dredging of a narrow breach that separates the pond from the Atlantic Ocean. These cuts are managed by the local government and typically made four times a year, twice in the spring and twice in the fall (Howes et al. 2008). Freshwater inputs come mostly from groundwater draining from the pond’s 4,505-acre watershed (Howes et al. 2008). Different inlets of the pond are subject to variable anthropogenic nutrient loads and flushing rates when the breach is opened. Mean depth of EGP ranges from 1 to 1.5 meters, and maximum depth is 3 meters (Howes et al. 2008). A 2008 study by the Massachusetts Estuaries Project reported significant declines and impairment of eelgrass in the pond. They compared aerial imagery of eelgrass beds in 1951 with sampling in 2002, estimating a 90% loss of eelgrass coverage. Eelgrass declines in Edgartown Great Pond are likely a result of the same issues that have affected eelgrass globally. With development and human encroachment comes increased nutrient loading. These nutrients—
primarily nitrate, ammonium, and phosphate—change the nutrient cycling in estuaries and lead to algal blooms that shade eelgrass and deprive it of oxygen (Hauxwell et al. 2001).

Extensive research on eelgrass has identified various limits on its growth and distribution. A study by Xu et al. (2016) found that seedlings performed best at salinities of 20-30ppt, struggling to develop below 20ppt. Another study found that plants from low salinity areas were able to adapt to increased salinity while plants from high salinity areas performed poorly at low salinities (Salo et al. 2014). Salinity and nutrient load have an interactive effect on eelgrass health, as well, with high nutrient loading limiting eelgrass to low salinity areas (van Katwijk et al. 1999). Eelgrass distribution is also driven by light attenuation, which ties it to macro and microalgal blooms caused by nutrient loading (Short et al. 1995). In addition, nitrate enrichment alone is detrimental to eelgrass (Burkholder et al. 1992). Temperature also affects eelgrass distribution, with diebacks occurring, and germination improbable, at 30°C (Jarvis et al. 2014).

Eelgrass can be perennial or annual (Orth et al. 2000). Reproduction can be sexual or asexual and eelgrass plants are monoecious. In asexual reproduction, eelgrass rhizomes, similar to a root, elongate and produce new shoots. As part of sexual reproduction, plants typically flower in spring. Pollen grains are at the whim of currents, fertilizing other eelgrass plants when they land propitiously. Fertilized plants develop seeds in a specialized reproductive organ called a spathe. When seeds are mature, typically late spring through late summer, the spathe breaks off and floats to the surface (Murphy et al. 2011). From there, seeds are released to drift and land in sediment. Once seeds have settled, they are buried through sediment accumulation and infaunal bioturbation (Blackburn and Orth 2013). Although they are susceptible to predation and decay, eelgrass seeds can persist in sediment for years. Brush and Davis (1984) found macrophyte seeds, including eelgrass, dating from approximately 1400 A.D. to the present in 1-2m sediment
cores from the lower Chesapeake Bay. Stratified chronologically, the presence of seeds in the sediment showed changes in species composition over time. Research on eelgrass seeds and seed banks also provides insight into resilience after disturbance and limits on eelgrass germination (Orth et al. 2000).

I hypothesized that salinity would have a positive relationship with, and the greatest influence on, eelgrass distribution in EGP, and that remotely operated vehicle (ROV) footage and seed counts in sediment cores would reflect patterns in salinity. I also expected that nutrient load, using dissolved inorganic nitrogen as a proxy, would be negatively correlated with eelgrass density and distribution. I investigated the distribution of eelgrass (Zostera marina), in connection with water quality, in Edgartown Great Pond (EGP). In addition to evaluating the range and limits of eelgrass beds in EGP, I took sediment cores to assess distribution of eelgrass seeds over time. To gauge water quality, I measured dissolved inorganic phosphate, ammonium, and nitrate, salinity, temperature, and dissolved oxygen. I limited my analyses of water quality parameters to salinity and dissolved inorganic nitrogen.

Methods & Materials

Study Site

My research was based in Edgartown Great Pond, a coastal pond on the south shore of Martha’s Vineyard, an island off the coast of Massachusetts. At high water, it is 890 acres and has a max depth of 3m (Howes et al. 2008). Edgartown Great Pond was historically open to the ocean, but the barrier beach has migrated, closing it off from tides (Howes et al. 2008). About four times a year, a narrow part of the barrier island is dredged, flushing and replenishing the embayment. UMass Dartmouth’s School for Marine Science and Technology, Massachusetts
Estuaries Project, and Great Pond surveys of the EGP have necessitated the establishment of several sampling stations. I sampled at five of these stations: EGP 3, 6, 9, 12, and 13 (Figure 1). The stations I sampled reflect a gradient of distance from the breach and into Wintucket Cove, south of a dike that historically separated Edgartown’s freshwater supply from the pond’s brackish influence. EGP 12 and 13 are newly established GPF sites, so they lack the historical data collected at other sites. On the other hand, they fill a gap in the distribution of sites with their placement above Swan Neck Point, providing insight into a different area. EGP 13 is fairly deep and there are no concrete reports on the presence/absence of eelgrass, whereas EGP 12 is shallower and known to host a bed of eelgrass.

**Field Sampling**

I addressed my hypotheses through analysis of water quality parameters, eelgrass density ratings developed using remotely operated vehicle (ROV) footage of the stations, and a survey of seeds in sediment cores taken at each station. We first sampled on the morning of November 18, 2018. Dredging of the barrier beach began shortly before. Using a Hydrolab®, I collected photosynthetically active radiation (PAR) measurements, salinity, temperature, and dissolved oxygen data at each station, recording measurements approximately every half meter through the water column. At each site, we collected 2L of water from elbow depth, filling and rinsing the sample bottles three times before closing the bottles and storing them in a cooler. Using 60ml syringes, we filtered 1 liter from each station through a Swinnex® filter holder with a pre-ashed glass fiber filter (GFF) into 20ml scint vials for dissolved inorganic nitrate, ammonium, and phosphate analysis. We used the remaining water to measure chlorophyll and particulate carbon and nitrogen. In addition, we deployed a Gladius ROV, courtesy of the Great Pond Foundation,
to record video of the pond floor at each station except EGP 12, due to time constraints and mechanical issues with the equipment. By our second sampling day, November 30, 2018, tides had filled the breach back in. We collected sediment cores and measured salinity at each station. We measured salinity with a Hydrolab® at EGP 6, 13, and 12. We measured salinity at EGP 9 and 3 with a refractometer, using water collected with the sediment cores. On our second day of sampling, we were able to complete ROV video data collection at EGP 12.

**Nutrient and Chlorophyll Measurements**

Adapting a Wood et al. procedure (1967), we used a Lachat instrument to measure nitrate concentration in the filtered water samples. To determine ammonium concentrations, I used a modified Solorzano protocol (1969). Dissolved inorganic nitrogen (DIN) is a measure of combined nitrate and ammonium concentrations. To determine phosphate concentrations, I employed an adapted Murphy and Riley method (1962) using the Lachat. I measured particulate organic nitrogen by filtering a measured volume through pre-ashed 25mm GFF filters, drying the filters, packing the filters, and running them on the organic elemental analyzer Thermo Scientific Flash 2000. To measure water column chlorophyll, we used a modified Lorenzen protocol (1967).

**Seed and ROV Footage Analysis**

To evaluate eelgrass seeds from the sediment cores, I used a protocol adapted from Costa (1988). At each station, we collected sediment cores using a pole corer and clear plastic cores 9.5cm in diameter and 0.5m in height. We plugged and transported the cores back to lab. I extruded the cores, sectioning them into 3cm sections starting from the top (Figure 2). Each core
section was about 215 cm³ in volume. I stored the sections in falcon tubes before wet sieving each with a 1 mm sieve. I sorted through the contents of each section under a microscope, counting each seed type and photographing them to confirm species identification. I analyzed each station’s eelgrass density and abundance from the ROV footage using a relative scale. A station with no eelgrass present would be a zero. A rating of 1 indicates that eelgrass is present, but very sparse. At 2, eelgrass is present and denser. The rating increases up to 3 at stations where eelgrass is most dense in Edgartown Great Pond.

Statistical Analysis

I conducted linear regressions of eelgrass density rating and seed count with both salinity and DIN. I repeated seed count analyses while excluding EGP 6. I performed statistical analyses using the Data Analysis package in Microsoft® Excel for Mac (Version 16.16.5, 2018). I used linear regressions and resulting R² and P values to assess the strength of relationships between indicators of water quality (DIN, salinity) and a proxy measure of eelgrass density and seed count.

Results

Water Quality Measurements

Salinity did not vary greatly between the stations on either day of sampling, but increased significantly across all stations after the pond was cut and flushed by the ocean (Figure 3). Salinity before dredging ranged from a high of 13 ppt at EGP 6 to a low of 9 ppt at EGP 3, a range of just 4 ppt. After the cut, the pond’s maximum salinity was 27 ppt at EGP 6 and minimum salinity was 25 ppt at EGP 3, a range of only 3 ppt. From pre to post cut, the range of salinity was
18ppt. Dissolved inorganic nitrogen (DIN), was greatest at EGP 9 with a concentration of 5μM and was lowest at EGP 6 with a concentration of 2μM (Figure 4).

**Sediment Core Seed Analysis**

I found 267 seeds in the 15 core sections analyzed. I found seeds belonging to four species of aquatic vegetation: eelgrass, widgeon grass, redhead grass, and horned pondweed (Figure 5). There were differences in abundance and variety of species of seeds across the stations (Figure 6). Eelgrass seeds, present at all stations, were most abundant in the top 3cm of EGP 6 with 32 seeds (Figure 7). Redhead grass seeds were present at EGP 6 and the dominant species at all other stations, increasing in abundance with distance from the location of the dredging. Widgeon grass seeds were also present in the cores from all five stations, but most abundant at EGP 12 with 9 seeds. Horned pondweed seeds were only present at EGP 13, 12, and 3 and were no more abundant than 6 seeds per station.

**ROV Footage and Eelgrass Density**

We recorded the presence eelgrass at three of the five stations sampled: EGP 6, 12, and 9 (Table 1). We found no eelgrass at EGP 13 or 3, which earned these stations a rating of 0. Eelgrass was most dense at EGP 6 with a rating of 3. Eelgrass was less dense at EGP 12 with a rating of 2, and even less so at EGP 9 with a rating of 1. At the three sites with eelgrass, there was evident epiphytic colonization of the plants. Eelgrass blades were still green in color. We also captured footage of tunicates on eelgrass. The sparse eelgrass we found at EGP 9 is the first reported finding in that area of Edgartown Great Pond. At all stations but EGP 6, we saw benthic algal mats.
**Statistical Analysis**

I also compared eelgrass plant and seed density with water quality parameters. Eelgrass seed abundance had a negative relationship with DIN (Figure 8) \((R^2 = 0.89, P < 0.02)\). There was also a negative relationship between eelgrass density rating and DIN (Figure 9) \((R^2 = 0.54, P < 0.2)\). Analyses showed positive relationships between eelgrass seed abundance and both pre (Figure 10) \((R^2 = 0.19, P < 0.5)\) and post cut salinity (Figure 11) \((R^2 = 0.53, P < 0.2)\). The relationships between eelgrass density rating and pre (Figure 12) \((R^2 = 0.29, P < 0.4)\) and post cut salinity were also positive (Figure 13) \((R^2 = 0.56, P < 0.2)\). I also conducted the seed count analyses excluding EGP 6. Contrary to the finding with EGP 6, seed abundance and DIN showed no correlation (Figure 14) \((R^2 = 0.002, P < 0.9)\). With EGP 6 excluded, the relationships of seed abundance with both pre (Figure 15) \((R^2 = 0.53, P < 0.5)\) and post cut salinity remained positive (Figure 16) \((R^2 = 0.79, P < 0.2)\).

**Discussion**

An inadvertent but valuable finding from this study was our record of the change in salinity caused by dredging the barrier beach. These results indicate a need for sustained, periodic measured on how the change in salinity affects eelgrass in Edgartown Great Pond. The transition from nearly fresh to saline is drastic and rapid (Figure 3). The return to fresh is more gradual, a result of groundwater inflow and rainfall. Based on our sampling and that of the Great Pond Foundation, salinity at EGP 6 takes several months to drop by 10ppt, while a cut can increase it by the same margin within days (Figure 17). The sensitivity of eelgrass to salinity varies based on the plant’s life stage and the salinity where it developed. In a 2014 study, Salo et
al. found that eelgrass plants from low salinity areas were able to adapt to increased salinity while plants from high salinity areas performed poorly at low salinities. This indicates that eelgrass in Edgartown Great Pond could be most successful if the pond was kept fresh rather than saline in their early life so they would be better able to manage the drastic increases in salinity. Research by Xu et al. (2016) found that seedlings struggle to develop when salinity is below 20ppt, but seeds germinate at higher rates in lower salinities. Following these studies, timing of cuts should be based on the current salinity and stage in the eelgrass lifecycle. At present, cuts are based on pond level, tides, and weather (personal communication, November 2018, Emily Reddington)

Temperature and oxygen levels around seeds also factor into germination. Moore et al. (1993) found that eelgrass seed germination occurs at the highest rate in anoxic conditions and when buried in sediment. Marion and Orth expanded on this with their finding that eelgrass seed germination and seedling establishment were more successful when seeds were buried 2-3cm in sediment rather than on the surface (2012). These studies could explain a lag between seed release and seed germination in Edgartown Great Pond, another avenue for further research on the eelgrass population. Moore et al. also found that peak eelgrass seed germination occurs at 15°C and sprouting occurs 1-2 weeks later (1993). In Edgartown Great Pond, water typically reaches 15°C in early October and late May (Figure 18). Managed opening of the pond is typically conducted four times a year, twice in the spring and twice in the fall. Various factors influence cut management but the effect of changes in salinity on eelgrass should be carefully considered due to eelgrass’s outsize effect on the health of the ecosystem (Murphy et al. 2011).

Salinity and nutrient loading have a combined effect on eelgrass. A 1999 experiment by van Katwijk et al. indicated that increased nutrient loading limits eelgrass to areas with lower
salinity. When combined with nutrient loading of 625 kg N ha\(^{-1}\) yr\(^{-1}\), eelgrass in salinities 26-30ppt experienced declines in vitality and shoot abundance (van Katwijk et al. 1999). Nutrient loading has been the driver of eelgrass declines globally, and continues to be an issue in Edgartown Great Pond. The 2008 MEP report on Edgartown Great Pond found that nutrient loading caused declines in eelgrass populations and relegated remaining growth to shallower parts of the estuary, a consequence of nutrient-induced algal shading (Howes et al. 2008). As work to reduce the pressure of nutrient loading continues, it will benefit Edgartown Great Pond to keep salinity in mind as well.

Seed distribution and density can tell us about the relative abundance of different species in different areas of the pond and how that has changed through time. Because Edgartown Great Pond is closed off from the ocean, limiting strong tidal currents, SAV seeds are more likely to be deposited near their source eelgrass beds, rather than distributed to distant locations. Thus, seed distribution and abundance may be a good indicator of SAV diversity and abundance in that location. This is especially notable when comparing redhead grass seeds and eelgrass seeds. As eelgrass seed density declines, redhead grass seed density increases, following a gradient of distance from the ocean. Despite the abundance of redhead grass seeds, we saw no redhead grass on ROV footage at any of the stations we visited, suggesting that those environments were inhospitable for redhead grass. Nonetheless, redhead grass has previously been identified in Edgartown Great Pond (Cullina 2016), indicating that other areas of the pond are suitable for its growth and reproduction. Further research on submerged aquatic vegetation in Edgartown Great Pond should look in-depth at all species.

DIN was lowest at EGP 6, which was contradictory to our expectations because of its proximity to a developed area and the occurrence of algal blooms in the past, a consequence of
nitrogen loading. Another interesting result of our analyses were the connections between eelgrass plant and seed density and dissolved inorganic nitrogen in Edgartown Great Pond. Both seed and eelgrass density were negatively correlated with DIN concentration. This could indicate that DIN inhibits eelgrass reproductive success or that the presence of eelgrass leads to a decline in DIN. A 1999 study by van Katwijk et al. reported eelgrass nutrient uptake outpacing replenishment rates, suggesting the dense eelgrass bed at EGP 6 could be the driver of low DIN at this station. Alternatively, high DIN has frequently been reported as a driving factor in eelgrass declines (Burkholder et al. 1992, Hauxwell et al. 2001). The results of this study don’t provide a conclusive answer as to the driver of this relationship, but further research on the interactions between eelgrass and dissolved nitrogen concentrations in Edgartown Great Pond could inform management.

We noted that epiphytic algae were present on eelgrass in Edgartown Great Pond. This is typical for eelgrass in estuaries with high nutrient loading (Borum 1985) and increases as plants senesce in the late fall. We also noted the presence of benthic algal mats at all but EGP 6. Future study should identify and track their presence and influence on the Edgartown Great Pond ecosystem. Another valuable finding of this study was the discovery of eelgrass at EGP 9, an area of Edgartown Great Pond where it has not been previously found. This is a positive sign for Edgartown Great Pond and a development to continue following.

Analyses comparing pre or post cut salinity with eelgrass density or seed abundance can only provide limited insights to how salinity affects eelgrass in Edgartown Great Pond. We recorded salinity on only two occasions, separated by 12 days and an influx of ocean tides from the dredging of the narrow beach. As has been previously reported (Howes et al. 2008), water quality parameters do not have a strong horizontal gradient in Edgartown Great Pond. This was
the case in the salinity data both before and after the cut. Salinity did not vary across stations by more than 3ppt in either sampling event (Figure 3). The lack of a strong gradient undercuts any relationship we see between eelgrass and salinity. Nonetheless, there are differences in eelgrass density and seed abundance between the stations. Although they are not sufficient to explain a pattern of salinity’s effect on eelgrass density and distribution, the change in salinity from pre to post cut does pose an interesting opportunity for study.

In addition, both our water quality and eelgrass data are limited. The nutrient measurements were limited to one day in late November and can only hint at a general pattern of nutrient levels across the five EGP stations. Serial measures throughout the year would add to our understanding of seasonal variation in water quality in Edgartown Great Pond. With additional, and temporally spaced, measurements of eelgrass in Edgartown Great Pond, we would be better able to draw connections between different water quality parameters and eelgrass.

Analyses comparing eelgrass seed abundance and water quality parameters are skewed by the abundance of eelgrass seeds at EGP 6. Eelgrass seeds were over 8 times more abundant in the core from EGP 6 than all other stations and, in most cases, greater than 10 times more abundant. However, the majority of seeds (32) were found in the top 3cm of sediment, triple the seeds in the other two sections of the core. As we saw from ROV footage, EGP 6 also has the highest density of eelgrass plants in Edgartown Great Pond. The dense eelgrass bed likely explains the high seed count. Costa found that eelgrass seed density declined substantially with distance from eelgrass beds (1988). The abundance of eelgrass seeds at EGP 6 skews the observed relationships by creating the impression of range in seed counts between sites. Without EGP 6, there is no relationship between eelgrass seed count and DIN (Figure 14), making the
significant negative relationship between them (when EGP 6 is included) highly suspect (Figure 8). Excluding EGP 6 from analyses comparing seed counts and salinity did not substantially affect the results as the relationships, although positive, were not statistically significant (Figures 15 & 16).

We collected just one sediment core from each station. Collecting additional core samples would provide data for estimation and would support our findings regarding abundance and distribution of SAV seeds in Edgartown Great Pond. More samples, and longitudinal collection, would permit analyses to better understand the density of each species and the factors supporting or inhibiting successful propagation. In addition, we collected the cores post dredging of the barrier beach, which opened the pond to ocean tides. It is possible that the resulting tides moved the sediment and seeds, affecting the density and distribution of seeds in the top layer. Additional research on the levels of seed production and expected seed dispersal for each species would add to our understanding of how seed counts translate to plant coverage in Edgartown Great Pond.

A methodological enhancement that might be applied to future study of eelgrass density and distribution could include the use of quadrats in connection with ROV footage collection. The use of ROV footage or still images of quadrats could improve the ease and accuracy of data analysis, providing for greater validity of density estimates.

The results of this project, in combination with previous research, suggest many questions about how best to manage Edgartown Great Pond. Although the results are limited in what they can tell us about the water quality parameters that affect distribution and density of eelgrass in Edgartown Great Pond, they do provide preliminary findings that can guide future research. The water quality results, eelgrass density from ROV footage, and sediment core seed
counts all tell new stories about the health of the pond at this time. Further study on environmental pressures, eelgrass lifecycle, and factors affecting reproductive success should be conducted on eelgrass in Edgartown Great Pond. Additional research would provide a solid foundation for the implementation of eelgrass propagation and transplantation, a promising restoration strategy (Xu et al. 2016, Orth et al. 2000).

Acknowledgements

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References


Figures & Tables

**Figure 1.** The five stations we sampled in Edgartown Great Pond are circled in red. The section of the barrier beach that is dredged about four times a year is circled in black.

**Figure 2.** We split sediment cores from the five EGP stations into three 3cm sections from the top.
Figure 3. Salinity (ppt) across five stations in Edgartown Great Pond measured before an engineered breach of the barrier beach separating EGP from the ocean on 11/18/18 and afterwards on 11/30/18. Precut measurements were taken using a Hydrolab®. Post cut measurements were taken using a refractometer and water stored in sediment cores.

Figure 4. Dissolved inorganic nitrogen, combined ammonium and nitrate concentrations, in µM across five sampling stations in Edgartown Great Pond. We collected the samples on 11/18/18.
Figure 5. Seeds of the four species of aquatic vegetation we found in sediment cores from Edgartown Great Pond.

Figure 6. The distribution and density of seeds from four different species of aquatic vegetation found in the sediment cores from Edgartown Great Pond.
**Figure 7.** Eelgrass seed density and distribution across 5 stations and 3 sediment sections (0-3 cm, 3-6 cm, and 6-9 cm) in Edgartown Great Pond.
Table 1. Relative eelgrass density rating and representative image from five stations in Edgartown Great Pond. Values are based on ROV footage.

<table>
<thead>
<tr>
<th>Station</th>
<th>Rating</th>
<th>Image Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EGP 9</td>
<td>1</td>
<td><img src="image1.jpg" alt="Image" /></td>
</tr>
<tr>
<td>EGP 3</td>
<td>0</td>
<td><img src="image2.jpg" alt="Image" /></td>
</tr>
<tr>
<td>EGP 12</td>
<td>2</td>
<td><img src="image3.jpg" alt="Image" /></td>
</tr>
<tr>
<td>EGP 13</td>
<td>0</td>
<td><img src="image4.jpg" alt="Image" /></td>
</tr>
<tr>
<td>EGP 6</td>
<td>3</td>
<td><img src="image5.jpg" alt="Image" /></td>
</tr>
</tbody>
</table>

This is one of several small pockets of eelgrass at EGP 12
Figure 8. Scatter plot and linear regression comparing eelgrass seed abundance and DIN (µM) at five sampling stations in Edgartown Great Pond.

\[ y = -20.109x + 86.549 \]
\[ R^2 = 0.89 \]
\[ P < 0.02 \]

Figure 9. Scatter plot and linear regression comparing eelgrass density rating and DIN (µM) at five sampling stations in Edgartown Great Pond.

\[ y = -1.1655x + 5.5903 \]
\[ R^2 = 0.54 \]
\[ P < 0.2 \]
Figure 10. Scatter plot and linear regression comparing eelgrass seed abundance and salinity (ppt) at five sampling stations in Edgartown Great Pond. Salinity measurements were taken before the pond was opened to the ocean.

\[ y = 5.8845x - 57.969 \]
\[ R^2 = 0.19 \]
\[ P < 0.5 \]

Figure 11. Scatter plot and linear regression comparing eelgrass seed abundance and salinity (ppt) at five sampling stations in Edgartown Great Pond. Salinity measurements were taken after the pond was opened to the ocean.

\[ y = 16.523x - 421.79 \]
\[ R^2 = 0.53 \]
\[ P < 0.2 \]
Figure 12. Scatter plot and linear regression comparing eelgrass density rating and salinity (ppt) at five sampling stations in Edgartown Great Pond. Salinity measurements were taken before the pond was opened to the ocean.

\[ y = 0.5442x - 5.16 \]
\[ R^2 = 0.29 \]
\[ P < 0.4 \]

Figure 13. Scatter plot and linear regression comparing eelgrass density rating and salinity (ppt) at five sampling stations in Edgartown Great Pond. Salinity measurements were taken after the pond was opened to the ocean.

\[ y = 1.2619x - 31.836 \]
\[ R^2 = 0.56 \]
\[ P < 0.2 \]
**Figure 14.** Scatter plot and linear regression comparing eelgrass seed abundance and DIN (µM) at EGP 3, 12, 13, and 9 in Edgartown Great Pond. This analysis excludes EGP 6.

\[
y = -0.3021x + 4.2427 \\
R^2 = 0.002 \\
P > 0.9
\]

**Figure 15.** Scatter plot and linear regression comparing eelgrass seed abundance and salinity (ppt) at EGP 3, 12, 13, and 9 in Edgartown Great Pond. Salinity measurements were taken before the pond was opened to the ocean. This analysis excludes EGP 6.

\[
y = 0.9604x - 8.0152 \\
R^2 = 0.53 \\
P < 0.5
\]
Figure 16. Scatter plot and linear regression comparing eelgrass seed abundance and salinity (ppt) at EGP 3, 12, 13, and 9 in Edgartown Great Pond. Salinity measurements were taken after the pond was opened to the ocean. This analysis excludes EGP 6.

Figure 17. Mean of surface, mid, and bottom salinity (ppt) at EGP 6 over time. Sampling was conducted, and data provided, by the Great Pond Foundation. We collected data points for 11/18/18 and 11/30/18 separately. They are not an average of bottom, mid, and surface salinities.
Figure 18. Mean of surface, mid, and bottom temperature (°C) at EGP 6 over time. Sampling was conducted, and data provided, by the Great Pond Foundation. We collected data points for 11/18/18 and 11/30/18 separately. They are an average of temperature approximately every 0.5 m in depth.