DETERMINING THE ROLE OF SALT MARSH MACROALGAE (ECADS) IN CAPE COD SALT MARSHES

Jennifer Burkhardt, Megan Tyrrell, Carol Thornber

1. INTRODUCTION:

Salt marshes are vital ecosystems on Cape Cod, especially within the boundaries of the national seashore and are considered critical coastal resources. These ecosystems make up approximately 2,500 acres of the 44,600 acres of the Cape Cod National Seashore. Salt marshes are among the most biologically productive ecosystems on earth. In addition to being an important habitat for plants and animals they also reduce coastal erosion, decrease nutrient inputs to the marine environment and protect shorelines by reducing the force of storms (Bertness, 1999). Salt marshes are also an important form of ecotourism on Cape Cod as over four million people visit the seashore each year to enjoy the natural resources that it has to offer.

The long term sustainability of these ecosystems is threatened by multiple factors including sea-level rise and salt marsh dieback. Salt marshes are very susceptible to climate change because often the sediment accretion rate on salt marsh platforms cannot keep up with sea level rise and therefore these parts of the salt marsh effectively drown (Morris et al., 2002). The issue of dieback along the lower salt marsh, characterized by the zone of *Spartina alterniflora*, is that of overgrazing by the native purple marsh crab causing a dramatic loss of salt marsh vegetation resulting in large bare zones (Holdredge, et al., 2008). This is causing a loss of creek bank marsh vegetation which creates erosion and widening and lengthening of tidal creeks and an overall decrease in marsh area (Smith, 2009). Currently, salt marsh restoration is a major focus of management and research at the Seashore. Two long-term monitoring protocols are in place, monitoring salt marsh vegetation and monitoring salt marsh elevation, that investigate these issues.

While some features of salt marshes on the eastern U.S. coastline have been extensively studied (i.e. salt marsh plant zonation patterns and relative impacts of physical vs. biological factors in structuring these communities), surprisingly little is known about macroalgae (seaweeds) that can form dense structures within salt marshes (Bertness, 1999). These specialized macroalgae are most commonly referred to as ecads. The picture to the right shows how these ecads form mats along the edges of the marsh and within the *Spartina alterniflora* zone. Ecads are ecosystem engineers, since they can create and/or modify their habitat substantially (Jones et al 1994). Ecads are a species of *Ascophyllum* and *Fucus* (rockweeds) that are morphologically different from their counterparts in rocky intertidal habitats (Fig. 2A-D) They are often much smaller, have limited or no reproductive structures and therefore reproduce vegetatively, have increased branching and have a modified shape (shown below). (Mathieson, et al., 2006) There were five research objectives that were undertaken this summer that are described in the following pages.

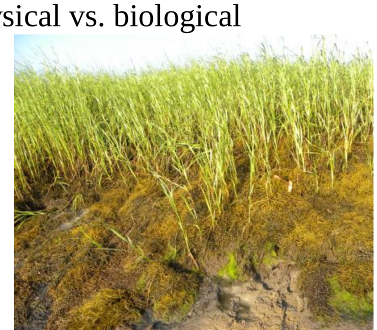


Fig 1. Ecads in a salt marsh

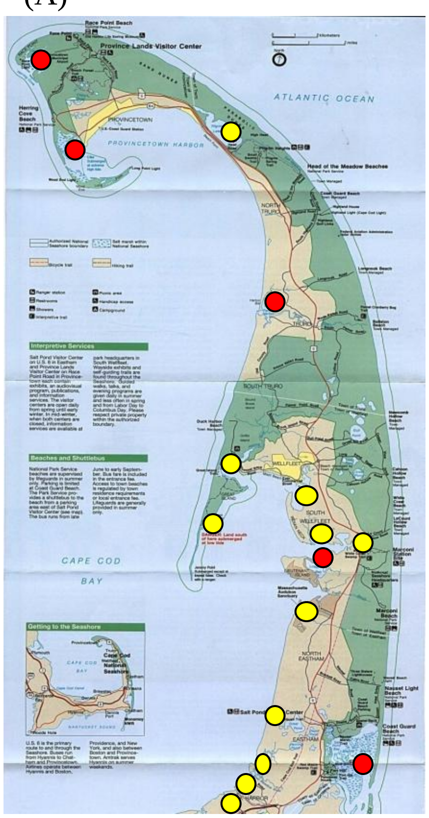
(A) *Ascophyllum*, ecad (B) Ascophyllum, Rocky Intertidal (C) Fucus, ecad (D) Fucus, Rocky Intertidal

Fig 2. Morphological differences shown between ecads (A) and (C) and Rocky Intertidal (B) and (D) photo (D) found at medicherb.voila.net/img/fucus.jpg

RESEARCH OBJECTIVE: Where are ecads located on Cape Cod?

In May of 2011 we did a short survey of salt marshes on the lower cape to determine where ecads were present. We surveyed sixteen salt marshes and found evidence of ecads in six salt marshes and no evidence of ecads in ten salt marshes (Fig. 2A, B). Ecads were found in highest abundance in Hatches Harbor Marsh and West End Marsh. We were unable to determine if the presence of ecads was correlated with the physical properties of the salt marshes. As you can see in Figure 3 there was no pattern as to where the ecads were found. They were found in marshes on both the ocean side and the bay side of the lower cape. In the future we hope to examine the elevation of each salt marsh, the sediment type, and the potential sources of recruitment of ecads for each marsh. During our survey these seemed to be the three major differences between marshes that may affect recruitment and settlement of an ecad community.

(A)



(B)

PRESENT:

- West End
- Hatches Harbor
- Pamet Harbor at Corn Hill
- Lieutenant Island
- Nauset Marsh
- Pleasant Bay (not pictured here)

ABSENT:

- The Gut
- Middle Meadow
- Wellfleet Bay Wildlife Sanctuary
- Moon Pond
- Drummer Cove/ Blackfish Creek
- Chipmans Cove
- Fox Marsh
- North Sunken Meadow/Sunken Meadow
- Herring River
- Boat Meadow

Fig. 3. (A) Map of lower Cape Cod with red dots symbolizing marshes where ecads were present and yellow dots symbolizing marshes where ecads were not present. (B) List of marshes represented in the map.

RESEARCH OBJECTIVE: How does the presence of ecads affect the physical properties of the salt marsh surface?

Experiment: In May of 2011 we set up a control/removal experiment in West End and Hatches Harbor. Ten 2m x2m plots were set up along the edge of the salt marsh. Ecads were removed in five of the plots to create the experimental plots and ecads were left in place in five of the plots as the control plots (Figure 4A,B). A set of five paired 2m x 2m interior plots were also created to examine the effect of ecads on the interior of the salt marsh platform. These plots were spaced 5 m apart, moving landward (upslope) from the marsh edge. All of the following experiments were performed in both salt marshes to determine if the results were dependent on the specific marsh or applicable over a larger scale. Data was collected at various time periods over the course of the experiment.

(A) (B)

Fig. 4. (A) Control plot with ecads (B) Experimental plot with ecads removed

The physical parameters of sediment movement, composition of sediments, and physical properties were all examined through various experiments in all of these plots. Sediment movement in these plots was determined via five different experiments. The first was to place five flags at a height of 20cm in each plot and measure the flags at three different points in the summer to determine the accretion and erosion of sediments in each plot (Fig 5A). The second was to place three 10cm x 10cm sediment traps made of flashing on the sediment surface of each plot to examine sediment deposition (Fig. 5B). To examine sediment deposition patterns over time, one trap was removed every 6 weeks. Each trap was individually bagged and returned to the laboratory where dry weight was determined. The third experiment was to create plaster of paris “popsicles” to be placed in each plot to examine the relative flow rate over the surface of each plot (Fig. 5C). The plaster of paris was removed at the end of two weeks, dried and weighed, and the percentage lost was determined. The fourth experiment was to determine the total suspended solids in each plot during an outgoing tide (Fig. 5D). Water was suctioned from 5cm above the salt marsh platform in eight different plots, filtered in the lab, and weighed to determine total suspended solids. This experiment was only performed in the edge plots of West End. The final experiment to examine sediment movement was to place two PVC tubes in each of the plots to examine vertical deposition of sediment particles (Fig. 5E). One tube was placed so the opening was about 2cm above the sediment surface and the other tube was placed at the same height as the ecad canopy (or what the ecad canopy height would have been in the removal plots). These were left in the field for two weeks and when removed the sediment was dried and weighed.

(A) (B) (C) (D) (E)

Fig. 5. Experiments used to determine sediment movement in research plots. (A) Sediment flags (B) Sediment traps (C) Plaster of paris “popsicles” (D) Total Suspended Solids (E) PVC Pipes

The organic content of sediments in control and removal plots was measured via two different experiments. The first was to take sediment scrapings 1.5cm deep at three different time periods throughout the summer and burn a small portion of that sediment at 550°C in a muffle oven, which burns off all organic content, leaving only inorganic materials. (Fig. 6A,B). The percent organic material was then determined based on the amount of material lost when burned. This process was also repeated using the sediments on the sediment traps that were being pulled throughout the summer.

We also examined the decomposition rate of *Spartina alterniflora* in each plot (Fig. 6C). To do this we made bags out of mesh, placed one *Spartina alterniflora* plant in each bag, closed up the bag, and placed five bags in each plot along the edge of the salt marsh. We then randomly pulled one bag from each plot at 2, 4, 8, 10, and 14 weeks, dried and weighed each bag and determined the amount of plant material lost.

(A) (B) (C)

Fig. 6. Experiments used to determine sediment composition (A) Sediment scrapings. (B) Sediments after being burned in a muffler at 550°C for three hours. (C) Decomposition bags of *Spartina alterniflora.*

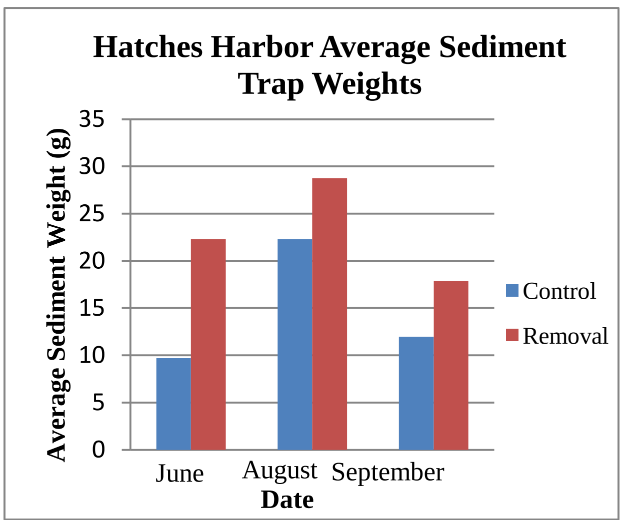
The final component of this experiment was to examine the physical factors. We did this by using HOBO loggers (Fig. 7A,B) to measure conductivity, light and temperature in the control and removal plots along both the edge and the interior of the marsh.

(A) (B)

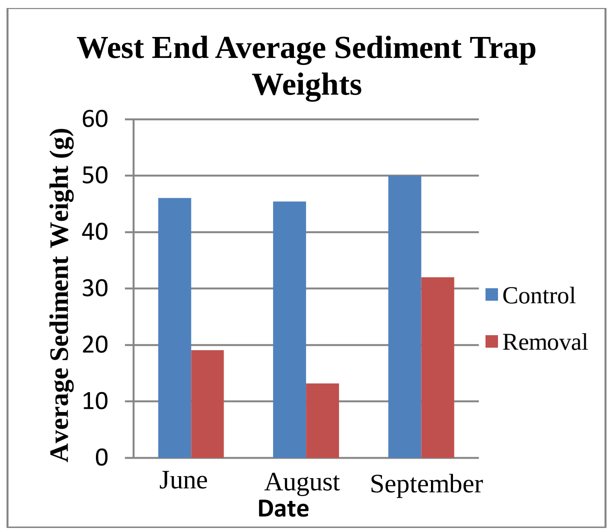
Fig. 7. HOBO loggers used to measure (A) Conductivity and (B) Light and temperature

Results:

The edge plots in West End and Hatches Harbor indicated that sediment movement was minimal in these habitats. Changes in the height of flags above the sediment surface were relatively small; the differences between the treatments (control and ecad removal) are not likely significant. The results from the sediment traps are opposite in the two marshes (Fig. 8A, B). There was a higher amount of deposition on the traps in the removal plots in Hatches Harbor than the ecad plots. There was a higher amount of deposition on the traps in the ecad plots in West End than the removal plots. The results from the plaster of paris experiment showed that there was a higher relative flow rate in the removal plots at both sites which would indicate a greater movement of particles when no ecads are present (Fig. 9A,B). The results from the total suspended solids portion of this experiment show that there is a much higher amount of suspended solids in the plots with ecads than the removal plots. Finally, the results from the PVC pipes indicated that there was a greater deposition at the surface of the marsh than at the ecad canopy indicating a greater amount of deposition from horizontal movement instead of passive deposition from the water column (Fig. 10A, B). Also, there was greater deposition in the ecad plots than the removal plots, most likely because the ecads slow water flow and create turbulent conditions, which leads to particles settling out at the sediment surface. The results from the PVC pipe were consistent at both sites.

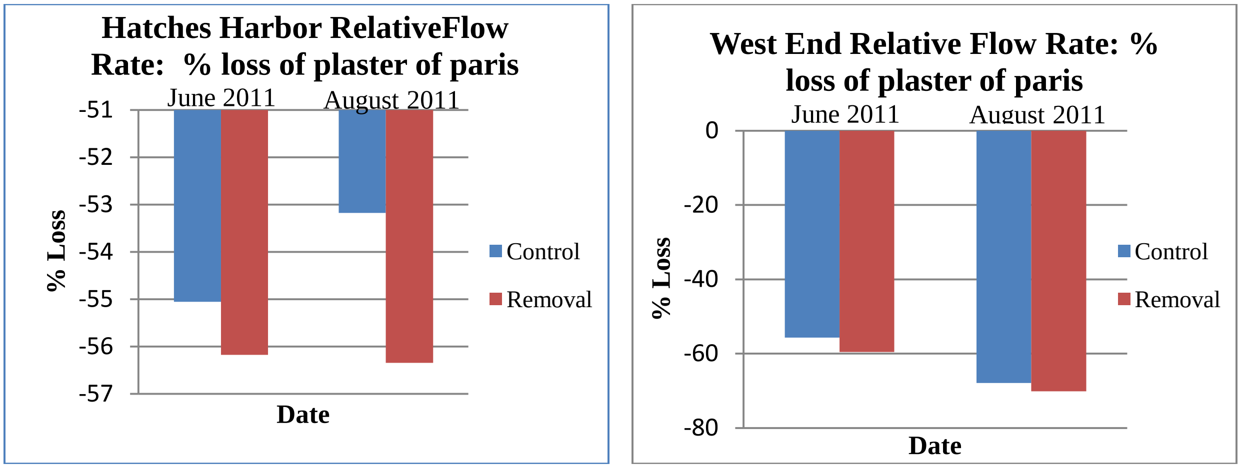


A.



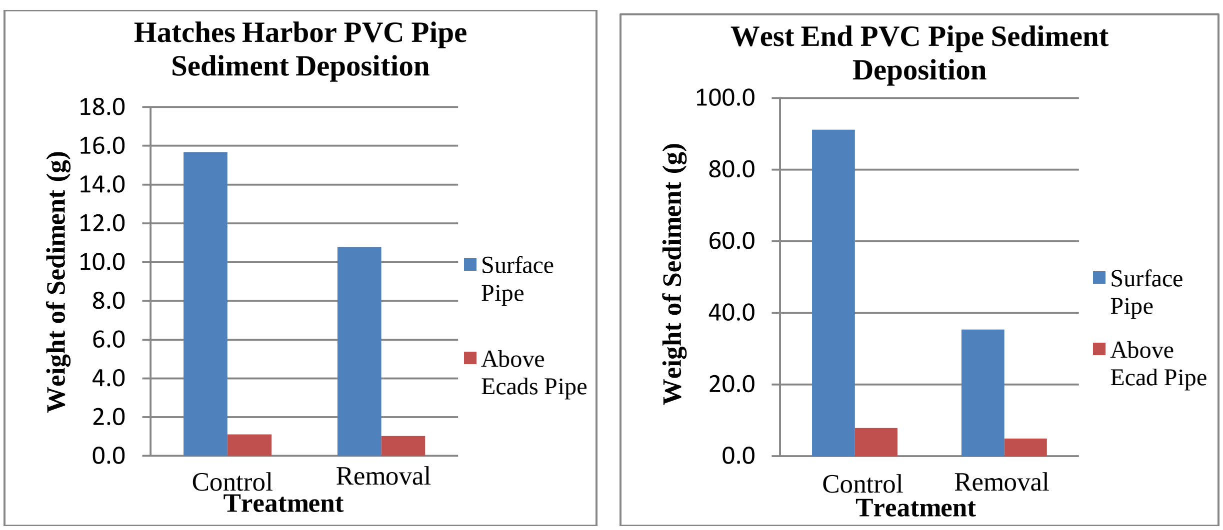
B.

Fig. 8. Average Sediment Weight of sediments deposited on the sediment traps (10cm x 10cm) in control and removal plots in June, August, and September in (A) Hatches Harbor and (B) West End



A. B.

Fig.9. Percent loss of plaster of paris in control and removal plots in June and August of 2011 for (A) Hatches Harbor and (B) West End.

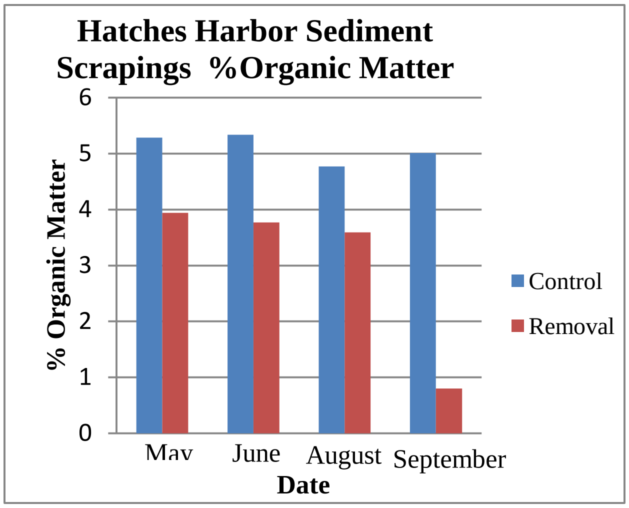


A. B.

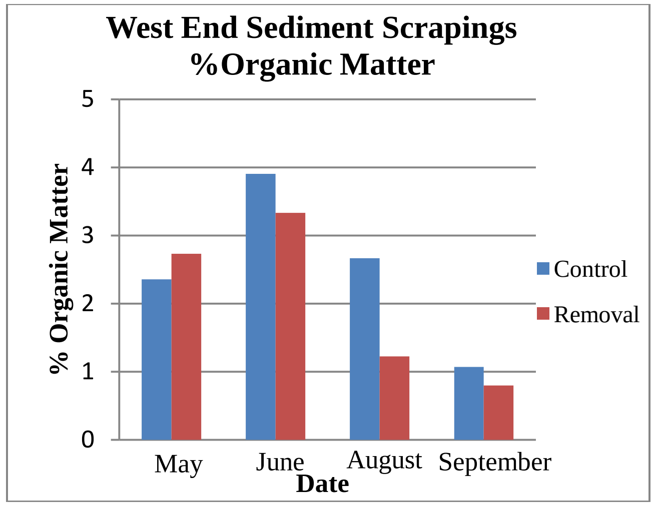
Fig.10. Average weight of sediments deposited in surface and above ecad pipes in control and removal plots in (A) Hatches Harbor and (B) West End.

We found a higher percent organic matter in sediments from plots with ecads than from removal plots in both experiments. The percent organic matter from the sediment scrapings was higher overall in the plots with ecads (Fig. 11A, B). The percent organic matter from the sediment traps was higher overall in the plots with ecads.

The rate of decomposition of *Spartina alterniflora* was higher in the plots with ecads than without and as expected, the decomposition rates increased over time (Fig. 12A, B). Overall these results point to the conclusion that the ecads increase decomposition of plant matter and increase the organic composition of the sediments.

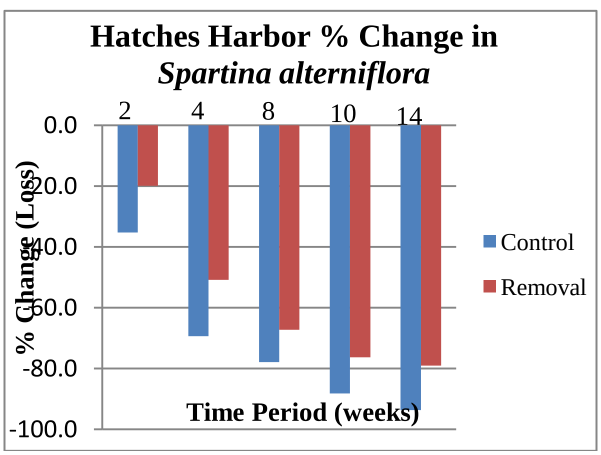


A.

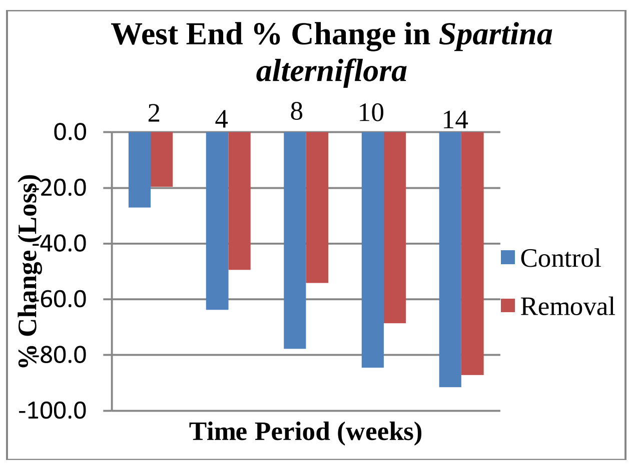


B.

Fig.11. Average percent organic matter for sediment scrapings from control and removal plots during May, June, August, and September in (A) Hatches Harbor and (B) West End



A.



B.

Fig.12. Average % change in weight of *Spartina alterniflora* after a period of 2, 4, 8, 10, or 14 weeks in decomposition bags in control and removal plots in (A) Hatches Harbor and (B) West End

RESEARCH OBJECTIVE: Do ecads have an effect on creek bank erosion?

Experiment: Ten 2m x 1m plots were set up in Hatches Harbor along the edge of the creek bank. Ecads were removed from five of the plots as experimental plots and ecads were left in place in five plots as the control plots. To determine the effect of ecads on creek bank erosion three different methods were used. The first was to measure the change in the width of the plot at eight different points (Fig. 13.). At the beginning of the experiment eight flags were placed parallel to each other along the bottom and top edges of the plot. The distance between each flag was measured at the beginning of the experiment and then again at the end of three months. The second way to measure erosion was to place flags (between 17 and 22 flags) along the lower edge of the plot to trace the outline of the creek bank (Fig. 14.). A piece of string was then strung along the flags to measure the approximate length of the creek bank. This was repeated at the end of three months. The final method used to determine erosion was to place five flags at a height of 20cm from the sediment surface in each plot. Each of these flags was measured after 6 weeks and then again at the end of the experiment (12 weeks) to determine accretion and erosion in each plot.

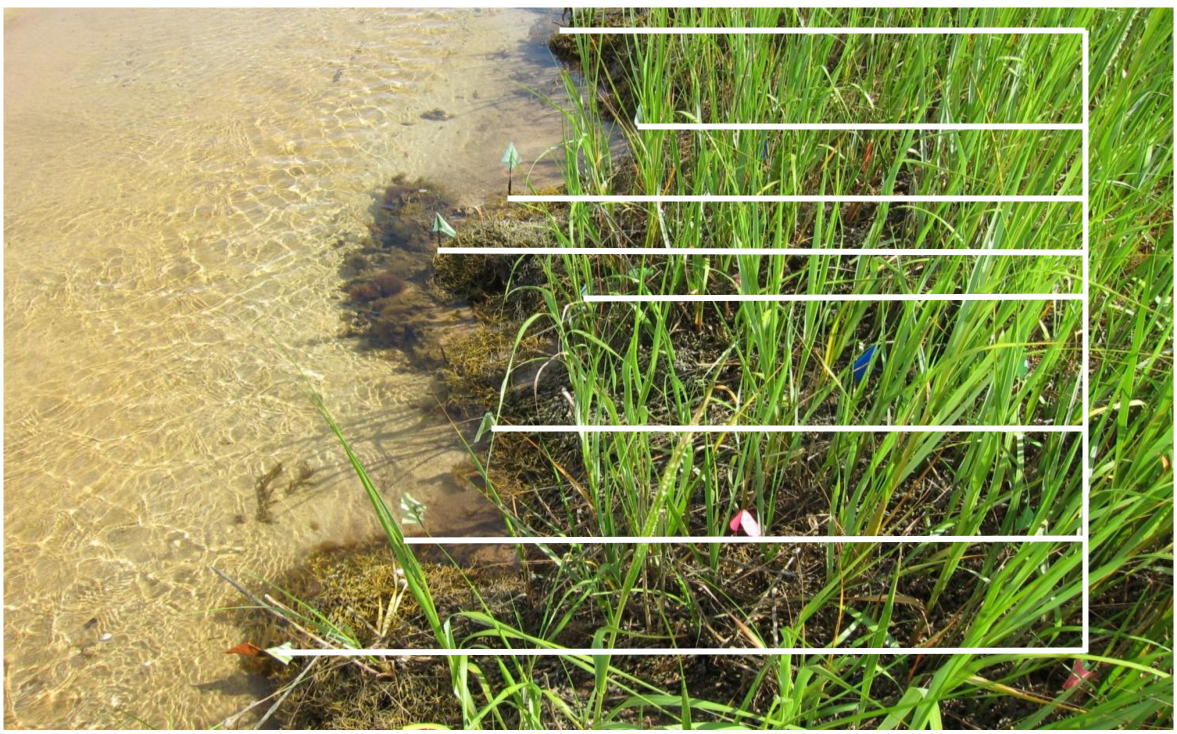


Fig. 13 Creek bank erosion experiment in Hatches Harbor measuring the change in width at eight different points (shown by the white lines) in control and experimental plots.

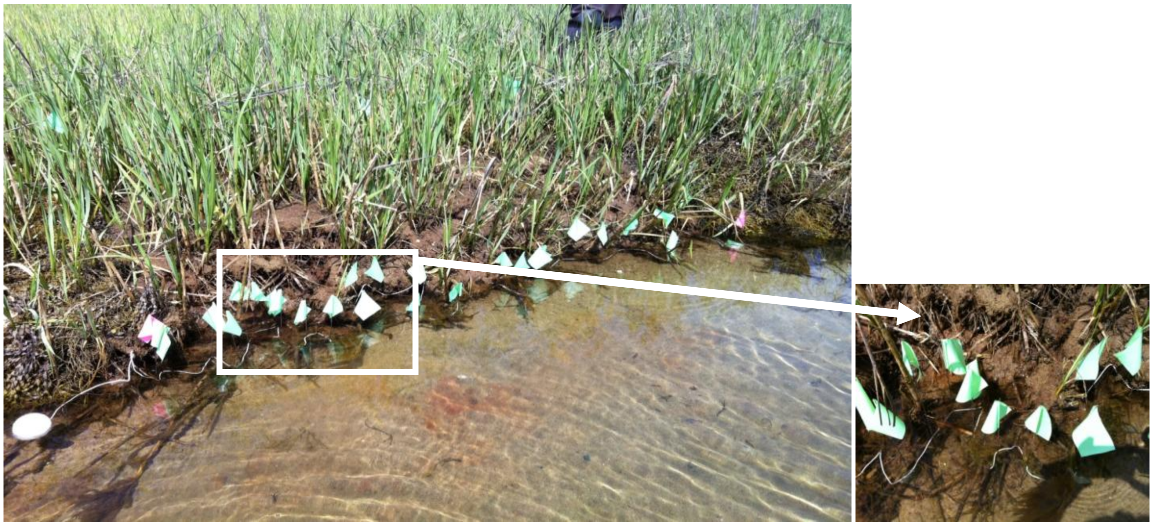


Fig. 14 Creek bank erosion experiment in Hatches Harbor where flags were used to create an outline of the creek bank.

Results:
The results from this experiment are not conclusive at the current time and more analysis needs to be done. However, the second experiment that was done does point to the conclusion that the removal of ecads leads to increased erosion along the creek bank.

RESEARCH OBJECTIVE: Do ecads have an effect on *Spartina alterniflora* seedling growth?

Experiment: We examined this objective via a field and a laboratory experiment. The field component of this experiment was set up in West End for approximately two months (Fig. 15.). 40 flower pots were sunk into the sand in a portion of the marsh that was devoid of plant life. In each flower pot a *Spartina alterniflora* seedling was planted and the plant height was measured and the number of dead leaves and live leaves were counted. Half of the pots (20) received ecads and half of the pots (20) remained bare. Cages were set up around each of the plots to keep the ecads in place. At the end of the two months the plant height was taken and the number of live leaves and dead leaves were counted. The plant was then removed and taken back to the lab where it was rinsed, dried, and the weight of the plant and the weight of the roots were measured separately.

A.

B.

Fig. 15. Photographs of *Spartina alterniflora* seedling experiment with (A) experimental pots where ecads were placed and (B) control plots that were left bare.

In the laboratory portion of this experiment one *Spartina alterniflora* plant was placed in a bucket with sand with a total of twenty buckets (Fig. 16C). 850g of ecads were added to ten buckets as the experimental buckets (Fig. 16B) and no ecads were added to ten of the buckets as the controls (Fig 16A). Each bucket was watered with seawater three times a week over a period of three months. The plant height was measured at the beginning and the end of the experiment and the number of live leaves and dead leaves were counted at the beginning and end of the experiment. At the end of the experiment sediment scrapings were taken from each bucket, dried, and burned in a muffler at 550°C to determine if the ecads changed the organic composition of the sediments. Each plant was also removed, rinsed, dried, and then the roots and the plant were weighed separately.

A. B. C.

Fig. 16. Photographs from laboratory *Spartina alterniflora* seedling experiment. (A) Control pot with *Spartina alterniflora* seedling (B) Experimental pot with *Spartina alterniflora* seedling and ecads (C) All of the twenty pots in the experiment.

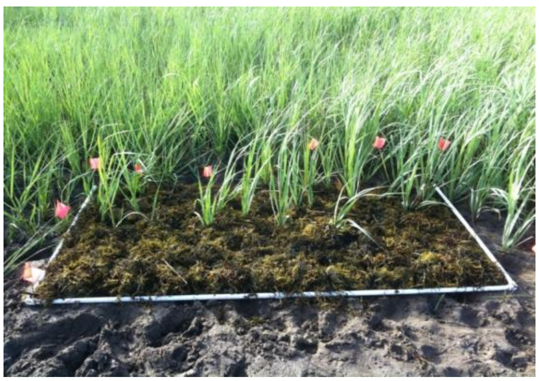
Results:
The initial results from the field experiment show that there was a greater survivorship of *Spartina alterniflora* plants in the control plots without ecads (100%) than there was in the ecad plots (60%). However, it appears that the plants that do survive in the ecad plots were healthier. They had a 65% increase in plant height as opposed to the 56% increase in plant height in the no ecad plots. The plants with ecads also had more live leaves and less dead leaves than their no ecad counterparts. Also the above and below ground biomass of the plants in the ecad plots was higher than the no ecad plots. (ecad: 0.86g aboveground and 0.69g belowground no ecad: 0.67g aboveground and 0.66g belowground)

The lab experiment also supported the field results except that there was 100% survivorship in both treatments, most likely due to the decrease in stress on the plants in the outdoor buckets. The average change in plant height in ecad buckets was 99% and was 82% in the no ecad buckets. The ecad buckets also had higher numbers of live leaves and lower numbers of dead leaves. Also the above and below ground biomass of the plants in the ecad buckets was higher than the no ecad buckets. (ecad: 2.6g aboveground and 7.9g belowground no ecad: 1.8g aboveground and 6.2g belowground) At the end of the experiment the buckets that had ecads had a higher organic content (1.22%) in the sediment than the buckets that did not have ecads (0.78%).

It would appear overall that the ecads decrease the initial survivorship of *Spartina alterniflora* seedlings but promote the growth of the *Spartina alterniflora* seedlings that do survive.

RESEARCH OBJECTIVE: Can ecads be used in salt marsh restoration projects?

Experiment: We transplanted ecads from West End marsh, where they are naturally abundant, to Lieutenant Island and The Gut in Wellfleet where they are not currently found. Both of these marshes had large patches that had been denuded by crabs where *Spartina alterniflora* was once found. We created five 2m x 1m paired plots in each marsh along the edge of the denuded area so that a portion of the plot was in the healthy *Spartina alterniflora* and a portion of the plot was in the denuded area (Fig. 17A,B). In each paired plot one plot was filled in with ecads as the experimental treatment and the other was left blank as the control. In each plot the number of *Spartina Alterniflora* stalks was counted and the number of plants that showed evidence of grazing was counted. At the end of the experiment (2 months) the same factors were accounted for in addition to counting the number of new stalks of *Spartina alterniflora* (plants under 10cm)


A.


B.

Fig.17. Salt marsh restoration experiment using (A) ecads in the experimental plots and (B) no ecads in the control plots.

Results:

The initial results from this experiment indicate that the ecads seemed to have no effect on the growth of *Spartina alterniflora* nor did they deter grazing by *Sesarma reticulatum*. In Lieutenant Island the average increase in *Spartina alterniflora* was 165% in the control plots and 152% in the experimental plots. The average number of grazed plants in each treatment at Lieutenant Island was 15 plants. The average number of new plants in the control plots at this site was 31 and the average number of new plants in the experimental plots was 24.

At the Gut the same results were found. The average increase in *Spartina alterniflora* in the control plots was 38% and the increase in the experimental plots was 40%. The average number of grazed plants in the control treatment was 36 and was 37 for the experimental treatment. The average number of new plants for both treatments was 51.

In both Lieutenant Island and The Gut the increase in *Spartina alterniflora* plants, the grazing pressure from the crabs, and the new growth of *Spartina alterniflora* from the beginning of the experiment to the end was not significantly different between treatments. However, it is interesting to note the differences between sites in that there was a larger increase in *Spartina alterniflora* at Lieutenant Island and a higher grazing pressure at The Gut.

FUTURE STUDIES:

Although much was accomplished this summer through this research project there are always more questions left at the end of a project than there are at the beginning. We would like to continue examining why ecads are found in certain marshes and not others on Cape Cod and throughout the region. We are also interested in where ecads are found within these marshes (what zone are they found in? What marsh plants are they primarily found entangled in?). Also, how are these ecads initially colonizing these salt marshes? It would also be interesting to continue examining the effect of ecads on creek bank erosion and stablilty.

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Hatches Harbor

West End