Apr 20th, 2:00 PM - 3:00 PM

Restoration Efforts at Stratford Point: The Development of a Living Shoreline

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Abstract

Coastal areas provide a variety of ecosystem services such as wave attenuation, wind breaking, and serving as habitat for a number of species (Davis et al. 2015). However, many of these areas have been degraded and destabilized due to human activity. Rising sea levels and increases in storm frequency and intensity threaten many regions, and have the potential to cause a substantial amount of property damage. Methods such as the installation of sea walls can alleviate some of these concerns, but they do not provide all the benefits that a natural shoreline can. Living shorelines, which refer to green and environmentally friendly infrastructure techniques, may serve as a better alternative due to their proven benefits ((Buccino et al. 2013). This paper examines the methods utilized to create a living shoreline and its impacts on habitat formation at Stratford Point. We found that *Spartina alternoflora* seagrasses were able to successfully grow and help establish a low marsh. Reef Balls were found to serve as habitat for oysters, and also did not appear to impact the spawning of Horseshoe Crabs. The methods utilized here serve as a model for future restoration efforts and showcase the positive impacts a Living Shoreline can have on coastal stability.

Introduction

Costal ecosystems have become a growing area of concern in recent years. Studies have examined the consistent rise in sea levels over a long period of time, and there is evidence that this rate appears to be accelerating (Church et al. 2011). This rise threatens the habitat of many species, such as Horseshoe Crabs (*Limulus*

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polyphemus). Costal areas play a large role in combatting these rising sea levels (Potouroglou et al. 2017). However, the stability of these coastal ecosystems is being threatened as well. Many reefs, which perform functions such as attenuating waves, trapping sediment, and altering water flow patterns have been degraded or removed completely in recent years (La Peyre et al. 2015). In some areas, such as Italy, Spain, and Japan, submerged breakwaters and seawalls have been used for erosion control (Buccino et al. 2013). This may have negative effects on habitat for certain species, as Horseshoe Crabs spawn on sandy beaches during their mating season.

An alternative solution to this issue lies in the utilization of Living Shorelines, which refers to native vegetation and offshore structures to stabilize the shoreline (Davis et al. 2015). Their ability to perform services such as wave attenuation, erosion control, and carbon sequestration has been studied and quantified (Davis et al. 2015). Oyster reefs were found to reduce marsh retreat by an average of 1 meter per year in coastal Louisiana (La Peyre et al. 2015). A study performed by Potouroglou et al. found an average difference in elevation rates of 31 mm per year between areas with seagrasses and those without (Potouroglou et al. 2017). As an alternative to these reefs, Reef Balls may provide some of the same benefits. These Reef Balls are hemispherical concrete units that help to abate wave energy and stabilize shorelines (Buccino et al. 2013). They are considered environmentally friendly, and help to attract marine life (Buccino et al. 2013). It's also worth noting

that the combined effects of several natural structures may be greater than their individual contributions (Guannel et al. 2016).

The research performed for the present study was done at Stratford Point, Connecticut located near the mouth of the Housatonic River. This site was home to the Remington Arms Gun club from 1926 to 1986 (The Connecticut Audubon Society). The operation of a trap and skeet range lead to the accumulation of lead shot in both the intertidal and upland portions of the site (The Connecticut Audubon Society). Although much of the shot was removed between 2000 and 2001, this distributed the native marsh vegetation present, leading to erosion and shoreline instability (The Connecticut Audubon Society). In order to address these issues, 64 Reef Balls were installed in May of 2014, followed by an additional 273 in November of 2016. *Spartina alterniflora* cordgrass plugs were planted in July of 2015 and April of 2017. Restoration efforts also included the placement of oyster shells, gravel cobble, and sand/organic material. The success of these interventions was evaluated by examining sediment deposition, wave attenuation, cordgrass growth, and oyster recruitment on the Reef Balls. The impact on Horseshoe Crab spawning was also analyzed. Based on the data collected, the restoration efforts utilized at this site provide evidence that this approach is an effective way to stabilize coastal areas.

Methods

Restoration Efforts

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64 Reef Balls were placed in the intertidal zone in May of 2014 to serve as a pilot study. They were found to be successful in terms of wave abatement and sediment deposition. Due to this success, another 273 Reef Balls were placed in November of 2016. In an attempt to restore the marsh, 3,000 smooth cordgrass (*Spartina alterniflora*) plugs were planed in July of 2015. Another 15,000 plugs were planted in April of 2017.

Seagrass Measurements

Spartina alterniflora were measured by running three 60 meter transects parallel to the shore. They were done in the low, middle, and high intertidal zones. A 0.25 meter^2 quadrat was placed at ten evenly spaced locations along each transect. The number of stems within each quadrat was then counted. In addition, the height of the five tallest shoots within each quadrat was measured. The mean stem height of these was then calculated. This was performed at a reference marsh in Milford, CT, an area at Stratford Point that was planted in 2014, an area at Stratford Point that was planted in 2017, and a naturally recolonizing area of *Spartina alterniflora* at Stratford Point. However, since this recolonizing area was more narrow than the other areas, only one 20 meter transect was used. Data was collected from ten evenly spaced 0.25 meter^2 quadrats.

Horseshoe Crab Spawning

In order to collect data on Horseshoe Crabs, surveys were conducted from May through June from the years 2012 to 2017. The surveys were conducted during full

and new moons at night, at high tide at Stratford Point. A three-meter transect line was walked in the intertidal zone from the edge of the tide into the water. The number of Horseshoe Crabs that fell into each measured area was recorded, as well as the total distance surveyed. The total area measured was multiplied by the total number of surveys performed to calculate the total number of meters^2 surveyed in that year. The total number of female Horseshoe Crabs found in that year was then divided by the total number of meters^2 surveyed in the same year to determine the number of spawning females per meter^2 surveyed per year. This allows us to account for the different amount of surveys performed in certain years.

Oyster Measurements

The number of oysters found on all of the Reef Balls was recorded for 2014, 2016, and 2017. Sizes were all measured for 129 random individuals.

Results

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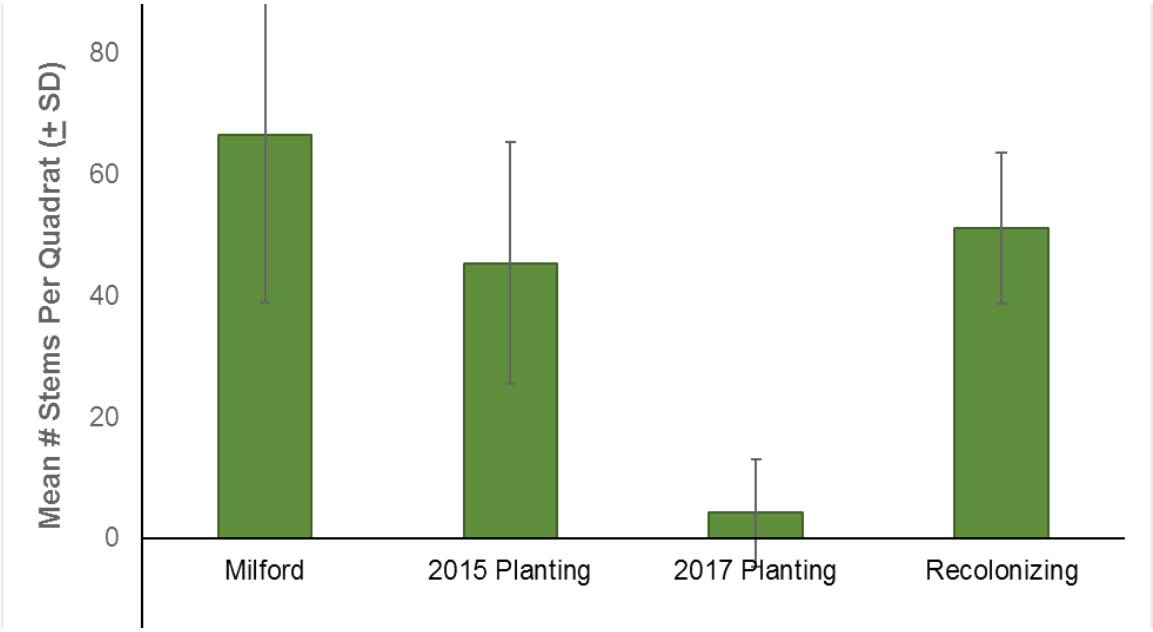

Figure 1. Mean density of *Spartina alterniflora* stems per quadrat ± SD at Milford reference site, two plantings at Stratford Point, and a naturally recolonizing area at Stratford Point during the summer of 2017. Source: Dr. Jennifer Mattei.

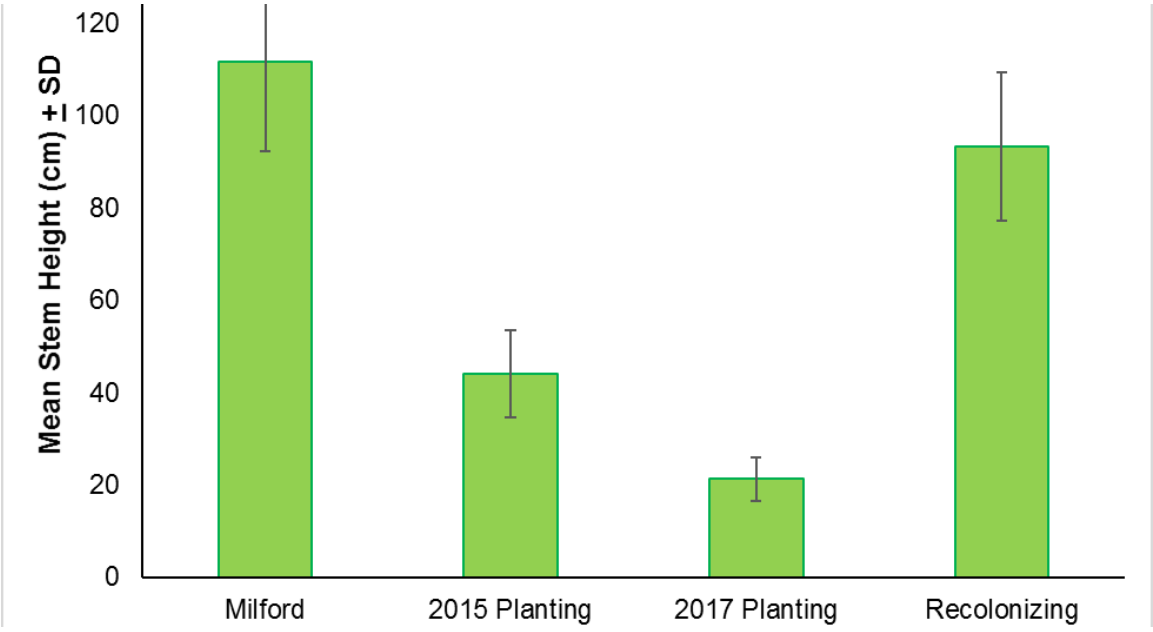

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Figure 2. Mean stem height of *Spartina alterniflora* (cm± SD) at Milford reference site, two plantings at Stratford Point, and a naturally recolonizing area at Stratford Point during the summer of 2017. Source: Dr. Jennifer Mattei.

Figures 1 and **2** show *Spartina alterniflora* growth in terms of the mean number of stems per quadrant and average height of the five tallest stems in each quadrant. Both figures report similar results in terms of the differences between each site. Milford and the recolonizing area have had more time to grow than either planting, and so it is reasonable that they are more developed.

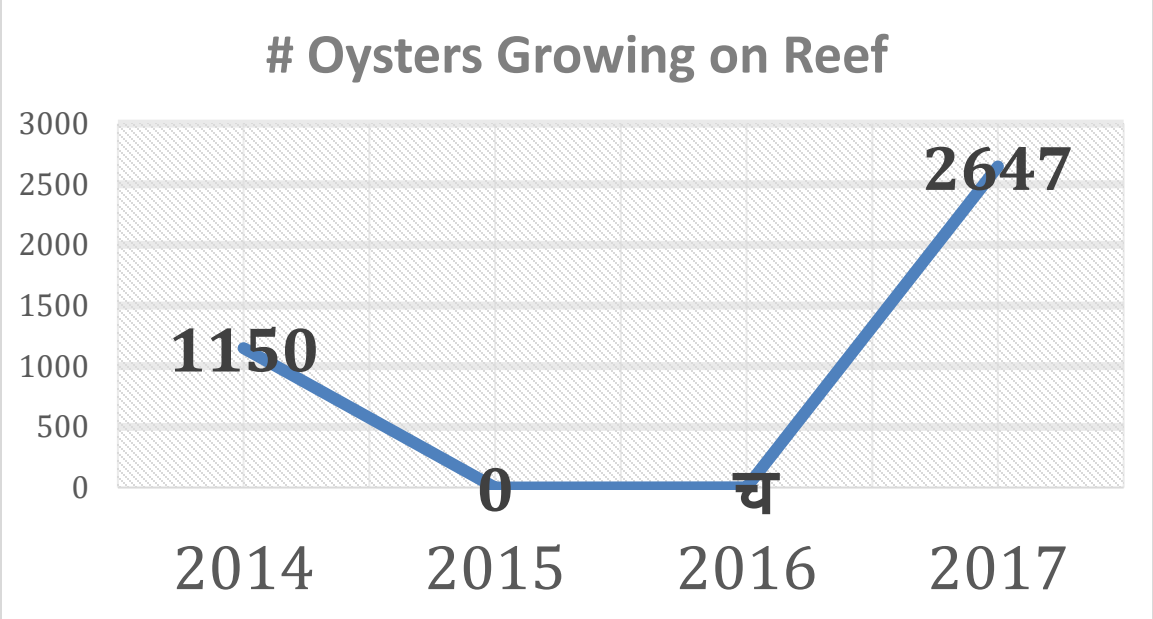

Figure 3. Total number of oysters growing on the reef in a particular year. Data was not collected for 2016. Source: Dr. Jennifer Mattei

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Figure 3 shows that total number of oysters growing on the Reef Balls. Data was only collected from the original reef from the pilot study in 2014, as those installed in 2016 had not had enough time to recruit these species. No oysters were found in 2015, due to severe cold during the winter. A survey was not conducted in 2016, however 2,647 individuals were found in 2017. **Figure 4** displays the length in mm of 129 random oysters. The average of these was 45 mm.

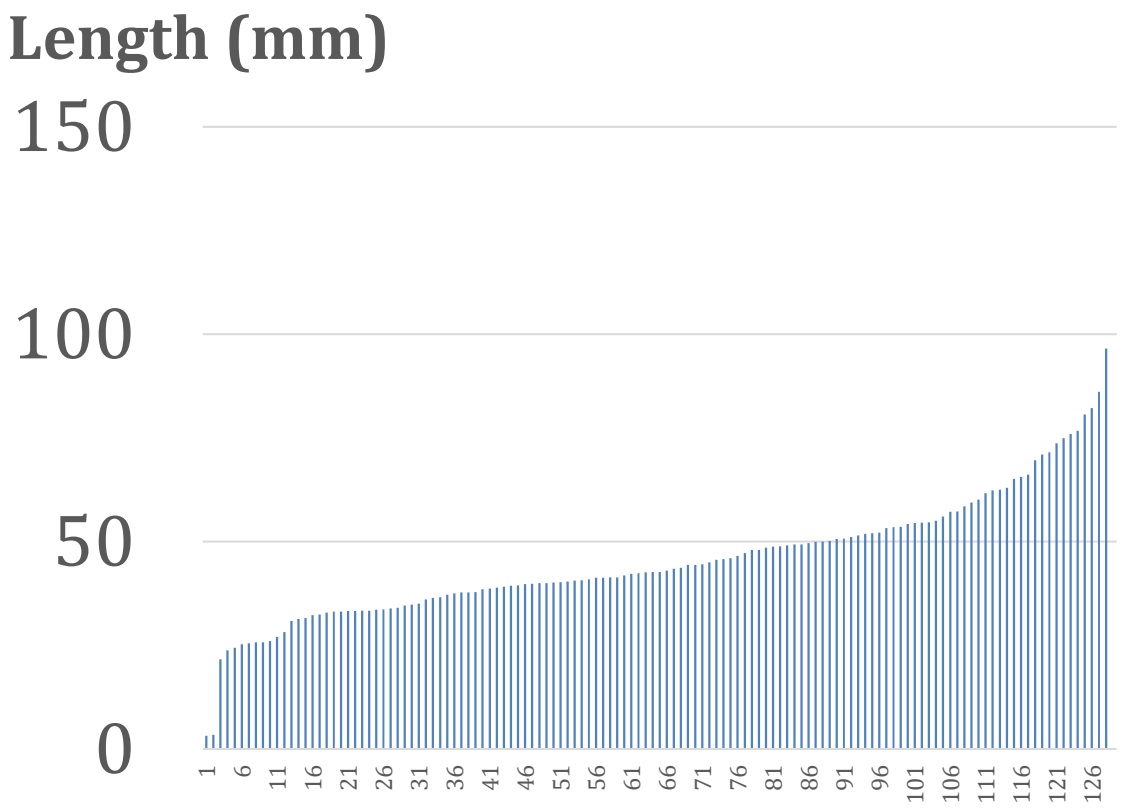

Figure 4. Oyster size range in mm of 129 randomly selected individuals. Average = 45 mm.

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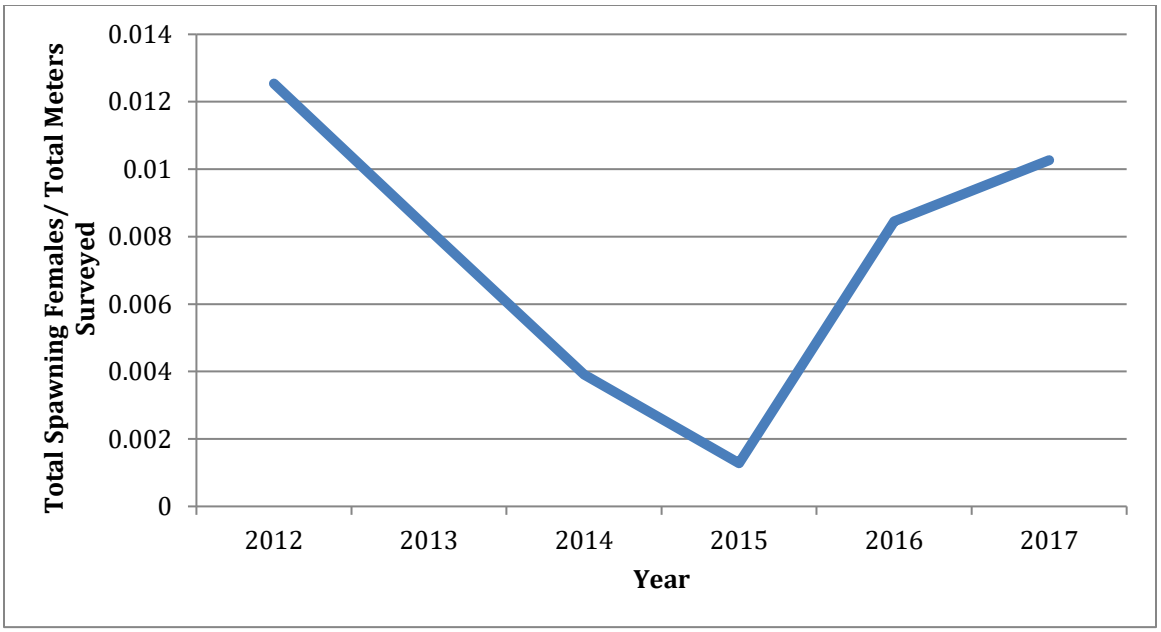

Figure 5. Total number of spawning females found per total meters surveyed for the years 2012 through 2017.

In **Figure 5**, the number of spawning females found per total meters surveyed is displayed for each year. There was a steady decline present until 2015, until the number has climbed since.

Discussion

Based on these results, the restoration methods utilized here do appear to be successful in stabilizing the shoreline and providing for habitat. Previous research at Stratford Point had found that wave intensity could be declined by around 30% due to the Reef Balls. In addition, over 30 cm of sediment was deposited behind the reef over the course of three years. The data presented here adds to the evidence that the Living Shoreline being constructed is highly beneficial to the coastline.

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The data suggests that the marsh is becoming more established as time goes by. As shown in **Figures 1** and **2**, the 2015 plantings have more stems per quadrant as well as taller stems within those same quadrants compared to the 2017 plantings. Given that they were the same size at the time of planting, this provides evidence that they are effectively progressing. Both the Milford and recolonizing area at Stratford are higher than our plantings, however this was expected based on the amount of time each area had to grow. We predict that our plantings should continue to fill in and reach levels similar to the Milford model site. This may take years to occur, but this data suggests that they are progressing towards recovery.

In terms of oyster growth, the Reef Balls do seem to be providing habitat for a good number of individuals. As shown in **Figure 3**, 1,150 oysters were found in 2014. However, due to the winter of 2015 being one of the coldest in Connecticut's history, a layer of ice developed and covered the Reef Balls. This resulted in no oysters surviving. No data was recovered for 2016, as it was believed there wouldn't be anything to report on. A survey was conducted in 2017, which determined there to be 2,647 oysters on the reef. **Figure 4** shows the length of a sample of 129 of these oysters, with the average size being 45 mm. As time progresses we should see the total number of oysters and their size increase. This would allow the reef to be more beneficial in terms of the services it provides, and so it should be interesting to see how this develops in the future.

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Although the Reef Balls did prove to be successful in serving as habitat, we also wanted to evaluate if they would have any negative effect on Horseshoe Crab spawning. Given that they mate and lay eggs in the intertidal zone, it was important to evaluate if these Reef Balls would impact this process. In **Figure 5**, the number of spawning females per meter surveyed appeared to decrees from 2012 to 2015. This may be evidence that the site was not ideal prior to our restoration efforts. Although it's just a correlation, the numbers did improve from 2015 until our latest surveys in 2017, possibly due to our restoration efforts having positive impacts. Even if the two aren't related, it was important to establish that our efforts are not negatively affecting their spawning numbers. Another area of concern was the possibility of Horseshoe Crabs going through the top of the Reef Balls and being trapped inside. Only two individuals were found throughout all of 2016 and 2017, indicating that this is a rather rare occurrence. Both of these areas need to be continued to be measured, in order to ensure that these methods are safe for a vital species.

In terms of future directions, the impacts evaluated in this and other studies need to continue to be measured. Although these restoration efforts have been proven to be effective in providing various ecosystem services, the extent of their impact should be quantified as time progresses. This will be useful in showing just how great an impact these methods can have, which may inform others in how to best combat problems just as sea level rise and destabilization of the coastline. Even though we have all ready seen positive results, this is a long-term project whose benefit may not be as apparent until more time passes. These methods may also have a

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synergistic effect, in that each component reinforces and supports the other so the total impact is greater than the sum of their parts.

Additional restoration techniques are currently being implemented and planned for the future as well. Although the effects of the low marsh were addressed in this study, other components of a natural coastline include the high marsh, dune systems, and upland tree and shrub habitat. Trees such as oaks, cedars, and pines have been planted upland of the marsh, as they usually serve the purpose of breaking wind and promoting biodiversity. This includes 35 species of trees and shrubs and around 800 individual woody plants. Given that these were relatively small at the time of planting during 2016 and 2017, it should take some time before their impact can be evaluated. A pollinator meadow has also been planted that includes 50 species of native wildflowers and grasses. This also serves to promote biodiversity and recruit a large number of pollinators. In order to establish a marsh sill, 4,240 bushels of oyster shells have been placed behind the Reef Balls. 45 cubic yards of common slipper shell (*Crepidula fornicate*) were also placed in order to extend the marsh sill. 12 inches of gravel cobble fill were placed behind the sill, and 6 inches of sand and organic material were placed on top. These efforts served to create a suitable elevation and act as a planting bench for salt-meadow cordgrass in the upper intertidal zone.

In terms of what is being planned, more sand and organic material will be placed behind the marsh sill to finish the establishment of the planting bench. Large woody

debris and root wads will be keyed into the planting bench to serve as the artificial wrack. More slipper shells and oyster clutch mix will be placed in areas that have been eroded during winter storms. Salt-meadow cordgrass (*Spartina patens*) will be planted between the sill and edge of the dune. In addition, more sand and organic material will be placed on the current coastal dune. This will then be planted with native plant species. These methods will be evaluated for effectiveness in the future, and the hope is that they will help to restore the high marsh and dune aspects of the coastline. This project is clearly trying to address all the natural components of a coast that allow it to provide its ecosystem services. We hope that the methods outlined here will serve as a model for future restoration efforts, especially given the growing concern over coastline stability. This would allow for the promotion of biodiversity, as well as protect valuable property and infrastructure along coastal regions.

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