

**Live Oak Point Living Shorelines ILF Project**  
**Monitoring Plan**  
**29 June 2020**

Annual quantitative monitoring will be conducted by NFWFMD staff and/or qualified environmental consultants until site release or as directed by USACE permit conditions. Quantitative monitoring of vegetation will be conducted twice during the first year of the project (spring and fall), and then annually thereafter each fall. Qualitative monitoring and inspections of the site will continue for the life of the ILF program. Reports will be submitted electronically to the USACE and posted at the NFWFMD website ([www.nfwfwater.com](http://www.nfwfwater.com)).

**Background on “Soft” Shoreline Enhancement**

Increasing shoreline loss and sea level rise has increased the global demand to protect coastal systems and saltmarshes (Gittman et al., 2016). In contrast to natural shorelines, hardened structures do not absorb wave energy (O’Connell, 2010) and alter sediment transport (Nordstrom et al., 2009). Hardened structures inhibit natural process and negatively impact the surrounding ecosystem (Gerber-Williams 2017). They also replace native vegetation and associated habitat, removing important food webs and habitat for fish and invertebrate species (Gittman et al., 2015; Gittman et al., 2016; Lawless & Seitz, 2014). Alternatively, hybrid shoreline stabilization methods, referred to as “living shorelines,” use a mix native vegetation, hard structure, such as oyster shell limerock, and natural organic materials such as coconut fiber mats or coir logs, that do not sever the connection between the aquatic and terrestrial environment (Gerber-Williams 2017; Sutton-Grier et al., 2015). These “soft” designs absorb wave energy which hardened shorelines do not and allow the deposition of organic and inorganic sediment as well as providing a substrate for vegetation to thrive. Wave reducing vegetation enhances the protected shoreline and restores natural processes (Craft and Sacco, 2003). In addition, it has been demonstrated that breakwater vegetation generates belowground biomass and enhances marsh bank stabilization (Bilkovic & Roggero, 2008).

**Reference Wetlands Site**

The success of the saltmarsh restoration will be evaluated in relationship to a reference saltmarsh occurring on NFWFMD-owned lands at Live Oak Point approximately 3,000 FT southwest of the Living Shorelines project area (Figure 1). The reference site has similar geomorphology, tidal range, elevations, and vegetation community structure relative to the project area and will be used to guide the development of restoration targets and measurable performance standards.

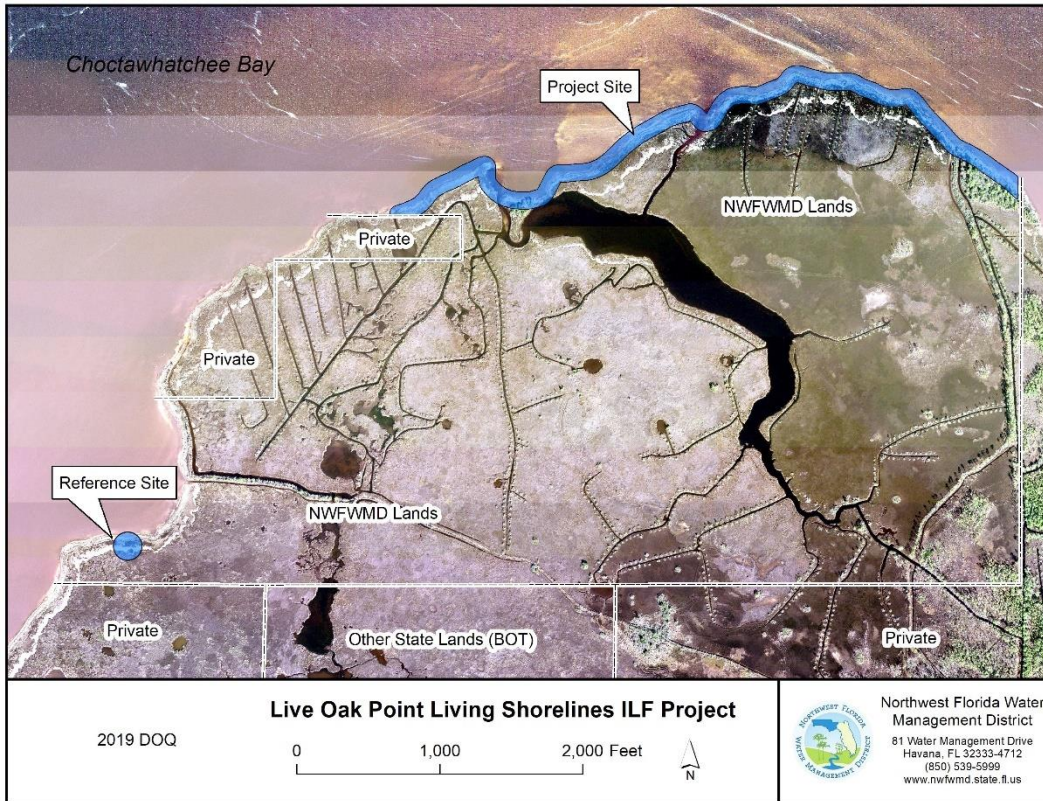


Figure 1. Reference Wetlands Site in Relation to Project Area

## Vegetation Monitoring

Performance standards will be established to measure project success and guide credit releases.

### Vegetation Performance Standards:

- Nuisance vegetation  $\leq$  5% cover per acre.
- Exotic vegetation  $\leq$  1% cover per acre.
- Monitoring protocols necessary to ensure effective preservation, enhancement, restoration, and management will be conducted annually for a minimum of five years from the start of mitigation activities. Quantitative monitoring of vegetation will be conducted twice (spring and fall) during the first year of project implementation, and thereafter in the fall of each year. Monitoring will be performed by NFWFMD staff or qualified consulting firms. Annual reports will be generated, sent to the USACE and posted at [www.nfwwater.com](http://www.nfwwater.com) (or any successor website).
- Panoramic photo points will be established within the reference and restoration sites (Figure 2).

Quantitative vegetation transects will be established that extend from the landward toe of the breakwater into the high marsh and will generally cover three vegetation zones: low marsh dominated by smooth cordgrass (*Spartina alterniflora*), the mid-marsh dominated by saltmarsh cordgrass (*Spartina patens*), and the high marsh dominated by black needle rush (*Juncus roemerianus*). Transects will be established in both the reference site and the restoration site. Because the low marsh, mid-marsh, and high marsh zones are of variable width, nested quadrats within each zone will be utilized. Quantitative monitoring will consist of three transects within the reference site and six transects within the restoration project site.

Transects will be marked at each end with PVC or metal t-posts. Four nested 0.5-meter square quadrats will be randomly placed within each of the low marsh, mid-marsh and high marsh zones associated with each transect (Figure 3). Data recorded in each quadrat will consist of visually estimated percent cover of each plant species, including individuals rooted in the quadrat as well as overhanging. Bare ground will be estimated in each quadrat as a percentage of ground not obscured by plant cover or large woody debris. Qualitative monitoring will consist of recording the species and vegetation structure observed along meandering pedestrian transects through each of the three vegetation zones (i.e., low marsh, mid-marsh, and high marsh).

At establishment, the restoration site will meet or exceed 45% cover of the low marsh, mid-marsh, and high marsh vegetation with respect to the reference site. At year one, the restoration site will meet or exceed 55% cover of the reference site. At year two, the restoration site will meet or exceed 65% percent of the reference saltmarsh. At year three, the restoration site will meet or exceed 75% of the reference site. By year four, the restoration site will meet or exceed 85% of the reference site. At year five or release, the restoration site will meet or exceed 95% of the reference site.

Vegetation species coverage statistics will be recorded. The percent coverage for each species will be generated by adding all quadrat observations separately for the low, mid-marsh and high marsh. The vegetation cover will be summed within each zone separately and divided by the total cover for each species. This represents a modified Daubenmire cover scale where vegetation species statistics are used to determine the percent cover by species.

A similarity index will be used to compare the reference and restored saltmarshes annually

$Sim = \frac{2 \sum nc}{\sum n1 + \sum n2}$	<p><u>Where:</u>  <i>nc</i> = number of common species between sites  <i>this number is the lowest value among the compared sites</i>  <i>n1</i> = number of individuals of site 1  <i>n2</i> = number of individuals of site 2</p>
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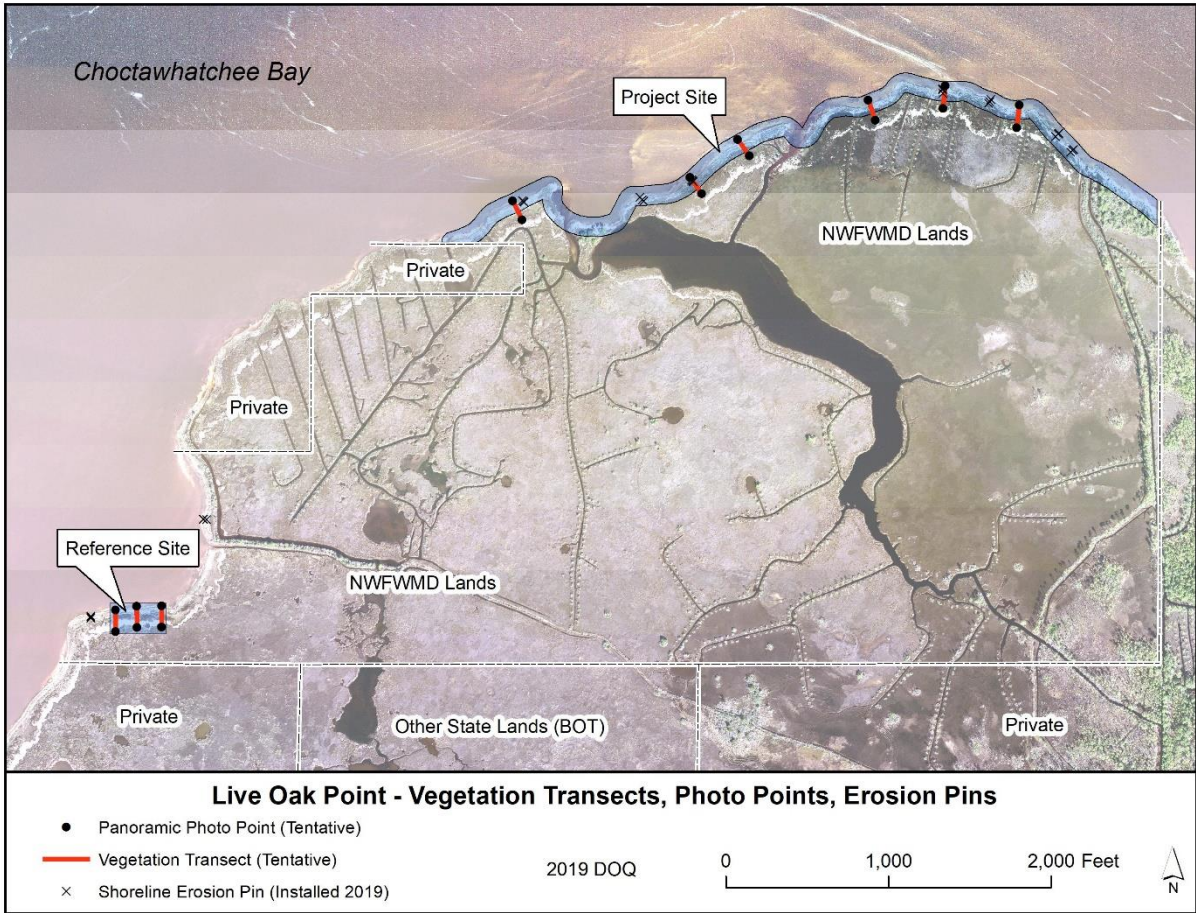


Figure 2. Vegetation Transects, Panoramic Photo Points, Shoreline Erosion Pins

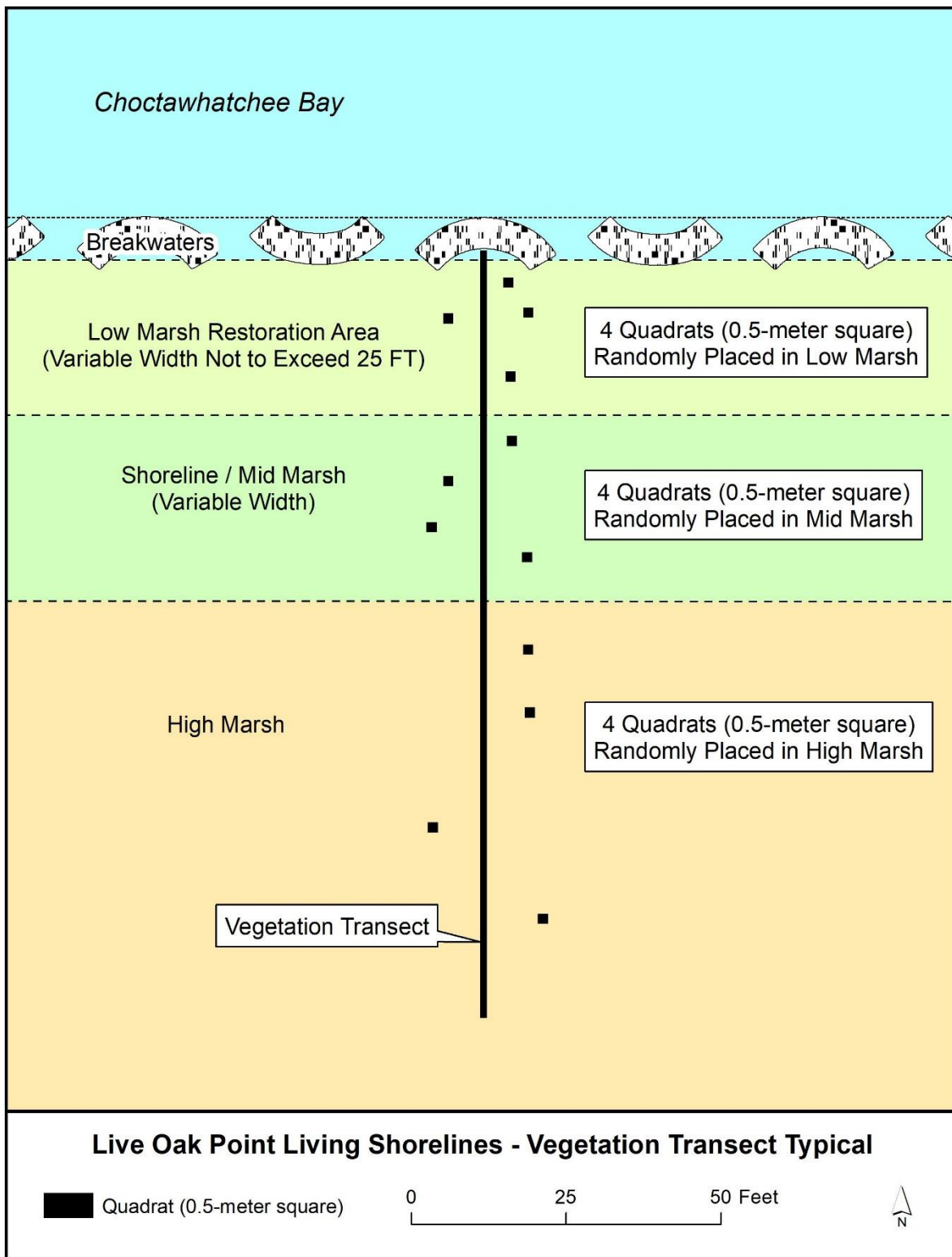


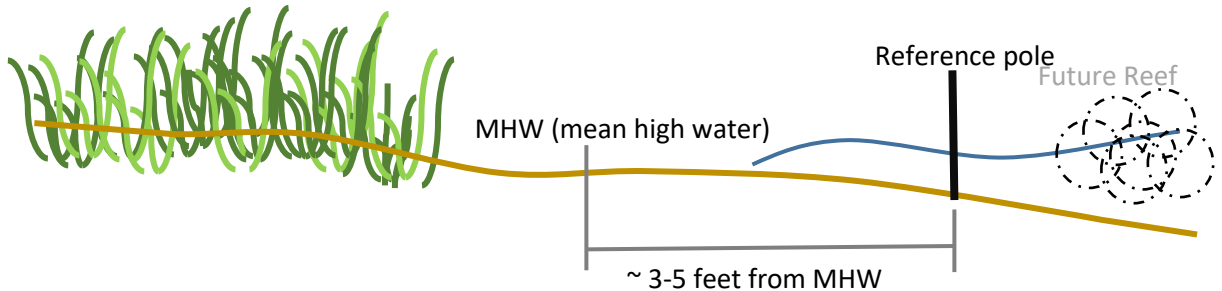
Figure 3. Quantitative Vegetation Transect Sample Design (Typical)

## Oyster Monitoring Protocol

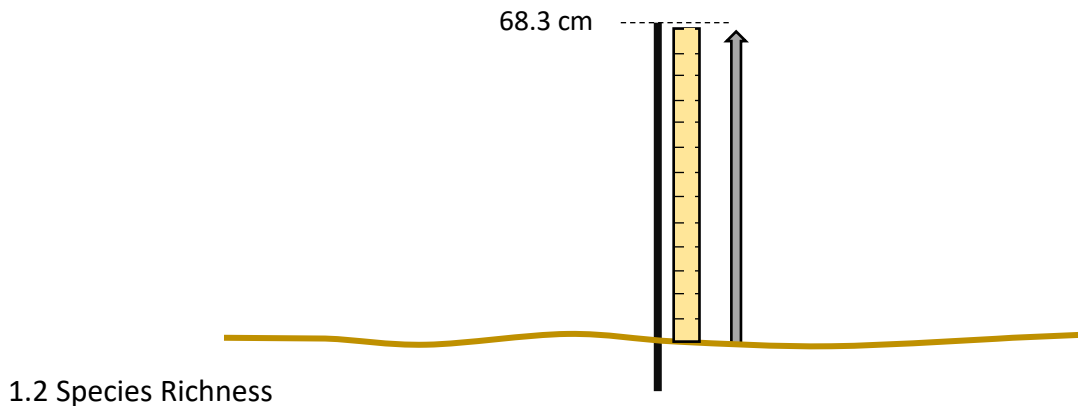
Established oyster reefs provide shoreline protection and stability, promote native oysters' growth and reproduction, improve water quality, and enhance habitat for species of the Choctawhatchee Bay and Gulf of Mexico. The success of oyster reefs is assessed through monitoring procedures that measure sediment accretion/erosion, number and size range of live oysters, species diversity and water quality variables.

### 1. Pre-Construction Monitoring 1.1 Shoreline Sediment Height

Prior to reef construction, multiple PVC or rebar poles are placed roughly 3 to 5 feet water-ward of the mean high water, approximately just behind the future footprint of a reef sections. Depending on projected total reef length, 2-4 poles may be spaced out along the length of the shoreline. The reference poles are used as a baseline sediment height assessment measuring tool for pre-construction and reef sites.



Using a metric measuring tape, measuring from the top of the sediment to the top of the reference pole, to the nearest 0.1 centimeter.



### 1.2 Species Richness

A seine net is used to capture fish species diversity prior to reef construction

- I. Siene two times at each reference pole, if applicable seine in front of and behind reef footprint

II. Identify fish species and record number of species caught.

Fish Species (Example)	Total (Example)
Silverside	10
Croaker	5

1.3 Water Quality

A Hydrolab Datasonde will be used during annual monitoring to record hydrologic conditions near reef locations at approximately a 0.5-meter depth.

I. Use Hydrolab datasonde to record water quality variables: temperature, specific conductivity, dissolved oxygen, pH, depth, salinity, dissolved oxygen percent saturation, and turbidity at approximately 0.5-meter depth.

Water Quality Variable	Sample Values
Temperature (°F)	82.0
Specific Conductivity (mS/cm)	25.5
Dissolved Oxygen (mg/L)	7.35
pH	7.10
Depth (Feet)	1.0
Salinity (PPS/PPT)	20.23
Dissolved Oxygen Saturation (%)	75.5
Turbidity (NTU)	0.0

2. Post-Construction Oyster Reef Monitoring

2.1 Reef Height and Slope

To calculate reef height, using string and a string (line) level, run the string straight out from the highest point on reef a stadia rod or marked PVC pipe positioned at the reef perimeter. Place the string level on the line and adjust the vertical position of the string until level. Measure the height of the reef by measuring the distance from the string to the base of the pole.

## 2.2 Oyster Recruitment and Size Range

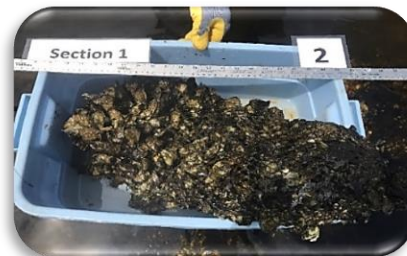
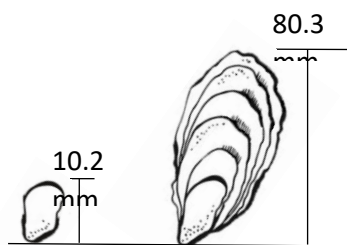
The total number of live oysters will be measured by averaging five 0.5-meter square quadrats placed at random along the oyster reef to estimate the total number of oysters per meter square.

Choose representative oyster sampling sites at random.

Count number of live oysters within one-square foot quadrat.



Measure the smallest and the largest hinge-lip distance of live oysters visible on bag or within quad to nearest 0.1 mm



Document oyster quadrat by taking a photo with a scale reference (meter stick) and with appropriate reef section location.

“Section 1 – PVC 2”

## 2.3 Species Diversity

Each representative quadrat will be examined for species richness. All species within five, 0.5-meter quadrats will be identified. In addition, two seine sweeps will be at each reference pole. Associated Fauna: In each 0.25 m x 0.25 m quadrat, record the total number of sessile invertebrates by taxa (barnacles, mussels, solitary and clonal ascidians, etc.) encountered in a tally for the quadrat on data sheet. From the basket, record the tally number of motile invertebrates (porcelain crabs, quahog clams, oyster drills, and other species) to the lowest taxon level possible) on data sheet. For mussels, clams, and oyster drills, record each shell length in mm in space provided on data sheet for the first ten individuals of each species. For porcelain crabs, record carapace width in mm for first 10 crabs removed from basket. Make a

special note and collect known invasive species on oyster reefs: pink barnacles, green mussels, black charru mussel (no ribs). Place invasive mussels and barnacles in alcohol and label jar by location and submit for DNA extractions.

Crown conchs and other mollusks: Within the 0.5 m X 0.5 m quadrat, record the total number of crown conch shells visible on data sheet. For each individual, record the shell length from tip to maximum extent of the aperture in mm using digital calipers. Additionally, record if shell contains a conch, hermit crab or appears to be empty on data sheet. Collect the same data for any other large mollusks in quadrat (tulip shells, horse conch, whelks, etc.). Note the number of egg cases for mollusks within each quadrat on data sheet.

Species will be identified and recorded on a data sheet for each sampling location.

Example Table

Flora/Fauna	Section 1				Reef Section #
	PVC 1	PVC 2	PVC 3	PVC 4	Reference
Barnacles	✓				
Algae					
Bryozoans					
Crabs					
Isopods	✓				
Amphipods	✓				
Shrimp					
Mussels					
Gastropods (Snails)					
Annelids (worms)	✓				
Other:	Gobi and toadfish				

## Benthic Monitoring

Adapted from Gerber-Williams 2017

Rader et al. (1984) determined that the greatest benthic diversity occurred within the culms of *S. alterniflora*. The mid-marsh dominated by *S. patens* had fewer benthic organisms compared to the areas dominated by *S. alterniflora* (Rader 1984). Bare sediments just off the shoreline had the fewest benthic organisms due to constant disturbance (Rader 1984). A sediment core (6.5 cm diameter, 14 cm long) will be used to determine species abundance and biomass. Cores will be collected in late summer haphazardly within 50 cm either side of replicate four meter-long transects (perpendicular to the shoreline) at zero meters (edge of shoreline), two meters, and four meters. Each sample will be washed over a 250  $\mu\text{m}$  mesh sieve in the field. All material retained on the screen will be stored in a labeled plastic 0.5 L container and preserved with 70% isopropyl alcohol and 30% water with rose Bengal added. Organisms will be removed from the sediment under a stereomicroscope to the lowest practical taxonomic level. Total density (individuals / m<sup>2</sup>) and biomass (g / m<sup>2</sup>) were calculated as the mean of the two replicate cores collected within each treatment (site) (n = 6 / site) for the breakwater sites and two within the reference site. Shannon-Weiner Diversity Index ( $H' = -\sum [p_i \times \ln(p_i)]$ ) where  $p_i$  is the proportion of total sample represented by species  $i$ ) and species richness (S) was calculated for each core.

Species collected will be placed into feeding guilds (filter feeder, deposit feeder, scavenger, omnivore, carnivore, and herbivore). Mean abundance within guilds at each of the site will be used to determine differences between breakwater and reference benthic community.

## Sediment Accretion Monitoring

Compared to a mud flat, more than 80% of wave attenuation was ascribed to the presence of vegetation (Yang et al. 2012). Sediment accretion rates vary greatly depending on vegetation type and where they are sampled. *Spartina alterniflora* has been observed to trap the greatest amount of sediment compared to other species Li and Yang 2009 and can trap greater than 10% sediment observed annually. Low marshes dominated by *S. alterniflora* trap significant amounts of sediment. Within the *Spartina alterniflora* canopy, approximately 50% of the initial mean velocity and is reduced within 5 m of the canopy edge (Leonard and Croft 2006). Sediment trapping rates of the low marsh exceeded current sea level rise estimates by 1.5-1.7% (Brickerson-Orso et al. 1989). Estimates of accretion for low marsh dominated by *Spartina alterniflora* had accretion rates of 6.5 – 10.5 cm a year whereas the mid-marsh dominated by *Spartina patens* had accretion rates of 1.5 to 1.7 cm per year (Hopkins et al. 2018).

The goal of the saltmarsh restoration is to demonstrate the restored marsh is similar to a reference marsh while stabilization of the shoreline, establishing a low and mid-marsh and enhancing the high marsh. In addition, the restoration will demonstrate accretion rates greater than sea level rise. Scientific studies have monitored accretion rates in the area between the

breakwater and shoreline, just above the shoreline and within the mid-marsh and upper marsh. The area in-between the breakwater and shoreline accrete and scours. At least initially there is no vegetation within this area to trap the sediment and accretion is due to larger sized sand particles dropping out of the water column due to reduced wave action. This area had the lowest accretion rates of any of the areas sampled. The mid-marsh dominated by *Spartina patens* only intermittently receives wave action and has less ability to trap sediment while the high marsh traps the least amount of sediment of the vegetated areas (Li and Yang 2009). The low marsh trapped the greatest amount of sediment if *Spartina alterniflora* occurred (Li and Yang 2009). On average established areas with *Spartina alterniflora* can trap up to 0.6 – 10.5 cm of sediment a year depending on location and sediment type. Accretion rates will be measured in the low marsh dominated *Spartina alterniflora*.

### **Sedimentation plates**

In an evaluation of different sediment monitoring techniques, Nottle et al. (2012) determined that sediment plates were the most accurate in determining sediment accretion rates in shorelines with heavier wave action. Sediment plates will be installed at one half meter from the shoreline planted with *Spartina alterniflora* and one meter in from the reference shoreline. A total of six sediment plates will be installed within the created breakwater area and three within the reference. With the sedimentation plate method, the marker horizon consists of a perforated plate made of metal or plastic that allow natural percolation of water (Watson 2008; Stokes et al. 2010). The plate is buried in the soil just below the rooting zone under a carefully extracted block of marsh turf, which is then placed back on top of the sedimentation plate (French and Burningham 2003). Thus, vegetation disturbance is kept to a minimum. Small holes drilled into the plate reduce the influence of the plate on drainage conditions and plant rooting. The plates should be placed in a perfectly horizontal position to allow for reliable repeated measurements. After burial, the location of the plate is marked with a PVC pipe to be easily located during sampling. The plates need to settle for at least 1 month before the first measurement can be taken (Stokes et al. 2010). To measure sediment accretion, a thin metal pin is pushed into the sediment until it hits the plate, and its length above the sediment is determined.

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## Monitoring Parameters (Project Site and Reference Site)

- Vegetation transects.
  - Percent cover for each species and bare ground.
  - Percent cover of nuisance vegetation, if any.
  - Percent cover of exotic vegetation, if any.
  - Planted vegetation mortality (project site only).
  - General assessments of overall vegetation health.
- Benthic macroinvertebrate transects (species diversity and abundance).
- Utilization by faunal species.
  - Fish species richness.
  - Other faunal usage.
- Sediment accretion and/or erosion rates.
- Water quality (via Hydrolab Datasonde).
  - Temperature (°F).
  - Specific conductivity (mS/cm).
  - Dissolved oxygen (mg/L).
  - pH.
  - Water depth (FT).
  - Salinity (PPS/PPT).
  - Dissolved oxygen saturation (%).
  - Turbidity (NTU).
- Limerock breakwater.
  - Overall condition.
  - Height.
  - Width.
  - Slope.
- Oyster spat recruitment on breakwater.
- Photo monitoring.
  - Panoramic photos at established points.
  - Other photo-documentation.