

LIVE OAK POINT LIVING SHORELINES

2026 (Spring) Project and Reference Site Monitoring Report



USACE Permit No.: SAJ-2011-00287

FDEP Permit No.: 0387876-001-EI-66

Permittee: Northwest Florida Water Management District
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Entity Conducting Monitoring: Choctawhatchee Basin Alliance of Northwest Florida
(Vegetation and Benthics; All State College
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Project Location: Live Oak Point Salt Marsh
30.43° North, -86.25° West (Project Site)
30.42° North, -86.27° West (Reference Site)
Approximately 2 ½ Miles NW of Santa Rosa Beach
Walton County, Florida

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Synopsis

Live Oak Point contains the largest salt marsh system (approximately 1,000 acres) in Choctawhatchee Bay. However, its ecological integrity and long-term survival has been threatened by ongoing erosion and shoreline retreat. Analyses of historic aerials indicate that since 1941, salt marsh retreat has exceeded 300 FT along the northern edge. In situ measurements and analysis of more recent digital orthophoto quads (DOQs) show that, prior to implementation of a living shoreline (completed 2025), the rate of shoreline retreat was increasing and had averaged >4 FT per year since 2007.

The objectives of the Live Oak Point Living Shorelines (LOPLS 1) project are 1) halting loss of salt marsh habitat at Live Oak Point, 2) restoring/expanding salt marsh habitat in a narrow strip parallel to the current shoreline protected by limerock/Oyster Castle¹ breakwaters, and 3) enhancing the functional value of the interior of the existing salt marsh via improved buffers. To achieve these objectives, a living shoreline (consisting of breakwaters and supplemental plantings of appropriate marsh species) has been implemented along the northern edge of the Live Oak Point salt marsh.² Current observations strongly suggest that the living shoreline is functioning as intended and that trajectories have been established that will result in all objectives being achieved.

Construction of approximately 4,130 FT of breakwaters, with supplemental plantings of appropriate marsh species (*Spartina patens*, *Juncus roemarianus*, *Spartina alterniflora*), commenced in August 2021 and was completed in August 2025. As a component of the Northwest Florida Water Management District (NFWFMD) In-Lieu Fee (ILF) mitigation program (USACE Permit SAJ-2011-00287), the Live Oak Point Living Shorelines project is expected to generate up to 2.61 estuarine mitigation credits. Any credit generated is reserved for the sole use of the Florida Department of Transportation (FDOT).

This 2026 (Spring) Project and Reference Site Monitoring Report has been developed to comply with federal and state monitoring requirements. It is the tenth monitoring report for the reference site (monitoring commencing Fall 2021) and the sixth monitoring report for the project area (monitoring commencing Fall 2023; monitoring of the project area, as planned, commenced after substantial breakwater construction was completed). Parameters for the Spring 2026 project and reference site monitoring are vegetation cover, sediment accretion, benthic invertebrates, panoramic and general photo documentation. Vertical drone

¹ Loose limerock was used for approximately 85% of breakwater construction. "Oyster Castle" blocks (12" x 12" x 8" interlocking blocks made by the Allied Concrete Company using a proprietary mixture of concrete and crushed oyster shell that is said to facilitate oyster spat recruitment) were used in locations where submerged aquatic vegetation (SAV) prevented use of limerock (i.e., the "Oyster Castle" breakwaters have a smaller footprint than loose limerock and can be more precisely placed with less potential for disturbance to nearby SAV when compared with using loose limerock).

² The NFWFMD contracted with the Choctawhatchee Basin Alliance of Northwest Florida State College (CBA) to implement the Live Oak Point Living Shorelines project (NFWFMD Contract 21-036). Construction occurred from August 2021 to August 2025.

photography of the project site was acquired 10/28/2025. The reference site (also part of the Live Oak Point salt marsh) has similar geomorphology, tidal range, elevations, and vegetation community structure when compared with the project site (the reference site is located approximately 3,000 FT southwest of the project site).

Results of the Spring 2026 vegetation monitoring continue to indicate strong similarity between the project site and the reference site. The Sorensen's Similarity Index comparing vegetation at the project site with the reference site is 0.83 (1 = perfect similarity; 0 = no similarity). Vegetation diversity is limited at both sites (Simpson's Diversity Index at the Project Site = 0.71; Simpson's Diversity Index at the Reference Site = 0.74).³ At both the project site and reference site, the low marsh is dominated by *Spartina alterniflora*, the mid marsh is dominated by *Spartina patens*, and the high marsh is dominated by *Juncus roemerianus*. At the project site, sediment continues to accrete behind the constructed breakwaters, with *Spartina alterniflora* expanding in places. Oyster colonies have rapidly established on the breakwaters and submerged aquatic vegetation (SAV), primarily *Halodule wrightii*, has moved in behind breakwaters in multiple locations. Planted vegetation has generally done well in locations protected by limerock breakwaters and now blends in seamlessly with natural salt marsh expansion.

Benthic invertebrates were sampled in April 2026 at both the project site and the reference site. Results indicate very high similarity in feeding guilds between both sites (Sorensen's Similarity Index = 0.91), although taxa appear substantially different (Sorensen's Similarity Index = 0.31). Taxa diversity and evenness is greater at the project site compared to the reference site.⁴

All monitoring reports for the Live Oak Point Living Shorelines project site and reference site are posted at <https://nwfwater.com/Water-Resources/Regional-Wetland-Mitigation-Program/Regional-Mitigation-Plan/>.

³ A Simpson's Diversity Index of 0 = infinite diversity; a Simpson's Diversity Index of 1 = no diversity.

⁴ Shannon Diversity Index (H') for the project site is 1.88 (indicating moderate diversity of taxa), compared with 0.64 for the reference site (indicating low diversity of taxa). Pielou's Evenness Index (J') at the project site is 0.64 (indicating a semi-balanced distribution of taxa), compared with 0.25 at the reference site (indicating an unbalanced distribution of taxa). [H' at the reference site and J' at the reference site were both 0.64 and is not a reporting error.]

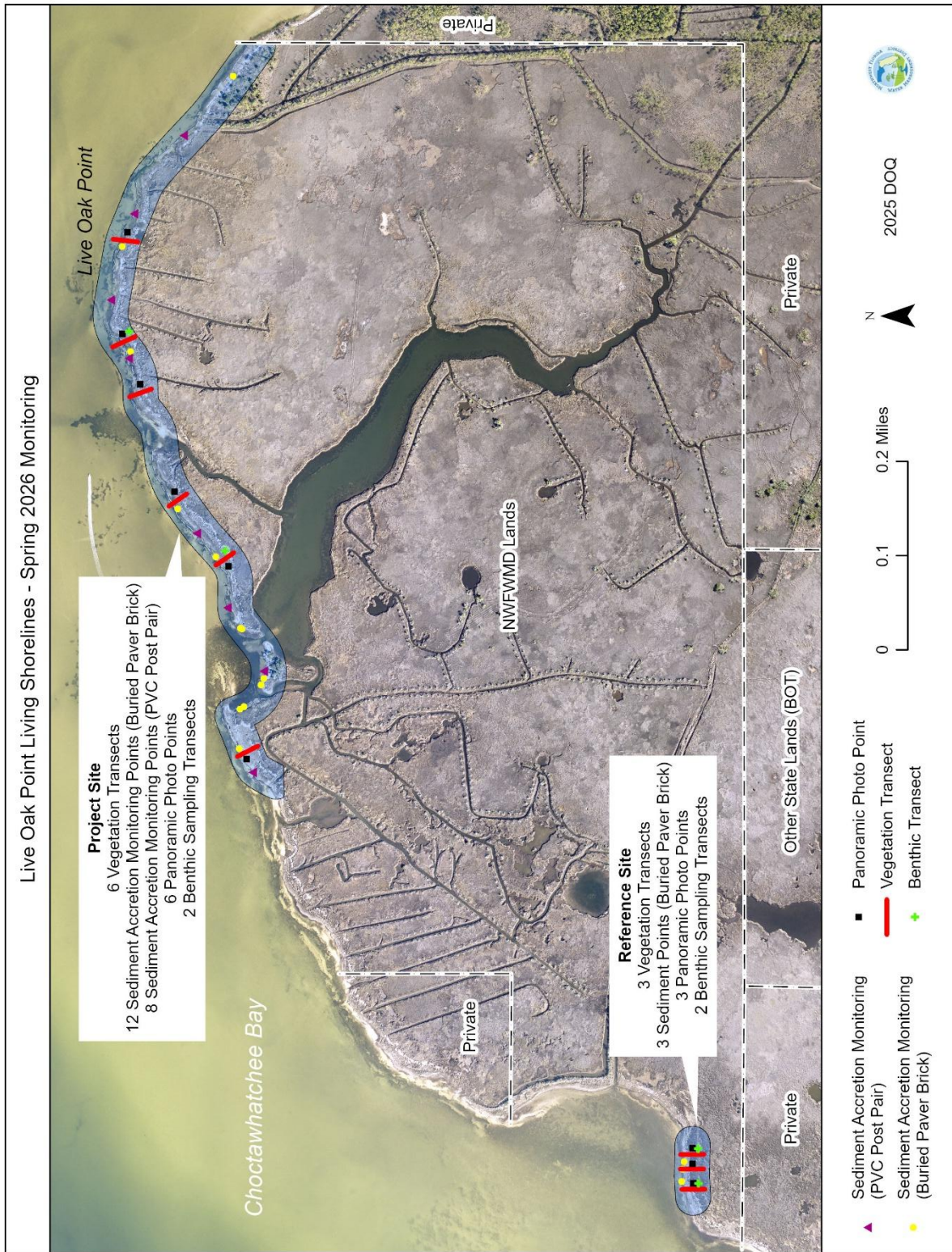


Figure 1. Spring 2026 Monitoring Overview

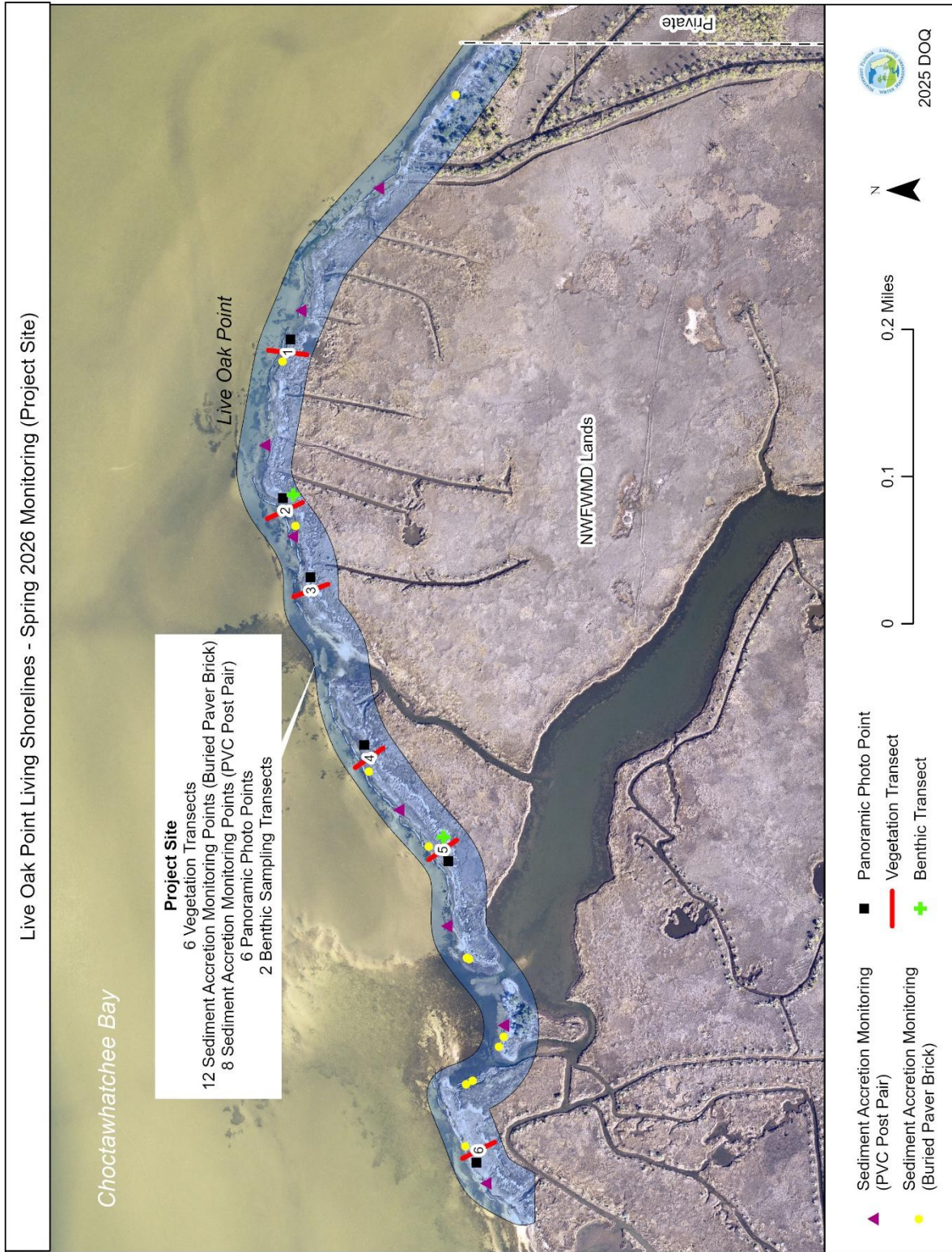


Figure 2. Spring 2026 Project Site Monitoring

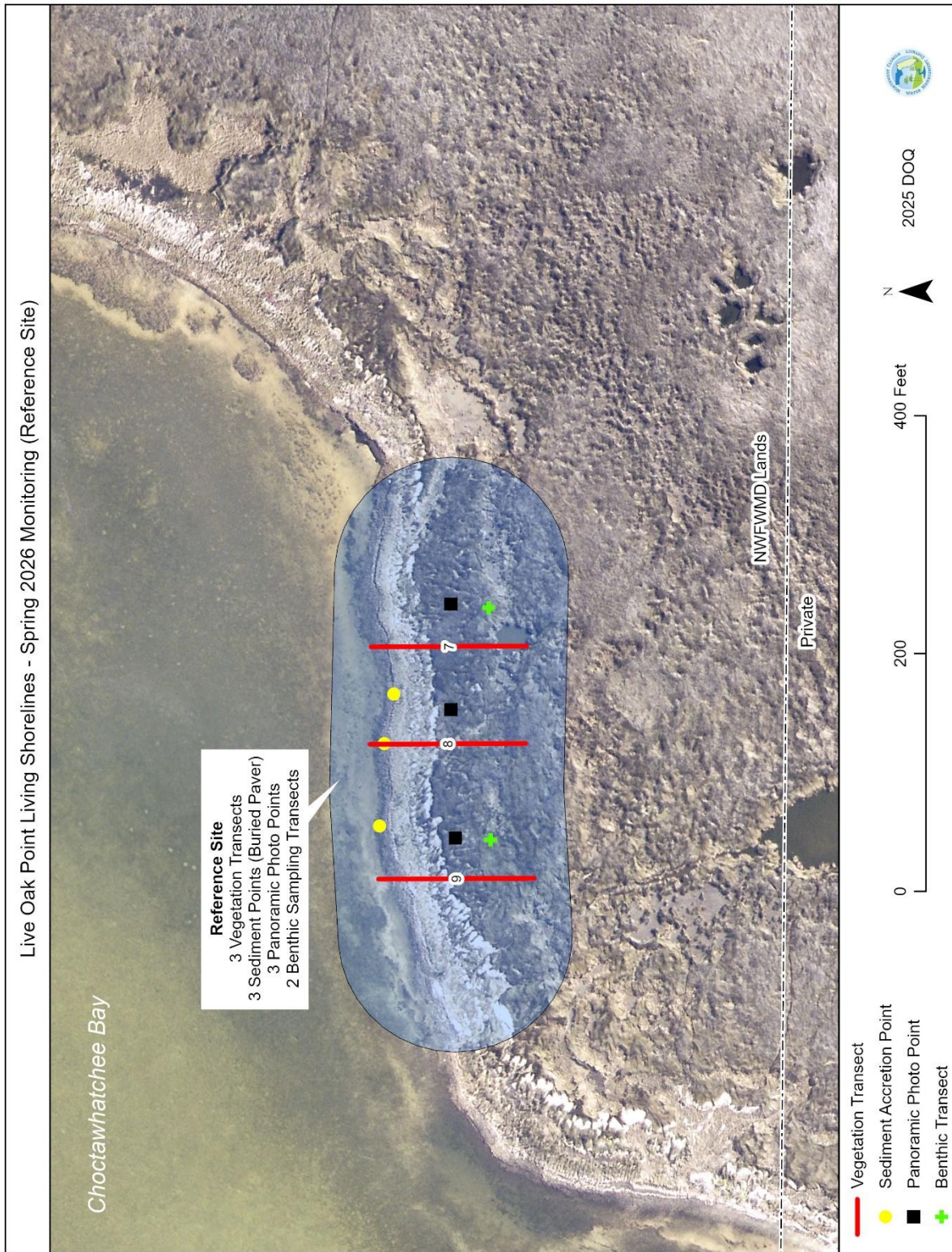


Figure 3. Spring 2026 Reference Site Monitoring

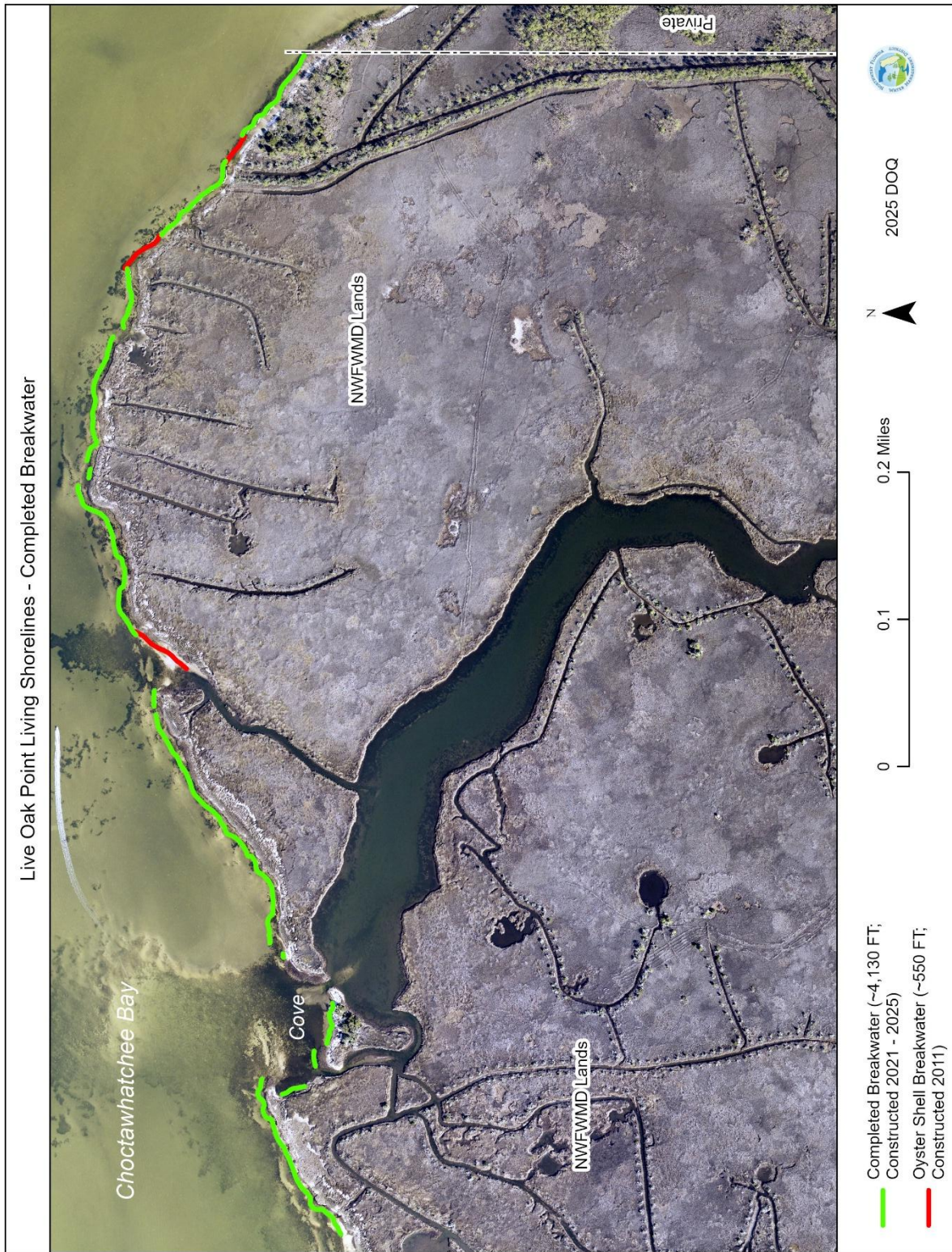


Figure 4. Completed Breakwater (Constructed 2021 – 2025)

Vegetation Monitoring

Vegetation cover at the project site and reference site was quantitatively measured on 4/27/2026 using a modified Daubenmire method.⁵ Three (3) transects of variable length previously established in the reference area and six (6) transects of variable length previously established in the project area were sampled. Each transect began in the low marsh and extended into the high marsh. Twelve (12) 0.5-meter square (0.25m²) quadrats were sampled along each transect. Four (4) quadrats were located in the low marsh, four (4) in the mid marsh, and four (4) in the high marsh. All plant species were identified in each quadrat. Percent cover of vegetation by species, bare ground, and duff layer, was visually estimated.

No exotic or invasive plants were present in any transect. Consistent with previous monitoring, data collected on 4/27/2026 indicate that, at both the project site and reference site, the low marsh is dominated by *Spartina alterniflora*, the mid marsh by *Spartina patens*, and the high marsh by *Juncus roemerianus*.

Average percent cover of live vegetation for the low marsh was 49% at the project site compared with 20% for the reference site; for the mid marsh it was 78% at the project site compared with 90% for the reference site; and for the high marsh it was 56% at the project site compared with 61% at the reference site.

Table 1. Percent Cover of Vegetation (Spring 2026; Project Site versus Reference Site)

| | | Project Site | Reference Site |
|-------------------|--------------------------------------|--------------|----------------|
| Low Marsh | Live Vegetation | 49% | 20% |
| | Bare Ground / Duff / Dead Vegetation | 51% | 80% |
| Mid Marsh | Live Vegetation | 78% | 90% |
| | Bare Ground / Duff / Dead Vegetation | 22% | 10% |
| High Marsh | Live Vegetation | 56% | 61% |
| | Bare Ground / Duff / Dead Vegetation | 44% | 39% |

⁵ Daubenmire, Rexford. 1959. A Canopy-coverage method of vegetational analysis. Northwest Science 33:43-64.

Simpson's Diversity Index ($D = 1 - \sum (P)^2$; where P = percent cover for a given species)⁶ was similar at both the project site ($D = 0.71$) and the reference site ($D = 0.74$) and indicates limited species diversity consistent with typical salt marsh habitat in Choctawhatchee Bay.⁷

Table 2. Simpson's Diversity Index (Spring 2026)

| Species | Project Site | | Reference Site | |
|--|-------------------|----------------|-------------------|----------------|
| | Percent Cover (P) | p ² | Percent Cover (P) | p ² |
| <i>Halodule wrightii</i> (Shoalweed) | 0.0353 | 0.0012495 | Not Present | Not Present |
| <i>Iva frutescens</i> (Marsh Elder) | 0.0376 | 0.0014159 | Not Present | Not Present |
| <i>Juncus roemerianus</i> (Needlerush) | 0.3603 | 0.1298300 | 0.3369 | 0.1135146 |
| <i>Schoenoplectus pungens</i> (Threesquare Bulrush) | 0.0046 | 0.0000208 | 0.0396 | 0.0015689 |
| <i>Spartina alterniflora</i> (Smooth Cordgrass) | 0.2294 | 0.0526328 | 0.1443 | 0.0208093 |
| <i>Spartina patens</i> (Saltmeadow Cordgrass) | 0.3316 | 0.1099486 | 0.3100 | 0.0961152 |
| <i>Sporobolus</i> spp. (Dropseed) | 0.0011 | 0.0000013 | 0.1692 | 0.0286263 |
| Total | 1.000 | 0.2950989 | 1.000 | 0.2606343 |
| Simpson's Diversity Index (D) = 1 - $\sum (P)^2$ | 0.71 | | 0.74 | |

⁶ Simpson, E.H. 1949. Measurement of Diversity. Nature, 163:688.

⁷ Percent cover of bare ground, duff, and dead vegetation excluded from Simpson's Diversity Index (D) calculations; D = 0 indicates infinite diversity and D = 1 indicates zero diversity.

Sorensen's Similarity Index ($SI = 2C / A + B$; where A = the number of species at the project site, B = the number of species at the reference site, and C = the number of species common to both sites)⁸ was 0.83, indicating strong species composition similarity between the project site and reference site.

Table 3. Sorensen's Similarity Index (Spring 2026; Project Site and Reference Site)

| | |
|---|---|
| A = Number of Species at Project Site | 7 |
| B = Number of Species at Reference Site | 5 |
| C = Number of Species in Common Between Project Site and Reference Site | 5 |
| Sorensen's Similarity Index ($SI = 2C / (A + B) = 2(5) / (7 + 5) = 10 / 12 = 0.83$) | |

⁸ Sorensen, T. 1948. A method of establishing groups of equal amplitude in plant sociology based on similarity of species and its application to analyses of the vegetation on Danish commons. Kongelige Danske Videnskabernes Selskab. 5 (4): 1–34. Values 0.80 – 1.00 = Very High Similarity; 0.60 – 0.79 = High Similarity; 0.40 – 0.59 = Moderate Similarity; 0.20 – 0.39 = Low Similarity; 0.00 – 0.19 = Very Low Similarity.

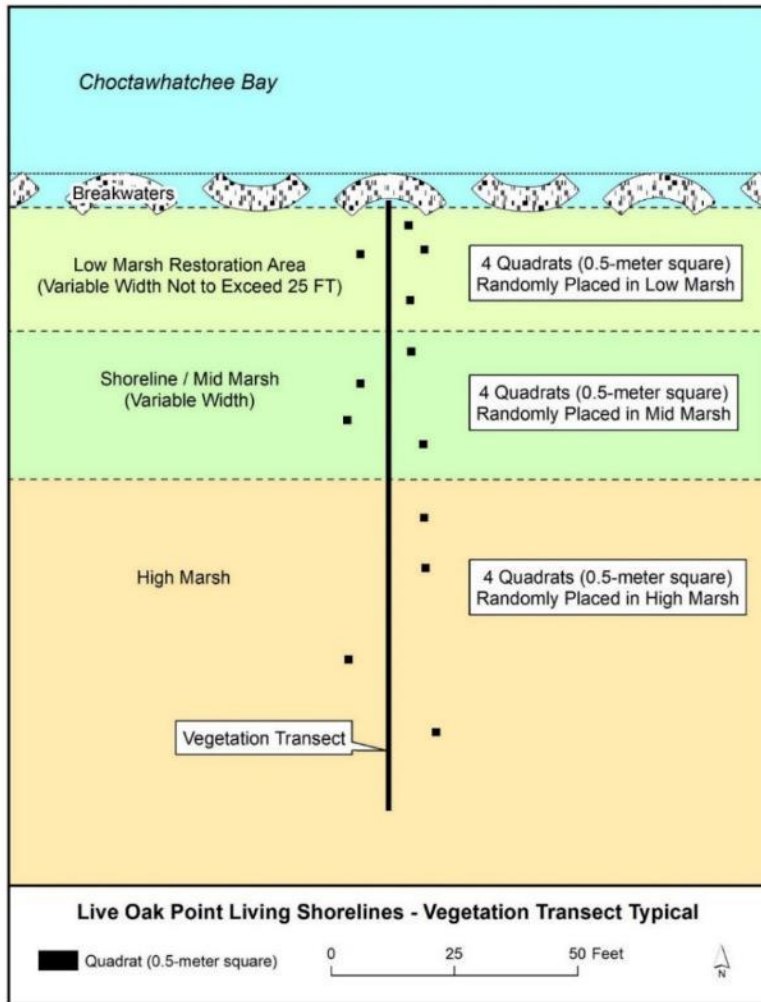


Figure 5. Vegetation Transect Sampling Design (Breakwaters Not Present at Reference Site)

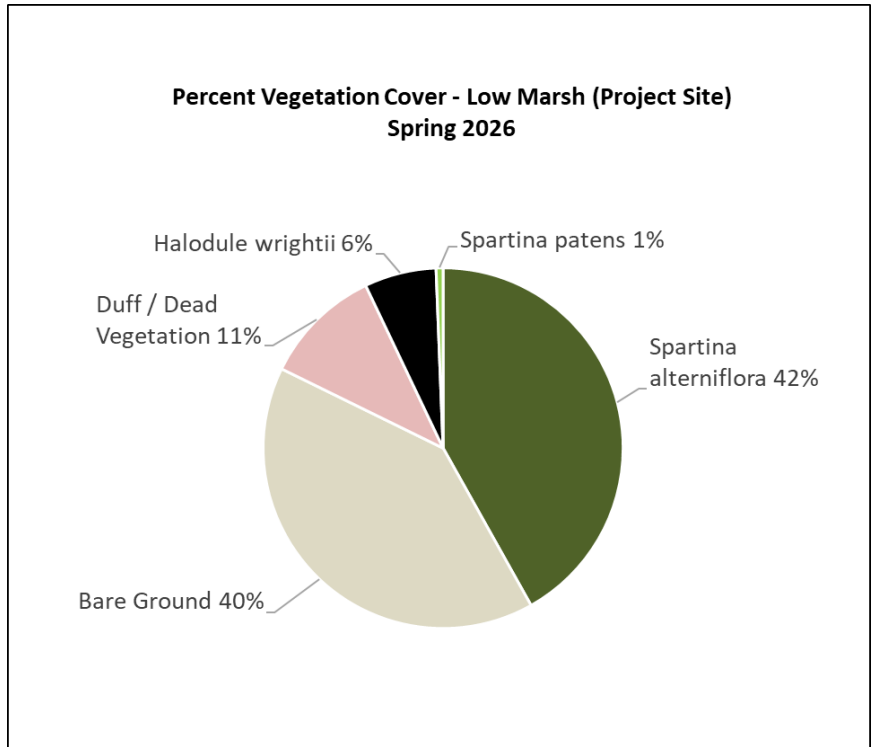


Figure 6. Project Site Low Marsh Vegetation (Average of Transects T1 - T6)

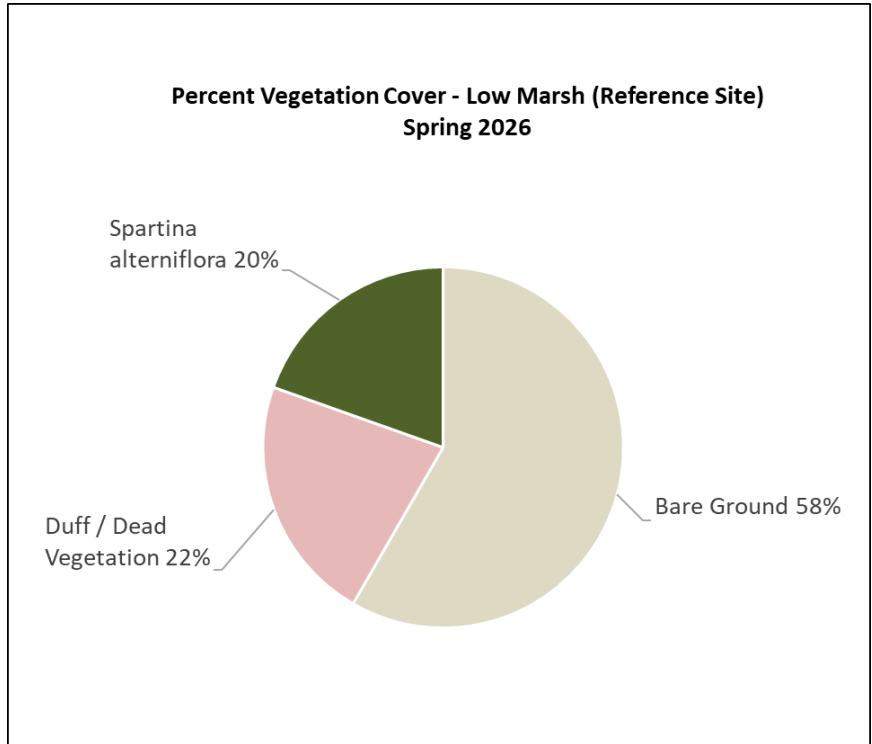


Figure 7. Reference Site Low Marsh Vegetation (Average of Transects T7 - T9)

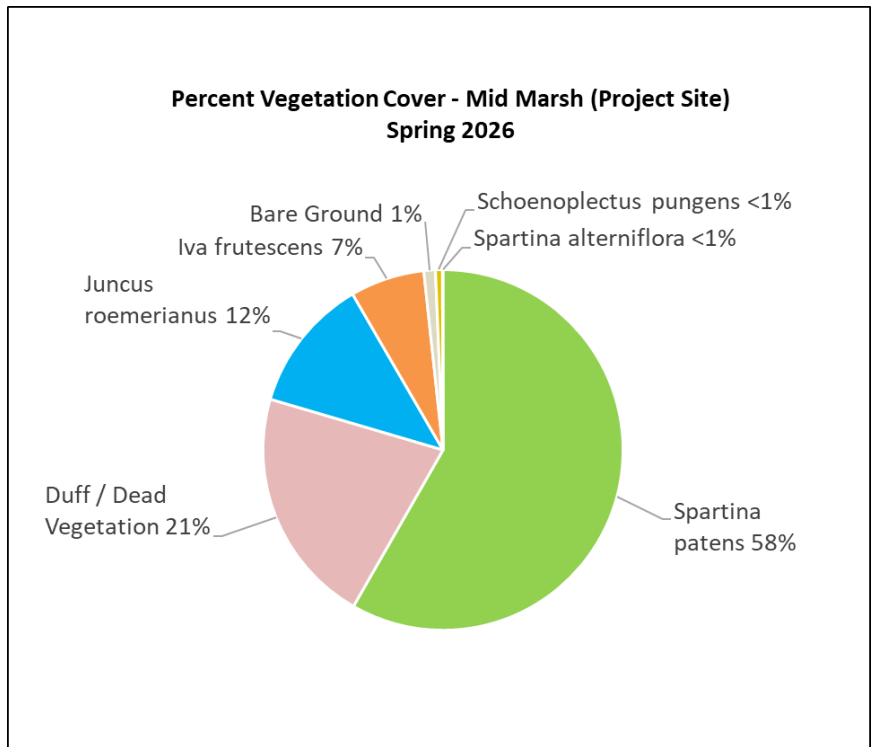


Figure 8. Project Site Mid Marsh Vegetation (Average of Transects T1 - T6)

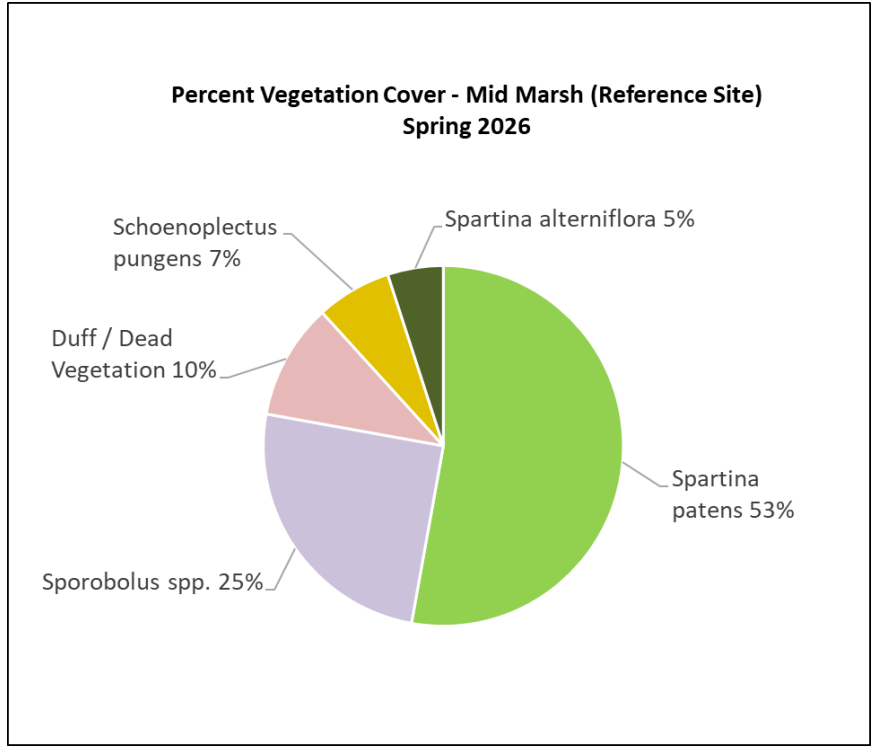


Figure 9. Reference Site Mid Marsh Vegetation (Average of Transects T7 - T9)

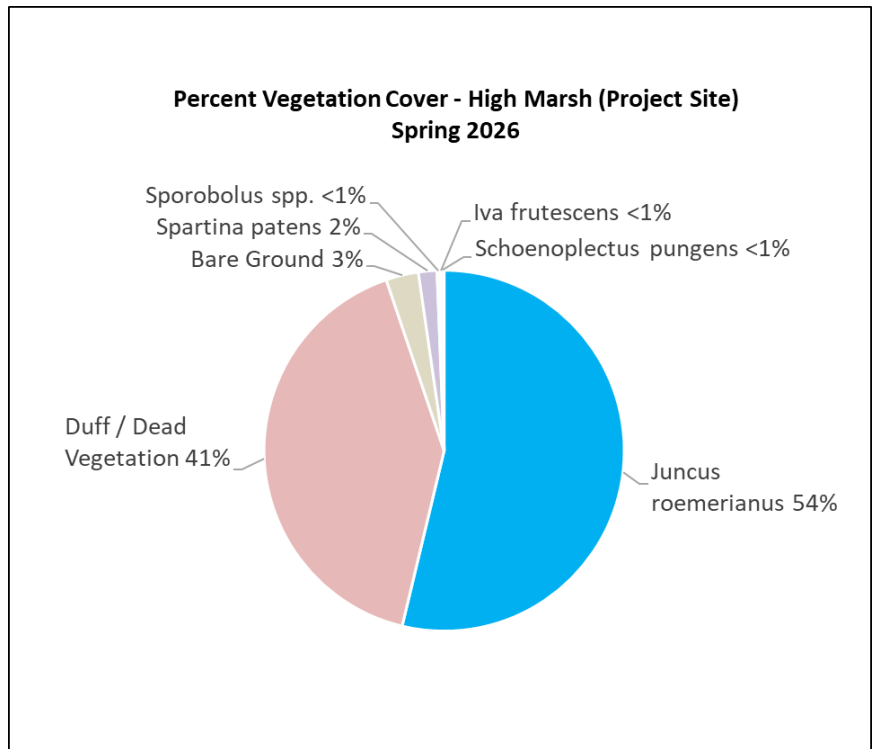


Figure 10. Project Site High Marsh Vegetation (Average of Transects T1 - T6)

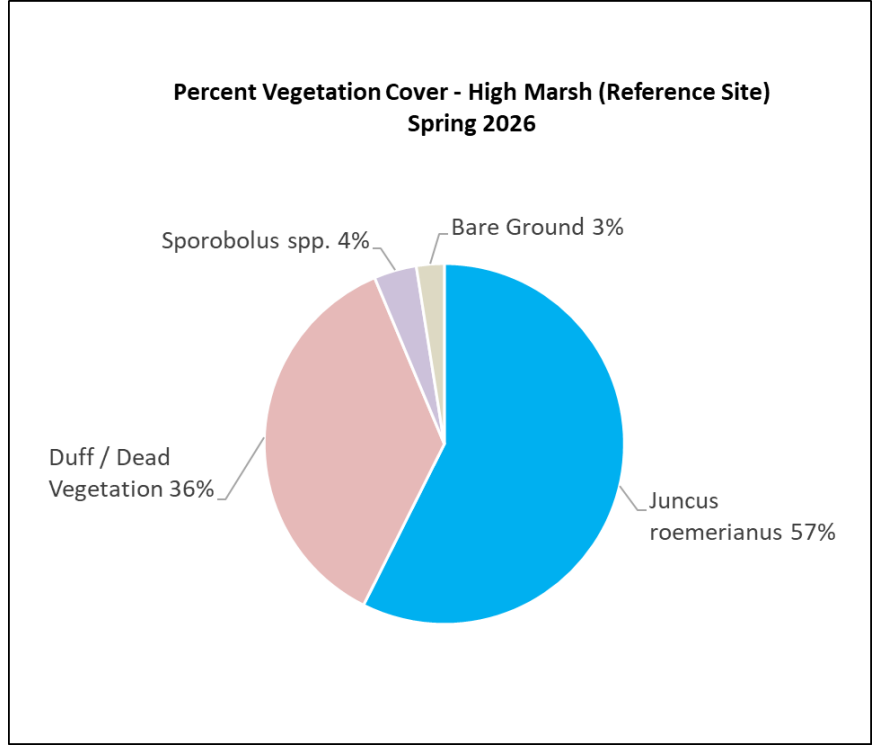


Figure 11. Reference Site High Marsh Vegetation (Average of Transects T7 - T9)

Table 4. Reference Site and Project Site Vegetation (Spring 2026) by Marsh Zone

| Species | Project Site | | | Reference Site | | |
|--|--------------|-----------|------------|----------------|-----------|------------|
| | Low Marsh | Mid Marsh | High Marsh | Low Marsh | Mid Marsh | High Marsh |
| <i>Halodule wrightii</i> (Shoalweed) | 6.46% | 0% | 0% | 0% | 0% | 0% |
| <i>Iva frutescens</i> (Marsh Elder) | 0% | 6.67% | 0.21% | 0% | 0% | 0% |
| <i>Juncus roemerianus</i> (Needlerush) | 0% | 12.08% | 53.75% | 0% | 0% | 57.42% |
| <i>Schoenoplectus pungens</i> (Threesquare Bulrush) | 0% | 0.63% | 0.21% | 0% | 6.75% | 0% |
| <i>Spartina alterniflora</i> (Smooth Cordgrass) | 41.88% | 0.04% | 0% | 19.58% | 5.00% | 0% |
| <i>Spartina patens</i> (Saltmeadow Cordgrass) | 0.63% | 58.29% | 1.67% | 0% | 52.83% | 0% |
| <i>Sporobolus</i> spp. (Dropseed) | 0% | 0% | 0.21% | 0% | 25.00 | 3.83% |
| Bare Ground | 40.38% | 1.04% | 2.92% | 58.33% | 0% | 2.50% |
| Duff / Dead Vegetation | 10.67% | 21.25% | 41.04% | 22.08% | 10.42% | 36.25% |

*Due to rounding, percentages may not sum to precisely 100%.

Sediment Accretion Monitoring

To estimate vertical sediment accretion in the existing marsh of the reference area and project area, fifteen sediment accretion monitoring points (i.e., buried paving bricks) were established, with systematic data collection beginning May 2023.⁹ Each point, assigned a unique ID of SB1 through SB15, consists of a 4" x 7" concrete paving brick buried approximately 20± cm below the vegetated ground surface. Measurements are made by inserting a thin metal rod into the ground until it contacts the buried paving brick, retracting the rod, and then measuring the rod against a meter stick. By design, these points are located within the existing marsh and not within the marsh restoration zone (i.e., they are not placed in the area between the breakwaters and the existing marsh/shoreline).¹⁰

Use of buried markers (e.g., buried paving bricks) is common in monitoring sediment accretion in salt marsh habitat. Our experience at the Live Oak Point Living Shorelines project suggests that useful data may be generated at a coarse level. However, this technique is inappropriate for obtaining trends at millimeter resolutions. Although measurements from May 2023 to April 2026 in the existing marsh at the project site indicate an annual average vertical loss rate of 4 mm per year (Table 5), visual observations strongly suggest that little or no measurable change in the surface elevation is occurring in the existing marsh at either the project site or the reference site. The unevenness of the marsh surface at the monitoring points, the potential for continued settling of soil after burial of the paving brick, possible surface compaction from animals or human foot traffic, and imprecise leveling of the buried paving brick, make measurement resolutions in the millimeter range highly problematic.

Given the limitations of the buried markers (paver bricks) in the existing salt marsh, and to expand the monitoring to include the marsh restoration/marsh expansion zone located between breakwater segments and the current shoreline, eight additional monitoring stations using a different design were established on 11/25/2024. Referred to here as "PVC post pairs," each station (assigned a unique ID of SP1 through SP8) consists of two 2" DIA, SCH 40 PVC pipes (10-FT length) driven approximately 7 ½ FT into the underlying sandy sediments, placed approximately 7 FT apart, and forming a line approximately perpendicular to the existing shoreline. During monitoring events, a rigid cross bar (marked in 1-FT intervals) is temporarily placed on the two PVC posts. At each station, height from the bottom of the cross bar to the sediment surface is measured at six 1-FT intervals (decreasing height measurements over time indicate accretion of sediment).

Monitoring of the PVC post pairs within the marsh expansion zone (Table 6 & Table 7) began on 11/25/2024, with the most recent measurements taken on 4/2/2026. Over the course of 493

⁹ Earlier attempts at measuring sediment accretion either washed out or were vandalized.

¹⁰ When monitoring protocols for this project were being developed to comply with permit conditions, it was initially decided not to place sediment accretion monitoring points within the zone between the breakwaters and existing marsh because of expected volatility in sediment accumulation and movement within this area. Sediment accretion monitoring has since been expanded to include the zone between the breakwaters and existing marsh.

days (11/25/2024 – 4/2/2026), average sediment accretion, as measured by the PVC post pairs SP 1 – SP8, was 7.6 cm (max. accretion = 22.3 cm; min. accretion = -1.0 cm). Average annualized rate of sediment accretion is 57 mm (5.7 cm), well in excess of the $3\pm$ mm estimated rate of annual sea level rise for northwest Florida¹¹).

¹¹ Sea level rise for the Panama City area has been estimated by National Oceanic and Atmospheric Administration area at 3.13 mm per year (Station 8729108; Panama City, Florida; Relative Sea Level Trend; 3.13 mm \pm 0.58 mm per year; 1973 to 2024.

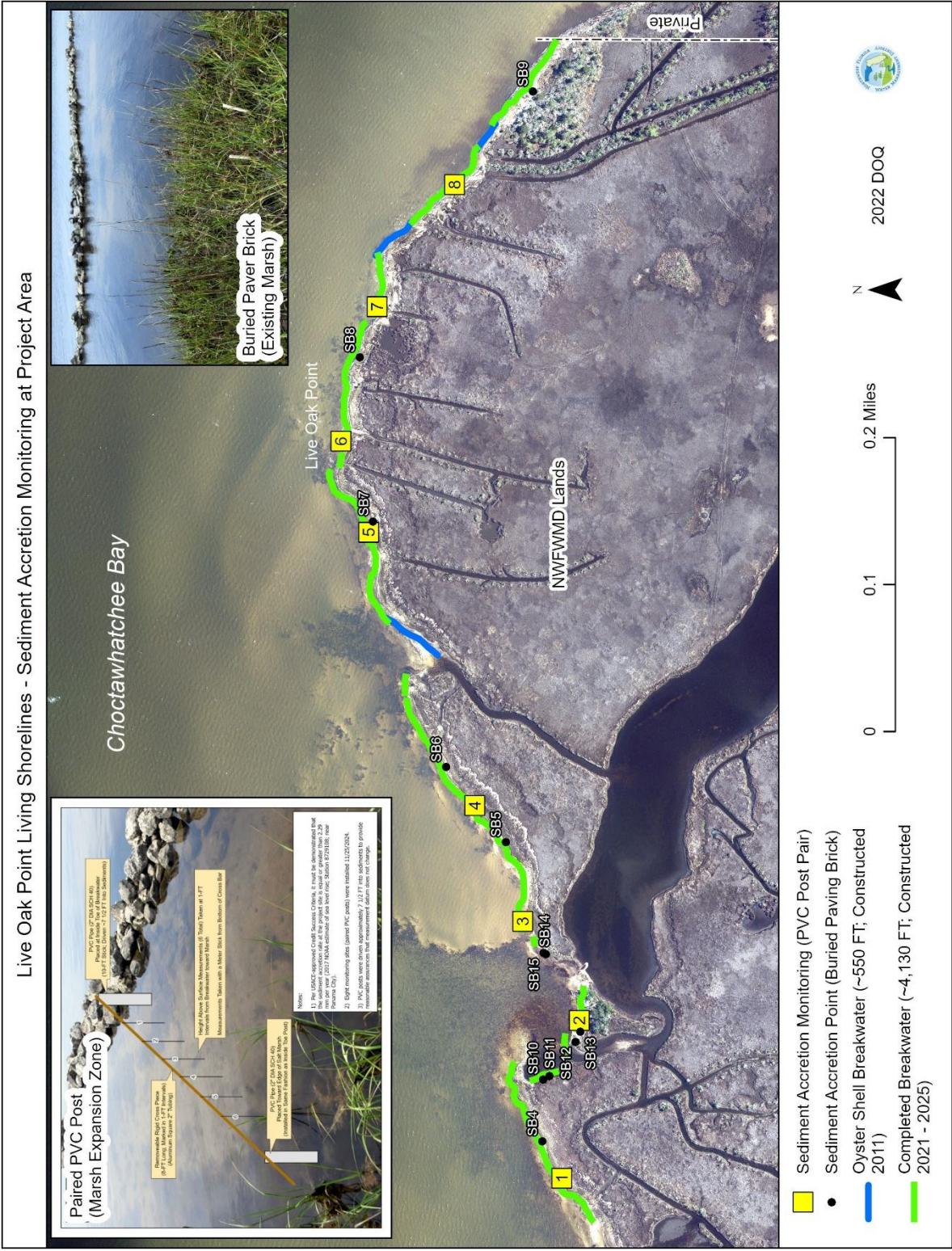


Figure 12. Sediment Accretion Monitoring at Project Site

Table 5. Vertical Sediment Accretion Monitoring (Buried Paver Brick; Existing Marsh)

| | | Average Depth Below Ground Surface (cm) | | | | | | | | | | | |
|-------------------|----------|---|-------------------|-------------------|-------------------|------------------|-------------------|-------------------|-------------------|-------------------|------------------|---|--|
| Site | Point | 4 MAY 2023 | 18 MAY 2023 | 21 JLY 2023 | 18 OCT 2023 | 3 MAY 2024 | 15 OCT 2024 | 11 APR 2025 | 15 APR 2025 | 24 OCT 2025 | 2 APR 2026 | Change in Ground Surface Elevation (mm) | Annualized Rate of Change (mm/yr) |
| Reference Site | SB-1 | 17.1 | 15.8 | 16.6 | 17.4 | 19.2 | 20.7 | 23.8 | - | 22.6 | M | - | - |
| | SB-2B | - | 19.0 | 18.0 | 18.1 | 18.0 | 18.2 | M | M | M | M | - | - |
| | SB-3B | - | 18.1 | 17.2 | 17.3 | 17.5 | M | M | M | M | M | - | - |
| | Average: | 17.1 | 17.6 | 17.3 | 17.6 | 18.2 | 19.5 | 23.8 | - | - | M | - | - |
| Project Site | SB-4 | 21.2 | - | 21.4 | 21.1 | 20.7 | 19.5 | 19.2 | 19.4 | 20.9 | 21.6 | 4 | 1 |
| | SB-5 | 20.7 | - | 19.4 | 17.6 | 17.0 | 15.7 | - | 15.2 | 15.0 | 14.7 | -60 | -21 |
| | SB-6 | 17.3 | - | 16.9 | 16.8 | 16.3 | 16.2 | - | 16.3 | 15.8 | 16.6 | -7 | -2 |
| | SB-7 | 19.9 | - | 19.2 | 19.8 | 18.9 | 15.2 | - | 14.3 | 12.3 | M | - | - |
| | SB-8 | 24.5 | - | 24.1 | 23.8 | 23.9 | M | - | 14.9 | 5.6 | M | - | - |
| | SB-9 | 11.6 | - | 6.9 | 2.8 | 9.3 | M | - | M | M | M | - | - |
| | SB-10 | 27.0 | - | 27.2 | 25.7 | 25.6 | 25.2 | - | 25.1 | 25.1 | 24.8 | -22 | -7 |
| | SB-11 | 17.7 | - | 17.4 | 16.3 | 15.6 | 15.1 | - | 15.2 | M | 13.7 | -40 | -14 |
| | SB-12 | 8.3 | - | 10.0 | 8.5 | 4.9 | 7.6 | - | 5.9 | 5.5 | 6.2 | -21 | -7 |
| | SB-13 | 12.7 | - | 12.7 | 11.0 | M | M | - | M | M | M | - | - |
| | SB-14 | 15.0 | - | 14.9 | 14.5 | 14.5 | 14.3 | - | 14.2 | 13.8 | 14.8 | -2 | -1 |
| | SB-15 | 11.2 | - | 10.9 | 10.8 | 12.7 | 14.7 | - | 15.7 | 14.7 | 16.1 | 49 | 17 |
| | Average: | 17.2 | - | 16.8 | 15.7 | 16.3 | 15.9 | - | 15.6 | 14.3 | 16.0 | -12 | -4 |

Table 6. Vertical Sediment Accretion Monitoring (PVC Post Pairs SP1 – SP4; Marsh Expansion Area)*

| Sediment PVC Post Pair | Measurement Position | 11/25/2024 (cm) | 12/16/2024 (cm) | 4/11/2025 (cm) | 8/28/2025 (cm) | 10/24/2025 (cm) | 2/10/2026 (cm) | 4/2/2026 (cm) | Surface Elevation Change (cm) 11/25/2024 - 4/2/2026 493 Days | Annualized Rate of Change (mm/yr) | Note |
|------------------------|----------------------|-----------------|-----------------|----------------|----------------|-----------------|----------------|---------------|--|-----------------------------------|---|
| SP1 | 1FT | 72.6 | 69.6 | 64.8 | 58.3 | 58.1 | 44.7 | 49.2 | 23.4 | 173.2 | Breakwater Segment Installed at This Location 2021/22 |
| | 2FT | 72.5 | 69.4 | 64.3 | 58.2 | 57.7 | 42.9 | 47.8 | 24.7 | 182.9 | |
| | 3FT | 70.5 | 66.8 | 63.0 | 59.1 | 58.3 | 43.0 | 48.5 | 22.0 | 162.9 | |
| | 4FT | 68.2 | 66.8 | 63.0 | 58.9 | 58.5 | 43.3 | 46.2 | 22.0 | 162.9 | |
| | 5FT | 65.9 | 65.5 | 62.0 | 59.8 | 58.8 | 42.4 | 45.2 | 20.7 | 153.3 | |
| | 6FT | 64.7 | 65.0 | 62.8 | 62.8 | 60.2 | 40.7 | 44.0 | 20.7 | 153.3 | |
| | AVG: | 69.1 | 67.2 | 63.3 | 59.5 | 58.6 | 42.8 | 46.8 | 22.3 | 164.7 | |
| SP2 | 1FT | 73.5 | 71.8 | 74.8 | 73.6 | 75.2 | 74.0 | 81.0 | -7.5 | -55.5 | Breakwater Segment Installed at This Location 2024/25 |
| | 2FT | 75.9 | 70.5 | 71.4 | 70.5 | 71.0 | 71.0 | 72.0 | 3.9 | 28.9 | |
| | 3FT | 69.8 | 68.9 | 69.1 | 70.2 | 69.8 | 69.3 | 72.8 | -3.0 | -22.2 | |
| | 4FT | 72.6 | 70.8 | 68.2 | 68.5 | 70.1 | 68.9 | 69.0 | 3.6 | 26.7 | |
| | 5FT | 66.9 | 66.4 | 68.8 | 67.9 | 70.0 | 68.4 | 68.5 | -1.6 | -11.8 | |
| | 6FT | 66.8 | 65.8 | 68.0 | 67.6 | 70.0 | 68.0 | 68.4 | -1.6 | -11.8 | |
| | AVG: | 70.9 | 69.0 | 70.1 | 69.7 | 71.0 | 69.9 | 72.0 | -1.0 | -7.7 | |
| SP3 | 1FT | 88.9 | 89.1 | 89.5 | 86.6 | 87.3 | 84.6 | 85.5 | 3.4 | 25.2 | Breakwater Segment Installed at This Location 2021/22 |
| | 2FT | 90.6 | 89.2 | 90.0 | 87.0 | 88.1 | 85.4 | 85.3 | 5.3 | 39.2 | |
| | 3FT | 88.3 | 89.3 | 91.0 | 87.3 | 88.3 | 86.0 | 85.9 | 2.4 | 17.8 | |
| | 4FT | 88.6 | 89.8 | 91.0 | 88.6 | 88.8 | 87.8 | 86.5 | 2.1 | 15.5 | |
| | 5FT | 88.7 | 89.5 | 91.0 | 88.8 | 88.4 | 87.2 | 87.1 | 1.6 | 11.8 | |
| | 6FT | 89.0 | 89.6 | 91.5 | 88.2 | 89.6 | 87.7 | 89.0 | 0.0 | 0.0 | |
| | AVG: | 89.0 | 89.4 | 90.7 | 87.8 | 88.4 | 86.5 | 86.6 | 2.5 | 18.3 | |
| SP4 | 1FT | 78.5 | 74.7 | 82.6 | 78.4 | 78.4 | 76.5 | 80.3 | -1.8 | -13.3 | Breakwater Segment Installed at This Location 2021/22 |
| | 2FT | 79.4 | 75.6 | 81.6 | 79.8 | 77.9 | 75.6 | 79.3 | 0.1 | 0.7 | |
| | 3FT | 79.4 | 76.6 | 81.8 | 79.4 | 79.0 | 76.5 | 78.3 | 1.1 | 8.1 | |
| | 4FT | 81.5 | 77.6 | 81.2 | 79.6 | 78.6 | 76.9 | 76.6 | 4.9 | 36.3 | |
| | 5FT | 81.9 | 79.6 | 80.7 | 80.5 | 79.3 | 77.6 | 79.3 | 2.6 | 19.2 | |
| | 6FT | 84.1 | 81.0 | 81.0 | 80.7 | 82.0 | 80.5 | 80.7 | 3.4 | 25.2 | |
| | AVG: | 80.8 | 77.5 | 81.5 | 79.7 | 79.2 | 77.3 | 79.1 | 1.7 | 12.7 | |

*Measurements are from crossbar down to sediment surface. Decreasing distance from crossbar to surface equals increasing sediment elevation.

Table 7. Vertical Sediment Accretion Monitoring (PVC Post Pairs SP5 - SP8; Marsh Expansion Area)*

| Sediment PVC Post Pair | Measurement Position | 11/25/2024 (cm) | 12/16/2024 (cm) | 4/11/2025 (cm) | 8/28/2025 (cm) | 10/24/2025 (cm) | 2/10/2026 (cm) | 4/2/2026 (cm) | Surface Elevation Change (cm) 11/25/2024 - 4/2/2026 493 Days | Annualized Rate of Change (mm/yr) | Note |
|------------------------|----------------------|-----------------|-----------------|----------------|----------------|-----------------|----------------|---------------|--|-----------------------------------|--|
| SP5 | 1FT | 86.1 | 78.0 | 76.7 | 75.5 | 71.2 | 66.3 | 67.0 | 19.1 | 141.4 | Breakwater Segment Installed at This Location 2021/22 |
| | 2FT | 84.5 | 80.1 | 74.9 | 72.7 | 69.9 | 63.2 | 66.3 | 18.2 | 134.7 | |
| | 3FT | 86.2 | 80.6 | 74.4 | 74.0 | 69.3 | 62.1 | 65.0 | 21.2 | 157.0 | |
| | 4FT | 81.1 | 80.4 | 74.1 | 71.6 | 68.5 | 61.4 | 67.0 | 14.1 | 104.4 | |
| | 5FT | 80.7 | 80.1 | 73.4 | 69.9 | 68.6 | 60.9 | 65.0 | 15.7 | 116.2 | |
| | 6FT | 80.4 | 78.3 | 73.6 | 68.8 | 68.6 | 61.2 | 64.2 | 16.2 | 119.9 | |
| | AVG: | 83.2 | 79.6 | 74.5 | 72.1 | 69.4 | 62.5 | 65.8 | 17.4 | 128.9 | |
| SP6 | 1FT | 86.0 | 90.8 | 92.8 | 92.4 | 76.6 | 72.3 | 77.6 | 8.4 | 62.2 | Breakwater Segment Installed at This Location AUG 2025 |
| | 2FT | 85.3 | 90.4 | 92.0 | 91.5 | 79.0 | 72.1 | 81.8 | 3.5 | 25.9 | |
| | 3FT | 84.4 | 87.8 | 90.0 | 90.5 | 80.7 | 70.7 | 77.4 | 7.0 | 51.8 | |
| | 4FT | 83.3 | 87.6 | 90.0 | 90.6 | 82.9 | 69.7 | 77.4 | 5.9 | 43.7 | |
| | 5FT | 83.2 | 87.6 | 88.7 | 89.0 | 83.7 | 68.7 | 74.7 | 8.5 | 62.9 | |
| | 6FT | 84.3 | 87.3 | 87.9 | 89.3 | 85.4 | 67.9 | 75.0 | 9.3 | 68.9 | |
| | AVG: | 84.4 | 88.6 | 90.2 | 90.6 | 81.4 | 70.2 | 77.3 | 7.1 | 52.6 | |
| SP7 | 1FT | 78.5 | 74.5 | 70.3 | 75.2 | 83.1 | 66.5 | 78.4 | 0.1 | 0.7 | Breakwater Segment Installed at This Location 2021/22 |
| | 2FT | 79.5 | 73.5 | 69.2 | 71.6 | 81.6 | 66.3 | 76.6 | 2.9 | 21.5 | |
| | 3FT | 80.4 | 75.0 | 69.5 | 70.9 | 79.2 | 64.8 | 74.0 | 6.4 | 47.4 | |
| | 4FT | 80.2 | 75.8 | 69.0 | 70.8 | 74.2 | 64.5 | 71.6 | 8.6 | 63.7 | |
| | 5FT | 82.6 | 77.3 | 71.0 | 71.0 | 70.3 | 65.2 | 68.3 | 14.3 | 105.9 | |
| | 6FT | 80.4 | 79.4 | 73.0 | 69.5 | 69.6 | 66.4 | 68.0 | 12.4 | 91.8 | |
| | AVG: | 80.3 | 75.9 | 70.3 | 71.5 | 76.3 | 65.6 | 72.8 | 7.4 | 55.2 | |
| SP8 | 1FT | 86.1 | 87.9 | 82.7 | 88.1 | 88.6 | 81.7 | 90.2 | -4.1 | -30.4 | Breakwater Segment Installed at This Location 2021/22 |
| | 2FT | 87.0 | 87.2 | 82.4 | 81.8 | 88.1 | 82.8 | 85.1 | 1.9 | 14.1 | |
| | 3FT | 87.8 | 87.0 | 83.9 | 83.6 | 88.2 | 84.8 | 83.5 | 4.3 | 31.8 | |
| | 4FT | 90.0 | 88.4 | 85.9 | 83.9 | 88.1 | 85.8 | 84.2 | 5.8 | 42.9 | |
| | 5FT | 92.3 | 90.3 | 86.7 | 83.4 | 88.4 | 85.8 | 85.1 | 7.2 | 53.3 | |
| | 6FT | 92.8 | 91.5 | 88.0 | 86.9 | 89.8 | 86.5 | 85.1 | 7.7 | 57.0 | |
| | AVG: | 89.3 | 88.7 | 84.9 | 84.6 | 88.5 | 84.6 | 85.5 | 3.8 | 28.1 | |

*Measurements are from crossbar down to sediment surface. Decreasing distance from crossbar to surface equals increasing sediment elevation.

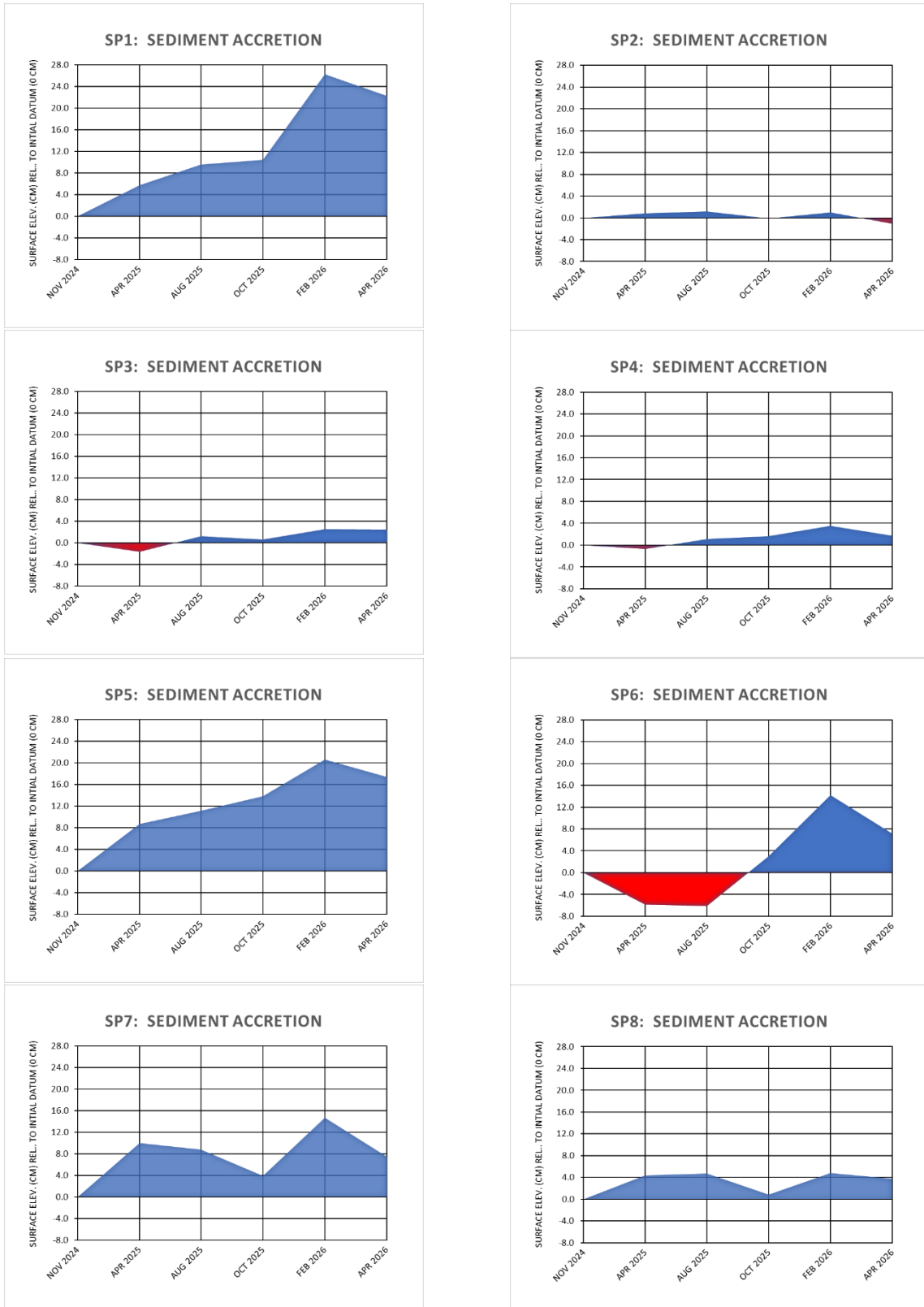


Figure 13. Sediment Accretion Over Time (PVC Post Pairs)

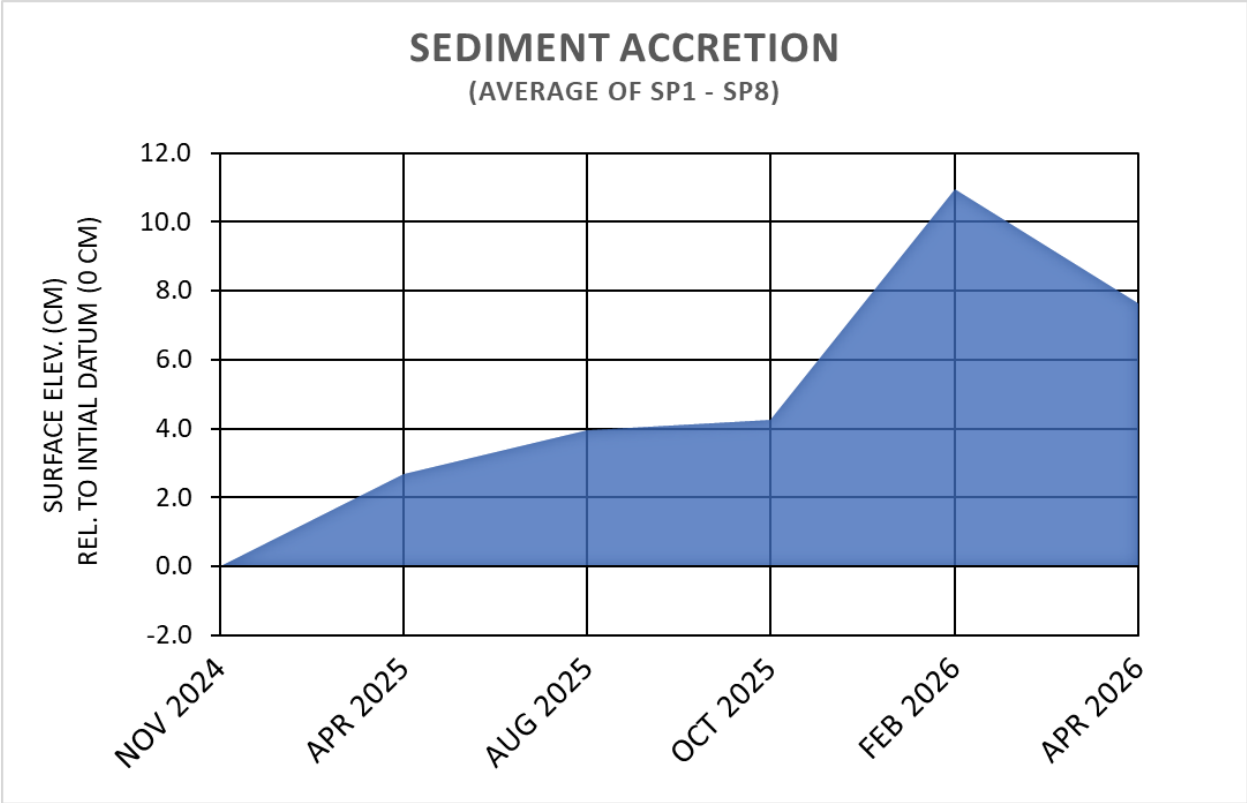


Figure 14. Sediment Accretion Over Time (Average of SP1 - SP8)

Benthic Invertebrate Monitoring

Twelve (12) sediment cores were collected on 4/27/2026 for analysis of benthic communities. Six (6) sediment cores were obtained at the project site along two (2) transects (3 cores per transect), and six (6) cores were obtained at the reference site along two (2) transects (3 cores per transect). On each transect, one (1) core was collected from the low marsh, one (1) from the mid marsh, and one (1) from the high marsh. Each core sample was washed in the field over a 500 μm mesh sieve using water gathered from the adjacent bay. All material retained on the screen mesh was stored in a labeled Nalgene 0.5 L container and preserved with formalin and later stained with 70% isopropyl alcohol and 30% water with Rose Bengal dye added. The collected samples were analyzed by Barry A. Vittor & Associates, Inc.¹²

Results of benthic invertebrate sampling indicate very high similarity in feeding guilds between the project site and reference site (Sorensen's Similarity Index = 0.91). Deposit feeders comprised 87% of sampled organisms at the project site and 94% at the reference site. Filter feeders accounted for 6% of organisms at the project site and 4% at the reference site.

Naididae (LPIL¹³) was the dominant taxon at both the project site (47%) and reference site (88%). *Mediomastus ambiseta* comprised 23% of benthic organisms at the project site, though <1% at the reference site. Both Naididae (LPIL) and *Mediomastus ambiseta* are highly tolerant of organic pollution, which suggests impaired water quality. Although water quality in Choctawhatchee Bay is generally good to very good, Hogtown Bayou (which comprises the southern boundary of the Live Oak Point salt marsh) does experience elevated nutrient and bacteria levels from stormwater runoff and the widespread use of septic systems in the subbasin. As commonly occurs in salt marsh habitat, both pollution-tolerant and non-tolerant benthic organisms are present at both the project site and reference site and is possibly explained by microhabitat patchiness and environmental gradients.

Eighty-six individual benthic organisms were collected at the project site versus 128 collected at the reference site. Calculated Shannon Diversity Indices (H') indicate that the project site is substantially more diverse in taxa (19 taxa; $H' = 1.88$; moderate diversity) than the reference site (13 taxa; $H' = 0.64$; low diversity). Evenness of taxa distribution is also greater at the project site (Project Site: Pielou's Evenness Index $J' = 0.64$, indicating Semi-Balanced Evenness) as compared to the reference site (Reference Site: Pielou's Evenness Index $J' = 0.25$ indicating Unbalanced Evenness).

¹² Barry A. Vittor & Associates, Inc., 8060 Cottage Hill Road, Mobile, AL 36695.

¹³ LPIL = Lowest Practical Identification Level.

Table 8. Benthic Invertebrate Sampling

| Site | Phylum | Class | Order | Family | Taxa | Feeding Guild | No. | |
|--|--------------------|------------------------------|------------------------------|--------------------------|--------------------------------|--------------------------------|------------------------|---------------|
| ----- Project Site ----- | Annelida | Clitellata | Tubificida | Lumbriculidae | <i>Lumbriculidae (LPIL)</i> | Deposit Feeder | 1 | |
| | | | | Naididae | <i>Naididae (LPIL)</i> | Deposit Feeder | 40 | |
| | | Polychaeta | Orbiniida | Orbiniidae | <i>Leitoscoloplos (LPIL)</i> | Deposit Feeder | 1 | |
| | | | | Phyllodocida | Nereididae | <i>Nereis succinea</i> | Omnivore | 1 |
| | | | | | Phyllodocidae | <i>Hypereteone heteropoda</i> | Deposit Feeder | 2 |
| | | | Pilargidae | | <i>Parandalia tricuspis</i> | Omnivore | 1 | |
| | | | Sabellida | Sabellidae | <i>Chone infundibuliformis</i> | Filter Feeder | 1 | |
| | | | Scolecida | Capitellidae | <i>Capitella capitata</i> | Deposit Feeder | 3 | |
| | | | | | <i>Capitellidae (LPIL)</i> | Deposit Feeder | 3 | |
| | | | | | <i>Mediomastus ambiseta</i> | Deposit Feeder | 20 | |
| | | | Spionida | Spionidae | <i>Dipolydora socialis</i> | Deposit Feeder | 2 | |
| | | | | | <i>Scolelepis texana</i> | Deposit Feeder | 1 | |
| | | <i>Streblospio benedicti</i> | | | Deposit Feeder | 2 | | |
| | | Arthropoda | Malacostraca | Amphipoda | Ampeliscidae | <i>Ampelisca (LPIL)</i> | Filter/Deposit Feeder | 1 |
| | | Mollusca | Bivalvia | Mytiloidea | Mytilidae | <i>Mytilidae (LPIL)</i> | Filter Feeder | 1 |
| | | | | | Veneroidea | Psammobiidae | <i>Tagelus plebius</i> | Filter Feeder |
| Solenidae | <i>Ensis minor</i> | | | Filter Feeder | | 2 | | |
| Gastropoda | Archaeopulmonata | | Ellobiidae | <i>Melampus (LPIL)</i> | Herbivore/Deposit Feeder | 1 | | |
| Nemertea | - | - | - | <i>Nemertea (LPIL)</i> | Mixed Feeder | 2 | | |
| Project Site: 86 Individuals; 4 Phylums; 6 Classes; 11 Orders; 15 Families; 19 Taxa; 6 Feeding Guilds; Shannon Diversity Index (H') for Taxa = 1.88 (Moderate Diversity); Pielou's Evenness/Shannon Equitability Index (J') = 0.64 (Semi-Balanced Evenness); Density = ~1,590/m ² . | | | | | | | | |
| ----- Reference Site ----- | Annelida | Polychaeta | Tubificida | Naididae | <i>Naididae (LPIL)</i> | Deposit Feeder | 113 | |
| | | | | Sabellida | Sabellidae | <i>Chone infundibuliformis</i> | Filter Feeder | 1 |
| | | | <i>Fabricinuda trilobata</i> | | | Filter Feeder | 2 | |
| | | | Scolecida | Capitellidae | <i>Heteromastus filiformis</i> | Deposit Feeder | 1 | |
| | | | | | <i>Mediomastus ambiseta</i> | Deposit Feeder | 1 | |
| | | | | | <i>Streblospio benedicti</i> | Deposit Feeder | 1 | |
| | Terebellida | Ampharetidae | <i>Hobsonia florida</i> | Deposit Feeder | 1 | | | |
| | Arthropoda | Malacostraca | Insecta | Diptera | Ceratopogonidae | <i>Ceratopogonidae (LPIL)</i> | Omnivore | 1 |
| | | | | Amphipoda | Ampeliscidae | <i>Ampelisca (LPIL)</i> | Filter/Deposit Feeder | 1 |
| | | | Decapoda | | - | <i>Decapoda (LPIL)</i> | Mixed Feeder | 1 |
| | | | Tanaidacea | Leptocheliidae | <i>Hargeria rapax</i> | Deposit Feeder | 3 | |
| Mollusca | Bivalvia | Veneroidea | Mactridae | <i>Mulinia lateralis</i> | Filter Feeder | 1 | | |
| | | | Tellinidae | <i>Angulus (LPIL)</i> | Filter Feeder | 1 | | |
| Reference Site: 128 Individuals; 3 Phylums; 5 Classes; 10 Orders; 10 Families; 13 Taxa; 5 Feeding Guilds; Shannon Diversity Index (H') for Taxa = 0.64 (Low Diversity); Pielou's Evenness/Shannon Equitability Index (J') = 0.25 (Unbalanced Evenness); Density = ~2,370/m ² . | | | | | | | | |

Note: LPIL = Lowest Practical Identification Level.

Table 9. Benthic Invertebrate Sampling Analysis Summary

| Metric | Project Site | Reference Site |
|---|----------------------------------|-------------------------------|
| No. of Cores | 6 | 6 |
| Core Diameter | 0.107 m | 0.107 m |
| Core Area | 0.00900009 m ² | 0.00900009 m ² |
| Sample Area | 0.054 m ² | 0.054 m ² |
| No. of Individuals | 86 | 128 |
| Average No. of Individuals per Core | 14.3 | 21.3 |
| Pielou's Evenness (J') | 0.64 (Semi-Balanced Evenness) | 0.25 (Unbalanced Evenness) |
| Shannon Diversity Index (H') | 1.88 (Moderate Diversity) | 0.64 (Low Diversity) |
| Density of Individuals | ~1,590/m ² | ~2,370/m ² |
| No. of Phyla | 4 | 3 |
| No. of Classes | 6 | 5 |
| No. of Orders | 11 | 10 |
| No. of Families | 15 | 10 |
| No. of Taxa | 19 | 13 |
| No. of Feeding Guilds | 6 | 5 |
| Sorensen's Similarity Index (Phylum) | 0.86 (Very High Similarity) | |
| Sorensen's Similarity Index (Class) | 0.73 (High Similarity) | |
| Sorensen's Similarity Index (Order) | 0.57 (Moderate Similarity) | |
| Sorensen's Similarity Index (Family) | 0.40 (Moderate Similarity) | |
| Sorensen's Similarity Index (Taxa) | 0.31 (Low Similarity) | |
| Sorensen's Similarity Index (Feeding Guild) | 0.91 (Very High Similarity) | |

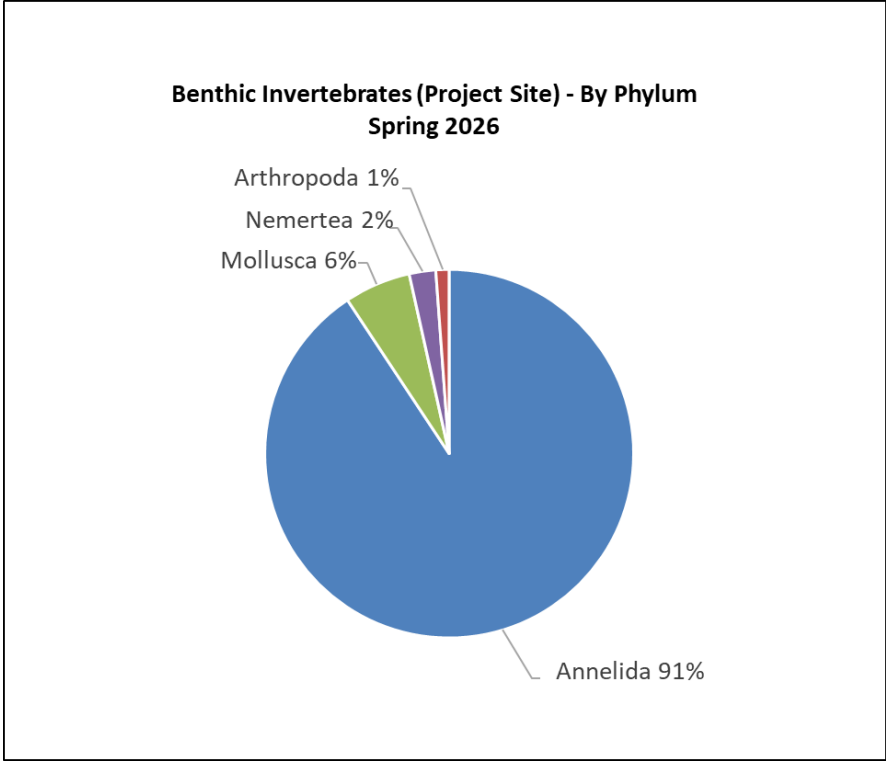


Figure 15. Benthic Invertebrates (Project Site) by Phylum

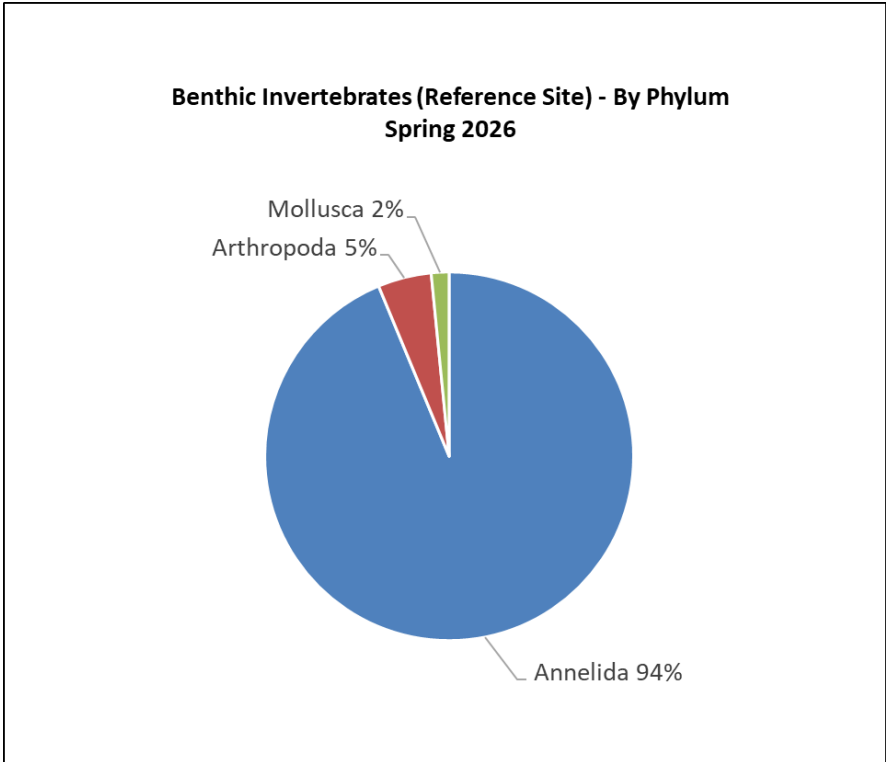


Figure 16. Benthic Invertebrates (Reference Site) by Phylum

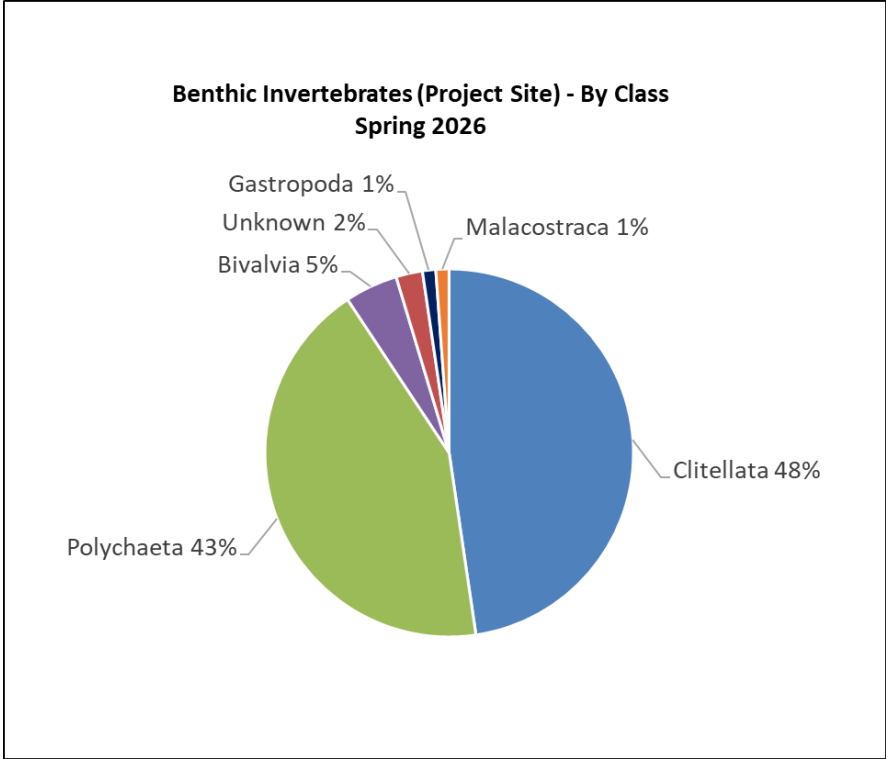


Figure 17. Benthic Invertebrates (Project Site) by Class

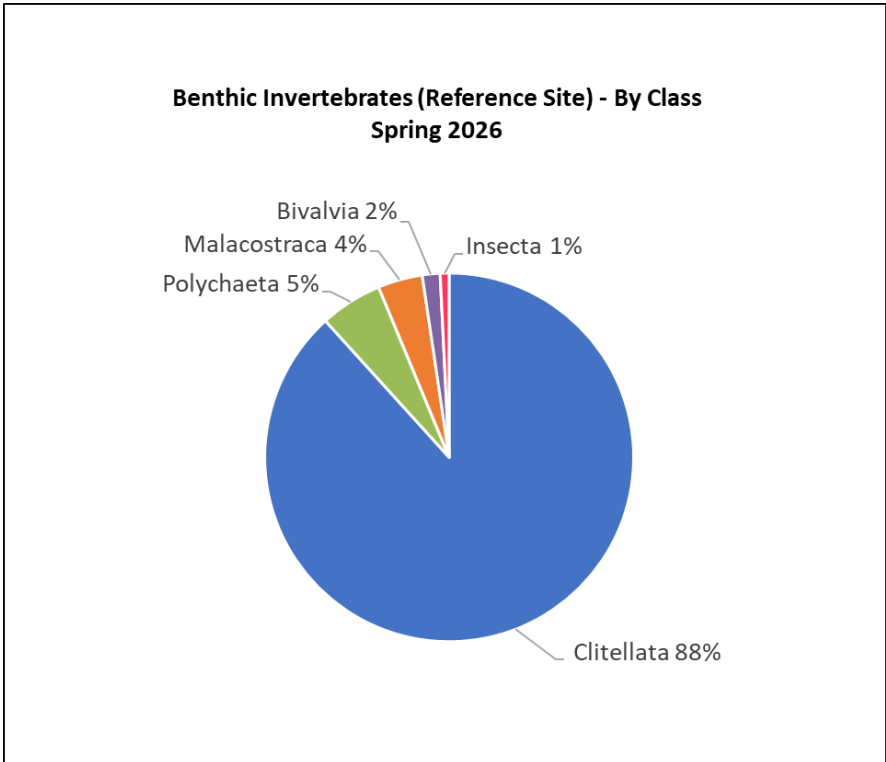


Figure 18. Benthic Invertebrates (Reference Site) by Class

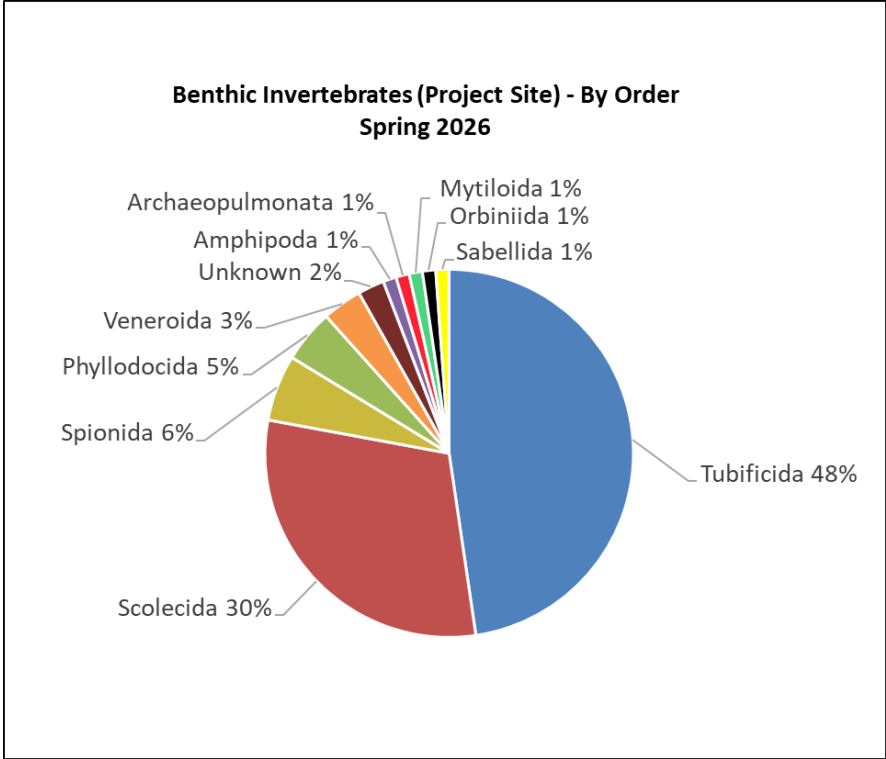


Figure 19. Benthic Invertebrates (Project Site) by Order

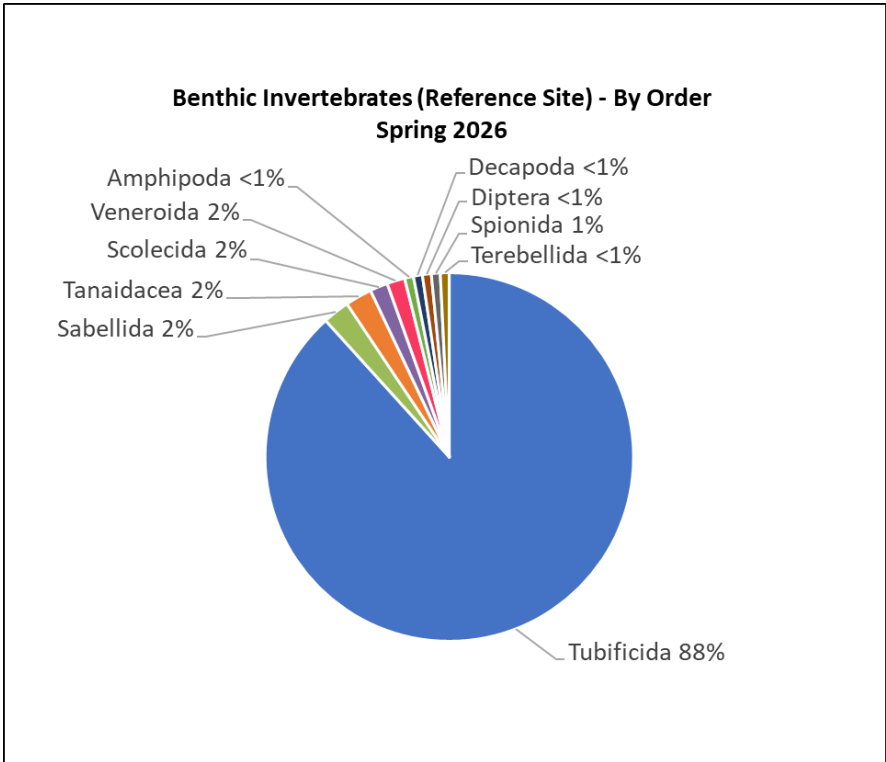


Figure 20. Benthic Invertebrates (Reference Site) by Order

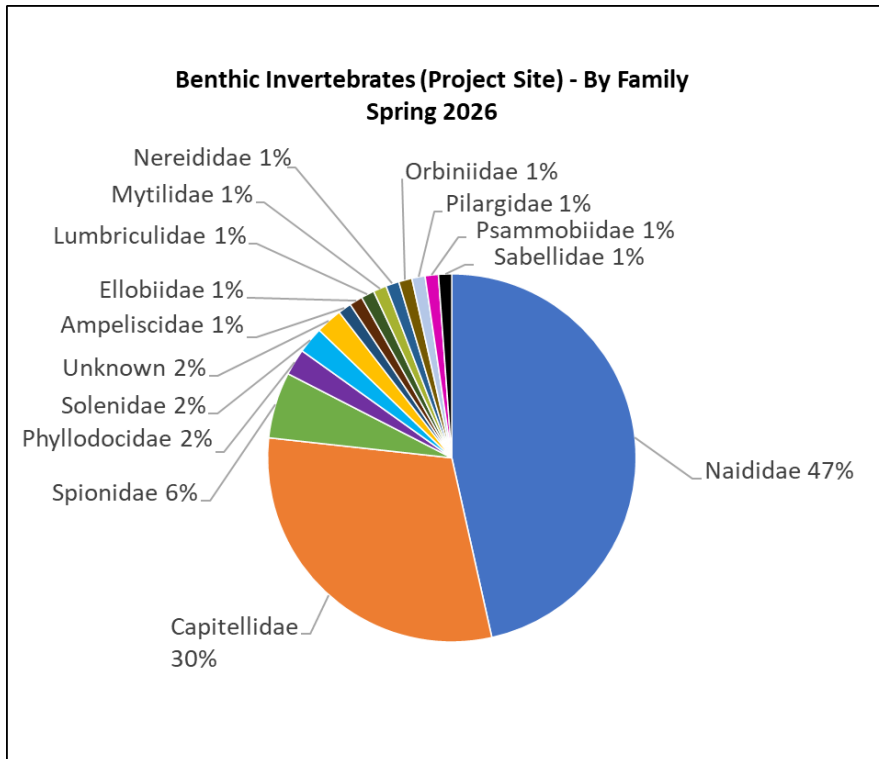


Figure 21. Benthic Invertebrates (Project Site) by Family

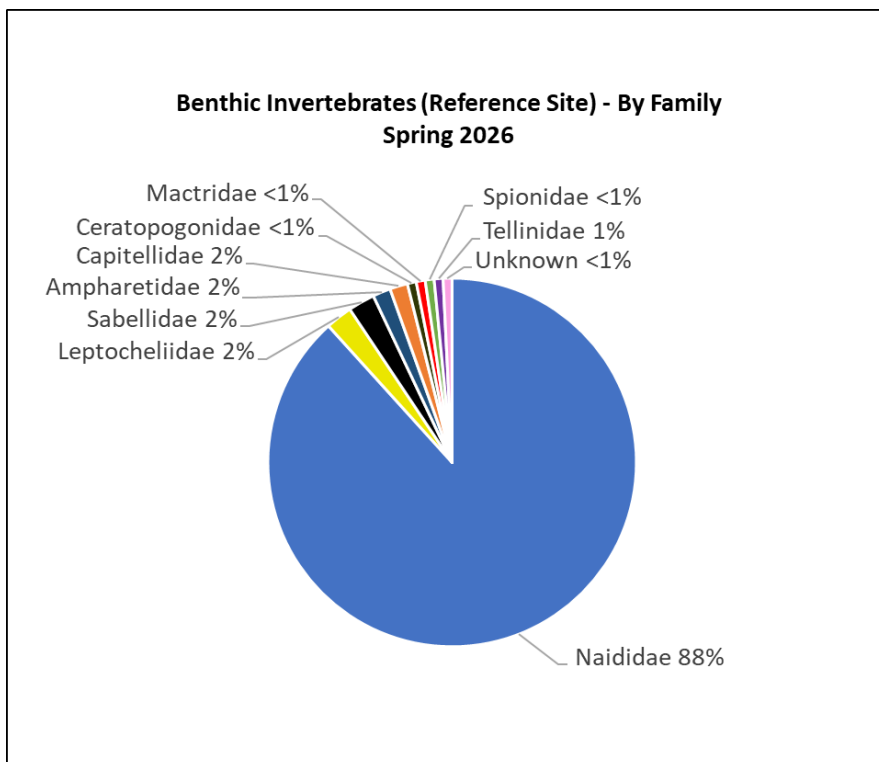


Figure 22. Benthic Invertebrates (Reference Site) by Family

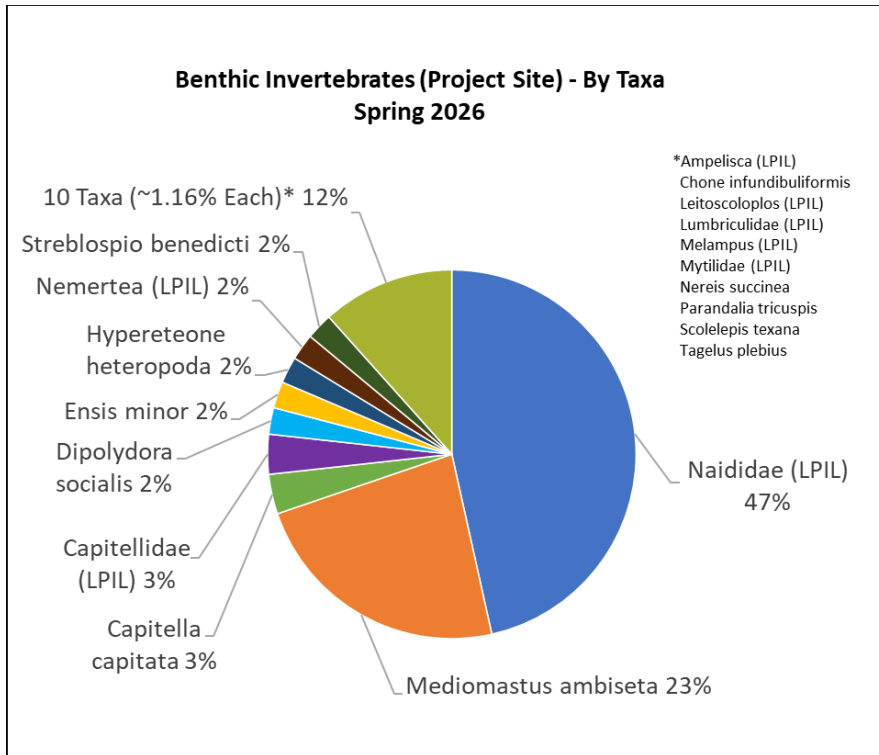


Figure 23. Benthic Invertebrates (Project Site) by Taxa

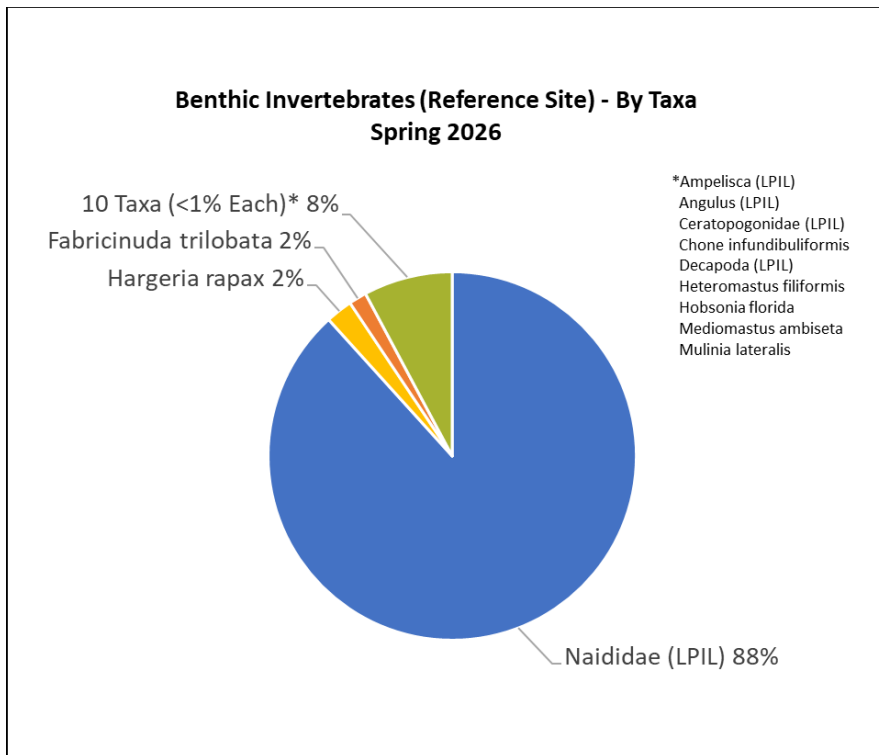


Figure 24. Benthic Invertebrates (Reference Site) by Taxa

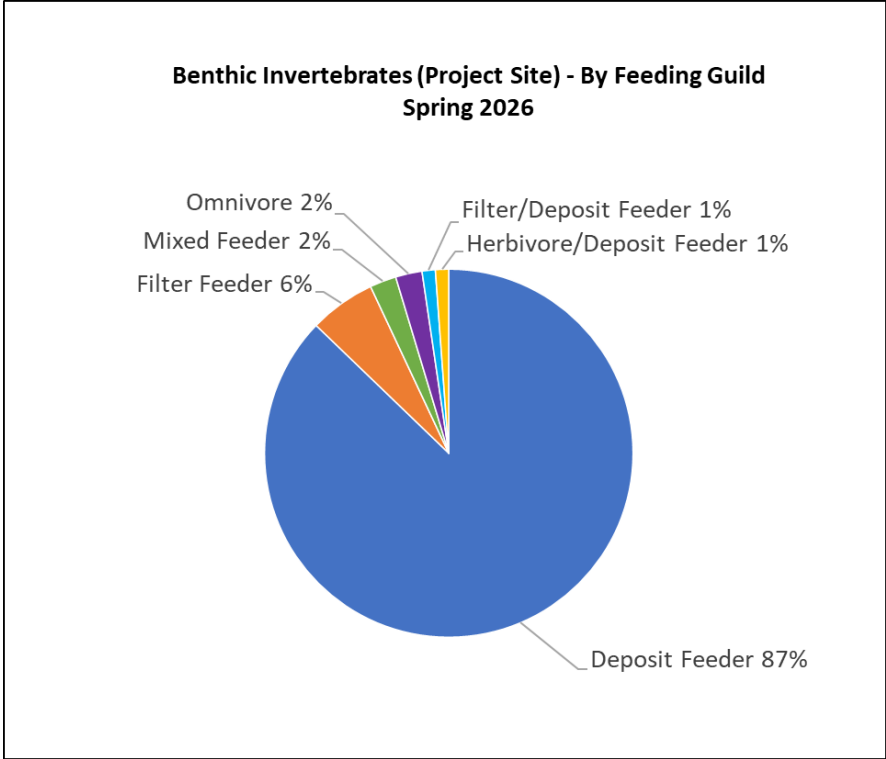


Figure 25. Benthic Invertebrates (Project Site) by Feeding Guild

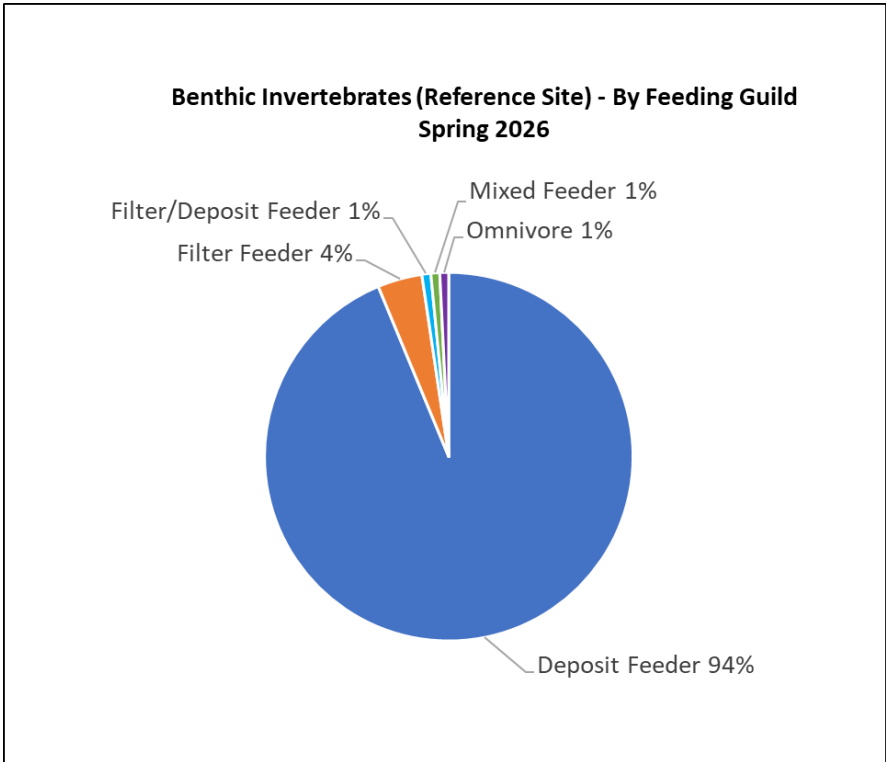


Figure 26. Benthic Invertebrates (Reference Site) by Feeding Guild

Panoramic Photo Monitoring

Project Site Photo Photos



Figure 27. Project Site Photo Point T1 – 4/2/2026



Figure 28. Project Site Photo Point T2 – 4/2/2026



Figure 29. Project Site Photo Point T3 – 4/2/2026



Figure 30. Project Site Photo Point T4 – 4/2/2026



Figure 31. Project Site Photo Point T5 – 4/2/2026



Figure 32. Project Site Photo Point T6 – 4/2/2026

Reference Site Photos



Figure 33. Reference Site Photo Point T7 – 4/2/2026



Figure 34. Reference Site Photo Point T8 – 4/2/2026



Figure 35. Reference Site Photo Point T9 – 4/2/2026

Other Photo Documentation



Figure 36. Benthic Community Sampling (4/27/2026)



Figure 37. Spring 2026 Vegetation Monitoring (4/27/2026)



Figure 38. Sediment Accretion Monitoring Station (PVC Post Pairs; Station SP-1) and Marsh Expansion Between Breakwater and Shore (4/27/2026)



Figure 39. Oyster and Other Bivalve Colonization on Breakwater (2/10/2026)



Figure 40. Marsh Expansion Behind Breakwaters



Figure 41. SAV Colonization Behind Breakwaters