# Site Report: Duke Marine Lab

*Original restoration completed in 2002*

This site was created through a collaboration between Duke University Marine Lab and the North Carolina Coastal Federation with funding from NOAA's Community Based Restoration Program. The project converted a previously hardened shoreline to a marsh sill living shoreline.

## Where, What, Why

This project involved the replacement of a hardened shoreline on Pivers Island in Beaufort, NC with a granite sill living shoreline (Figure 1). The original hardened shoreline was a seawall with cement fish pens that extended from the seawall to approximately 50 feet offshore. The seawall and fish pens were completely removed and the living shoreline was constructed **as a demonstration of the potential for living shorelines to defend against erosion while also providing valuable shoreline habitat.**

**Figure 1**. Aerial image of Duke Living Shoreline from 2019

## How

Construction of the living shoreline involved placement of clean, sand fill that was graded to an 8% slope, followed by installation of an 80 m long granite sill at the shoreward edge, and creation of a sand berm (~ 2 feet tall) at the marsh/upland transition. The berm was planted with red cedars. The marsh component was grid-planted with nursery grown plugs of *Spartina alterniflora* at low marsh elevations and *Spartina patens* at high marsh elevations (Figure 2). The sill was built as a pyramid of granite rubble with a base elevation near the mean low water mark and a peak elevation just above mean sea level. The sill is curved so that both ends join the existing sea wall, and includes two drop downs (sections where the max sill height is ~ 1 foot lower than the rest of structure), each 6 feet in length, to allow fish utilization of the marsh. The long-term monitoring plan for this site involves documenting vegetative community composition and total cover at 30 fixed locations. In addition, two surface elevation tables (SETs) installed at this site provide the ability to track changes in elevation over time with mm scale resolution. The SET data collection began in 2004 and the vegetation data collection began in 2008.

**Figure 2**. Duke Marine Lab Living Shoreline shortly after construction and planting.

## Site Physical Characteristics

The western shoreline of Pivers Island, where the Duke Living Shoreline is located, is in a small (max fetch < 1km), shallow (max depth < 1.5 feet MLLW) basin. The predominate southwest winds experienced at this site result in wave heights that average 10-15 cm (Figure 3).

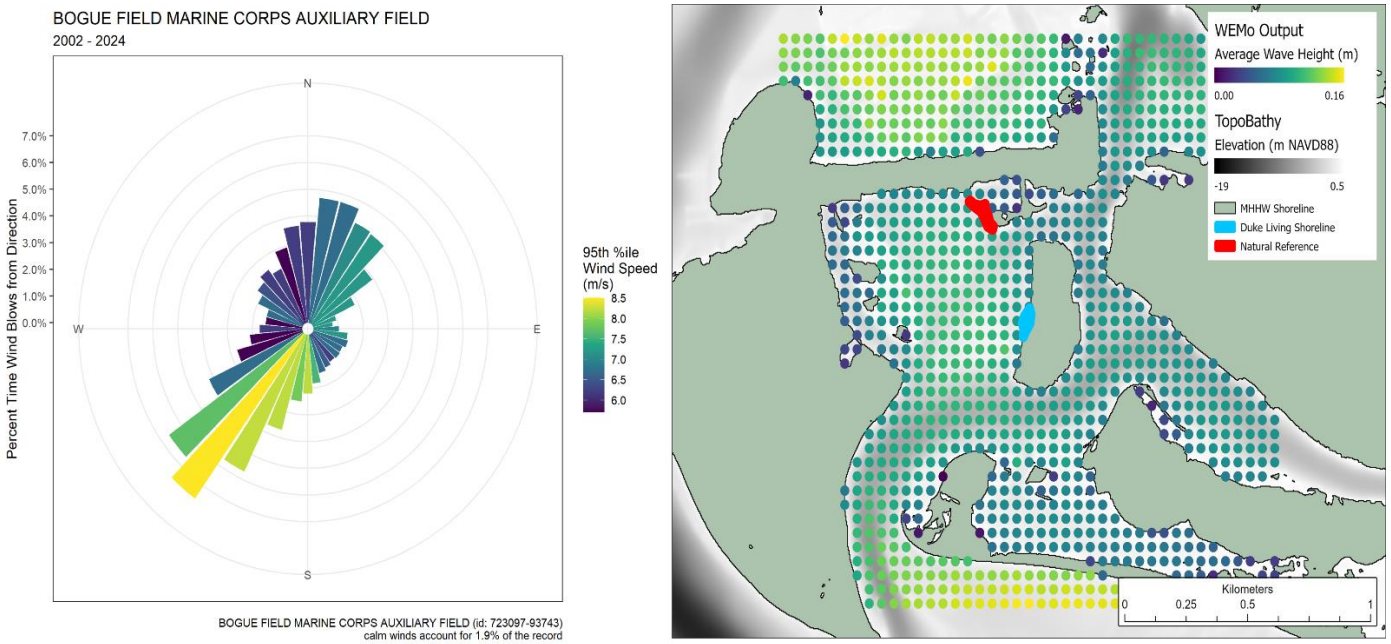


**Figure 3**. Average recorded wind conditions over the project lifespan (left) were used to model wave heights in the vicinity of each project area using the Wave Exposure Model (WEMo, right). Colored points represent modeled wave heights within a 2 x 2 km grid surrounding the project site. The Duke Sill is represented by the blue polygon; the natural reference site is represented by the red polygon. Gridded points are spaced 50 m apart.

## Performance Over Time

The rock sill at the shoreward edge of this site has effectively held the line against shoreline erosion. Wave gauges deployed waterward and landward of the sill suggest that incident waves are attenuated by up to 88%, with an average wave attenuation of 45%. For reference, average wave attenuation at a nearby natural and restored oyster reefs were 16% and 18%, respectively. Comparison of elevation surveys conducted on the sill just after construction and again in 2025 indicate that the sill elevation has been consistent over time (i.e., there has been no measurable settling of the structure under its own weight, or wave-induced movement). The sides and base of the sill have become encrusted with oysters (Figure 4) and independent research has confirmed that this sill and others like it support higher abundances and diversity of fish than nearby shorelines without sills[1]. Over the lifespan of the Duke Living Shoreline site, the nearby natural marsh that serves as a reference site has experienced measurable edge retreat.

Figure 4. Duke Marine Lab Living Shoreline Sill (left) with close up of oyster colonization (right)

The planted vegetation grew in quickly and has become more diverse through natural recruitment of additional species as the site has matured. As of 2025, the vegetative community at the sill marsh is visually indistinguishable from nearby natural shoreline-fringing marshes at the same elevation in terms of community composition. Comparison of data from surface elevation tables (SETs) installed at this marsh and at a nearby natural marsh without a sill show that the sill-protected marsh is gaining elevation while the unprotected marsh has lost elevation over the same time period (Table 1).

| Elevation change (mm/year) | Lower-marsh | Mid-marsh |
|---|---|---|
| **Sill Site** | **2.0** | **0.3** |
| **Natural Site** | **-2.3** | **1.9** |

Over the same time period encompassed by the marsh surface elevation data records (2004 through 2024), average mean seal level has increased by 9 cm (3.5 inches) which equates to a rate of 4.5 mm/year. While the sill-marsh is doing a better of job of keeping pace with sea level than the natural marsh (at lower marsh elevations), it is slowly falling behind local relative sea level rise.

## Sediments and Carbon Accumulation

The sediments used to create this site consisted of 95% sand. Surface sediments at this site continue to be predominantly sand although the lower elevation regions just inside of the sill are noticeably siltier than the higher portions of the marsh that experience less frequent inundation. Just after construction, the average percent organic matter content of surface (< 5 cm) sediments was 0.5% of the total weight; by 2015 this value had increased to 3.5%. As of 2024, total carbon content in surface sediments averaged ~ 450 grams per square meter.

## Performance Summary

Sill based living shorelines like the one at Duke Marine Lab are highly effective at attenuating wave energey and protecting against shoreline erosion. At this site, the vegetative cover closely mirrors that of nearby natural marsh shorelines and the sill has been shown to support an abundance of fish and bivalves. Cumulatively these observations indicate that the site is providing valuable habitat that is similar to that provided by natural shorelines. While the structure is effectively holding the line against erosion, it is becoming lower in the tidal frame over as sea levels continue to rise. Eventually it is likley that the structure will require modification in order to afford the same level of protection.

[1]Gittman, R.K., C.H. Peterson, C.A. Currin, F.J. Fodrie, M.F. Piehler and J.F. Bruno. 2016. Living shorelines can enhance the nursery role of threatened estuarine habitats. Ecological Applications. 26(1): 249-263.

Report Credit: Davis, J., Walker, Q., Puckett, B., LeClaire, A., Bost, M and Giannelli, R (2024). Site Report: Duke Marine Lab Living Shoreline. US DOC NOAA NOS National Centers for Coastal Ocean Science (NCCOS). Marsh Sill Living Shorelines.