Influence of Land Development on Marsh Soil Dynamics in Barnegat Bay, New Jersey

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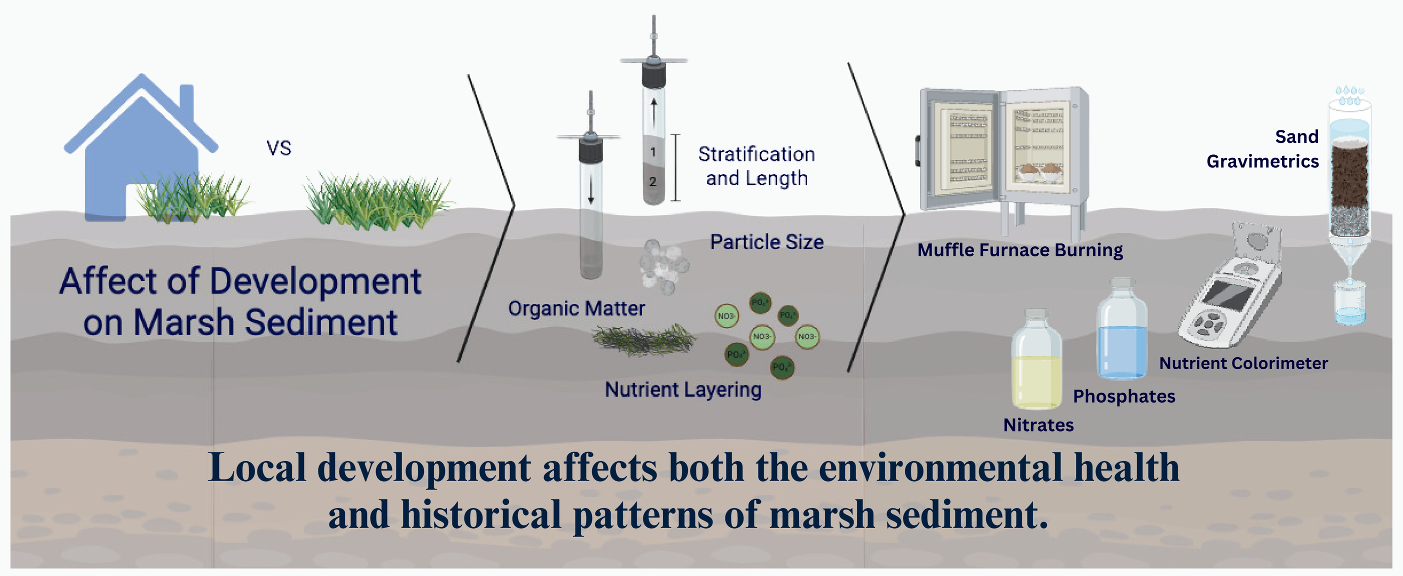
Objective: to reconstruct the historical ecological patterns within marsh ecosystems along Barnegat Bay, New Jersey, with a specific focus on developmental impacts on sediment stratification.

Visual Abstract



Introduction

- Tidal wetlands provide ecosystem services that are heavily relied on, but are continuously threatened by anthropogenic disturbances, such as urban development, impacts of climate change, and hydrogenous variations.
- Utilizing sediment stratigraphy in local marsh ecosystems provides a detailed record of historical and modern environmental systems.
- Larger, heavier particles (greater than 20 µm), such as pebbles and sand, sink faster to the bottom. Finer particles, like silt and clay, stay suspended in water, potentially indefinitely (Stumpf, 1983).
- Sediment compaction facilitates the sequestration of carbon, called "blue carbon," which, because of continual redistribution of sediments, gets trapped, and progressively buried deeper into the marsh substrate.
- Reduction in carbon storage capacity, through processes such as erosion, oxygen exposure, and temperature fluctuations, within marsh ecosystems exacerbate the challenges of mitigating climate change.
- High levels of nitrogen and phosphorus, originating from agricultural fertilizers, can lead to eutrophication and accelerated proliferation of macroalgae, in addition to human-induced activities, including construction and deposition of materials, presenting substantial risks by altering historical dynamics of marsh systems (Razaq et al., 2017).

Methodology

Sampling

- Two undeveloped sites: Sedge Island Marine Conservation Zone (Waretown, NJ) and Cedar Run Dock Road (Manahawkin, NJ)
- Two developed sites: Tuscarora Ave (Barnegat, NJ) and Long Beach Island Foundation of the Arts and Sciences (Long Beach, NJ)
- Each developed site has three subsequent sample locations, and each undeveloped site will have two subsequent sample locations
- Each location has a total of 4 samples: shoreline (0 m out), 2 m out, 4 m out, and 6 m out
- Developed sites have a total of 12 samples
- Undeveloped sites have a total of 8 samples
- In total, we took 40 piston core samples
- Samples were taken with a piston core
  - Layers were determined, extracted, and measured (cm) in the field based on color and textural changes in sediment

Sedimentation

LaMotte Settling Tubes were used to collect the sand fractions for each sample: add 15mL of sediment, add 30mL of water, shake, observe value of material settled out after 30 seconds

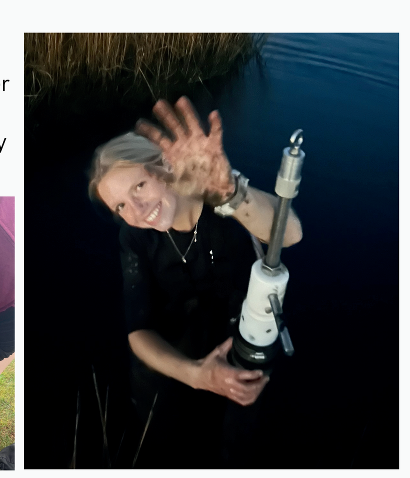
Mapping

Created tables using self-derived data and displayed the means on the generalized coordinates. The size and color of the points were then adjusted to correlate with the data. All mapping was done using ArcGIS Pro software.

Organic Matter

About 10 g of each sample was measured before and after being burned in the muffle furnace

Figure 1 (left to right): Piston core proudly displayed by Abby; Lilly measuring the length of each distinguishable layer from the extracted core, Abby preparing the piston core for sampling; Lilly taking a piston core sample. All images display our field sampling practices.



Results

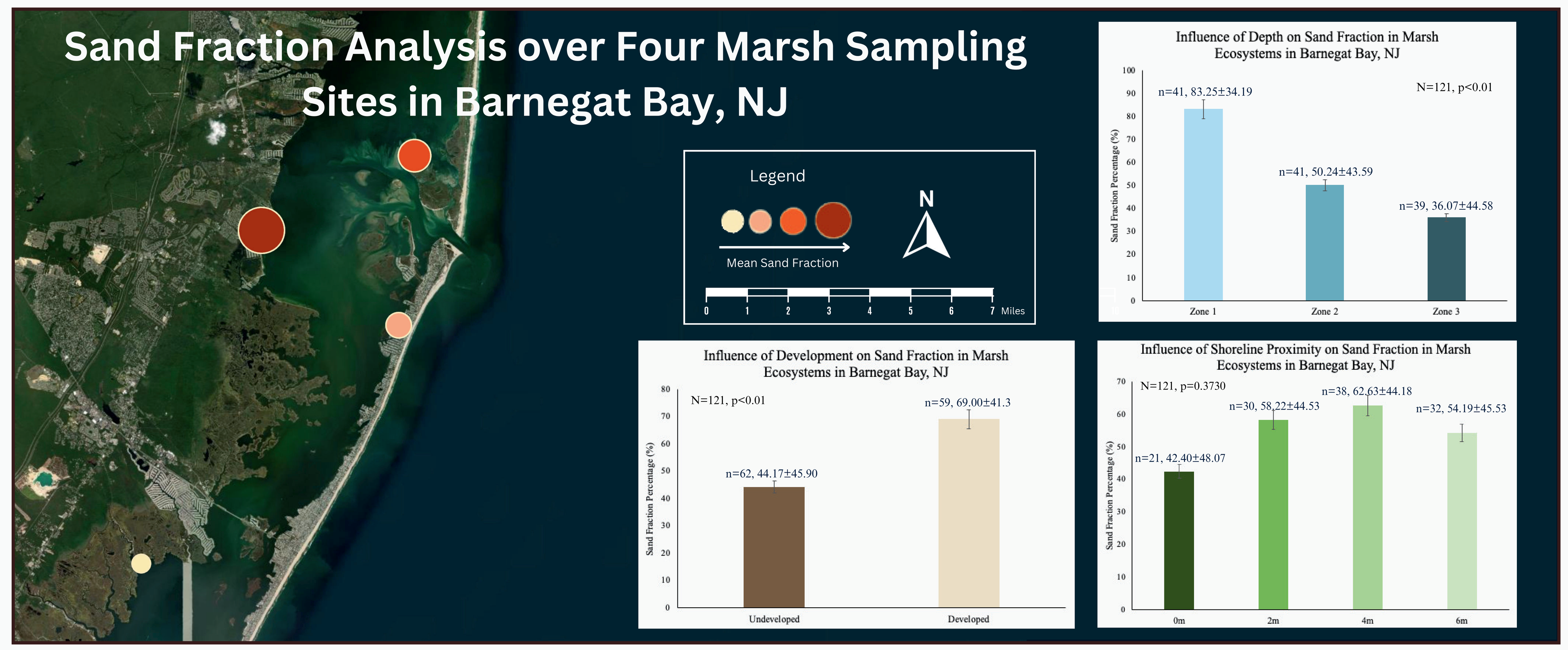


Figure 2: Comprehensive analysis of sand fraction between zone depth, shoreline proximity, and developmental status. The map displays each site (2 undeveloped and 2 developed), with both size and color showing the comparisons of sand fraction percentages. Zone 1, 4m from the shoreline, developed areas, and Tuscarora Ave all had the highest sand percentages respectively (error bars: 5%).

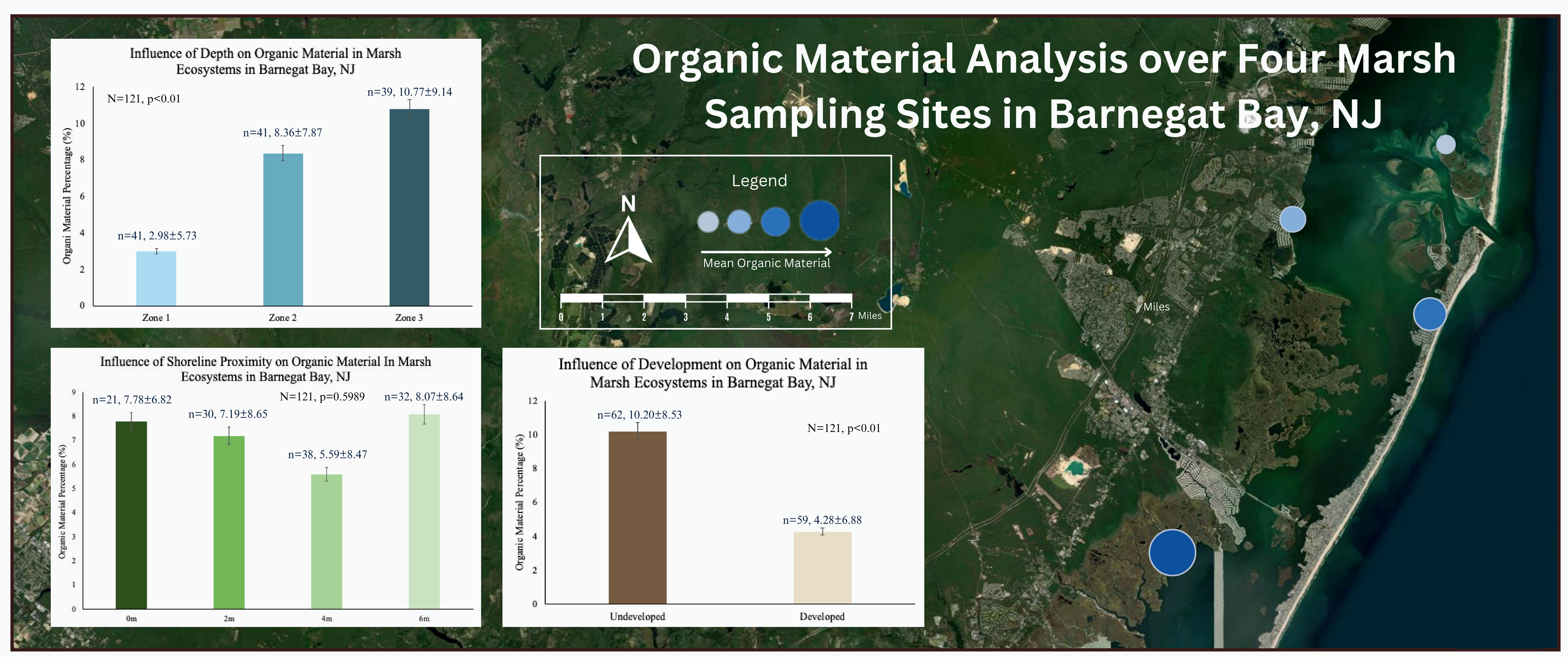


Figure 3: Comprehensive analysis of organic material between zone depth, shoreline proximity, and developmental status. The map displays each site (2 undeveloped and 2 developed), with both size and color showing the comparisons of organic material concentrations. Zone 3, 6m from the shoreline, undeveloped areas, and Cedar Run Dock Rd all had the highest organic percentages respectively (error bars: 5%).

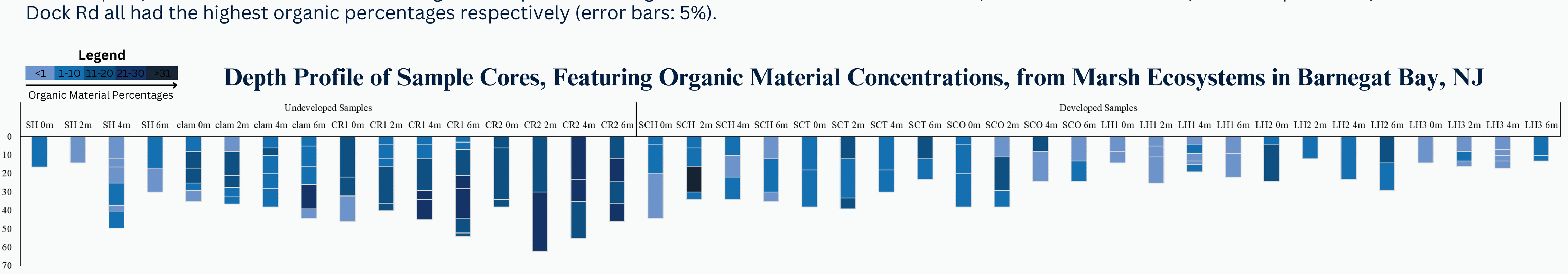


Figure 4: Comprehensive analysis of sample cores, with the length of each layer included, and organic material concentration range by color. All testing locations, separated by development status is included, with Cedar Run Dock Road (location 2 - CR2) 2m from the shoreline has the deepest core, and Tuscarora Ave (location 2 - LH2) 2m from the shoreline shallowest core.

Discussion

- All tested variables, except nutrients, all showed significant differences between the developed and undeveloped sites.The undeveloped sites had more layers, deeper cores, more organic material, and lower sand fractions, supporting the idea that the undisturbed, undeveloped marsh ecosystems show a greater number of historical trends and are composed of finer, less compact sediments.
- There was a significant difference between Zone 1 (2.98±5.73) and Zone 3 (10.77±9.14), and Zone 2 (8.36±7.87) and Zone 3 for organic material, displaying the organic material concentrations are dependent on the depths found in the marsh, and that the highest values of organics were found deepest. Additionally, between Zone 1 (83.25±34.19) and Zone 2 (50.24±43.49), and Zone 1 and Zone 3 (36.07±44.58) for sand fraction, there was a difference.
- Species' habitat predictions based on sediment type results can be concluded, including species such as Mercenaria mercenaria, the hard clam, and Zostera marina, common eelgrass, which both provide essential contributions to the environment, such as recreation and stabilization of shorelines, and prefer to live in sand to fine-sediment types (Lønborg et al., 2024).
- The New Jersey Bay Islands Initiative is one example of a total salt marsh restoration project from Bay Head to Absecon Inlet, determining crucial resources that would be best suited to help protect and preserve marsh ecosystems.

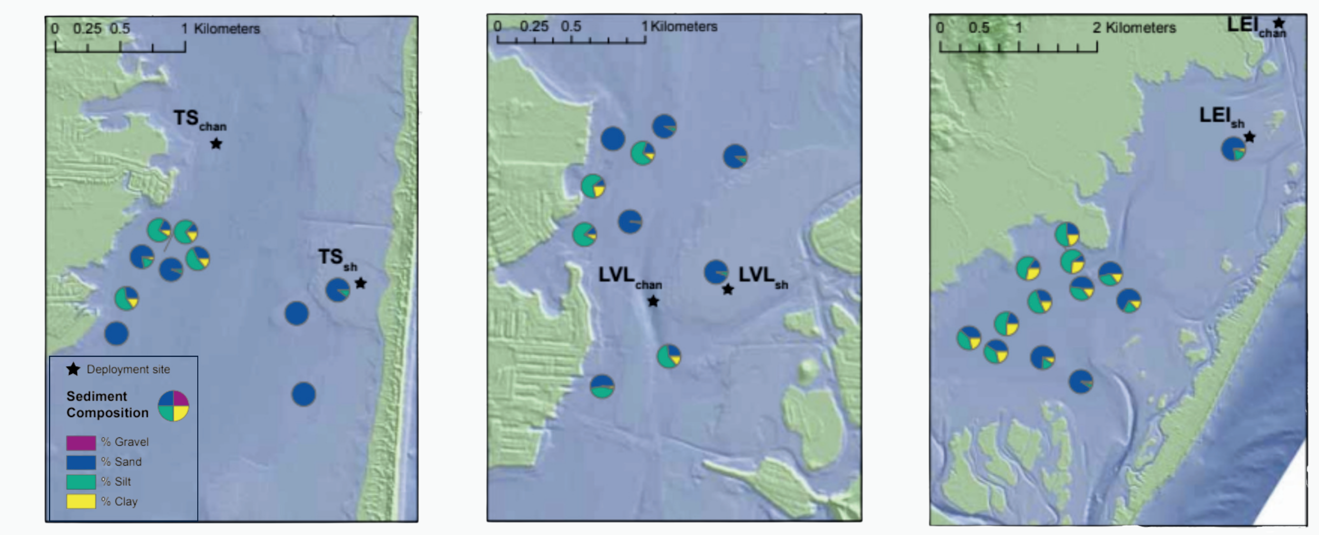


Figure 5: Sediment composition throughout specific testing points in Barnegat Bay, NJ. Each point is a pie chart relating to the composition of the sediment: gravel, sand, silt, and clay. Our sample sites with the highest sand fractions, including Sedge Island, are near or on shoal sites as defined in this study. The hydrology, especially in the back-bay, is a major component in sand dispersion and overall sand fractions in all locations (Ganju et al., 2014).

Conclusions

- Results supported the hypothesis
  - Statistical analyses indicate that anthropogenic factors, particularly development, significantly affect both the ecological health and historical dynamics of marsh ecosystems.
- Maintaining the integrity of the marsh system is vital in studying the changes over time, and assessing what protective measures are necessary in order to preserve salt marshes as they are faced with more extreme and destructive conditions.
- This study has created a comprehensive marsh analysis that can help with coastal resilience planning, restoration projects, and understanding past storm histories in Barnegat Bay, NJ.
  - Expansion of this project would consist of more sites and attempting to work side-by-side with other Barnegat Bay initiatives

Acknowledgments

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Selected References

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