OBSERVATIONS AND MODELING OF EROSION AND RECOVERY OF A COUPLED BEACH-DUNE SYSTEM

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MOTIVATION

The geomorphic and ecological vulnerability of barrier islands is influenced by the way they respond to oceanographic and anthropogenic forcing over a broad range of temporal scales. Integrated models capable of simulating these processes are increasingly necessary to understand barrier island trajectories under future conditions and to aid in management decisions by evaluating the impact of potential restoration activities. While there are numerical models capable of simulating some of the dominant barrier processes, the role of beach berm evolution is rarely included despite the important function of berms in sustaining beaches, enabling dune growth via Aeolian transport, and mitigating backshore and dune erosion during storm events. This is primarily due to a lack of available data that resolves details of beach profile evolution at necessary temporal scales (e.g., seasonal, post-storm recovery, etc.) to test and develop models and the inherent difficulty of including these intra-annual processes into decadal scale models of barrier island evolution. Here we describe a unique and growing dataset of environmental forcing and barrier island topographic change. We also use the dataset to develop and test a model for barrier island evolution and quantify the role of storms, moderate wave conditions, and wind-driven transport in dictating coastal change on various timescales.

STUDY SITE & DATA COLLECTION

Masonboro Island, is a transgressive barrier island juxtaposed between the two developed and regularly nourished islands in southeast North Carolina. It is part of the North Carolina National Estuarine Research Reserve and provides valuable habitat for a number of federally threatened and listed species. Masonboro Island reserve managers currently lack tools to make critical decisions about if, when, and where to advocate for sand placements on the island to reduce the vulnerability of ocean beach habitats and provide sediment that may overwash into backbarrier marshes to maintain critical habitats as sea-level rises. The data collected and models developed in this work are intended to aid in strategic planning for the reserve.

A synoptic dataset of storm-driven water levels, beach and dune topography via ground-based surveys and drone imagery, and Aeolian sediment transport volumes using two vertical arrays of sediment traps along Masonboro Island, NC has been collected from August 2018 (pre-hurricane Florence) to present at 8-12 week intervals. Sedimentological characteristics are also documented. An array of offshore wave and meteorological buoys is used to characterize the oceanographic forcing and two weather stations have been installed on the island to quantify wind processes.

The dataset includes three hurricane events (Florence, Dorian, and Isaias) and subsequent recovery periods. Significant evolution of the beachface is present but extremely variable across the different areas of the island.

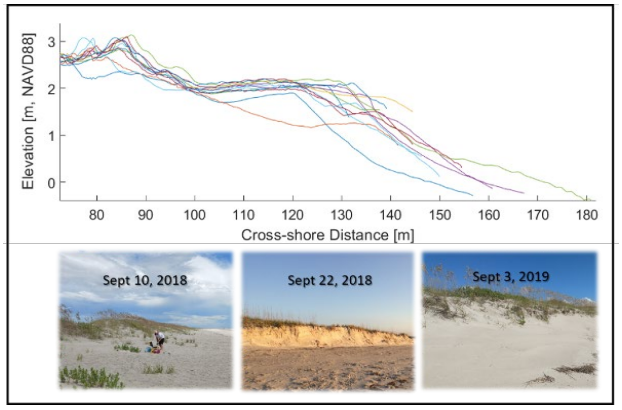

Figure 1 – (top) Beach profiles from the southern end of Masonboro Island collected from 2018 to 2022. (bottom) Photos of the primary sand dune from September 2018 – September 2019.

MODELING

Storm-driven processes during the study period have been accurately simulated (Beckman et al. 2021) but here data from Masonboro Island is used to test, calibrate, and extend the new XBeach-Duna model which was developed to simulate erosion and recovery of the coupled beach-dune system (Roelvink and Costas, 2019). The model includes the contribution of sediment to the profile from longshore transport, Aeolian processes, vegetation characteristics, and storm-driven wave runup. Based on the literature, the model has been applied at only a few locations and the data at Masonboro Island is well-suited for model testing and refinement. XBeach-Duna is incorporated into a larger modeling framework that includes a schematized wind and wave climatology and statistical longshore transport gradients. The model has been applied at multiple transects on Masonboro Island and is sensitive to the wind and wave schematizations.

REFERENCES

Beckman, J. N., Long, J. W., Hawkes, A. D., Leonard, L. A., & Ghoneim, E. (2021). Investigating Controls on Barrier Island Overwash and Evolution during Extreme Storms. *Water*, 13(20), 2829.

Roelvink, D., & Costas, S. (2019). Coupling nearshore and aeolian processes: XBeach & Duna process-based models. *Environmental Modelling & Software*, 115, pp. 98-112.