Coupled Mapping and Modeling Approach to Quantify Historical Sediment Fluxes at Sandy Hook, New Jersey

Daniel J. Ciarletta, Mathew Sandefur, Christopher Tenebruso, & Jorge Lorenzo-Trueba
Department of Earth and Environmental Studies, Montclair State University, Montclair, NJ 07043

Abstract

Recent work has shown that long-term trends in the sediment budgets of coastal barrier islands are reflected not only in shoreline changes, but also in the surface morphology of relict and active foredune ridges. Using a cross-sectional morphodynamic model of barrier island foredune ridge and swale development, it is possible to quantify the magnitude of past changes in shoreface and foredune fluxes along prograding coastlines. In this study, we apply our model to a prograding barrier-spit, Sandy Hook, located at the mouth of Lower New York Bay, in New Jersey. Sandy Hook is a terminal depocenter for sand transported north along the Central Jersey coast, and the spit shoreline has advanced northward almost 1 kilometer since 1920, partly under the influence of episodic beach nourishment at downdrift locations. Utilizing a combination of historical aerial photos and subsurface imaging from ground penetrating radar (GPR), we construct a time-series analysis of recent shoreline change at the northern tip of Sandy Hook. We use this analysis to inform our model and quantify past sediment fluxes to the system, exploring the possibility of detecting the signal of beach nourishment in modern morphology. Ultimately, we use our investigation to begin inferring the sensitivity of Sandy Hook to natural and human changes in sediment budget, allowing for greater understanding of future change that may result from increasing rate of sea level rise and other anthropogenic forcing.

Oblique view of Sandy Hook from the Twin Lights of Navesink in Atlantic Highlands, NJ looking north towards New York City.

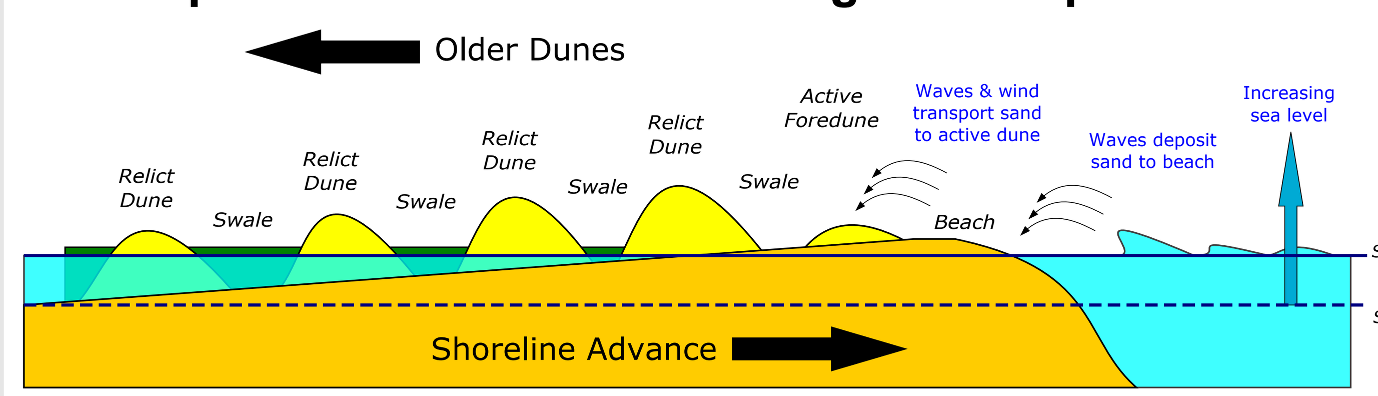
Overview of Sandy Hook

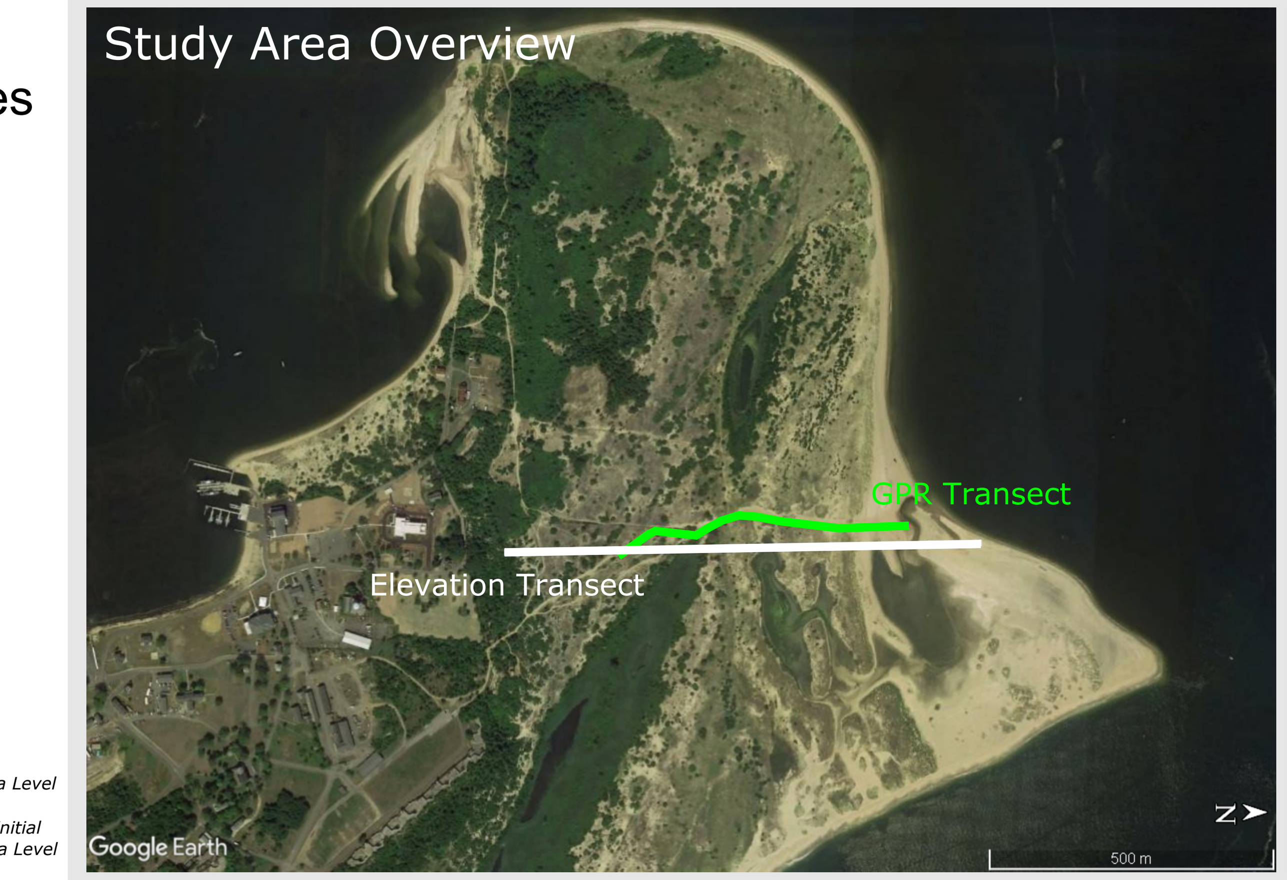
1920 photo of Sandy Hook overlaid on modern imagery. Modern shoreline highlighted in pink and 1920 shoreline shown in yellow. The tip of Sandy Hook has grown ~1 km northward since 1920.

Project Goals

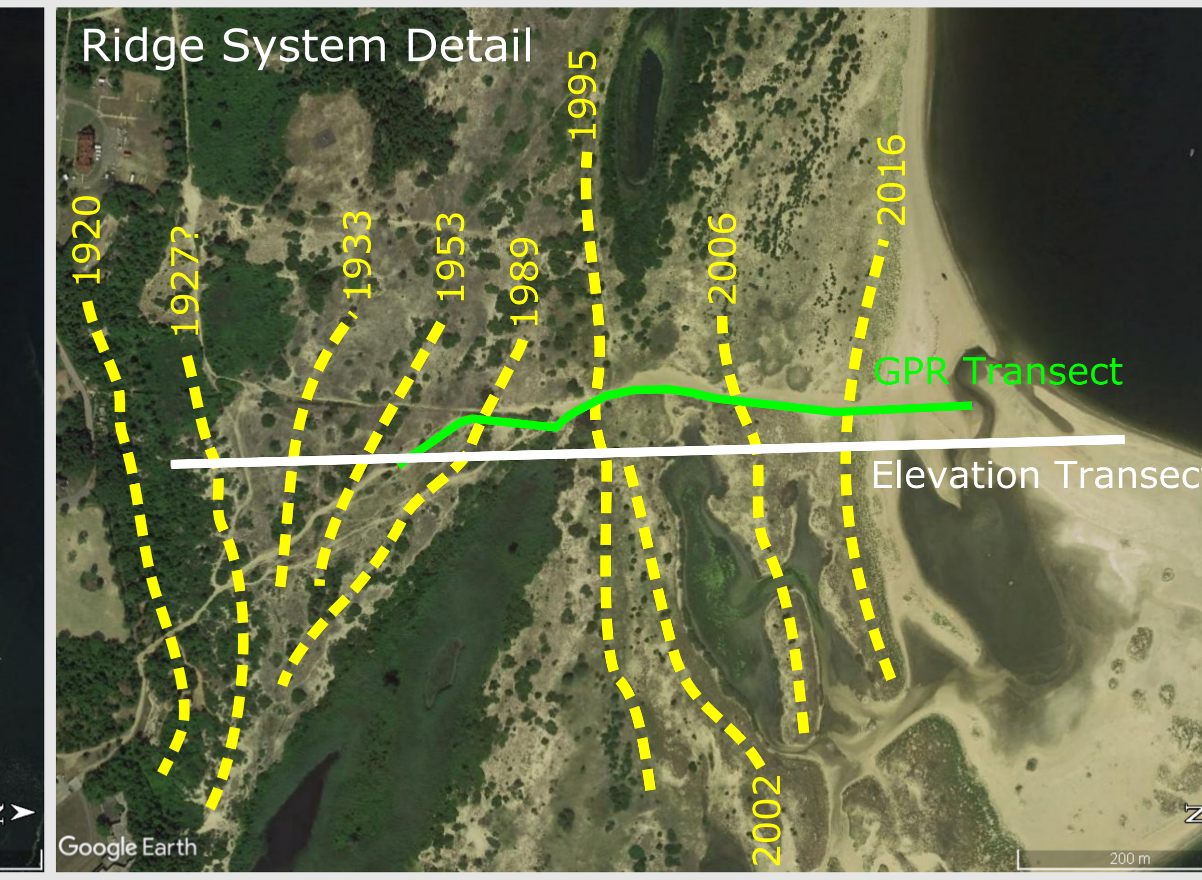
- Construct time-series of sand fluxes to beach and foredunes using LiDAR topography, historic aerial photo progression, and ground penetrating radar survey
- Use time-series to inform a cross-shore morphodynamic model of beach and foredune ridge development

Conceptual Model of Beach & Ridge Development



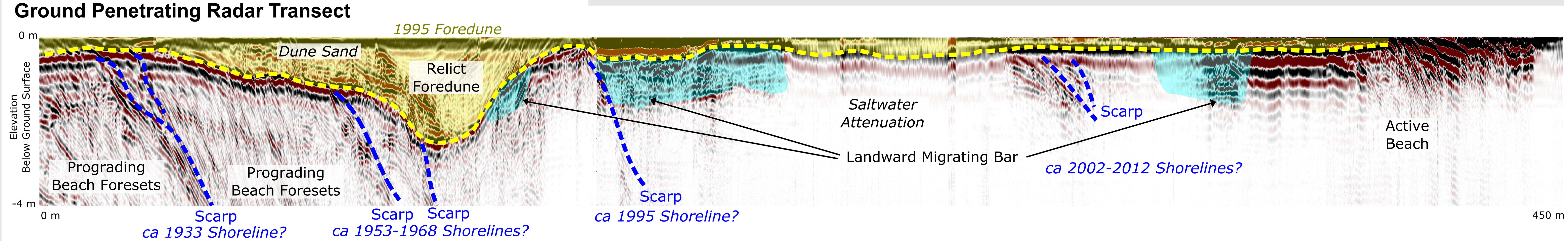


North-right oriented image of northern Sandy Hook, with study transects labeled. Transects cross multiple relict foredune ridges.

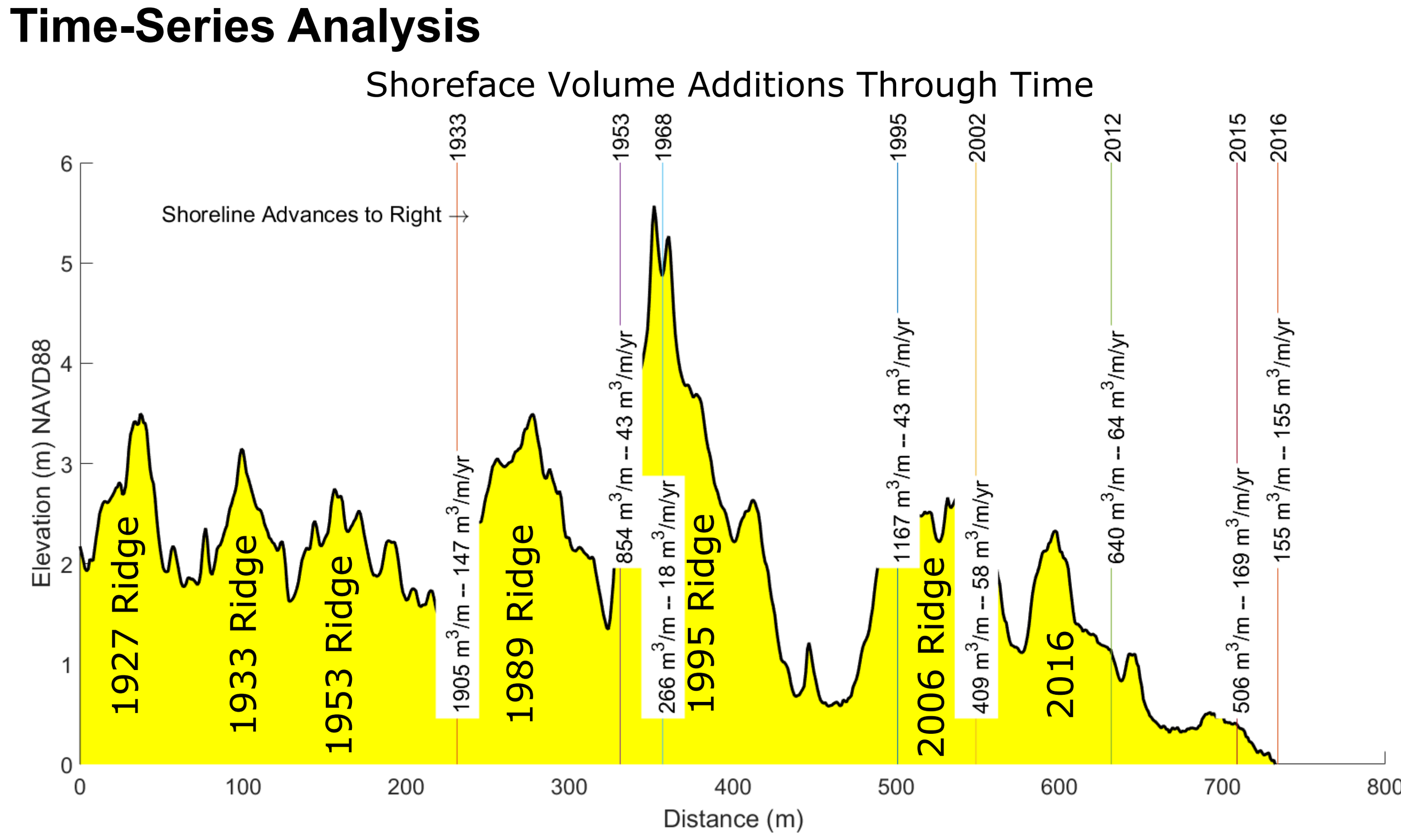


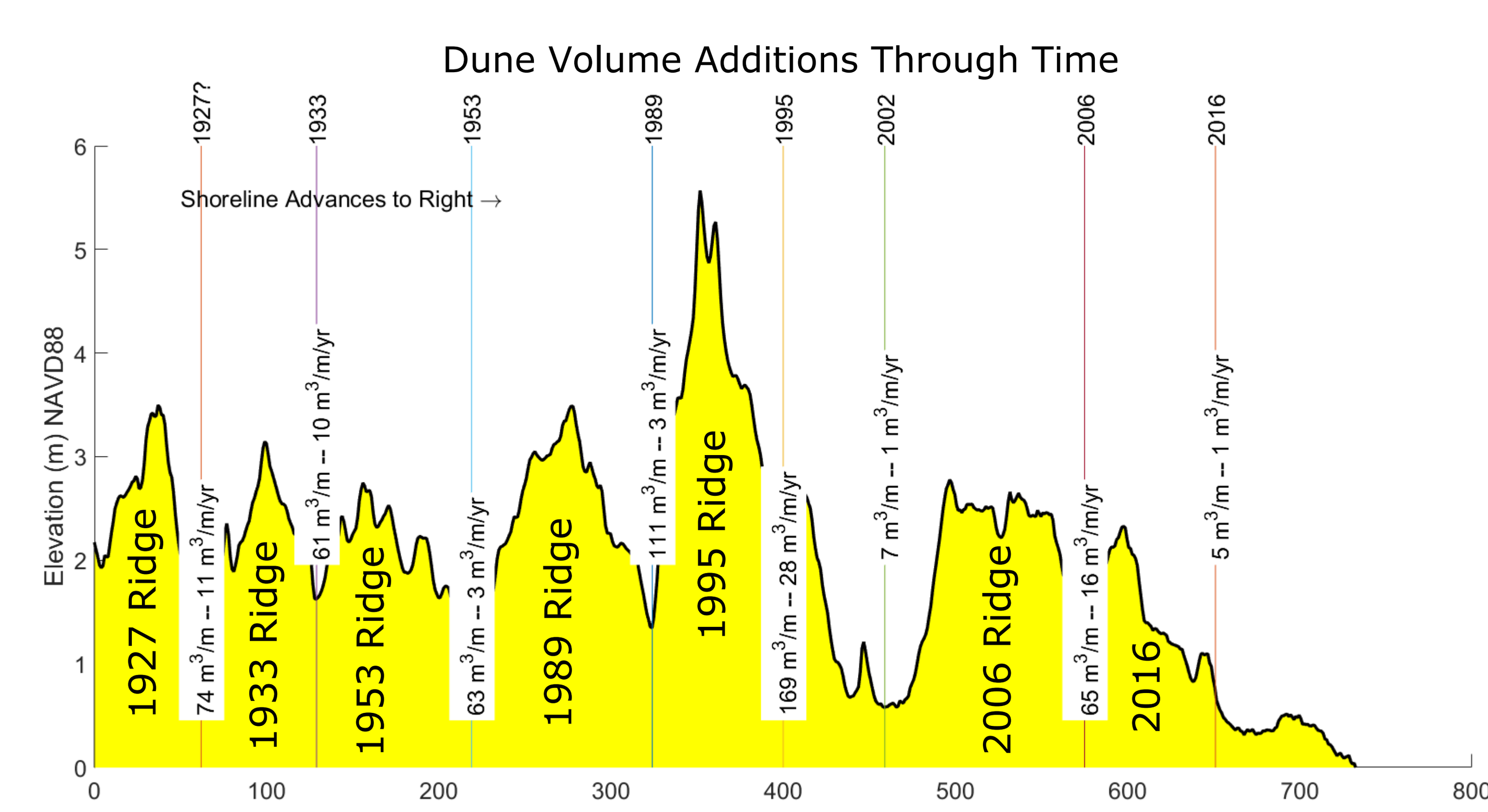
Detail of study area, with foredune crests delineated (yellow). Foredune ridges dated based on approximate year of abandonment, derived from historic aerial imagery.

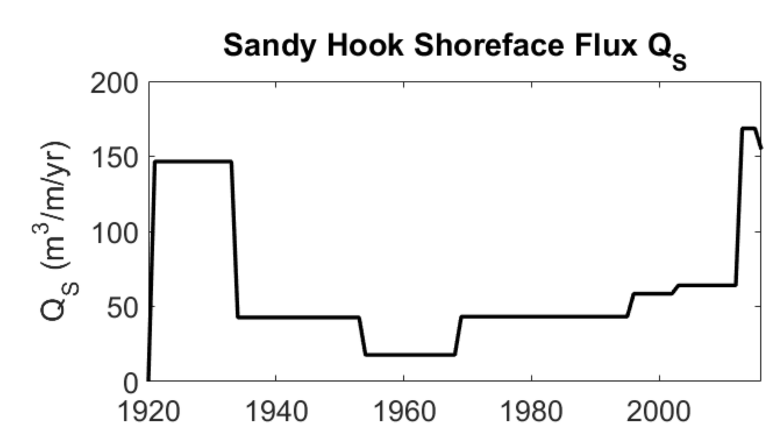
Ground Penetrating Radar Transect

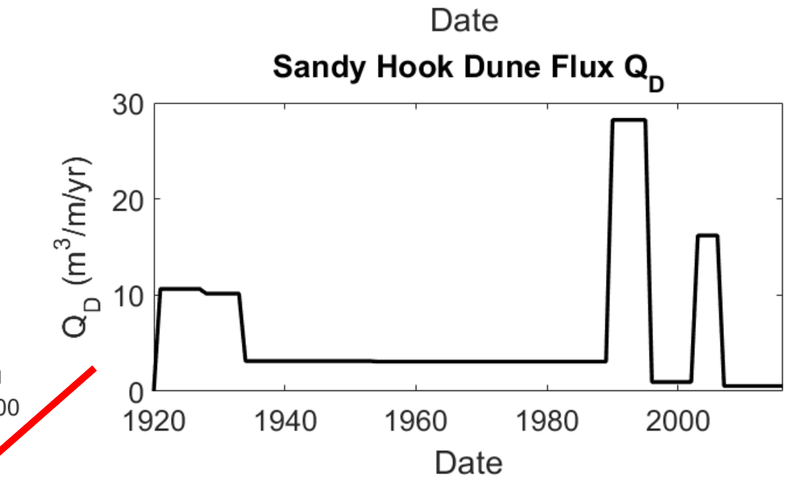


Time-Series Analysis

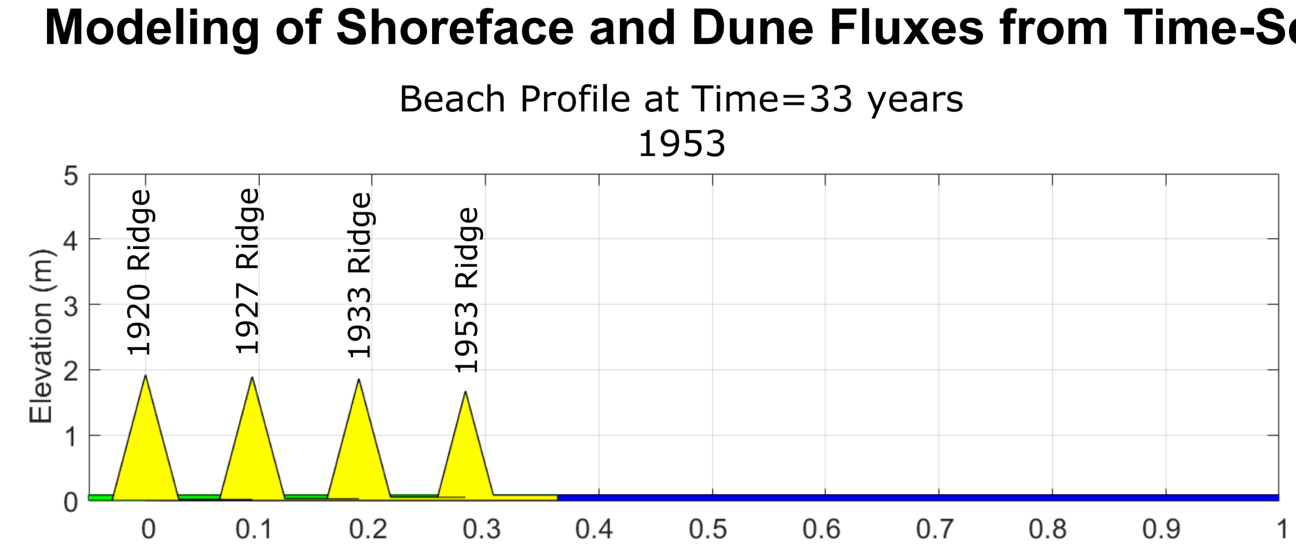


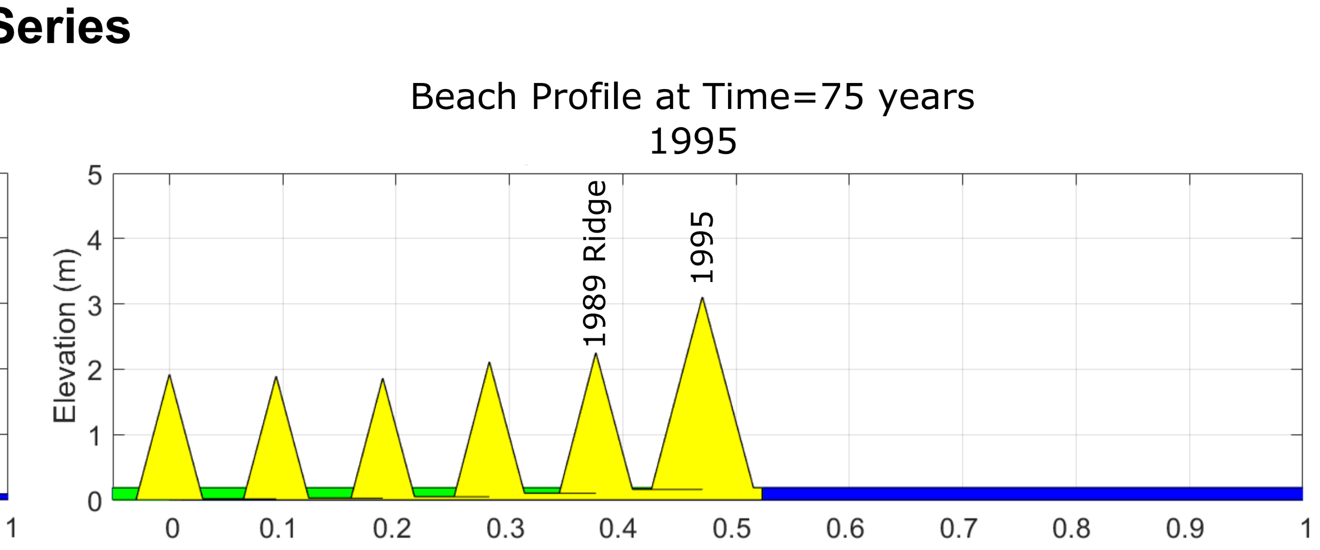


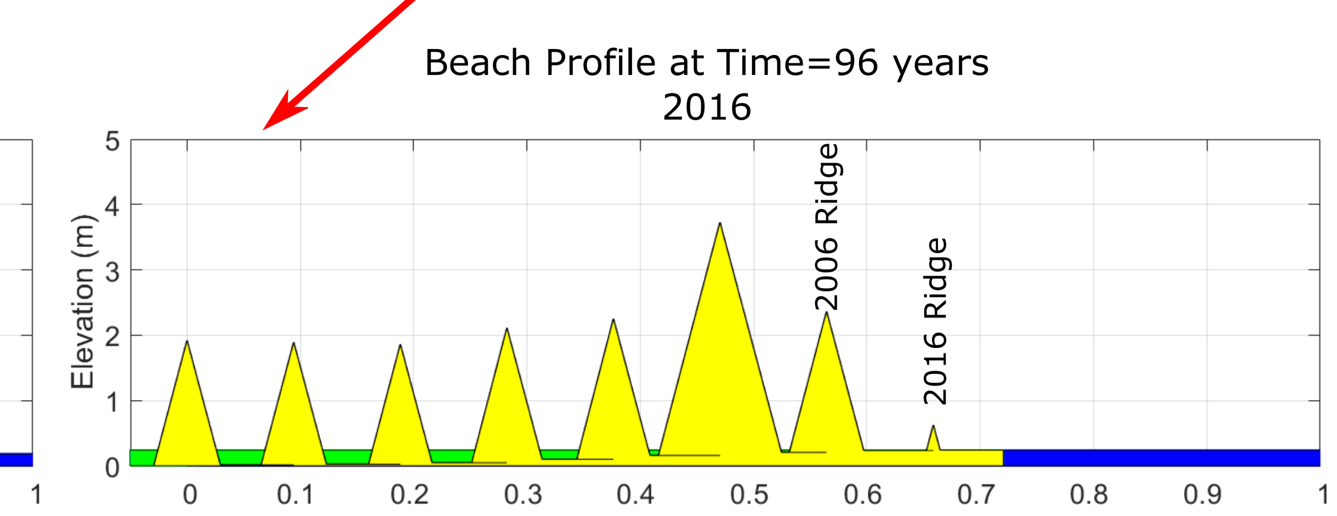




Modeling of Shoreface and Dune Fluxes from Time-Series







Conclusions: The model is able to capture the timing of ridge development based on the time-series, which suggests the framework could be used at Sandy Hook to perform sensitivity analyses on input fluxes. In the future, we intend to explore the impact of fluxes from beach nourishment.

Model Info: Ciarletta, D.C., Shawler, J.L., Tenebruso, C., Hein, C.J., and Lorenzo-Trueba, J. (in review). Reconstructing Coastal Sediment Budgets from Beach- and Foredune- Ridge Morphology: A Coupled Field and Modeling Approach.