MORPHOLOGICAL EVOLUTION OF A STABILIZED TIDAL INLET AND IMPLICATIONS FOR COASTAL INFRASTRUCTURE VULNERABILITY

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INTRODUCTION

The location of tidal inlets in the interface between oceans and estuaries makes them strategic areas that provide economic and environmental services at local and regional scales. To ensure navigability and stability of adjacent shorelines, many tidal inlets have been engineered (Kraus, 2009; FitzGerald, 1988). Dabees and Moore (2014) reported that inlet dredging and terminal structures could result in ebb shoal asymmetry. However, the combined effects of long-term anthropogenic and natural processes can lead to other large-scale morphological changes that are not easily predictable. Here, 10 years of remotely sensed data, hydrographic surveys, and a morphological numerical model are used to identify three-dimensional evolutionary patterns in a stabilized inlet and its adjacent barrier islands. The results will be discussed in the context of infrastructure vulnerability near tidal inlets, with emphasis on neighboring transportation corridors that traverse these dynamic coastal features.

STUDY AREA

Oregon Inlet is a dynamic tidal inlet located in the Outer Banks of North Carolina, USA. Oregon Inlet migrated to the south until its down drift shoulder was stabilized with a terminal groin in 1991 (Fig. 1). This structure was built to protect the southern abutment of the bridge that crosses the inlet from scour by the migrating channel. A navigation channel is maintained at an authorized depth of 4.3 m by the U.S. Army Corps of Engineers. However, the accretion of the spit on the opposite side of the inlet from the terminal groin intensifies the need for dredging.

METHODS

Responses of the inlet to natural forces and dredging of its navigation channel are analyzed from sub-aerial features evolution, bathymetric changes, and morphometric parameters obtained from multi-temporal aerial photography (2005-2015). A morphological model built within Delft3D is used to identify evolutional trends caused by natural processes and to quantify the relative contribution of tides and waves to the morphology of the inlet. The results from analysis of observations and modeling scenarios are used to propose a conceptual model of how natural and human-induced processes drive different aspects of tidal inlet morphological evolution.

RESULTS AND DISCUSSION

Tidal currents account for 55% of sediment transport into the inlet, while waves account for the remaining 45%. Simulations forced with tides and waves indicate that sediments from the subaqueous spit tend to form a detached shoal in the north side of the flood delta, while, the main channel remains open branching into two dominant channels in the flood and ebb deltas.

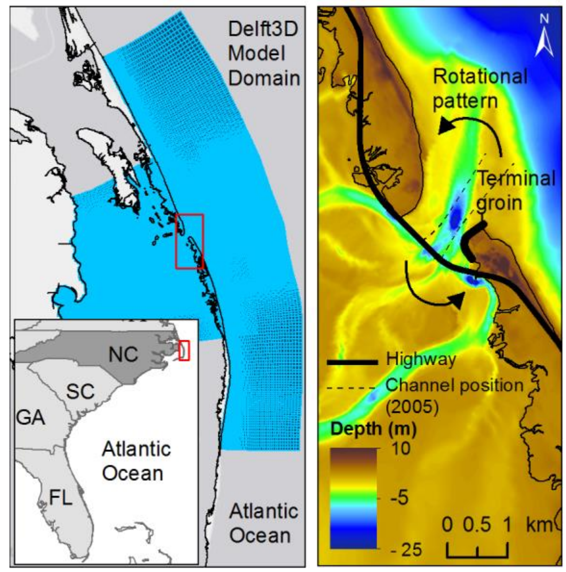

Figure 1 – Study area and numerical model domain.

A cyclical geometric adjustment of the inlet to dredging indicates that the system is in stable equilibrium. The main channel of the inlet is likely to remain open due to tidal currents that can exceed 2 m/s. This channel has been experiencing a counterclockwise rotation (Fig. 1) caused by the growth of the spit southwards and the presence of the terminal groin that restricts the inlet migration. As this rotation continues, the southernmost flood channel has been encroaching into the down drift back barrier at an average rate of 3 m/yr. Continued erosion along the estuarine shoreline could increase the vulnerability of the existing roadway from the estuarine side. Current research is focused on modeling and measuring water levels and currents in the southernmost flood channel of the inlet to evaluate the sound-side and inlet-related processes driving the inner-bank erosion that is narrowing the island, degrading marshes, and increasing the vulnerability of a coastal highway to flooding events.

REFERENCES

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