REINFORCING ECOSYSTEM ENGINEERS WITH ENHANCED VEGETATION AND AN ARTIFICIAL REEF ALONG THE US RHODE ISLAND COASTAL BARRIER SYSTEMS

Annette Grilli, annette_grilli@uri.edu, Elin Schuh, elin_schuh@uri.edu, Félix Groetsch, f_groetsch@uri.edu, Alexa Leone, alexaleone@uri.edu , Deborah Crowley, dcrowley@uri.edu, Stephan Grilli, grilli@uri.edu, Isaac Ginis, iginis@uri.edu, John Walsh, jpwalsh@uri.edu, Pamela Rubinoff, rubinoff@uri.edu, Christopher Damon, cdamon@uri.edu , Roland Duhaime, roland@uri.edu, University of Rhode Island, USA & Peter Stempel, pjs6035@psu.edu, Pen State College of Art and Architecture

BACKGROUND

Beach barrier systems (BBS) act as "ecosystem engineers" (EE), protecting the mainland and back bays from direct wave impact and reducing storm surge and flow passing through their inlets. BBS naturally adapt to slowly evolving wave climates by regressing or transgressing. However, observations show that BBS have been destabilized during past periods of fast changes in sea level or wave climate, potentially leading to drowning of the barrier. In this respect, current predictions of large changes in future Sea Level Rise (SLR) and wave climate, combined with anthropogenic effects, are concerning as these could challenge the natural adaptability of BBS. This raises the following questions: (1) can the future protective ability of local EE be predicted? (2) can the added benefits of implementing selected Nature Based Solutions (NbS) to enhance this natural protective ability be quantified, as well as their potentially negative feedback effects? In this study, these questions are considered for the south shore of Rhode Island (RI) through numerical modeling, in part based on earlier regional storm hazard assessment (Grilli et al., 2020). Specifically, here, as part of a NOAA project ("Effects of Sea-Level Rise 2021, Coastal Resilience" program), we assess the efficiency of NbS in changing climate conditions, while integrating local concerns, observed trends, and supporting local ecosystem and people's way of life.

METHODOLOGY

Targeting a medium range of 50-100 years for future changes, we consider both long- and short-term changes in wave climate and shoreline morphology by simulating: (i) long-term morphodynamic shoreline changes using 1D-ShorelineS (Roelvink et al., 2020); and (ii) short-term (storm scale) beach changes using 2D-XBeach (Roelvink et al., 2009). To identify areas of vulnerabilities, we simulate future storms with XBeach (ii), with the expected modified shoreline conditions from (i), including tropical storms and nor'easters expected in a changing climate. We implement selected NbS to assist the natural coastal BBS and assess their adequacy and efficiency with XBeach. Scenarios are based on consultation with representatives of local communities. In particular, we present the results of: (1) an optimization of the vegetation coverage; and (2) the implementation of a submerged artificial reef. For both we discuss their impact in reducing the exposure of the local communities to future tropical storms and nor'easters.

The vegetation coverage is mapped at a fine scale (5 m discretization), using high resolution aerial surveys, and is translated into roughness and ultimately into a Manning coefficient map, to parametrize bottom friction in the numerical simulations. The dynamic roughness module is used to include time changes in bottom roughness. Changes in exposure are assessed for selected land use scenarios, including a potential optimization of the vegetation coverage based on local species and current land use; a sense of the confidence/uncertainty in the simulations is provided through a sensitivity study of the attributed Manning values to the vegetation coverage and comparison with available data.

Conceptual "artificial reefs" or submerged breakwaters (SBW) are designed and sited based on the results of previous studies (Ranasinghe et al.,2010; van der Baan,2013) with the objective of creating a long-term accretional zone in the lee of the reefs. The complex processes induced by reefs are explored for a range of designs, sea states and wave climates with an attempt to assess and quantify the protective ability of SBWs in the short and long-term using standard metrics of exposure (e.g., Base Flood Elevation (BFE), eroded /accreted volumes) as well as to identify potential negative feedback effects, such as increased currents or erosion.

Storm scenarios include combinations of SLR and tropical storms or nor'easters, that were historically destructive on the Rhode Island South Shore.

REFERENCES

Grilli, Westcott, Grilli, Spaulding, Shi, Kirby (2020). Assessing coastal hazard from extreme storms with a phase resolving wave model: Case study of Narragansett, RI, USA. Coastal Engineering, 160, 103735.

Ranasinghe, Larson, Savioli (2010). Shoreline response to a single shore-parallel submerged breakwater. Coastal Engineering, 57(11-12), 1006-1017.

Roelvink, Huisman, Elghandour, Ghonim, Reyns (2020). Efficient Modeling of Complex Sandy Coastal Evolution at Monthly to Century Time Scales. Frontiers in Marine Science, 7, 535.

Roelvink, Reniers, van Dongeren, van Thiel de Vries, McCall, Lescinski (2009). Modelling storm impacts on beaches, dunes and barrier islands. Coastal Engineering, 56(11-12), 1133-1152.

van der Baan (2013). *Developing a design criterion for the shoreline response to multiple submerged breakwaters*. MS Thesis. DELTARES