Adaptation Strategies to Mitigate Impacts of Sea Level Rise on a Freshwater Aquifer Supply on a Barrier Island

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Abstract

Coastal breaching can result in saltwater intrusion to coastal aquifers which supply freshwater to residents. Adaptation strategies are used to minimize breaching in response to storms and sea-level rise (SLR). An adaptation tipping point for a barrier island is said to exist when an adaptation strategy fails, and the island can no longer avoid breaching due to frequent storm occurrence and increasing sea-levels. Previous studies have applied statistics to identify adaptation tipping points and construct adaptation pathways as a function of quantity of SLR. This study is focused on Alligator Lake on the barrier island Dauphin Island, AL; a site residents and community leaders identified as a vulnerable to breaching under future SLR conditions. Therefore, the purposes of this study are to numerically simulate impacts of a storm and SLR scenarios on a barrier island freshwater aquifer, evaluate the effectiveness of adaptation strategies to protect saltwater intrusion of the aquifer as sea levels rise, and develop an adaptation pathway for protecting the freshwater supply under future climate scenarios. XBeach was used to simulate morphological changes to the region near Alligator Lake with merged DEM and Lidar data. Hydrodynamic forcings included Hurricane Nate water levels recorded from the Dauphin Island tide gauge 8735180, and spectral wave conditions recorded from NOAA data buoy station 42012. SLR scenarios (0.4 m, 0.53 m, 0.66 m, 0.75 m, 1.0 m, 1.26 m, and 1.93 m) were simulated with Hurricane Nate hydrodynamic conditions. Manning's roughness coefficients were used as a model input to account for frictional losses from land cover and open water. This poster will present results on quantitative differences between initial and final bed elevations and changes in bed elevations generated in MATLAB for Alligator Lake in response to Hurricane Nate and SLR scenarios. Future work will include simulating adaptation strategies and creating an adaptation pathway. This study will contribute to adaptation management and policy through stakeholder involvement to protect the freshwater supply on the east end of Dauphin Island.

Introduction

Storm occurrence determines barrier island stability with respect to sea-level rise (SLR). The foredune is the major line of defense for a barrier island, and its ability it limited to excursion (tides + storm surge + wave runup). Breached coastal areas, inundation, and saltwater intrusion of coastal aquifers occur as consecutive events. However, breaching and inundation occur within days while saltwater intrusion can occur over several years. An adaptation strategy to SLR and the resulting intrusion may individually incorporate or combine planned retreat, accommodate, and protect. Adaptation tipping points (ATPs) are instances when management strategies can no longer fulfill their intended outcomes because of changing environmental factors. The purpose of this study is to investigate (1) Hurricane Nate and SLR impacts near Alligator Lake and an aquifer site on Dauphin Island, AL through numerical modelling (XBeach), (2) simulate adaptation strategies, and (3) develop an adaptation pathway in response to simulated adaptation strategies.

Research Questions

1. How will adaptation strategies and adaptation pathways accommodate Dauphin Island with storm and SLR impacts?
2. Can existing adaptation strategies be used for Alligator Lake and the aquifer site?
3. Can adaptation strategies be used to help with adaptation management for Dauphin Island?

Methodology

Merged LIDAR and DEM data in UTM coordinates

589 x 318 model grid was created with merged LIDAR and DEM data in MATLAB

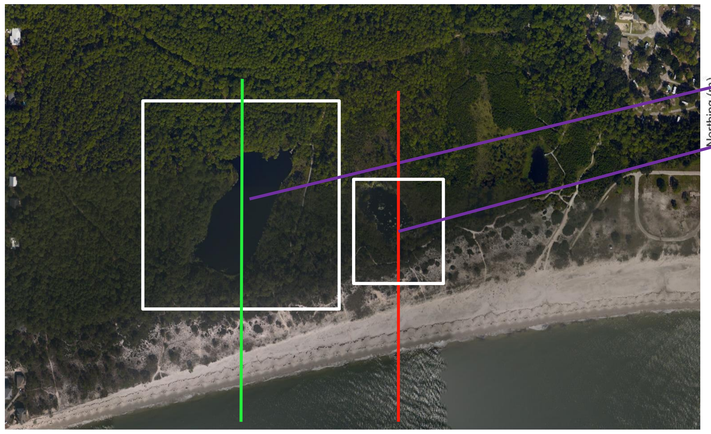
Inputs were specified using Hurricane Nate spectral wave characteristics, water levels, and Manning's roughness coefficient

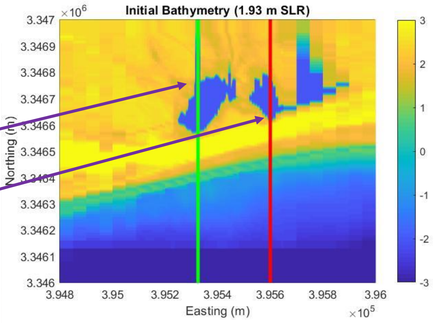
No SLR and SLR scenarios used were : **0.4 m, 0.53 m, 0.66 m, 0.75 m 1.0 m, 1.26 m, and 1.93 m.**

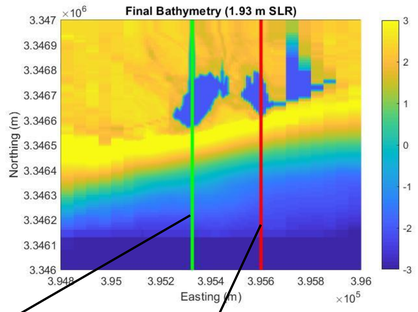
Final bed elevations and changes in bed elevations were quantified with MATLAB

Adaptation strategies will be simulated to identify ATPs

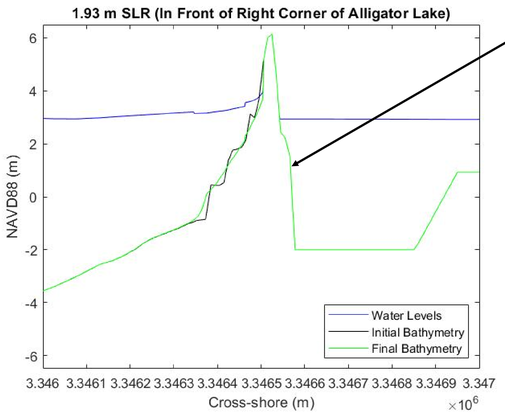
An adaptation pathway will be created with adaptation strategies as a function of SLR

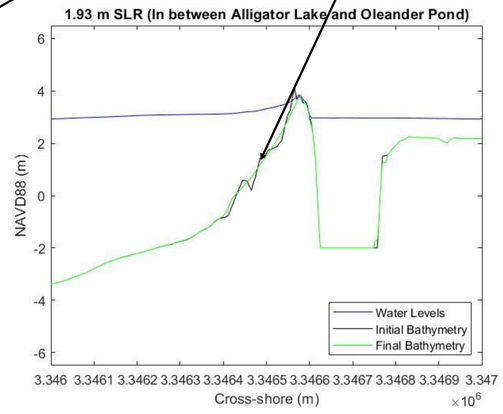




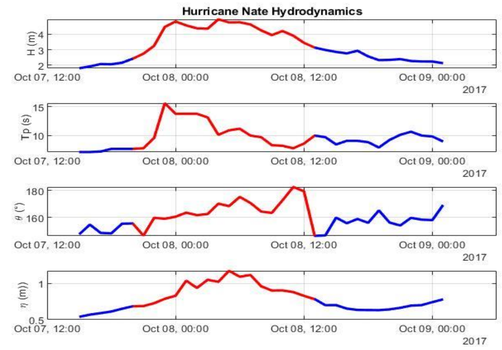


Results





SLR Scenario (m)	Cross-Shore Transect	Site Description	Timestep of Overtopping (hr)	Peak Water Levels (m)	Initial Dune Crest Height (m)	Final Dune Crest Height (m)	Initial Water Level (m)
1.93	395600 m E	In between Alligator Lake and Oleander Pond	6.00	3.84	3.80	3.61	2.61
1.93	395325 m E	In Front of Right Corner of Alligator Lake		3.99	6.14	6.14	2.61



Discussion and Conclusion

- Overtopping did not occur at Alligator Lake
- Overtopping did occur between Alligator Lake and Oleander Pond
- Overtopping between the lake and pond indicates saltwater intrusion to the body of water present
- Peak water levels from hydrograph follow behind Hp suggesting that wave heights stacked with tides and storm surge
- Peak water levels from hydrograph occurred at 5:00 a.m. while XBeach simulated max water levels 6 hrs into the storm
- No changes in bed elevation in front of Alligator Lake
- Dune erosion at both transects makes dunes more susceptible to dune collapse, thus potentially requiring nourishment

Future Work

- Expanding the resolution of the grid
- Shifting the grid
- Modelling adaptation strategies
- Creating an adaptation pathway for No SLR and all SLR scenarios
- Further engagement with stakeholders

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