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The Impacts of Extreme High Tide Events on Sea Turtle Nesting along the Georgia Barrier Islands

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GEORGIA DEPARTMENT OF NATURAL RESOURCES
WILDLIFE RESOURCES DIVISION

Abstract

Threats to coastal Georgia barrier islands from global climate change include increasing vulnerability to storm surge, flooding and high tide events. The Georgia coast is prime reproductive habitat for loggerhead sea turtles (*Caretta caretta*), which are listed as threatened under the U.S. Endangered Species Act. The objectives of this study were to quantify the changes in frequency of high tide events and assess effects of tide dynamics on nest success of sea turtles using five of Georgia's islands.

We collected data on nest elevation, number of inundation events, microhabitat elevations and daily high tide levels from Ossabaw Island, Sapelo Island, Little St. Simon's Island, Cumberland Island, and Jekyll Island. We used a hierarchical model within a Bayesian framework to estimate the relationships between these physical attributes and nest success. Modeling results revealed that high tide, nest elevation, inundation events and the nest's distance from high tide line were correlated with nest success.

Increasing trends in high tides will threaten marine turtles' reproductive habitats, and this study will enable beach managers to more reliably assess nest site selections. Predictions from this study may have applications to other loggerhead sea turtle nesting beaches in the NW Atlantic facing more frequent extreme high tide events.

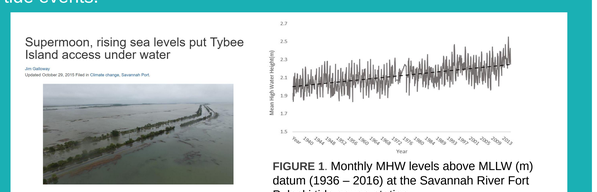
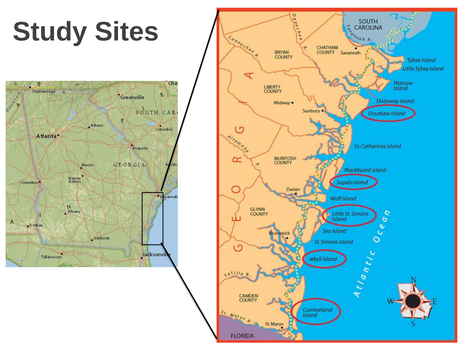


FIGURE 1. Monthly MHW levels above MLLW (m) datum (1936 – 2016) at the Savannah River Fort Pulaski tide gauge station

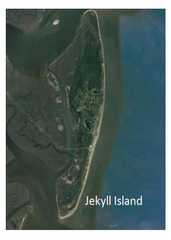
Study Sites

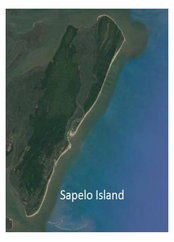


Georgia barrier islands play key roles in the ecosystem of coastal Georgia, protecting the mainland, salt and tidal marshes from wind and waves.

Due to particular land ownerships and long term conservation efforts, most of these islands are undeveloped and remain the least disturbed environments along the eastern coast (DNR, 2015).

Five islands, Ossabaw, Sapelo, Little St. Simons, Jekyll and Cumberland were included in this study as a representative sample of the Georgia Coast.





Methods

Nest & Hatching Surveys

Nest surveys were conducted daily by teams of trained surveyors (May - Aug). Daily surveys were conducted along the high tide line for evidence of new emergences. Nests were monitored and data recorded daily during the incubation period for signs of full or partial predation, wash overs, and hatchling emergence.

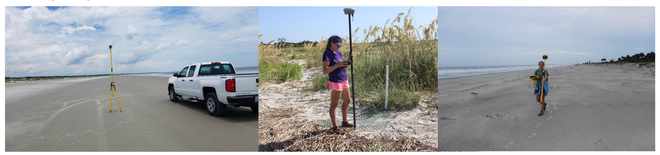
Hatching inventories were conducted daily by teams of trained surveyors (July – October). Nests were monitored daily during the incubation period and any significant events (predation or wash overs) were recorded. Emergence success rates were determined by excavating each nest for clutch size counts and recording hatched, unhatched, dead and live hatchlings.

Loggerhead sea turtle nest with Predator screen & stake for identification

Nest inventory after hatchling emergence

Elevation Measurements

Elevation measurements for each nest were taken using novel GPS technology. A Real Time Kinematic (RTK) satellite navigation unit with a Base and Rover system was used to achieve centimeter level accuracy in the vertical direction. The base station acquired its position at each set up through the global navigation satellite system. A radio broadcast between the base and rover units allowed nest elevation measurements within a mile radius of the base and accuracy within 2 cm once postprocessed.



Nest elevation measurements using the Base and Rover unit setup

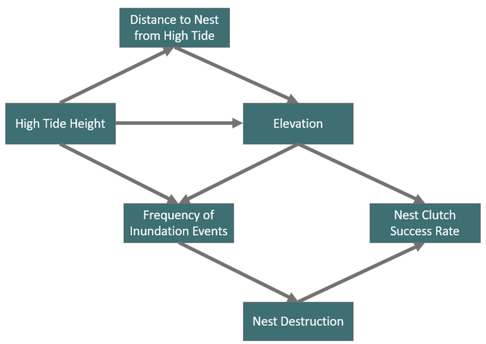


Figure 2. Diagram of our hierarchical model used to assess the variables associated with sea turtle nest hatch success rate

Preliminary Results

A Bayesian hierarchical model was used to assess the nest success response to extreme high tide events. Results from the model show higher high tide events and longer distances traveled from high tide induce higher nest elevations (Fig 3). Thus, with increasing high tide events, turtles respond by nesting higher up in the dune system. We found that nest success was positively correlated with high tide at emergence and with nest elevation (Fig 4). Finally, the probability of a nest being destroyed increased with the frequency of inundation events and decreased with higher nest elevations. Elevated nests are less exposed to wash overs and experience less time inundated, increasing the likelihood of surviving to hatching.

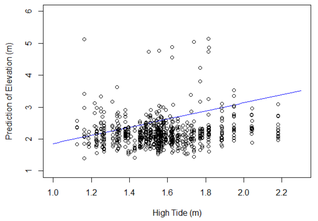


Figure 3. Predicted nest elevation (m) in response to high tide on the night of the turtle's emergence (m).

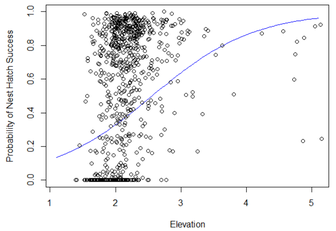


Figure 4. Predicted nest hatch success rate in response to nest elevation (m).

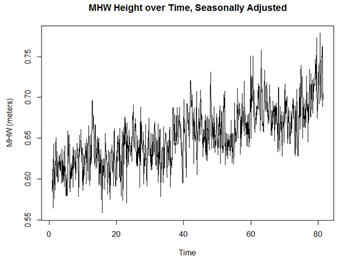


Figure 5. Plot of trend & random component, after the removal of the monthly seasonality for Fort Pulaski , Savannah GA (1936 – 2016)

Loess Trend and Seasonal Decomposition

Loess time series analysis, using additive decomposition was used to estimate the tide gauge trend from 1936 to 2016 at Fort Pulaski, Savannah, GA (Fig. 5). Results show an increasing trend of 1.68 mm per year in average monthly mean high water levels (MHW). Continued work with tide gauge stations along the Southeast coast and predictions under climate change scenarios are ongoing.

Conclusion

An increasing trend in high tide levels along the Atlantic coast may have important consequences for sea turtle's reproductive habitat and long lasting implications for population dynamics. These extreme high tide events will also have implications for coastal Georgia. Flooding, erosion, storm surge and other hazards from higher than average tides will lead to costly challenges for coastal communities in the near future.

By understanding the processes that drive nest site selection, we can better evaluate nest success and better inform decision making for conservation measures. The hierarchical model may be used to predict tide height and nest elevation levels that indicate desired management thresholds for hatch success; thus the model serves as a tool to assess nest site selections and assist with decisions about nest relocation procedures. The probability of a nest being destroyed due to inundation events will be better determined based on variables such as high tide on the date of emergence, nest elevation and distance from high tide, and will allow managers to improve their evaluation of a nest's placement on the beach. Predicting tidal trends will also enable us to better understand consequences of an increasing frequency of extreme high tides on sea turtle demography and population recovery.

Predictions from this study may have applications to other loggerhead sea turtle nesting beaches in the NW Atlantic that may be affected by extreme high tide events. Further research on these climate change impacts for sea turtle nesting behavior and subsequent nest success is ongoing.

Acknowledgements

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