HYDRODYNAMIC MODELING APPLIED TO DESIGN OF LIVING SHORELINES IN LAKE WORTH LAGOON

Manisha Thenuwara+ (manisha@Knights.ucf.edu), Madison Giuntoli+ (mgiuntoli@knights.ucf.edu), Thirusankaranand Mathavan+ (sankar_anand@knights.ucf.edu), Jennifer Baez * (jbaez1@pbcgov.org), Beth Orlando * (borlando@pbcgov.org), Melinda Donnelly± (melinda.donnelly@ucf.edu) and Kelly M. Kibler+ (kelly.kibler@ucf.edu)

+Department of Civil, Environmental & Construction Engineering, University of Central Florida, *Department of Environmental Resources Management, Palm Beach County, ±Department of Biology, University of Central Florida

Introduction

The developed shorelines of Lake Worth Lagoon face ecological challenges due to shoreline hardening and modification of natural wetland habitats (Figure 1). To preserve and restore ecological function to these vital shoreline ecotones, coastal defense strategies include the use nature-based infrastructure that utilize erosion protection by native species such as mangroves, sea grasses, and oyster beds. However, when organisms are the building blocks of infrastructure, projects must be designed to match organism ecology with the site hydrodynamic conditions. This is often a challenging task, as both hydrodynamic habitat thresholds of species and site-scale hydrodynamics may be unknown to practitioners. To support shoreline restoration efforts in Lake Worth Lagoon, this research aims to provide hydrodynamic design information in an accessible format that can be easily applied to project prioritization and design.

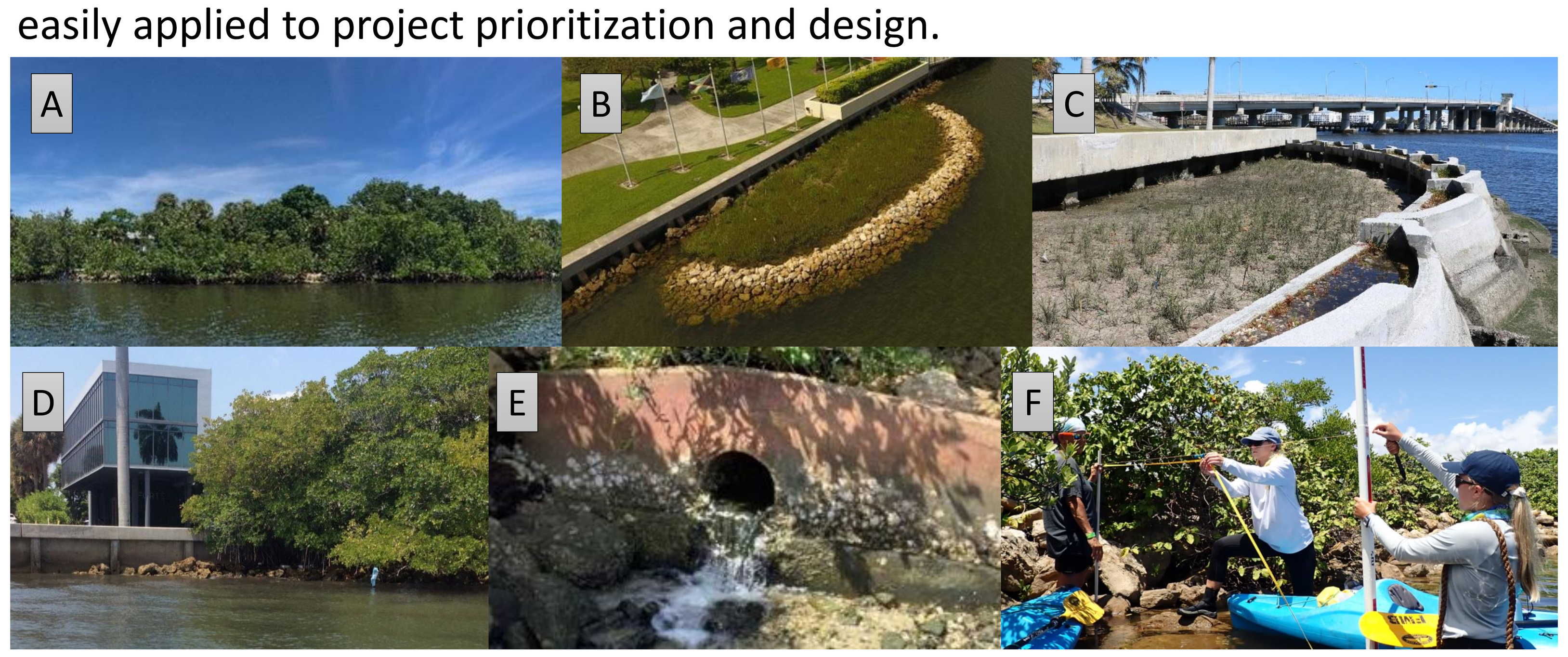

Figure 1: Example shorelines in LWL. **A)** Reference-condition wetland shoreline; altered shorelines using **B)** coquina rock, **C)** seawall, **D)** transition from seawall to wetland, **E)** stormwater outfall; **F)** collection of shoreline slope data.

Methods

Shoreline and hydrodynamic data will be integrated to create Living Shoreline Prioritization and Habitat Suitability maps of the LWL, identifying areas of high vulnerability and highlighting the impact of the hydrodynamic environment (Figure 2). This map will be a tool for those involved in habitat restoration efforts, guiding site-specific restoration towards more robust designs with higher chances of success. A map like this, identifying restoration need and areas of suitable mangrove habitat, has already been created for parts of Indian River Lagoon (see example data in Figure 3 and scan QR code in Figure 2 to view GIS data).

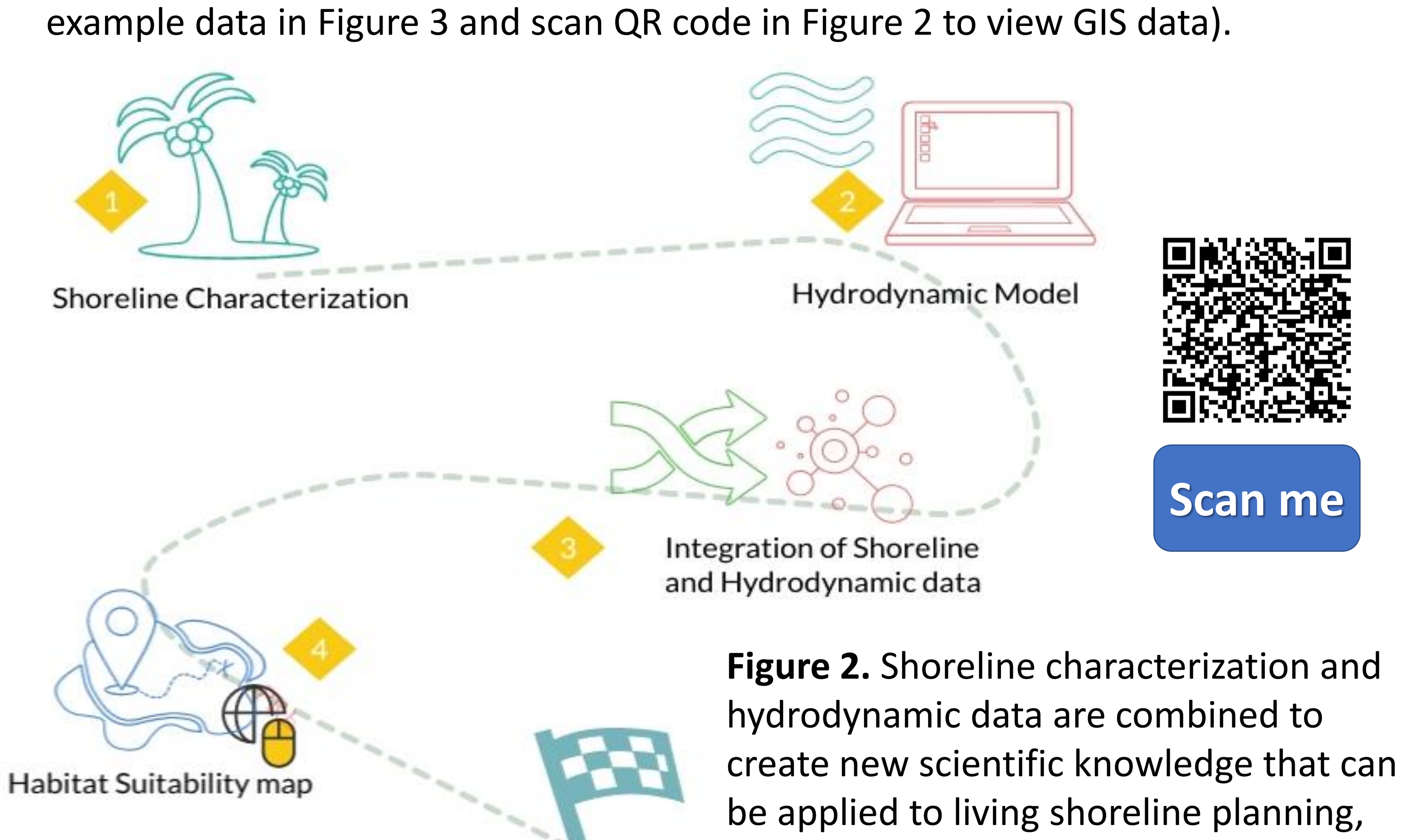

Figure 2. Shoreline characterization and hydrodynamic data are combined to create new scientific knowledge that can be applied to living shoreline planning, design, and engineering.

Shoreline Characterization

In 2020, a high-resolution field characterization of LWL shorelines was undertaken by Palm Beach County (Figure 1F). At each point along the shoreline (approximately every 30 meters), data were collected on slope, intertidal width, species present, and evidence of erosion. Findings of this study highlighted the urgency for Palm Beach County to conserve remaining natural habitats and apply soft-armoring techniques, such as living shorelines, to combat shoreline erosion.

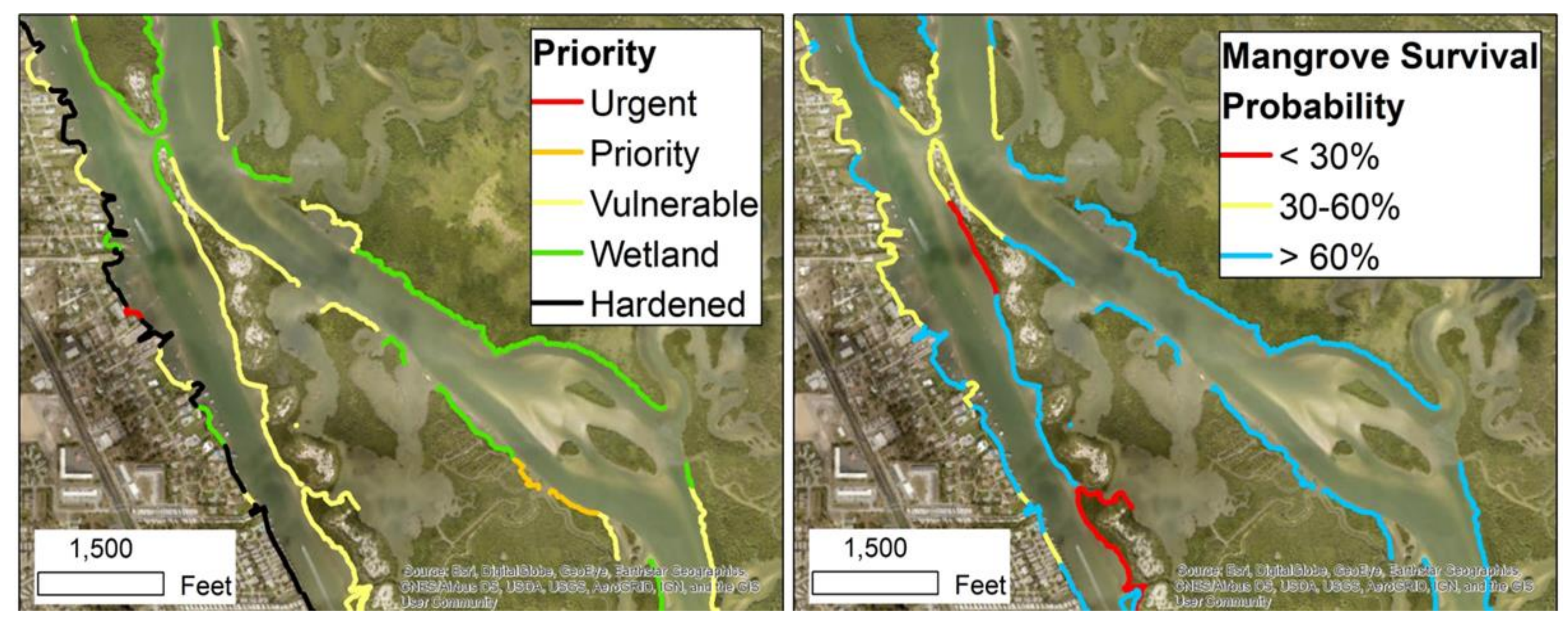

Figure 3: Example outcome: A) Shoreline priority model highlights stabilization opportunities based on current conditions. B) Habitat suitability models (probability of mangrove survival shown as example here) facilitate robust project designs.

Hydrodynamic Modeling

Hydrodynamics play an important role in shoreline habitat suitability in the LWL. If the species utilized in natural infrastructure, such as living shoreline, are placed outside of their preferred hydrodynamic range, the probability of restoration success drops (Figure 4). Understanding the hydrodynamic environment and tolerance of shoreline species is therefore a crucial part of coastal restoration.

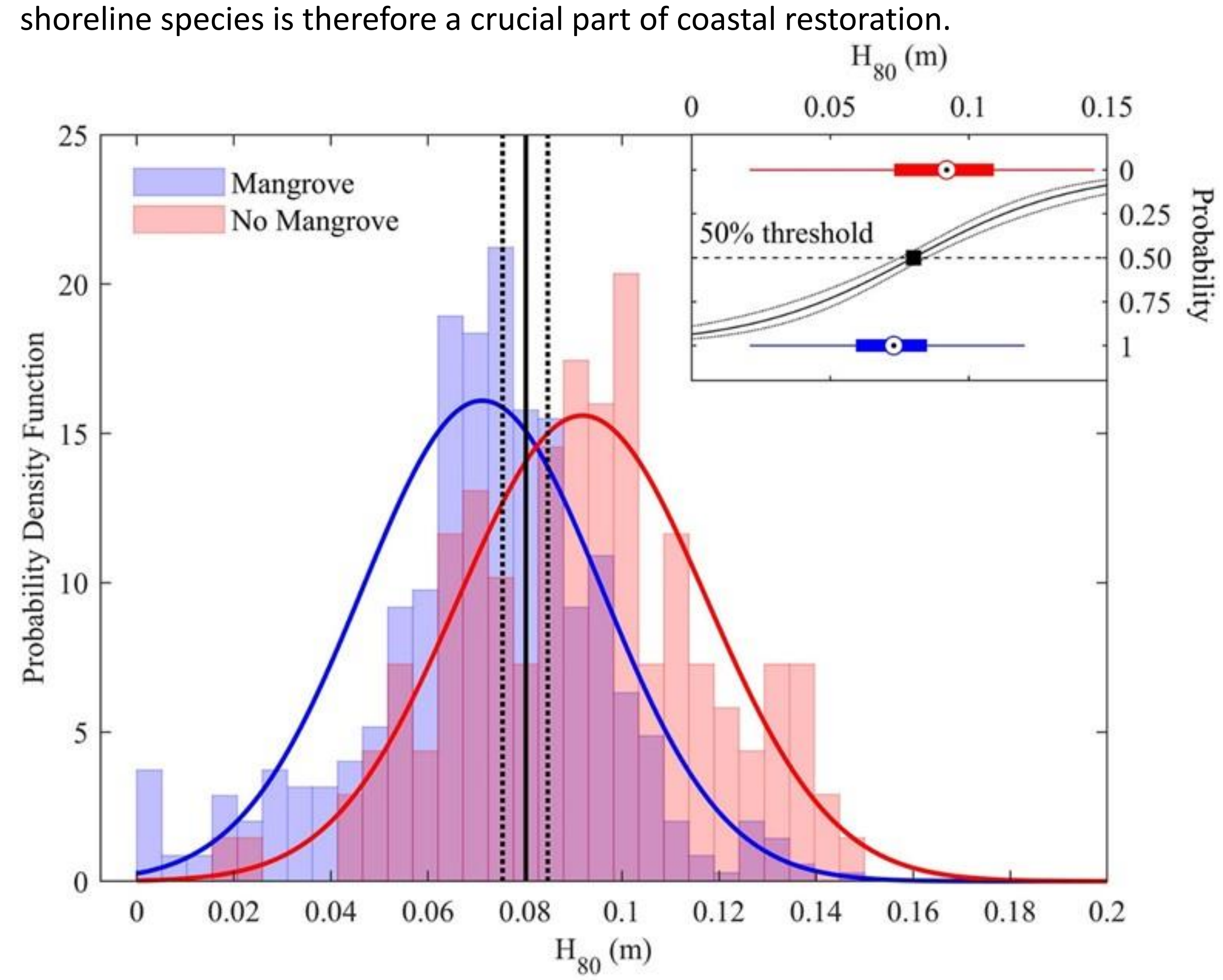

Figure 4. Probability of mangrove survival (blue) and failure (red) for the 80th percentile wave height. A shoreline with 80th percentile wave height greater than 8 cm has a low chance of supporting mangrove vegetation (Cannon et al. 2020).

Hydrodynamic Modeling (Continued)

It is impractical and expensive to monitor hydrodynamic data along the entire coast, so we use the Simulating Waves Nearshore (SWAN) numerical model to characterize wave climate (wave height and frequency) at every 70 m of shoreline (Figure 5). The SWAN modeling is carried out at the University of Central Florida's Advanced Research Computing Center. To ensure that the model accurately reflects the real in situ conditions, the model needs to be calibrated and validated with observed data. A monitoring station in LWL will observe wind speed and direction (YOUNG Model 05305 Wind Monitor-AQ) as well as wave height (Sonic Wave Sensor XB OSSI-010-035) (Figure 6).

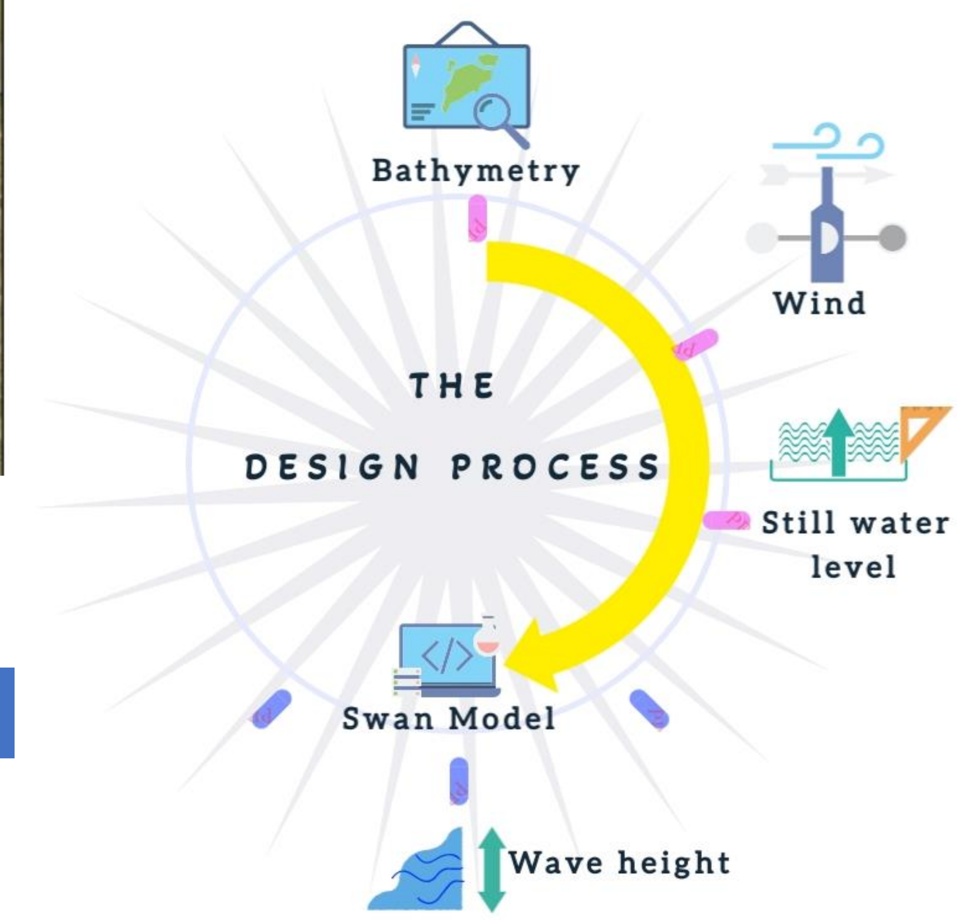

Figure 5. The Simulating Waves Nearshore (SWAN) numerical model is used to characterize wave climate (wave height and frequency) at every 70 m of shoreline.

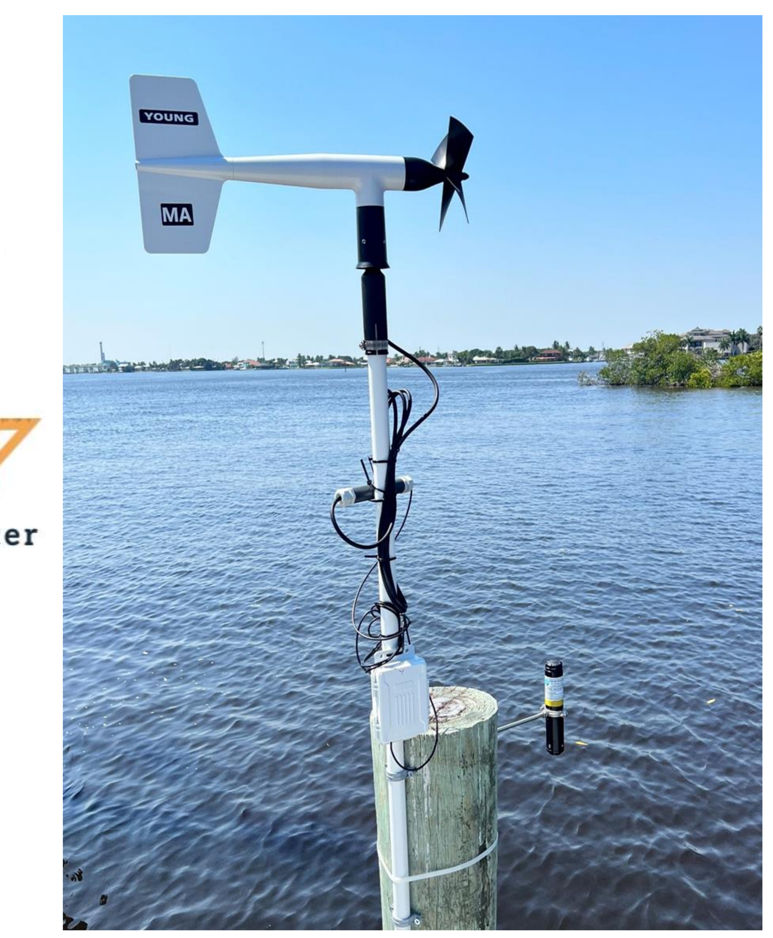

Figure 6. Hydrodynamic data are collected in LWL to validate hydrodynamic modeling. Example instruments installed at the monitoring station are shown.

Conclusion

The wind-wave data will be used in conjunction with shoreline characterization data to better understand preferences of shoreline ecosystem engineers. For example, prior study in Indian River Lagoon revealed the hydrodynamic habitat preferences of mangrove vegetation (Figure 4), guiding restoration practitioners in matching sites with robust stabilization methods. What will we learn next in LWL? In addition to learning new things about habitat preferences of shoreline species, this project will provide a vital resource for coastal management and planning in the LWL. An easily accessible shoreline suitability map will help end-users make more informed decisions about how to best protect the coastline of the Lake Worth Lagoon.

Acknowledgements

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References

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