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JUNE 28th-30th, PANAMA

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“ASSESSING THE IMPACTS OF SEAGRASS BED DEGRADATION AND RESTORATION ON NEARSHORE HYDRODYNAMICS AT THE BON ACCORD LAGOON, TOBAGO BY THE USE OF A NUMERICAL MODELLING TOOL.”

By: Ms. Arianna Joseph

DEFINITIONS

Hydrodynamics

The science of water flow and the forces that cause that flow.

Wave Attenuation

The total loss of wave height due to bottom friction.

Wave Dissipation

The loss of wave energy due to bottom friction.

PROBLEM STATEMENT

- Recent evaluations indicated that the seagrass beds at Bon Accord Lagoon recorded the **lowest biomass and density** which was opposite to previous data.
- Land-based pollution, coastal development, destructive tourism practices and sargassum influxes have resulted in the **dieback of seagrass beds**.
- This nutrient loading contributed to **the extensive growth of phytoplankton and macroalgae** which compete with seagrasses for light and space.
- Sea levels are expected to rise at approximately **0.3 to 0.5m by 2050** and at approximately 1m by 2100.

OBJECTIVES

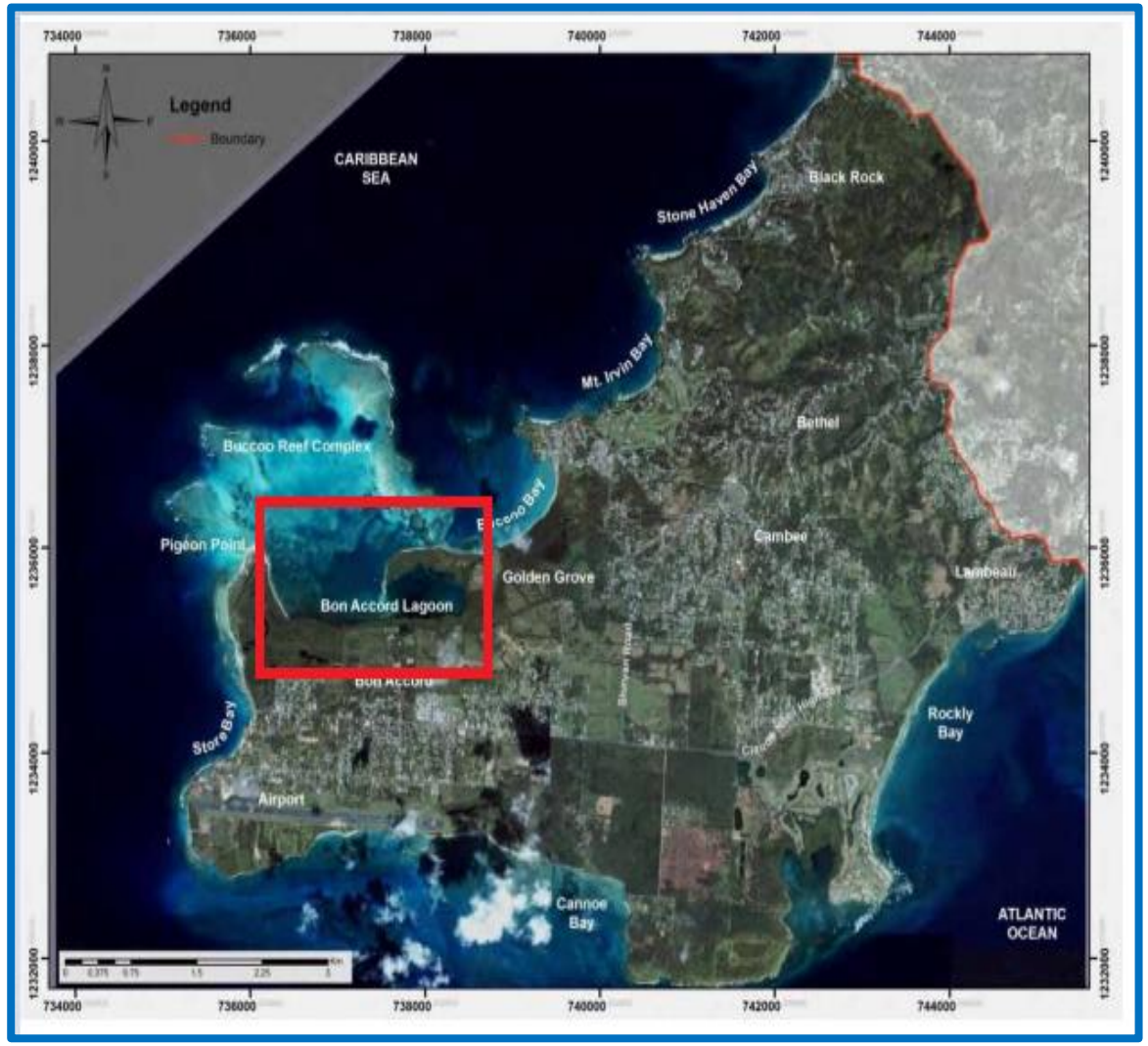
- **Objective 1:** To utilize a numerical model to determine the nearshore hydrodynamics at the Bon Accord Lagoon.
- **Objective 2:** To investigate the effect of the seagrass bed community on wave attenuation and dissipation within the study area.
- **Objective 3:** To evaluate future wave conditions at the site due to seagrass degradation during different sea level rise scenarios.

AREA OF STUDY

- The Bon Accord Lagoon

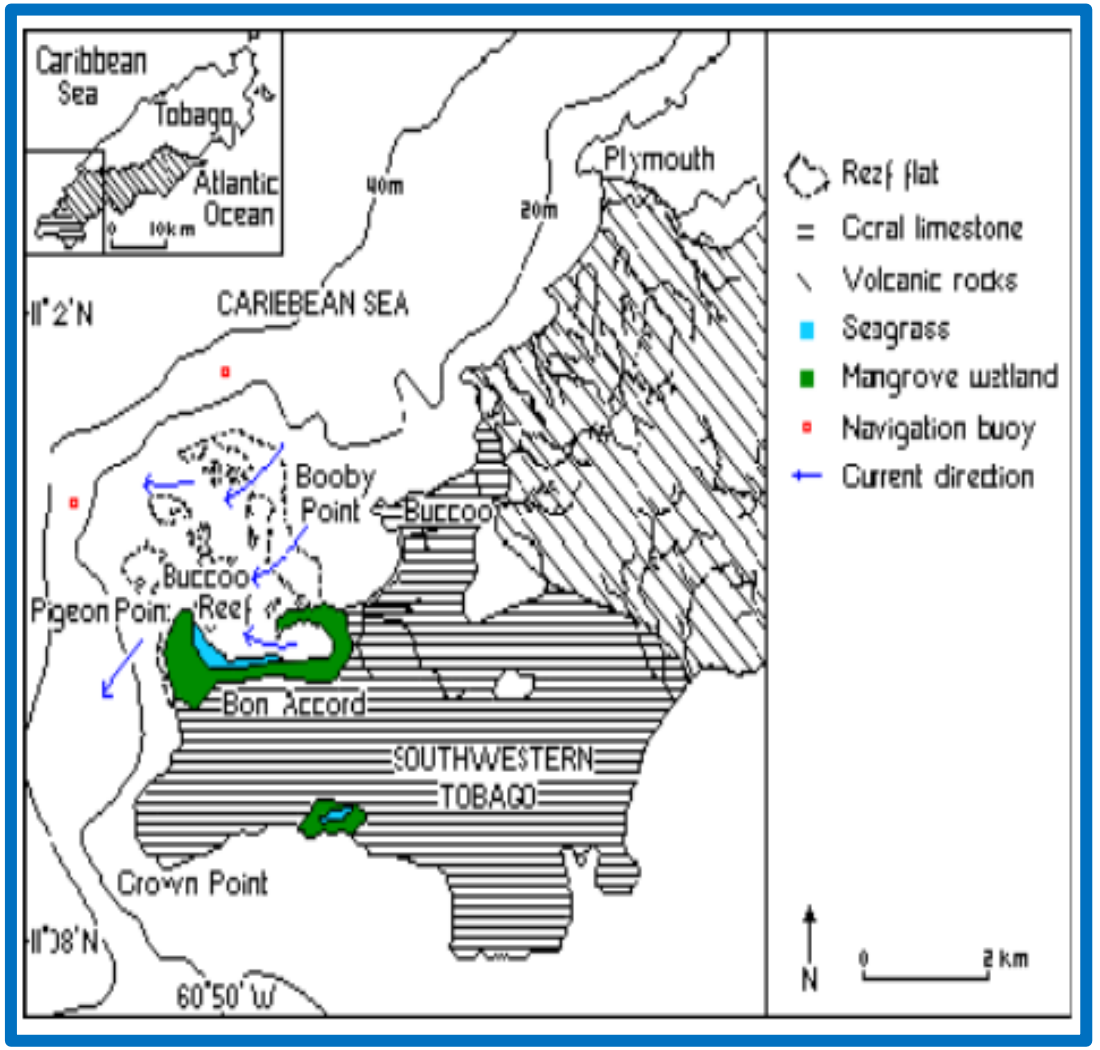
- Between latitudes 11°08’ to 11°12’N and longitudes 60°40’ to 60°51’W.

- Interrelated complex system creating a **mangrove-seagrass-coral reef continuum**.



AREA OF STUDY

- The Bon Accord Lagoon covers an estimated area of **1.2 square kilometres.**
- **Thalassia testudinum** is the dominant seagrass species covering **80%** of the total area.
- Seagrass beds within and adjacent to the Bon Accord Lagoon has a surface area of approximately **0.5 square kilometres.**



WAVE CLIMATE

- Has a depth which varies from **1m** to approximately **6m** that is conditioned to **wind-generated waves.**
- The mean spring tidal range is approximately **0.78 m** and a mean neap tidal range of approximately **0.4 m.**
- Residual currents within the lagoon are influenced by the North Brazil Current which moves westerly at a speed of **0.1 - 1.11 m/s**.

WHAT ARE SEAGRASS BEDS?

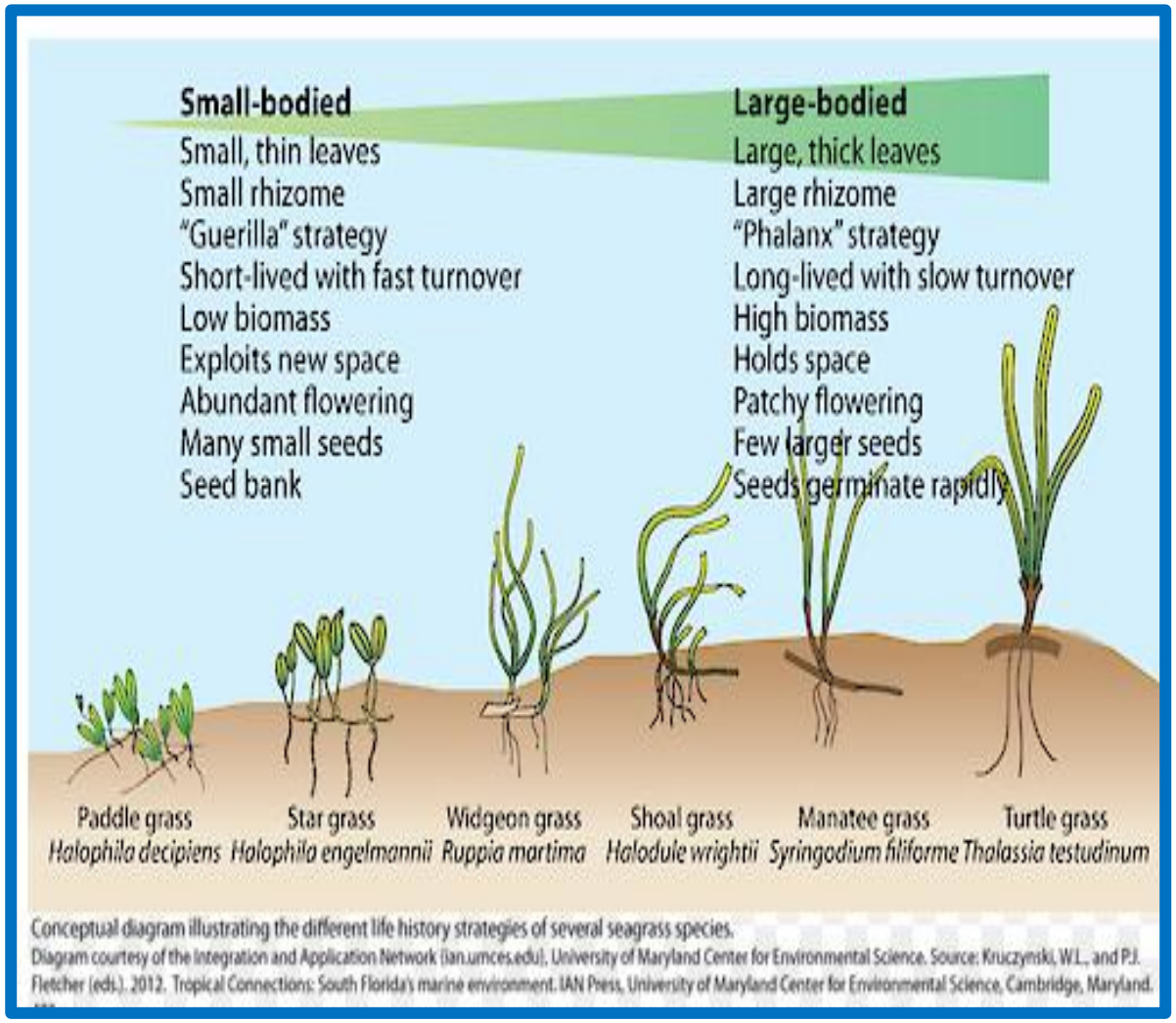
- Flowering plants with grass-like leaves which thrive in shallow and clean coastal waters.
- Can be found within intertidal zones to depths of 90m.
- Confined to shallower waters due to rapid light attenuation.
- Tropical species are primarily found in areas **above 25°C**.

SEAGRASS MORPHOLOGY

- Nutrients and water are transported around the plant through the **vein** system whilst the roots and **rhizomes** are tasked with storing and absorbing nutrients.

- Leaves contain minute air pockets **(lacunae)** which assist with leaf buoyancy and gaseous exchange.

- Both intertidal and subtidal zones grow asexually **(colonial growth)** and sexually **(pollination).**



Conceptual diagram illustrating the different life history strategies of several seagrass species.
Diagram courtesy of the Integration and Application Network (ian.umces.edu). University of Maryland Center for Environmental Science. Source: Kruczynski, W.L., and P.J. Fletcher (eds.). 2012. Tropical Connections: South Florida's marine environment. IAN Press, University of Maryland Center for Environmental Science, Cambridge, Maryland.

SEAGRASS BEDS & WAVE DISSIPATION

- Energy dissipation occurs due to the **form drag** of the plant's frontal area which creates turbulence behind the leaves frontal area.

- Form drag can be measured through changing **velocities**.

- A higher seagrass shoot density per unit area generally increases the drag to impede the perpendicular flow.

$$F_{drag} = \frac{1}{2}\rho U_{rel}^2 C_D A_c$$

SEAGRASS BEDS & WAVE ATTENUATION

Shoot Density:

Wave energy and height remains elevated over seagrass bed meadows with a sparse distribution, (Nielsen, 1992).

Leaf Length:

Seagrass species with lower leaf height result in a lower percentage of wave attenuation, (Fonseca and Cahalan, 1992).

Blade Stiffness:

Stiffer leaves attenuate waves much more effectively than the flexible seagrasses, (Bouma et al. 2010).

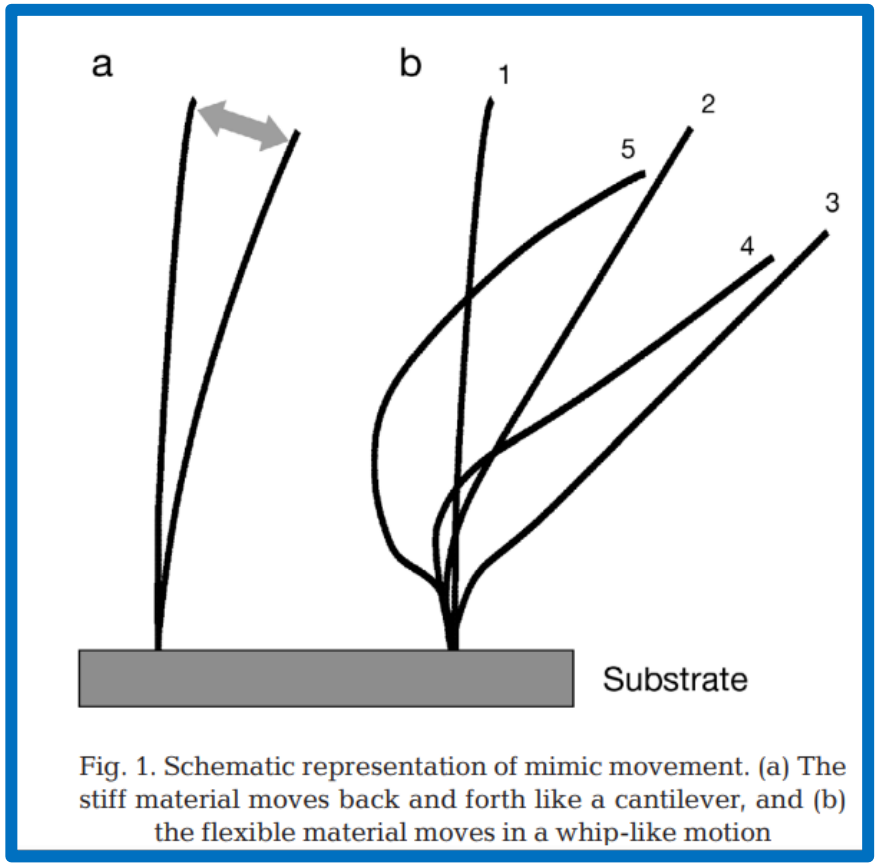
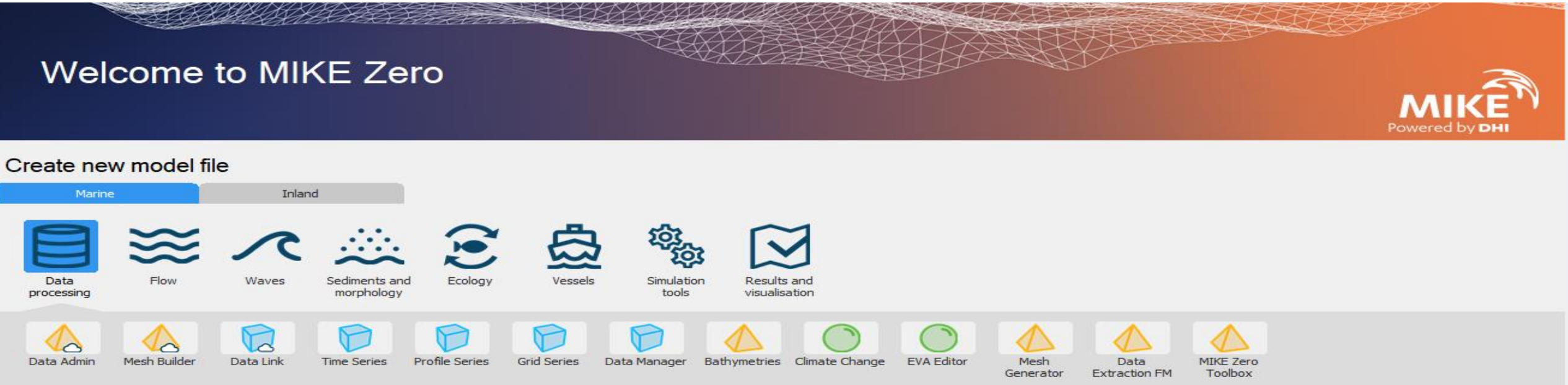


Fig. 1. Schematic representation of mimic movement. (a) The stiff material moves back and forth like a cantilever, and (b) the flexible material moves in a whip-like motion

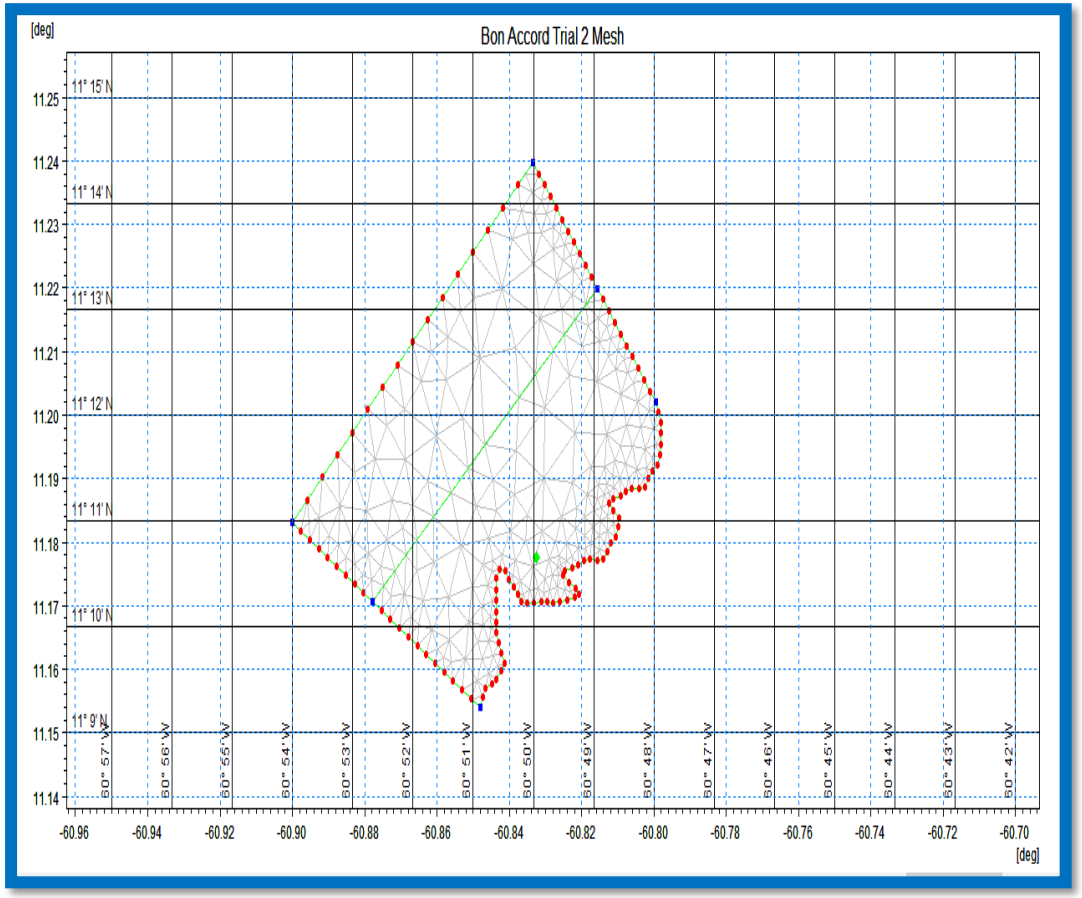
MIKE ZERO NUMERICAL MODEL

- **Hydrodynamic Module:** utilizes the Reynold Average Equation , alongside other input parameters to output **water levels and current conditions**.

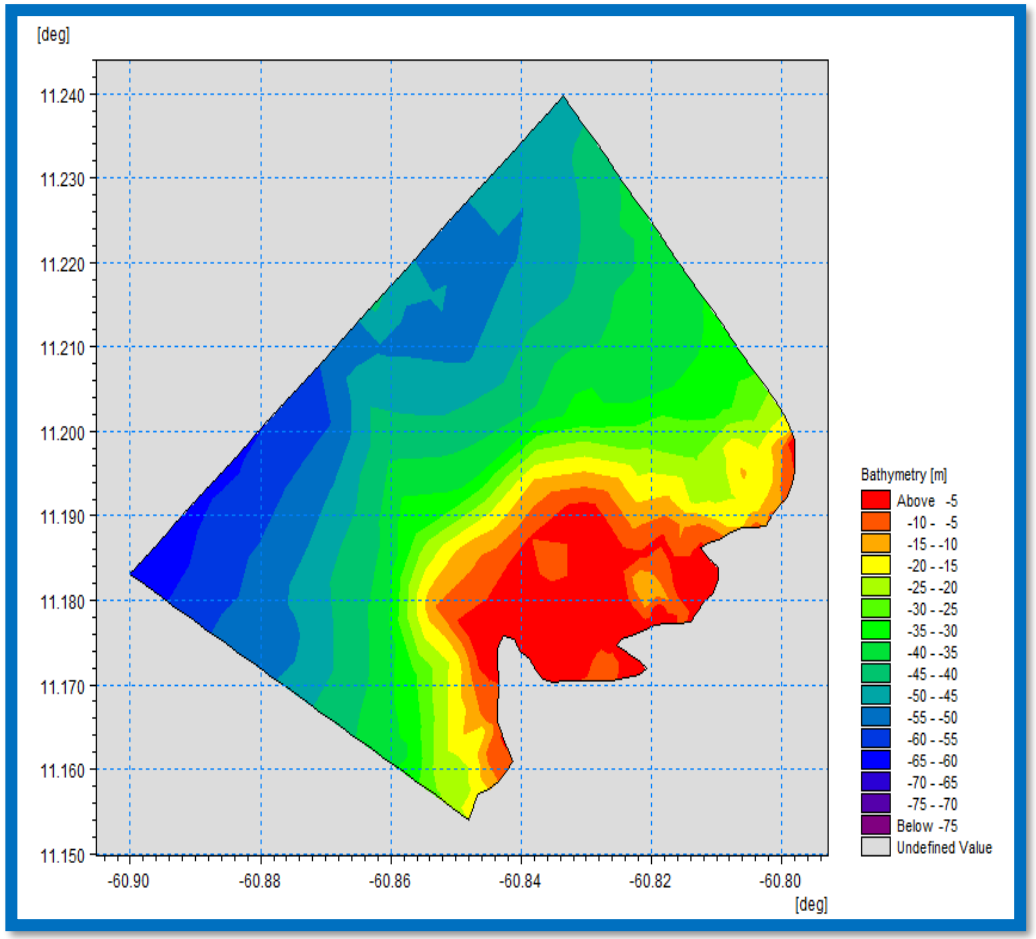
- **Spectral Wave Module:** simulates the transformation of wind-generated waves and swells within the nearshore region to output **wave heights, period and velocities.**



MESH GENERATION

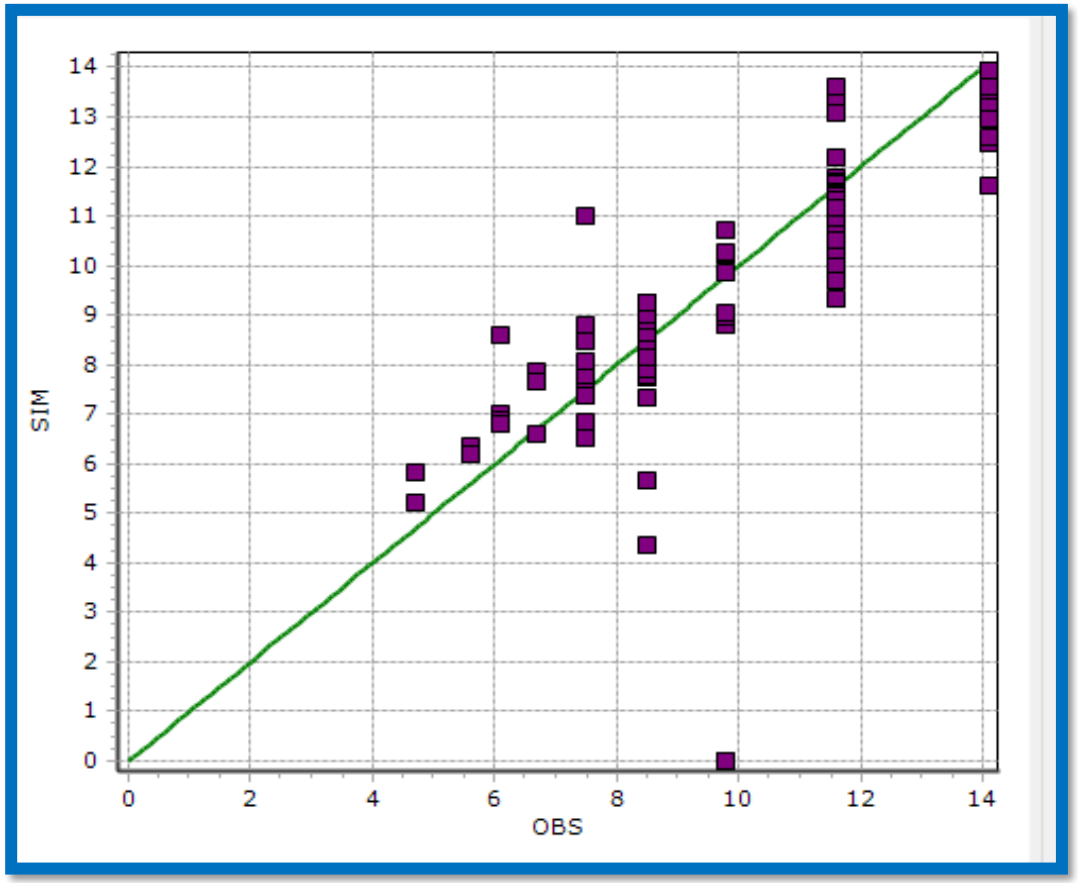


Model grid used for HD and SW modules.

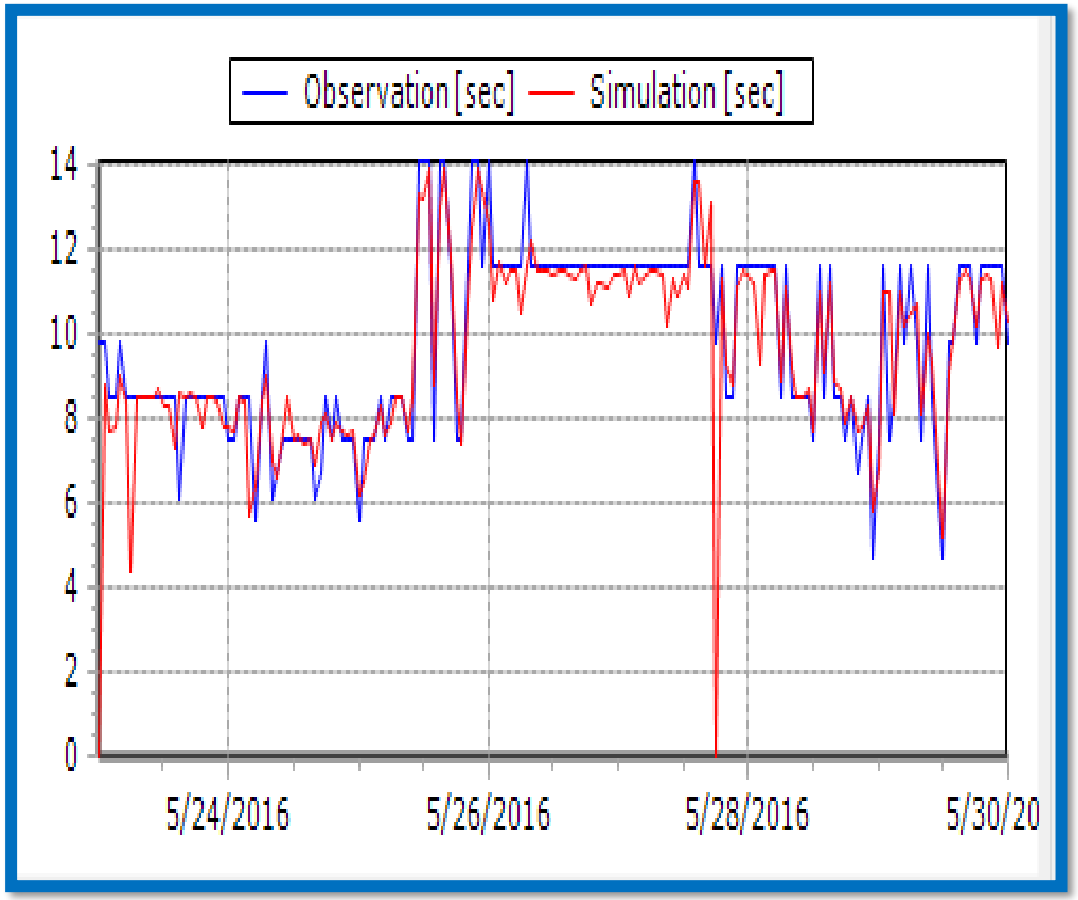


Interpolated grid using bathymetric data.

WAVE PERIOD MODEL CALIBRATION

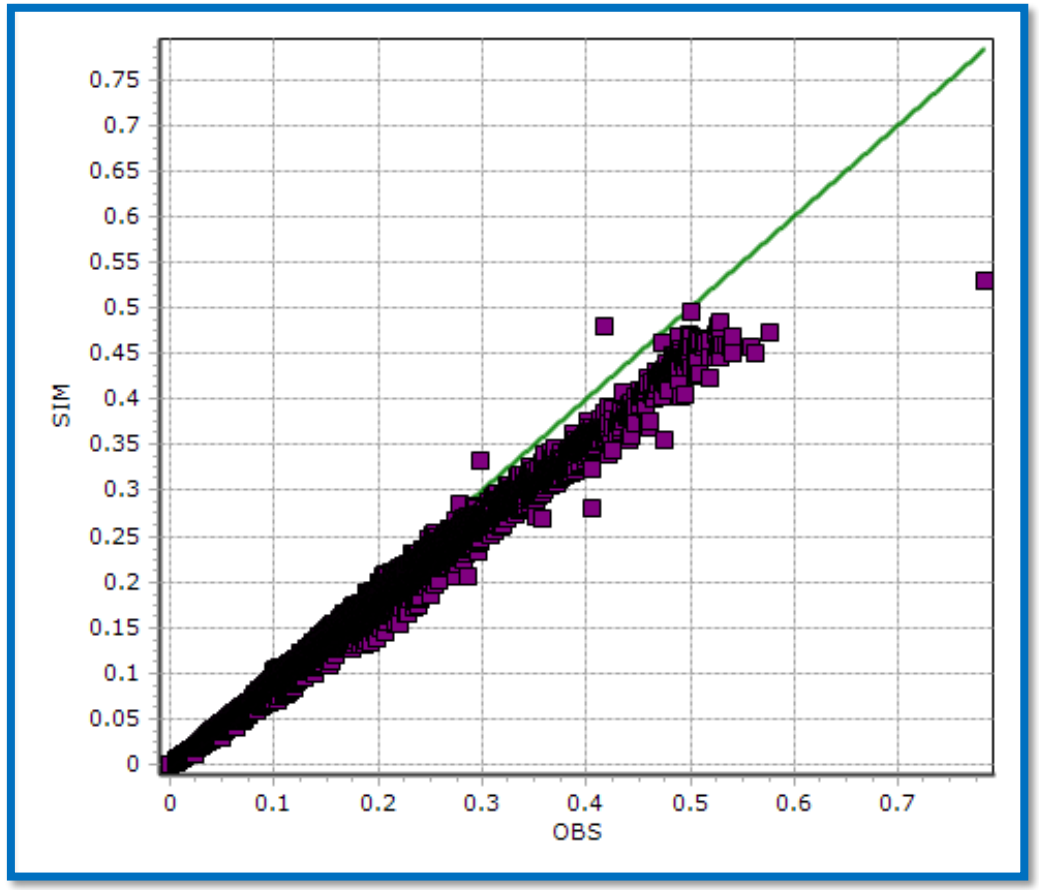


Nearshore measured vs modelled wave periods.

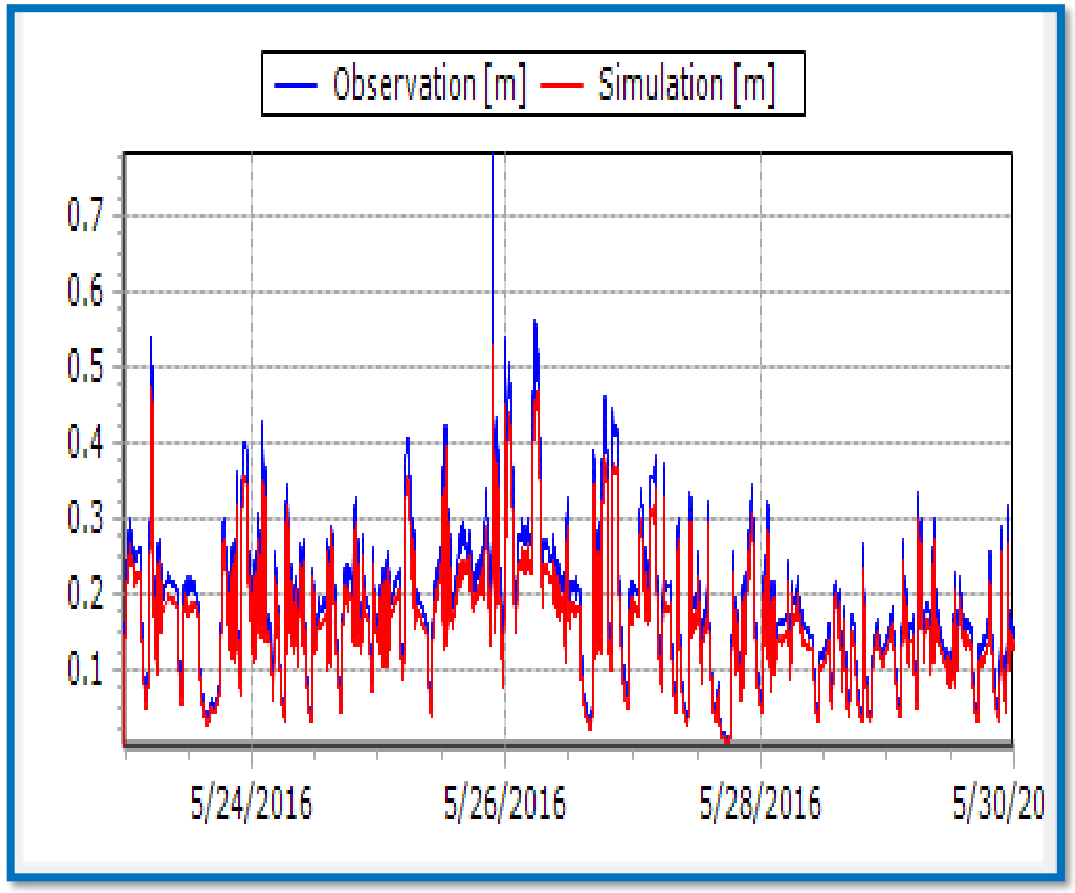


Nearshore calibrated measured and modelled wave periods.

WAVE HEIGHT MODEL CALIBRATION



Nearshore measured vs modelled wave heights.



Nearshore calibrated measured and modelled wave heights.

CONCLUSION

1

Seagrass beds dissipate wave energy mainly through bottom friction due to their roughness.

2

Seagrass beds with higher densities or less degradation have more surface roughness which dissipates wave energy more effectively than lower densities or more degradation.

3

With increasing sea levels, the results show that there is a significant increase in the wave heights within the Bon Accord Lagoon and a decrease in the wave attenuation.

4

When seagrasses deplete whilst sea levels continue to rise, there will be a reduction in flow obstruction.

5

Seagrass bed rehabilitation strategies and management practices should be performed in a flume experiment to determine the feasibility at the Bon Accord Lagoon.

REFERENCES

- Asmus, Harald and Anja Schanz. 2003. “Impact of hydrodynamics on development and morphology of intertidal seagrasses in the Wadden Sea,” Marine Ecology Progress Series. Alfred Wegener Institute for Polar and Marine Research, Wadden Sea Station Sylt, Hafenstrasse 43, 25992 List, Germany.
- Biodiversity, Trinidad. 2020. "Ramsar - BUCCOO REEF Bon Accord Lagoon." Bird, Eric CF. 2011. Coastal geomorphology: an introduction. John Wiley & Sons.
- Bouws, and Komen. 1983. "On the Balance Between Growth and Dissipation in an Extreme Depth Limited Wind-Sea in the Southern North Sea." Journal of Physical Oceanography 13 (9): 1653-1658. DOI: https://doi.org/10.1175/1520-0485(1983)013<1653:OTBBGA>2.0.CO;2
- Donatelli, Carmine and Neil K. Ganju. 2017. *“Changes in hydrodynamics and wave energy as a result of seagrass decline along the shoreline of a microtidal back-barrier estuary,”* Department of Earth and Environment, Boston University, 675 Commonwealth Avenue, Boston, MA 02215, USA.
- Goreau, T. F. 1967. Buccoo Reef and Bon Accord Lagoon, Tobago: Observations and Recommendations Concerning the Preservation of the Reef and its Lagoon in Relation to Urbanisation of the Neighbouring Coastal Islands. Memorandum to Permanent Secretary (Agriculture), Economic Planning Unit, Prime Minister’s Office, Government of Trinidad and Tobago, 8 pp.