Ecological Engineering in Coastal Protection: *Leveraging Advanced Hydrodynamic Models for Living Shorelines*

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Living Shorelines & Infrastructure

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- Large investments are being made in Florida infrastructure due to sea level rise

  Significant growth in work along waterfronts

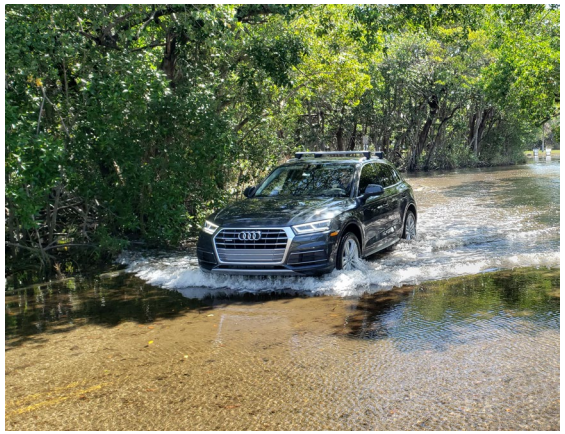
  Increased attention and funding towards living shorelines

  Lots of excitement about living shorelines - environmental benefits, low cost, looks good, feels good…

- Do living shorelines actually work with infrastructure projects or only for environmental enhancement?





Engineering Shorelines & Infrastructure

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- Work along shorelines for infrastructure work is for shoreline stabilization
- Stabilizing and protecting upland areas
- Often seawalls or rock revetments

Traditional Approaches

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Seawalls / Bulkheads

- Protection from
  - Wave energy
  - Shoreline erosion
  - Tidal flooding
  - Storm surge
- Benefit
  - Easy to permit
  - Known installation practices
  - Contractor knowledge

Disadvantages of Seawalls

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- Expensive to build and maintain
- Reflect wave energy rather than dissipate it
- Can be unattractive
- Disturb or prevents habitat
- Limited adaptation options

Seawall Enhancements

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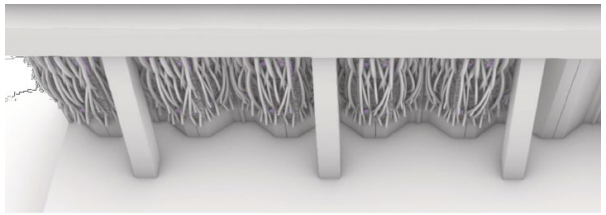
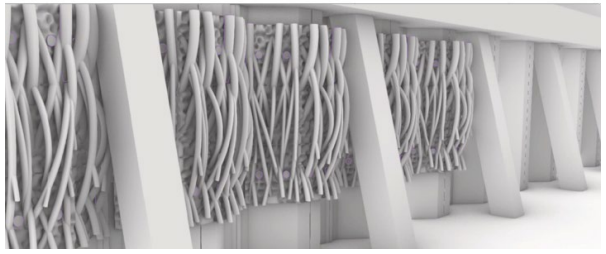
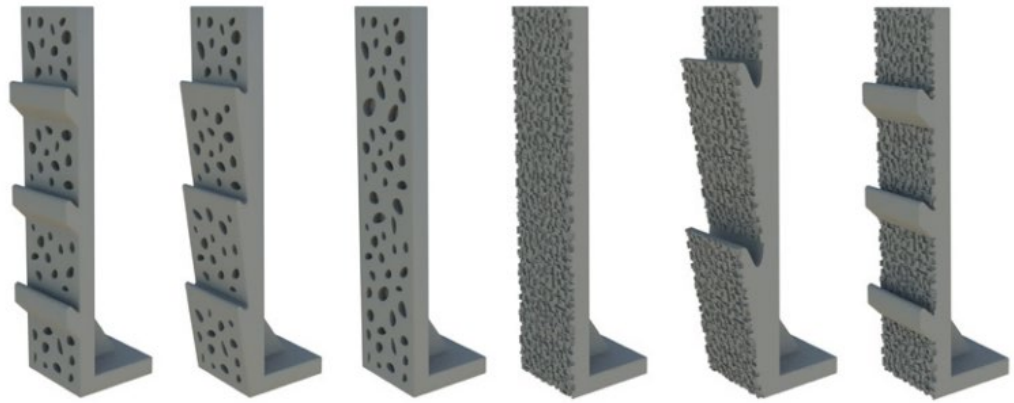




Ecological Enhanced Seawall



Reef Wall Paneling

Nature Based Features

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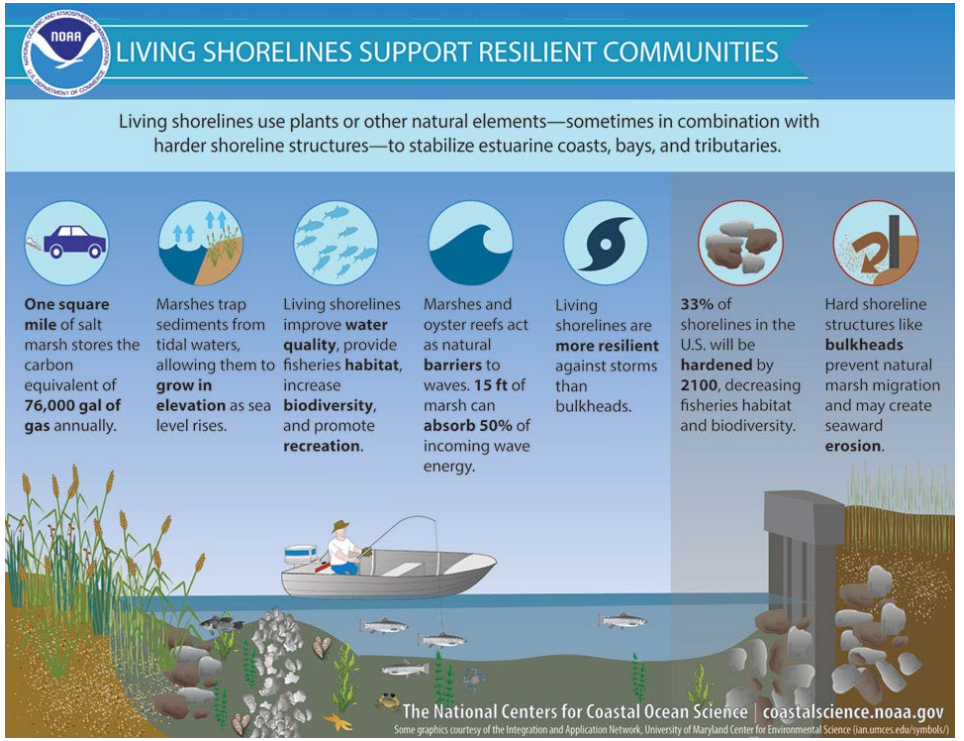
- Living Shoreline – protected and stabilized coastal edge
  - made of natural materials such as plants, sand or rock
  - grow over time
  - to stabilize estuarine coasts, bays, or tributaries



Examples of Typical Living Shorelines

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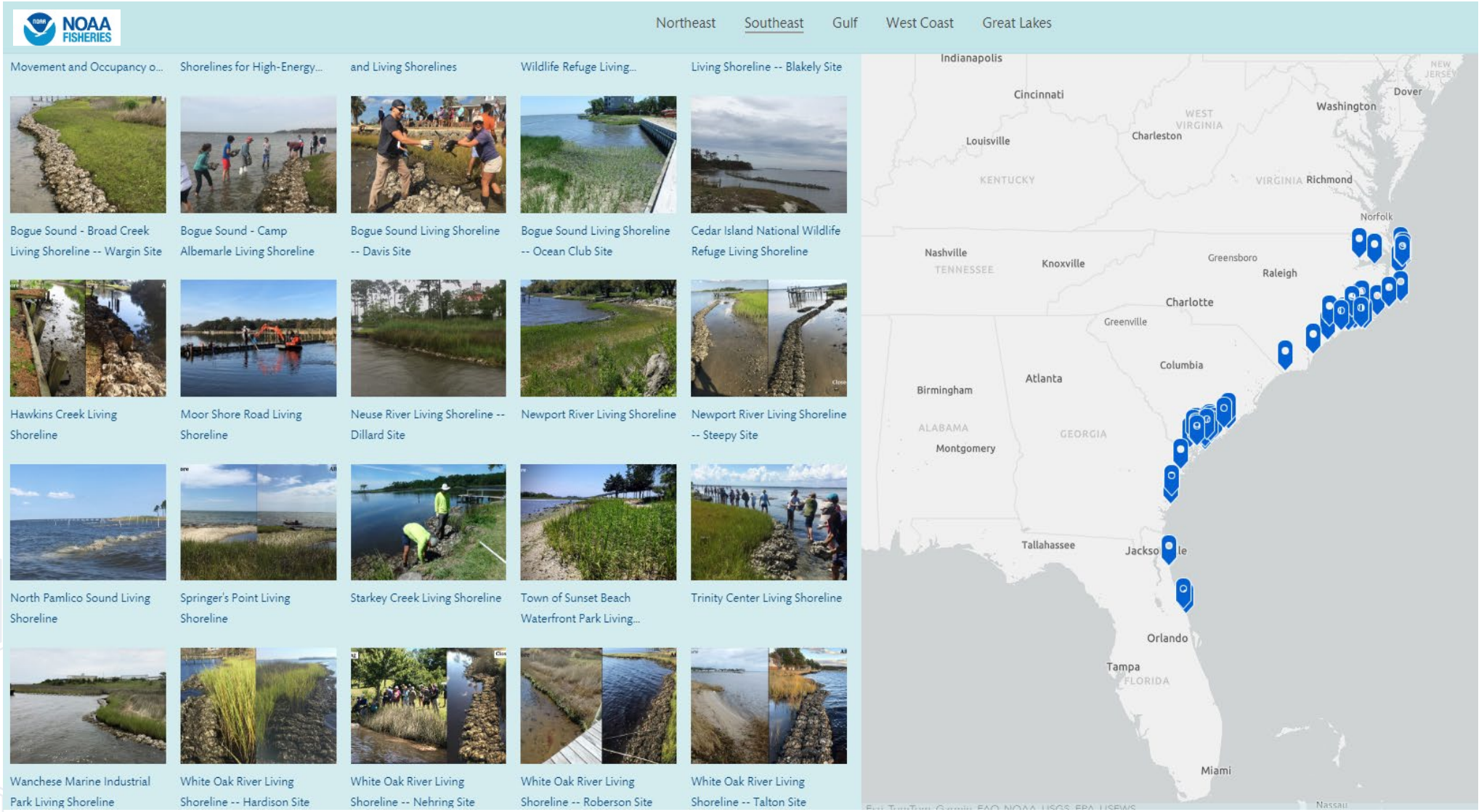

Environmental Enhancement

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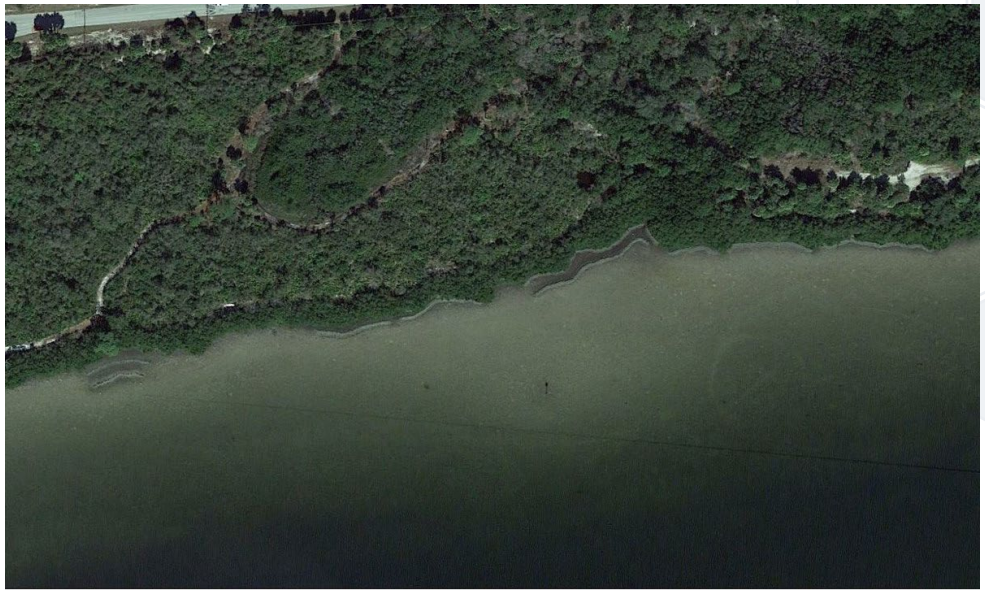
- Restoration of mangroves, seagrass, marshes
- Often in areas not protecting anything and where footprint is not an issue
- Commonly constructed in mild wave climate areas expanding existing soft shoreline
- May or may not help with attenuating storm impacts
- Typically NOT designed for storm impacts….



Infrastructure Considerations

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- Living Shorelines need to be engineered
- Performance needs to quantified
- Needs to meet performance and design criteria

If not walls, what is required to stabilize shorelines?

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- Rocks, blocks, gravel, sand, vegetation
- Already used in very exposed locations
- Understanding of coastal engineering dynamics and structures
- Can be designed to specific performance criteria

Design Considerations

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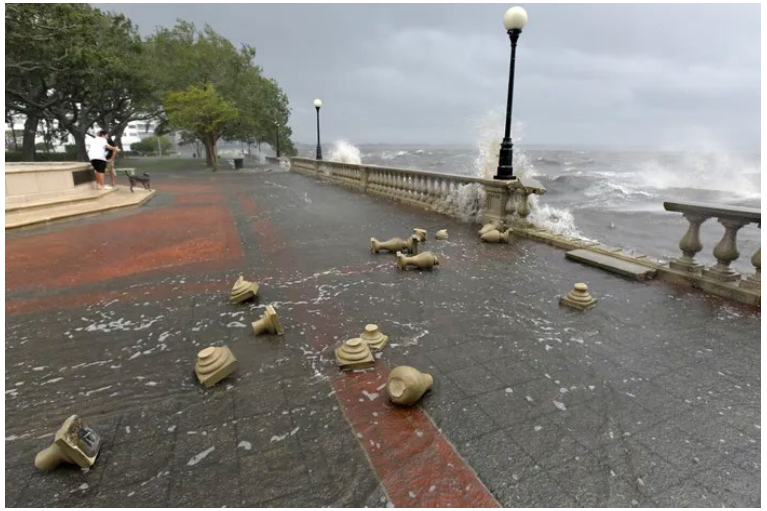
- Waves
- Storm surge
- Currents
- Wave overtopping
- Hydraulic stability
- Wave loads
- Scour



Site Selection

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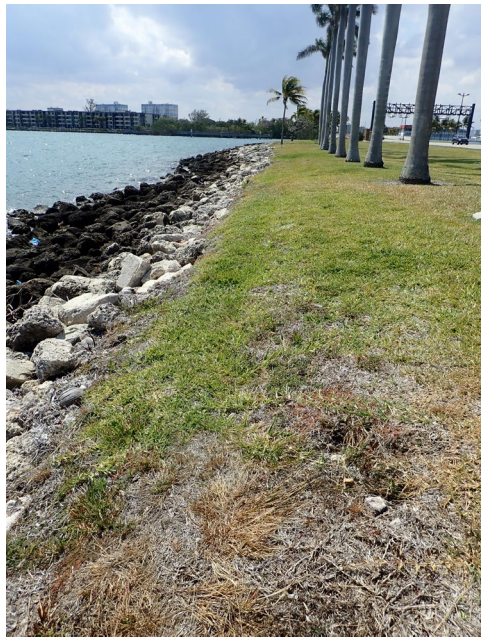
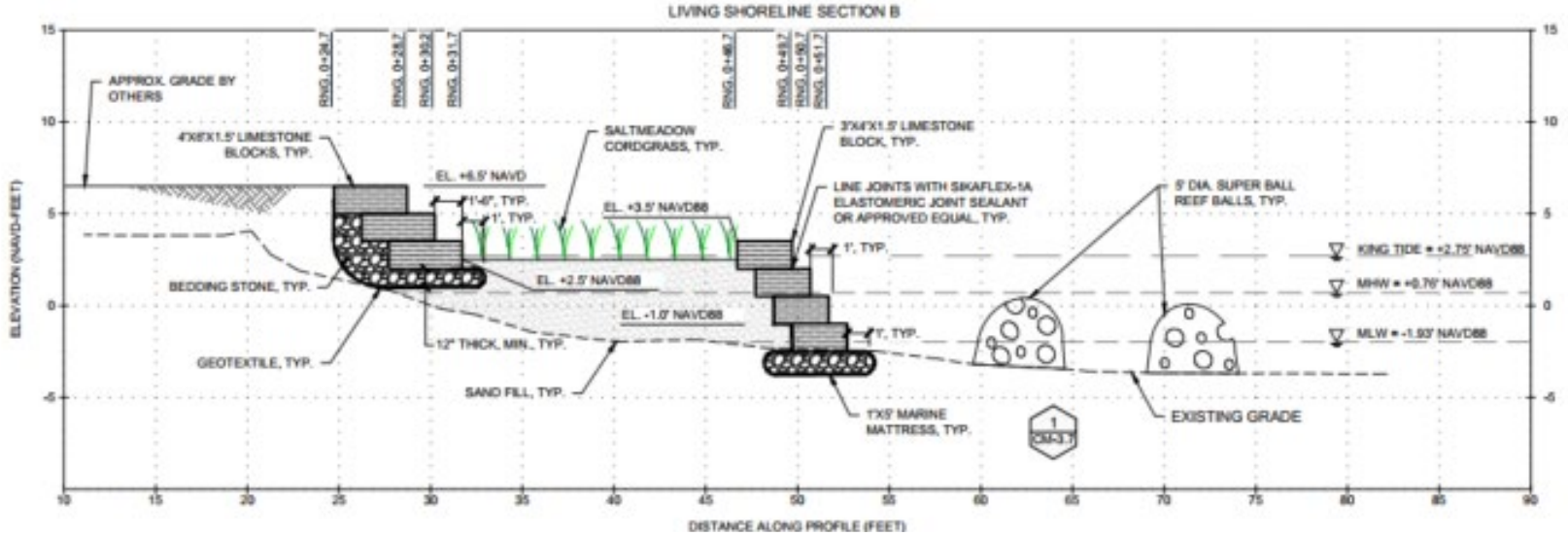
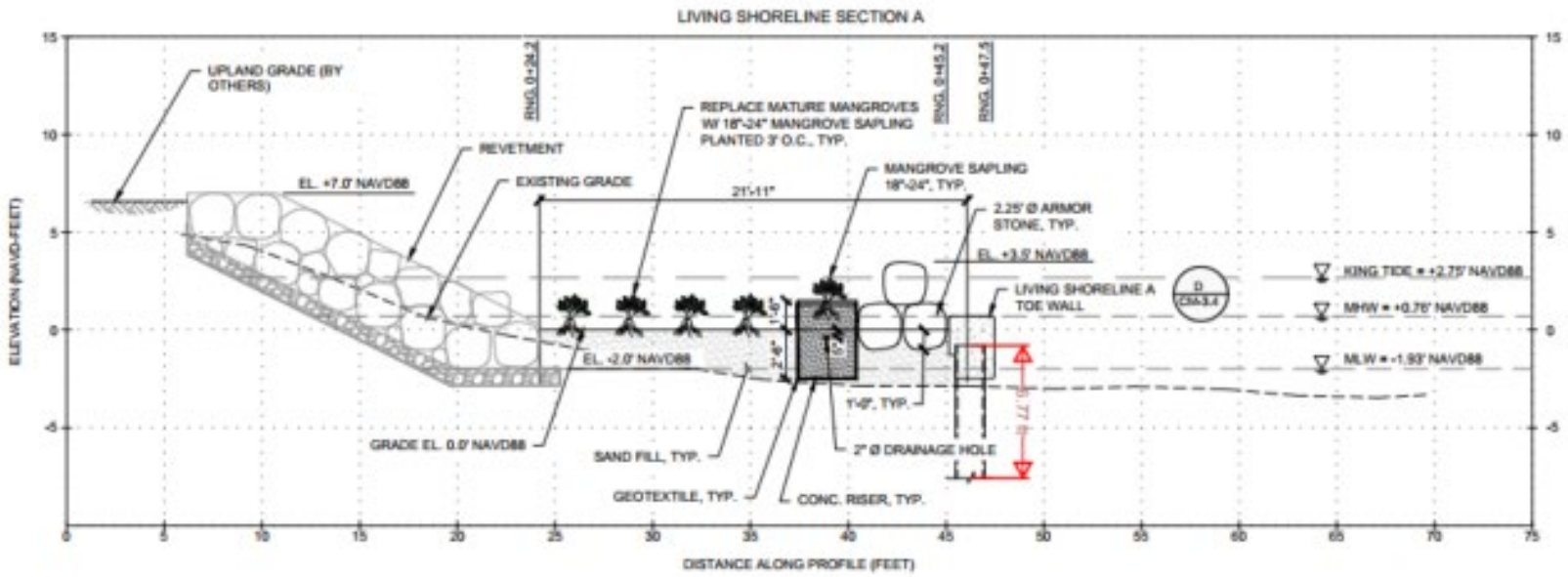
- Upland space, use, and functionality
- Length of shoreline
- Existing marine resources
- Water depth
- Wave exposure



Living Shoreline Sections





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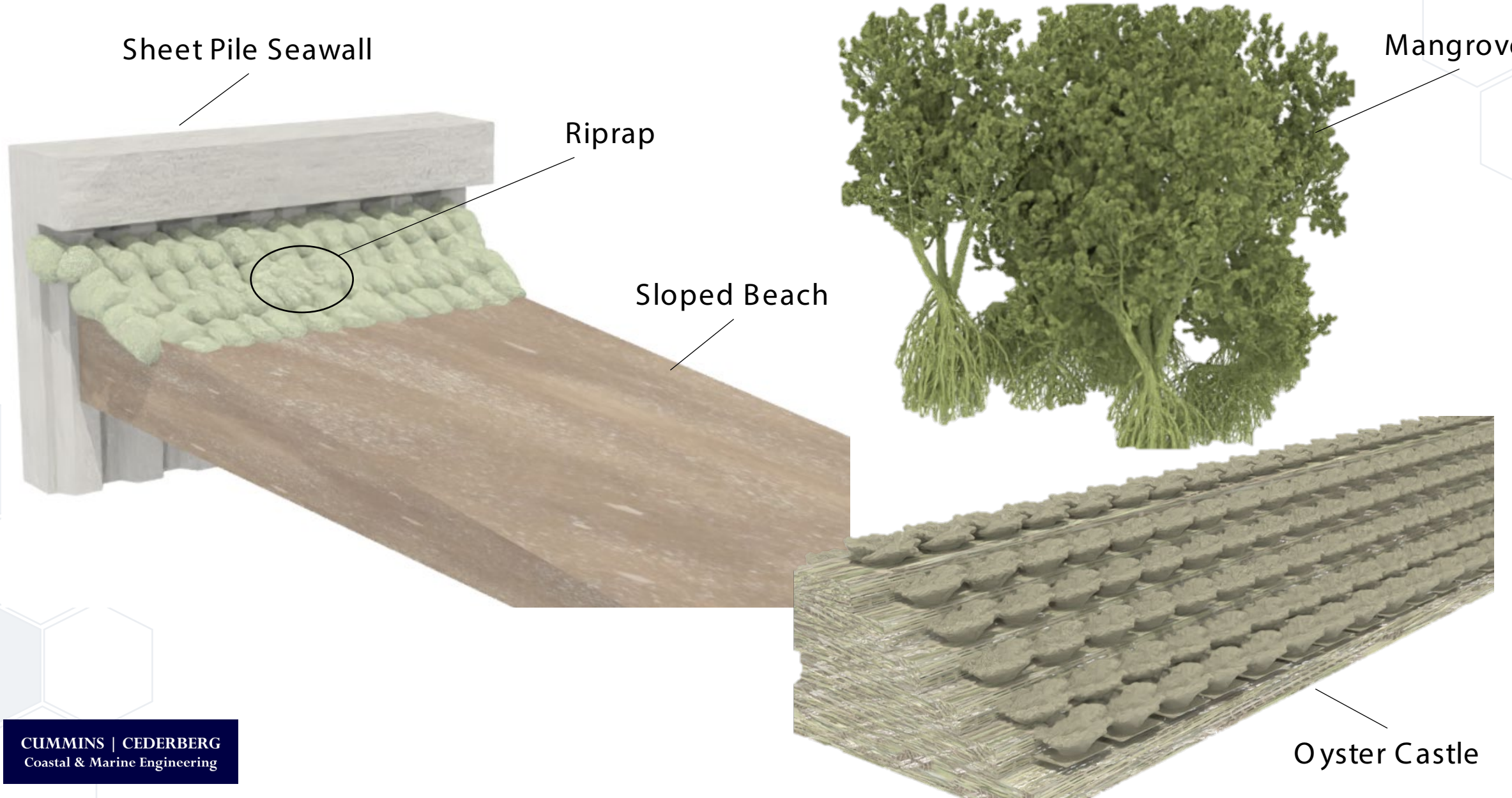
Living Shoreline Modeling Elements



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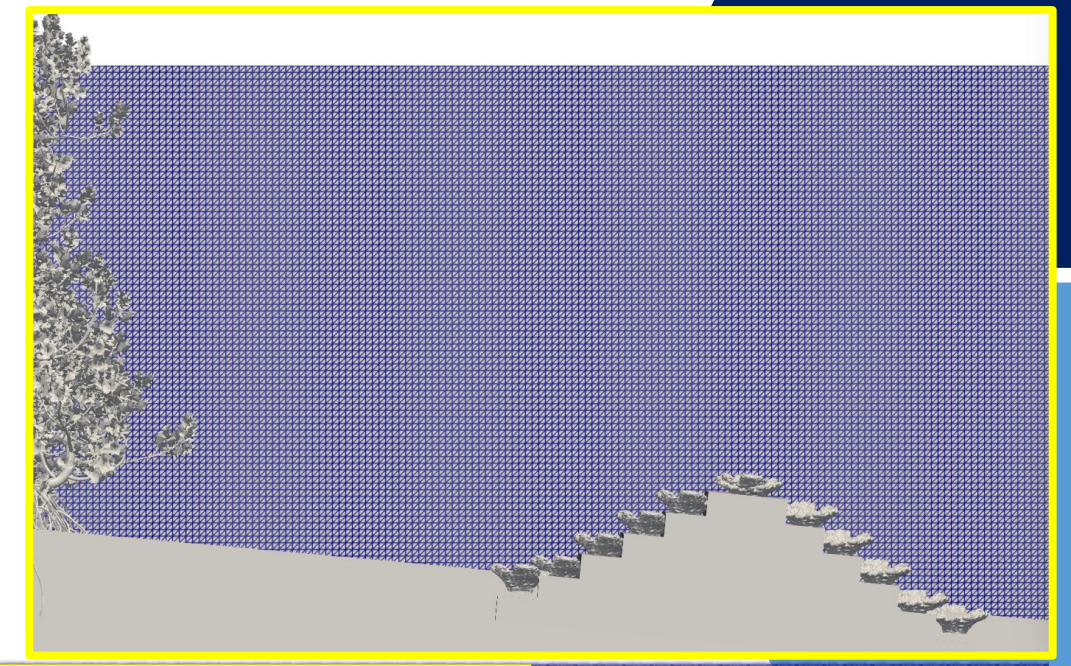
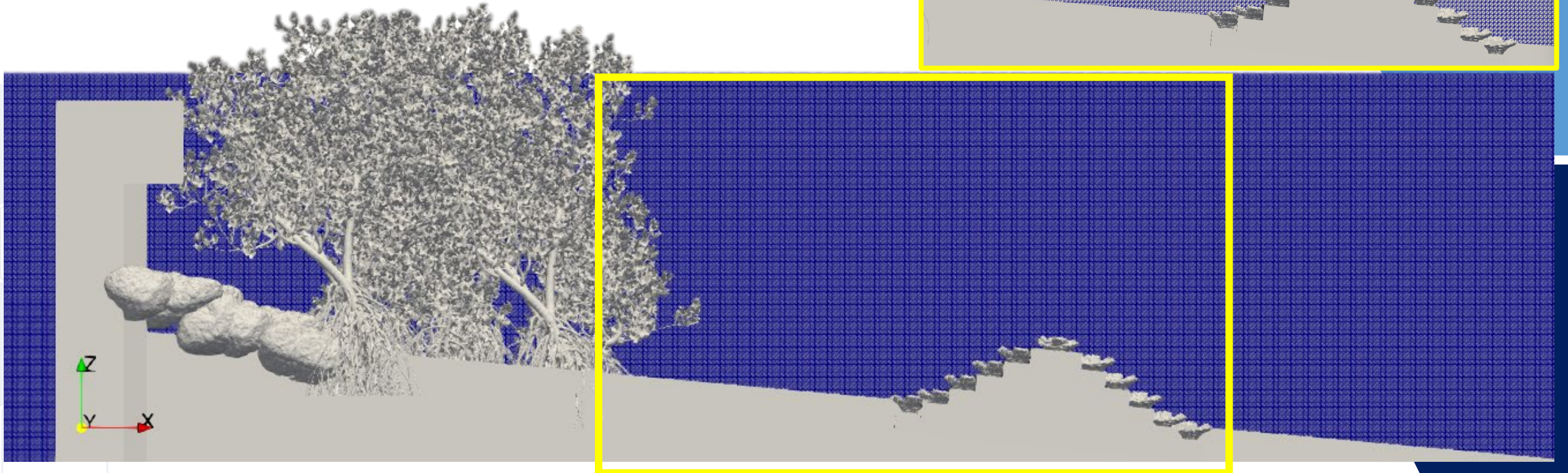
Computational Model

- Solves for two incompressible, isothermal immiscible fluids using VOF method (Navier-Stokes Equation Solver)
- Computational mesh that resolves water to 0.05*Hs (significant wave height)





Model Sampling Locations

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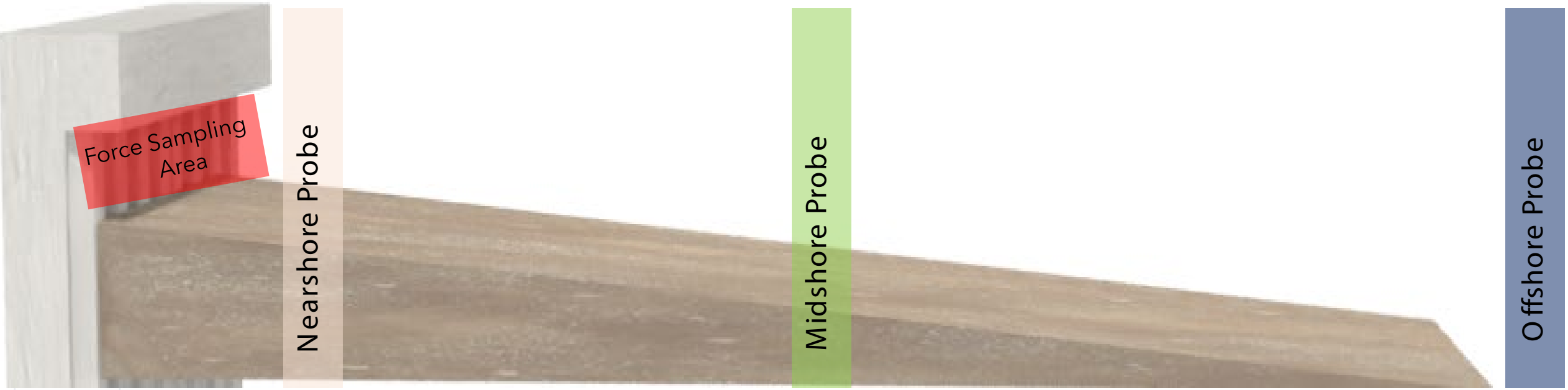
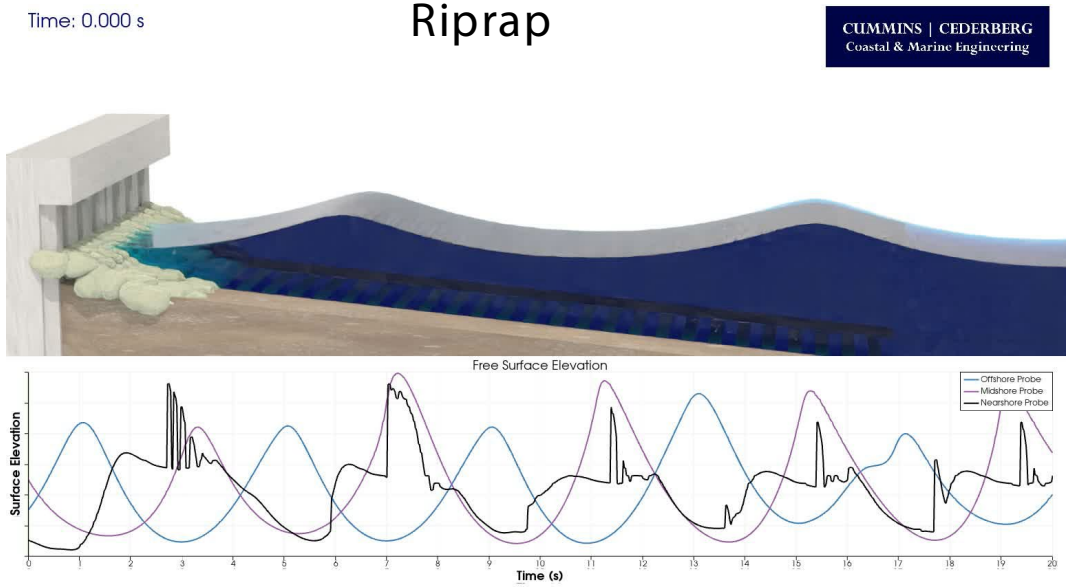
- Probed surface elevation at 3 locations
- Sampled hydrodynamic forces acting on wall

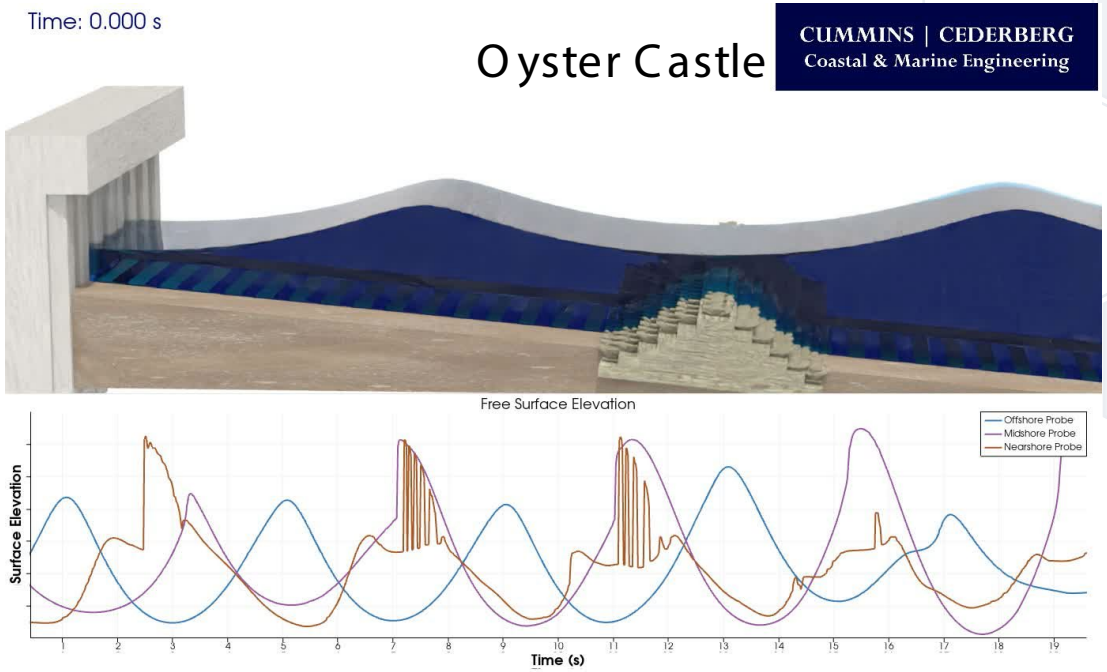


Free Surface Elevation Comparison

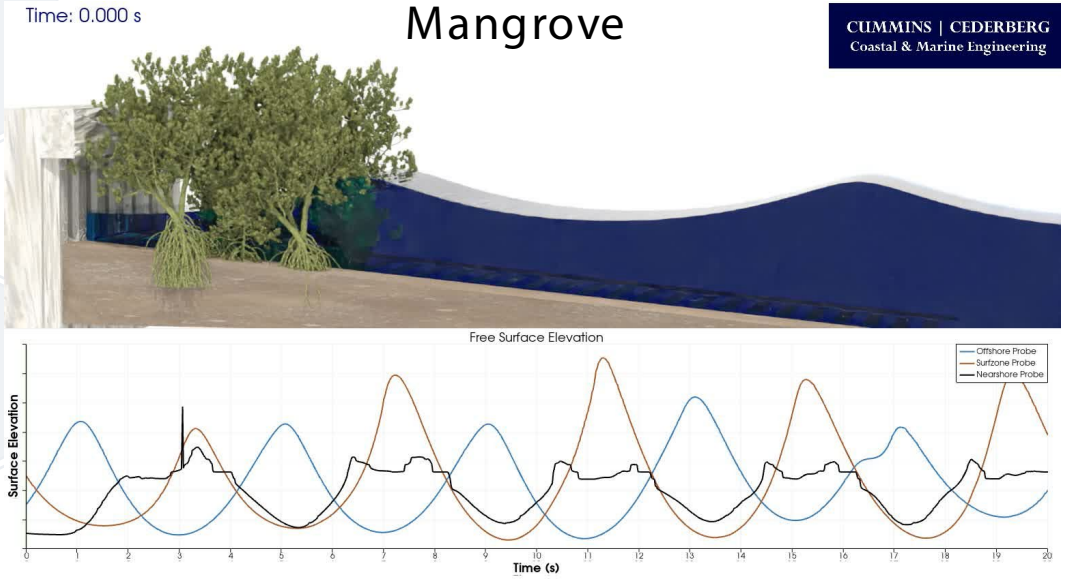
Riprap



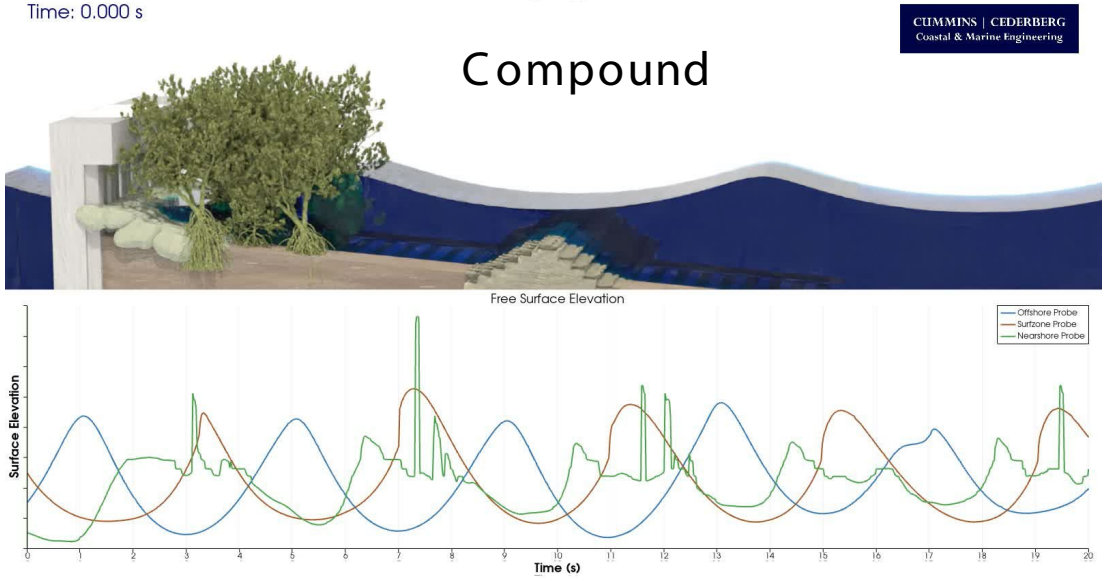
Oyster Castle



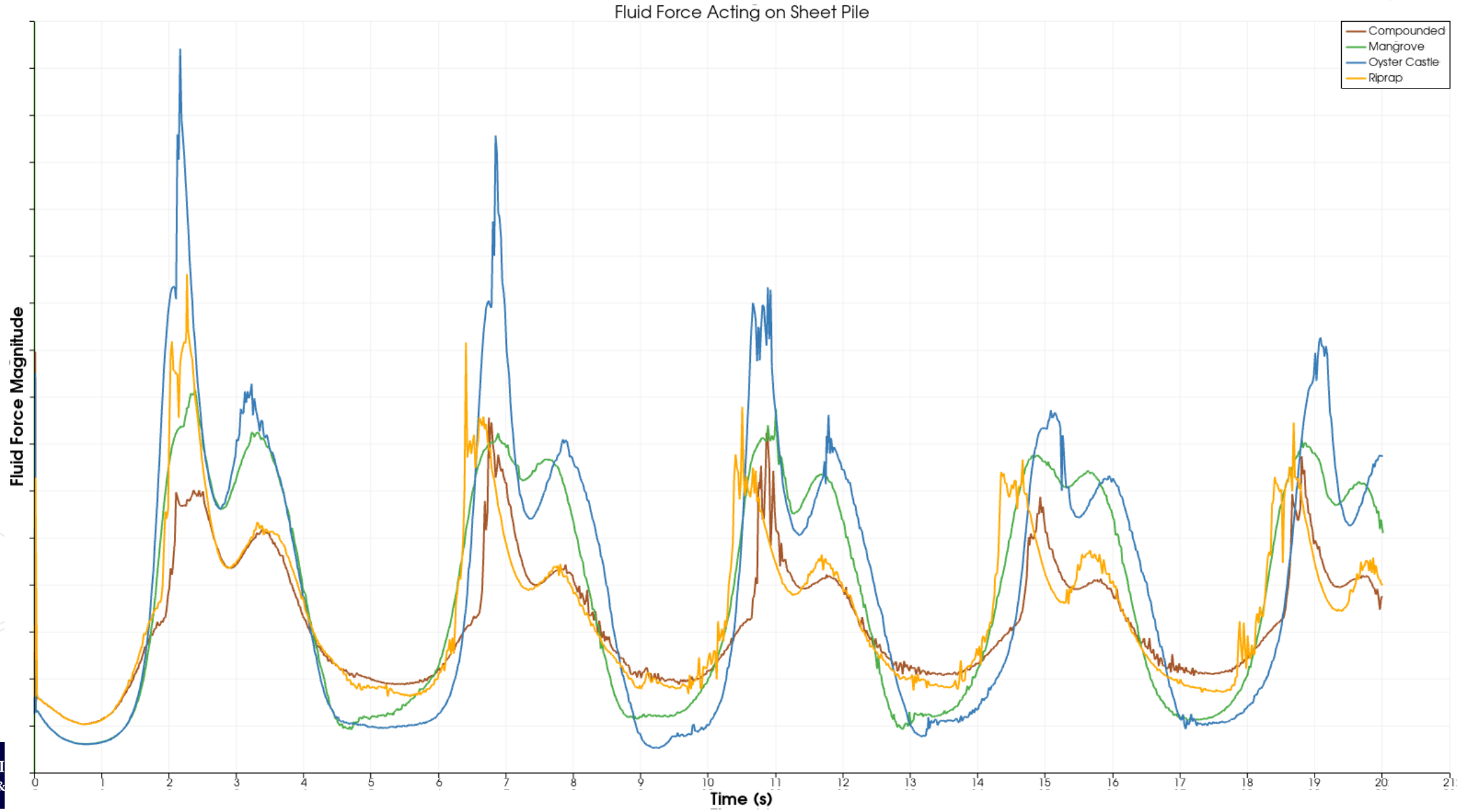
Mangrove



Compound



Fluid Force Acting on Sheet Pile Comparison for Different Shorelines



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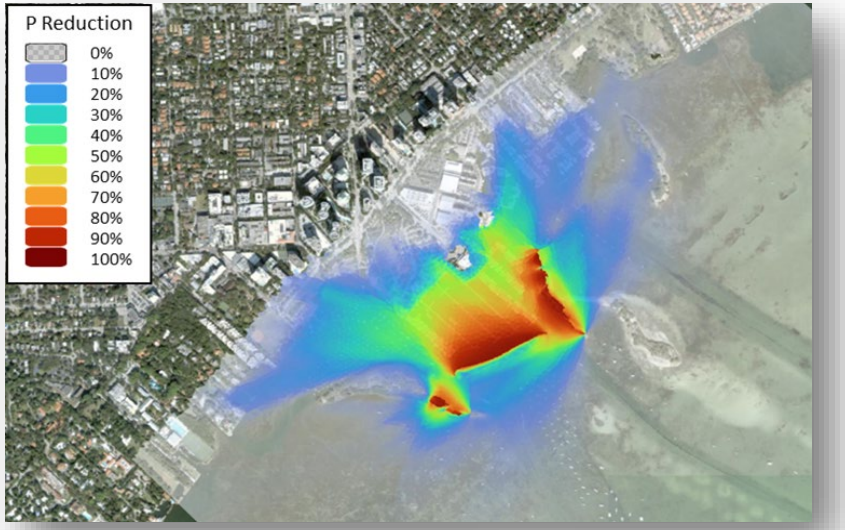
Maximum Wave Power Reduction

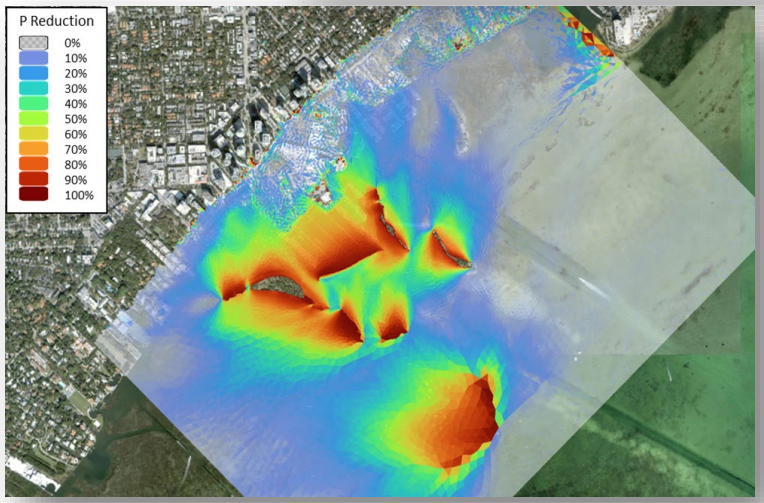
- Proposed concepts were incorporated into the detailed wave model and simulations of storm scenarios

- Illustration shows maximum percent reduction of wave power under the 50-year return period

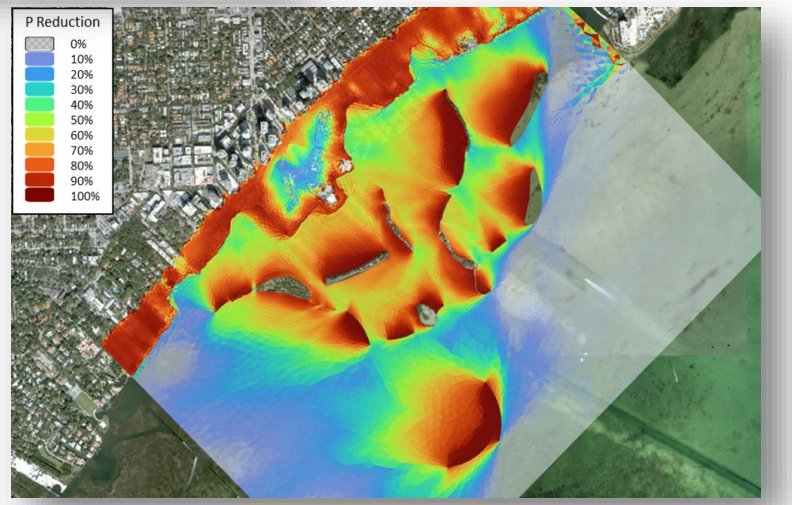
Red indicates strongest wave protection

1) Base Concept





2) Enhanced Intermediate Concept



3) Enhanced Full Concept

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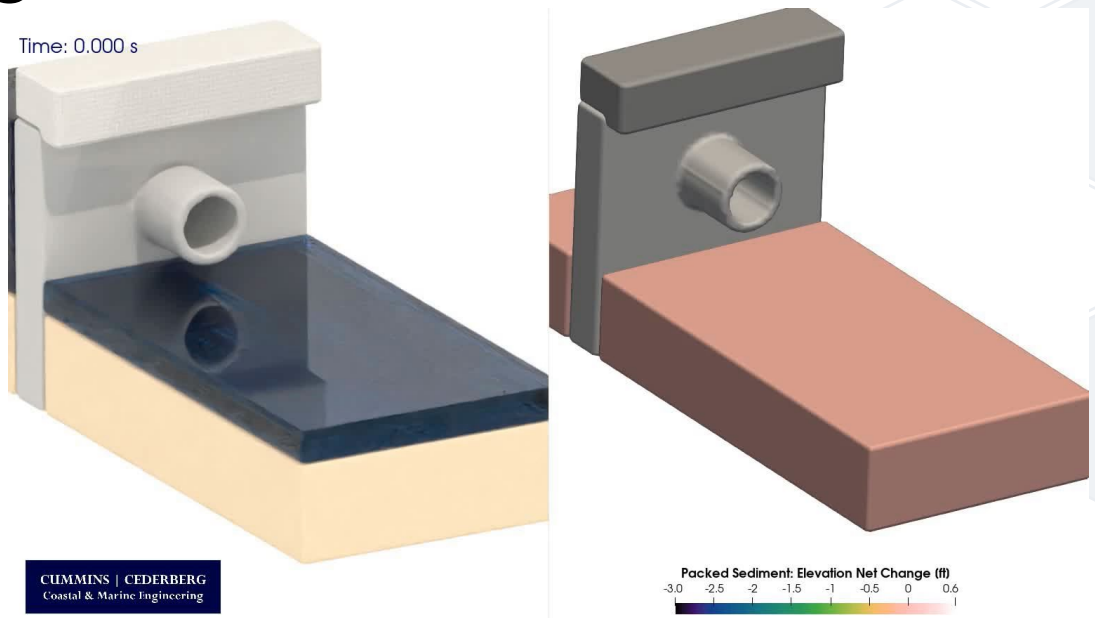
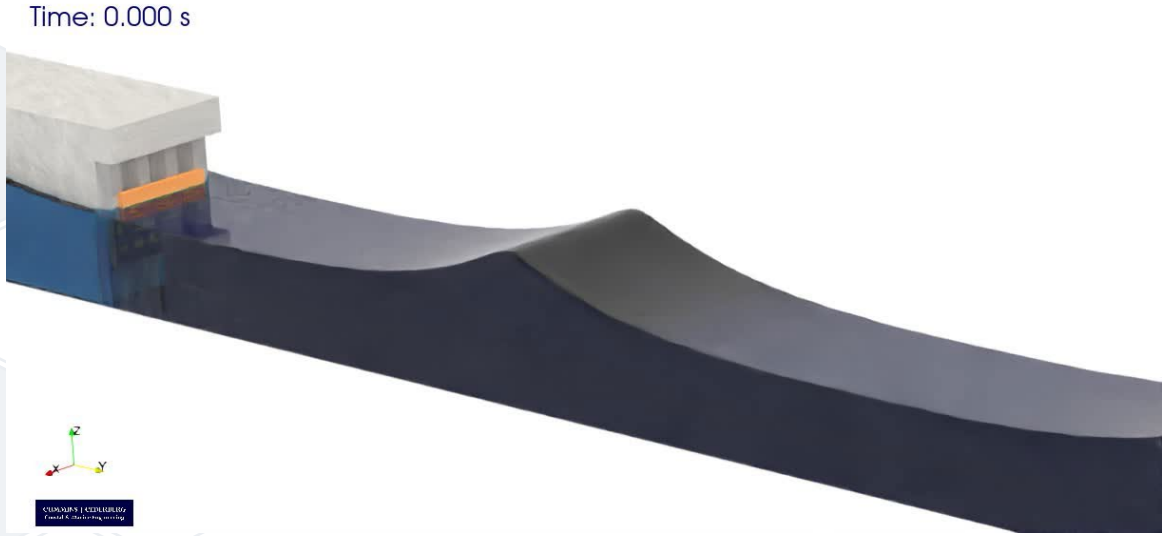
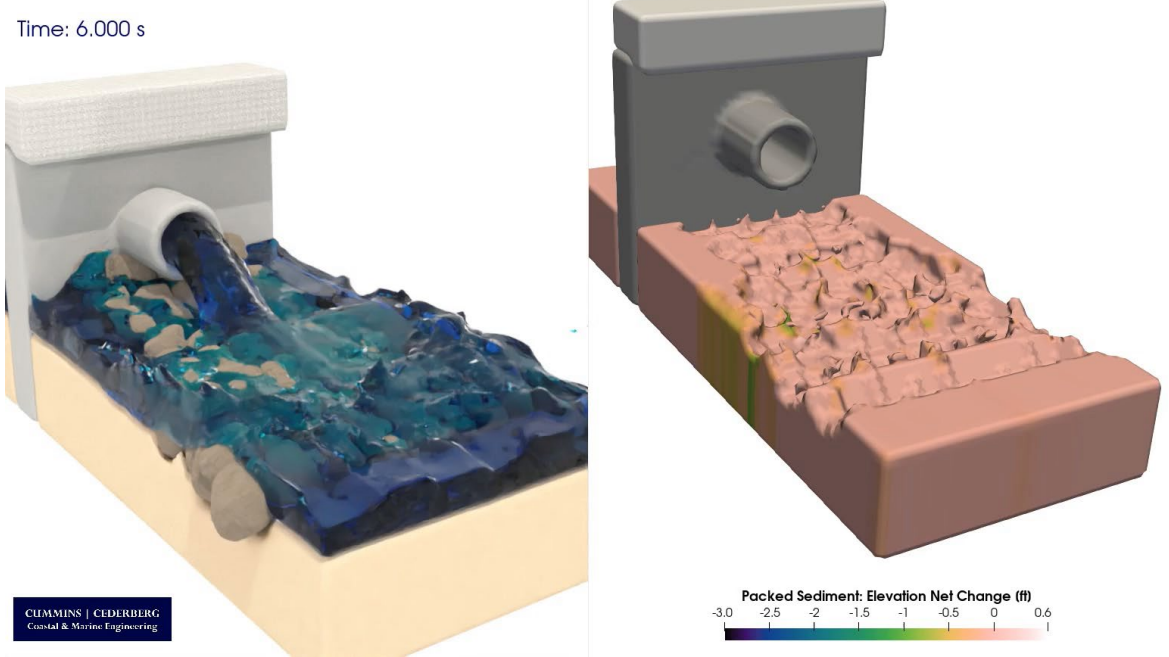
Additional Applications of Modeling for Small Scale Processes

- Analysis of 3D printed retrofit panels to promote marine growth



- Scour analysis to find solutions minimizing scour





Summary

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- Living Shorelines are a feasible option for infrastructure projects
- Performance based engineering required to accurately quantify efficiencies obtained from living shorelines
- Adds additional dimensions to the design process and should be considered early on
- Cost effectiveness can be quantified

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