ICCE 2018

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The State of the Art and Science of Coastal Engineering

Optimizing Nature-Based Features For Wave Dissipation And Land-Water Connectivity

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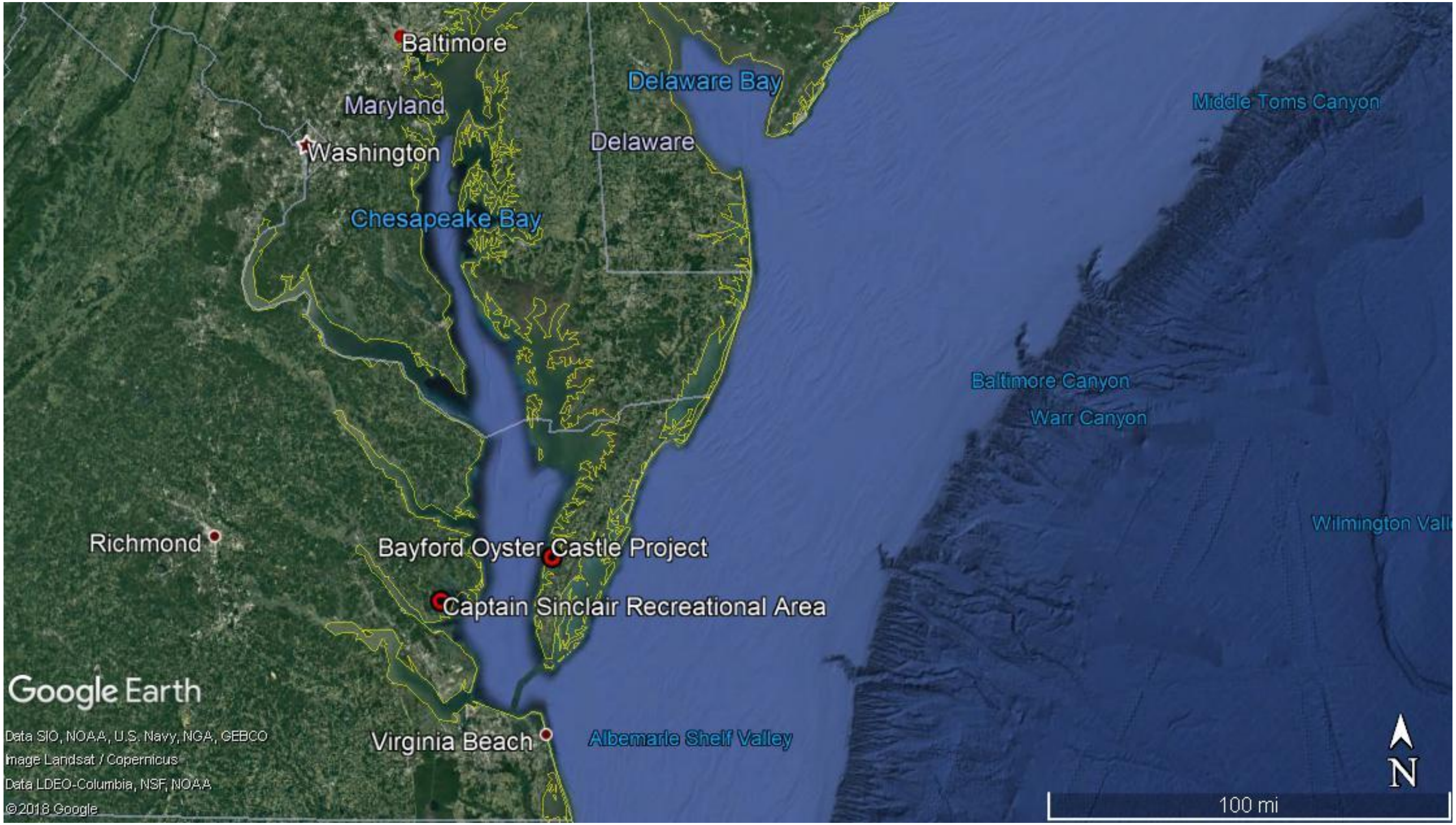
Background

- Living shorelines are the preferred method for shoreline erosion mitigation
- Minimal post-construction study
- Engineering design guidance is lacking
- Cross-disciplinary measurements of success are present

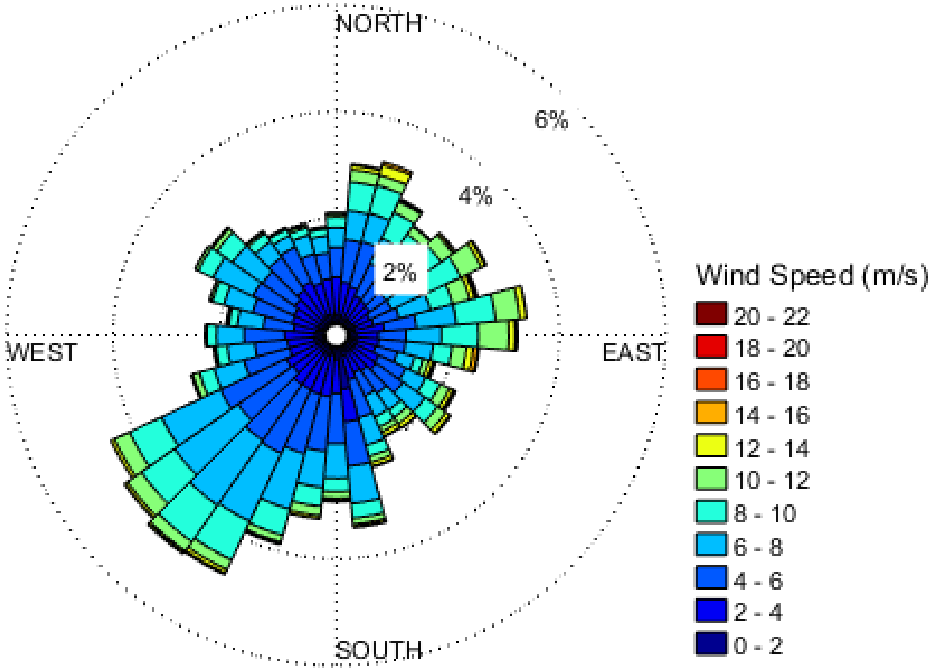
Field Study Locations



Captain Sinclair Marsh Sill

- Eroding marsh
- Constructed in 2016
- 4 rock sills, sand fill, vegetation

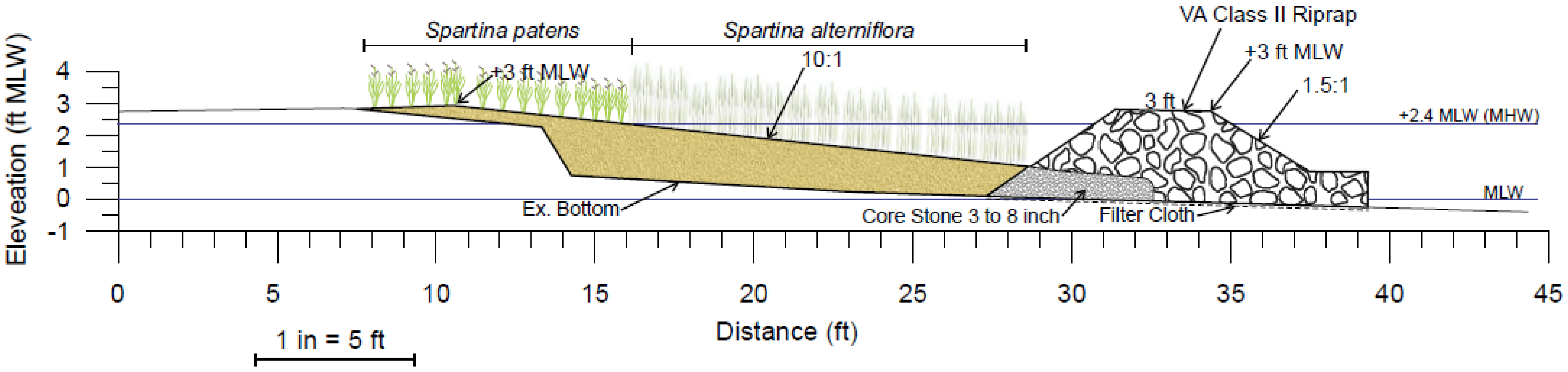
Captain Sinclair Marsh Sill



Fetch: 2 miles SW, 1 mile S, 1.5 miles SE

Tide Range: 0.73 m

Captain Sinclair Marsh Sill



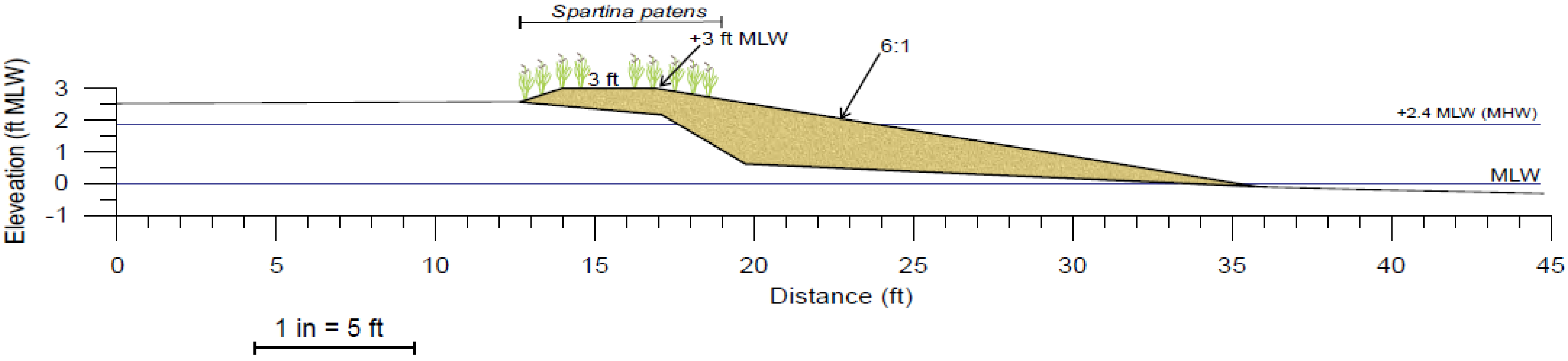
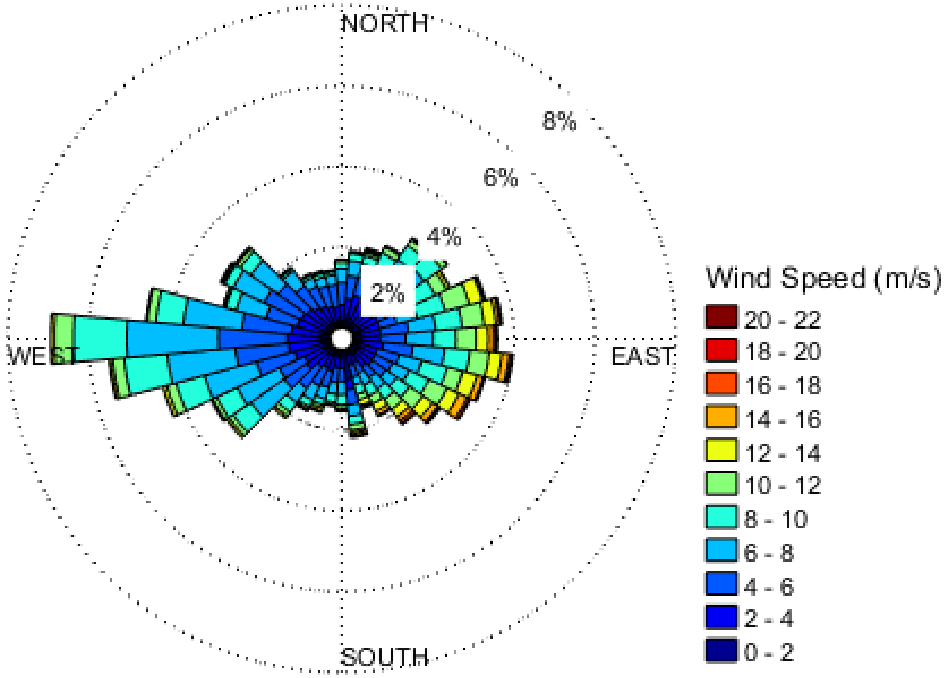


Image Source: VIMS

Bayford Oyster Castle

- Eroding marsh
- Constructed in 2014
- 756 feet of oyster castle array

Bayford Oyster Castle

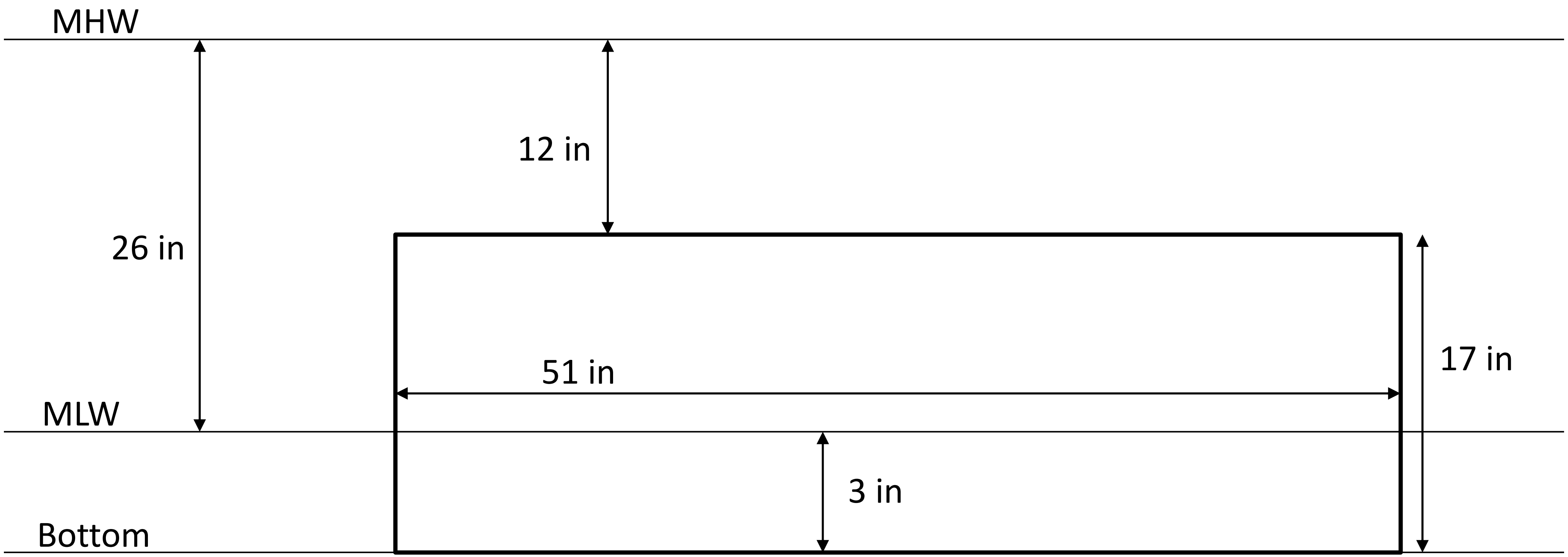


Fetch: 0.9 miles S, 17 miles W

Tide Range: 0.48 m

Photo Credit: VMRC

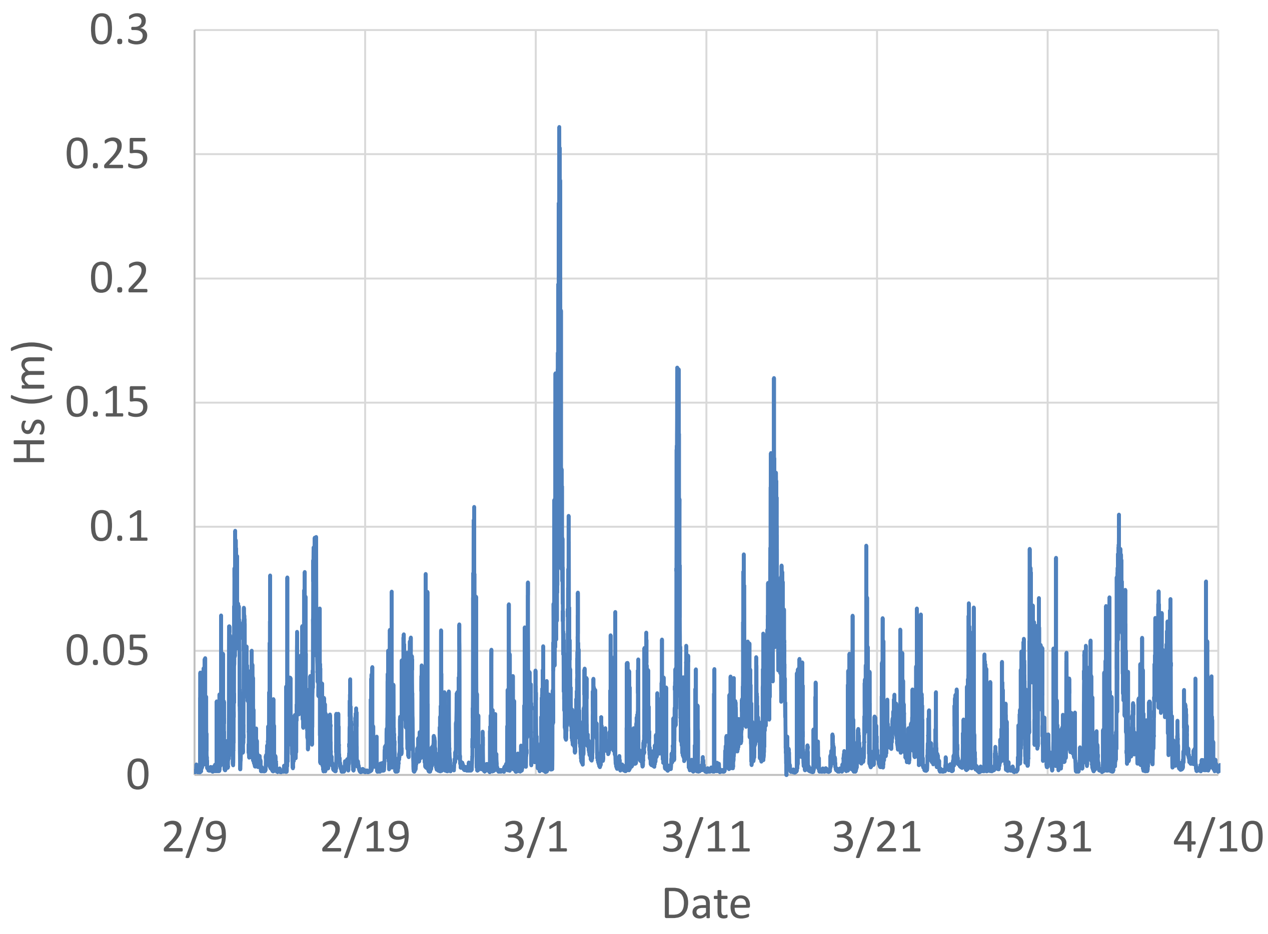
Bayford Oyster Castle



Data Collection Methods

- Pressure gauges
- Acoustic Doppler Current Profiler
- Surveying

Data Post-Processing



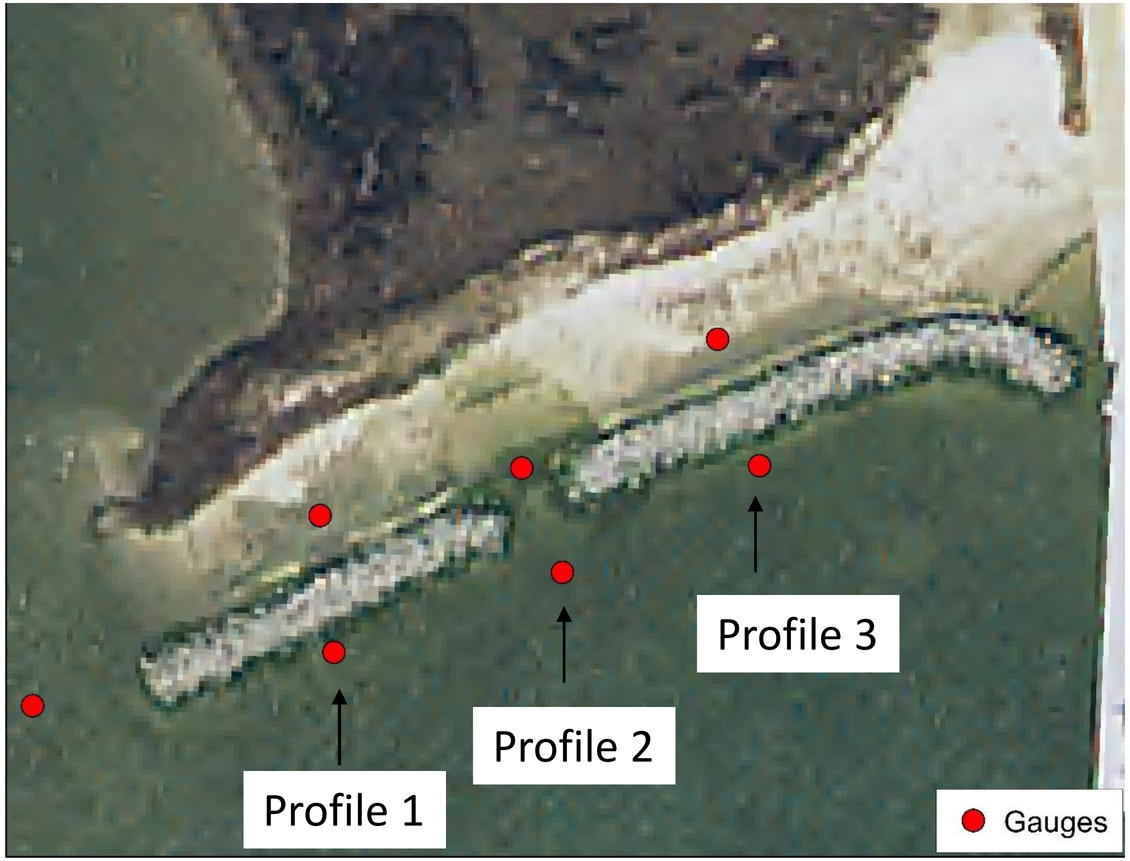
Wave Energy Density Flux:

$$F = \frac{1}{2}\rho g a^2 c_g$$

Dissipation:

$$\varepsilon = \frac{F_n - F_{n-1}}{\Delta r}$$

Field Results – Captain Sinclair



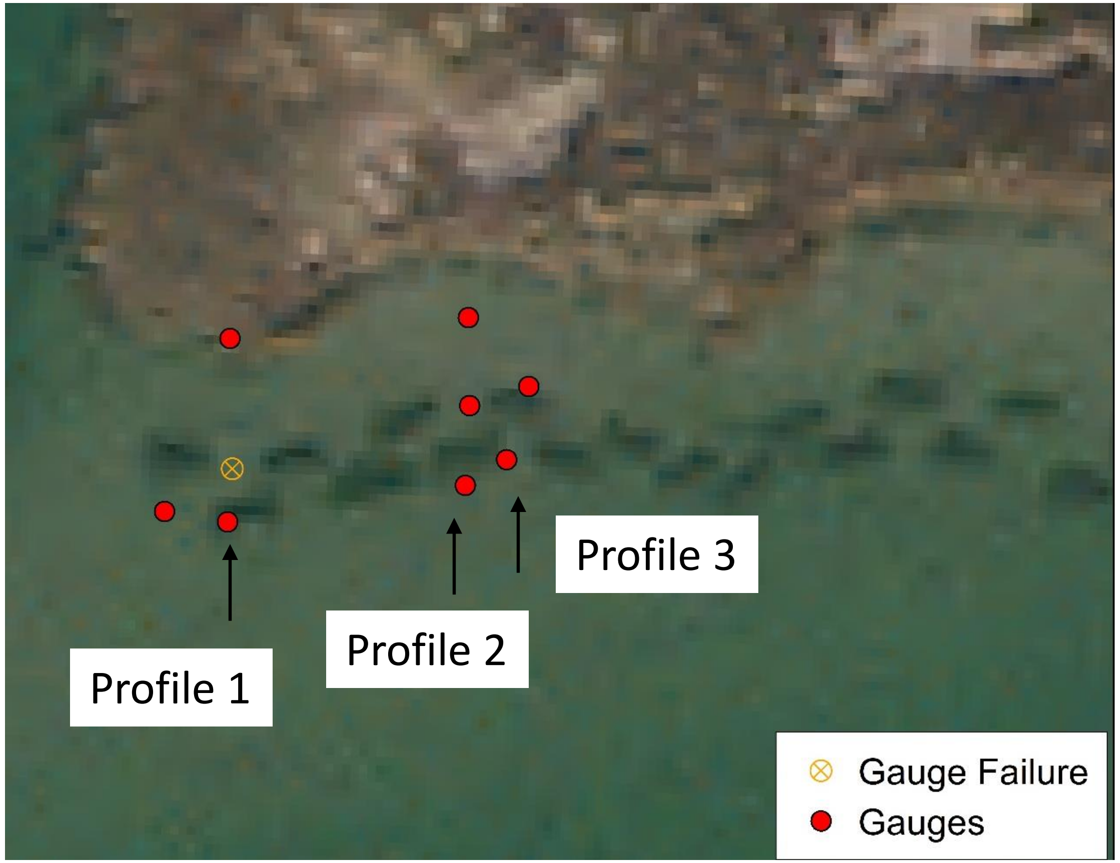
April 11-13

Profile	Dissipation (seaward to landward)
1	55.6%
2	25.8%
3	76.9%

May 25-27

Profile	Dissipation (seaward to landward)
1	78.6%
2	74.6%
3	67.9%

Field Results – Bayford



March 4-9

Profile	Dissipation (seaward to landward)	
1	20.3%	
2	28.7%	-27.1%
3	34.9%	

March 26-30

Profile	Dissipation (seaward to landward)	
1	18.0%	
2	4.1%	-1.4%
3	44.5%	

Non-Hydrostatic Wave Model (NHWAVE)

(Ma et al. 2012)

- Solves incompressible Navier-Stokes equations

$$\frac{\partial u_i}{\partial x_i^*} = 0$$

$$\frac{\partial u_i}{\partial t^*} + u_j \frac{\partial u_i}{\partial x_j^*} = -\frac{1}{\rho}\frac{\partial p}{\partial x_i^*} + g_i + \frac{\partial \tau_{ij}}{\partial x_j^*}$$

- Bottom and surface geometry, σ-coordinate

$$t = t^* \quad x = x^* \quad y = y^* \quad \sigma = \frac{z^* + h}{D}$$

Non-Hydrostatic Wave Model (NHWAVE)

- Staggered grid framework with velocities at cell center and pressure at vertically-facing cell faces
- $k - \epsilon$ turbulence model
- Spatial derivatives by a Godunov-type finite volume scheme
- Time stepping – Runge Kutta scheme

Non-Hydrostatic Wave Model (NHWAVE)

- Computationally efficient by using 3-5 vertical layers as compared to typical 10-20 vertical layers
- Vegetation module

Next Steps

- Calibrate NHWAVE model with field results
- Collaborate to include module for site specific flexible vegetation
- Analyze scenarios to determine potential areas for design optimization

Acknowledgements

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Virginia Institute of Marine Science

- Center for Coastal Resources Management
- Shoreline Studies Program