SEAGRASS MITIGATION THROUGH WIND WAVE AND BOAT WAKE REDUCTION

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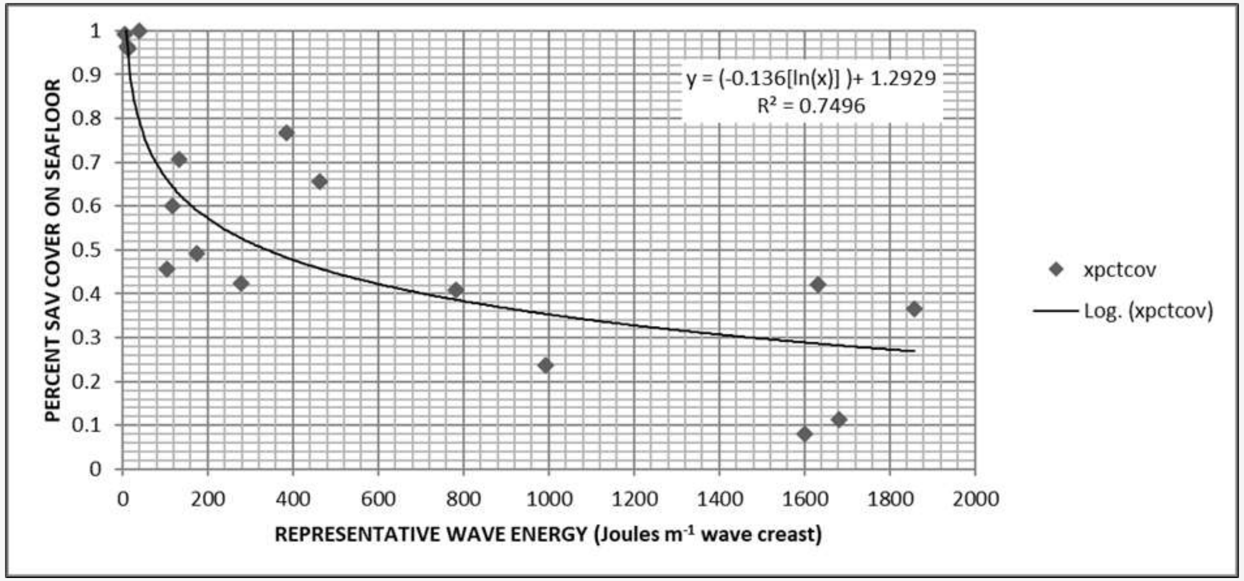
Project Need & Concept

- Impacts to seagrass from bridge construction estimated at 1.28 acres
- Lack of injury sites for traditional seagrass mitigation methods
- NCDOT fund experimental science project for seagrass coalescence
- Concept: employ “green engineering” to encourage natural coalescence of patchy seagrass

Background: Guiding Principles

1) As wave energy ⬇ cover of seagrass ⬆



Recomputed from Fonseca & Bell, 1998

2) Seagrass abundance ⬆ in lee of formations

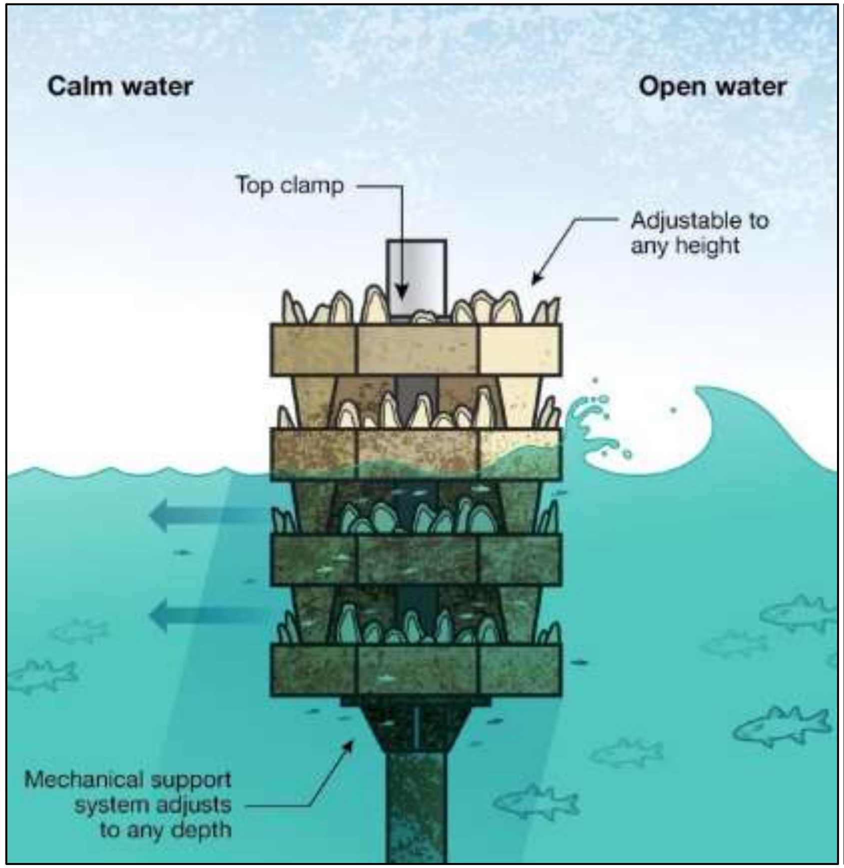
Project Feasibility Study

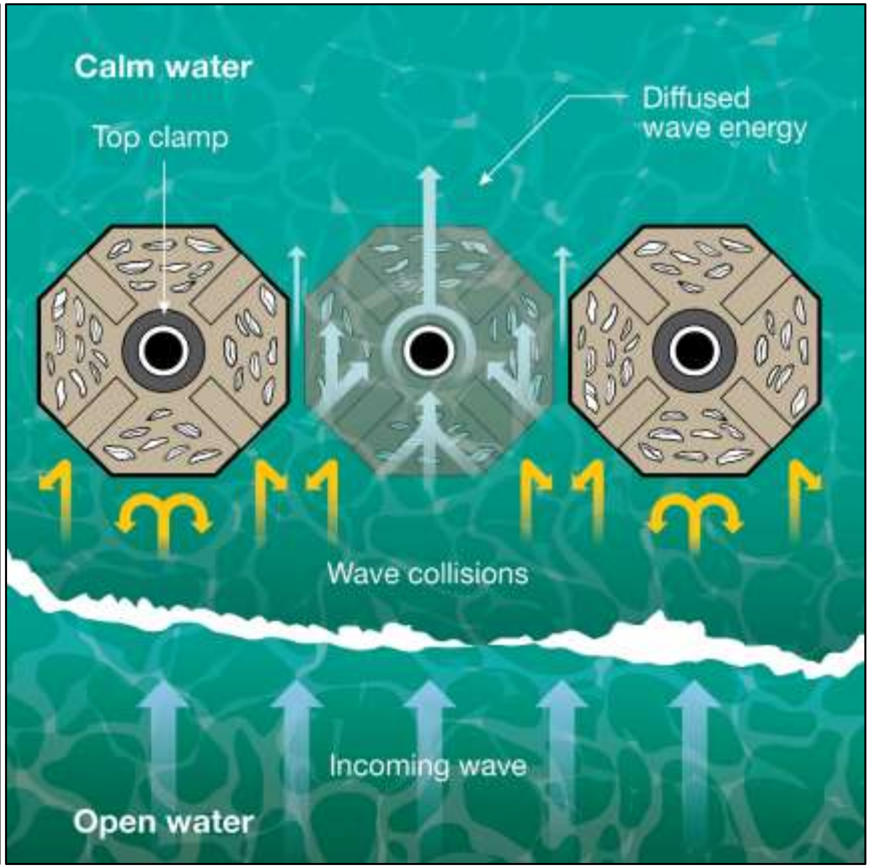
- Eight options
- Factors reviewed/ studied
  - Mobilization challenges
  - Installation issues
  - Maintenance concerns
  - Costs
  - Estimated essential fish habitat (EFH) utility
  - Potential site impacts

Method	Installation issues	Mobilization issues	Maintenance issues	Cost installed for 1600 linear feet (without transportation); all numbers are rough estimates and not to be used for bidding	Wave attenuation and estimated resiliency over ~10y	Est. EFH utility (low, medium, high)	Potential site impacts (lower impacts result in a higher score)	Remarks	links
Living Wave Barrier (28)	Weight; can be moved in variable amounts with associated costs of handling (5)	Versatile because of piecemeal construction and comparatively light lift per piece (5)	Limited potential for settling (5)	TBD; without deep anchors as required for previous projects (not required at this site): $400 per linear foot	High: solid objects embedded in shoal with an ability to maintain position - single row effectiveness in wave dampening (5)	Moderate – high: abundant surface area for attachment and interstitial space for small fauna (4)	Low-moderate because of piecemeal construction (4)	Specifically designed for wave breaking and oyster habitat provision. Engineering being established but based on well-known materials. One row of structure will suffice. Pre-designed	http://www.reefmaker.com/news/2013/ecosystems-living-wave-barrier
Reef Links (28)	Weight; moved in low to moderate weight modular units (5)	Versatile because of piecemeal construction and comparatively light lift per piece (5)	Limited potential for settling (5)	$125-250 per linear foot	High: solid objects both linked and embedded in shoal with an ability to maintain position - single row effectiveness in wave dampening (5)	Moderate; highly abundant surface area for attachment; modifiable to provide internal access to larger fauna (4)	Low-moderate because of piecemeal construction (4)	Specifically designed for wave breaking and oyster habitat provision. Engineering being established but based on well-known materials. One row of structure will suffice. Pre-designed	Patent pending: CSA
Oyster reef (24)	Weight; can be moved in variable amounts with associated costs of handling (5)	Versatile because of piecemeal construction (5)	Potential addition of shell over time due to changing geometry (depending on recruitment) and settling (3)	$45-55 per yd³; Est 1000 yd3 needed	Low-moderate based on erodability vs. natural recruitment and growth success - single row effectiveness in wave dampening if elevation can be sustained (2)	High; oysters play the role of an ecosystem engineer if displaying successful recruitment (5)	Low-moderate because of piecemeal construction (4)	Extremely valuable habitat but unknown whether it would persist in this wave energy. Would likely require additional engineering to be high enough to break waves and remain stable (e.g., some core structure). One row of structure could suffice.	http://masucares.com/crec/envi/publications/living_shorelines_cost_estimates.pdf
Reef Balls (24)	Weight; moved in low to moderate weight modular units (3)	Versatile because of piecemeal construction and comparatively light lift per piece (3)	Potential for settling (3)	$44 per linear foot * estimated 4 rows for complete wave energy reduction	Moderate: solid objects but unknown ability to maintain position in the apparent absence of a connection system - multiple rows need for complete wave dampening (3)	Moderate-high; highly abundant surface area for attachment; modifiable to provide internal access to larger fauna (4)	Low-moderate because of piecemeal construction (4)	Several rows to provide required wave attenuation. Pre-designed. Additional licensing costs TBD	http://www.gulfalliancetraining.org/dbfiles/Cost%20and%20Maintenance%20of%20Living%20Shorelines.pdf
Rip-rap (22)	Weight; can be moved in variable amounts with associated costs of handling (5)	Versatile because of piecemeal construction (5)	Some addition of rock over time due to changing geometry and settling (3)	$125 per linear foot	Low-Moderate; absence of structural connectivity and highly dependent on size and material density - single row effectiveness in wave dampening (2)	Moderate; abundant surface area for attachment and interstitial space for small fauna (5)	Low-moderate because of piecemeal construction (4)	Slow change in geometry over time will require planned maintenance; Well-established engineering; One row of structure will suffice.	http://masucares.com/crec/envi/publications/living_shorelines_cost_estimates.pdf
Beach Prisms (21)	Weight; moved in moderate to high weight modular units (4)	Large modular units require moderate heavy lift (3)	Potential for settling (3)	$127.50 per linear foot	Moderate-High: solid objects but unknown ability to maintain position in the apparent absence of a connection system - single row effectiveness in wave dampening (4)	Moderate; modifiable to provide internal access to larger fauna (4)	Moderate-high because of fixed module construction (3)	Limited information on actual wave attenuation and habitat value. Stability of geometry questionable. Unknown number of rows to provide required wave attenuation. Pre-designed.	http://www.beachprisms.com/
Gabions (21)	Weight; can be moved in variable amounts with associated costs of handling (5)	Versatile because of piecemeal construction (5)	Containment will deteriorate, changing functional geometry; needs maintenance every few years; potential for settling (2)	TBD	Low-Moderate: based on containment decay – single row effectiveness in wave dampening (2)	Moderate; abundant surface area for attachment and interstitial space for small fauna (3)	Low-moderate because of piecemeal construction (4)	Containment with plastic problematic because of photodegradation and fragmentation; containment with wire leads to puncture wound potential; in a wave prone system the change in geometry is also problematic. One or more rows of structure may be required.	http://www.seaengineering.com/project/historic-riverfront-erosion-mitigation/
WADS (19)	Weight; moved in moderate to high weight modular units (4)	Large modular units require moderate heavy lift (3)	Potential for settling (3)	WAD at $180 to $250 per linear foot	Moderate – and multiple rows need for complete wave dampening (3)	Low; smooth surfaces may limit attachment; modifiable to provide internal access to larger fauna (3)	Moderate-high because of fixed module construction (3)	Requires at least 3 rows of structure. Stable but very heavy. Pre-designed. Additional licensing costs TBD	http://www.seaandshoreline.com/#!wave-attenuation-device-wads/c1igz

Wavebreak Construction – Atlantic Reefmaker Ecodisks

- Pile-based, flow through system – negligible substrate impact
- Mechanical support system – set disks at designated design height
- Modularly constructed – easy modification for SLR adjustments
- Perched above substrate – movement of sand & marine life
- Scalable to wave environment
- Shape – square & octagonal
- Porosity is changeable (20% & 0%)





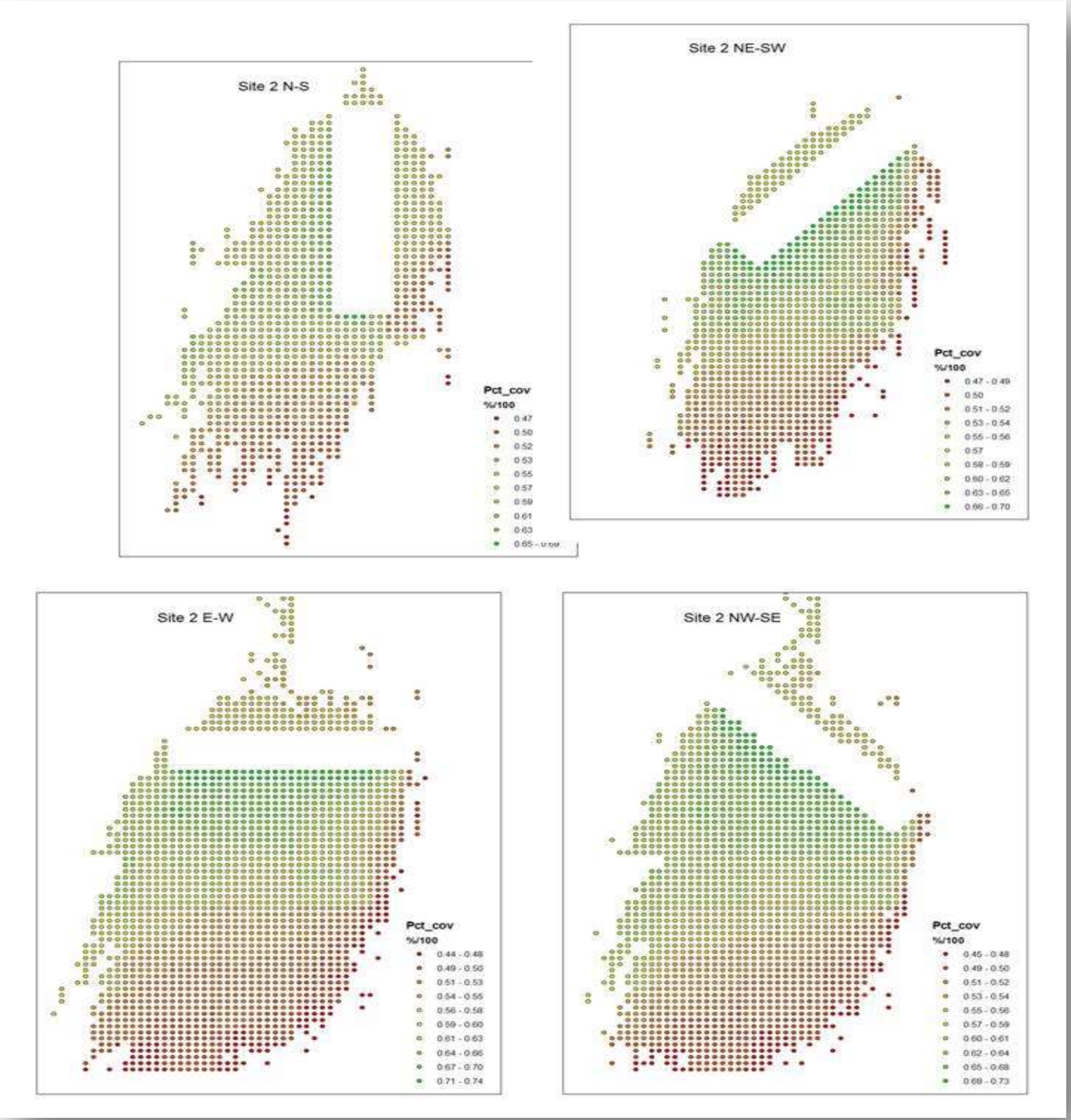
67-84% decrease in wave energy (ERDC, 2020)

Study link – https://ewn.erdc.dren.mil/?p=7412

Project Approach

Forecast seagrass cover response to wave ↓

- Seagrass cover *f*(RWE) before *vs* after wall
- For every foot of wall, CSA forecast ↑ 150 ft^2 (13.9 m^2) of seagrass
- 500' of wall = ~1.7 ac (0.69 ha)

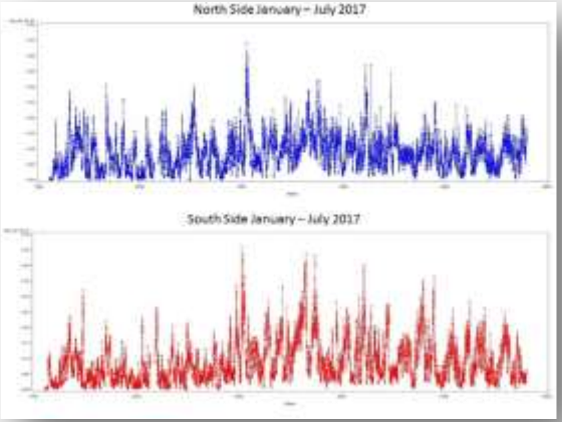


Wavebreak Construction Using Atlantic Reefmaker Ecodisks

- Chevron shape, due North
- 101 square-shaped units; 500 ft long
- Wave energy dissipation with flow through system (20% porous)
- Seagrass from construction footprint relocated
- No dredging of construction access channel for implementation
- Low draft conditions

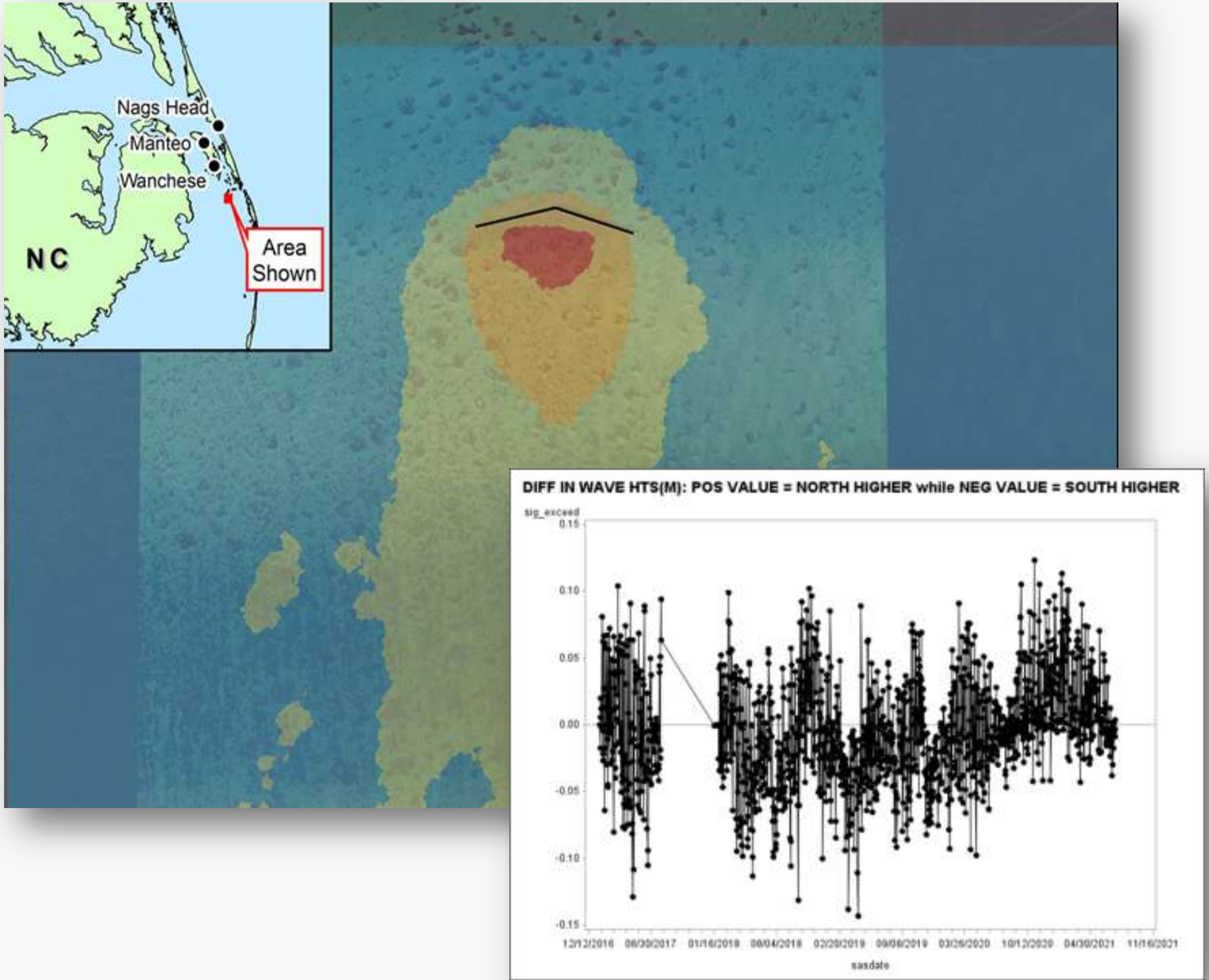
Monitoring Program

- Wave heights – north & south
- Sediment elevation – near-field & far-field
- Epibiota colonization of wavebreak
- Seagrass cover – aerial imagery



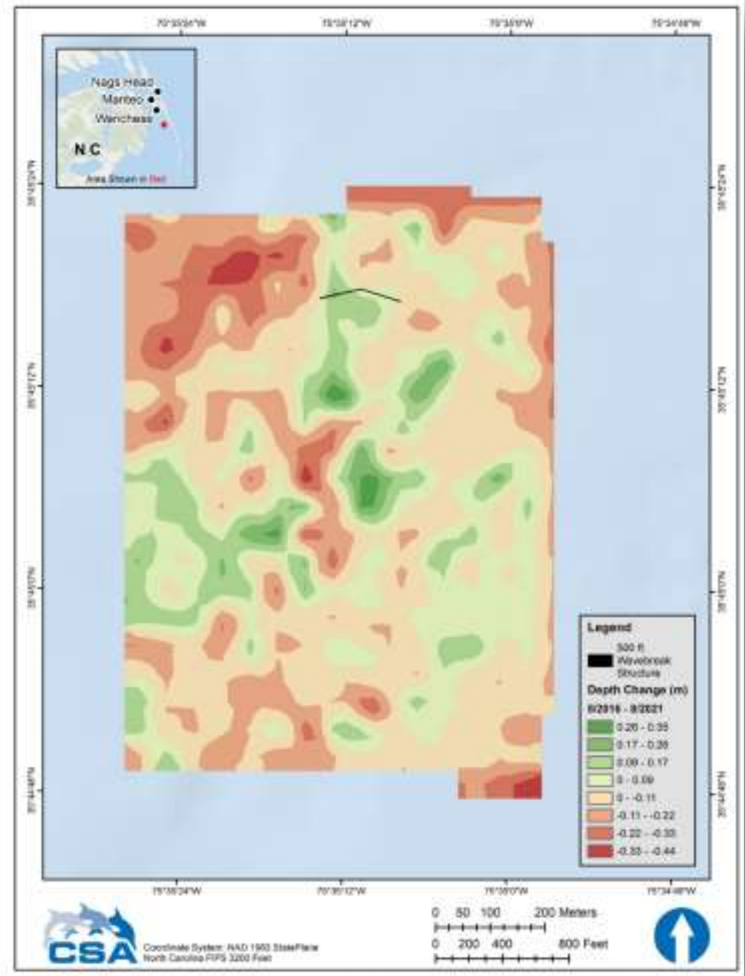
Results: Wave Height

- Strongest wind events; thus, wave energy predicted from the north
- Daily wave height data – alternation of higher waves on north and south sides
- Top 5% of wave heights occurred 5 times more frequently on the north side
- “Extreme event” results supported forecasted wind energy reduction zones



Results: Sediment Elevation

- Near-Field: Sediment elevation along transects within 150 ft of wavebreak
- Far-Field: Digital Elevation Model (DEM) within ~118-acre area surrounding wavebreak



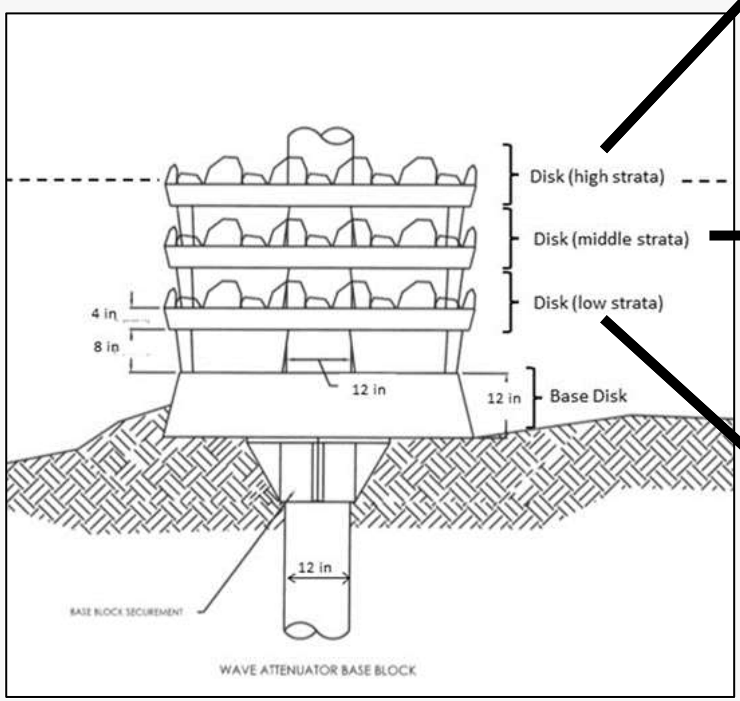
Results: Sediment Elevation

Sediment Scouring

- Scour pits developed under wavebreak
- Creation of “sand apron”
- Delayed colonization of transplanted seagrass
- Octagonal Reefmaker shape and alternative orientation in testing to alleviate scouring

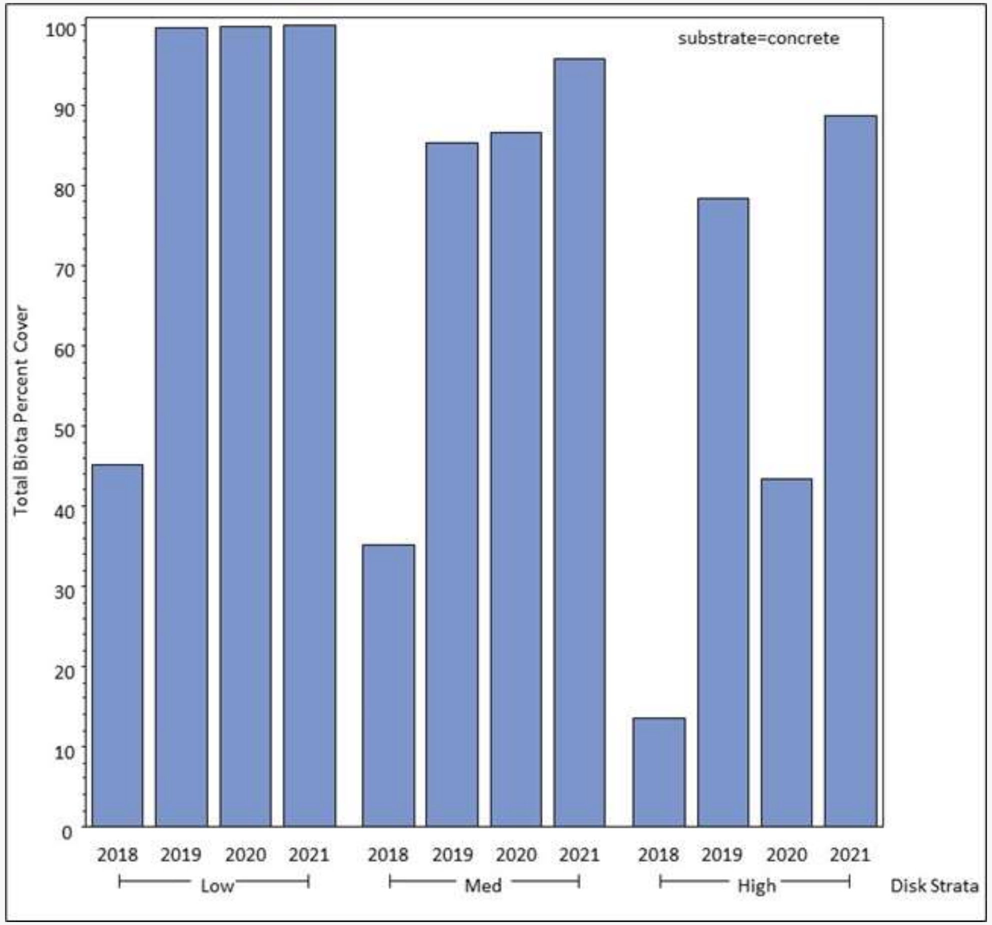
Results: Epibiota Monitoring

- Substrates - Rock (granite) vs. Concrete
- Elevation - Low vs. Middle vs. High
- Colonization - macroalgae, hydroids, barnacles, oysters, cyanobacteria
- Concrete primarily colonized by macro & barnacles
- Rock colonization = macro/barnacles → macro → macro/oysters
- 2-year lag for oysters, 8-12x higher cover on rock vs. concrete

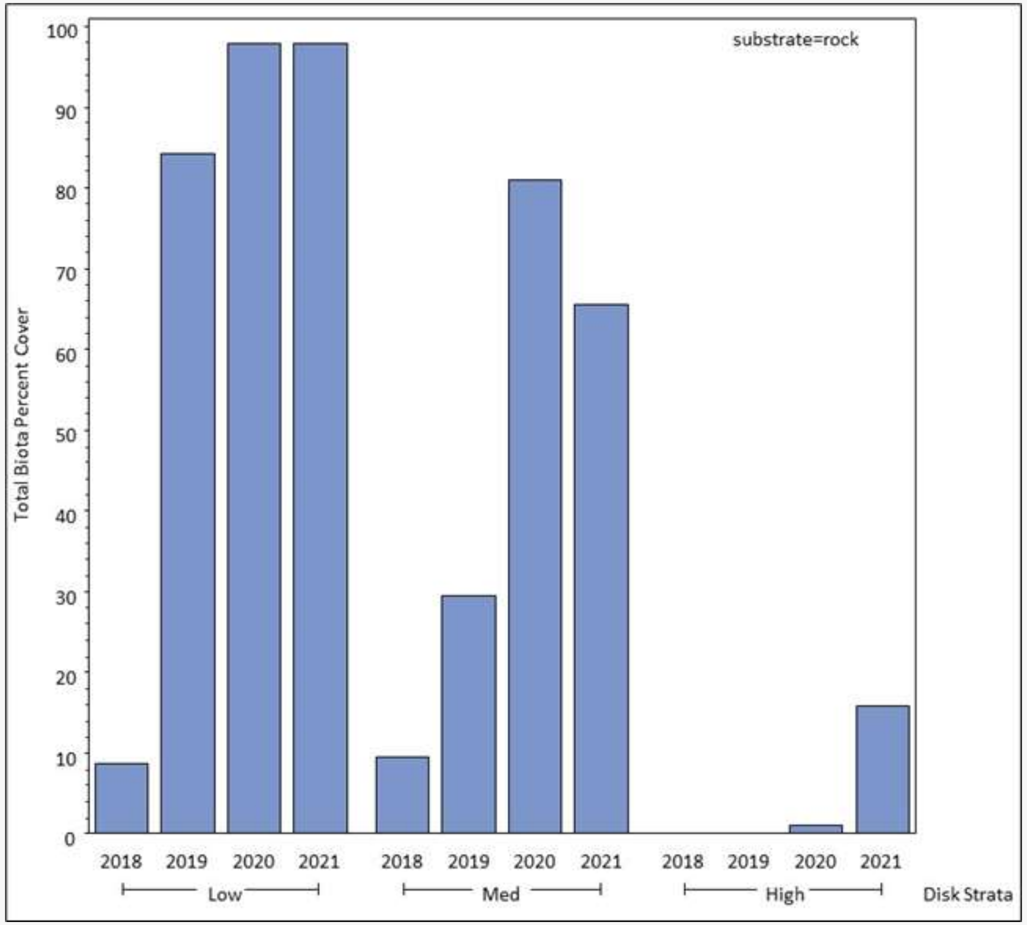


Epibiota Monitoring Results

Percent Cover Total Biota

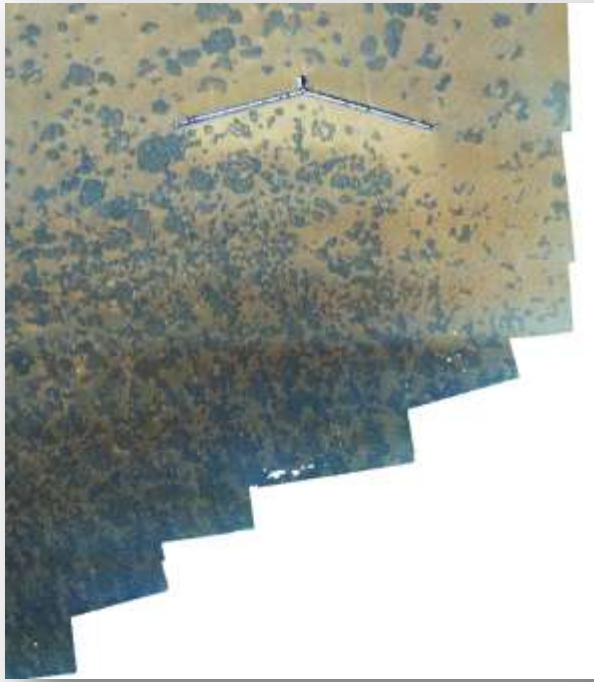


Concrete



Rock (Granite)

Results: Seagrass Mapping



AUG 2018

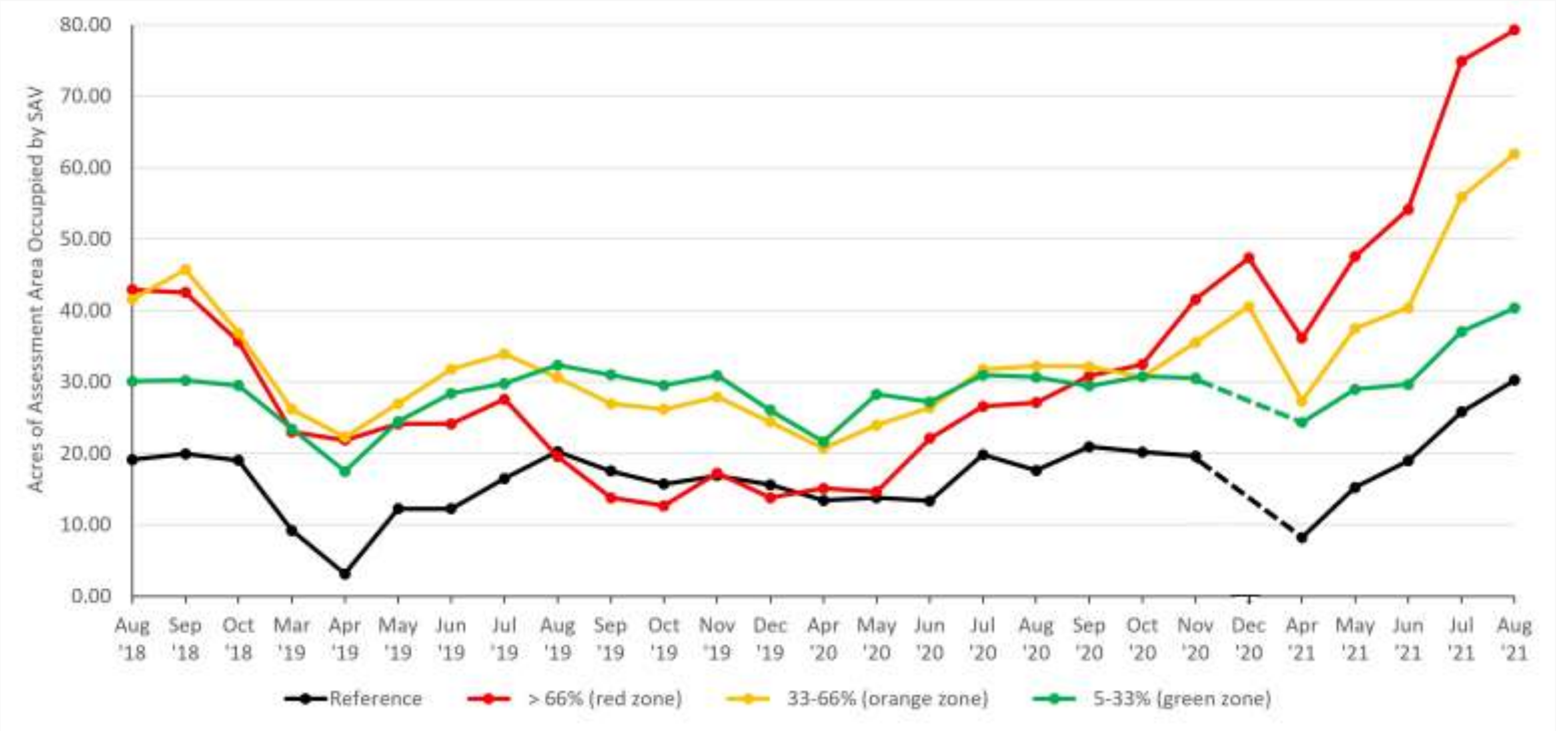
AUG 2019

AUG 2020

AUG 2021

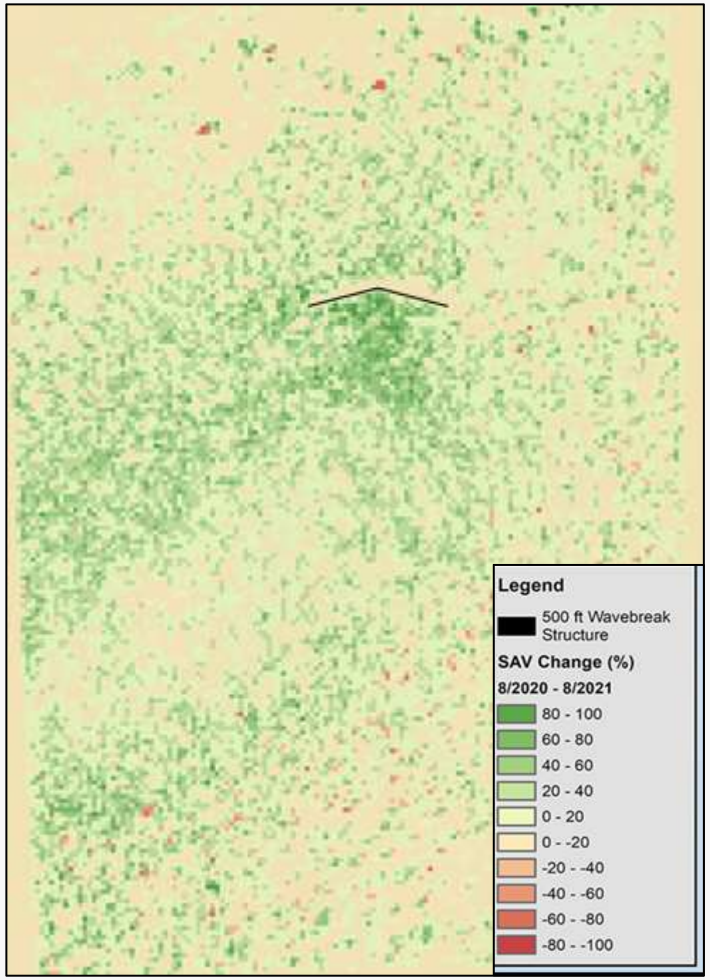
Results: Seagrass Mapping

Total Acres Seagrass by Zone: Aug 2018 to Aug 2021



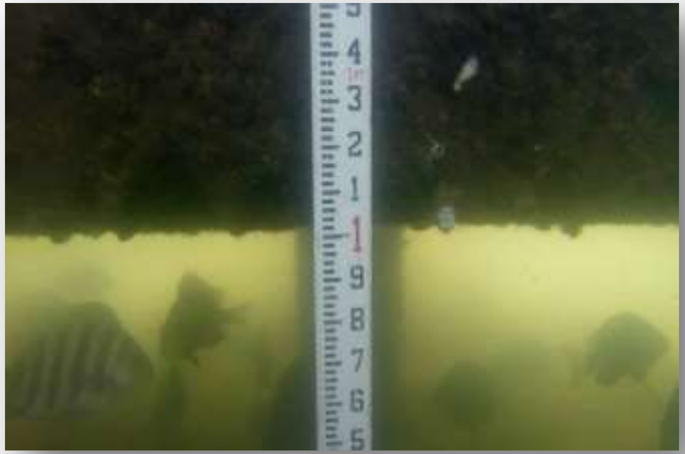
High (red) + Med (yellow) = + 1.77 acres (Aug 2020 to Aug 2021)
High (red) + Med (yellow) = + 1.15 acres (Aug 2018 to Aug 2021)

Change in Cover of Seagrass: Aug 2020 vs. Aug 2021



Take-Aways

- Ecological services were enhanced: seagrass, seabirds, essential fish habitat (EFH)
- Net gain in seagrass cover
- Alternative Reefmaker unit shape and configuration may alleviate scouring
- Durable engineering solution to reduce wave energy (wind, boat wakes)
- Viable mitigation strategy, employed principles of “green engineering”



Project Recognition

An ATLAS Volume 2

Nomination Criteria: The project should relate to EWN key elements

1. Using science and engineering to produce operational efficiencies.
2. Using natural processes to maximum benefit.
3. Increasing the value provided by the project to include social, environmental, and economic benefits.
4. Using collaborative processes to organize and focus interests, stakeholders, and partners.

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