Bonner Bridge Submerged Aquatic Vegetation Mitigation

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Western Dredging Association
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Session 2B-1

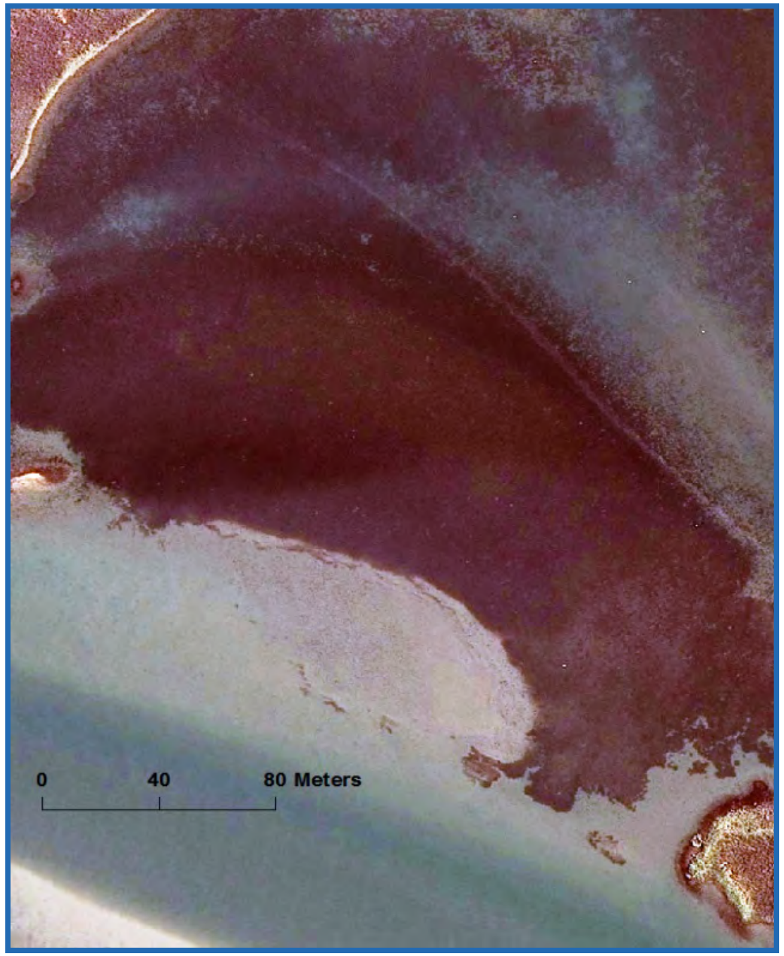
Bonner Bridge seagrass impacts

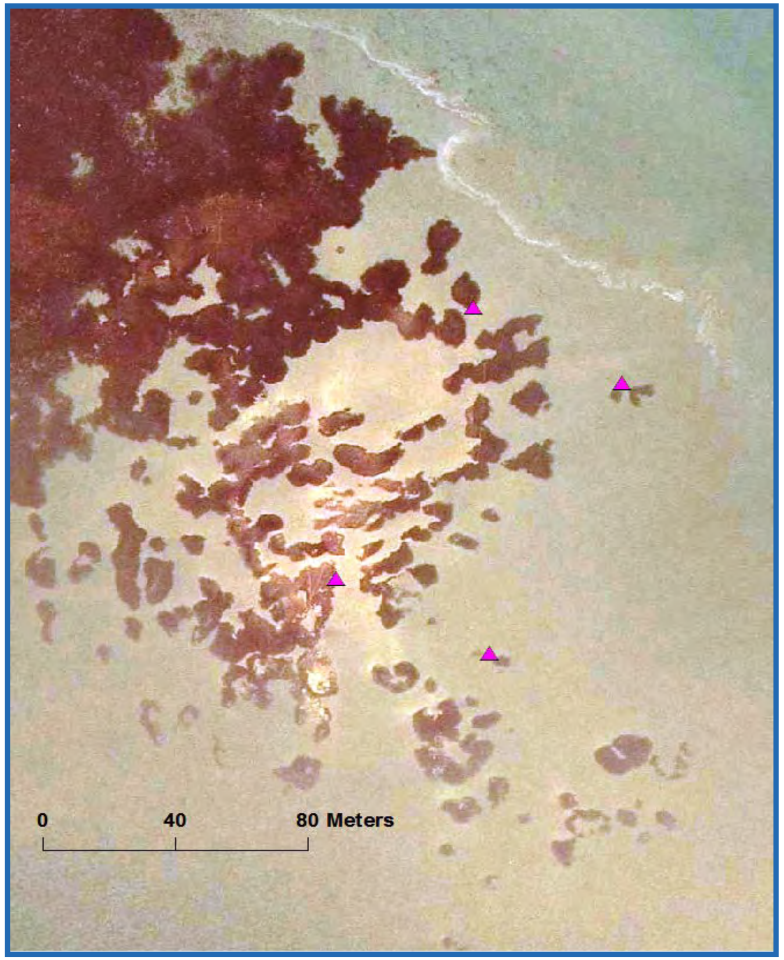
- Bonner Bridge only direct connection of the NC Outer Banks to the mainland – in severe disrepair and required replacement
- Need 1.28 acres (0.52 hectare) new seagrass for Bonner Bridge impacts
- No nearby candidate areas to be “fixed”
- Here:
  - Apply models of wave energy ↔ seagrass landscapes
  - Reduce wave energy on patchy seagrass beds
  - ↑Seagrass patch #, expansion, coalescence = increased acreage

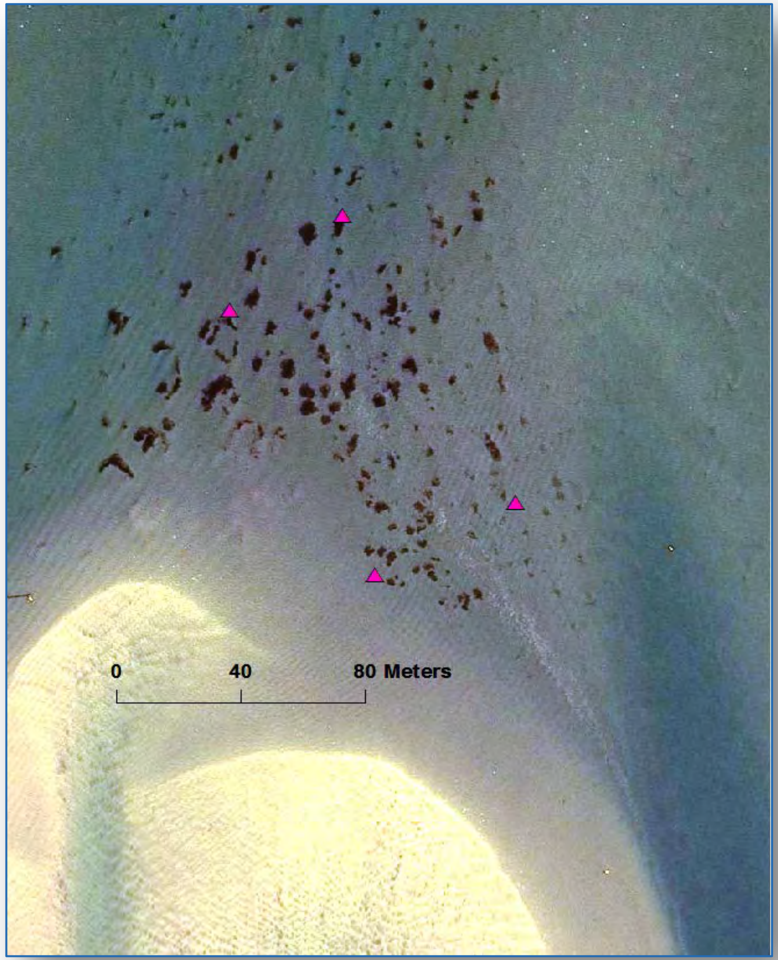
Seagrass landscapes change across disturbance gradients

Increasing currents, waves, bioturbation

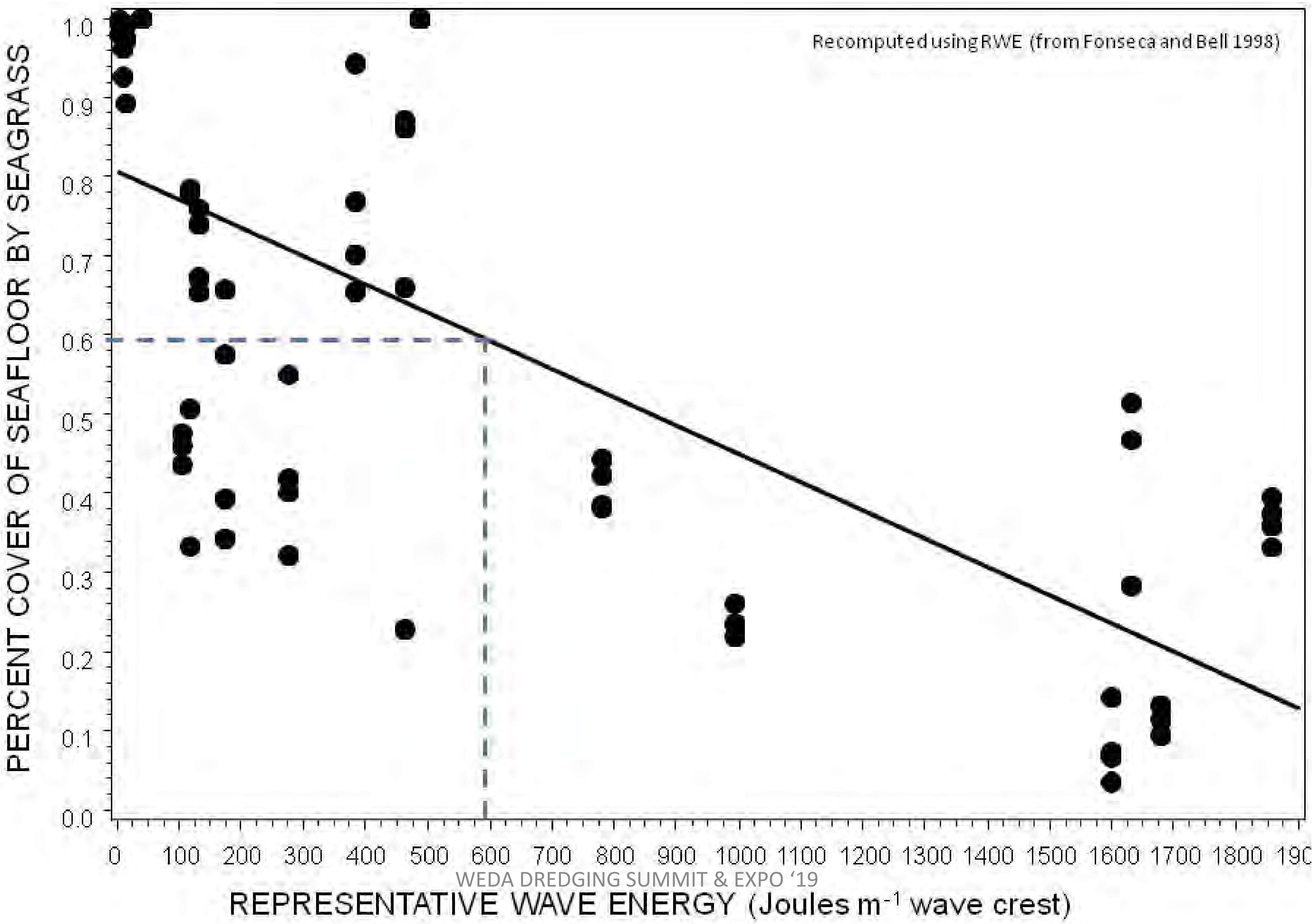
(disturbance extent, intensity, duration, frequency, sequence)



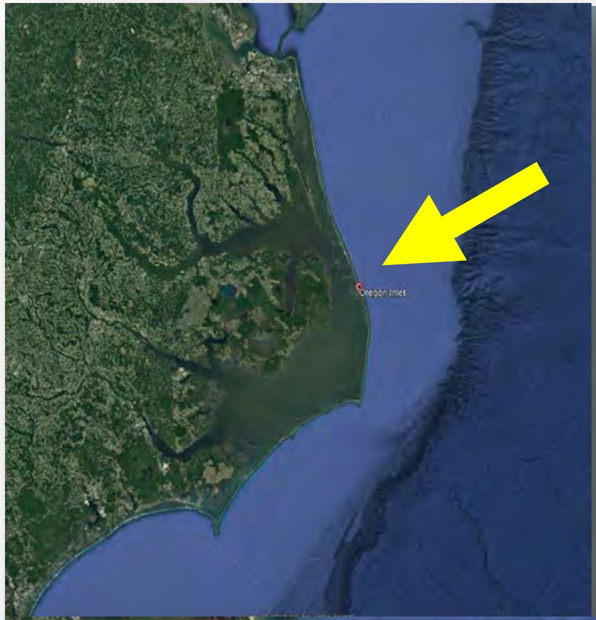


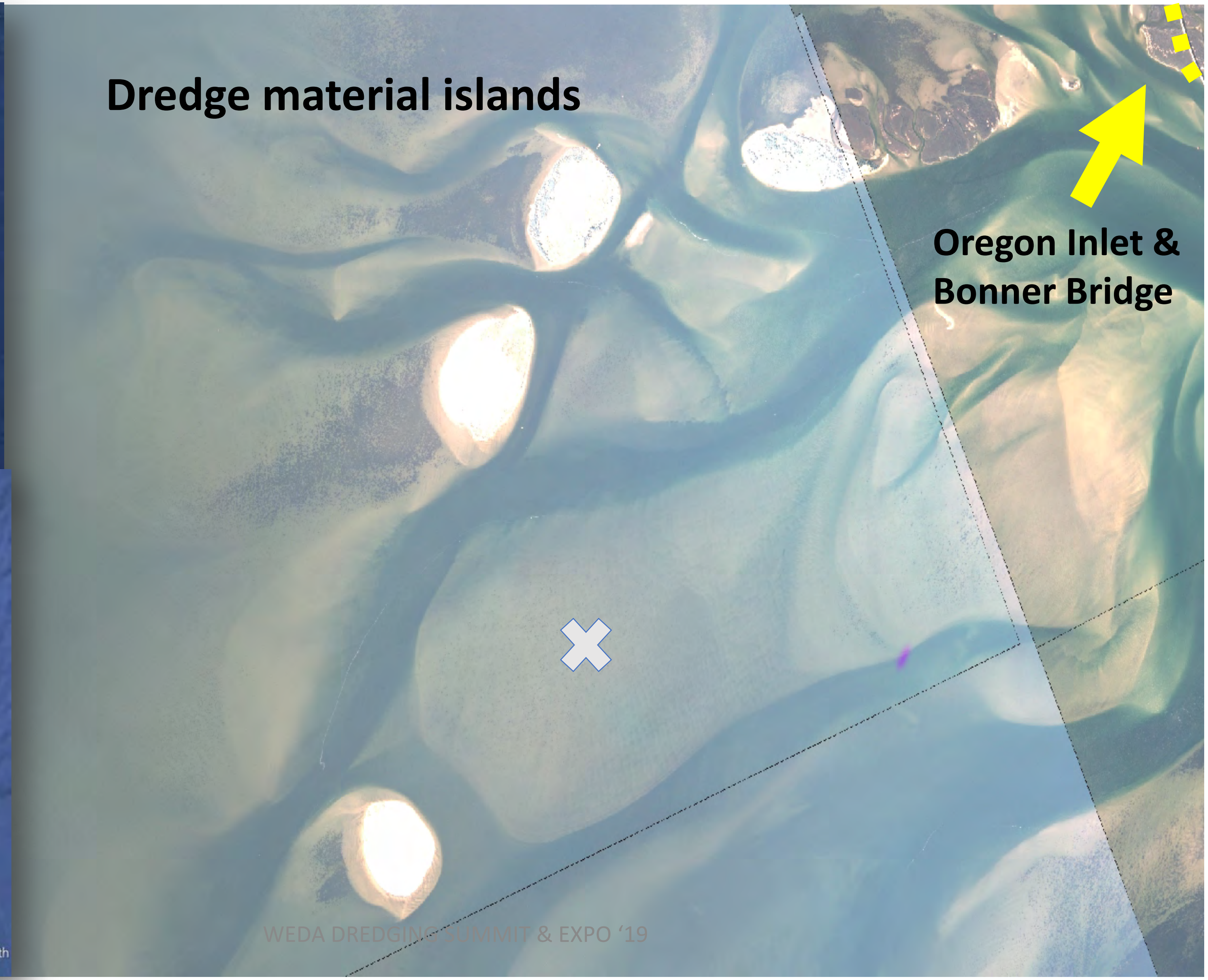


Tipping points in NC seagrass cover



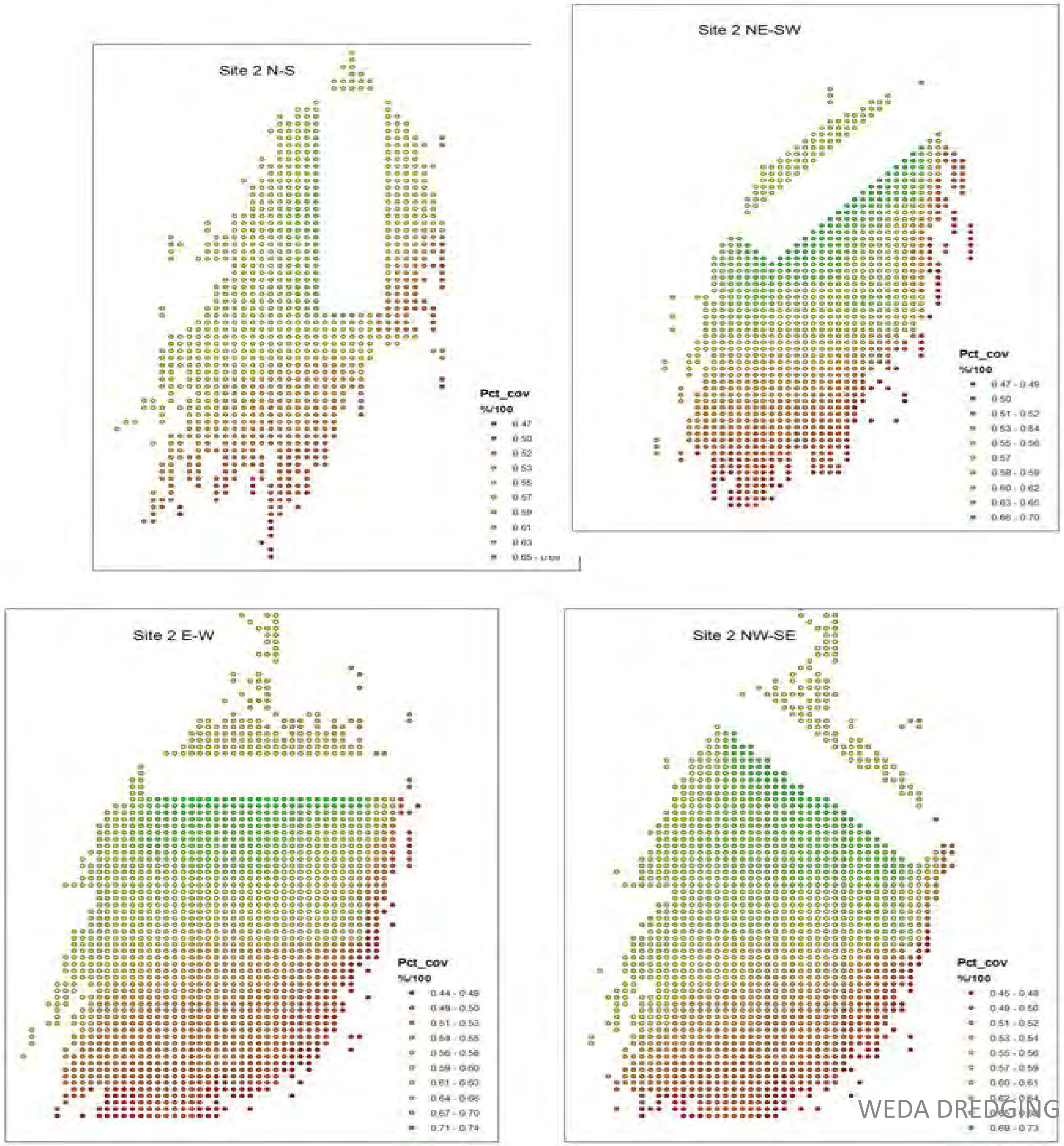
Mitigation location and strategy



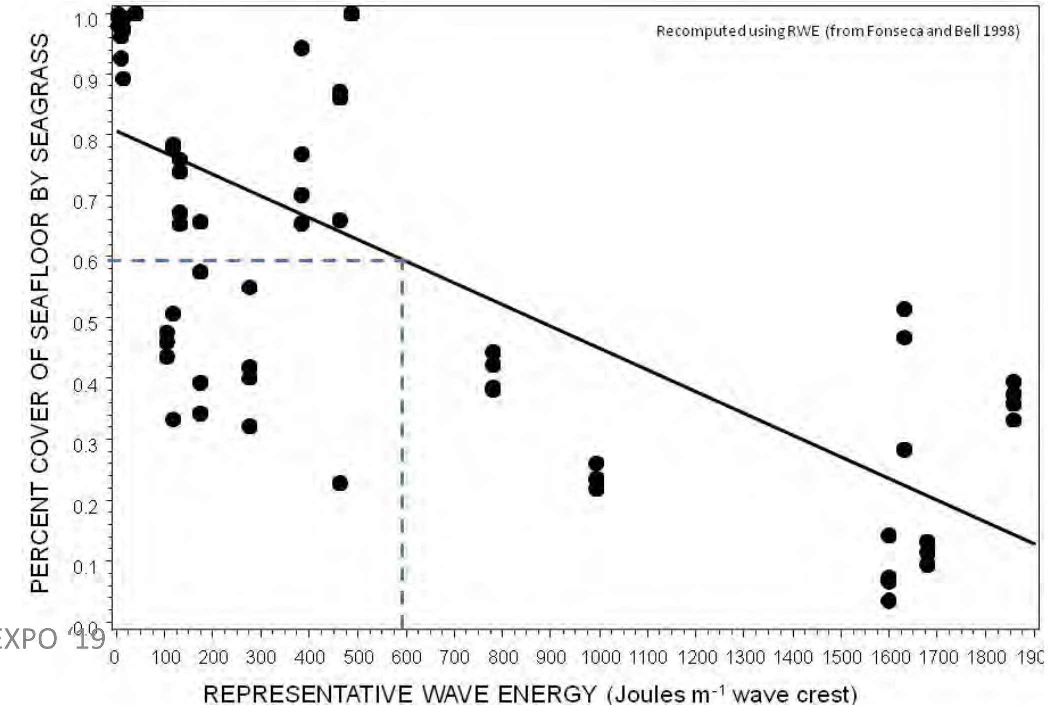


APPROACH

Forecast seagrass cover response to wave ↓



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

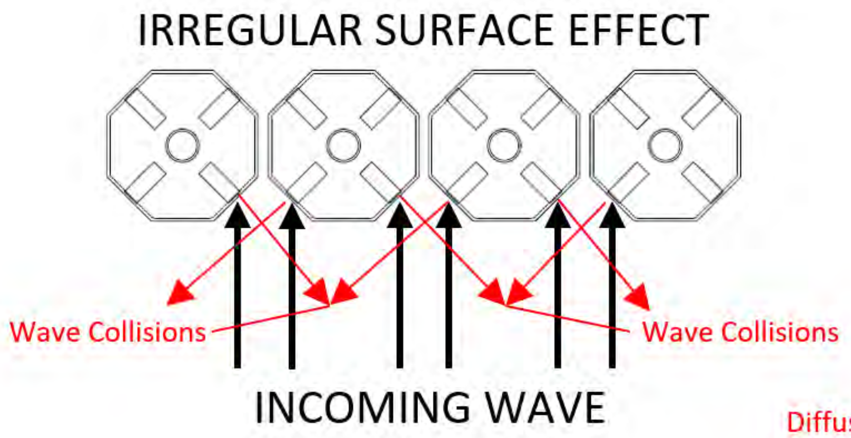


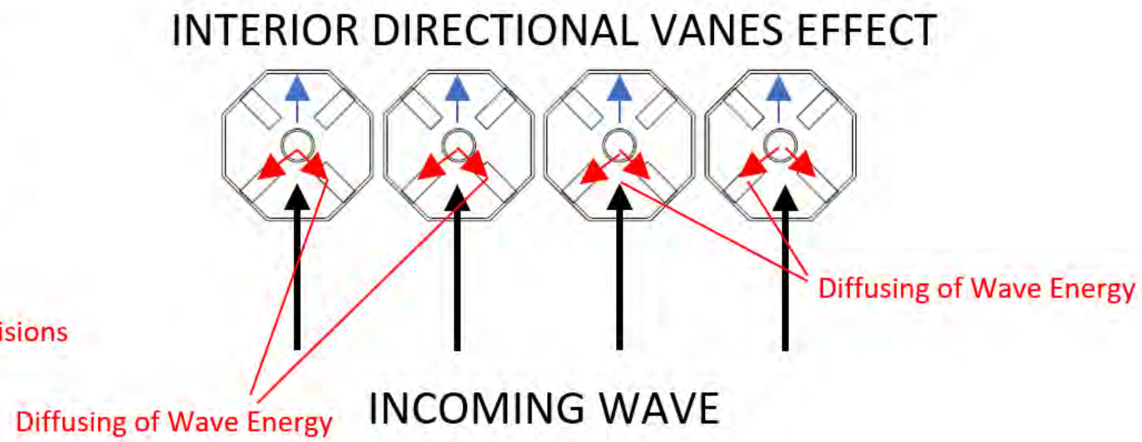
Mitigation Alternatives Analysis

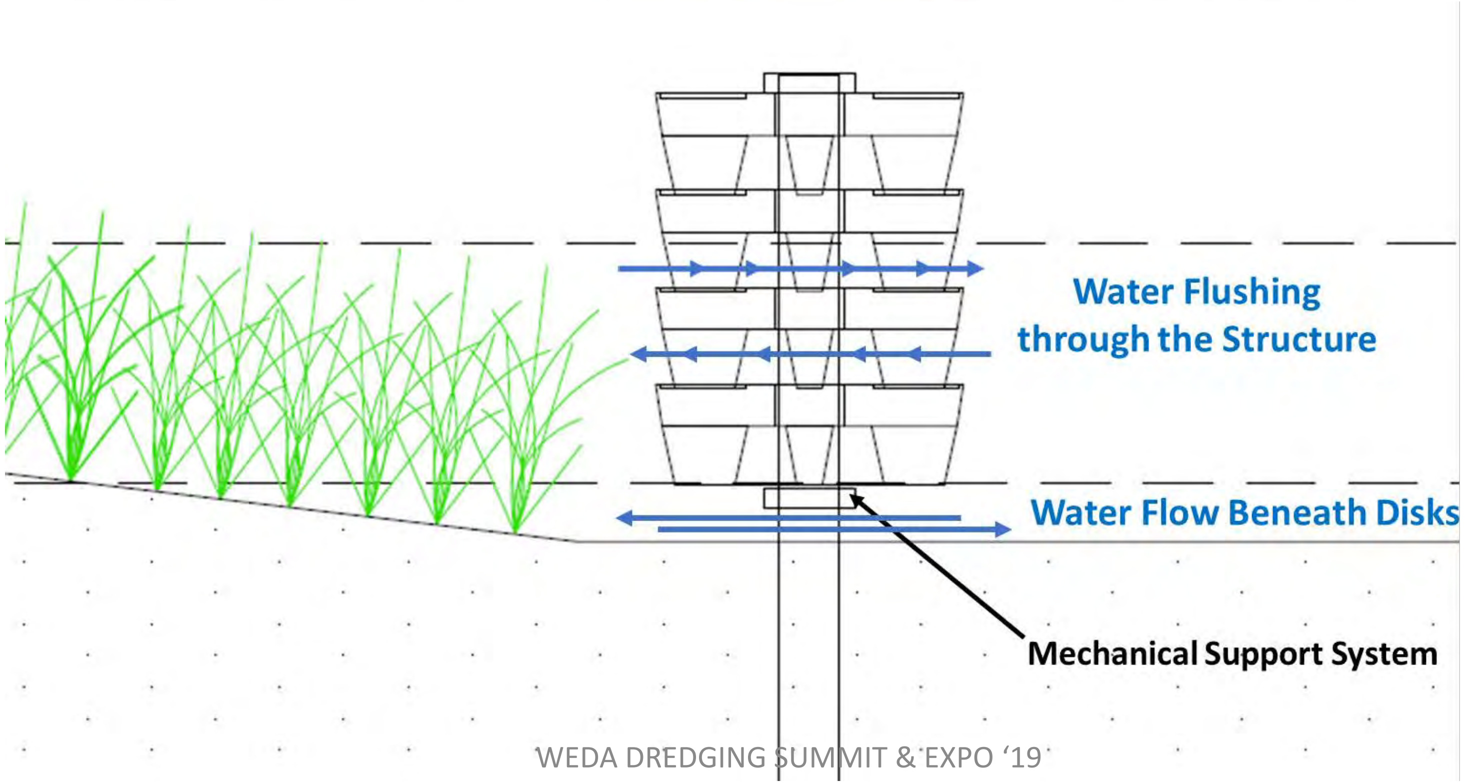
Method	Installation issues	Mobilization issues	Maintenance issues	Cost installed for 1800 linear feet (without transportation); all numbers are rough estimates and not to be used for bidding	Wave attenuation and estimated resiliency over ~10y	Est. EFH utility (low, medium, high)	Potential site impacts (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://msucares.com/crec/envi/publications/living_shorelines_cost_estimates.pdf
Reef Balls (24)	Weight, moved in low to moderate weight modular units (5)	Versatile because of piecemeal construction and comparatively light lift per piece (5)	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 (3)	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://msucares.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.sepiengineering.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 2 rows of structure. Stable but very heavy. Pre-designed. Additional licensing costs TBD	http://www.seaandshoreline.com/#!wave-attenuation-device-wads/c1qrg

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

How Atlantic Reefmaker Technology Works





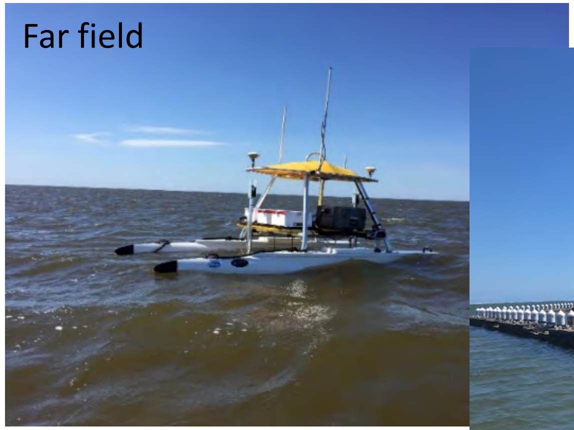


Installation Dec 2016 – Jan 2017

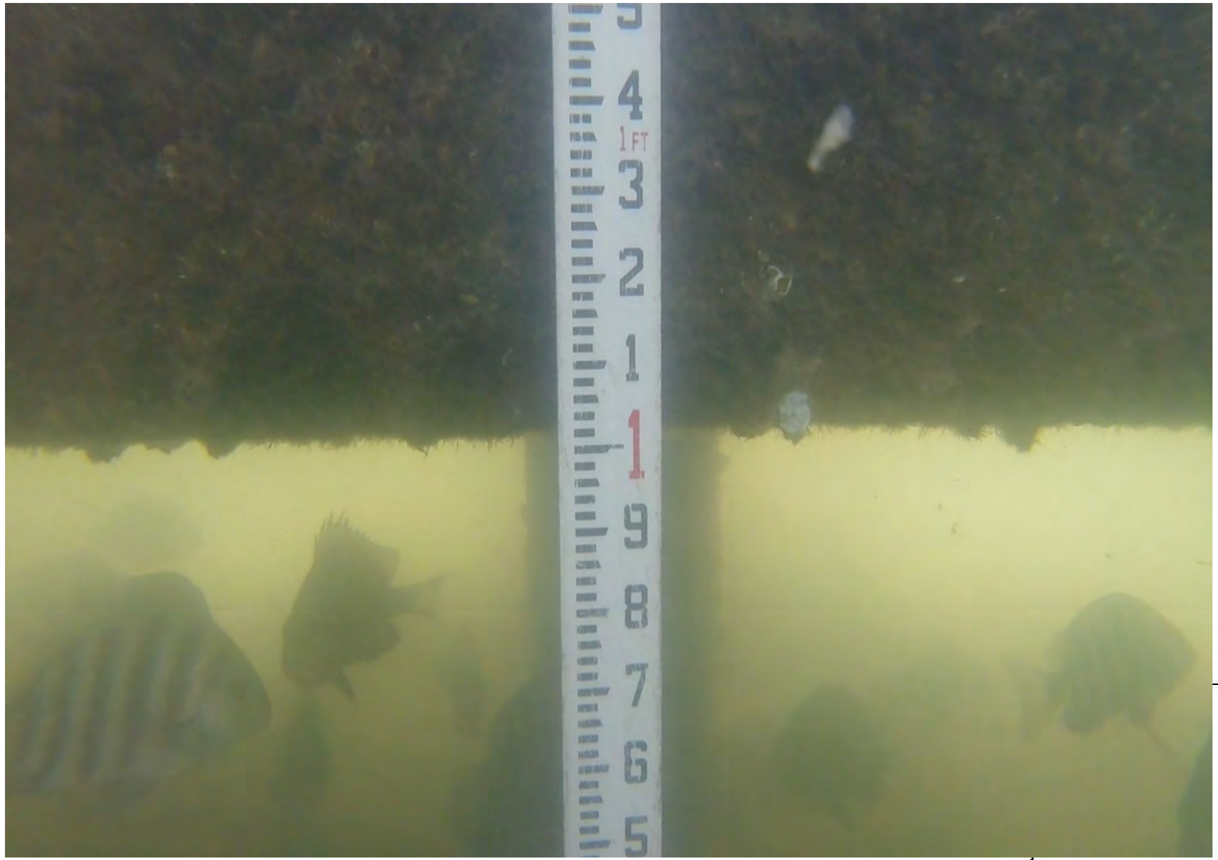
RESULTS

Full Installation & Monitoring

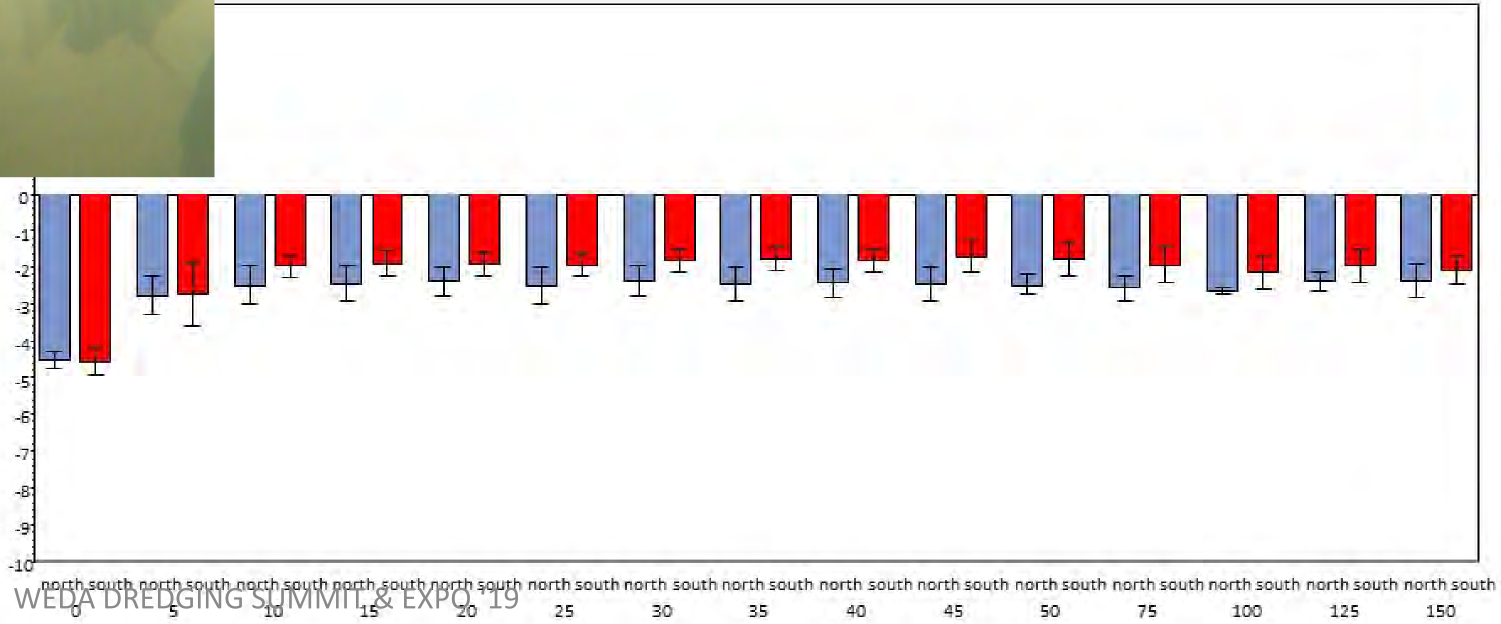
- **Δ Biological colonization**
- **Δ Sediment elevation**
- **Δ Seagrass coverage**



Near field sediment elevation survey

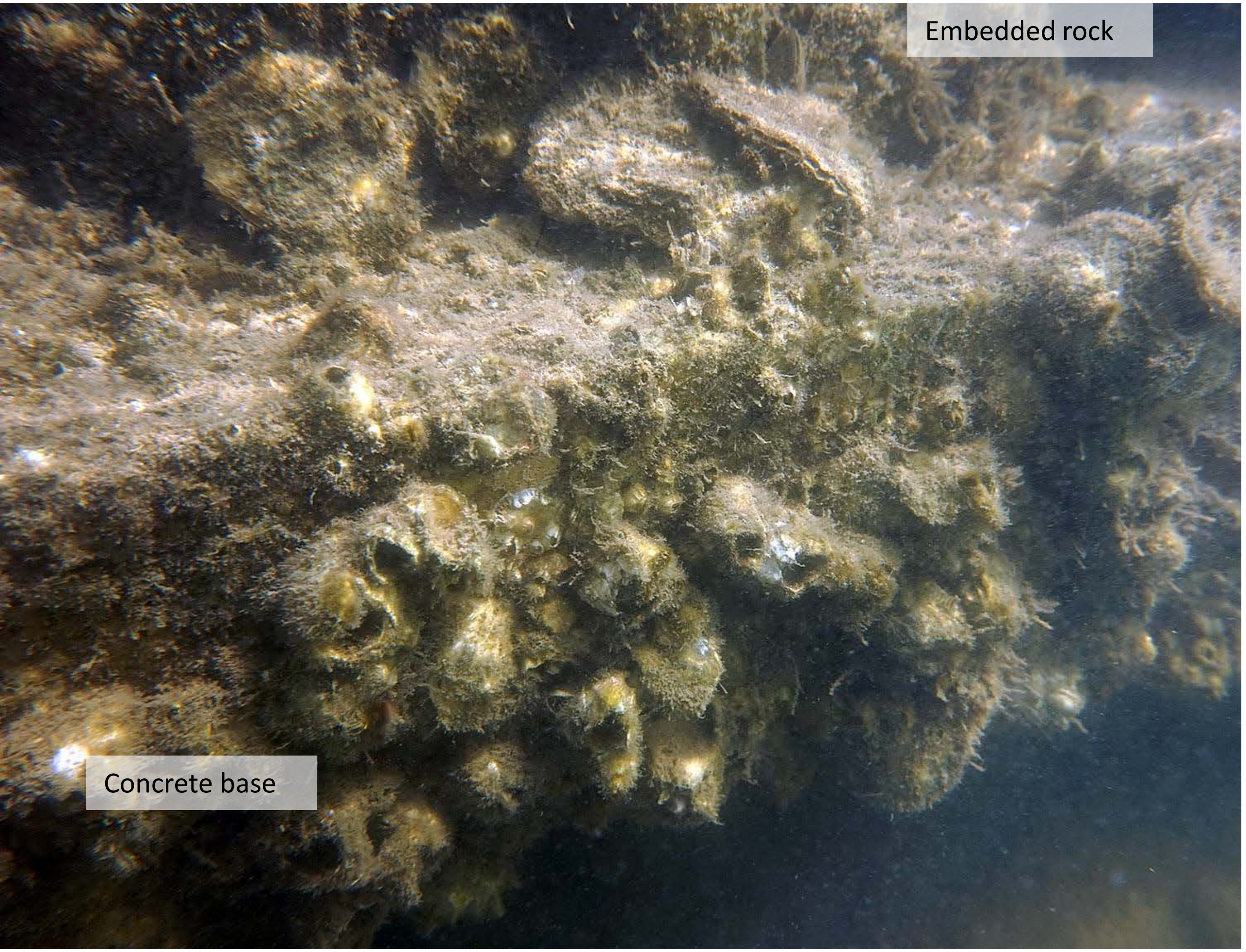


- **Transect surveys of elevation**
- **Erosion pits under structure**
- **Shoaling on south (lee) side**



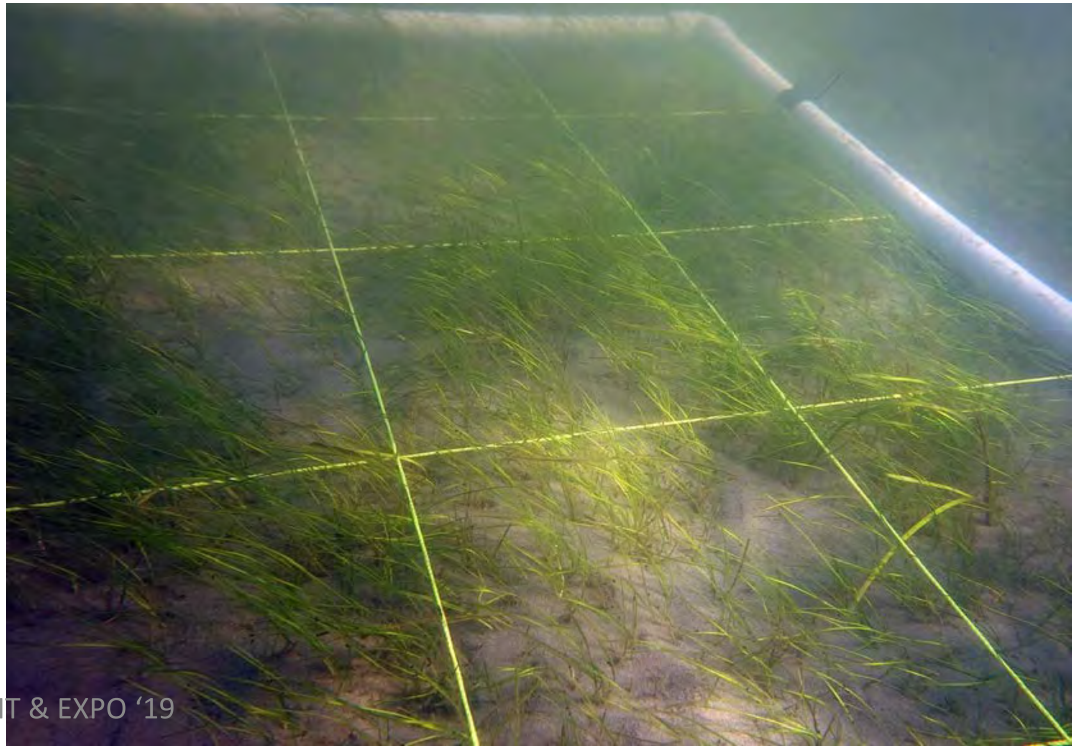
RESULTS

Near field sediment elevation survey

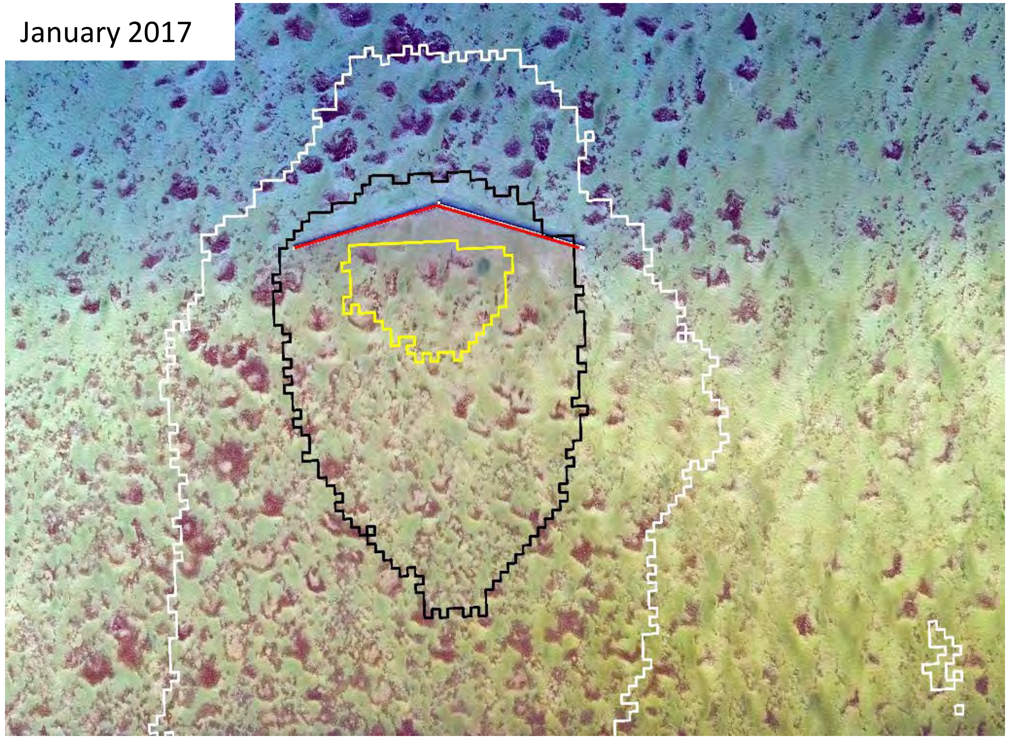


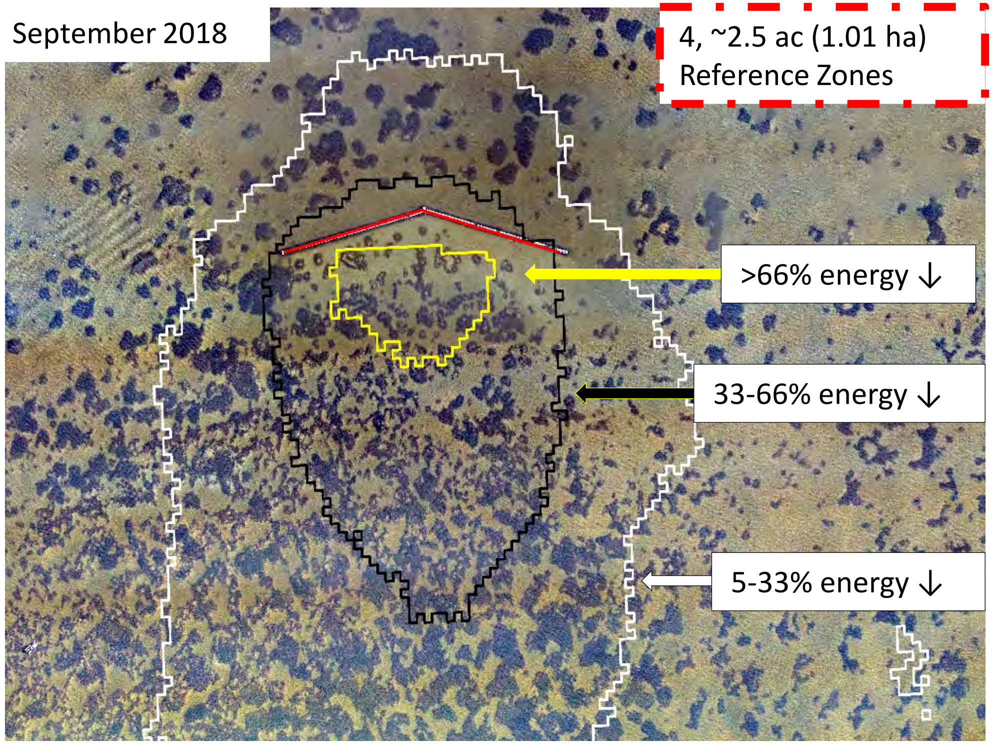
~15% areal cover relocated seagrass

Substrate % Cover	Infrequent Inundation	Frequent Inundation	Near-continual Inundation
Embedded Granite Rock	0	19	17
Concrete Base	27	70	90



Epibiont Cover/Relocated Seagrass





+ 1.34 acres (0.54 ha) in zones with >33% energy ↓

Areas of assessment	% cover 2017	% cover 2018	Gain per base (ac/ ha)	Ref. adj change % cover
Reference areas (4, 2.48 ac/ 1.00 ha)	16%	20%	0.22/ 0.09	
Total area of >66% wave Energy decrease	20%	43%	1.18/ 0.48	22%
Total area of 34-66% wave Energy decrease	23%	46%	1.02/ 0.41	18%
Total area of 5-33% wave Energy decrease	30%	30%	0.31/ 0.13	6%

Conclusions

- Seagrass coverage changes across disturbance gradients
- NC seagrass/disturbance well studied and modeled
- Manipulation of gradient = changes in seagrass coverage
- Reefmaker method with suspended wavebreak structure:
  - Supported new, persistent seagrass cover
  - Provided substantial additional EFH service
- Cautiously optimistic - seagrass acreage > mitigation requirements
- Continued monitoring to validate and improve forecasting

Questions?

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