# Evaluating coastal protection benefits of restored oyster reef designs

MS Thesis Defense

November 2, 2022

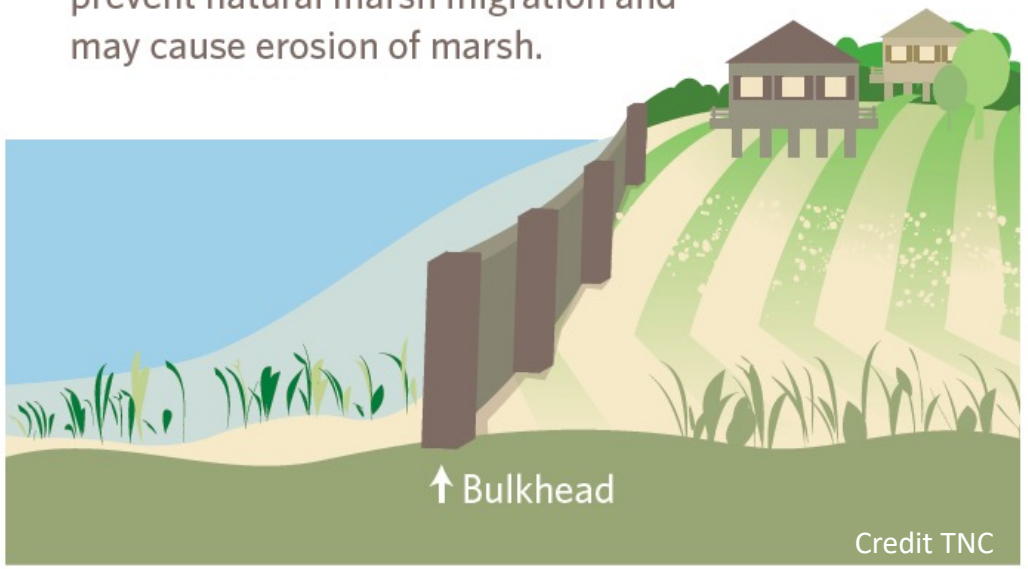
Libby Bieri

Credit Bo Lusk, TNC

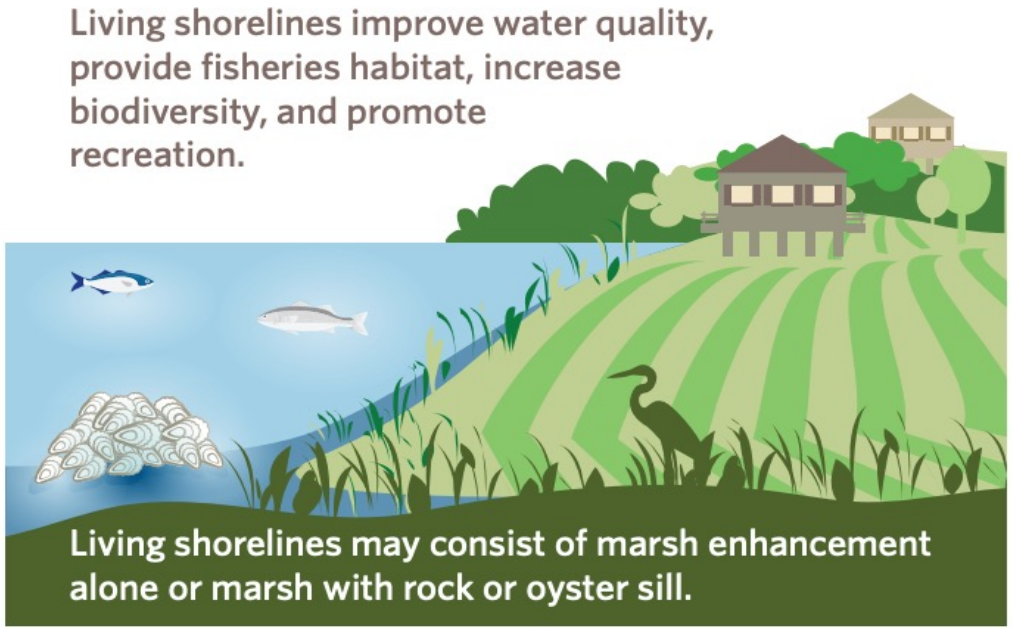
# Outline

- Background & Study Area
- Objectives
- Methods
- Results
- Conclusion
- Acknowledgements & Questions


Credit VIMS


Hard shoreline structures like bulkheads prevent natural marsh migration and may cause erosion of marsh.
Bulkhead
Credit TNC


Credit CBF


Living shorelines improve water quality, provide fisheries habitat, increase biodiversity, and promote recreation.
Living shorelines may consist of marsh enhancement alone or marsh with rock or oyster sill.

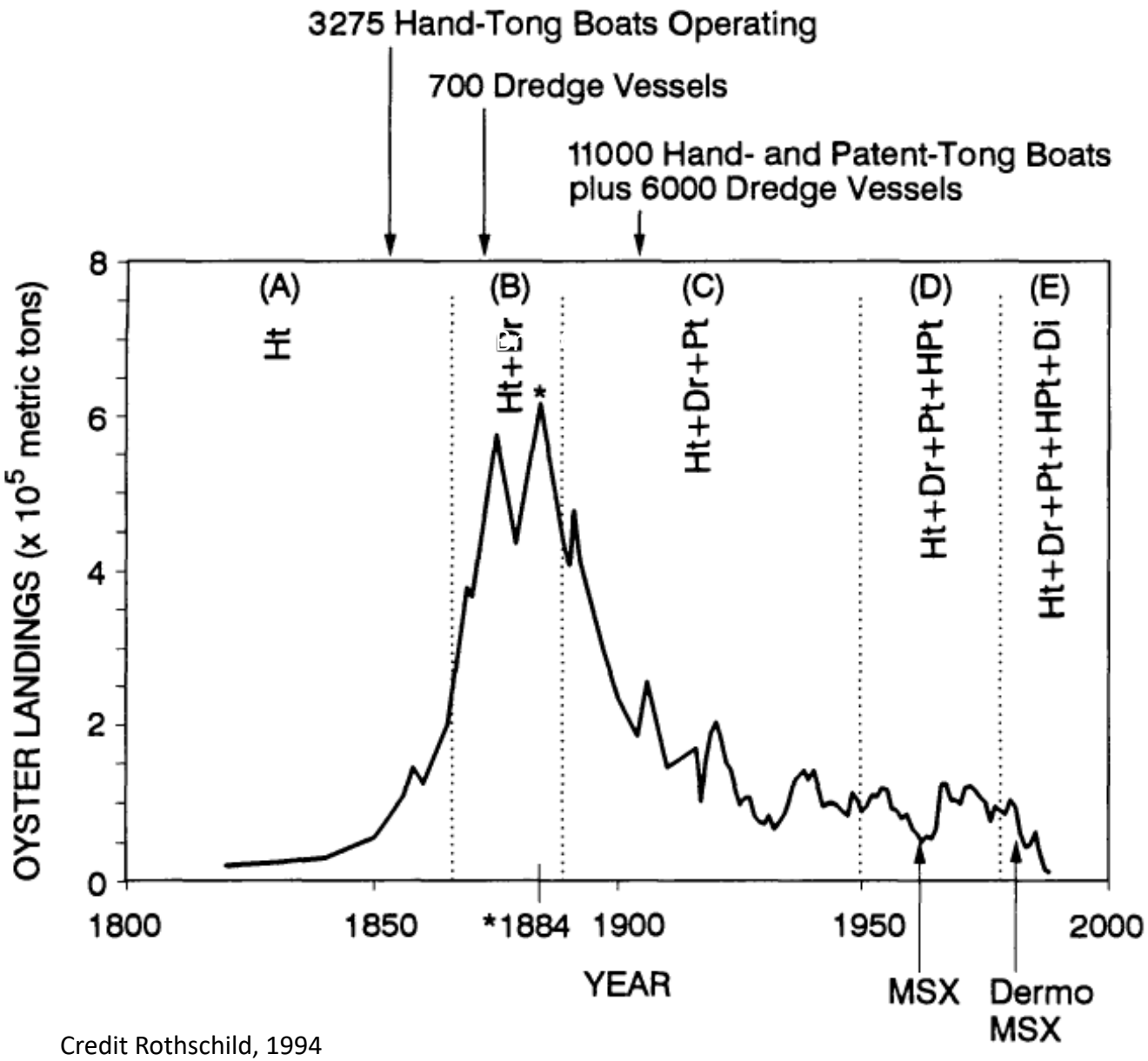
# Nature-based solutions

"actions to **protect**, sustainably **manage**, and **restore** natural or modified ecosystems, that **address societal challenges** effectively and adaptively, simultaneously providing **human well-being** and **biodiversity benefits**" –IUCN 2021

# Oyster decline

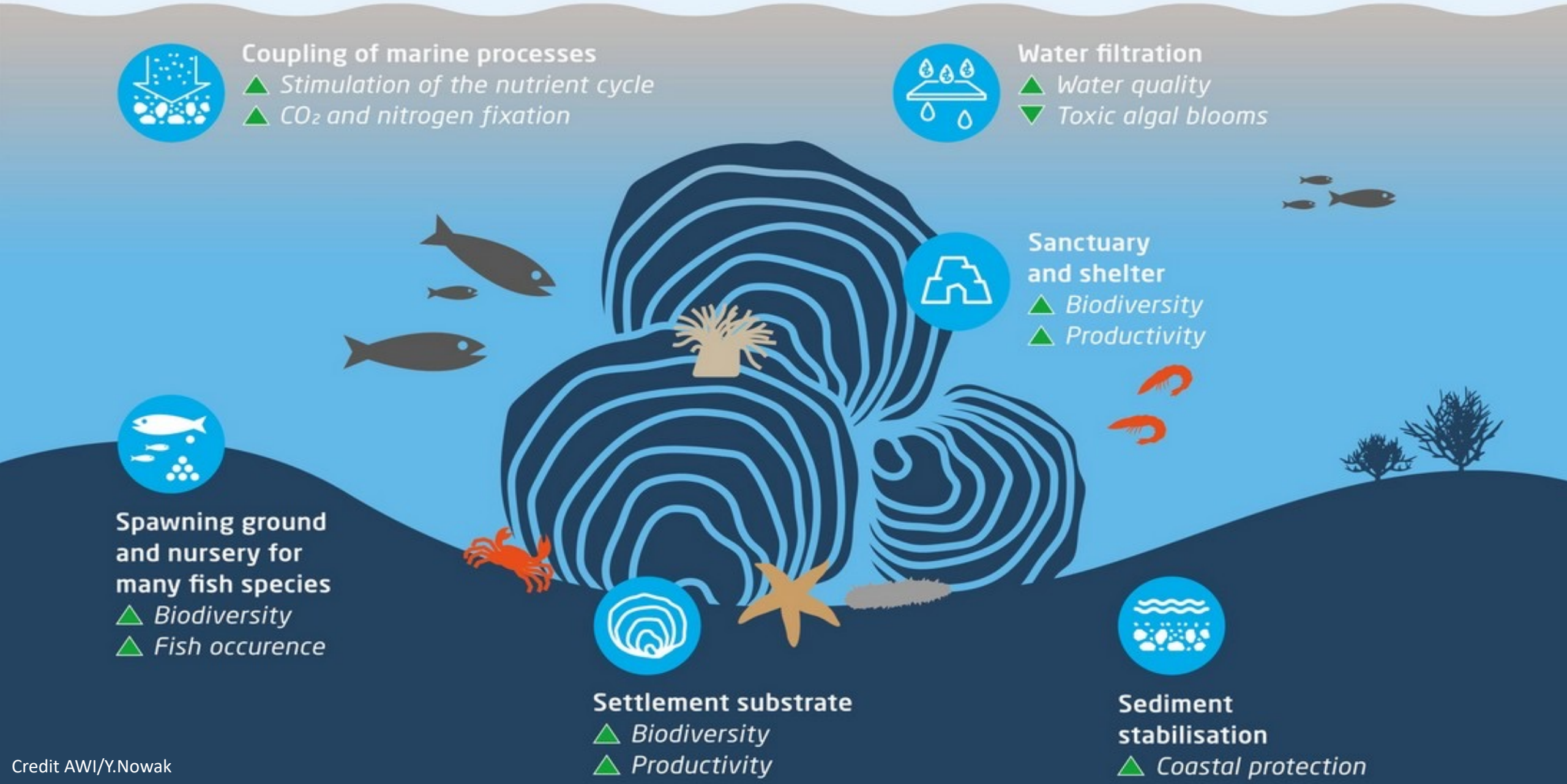
population decline in Virginia's coastal bays is thought to follow similar patterns as in Chesapeake Bay

In Chesapeake Bay




Credit Rothschild, 1994

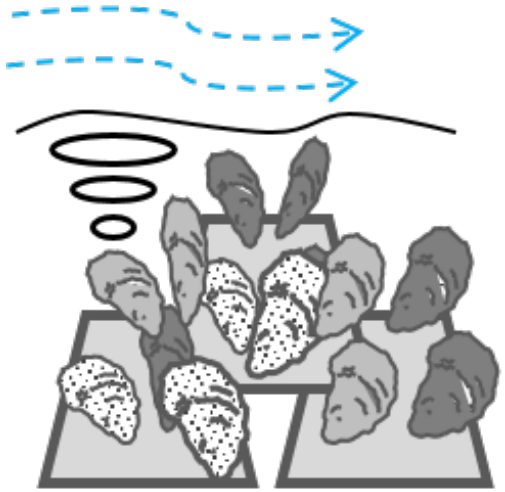
# Oysters as ecosystem engineers




Credit AWI/Y.Nowak

# Wave attenuation by oyster reefs


Credit Cora Baird


Credit Ferguson 2010, adapted from Taube 2013

oyster reefs can increase shoreline protection by dampening incoming wave energy

# Oyster restoration efforts

- require suitable substrate
- importance of local hydrodynamics and reef elevation

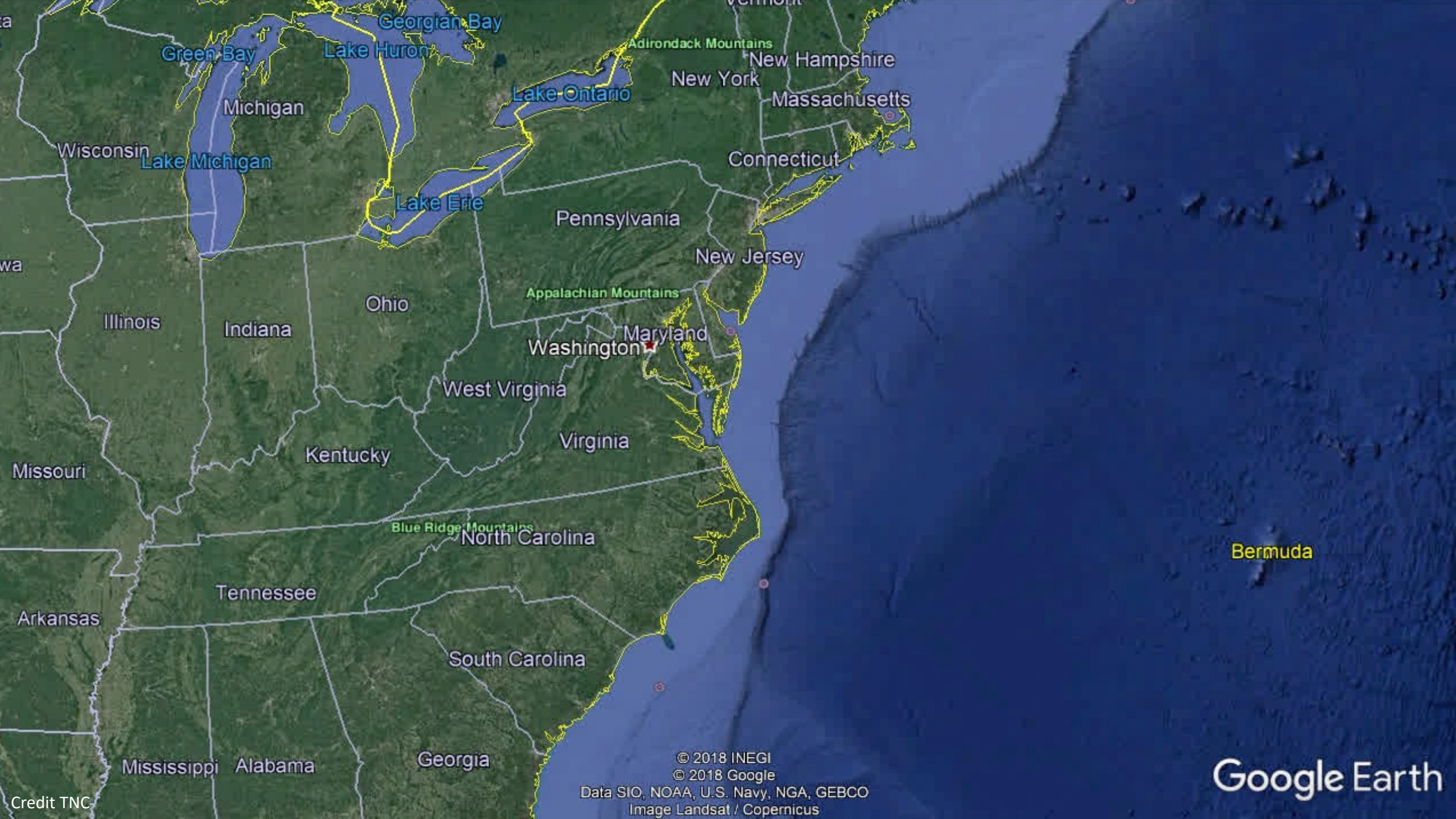
Credit TNC

Credit At Altitude Gallery, 2018

# Marshes as natural buffers

- marshes act as natural buffers to wind waves
- wave attack is the driving force causing marsh retreat
- sea level rise is expected to escalate coastal erosion problems

Credit At Altitude Gallery, 2018


Georgian Bay
Green Bay
Lake Huron
Adirondack Mountains
New Hampshire
New York
Lake Ontario
Michigan
Massachusetts
Wisconsin
Lake Michigan
Connecticut
Lake Erie
Pennsylvania
New Jersey
Appalachian Mountains
Ohio
Illinois
Indiana
Maryland
Washington
West Virginia
Virginia
Kentucky
Missouri
Blue Ridge Mountains
North Carolina
Bermuda
Tennessee
Arkansas
South Carolina
Mississippi
Alabama
Georgia
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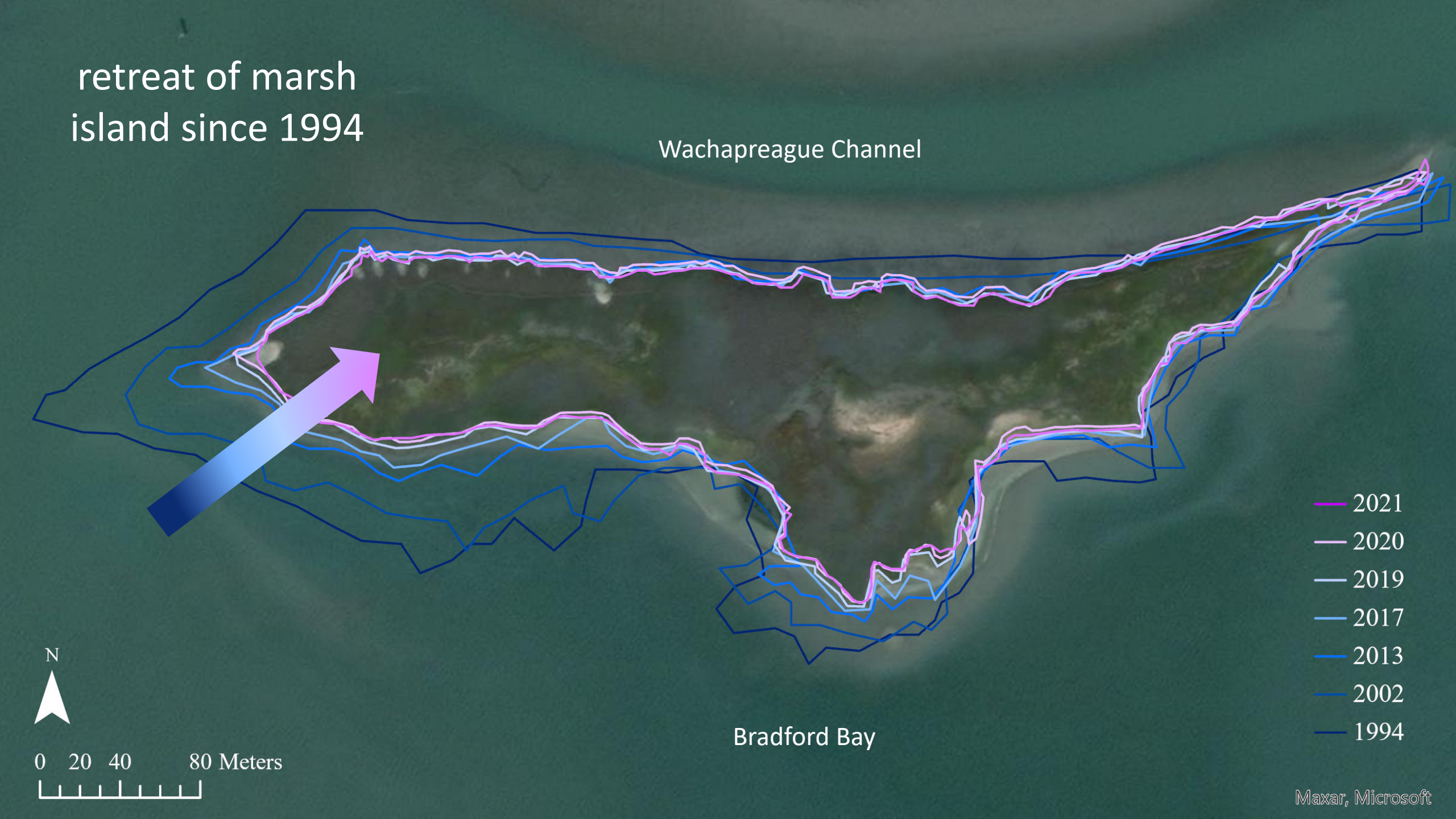
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
Google Earth

Credit TNC

Credit TNC

Credit TNC


Town of
Wachapreague
this marsh reduces
wave heights by ~90%
Wachapreague Channel
Bradford Bay
Google Earth

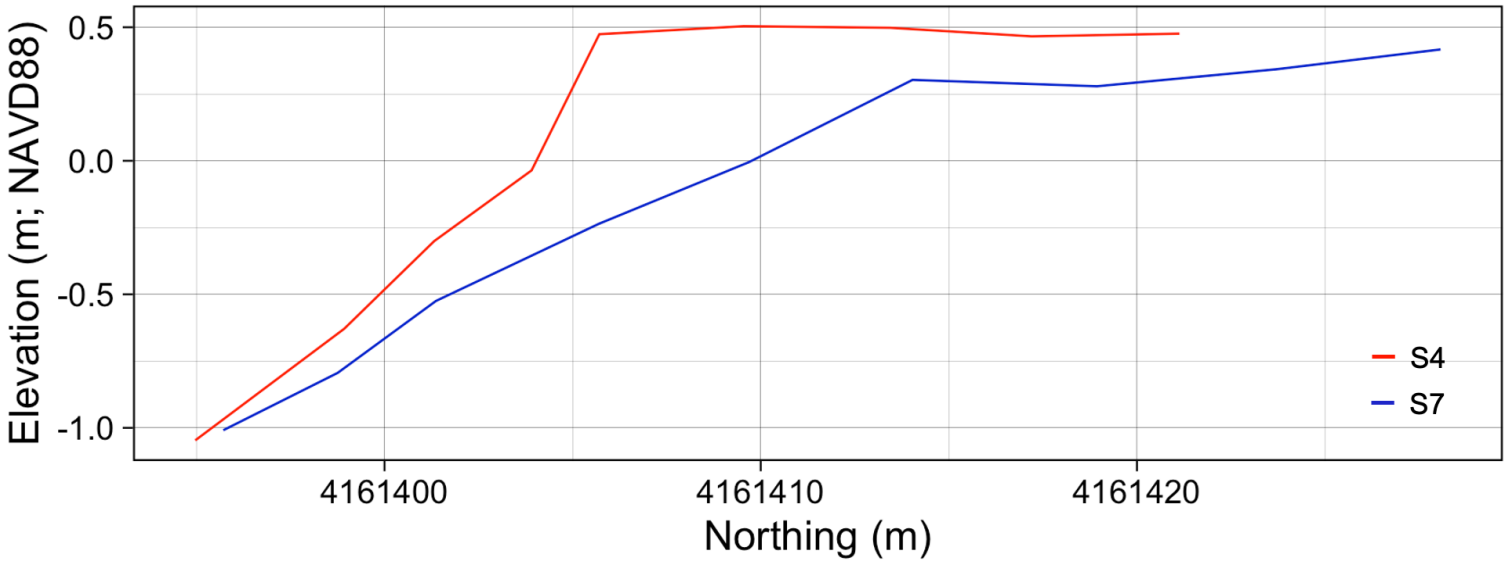

retreat of marsh island since 1994
Wachapreague Channel
Bradford Bay
2021
2020
2019
2017
2013
2002
1994
N
0 20 40 80 Meters
Maxar, Microsoft

# Artificial oyster reefs

## oyster castles


## Sandbar substrate


Credit Bo Lusk & Britt Collins, TNC





Credit Bo Lusk, TNC

# Objectives

1. Study the effectiveness of restored oyster reef designs at attenuating waves, accreting marsh area and altering edge morphology.



2. Document the role of restored oyster reefs in habitat creation and enhancement.

Credit Bo Lusk & Britt Collins, TNC


**wave attenuation** was quantified as change in wave heights (*Hs*) over the reefs

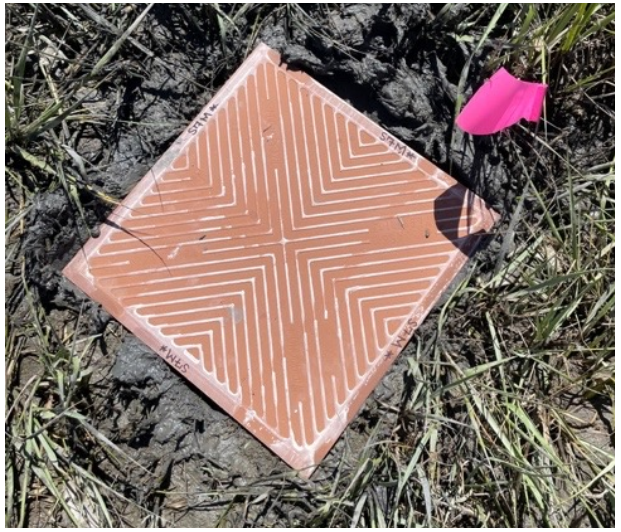

Offshore

Oyster Castles

Oyster Castles

Nearshore


**marsh sedimentation** was measured using sediment accumulation plates



change in **marsh edge position** was determined using erosion pins

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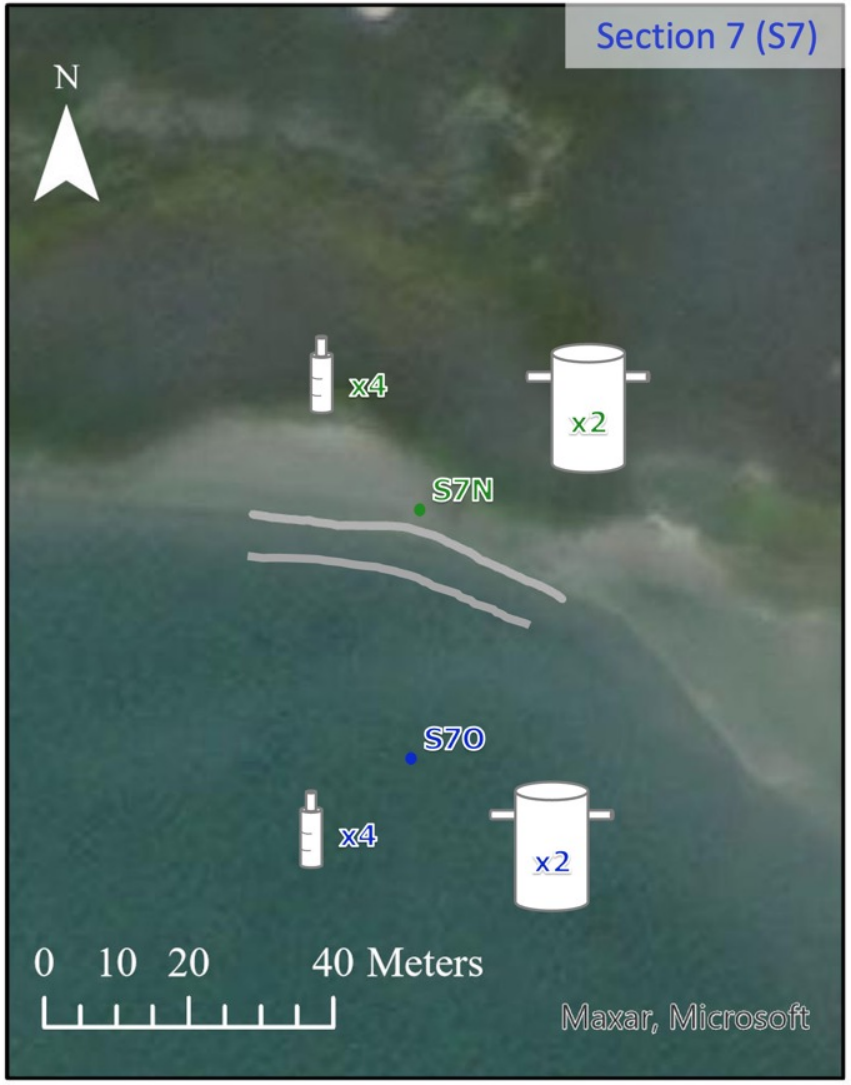
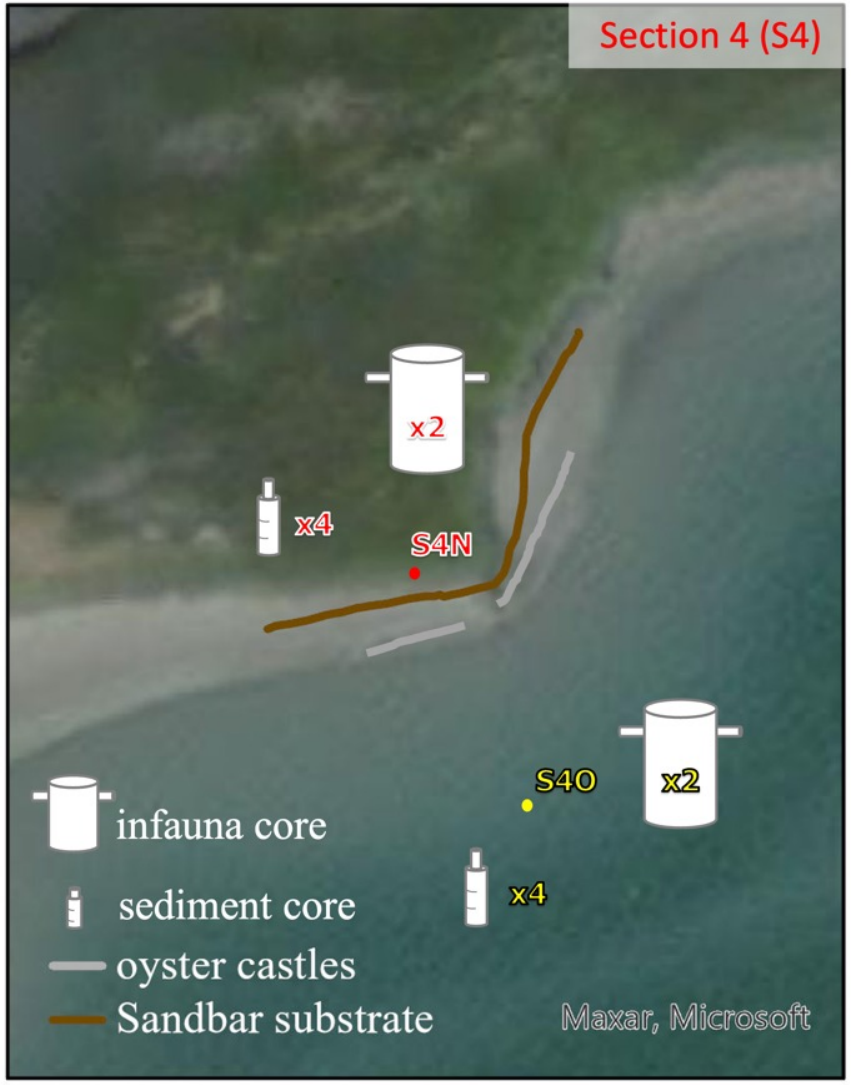
Credit Bo Lusk & Britt Collins, TNC

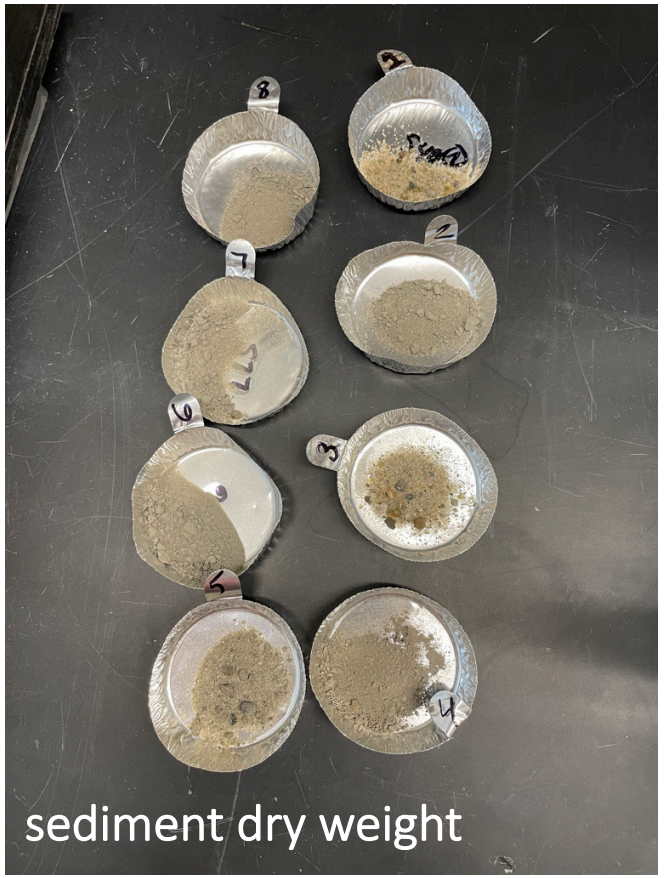
# Methods

**sediment and infauna** samples were collected





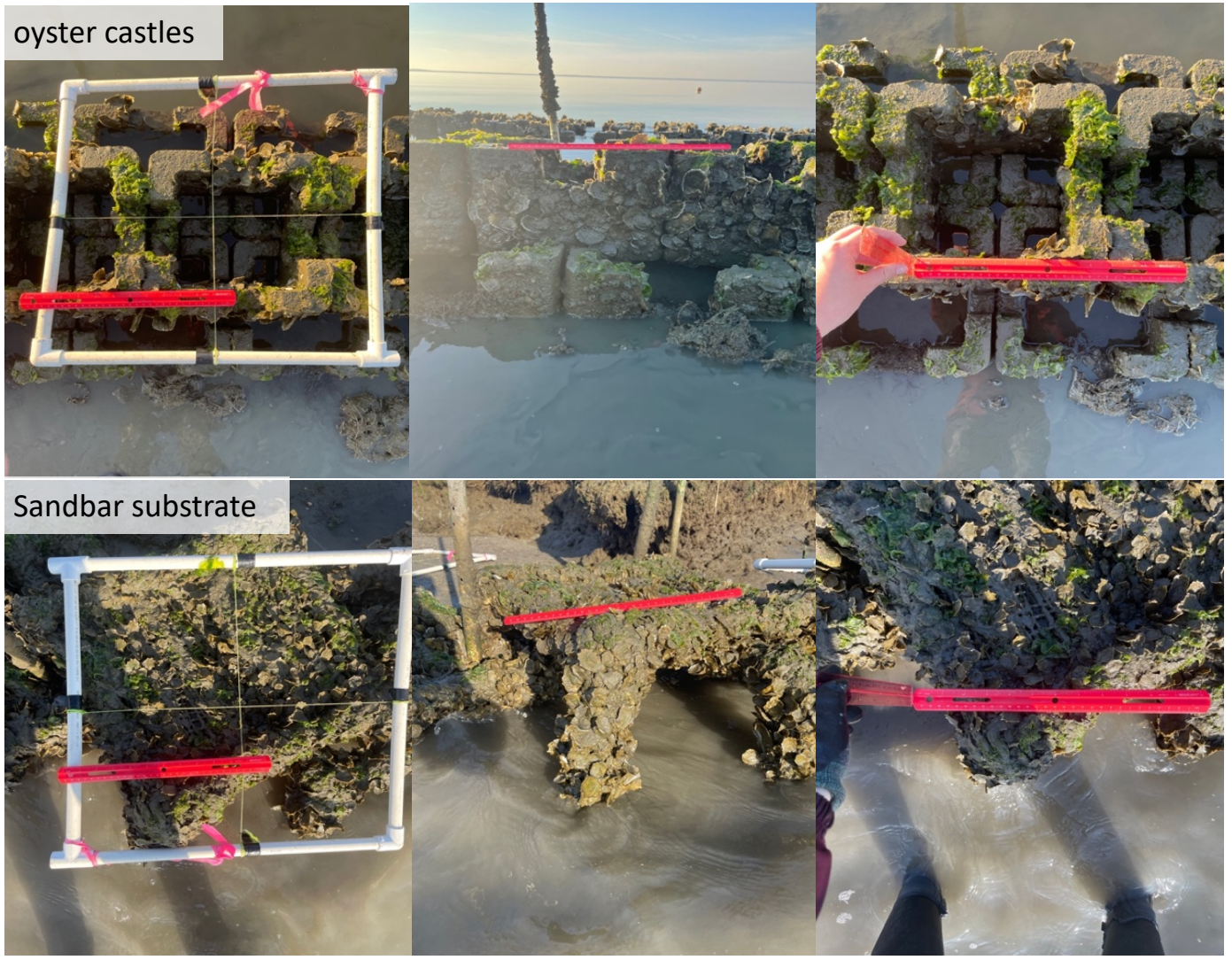





organic matter content = dry weight (g) - ash weight (g)


**recruitment** was measured using larval settlement tiles


**oyster densities** and **shell lengths** were recorded for the substrates



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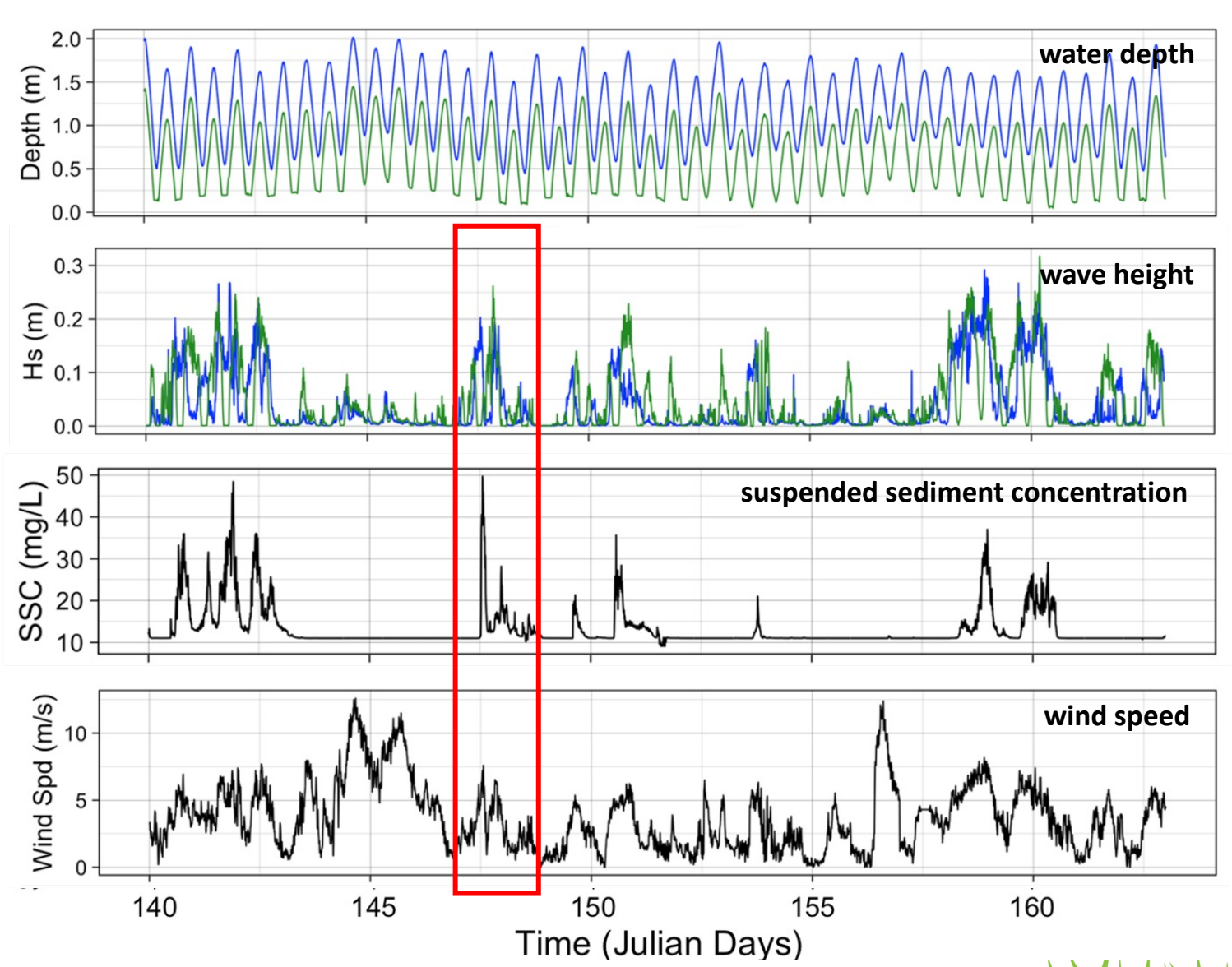
Credit Bo Lusk & Britt Collins, TNC


*Hs* offshore > *Hs* nearshore

*Hs* responds to elevated wind speeds

SSC may respond to an increase in *Hs*



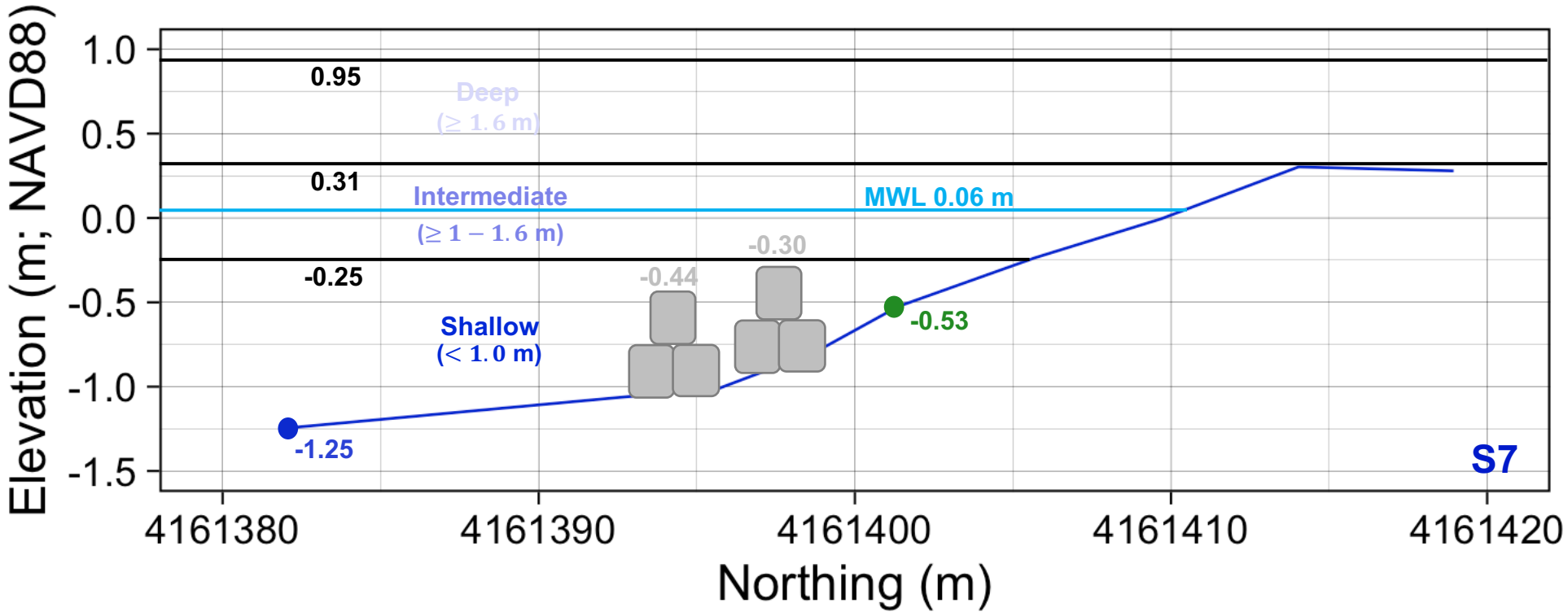

Offshore

Oyster Castles

Oyster Castles

Nearshore


# cross-sectional profiles were created to group wave data by water depth



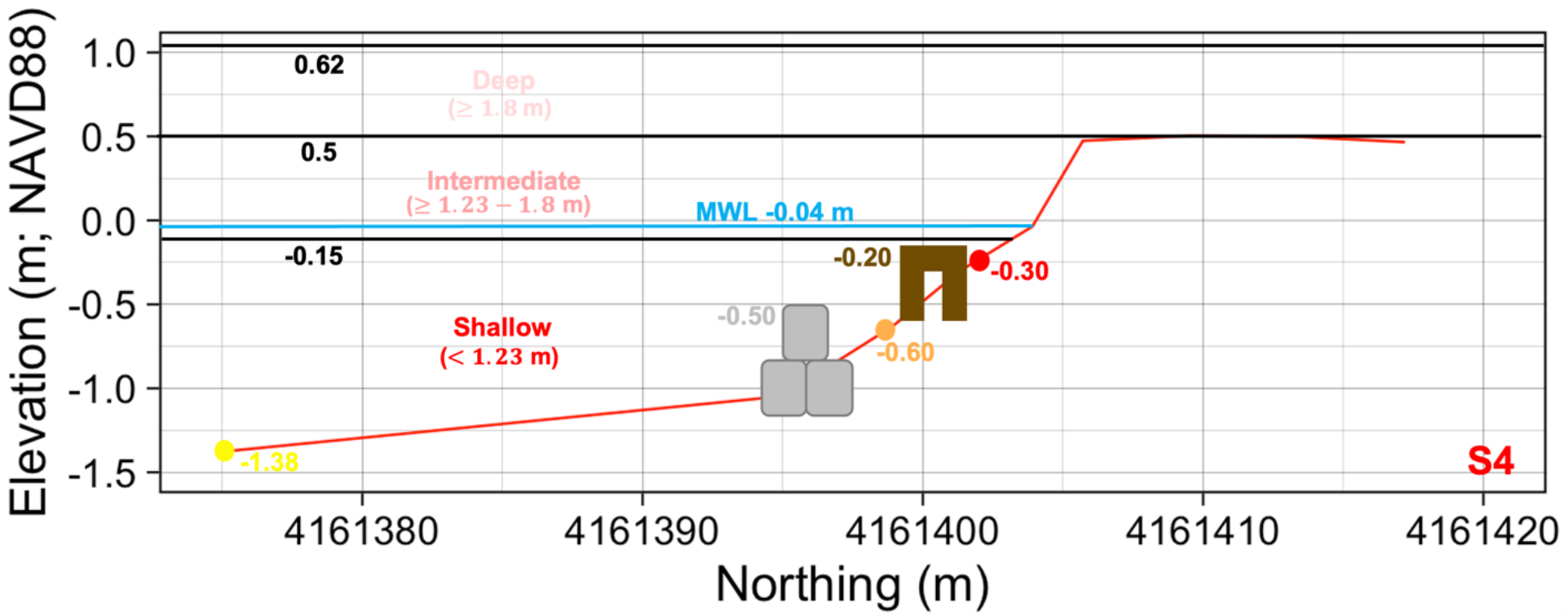

Offshore

Oyster Castles

Oyster Castles

Nearshore


# cross-sectional profiles were created to group wave data by water depth




Offshore

Oyster Castles

Middle

Sandbar Substrate

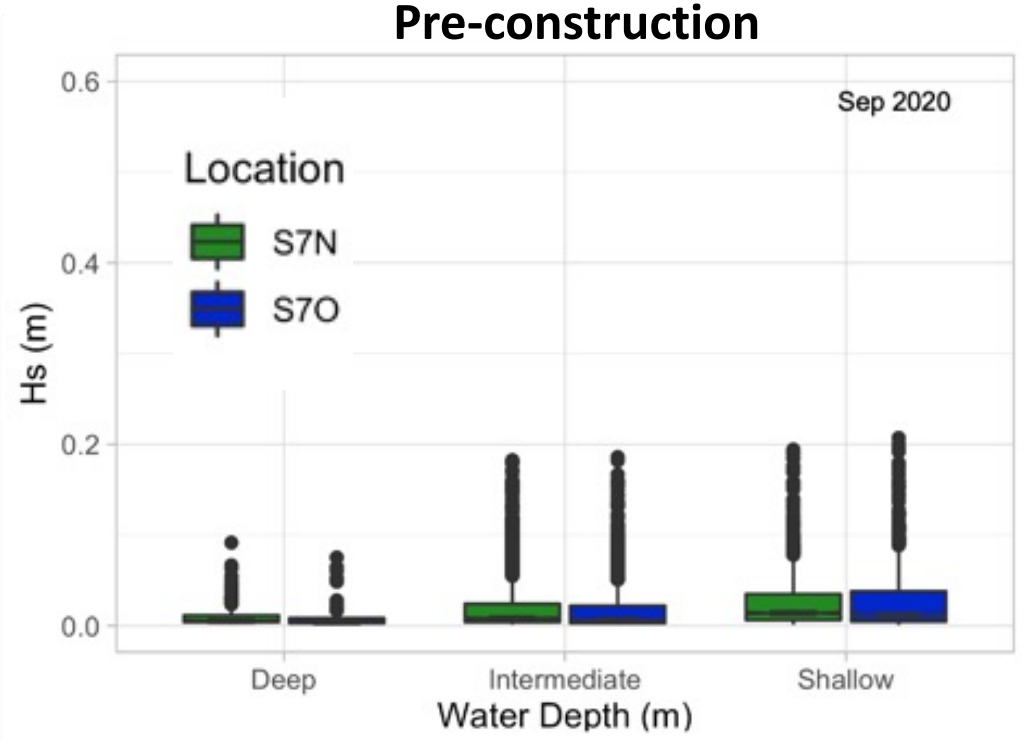
Nearshore


no reduction in *Hs*, only amplification

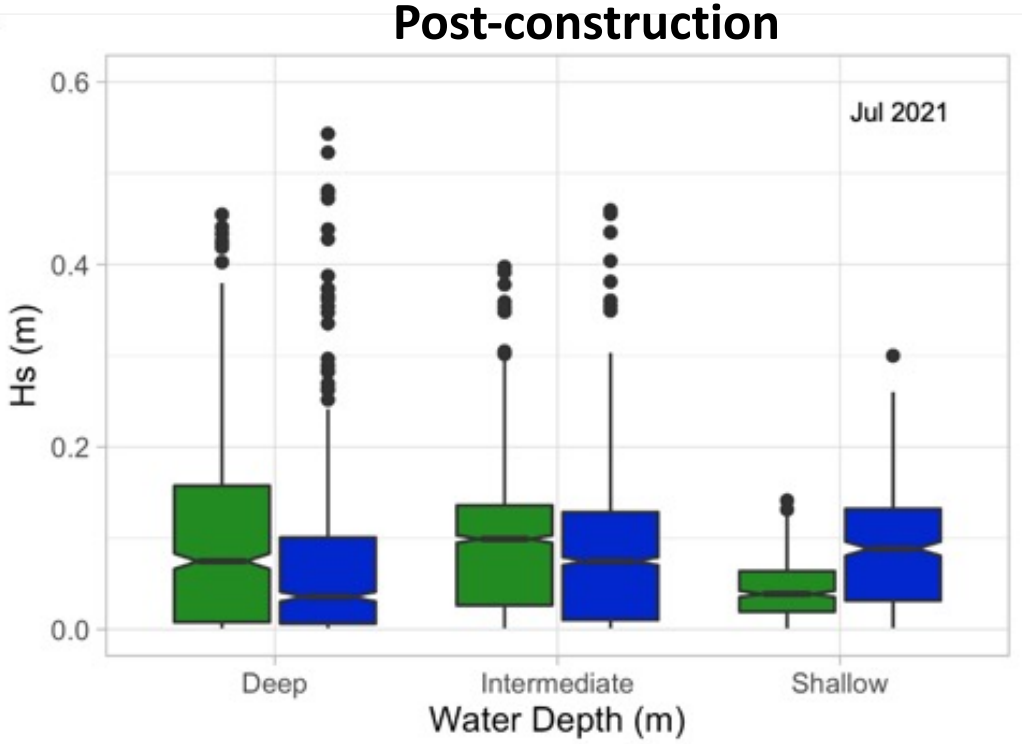
reduction in *Hs* in shallow water only (< 1.0 m water depth)

**S7**

**Pre-construction**




**Post-construction**




Offshore

Oyster Castles

Oyster Castles

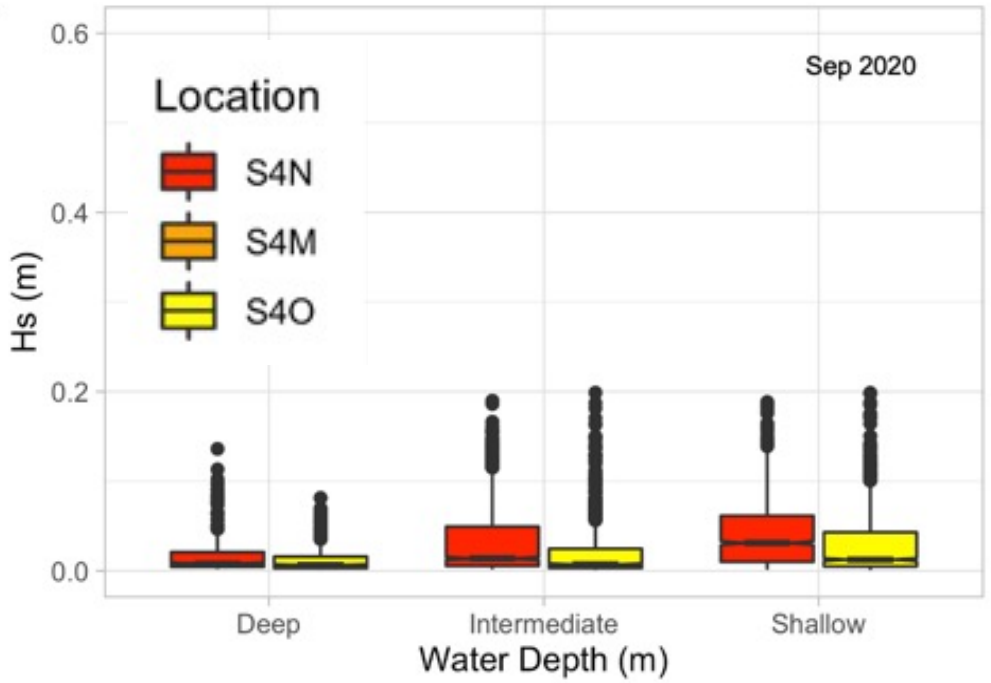
Nearshore

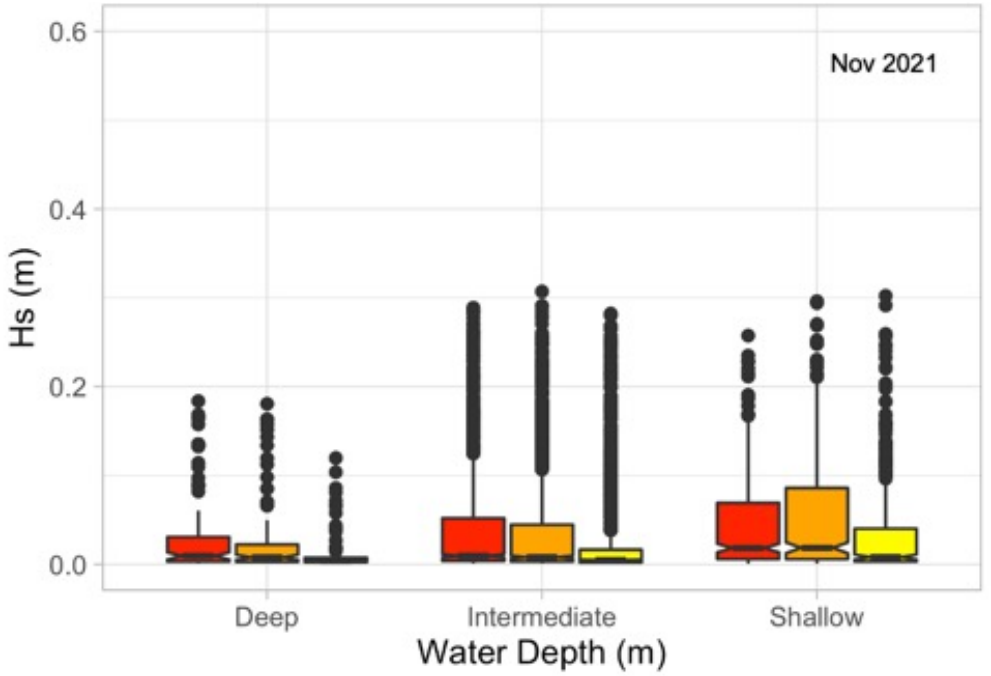

# wave attenuation by oyster reefs is dependent on water depth

**Pre-construction**

**Post-construction**

**S4**




Offshore

Oyster Castles

Middle

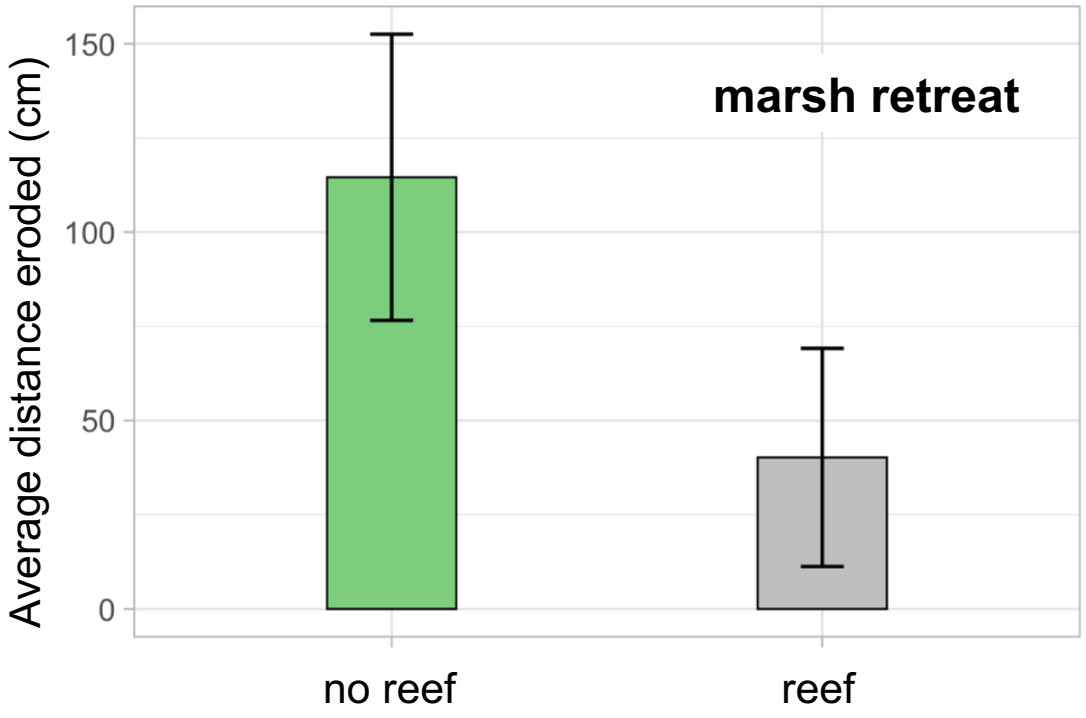
Sandbar Substrate

Nearshore

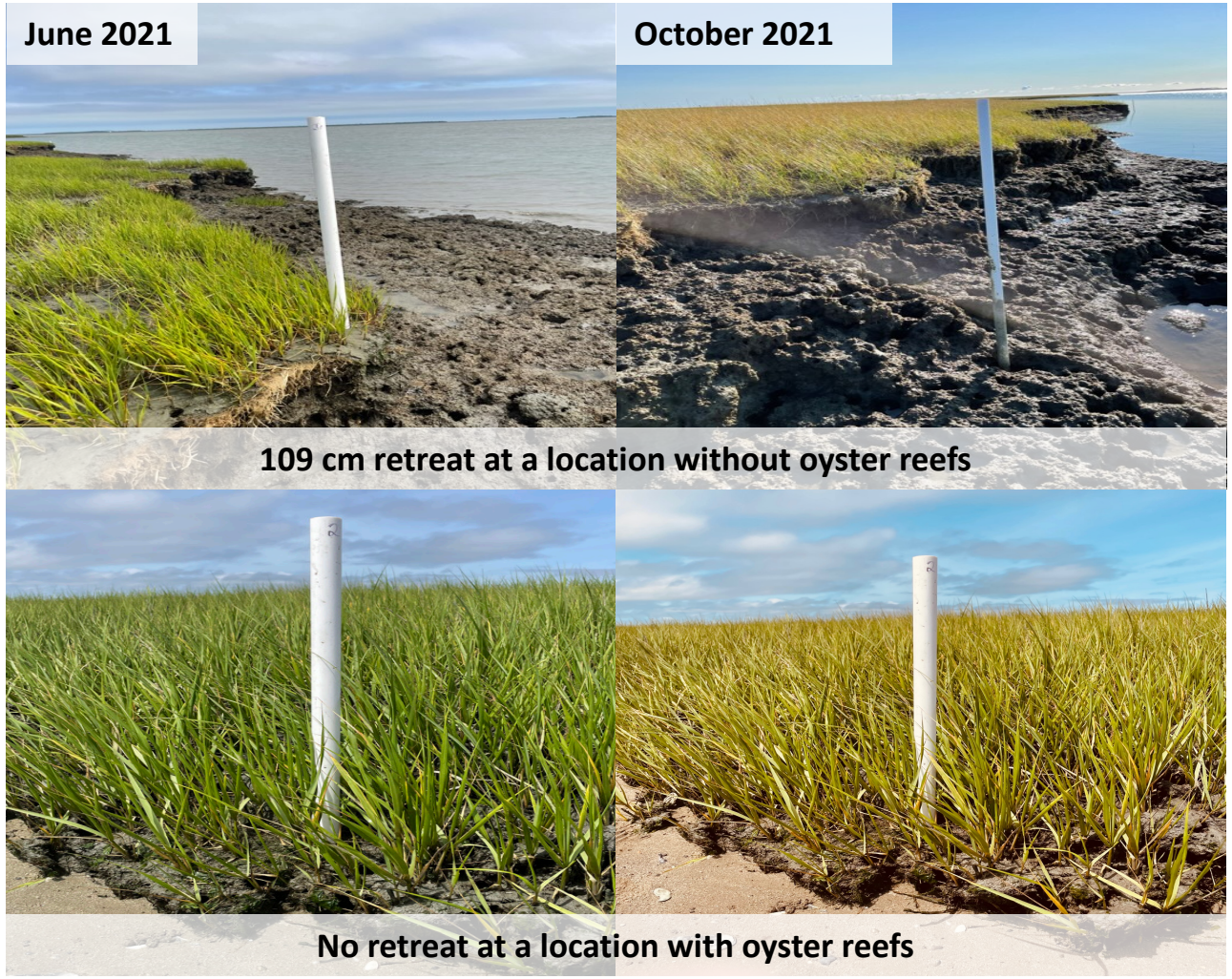

# the impact of reef wave attenuation on marsh edges depends on marsh morphology



Credit Bo Lusk & Britt Collins, TNC

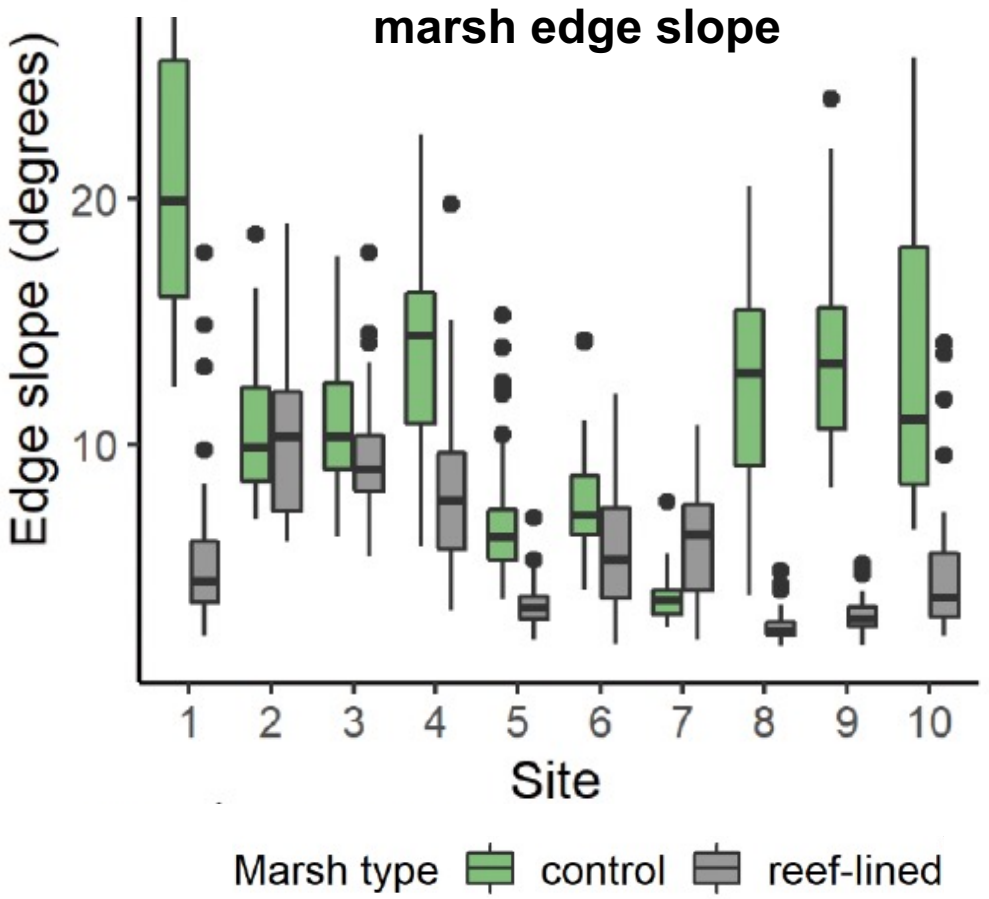




constructed reefs reduced rates of marsh edge erosion

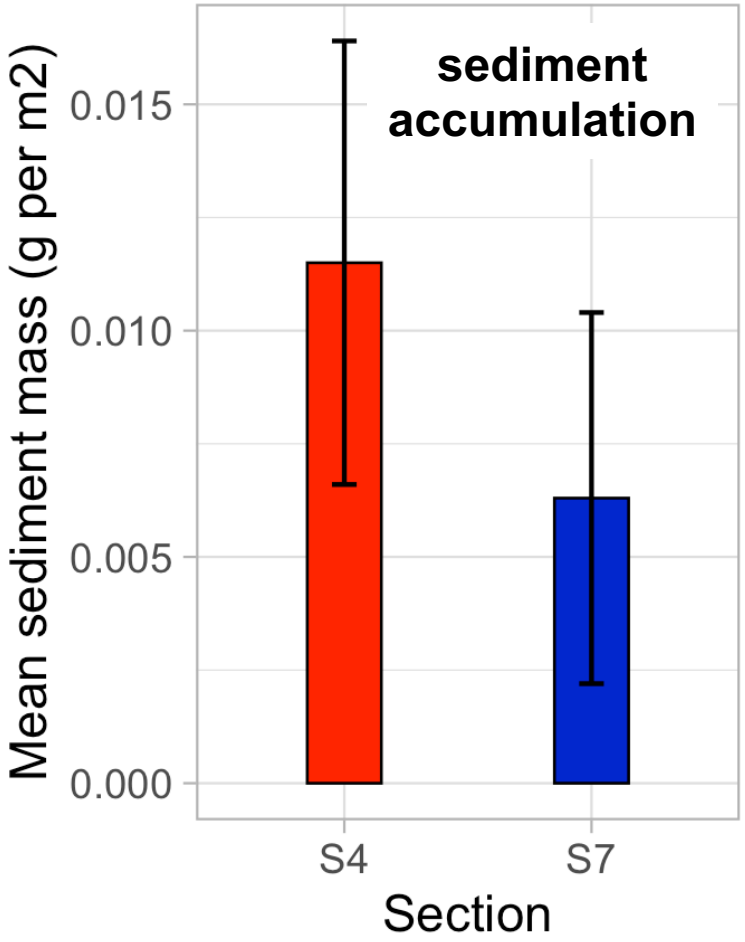



# Previous studies in the VCR

- reef-lined marshes reduce slope values
- oyster reefs facilitate marsh edge elongation
- changes in marsh edge morphology are precursors to changes in marsh retreat




Credit Hogan et al., 2019


quantitatively, there was no significant difference in sediment accumulation between sections


Credit Bo Lusk & Britt Collins, TNC


Marsh edge morphology and elevation are at least as important as the presence of fringing oyster reefs in reducing wave energy driving marsh retreat.

Credit Bo Lusk & Britt Collins, TNC

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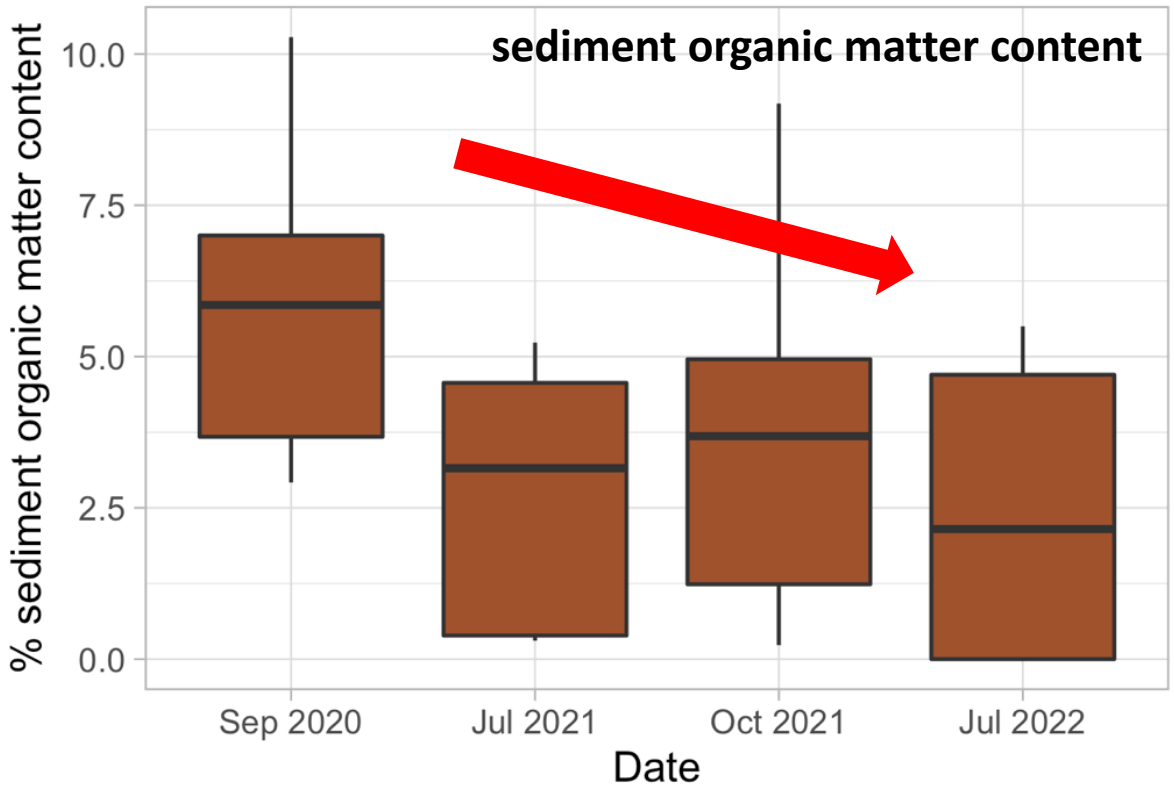
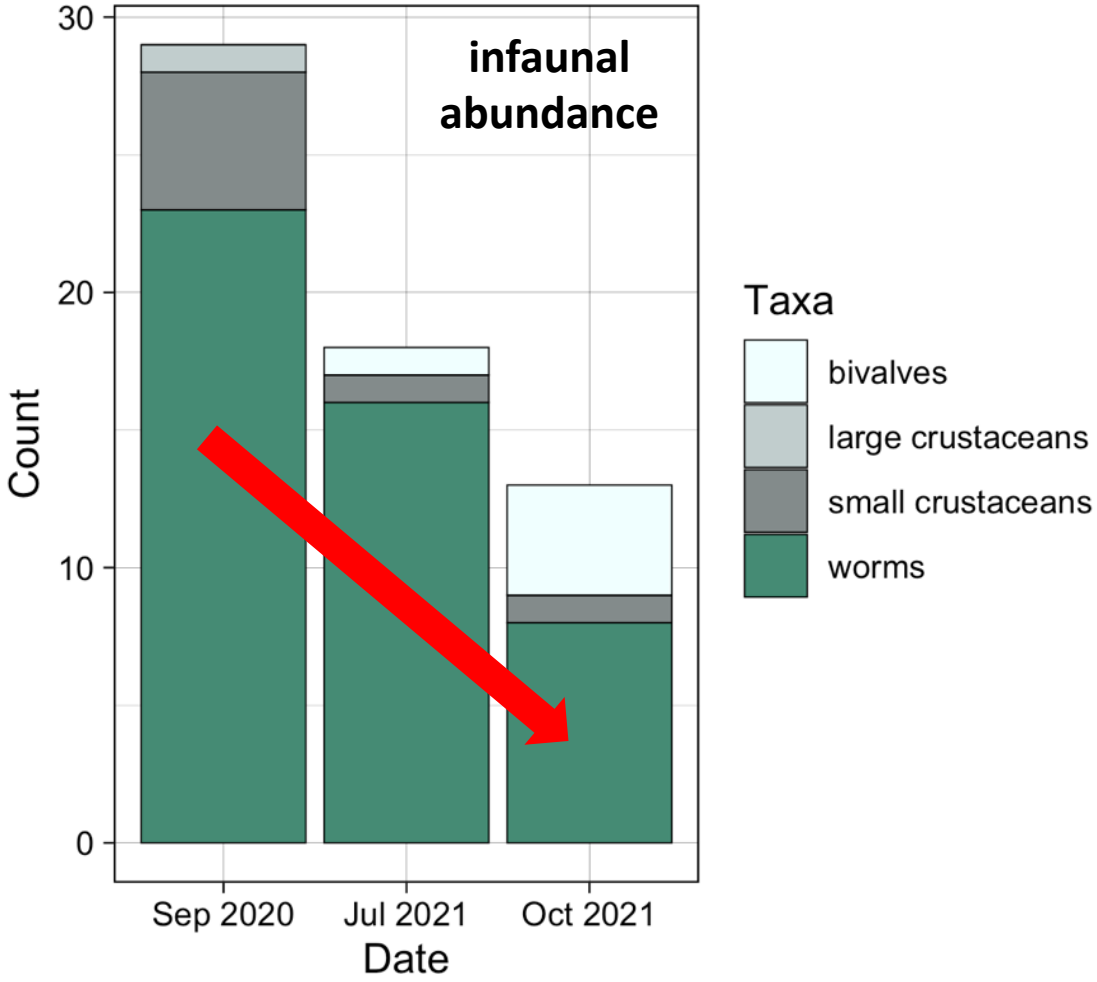
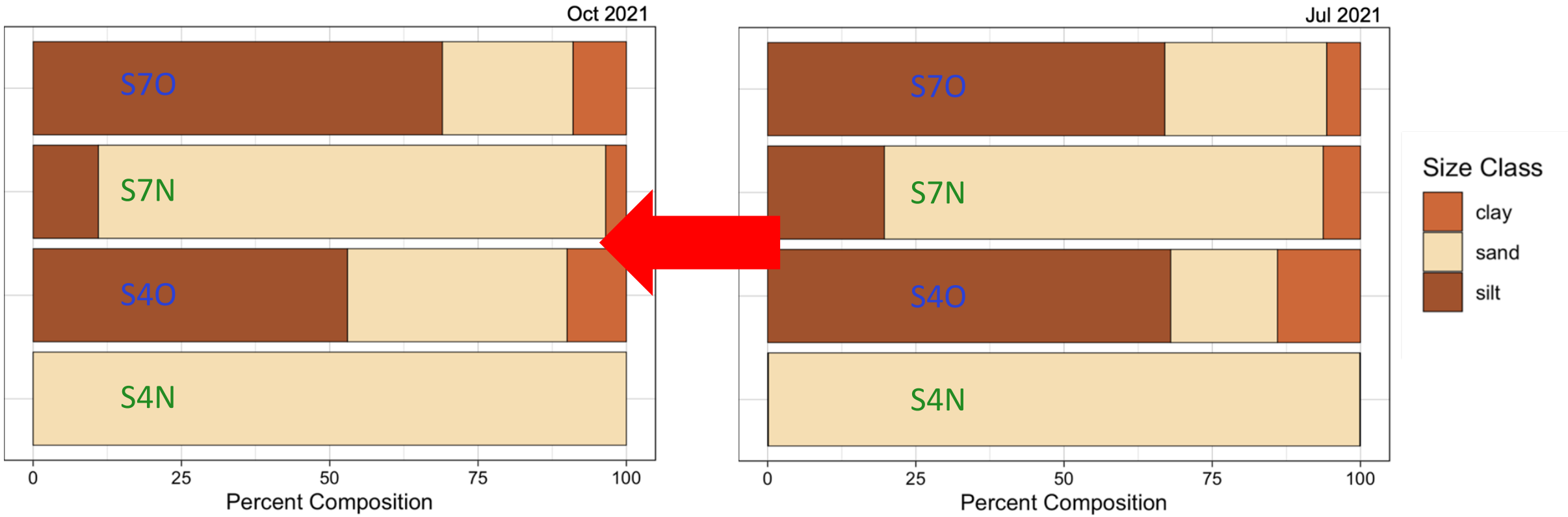
Credit Bo Lusk & Britt Collins, TNC


infauna and sediment metrics were not significantly different between dates nor sections, though trends are beginning to appear

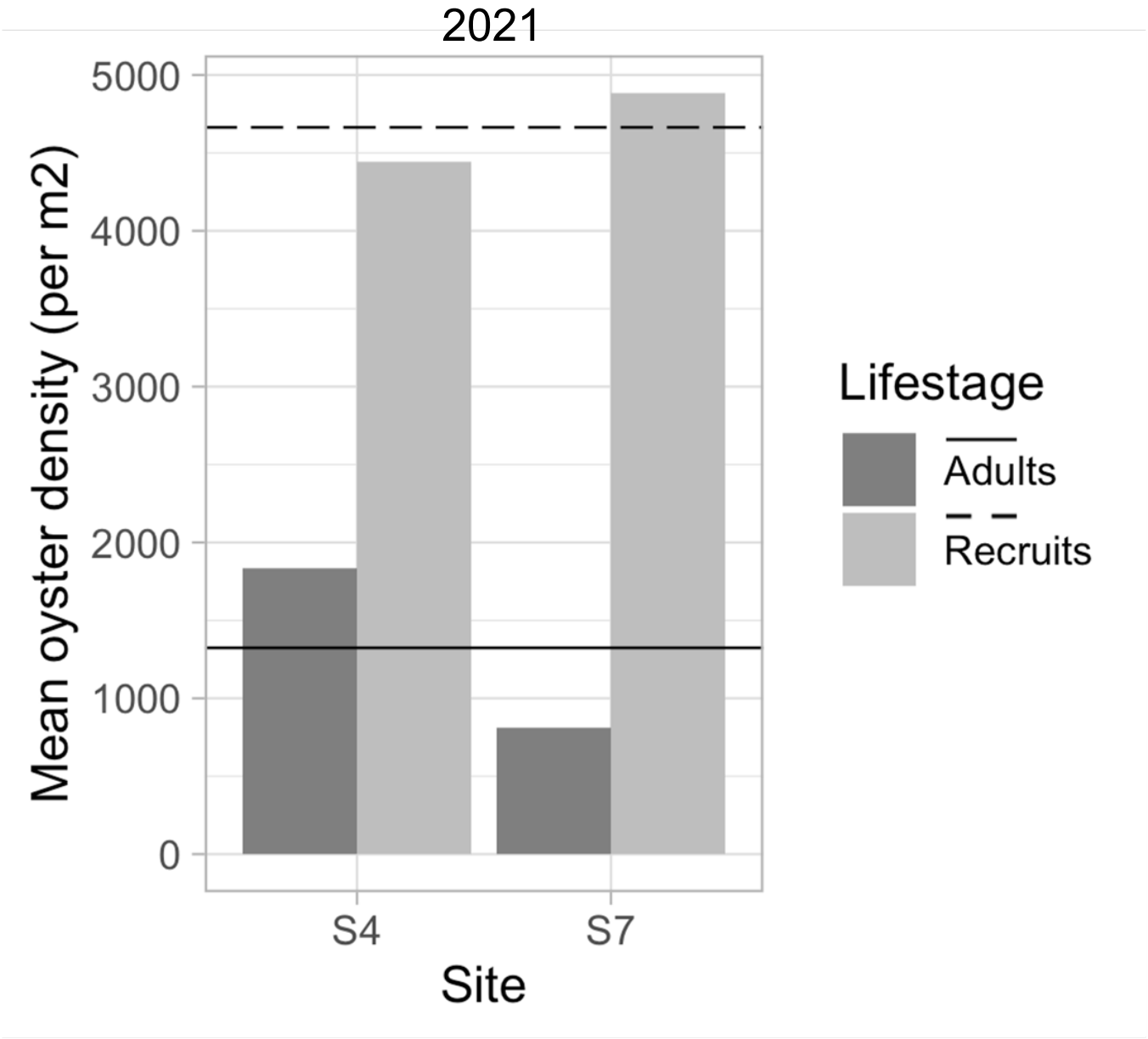


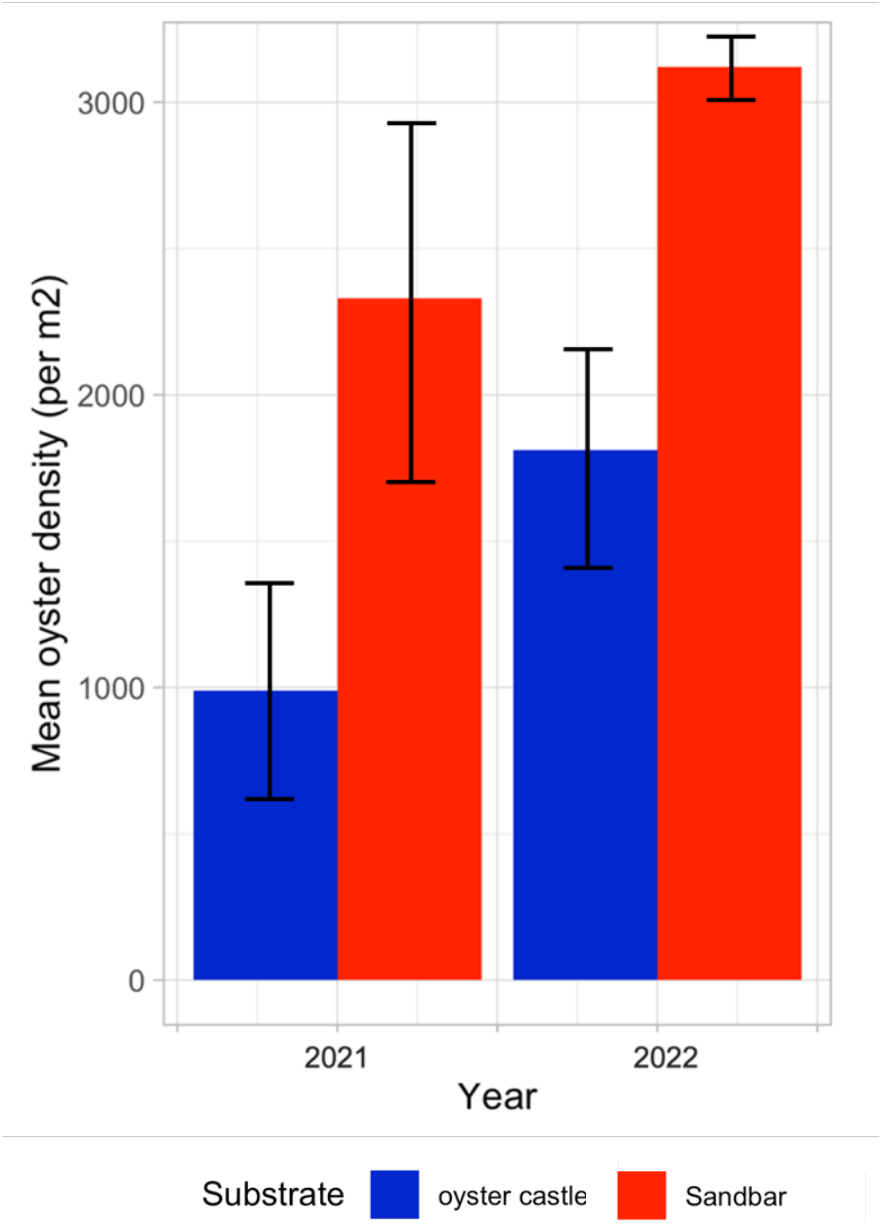

no significant difference in grain size between dates, indicating no wave-driven transport of sediments from offshore to nearshore




adult oyster densities were lower and less variable than recruit densities




greater oyster densities were found on Sandbar substrate than on oyster castles






Restored oyster reefs in this study can enhance oyster populations. Long-term monitoring is needed to better understand changes in local ecology.

Credit Bo Lusk & Britt Collins, TNC

# Although restored oyster reefs in this study have limited wave attenuation effectiveness, they are capable of…

1. slowing retreat of marsh edges and

2. increasing oyster populations.

Credit Bo Lusk & Britt Collins, TNC

Credit Bo Lusk & Britt Collins, TNC

# Thank you!

Credit At Altitude Gallery, 2018