Assessing the Impact of Mangrove-Driven Acidification on Intertidal Oyster Reefs

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The Indian River Lagoon

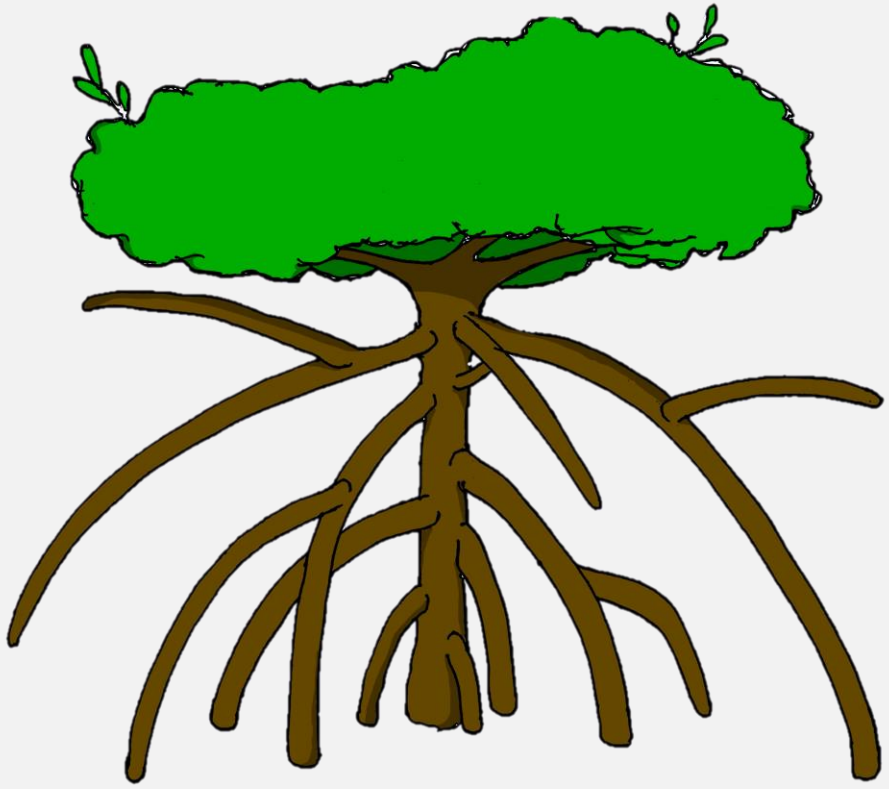
Habitat Ecosystem Services

Intertidal Oyster Reef
(*Crassostrea virginica*)

Red Mangrove
(*Rhizophora mangle*)

Climate Shift: Tropicalization

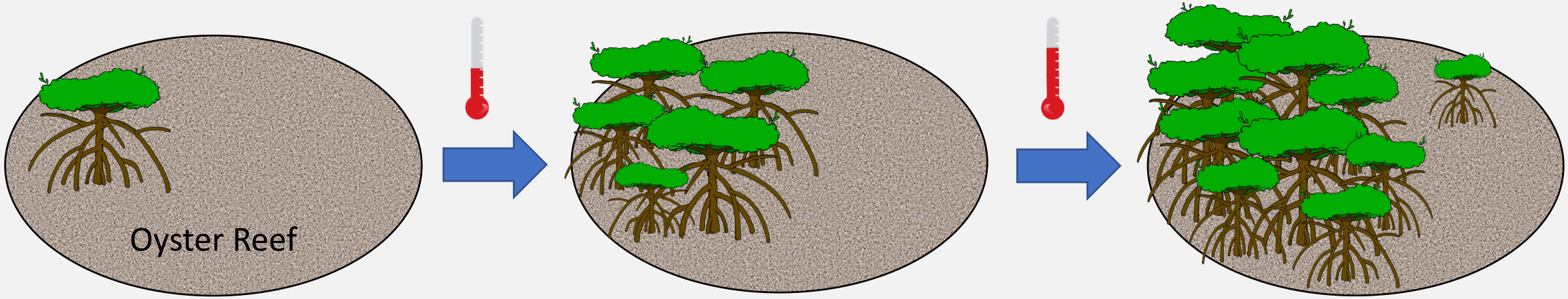
The poleward movement of tropical and subtropical species as minimum cold temperatures have increased over the past multiple decades



- Mangroves have expanded poleward and increased in historical ranges
- Mangrove expansion has reduced salt marsh area throughout the southeastern USA

Cavanaugh et al. 2019, Saintilin et al. 2014, Steinmuller et al. 2020, Krauss et al. 2011, Osland et al. 2013

Mangroves on Intertidal Oyster Reefs



- McClenachan et al. (2021) found in Mosquito Lagoon, FL mangrove area on intertidal oyster reefs has increased by **198% since 1984**
- Encroachment is predominantly driven by red mangroves

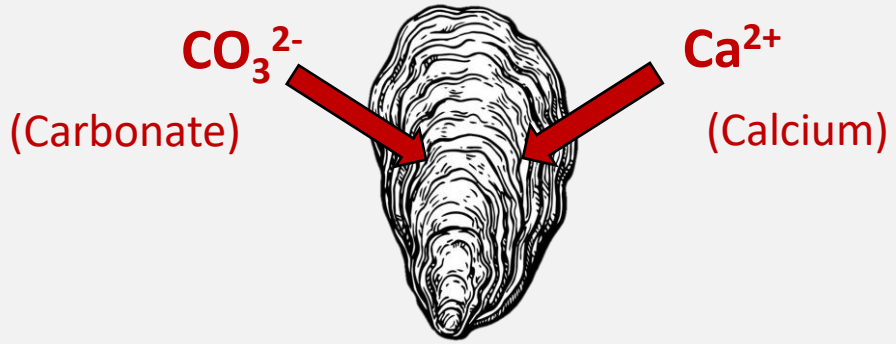
McClenachan, G., M. Witt, and L.J. Walters. 2021. Replacement of oyster reefs by mangroves: Unexpected climate-driven ecosystem shifts. Global Change Biology. 00:1-13.

Red Mangroves and Acidification

- Coastal water pH ~ 8.2
- Red mangroves acidify surrounding sediment to a pH of 6.5
- Mangroves create carbonic and sulfuric acids in the sediment

Marchand et al. 2004, Middelberg et al. 1996, Aller 1982

How will this impact oyster reefs?



↓ pH = ↓ CO_3^{2-}

- Acidity reduces availability of carbonate and leads to shell dissolution
- Oyster shell dissolution increases when shells are consistently exposed a pH of 7.17 or less

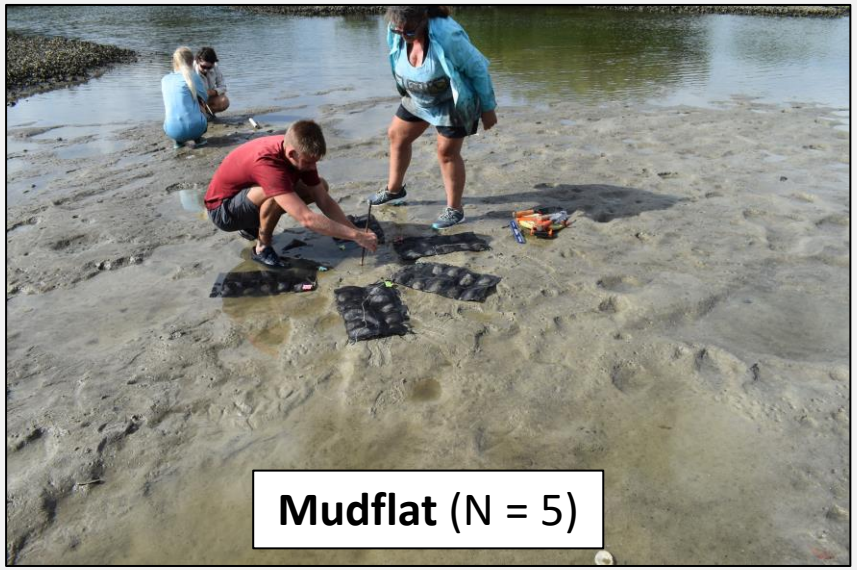
Waldbusser et al. 2011

Research Questions

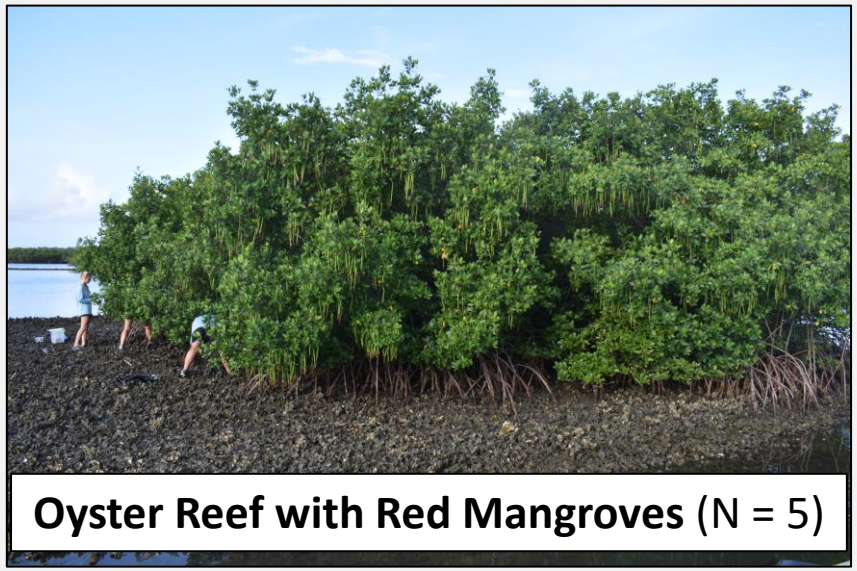
Q1: Do red mangroves cause acidification of oyster reef sediments by decreasing pore-water pH?

Q2: If yes, do red mangroves decrease sediment pH across the entire reef landscape?

Site Types



Mudflat (N = 5)



Oyster Reef with Red Mangroves (N = 5)

Oyster Reef (N = 5)

Red Mangrove Island (N = 5)

Q1

Pore-Water pH: Methods

Water from within the sediment (i.e., pore-water) was collected and tested for pH measures

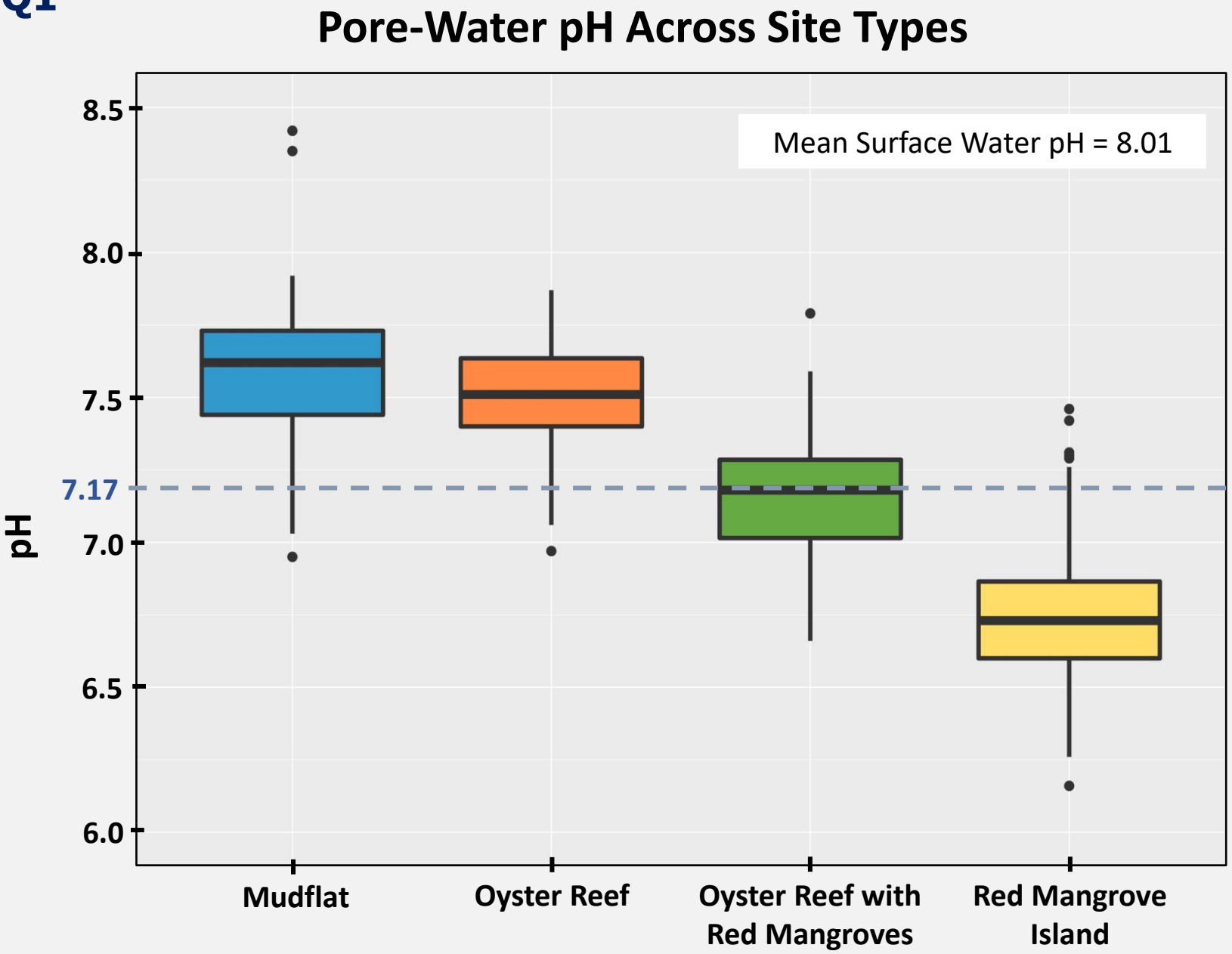
- Sediment core was extracted and discarded
- Pore-water seeped into remaining hole

- Extracted pore-water and placed into a scintillation vial
- Pore-water was immediately tested for pH with a portable pH meter

Oyster Reefs with Mangroves:

- Large, established red mangrove stands
- Pore-water collected at the encroachment line

Q1



7 months of pH data; Site types: N = 5

Pore-Water pH:

GLMM Results

Oyster Reef Sites Compared to:	P-Value
Mudflat	0.186
Oyster Reef with Red Mangroves	< 0.001
Red Mangrove Island	< 0.001

Q2

Do red mangroves decrease sediment pH across the entire reef landscape?

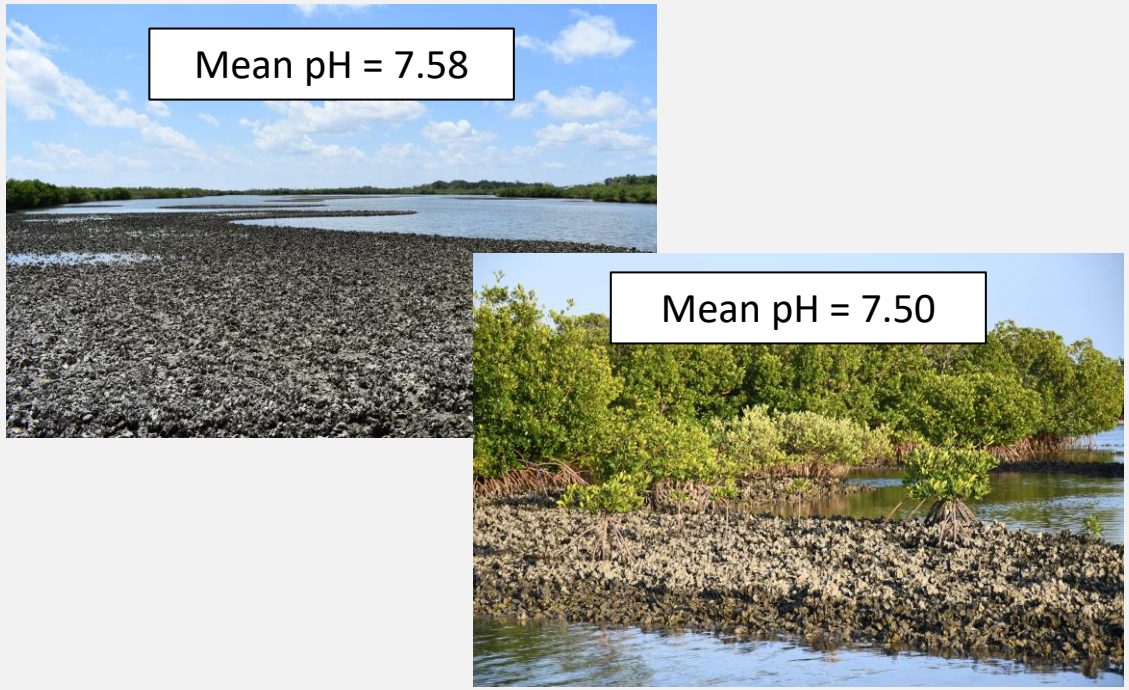
Reef Landscape pH: Methods

- Grids of 40 random sampling points set up across reef landscape
- Pore-water was extracted from the 40 points
- Distance to the nearest mangrove was recorded for each random sampling point

Q2

Reef Landscape pH: Results

T-Test Results



Overall pH means between the two site types were not different (p-value = 0.317)

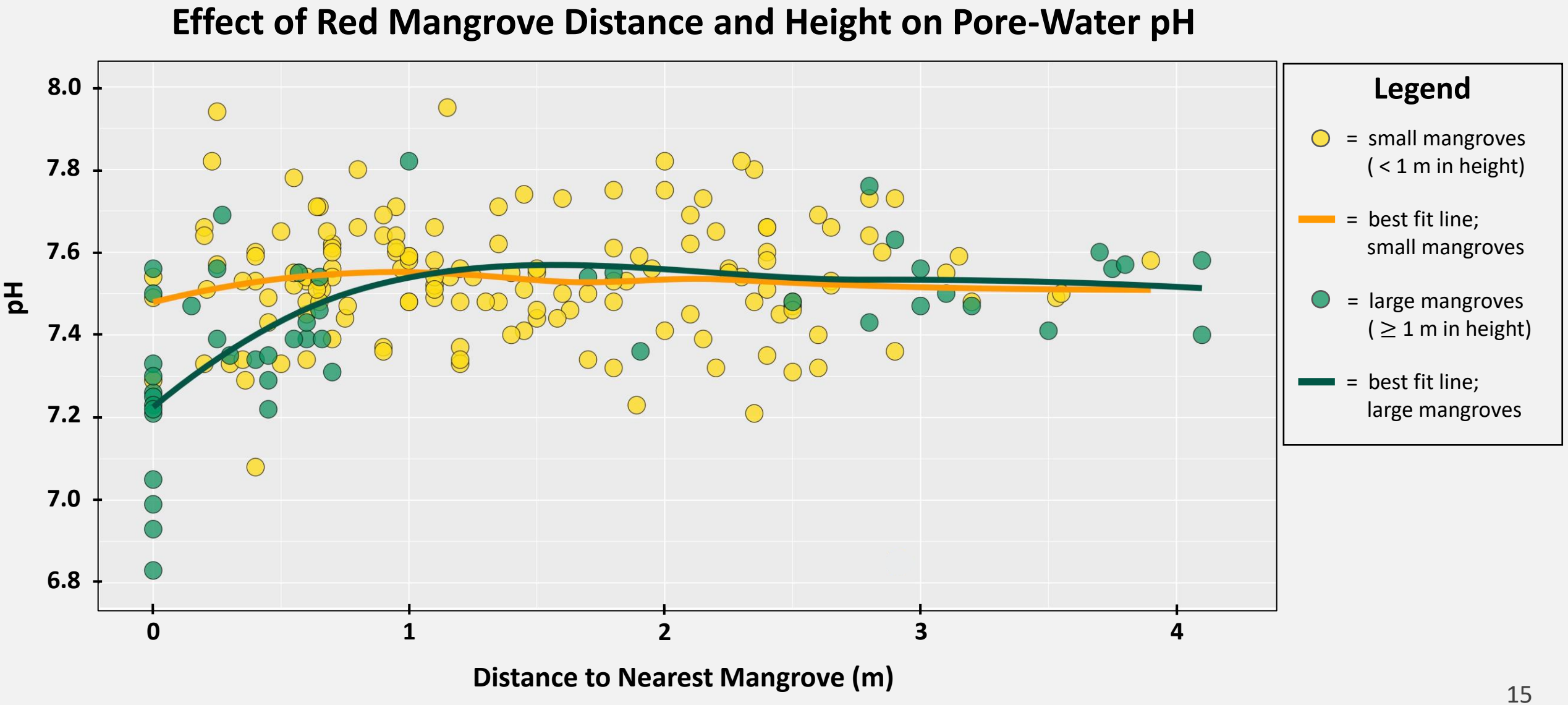
GLM Results

Comparison	P-Value
Distance from Mangrove	0.155
Mangrove Height	< 0.001
Interaction (Distance : Height)	< 0.01

Interaction between distance from mangrove and mangrove height affected pore-water pH

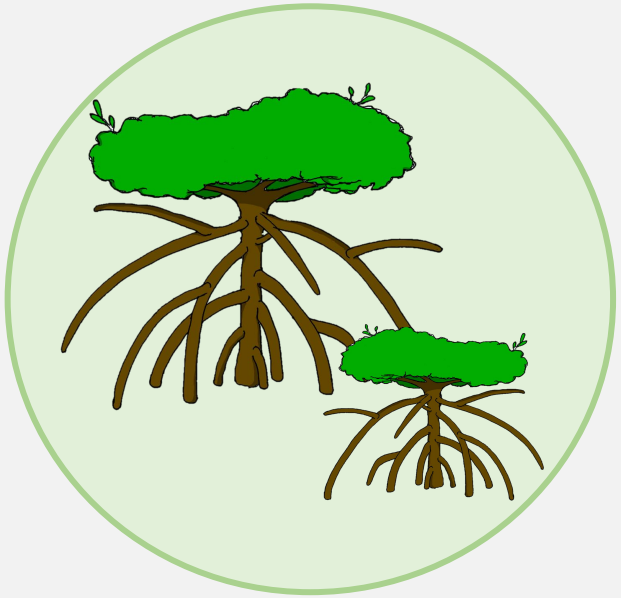
Q2

Reef Landscape pH: Results



Discussion

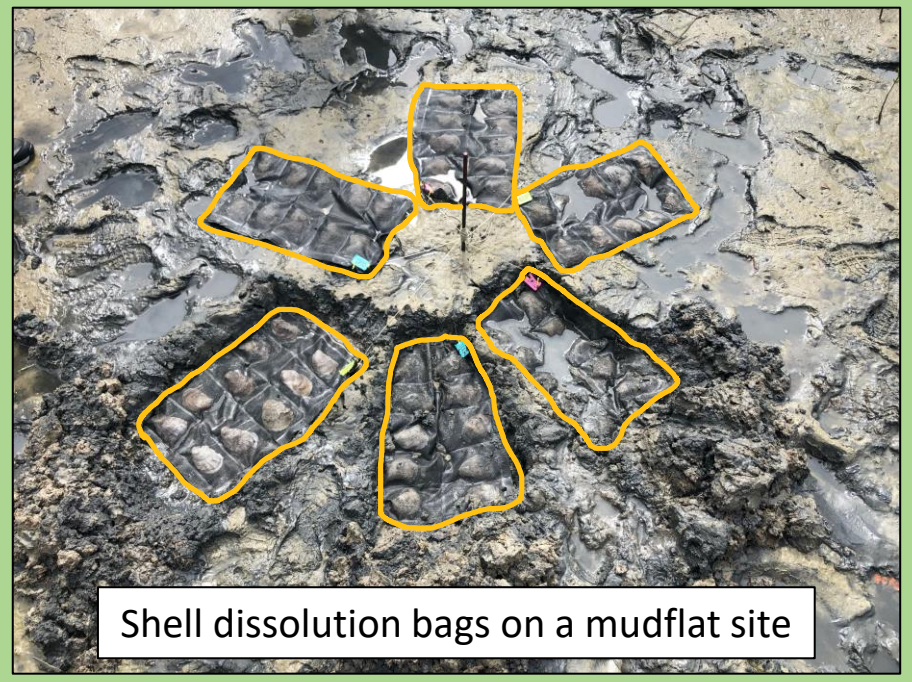
- Results suggest red mangroves acidify oyster reef sediments
- Localized effect



- Small red mangroves have potential to drive acidification as they grow

- Red mangroves decrease pH as low as 6.86 on oyster reefs
- Potential to impact shell dissolution

Pioneer red mangrove on an oyster reef



Shell dissolution bags on a mudflat site

Future Directions

- What is the extent of pH change in oyster reef sediments under adult, pioneer red mangroves?
- Do black mangroves (*Avicennia germinans*) on oyster reefs drive sediment acidification?
- Do red mangroves on oyster reefs cause oyster shell dissolution?

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