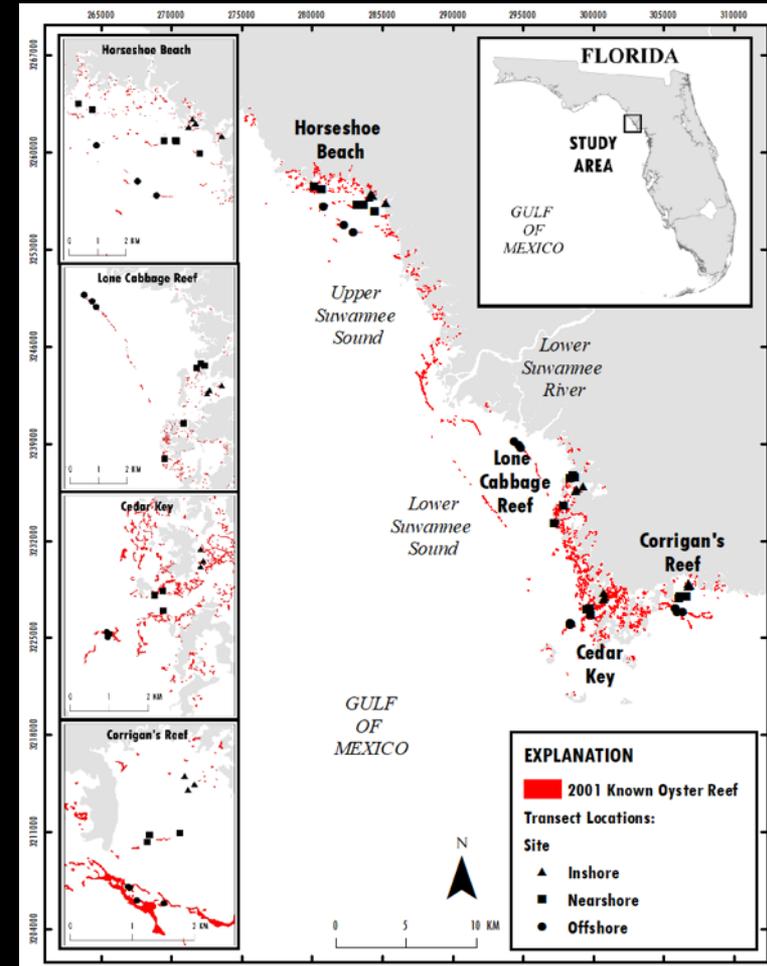


Lone Cabbage Reef (LCR) Restoration

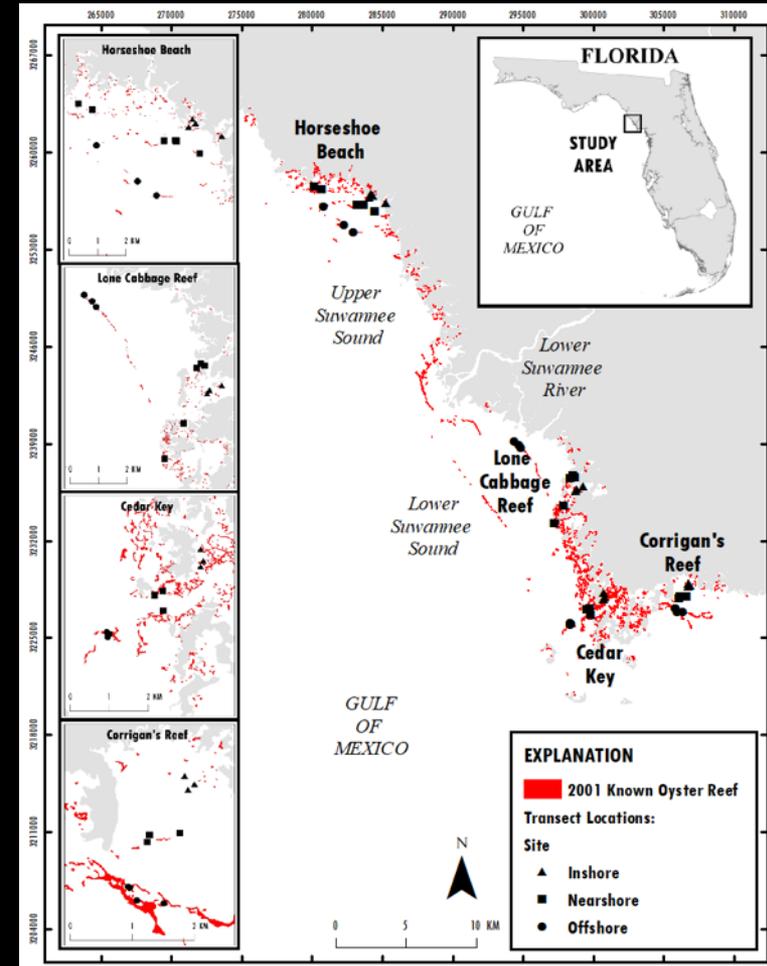
LCR Restoration: Motivation

- Seavey et al. 2011: large losses in intertidal oyster reefs 1982-2011
 - Aerial surveys and on-the-ground assessment
 - Horseshoe Beach to Corrigan's Reef



LCR Restoration: Motivation

- 66% loss of intertidal oyster reef 1982-2011
- Largest losses “offshore” oyster reef



LCR Restoration: Motivation

- *Seavey et al. results led to...*
- Pilot restoration project 2013 (Frederick et al. 2016)



Pilot LCR Restoration: What are we learning?

- Ho: Does addition of rock as durable substrate allow oyster colonization and persistence?



Pilot LCR Restoration: What are we learning?

- Ho: Does addition of rock as durable substrate allow oyster colonization and persistence?
 - 4 rock restoration sites
 - 4 control sites
 - Each about 21 m x 21 m



Pilot LCR Restoration: What are we learning?

- Ho: Does addition of rock as durable substrate allow oyster colonization and persistence?
 - 4 rock restoration sites
 - 4 control sites
 - Each about 21 m x 21 m
 - **9x increase in oysters on restored vs. control sites**



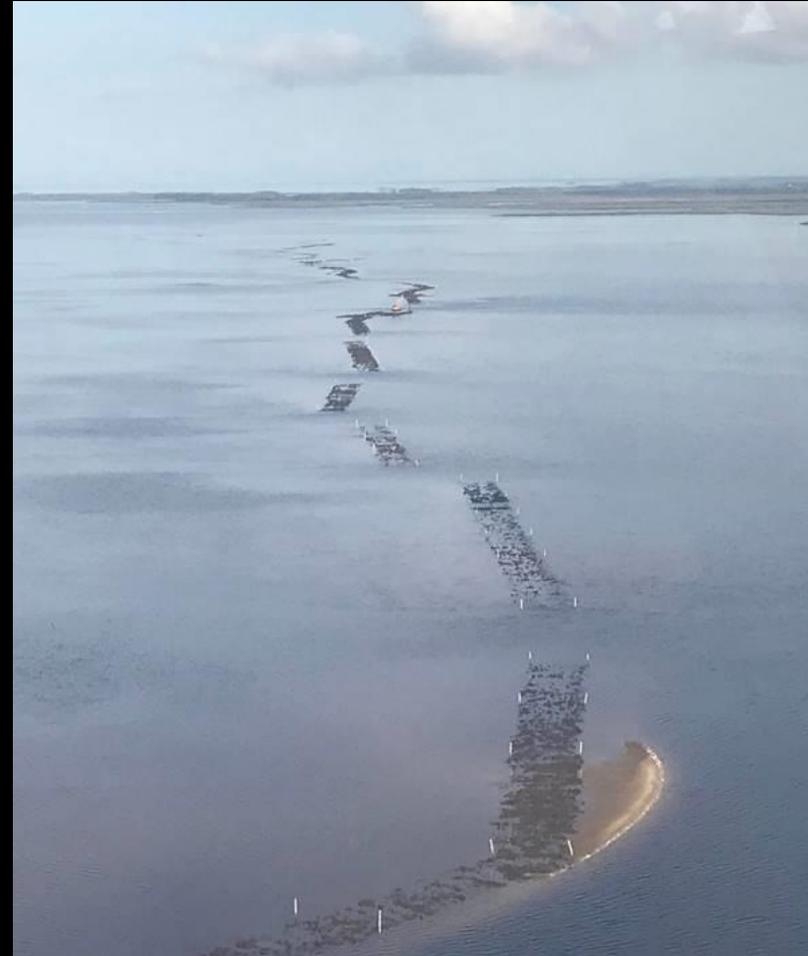
Pilot LCR Restoration: What are we learning?

- *Frederick et al. pilot project results led to...*
- Large-scale restoration of LCR 2017-2024



LCR Restoration: What are we learning?

- 22 reef elements along relic reef footprint identified from maps created in the 1800's



LCR Restoration: What are we learning?

- 22 reef elements along relic reef footprint identified from maps created in the 1800's
- ~17,000 yds³ locally sourced limestone 8-18" in size (13,00m³; 20-45 cm)
 - Same limestone as found along this coast "Ocala formation"



LCR Restoration: What are we learning?

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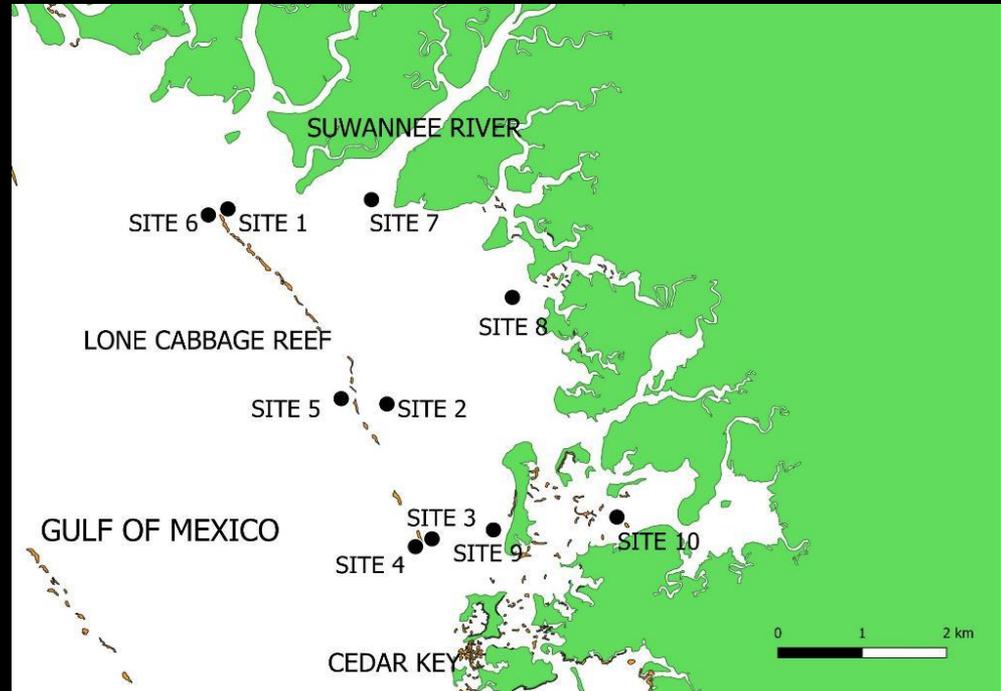
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- ~ 5 km in total length; ~ 10-m wide
- **Construction completed summer 2018**



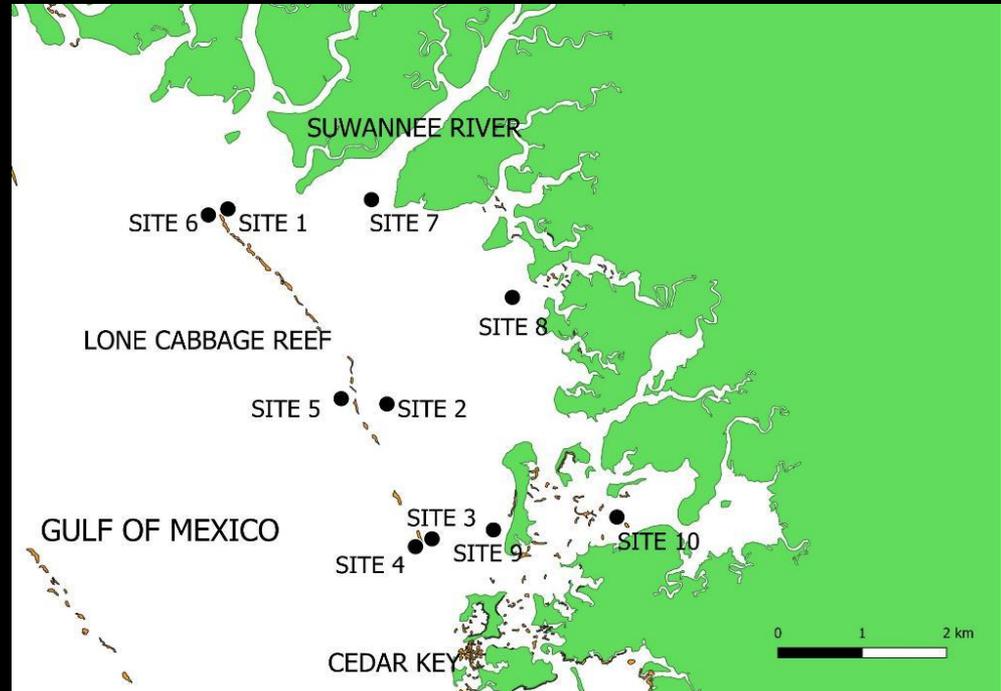
LCR Restoration: What are we learning?

- Line transect to monitor restored and wild intertidal oyster bars
- Autonomous WQ monitoring stations at 10 sites
- Rigorous data management and reporting standards



LCR Restoration: What are we learning?

- Line transect to monitor restored and wild intertidal oyster bars
- Autonomous WQ monitoring stations at 10 sites
- **Rigorous data management and reporting standards**
 - Database to manage WQ files
 - WQ sensor library
 - Data entry system
 - Standard reports routinely generated using R-markdown
 - Shiny App for water quality



Shiny App for Public WQ Visualization

oysterprojectck.shinyapps.io/wq_lcr_shiny_app/

MAP OF SELECTED SITES DATA LOGGER MEASUREMENTS ALL SITES COMPARISON **ROLLING AVERAGES** LAKEWATCH WIND ROSE

SITE (input needed for all tabs, except Wind Rose)
1

COMPARISON SITE (input needed for all tabs, except Wind Rose)
3

DATE RANGE (input needed for Data Logger, Rolling Averages and Windrose Tabs)
2021-01-10 to 2021-02-24

OBSERVATIONS (input needed for Data Logger Measurements and Rolling Averages tabs)
 Salinity (ppt)
 Conductivity (mS/cm)
 Temperature (C)

Overlay only available in 'Hourly' Temporal Resolution (Data Logger Measurements tab)
 Overlay point sample data (Salinity (YSI only), Conductivity (Lakewatch and YSI), or Temperature (YSI only))?

TEMPORAL RESOLUTION (input needed for only Data Logger Measurements tab)
 Hourly
 Daily Mean

LAKEWATCH TAB OPTIONS
DATE RANGE (Lakewatch)
2019-02-01 to 2021-01-01

LAKEWATCH OBSERVATIONS
 Phosphorus (ug/L)
 Nitrogen (ug/L)

Rolling averages definition

Rolling or moving averages are a way to reduce noise and smooth time series data. Rolling averages were calculated using the function `rollmean()` in the R package `'zoo'`. Select the desired Date Range, Site and Comparison Site. Select additional information such as the type of Observations (Salinity, Conductivity, or Temperature) for the figure to display.

Rolling Averages of Sites 1 and 3 (2021-01-10 to 2021-02-24)

The figure displays six line charts arranged in a 2x3 grid. The top row shows data for Site 1, and the bottom row shows data for Site 3. The columns represent different rolling average durations: Three Days, Seven Days, and Fifteen Days. The y-axis for all charts is labeled 'Salinity' and ranges from 0 to 30. The x-axis is labeled 'Date' and shows dates from 01-15-2021 to 02-15-2021. The charts show highly variable data points that become progressively smoother as the rolling average duration increases. The colors of the lines are red for Site 1, green for Site 1 (Seven Days), blue for Site 1 (Fifteen Days), red for Site 3, green for Site 3 (Seven Days), and blue for Site 3 (Fifteen Days).

LCR Restoration: What are we learning?

Restored reef with rocks



Wild reef no rocks



LCR Restoration: What are we learning?



- Monitoring program through simulation and analyses
 - Inform monitoring based on oyster counts in previous years

LCR Restoration: What are we learning?



- Monitoring program through simulation and analyses
- Pre-season power analyses to determine sampling effort

LCR Restoration: What are we learning?



- Monitoring program through simulation and analyses
- Pre-season power analyses to determine sampling effort
- In-season assessments to update effort allocation and track progress

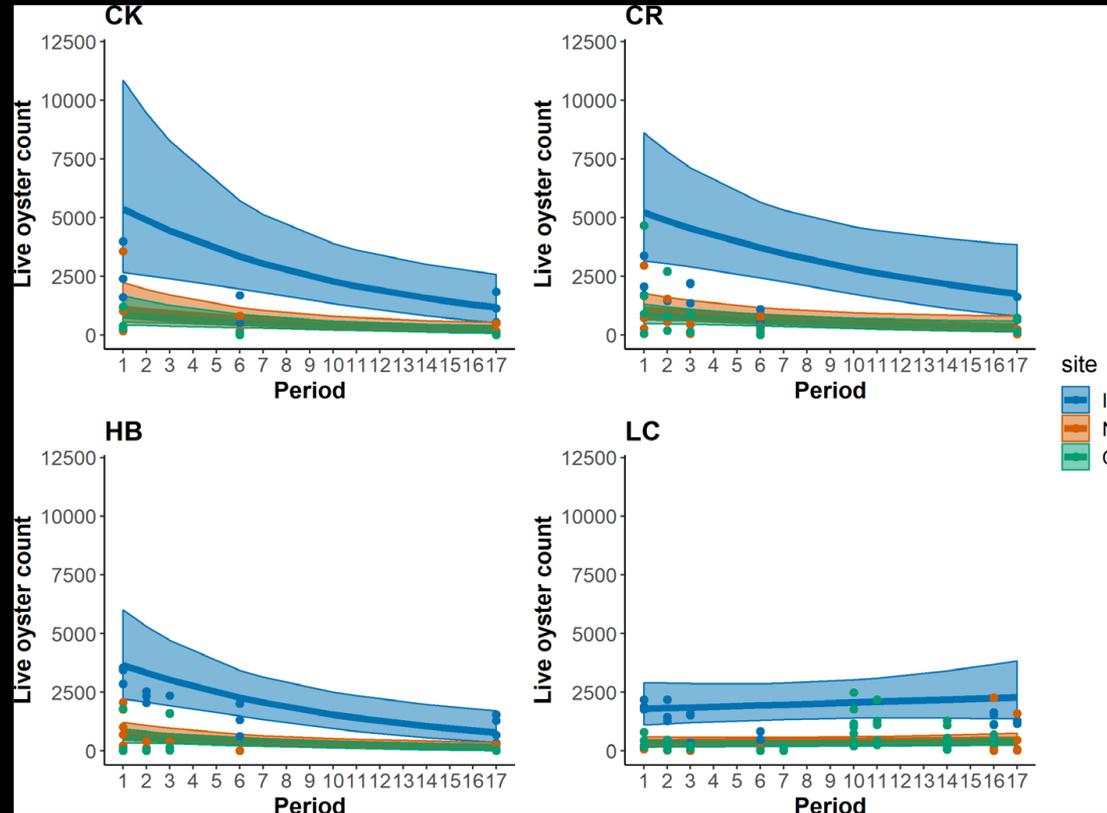
LCR Restoration: What are we learning?



- Monitoring program through simulation and analyses
- Pre-season power analyses to determine sampling effort
- In-season assessments to update effort allocation and track progress
- End-of-season analyses to update learning

Large Scale: What are we learning?

- Big Bend intertidal oyster resources – declining rapidly
- 237% decline in counts since 2010
- Intertidal reefs are becoming more similar...

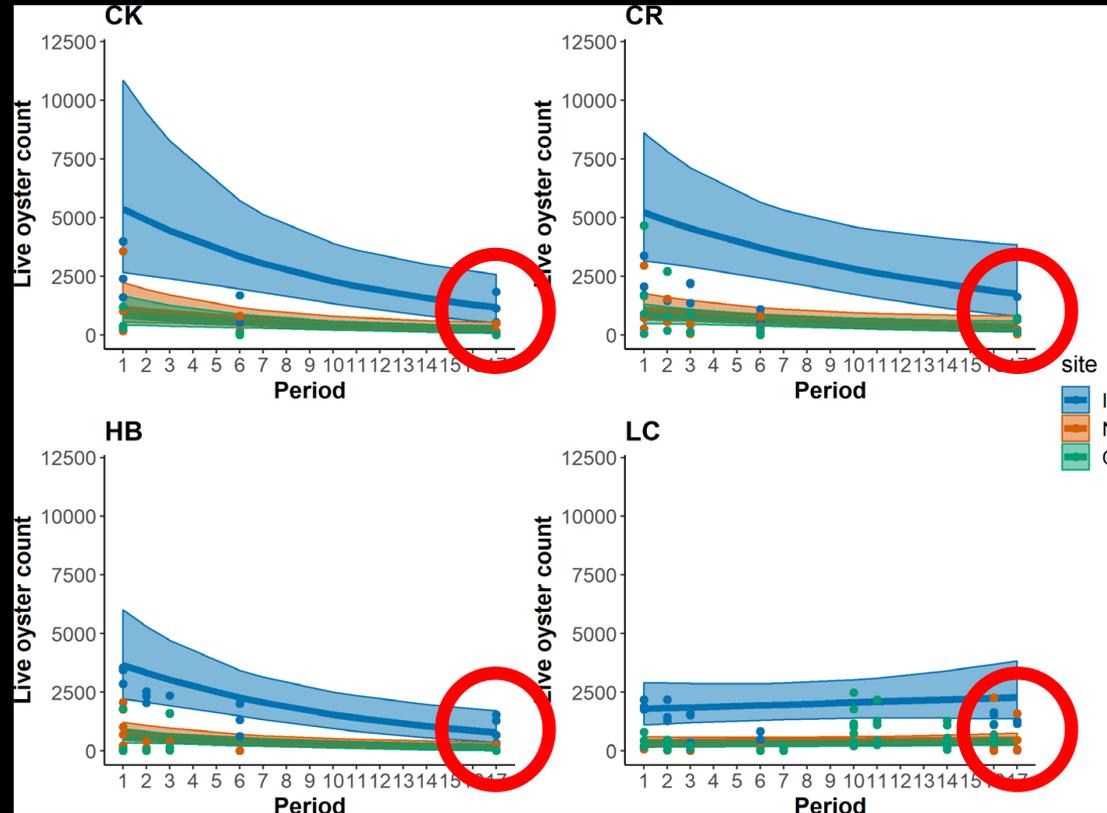


(Moore et al. 2020)

Large Scale: What are we learning?

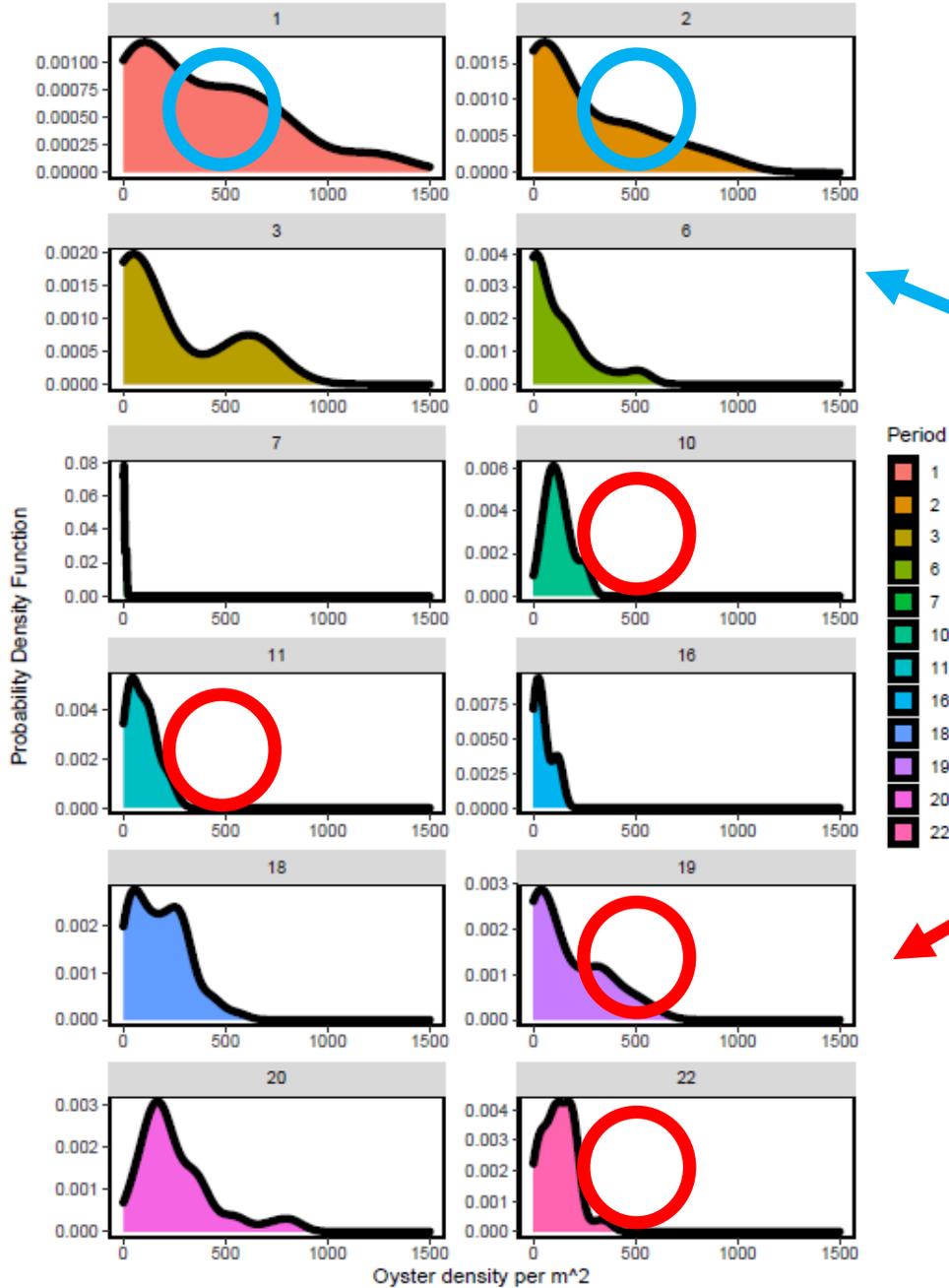
- Big Bend intertidal oyster resources – declining rapidly
- 237% decline in counts since 2010
- Intertidal reefs are becoming more similar...

- But more similar at LOWER NUMBER OF OYSTERS



(Moore et al. 2020)

Live Oyster Density by Period

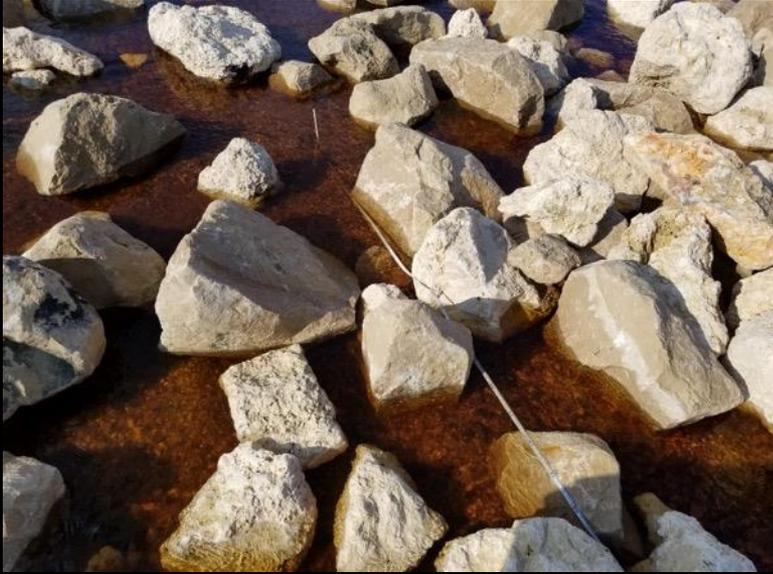


Since 2010, distinct loss of highest density intertidal oyster bars

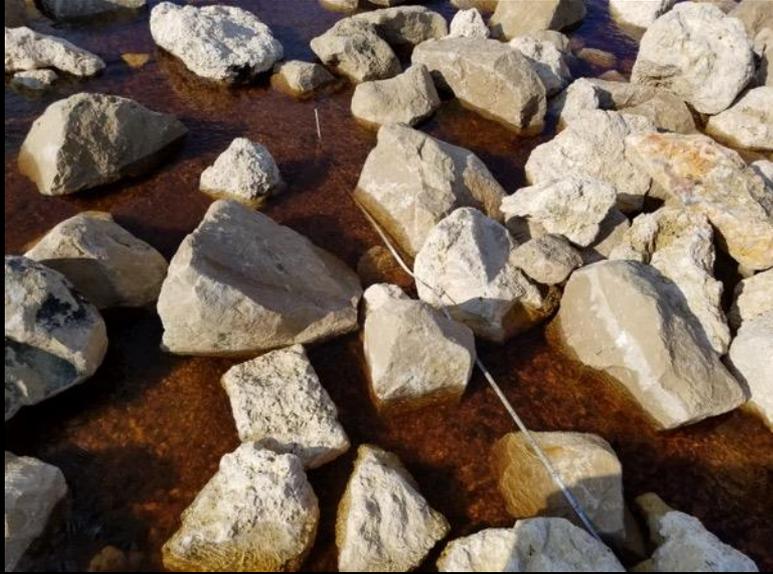
Can restoration help?



July 2018



July 2018



December 2018



July 2018



December 2018



July 2019



Can restoration help?

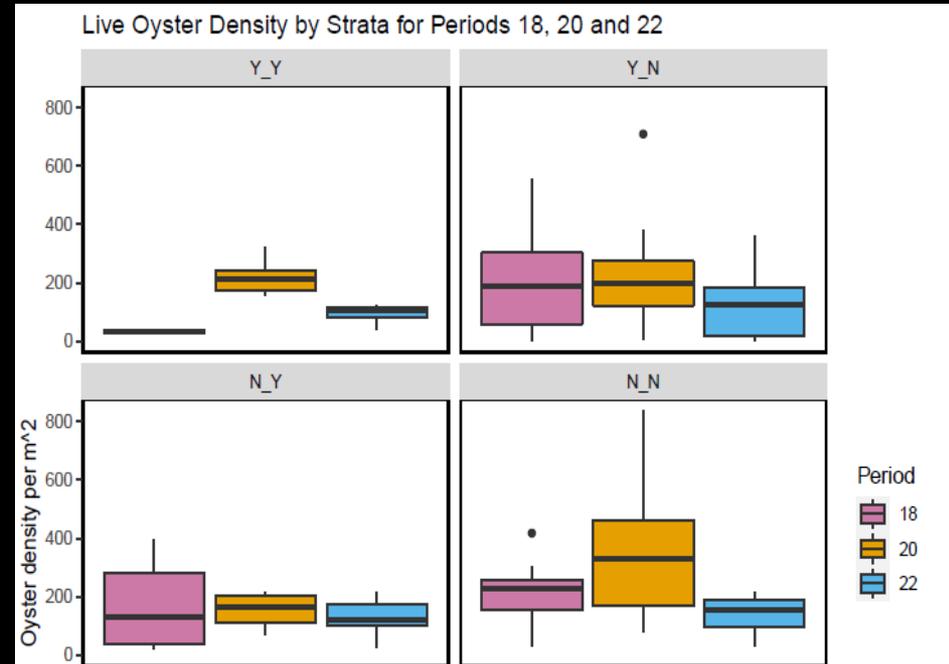


- Local effect of oysters growing on rocks? **YES!**
- But do these oysters persist?



Can restoration help?

- Oysters persist on restored reefs (so far)
- Similar density of oysters of rock reefs compared to wild reefs



Can restoration help?

- Benefits beyond the ribbon of rock?

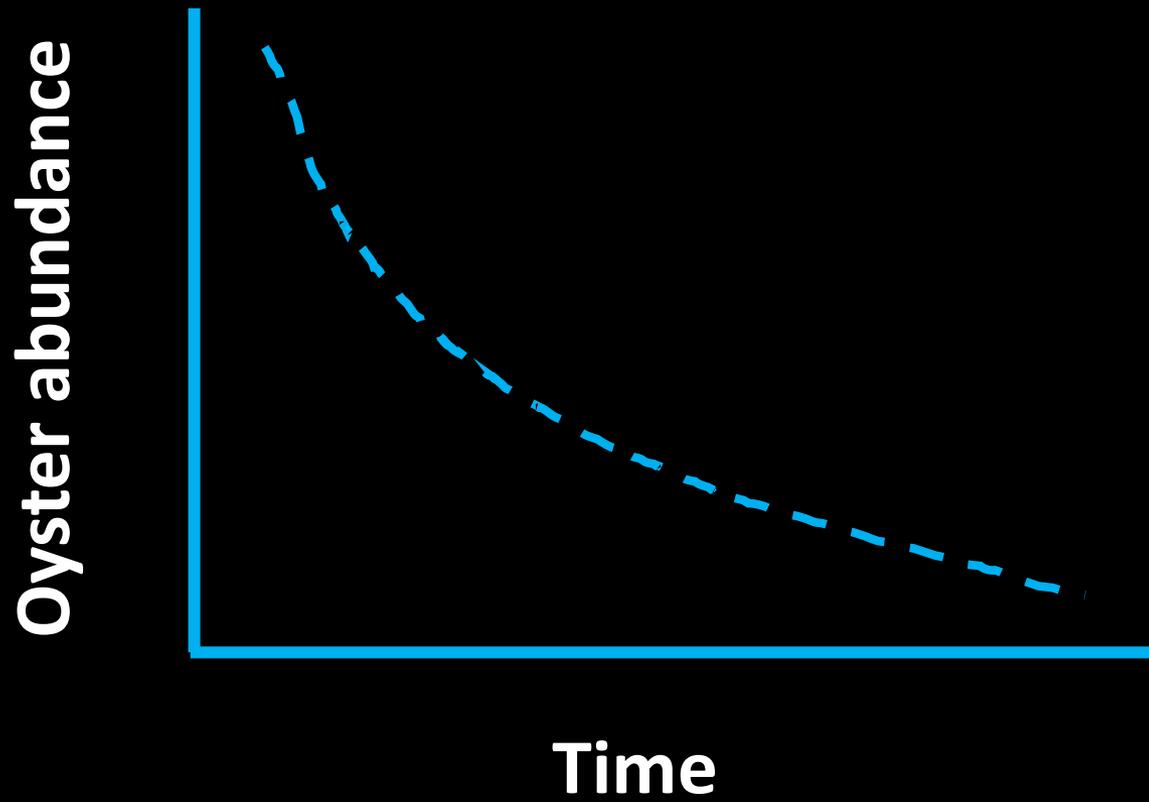


Can restoration help?

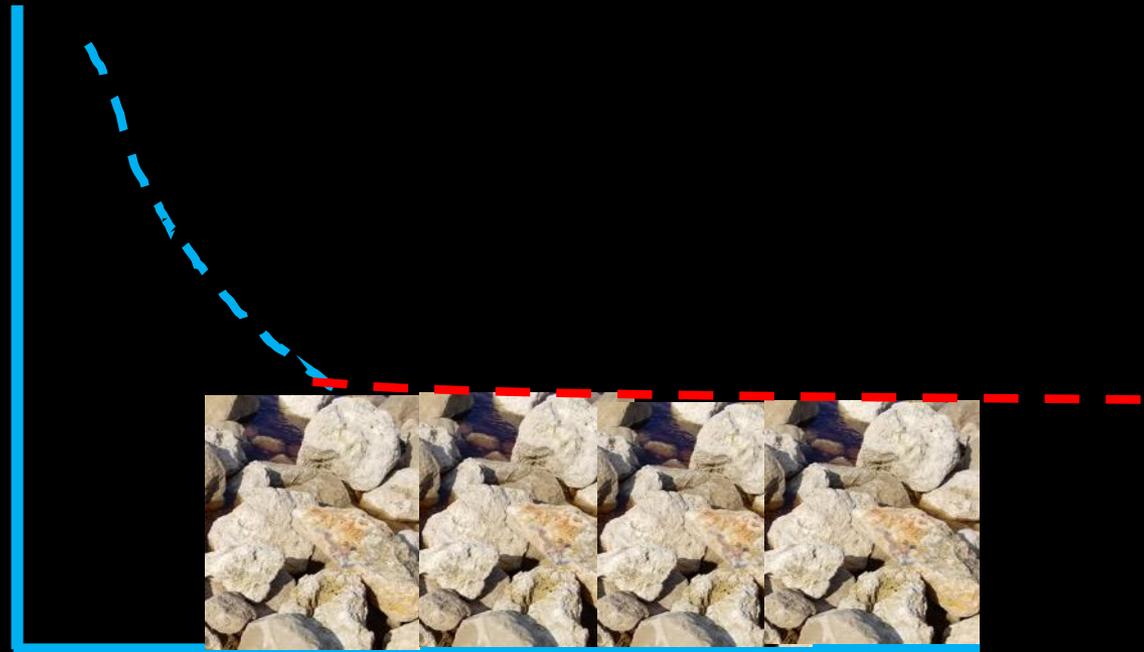
- Benefits beyond the ribbon of rock?
- Not yet known...
 - My dissertation focuses on responses of oyster populations and water quality



Going forward...

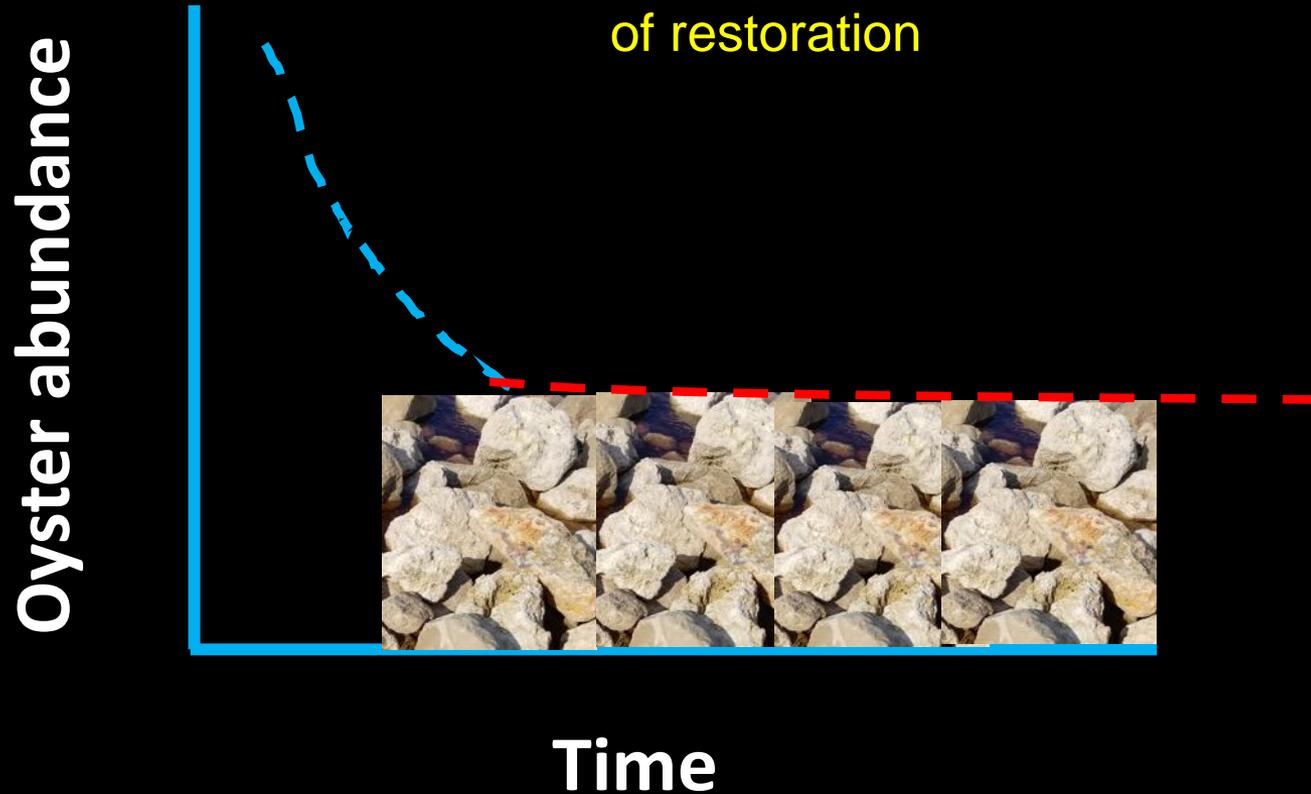


Oyster abundance



Time

- But if spat sources persist, the hope is that the “floor” of the restored reefs are higher than it would be in absence of restoration



Going forward...

- A ribbon of rock
 - LCR restoration is “large” for a restoration
 - But “small” compared to changes that are ongoing in the region
 - Sea-level rise
 - River discharge patterns



Going forward...

- Treat restoration projects as experiments, not solutions



Going forward...

- Treat restoration projects as experiments, not solutions
- Focus efforts on promoting resilience in existing wild reefs



End

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- Bill Pine billpine@ufl.edu



- Thank you for this opportunity
- Funding for restoration provided by National Fish and Wildlife Foundation
- Project co-PIs Leslie Sturmer, Peter Frederick, and Mike Allen
- Massive team effort Peter, Mel, Steve, Brad, Jennifer, Jamie, Joe, and many others