FKNMS Benthic Habitat Monitoring Program May 2018 Report

Dr. James W. Fourqurean and Sara S. Wilson

Water Quality Protection Program Steering Committee Meeting
May 22nd, 2018 – Marathon, FL

Outline

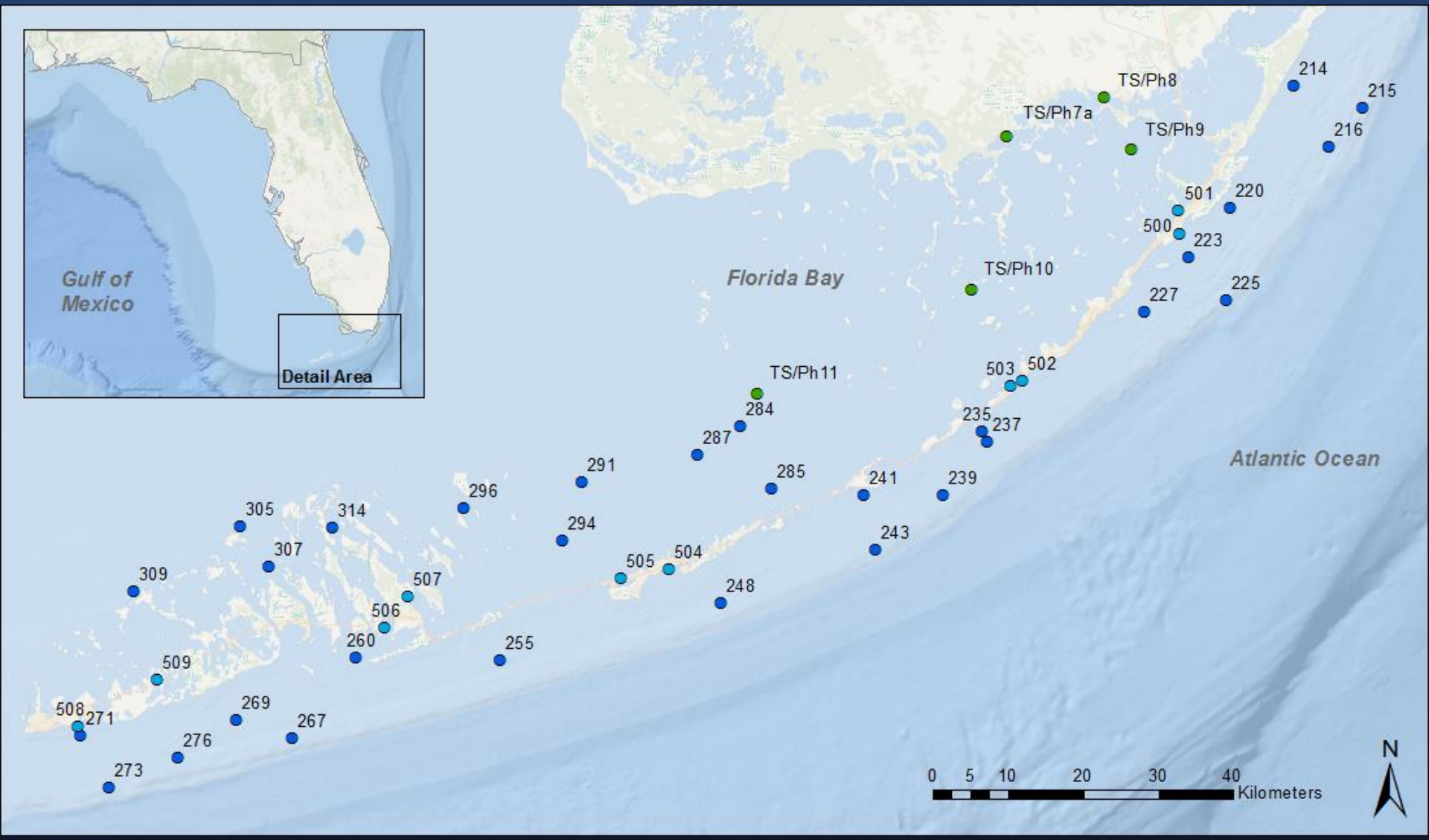
- Goals for the FKNMS WQPP Benthic Habitat Monitoring Program
- Review of major project accomplishments
- Review of seagrass status criteria generated from ecosystem behavior models
    - 1- Species composition index
    - 2- Elemental indicator
- Presentation of novel findings and current work
    - New website functionality and features
    - Post-Hurricane Irma impact analysis
- Brief overview of Benthic Monitoring for Canal Restoration Program
    - Overview of where and what we are sampling
    - Brief presentation of results

Goals for the Project

As originally envisioned, the goal was to address these points at the regional scale

- **Define the present distribution of benthic communities within the FKNMS**
- **Provide high-quality, quantitative data on the status of the seagrasses within the FKNMS**
- **Define the baseline conditions of seagrass communities in the FKNMS**
- **Quantify the importance of seagrass primary production in the FKNMS**
- **Detect trends in the distribution and status of benthic communities**
- **Determine relationships between water quality and benthic community status**

Current Monitoring Stations

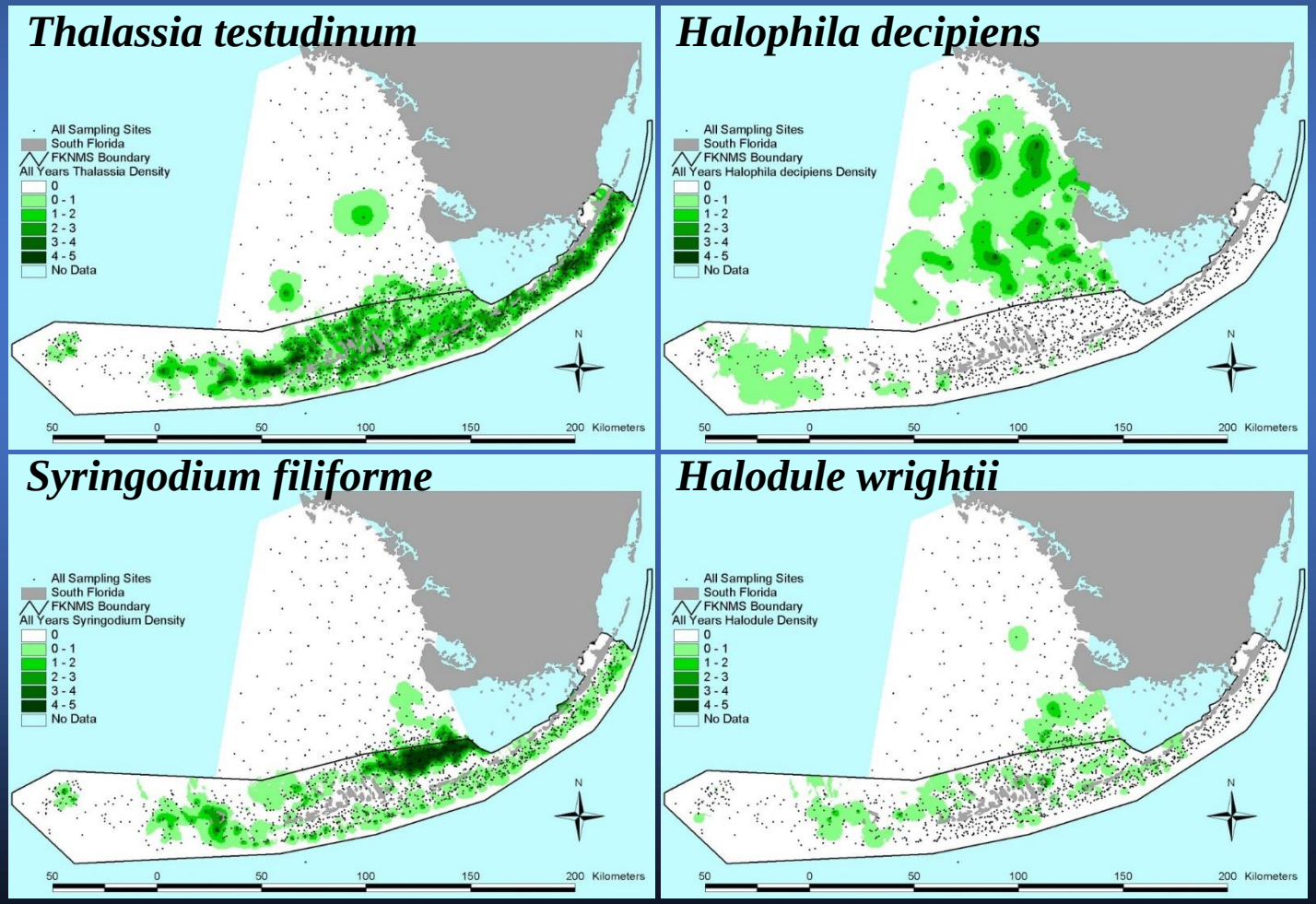


Information being collected

- Distribution & abundance of seagrasses and associated fauna and flora using rapid assessment Braun-Blanquet surveys
- Seagrass nutrient availability using tissue concentration assays and stable isotopic analyses
- Water column physiochemical data (sites co-located with water quality sites: FIU Briceño lab)
- 40 permanent sites 2 times a year
- Ca. 200 mapping sites/year (1996-2000, 2003-2007, 2010-2011)

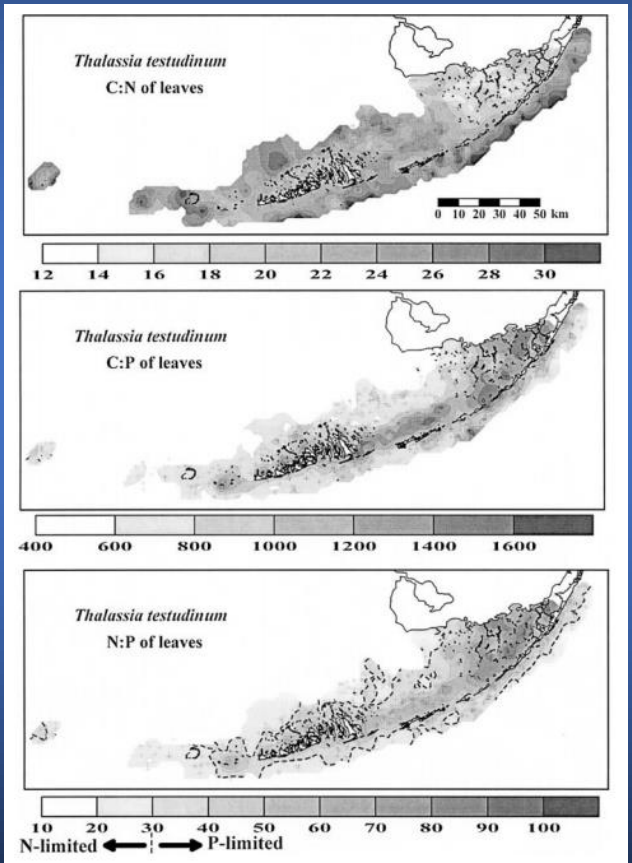
Major Project Accomplishments

- We have **defined the spatial extent and species composition** of the largest documented seagrass bed on earth, and **solidly defined a baseline** to assess change



Major Project Accomplishments (cont.)

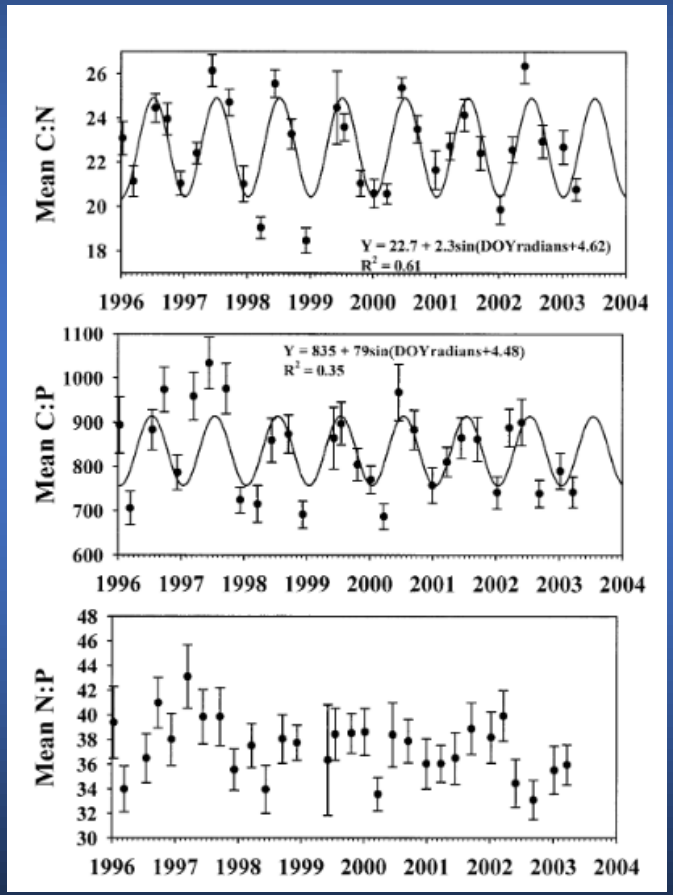
- We have **defined the spatial and temporal pattern of seagrass community dynamics** in the FKNMS and made predictions about future trajectories



Example:

There are both spatial and temporal trends in seagrass leaf nutrient content within the FKNMS

We can use these data to make predictions about future seagrass nutrient content, and use these predictions to investigate any observed deviations



Fourqurean et al. 2005

Major Project Accomplishments (cont.)

- We have experimentally confirmed the role of nitrogen and phosphorus offshore, nearshore and in Florida Bay, for **controlling seagrass bed structure and productivity.**

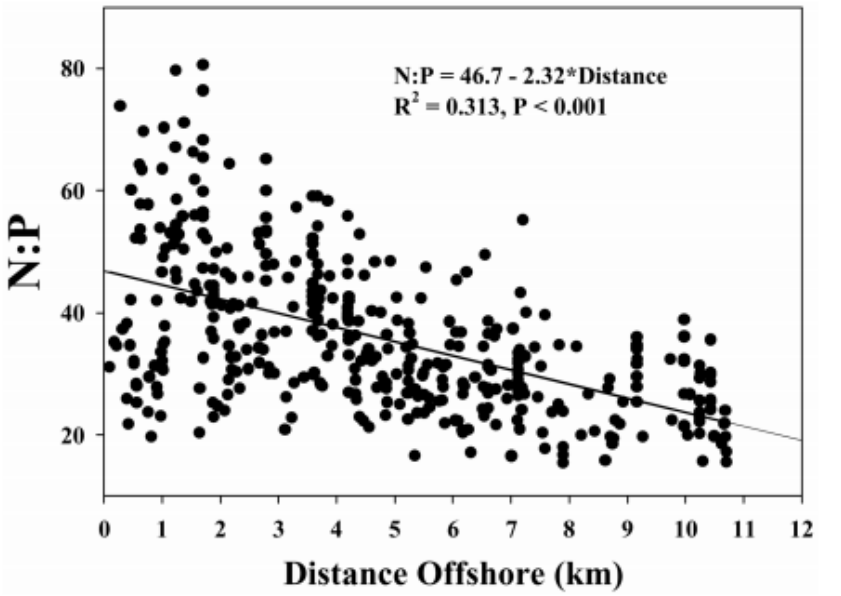


Figure 6. The relationship between the distance offshore and the N:P of leaves of *Thalassia testudinum* collected from the Atlantic Ocean side of the Florida Keys. The solid line represents the statistically significant regression (n = 405)

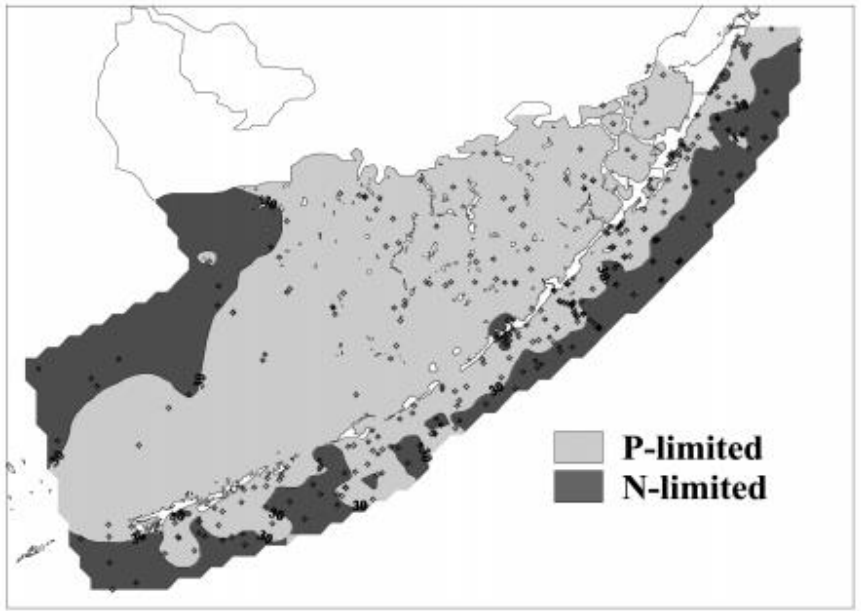
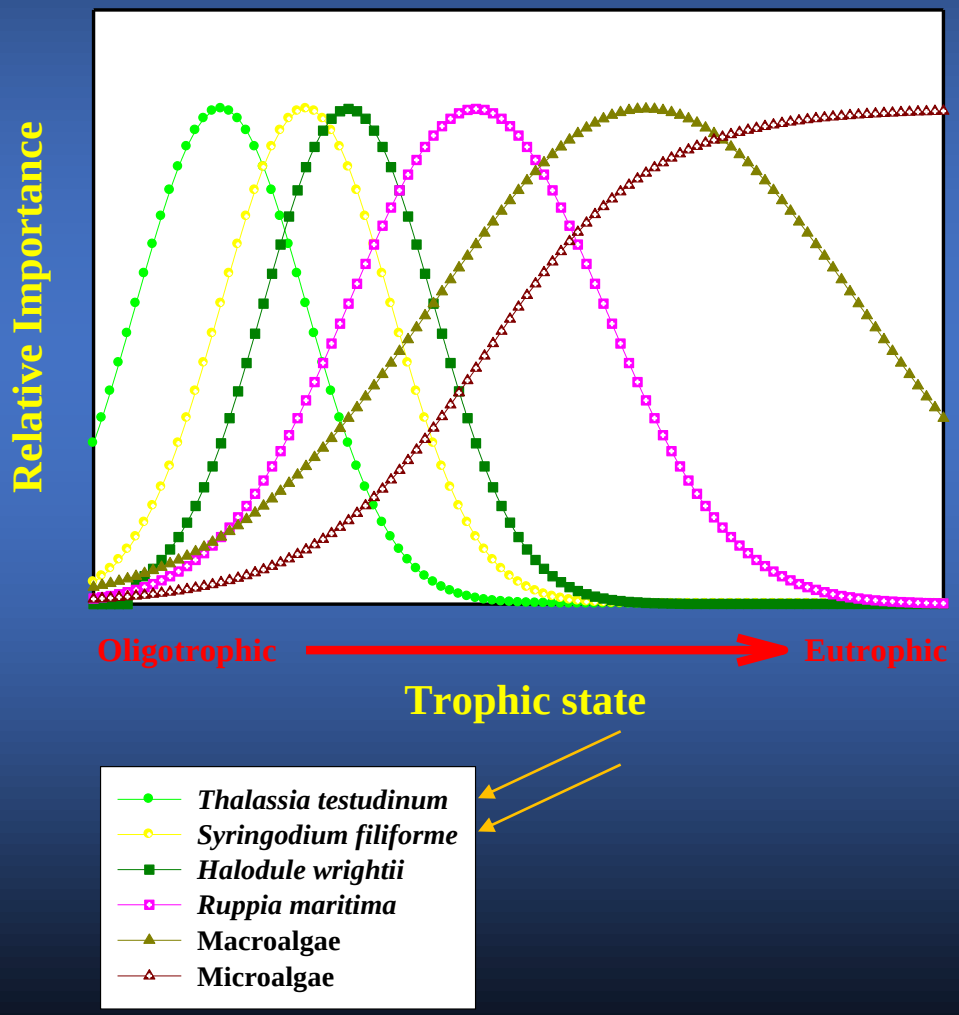


Figure 7. Zones of N–and P-limited seagrass communities in south Florida. The N:P contour of 30 (Figure 5) was used to delineate N-limited (N:P < 30) from P-limited (N:P > 30) regions

(Fourqurean and Zieman 2002)

Eutrophication Model of Ecosystem Behavior

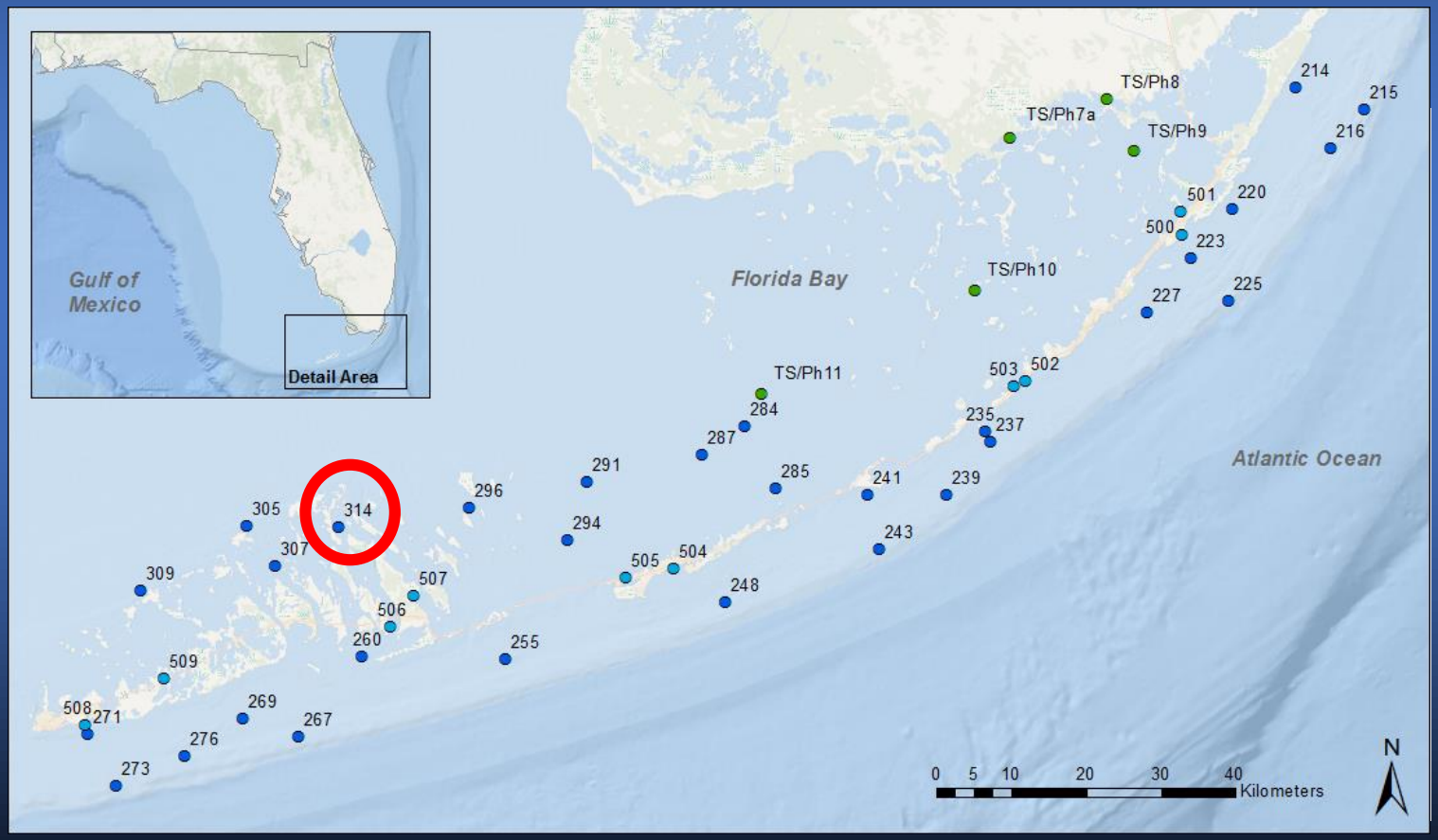


- We have defined the effects of changing water quality on seagrass communities in south Florida
- Nutrient pollution will lead to changes in relative abundances of primary producers in a predictable way

Fourqurean and Rutten 2003

Major Project Accomplishments (cont.)

- **Example: We have identified long-term trends at stations in the FKNMS that are consistent with increases in nutrient availability**



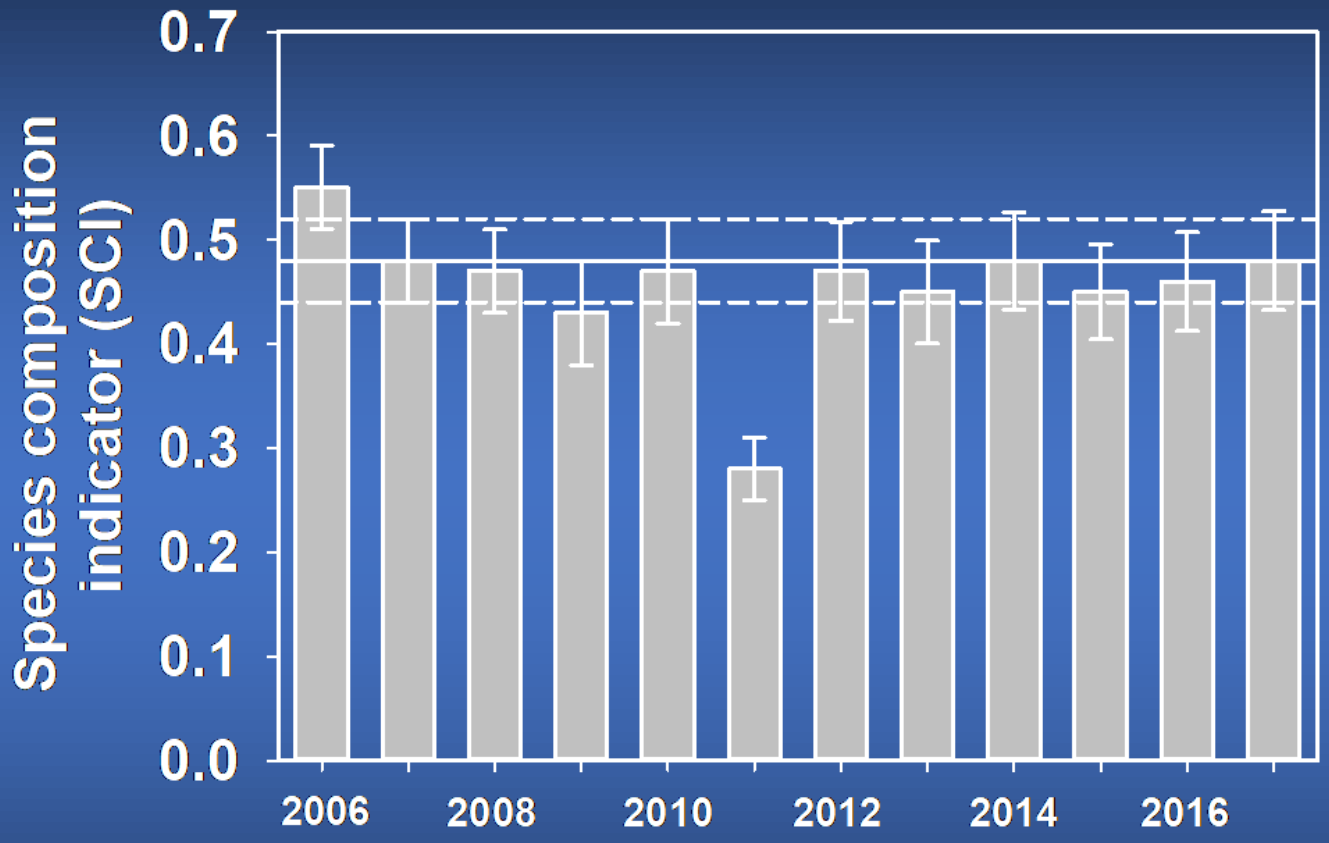
FKNMS Seagrass Status Criteria #1

- **Species Composition Index (SCI)**
- **Based on the relative dominance of slow-growing species:**

$$SLOW = \frac{D_{Tt}}{D_{Tt} + D_{Sf} + D_{Hw} + DMacroalgae} \qquad SCI = \frac{\sum_{i=1}^{30} SLOW_i}{30}$$

- **Any decrease in SCI indicates declining water quality.**
- **The baseline SCI, calculated from data collected between 1995-2005, was 0.48 ± 0.04.**

Species Composition Index 2006-2017



Baseline = 0.48

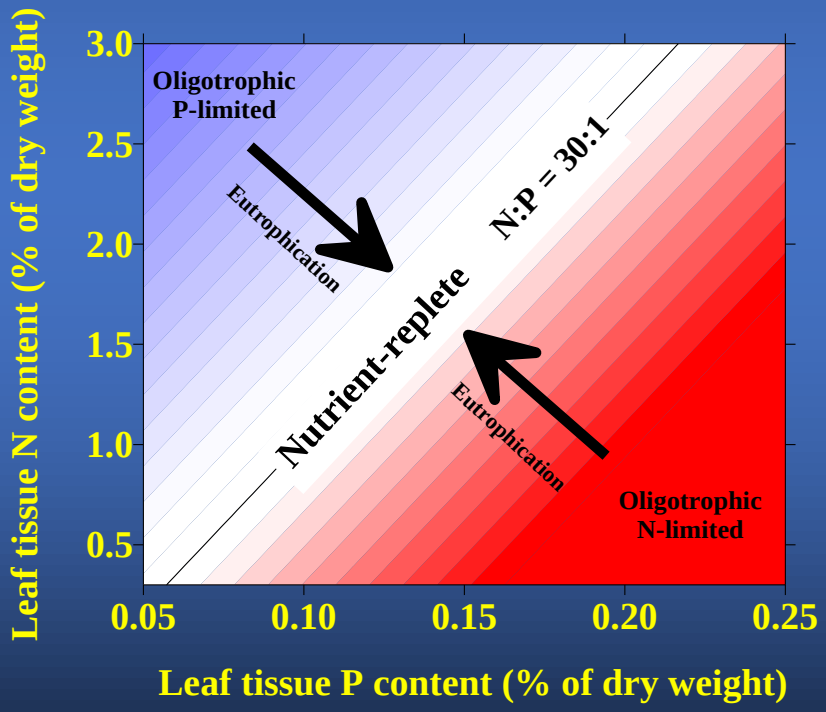
2017 = 0.48

2018 not yet calculated (need to include summer data)

- **Any decrease in SCI indicates declining water quality.**
- **FKNMS seagrass species composition has remained very stable recently**

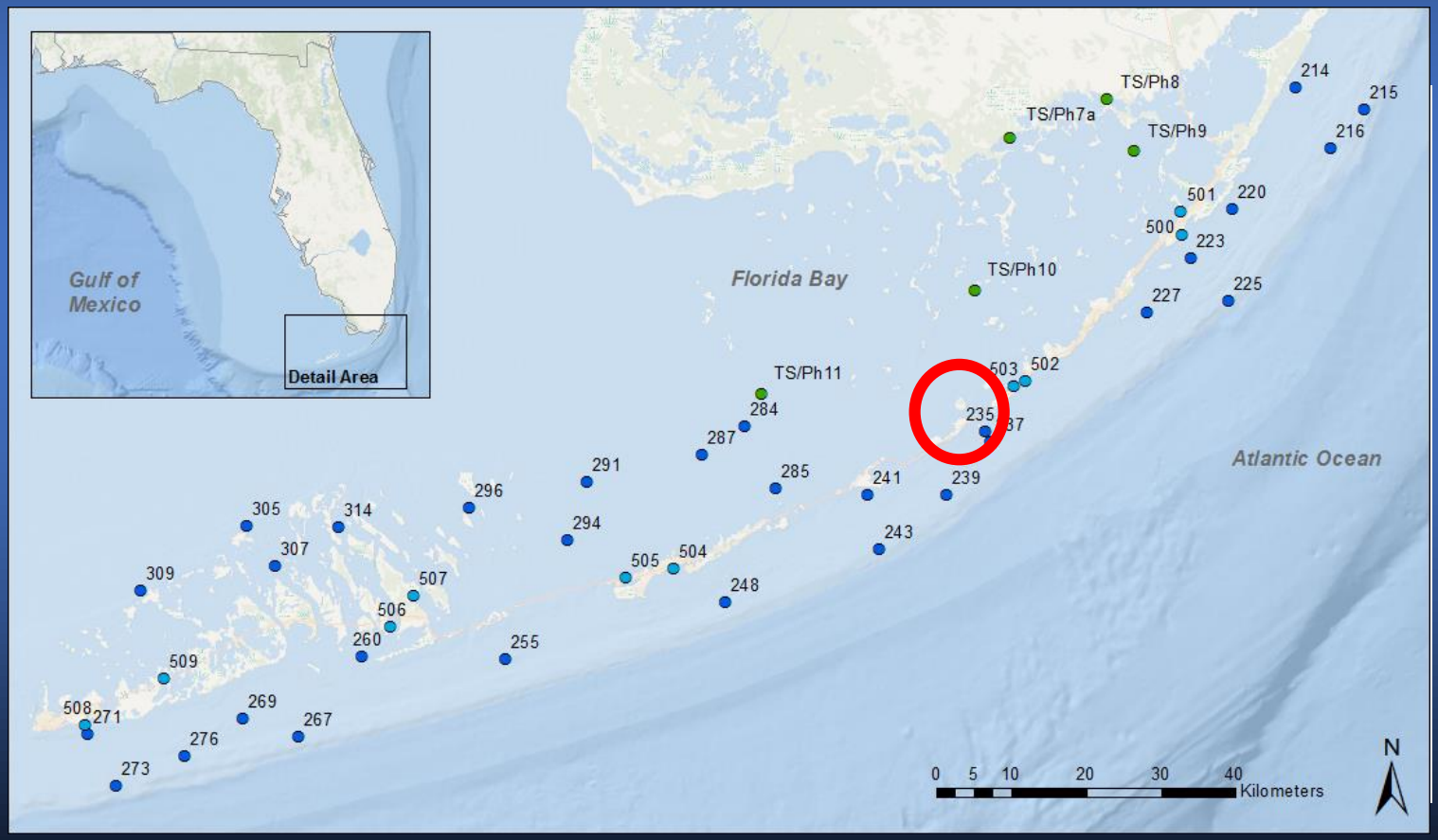
“Redfield Ratio Model” of Ecosystem Behavior

- Nutrient pollution will shift N:P molar ratios of primary producers towards a taxon-specific “Redfield ratio” of 30:1 (Fourqurean and Rutten 2003)



Major Project Accomplishments (cont.)

- **We have experimentally confirmed the role of nitrogen, and of phosphorus in FKNMS and in Florida Bay, in controlling seagrass bed structure and productivity**



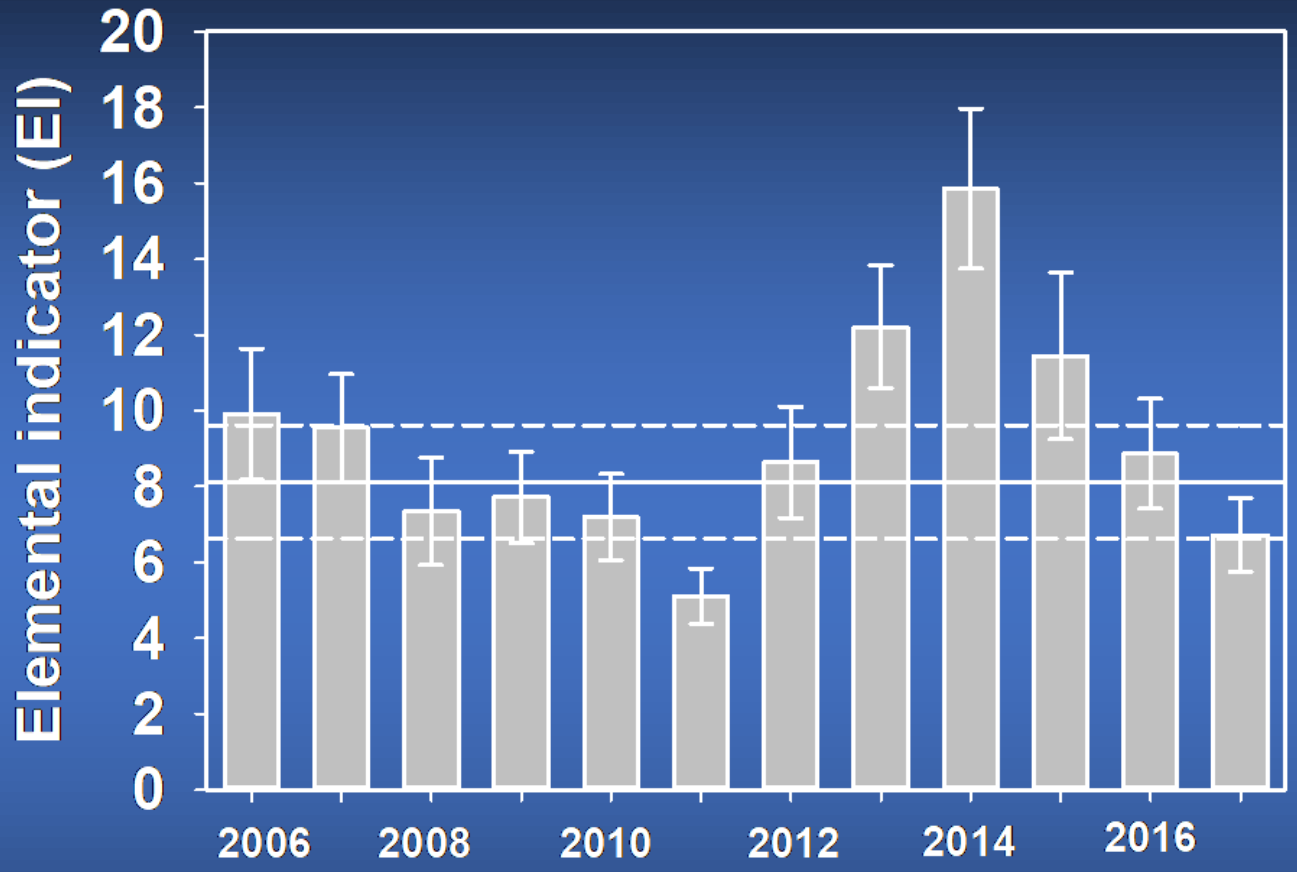
FKNMS Seagrass Status Criteria #2

- **Elemental Indicator (EI)**
- **Based on nutrient content of the slowest growing species:**

$$EI = \frac{\sum_{i=1}^{30} |NP_i - 30|}{30}$$

- **Any decrease in EI indicates declining water quality.**
- **The baseline EI, calculated from *T. testudinum* leaf tissue collected between 1995-2005, was 8.28 ± 1.47**

Elemental Indicator 2006-2017



Baseline = 8.28

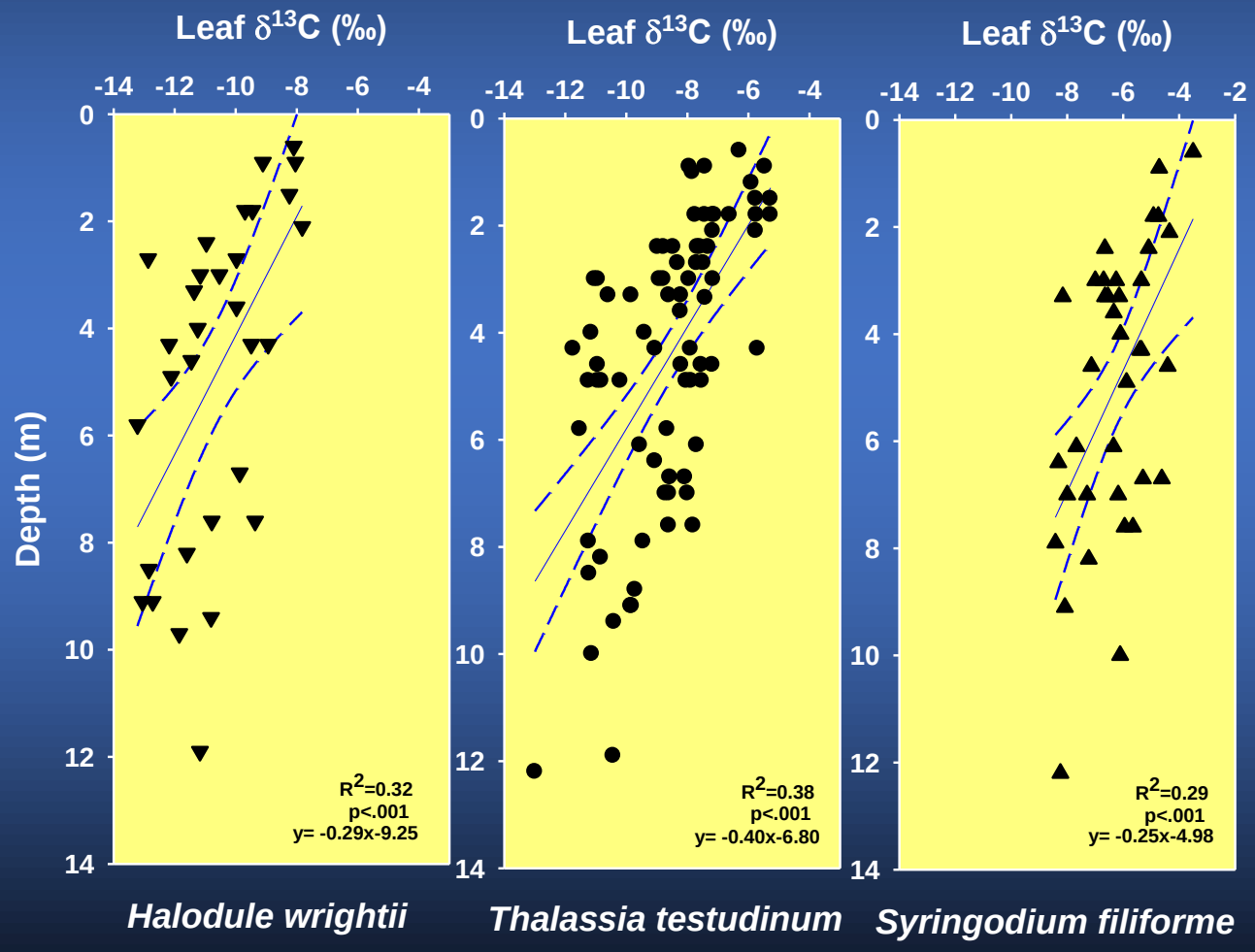
2017 = 6.7

2018 not yet calculated (need to include summer data)

- **Any decrease in EI indicates declining water quality.**
- **FKNMS seagrasses became more nutrient limited from 2011-2014, then less nutrient limited from 2014-2017**

"δ^{13}C Model" of Ecosystem Behavior

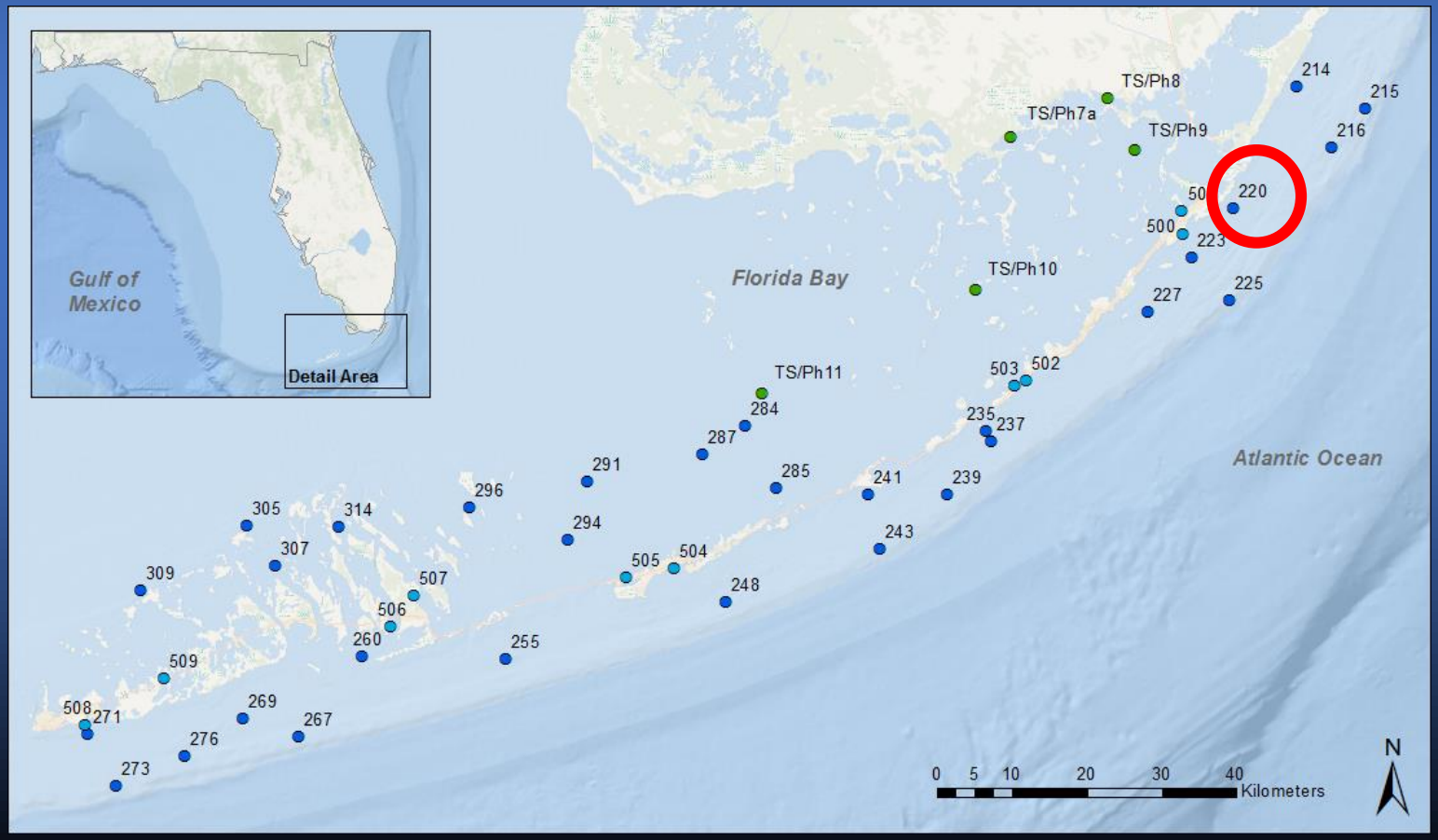
- As light decreases ~~with depth~~, δ^{13}C decrease



Campbell and Fourqurean 2009

Major Project Accomplishments (cont.)

- We have identified areas experiencing changes in light availability, as indicated by seagrass tissue isotopic composition
- Site 220 shows a decreasing $\delta^{13}C$ (at constant depth), indicative of lower light availability



Major Project Accomplishments (cont.)

- **25 scientific publications have resulted from this monitoring project to date**

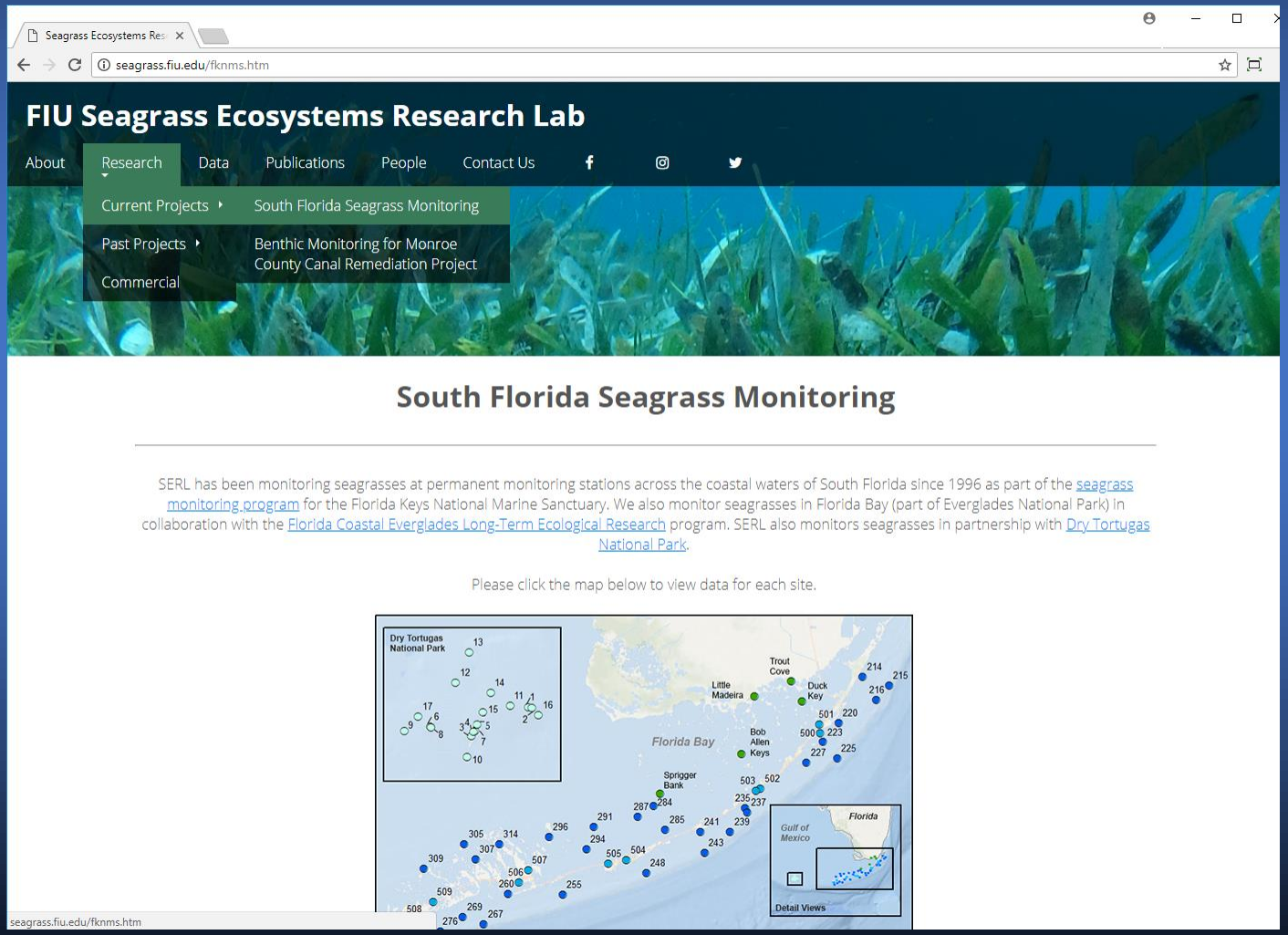
- ***In prep:*** **Wilson, SS, BT Furman, MO Hall, KM Cunniff, JW Fourqurean. South Florida seagrass communities were resilient to the passage of Hurricane Irma.** ***Target journal: Estuaries and Coasts***

- ***In prep:*** **Howard, JH, CC Lopes, CI Carrion, SS Wilson, JW Fourqurean. Importance of sediment type on the stability of seagrass blue carbon.** ***Target journal: Biogeochemistry***

- ***In progress:*** **Arias, A. et al. Survey of C_{org} inventories in FKNMS seagrass communities.** ***Field work completed, currently processing samples for C_{org} content and Pb^{210} dating***

Novel Project Accomplishments

- **New website functionality and content (seagrass.fiu.edu)**



Novel Project Accomplishments (cont.)

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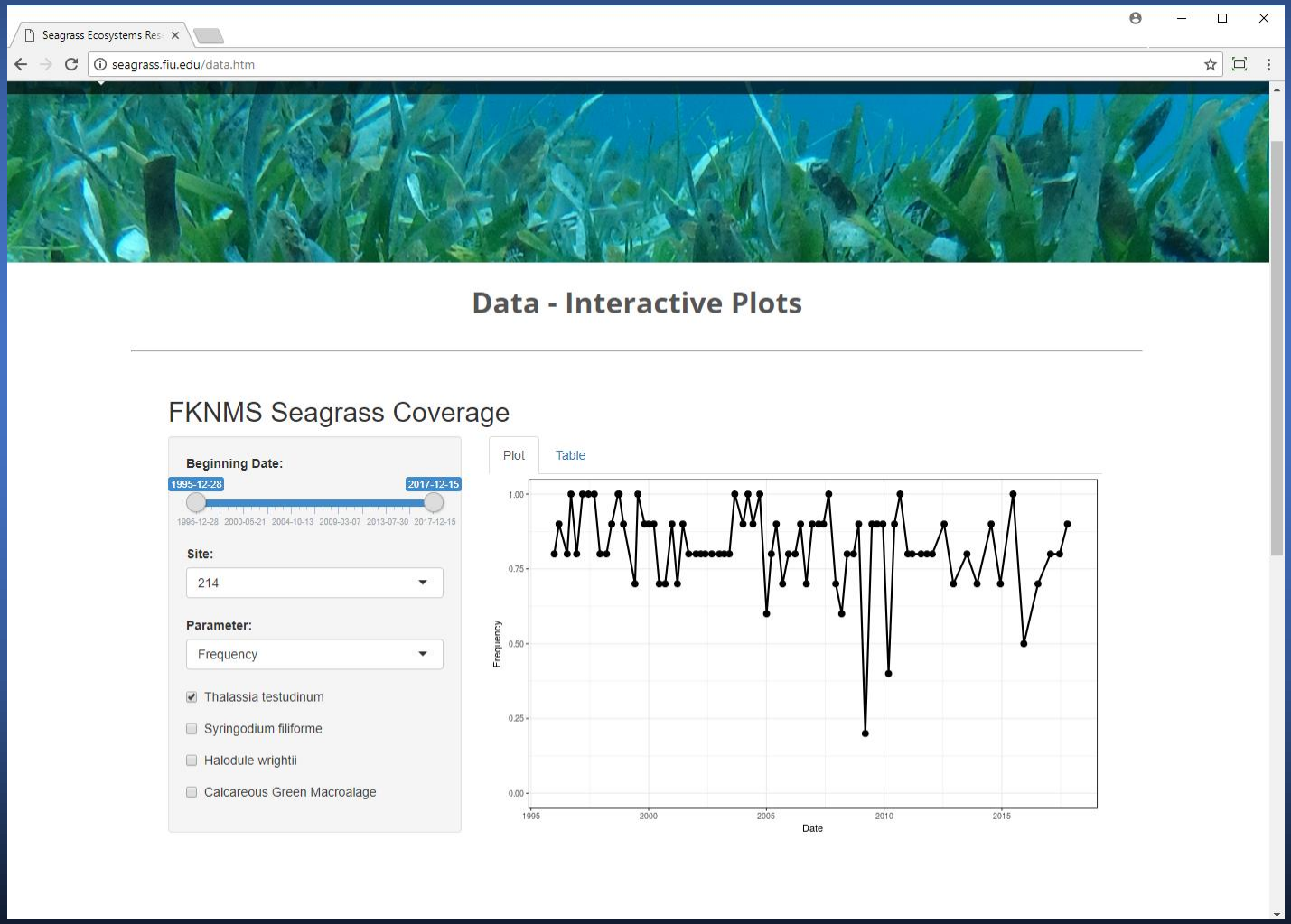
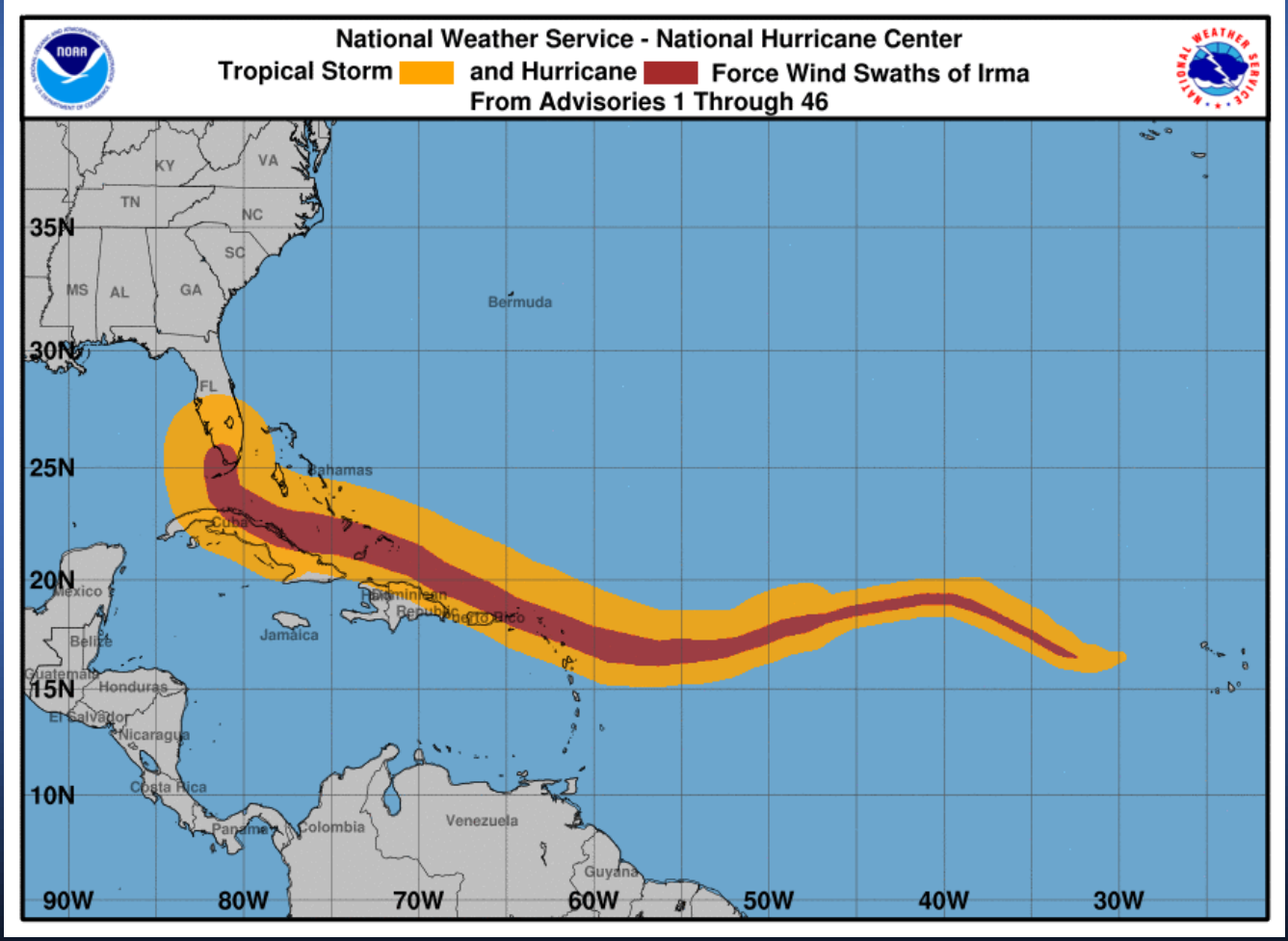


Hurricane Irma Updates

- Regularly scheduled FKNMS summer sampling occurred in June 2017
- Post-Irma re-sampling took place from October-December 2017



Hurricane Irma Updates

- Notable erosion at 6 of our 40 sites
  - Potentially quite dangerous for seagrasses if rhizomes are uprooted and swept away, could lead to little or slow recolonization of the patch
- Notable canopy thinning at 2 of our 40 sites
  - Not likely to severely impact the seagrasses if rhizomes are still intact, they will sprout new leaves
  - Previous research in FKNMS estimates a Leaf Emergence Rate of ~35 days for each new leaf (Peterson and Fourqurean 2001)
- Notable sediment deposition at 9 of our 40 sites
  - Not likely to severely impact the seagrasses since burial was not very deep (5-10cm), allowing for leaves to continue to photosynthesize

Erosion and Thinning at Site 241

June 2017

Quadrats had lush Tt

October 2017

> 30% of shoots in quadrat had leaves stripped away

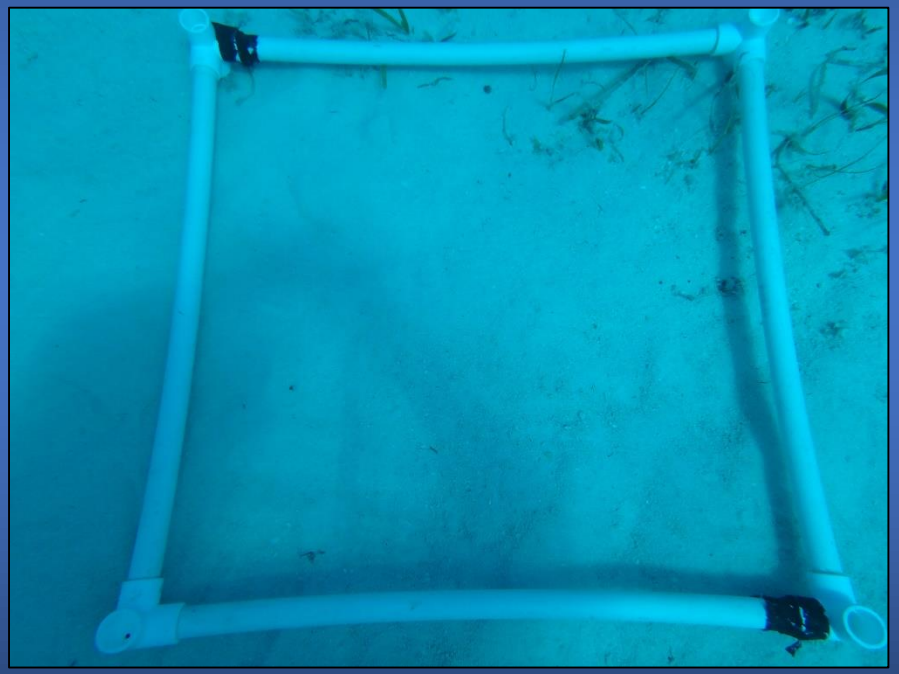
Erosion and Thinning at Site 294

Erosion or Burial at Site 243?

June 2017

Half of quadrats had lush Tt, half were bare

October 2017

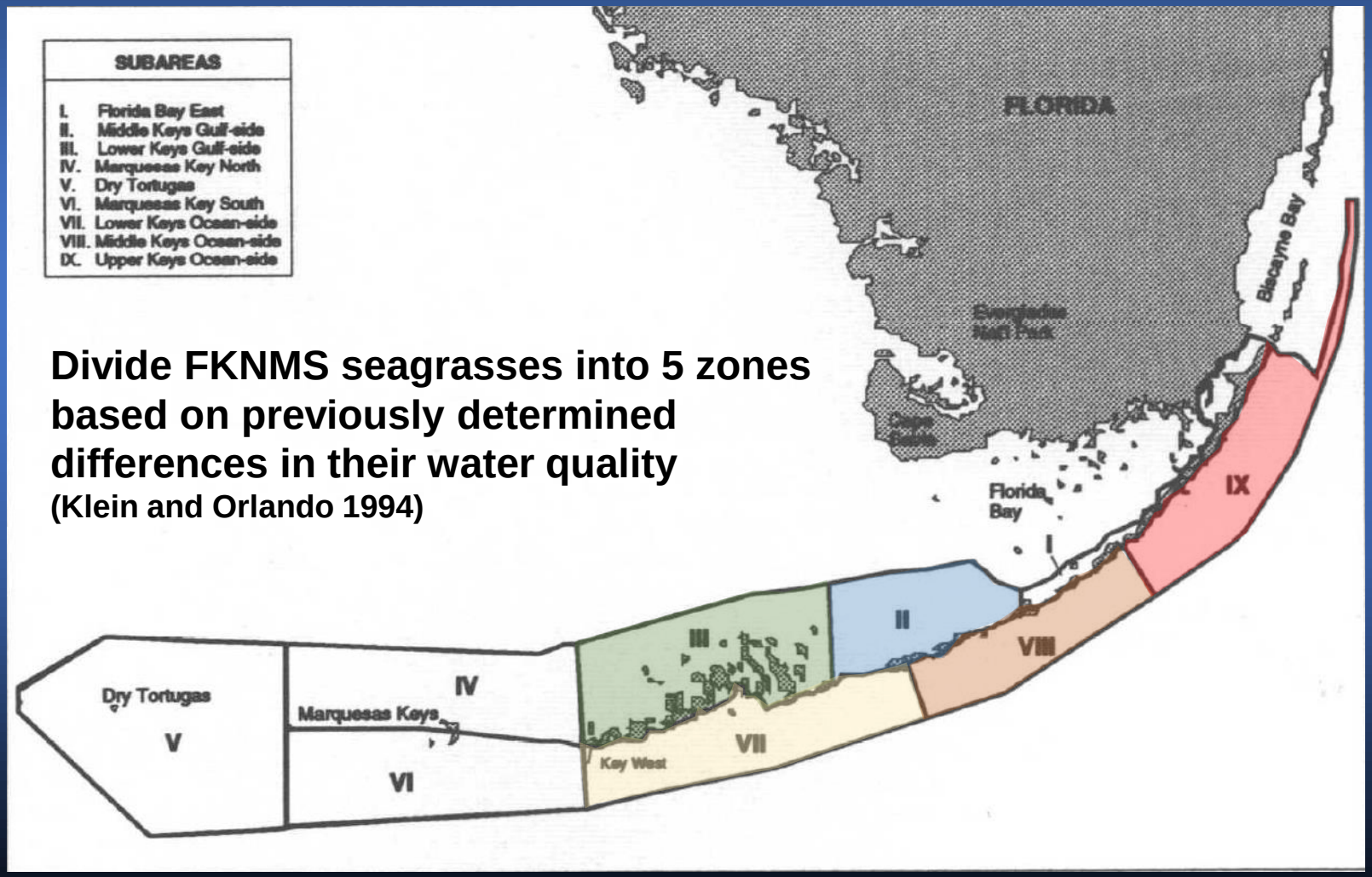


Only quadrat left with seagrass

Burial at Site 269

Spatial and Temporal Analysis

- **Were changes in seagrass density from Summer 2017 to Fall 2017 (Pre-/Post-Irma) significantly different than observed annual changes from recent years (2012-2017) ?**

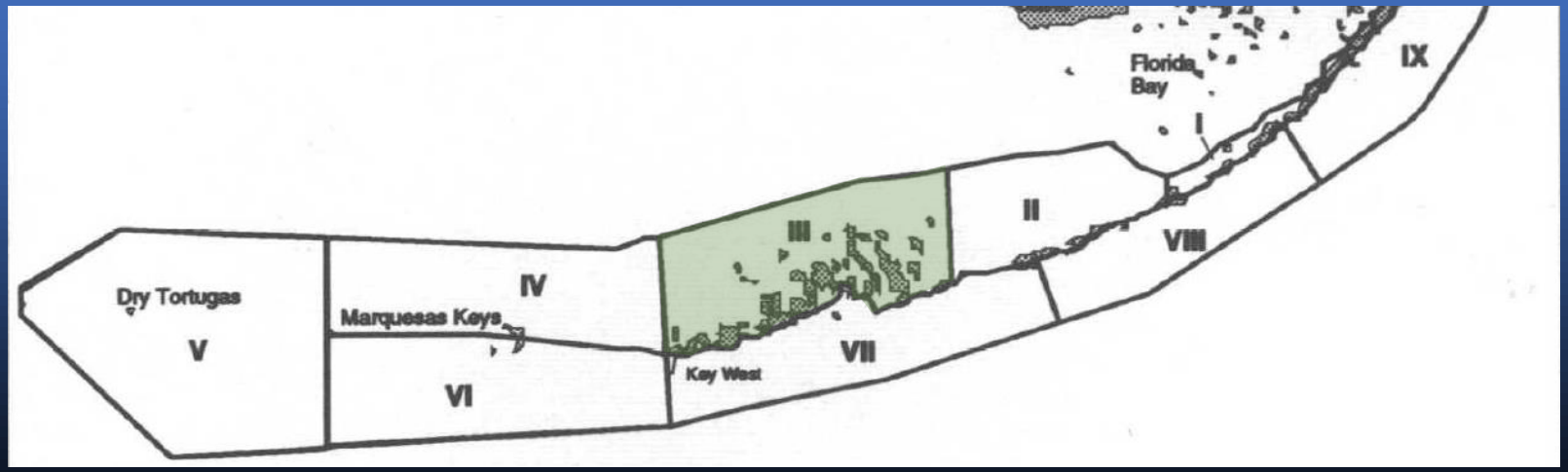


Divide FKNMS seagrasses into 5 zones based on previously determined differences in their water quality
(Klein and Orlando 1994)

Spatial and Temporal Analysis

- Repeated-measures non-parametric spatial and temporal analysis showed a possibly significant impact of Hurricane Irma on seagrasses in FKNMS
  - Wald-type statistic $p<0.001$ (significant impact)
  - ANOVA-type statistic $p>0.05$ (non-significant impact)

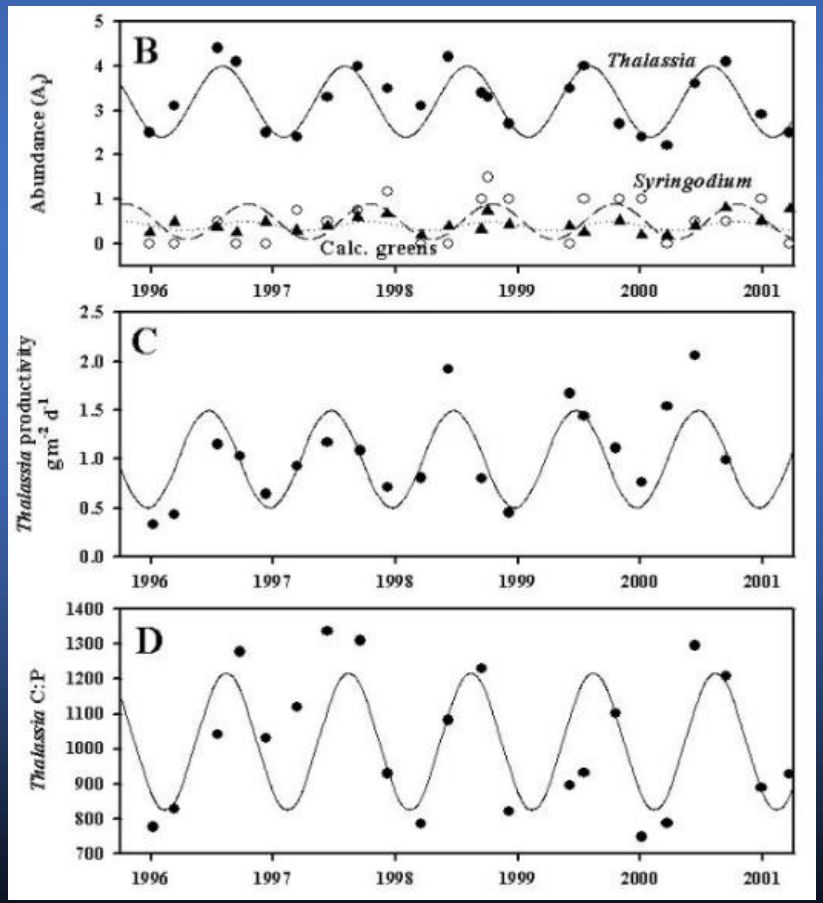
- Results of post-hoc tests show that seagrass density decreased from summer 2017 to fall 2017 (Pre-/Post-Irma) more than decreases between summer sampling across all other years (2012-2016) in Zone 3 only



Seasonal Analysis

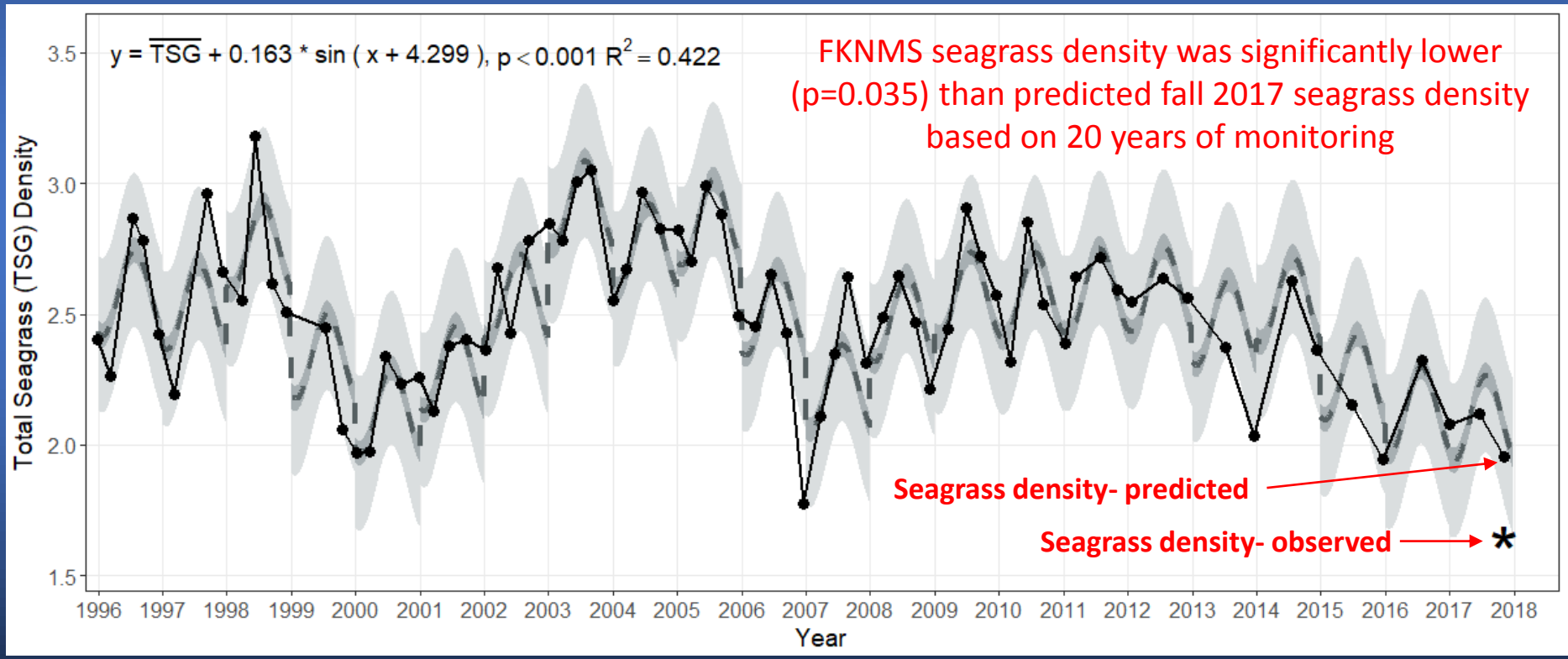
- **Were observed changes in seagrass density from summer 2017 to fall 2017 (Pre-/Post-Irma) driven by natural seasonal trends?**

- **We know that condition of FKNMS seagrasses follow a sine wave function, demonstrating regular seasonality**



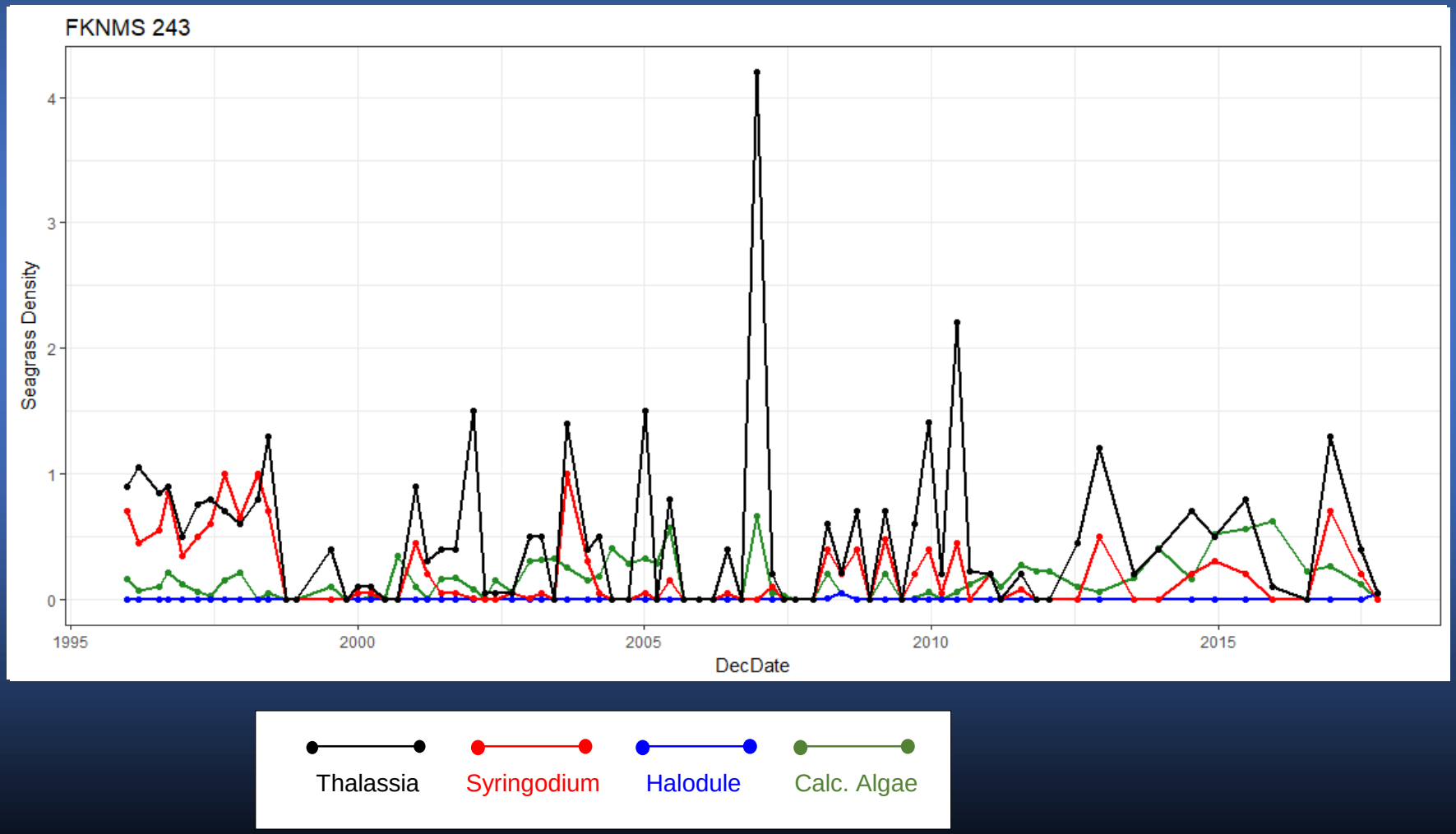
Seasonal Analysis

- We generated an autoregressive sinusoidal function that significantly described FKNMS seagrass density from 1996-2017
- We compared the model's predicted fall 2017 seagrass density to the seagrass density that we observed during our monitoring (*)



Differential Recovery Trajectory

- **Interestingly, the 3 sites most severely impacted by Hurricane Georges in 1998 have had different recovery trajectories / timelines**



Summary Points

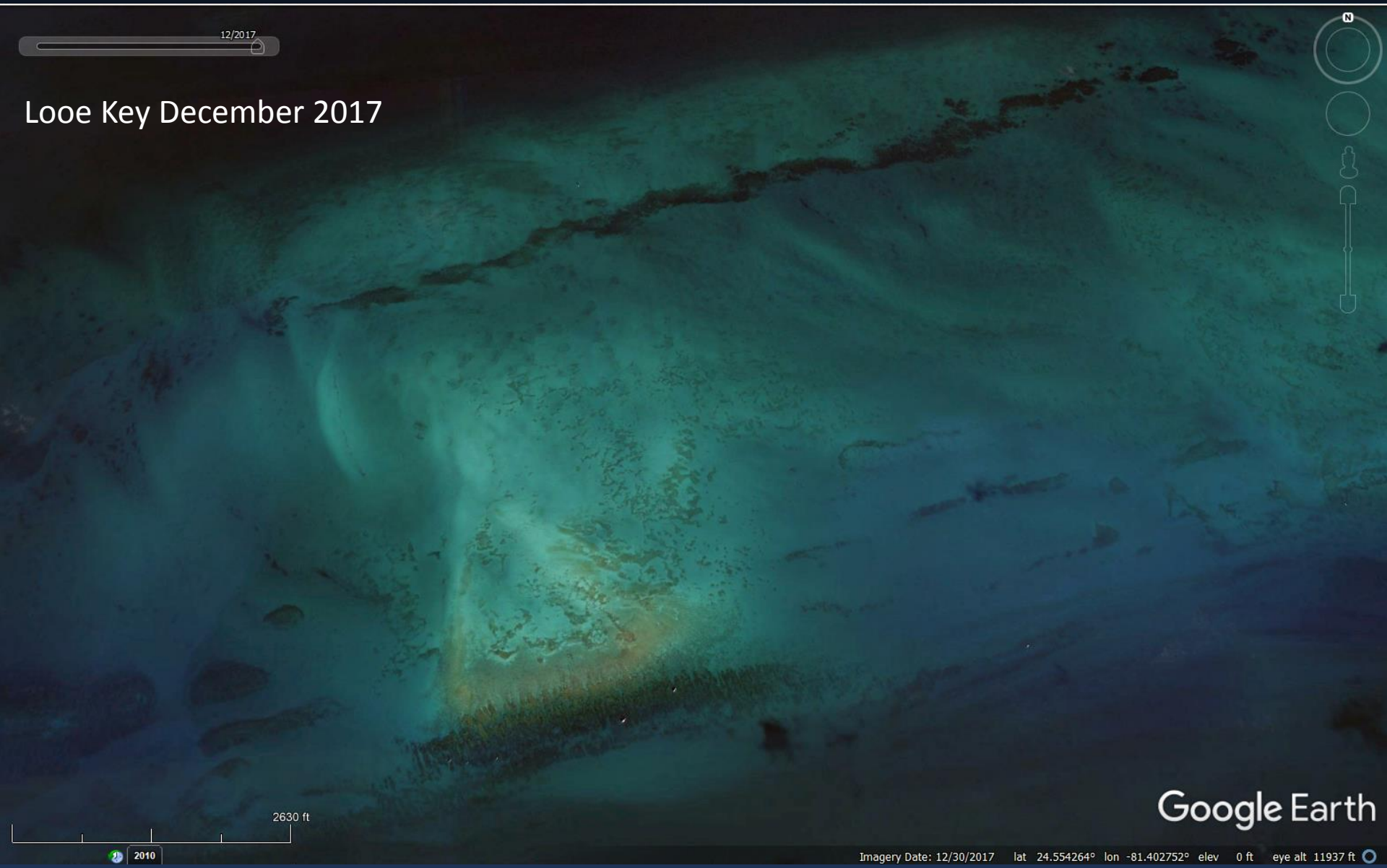
- Hurricane Irma heavily impacted seagrasses at some FKNMS sites, but left many sites unaffected. Florida Bay sites were all unimpacted.

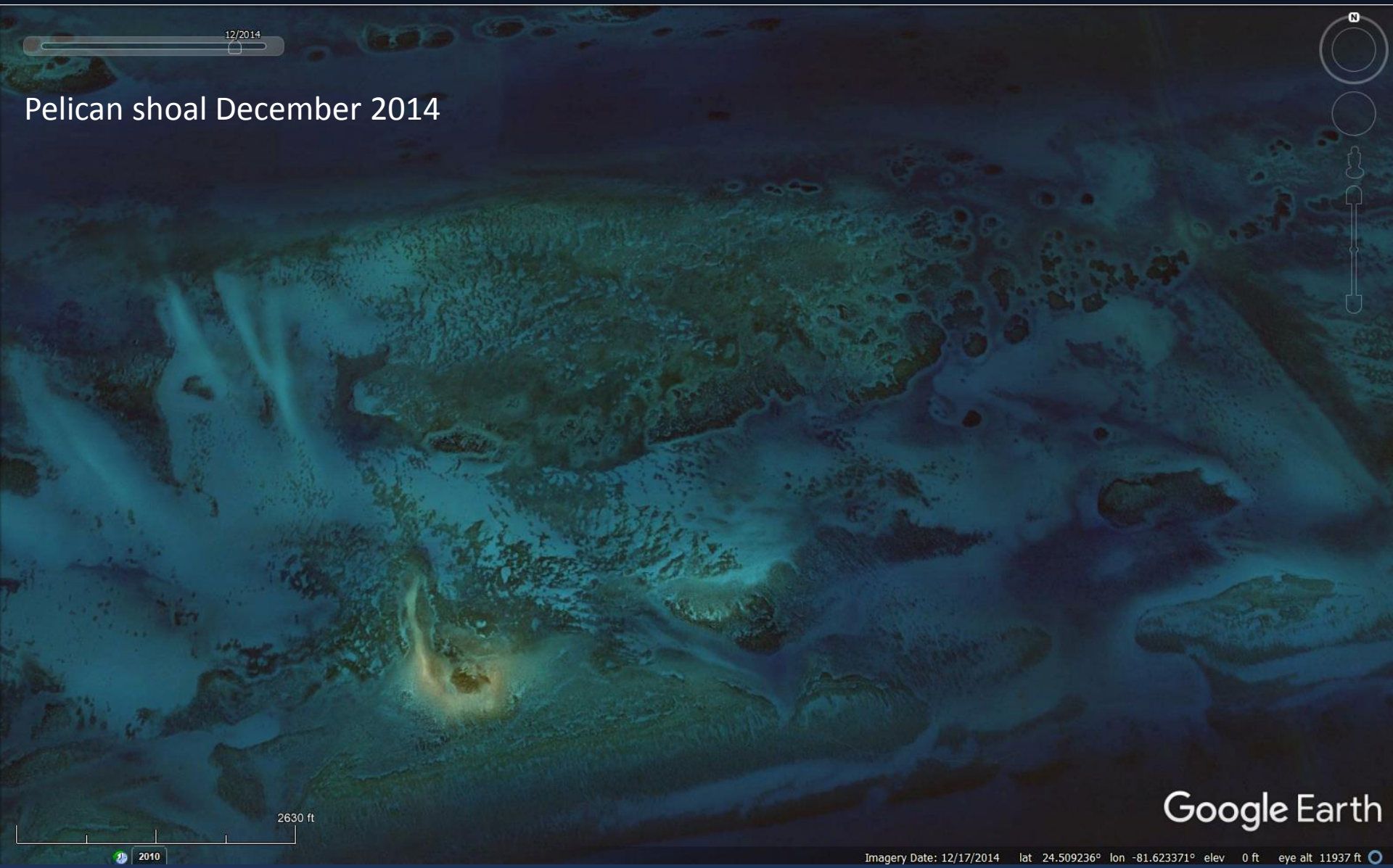
- The degree of storm impact on a site is likely a function of the degree of protection from winds offered by the reef tract or Keys, combined with distance from the eye of the storm and water depth (Fourqurean and Rutten 2004)

- The 3 sites heavily impacted by Hurricane Georges (216, 243, 309) were again heavily impacted by Irma.
  - Suggests bathymetry may be a strong driver
  - Will be interesting to follow the new recovery trajectories

- Fixed station monitoring across a large spatial area offers a broad look at system-wide changes, but has limited utility as we cannot observe the whole system.
  - Mote Marine Lab conducting an analysis of digital imagery to map observed seagrass losses
    - Contact: Dr. Rob Nowicki


3/2017
1994
2017
Looe Key March 2017
2630 ft
2010
Google Earth
Imagery Date: 3/18/2017 lat 24.554264° lon -81.402752° elev 0 ft eye alt 11937 ft

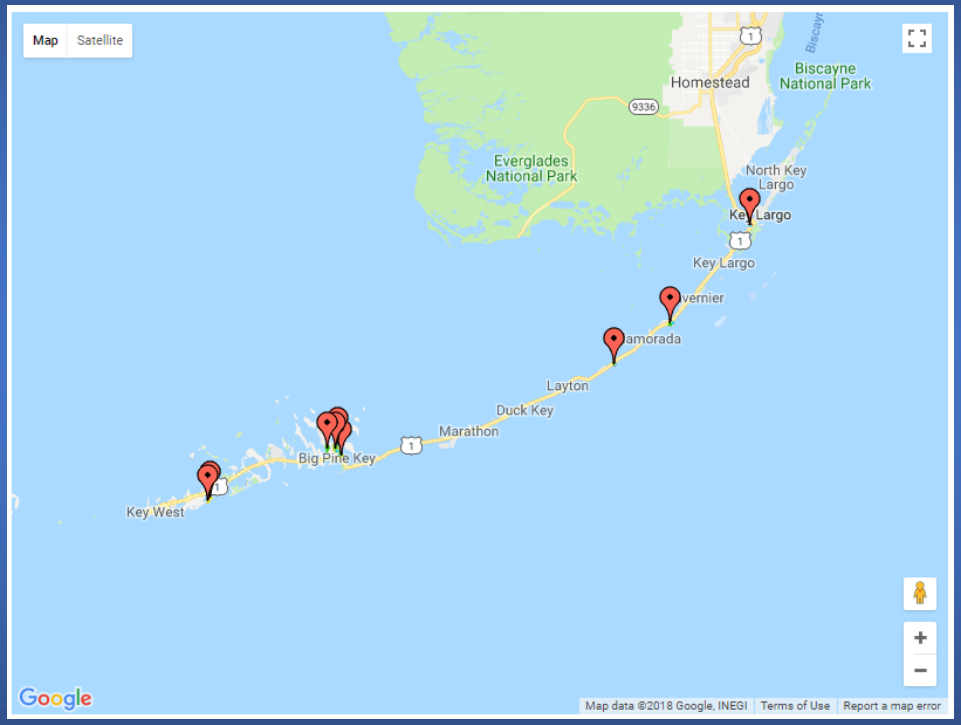

12/2017
Looe Key December 2017
2630 ft
2010
Google Earth
Imagery Date: 12/30/2017 lat 24.554264° lon -81.402752° elev 0 ft eye alt 11937 ft


12/2014
Pelican shoal December 2014
2630 ft
2010
Google Earth
Imagery Date: 12/17/2014 lat 24.509236° lon -81.623371° elev 0 ft eye alt 11937 ft


12/2017
Pelican Shoal December 2017
2630 ft
2010
Google Earth
Imagery Date: 12/30/2017 lat 24.509236° lon -81.623371° elev 0 ft eye alt 11937 ft

Benthic Habitat Monitoring - Canals

- 19 canals (7 treatments)
  - 5 Islamorada canals
- Benthic community assessment
  - Vegetation coverage
  - Seagrass nutrients
  - Fish surveys
  - Seawall assessments
- Sediment (“muck”) measurements
  - Muck depth
  - Sediment bulk density
  - Sediment nutrients



Canal # 282 Post-Irma

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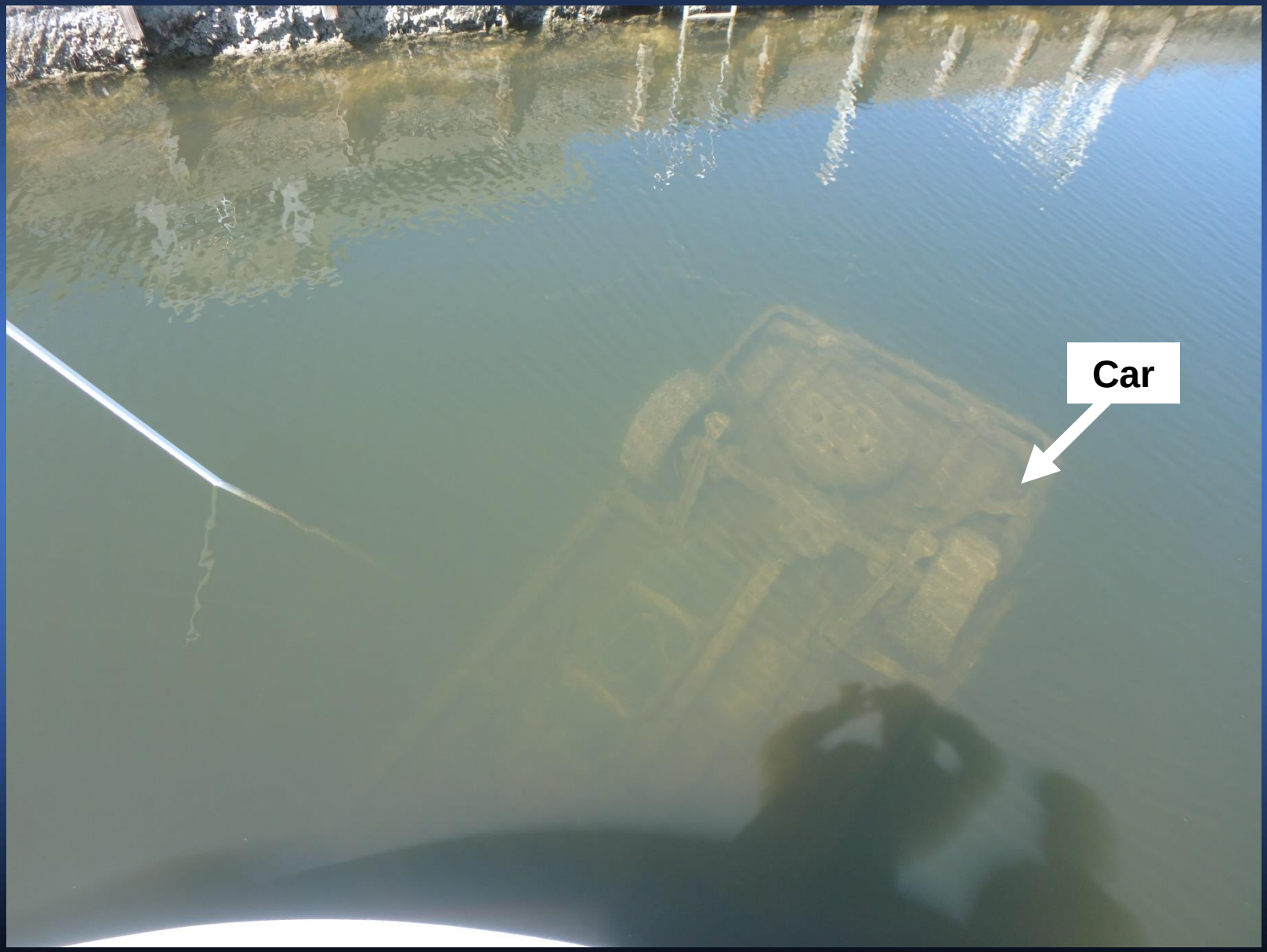
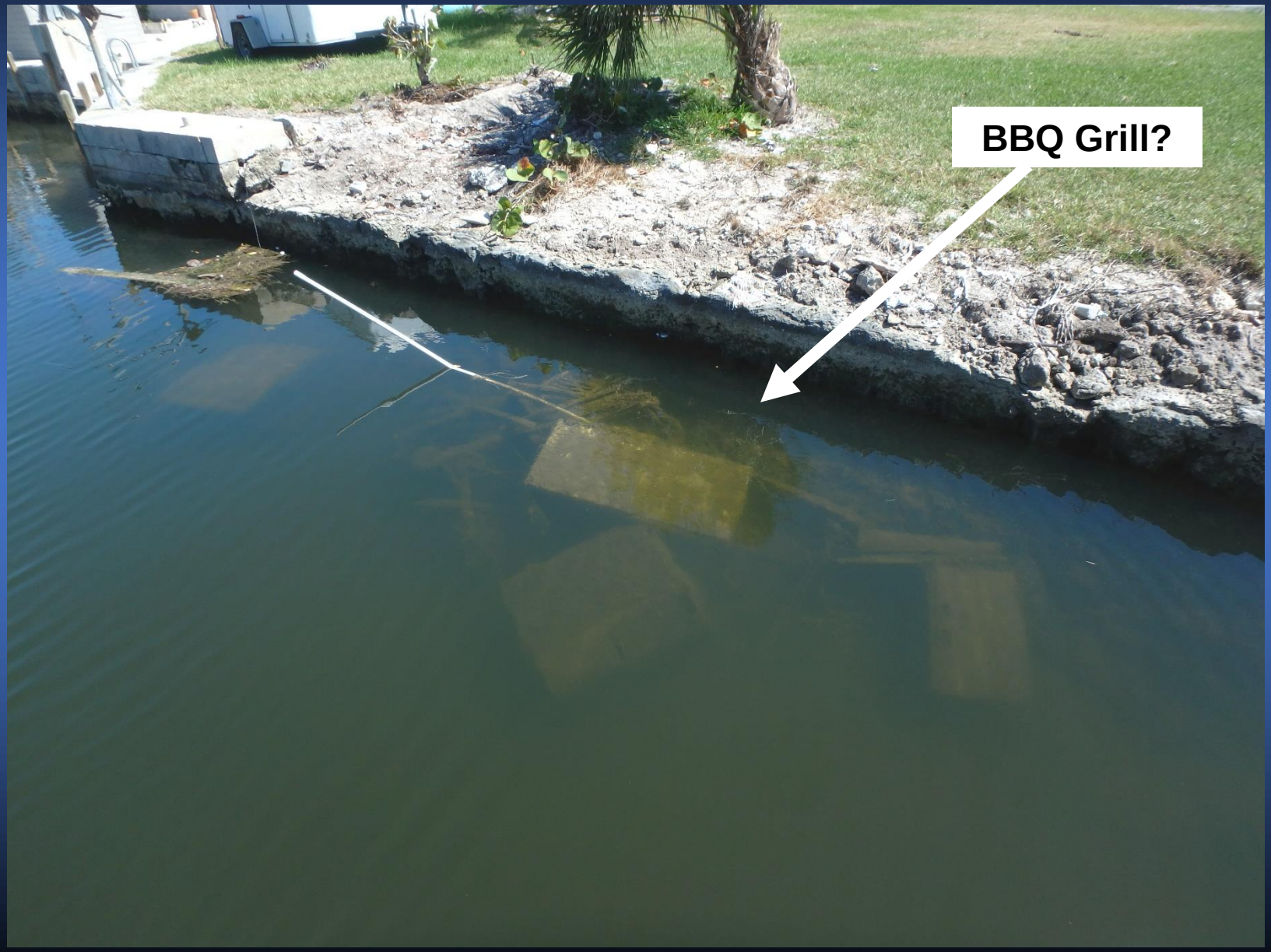
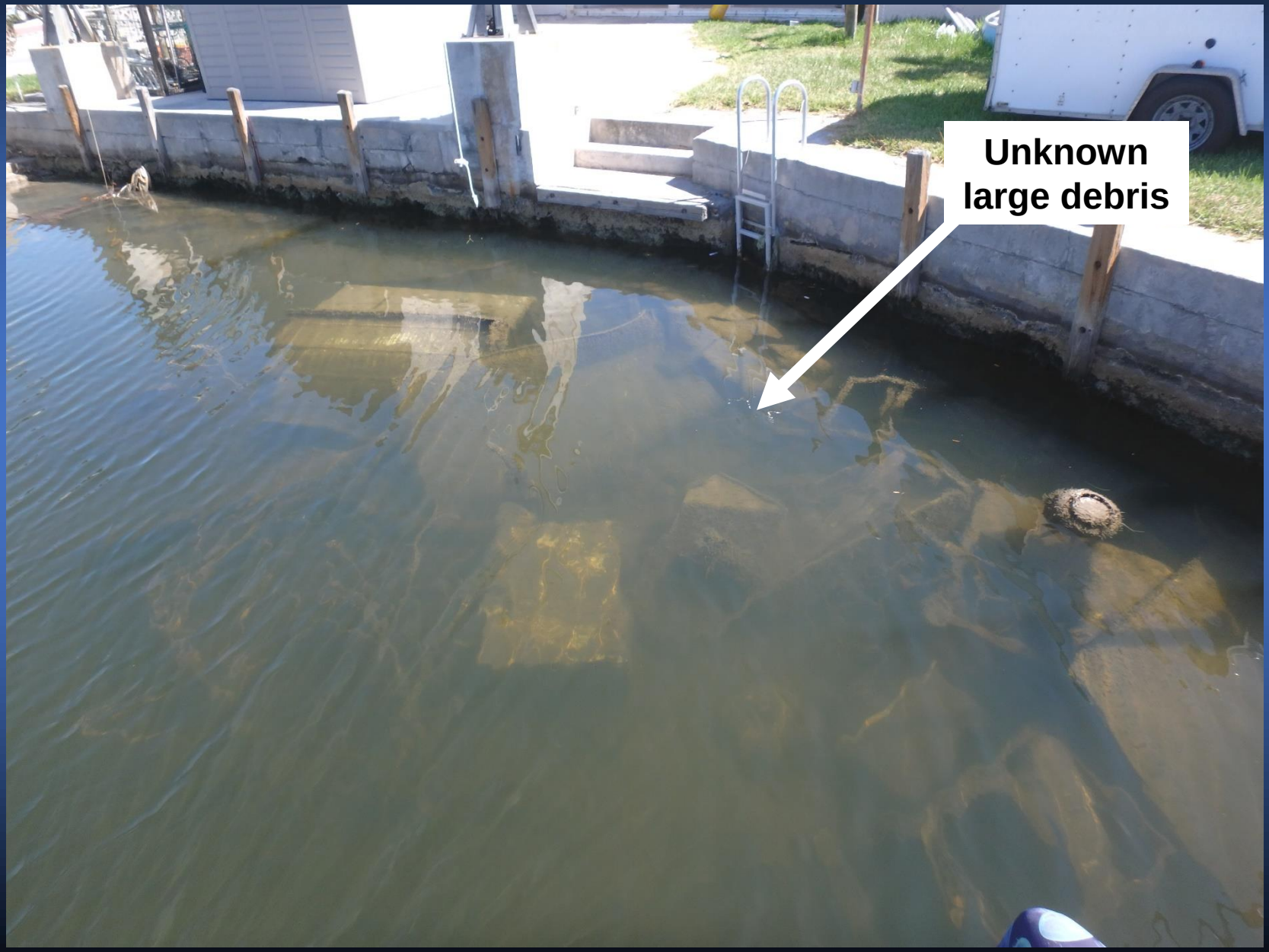


Canal # 282 Post-Irma



Canal # 282 Post-Irma



Canal # 282 Post-Irma

Canal # 148 Post-Irma

Deliverables Timeline

- 2017 “Fall” sampling (usu. Sep/Oct) pushed back, occurred February 2018
- Sample processing during March and April 2018
- Currently analyzing data
- We estimate completion of the Final Project Report by end of June 2018
- Funded through Village of Islamorada (help from Susan Sprunt) to continue our monitoring- will conduct fall/summer sampling beginning fall 2018
- We will continue to update the website and provide data as it is generated
  - http://seagrass.fiu.edu/canals.htm