FKNMS Benthic Habitat Monitoring Program December 2017 Report

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Water Quality Protection Program Steering Committee Meeting
December 6th, 2017 – Marathon, FL

FIU
Southeast Environmental Research Center

Goals for the Project

As originally envisioned, the goal was to address these points at the <u>regional</u> 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**

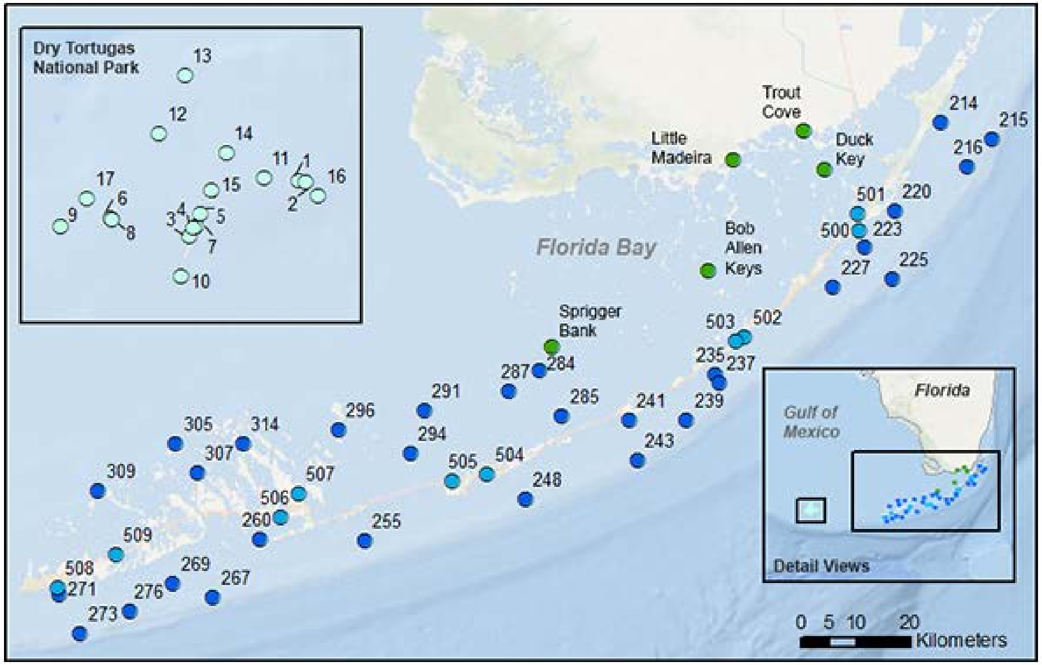
Information being collected

- Distribution & abundance of seagrasses and associated fauna and flora using rapid assessment Braun-Blanquet surveys
  - 40 permanent sites 2 times a year

- Seagrass nutrient availability using tissue concentration assays and stable isotopic analyses
  - 40 permanent sites 2 times a year
  - Ca. 200 mapping sites/year (1996-2000, 2003-2007, 2010-2011)

- Water column physicochemical data
  - Sites co-located with water quality sites
  - 40 permanent sites 2 times a year in addition to quarterly water quality sampling (Briceño)

Current Monitoring Stations



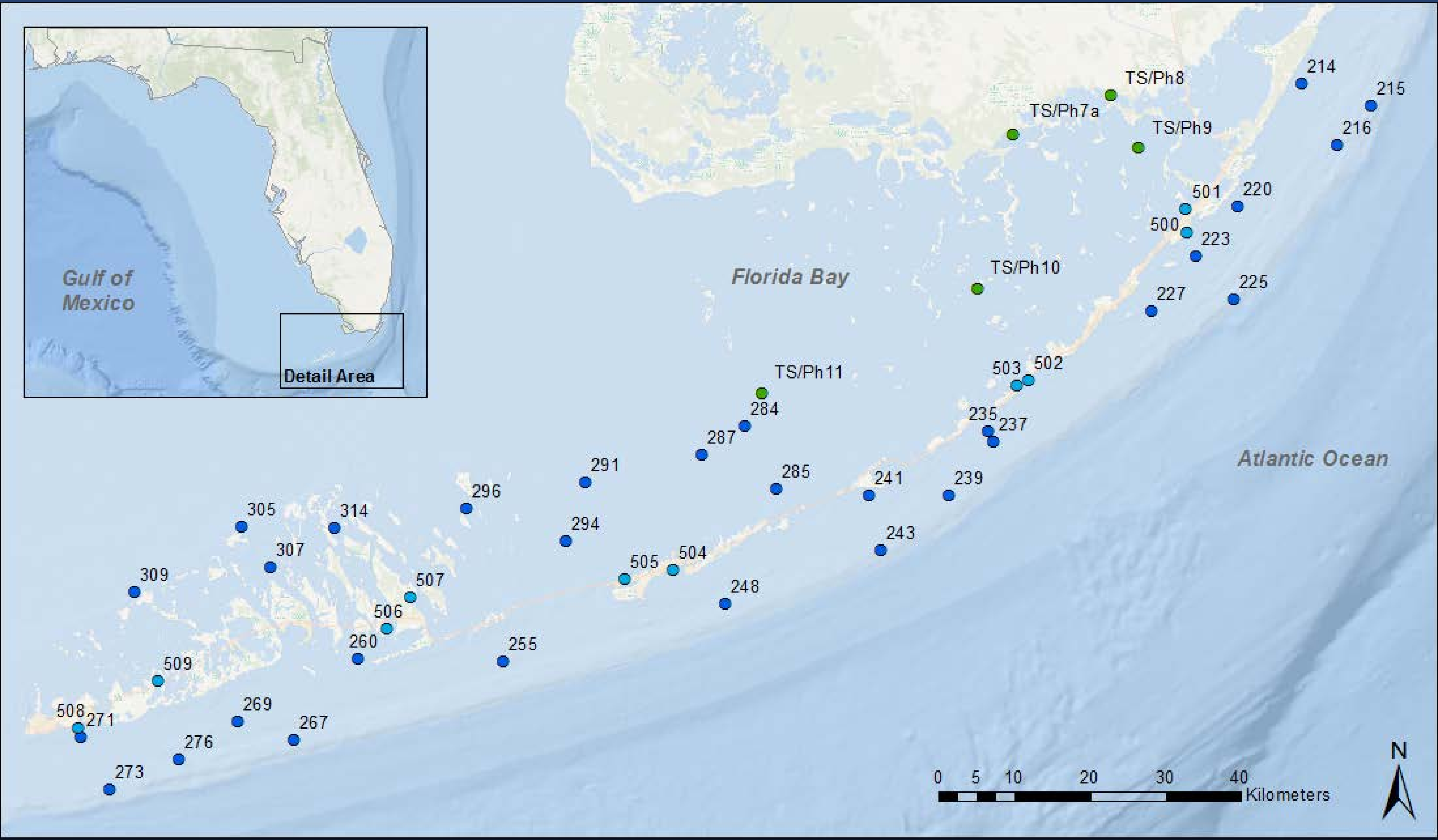
● = Long Term Ecological Research (LTER) Sites (2002-present)

● = Florida Keys National Marine Sanctuary (FKNMS) Offshore Sites (1996-present)

● = Florida Keys National Marine Sanctuary (FKNMS) Nearshore Sites (2012-present)

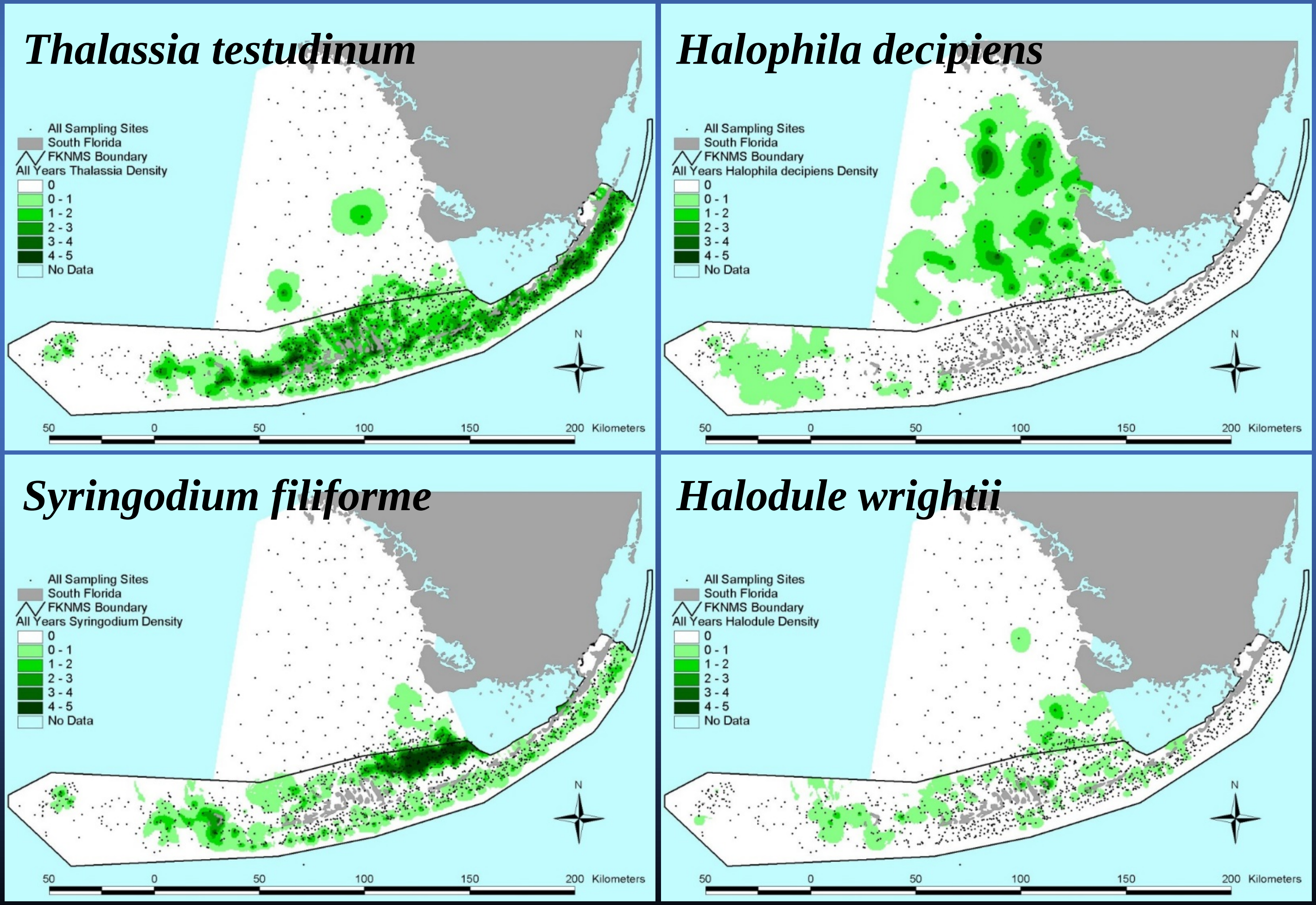
○ = Dry Tortugas National Park (DRTO) Sites (2011-present)

Current Monitoring Stations



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**
  Ca. 200 mapping sites/year (1996-2000, 2003-2007, 2010-2011)



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**
  (Fourqurean et al. 2001, Peterson and Fourqurean 2001, Fourqurean et al. 2005)

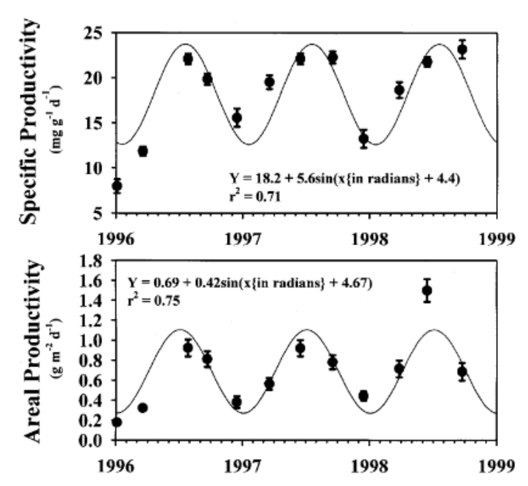


Fig. 6 Seasonality of productivity of *T. testudinum* at the 30 permanent sites. *Each point* is the mean of the 30 site means at each sampling period; *error bars* indicate +1 SE. *Lines* are the results of fitting the sine model (Eq. 4) to the data using an iterative least-squares routine

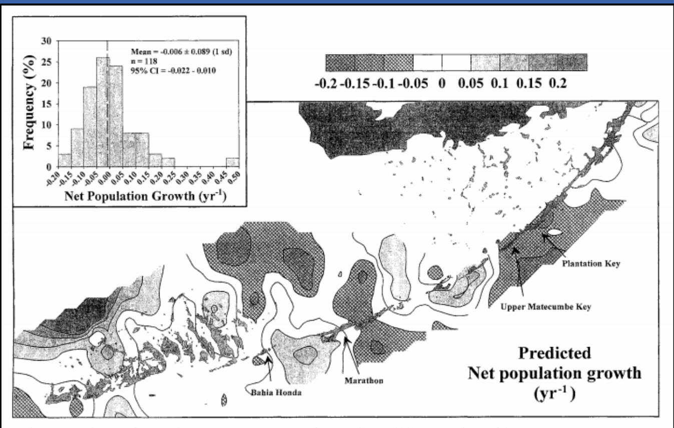


Fig. 10. Spatial plot of the predicted net population growth of *T. testudinum* within the boundaries of the FKNMS. Frequency histogram of the estimated net population growth for the 118 samples with mean and 95% CI is shown as the insert.

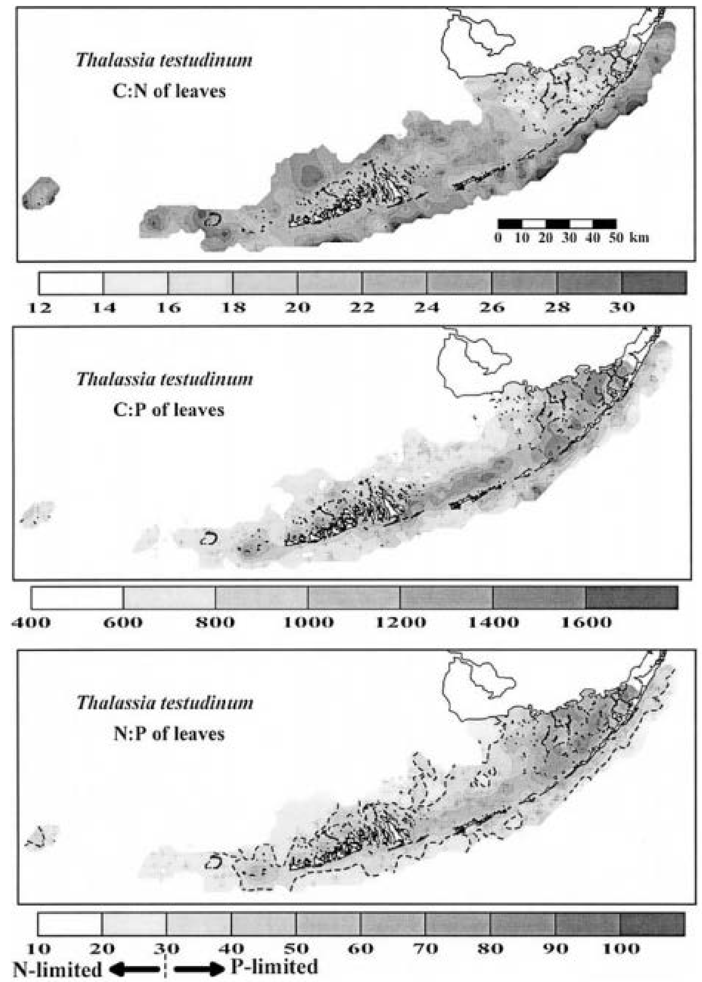


Fig. 9. Spatial pattern of the C:N, C:P, and N:P of green leaves of *Thalassia testudinum* in south Florida. All data was collected in the summer months to control for the seasonal pattern. Bottom panel: an N:P ratio of 30 was used to delimit N-limited and P-limited areas.

Major Project Accomplishments (cont.)

- **We have experimentally confirmed the role of nitrogen, and of phosphorus nearshore and in Florida Bay, in controlling seagrass bed structure and productivity near the reef tract in the FKNMS**
  (Fourqurean and Zieman 2002)

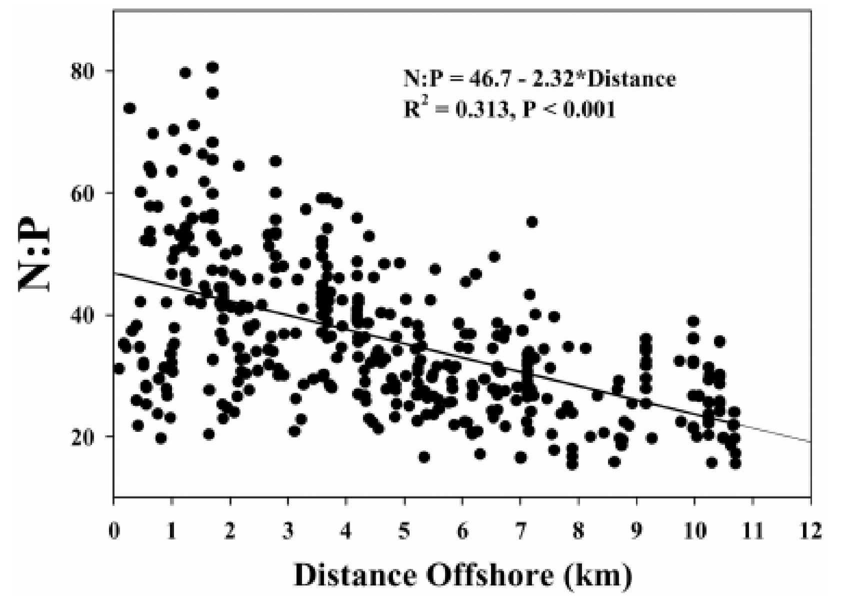


Figure 6. The relationship between the distance offshore and the N:P of leaves of *Thalassia testudinum* collected from the Atlantic Ocean side of the Florida Keys. The solid line represents the statistically significant regression (n = 405)

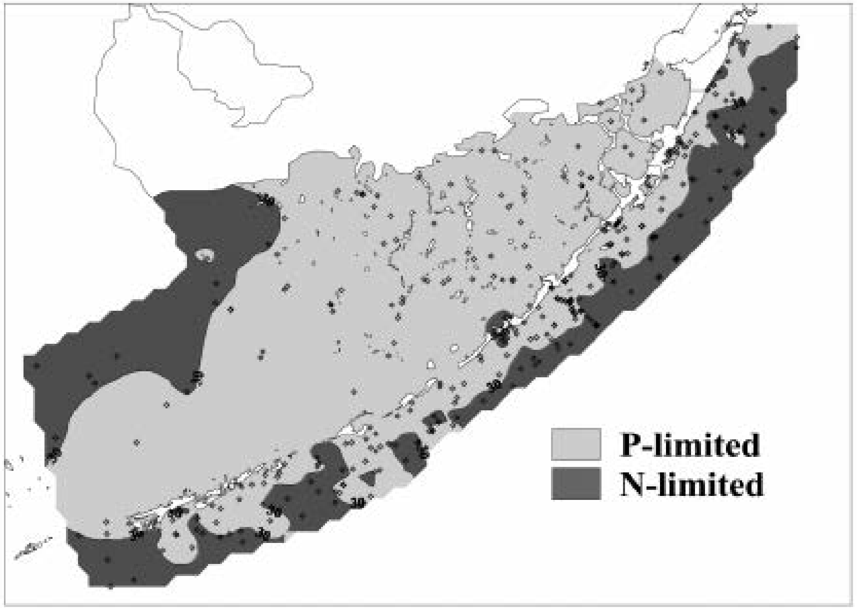
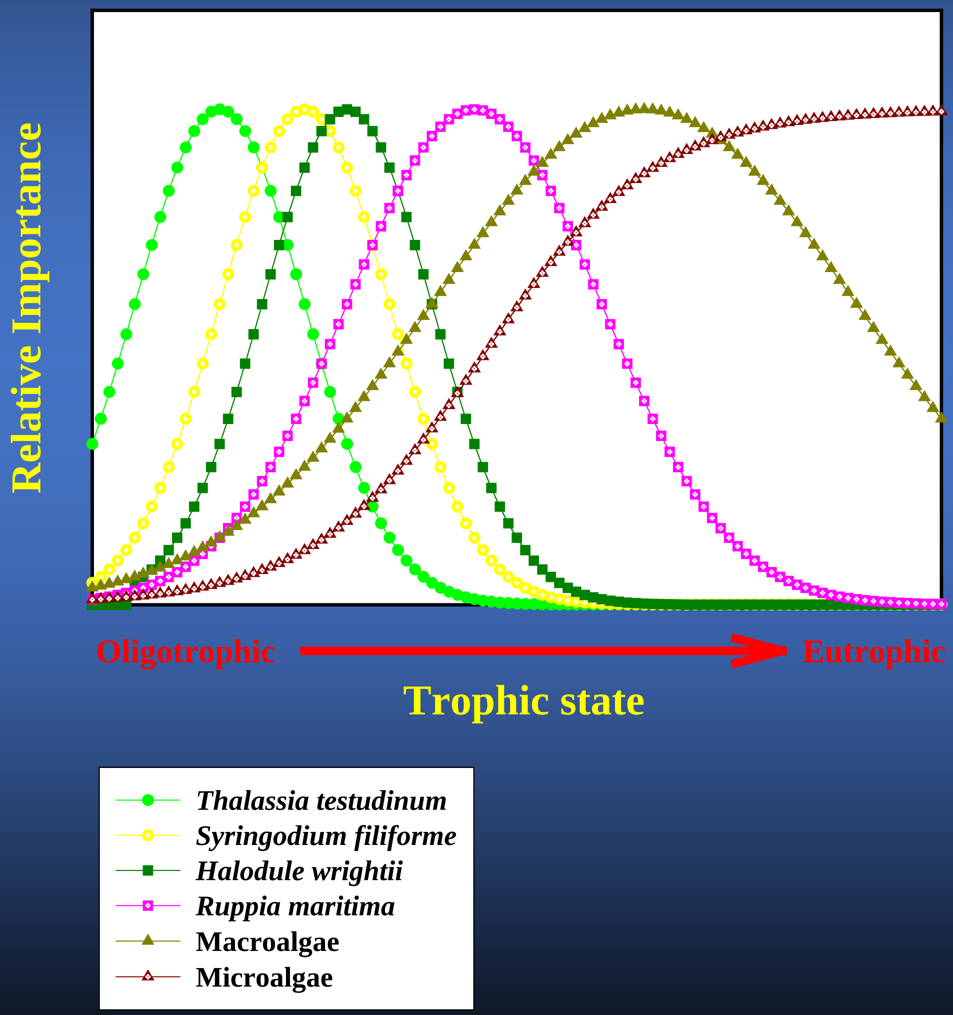


Figure 7. Zones of N–and P-limited seagrass communities in south Florida. The N:P contour of 30 (Figure 5) was used to delineate N-limited (N:P < 30) from P-limited (N:P > 30) regions

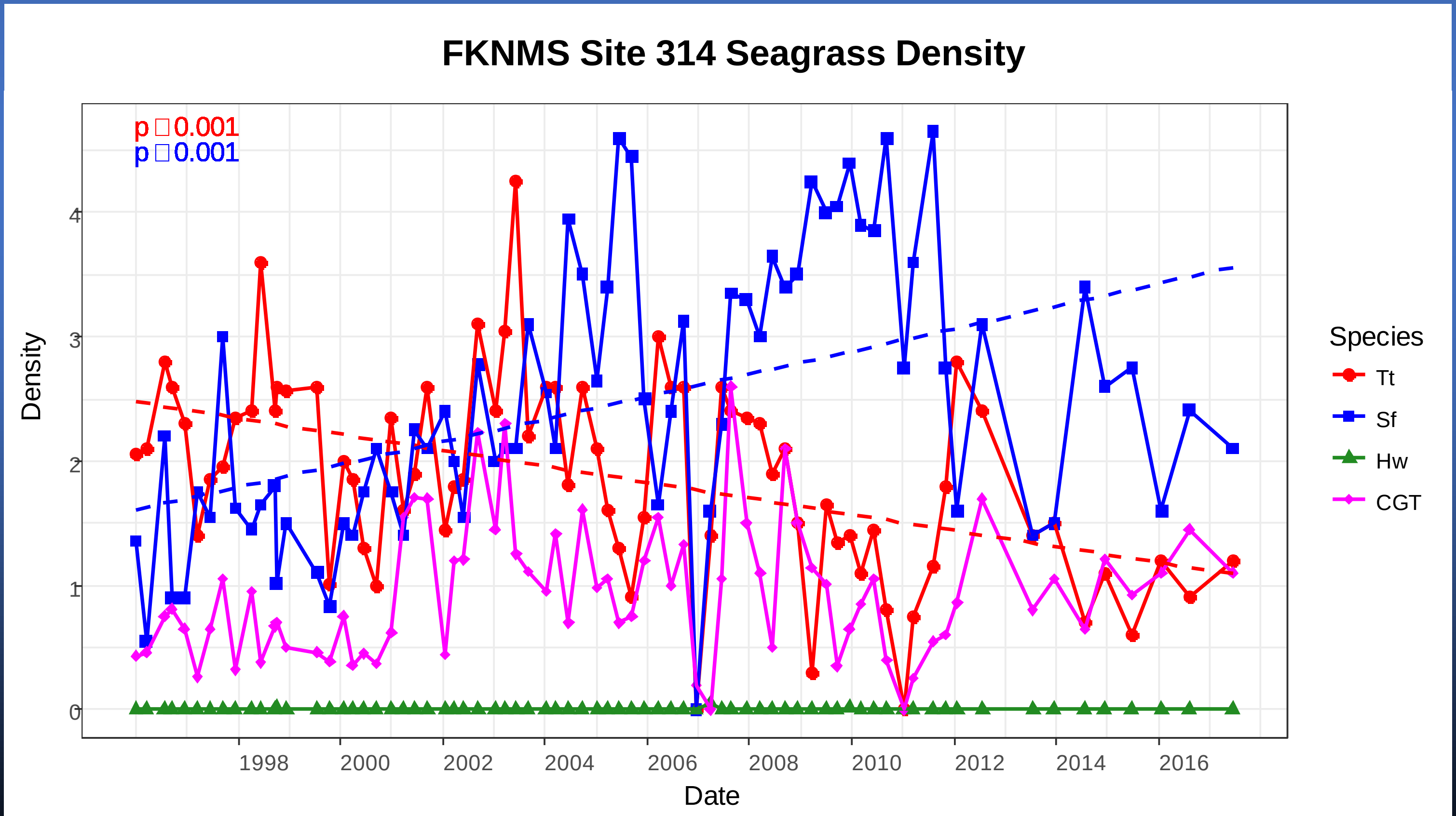
Model of Ecosystem Behavior #1
Eutrophication Model



- **Nutrient pollution will lead to changes in relative abundances of primary producers in a predictable way**
  (Fourqurean and Rutten 2003)

Major Project Accomplishments (cont.)

- We have identified long-term trends at stations in the FKNMS that are consistent with increases in nutrient availability
- We have defined the effects of changing water quality on seagrass communities in south Florida



FKNMS Seagrass Status Criteria #1

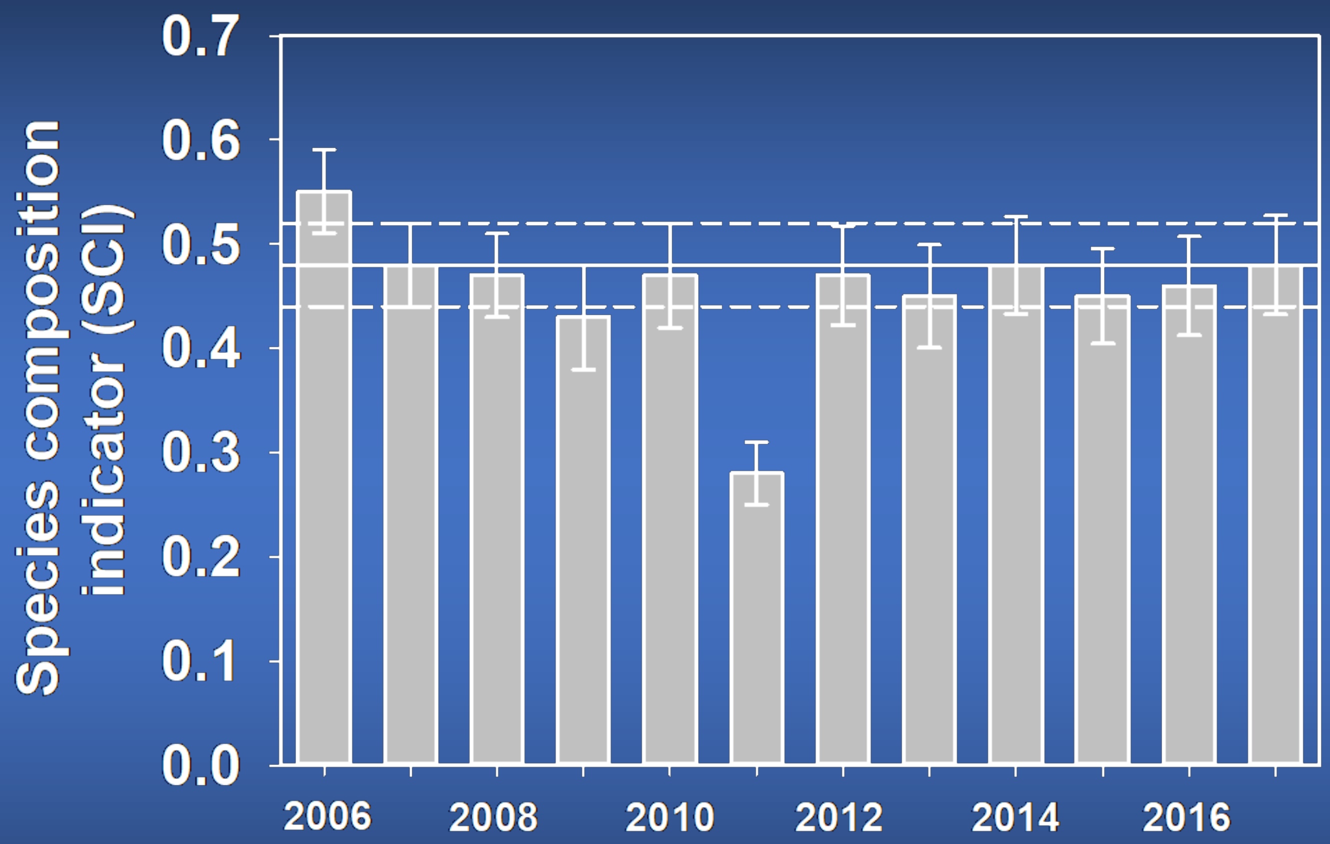
- We have defined 2 criteria to track the status of seagrasses Sanctuary-wide, based on our conceptual models.
- The first is based on the relative dominance of slow-growing species:

$$SLOW = \frac{D_{Tt}}{D_{Tt} + DSf + DHw + DMacroalgae}$$

$$SCI = \frac{\sum_{i=1}^{30} SLOW_i}{30}$$

- We call this the Species Composition Index (SCI)
- The baseline SCI, calculated from data collected between 1995-2005, was 0.48 ± 0.04.
- Any decrease in SCI indicates declining water quality.

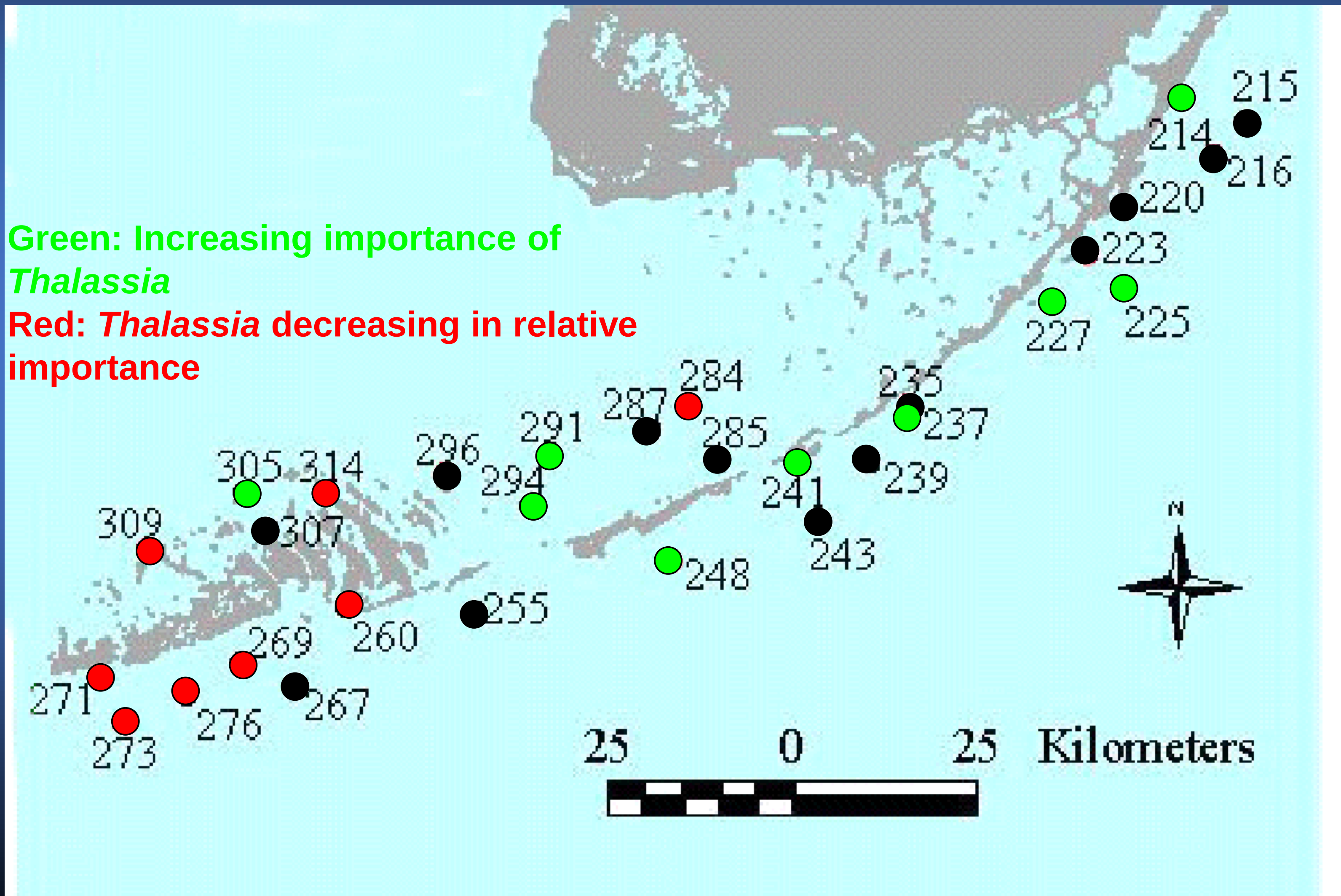
Species Composition Index 2006-2017



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

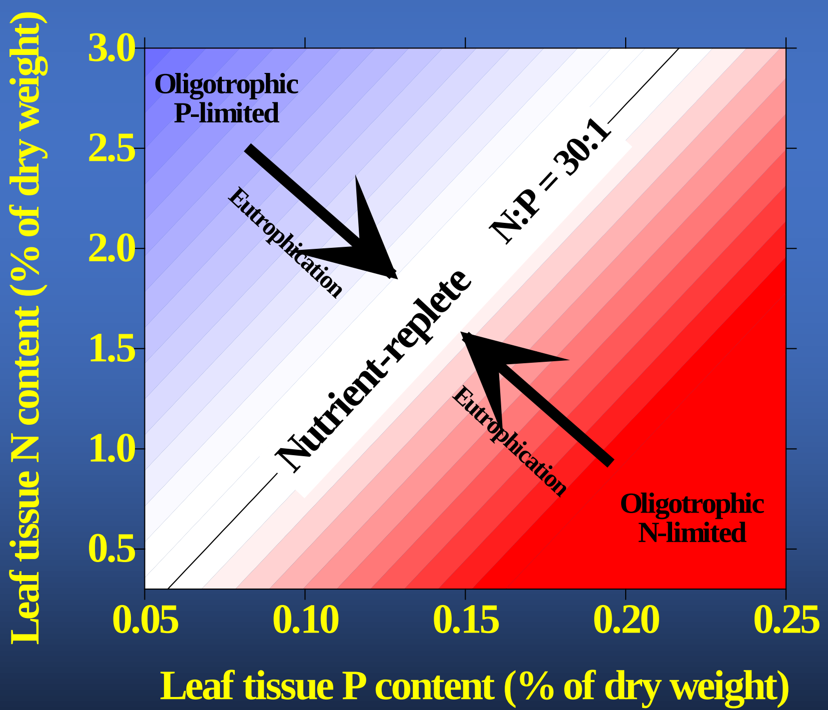
Species Composition Index 2006-2017 (cont.)

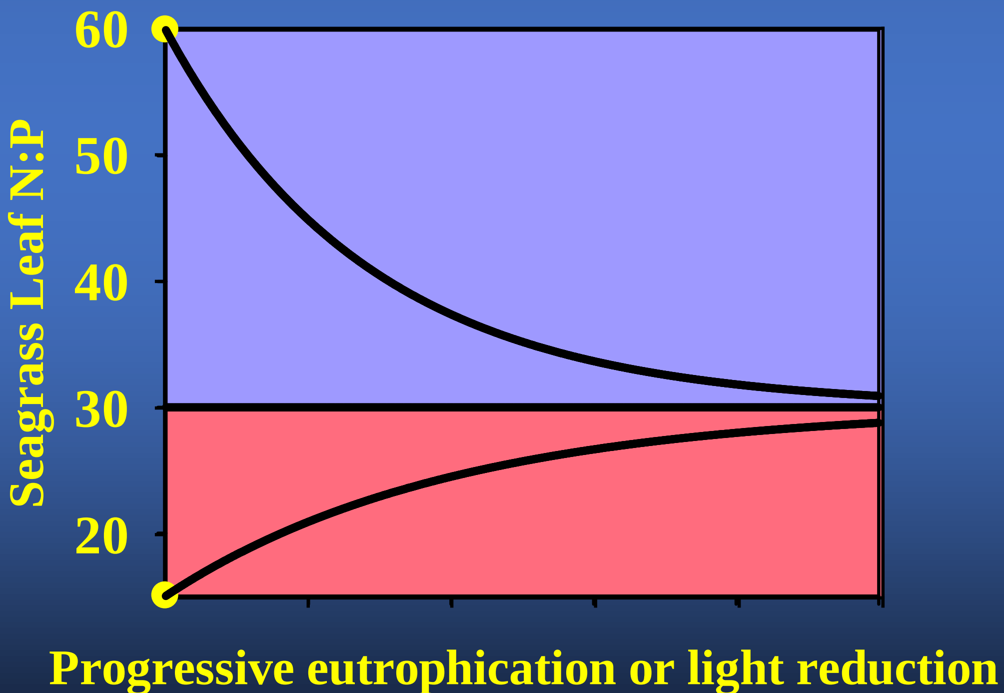
- **At 17 of 30 sites, species composition has shifted in a manner consistent with changes in nutrient availability**



Model of Ecosystem Behavior #2 "Redfield Ratio model"

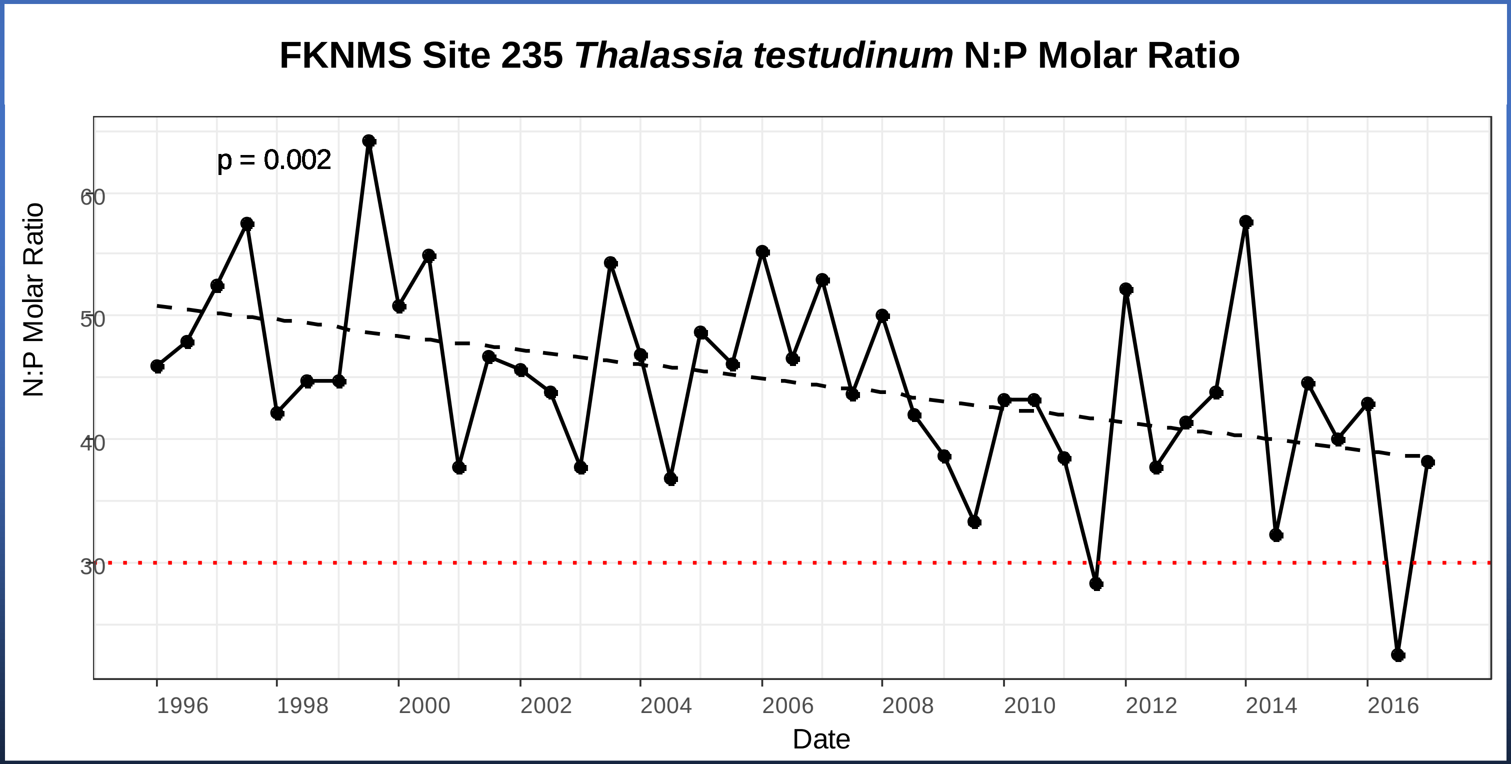
- Nutrient pollution will shift N:P molar ratios of primary producers towards a taxon-specific "Redfield ratio" of 30:1 (Fourqurean and Rutten 2003)





Major Project Accomplishments (cont.)

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



FKNMS Seagrass Status Criteria #2

- **We have defined 2 criteria to track the status of seagrasses Sanctuary-wide, based on our conceptual models.**

- **The second is based on nutrient content of the slowest growing species:**

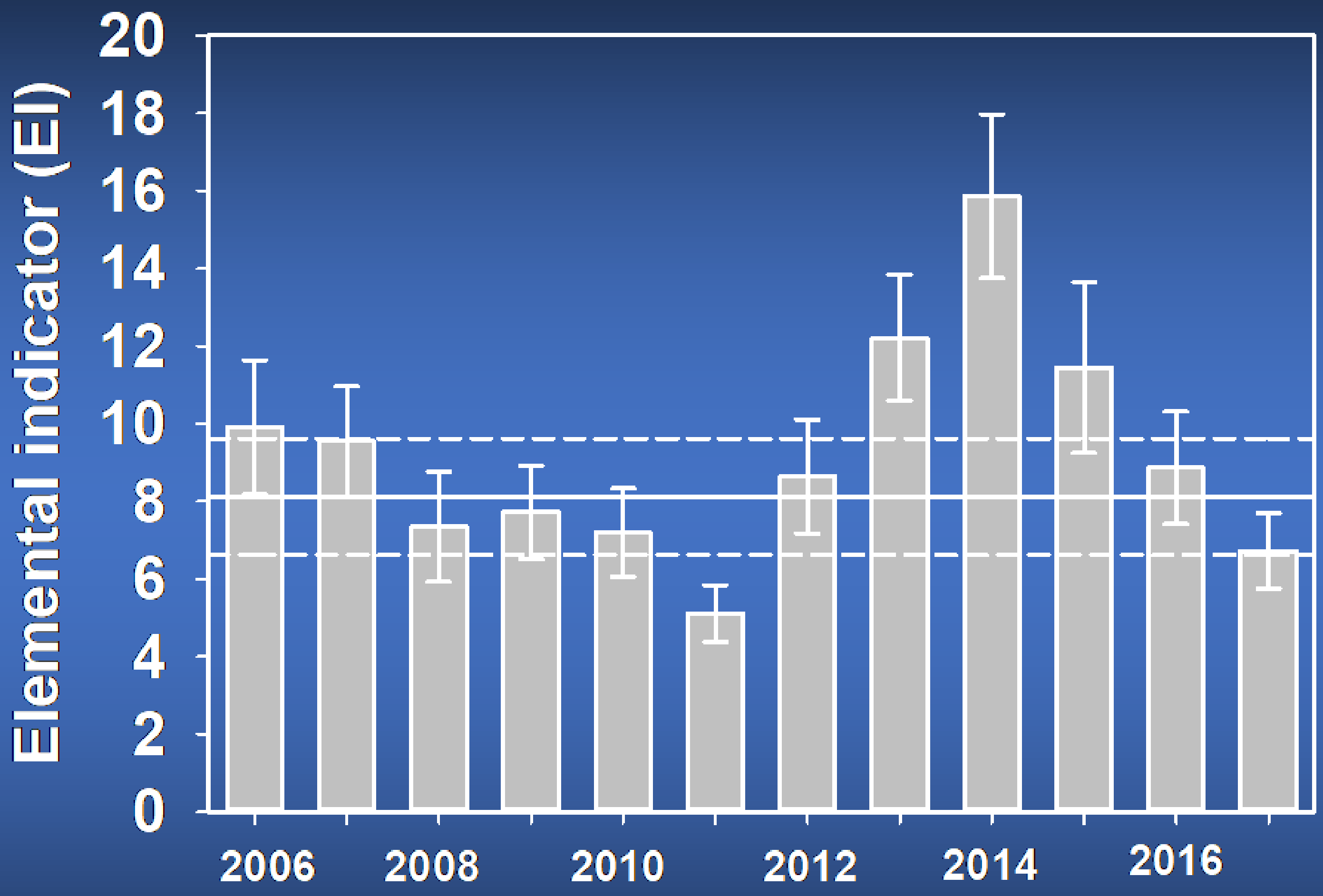
$$EI = \frac{\sum_{i=1}^{30} \left| NP_i - 30 \right|}{30}$$

- **We call this the Elemental Indicator (EI)**

- **The baseline EI, calculated from *T. testudinum* leaf tissue collected between 1995-2005, was 8.28 ± 1.47**

- **Any decrease in EI indicates declining water quality.**

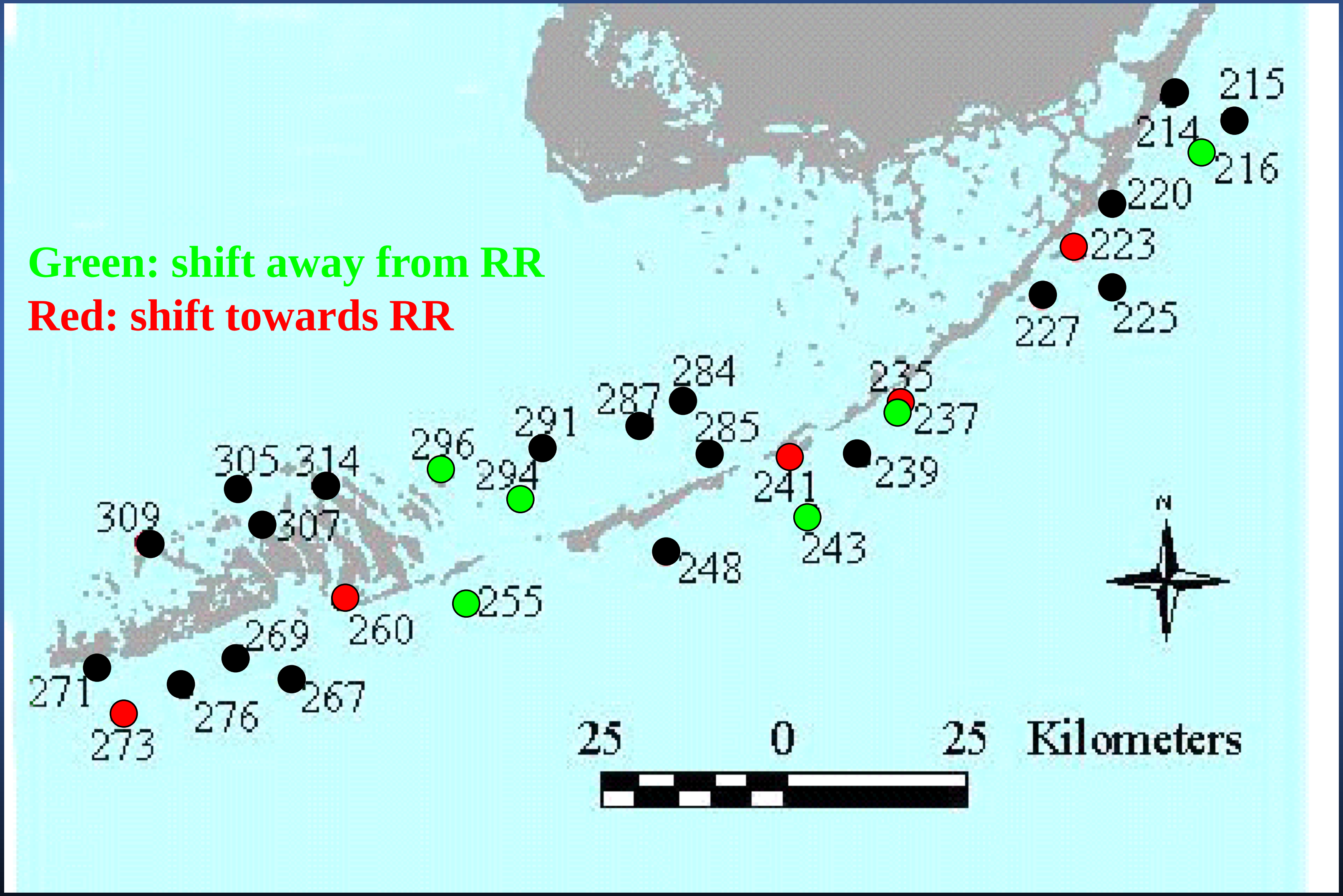
Elemental Indicator 2006-2017



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

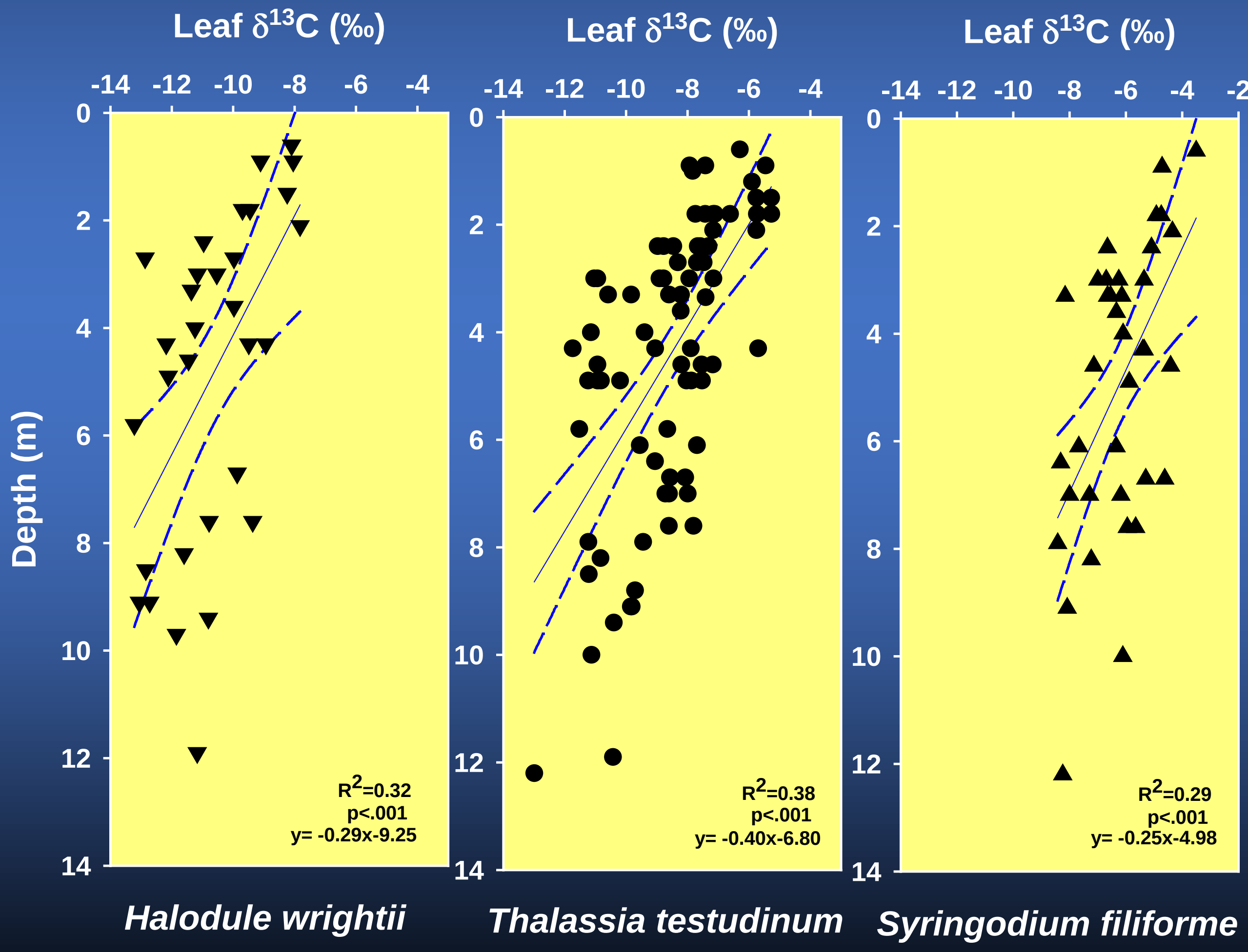
Elemental Indicator 2006-2017 (cont.)

- At 11 of 30 sites, seagrass nutrient content has shifted in a manner consistent with changes in nutrient availability



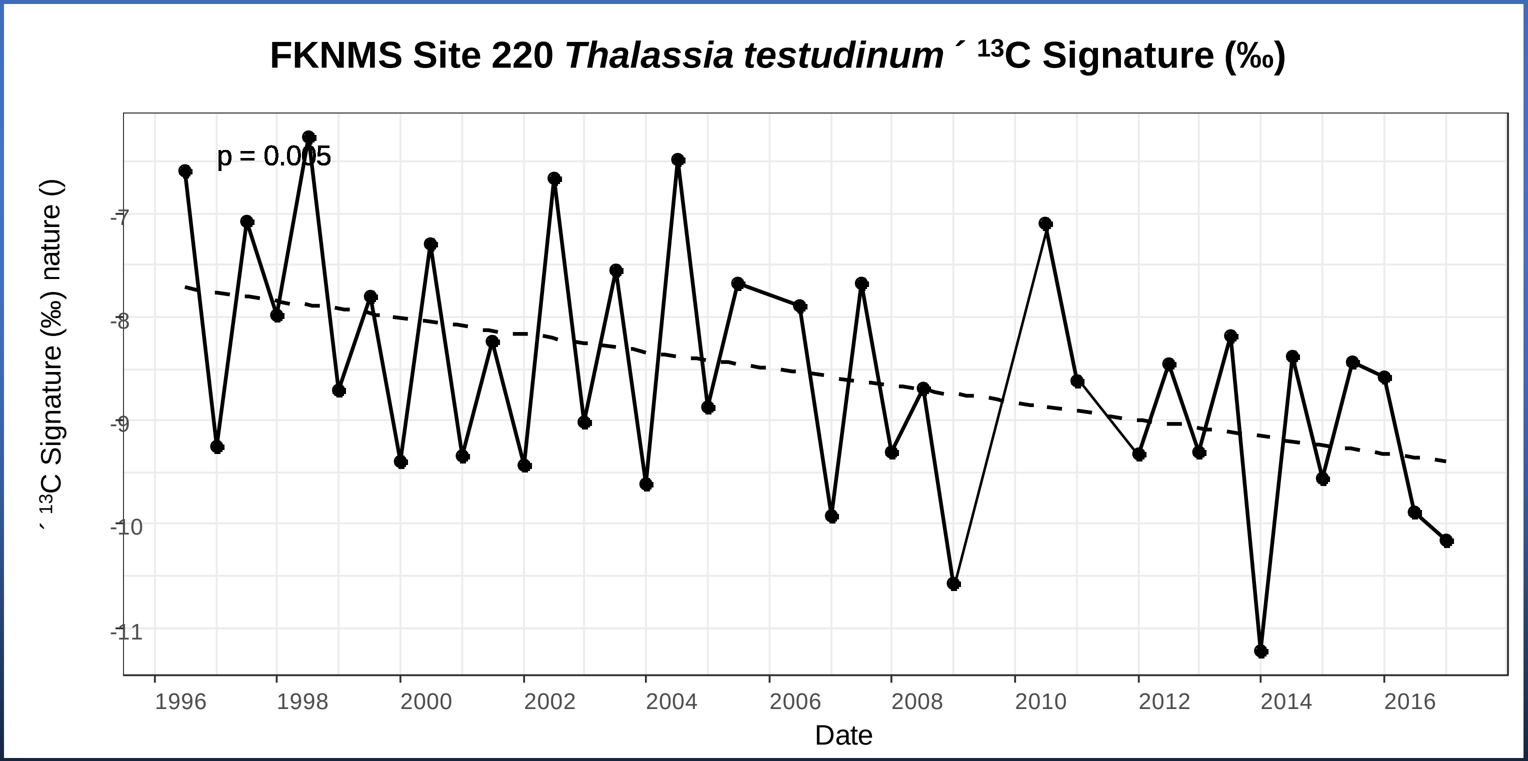
Model of Ecosystem Behavior #3
"´δ13C model"

- As light decreases with depth, ´ 13C decreases (Campbell and Fourqurean 2009)



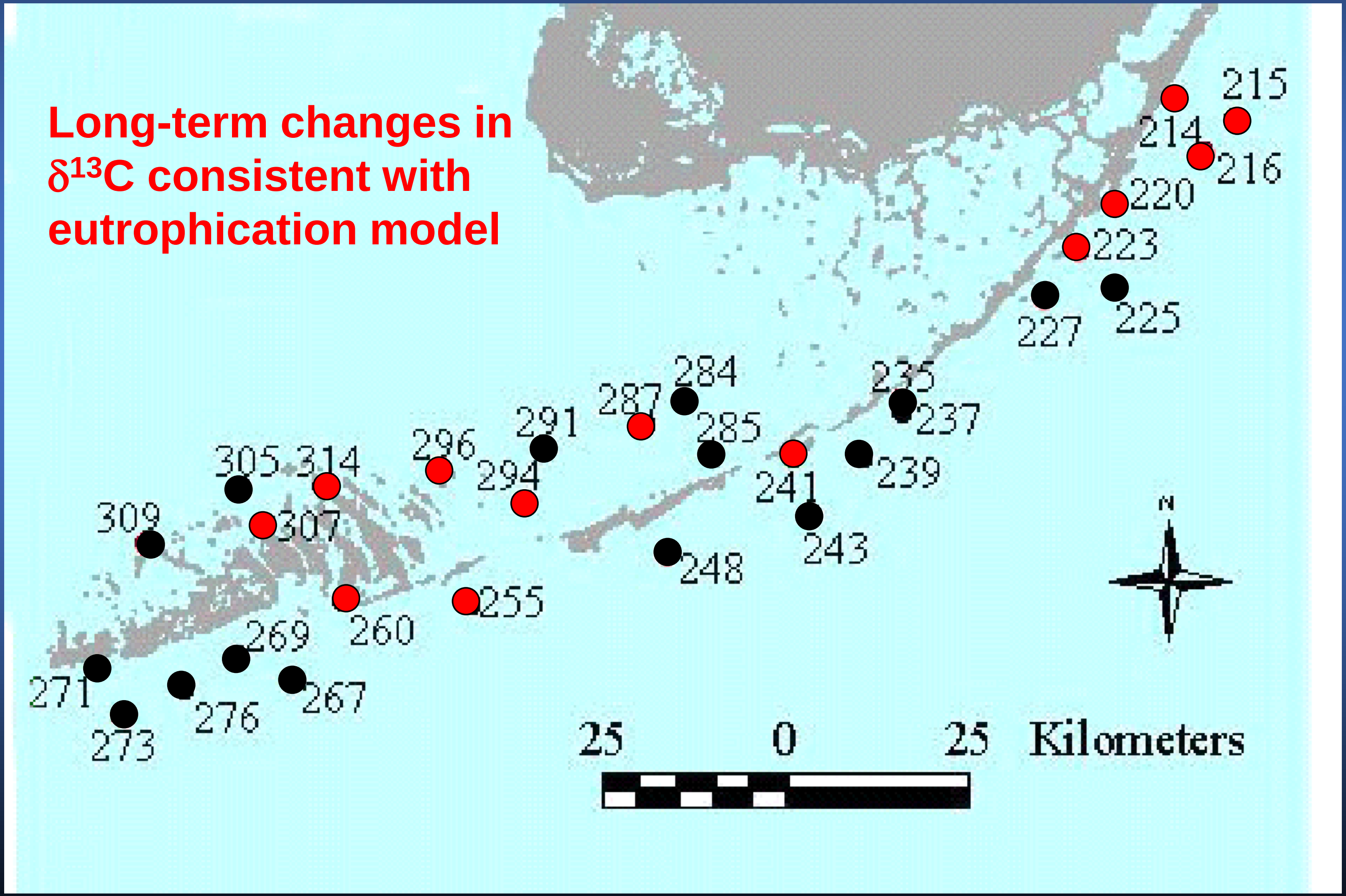
Major Project Accomplishments (cont.)

- We have identified areas experiencing changes in light availability, as indicated by seagrass tissue isotopic composition



δ^{13}C model

- At 13 of 30 sites, significant δ^{13}C trends consistent with eutrophication



Major Project Accomplishments (cont.)

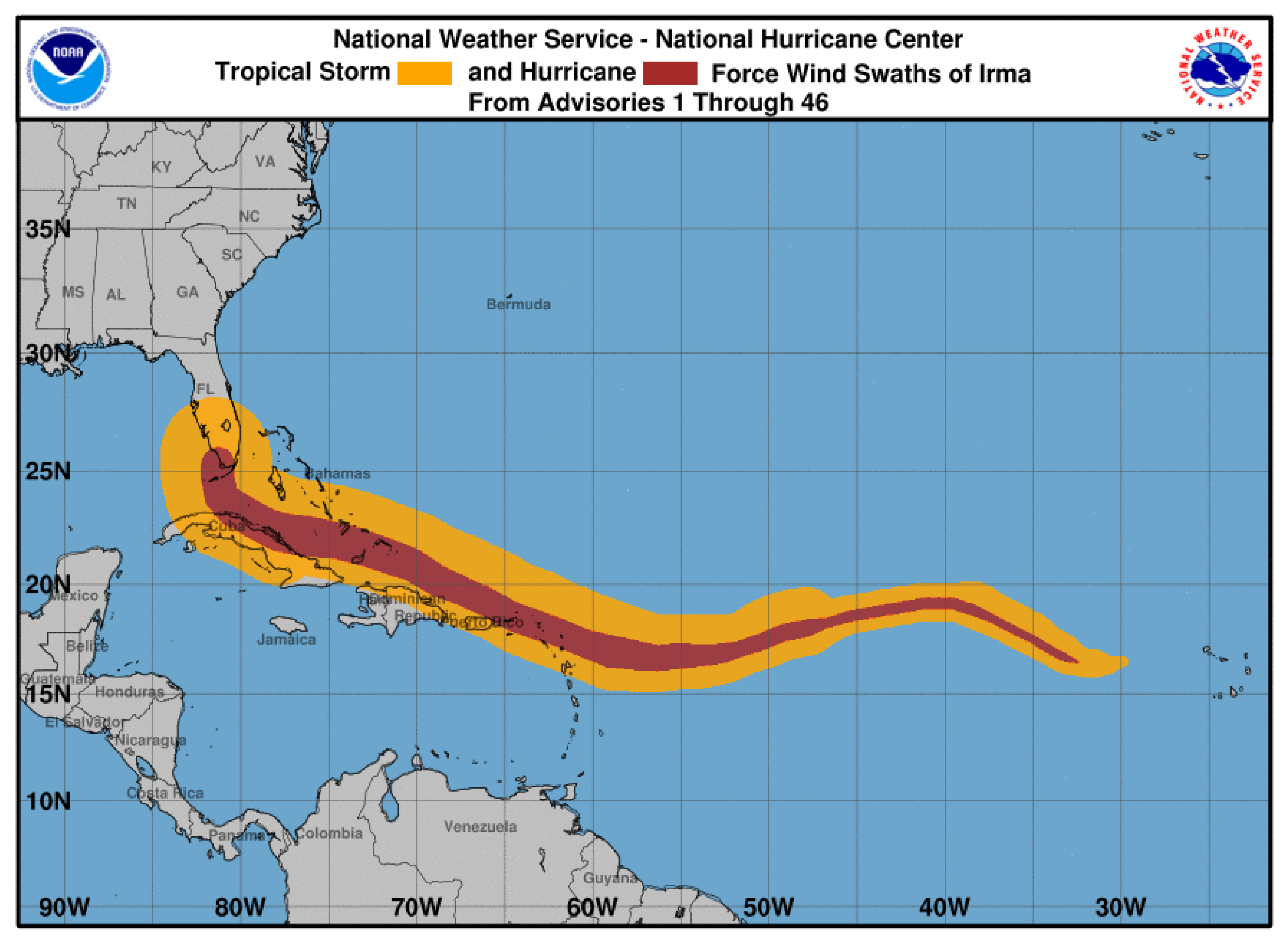
- **25 scientific publications have resulted from this monitoring project to date**
- ***In prep:* Howard, JH, CC Lopes, CI Carrion, SS Wilson, JW Fourqurean. Importance of sediment type on the stability of seagrass blue carbon. *Target journal: Biogeochemistry***
- ***In progress:* Arias, A. et al. Survey of C_{org} inventories in FKNMS seagrass communities. *Field work completed, currently processing samples for C_{org} content and Pb^{210} dating***
- **We have documented the effects of storms on seagrass communities**

Hurricane Irma

- Regularly scheduled FKNMS summer sampling occurred in June 2017
- Hurricane Irma hit Cudjoe Key on September 10, 2017 as a category 4 storm with sustained wind speeds of 130 mph
- Hurricane force winds (> 74 mph) extended 80 miles from the center, and tropical storm force winds (> 39 mph) extended 400 miles from the center

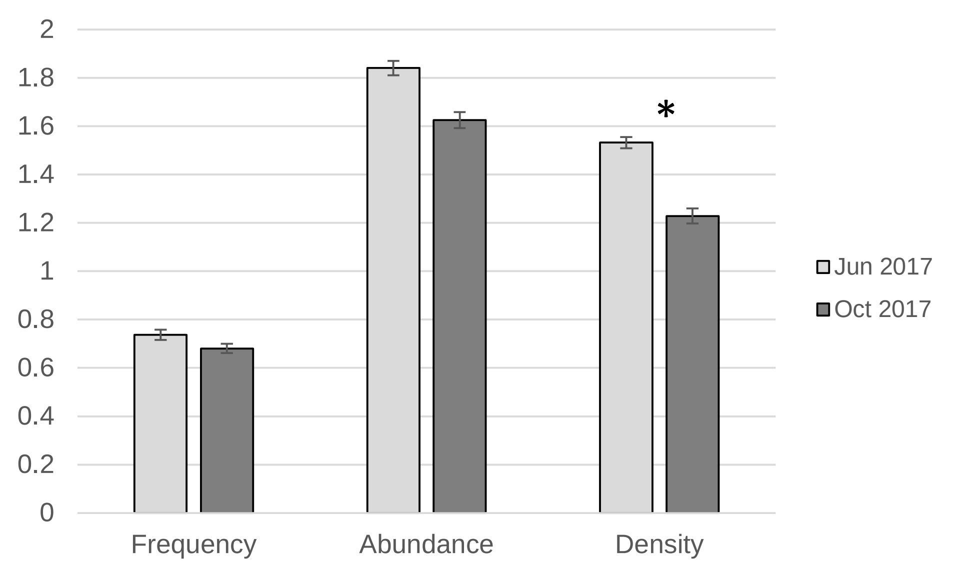
Hurricane Irma (cont.)

- **Heavy winds from Irma affected the entire island chain of the Florida Keys, and the nearshore marine habitats of the FKNMS**



Preliminary Impacts

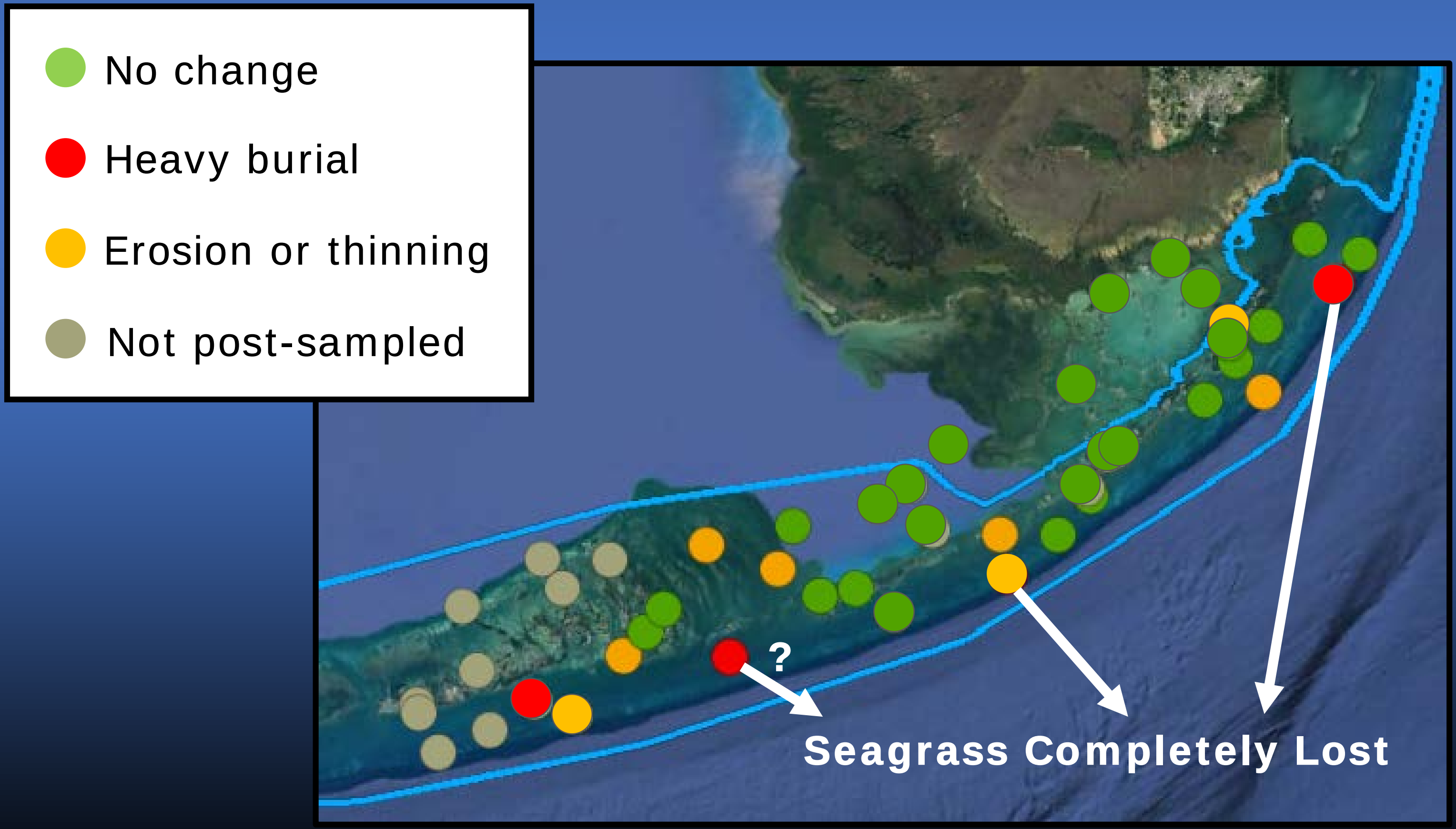
- So far we have post-sampled 31 out of 40 FKNMS sites
- No change at Florida Bay sites
- We have seen lower Frequency, Abundance and Density of *Thalassia* compared to our summer sampling
- So far, pre-/post-Irma differences are greater than pre-/post-Georges differences (Fourqurean and Rutten 2004)



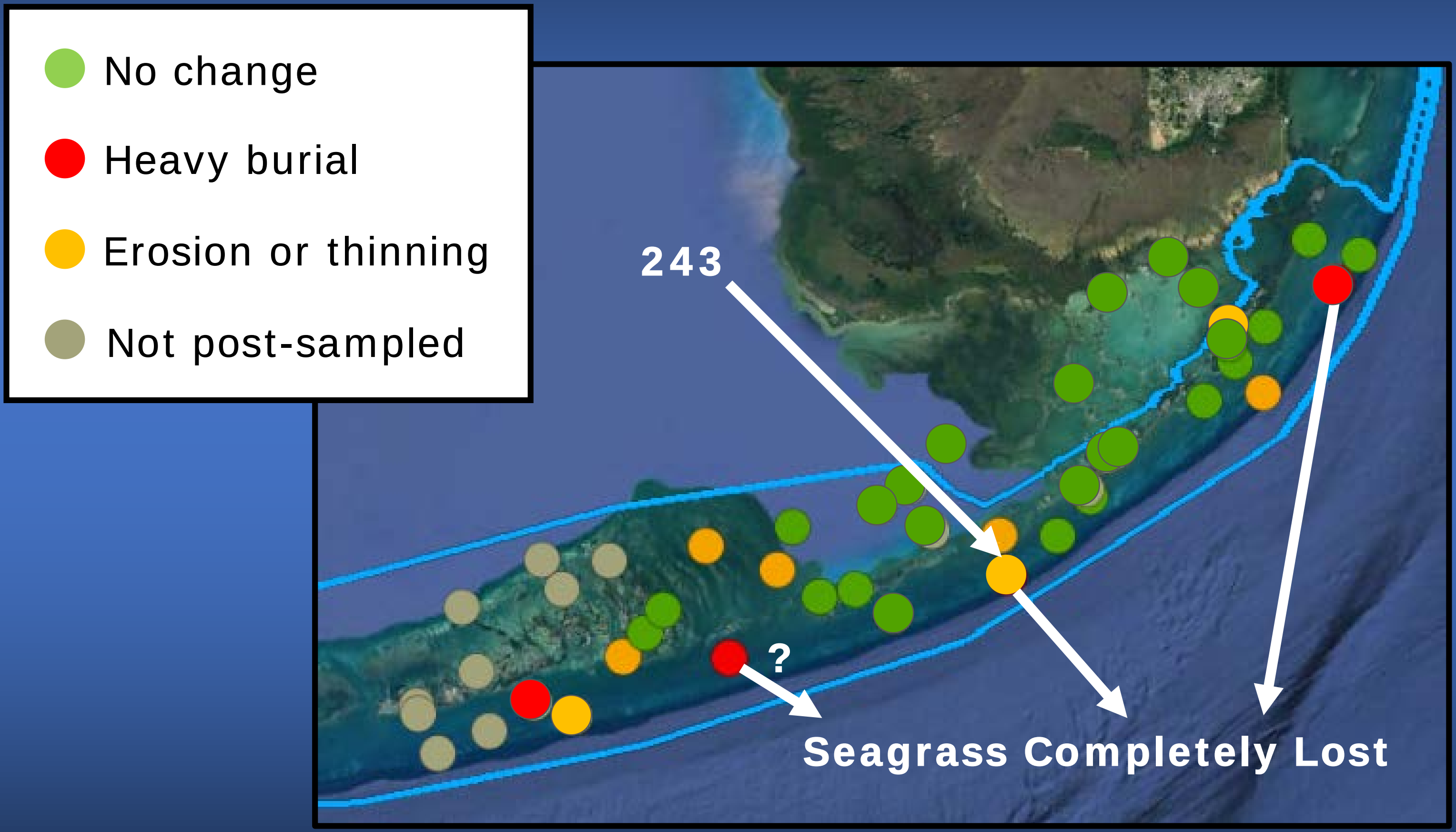
- Three main effects on seagrass communities:
  - <u>Burial</u>
  - <u>Erosion</u>
  - <u>Mechanical Thinning</u>

Preliminary Impacts

- Of the 31 FKNMS sites post-sampled, 20 showed no major changes. 3 sites had heavy burial, and 8 sites had heavy erosion or thinning.
- 2 sites (216 and 243) had a nearly complete loss of seagrass. These sites also had total seagrass loss in 1998 in Hurricane Georges.
- 1 site (255) may end up being a loss because only leaf tips (~2cm) were visible (>10 cm burial).



Heavy Erosion at Site 243



Heavy Erosion at Site 243

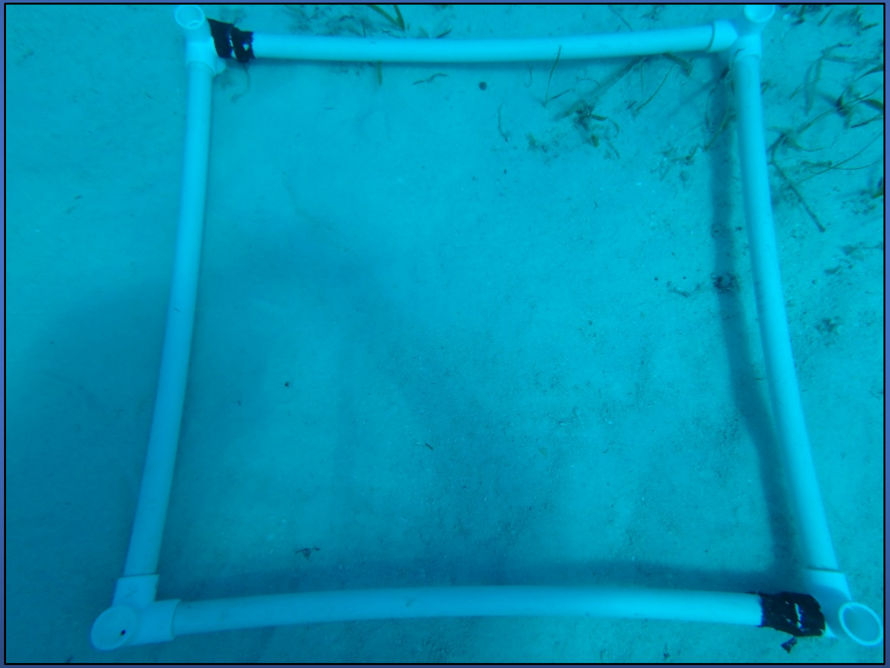



Heavy Erosion at Site 243

June 2017

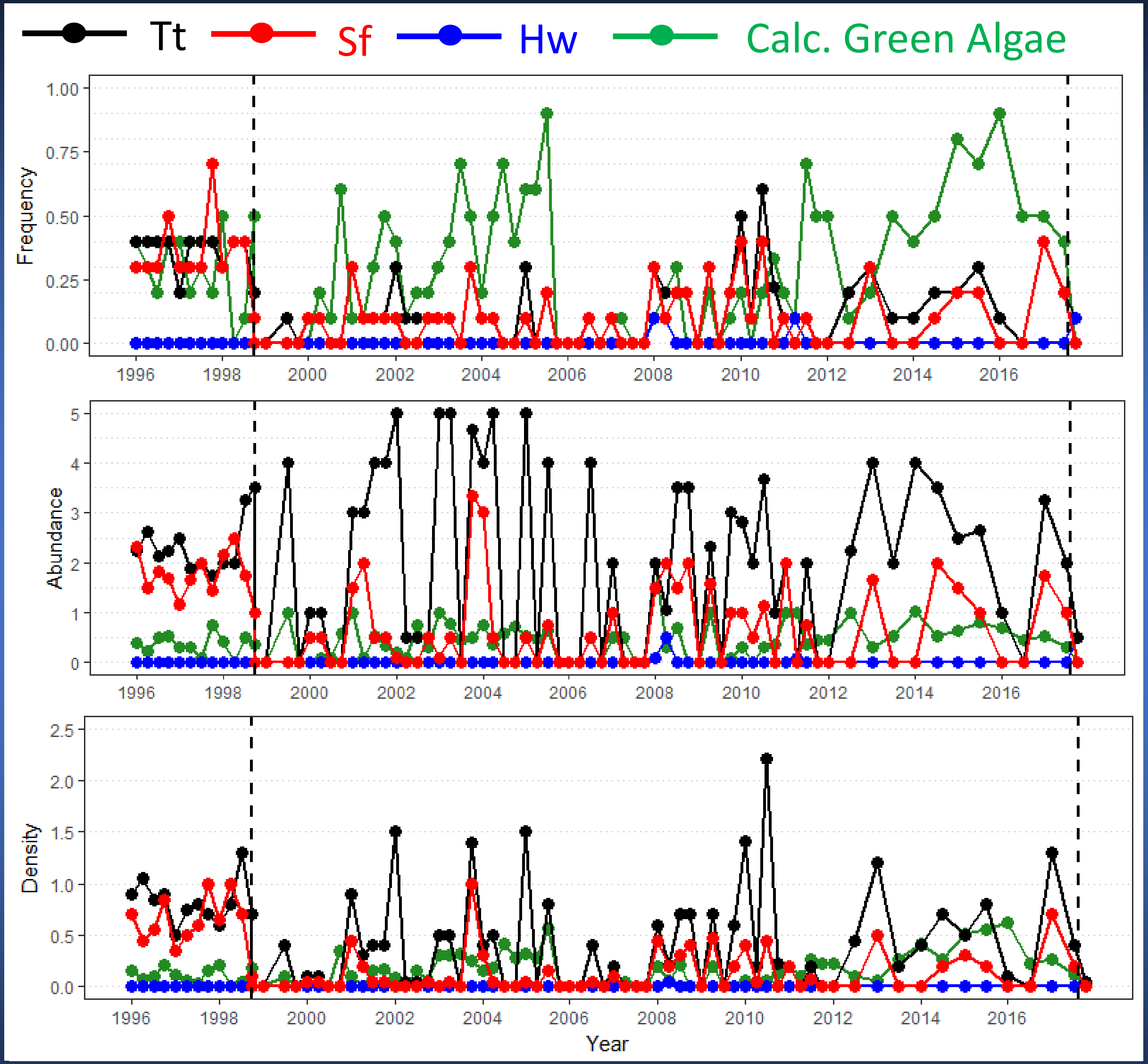
Half of quadrats had lush Tt, half were bare

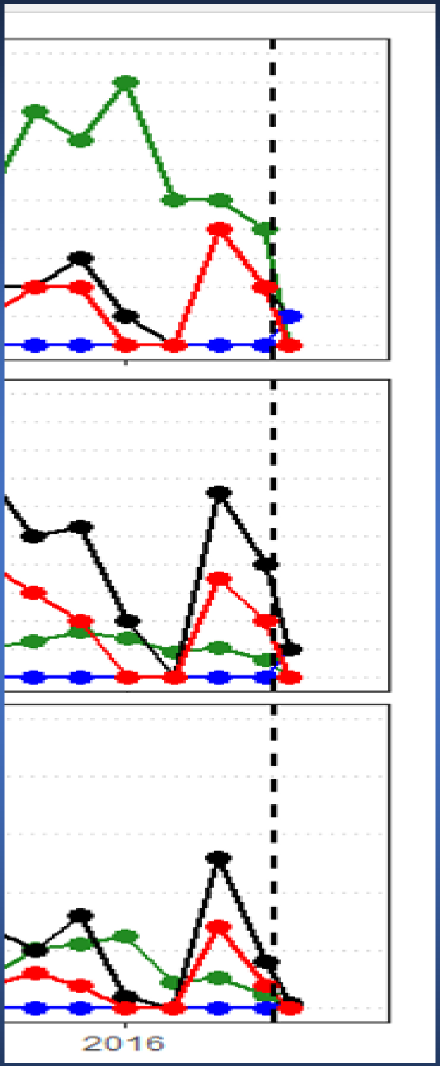
October 2017



Only quadrat left with seagrass

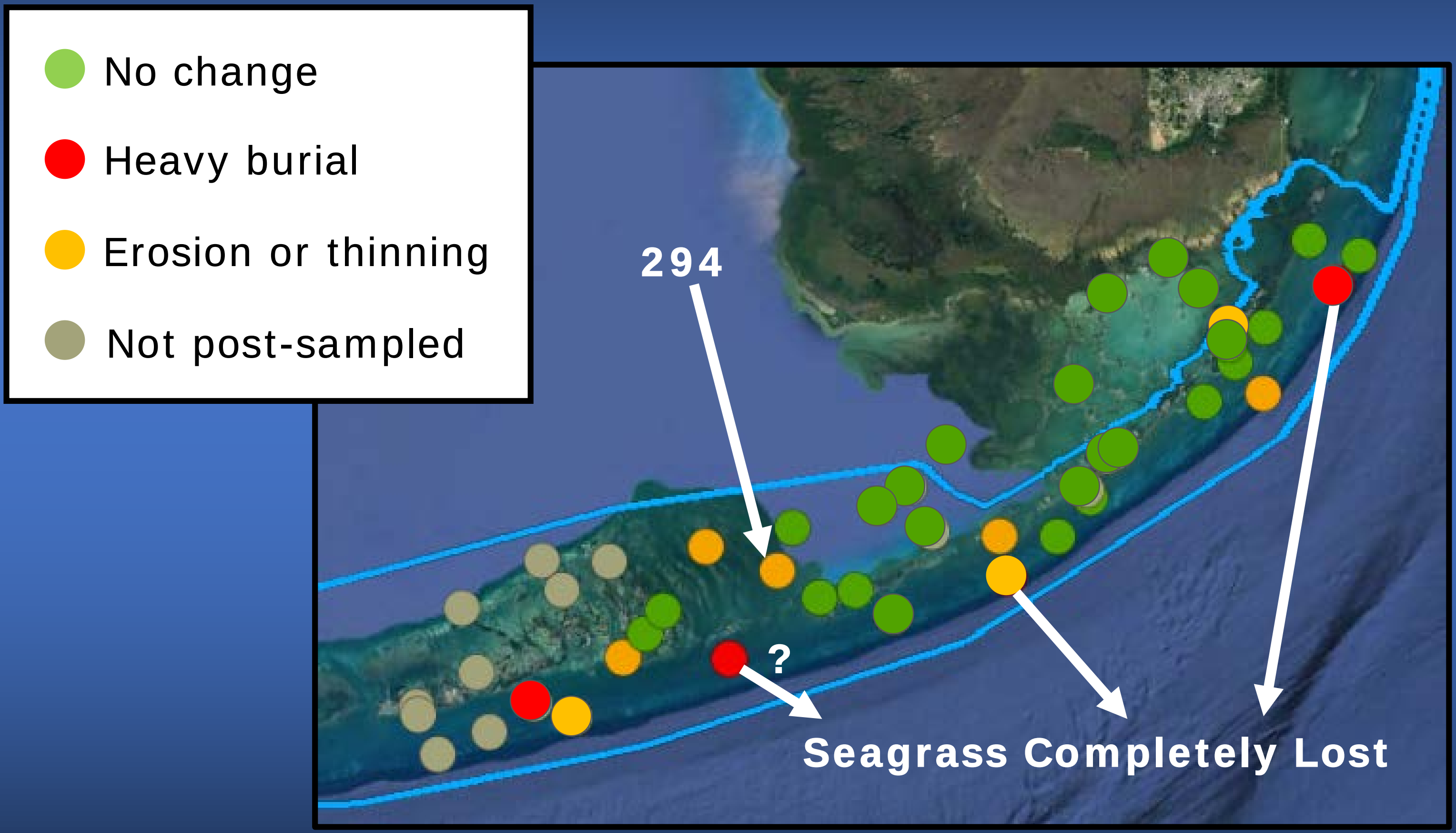
Heavy Erosion at Site 243





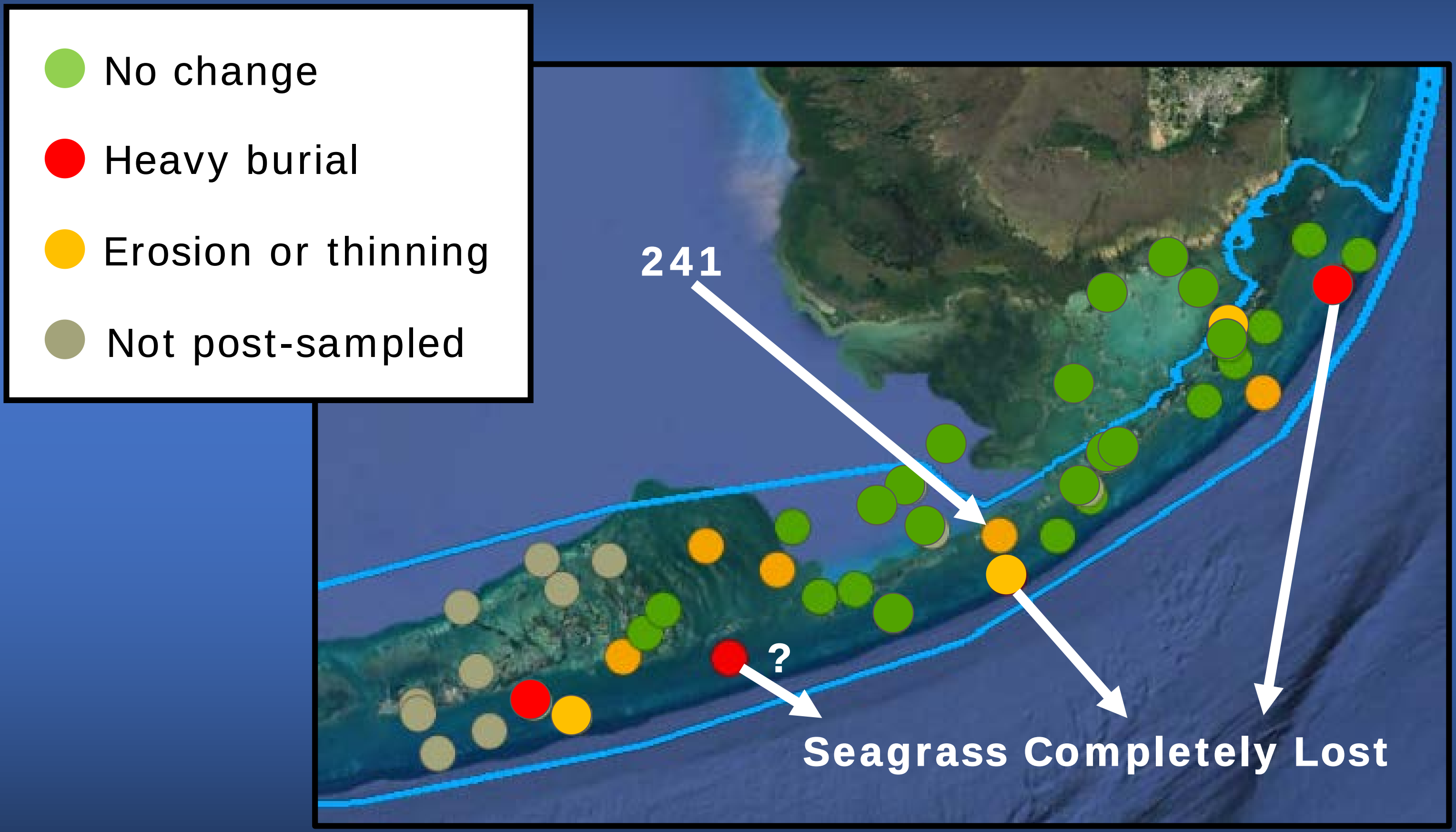
Seagrass Frequency, Abundance and Density measurements from 1996-2017 at site 243. Dashed lines indicate Hurricane Georges in 1998 and Hurricane Irma in 2017. This is an example of a heavily eroded site.

Erosion and Thinning at Site 294



Erosion and Thinning at Site 294

Erosion and Thinning at Site 241



Erosion and Thinning at Site 241

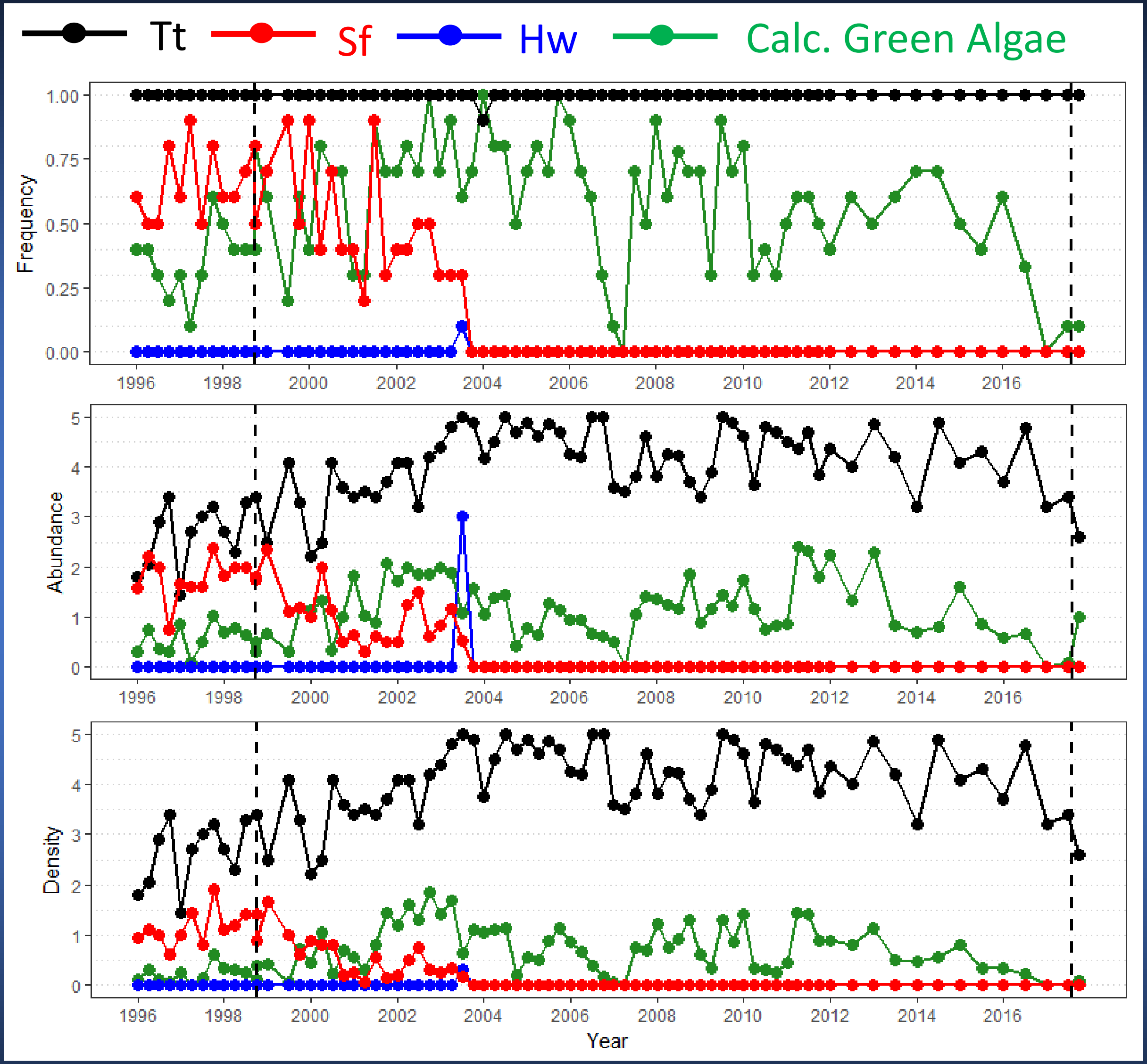
June 2017

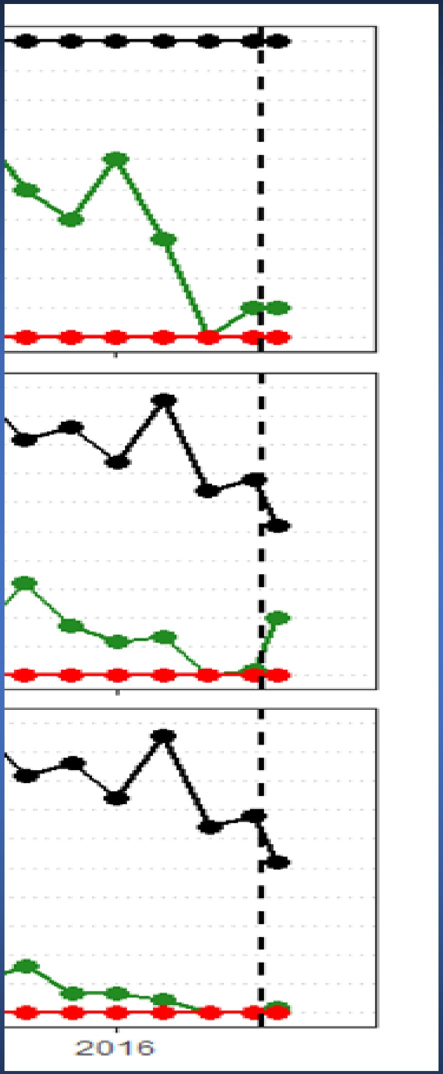
Quadrats had lush Tt

October 2017

> 30% of shoots in quadrat had leaves stripped away

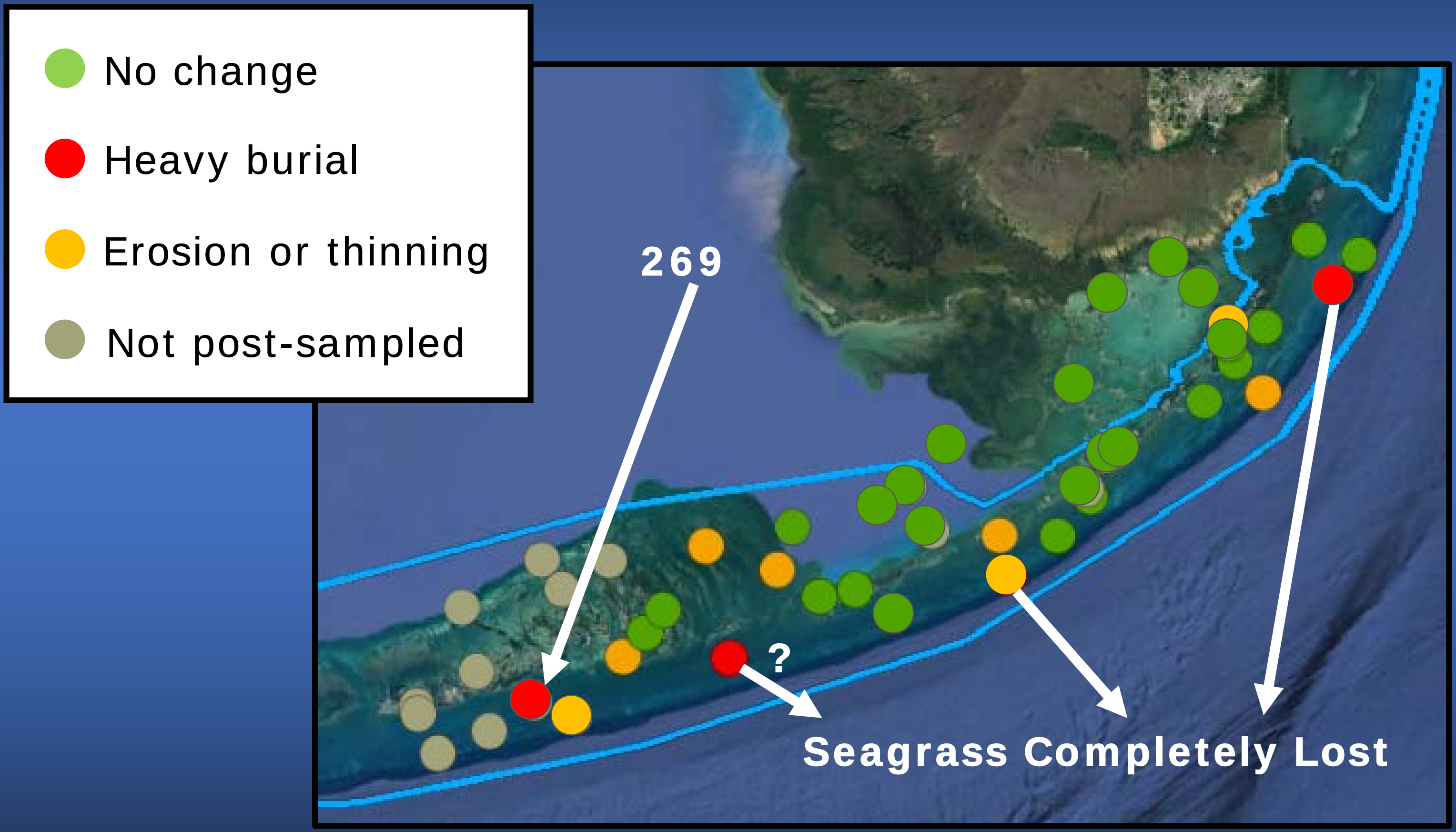
Erosion and Thinning at Site 241



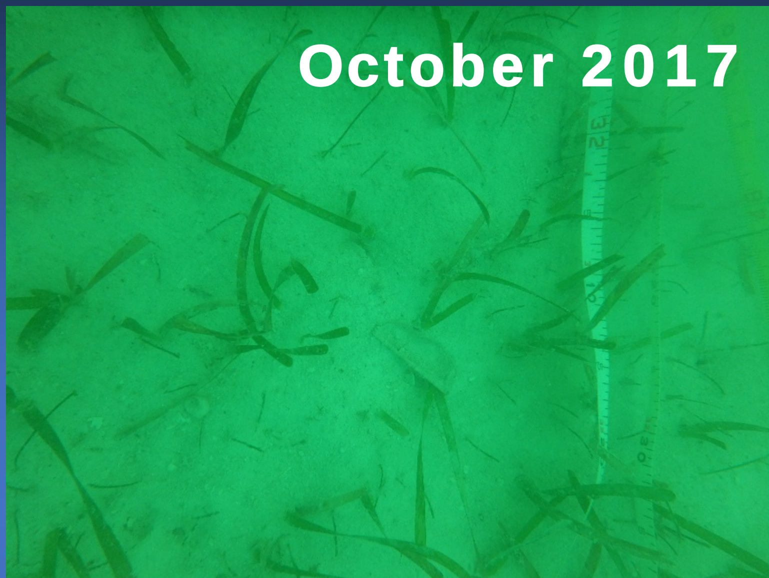


Seagrass Frequency, Abundance and Density measurements from 1996-2017 at site 241. Dashed lines indicate Hurricane Georges in 1998 and Hurricane Irma in 2017. This is an example of a moderately eroded and heavily thinned site.

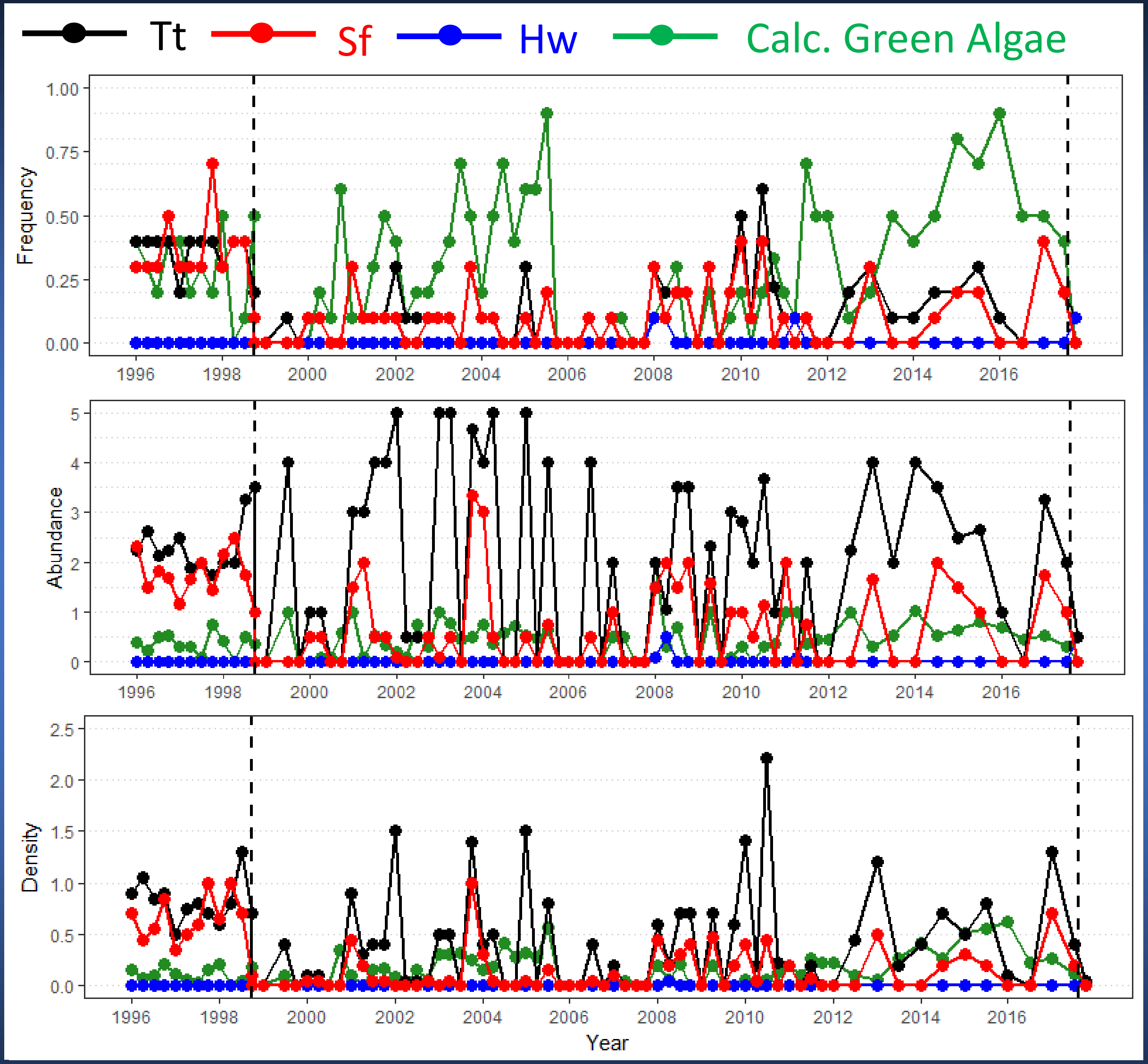
Burial at Site 269

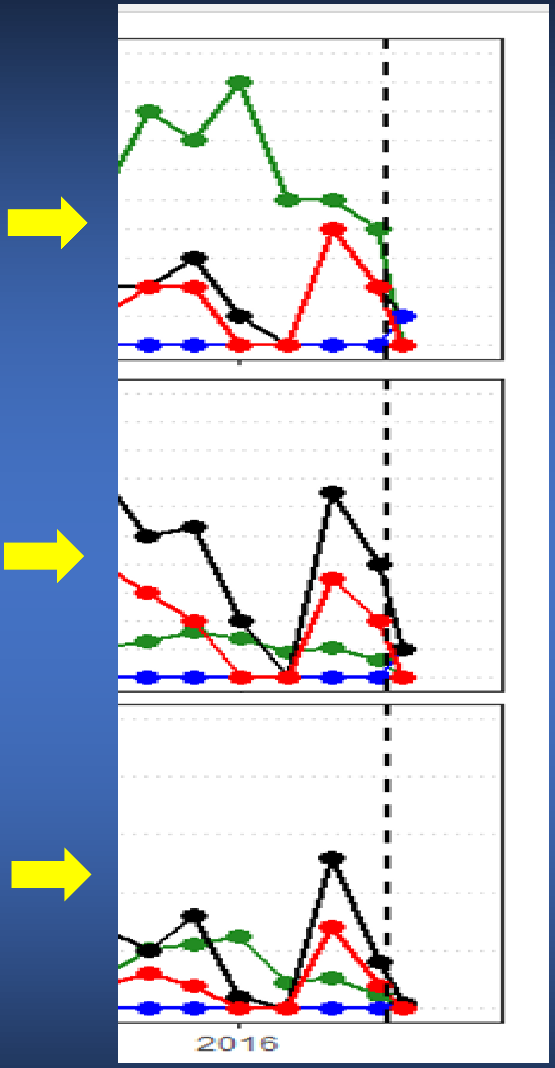


Burial at Site 269



Burial at Site 269

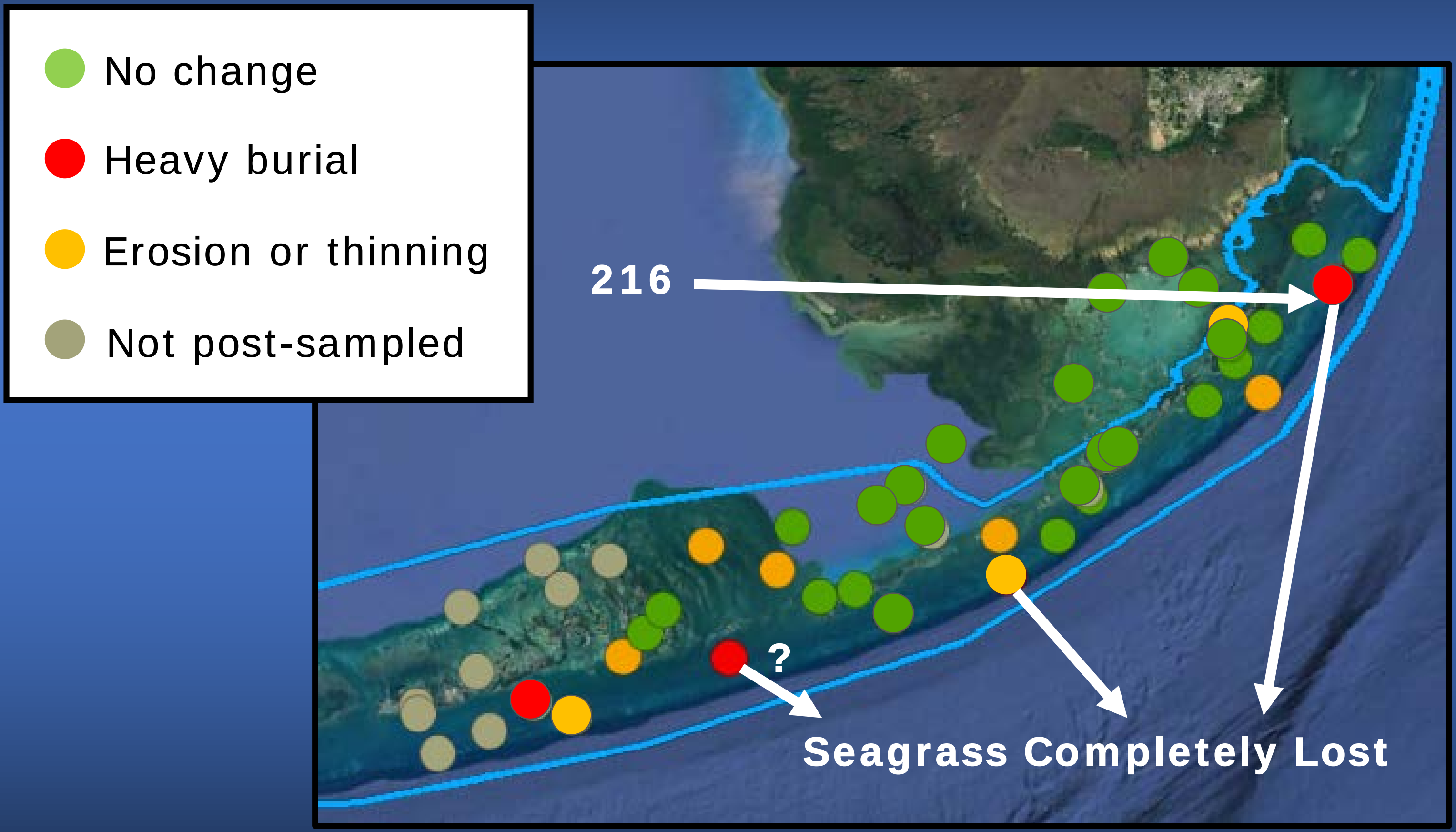




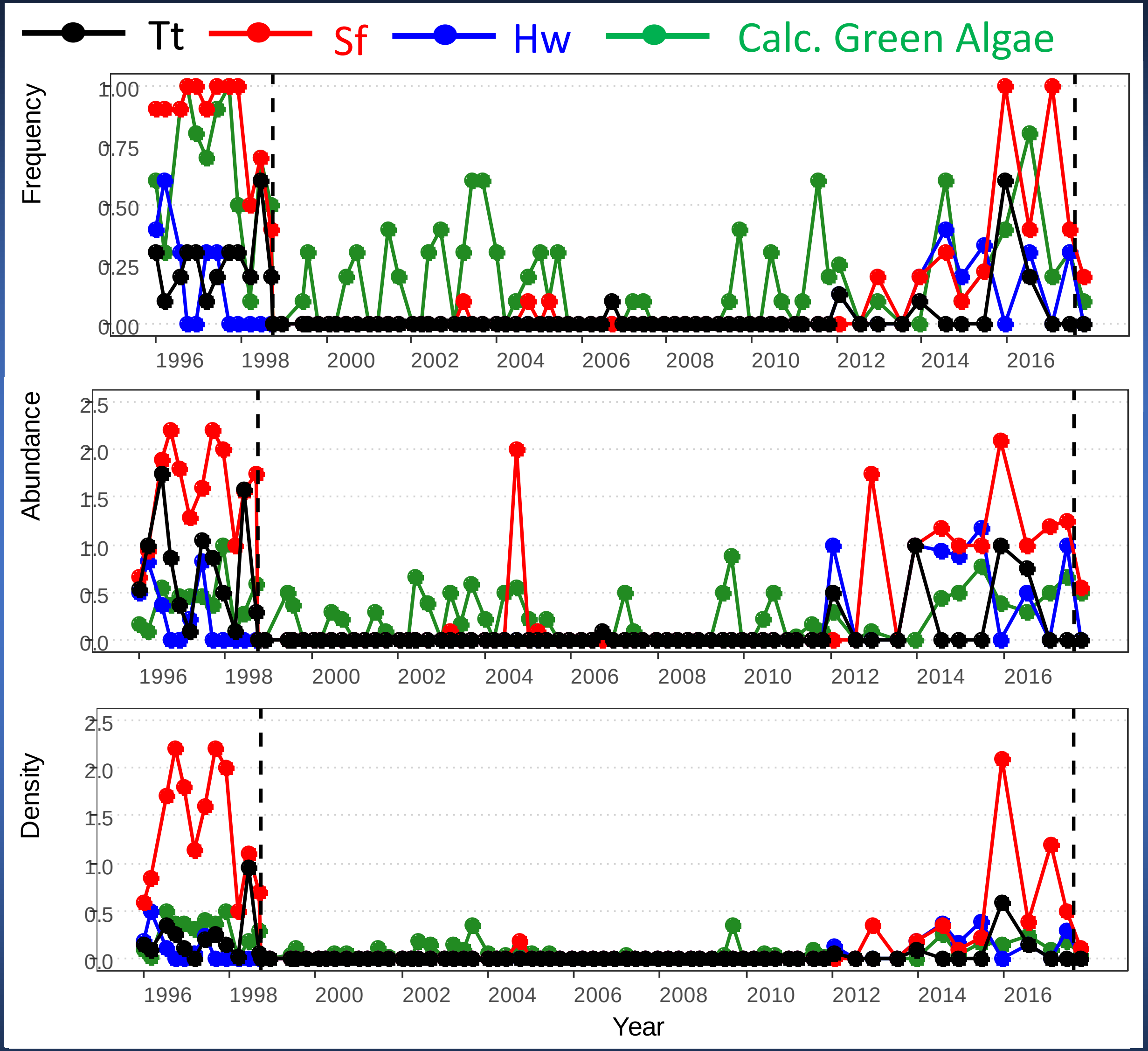
Seagrass Frequency, Abundance and Density measurements from 1996-2017 at site 269. Dashed lines indicate Hurricane Georges in 1998 and Hurricane Irma in 2017. This is an example of a moderately buried site.

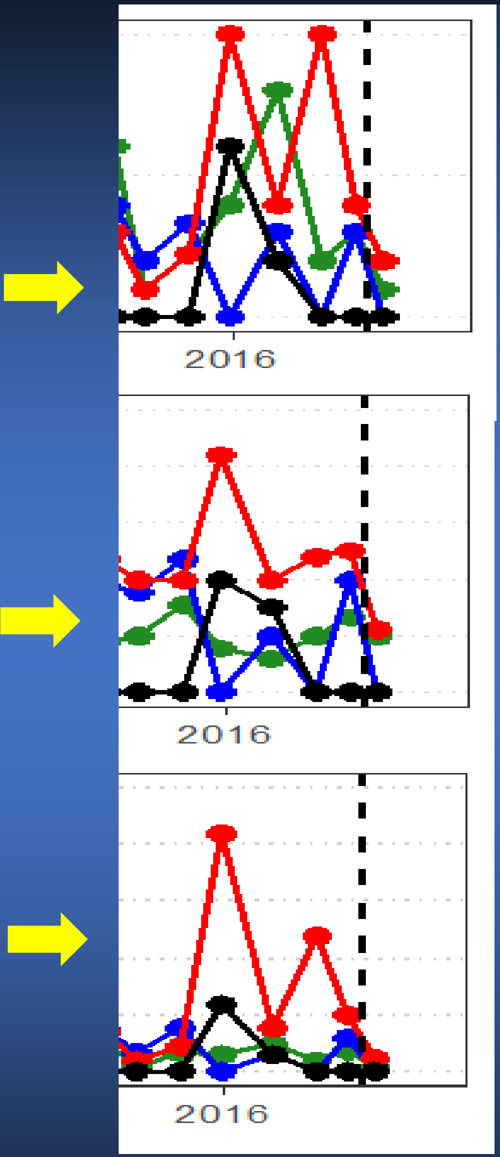
Burial at Site 216

- Site 216 was buried in Hurricane Georges and never fully recovered.



Burial at Site 216





Seagrass Frequency, Abundance and Density measurements from 1996-2017 at site 216. Dashed lines indicate Hurricane Georges in 1998 and Hurricane Irma in 2017. This is an example of a site that never fully recovered after Hurricane Georges.

Summary Points

- Hurricane Irma heavily impacted seagrasses at some FKNMS sites, but left many sites unaffected. Florida Bay sites were all unimpacted.
- The 2 sites heavily eroded by Hurricane Georges (216, 243) were again heavily impacted by Irma, although 216 appears to have been eroded during Georges and buried during Irma.
- With 31 sites re-sampled, so far Hurricane Irma has had a stronger impact on seagrass Frequency, Abundance, and Density than Hurricane Georges.
- Sites with heavy erosion and heavy burial may take a very long time (>5 years) to recover, similar to 216 after Hurricane Georges.
- Sites with thinning and minor burial may recover quickly (<5 years), similar to 291 after Hurricane Georges.
- 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)

Site-specific indicator summary

Significance of linear trends, 1995-2017

Site	N:P	SCI	$\delta^{13}C$	$\delta^{15}N$
214		**	*	
215			*	
216	**		*	
220			**	
223	*		**	
225				*
227				
235	**			
237	**			
239				
241	**	***	**	
243	**			
248		***		
255	*		*	
260	*	***	**	

Site	N:P	SCI	$\delta^{13}C$	$\delta^{15}N$
267				*
269		*		*
271		*		
273	*	***		
276				
284				**
285		**		
287			**	
291		***		
294	***	**	**	
296	*		*	
305		**		
307			**	
309		**		
314		**	**	

Recent Updates

- **C:N, C:P and N:P molar ratios, and ´ ^{13}C and ´ ^{15}N isotopic signatures for *T. testudinum* in the FKNMS are within normal ranges**