FKNMS
Benthic Habitat Monitoring Program

FKNMS Steering Committee Meeting, Feb 20, 2013, Marathon, FL

Goals for the project

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**
- **Quantify the importance of seagrass primary production in the FKNMS**
- **Define the baseline conditions for the seagrass communities of south Florida**
- **Determine relationships between water quality & benthic community status**
- **Detect trends in the distribution and status of the benthic communities**

Monitoring strategy

Given that it is not possible to measure everything, everywhere, all the time:

- **Limited resources had to be allocated to addressing the competing goals of spatial comprehensiveness and temporal sensitivity.**
- **Spatial comprehensiveness assured by adopting a distributed, stratified-random site selection procedure for "synoptic mapping" sites (REMAP).**
- **Temporal sensitivity assured by concentrating some of the sampling effort on randomly-selected, permanent sites**

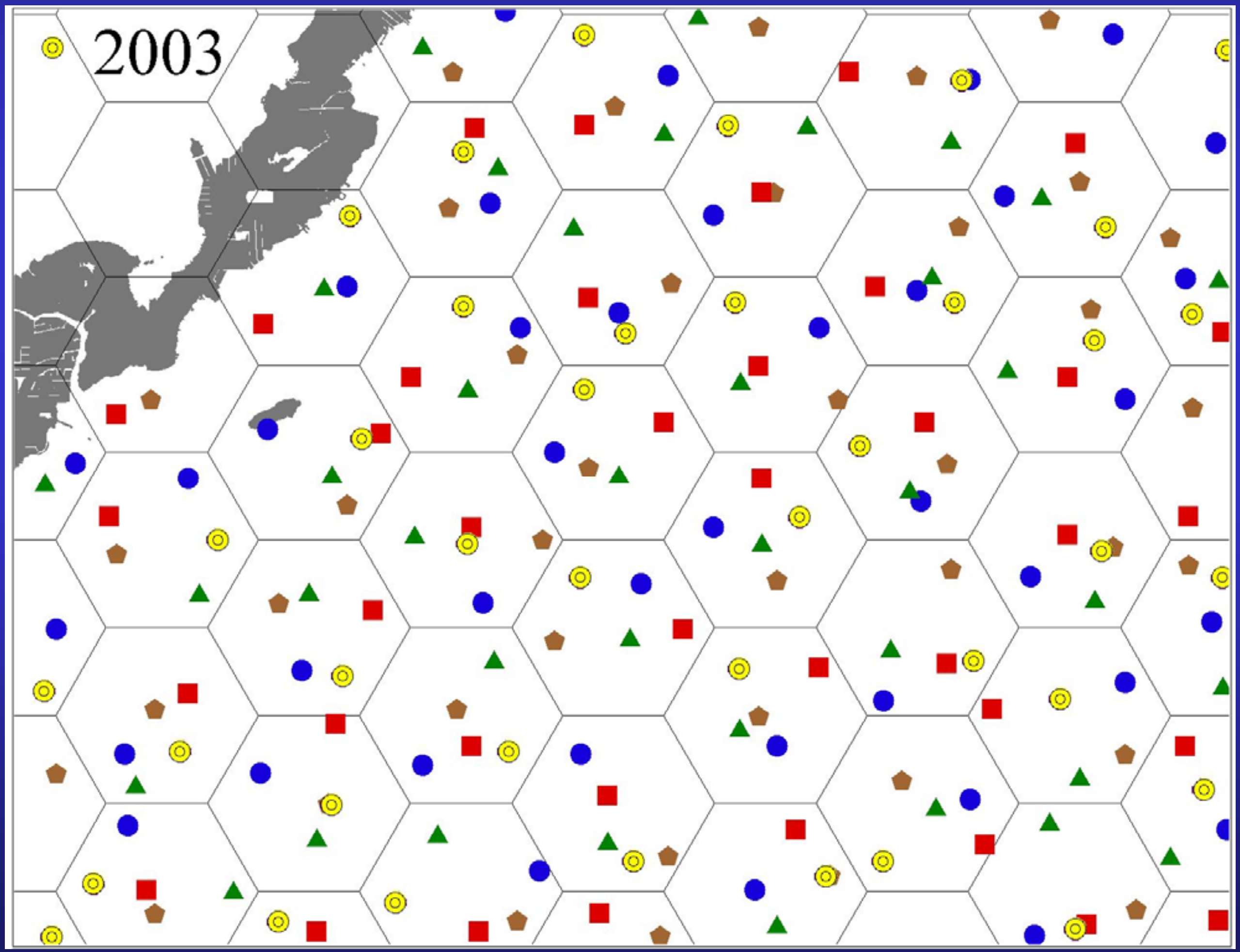
Information being collected

- Distribution & abundance of seagrasses and associated fauna and flora using rapid assessment Braun-Blanquet surveys
  - ~~30~~ 40 permanent sites ~~4~~ 2 times a year
  - ~~Ca. 200 mapping sites/year~~

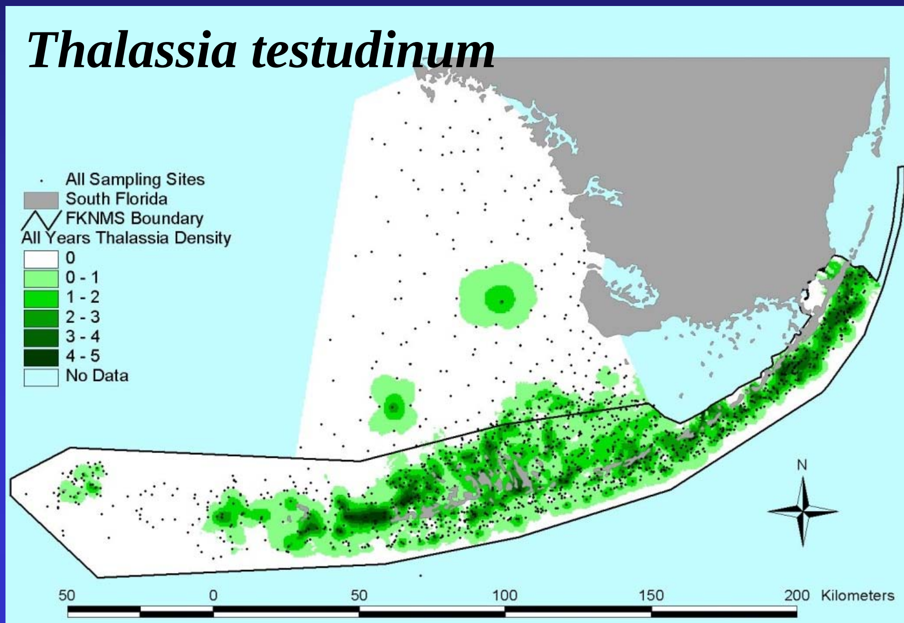
- Seagrass nutrient availability using tissue concentration assays and stable isotopic analyses
  - ~~30~~ 40 permanent sites ~~4~~ 2 times a year
  - ~~Ca. 200 mapping sites/year~~

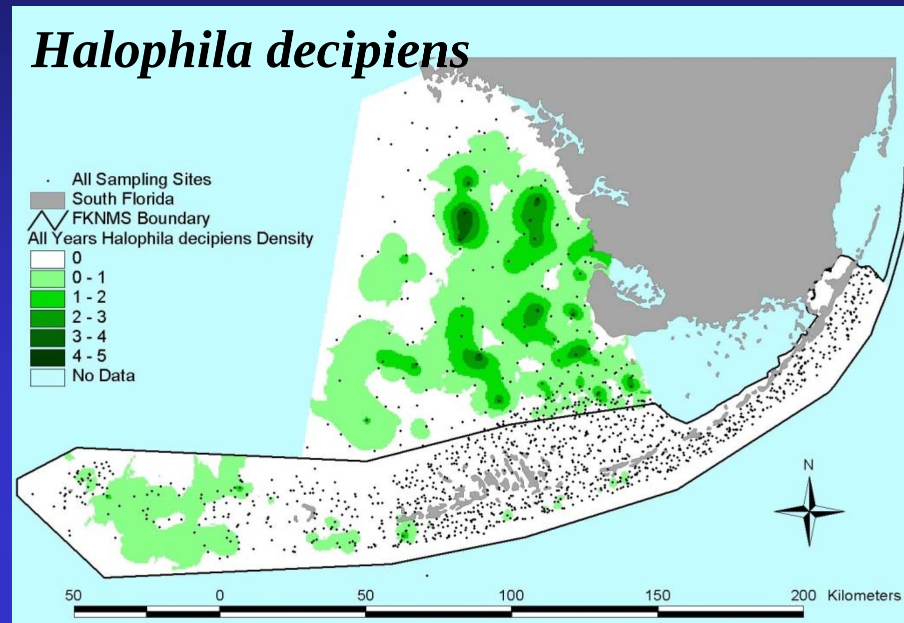
- Water column physicochemical data
  - ~~30~~ 40 permanent sites ~~4~~ 2 times a year
  - ~~Ca. 200 mapping sites/year~~

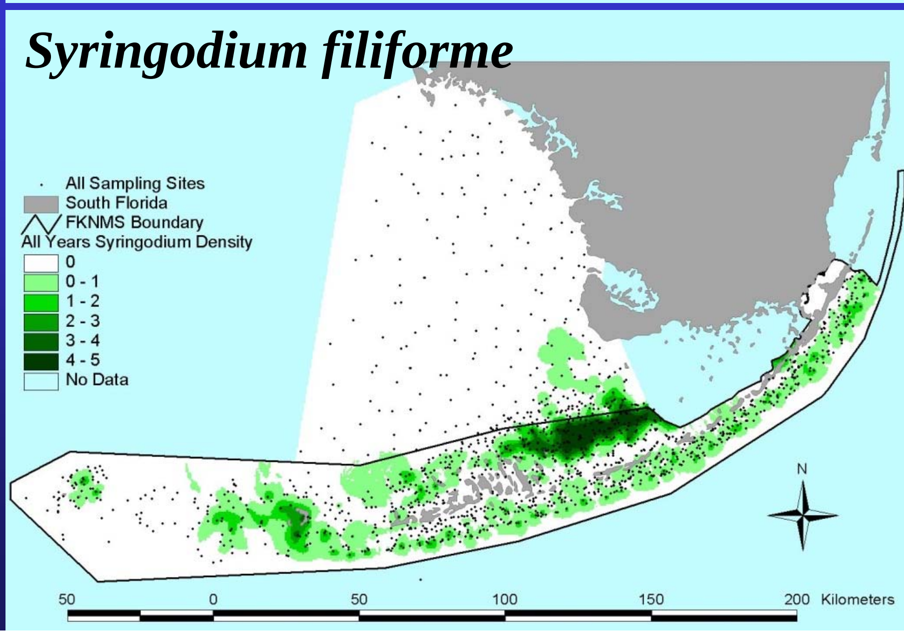
Describing spatial pattern in monitoring data – Stratified-random sampling

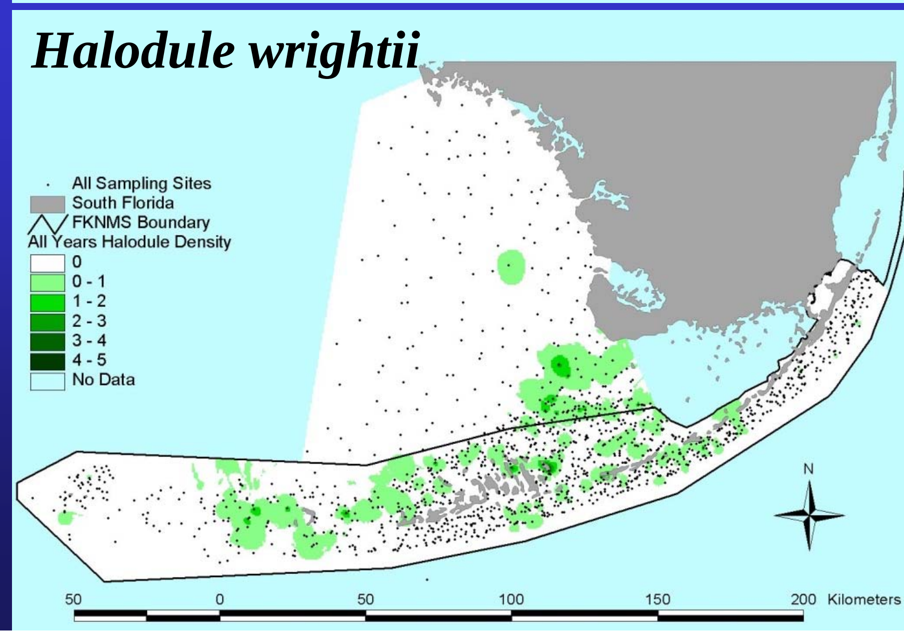


Synoptic Surveys: Species distributions

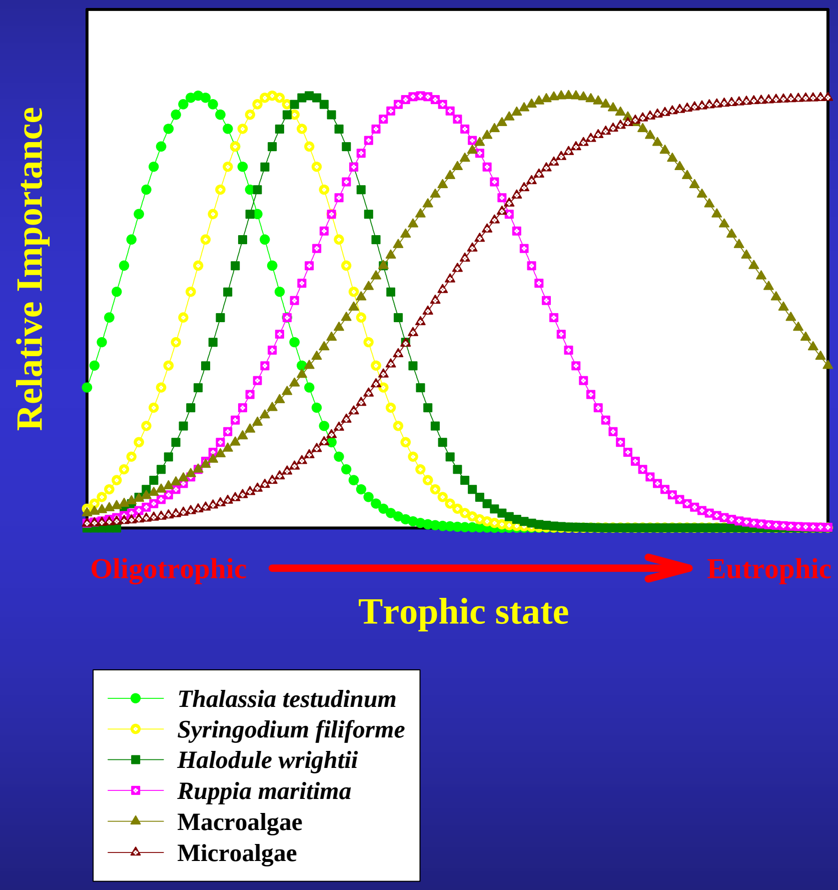








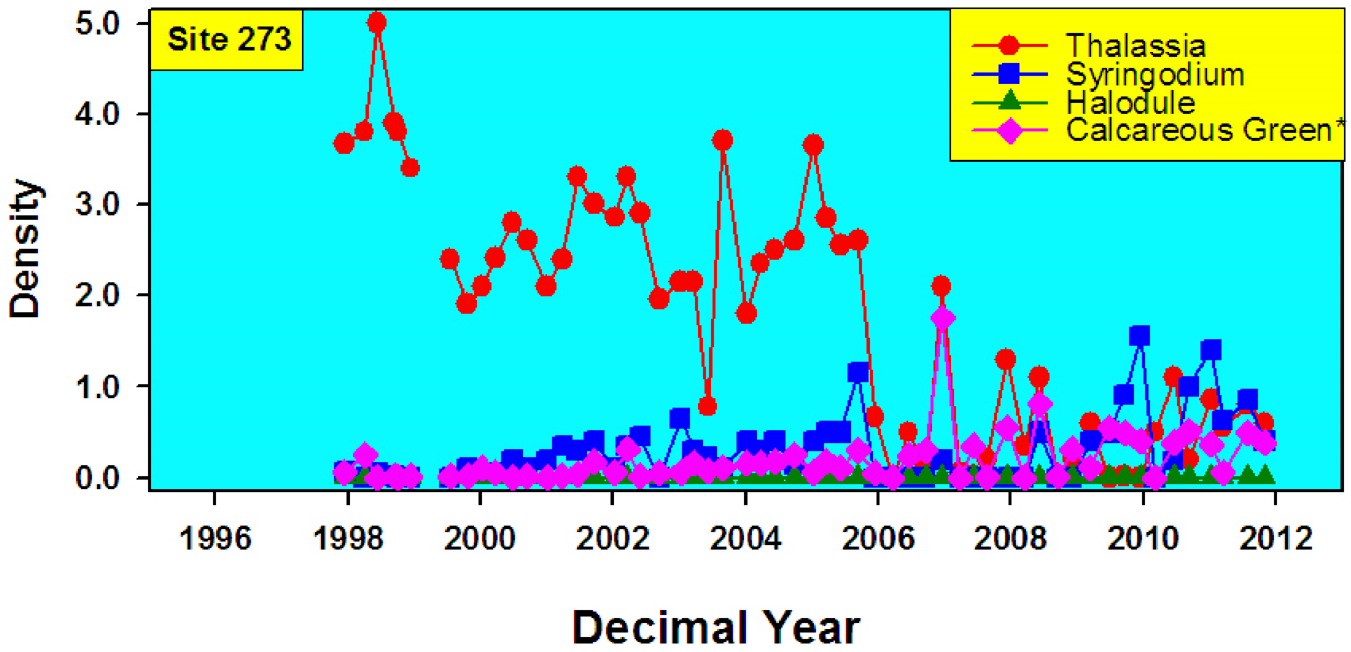
Eutrophication model



Explicit model of ecosystem behavior #1

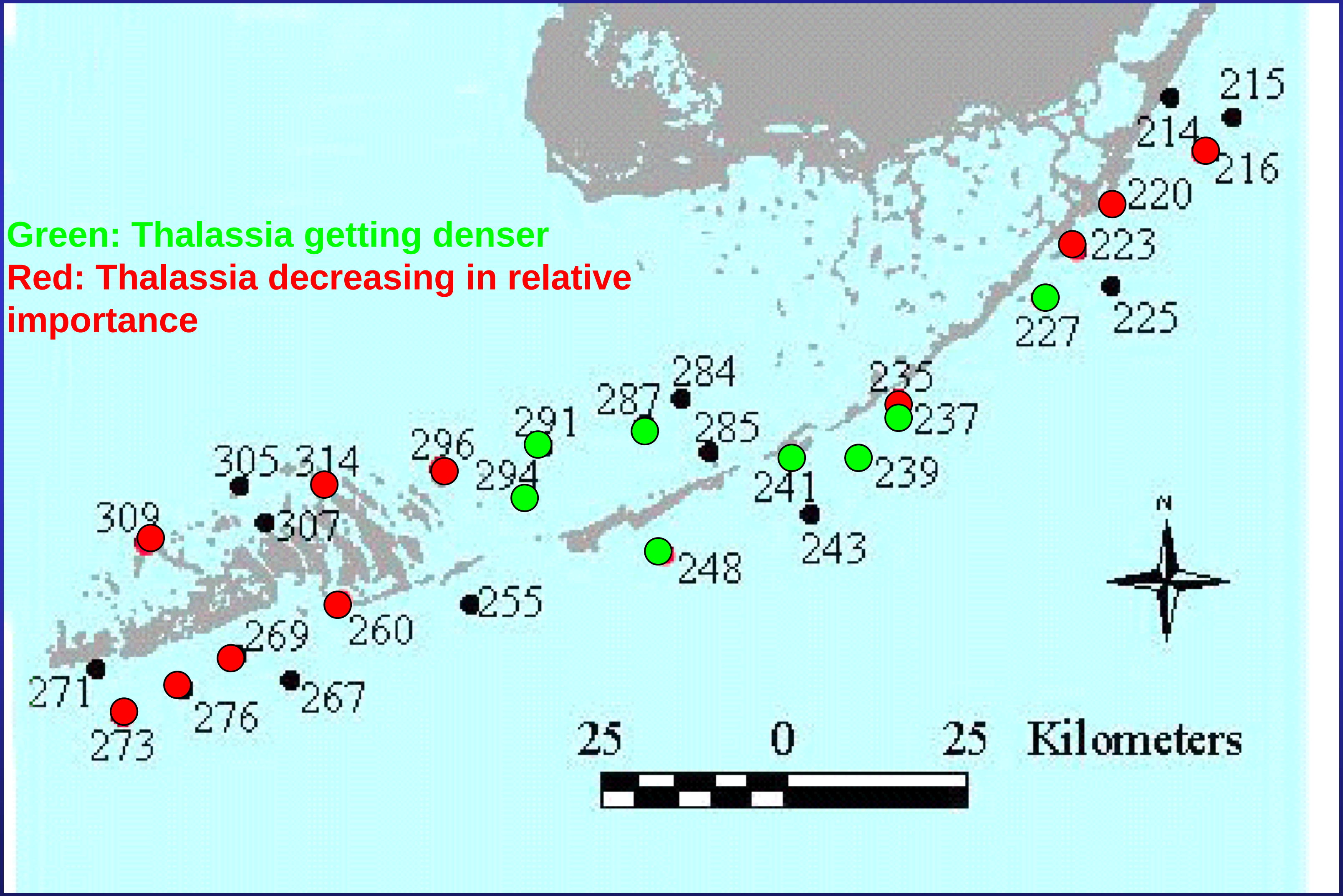
Nutrient pollution will lead to changes in relative abundances of primary producers in a predictable way.

Changes in relative abundance of primary producers



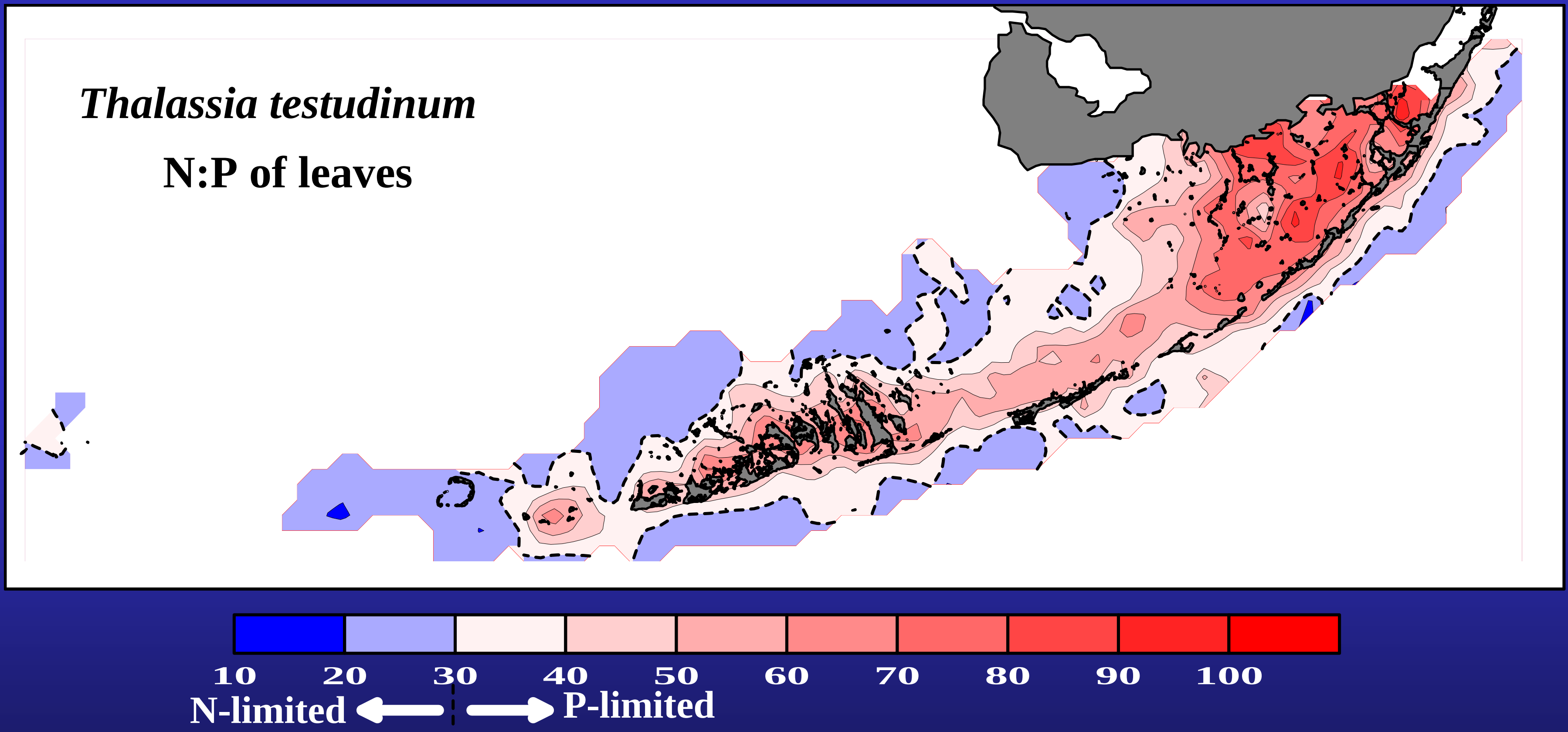
Changes in relative abundance of primary producers

At 19 of 30 sites, species composition has shifted in a manner consistent with increased nutrient availability



Changes in N:P of primary producers #1:

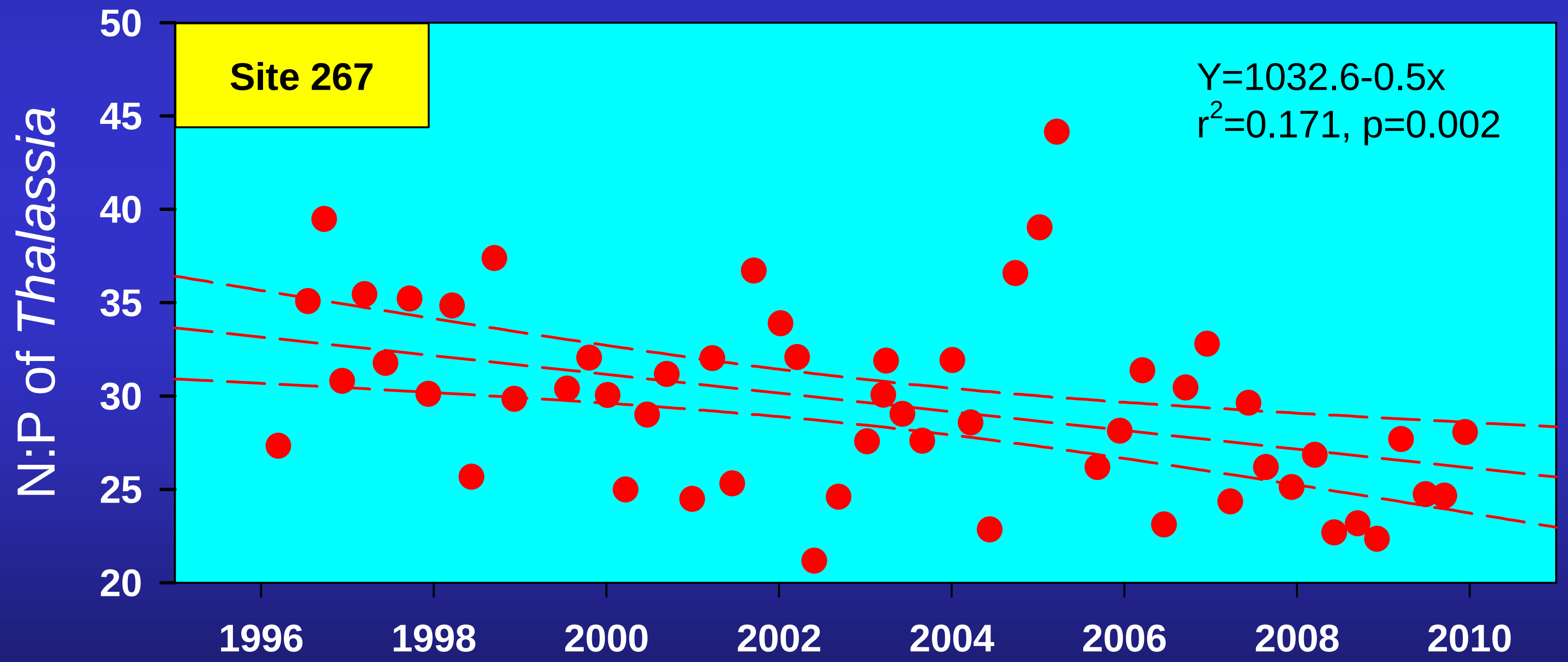
There is a spatial pattern in the relative availability of N and P



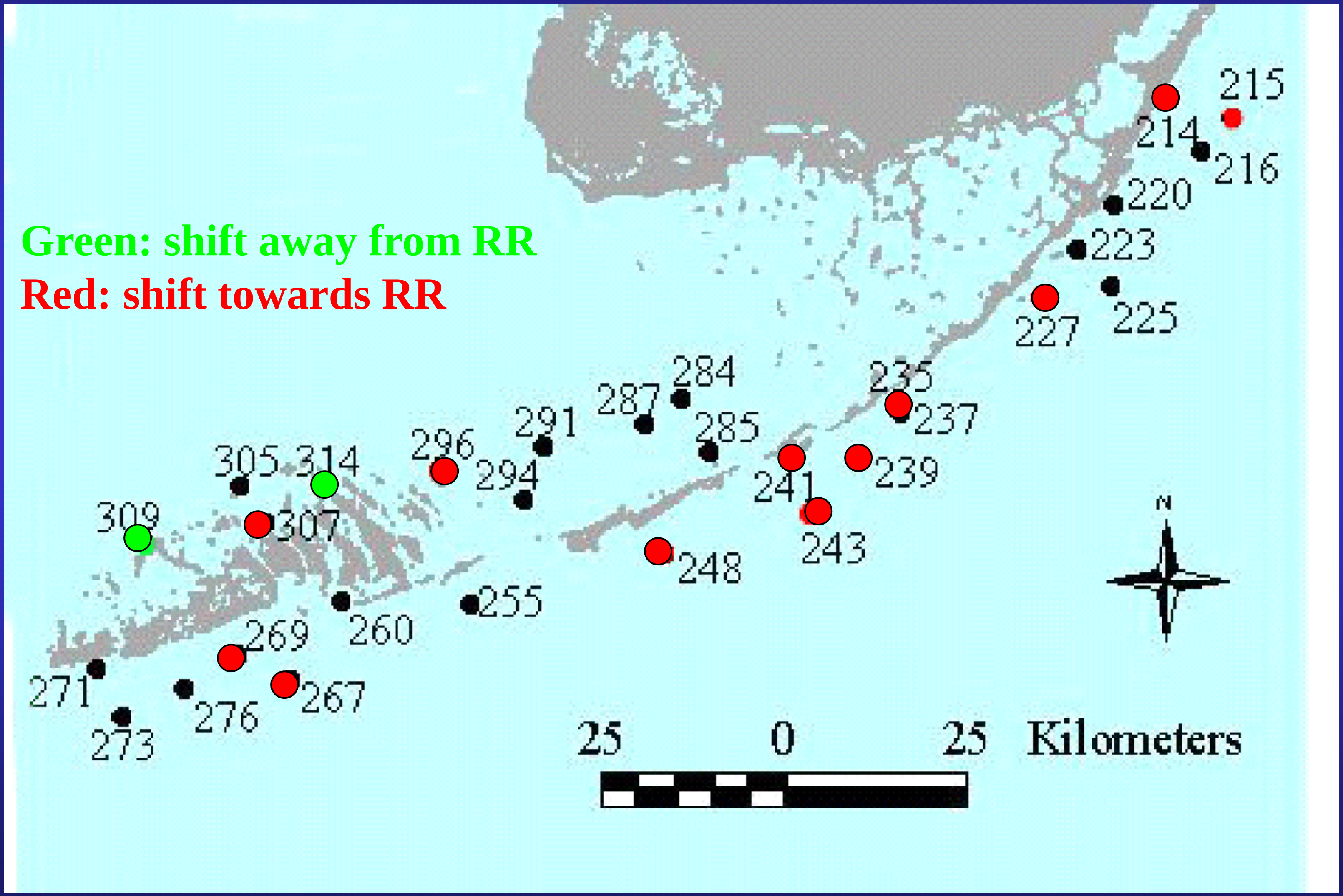
Fourqurean et al Estuaries 2005

Changes in N:P of primary producers

At 13 of 30 sites, N:P is trending towards "seagrass Redfield ratio"

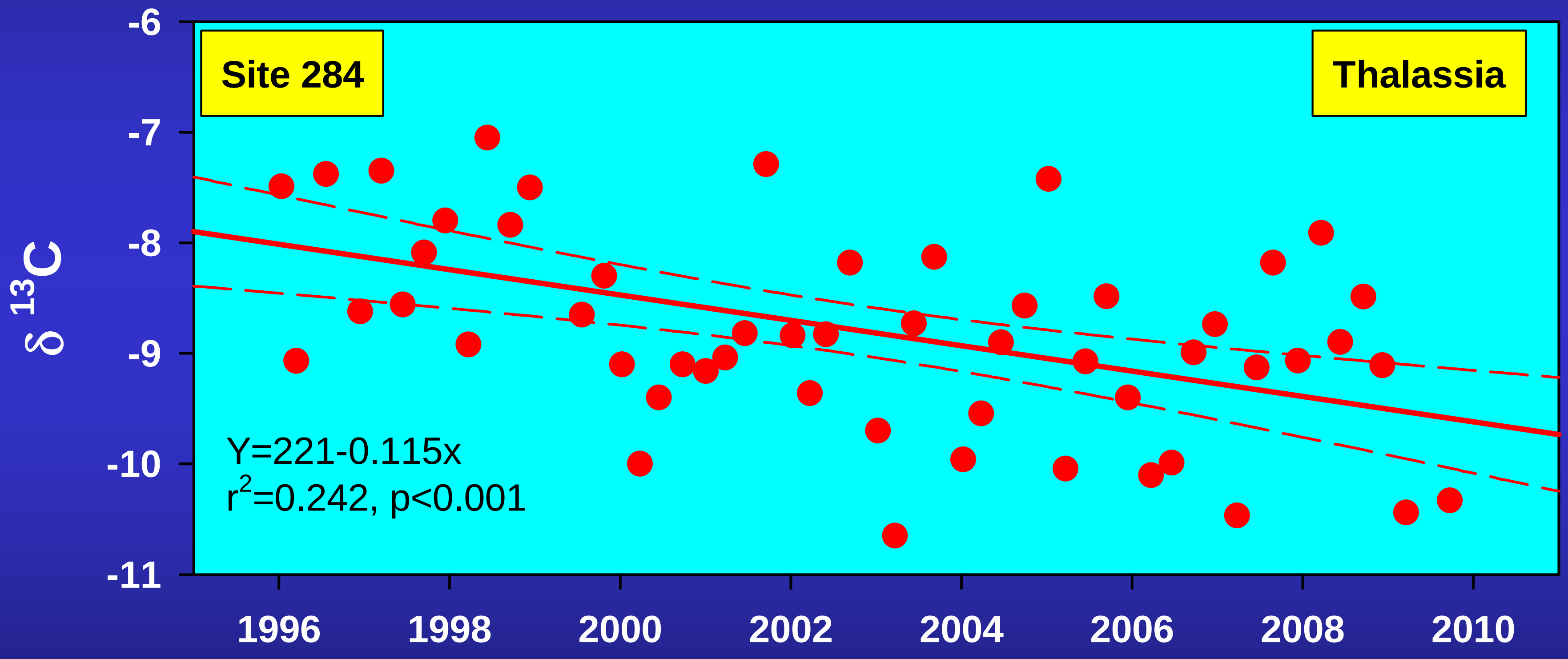


Changes in N:P of primary producers

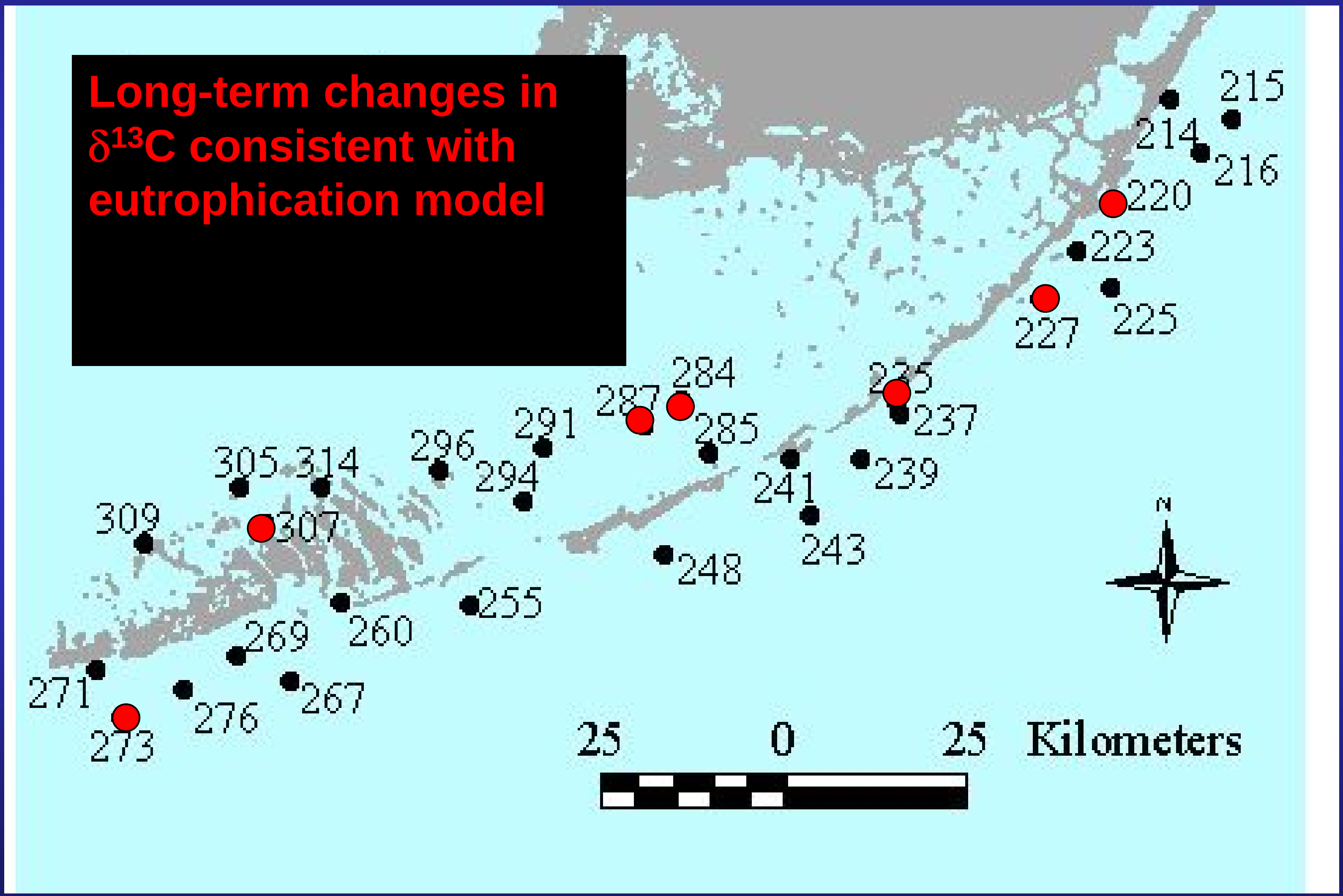


Changes in δ¹³C of primary producers

At 7 of 30 sites, significant δ¹³C trends consistent with eutrophication (7 of 30 last year)



Changes in $\delta^{13}C$ of primary producers #2



Site-specific indicator summary 1995-2009

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	+			-

FKNMS Seagrass Status Criteria

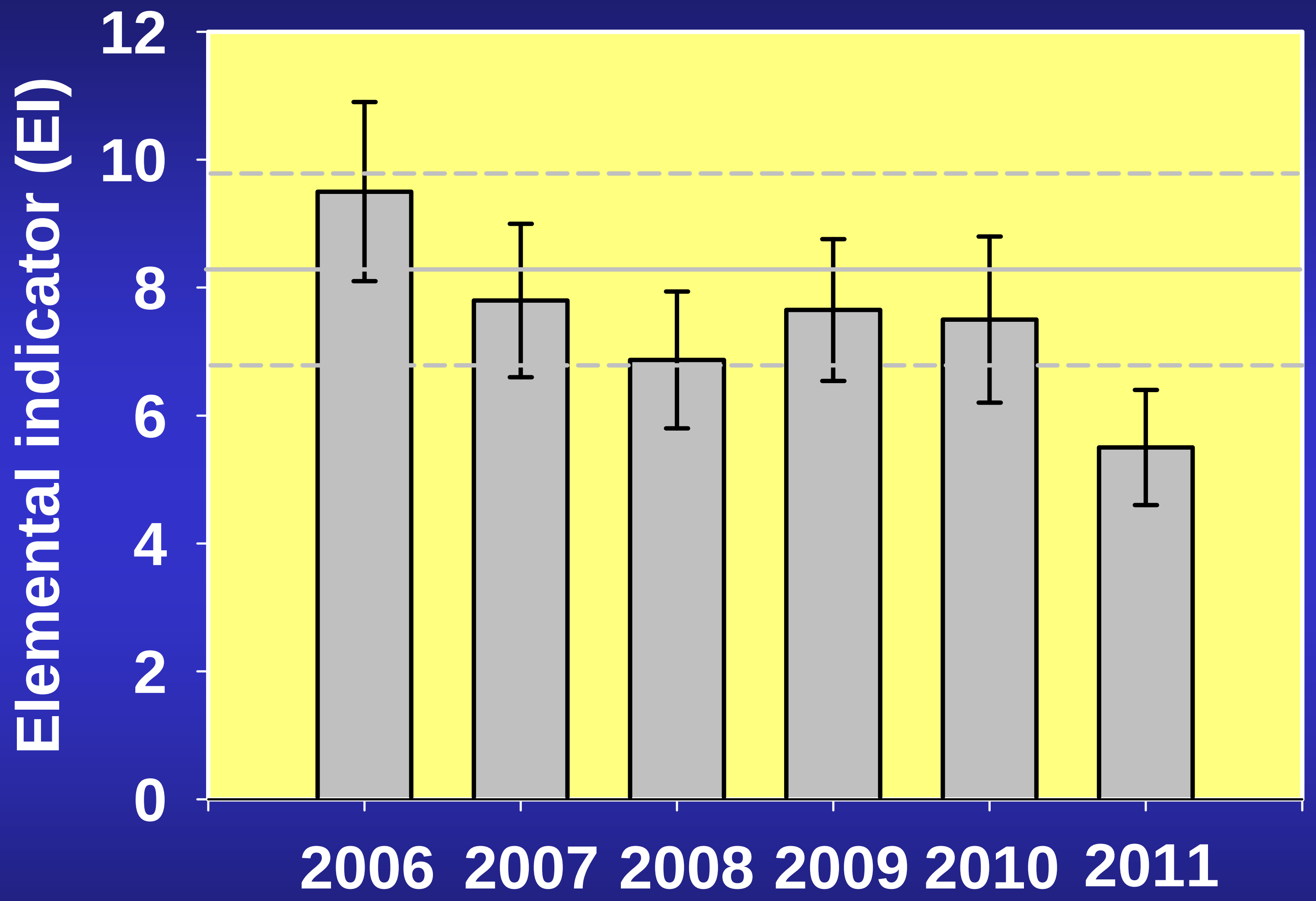
- **We have defined 2 criteria to track the status of seagrasses Sanctuary-wide, based on our conceptual models**
- **The first is based on the relative dominance of slow-growing species:**

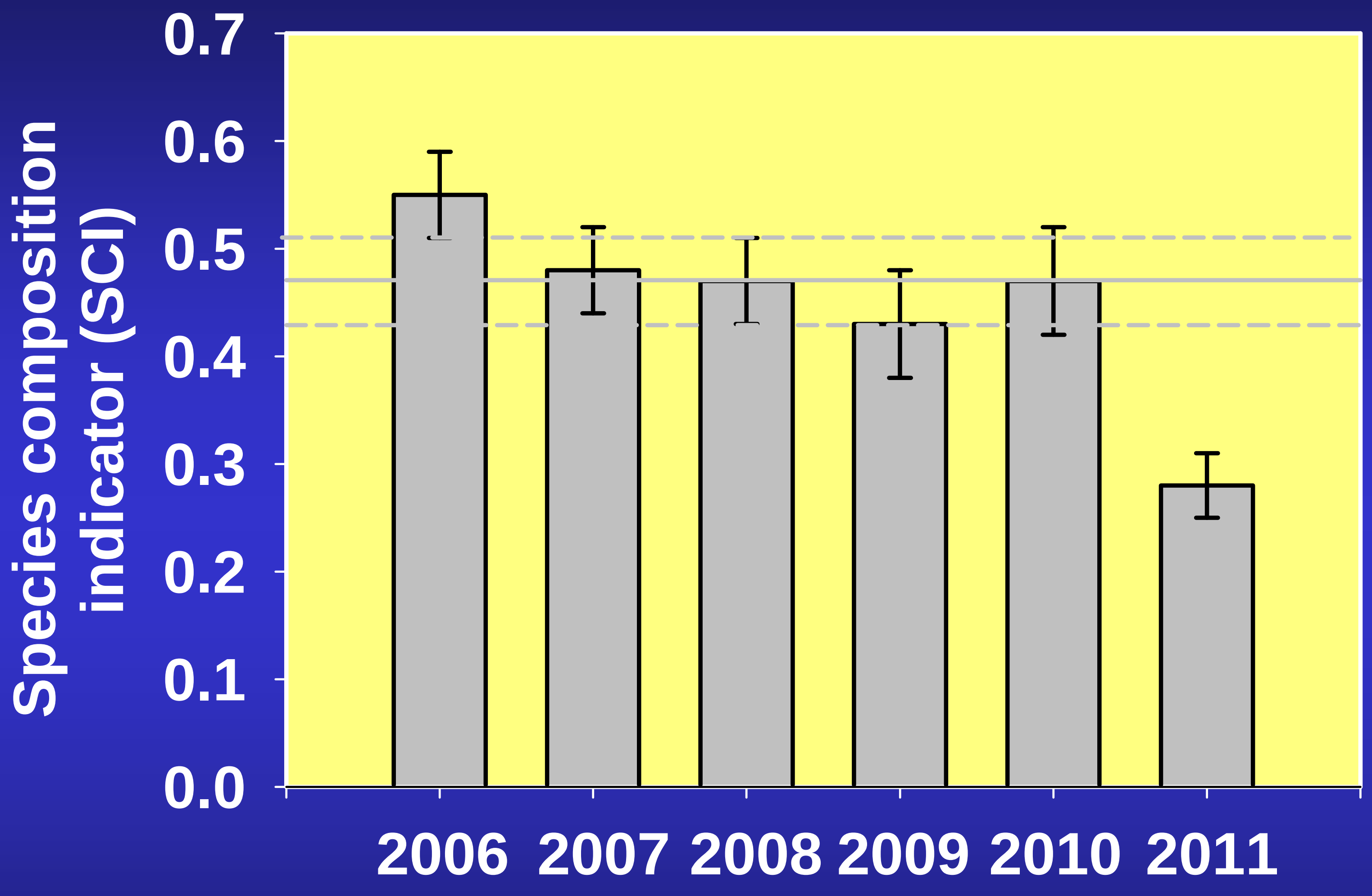
$$SLOW = \frac{A_{Tt}}{A_{Tt} + A_{Sf} + A_{Hw} + A_{Macroa\lg ae}} \qquad SCI = \frac{\sum_{i=1}^{30} SLOW_i}{30}$$

- **The baseline SCI, calculated from data collected between 1995-2005, was 0.48 ± 0.04. Any decrease in SCI indicates declining water quality**
- **The second is based on nutrient content of the slowest growing species:**

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

- **The long-term average EI of *Thalassia* leaves at the 30 sites is 8.28 ± 1.47**


Elemental indicator (EI)
12
10
8
6
4
2
0
2006
2007
2008
2009
2010
2011


Species composition indicator (SCI)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
2006
2007
2008
2009
2010
2011

Summary points

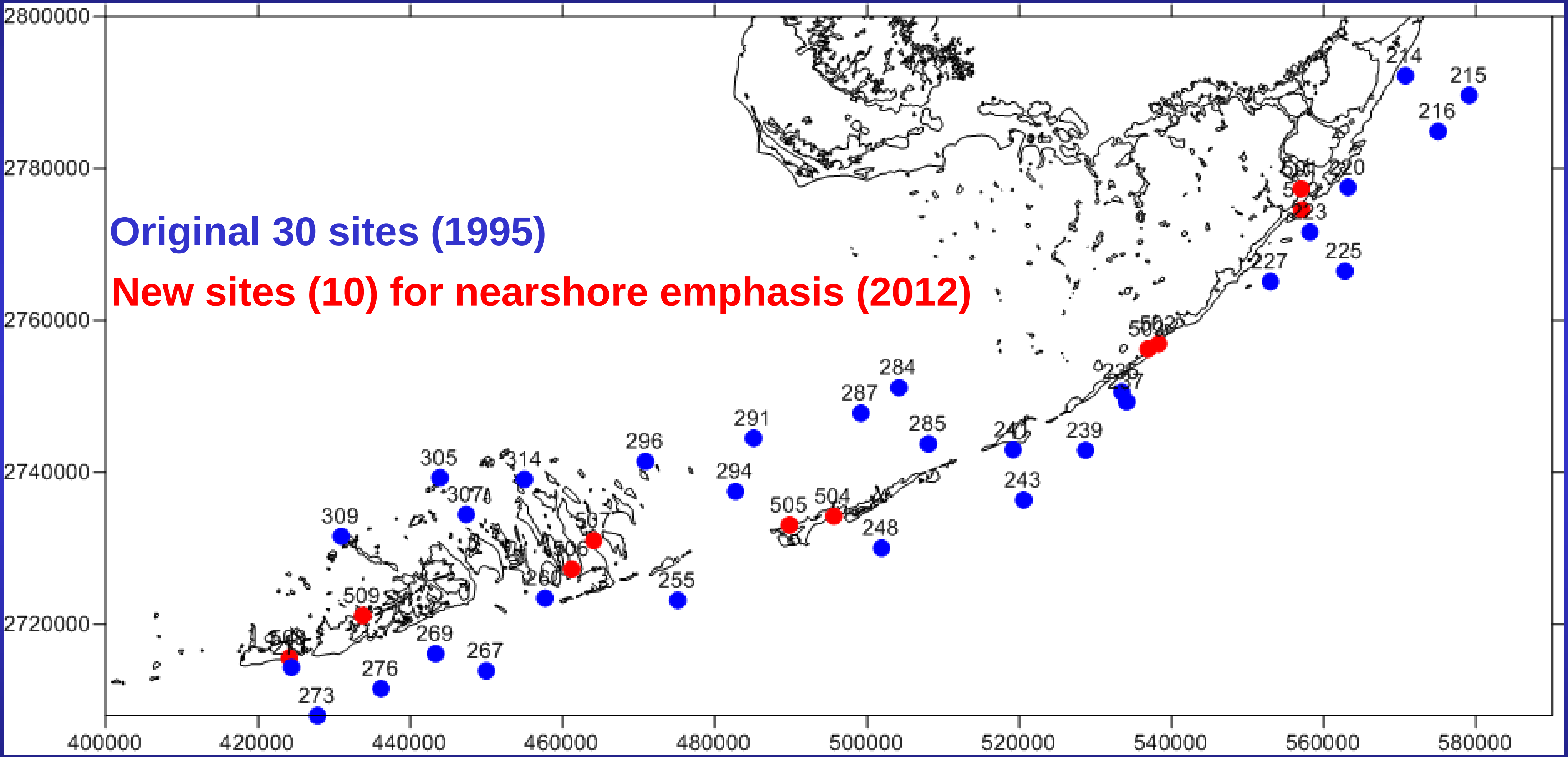
- Rapid population increases adjacent to oligotrophic marine ecosystems in south Florida *may* have deleterious effects on those ecosystems
- Changes are occurring in south Florida seagrass beds that are consistent with increased nutrient availability in the system – *but few increases have been observed in the water column*
- These changes are relatively subtle, we have not witnessed loss of seagrass beds in this regional and decadal scale program. *There is time to act!*
- Many different factors can influence our indicators that are independent of the main management concern – anthropogenic nutrient enrichment
- Congruence of patterns among independent indicators increases confidence in the observations

Major project accomplishments:

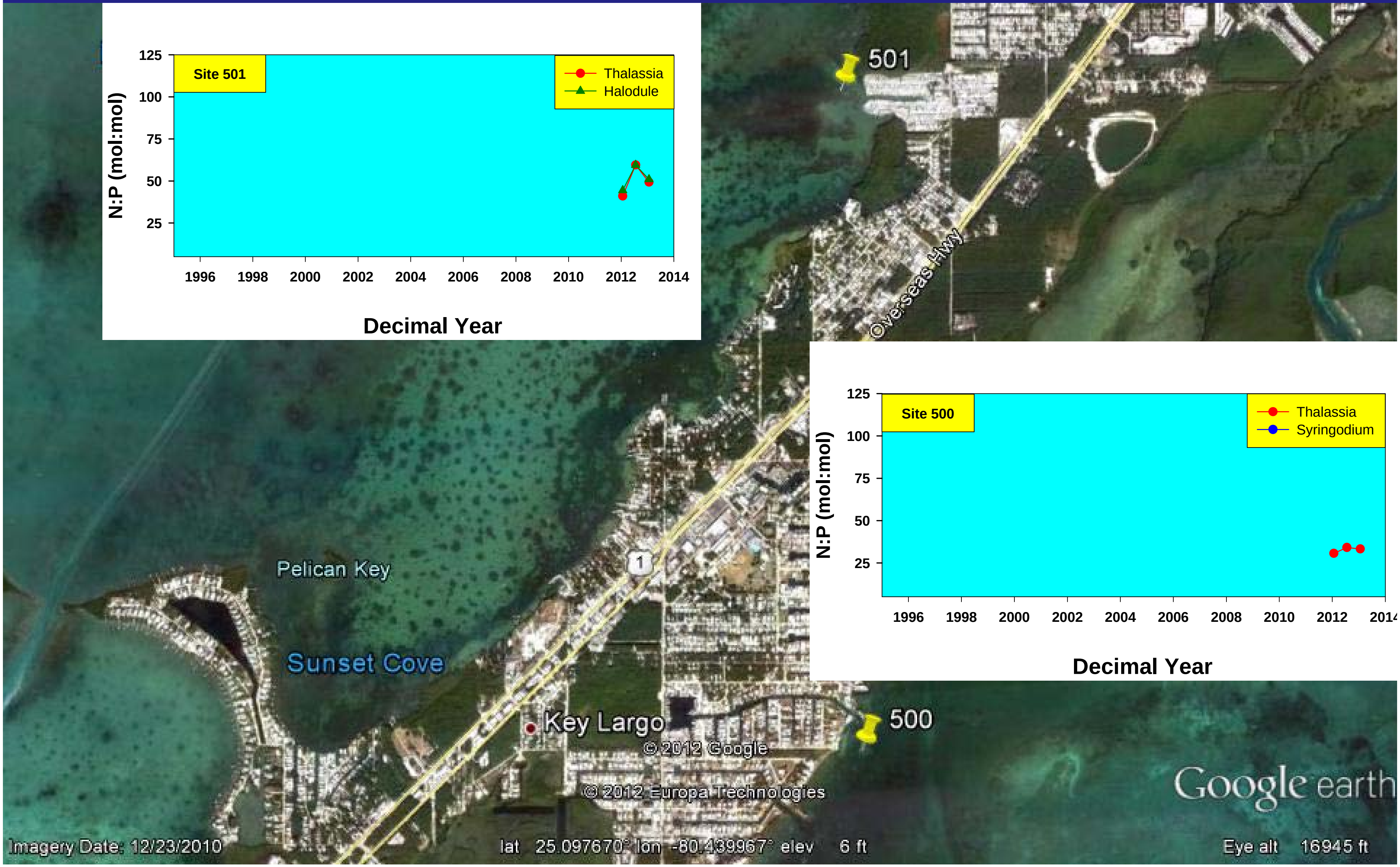
- We have defined the spatial extent and species composition of the largest documented seagrass bed on earth, and solidly defined a baseline to assess change.
- We have defined the spatial and temporal pattern of seagrass community dynamics in the FKNMS and made predictions about future trajectories.
- 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
- We have documented the effects of storms on seagrass communities.
- We have experimentally confirmed the role of nitrogen, and of phosphorus near shore and in Florida Bay, in controlling seagrass bed structure and productivity near the reef tract in the FKNMS.
- We have provided data for the analysis of potential human impacts on benthic communities to other groups and agencies.
- 23 scientific publications have resulted from this monitoring project to date.

- Not all environmental threats can be monitored in a given monitoring program
- The original monitoring program design was regional in scope

Benthic Habitat Permanent Monitoring Sites

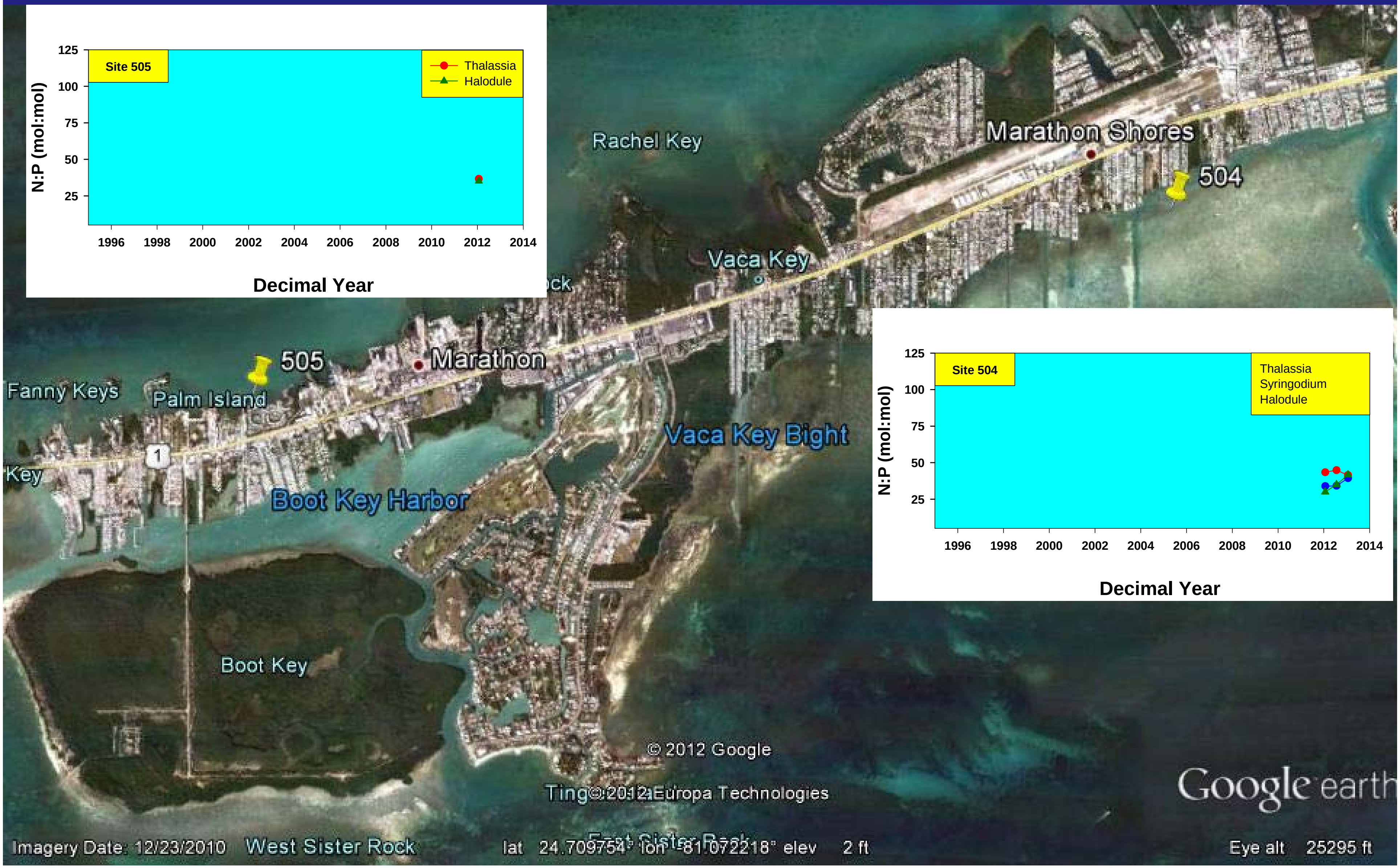


New nearshore sites – Key Largo



New nearshore sites – Islamorada

New nearshore sites – Marathon



ch Key Mangroves
Water Key
Mayo Key
Little Pine Key
Porpoise Key
Friend Key
Big Torch Key
Toptree Hammock Key
down Key
507
No Name Key
Big Pine Key
ttle Knockemdown Key
Howell Key
Middle Torch Key
Refuge Key
Big Pine Key
Little Torch Key
Summerland Key
Summerland Key
506
Don Quixote Key
Bahia Honda Key
Spanish Harbor
Overseas Hwy 1
Ramrod Key
Spanish Harbor Keys
West Summerland Key
Coupon Bight
Venture Key
Out Key
Crab Key
Pye Key
Newfound Harbor Keys
Cook Island
© 2012 Google
Munson Island
Big Munson Island
© 2012 Europa Technologies
Google earth
Imagery Date: 12/27/2010
lat 24.675822° lon -81.357998° elev 1 ft
Eye alt 13.00 mi

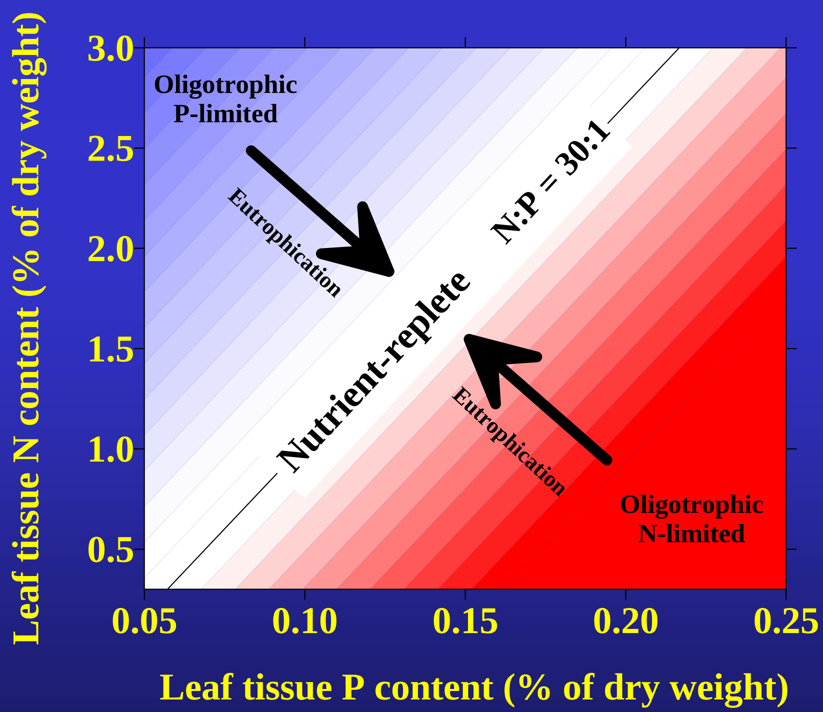
New nearshore sites – Key West

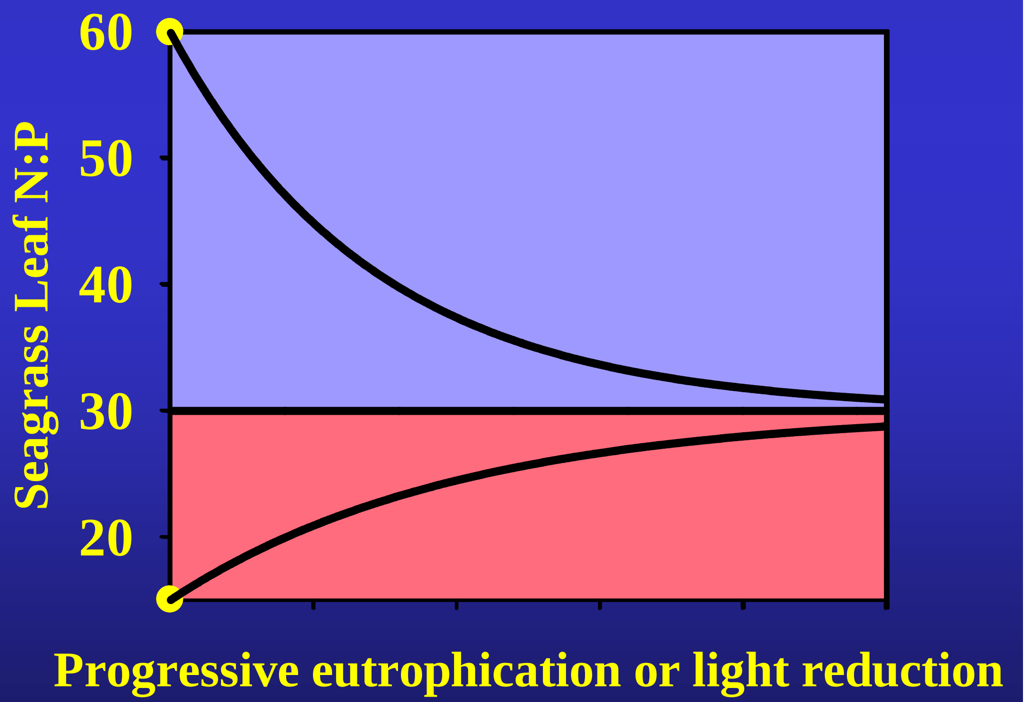
Are we describing locally-induced changes, responses to larger-scale processes, or natural cycles?

Our redesigned sampling program will contribute to answering this question

Explicit model of ecosystem behavior #2

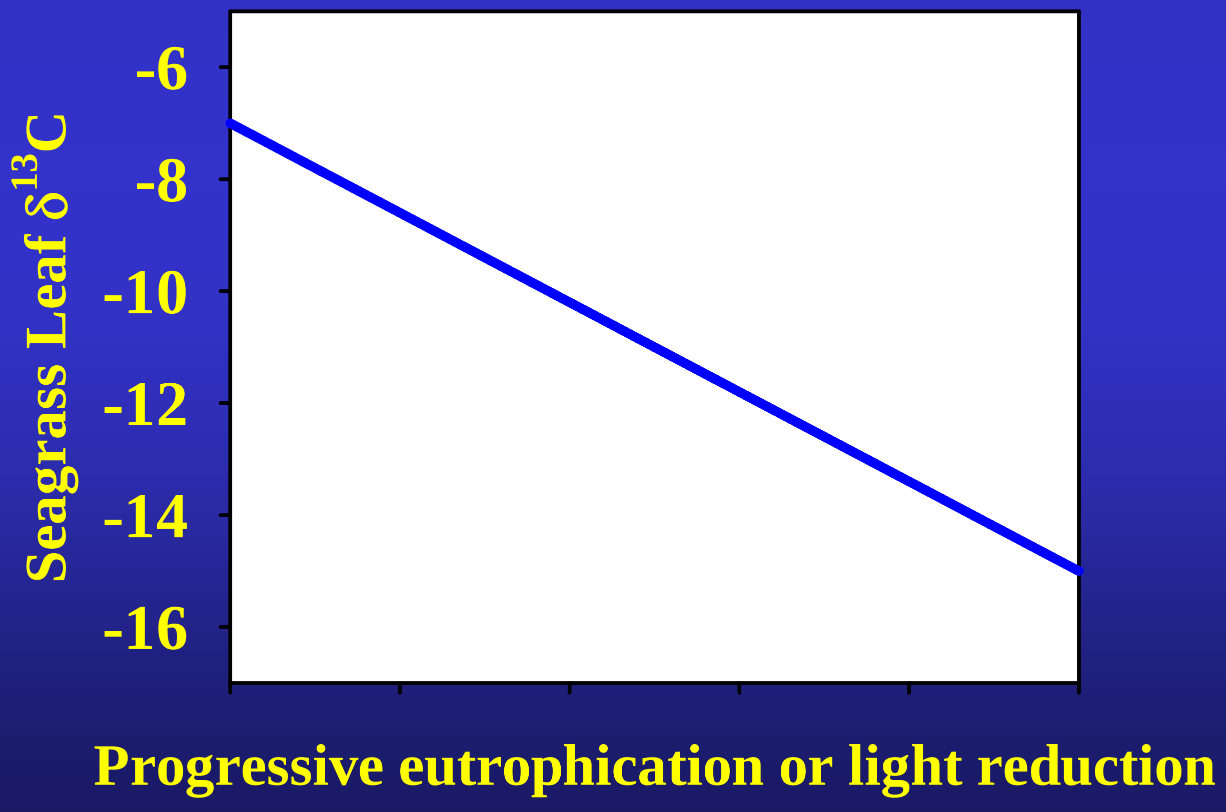
Nutrient pollution will shift N:P ratios of primary producers towards a taxon-specific "Redfield ratio"





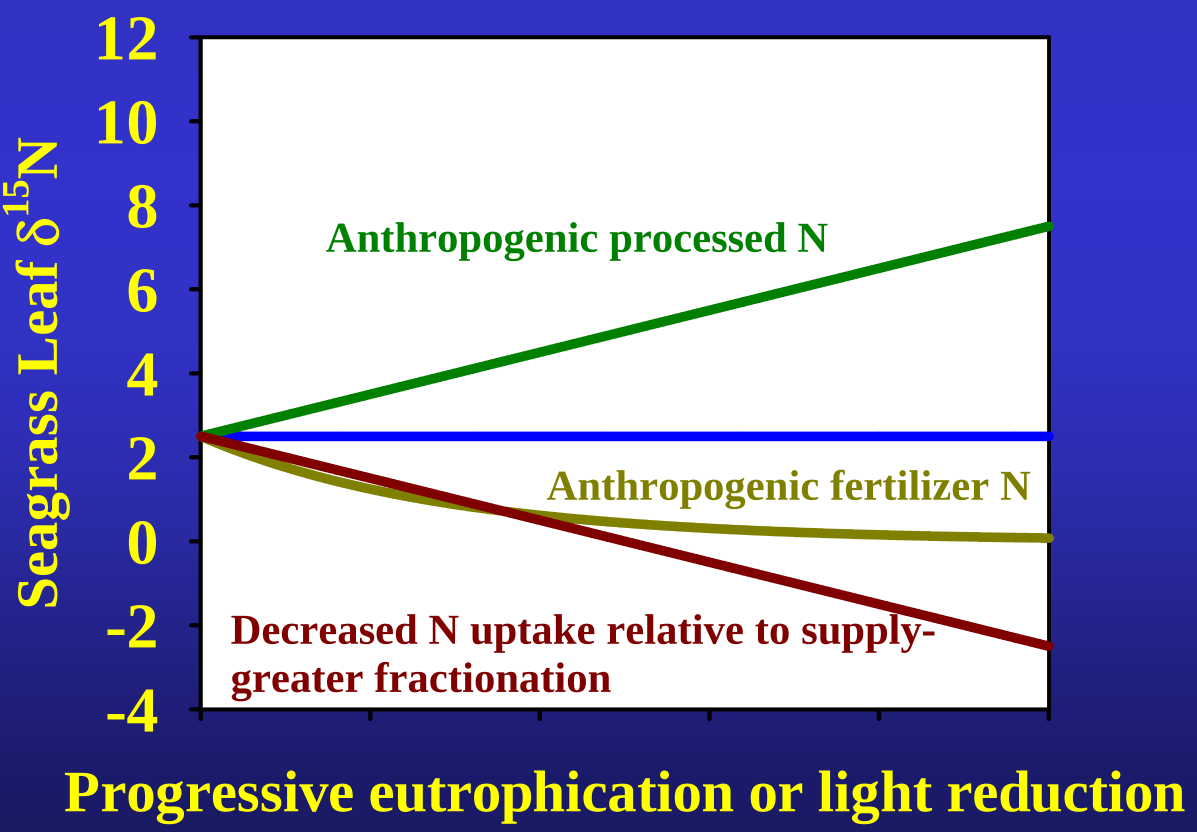
Explicit model of ecosystem behavior #3

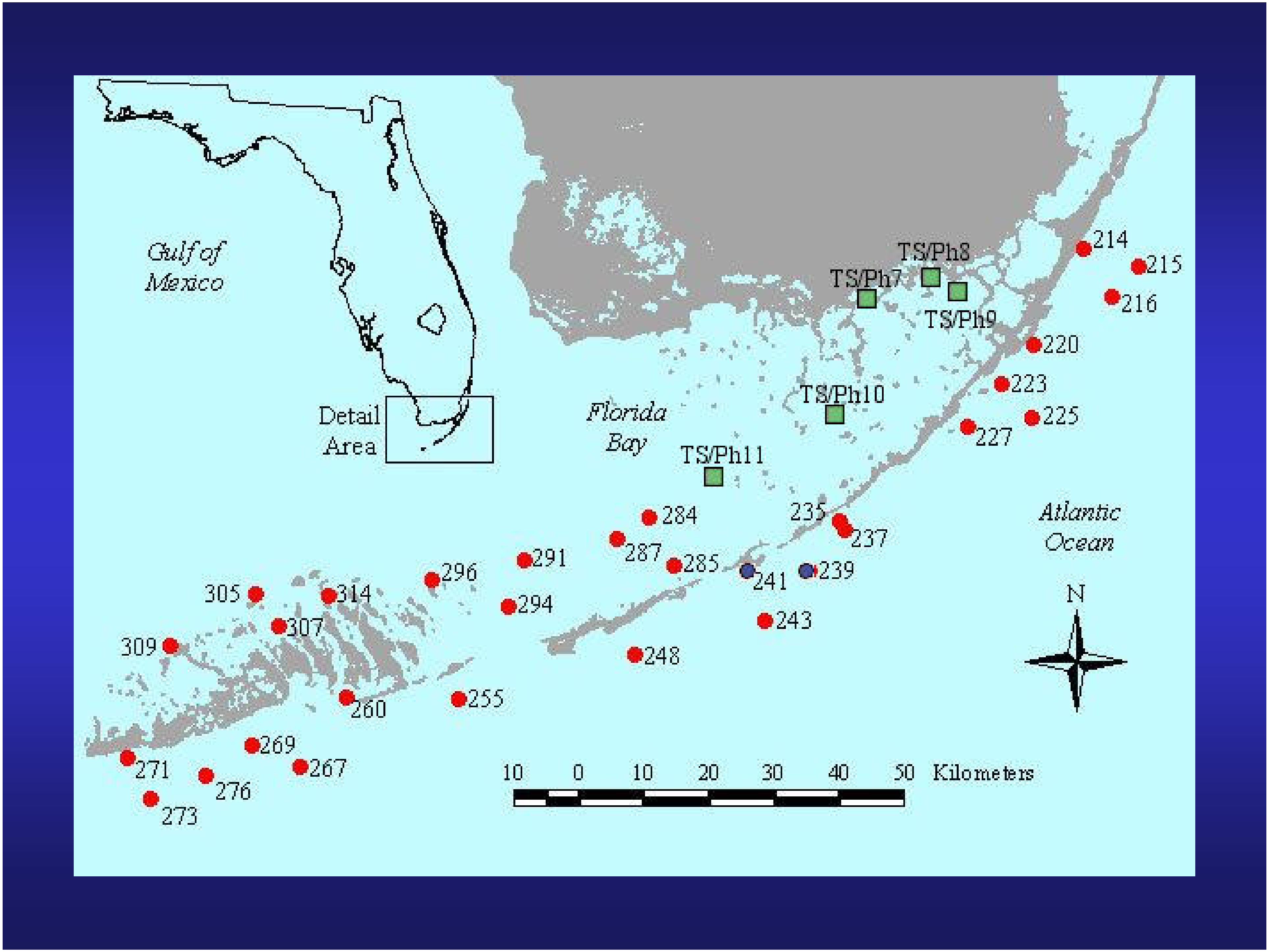
Nutrient pollution will shift seagrass $\delta^{13}C$ towards more negative values because of increased discrimination against ^{13}C in low light conditions



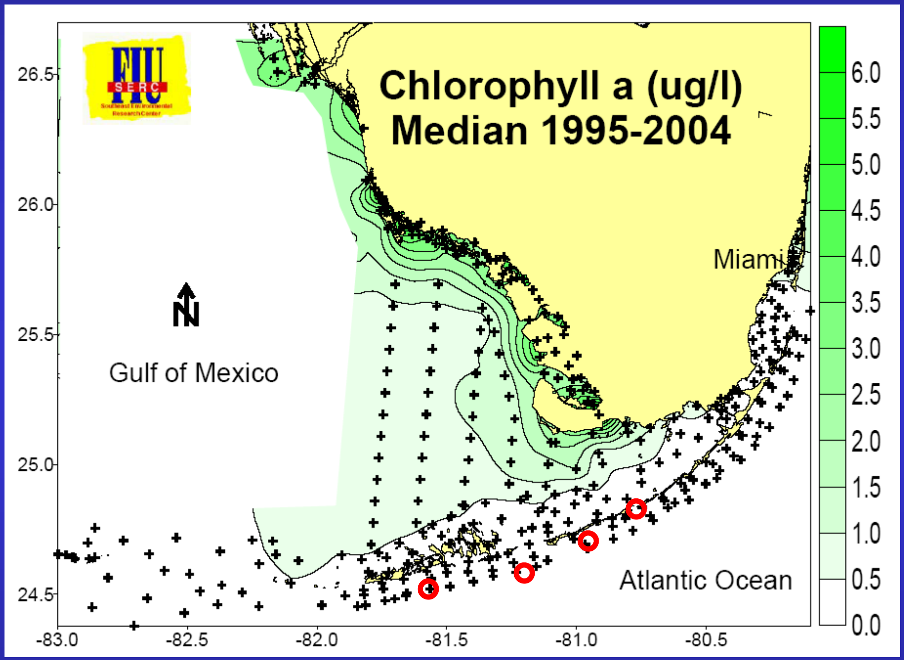
Not-so-Explicit model of ecosystem behavior #4

Nutrient pollution will cause some kind of change in $\delta^{15}N$ of primary producers




Gulf of Mexico
Detail Area
Florida Bay
Atlantic Ocean
TS/Ph7
TS/Ph8
TS/Ph9
TS/Ph10
TS/Ph11
214
215
216
220
223
225
227
235
237
239
241
243
248
255
260
267
269
271
273
276
284
285
287
291
294
296
305
307
309
314
N
10 0 10 20 30 40 50 Kilometers

Changes in relative abundance of primary producers #1



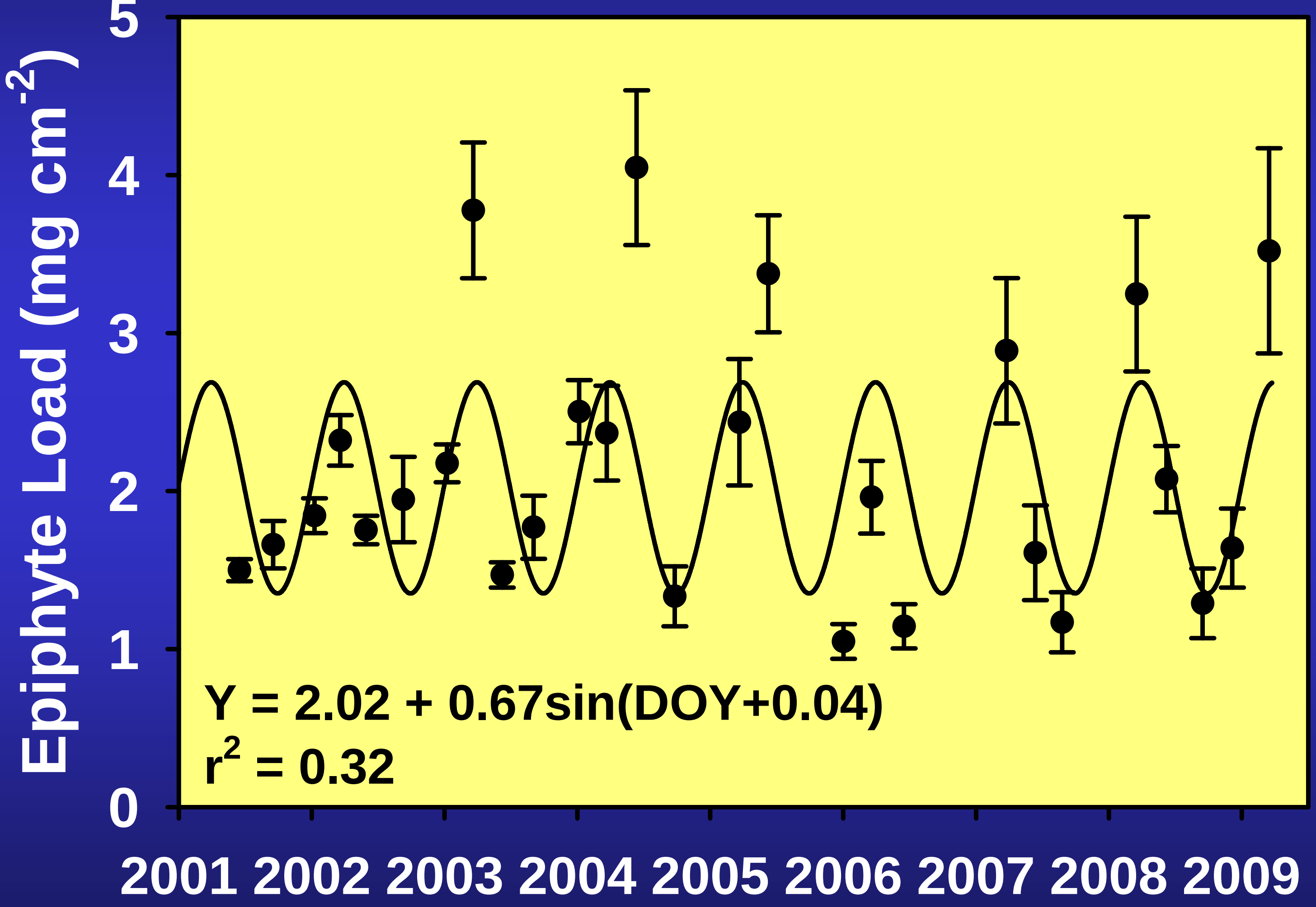
Phytoplankton concentrations are low across the system, and there are no sites with a significant increase in Chl-*a* over the time period.

In fact, at four of our monitoring sites, there has been a statistically significant decrease in Chl-a over the period (slopes of -0.03 $\mu g\ l^{-1} y^{-1}$)

Data from FKNMS water quality monitoring program

Changes in relative abundance of primary producers #2

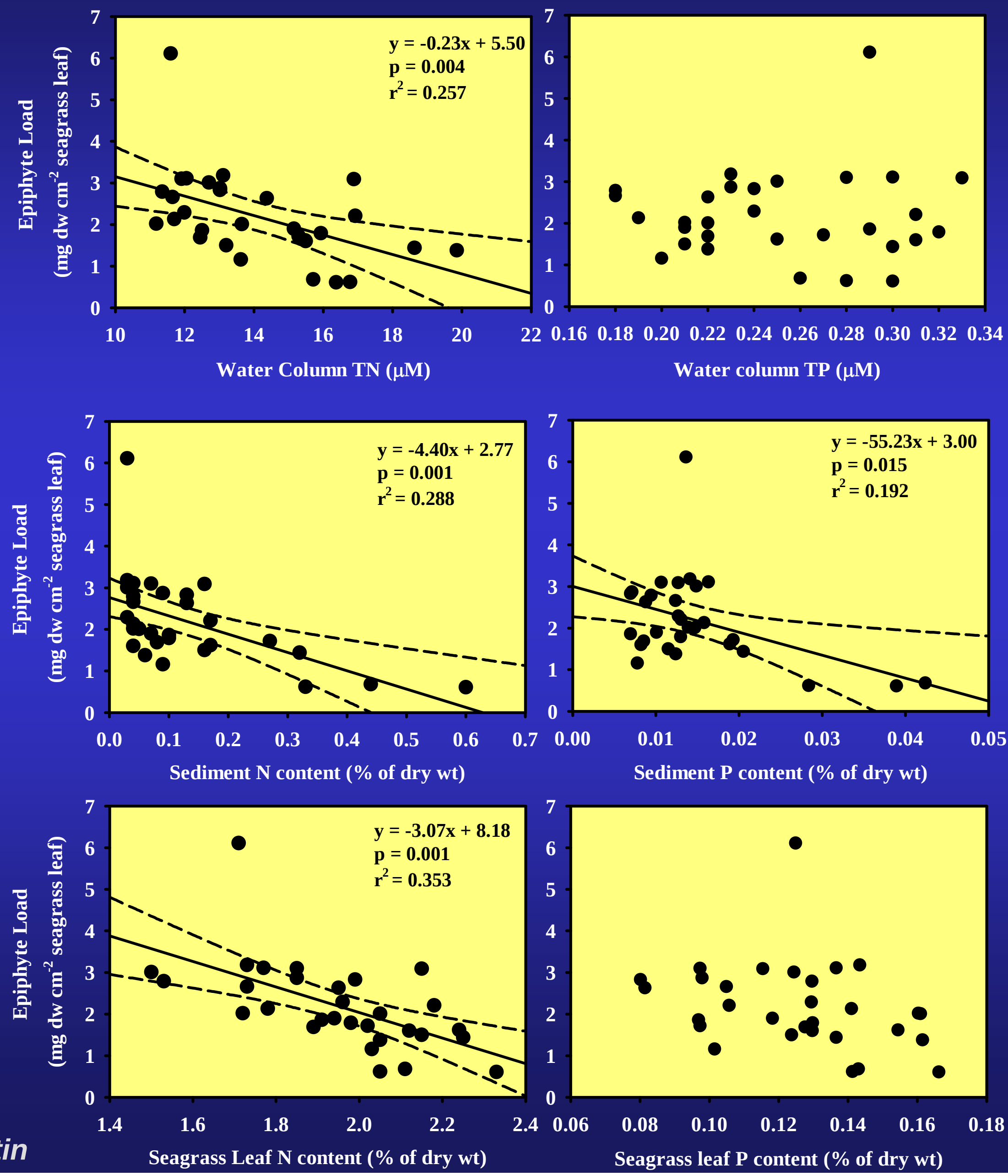
Epiphyte loads are highly seasonal in the FKNMS



Fourqurean et al. 2010 Marine Pollution Bulletin

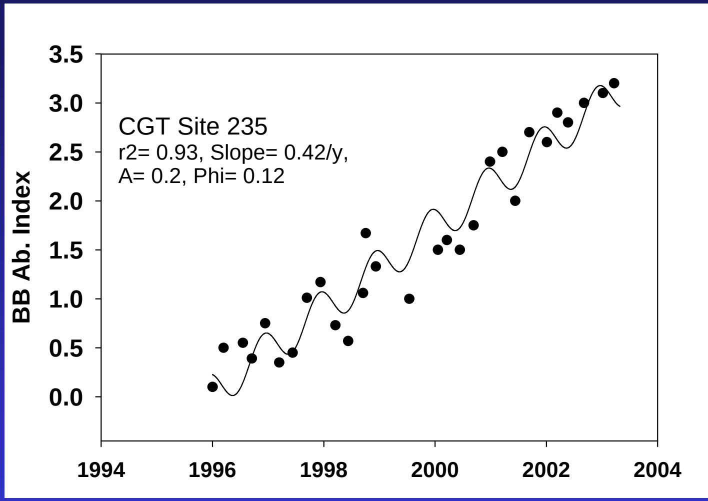
Changes in relative abundance of primary producers #3

Unlike more eutrophic systems, epiphyte loads are not correlated with increased nutrient loads at the scale of our sampling in the FKNMS

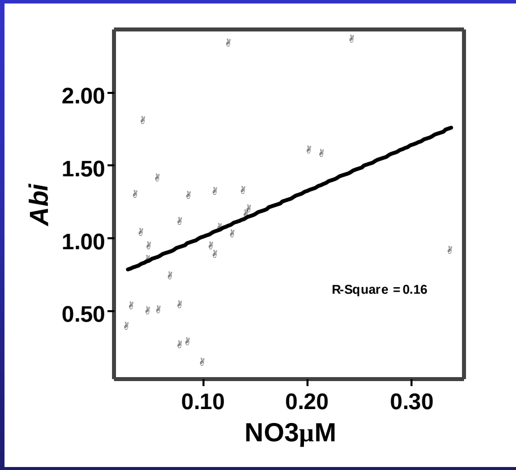


Fourqurean et al. 2010 Marine Pollution Bulletin

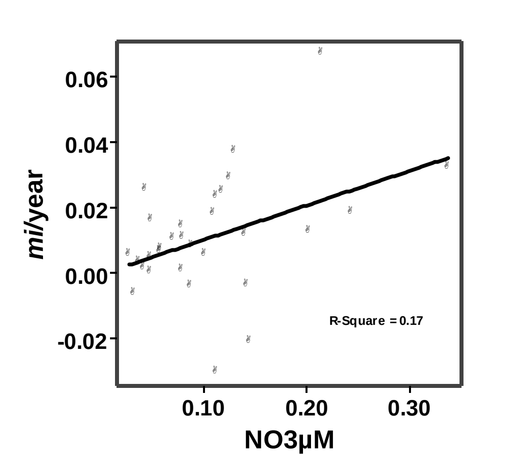
What do the stations with increasing abundance of fast-growing algae have in common?



Algae are more abundant in high nitrogen areas

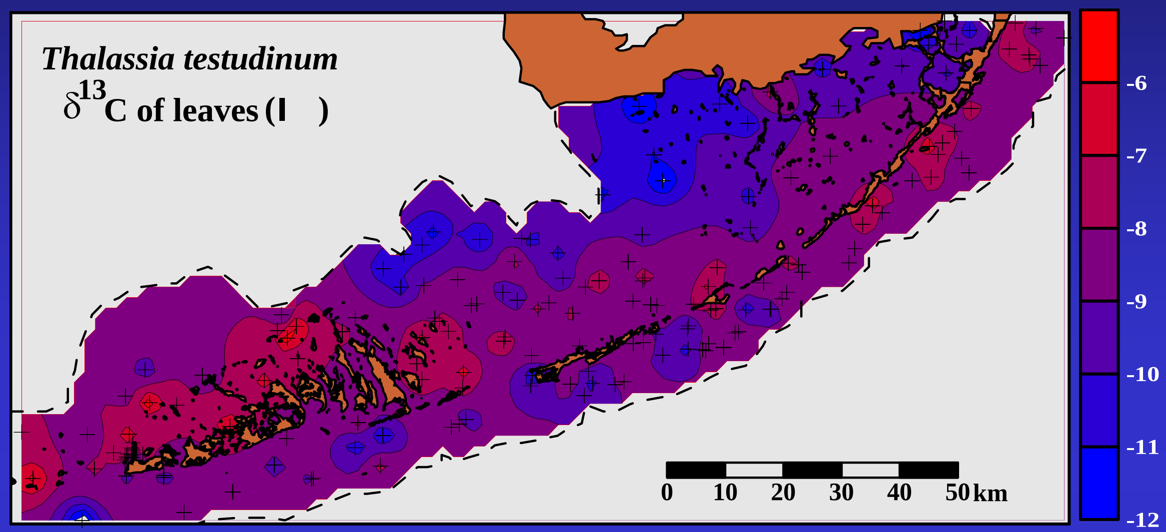


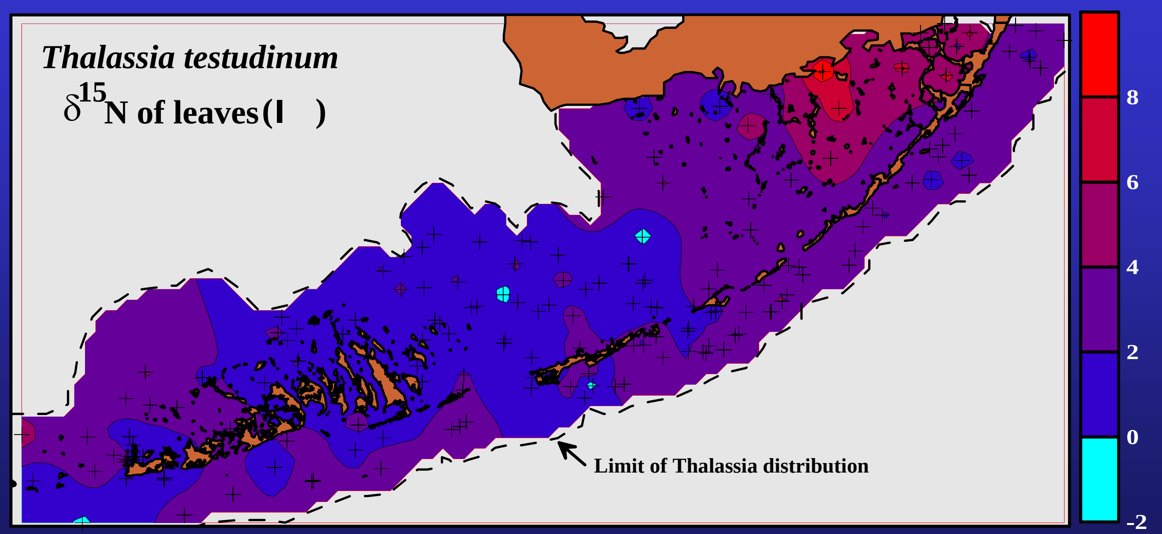
…and high-N stations have higher increases in algae



Collado-Vides et al. 2007, Estuarine Coastal and Shelf Science

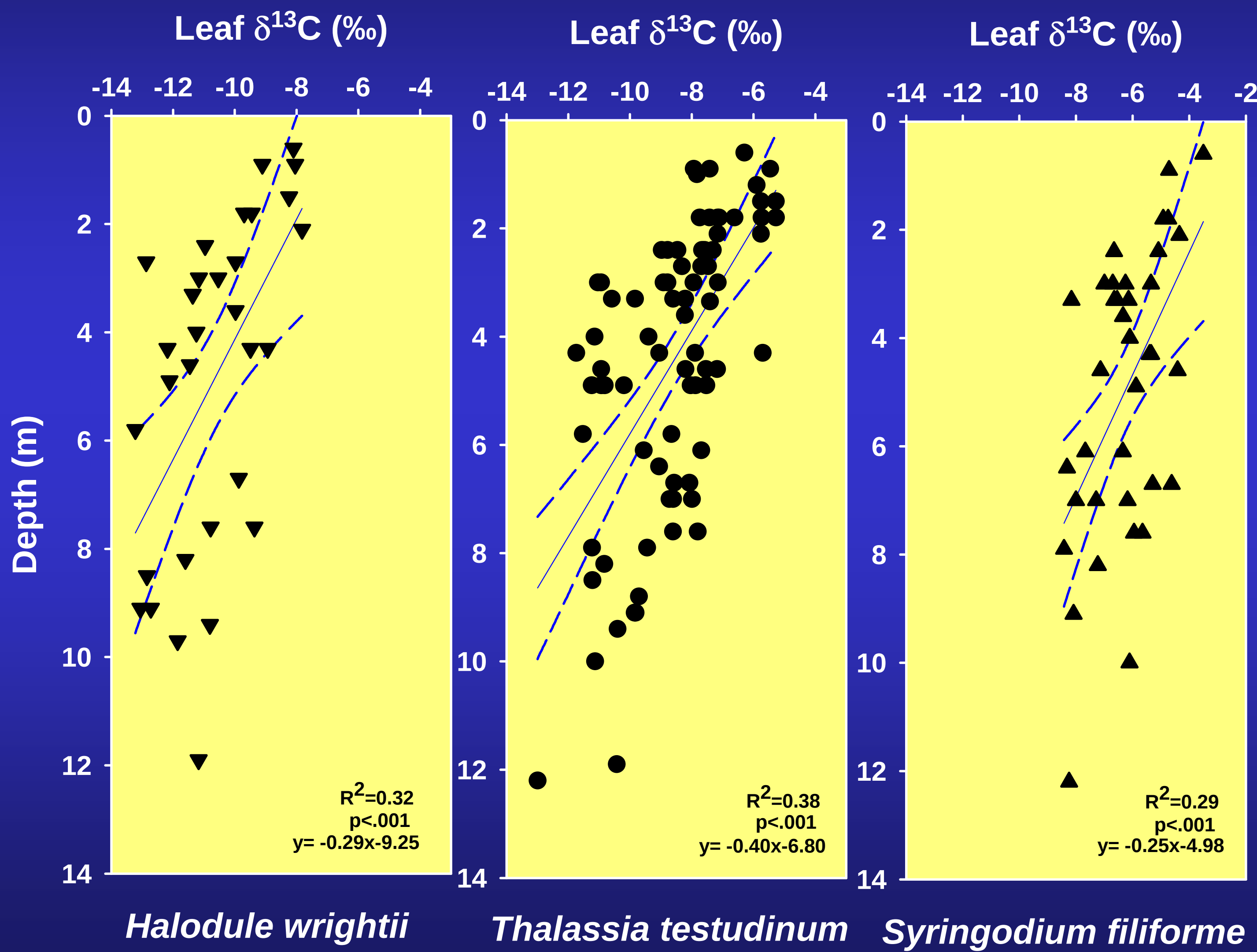
Spatial patterns in stable isotope ratios in south Florida





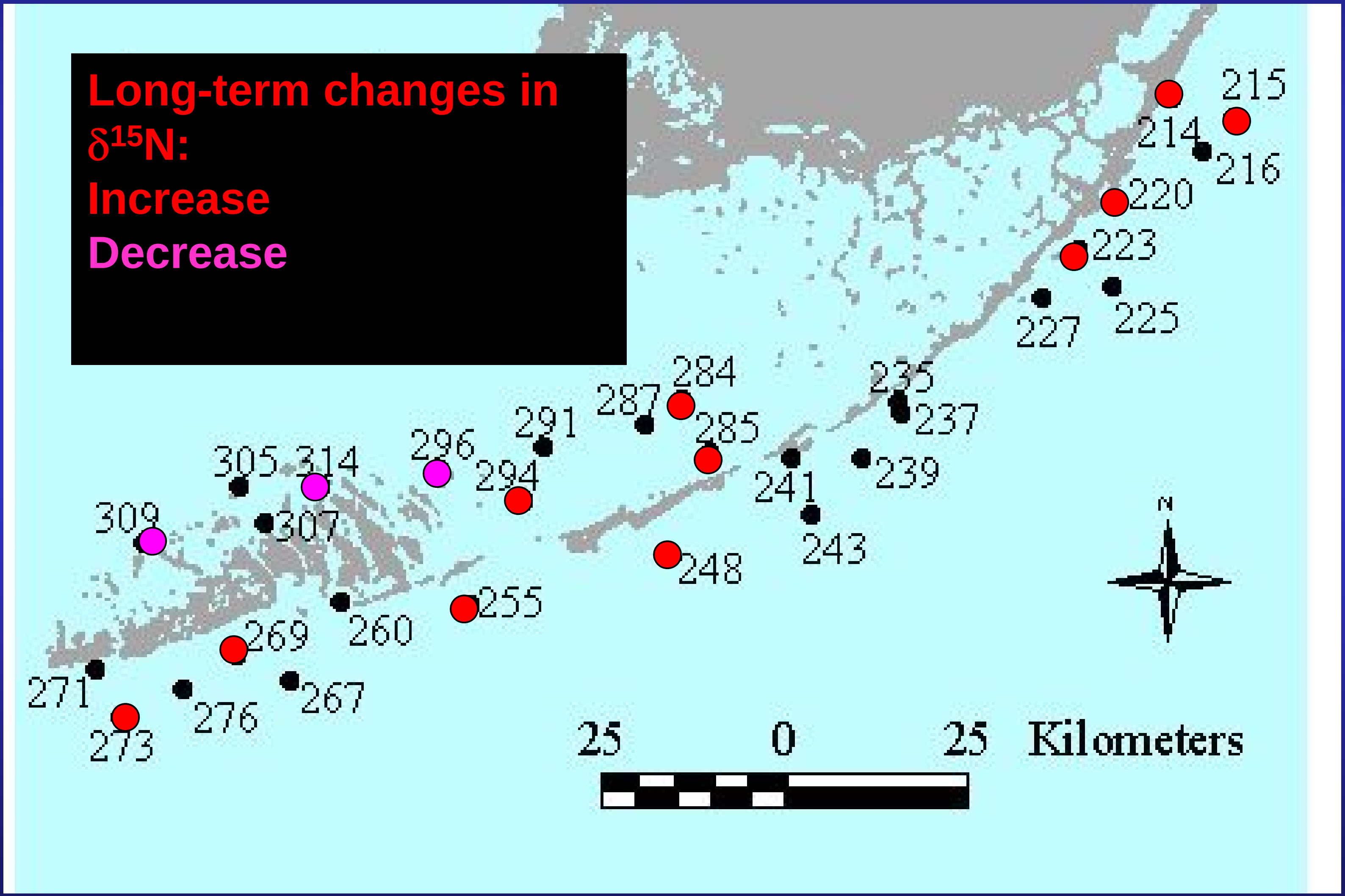
Fourqurean et al Estuaries 2005

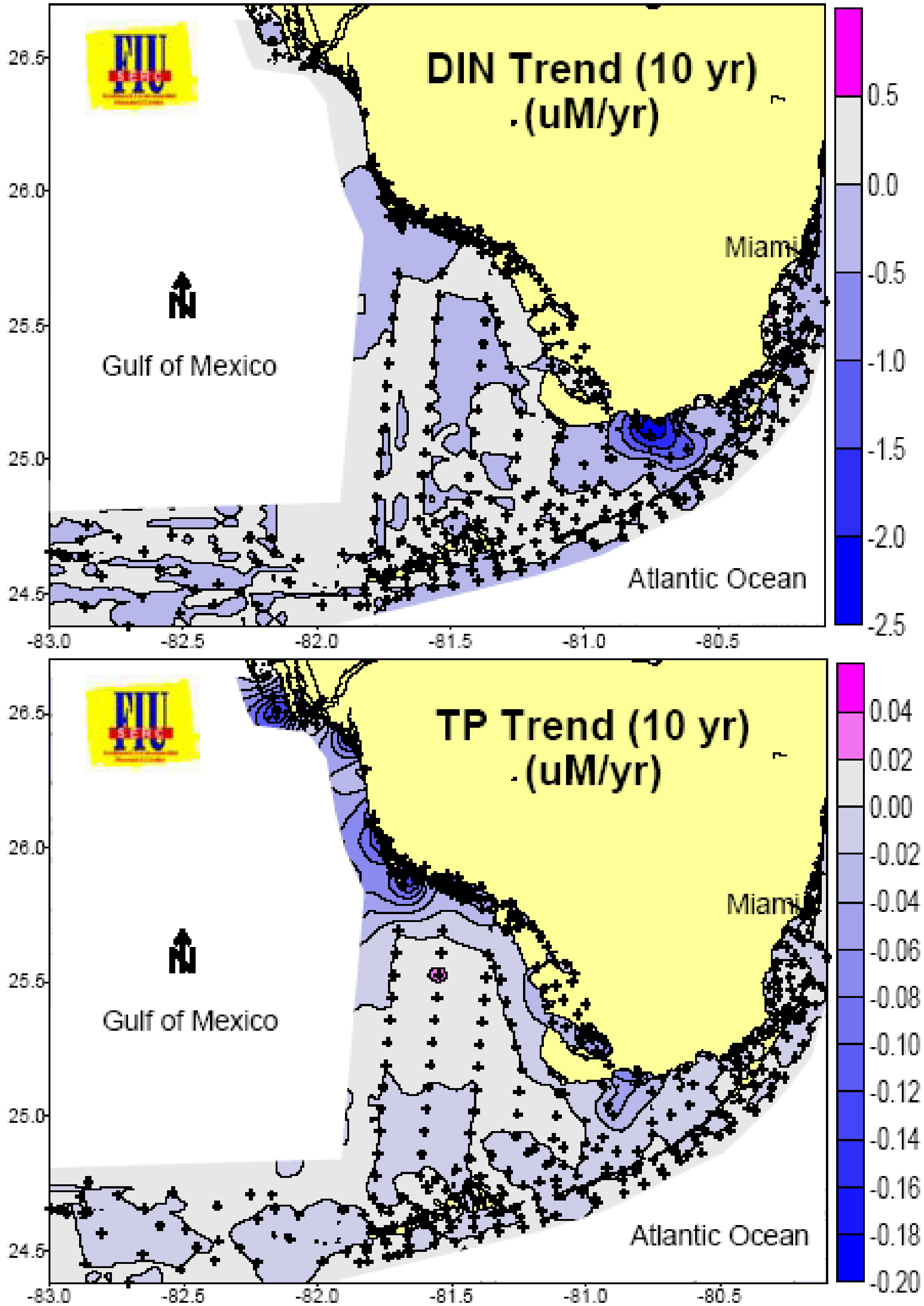
Changes in δ13C of primary producers #1:
As light decreases with depth, δ13C decreases



Campbell and Fourqurean, 2009, MEPS

Changes in $\delta^{15}N$ of primary producers #2





Our benthic indicators of eutrophication of the system are measuring troubling changes, even in the absence of trends in water quality

Is the benthos more sensitive to changes in nutrient loading than water column nutrient concentrations?

Are we perhaps merely measuring a long-term cyclicity of the seagrasses of south Florida?

Oil Spills in Seagrass beds

- Seagrasses are the most extensive of the marine habitats of south Florida
- Seagrass beds have a high ecological and economic value
- WQPP monitoring sites are providing baseline data for assessing ecological effects of Deepwater Horizon oil spill

Oil Spills in Seagrass beds

- GOOD NEWS: Seagrasses are relatively insensitive to oil and dispersants.
- BAD NEWS: The animals that live in seagrass beds are very sensitive to oil and dispersants.

Web accessibility of data and reports:
www.fiu.edu/~seagrass