Halimeda Dynamics Relative to Nutrients Availability in The Florida Keys National Marine Sanctuary:

A Good Indicator of Productivity and Acidification.

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Linking Science with management
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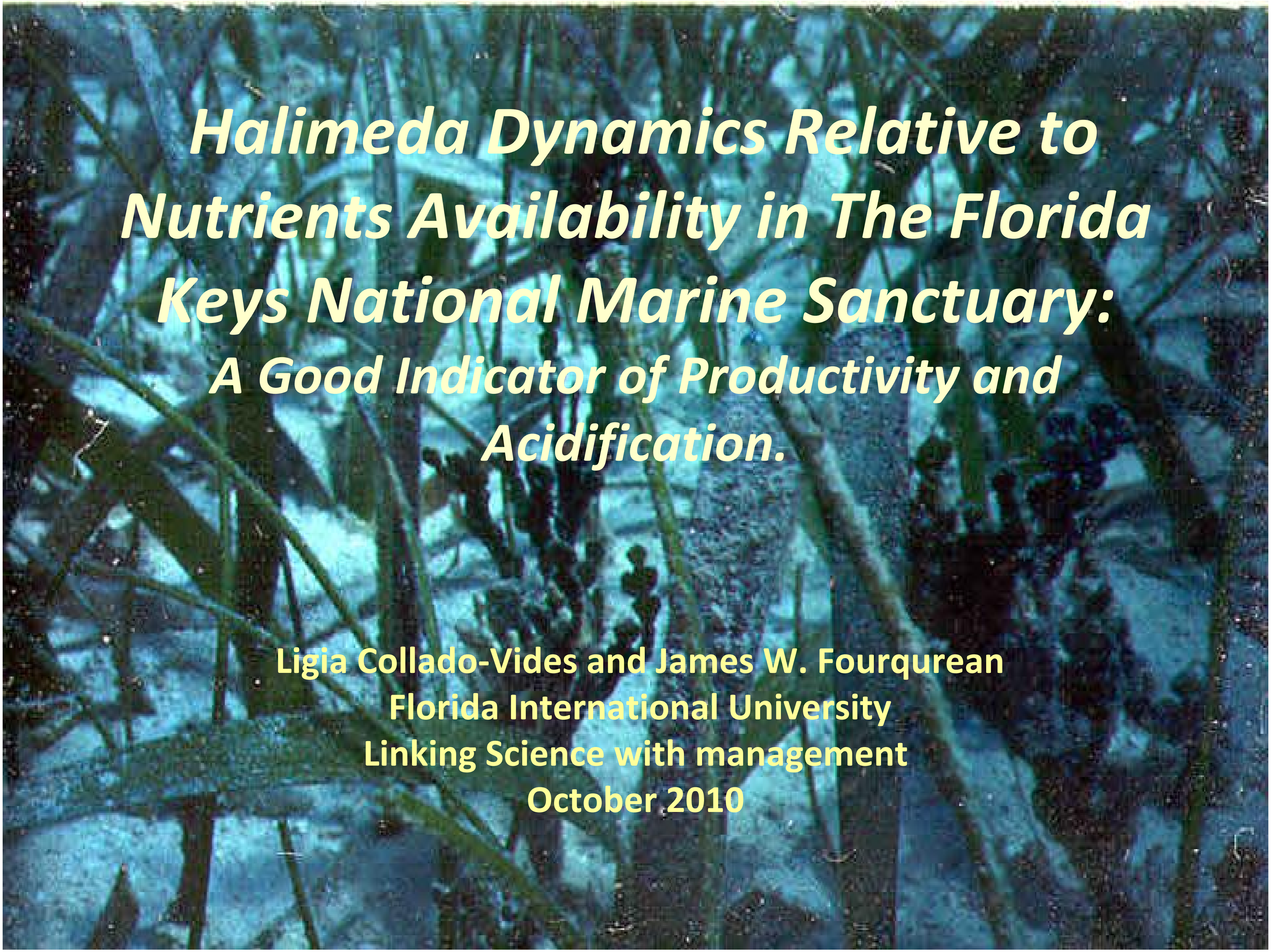
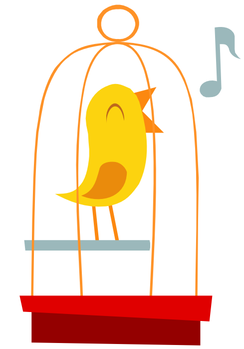


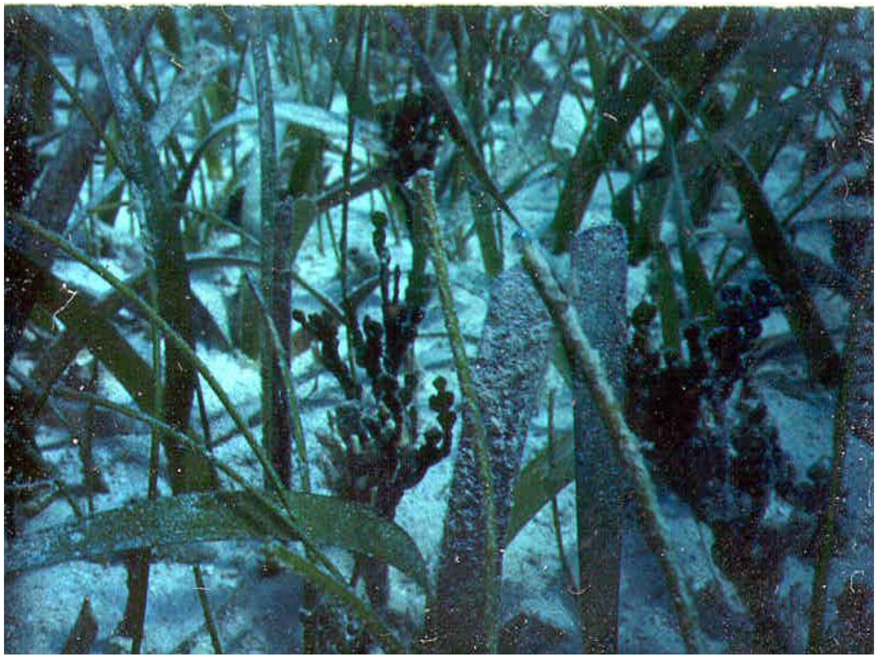
Linking science to management: Search for a Miner's Canary



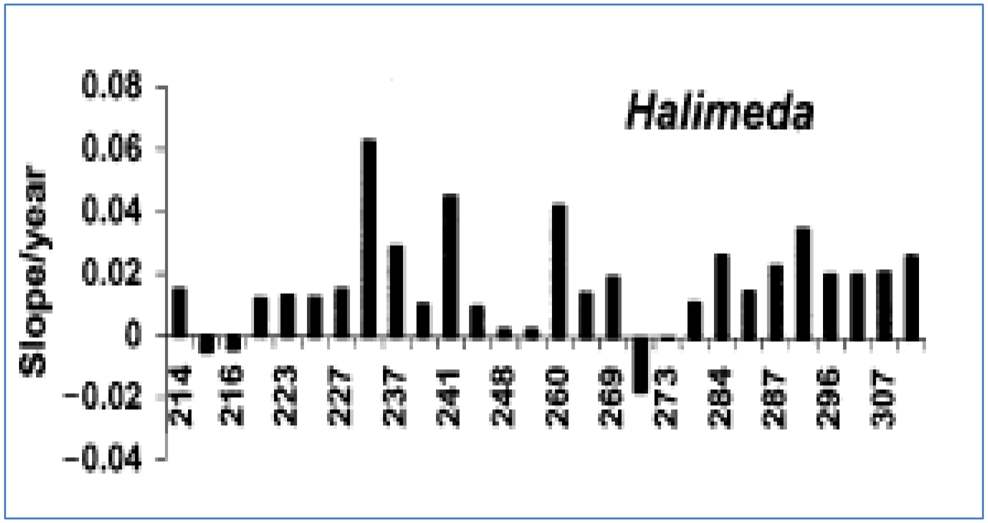
- Describe the spatial and temporal dynamics of the genus *Halimeda* in the seagrass beds in the FKNMS.
- Evaluate the mass production and correlate it with nutrient availability.
- Evaluate the potential use of *Halimeda* as an indicator for changes in productivity and acidification.

Why Halimeda?

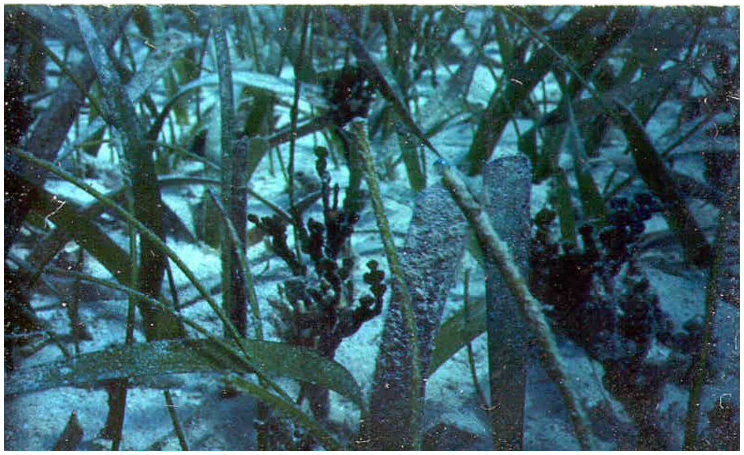
•Calcareous green macroalgae are the dominant non-vascular flora found in seagrass in the FKNMS (Fourqurean and Rutten 2001).



•Seagrass monitoring program show that calcareous green species of the genus *Halimeda* are increasing in the FKNMS. (Collado-Vides et al 2005, 2007).



Why Halimeda?



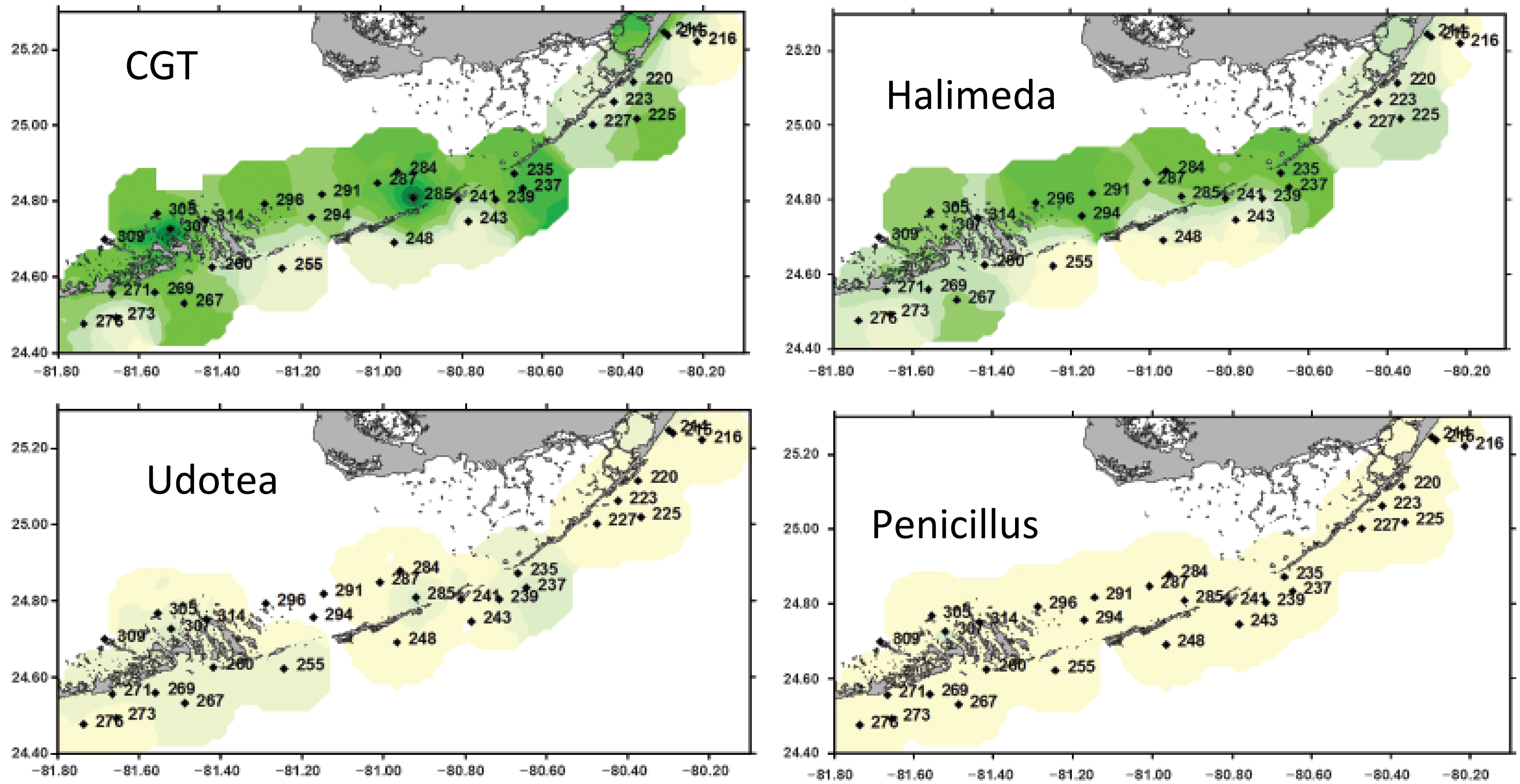
Halimeda is a genus of considerable importance in coral reef areas including seagrass beds, contributing both organic production and significant amounts of calcareous sediment.

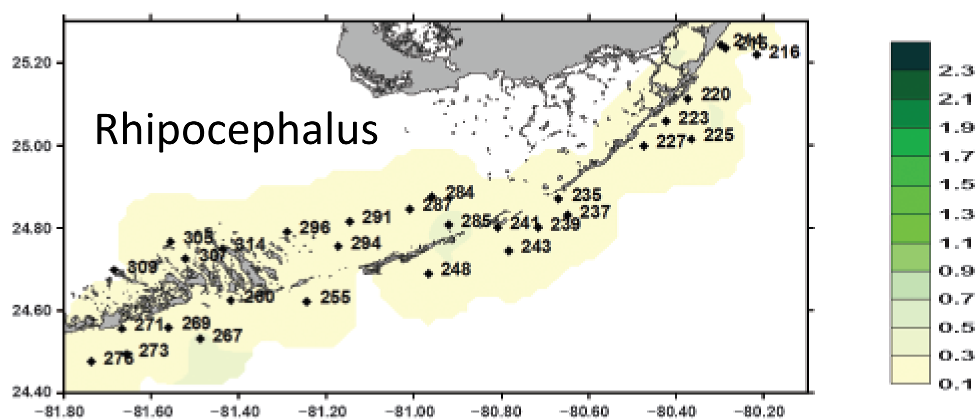
Deposition of calcium carbonate by marine algae (in shallow and deep sea environments) is an important aspect of the global carbon cycle (blue carbon).

Carbonate sediments produced by the Codiacean genus *Halimeda* make a **major** contribution to reef mass in regions such as the Bahamas, Tahiti and the Great Barrier Reef.

Good indicators for historic climatic reconstructions.

(Drew and Abel 1985, Blair and Norris 1988; Drew and Abel 1988; Payri 1988, Flügel 1988; Marshall and Davies 1988)

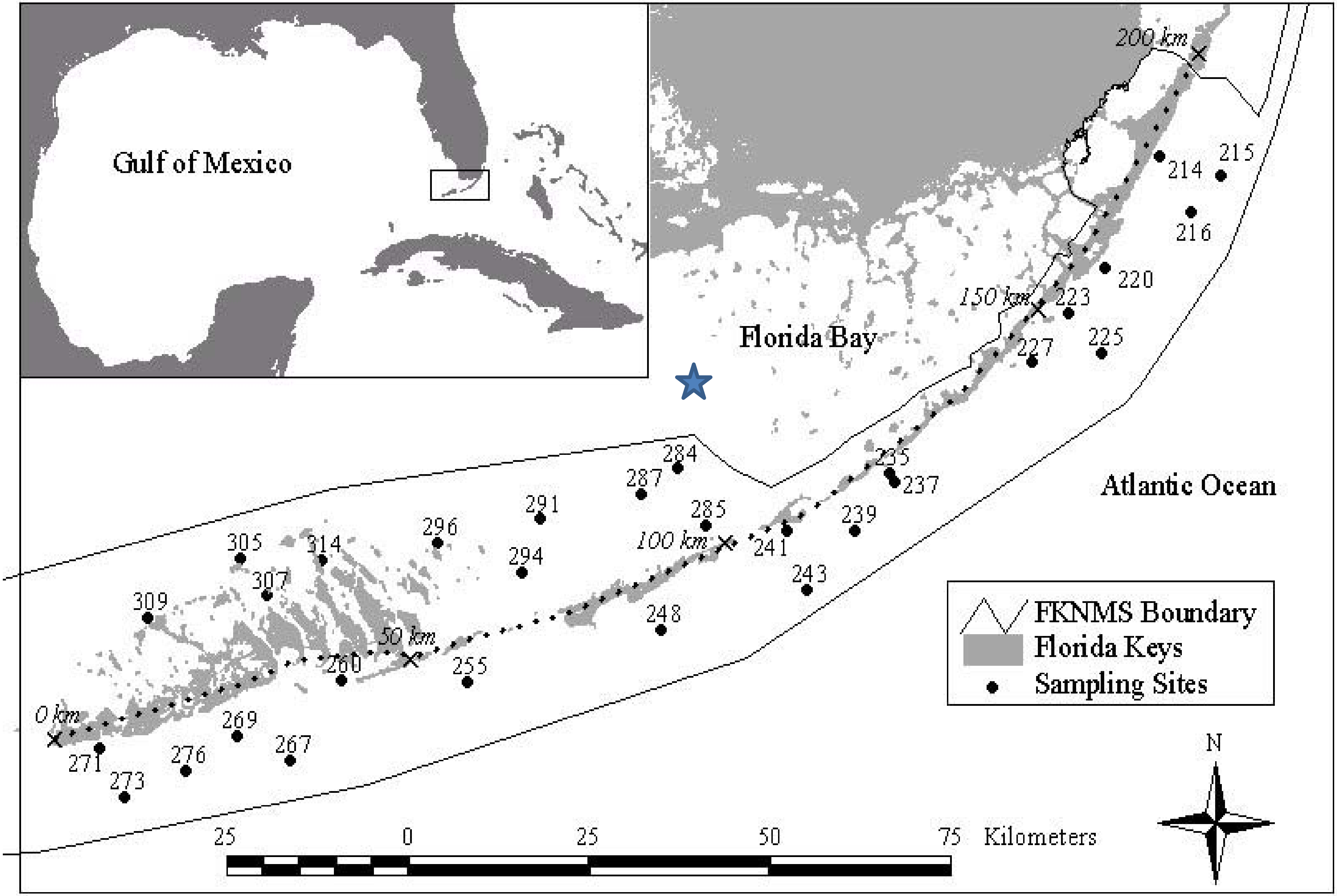




Braun-Blanquet Abundance
Index Scale

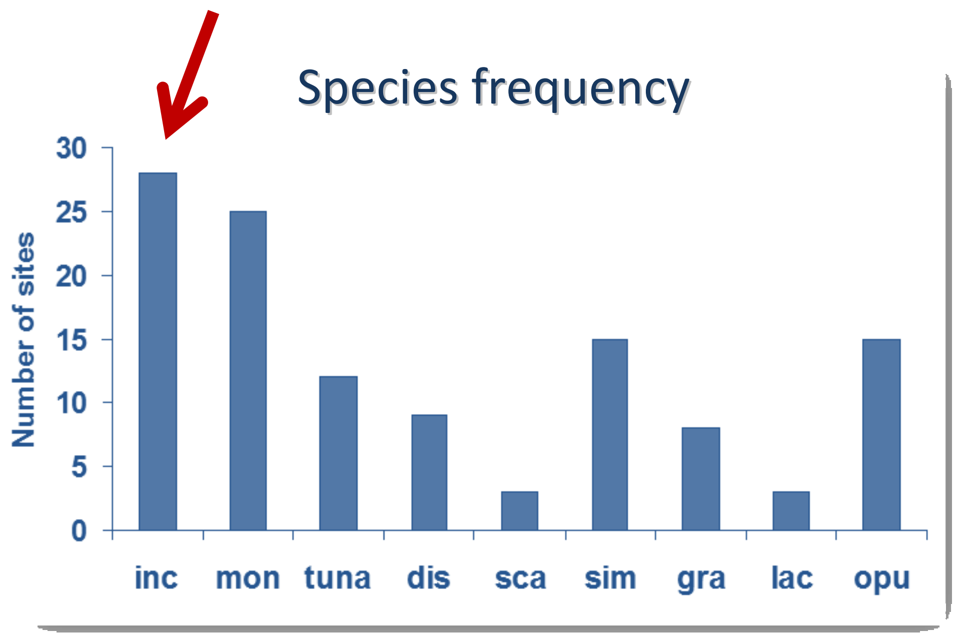
Spatial Distribution of Calcareous Green Algae

Collado-Vides et al 2005



30 sites in the FKNMS studied during 2005-2006 and a long term study in Sprigger Bank

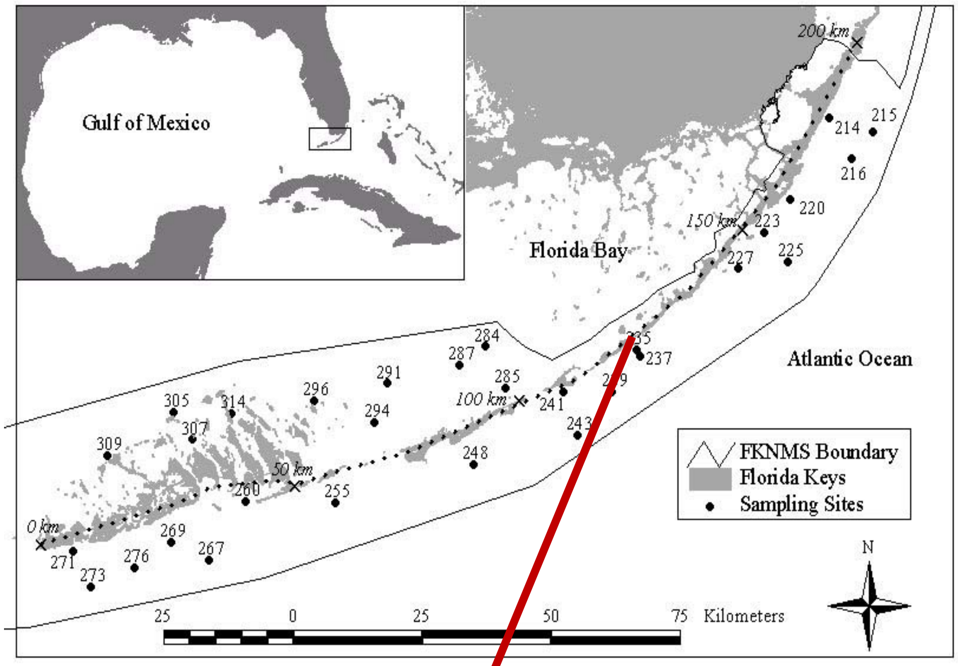
Halimeda in the FKNMS



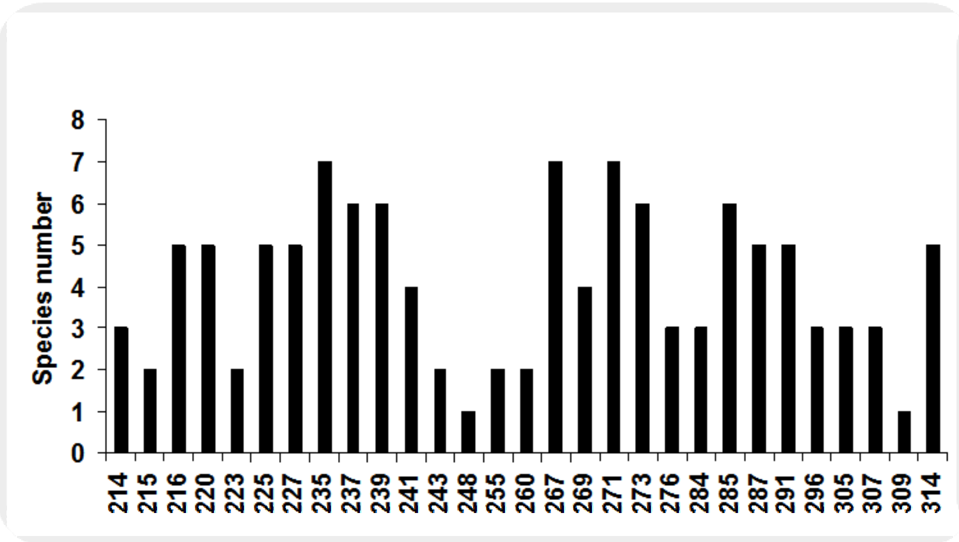
Halimeda incrassata
Halimeda monile
Halimeda tuna
Halimeda discoidea
Halimeda scabra
Halimeda simulans
Halimeda gracilis
Halimeda lacrimosa
Halimeda opuntia

Spatial distribution

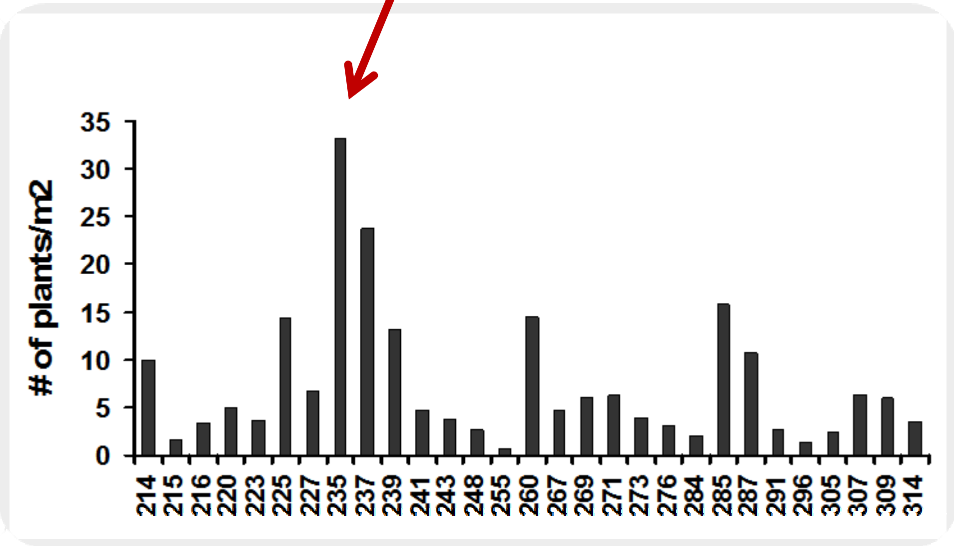
Halimeda is widely distributed in the FKNMS seagrass beds



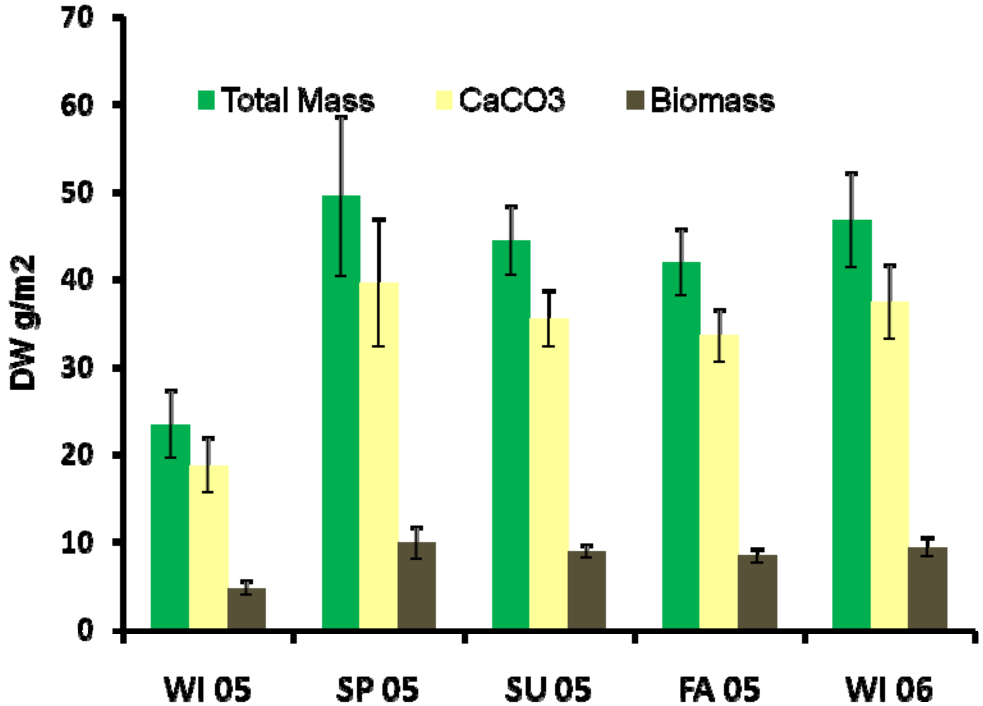
Number of species per site



Thallus frequency



DW g/m2	31 sites along the FKNMS: Mass	CaCO3	Biomass	Sprigger Bank FL Bay: Mass	CaCO3	Biomass
Mean	41	33	8.2	341	273	68.2
S. D. mean	10	8.3	2.1	88.5	70.8	17.7
Max	336 SP	269	67	1013 SP	810	203

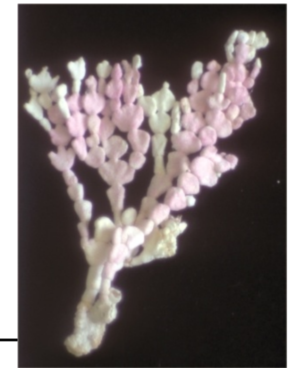


Puerto Morelos Mexico

DW g /m2	Mass
Mean	103.3
Max	260.92
Min	8.65

Tussenbroek and Djik 2005

Halimeda $CaCO_3$ production



	SP	SU	FA	WI
Mean Growth	6.65	20.14	6.52	3.50
Density	29.53	49.48	5.76	15.30
CaCO3/m2/y	157.10	797.25	30.04	42.84
Grand mean	256.81			

50 -2323 g CaCO3 m-2/y world wide reports.

(Wefer 1980, Multer 1988, Payri 1988, Freile and Hillis 1997)

23 g m−2/y on a backreef the Florida Keys (Bosence et al., 1985)

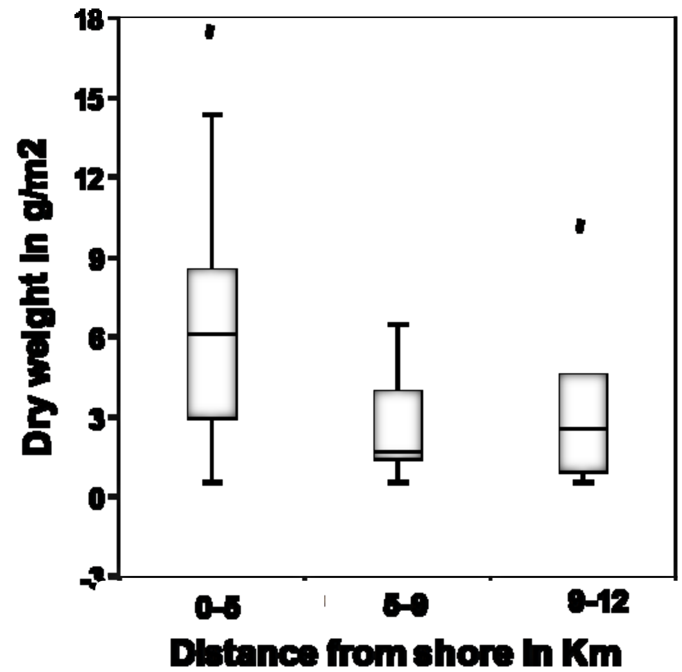
1000 g m−2/y in the Marquesas Keys (Hudson 1985).

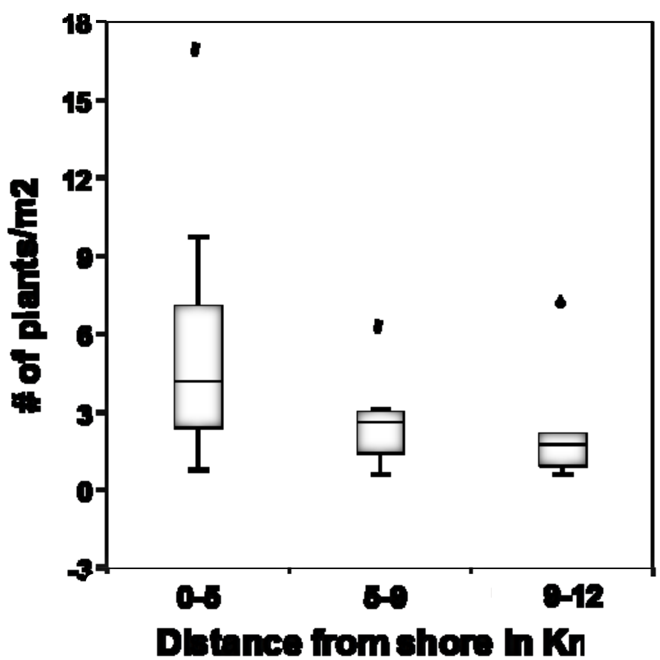
225 g m−2/y 200 Km from Marquesas Keys (Davis and Fourqurean 2001)

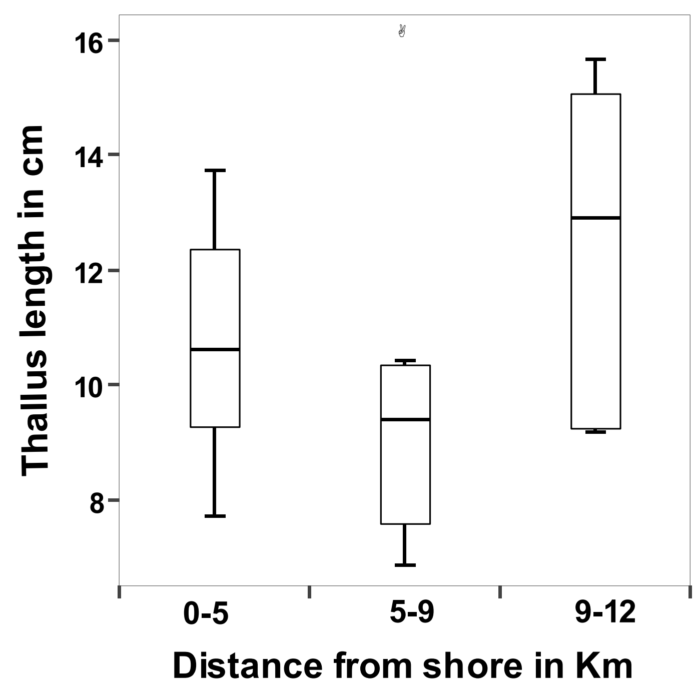
815 g m-2/y Puerto Morelos Mexico (Tussenbroek and Djik 2005)

Distribution and morphometric variability as a function of distance from shore

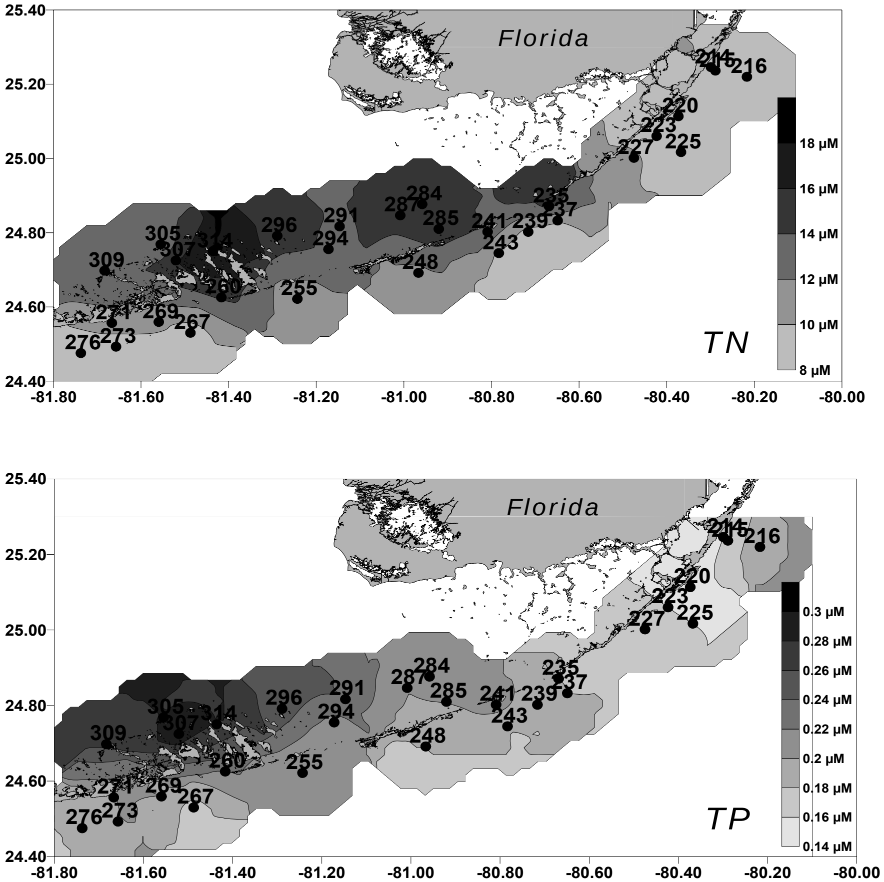
Distance from shore		
Close	**Mid**	**Long**
Abundant	Fewer	Fewer
More mass	Less mass	Less mass
Short size	Short size	Larger







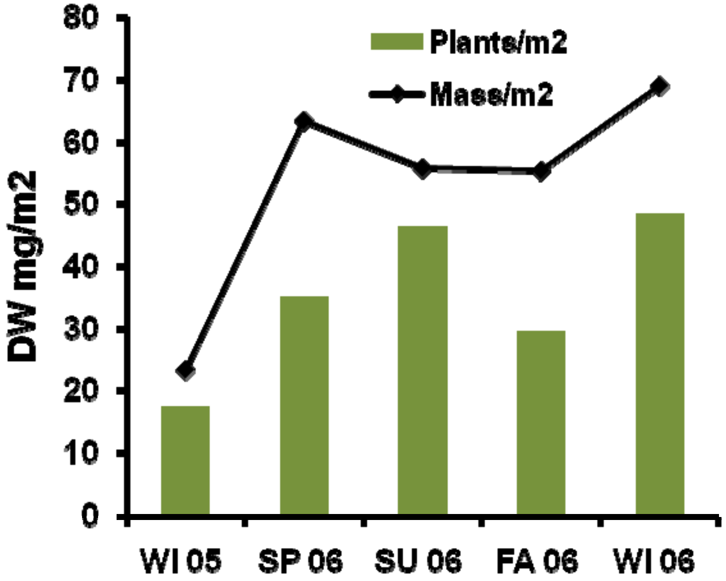
Nutrient correlations

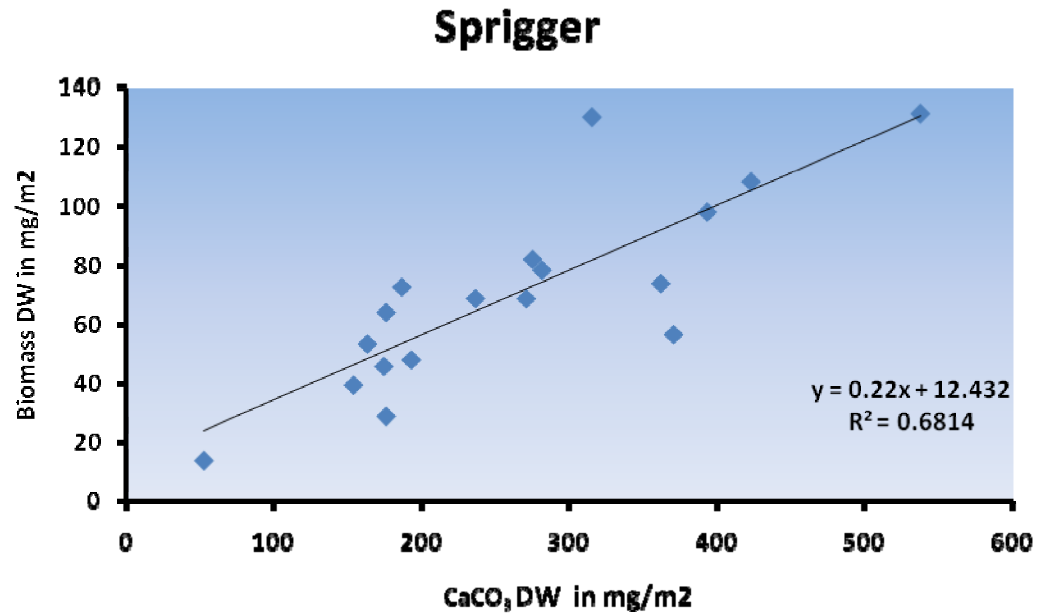


Collado-Vides et al 2007

	TN	TP
# of Thallus/m2	0.08	0.07
p	0.57	0.59
Mass g/m2	0.28	0.26
p	**0.04**	**0.05**
Length	0.39	0.21
p	**0.00**	0.13
Order of Bran.	0.41	0.34
p	**0.00**	**0.02**

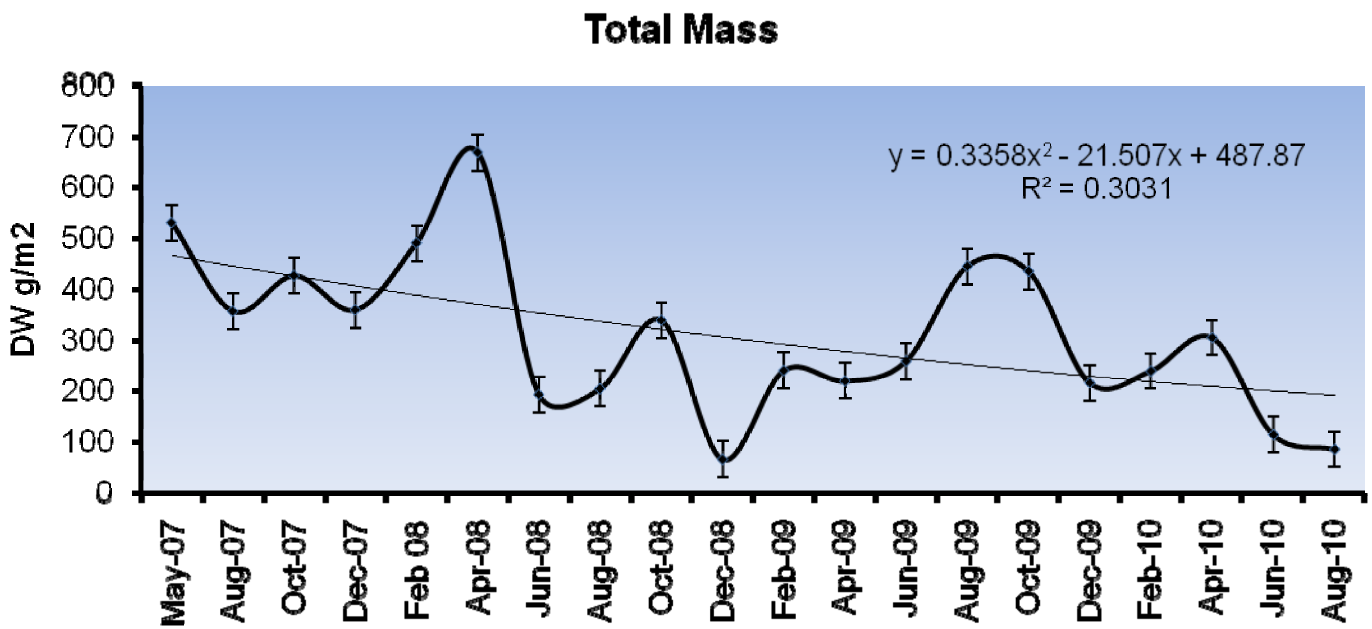
Kendall tau b correlation between *Halimeda* and TN and TP

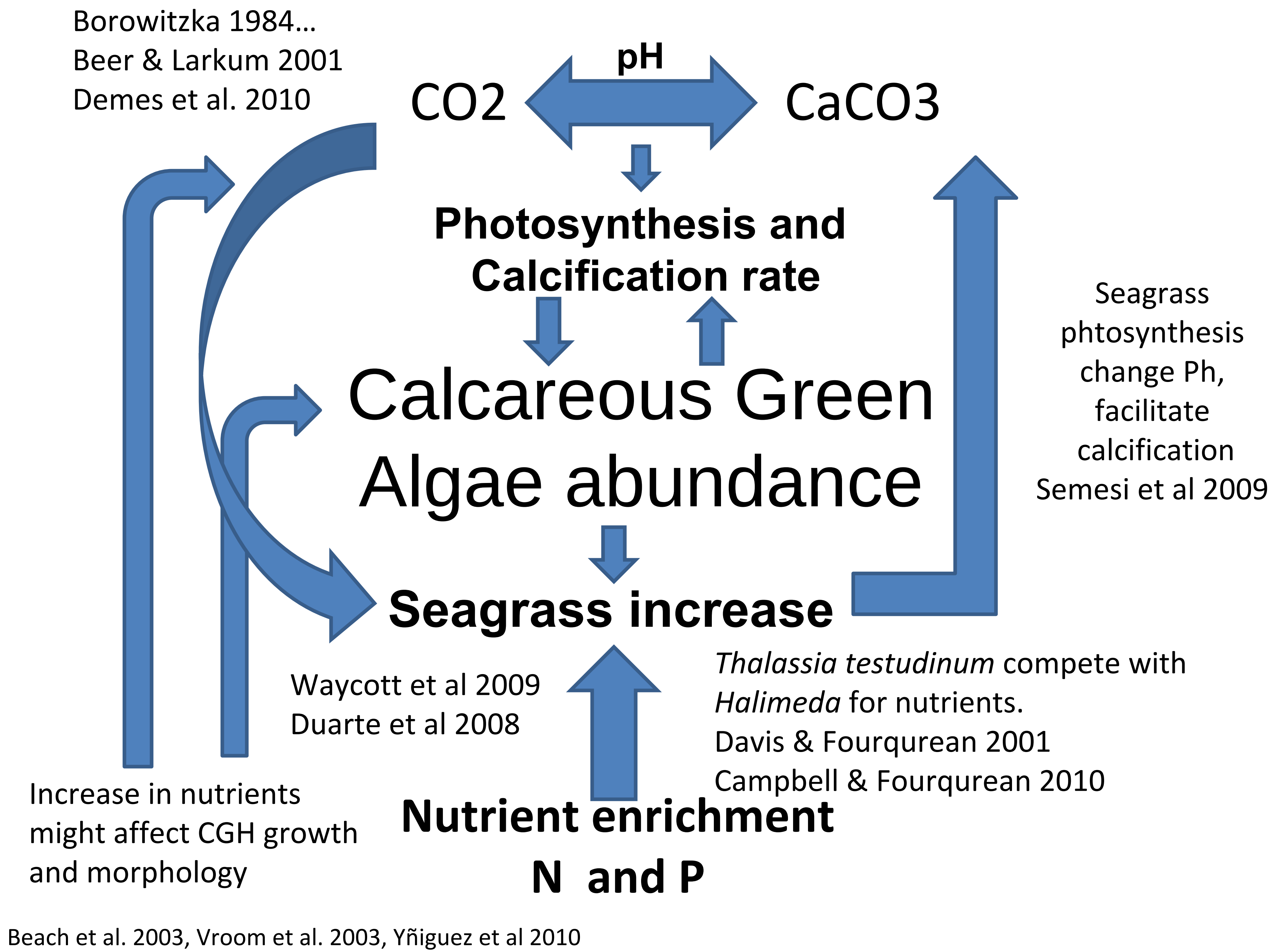




- Morphometrics of *Halimeda can be good indicator* of the conditions under which they are found
  - Yñiguez et al 2010
- Larger and more upright forms tend to be in lower-light, higher-nutrient, and calmer environments
  - Beach et al. 2003, Vroom et al. 2003
- Linear correlation between CaCO3 and biomass, a ratio that can be used as indicator of calcification status. Loss of CaCO3 is expected as pH decreases.
  - Borowitzka 1984 , Andersson et al 2009, many others

Recent shifts in *Halimeda* trends in Sprigger Bank




Borowitzka 1984…
Beer & Larkum 2001
Demes et al. 2010
pH
CO2
CaCO3
Photosynthesis and Calcification rate
Calcareous Green Algae abundance
Seagrass phtosynthesis change Ph, facilitate calcification
Semesi et al 2009
Seagrass increase
Waycott et al 2009
Duarte et al 2008
Thalassia testudinum compete with *Halimeda* for nutrients.
Davis & Fourqurean 2001
Campbell & Fourqurean 2010
Increase in nutrients might affect CGH growth and morphology
Nutrient enrichment
N and P
Beach et al. 2003, Vroom et al. 2003, Yñiguez et al 2010

Conclusions

- Our data set is a base-line that will allow us detect potential changes in $CaCO_3$ expected to happen under change of CO_2 and pH scenarios.
- Changes in *Halimeda* will be the result of a set of complex processes in which nutrients and competition will play an important role in the final output, as well as CO_2 and pH changes.
- We suggest that *Halimeda* should be included in long term monitoring programs as indicators of productivity and acidification at large scales in the FKNMS.

Acknowledgments

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