Sources of Nutrients in Biscayne Bay
A Nitrogen Tracer Study

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Take Home Message

- In Biscayne Bay there is a clear signature of N derived from anthropogenic sources in the Nitrate, POM, algae, sponges, seagrasses, and sediments.
- No differences in the trends (2006-2007) between any of these components
- This signature is only present close to the major sources of N
- This emphasis the lack of an anthropogenic signature in the Florida Reef track

Biscayne Bay

- An area of outstanding water in which the flora and fauna has declined over the past century as a result of the input of sewage, dredging, pollution and other activities
- Adjacent to a pollution of 5 million people who create waste
- Adjacent to large land fill ‘Mount Trashmore’ and Black Point Sewage Treatment plant which leaches organic material into the Bay.

Tracers

$$\delta^{15}N(^{0}/_{00}) = \frac{N^{15}/{}^{14}N_{sample}}{{}^{15}N/{}^{14}N_{standard}} - 1*1000$$

What are the Ranges?

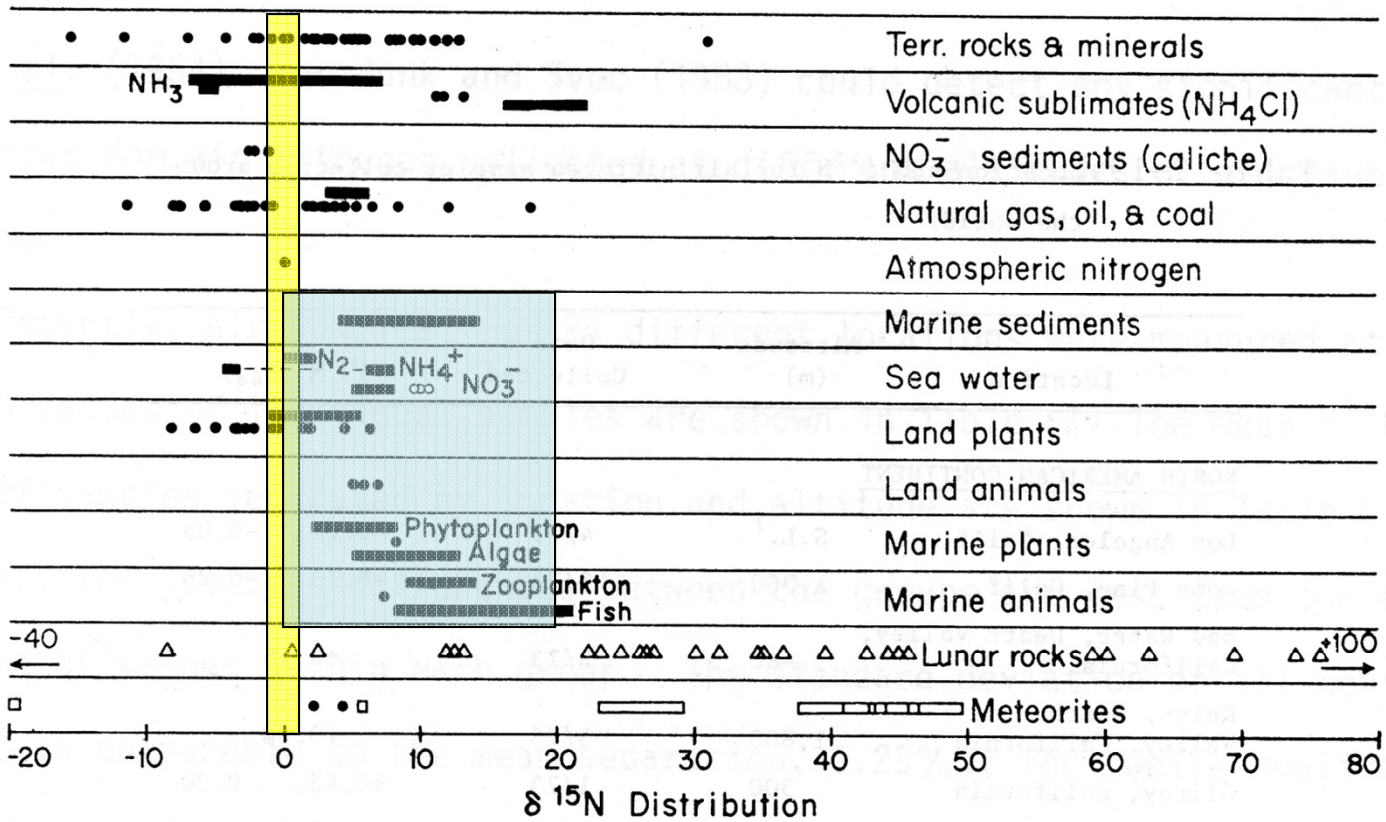
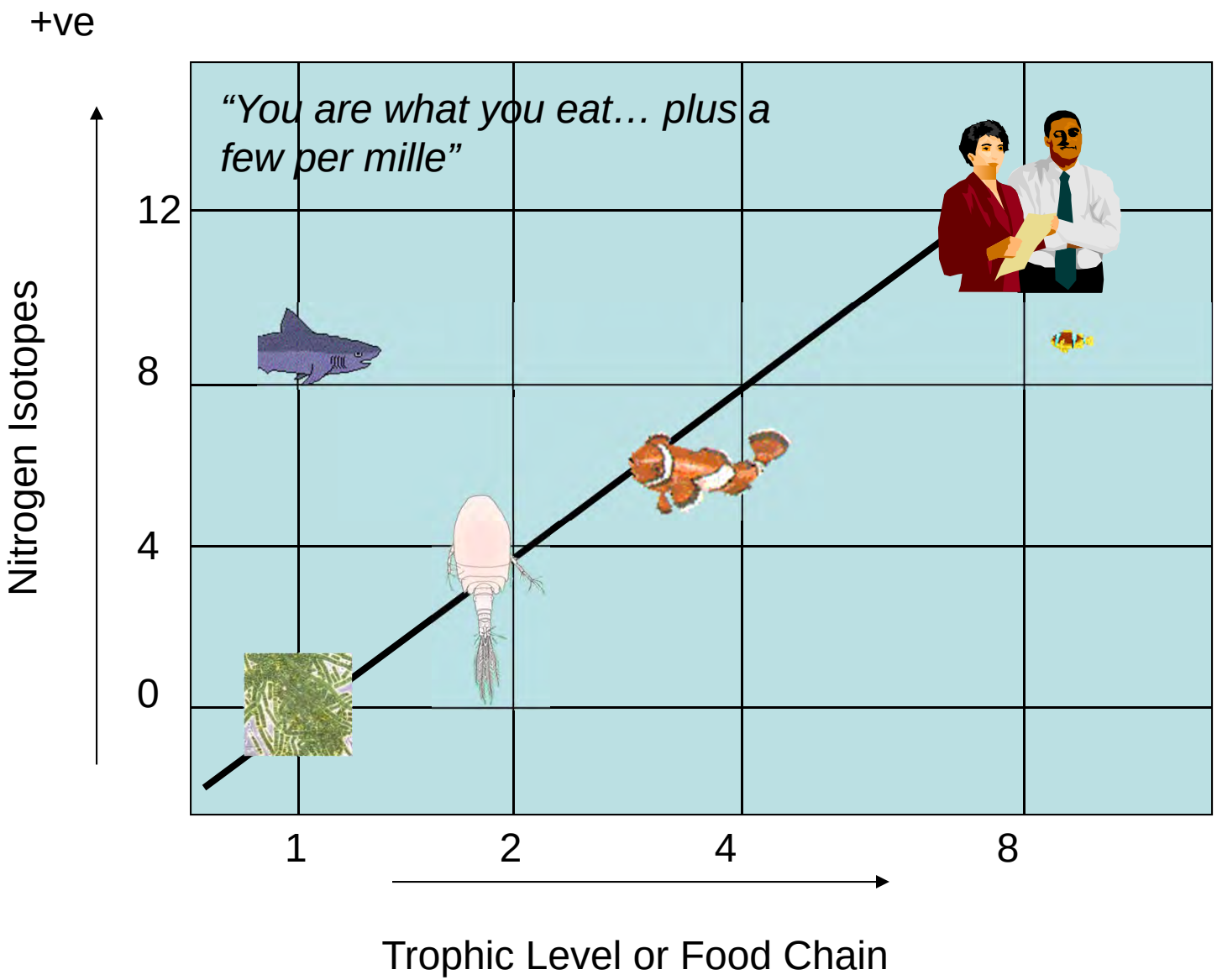


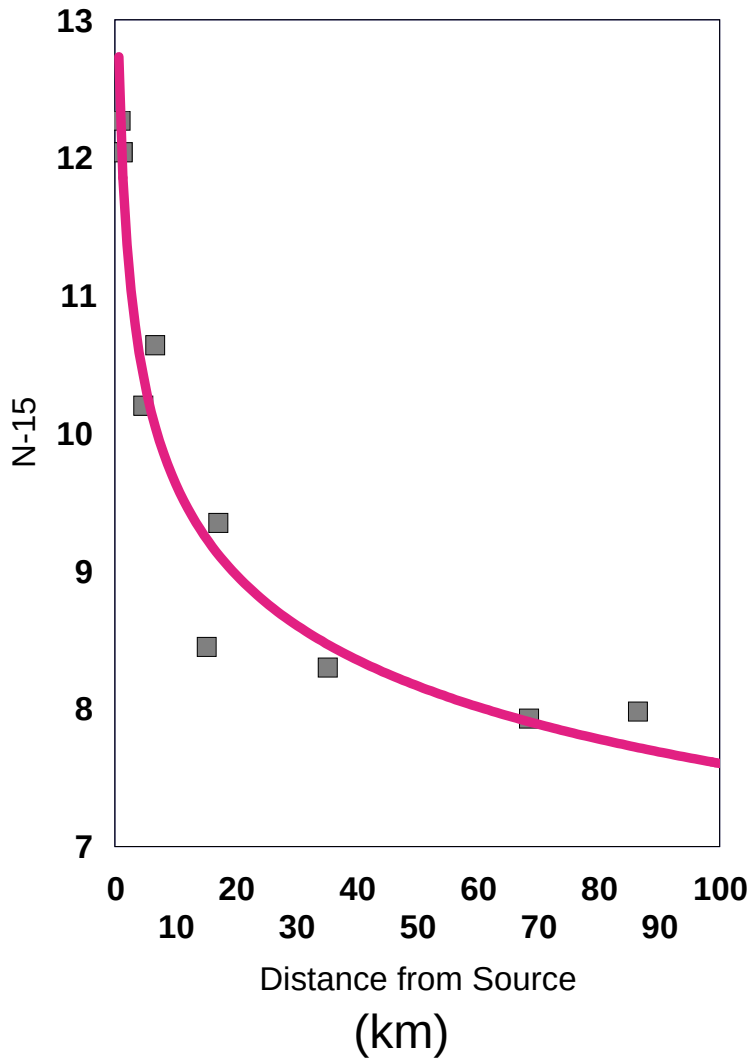
Figure 2-15. General distribution of $\delta^{15}N$ for various natural substances (revised after Miyake and Wada, 1967; Wlotzka, 1972; and Kaplan, 1975)

What do different values mean?



Nitrogen as Indicator of Sewage

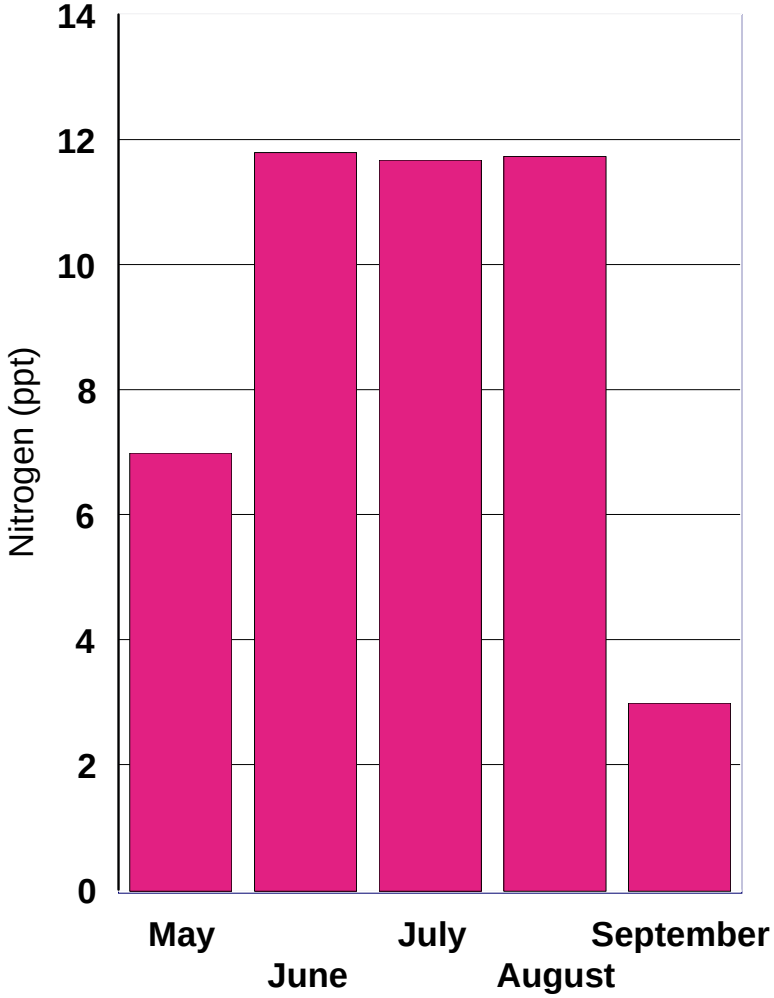
- Numerous papers have been published which report the use of stable isotopes in benthic organisms in order to distinguish sewage
  - (Heikoop et al. 2000a,b; Sammarco et al., 1999; Risk and Erdmann, 2000; Costanzo et al., 2001, 2004).



Risk and Erdman 2000

Measured $\delta^{15}N$ values in *Codium sp.* from Jupiter Inlet Values reached to almost +12 ‰ during summer which he concluded was a result of freshwater bringing high $\delta^{15}N$ nitrogen from animal waste.

Lapointe (1997)



Controversy

'…macroalgae in nearshore waters around Big Pine Key had elevated $\delta^{15}N$ values (~ + 4‰) characteristic of sewage enrichment… '

LaPointe et al., (1997)

'Our conclusion that chronic anthropogenic nutrient enrichment has supported algal blooms, eutrophication, and reef coral die-off in the FKNMS'

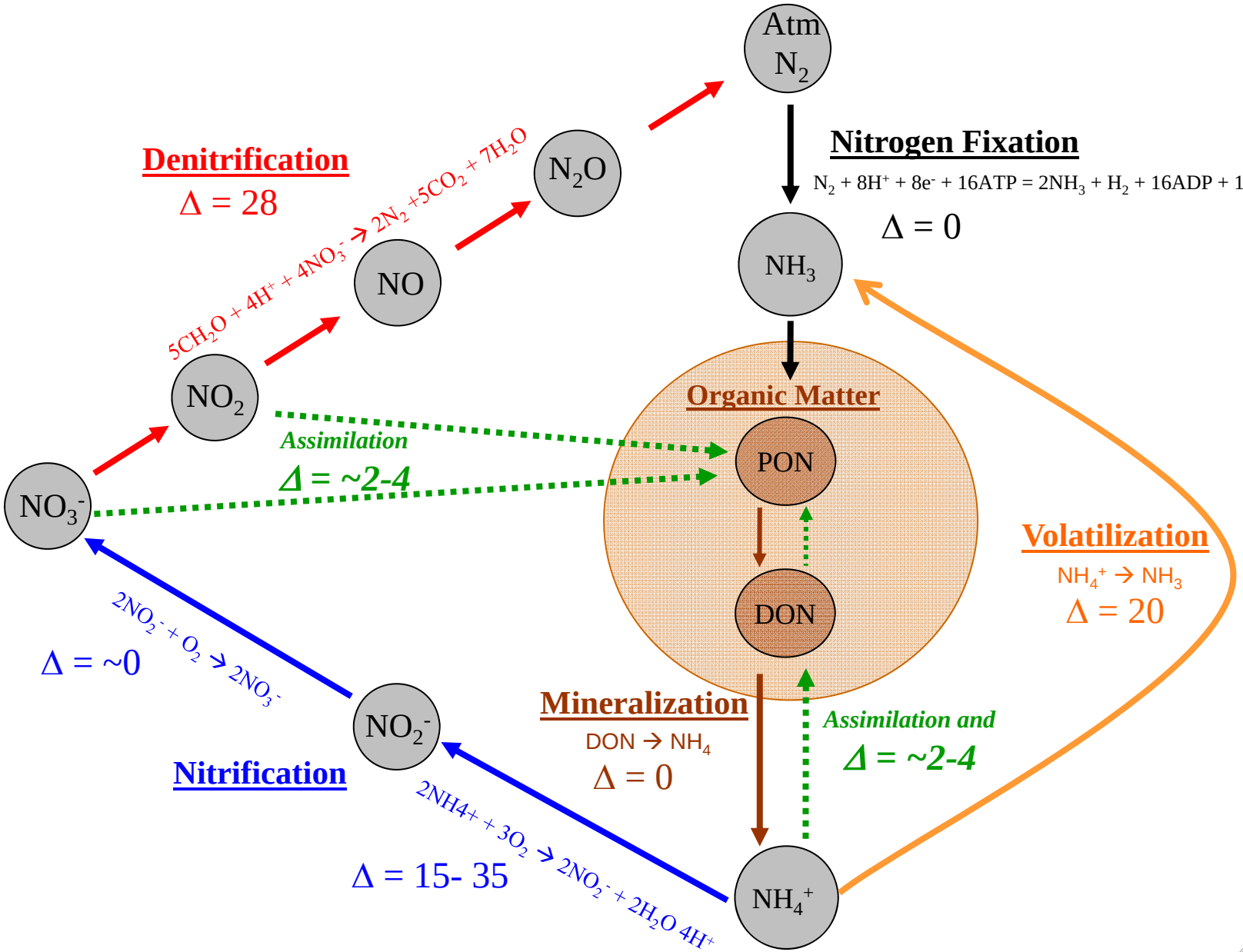
LaPointe et al., (1997)

'Based on a comparison with previously published $\delta^{15}N$ data on coral tissues that classified coral reefs into sewage influenced and pristine, the data presented in this article would place these corals in the unaffected-by sewage category.'

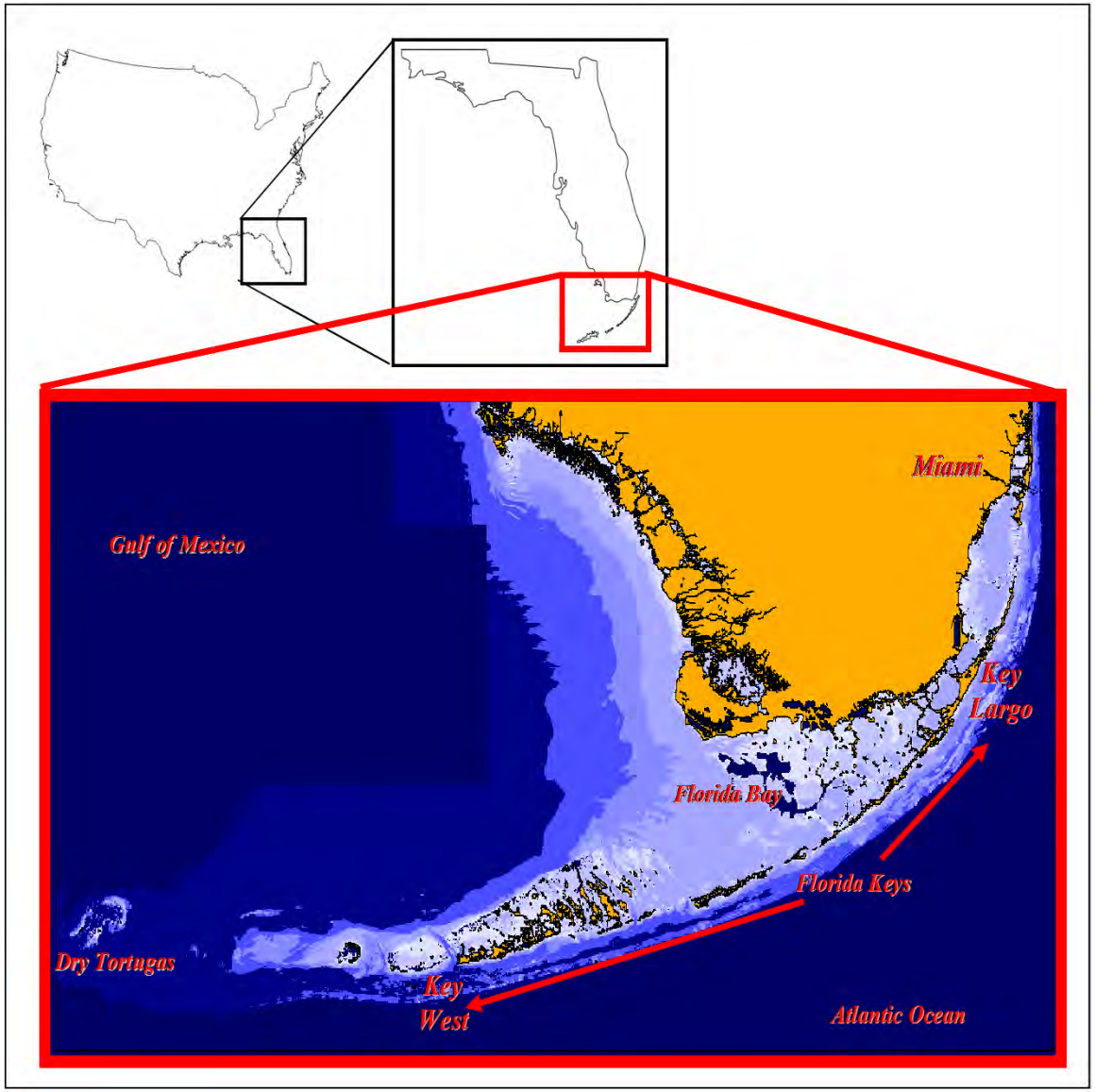
Swart et al. (2005)

'….the principal source of organic material contributing to the POM in the nearshore was organic detritus derived from seagrasses and not from land based sources.'

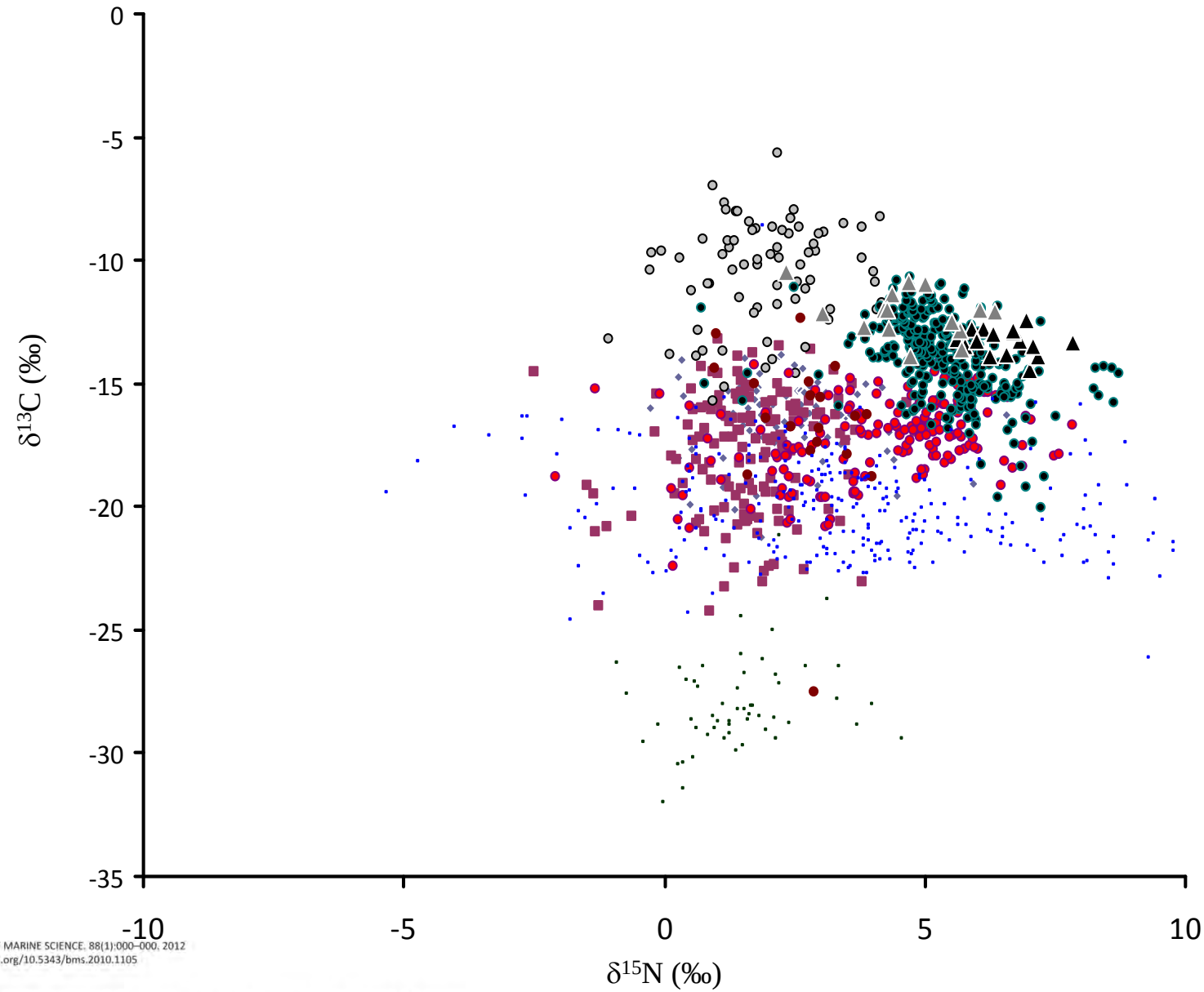
Lamb and Swart (2008)


Atm N_2
Nitrogen Fixation
$N_2 + 8H^+ + 8e^- + 16ATP = 2NH_3 + H_2 + 16ADP + 16\ Pi$
$\Delta = 0$
NH_3
Organic Matter
PON
DON
Volatilization
$NH_4^+ \rightarrow NH_3$
$\Delta = 20$
Assimilation and
$\Delta = \sim 2\text{-}4$
Mineralization
DON → NH_4
$\Delta = 0$
NH_4^+
$2NH4^+ + 3O_2 \rightarrow 2NO_2^- + 2H_2O\ 4H^+$
$\Delta = 15\text{-}\ 35$
NO_2^-
Nitrification
$2NO_2^- + O_2 \rightarrow 2NO_3^-$
$\Delta = \sim 0$
NO_3^-
Assimilation
$\Delta = \sim 2\text{-}4$
NO_2
$5CH_2O + 4H^+ + 4NO_3^- \rightarrow 2N_2 + 5CO_2 + 7H_2O$
NO
N_2O
Denitrification
$\Delta = 28$

Lamb 2006


Miami
Gulf of Mexico
Key
Largo
Florida Bay
Florida Keys
Dry Tortugas
Key
West
Atlantic Ocean

Florida Reef Tract



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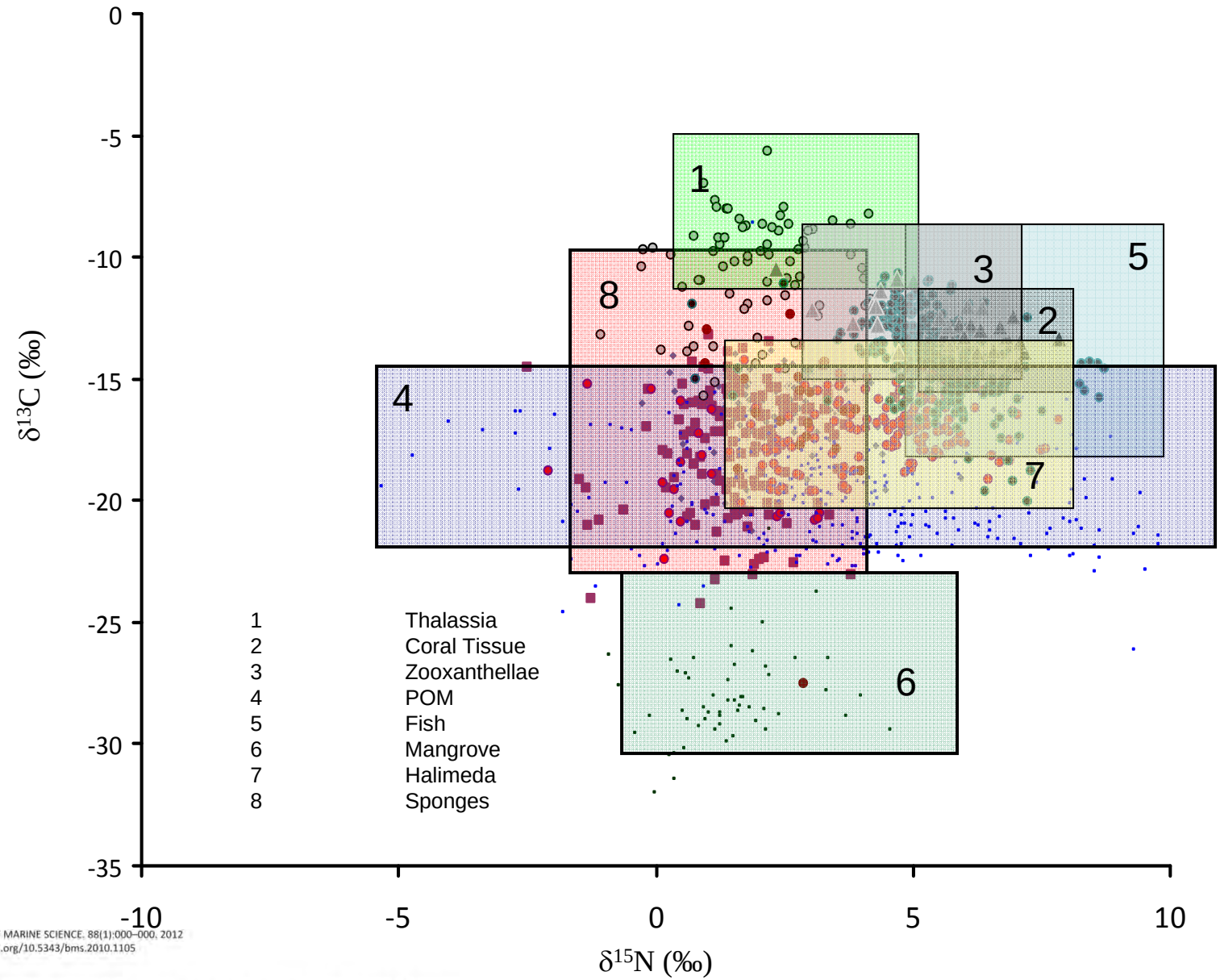
NITROGEN AND CARBON ISOTOPIC SYSTEMATICS
OF THE FLORIDA REEF TRACT

K Lamb, PK Swart, and MA Altabet

Florida Reef Tract



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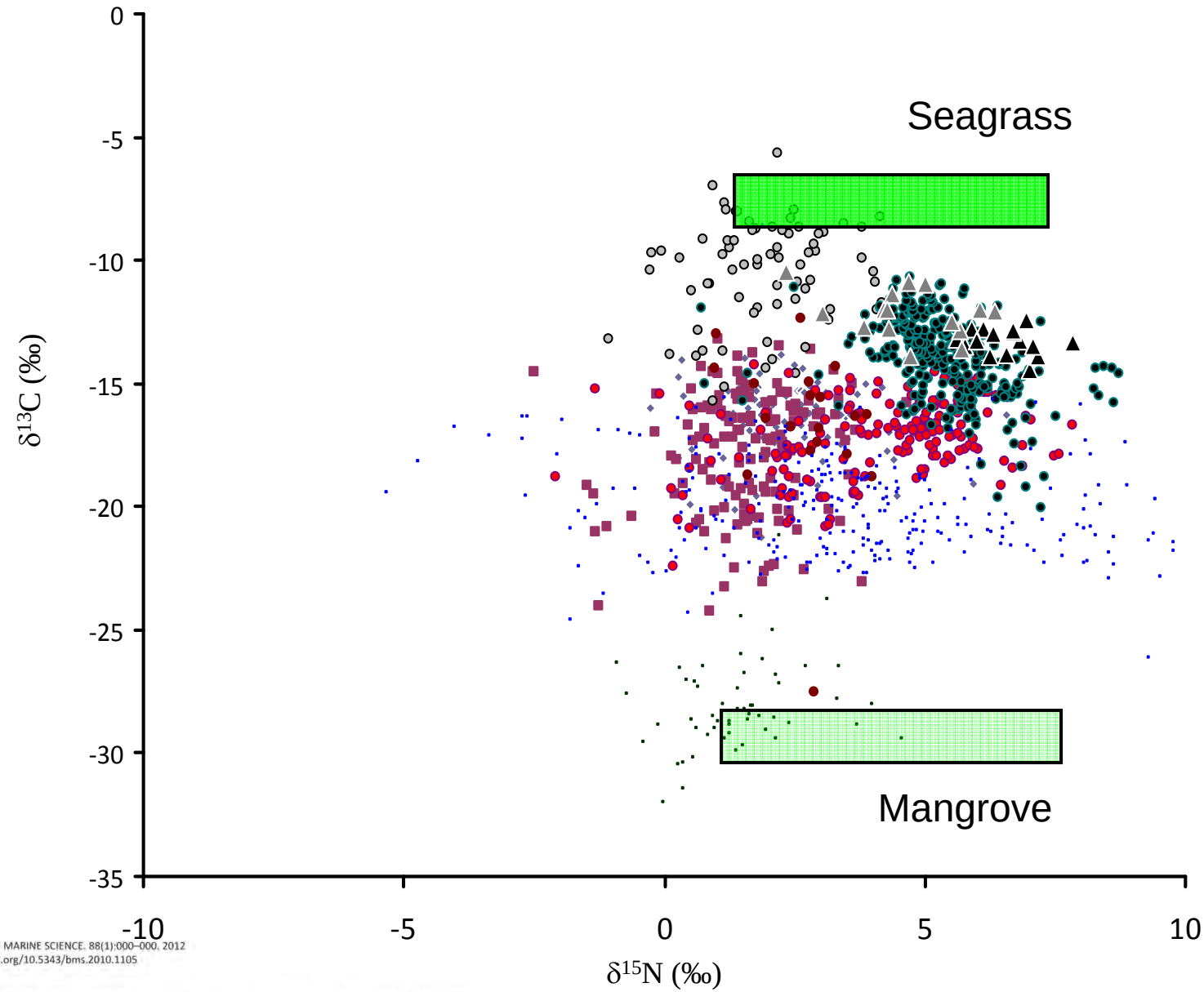

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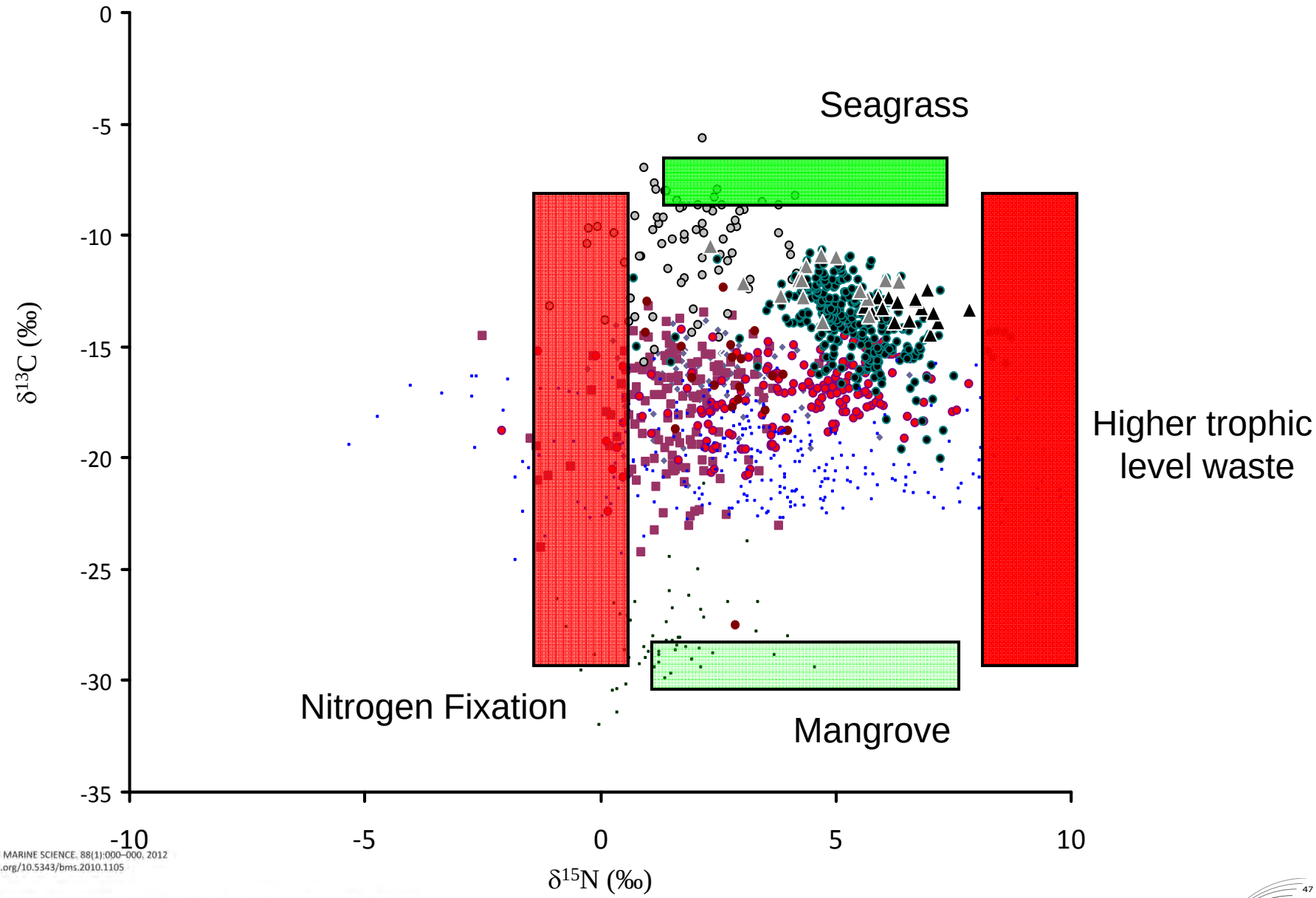

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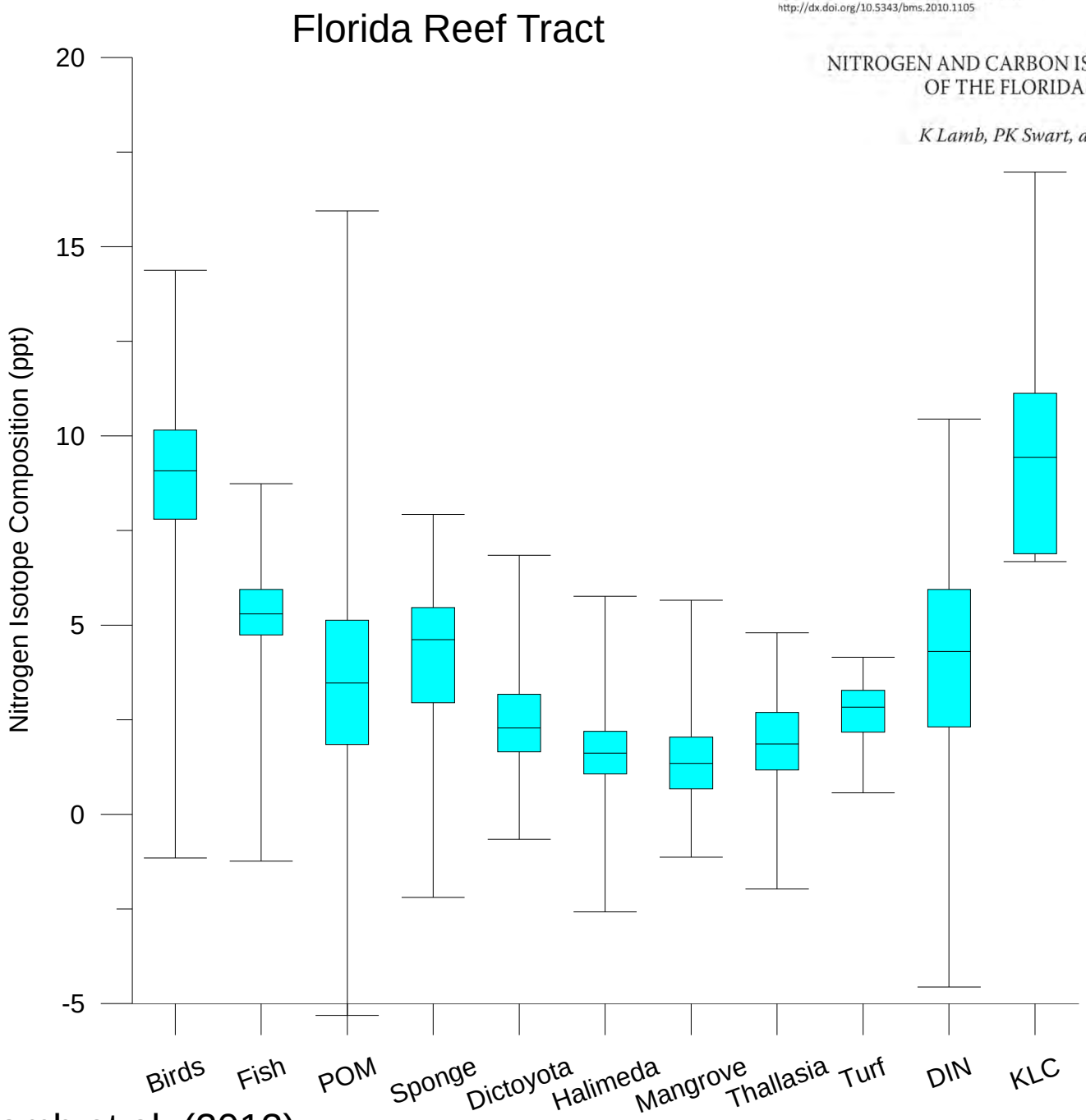
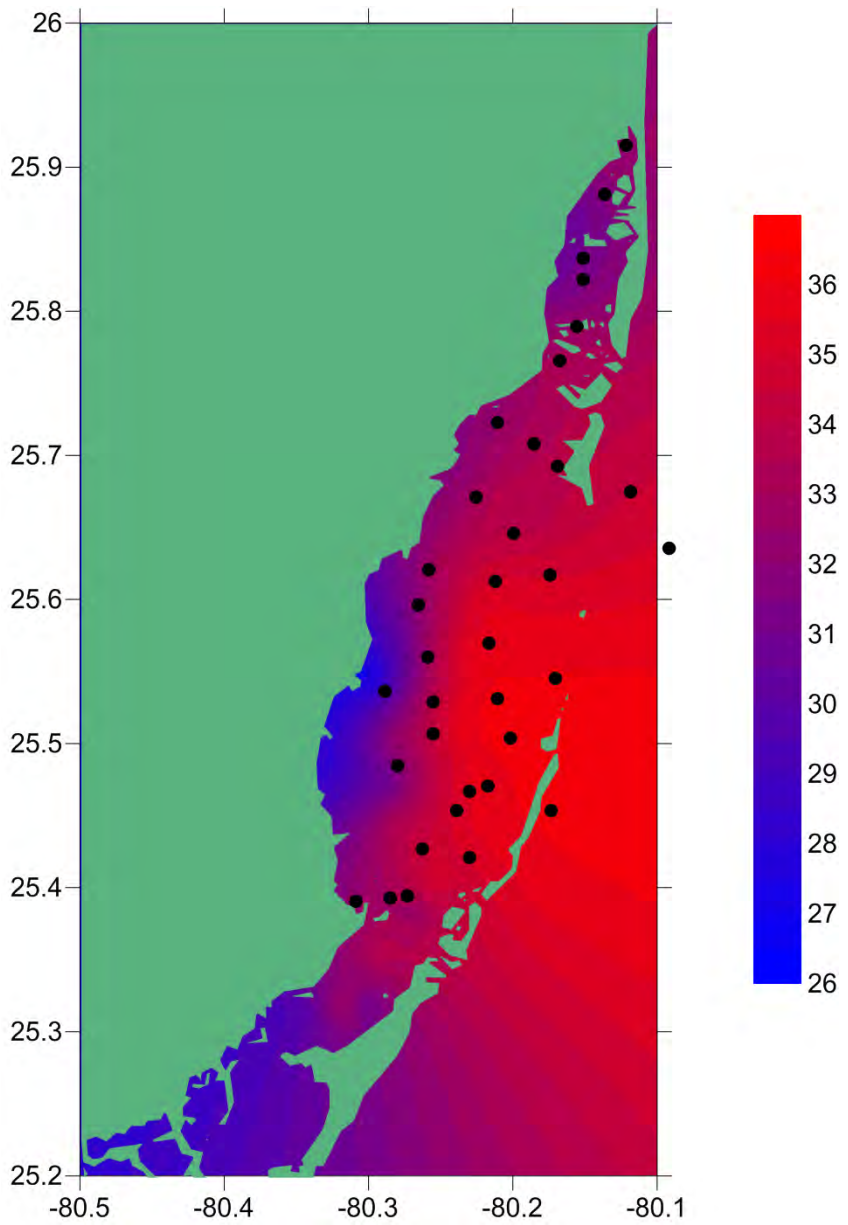


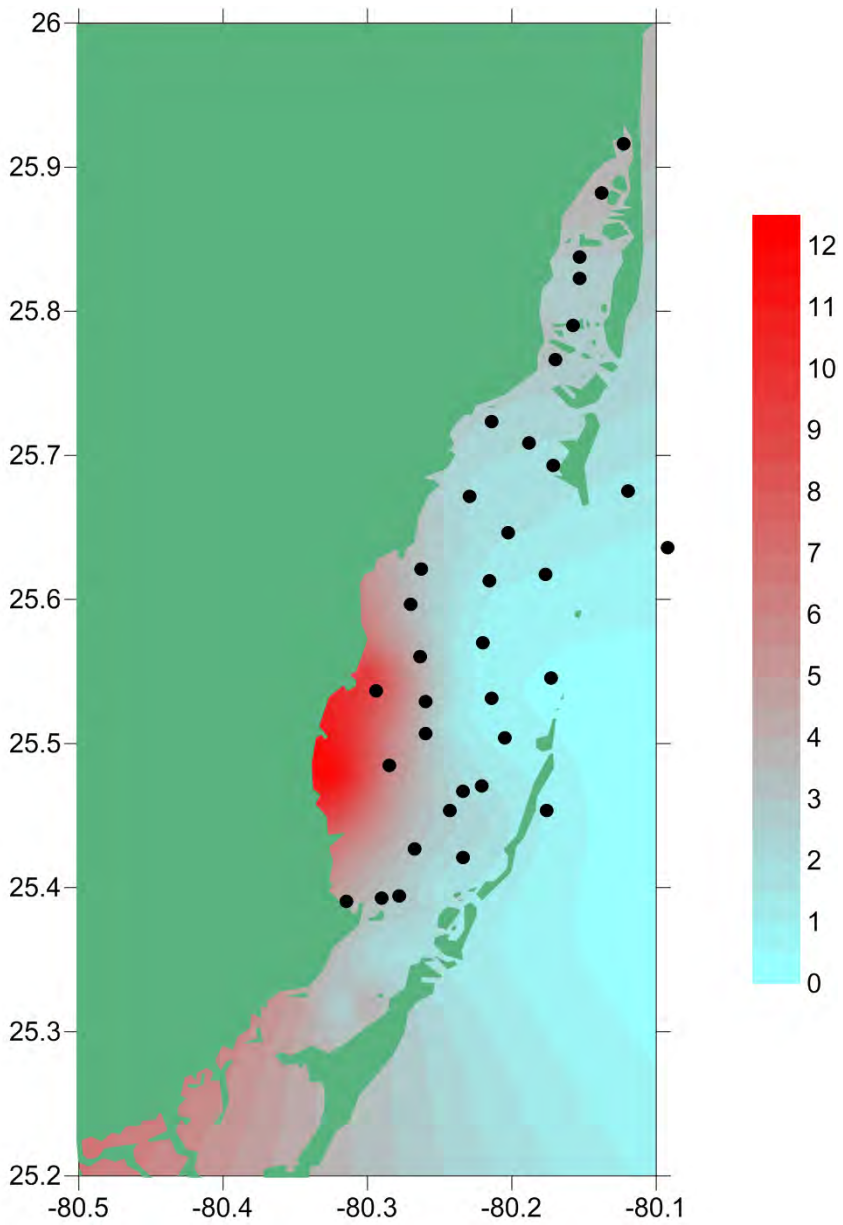
Data from Lamb et al. (2012)

Salinity

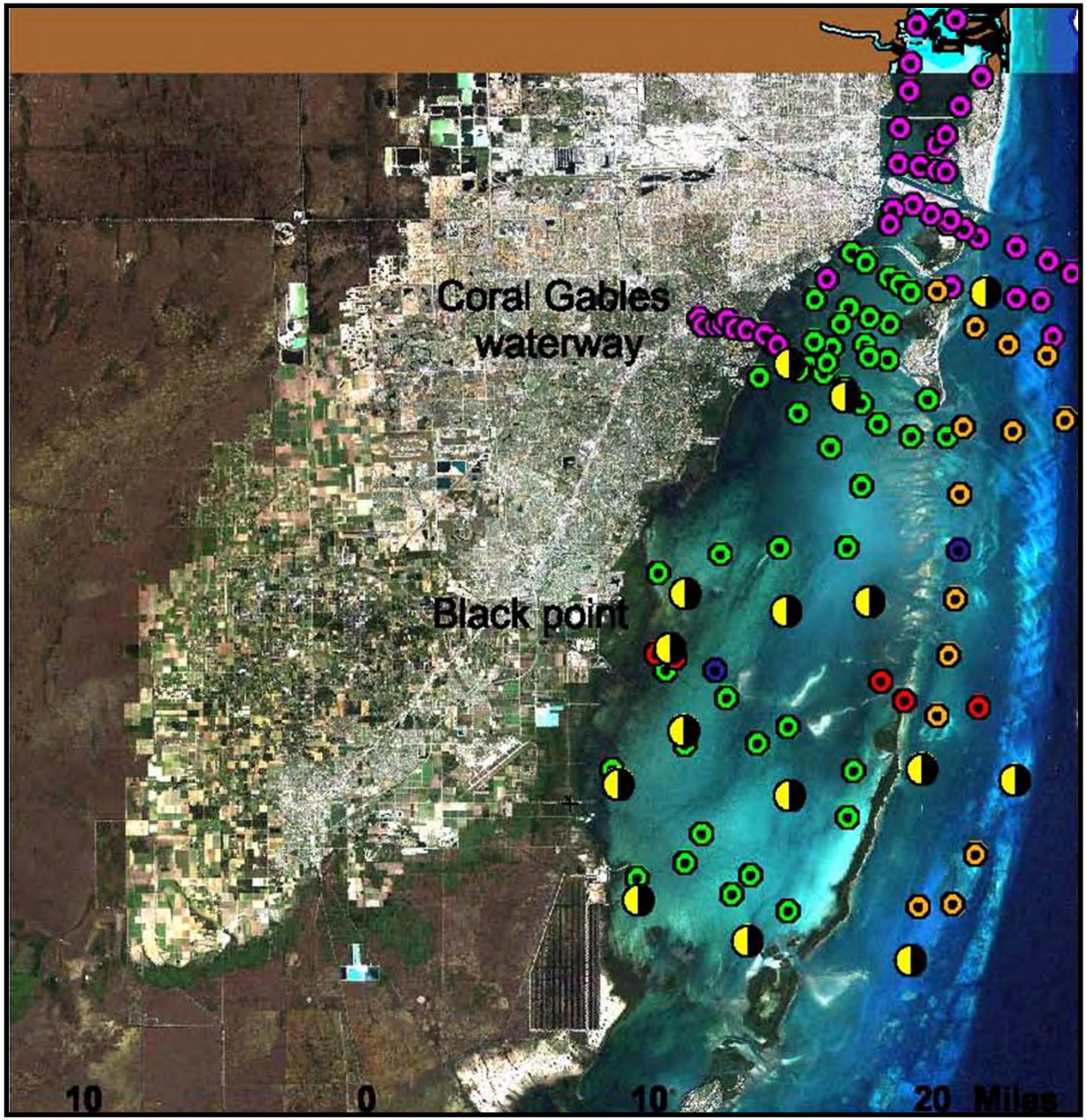


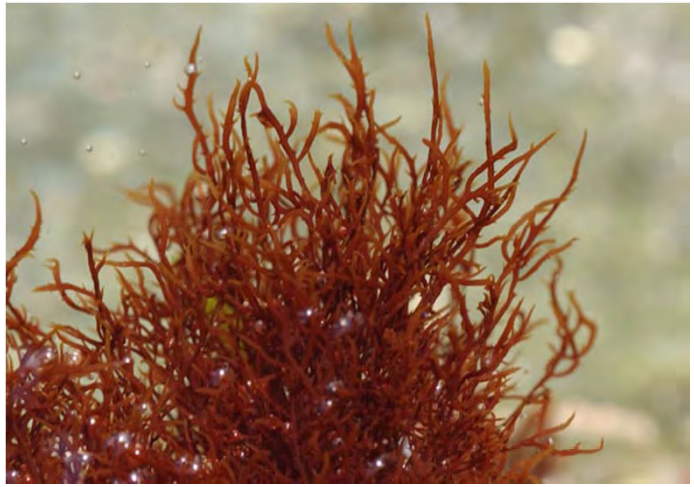
Average salinity from 1997-2009 (Data from FIU)

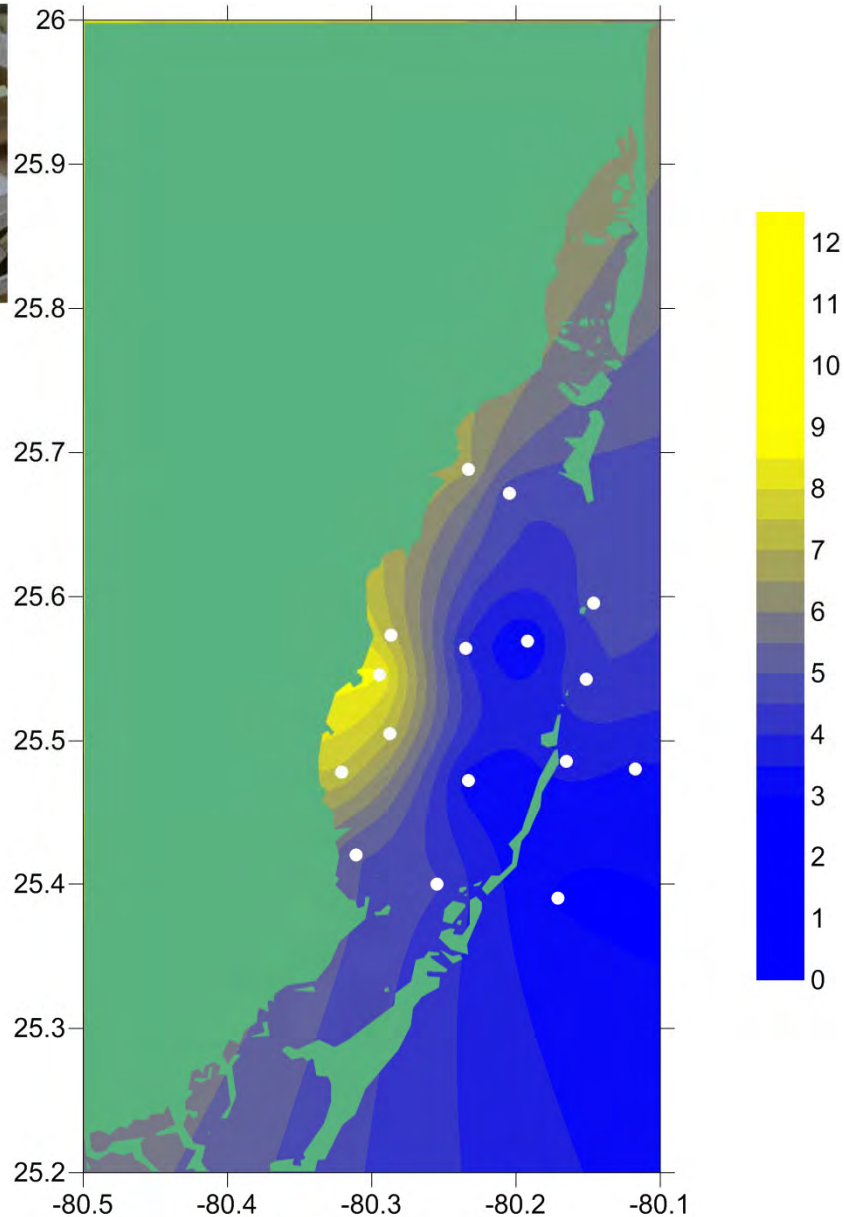
Mean NOx (μm)



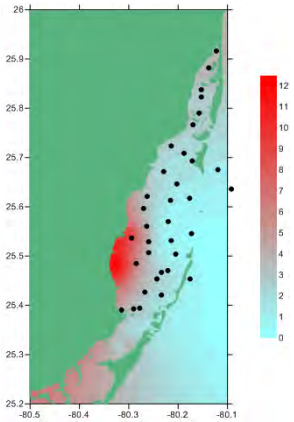
Average NOx from 1997-2009 (Data from FIU)


Coral Gables
waterway
Black point
10
0
10
20 Miles



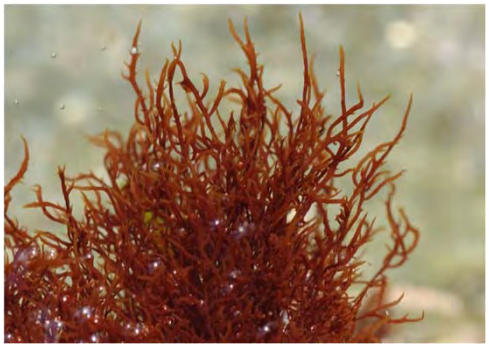


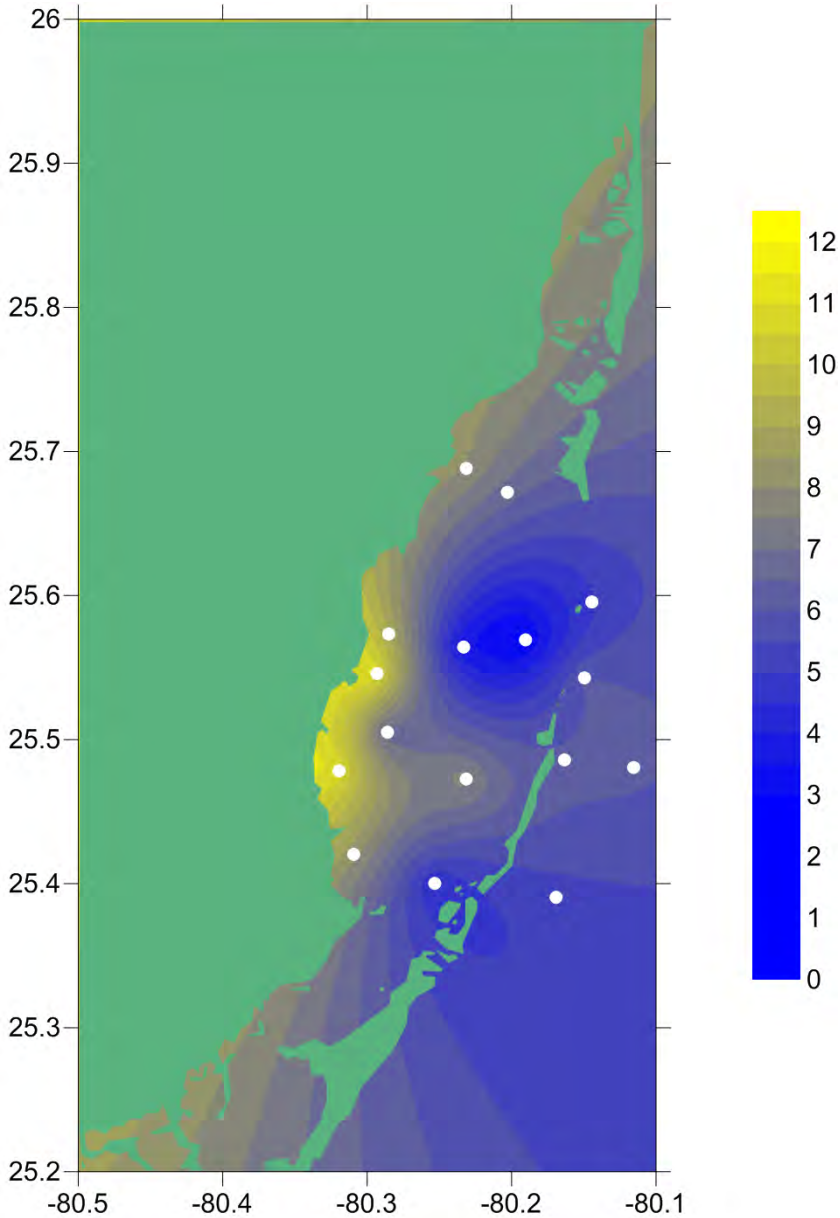
POM

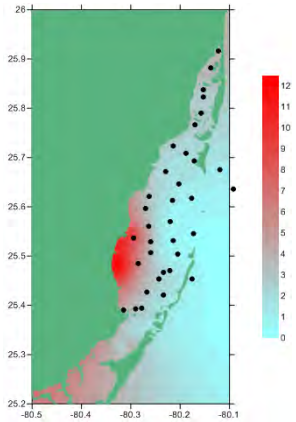


Nitrogen

Red Algae

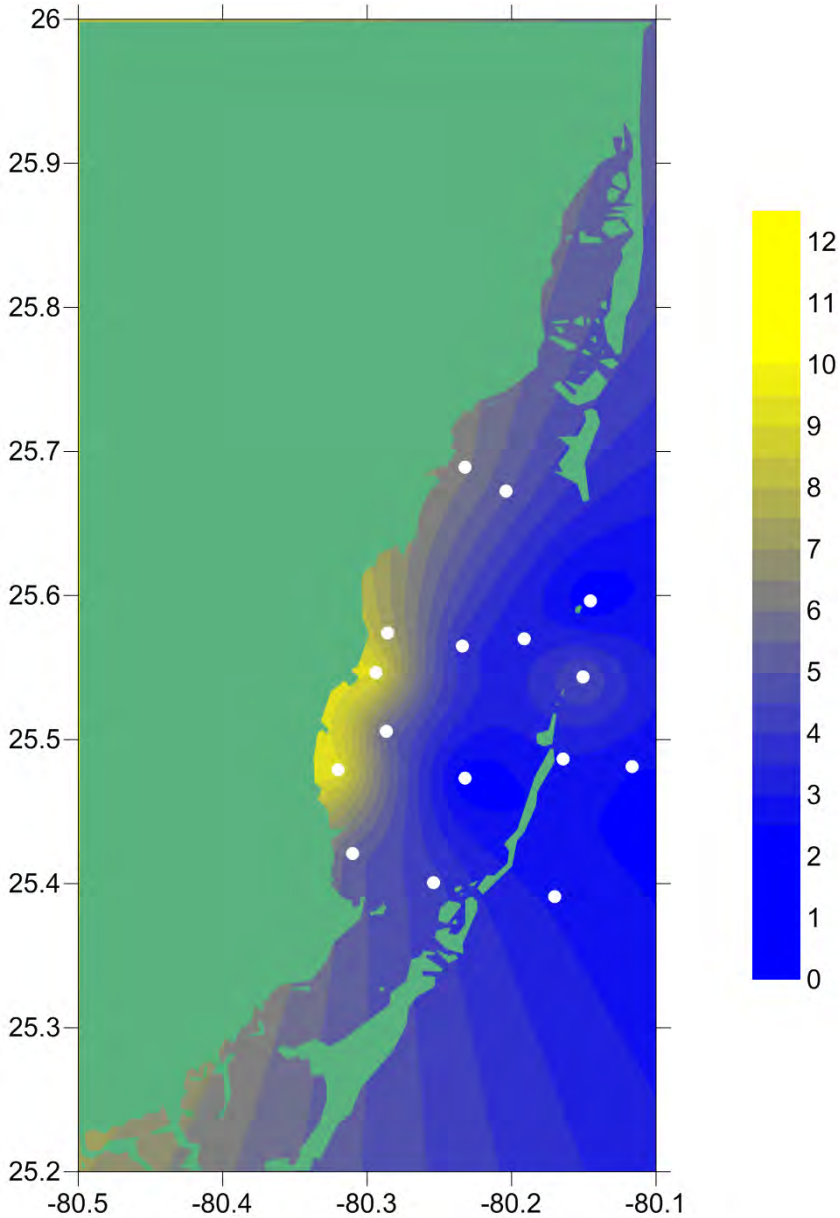


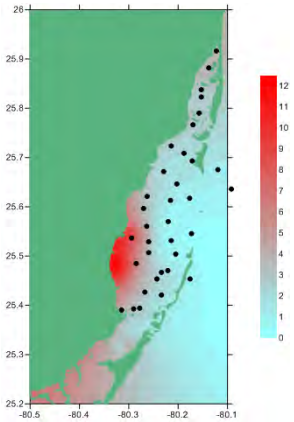




Nitrogen

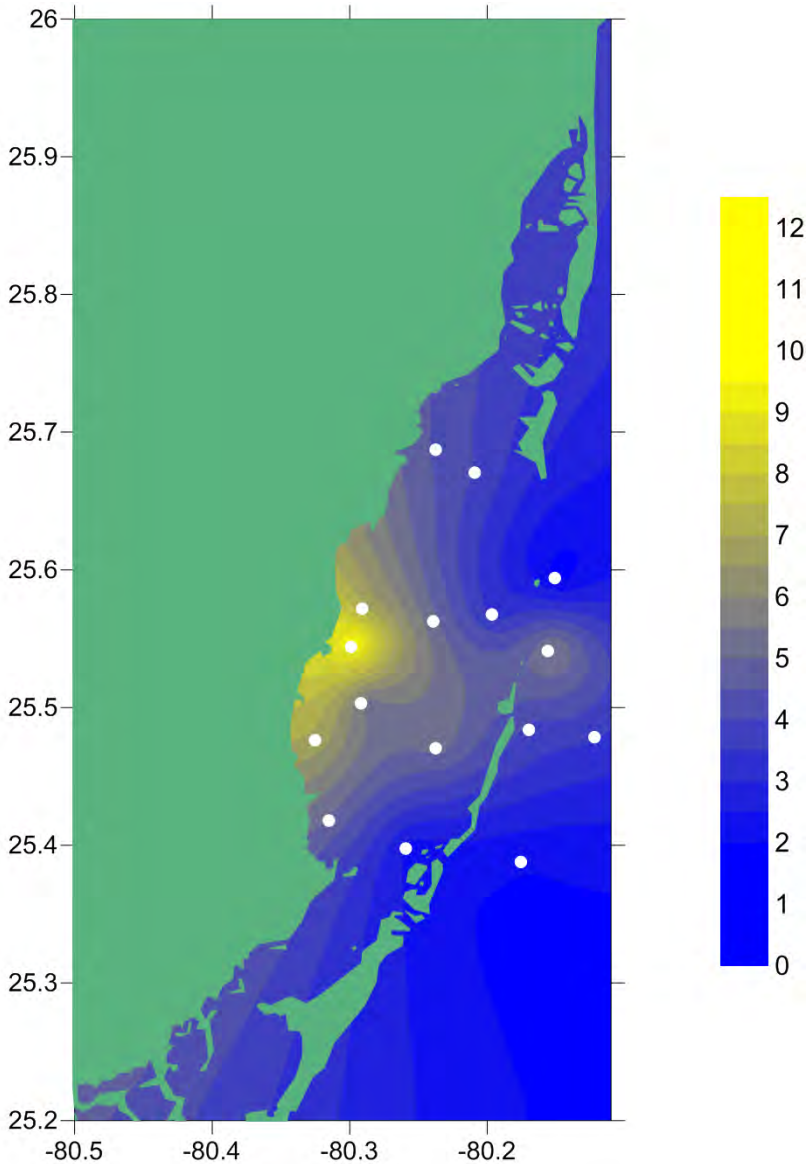
Green Algae

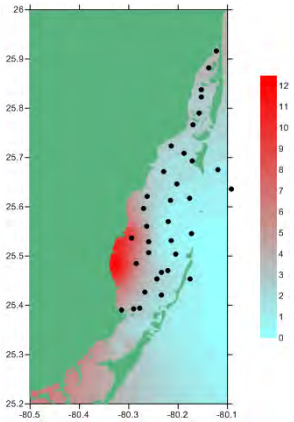




Nitrogen

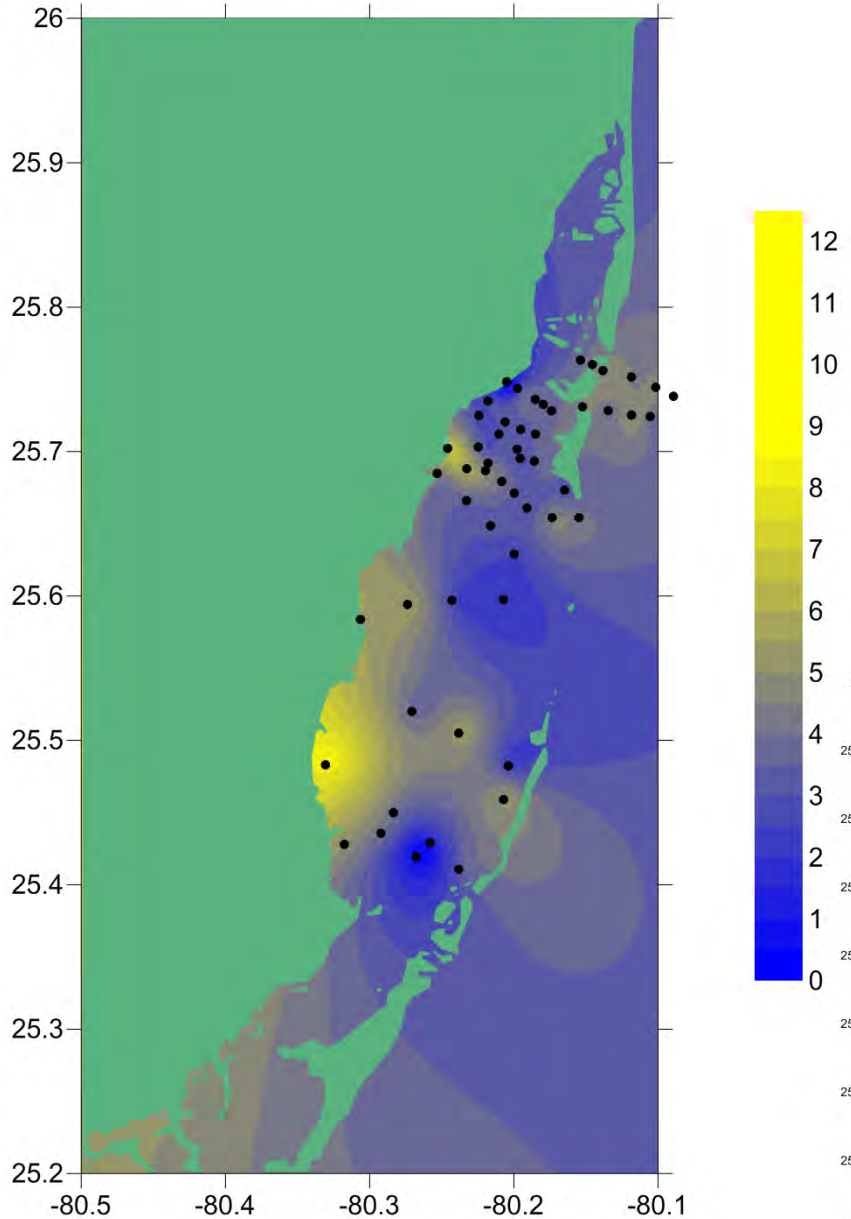
Seagrass

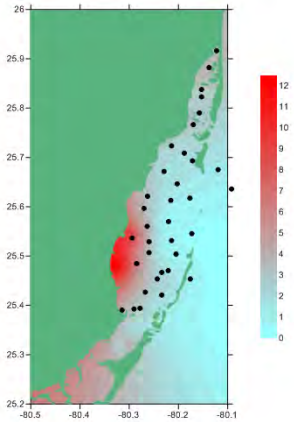


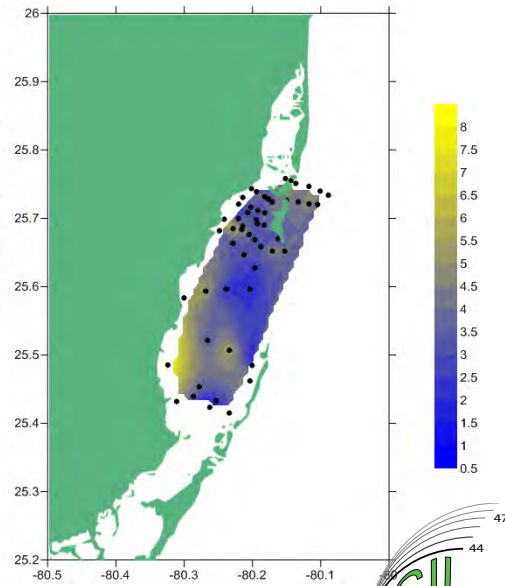


Nitrogen

Sedimentary Organic Material

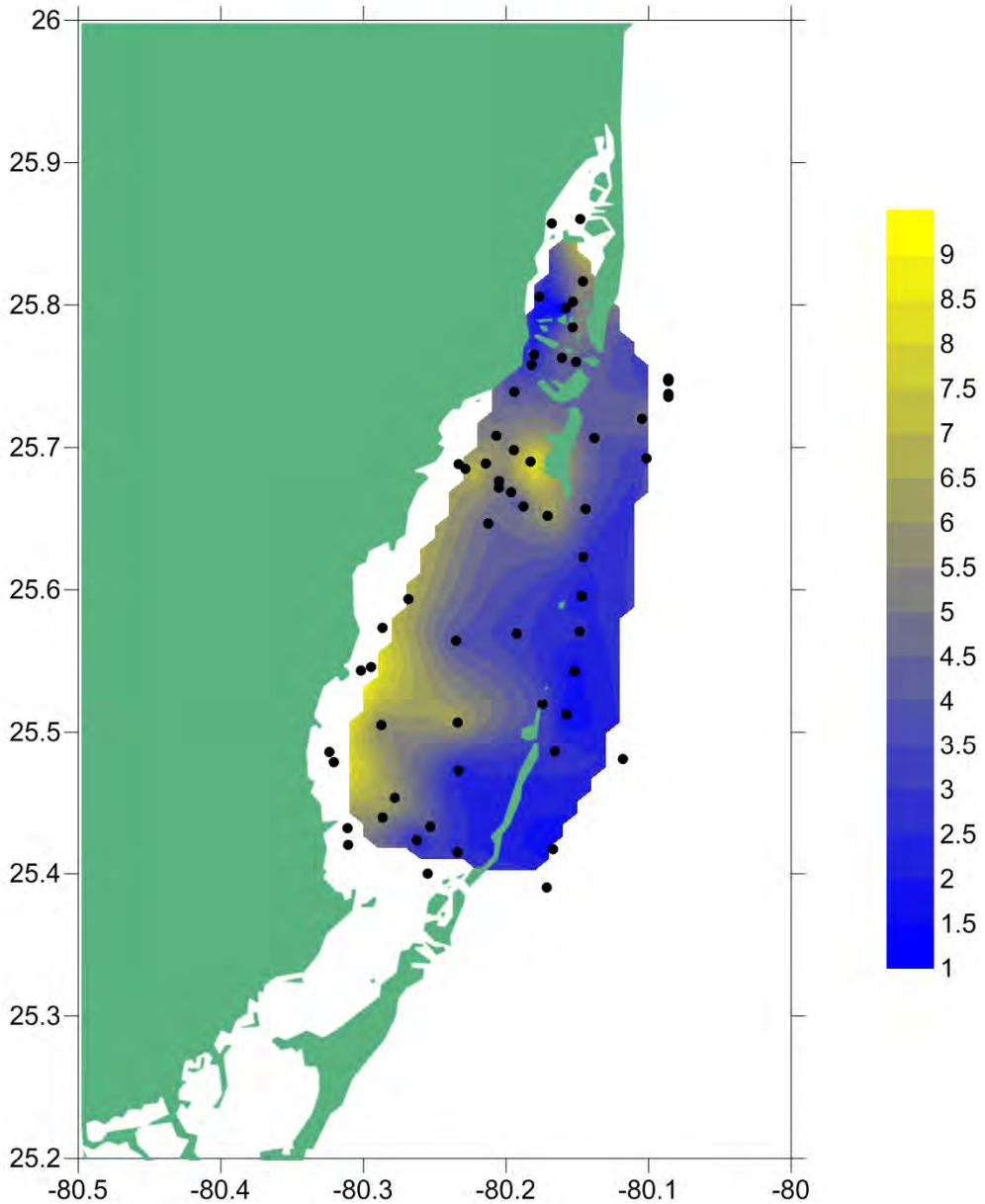


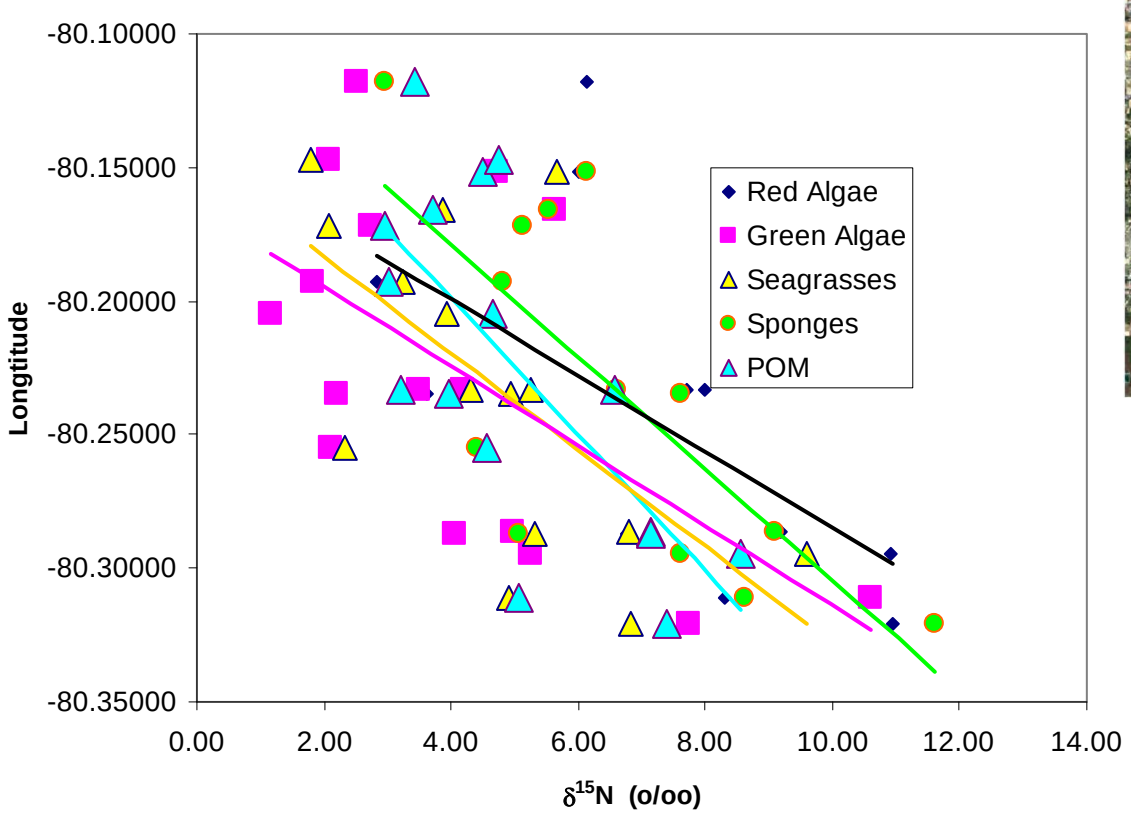


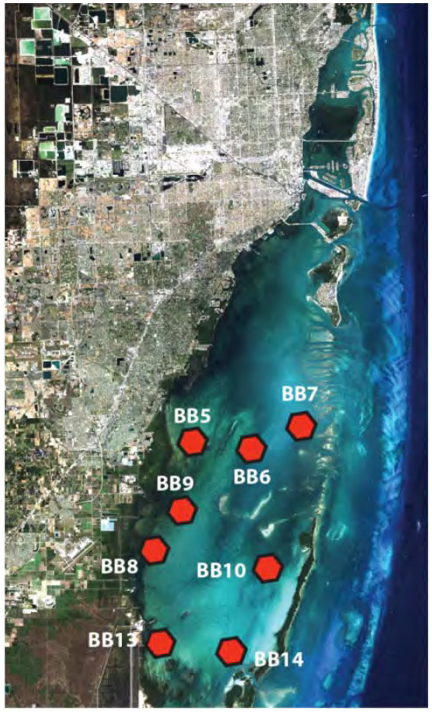


Nitrogen

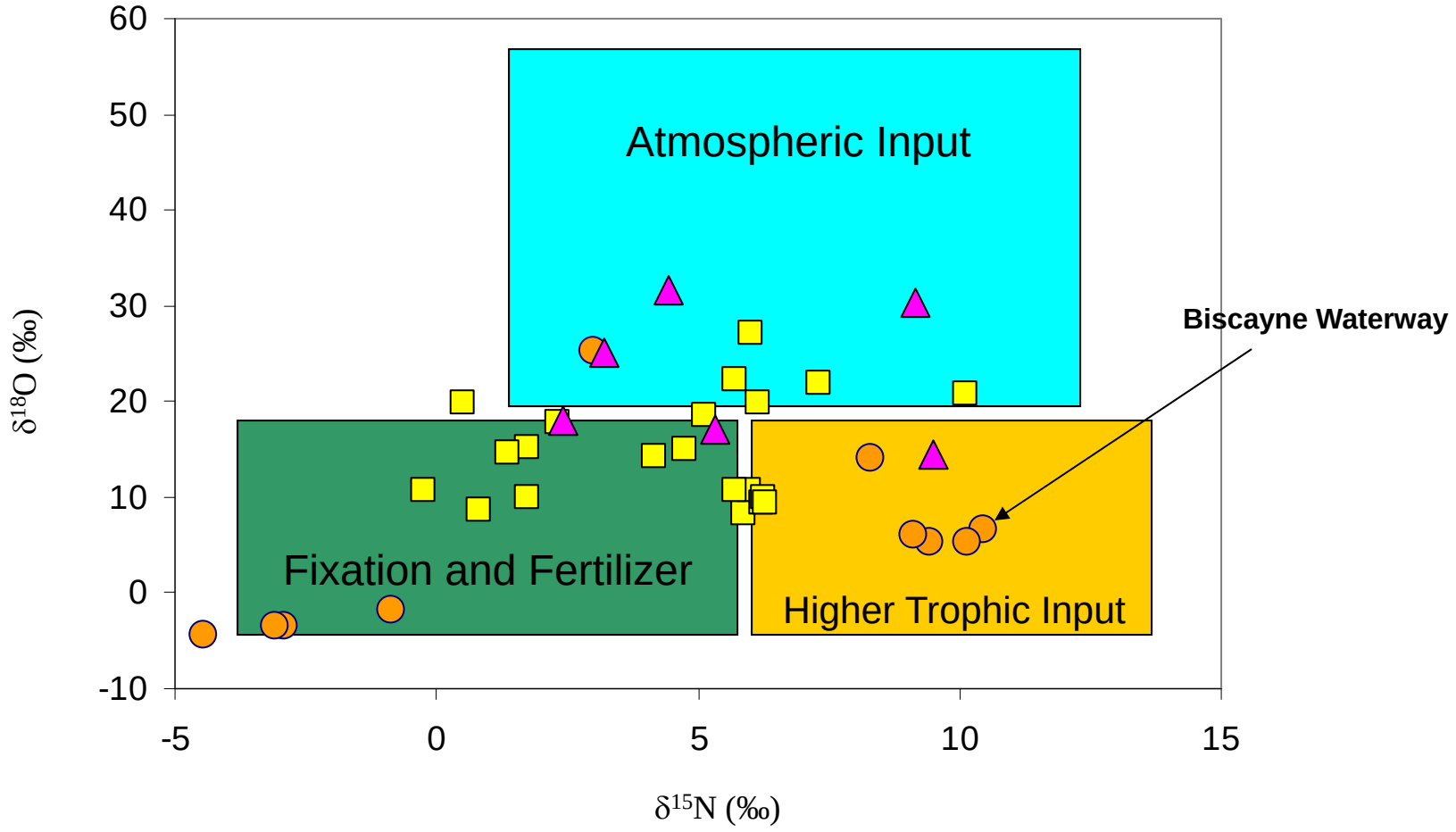
Green Algae

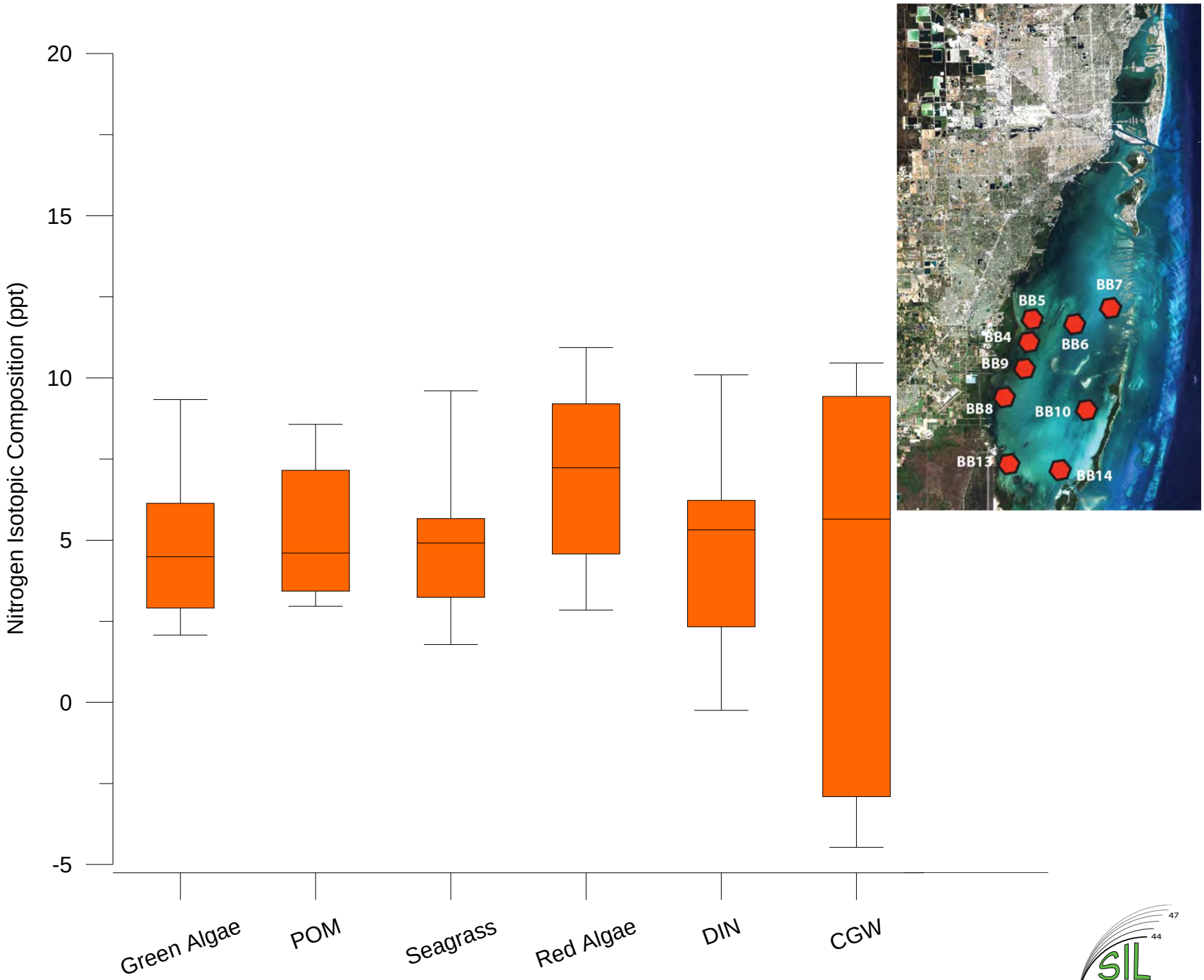

26
25.9
25.8
25.7
25.6
25.5
25.4
25.3
25.2
-80.5
-80.4
-80.3
-80.2
-80.1
-80
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1

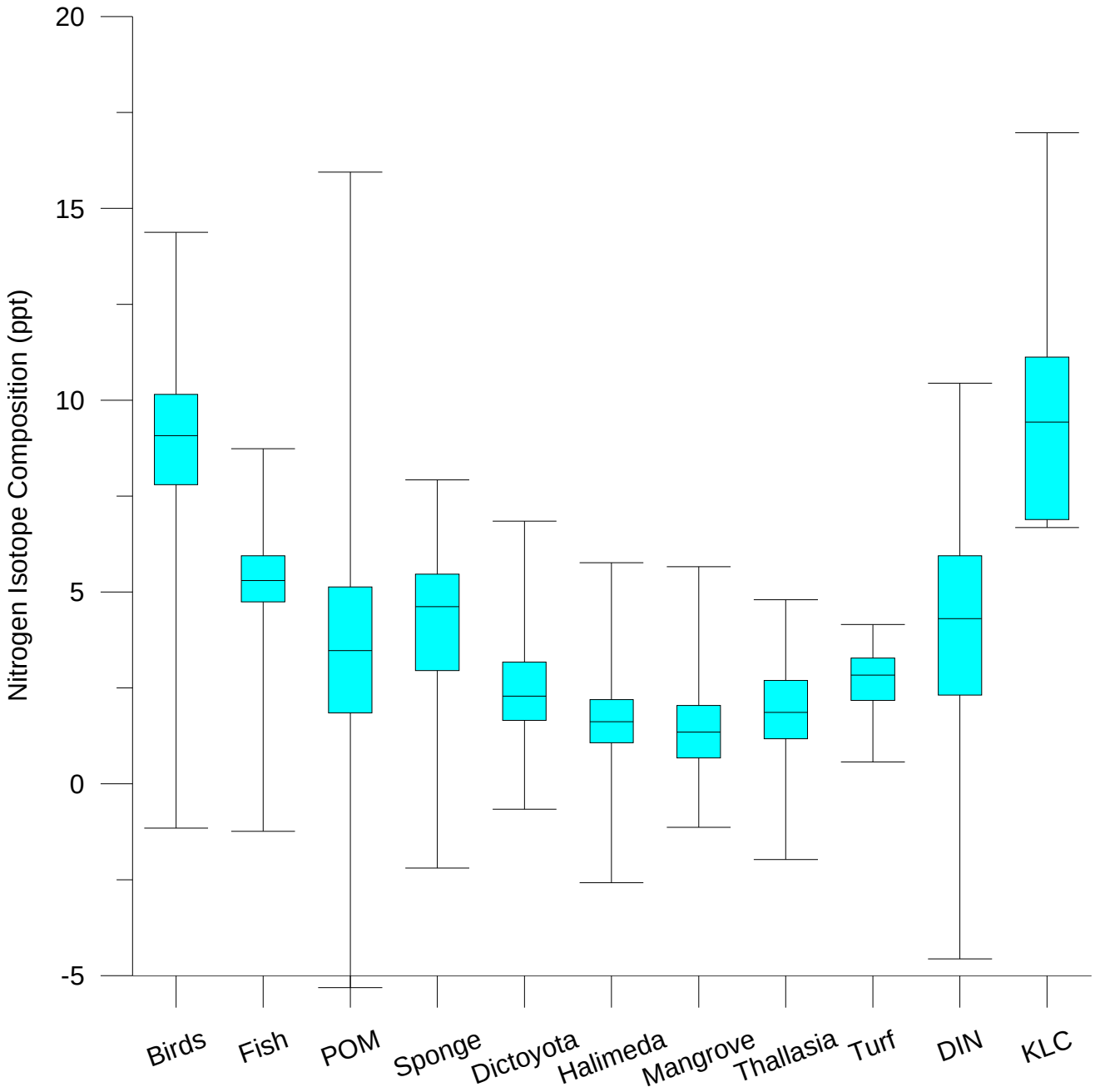

-80.10000
-80.15000
-80.20000
-80.25000
-80.30000
-80.35000
Longtitude
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
δ15N (o/oo)
Red Algae
Green Algae
Seagrasses
Sponges
POM


BB7
BB5
BB6
BB9
BB8
BB10
BB13
BB14

Dissolved Nitrate Biscayne Bay




Nitrogen Isotopic Composition (ppt)
20
15
10
5
0
-5
Green Algae
POM
Seagrass
Red Algae
DIN
CGW
BB5
BB7
BB4
BB6
BB9
BB8
BB10
BB13
BB14



Data from Lamb et al. (2012)

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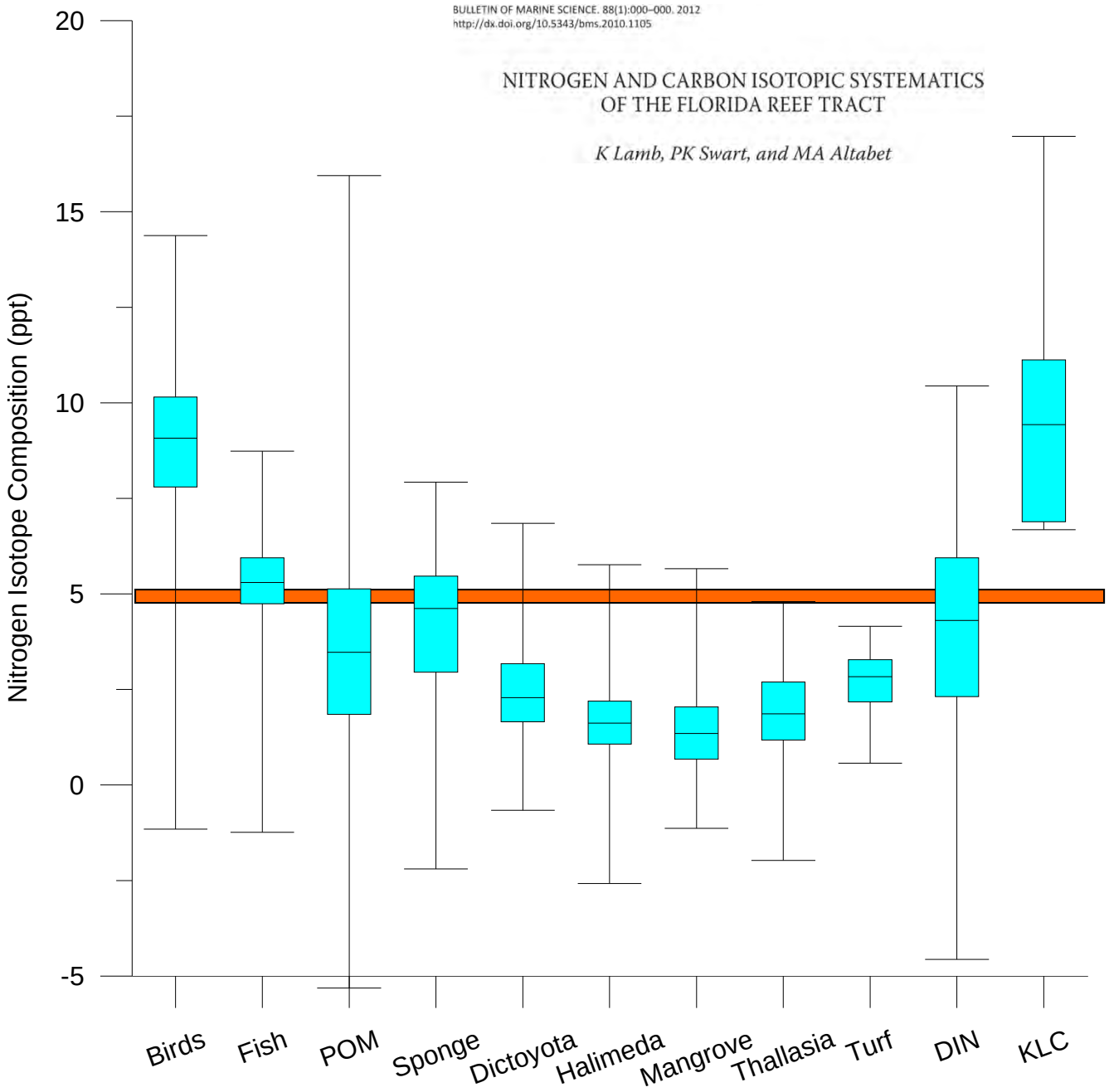


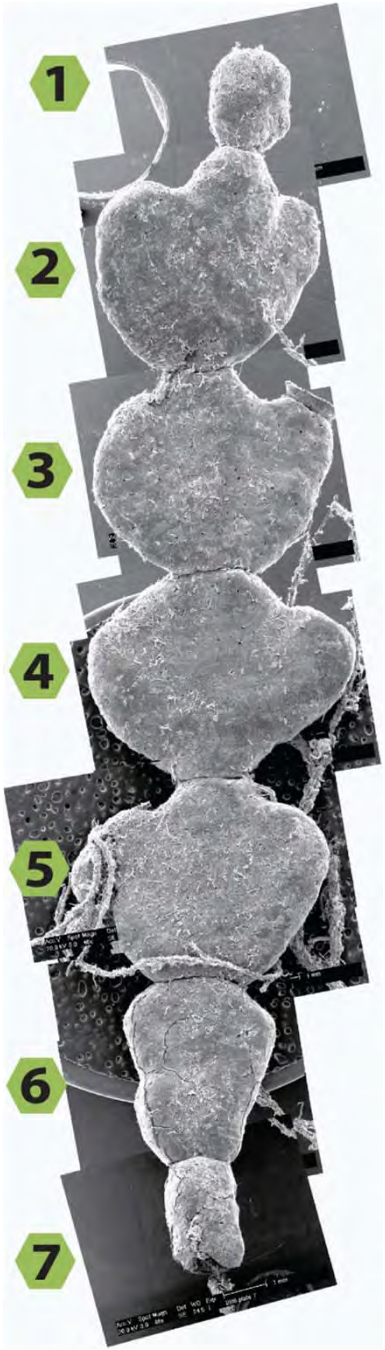
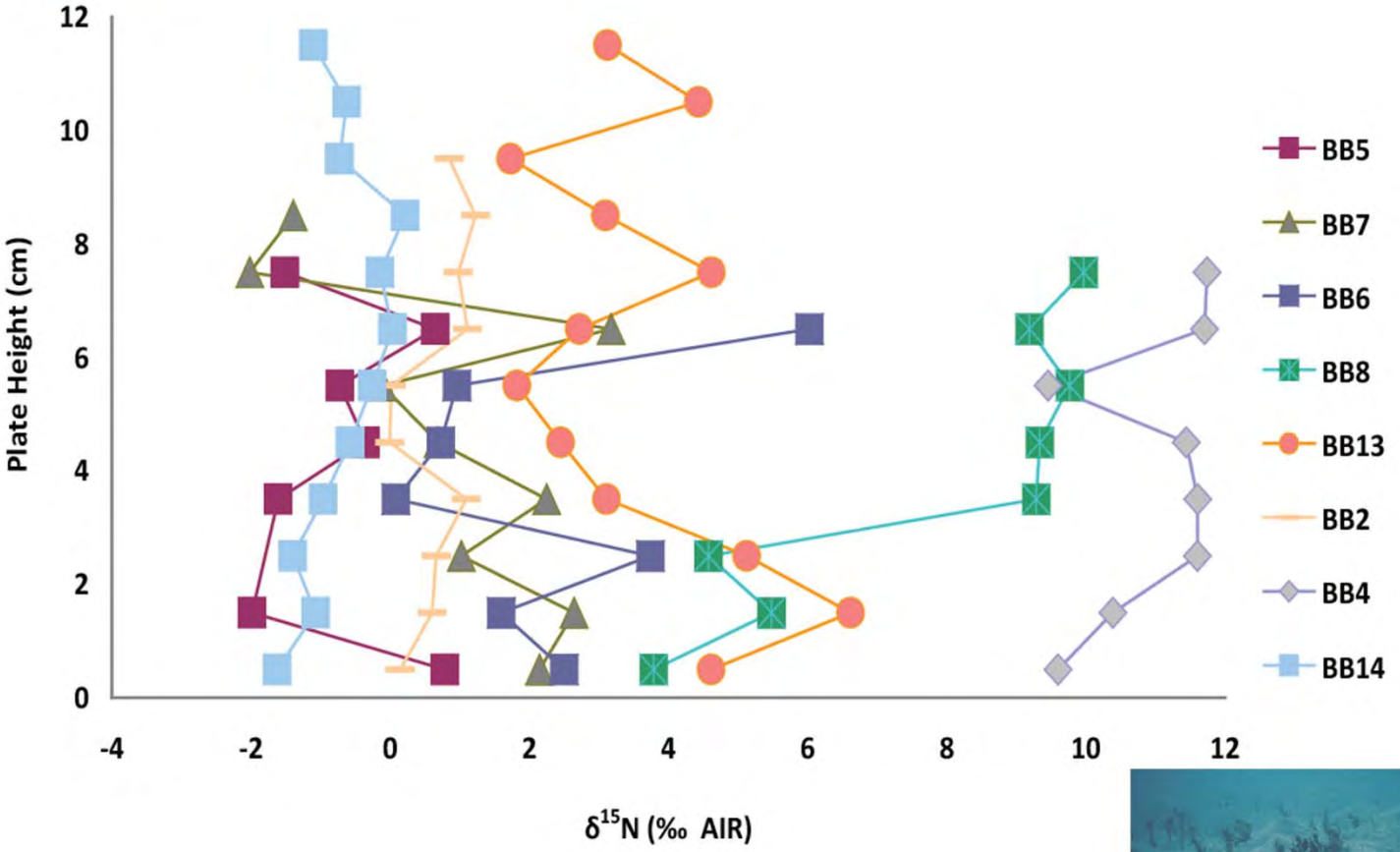
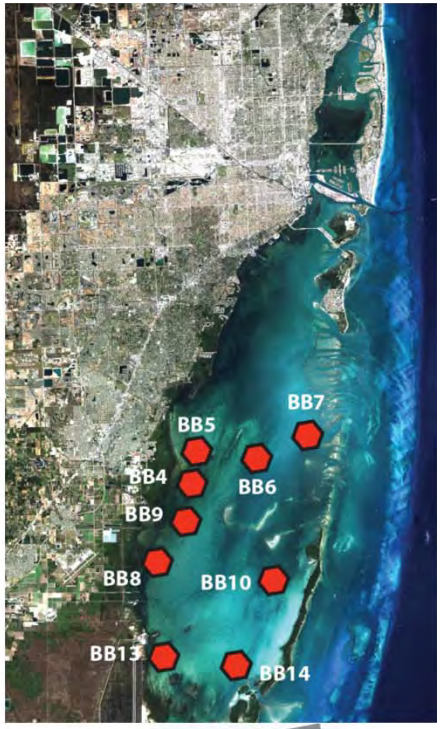

1
2
3
4
5
6
7

Plate Height and $\delta^{15}N$





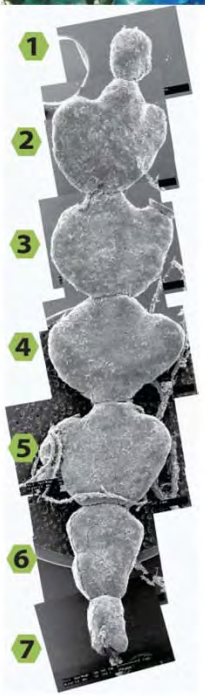
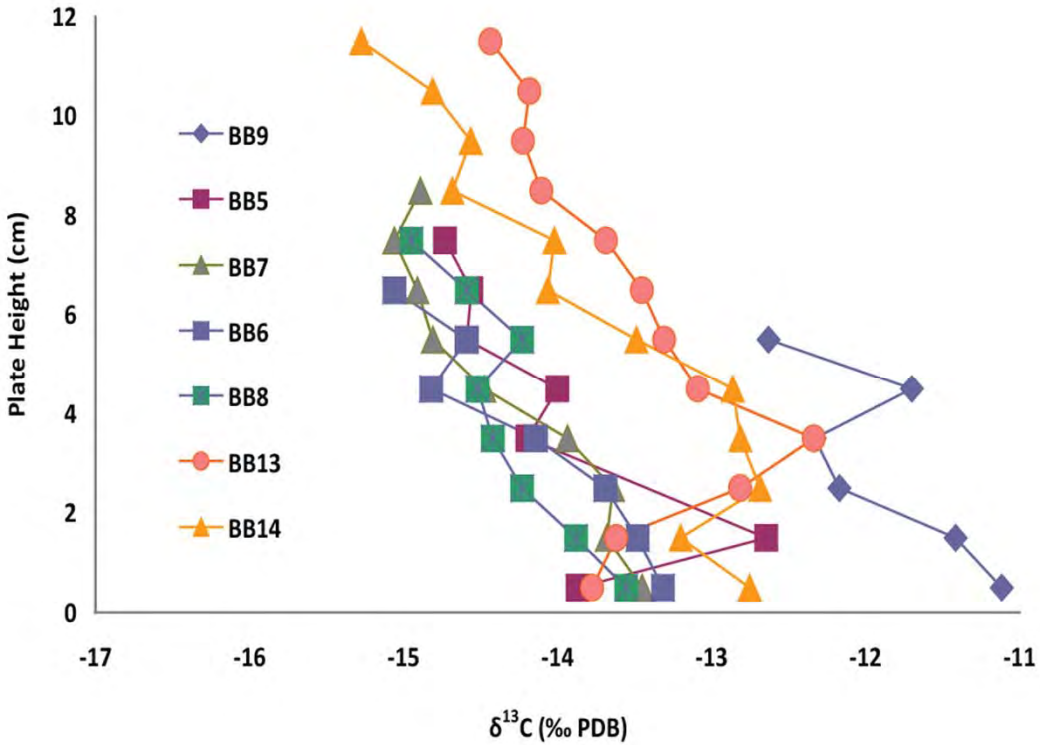
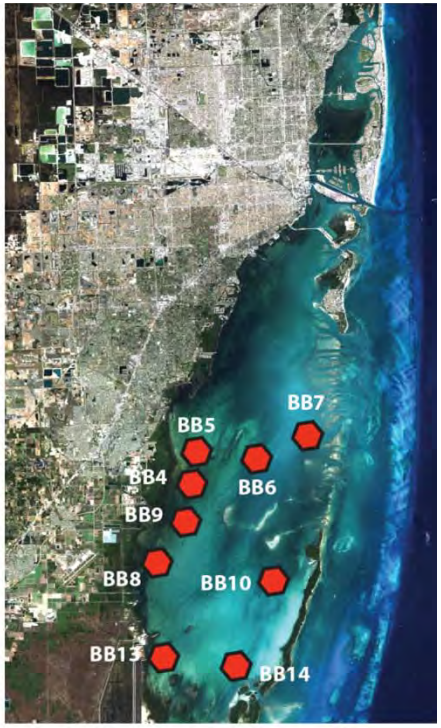


Plate Height and $\delta^{13}C$





Conclusions

- In Biscayne Bay there is a clear signature of isotopically positive N derived from anthropogenic sources in the Nitrate, POM, algae, sponges, seagrasses, and sediments.
- No differences in the trends between any of these components
- This signature is only present close to the major sources of N
- This emphasis the lack of an anthropogenic signature in the Florida Reef track