Compound Interest: The Value of Long-Term Water Quality Monitoring in the FKNMS

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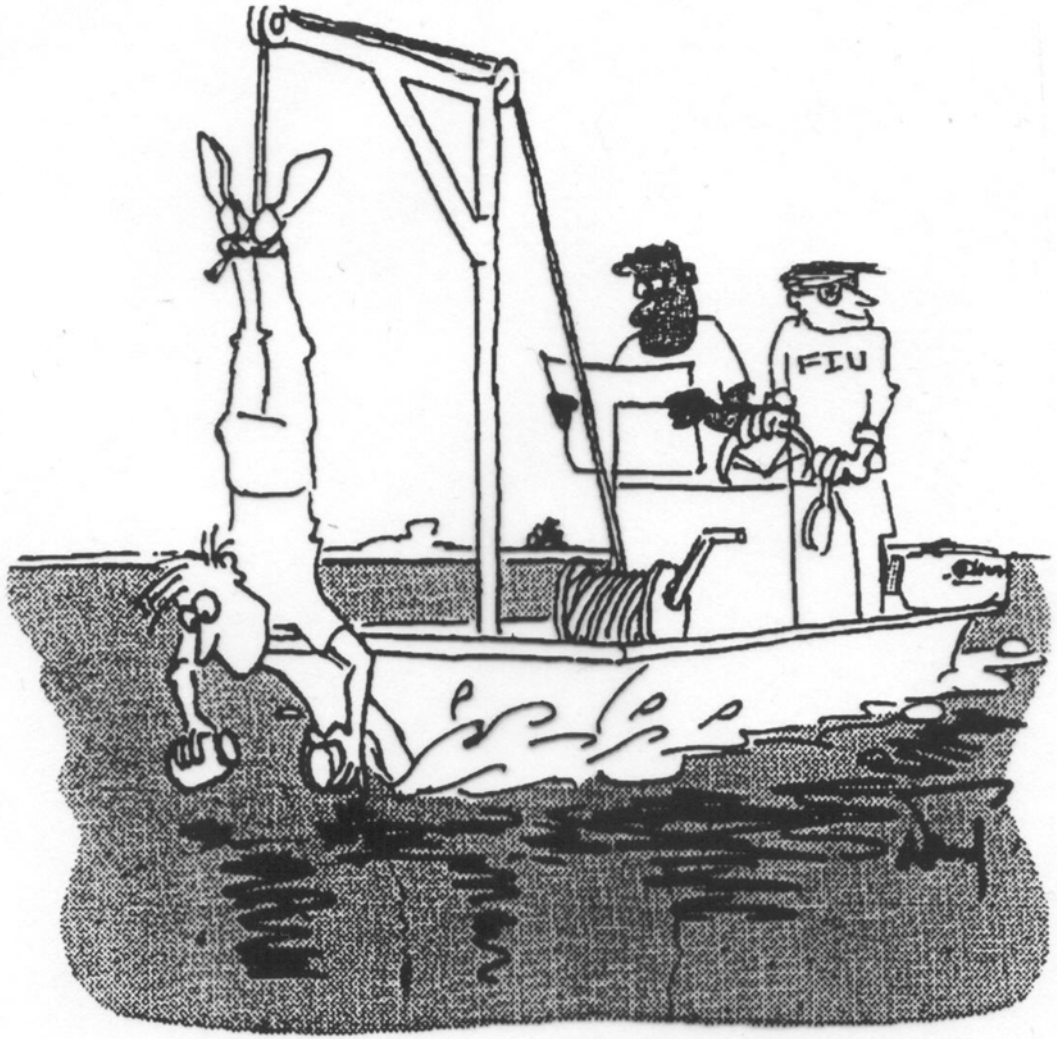
Miami, FL 33199

Can you get sexy science from a routine water quality monitoring program?

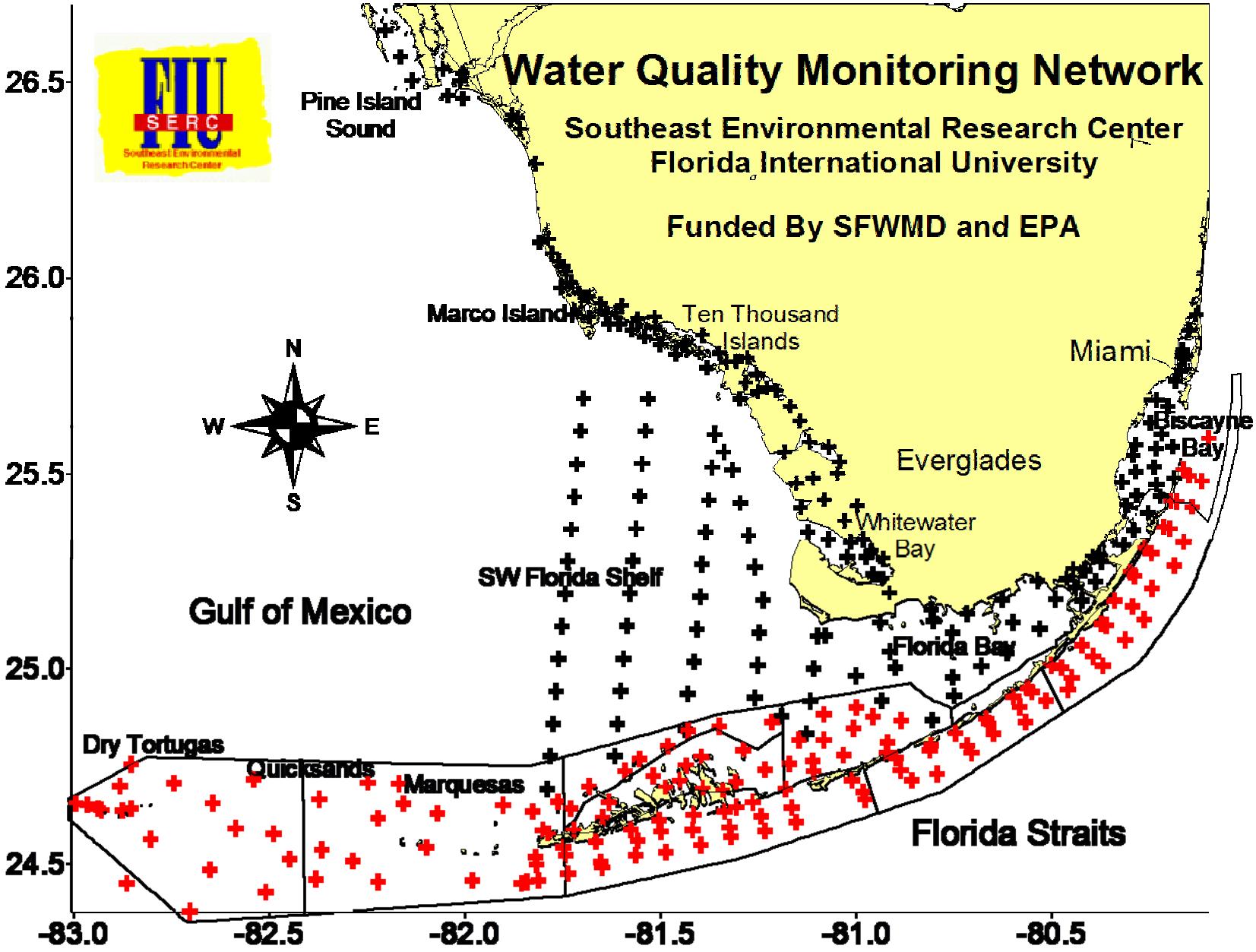


Why Monitor Water Quality?

1. **Establish baseline** information about a body of water
2. **Document events**, both chronic and episodic
3. **Assess trends** or changes over time in a body of water
4. **Explain causes** in WQ w/ changes internal & external drivers
5. **Provide information** for resource management decisions
6. **Monitor compliance** practices (regulatory)
7. **Educate stakeholders** about water quality

Project Sampling Particulars

- 155 fixed sampling sites from upper Key Largo to the Dry Tortugas
- Quarterly, semi-synoptic sampling events (generally w/in a month or two)
- Vertical profile of water column (CTD) for:
  salinity, temp., density, DO, PAR, turbidity, and CHLA fluorescence
- Collection of surface and bottom water for analysis of:
  NO_3^-, NO_2^-, NH_4^+, TN, TON, TP, SRP, SiO_2, TOC, and CHLA

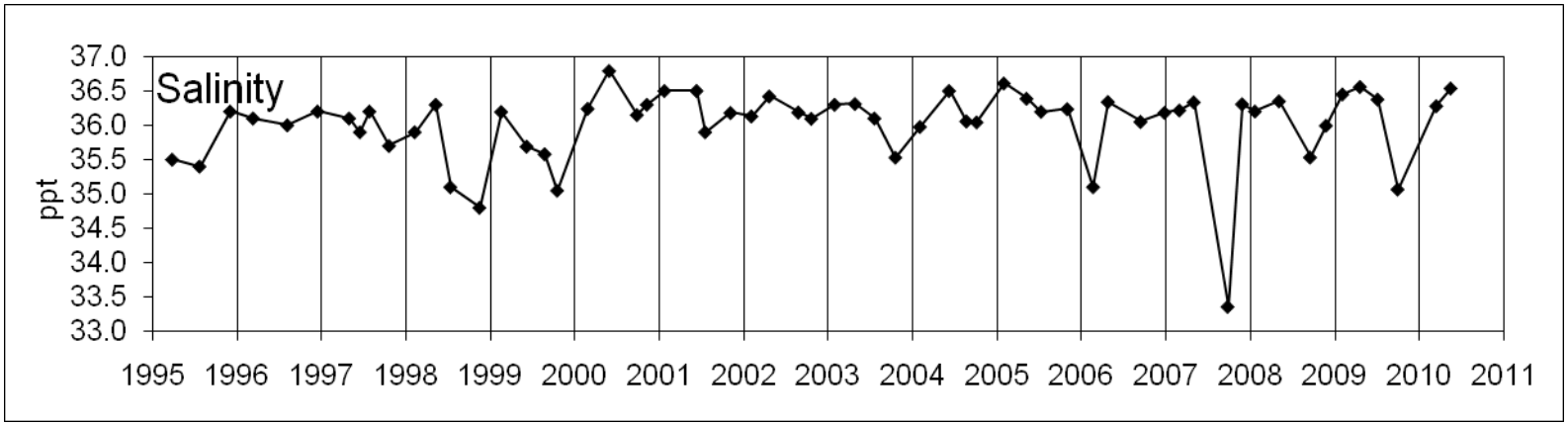

Water Quality Monitoring Network
Southeast Environmental Research Center
Florida International University
Funded By SFWMD and EPA
Pine Island Sound
Marco Island
Ten Thousand Islands
Miami
Biscayne Bay
Everglades
Whitewater Bay
SW Florida Shelf
Gulf of Mexico
Florida Bay
Dry Tortugas
Quicksands
Marquesas
Florida Straits
N
W
E
S
26.5
26.0
25.5
25.0
24.5
-83.0
-82.5
-82.0
-81.5
-81.0
-80.5

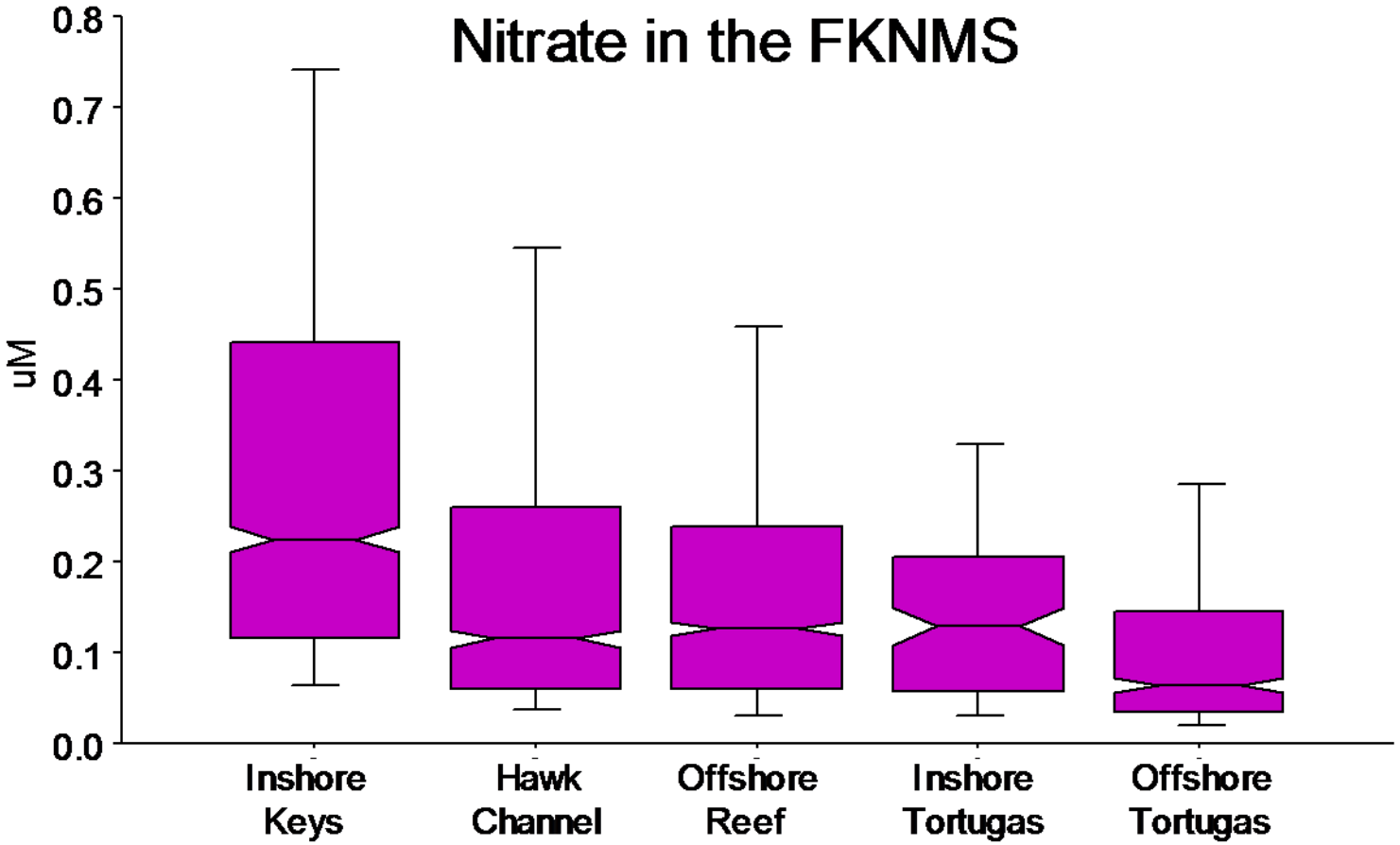
1. Establish a Baseline

Only by keeping finger on the pulse of the system, can we recognize deviations from the status quo.

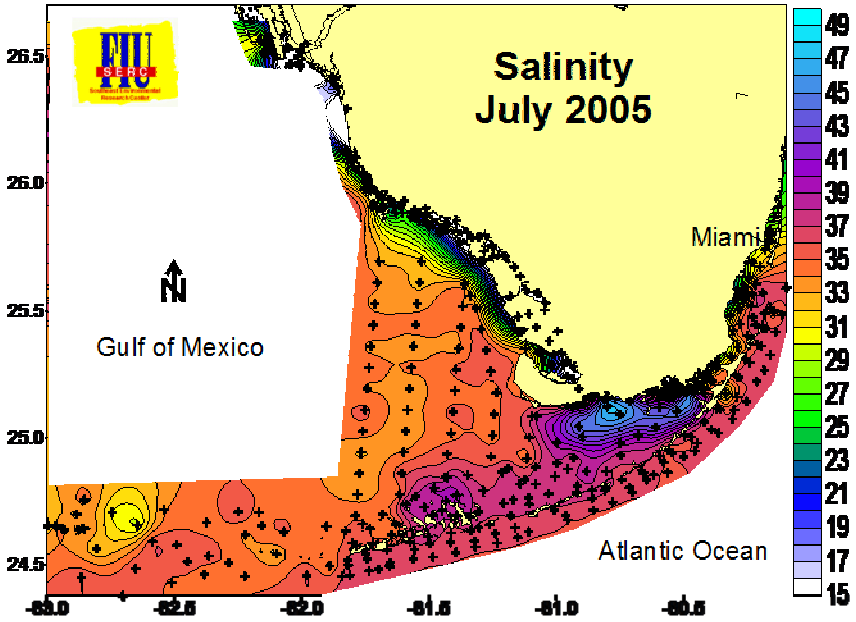
So, we must know the baseline before addressing further topics.

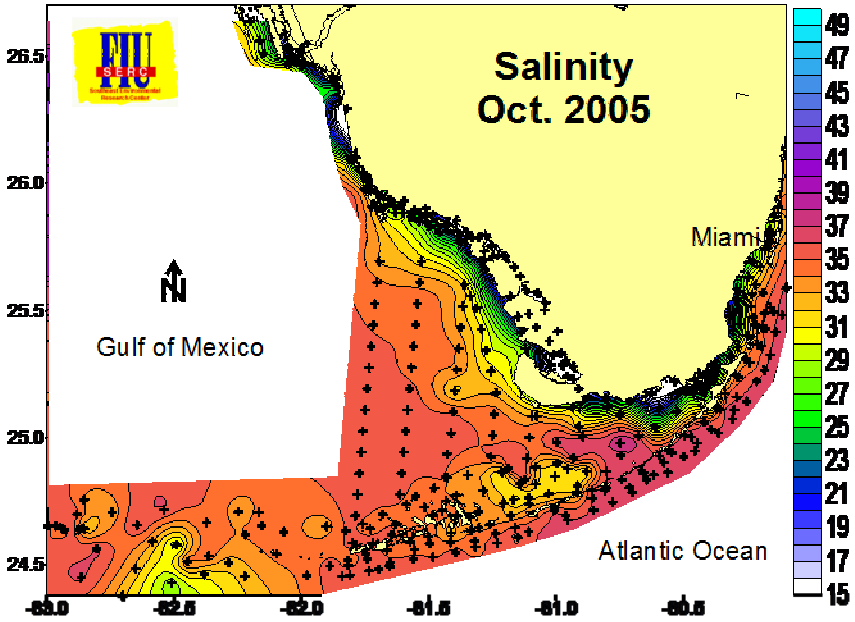
Fowey Rocks (Sta. 200)

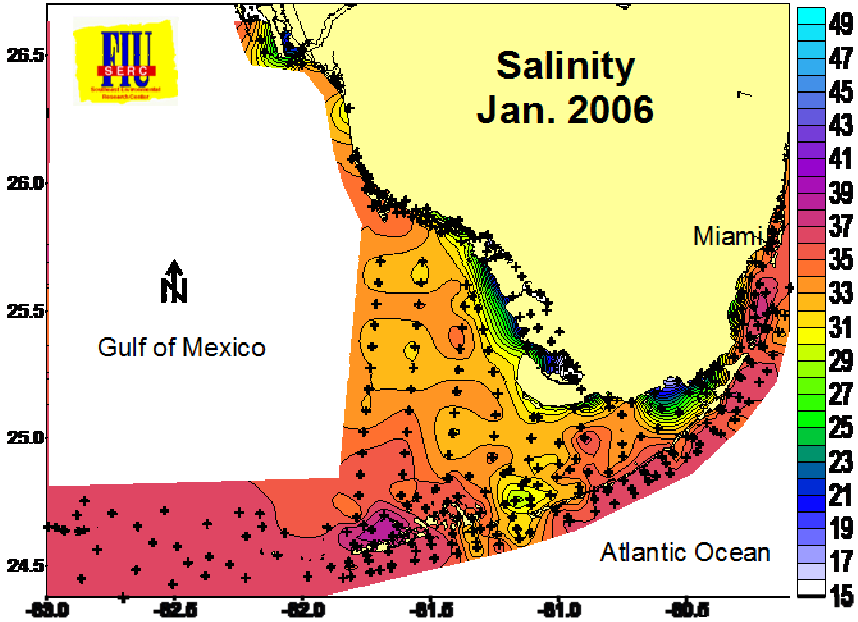


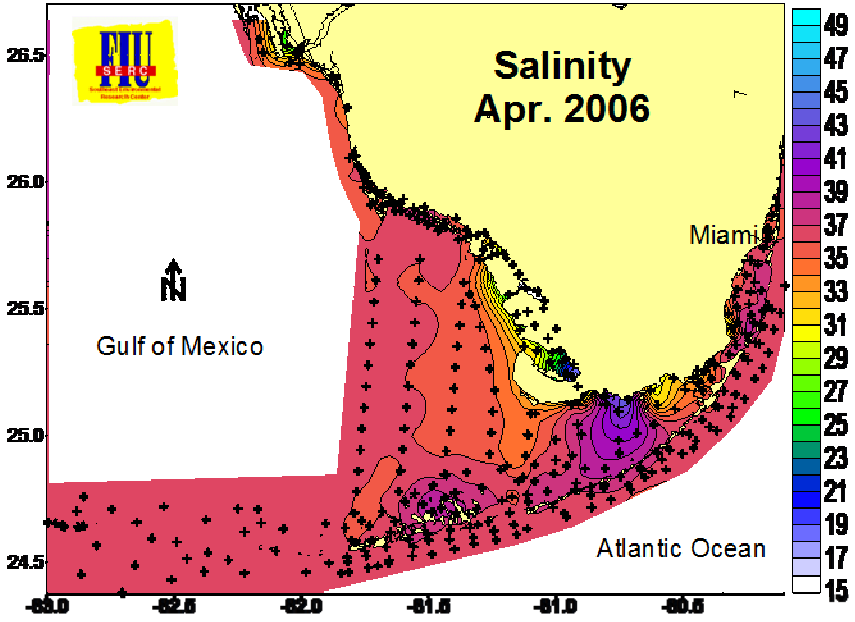


- Elevated DIN inshore of Keys
- Slightly elevated DIN in Tortugas transect
- No elevated TP or CHLA in Keys or Tortugas transects
- Elevated TOC & TON in Keys but not in Tortugas transects


Salinity
July 2005
Miami
Gulf of Mexico
Atlantic Ocean
26.5
26.0
25.5
25.0
24.5
-83.0
-82.5
-82.0
-81.5
-81.0
-80.5
49
47
45
43
41
39
37
35
33
31
29
27
25
23
21
19
17
15


Salinity
Oct. 2005
Miami
Gulf of Mexico
Atlantic Ocean
26.5
26.0
25.5
25.0
24.5
-83.0
-82.5
-82.0
-81.5
-81.0
-80.5
49
47
45
43
41
39
37
35
33
31
29
27
25
23
21
19
17
15


Salinity
Jan. 2006
Miami
Gulf of Mexico
Atlantic Ocean
26.5
26.0
25.5
25.0
24.5
-83.0
-82.5
-82.0
-81.5
-81.0
-80.5
49
47
45
43
41
39
37
35
33
31
29
27
25
23
21
19
17
15


Salinity
Apr. 2006
Miami
Gulf of Mexico
Atlantic Ocean
26.5
26.0
25.5
25.0
24.5
-83.0
-82.5
-82.0
-81.5
-81.0
-80.5
49
47
45
43
41
39
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35
33
31
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23
21
19
17
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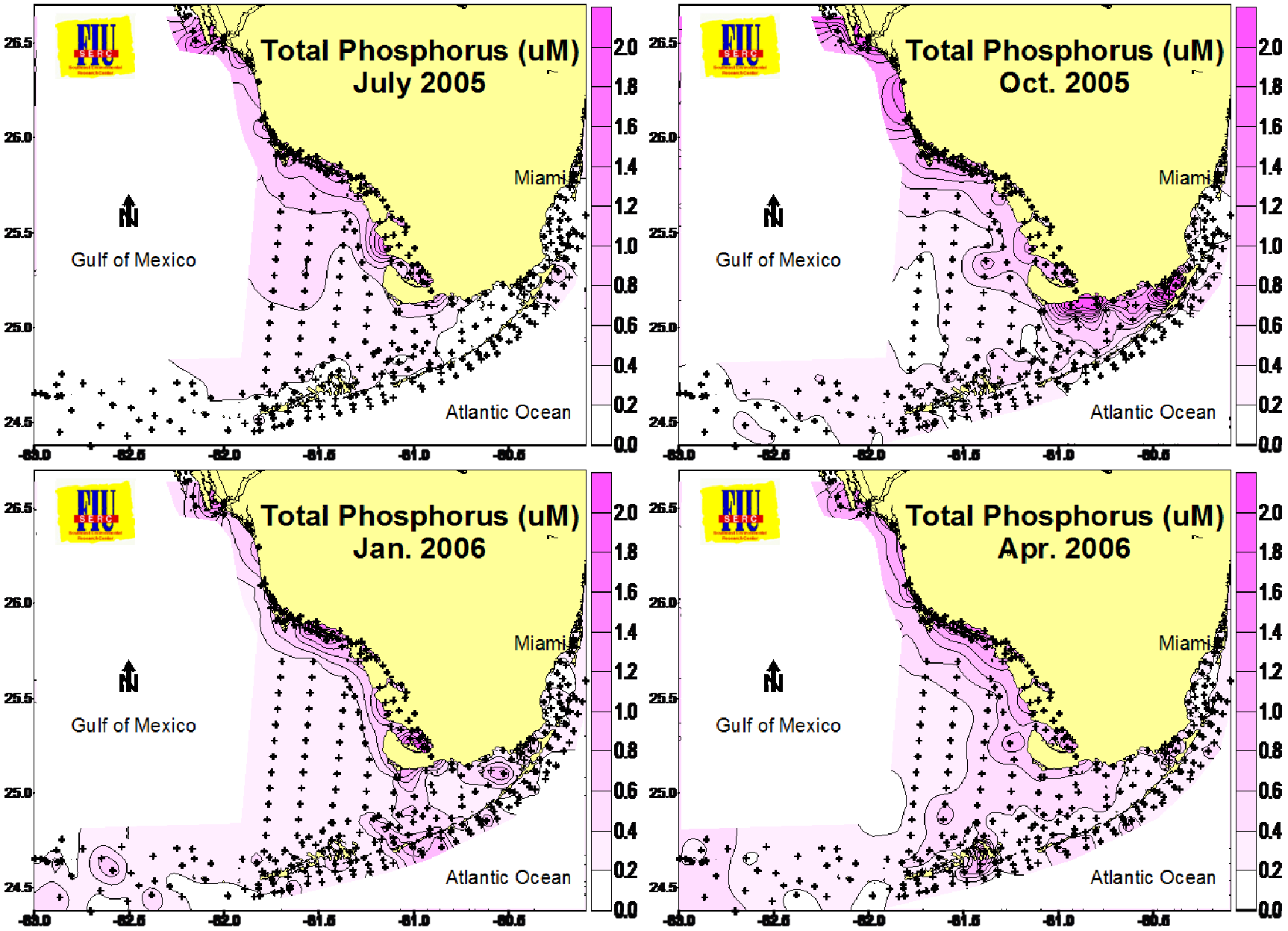
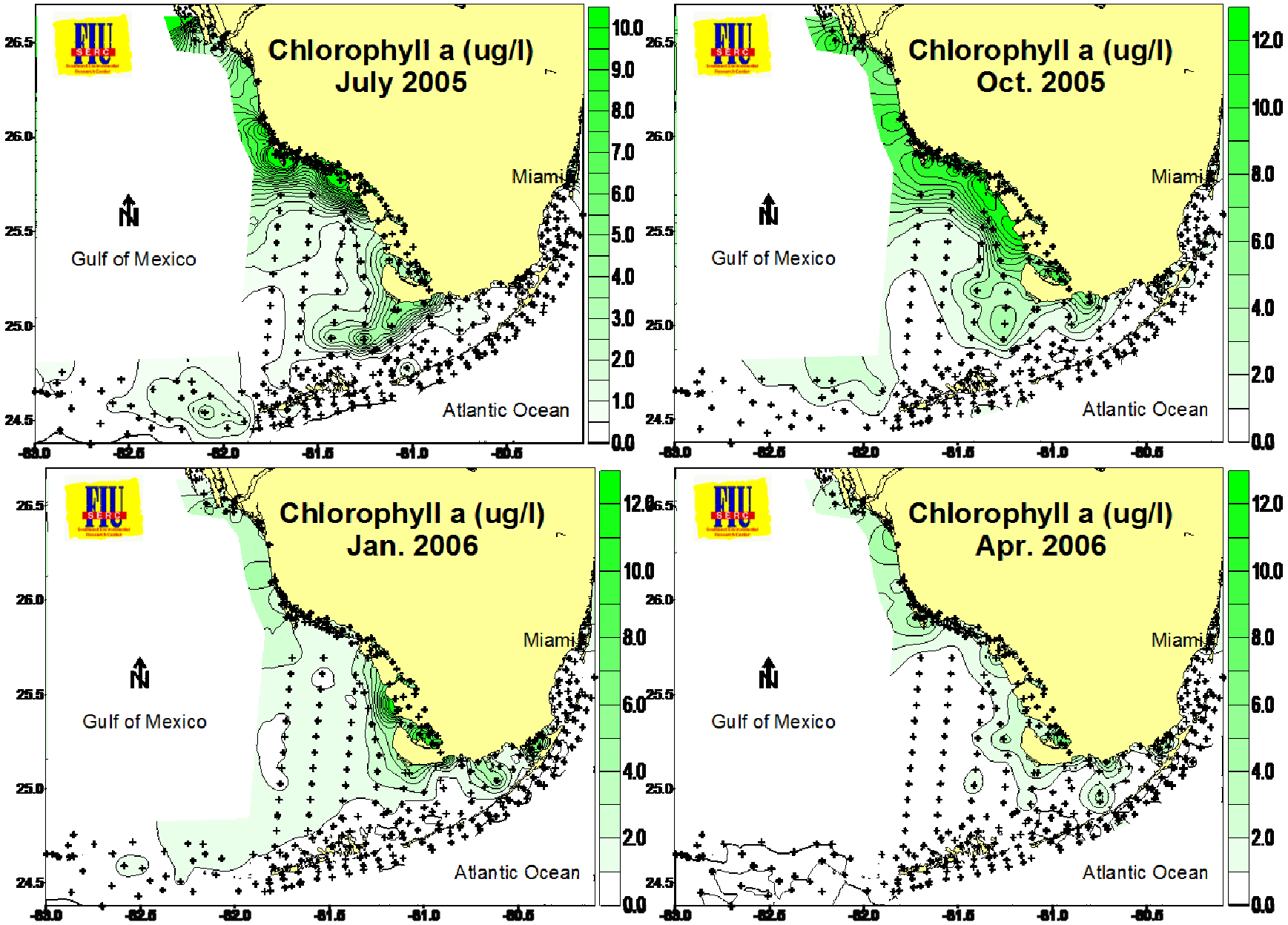
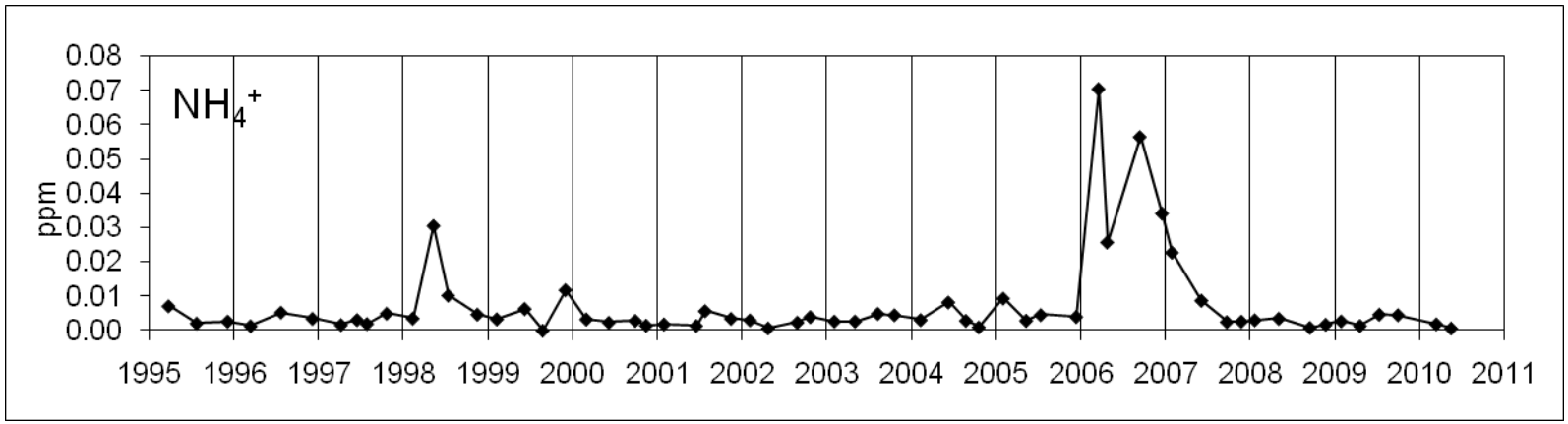
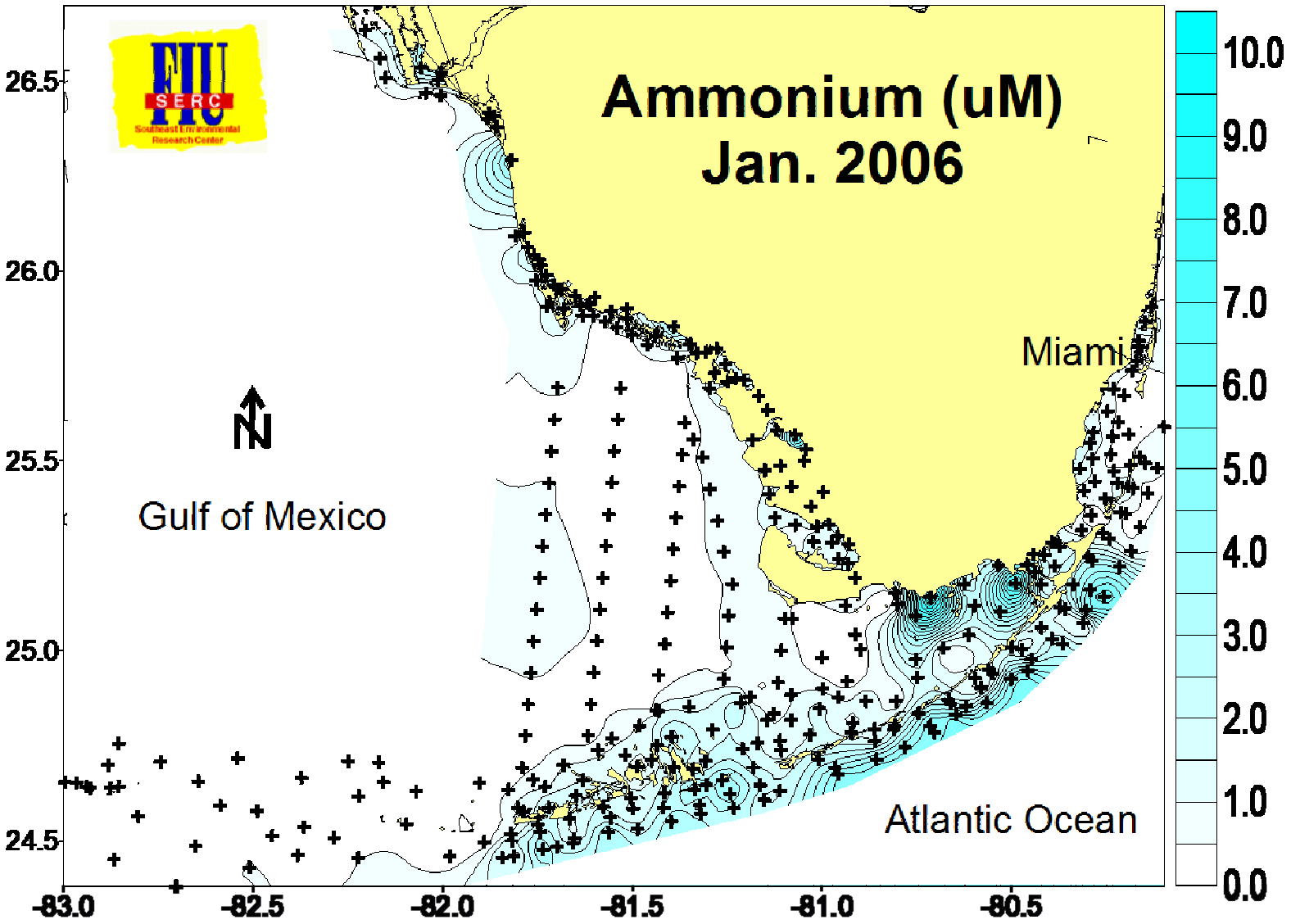

Total Phosphorus (uM)
July 2005
Miami
Gulf of Mexico
Atlantic Ocean
Total Phosphorus (uM)
Oct. 2005
Miami
Gulf of Mexico
Atlantic Ocean
Total Phosphorus (uM)
Jan. 2006
Miami
Gulf of Mexico
Atlantic Ocean
Total Phosphorus (uM)
Apr. 2006
Miami
Gulf of Mexico
Atlantic Ocean
26.5
26.0
25.5
25.0
24.5
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0


Chlorophyll a (ug/l)
July 2005
Miami
Gulf of Mexico
Atlantic Ocean
26.5
26.0
25.5
25.0
24.5
-83.0
-82.5
-82.0
-81.5
-81.0
-80.5
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Chlorophyll a (ug/l)
Oct. 2005
Miami
Gulf of Mexico
Atlantic Ocean
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Chlorophyll a (ug/l)
Jan. 2006
Miami
Gulf of Mexico
Atlantic Ocean
Chlorophyll a (ug/l)
Apr. 2006
Miami
Gulf of Mexico
Atlantic Ocean

2. Document Events

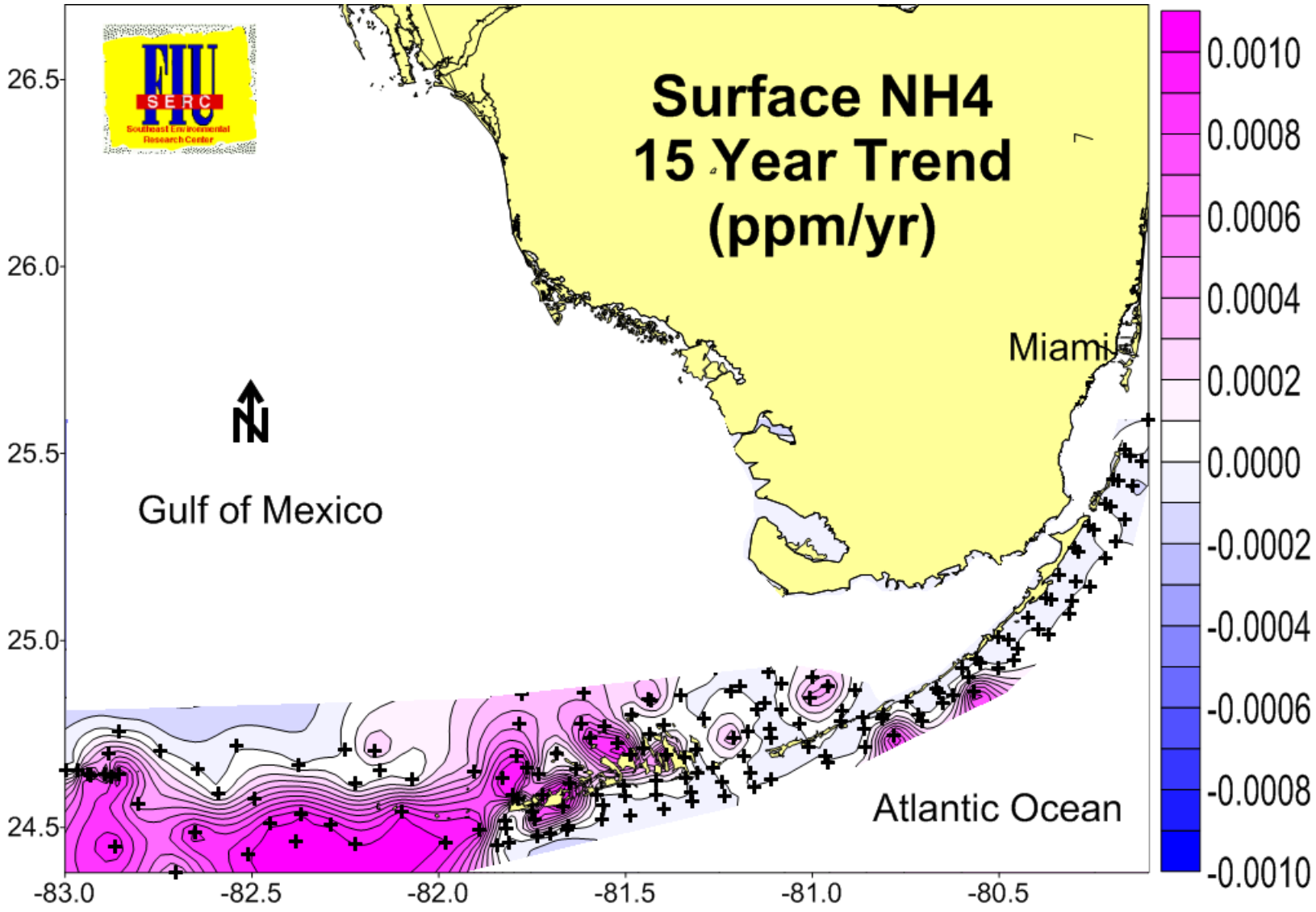
Davis Reef (Sta. 231)

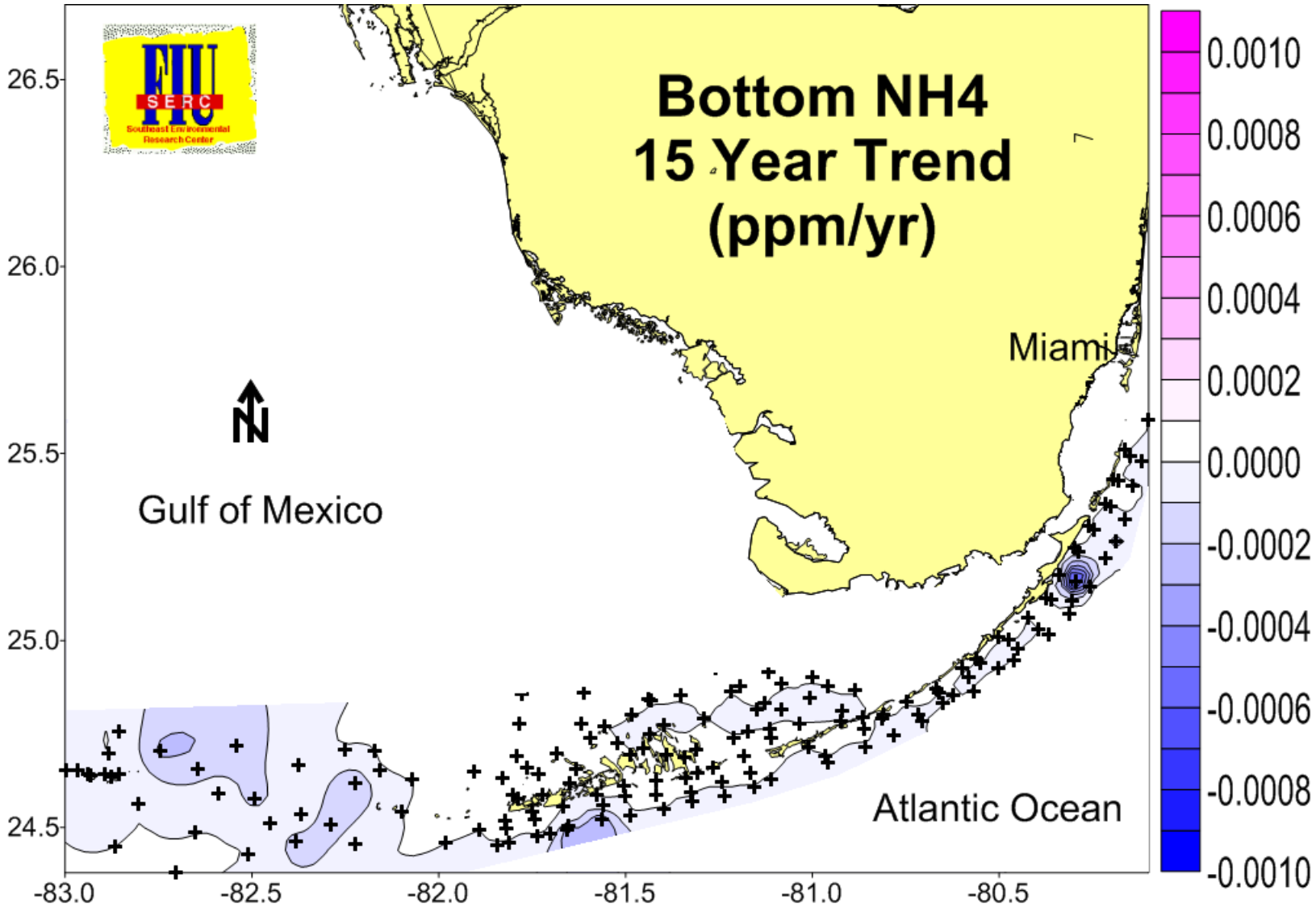


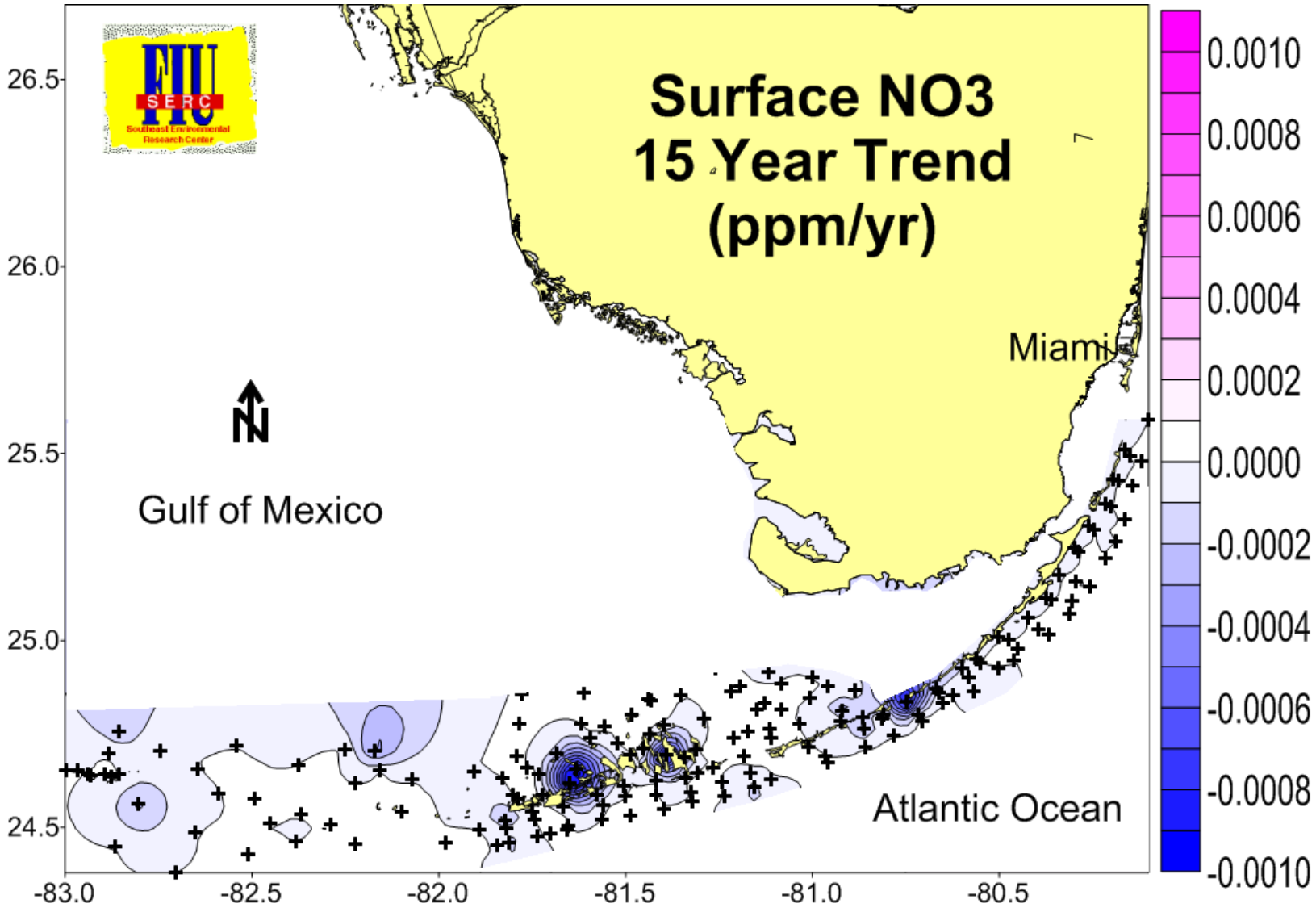

Ammonium (uM)
Jan. 2006
FIU
SERC
Southeast Environmental Research Center
Miami
Gulf of Mexico
Atlantic Ocean
N
26.5
26.0
25.5
25.0
24.5
-83.0
-82.5
-82.0
-81.5
-81.0
-80.5
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0

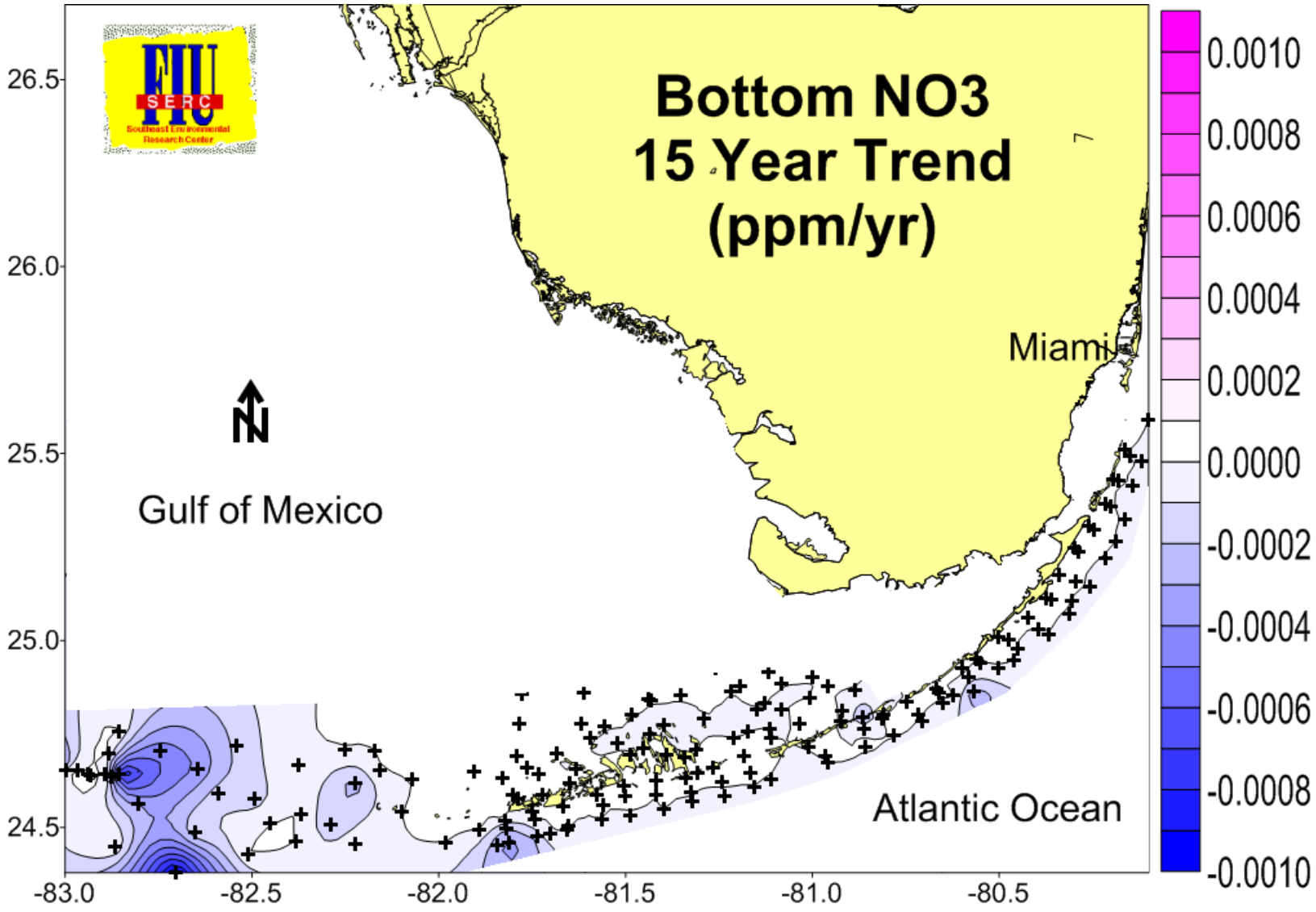
3. Assess Long-term Trends

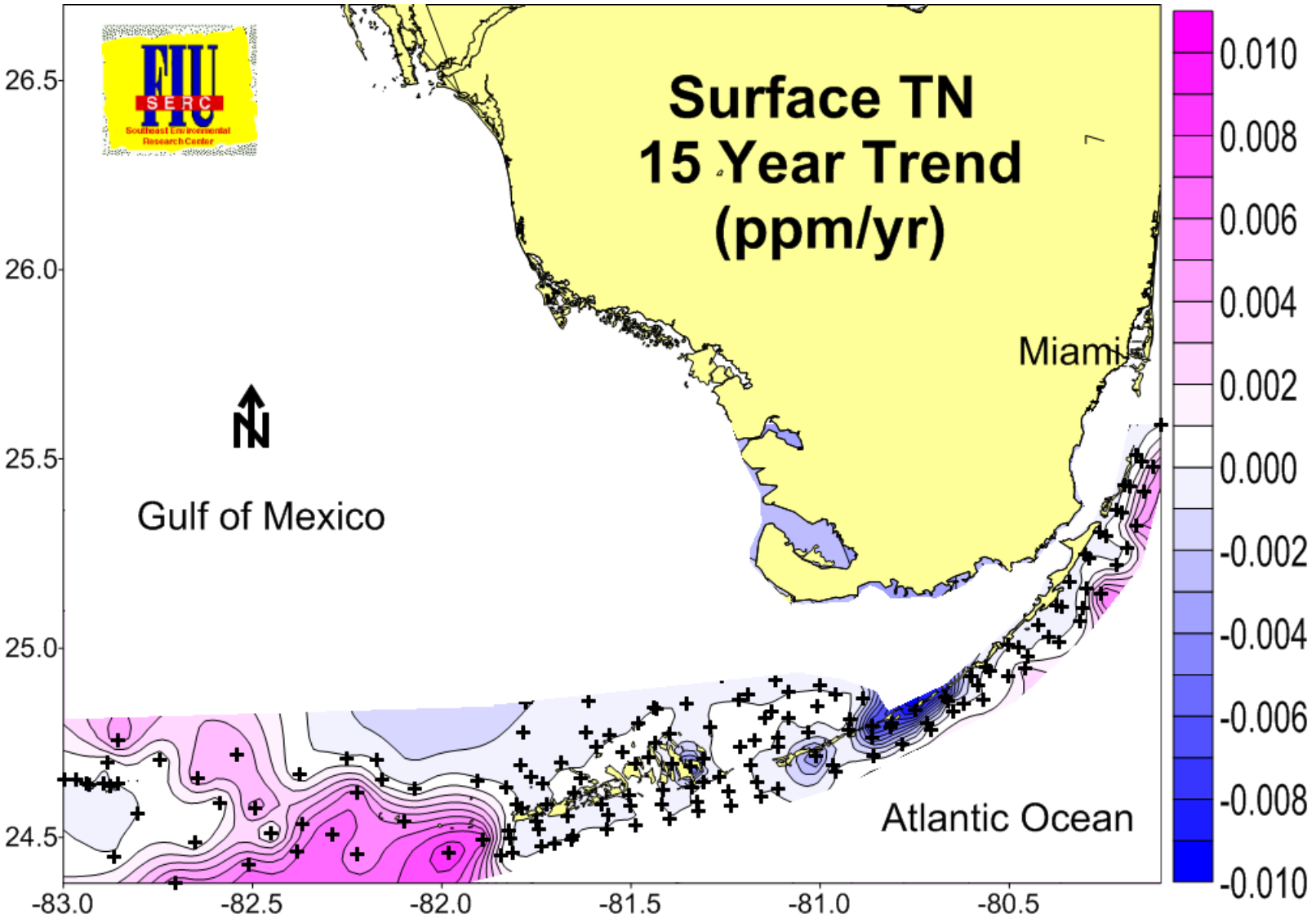
- Trends were derived at each station for each parameter using linear regression.
- Significance was set as $p < 0.10$

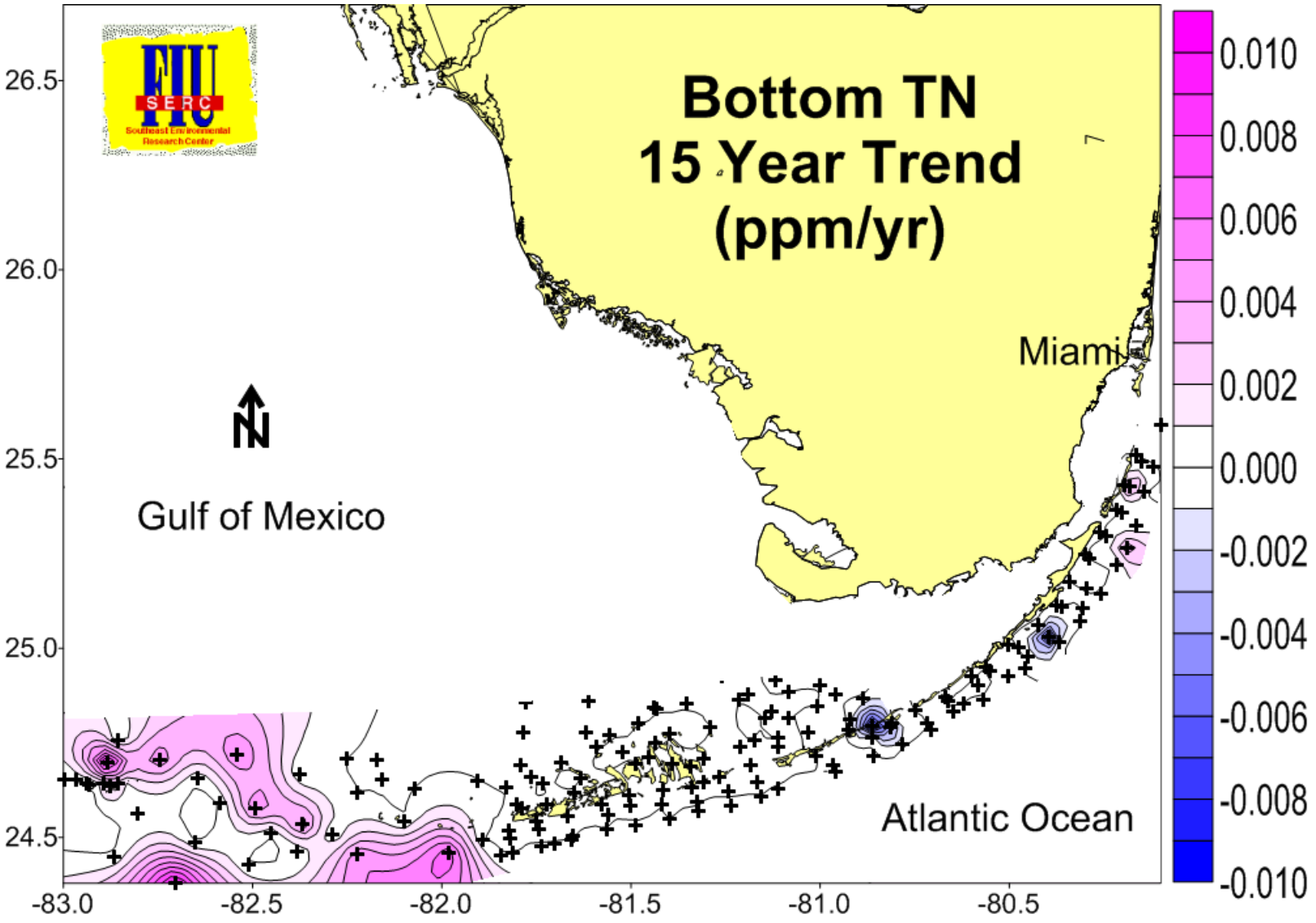

Surface NH4
15 Year Trend
(ppm/yr)
Miami
Gulf of Mexico
Atlantic Ocean
N
26.5
26.0
25.5
25.0
24.5
-83.0
-82.5
-82.0
-81.5
-81.0
-80.5
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
-0.0002
-0.0004
-0.0006
-0.0008
-0.0010

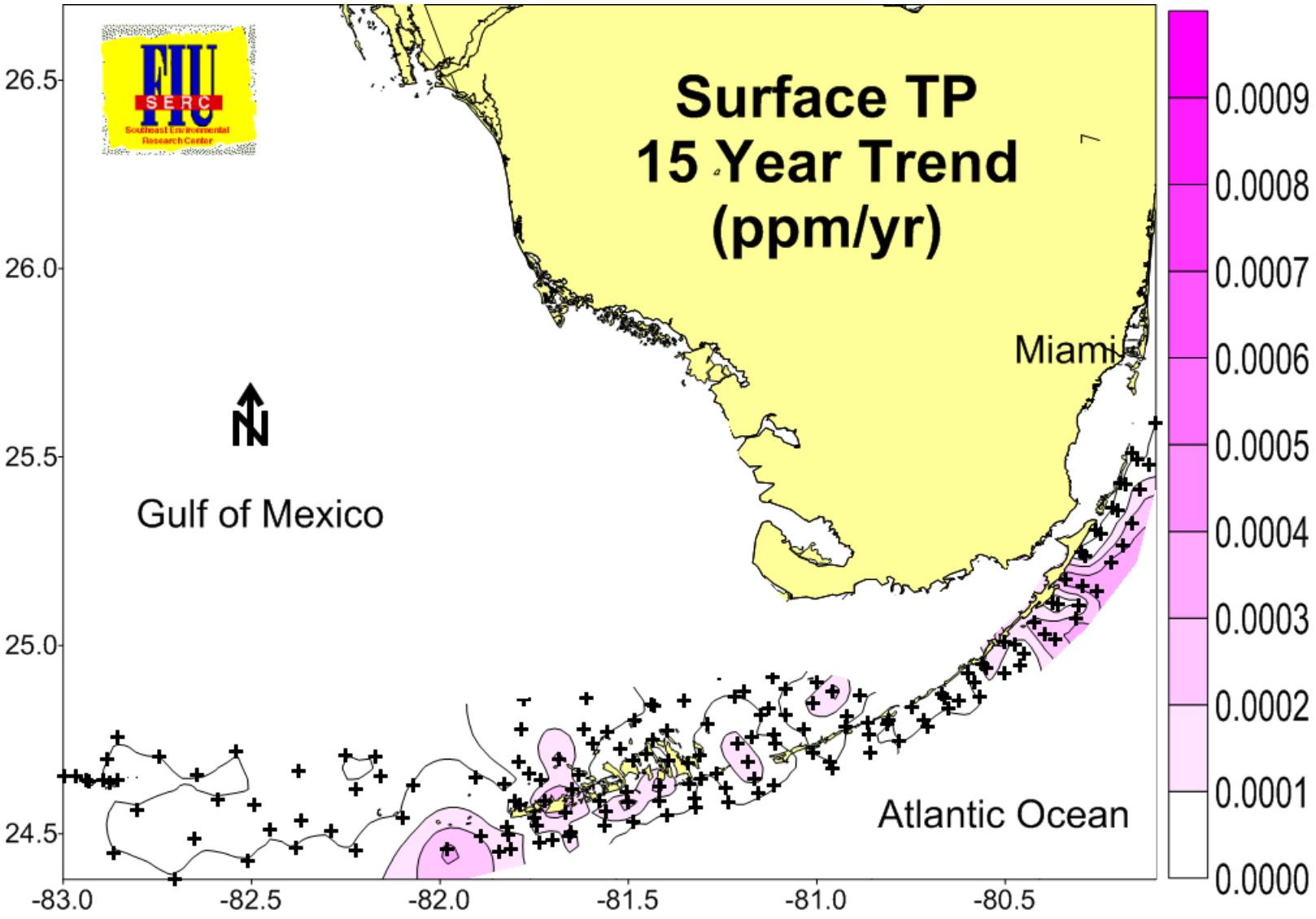

Bottom NH4
15 Year Trend
(ppm/yr)
FIU
SERC
Southeast Environmental Research Center
Miami
Gulf of Mexico
Atlantic Ocean
N
26.5
26.0
25.5
25.0
24.5
-83.0
-82.5
-82.0
-81.5
-81.0
-80.5
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
-0.0002
-0.0004
-0.0006
-0.0008
-0.0010


Surface NO3
15 Year Trend
(ppm/yr)
Miami
Gulf of Mexico
Atlantic Ocean
26.5
26.0
25.5
25.0
24.5
-83.0
-82.5
-82.0
-81.5
-81.0
-80.5
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
-0.0002
-0.0004
-0.0006
-0.0008
-0.0010


Bottom NO3
15 Year Trend
(ppm/yr)
FIU
SERC
Southeast Environmental Research Center
Miami
Gulf of Mexico
Atlantic Ocean
N
26.5
26.0
25.5
25.0
24.5
-83.0
-82.5
-82.0
-81.5
-81.0
-80.5
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
-0.0002
-0.0004
-0.0006
-0.0008
-0.0010


Surface TN
15 Year Trend
(ppm/yr)
FIU
SERC
Southeast Environmental Research Center
Miami
Gulf of Mexico
Atlantic Ocean
N
26.5
26.0
25.5
25.0
24.5
-83.0
-82.5
-82.0
-81.5
-81.0
-80.5
0.010
0.008
0.006
0.004
0.002
0.000
-0.002
-0.004
-0.006
-0.008
-0.010


Bottom TN
15 Year Trend
(ppm/yr)
Miami
Gulf of Mexico
Atlantic Ocean
N
FIU
SERC
Southeast Environmental Research Center
26.5
26.0
25.5
25.0
24.5
-83.0
-82.5
-82.0
-81.5
-81.0
-80.5
0.010
0.008
0.006
0.004
0.002
0.000
-0.002
-0.004
-0.006
-0.008
-0.010


Surface TP
15 Year Trend
(ppm/yr)
Miami
Gulf of Mexico
Atlantic Ocean
N
26.5
26.0
25.5
25.0
24.5
-83.0
-82.5
-82.0
-81.5
-81.0
-80.5
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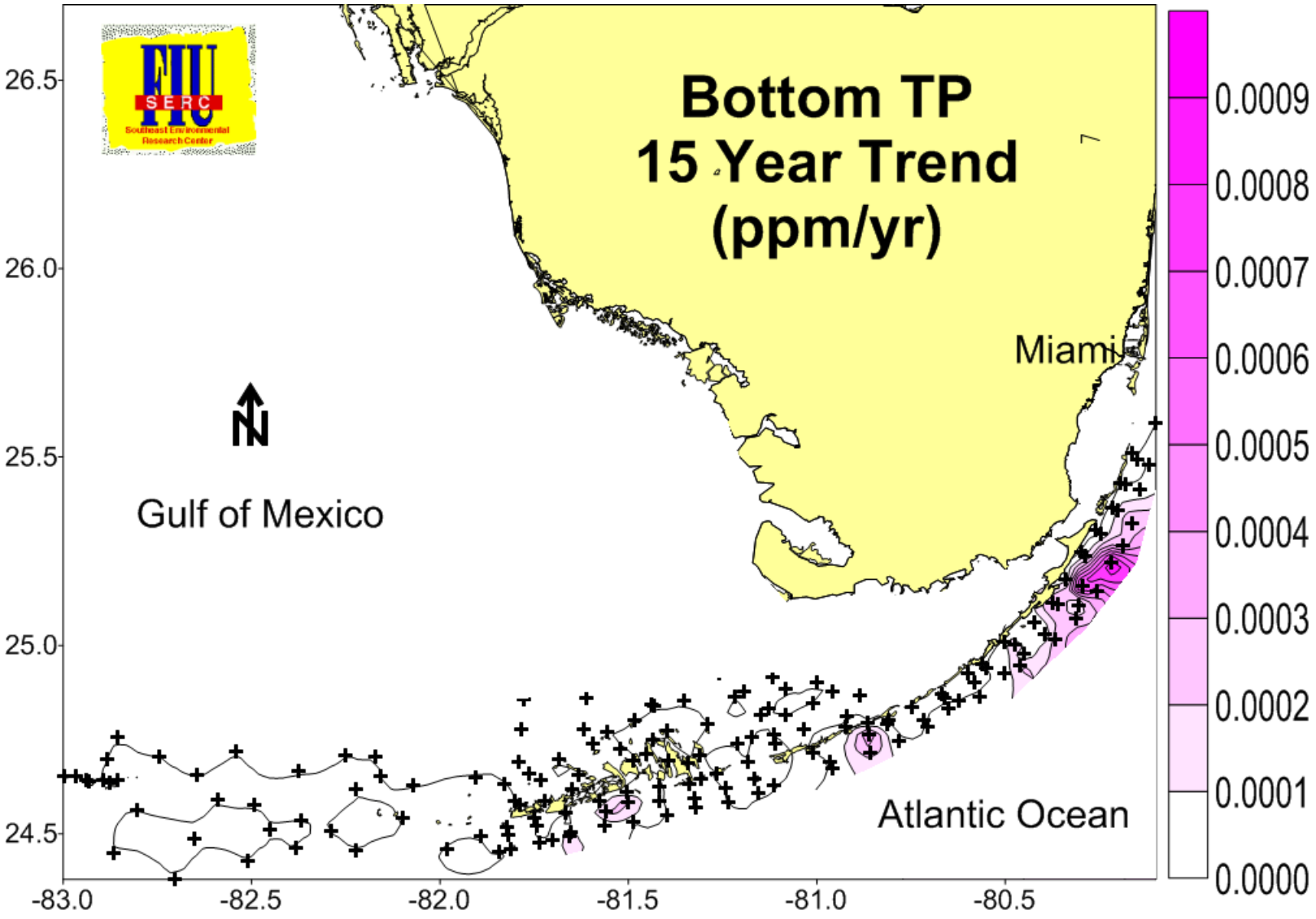
0.0000


Bottom TP
15 Year Trend
(ppm/yr)
Miami
Gulf of Mexico
Atlantic Ocean
N
FIU
SERC
Southeast Environmental Research Center
26.5
26.0
25.5
25.0
24.5
-83.0
-82.5
-82.0
-81.5
-81.0
-80.5
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0.0007
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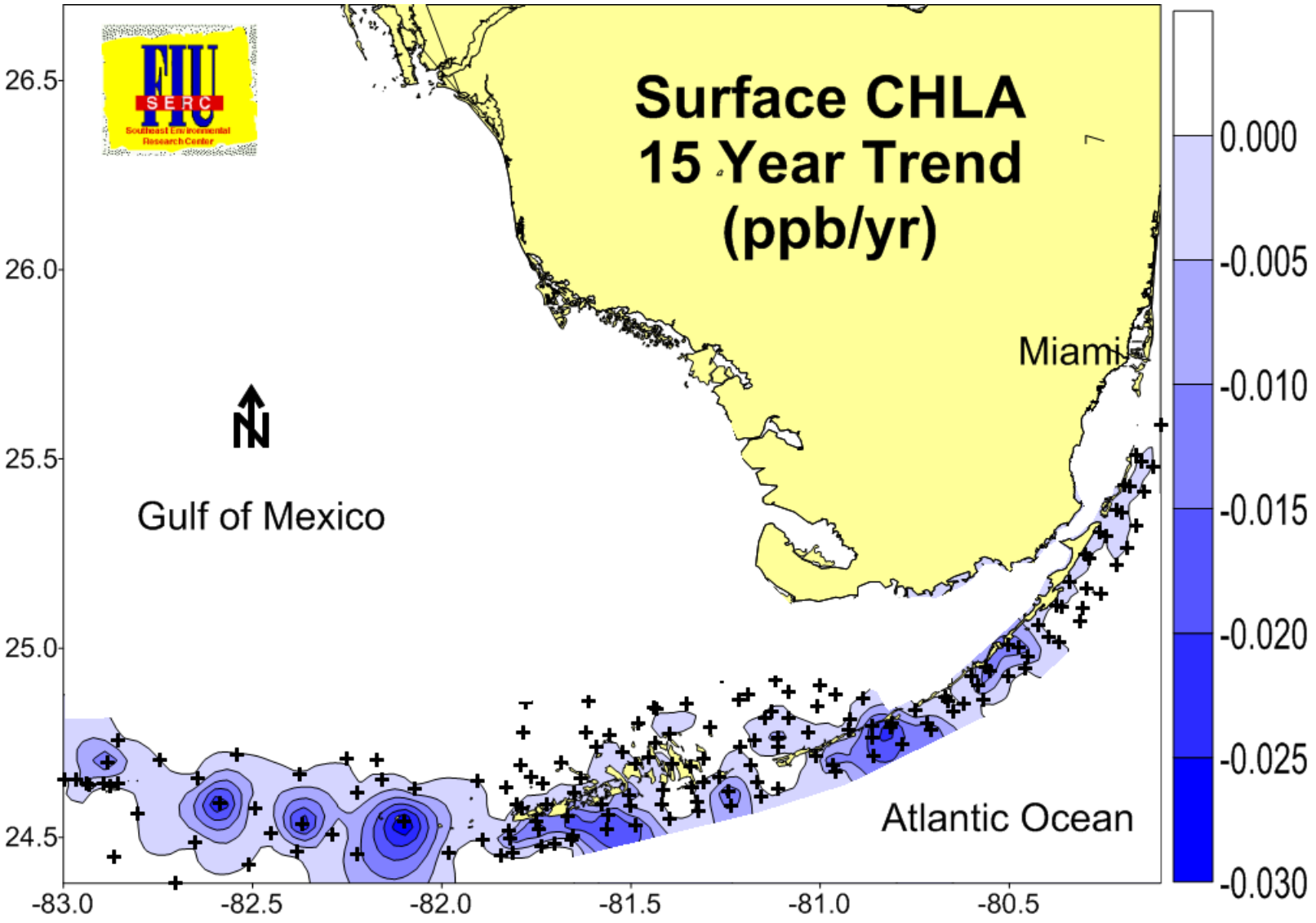
0.0000


Surface CHLA
15 Year Trend
(ppb/yr)
FIU
SERC
Southeast Environmental Research Center
Miami
Gulf of Mexico
Atlantic Ocean
N
26.5
26.0
25.5
25.0
24.5
-83.0
-82.5
-82.0
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-0.015
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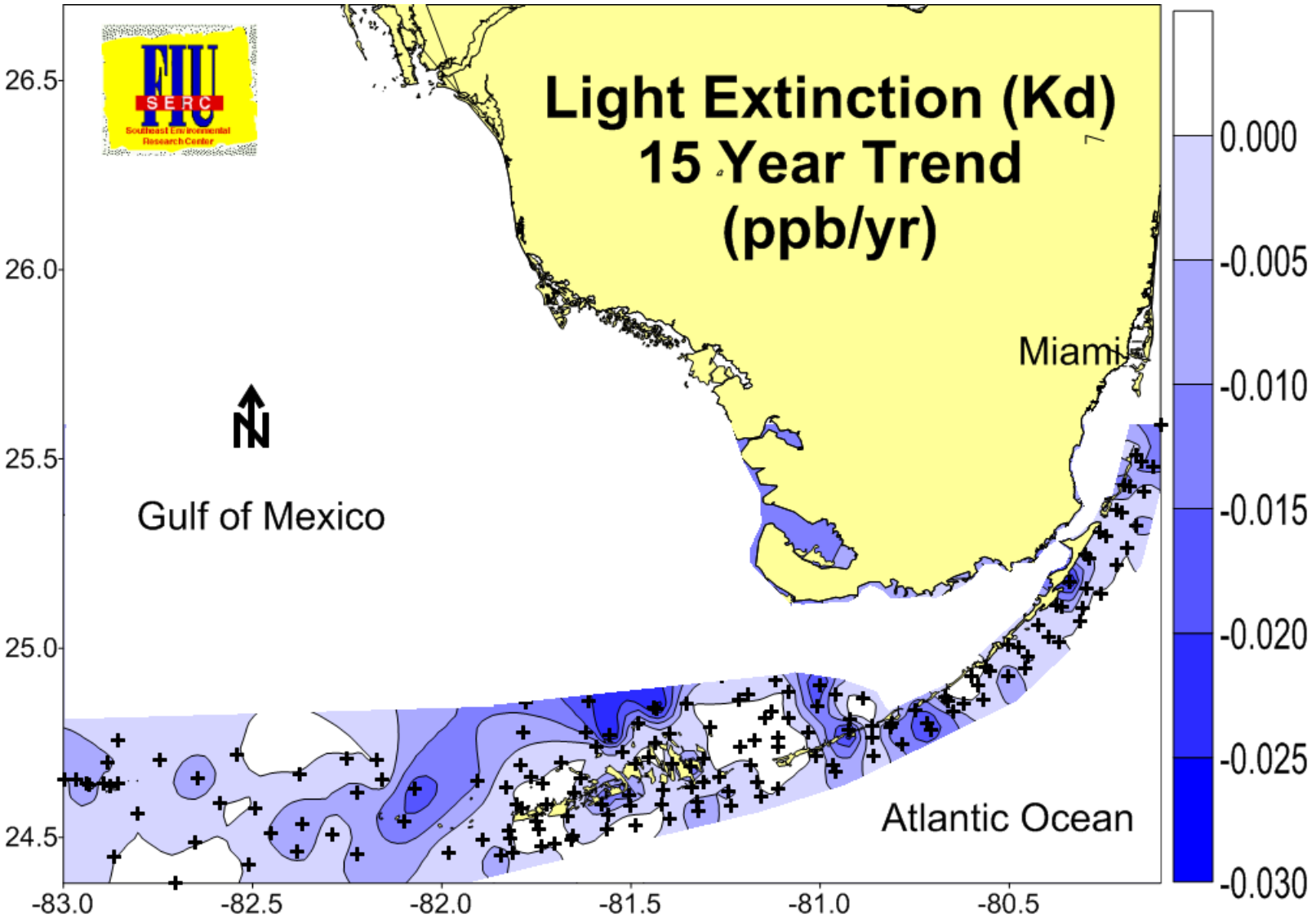
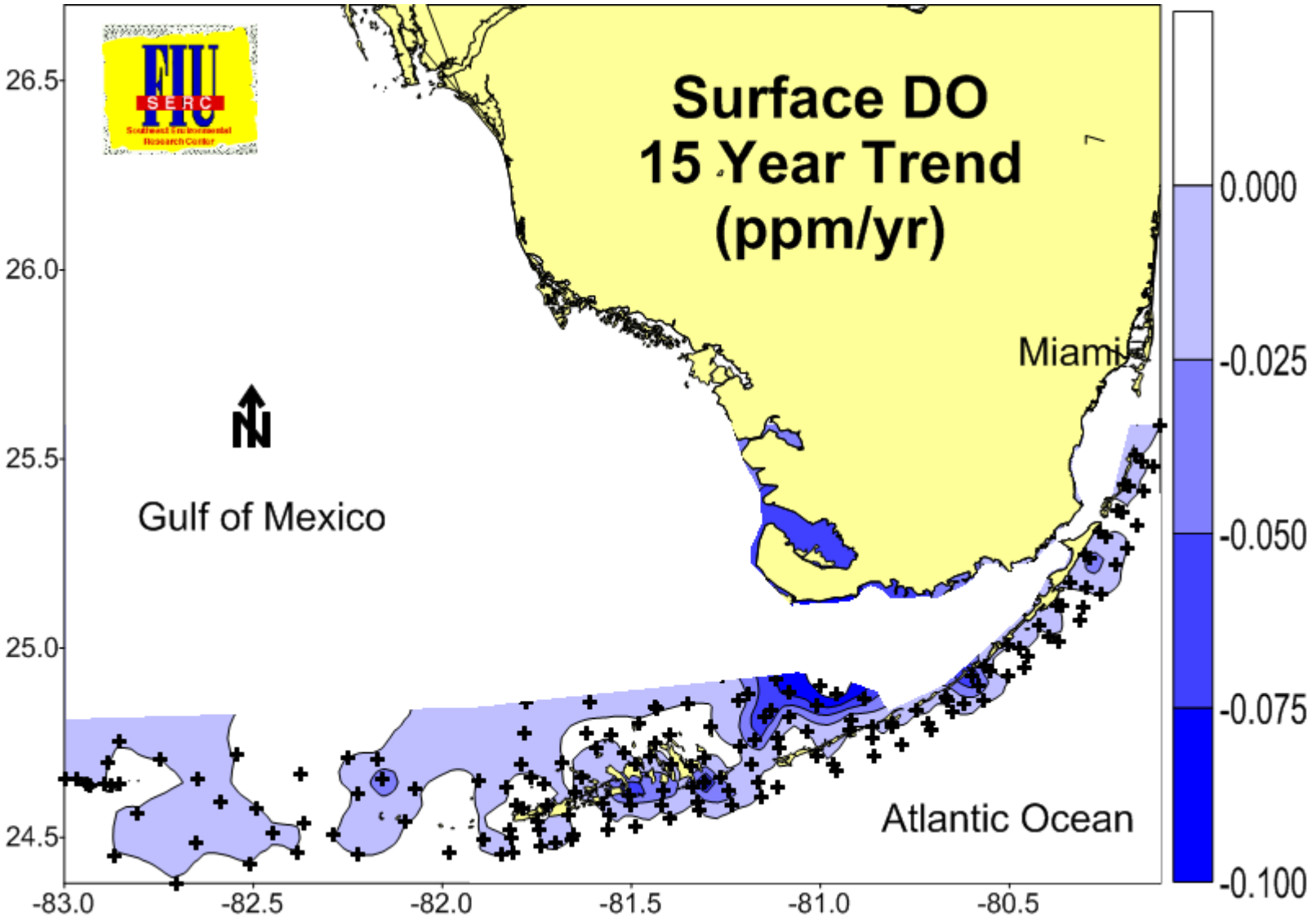
-0.025
-0.030


Light Extinction (Kd)
15 Year Trend
(ppb/yr)
FIU
SERC
Southeast Environmental Research Center
Miami
Gulf of Mexico
Atlantic Ocean
N
26.5
26.0
25.5
25.0
24.5
-83.0
-82.5
-82.0
-81.5
-81.0
-80.5
0.000
-0.005
-0.010
-0.015
-0.020
-0.025
-0.030


Surface DO
15 Year Trend
(ppm/yr)
Miami
Gulf of Mexico
Atlantic Ocean
26.5
26.0
25.5
25.0
24.5
-83.0
-82.5
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-81.5
-81.0
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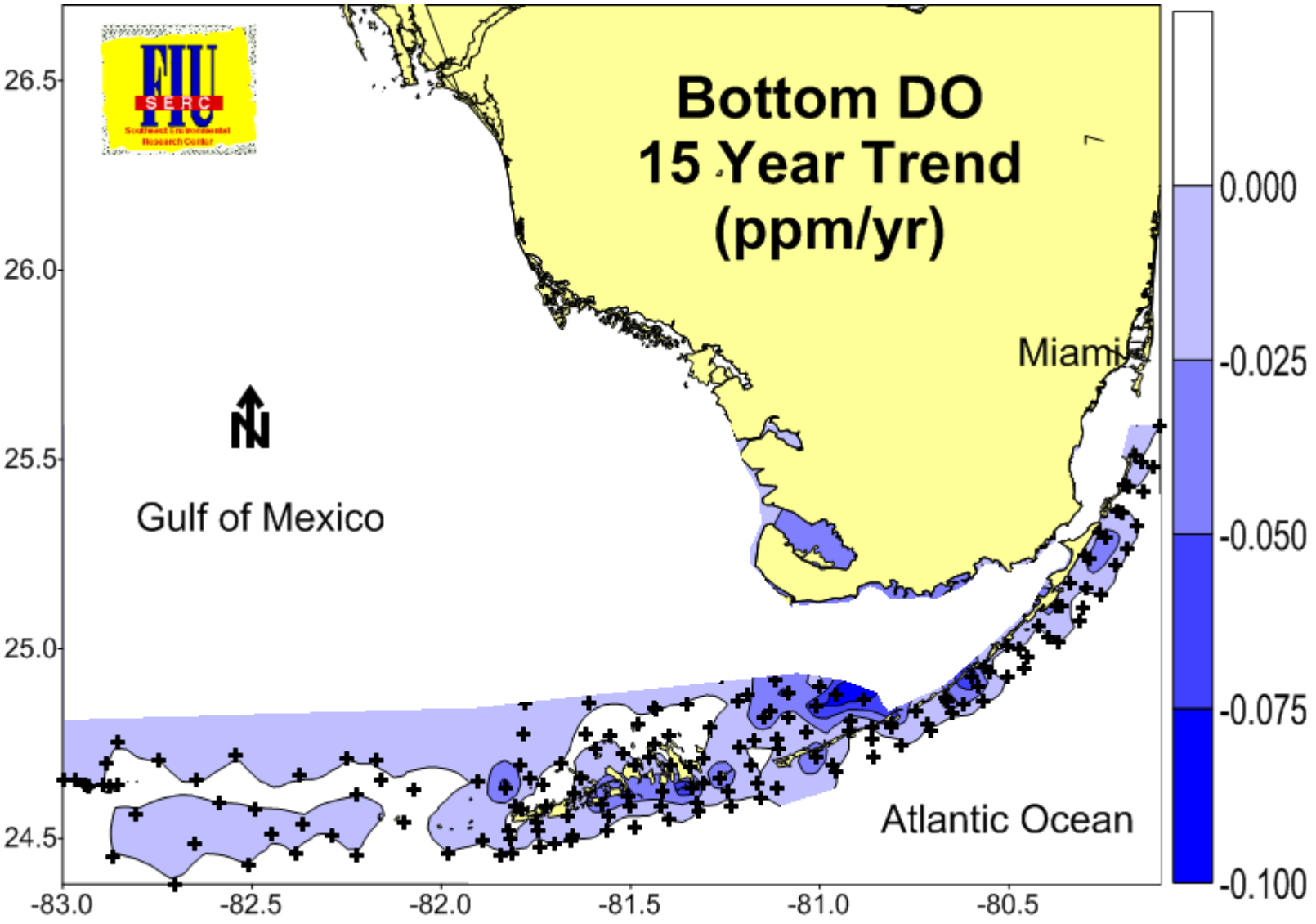
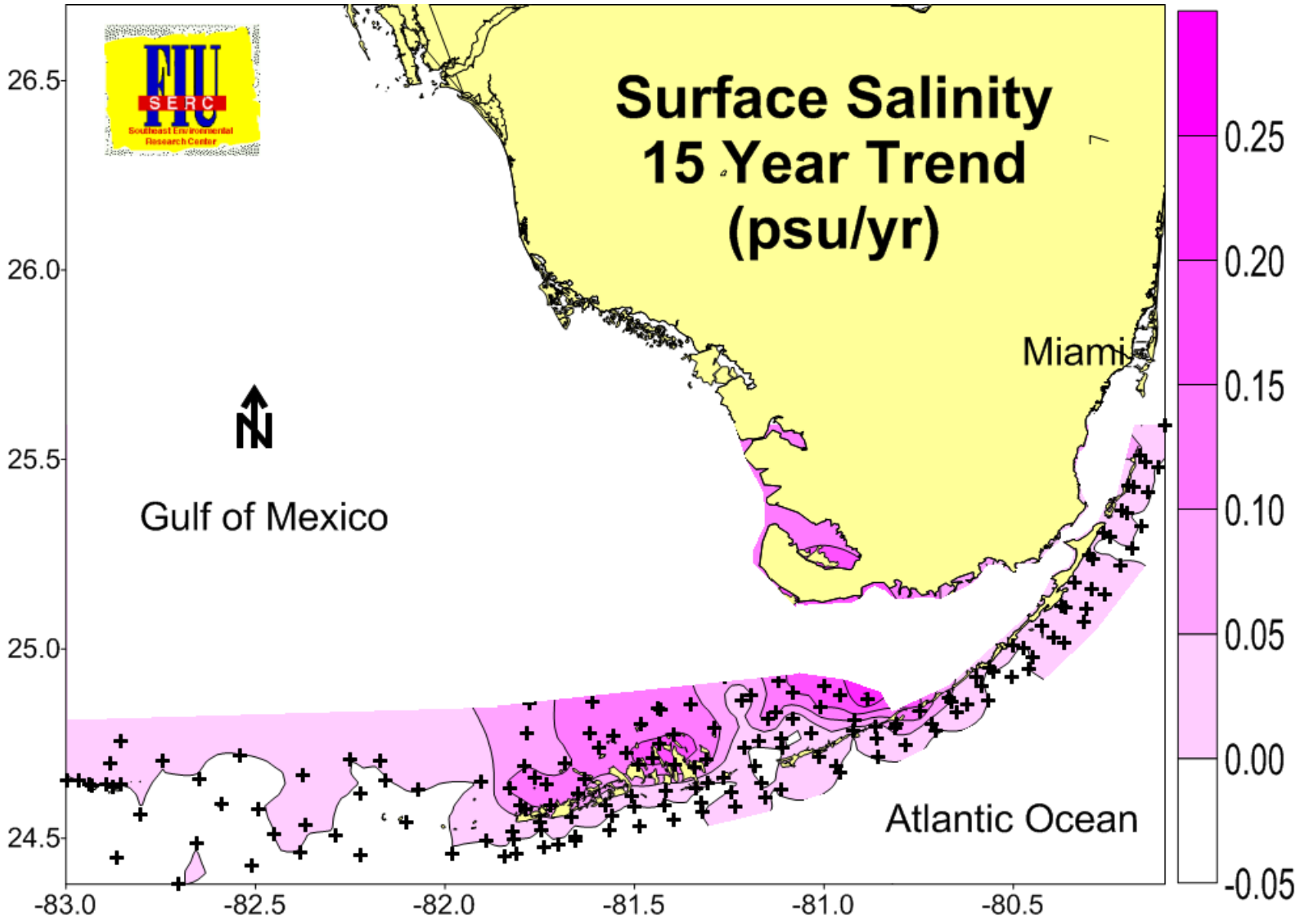
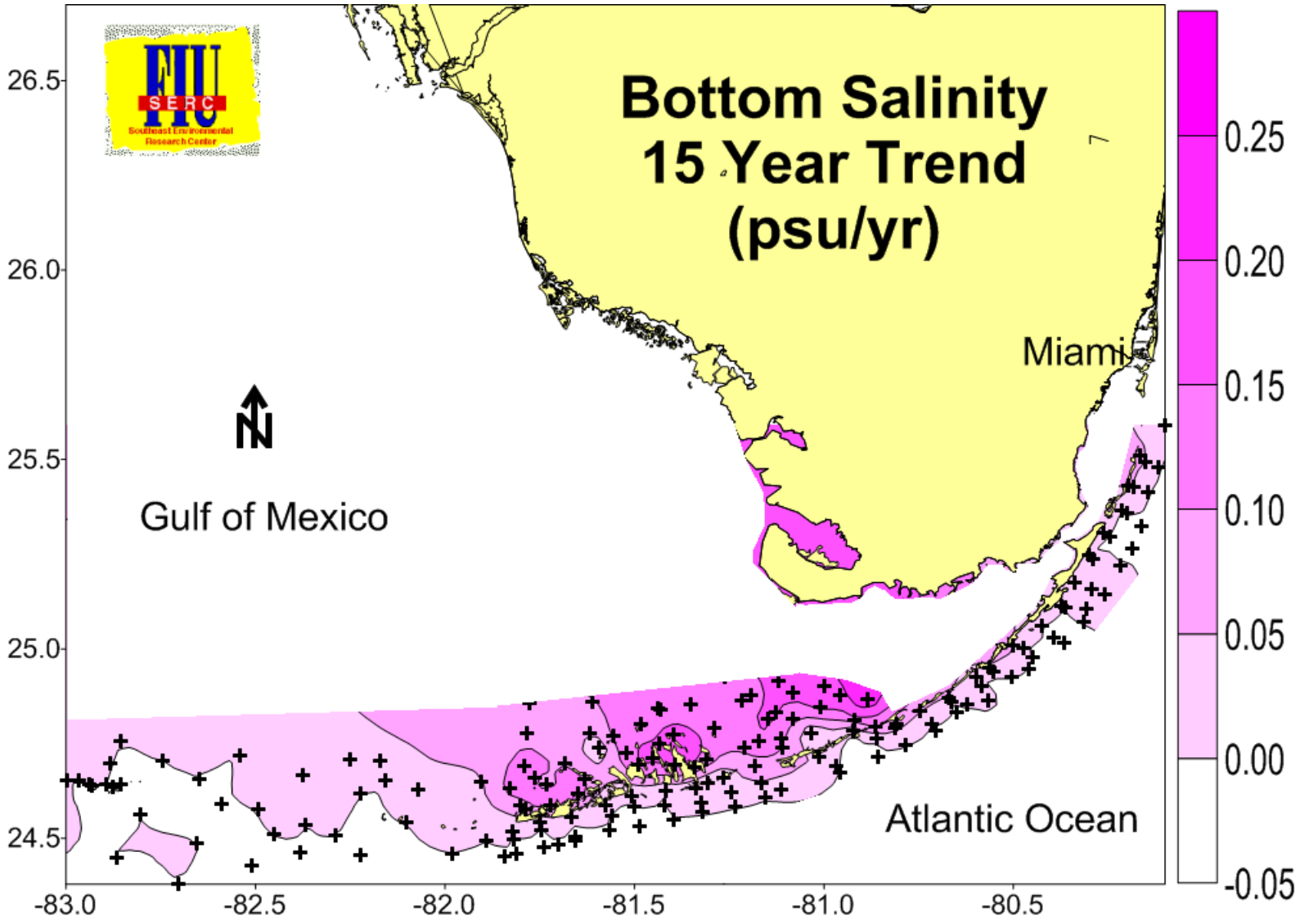
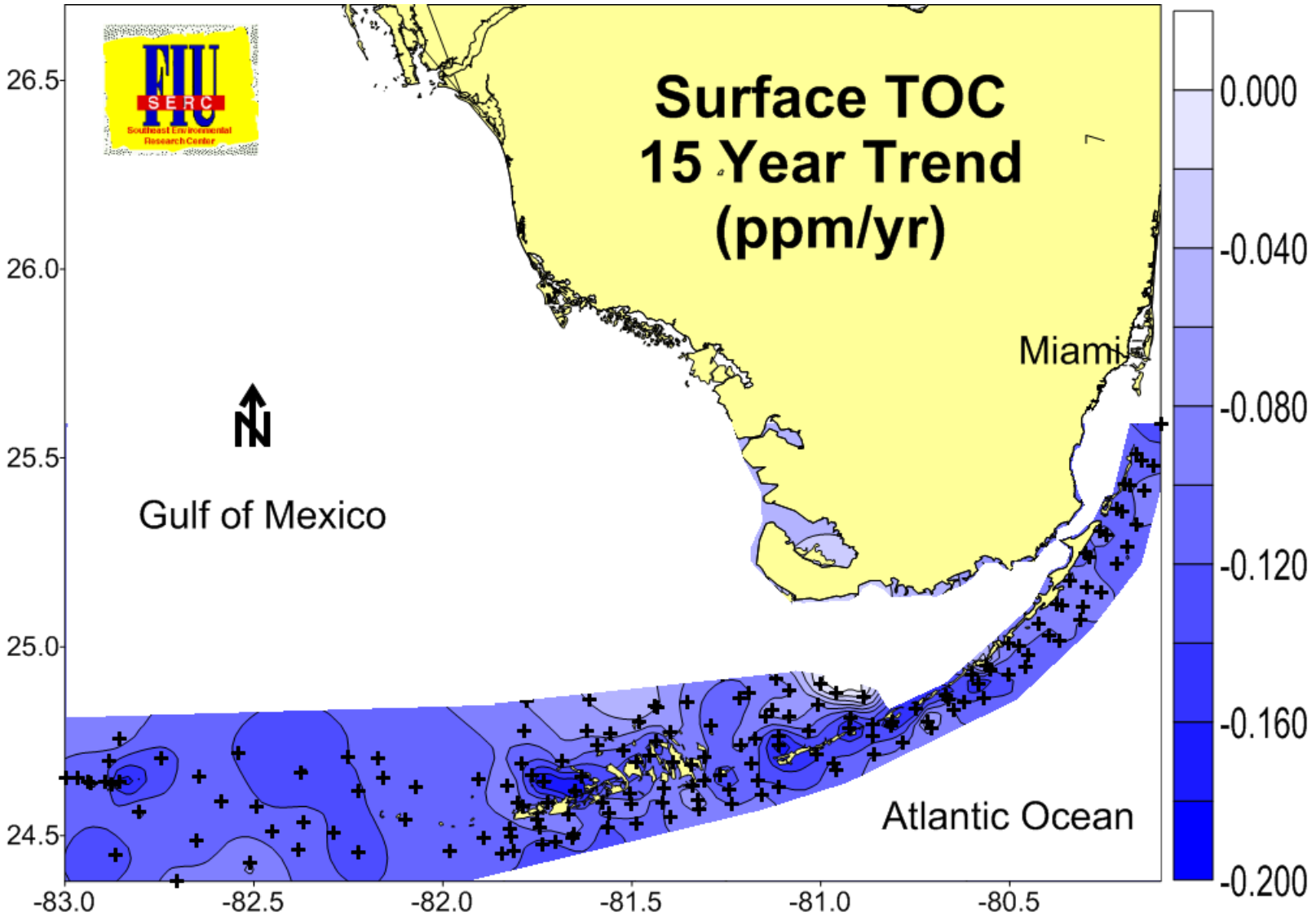
-0.075
-0.100


Bottom DO
15 Year Trend
(ppm/yr)
FIU
SERC
Southeast Environmental Research Center
Miami
Gulf of Mexico
Atlantic Ocean
N
26.5
26.0
25.5
25.0
24.5
-83.0
-82.5
-82.0
-81.5
-81.0
-80.5
0.000
-0.025
-0.050
-0.075
-0.100


Surface Salinity
15 Year Trend
(psu/yr)
FIU
SERC
Southeast Environmental Research Center
Miami
Gulf of Mexico
Atlantic Ocean
N
26.5
26.0
25.5
25.0
24.5
-83.0
-82.5
-82.0
-81.5
-81.0
-80.5
0.25
0.20
0.15
0.10
0.05
0.00
-0.05


Bottom Salinity
15 Year Trend
(psu/yr)
FIU
SERC
Southeast Environmental Research Center
Miami
Gulf of Mexico
Atlantic Ocean
N
26.5
26.0
25.5
25.0
24.5
-83.0
-82.5
-82.0
-81.5
-81.0
-80.5
0.25
0.20
0.15
0.10
0.05
0.00
-0.05


Surface TOC
15 Year Trend
(ppm/yr)
FIU
SERC
Southeast Environmental Research Center
Miami
Gulf of Mexico
Atlantic Ocean
N
26.5
26.0
25.5
25.0
24.5
-83.0
-82.5
-82.0
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-81.0
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-0.080
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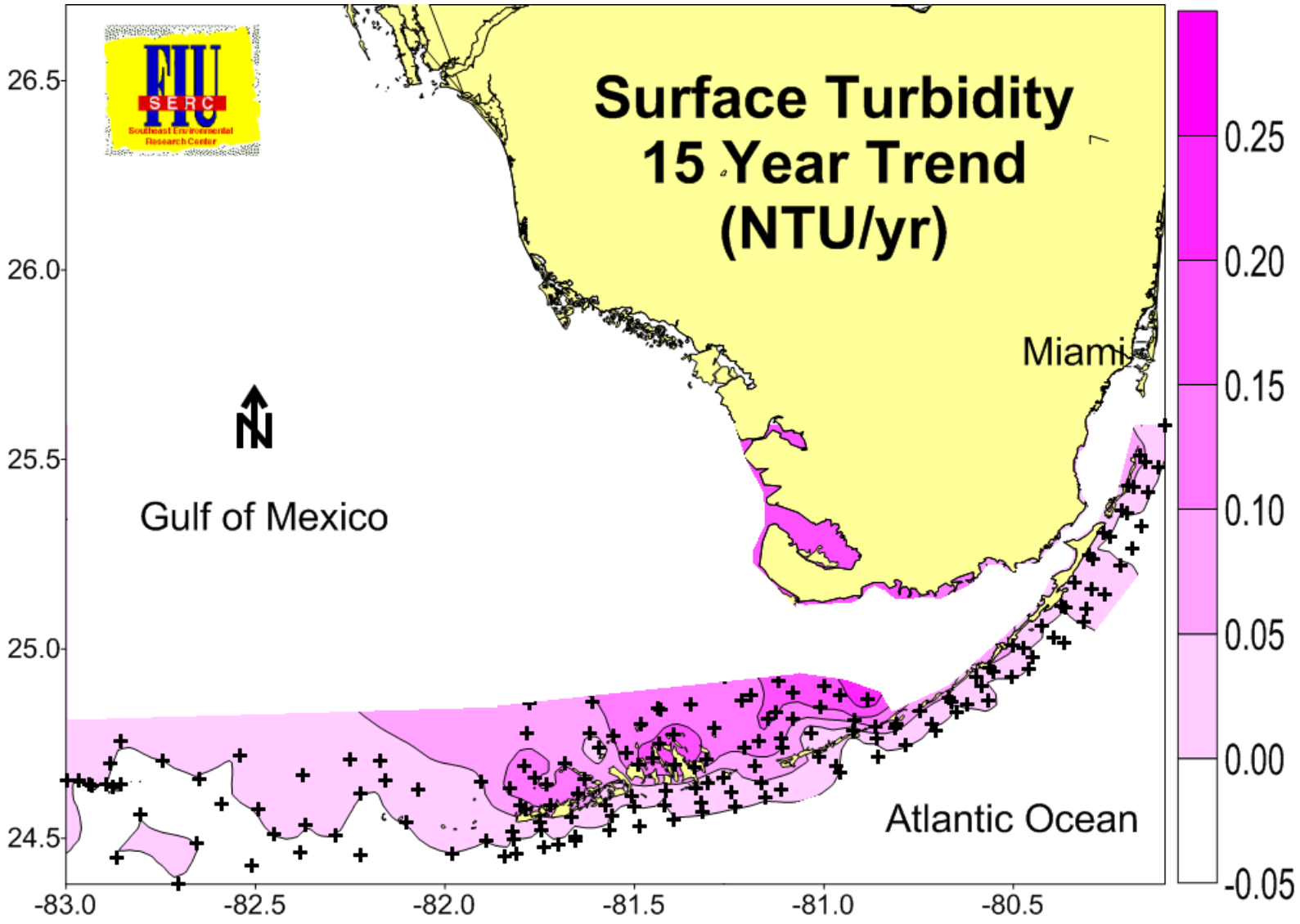
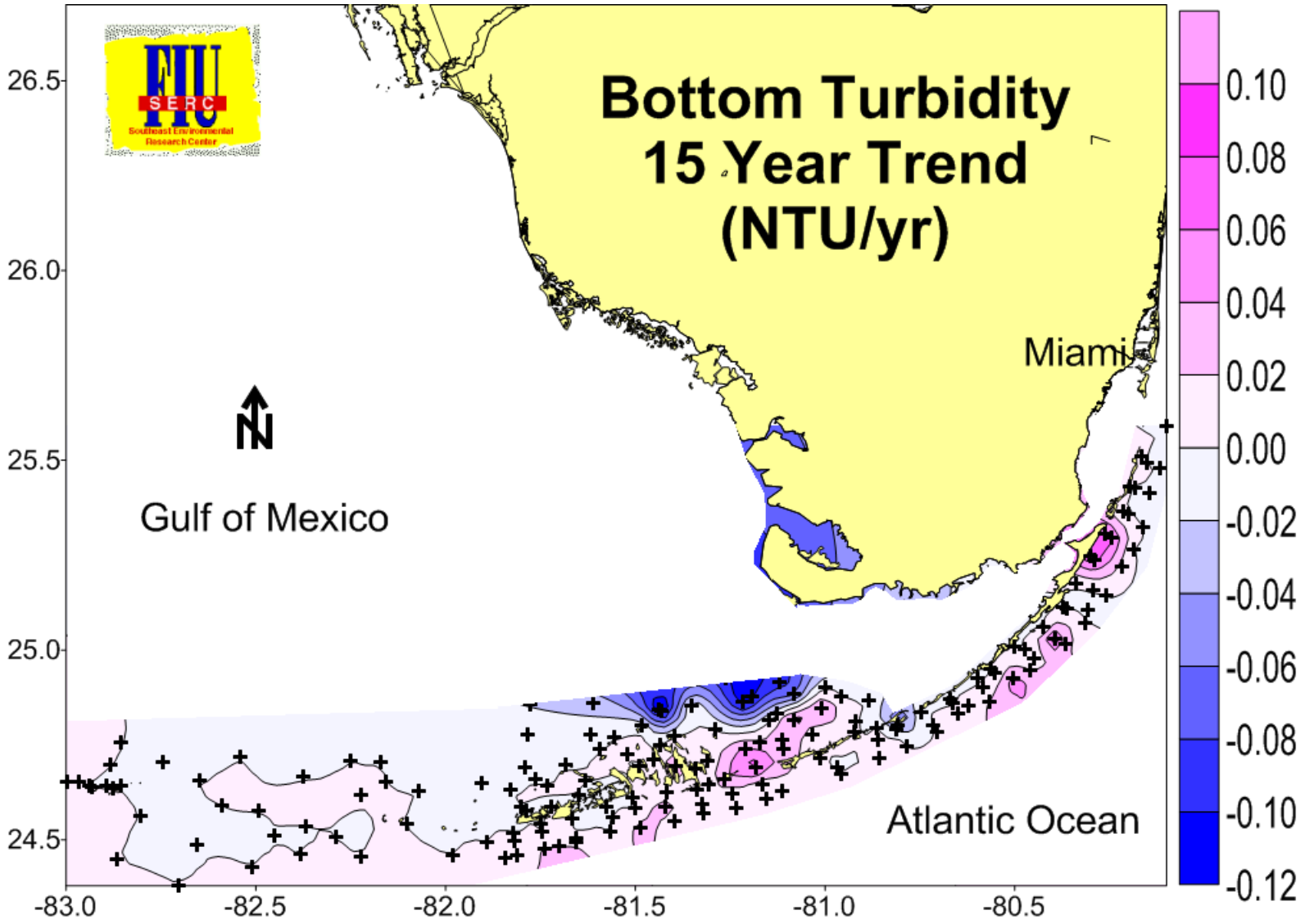
-0.200


Surface Turbidity
15 Year Trend
(NTU/yr)
Miami
Gulf of Mexico
Atlantic Ocean
N
FIU
SERC
Southeast Environmental Research Center
26.5
26.0
25.5
25.0
24.5
-83.0
-82.5
-82.0
-81.5
-81.0
-80.5
0.25
0.20
0.15
0.10
0.05
0.00
-0.05


Bottom Turbidity
15 Year Trend
(NTU/yr)
FIU
SERC
Southeast Environmental Research Center
Miami
Gulf of Mexico
Atlantic Ocean
N
26.5
26.0
25.5
25.0
24.5
-83.0
-82.5
-82.0
-81.5
-81.0
-80.5
0.10
0.08
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
-0.08
-0.10
-0.12

4. Explain Causes of Trends & Events

We generally don't have good explanations except to say that most is due to hydrological connectivity and climatology.

Most effects are "far field" meaning not related to land-based activities in the Keys.

More work needs to be done with coupling monitoring with remote sensing technologies and coastal ocean observation systems.

5. Provide Information for Management

Hot topic: Numerical Nutrient Criteria development

See poster by Henry Briceño on Nutrient Threshold Analysis

Background

- 2008 lawsuit by Earthjustice against EPA
- EPA formal determination that numeric nutrient criteria are “necessary” for estuarine and coastal waters under CWA
- Criteria will be proposed by EPA on Nov. 2011 and adopted by Aug. 2012
- FDEP instituted MTAC w/ first mtg 9/29/10
- EPA SAB will vet **process** to develop scientifically defensible and protective criteria values for marine waters

Nutrient Criteria Development Process

1. Zone Selection
2. Assessment Method
   A. Comparison to local reference condition
   B. Existing conditions – if protective
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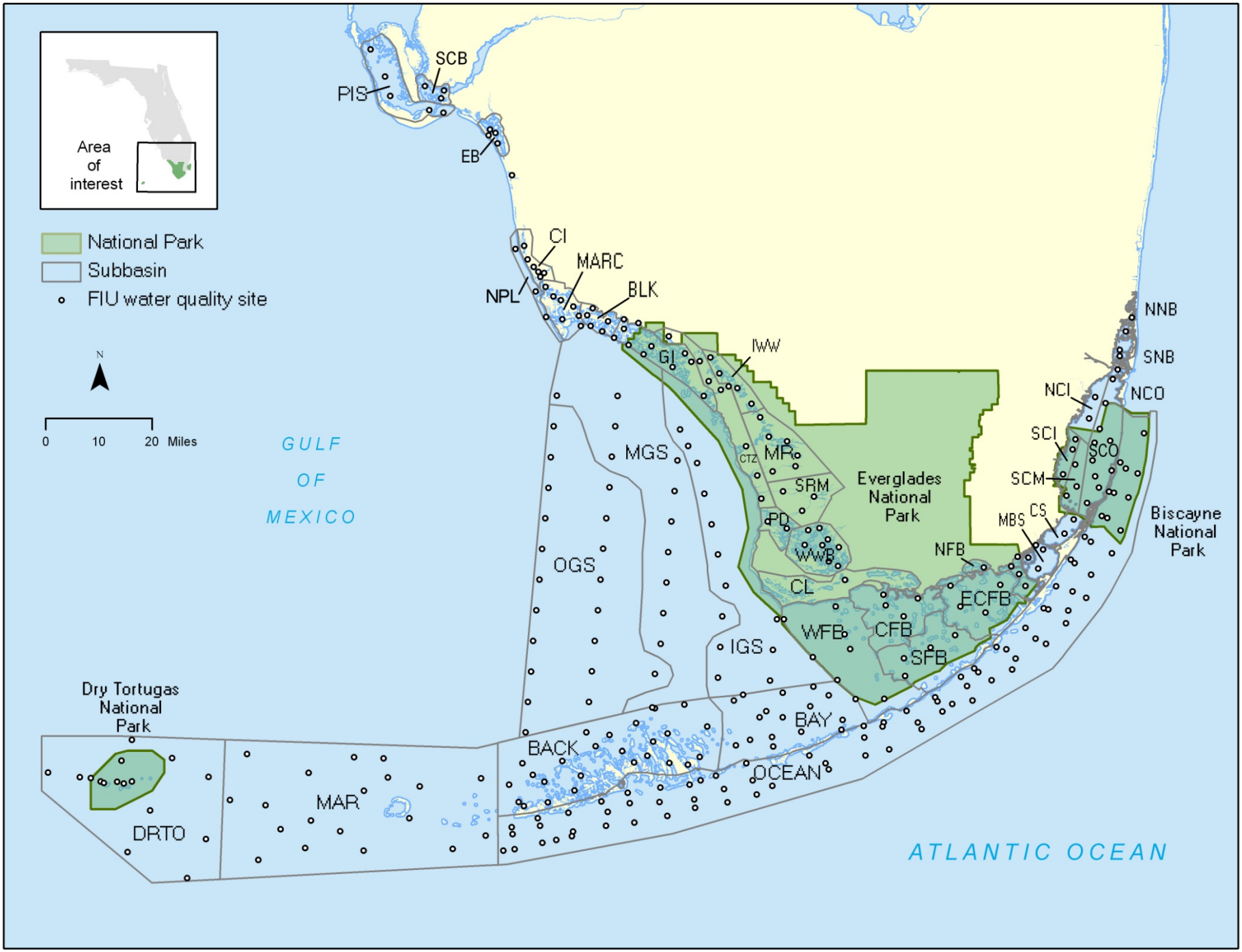
      ii. Ecosystem indicator approach (eg. CHLA)
      iii. Modeling (TMDL or RAD)
      iv. Threshold Analysis
   C. Comparison with other coral reef ecosystems
3. Implementation
   A. Spatial jurisdiction
   B. Magnitude, Frequency, and Duration


Area of interest
National Park
Subbasin
FIU water quality site
N
0 10 20 Miles
GULF OF MEXICO
ATLANTIC OCEAN
Everglades National Park
Biscayne National Park
Dry Tortugas National Park
SCB
PIS
EB
CI
MARC
NPL
BLK
GI
IWW
MGS
CTZ
MP
SRM
PD
WWB
CL
OGS
IGS
WFB
CFB
ECFB
NFB
SFB
BAY
BACK
OCEAN
MAR
DRTO
NNB
SNB
NCO
NCI
SCI
SCO
SCM
MBS
CS

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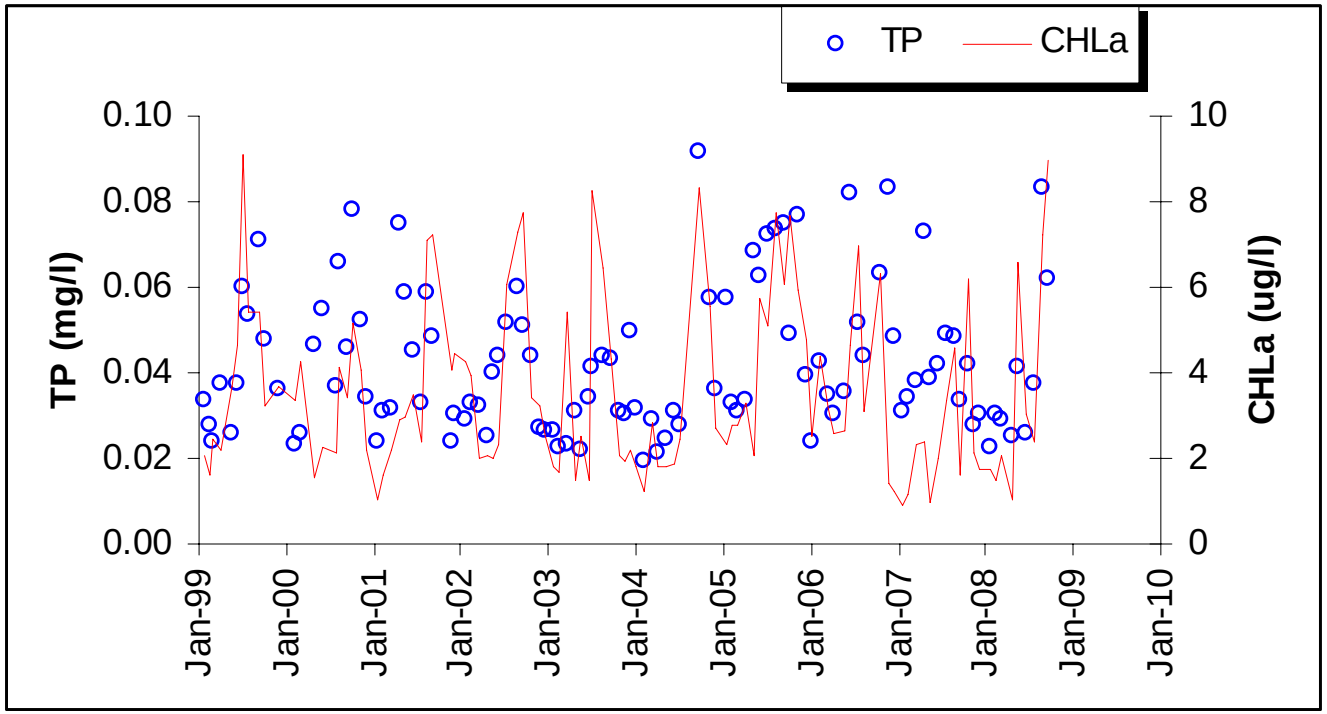
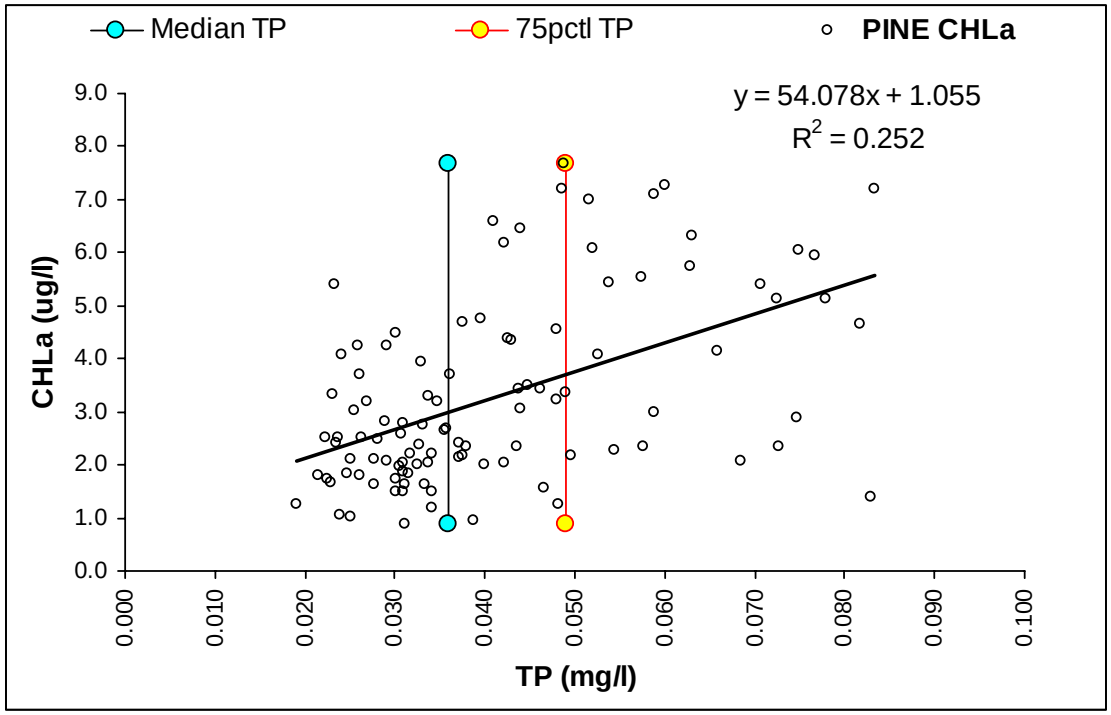
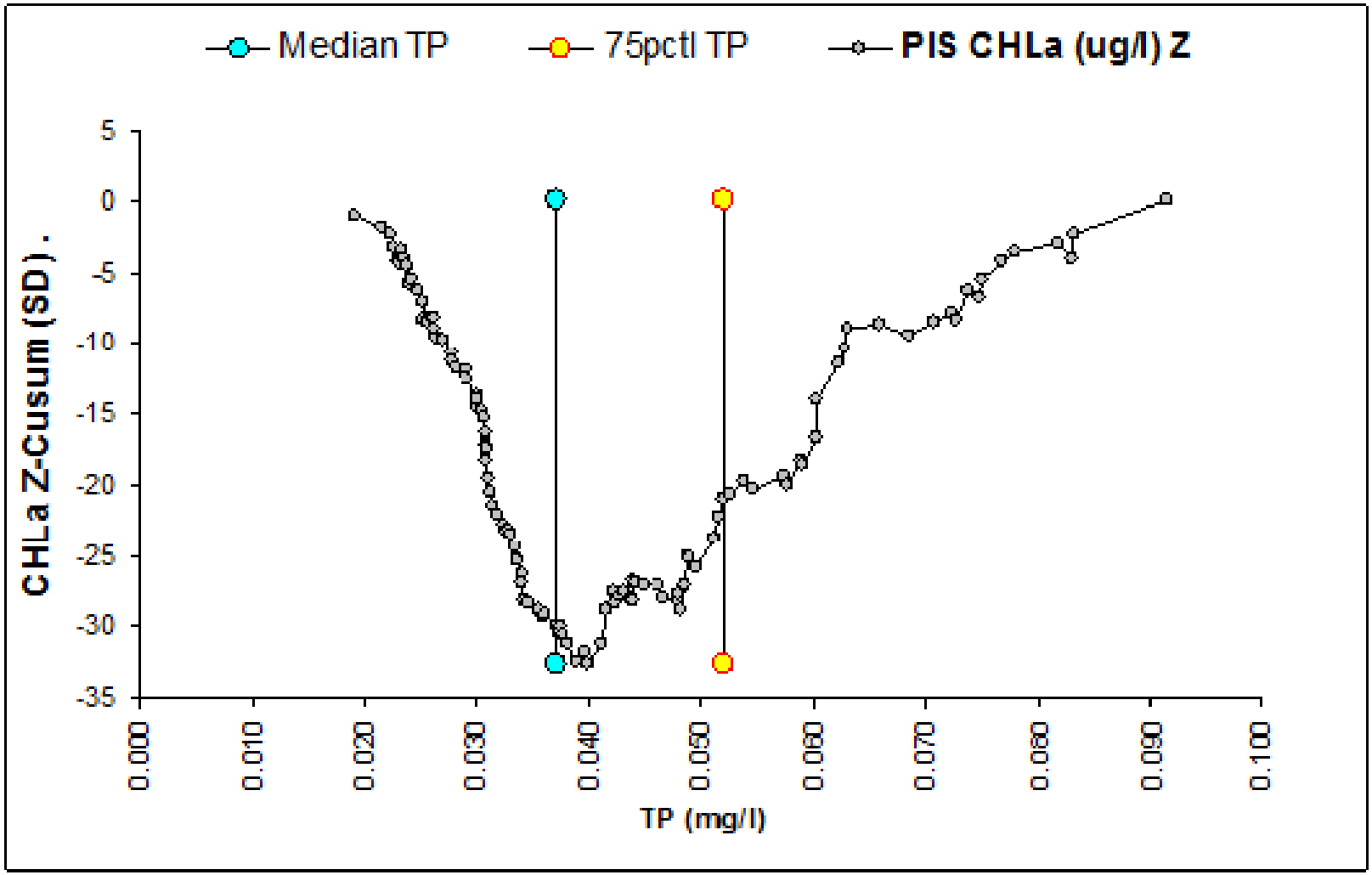
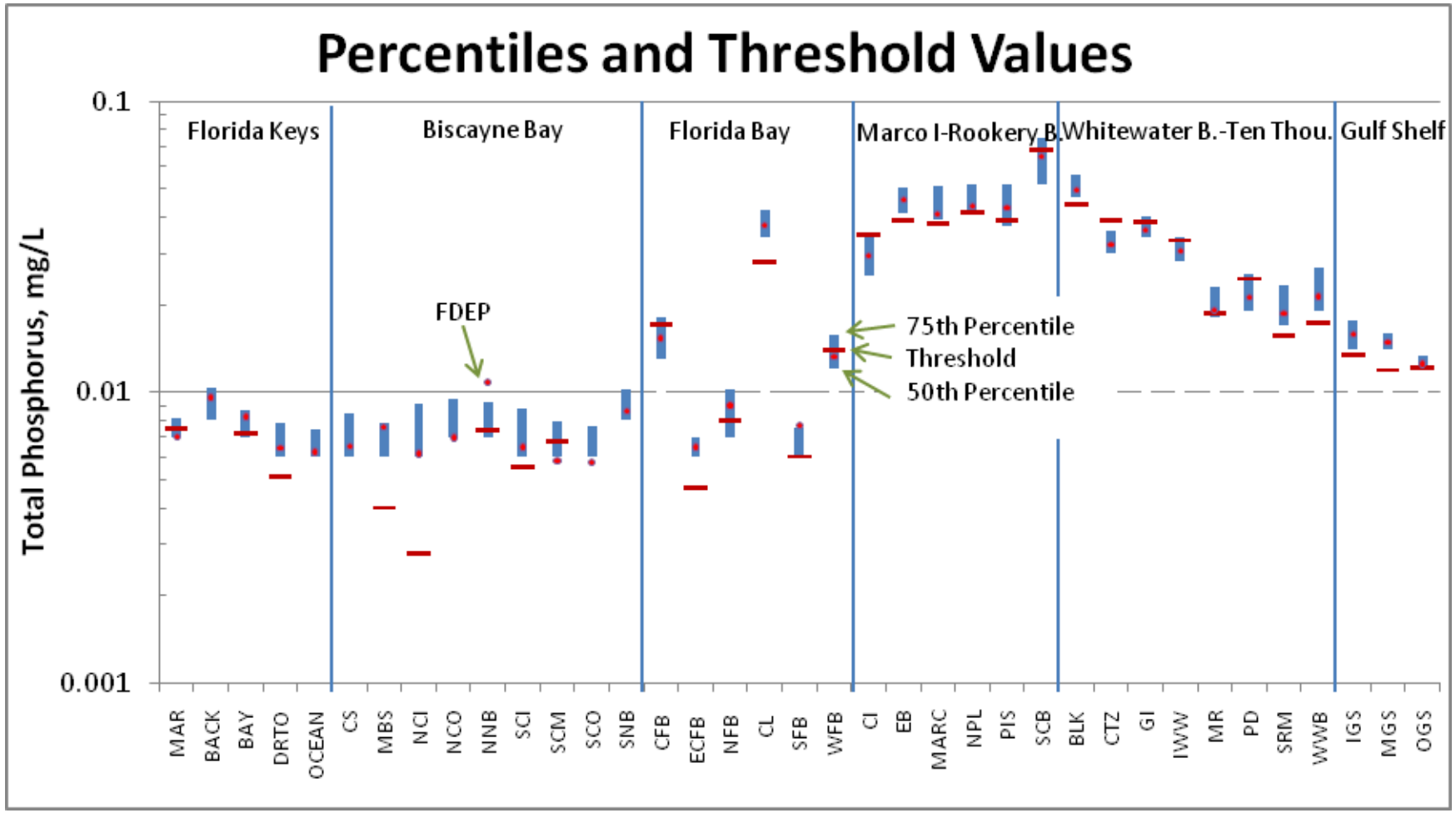

TP
CHLa
TP (mg/l)
CHLa (ug/l)
0.10
0.08
0.06
0.04
0.02
0.00
10
8
6
4
2
0
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10


Median TP
75pctl TP
PINE CHLa
y = 54.078x + 1.055
R2 = 0.252
CHLa (ug/l)
TP (mg/l)
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0.000
0.010
0.020
0.030
0.040
0.050
0.060
0.070
0.080
0.090
0.100

Threshold Analysis

See poster by Henry Briceño on Nutrient Threshold Analysis




Percentiles and Threshold Values
Total Phosphorus, mg/L
0.1
0.01
0.001
Florida Keys
Biscayne Bay
Florida Bay
Marco I-Rookery B.
Whitewater B.-Ten Thou.
Gulf Shelf
FDEP
75th Percentile
Threshold
50th Percentile
MAR
BACK
BAY
DRTO
OCEAN
CS
MBS
NCI
NCO
NNB
SCI
SCM
SCO
SNB
CFB
ECFB
NFB
CL
SFB
WFB
CI
EB
MARC
NPL
PIS
SCB
BLK
CTZ
GI
IWW
MR
PD
SRM
WWB
IGS
MGS
OGS

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Nutrient Criteria Comparison

Parameter	Bell et al.	Moss et al.	De'ath& Fabricius	Hawaii	EPA Target	FKRAD	Boyer& Briceno	Briceno Threshold
CHLA (ug l^{-1})	0.5	0.5-0.6	0.3-0.63	0.15-0.30	0.35		0.31	0.22
TN (ug l^{-1})		130-160		110-150		124-145	186	156
PN (ug l^{-1})			17.5-25					
NH_4^+ (ug l^{-1})				2.0-3.5			5.0	
NO_x^- (ug l^{-1})				3.5-5.0			3.0	
DIN (ug l^{-1})	14.0	1.0-2.0			10.0		9.0	
TP (ug l^{-1})		30		16-20	7.7	7.0-9.0	7.0	8.0
SRP (ug l^{-1})	1.4-2.8	3.0					1.0	
PP (ug l^{-1})			2.3-3.3					
Turb. (NTU)				0.2-0.5			0.7	
Secchi (m)			10					
K_d (m^{-1})			0.144		0.2		0.21	
Secchi of 10 m ~ K_d of 0.144								

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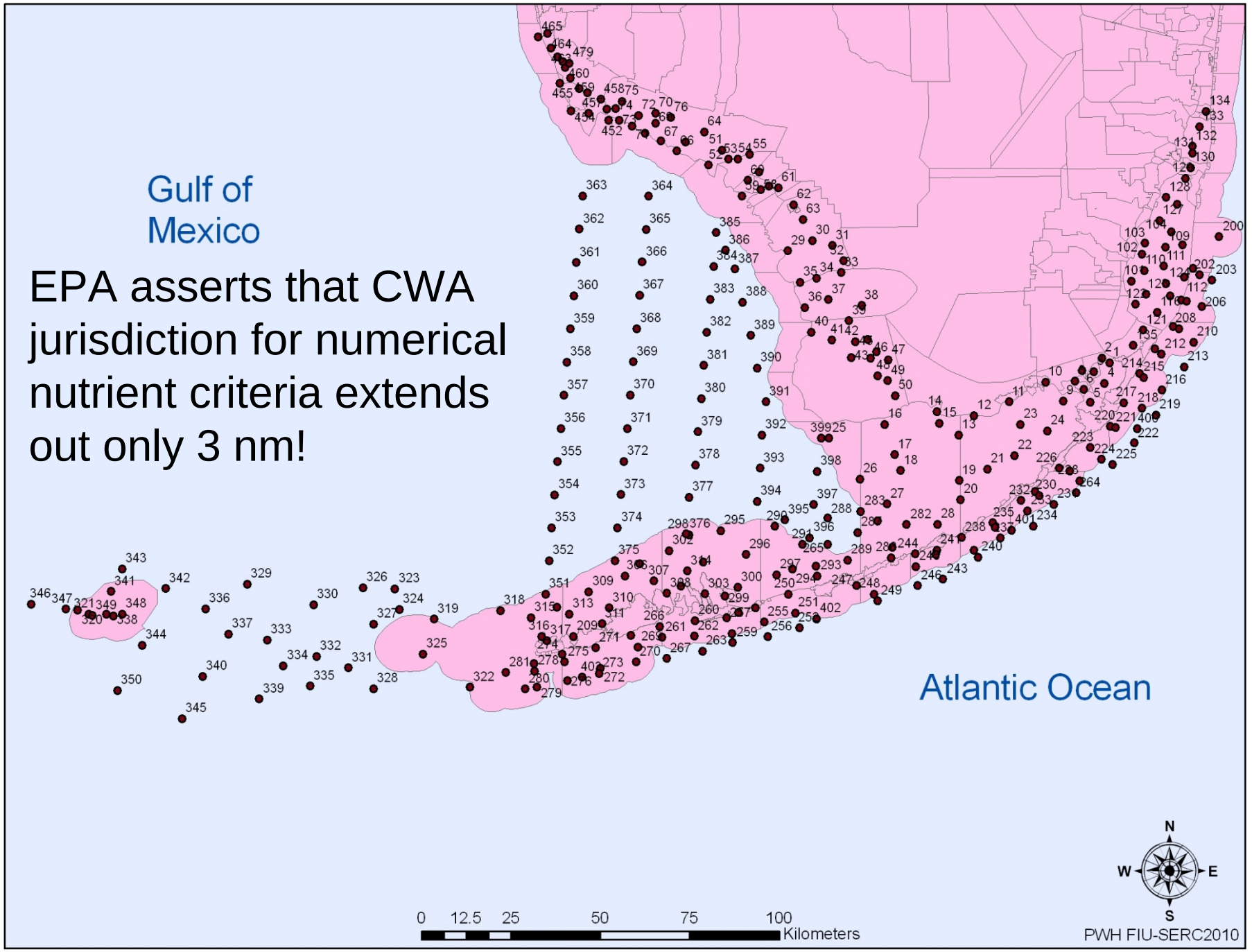
Gulf of Mexico
EPA asserts that CWA jurisdiction for numerical nutrient criteria extends out only 3 nm!
Atlantic Ocean
0 12.5 25 50 75 100
Kilometers
N
W
E
S
PWH FIU-SERC2010

Magnitude, Frequency, and Duration

- Long-term geometric mean from the long-term dataset for each sub-basin or salinity zone
- For anti-degradation evaluations, EPA considers a 10% change in a water quality parameter to represent an insignificant departure from the existing condition.
- This *de minimus* concept upheld by Sixth District Court (2008)

6. Monitor Compliance

Separate issue, typically involving agency participation.

7. Educate Stakeholders

- We need to put more effort into this task.
- Scientists are not necessarily best media contacts.
- We need training in communication skills and help in gaining access to the “right” people.

Summary

- Water quality in the FKNMS responds to complex interactions of climate, marine currents, terrestrial runoff, and other anthropogenic activities.
- We need to use a nutrient budgeting approach and do better at interfacing with other regional research programs.
- Water quality monitoring is not an esoteric pursuit but should developed to become a more practical tool for answering management questions and developing new scientific hypotheses.

Reports and data available at:
www.serc.fiu.edu/wqmnetwork/
Click on FKNMS