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2 December 2010

Ms. Stephanie Sanzone
Designated Federal Officer (DFO)
EPA Science Advisory Board Staff Office (1400R)
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, NW
Washington, DC 20460

Re: EPA SAB Nutrient Criteria Review Panel

Dear Ms. Sanzone:

We would like to provide comment to the EPA Scientific Advisory Board, Nutrient Criteria Review Panel, concerning the Nov. 17, 2010 EPA document, Methods and Approaches for Deriving Numeric Criteria for Nitrogen/Phosphorus Pollution in Florida's Estuaries, Coastal Waters, and Southern Inland Flowing Waters. We speak as members of South Florida scientific community, principal investigators for many years of a large marine water quality monitoring network, contributors of statistical and modeling approaches to the above document, and member (Boyer) of Florida's Marine Numeric Nutrient Criteria Technical Advisory Committee (MTAC).

Incomplete Jurisdiction

Our first issue of overriding concern is one of jurisdiction. The EPA document states that "marine waters include estuarine and coastal waters extending three nautical miles offshore." Under this CWA designation, much of the reef tract and large swaths of open waters in the Marquesas/Tortugas of the Florida Keys National Marine Sanctuary (FKNMS) will excluded from numeric nutrient criteria (NNC) development and implementation (Fig. 1). We request that this discrepancy be discussed, noted, and addressed by the SAB Panel, EPA, FDEP, and NOAA.

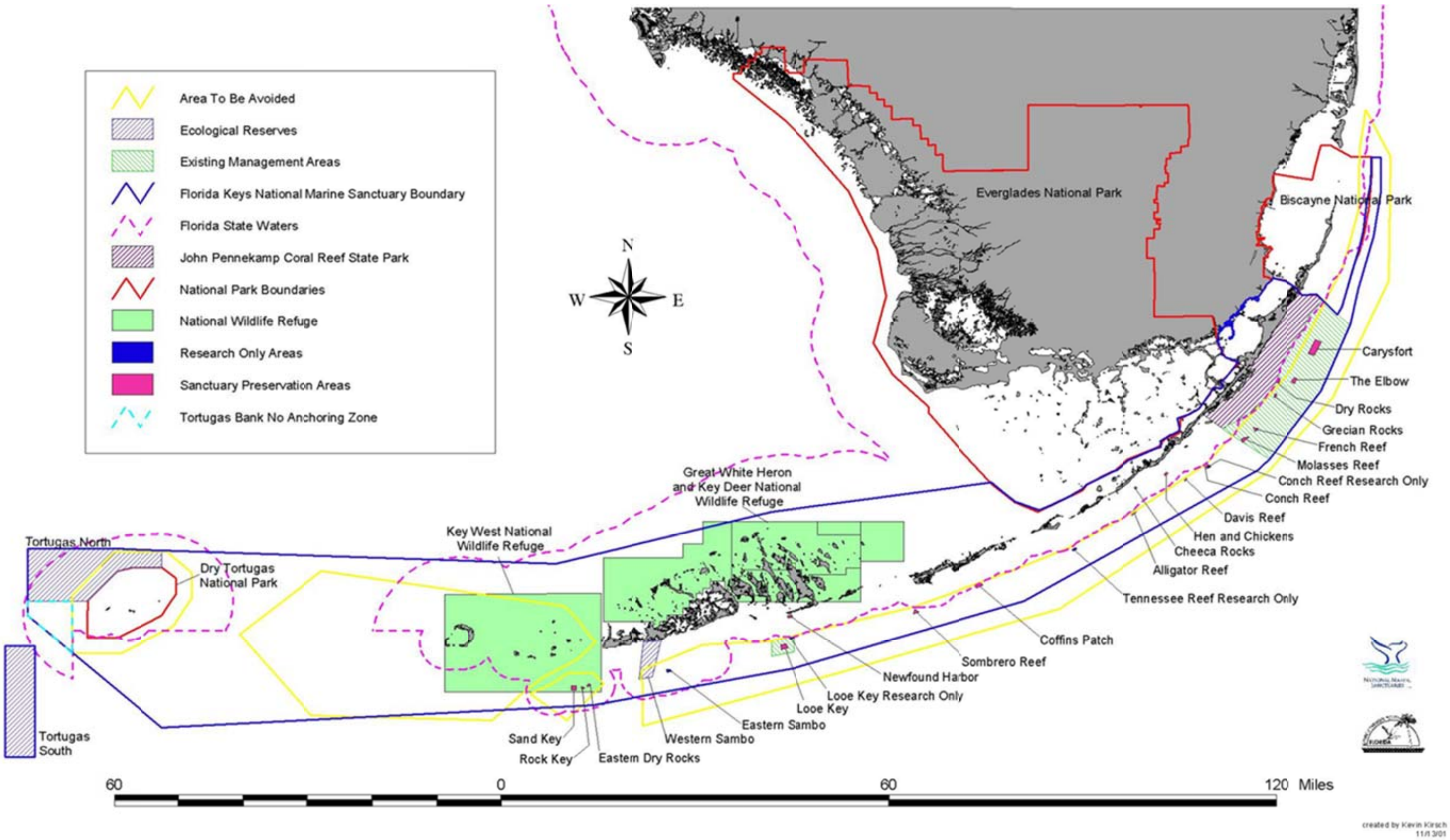


Figure 1. Jurisdictional areas of South Florida including Florida Keys National Marine Sanctuary (blue) and CWA boundary (dotted pink). Notice that most of coral reef tract and area between Marquesas and Tortugas are outside of CWA limit.

Omission of Dissolved Oxygen (DO) Criteria

Another concern is the assertion that "EPA is not considering the development of dissolved oxygen criteria." We think this is a mistake because the existing State of Florida rule has been strongly criticized and is in need of revision. Many water bodies fail the Florida criteria on a regular basis due to natural environmental conditions of high temperature and salinity. DO saturation (%) might be a better metric of oxygen condition because it takes temperature, salinity, and pressure into account and is therefore a more accurate measure of what animals and plants experience.

Many states have found that there are benefits to using DO % saturation as a secondary criterion because it can highlight areas that are not meeting the minimum DO criteria due to temperature/salinity effects. A dual criteria, which also considers the DO % saturation can be set to maximize saturation level when temperature and elevation naturally act to lower the DO concentration.

Secondly, in many estuaries, the presence of low DO concentrations is completely unrelated to nutrient loading. For example, eastern Florida Bay exhibits some of the most oligotrophic nutrient conditions of any estuary in the world yet experiences weekly if not daily DO levels below 4 ppm. This a function of the elevated temperatures and high salinity present in the ecosystem, not nutrient loading.

Thirdly, Florida State DO rule does not address natural stratification of water bodies. It is well established that stratification is a strong physical driver of hypoxia in bottom waters.

Potential Use of Light Field Characteristics as Criteria

Overall benthic community health is South Florida waters is partially driven by light availability. Seagrass, macroalgae, coral, etc. are all dependent on adequate light penetration for maintenance and growth. Water quality parameters such as turbidity, colored dissolved organic matter (CDOM), and phytoplankton chlorophyll a (CHLA) all act to decrease light penetration in the water column. The two most common measurements of the aquatic light field are secchi depth and the vertical light attenuation coefficient (K_d). A secchi depth of 10 m generally equates to a K_d of 1.44. The percent of surface irradiance reaching the bottom, as calculated from K_d and site depth, is a powerful indicator of water clarity and can help define depth limits of growth of certain seagrass and coral. We believe that it is important that serious thought be given to including a light field criteria.

"Missing" Estuaries

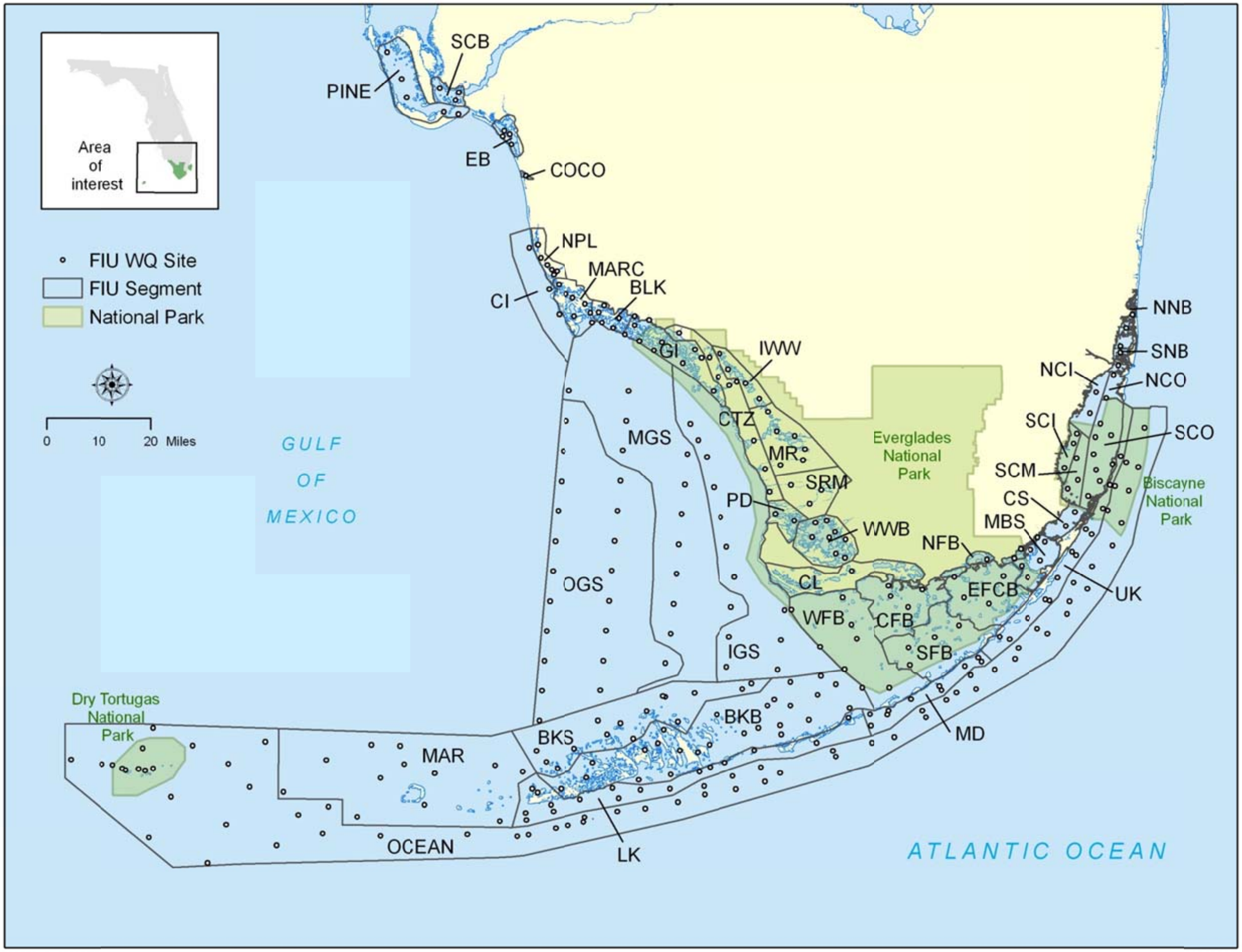
Chapter 5 mentions only Florida Bay and the Florida Keys as regions to be addressed in South Florida. We believe that in addition to these two regions, the other named estuaries and coastal waters be listed and discussed in the document. These include: Biscayne Bay, Whitewater Bay, Ten Thousand Islands mangrove estuaries complex, and the SW Florida Shelf. We believe these omissions were due to EPA's consideration of our prior segmentation analysis, which does include those waters, but feel they warrant mention in EPA text.

Omission of Mangroves as Estuarine Habitat Type

Outside of referenced literature, there is no mention of the word mangrove in this document. We feel this is a serious omission because extensive mangrove forests are significant component of the estuarine ecosystems of South Florida. The health of mangrove forests should also be considered while developing DPV for NNC.

Outdated Florida Keys Segmentation

We are pleased that EPA chose to use our statistical segmentation approach for South Florida estuaries but are perplexed as to why they decided to use the segmentation approach of Klein and Orlando (1994) for the Florida Keys. Over 15 years of quarterly water quality sampling of 16 variables at 150 sites throughout the Keys has been conducted since Klein and Orlando (1994), resulting in over 200,000 data points. This database was used to develop the original segmentation in Appendix D. We have since modified our approach to address onshore-offshore differences and have come up with a new segmentation scheme for the FKNMS which is even more intuitive and explanatory than the previous one (Fig. 2).



Area of interest
FIU WQ Site
FIU Segment
National Park
0 10 20 Miles
GULF OF MEXICO
ATLANTIC OCEAN
Everglades National Park
Biscayne National Park
Dry Tortugas National Park
PINE
SCB
EB
COCO
NPL
MARC
BLK
CI
GI
IWW
CTZ
MR
SRM
PD
WWB
MGS
OGS
IGS
CL
WFB
CFB
SFB
EFCB
NFB
MBS
CS
SCM
SCI
SCO
NCI
NCO
NNB
SNB
UK
MD
BKB
BKS
MAR
OCEAN
LK

Omission of Coastal Waters Nutrient Criteria

We believe EPA's proposal that "numeric criteria derived for estuarine waters … will inherently protect coastal waters" is not necessarily true. In South Florida, many of the estuaries are phosphorus limited (sensu Redfield). Excess N loading to these estuaries may not have significant effect on phytoplankton growth. However, these waters may be rapidly transported offshore to coastal regions which are typically N limited. The resulting increase in N to these areas may promote algal bloom formation and affect existing seagrass beds.

Reliance on Remote Sensed Chlorophyll a

While we think that remote sensing of chlorophyll *a* (CHLA) in coastal waters has great promise, we do not believe that reliance on this technique is wise. Without going into all the details, remote sensing of CHLA in shallow inshore waters has significant problems in technical interpretation. There are many inherent properties of coastal waters which preclude good outcomes.

1) In clear shallow waters it is very difficult (if not impossible) to distinguish water column CHLA from that of the bottom (seagrass, algal mat, etc). This is manifest in all aspects of remote sensed data and has not been fully addressed by the scientific community. The result is serious overestimation of remote sensed CHLA in shallow waters.

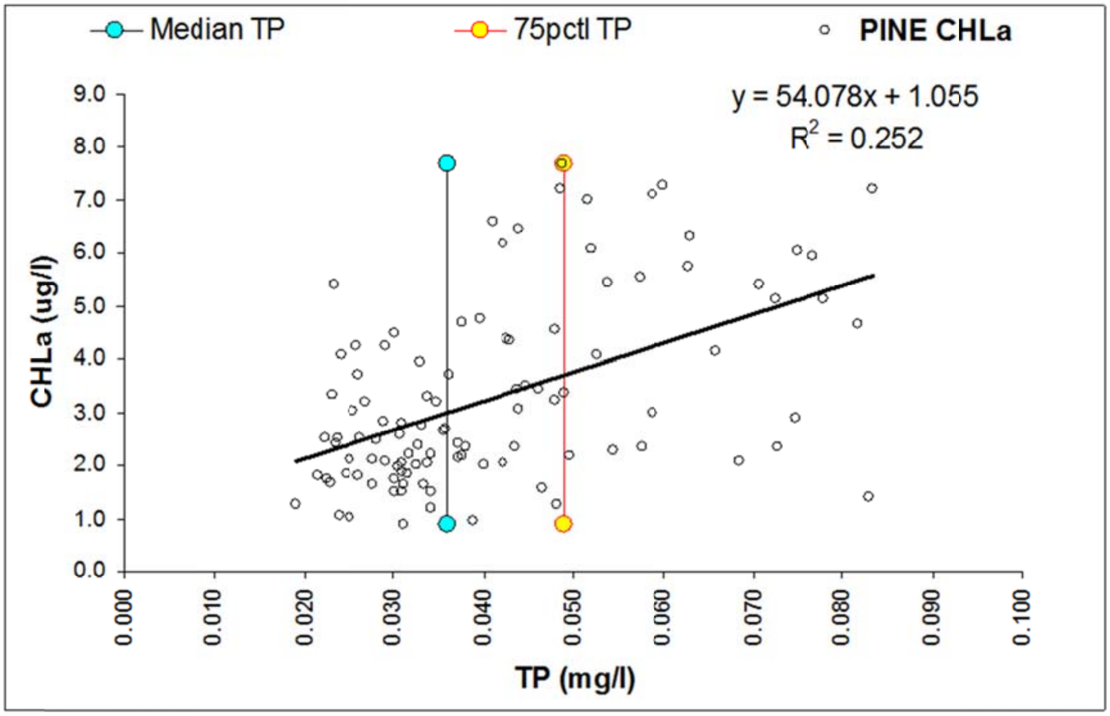
2) Large interferences in CHLA signal occur in areas with presence of significant colored dissolved organic matter (CDOM). Most of this CDOM originates from coastal forests, mangroves, and salt marshes and is transported to coastal waters. The result is serious overestimation of remote sensed CHLA in these receiving waters.

3) Large interference in CHLA signal occurs in areas with presence of significant turbidity. Much of this turbidity originates from resuspension of shallow sediments and from estuarine transport of terrestrial runoff. The result is serious underestimation of remote sensed CHLA because of low optical pathlength and scattering.

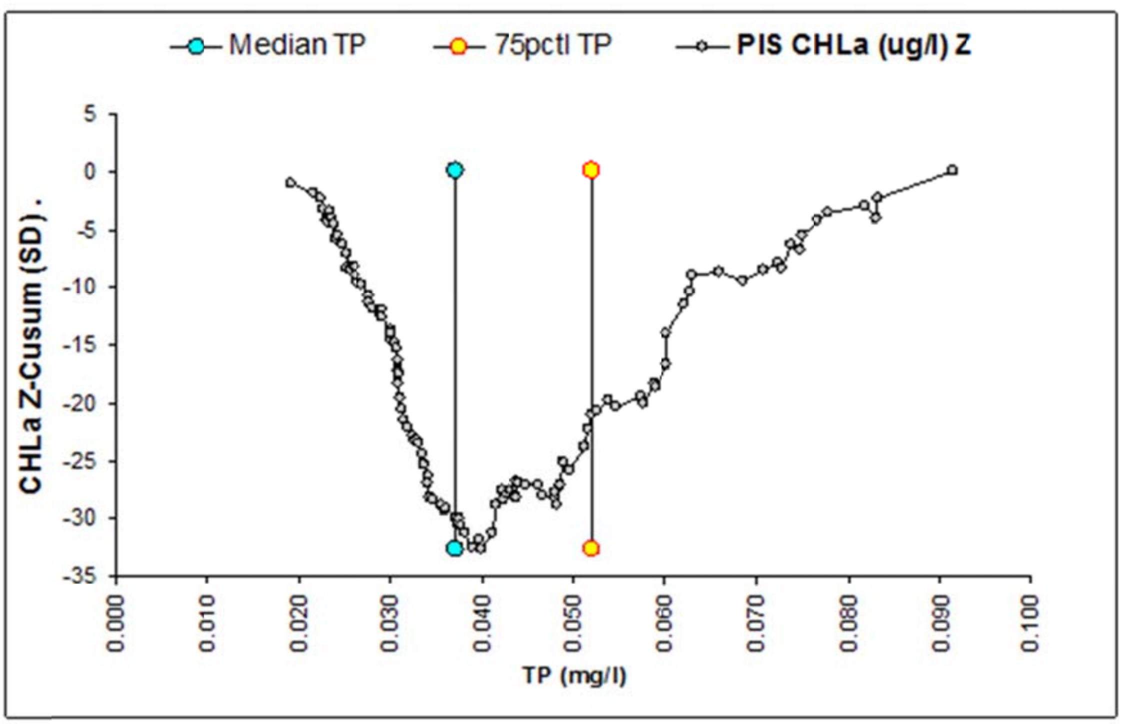
4) There are insufficient ground-truth studies of the relationship between in situ and remote sensed CHLA. The only study mentioned in the EPA document used 62 in situ CHLA concentration measurements to build a linear regression model with remote sensed data. This regression has an r^2 of 0.52, which may be significantly different than zero (not provided), but will definitely not be predictive. In addition the slope of 0.85 means the relationship is relatively insensitive. The y-intercept of 0.35 $\mu g\ l^{-1}$ CHLA means that the minimum detectable CHLA concentration would be too high for many of South Florida Coastal waters. Using SeaWiFS could result in an inordinate number of false positives in oligotrophic waters where ambient CHLA is $<0.35\ \mu g\ l^{-1}$.

Reliance on a Single Stressor/Response Approach

Usual Stressor/Response approaches to development of NNC are limited by strength of regression among nutrients and typically, CHLA. As an example, the general problem is that either TN or TP is statistically ($p<0.05$) related to CHLA but is not very predictive (Fig. 3).



We suggest to use a modification of Z-CUSUM approach which we call ***Threshold Analysis***. Using the same data, the relationship between TP and CHLA becomes more evident with the threshold being close to the median (Fig. 4). The document, *Proposed Methodology for the Assessment of Protective Numeric Nutrient Criteria for South Florida Estuaries and Coastal Waters*, describing this approach in detail will be submitted separately by Dr. Henry Briceno.



Omission of Other Aquatic Biological Indicators

EPA has decided to omit using other biological indicators, such as seagrass, coral, fish, etc. in NNC development of marine waters. We think other biological indicators should be used if it can be shown that they are sensitive to nutrient enrichment. In fact, we propose such uses as Multiple Lines of Evidence (see following) towards development of NNC. If different species or communities respond in like manners to similar levels of nutrient enrichment, the applicability of the selected criteria would be bolstered.

Example of Multiple Lines of Evidence for Coral Reef NNC

In an effort to reduce verbiage but to put forward a pertinent approach, we have included as an **appendix**, the following presentation originally given to the Steering Committee of the Water Quality Protection Program for the Florida Keys National Marine Sanctuary. The purpose of this is to suggest inclusion of other biological Indicators in the process and that a multiple lines of evidence approach may be beneficial to providing scientific consensus towards NNC for Florida coral reef ecosystems.

We thank EPA and the SAB for their patience in reviewing our comments. If you have any questions about the content of this response, please do not hesitate to contact me at 305-348-4076 or boyerj@fiu.edu.

Sincerely,

Dr. Joseph N. Boyer, Director and Assoc. Professor
Southeast Environmental Research Center
Department of Earth & Environment
Florida International University

Dr. Henry O. Briceño, Research Faculty
Southeast Environmental Research Center
Florida International University

Development of Numeric Nutrient Criteria for the Florida Keys

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Dept. Earth & Environment
Florida International University
Miami, FL 33199

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

Desired Outcome

- Derive numeric targets (loading or concentration) needed for protecting or restoring the system, including a demonstration of the scientific bases for the nutrient targets.
- Link criteria to designated use (healthy, well balanced ecosystem)

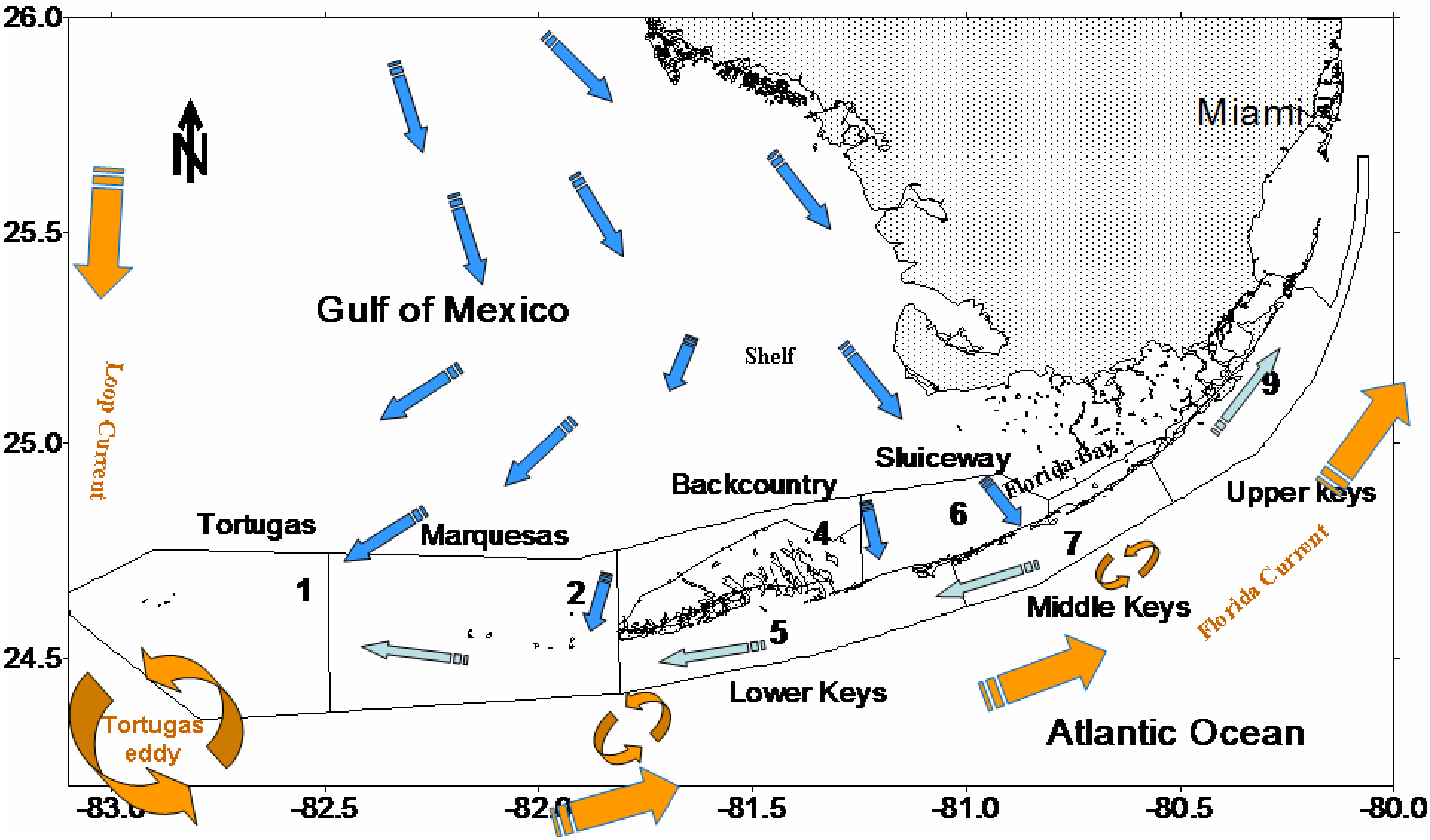
Outline of Presentation

1. Nutrient Regime
2. Valued Biological Resources
3. Nutrient Criteria Development Approaches
4. Potential Nutrient Criteria
5. Implementation

1. Nutrient Regime

- Sources and Fates of Nutrients in System
- Concentration and Loading of P and N
- Established Hydrodynamic or Nutrient Water Quality Models?
- Other Nutrient Information

Regional Circulation



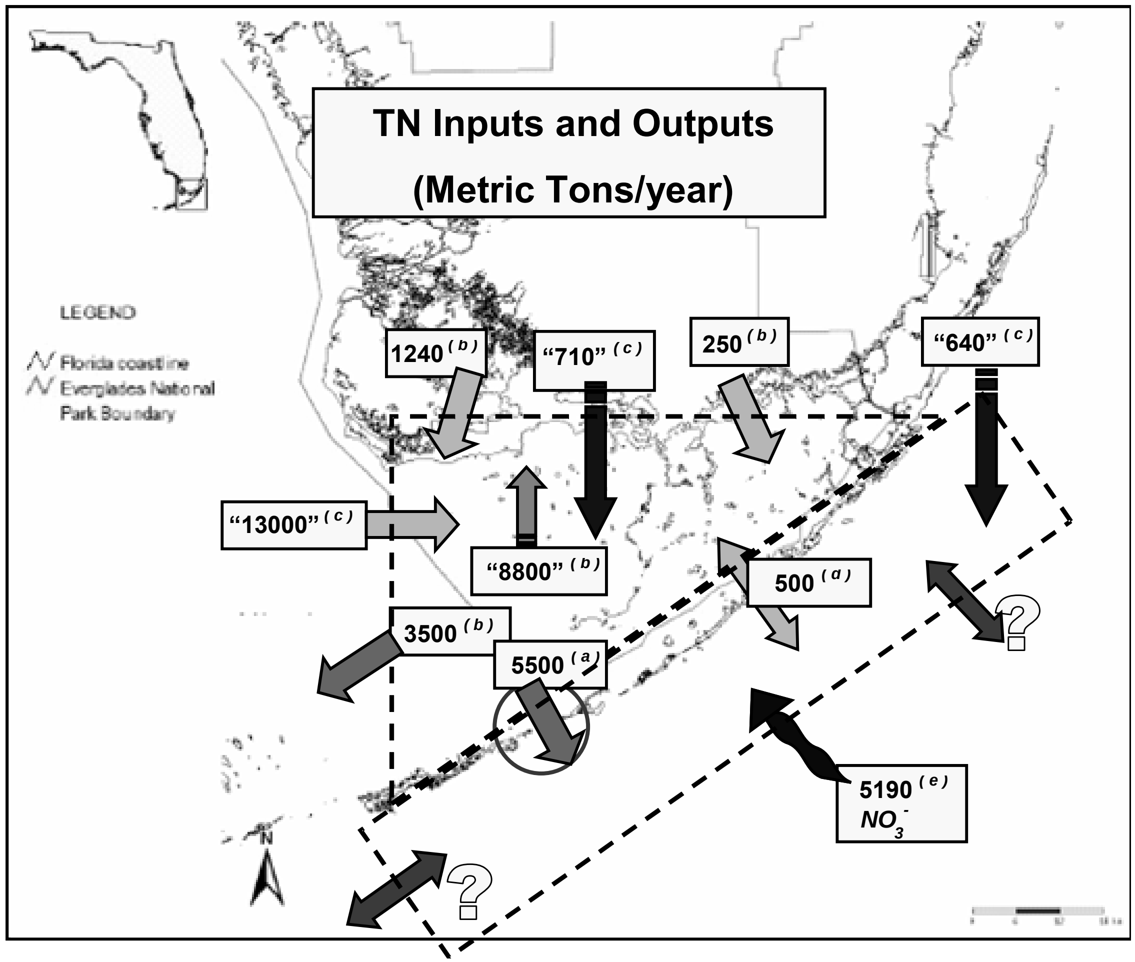
Nutrient Sources

- Septic System Leaching
- Shallow Well Injection - Groundwater
- Stormwater
- Canal Exchange
- Ocean Upwelling
- Gulf of Mexico – SW Shelf Advection

1. Nutrient Regime

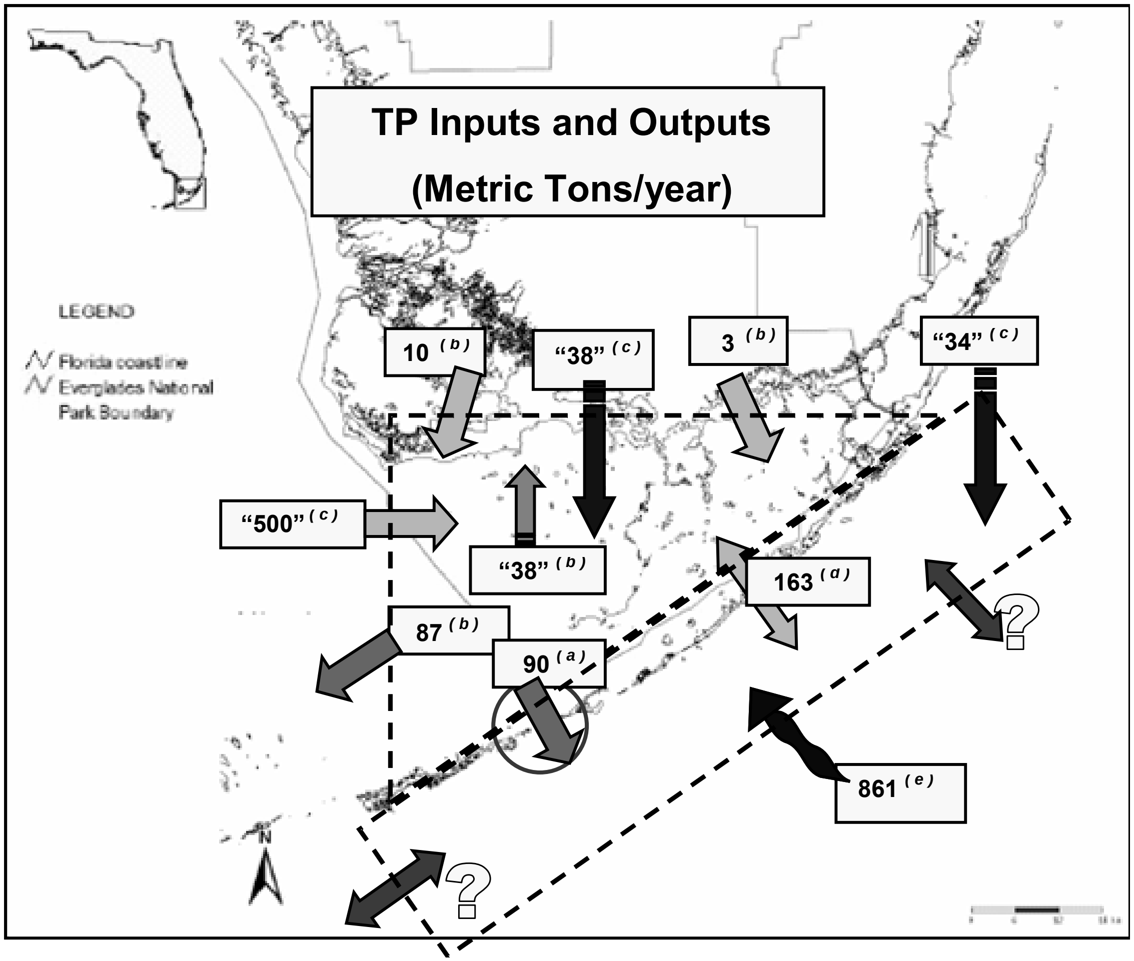
- Sources and Fates of Nutrients in System
- Concentration and Loading of P and N
- Established Hydrodynamic or Nutrient Water Quality Models?
- Other Nutrient Information

Nitrogen Loading



Gibson et al. 2008

Phosphorus Loading



Gibson et al. 2008

1. Nutrient Regime

- Sources and Fates of Nutrients in System
- Concentration and Loading of P and N
- Established Hydrodynamic or Nutrient Water Quality Models?
- Other Nutrient Information

Models

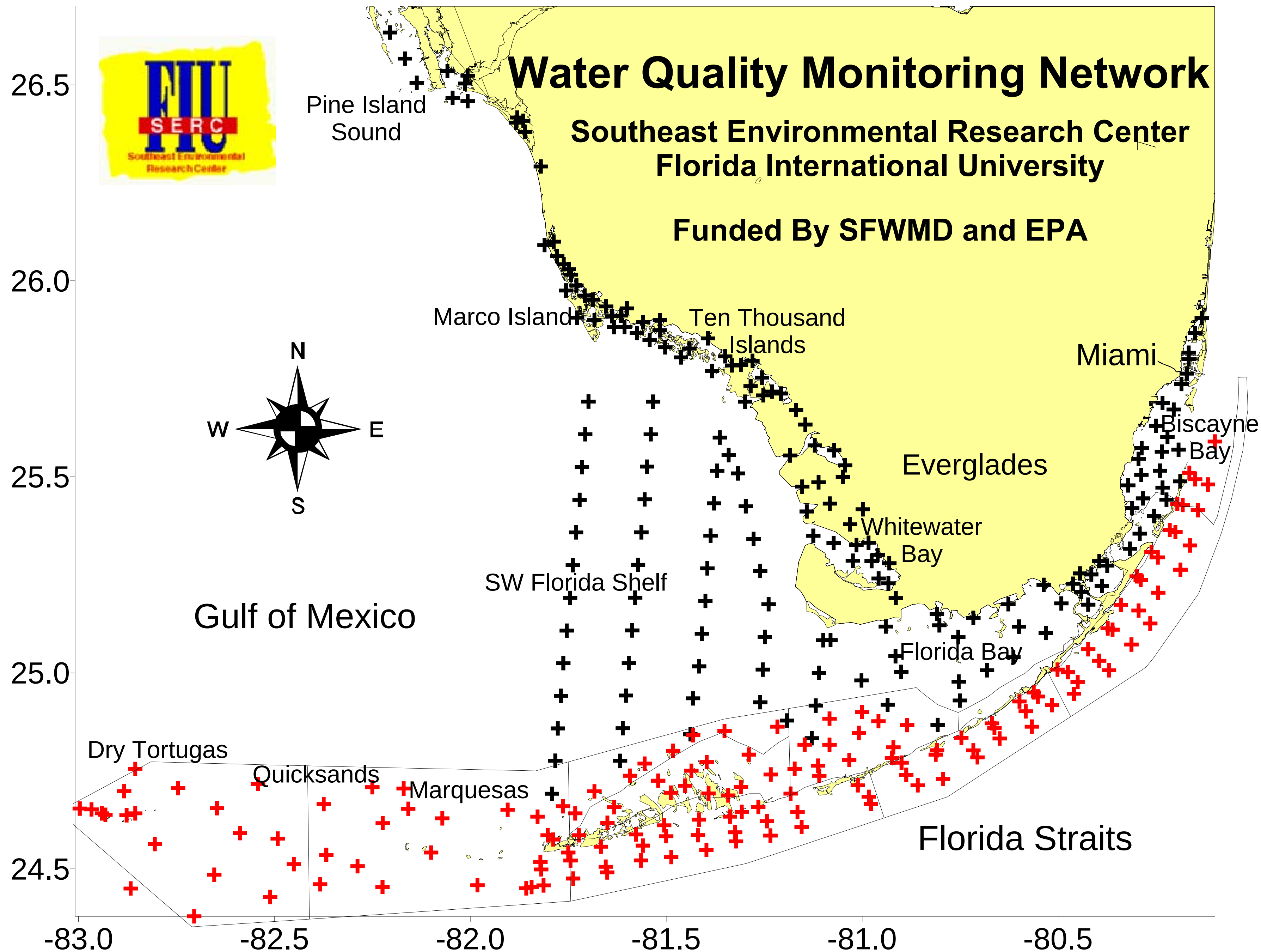
- HYCOM – hydrodynamic
- EFDC – hydrodynamic w/ potential nutrients
- Madden – FATHOM/seagrass/nutrients
- Reasonable Assurance Document (in lieu of TMDL)

1. Nutrient Regime

- Sources and Fates of Nutrients in System
- Concentration and Loading of P and N
- Established Hydrodynamic or Nutrient Water Quality Models?
- Other Nutrient Information

WQ Monitoring

- Quarterly grab sampling at 150-155 sites in FKNMS since 1995
- Semi-continuous CTD profile of water column for: salinity, temp., density, DO, PAR (calc. K_d), turbidity, and CHLA fluorescence
- Surface and bottom water collected and analyzed for: NO_3^-, NO_2^-, NH_4^+, TON, TP, SRP, SiO_2, TOC, and CHLA


Water Quality Monitoring Network
Southeast Environmental Research Center
Florida International University
Funded By SFWMD and EPA
FIU
SERC
Southeast Environmental Research Center
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
S
W
E
26.5
26.0
25.5
25.0
24.5
-83.0
-82.5
-82.0
-81.5
-81.0
-80.5

Nutrients Are Not The Only Problem

- Light field effects are strong drivers of coral and seagrass heath.
- Chlorophyll *a* is a tiny component of light extinction. Greatest contribution is from turbidity with DOM a far second.

2. Valued Biological Resources

Those biological communities shown to respond to nutrient enrichment:

- Phytoplankton/ chlorophyll (**Yes**)
- Zooplankton (little data, but do respond to CHLA)
- Coral (**Yes**)
- Submerged Aquatic Vegetation (**Yes**)
- Benthic Invertebrates (little data)
- Fish and Other Wildlife (little data)

Habitats

Coral Reefs
Hardbottom
Mangrove Fringed Shorelines & Islands
Sand Flats
Seagrass Meadows

Species

Brain & Star Coral (some endangered)
Sponge Communities
Tropical Reef Fish
Spiny Lobster
Bottlenose Dolphin
Snapper/Grouper/Trout…

People

Local Community

Tourism

- **Fishing**
- **Diving**
- **Partying**

Development

In 2000-01, all uses of the reefs of the FKNMS generated over $504 million in Sales/Output. This generated $140 million in income in Monroe County, which supported almost 10,000 full and part-time jobs.

The total economic value of fishing in Florida is valued at ~$9 billion, much of it driven by the fisheries in Florida Bay and the FKNMS

3. Nutrient Criteria Development Approaches

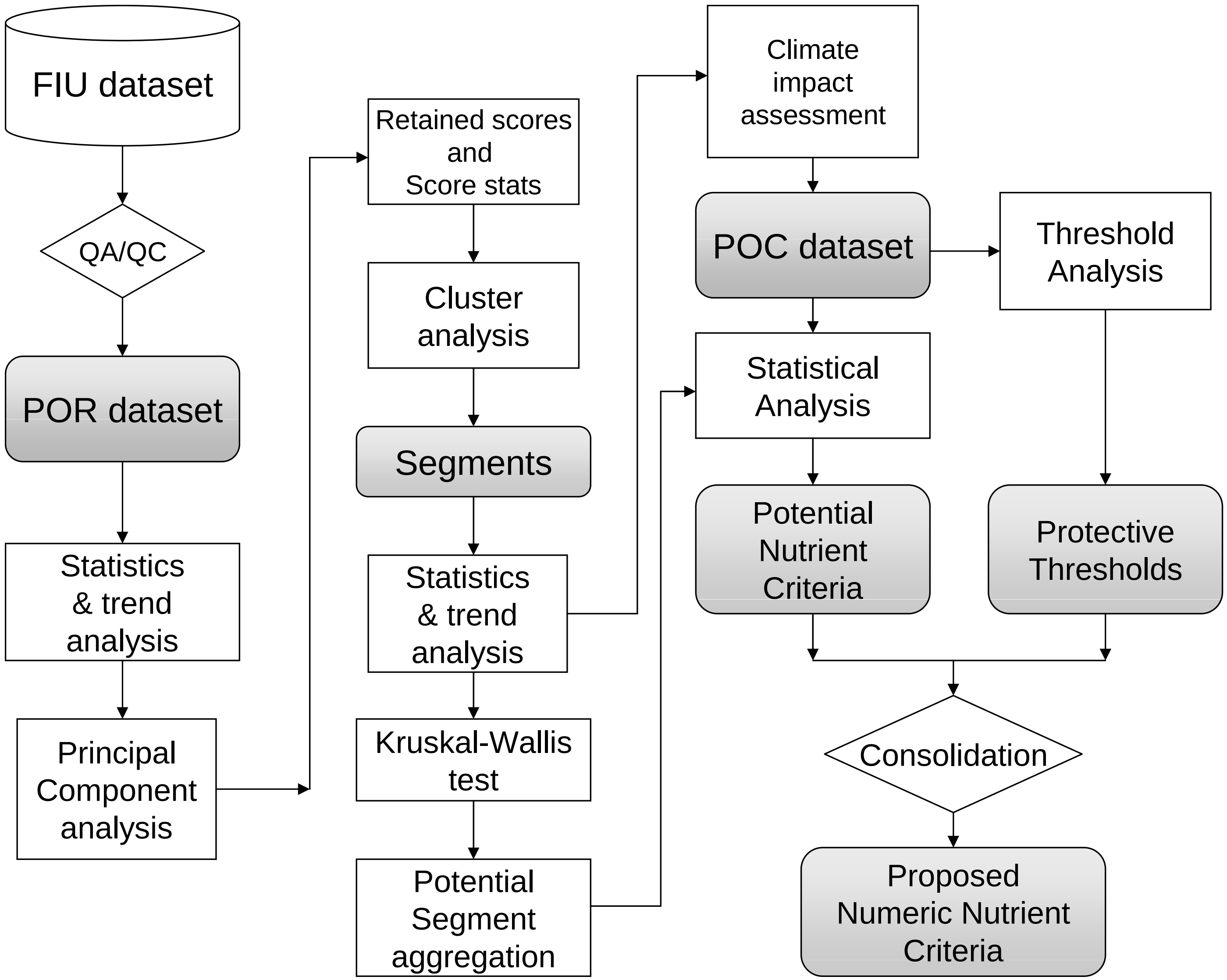
A. Reference Comparison Approach
B. Maintain Healthy Existing Conditions Approach
C. Historical Conditions Approach
D. Response-Based Approach

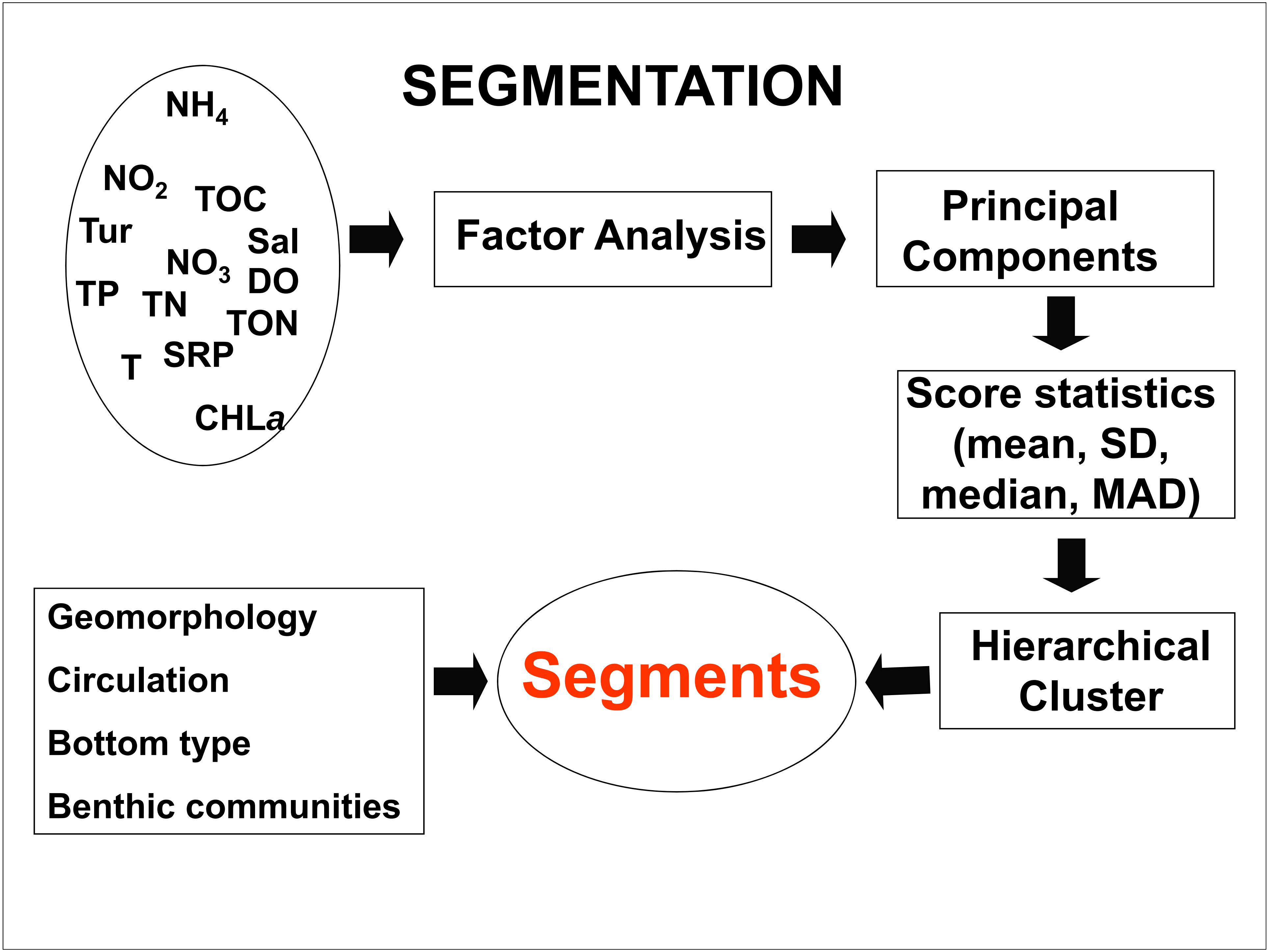
3. Nutrient Criteria Development Approaches

A. Reference Comparison Approach
B. Maintain Healthy Existing Conditions Approach
C. Historical Conditions Approach
D. Response-Based Approach

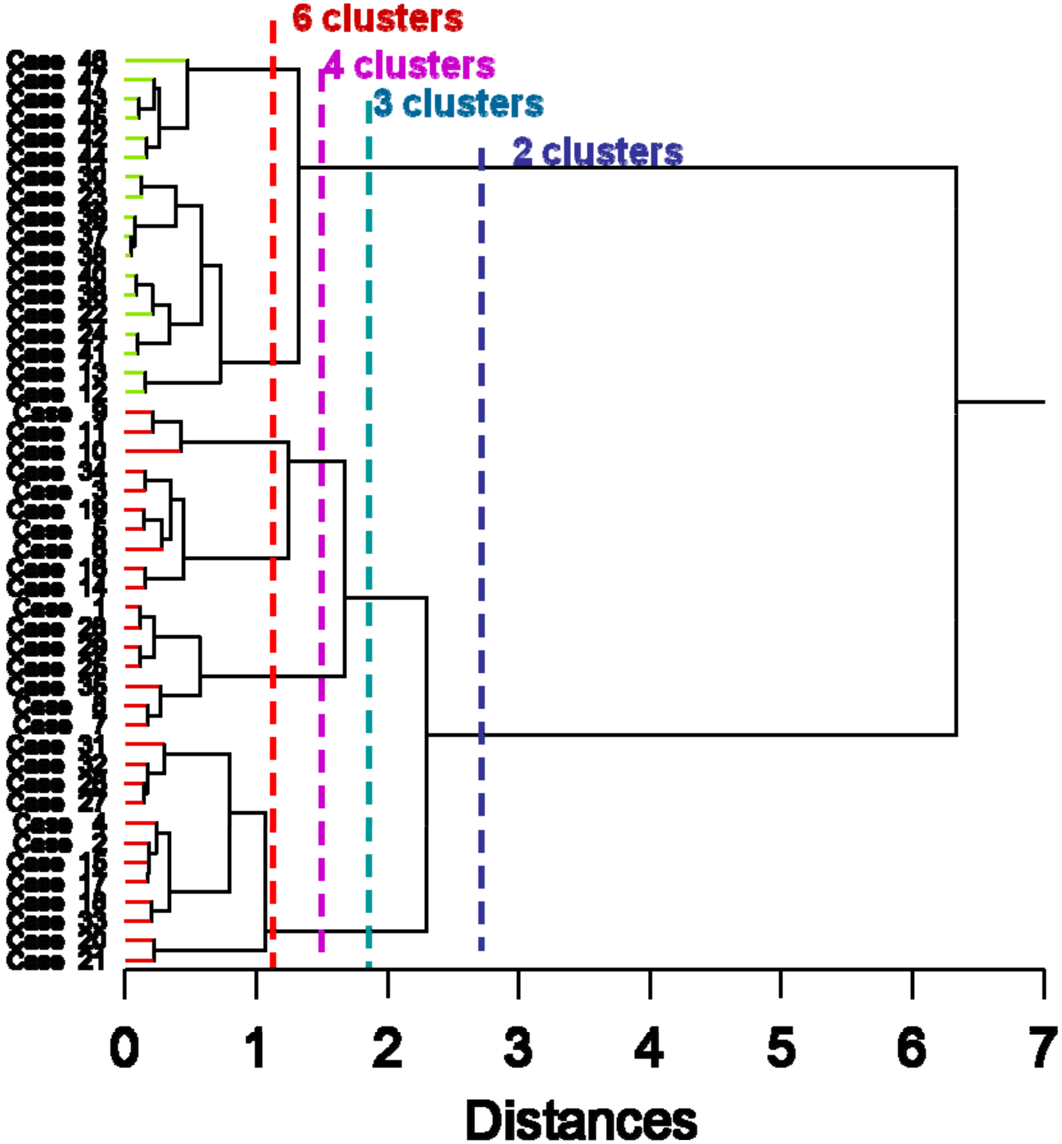
Digression

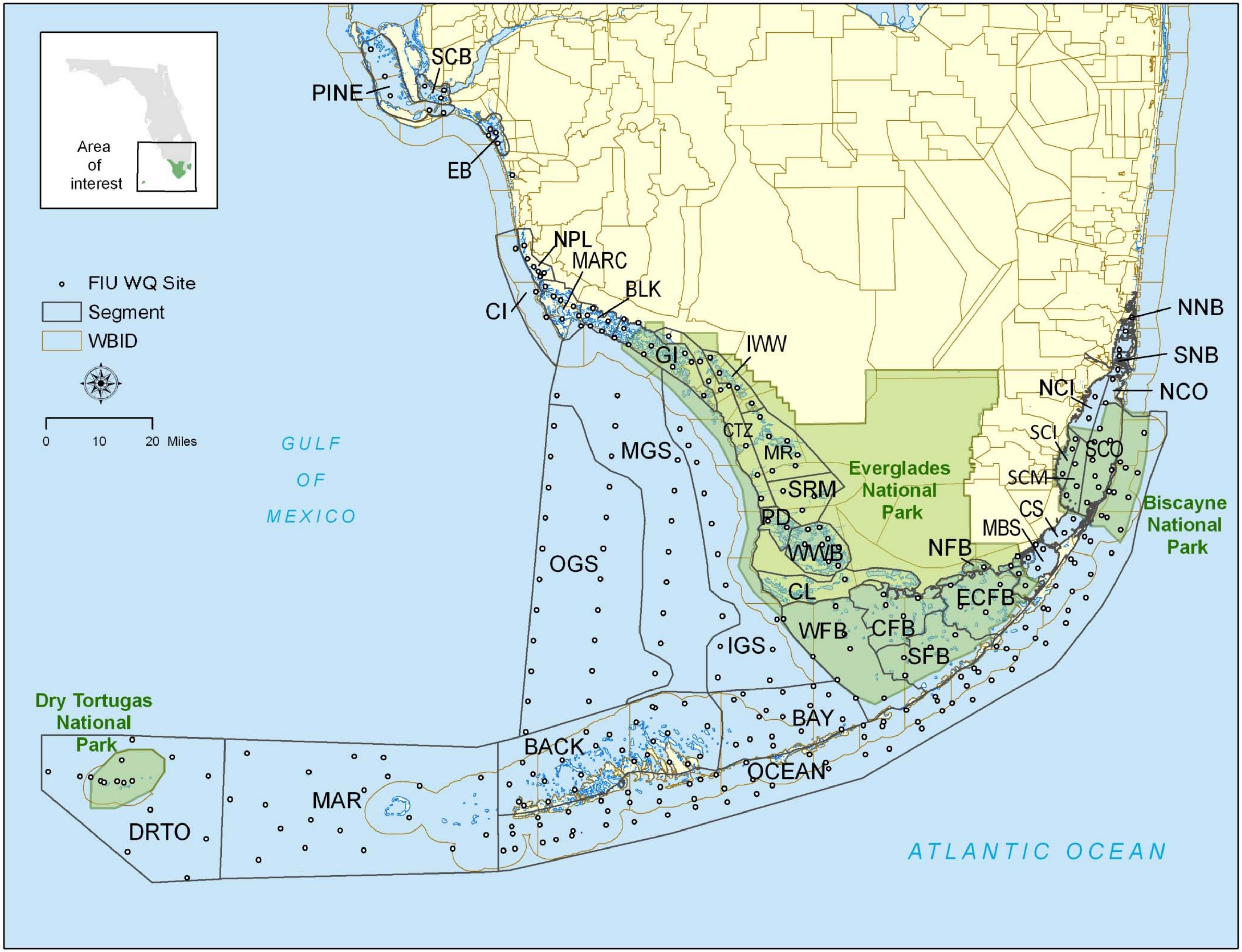
- First step is spatial delineation or Zonation/Segmentation of estuary/coast.
- Not all areas of estuary should necessarily be held to same criteria.


FIU dataset
QA/QC
POR dataset
Statistics & trend analysis
Principal Component analysis
Retained scores and Score stats
Cluster analysis
Segments
Statistics & trend analysis
Kruskal-Wallis test
Potential Segment aggregation
Climate impact assessment
POC dataset
Threshold Analysis
Statistical Analysis
Potential Nutrient Criteria
Protective Thresholds
Consolidation
Proposed Numeric Nutrient Criteria


SEGMENTATION
NH_4
NO_2
TOC
Tur
Sal
NO_3
DO
TP
TN
TON
SRP
T
CHL*a*
Factor Analysis
Principal Components
Score statistics (mean, SD, median, MAD)
Hierarchical Cluster
Segments
Geomorphology
Circulation
Bottom type
Benthic communities

Cluster Tree





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

3. Nutrient Criteria Development Approaches

A. Reference Comparison Approach
   - Not viable for Keys as no local reference exists
   - However, other WQ from coral reefs around the world may be pertinent

A. Reference Comparison 1

Bell et al. 1987 Eutrophication threshold model w/ nutrient threshold conc

- Empirical approach
- CHLA 0.5 ug l^{-1} (now 0.3 ug l^{-1})
- DIN 14.0 ug l^{-1}
- SRP 1.4-2.8 ug l^{-1}

A. Reference Comparison 2

Moss et al. 2005 for GBR, Cape York

- Percentile approach (80^{th})
- CHLA 0.3-0.5 ug l^{-1}
- DIN 1.0-2.0 ug l^{-1} (possible error)
- TN 130-160 ug l^{-1}
- TP 30.0 ug l^{-1}
- SRP 3.0 ug l^{-1}

A. Reference Comparison 3

De’ath & Fabricius 2008 for GBR, Cape York reference

- Annual Mean w/ zonation
- CHLA 0.3-0.63 ug/l (win-sum) 0.45 avg
- Secchi 10 m (~0.144 K_d)
- SSed 1.6-2.4 mg l^{-1}
- PN 17.5-25.0 µg l^{-1}
- PP 2.3-3.3 µg l^{-1}

A. Reference Comparison 4

State of Hawaii 1977

- Annual Geometric Mean (dry vs wet)
- CHLA 0.15-0.3 ug/l
- TN 110-150 ug l^{-1}
- NH_4 2.0-3.5 ug l^{-1}
- NO_x 3.5-5.0 ug l^{-1}
- TP 16.0-20.0 µg l^{-1}
- Turb. 0.2-0.5 NTU

A. Reference Comparison 5

EPA WQPP Targets 2006 for FKNMS

- Percentile (75th)
- CHLA (reef) 0.35 ug l^{-1}
- K_d (reef) 0.20 m^{-1}
- DIN (all) 10.0 ug l^{-1}
- TP (all) 7.7 µg l^{-1}

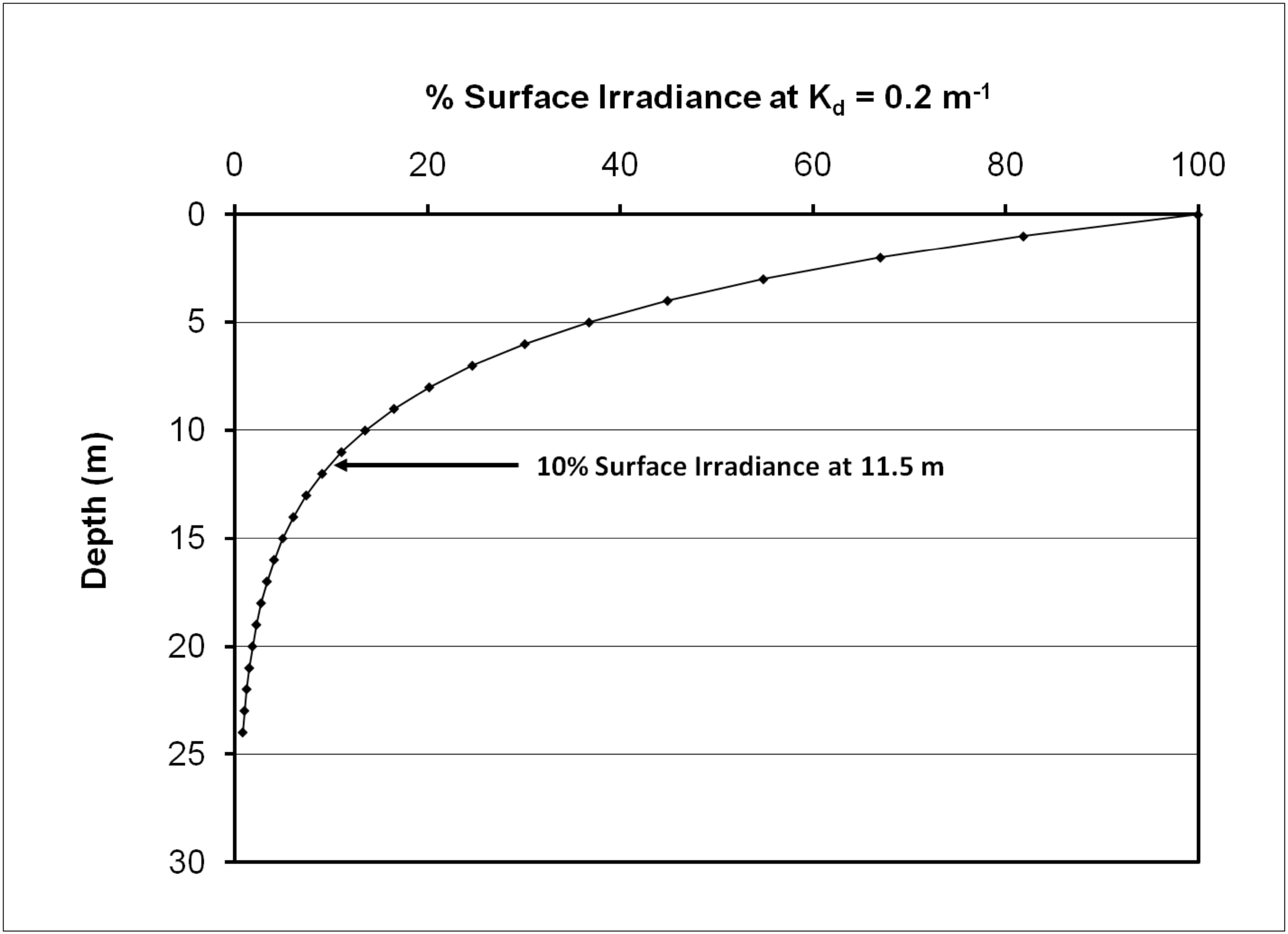
EPA WQPP Water Quality Targets

Year	Reef Stations		All Stations	
	CHLA ≤ 0.35 μg l^{-1}	K_d ≤ 0.20 m^{-1}	DIN ≤ 0.75 μM (0.010 ppm)	TP ≤ 0.25 μM (0.0077 ppm)
1995-05	1493 of 1982 (76%)	1036 of 1388 (75%)	7923 of 10254 (76%)	8304 of 10267 (81%)
2006	171 of 194 (88%)	179 of 194 (92%)	432 of 990 (44%)	312 of 995 (31%)
2007	171 of 197 (87%)	162 of 176 (92%)	556 of 993 (60%)	608 of 941 (65%)
2008	157 of 200 (84%)	179 of 192 (93%)	836 of 1,000 (84%)	685 of 1,004 (68%)
2009	182 of 200 (91%)	188 of 198 (95%)	909 of 1,101 (82%)	889 of 1,102 (81%)

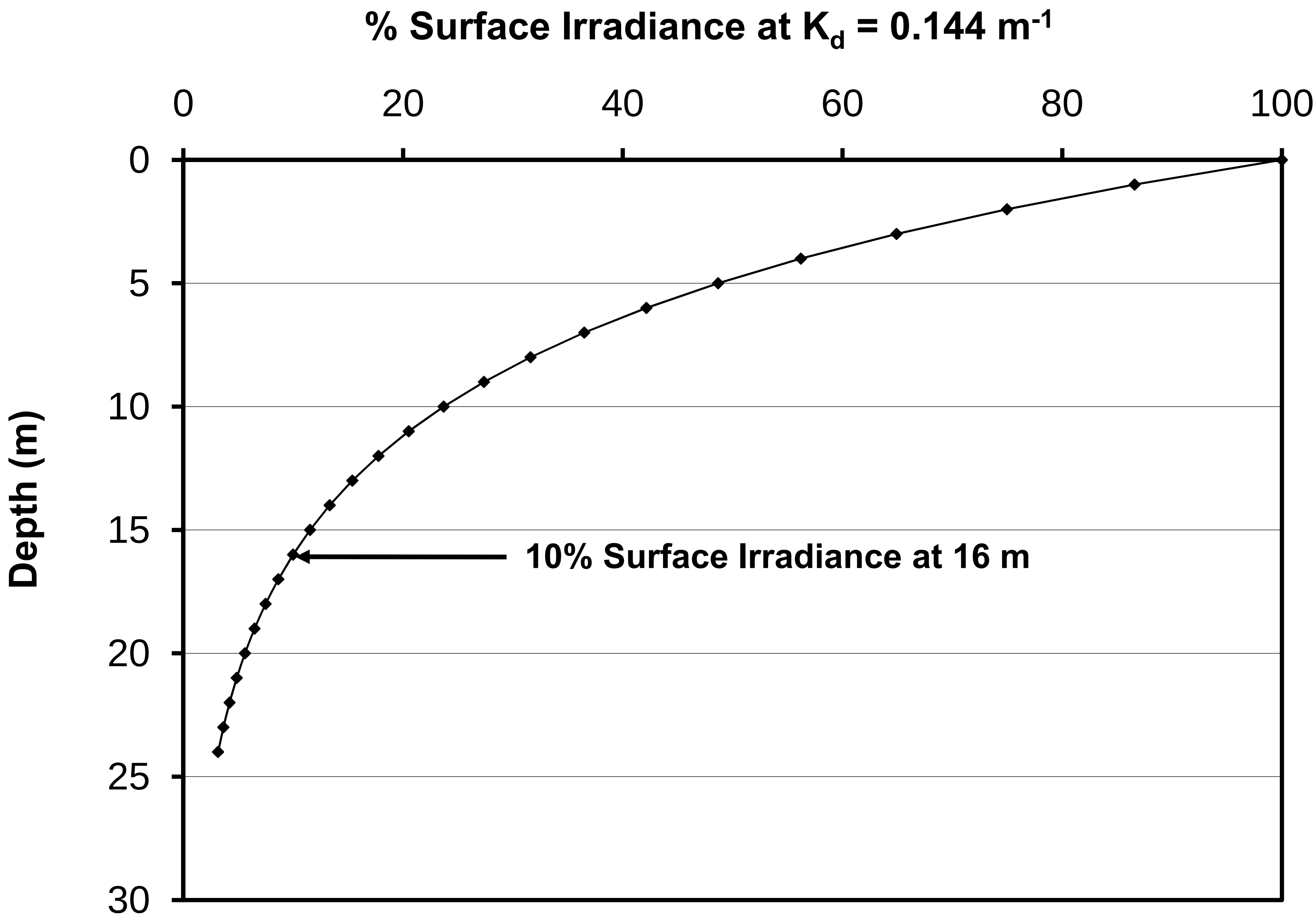
Digression

Why is the light field so important?

Because coral need at least ~10% of surface irradiance to thrive.



% Surface Irradiance at K_d = 0.2 m^{-1}
0
20
40
60
80
100
0
5
10
15
20
25
30
Depth (m)
10% Surface Irradiance at 11.5 m


% Surface Irradiance at K_d = 0.144 m^{-1}
0
20
40
60
80
100
0
5
10
15
20
25
30
Depth (m)
10% Surface Irradiance at 16 m

A. Reference Comparison 6

Florida Keys Reasonable Assurance Document (FKRAD) 2008

- Model
- TN 124-145 ug l^{-1}
- TP 7.0-9.0 µg l^{-1}

3. Nutrient Criteria Development Approaches

A. Reference Comparison Approach

B. Maintain Healthy Existing Conditions Approach

- First need to determine if existing conditions are protective or degraded
- 75^{th} percentile approach
- Ecosystem indicator approach (eg. CHLA)
- Modeling

C. Historical Conditions Approach

D. Response-based Approach

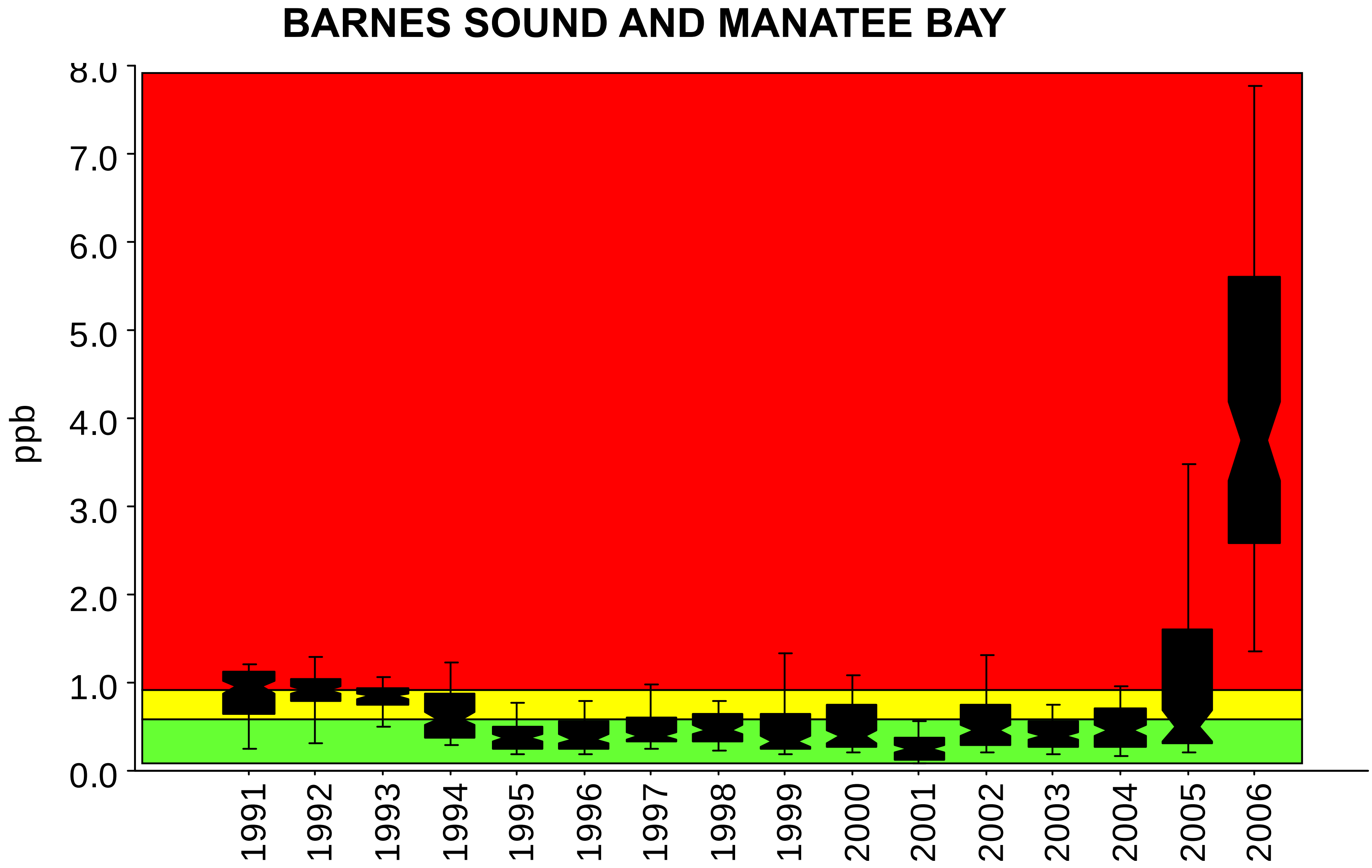
B. Existing Conditions

75th Percentile

- Derive annual target concentration as an upper percentile of the distribution of the long-term geometric mean limit
- 75th percentile of the annual geometric means from the long-term dataset

Target thresholds for evaluating chlorophyll *a* (ppb) Performance Measure to determine color code

Sub-region		Valid N	25th Percentile	Median	75th Percentile
Blackwater, Manatee, Barnes	BMB	1704	0.306	0.526	0.910
Central Biscayne Bay	CBB	1673	0.200	0.313	0.566
Mangrove Transition Zone	MTZ	3803	1.690	2.863	4.903
North Biscayne Bay	NBB	635	0.670	1.048	1.648
North-central Florida Bay	NCFB	1399	0.585	1.216	3.710
Northeast Florida Bay	NEFB	1979	0.254	0.417	0.790
South Biscayne Bay	SBB	2257	0.181	0.264	0.426
South Florida Bay	SFB	1695	0.327	0.533	1.059
Southwest Florida Shelf	SWFS	1297	0.739	1.180	1.976
West Florida Bay	WFB	2304	0.653	1.345	2.845


BARNES SOUND AND MANATEE BAY
ppb
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
1991
1992
1993
1994
1995
1996
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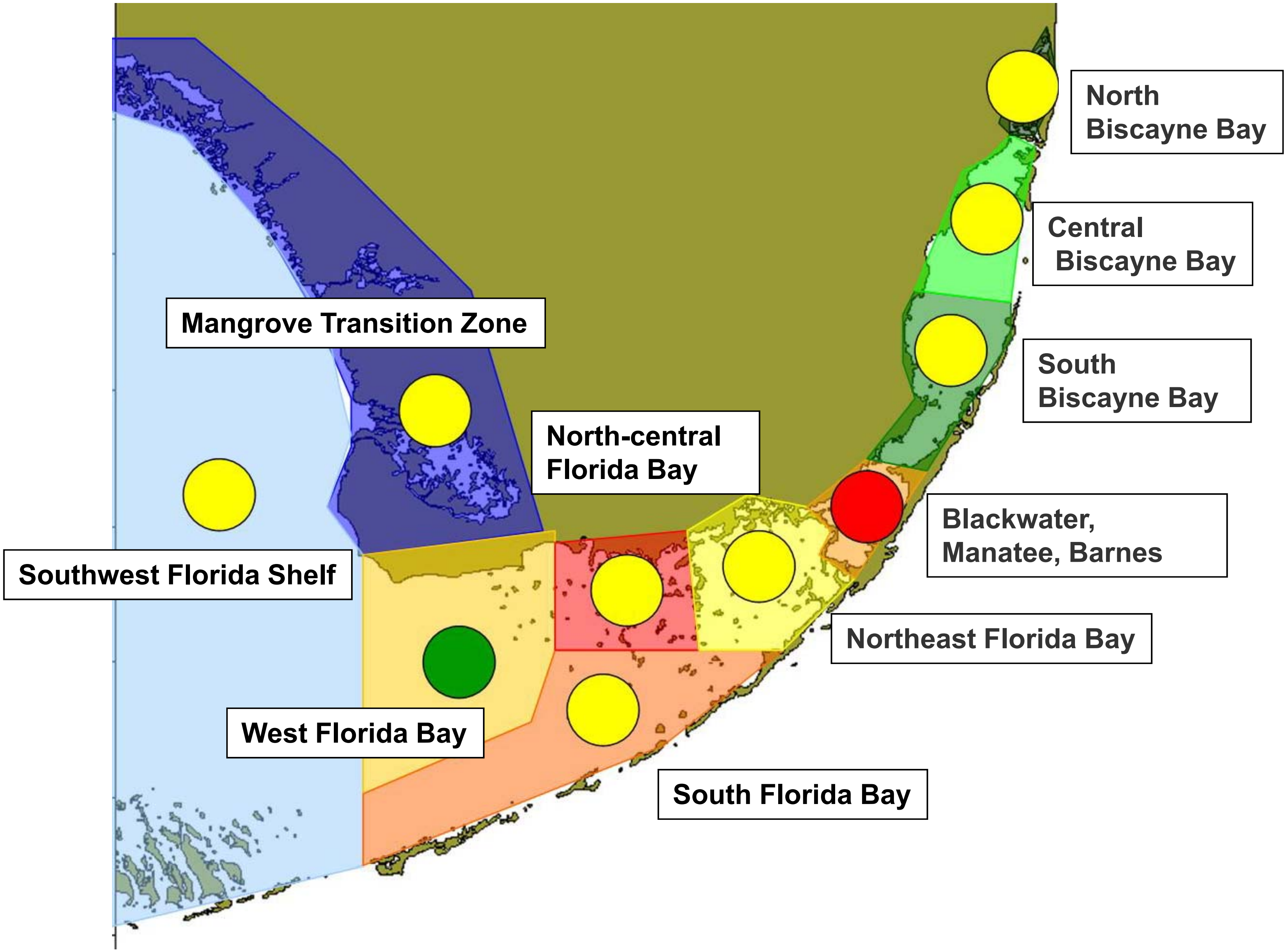
2001
2002
2003
2004
2005
2006


North Biscayne Bay
Central Biscayne Bay
South Biscayne Bay
Mangrove Transition Zone
North-central Florida Bay
Blackwater, Manatee, Barnes
Southwest Florida Shelf
Northeast Florida Bay
West Florida Bay
South Florida Bay

B. Existing Conditions

Boyer and Briceño 2010 FKNMS data as Percentile (75th) w/ Zonation

- CHLA 0.31 µg l^{-1}
- NH4 5.0 µg l^{-1}
- NO3 3.0 µg l^{-1}
- TN 186 µg l^{-1}
- TP 7.0 µg l^{-1}
- SRP 1.0 µg l^{-1}

3. Nutrient Criteria Development Approaches

A. Reference Comparison Approach
B. Maintain Healthy Existing Conditions Approach
C. Historical Conditions Approach
   – Don’t have historical data but can be done if data prior to degradation exists
D. Response-Based Approach

3. Nutrient Criteria Development Approaches

A. Reference Comparison Approach
B. Maintain Healthy Existing Conditions Approach
C. Historical Conditions Approach
D. Response-Based Approach
   – Experimental
   – Threshold Analysis

D. Response-Based Approach

Experimental

Is there scientific evidence describing the relationship between nutrient inputs and adverse effects on biological communities?

Coral Effects 1

- Fabricius 2005, Cooper, Gilmour, & Fabricius 2009
- Extensive review of water quality – coral effects
- Suggested monitoring suite of coral-specific bioindicators tied to nutrients, light, etc.

Coral Effects 2

- Bruno et al. 2003.
- "Experimentally increasing nutrient concentrations by 2-5x nearly doubled host tissue loss caused by yellow band disease."
- NO3 14.0-89.6 ug l^{-1}
- NH4 14.0-154 ug l^{-1}
- PO4 28.0-143 ug l^{-1}

Coral Effects 3

- Voss & Richardson 2006.
- “nutrient-dosed black band disease infections migrated on average twice as quickly as controls”
- NO_3 up to 42.0 ug l^{-1}

Coral Effects 4

- Szmant 2002, Miller & Hay 1999, ENCORE 2001, Sotka & Hay 2009, etc.
- No nutrient effect

Coral Effects 5

- Kline et al. 2006 and Hass et al. 2009
- Dissolved organic matter implicated in coral mortality
- Both used glucose, not typical component of DOM
- No DIN or P effects

Coral Effects 6

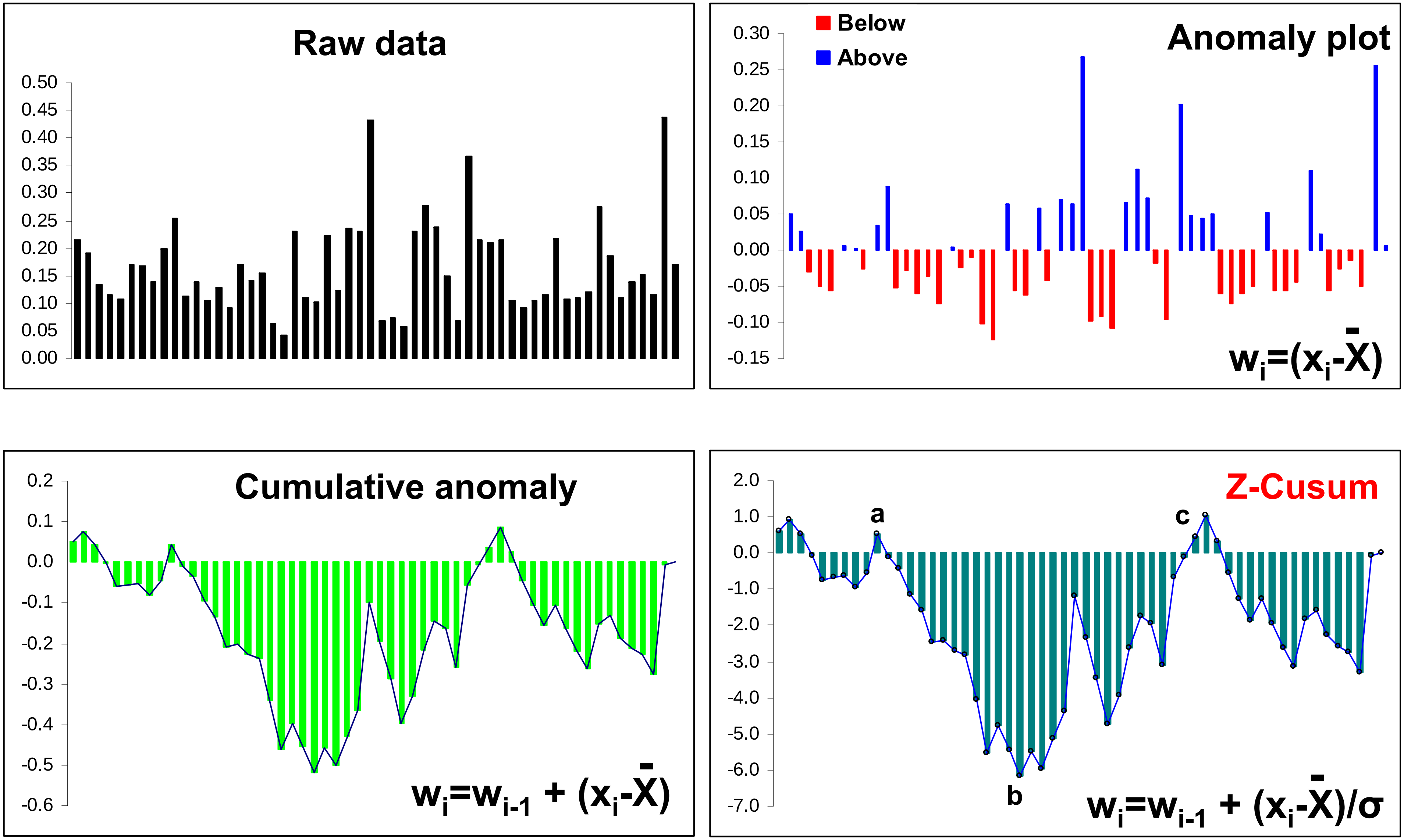
- Wooldridge & Done 2009.
- Conceptual model for the warm water breakdown (bleaching) of the coral-algae symbiosis
- “reduced DIN…could directly benefit corals by enhancing their resistance to heat stress”
- No threshold given

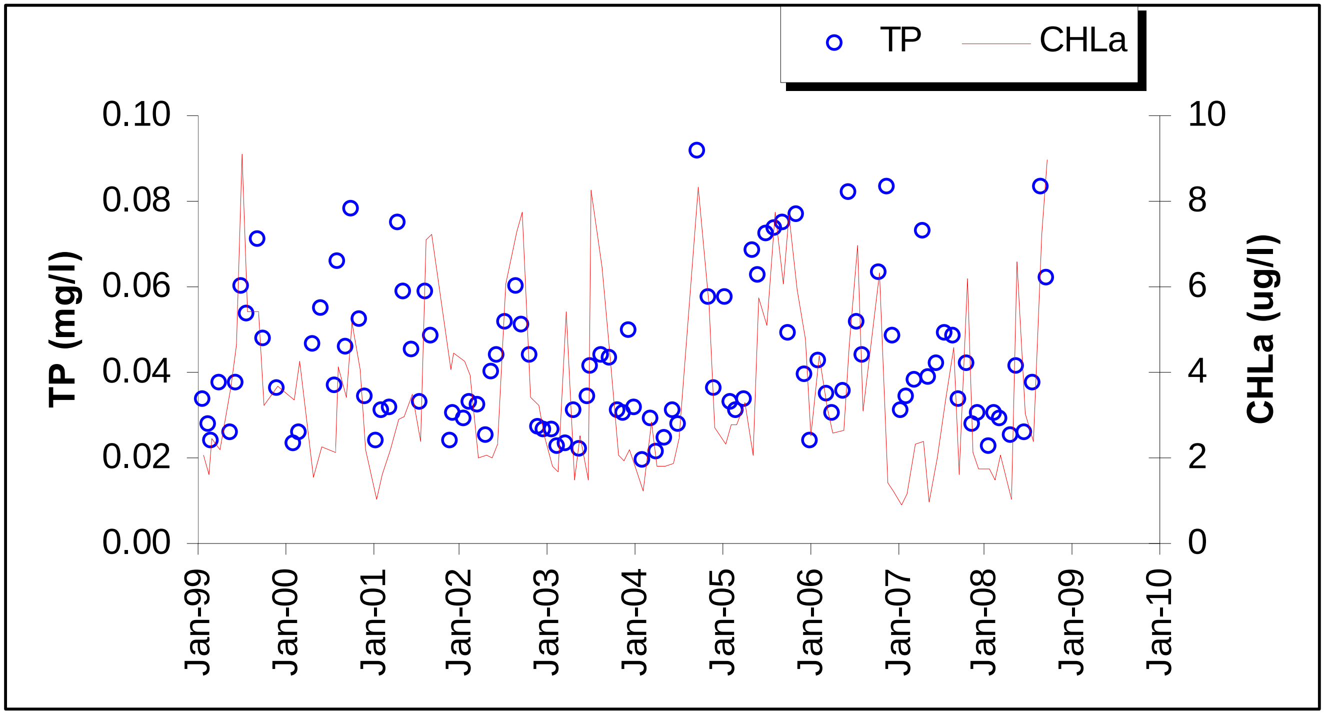
Seagrass Effects

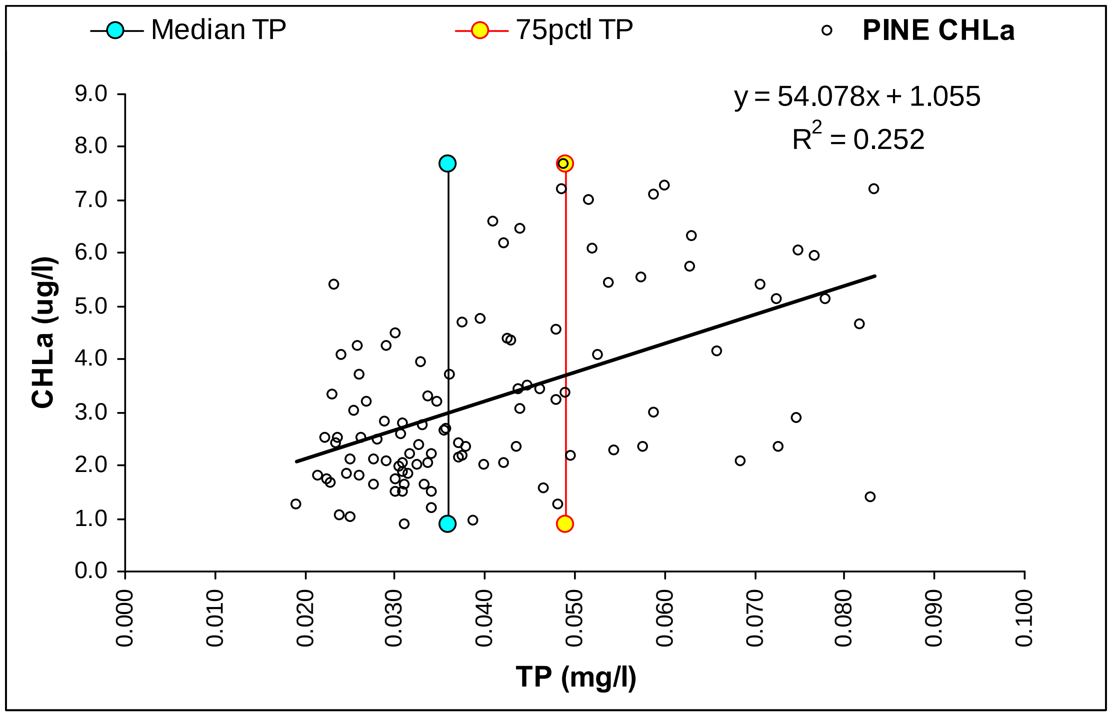
- Jim Fourqurean’s data from FKNMS monitoring program
- Changes are occurring in south Florida seagrass beds are consistent with increased nutrient availability in the system – but increases have not been observed in the water column
- Have not witnessed loss of seagrass or shift in community structure

3. Nutrient Criteria Development Approaches

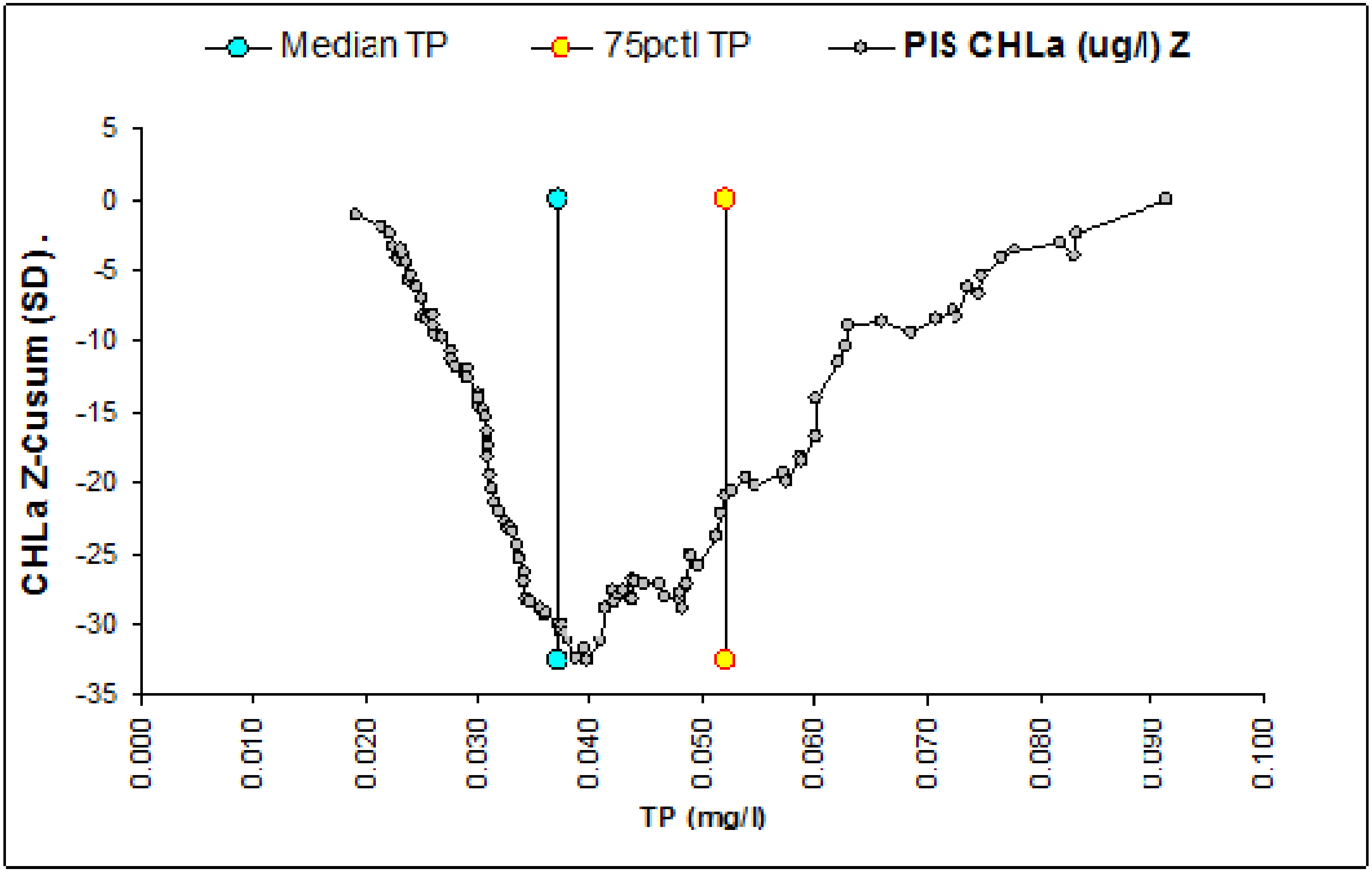
A. Reference Comparison Approach
B. Maintain Healthy Existing Conditions Approach
C. Historical Conditions Approach
D. Response-Based Approach
   - Experimental
   - Threshold Analysis


Raw data
Below
Above
Anomaly plot
$w_i=(x_i-\bar{X})$
Cumulative anomaly
$w_i=w_{i-1} + (x_i-\bar{X})$
Z-Cusum
a
b
c
$w_i=w_{i-1} + (x_i-\bar{X})/\sigma$


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
R^2 = 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

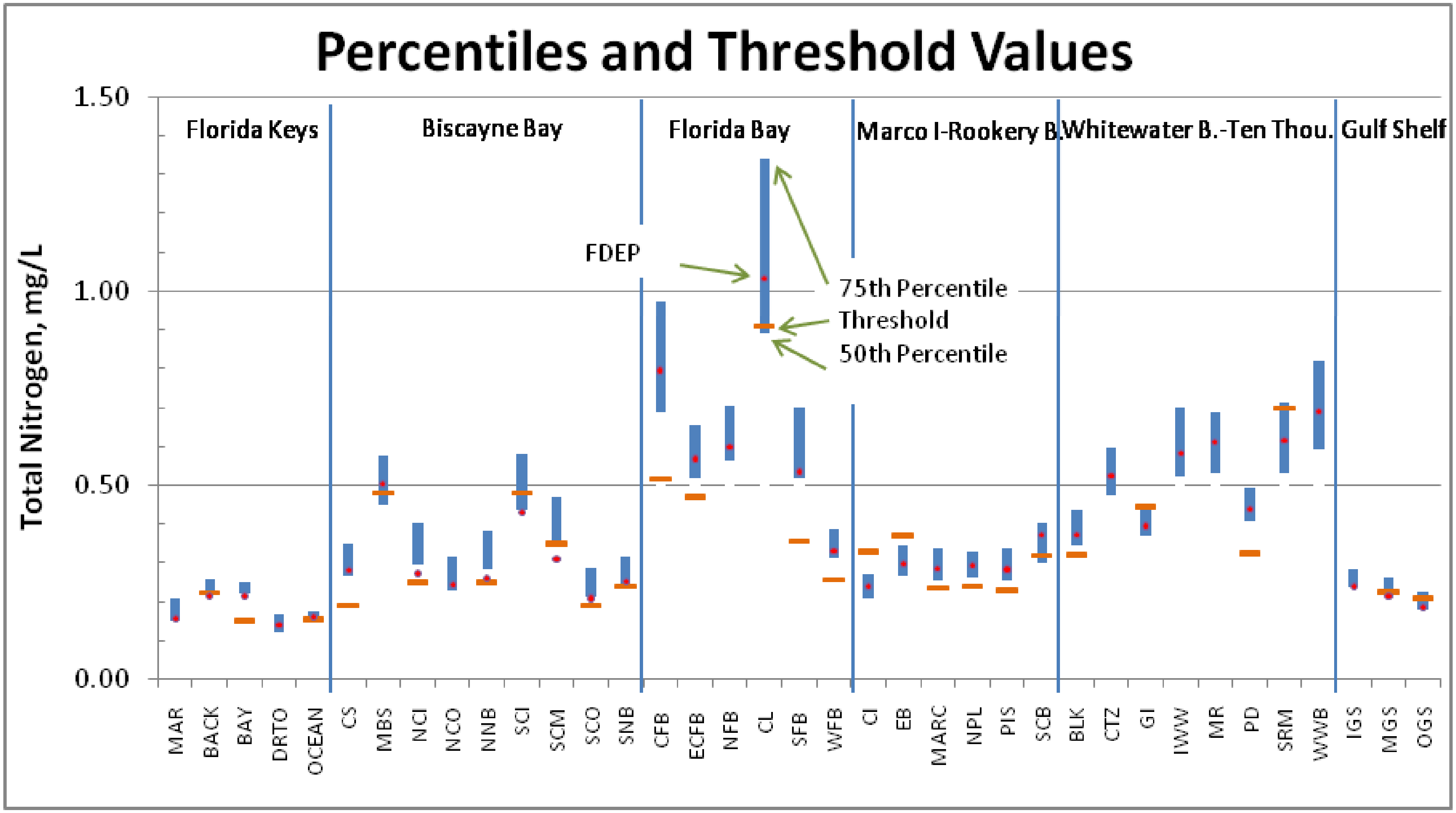


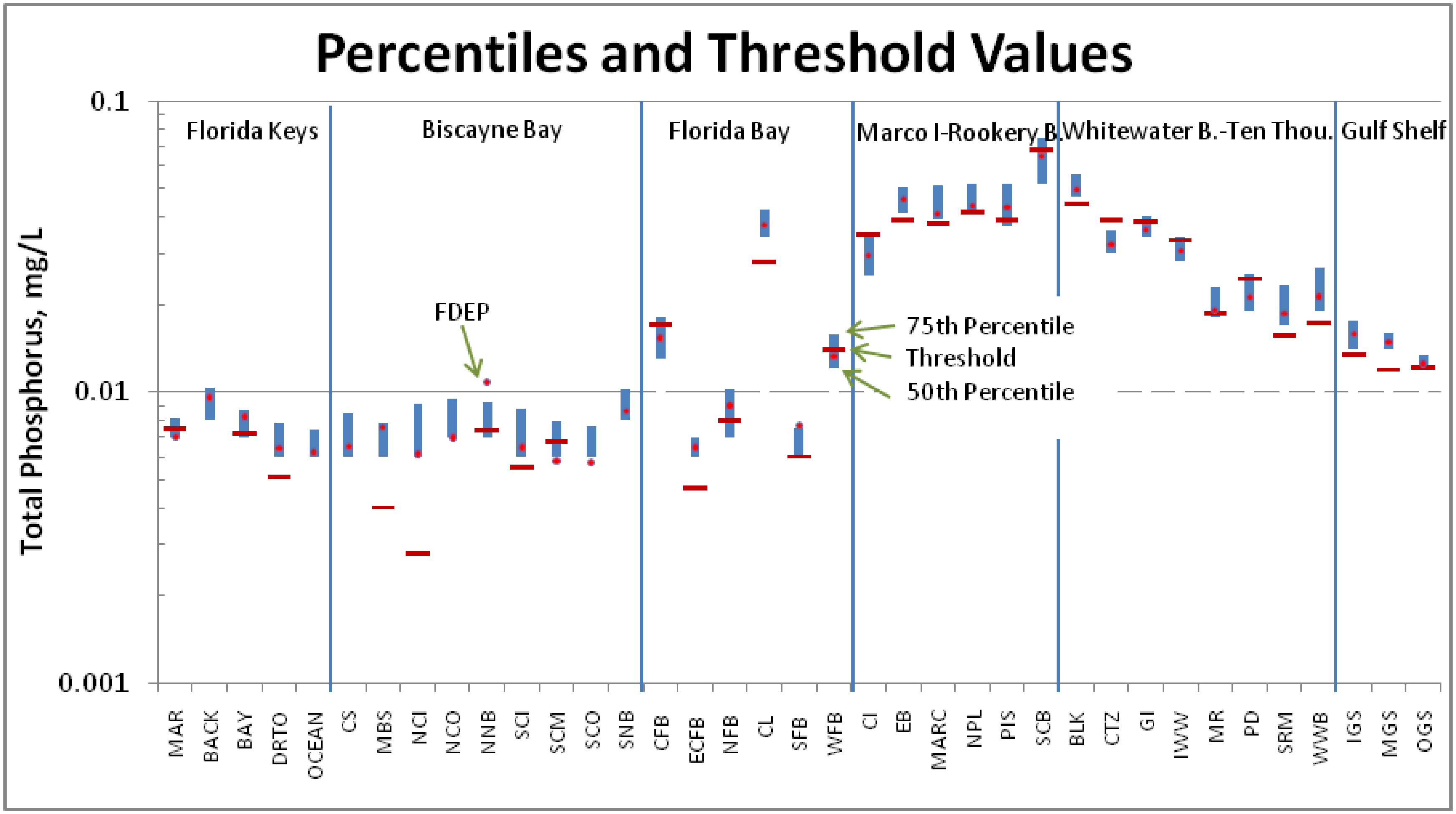
A. Reference Comparison 8

Briceño and Boyer 2010 FKNMS Threshold Analysis

- CHLA 0.22 µg l^{-1}
- TN 156 µg l^{-1}
- TP 8.0 µg l^{-1}

4. Potential Nutrient Criteria




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

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								