Where freshwater and saltwater systems merge: environmental considerations in Manatee County

Jay Leverone, Ph. D.
Staff Scientist
Sarasota Bay Estuary Program

2012 Water School
Manatee County Extension Office

Today's Presentation

- Review SBEP development of NNC for Sarasota Bay portion of Manatee County
- Summarize SBEP Pollutant Load Models
- Brief discussion of Sarasota Bay circulation and residence times
- Summarize TBEP NNC for Manatee County waters from Tampa Bay
- Comments on nutrient criteria in tidal creeks

SBEP Mission

“ The Sarasota Bay Estuary Program is dedicated to restoring the region’s greatest and most important natural asset- Sarasota Bay. The program strives to improve water quality, increase habitat and enhance natural resources of the area for the use and enjoyment to the public.”

SBEP Goals

- Improve water (quality)
- Reduce quantity and improve quality of stormwater runoff
- Restore seagrass and shoreline habitats
- Establish an effective management structure
- Increase public access to Sarasota Bay
- Help restore and sustain fish and other living resources

SBEP Technical Advisory Committee made up of local experts with specific knowledge of Sarasota Bay and its watershed

- Sarasota County
- Manatee County
- City of Sarasota
- City of Bradenton
- Town of Longboat Key
- SWFWMD
- FDEP
- NOAA
- US FWS
- Atkins
- Stantec
- VHB
- Jones Edmunds
- Entrix
- Mote Marine Laboratory
- USF
- UF

Basic Approaches to NNC Development

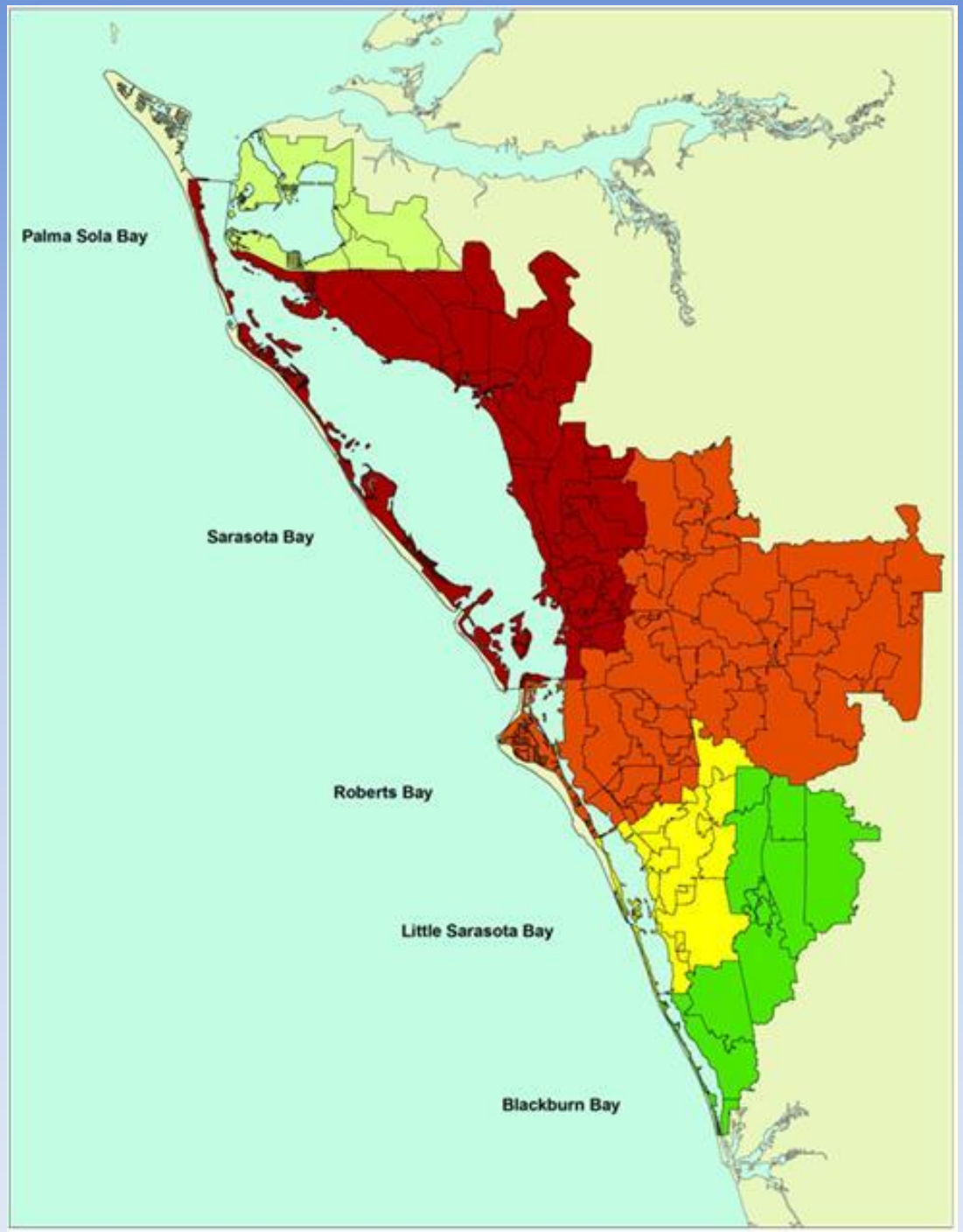
- Mechanistic models
- Stressor-response relationships
- Reference conditions (reference period)

Numeric Nutrient Criteria for Manatee County Estuarine Waters

- Partly derived from the SBEP
- Partly derived from TBEP and the Nitrogen Management Consortium

Sarasota Bay Estuary Program

Bay Segments and their respective watersheds



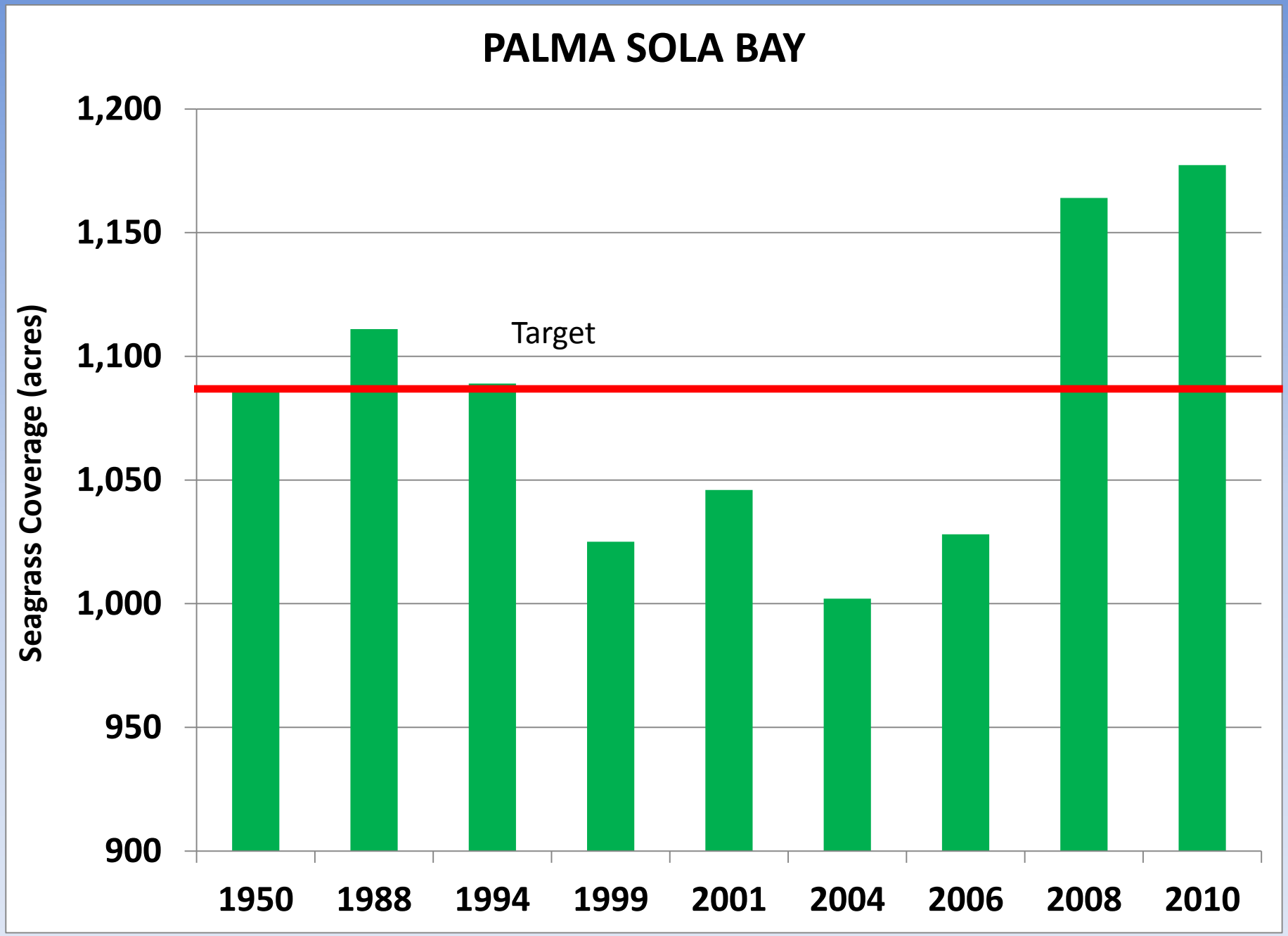
SBEP NNC Criteria Development Process

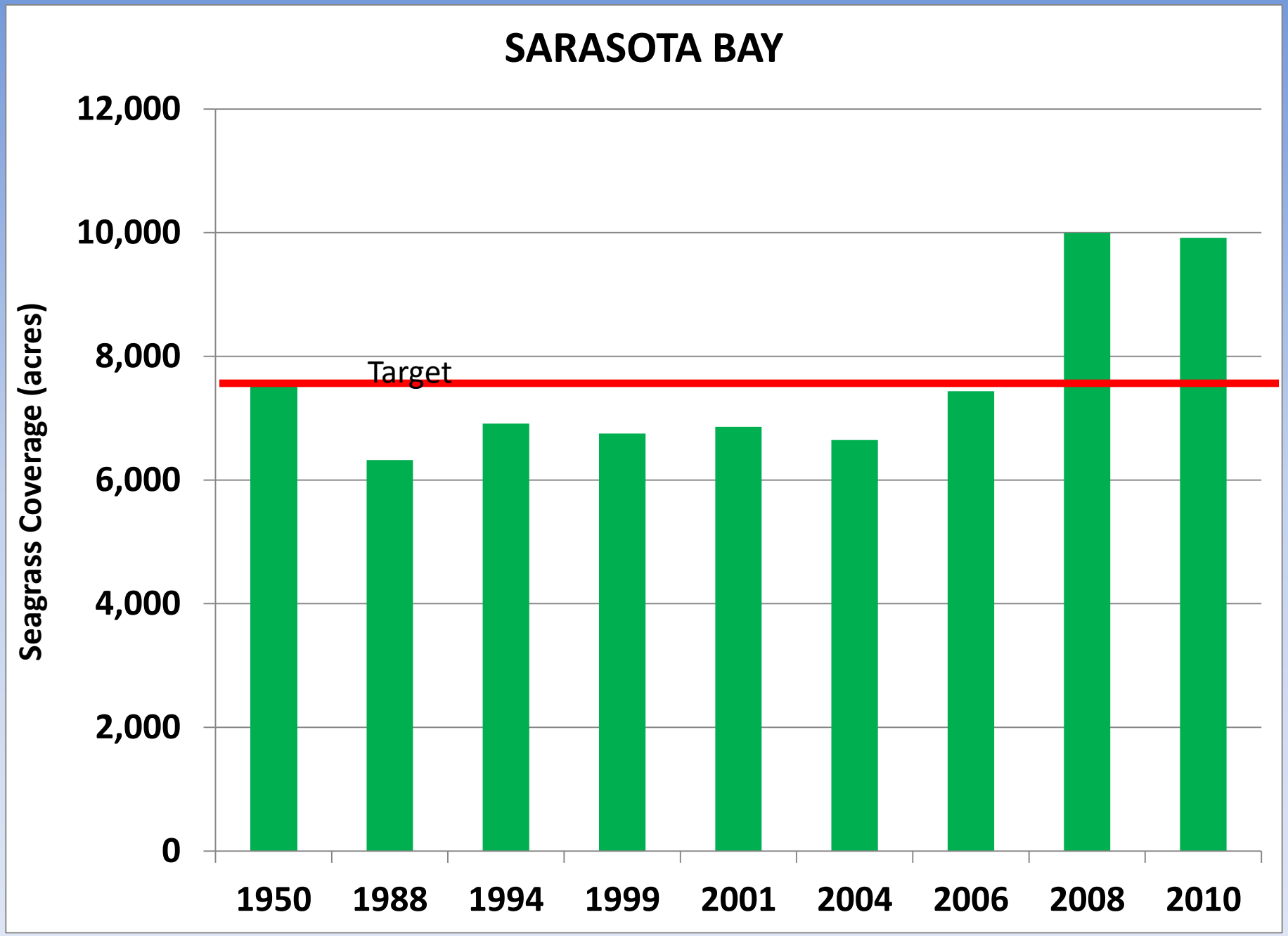
- Develop database of water quality and nutrient loads for each bay segment
- Define seagrass and chlorophyll targets for each bay segment
- Define relationships between chlorophyll and nutrient concentrations by segment
- Derive numeric nutrient criteria by bay segment based on chlorophyll thresholds

SEAGRASS TARGETS

- Seagrass coverage provided by SWFWMD
- Seagrass has been steadily increasing over the past 10 years
- Most segments have more seagrass than in 1950
- TAC recommended targets as the greater of the historical (1950) or 2004-2006 average coverage
- Seagrass targets set before the 2008 survey

SBEP seagrass coverage and targets. Unit of measure=acres.			
Bay Segment	Historical (1950)	2004-2006 Average	Seagrass Target
Palma Sola	1,031	1,015	1,031
Sarasota	7,269	7,041	7,269
Roberts	283	348	348
Little Sarasota*	883	702	702
Blackburn	273	447	447
Total	9,739	9,552	9,997


PALMA SOLA BAY
Seagrass Coverage (acres)
1,200
1,150
1,100
1,050
1,000
950
900
Target
1950
1988
1994
1999
2001
2004
2006
2008
2010


SARASOTA BAY
Seagrass Coverage (acres)
12,000
10,000
8,000
6,000
4,000
2,000
0
Target
1950
1988
1994
1999
2001
2004
2006
2008
2010

Chlorophyll Targets

- Reference period approach.
- Define the period of time that would best reflect the light and nutrient environment for seagrasses during the current period.
- (Dominant seagrass is the slower growing *Thalassia testudinum*).
- 2001 – 2005 was selected as the reference period for water quality to protect Sarasota Bay seagrasses.

SBEP Chlorophyll a Targets and Thresholds

Bay Segment	Target Chlorophyll a (µg/L)	Inter-annual Variability (1 SD of Annual Means)	Threshold Chlorophyll a (µg/L)
Palma Sola	8.5	3.3	11.8
Sarasota	5.2	0.9	6.1
Roberts	8.2	2.8	11.0
Little Sarasota	8.2	2.2	10.4
Blackburn	6.0	2.2	8.2

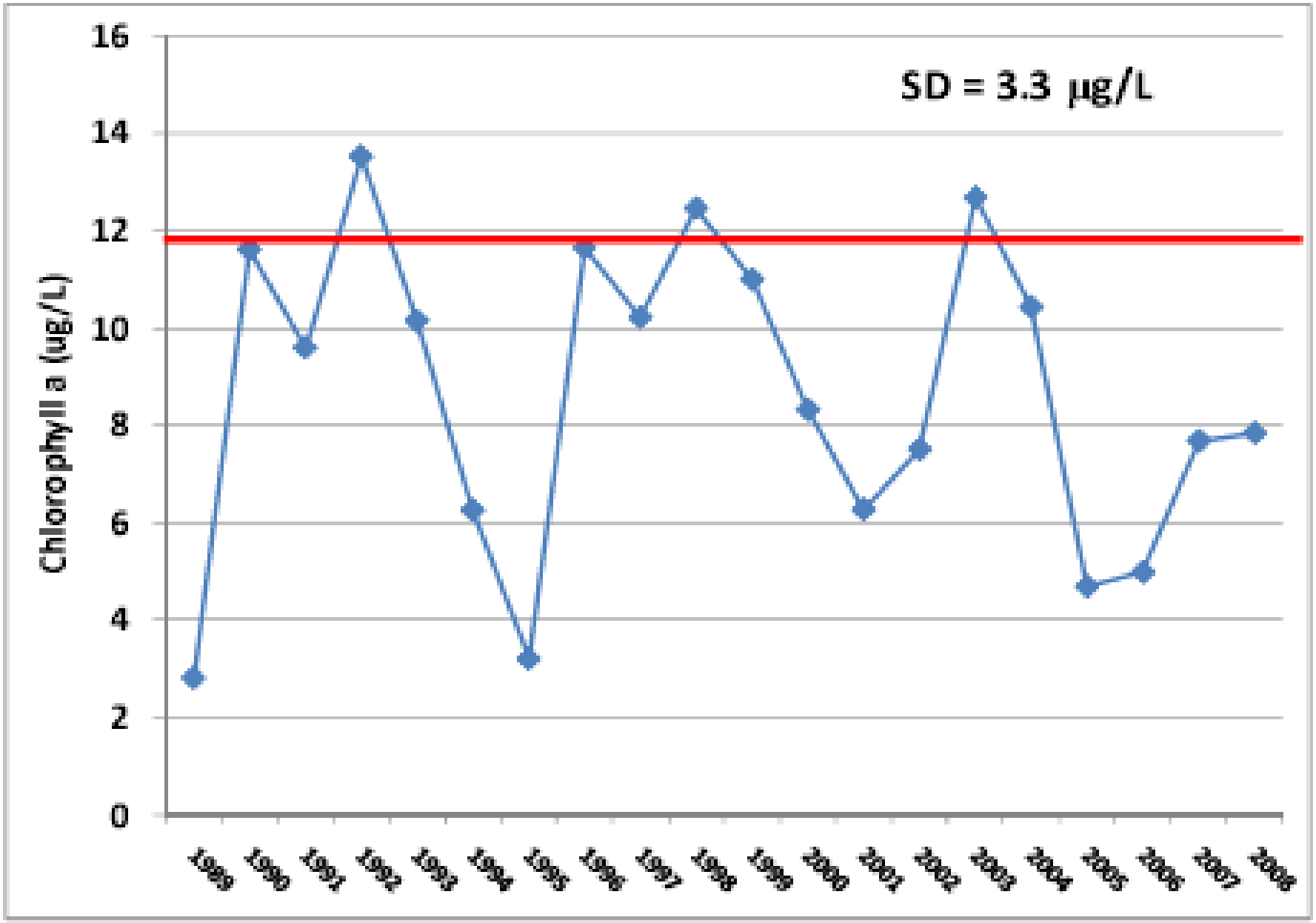


Figure 7. Annual mean chlorophyll concentrations in Palma Sola Bay.

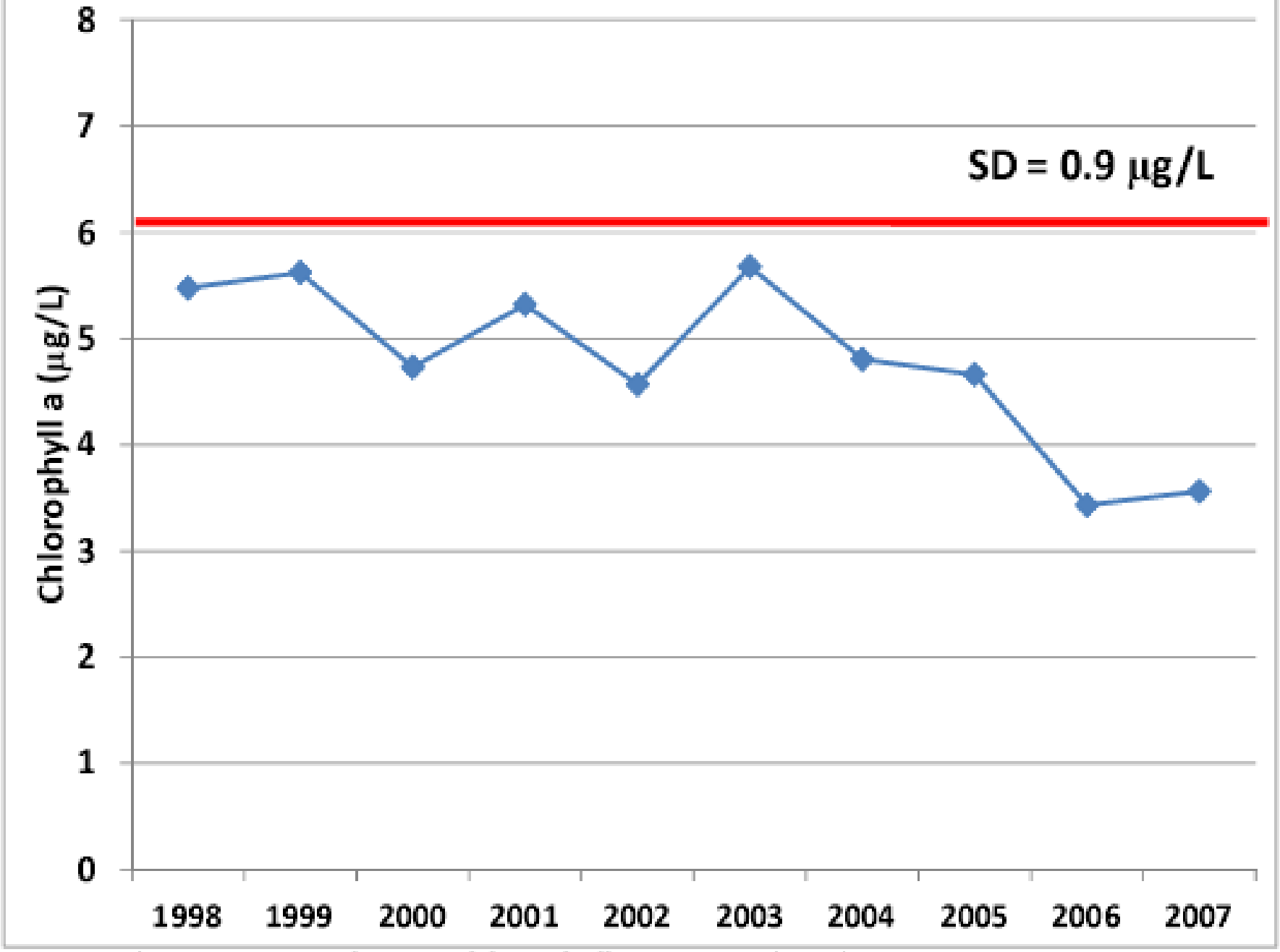
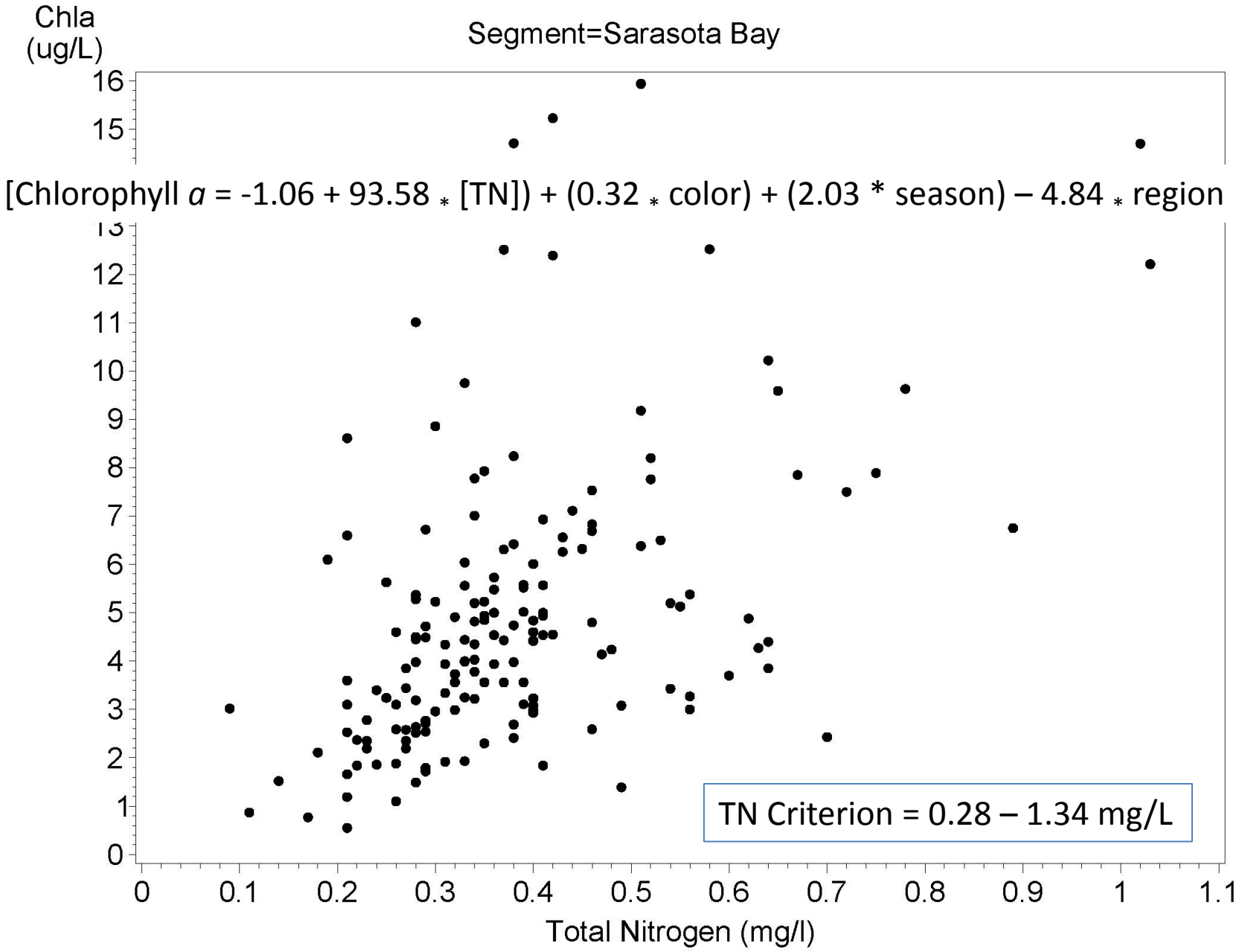
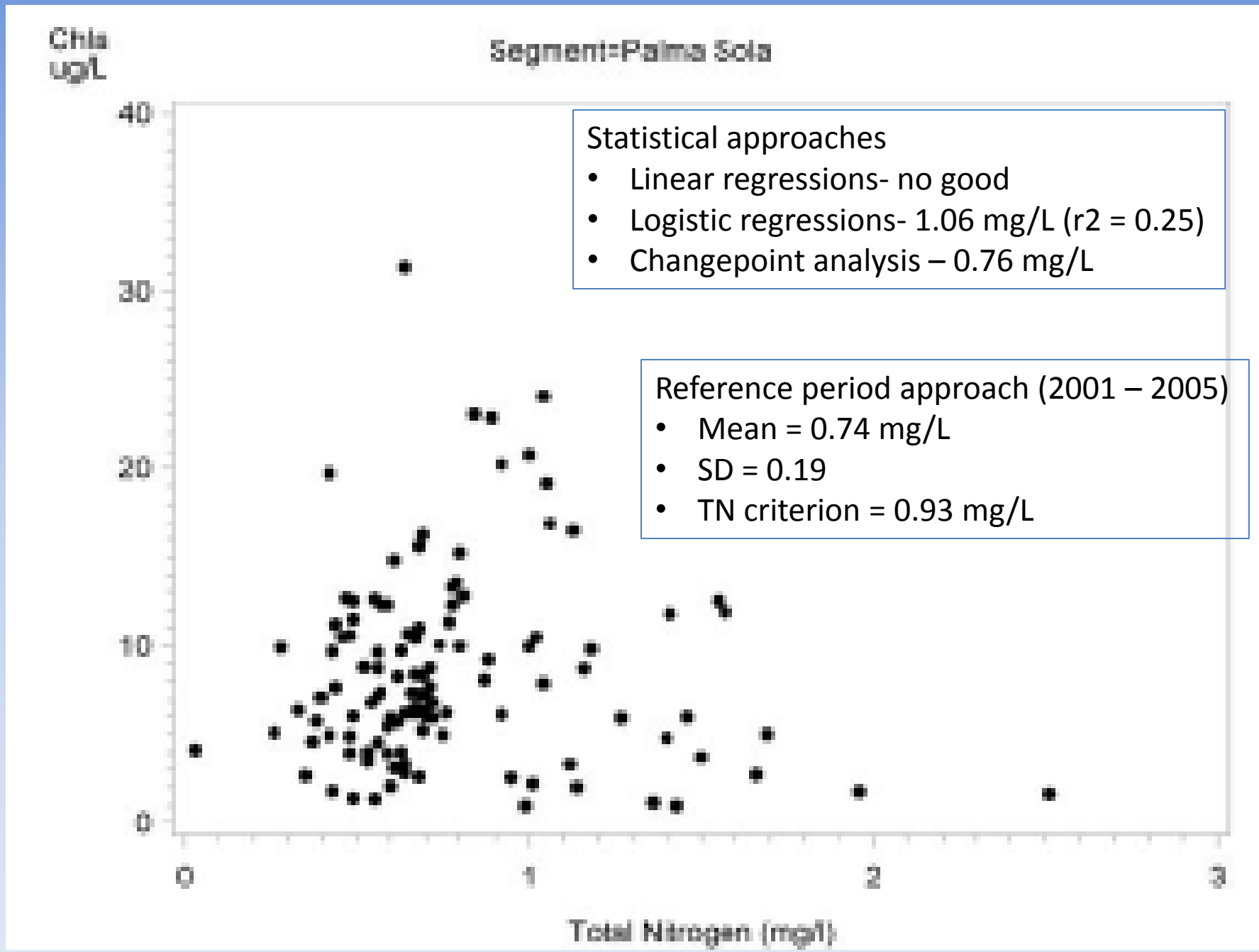


Figure 8. Annual mean chlorophyll concentrations in Sarasota Bay.

SBEP Chlorophyll *a* – TN Relationships

- Roberts Bay, Little Sarasota Bay. and Blackburn Bay – regressions of [TN] on chlorophyll *a* were significant.
- Sarasota Bay – significant multivariate relationship identified between chlorophyll *a* and [TN], color and region of the bay.
- Palma Sola Bay – poor relationship; criteria based on reference period of 2001-2005.


Chla
(ug/L)
Segment=Sarasota Bay
[Chlorophyll a = -1.06 + 93.58 * [TN]) + (0.32 * color) + (2.03 * season) – 4.84 * region
16
15
12
11
10
9
8
7
6
5
4
3
2
1
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
Total Nitrogen (mg/l)
TN Criterion = 0.28 – 1.34 mg/L



Statistical approaches

- Linear regressions- no good
- Logistic regressions- 1.06 mg/L (r2 = 0.25)
- Changepoint analysis – 0.76 mg/L

Reference period approach (2001 – 2005)

- Mean = 0.74 mg/L
- SD = 0.19
- TN criterion = 0.93 mg/L

SBEP Recommended TN Criteria	
Bay Segment	TN Criteria (mg/L)
Palma Sola	0.93
Sarasota	Dependent upon observed color; for the period 1998-2009 the criteria would vary between 0.28 - 1.34 mg/L
Roberts	0.54
Little Sarasota	0.60
Blackburn	0.43

Year	Palma Sola Bay	Sarasota Bay	Roberts Bay	Little Sarasota Bay	Blackburn Bay
1996	Yes	Yes			
1997	Yes	Yes			
1998	No	Yes	Yes	Yes	Yes
1999	Yes	Yes	Yes	Yes	Yes
2000	Yes	Yes	Yes	Yes	Yes
2001	Yes	Yes	No	No	No
2002	Yes	Yes	Yes	Yes	Yes
2003	No	Yes	Yes	Yes	Yes
2004	Yes	Yes	Yes	Yes	Yes
2005	Yes	Yes	Yes	Yes	Yes
2006	Yes	Yes	Yes	Yes	Yes
2007	Yes	Yes	Yes	Yes	Yes
2008	Yes	Yes	Yes	Yes	Yes
2009		Yes	Yes	Yes	Yes

Additional NNC Reports

- TP and Loadings Criteria
- Characteristics of DO in Sarasota Bay Related to the FDEP DO Standard
- Downstream Protection Values (DPVs)
- Implementation Issues
- Tidal Creek Issues

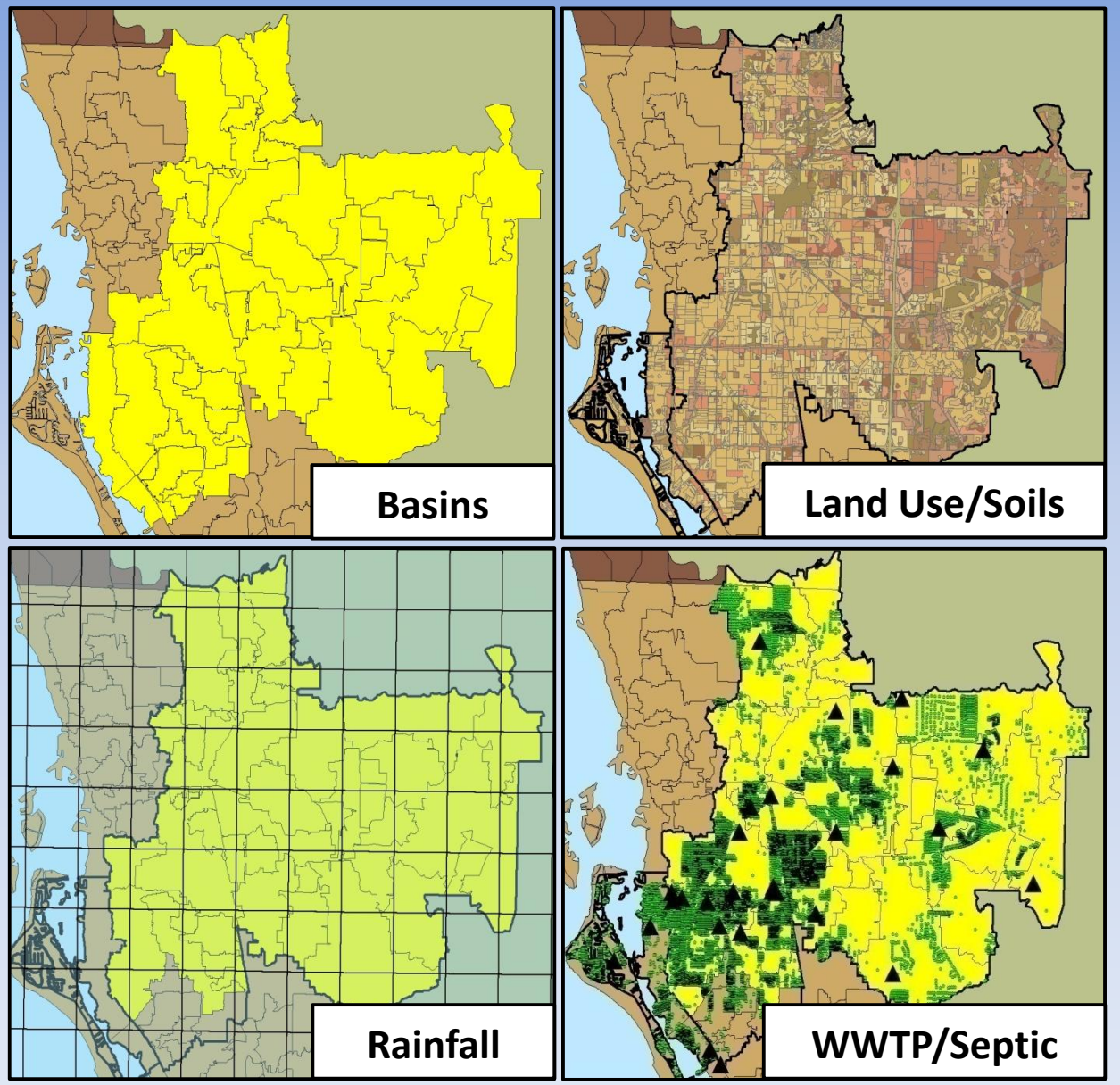
Modeling Pollutant Loads

Pollutant Load Modeling

- Summary of Loading Estimates to Sarasota Bay Segments.
- Comparison of Loading Estimates between SIMPLE-MONTHLY and CDM Models.
- Analysis of Chlorophyll a and Loading Relationships in Blackburn, Little Sarasota and Roberts Bays.

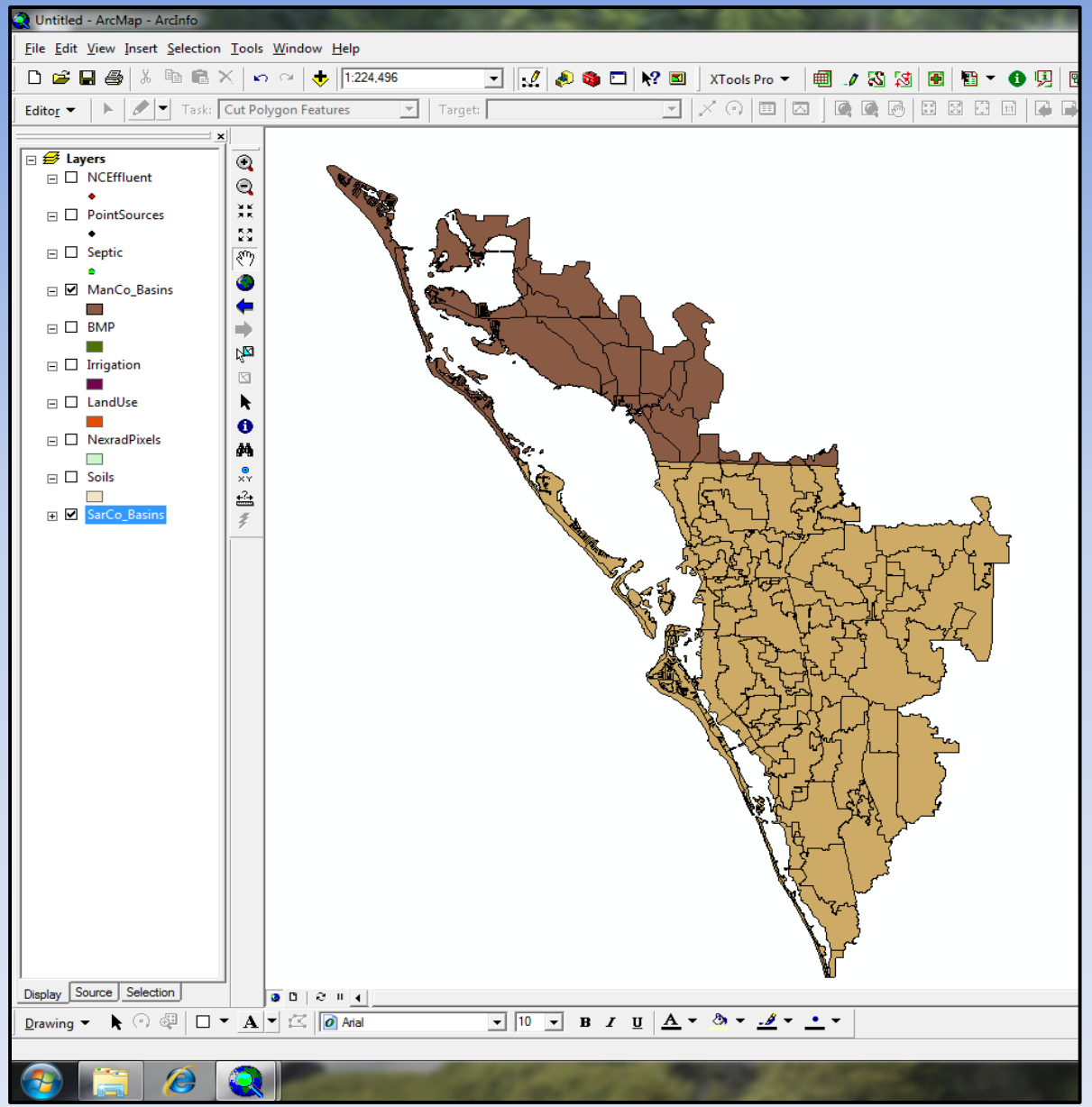
Spatially **I**ntegrated **M**odel for **P**ollutant **L**oading **E**stimates (**SIMPLE**)

- Developed by Jones-Edmunds and Associates for Sarasota County
- GIS-based model



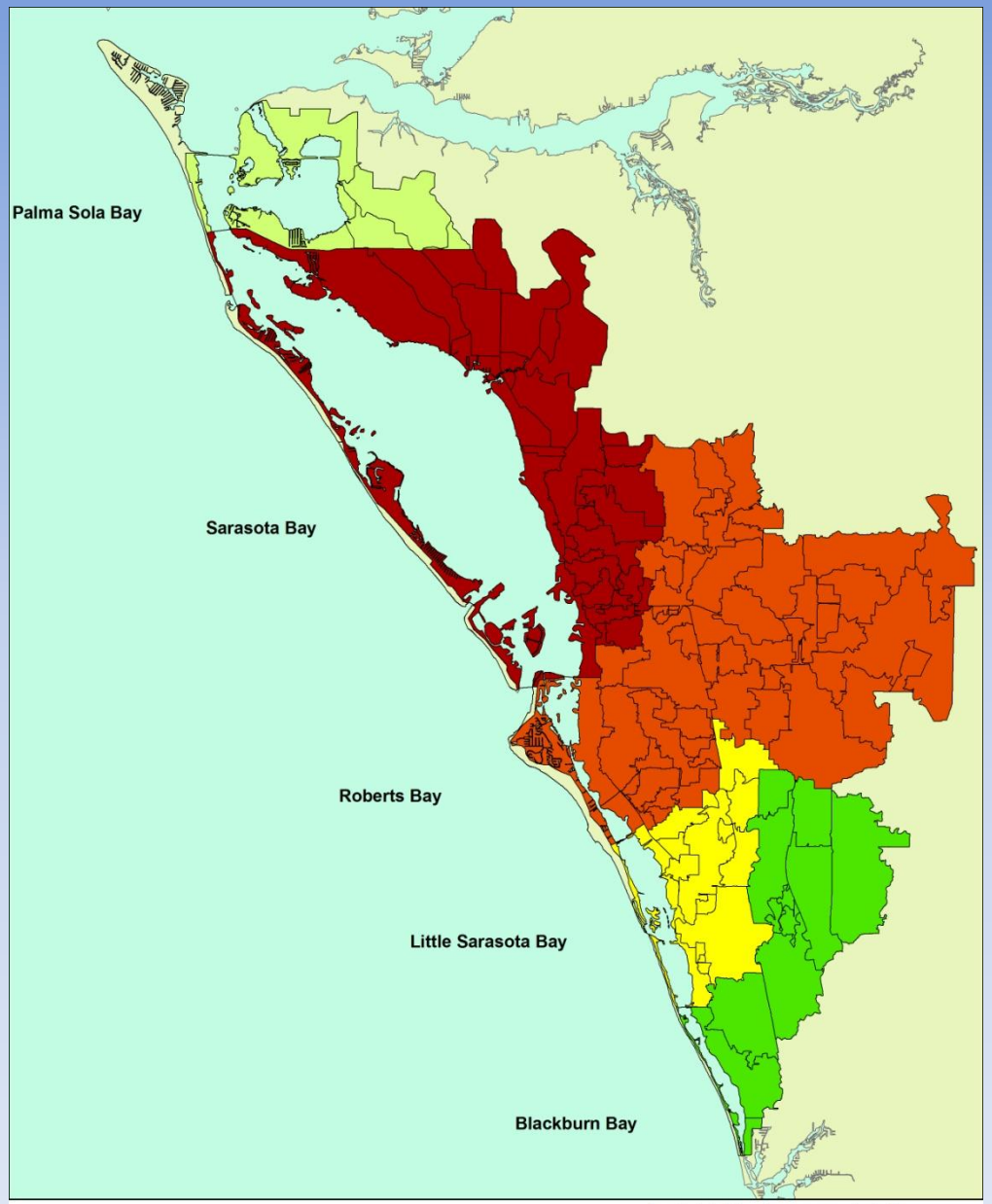
Expanded Model Universe

- Used existing input data for Sarasota County
- Expanded temporal coverage to include 1988-2008
- Expanded spatial coverage to include all 5 Bay Segments including Manatee County basins



SIMPLE Basins

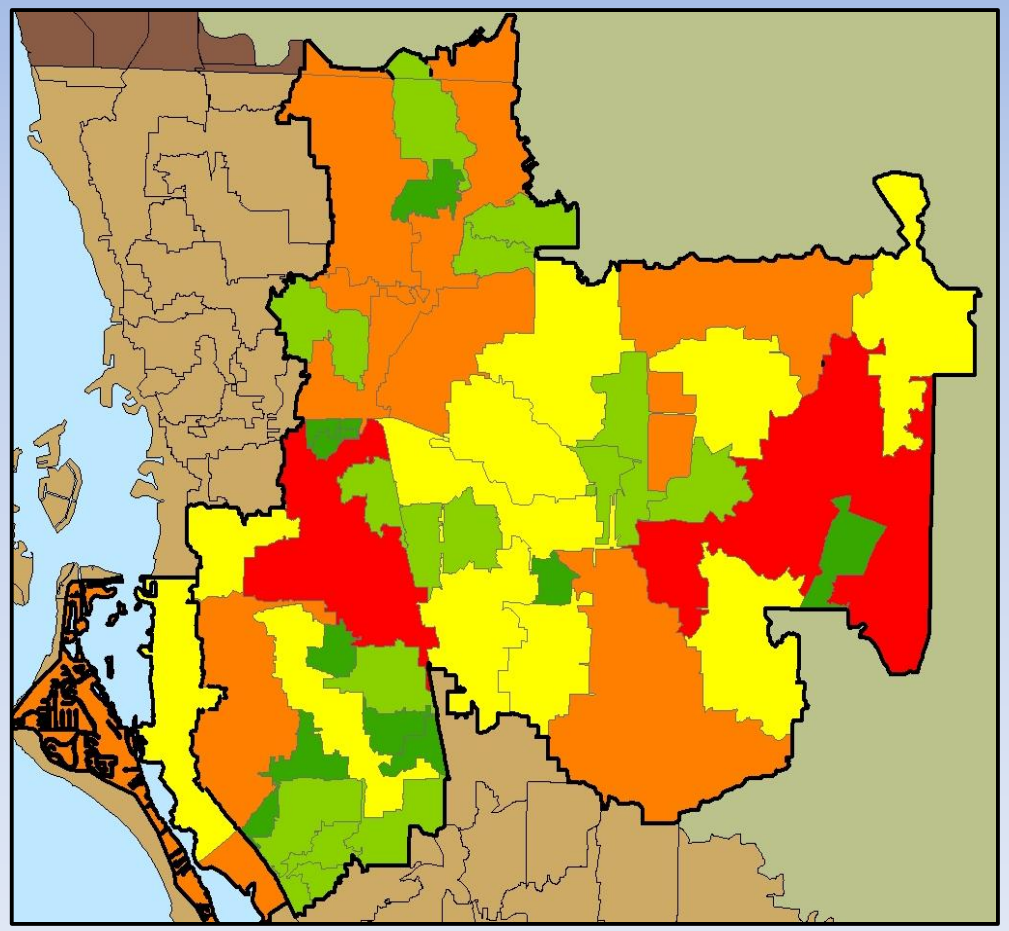
- Estimate generated for 5 bay segments within the SBEP watershed
  - Palma Sola Bay
  - Sarasota Bay
  - Roberts Bay
  - Little Sarasota Bay
  - Blackburn Bay



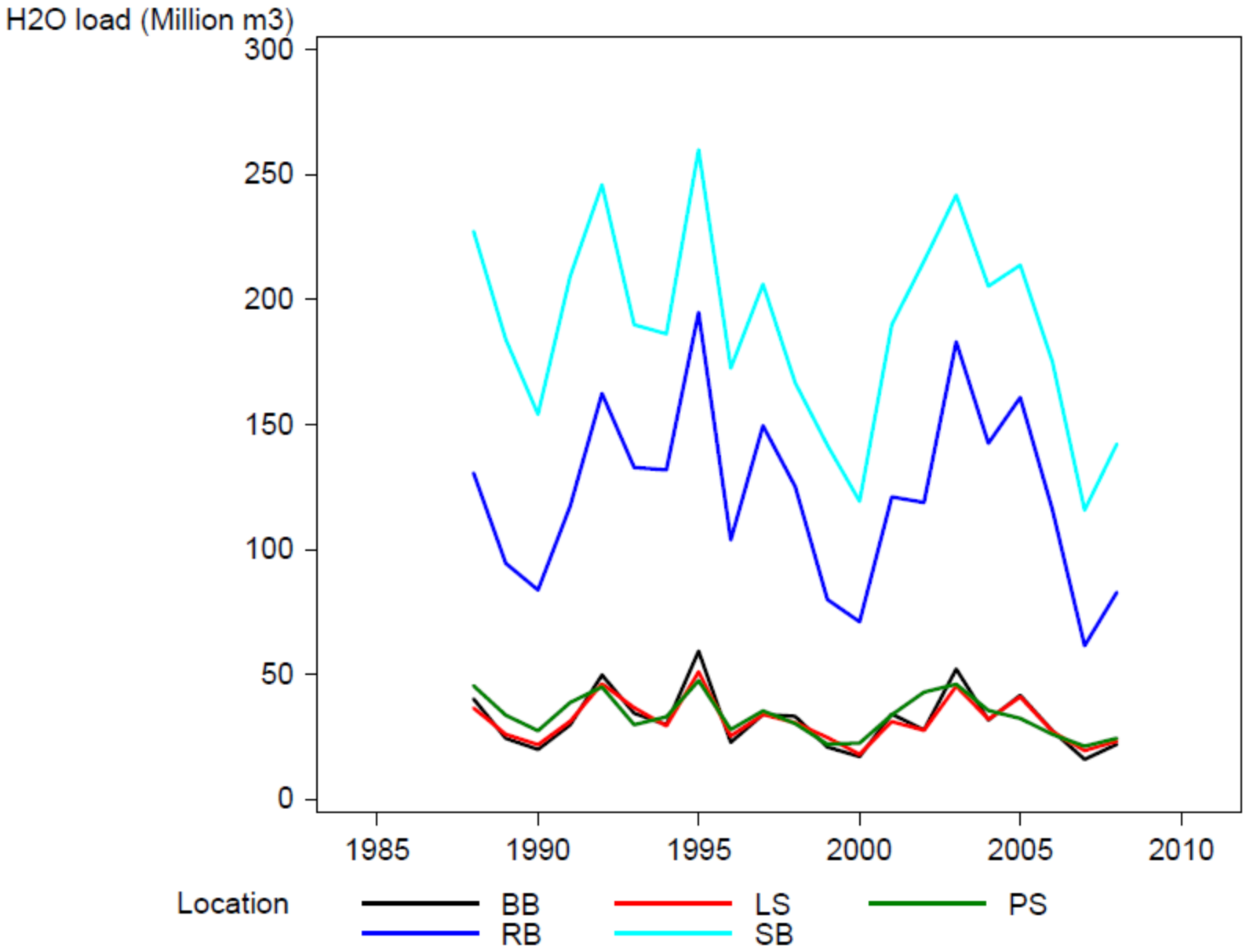
Janicki Environmental, Inc.
Map Publication No. A10 00101

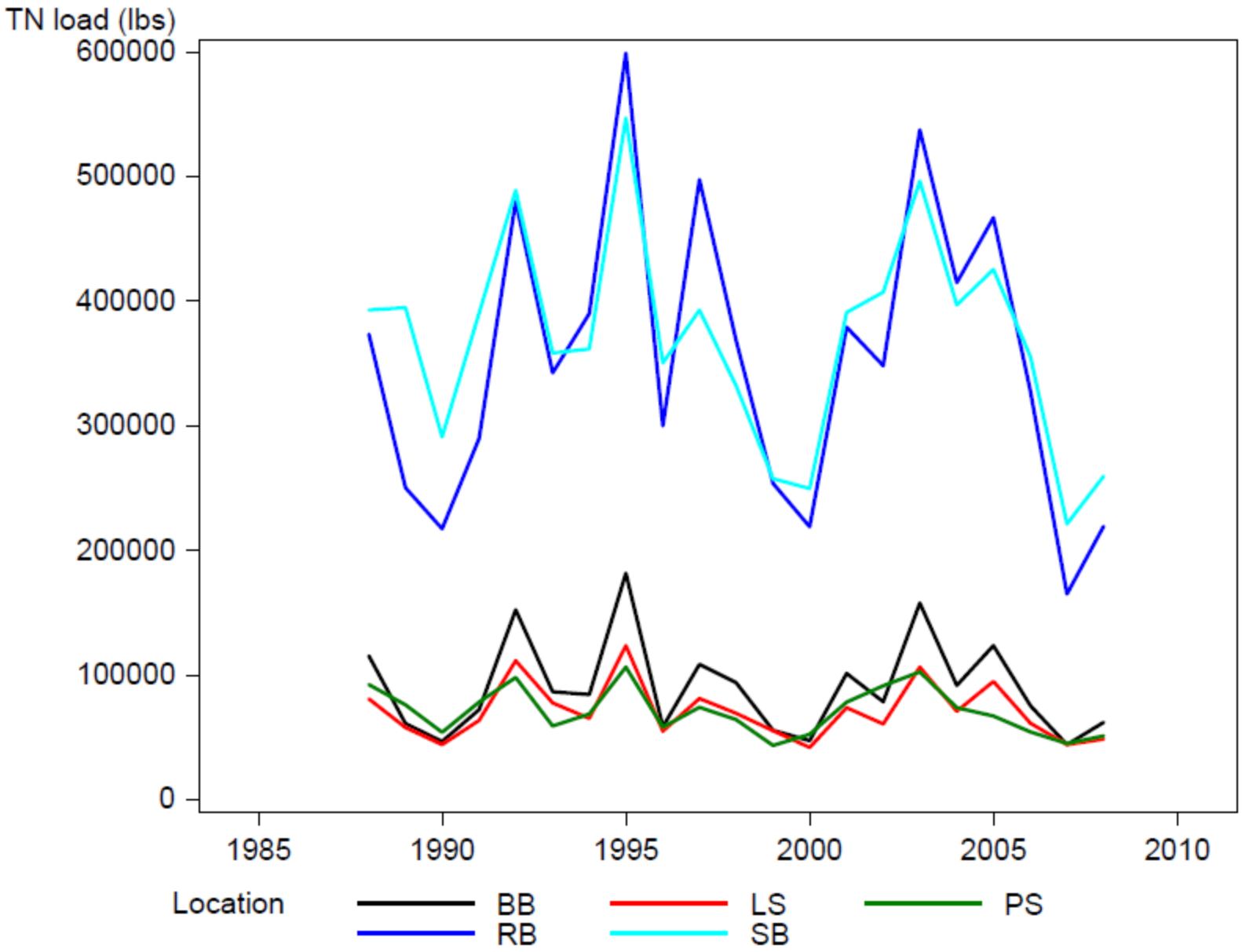
Nutrient Loading Estimates

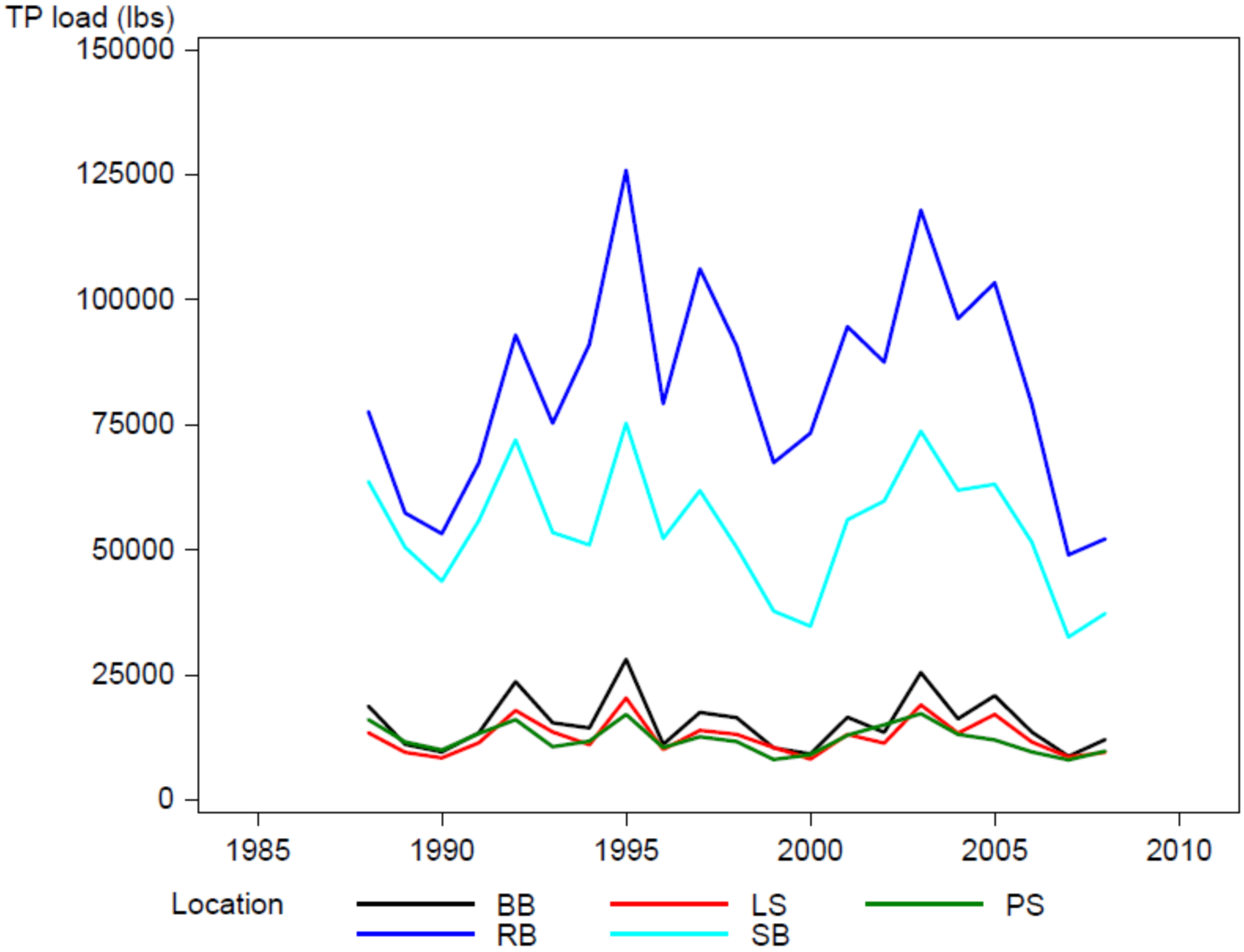
- Monthly loads
- Total loads for TN, TP, TSS, BOD and hydrologic loads
- Source-specific loads from:
  - Runoff
  - Point Source
  - Septic tanks
  - Groundwater
  - Irrigation
  - Atmospheric deposition (estimated externally)

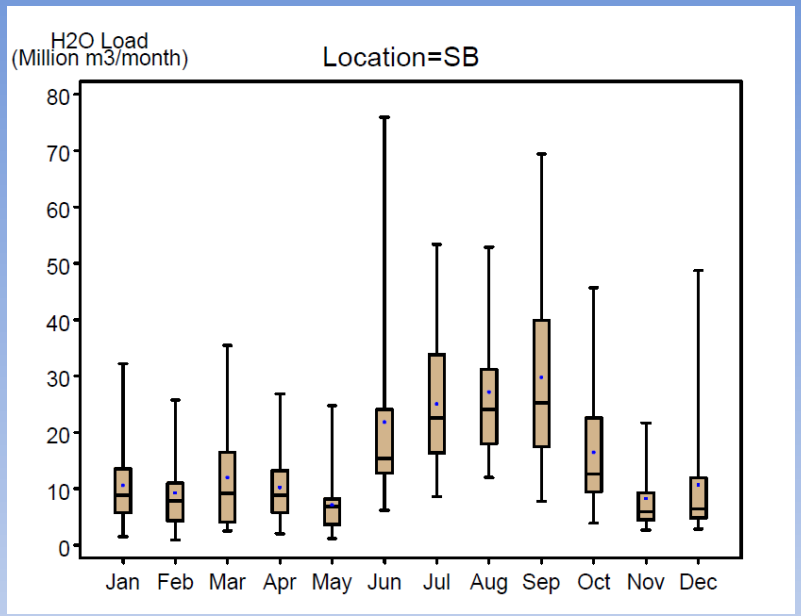


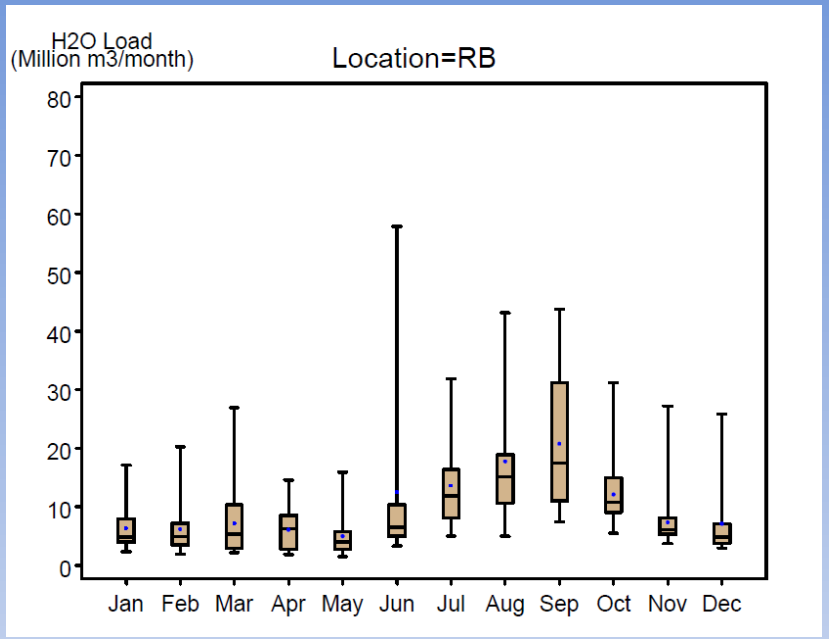
Results

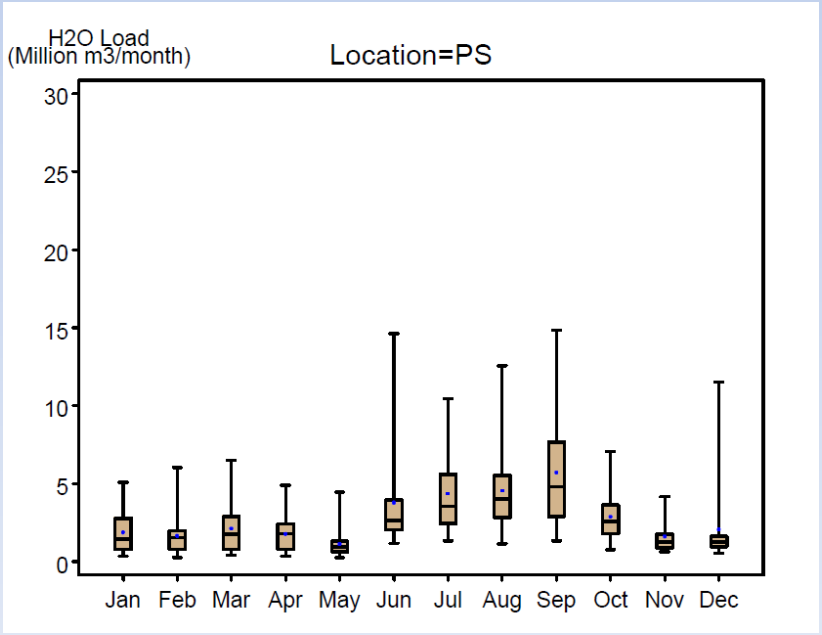

H2O load (Million m3)
300
250
200
150
100
50
0
1985
1990
1995
2000
2005
2010
Location
BB
RB
LS
SB
PS

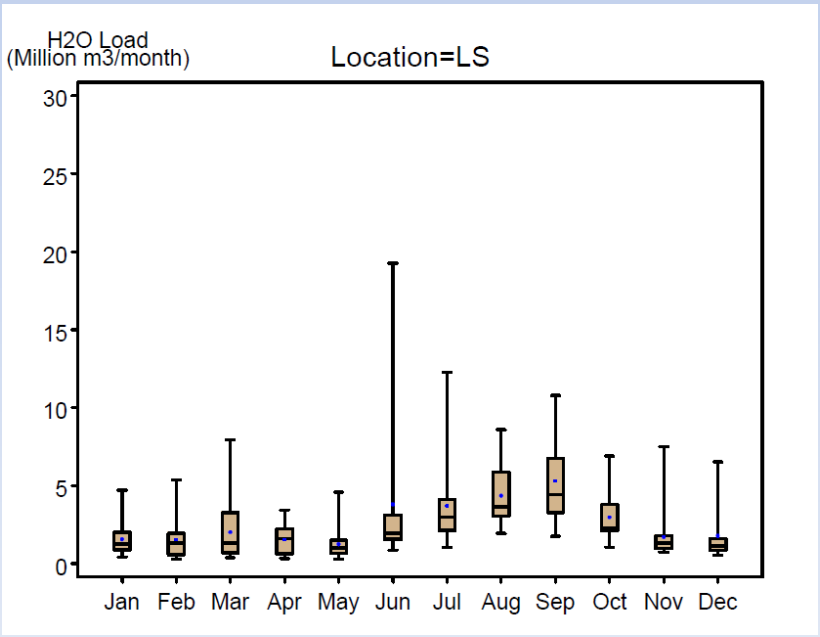

TN load (lbs)
600000
500000
400000
300000
200000
100000
0
1985
1990
1995
2000
2005
2010
Location
BB
RB
LS
SB
PS


TP load (lbs)
150000
125000
100000
75000
50000
25000
0
1985
1990
1995
2000
2005
2010
Location
BB
RB
LS
SB
PS


H2O Load
(Million m3/month)
Location=SB
80
70
60
50
40
30
20
10
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec


H2O Load
(Million m3/month)
Location=RB
80
70
60
50
40
30
20
10
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec


H2O Load
(Million m3/month)
Location=PS
30
25
20
15
10
5
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec


H2O Load
(Million m3/month)
Location=LS
30
25
20
15
10
5
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

Comparison to Camp Dresser & McKee Model (1992)

- Pollutant loading model for SBEP to quantify nutrients and metals by point and non-point sources
- Pollutant loads estimated for three different scenarios:
    - Existing conditions
    - Five year build-out
    - Twenty year build-out

Comparison between the SIMPLE and CDM model estimates

	AREA		TOTAL NITROGEN						TOTAL PHOSPHORUS					
	(acres)		(pounds)		(lb/ac)		(mg/L)		(pounds)		(lb/ac)		(mg/L)	
	SIMPLE	CDM	SIMPLE	CDM	SIMPLE	CDM	SIMPLE	CDM	SIMPLE	CDM	SIMPLE	CDM	SIMPLE	CDM
Palma Sola Bay	7,727	9,224	70,398	80,670	9.11	8.75	1.32	1.31	15,355	16,460	1.99	1.78	0.29	0.27
Sarasota Bay	25,164	21,890	232,253	265,520	9.23	12.13	1.32	1.65	49,413	55,380	1.96	2.53	0.28	0.35

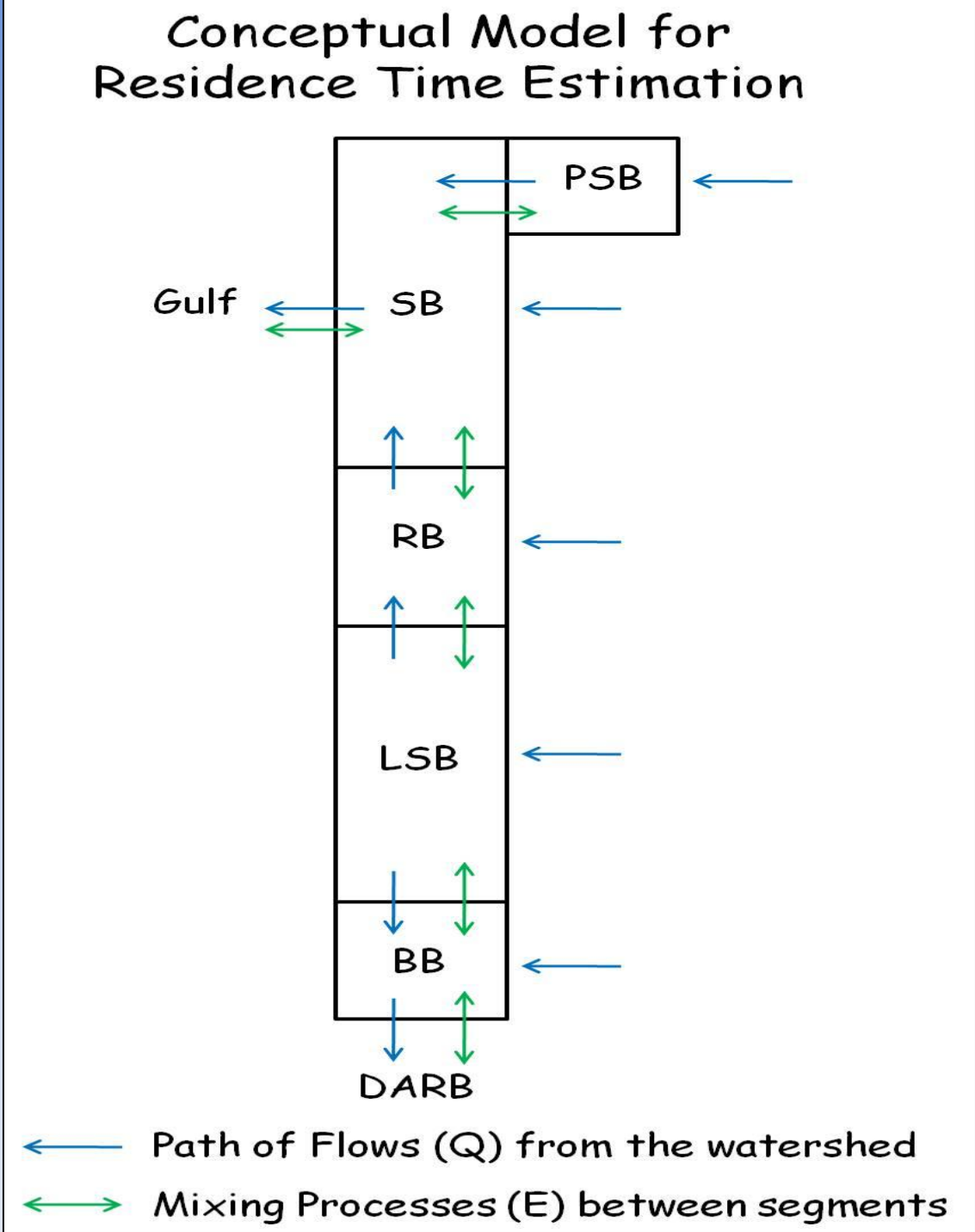
Caveats about comparing the two models.

1. Boundaries are different
2. Rainfall Calculations
3. Atmospheric Deposition

Sarasota Bay Residence Time

- Box model to estimate hydraulic (pulse) residence times within Bay segments
- Based on observed salinity distributions and estimated freshwater inflows
- Assumed all waters were well mixed vertically
- Predicated on a well-defined flow path for freshwater beginning at the head of the estuary

Box Model Schematic For Sarasota Bay Segments



Median Annual Pulse Residence Time (Based on 1994 – 2007 Conditions)

Bay Segment	Pulse Residence Time (Days)
Palma Sola Bay	35.8
Sarasota Bay	28.8
Roberts Bay	2.8
Little Sarasota Bay	19.2
Blackburn Bay	3.0

Tampa Bay Estuary Program

Four Mainstem Segments

Tampa Bay Nitrogen Management Paradigm

TN Load → Chlorophyll → Light Attenuation

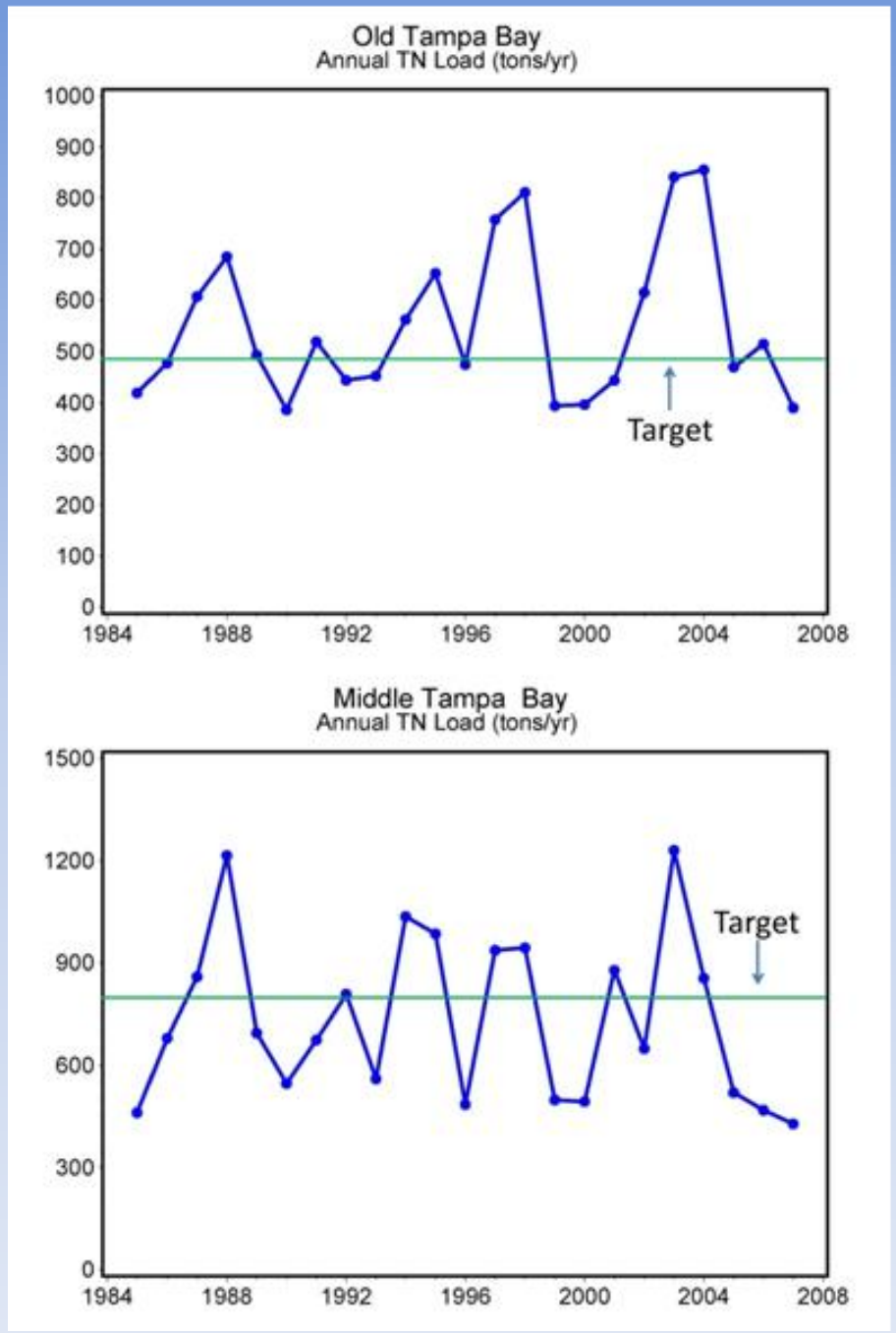
Seagrass Light Requirement → Seagrass Growth & Reproduction

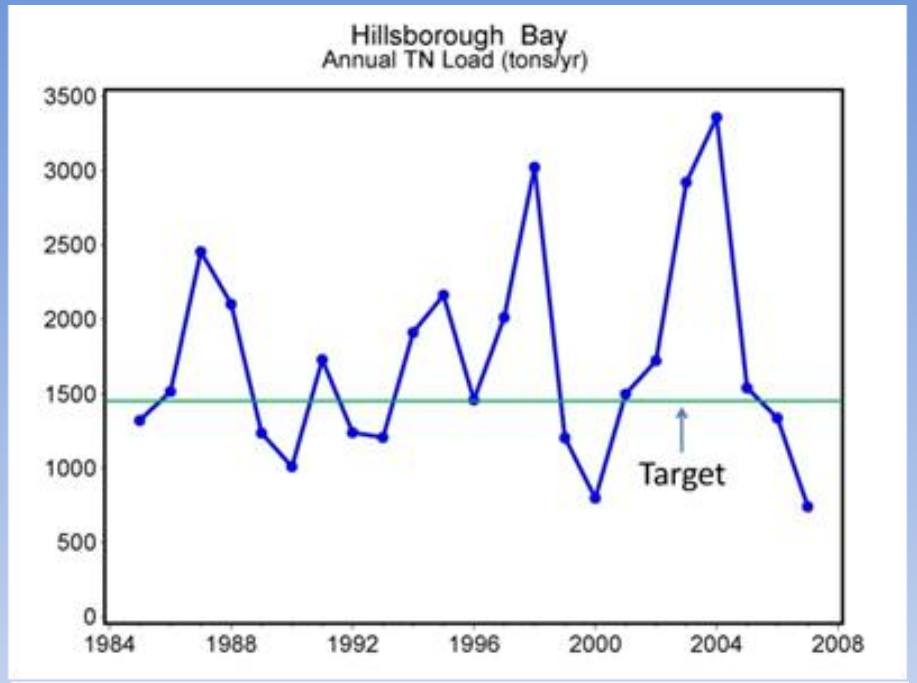
TAMPA BAY ESTUARY PROGRAM

- Established seagrass targets in 1995
- Established chlorophyll *a* targets in 1996
- Developed Reasonable Assurance in 2002; updated in 2010
- Developed proposed numeric nutrient criteria in 2010

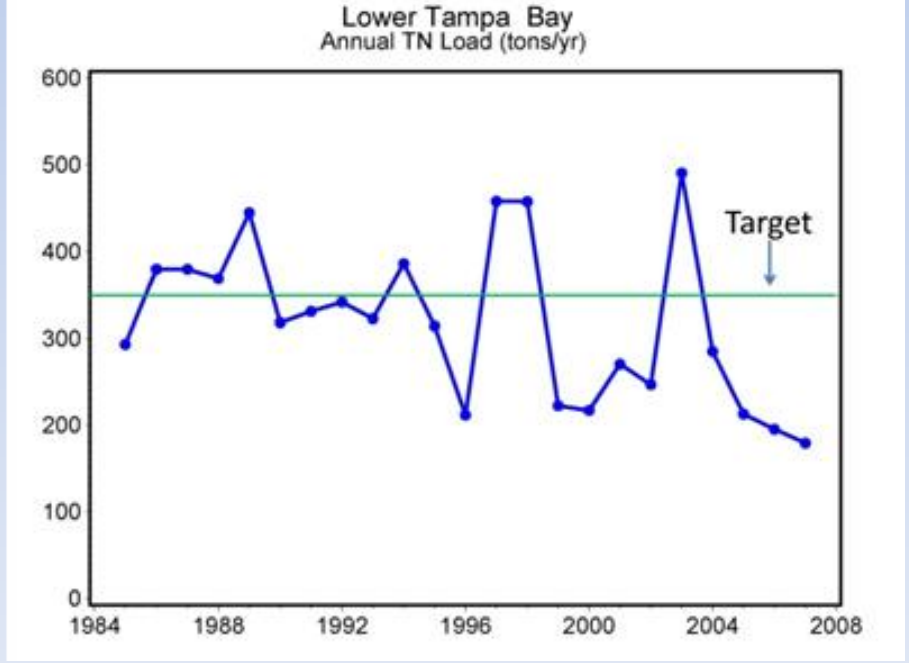
SEAGRASS TARGETS

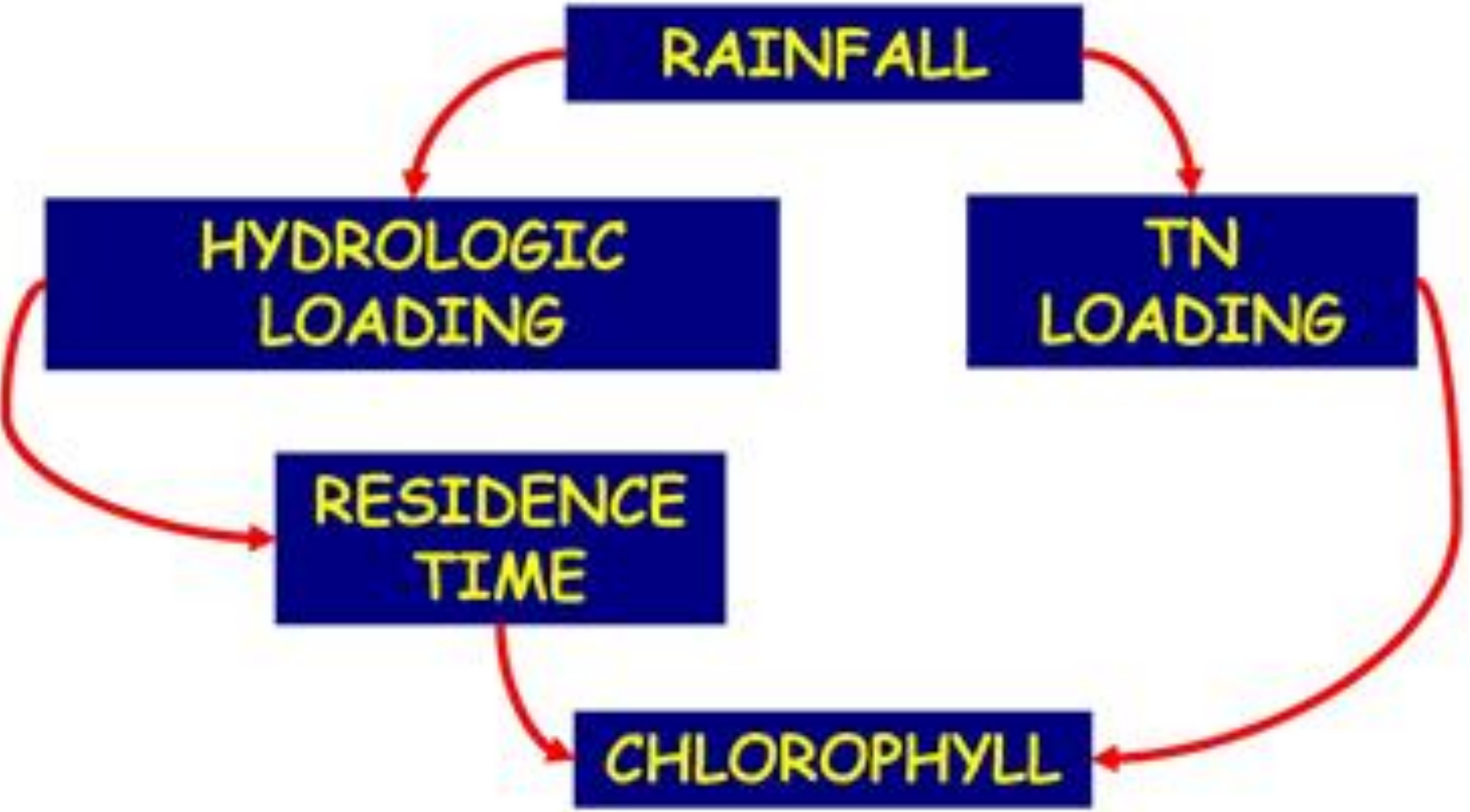
- Based on historical (ca. 1950) and recent seagrass coverages
- Segment-specific
- Accounted for non-restorable areas


Old Tampa Bay
Annual TN Load (tons/yr)
1000
900
800
700
600
500
400
300
200
100
0
1984
1988
1992
1996
2000
2004
2008
Target


Hillsborough Bay
Annual TN Load (tons/yr)
3500
3000
2500
2000
1500
1000
500
0
1984
1988
1992
1996
2000
2004
2008
Target

Middle Tampa Bay
Annual TN Load (tons/yr)
1500
1200
900
600
300
0
1984
1988
1992
1996
2000
2004
2008
Target


Lower Tampa Bay
Annual TN Load (tons/yr)
600
500
400
300
200
100
0
1984
1988
1992
1996
2000
2004
2008
Target

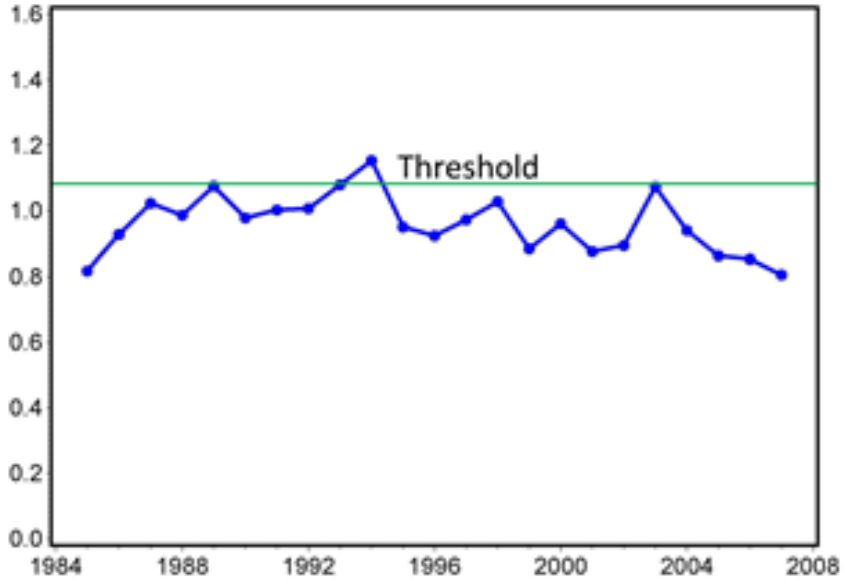

RAINFALL
HYDROLOGIC LOADING
TN LOADING
RESIDENCE TIME
CHLOROPHYLL

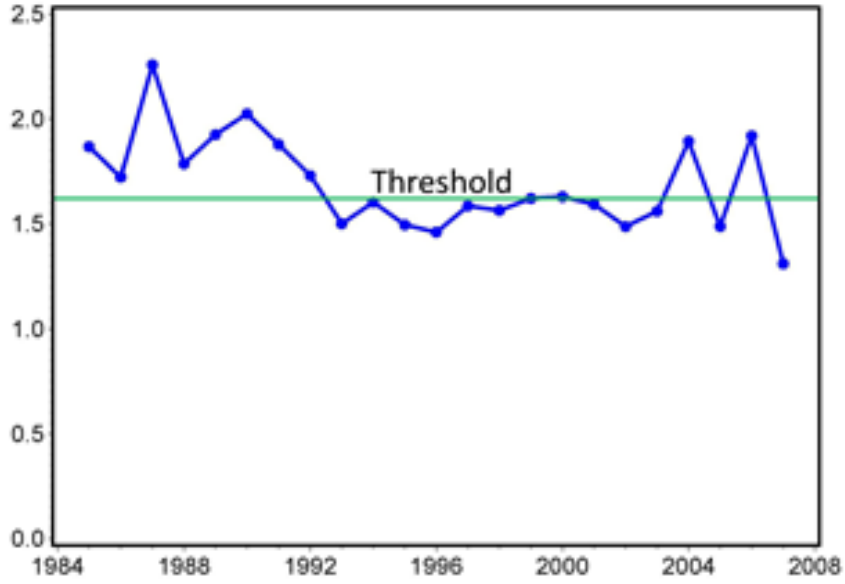
A method to account for the influence of variation in the hydrologic loads was needed.

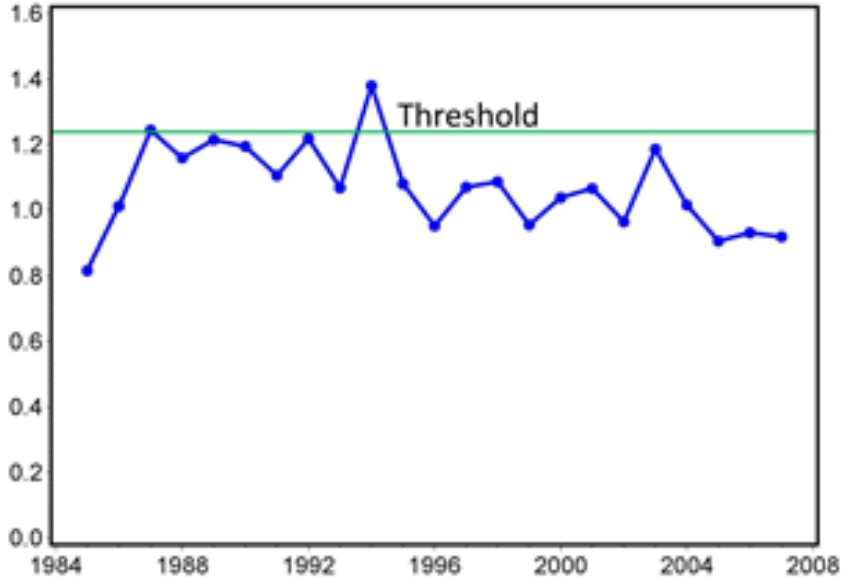
Hydrologic Normalization:

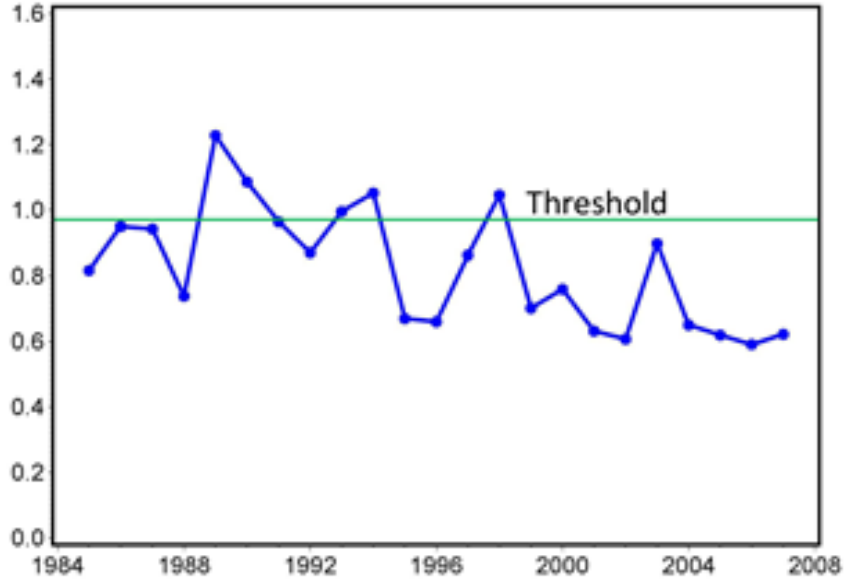
Adjust Annual TN Load by the Hydrologic Load

Nitrogen Delivery Ratio=TN Load/Hydrologic Load


Old Tampa Bay
Annual TN Load/Hydrologic Load (tons/million m3)
Threshold
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1984
1988
1992
1996
2000
2004
2008

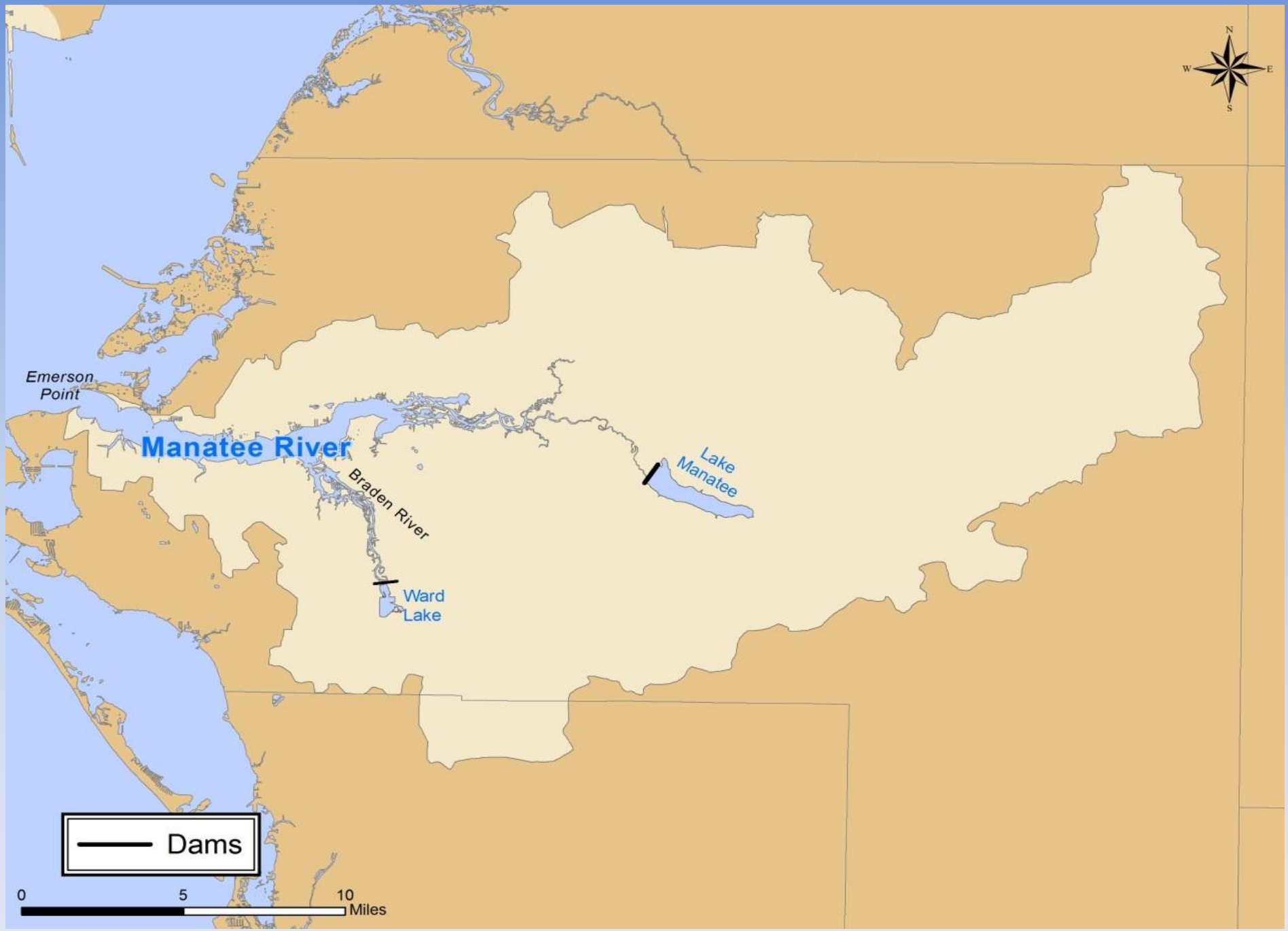

Hillsborough Bay
Annual TN Load/Hydrologic Load (tons/million m3)
Threshold
2.5
2.0
1.5
1.0
0.5
0.0
1984
1988
1992
1996
2000
2004
2008

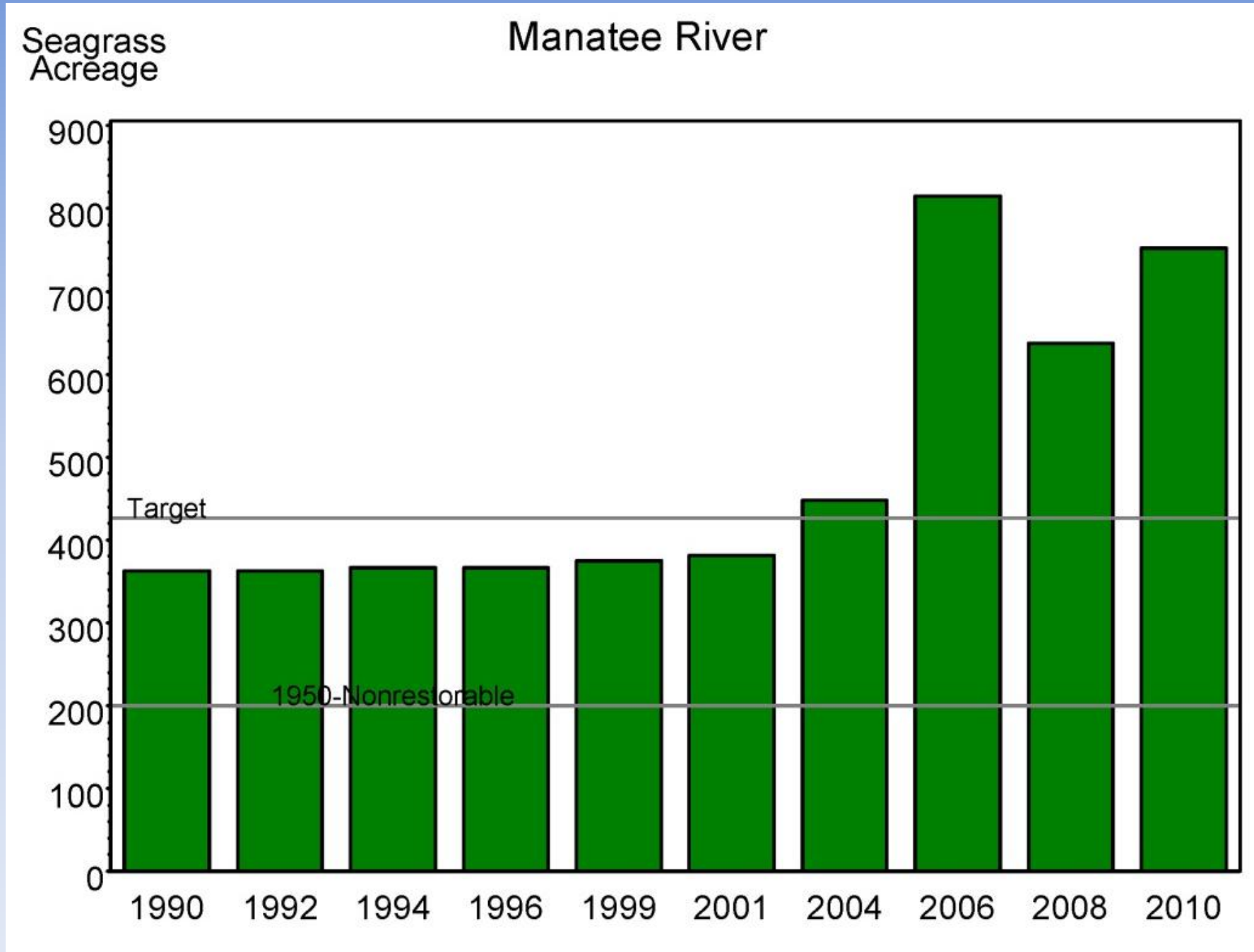

Middle Tampa Bay
Annual TN Load/Hydrologic Load (tons/million m3)
Threshold
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1984
1988
1992
1996
2000
2004
2008


Lower Tampa Bay
Annual TN Load/Hydrologic Load (tons/million m3)
Threshold
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1984
1988
1992
1996
2000
2004
2008

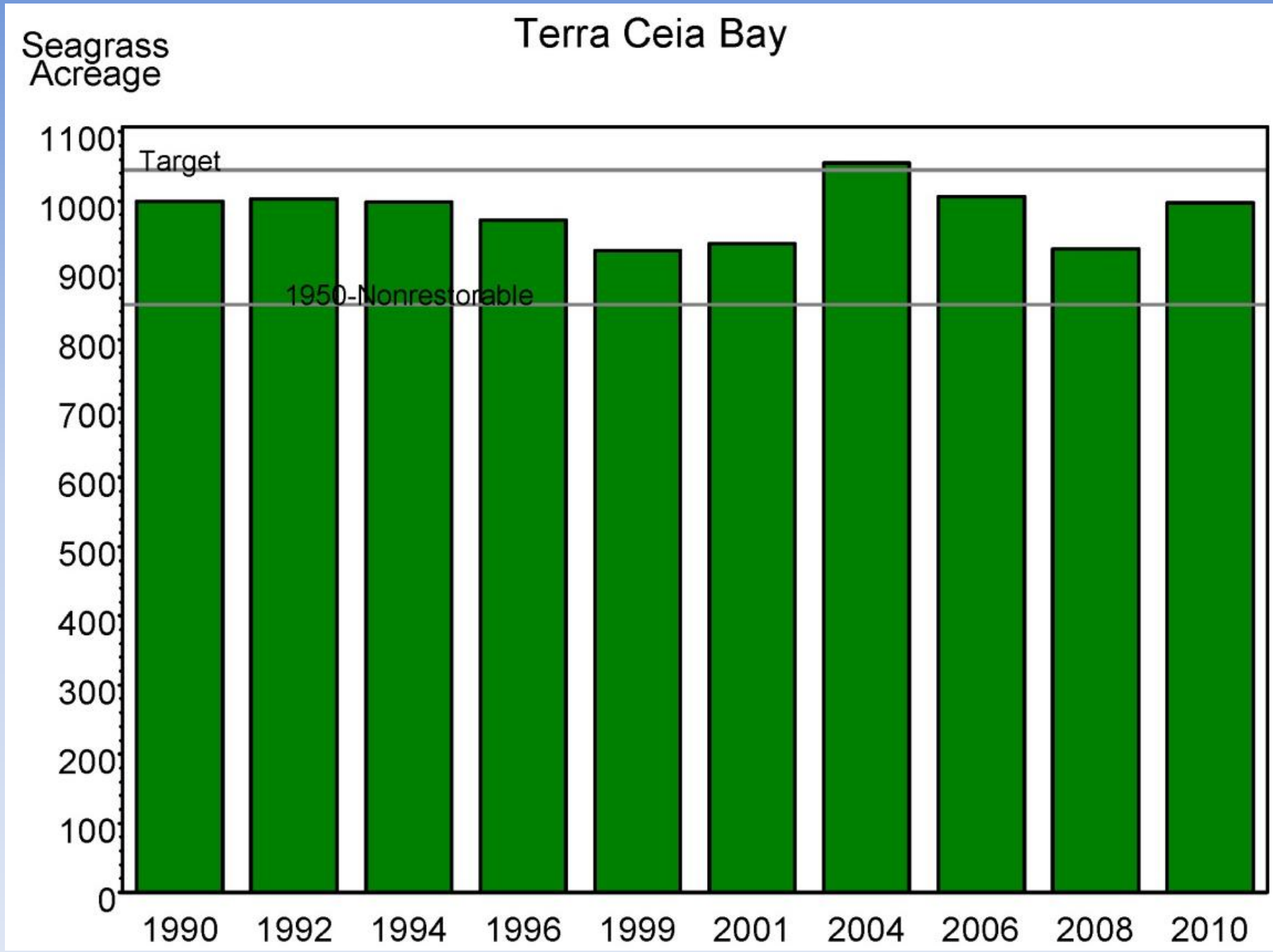
Tampa Bay Estuary Program

Boca Ciega Bay
Terra Ceia Bay
Manatee River


N
W
E
S
Emerson Point
Manatee River
Braden River
Lake Manatee
Ward Lake
Dams
0
5
10
Miles


Manatee River
Seagrass Acreage
900
800
700
600
500
400
300
200
100
0
Target
1950-Nonrestorable
1990
1992
1994
1996
1999
2001
2004
2006
2008
2010


N
W
E
S
Sister Keys
Rattlesnake Key
Bird Key
Terra Ceia Bay
Emerson Point
Snead Island
0
1
2
Miles

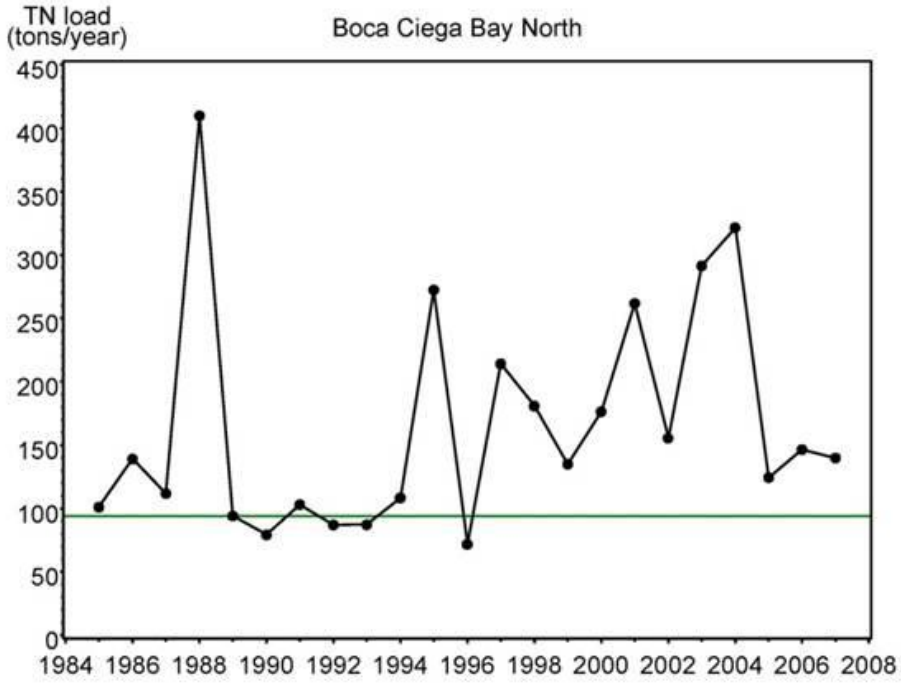

Terra Ceia Bay
Seagrass Acreage
1100
1000
900
800
700
600
500
400
300
200
100
0
Target
1950-Nonrestorable
1990
1992
1994
1996
1999
2001
2004
2006
2008
2010

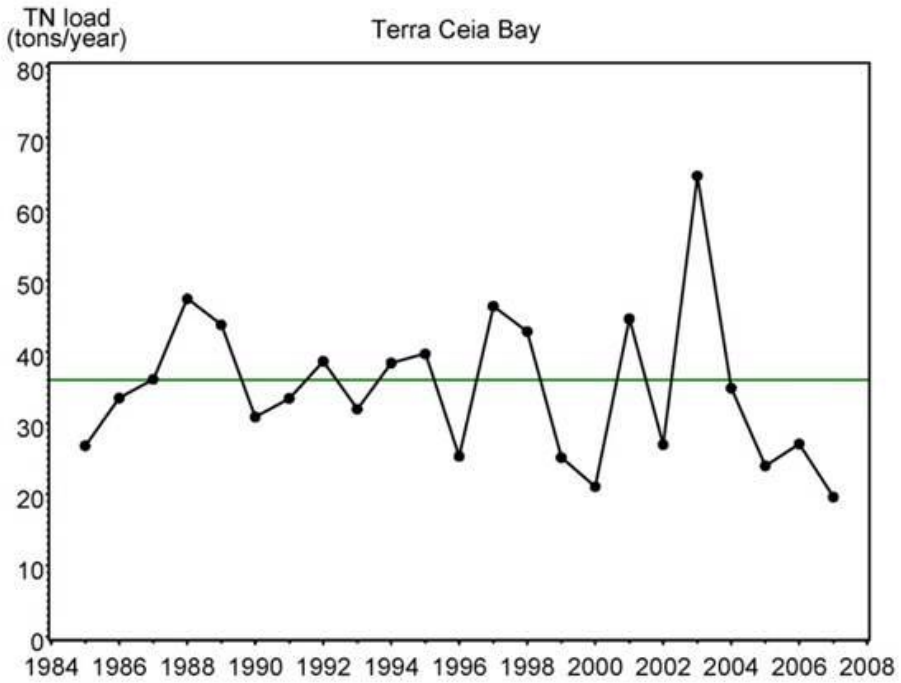
Segment-specific chlorophyll a targets and thresholds

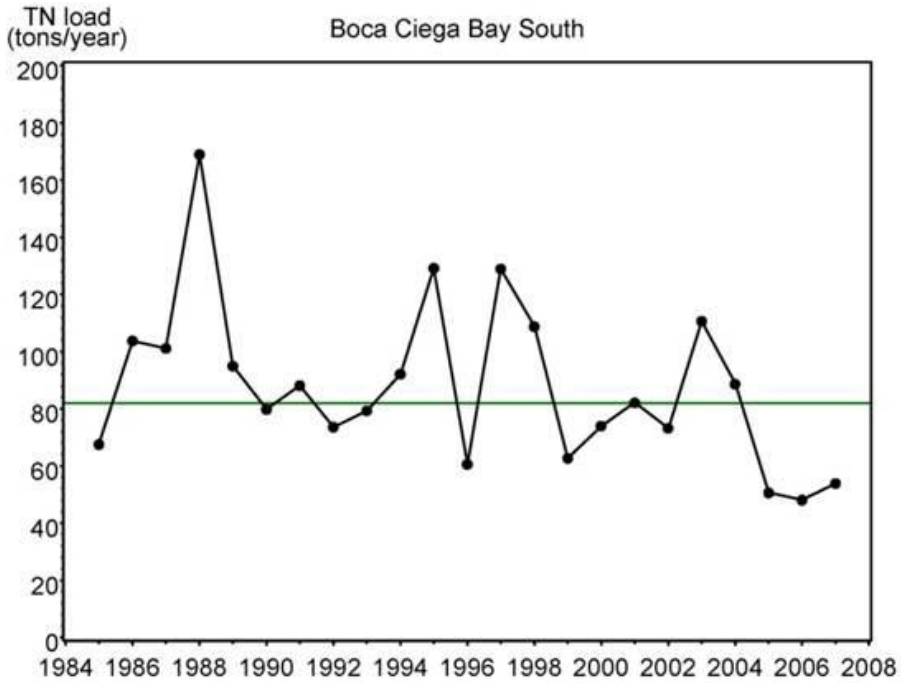
Segment	Chlorophyll a Target (µg/L)	Chlorophyll a Threshold (µg/L)
Terra Ceia Bay	7.5	8.7
Manatee River	7.3	8.8

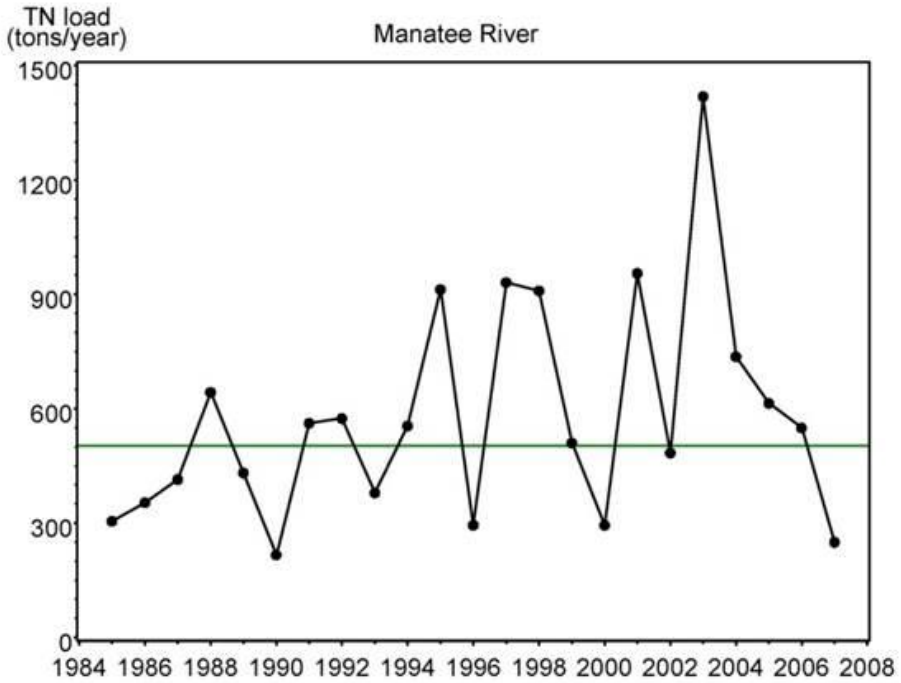
Segment-specific TN loading targets

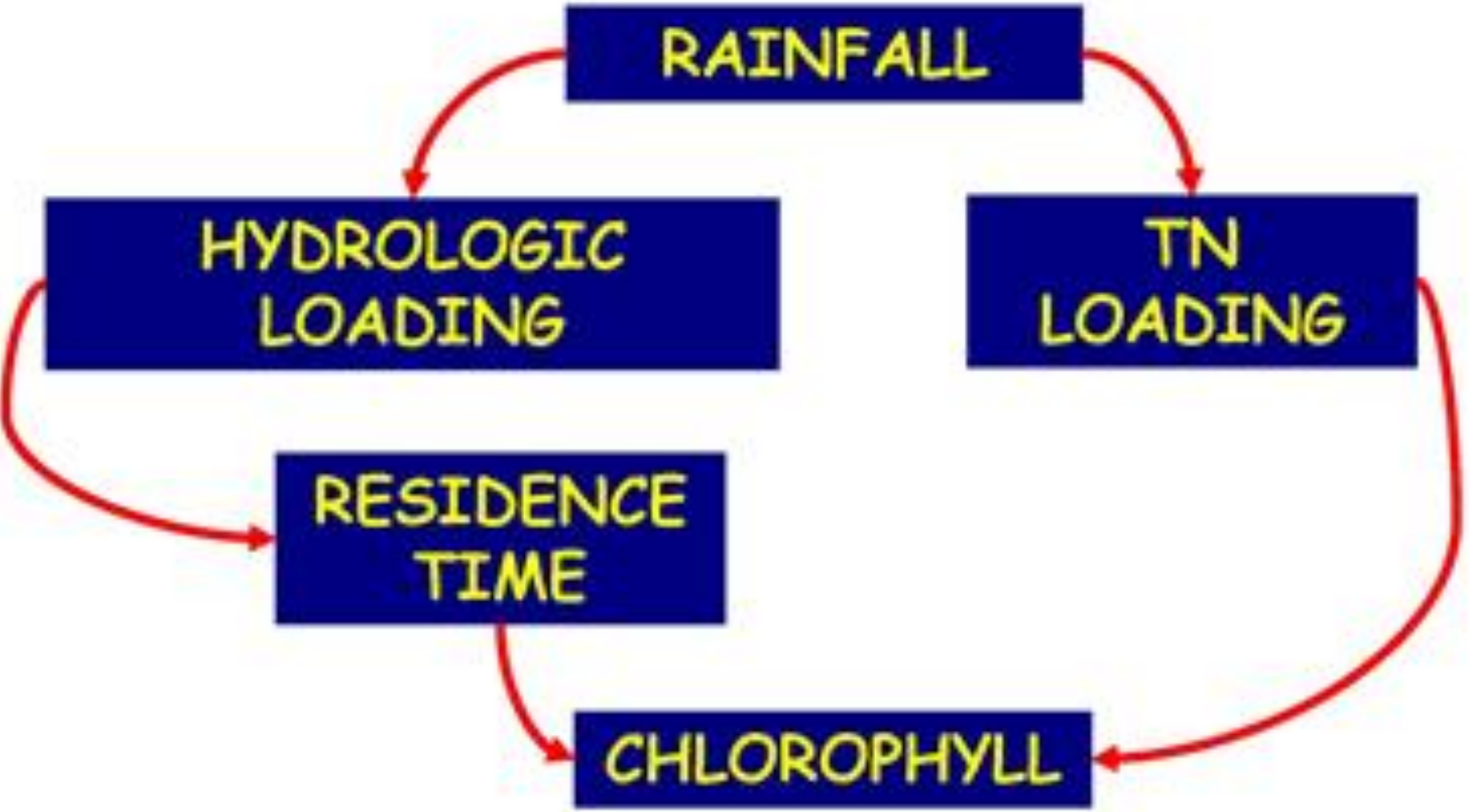
Segment	TN Load Target (tons/year)
Terra Ceia Bay	36
Manatee River	503

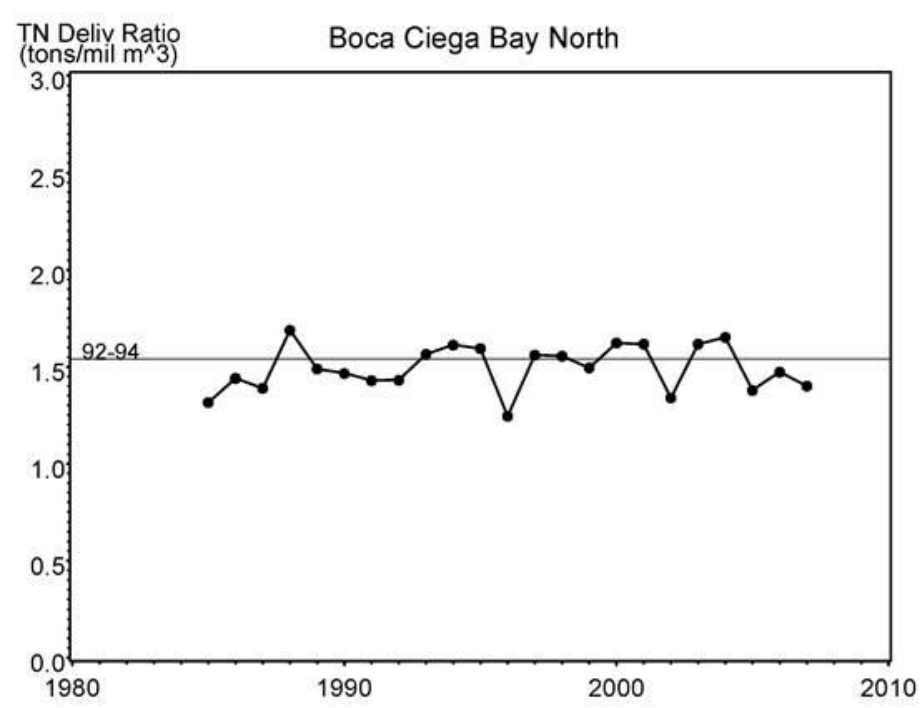

TN load
(tons/year)
Boca Ciega Bay North
450
400
350
300
250
200
150
100
50
0
1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008

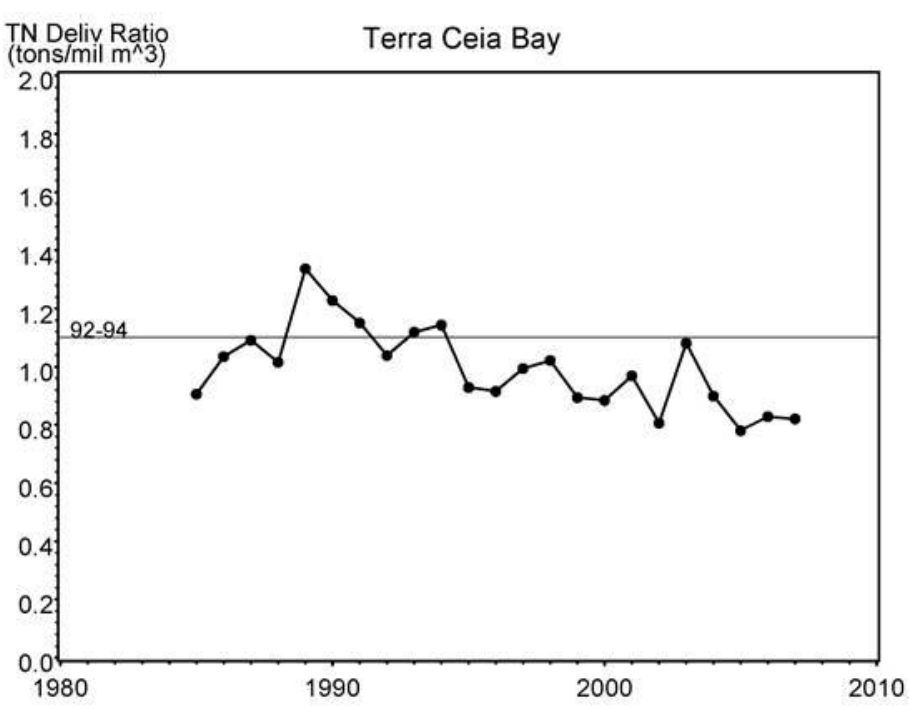

TN load
(tons/year)
Terra Ceia Bay
80
70
60
50
40
30
20
10
0
1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008

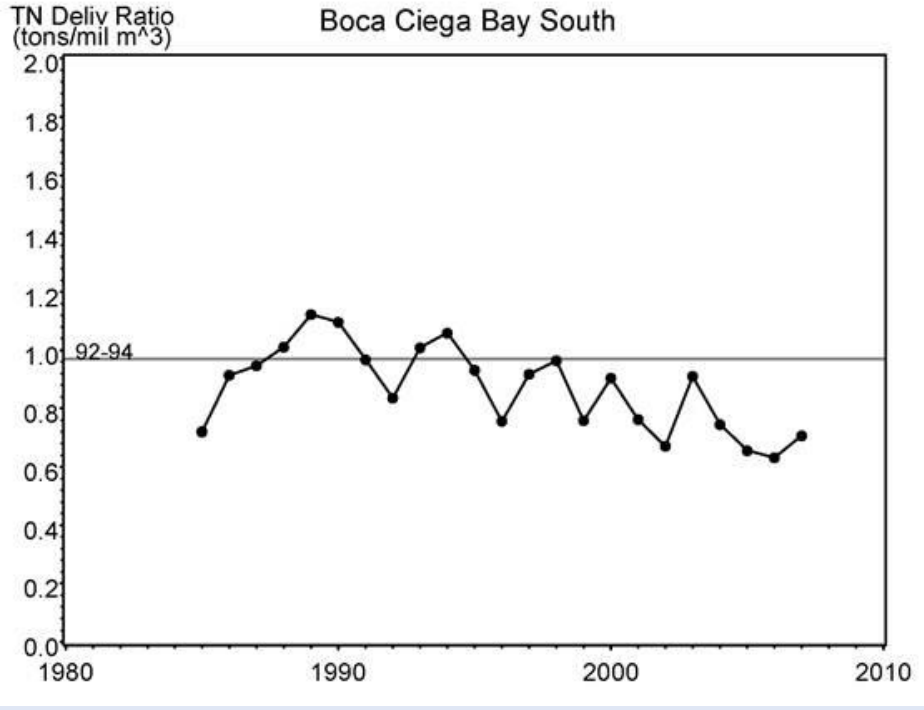

TN load
(tons/year)
Boca Ciega Bay South
200
180
160
140
120
100
80
60
40
20
0
1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008

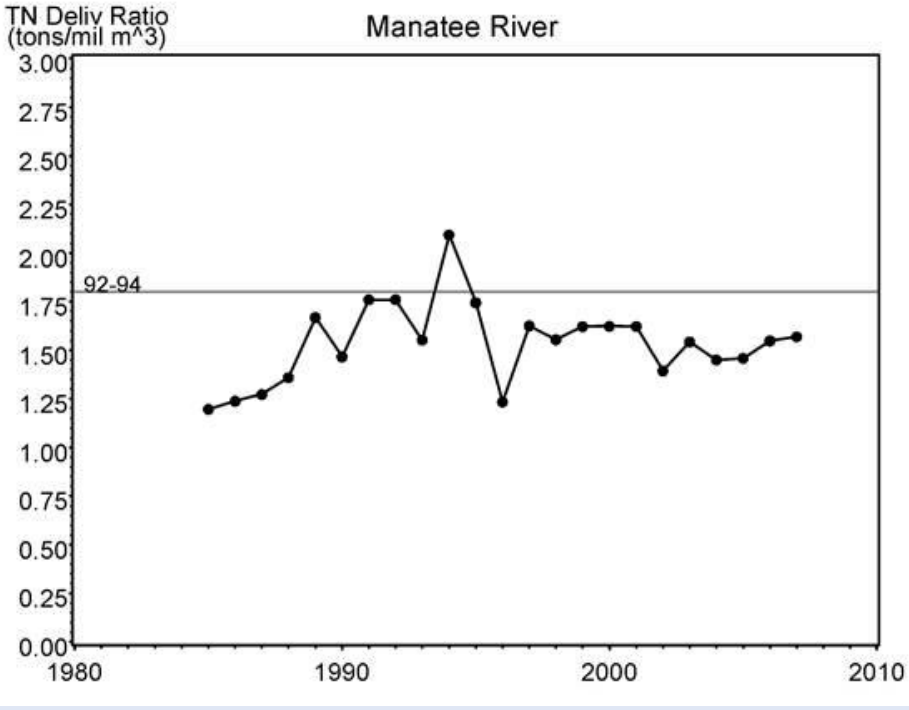

TN load
(tons/year)
Manatee River
1500
1200
900
600
300
0
1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008


RAINFALL
HYDROLOGIC LOADING
TN LOADING
RESIDENCE TIME
CHLOROPHYLL


TN Deliv Ratio
(tons/mil m^3)
Boca Ciega Bay North
3.0
2.5
2.0
1.5
1.0
0.5
0.0
92-94
1980
1990
2000
2010


TN Deliv Ratio
(tons/mil m^3)
Terra Ceia Bay
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
92-94
1980
1990
2000
2010


TN Deliv Ratio
(tons/mil m^3)
Boca Ciega Bay South
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
92-94
1980
1990
2000
2010


TN Deliv Ratio
(tons/mil m^3)
Manatee River
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
92-94
1980
1990
2000
2010

TBEP estuarine NNC expressed as Nitrogen Delivery Ratio (tons TN per million m^3 hydrologic load) based on 1992-1994 conditions.	
Segment	**Nitrogen Delivery Ratio Threshold (tons/million m^3)**
Terra Ceia Bay	**1.10**
Manatee River	**1.80**

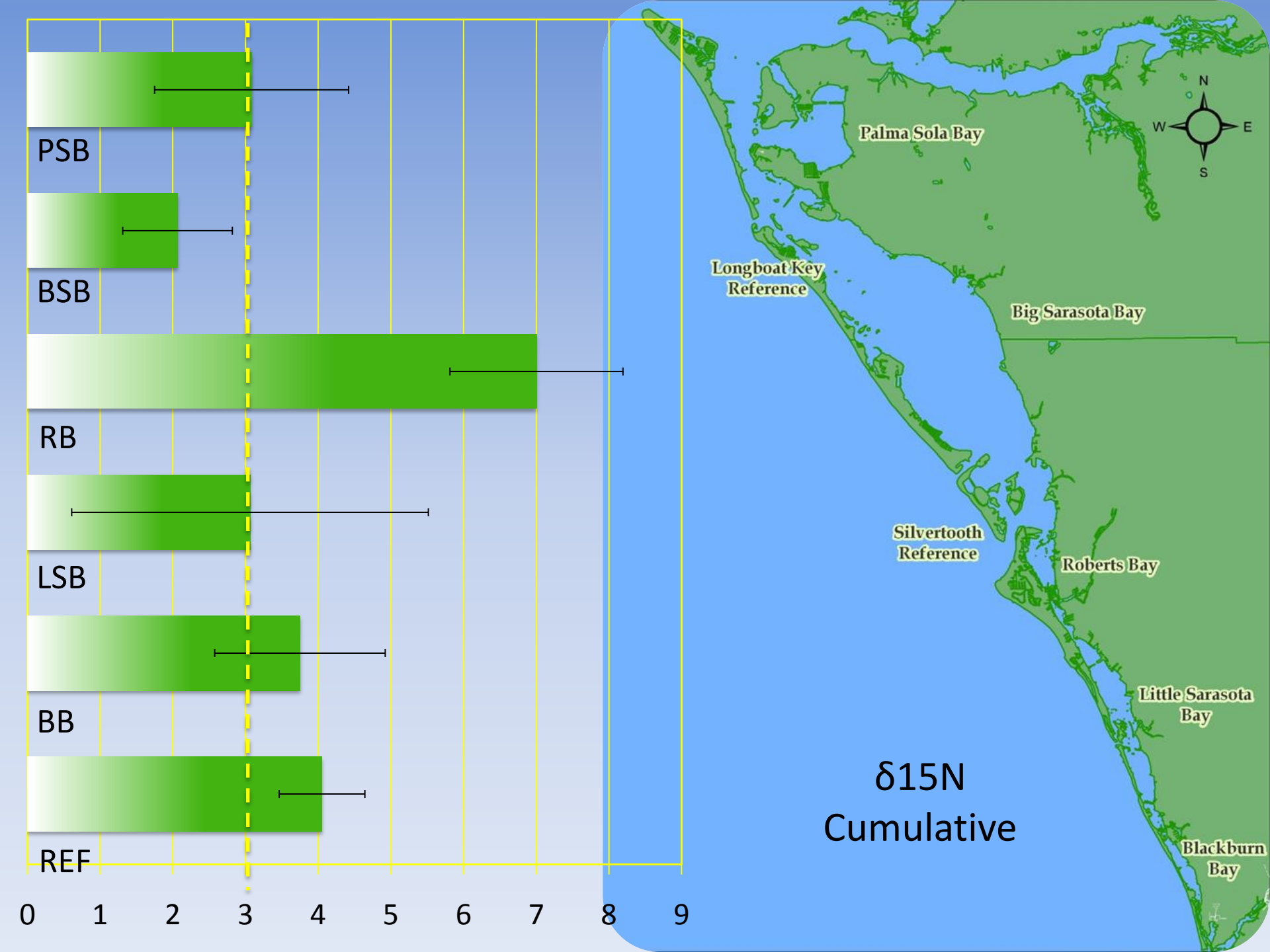
Water Quality Criteria for Tidal Creeks

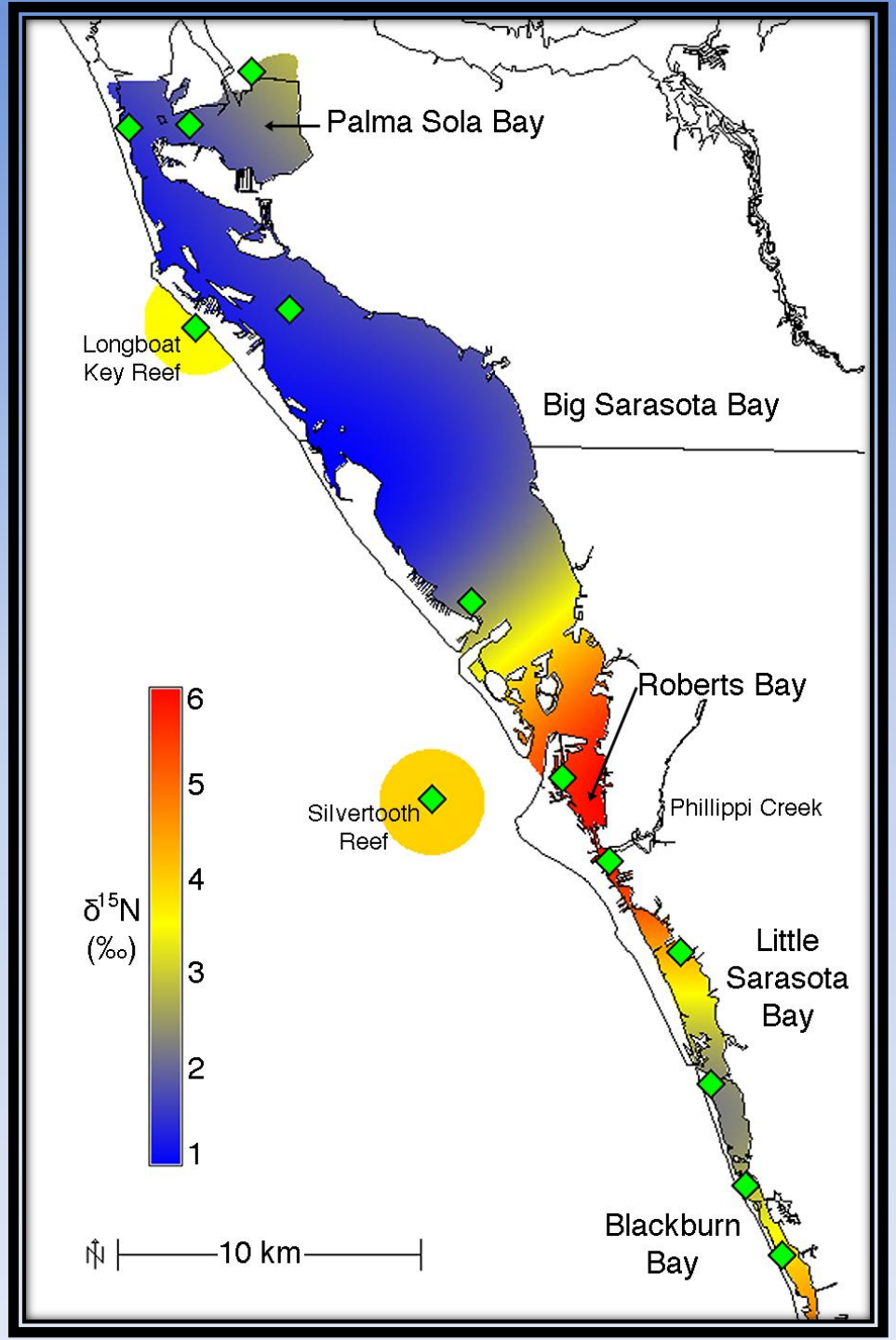
- Questions have been raised as to whether the numeric nutrient criteria proposed for the estuary proper should apply to tidal creeks that drain to the estuary
- Tidal creeks play an integral role in the ecological function of coastal estuaries
- Treatment of tidal creeks in implementing estuarine numeric nutrient criteria is, therefore, a significant issue

- NNC established for tidal creeks must consider the different ecological processes and functions that distinguish them from both from the freshwater systems upstream and the open estuary downstream
- Therefore, the SBEP recommended that unique NNC be established for tidal creeks

Sarasota Bay Macroalgae Study

- Collect macroalgae seasonally throughout Sarasota Bay
- Identify taxa and process for stable N isotope analysis to identify N source(s)
- Calculate %N, %C, and C:N ratio to gauge N-limitation
- Collect physical and biological data


PSB
BSB
RB
LSB
BB
REF
0
1
2
3
4
5
6
7
8
9
Palma Sola Bay
Longboat Key Reference
Big Sarasota Bay
Silvertooth Reference
Roberts Bay
Little Sarasota Bay
Blackburn Bay
N
W
E
S
δ15N
Cumulative



δ15N
July 2009

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