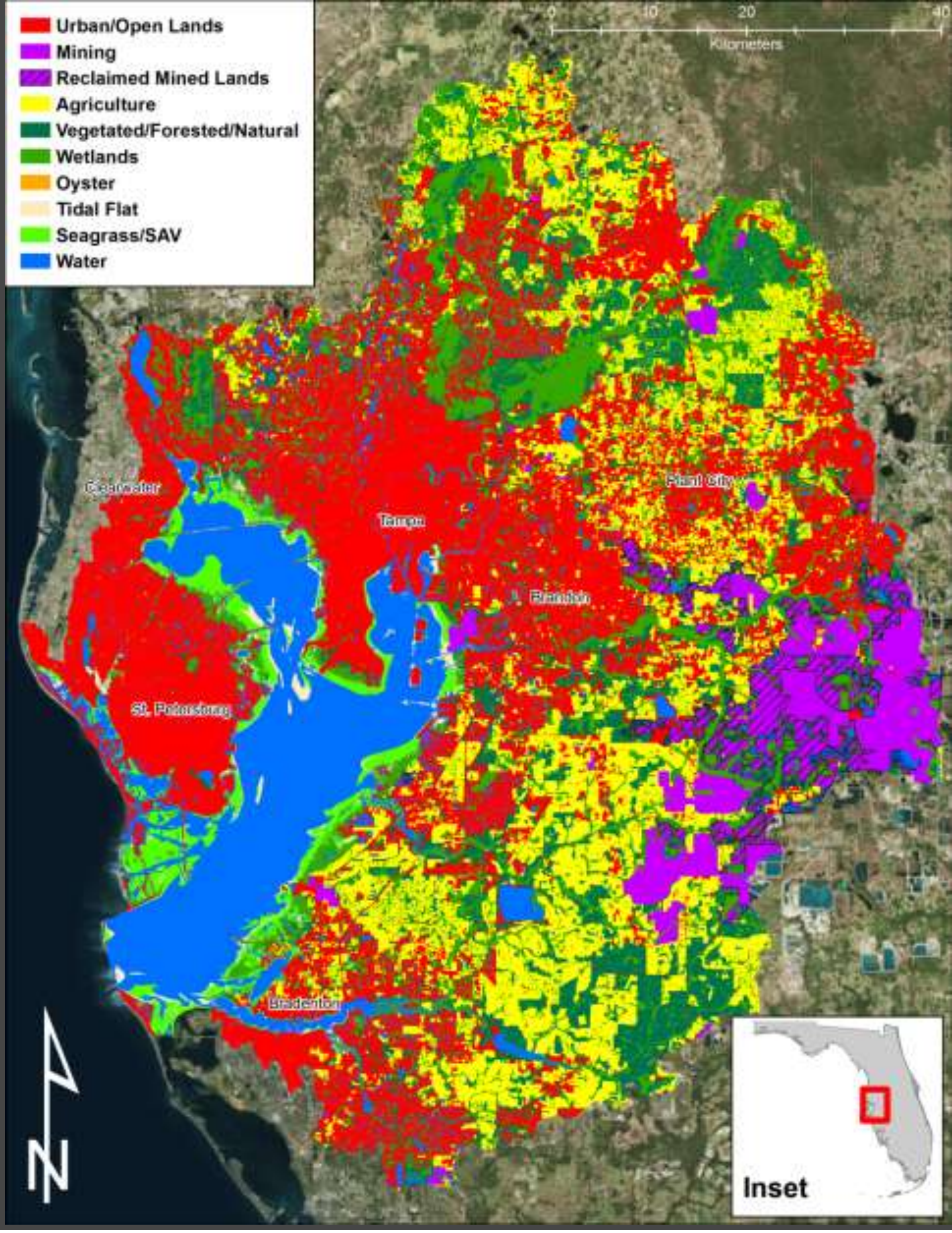
TAMPA BAY: ENVIRONMENTAL ISSUES, RESTORATION & SUSTAINING THE BAY'S RECOVERY

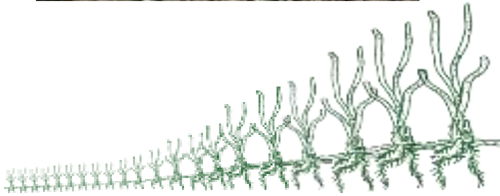


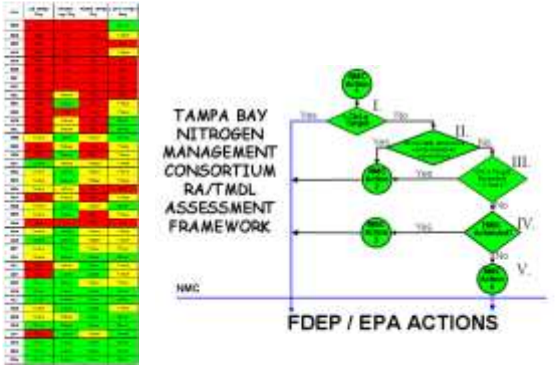
Ed Sherwood
Tampa Bay Estuary Program

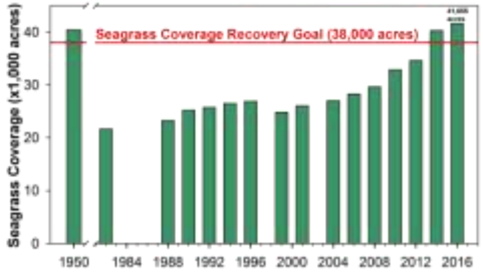
June13, 2017: CBP STAC

Overview

- A Polluted Bay
- A Call to Action
- Defining Resource Based Goals
- Identifying WQ Targets
- Measuring Success
- Measuring Compliance
- Achieving Results
- What Worked for Tampa Bay

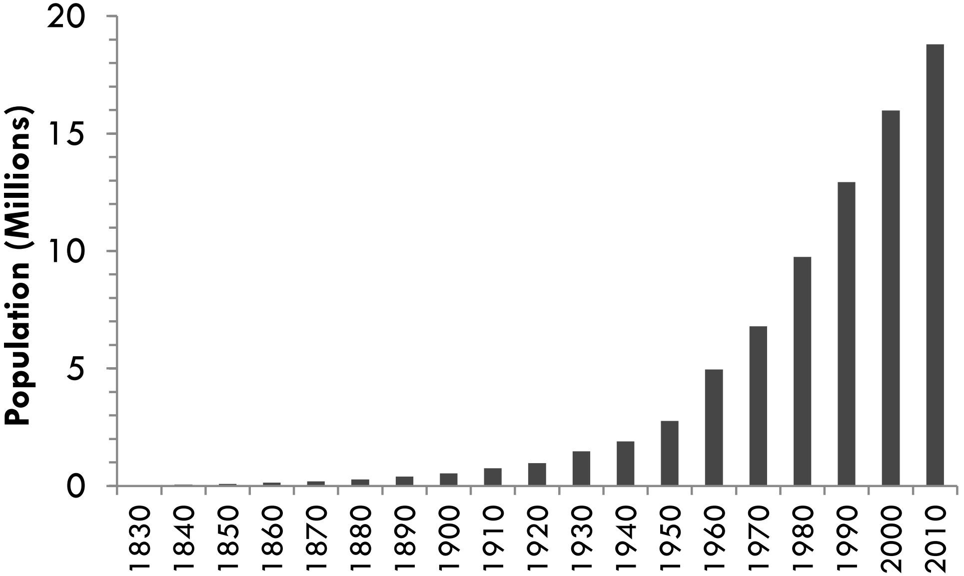






The Start of Tampa Bay's Problem

- Dr. John Gorrie, inventor of first mechanical air conditioning unit (1850s)
- Home air conditioners become increasingly available in 1950s
- Florida's population boom begins

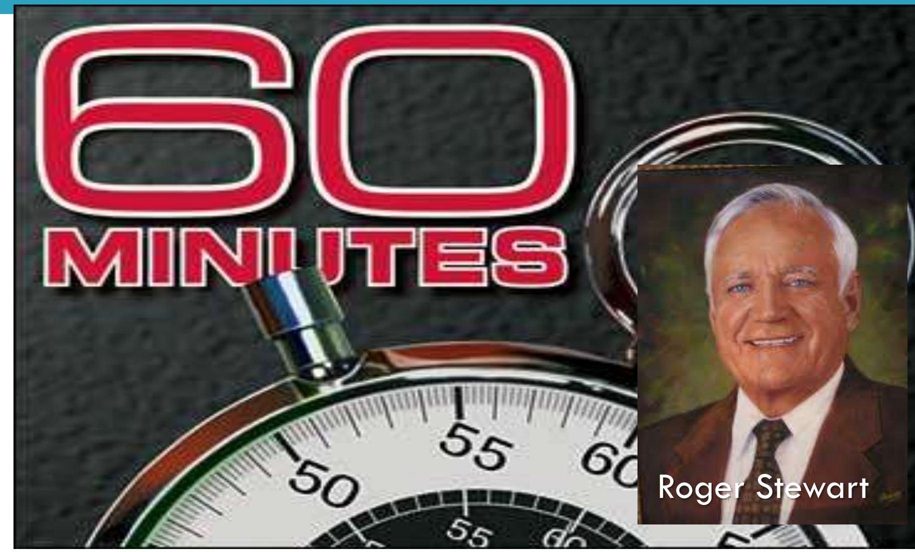


Tampa Bay in the 1970s - Early 1980s

- Poorly-treated Domestic Point Sources, Untreated Industrial Point Sources & Stormwater, Rampant Dredge & Fill Activities
- Phytoplankton and macroalgae dominated
- Loss of subtidal & emergent wetlands
- Newspapers declared Tampa Bay "dead"

Citizens Demanded Action (1970s -1980s)

- Citizens in Tampa (w/ water views) demanded legislative action
- Citizens desired a bay that resembled 1950s conditions, rather than the polluted condition of the 1970s - 1980s
- Led to Tampa Bay's first kick-start to recovery (Reduced DPS loads through FL Legislative Acts)

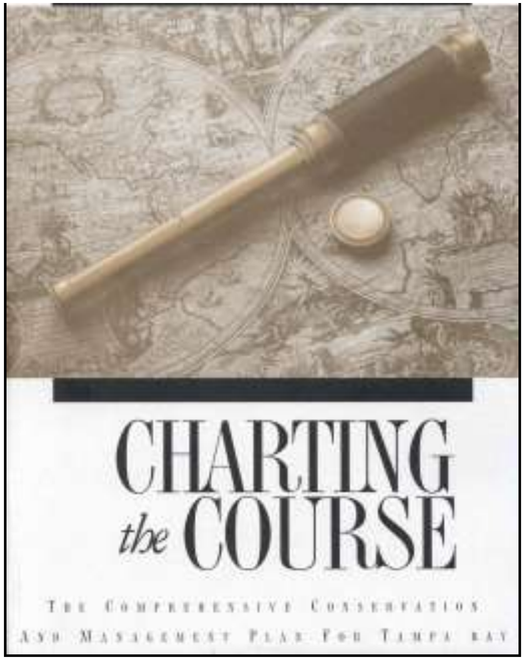


Tampa Bay Estuary Program: Regional Partnership Formation

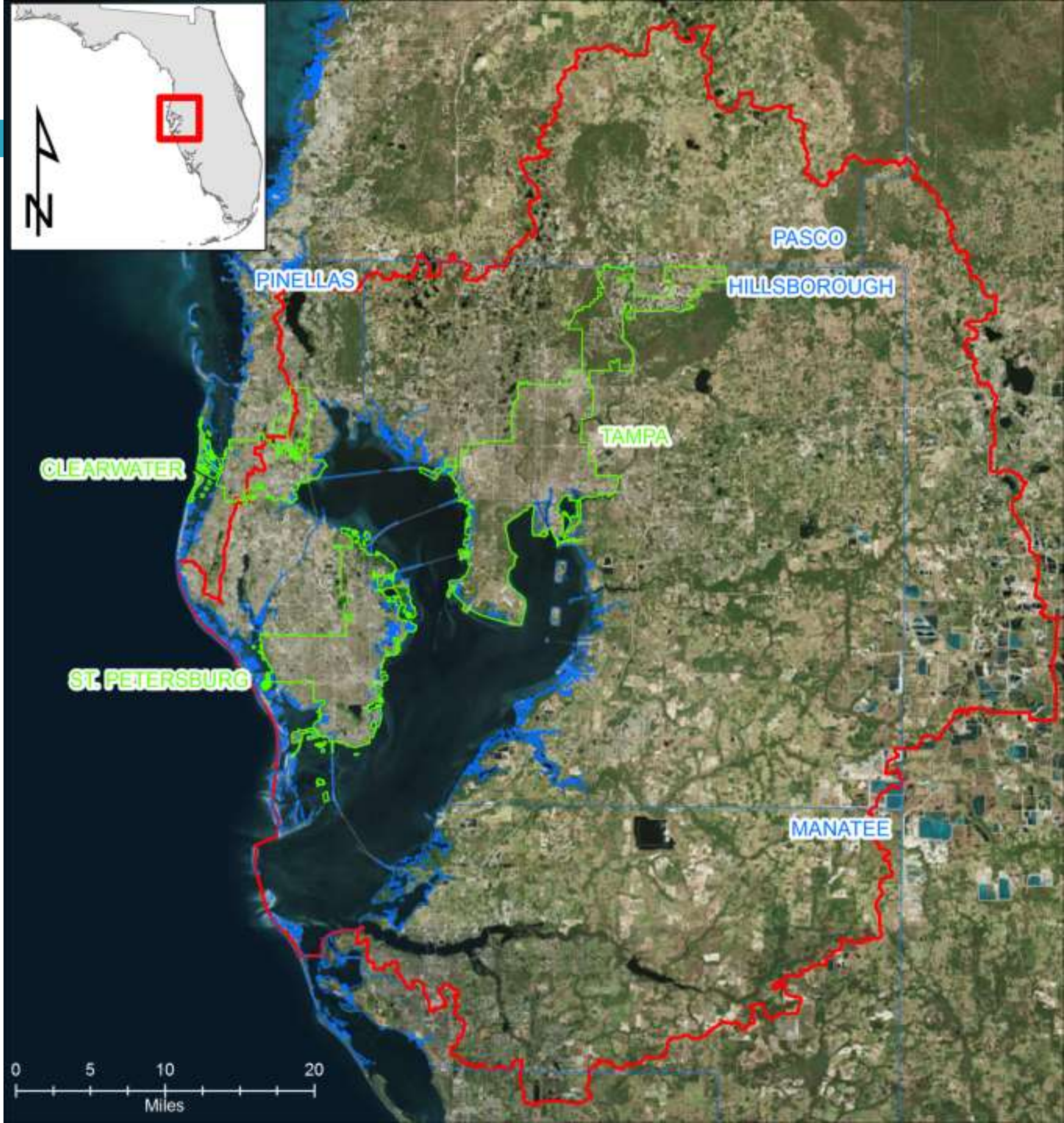
- Tampa Bay designated as an “estuary of national significance” in 1991 → Established as an NEP under U.S. EPA

- TBEP partners enter into an Interlocal Agreement (1998) forming an Independent Special District (Florida Statute 189)
  - Local funding commitments based on municipality population
  - Public sector reporting
  - Independent from State

- Mission: Develop and implement a science-based, management and restoration plan for the Tampa Bay estuary



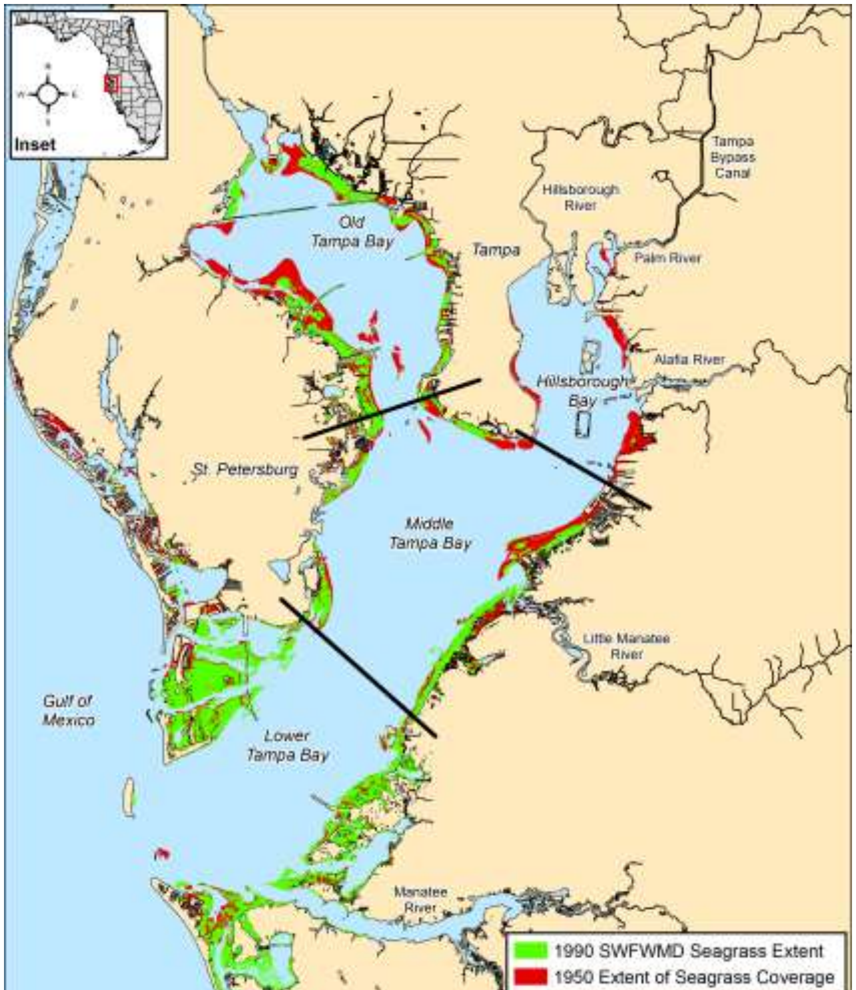
Partners

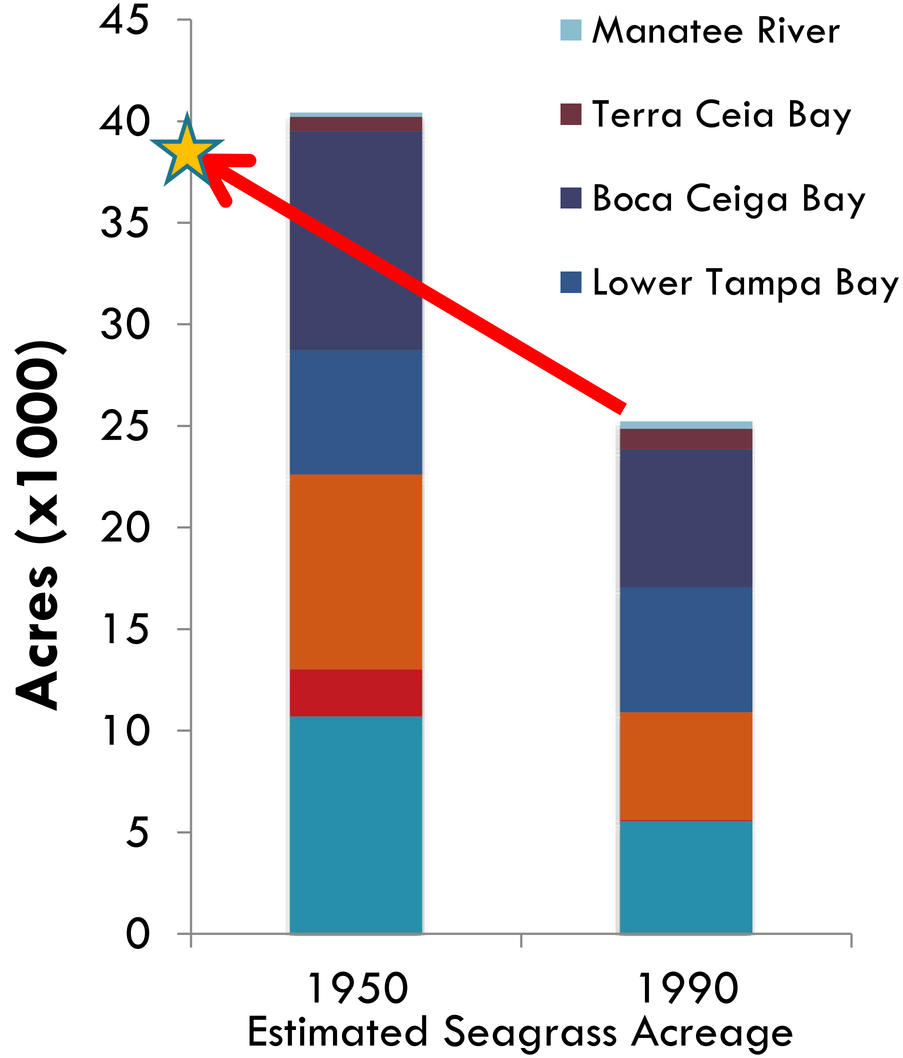


PASCO
PINELLAS
HILLSBOROUGH
TAMPA
CLEARWATER
ST. PETERSBURG
MANATEE
0
5
10
20
Miles

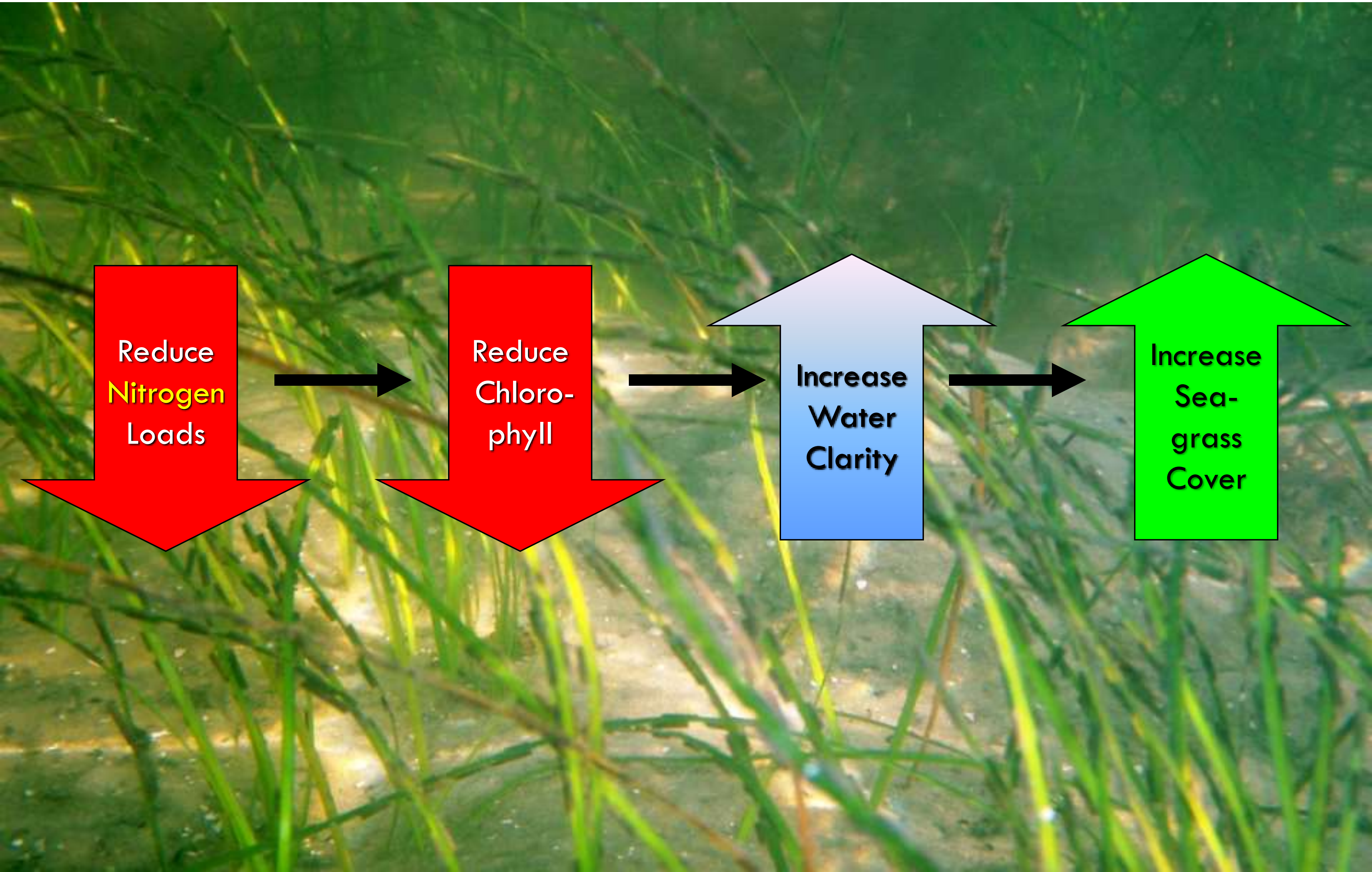
Restore Seagrass to Promote Overall Ecological Recovery

- 1950 Benchmark period (Complete aerial photos available)
- Protect & Restore Tampa Bay Seagrass to 95% of 1950s Levels (38,000 acres)



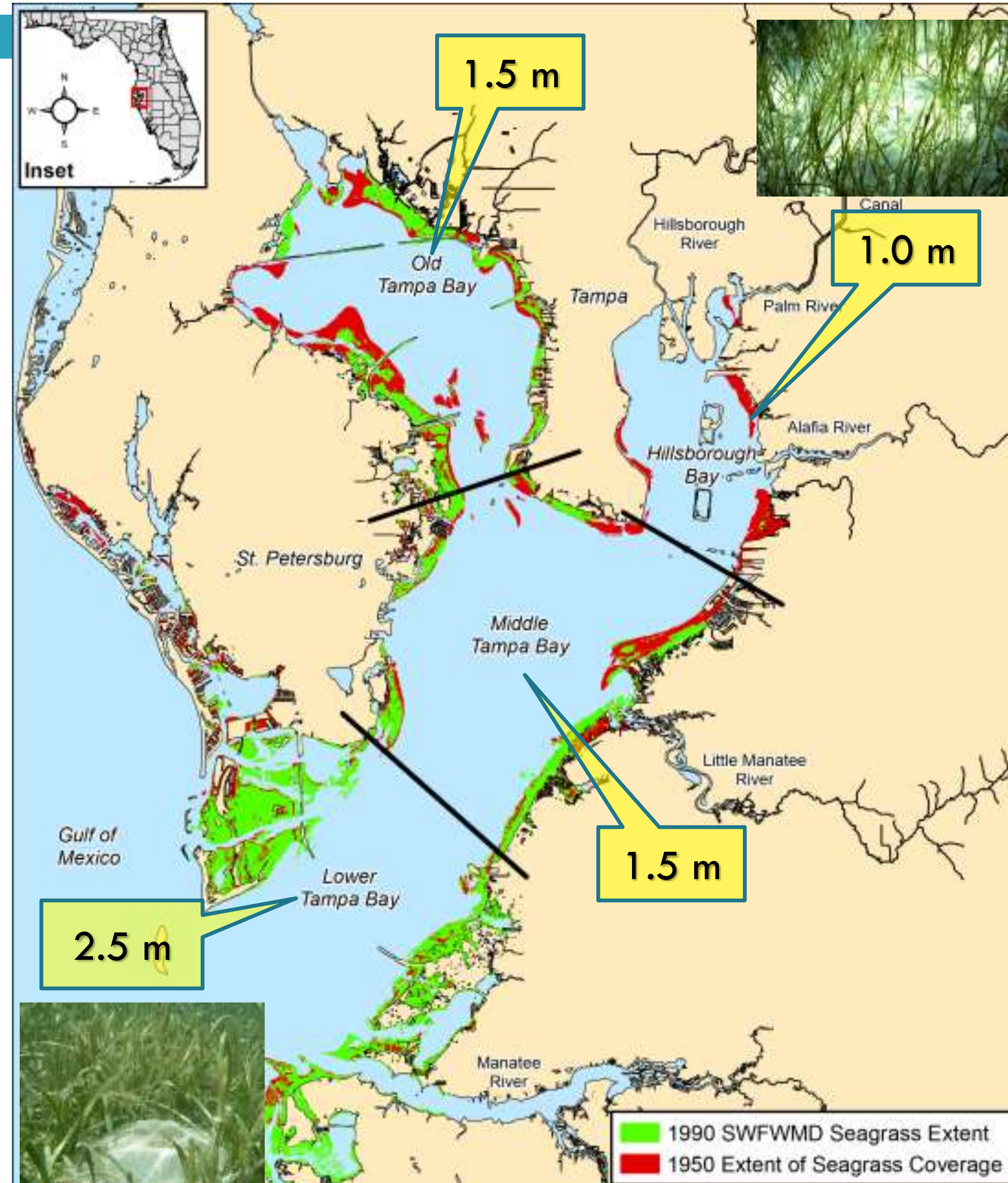


Tampa Bay Nitrogen Management Strategy



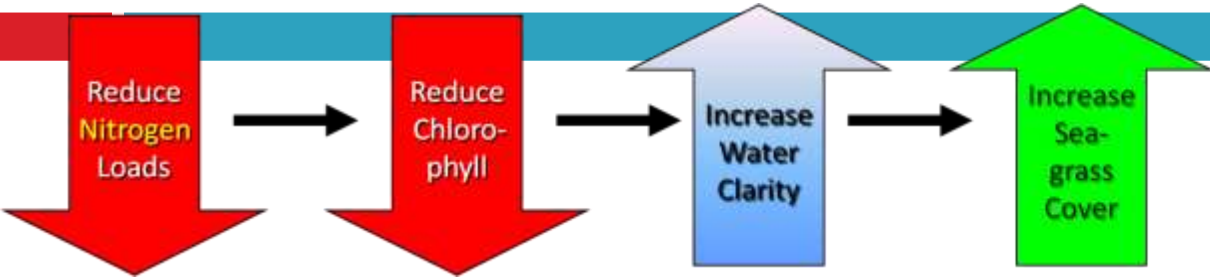
First-things-First: Necessary Light Conditions?

- Historic (1950) deep edge of seagrass extent guides water quality target development
- Bay's seagrass composition variable by major bay segment
- **~20-25%** incident light needed to maintain LTB seagrass (Dixon & Leverone 1995[a]; Dixon 1999)
- 20.5% incidence light used to develop criteria at historical target depths

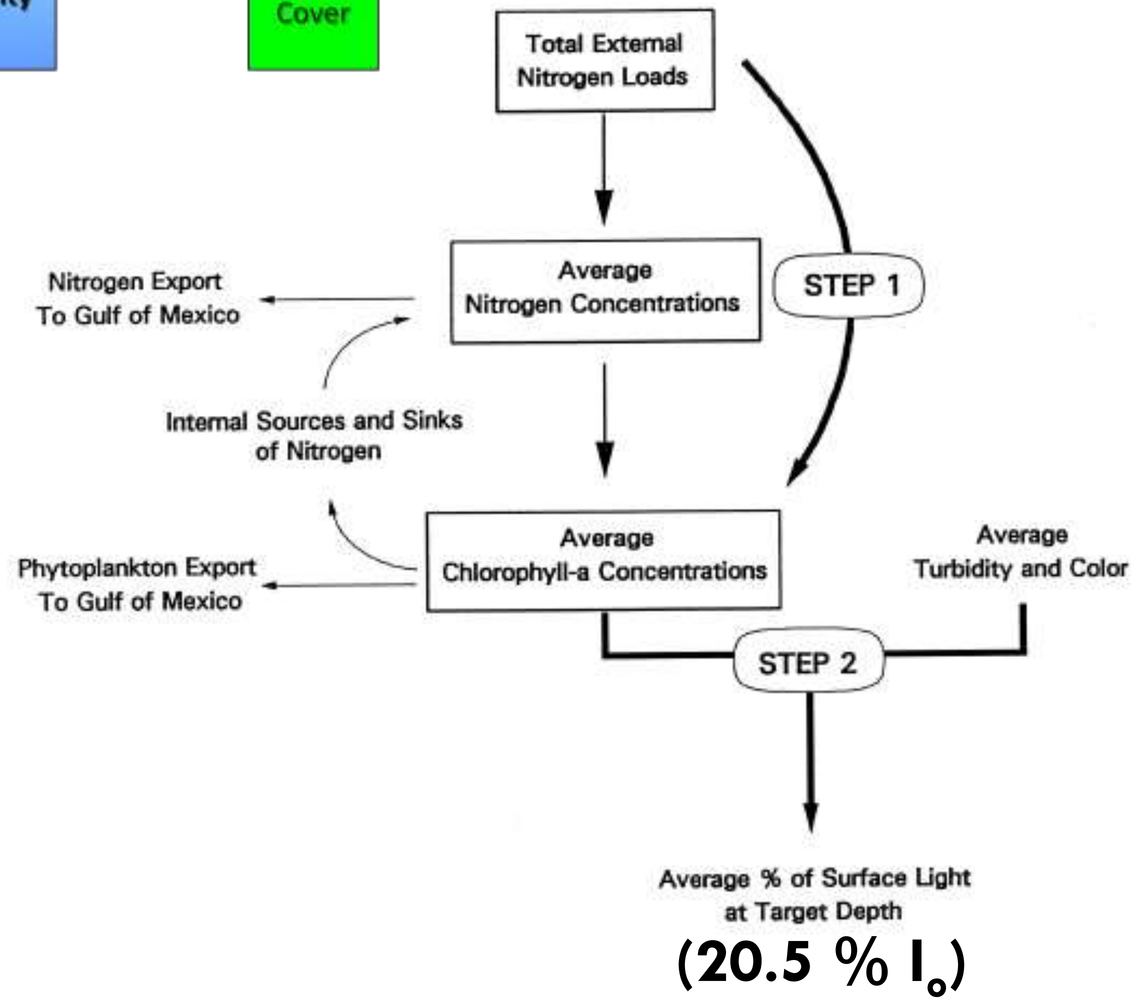


[a]https://dspace.mote.org/dspace/handle/2075/75

KISS: Empirical Modeling Approach Pursued



- Step 1:
  - TN Load to Chl-a Concentrations
- Step 2:
  - Chl-a to Light @ Depth Target

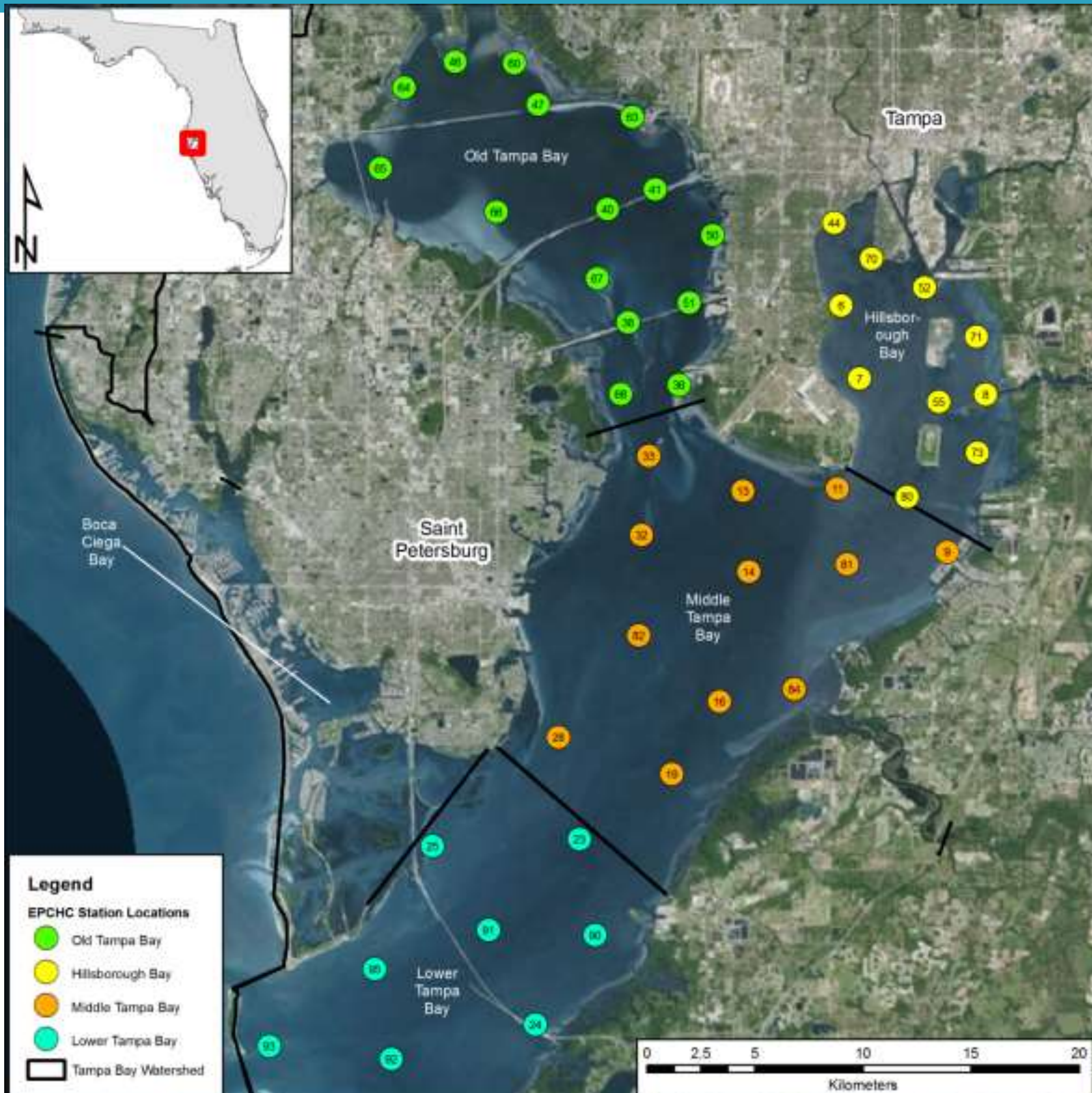


Janicki & Wade 1996: Estimating Critical N Loads for the Tampa Bay Estuary: An Empirically Based Approach to Setting Management Targets.
http://www.tbeptech.org/TBEP_TECH_PUBS/1996/TBEP_06_96ExternalTNLoads.pdf

Early Monitoring Provides Foundation for Target Development

- 1972: Hillsborough County establishes 53 fixed stations throughout Tampa Bay (now 254+ in watershed)

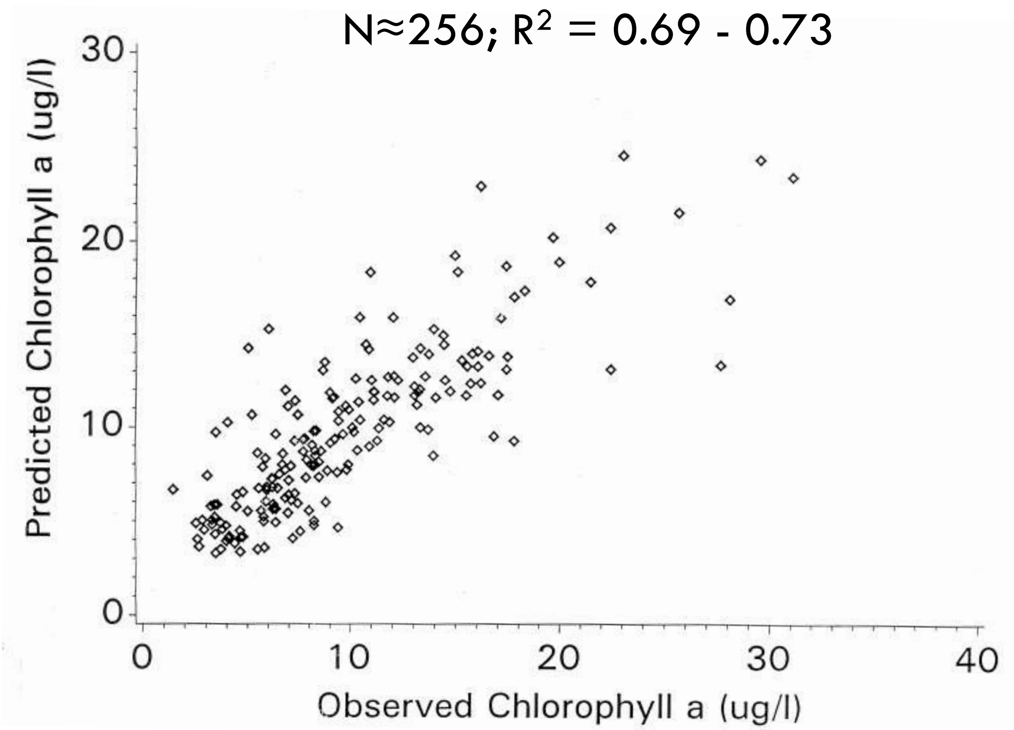
- 1990s: Other County programs established to fill-in spatial gaps (both fixed and stratified-random approaches employed)



Step 1: TN Load to Chl-a Relationships

- Monthly TN Loading Data
  - Industrial Point Sources
  - Domestic Point Sources
  - Atmospheric Deposition
  - Non-Point Sources (all watershed loads)
  - Port Fertilizer Losses
  - Groundwater
  - Springs
- *Various Monthly TN Load Lags Tested
- Monthly Chl-a Data
  - 45 Stations in 4 Main Bay Segments
- 1985-1994 Data Used

$$(Chl\ a)_{t,s} = \alpha_{t,s} + \beta_s \cdot (TN\ Load)_{t*,s}$$

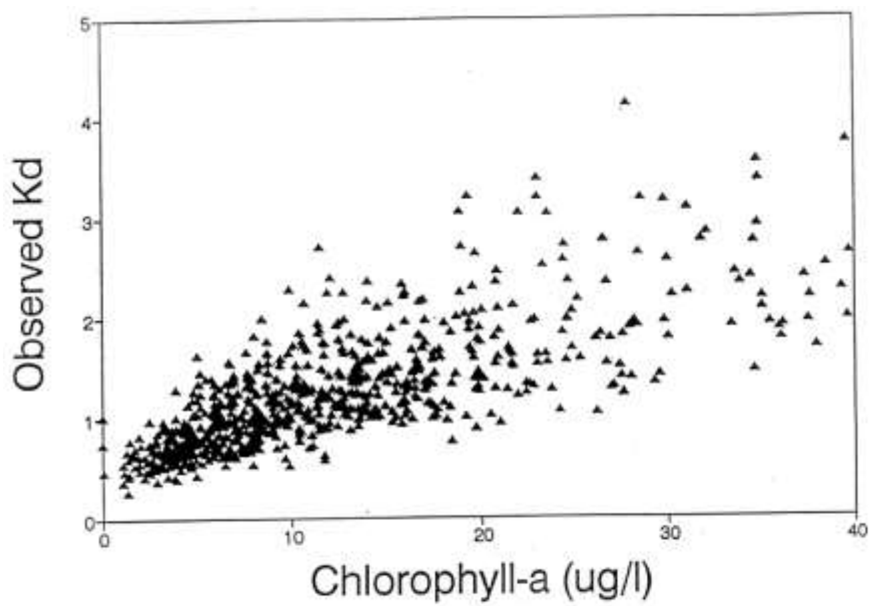


Step 2: Z (Light @ Target Depth) to Chl-a Relationships

- Monthly Chl-a Data
  - 45 Stations in 4 Main Bay Segments
- Monthly Secchi Disk depths utilized to approximate K_d
  - Beer's Law used to calculate Z at 20.5%
- Turbidity and Color also important WQ parameters & assessed in regressions
- 1974-1994 Data Used

$$\ln(Chl\ a)_{t,s} = \alpha_{t,s} + \beta_s \cdot \ln(Z_{t,s})$$

N≈787; $R^2 = 0.67$



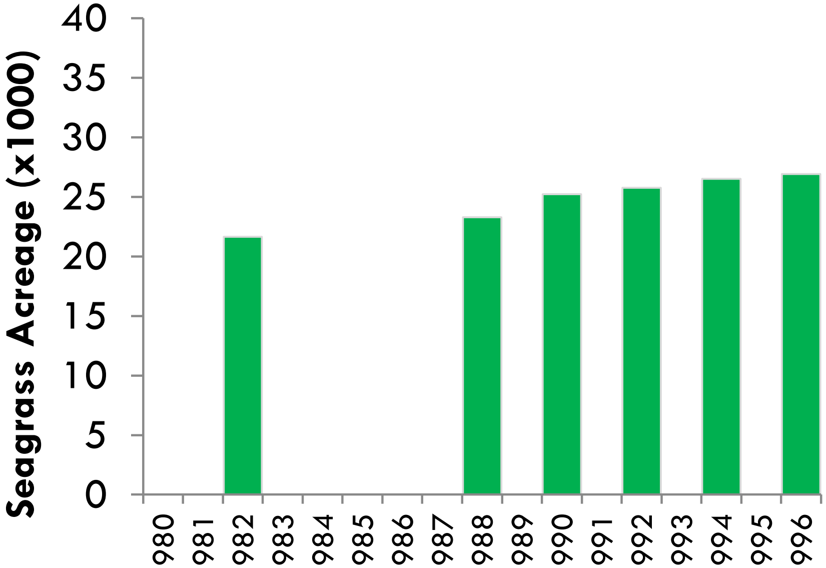
Water Qual. Management Targets Defined

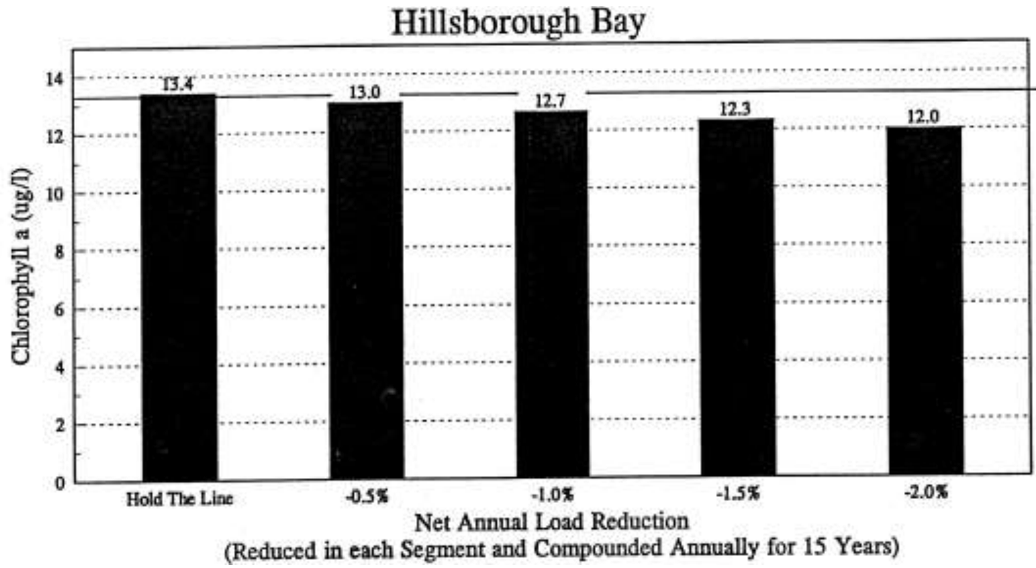
- Seagrass coverage extent improved from 1990-1996
- Either empirical estimates or mean observed levels selected

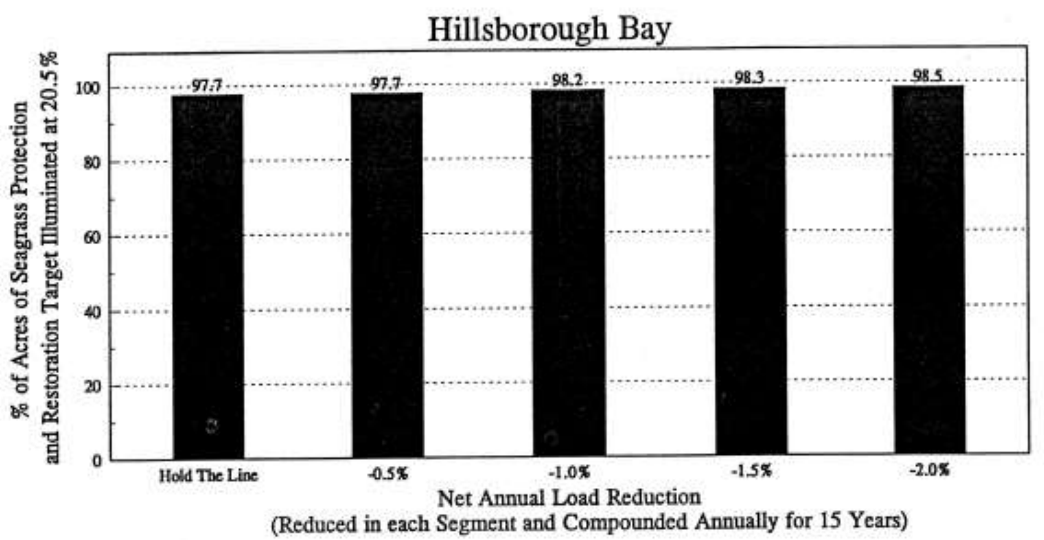
Chlorophyll-a (ug/L)	Old Tampa Bay	Hillsborough Bay	Middle Tampa Bay	Lower Tampa Bay
Mean 1992-1994 (95% C.I.)	**8.5** (8.2-8.8)	**13.2** (11.9-14.5)	8.1 (7.3-8.9)	4.8 (4.5-5.0)
Required Level to Reach 90% of Recovery Goal Illuminated at 20.5% Light (95% C.I.)	10.3 (9.6-11.1)	17.6 (15.7-19.7)	8.6 (7.7-9.6)	5.4 (4.1-7.1)
Required Level to Reach 95% of Recovery Goal Illuminated at 20.5% Light (95% C.I.)	9.2 (8.7-9.8)	16.1 (14.6-17.8)	**7.4** (6.8-8.0)	**4.6** (4.0-5.2)

TN Load Management Plan: "Hold the Line"

- Realistic load reduction scenarios empirically modeled
- "Hold the Line" considered a viable option as seagrass extent was improving







Janicki & Wade 1996

Beginning of TB's Collaborative Approach

- Public sector realized that nitrogen management goals were unattainable without private sector help

- Private sector invited to participate with the public sector in the voluntary "Tampa Bay Nitrogen Management Consortium"

- Each partner contributed to nitrogen management goal as they were able – at the time no requirements or allocations

Tampa Bay Nitrogen Management Consortium

- Formed in 1998, now includes 45+ public/private partners
- Members include TBEP government and regulatory agency participants, local phosphate companies, agricultural interests and electric utilities
- Mid-1990s, collectively accepted responsibility for meeting nitrogen load reduction goals
- Consortium members may choose to implement any combination of projects to maintain loads to Tampa Bay at 1992-1994 levels

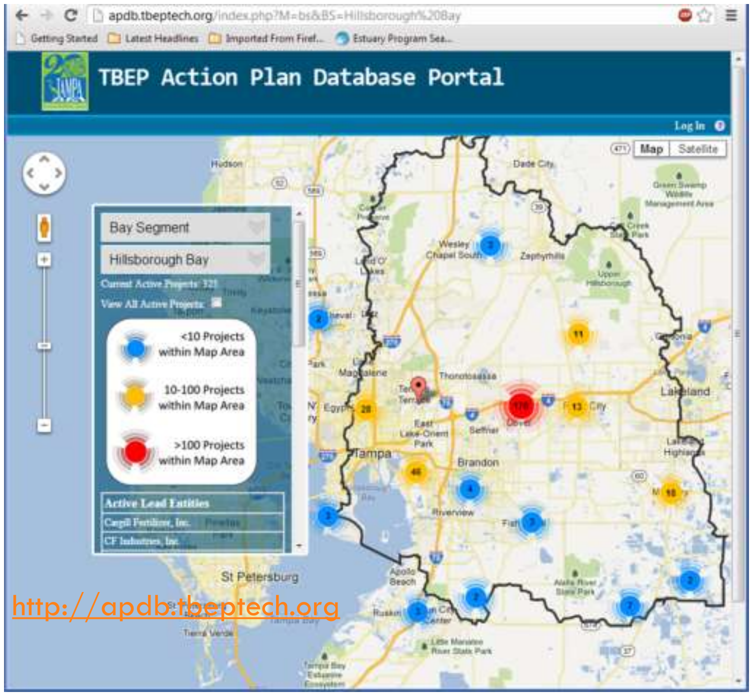
Public Partners:

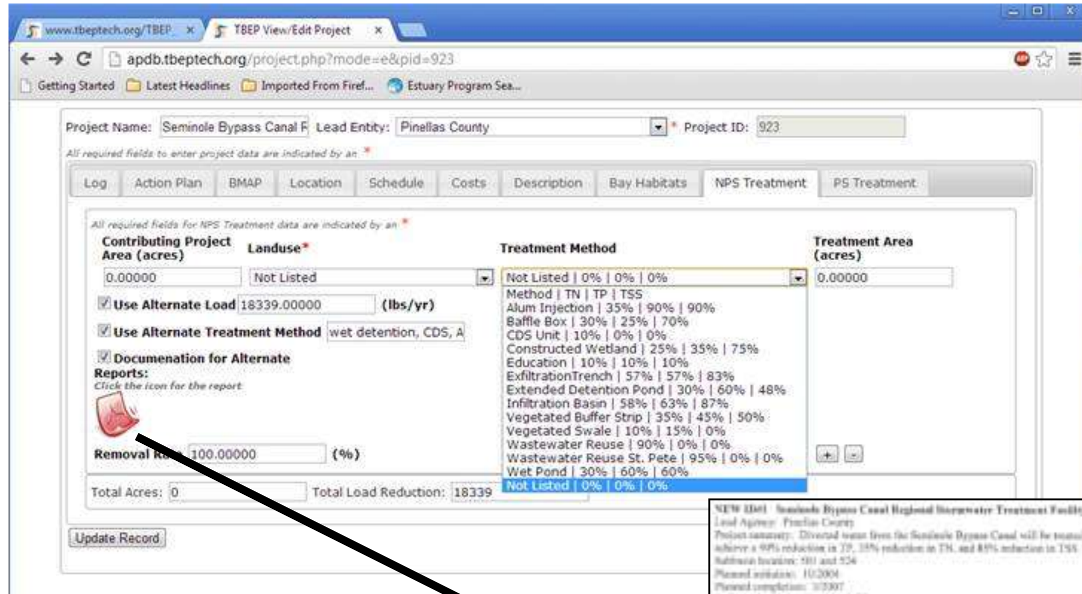
- Hillsborough County
- Manatee County
- Pinellas County
- Pasco County
- Polk County
- Sarasota County
- City of Tampa
- City of St. Petersburg
- City of Clearwater
- City of Palmetto
- City of Bradenton
- City of Largo
- City of Lakeland
- City of Oldsmar
- City of Gulfport
- City of Mulberry
- City of Plant City
- City of Safety Harbor
- SWFWMD
- US EPA
- FDEP
- FDACS
- FDOH
- FDOT
- MacDill AFB
- TBRPC
- Tampa Bay Water
- Tampa Port Authority
- EPC of Hillsborough County
- AEDC of Hills. County

Private Partners:

- Eastern Terminals
- Mosaic
- CSX Transportation
- Florida Power & Light
- CF Industries
- Tampa Electric Co.
- Kinder Morgan Bulk T., Inc.
- Duke Energy
- Tropicana Products, Inc.
- Kerry I&F
- Trademark Nitrogen
- Yara N.A.
- Alafiia Preserve, LLC
- Eagle Ridge, LLC
- LDC Donaldson Knoll Investments, LLC

Partner-Driven Load Reduction Reporting





- Partners can enter either NPS or PS load reductions
- Default calculations and BMP efficiencies used based on land use, subbasin, and treatment method
- User-defined efficiencies & reductions can also be entered
- TBEP collates and reports by major bay segment
- **1990-2017: 450+ Projects, 534 Tons TN Prevented from entering TB**

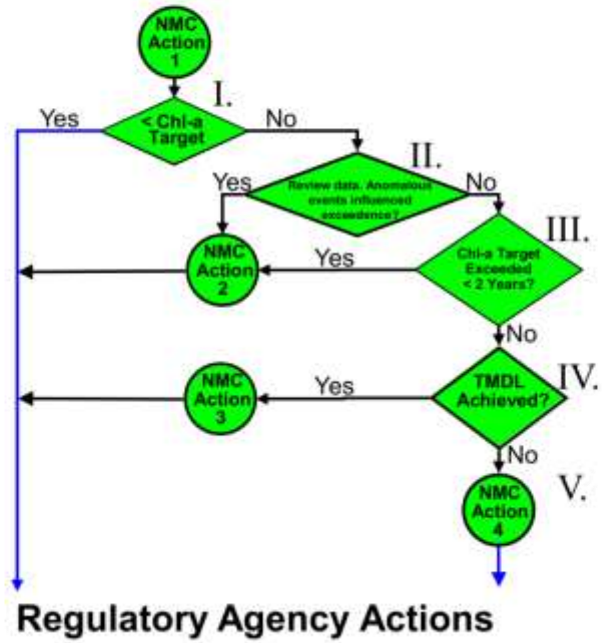
- Guidelines for Calculating Nitrogen Load Reduction Credits. 1997. Technical Report #02-97 of the Tampa Bay National Estuary Program. Prepared by Coastal Environmental (H.W. Zarbock and A.J. Janicki).

Voluntary Actions Become Regulatory Requirements

- In mid-1990s, TBEP established goal to “Hold the Line” on TN loadings to the bay & preclude 17 tons TN / yr from entering bay to offset anticipated loads from continued growth
- 1998 – TMDL for TN first established by EPA (based on 1992-1994 TN loads to Tampa Bay)
- 2002 – NMC and TBEP granted “Reasonable Assurance” that TB will meet State WQ Criteria for Nutrients
- 2007 – FDEP and EPA require allocations to be developed to meet federal TMDL and continue State “Reasonable Assurance” determination
- 2009 – NMC voluntarily developed TN load allocations to 189+ sources in the bay; Effectively capping TN loads
- 2012/17 – Providing 5-yr Reasonable Assurance Updates to FDEP/EPA

If WQ is Poor, Regulatory Steps Now Required (2009 – Present)

- Triggered when Chl-a above thresholds for 2 straight years
- Bay Segment / Entity TN Loads investigated
- May require further adjustment of TN TMDL and/or Entity-Specific Load Allocations



NMC Action 1: Document annual bay segment specific chlorophyll-a levels relative to regulatory thresholds using the long-term EPCHC monitoring dataset.

NMC Action 2: A full report of the anomalous event(s) or data which influenced the annual bay segment chlorophyll-a exceedence will be delivered to regulatory agencies after TBNMC review.

NMC Action 3: Consider re-evaluation of the bay segment assimilative capacity based on nonattainment of bay segment chlorophyll-a threshold while meeting federally-recognized TMDL.

NMC Action 4: If federally-recognized TMDL not achieved, compile nitrogen load data for regulatory review and identify potential further actions needed to achieve reasonable assurance for bay segment nitrogen load allocations.

Assessment Step Linked to Roman Numerals of Figure Above	Result	Action
I. Determine annual bay segment specific chlorophyll-a regulatory threshold attainment.	Yes	NMC Action 1
	No	NMC Action 1
II. Review data and determine if an anomalous event(s) influenced non-attainment of the bay segment specific chlorophyll-a threshold.	Yes	NMC Action 2
	No	Go to III.
III. Determine if the chlorophyll-a thresholds have been exceeded for <2 consecutive years.	Yes	NMC Action 2
	No	Go to IV.
IV. Determine if the bay segment specific federally-recognized TMDL has been achieved.	Yes	NMC Action 3
	No	Go to V.
V. For a given year or for multiple years, compile and report entity-specific combined source loads in comparison to source allocations.	Compile & Report	NMC Action 4

Adopted Water Quality Targets & Thresholds

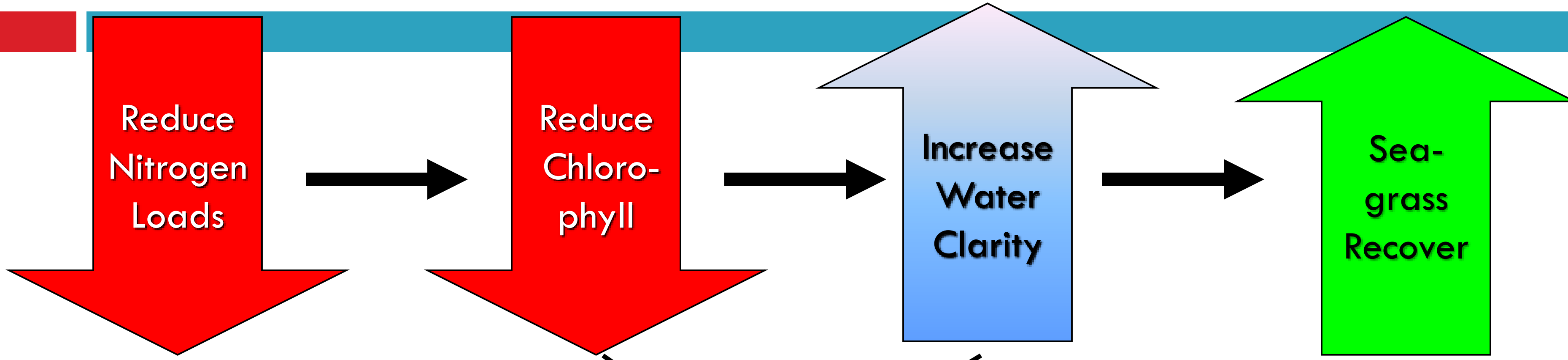
	TBEP Management Targets Established ~2000 (Desired Bay Conditions)		Regulatory WQ Threshold Adopted 2002 (Adverse Impacts Expected)	Regulatory NNC Adopted 2012
Bay Segment	Chl-a Management Target (ug/L)	K_d (m^{-1}) Management Target	Chl-a Regulatory Threshold (ug/L)	TN Load Delivery (tons / million m^3 FW)
Old Tampa Bay	8.5	0.83	9.3	1.08
Hillsborough Bay	13.2	1.58	15.0	1.62
Middle Tampa Bay	7.4	0.83	8.5	1.24
Lower Tampa Bay	4.6	0.63	5.1	0.97

Annual TBEP WQ Report Card

Assess Annual TN Load Reduction Effectiveness

Assess TMDL Compliance (Contingent on >2yr poor WQ)

Summary: Tracking our Progress



- Limits (voluntarily) and proactively developed by NMC local partners
- Regulatory agencies partner in the process
- Load allocation targets periodically re-assessed

- Local-programs consistently monitor water quality since 1970's
- Bay-Segment Specific Annual Targets Developed
- Targets tied to Seagrass Restoration Goal

- Regional-program consistently estimates seagrass coverage since 1980's
- Restoration endpoint clearly defined

Bottom Line

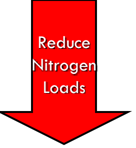
5-Yr Annual Assessment;
Tied to Observed Bay Conditions

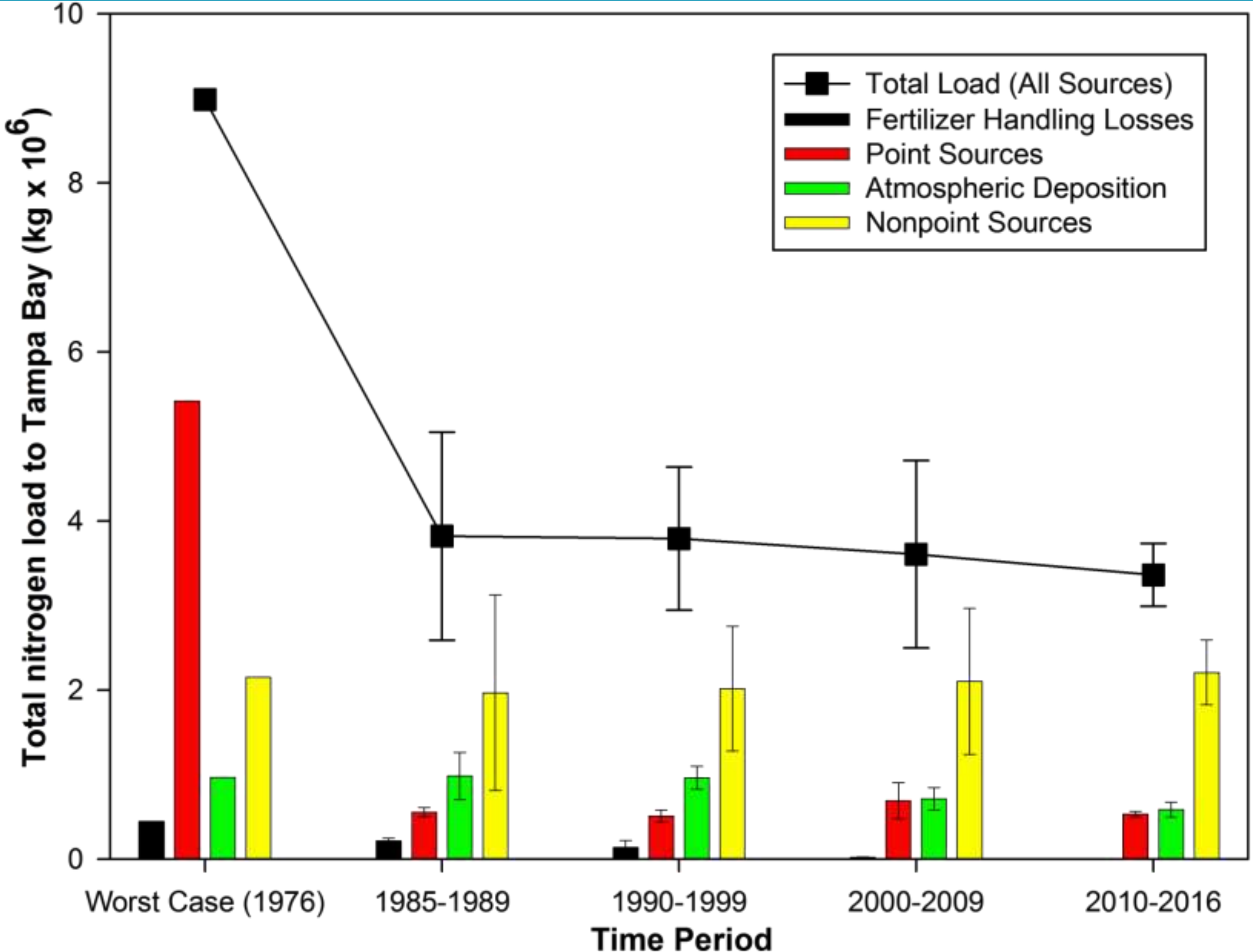
Annually-Assessed;
Localized Management Responses Implemented, if necessary

~2-Yr Assessment;
Water-quality Targets Re-Evaluated, if necessary

So What: Has it Worked?

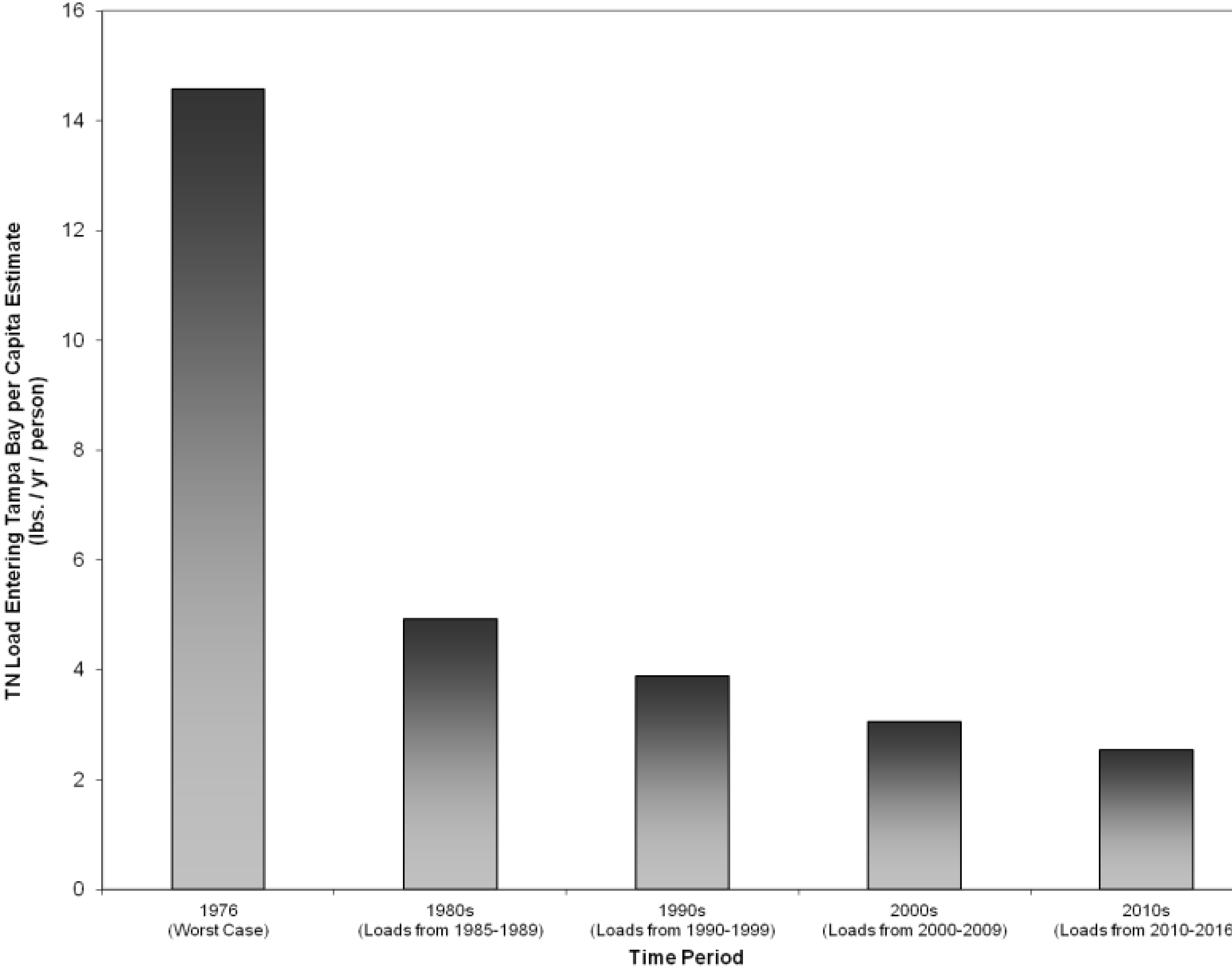
Reduced Nitrogen Loads to Tampa Bay





Reduce Nitrogen Loads

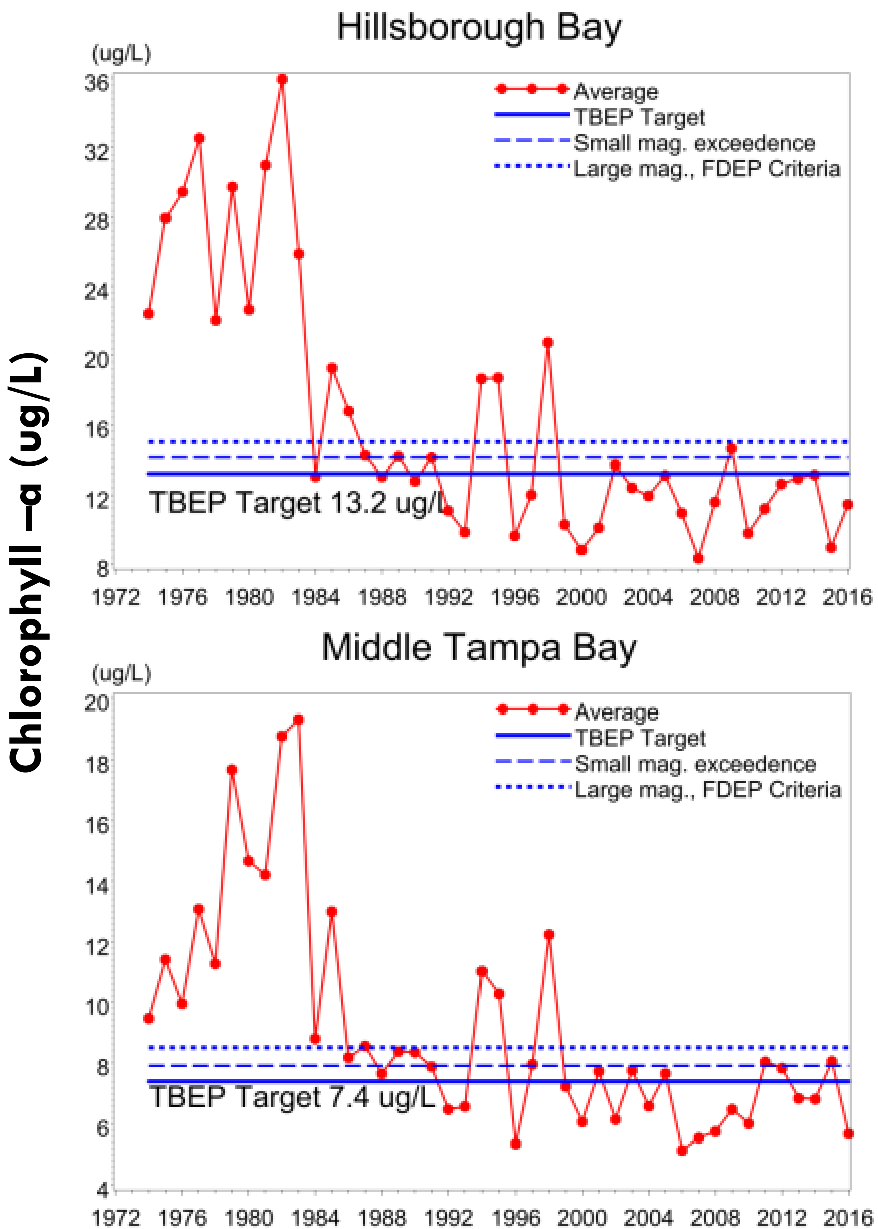
Reduced Per Capita TN Loads to TB



Reduce Chlorophyll

Water Quality Has Improved

Increase Water Clarity



AWT & Reuse Standards Implemented

Stormwater Regulations Enacted

TBEP Partner & NMC Actions Implemented

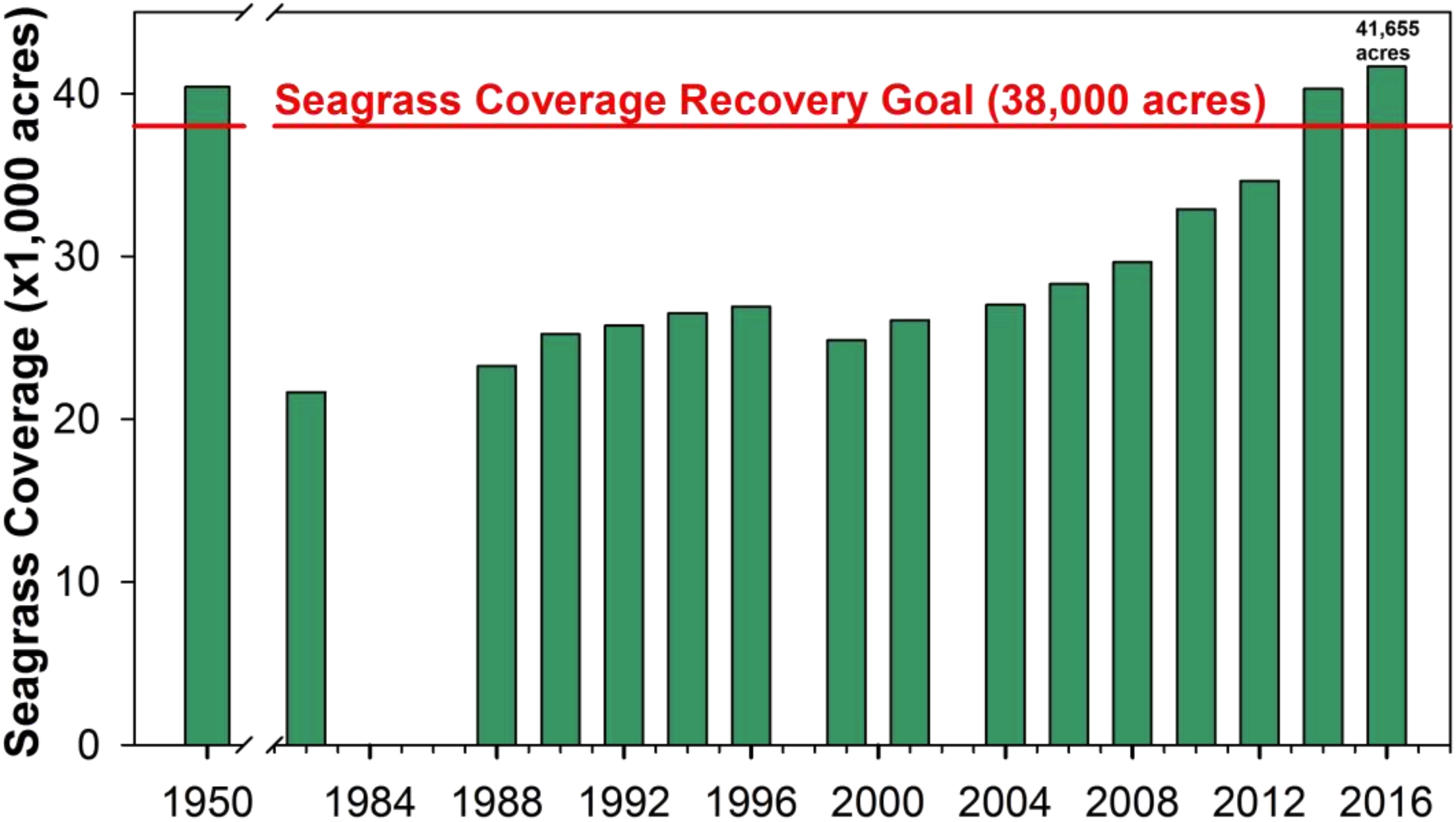
Power Plant Upgrades

Port Facility Upgrades

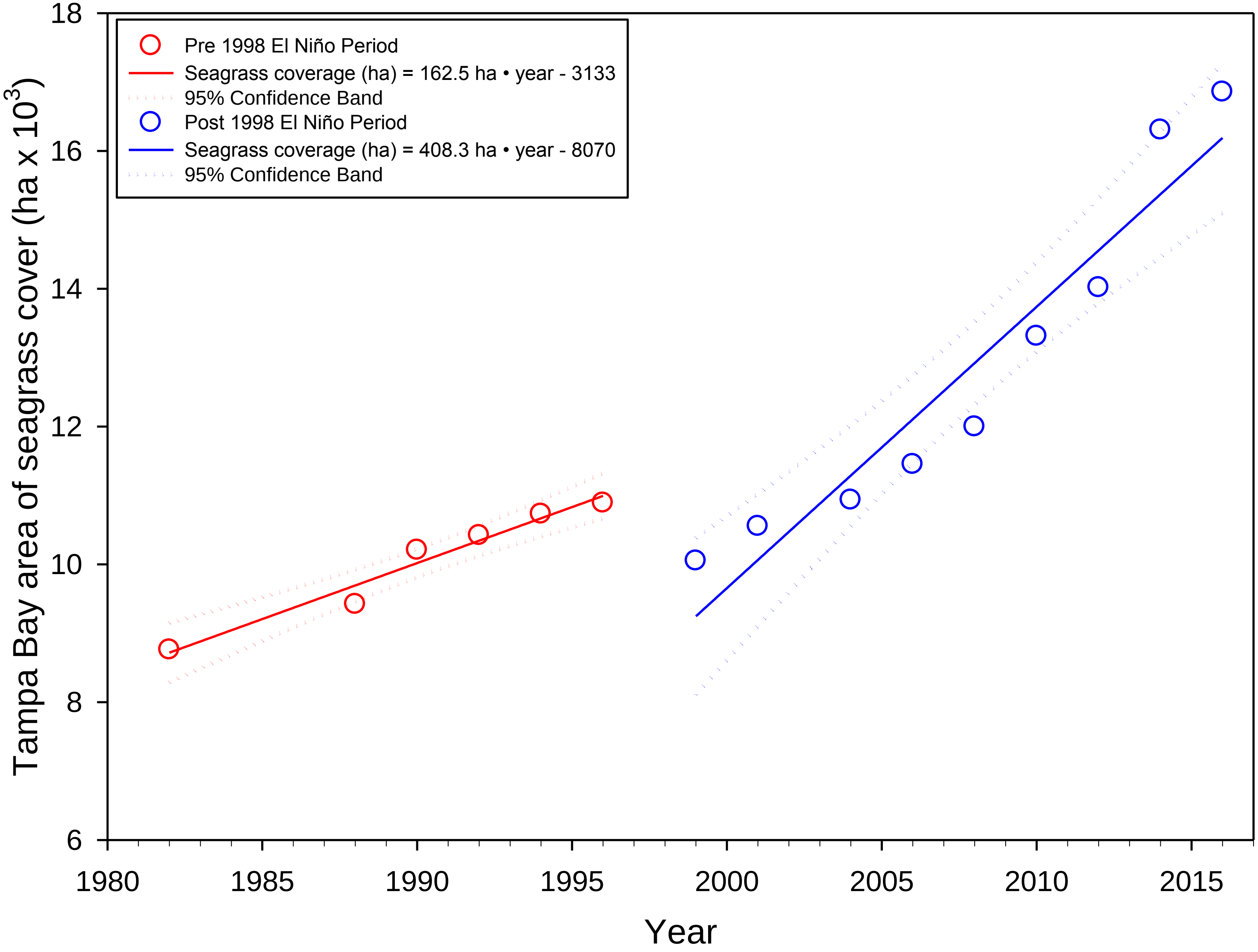
Fertilizer Restrictions

Year	Old Tampa Bay	Hillsborough Bay	Middle Tampa Bay	Lower Tampa Bay
1975	Red	Red	Red	Green
1976	Red	Red	Red	Yellow
1977	Red	Red	Red	Red
1978	Red	Red	Red	Yellow
1979	Red	Red	Red	Red
1980	Red	Red	Red	Red
1981	Red	Red	Red	Red
1982	Red	Red	Red	Red
1983	Red	Yellow	Red	Red
1984	Red	Green	Red	Yellow
1985	Red	Red	Red	Yellow
1986	Red	Yellow	Red	Green
1987	Red	Yellow	Red	Green
1988	Yellow	Green	Yellow	Green
1989	Red	Yellow	Red	Yellow
1990	Red	Green	Red	Yellow
1991	Green	Yellow	Yellow	Yellow
1992	Yellow	Green	Yellow	Yellow
1993	Yellow	Green	Yellow	Yellow
1994	Yellow	Yellow	Red	Red
1995	Red	Yellow	Red	Yellow
1996	Yellow	Green	Yellow	Green
1997	Yellow	Green	Red	Yellow
1998	Red	Red	Red	Red
1999	Yellow	Green	Yellow	Yellow
2000	Green	Green	Yellow	Yellow
2001	Yellow	Green	Yellow	Yellow
2002	Yellow	Green	Green	Green
2003	Red	Yellow	Green	Yellow
2004	Red	Green	Green	Yellow
2005	Green	Green	Yellow	Yellow
2006	Green	Green	Green	Green
2007	Green	Green	Green	Green
2008	Yellow	Green	Green	Yellow
2009	Yellow	Yellow	Green	Green
2010	Green	Green	Green	Green
2011	Red	Green	Yellow	Green
2012	Green	Green	Green	Green
2013	Green	Green	Green	Green
2014	Green	Green	Green	Green
2015	Yellow	Green	Yellow	Green
2016	Yellow	Green	Green	Green

Seagrass Coverage Now Exceeds Recovery Goal & 1950s Benchmark Period Extent

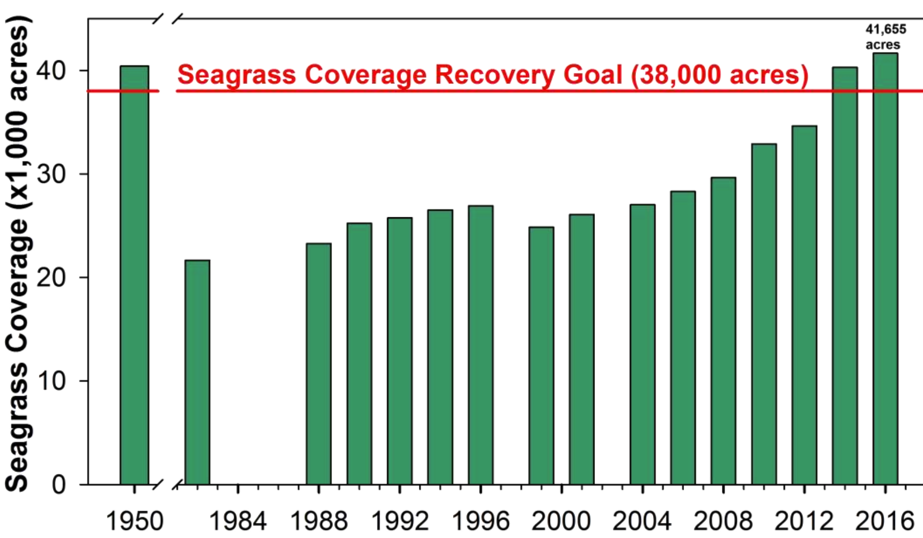


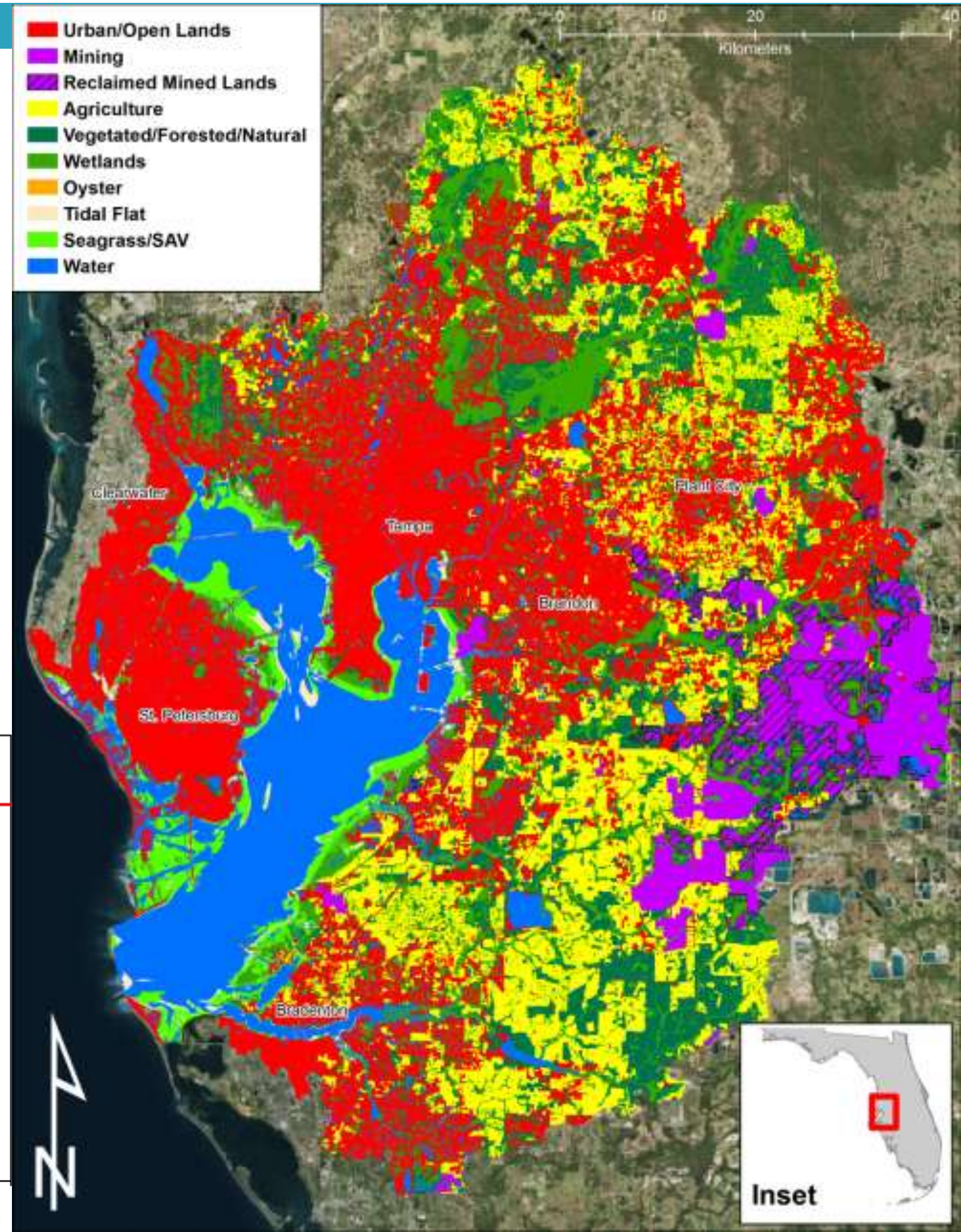
Positive Feedbacks from Continuing Seagrass Recovery?



Tampa Bay 2017: A Recovering Urban Estuary

- Urban Centers in Pinellas County & City of Tampa
  - 43% Urb. / Suburban Lands
  - 20% Ag. / 5% Mining Lands
- Successful estuarine recovery despite continued population growth from 1980 – 2017
- Metro Pop. = 3,030,953 (+~7% since 2010)



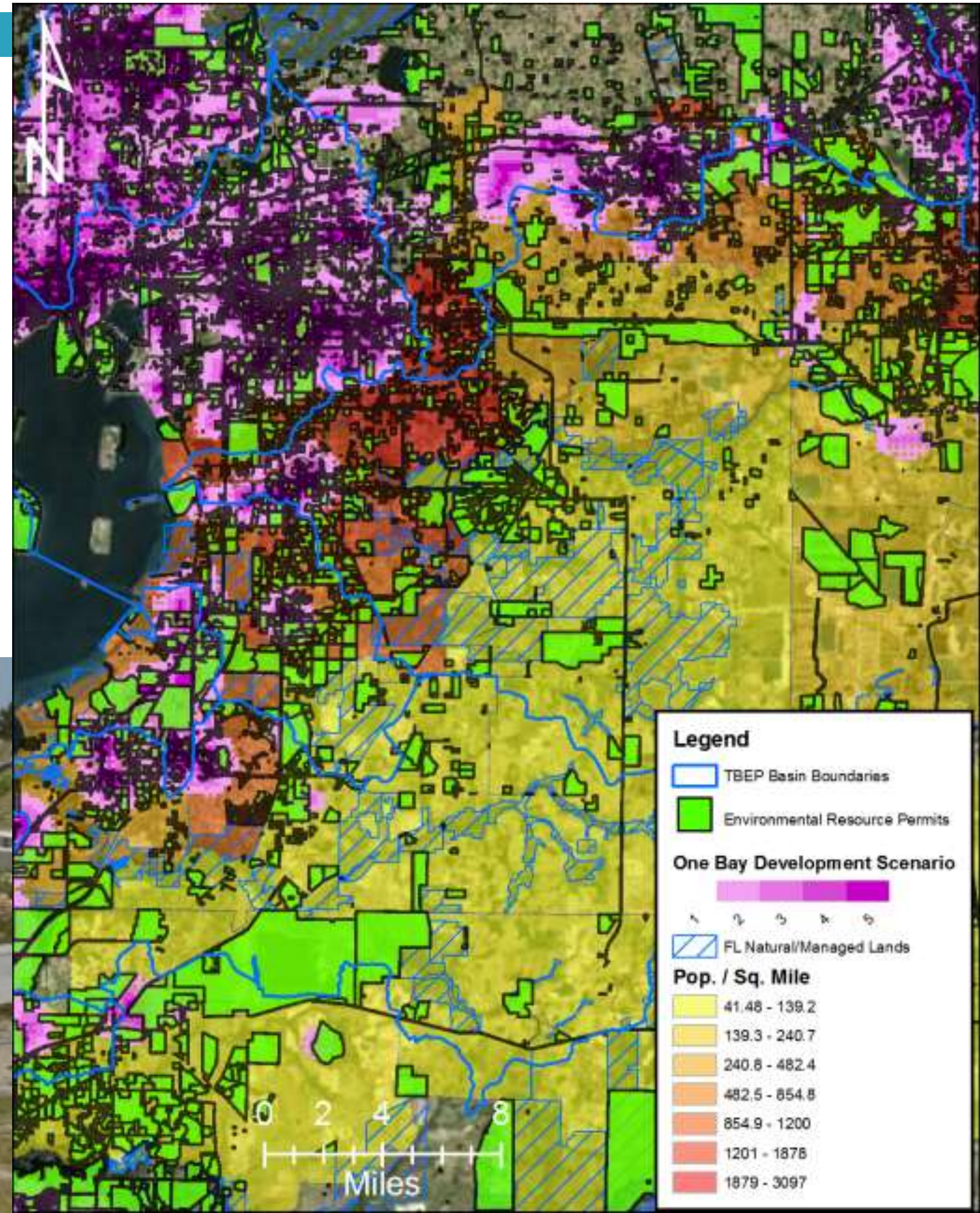


New Management Actions That Will Make a Future Difference for Water Quality

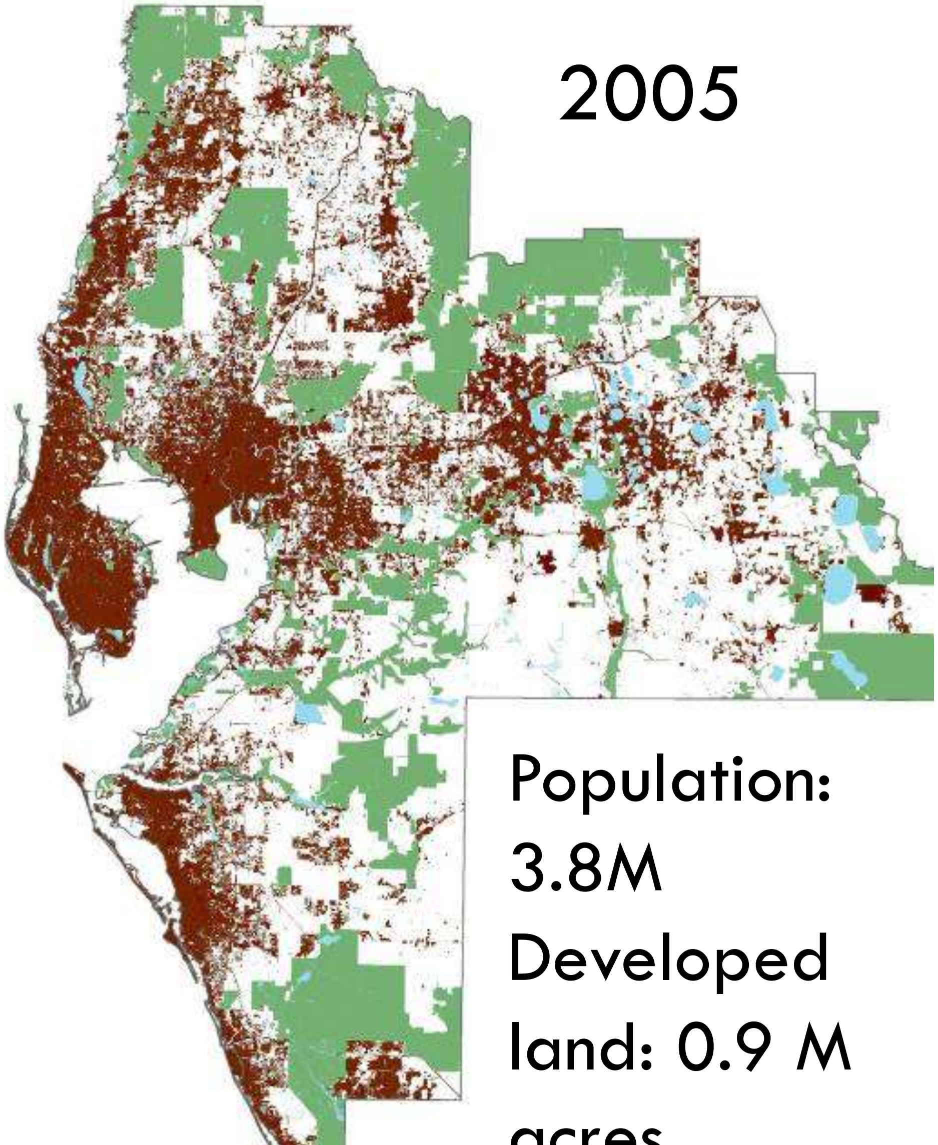
- Reduce Residential Fertilizer Contributions to Stormwater Runoff
- Continue to Reduce Wastewater & Stormwater Inputs Through Expansion of Reuse / Aquifer Storage Recovery & Recharge Projects
- Develop & Fund Localized Research & Management Actions for Problematic Areas (e.g. Old Tampa Bay) – Integrated Model Completed in 2015
- Improve and Restore Other Coastal Habitats

Future Challenges to the Bay's Recovery

- Sprawling Development & Continuing Population Increase
- Limited Land Purchasing Opportunities for Upland SW Management & Habitat Restoration Activities
- Sea Level Rise & Climate Change

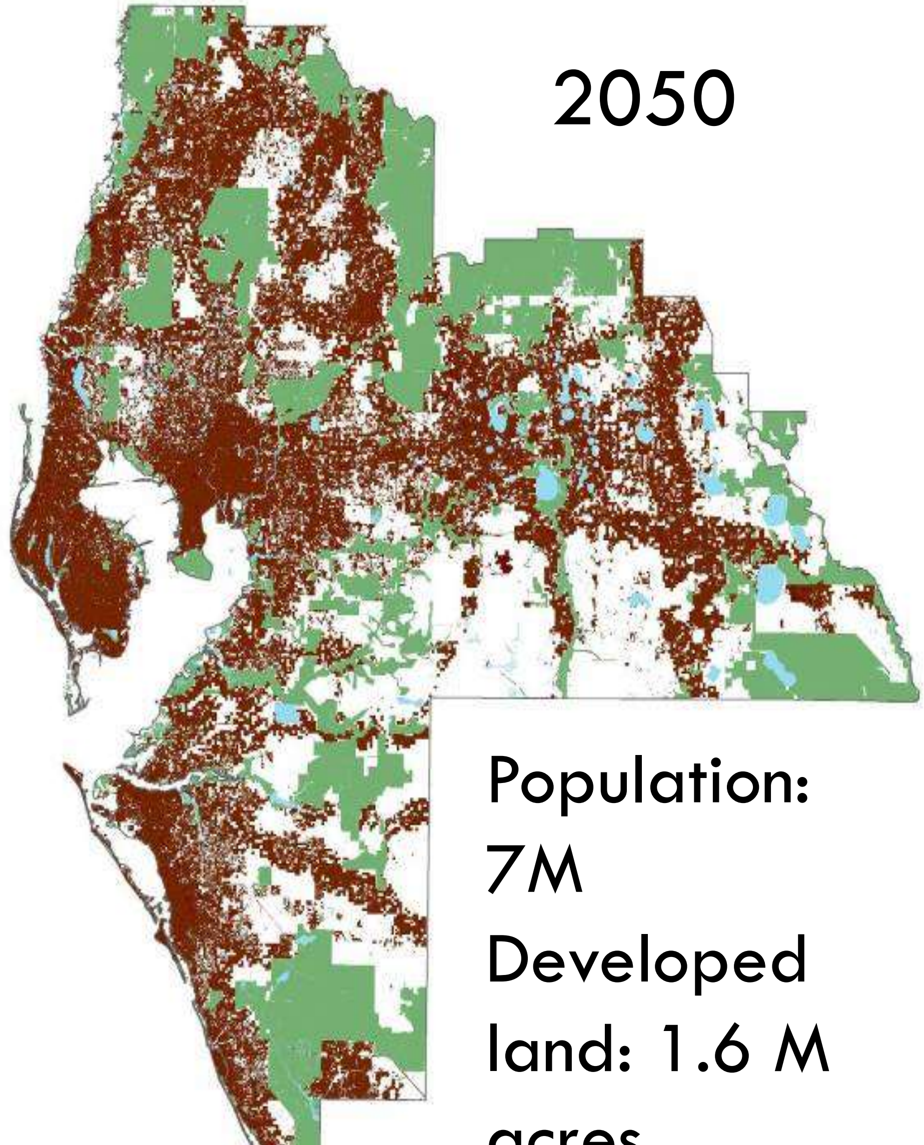


Population expected to double



2005

Population: 3.8M Developed land: 0.9 M acres



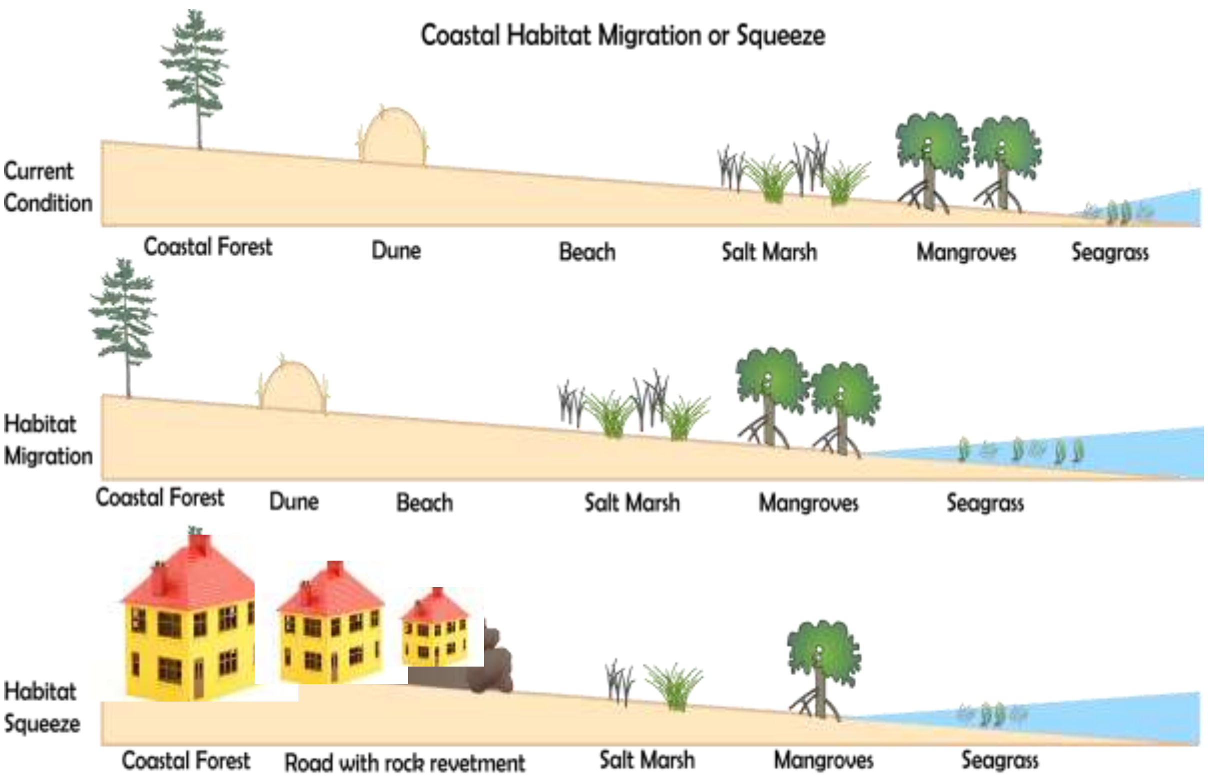
2050

Population: 7M Developed land: 1.6 M acres

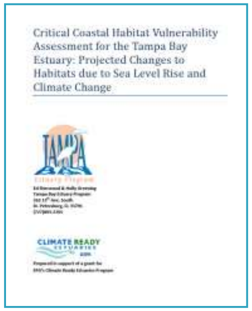
Source: One Bay 2010

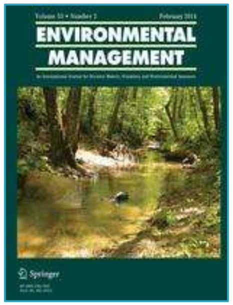
Future Coastal Habitat Extent Threatened

- Develop restoration goals that recognize the potential for future climate change & SLR impacts



- Habitat migration and "squeeze" likely
- Changes in habitat ranges likely
- Upland and subtidal refugia needed to maintain current habitat extent

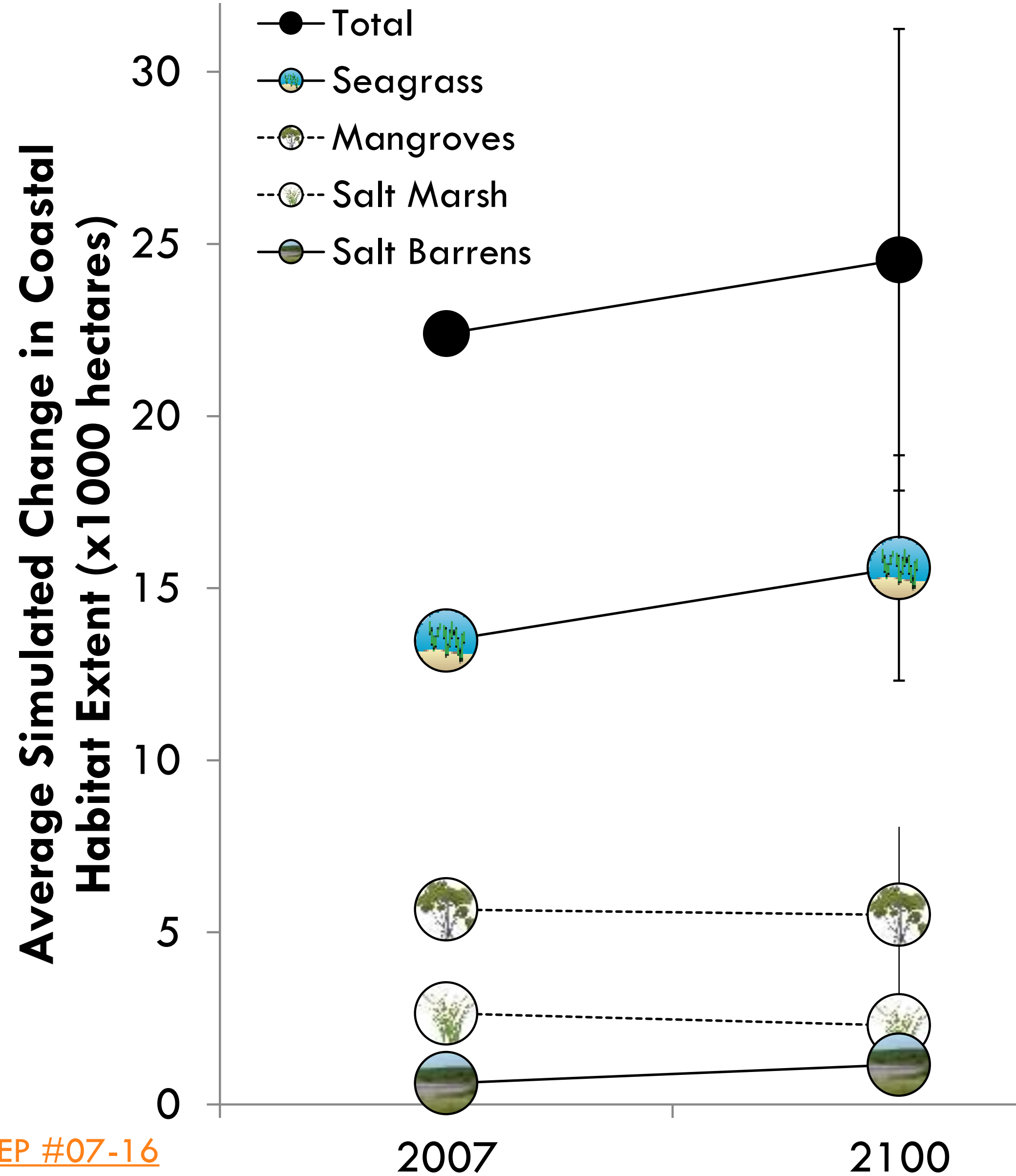




http://link.springer.com/article/10.1007%2Fs00267-013-0179-5

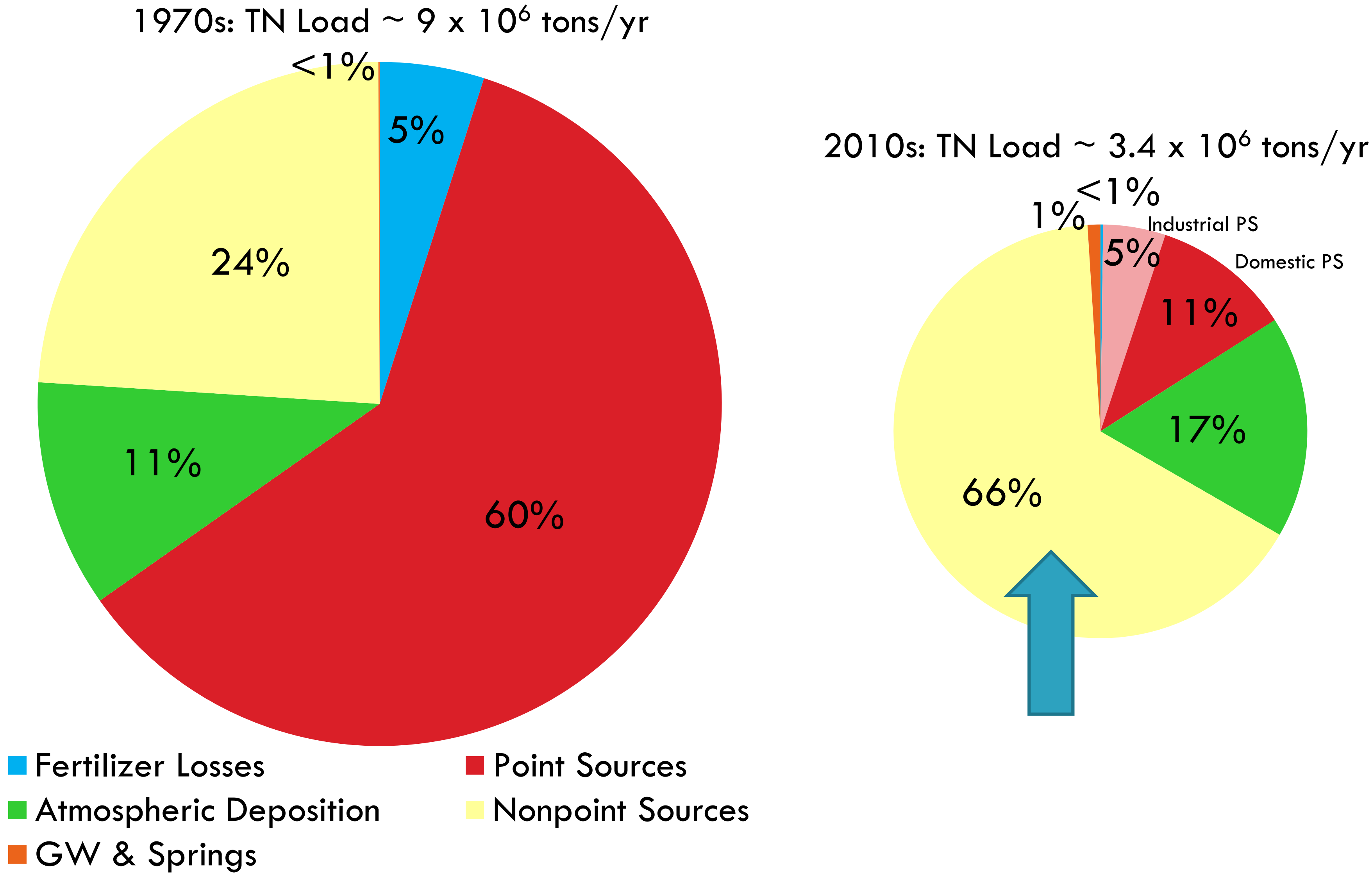
Potential Habitat Changes by 2100

- Modeled Future Habitat "Evolution"
- Future Extent Dependent Upon:
  - Rate of SLR
  - Habitat Accretion Rates
  - Current & Future Habitat Migration Constraints
  - Maintaining Good WQ for Seagrass
- Maintaining the Bay's Future C & Nutrient Assimilation Capacity



•Sheehan & Crooks. 2016. TB Blue Carbon Assessment. TBEP #07-16

Managing Stormwater Inputs a Future Priority



Key Elements in Tampa Bay's Recovery & Future Resiliency

- Long-term monitoring
- Target resources identified by both public and scientists as "worthwhile" indicators (seagrass, emergent wetlands)
- Science-based numeric goals & targets
- Multiple tools: Regulation; Public/private collaborative actions; Citizen actions
- Recognized "honest broker" to track, facilitate, assess progress
- Ongoing assessment & adjustment (Adaptive Management)

- Recently → Link to Regional Economic Valuations & Climate Change Mitigation Benefits

Questions?

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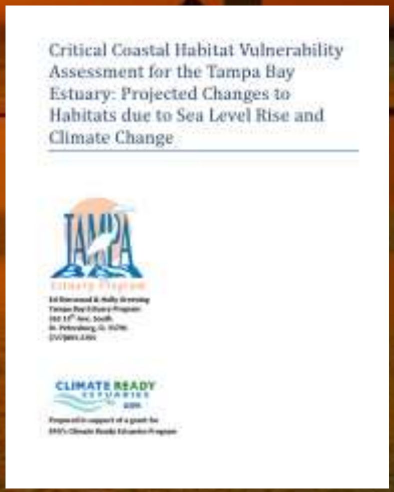
Visit TBEP on Facebook


Estuarine, Coastal and Shelf Science
Ecosystem responses to long-term nutrient management in an urban estuary: Tampa Bay, Florida, USA


Regional Studies in Marine Science
Tampa Bay estuary: Monitoring long-term recovery through regional partnerships



http://dx.doi.org/10.1016/j.ecss.2014.10.003

http://dx.doi.org/10.1016/j.rsma.2015.05.005

http://www.tbeptech.org/TBEP_TECH_PUBS/2012/TBEP_03_12_Updated_Vulnerability_Assessment_082012.pdf

Identifying Additional Incentives for Continued Investment in Tampa Bay's Recovery

- A "Healthy" Estuary

  => A Healthy Regional Economy

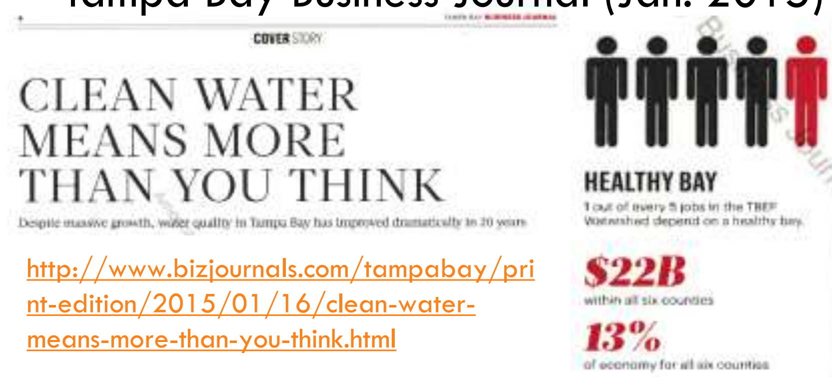
- Blue Carbon: C Sequestration & GHG Offsets

  => Voluntary C Market to Support Additional Restoration Activities?

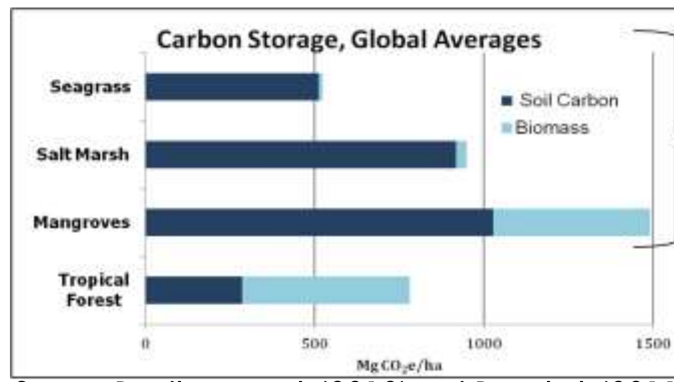
- Other Benefits of the Estuary's Recovery

  => Coastal Acidification Buffering??

Tampa Bay Business Journal (Jan. 2015)

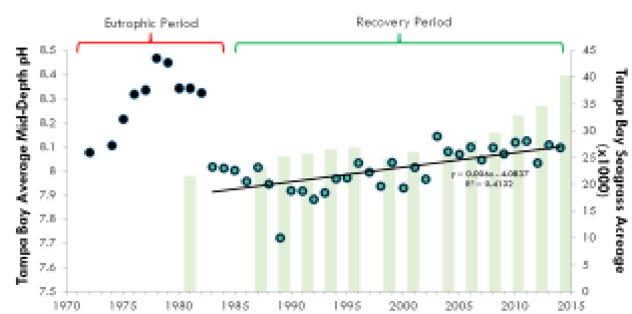


http://www.bizjournals.com/tampabay/print-edition/2015/01/16/clean-water-means-more-than-you-think.html



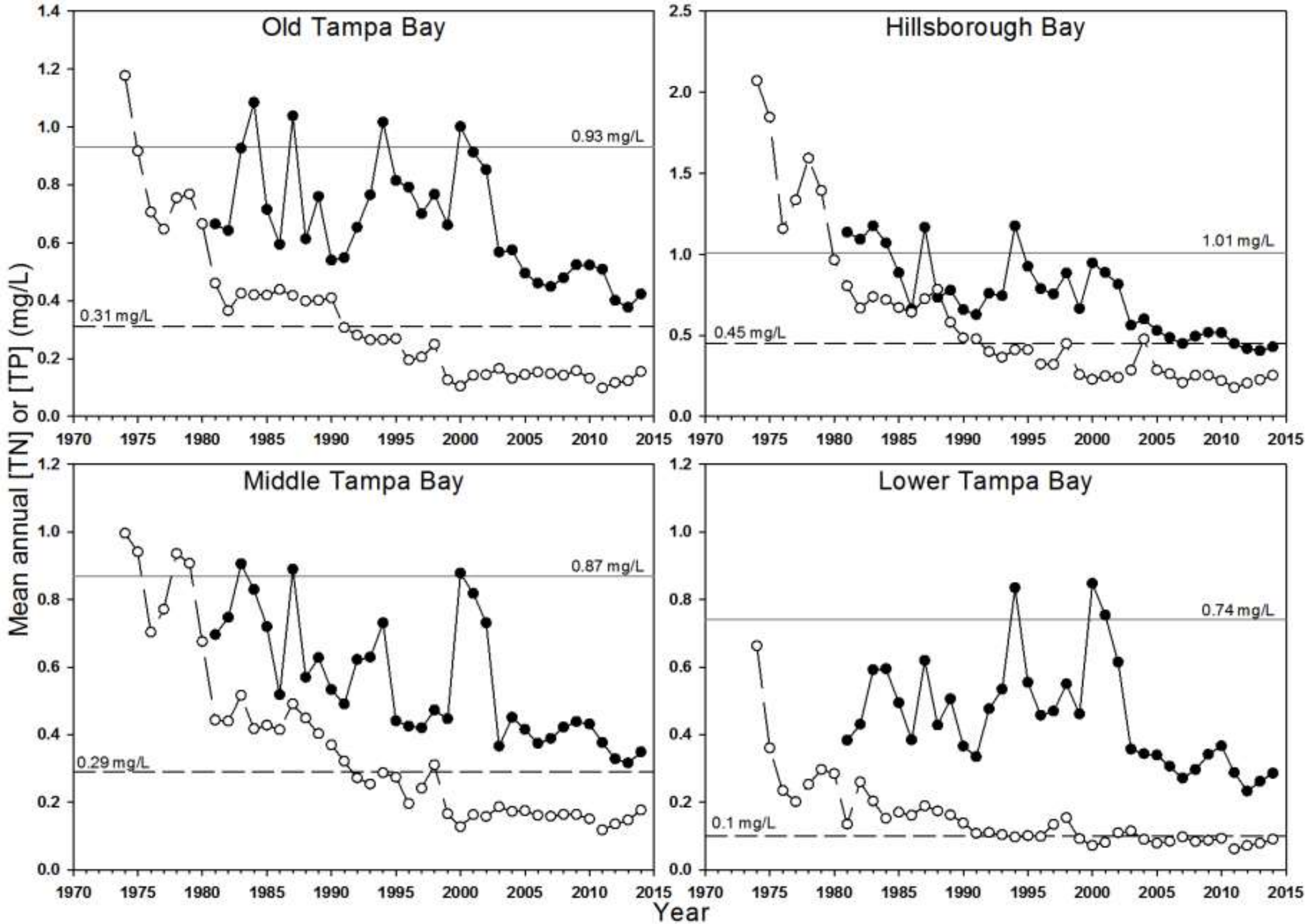
Soil carbon values for 1st meter of depth only (total depth may be several meters)

Source: Pendleton et al. (2012) and Pan el al, (2011)

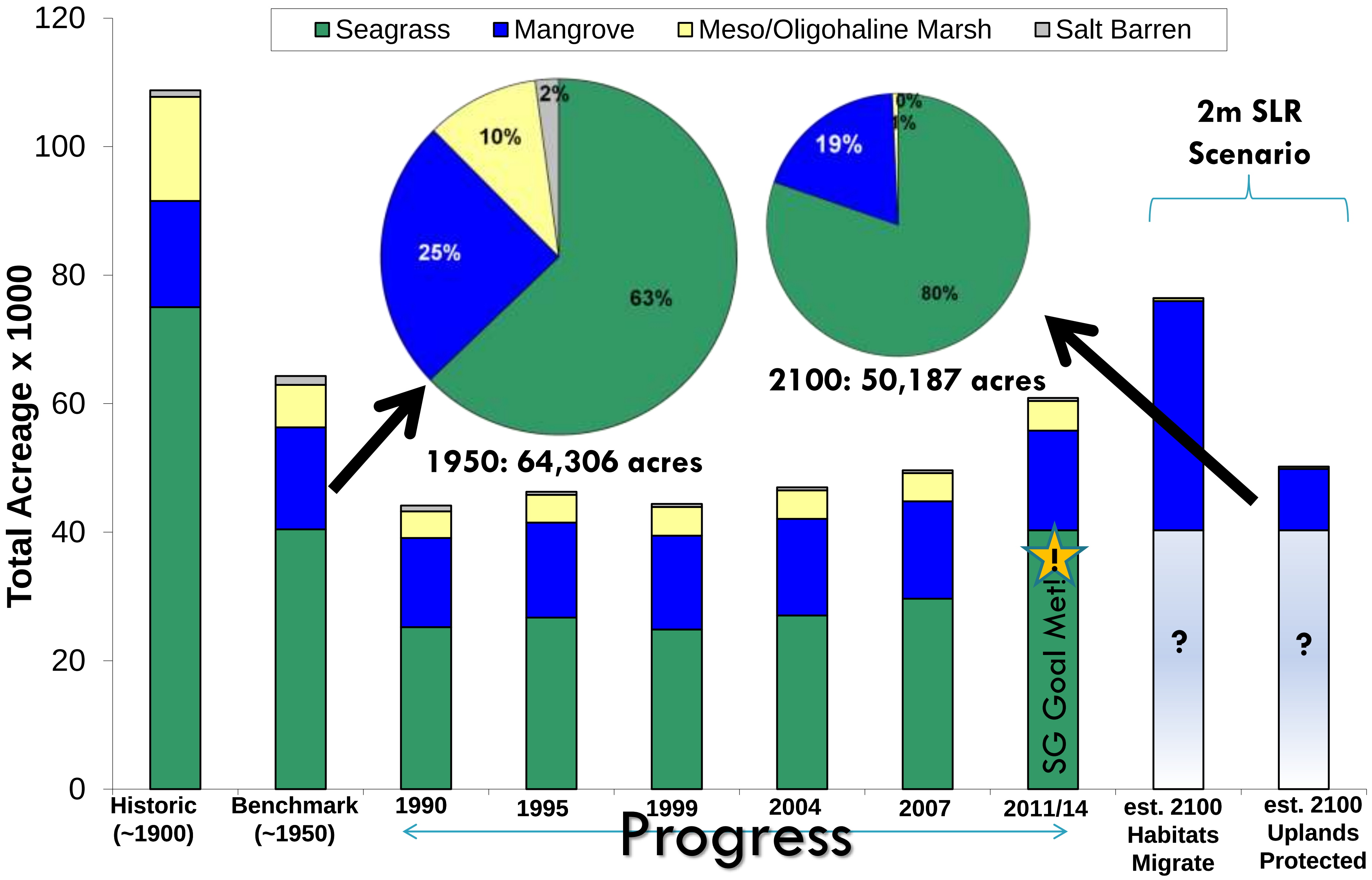


So What: Has it Worked?

Tampa Bay [TN] & [TP] Trends



Business as Usual: Forecast Grim for Coastal Habitats
Potential Reversal of Successful Recovery



Adapted from: Sherwood & Greening (2014

Annual Water Quality Assessment / Management Framework

- Bay segment observed values compared to established bay segment targets for chlorophyll-a and light attenuation
- Results of each comparison placed into a decision matrix framework
- Overall management response determined for each bay segment in a clear, "policy-level" format

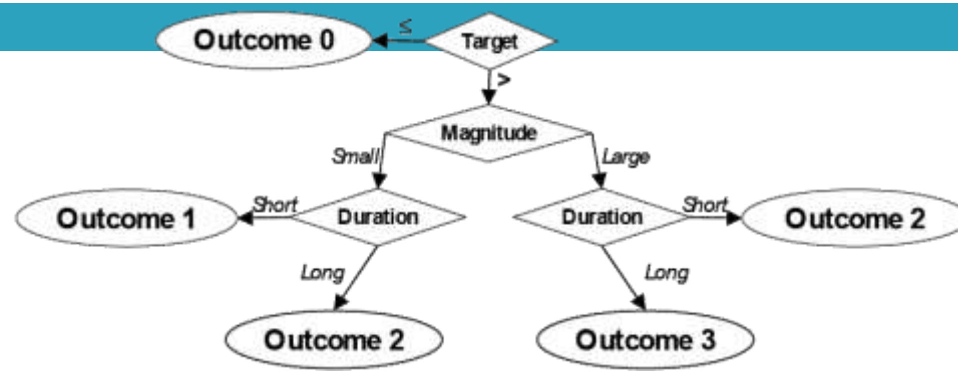


Table 1. Decision matrix identifying appropriate categories of management actions in response to various outcomes of the monitoring and assessment of chlorophyll-*a* and light attenuation data.

CHLOROPHYLL ↓	LIGHT ATTENUATION Outcome 0	Outcome 1	Outcome 2	Outcome 3
Outcome 0	*GREEN*	*YELLOW*	*YELLOW*	*YELLOW*
Outcome 1	*YELLOW*	*YELLOW*	*YELLOW*	*RED*
Outcome 2	*YELLOW*	*YELLOW*	*RED*	*RED*
Outcome 3	*YELLOW*	*RED*	*RED*	*RED*

Green	"Stay the course;" partners continue with planned projects to implement the CCMP. Data summary and reporting via the Baywide Environmental Monitoring Report and annual assessment and progress reports.
Yellow	TAC and Management Board on caution alert; review monitoring data and loading estimates; attempt to identify causes of target exceedences; TAC report to Management Board on findings and recommended responses needed.
Red	TAC, Management and Policy Boards on alert; review and report by TAC to Management Board on recommended types of responses. Management and Policy Boards take appropriate actions to get the program back on track.

TN Loads Capped & Reductions Documented

- All TN Loads Apportioned to Sources
- Future loads will require offsets/transfers
- http://apdb.tbeptech.org
- Load reductions reported every 5-yrs

Table IX-3: Proposed allowable, transferable nitrogen allocations for 2008-2012 for Middle Tampa Bay. SW=Surface water discharge, RE=Reuse discharge.

Entity	Source	Proposed MS4 and Point Source Permit Limit (%)	TMDL Load (tons/year)
Harbor Bay	NPS	<0.1%	0.2
Hillsborough County	MS4	9.9%	70.9
	Point Source - South County RE		0.5
MacDill Air Force Base	MS4	1.0%	7.0
	Point Source - WWTP RE		0.7
Manatee County	MS4	3.0%	21.8
Pinellas County	MS4	0.5%	3.2
City of Pinellas Park	MS4	0.7%	5.3
City of St. Petersburg	MS4	6.5%	46.5
	Point Source - St. Pete Facilities RE		20.8
Mosaic	Point Source - Four Corners SW	4.1%	29.3
TECO Big Bend*	Point Source – SW*		56.5*
	Point Source - RE		2.1
Non-MS4/Non-Ag NPS		0.5%	3.8
Atmospheric Deposition		35.2%	252.1
Other (Groundwater, Springs, Conservation)		5.1%	36.7
FDACS (Agriculture)		33.4%	239.2
Small Sources			2.4
Total			799
Note: The resulting MS4 and point source TMDL loads based on percent allocations are not proposed as permit limits.			

**Includes a Set Allocation of 35.0 tons/year and an Interim Allocation through 2012 of an additional 21.5 tons/year to allow determination of new discharge loads.*