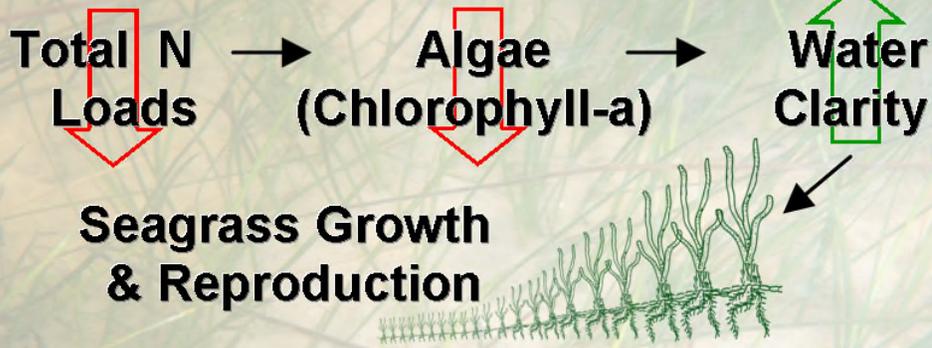
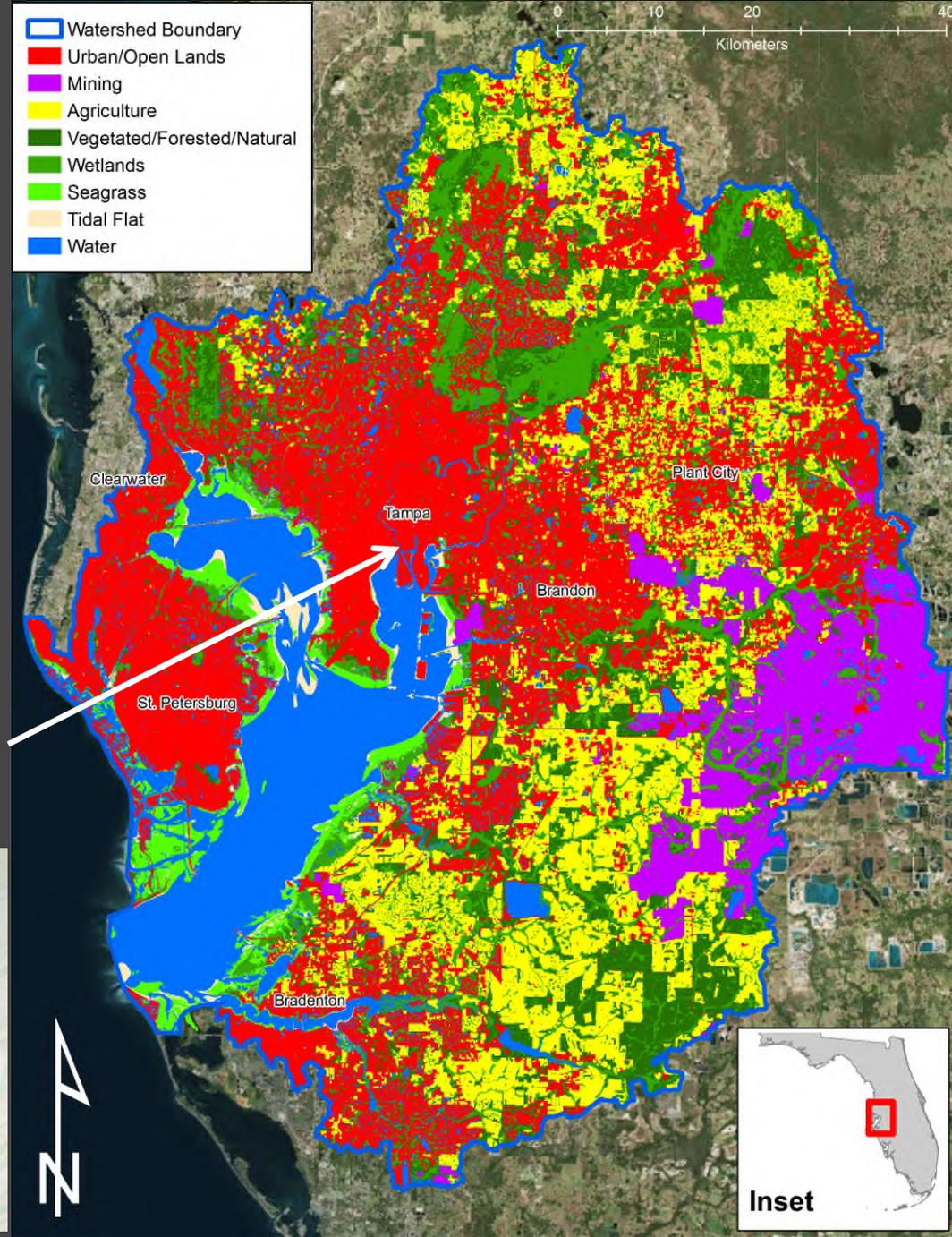


TAMPA BAY ESTUARY: MONITORING LONG- TERM RECOVERY THROUGH REGIONAL PARTNERSHIPS

You are Here!

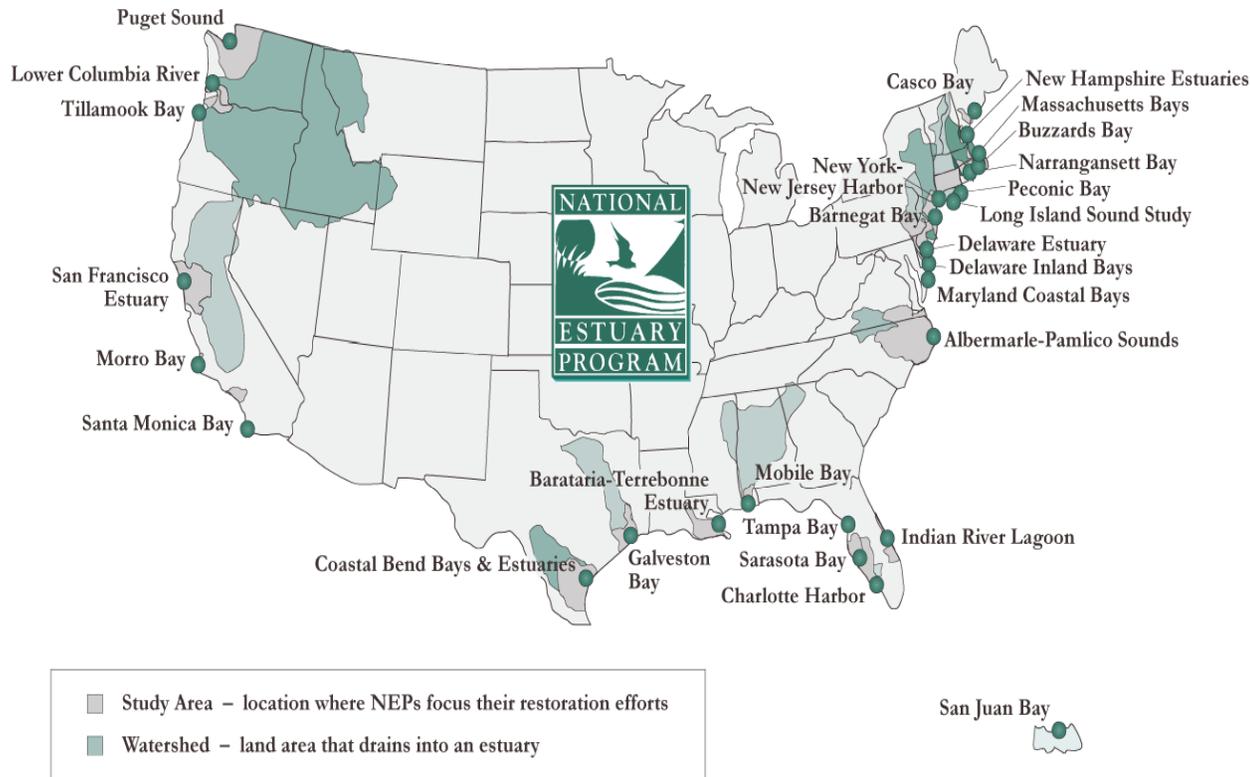


Ed Sherwood
Tampa Bay Estuary Program

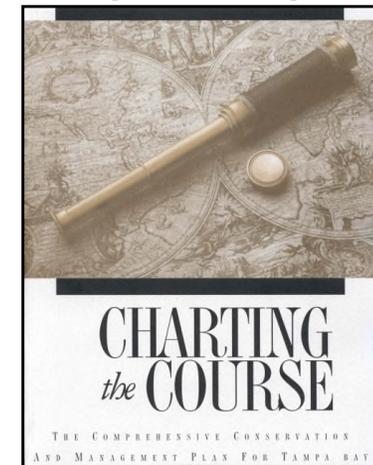
May 5, 2016: NWQMC

National Estuary Programs (NEP)

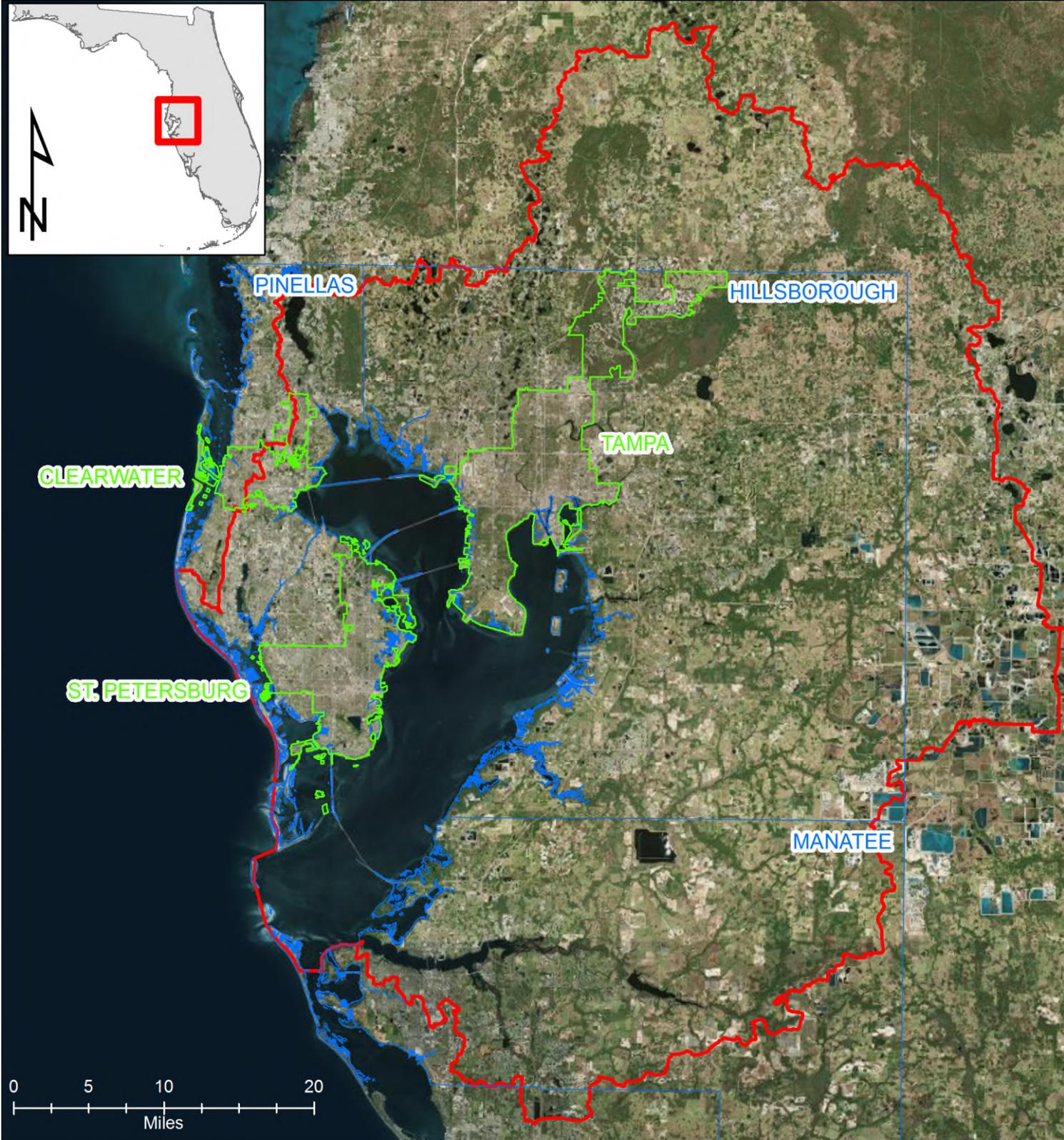
Local watershed programs making a difference



- Focus on the watershed or ecosystem
- Collaborative problem solving
- Integrate good science with sound decision making
- Public participation



TBEP Policy Board



Overview

□ Greening et al. 2014. Ecosystem responses to long-term nutrient management in an urban estuary: Tampa Bay, Florida. ECSS 151:A1-A16

□ <http://dx.doi.org/10.1016/j.ecss.2014.10.003>

□ Sherwood et al. 2015. Tampa Bay estuary: Monitoring long-term recovery through regional partnerships. Regional Studies in Marine Sciences 4:1-11.

□ <http://dx.doi.org/10.1016/j.rsma.2015.05.005>

Estuarine, Coastal and Shelf Science 110 (2014) A1–A16

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Estuarine, Coastal and Shelf Science

journal homepage: www.elsevier.com/locate/ecss

Invited feature

Ecosystem responses to long-term nutrient management in an urban estuary: Tampa Bay, Florida, USA

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ABSTRACT

In subtropical Tampa Bay, Florida, USA, we evaluated restoration trajectories before and after nutrient management strategies were implemented using long-term trends in nutrient loading, water quality, primary production, and seagrass extent. Following citizen demands for action, reduction in wastewater nutrient loading of approximately 90% in the late 1970s lowered external total nitrogen (TN) loading by more than 50% within three years. Continuing nutrient management actions from public and private sectors were associated with a steady decline in TN load rate and with concomitant reduction in chlorophyll *a* concentrations and ambient nutrient concentrations since the mid-1980s, despite an increase of more than 1 M people living within the Tampa Bay metropolitan area. Water quality (chlorophyll *a* concentration, water clarity as indicated by Secchi disk depth, total nitrogen concentration and dissolved oxygen) and seagrass cover are approaching conditions observed in the 1950s, before the large increases in human population in the watershed, following recovery from an extreme weather event in 1987–1988, water clarity increased significantly and seagrass is expanding at a rate significantly different than before the event, suggesting a feedback mechanism as observed in other systems. Key elements supporting the nutrient management strategy and concomitant ecosystem recovery in Tampa Bay include: 1) active community involvement, including agreement about quantifiable restoration goals; 2) regulatory and voluntary reduction in nutrient loadings from point, atmospheric, and nonpoint sources; 3) long-term water quality and seagrass extent monitoring; and 4) a commitment from public and private sectors to work together to attain restoration goals. A shift from a turbid, phytoplankton-based system to a clear water, seagrass-based system that began in the 1980s following comprehensive nutrient loading reductions has resulted in a present-day Tampa Bay that looks and functions much like it did in the relatively pre-disturbance 1950s period.

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1. Introduction

A primary water quality challenge facing estuaries throughout the world is cultural eutrophication – a process in which human activities in the watershed and airshed lead to increased nutrient inflows to the water body, producing levels of over-fertilization that stimulate undesirable blooms of phytoplankton and macroalgae (Nixon, 1995; Bricker et al., 1999, 2007; NRC, 2000; Cloern, 2001; Swartz et al., 2013). Such blooms affect estuarine ecosystems in several ways. They reduce water clarity and block sunlight, reducing the size, quality, and viability of submerged aquatic vegetation (SAV) including seagrass meadows and other aquatic habitats. Several bloom-forming phytoplankton species also produce toxins that can negatively affect the structure and function of aquatic food webs (Anderson et al., 2002) and pose health threats to wildlife and humans (Burns, 2008). As phytoplankton and macroalgae die and decompose, dissolved oxygen (DO) is removed from the water column and bottom sediments. Because an adequate water quality and seagrass extent monitoring program is essential to the survival of most aquatic organisms, such reductions can have substantial impacts on the local fauna (Carp et al., 2002; Diaz and Rosenberg, 2008). Eutrophication conditions are widespread—in 1999, Rabalais et al. concluded that nearly all estuarine waters in the USA now exhibit some symptoms of eutrophication. Cases of gradual estuarine eutrophication have been known for more than 50 years and include large systems such as Chesapeake Bay (Boesch et al., 2001; Kemp et al., 2005; Williams et al., 2010) and the Baltic Sea (Dortch et al., 2007; Heiskanen and Conzelmann, 2009), and smaller systems such as Waquoit Bay

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journal homepage: www.elsevier.com/locate/rsma

Tampa Bay estuary: Monitoring long-term recovery through regional partnerships

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ABSTRACT

Historically, significant impacts to Tampa Bay's water quality (e.g. chlorophyll *a* concentrations) and ecosystems (e.g. seagrass coverage) have been documented as a result of early coastal development and urban expansion that occurred between the 1950s and 1980s. Since this time, Tampa Bay estuarine water quality and ecosystems have significantly recovered. A long-term water quality monitoring program, first established by the Environmental Protection Commission of Hillsborough County (EPCMC) in 1972, was instrumental in the development of water quality management targets and regulatory standards related to the recovery of seagrass that helped guide restoration activities in the Bay from the 1980s to present. The EPCMC monitoring program has provided over 40 years of consistent and quality assured data that have been used to document Tampa Bay's ecosystem recovery, to guide future research, monitoring, and management actions. Forecasted future pressures of continuing coastal population growth and climate change impacts further necessitate the need for enhanced water quality monitoring efforts in the Tampa Bay estuary. Maintenance of a robust estuarine monitoring program will not only help to identify future risks to the important environmental assets represented in the Tampa Bay estuary, but also help to identify potential risks to Tampa Bay's economic vitality that are garnered from maintaining a "healthy" Tampa Bay.

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1. Background

Henry B. Plant is credited with initiating modern industrial and commercial development of the Tampa Bay area through the establishment of railroad and steamship transportation networks to and from the region in the 1880s (Stinson, 1974). Since that time, port development and shipping interests have benefited from a federally maintained navigation channel also established in the 1880s. Today, Tampa Bay ranks among the U.S.'s most productive port regions (United States Army Corps of Engineers). Establishment and maintenance of the shipping channel (Fig. 1) was one of the first anthropogenic alterations influencing Bay water quality conditions (Meyers et al., 2014; Zhu et al., 2015).

The region continued to expand throughout the 20th century as agriculture, phosphate mining, and industry grew, but it was not until after World War II when indoor air conditioning became readily available to homeowners that widespread suburban and urban development ensued. Population within the region continues to expand, and it is estimated that the region will approach 3M people by mid-century (Tampa Bay Partnership). Significant alterations to fresh and saltwater wetlands, submerged aquatic vegetation, and other natural uplands have been documented throughout Tampa Bay's 20th century coastal development (Rabalais, 2015; Kins and Schraga, 2015; Yates et al., 2011). Hydrologic alterations to the landscape (e.g. mosquito ditching, creek channelization and diking, and spoil removal and borrow pit creation), as well as, changes in land use and intensity (e.g. conversion of natural lands to agricultural or residential) and urban development have further influenced Bay water quality during this period. In addition, causeway and bridge construction across Old Tampa Bay and Lower Tampa Bay further modified hydrodynamics within the Bay proper (Meyers et al., 2014; Zhu et al., 2015).

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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
- ❑ 50% loss of seagrass coverage between 1950 and 1980
- ❑ Newspapers declared Tampa Bay “dead”



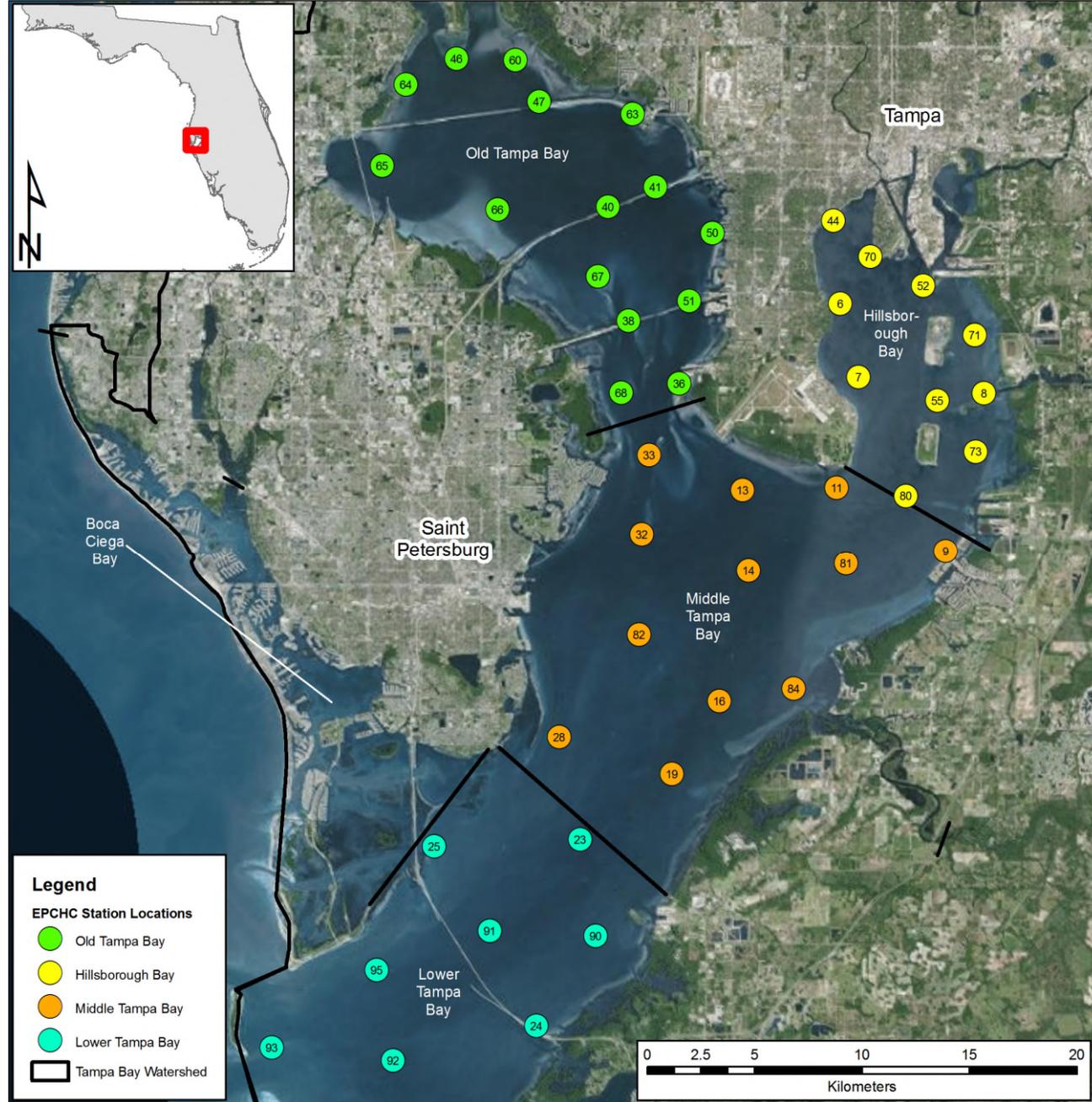
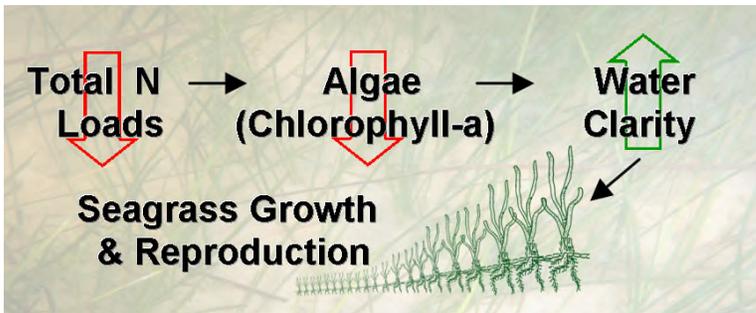
Citizens Demanded Action (1970s-1980s)

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



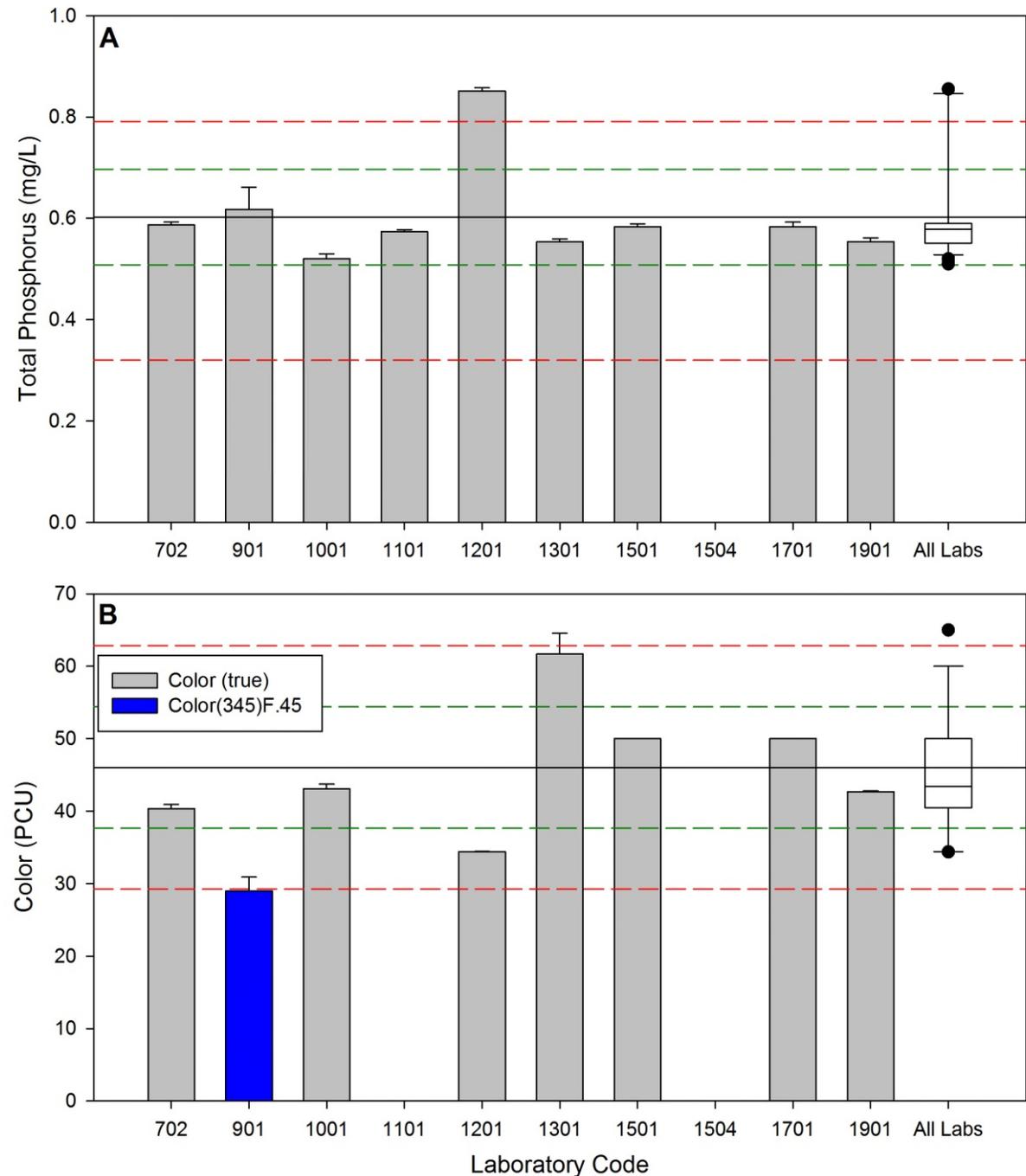
Early Monitoring Provides Foundation for WQ Target Development: Focus on Restoring Seagrass Coverage

- 1972: Hillsborough County establishes fixed station monitoring program throughout Tampa Bay
- Chlorophyll-a & Secchi Disk Depth Targets Defined for Each Bay Segment to Support Seagrass Restoration (mid-1990s)



Regional Monitoring Efforts Expanded

- 1990s: Other County programs established to fill-in spatial gaps (both fixed and stratified-random approaches employed)
- Regional Ambient Monitoring Program (RAMP) established to ensure data comparability among field & laboratory procedures
- To date, 79 quarterly round robins conducted
<http://www.tbepotech.org/committees/swfl-ramp>



Adopted Water Quality Targets & Thresholds

Bay Segment	TBEP Management Targets Established ~2000 (Desired Conditions)		Regulatory Threshold Adopted 2002 (Adverse Impacts Expected)
	Chl-a Management Target (ug/L)	K_d (m^{-1}) Management Target	Chl-a Regulatory Threshold (ug/L)
Old Tampa Bay	8.5	0.83	9.3
Hillsborough Bay	13.2	1.58	15.0
Middle Tampa Bay	7.4	0.83	8.5
Lower Tampa Bay	4.6	0.63	5.1

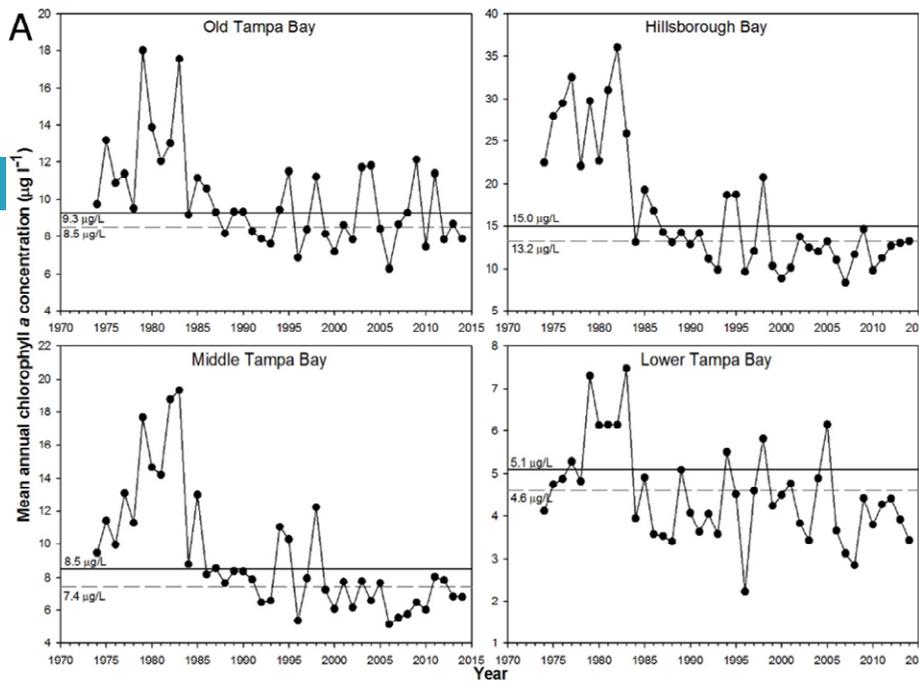
Annual WQ Report Card

Assess Annual TN Load
Reduction Effectiveness

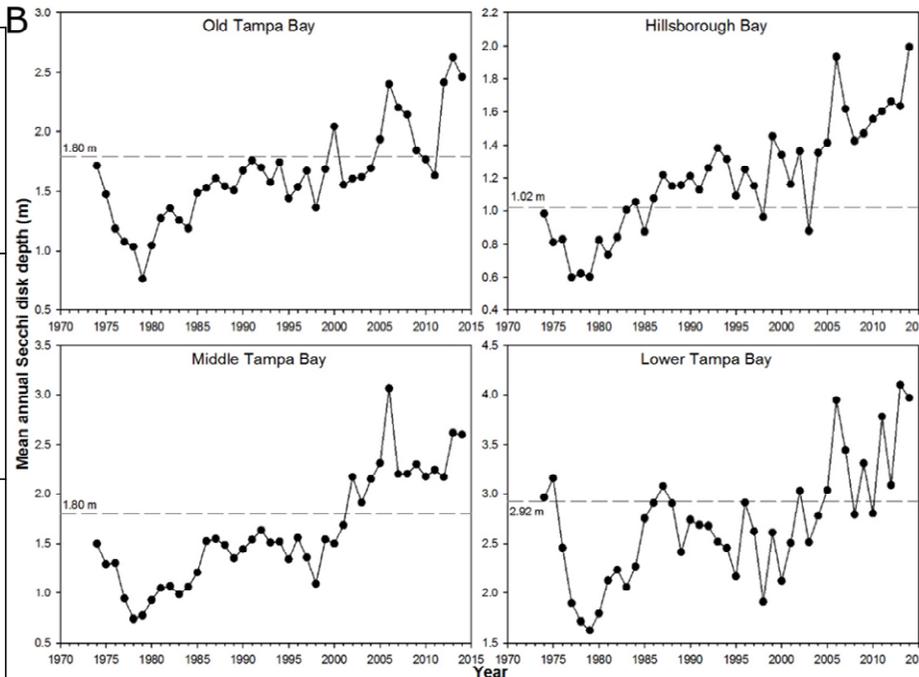
- “Hold the Line” on TN Loads: Preclude 17 tons/yr to offset for future growth in region ([TBEP Tech Pub. #06-96](#))

Historical WQ Conditions

- Chl-a (A) and secchi disk depths (B) annually assessed relative to targets
- (C) Management Response Defined



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



Green	“Stay the Course.” Continue planned projects. Report data via annual progress reports and Baywide Environmental Monitoring Report.
Yellow	“Caution Alert.” Review monitoring data and nitrogen loading estimates. Begin/continue TAC and Management Board development of specific management recommendations.
Red	“On Alert.” Finalize development and implement appropriate management actions to get back on track.

Tampa Bay NMC

A Public - Private Partnership

Tampa Bay Nitrogen Management Consortium

- Formed in 1998, now includes 50+ 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; Proactively developed TN load allocations in 2009/10 that have been subsequently integrated into permit conditions
- Consortium members may choose to implement any combination of projects to maintain loads to Tampa Bay at 1992-1994 levels

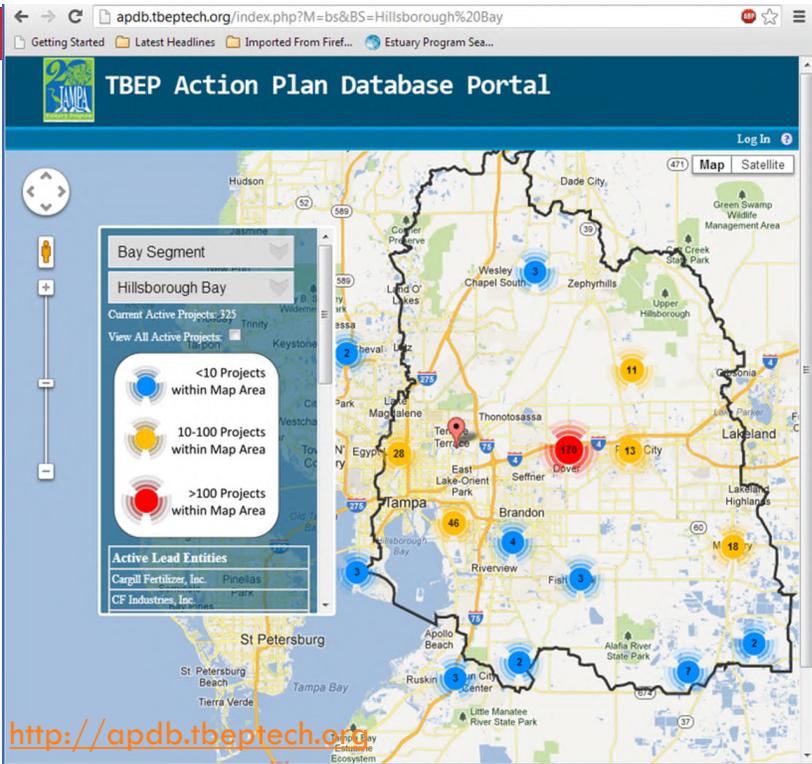
Public Partners:

- 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.
- Progress 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



The screenshot shows the 'TBEP View/Edit Project' form for the 'Seminole Bypass Canal' project in Pinellas County. The form includes fields for 'Project Name', 'Lead Entity', and 'Project ID: 923'. Below these are tabs for 'Log', 'Action Plan', 'BMAP', 'Location', 'Schedule', 'Costs', 'Description', 'Bay Habitats', 'NPS Treatment', and 'PS Treatment'. The 'NPS Treatment' tab is active, showing a table of 'Treatment Method' and 'Treatment Area (acres)'. The 'Contributing Project Area (acres)' is 0.00000 and 'Landuse' is 'Not Listed'. The 'Treatment Method' is 'Not Listed' with 0% efficiency. The 'Removal Rate' is 100.00000 (%). The 'Total Acres' is 0 and 'Total Load Reduction' is 18339. An arrow points from the 'Total Load Reduction' field to a detailed report box on the right.

NEW ID#1 Seminole Bypass Canal Regional Stormwater Treatment Facility
 Lead Agency: Pinellas County
 Project summary: Diverted water from the Seminole Bypass Canal will be treated with alum to achieve a 90% reduction in TP, 35% reduction in TN, and 85% reduction in TSS.
 Subbasin location: 501 and 524
 Planned initiation: 10/2004
 Planned completion: 3/2007
 Drainage basin area (acres): 5120 acres
 Drainage basin land use and percentages or acres by land use type (approximate):

LAND USE	ACRES	%
RESIDENTIAL HIGH DENSITY	6536.2622	46.07%
COMMERCIAL AND SERVICES	1078.5667	7.44%
INDUSTRIAL	991.2264	6.84%
BAYS AND ESTUARIES	857.3327	5.91%
RECREATIONAL	677.2672	4.67%
LAKES	668.6781	4.61%
INSTITUTIONAL	578.0629	3.99%
OPEN LAND	502.7464	3.47%
TRANSPORTATION	415.7077	2.87%
RESIDENTIAL MED DENSITY 2->5 DWELLING UNIT	323.9621	2.23%
RESERVOIRS	305.6389	2.11%
RESIDENTIAL LOW DENSITY < 2 DWELLING UNITS	266.5345	1.84%
PINE FLATWOODS	235.9639	1.63%
HARDWOOD CONIFER MIXED	191.6533	1.32%
WETLAND FORESTED MIXED	176.4321	1.22%
UTILITIES	113.8942	0.78%
OTHER	581.3124	4.01%
LAND USE TOTAL (ACREAGE AND %)	14501.2407	100.00%

Treatment method (wet detention, CDS, etc): Alum
 Current load: 23,772 kg/yr (52,398 lbs)
 TN removal rate for alum injection: 35%
 Load reduction (lbs/yr): 18,339 lbs/yr
 Total estimated cost, if available: \$1,198,500
 Funding sources, if available: SWFWMD SWIM, FDEP 319(h), and Pinellas County

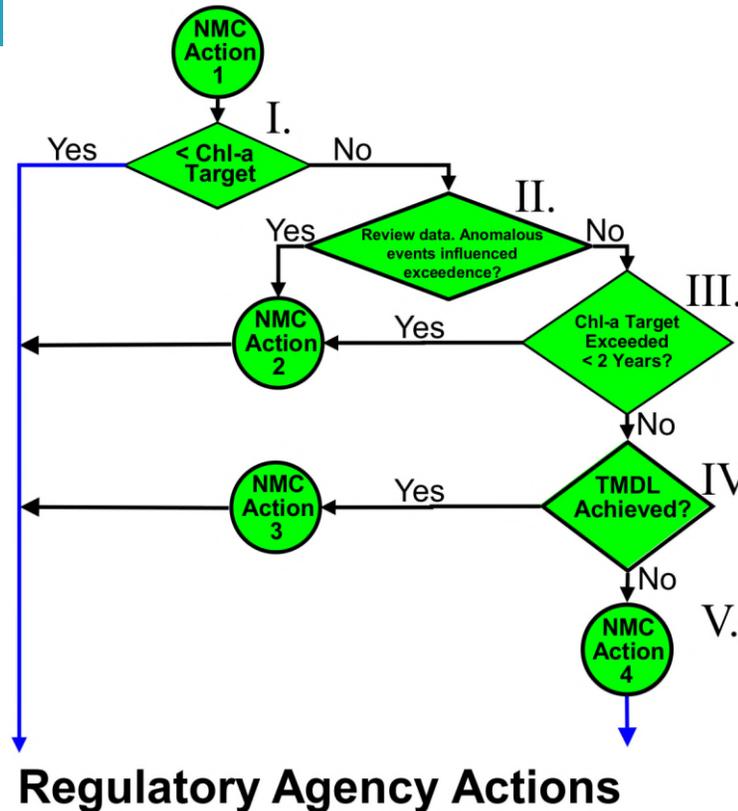
NEW ID#2 Alum treatment of five priority sub basins discharging to Lake Seminole
 Lead Agency: Pinellas County
 Project summary: Alum treatments of stormwater systems in Lake Seminole SubBasins 1,2,3,6 and 7.
 Subbasin location: 524
 Planned initiation: 10/2004
 Planned completion: Phase I: 3/2007; Phase II 12/2009
 Drainage basin area (acres): 2,532

- 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 to FDEP/EPA on a 5-yr basis by major bay segment
- **1992-2015: 450+ Projects, 537 Tons TN Precluded from TB, \$0.6+ Bil**

Consequences for Not Meeting WQ Thresholds

Annual chlorophyll-a concentrations drive entity allocation assessments

If WQ is poor, nitrogen load responsibilities re-evaluated



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.

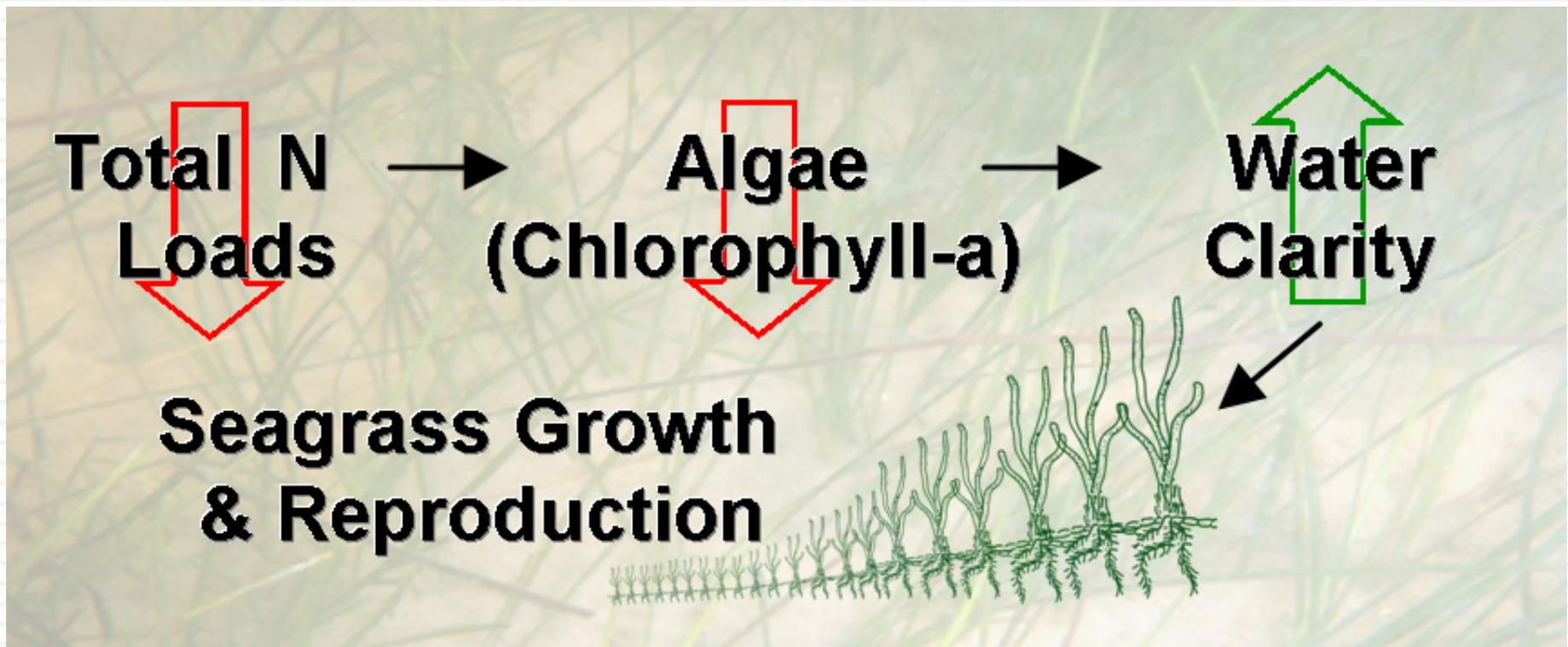
NMC Action 4: If federally-recognized TMDL not achieved, compile nitrogen load data for regulatory review and identify potential further actions needed to achieve reasonable assurance for bay segment nitrogen load allocations.

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

Example Compliance Assessment Steps

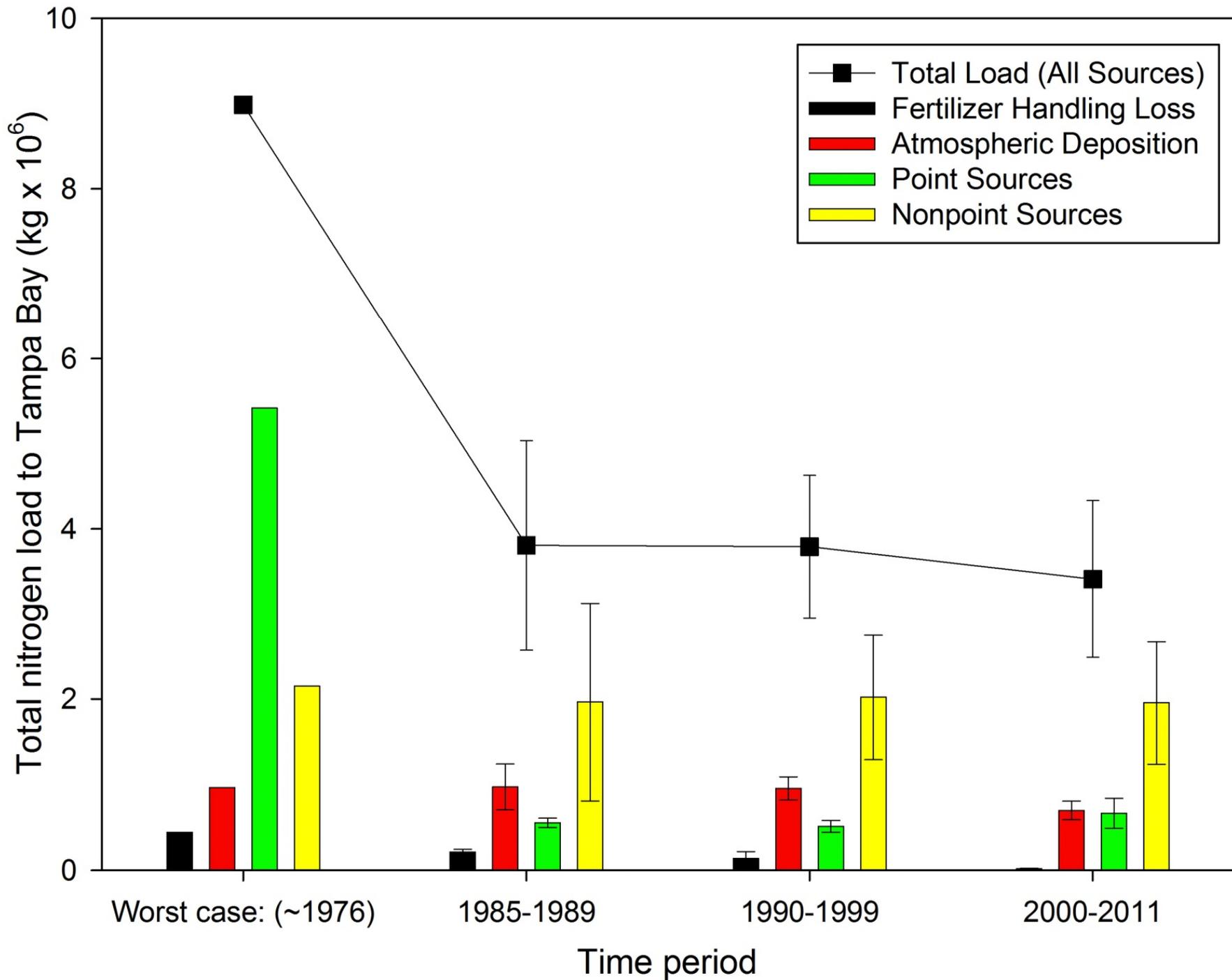
Bay Segment Reasonable Assurance Assessment Steps			EXAMPLE DATA USED TO ASSESS INTERIM REASONABLE ASSURANCE					Comment
			Year 1	Year 2	Year 3	Year 4	Year 5	
NMC Action 1: Determine if observed chlorophyll-a exceeds hypothetical regulatory threshold of 10.0 µg/L			12.0 µg/L (Yes)	14.0 µg/L (Yes)				Chlorophyll-a exceedences occurred during first 2 years of assessment period necessitating further NMC actions
NMC Action 2: Determine if any observed chlorophyll-a exceedences occurred for 2 consecutive years			No	Yes				Year 2 triggers additional NMC Action 3
NMC Action 3: Determine if observed hydrologically-normalized total load exceeds hypothetical federally-recognized total maximum daily load (TMDL) of 1000 tons/year			900 tons/yr (No)	1100 tons/yr (Yes)				Year 2 exceeds the TMDL after accounting for hydrology, NMC performs NMC Actions 4-5
NMC Actions 4-5: Determine if any entity/source/facility specific exceedences of 5-yr average allocation occurred during implementation period								At end of 5-year period, facility/source-specific exceedences listed in this column ↓
ENTITY	SOURCE	Allocation	EXAMPLE DATA USED TO ASSESS INTERIM REASONABLE ASSURANCE					5-Yr Average
			Year 1	Year 2	Year 3	Year 4	Year 5	
Entity A	Set Allocation – Domestic PS A	300 tons	290 tons	380 tons				
	NPS % Contribution (normalized tons)	30.0%	29.0%	38.0%				
Entity B	Set Allocation – Domestic PS B	200 tons	180 tons	190 tons				
	NPS % Contribution (normalized tons)	50.0%	48.0%	49.0%				
Entity C	Set Allocation – Industrial PS C	50 tons	45 tons	48 tons				
	NPS % Contribution (normalized tons)	20.0%	23.0%	13.0%				

So what, has it really worked?



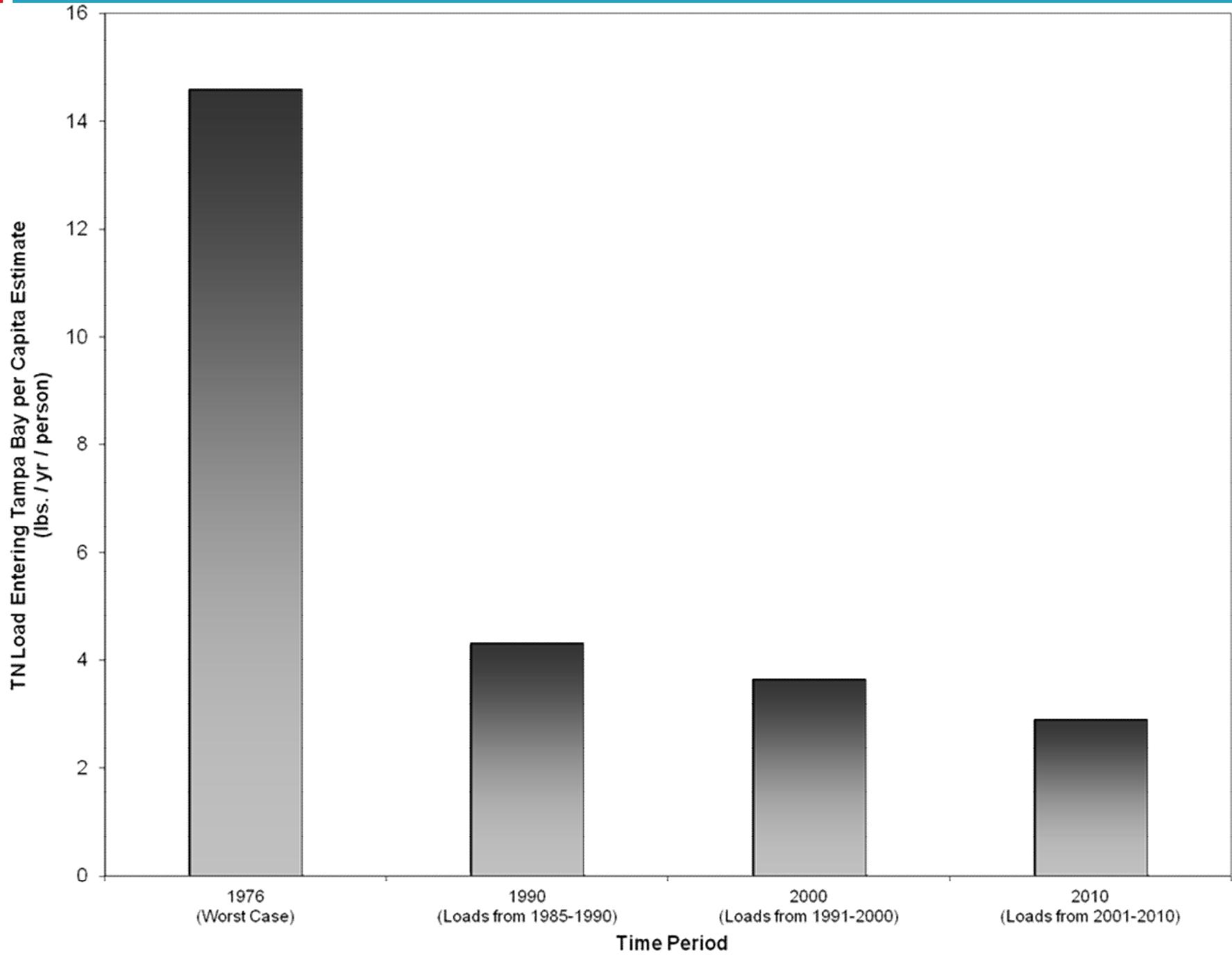
Reduce
Nitrogen
Loads

Reduced TN Loads to Tampa Bay



Reduce
Nitrogen
Loads

Per Capita TN Load Reduced by 80%

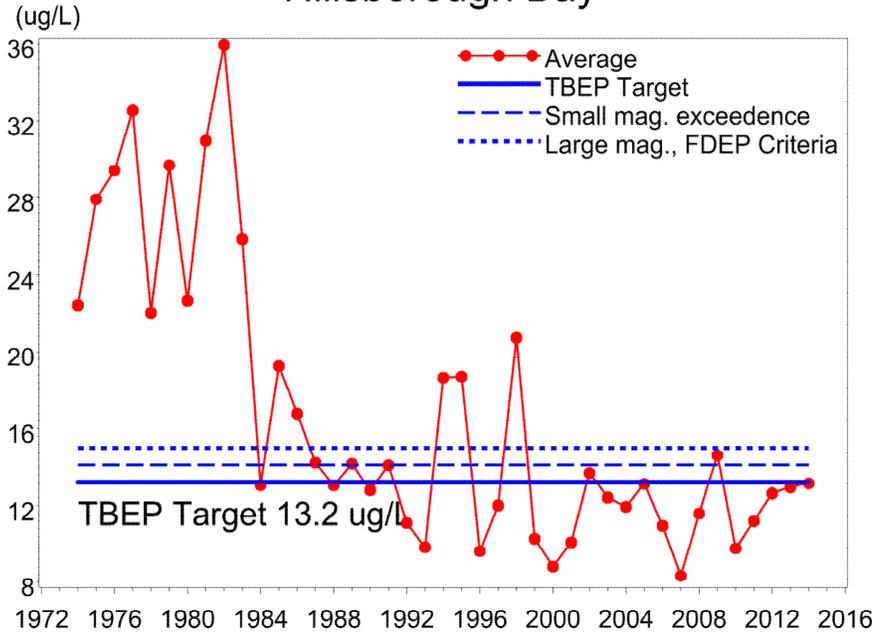


Reduce Chlorophyll

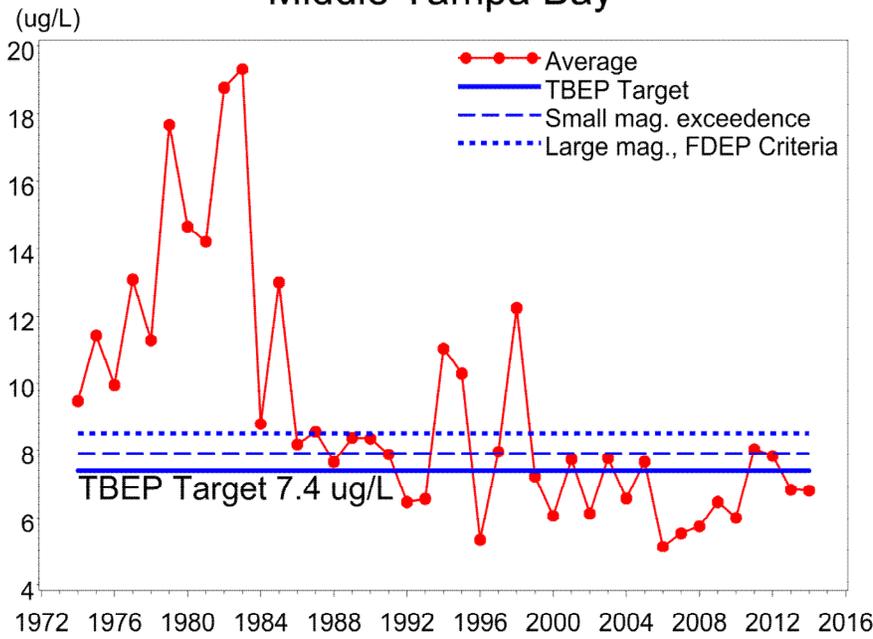
Water Quality Has Improved

Increase Water Clarity

Hillsborough Bay



Middle Tampa Bay



AWT & Reuse Standards Implemented

Stormwater Regulations Enacted

TBEP Partner & NMC Actions Implemented

Power Plant Upgrades

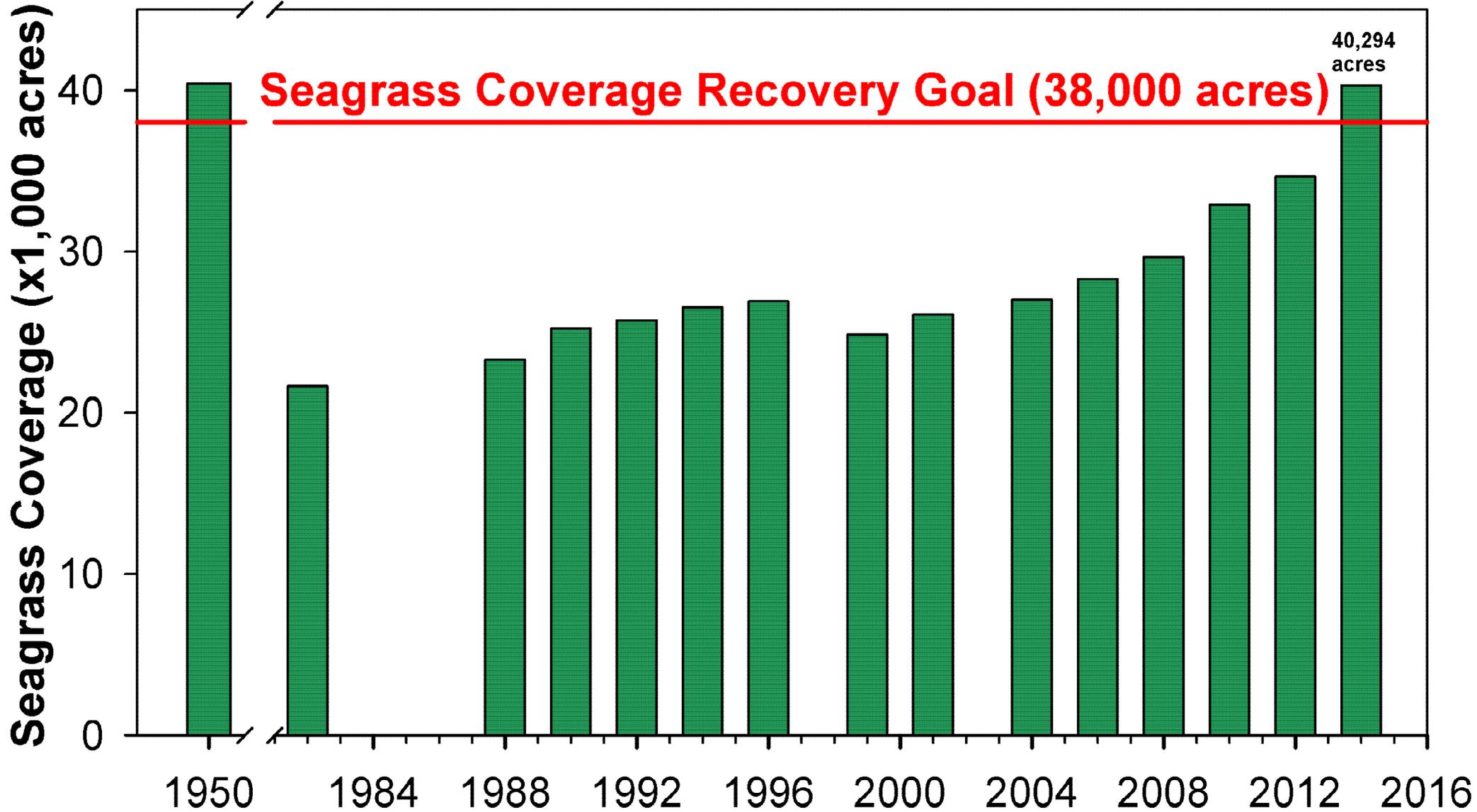
Port Facility Upgrades

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

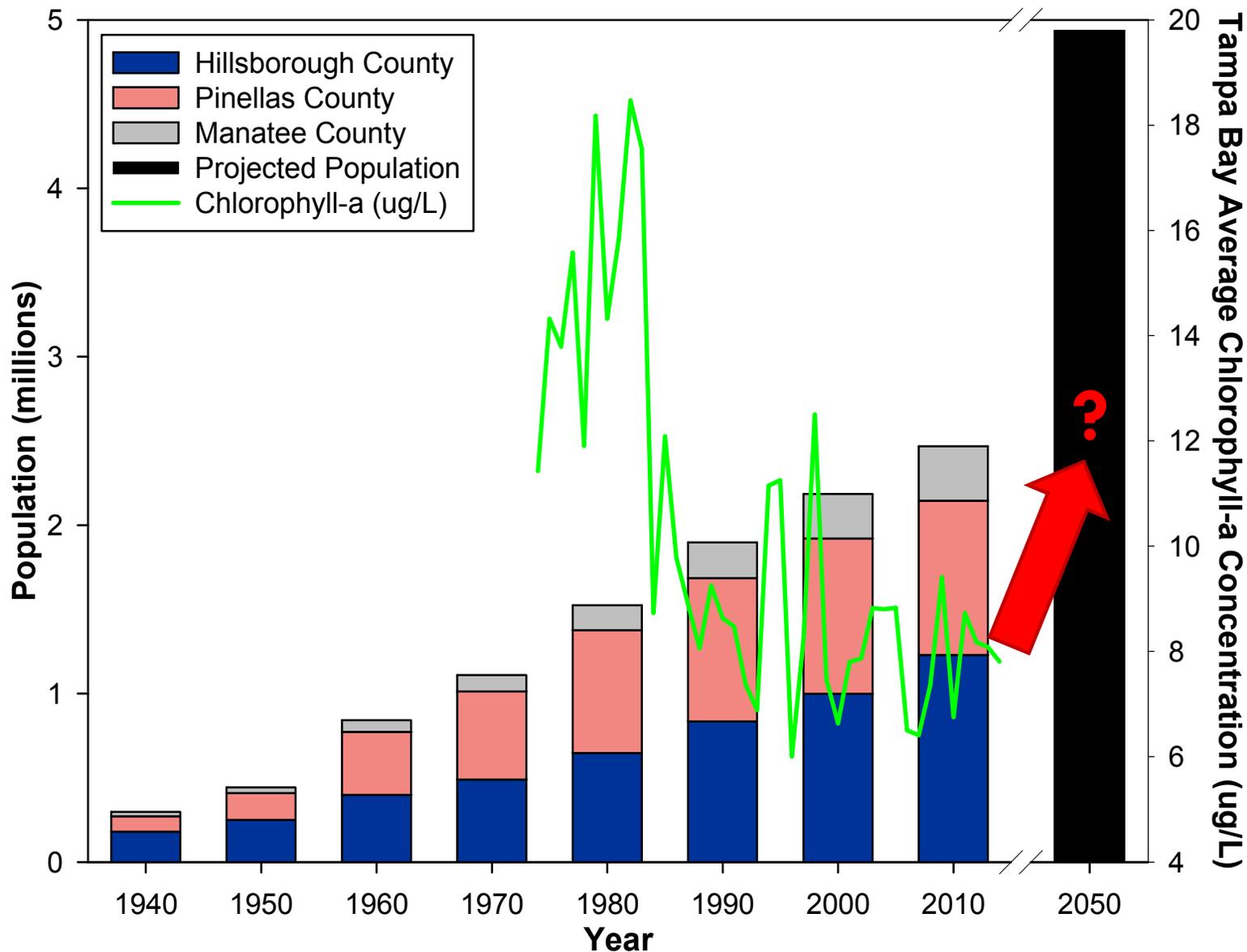


Seagrass Coverage Now Exceeds Recovery Goal



Sustaining Success: Adaptively Managing TB

- Can recovery be maintained w/ increasing population?
- Expected to double by 2050
- New Actions / Offsets will be Needed



Key Elements in Tampa Bay's Recovery

- Target resources identified by both public and scientists as “worthwhile” indicators (seagrass)
- Long-term monitoring
- 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 through active regional monitoring partnerships
- Recently, estuarine health linked to *Regional Economic Value/Output & Climate Change Benefits*



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



COVER STORY

CLEAN WATER MEANS MORE THAN YOU THINK

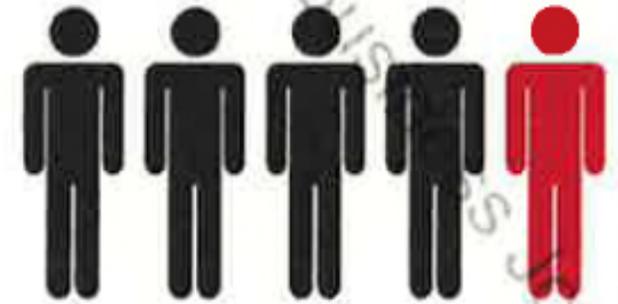
Despite massive growth, water quality in Tampa Bay has improved dramatically in 20 years



LATEST ISSUE
July 2015



Dorian Photography Inc.



HEALTHY BAY

1 out of every 5 jobs in the TBEP Watershed depend on a healthy bay.

\$22B

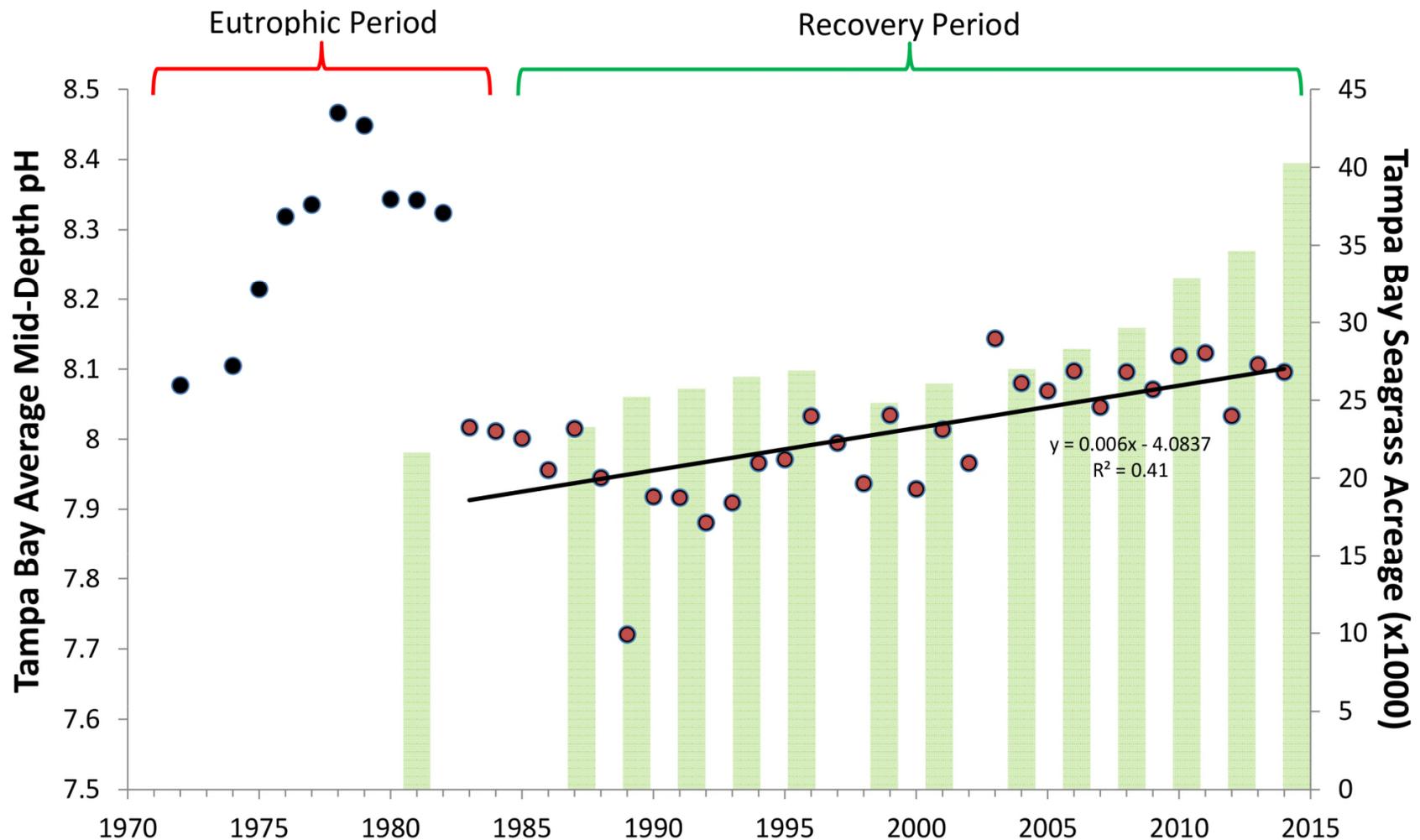
within all six counties

13%

of economy for all six counties

Ancillary Climate Change Benefits?

- Greenhouse Gas Sequestration → Coastal Blue Carbon
- Ocean Acidification Buffering / Refugia



Population expected to double

