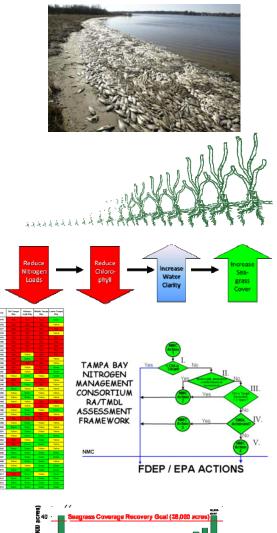
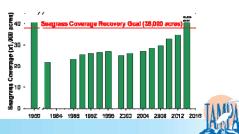


Overview

- 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

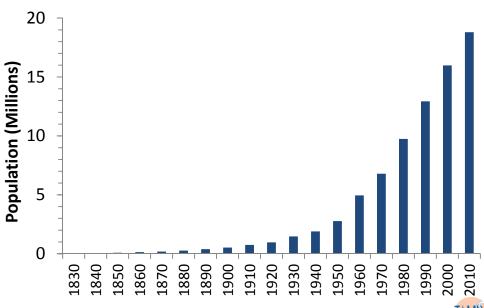




The Start of Tampa Bay's Problem

- Dr. John Gorrie, inventor of first mechanical air conditioning unit (1830s)
- Home air conditioners become increasingly available in 1950s
- Florida's population boom begins







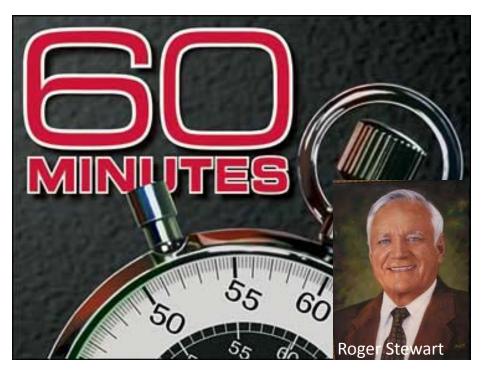
Tampa Bay in the 1970s-Early 1980s

- Poorly-treated Domestic Point Sources, Untreated Industrial Point Sources & Stormwater, Rampant Dredge & Fill Activities
- Phytoplankton and macroalgae dominated
- 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)
- Water quality degradation first documented during this period

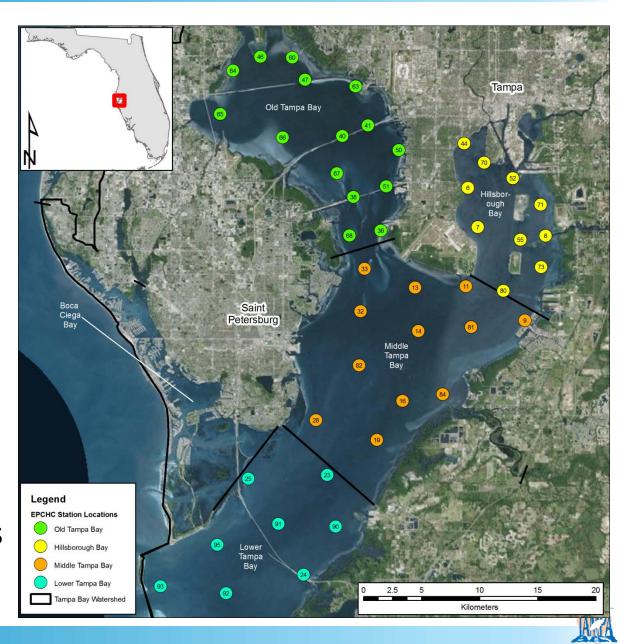






Early Monitoring Provides Management Foundation

- 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 stratifiedrandom approaches employed)



Tampa Bay Estuary Program Formed

- 1980s-1990s some Bay improvements
- Tampa Bay declared an "Estuary of National Significance" by Congress (1990)
- Unique federal-local partnership begins 1991
- Enhanced Bay recovery efforts ensue







Citizens Adopt Goals for a Healthier Bay

To make the Bay look more like it did in the 1950s rather than how it looked in 1980

Citizen Input:

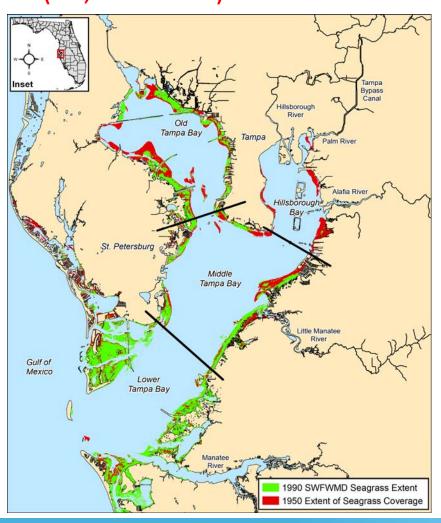
- Clear water, like the "good old days"
- Better fishing
- Swimming without "seaweed" (macroalgae)

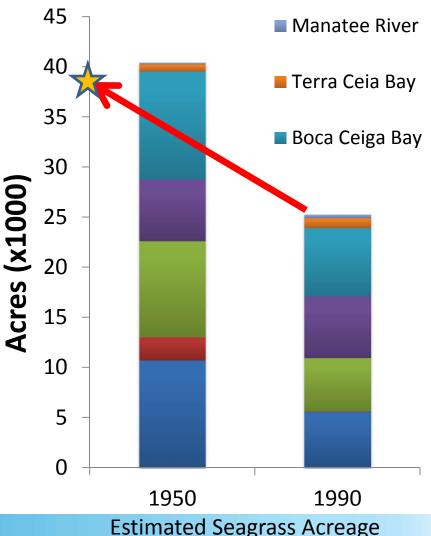
Photo by Capt. Bryon Chamberlin



Seagrass: Canary in the Coal Mine

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





Tampa Bay Estuary: An Urban Watershed

 Urban centers in Pinellas County & City of Tampa

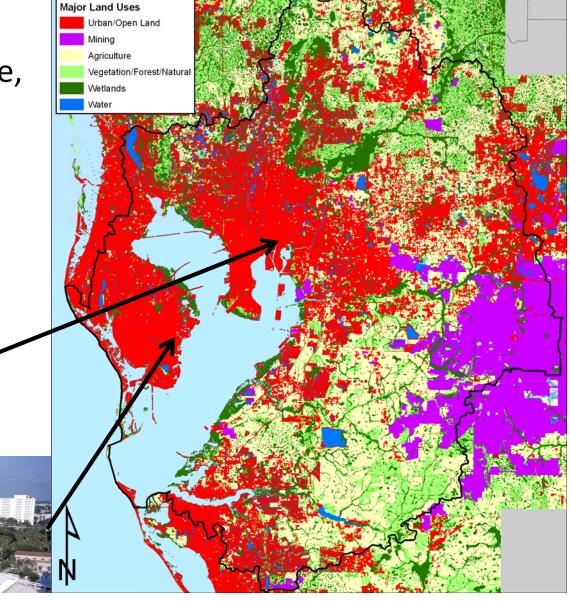
• 1980s: 1.5 million people,

2010s: 2.5 million+

Agriculture / Phosphate
 Mining activities in
 eastern watershed

St. Petersburg

Tampa



Bioassay Results Confirm Bay N Limitation

- City of Tampa WWTP required to assess nutrient limitation in Tampa Bay
- N is primary nutrient driving TB algal production

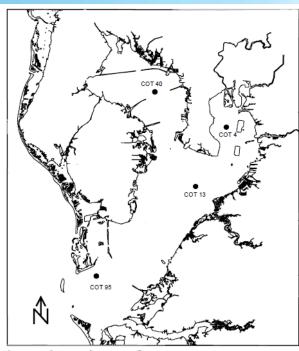


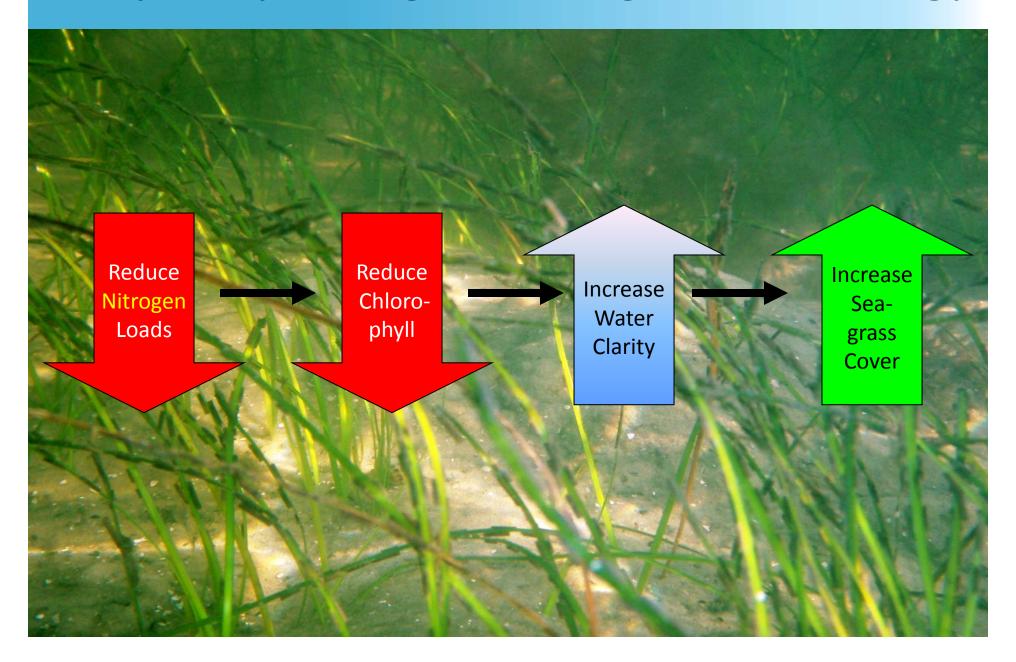
Table 1. Results from natural phytoplankton nutrient bioassays in the four major subsections of Tampa Bay, 1993 – 2009.

Bioassay response	Hillsborough Bay	Old Tampa Bay	Middle Tampa Bay	Lower Tampa
	COT4	COT40	COT13	Bay
				COT95
Exclusive N limitation	29	25	28	39
Primary N limitation	2	2	2	1
Balanced	0	0	0	0
Exclusive P limitation	0	0	0	0
Primary P limitation	0	0	0	0
No response	0	3	0	0

Johansson (2009)

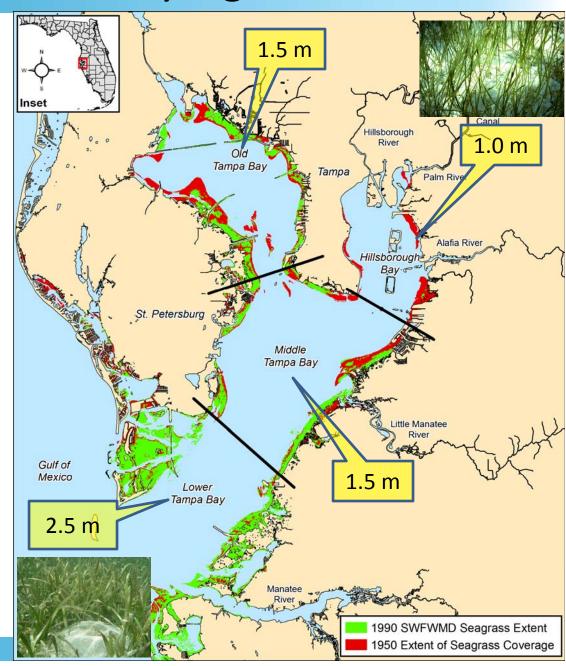


Tampa Bay Nitrogen Management Strategy

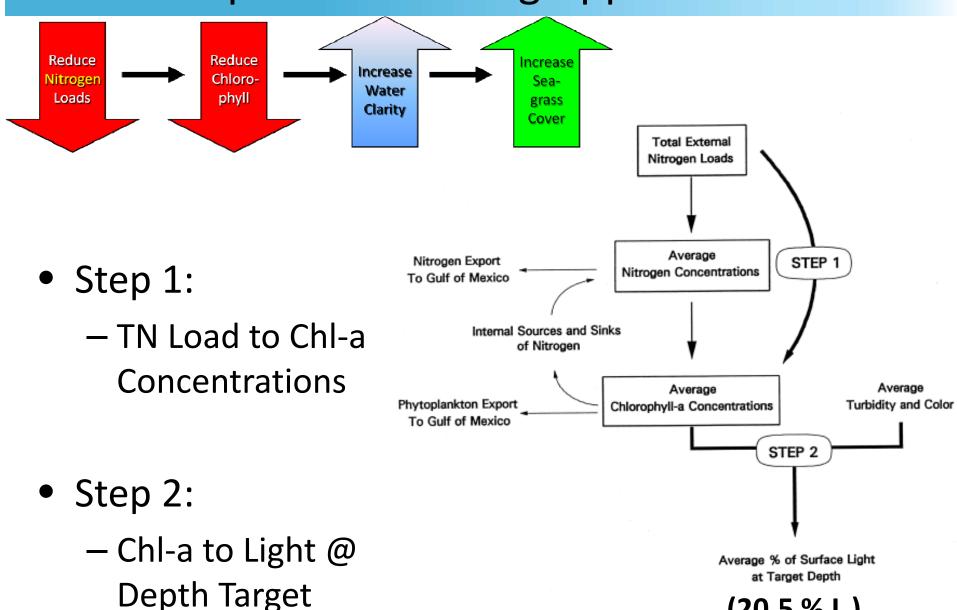


First-things-First: Necessary Light Conditions?

- Historic 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; Dixon 1999)
- 20.5% incidence light used to develop criteria at historical target depths



KISS: Empirical Modeling Approach Pursued



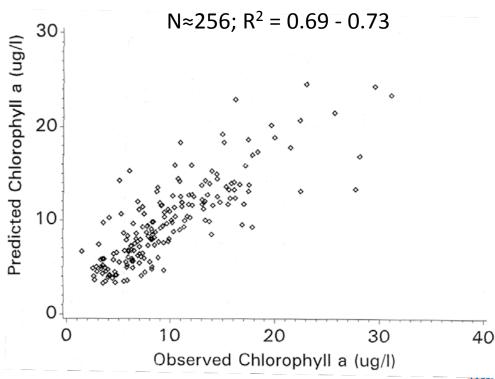


(20.5 % I₀)

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

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

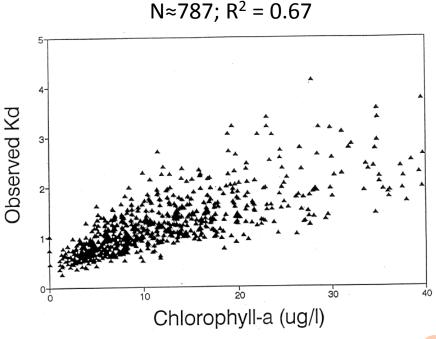




Step 2: Z (Light @ Target Depth) to Chl-a Relationships

- 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

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





TN Load Management Plan: "Hold the Line"

12

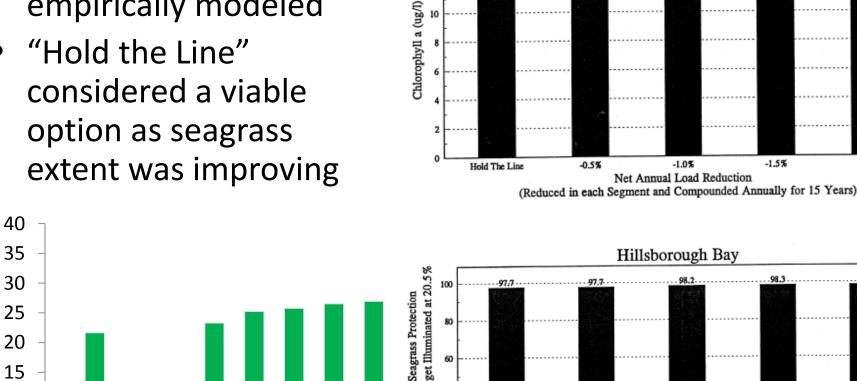
- Realistic load reduction scenarios empirically modeled
- "Hold the Line" considered a viable option as seagrass

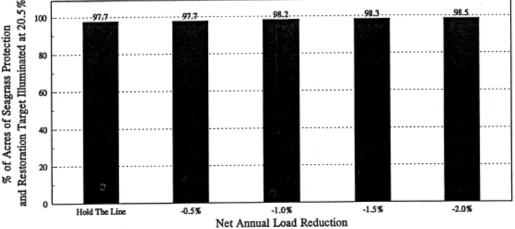
Seagrass Acreage (x1000)

10

5

1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994



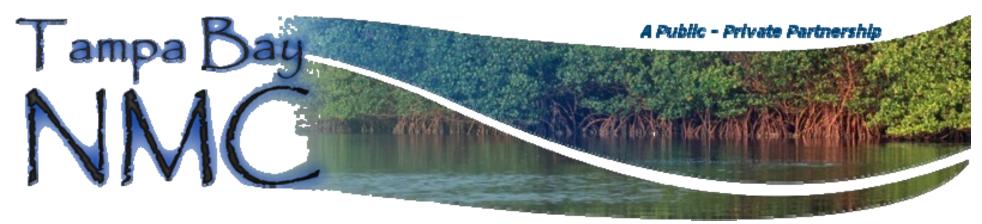


Hillsborough Bay

(Reduced in each Segment and Compounded Annually for 15 Years)



-2.0%



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.
- Progress Energy
- Tropicana Products, Inc.
- Kerry I&F
- Trademark Nitrogen
- Yara N.A.
- · Alafiia Preserve. LLC
- Eagle Ridge, LLC
- LDC Donaldson Knoll Investments,

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	Hillsborough	Middle	Lower
	Bay	Bay	Tampa Bay	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	17.6	8.6	5.4
	(9.6-11.1)	(15.7-19.7)	(7.7-9.6)	(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)

Adopted Water Quality Targets

	TBEP Management Targets Established ~2000		Regulatory Threshold Adopted 2002
Bay Segment	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
	Y		

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



Annual Water Quality Assessment / Management Framework

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

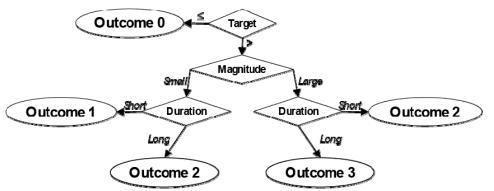


Table 1. Decision matrix identifying appropriate categories of management actions in response to various outcomes of the monitoring and				
assessment of chlorophyll– a and light attenuation data.				
CHLOROPHYLL	LIGHT ATTENUATION			
+	Outcome 0	Outcome 1	Outcome 2	Outcome 3
Outcome 0	GREEN	YELLOW	YELLOW	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.

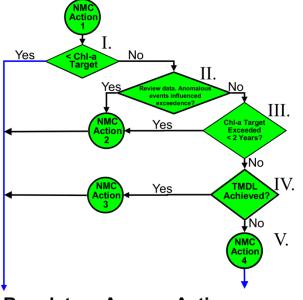
Voluntary Actions Become Regulatory Requirements

- 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



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 reduction of TN TMDL and/or Entity-Specific Load Allocations



specific chlorophyll-a levels relative to regulatory thresholds using the long-term EPCHC monitoring dataset.

NMC Action 1: Document annual bay segment

- 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.

Regulatory Agency Actions

Assessment Step Linked to Roman Numerals of Figure Above	Result	Action
Determine annual bay segment specific chlorophyll-a regulatory threshold	Yes	NMC Action 1
attainment.	No	NMC Action 1
II. Review data and determine if an anomalous event(s) influenced non-attainment	Yes	NMC Action 2
of the bay segment specific chlorophyll-a threshold.	No	Go to III.
III. Determine if the chlorophyll-a thresholds have been exceeded for <2	Yes	NMC Action 2
consecutive years.	No	Go to IV.
IV. Determine if the bay segment specific federally-recognized TMDL has been	Yes	NMC Action 3
achieved.	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

TN Loads Capped & Reductions Documented

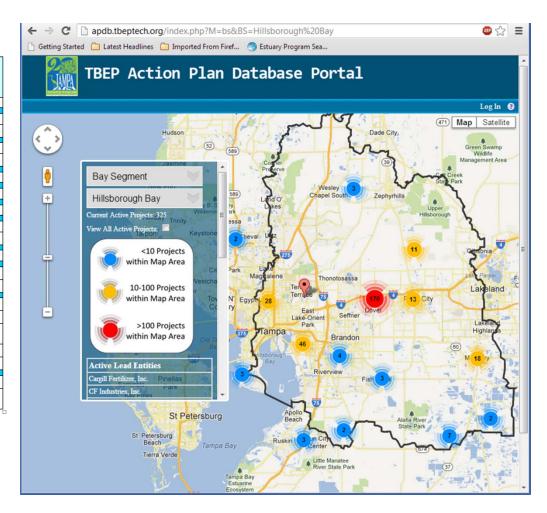
- •All TN Loads Apportioned to Sources
- •Future loads will require offsets/transfers

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
10.	MS4	9.9%	70.9
Hillsborough County	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
00 10 0 1	MS4	6.5%	46.5
City of St. Petersburg	Point Source - St. Pete Facilities RE		20.8
Mosaic	Point Source - Four Corners SW	4.1%	29.3
TECO Dia Dand*	Point Source – SW*		56.5*
TECO Big Bend*	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.			

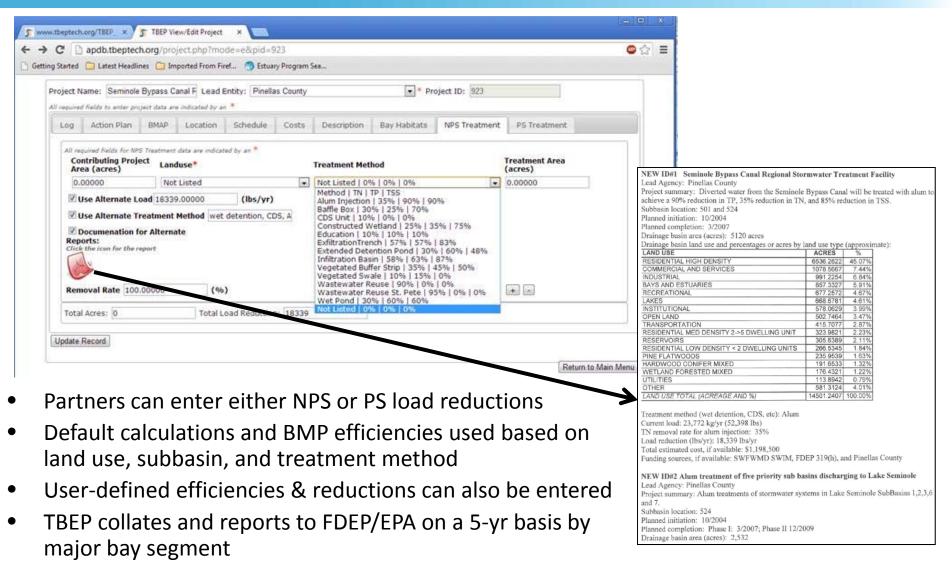
*Includes a Set Allocation of 35.0 tons/year and an Interim Allocation through 2012 of an additional 21.5 tons/year to allow determination of new discharge loads.

- •http://apdb.tbeptech.org
- Load reductions reported every 5-yrs



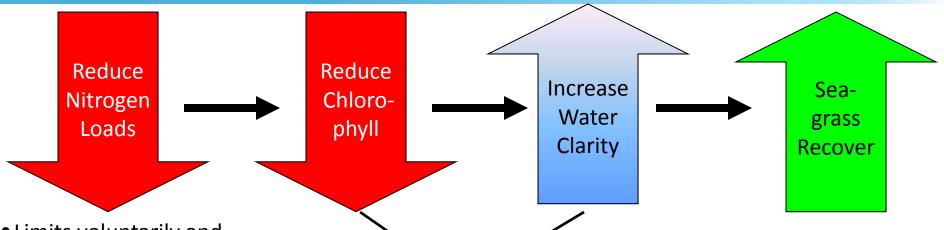


Partner-Driven Load Reduction Reporting



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).

Summary: Tracking our Progress



- Limits voluntarily and proactively developed by NMC local partners
- Regulatory agencies partners 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

- Local-program

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

5-Yr Annual Assessment; Tied to Observed Bay Conditions

Bottom Line

Annually-Assessed; Localized Management Responses Implemented, if necessary ~2-Yr Assessment;

Water-quality Targets Re-Evaluated, if necessary

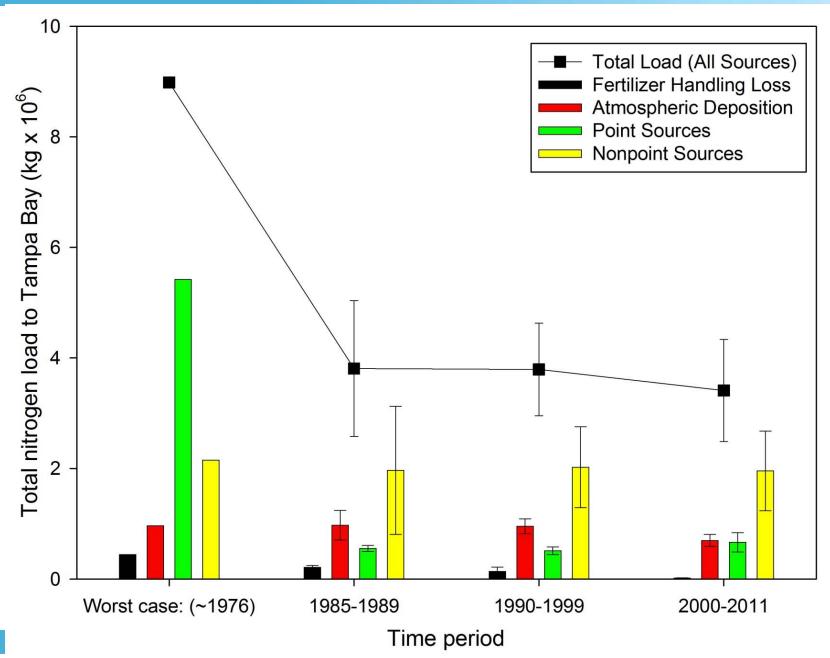


So What: Has it Worked?





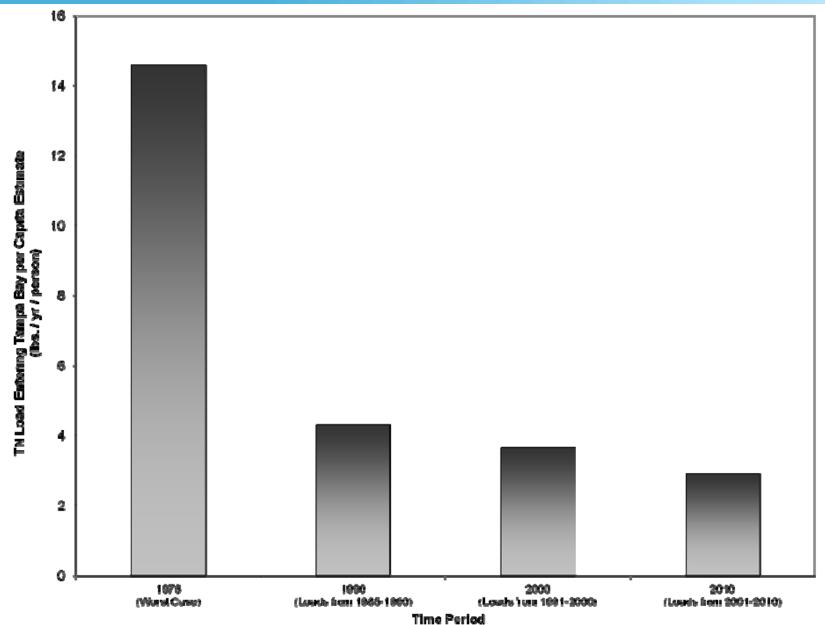
Reduced TN Loads to Tampa Bay







Per Capita TN Load Reduced by 80%







(ug/L)

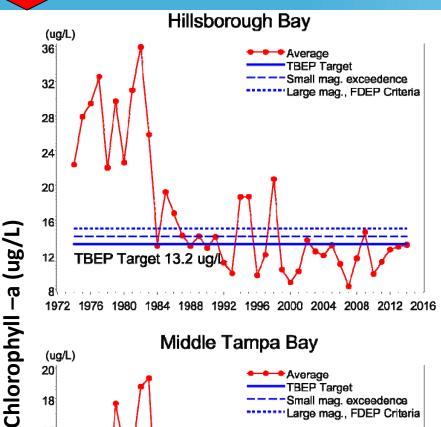
18

16

14

Water Quality Has Improved





AWT & Reuse Standards Implemented **◄**

> Stormwater Regulations **Enacted**

Old Tampa Hillsbor-Bay ough Bay 1975 Green Yellow Yellow 1979 Yellow 1984 Green Yellow Yellow Yellow Green 1987 Yellow Green Yellow Green 1989 Yellow Yellow Yellow Yellow Green Yellow Yellow 1994 Yellow Yellow Yellow Yellow Yellow Yellow Yellow Yellow Green 1999 Yellow Yellow Yellow Green Yellow Yellow Green Yellow Yellow Yellow Green Green Green Yellow Yellow 2004 Green Green Yellow Green Yellow Yellow Green Green Green Green Green Green Green Yellow Green Yellow 2009 Yellow Yellow Green Green Green Green Green Green Green Green 2013 Green Green Green Green Green

Middle Tampa Bay FBEP Target Small mag. exceedence Large mag., FDEP Criteria

12 10 TBEP Target 7.4 ug/L 6 1972 1976 1980 1984 1988 1992 1996 2000 2004 2008 2012 2016 Citizen Actions

TBEP Partner &

NMC Actions

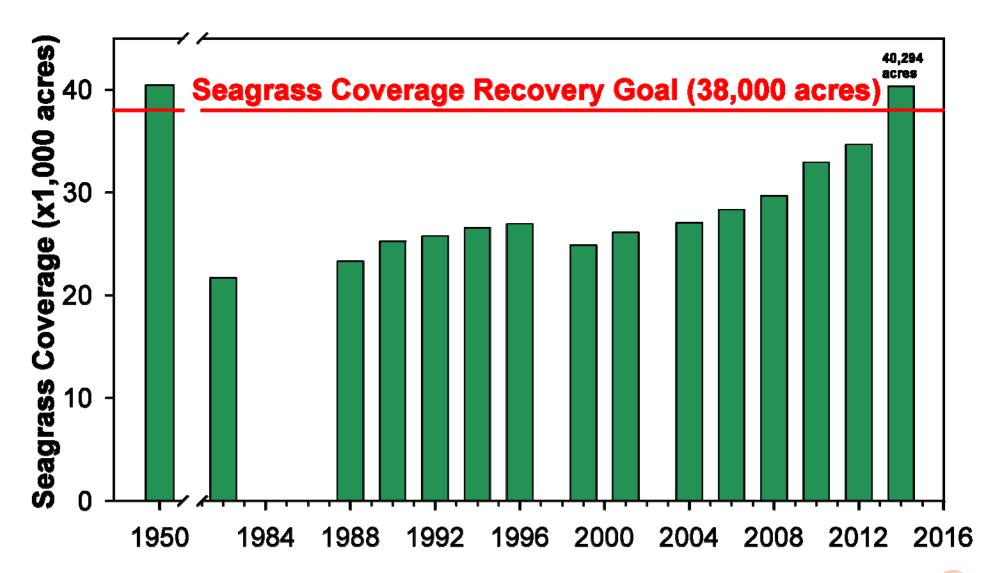
Implemented

Power Plant Upgrades

Port Facility **Upgrades**

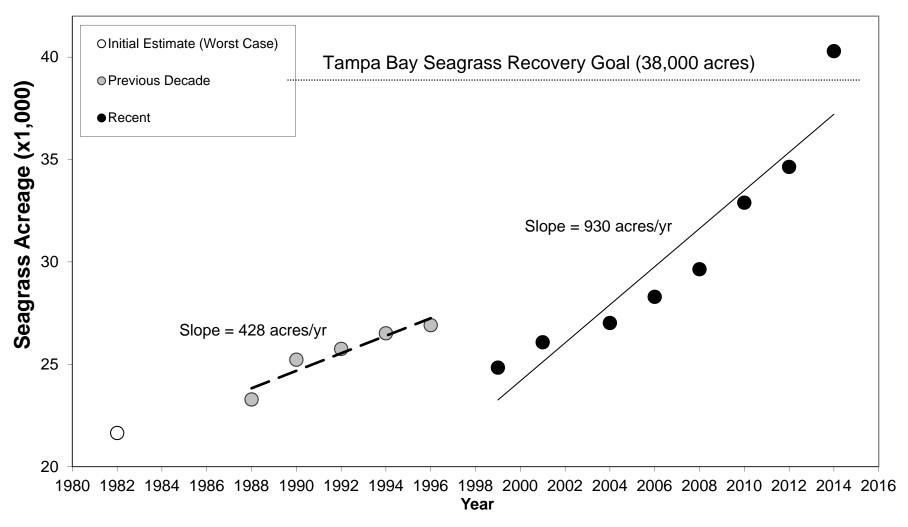


Seagrass Coverage Now Exceeds Goal





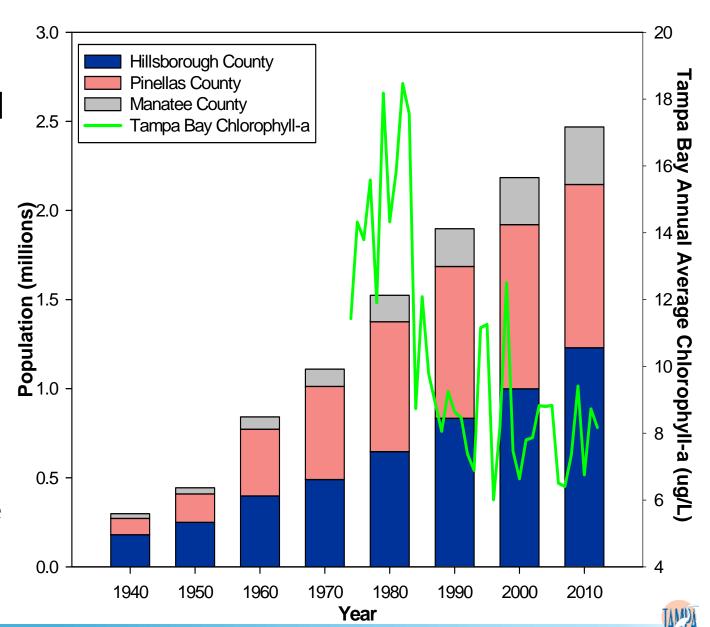
Positive Feedbacks?





Sustaining Success: Adaptively Managing TB

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



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





TBEP's Role In the Process

- Facilitate scientific and technical discussions and evaluations – Convene the NMC
- Provide public education and communication
- Develop and foster partnerships to restore and protect Tampa Bay across local, regional, state and federal entities
- Keep the ball-rolling and showcase partner's continuing, successful efforts ...



Key Elements in Tampa Bay's Adaptive Management Approach & Success

- Long-term monitoring
- Target resources identified by both public and scientists as "worthwhile" indicators (seagrass)
- 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
- Recently, Linked to Regional Economic Value



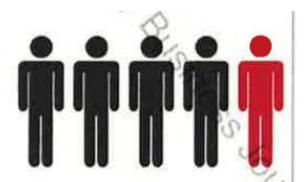
COVER STORY

CLEAN WATER MEANS MORE THAN YOU THINK

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







HEALTHY BAY

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

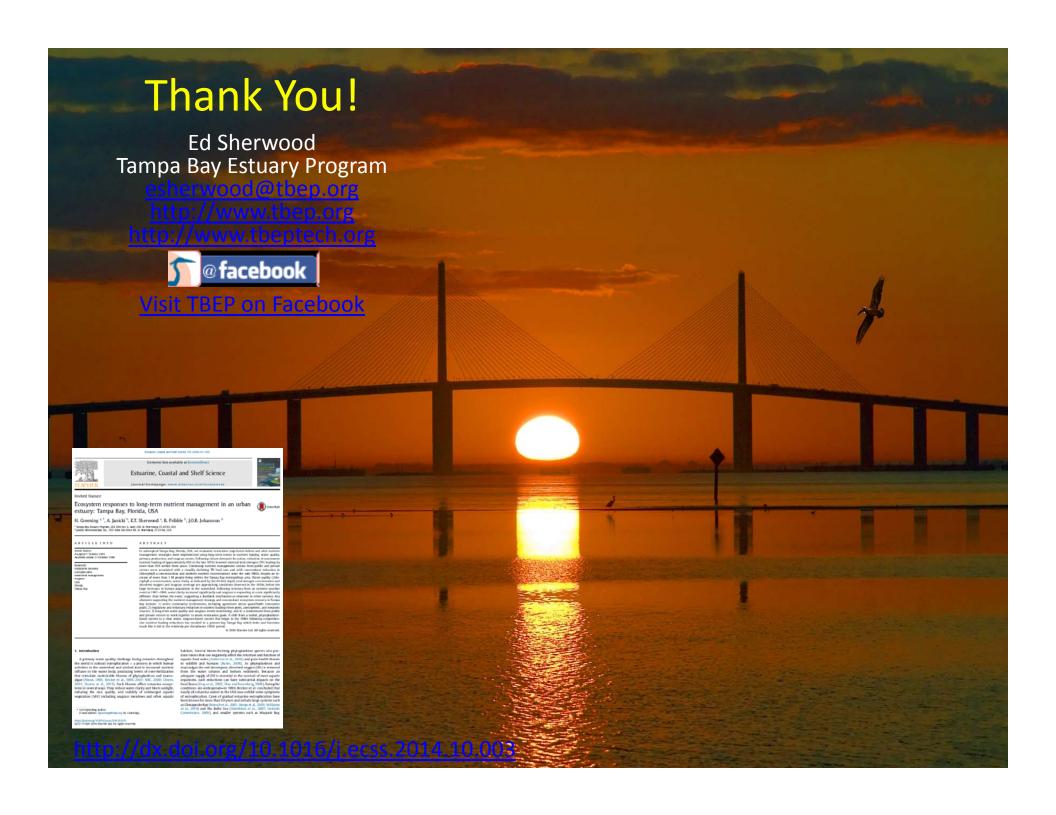
\$22B

within all six counties

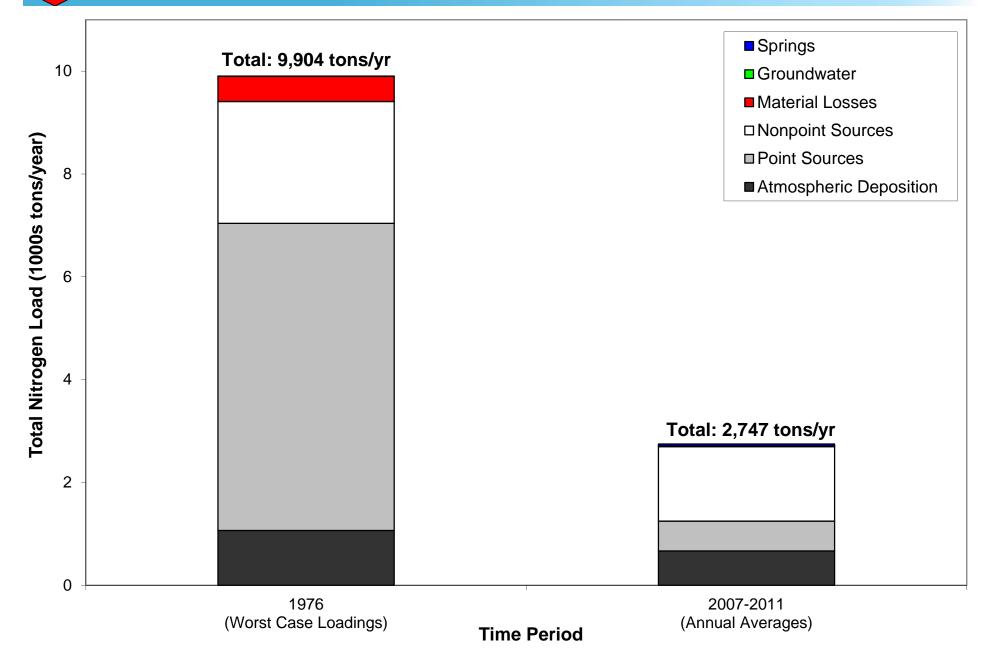
13%

of economy for all six counties

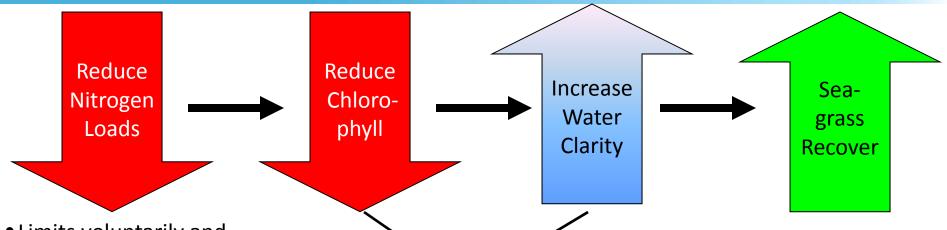




Reducing TN Loads to Tampa Bay



Tracking our Progress



- Limits voluntarily and proactively developed by NMC local partners
- Regulatory agencies partners in the process
- Load allocation targets periodically re-assessed
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- Bay-Segment Specific
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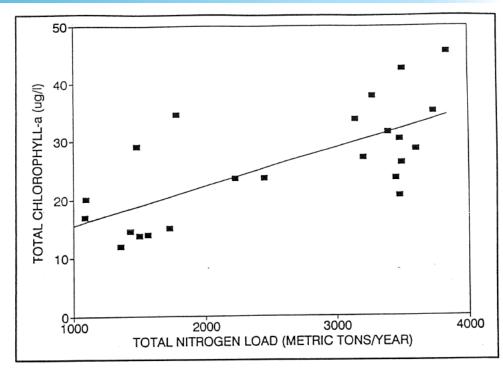
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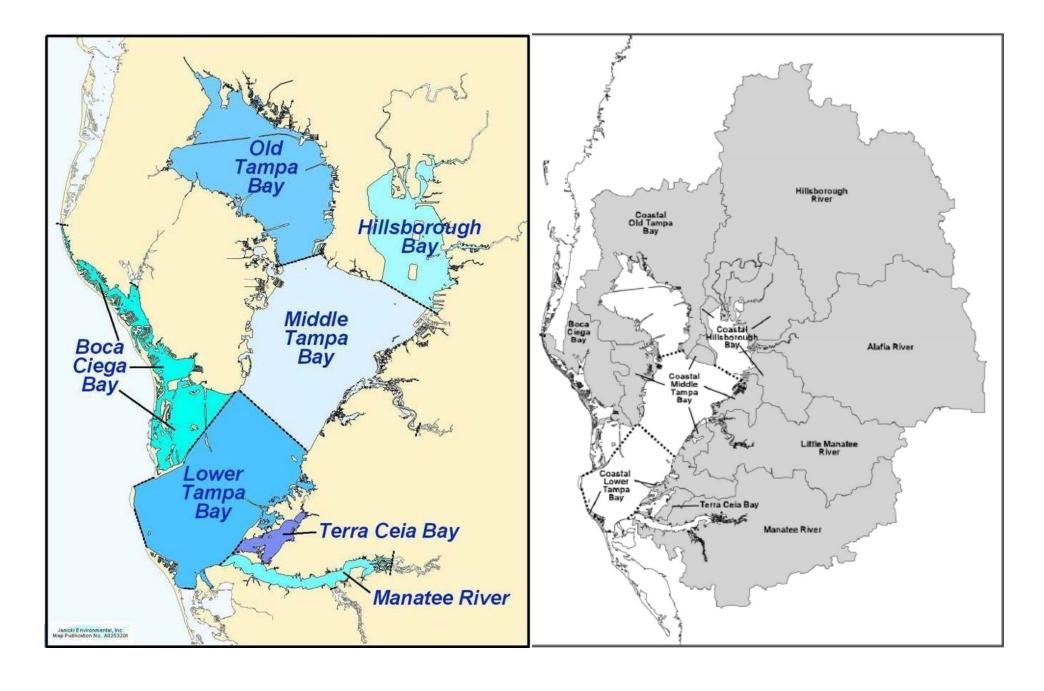




TN Loads vs. Chlorophyll-a (1968-1990) (Johansson 1991)

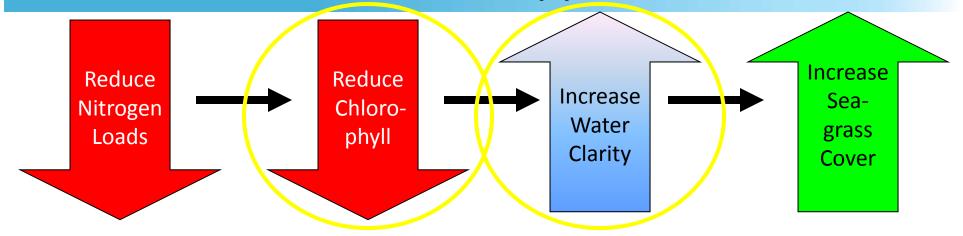


Open Bay Segments & Drainage Areas



Hillsbor-Mid Tampa LowTampa Old Tampa Year **Meeting Regulatory Thresholds** Bay ough Bay Bay Bay 1974 No No No Yes 1975 No No No Yes Hillsborough Bay 1976 No Yes No No (ug/L) 1977 No No No No 36 Average 1978 No No No Yes **AWT & Reuse** Regulatory Threshold 1979 No No No No 32 1980 No **Standards** No No No 1981 No No No No **Implemented** 28 1982 No No No No 1983 No No No No Stormwater 24 1984 Yes Yes No Yes 1985 No No No Yes Regulations < 20 1986 No Yes No Yes **Enacted** 1987 No Yes No Yes 16 1988 Yes Yes Yes Yes 15.0 ug/L 1989 No Yes Yes Yes 12 1990 No Yes Yes Yes 1991 Yes Yes Yes Yes 1992 Yes Yes Yes Yes 1976 1980 1984 1988 1992 1996 2000 2004 2008 2012 2016 1993 Yes Yes Yes Yes Old Tampa Bay 1994 No No No No (ug/L) No 1995 No No Yes 18 Average 1996 Yes Yes Yes Yes Regulatory Threshold Yes 1997 Yes Yes Yes 16 1998 No No No No 1999 Yes Yes Yes Yes Yes 2000 Yes Yes Yes 14 TBFP Partner & 2001 Yes Yes Yes Yes 2002 Yes Yes Yes Yes 12 NMC Actions < 2003 No Yes Yes Yes 2004 No Yes Yes Yes **Implemented** Yes Yes 2005 Yes 10 No 2006 Yes Yes Yes Yes 9.3 ug/L 2007 Yes Yes Yes Yes 2008 Yes Yes Yes Yes Yes Yes 2009 No Yes 2010 Yes Yes Yes Yes 1972 1976 1980 1984 1988 1992 1996 2000 2004 2008 2012 2016 2011 No Yes Yes Yes 2012 Yes Yes Yes Yes

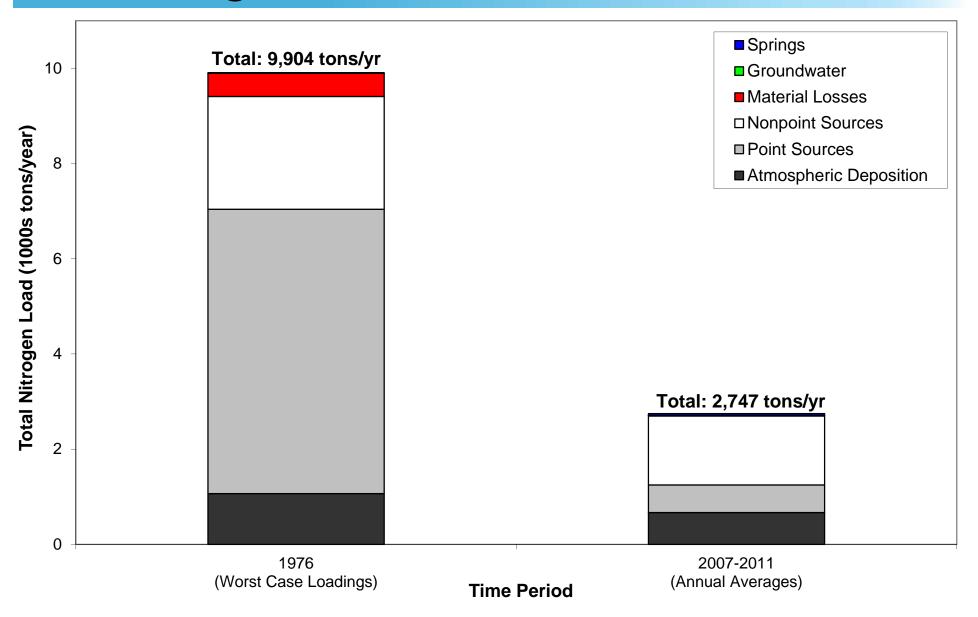
Annual Decision Support Process



- Annual report card for Tampa Bay
- Specific to each of the 4 major bay segments

Provides for adaptive management of a sentinel estuarine indicator (seagrass)

Restoration Success Tied to Significant Nutrient Reductions



Water Quality Assessment / Management Framework

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

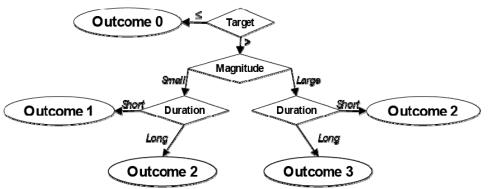
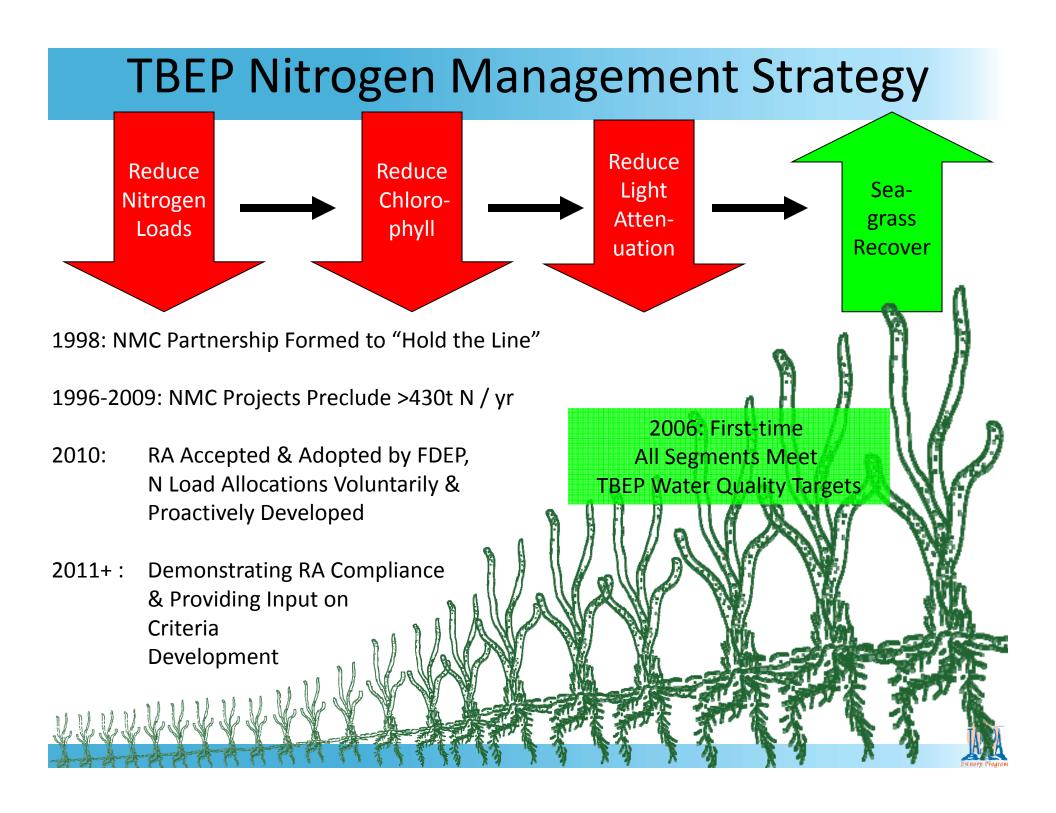


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CHLOROPHYLL	LIGHT ATTENUATION				
+	Outcome 0	Outcome 1	Outcome 2	Outcome 3	
Outcome 0	GREEN	YELLOW	YELLOW	YELLOW	
Outcome 1	YELLOW	YELLOW	YELLOW	RED	
Outcome 2	YELLOW	YELLOW	RED	RED	
Outcome 3	YELLOW	RED	RED	RED	

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.



Tampa Bay in the 1970s-Early 1980s

- Phytoplankton and macroalgae dominated
- 50% loss of seagrass coverage between 1950 and 1980
- Newspapers declared Tampa Bay "dead"
- Poorly-treated Domestic Point Source, Untreated Industrial Point Sources & Stormwater, Rampant Dredge & Fill Activities

