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

Ed Sherwood
Tampa Bay Estuary Program

June 13, 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 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)

Clearer water, Better fishing
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
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

- Reduce Nitrogen Loads
- Reduce Chlorophyll
- Increase Water Clarity
- Increase Seagrass Cover
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 1995a; Dixon 1999).

- 20.5% incidence light used to develop criteria at historical target depths.

*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

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

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

\[N \approx 256; \ R^2 = 0.69 - 0.73\]
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

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

$N \approx 787; R^2 = 0.67$
• Seagrass coverage extent improved from 1990-1996
• Either empirical estimates or mean observed levels selected

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

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.


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
## Adopted Water Quality Targets & Thresholds

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td></td>
<td>Chl-a Management Target (ug/L)</td>
<td>Chl-a Regulatory Threshold (ug/L)</td>
<td>TN Load Delivery (tons / million m³ FW)</td>
</tr>
<tr>
<td>Old Tampa Bay</td>
<td>8.5</td>
<td>9.3</td>
<td>1.08</td>
</tr>
<tr>
<td>Hillsborough Bay</td>
<td>13.2</td>
<td>15.0</td>
<td>1.62</td>
</tr>
<tr>
<td>Middle Tampa Bay</td>
<td>7.4</td>
<td>8.5</td>
<td>1.24</td>
</tr>
<tr>
<td>Lower Tampa Bay</td>
<td>4.6</td>
<td>5.1</td>
<td>0.97</td>
</tr>
</tbody>
</table>

### Notes
- Annual TBEP WQ Report Card
- Assess Annual TN Load Reduction Effectiveness
- Assess TMDL Compliance (Contingent on >2yr poor WQ)
Summary: Tracking our Progress

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

2. **Reduce Chlorophyll**
   - Local-programs consistently monitor water quality since 1970’s
   - Bay-Segment Specific Annual Targets Developed
   - Targets tied to Seagrass Restoration Goal

3. **Increase Water Clarity**
   - Regional-program consistently estimates seagrass coverage since 1980’s
   - Restoration endpoint clearly defined

**Bottom Line**

5-Yr Annual Assessment; Tied to Observed Bay Conditions

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

Annually-Assessed; Localized Management Responses Implemented, if necessary
So What: Has it Worked?
Reduced Nitrogen Loads to Tampa Bay

Graph showing the total nitrogen load to Tampa Bay over different time periods. The graph compares Total Load (All Sources), Fertilizer Handling Losses, Point Sources, Atmospheric Deposition, and Nonpoint Sources. The data is presented from Worst Case (1976) to 2010-2016, with a clear downward trend in nitrogen loads over time.
Reduced Per Capita TN Loads to TB

- 1976 (Worst Case)
- 1980s (Loads from 1985-1989)
- 1990s (Loads from 1990-1999)
- 2000s (Loads from 2000-2009)
- 2010s (Loads from 2010-2016)
Water Quality Has Improved

- Reduce Chlorophyll
- Increase Water Clarity
- AWT & Reuse Standards Implemented
- Stormwater Regulations Enacted
- TBEP Partner & NMC Actions Implemented
- Power Plant Upgrades
- Port Facility Upgrades
- Fertilizer Restrictions
Seagrass Coverage Now Exceeds Recovery Goal & 1950s Benchmark Period Extent

Seagrass Coverage Recovery Goal (38,000 acres)

Seagrass Coverage (x1,000 acres)

<table>
<thead>
<tr>
<th>Year</th>
<th>Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td>38,000</td>
</tr>
<tr>
<td>1984</td>
<td>20,000</td>
</tr>
<tr>
<td>1988</td>
<td>22,000</td>
</tr>
<tr>
<td>1992</td>
<td>25,000</td>
</tr>
<tr>
<td>1996</td>
<td>27,000</td>
</tr>
<tr>
<td>2000</td>
<td>29,000</td>
</tr>
<tr>
<td>2004</td>
<td>31,000</td>
</tr>
<tr>
<td>2008</td>
<td>33,000</td>
</tr>
<tr>
<td>2012</td>
<td>35,000</td>
</tr>
<tr>
<td>2016</td>
<td>41,655</td>
</tr>
</tbody>
</table>
Positive Feedbacks from Continuing Seagrass Recovery?

Pre 1998 El Niño Period
Seagrass coverage (ha) = 162.5 ha • year$^{-3}$
95% Confidence Band
Post 1998 El Niño Period
Seagrass coverage (ha) = 408.3 ha • year$^{-3}$
95% Confidence Band

Tampa Bay area of seagrass cover (ha x 10$^3$)

Year

16
14
12
10
8
6

18
16
14
12
10
8
6


Year
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

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

1970s: TN Load ~ 9 x 10^6 tons/yr
- Fertilizer Losses: <1%
- Atmospheric Deposition: 11%
- Nonpoint Sources: 60%
- GW & Springs: 24%
- Point Sources: 5%

2010s: TN Load ~ 3.4 x 10^6 tons/yr
- Industrial PS: 1%
- Domestic PS: 5%
- Nonpoint Sources: 66%
- Point Sources: 11%
- Metropolitan Area: 17%
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

http://dx.doi.org/10.1016/j.ecss.2014.10.003
http://dx.doi.org/10.1016/j.rsma.2015.05.005

http://www.tbep.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)


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

**Old Tampa Bay**
- Mean annual [TN] or [TP] (mg/L) values:
  - 0.93 mg/L

**Hillsborough Bay**
- Mean annual [TN] or [TP] (mg/L) values:
  - 1.01 mg/L

**Middle Tampa Bay**
- Mean annual [TN] or [TP] (mg/L) values:
  - 0.87 mg/L

**Lower Tampa Bay**
- Mean annual [TN] or [TP] (mg/L) values:
  - 0.74 mg/L
Business as Usual: Forecast Grim for Coastal Habitats
Potential Reversal of Successful Recovery

Total Acreage x 1000

1950: 64,306 acres
2100: 50,187 acres

Adapted from: Sherwood & Greening (2014)
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>
<thead>
<tr>
<th>CHLOROPHYLL</th>
<th>LIGHT ATTENUATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outcome 0</td>
<td>GREEN</td>
</tr>
<tr>
<td>Outcome 1</td>
<td>YELLOW</td>
</tr>
<tr>
<td>Outcome 2</td>
<td>RED</td>
</tr>
<tr>
<td>Outcome 3</td>
<td>RED</td>
</tr>
</tbody>
</table>

"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.

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.

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

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

<table>
<thead>
<tr>
<th>Entity</th>
<th>Source</th>
<th>Proposed MS4 and Point Source Permit Limit (%)</th>
<th>TMDL Load (tons/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harbor Bay</td>
<td>NPS</td>
<td>&lt;0.1%</td>
<td>0.2</td>
</tr>
<tr>
<td>Hillsborough County</td>
<td>MS4</td>
<td>9.9%</td>
<td>70.9</td>
</tr>
<tr>
<td></td>
<td>Point Source - South County RE</td>
<td></td>
<td>0.5</td>
</tr>
<tr>
<td>MacDill Air Force Base</td>
<td>MS4</td>
<td>1.0%</td>
<td>7.0</td>
</tr>
<tr>
<td></td>
<td>Point Source - WWTP RE</td>
<td></td>
<td>0.7</td>
</tr>
<tr>
<td>Manatee County</td>
<td>MS4</td>
<td>3.0%</td>
<td>21.8</td>
</tr>
<tr>
<td>Pinellas County</td>
<td>MS4</td>
<td>0.5%</td>
<td>3.2</td>
</tr>
<tr>
<td>City of Pinellas Park</td>
<td>MS4</td>
<td>0.7%</td>
<td>5.3</td>
</tr>
<tr>
<td>City of St. Petersburg</td>
<td>MS4</td>
<td>6.5%</td>
<td>46.5</td>
</tr>
<tr>
<td></td>
<td>Point Source - St. Pete Facilities RE</td>
<td></td>
<td>20.8</td>
</tr>
<tr>
<td>Mosiac</td>
<td>Point Source - Four Corners SW</td>
<td></td>
<td>29.3</td>
</tr>
<tr>
<td>TECO Big Bend*</td>
<td>Point Source – SW*</td>
<td>56.5%</td>
<td>2.1</td>
</tr>
<tr>
<td></td>
<td>Point Source – RE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-MS4/Non-Ag NPS</td>
<td></td>
<td>0.5%</td>
<td>3.8</td>
</tr>
<tr>
<td>Atmospheric Deposition</td>
<td></td>
<td>35.2%</td>
<td>252.1</td>
</tr>
<tr>
<td>Other (Groundwater, Springs, Conservation)</td>
<td></td>
<td>5.1%</td>
<td>36.7</td>
</tr>
<tr>
<td>FDACS (Agriculture)</td>
<td></td>
<td>33.4%</td>
<td>239.2</td>
</tr>
<tr>
<td>Small Sources</td>
<td></td>
<td>2.4</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>799</strong></td>
<td></td>
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</tbody>
</table>

*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.