

# **Narragansett Bay: a Historical Perspective on our Changing Bay**

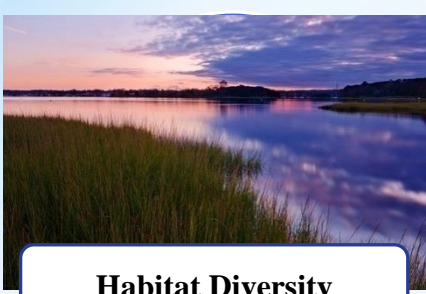
## *Sins of the Past & Future Opportunities*

Thomas Uva

Director of Environmental Science & Compliance

Narragansett Bay Commission





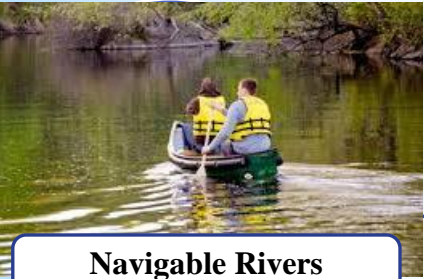
**Habitat Diversity**



**Dissolved Oxygen  
>4.8 mg/L**



**Eelgrass Beds**



**Navigable Rivers  
(fish & people)**



**Viable Fisheries  
(safe to eat)**

**Ecosystem based management**

**Sustainable**

**Holistic**



**Harvestable Shellfish**

**EPA GOAL:  
Fishable  
Swimmable**

**Cooperation**

**Collaboration**



**Clean Sediment**

**Shared Vision**

**Compromise**



**Biological Diversity**



**Increased Water Clarity**



**Open Upper Bay Beaches**

# Issues affecting Narragansett Bay...



[www.waikatoregion.govt.nz](http://www.waikatoregion.govt.nz)

- Loss of wetlands & eelgrass
- Contaminated Sediments
- Alteration of coastline
- Circulation and Flushing Issues
- Climate Change
- Installed Dams & Breakwalls
- Silted up Rivers/Filled Bay
- Impervious cover/Runoff
- Stratification of the Water Column
- Changes in Bay Fisheries

**Many Ecosystem-wide problems  
began decades ago...**

**Need to look at Historical Record**



# Historical Changes in Bay Fisheries

- **Mid 1800s**
  - Fishermen report hugely abundant and diverse fish populations
  - Atlantic salmon, herring, smelt, scup, tautog, sea bass, cod, striped bass and shad
  - Lobster and shellfish were abundant
- **Late 1800s**
  - Highest oyster yield in Providence River
  - Scallops and clams abundant in Greenwich Bay, Pawtuxet, Apponaug
- **1870** - Atlantic salmon fishery is lost
- **Early 1900's**: 500 dams in RI
- **1930s**
  - River herring fishery is significantly depleted
  - Eel grass beds die from waste disease
  - Scallops decline due to habitat loss, decreased water clarity
- **1950s**
  - Improved fishing technologies lead to overfishing and declines in commercial stock species



Tallman &  
Mack Fish &  
Trap Co. Inc.  
Spring Wharf,  
Newport, RI,  
date unknown

Providence Public Library,  
Providence, RI



Scalloptown, East Greenwich, RI,  
date unknown

<https://patch.com/rhode-island/eastgreenwich/scalloptown-really-was-here>



# What Happened to Bay Fisheries?

- **Present Day:**

- Over 700 dams in RI
  - ✓ Caused excess siltation, decreasing river depth, deprecation of benthic habitats, loss of fish runs
  - ✓ Dam removal and fish ladder restorations look promising
- More than 50 percent of Narragansett Bay's salt marshes have been destroyed in the past 300 years
- Winter flounder stocks have declined 90% since the 1980s (NOAA)
- Since 1981, annual winter flounder landings have dropped from nearly 10 million pounds to less than 2 million (DEM)
- Lobsters have been in decline since 2001



**Slater Mill.** Rhode Island Collection, Providence  
Public Library, 1955, Pawtucket, RI.

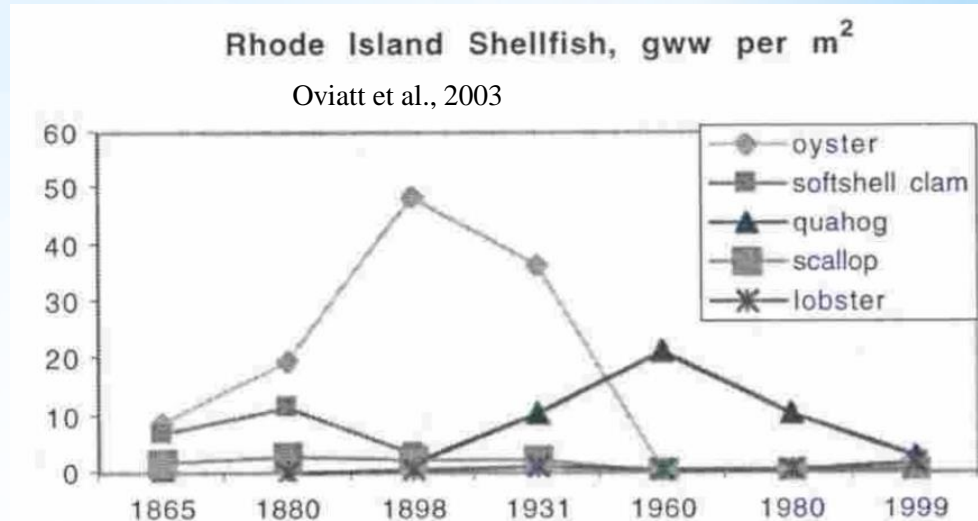


**Fish ladder, Manton Dam,  
Woonasquatucket River.**

<http://johnstonsunrise.net/stories/a-fish-swims-through-them,123103>

# Historical Changes in Bay Fisheries

- Major changes in species of Shellfish harvested over time
- Oyster Productivity Reached its peak in 1910
- Leased oyster beds covered 5,000 acres in the Providence River & upper Bay (Fuller 1905)
- Generated \$45,000 in 1903 dollars from lease fees (Fuller 1905)
- Produced ~7,000 metric tons of oysters a year (Rice et al 2000)
- People became sick from contaminated oysters due to bacterial pollution
- Fishery began to decline in 1911 due to anthropogenic inputs, disease & Great Hurricane of 1938

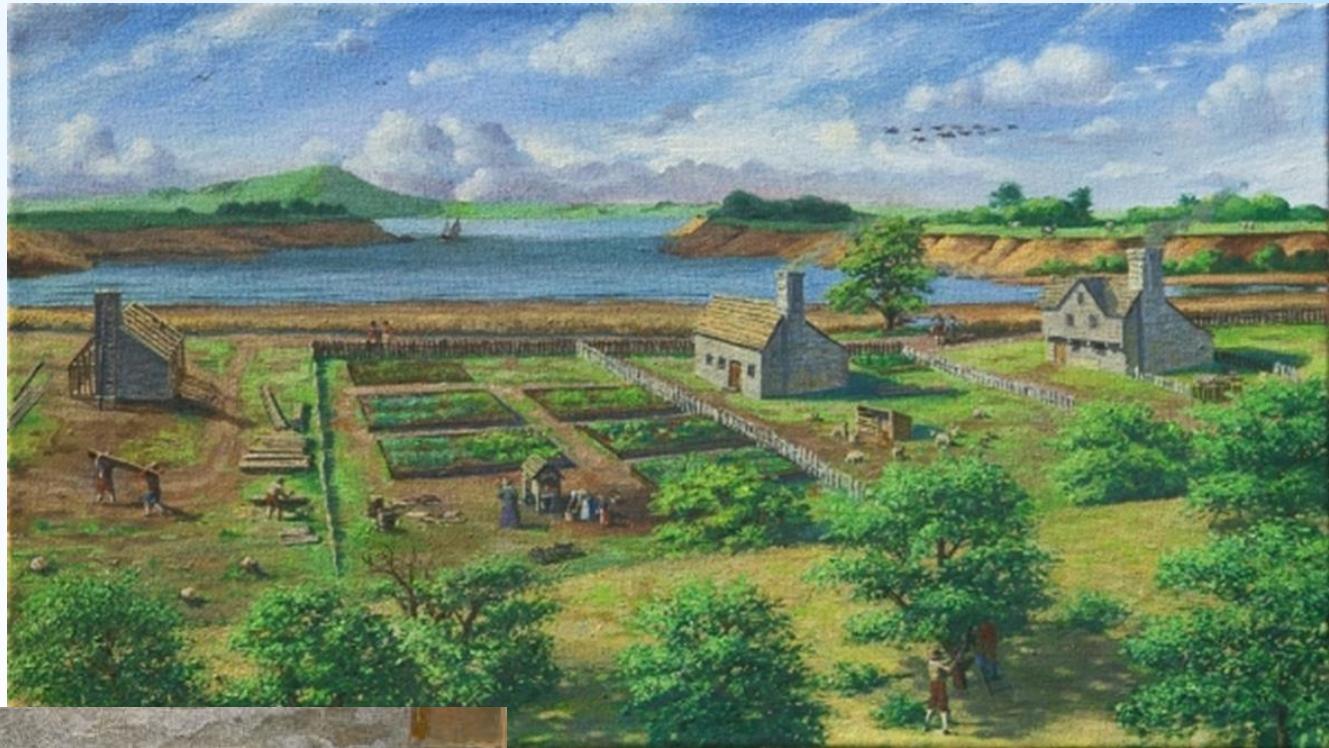


Field's Point, 1911; Photo in 41°N (vol 4; issue 2); from 1912 annual report of the RI Shellfisheries Commission



# Changes in Rhode Island's Landscape

- The “Great Salt Cove” in Providence circa 1650
- The RI Statehouse would later be built on the plateau on the right



<https://www.npca.org/parks/roger-williams-national-memorial>



- View of the cove from Smith Hill in 1880...



# Changes in Rhode Island's Landscape

- **1636**
  - ✓ First European settlement at Providence
  - ✓ RI population remains low through Colonial Period
- **1660**
  - ✓ Beaver population in Narragansett Bay is depleted by fur trade
  - ✓ Removal of beavers increases stream flow and sedimentation
- **1700**
  - ✓ Land cleared for agriculture
  - ✓ ~78% of RI is forested (95% pre-European)
- **1775** - Jewelry industry begins in Providence, RI
- **1790** – Birth of the Industrial Revolution
  - ✓ Samuel Slater introduces factory system at Moses Brown's cotton factory on the Blackstone River
- **1800** - A period of rapid population growth begins in Providence, averaging 3.1% per year from 1800-1910
- **1820** - ~54% of RI is forested
- **1830** – 27 Jewelry Firms/280 Workers
- **1840** - Cotton mills concentrated on Blackstone, woolen mills in SW RI



Beaver Pond, Exeter, RI

<http://www.providencejournal.com/article/20151026/NEWS/151029423>



Farm family, Portsmouth, RI, 1885

Rhode Island Collection, Providence Public Library

# Changes in Rhode Island's Landscape

- **1850**

- ✓ 9,200 farms exist in the Narragansett Bay watershed
  - ✓ More cleared land used for animals than for crops
- ✓ Cleared land increases sedimentation

- **1853**

- ✓ First dredging in Providence River

- **Late 1850s**

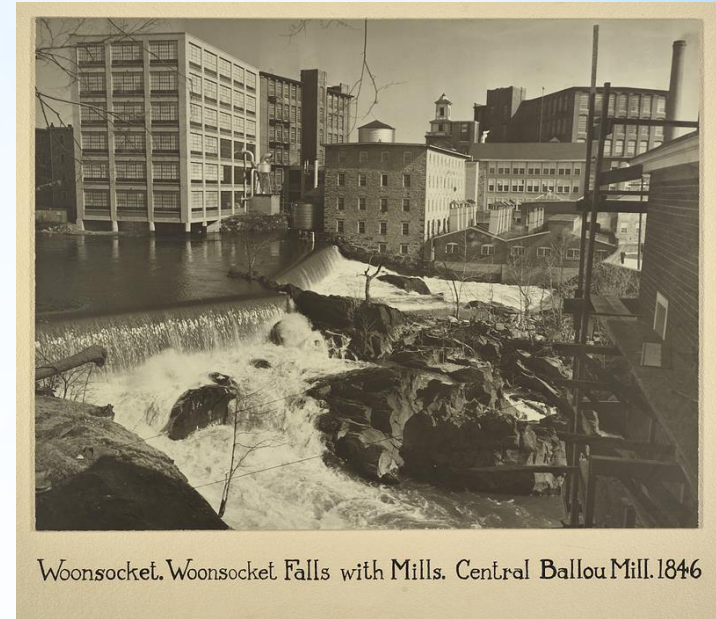
- ✓ Coal-tar dyes introduced in textile industry (contain heavy metals)
- ✓ 57 Jewelry Firms/590 Workers

- **1860**

- ✓ Providence leading industrial center in south NE, manufactures steam engines
- ✓ RI most industrialized state in nation from Civil War through 1900
- ✓ RI became one of the most industrialized states with large numbers of textile factories
- ✓ The state also had significant machine tool, silverware, and costume jewelry industries

- **Late 1800's**

- ✓ Rhode Island Largest Jewelry Manufacturer in country
- ✓ Produces 25% of Nations Jewelry
- ✓ Sediment core samples show significant increases in Metals including zinc, copper, lead, and chromium during this time period



Woonsocket. Woonsocket Falls with Mills. Central Ballou Mill. 1846

Providence Public Library, Providence, RI



# Changes in Rhode Island's Landscape

- **1938**
  - ✓ The Bay has changed from mostly hard-bottomed to mostly soft-bottomed due to siltation
  - ✓ Great New England Hurricane of 1938
- **1966** – Providence Hurricane Barrier Completed
- **1970s:**
  - ✓ Jewelry Manufacturing peaked. Providence is the “Jewelry Capital of the World”
  - ✓ 32,500 jewelry workers in RI
- **Present Day**
  - ✓ Manufacturing and jewelry production declined in Rhode Island
  - ✓ Existing Manufacturing Firms Treat toxics to remove pollutants
  - ✓ ~59% of state (393,000 acres) still forested  
(DEM)



Providence River, 1895



Fox Point, Providence, 1930

Rhode Island Collection, Providence Public Library



# Changes in Rhode Island's Landscape

## *Providence Waterfront Then....*

- *Field's Point in 1800s:  
Farmlands, Fishing & Trade*



# Changes in Rhode Island's Landscape

## *Providence Waterfront Then....*

- *Field's Point in 1800s:  
Farmlands, Fishing & Trade*



FIELDS POINT, PROVIDENCE, R. I.

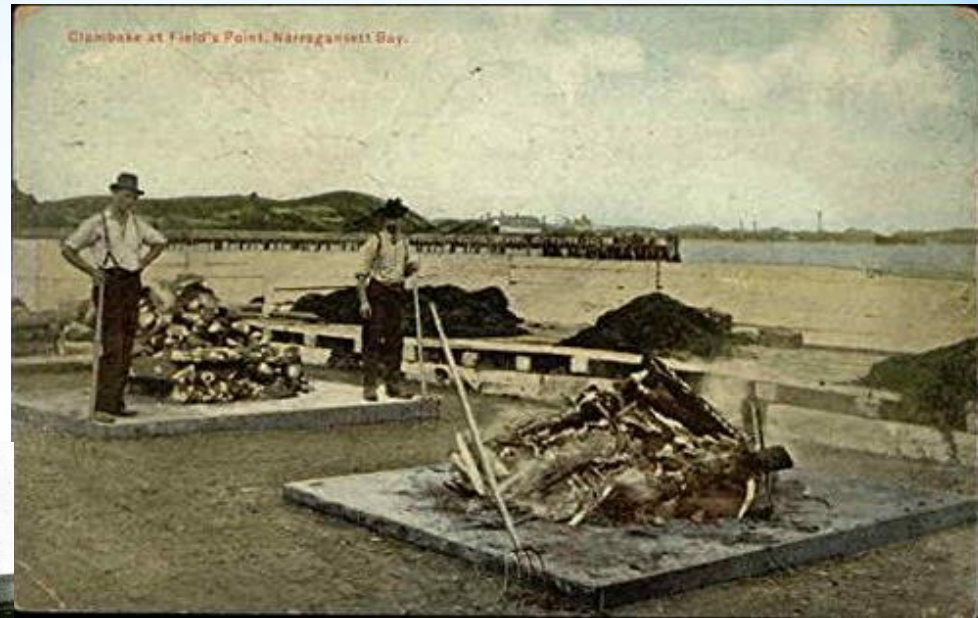
315



# Changes in Rhode Island's Landscape

## *Providence Waterfront Then....*

- *Field's Point was noted for its famous Clam Bakes and waterfront picnic grounds in the 1800s*





# Changes in Rhode Island's Landscape

## *Providence Waterfront Then...*

- *Field's Point in 1800s:  
Farmlands, Fishing & Trade*



# Changes in Rhode Island's Landscape

## *Providence Waterfront Then....*

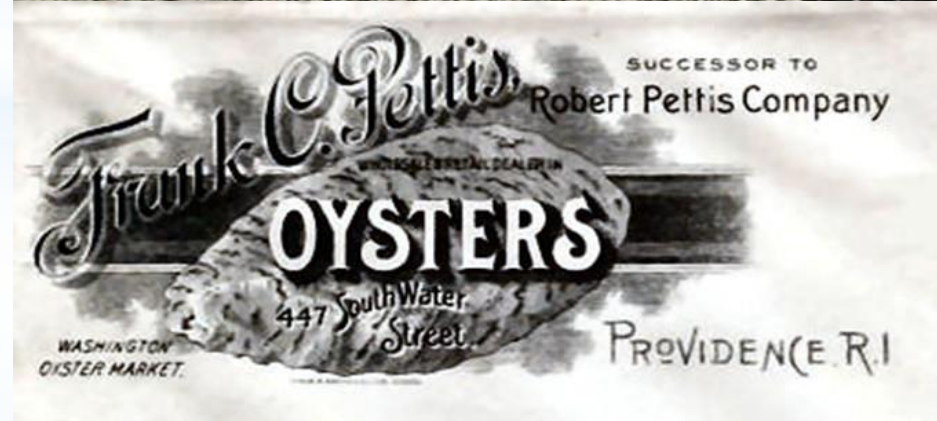
- *Field's Point early 1900s:  
Fishing & Trade*
- *Oystering was the major  
business*



Rhode Island Collection, Providence Public Library



Rhode Island Collection, Providence Public Library





# Changes in Rhode Island's Landscape

## *Providence Waterfront Then....*

- *Field's Point early 1900s:  
Farmlands and Fishing*
- *Oystering was the major  
business*





# Changes in Rhode Island's Landscape

## *Providence Waterfront Now....*





# Changes in Rhode Island's Landscape

## *Providence Waterfront Now....*

- *Industrial Working Waterfront*
- *Significant Shipping Port*





# Changes in Rhode Island's Landscape

## *Providence Waterfront Now....*

- *Scrap Metals Operations*
- *Rhode Island's Largest Export*



# Changes in Rhode Island's Landscape

## *Providence Waterfront Now....*

- *Salt Storage and Distribution*
- *Where does all this salt end up???*





# Changes in Rhode Island's Landscape

## *Providence Waterfront Now....*

- *Coal Storage and Distribution*



# Changes in Rhode Island's Landscape

## *Providence Waterfront Now....*

- *Coal Storage and Distribution*
- *Where does that dust settle???*





# Changes in Rhode Island's Landscape

## *Providence Waterfront Now....*

- *Fuel Oils, LNG Storage & Distribution*
- *Cement Storage & Distribution*



# Changes in Rhode Island's Landscape

## *Providence Waterfront Now....*

- *NBC Sewage Treatment plant, a university, lumber yard, chemical mfg, and various other businesses...*





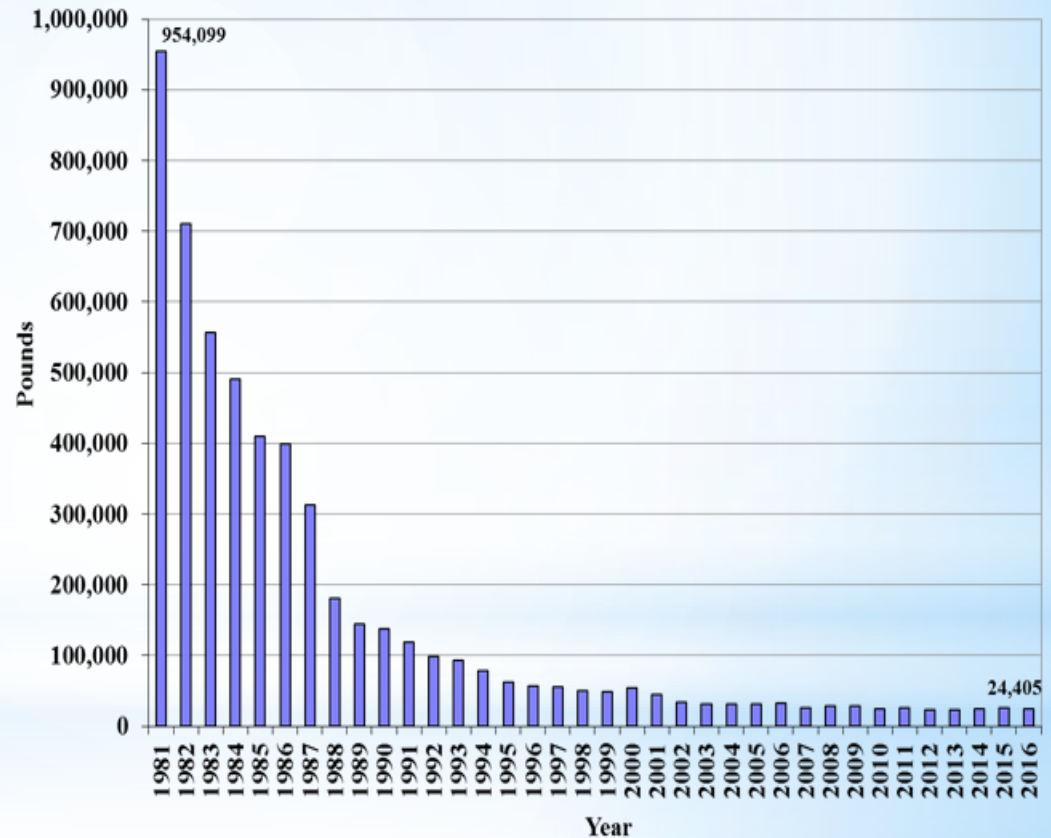
# Overview of Rhode Island Environmental Regulation

*Environmental Regulation is Relatively new in the Bay's Timeline:*

- 1842 - Commission of Shellfisheries established
  - Regulates the leasing of public lands to oyster cultivation
- 1870 - Commission of Inland Fisheries established
  - Regulates inland fisheries
- 1899 - Commission of Birds established
  - Enforces laws relating to game and birds
- 1935 - Commissions of Shellfisheries, Birds, and Inland Fisheries joined under the Division of Fish and Game
- 1965 - Division of Fish and Game replaced by Department of Natural Resources
- 1971 – RI Coastal Resources Management Council established
- 1972 - Clean Water Act Established
- 1978 - Department of Natural Resources replaced by Department of Environmental Management (RIDEM)

# History of Toxic Impacts on Narragansett Bay

- RI Pretreatment Programs began to enforce Clean Water Act regulation for toxics in 1980s
- Pretreatment Programs have been very successful reducing toxic pollutants to the Bay
- 97.4 % Reduction toxics discharged to Field's Point since 1981
- Similar Reductions in Toxics Discharged to Bay





# History of RI Sewage Treatment

- **1700s** -Sewage flows directly into local rivers, in the belief that dilution will render the waste harmless
- **1870s** -The City of Providence constructs a sewer system to discharge City's waste into Providence's urban rivers and harbor
- 65 sewer outfalls built to directly discharge to Rivers



# Bacteria Pollution – Birth of Sewage Treatment

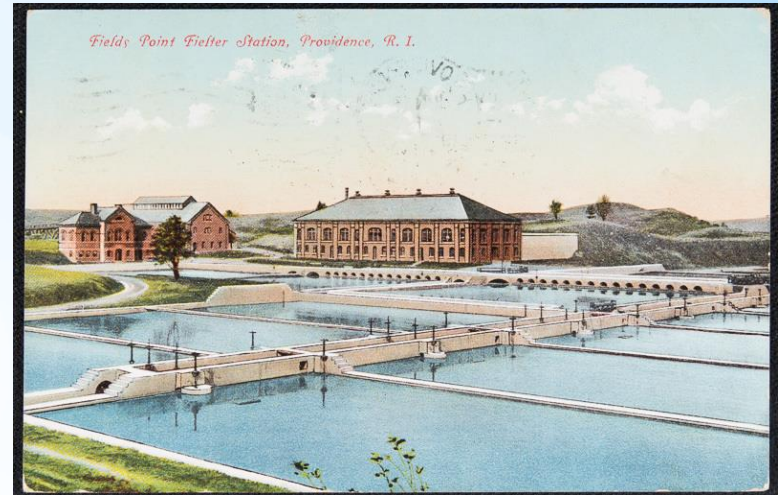
- Animal waste would be flushed off streets into the rivers
- **1884** - Providence recognizes need to treat sewage City. Engineer Samuel M. Gray recommends interceptors to a chemical precipitation plant at Field's Point
- **1892** - Interceptor sewers began carrying sewage from the city of Providence to Field's Point, where it is conveyed into the Bay





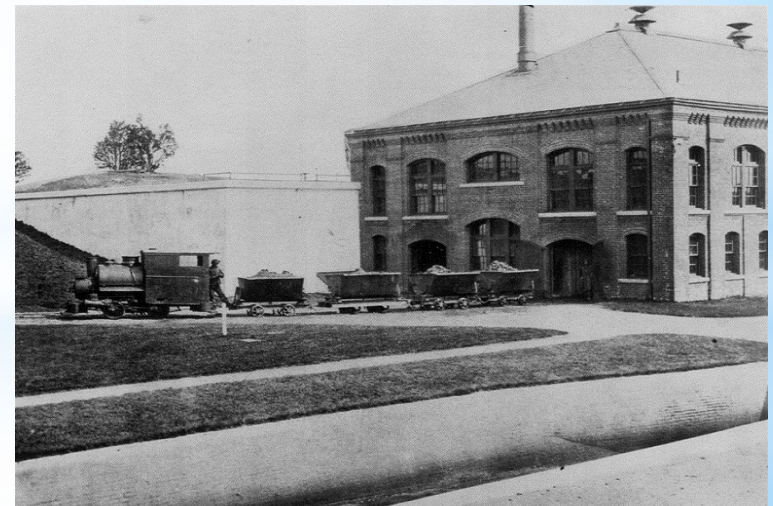
# History of RI Sewage Treatment

- **1901** - The Providence Sewage chemical precipitation plant opens at Field's Point. Sewage was dewatered and sludge used as fill on site.
- **1908** - The plant's capacity is no longer adequate. Sludge was dumped east of Prudence Island in the Bay.
- **1910** - A Shellfish Commission study finds significant sewage contamination in oyster beds
- **1912** - Bleaching of the effluent is added at Field's Point, reducing bacteria in the effluent by 97%



Field's Point Filter Station, 1908

Providence Public Library, Providence, RI



Field's Point Sludge Train, 1910

Providence Public Library, Providence, RI

# History of RI Sewage Treatment

- **1930s**

- ✓ Field's Point plant upgraded to activated sludge process
- ✓ Woonsocket secondary treatment plant build

- **1942**

- ✓ Cranston secondary treatment plant built

- **1949**

- ✓ Sludge from Field's Point is no longer dumped directly into the Bay

- **1965**

- ✓ Warwick builds secondary treatment plant

- **1970's**

- ✓ Field's Point plant in poor repair; nearly 65 MG of untreated sewage flow into Bay daily
- ✓ East Providence WWTF upgraded to secondary treatment in 1976

- **1980's**

- ✓ NBC acquires the Field's Point WWTF and begins transforming the failing facility
- ✓ \$100 million Field's Point upgrade complete

- **1991**

- ✓ Newport WWTF upgraded from primary to secondary treatment

- **1992**

- ✓ NBC begins operating Bucklin Point WWTF

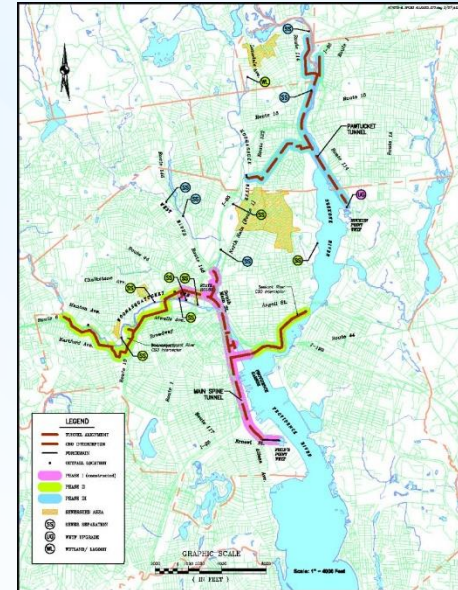


**Field's Point 1984**  
Providence Public Library, Providence, RI



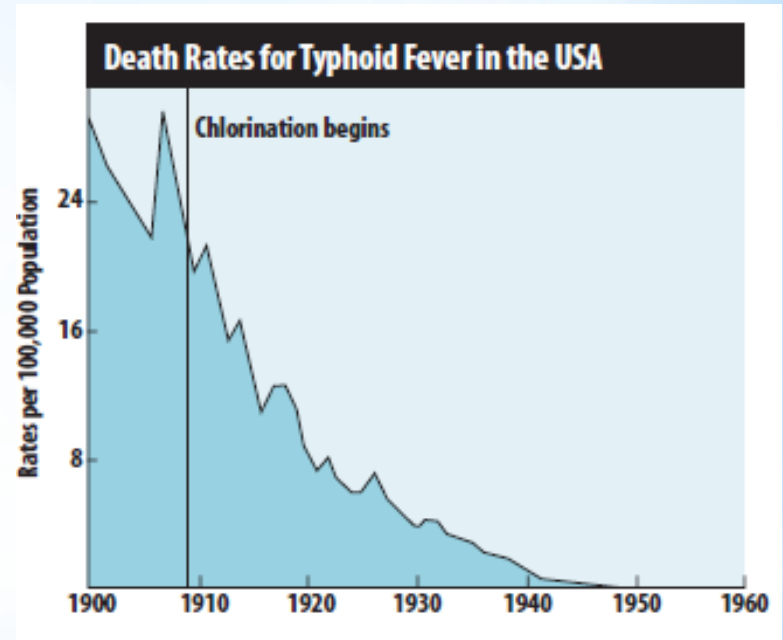
# History of RI Sewage Treatment

- **1998** - Sodium hypochlorite wet weather disinfection systems installed at Field's Point and Bucklin Point
- **1999** - Sodium bisulfite dechlorination added at Field's Point
- **2004-2005** - NBC upgrades Bucklin Point WWTF to meet a TN limit of 8.5 mg/L & install UV at a cost of \$77 million
- **2008** - NBC's Phase I CSO Tunnel is put into operation, cost \$359 million
- **2013** - IFAS system at Field's Point complete; cost \$31 million
- **2014 - Present**
  - ✓ BNR upgrades are complete at Bucklin Point; cost \$13 million
  - ✓ CSO Phase II Complete, Costs \$270 Million
  - ✓ CSO Phase III Project Begins - will cost about \$850 Million



# Importance of Disinfection

- **1854 – Providence’s 2<sup>nd</sup> cholera outbreak in 5 years (150 die)**
- By the early **1900s**, it became apparent that the discharge of **untreated wastewater** was **causing detrimental effects** to receiving waters and public health.
- Field’s Point effluent treated with bleach beginning in 1912
- **Water disinfection a huge public health success.**
  - **By 1940, incidence of waterborne diseases had decreased dramatically** across the United States, due to the prevalence of proper wastewater and water treatment systems.
  - **Typhoid mortality decreased 96% from 1900-1936** (Cutler and Miller 2004).



<http://waterandhealth.org/drinkingwater/whitepapercl.html>



# Disinfection at NBC

- **Field's Point**

- Sodium hypochlorite chlorination (installed in 1998)
- Sodium bisulfite dechlorination (added in 1999)
  - ✓ Converts remaining residual chlorine to chloride ion (constituent of seawater)

- **Bucklin Point**

- ✓ Ultraviolet (UV) disinfection system

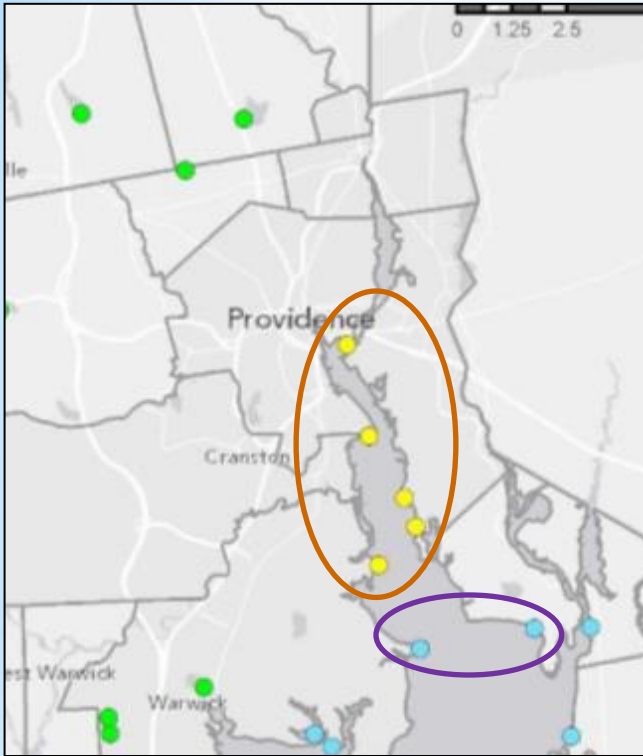
- **NBC Total Residual Chlorine**

- Averages 2.5  $\mu\text{g/L}$ 
  - ✓ 96% below permit limit
- RIDEM limit = 65  $\mu\text{g/L}$ 
  - ✓ Meets EPA limit to prevent chronic and acute effects in aquatic organisms



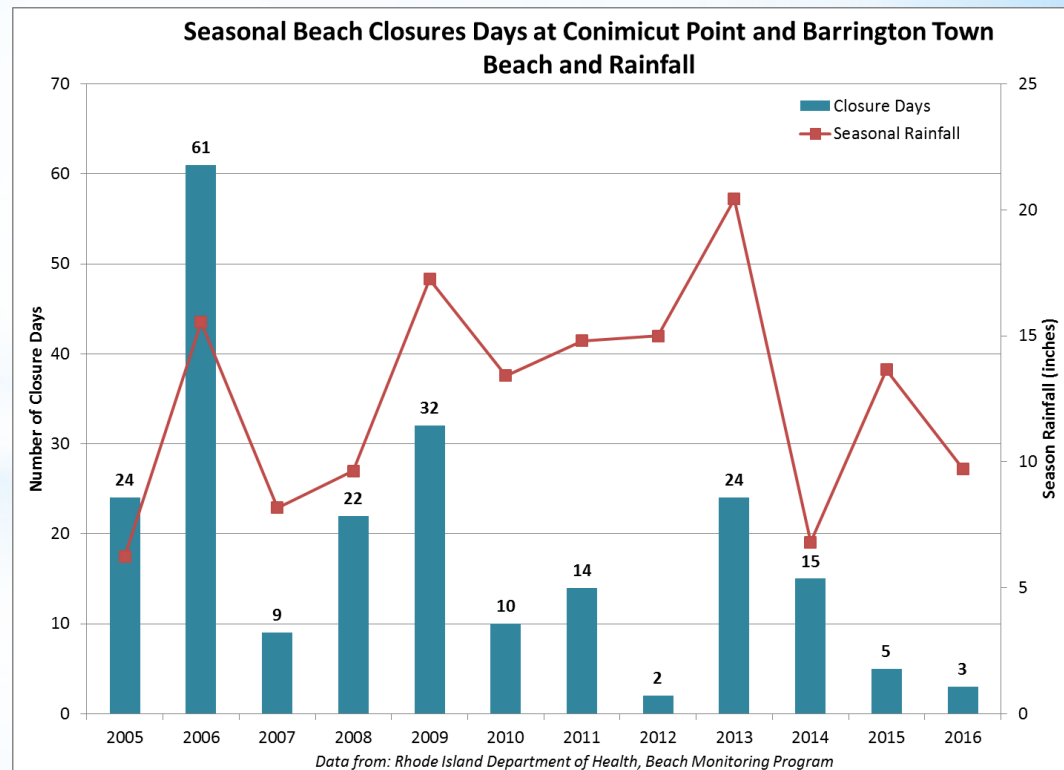
[https://www.alibaba.com/product-detail/UV-Disinfection-China-wastewater-treatment-plant\\_60106086822.html](https://www.alibaba.com/product-detail/UV-Disinfection-China-wastewater-treatment-plant_60106086822.html)

# Upper Bay Beaches and Urban Beach Initiative - RIDOH



RIDOH, Beach Report, 2015

- Began in 2010
- 5 beaches tested for *Enterococci*
  - Sabin's Point, EP
  - Rosa Larissa Park, EP
  - Bold Point Park, PVD
  - Field's Point, PVD
  - Gaspee Point, Warwick

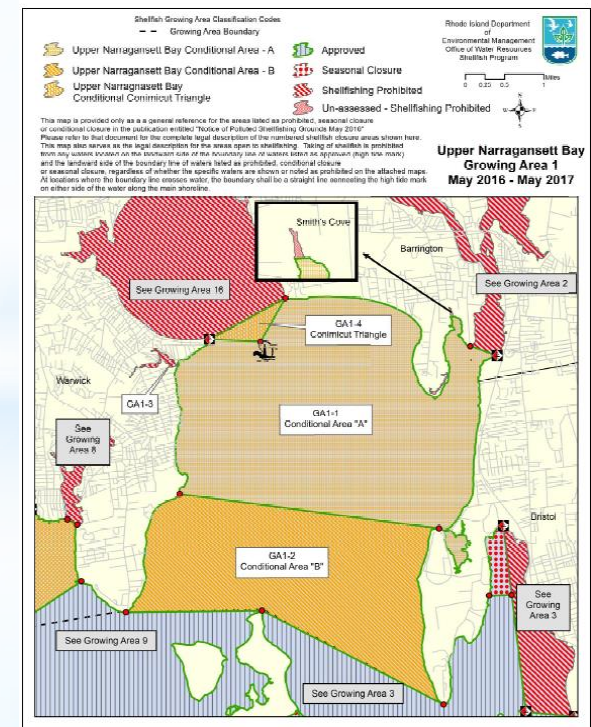


✓ Closures at Conimicut Point and Barrington Beach have decreased by ~45% since CSO tunnel



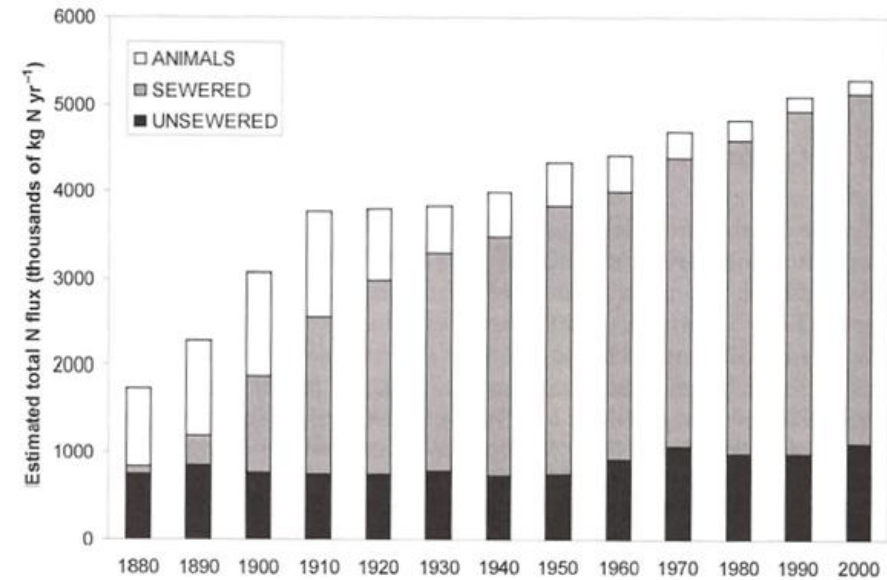
# DEM Regulations Allow more days and areas Open to Shellfishing due to CSO Abatement Project

- **Feb 2009:** DEM and FDA agree on new monitoring procedures to allow DEM to re-open Conditional Areas A & B to shellfish harvesting as soon as the data demonstrates it is safe to do.
  - Has resulted in ~ 36 days of early opening since 2009 due to good water quality
- **May 2011:** Conditional Area A, closed after 0.8 inch of rainfall, up from 0.5 inch. Conditional Area B closed after 1.5 inches of rainfall, up from 1.0 inch
  - Area A: open ~ 65 more days/year;
  - Area B: open ~ 45 more days/year
  - Closure criteria remained at 0.5 inches rainfall at Conimicut Triangle
- **May 2013:** 462 acre area in Lower PR: rainfall closure criteria increased from 0.5 inches to 0.8 inches of rainfall received in the Providence area. Size of the "Conimicut Triangle" will be reduced and the size of Conditional Area A will increase
- **May 2016:** Lower portion of Providence River is showing promise and may be reopened conditionally to shell fishing in future years, though shellfish management plans must be developed
  - 2 most southern monitoring stations have shown results in compliance with shellfishing standards in 3 of the past 4 years!

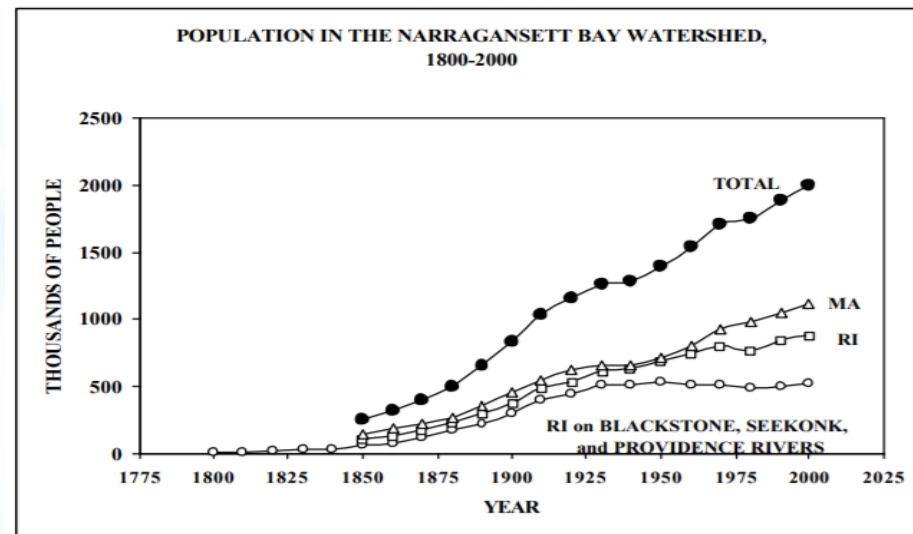


# History of Nitrogen Pollution

- Nitrogen loadings to the Bay have steadily increased from the 1880s
- Nitrogen loadings increased as population increased in watershed
- Largest contributions from sewerage plants
- Some WWTFs began to treat to reduce nitrogen in early 2000s
- Dramatic nitrogen reductions by POTWs implemented in past few years



Estimated total Nitrogen flux to Narragansett Bay from human and animal waste from 1880 to 2000, using the "mid" case parameters—Desbonnet, A., and Costa-Pierce, B.A. 2008. Science for Ecosystem-Based Management: Narragansett Bay in the 21<sup>st</sup> Century. New York: Springer.



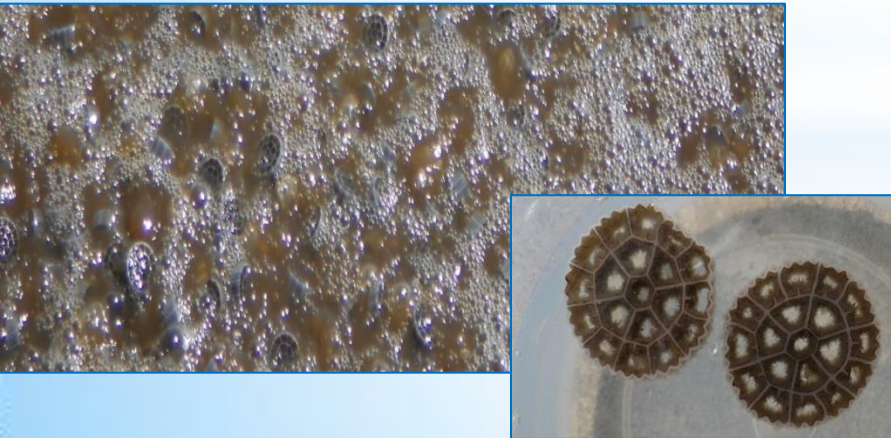


# Biological Nutrient Removal (BNR)

- Optimize conditions for nitrification and denitrification
- NBC Permit limit (5 mg/L) in effect May – October
- **Total NBC Upgrade Cost: \$44 Million**

## Field's Point

- Integrated Fixed Film Activated Sludge (IFAS) – Largest in the world!
- 5 mg/L Permit limits in effect May 2014

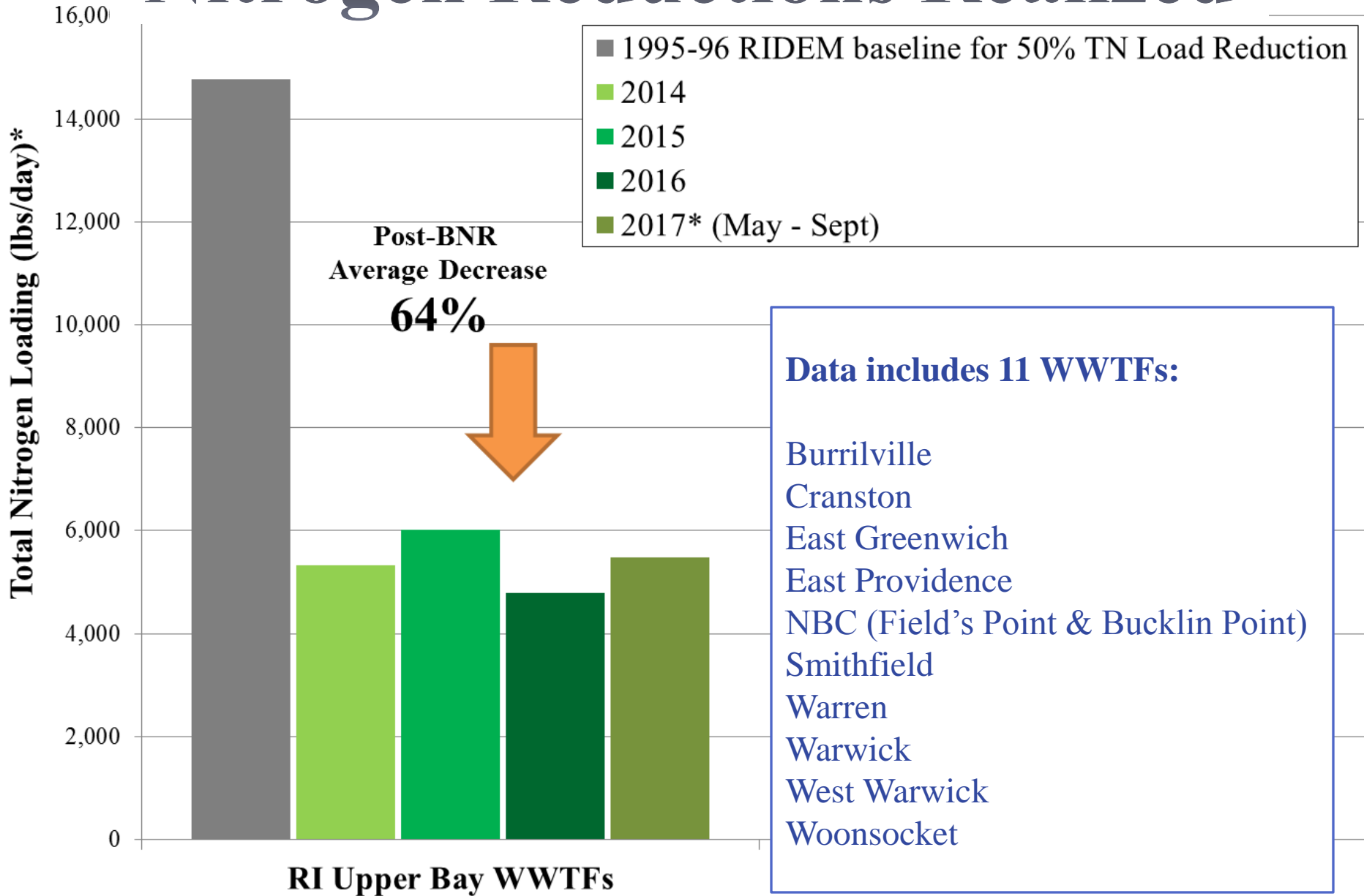


## Bucklin Point

- Initial upgrades to 8 mg/L completed in 2006
- 5 mg/L limit in effect July 2014



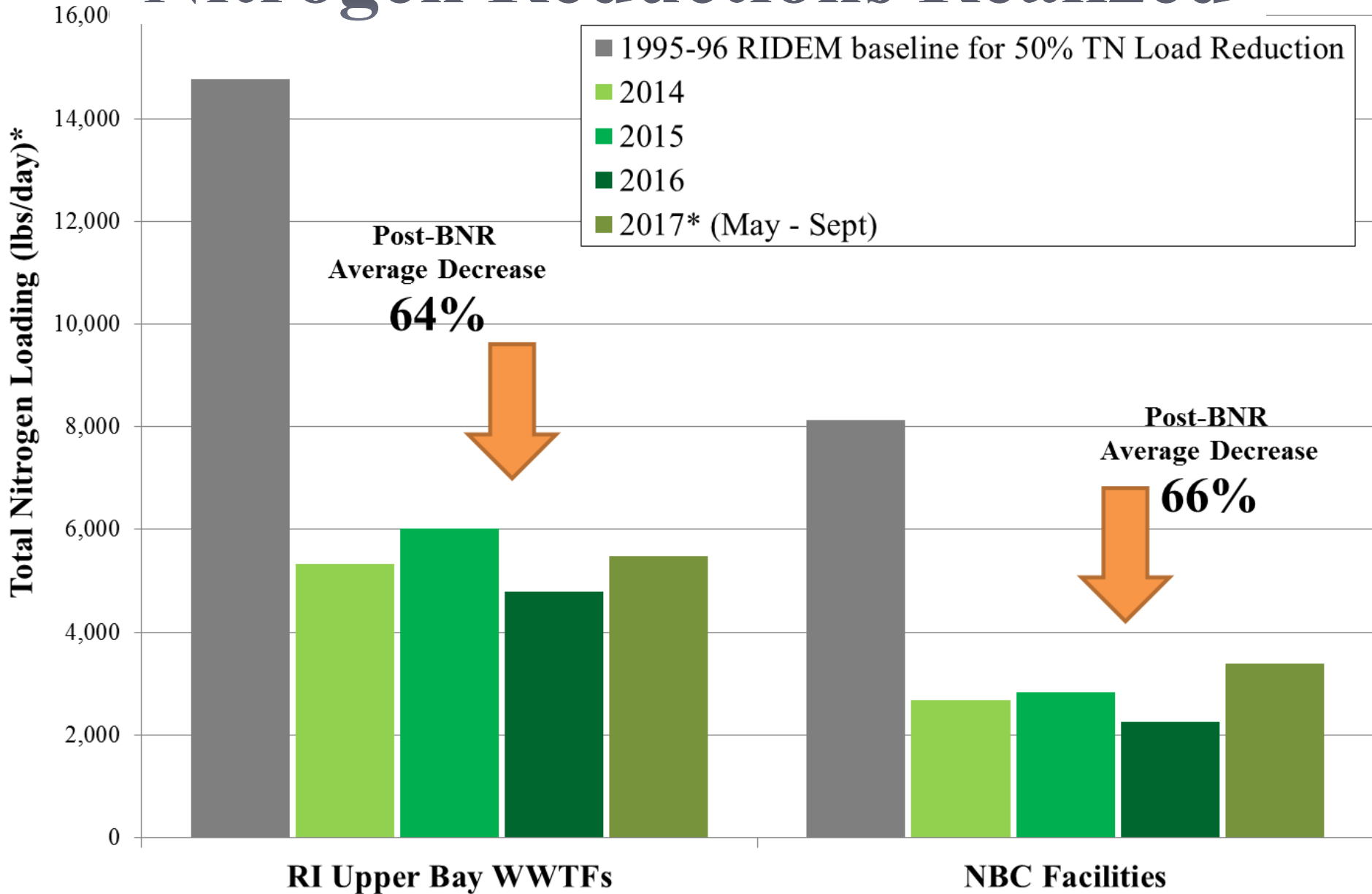
# Nitrogen Reductions Realized



\*Loading calculations based upon monthly TN maximum concentration and monthly average flow



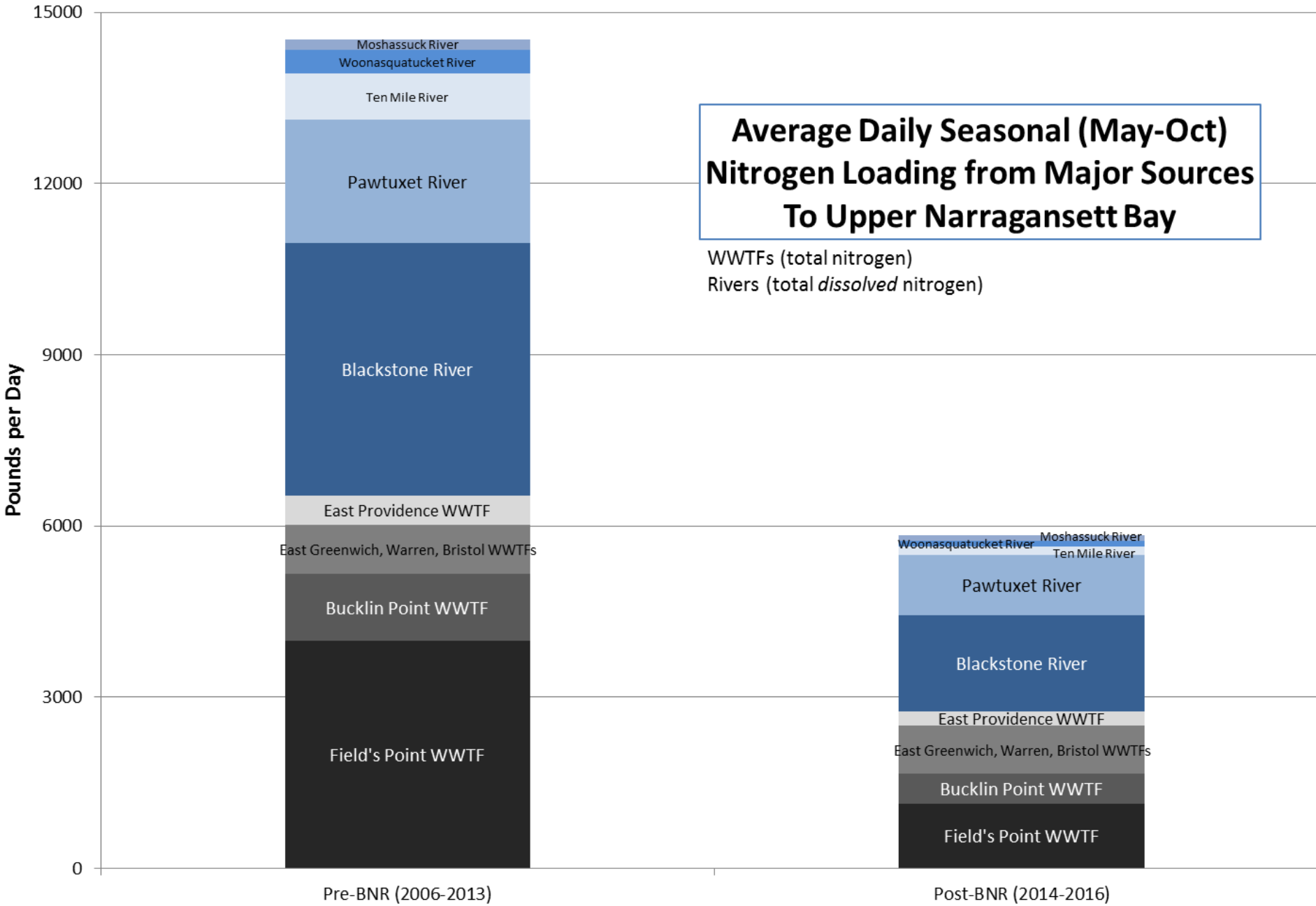
# Nitrogen Reductions Realized



\*Loading calculations based upon monthly TN maximum concentration and monthly average flow

# Average Daily Seasonal (May-Oct) Nitrogen Loading from Major Sources To Upper Narragansett Bay

WWTFs (total nitrogen)  
Rivers (total *dissolved* nitrogen)





# “The Grand Experiment”

- Professor Nixon expressed his concern regarding the “Grand Experiment” to dramatically reduce nitrogen loadings to the Bay by 50%
- How will the nitrogen reductions ultimately impact primary and secondary productivity of the Bay?
- “Would Goldilocks say a 50% Nitrogen Reduction was just right????” (Oviatt)
- Time will tell, but observed water quality improvements look promising.



*Professor Scott Nixon touring the  
NBC CSO Tunnel Pump Station*

(Photo Veronica Berounsky)

# DIN Concentrations in the Bay

Compared to National Coastal Condition Assessment Guidelines

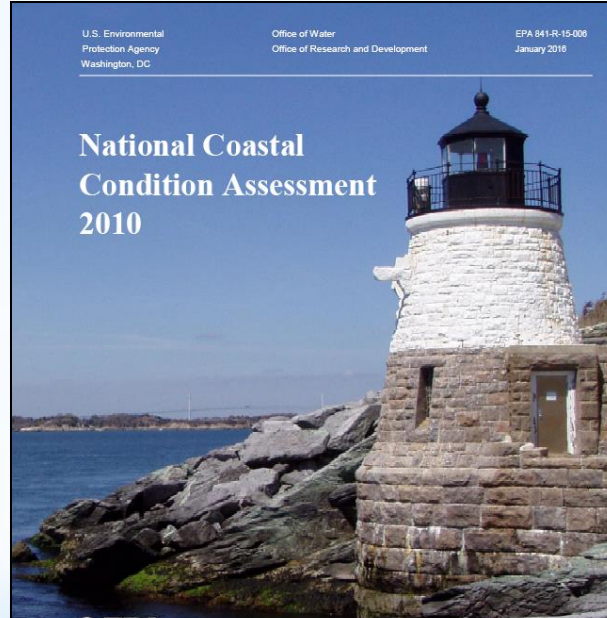
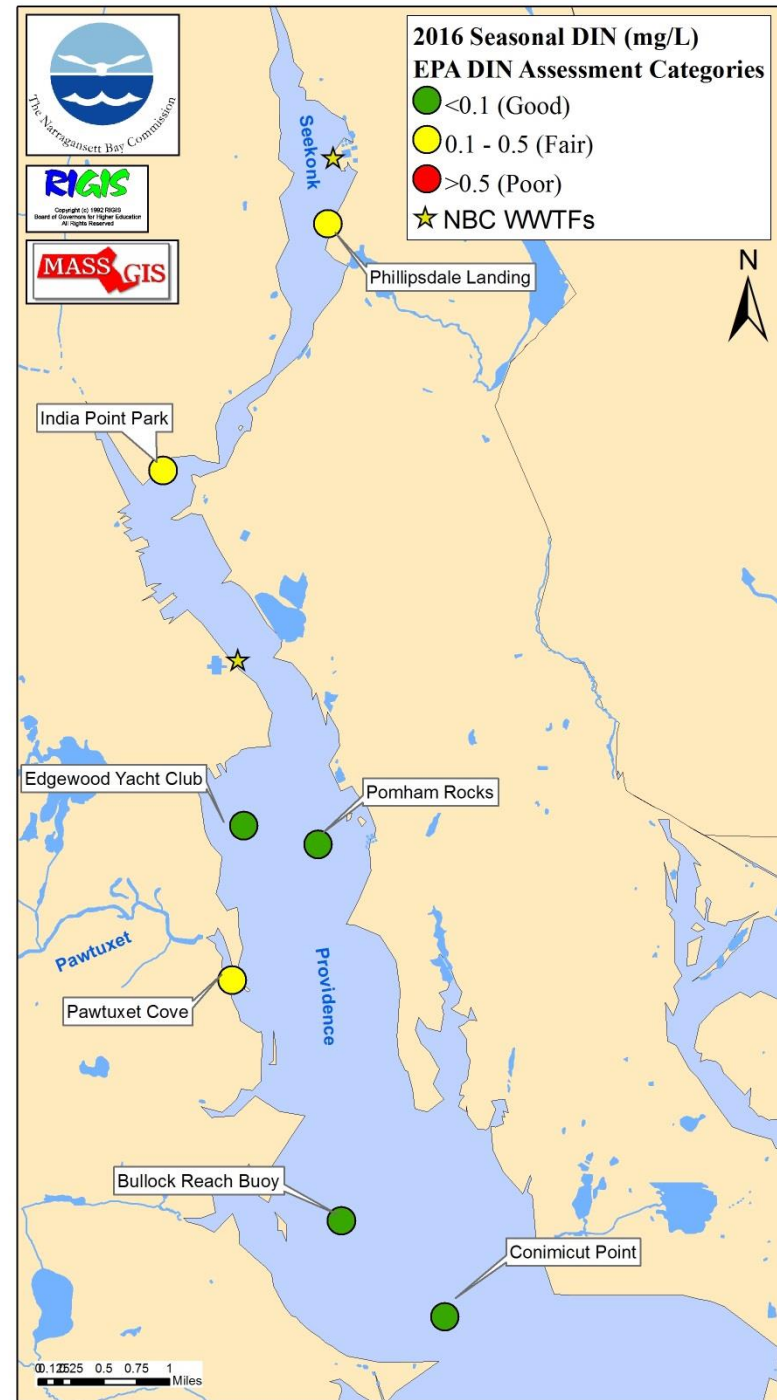


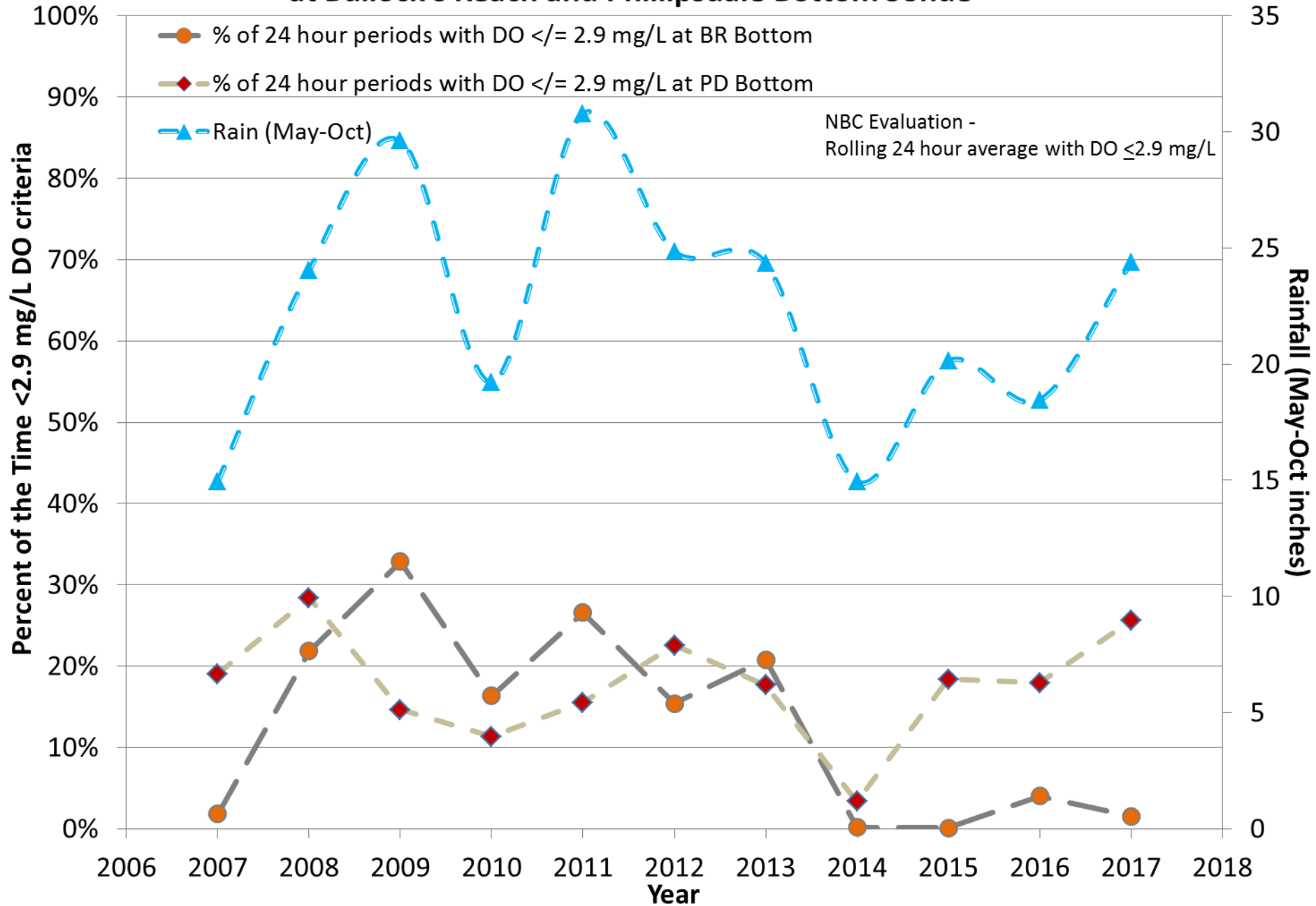
Table 2-5. NCCA guidelines for evaluating the five component indicators used in the water quality index to assess estuarine coastal condition.

Estuarine Water Quality Thresholds				
	Region	Good	Fair	Poor
Surface Concentrations of Dissolved Inorganic Nitrogen (DIN): Estuaries	Northeast Southeast Gulf	< 0.1 mg/L	0.1 – 0.5 mg/L	> 0.5 mg/L
	West	< 0.35 mg/L	0.35 – 0.5 mg/L	> 0.5 mg/L
	Tropical <sup>a</sup>	< 0.05 mg/L	0.05 – 0.1 mg/L	> 0.1 mg/L





# Hypoxia and Rainfall at Bullock's Reach and Phillipsdale Bottom Sonde



# Map of Providence Harbor in 1910

- Based on 1865 – 1878 “Hydrography”
- Some Water Quality issues are Localized
- Let’s look at the Historical Changes to Providence Harbor





# Map of Providence Harbor in 1910

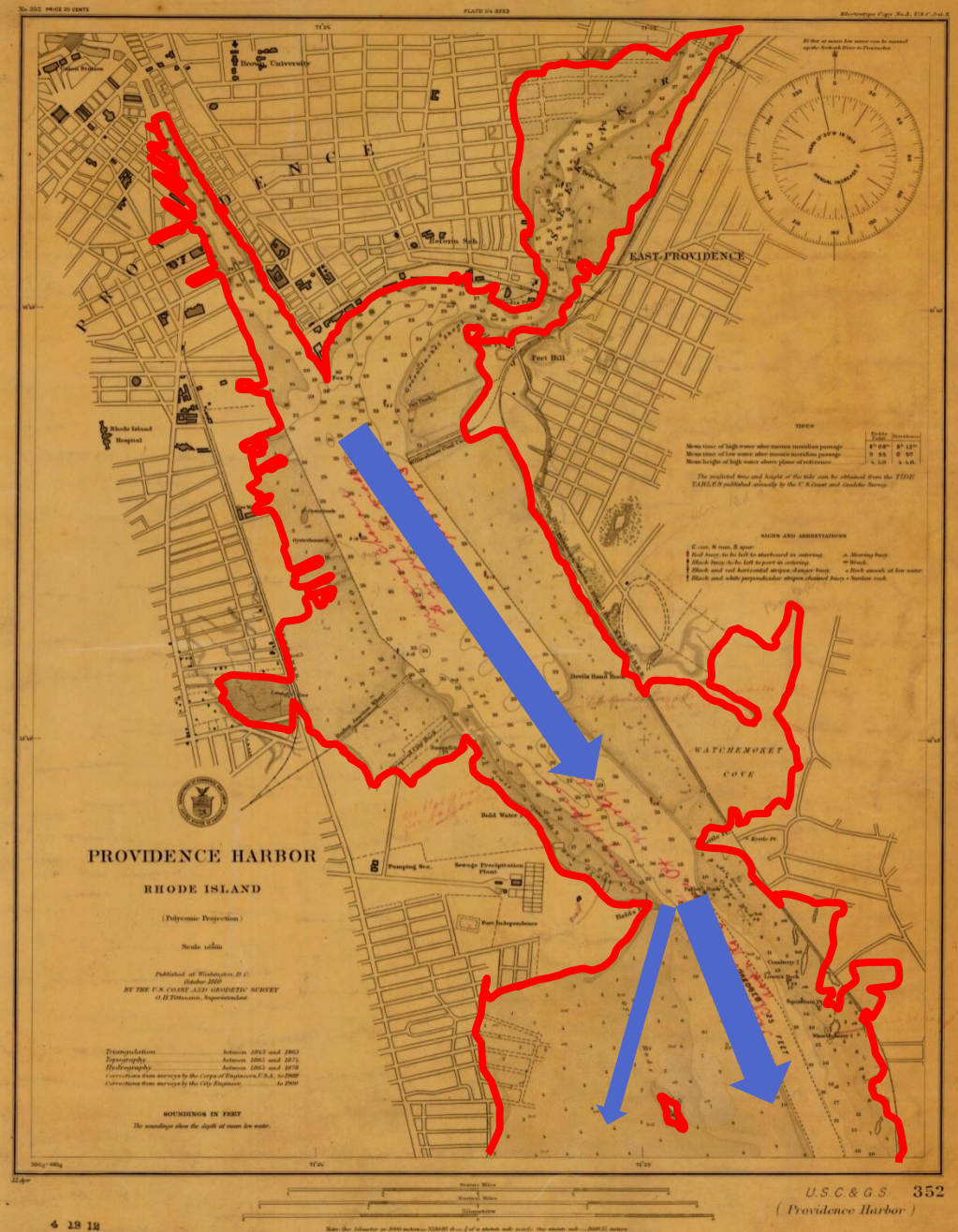
- Map Clearly Shows:
  - ✓ Wetlands & Eel Grass Beds
  - ✓ Oyster Beds (5000 leased acres)
  - ✓ Seekonk River - 37' deep
  - ✓ Prov River Channel – dredged to 25' depth





# Map of Providence Harbor in 1910

- 1910 Coast Line in Red
- City plans to Fill Bay and Build Roads
- Note:
  - ✓ Much Shallower River
  - ✓ Starved Goat Island
- What was flow circulation pattern in 1910?

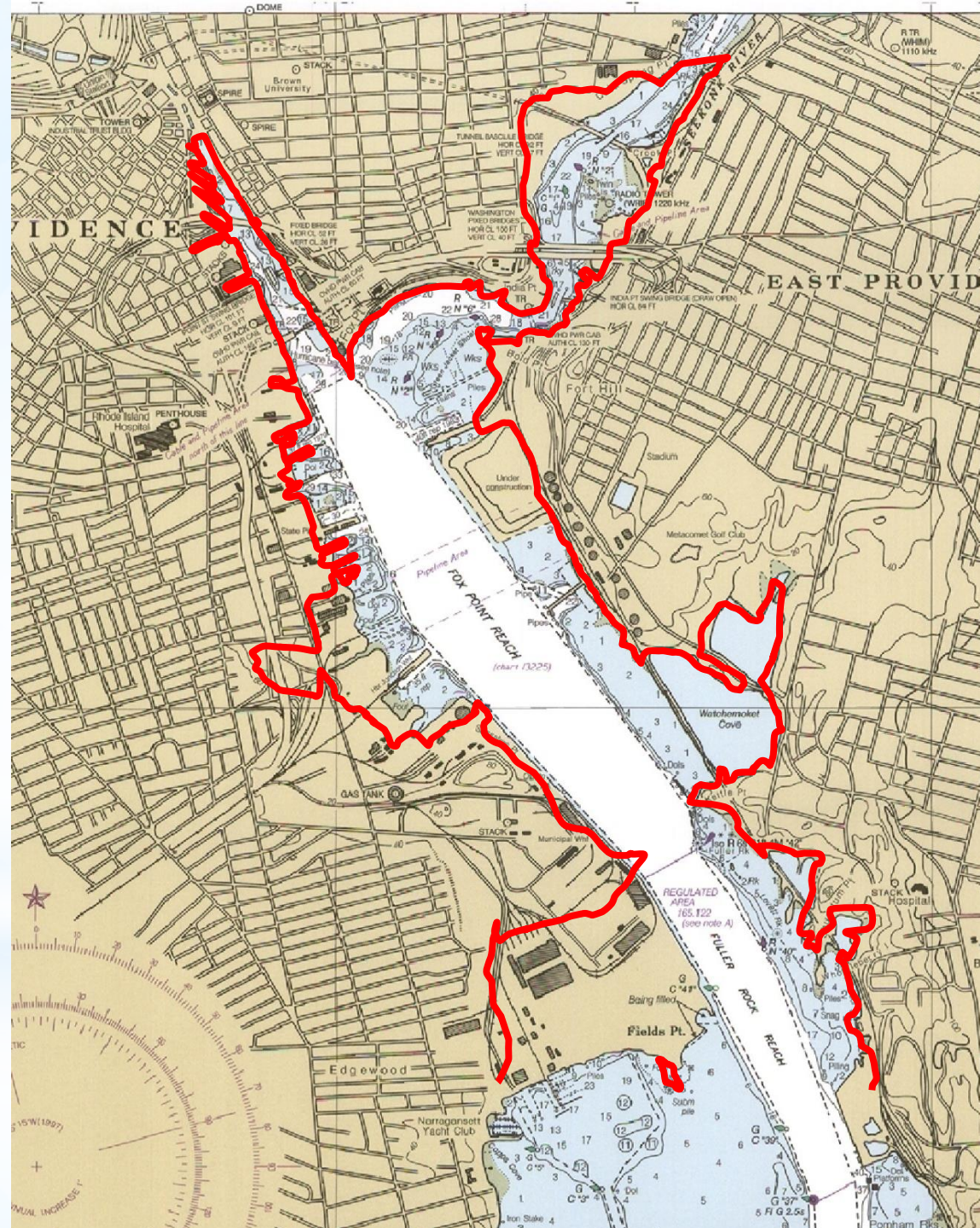




# Upper Providence River Today

## 1910 Coastline in Red

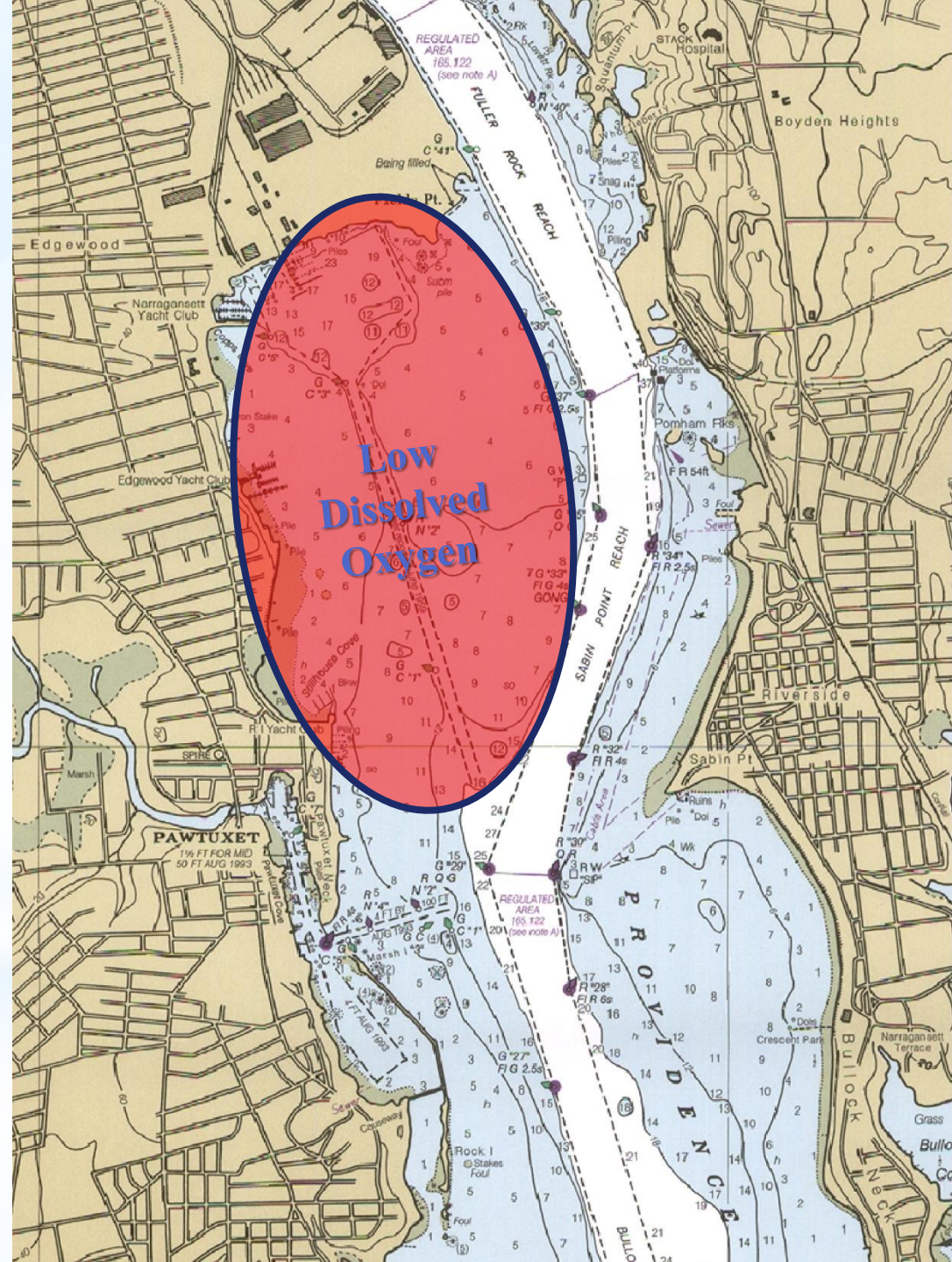
- We Filled the Bay & Wetlands
- Built the Hurricane Barrier
- Built Pawtuxet River Breakwall
- Allowed Rivers to Silt up
- Dredged Channel to 50+'





# Water Quality Problems

- Edgewood Shoals area is DO impaired!!! WHY???
- ✓ We Changed Flow Circulation Patterns
- ✓ Poor flushing
- ✓ Nitrogen enrichment
- ✓ Stratification

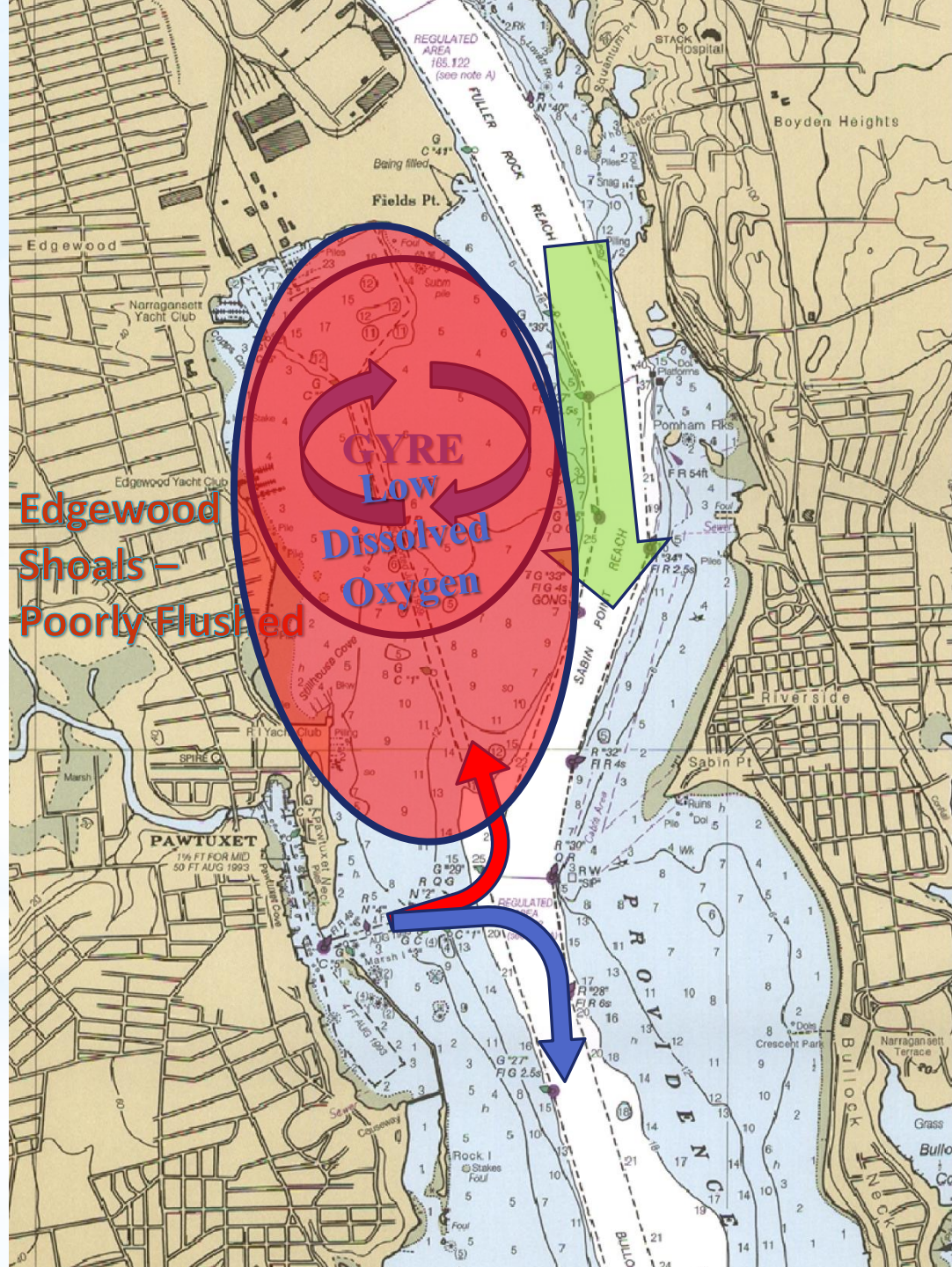




# Water Quality Problems

## ROMS Model Indicates:

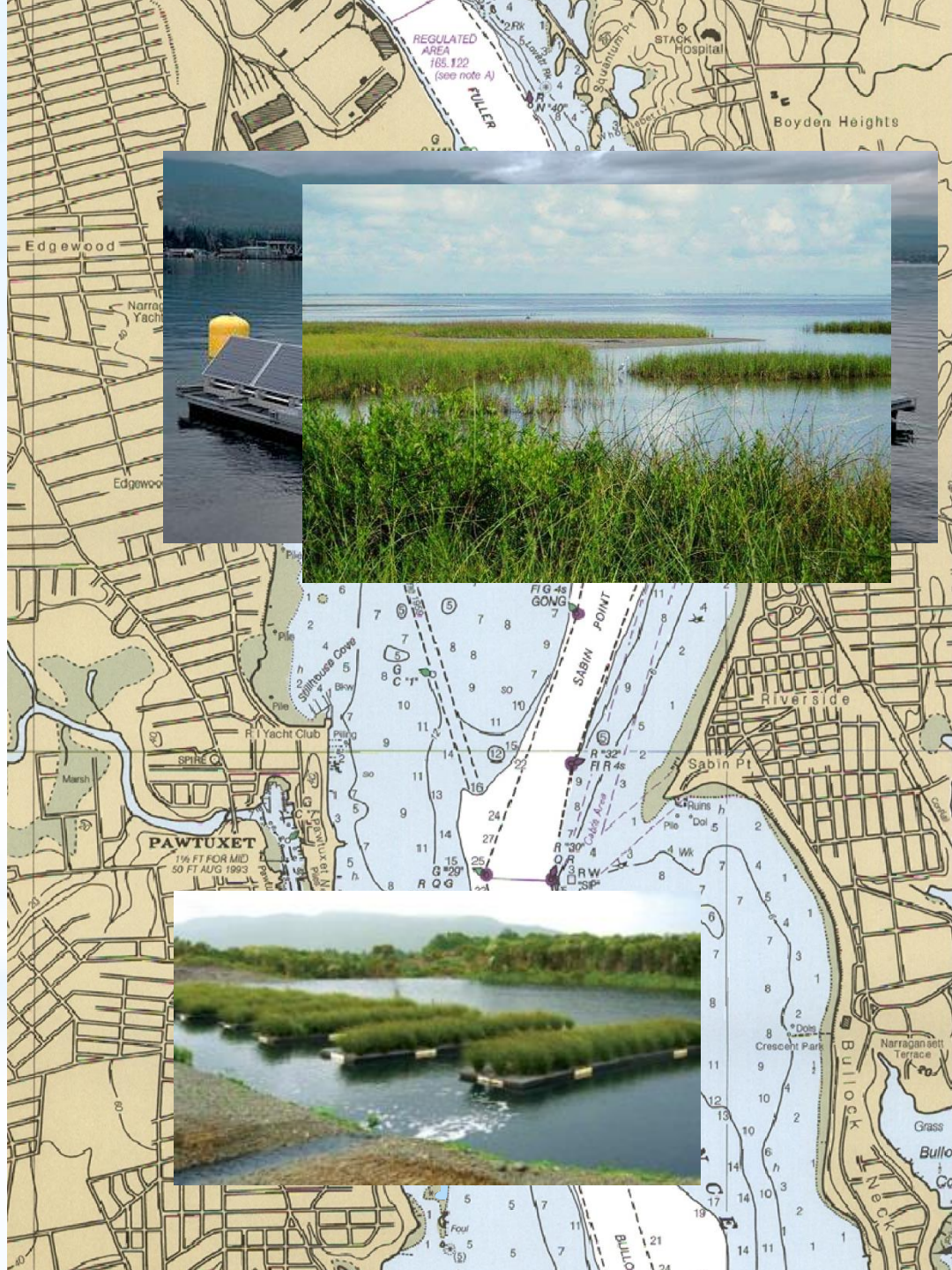
- ✓ Jet of water down the shipping channel
- ✓ Sets up a clockwise Gyre on Shoal
- ✓ **Bottom waters** from Pawtuxet River transport Nitrogen onto the shoal





# Possible Sustainable Solutions

- *Lets take a Holistic Approach to Watershed Management*
- *Can we Improve the Bay with “Smart Engineering”?*
- ✓ Selective Dredging?
- ✓ Redirect flows to improve circulation?
- ✓ Remove or open breakwalls to improve circulation?
- ✓ Create Islands, Wetland Habitats, natural buffers?
- ✓ Establish Bio-extraction or Aquaculture Projects?





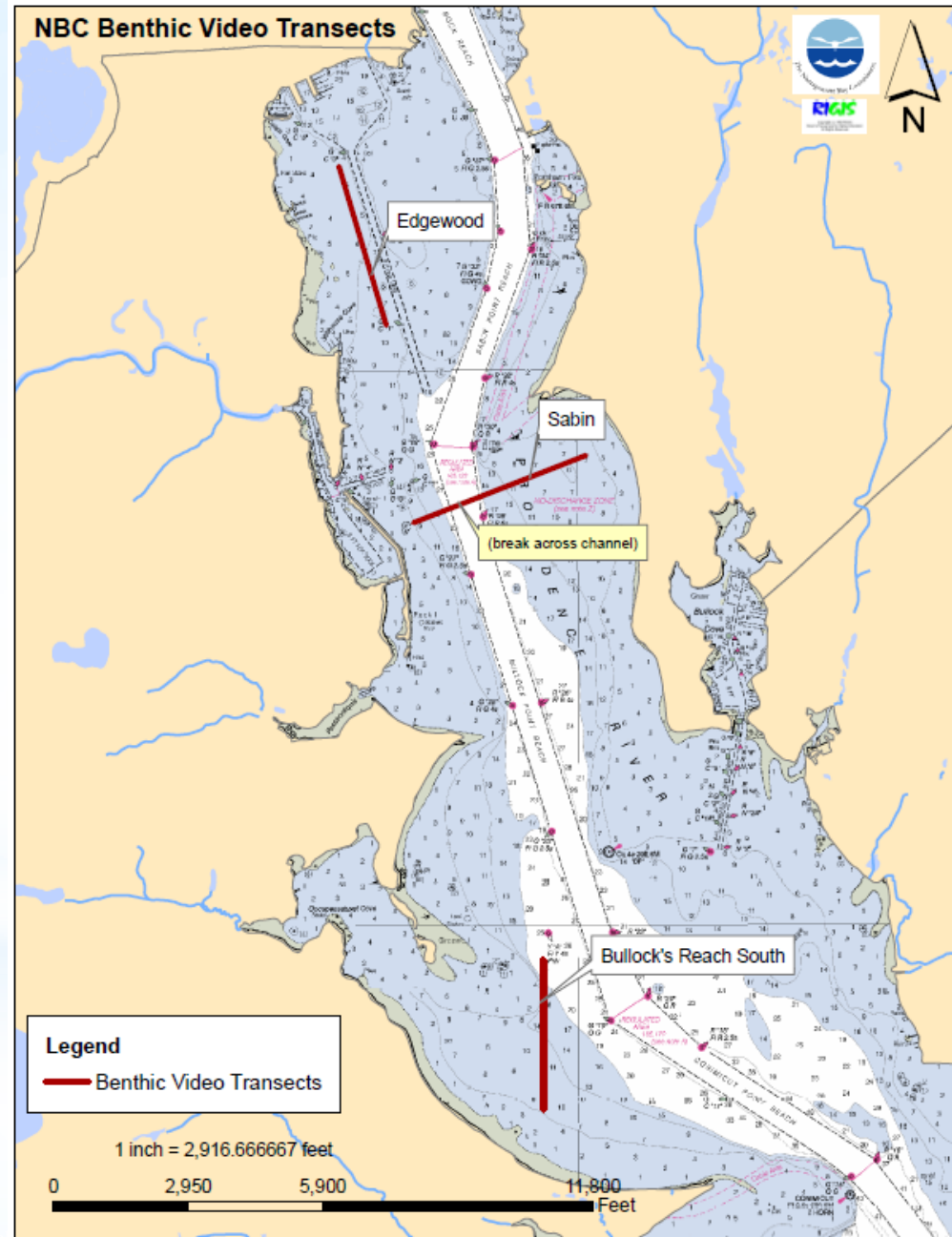
# Beneficial Use of Excess Nitrogen

- Wetlands & salt marsh restoration – remove 250 to 630 g N m<sup>-2</sup> yr<sup>-1</sup>
- Bio-extraction –
  - ✓ Ribbed Mussels 1.2 % N
  - ✓ Algae...
- Relay aquaculture
  - ✓ Oysters - 0.52 g N/oyster
  - ✓ Quahogs -16.2 g N/kg meat
- **Goals & Benefits:**
  - ✓ Improved Fisheries - Shellfish & Benthic species Restoration & Enhancement
  - ✓ Habitat Creation & Restoration
  - ✓ Create Green Jobs for the Future
  - ✓ Best WQ Improvement for the Buck



# NBC Benthic Video Monitoring

- Began in 2011 - Attempt to survey monthly
- Goal: note observable changes to benthos
- Underwater camera towed on custom sled
- Even the Upper Bay is Alive!!!







# Visitors to Narragansett Bay

- *Whales*



<http://wnpr.org/post/rhode-islands-beluga-whale-mystery-continues>



<http://www.thenewportbuzz.com/humpback-whale-spotted-breaching-in-narragansett-bay/5867>



# Visitors to Narragansett Bay

- *Dolphins*



# Visitors to Narragansett Bay

- *Seals*
- *What are these Bay's visitors feeding on???*





# The Bay is Alive

- ✓ *The Bay is Alive and definitely NOT Sterile!!!*
- ✓ *Man has Negatively Impacted the Bay over the past 350+ years*
- ✓ *Water Quality is Improving significantly, at a rapid rate, but Clean Water is very costly*
- ✓ *The Bay is Changing and so are it's inhabitants*



# Questions ???

**Special thank you to the NBC Science Team:**

*Sarah Flickinger, Eliza Moore, Christine Comeau, Karen Cortes,  
Jim Kelly, John Motta & Kim Kirwan for assistance with this  
presentation and data analysis*



**NBC Data is available on our Snapshot of the Bay Website at**

**<http://snapshot.narrabay.com>**



