

Eelgrass Analysis to Develop Nutrient Criteria for the Great Bay Estuary

Philip Trowbridge, P.E.

Piscataqua Region Estuaries Partnership &
NH Dept. of Environmental Services

Philip.Trowbridge@des.nh.gov

Presented by

Paul Currier, NH Dept. of Environmental Services

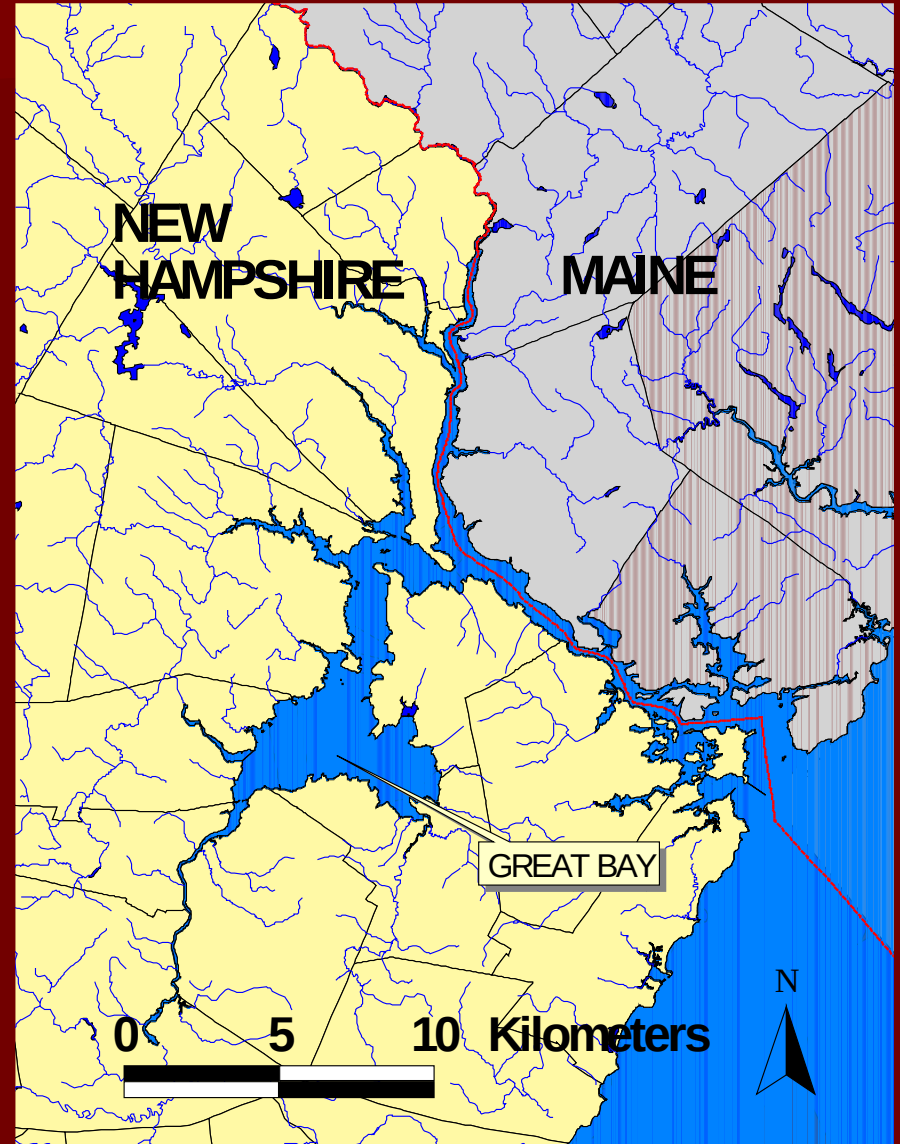


What are “Nutrient Criteria”?

- Numeric translators for narrative criteria for nutrients (Env-Wq 1703.14)
- Different criteria are needed for different designated uses
- DES already uses chlorophyll-a >20 ug/L as the threshold for Primary Contact Recreation
- DES is proposing thresholds for nitrogen, chlorophyll-a, and water clarity for Aquatic Life based on:
 - Preventing dissolved oxygen violations
 - Preventing eelgrass loss (THIS PRESENTATION)

Geographic Scope

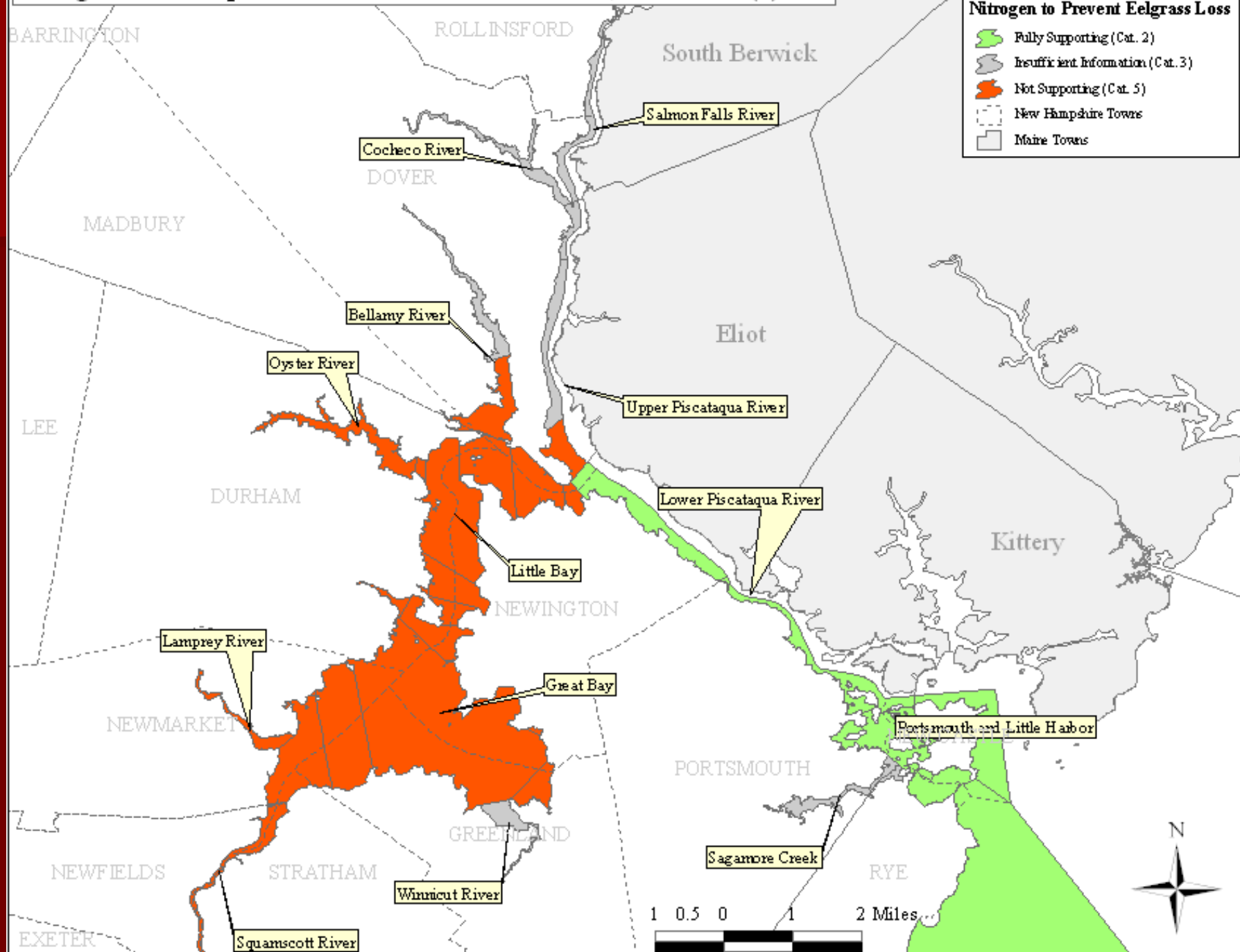
- Criteria will be for the Great Bay Estuary
- Complex hydrology with tidal creeks, bays, and narrow channels
- Watershed covers 1,023 mi²
- Watershed is home to 14% of NH and ME population



Nitrogen-Based Impairments to be Added to the 2008, Section 303(d) List

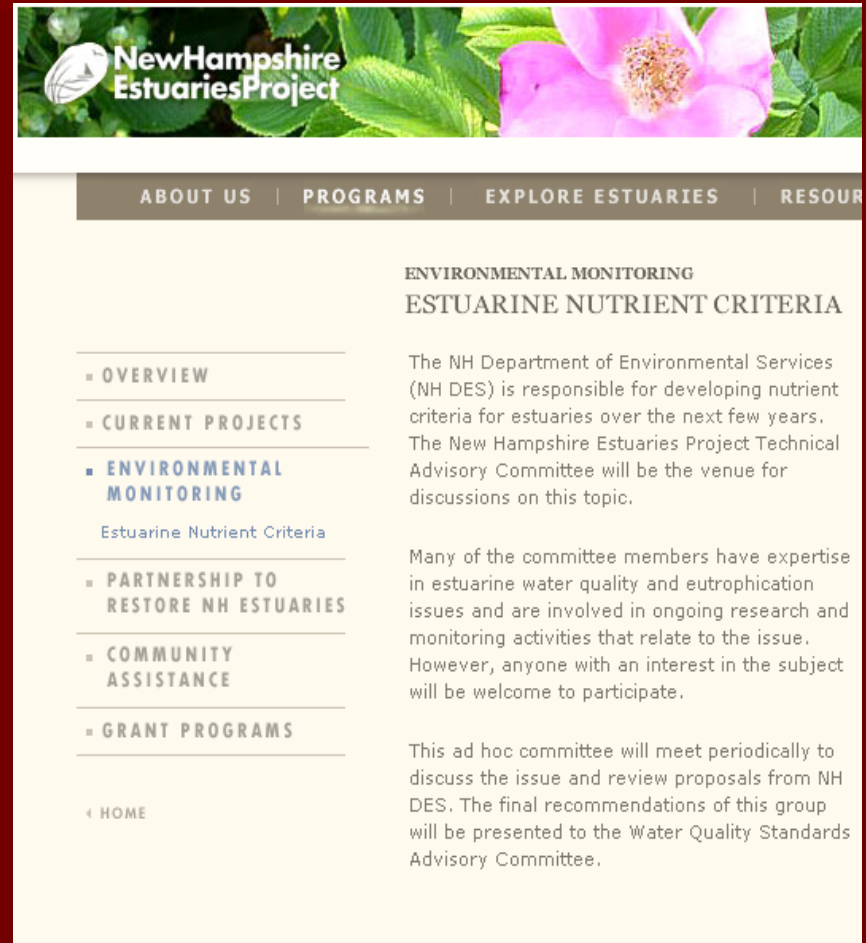
Aquatic Life Use, Nitrogen to Prevent Eelgrass Loss

- Fully Supporting (Cat. 2)
- Insufficient Information (Cat. 3)
- Not Supporting (Cat. 5)
- New Hampshire Towns
- Maine Towns

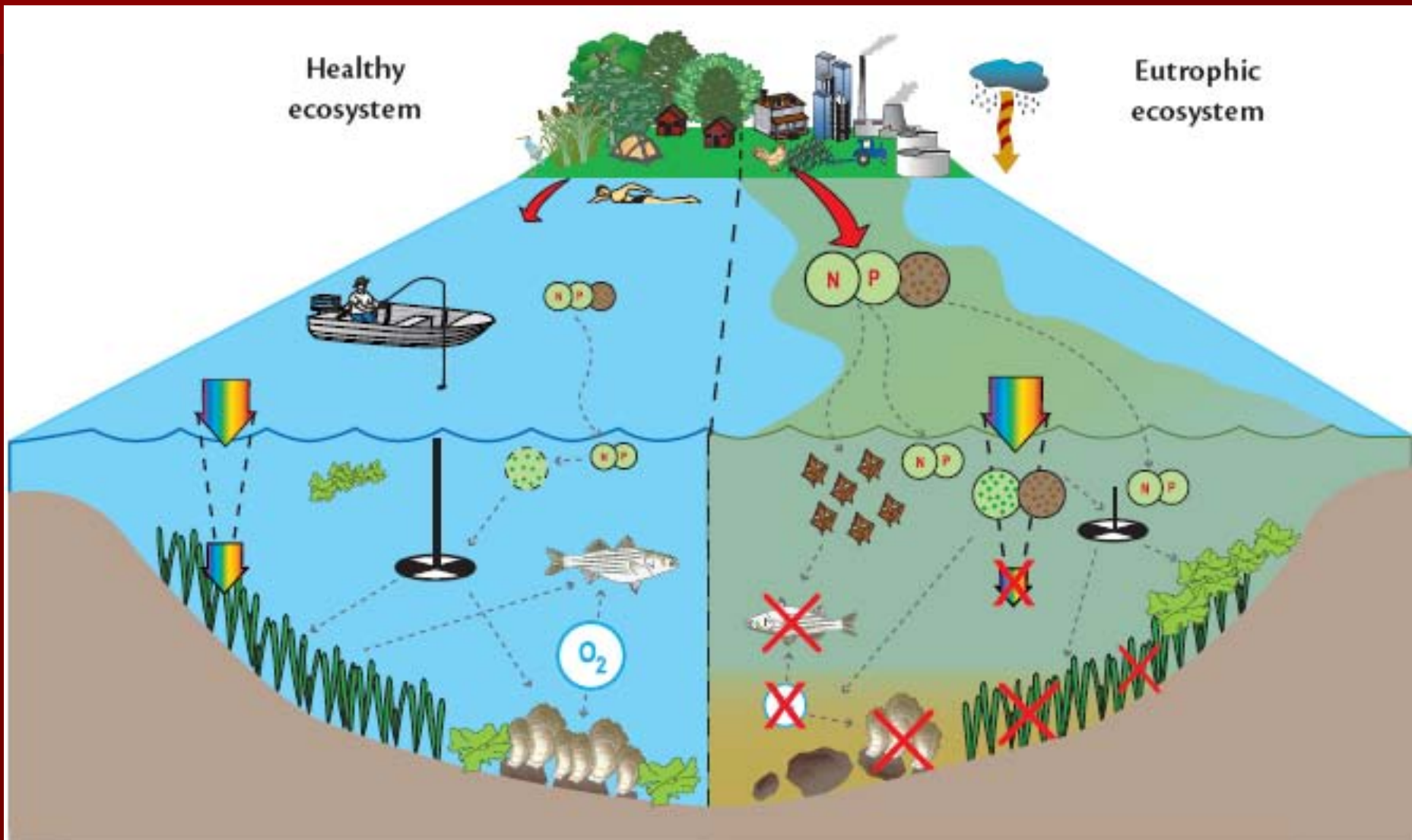


Partners

- PREP Technical Advisory Committee
- EPA (ORD and R1)
- Maine DEP
- UNH
- Municipalities
- Consultants
- NGOs



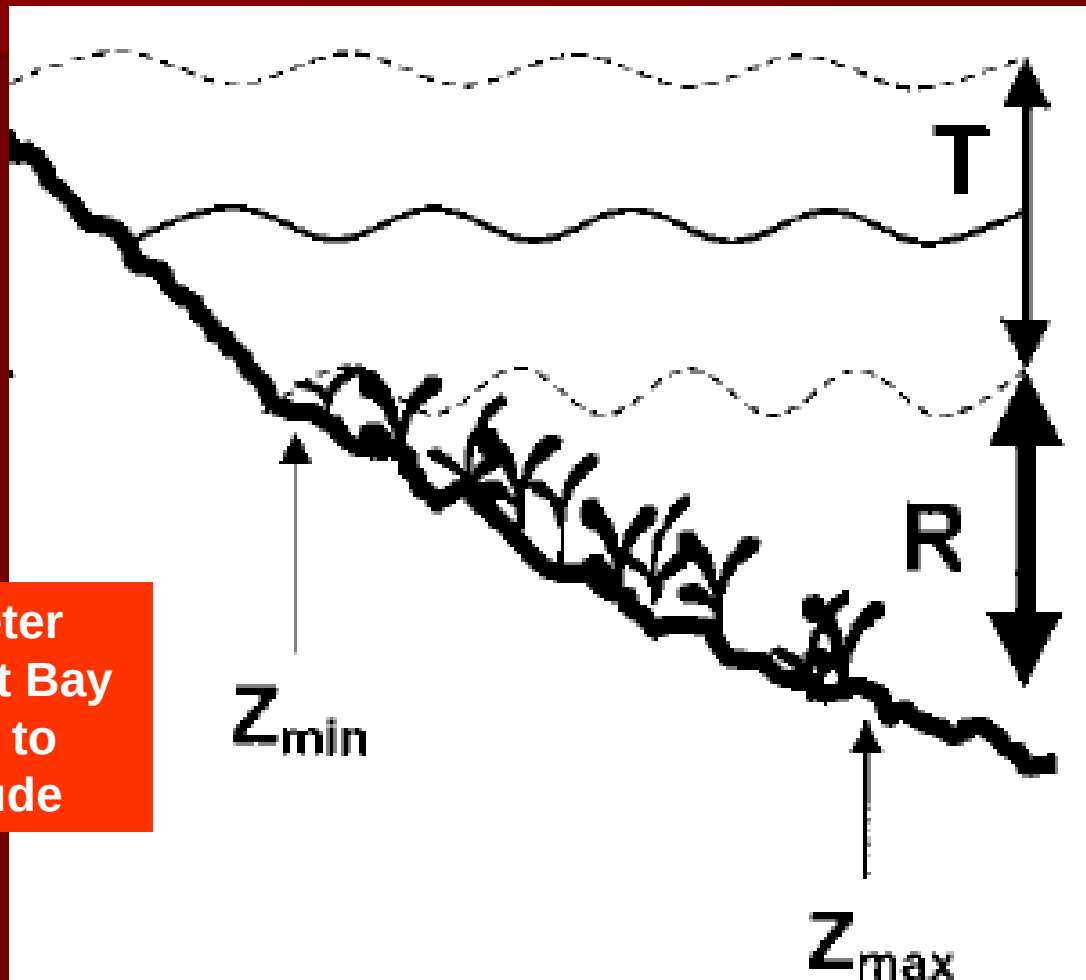
Conceptual Model of Eutrophication (Bricker et al. 2007)



Proposed Numeric Nutrient Criteria for the Great Bay Estuary

Designated Use / Regulatory Authority	Parameter	Threshold	Statistic	Comments
Primary Contact Recreation ¹ (Env-Wq 1703.14)	Chlorophyll-a	20 ug/L	90 th percentile during summer	Applies to all areas of the Great Bay Estuary
Aquatic Life Use Support – to protect Dissolved Oxygen ¹ (RSA 485-A:8)	Total Nitrogen	0.45 mg N/L	Median	Applies to all areas of the Great Bay Estuary
	Chlorophyll-a	12 ug/L	90 th percentile during summer	
Aquatic Life Use Support – to protect Eelgrass ^{1,2} (Env-Wq 1703.14)	Total Nitrogen	0.32 mg N/L	Median	Portsmouth Harbor, Little Harbor, Fiscataqua River, Great Bay, Little Bay, and areas of tidal tributaries where eelgrass has existed in the past
	Light Attenuation Coefficient (Water Clarity)	0.75 m ⁻¹	Median	

Minimum Water Clarity for Eelgrass Survival



Z_{min} = 1 meter
for the Great Bay
Estuary due to
tidal amplitude

Z_{max} should be >1
m below Z_{min} for
viable eelgrass beds
(i.e., Z_{max} > 2 m)

CBP set 0.22 as the
minimum value for
 I_z/I_o for eelgrass

For Z_{max} =2 and
 I_z/I_o =0.22, K_d
should be 0.75 1/m.

$$Z_{max} = \frac{-\ln\left(\frac{I_z}{I_o}\right)}{K_d}$$

Predicted Presence/Absence of Eelgrass Based on Measured K_d

K_d (m^{-1})	Z_{max}- Z_{min} (m)	Predicted Eelgrass	Locations
-3.6 to -1.7	<0	None	SQM, LMP, OYS, CCH, SFR
-1.0	0.5	Partial	GB, LB, UPR
-0.6 to -0.5	~2	Yes	LPR, PH

Factors Affecting Water Clarity are Related to Nitrogen

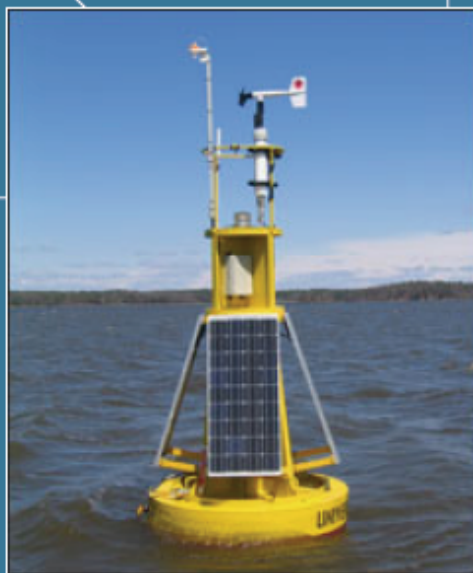
- Chlorophyll-a: Increasing nitrogen results in phytoplankton blooms
- Colored Dissolved Organic Matter: Produced in upland watershed but contains nitrogen
- Turbidity: Primarily caused by particulate organic matter which is correlated with nitrogen

UNH Great Bay Coastal Buoy

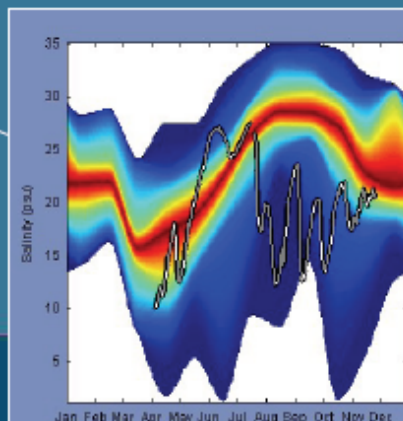
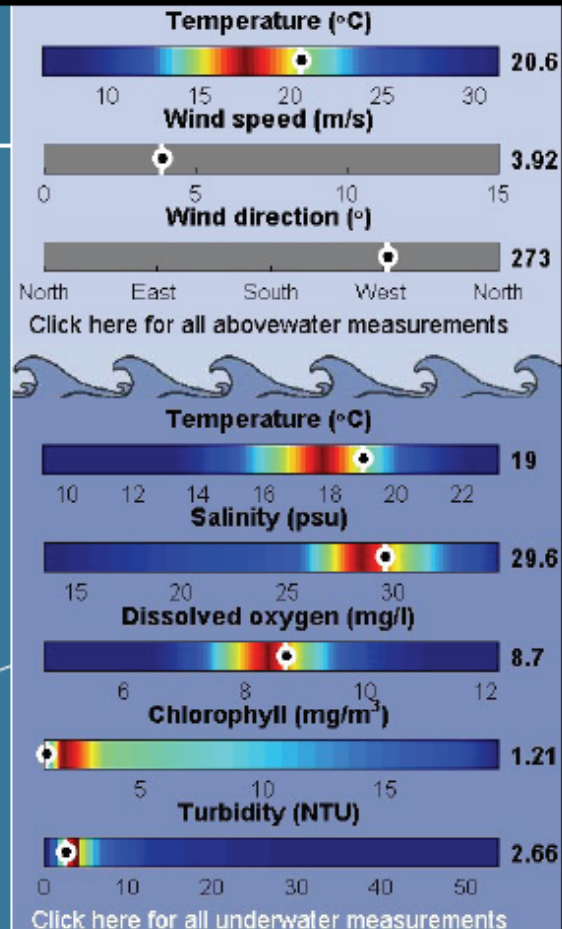
Stakeholders: buoy designed and located after consultation with stakeholders. Current users include: Teachers and students, lobstermen, coastal management, recreational, researchers.

Technology: Sentinel buoy test-bed measuring a comprehensive suite of environmental indicators from nutrients to chlorophyll. Robust, cheap, wireless telemetry to shore

Products: New visualizations to bring historical context to real-time Ocean Observing data to engage users

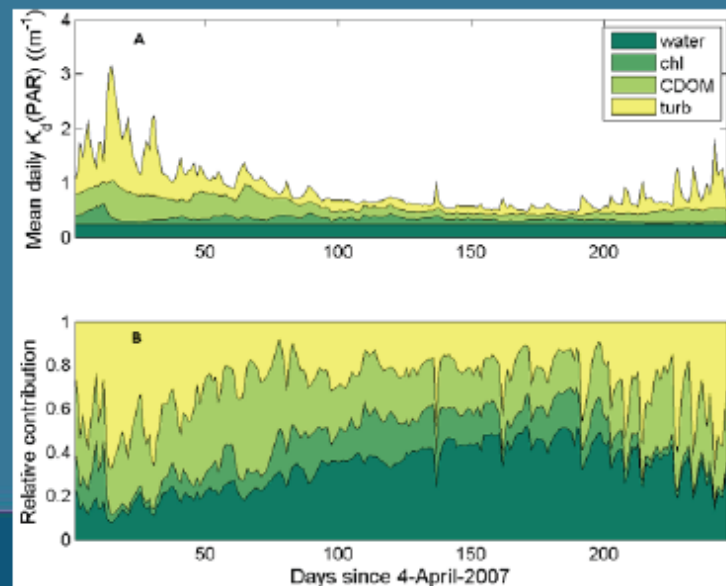
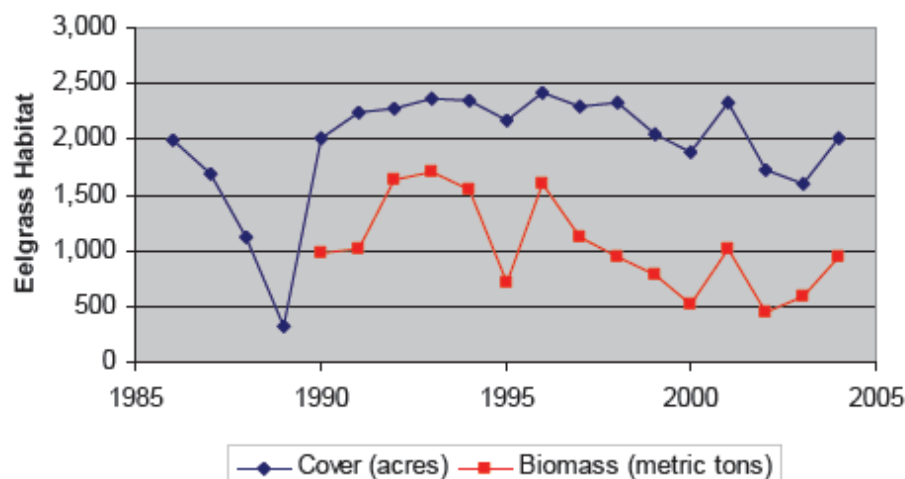
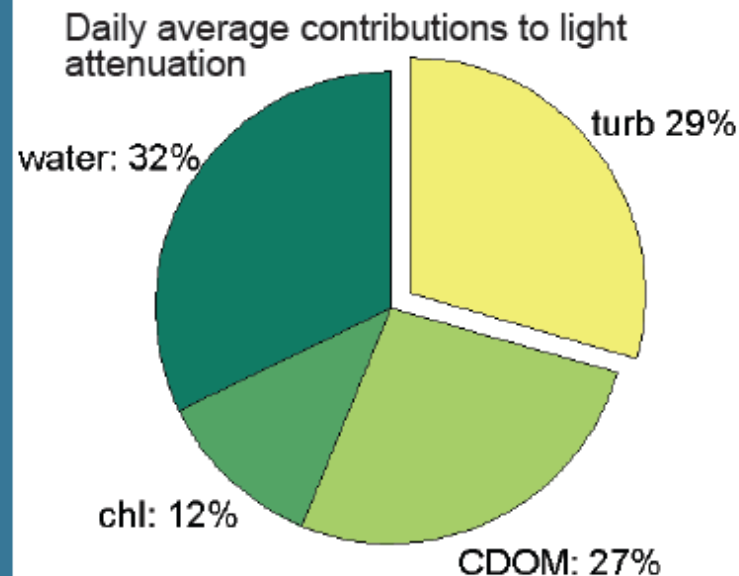


Partners: NHDES, PREP, Great Bay NERR, GoMOOS, Wetlabs, Satlantic, CICEET, AIRMAP,



Nutrient Criteria in Great Bay Estuary

- Eelgrass declining in Great Bay Estuary
- Nutrient criteria developed in part based on protecting eelgrass health
- Water clarity important
- Great Bay buoy provided the detailed measurements needed to understand controls on water clarity
- Nutrient Criteria developed (Dec 2008) with a number of IOOS assets / activities
 - Great Bay Coastal Buoy
 - Hyperspectral Imagery
 - GB NERR datasondes
 - GB NERR (& others) grab samples



In partnership with NHEP (now PREP) the IOOS buoy work was leveraged to obtain EPA funds for hyperspectral imagery

Water Clarity

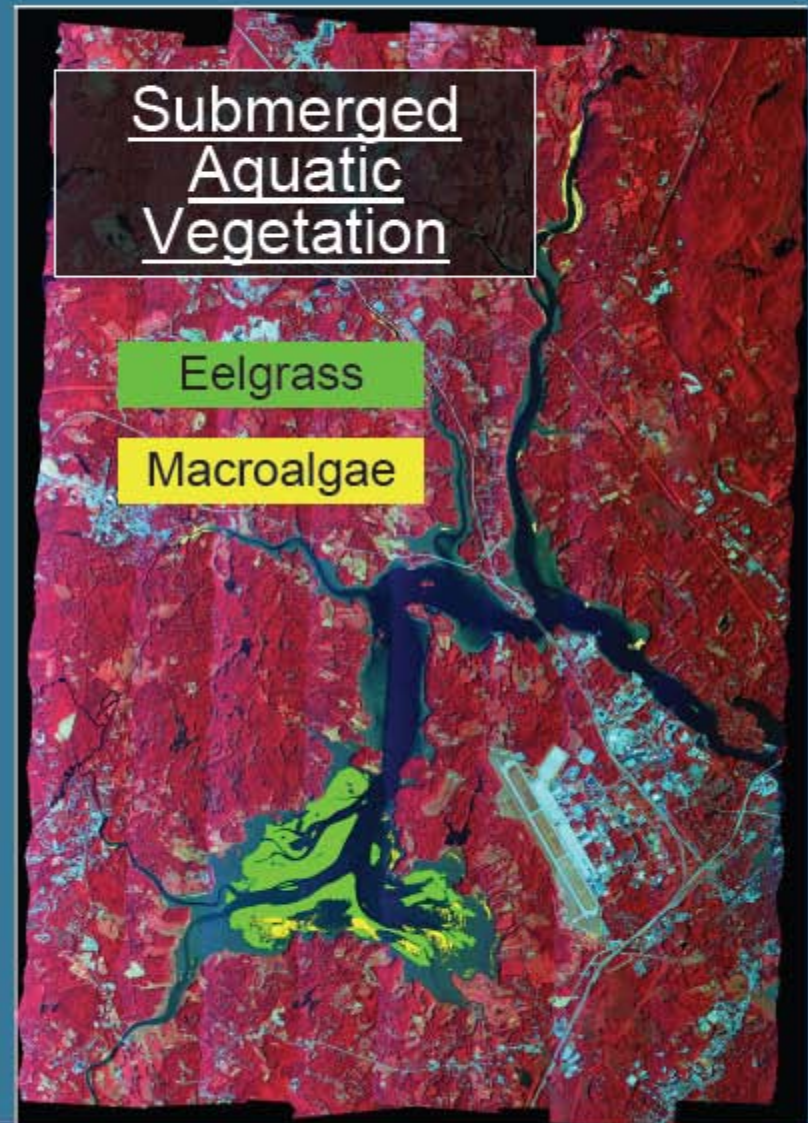
“Development of nutrient criteria would have been impossible without IOOS information”



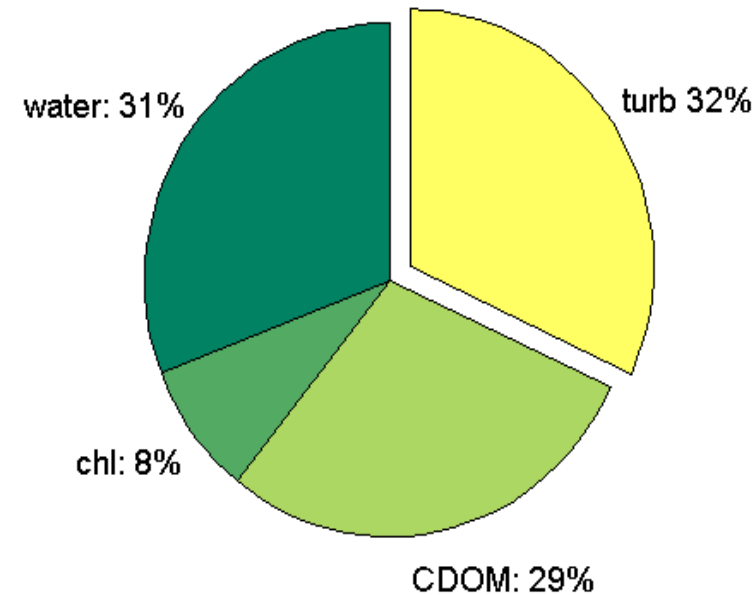
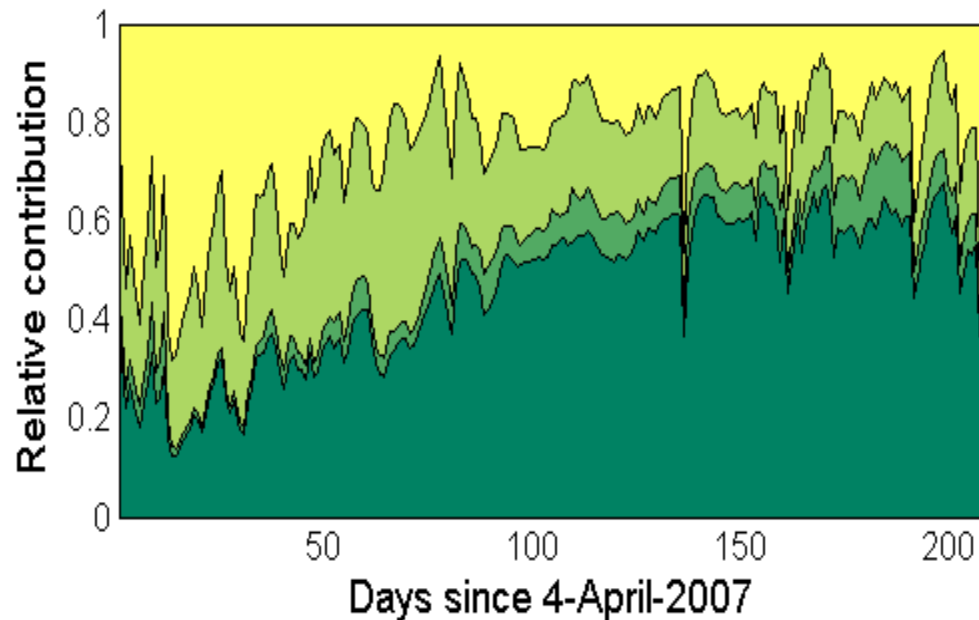
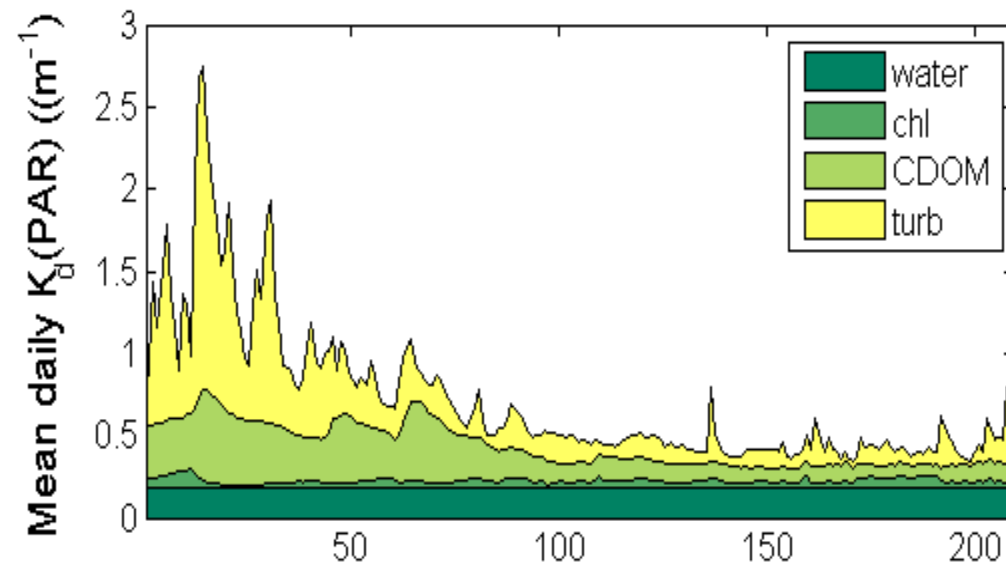
Submerged Aquatic Vegetation

Eelgrass

Macroalgae

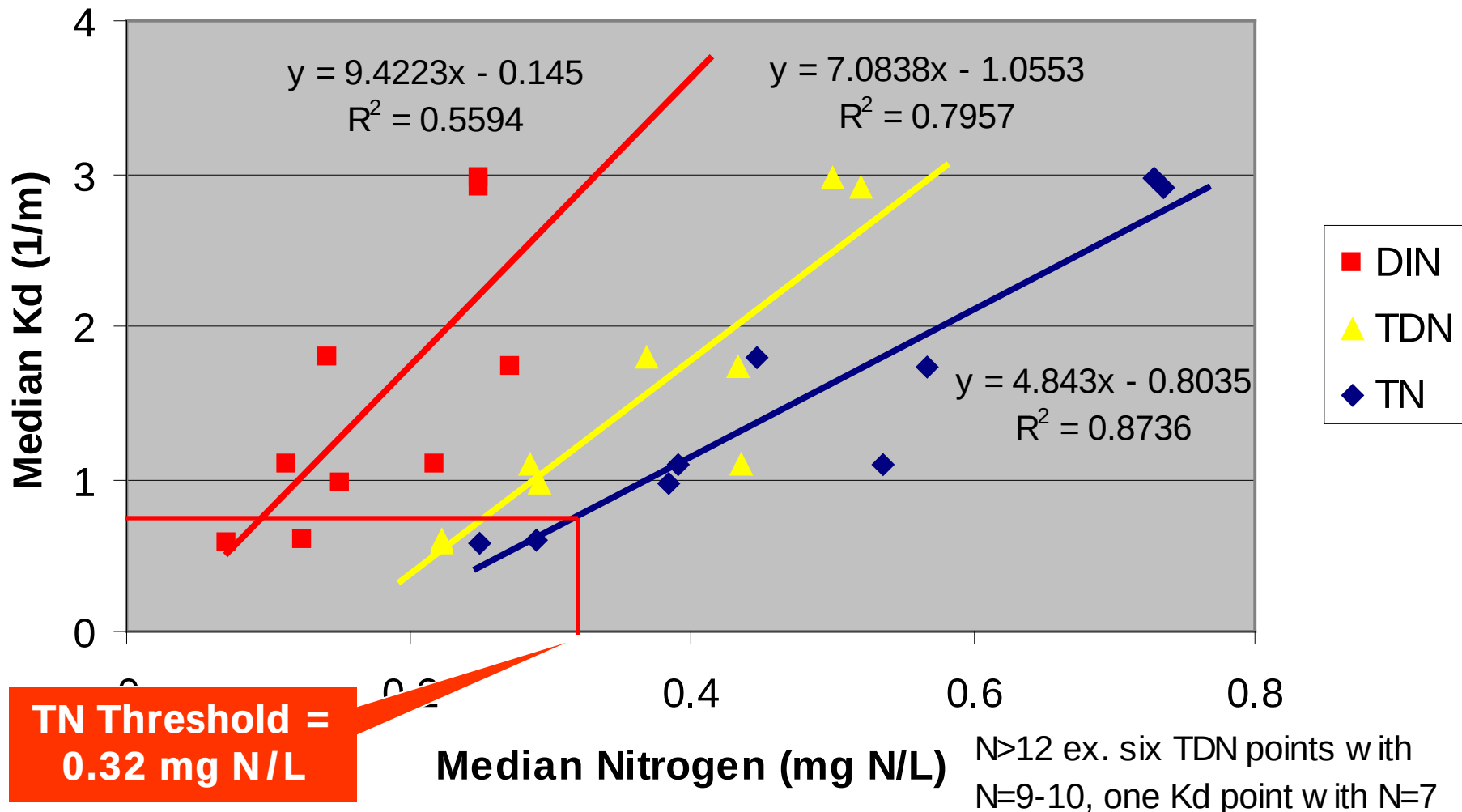


Contributions to $K_d(\text{PAR})$

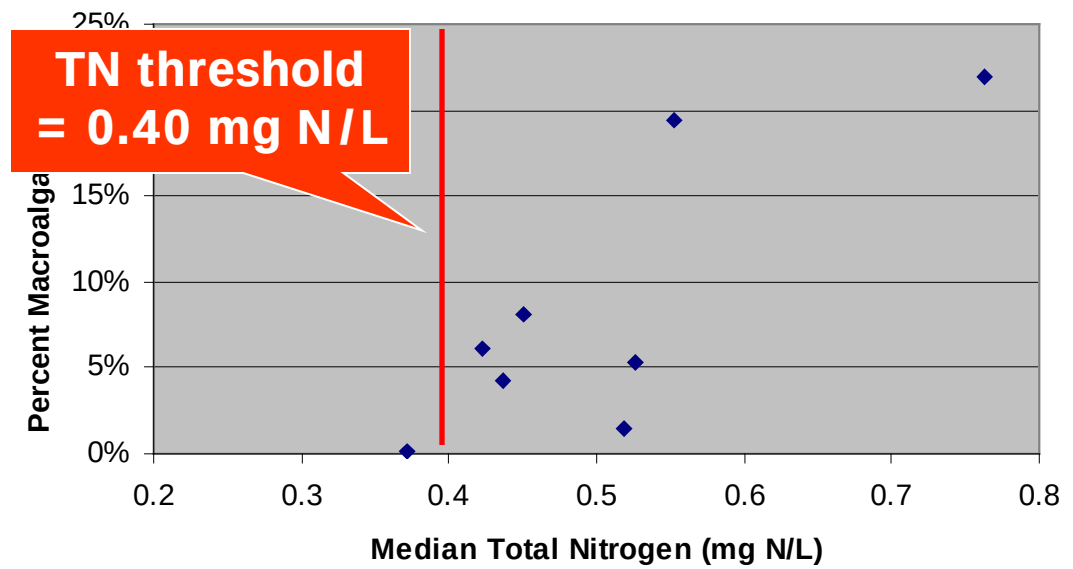
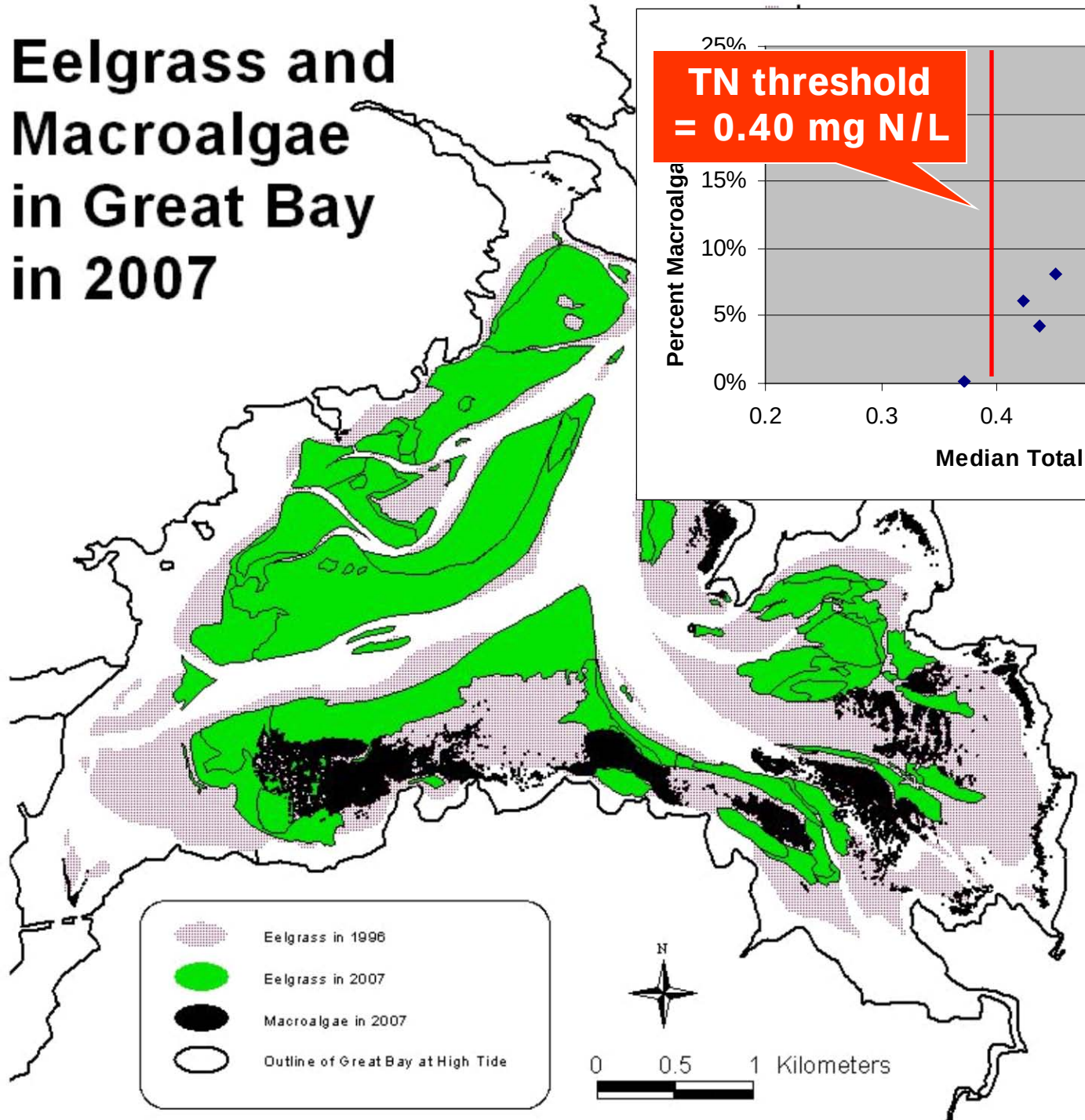


From Morrison
et al. (2008)

Water Clarity Decreases with Increasing Nitrogen Concentrations



Eelgrass and Macroalgae in Great Bay in 2007



**Median TN in
Great Bay =
0.42 mg N/L**

**An Area with
Obvious
Macroalgae
Proliferation**

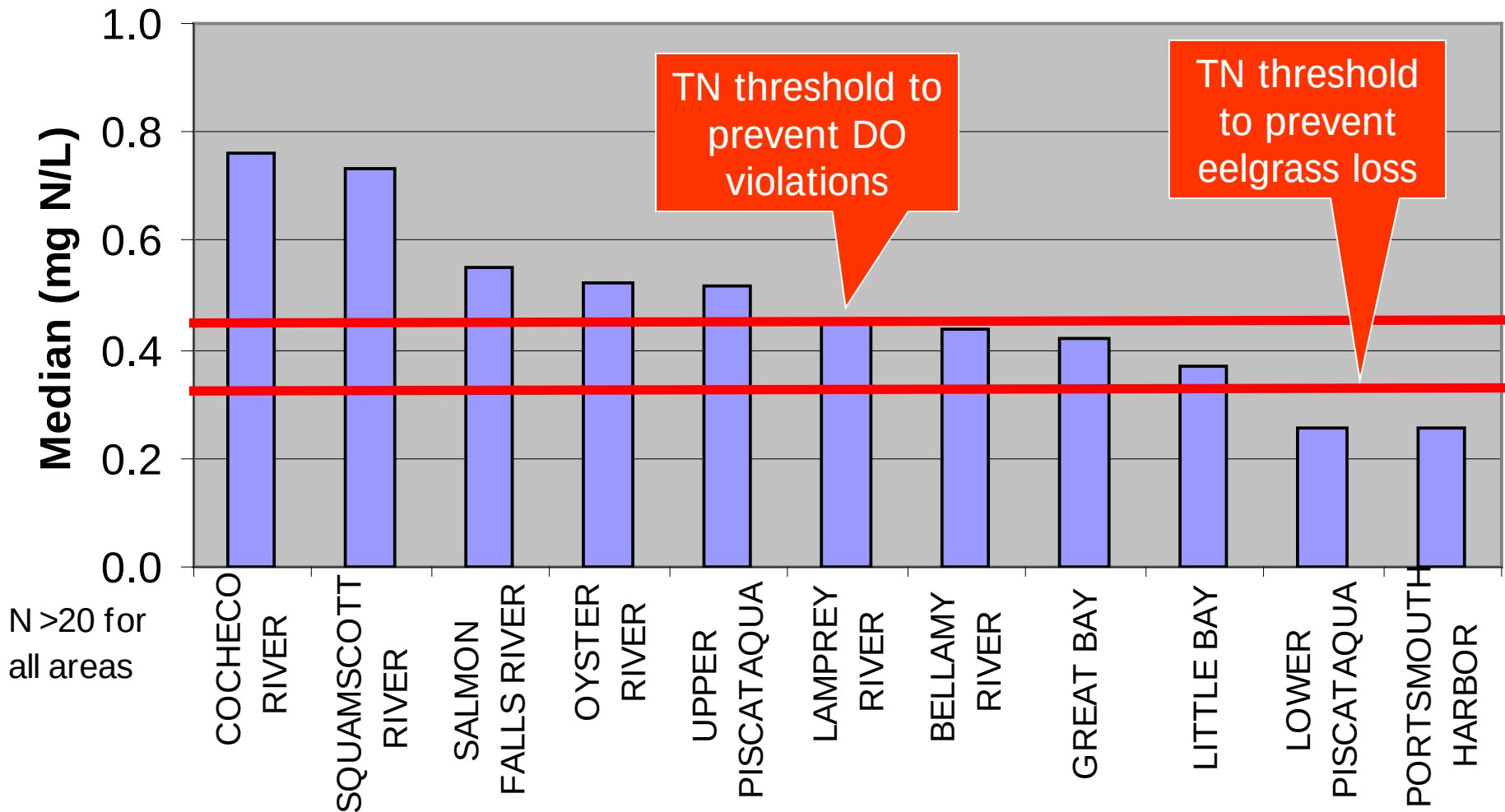
**From Pe'eri et
al. (2008)**

Nutrient Criteria to Prevent Eelgrass Loss

- Maximum light attenuation coefficient to maintain eelgrass
 - $K_d = 0.75$ (1/m)
- TN associated with K_d threshold from regressions
 - TN = 0.32 mg N/L
- Macroalgae proliferation
 - No problems for TN < 0.40 mg N/L
- Ocean background
 - TN = 0.24 mg N/L
- Reference concentration where eelgrass still exists (Portsmouth Hbr)
 - TN = 0.32 mg N/L (75th percentile)
- TN thresholds set for other estuaries in NE
 - TN = 0.35-0.38 mg N/L (Mass. Estuaries Project, Nantucket Sound)
- Weight of evidence threshold
 - TN threshold for eelgrass in GBE = 0.32 mg N/L

Proposed Nitrogen Impairments

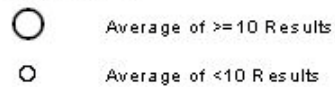
Total Nitrogen Concentrations in the GB Estuary



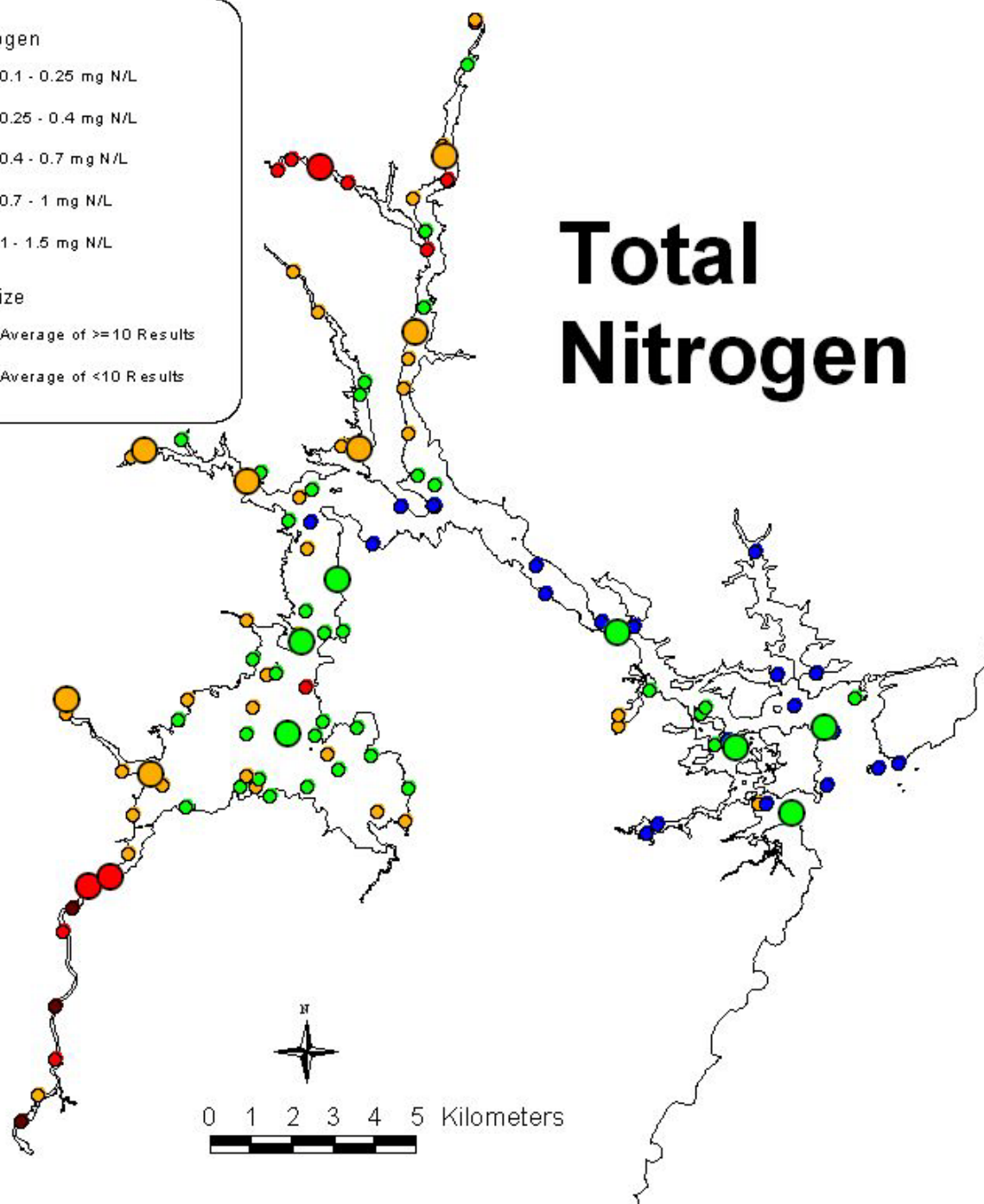
Total Nitrogen



Sample Size



Total Nitrogen



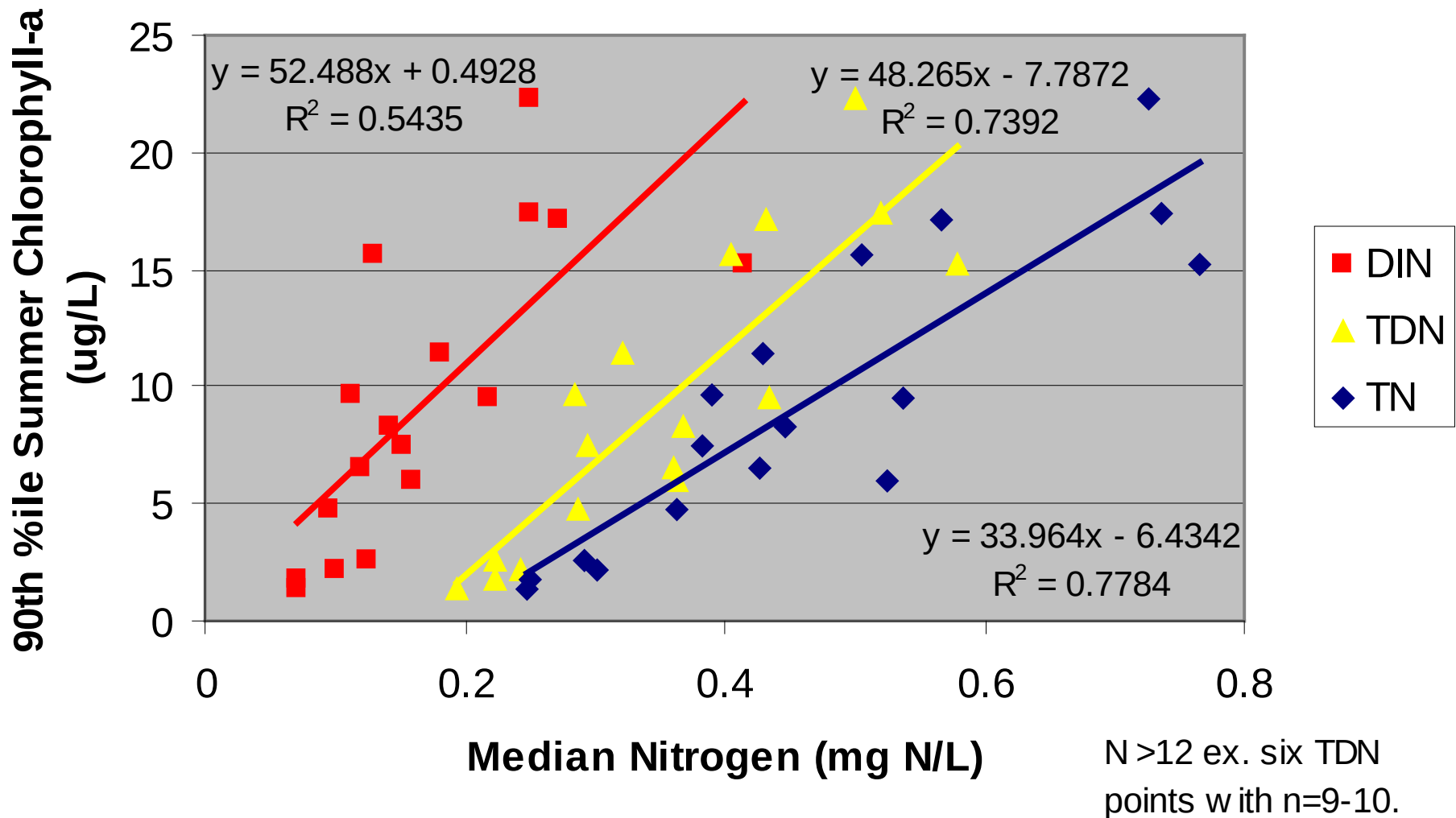
Management Implications for Nitrogen Impairments

- NPDES permitted sources for nitrogen must hold their loadings at the existing levels (e.g., WWTFs, MS4s).
- New permitted sources (e.g., AoT or CGP permittees) within the upstream watershed of an impaired waterbody would have to demonstrate zero additional loads of nitrogen or arrange for trading within the watershed.
- The “hold the load” restriction would continue until a TMDL is completed, at which point the load allocations from the TMDL would become effective. The TMDL allocations will likely require reductions in loading.

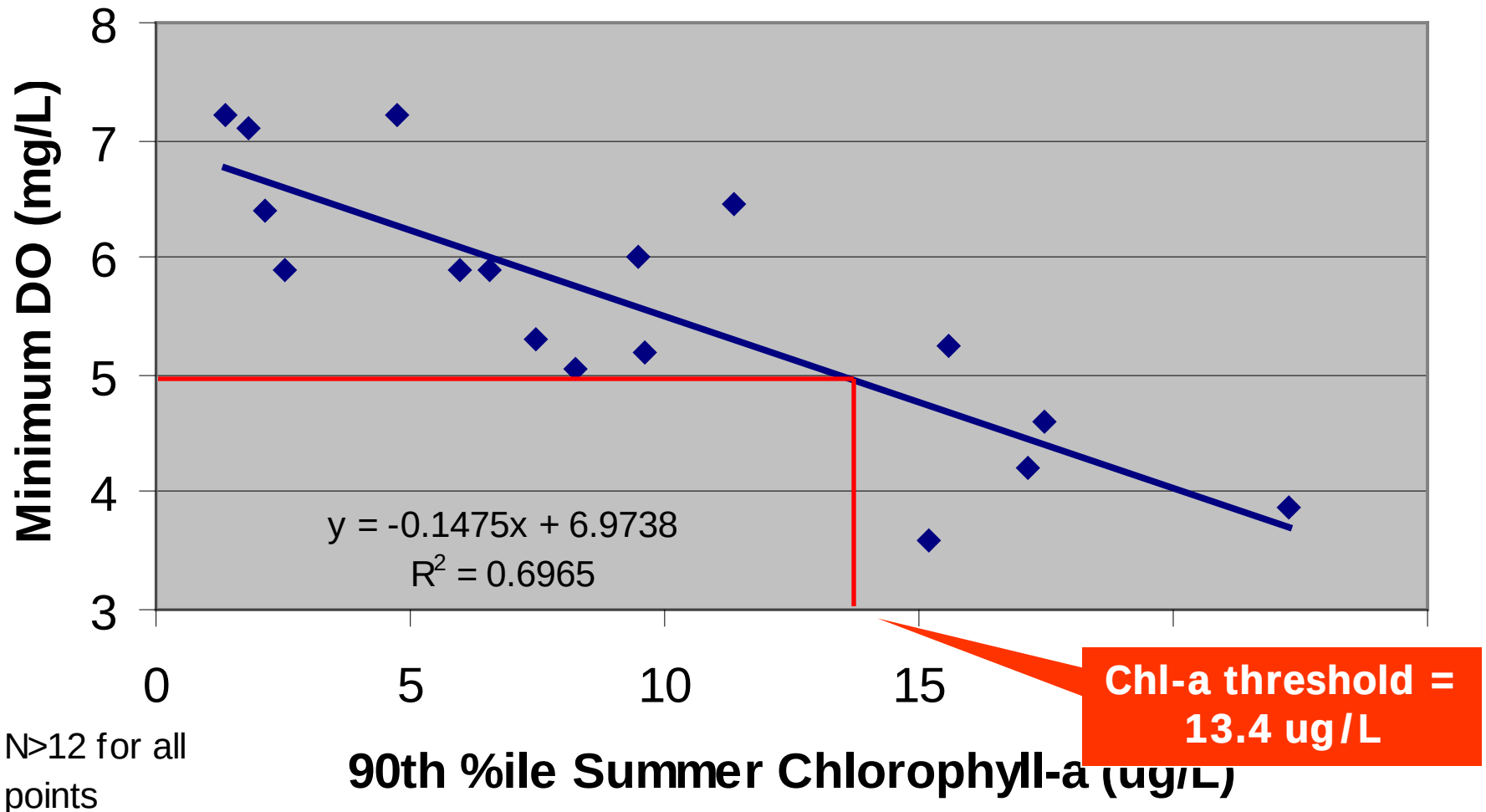
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	Light Attenuation Coefficient (Water Clarity)	0.75 m ⁻¹	Median	

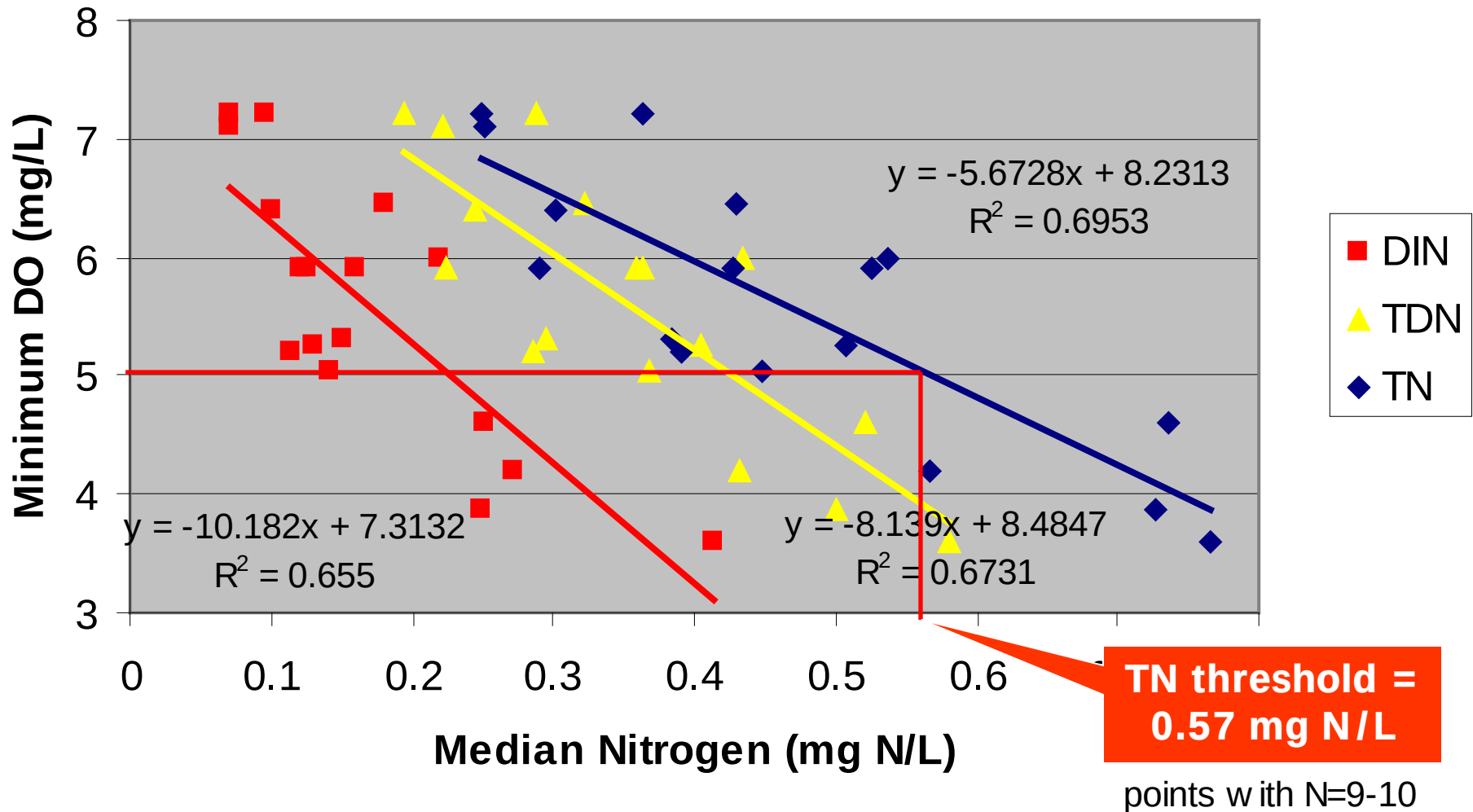
Increasing Nitrogen Concentrations Cause Phytoplankton Blooms



Increasing Phytoplankton Blooms Result in Lower Dissolved Oxygen

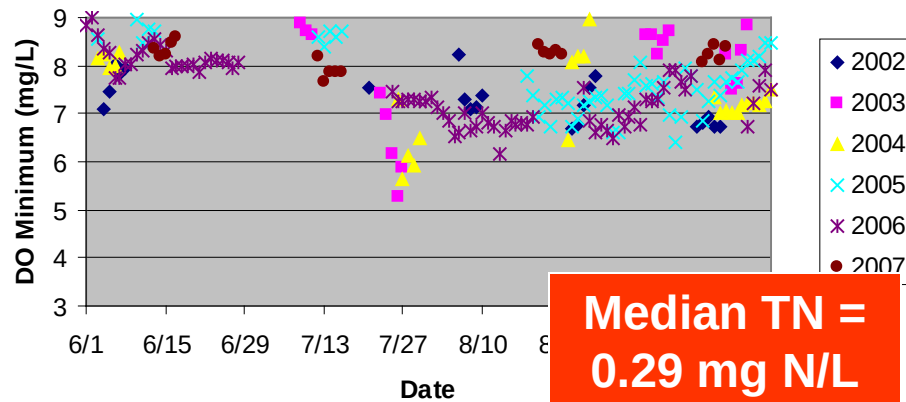


Therefore, Increasing Nitrogen Result in Lower Dissolved Oxygen

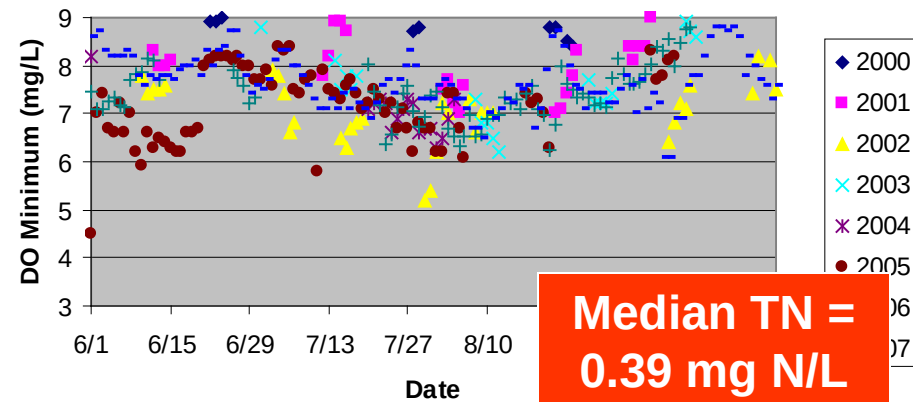


Daily Minimum Dissolved Oxygen at Datasondes Without Violations

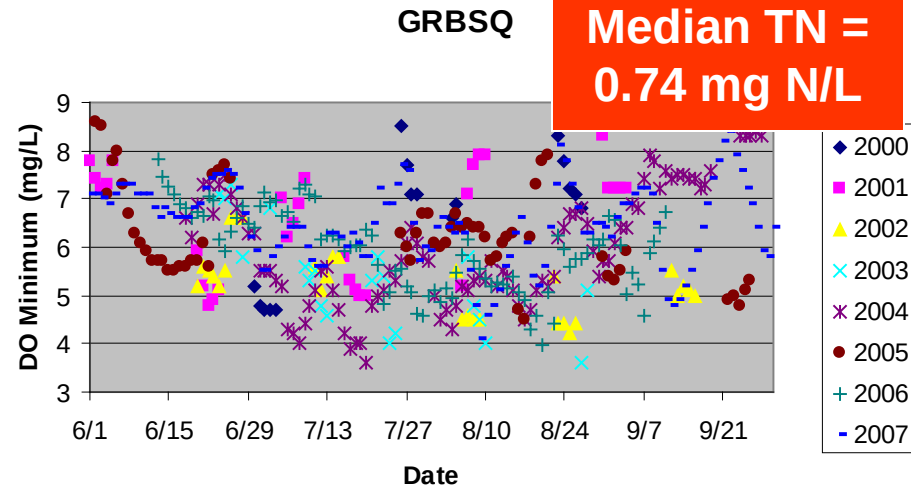
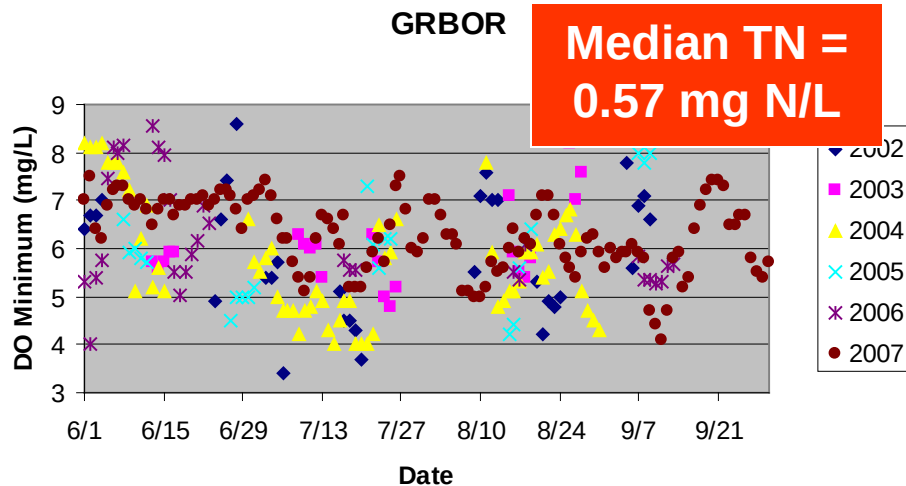
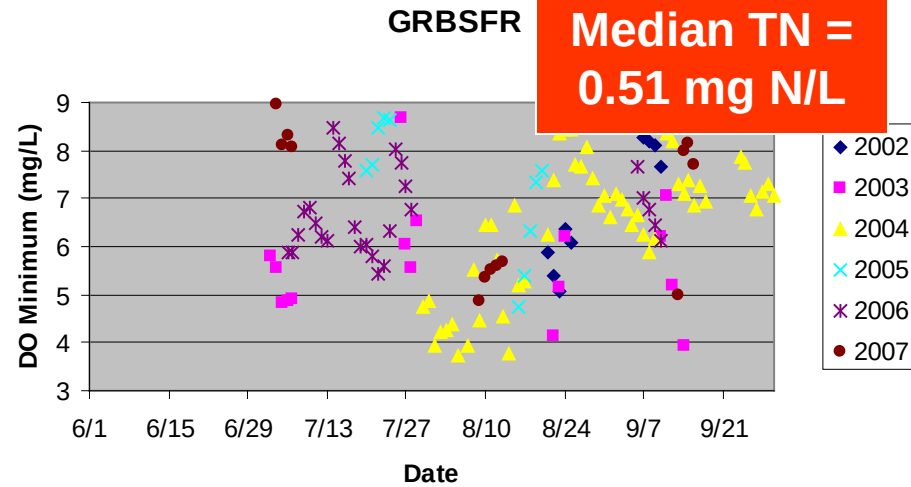
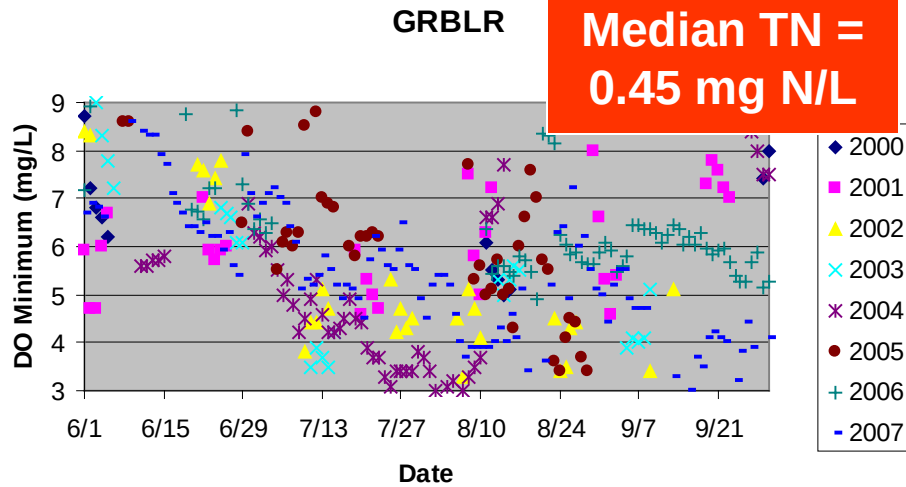
GRBCML



GRBGB



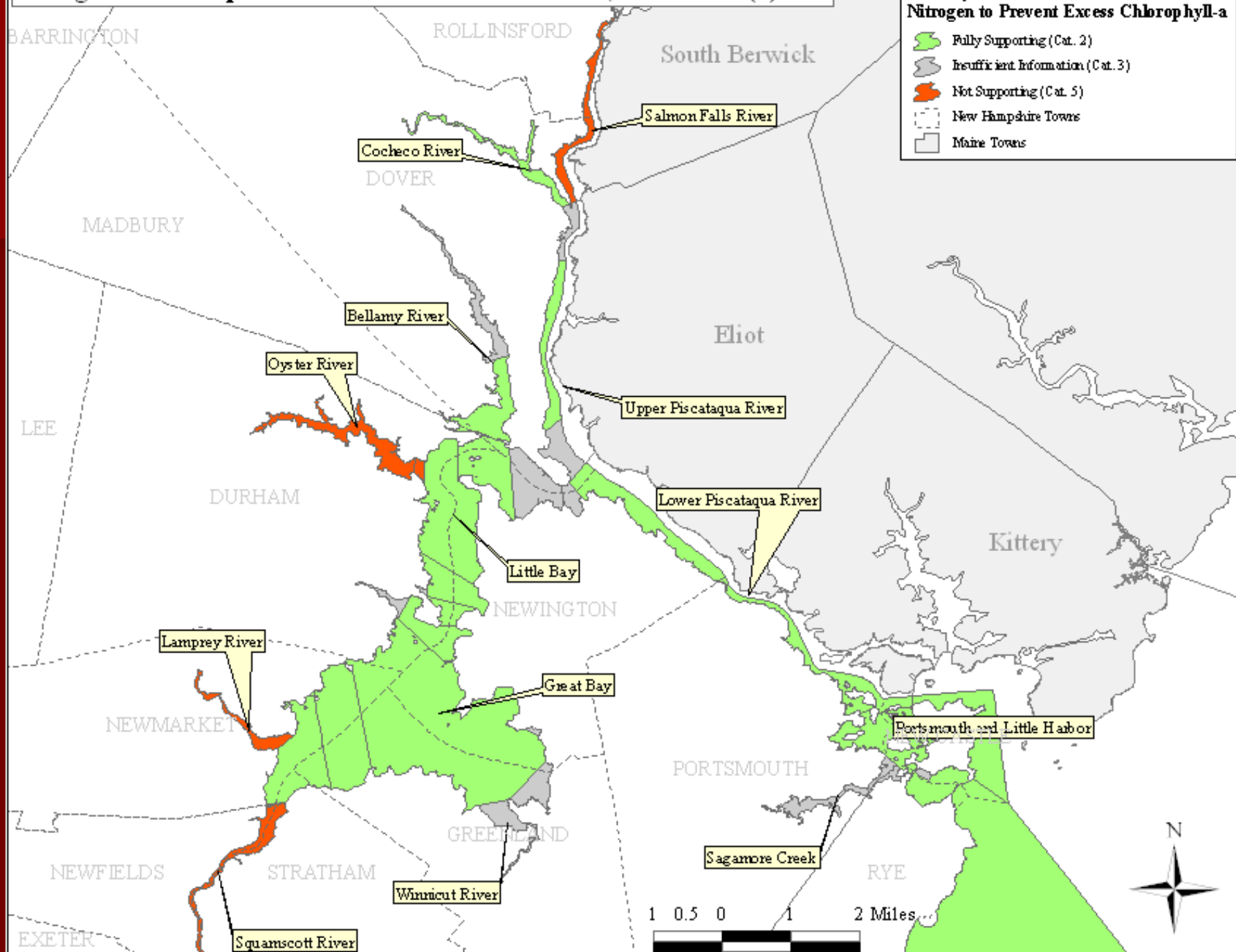
Daily Minimum Dissolved Oxygen at Datasondes With Violations



Nutrient Criteria to Prevent Dissolved Oxygen Violations

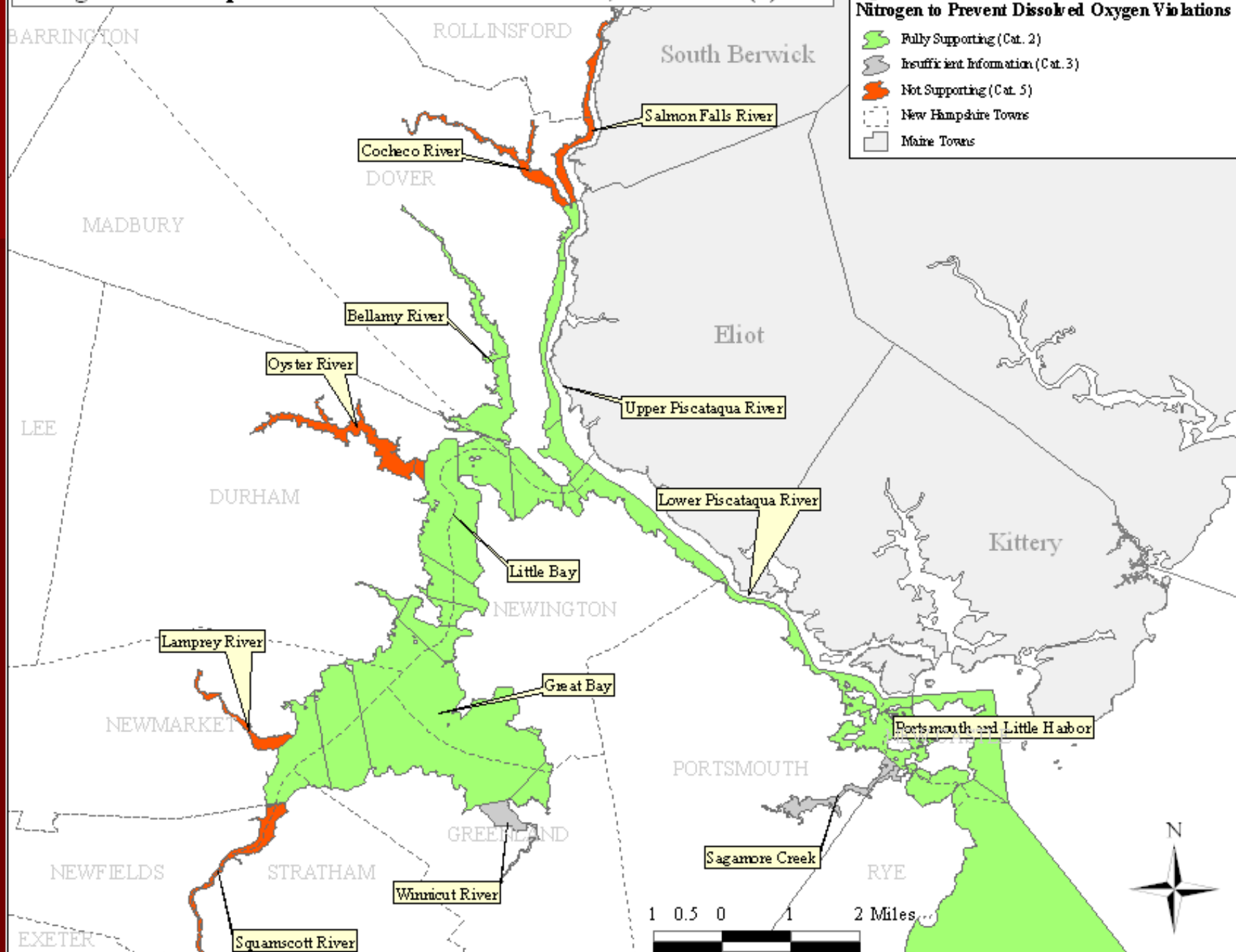
- Regression from Grab Samples for DO=5 mg/L
 - TN = 0.57 mg N/L Chl-a = 13.4 ug/L
- DO Violations Measured by Datasondes
 - No problems for
TN = 0.29 - 0.39 mg N/L Chl-a = 2.5 - 9.6 ug/L
 - Violations for
TN = 0.51 - 0.74 mg N/L Chl-a = 15.6 - 17.5 ug/L
 - Lamprey River DO violations affected by stratification
TN = 0.45 mg N/L Chl-a = 8.2 ug/L
- Weight of Evidence Thresholds
 - TN = 0.45 mg N/L Chl-a = 12 ug/L

Nitrogen-Based Impairments to be Added to the 2008, Section 303(d) List



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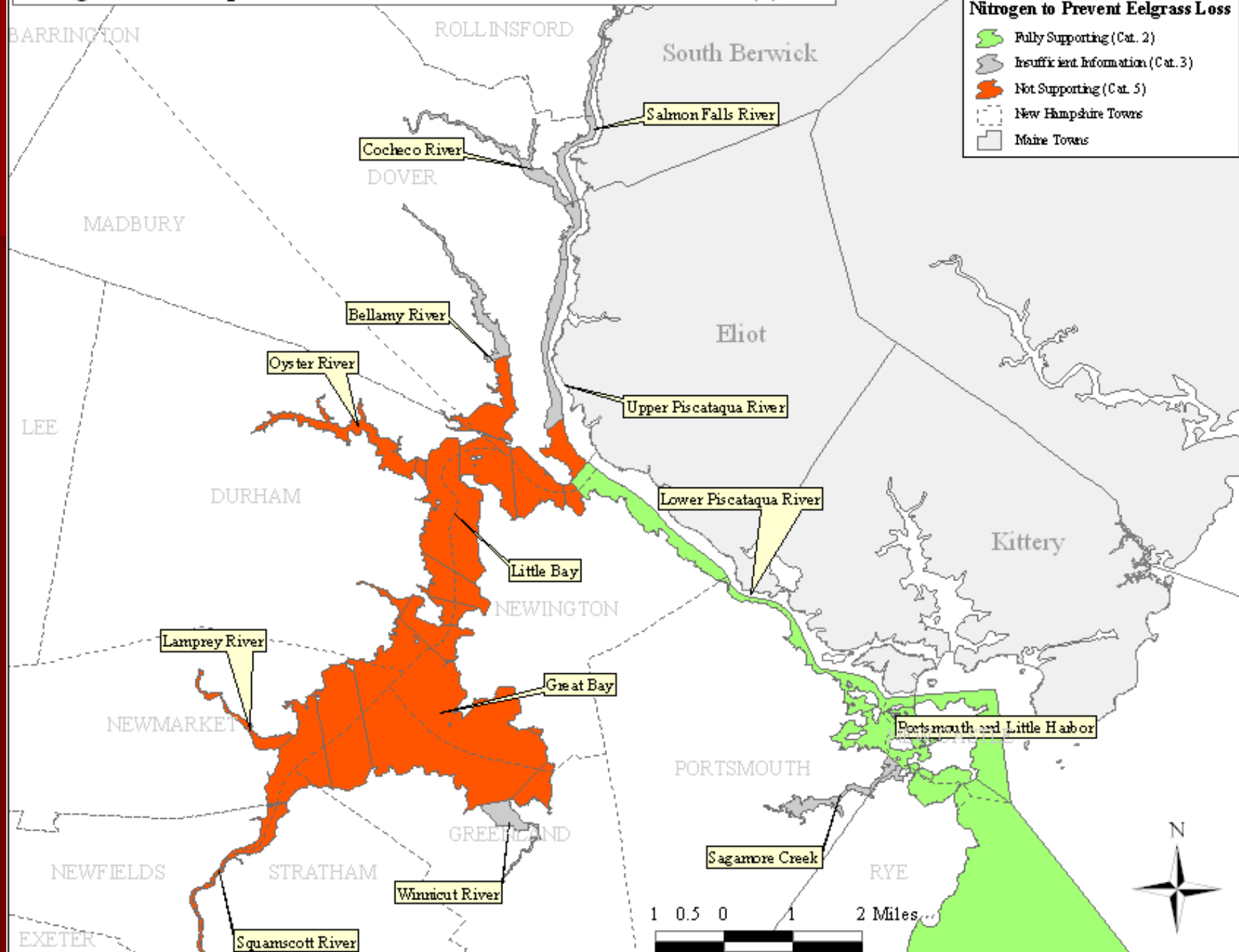
Aquatic Life Use,
Nitrogen to Prevent Dissolved Oxygen Violations



Nitrogen-Based Impairments to be Added to the 2008, Section 303(d) List

Aquatic Life Use, Nitrogen to Prevent Eelgrass Loss

- Fully Supporting (Cat. 2)
- Insufficient Information (Cat. 3)
- Not Supporting (Cat. 5)
- New Hampshire Towns
- Maine Towns



Public Comment Period for Proposed Nutrient Criteria

- 11/17/08: Presentation to NHEP TAC for initial review
- 12/30/08: Revised document sent to TAC
- 1/9/09: Document sent to WQSAC and 303d distribution lists
- 2/9/09: Deadline for written comments

Document Available at:

<http://www.nhep.unh.edu/programs/nutrient.htm>

Email comments to Philip.Trowbridge@des.nh.gov

Contact Information

Philip Trowbridge, P.E.
State of New Hampshire
Piscataqua Region Estuaries
Partnership &

Dept. of Environmental
Services

Concord, NH

Tel: 603.271.8872

Philip.Trowbridge@des.nh.gov



THANKS!