Nutrient Monitoring Research in New Jersey

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New Jersey Water Monitoring Coordinating Council
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Trenton New Jersey

NJDEP

I. COMPLETED NJDEP NUTRIENT STUDIES (FY00 – 06)

- Northern New Jersey - Trophic Diatom Index (TDI)
- Southern New Jersey - Trophic Diatom Index (TDI)
- TDI-MUA Study

II. ONGOING NJDEP NUTRIENT STUDIES (FY07)

- Tiered Aquatic Life Use (TALU) Study (NJDEP Funded)
- Paleolimnology Lake Study (EPA Funded)
- Nutrient Biotic Index (NBI) Study (EPA Funded)

III. FUTURE NUTRIENT RESEARCH NEEDS

- Estuarine
- Oceanic

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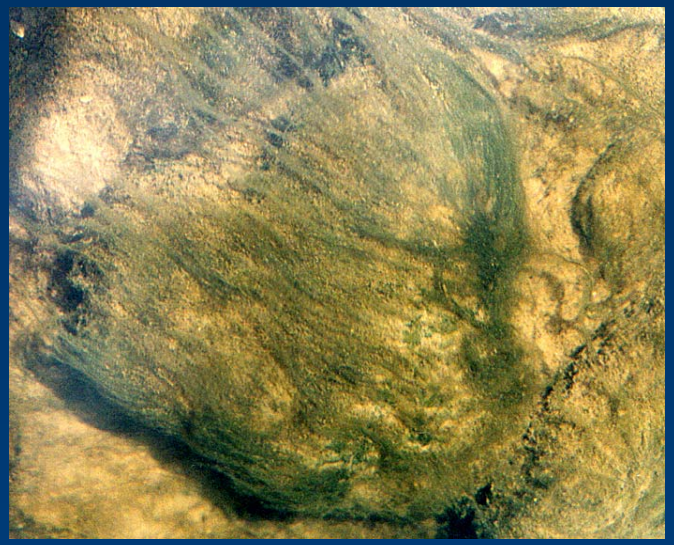
Algal Indicators of Nutrient Conditions

States need:

- Monitoring and regulatory tools
- Accurately characterize nutrient enrichment and biological response
  - determine impairment
  - diagnose cause of impairment
- Consistent with extant State nutrient criteria



Construction of Simple Diatom TP Metrics

(Potapova and Charles, EI, 2006)*

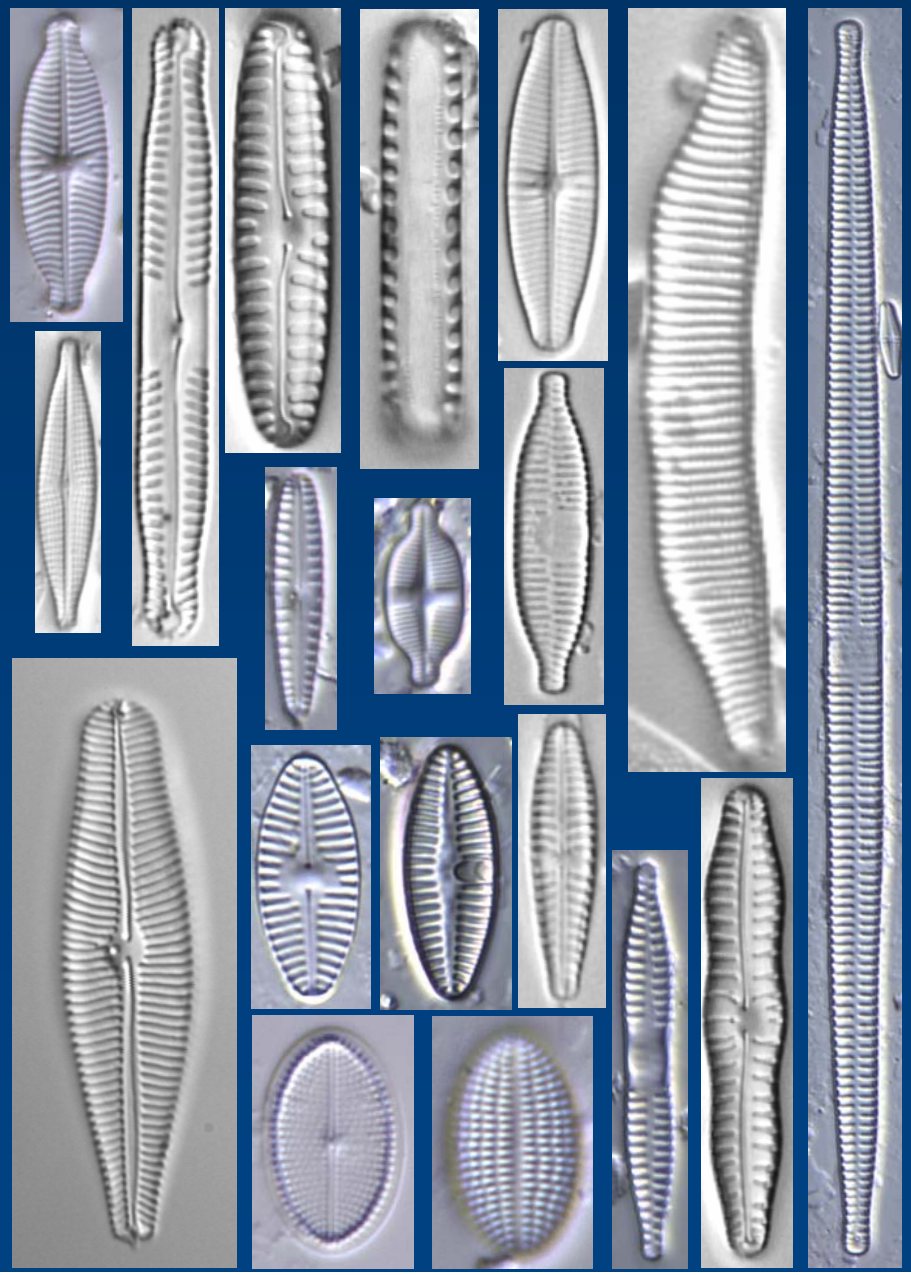
- Use state and federal data to quantify indicator properties of diatoms at national/regional scales
- Identify taxa in low- and high-nutrient categories
- Calculate metrics based on % of individuals in these categories
- Compare with other metrics (e.g., Van Dam)
- Test metrics using independent diatom dataset.

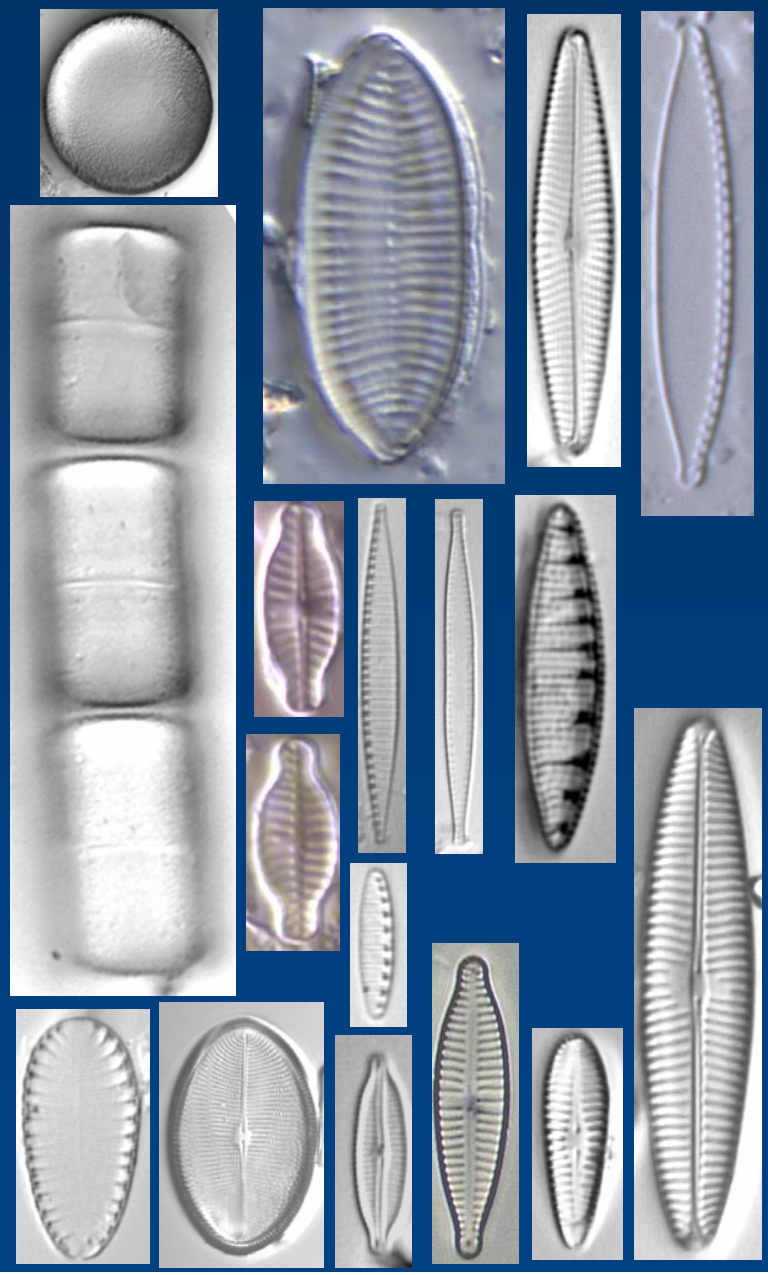
* Potapova M & DF Charles. 2007. Diatom metrics for monitoring eutrophication in rivers of the United States. *Ecological Indicators* 7: 48-70.

Low TP, < 10 µg/L

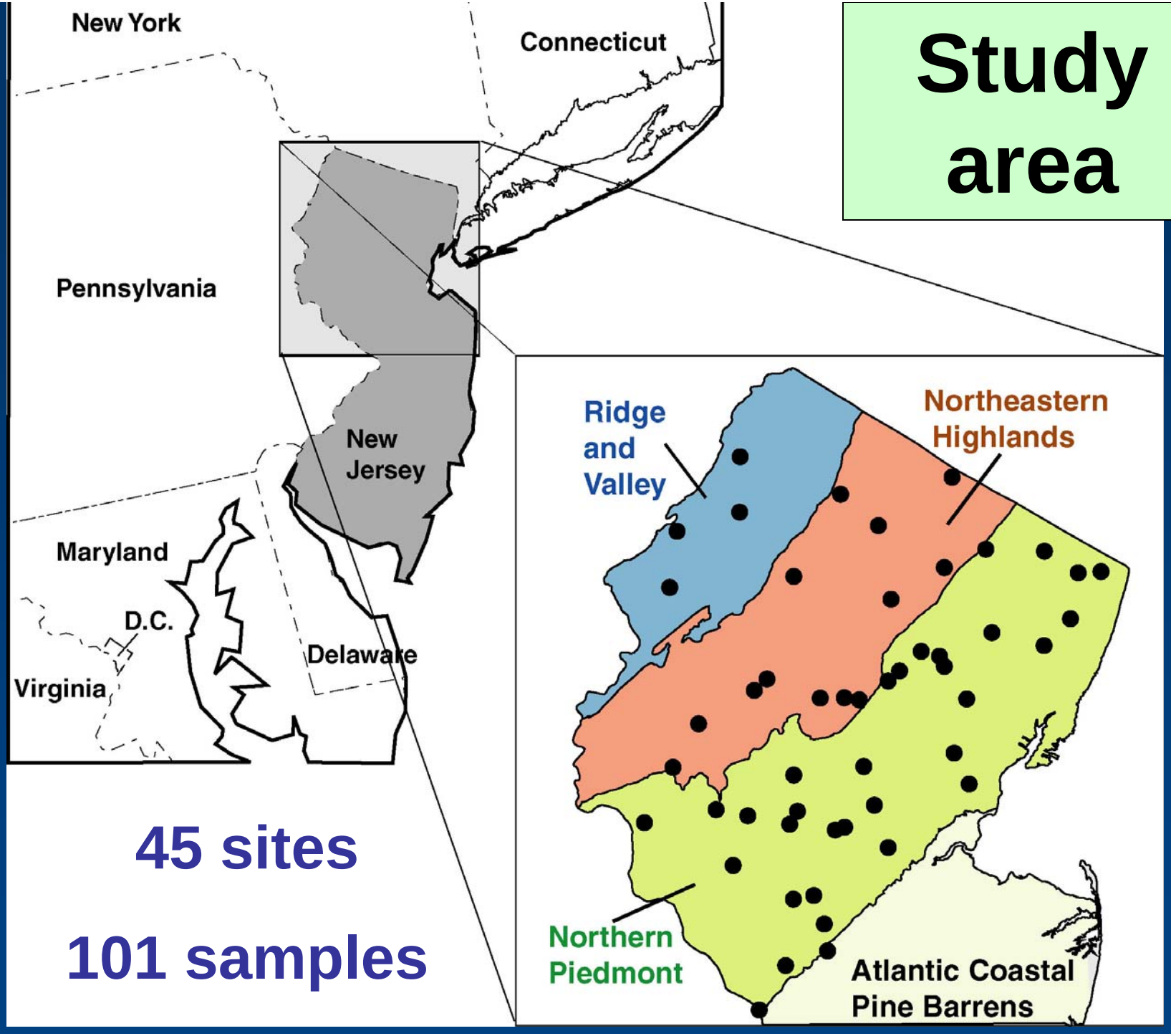
371 Taxa

High TP, > 100 µg/L



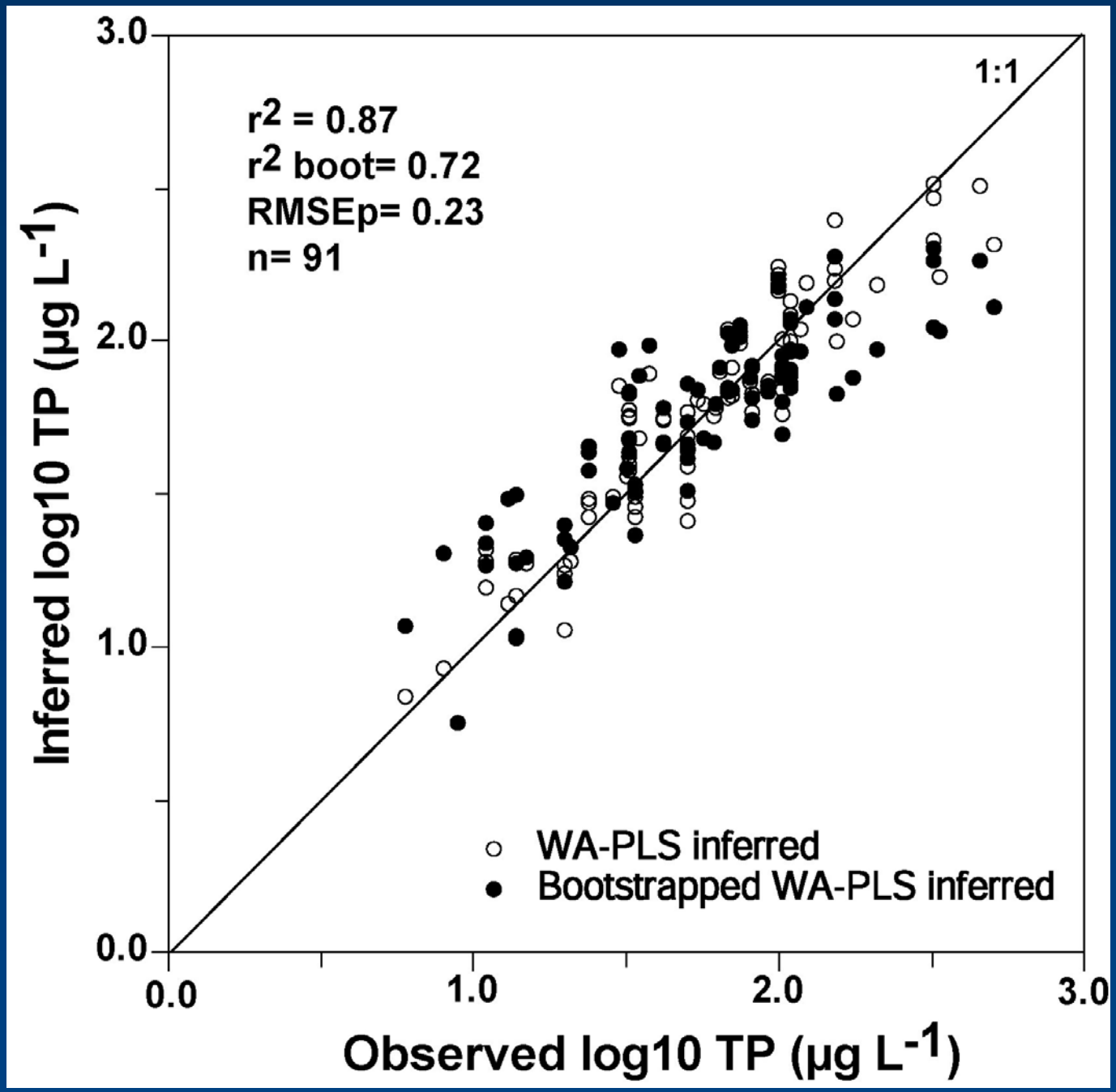


Study area



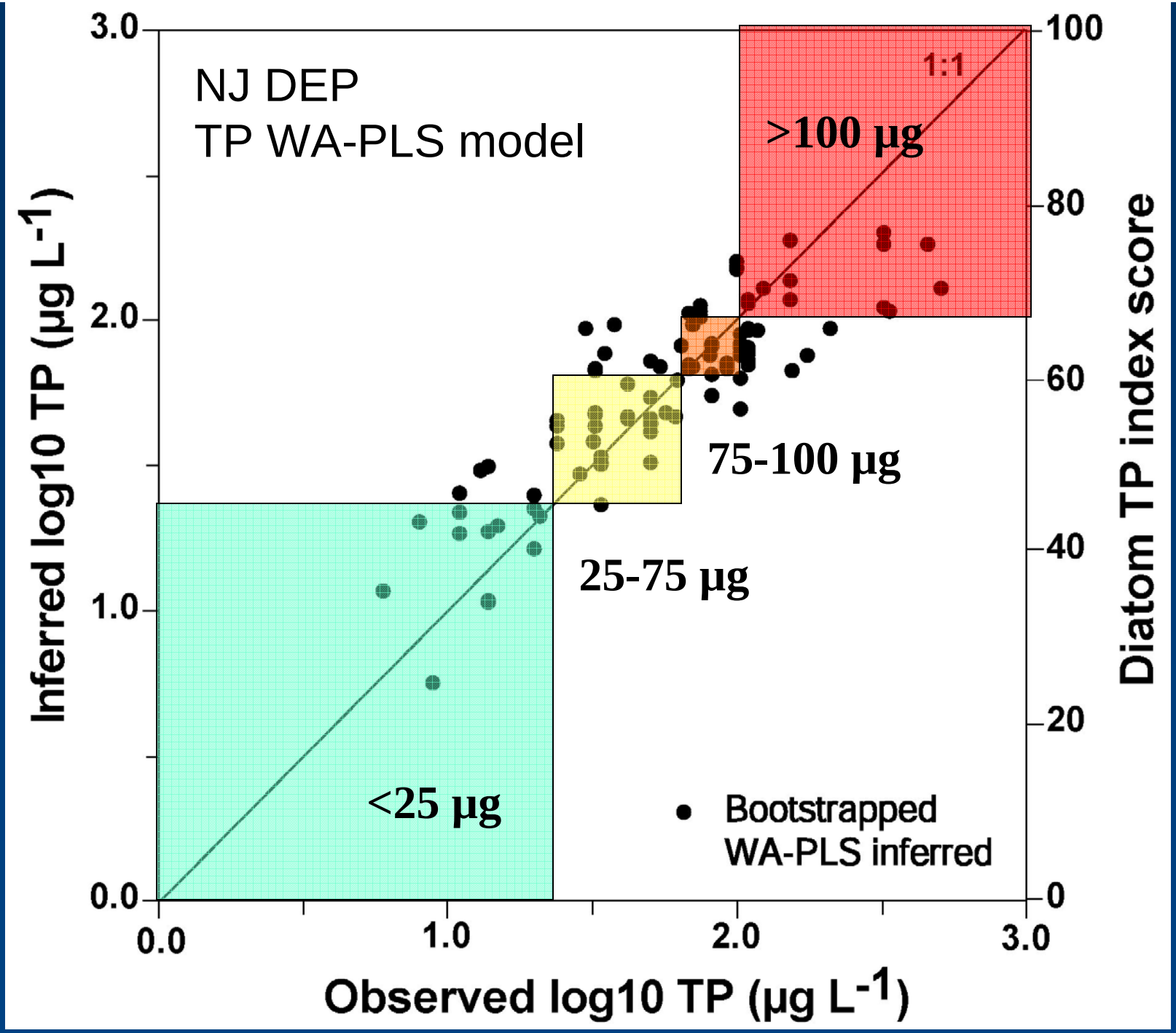
45 sites

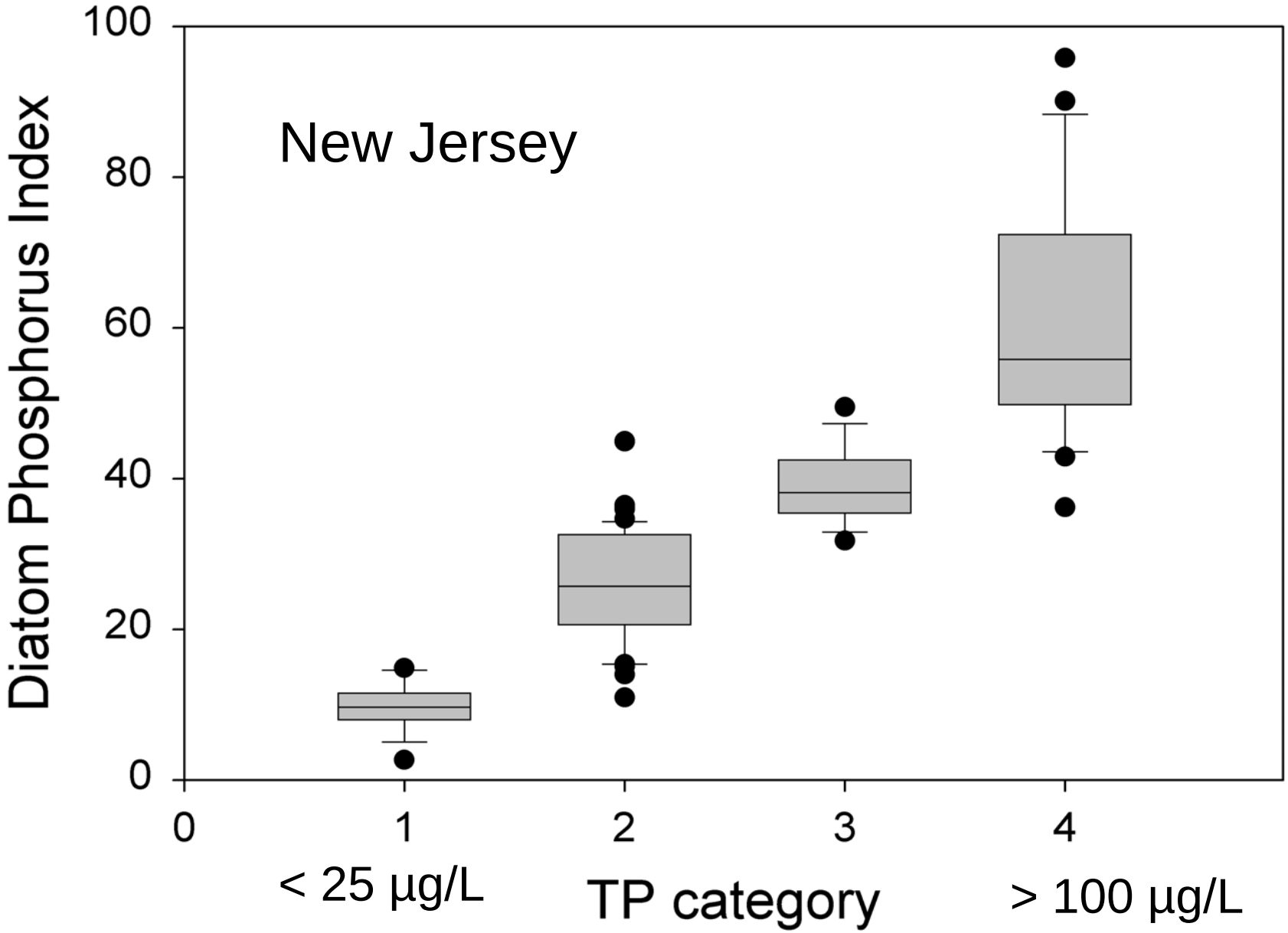
101 samples



New Jersey Diatom TP Inference model

Weighted Average-Partial Least Squares WA-PLS


NJ DEP
TP WA-PLS model
1:1
>100 µg
75-100 µg
25-75 µg
<25 µg
Bootstrapped
WA-PLS inferred
Inferred log10 TP (µg L-1)
Observed log10 TP (µg L-1)
Diatom TP index score
0.0
1.0
2.0
3.0
0
20
40
60
80
100


New Jersey
Diatom Phosphorus Index
100
80
60
40
20
0
0
1
2
3
4
< 25 µg/L
TP category
> 100 µg/L

Conclusions NJ-TDI Development*

- Simple diatom TP metrics and inference models are effective indicators of nutrient conditions
- Metrics based on both national and regional data perform better than commonly metrics
- Accuracy of metrics will improve with additional and better diatom and water chemistry data

*Ponader, K.C. Charles, D.F. and T.J. Belton. 2007. Diatom-Based TP and TN Inference Models and Indices for Monitoring Nutrient Enrichment of New Jersey Streams, *Ecological Indicators*, Vol. 7, pp 79-93.

*Ponader, K.C. Charles, D.F. and T.J. Belton. 2007.Totla Phosphorus Inference Models and Indices for Coastal Plain Streams Based on Diatom Assemblages from Artificial Substrates, (In Preparation).

Municipal Utility Authority Study

Designed to address status of eutrophic conditions on localized stream segments of two waterways in northern New Jersey; the Musconetcong and the Pequest Rivers.

Municipal Utility Authorities (MUAs) have expressed interest in performing phosphorus evaluation studies (possibly resulting in a site-specific water quality based effluent limit or WQBEL) for TP.

Immediate objective is to investigate whether diatoms (and specifically TDI developed for northern NJ) could be used to give more detailed information on biotic integrity above and below outfalls of two STPs

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Diatom Metrics

Metric	Description
Richness, S-W Diversity	# species, Genera, Divisions; SW Diversity Index
Percent Similarity	Rel abundance community similarities
Diatom PTI	Pollution Tolerance Index
% Sensitive	% composition intolerant species
% *Achnanthes minutissima*	proportional time since scouring/toxic pollution
Siltation Index	%composition motile diatoms
Diagnostic metrics	autoecology of species to infer environmental stressors
Simple Autoecological Indices (SAI)	ranked ecological preferences of taxa to infer environmental conditions

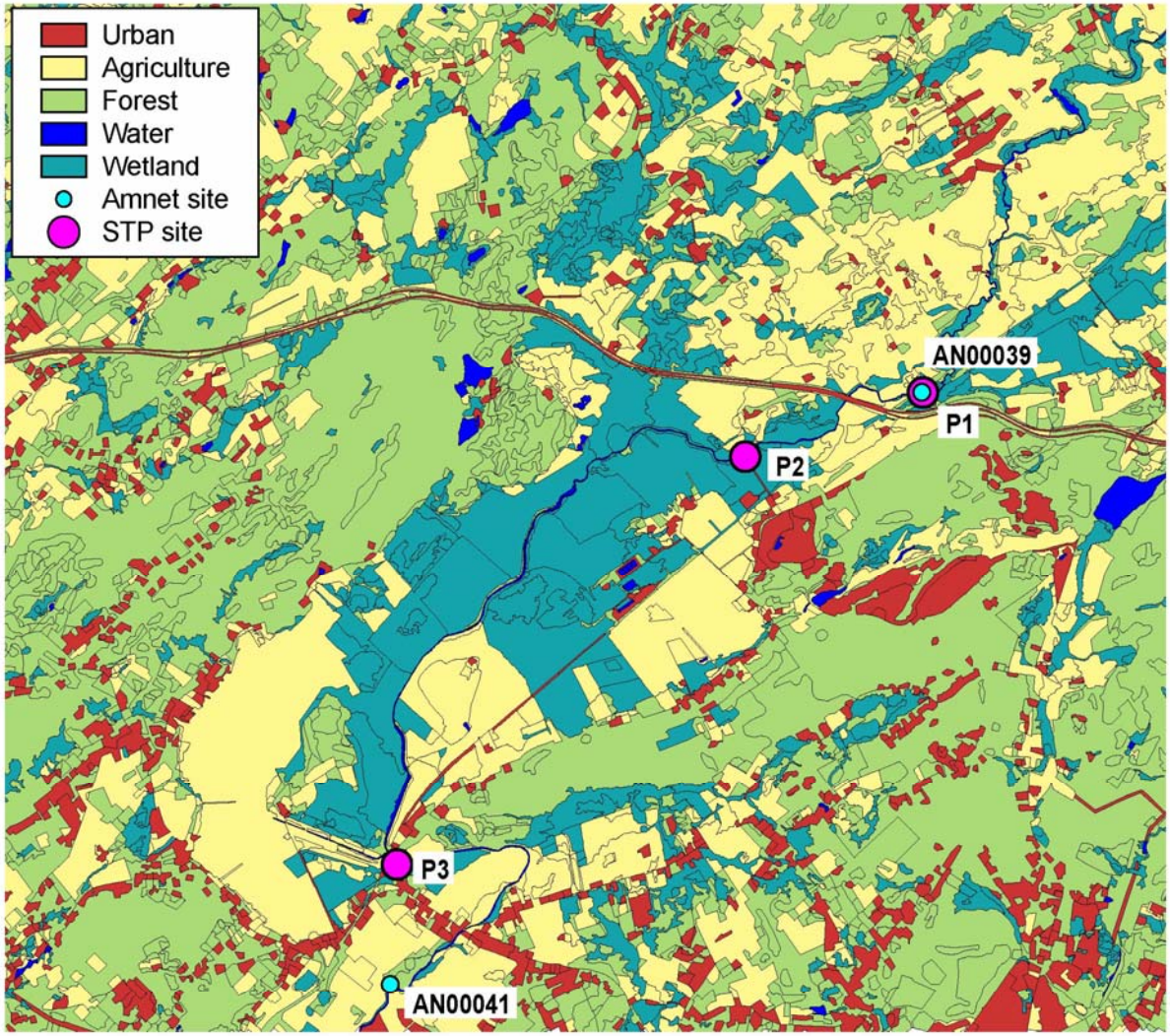


Figure 1 - Pequest River Sampling Site Locations

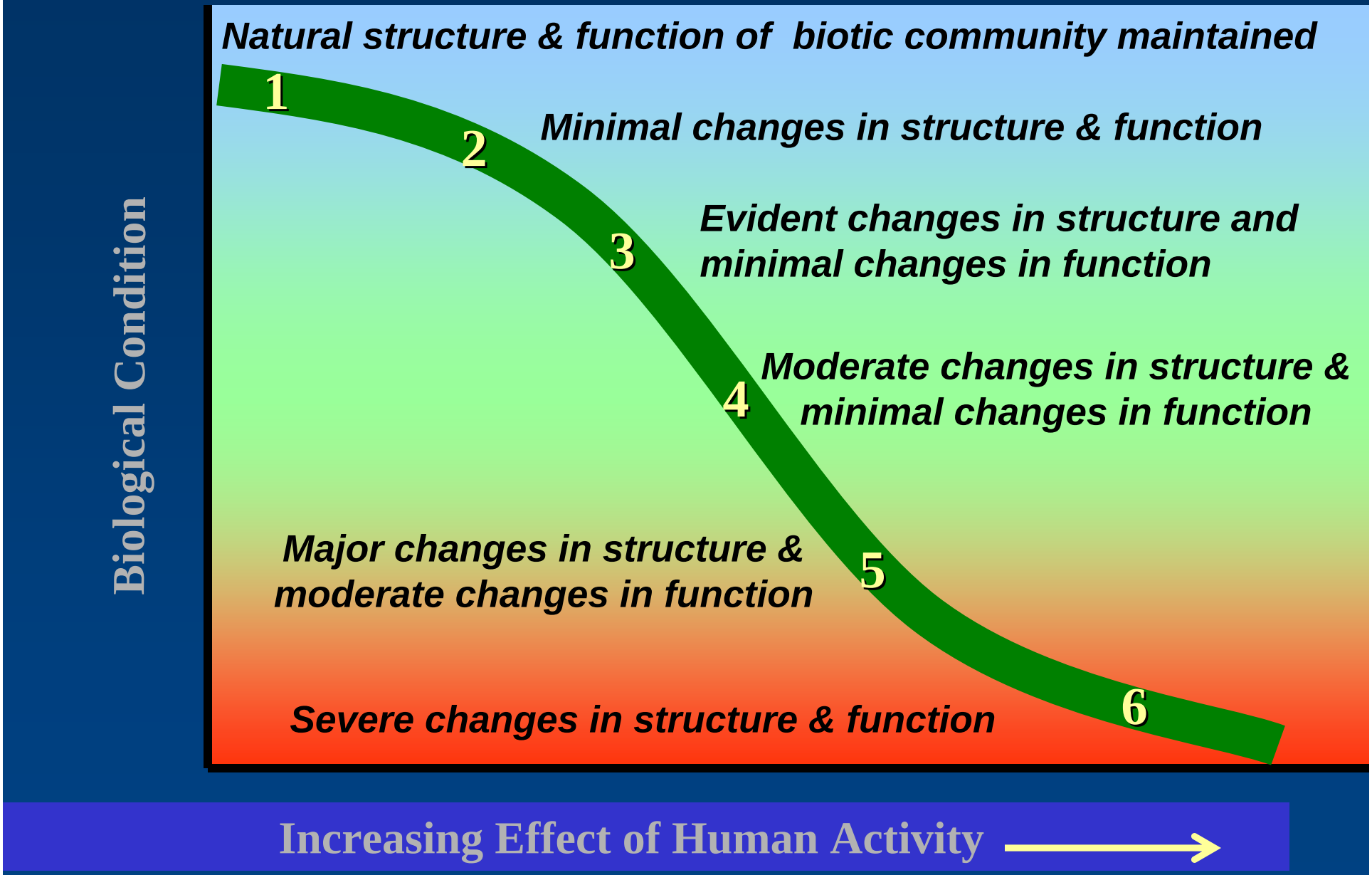
Tiered Aquatic Life Use (TALU) Study (Diatoms)

The Biological Condition Gradient is a scientific model for predicting biological response to anthropogenic stresses.

Usefulness for Implementation in Water Programs:

1. **Allows a framework for State program monitoring, supplies assessment and listing guidance.**
2. **Supplies a translating mechanism from narrative description of uses to actual assessment of use.**
3. **Mechanism to interpret numeric biological criteria in WQS to define full, partial, and non-support.**
4. **Supplies a framework for refining designated aquatic life uses (e.g., possibly based on high vs. low gradient, cold vs. warm water species).**

The Biological Condition Gradient – Concept



NJDEP Macroinvertebrate TALU Study
(TALU used to evaluate macroinvertebrate data)*

The BCG for macroinvertebrates described how ten biological attributes of natural aquatic system changes in response to increasing pollution and disturbance including:

1. Historically documented, sensitive, long-lived or regionally endemic taxa
2. Sensitive and rare taxa
3. Sensitive but ubiquitous taxa
4. Taxa of intermediate tolerance
5. Tolerant taxa
6. Non-native taxa
7. Organism condition
8. Ecosystem functions
9. Spatial and temporal extent of detrimental effects
10. Ecosystem connectance

* Gerritsen, J., and E.W. Leppo. 2005. Biological Conditions Gradient for Tiered Aquatic Life Use in NJ: NJ TALU Workshop Documentation, Report to USEPA and NJDEP by Tetra Tech, Inc., 400 Red Brook Boulevard, Suite 200, Owings Mills, MD 21117, January 2005.

NJDEP Diatom TALU Study
(Current TALU approach used to evaluate TDI Diatom data)*

Metric	Description
Richness, S-W Diversity	# species, Genera, Divisions; SW Diversity Index
Percent Similarity	Rel abundance community similarities
Diatom PTI	Pollution Tolerance Index
% Sensitive	% composition intolerant species
% *Achnanthes minutissima*	proportional time since scouring/toxic pollution
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NJ-NY Paleolimnology Lake Study

Project Objectives

1. Support nutrient and other biological criteria development in New Jersey and New York lakes.
2. Use diatom assemblages and Chironimids in lake sediment cores as biological indicators of nutrient and eutrophication status of lakes.
3. Provide an historical perspective of past conditions that can be used to assess amounts and timing of change that has occurred, to quantify reference conditions, and to help set targets for ecological restoration.

Goals

(1) Verify lake reference conditions with respect to trophic indices within major Level 3 Ecoregions of New Jersey and New York, and
(2) Assess historical hypolimnectic dissolved oxygen conditions in representative lake systems within major Level 3 Ecoregions of New Jersey and New York.
(3) Additionally, the proposed work may provide important verification/validation of the USEPA ecoregional construct as applied to nutrient criteria implementation.

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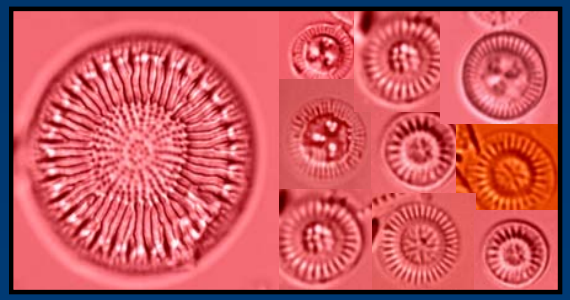
“Top-Bottom” Sediment Sampling Approach

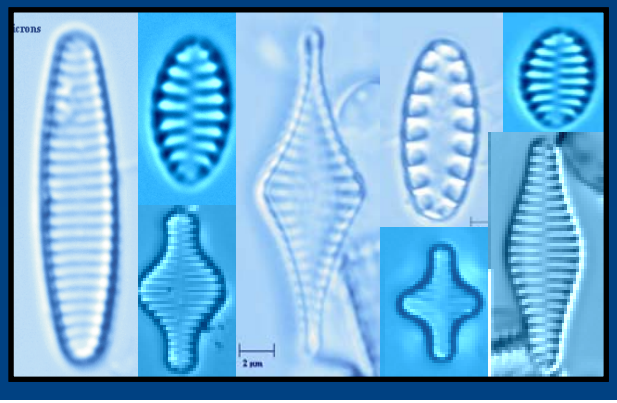
TOP

Deposited in recent lake environment



BOTTOM

Deposited in pre-industrial lake environment



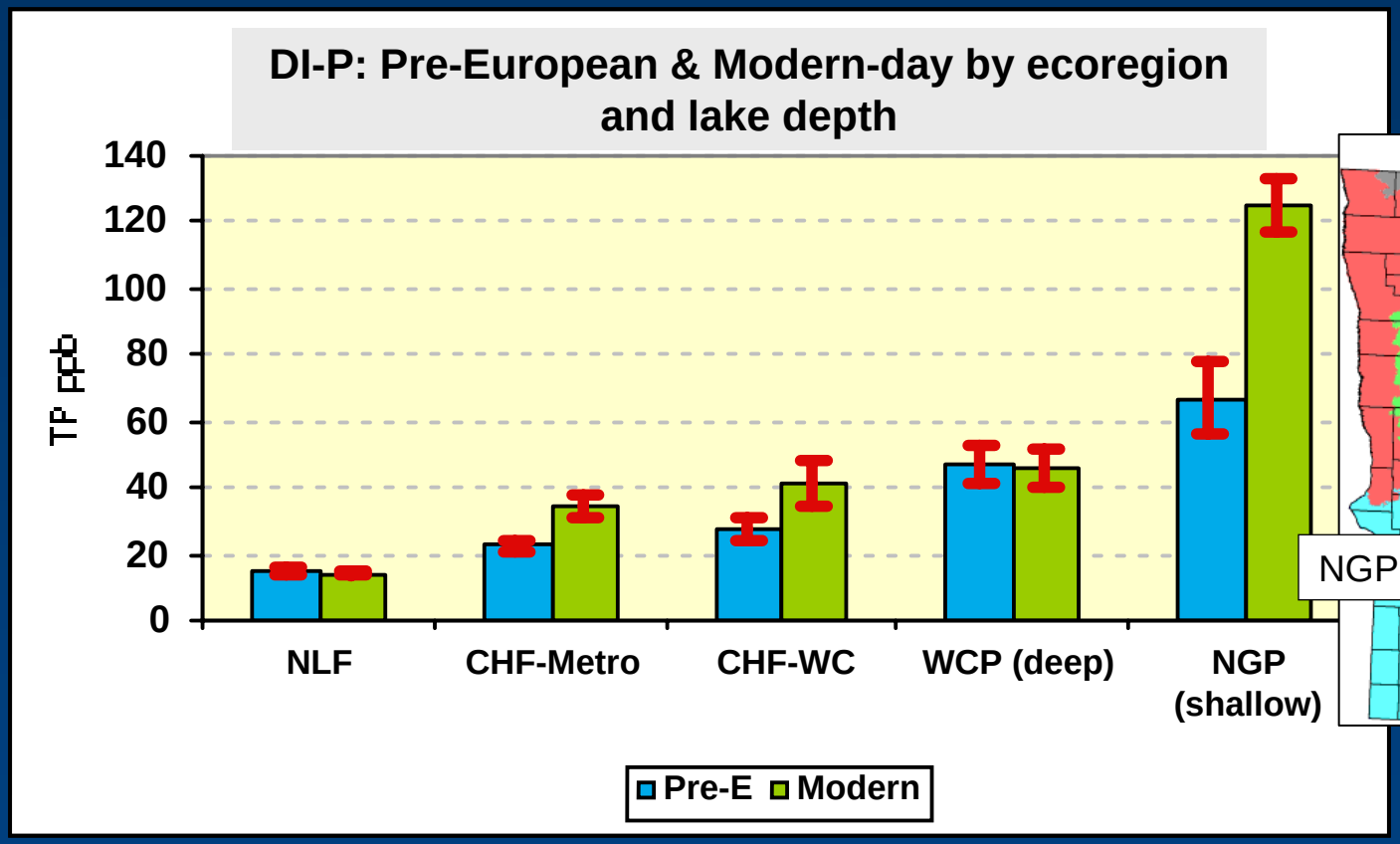
J. Smol

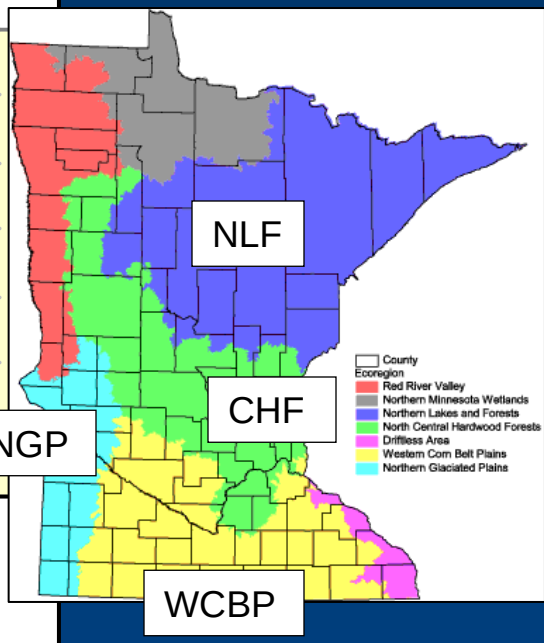
Lake survey questions that can be addressed

- What was the pre-disturbance / reference condition?
- What is the range of natural variability?
- Have conditions changed?
- How? How much? How fast? When?
- What is the cause of the change?
- How much improvement can be expected?

Pre-European TP vs. modern water quality by MN ecoregion

M. Edlund





- 61 sediment cores from throughout Minnesota
- ecoregional patterns evident in Pre-European as well as modern-day TP
- NLF lakes minimally impacted, CHF lakes with elevated modern TP levels
- significantly different response between shallow and deep prairie lakes

NJ Nutrient Biotic Index (NBI) Study

Aquatic macroinvertebrates have been among the principal biological communities used for freshwater monitoring and assessment for several decades, but macroinvertebrate biomonitoring has not incorporated nutrient measures into assessment strategies.

NYSDEC developed a novel NBI* for evaluating benthic macroinvertebrate communities as it pertains to nutrients.

Two nutrient biotic indices were developed for benthic macroinvertebrate communities, one for total phosphorus (NBI-P), and one for nitrate (NBI-N).

Weighted averaging was used to assess the distributions of 164 macroinvertebrate taxa across TP and NO3 gradients and to establish nutrient optima and subsequent nutrient tolerance values.

A three-tiered scale of eutrophication for TP and NO3 as oligotrophic, mesotrophic and eutrophic was established through cluster analysis of invertebrate communities using Bray–Curtis (quantitative) similarity.

* Smith, A.J., Bode, R.W. and G.S. Kleppel. 2007. A nutrient biotic index (NBI) for use with benthic macroinvertebrate communities, Ecological Indicators Vol. 7 pp. 371–386

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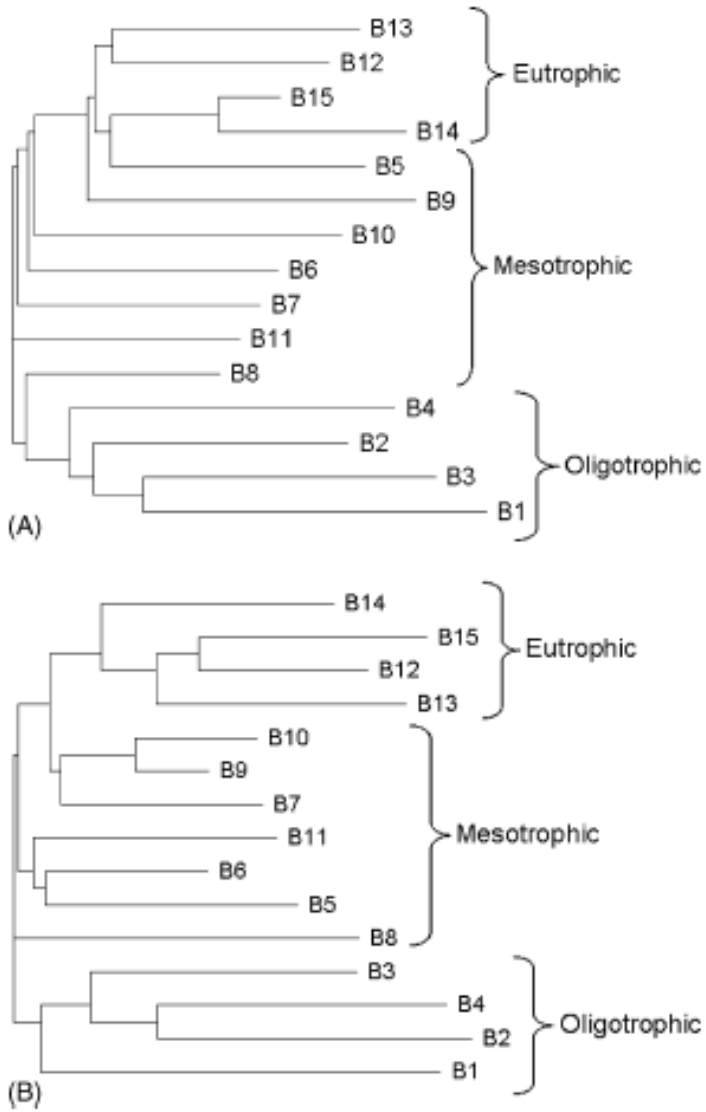

Fig. 4. Additive tree clusters based on mean pair-wise Bray-Curtis similarity between TP (A) and NO_3^- (B) bins. Clusters of bins are designated with their appropriate trophic state. Bins with higher numbers signify greater nutrient concentration. On the basis of bin clusters trophic state boundaries were set as follows; TP oligo-

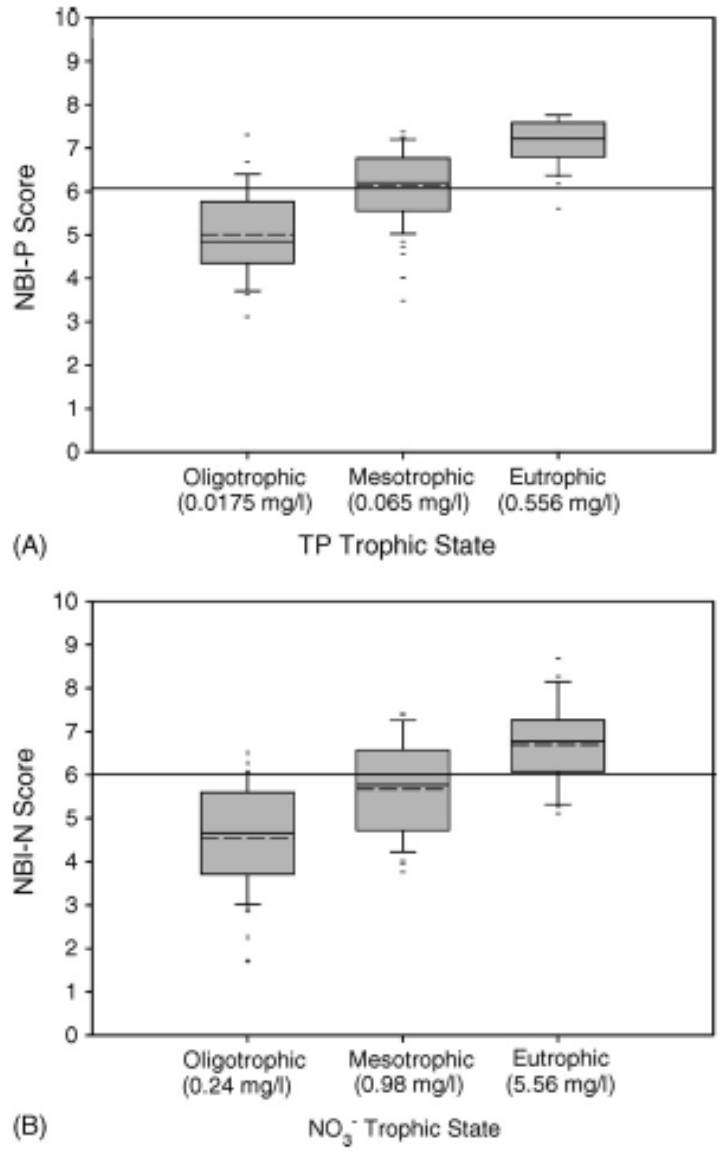

Fig. 5. Nutrient Biotic Index scores classified by trophic state determined by nutrient concentration boundaries developed using mean pair-wise Bray-Curtis similarity (Fig. 4, A and B). Dashed lines represent means, solid lines represent medians. Outliers are

NJ Nutrient Biotic Index (NBI) Study

PROJECT OBJECTIVES

1. Apply NBI methodology to NJDEP's extensive macroinvertebrate data to determine applicability to NJ waters.
2. Compare boundary results (i.e., oligotrophic, mesotrophic and eutrophic) to the NJDEP TDI outputs to determine whether diatom algae and macroinvertebrates reflect similar thresholds of eutrophic condition (impairments).

PROJECT GOALS

1. Database development and final report with recommendations on eutrophic condition.
2. Two independent assessments of eutrophic condition (NBI and TDI).
3. Potential tools for bi-annual Integrated Assessment Report.
4. Possible quantitative benchmarks for narrative nutrient criteria.
5. Recommendations for operationally defined tiers for setting restoration goals and aquatic life protection criteria.

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Future Nutrient Research

Estuarine Nutrient Impacts and Assessment Needs

1. Delaware Estuary (DRBC)
2. New York-New Jersey Harbor Estuary (CARP)
3. Barnegat Bay Estuary (NJDEP)

Ocean Nutrient Impacts and Assessment Needs

1. Seasonal Dissolved Oxygen Depressions
2. Harmful Algal Blooms (HABs)

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