THE UTILITY OF A BROAD-BASED APPROACH IN ASSESSING ECOSYSTEM CHANGES IN THE LAURENTIAN GREAT LAKES

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The Great Lakes

A Global Resource

- Largest system of fresh, surface water on earth; 20% of the world supply
- Over 10,000 miles of shoreline
- 5,000 cubic miles of water, or enough to cover the US 6 feet deep
- 25 million US residents and 8 million Canadian residents
- Over 100 species of globally rare plants and animals

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GLNPO’s Multi-media Monitoring Programs

- Integrated Atmospheric Deposition Network (IADN) Air Monitoring Program
- Fish Monitoring Program
- Limnology Program
- Organics Monitoring Program
- Biological Indicators (phytoplankton, zooplankton and benthic invertebrates) Program

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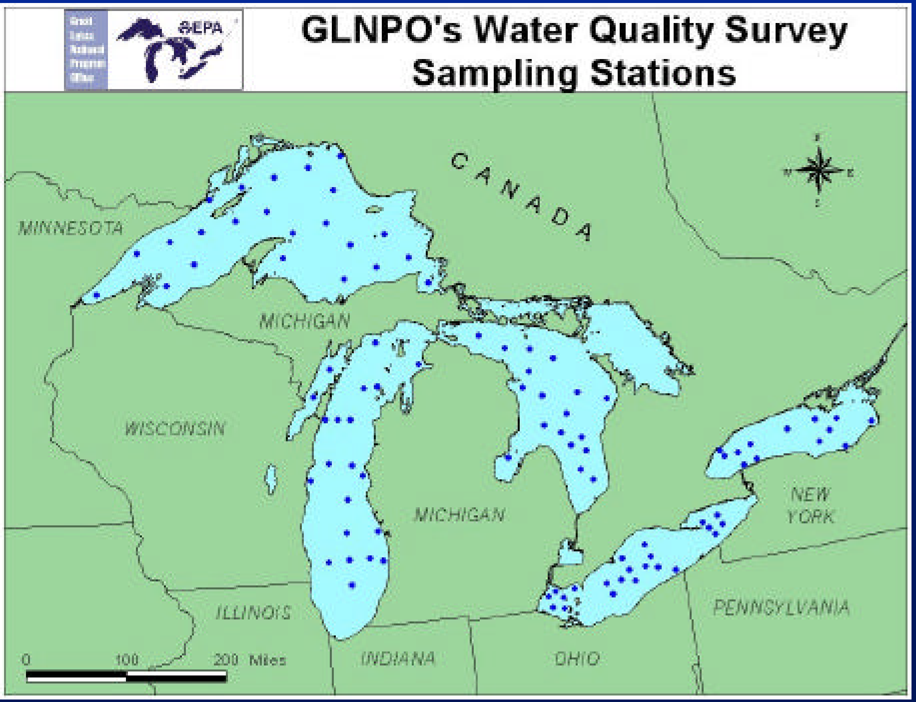
Limnology Program

Design:

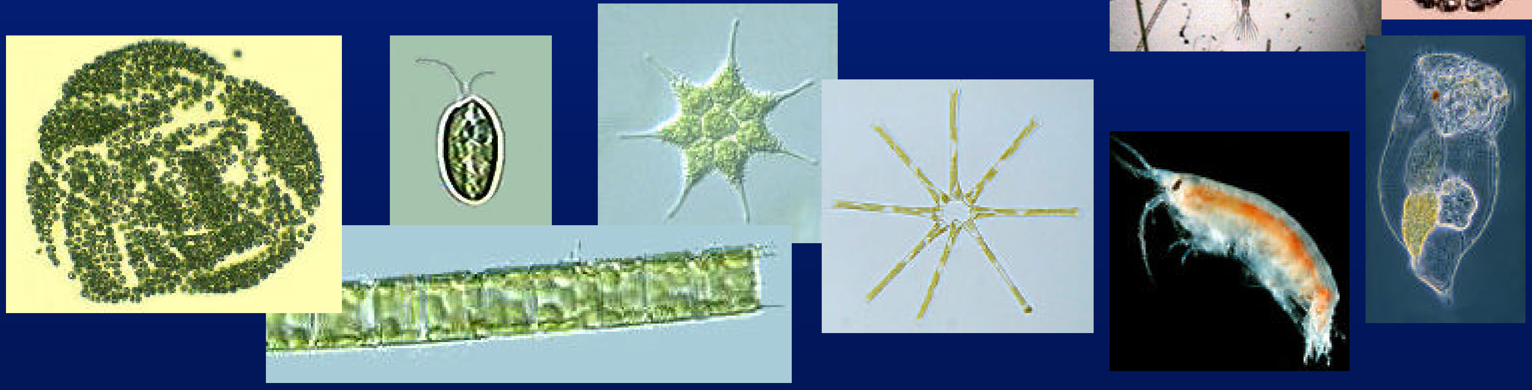
- 72 sampling stations throughout the Great Lakes
- Annual spring and summer monitoring
- Monitored analytes:
  - Silica
  - Phosphorus
  - Nitrogen
  - Alkalinity
  - Dissolved Oxygen
  - Chloride
  - pH
  - Secchi depth



Biological Indicators Program

Design:

- Organisms monitored
  - Phytoplankton
  - Zooplankton
  - Benthic Invertebrates
- High degree of taxonomic resolution



Limnology/Biology Program

Two Major Objectives:

- Detect and evaluate water quality trends over time
  - Assess recovery from nutrient enrichment (eutrophication)
- Identify impacts of invasive species

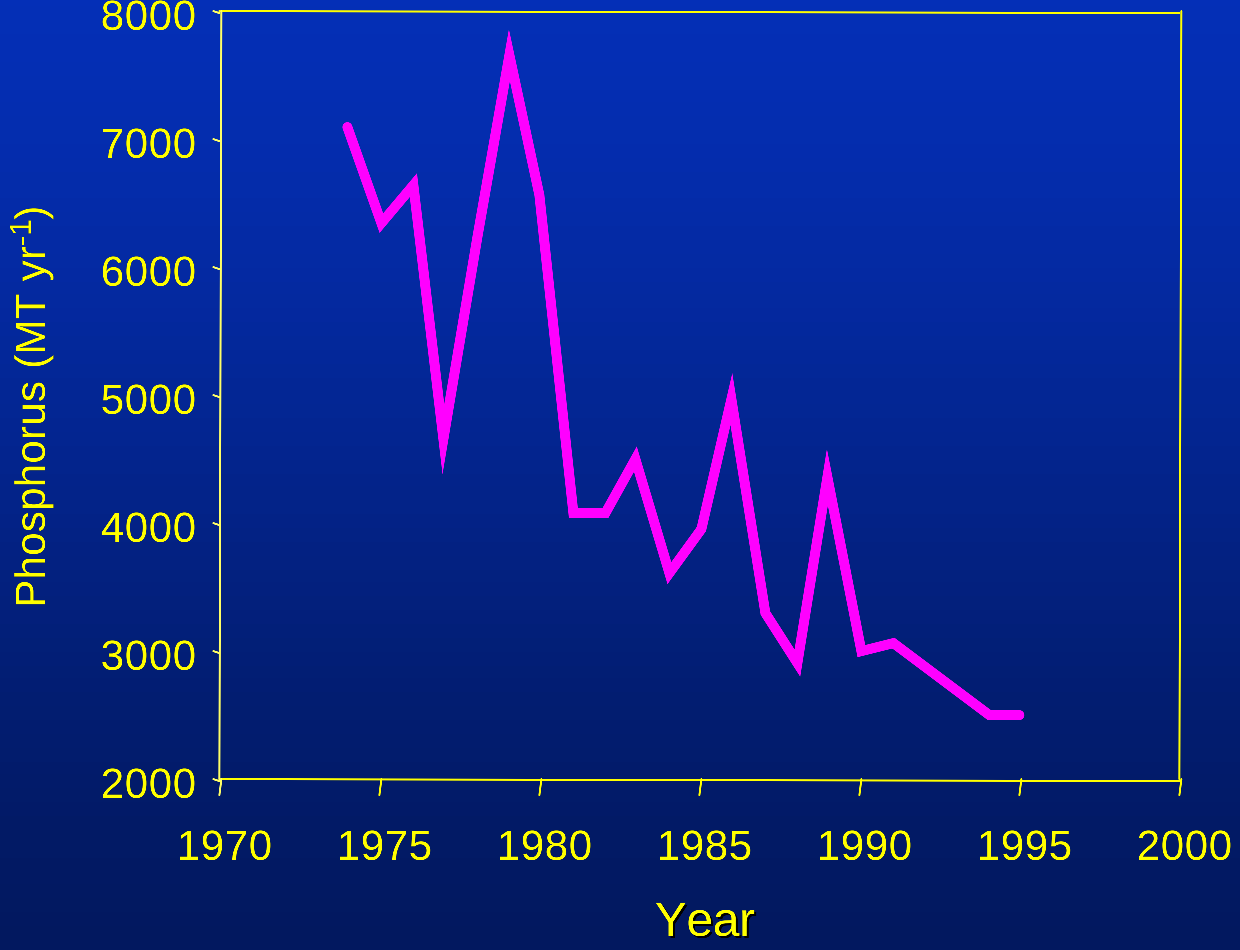
Eutrophication

- Inputs of nutrients to the Great Lakes increased dramatically in the 20^{th} century
- Great Lakes Water Quality Agreement (1972):
  - Legislation to reduce P loading
    - Removal of P from detergents; advanced wastewater treatment
  - Required monitoring of P load reductions
- Great Lakes National Program Office
  - Began monitoring lakes in 1983

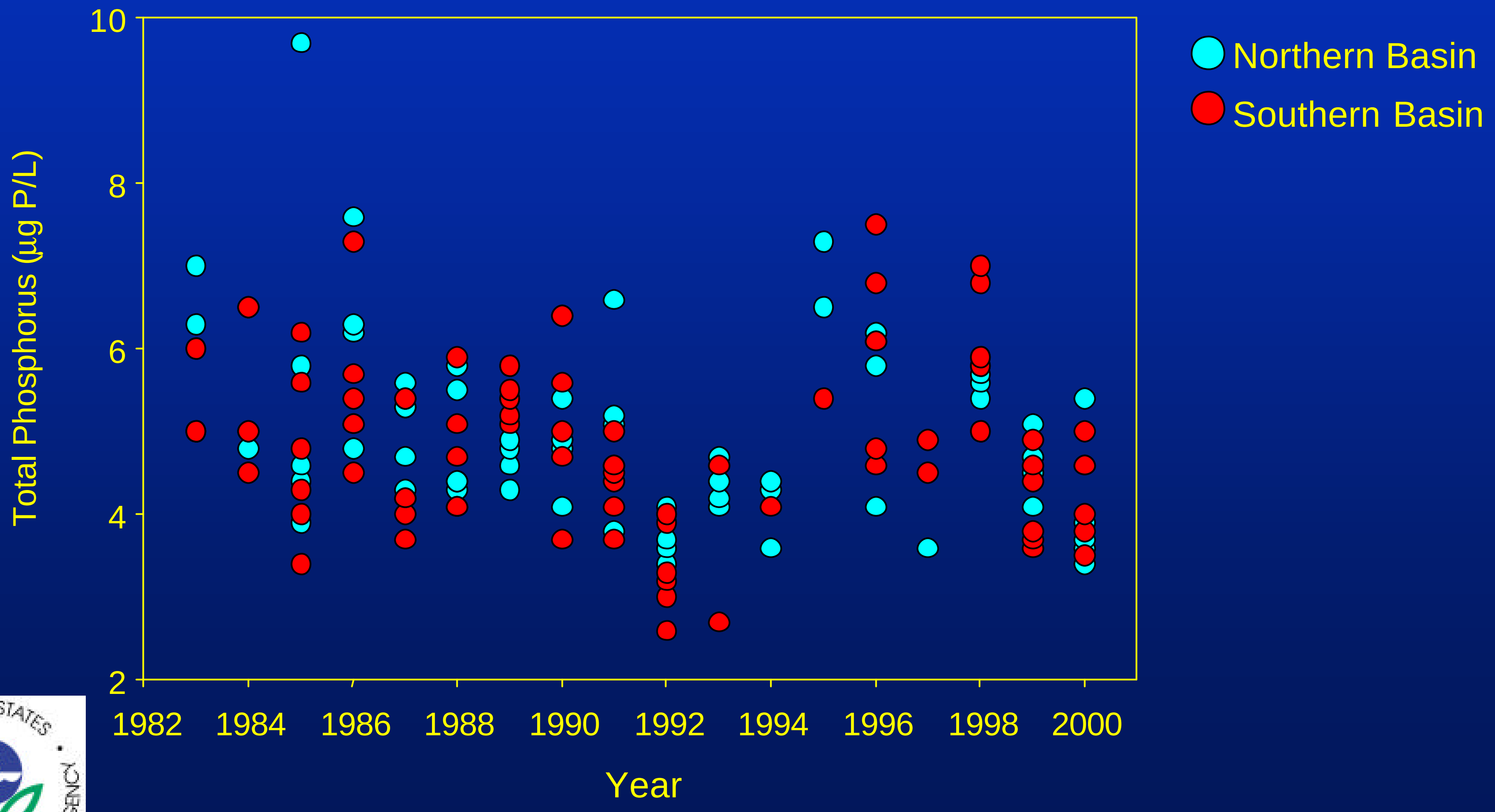
Eutrophication

- In-Lake P has declined in Lakes Erie and Ontario
- Harder to discern change in Lake Michigan
  - Concentrations much lower
  - Interannual variability very high

Phosphorus Loads to Lake Michigan



Spring Total Phosphorus Concentration in Lake Michigan, 1983-2000



Can We Use an Alternate Signal?

- Main phytoplankton group in the lake is the diatoms
- Diatoms require silica for growth
- Concentrations of silica are orders of magnitude higher than phosphorus, so easier to measure
- Also less natural variability

Silica Depletion Sequence

On An Annual Basis:

Increased Phosphorus Loading →

Increased Diatom Production →

Increased Silica Sedimentation →

Increased Permanent Sedimentation Loss of Si →

Long-Term Decrease in Si Reservoir in Lake

Schelske and Stoermer 1971

Silica Depletion Sequence

On A Seasonal Basis:

Increased Phosphorus Loading ⇒

Increased Diatom Production ⇒

Increased Uptake of Silica in Spring ⇒

Decreased [Si] at Stratification ⇒

Development of Summer Silica Limitation ⇒

Decrease in Summer Diatom Populations

Schelske and Stoermer 1971

So With Increases in Phosphorus Loads

Silica Concentrations Decreased

And

Summer Diatom Populations Decreased

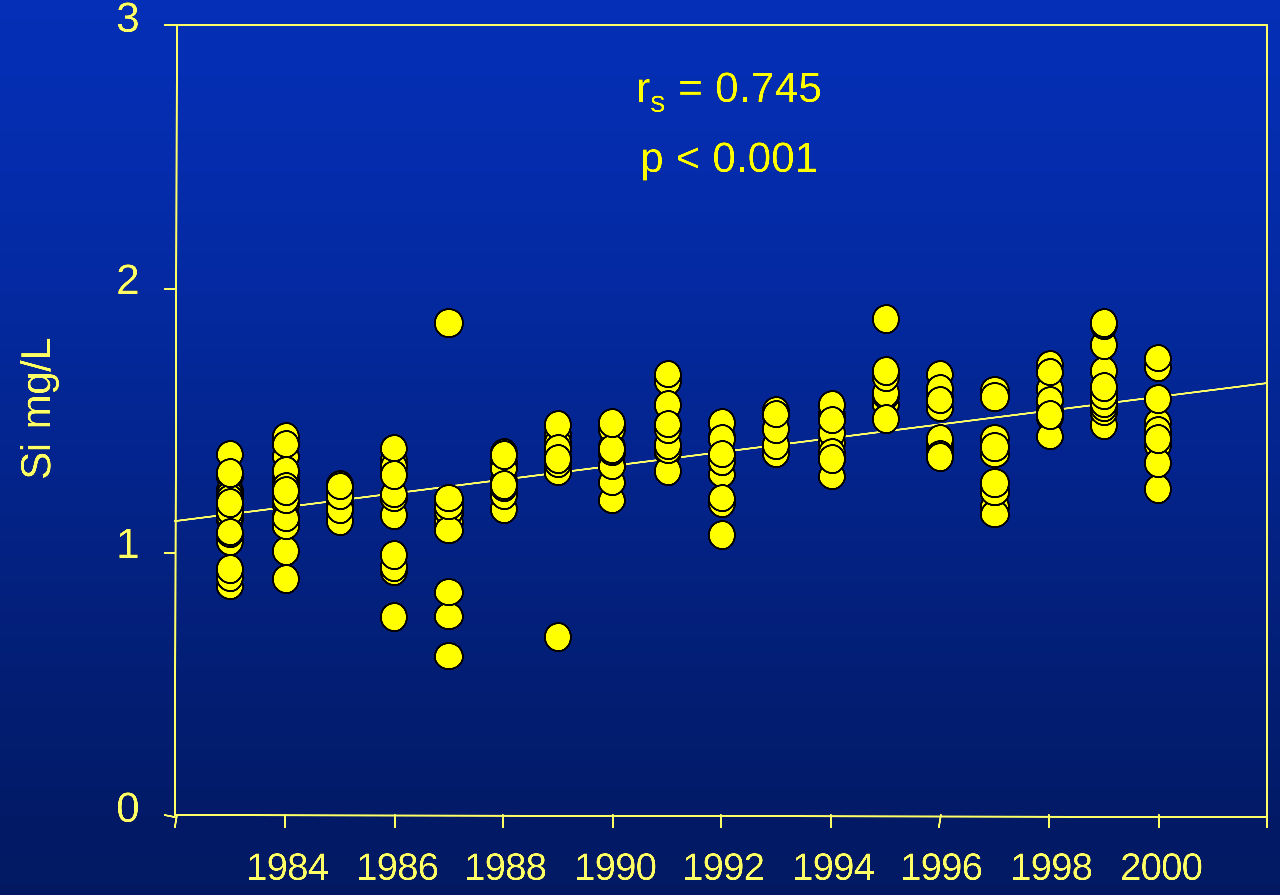
As P Levels Decline, We'd Expect

Silica Concentrations Should Increase

And

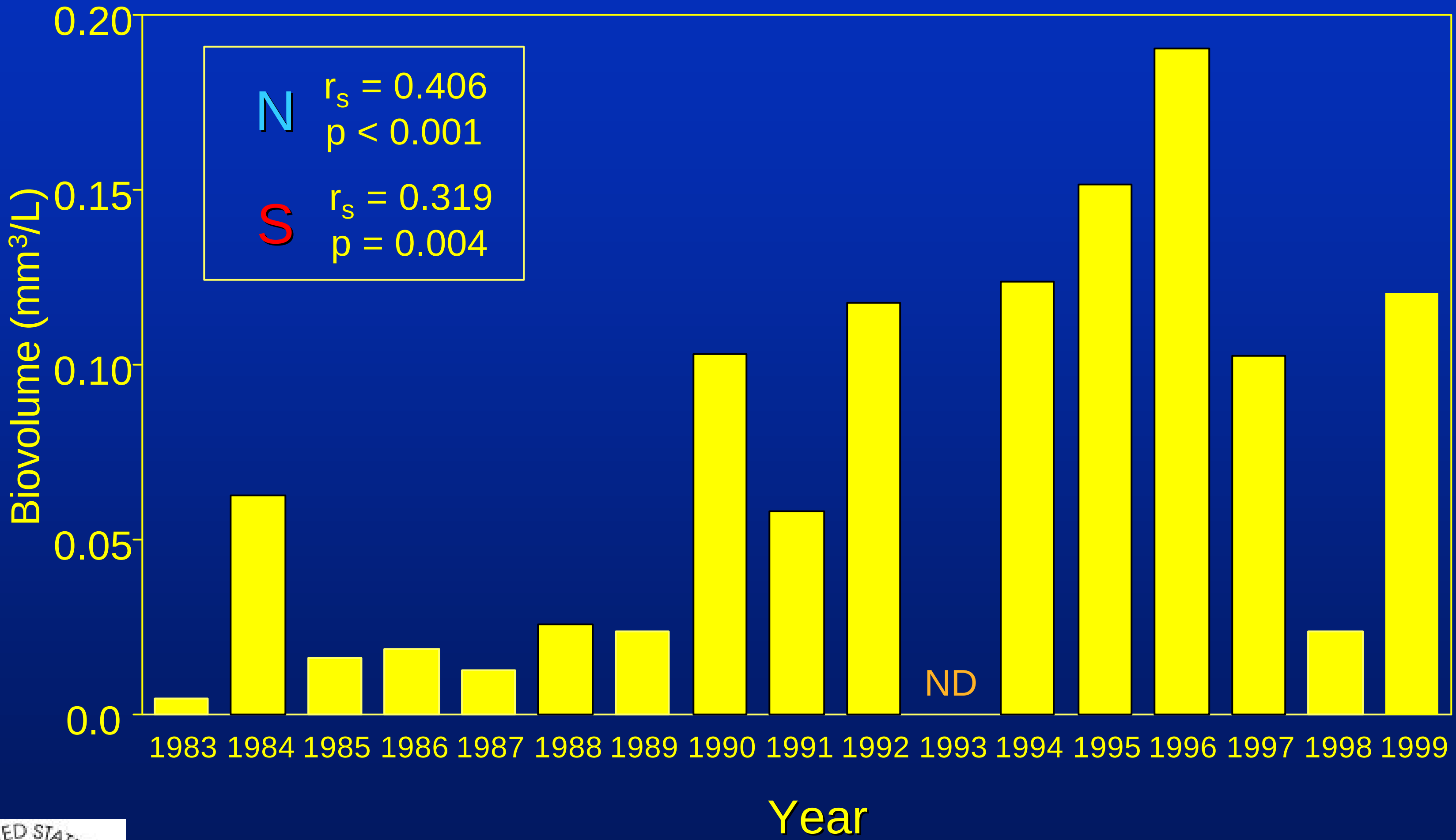
Summer Diatom Populations Should Increase

Trend In Spring Silica Concentration, 1983-2000



R.P. Barbiero, M.L. Tuchman, G.J. Warren and D.C. Rockwell. 2002. Evidence of Recovery From Phosphorus Enrichment in Lake Michigan. **Canadian Journal of Fisheries and Aquatic Sciences** 59(10):1639-1647.

Summer Diatom Community 1983-1999



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Summary

- Both silica content and summer diatom populations have increased since the institution of P controls
- *Silica* and *diatom populations* have been more sensitive indicators of decreases in phosphorus loading than in in-lake phosphorus concentrations

Summary

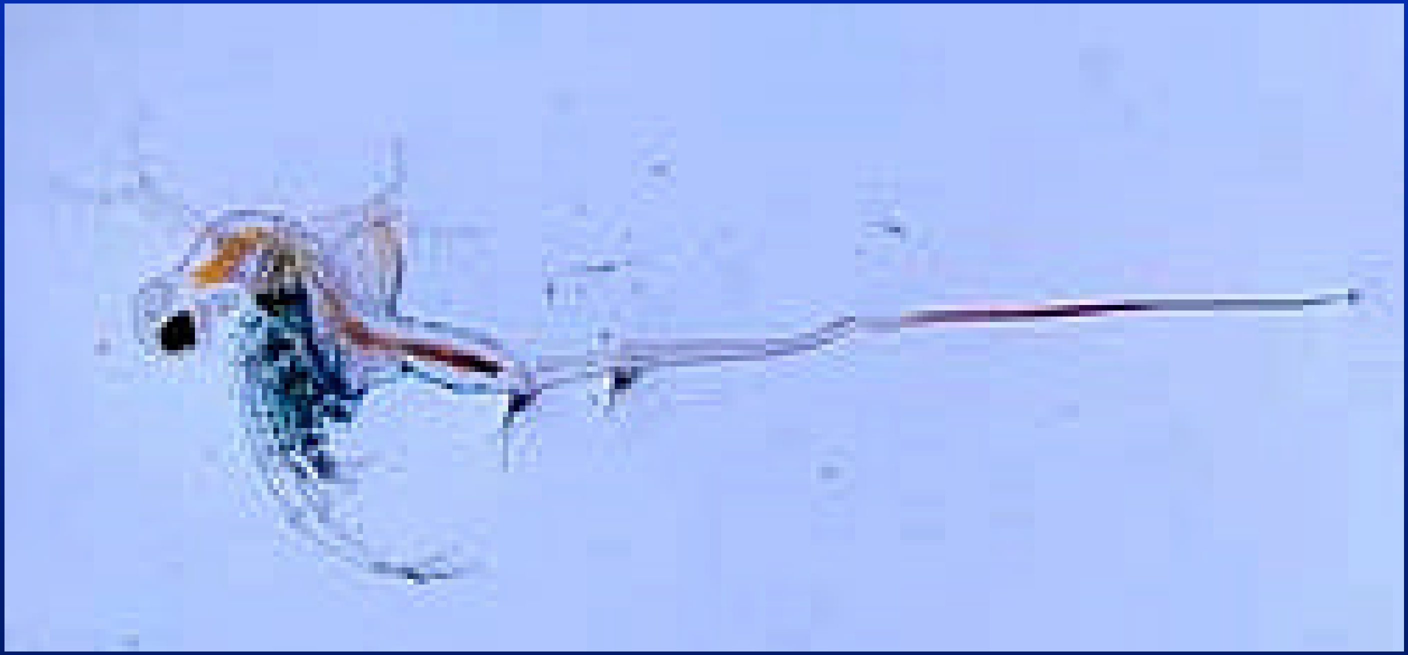
- It is not always possible to know which variables will turn out to be useful indicators of what you’re trying to track
- Where economically feasible, cast as broad a net as possible
- In-depth, scientific knowledge of the system you’re monitoring is crucial

Invasive Species

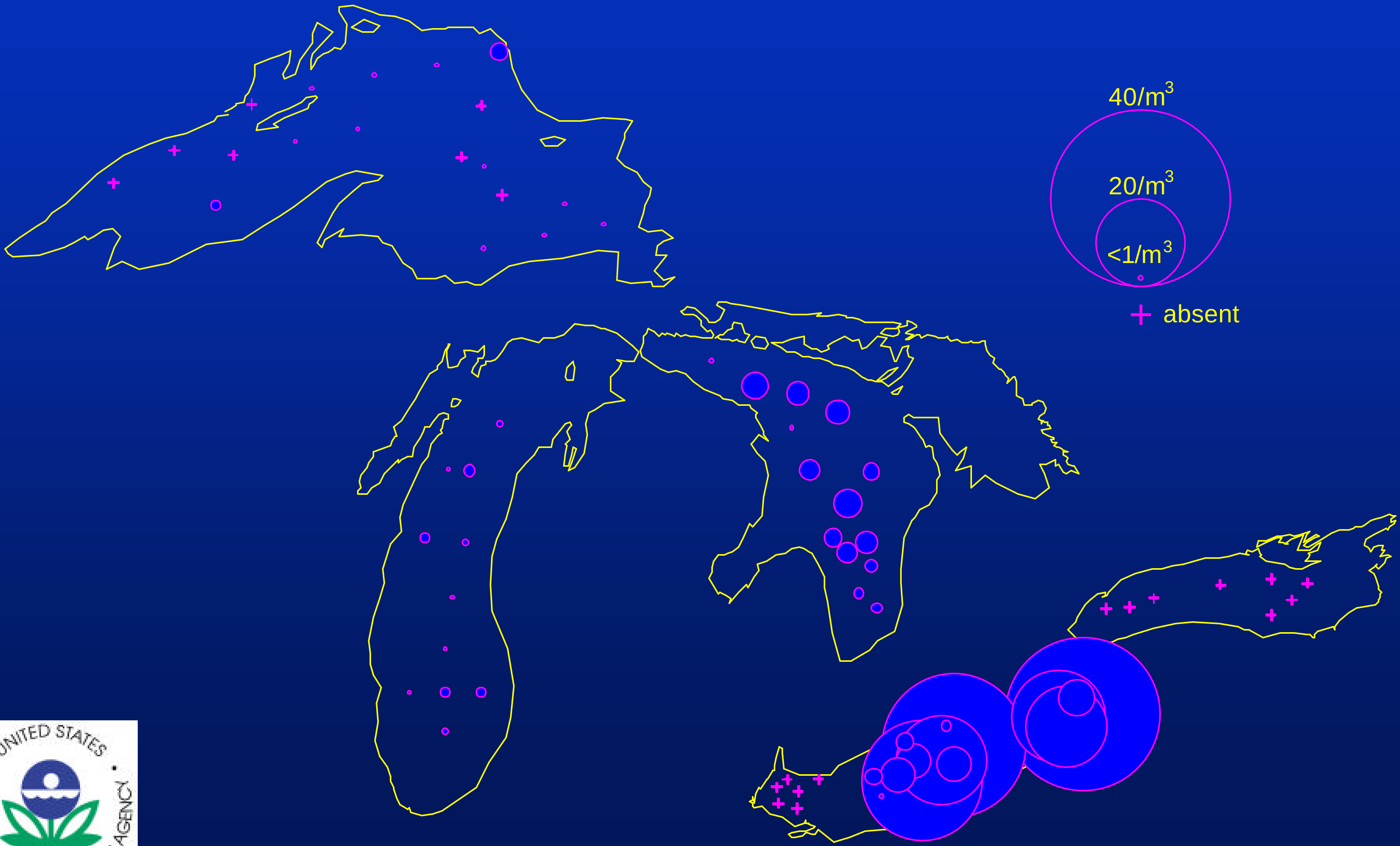
- Over 160 species have been introduced into the Great Lakes basin since the 1800s.
- More than 1/3 of the species have been introduced into the Great Lakes in the last half of the 20^{th} century

Bythotrephes

Non-indigenous Predatory Cladoceran



Distribution of *Bythotrephes in* 1999



Cladocerans

Daphnia retrocurva

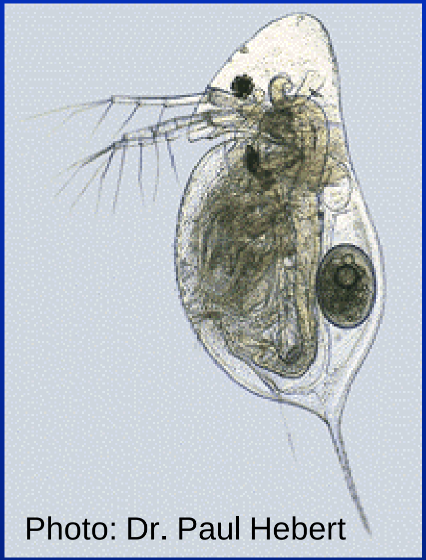


Photo: Dr. Paul Hebert

Bosmina longirostris

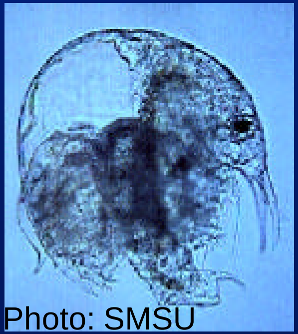


Photo: SMSU

Copepods

Cyclopoids

Mesocyclops edax

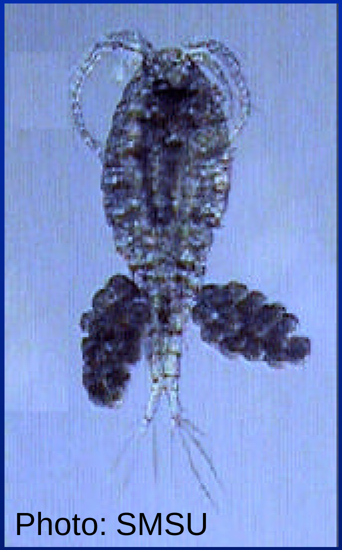


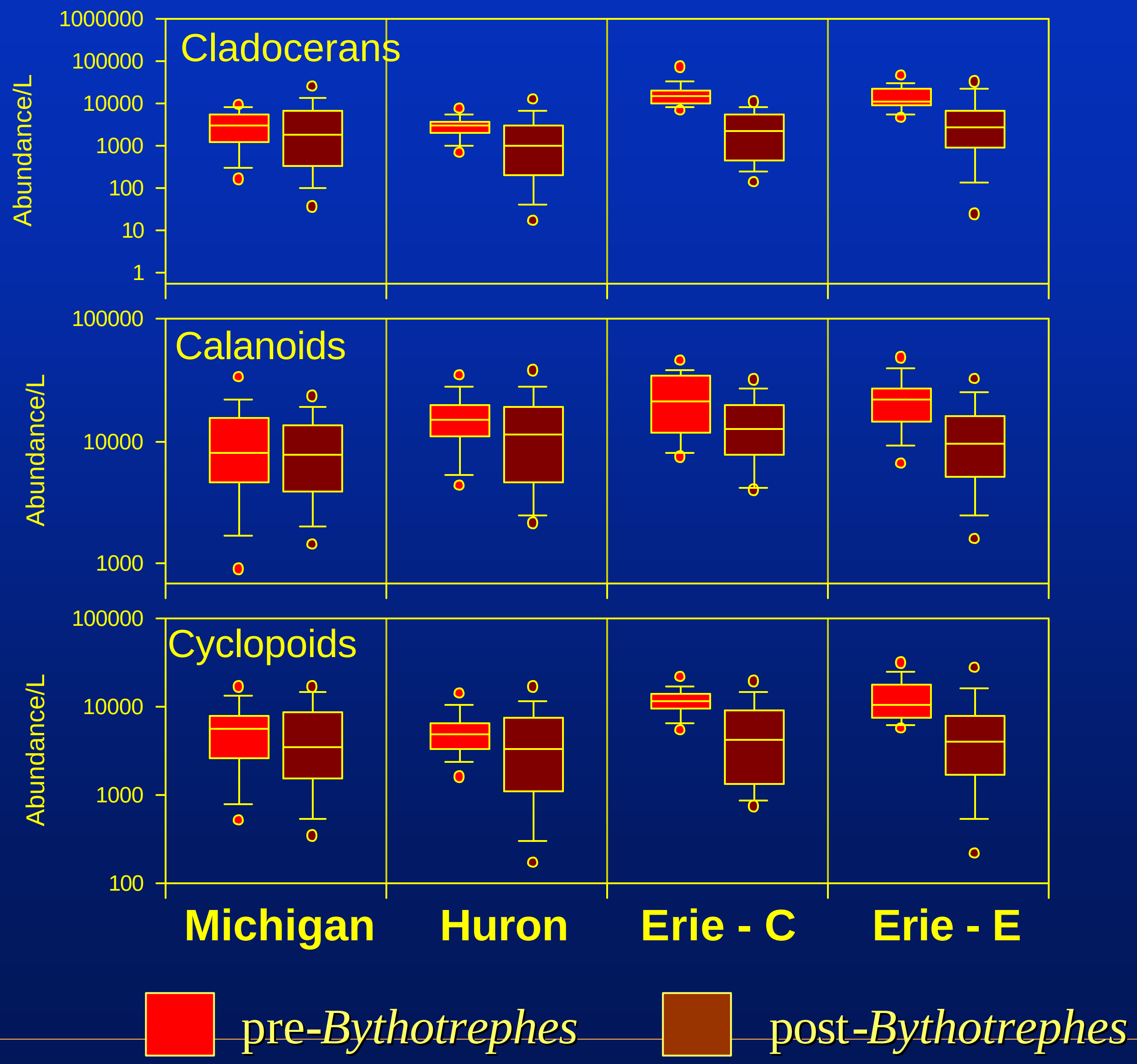
Photo: SMSU

Calanoids

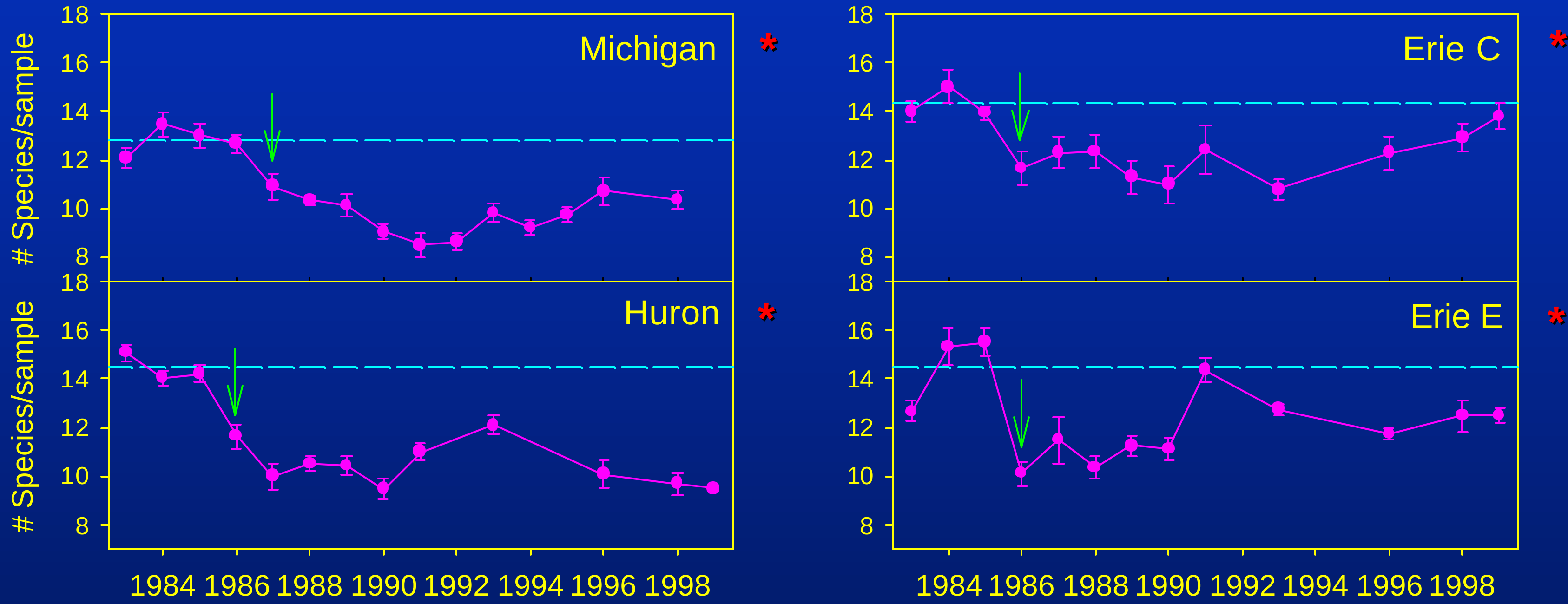
Diaptomus silicoides

Photo: SMSU

Changes in Major Crustacean Groups



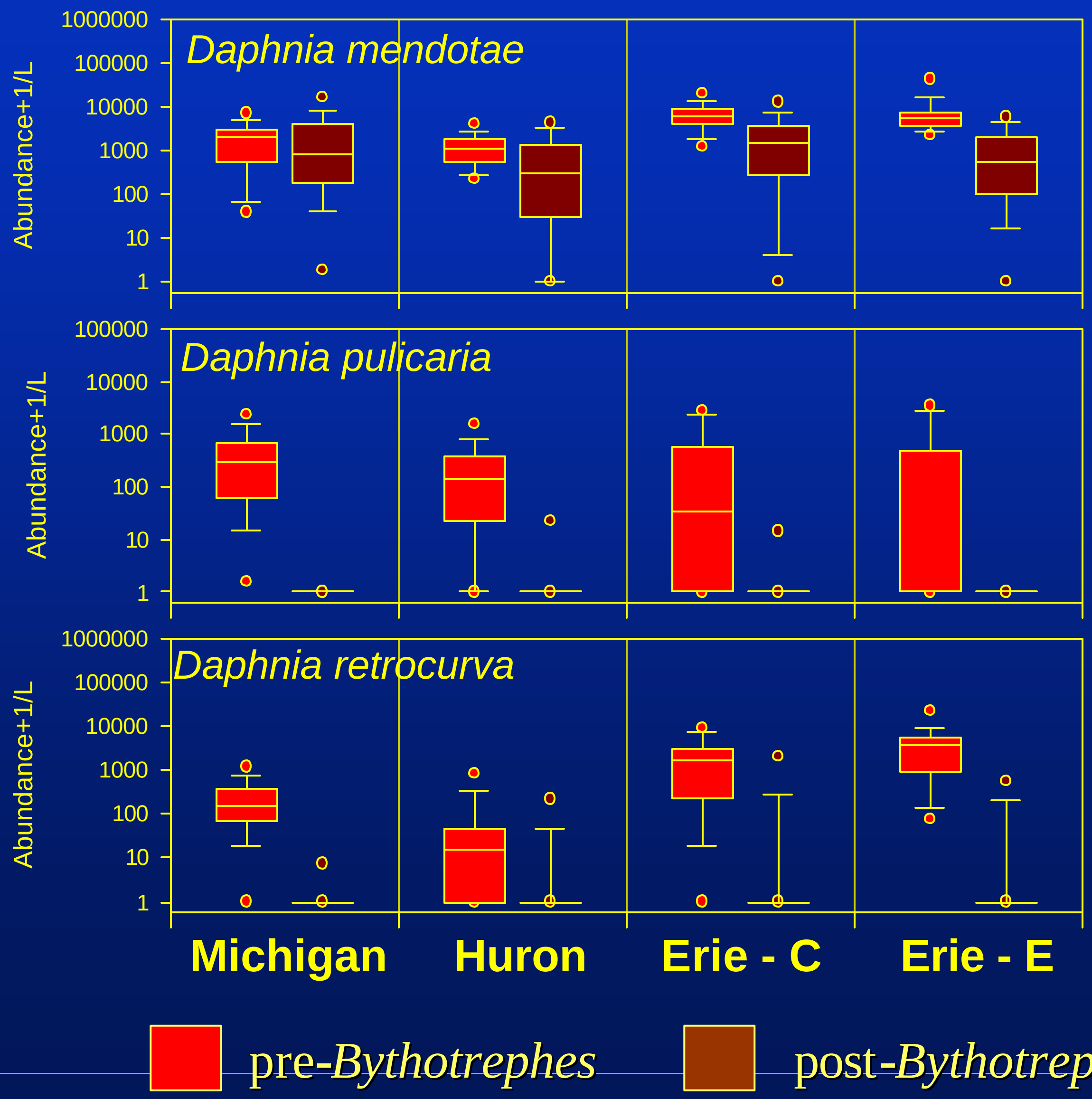
Changes in Species Richness

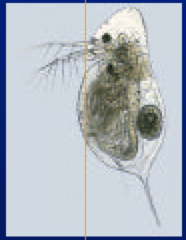


* p = < 0.05

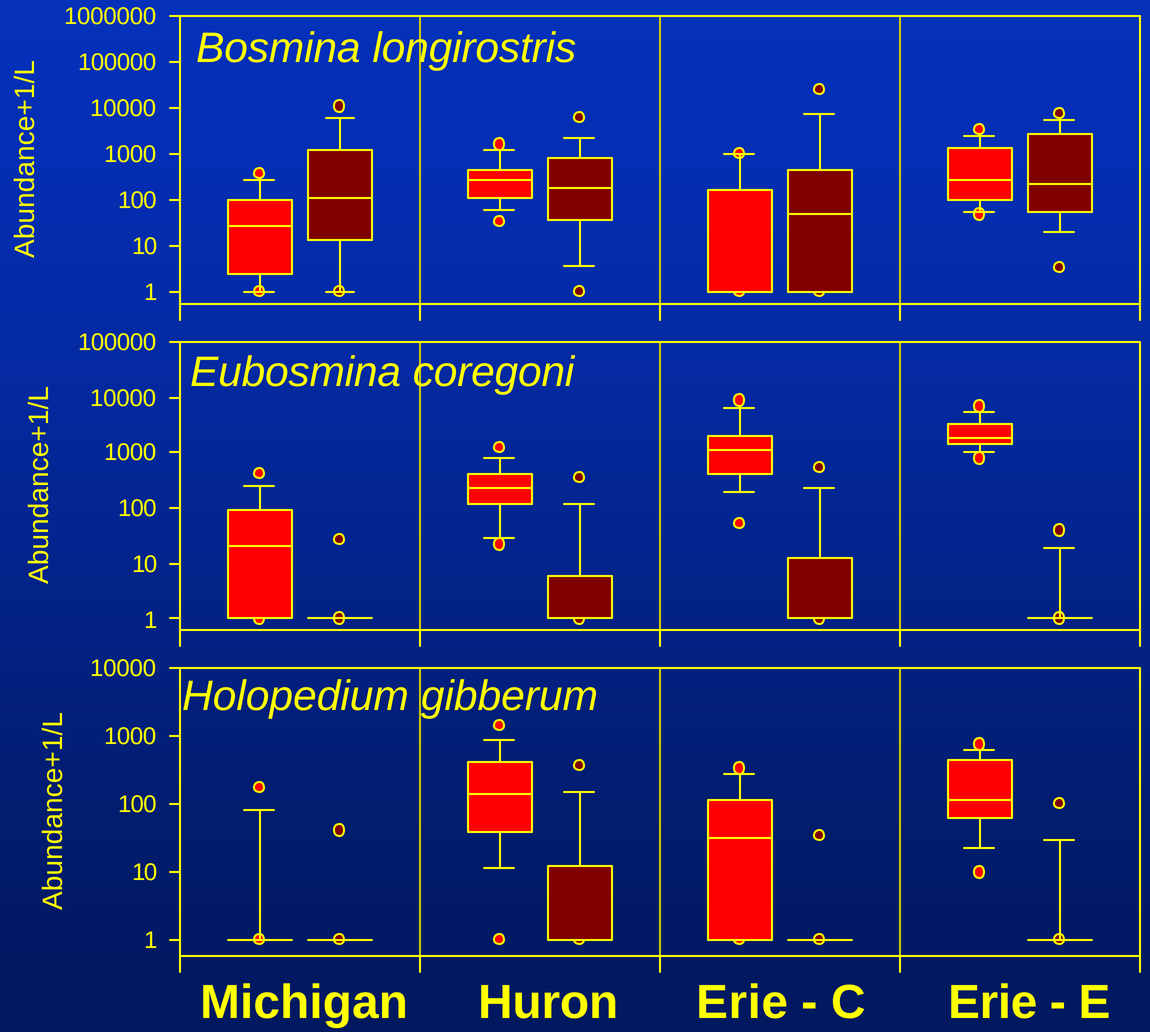
R.P. Barbiero and M.L. Tuchman. 2004. Effects of Bythotrephes on the crustacean communities of Lakes Michigan, Huron and Erie. **Canadian Journal of Fisheries and Aquatic Sciences** (in press)

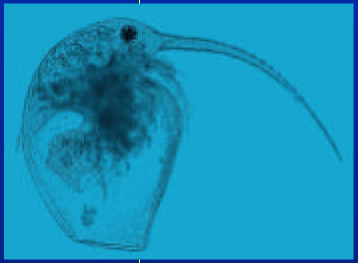
Changes in Main *Daphnia* Species





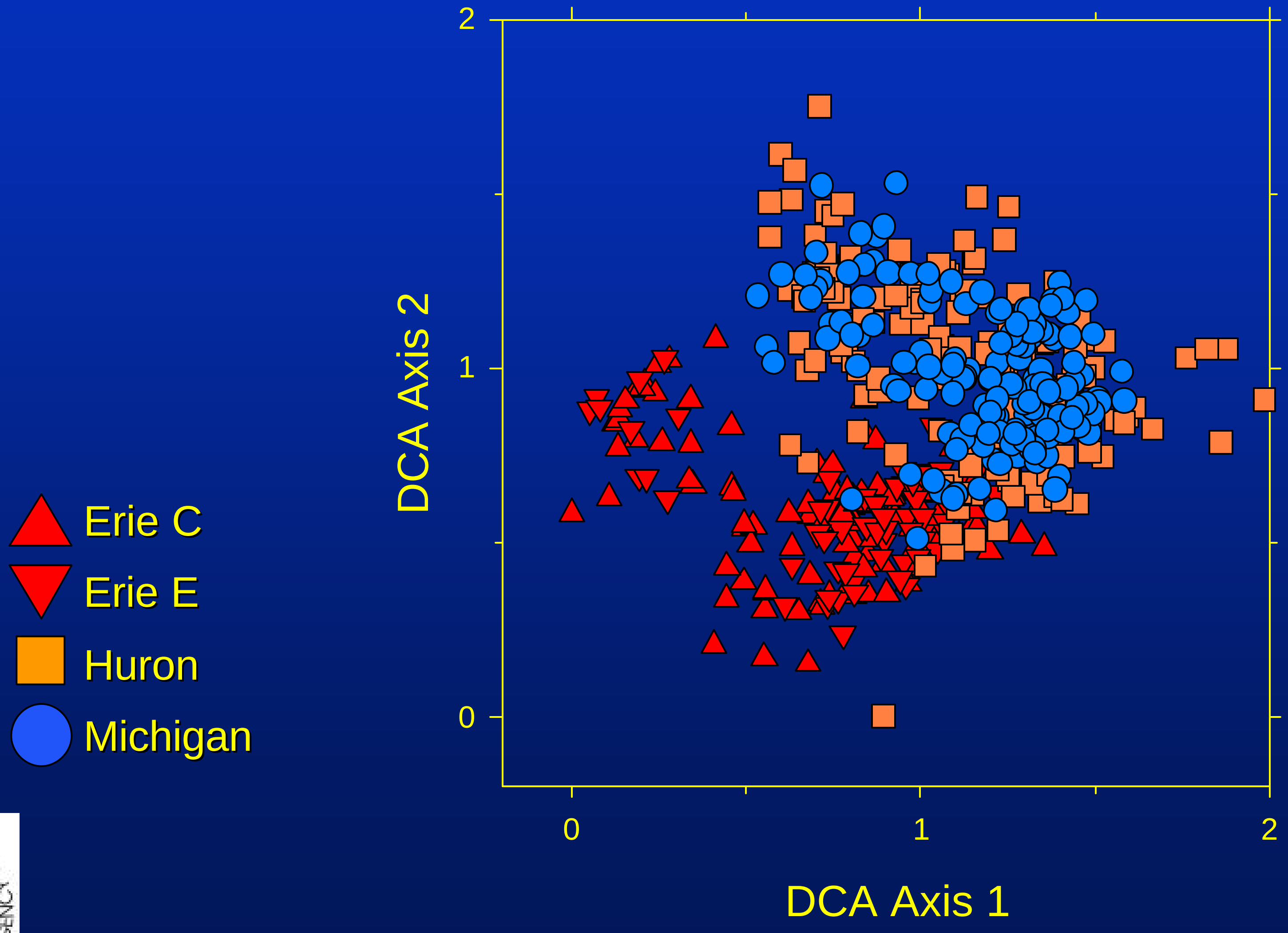
Changes in Smaller Cladoceran Species





pre-*Bythotrephes* post-*Bythotrephes*

DCA Ordination of Samples



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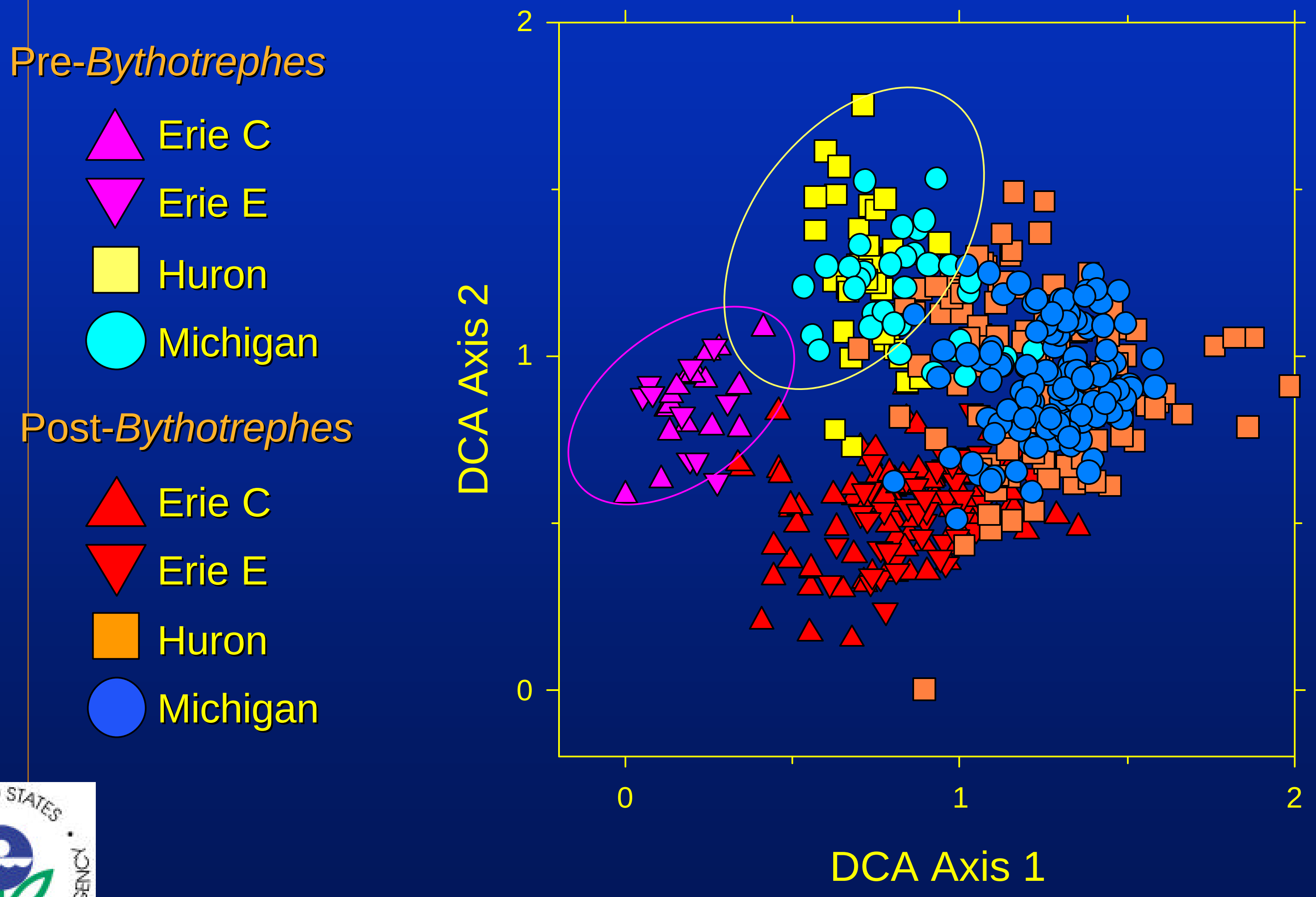

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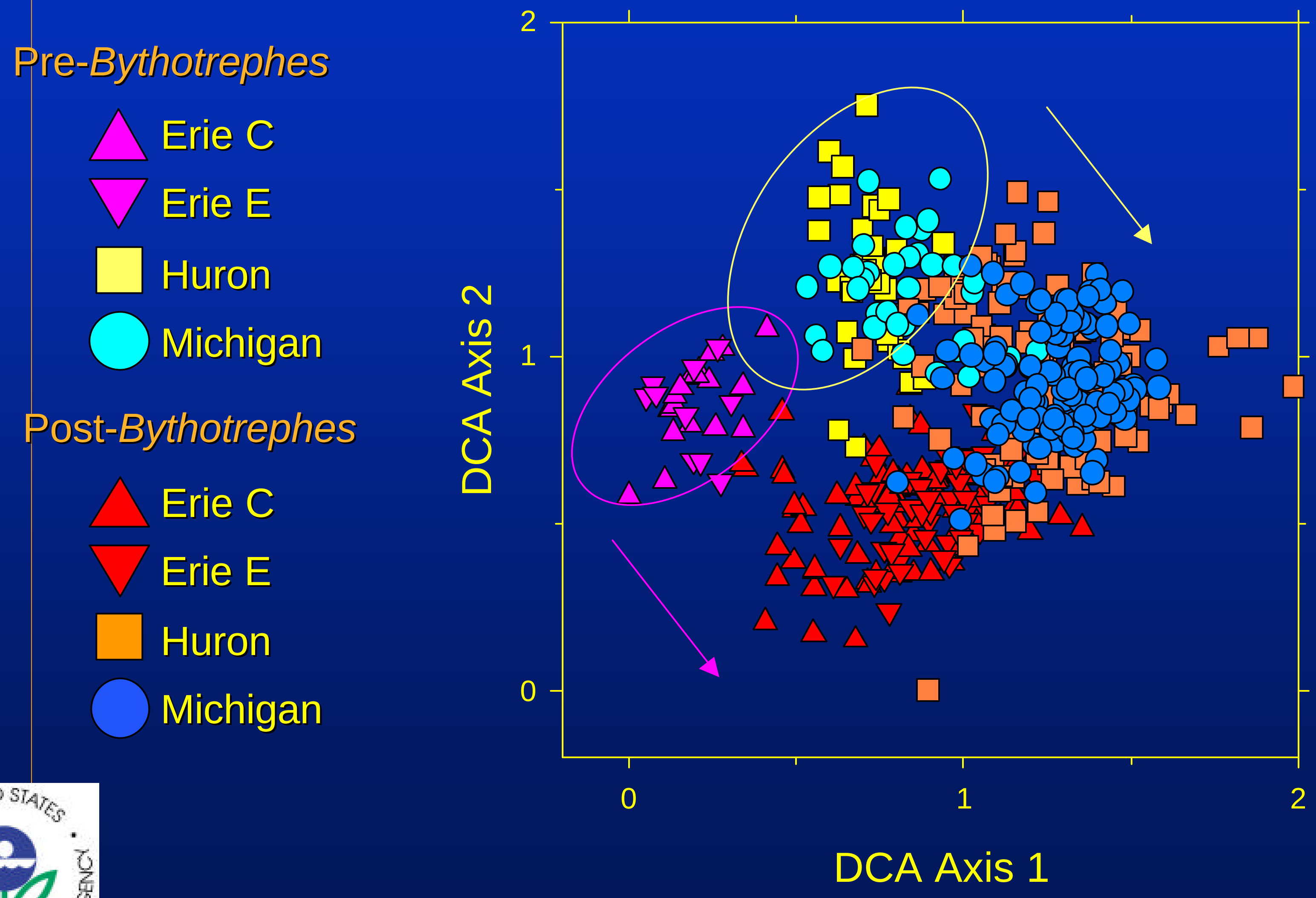

Summary

- *Bythotrephes* has had a clear impact on crustacean communities
  - Several species dramatically reduced
- However, changes not apparent at level of major groups
- Necessary to incorporate a high level of taxonomic detail in monitoring program to discern impacts

Conclusions

- Long-Term Monitoring Essential
  - Provides information research cannot
  - Provides ‘before’ data for emerging issues
- Interpretation of Chemical and Biological Data Linked
- In-Depth Analysis of Monitoring Data Needed
  - Trends not always apparent in ‘obvious’ variables
  - Understanding of underlying mechanisms important

Additional Information

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Questions?

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