

Lake Ontario 2008 Biological Monitoring Workshop

Kingston, Ontario, October 23 – 24, 2006

Lake Ontario Drainage Basin

MODELING THE LAKE ONTARIO ECOSYSTEM: A Proposal



Joseph V. DePinto

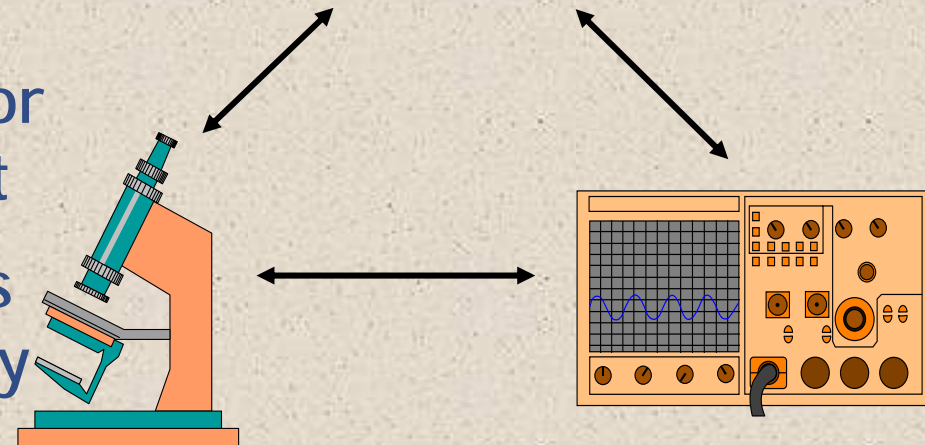
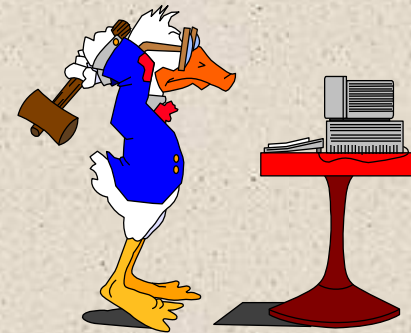
Limno-Tech, Inc.

Thomas J. Stewart

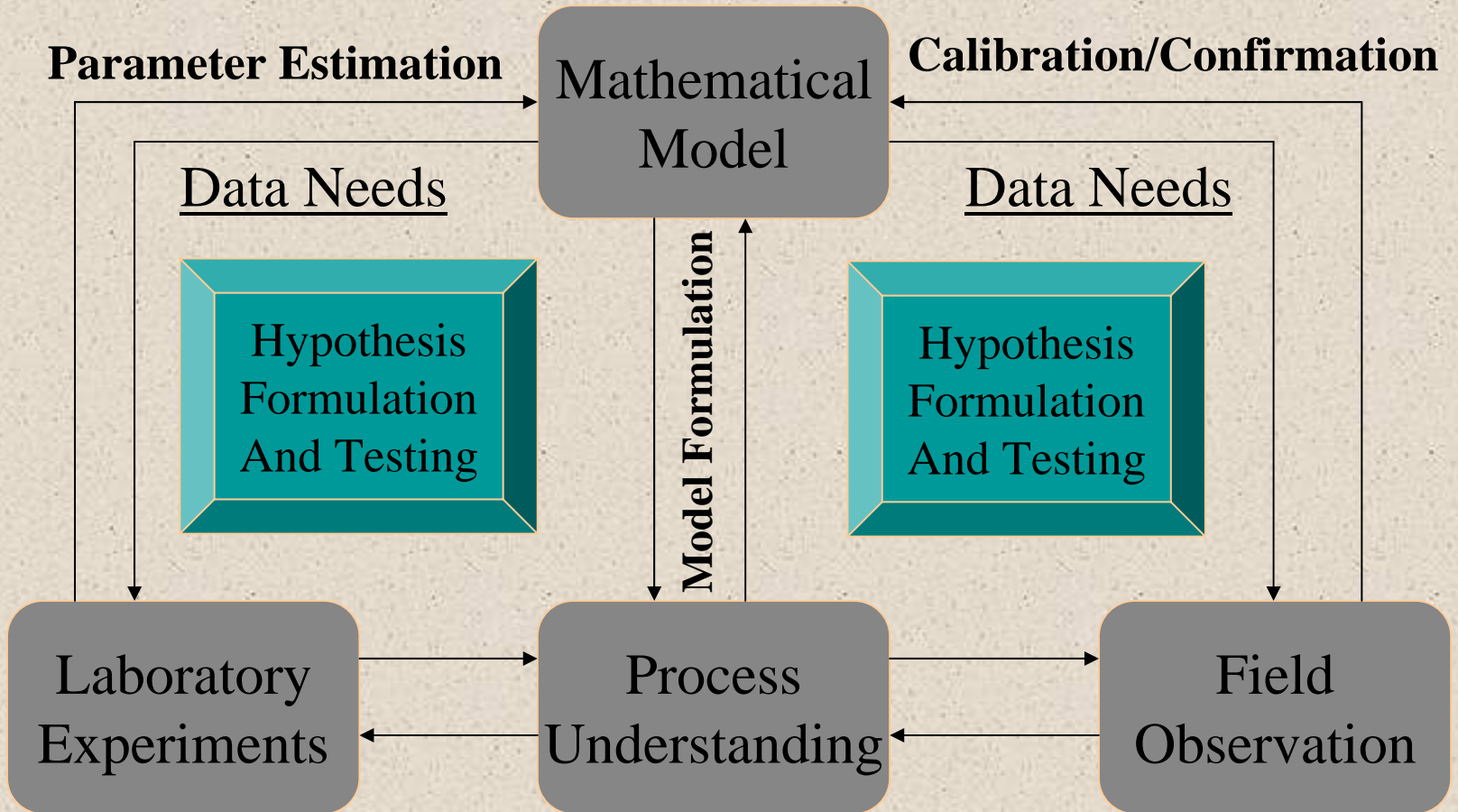
University of Toronto - Mississauga

Modeling/Monitoring/Research Symbiosis

- **Models** provide insight and make projections
- **Research** provides Understanding and parameterization for Model Development
- **Monitoring** provides input and credibility for Models



Models as Research and Monitoring Analysis and Interpretation Tools



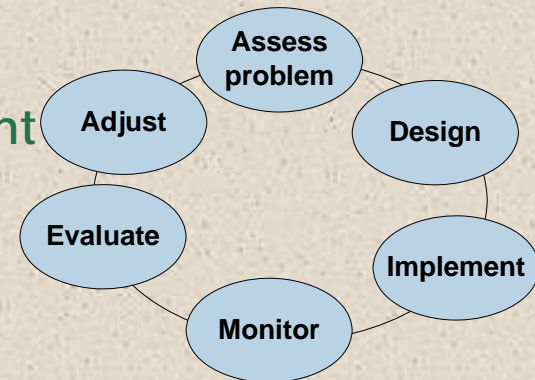
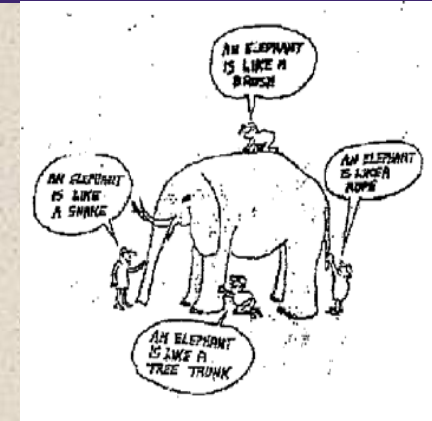
An Ecosystem Model will support *Adaptive Ecosystem Management* of Lake Ontario

■ Models provide a means to visualize the “big picture”

- Quantitative framework for integrating the diverse physical, chemical and biological information and observations
 - Vehicle for developing an enhanced understanding of how ecosystems function
- Models can identify gaps in knowledge and data

■ Models can aid *Adaptive Ecosystem Management*

- Compare and evaluate management options
- Quantify and assess outcomes of management actions
- forecast the impact of extreme events for which there is no actual experience



Thomann LAKE 1 Model Framework (used for setting Target P load in Annex 3)

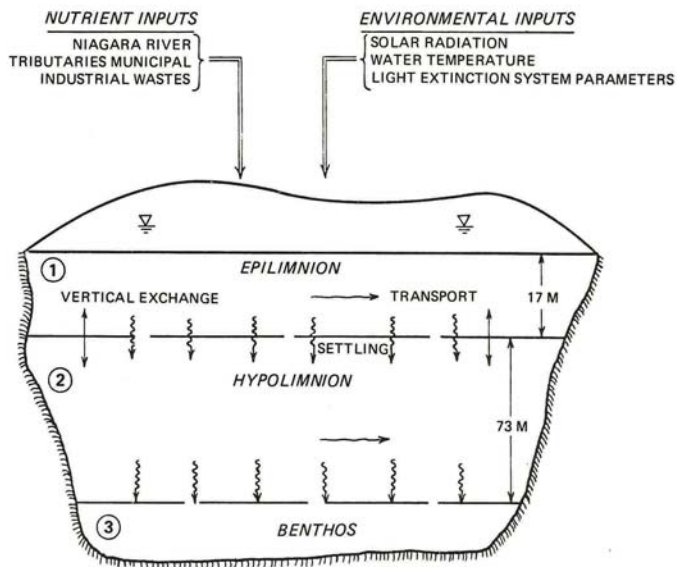
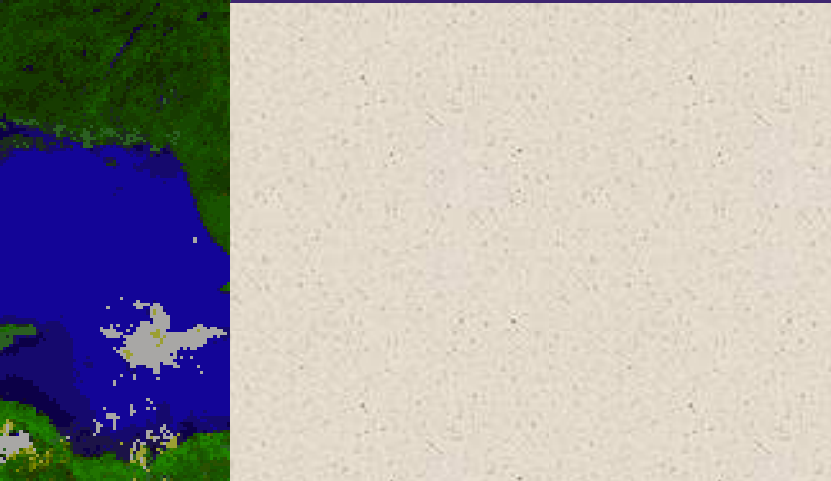


Figure 1 Major physical features included in Lake 1 model

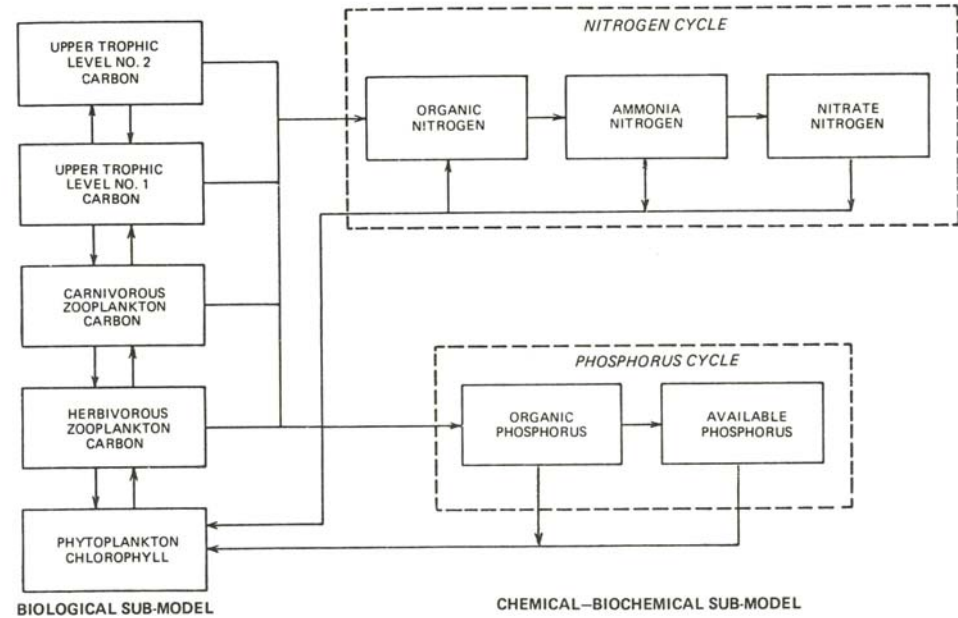
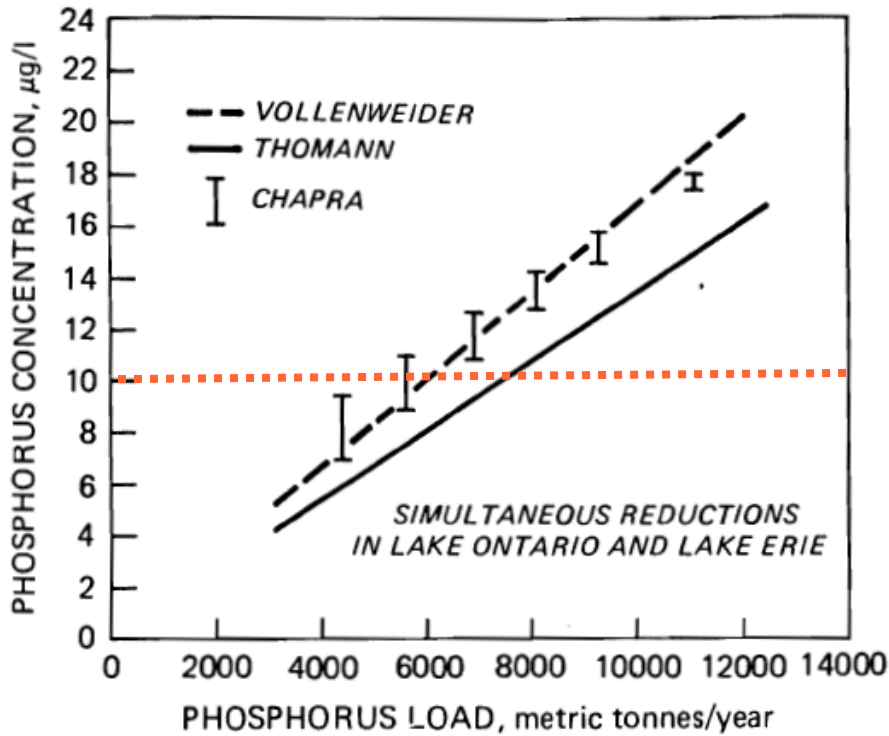


Figure 2 System diagram - Lake 1 model



Determination of Target TP Load for Lake Ontario

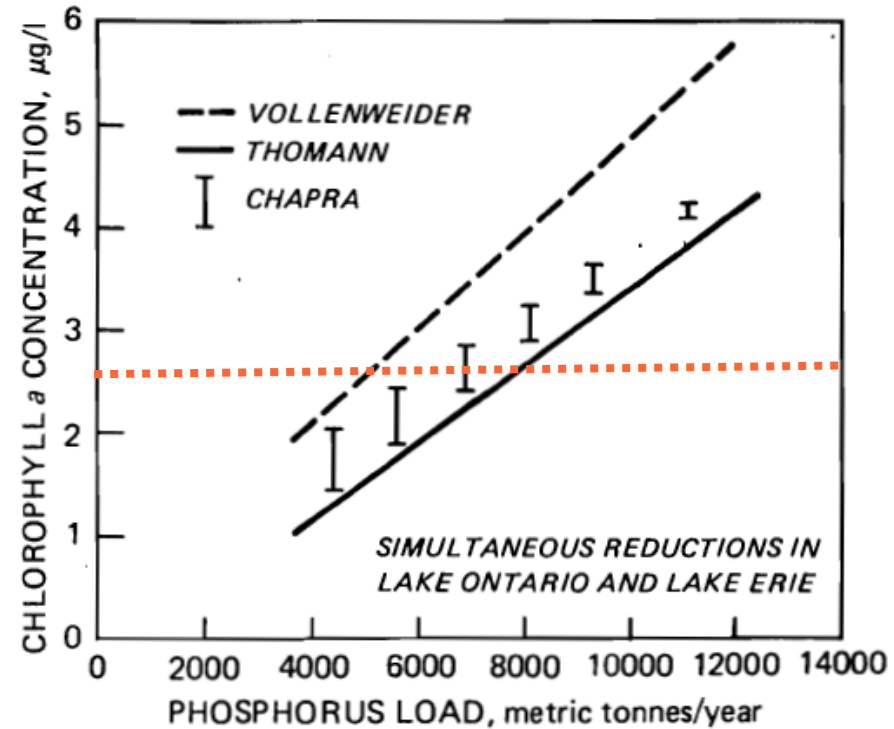
LAKE ONTARIO



↑ 100% ↑ 75% ↑ 50% ↑ 25% ↑ 1 mg/l ↑ BASE 1976
↑ YEAR LOAD

DIFFUSE SOURCE REDUCTION AFTER 1 mg/l

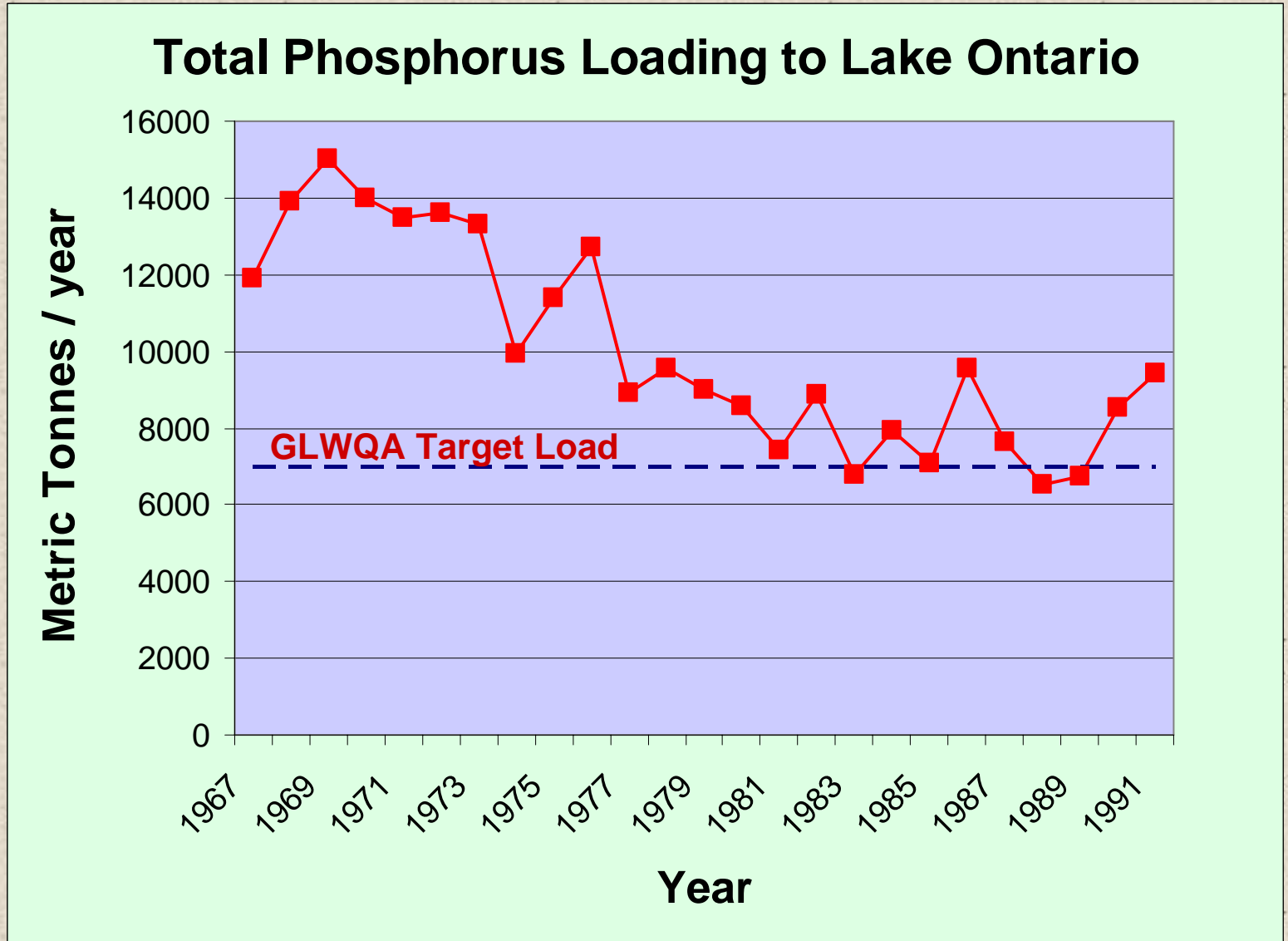
LAKE ONTARIO



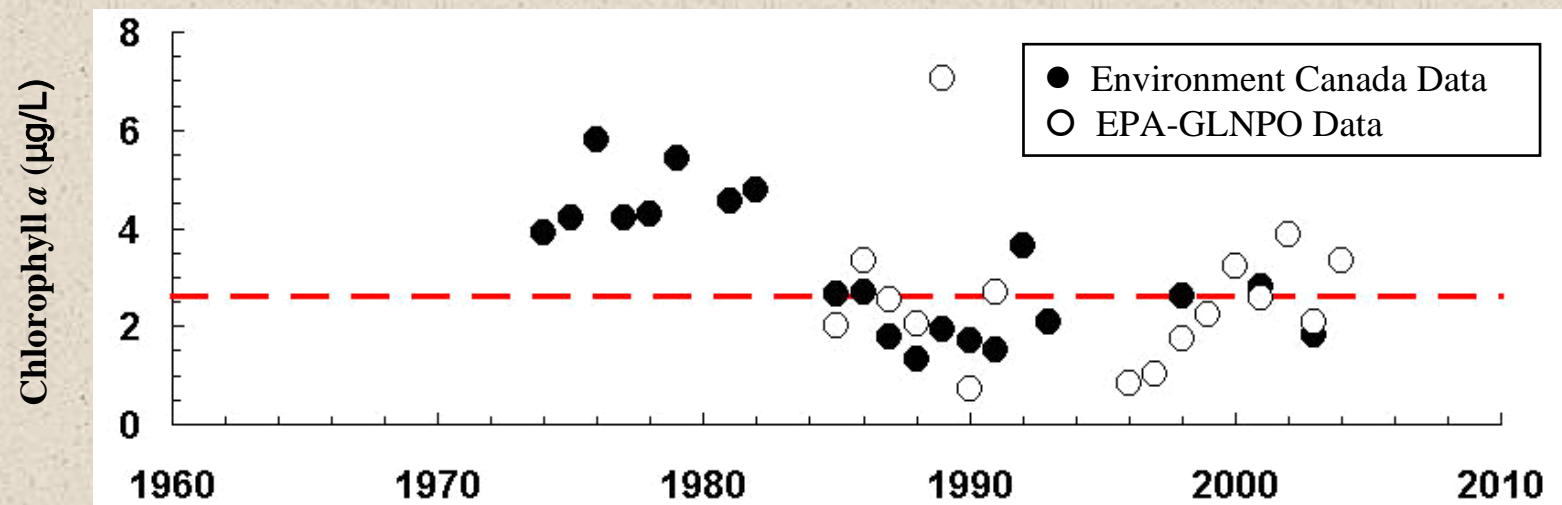
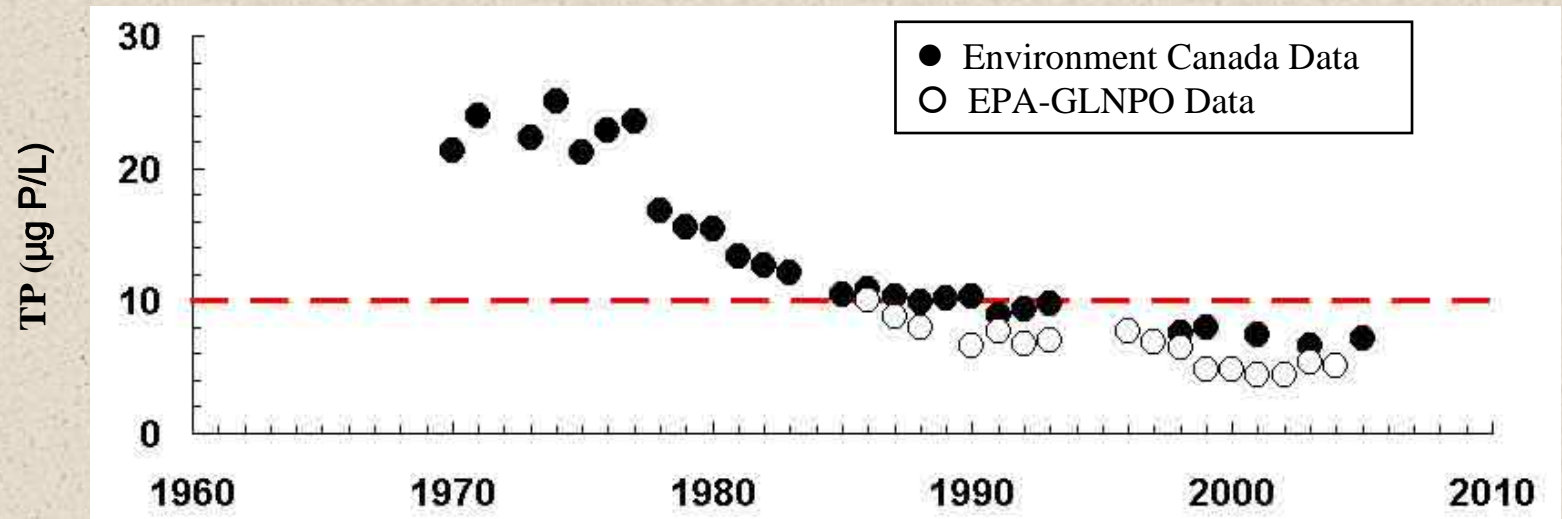
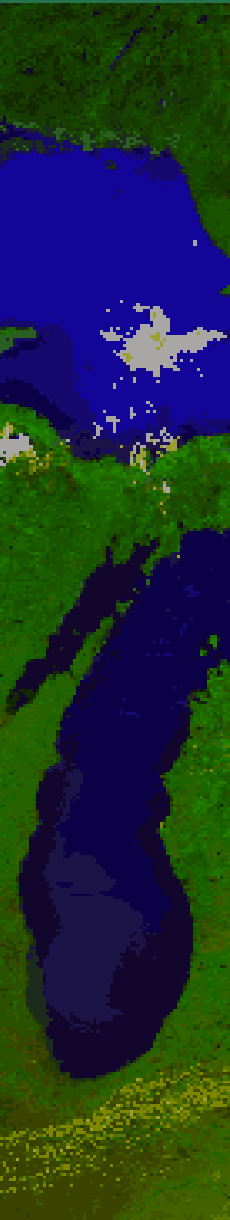
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DIFFUSE SOURCE REDUCTION AFTER 1 mg/l

Results of Phosphorus Load Control Program

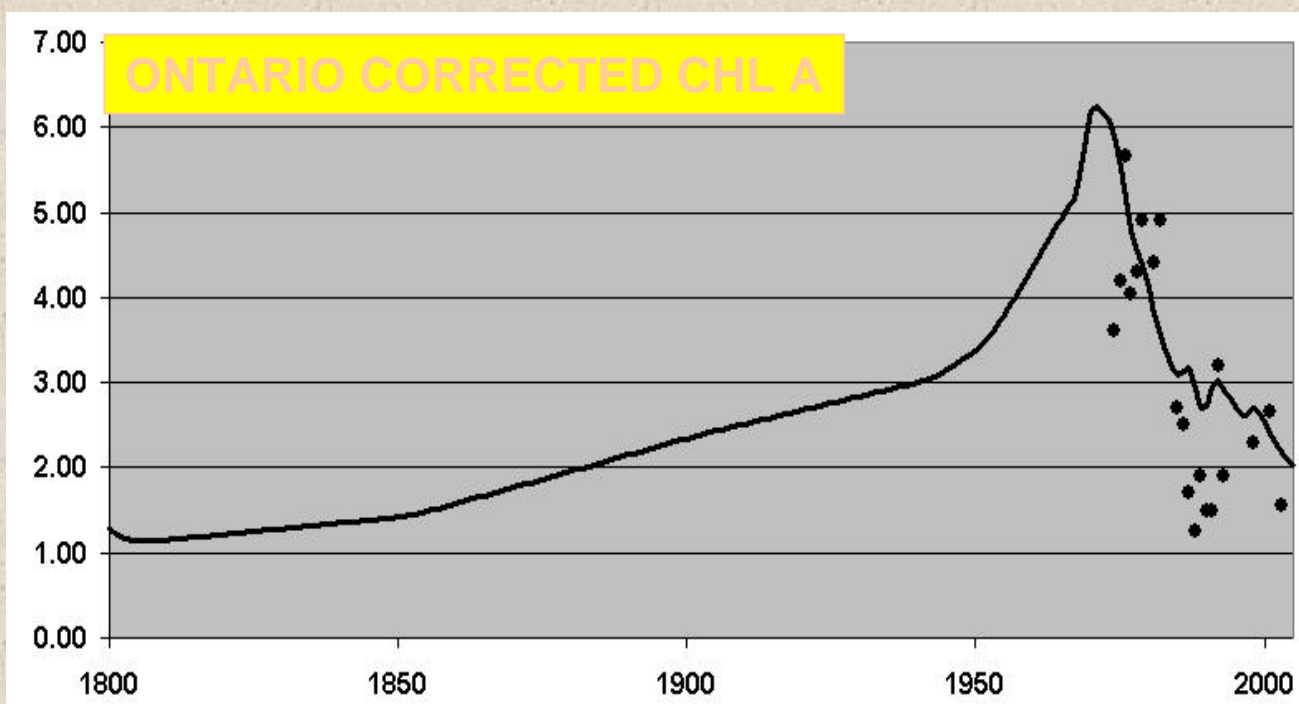
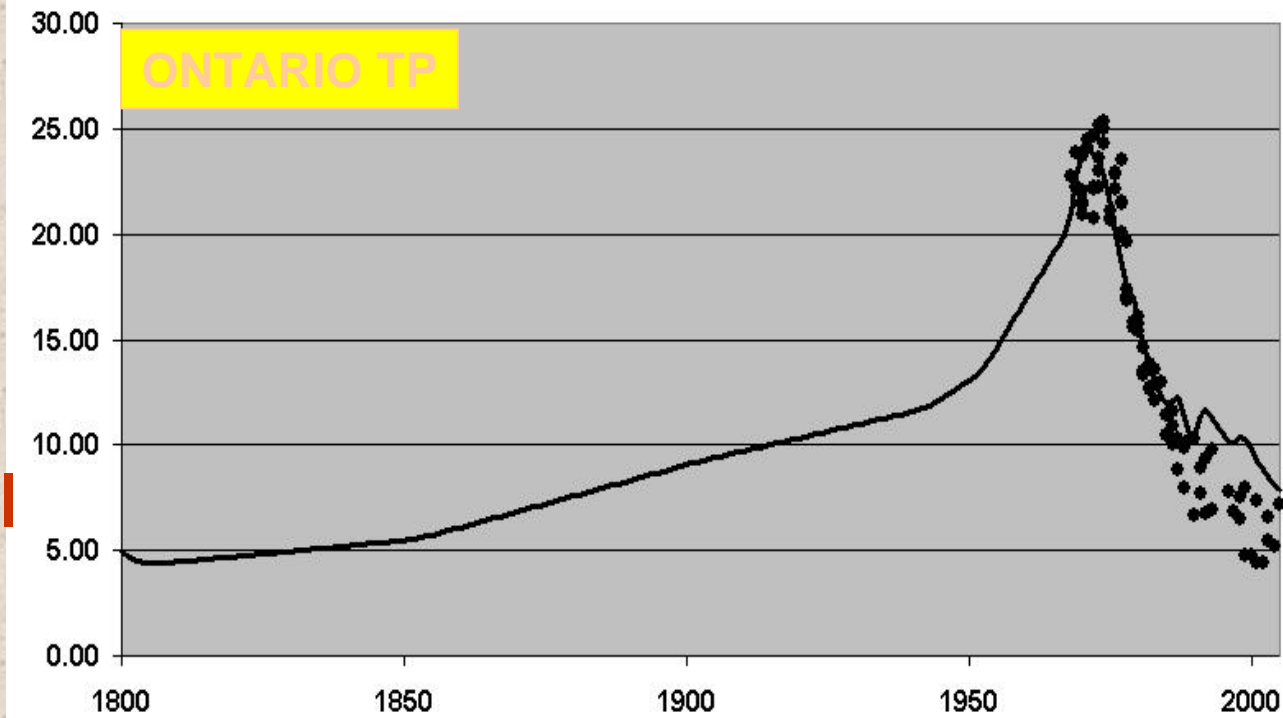


Response of Mean Spring TP and Summer Chlorophyll *a* in Offshore Waters of Lake Ontario

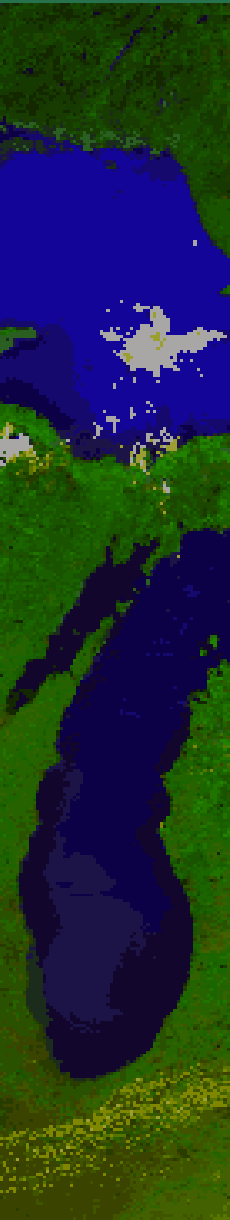


Post-audit of Chapra TP Model

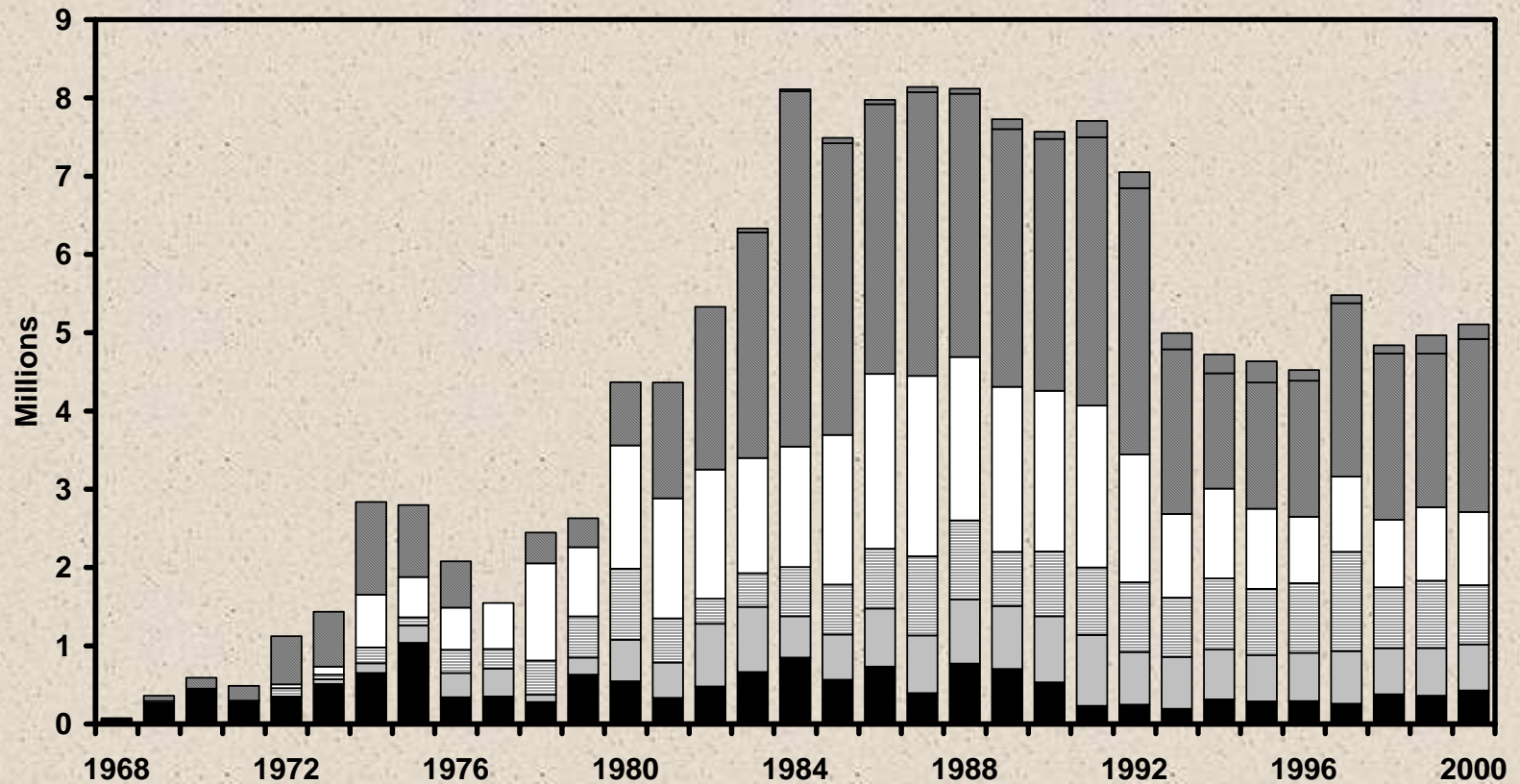
(assumes 3.3%/yr load decrease after 1991)



Paradox in Recent Lake Ontario Observations?

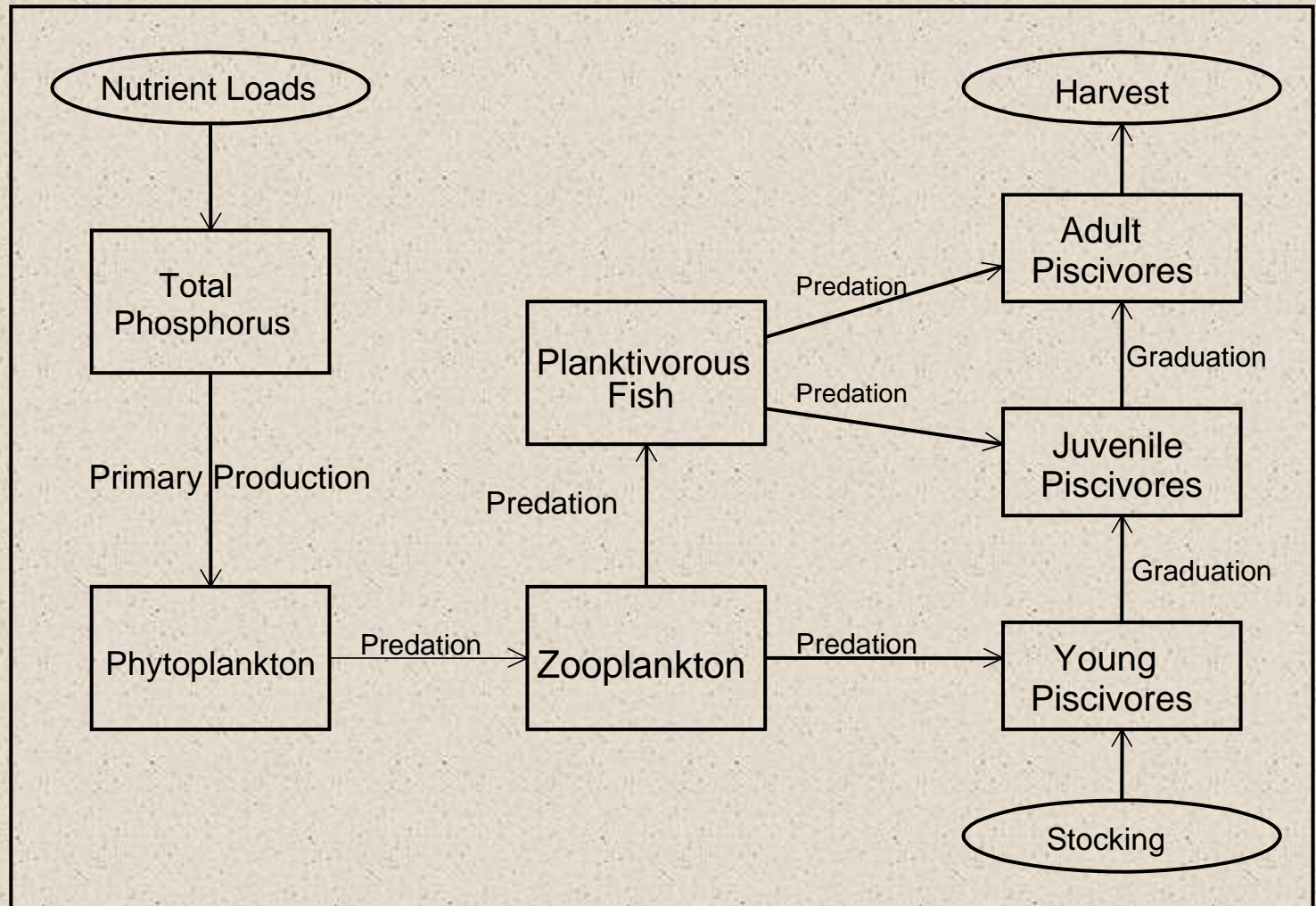
- 
- TP response was predicted by models: TP reached $10 \mu\text{g P/L}$ objective in 1983 when load reached 7000 mta
 - Open water TP has continued to drop despite no continued drop in TP load after mid-1980s
 - Nearshore conditions have returned to pre-TP load control period (see Makarewicz and Howell)
 - What is the answer??
 - Loads have dropped since early 1990s?
 - Nearshore ecosystem is trapping phosphorus?
 - Coastal zone direct P runoff or internal loading not being accounted for in load estimates?

Salmonid Stocking was increasing as TP load was decreasing

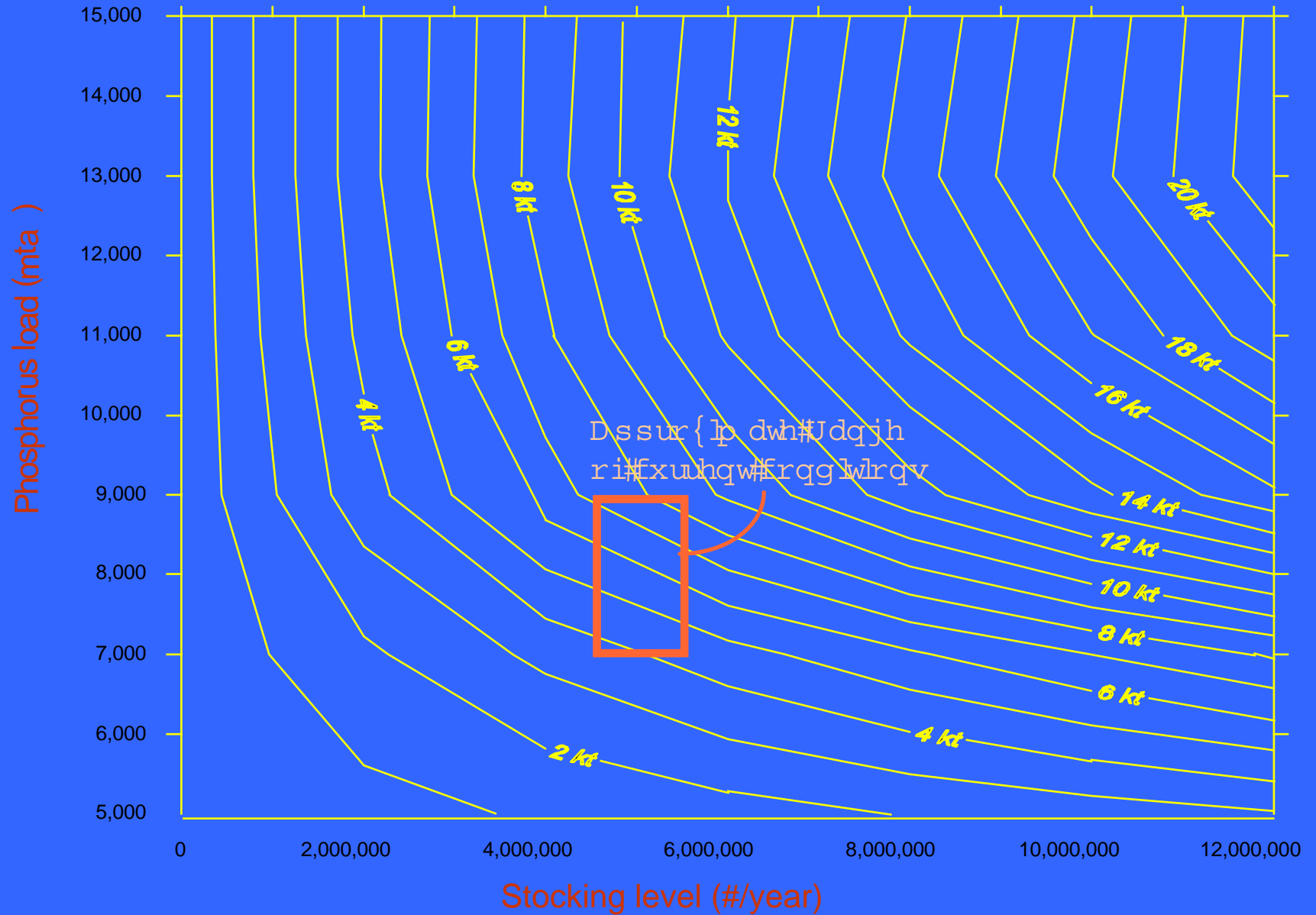


(from Mills, et al., CJFAS, 2003)

Conceptual Model of Simplified Lake Ontario Ecosystem Model



Adult Piscivore Biomass in Lake Ontario



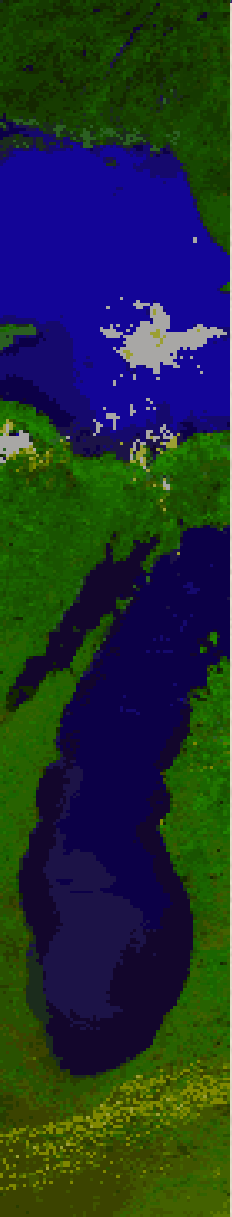
Need to Build a Lake Ontario Ecosystem Model (LOEM)

■ Goals

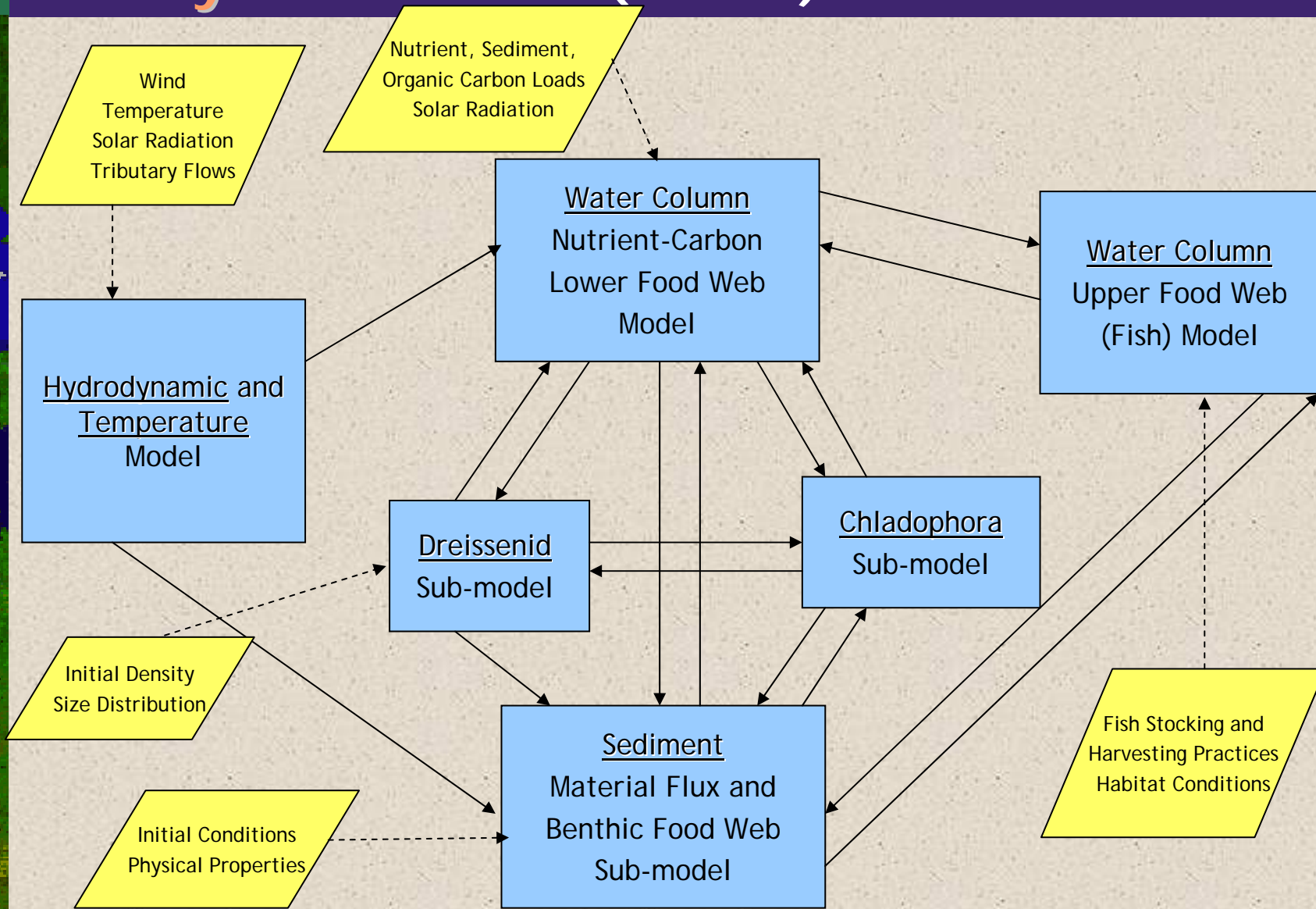
- Build a quantitative framework within which to synthesize and integrate the recent experimental and monitoring data on the Lake Ontario ecosystem; and
- Build a model that can inform management decisions on how to move the Lake Ontario fishery toward a more healthy and diverse community in the face of the multiple stressors:
 - P loading
 - Species invasions
 - Fish diseases
 - Toxic chemicals/endocrine disruptors
 - Fishery management (stocking and harvesting)
 - Fish-eating birds
 - Climate change
 - Water level and flow regulation
 - Land use changes

■ LOEM can help to understand:

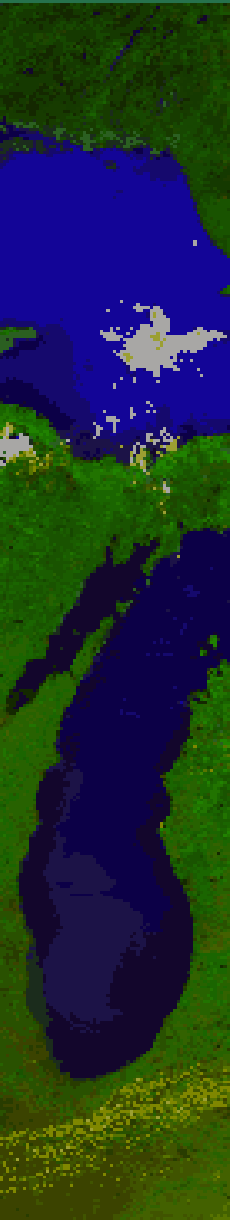
- Coastal zone - nearshore interactions
- Nearshore - offshore exchanges and interactions
- How physical factors affect chemical and biological processes
- Benthic - pelagic food web interactions



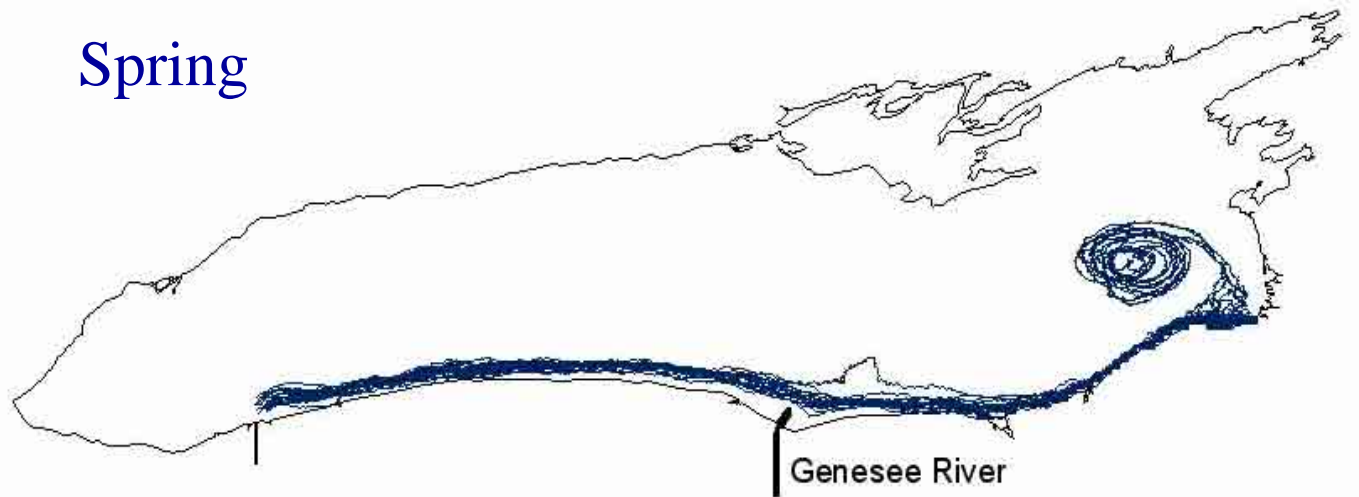
Components of Lake Ontario Ecosystem Model (LOEM)



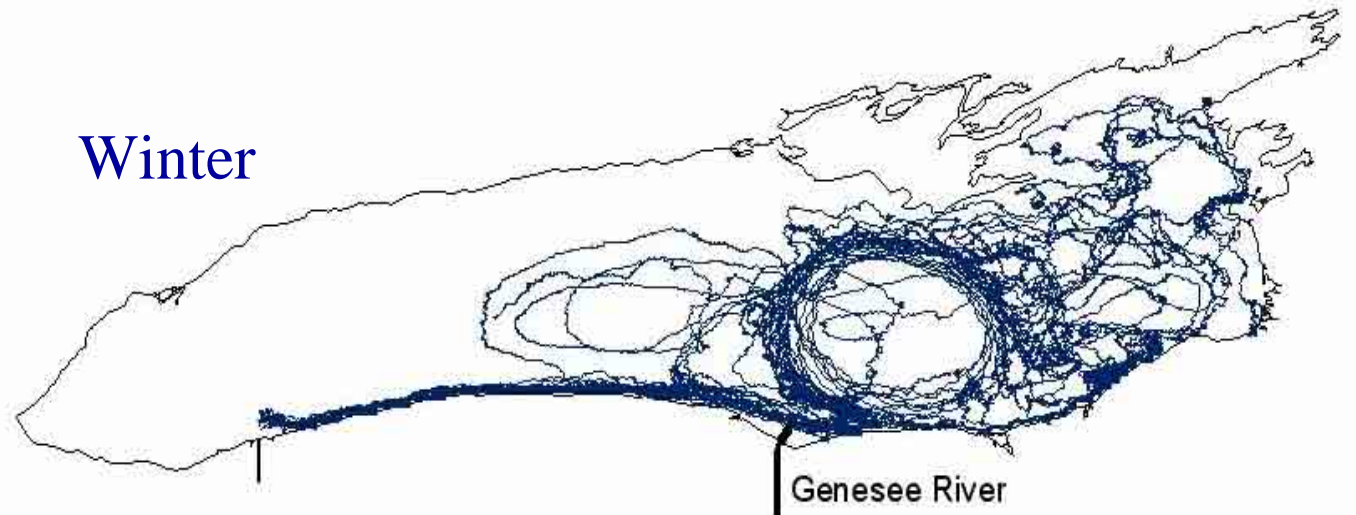
Niagara River plume using POM particle tracking (from Atkinson)



Spring

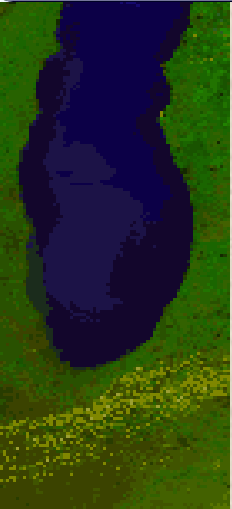
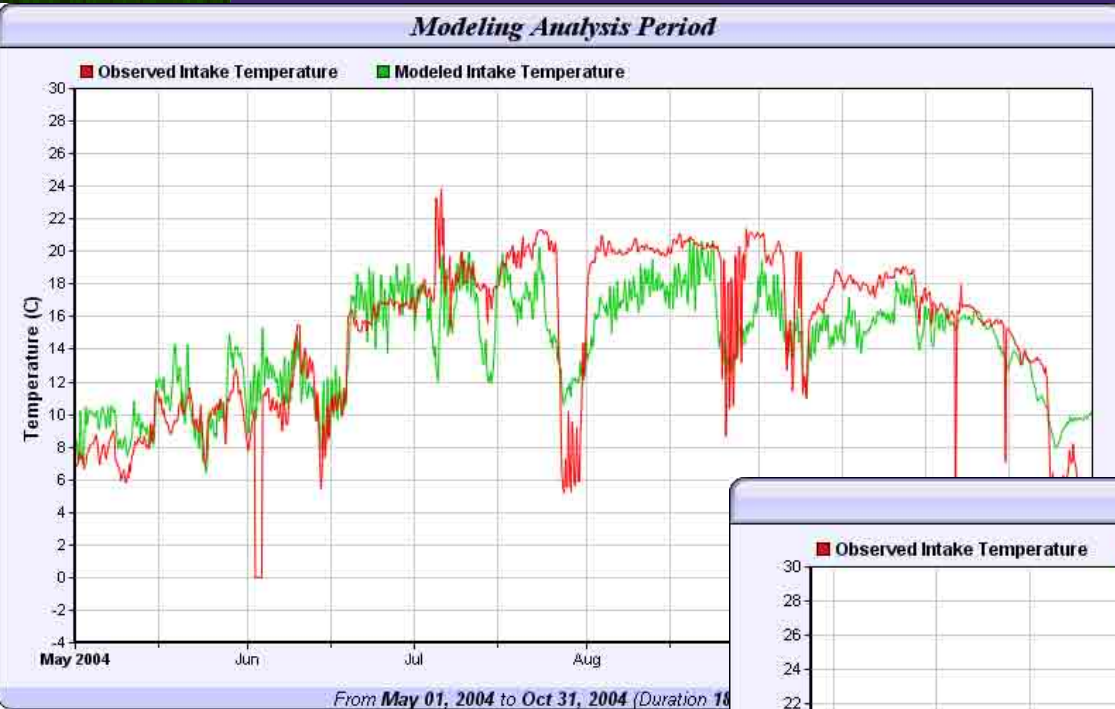


Winter

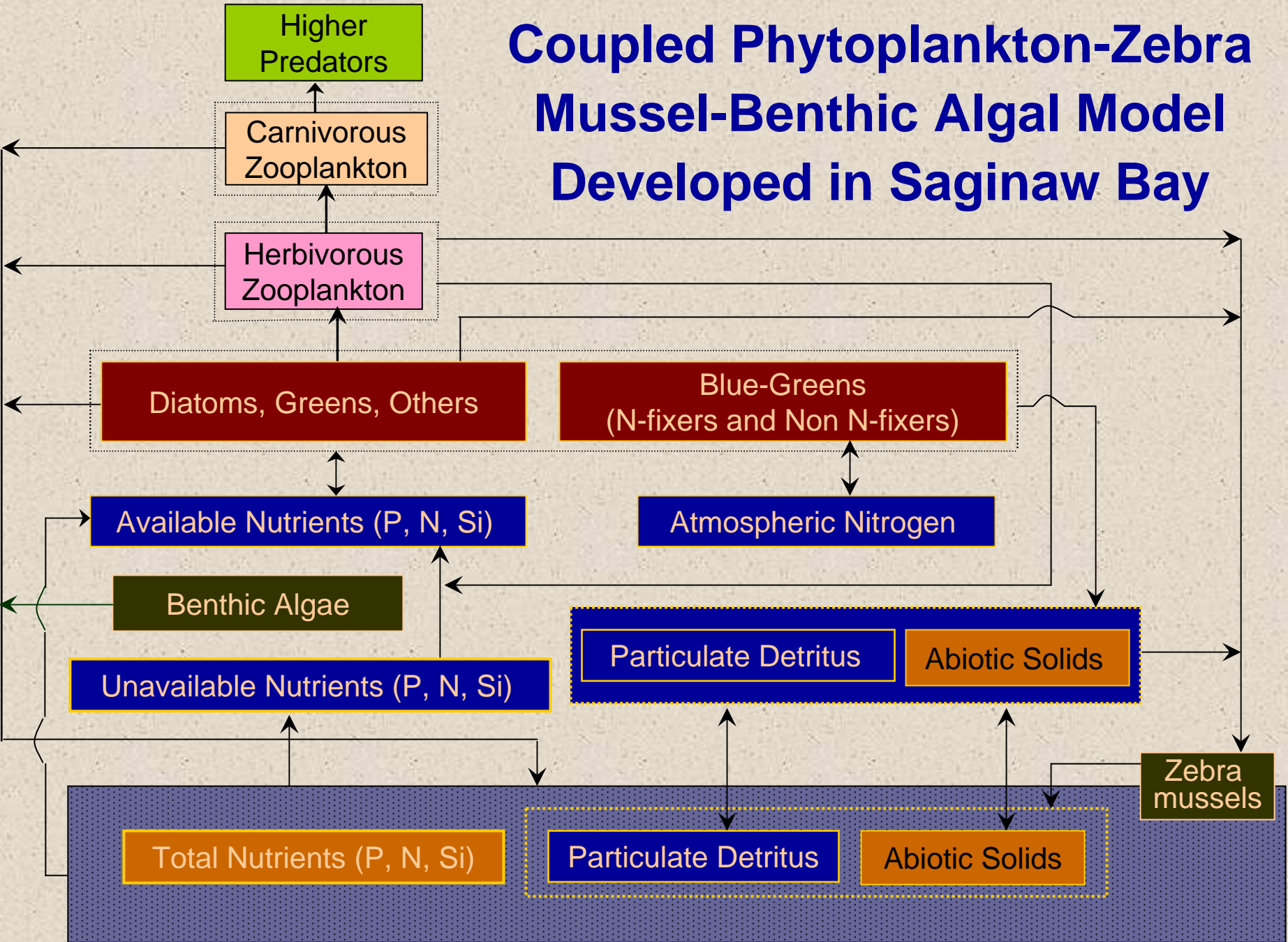


Upwelling events near Rochester

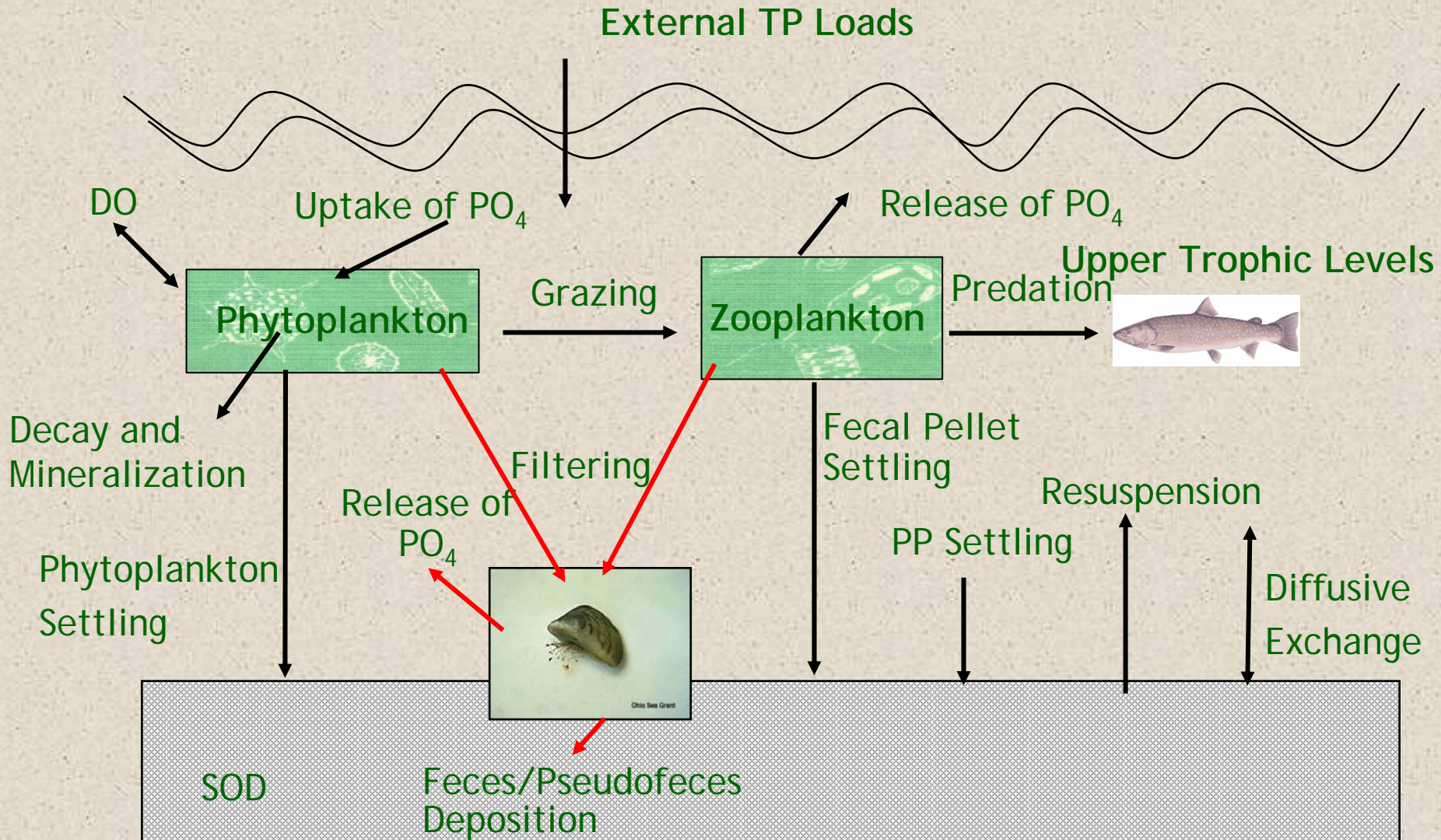
(from Atkinson)



Coupled Phytoplankton-Zebra Mussel-Benthic Algal Model Developed in Saginaw Bay

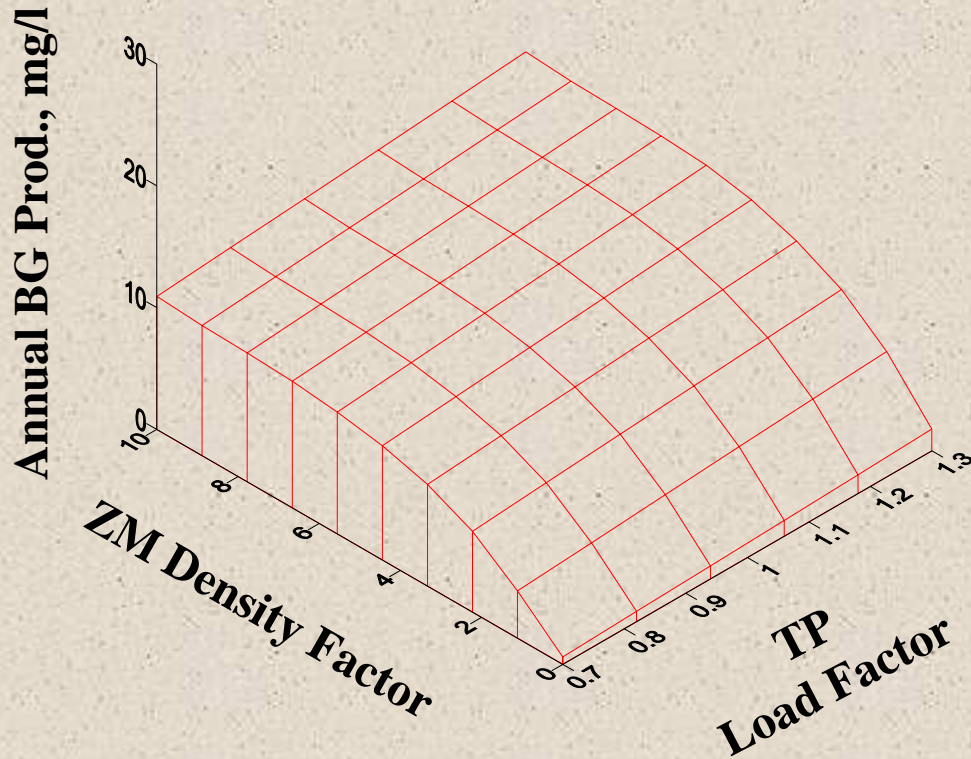


Nutrient Transfer Processes Change w/ ZM

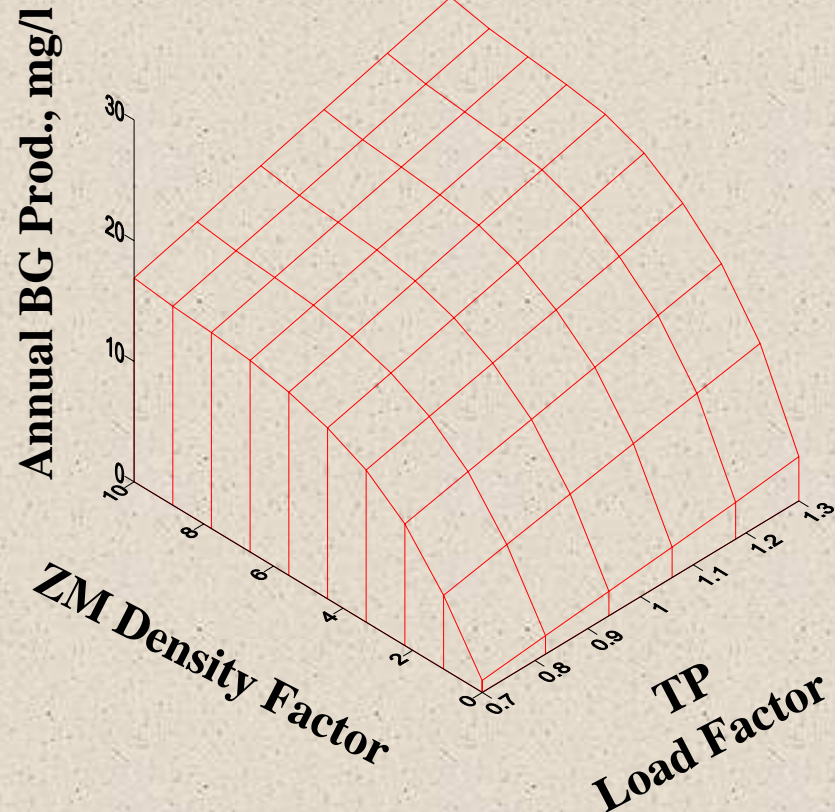


Model Diagnostic Results

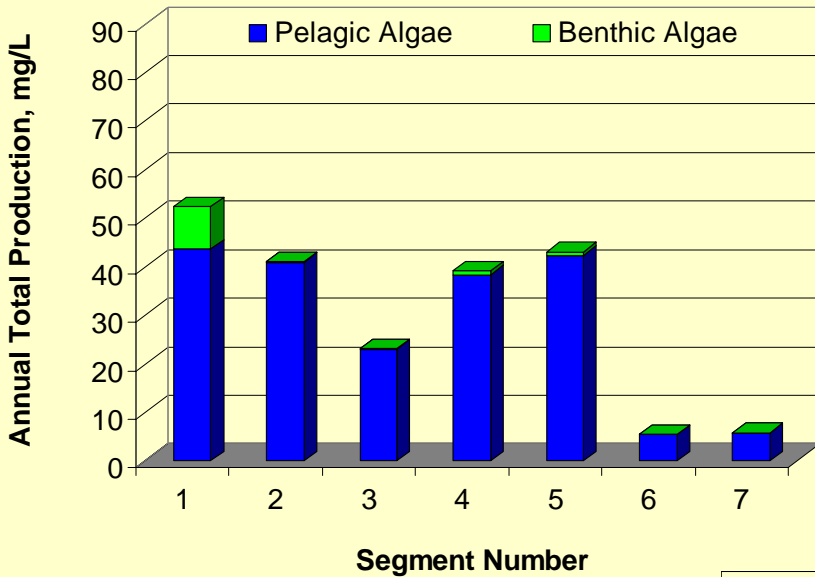
Open Water Responses



Near Shore Responses

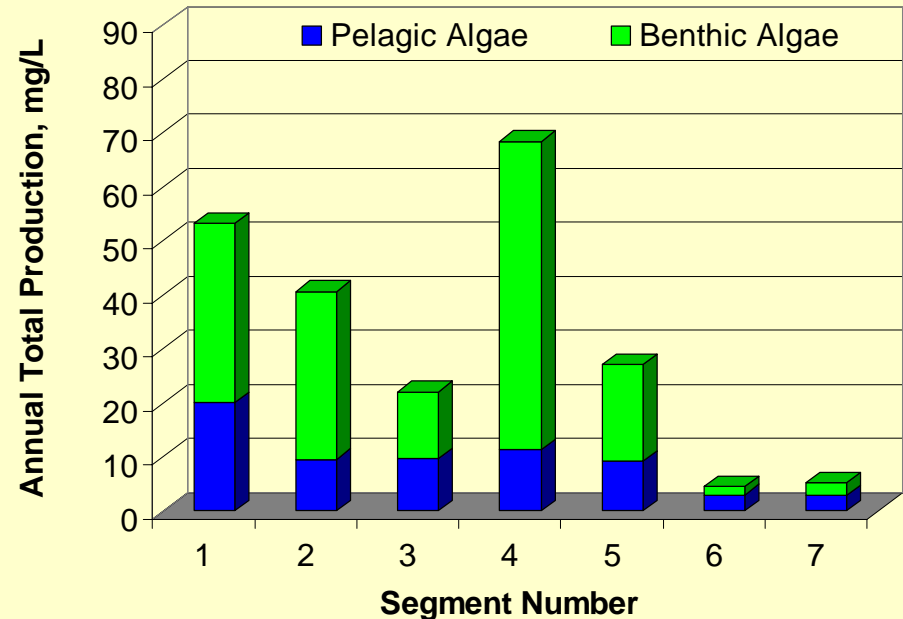


Increased Water Clarity Promotes Benthic Primary Production



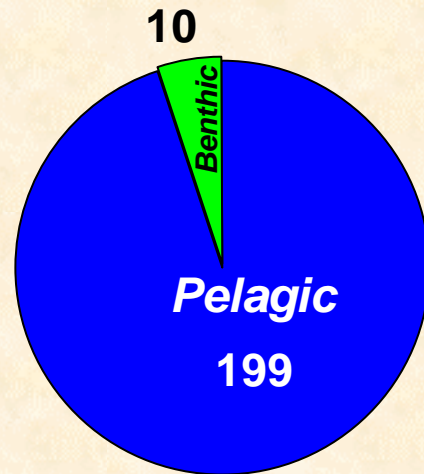
Scenario 1 - No Zebra Mussels

Scenario 2 - Zebra Mussels



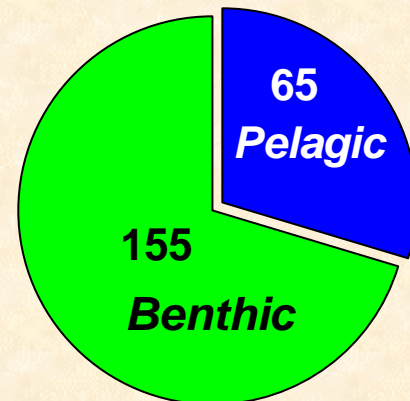
Bay-wide Primary Production

without Zebra Mussels

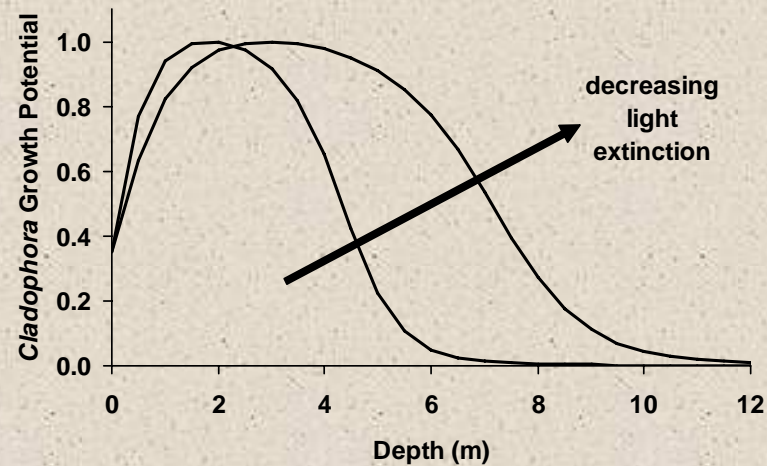
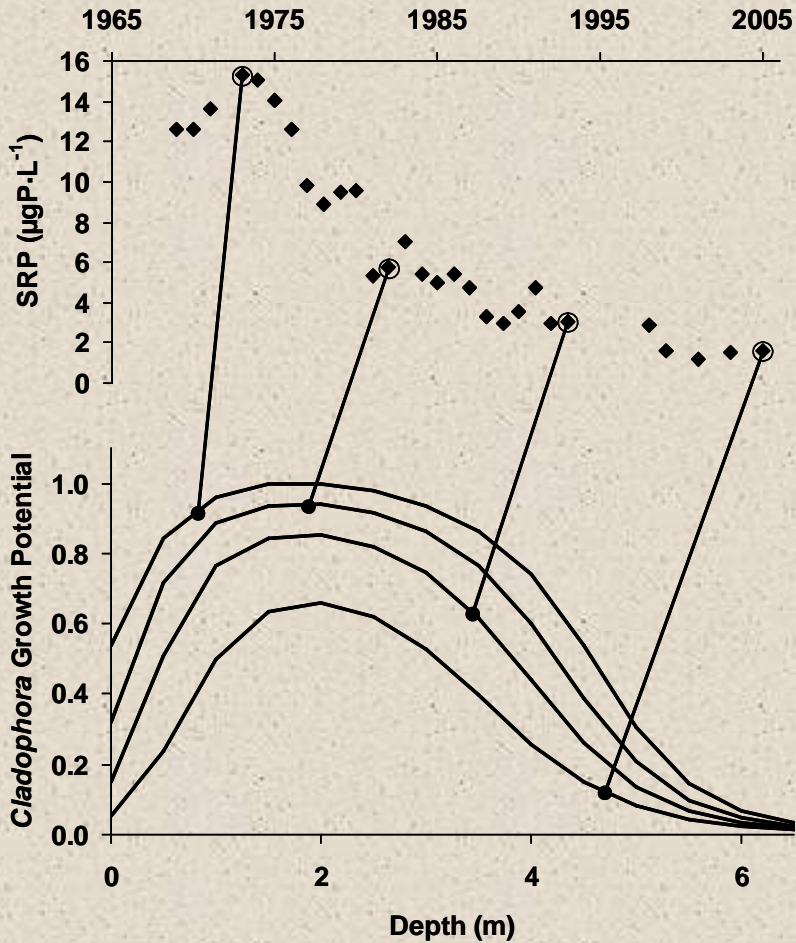
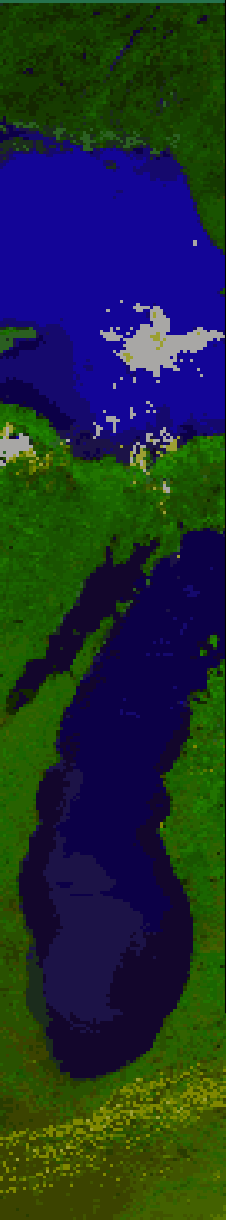


Gross Production Remained Same

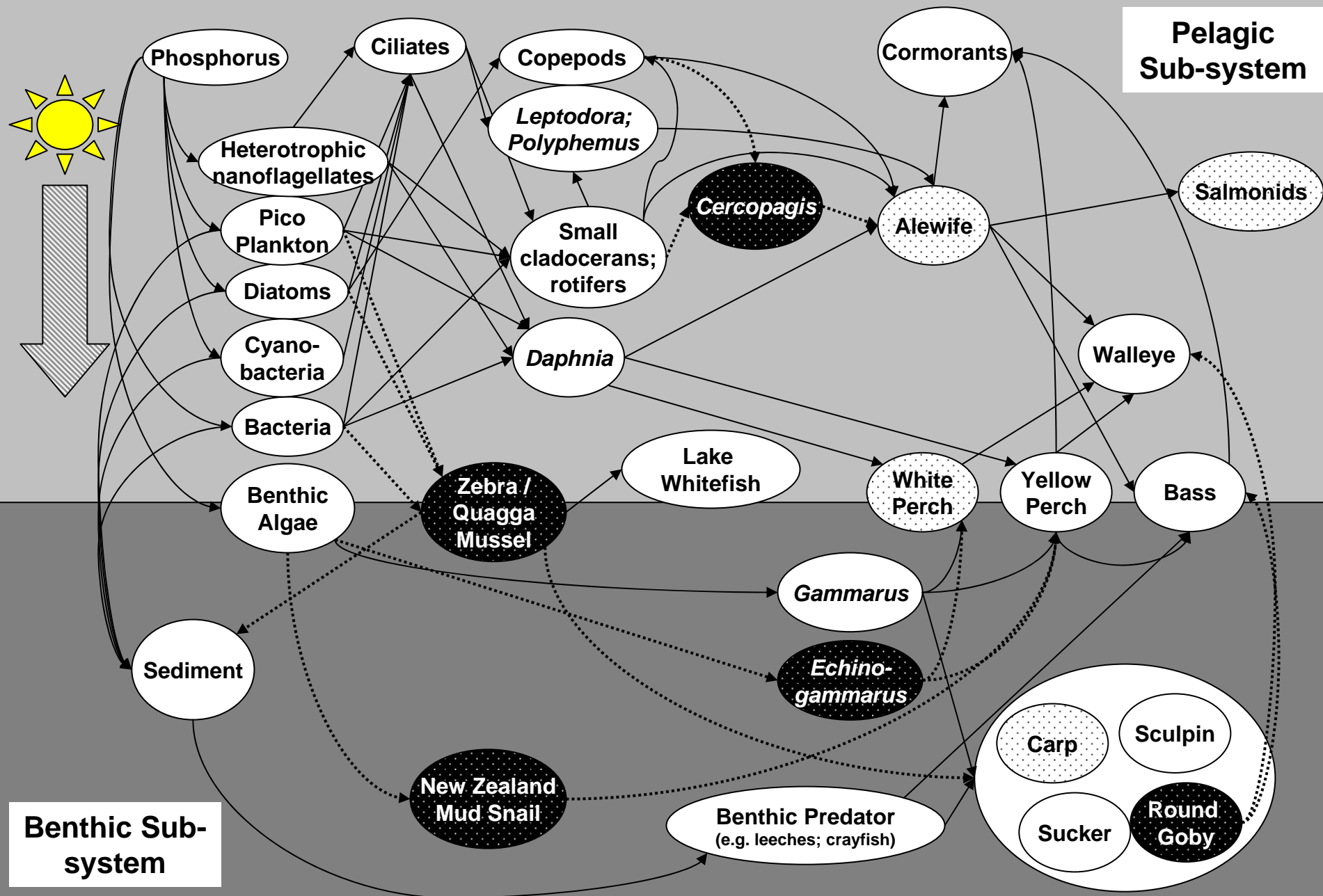
with Zebra Mussels



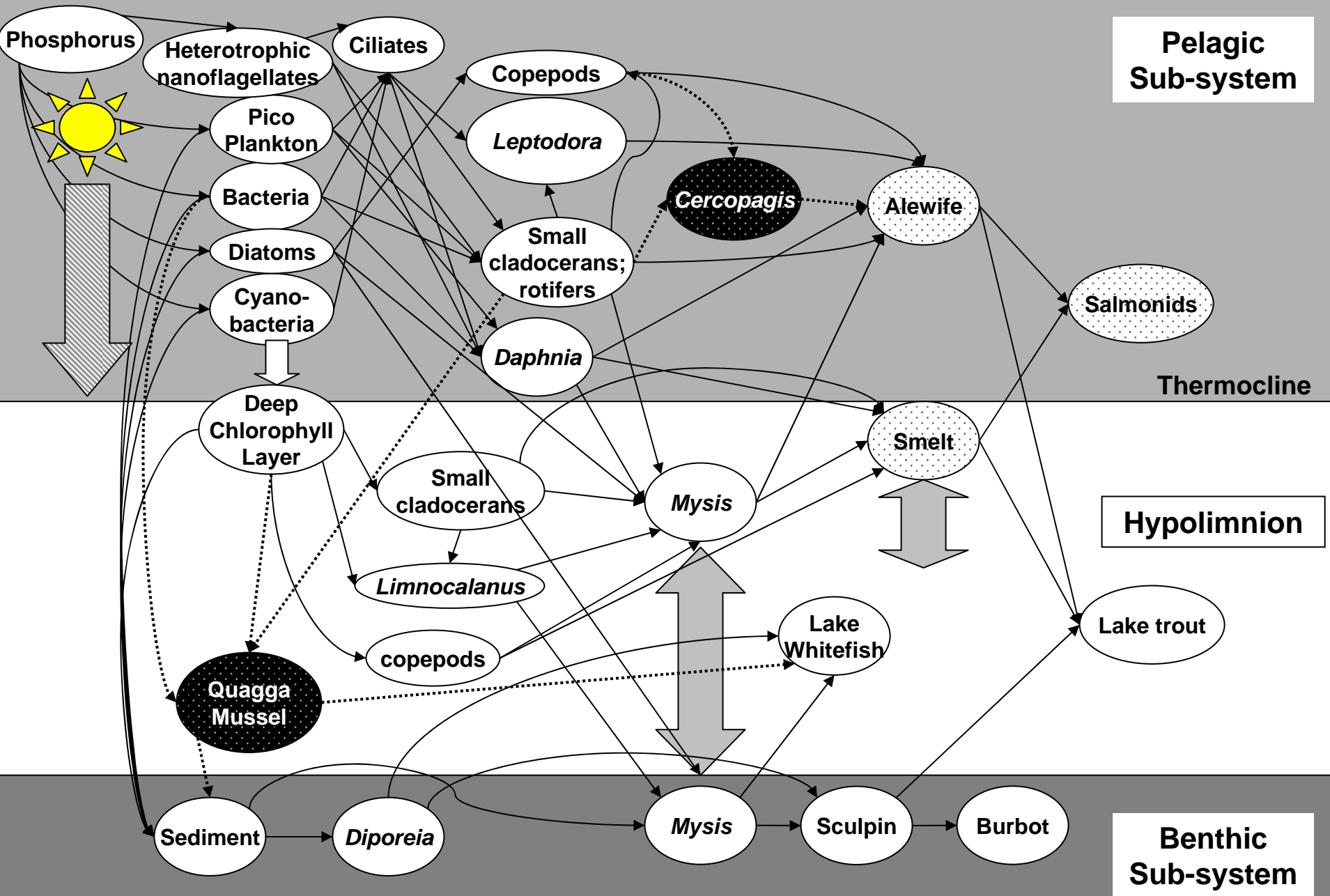
Cladophora Respond to Nearshore SRP and Light Availability (Auer, Higgins, et al.)



Nearshore 2000 (from Mills, et al. CJFAS, 2003)

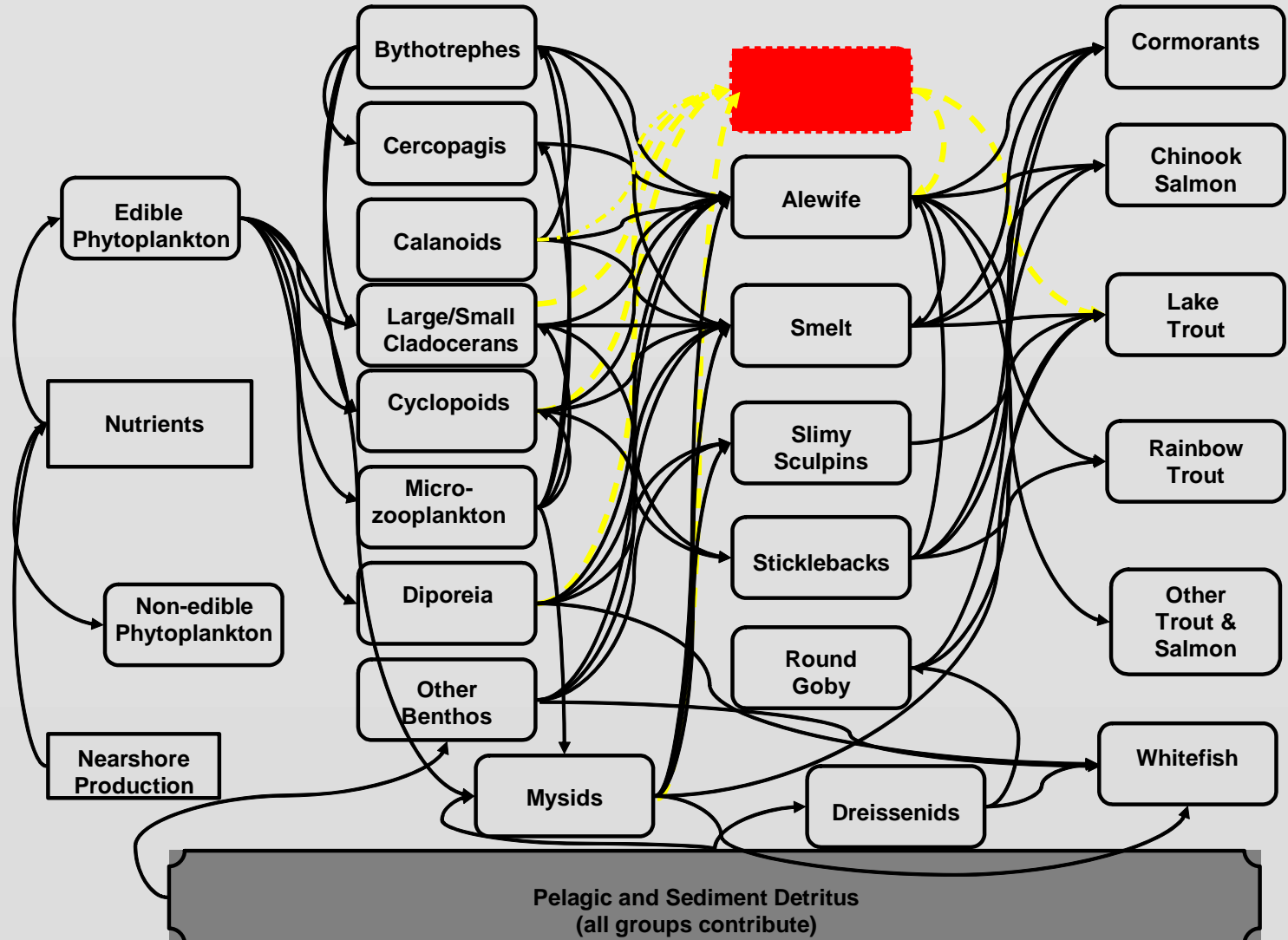


Offshore 2000 (from Mills, et al. CJFAS, 2003)

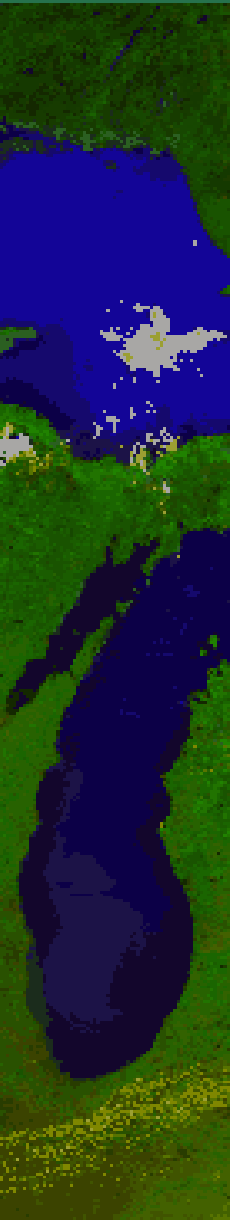


Offshore Food Web proposed by Stewart (2006)

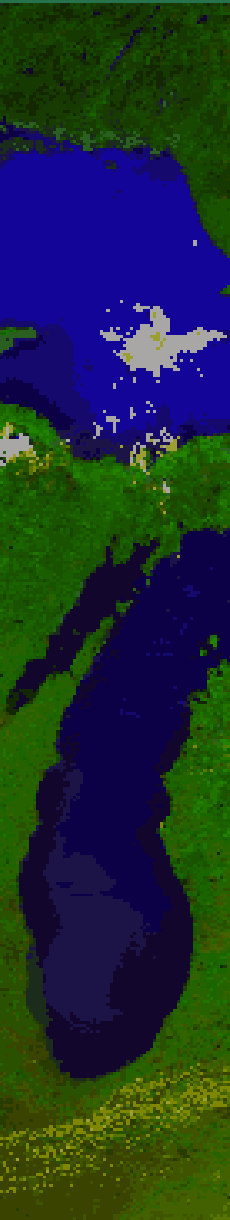
Simplified Lake Ontario Offshore Food Web



Data Needs for LOEM

- 
- Phosphorus loading
 - Long-term trends by major tributary
 - Will have to construct estimates for 1991 - current
 - *In situ* water column and sediment data
 - Nutrients and other water quality data
 - Spatial and temporal profiles
 - Focus on simultaneous nearshore and offshore monitoring
 - Measure inter-segment fluxes of chemistry and plankton
 - Fisheries management data
 - Stocking and harvesting
 - Recruitment estimates

Data Needs for LOEM (cont'd)

- 
- Biomass measurements of important food web species - spatial and temporal density profiles
 - Microbial component
 - Phytoplankton by functional group
 - Zooplankton and zoo-benthos populations
 - Prey fish populations
 - Predator fish populations
 - Invasive species densities
 - Food web bioenergetics and trophic transfer information
 - Species bioenergetics data
 - Predator-prey food preferences and consumption functions
 - Survival functions

A vibrant sunset over a dark, choppy ocean. The sun is a bright, glowing orb on the horizon, casting a shimmering path of light across the water's surface. The sky transitions from a deep orange near the horizon to a pale yellow at the top. The text "Keep 'em Great!" is rendered in large, bold, 3D orange letters with a slight shadow, positioned in the lower-middle part of the frame.

Keep 'em Great!