Operational Ecosystem Modeling to Support Adaptive Management – Lessons from 40 Years of Decision Support in the Great Lakes

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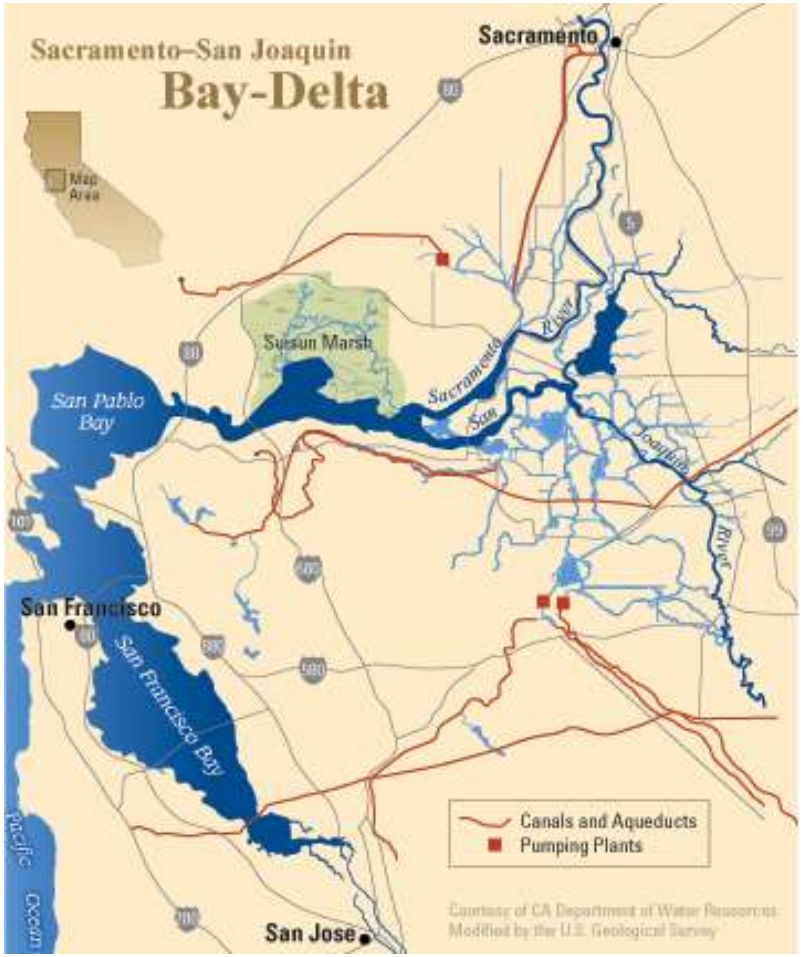
LimnoTech

Water Environment | Scientists Engineers

Making Connections

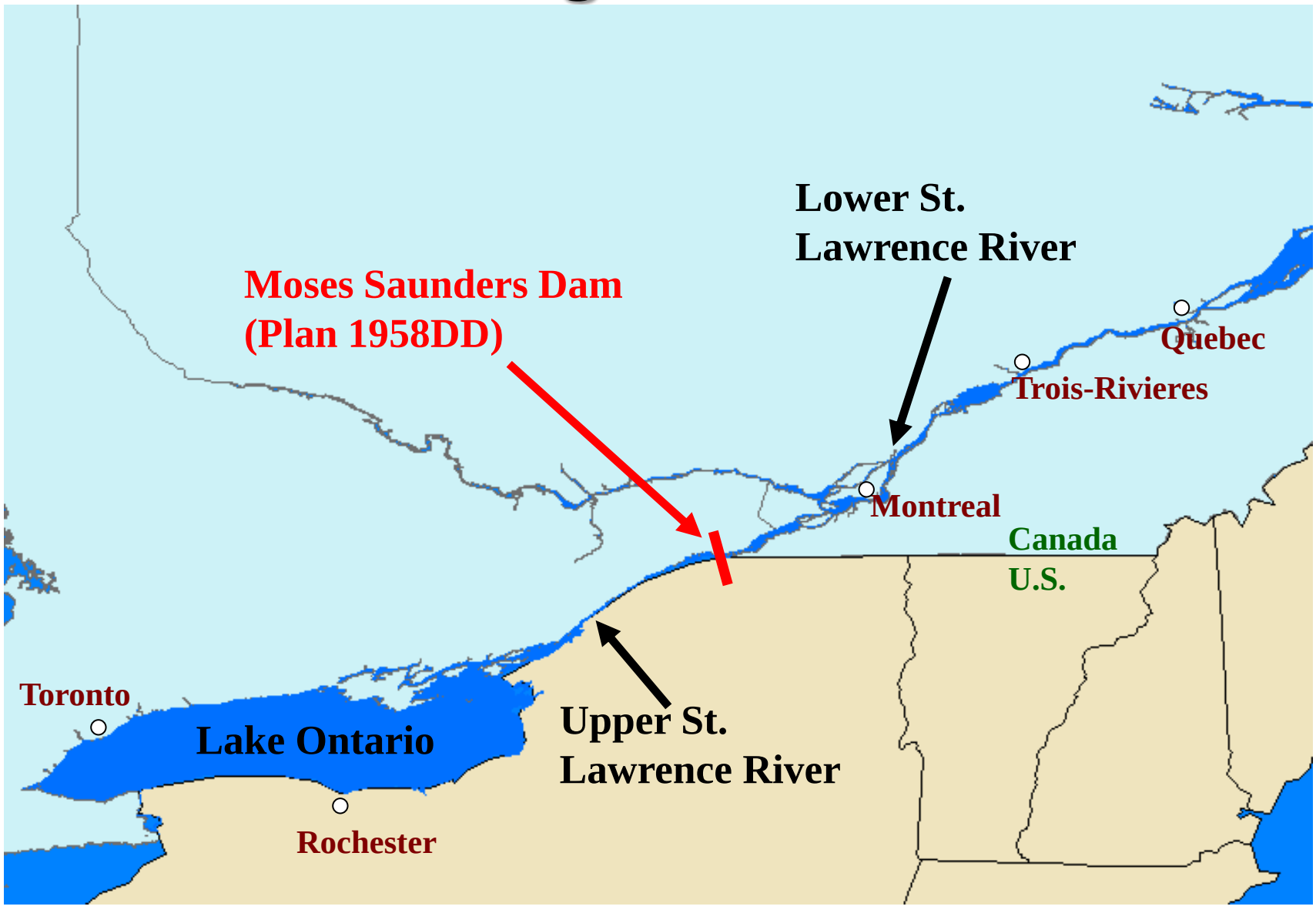
- Bay Delta connections
  - Weather
  - Flows
  - Physical impacts
  - Chemical impacts
  - Ecosystem impacts
  - Invasives
- Multiple stakeholders
- Requires integrative modeling, cooperative planning, and adaptation



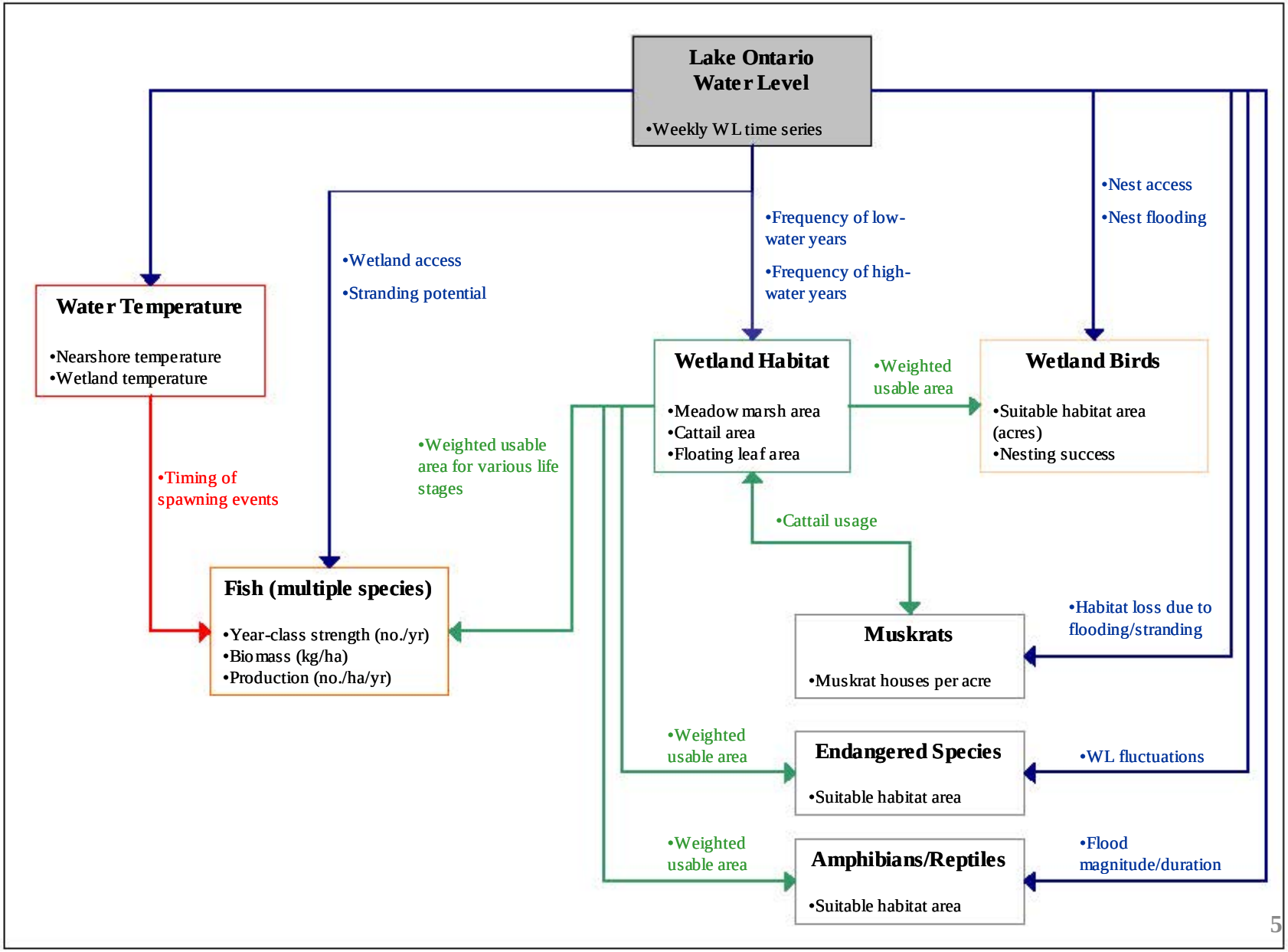
Integrated Ecological Response Models for Water Level Regulation (IERM, IERM2)

Simulation of shoreline ecosystem responses to varying water level regimes governed by regulation and net basin hydrologic supplies for Lake Ontario-St. Lawrence River and Upper Great Lakes

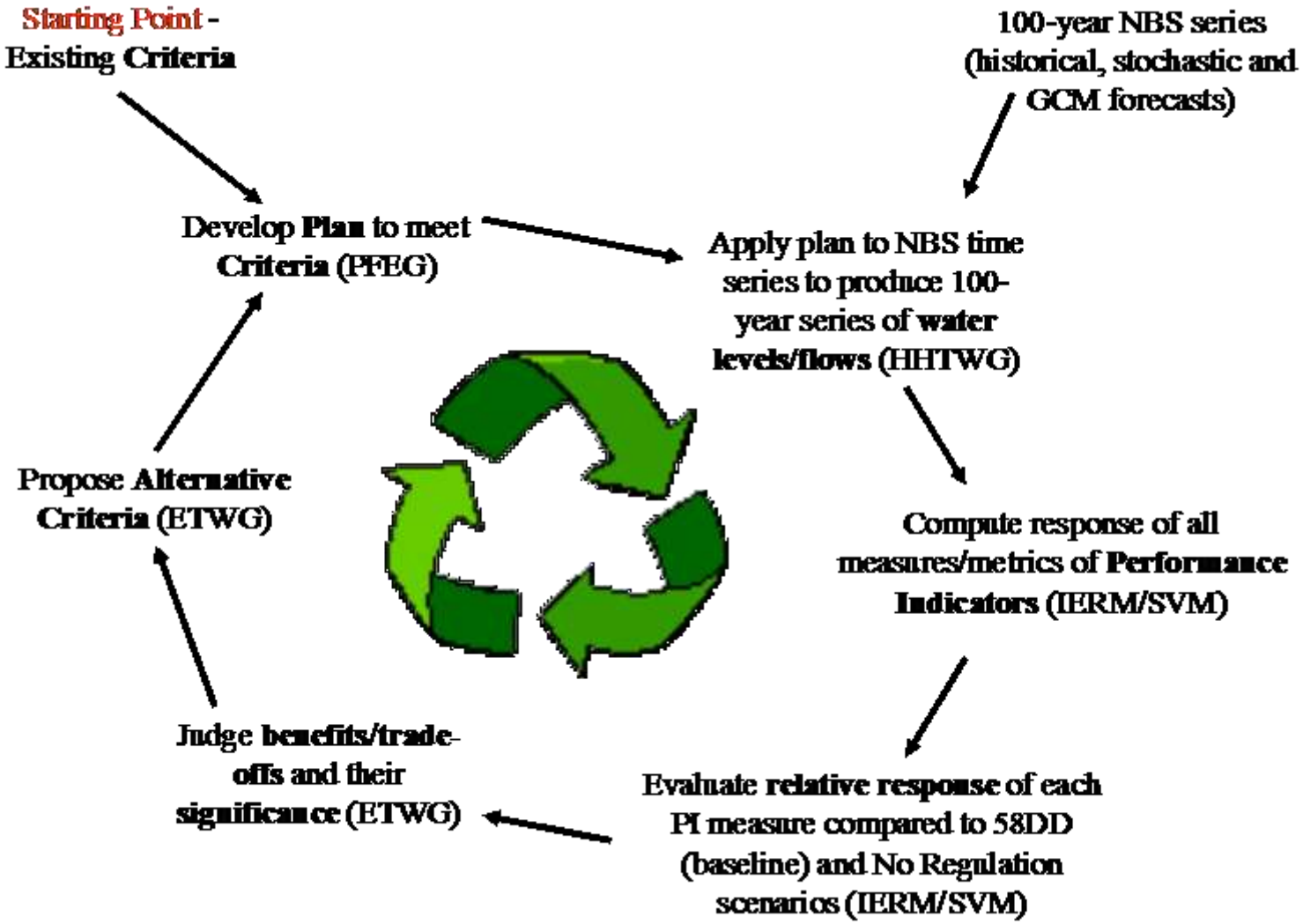
LOSL Study – Water Level and Flow Regulation



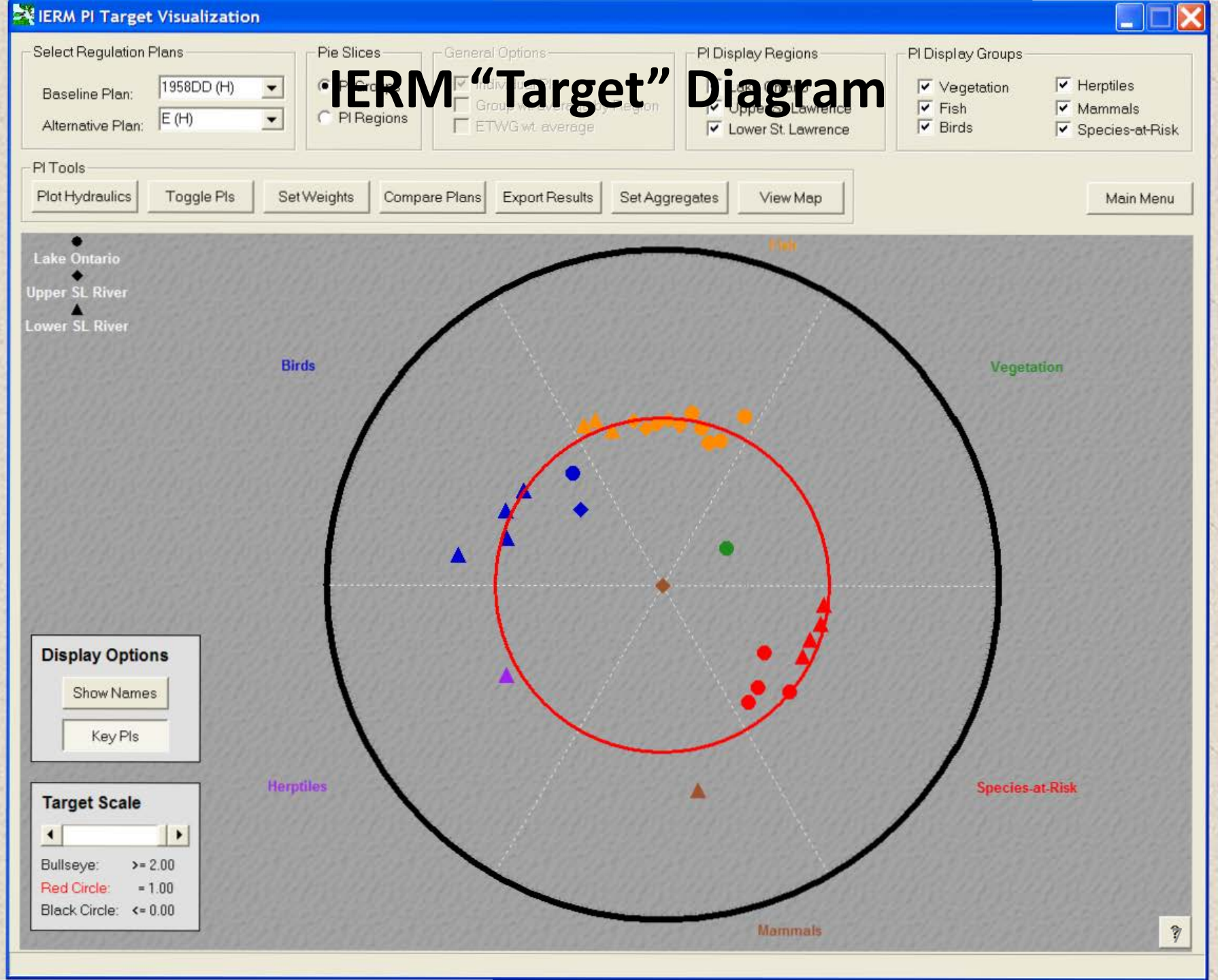
IERM Conceptual Model – LOSL Study



Iterative Process of Regulation Plan Evaluation and Design



IERM "Target" Diagram



Lessons Learned

- Ecological impacts can be integrated into system-wide models of flow and water level
  - Modelers need to work closely with biologists
- Consensus management requires an iterative process in consultation with stakeholders
  - Models need to be nimble and flexible to accomplish that

Eutrophication Modeling in Great Lakes

Late 1960's – early 1980's

Models used to establish P as limiting nutrient in Great Lakes

Models used to set targets loads for phosphorus to lakes for Annex 3 of Great Lakes Water Quality Agreement

~ 2010 to present

Recurrence of harmful algal blooms requires reassessment

Models being used to assess causes and develop new targets

Lake Erie declared "dead" in late 1960's

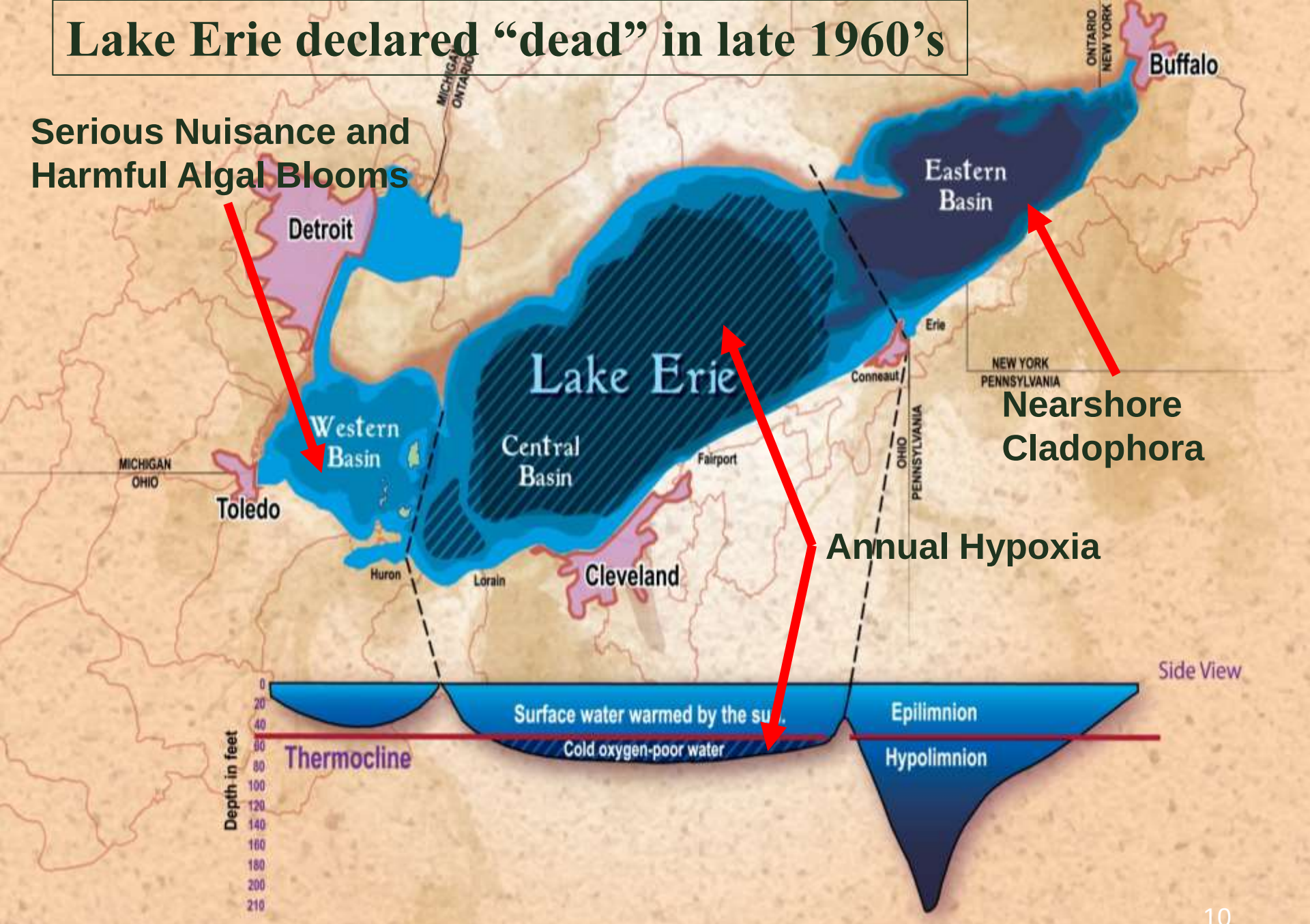


Photo: Ohio Sea Grant

Calibration (1970 data) and confirmation (1975 data) of Lake Erie Model

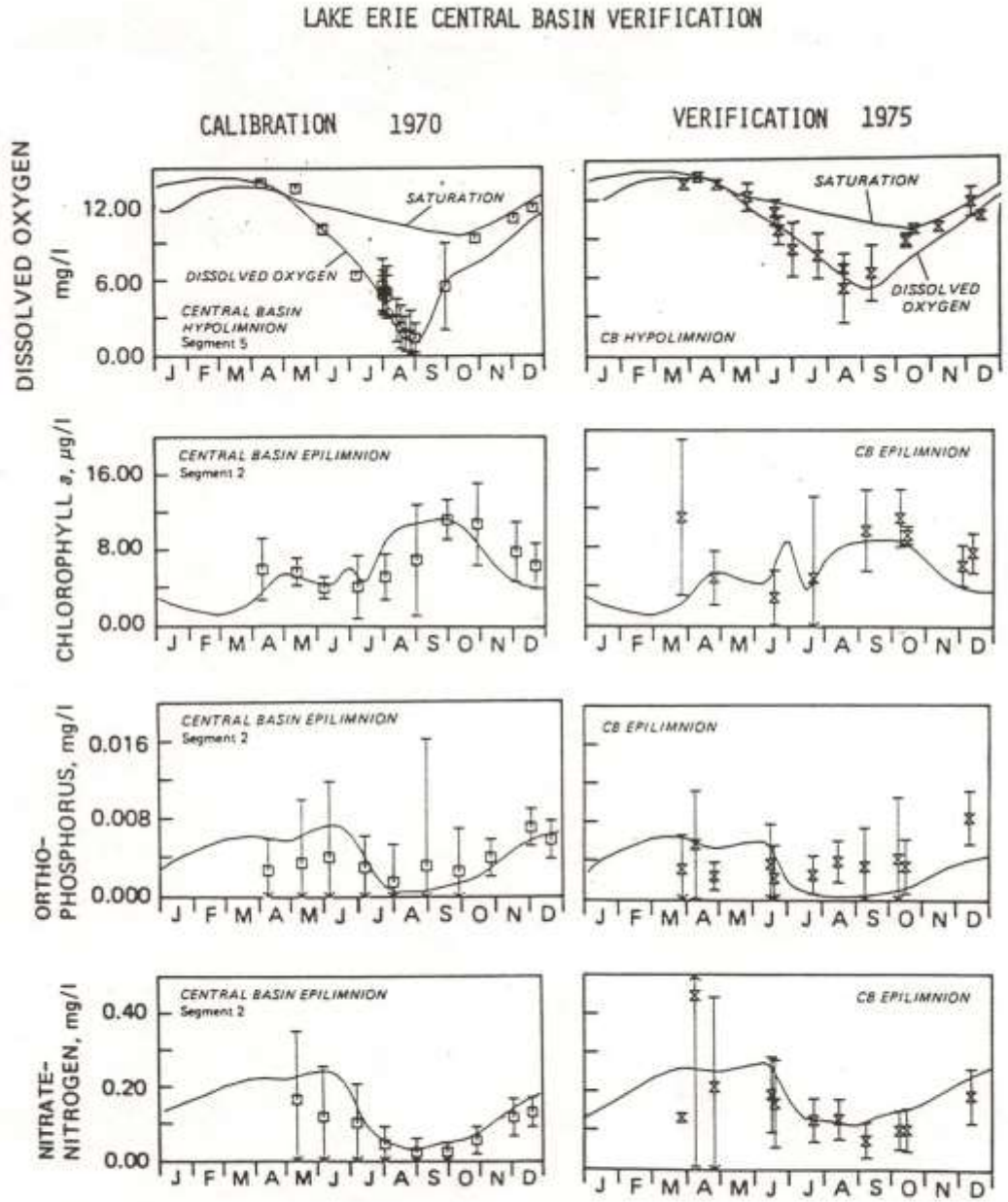


FIG. 5. Comparison of 1970 calibration (lefthand side) and 1975 verification (righthand side). Dissolved oxygen (top), chlorophyll a (upper middle), orthophosphorus (lower middle), nitrate nitrogen (bottom). Symbols mean ± standard deviation; lines are the computations.

P Load - Area of Anoxia Relationship in Central Basin

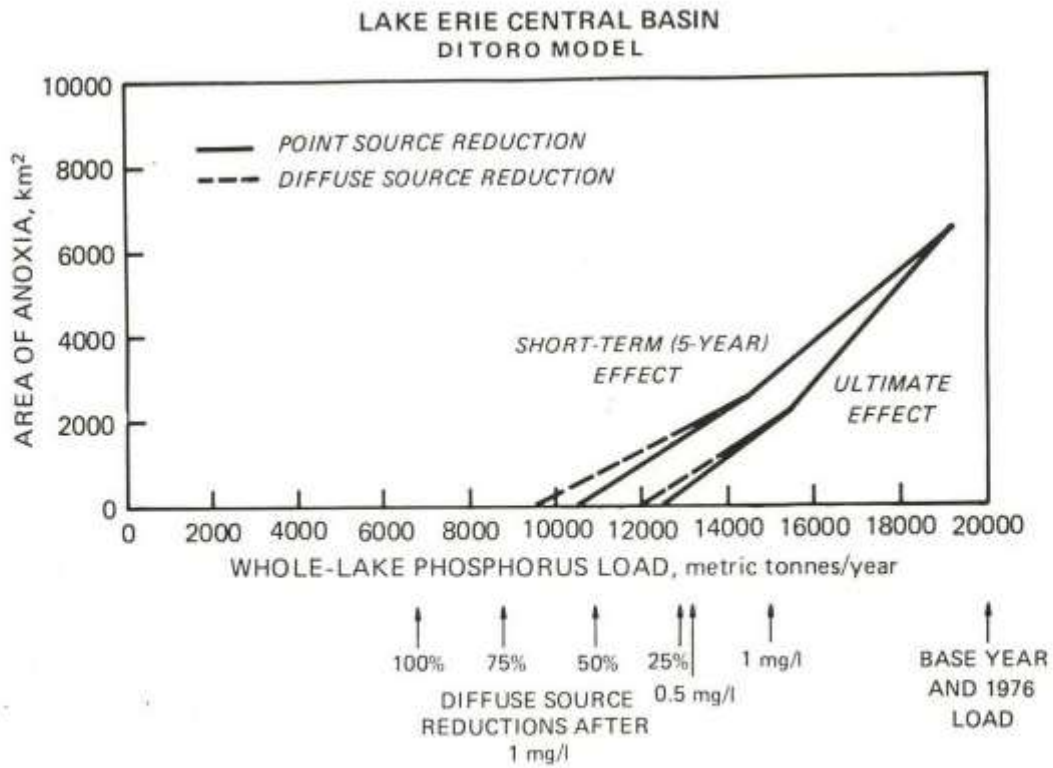


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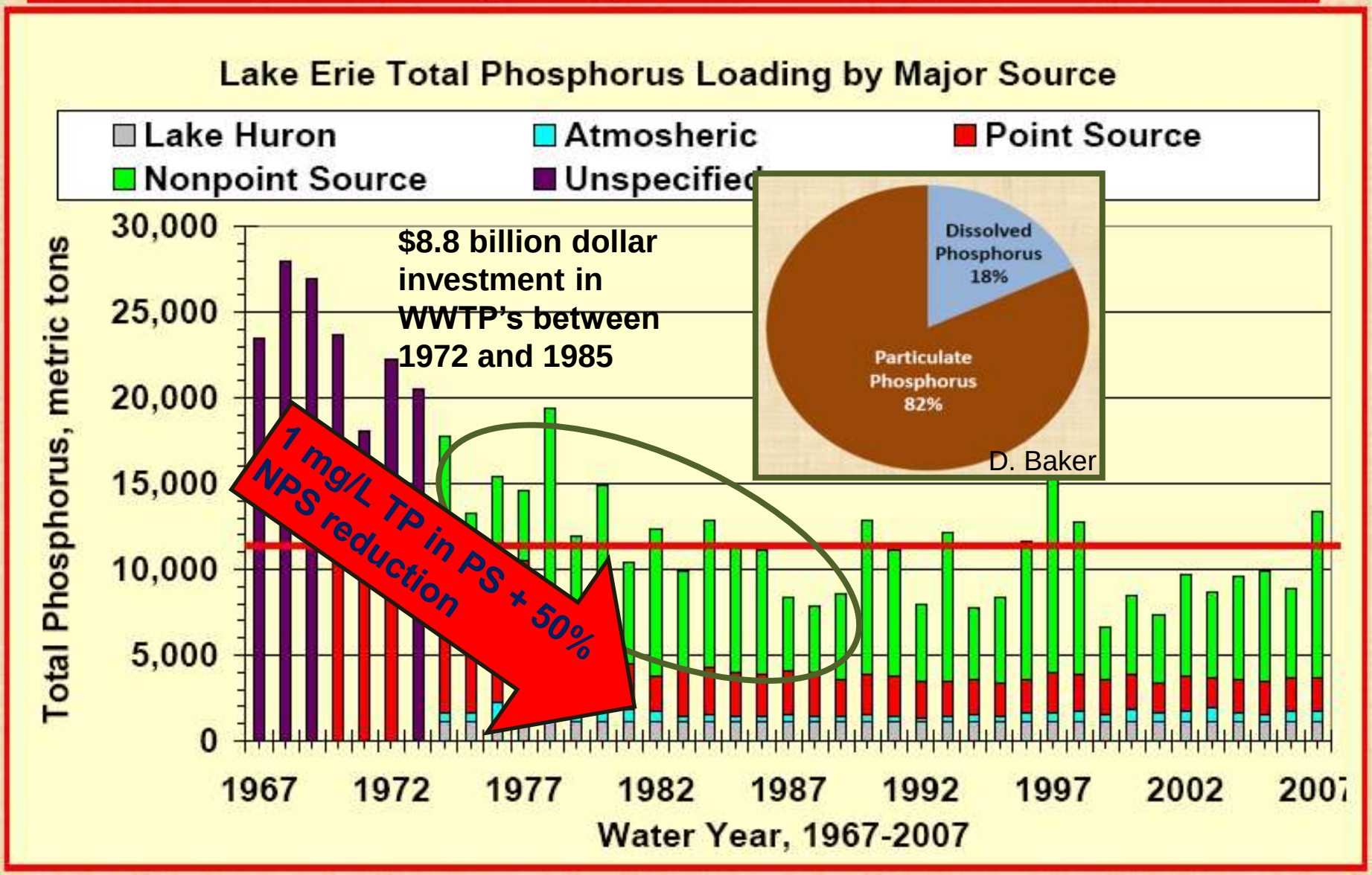
FIGURE 9

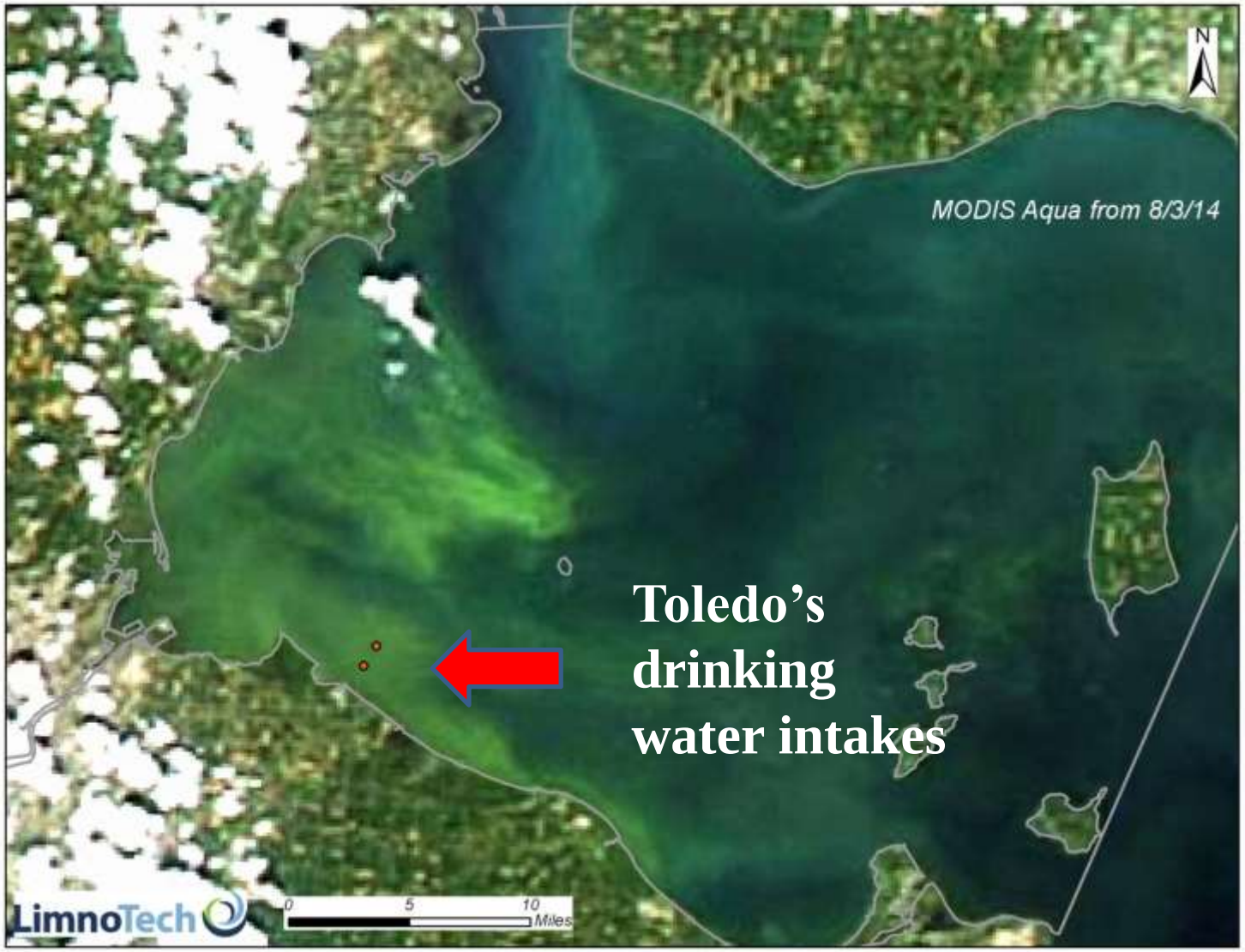
Relationship between area of anoxia and whole-lake phosphorus load in the Central Basin of Lake Erie for the DiToro model

An overview of phosphorus loading to Lake Erie



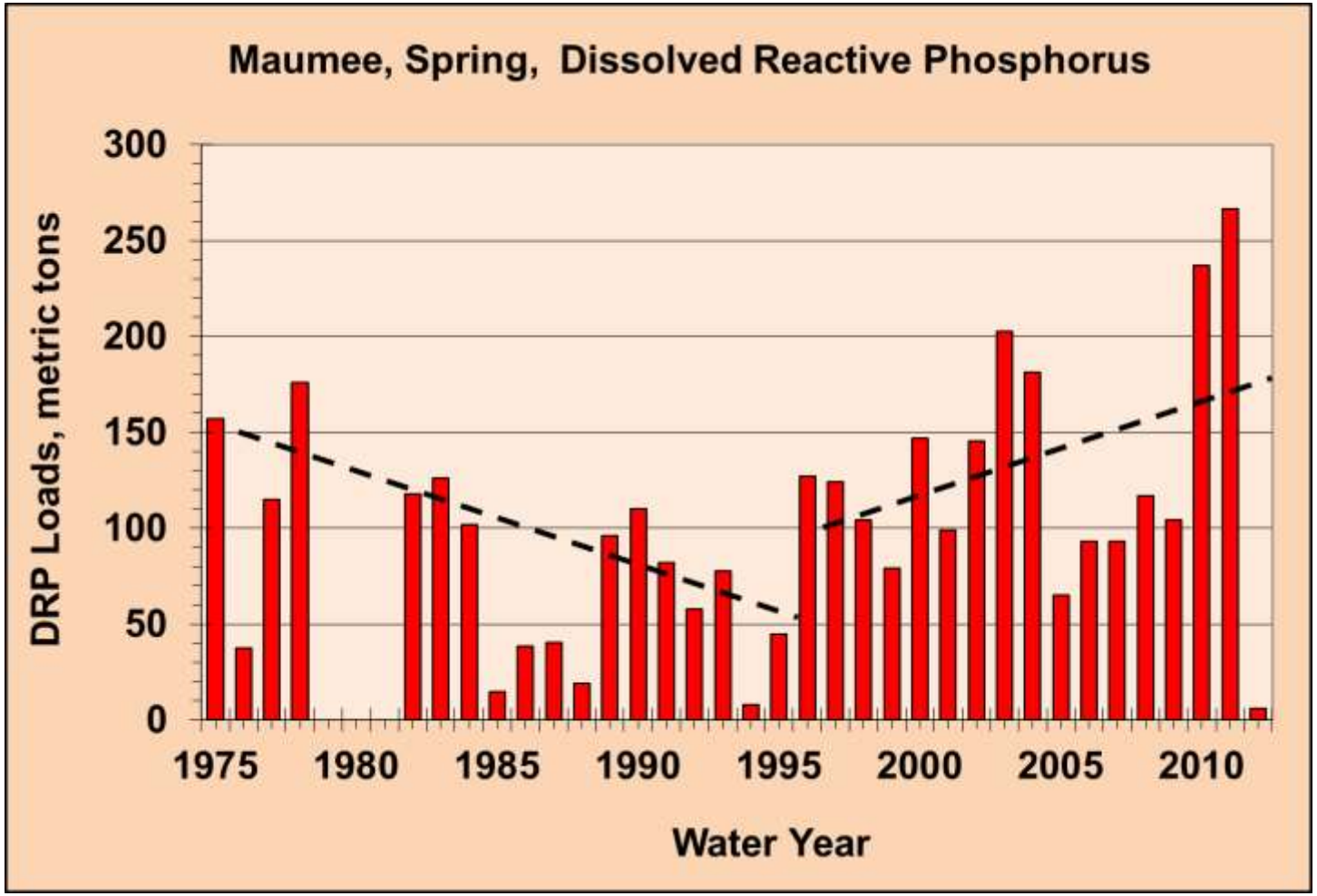
Data from Rockwell and Dolan

Re-occurrence of Harmful Algal Blooms and Nuisance Benthic Algae



Spring Maumee DRP loads

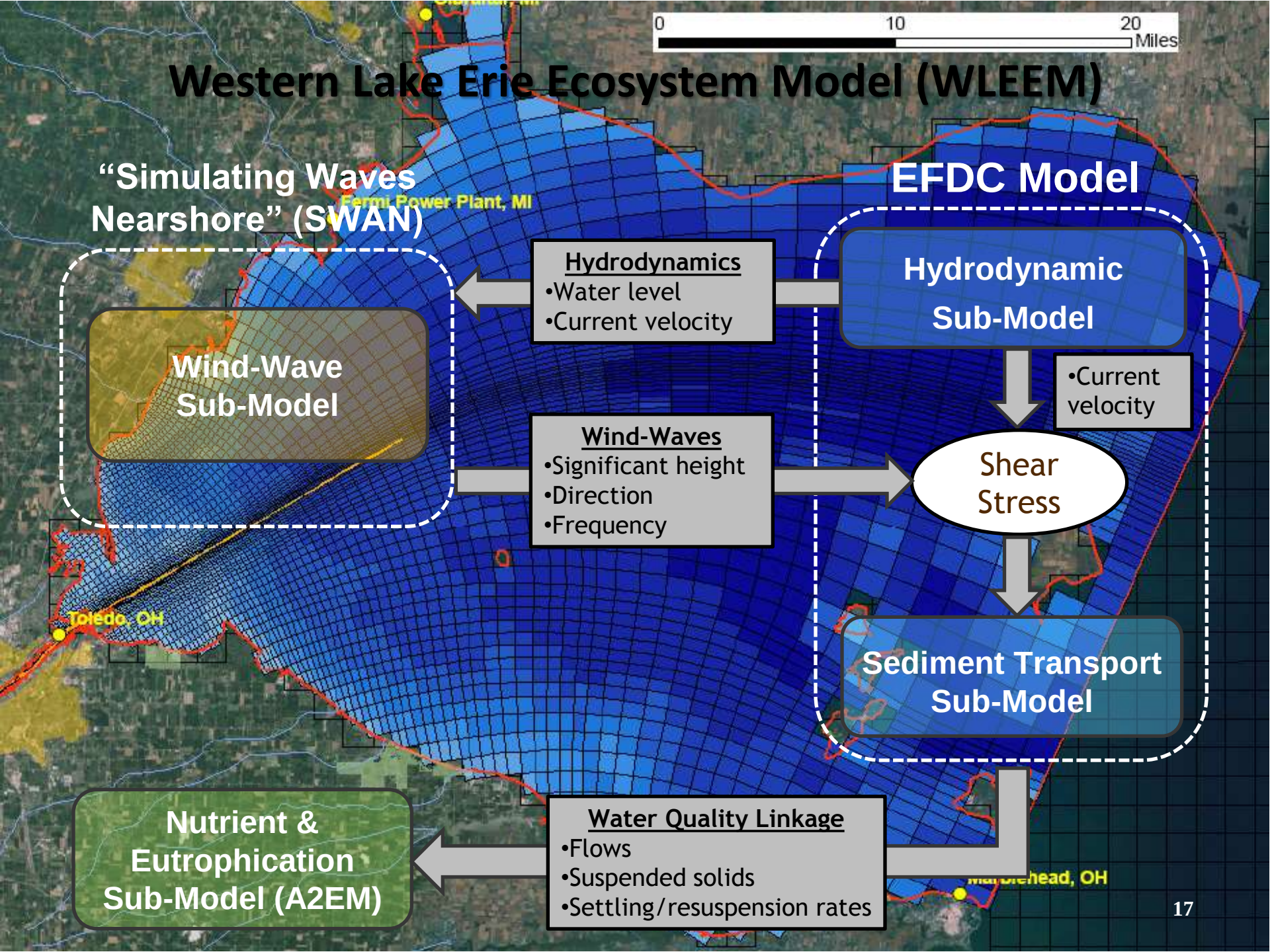
(Heidelberg University)



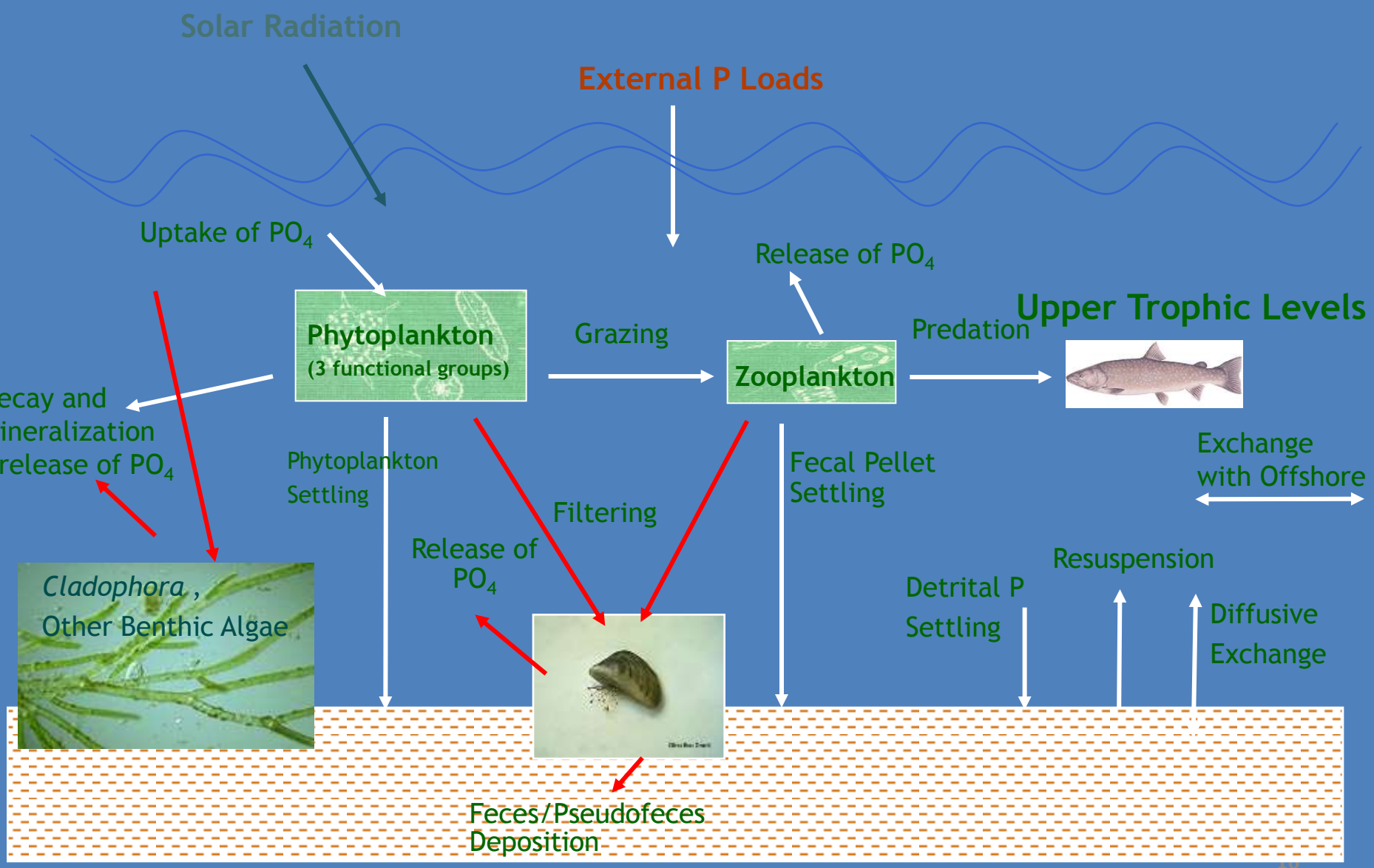
Re-Eutrophication in Great Lakes

- The Problem…
  - Re-occurrence of nearshore attached algal blooms (Cladophora, Lyngbya)
  - Re-occurrence of Hazardous Algal Blooms (Microcystis)
  - Hypoxia in the hypolimnion of the Central Basin of Lake Erie
- Potential Causes…
  - Dreissenid invasion
    - Impacts on light, plankton production, and phosphorus cycling
  - Phosphorus loading changes
    - Non-point source loads
    - Phosphorus bioavailability
- A Solution…
  - Control phosphorus loads
- But, need an assessment of how much…
  - Great Lakes Advanced Aquatic Ecosystem Model (EFDC-A2EM) framework

Western Lake Erie Ecosystem Model (WLEEM)



Phosphorus Cycling in A2EM Ecosystem



Lessons Learned

- Behavior changes and ecosystems evolve
  - Complex interactions require integrated modeling

- Models can inform adaptive management
  - Help understand what's changed
  - Help set new targets

Bay Delta Modeling Challenges

- Modeling is fragmented
  - Storage, flows modeled at system scale
    - Time scale based on water allocations (monthly)
  - Ecosystem impacts modeled more locally
    - Shorter time scales are often critical
- Scenario development
  - Challenging to iterate through alternative scenarios with existing models
  - Challenging to achieve consensus
- Adaptive Management
  - Challenging to represent climate futures with existing models

Lessons Learned – It Can Work!

- Models can help set targets to meet multiple goals. Strive for:
  - Process integration – one delta/one model
  - Tractable and flexible tools that can be used iteratively
  - Constructive engagement of stakeholders in that iterative process
- Things will change and systems will evolve on a multi-decadal scale. Integrated models can help understand those changes and support decisions to revise targets in the future.

Questions?