LEMN 2008 Conference
University of Windsor
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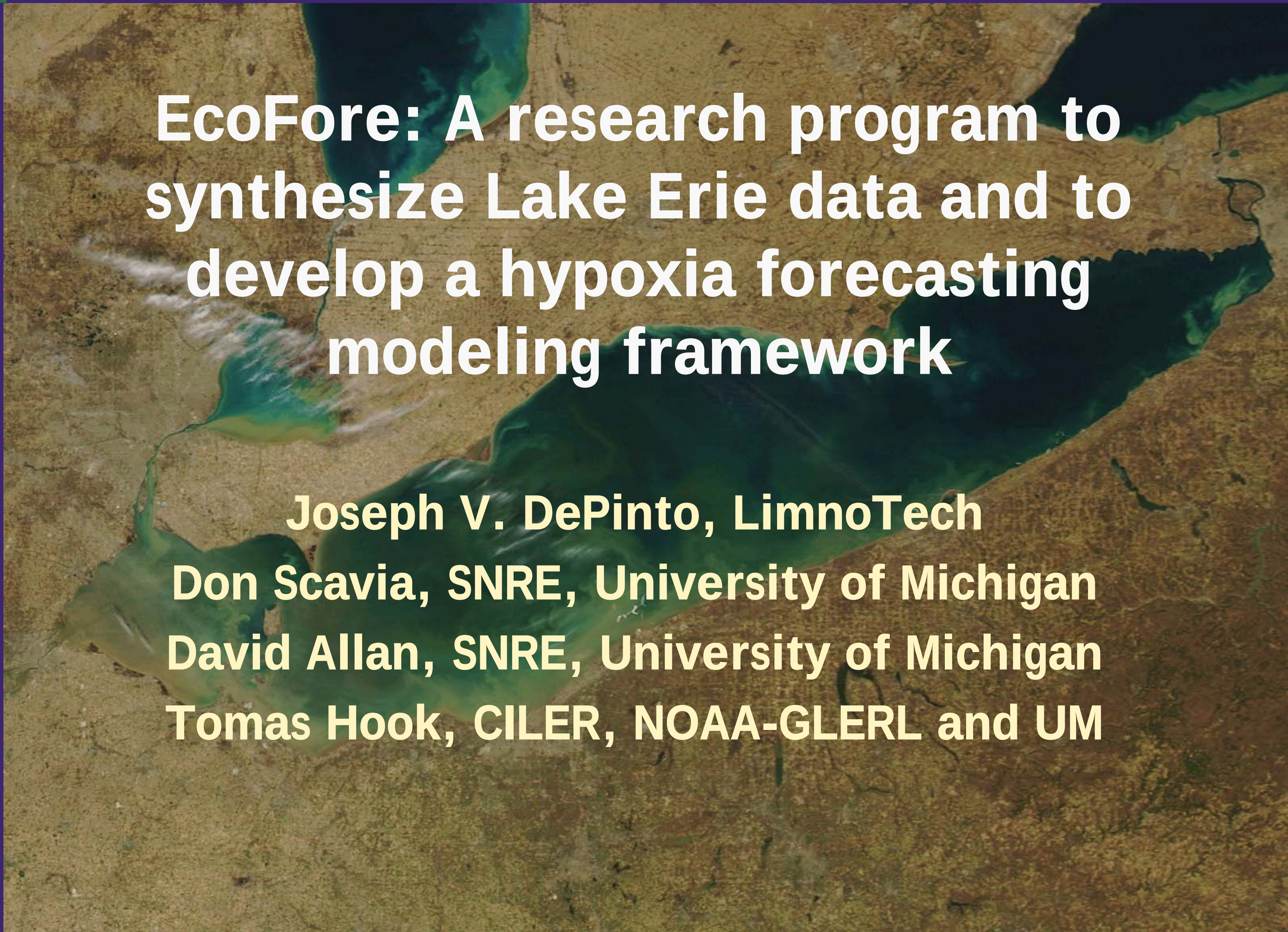


EcoFore: A research program to synthesize Lake Erie data and to develop a hypoxia forecasting modeling framework

Joseph V. DePinto, LimnoTech

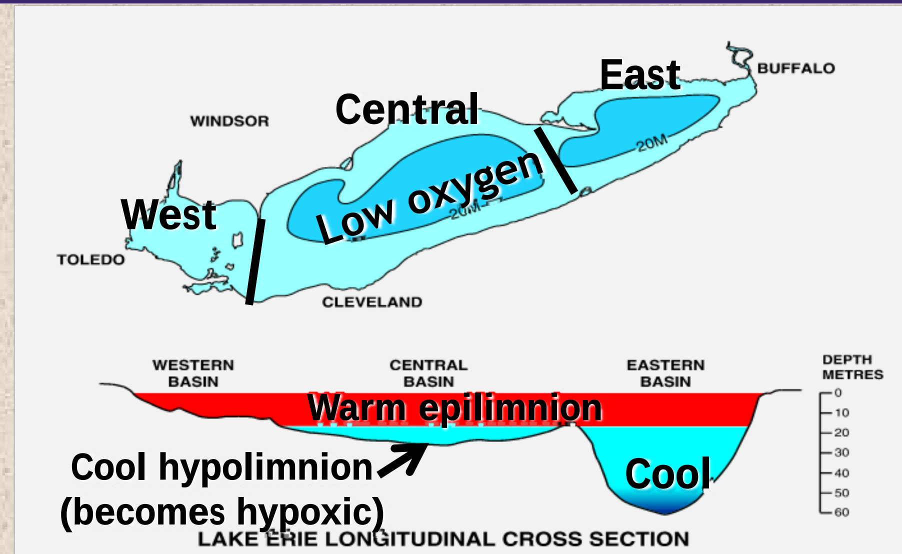
Don Scavia, SNRE, University of Michigan

David Allan, SNRE, University of Michigan

Tomas Hook, CILER, NOAA-GLERL and UM

EcoFore Motivation

- Field observation and research on <u>hypoxia</u> in central basin – LETS, IFYLE, EPA, EC

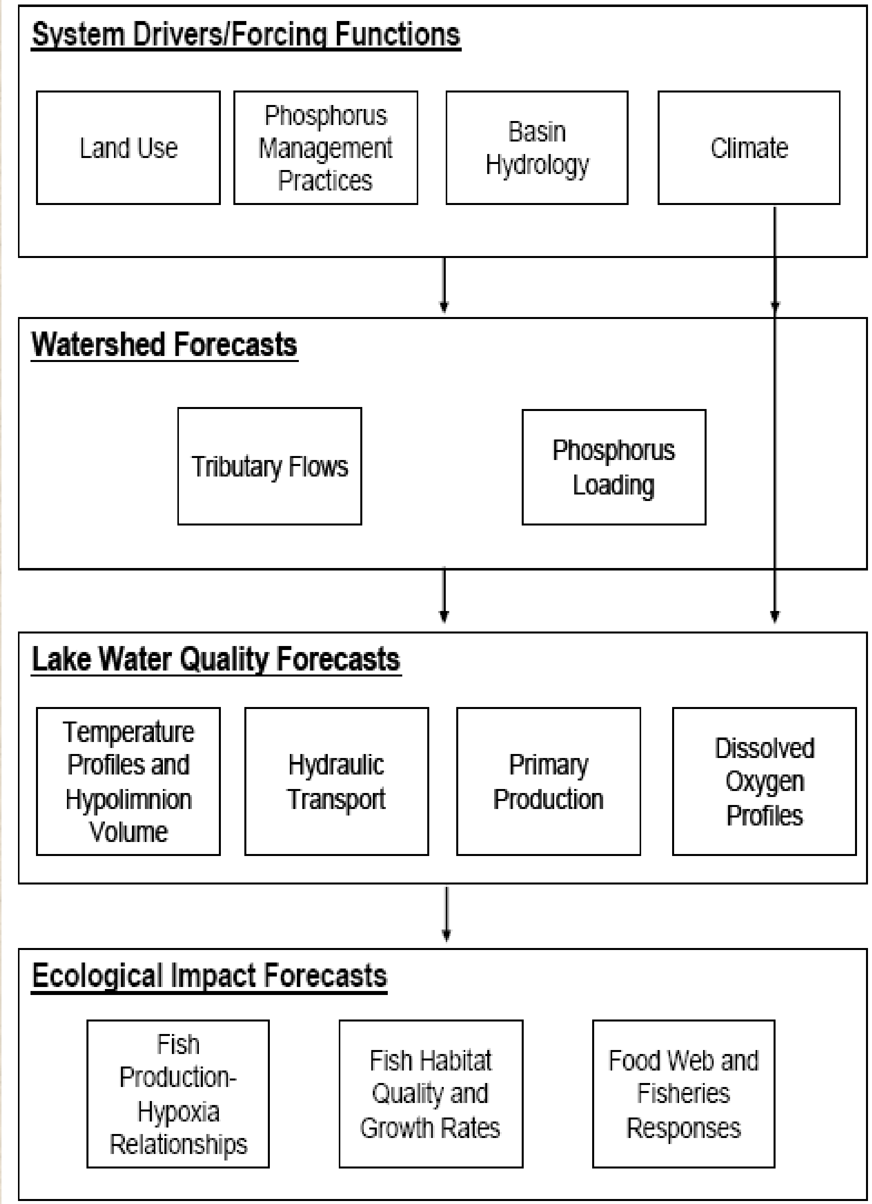


Source: Murray Charlton, NWRI

- Re-occurrence of HABs and nearshore nuisance attached algae

Ecosystem Forecasting of Lake Erie Hypoxia

- **What are the *Causes*, *Consequences*, and *Potential Remedies* of Lake Erie Hypoxia?**
- **Linked set of models to forecast:**
  - **changes in nutrient loads to Lake Erie**
  - **responses of central basin hypoxia to multiple stressors**
    - P loads, hydrometeorology, dreissenids
  - **potential ecological responses to changes in hypoxia**
- **Approach**
  - **Models with range of complexity**
  - **Consider both anthropogenic and natural stressors**
  - **Use available data – IFYLE, LETS, etc.**
  - **Will assess uncertainties in both drivers and models**
  - **Apply models within an Integrated Assessment framework to inform decision making for policy and management**



Lake Erie EcoFore Team

- **Watershed Modeling**
  - David Allan, UM - Lead
  - David Dolan, UWGB
  - Pete Richards, Heidelberg
  - Tom Croley, GLERL
  - Chansheng He, WMU
- **Hypoxia Modeling**
  - Don Scavia, UM – PI, co-lead
  - Joe DePinto, LTI – co-lead
  - Dmitry Beletsky, GLERL-UM
  - Dave Schwab, GLERL
  - Tom Johengen, UM
  - Steve Ruberg, GLERL
- **Ecological Effects Modeling**
  - Tomas Hook, GLERL-UM - Lead
  - Larissa Sano, UM
  - Stuart Ludsin, OSU
  - Ed Rutherford, UM
  - Steve Bartell, E2 Consulting
  - Doran Mason, NOAA-AOML
  - Steve Brandt, GLERL
  - Henry Vanderploeg, GLERL
- **Management Partners**
  - Roger Knight, ODNR
  - Paul Horvatin, EPA-GLNPO
  - David Rockwell, EPA-GLNPO

I. Watershed Loading

1) Estimate TP loads for all tributaries
   - Data from Heidelberg College, point sources
   - Examine sensitivity of loads to hydrologic variation

2) Quantify mass balance estimates for watersheds
   - Construct P budgets
   - Develop time sequence of P loadings
   - Compare inputs to exports

3) Evaluate conservation practices
   - Statistical analysis
   - Watershed agricultural estimates
   - Correlations between conservation and nutrient loading

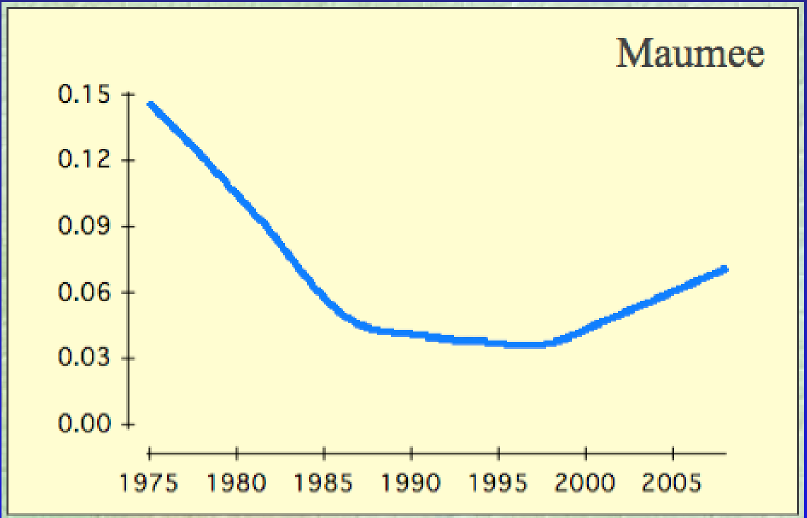
4) Develop models of hydrology and nutrient export
   - Soil and Water Assessment Tool (SWAT)
   - Distributed Large Basin Runoff Model (DLBRM)

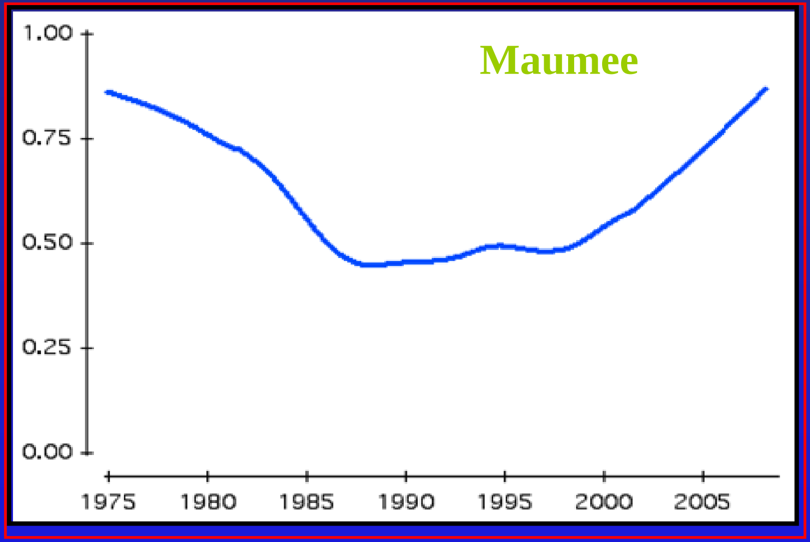
-inputs for hypoxia models

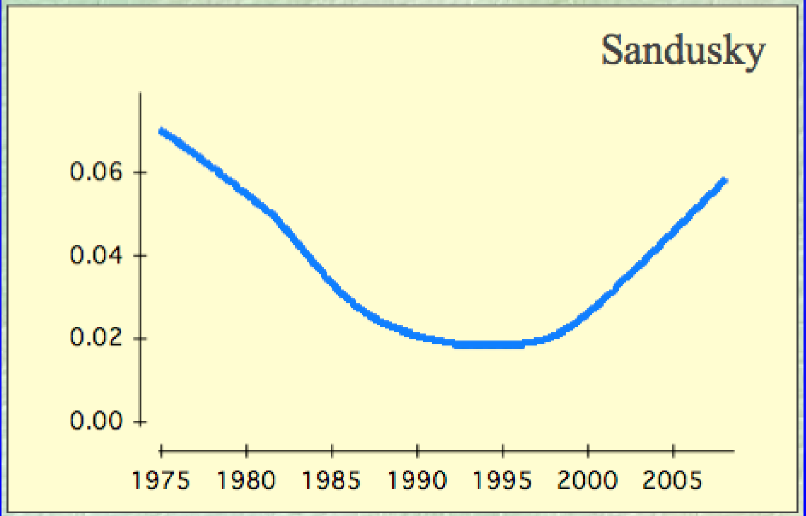
Heidelberg WQL Data for SRP, 1975-2007

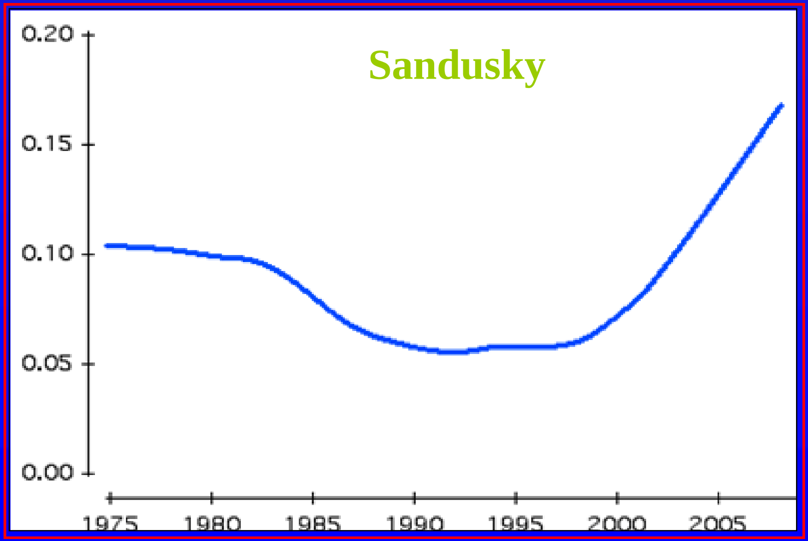
Ave. Daily Conc., mg/L

Ave. Daily Load, metric tons/day





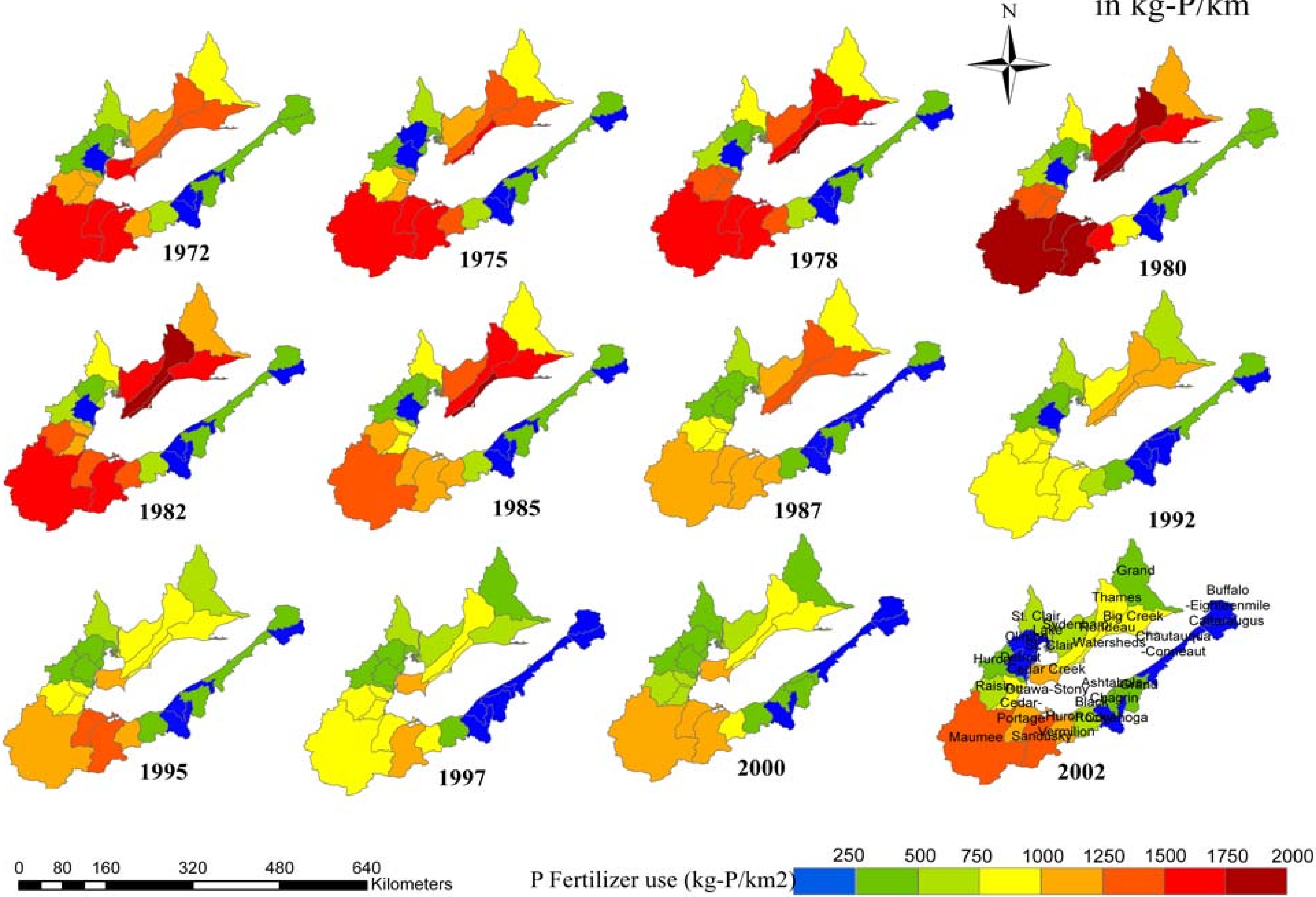




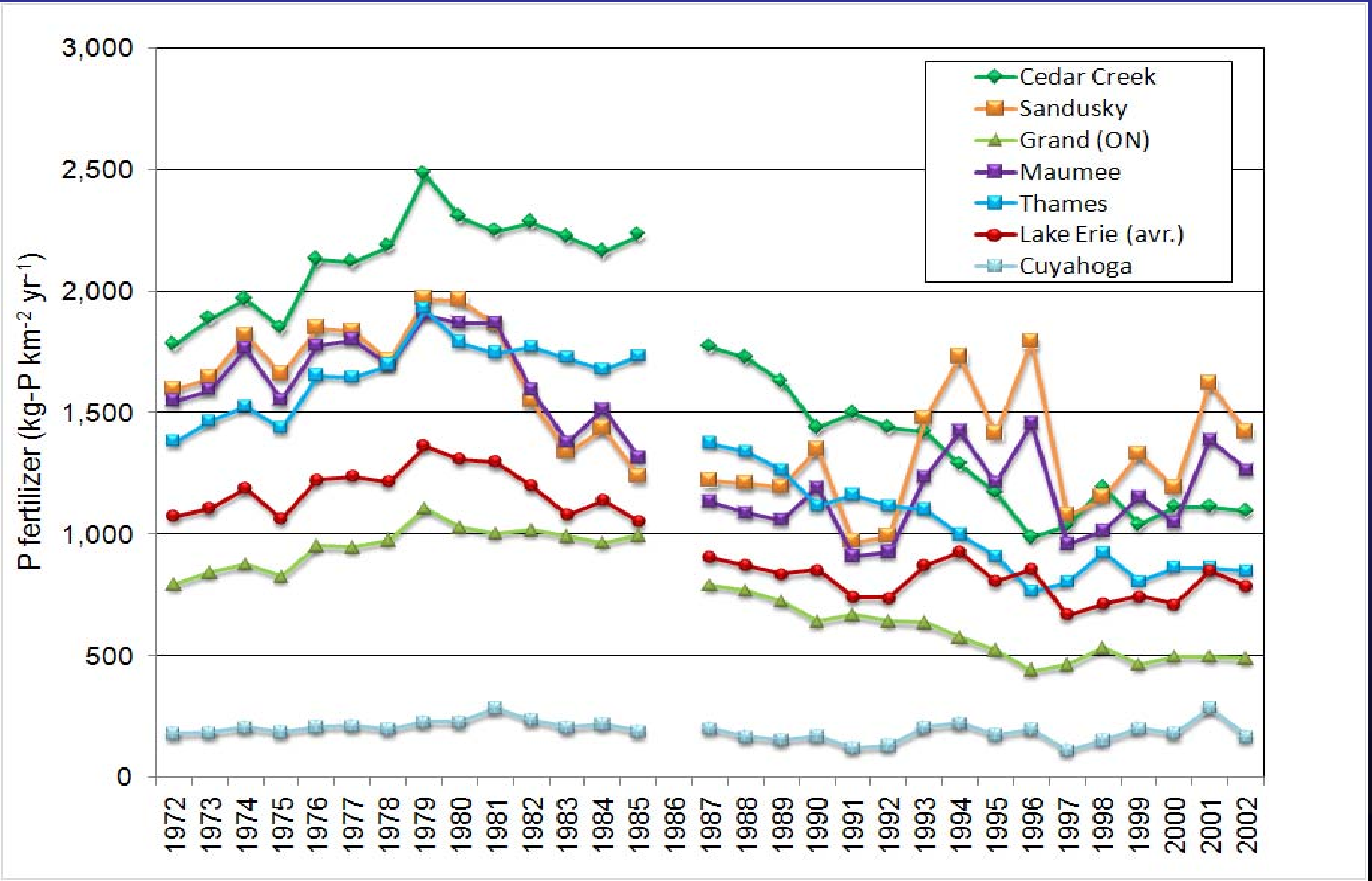
Study sites: 24 Lake Erie watersheds

P Fertilizer use for the Lake Erie watersheds from 1972 to 2002

in kg-P/km^2



Historical trend in annual P fertilizer input to selected watersheds and the entire LEB from 1972 to 2002



II. Hypoxia Forecasting Modeling Approaches

Models ranging in complexity

- <u>1D hydrodynamics with DO consumption rates</u>
  - Vertical thermal and mixing profiles from hydrodynamic model
  - DO mass lost from water column and sediment demand
- <u>1D hydrodynamics with simple mechanistic WQ model</u>
  - TP, Carbon, Solids mechanisms driven by central basin concentrations as boundary conditions
- <u>1D hydrodynamics with simple mechanistic WQ model</u>
  - TP, Carbon, Solids mechanisms driven by basin loads
- <u>3D hydrodynamics with complex mechanistic WQ model</u>
  - Advanced eutrophication model framework linked to and run at same scale as hydrodynamic model
  - Multi-class phyto- and zooplankton, organic and inorganic nutrients, sediment digenesis, etc
  - Addition of zebra mussels

-inputs for effects models

Calibrated Model Performance

-SOD = 0.75 g/m2/d

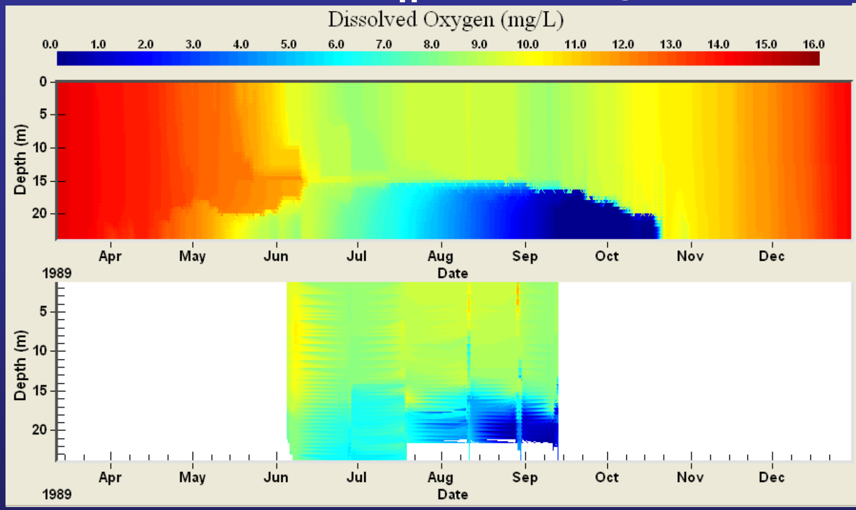
-WCOD$_e$ = 0.0 g/m3/d

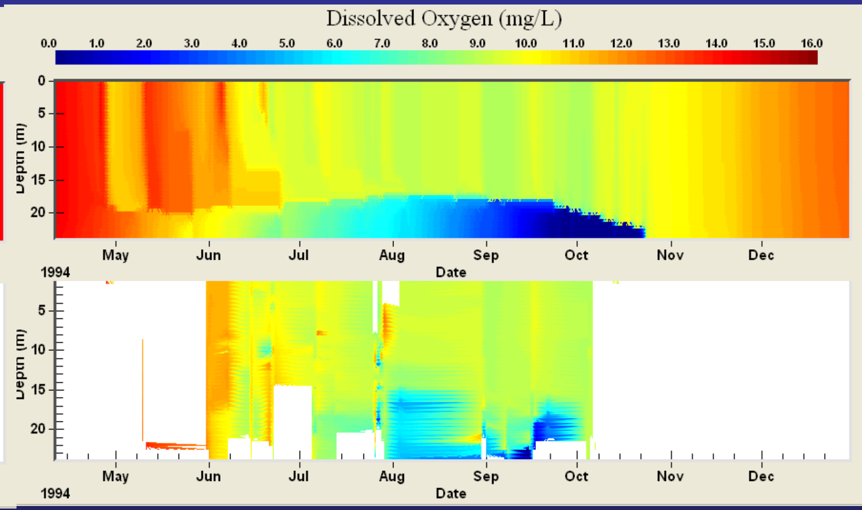
1989 WCOD$_h$ = 0.06 g/m^3/d

1994 WCOD$_h$ = 0.002 g/m^3/d

Model

Data



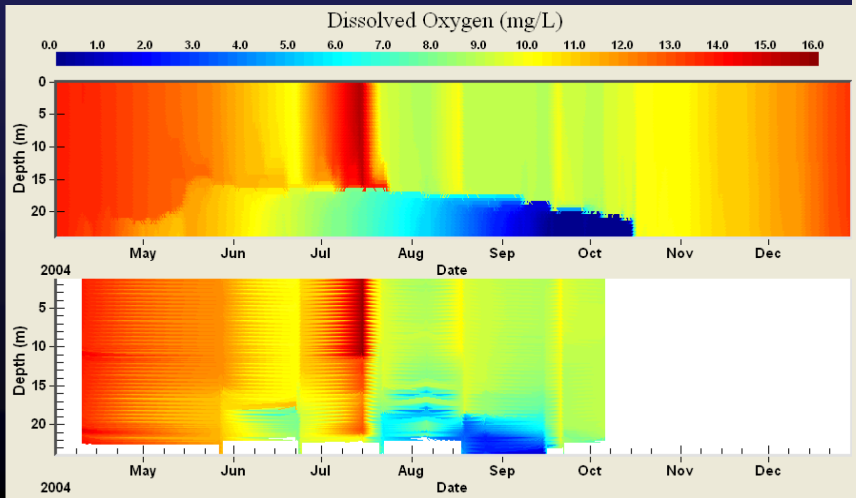


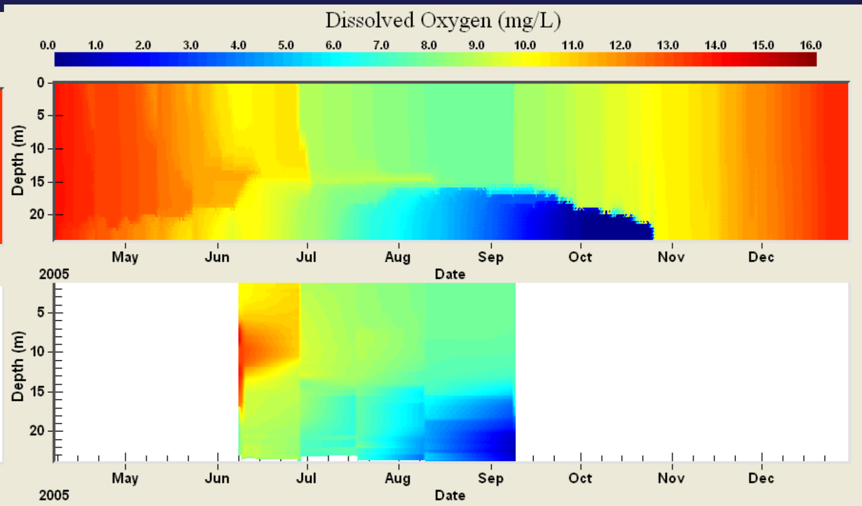
2004 WCOD$_h$ = 0.020 g/m^3/d

2005 WCOD$_h$ = 0.030 g/m^3/d

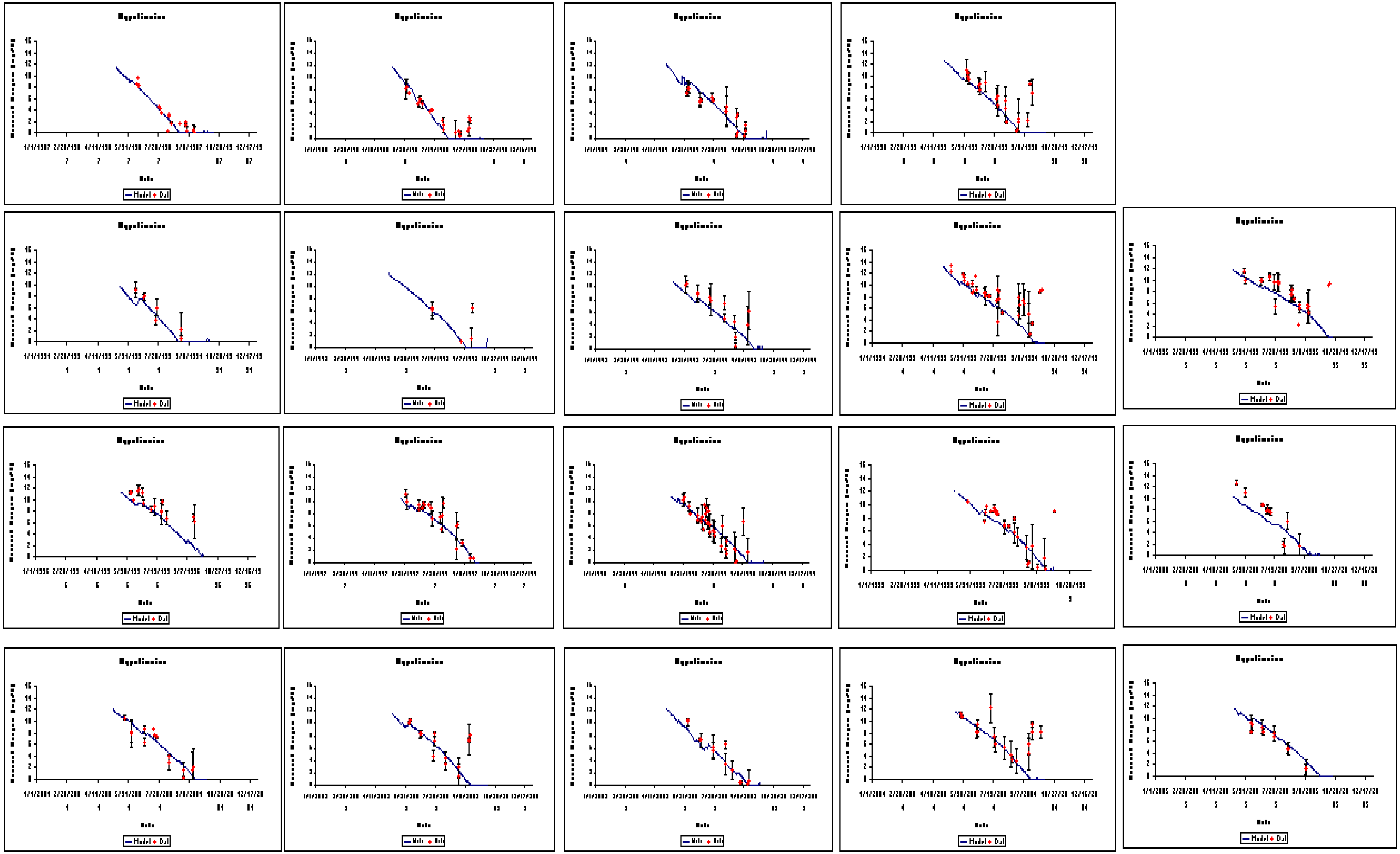
Model

Data



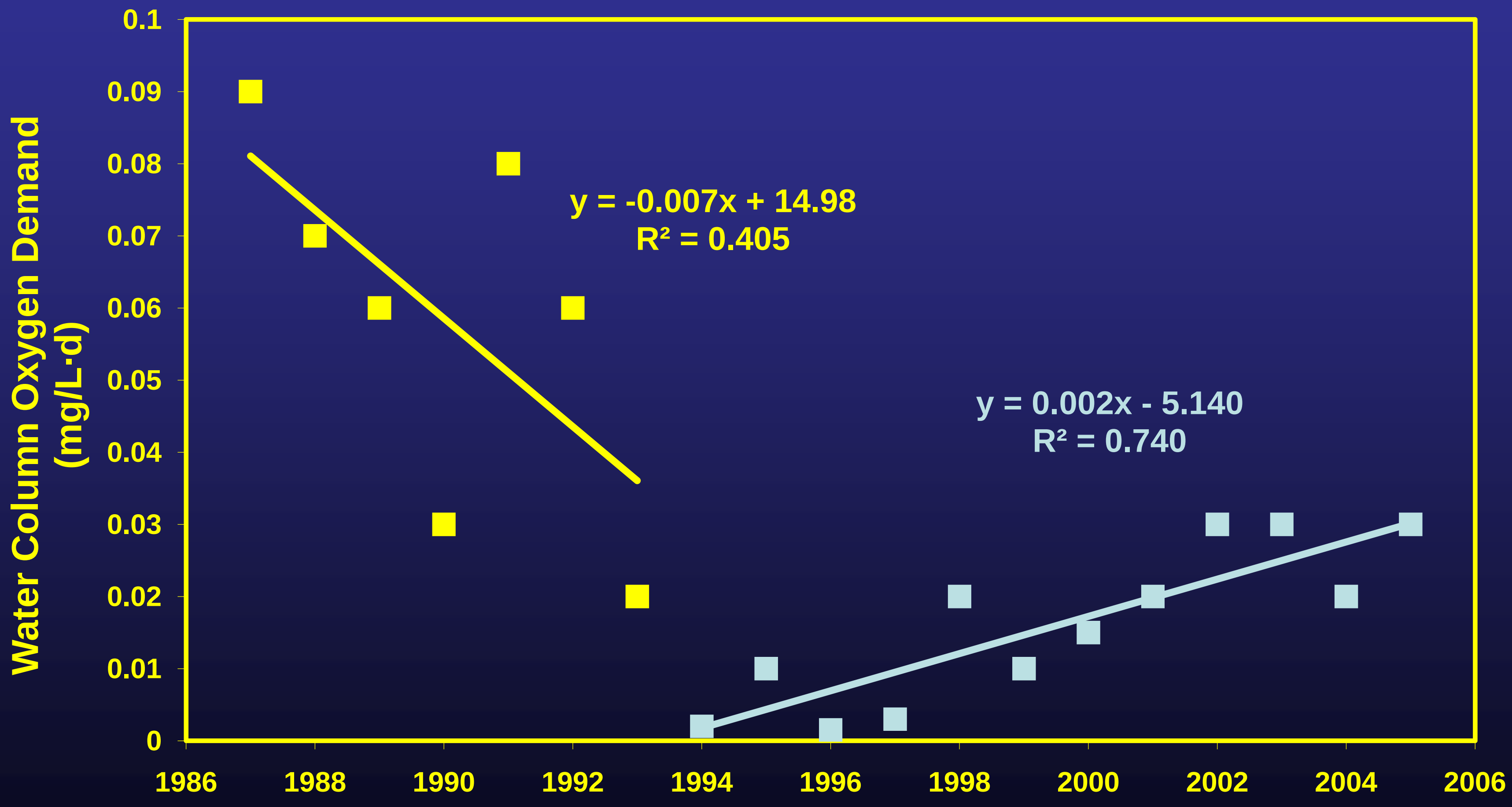


1D Simple Dissolved Oxygen Model



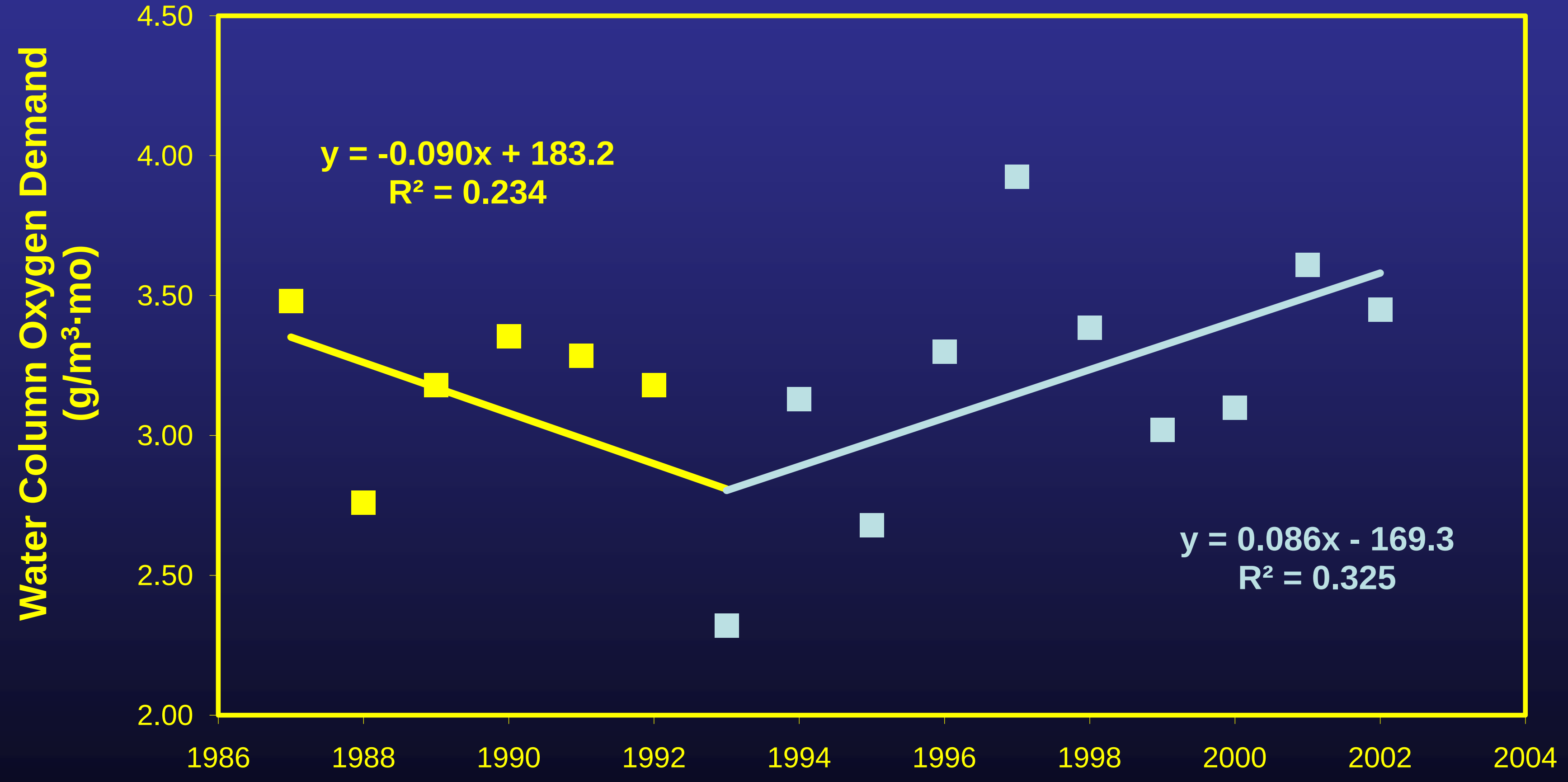
Central Basin Oxygen Depletion Rate

1D Model Calibration of Annual Hypolimnetic Deoxygenation Rate (Rucinski et al. (in prep))



Central Basin Oxygen Depletion Rate

D. Rockwell, GLNPO, using Rosa and Burns (1987)



III. Ecological Effects

Objective: develop forecasts that managers can use to guide fisheries policies in response to anticipated hypoxia impacts.

Ensemble of Models

- *Statistical models*
- *Bioenergetics-based population models*
  - *Growth Rate Potential (GRP)*
  - *IBM (Individual Based Bioenergetics)*
- *Food-web models*
  - *Comprehensive Aquatic Simulation Model (CASM)*
  - *EcoPath with EcoSim and EcoSpace*

Growth rate potential models (GRP)

Bioenergetic Growth Rate Potential (GRP; g g^{-1} day^{-1}):

Expected daily growth rate of a fish placed in a volume of water with known conditions:

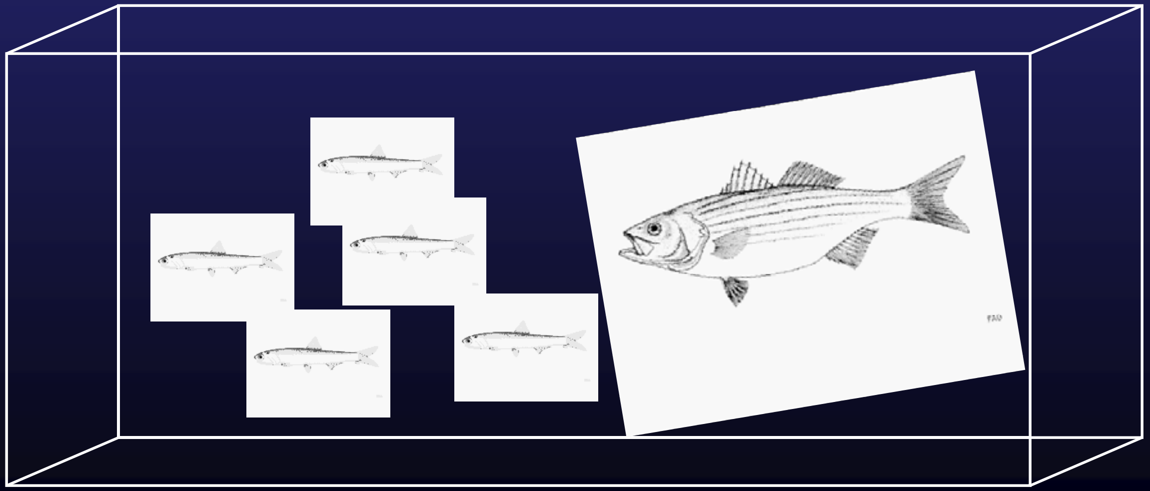
Potential input variables:

prey density (prey type, prey size)

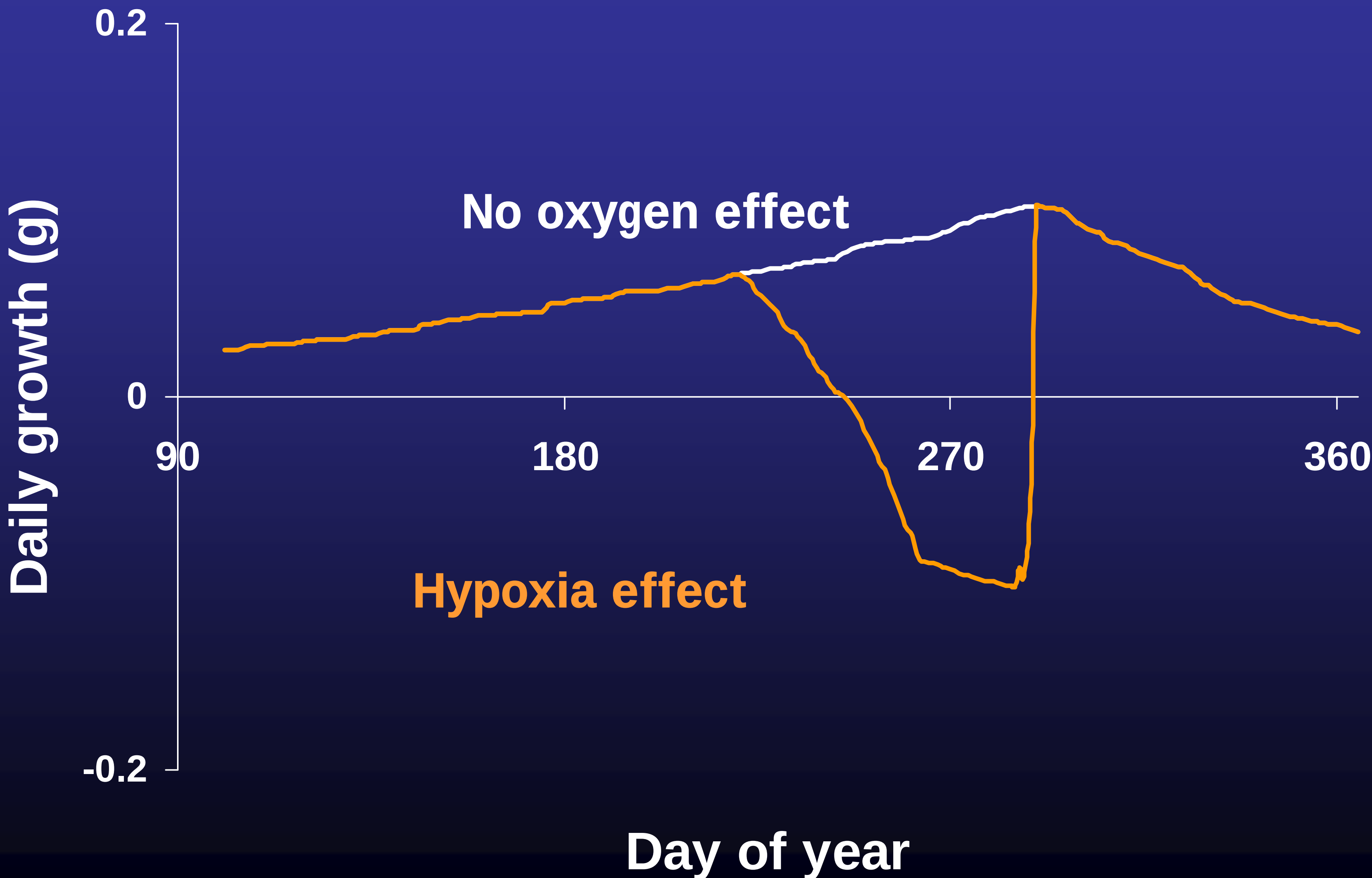
temperature

oxygen

light



Daily growth potential of 10-g yellow perch in hypolimnion of offshore Lake Erie during 1994



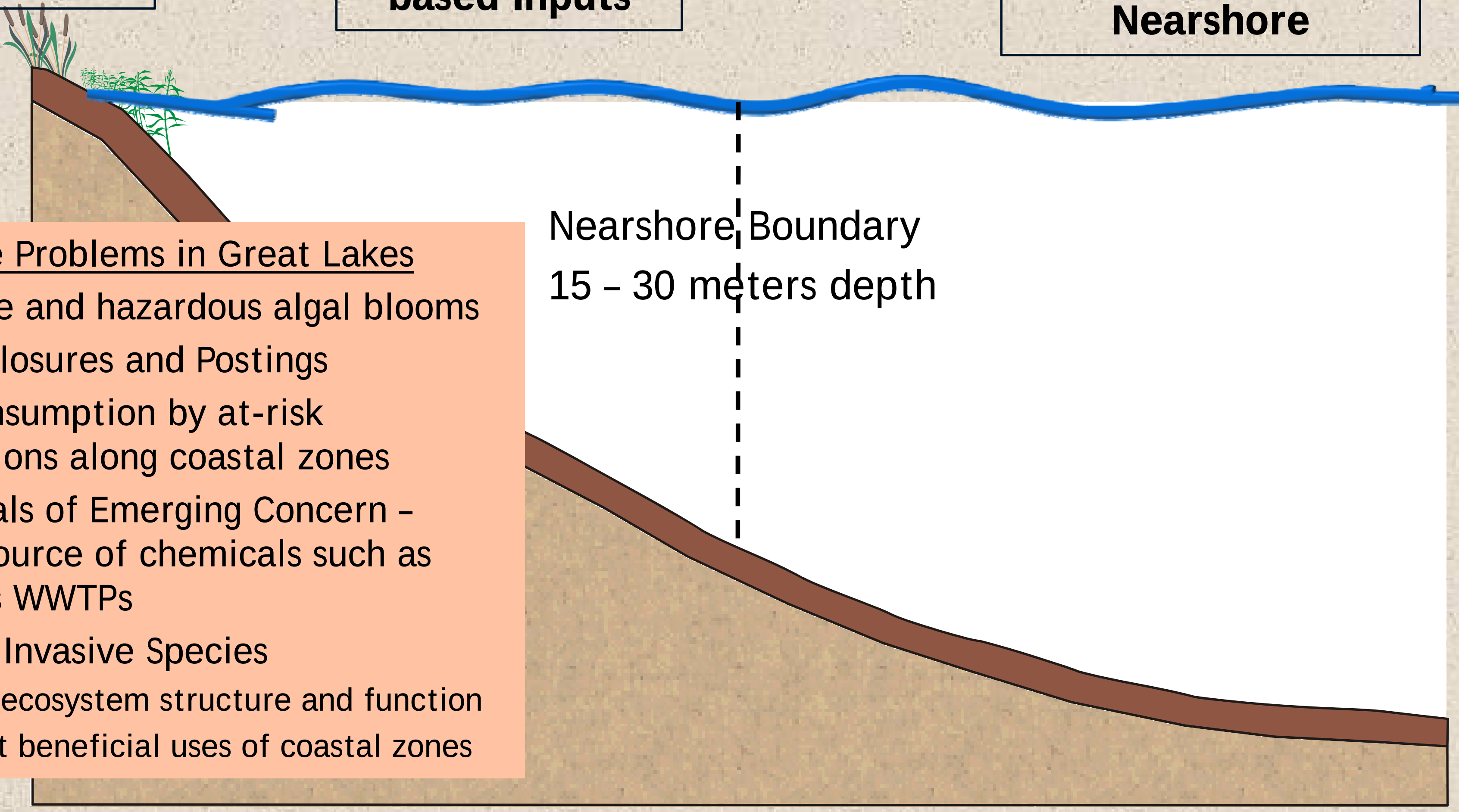
3D Modeling Analysis Provides Opportunity to Analyze Nearshore Problems

Watershed
Inflows, Runoff
Material Loads

Nearshore
Production and Cycling of Land-based Inputs

Material and Biota Exchange

Offshore
Production and Cycling of Material Transported from Nearshore



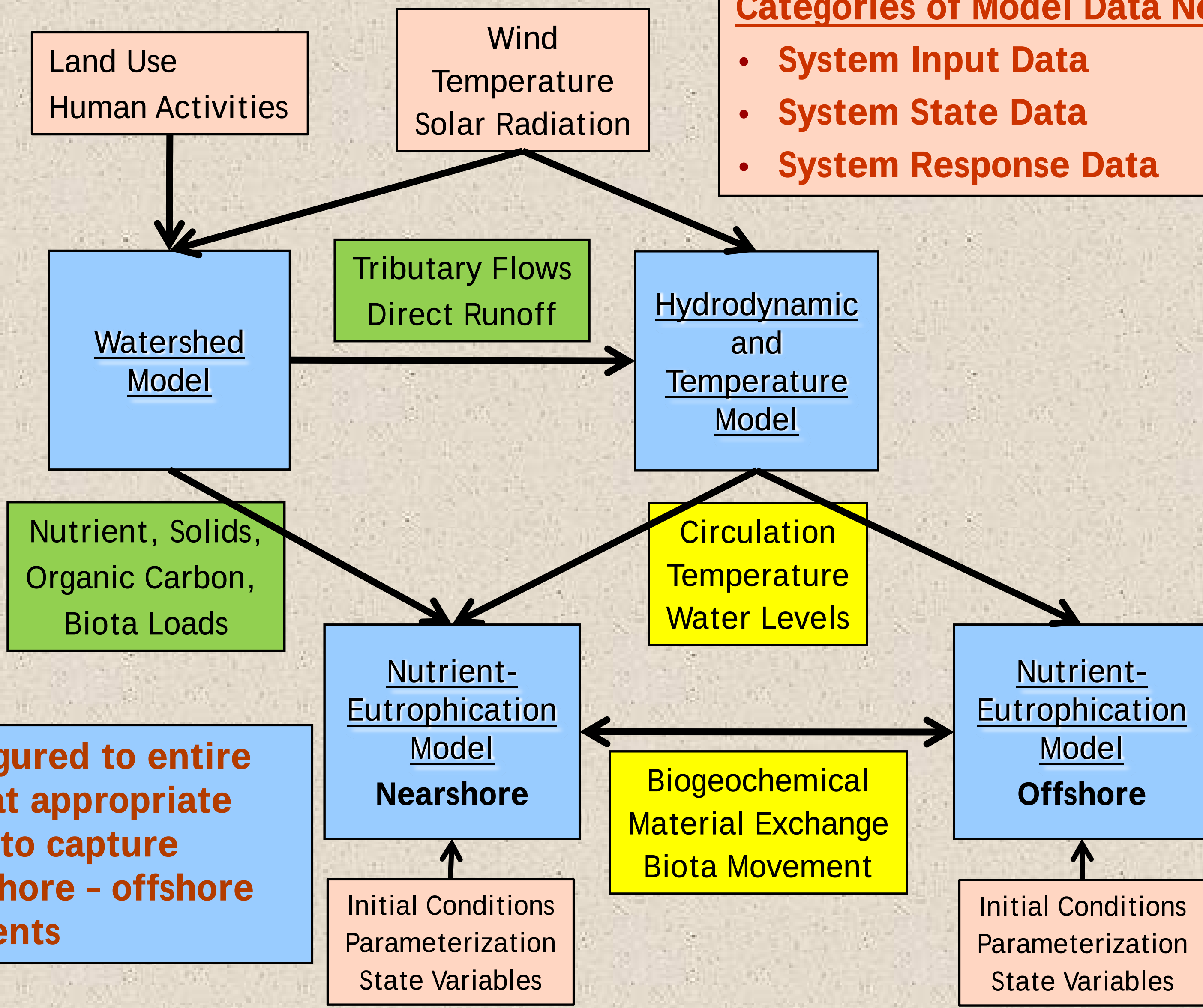
Nearshore Problems in Great Lakes

- Nuisance and hazardous algal blooms
- Beach Closures and Postings
- Fish Consumption by at-risk populations along coastal zones
- Chemicals of Emerging Concern – major source of chemicals such as PPCPs is WWTPs
- Aquatic Invasive Species
  - Alter ecosystem structure and function
  - Affect beneficial uses of coastal zones

Data Needs for 3D Eutrophication Models

Categories of Model Data Needs:

- **System Input Data**
- **System State Data**
- **System Response Data**



Configured to entire lake at appropriate scale to capture nearshore - offshore gradients

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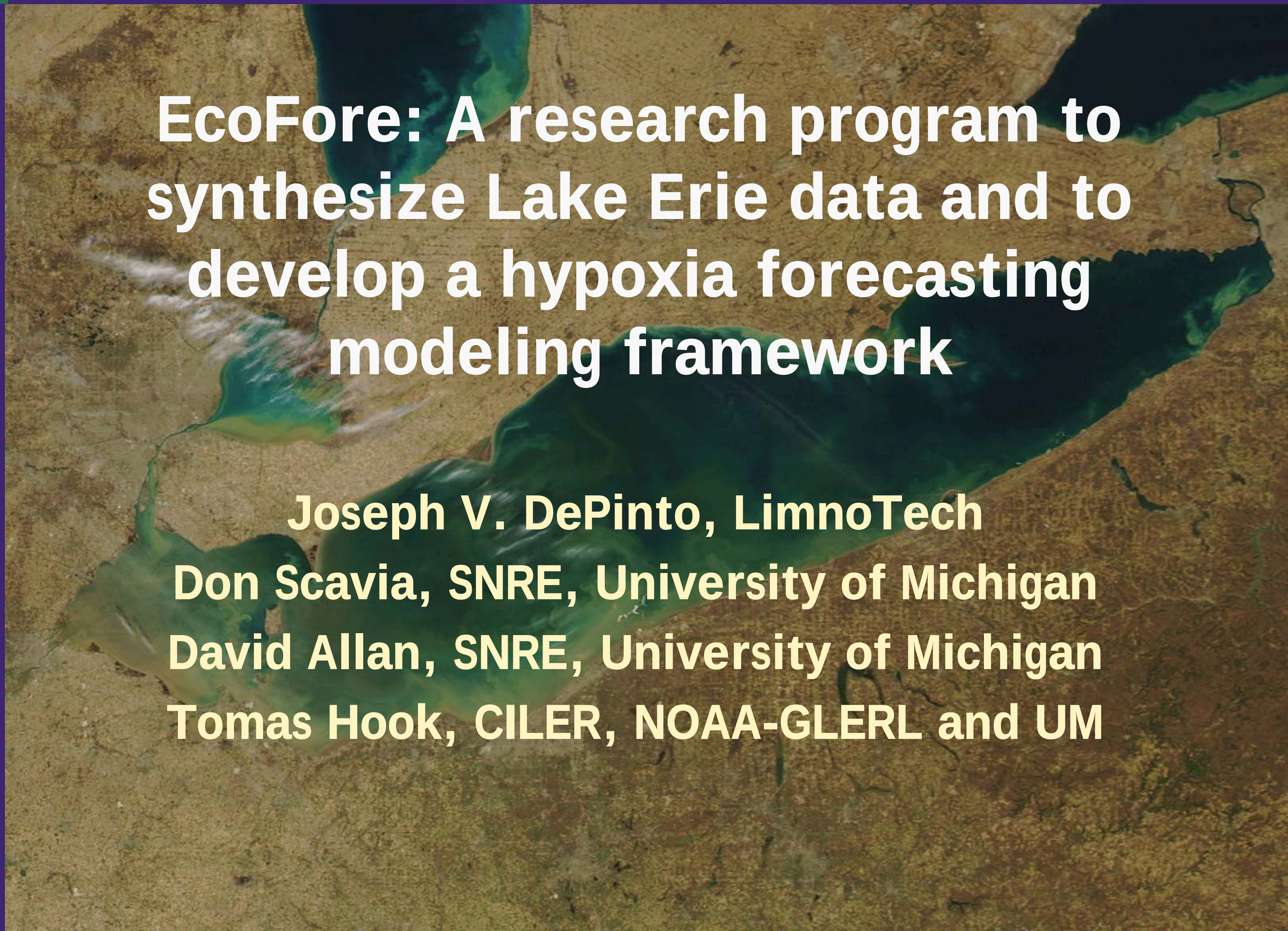

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