Assessment of Nutrient/Eutrophication Dynamics in Western Lake Erie

Thomas Bridgeman
Gerald Matisoff
Richard Becker
Kenneth Gibbons
John Bratton
Edward Verhamme
Sandra Kosek-Sills

Great Lakes RESTORATION

Collaborators

Proposed Response to HABs:
Reduce external P loading by 40%

RECOMMENDED BINATIONAL PHOSPHORUS TARGETS TO COMBAT LAKE ERIE ALGAL BLOOMS

GREAT LAKES WATER QUALITY AGREEMENT NUTRIENTS ANNEX SUBCOMMITTEE — JUNE 2015

Proposed Binational Phosphorus Load Reduction Targets

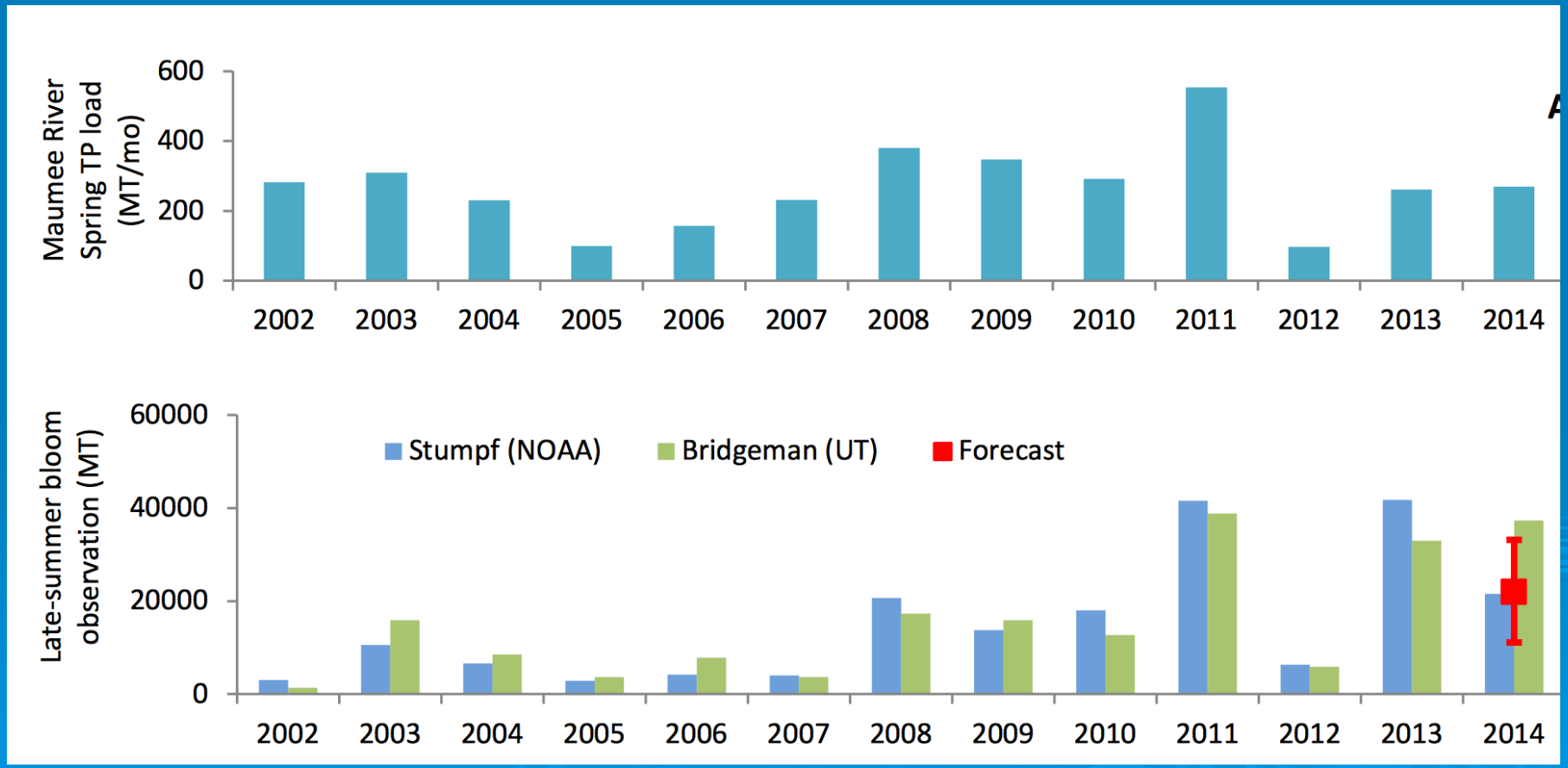
Lake Ecosystem Objectives Great Lakes Water Quality Agreement Annex 4, Section B	**Western Basin of Lake Erie**	**Central Basin of Lake Erie**
Minimize the extent of hypoxic zones in the Waters of the Great Lakes associated with excessive phosphorus loading, with particular emphasis on Lake Erie	40 percent reduction in total phosphorus entering the Western Basin and Central Basin of Lake Erie – from the United States and from Canada – to achieve 6000 MT Central Basin load	
Maintain algal species consistent with healthy aquatic ecosystems in the nearshore Waters of the Great Lakes	40 percent reduction in spring total and soluble reactive phosphorus loads from the following watersheds where localized algae is a problem:	
	Thames River - Canada Maumee River - U.S. River Raisin - U.S. Portage River - U.S. Toussaint Creek - U.S. Leamington Tributaries – Canada	Sandusky River - U.S. Huron River, OH – U.S.

USEPA

The Nagging Questions:

- Even if external loading is reduced by 40% or more
  - Will we still continue to have large HABs for years or decades because of recycling of P from Lake Sediments?
- Climate Change
  - Will it work for us or against us?

The ‘Natural Experiment’ of 2012



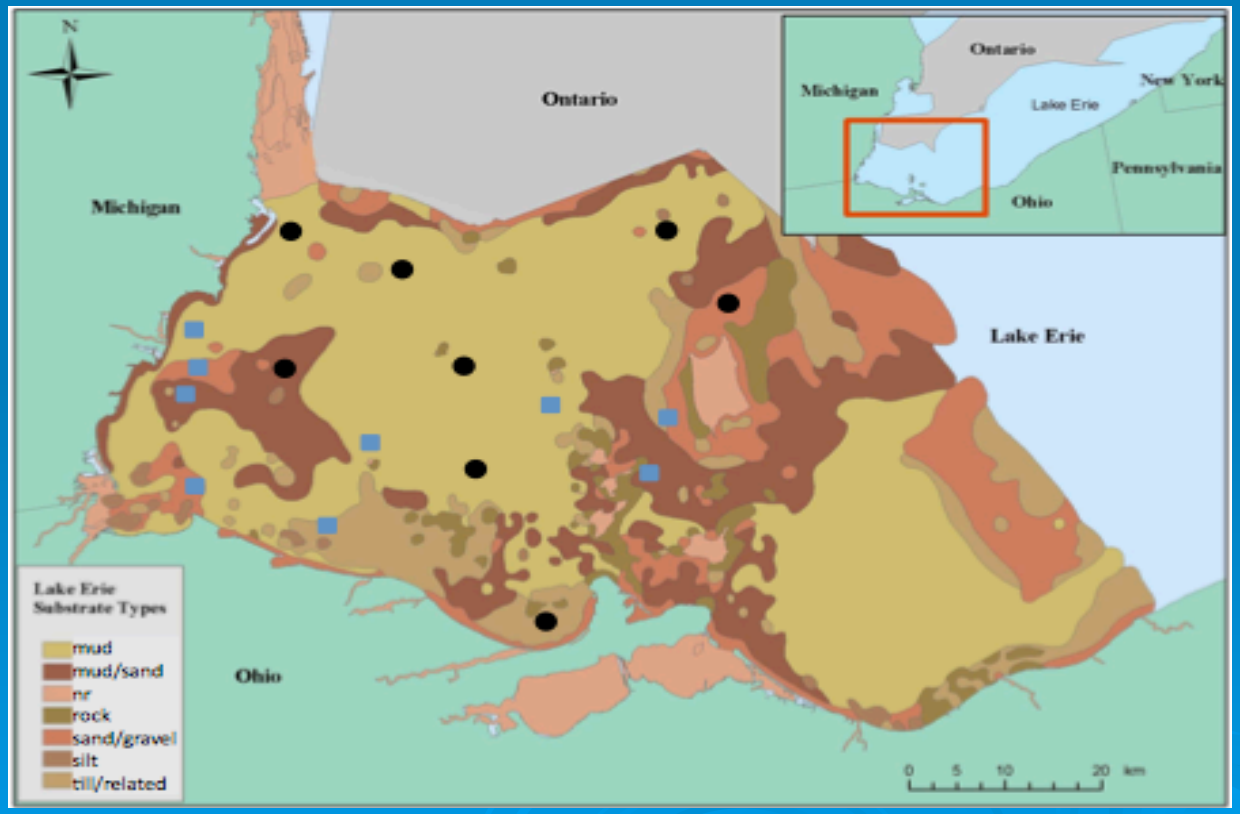
UM & NOAA-GLERL

The Project

- The 2012 natural experiment suggests that internal P loading is presently not a major concern, however
  - Updated sediment data are needed to support this conclusion (Objective 1)
  - Potential climate change scenarios could change the relative importance of internal loading (Objective 2).
  - Updated lake models are needed to evaluate the effects of external vs. internal P sources (Objective 3)

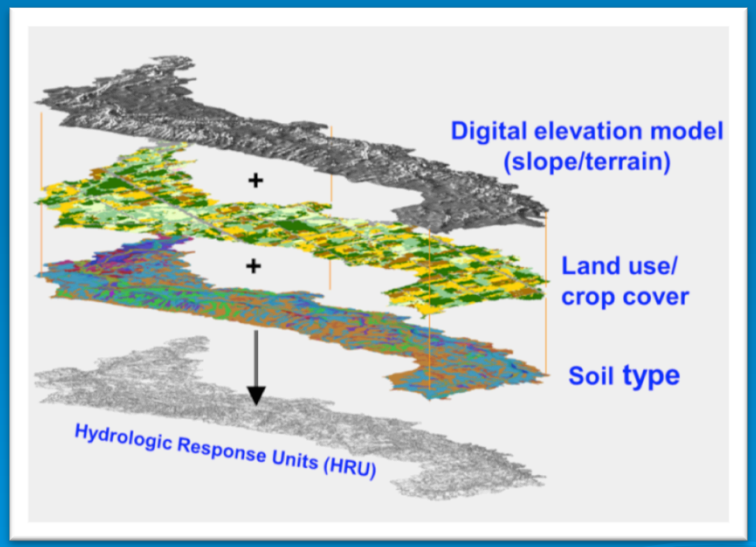
Objective 1

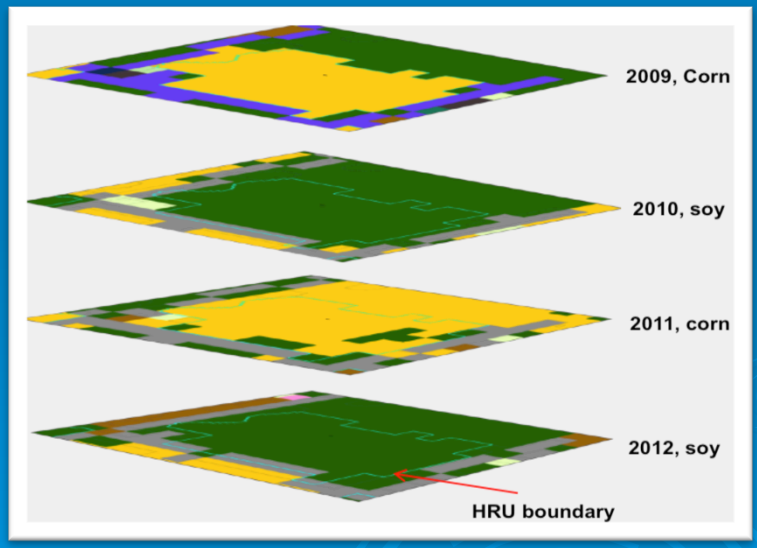
Quantifying the internal nutrient loads to the water column in the western basin



Objective 2

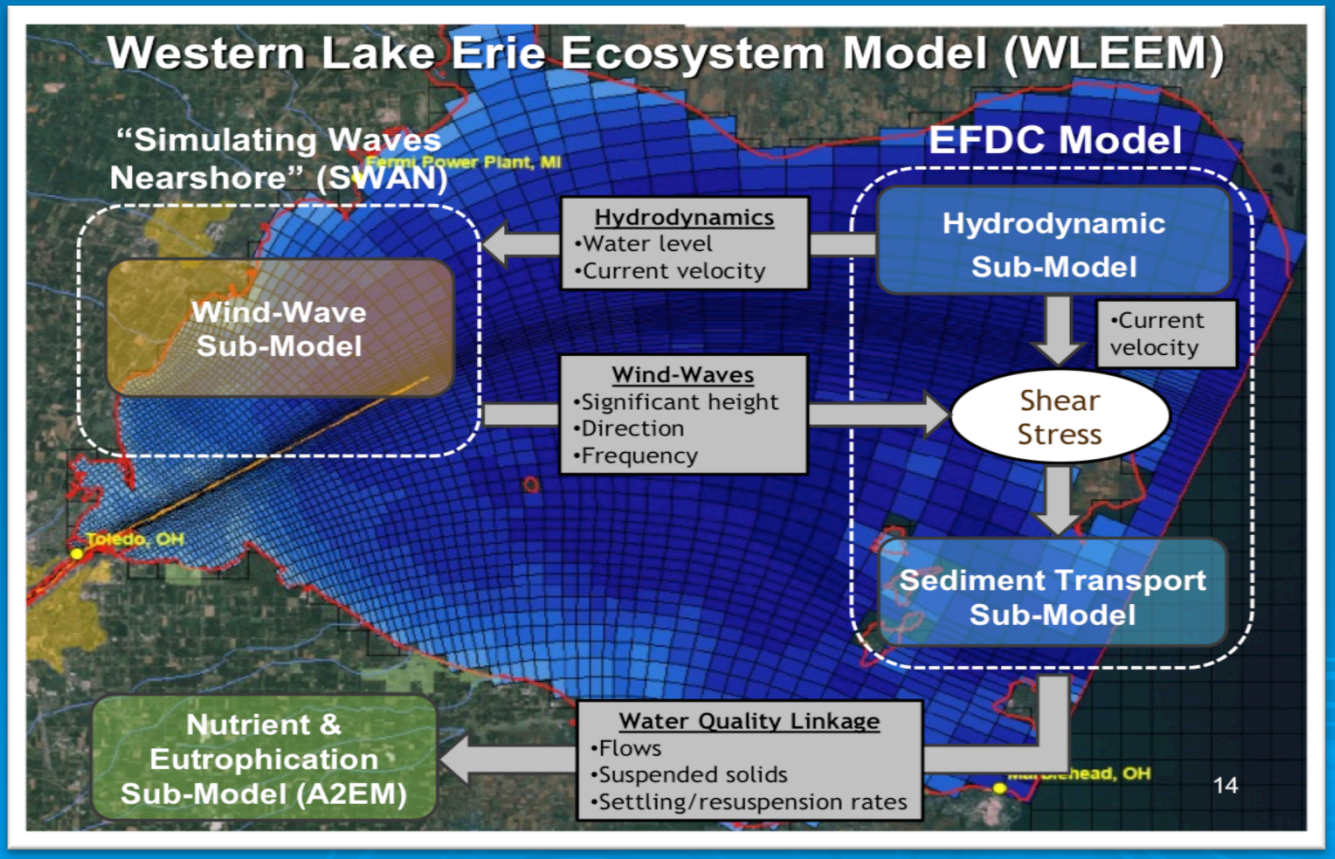
Evaluating climate impacts on harmful algal blooms





Objective 3

Developing a nutrient mass budget for the western basin of Lake Erie



Objective 1

The Challenges:

-Limited data for P flux from bottom sediments, mostly outdated.

-Different methods can give different results

Objectives:

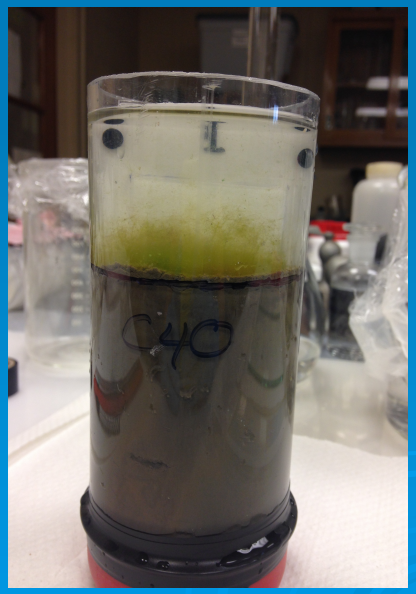
-Obtain estimates of the flux of phosphorus from sediments throughout the western basin of Lake Erie

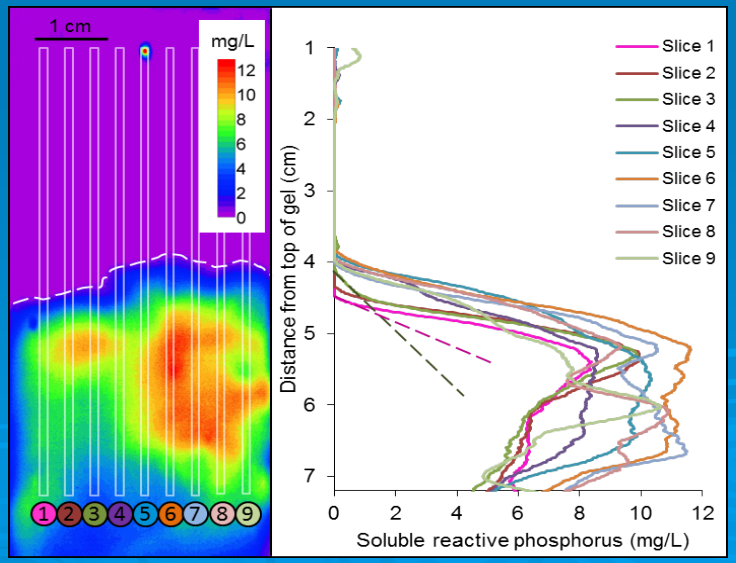
-Measure effects of sediment anoxia and elevated temperatures on phosphorus flux

Approaches:

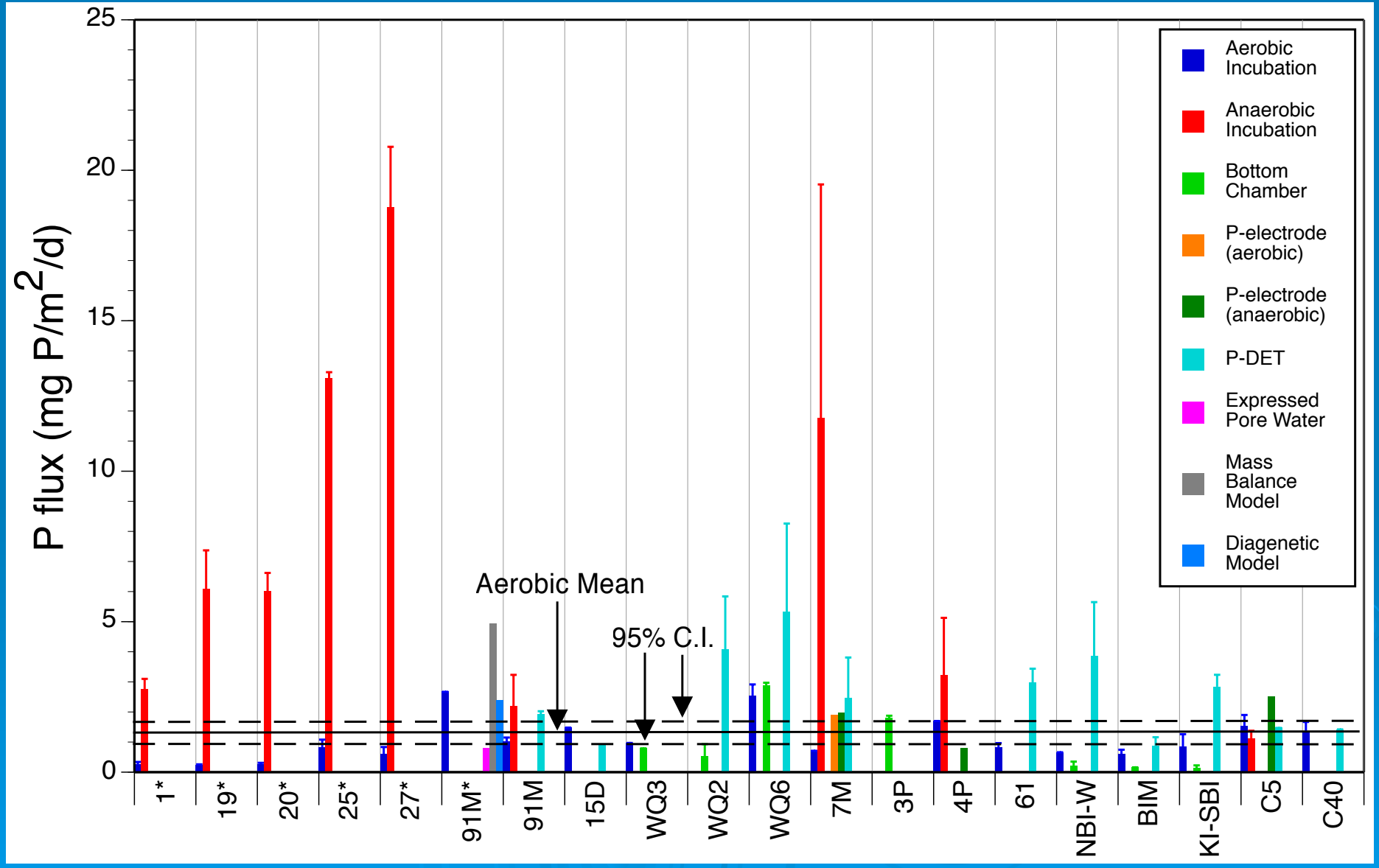
* Aerobic incubations
* Anaerobic incubations
* Field-deployed bottom chambers
* P-electrode
* P-DET gel
* Expressed pore water

Field and Lab Methods





Phosphorus Flux Summary



Conclusions and Implications

1. P Fluxes obtained by different techniques show reasonably good agreement. Also agrees with sediment P fluxes used in models.

2. Aerobic Summer Fluxes: average 1.4 mg P/m^2/day which translates to 3 - 7% of target tributary load.

3. Impact of external P load reductions will not be substantially delayed by internal recycling

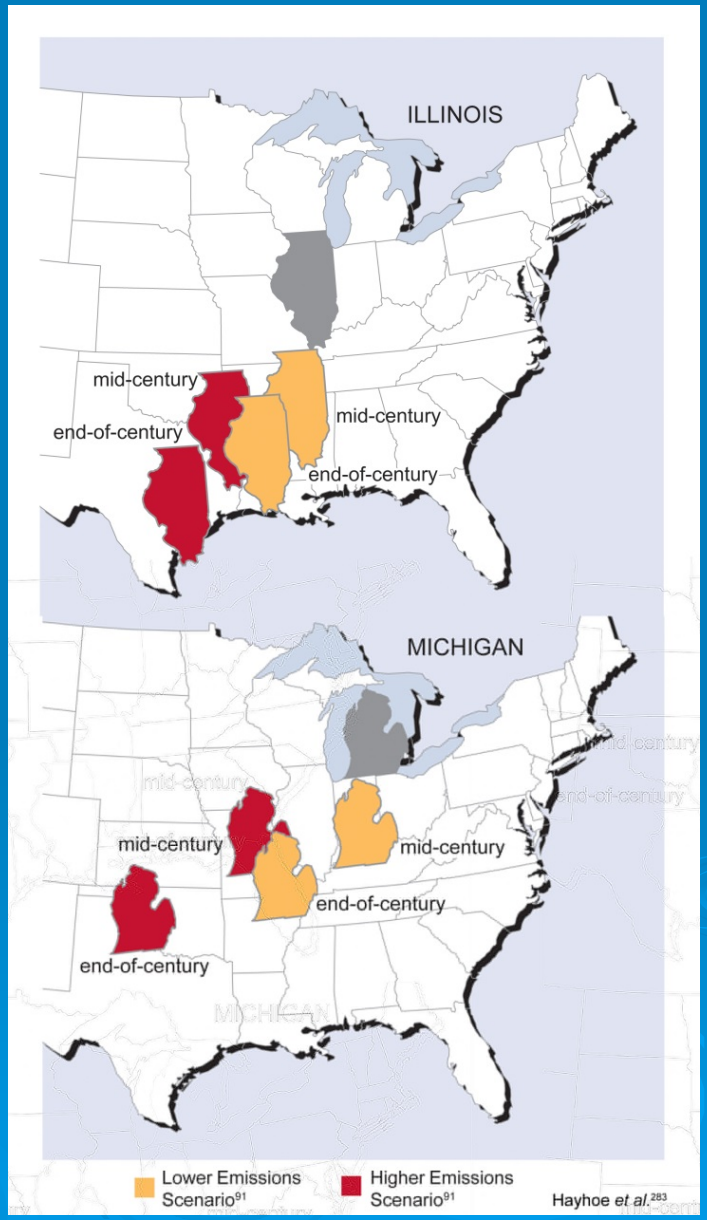
Matisoff G., Steely, R., Kaltenberg, E., Seo, J. Hummel, S., Gibbons, K. Bridgeman, T.B., Seo, Y., Behbahani, M., James, W., Doan, P. Dittrich, M., Evans, M., Chaffin, J., 2016. Internal Loading of Phosphorus in Western Lake Erie. *Journal of Great Lakes Research*. 42:775–788.

Objective 2

Evaluating climate impacts on harmful algal blooms

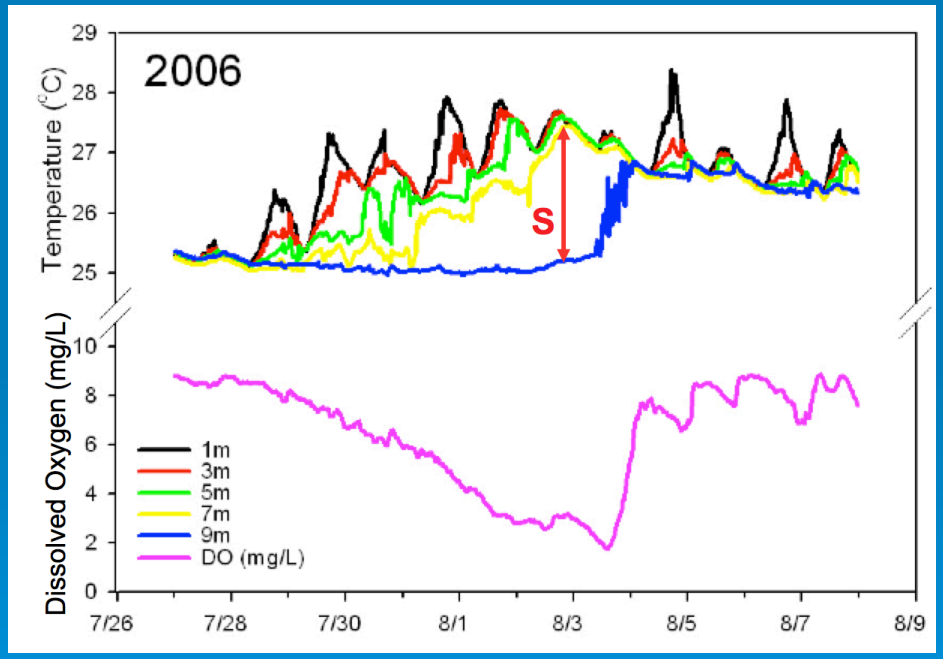
Climate Change

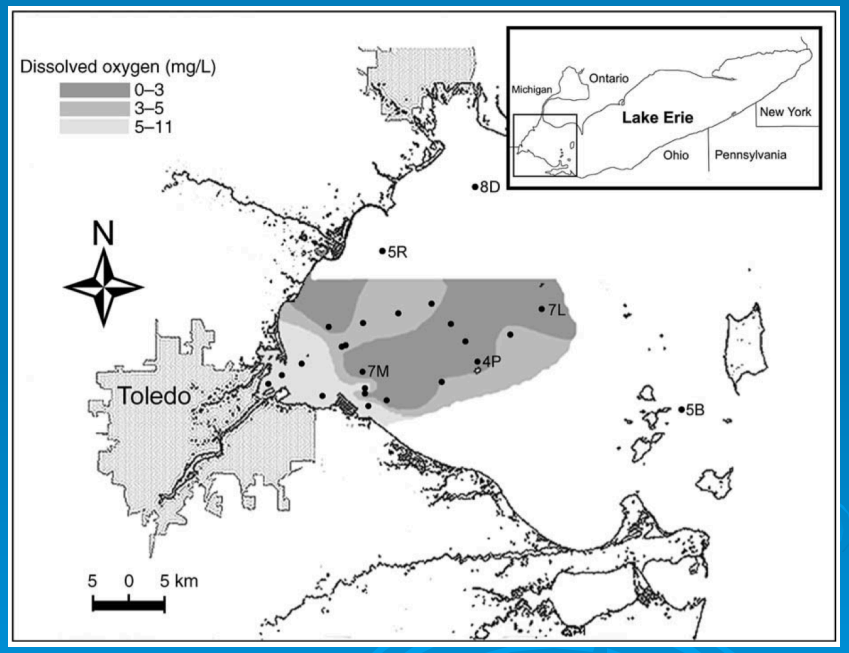
- Warmer lake temperatures
- Increase in winter and spring precipitation
- Summers predicted to be drier



Aerobic sediment P flux is low, but what about Anaerobic P flux?

Low oxygen in Western Lake Erie

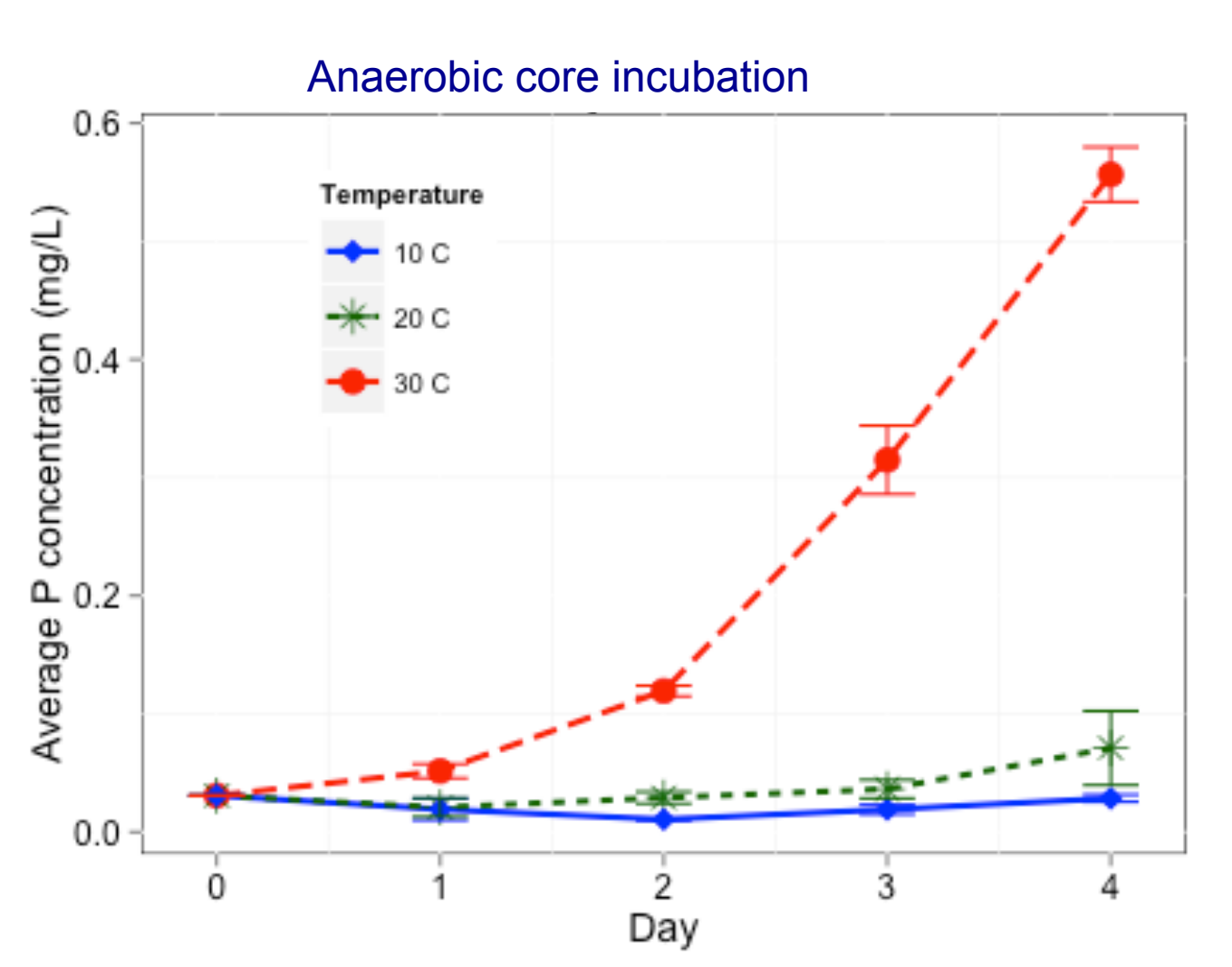




Under hot, calm conditions, Western Lake Erie bottom waters can become anoxic within a few days

Anoxic conditions can affect extensive areas in WLE

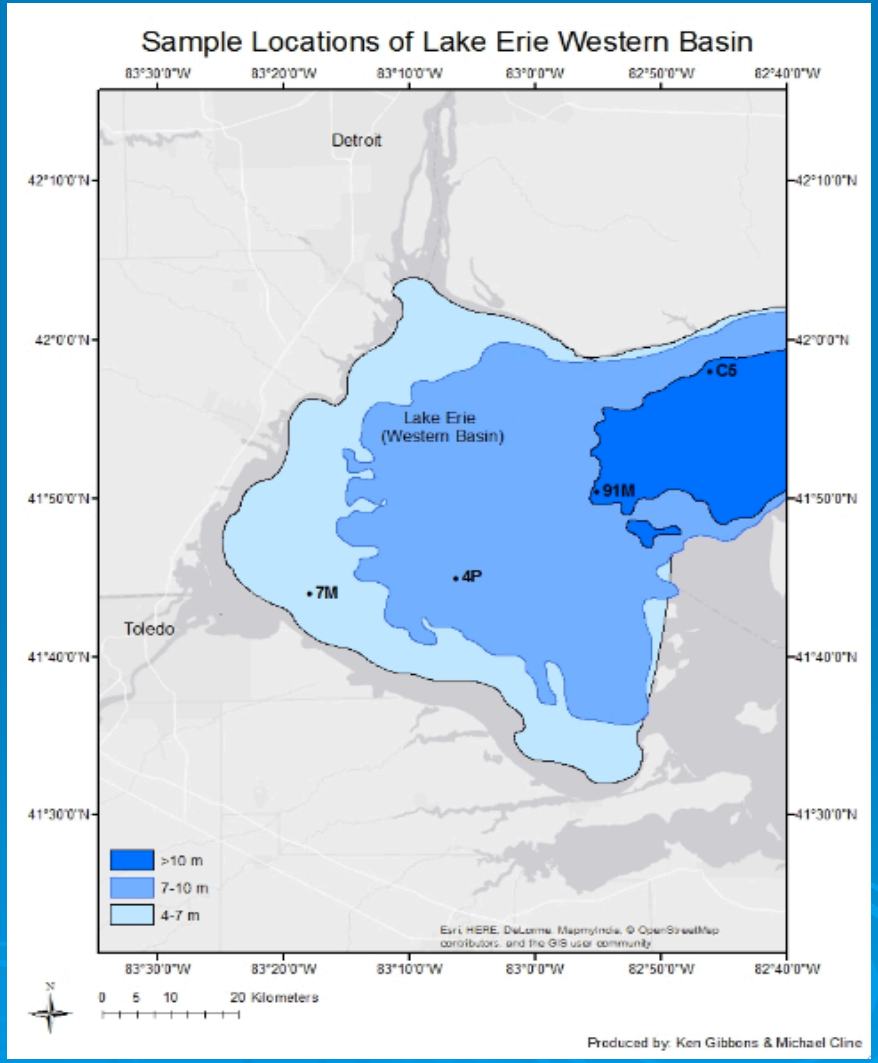
Large P flux at higher temperatures and anaerobic sediments



Calculating basin-wide P flux

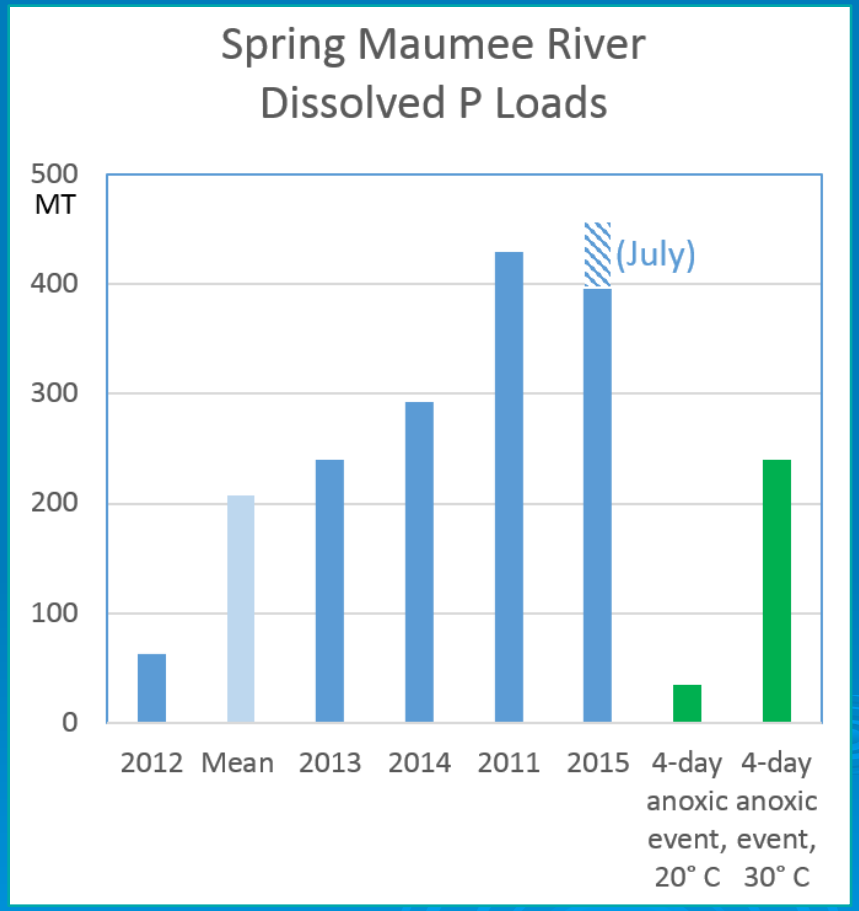
-Depths contours were used to scale core results to the entire basin.

-Depths less than 4 m are not likely to become anoxic



Comparing Anoxic Internal Load to Maumee River load

- P released from sediment would be dissolved and bioavailable
- 4-day anoxic event at 20°C yields load similar to single Maumee basin rain event
- 4-day anoxic event at 30°C yields load >mean spring load from Maumee R.

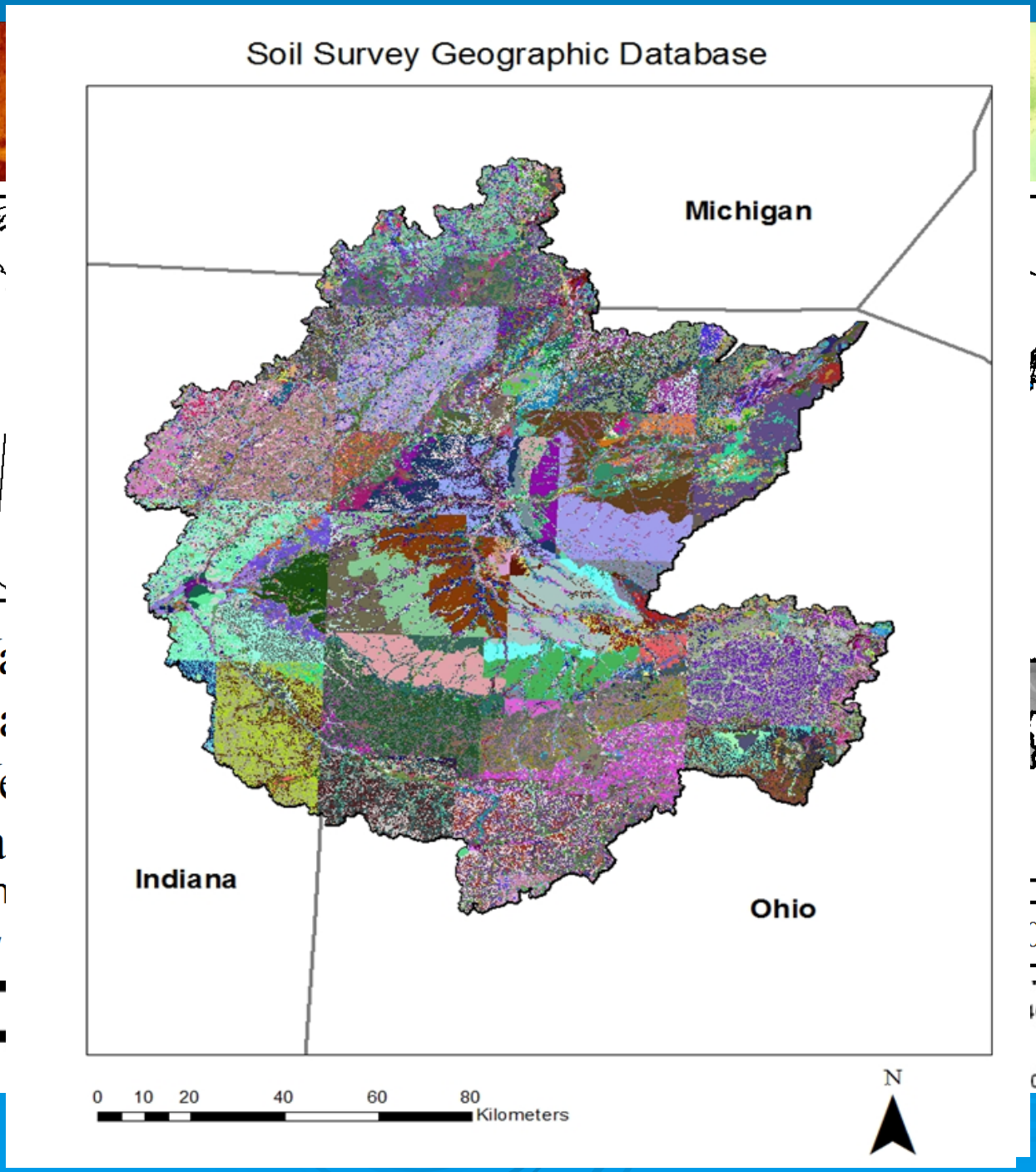


Objective 2

Evaluating climate impacts on harmful algal blooms

Modeling the Effects of Climate Change on Water, Sediment, and Nutrient Discharge from the Maumee River Watershed

Cousino, L.K., Becker, R.H., and Zmijewski, K.A.


Soil Survey Geographic Database
Michigan
Indiana
Ohio
0 10 20 40 60 80
Kilometers
N

Calibration Results

Scenario	NSE	R2	Perfomance Rating
Flow Calibration: 1995-1999	0.83	0.94	Very Good
Flow Validation: 2000-2002	0.87	0.92	Very Good
Sediment Concentration Calibration: 1995-1999	0.63	0.67	Satisfactory
Sediment Concentration Validation: 2000-2002	0.72	0.77	Good

Performance ratings are based on standards suggested by Moriasi et al. 2007

Major Trends (end of century)

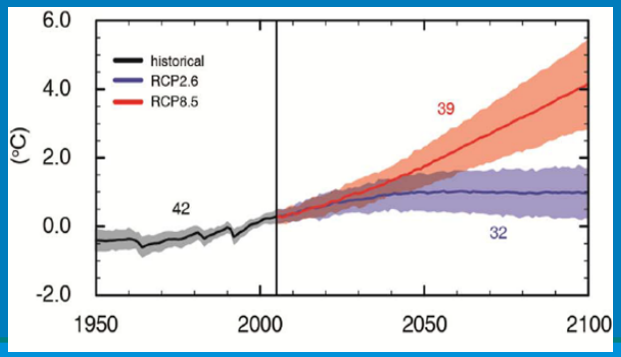
- Increase in annual precipitation (4-9%)
- Increase in storm events
  - Winter (17% to 45%)
  - Spring (-4.2% to 4.2%)
  - Summer (-36% to -28%)
    - Potentially a GOOD thing for HABs
- Increase in Evapotranspiration (44-49%)
  - Annual tributary flow decreased by 26-31%

Likely Impacts of Changing Climate

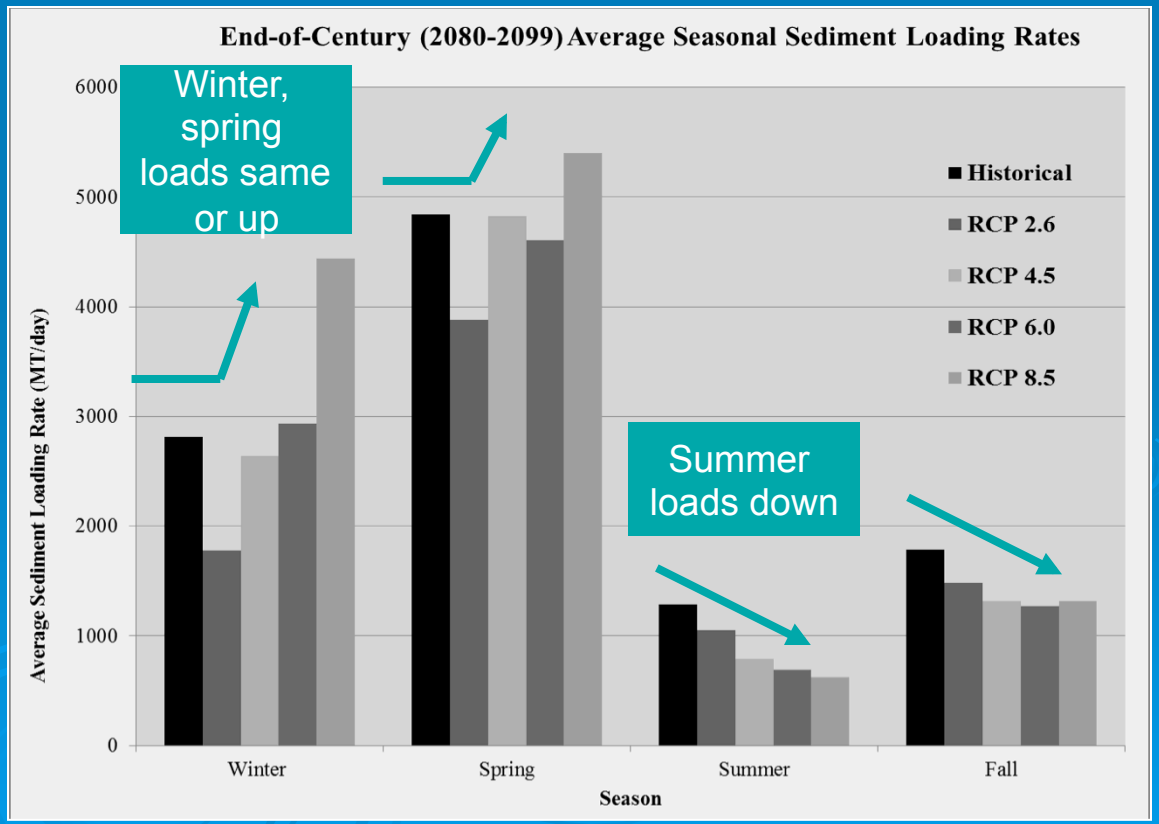
SWAT watershed models plus climate change scenarios

- **Moderate** warming may decrease Maumee P loads
- **Extreme** warming will increase Maumee P loads

Climate Change Scenarios



(L. Cousino, R. Becker, K. Zmijewski. 2015, J. Hydrology)



Contributors

- Sandra Kosek-Sills (LEC)
- Ricky Becker (UT)
- Tom Bridgeman (UT)
- Christine Mayer (UT)
- Song Qian (UT)
- Youngwoo Seo (UT)
- Justin Chaffin (OSU)
- MaryAnne Evans USGS
- Jeff Reutter (OSG)
- Rem Confesor (NCWQR)
- Laura Johnson (NCWQR)
- Gerry Matisoff (CWRU)
- Joe DePinto (LimnoTech)
- John Bratton (LimnoTech)
- Ed Verhamme (LimnoTech)
- STUDENTS