

OHIO SEA GRANT AND STONE LABORATORY

# Understanding the Critical Issues Impacting Lake Erie: Nutrient Loading, HABs, AIS, and Climate Change

Dr. Jeffrey M. Reutter

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# **Jeffrey M. Reutter, Ph.D., Director**

- 1895—F.T. Stone Laboratory**
- 1970—Center for Lake Erie Area Research (CLEAR)**
- 1978—Ohio Sea Grant College Program**
- 1992—Great Lakes Aquatic Ecosystem Research Consortium (GLAERC)**
- Grad student at Stone Lab in 1971 and never left. Director since 1987.**

## OHIO SEA GRANT AND STONE LABORATORY





# OSU's Island Campus



# Research Vessels (+Buckeye)

AND STONE LABORATORY



**Sea Grant**  
Ohio Sea Grant College Program

  
**THE OHIO STATE UNIVERSITY**



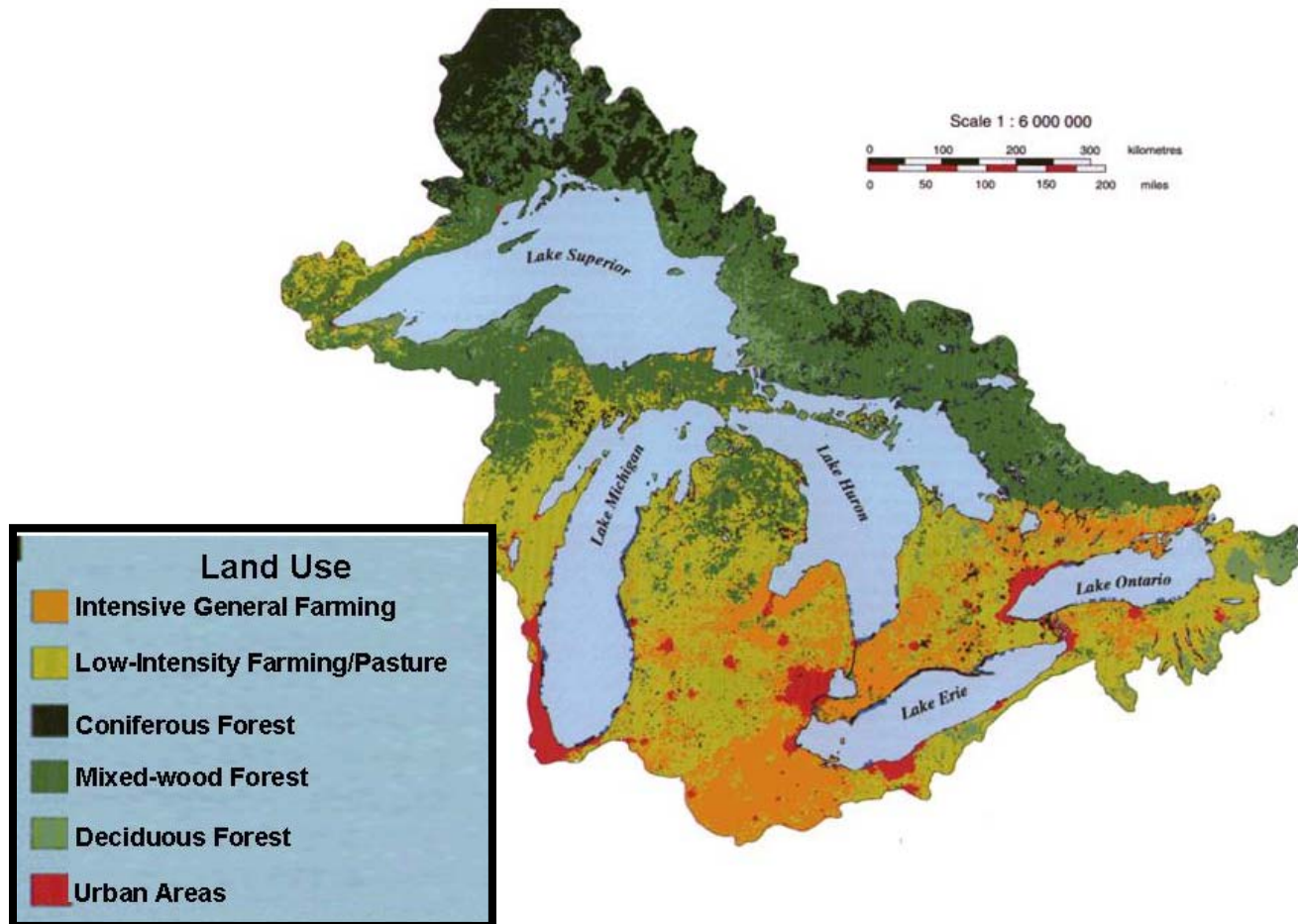


# Lake Erie's 6 Biggest Problems/Issues

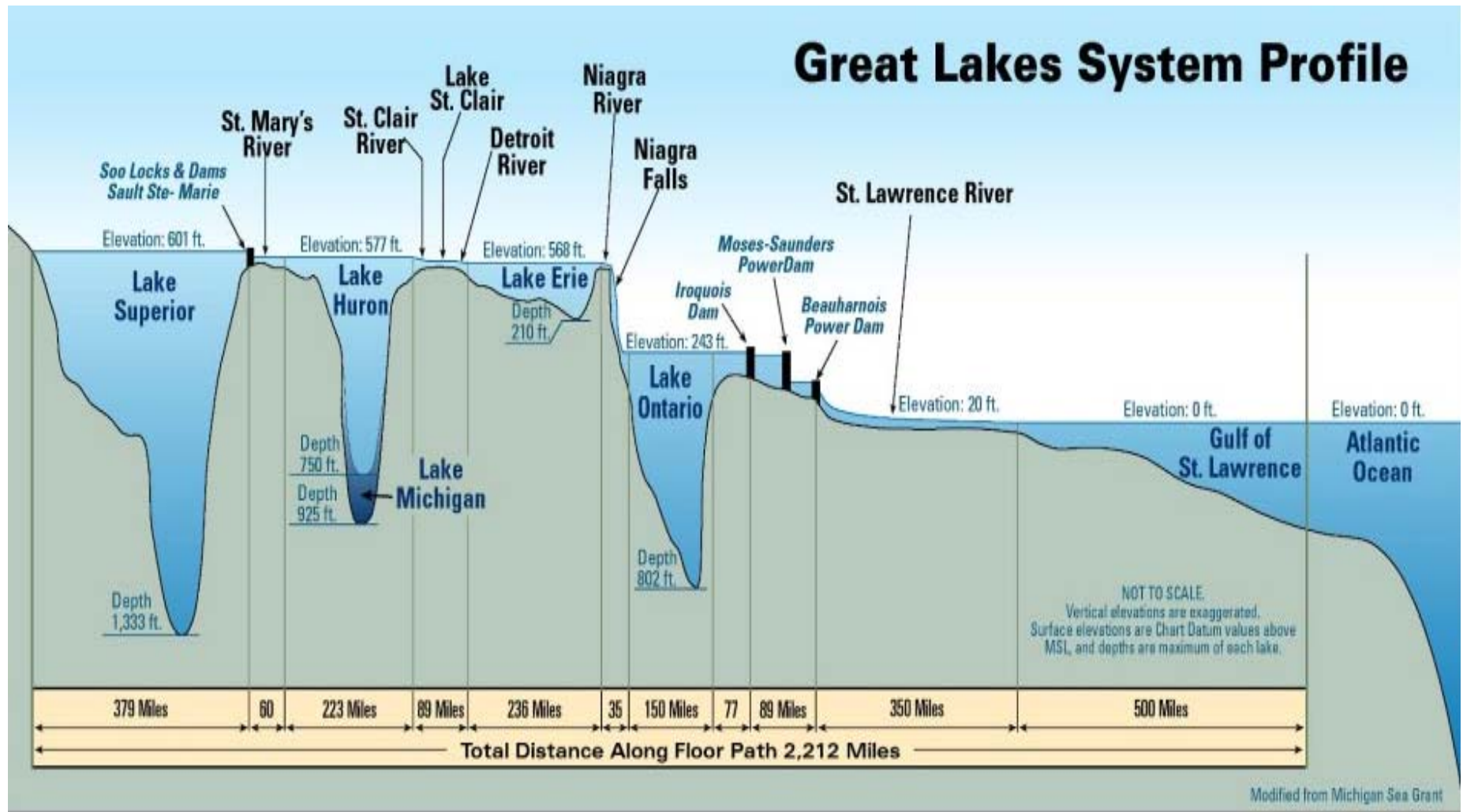
- Sedimentation
- Phosphorus and nutrient loading
- Harmful algal blooms
  - Western, Central, and Eastern Basin Differences
  - Different problems in different lakes (possibly more difficult than Lake Erie)
- Aquatic invasive species
- Dead Zone—exacerbated by nutrients
- Climate Change—Makes the others worse



# Southernmost

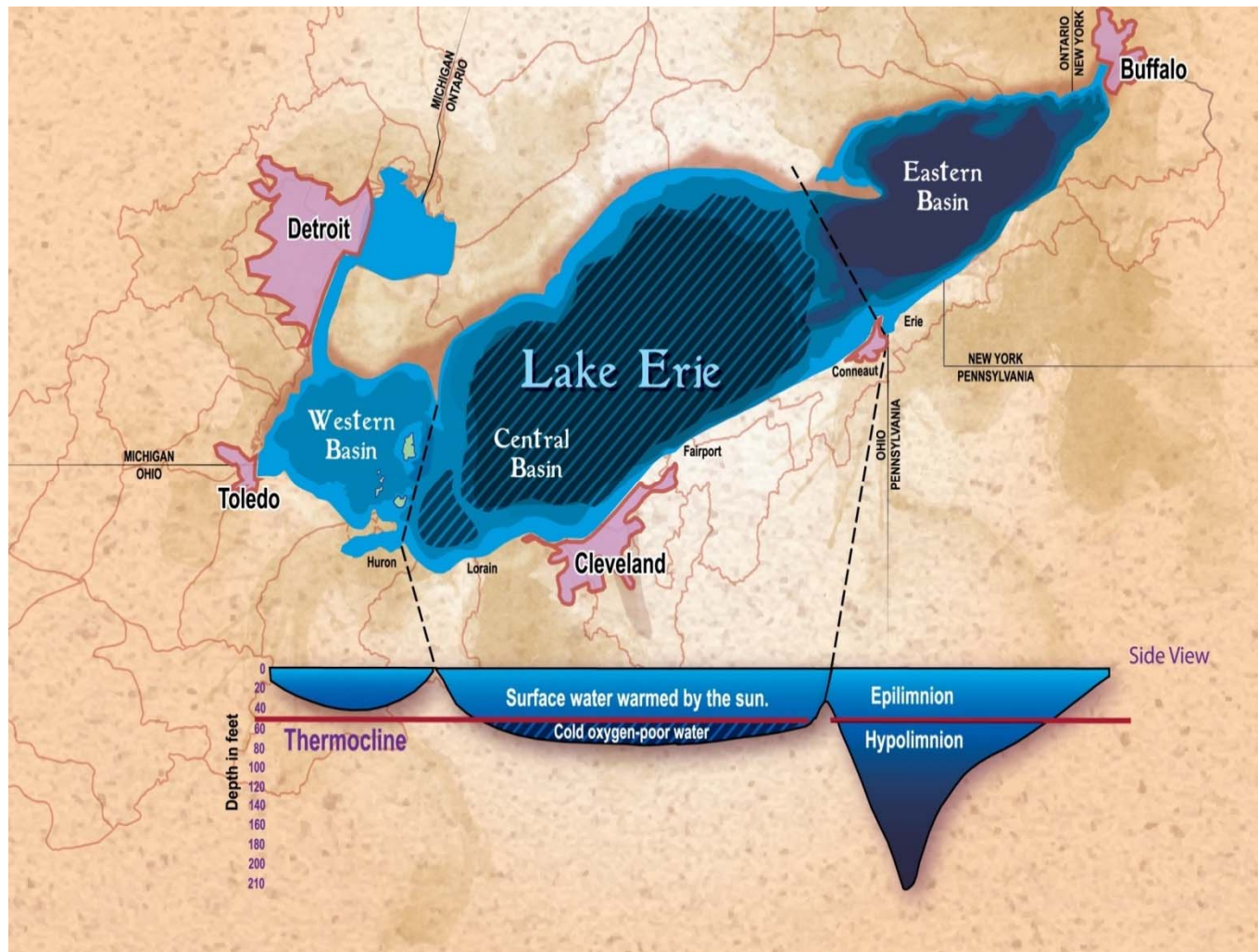


# Shallowest and Warmest





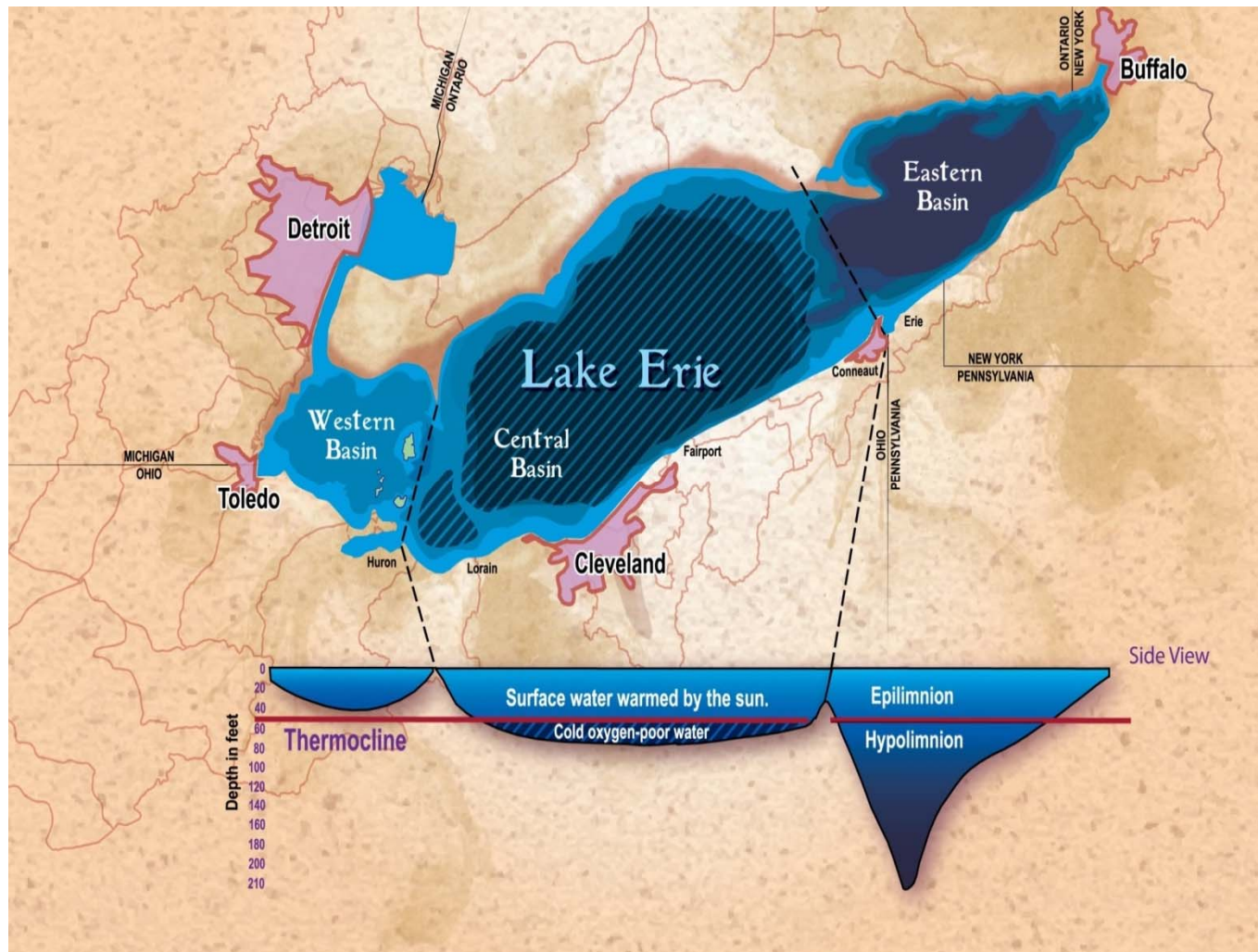
# Discuss 3 Basins & Retention Time



# 80:10:10 Rule

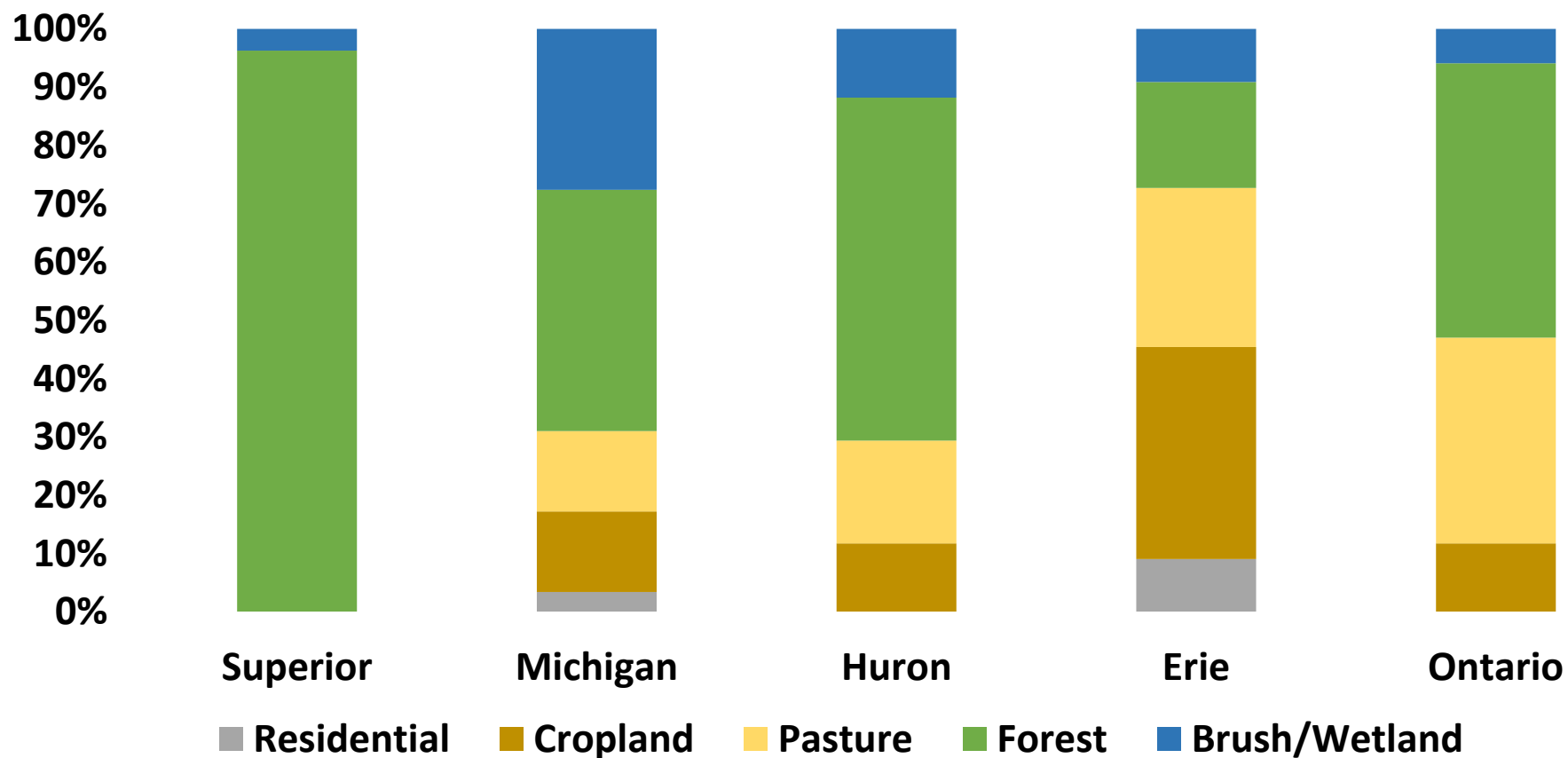
- **80% of water from upper lakes**
- **10% direct precipitation**
- **10% from Lake Erie tributaries**
  - **Maumee**
    - **Largest tributary to Great Lakes**
      - **Drains 4.2 million acres of ag land**
    - **3% of flow into Lake Erie**

# Discuss 3 Basins & Retention Time





# Major Land Uses in The Great Lakes

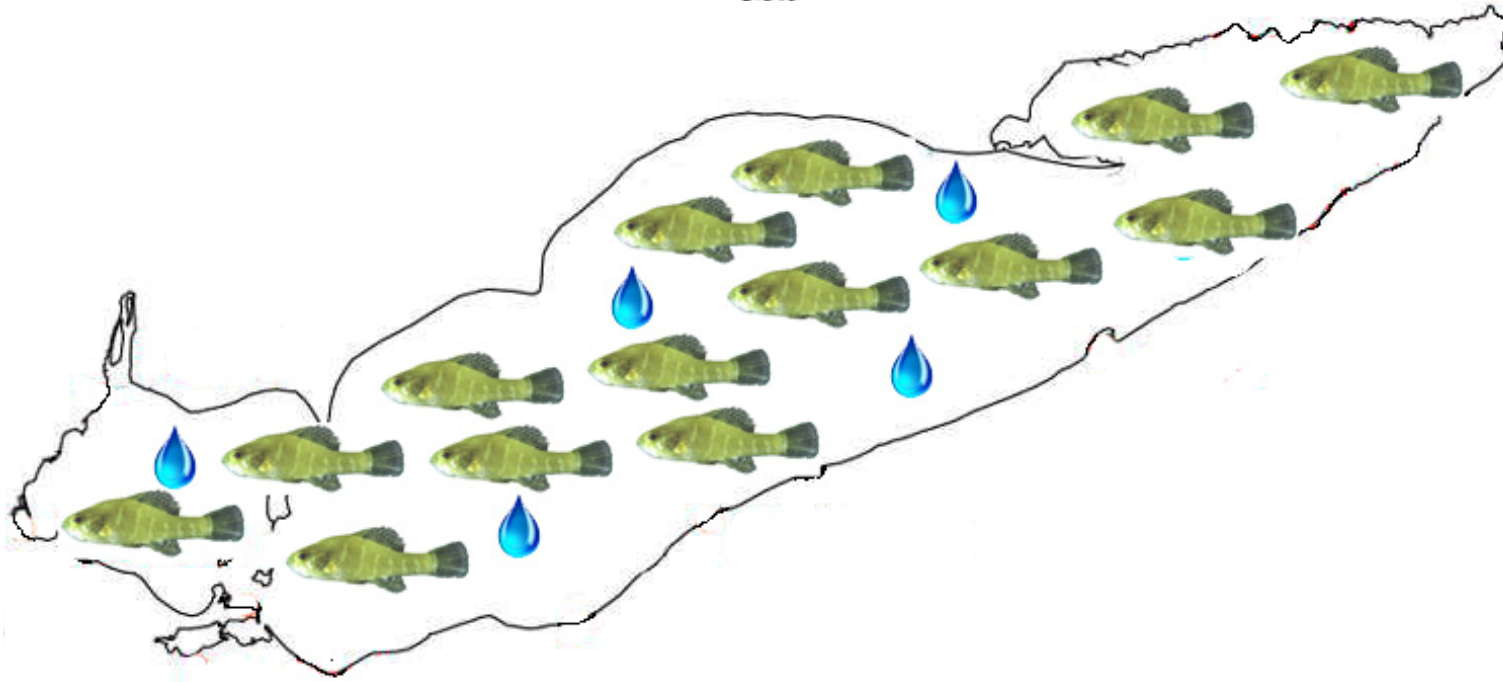


# Because of Land Use, Lake Erie Gets:

- More sediment
- More nutrients (fertilizers and sewage)
- More pesticides
- (The above 3 items are exacerbated by storms, which will be more frequent and severe due to climate change.)
- And Lake Erie is still biologically the most productive of the Great Lakes—And always will be!!!

# 50:2 Rule

(Not exact, but instructive)



**Lake Superior:**

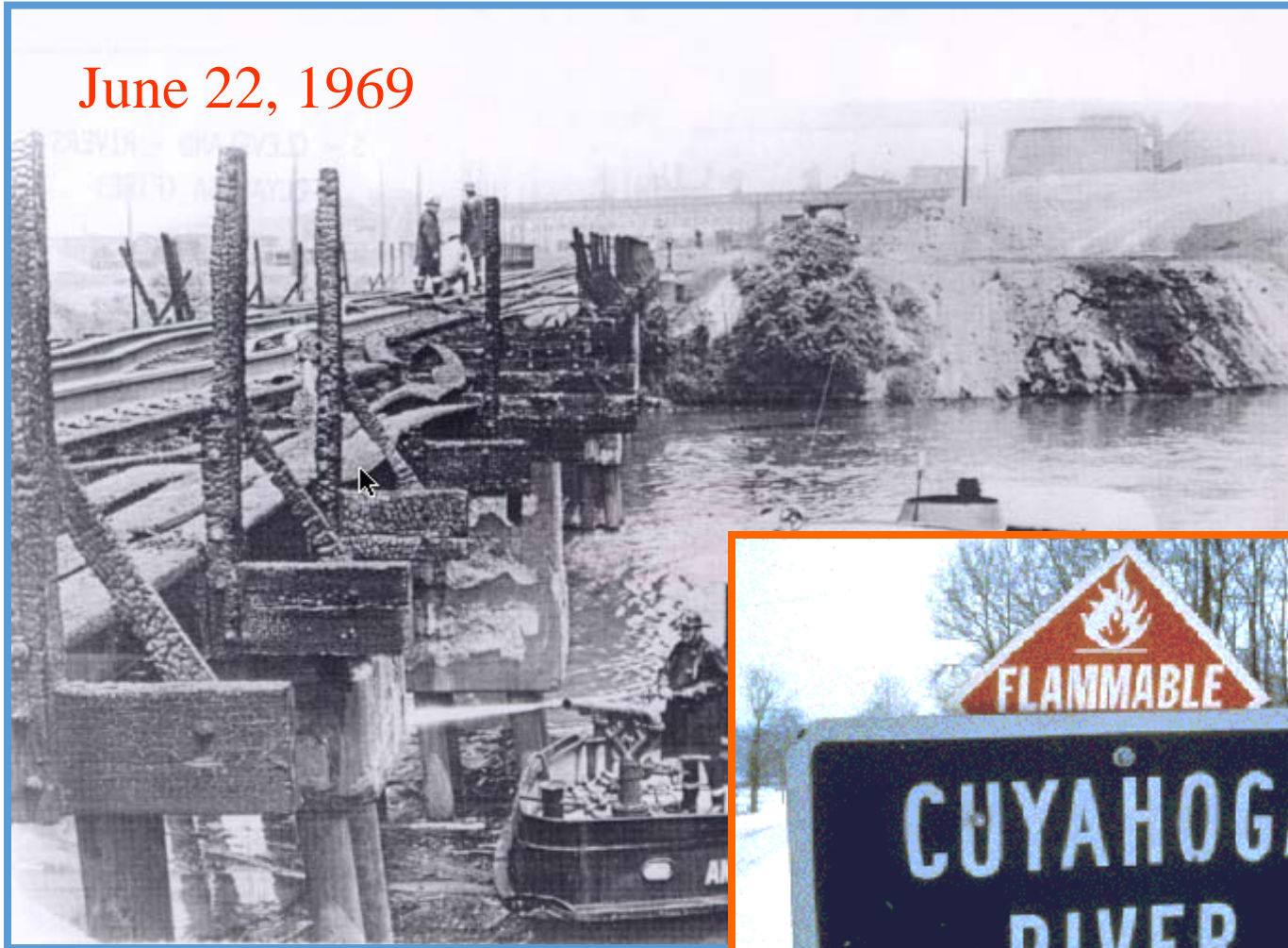
**50% of the water and 2% of the fish**



# Lake Erie: One of the Most Important Lakes in the World

- **Dead lake image of 60s and 70s.**
- **Poster child for pollution problems in this country.**
- **But, most heavily utilized of any of the Great Lakes.**
- **Shared by 5 states, a province, and 2 countries.**
- **Best example of ecosystem recovery in world.**

June 22, 1969



**Lake Erie wasn't always the  
Walleye Capital of the World**

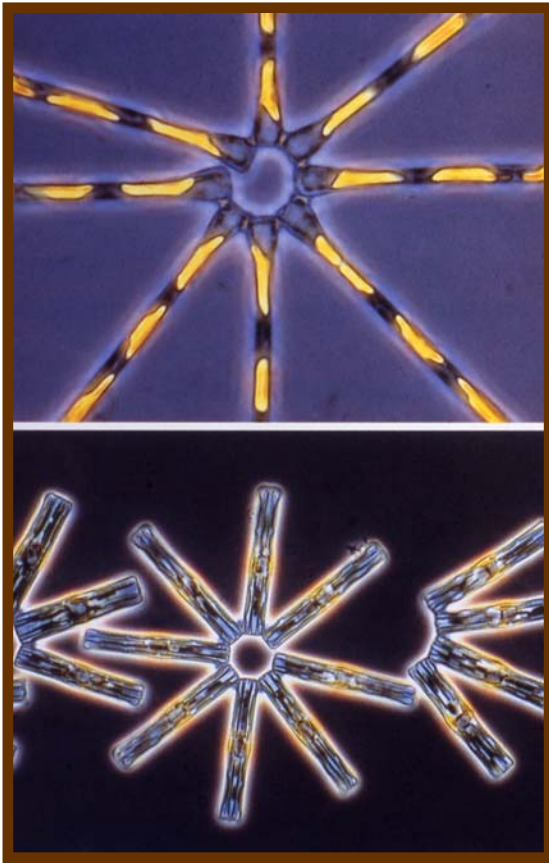
# Blue-green Algae Bloom circa 1971, Lake Erie



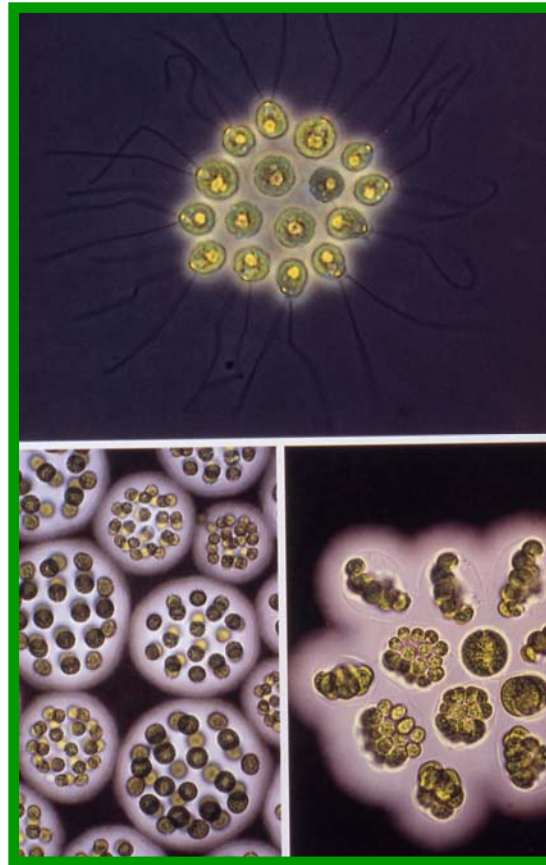
Photo: Forsythe and Reutter



# Major groups/kinds in Lake Erie



Diatoms



Greens



Blue-greens  
(Cyanobacteria)

Source: Tom Bridgeman, UT

# What brought about the rebirth (dead lake to Walleye Capital)?

- **Phosphorus reductions from point sources (29,000 metric tons to 11,000).**

# Impact of Ecosystem Recovery (rebirth)

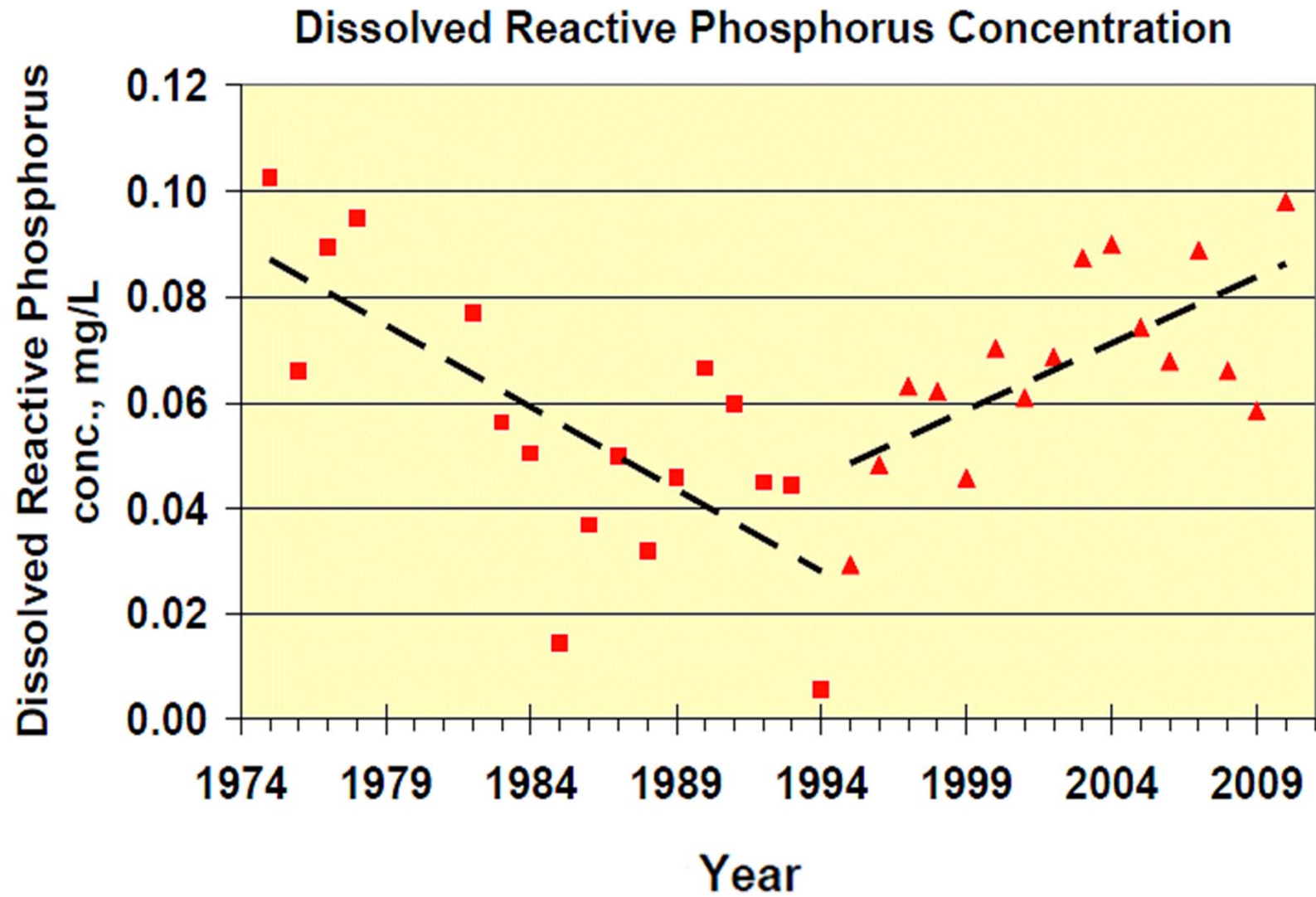
- Ohio walleye harvest 112,000 in 1976 to over 5 million by mid-80s
- 34 charter fishing businesses in 1975 to over 1200 by mid-80s and almost 700 today
- 207 coastal businesses to over 425 today



# Why did we target phosphorus?

- Normally limiting nutrient in freshwater systems
- P reduction is best strategy ecologically and economically
- Reducing both P and N would help





# Major Sources of Phosphorus

- **Lawn fertilizer—going down**
- **Sewage treatment plants and CSO's**
- **Non-point source runoff from urban**
- **Non-point source runoff from agriculture**
- **1970s—2/3 poor sewage treatment**
- **Today—2/3 agricultural runoff**

# Where did the dissolved phosphorus come from?

*Dissolved phosphorus is highly bioavailable to algae*

Indicators of non-point sources

*e.g., land runoff*

Example: Maumee River

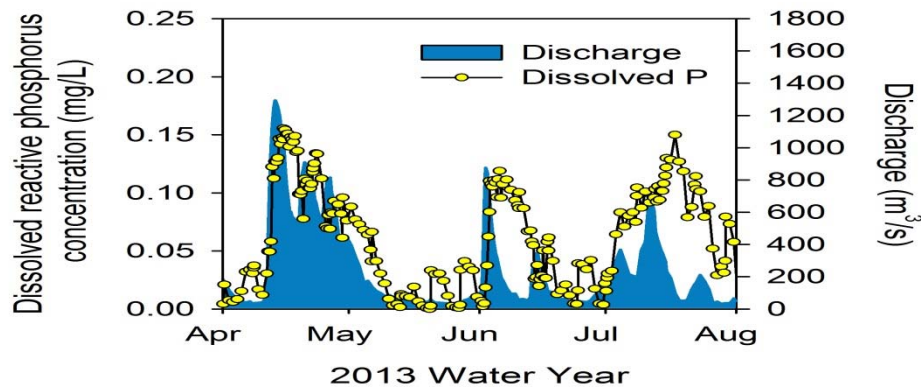


Indicators of point sources

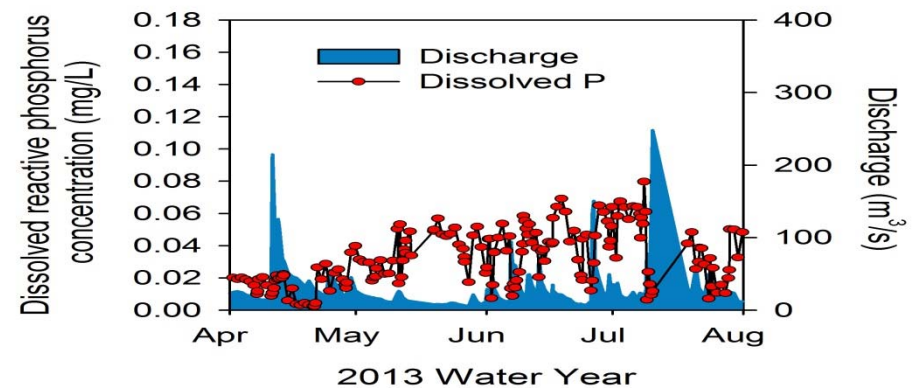
*e.g., effluent*

Example: Cuyahoga River

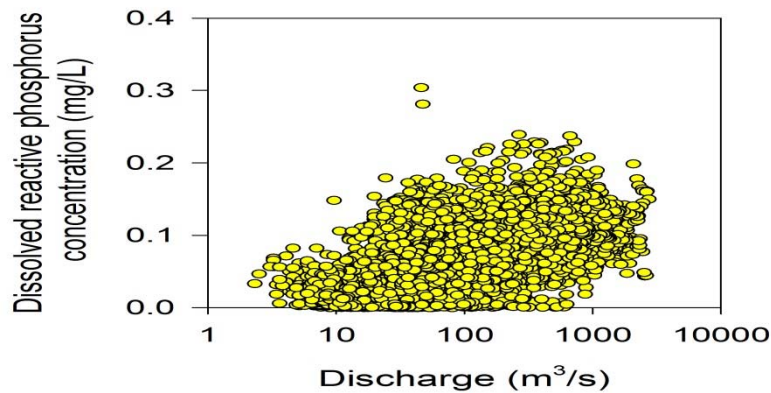
1) Concentration increases during storms



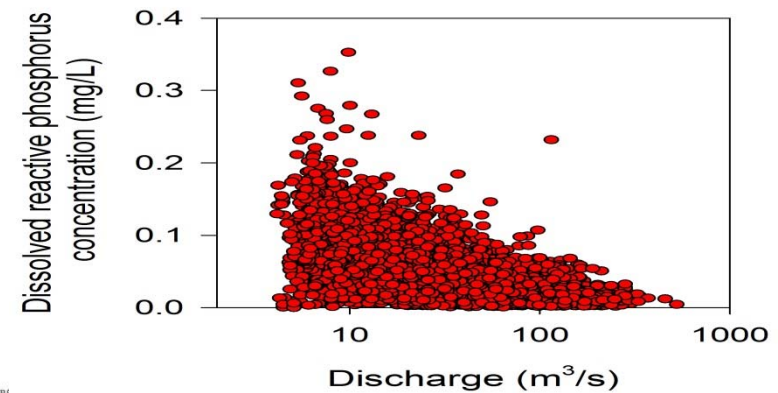
1) Concentration increases during low flow



2) Concentration increases with flow



2) Concentration decreases with flow



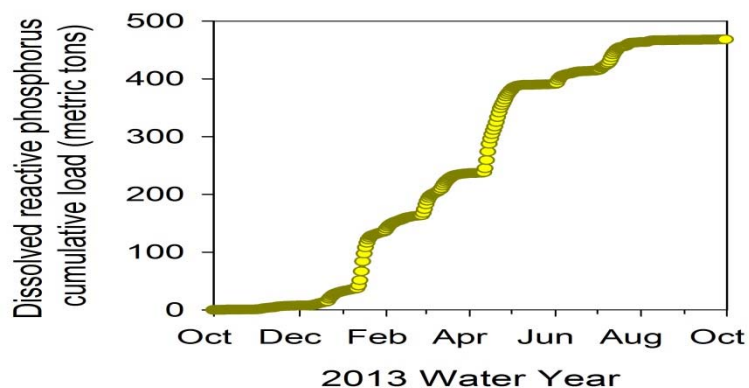


## Indicators of non-point sources

*e.g., land runoff*

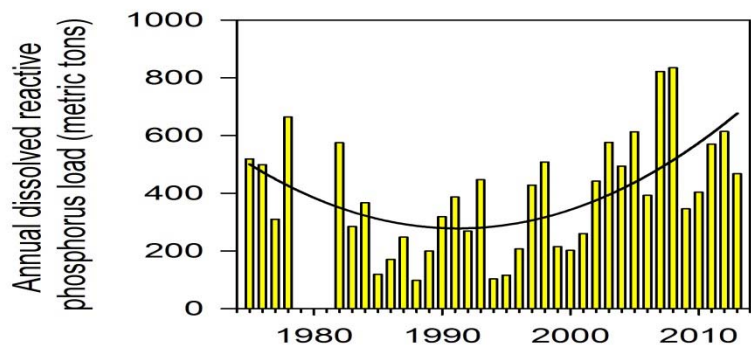
Example: Maumee River

### 3) Load is pulsed over time



*82% of the load delivered in the highest 25% of flows*

Since 1995, dissolved phosphorus has been increasing in agricultural watersheds



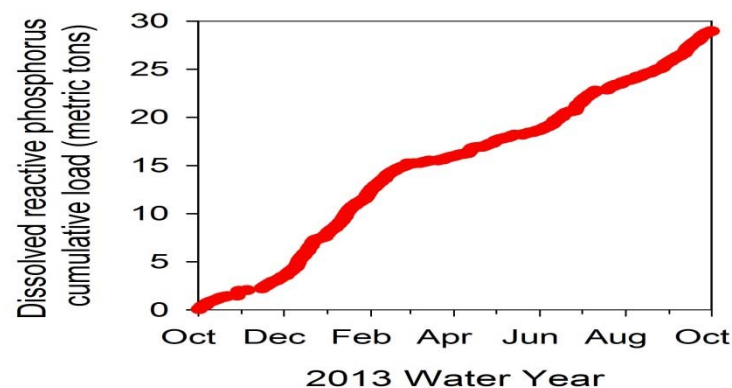
*Loading between March and June has the strongest effect on Lake Erie bloom intensity*

## Indicators of point sources

*e.g., effluent*

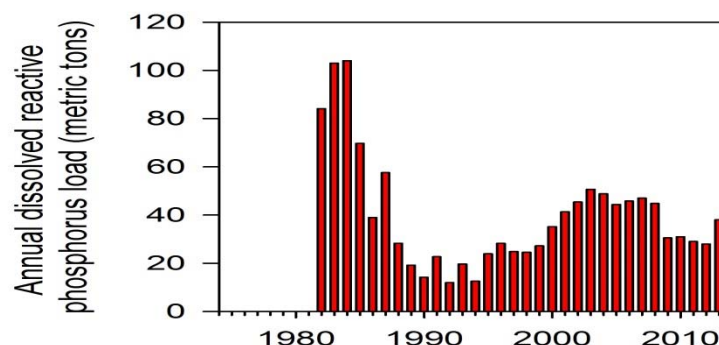
Example: Cuyahoga River

### 3) Load is constant over time



*40% of the load delivered in the highest 25% of flows*

Recently, dissolved phosphorus has been low compared to the early 1980's



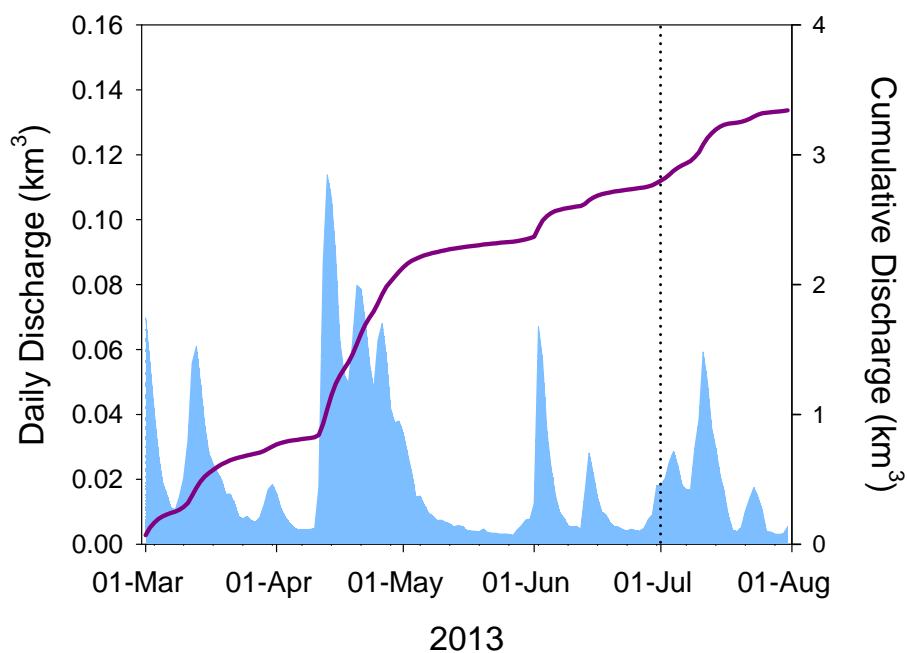
For more information visit <http://www.heidelberg.edu/ncwqr>  
or contact Laura Johnson: [ljohnso1@heidelberg.edu](mailto:ljohnso1@heidelberg.edu), 419-448-2056

# Nutrient Loading

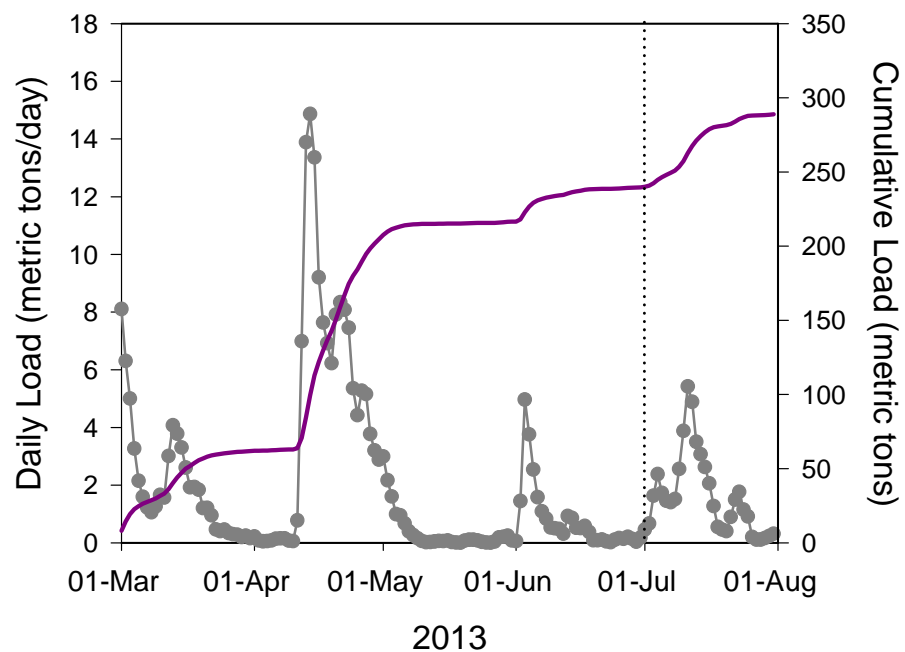
- **Majority of loading occurs during storm events**
- **80-90% of loading occurs 10-20% of time**
- **2012 = dry spring and low load—a very good thing!!**

# 2013 Spring Cumulative Discharge and Dissolved Phosphorus Loads

## 2013 discharge



## 2013 dissolved P



# Climate change is making these problems worse!

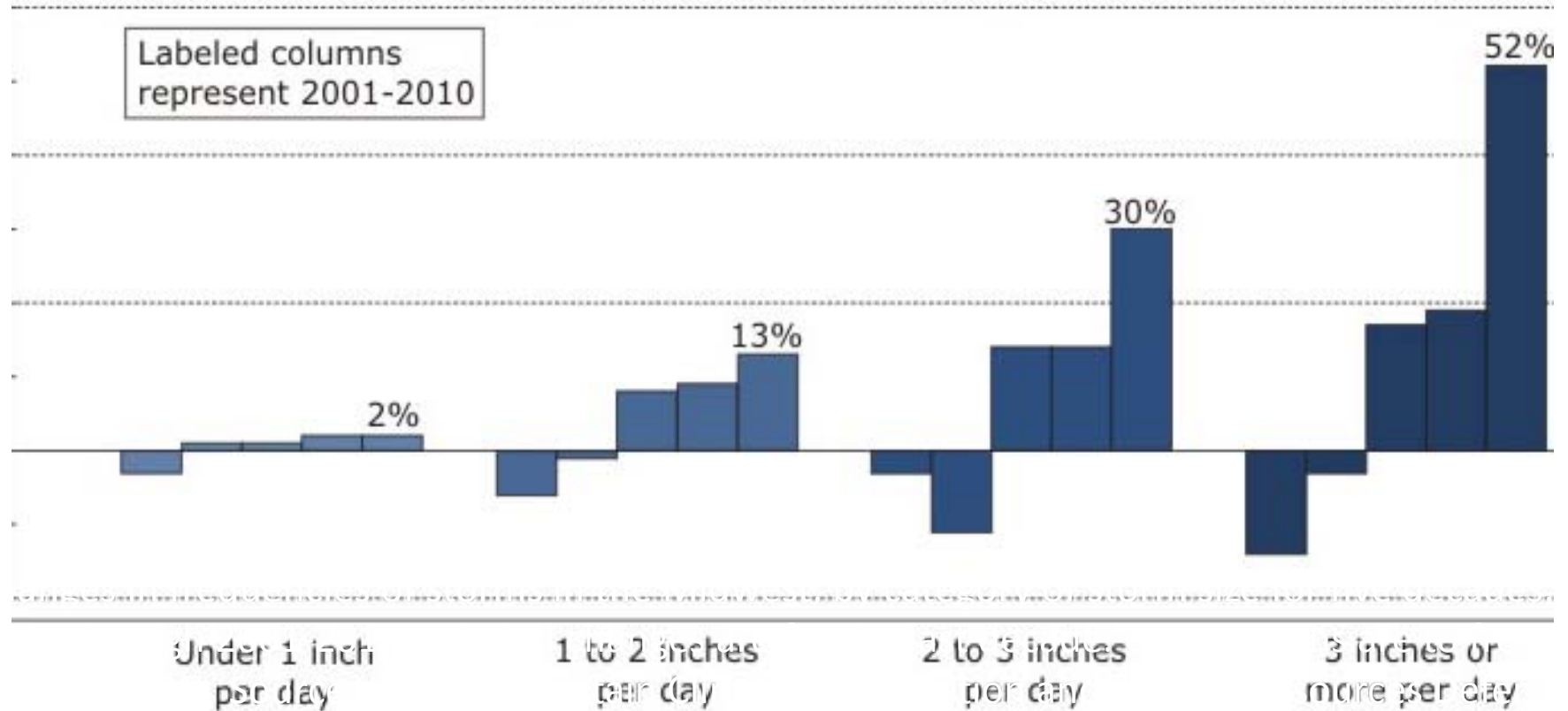
- Warm water increases oxygen depletion rates
- More severe storms will resuspend more sediment and increase erosion and nutrient loading
  - Critically important point—with no changes in Ag practices, warmer weather and increased frequency of severe storms could increase negative impact of existing practices.
- Lake levels—uncertain/probably down
- Warm water favors HABs





# Increased Frequency of Rainstorms

Changing Decadal Frequency of Storms by Size in the Midwest, 1961-2010



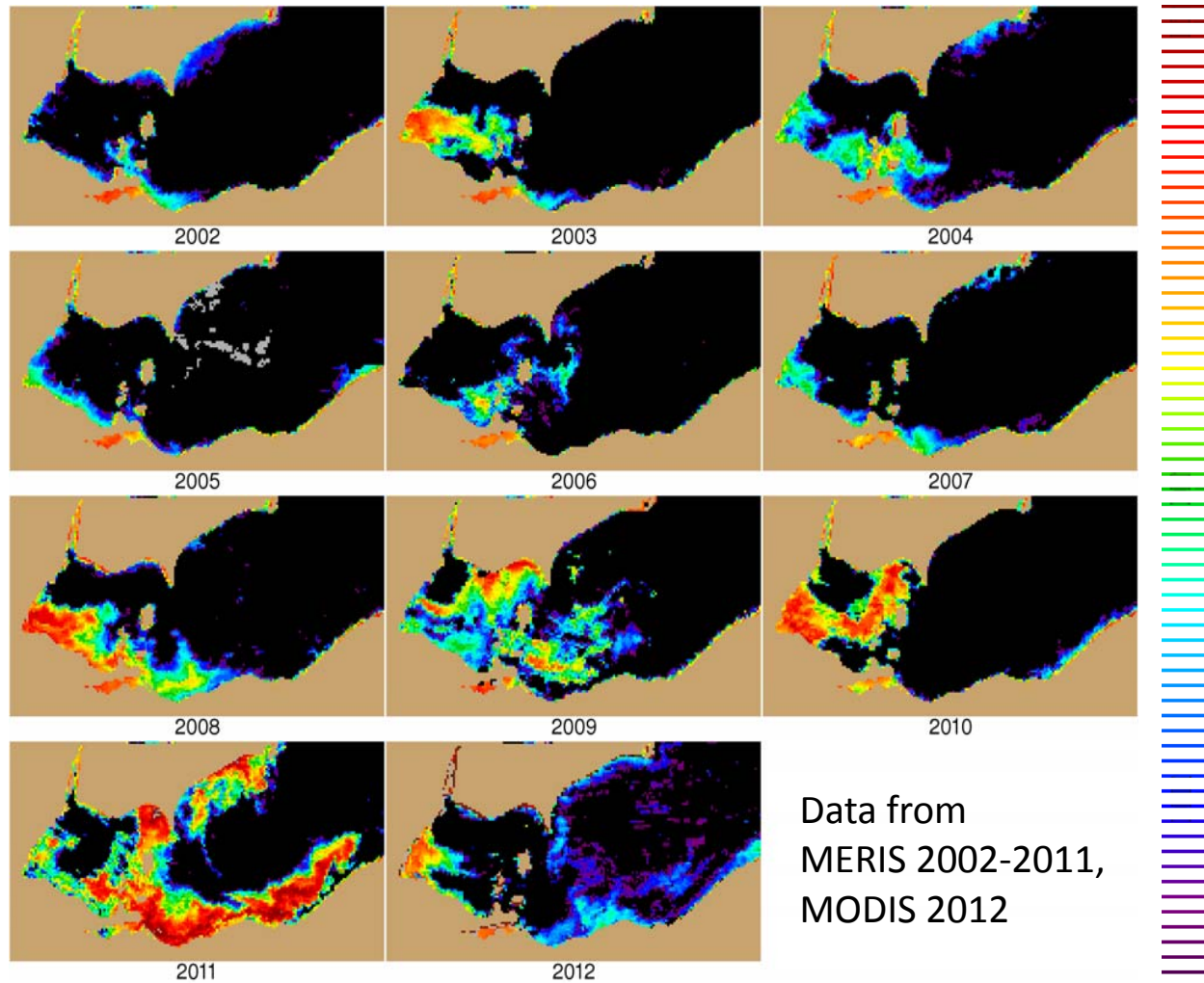
# ALS: Zebra/Quagga Mussels & Round Gobies



# Impacts of Increased Phosphorus Concentrations

- **HABs—If P concentrations are high (regardless of the source, Ag, sewage, etc.) and water is warm, we will have a HAB (nitrogen concentration will likely determine which of the 7-10 species bloom)**
- **Nuisance Algae Blooms**
  - **Cladophora—Whole lake problem. An attached form.**
  - **Winter algal blooms**
- **Dead Zone in Central Basin**

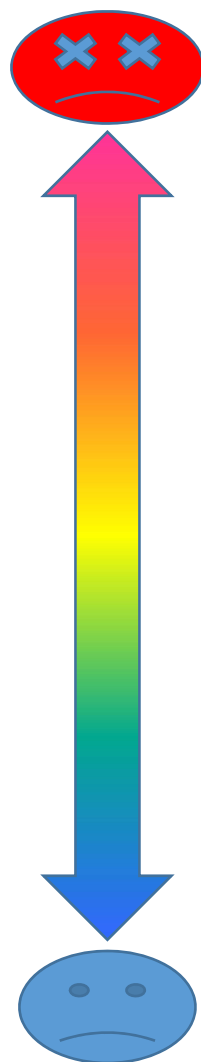
# 11 years of satellite data provide bloom extent





# Toxicity of **Algal Toxins** Relative to Other Toxic Compounds found in Water

- Reference Dose = amount that can be ingested orally by a person, above which a toxic effect may occur, on a milligram per kilogram body weight per day basis.



## Toxin Reference Doses

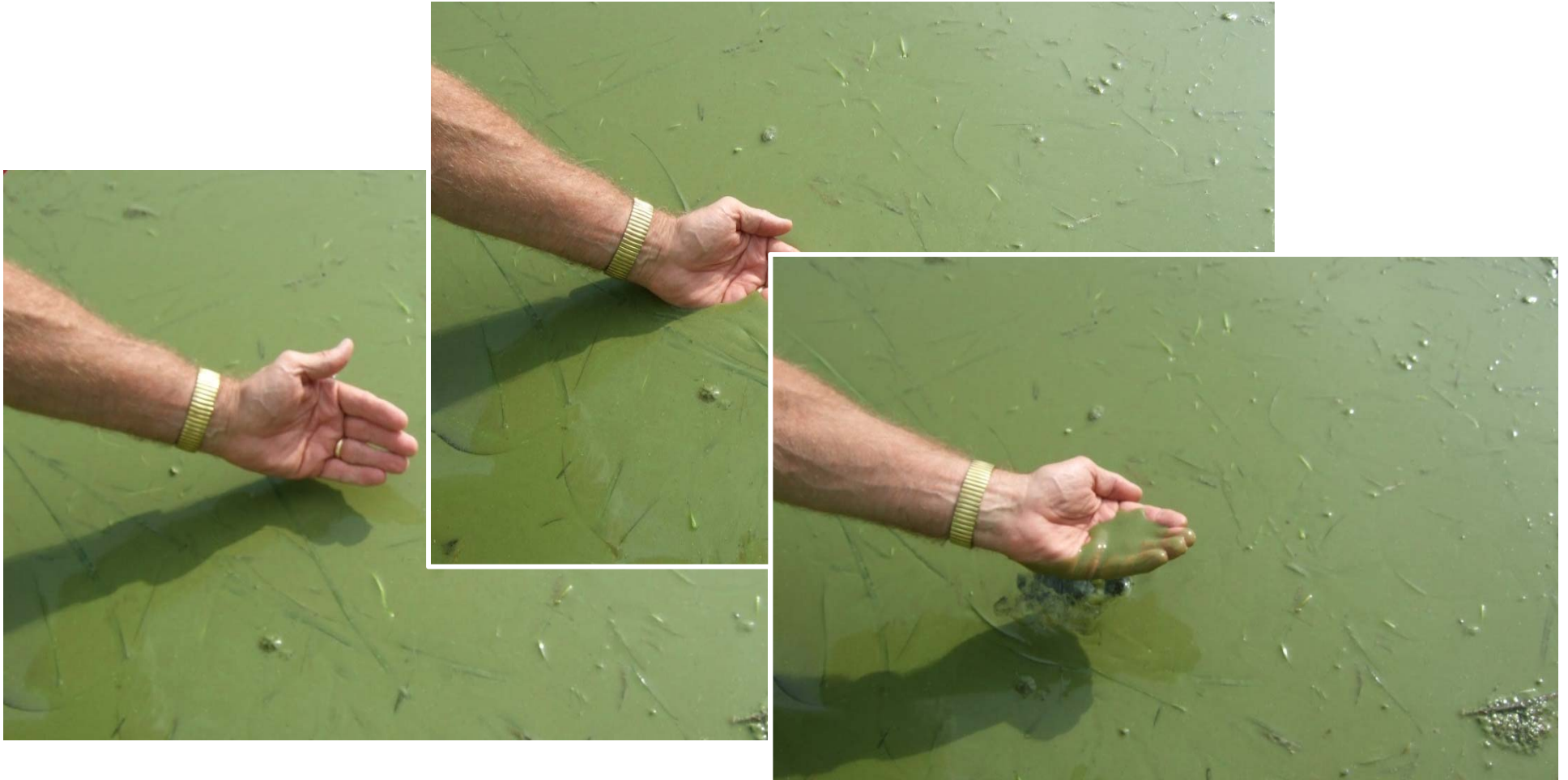
←	Dioxin (0.000001 mg/kg-d)
←	<b>Microcystin LR</b> (0.000003 mg/kg-d)
←	<b>Saxitoxin</b> (0.000005 mg/kg-d)
←	PCBs (0.00002 mg/kg-d)
←	<b>Cylindrospermopsin</b> (0.00003 mg/kg-d)
←	Methylmercury (0.0001 mg/kg-d)
←	<b>Anatoxin-A</b> (0.0005 mg/kg-d)
←	DDT (0.0005 mg/kg-d)
←	Selenium (0.005 mg/kg-d)
←	Botulinum toxin A (0.001 mg/kg-d)
←	Alachlor (0.01 mg/kg-d)
←	Cyanide (0.02 mg/kg-d)
←	Atrazine (0.04 mg/kg-d)
←	Fluoride (0.06 mg/kg-d)
←	Chlorine (0.1 mg/kg-d)
←	Aluminum (1 mg/kg-d)
←	Ethylene Glycol (2 mg/kg-d)

# Microcystin Concentrations

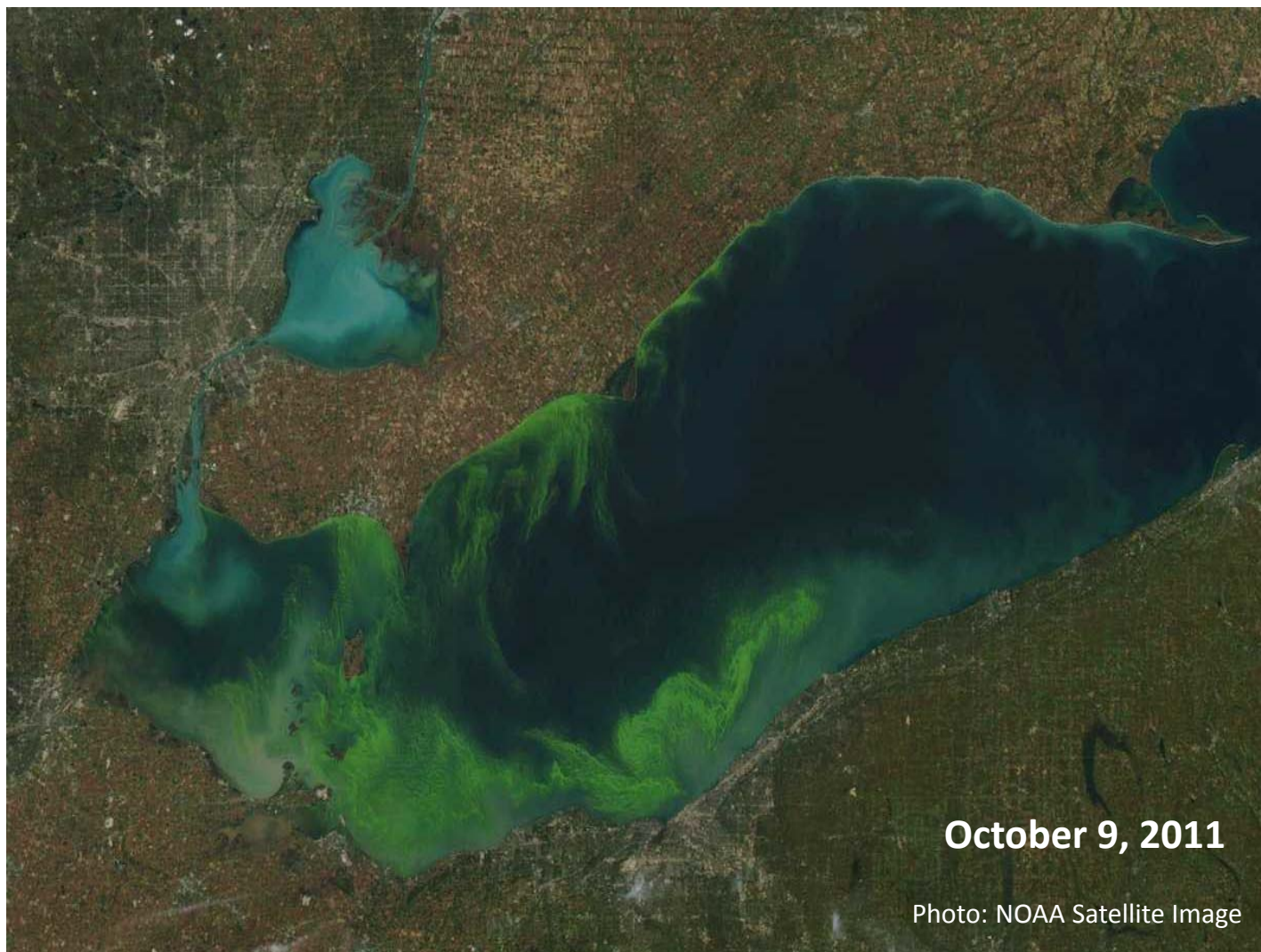
- 1 ppb WHO drinking water limit
- 20 ppb WHO swimming limit
- 60 ppb highest level for Lake Erie till 2011
- 84 ppb highest level for Grand Lake St. Marys till 2010
- 2000+ Grand Lake St. Marys 2010
- 1200 Lake Erie Maumee Bay area 2011



# Microcystis, Stone Lab, 8/10/10



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**October 9, 2011**

Photo: NOAA Satellite Image



# Microcystis, Stone Lab, 9/20/13



# **Are HABs only a Lake Erie and Ohio Problem?**

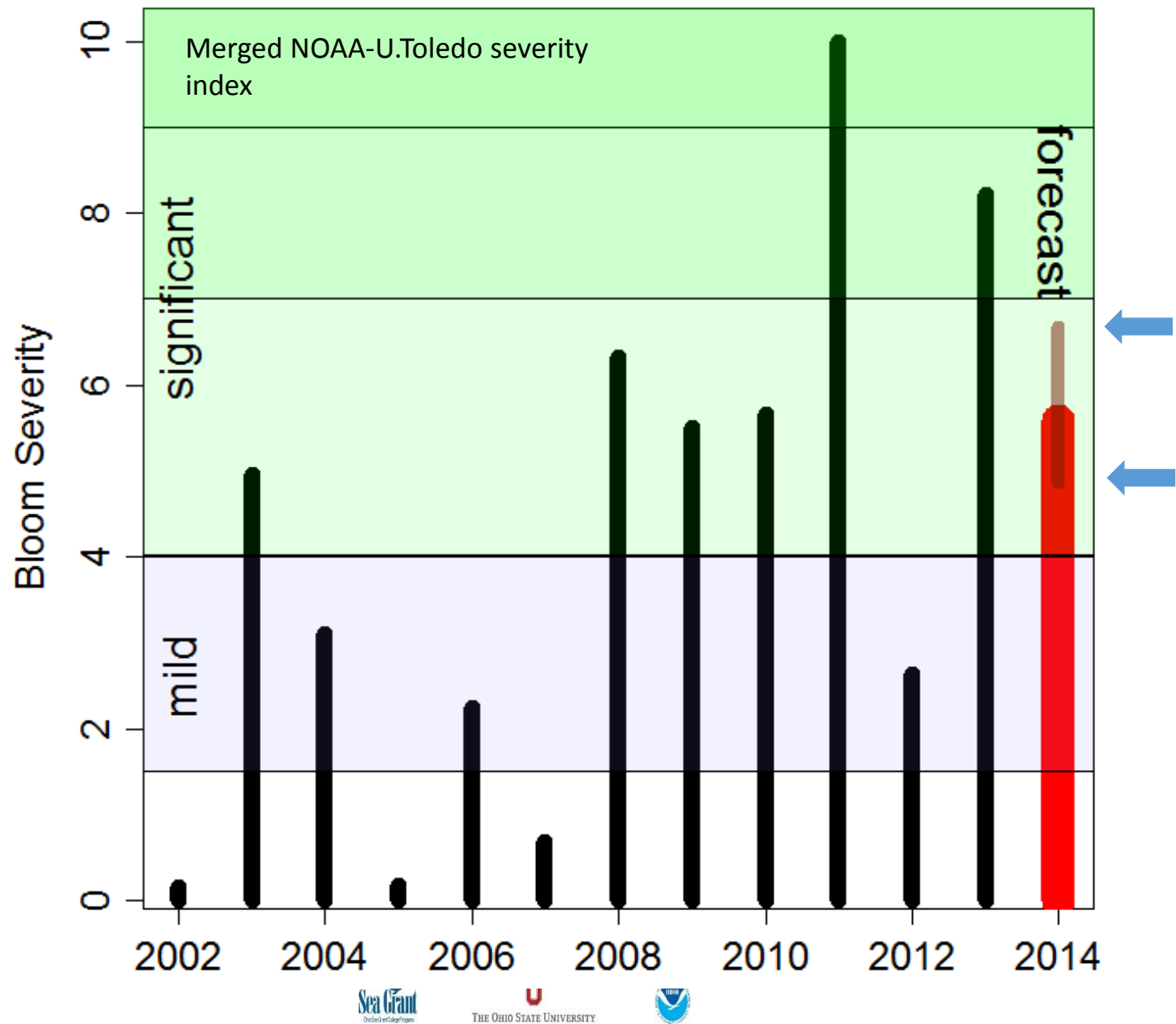
- **Serious problem in US and Canada**
- **21 states and Canada in 2012**
- **Global problem**
- **Chaired Loadings and Concentrations Subcommittee for Ohio P Task Force**
- **Now US Co-Chair of the Objectives and Loadings Task Team of Annex 4 (nutrients) Subcommittee of GLWQA**
- **Weather can determine how we experience a bloom**

# Current Forecast

- **Based on Heidelberg and USGS measurements of Maumee River discharge and P loading 1 March – 30 June**
- **Rick Stumpf's model (ground truthed by Stone Lab)**
- **Tom Bridgeman's Maumee Bay nutrient and HAB measurements and Justin Chaffin's Western and western portion of Central Basin measurements**

# 2014 forecast

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# Target Loads to Solve Problem

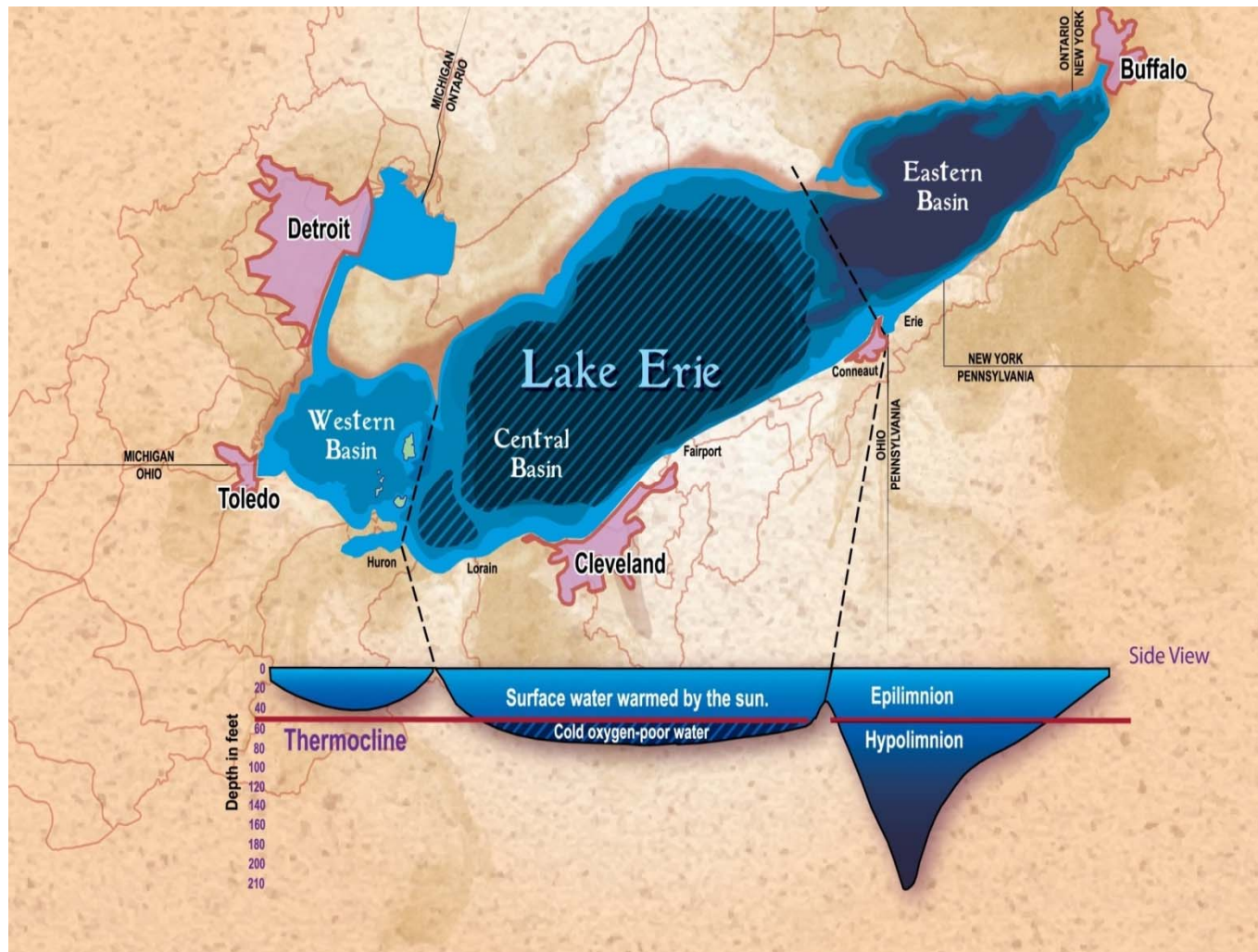
- **Leading subcommittee of the Ohio Phosphorus Task Force to identify both spring and annual target loads of both total P and DRP (Reutter comment) to prevent or greatly reduce HABs**
- **Target is 40% reduction (Ohio Phosphorus Task Force II, 3/14/13)**



# **Expect Rapid Recovery in Lake Erie, but must act quickly**

- **Due to rapid flush out rate**
  - **Lake Erie = 2.7 years**
  - **Western Basin = 20-50 days**
- **Other Great Lakes could be over 100 years**
- **Appears that less phosphorus is now causing blooms**
  - **Seedbank spread over lake bottom**

# Discuss 3 Basins & Retention Time



# HABs in the Central Basin

- **2012—1**
- **2013—5**
- **Severity—less than Western Basin**
- **Algal species are different—toxicity?**
- **Will the Toledo situation happen again at Toledo? Cleveland? Other cities?**

# Immediate Needs

- **Arm water treatment plants with tools, technology, and training to remove toxins**
  - **Assures that plants produce safe drinking water**
- **Reduce load of P into Lake Erie by 40%**
  - **Eliminates HABs and toxins**

# Issues to Consider

- **Should we be using corn, a food product, for ethanol production?**
- **Can we claim that we need to produce more food if we use 40% of our corn for ethanol?**
- **Farmers are using phosphorus more efficiently.**
- **Lots of farmers are doing a great job. How do we find the problems?**
- **How long do we try to do this voluntarily?**



# Stone Lab: Reducing Our Environmental Footprint

- Solar thermal on Dining Hall
- Solar panels on new pavilion and Lab roof
- Low-flow toilets
- Low-flow shower heads and faucets
- Compact fluorescent light bulbs or LEDs
- Attic insulation
- 4-cycle outboard motors
- Improved sewage treatment
- Terraces to reduce runoff

# Sustainable Energy Production



# Solar Pavilion





# Solar Thermal on Dining Hall



# **Stone Lab: Improve facilities and capabilities to address issues**

- **Stone Lab**
- **Research Building**
- **Water quality laboratory**
- **Research Vessels and equipment**
- **Research Coordinator**
- **Education and Outreach Coordinator**
- **Aquatic Visitors Center**
- **REU program**



# Sea Grant Research Projects

- **Beneficial reuse of dredged material in manufactured soil blending: Economic/logistical and performance considerations**  
PI: Elizabeth Dayton, Ohio State University
- **Impacts of climate change on public health in the Great Lakes due to harmful algae blooms**  
PI: Jay Martin, Ohio State University
- **Should nitrogen be managed in Lake Erie? The potential role of nitrogen fixation by cyanobacteria**  
PI: Darren Bade, Kent State University
- **Leveraging natural amenities for sustainable development in the Great Lakes region**  
PI: Elena Irwin, The Ohio State University
- **Source tracking and toxigenicity of *Planktothrix* in Sandusky Bay**  
PI: George S. Bullerjahn, Bowling Green State University
- **Mapping drain tile and modeling agricultural contribution to nonpoint source pollution in the western Lake Erie basin**  
PI: Kevin Czajkowski, University of Toledo
- **The role of nitrogen concentration in regulating cyanobacterial bloom toxicity in a eutrophic lake**  
PI: Justin Chaffin, Ohio State University
- **Delivery of sediment amendments using far-field ultrasound**  
PI: Linda K. Weavers, Ohio State University
- **Relative contributions of hypoxia and natural gas drilling to methane emissions from Lake Erie**  
PI: Amy Townsend-Small, University of Cincinnati



# Outreach Activities

- **22,000 visitors to Aquatic Visitors Center**
- **Media Coverage**
  - **403 articles from 158 different publications/venues in 2013 about our programs**
- **Stone Lab Workshops**
- **Twine Line Articles**
- **Personal speaking engagements**
  - **Over 50 last year**

# Stone Lab 1 or 2-Day Workshops

- **10 July, NOAA HAB Press Conference, Science Cruise and Webinar**
- **23 July, USDA Rural Development State Directors from twelve Midwest states**
- **24 July, Ohio Farm Bureau Group**
- **24 July, REU Presentations**
- **14 & 15 August, 2 groups of Michigan farmers**
- **18-19 August, Science Writers 2-day workshop**
- **20 & 26 August, Coastal County Commissioners, Mayors, and Decision Makers Day on Lake Erie**
- **25 August, Ohio Charter Captains**
- **27 August, Indiana Farming Leaders**
- **5-7 September, Annual Open House (approx 1,200 visitors)**

**For more information:  
Dr. Jeff Reutter, Director**

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