HABs State of the Science webinar series: HABs Blooms Sources & Movements

Speakers:

Michael McKay – Bowling Green State University

Kateri Salk – Michigan State University

Bart De Stasio – Lawrence University

Silvia Newell – Wright State University

Mark Rowe – University of Michigan

In partnership with:

NOAA

Sea Grant
Ohio Sea Grant College Program

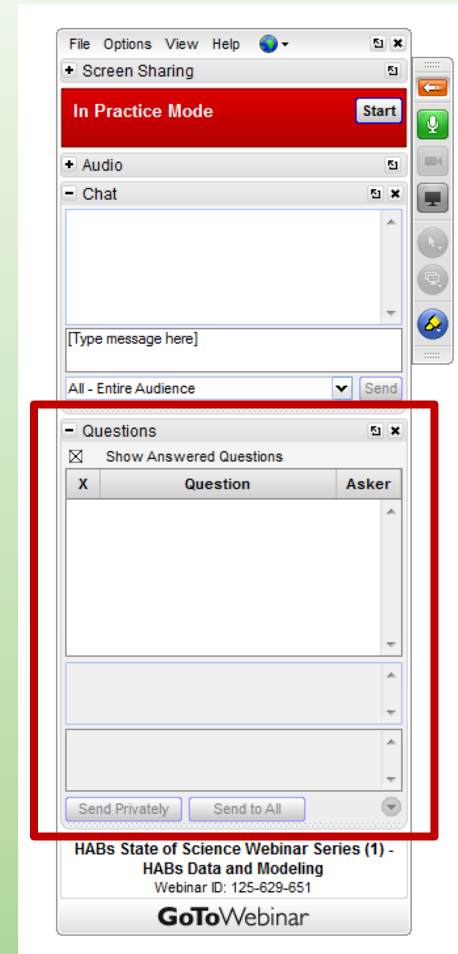
The Ohio State University

LimnoTech
Water Environment | Scientists Engineers

GoToWebinar Housekeeping Items

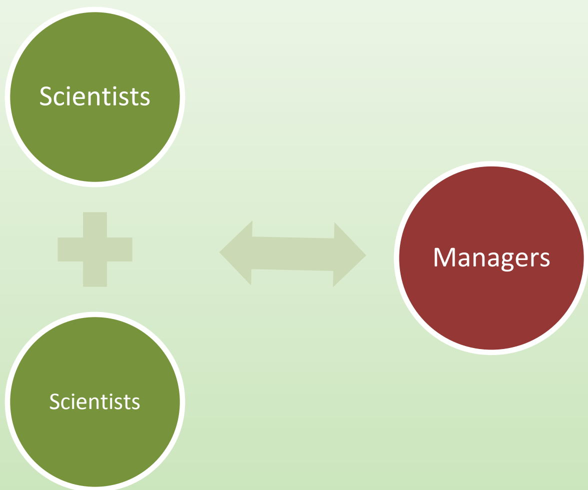
- Submit your text questions and comments using the Questions Panel

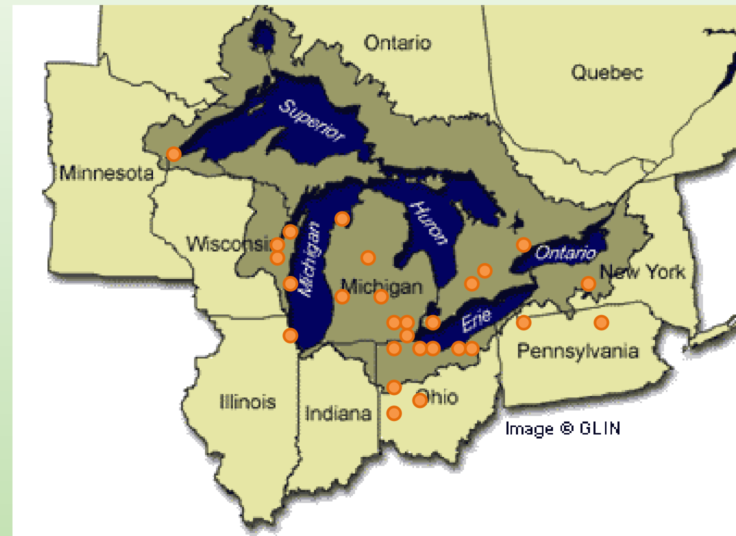
- Note: This webinar is being recorded and will be posted on the HABs Collaboratory website



Great Lakes HABs Collaboratory

"A virtual laboratory for information sharing and collective actions to address HABs"





- Multidisciplinary group, 100+ members from different Agencies, Ministries, Colleges, Universities and Organizations across the Great Lakes

Great Lakes Commission des Grands Lacs

USGS science for a changing world

HABs State of the Science webinar series

- Result of the inaugural meeting of the HABs Collaboratory
  - Identified need for communication between researchers, and between researchers and managers
- Present on-going research projects related to HABs in the Great Lakes region
- Goals:
  - Improve communication
  - Knowledge transfer
  - Opportunities for collaboration

Ohio Sea Grant / OSU Stone Lab

- Managing 55 HABS related projects (~$7,000,000)
  - 18 funded by Ohio Sea Grant
  - 5 funded by OSU's Field 2 Faucet initiative
  - 32 funded under the Ohio Department of Higher Education (OSU/UT; 18 vs. 14)
- Stone Lab Guest and Research Lecture Series
  - June 16th, 23rd, 30th, July 7th, 14th, 28th, and August 4th
  - 7pm -9pm
  - https://ohioseagrant.osu.edu/news/calendar
- 9/15/16 "State of Science" meeting in Toledo
  - Stranahan Theater
  - Modeling, BMPs, and Public Health-Water treatment

HAB DETECTION, MAPPING AND WARNING NETWORK: SANDUSKY BAY

Mike McKay – Bowling Green State University

HAB DETECTION, MAPPING AND WARNING NETWORK: SANDUSKY BAY

Robert Michael McKay – Bowling Green State University
George S. Bullerjahn – Bowling Green State University

BGSU

June 23, 2016

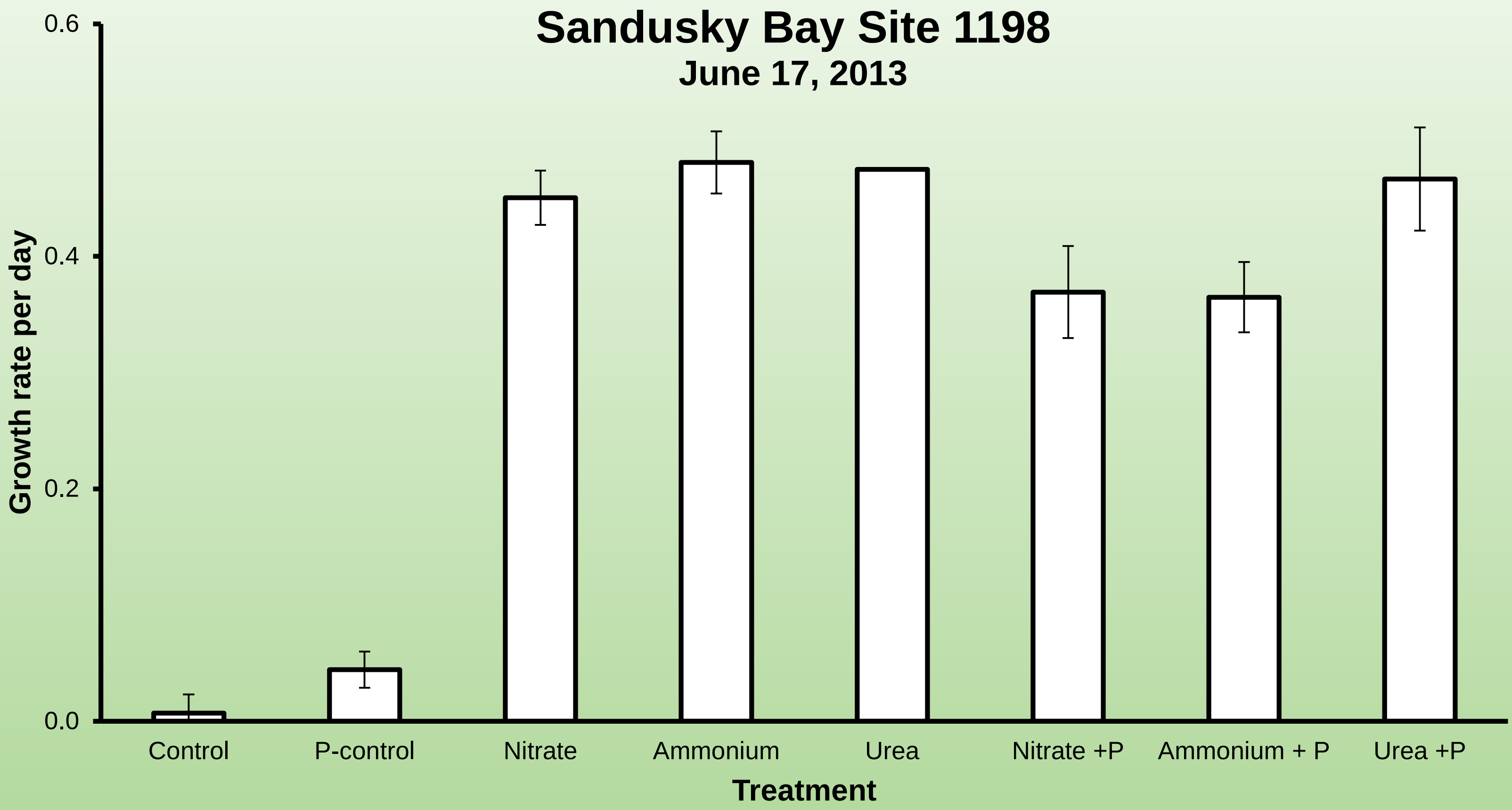
Project Overview

- HAB Detection, mapping and warning network: Sandusky Bay
- G.S. Bullerjahn, R.M. McKay: Bowling Green State University
  - J. Ortiz, D. Bade: Kent State Univ
  - J. Chaffin: OSU Stone Lab
  - D. Kane: Defiance College
- Ohio Department of Higher Education
- Sandusky Bay: 2015-present
- What makes *Planktothrix* bloom?

Objectives/Approach

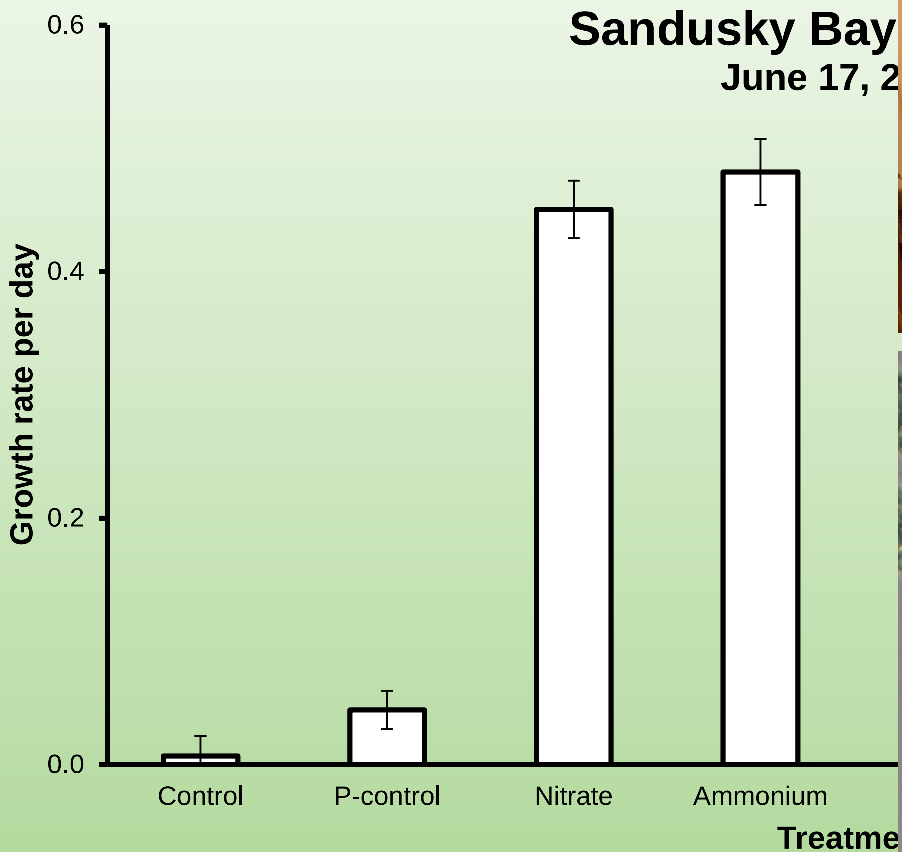
- Inform Big Island Water Works, lake managers and interested citizens on the extent and distribution of HABs in Sandusky Bay
  - weekly- to biweekly monitoring in cooperation with ODNR
  - deploy sondes at municipal water intakes capable of detecting algal- and cyanobacterial pigments in real-time
  - hyperspectral imaging via weekly NASA overflights
- Elucidate the relationship between nutrient cycling and bloom formation, persistence and toxicity
  - H_0: an active nitrogen cycle is important in structuring the *Planktothrix* bloom (Kateri Salk – to follow)

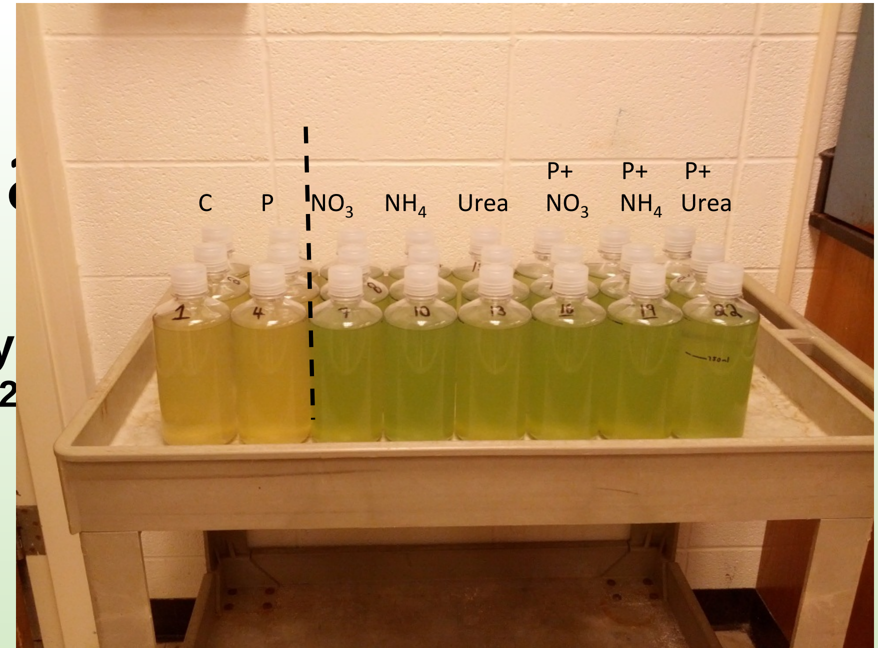
Rationale



Davis et al., 2015, *Environ. Sci. Technol.* 49: 7197-7207

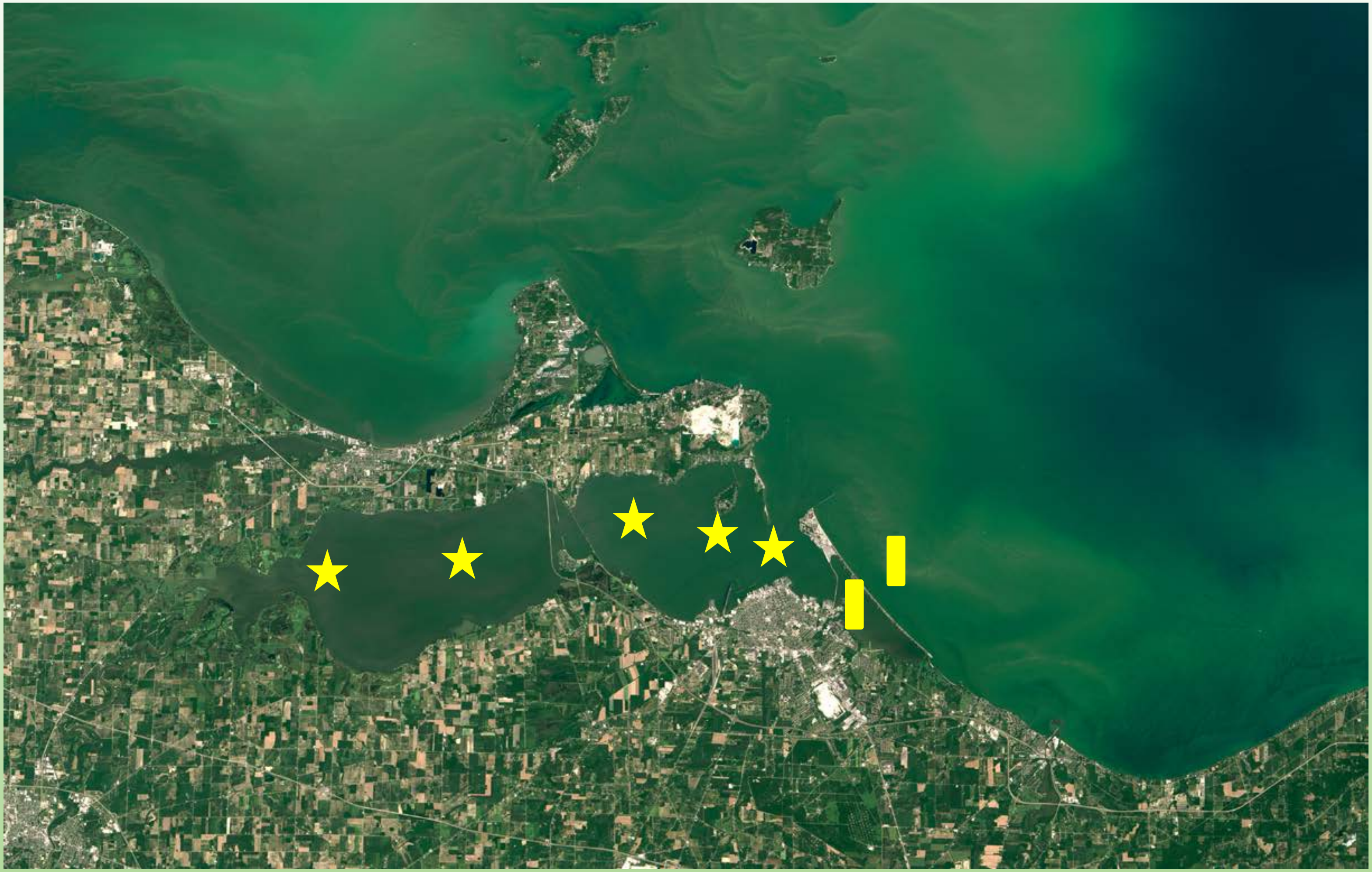
Rationa





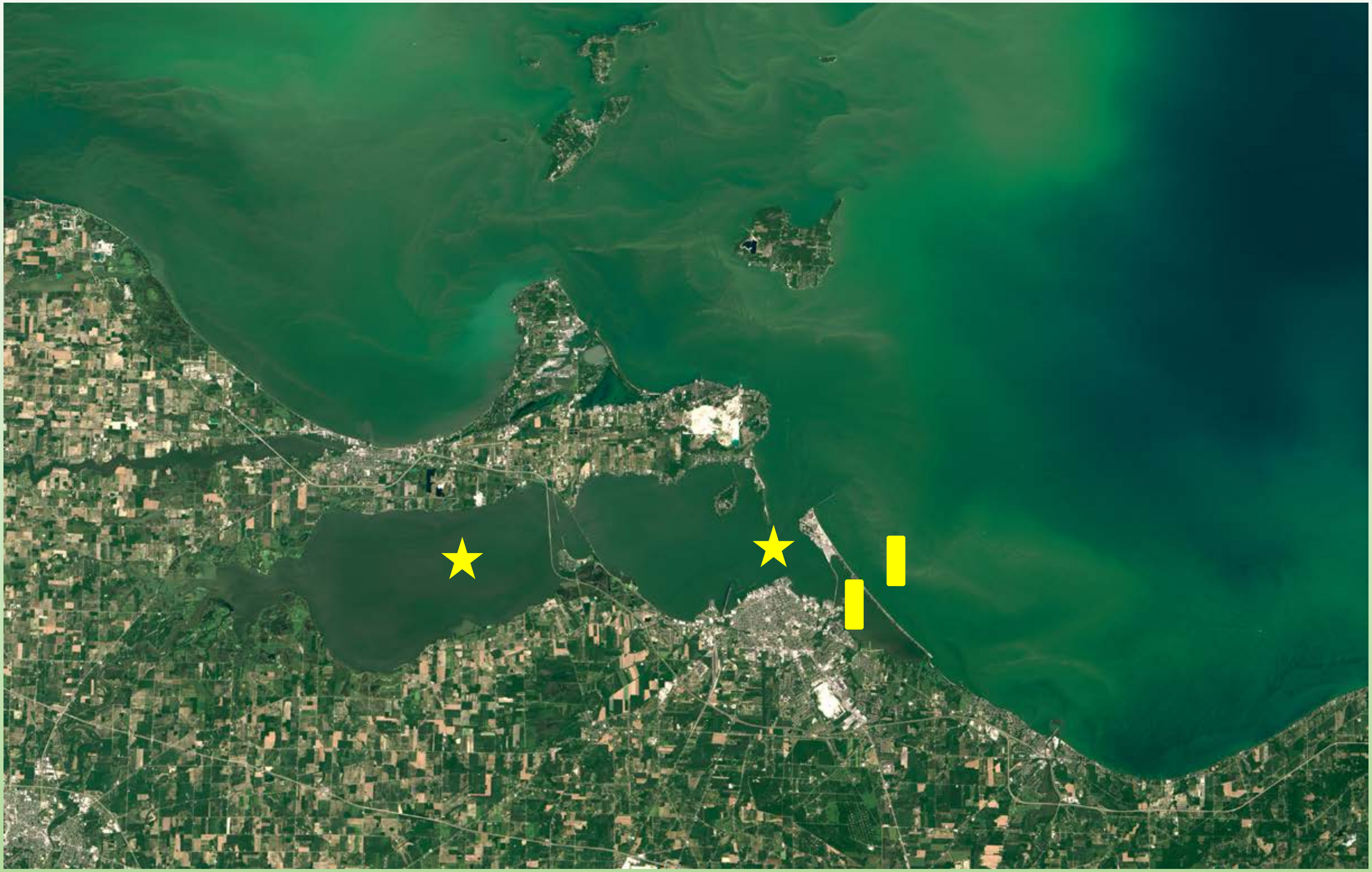
Davis et al., 2015, E

Field Sites



Landsat (28 July, 2015) imagery courtesy of NASA Goddard Space Flight Center and US Geological Survey

Field Sites

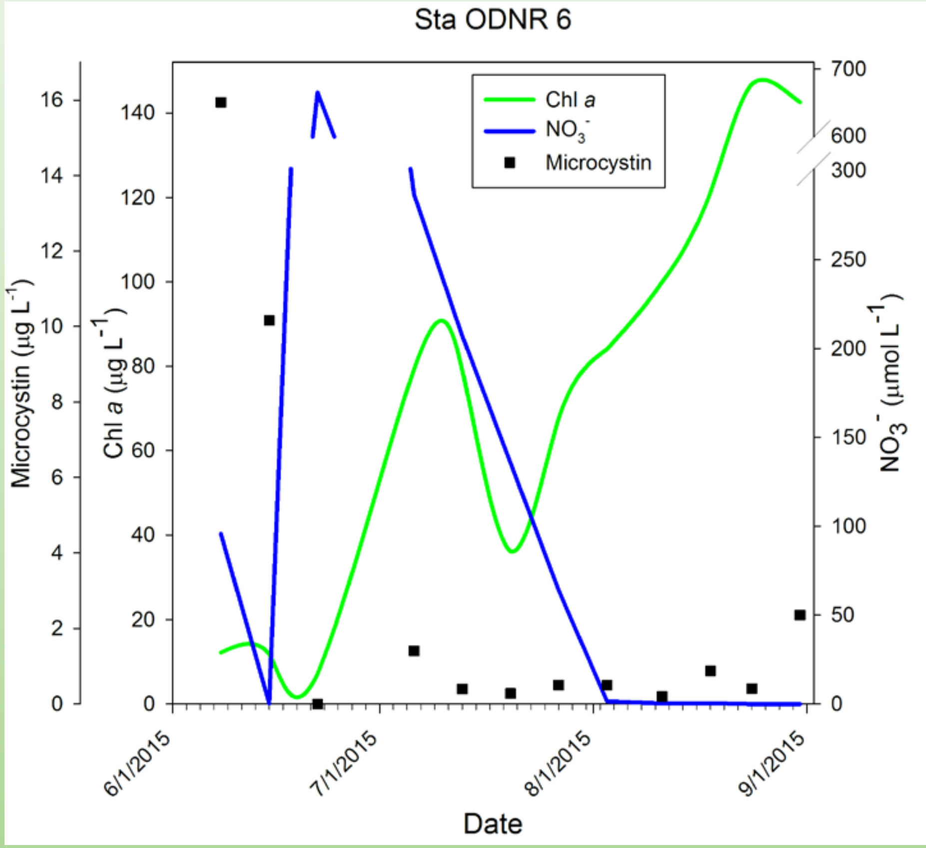


Landsat (28 July, 2015) imagery courtesy of NASA Goddard Space Flight Center and US Geological Survey

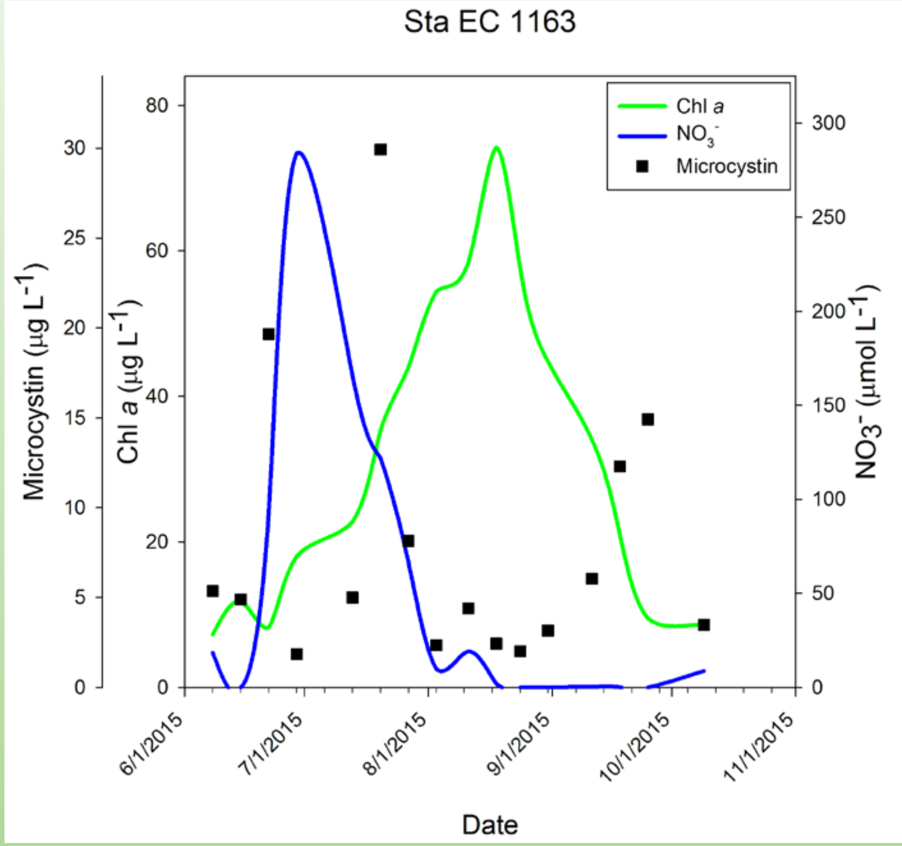
Summary of Findings:

HAB Biomass, Toxicity and Nitrogen Dynamics

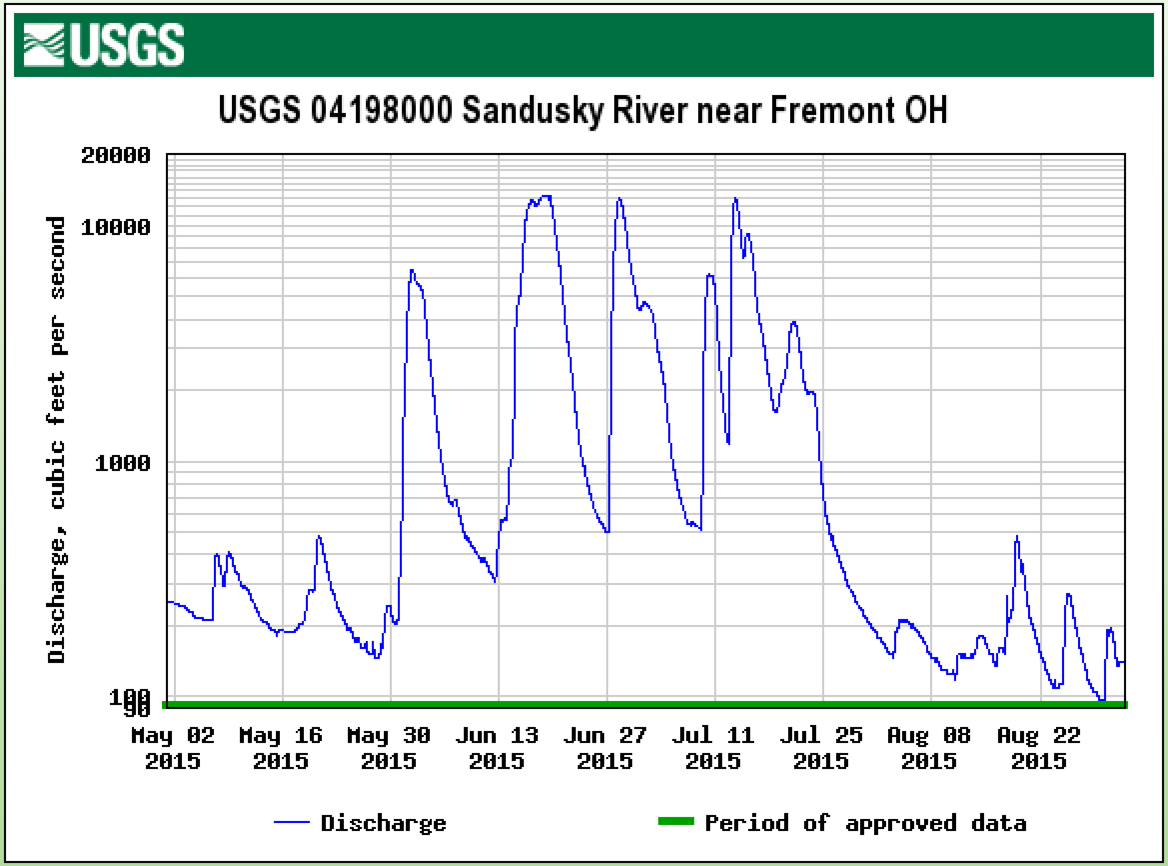
- Inner Bay



- Outer Bay



The unexpected…….

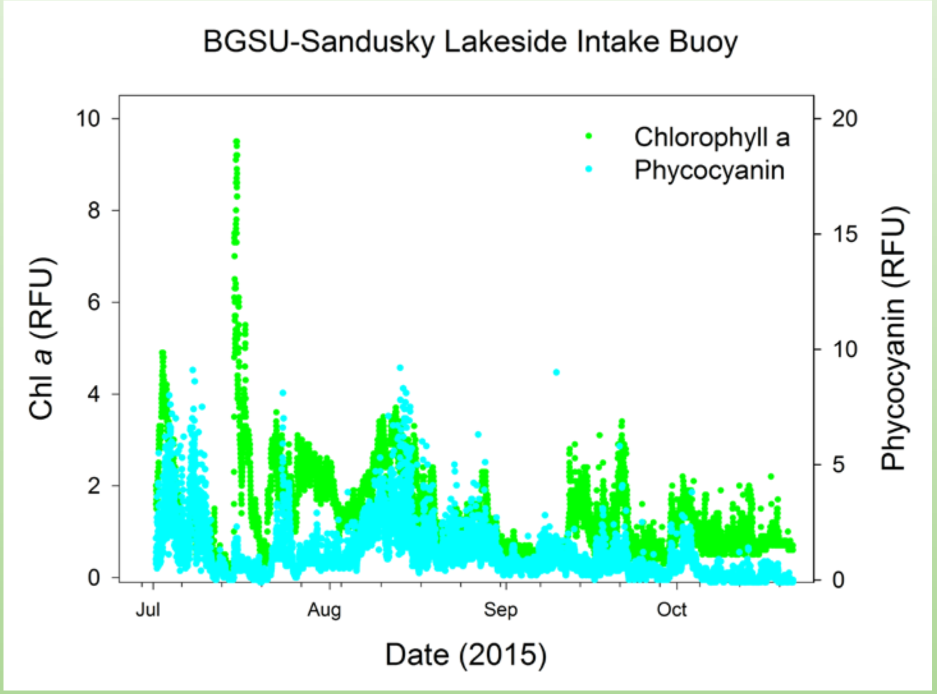


Relevance to Water Quality Managers:

Real-time monitoring

HABS Data Portal: http://habs.glos.us/map/

- Sandusky water intake



HABs Collaboratory

- *What questions still need to be answered about HABs?*
  - Environmental parameters and their role in bloom toxicity
    - A role for nitrogen in bloom development and toxicity?
  - Adopt 'omics approach
- *How can collaboration help your research?*
  - Expand genomics databases to include relevant Great Lakes isolates
    - Meyer et al. 2016, IAGLR: WLE *Microcystis* isolates
    - Ivanova et al., 2016, IAGLR: DNA Barcoding
    - Edge et al., 2016, IAGLR: EcoBiomics Initiative

LINKAGES OF ACTIVE NITROGEN CYCLING AND PLANKTOTHRIX BLOOMS IN SANDUSKY BAY, LAKE ERIE

Kateri Salk – Michigan State University

LINKAGES OF ACTIVE NITROGEN CYCLING AND PLANKTOTHRIX BLOOMS IN SANDUSKY BAY, LAKE ERIE

Kateri Salk – Michigan State University
Nathaniel Ostrom – Michigan State University

MICHIGAN STATE UNIVERSITY

NSF

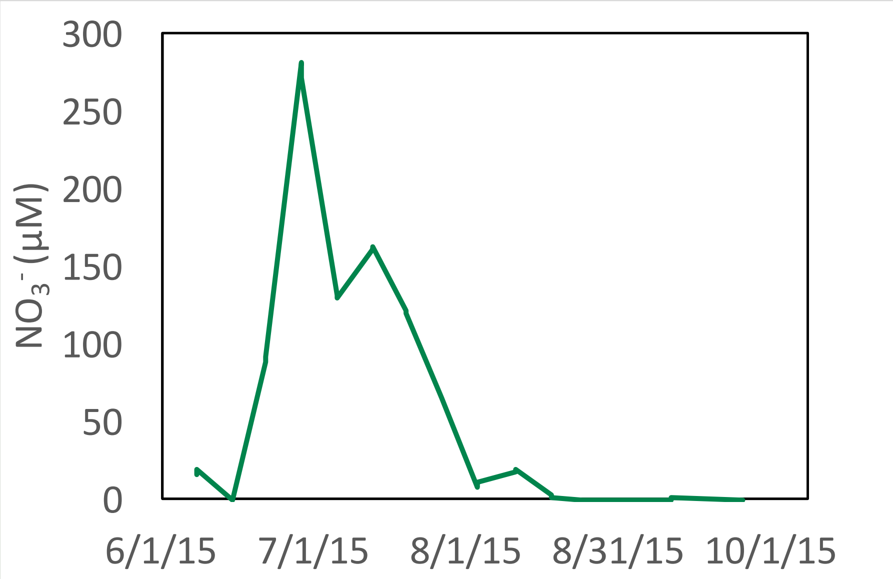
MICHIGAN STATE UNIVERSITY

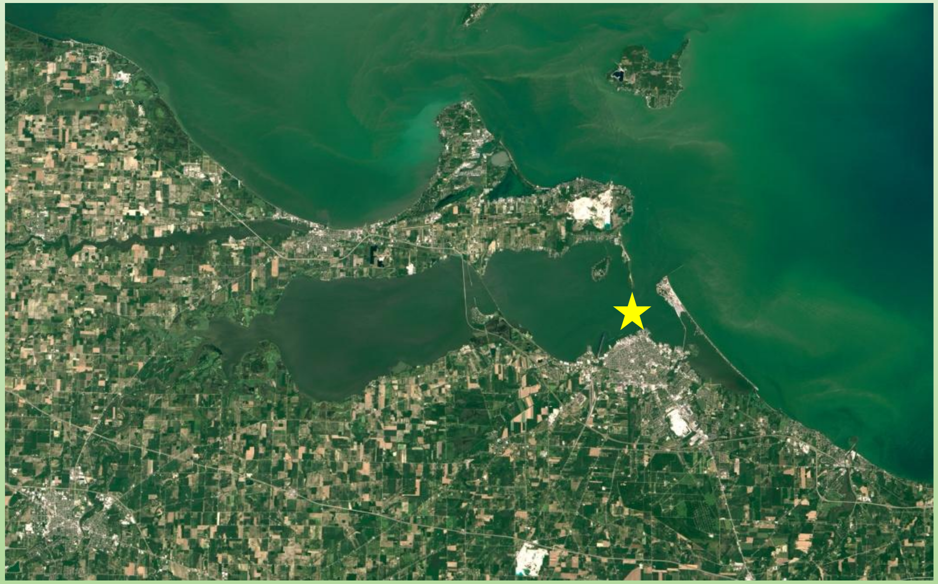
Project Overview

- Sandusky Bay, Lake Erie (2015-present)
  - Offshore Lake Erie – *Microcystis*
  - Sandusky Bay - *Planktothrix*
- How do N cycling processes affect HAB formation and composition in N-limited nearshore zones such as Sandusky Bay?
- Funding:
  - MSU Water Science Network WaterCube
  - MSU Marvin Hensley Endowed Fellowship
  - MSU Rose Graduate Fellowship in Water Research
  - NSF Graduate Research Fellowship

Project Hypotheses/Approach

- Hypothesis: an active N cycle is important in structuring *Planktothrix* bloom development and toxicity
- Microbial N loss processes drive N limitation in late summer
  - Sediment N loss measurements (denitrification, anammox, N_2O)
  - Isotope Pairing Technique
- N fixation provides a source of fixed N when DIN is scarce
  - Water column N fixation measurements
  - *Planktothrix* abundance and toxicity (Bullerjahn, McKay) may be bolstered by a commensal relationship with N fixers

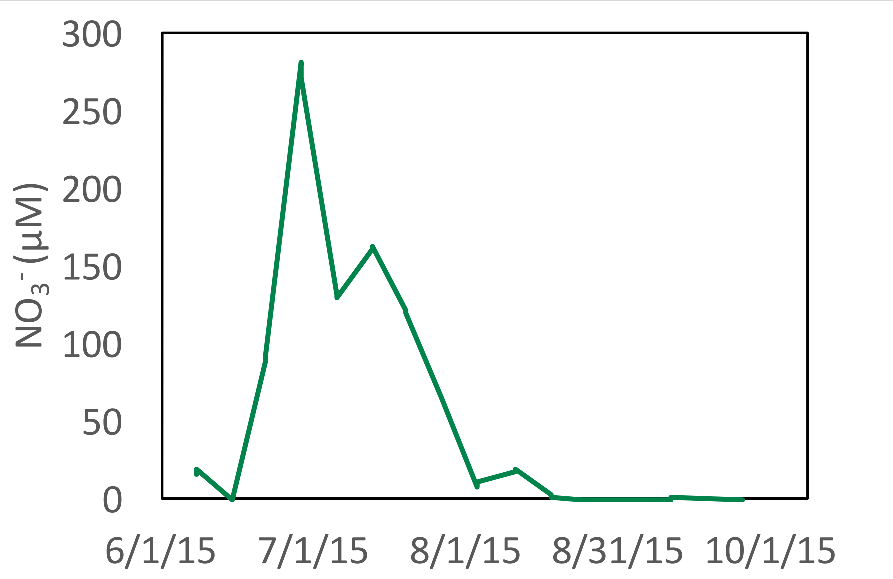


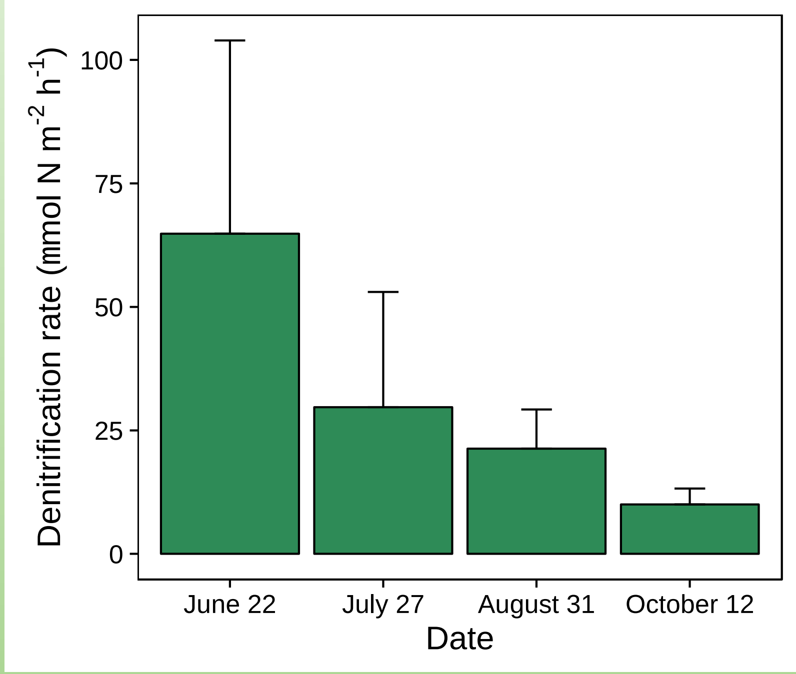


Landsat (28 July, 2015) imagery courtesy of NASA Goddard Space Flight Center and US Geological Survey

Inner Bay Station

- [NO_3^-] spikes in late June (Sandusky River discharge)
- [NO_3^-] decreases through August, remains low

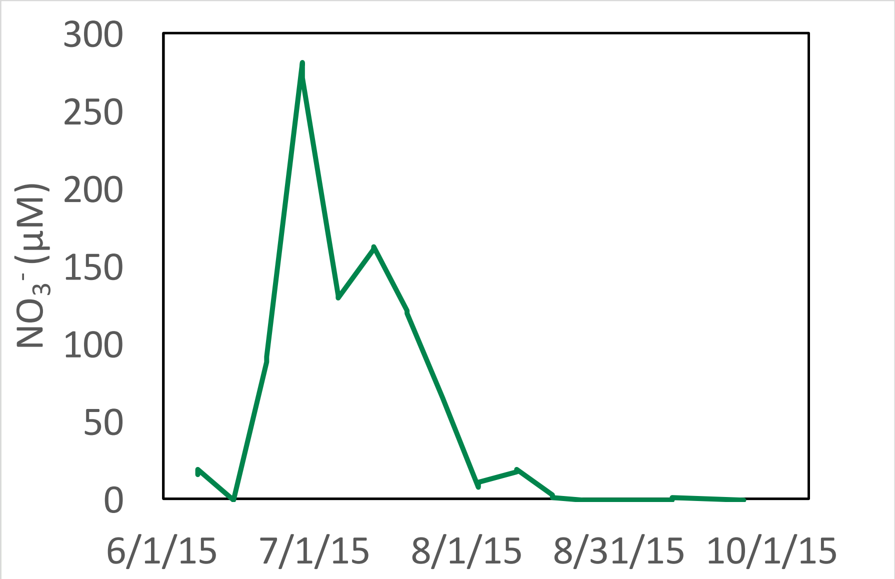




Denitrification

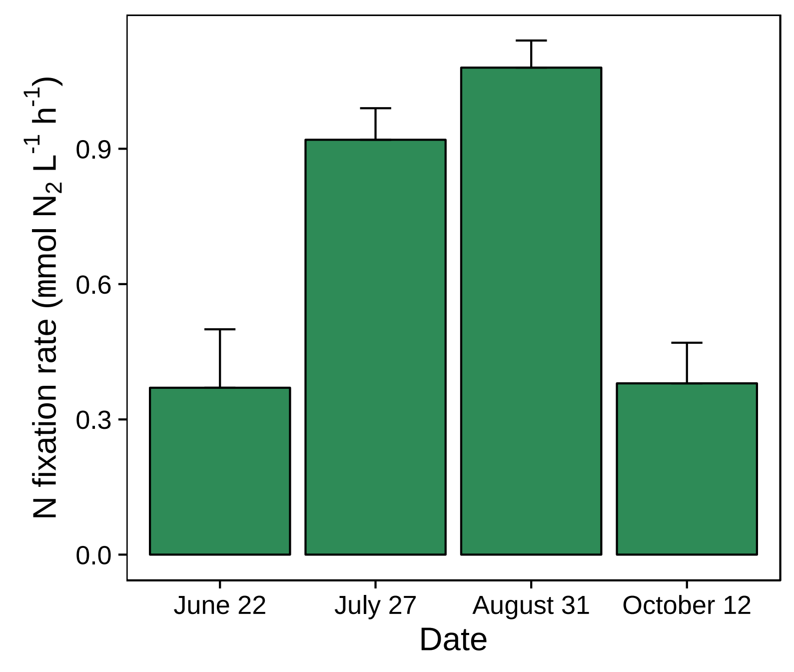
- Rates positively associated with ambient $[NO_3^-]$
- Mechanism for N drawdown, N limitation in Sandusky Bay

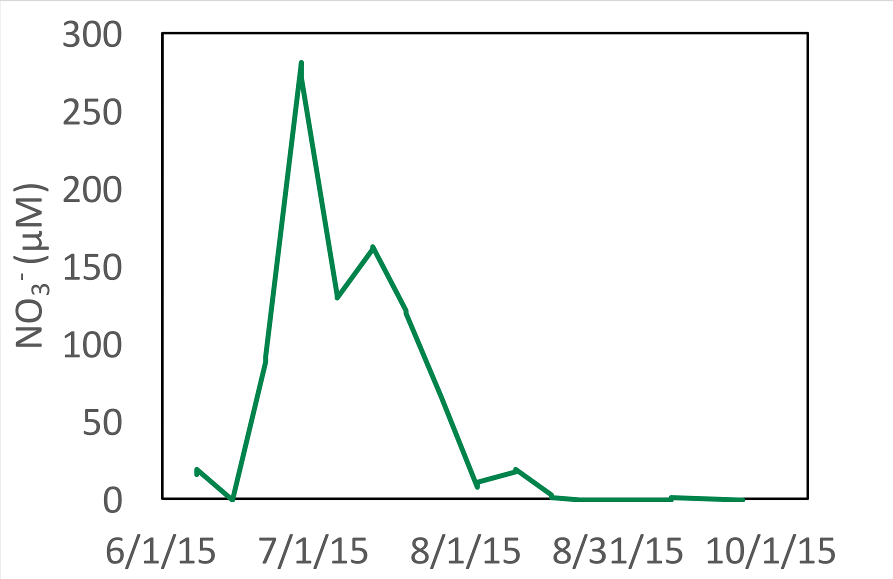
MICHIGAN STATE UNIVERSITY

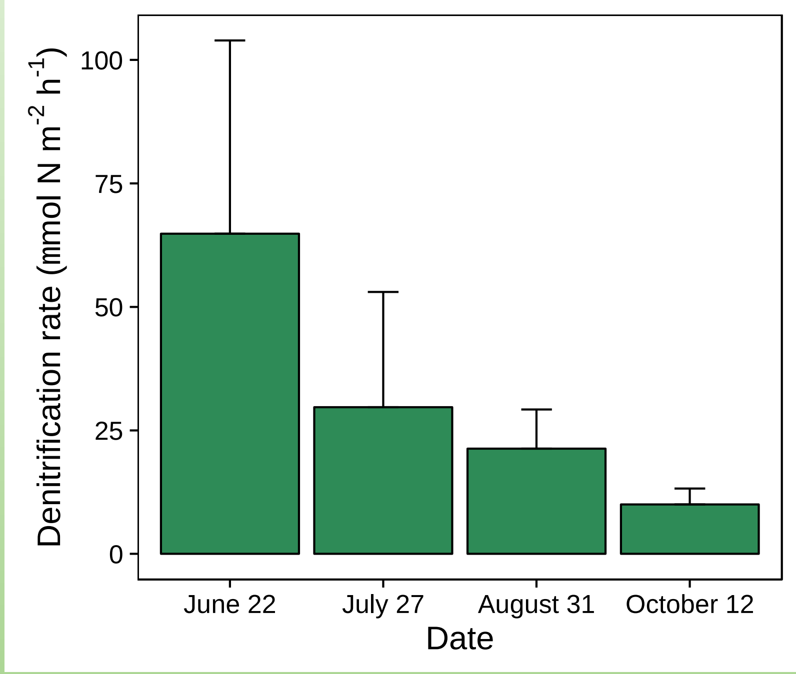


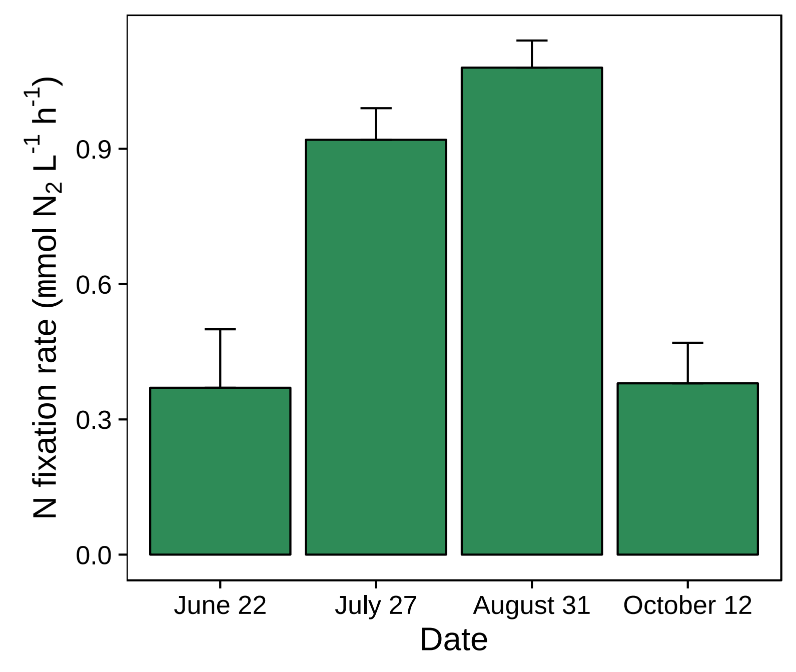
N fixation

- Rates peak as [NO_3^-] reaches a minimum
- Supplementation of fixed N in the Bay




300
250
200
150
100
50
0
NO3- (µM)
6/1/15
7/1/15
8/1/15
8/31/15
10/1/15


Denitrification rate (mmol N m-2 h-1)
100
75
50
25
0
June 22
July 27
August 31
October 12
Date


N fixation rate (mmol N2 L-1 h-1)
0.9
0.6
0.3
0.0
June 22
July 27
August 31
October 12
Date

MICHIGAN STATE UNIVERSITY

Summary of Findings

- What questions still need to be answered about HABs?
  - What is the overall role of N in Great Lakes HAB dynamics?
  - Linking biogeochemistry with HAB formation and toxicity → predictive models
- How can collaboration help your research?
  - Connecting omics techniques with measurements of environmental processes

UNEXPECTED CHANGES IN THE GREEN BAY, LAKE MICHIGAN FOOD WEB FOLLOWING INVASION BY ZEBRA MUSSEL

Bart De Stasio – Lawrence University

Unexpected changes in the Green Bay, Lake Michigan food web following invasion by zebra mussel

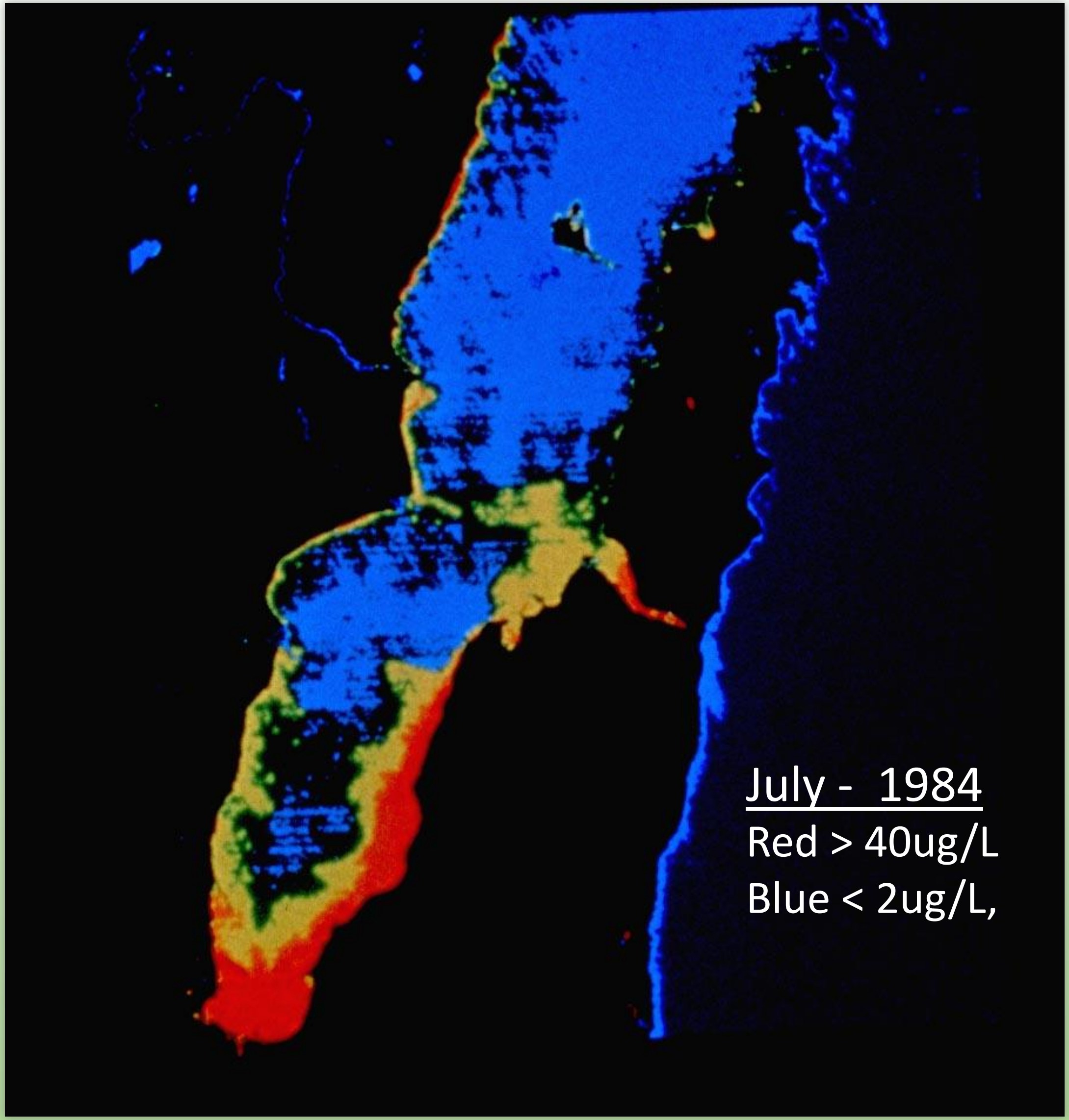
BART DE STASIO
BIOLOGY DEPARTMENT
LAWRENCE UNIVERSITY
APPLETON, WI

Project Overview

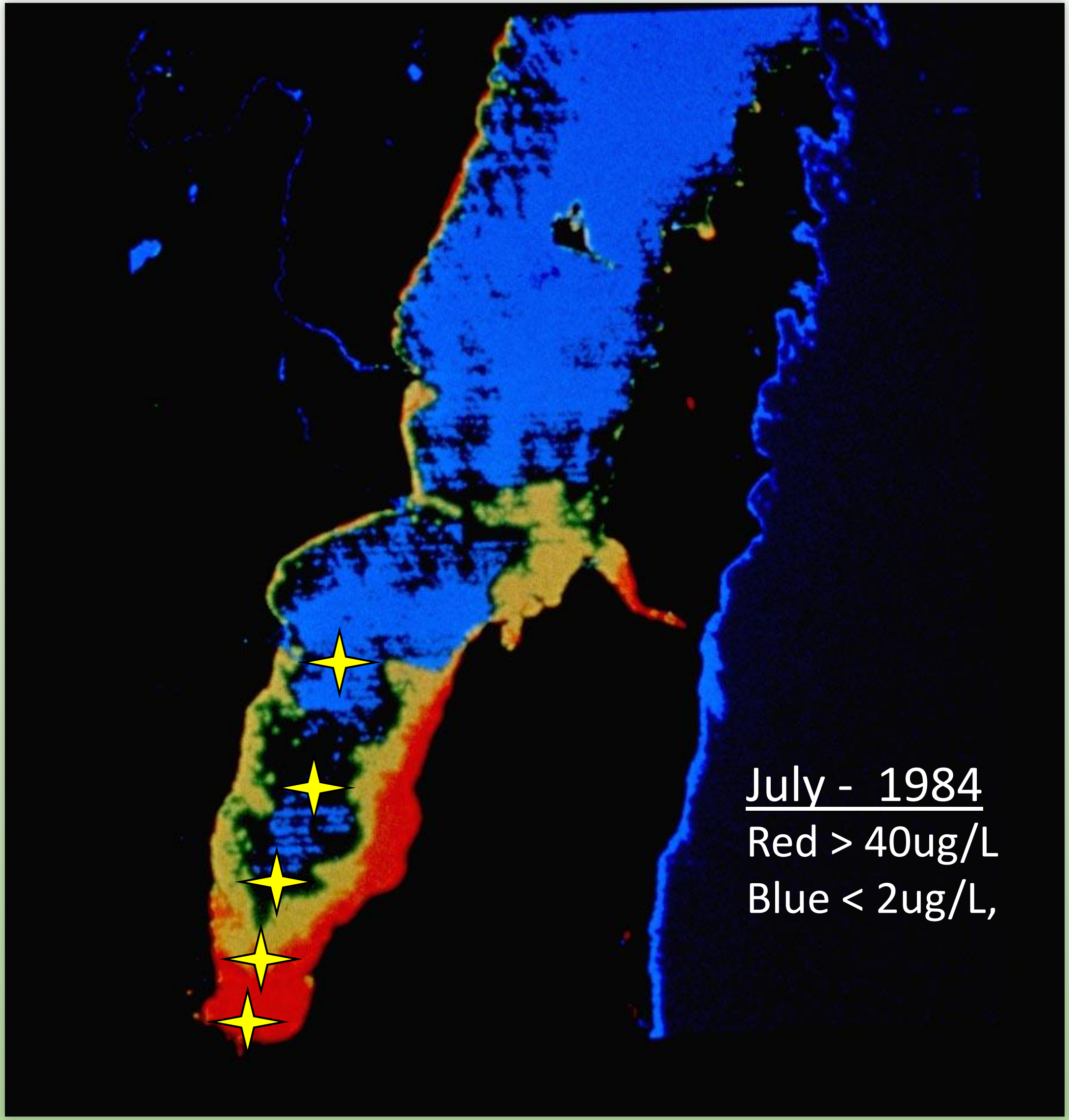
"Unexpected changes in the Green Bay food web following invasion by zebra mussel"

- PI: Bart De Stasio, Lawrence University, Wisconsin
- Funding:
  - Univ of Wisconsin Sea Grant Institute
  - American Philosophical Society
- Location: Green Bay (1980s – 2012)
- Objective: Test for phytoplankton community shifts following invasion by zebra mussels

Chlorophyll *a*



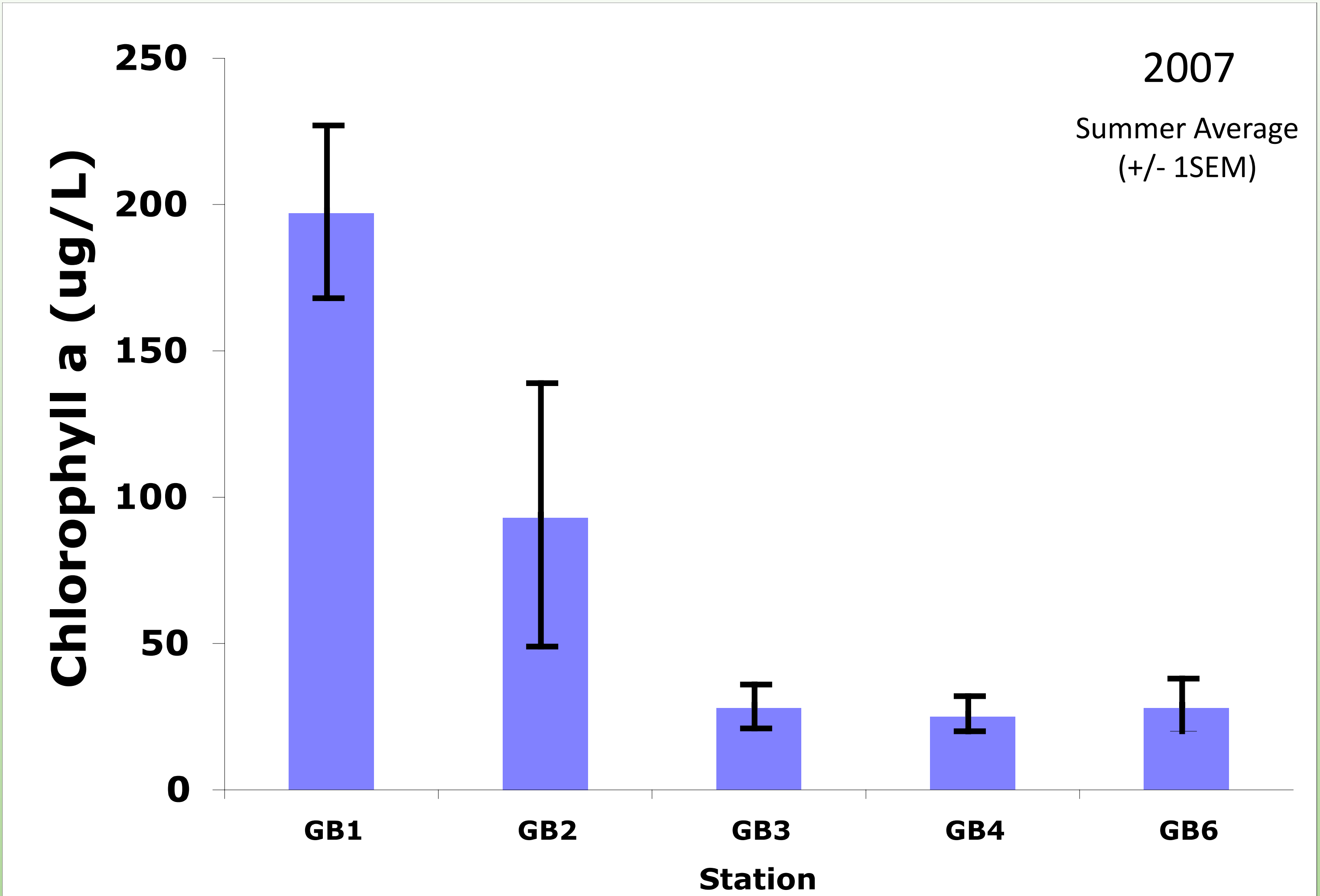
Chlorophyll *a*



Approach

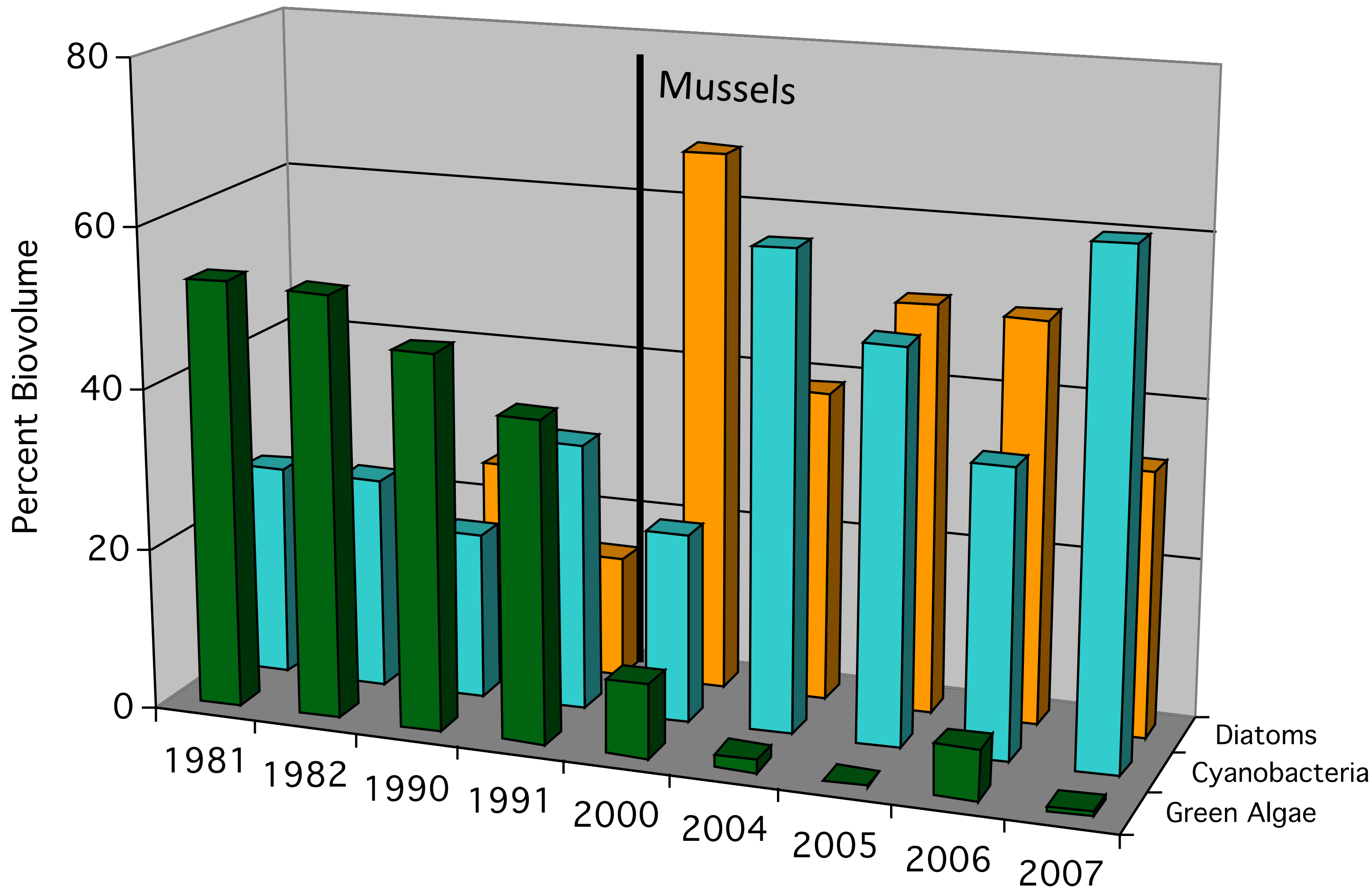
- Summer Biweekly Sampling 5 stations
- Phytoplankton Abundance (chlorophyll & counts)
- Primary Production (^{14}C uptake Method)
- Zooplankton Abundance
- Zooplankton Grazing Rates (^{14}C-labeled food uptake)

Post-Invasion Trophic Gradient



De Stasio *et al*. 2009

Lower Bay Algae



De Stasio *et al.* 2008

Summary of Comparisons

AFTER INVASION:

- **Phytoplankton biomass increased, NPP no change**
- **Cyanobacteria & Diatoms Increased (*Microcystis* dominant)**
- **Cyanotoxins can exceed WHO limits (1 ug/L) in late summer**
- **Chlorophyta decreased**
- **Zooplankton biomass & grazing decreased**

HABs Collaboratory

- What questions still need to be answered about HABs?
  - Role of dreissenids and Nitrogen availability
  - N_2-fixing vs. non-fixing cyanobacteria

- How can collaboration help your research?
  - Coordinated comparisons of food web processes
  - New avenues for addressing water quality issues

WATER COLUMN AMMONIUM DYNAMICS AFFECTING HARMFUL CYANOBACTERIAL BLOOMS IN WESTERN LAKE ERIE 2015-2016

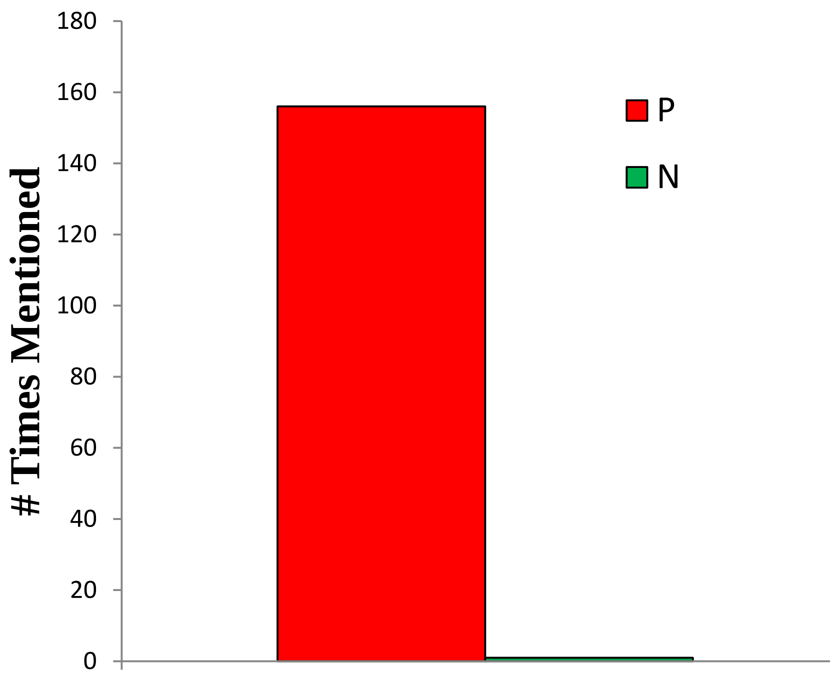
Silvia Newell – Wright State University

Wright State University
Changing Lives

WATER COLUMN AMMONIUM DYNAMICS AFFECTING HARMFUL CYANOBACTERIAL BLOOMS IN WESTERN LAKE ERIE 2015-2016

Daniel K. Hoffman, Mark J. McCarthy, Timothy W. Davis*, Justin A. Myers, and Silvia E. Newell
Wright State University and *NOAA-GLERL

GLERL NOAA Sea Grant



No N regulations in Ohio

Proposed 40% reduction in P loading in Great Lakes Water Quality Agreement – Annex IV

ARTICLE IN PRESS

JGLR-00684; No. of pages: 21; 4C: 3, 7, 12, 13, 16

Journal of Great Lakes Research xxx (2014) xxx–xxx

Contents lists available at ScienceDirect

Journal of Great Lakes Research

journal homepage: www.elsevier.com/locate/jglr

Review

Assessing and addressing the re-eutrophication of Lake Erie: Central basin hypoxia

Donald Scavia [a,*], J. David Allan [b], Kristin K. Arend [c], Steven Bartell [d], Dmitry Beletsky [e], Nate S. Bosch [f], Stephen B. Brandt [g], Ruth D. Briland [h], Irem Daloğlu [b], Joseph V. DePinto [i], David M. Dolan [j], Mary Anne Evans [k], Troy M. Farmer [h], Daisuke Goto [l], Haejin Han [m], Tomas O. Höök [n], Roger Knight [o], Stuart A. Ludsin [h], Doran Mason [p], Anna M. Michalak [q], R. Peter Richards [r], James J. Roberts [s], Daniel K. Rucinski [b,i], Edward Rutherford [p], David J. Schwab [t], Timothy M. Sesterhenn [n], Hongyan Zhang [e], Yuntao Zhou [q,u]

[a] Graham Sustainability Institute, University of Michigan, 625 E. Liberty, Ann Arbor, MI 48103, USA
[b] School of Natural Resources and Environment, University of Michigan, 440 Church St., Ann Arbor, MI 48109, USA
[c] Old Woman Creek National Estuarine Research Reserve, Ohio Department of Natural Resources, Division of Wildlife, Huron, OH 44839, USA
[d] Cardno ENTRIX, 339 Whitecrest Dr., Maryville, TN 37801, USA
[e] Cooperative Institute for Limnology and Ecosystems Research, School of Natural Resources and Environment, University of Michigan, 440 Church St., Ann Arbor, MI 48109, USA
[f] Environmental Science, Grace College, Winona Lake, IN 46590, USA
[g] Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR 97333, USA
[h] Aquatic Ecology Laboratory, Department of Evolution, Ecology, and Organismal Biology, The Ohio State University, 1314 Kinnear Rd., Columbus, OH 43212, USA
[i] LimnoTech, 501 Avis Drive, Ann Arbor, MI, 484108, USA
[j] University of Wisconsin-Green Bay, 2420 Nicolet Dr., Green Bay, WI, USA
[k] U.S. Geological Survey, Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI 48105, USA
[l] Center for Limnology, University of Wisconsin-Madison, 680 North Park Street, Madison, WI 53706, USA
[m] Korea Environment Institute, 215 Jinheungno, Eunpyeong-gu, Seoul 122-706, Republic of Korea
[n] Department of Forestry and Natural Resources, Purdue University, 195 Marsteller St, West Lafayette, IN 47907, USA
[o] Division of Wildlife, Ohio Department of Natural Resources, Columbus, OH 43229, USA
[p] Great Lakes Environmental Research Laboratory, NOAA, 4840 S. State Rd, Ann Arbor, MI 48108, USA
[q] Department of Global Ecology, Carnegie Institute for Science, 260 Panama St., Stanford, CA 94305, USA
[r] National Center for Water Quality Research, Heidelberg University, 310 E. Market St., Tiffin, OH 44883, USA
[s] U.S. Geological Survey, Fort Collins Science Center, 2150 Centre Ave, Fort Collins, CO 80523, USA
[t] Water Center, University of Michigan, 625 E. Liberty, Ann Arbor, MI 48103, USA
[u] Department of Civil and Environmental Engineering, University of Michigan, Ann Arbor, MI 48109, USA

ARTICLE INFO

Article history:
Received 14 September 2013
Accepted 17 January 2014
Available online xxxx

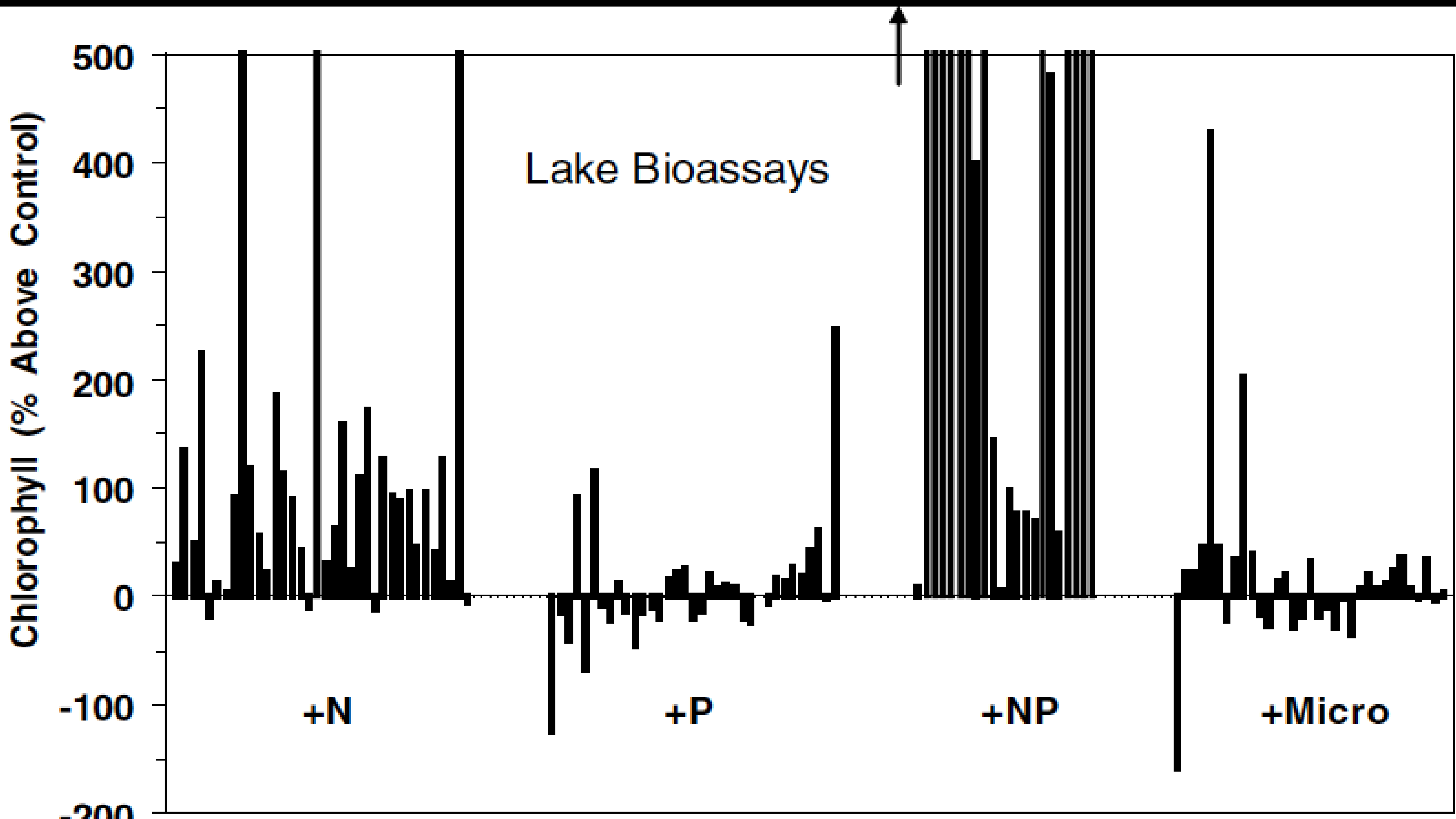
Communicated by Leon Boegman

Keywords:
Lake Erie
Hypoxia
Phosphorus load targets
Best management practices

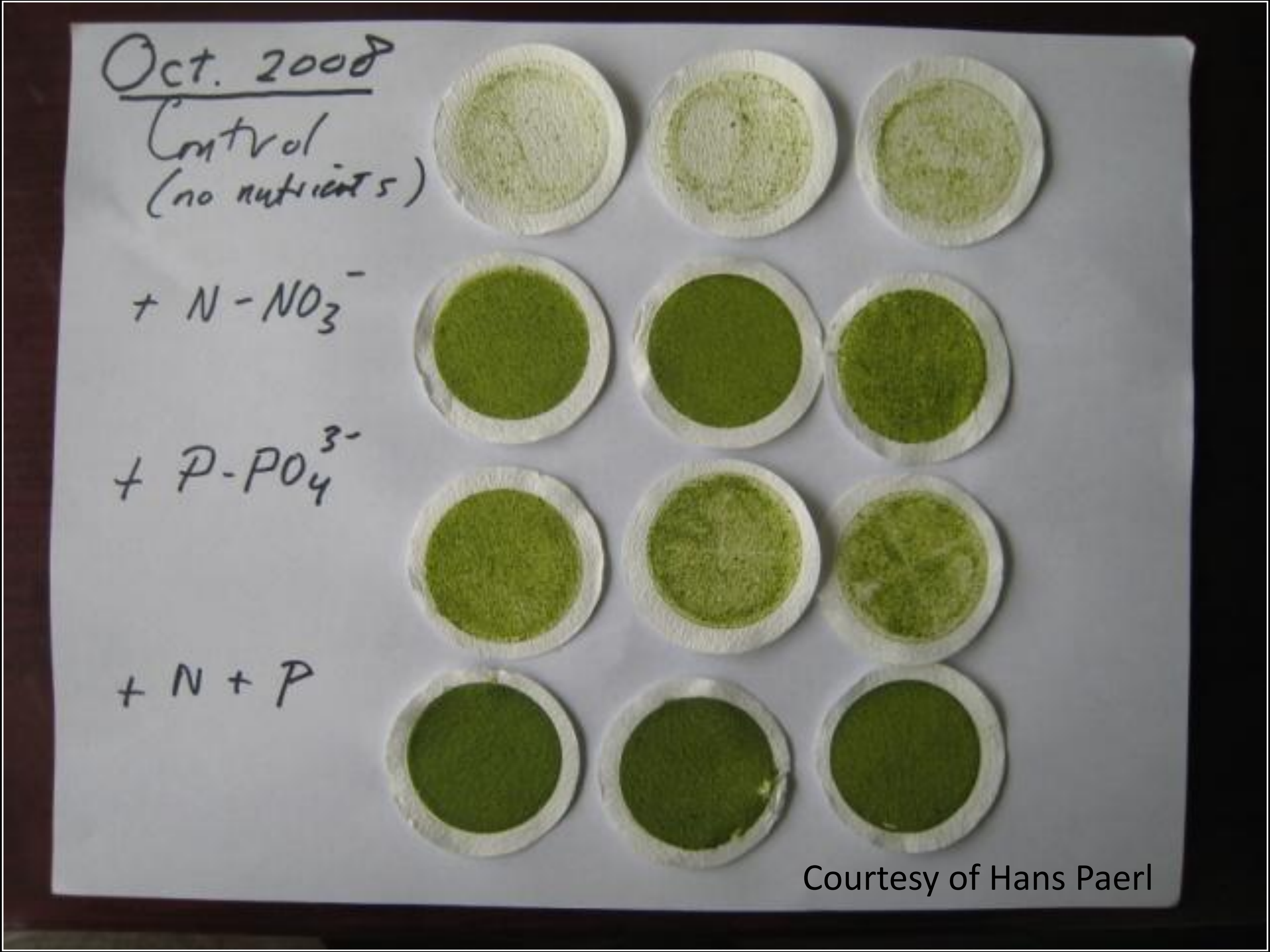
ABSTRACT

Relieving phosphorus loading is a key management tool for controlling Lake Erie eutrophication. During the 1960s and 1970s, increased phosphorus inputs degraded water quality and reduced central basin hypolimnetic oxygen levels which, in turn, eliminated thermal habitat vital to cold-water organisms and contributed to the extirpation of important benthic macroinvertebrate prey species for fishes. In response to load reductions initiated in 1972, Lake Erie responded quickly with reduced water-column phosphorus concentrations, phytoplankton biomass, and bottom-water hypoxia (dissolved oxygen <2 mg/l). Since the mid-1990s, cyanobacteria blooms increased and extensive hypoxia and benthic algae returned. We synthesize recent research leading to guidance for addressing this re-eutrophication, with particular emphasis on central basin hypoxia. We document recent trends in key eutrophication-related properties, assess their likely ecological impacts, and develop load response curves to guide revised hypoxia-based loading targets called for in the 2012 Great Lakes Water Quality Agreement. Reducing central basin hypoxic area to levels observed in the early 1990s (ca. 2000 km^2) requires cutting total phosphorus loads by 46% from the 2003–2011 average or reducing dissolved reactive phosphorus loads by 78% from the 2005–2011 average. Reductions to these levels are also protective of fish habitat. We provide potential approaches for achieving those new loading targets, and suggest that recent load reduction recommendations focused on western basin cyanobacteria blooms may not be sufficient to reduce central basin hypoxia to 2000 km^2.

Nutrient Addition experiments

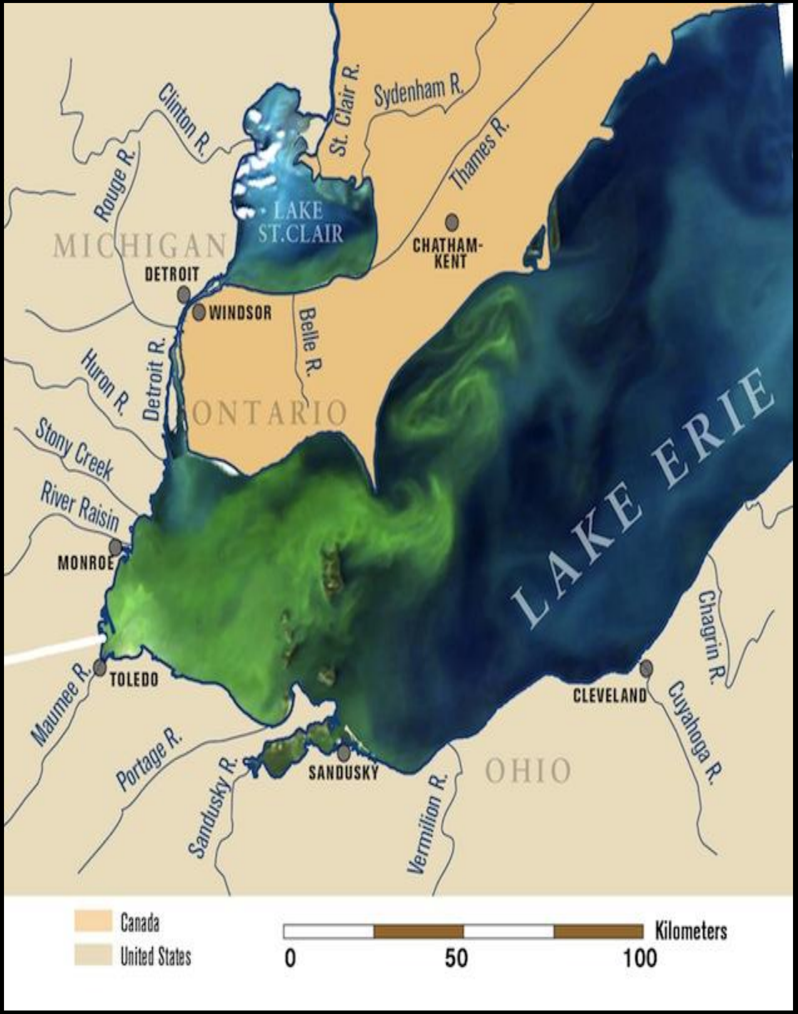


Courtesy of Wayne Wurtsbaugh



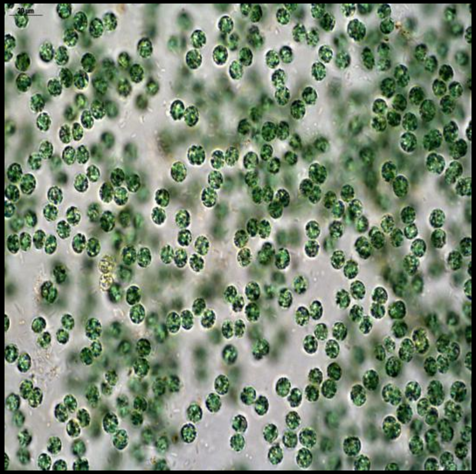
Courtesy of Hans Paerl

Lake Erie



© University of Michigan (2014)

© University of New Hampshire

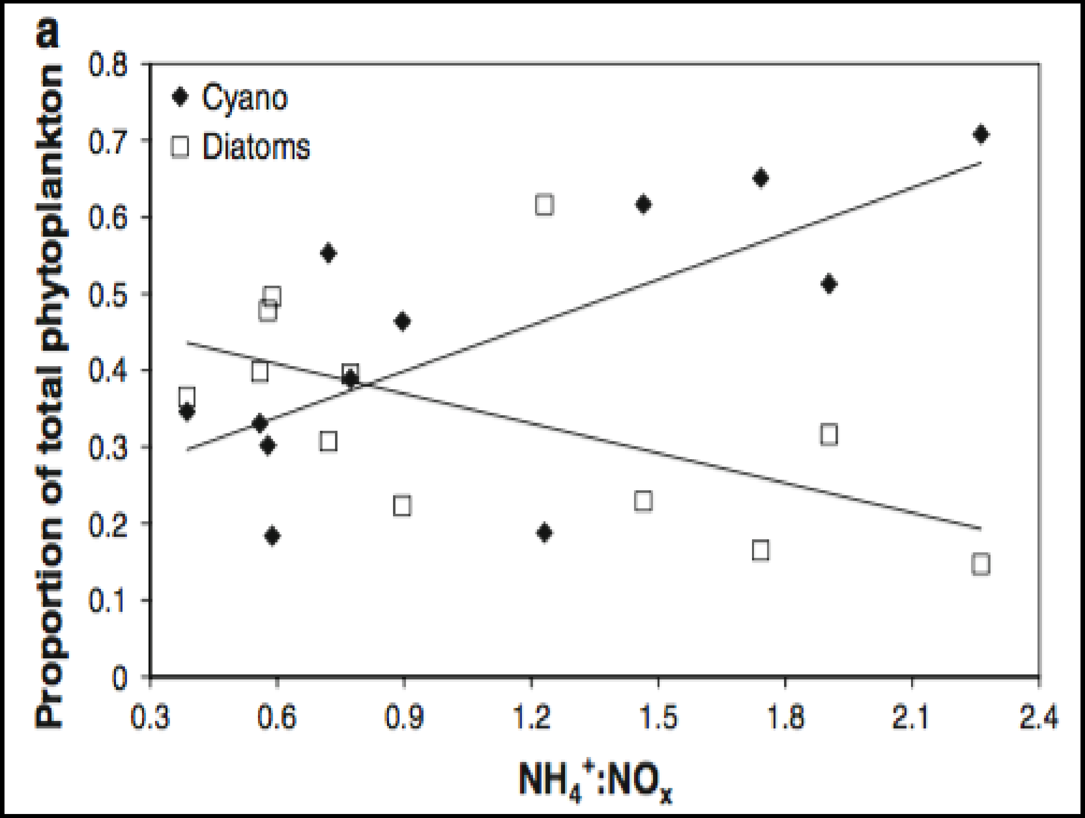


Microcystis: Non-N_2 fixers

From http://cyanobacteria.myspecies.info

N Form and Community Structure

- NO_3^- : favors diatoms
- Reduced N (NH_4^+ and urea): favors cyanobacteria



McCarthy et al. 2009

N and Cyanobacterial Toxicity

- N additions to **non-N-fixing** cyanobacteria can increase toxicity.
  (Davis et al. 2010, 2015)

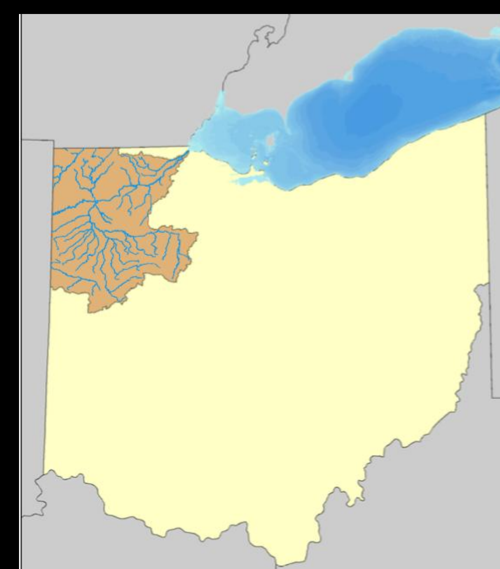
- Low NH_4^+ concentrations can inhibit toxin production
  (Kuniyoshi et al. 2010)

- Urea uptake may lead to both increased *Microcystis* biomass and toxin production
  (Finlay et al. 2010)

N Inputs to Western Lake Erie

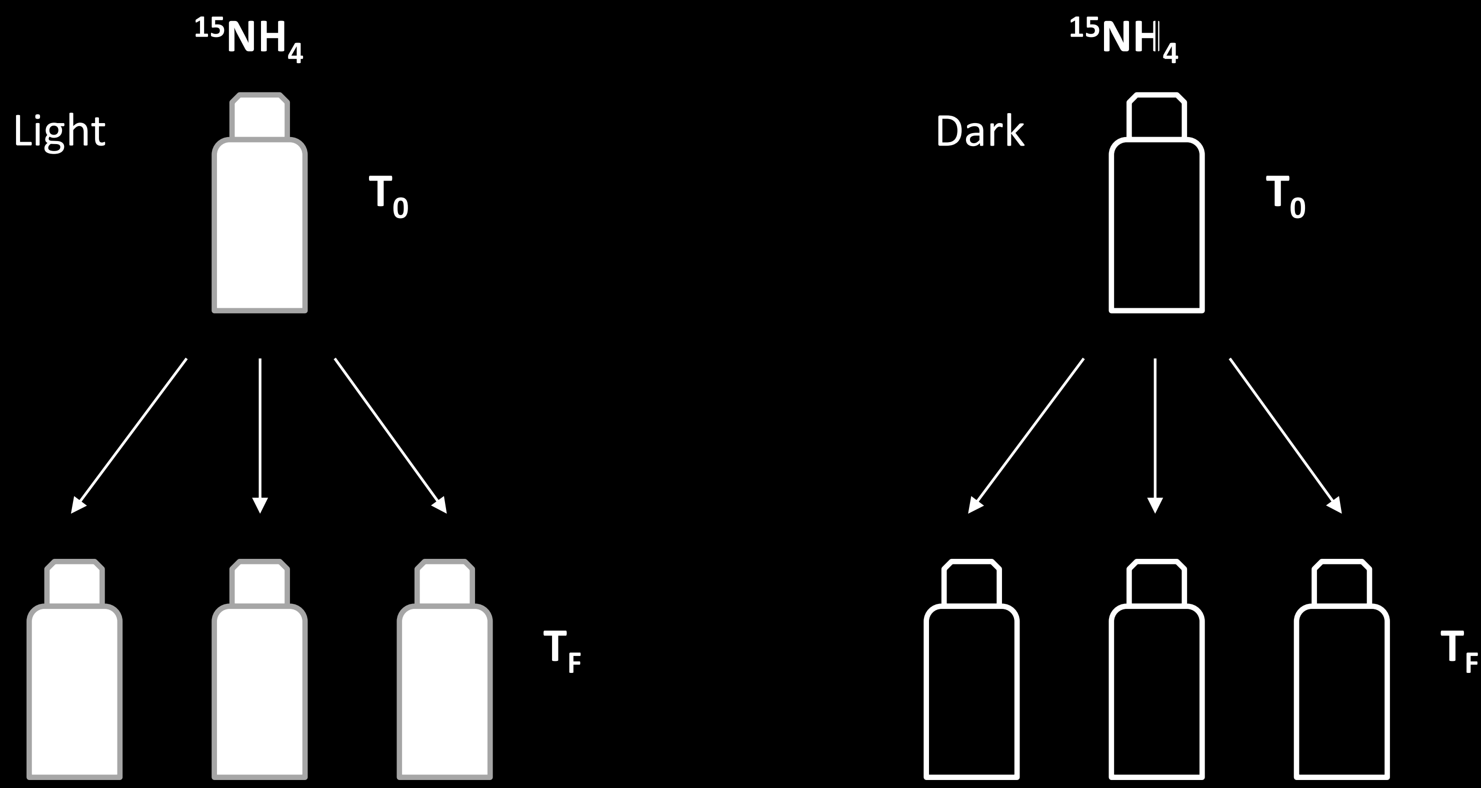
- Maumee River: 80% agricultural
  UAN or anhydrous NH4
- Kjeldahl N (NH_4^+ + organic N) load from Maumee River to Lake Erie
  = 9000 metric tons/yr
  ¼ of total Maumee N load

(Richards et al. 2010)

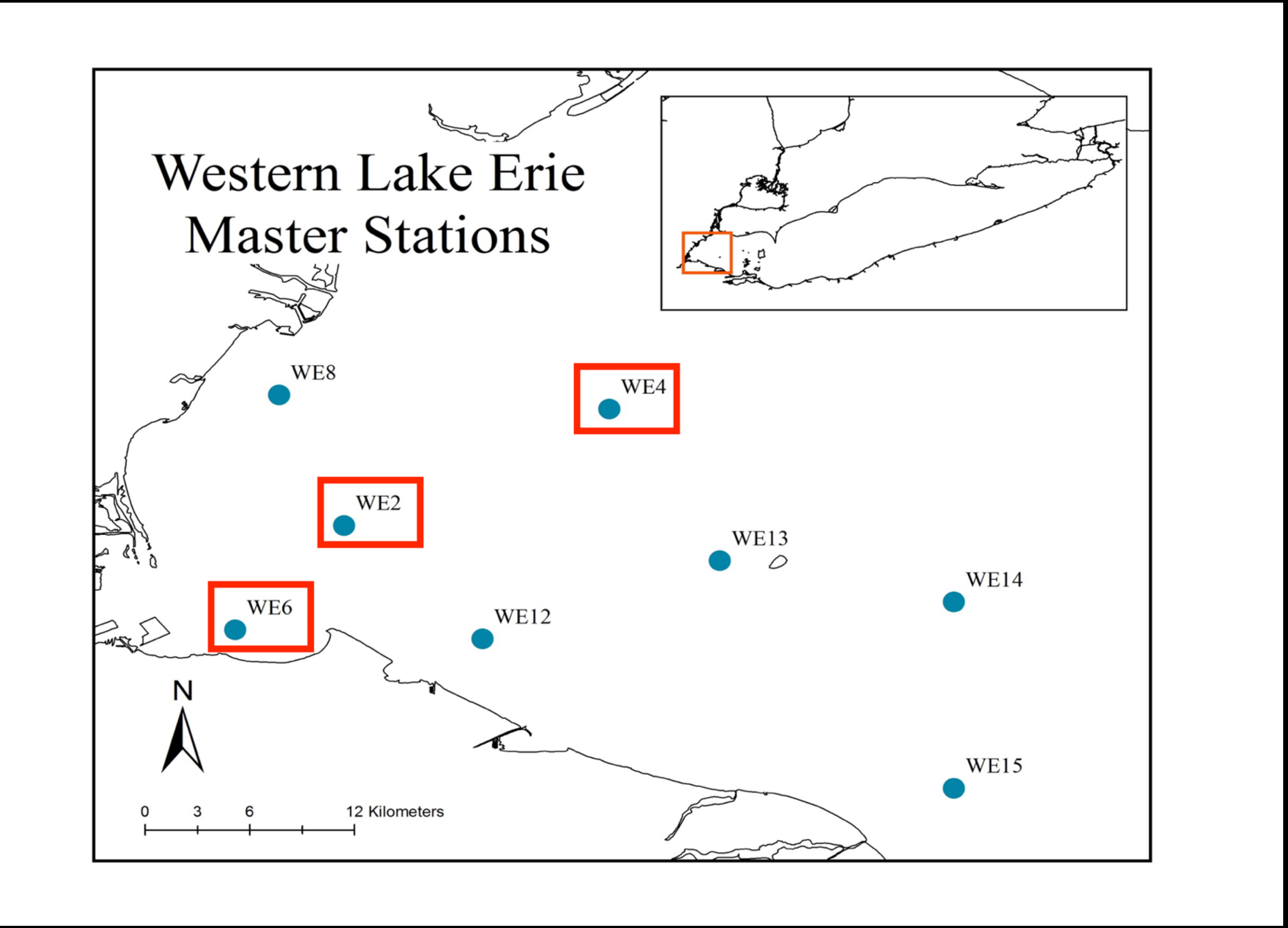


Question: How fast is the NH_4^+ turnover? Can it sustain phytoplankton growth? During the bloom?

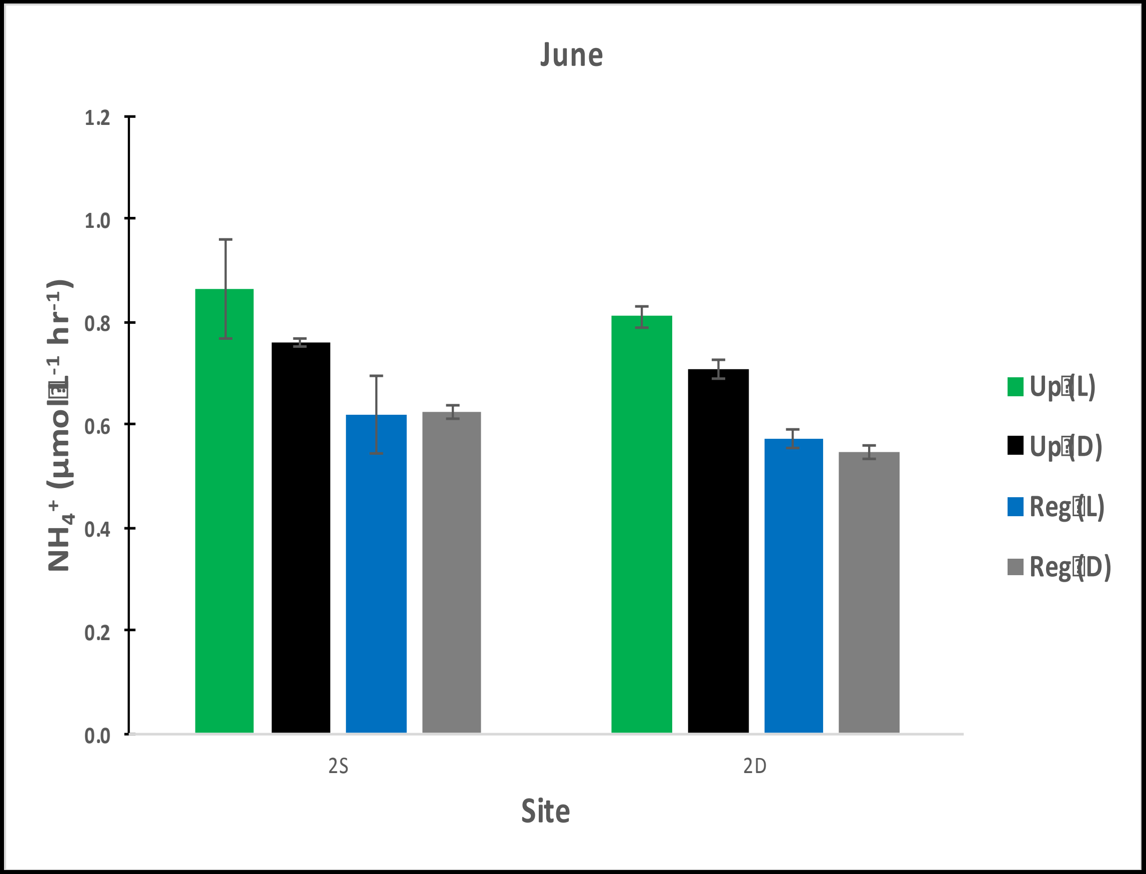
Approach: NH_4^+ Uptake and Regeneration



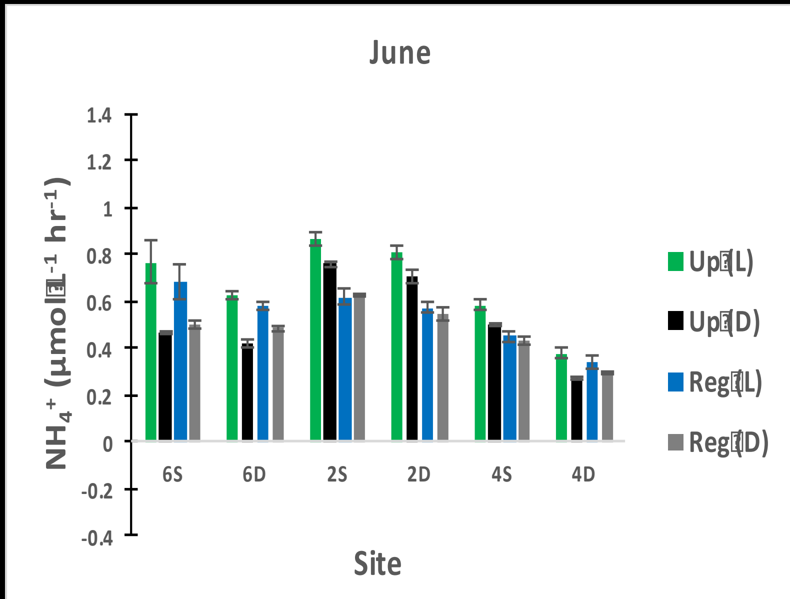
Sampling with NOAA GLERL

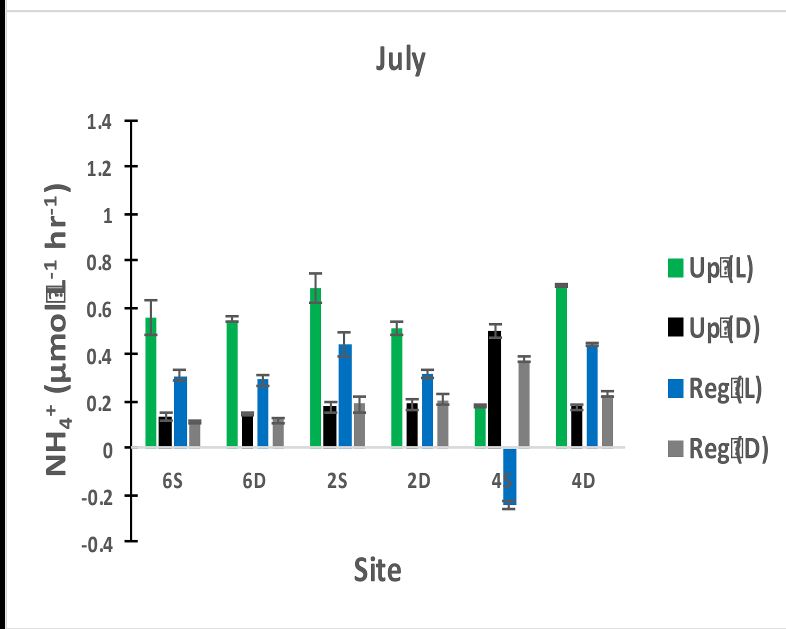


NH_4^+ Uptake/Regeneration

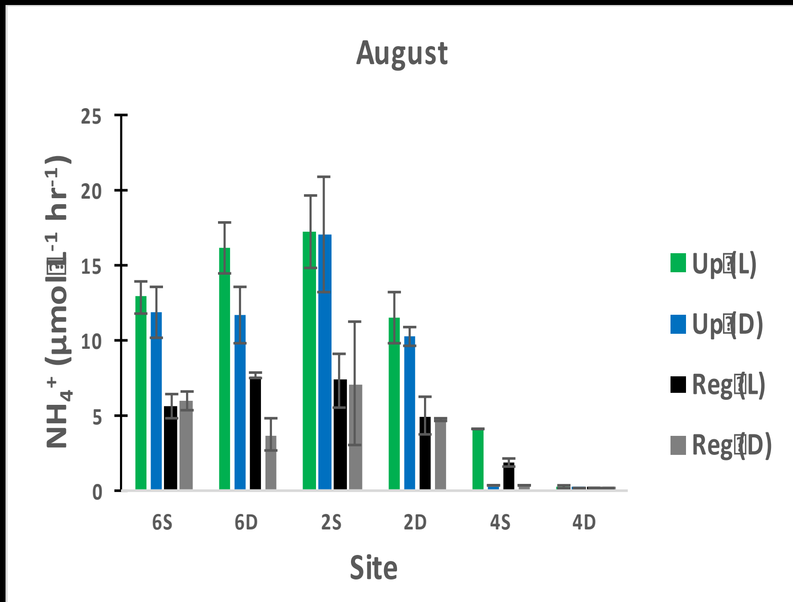


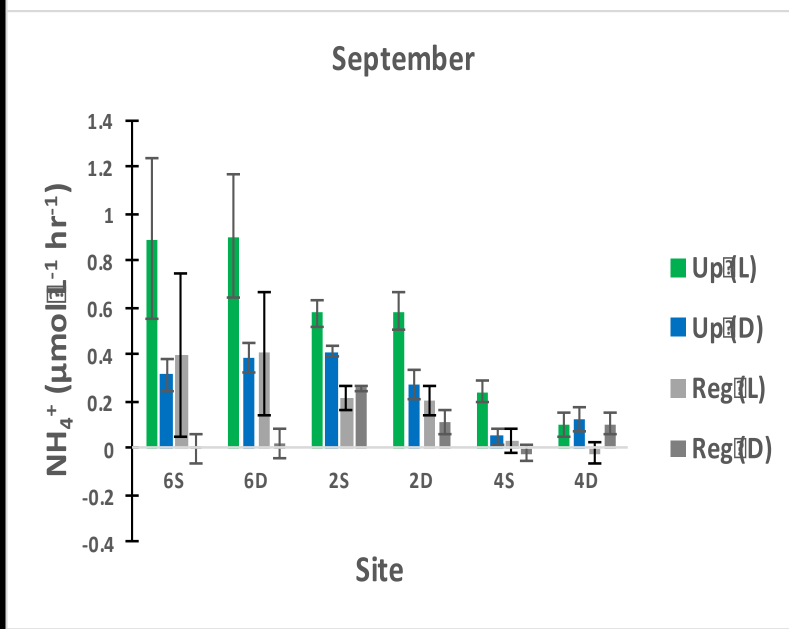
NH_4^+ Uptake/Regeneration





NH_4^+ Uptake/Regeneration





Summary of Findings

- Difference between uptake and regeneration rates is more pronounced as the cyanobacterial blooms increase
- Potential uptake rates balanced by regeneration before bloom, but not during – remaining supply must come from elsewhere or phytoplankton are N-limited
- Dual nutrient control is required to control blooms and toxicity in Lake Erie

HABs Collaboratory

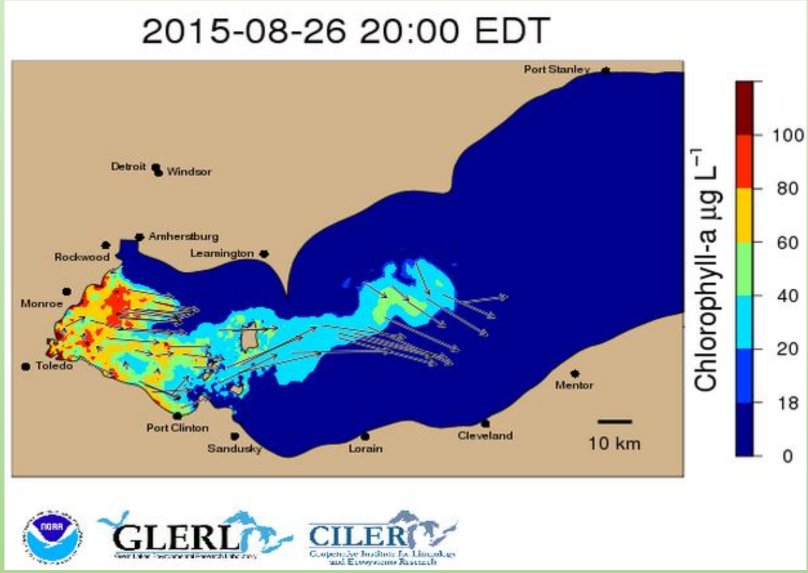
- We need a nitrogen budget for WLE
- Ammonium and Urea loads?
- Is there a model looking to incorporate N data?

SHORT-TERM FORECAST OF LAKE ERIE HAB DISTRIBUTION AND MOVEMENT: 2016 UPDATES

Mark Rowe – University of Michigan

HAB Tracker
Short-term forecast of Lake Erie HAB distribution and movement: 2016 updates

Mark Rowe
University of Michigan
Cooperative Institute for Limnology and Ecosystems Research
NOAA Great Lakes Environmental Research Laboratory



Project Overview

- Title: HABS Monitoring, Forecasting, and Genomics for the Great Lakes
- Large team, including

  Tim Davis, Eric Anderson, Hank Vanderploeg – NOAA GLERL

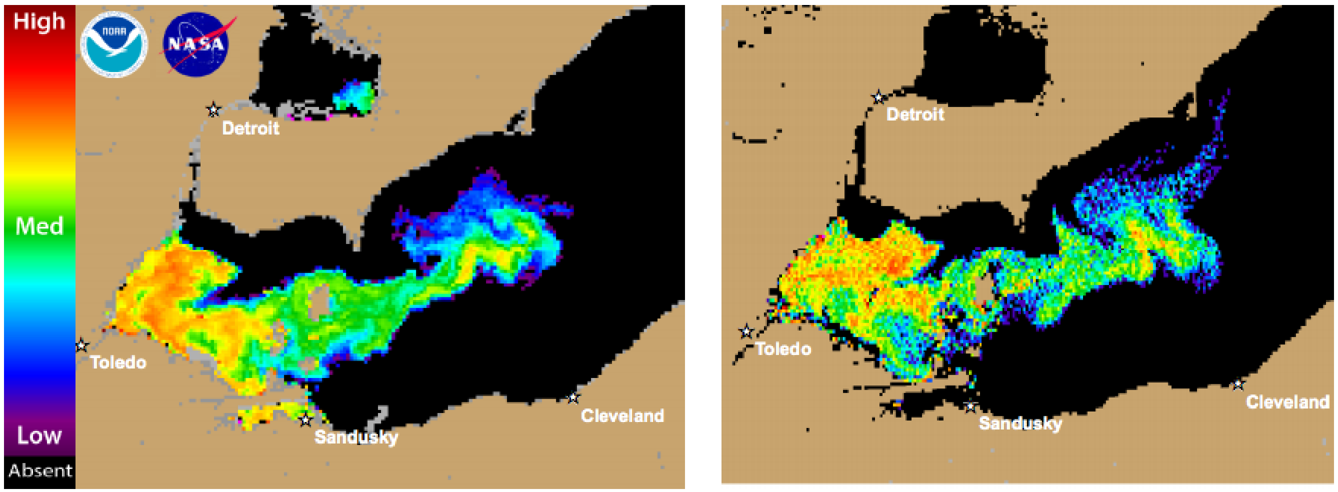
  Tom Johengen, Mark Rowe – CILER

  Rick Stumpf, Tim Wynne – NOAA NCCOS
- Funding: NOAA - GLRI
- Locations: Lake Erie and Saginaw Bay
- Objectives:
  - Understand the drivers of HAB development, toxicity, and transport
  - Develop new and enhance existing decision support tools for environmental and public health officials

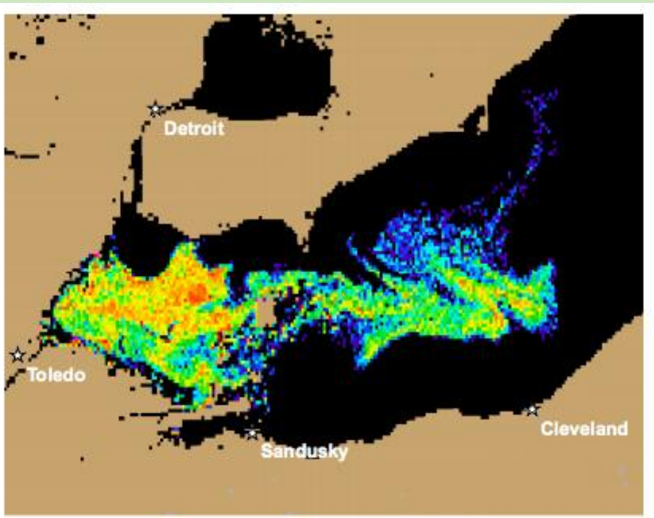
Experimental Lake Erie Harmful Algal Bloom Bulletin

National Centers for Coastal Ocean Science and Great Lakes Environmental Research Laboratory

24 August, 2015, Bulletin 13



Satellite-derived HAB nowcast



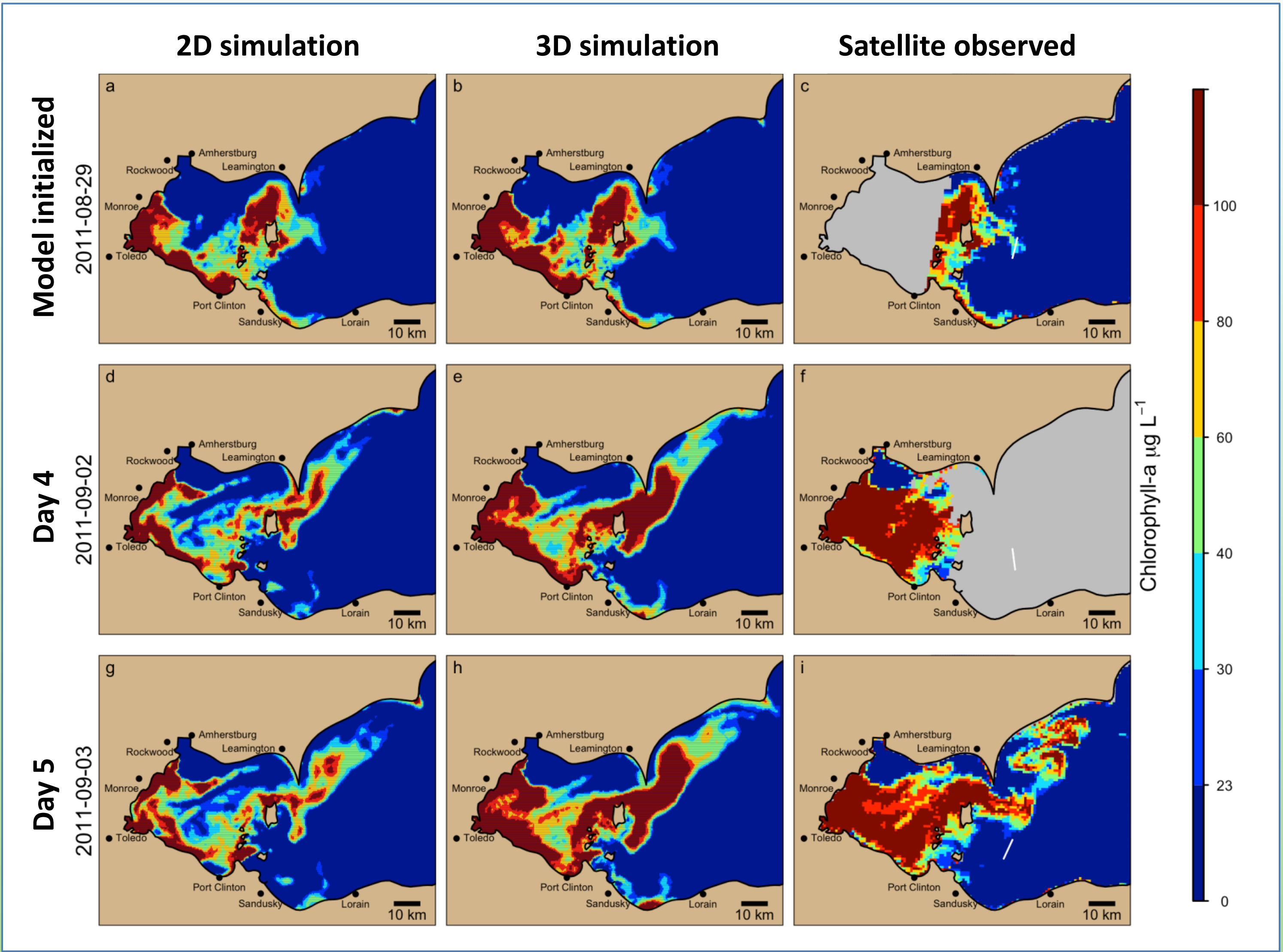
- 5-day forecast
  - Meteorological forecast
  - Hydrodynamic model
  - Lagrangian particle model

HAB Tracker experimental short-term forecast

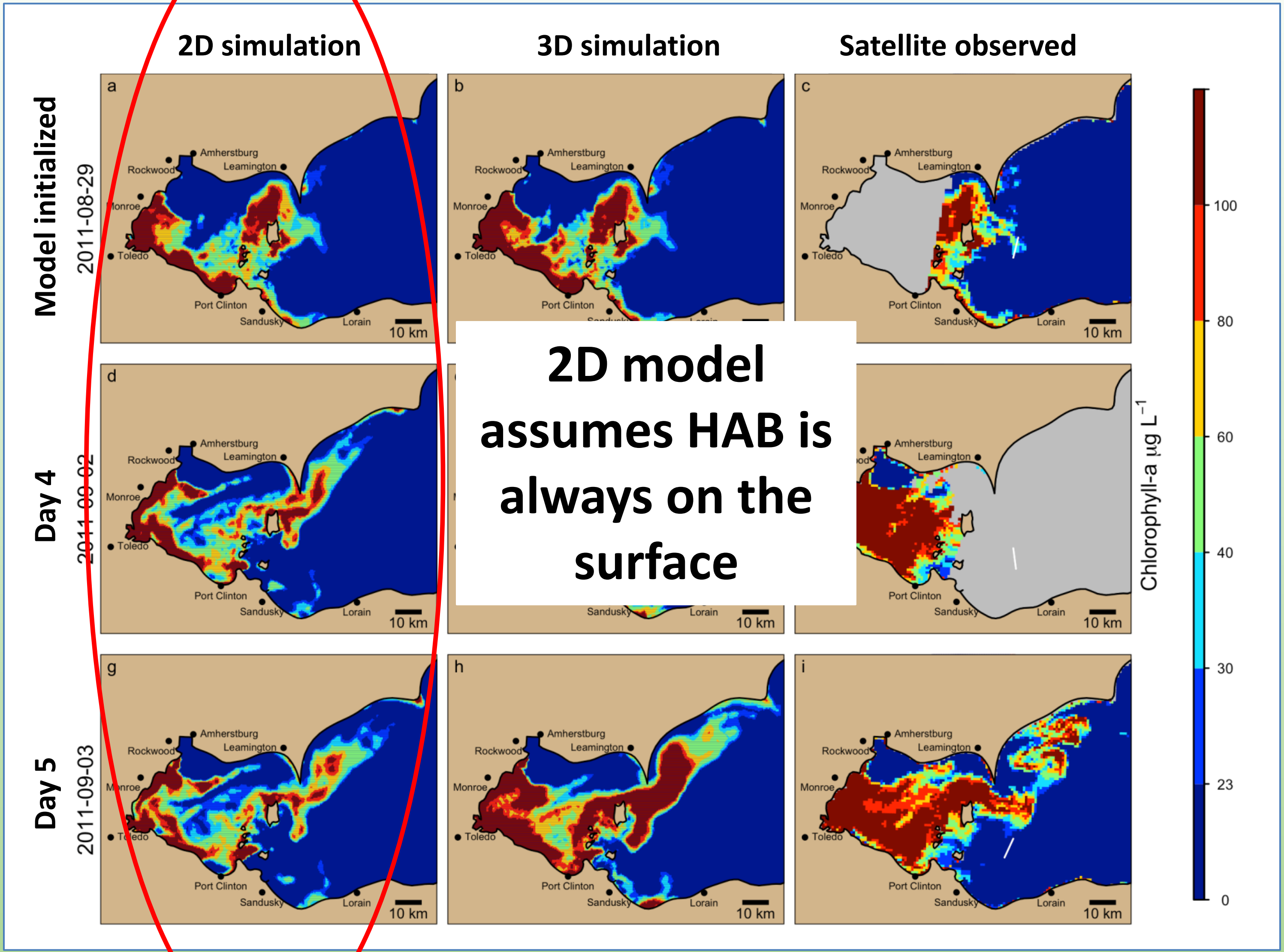
- 2015 improvements
  - Updated Lagrangian particle model linked to new FVCOM-based Lake Erie Operational Forecast model
  - Produce a more complete nowcast by using previous model run to fill in partial satellite images

- 2016 improvements
  - 3D simulation of *Microcystis* vertical distribution: buoyancy versus turbulent mixing

Hindcast skill assessment

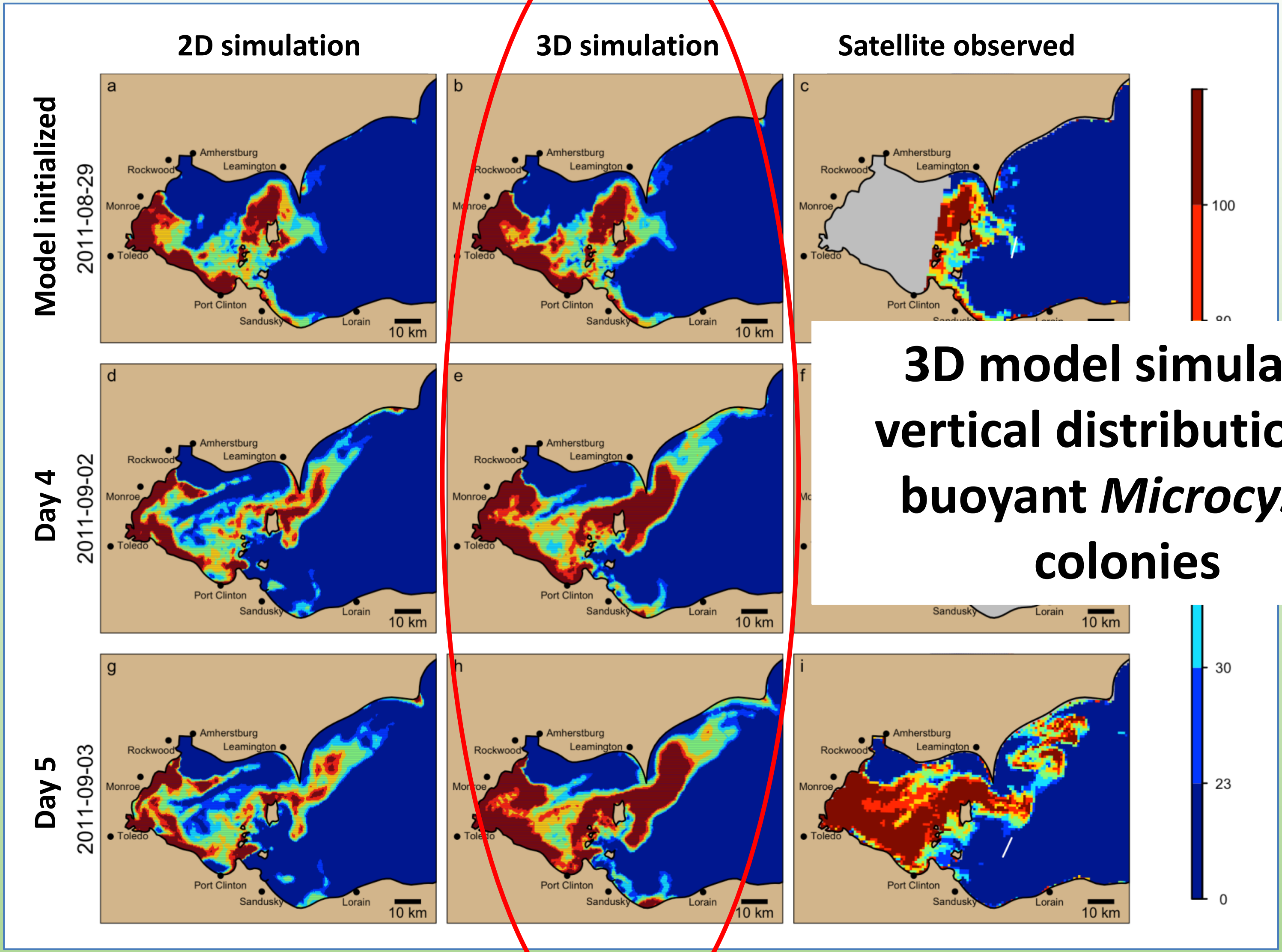


Hindcast skill assessment



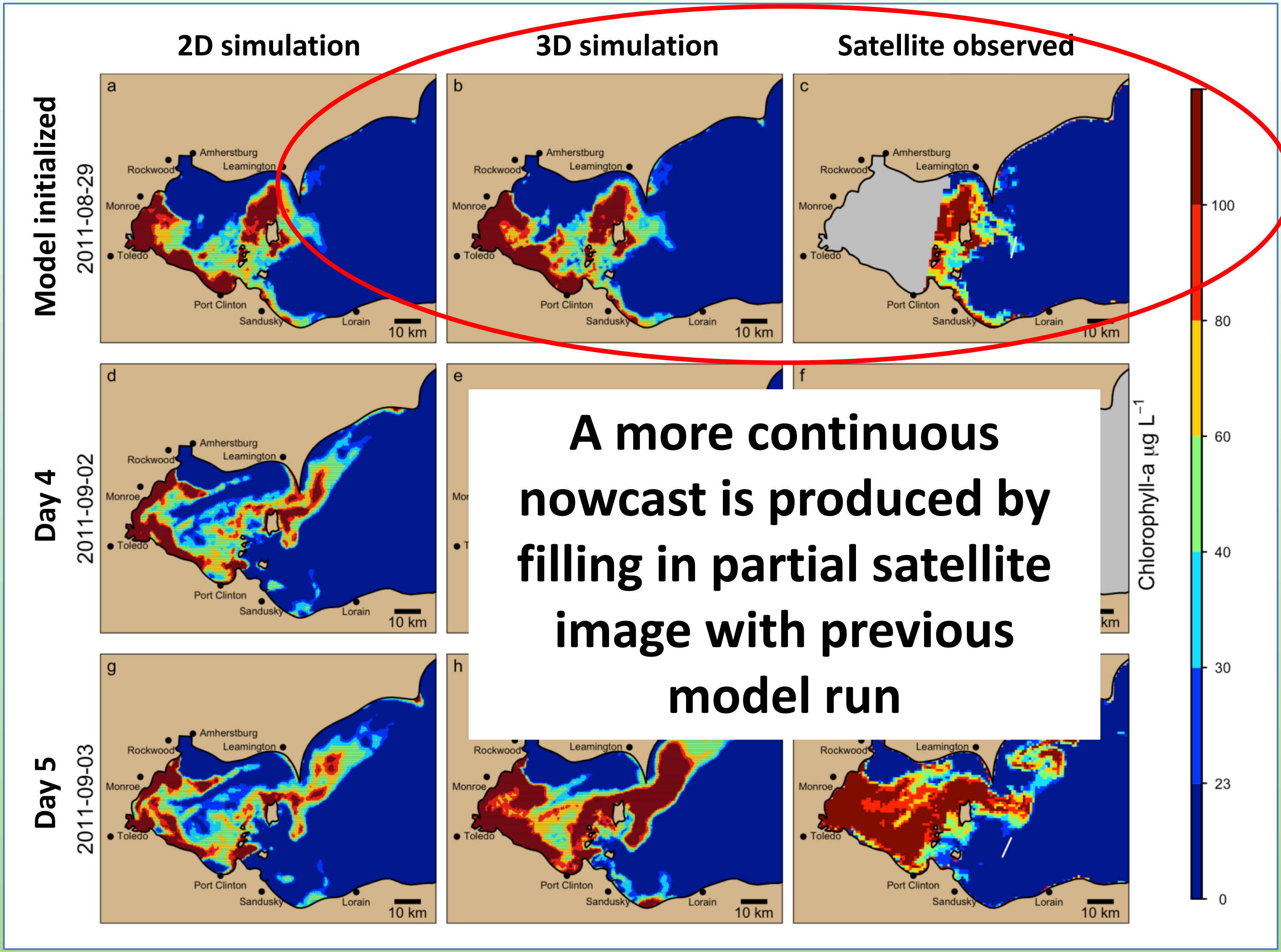
2D model assumes HAB is always on the surface

Hindcast skill assessment



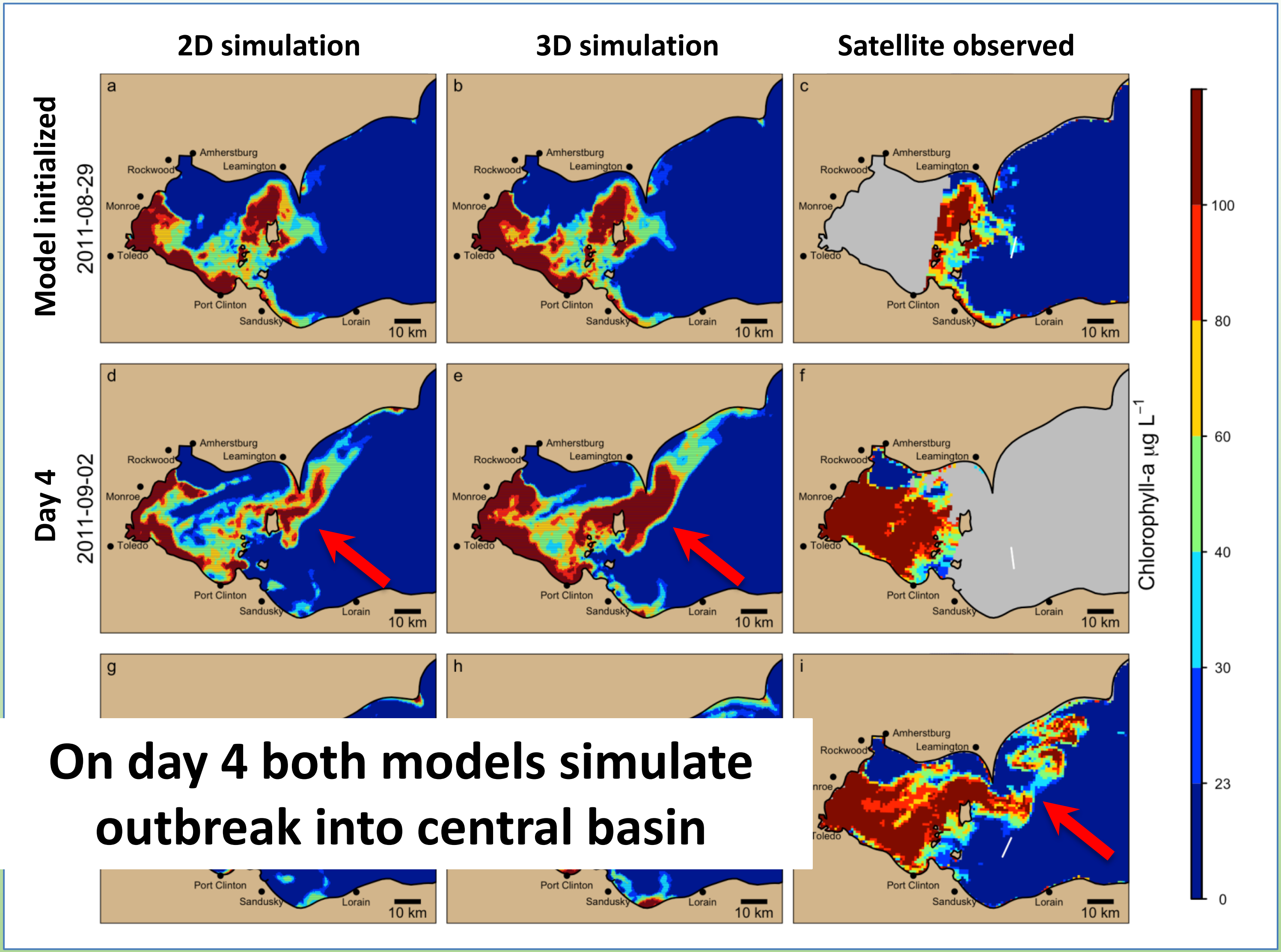
3D model simulates vertical distribution of buoyant *Microcystis* colonies

Hindcast skill assessment



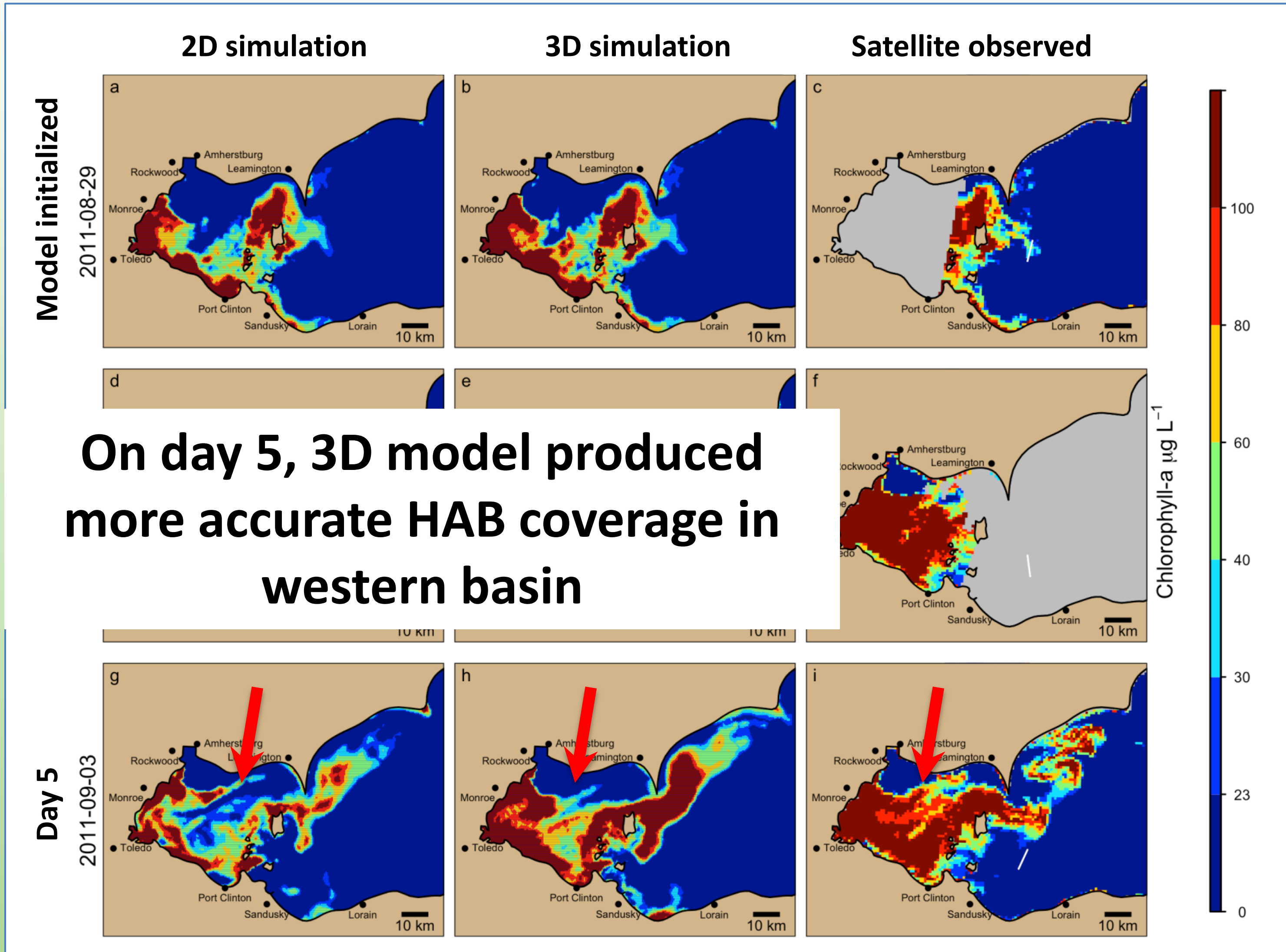
A more continuous nowcast is produced by filling in partial satellite image with previous model run

Hindcast skill assessment



On day 4 both models simulate outbreak into central basin

Hindcast skill assessment



On day 5, 3D model produced more accurate HAB coverage in western basin

Summary of Findings

- Skill assessment for record 2011 HAB season
  - 26 hindcast simulations
  - Statistically significant improvement in model skill by comparison to subsequent satellite images
    - 3D model had greater skill than 2D model
    - 3D model performed better than "persistence" forecast

M.D. Rowe, E.J. Anderson, T. T. Wynne, R. P. Stumpf, D. L. Fanslow, K. Kijanka, H. A. Vanderploeg, J.R. Strickler, T. W. Davis. J. Geophysical Research, *submitted*

HABs Collaboratory

- What questions still need to be answered about HABs?
  - Predictive models of *Microcystis* buoyancy and size distribution

HABs Blooms Sources & Movements

In partnership with:

NOAA · Sea Grant Ohio Sea Grant College Program · The Ohio State University · LimnoTech Water Environment | Scientists Engineers

Coming up next:

HABs & Safe Drinking Water

Thursday, July 7 2016, 1-2 p.m. (EDT)

HABs Blooms Detection, Composition & Effects – TBD

HABs Blooms Sources & Toxicity - TBD

HABs & Public Health – TBD

HABs Blooms Monitoring & Forecasting – TBD

HABs: Educate and Engage - TBD

To learn more about the HABs Collaboratory and the HABs State of the Science Webinar Series, visit us at:

http://glc.org/projects/water-quality/habs/

Great Lakes HABs Collaboratory

NOAA

Sea Grant Ohio Sea Grant College Program

The Ohio State University

LimnoTech Water Environment | Scientists Engineers