Expanding NOAA's ability to monitor and predict HAB events in western Lake Erie

Dr. Timothy Davis

CEGLHH
NOAA Center of Excellence for Great Lakes and Human Health

GLERL
Great Lakes Environmental Research Laboratory

NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

NOAA's HAB Team

Monitoring

Duane Gossiaux
Tom Johengen
Ashley Burtner
Danna Palladino
Russ Miller
Heidi Purcell
Greg Doucette

Remote Sensing

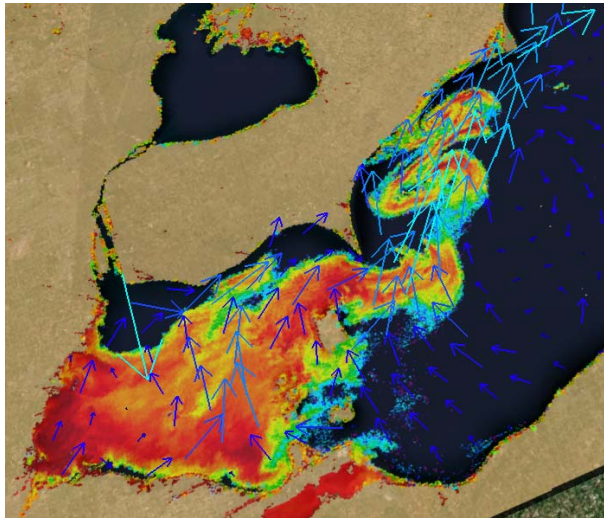
Steve Ruberg
Andrea van der Woude
Et al.

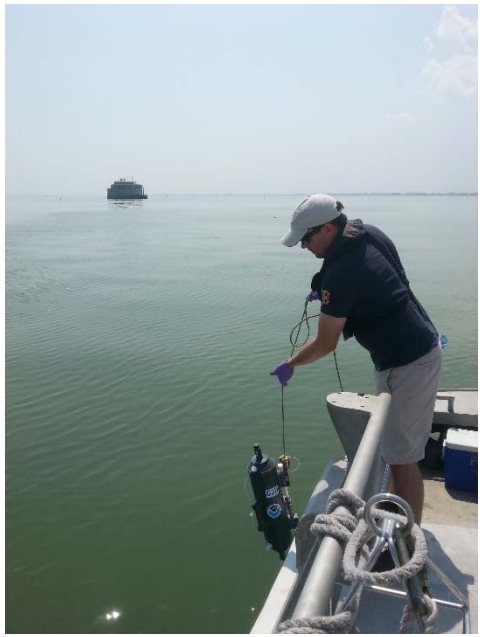
Modeling

Richard Stumpf
Eric Anderson
Dan Obenour
George Leshkevich
Greg Lang
Timothy Wynne

Communications

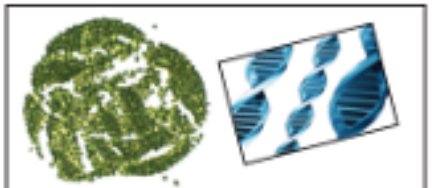
Sonia Joseph Joshi
Joe Smith
Quay Dortch
Marc Suddleson





NOAA uses an integrated approach to studying HABs

Developing Predictive Models to Improve Coastal and Human Health and Beach Forecasting - HAB Component



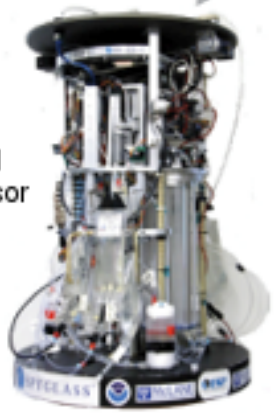
Understanding the environmental triggers of bloom toxicity using genetic techniques

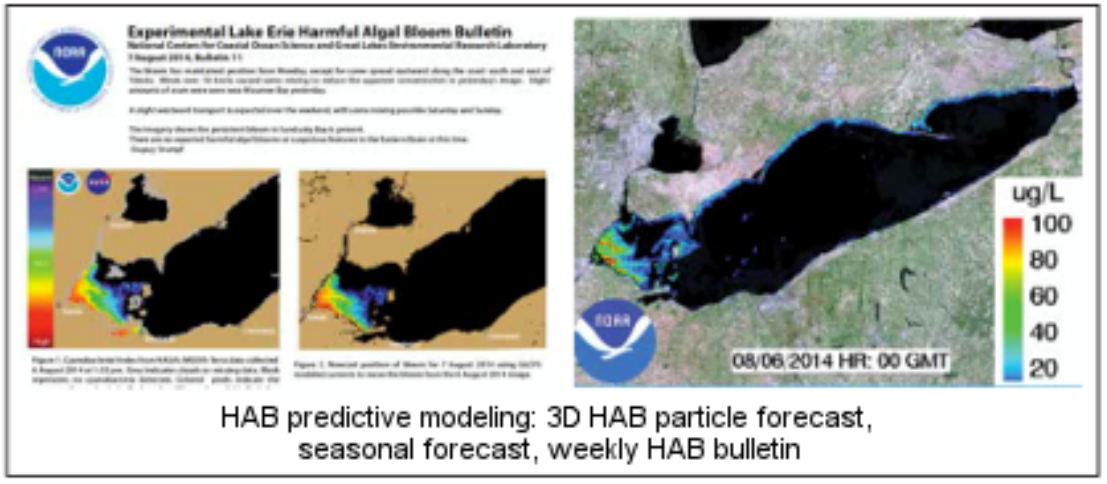
Monitoring and observations identify environmental conditions promoting *Microcystis* bloom occurrence and toxicity

Satellite algorithm assessment and remote sensing

Zebra mussel and microcystin relationship

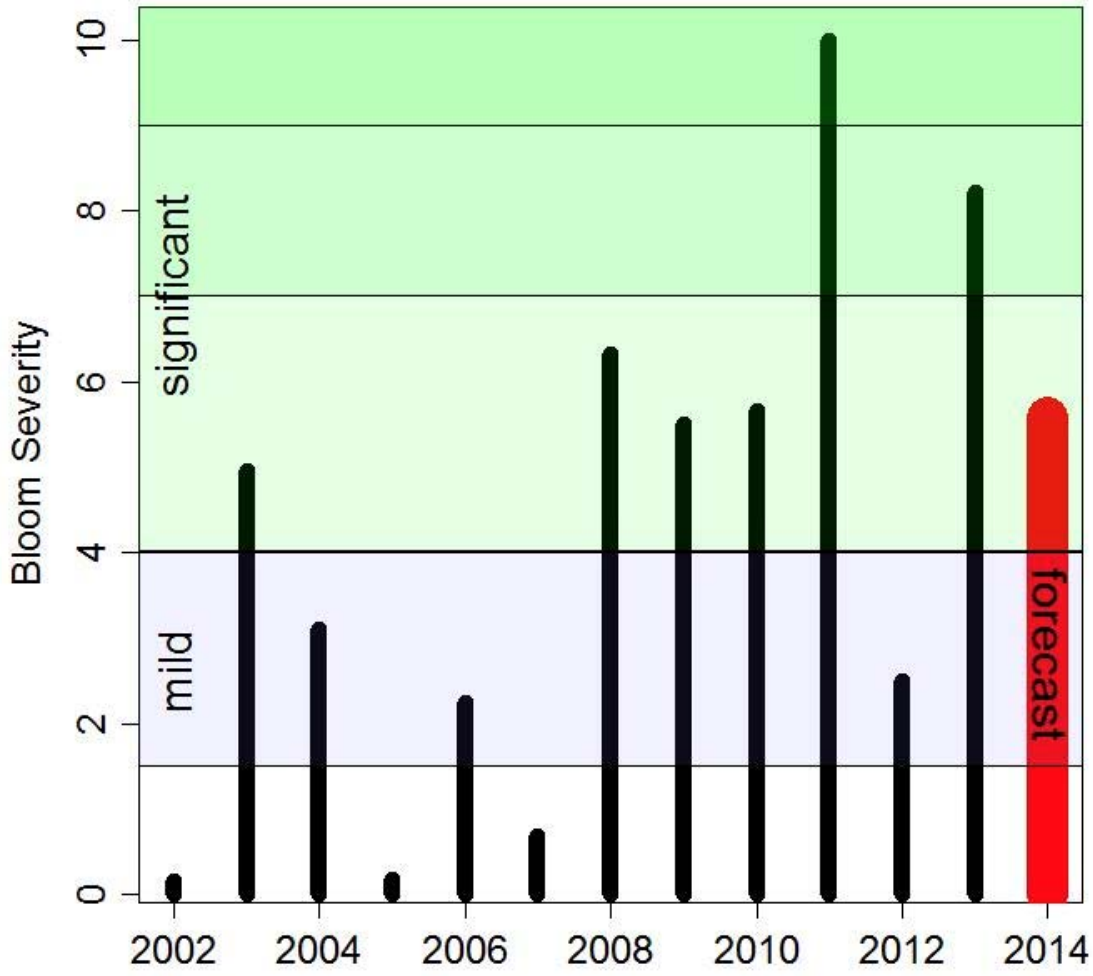
Environmental sample processor (ESP)





HAB predictive modeling: 3D HAB particle forecast, seasonal forecast, weekly HAB bulletin

NOAA and academic partners predict bloom severity



The forecast uses a 12-year Lake Erie nutrient flow data set, collected by Heidelberg University's National Center for Water Quality Research, and analysis of satellite data from the European Space Agency's ENVISAT and NASA's Terra and Aqua satellites.

Lake Erie Harmful Algal Bloom Summary

2014 HABs Summary

Bloom forecasts:
Stumpf – 38%
Obenour – 50%
of the 2011 bloom.

Average HAB extent in Western L. Erie Basin (derived from MODIS)	
2011	892 sq.km
2012	221 sq. km.
2013	676 sq. km
2014	470 sq. km

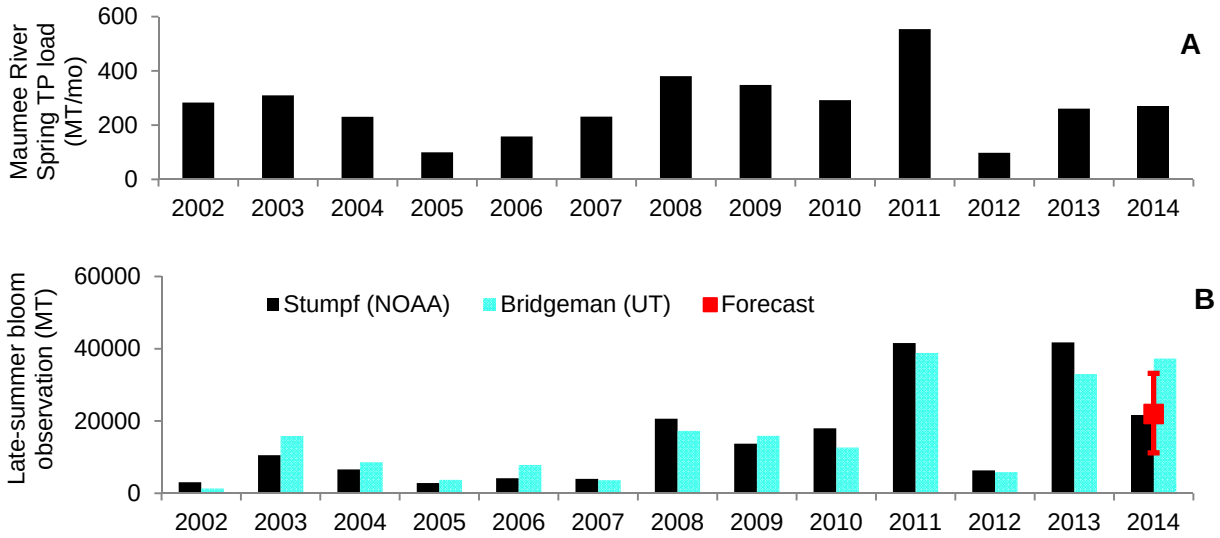


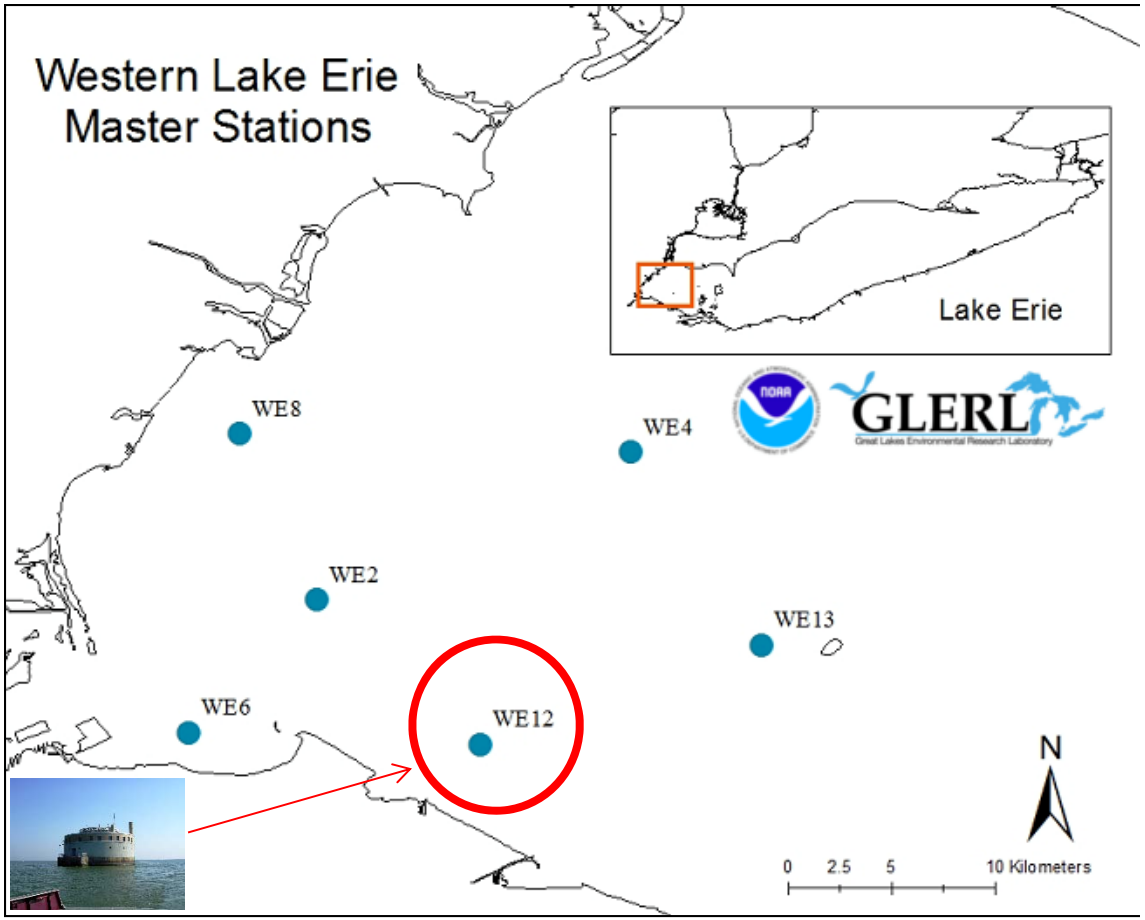
Figure: Spring TP loads (A) and western basin bloom observations (B) along with 2014 boom forecast and 95% predictive interval (red).

Summary:

In July of 2014, researchers from University of Michigan and NOAA Great Lakes Environmental Research Laboratory (GLERL) forecasted a western basin Lake Erie cyanobacteria bloom of 22,000 metric tons dry weight (MT), with a 95% predictive interval of 11,000 to 33,000 MT. The average observed late-summer bloom intensity, derived from NOAA remote sensing and University of Toledo field sampling, was approximately 29,000 MT, in general agreement with the forecasted range.

Weekly HAB sampling in Lake Erie

- June – October
- Surface water samples
- Ground-truth for remote sensing (bloom extent, distribution)
- Parameters:
  - Temperature
  - Kpar
  - CHN
  - SRP
  - Particulate P
  - Total P
  - $NO_3 + NO_2$
  - NH_3
  - Fluorescence
  - Chlorophyll
  - Particulate and dissolved microcystins
  - Phytoplankton community composition
  - Phycocyanin
  - DNA



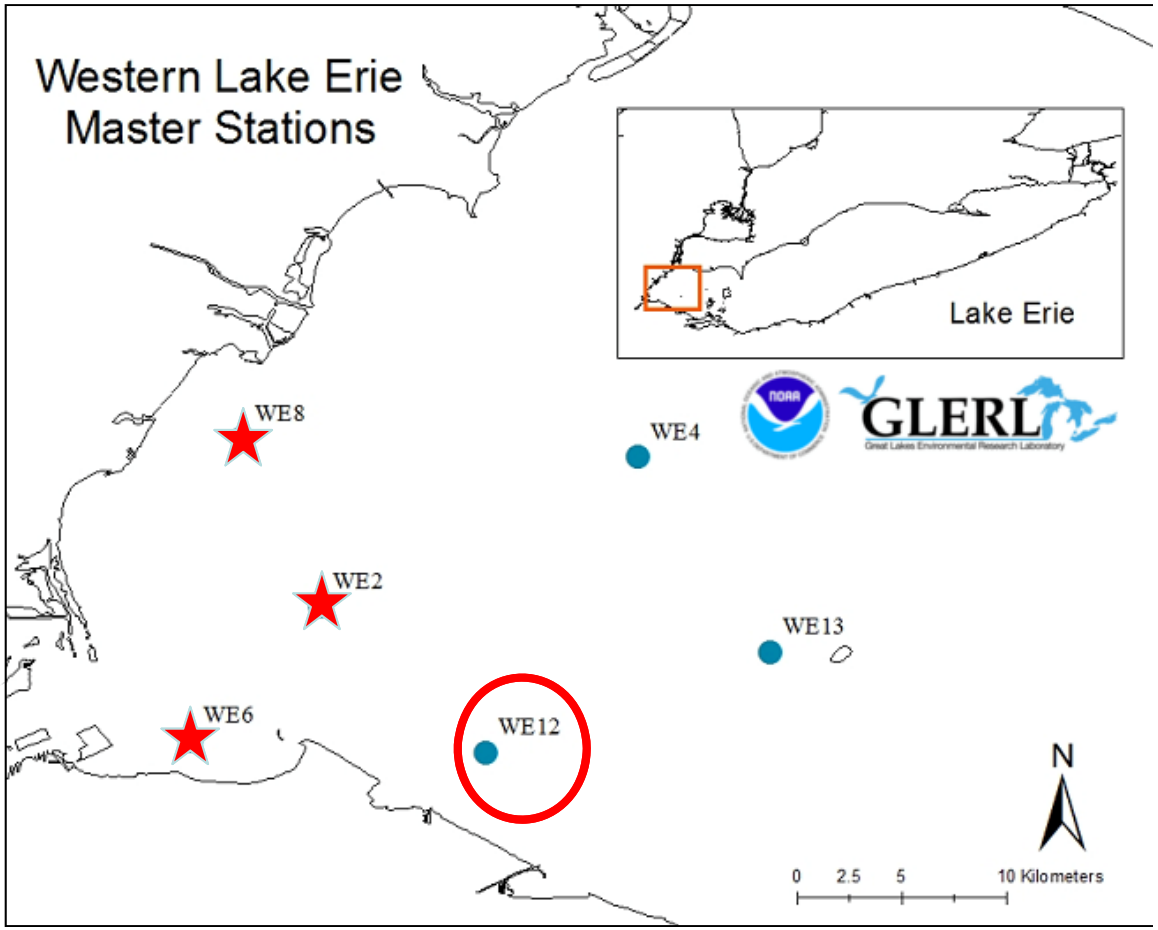
Western Lake Erie Real-time HABs Monitoring

Sensors:

. Turner C6, Cyclops sensors

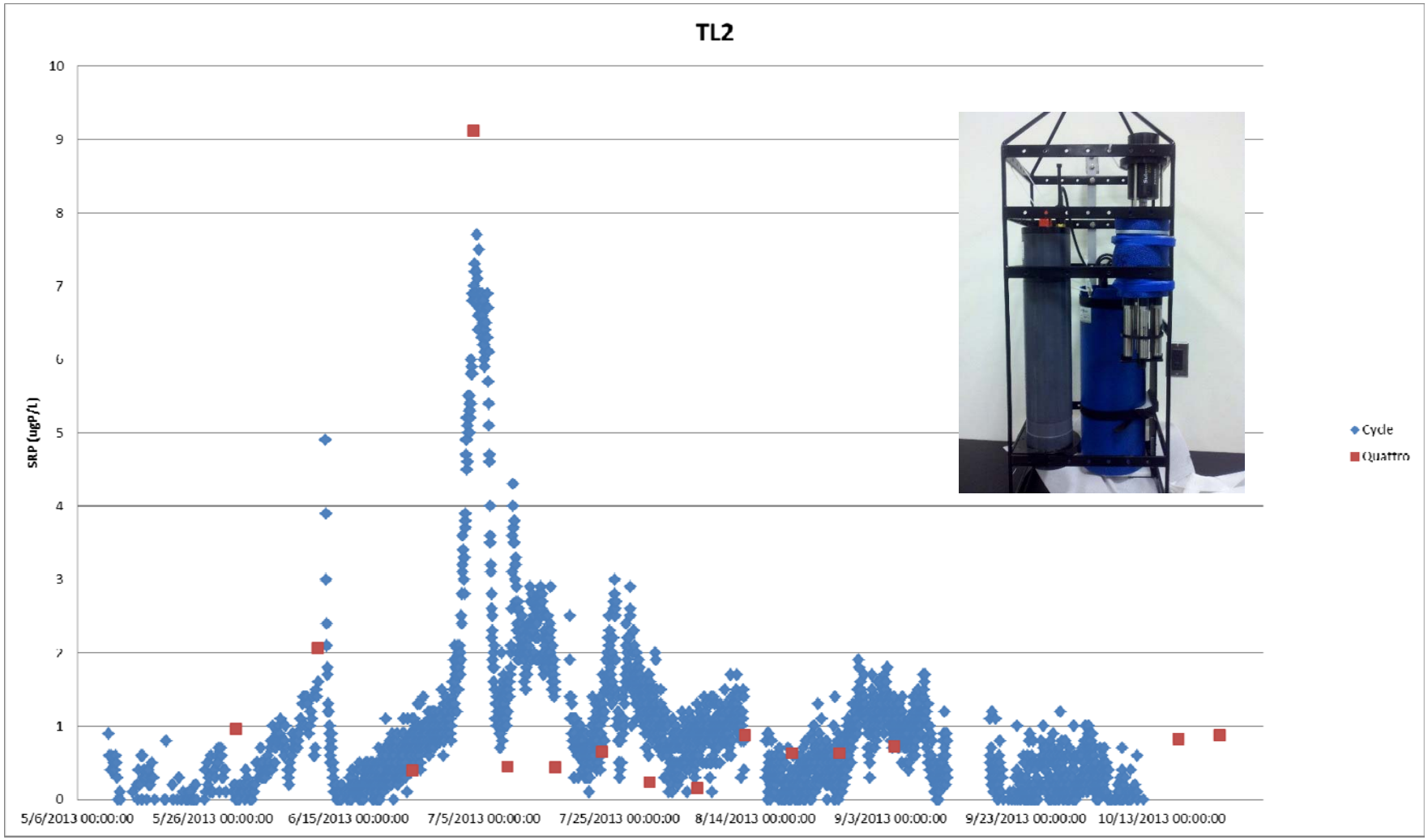
. Chlorophyll, Phycocyanin, Turbidity, CDOM

. Wetlabs Cycle -PO4

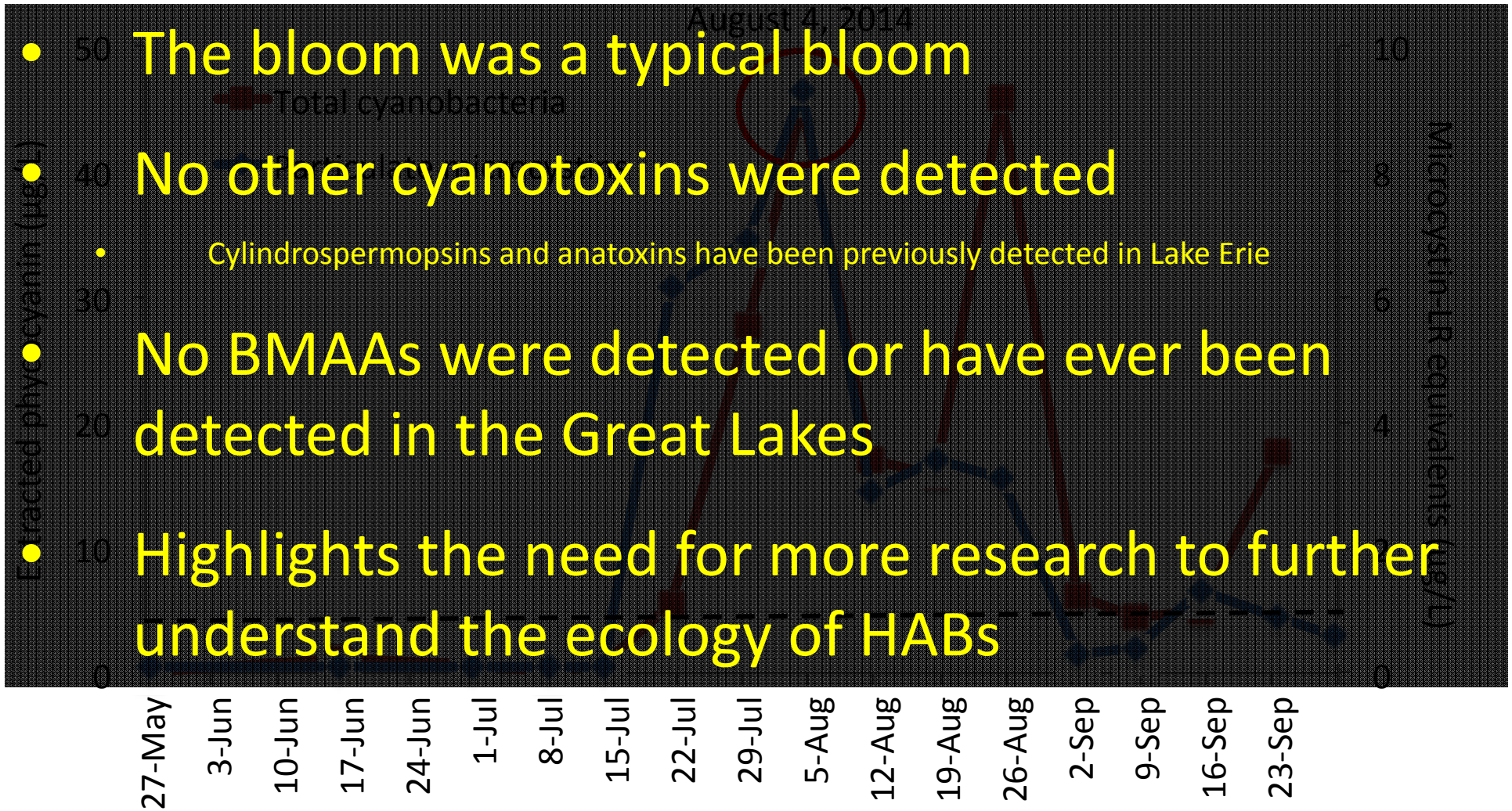


= Real-time observation station in 2014

Continuous inorganic phosphorus monitoring at WLE 4



Toledo water intake 2014 sampling data



- The bloom was a typical bloom
- No other cyanotoxins were detected
  - Cylindrospermopsins and anatoxins have been previously detected in Lake Erie
- No BMAAs were detected or have ever been detected in the Great Lakes
- Highlights the need for more research to further understand the ecology of HABs

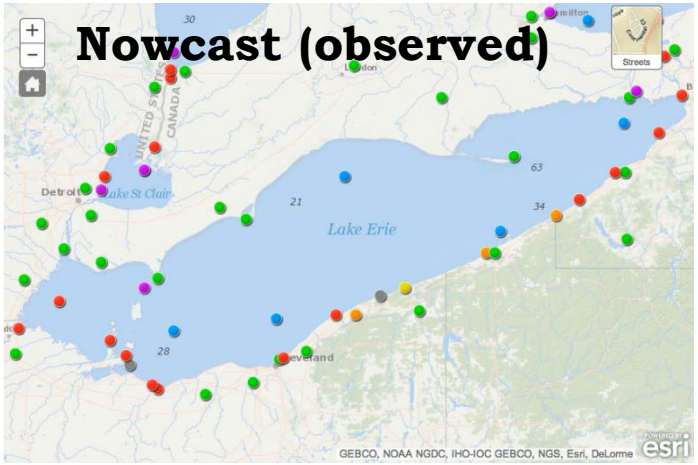
– – – = WHO guideline level for safe drinking water

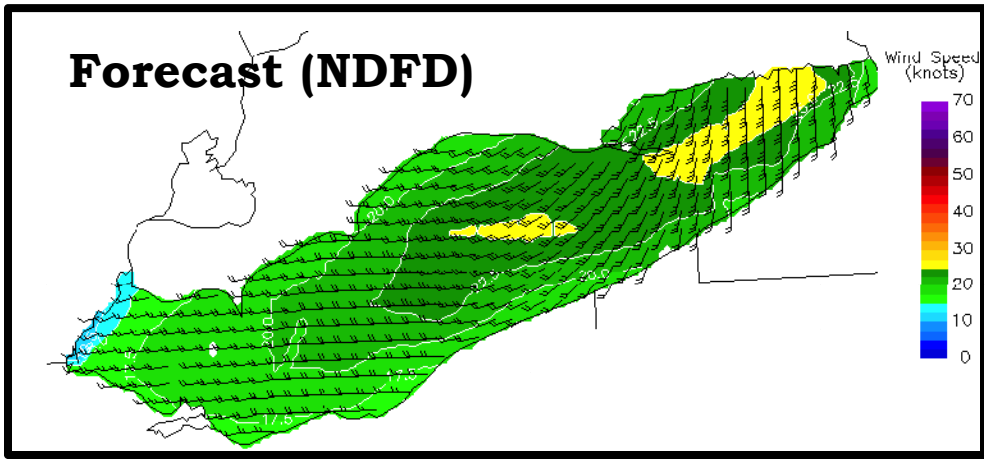
Remote sensing of HABs in Lake Erie

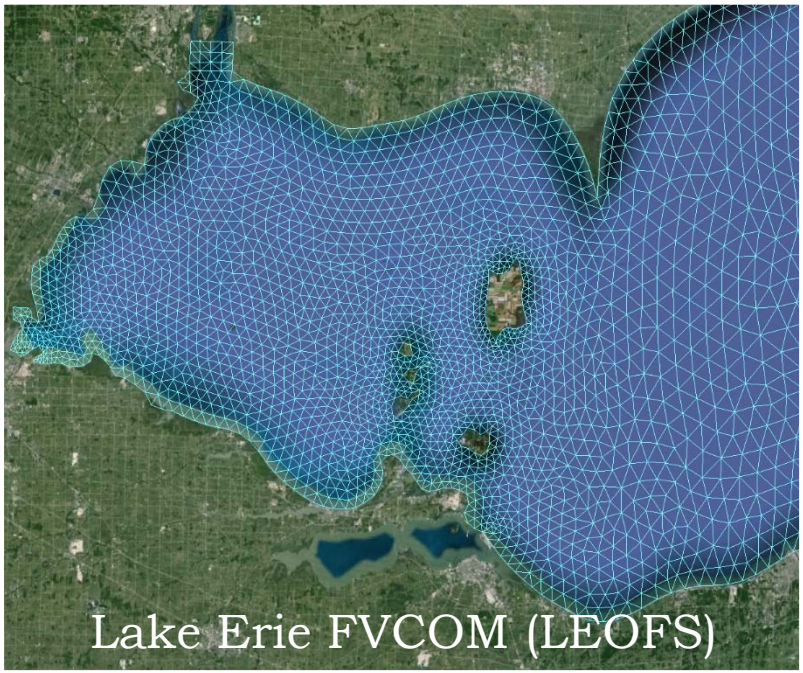
http://livingbetweenwednesdays.com/?p=486

MODIS satellite estimates of chlorophyll values for western Lake Erie → capturing HABs

Lake Erie hydrodynamic forecasts

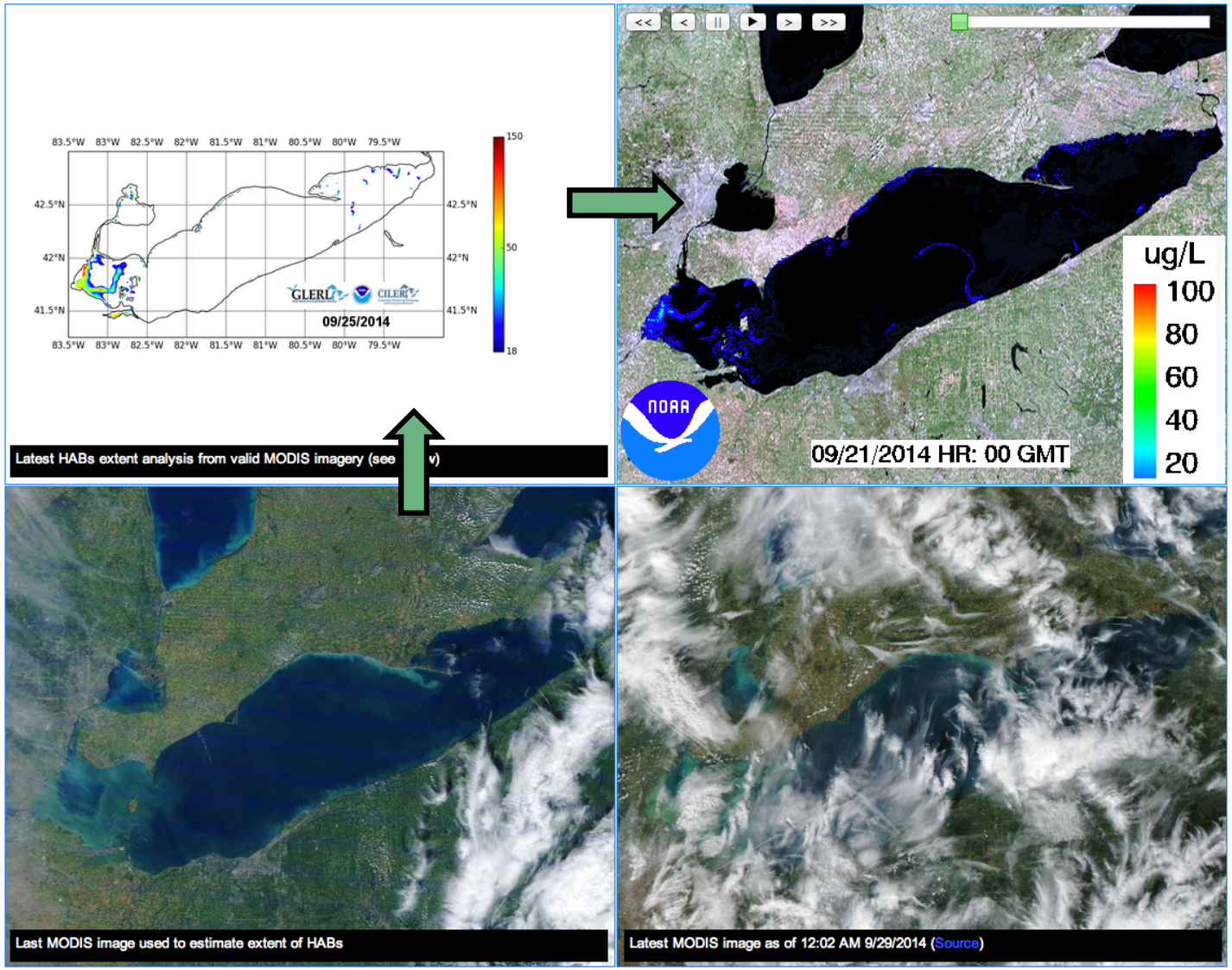




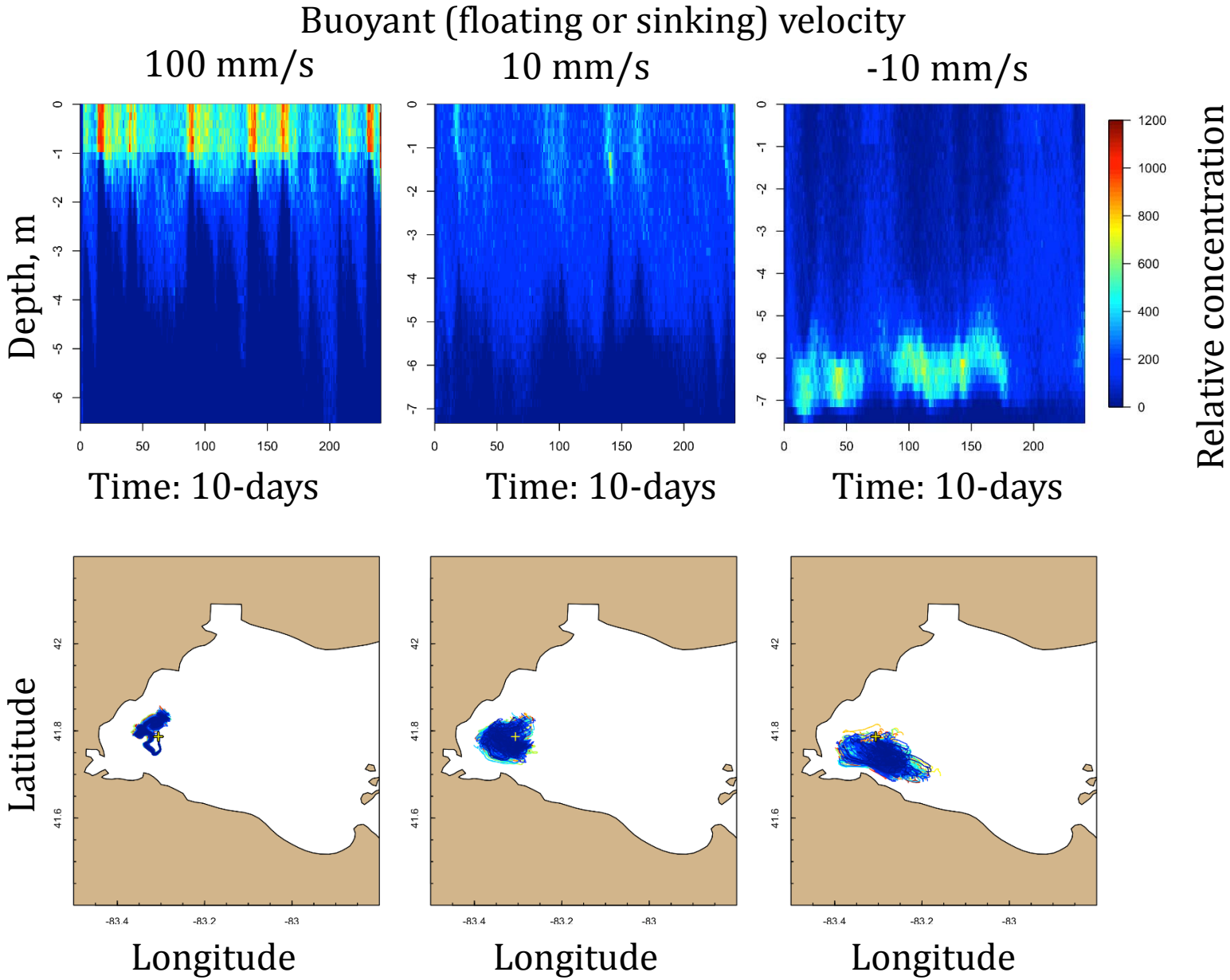


- Daily nowcast/forecast (120 hrs)
- Hourly currents
  - HAB advection

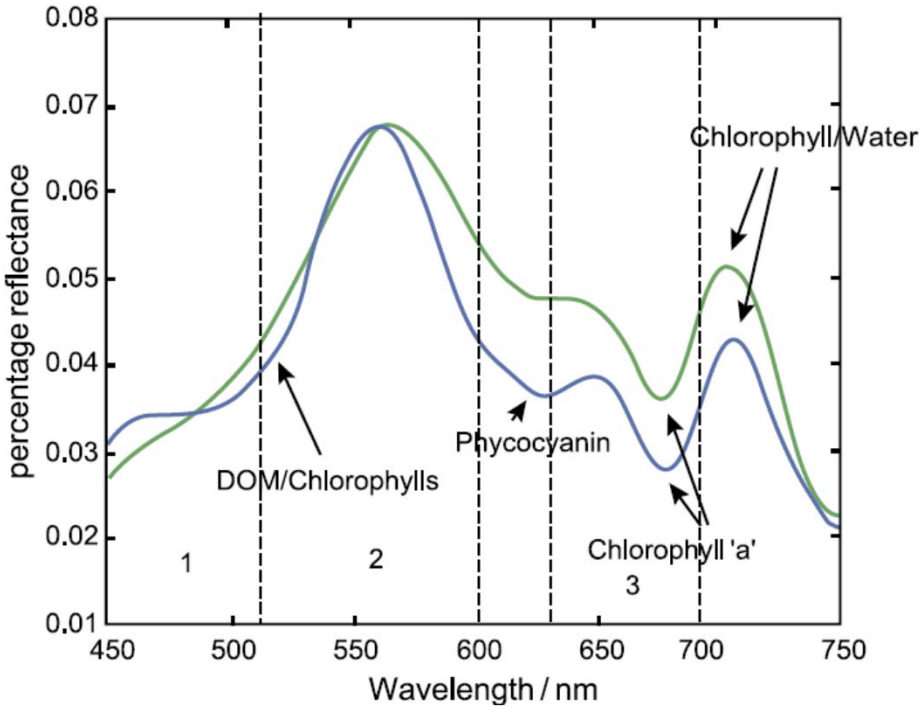
NOAA-GLERL HAB Tracker



Sensitivity of simulated HAB vertical concentration profiles and trajectories as a function of *Microcystis* colony buoyancy



HABs Flyovers



R. K. Vincent et al., *Remote Sensing of Environment*, **89** (2004) 381-392.

. Detect blooms near water intakes when satellite remote sensing products unavailable

. Airborne Sensor: 400-900 nm, 2.1 nm res

. GLRI funds available for 2015

. Pursuing MERHAB for 2016-18

NOAA-GLERL HAB webpage

National Oceanic and Atmospheric Administration
Great Lakes Environmental Research Laboratory

GLERL

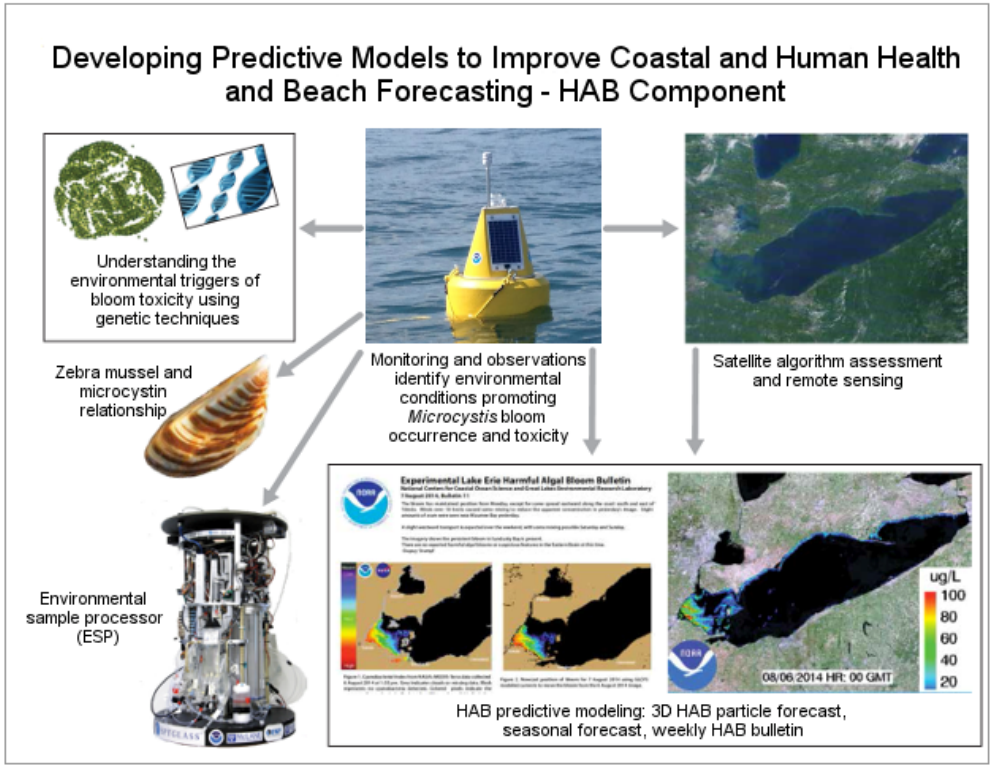
Research Data Products & Services Outreach About GLERL News & Events

Research Programs
By Subject
By Researcher
Publications

Overview | HABs | Hypoxia | Beach Water Quality | FAQ | Contacts

NOTICE: the agency will be undergoing site maintenance the evening of Monday, September 22, 2014. Services will be restored as soon as possible. Thank you for your understanding.

Harmful Algal Blooms



National Poison Control Center: 1-800-222-1222

Additional HAB Resources

Overview of guidelines on algal toxins

Latest Lake Erie HABs Bulletin

Lake Erie HAB Bulletin Sign Up

Lake Erie HAB Bulletin Archive

Algal Bloom Images (GLERL Flickr)

Great Lakes MODIS Satellite Imagery

Western Lake Erie Microcystin concentration sampling data.

Lake Erie HABs Tracker

Other HABs resources

Brochures and Factsheets

Harmful Algal Blooms in the Great Lakes: What they are and how they can affect your health (.pdf)

Experimental Lake Erie Harmful Algal Bloom Bulletin

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

4 August 2014, Bulletin 10

The microcystis bloom has intensified since last Thursday, and the area covered by medium to high concentrations (green to red) has increased. Calm winds have allowed the bloom to concentrate near surface; patches of scum were present in the areas of high concentration.

Today and Tuesday expect slight northeast transport (away from the Maumee Bay area). However, this pattern will change and light southward transport is expected through the end of the week. Mixing is expected to be weak.

The imagery shows the persistent bloom in Sandusky Bay is present.

There are no reported harmful algal blooms or suspicious features in the Eastern Basin at this time.

-Dupuy Stumpf

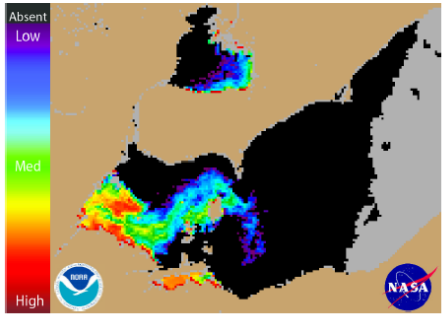


Figure 1. Cyanobacterial Index from NASA's MODIS-Aqua data collected 3 August 2014 at 1:10 pm. Grey indicates clouds or missing data. Black represents no cyanobacteria detected. Colored pixels indicate the presence of cyanobacteria. Cooler colors (blue and purple) indicate low concentrations and warmer colors (red, orange, and yellow) indicate high concentrations. The estimated threshold for cyanobacteria detection is 35,000 cells/mL.

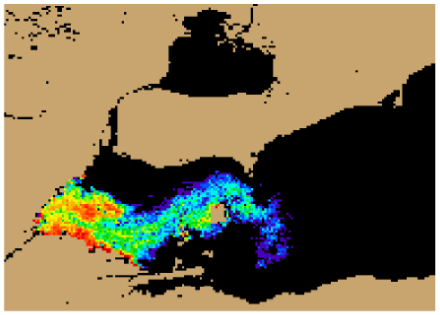


Figure 2. Nowcast position of bloom for 4 August 2014 using GLCFS modeled currents to move the bloom from the 3 August 2014 image.

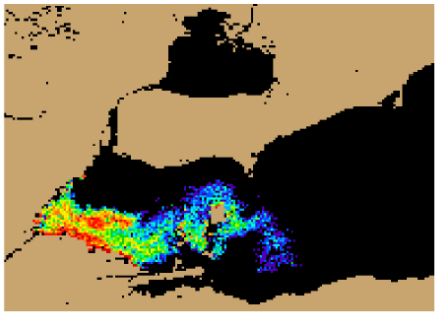
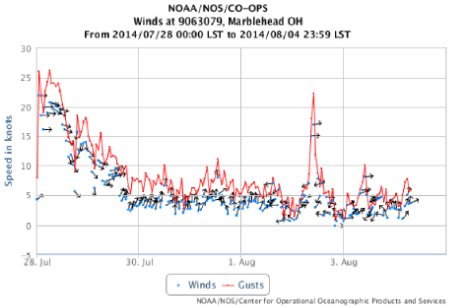
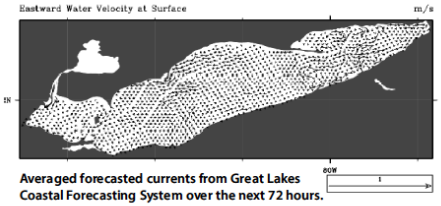


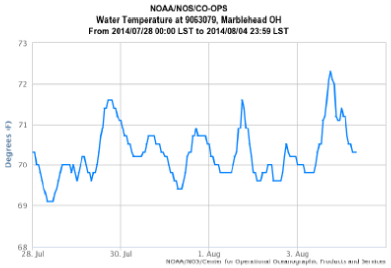
Figure 3. Forecast position of bloom for 7 August 2014 using GLCFS modeled currents to move the bloom from the 3 August 2014 image.



Wind Speed, Gusts and Direction from Marblehead, OH. From: NOAA/Center for Operational Oceanographic Products and Services (CO-OPS). Note: 1 knot = 0.51444 m/s. Blooms mix through the water column at wind speeds greater than 7.7 m/sec (~ 15 knots).



Averaged forecasted currents from Great Lakes Coastal Forecasting System over the next 72 hours.



Water Temperature from Marblehead, OH. From: NOAA/Center for Operational Oceanographic Products and Services (CO-OPS).

Supported by the NASA Applied Sciences Health and Air Quality Program.

For more information and to subscribe to this bulletin, go to:
http://www.glerl.noaa.gov/res/Centers/HABS/lake_erie_hab/lake_erie_hab.html

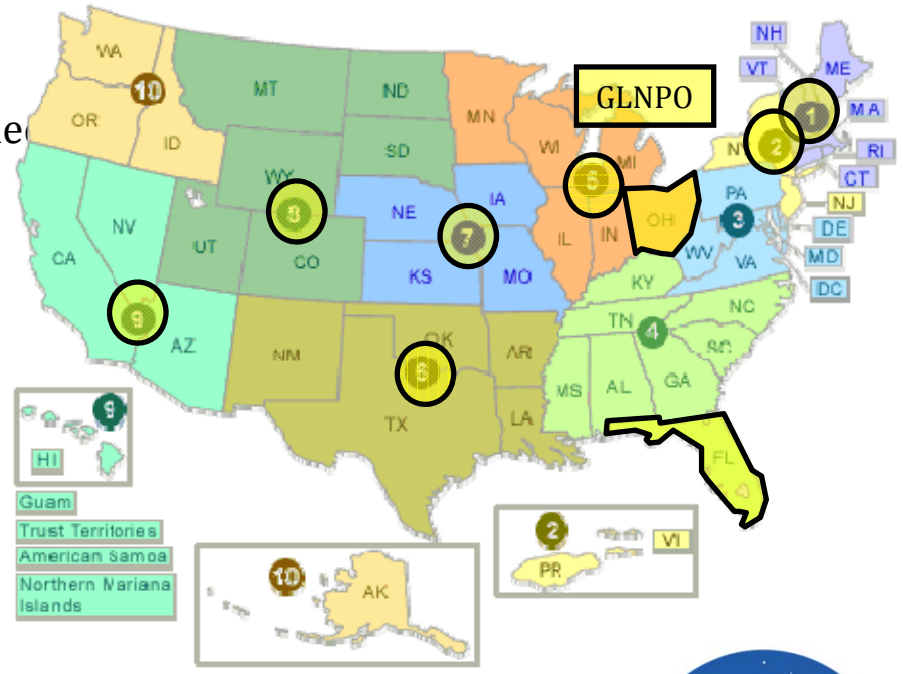
Cyanobacteria Assessment Network (CyAN)

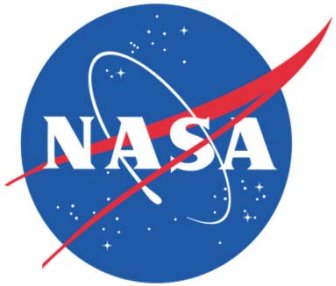
Getting satellite ocean color capabilities into U.S. water quality mgmt decisions

collaboration of EPA Office of Water; NOAA Natl Centers Coastal Ocean Science; NASA; USGS

Partners

- EPA Office of Water
  - Office of Wetlands, Oceans, and Watershe
  - Office of Wastewater Management
  - Office of Science and Technology
- EPA Regions
- U.S. Army Corps of Engineers
- States
  - Ohio EPA
  - St. Johns River WMD
  - S. Florida WMD

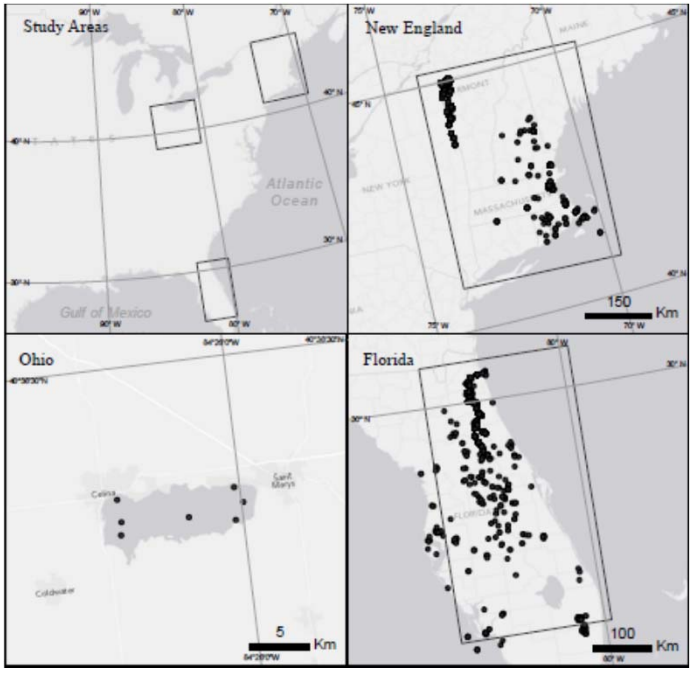


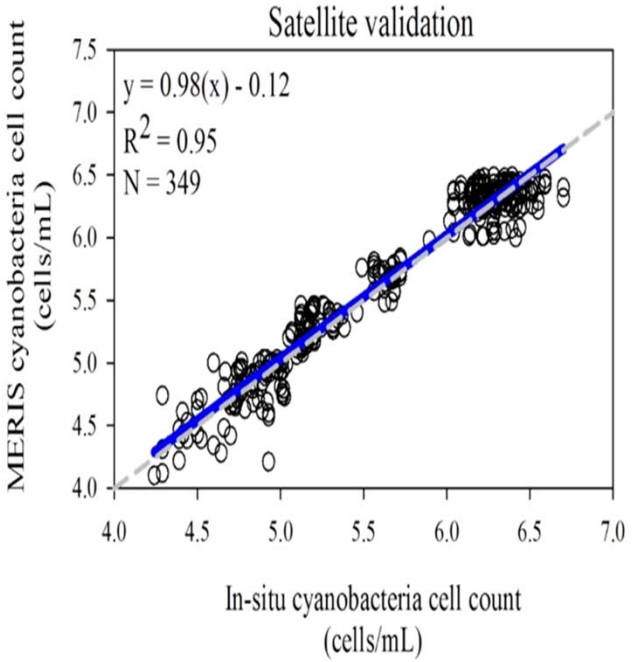


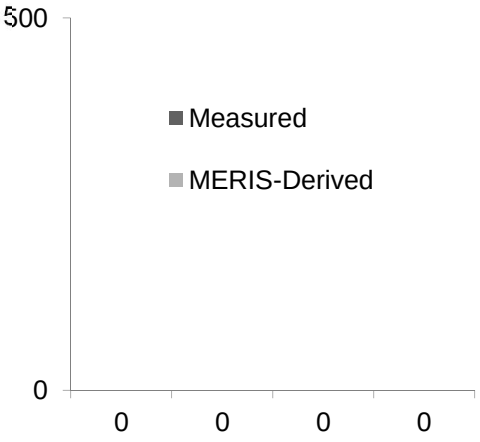
Validation of Lake Erie algorithm for other areas with EPA; start of Cyanobacteria Assessment Network

- **Remote Sensing**
  - *Uniform and systematic approach for identifying cyanobacteria blooms.*
    - Second derivative spectral shape algorithms (SS; Wynne et al. 2008)

$$SS(\lambda) = \rho_s(\lambda) - \rho_s(\lambda_-) + \{\rho_s(\lambda_-) - \rho_s(\lambda_+)\} * \frac{(\lambda - \lambda_-)}{(\lambda_+ - \lambda_-)}$$



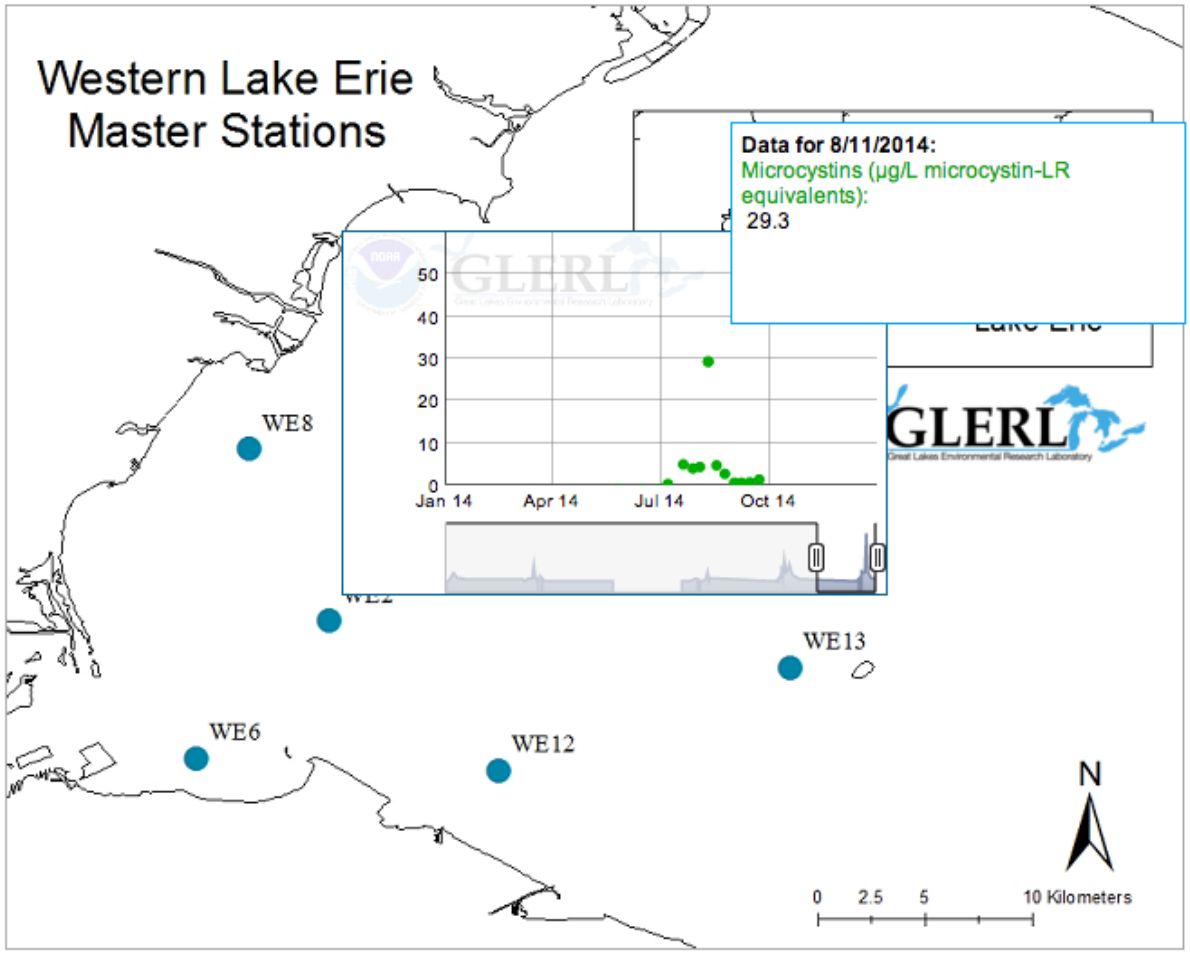




Lunetta, Schaeffer, Stumpf et al. Remote Sensing of Environment

NOAA- GLERL microcystins data

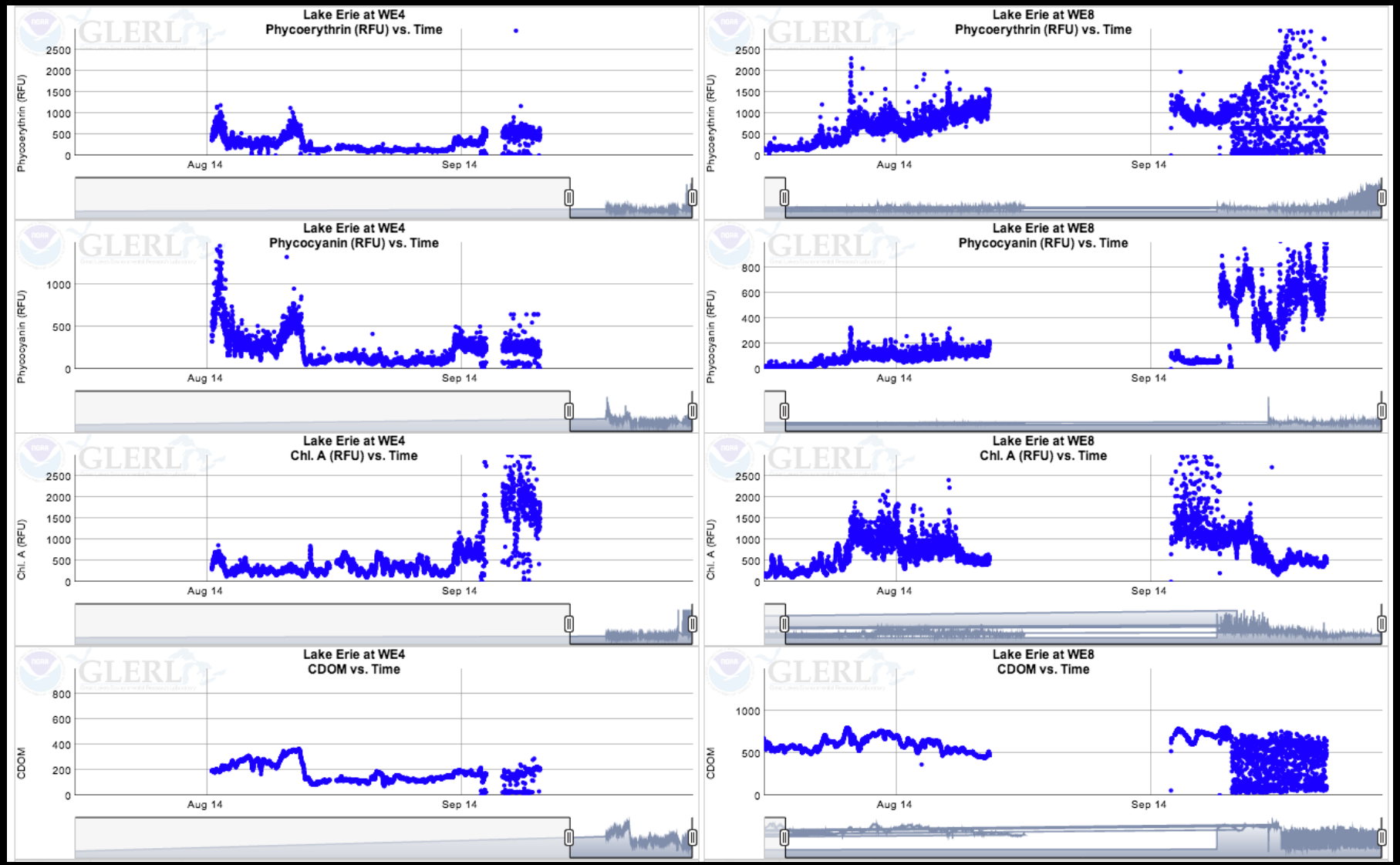
Microcystin estimates from western lake Erie



Hover over a sampling location in the map to view its time series of Microcystins (µg/L microcystin-LR equivalents).
Click on the map to close the chart.

Year to display (for time series plot): 2014

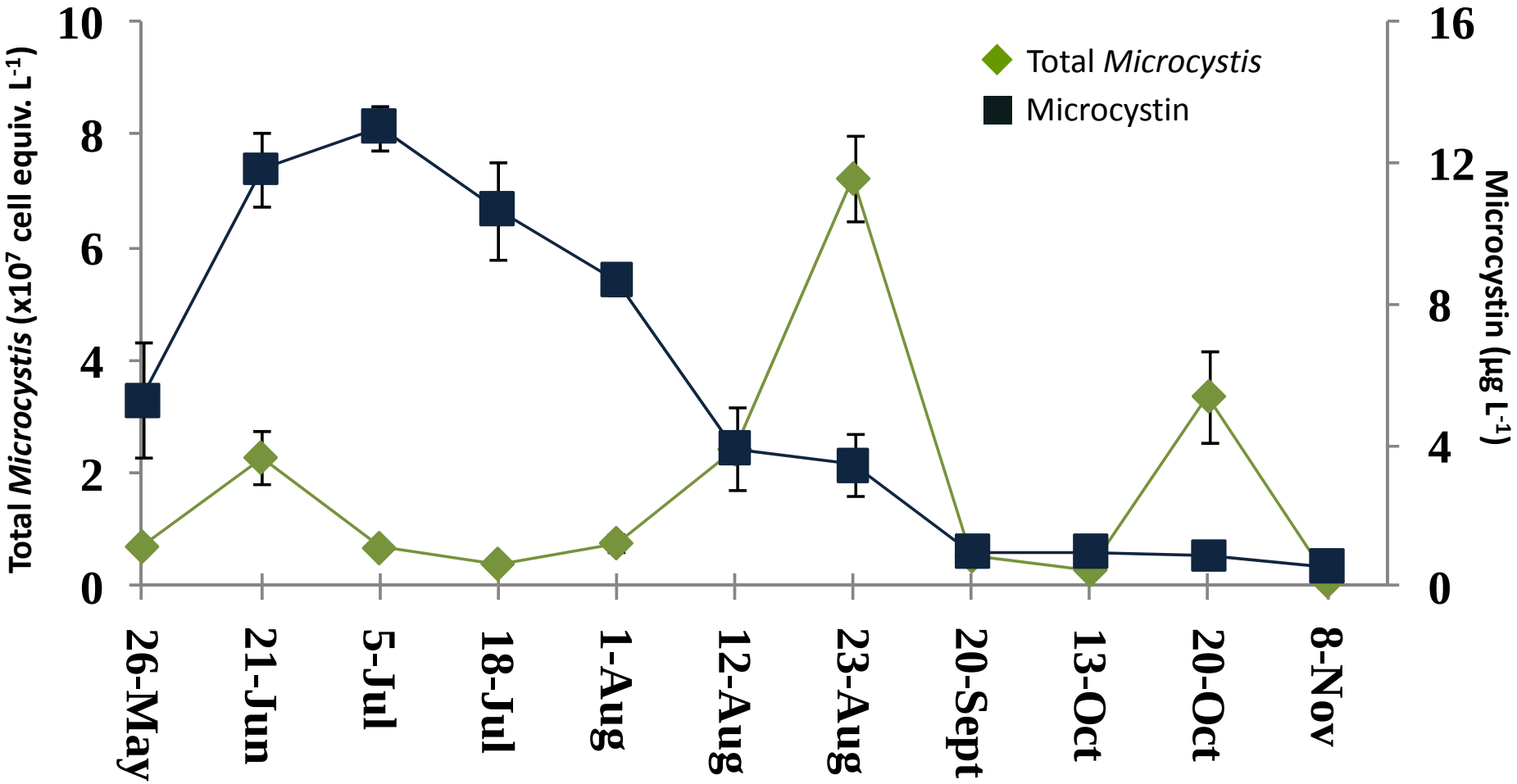
Water quality data



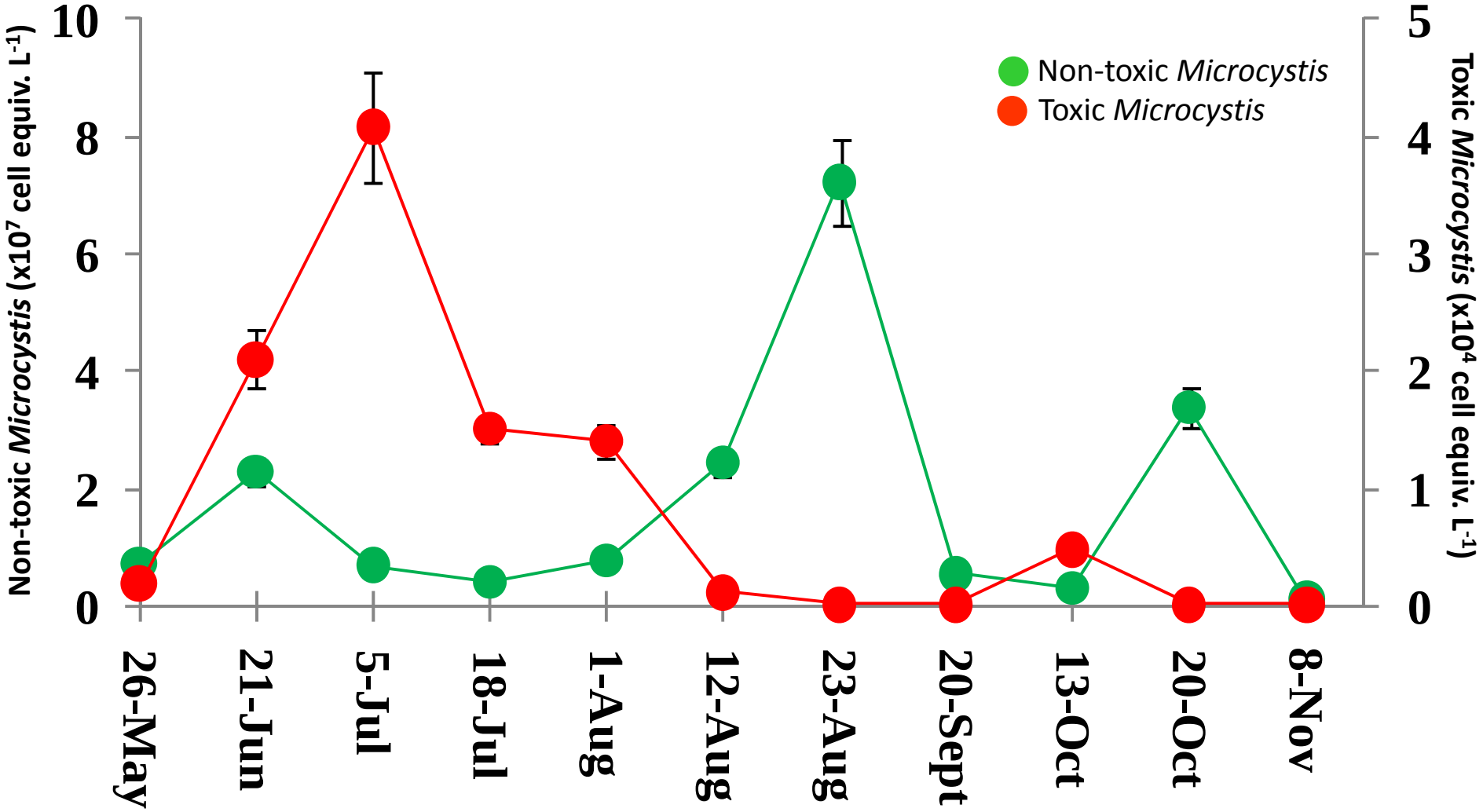
Overarching research statement:

Understanding the driver of bloom toxicity will aid in enhancing predictive models that forecast bloom size, location AND toxicity

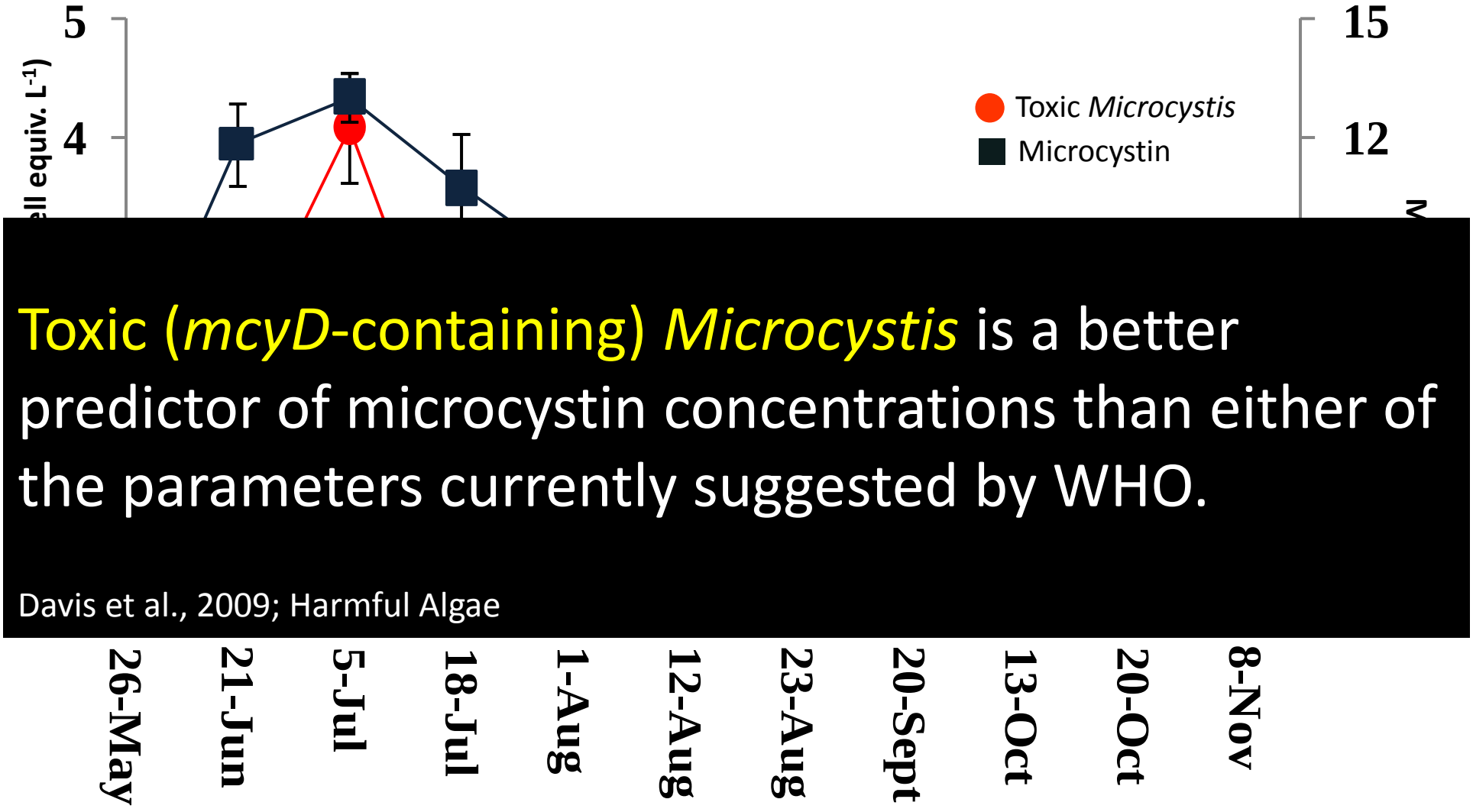
Total *Microcystis* and microcystin



Toxic and non-toxic *Microcystis*



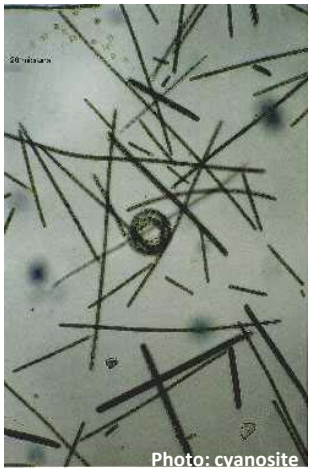
Toxic *Microcystis* and microcystin

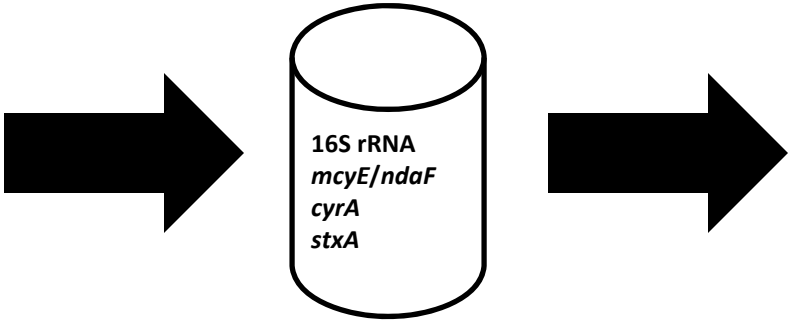


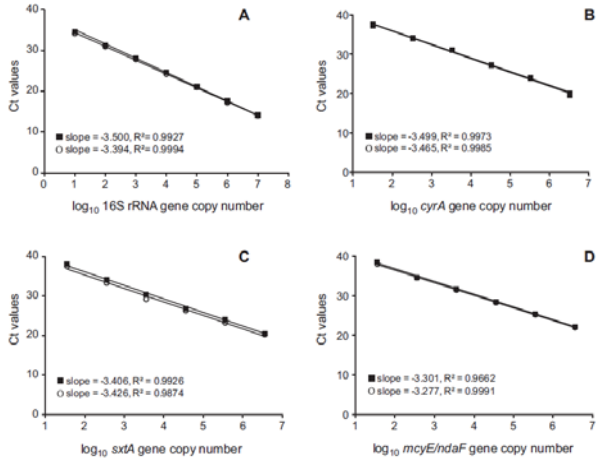
Toxic (*mcyD*-containing) *Microcystis* is a better predictor of microcystin concentrations than either of the parameters currently suggested by WHO.

Davis et al., 2009; Harmful Algae

Multiplex qPCR: quantifying multiple genes of interest in a single reaction

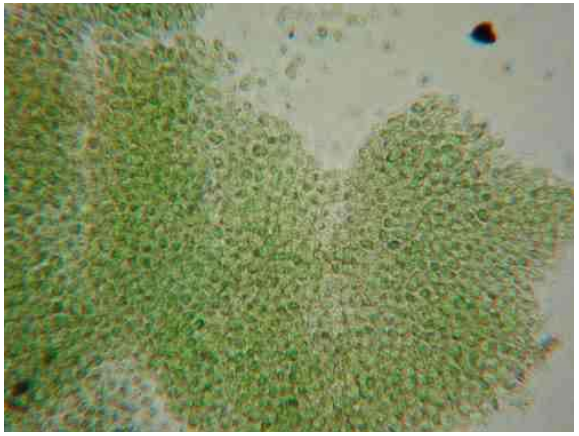


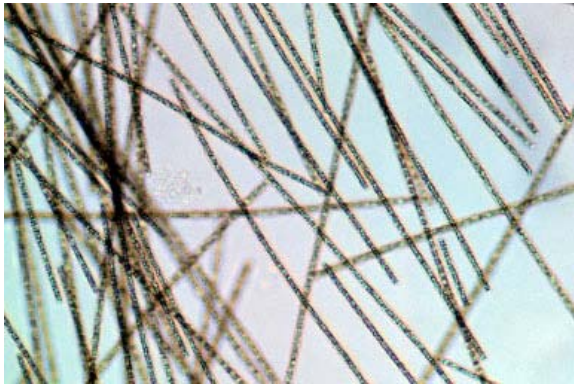




Multiplex qPCR: understanding competition among CHAB species in the Great Lakes

- This proposed work would be a continuation of my current grant
- In Lake Erie, cylindrospermopsin, anatoxin, and microcystin have been detected
- The specie(s) responsible for the production of CYN and ATX are currently unknown
  - CYN production: *Cylindrospermopsis* or *Aphanizomenon*?
- Would significantly enhance models aimed at predicating bloom toxicity
- Conducting mechanistic experiments that would help elucidate the competition between potential cyanotoxin producers





Elucidating ecological adaptions of Great Lakes CHAB species

- *Microcystis* blooms (Western Basin Lake Erie, Lake St. Clair, Green Bay, Hamilton Harbor) *Anabanea* blooms (Cleveland area & Western Basin of LE, Bay of Quinte) and *Planktothrix* blooms in Sandusky Bay

- Isolation of Great Lake HAB species from major bloom-forming genera

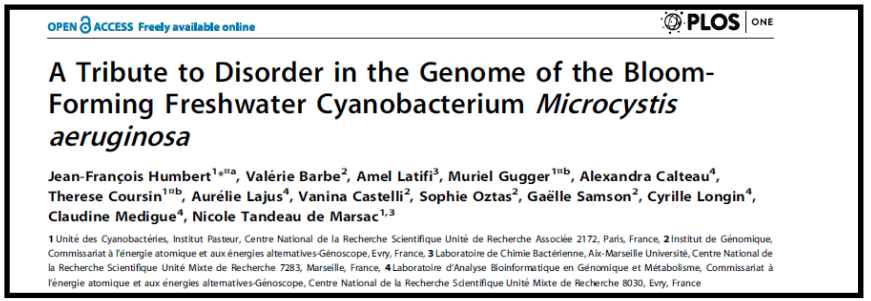
- Controlled laboratory experiments investigating the competition between species under varying environmental conditions

- Further understating the interactive roles of light, nutrients, and temperature on toxin production and community composition

- This would involve investigating the molecular response of these phytoplankton to different environmental variables (light, nutrient, temperature, CO_2) on a global level (comparative genomic/transcriptomic studies)

Omics of Great Lakes CHAB species

- Very few Great Lake HAB genomes have been sequenced
- Understanding the global response of HAB species to environmental stressors
- Comparative genomics of toxic and non-toxic strains
- Laboratory and field experiments aimed at elucidating the transcriptomic response of individual strains and the overall community to changes in the physical and chemical environment
- 13 strains of Great lakes CHAB species sequenced

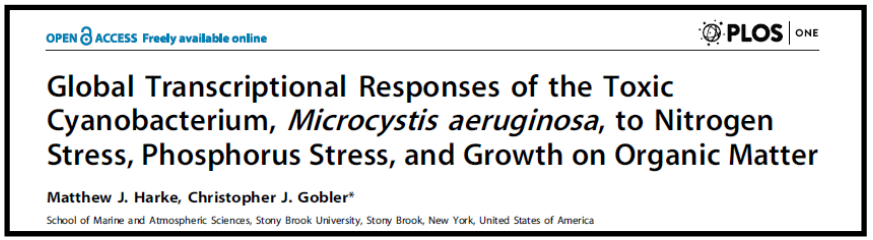


OPEN ACCESS Freely available online PLOS ONE

A Tribute to Disorder in the Genome of the Bloom-Forming Freshwater Cyanobacterium *Microcystis aeruginosa*

Jean-François Humbert[1¤a], Valérie Barbe[2], Amel Latifi[3], Muriel Gugger[1¤b], Alexandra Calteau[4], Therese Coursin[1¤b], Aurélie Lajus[4], Vanina Castelli[2], Sophie Oztas[2], Gaëlle Samson[2], Cyrille Longin[4], Claudine Medigue[4], Nicole Tandeau de Marsac[1,3]

1 Unité des Cyanobactéries, Institut Pasteur, Centre National de la Recherche Scientifique Unité de Recherche Associée 2172, Paris, France, 2 Institut de Génomique, Commissariat à l'énergie atomique et aux énergies alternatives-Génoscope, Evry, France, 3 Laboratoire de Chimie Bactérienne, Aix-Marseille Université, Centre National de la Recherche Scientifique Unité Mixte de Recherche 7283, Marseille, France, 4 Laboratoire d'Analyse Bioinformatique en Génomique et Métabolisme, Commissariat à l'énergie atomique et aux énergies alternatives-Génoscope, Centre National de la Recherche Scientifique Unité Mixte de Recherche 8030, Evry, France



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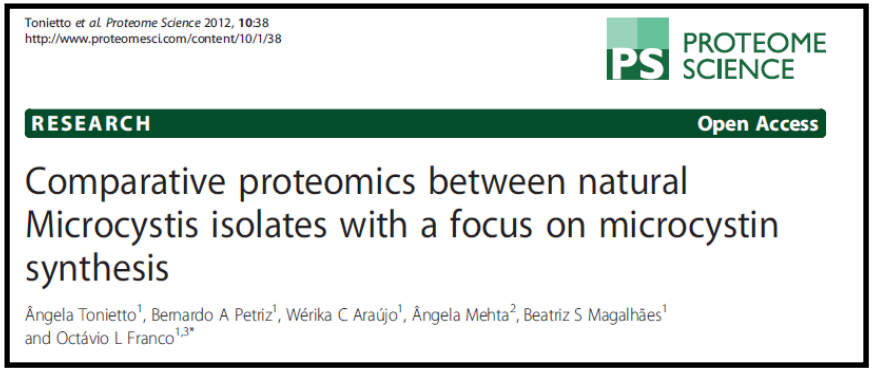
Global Transcriptional Responses of the Toxic Cyanobacterium, *Microcystis aeruginosa*, to Nitrogen Stress, Phosphorus Stress, and Growth on Organic Matter

Matthew J. Harke, Christopher J. Gobler*

School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, New York, United States of America



Tonietto *et al. Proteome Science* 2012, **10**:38
http://www.proteomesci.com/content/10/1/38

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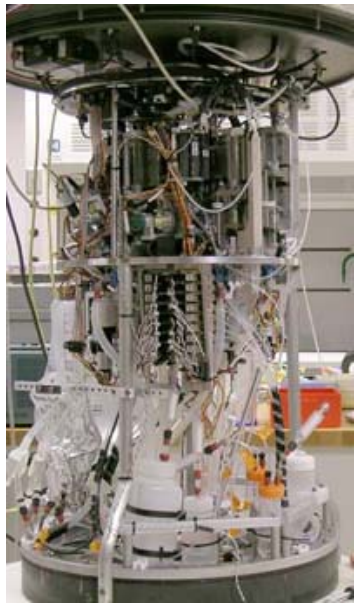
Comparative proteomics between natural Microcystis isolates with a focus on microcystin synthesis

Ângela Tonietto[1], Bernardo A Petriz[1], Wérika C Araújo[1], Ângela Mehta[2], Beatriz S Magalhães[1] and Octávio L Franco[1,3*]

Autonomous real-time toxin detection for Lake Erie

- EPA-GLRI supplemental funds
- Environmental Sample Processor (ESP; Monterey Bay Aquarium Research Institute)
- Would be able to track blooms toxicity at a resolution that was previously unattainable with traditional sampling
- Will be referenced against physical, chemical and biological conditions
- Will be extremely valuable in the development of more accurate bloom forecasting models



Photos: Monterey Bay Aquarium Research Institute


Thank you for your attention!
QUESTIONS?