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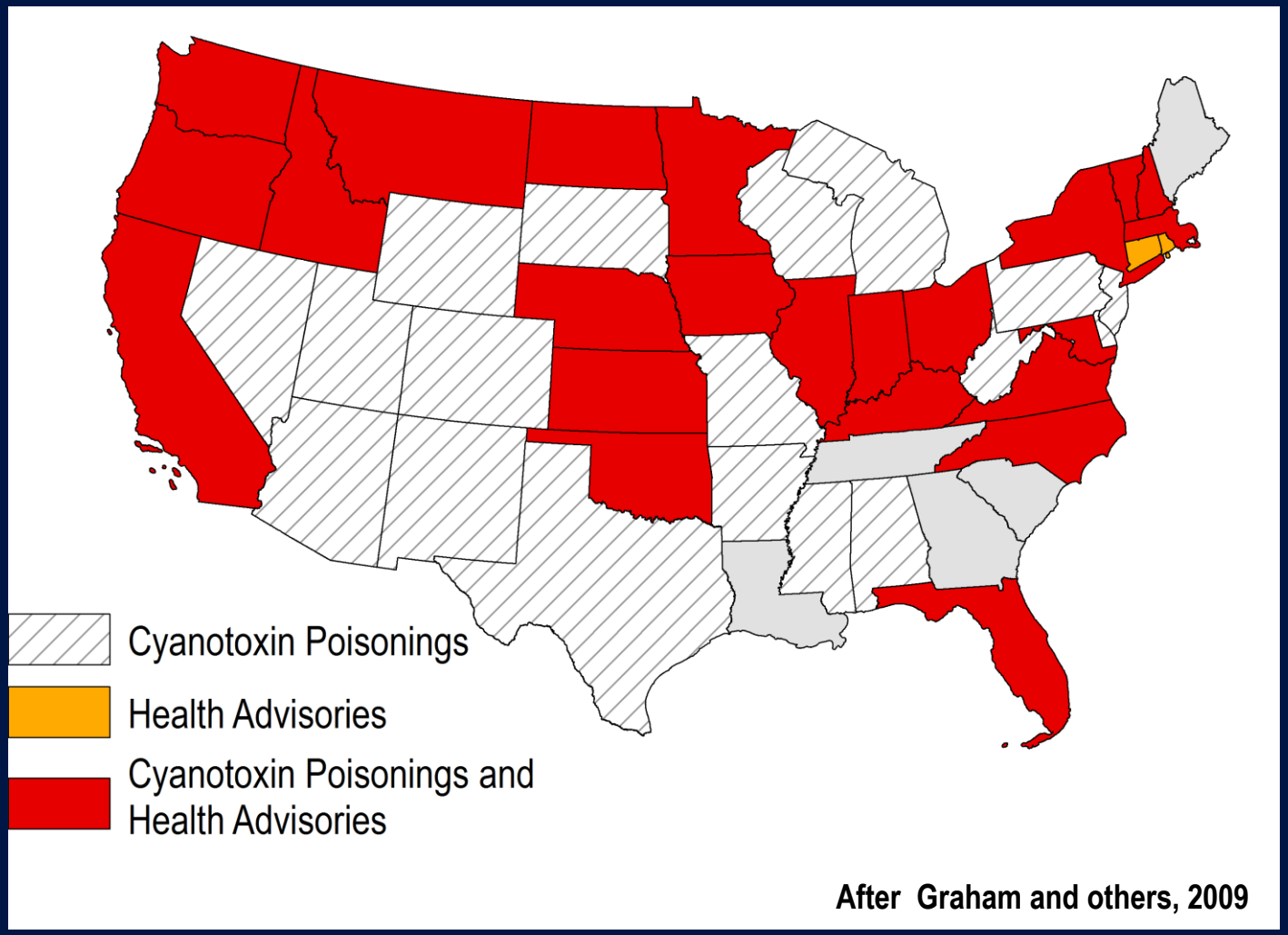
Cyanotoxins in Freshwaters of the United States: Occurrence and Emerging Technologies

Jennifer L. Graham, Keith A. Loftin, and Guy M. Foster
U.S. Geological Survey

EPA Region 10 HABs Workshop
March 29, 2016

At Least 39 States in the Nation Have Had Anecdotal Reports of Cyanotoxin Poisoning



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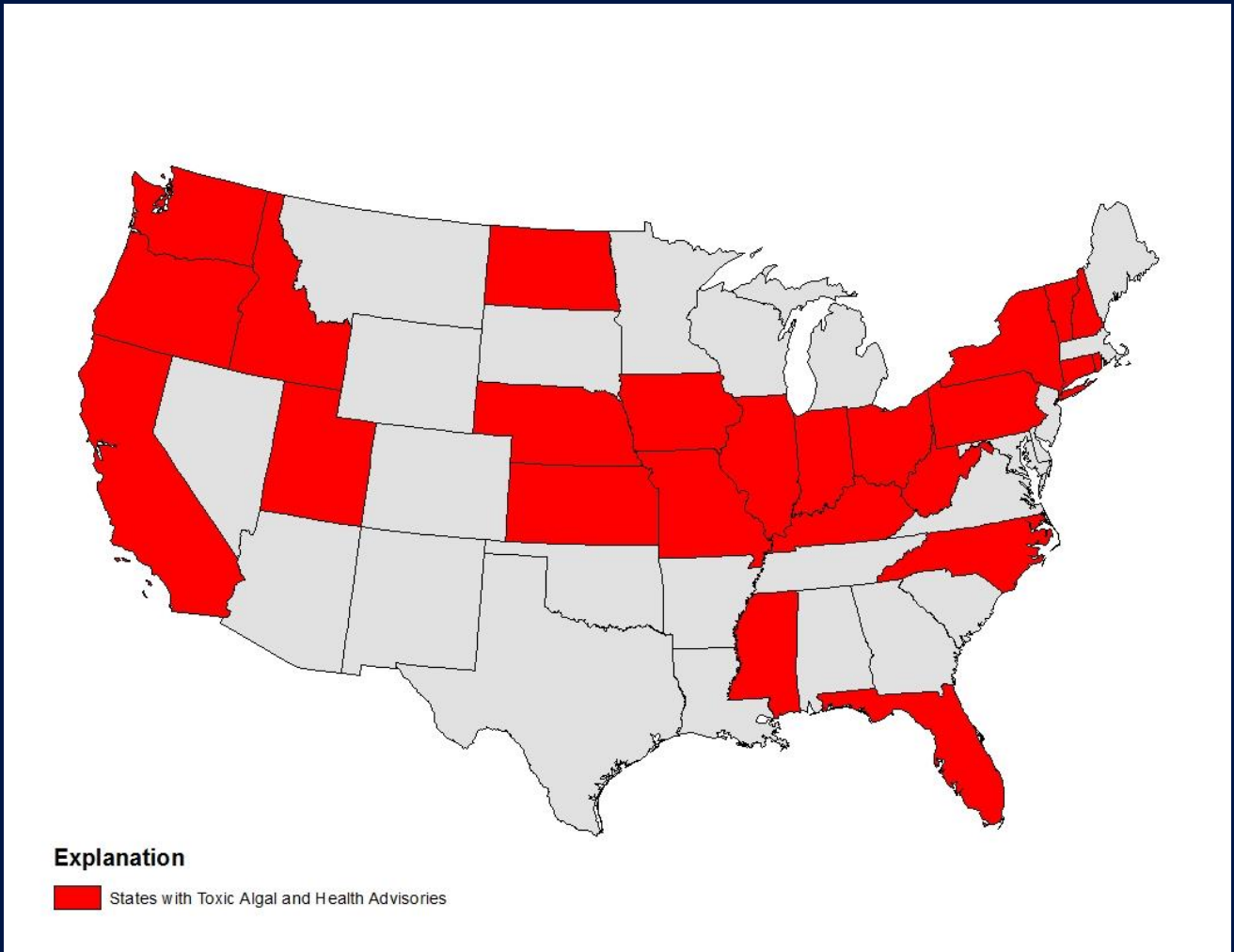
In August 2015, 24 States Had Toxic Algal and Health Advisories for Cyanobacteria



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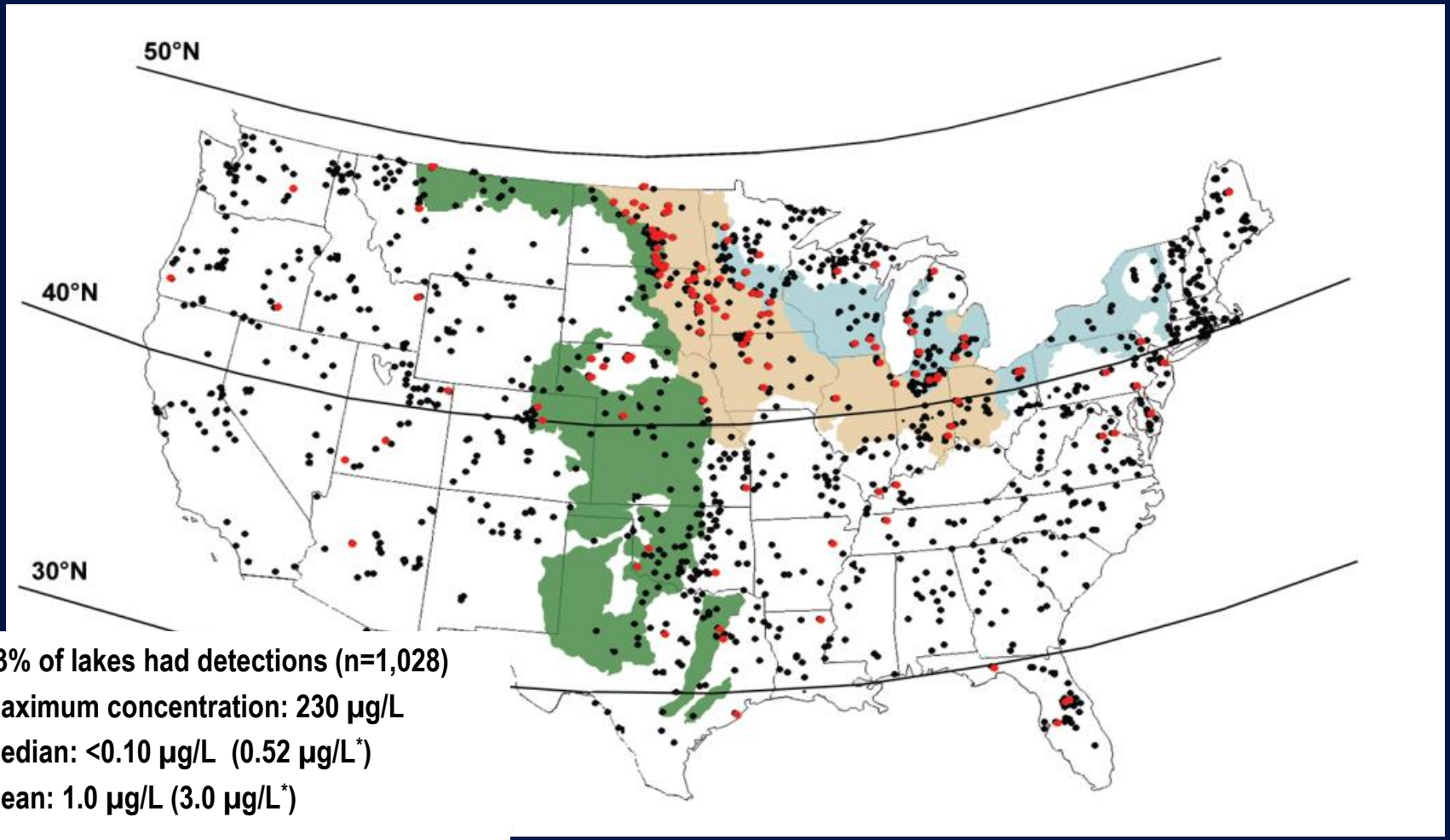
Data Compiled from EPA Freshwater HAB News

In the 2007 National Lake Assessment Microcystin Concentrations > 1 µg/L Were Most Common in the Upper Midwest



33% of lakes had detections (n=1,028)

Maximum concentration: 230 µg/L

Median: <0.10 µg/L (0.52 µg/L*)

Mean: 1.0 µg/L (3.0 µg/L*)

*Detections only

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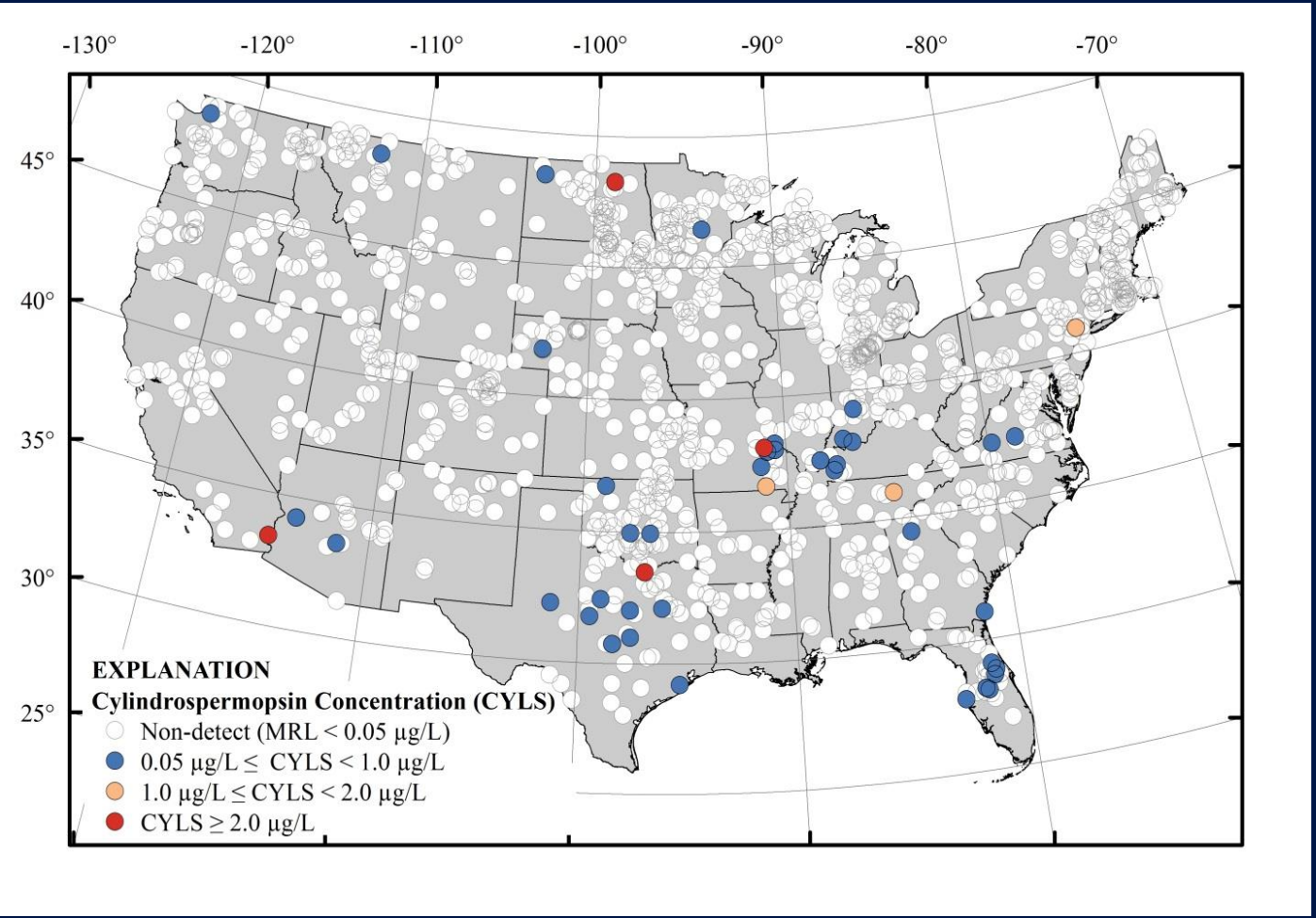
After Beaver and others, 2014

Cylindrospermopsins Were Detected by ELISA in About 4% (n=659) of Analyzed Lakes; Occurrence was Most Common in the South



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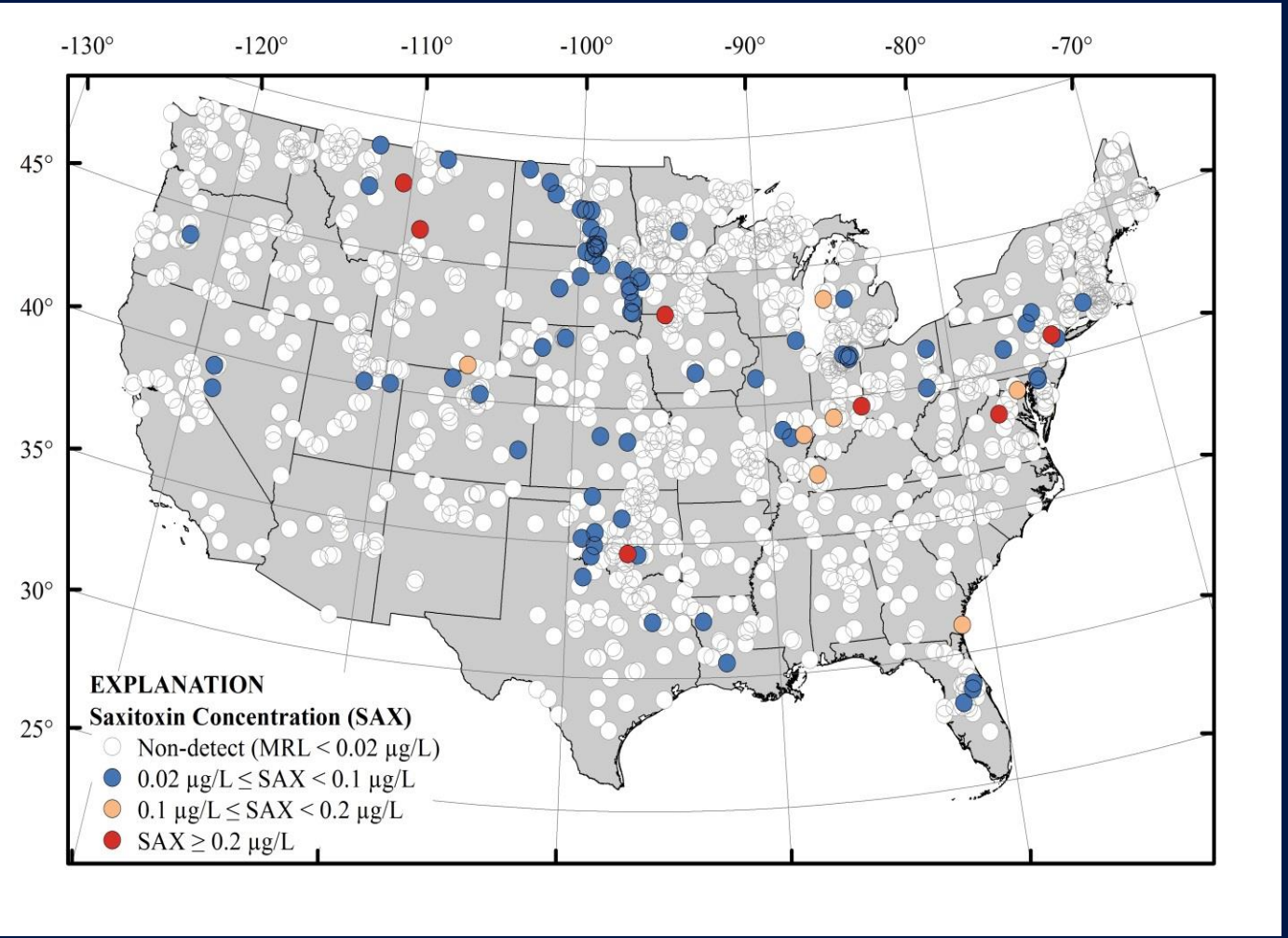
After Loftin and others, in press

Saxitoxins Were Detected by ELISA in About 8% (n=678) of Analyzed Lakes; Occurrence was Most Common in the Upper Midwest and the South



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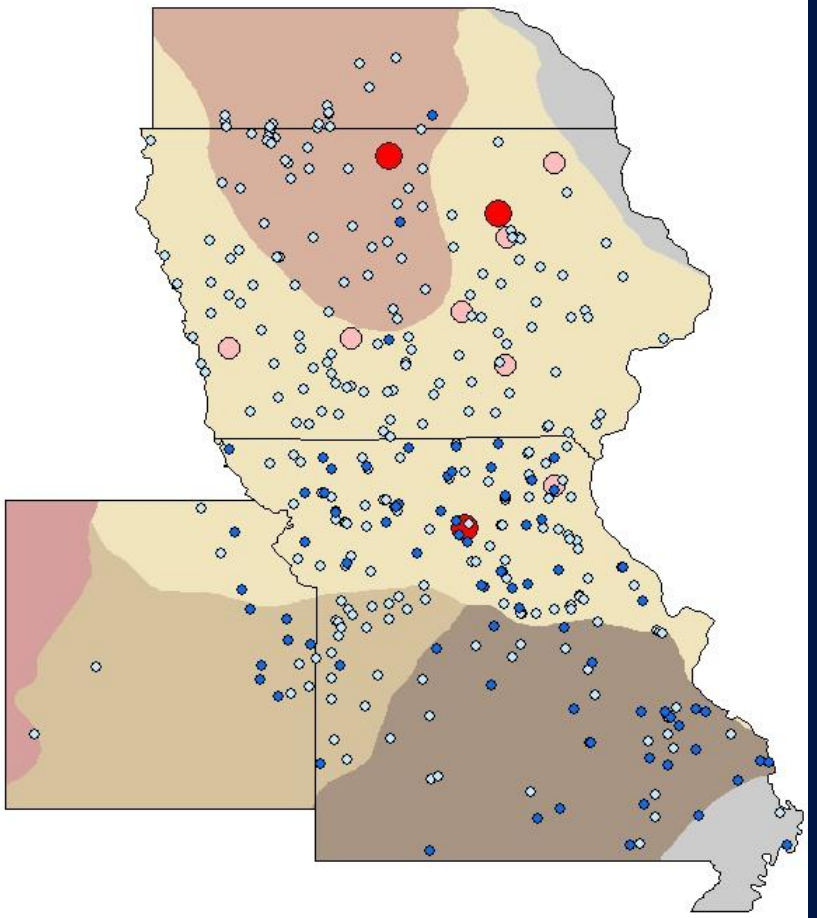
After Loftin and others, in press

Microcystins are Widespread and Common in the Midwest

OZARK HIGHLANDS (OH)
OSAGE PLAINS (OP)
DISSECTED TILL PLAINS (DT)
WESTERN LAKE (WL)
PLAINS BORDER (PB)

CONCENTRATION/RISK

- NOT DETECTED
- LOW (<10 ug/L)
- MODERATE (10-20 ug/L)
- HIGH (> 20 ug/L)



78% of lakes had detections (n=359)

Maximum concentration: 52 µg/L

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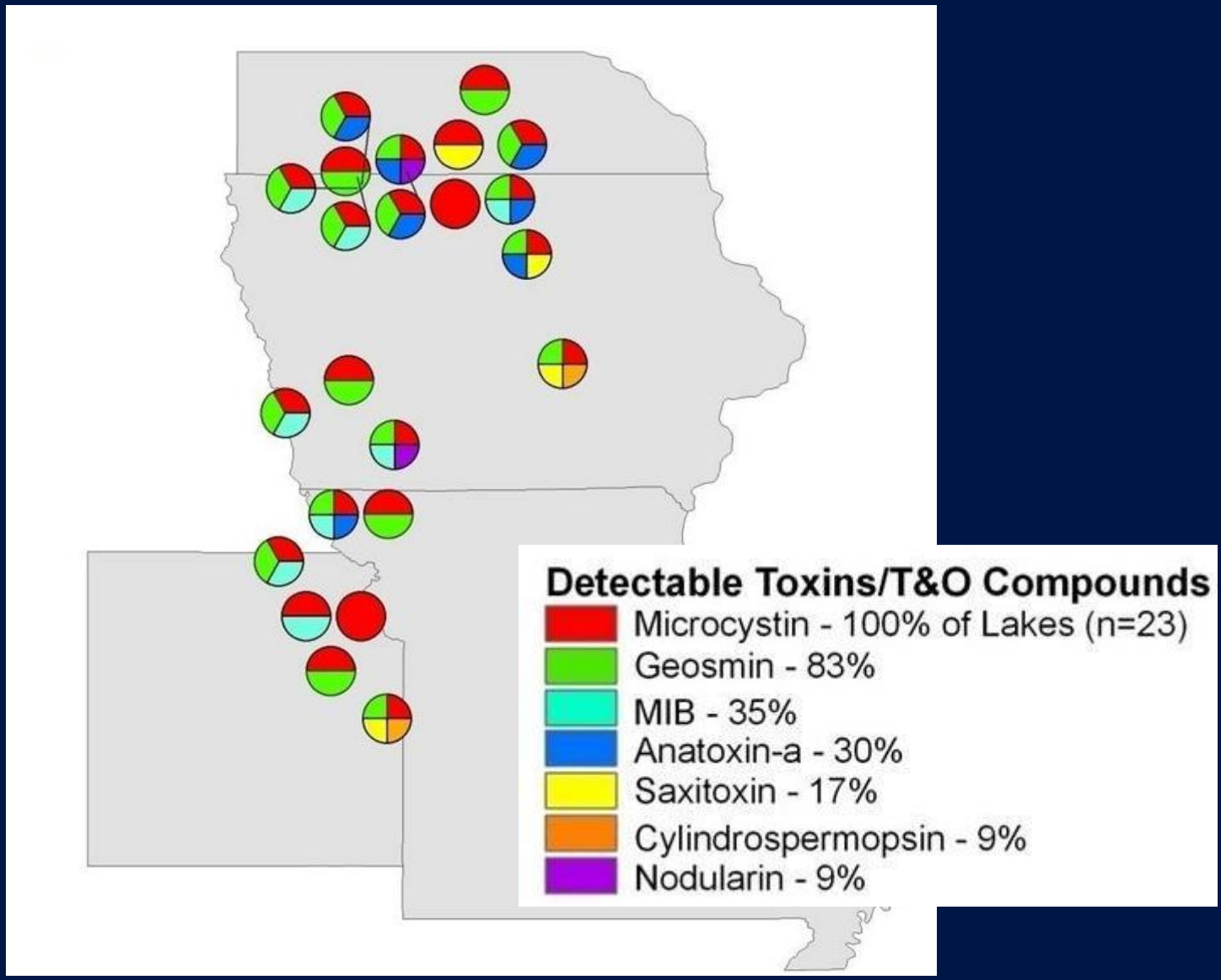
After Graham and others 2004, 2006, and 2009

Multiple Toxins and Taste-and-Odor Compounds Frequently Co-Occur in Cyanobacterial Blooms



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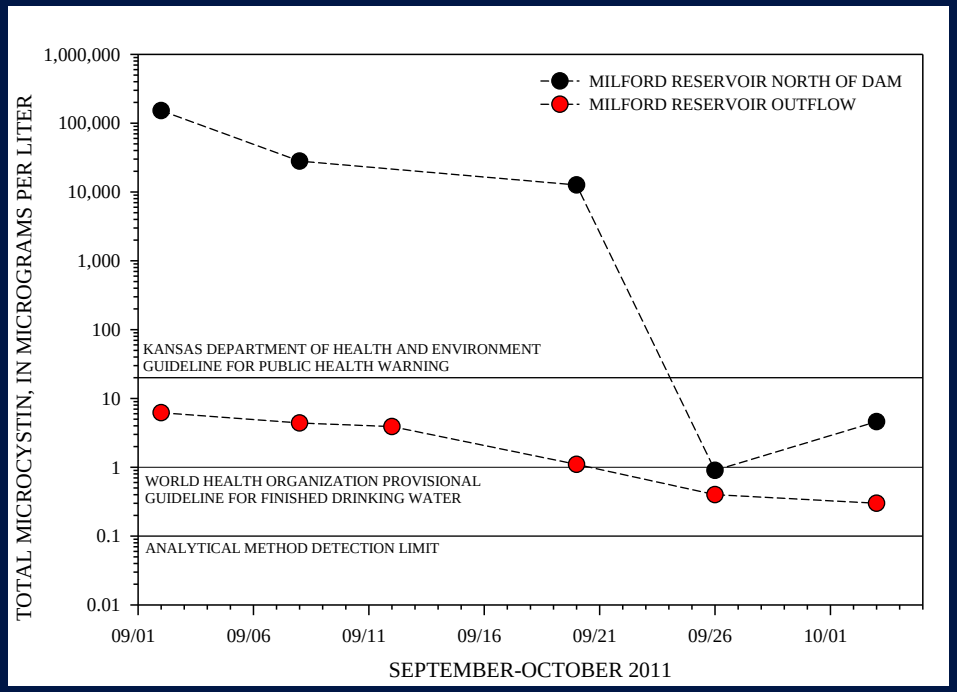
After Graham and others, 2010

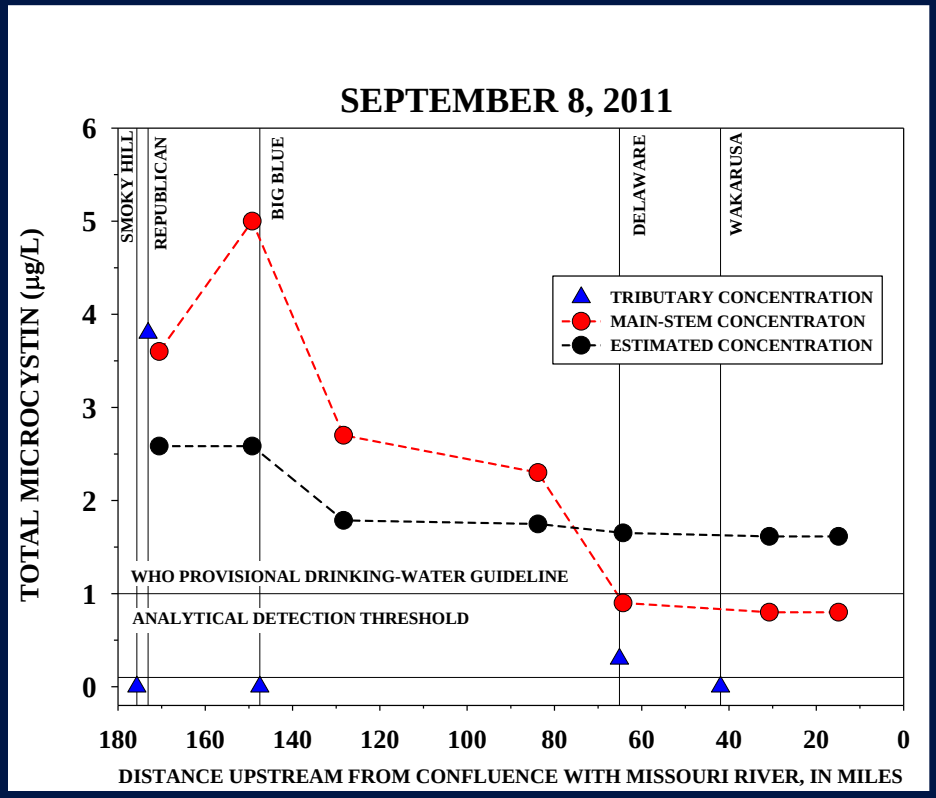
Cyanobacterial Toxins and Taste-and-Odor Compounds May Be Transported for Relatively Long Distances Downstream from Lakes and Reservoirs



Milford Lake release sends algae to Kansas River

MARIA SUDEKUM FISHER, Associated Press

Published 09:10 p.m., Wednesday, September 21, 2011



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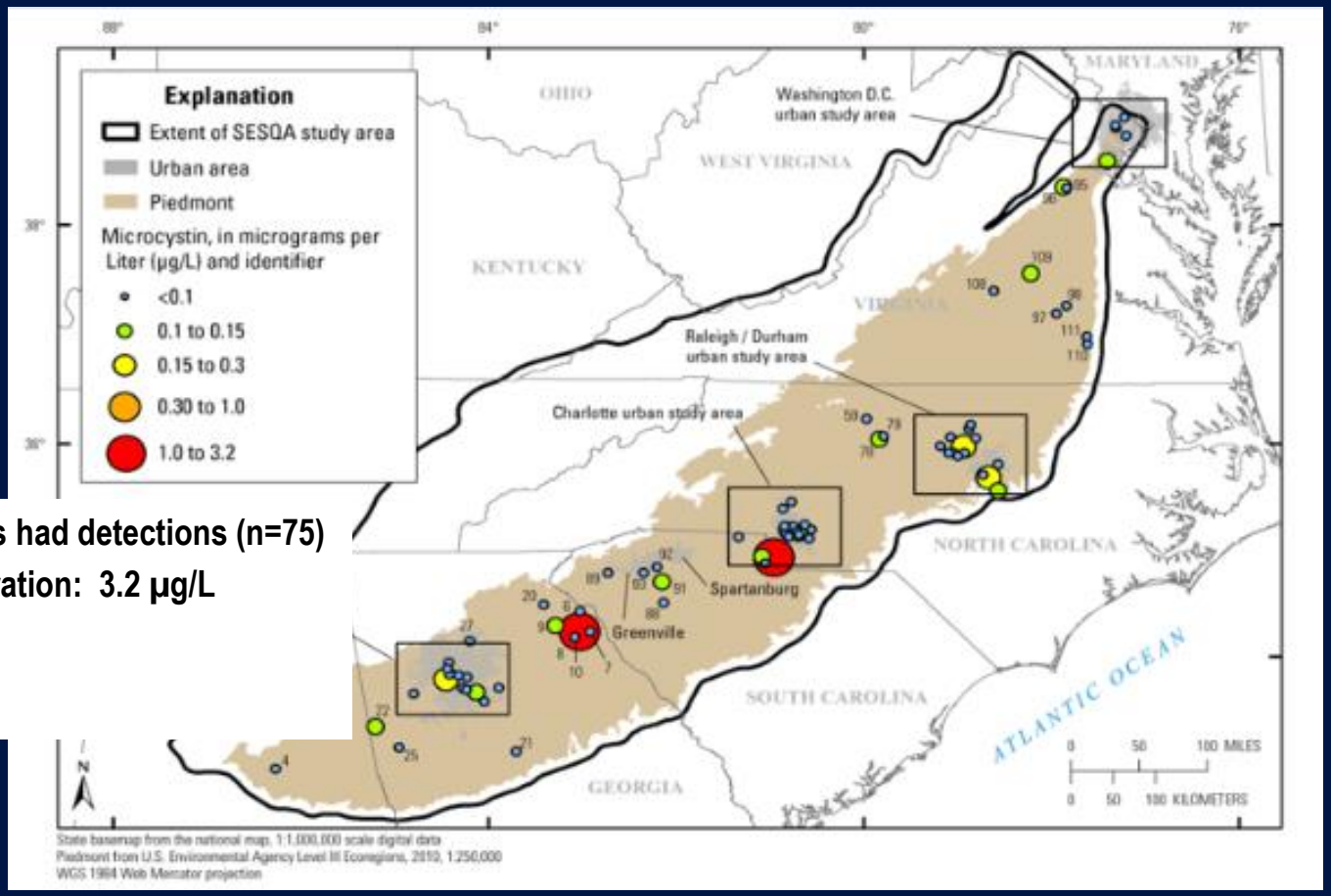
After Graham and others, 2012

Microcystins Also Occur in Smaller Streams



39% of stream sites had detections (n=75)

Maximum concentration: 3.2 µg/L

Median: 0.11 µg/L

Mean: 0.29 µg/L

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After Loftin and others, 2016

Vertical Migration or Wind Movement of Surface Accumulations May Rapidly Change the Areal Distribution of Cyanobacteria

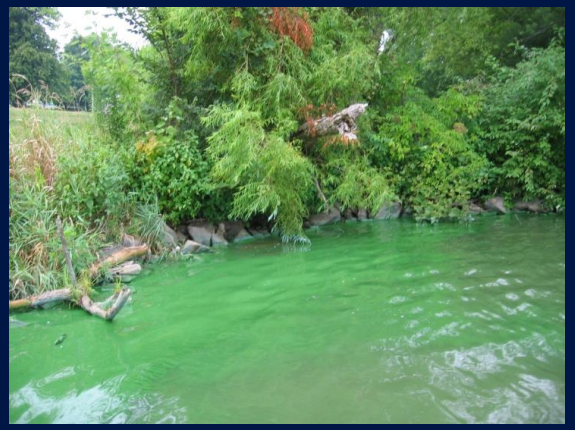
Rock Creek Lake, Iowa
2006 Beach Closure Event

Beach Area
Monday
July 31

Photos Courtesy of IA DNR

Beach Area
Thursday
August 3

Photo Courtesy of IA DNR



Boat Ramps
Friday
August 11

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Vertical Migration or Wind Movement of Surface Accumulations May Rapidly Change the Aerial Distribution of Cyanobacteria

Rock Creek Lake, Iowa
2006 Beach Closure Event

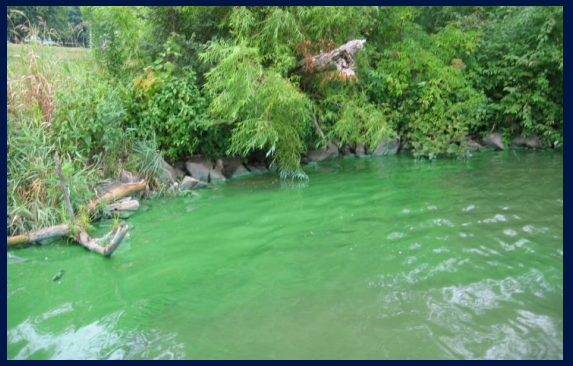
Beach Area

Beach Area
Thursday
August 3

WHERE DID THE CYANOBACTERIA GO?

Most likely explanation is redistribution in the water column

Photos Courtesy of IA DNR



Boat Ramps
Friday
August 11

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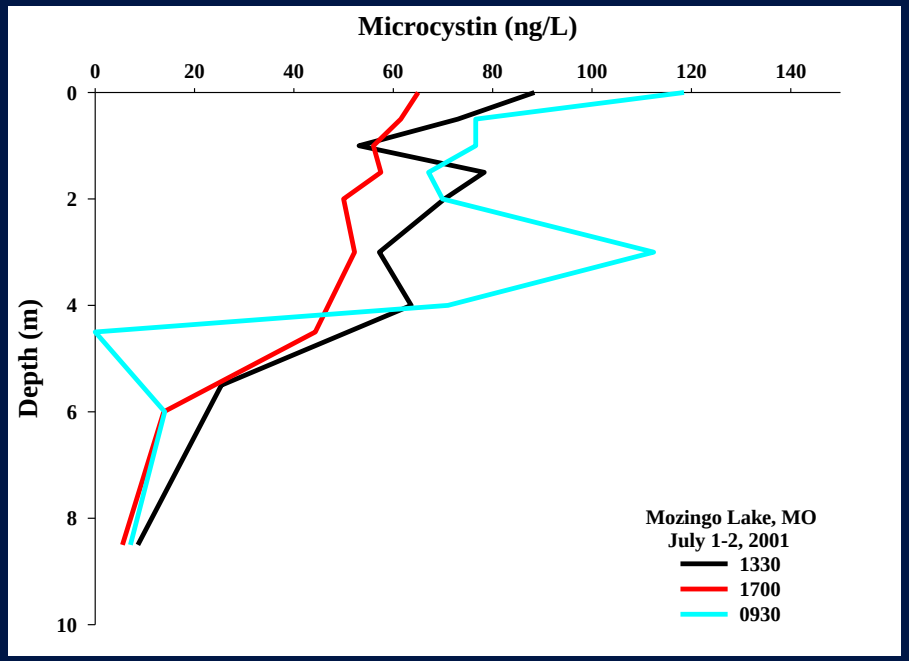
Sample Concentrations Can Vary Considerably Depending on When, Where, and How Samples Are Collected



Microcystis aeruginosa colonies

Time	Sample Type and Microcystin Concentration (ng/L)			
	Surface	Integrated Photic Zone	Integrated Epilimnion	Integrated Water Column
0930	118	74	84	61
1330	88	64	70	58
1700	65	50	55	45

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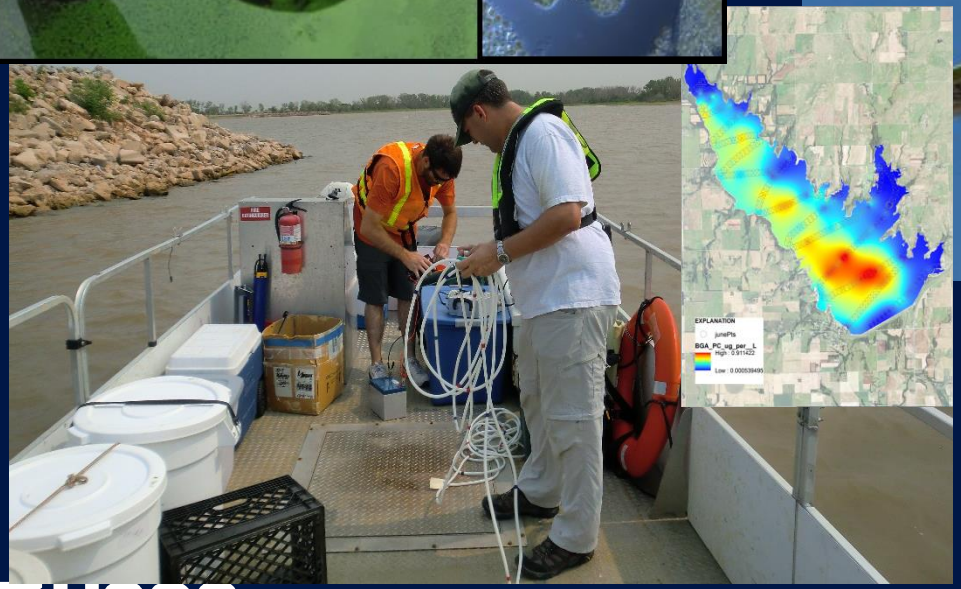
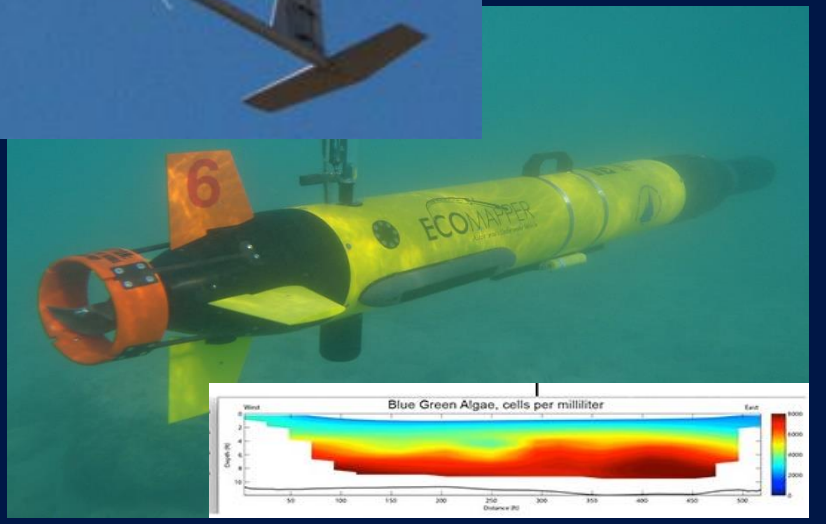
After Graham and others, 2006

New Technologies Allow Ground-to-Space Assessment of HABs





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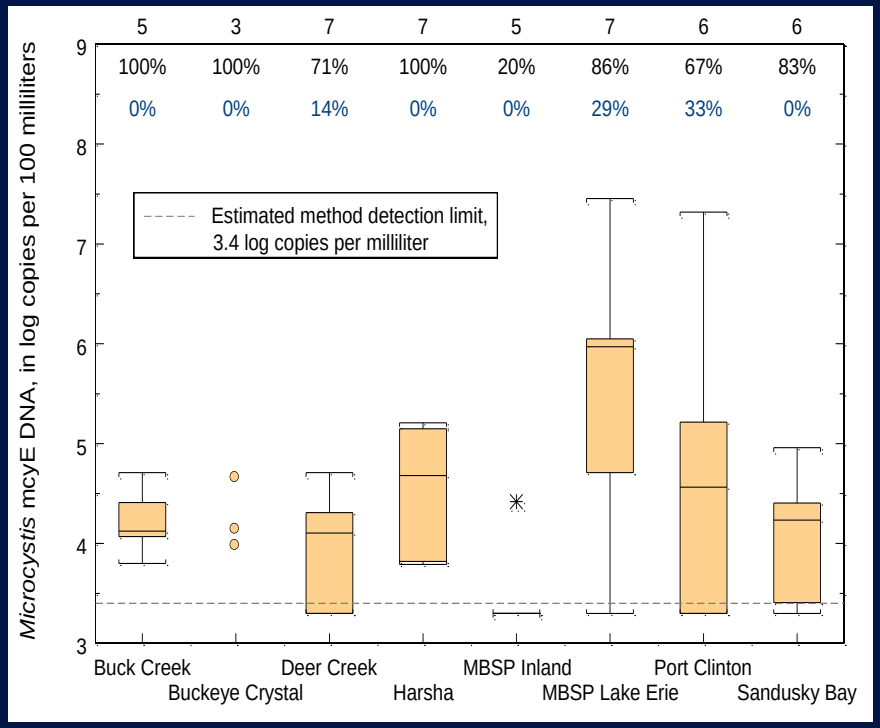
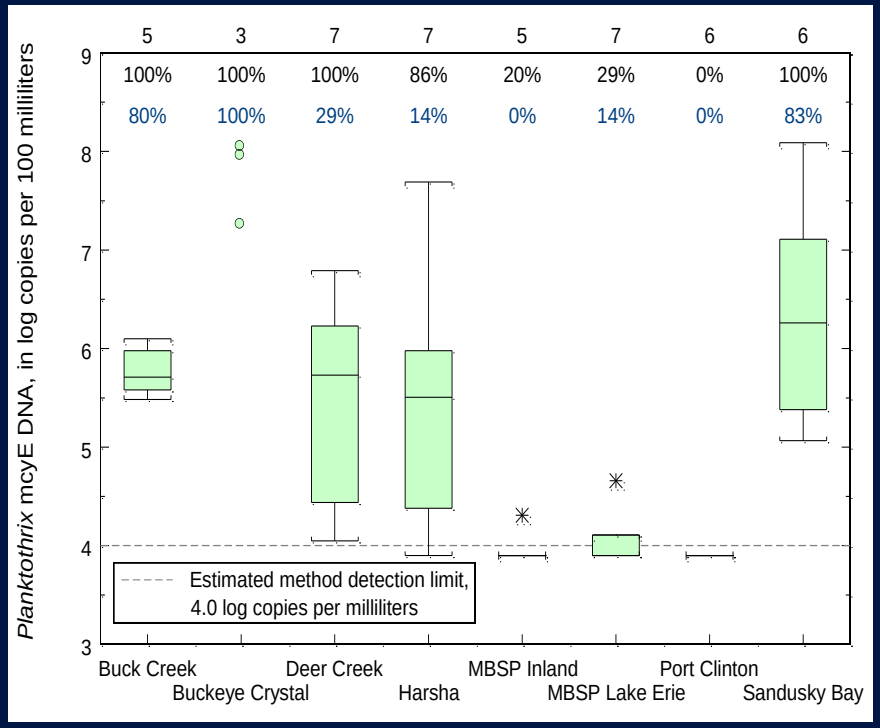
Genetic Data Help Identify Systems with the Potential for Cyanotoxin Production

Ohio Lakes, Summer 2013

Microcystis mcyE DNA



Planktothrix mcyE DNA



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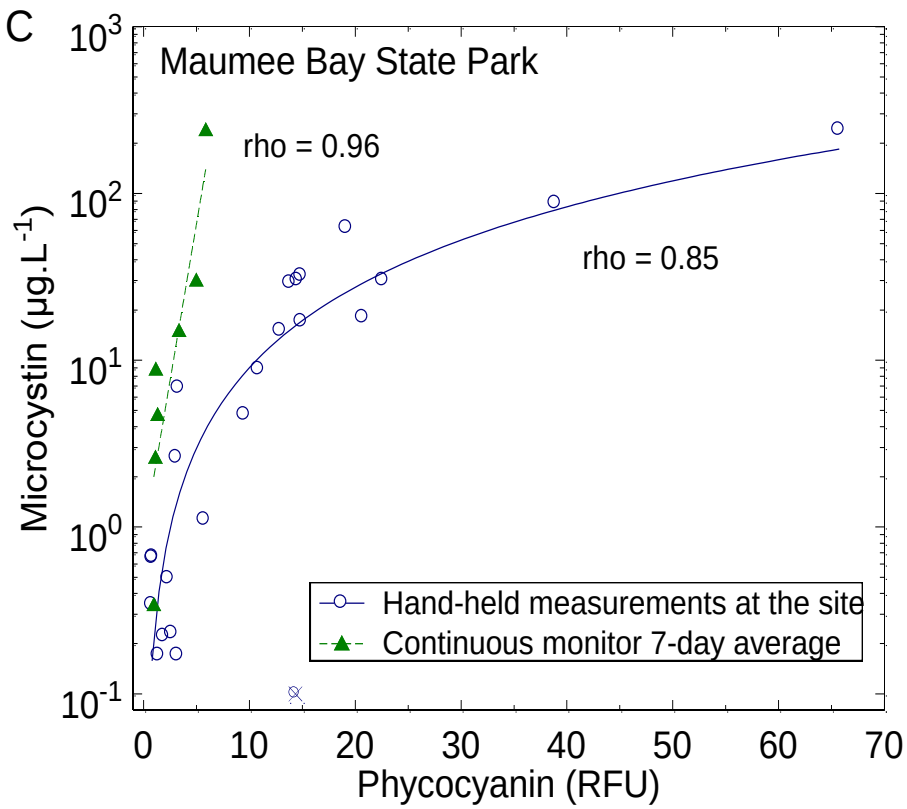
After Francy and others, 2015

New Sensors are Promising, But We Are Still Learning Limitations and Best Practices for Optimal Use



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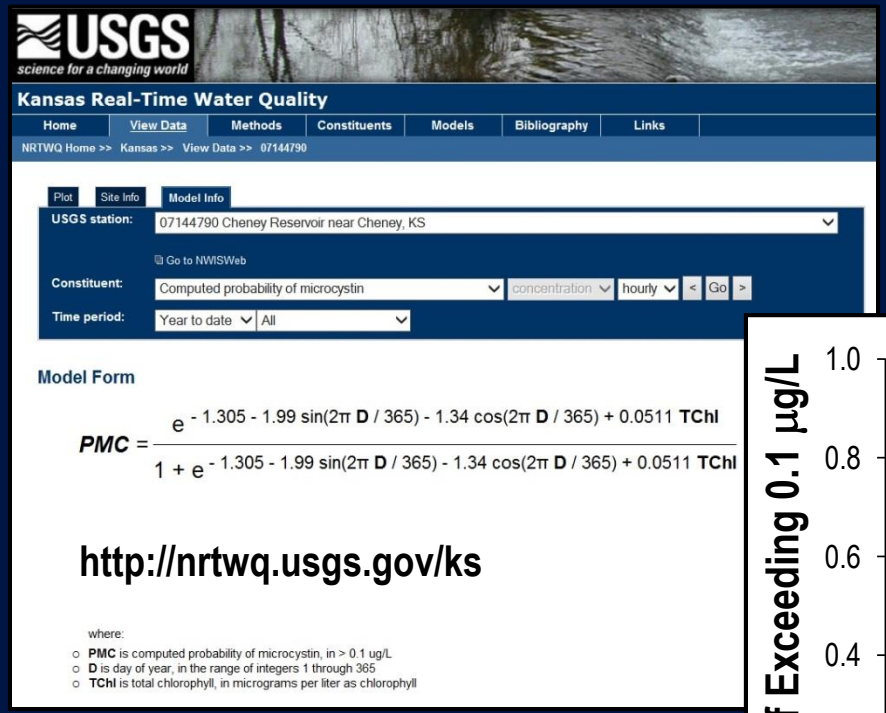
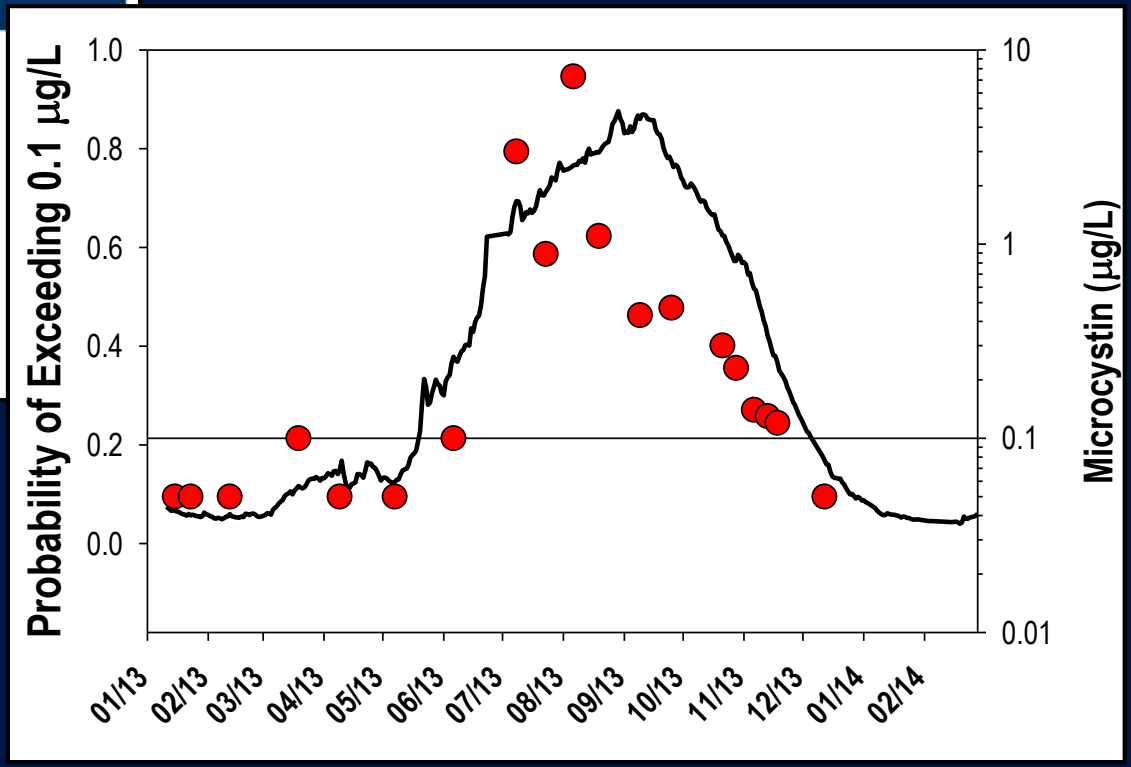
After Francy and others, 2015

Continuous Water-Quality Monitors Can Be Used to Develop Models to Compute Probability of Cyanotoxin Occurrence in Real Time





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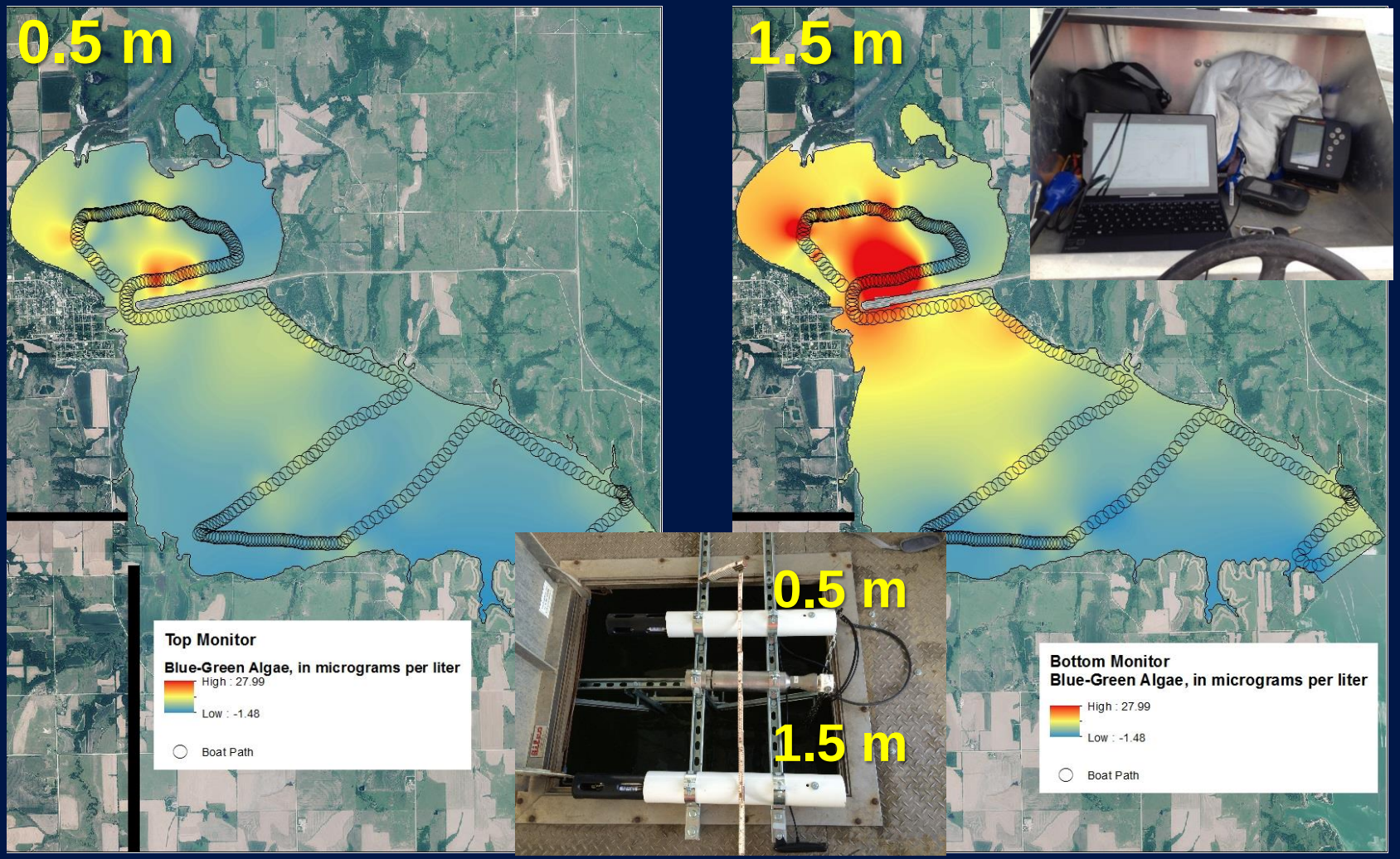
After Stone and Graham, 2013

New Sensor Technologies Allow New Applications, Such as High Resolution Spatial Data Collection



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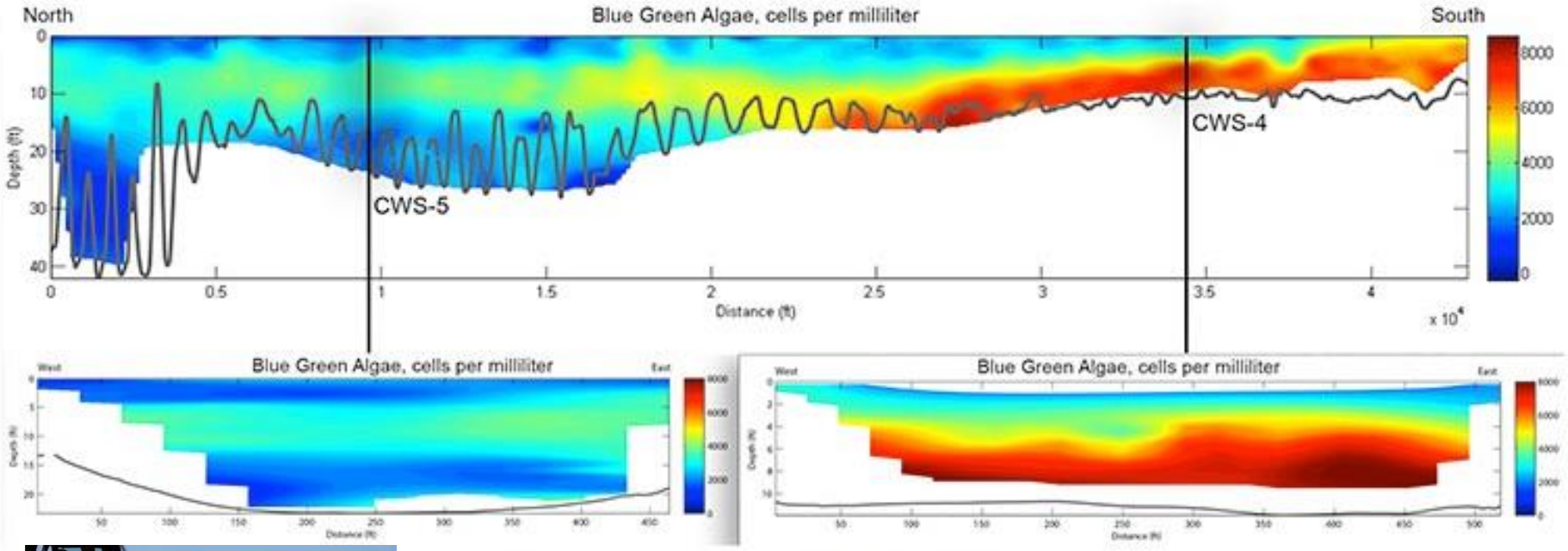
Milford Reservoir, KS, July 2015

New Sensor Technologies Allow New Applications, Such as High Resolution Spatial Data Collection



Longitudinal and cross-sectional AUV profiles of estimated blue-green algae.

Bushy Park Reservoir, SC

http://sc.water.usgs.gov/projects/bushypark_wq/

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Courtesy of C. Journey

Aerial- and Ground-Based Cameras Show Potential as Early Warning Indicators

Courtesy of E. Emory

Courtesy of C. Smith

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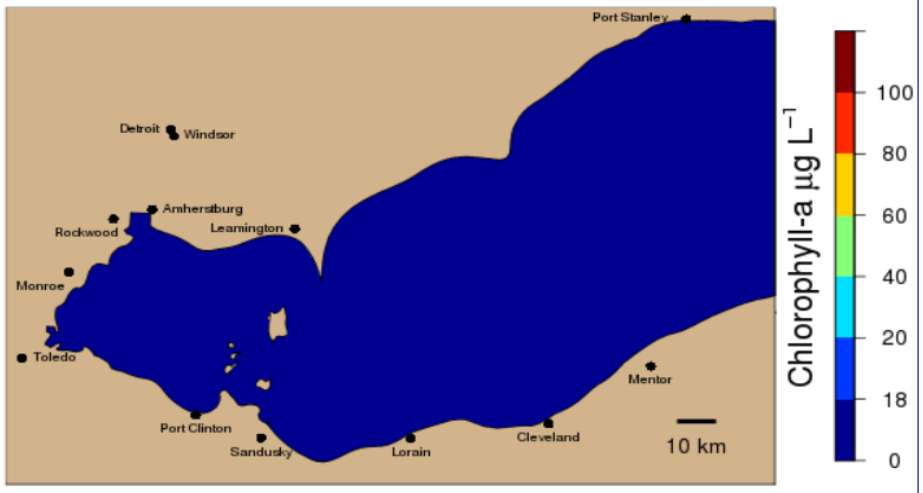
Satellites are Essential Tools for HAB Monitoring in Coastal Areas and the Great Lakes

LAKE ERIE HAB TRACKER

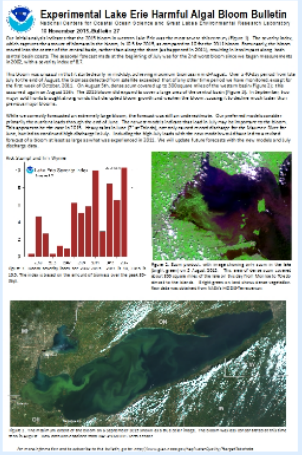
No HAB Detected



Please **click here** to access our *experimental* predictions of Lake Erie algal bloom intensity and extent. The HAB Tracker is updated daily to make five-day forecasts of harmful algal bloom intensity and distribution based on satellite remote sensing, forecast meteorology, and a hydrodynamic model.

Microcystin Sampling	Real-time Monitoring
HAB Tracker	Vertical Mixing Analysis
Hypoxia Monitoring	

Resources



Lake Erie HABs Bulletin (Experimental)

- **Bulletin Sign Up**
- Bulletin Archive

Overview of guidelines on algal toxins

HABs FAQs

Algal Bloom Flickr Gallery

MODIS Satellite Imagery

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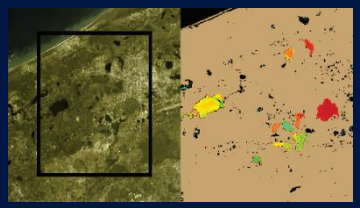
http://www.glerl.noaa.gov/res/HABs_and_Hypoxia/

Emerging Technologies

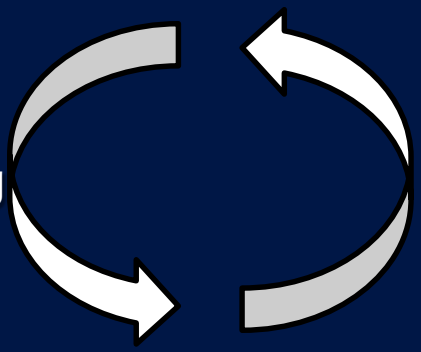
Tools to Utilize Satellites for Inland HAB Monitoring are Being Developed

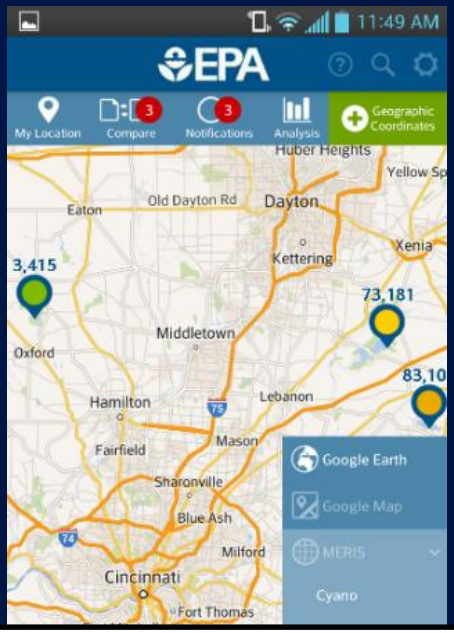
Cyanobacteria Assessment Network (CyAN) Project

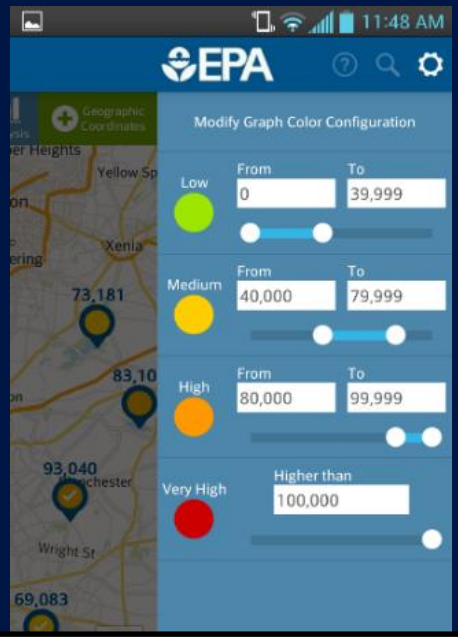


Remote Sensing

Field Data







UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

NASA

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

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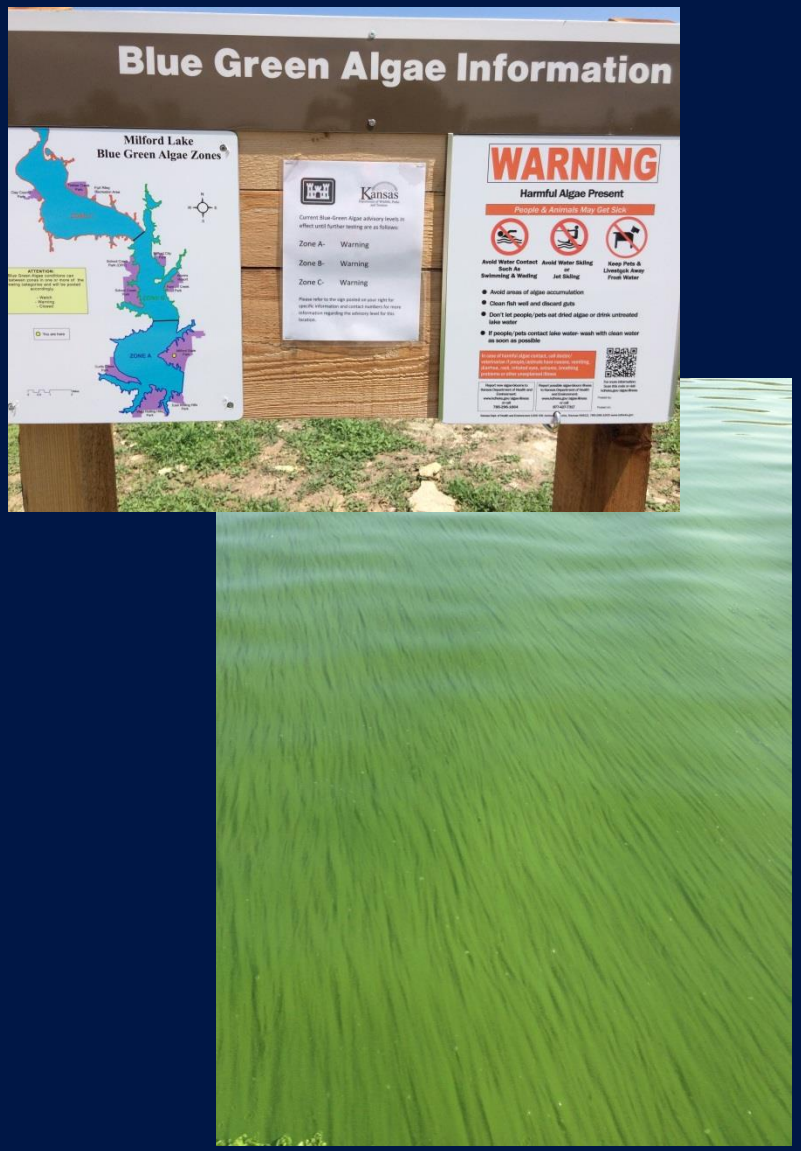
Unifying Themes in Harmful Algal Bloom Research

- Individual systems are unique.
- Spatial and temporal variability present challenges to data collection, analysis, and interpretation.
- Sensor technology and genetic approaches provide important information on spatiotemporal variability and environmental influences.
- A variety of tools for early warning and prediction are being developed and used.



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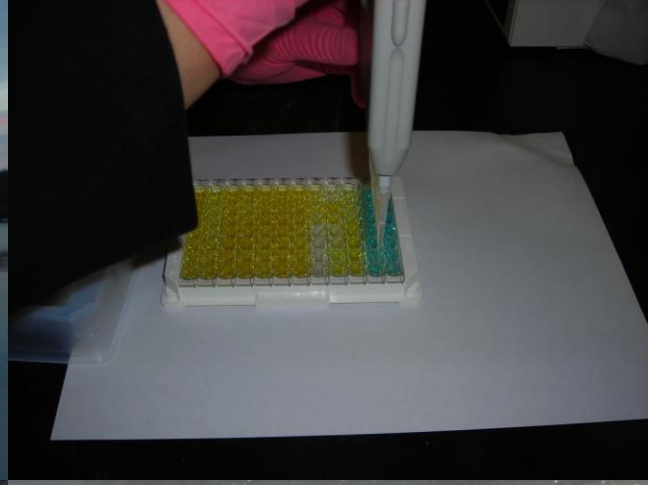



Additional Information:

http://ks.water.usgs.gov/cyanobacteria/

jlgraham@usgs.gov
785-832-3511

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