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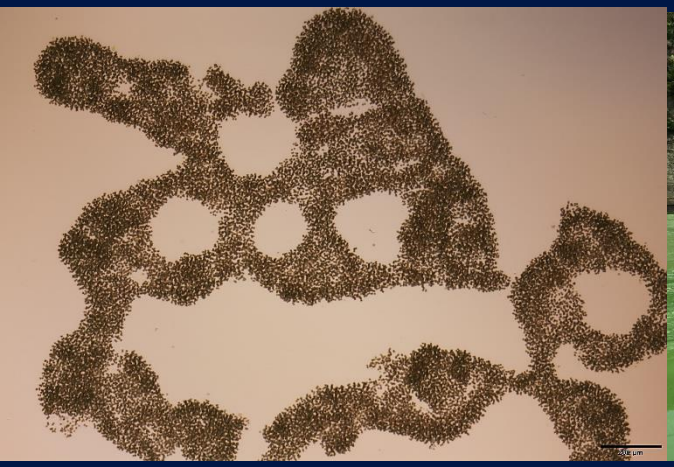
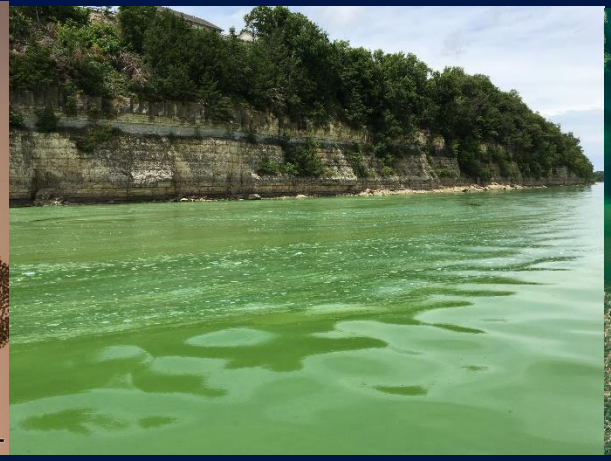
Cyanobacterial Harmful Algal Blooms and U.S. Geological Survey Science Capabilities





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

Governor's Conference on the Future of Water in Kansas
November 9, 2017

U.S. Geological Survey
Harmful Algal Bloom Science

- Develop field and laboratory methods to identify and quantify cyanobacteria and associated compounds.
- Understand causal factors, environmental fate and transport, ecological processes, and effects of environmental exposure.
- Develop early warning systems for potentially harmful blooms.

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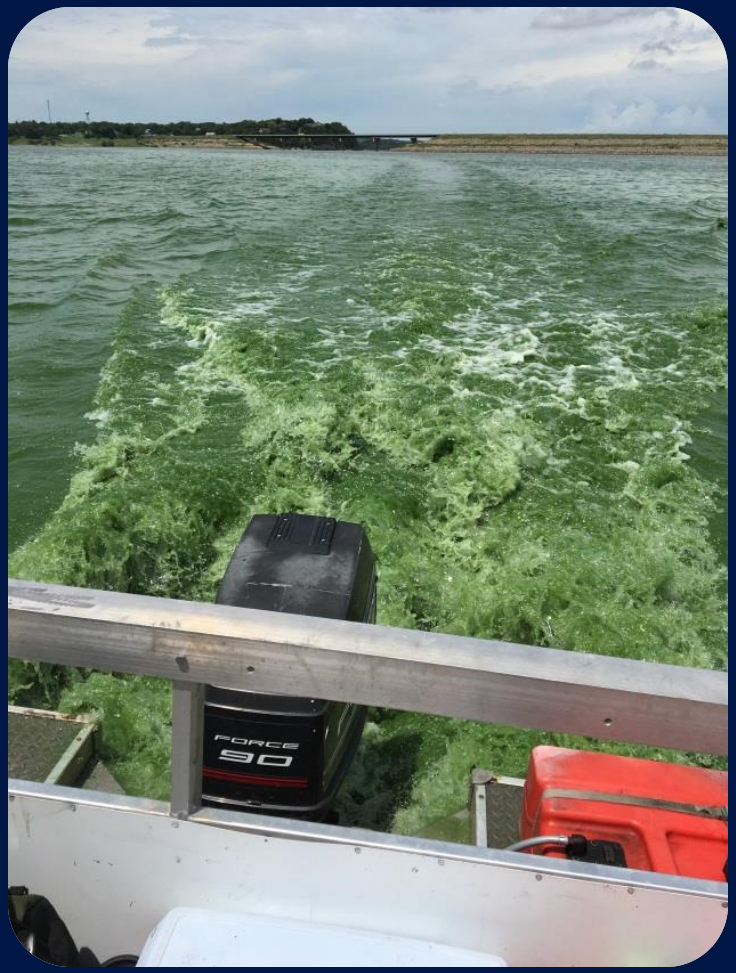
USGS Partnerships to Conduct HAB Research, Monitoring, and Modeling

- **Local, State, Tribal**
  - Kansas Department of Health and Environment, Kansas Water Office, Lawrence, Olathe, Topeka, Wichita, WaterOne
- **Federal**
  - USACE, BOR, CDC, EPA, FDA, FWS, NASA, NIH, NOAA, NPS, USDA
- **Universities**
  - Fort Hays State University, Kansas State University, University of Kansas



The USGS has invested ~$1.5 million in HAB studies in the state of Kansas over the last decade

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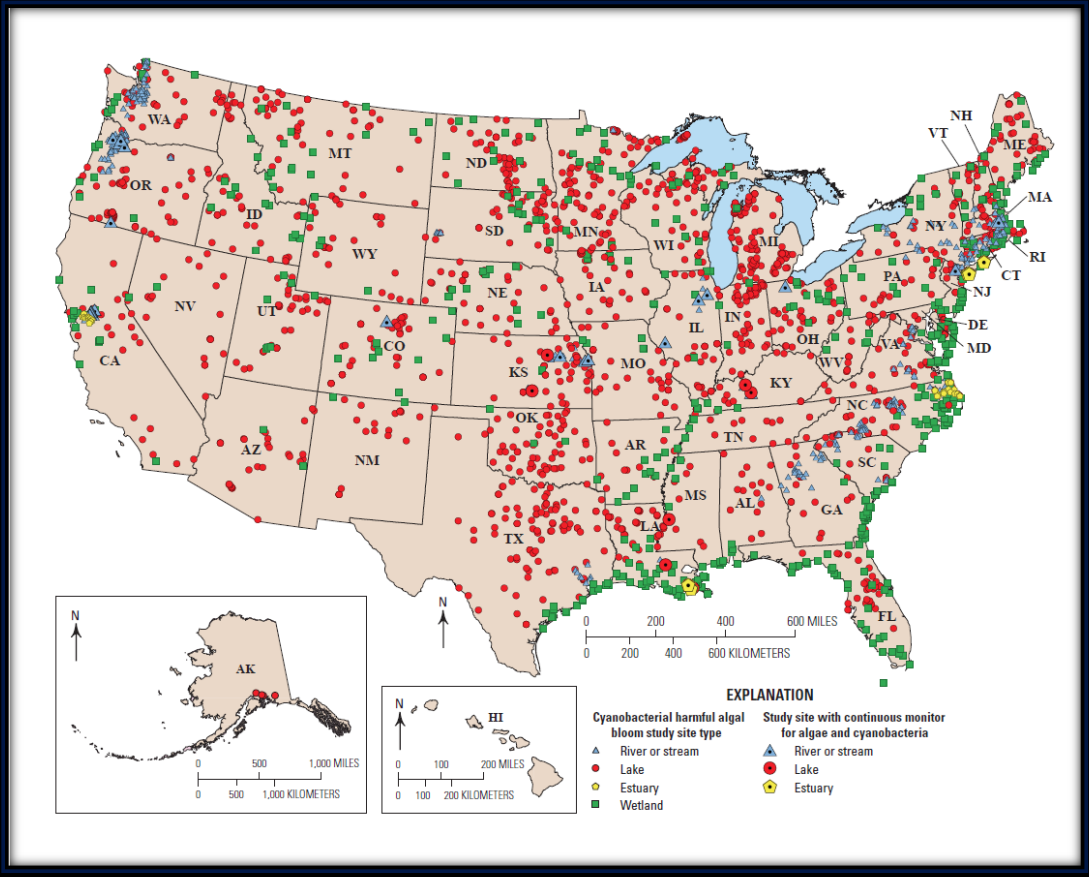
Where is the USGS Studying Toxic Cyanobacterial Blooms?

- Lakes and Reservoirs
- Small Streams
- Rivers
- Inland and Coastal Wetlands
- Estuaries



After Graham and others, 2016, USGS OFR 2016-1174
http://dx.doi.org/10.3133/ofr20161174

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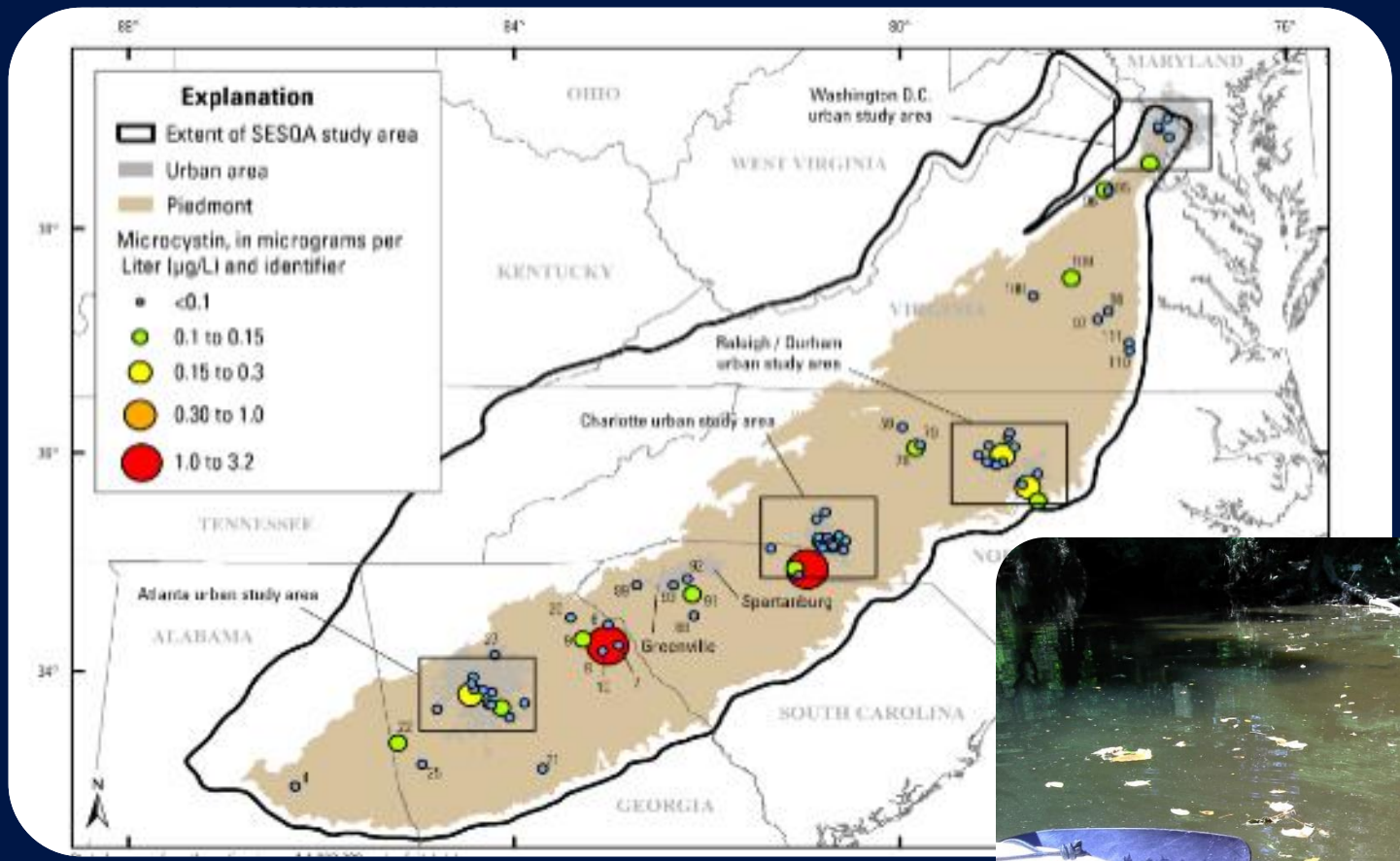
Occurrence - National and Regional Assessments of Microcystin

Microcystins in 39 percent of wadeable streams in the southeastern United States



After Loftin et al., 2016, Environ Toxicol Chem, 35: 2281-2287
doi: 10.1002/etc.3391

Indian Creek – July 2014
Microcystin: 17µg/L

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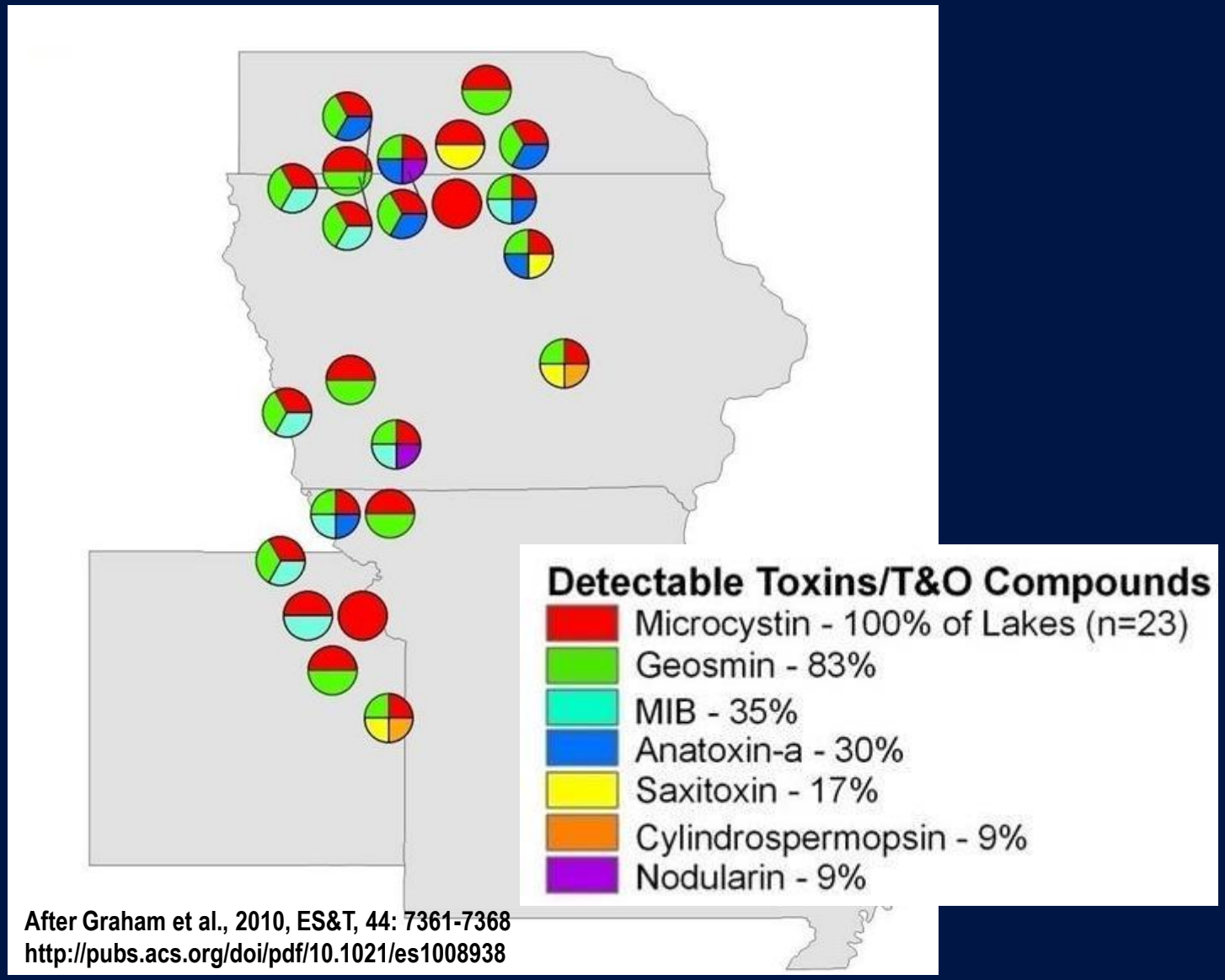
Occurrence – Regional Assessment of Mixtures

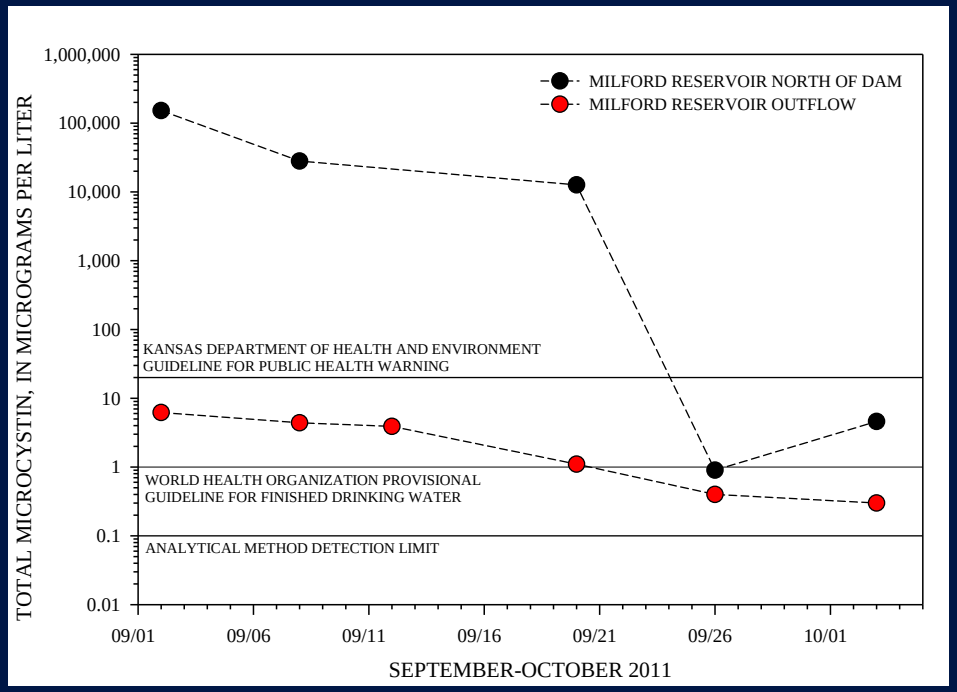
Multiple cyanotoxins occurred in 30 Percent of blooms

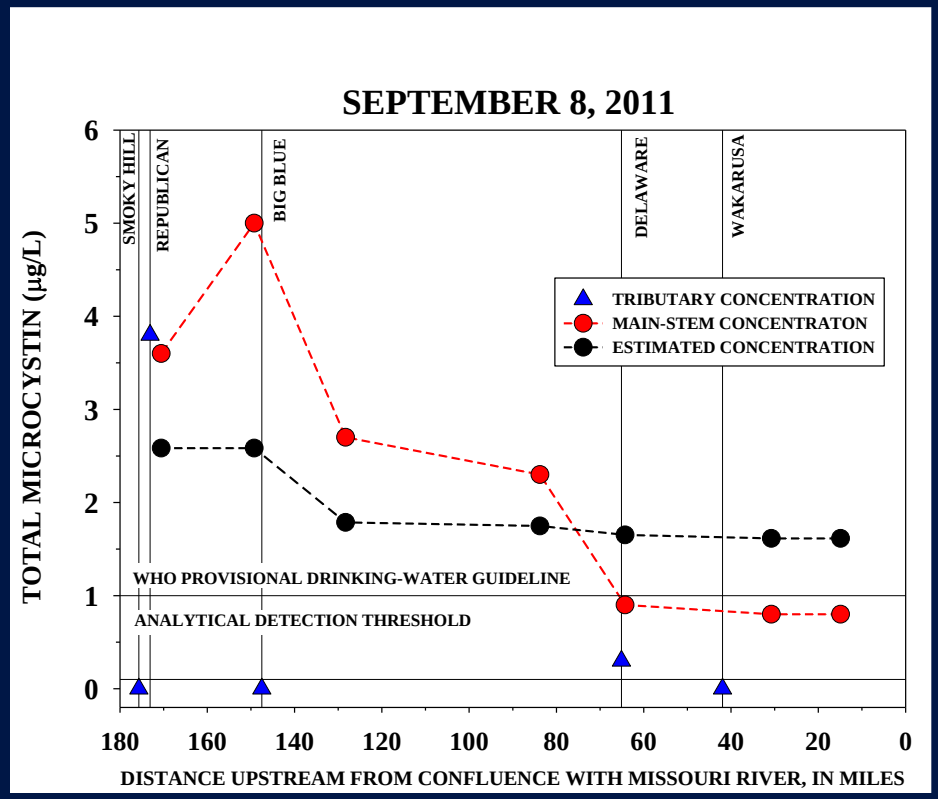


After Graham et al., 2010, ES&T, 44: 7361-7368
http://pubs.acs.org/doi/pdf/10.1021/es1008938

Fate and Transport

Cyanobacterial toxins and taste-and-odor compounds may be transported for relatively long distances downstream from lakes and reservoirs





After Graham et al., 2012, USGS SIR 2017-5016
http://pubs.usgs.gov/sir/2012/5129/

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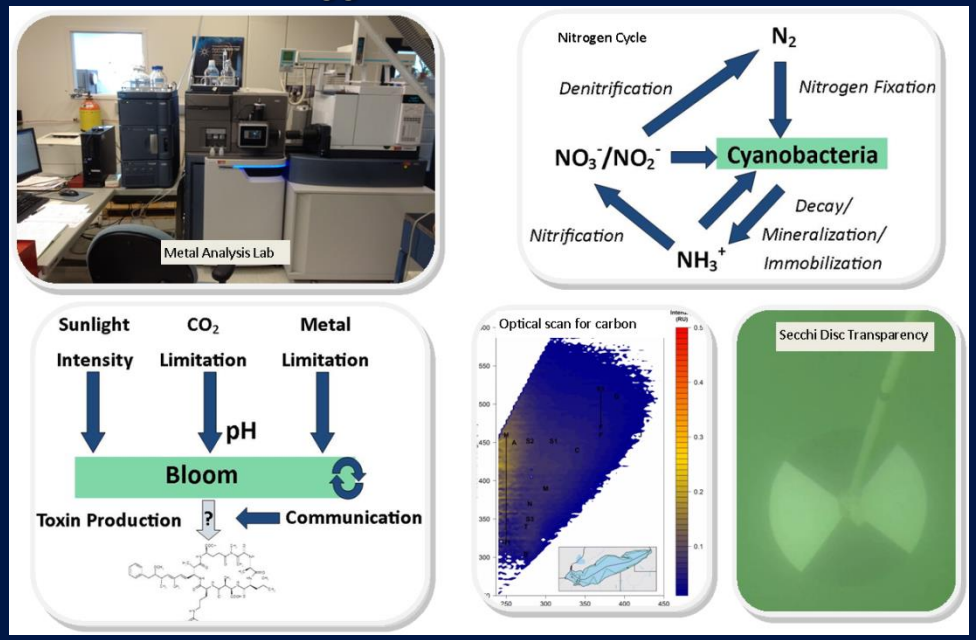
Ecological Processes

Integrated ecosystem studies combine multiple tools and technologies to better understand environmental drivers of HAB formation

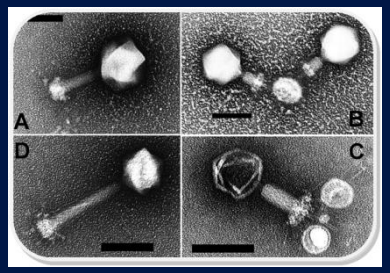
Does sediment seed next year's bloom?

What chemical, biological, and physical factors trigger HABs and toxins?

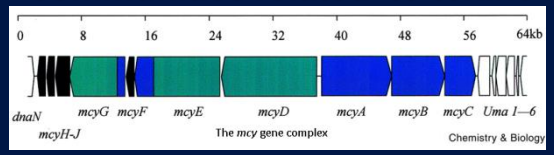


Do invasive species affect HABs?

Do viruses affect HABs?



How are cyanobacterial communities related to toxins?



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USGS GLRI CyanoHAB Research Team

Environmental Effects of Exposure

Microcystin may affect juvenile recruitment of endangered suckers in Upper Klamath Lake, Oregon

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Health and Condition of Endangered Juvenile Lost River and Shortnose Suckers Relative to Water Quality in Upper Klamath Lake, Oregon and Clear Lake, California

Summer Burdick, Diane Elliott, Carl Ostberg, Carla Conway, Amari Dolan-Caret, Kevin Feltz, Marshal Hoy, James Carter, and Kathy Echols

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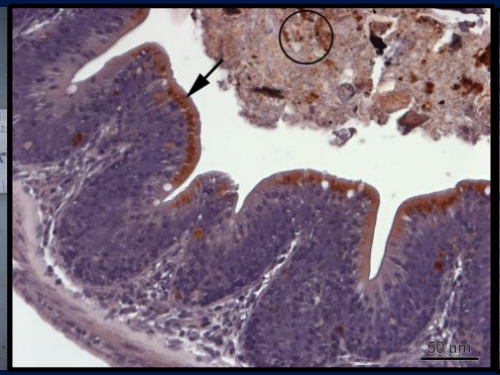
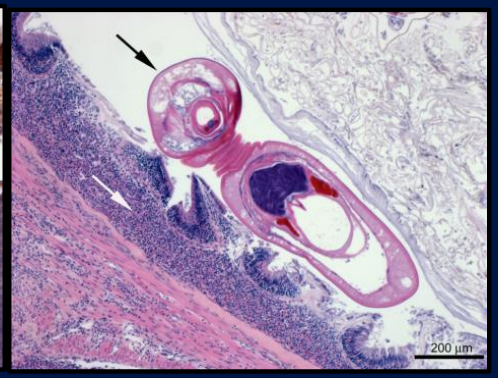
Effects of Microcystin on Juvenile Lost River Suckers

Barbara A. Martin[1], Kathy R. Echols[2], Kevin Feltz[2], Diane G. Elliott[3], and Carla M. Conway[3]
[1]USGS, Western Fisheries Research Center, Klamath Falls Field Station, 2795 Anderson Avenue Suite 106
[2]USGS Columbia Environmental Research Center, [3]USGS Western Fisheries Research Center





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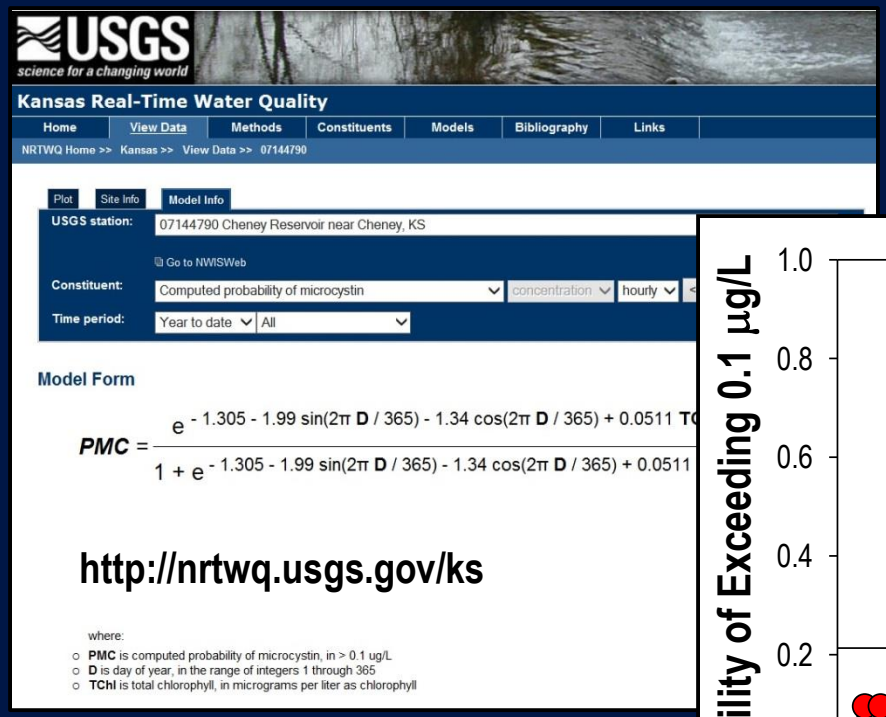
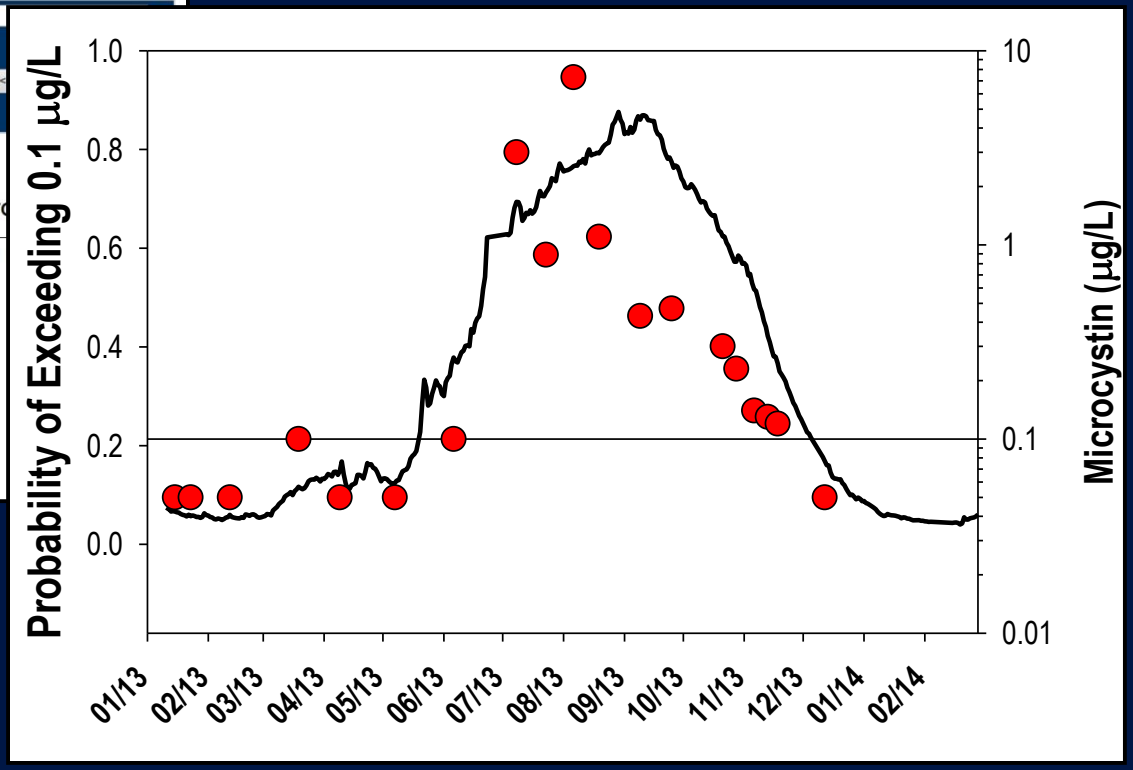
Early Warning Systems

Day of Year and Algal Abundance are Used to Provide Daily Estimates of the Probability of Cyanotoxin Occurrence in a Kansas Drinking-Water Supply





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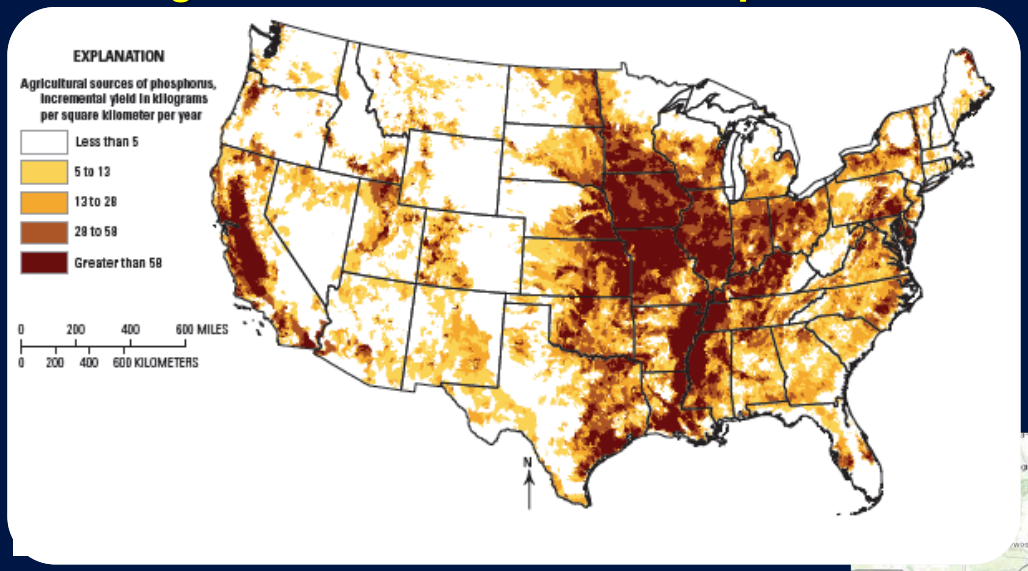
After Graham et al., 2017, USGS SIR 2017-5016
https://pubs.er.usgs.gov/publication/sir20175016

Modeling HAB Drivers: Stream Nutrient Inputs

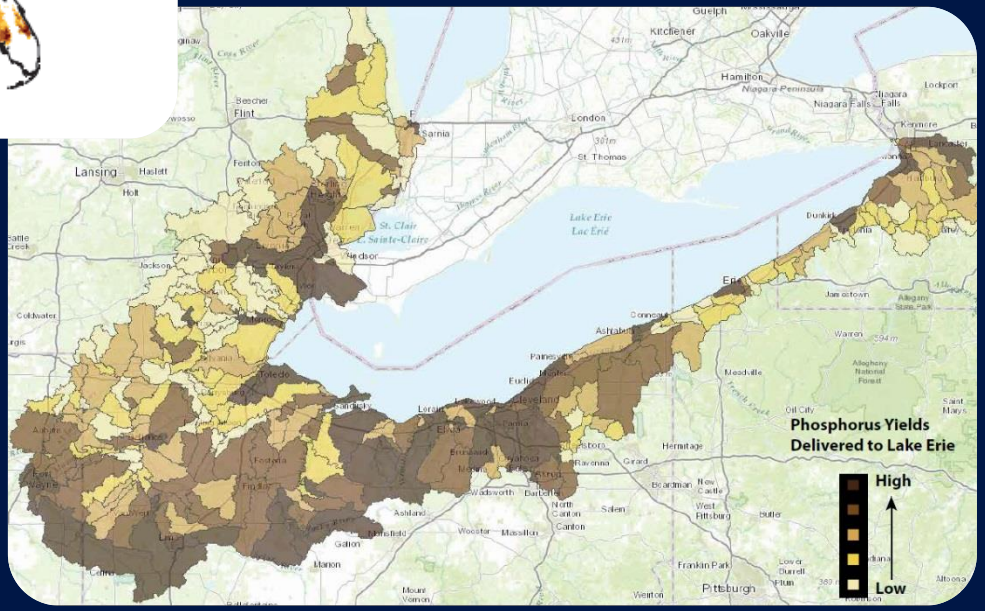
National to Watershed Scale

Agricultural Sources of Phosphorus



After Preston et al., 2011, JAWRA, 47: 887-890
http://dx.doi.org/10.1111/j.1752-1688.2011.00585.x.

Watershed Yields of Phosphorus



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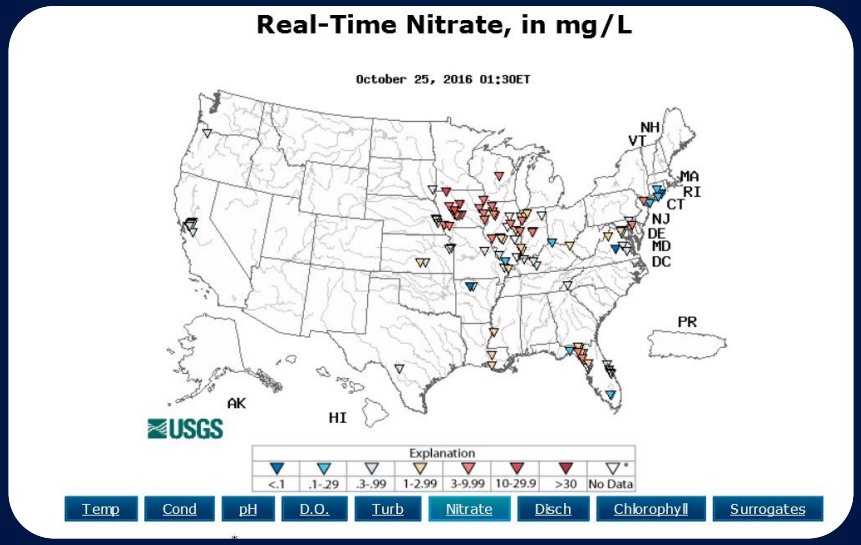
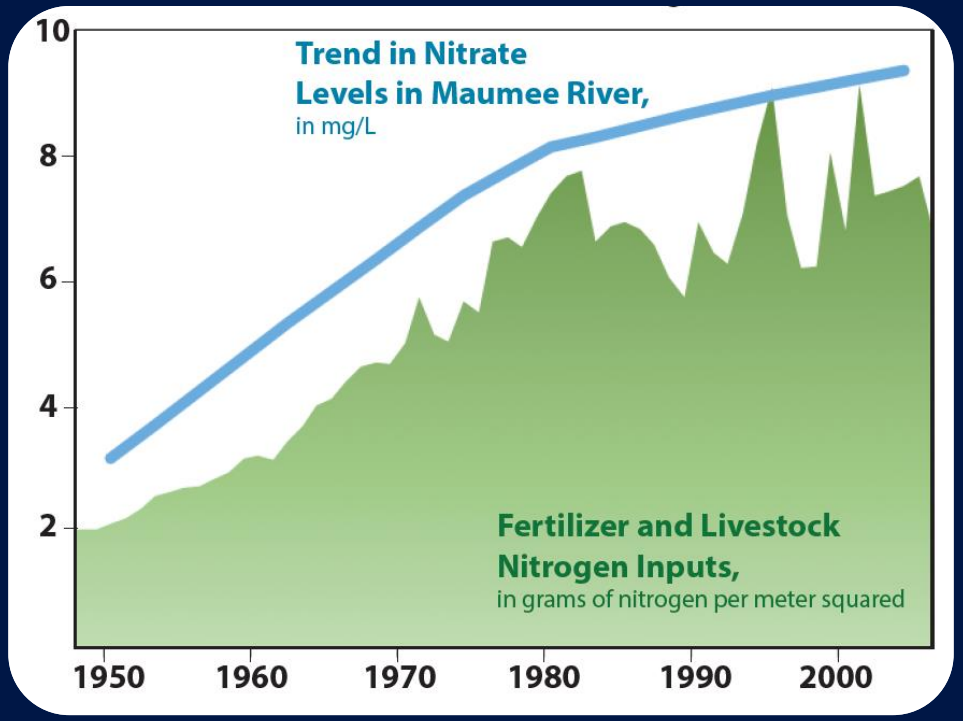
National Scale Monitoring and Analysis

Long-term national data are essential to understanding status and trends





After Stets et al., 2015, JAWRA, 54: 1394-1407
http://onlinelibrary.wiley.com/doi/10.1111/1752-1688.12321/pdf

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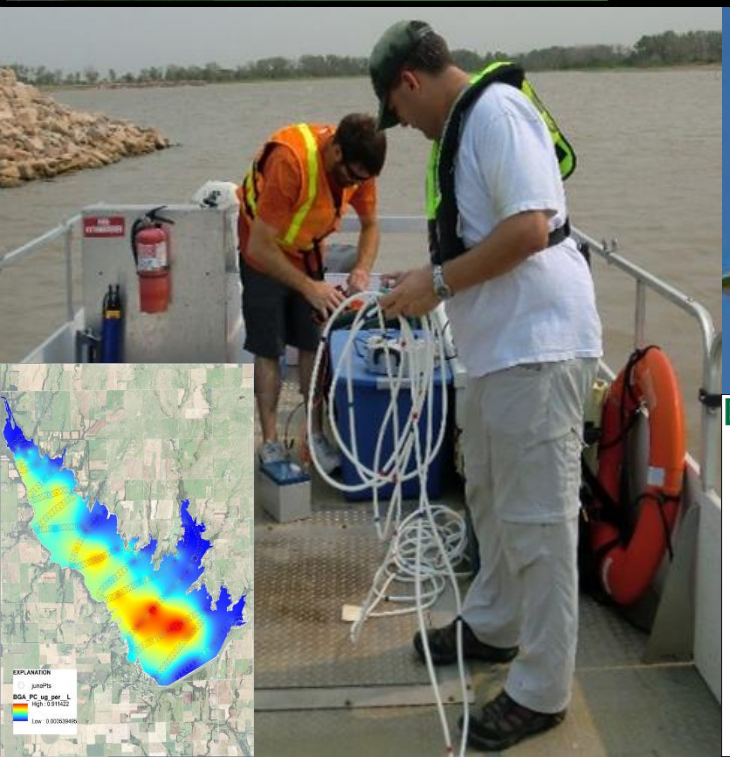
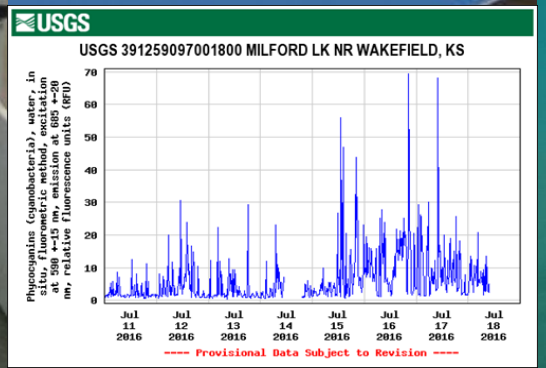
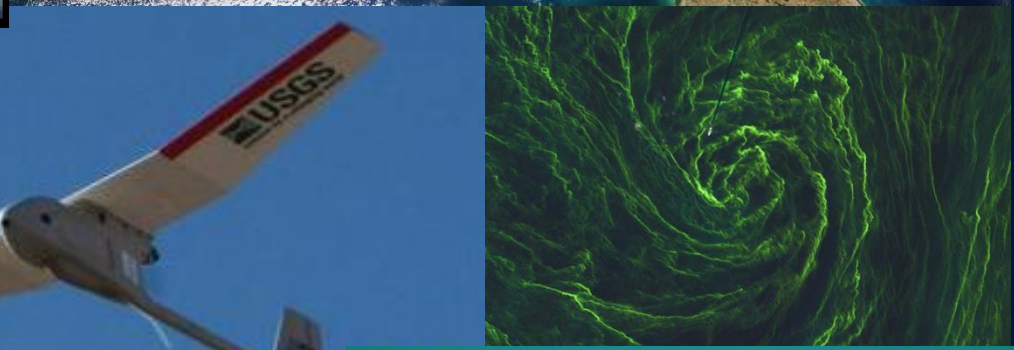
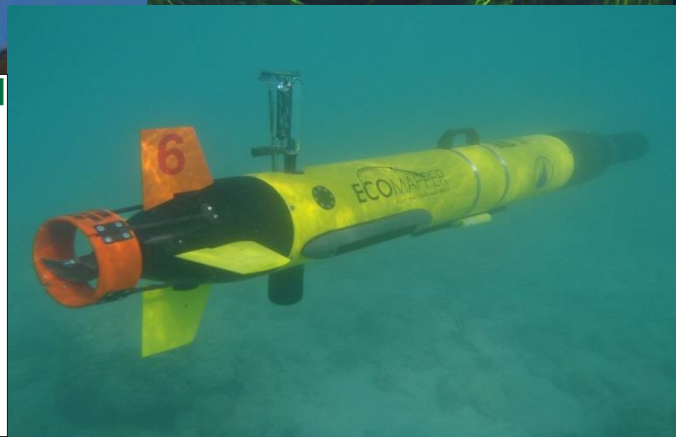


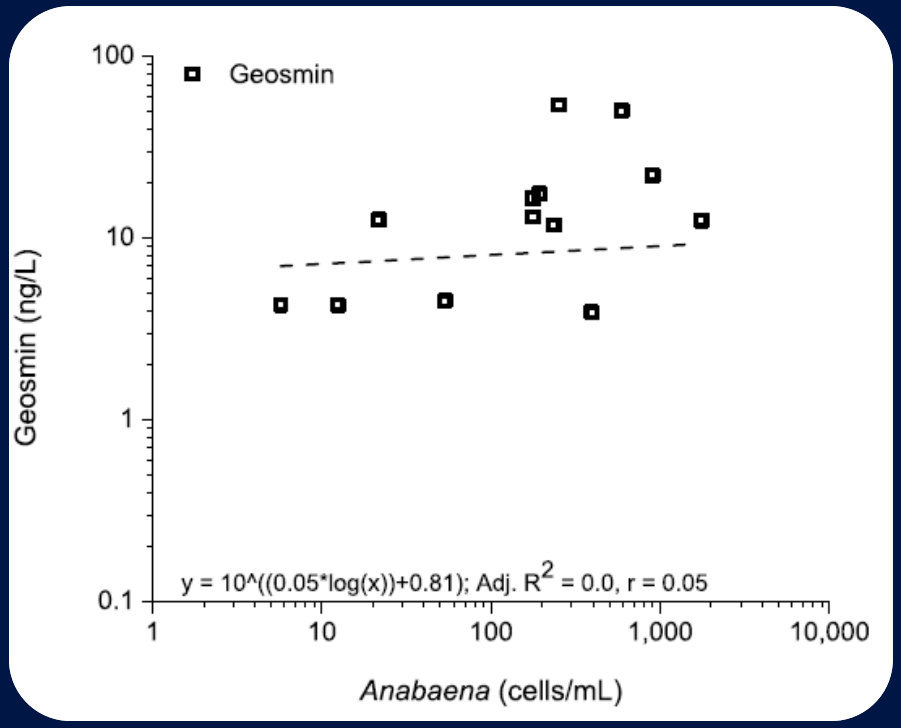


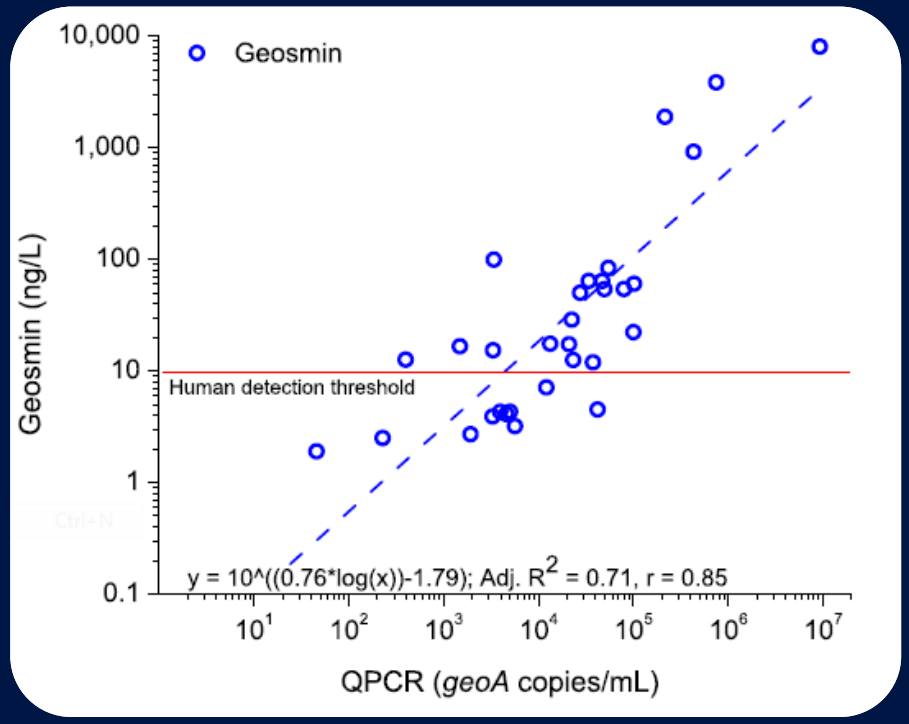




Emerging technologies allow integrated studies ranging from cells to satellites

Genetic Data Improve Understanding of the Occurrence of Cyanobacteria and Associated Compounds





After Otten et al., 2016, Appl. Environ. Microbiol., 82: 5410-5420
http://aem.asm.org/content/82/17/5410.full.pdf

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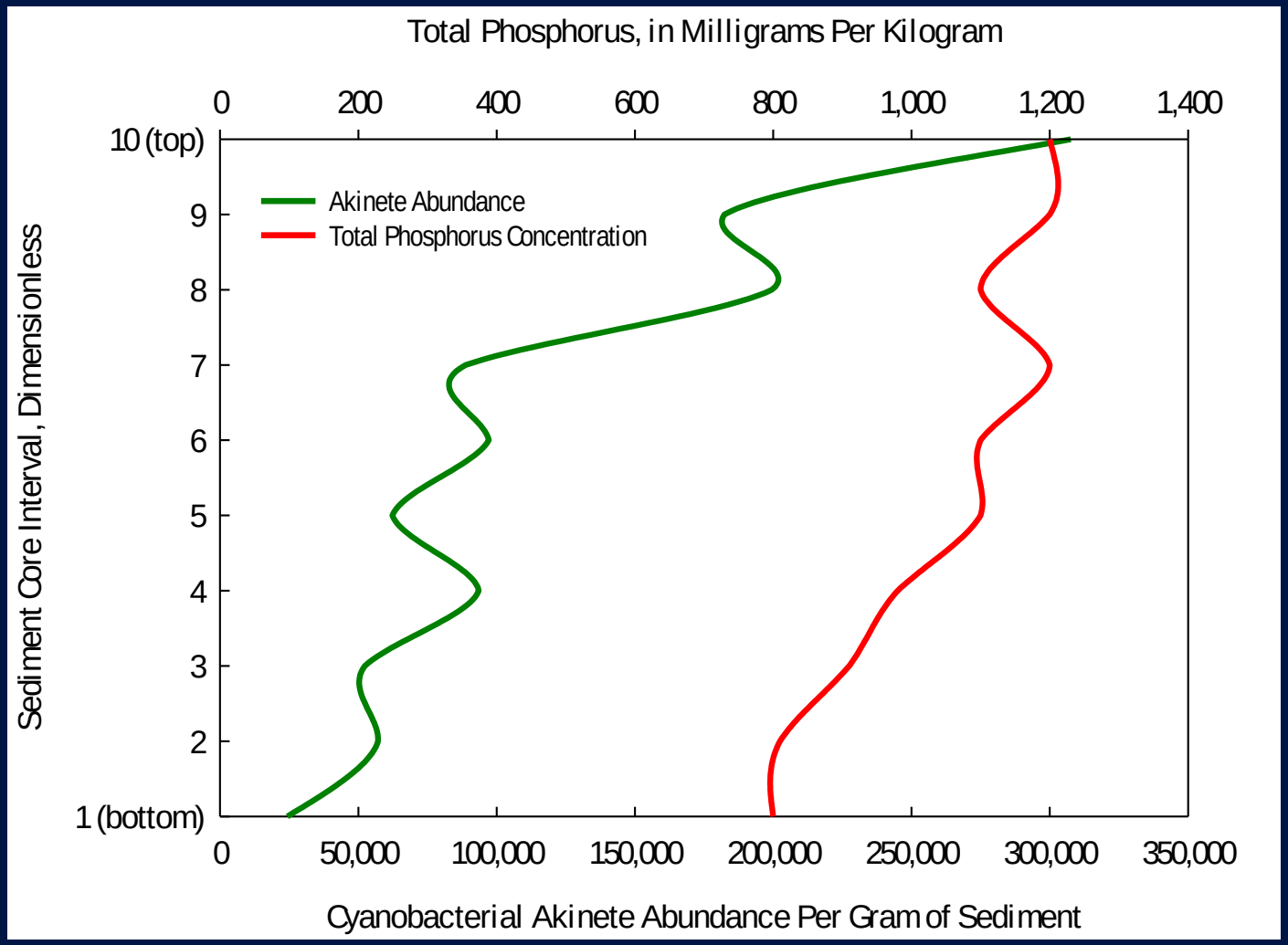
Reservoir Bottom Sediments May Contain Information About Changing Nutrient Concentrations and Harmful Algal Bloom Occurrence Over Time



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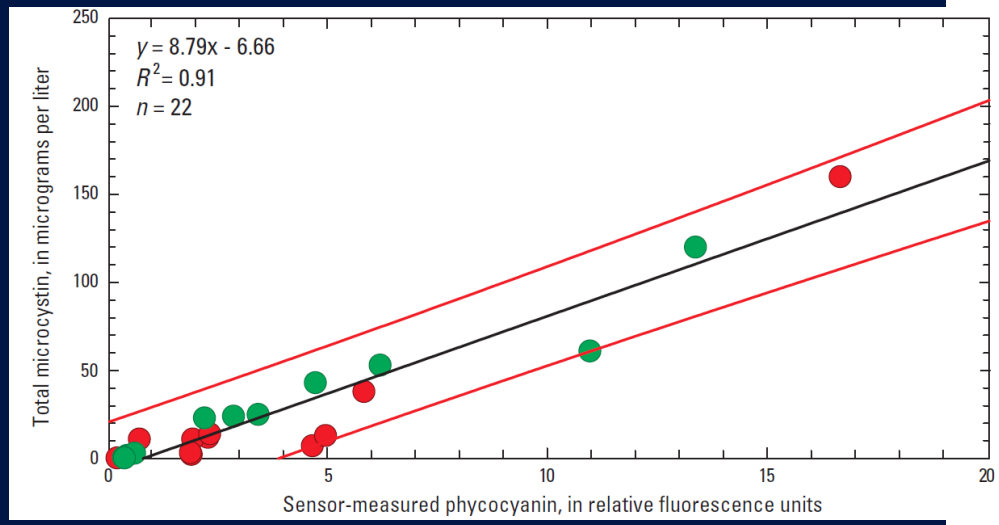
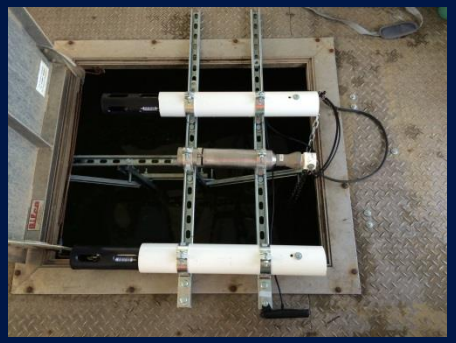
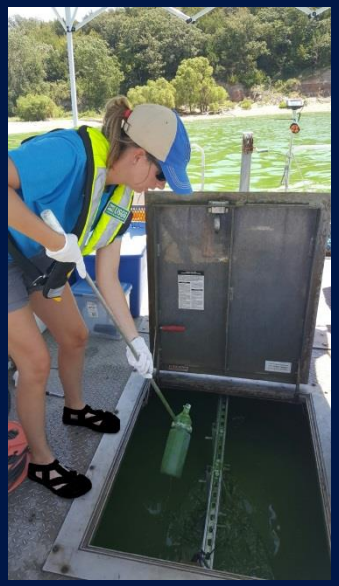
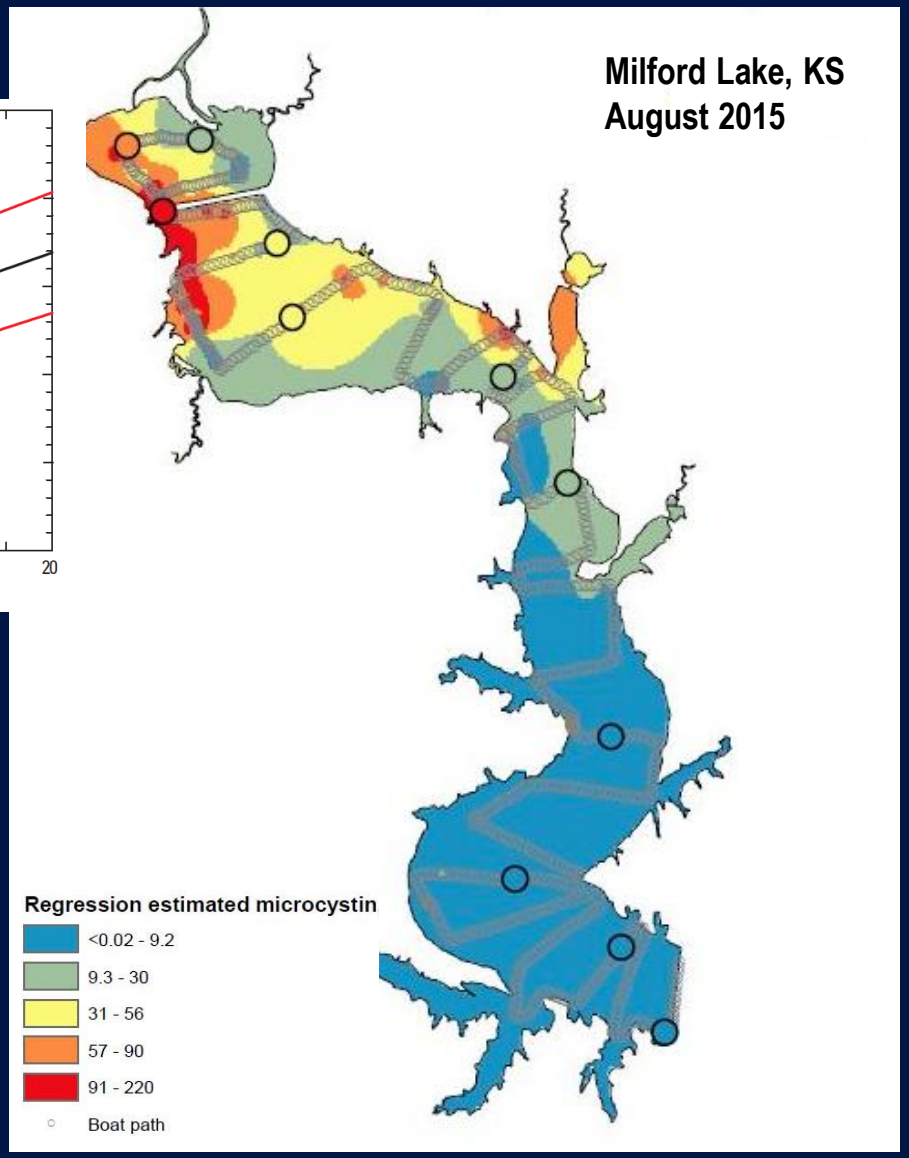
After Juracek, 2011, USGS SIR 2011-5037
https://pubs.usgs.gov/sir/2011/5037/

Mobile Sensor Arrays Capture Spatial Variability Across Larger Areas









After Foster et al., 2016, USGS SIR 2016-5168
https://pubs.er.usgs.gov/publication/sir20165168

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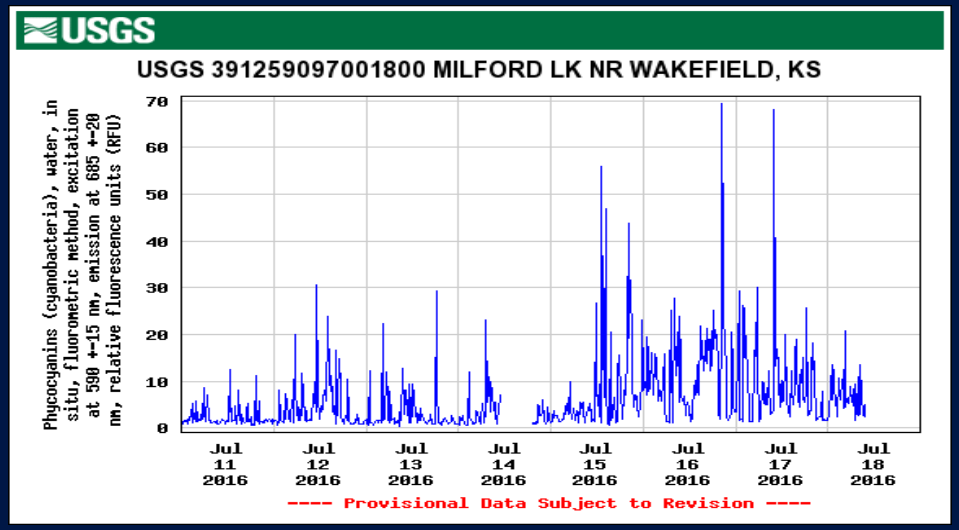
Time-Lapse Cameras and Fixed-Site Sensors Capture Temporal Variability at Sites of Interest

July 7, 2016 at 1700

July 7, 2016 at 1800



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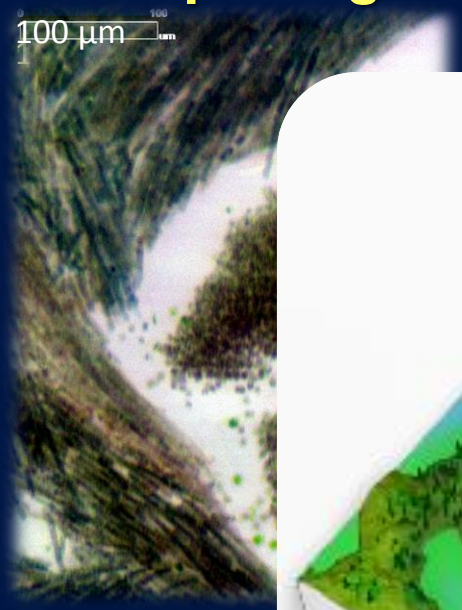
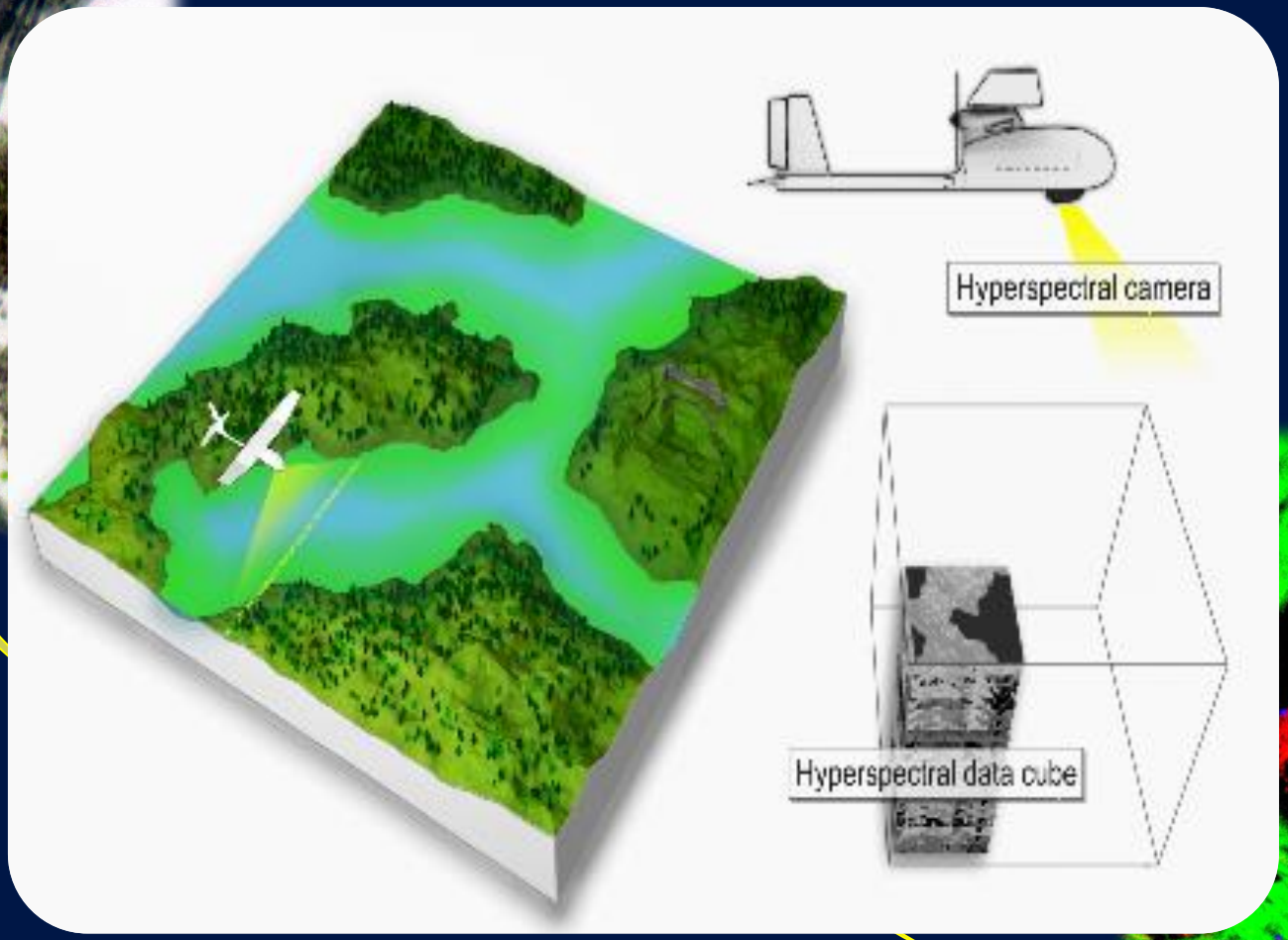
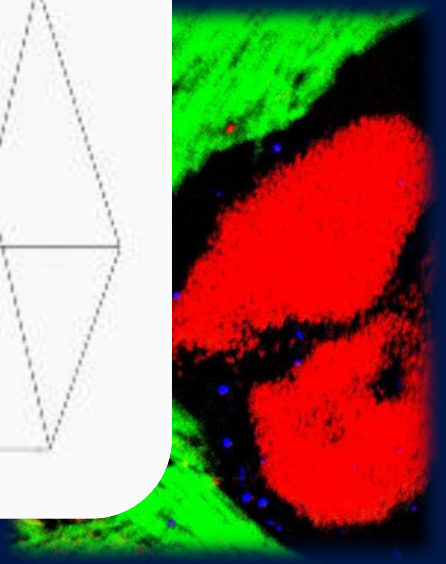
Hyperspectral Microscopy Can Potentially Be Used to Identify Unique Signatures of Harmful Algal Bloom Forming Taxa







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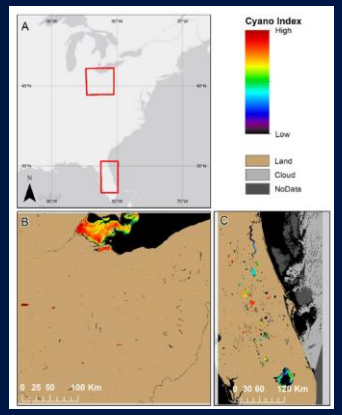
PML PHYSICAL MEASUREMENT LABORATORY

NIST National Institute of Standards and Technology U.S. Department of Commerce

Courtesy of T. Slonecker and N. Simon, USGS

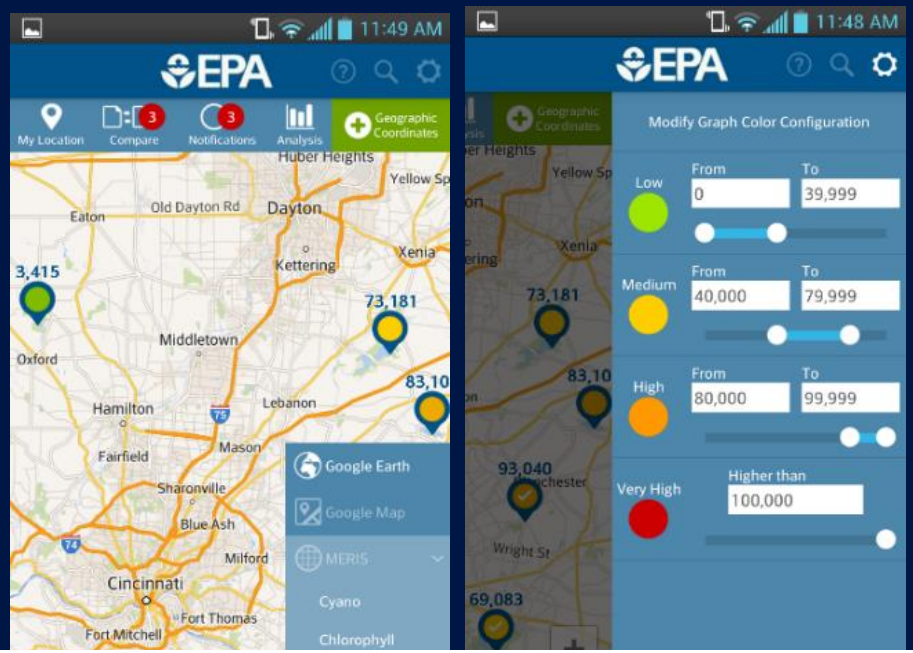
Tools to Utilize Satellites for Inland HAB Monitoring are Being Developed

Cyanobacteria Assessment Network (CyAN) Project



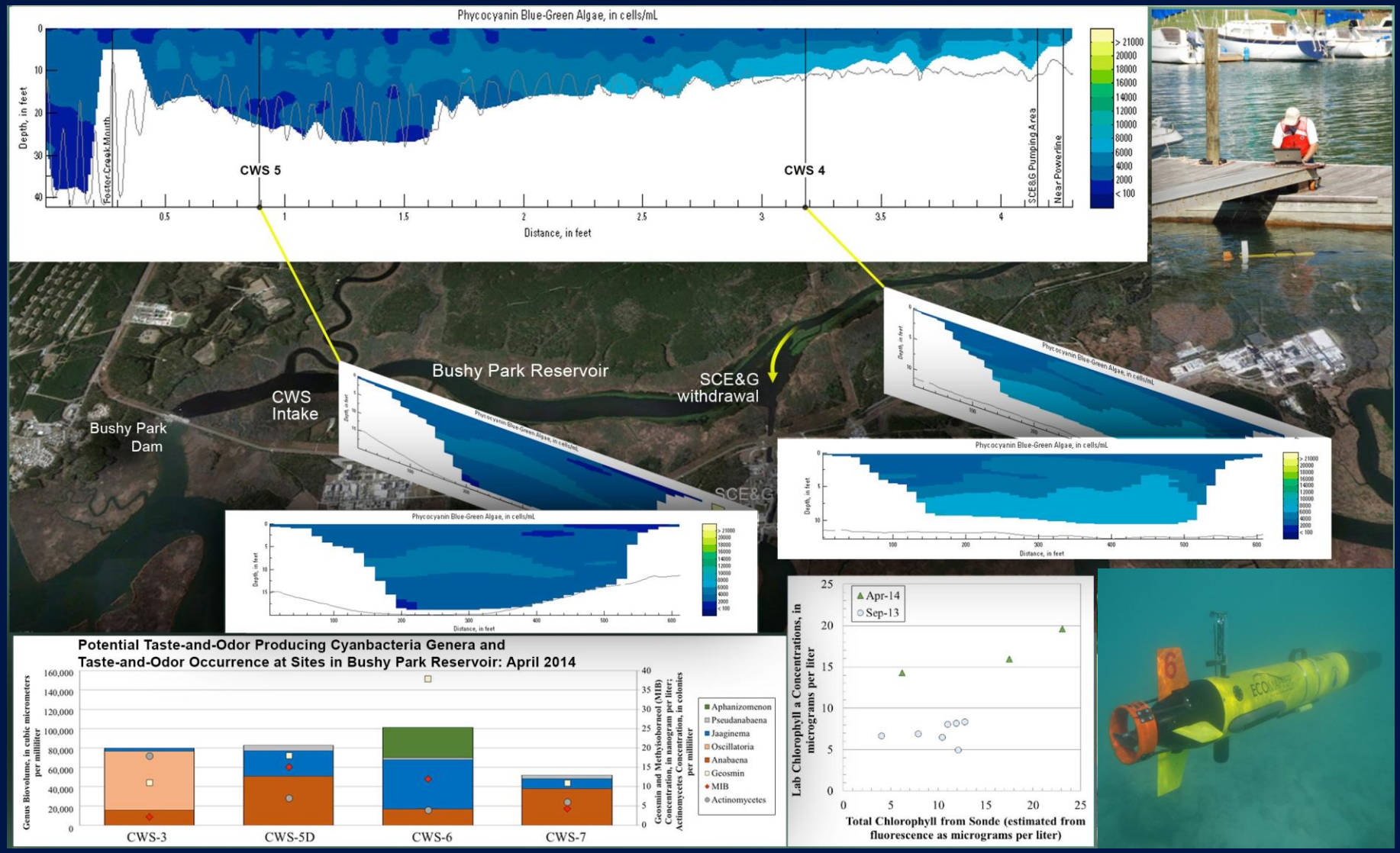
Remote Sensing

Field Data



https://www.epa.gov/water-research/cyanobacteria-assessment-network-cyan

On the Ground Approaches Are Needed to Capture Spatial and Temporal Variability with Depth



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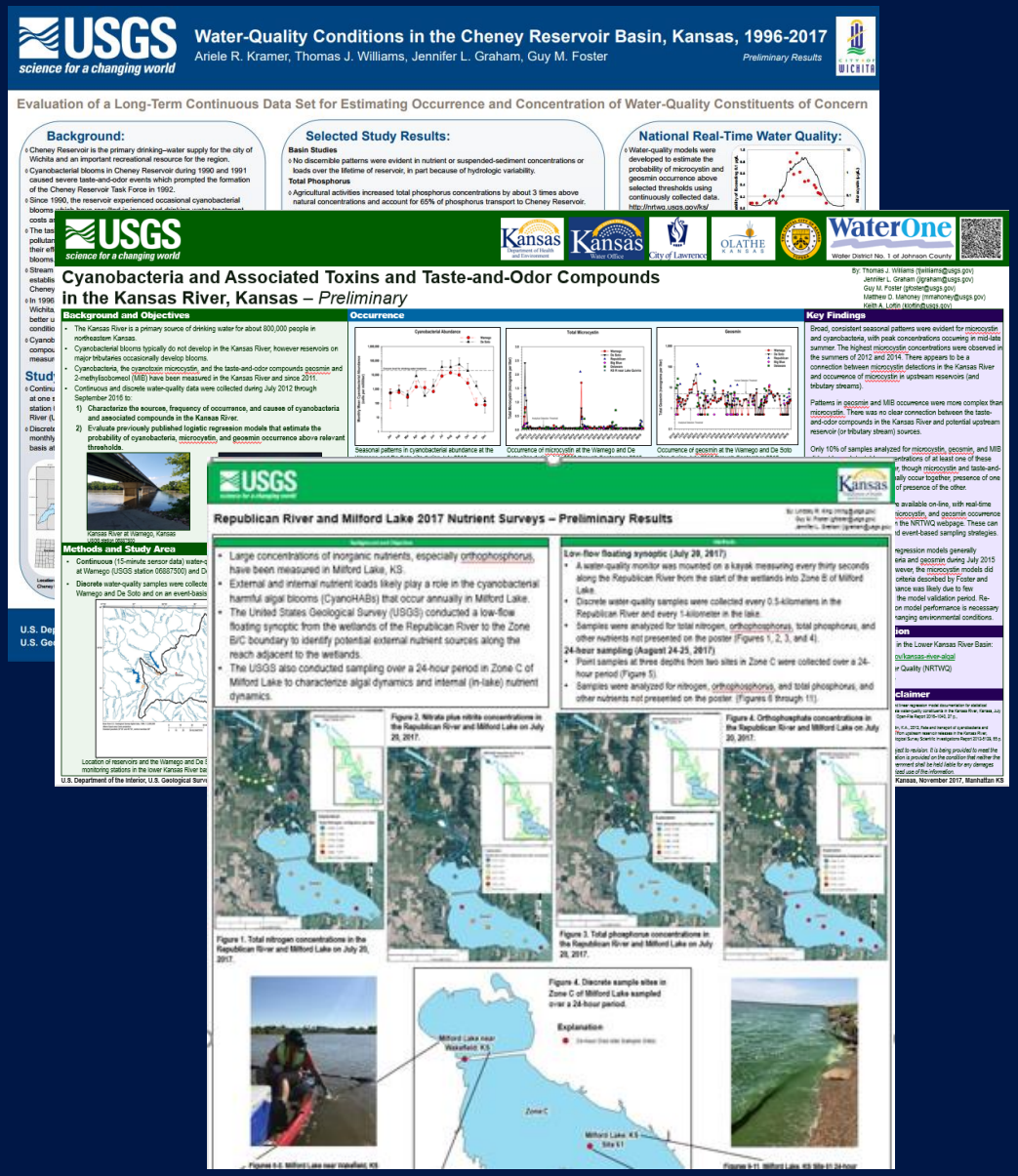
Courtesy of C. Journey, USGS

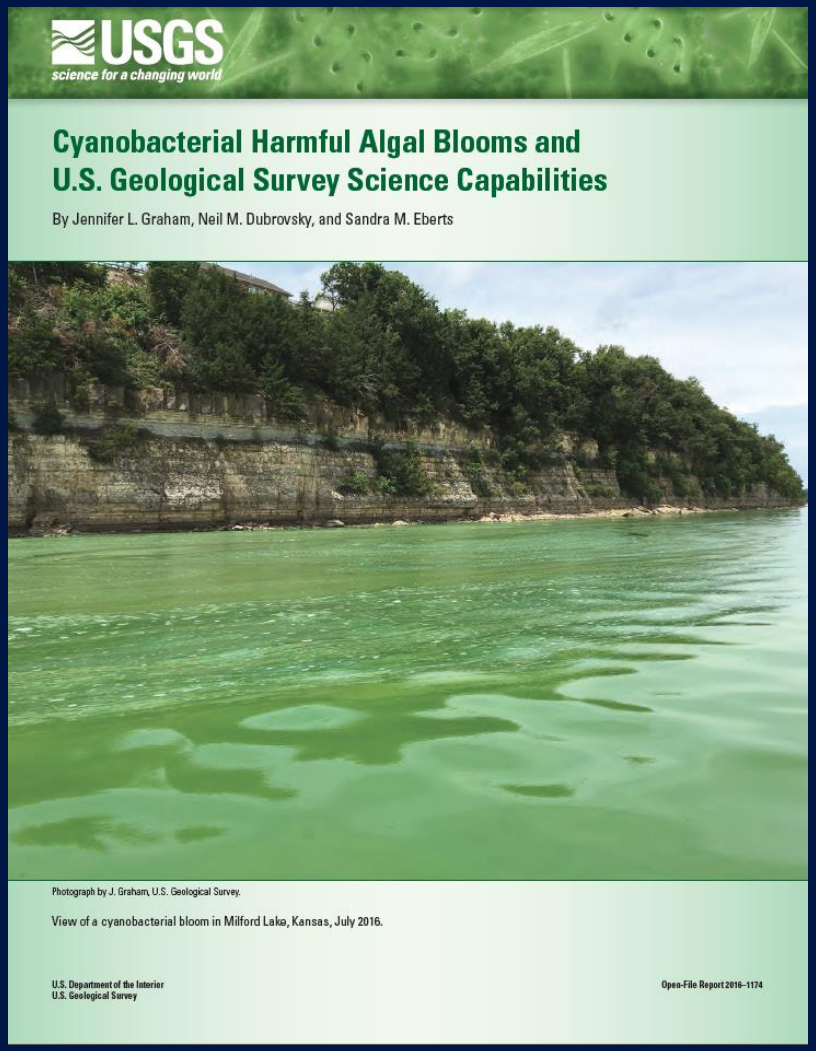
Additional Information on USGS Cyanobacterial Harmful Algal Bloom Science in Kansas is Available in the Poster Session

- Republican River and Milford Lake 2017 Nutrient Surveys
- Cyanobacteria and Associated Toxins and Taste-and-Odor Compounds in the Kansas River, Kansas
- Water-Quality Conditions in the Cheney Reservoir Basin, Kansas 1996-2017

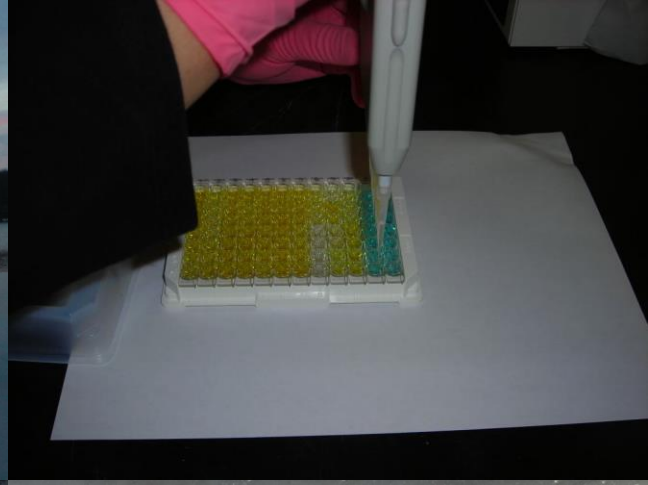


Integrated Approaches are Essential to Understand, Quantify, And Mitigate Harmful Algal Blooms

- Status and trends
- Environmental fate and transport
- Environmental drivers
- Ecosystem effects
- Exposure and health
- Drinking water and food impacts
- Mitigation and management



https://pubs.er.usgs.gov/publication/ofr20161174



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USGS:

https://www.usgs.gov/news/science-harmful-algae-blooms

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