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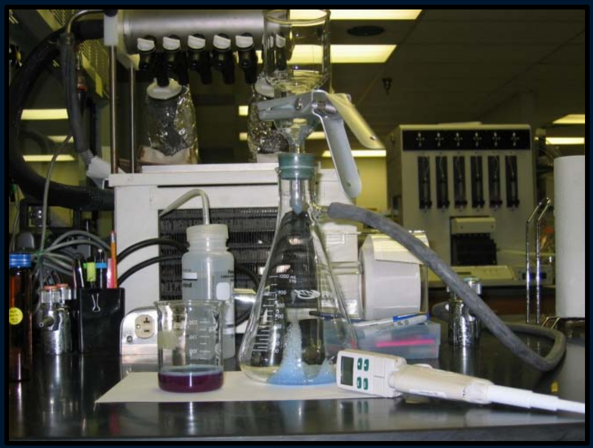
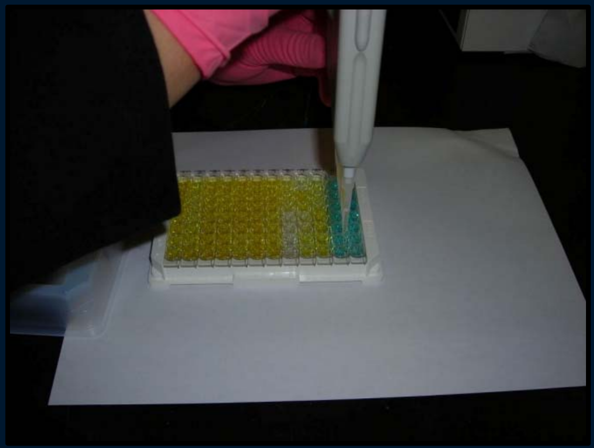
Guidelines for Design and Sampling of Cyanobacterial Toxin and Taste-and-Odor Studies





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

USEPA Region 9 Harmful Algal Bloom Meeting
April 26, 2017

U.S. Department of the Interior
U.S. Geological Survey

There are Many Potential Sources of Variability that May Influence Study Outcomes

Study Design and Sample Collection

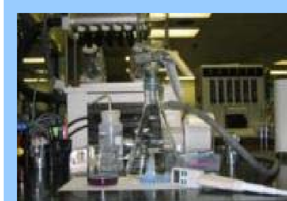




The Laboratory

Laboratory Processing

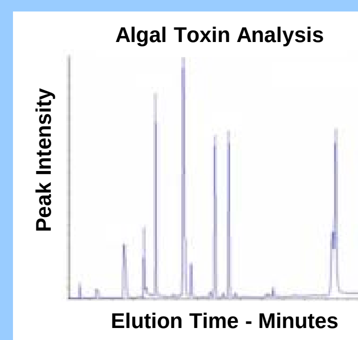




Analysis

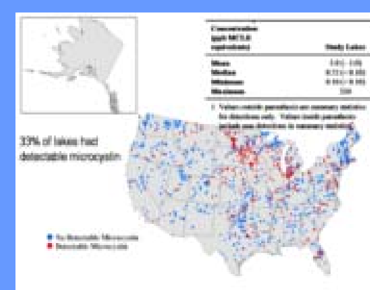


Data Reduction And Laboratory QA/QC



Study Results

Interpretation And Project QA/QC



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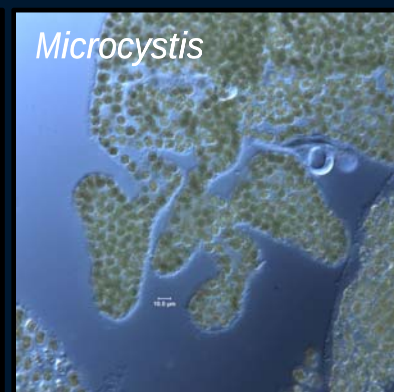
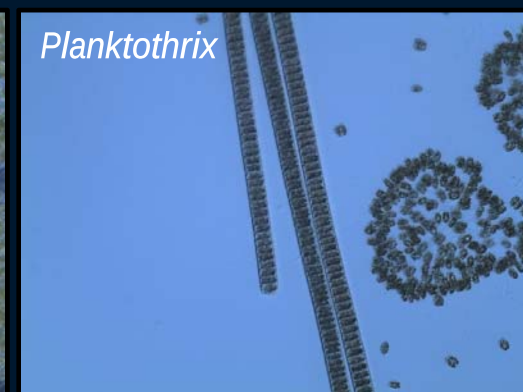
Many Cyanobacteria Produce Toxins and Taste-and-Odor Compounds

	Hepatotoxins		Neurotoxins		Dermatoxins	Taste/Odor	
	CYL	MC	ANA	SAX		GEOS	MIB
Dolichospermum	X	X	X	X	X	X	?
Aphanizomenon	X	?	X	X	X	X	
Microcystis		X			X		
Oscillatoria/Planktothrix		X	X	X	X	X	X

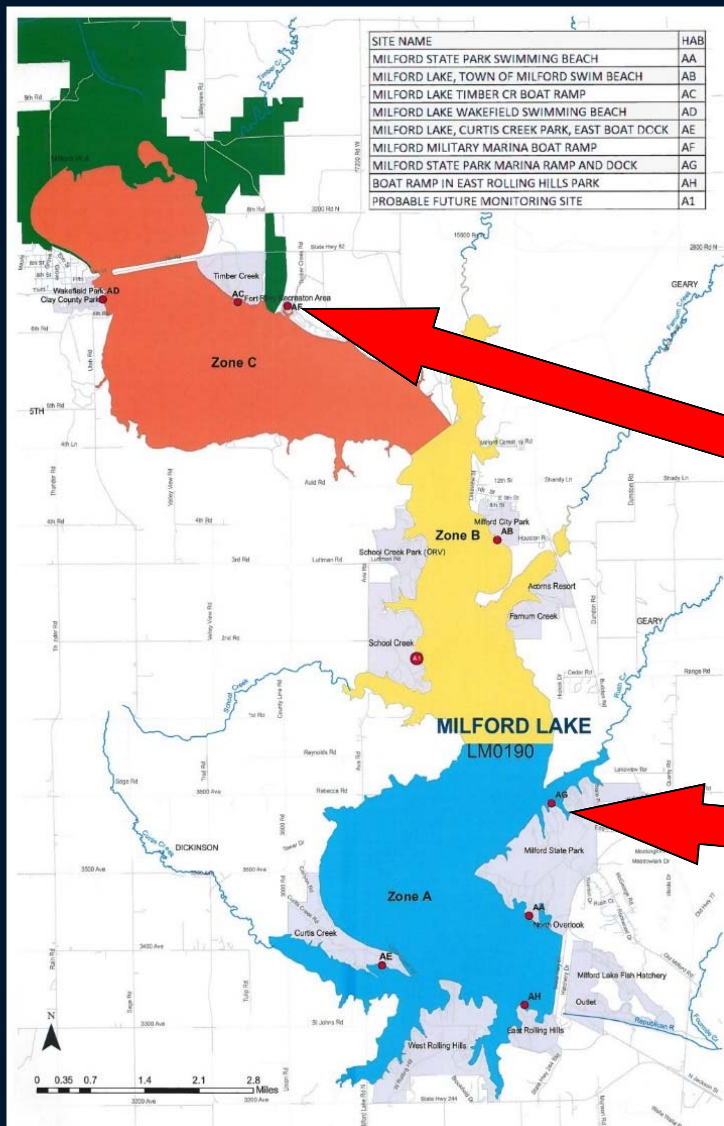




Photos courtesy of PhycoTech, Inc.

After Graham and others, 2008

Cyanobacteria Present Many Challenges to Study Design and Sample Collection



- Kansas Department of Health and Environment sample results from October 5, 2015
  - Cell count: 804,667,500 cells/mL
  - Microcystin Concentration: 30,000 µg/L
  - Cell count: 7,371 cells/mL
  - Microcystin Concentration: < 1 µg/L

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Cyanobacteria Present Many Challenges to Study Design and Sample Collection

July 7, 2016 at 5:00 pm

July 7, 2016 at 6:00 pm

July 20, 2016 at 3:54 pm

July 20, 2016 4:09 pm

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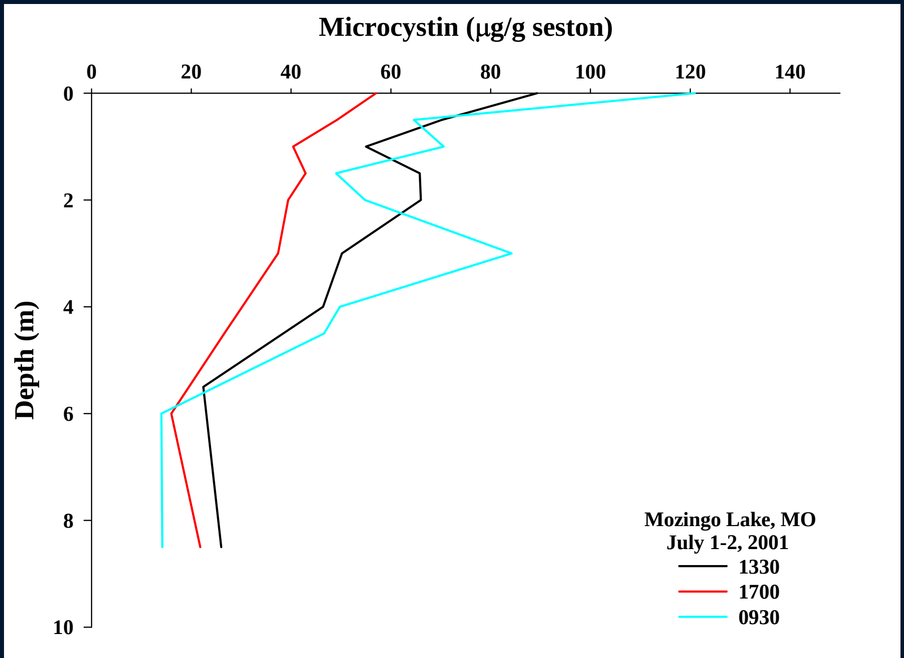
Sample Concentrations Can Vary Considerably Depending on When, Where, and How Samples Are Collected



Microcystis aeruginosa colonies

	Sample Type and Microcystin Concentration (µg/g Seston)			
Time	Surface	Integrated Photic Zone	Integrated Epilimnion	Integrated Water Column
0930	121	68	71	57
1330	89	58	66	55
1700	57	39	42	37

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After Graham and others, 2006

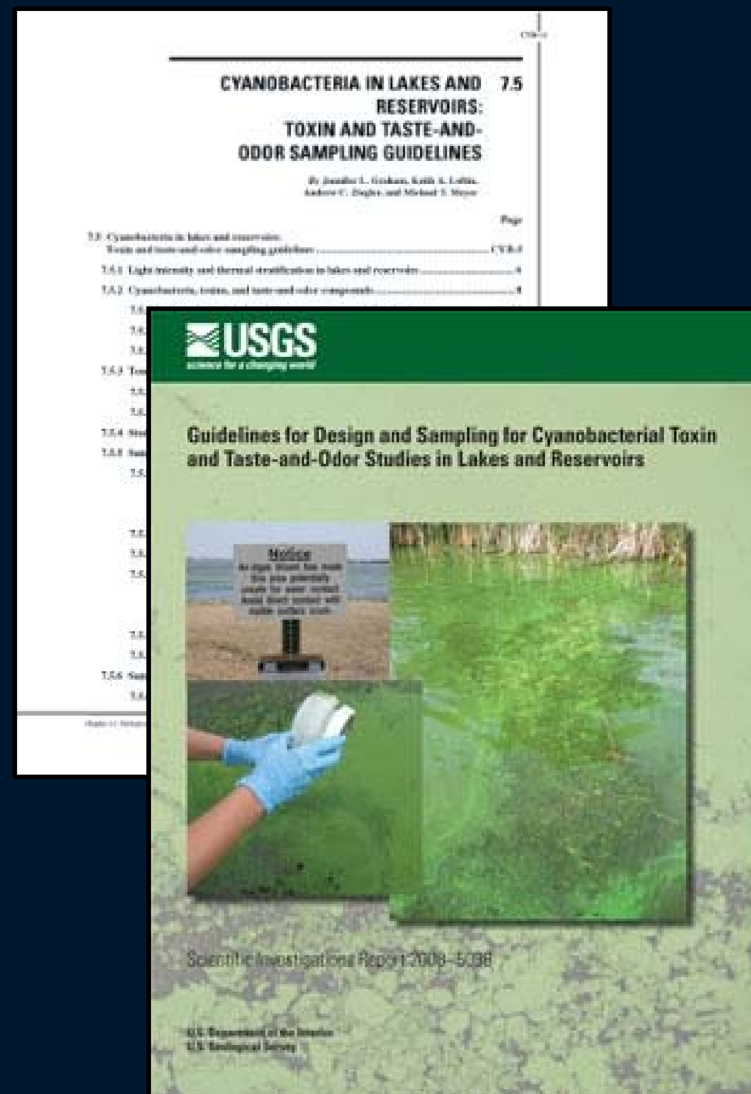
Consistent Guidelines for Study Design and Sample Collection are Essential for Nationally Comparable Data

SIR 2008-5038 ***Guidelines for Design and Sampling for Cyanobacterial Toxin and Taste-and-Odor Studies in Lakes and Reservoirs*** **(Graham and others)**

http://pubs.usgs.gov/sir/2008/5038

USGS National Field Manual Chapter 7.5
Cyanobacteria in Lakes and Reservoirs: Toxin and Taste-and-Odor Sampling Guidelines **(Graham and others)**

http://water.usgs.gov/owq/FieldManual/Chapter7/7.5



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Clear Understanding of Study Objectives is Essential to Selecting the Appropriate Sampling Approach

- Study objectives dictate:
  - When, where, and how samples are collected
  - Variables measured
  - Ancillary data collected

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Considerations When Choosing Sampling Locations and Approaches

- Specific study objectives
- Stratification
- Areal and water-column distribution of cyanobacteria
- Flexibility of sampling plans
  - Where and how to collect samples often is decided in the field

Common Types of Samples

- Surface samples
- Discrete-depth samples
  - Location of the cyanobacterial community is known
  - Structure of interest at depth
  - Vertical water column distribution of interest
- Depth-integrated samples
  - Integrated photic zone
  - Integrated epilimnion
  - Integrated water column

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Common Sampling Approaches

Plankton Net Sampling

Whole Water Sampling

Filter/Filtrate Sampling

Total Toxin

Dissolved Phase Toxin

Particulate Toxin

Reconnaissance Studies

Assess Occurrence, Distribution, and Concentration

General objective	Site location	Sample frequency	Sample type
Regional studies			
Spatial variability			
Emphasis on presence/absence	Single representative site, typically an open, deep water site	Single point in time when most cyanobacterial-related issues occur	Integrated photic zone Integrated epilimnion Surface sample
	Site will be determined based on the location of surface accumulations and scums	During known surface bloom events	Surface sample
Spatial and temporal variability			
Emphasis on presence/absence and changes in concentration with time	Single representative site, typically an open, deep water site	Multiple times during the period when most cyanobacterial-related issues occur • Weekly • Bi-weekly • Monthly • Annually	Integrated photic zone Integrated epilimnion Surface sample
Single-system studies			
Spatial variability			
Emphasis on presence/absence	Multiple sites	Single point in time when a cyanobacterial bloom is occurring	Integrated photic zone Integrated epilimnion Integrated water column Surface sample
Spatial and temporal variability			
Emphasis on presence/absence and changes in concentration over time	Multiple sites	Multiple times during the period when most cyanobacterial-related issues occur • Weekly • Bi-weekly • Monthly	Integrated photic zone Integrated epilimnion Integrated water column Surface sample
Emphasis on spatial changes within the lake or water column over relatively short periods of time	Single representative site Multiple sites	Multiple points in time when a cyanobacterial bloom is occurring • Hourly • Daily	Integrated photic zone Integrated epilimnion Integrated water column Surface sample Discrete depth

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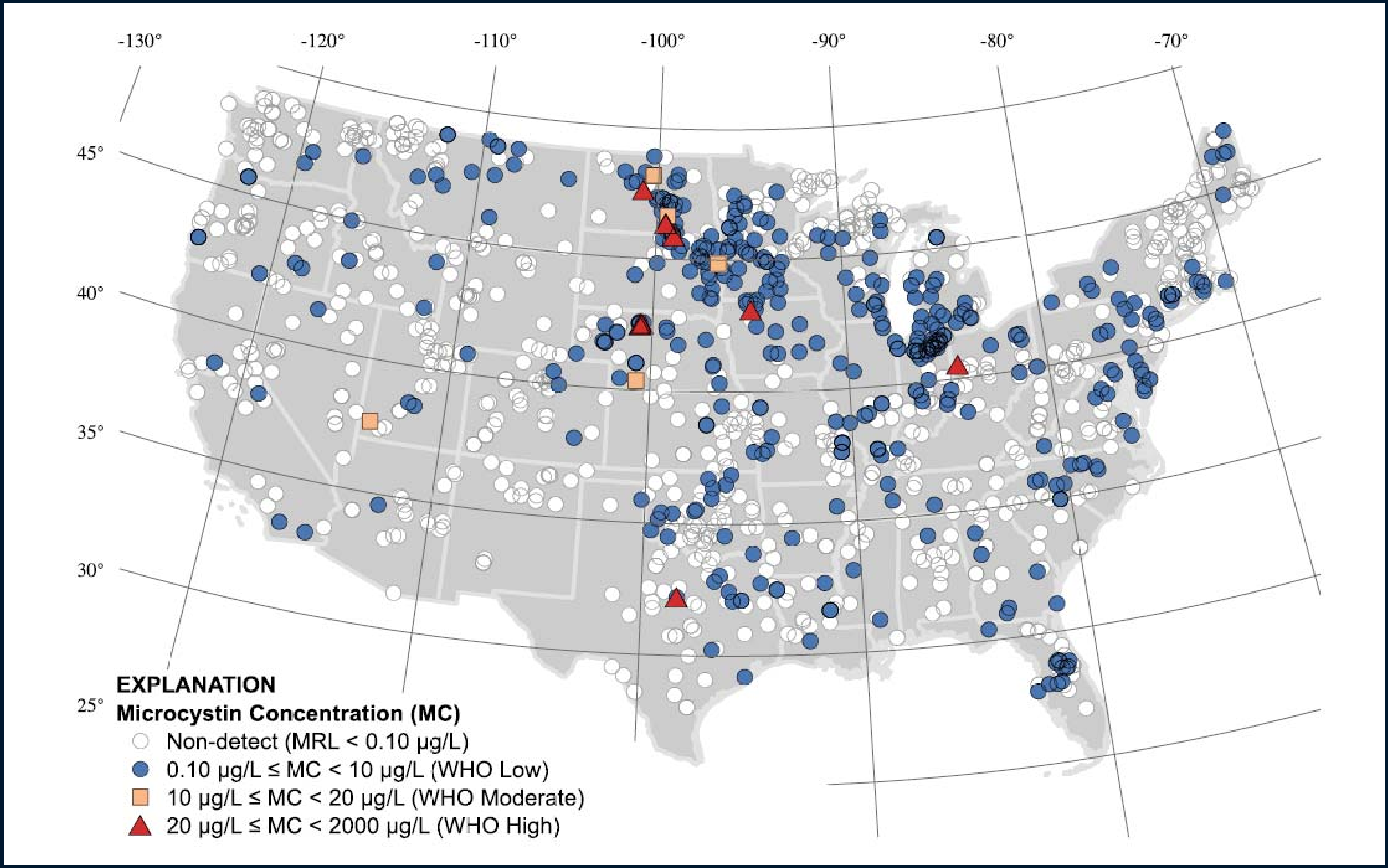
After Graham and others, 2008

In the 2007 National Lakes Assessment, Microcystins Were Detected in About 32% (n=1252) of Analyzed Samples



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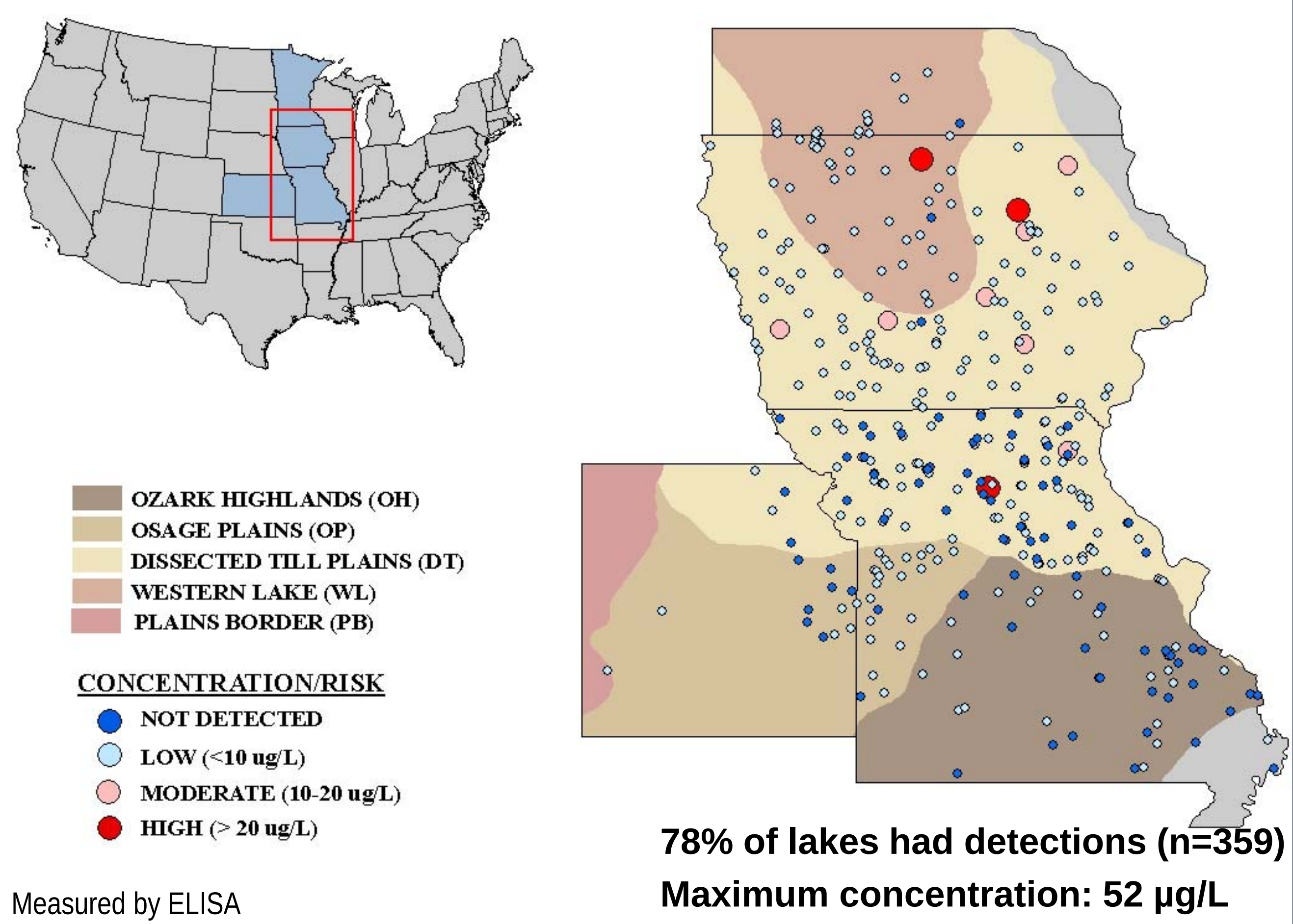
Loftin and others, 2016

Seventy-Eight Percent of Lakes in a Regional Study had Detectable Microcystins at Least Once During 1999-2006



78% of lakes had detections (n=359)
Maximum concentration: 52 µg/L

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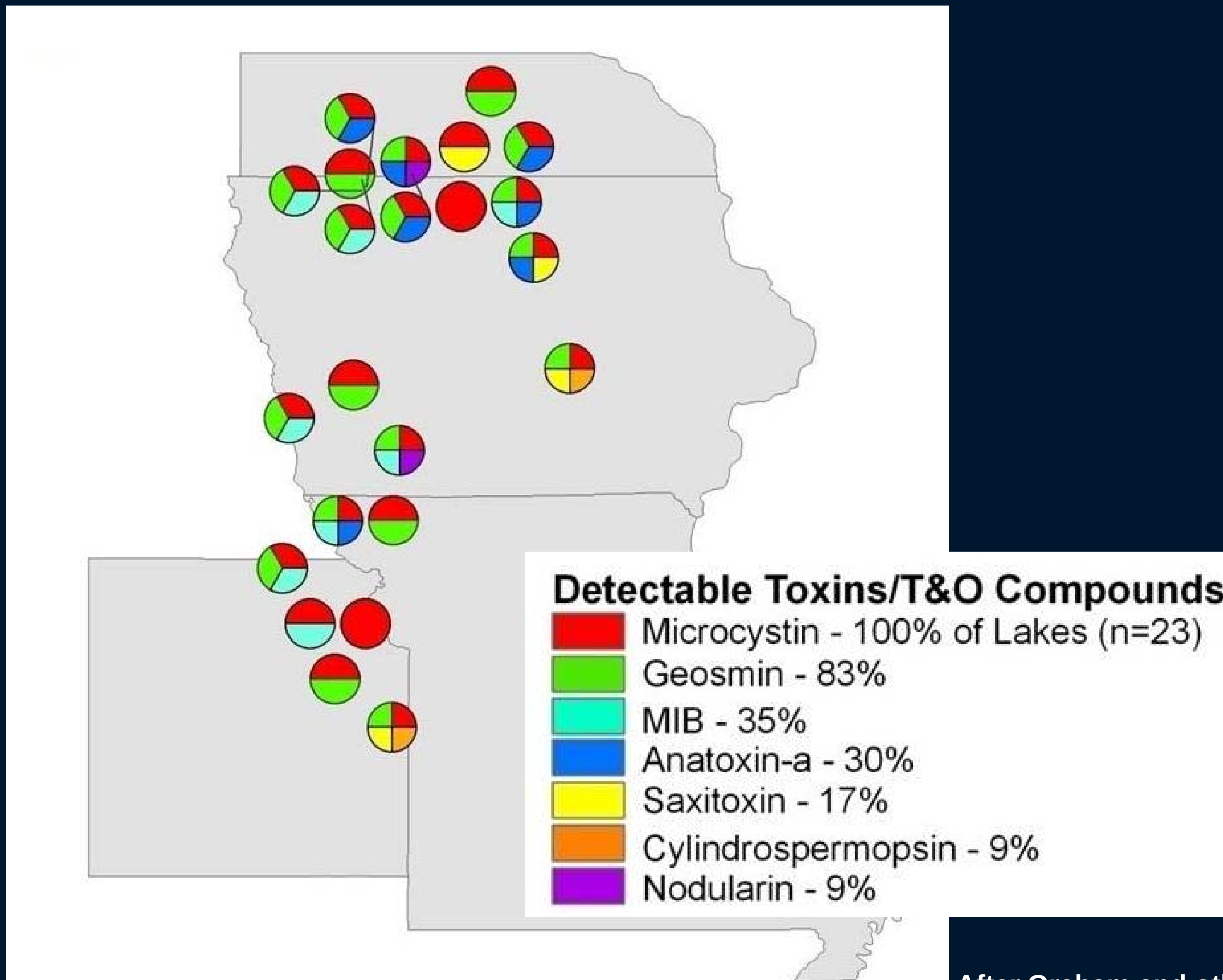
After Graham and others 2004, 2006, and 2009

Microcystins were Detected in All Bloom Samples Collected in a 2006 Regional Study



After Graham and others, 2010

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Monitoring Studies

Evaluate the Potential for Human Health Risks and Taste-and-Odor Events

General objective	Site location	Sample frequency	Sample type
Recreational areas	Beaches Open water areas used for full-body contact recreation Bay or cove areas used for full-body contact recreation Public access sites	Routine basis during periods of peak recreational use • Daily • Weekly	Surface sample Integrated photic zone
Drinking-water supplies	Location relevant to the drinking-water intake(s)	Routine basis • Daily • Weekly During periods when events have historically occurred During events	Discrete depth Integrated photic zone Integrated epilimnion Integrated water column

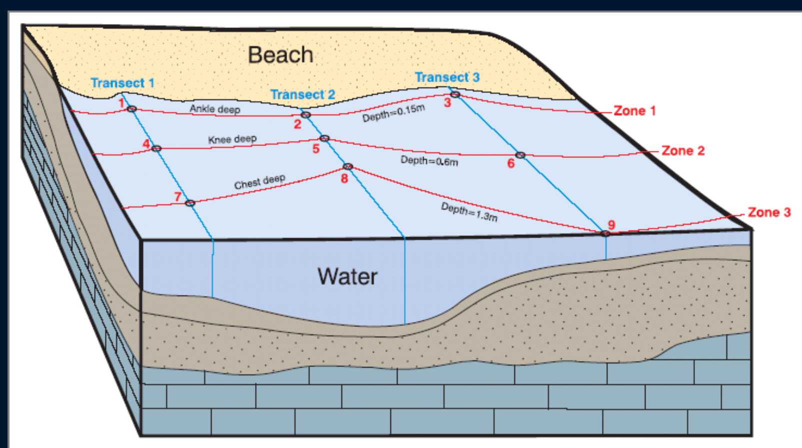

Figure Courtesy of E. O'Brien, IA DNR

After Graham and others, 2008

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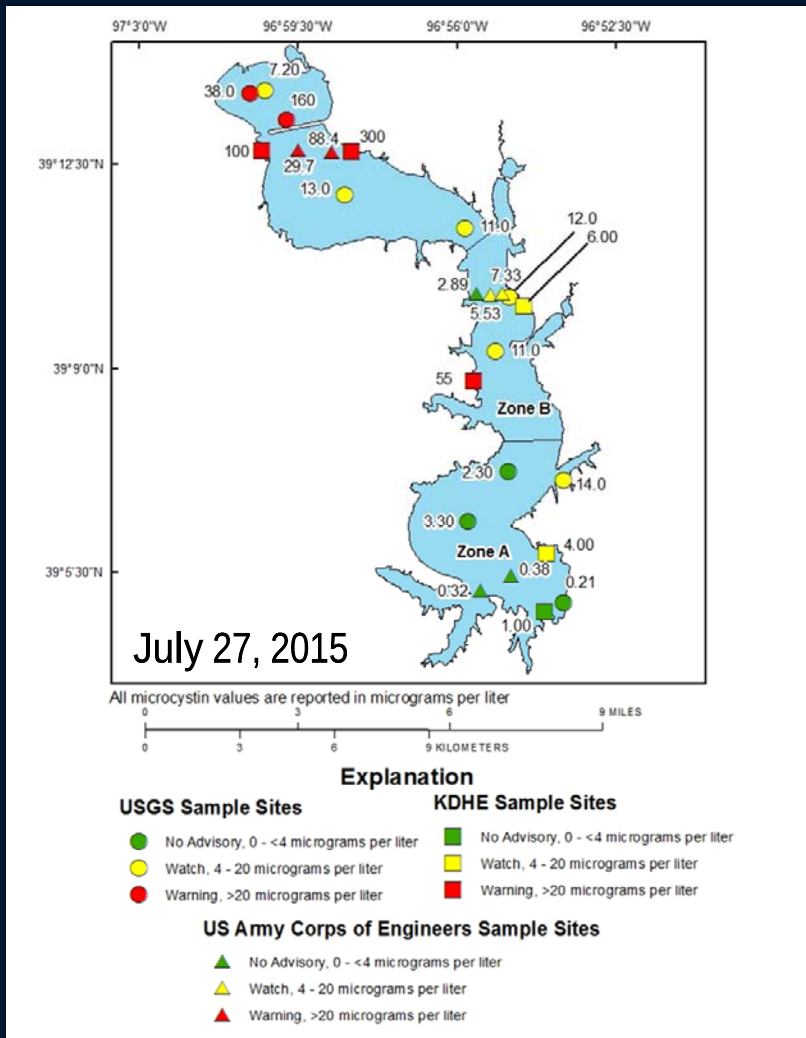
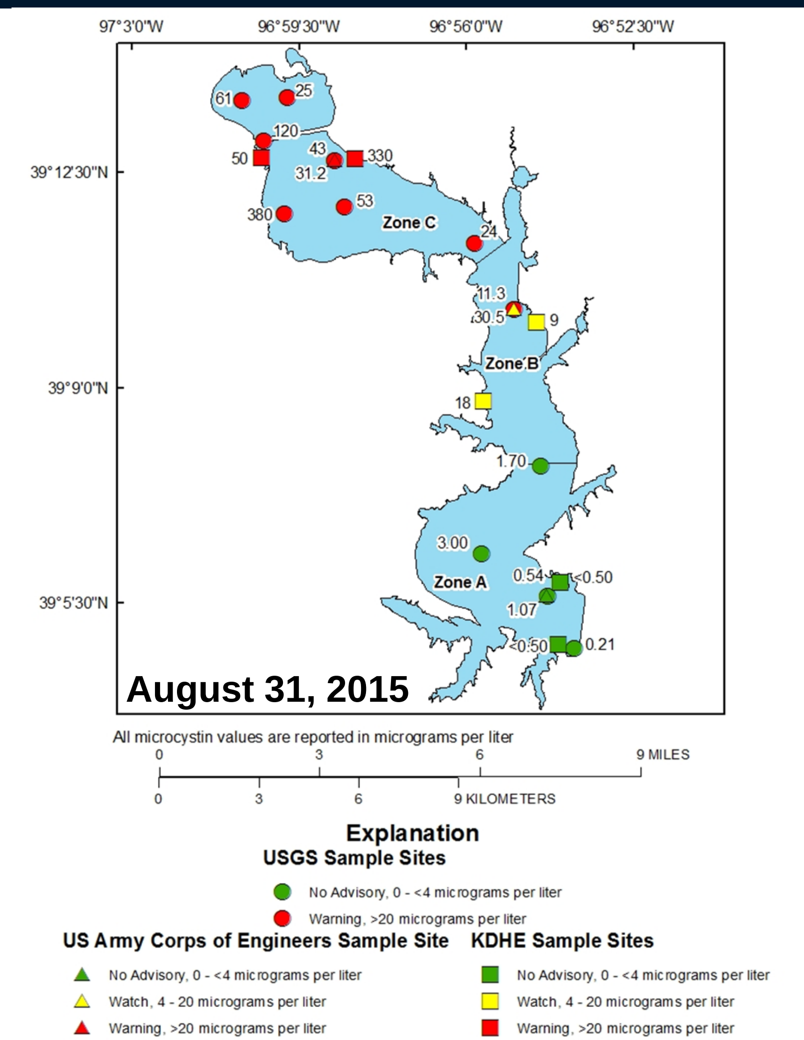
Zoned Warning Status in a Kansas Reservoir was Not Substantially Influenced by Sample Collection Technique





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After Foster and others, 2016

Interpretive Studies

Assess the Processes that Affect the Spatial and Temporal Distribution and Abundance of Cyanobacteria and Associated Compounds

General objective	Site location	Sample frequency	Sample type
Environmental factors influencing spatial and/or temporal occurrence Real-time estimation of occurrence/concentration Predictive models	Single representative site, typically an open, deep water site • Sites for drinking-water studies are typically located near intakes Multiple sites • Sites where cyanobacterial blooms are known to initiate • Sites where cyanobacteria are typically abundant • Inflow sites[1]	Routine basis • Weekly • Bi-weekly • Monthly	Integrated photic zone Integrated epilimnion Integrated water column Discrete depth
	Sites where surface accumulations/scums are located	Event samples Sampling plans need to be flexible enough to respond to events	Surface sample

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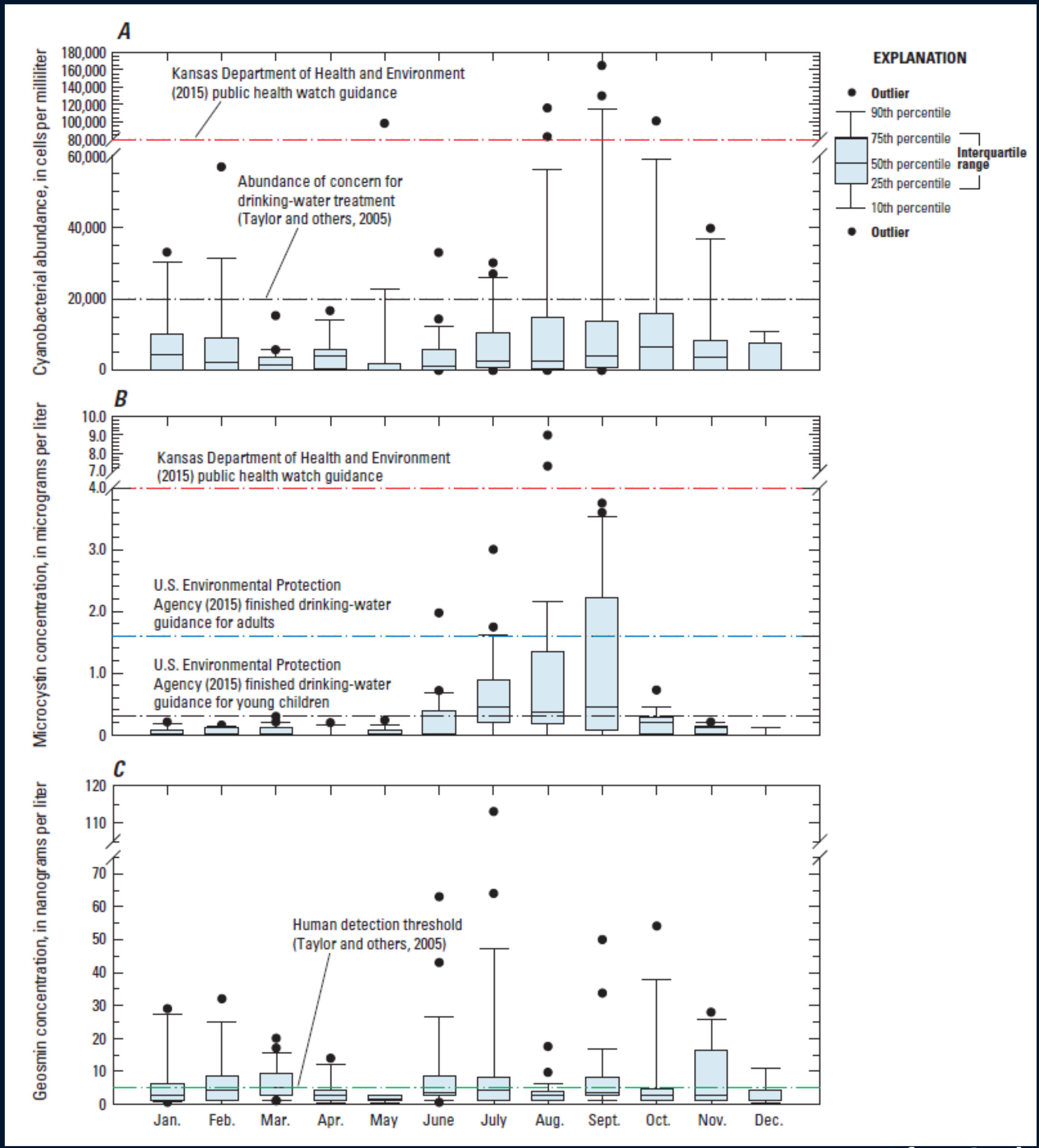
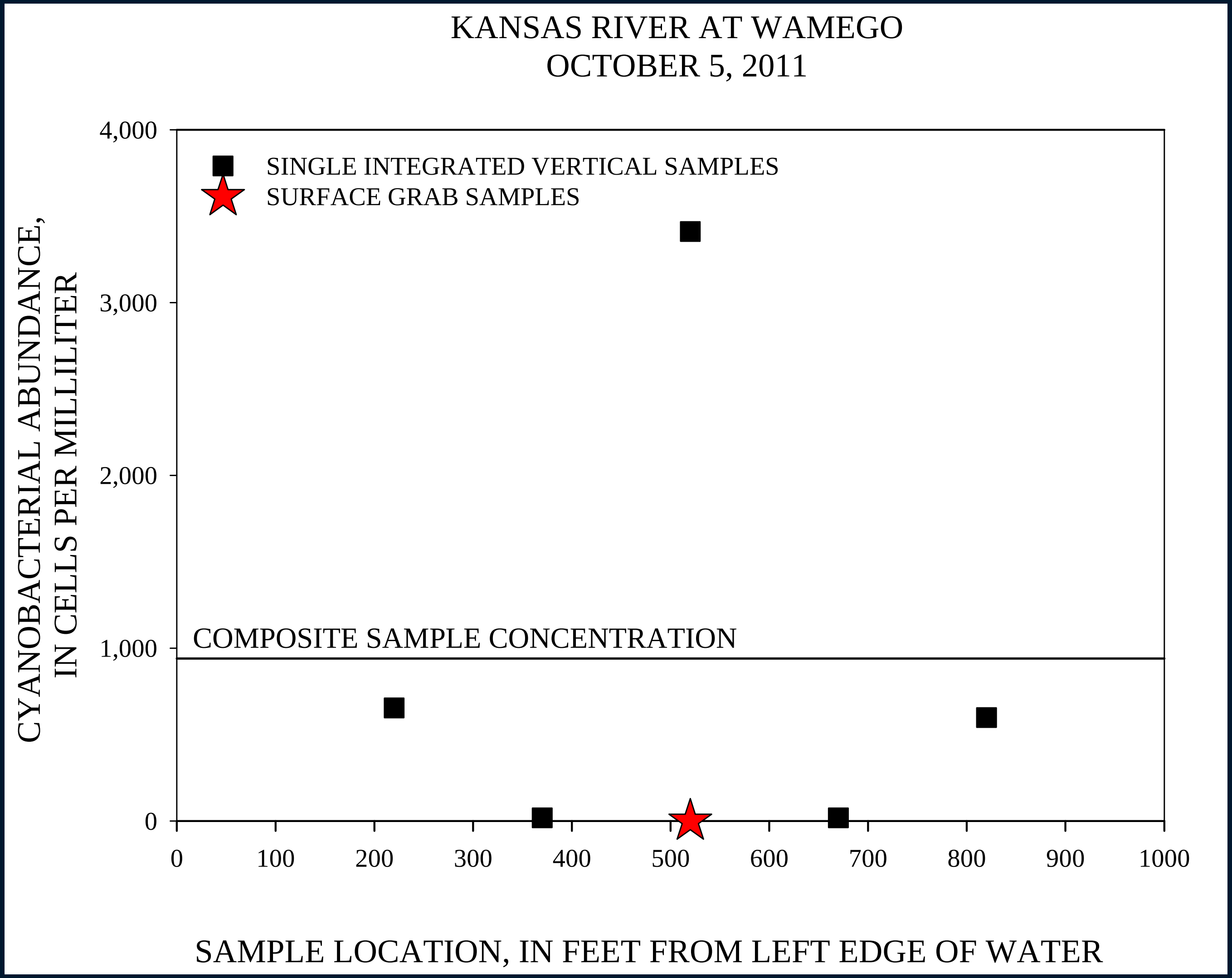
After Graham and others, 2008

Temporal Variability Also Can Span Orders of Magnitude Across Seasons and Years



After Graham and others, 2017

In the Kansas River, Measured Concentrations of Cyanobacteria and Associated Compounds Varied Depending on Sample Location and Method



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After Graham and others, 2012

Conclusions

- Cyanobacteria present several unique challenges to study design and sample collection.

- A clear understanding of study objectives is essential to selecting the appropriate sampling approach.

- Understanding and quantifying variability is key to interpreting results.

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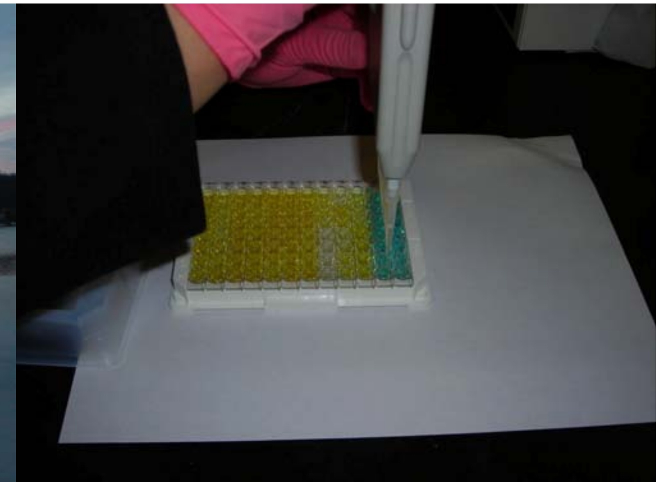


USGS:

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

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

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