Potential for Cyanotoxin Occurrence in the Nation's Large Rivers

Jennifer L. Graham, Neil M. Dubrovsky, Guy M. Foster, Lindsey R. King, Keith A. Loftin, Barry H. Rosen, and Erin A. Stelzer

11th National Monitoring Conference

March 26, 2019, Denver, CO

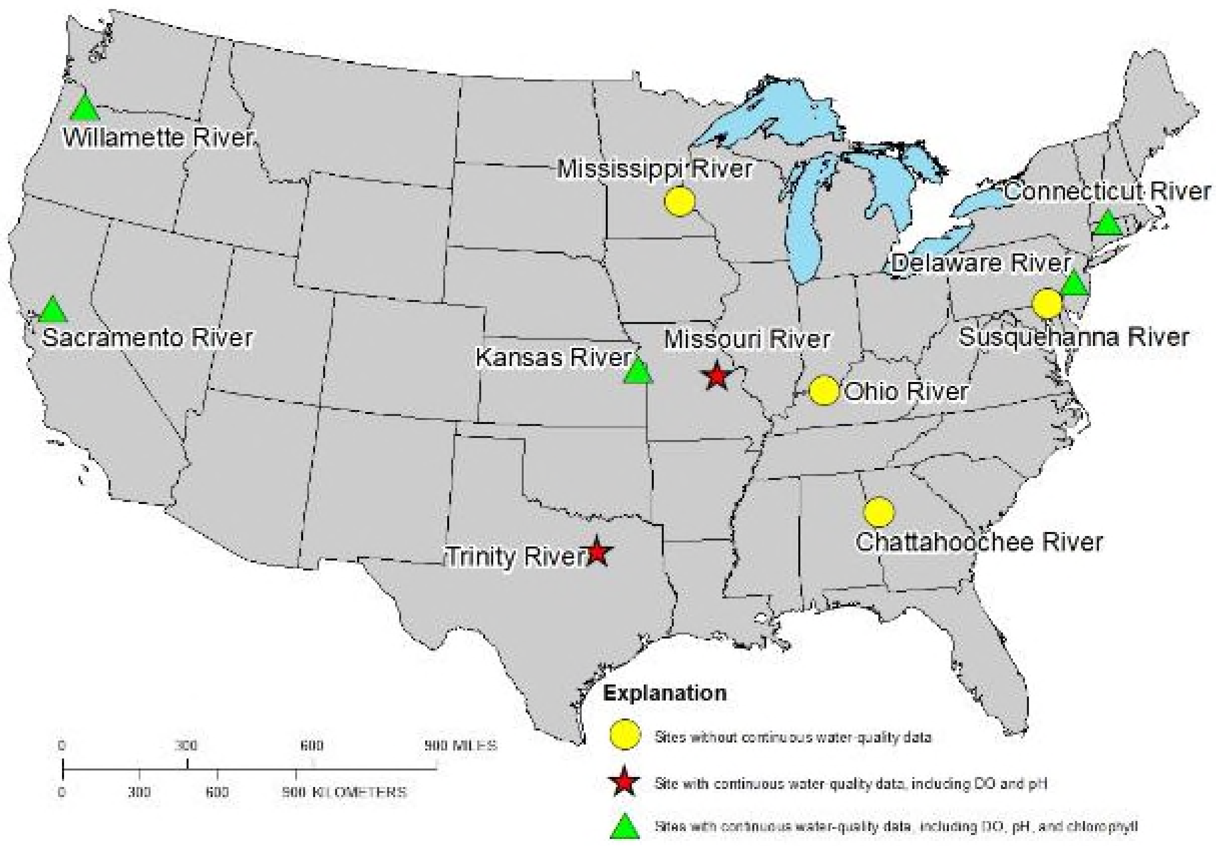
U.S. Department of the Interior
U.S. Geological Survey

Cyanotoxins in Large Rivers

- Cyanobacterial harmful algal blooms (CyanoHABs) are increasingly a global concern because they pose a threat to human and ecosystem health and cause economic damages.
- Toxins produced by some species of cyanobacteria (cyanotoxins) can cause acute and chronic illnesses in humans.
- Recent national and regional assessments have shown that cyanotoxins are commonly detected in the Nation's lakes, reservoirs, small streams, wetlands, and can also occur in large rivers.
    - 2011 – cyanotoxins affect 180 miles of the Kansas River
    - 2015 – cyanotoxins affect 650 miles of the Ohio River
    - 2018 - cyanotoxins in the Illinois and Hudson Rivers
- CyanoHAB studies have been conducted on large rivers in response to events – there has not been a comprehensive assessment of cyanotoxin occurrence in the Nation's large rivers.

Pilot Study Objectives

- Describe cyanotoxin occurrence in inland and coastal rivers during summer.
- Assess *potential* for cyanotoxin and algal bloom occurrence using a combination of traditional and emerging approaches.

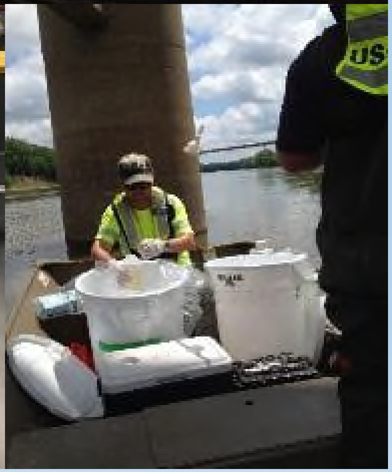


USGS
science for a changing world

Approach and Analyses

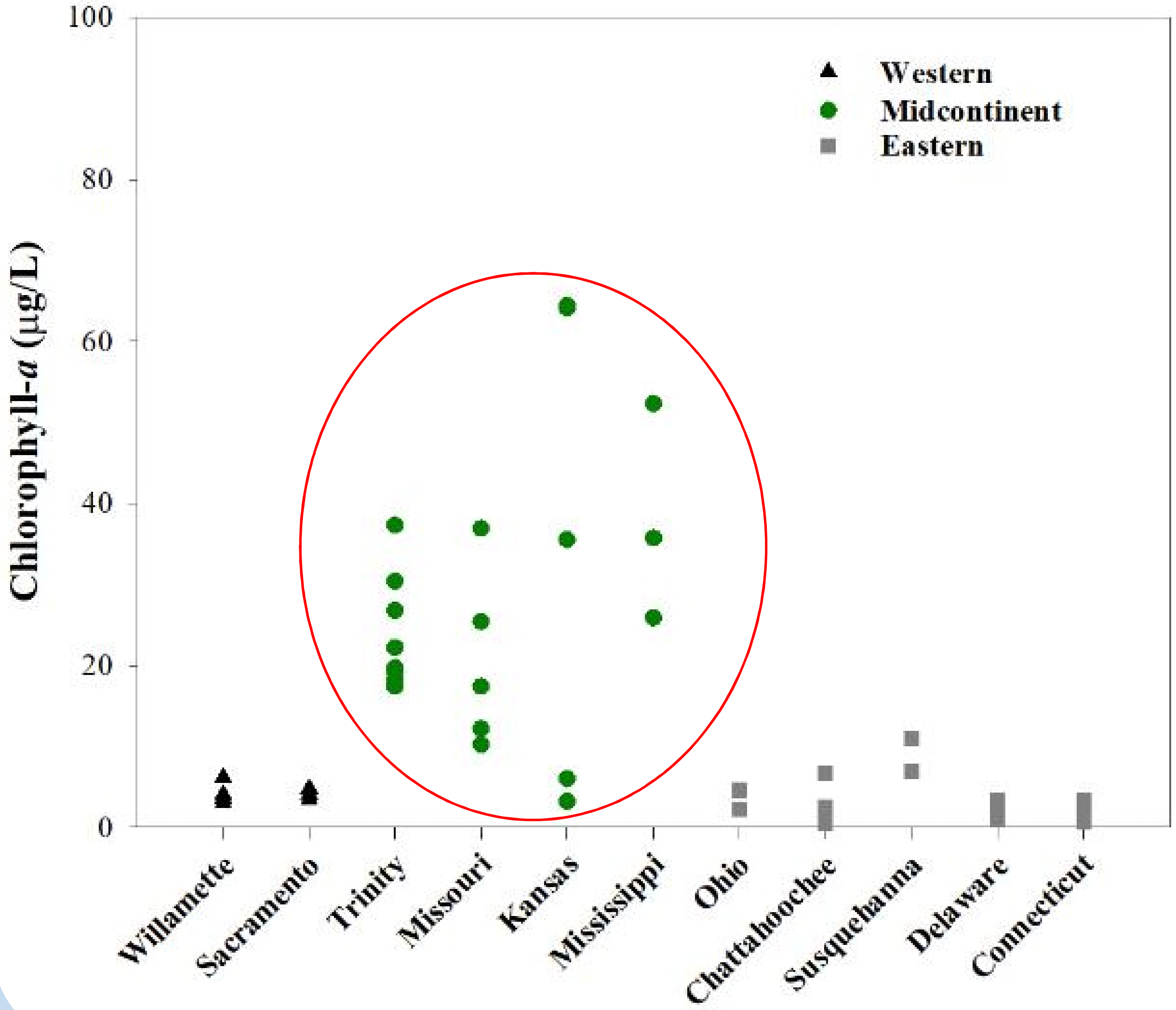
- All samples were collected during June-September 2017 based on pre-existing sampling schedules and in accordance with FY17 NAWQA discrete sample collection protocols (with the exception of genetic samples). Based on observations by field crews in 2017, samples in 2018 were collected during June-October. This approach will be maintained in 2019.

- Analyses:
  - Cyanotoxins by ELISA (anatoxin, cylindrospermopsin, microcystin, saxitoxin); 10% by LC/MS/MS
  - Genes present in anatoxin, cylindrospermopsin, microcystin, and saxitoxin synthetase gene clusters by qPCR
  - Phytoplankton community composition (live and preserved material)
  - Chlorophyll (algal biomass)
  - Continuous water-quality data



USGS
science for a changing world

Algal Biomass Was Highest in Midcontinent Rivers



USGS
science for a changing world

Graham et al., in preparation

Cyanobacteria Occurrence

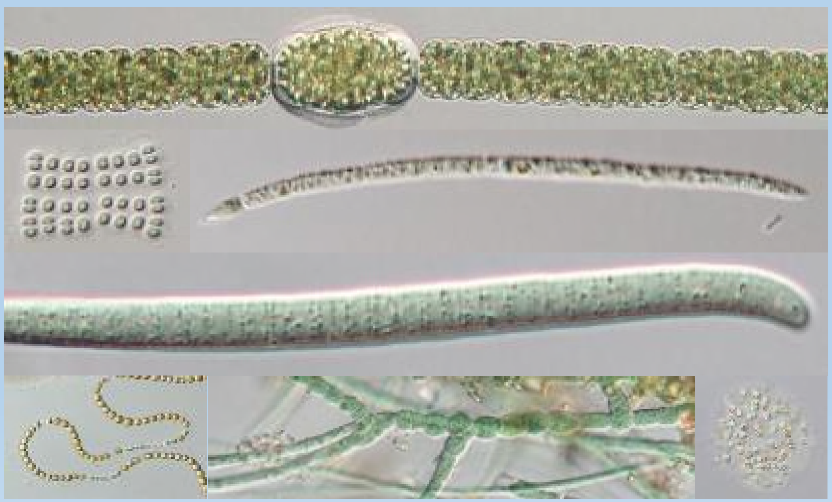
- About 25 unique cyanobacterial genera were identified in samples, including one that has not previously been identified in the United States (*Uzmekia*, pending verification).
- Seven cyanobacterial genera not detected by traditional microscopic approaches were found in subcultures from live samples.
- Cyanobacteria occurred at all study sites.

Genera	Sites	ATX	CYL	MC	SAX
Pseudanabaena	10	X		X	
Planktothrix	9	X		X	X
Aphanocapsa	6			X	
Dolichospermum	6	X	X	X	X
Cuspidothrix	5	X			X
Limnothrix	5				X
Merismopedia	5			X	
Eucapsis	4				
Planktolyngbya	4				
Aphanizomenon	3	X	X	X	X
Chroococcus	3				
Dactylococopsis	3				
Phormidium	3	X		X	X
Snowella	3				
Anabaenopsis	2			X	
Calothrix	2			X	
Coelosphaerium	2				
Cylindrospermopsis	2		X		X
Nostoc	2			X	
Anabaena	1	X	X	X	X
Cylindrospermum	1	X			X
Komvophoron	1				
Romeria	1				
Schizothrix	1				
Synechococcus	1			X	
Aphanothece	0				
Fiscella	0				
Fottea	0				
Geitlerinema	0			X	X
Haplosiphon	0			X	
Microcystis	0	X		X	
Uzmekia	0				

Potential for cyanotoxin production based on Graham et al. (2008) and Meriluoto et al. (2017)

Red indicates potential cyanotoxin production indicated by Graham et al. (2008) but not Meriluoto et al. (2017)

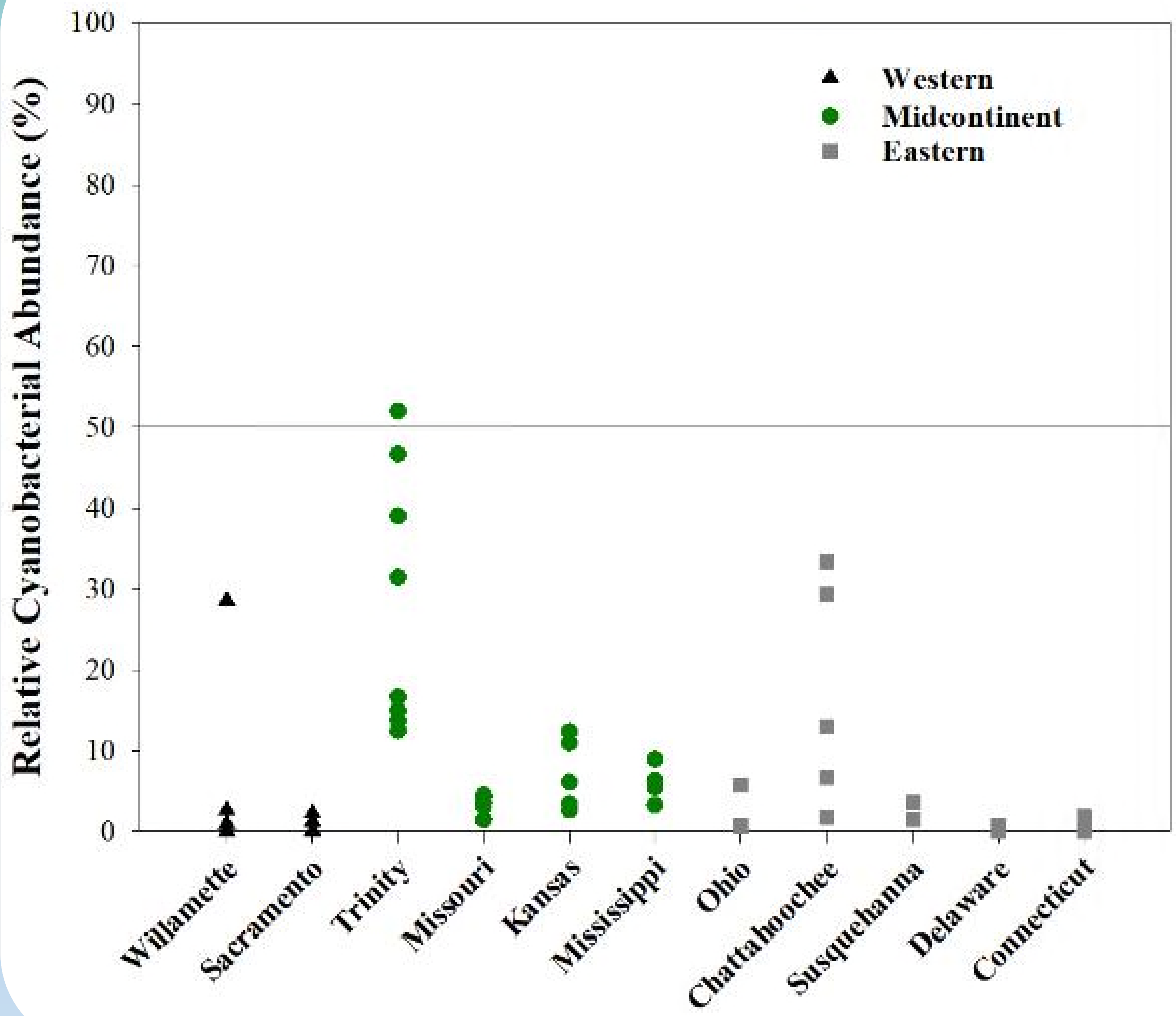
Blue indicates genera that are considered planktonic based on Komárek and Hauer (2013) and Cassamata and Hašler (2016)



USGS science for a changing world

Graham et al., in preparation

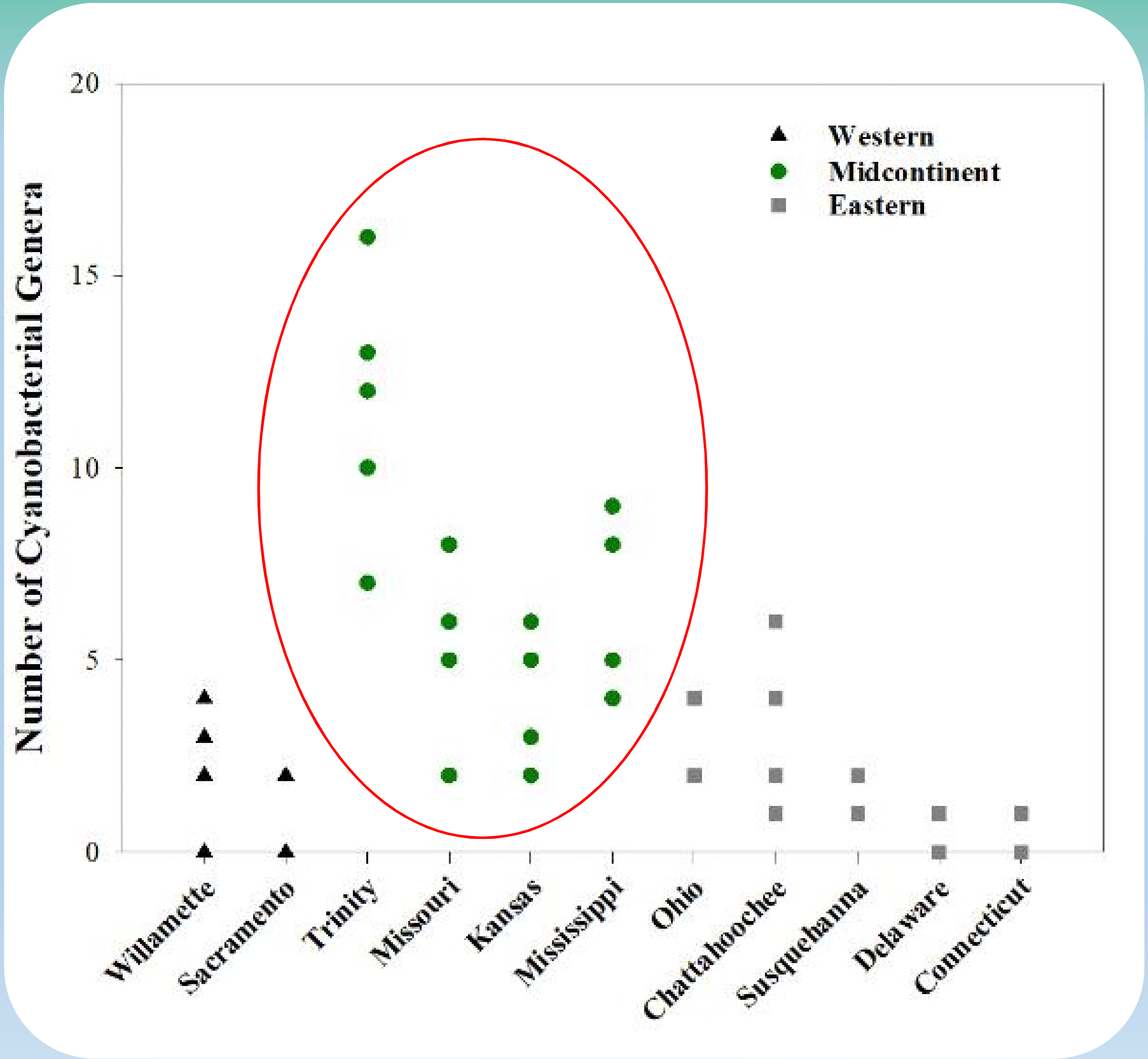
Cyanobacteria Did Not Dominate Algal Community Composition



USGS
science for a changing world

Graham et al., in preparation

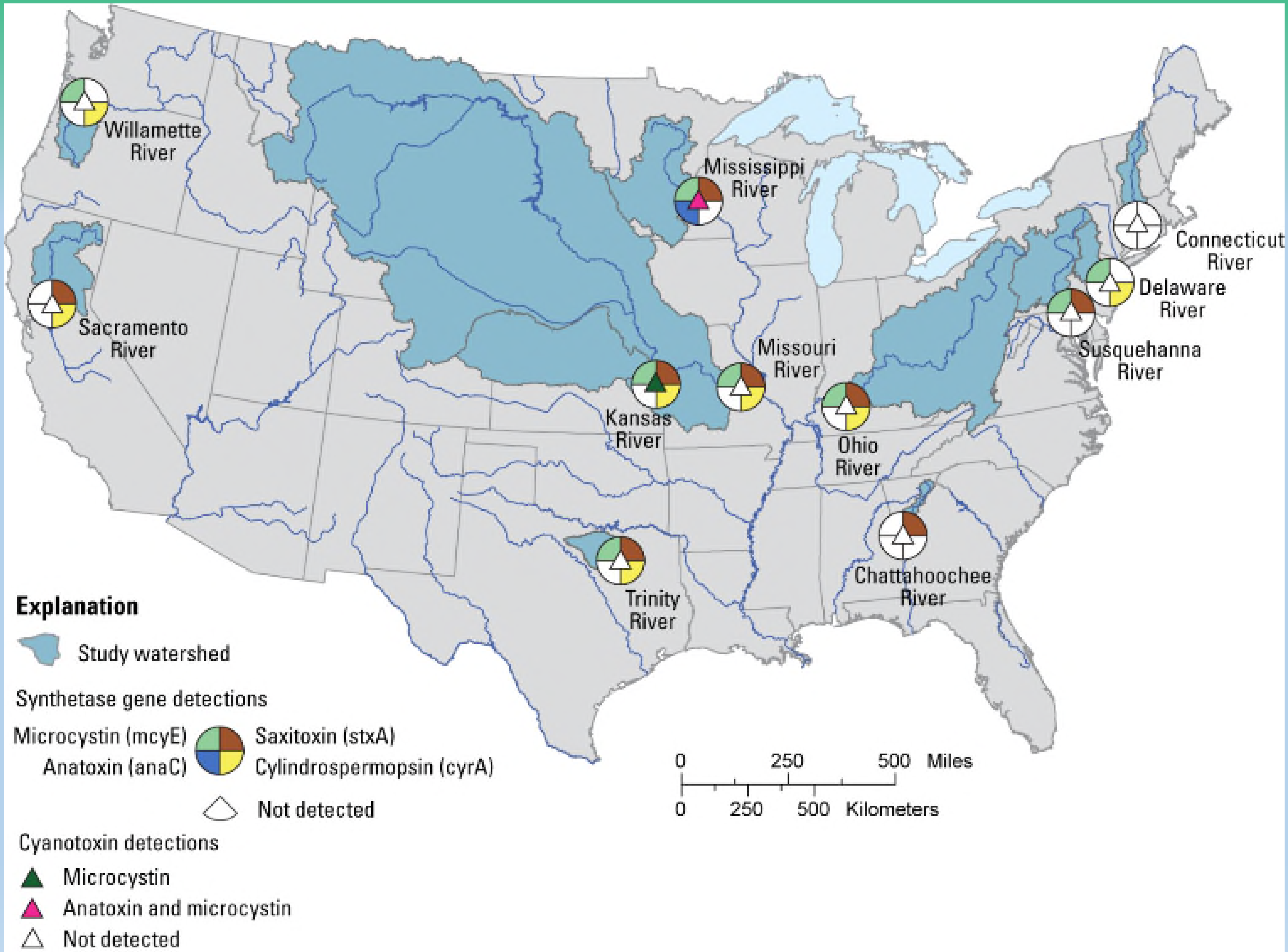
The Richness of Cyanobacterial Communities was Higher in Midcontinent Rivers



USGS science for a changing world

Graham et al., in preparation

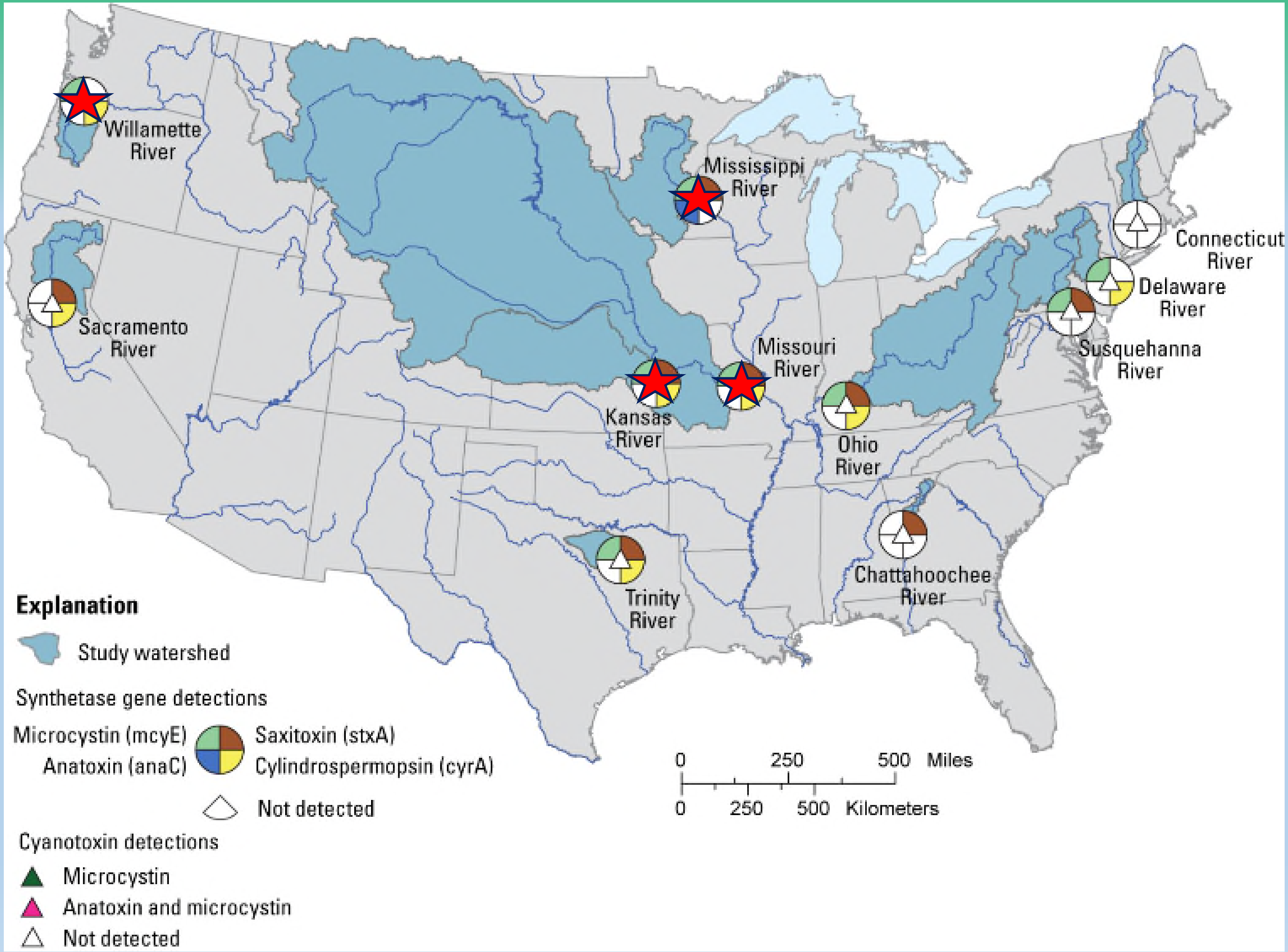
Cyanotoxin Occurrence and Potential



USGS science for a changing world

Graham et al., in preparation

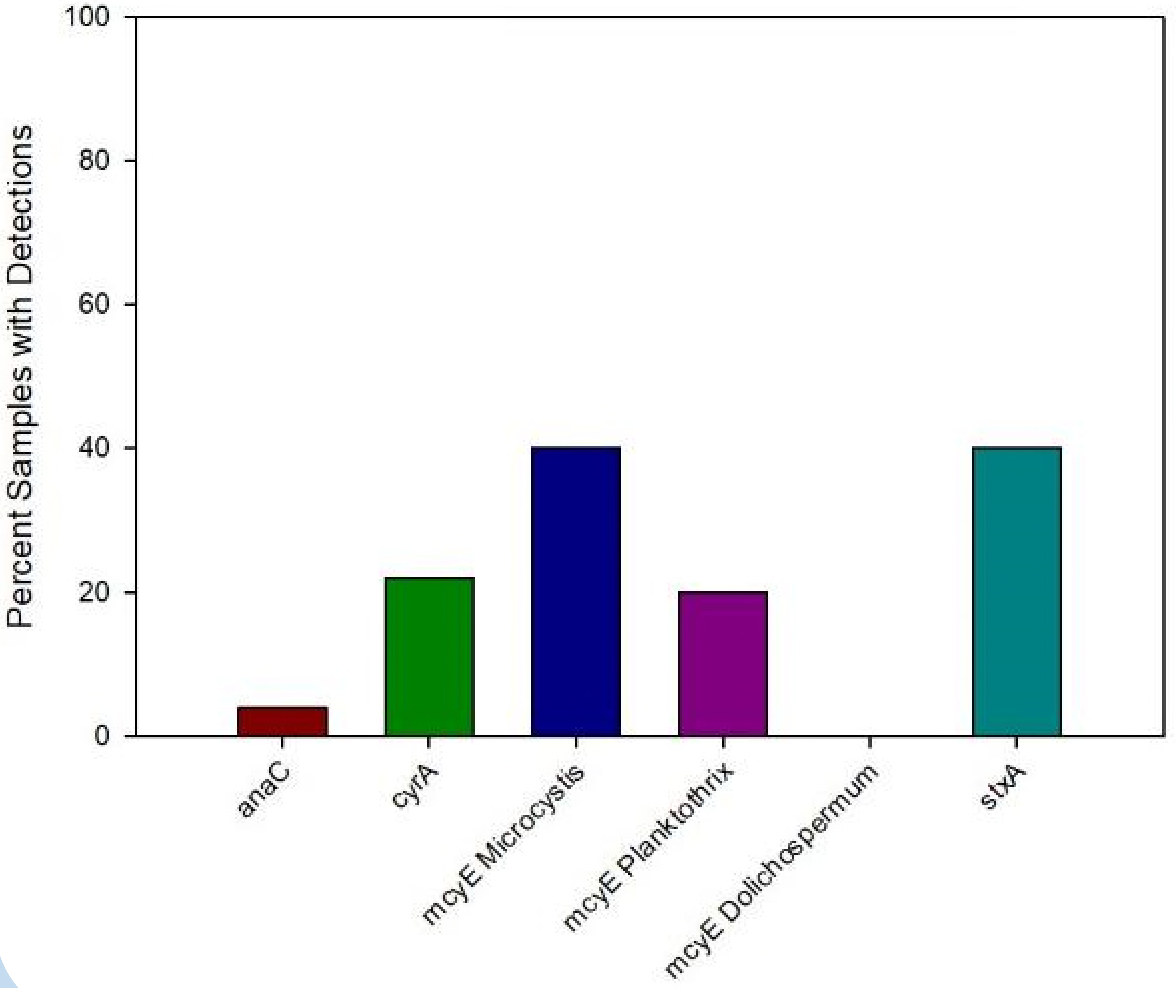
Cyanotoxin Occurrence and Potential



USGS
science for a changing world

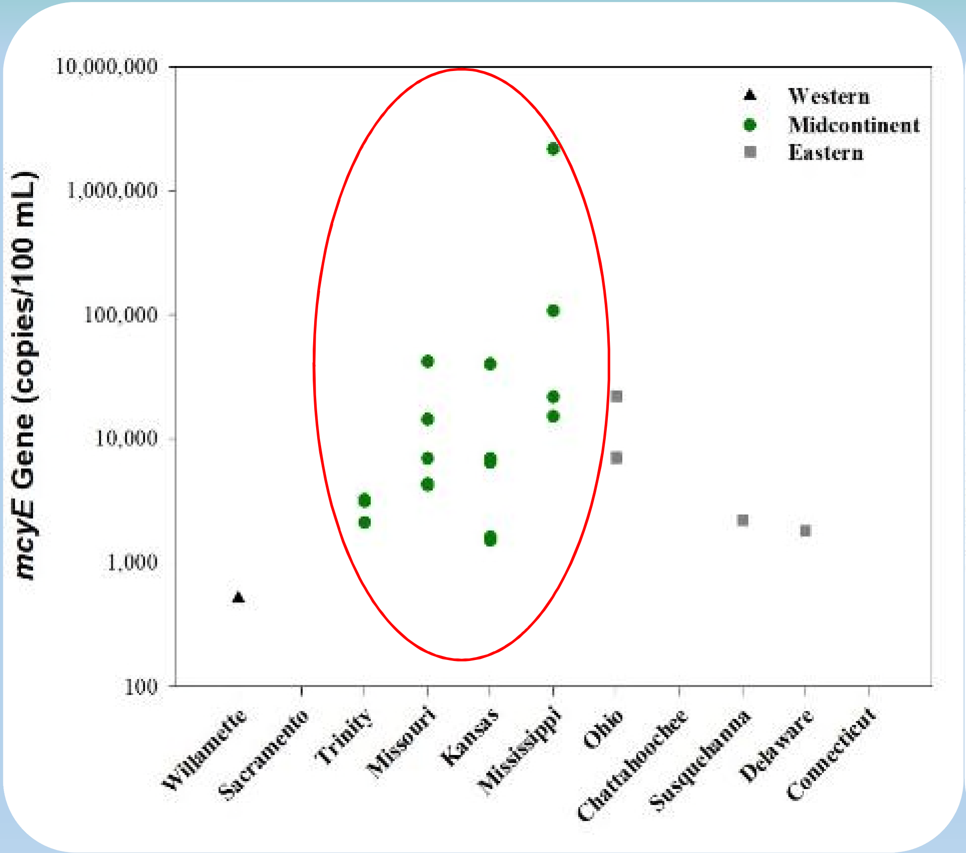
Graham et al., in preparation

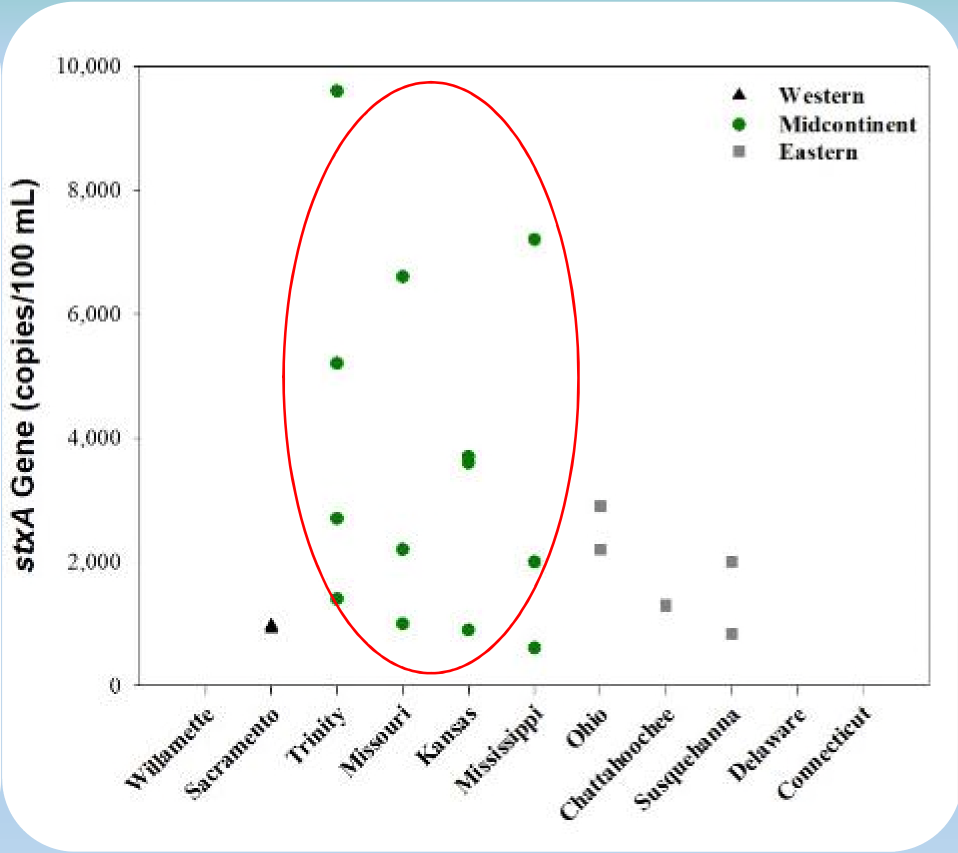
The *mcyE* and *stxA* Genes Were Most Common



Graham et al., in preparation

The *mcyE* and *stxA* Genes Were Most Abundant in Midcontinent Rivers





USGS
science for a changing world

Graham et al., in preparation

Summary

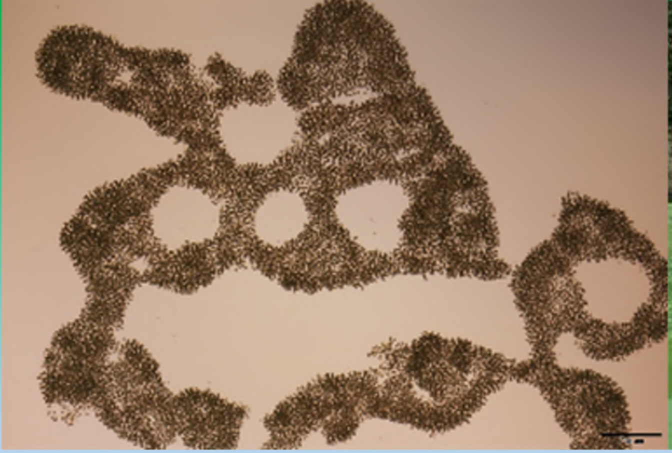
- Cyanobacteria and the genetic potential for cyanotoxin production were widespread and common in this small subset of U.S. rivers.
- Cyanotoxins were only detected in midcontinent rivers. Algal biomass, cyanobacterial community richness, occurrence and abundance of cyanotoxin synthetase genes also were highest in midcontinent rivers.
- Cyanotoxin concentrations were low, but microcystin concentrations in raw water were near the EPA finished drinking-water guidance value for small children (0.3 µg/L).

Courtesy of E. Emory, USACE

USGS
science for a changing world

Next Steps

- Continued data during summer 2019
  - Addition of the Hudson and Illinois Rivers.
  - Among-year patterns in occurrence.
  - Within and among-site differences related to occurrence.
- Characterize the physicochemical environment associated with cyanobacteria and cyanotoxins in these rivers to better understand how changing conditions may result in increased occurrence.



Jennifer Graham
jlgraham@usgs.gov
518-285-5706

USGS
science for a changing world