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

- Nitrogen Cycle
  - Denitrification
  - Nitrogen Fixation
- Nitrate/Nitrite ($\text{NO}_3^-/\text{NO}_2^-$)
- Nitrification
- Decay/Mineralization/Immobilization

**How are cyanobacterial communities related to toxins?**

**Do invasive species affect HABs?**

**Do viruses affect HABs?**
Environmental Effects of Exposure

Microcystin may affect juvenile recruitment of endangered suckers in Upper Klamath Lake, Oregon.
Day of Year and Algal Abundance are Used to Provide Daily Estimates of the Probability of Cyanotoxin Occurrence in a Kansas Drinking-Water Supply

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

Watershed Yields of Phosphorus

After Preston et al., 2011, JAWRA, 47: 887-890
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
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
Reservoir Bottom Sediments May Contain Information About Changing Nutrient Concentrations and Harmful Algal Bloom Occurrence Over Time

![Graph showing the relationship between Cyanobacterial Akinete Abundance Per Gram of Sediment and Total Phosphorus Concentration over time. The graph indicates that there is a correlation between the two variables, with periods of higher cyanobacterial abundance corresponding to higher phosphorus concentrations.]
Mobile Sensor Arrays Capture Spatial Variability Across Larger Areas
Time-Lapse Cameras and Fixed-Site Sensors Capture Temporal Variability at Sites of Interest

July 7, 2016 at 1700

July 7, 2016 at 1800
Hyperspectral Microscopy Can Potentially Be Used to Identify Unique Signatures of Harmful Algal Bloom Forming Taxa

Courtesy of T. Slonecker and N. Simon, USGS
Tools to Utilize Satellites for Inland HAB Monitoring are Being Developed

Cyanobacteria Assessment Network (CyAN) Project

https://www.epa.gov/water-research/cyanobacteria-assessment-network-cyan
On the Ground Approaches Are Needed to Capture Spatial and Temporal Variability with Depth.
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