National Experiences with Early Warning Systems and Monitoring

Jennifer L. Graham

U.S. Geological Survey

USEPA Region 10 CyanoHABs Workshop and Tabletop Exercise

Seattle, Washington

October 18, 2019

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

The Spatiotemporal Variability of Cyanobacteria Poses Unique Challenges to Monitoring and Assessment

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

Photo Credit: J. Graham, USGS

USGS
science for a changing world

Overview

- Screening Tools
- Genetic Indicators
- *In Situ* Sensors
- Satellites
- Emerging Technology

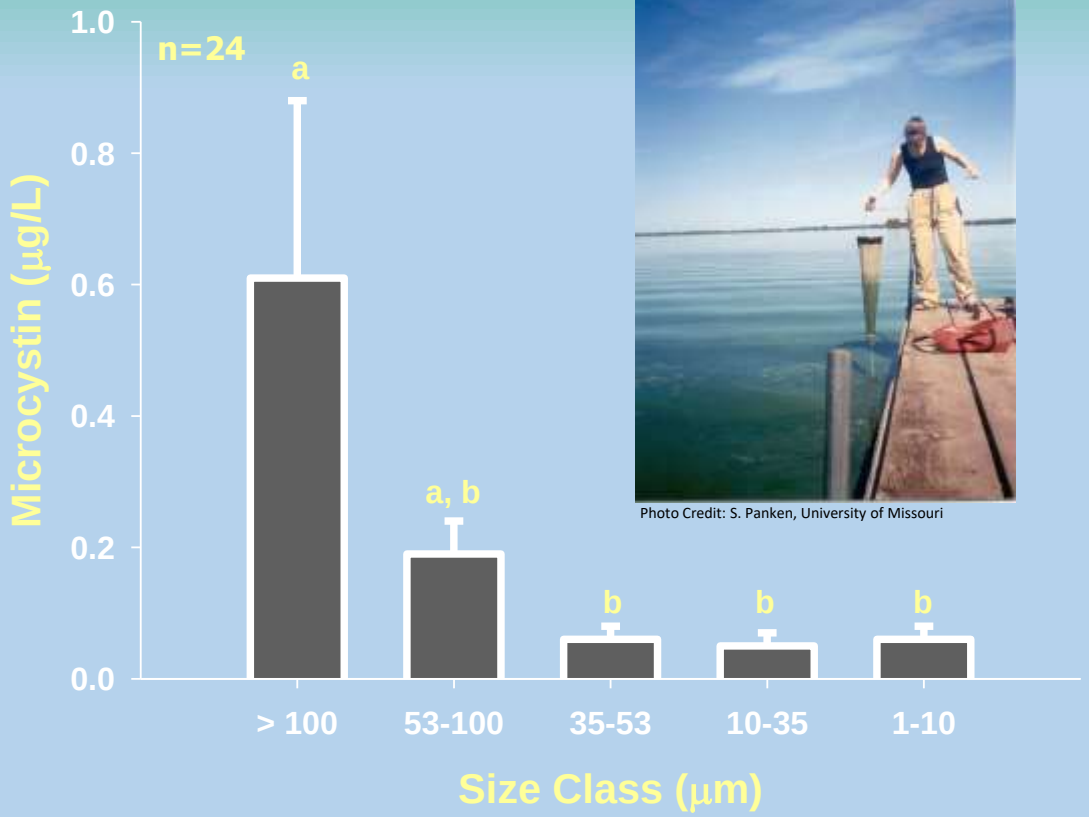
Photo Credit: B. Rosen, USGS

Photo Credit: J. Graham, USGS

Photo Credit: LandSat 8

USGS
science for a changing world

Cyanobacteria Colonies or Filaments Large Enough to Be Retained on a Net Can Be A Useful Indicator



After Graham and Jones, 2007, Lake and Reservoir Management

Photo Credit: S. Panken, University of Missouri

Photo Credits: J. Graham, USGS

USGS
science for a changing world

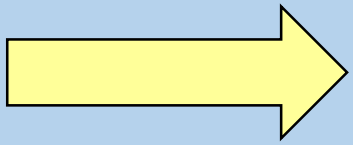
Aerial- and Ground-Based Cameras Show Potential as Early Indicators

Photo Credit: E. Emory, USACE

Photo Credit: C. Smith, USGS

July 20, 2016 at 3:54 pm

Photo Credit: G. Foster, USGS



Milford Lake, KS

July 20, 2016 4:09 pm

Photo Credit: G. Foster, USGS

USGS
science for a changing world

Test Strips May Be Effective for Rapid Detection of Relatively High Concentrations of Cyanotoxins

- Tests take a minimum of 45 minutes, and there are several critical steps
- Interpretation is difficult and highly subjective
- Work better at higher cyanotoxin concentrations

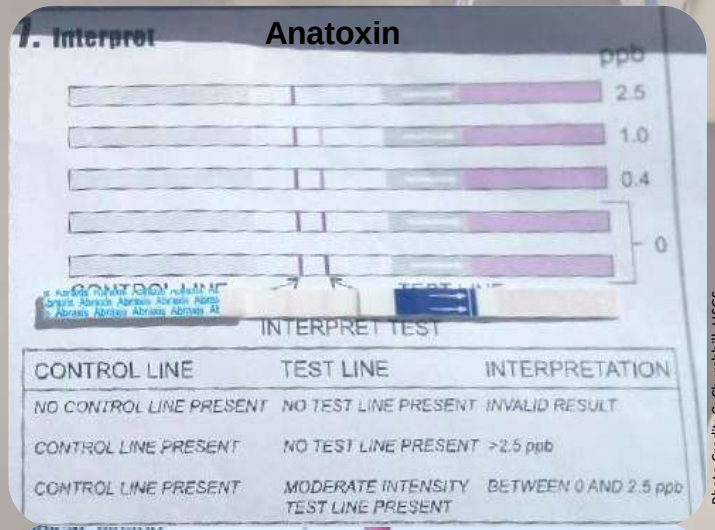


Photo Credit: C. Churchhill, USGS

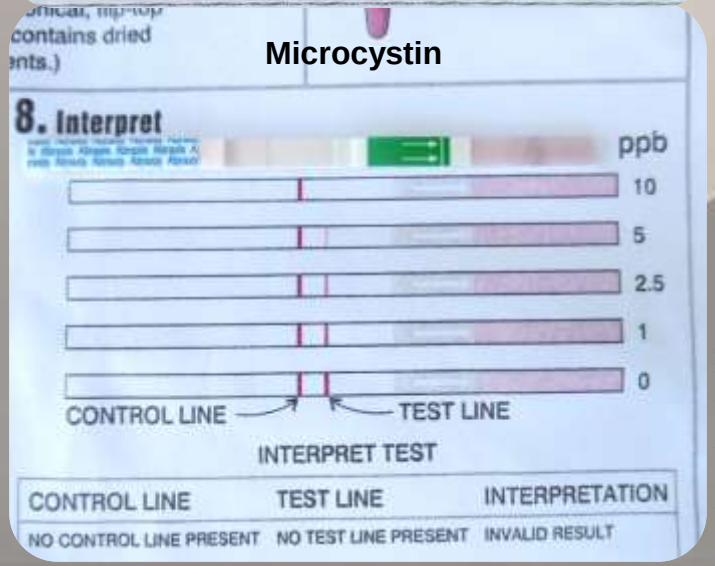
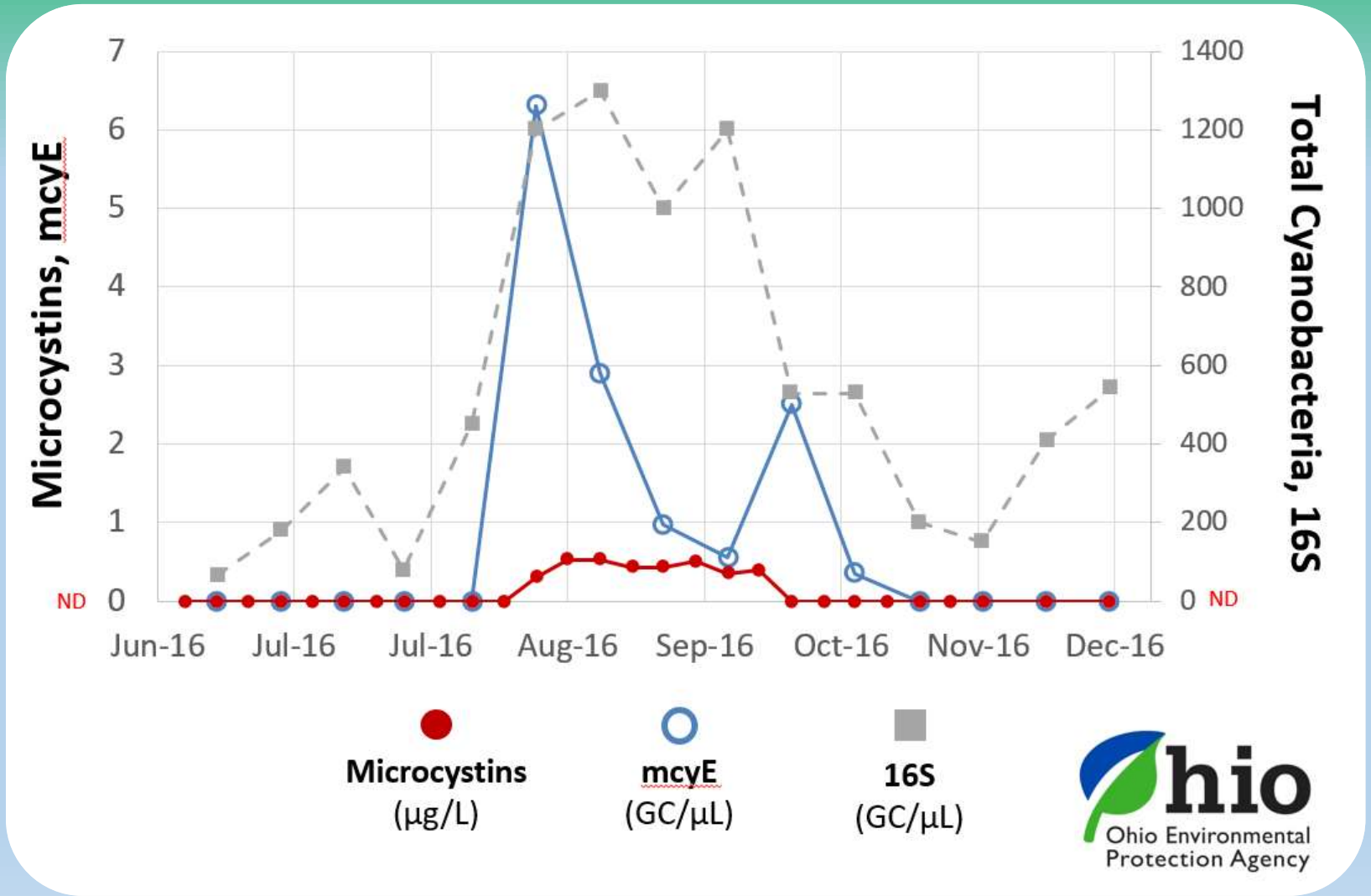


Photo Credit: C. Churchhill, USGS

USGS science for a changing world

Courtesy of V. Christensen and C. Churchill, USGS

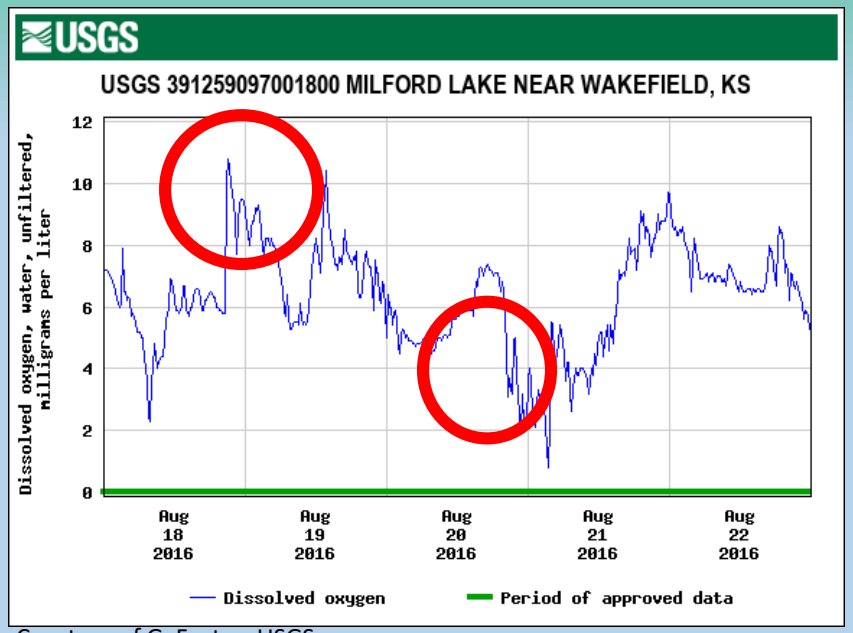
Genetic Data May Provide an Early Indicator of Cyanotoxin Occurrence



USGS
science for a changing world

Courtesy of R. Briland, OH EPA

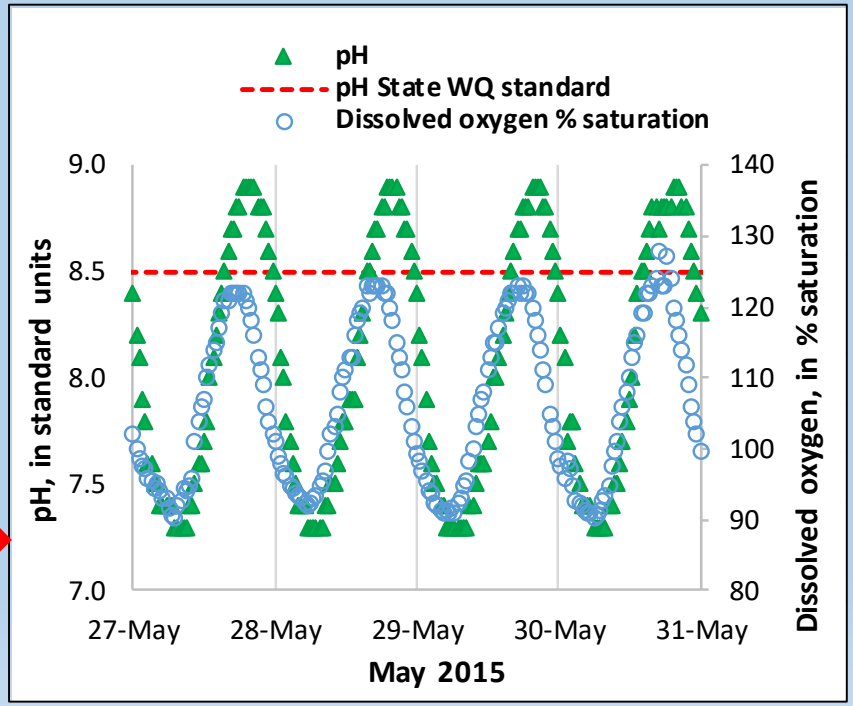
Diurnal Patterns in pH and Dissolved Oxygen May Be Indicative of Potentially Harmful Blooms



Courtesy of G. Foster, USGS

DO response during a lake HAB event in Milford Lake, KS

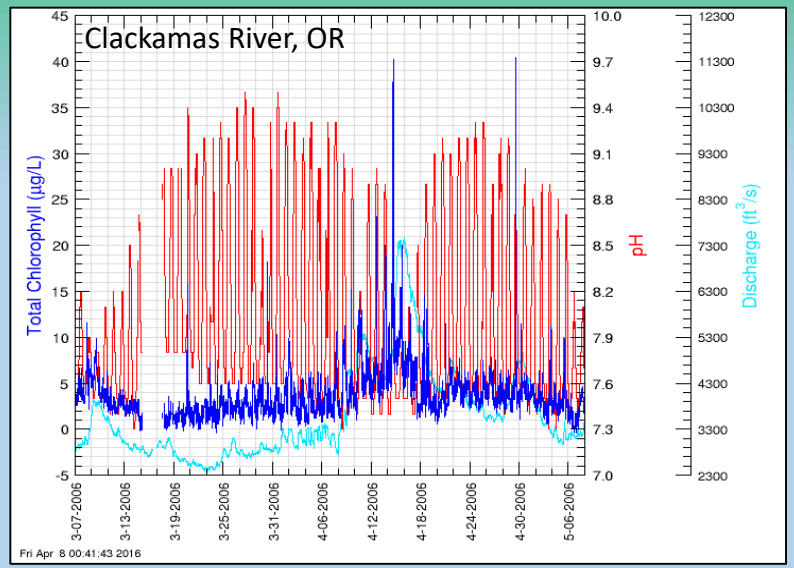
DO & pH response during a river benthic bloom event in the Clackamas River, OR



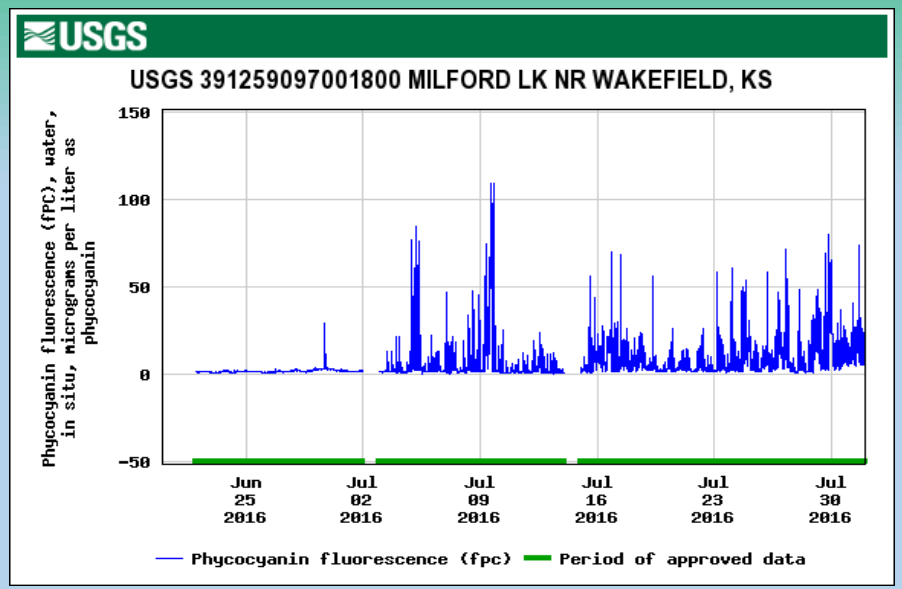
Courtesy of K. Carpenter, USGS

USGS science for a changing world

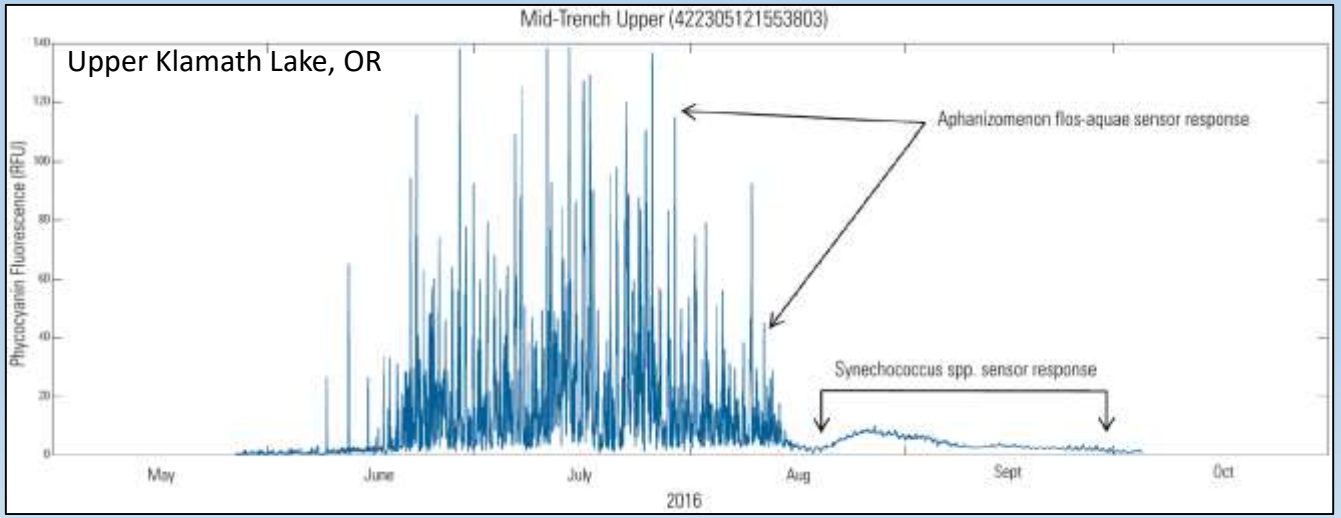
Diurnal or Noisy Patterns in Algal Fluorescence May Be Indicative of Potentially Harmful Algal Blooms



Courtesy of K. Carpenter, USGS



Courtesy of G. Foster, USGS



Courtesy of O. Stoken, USGS

USGS science for a changing world

Cameras May Provide Additional Lines of Evidence When Interpreting Sensor-Based Data

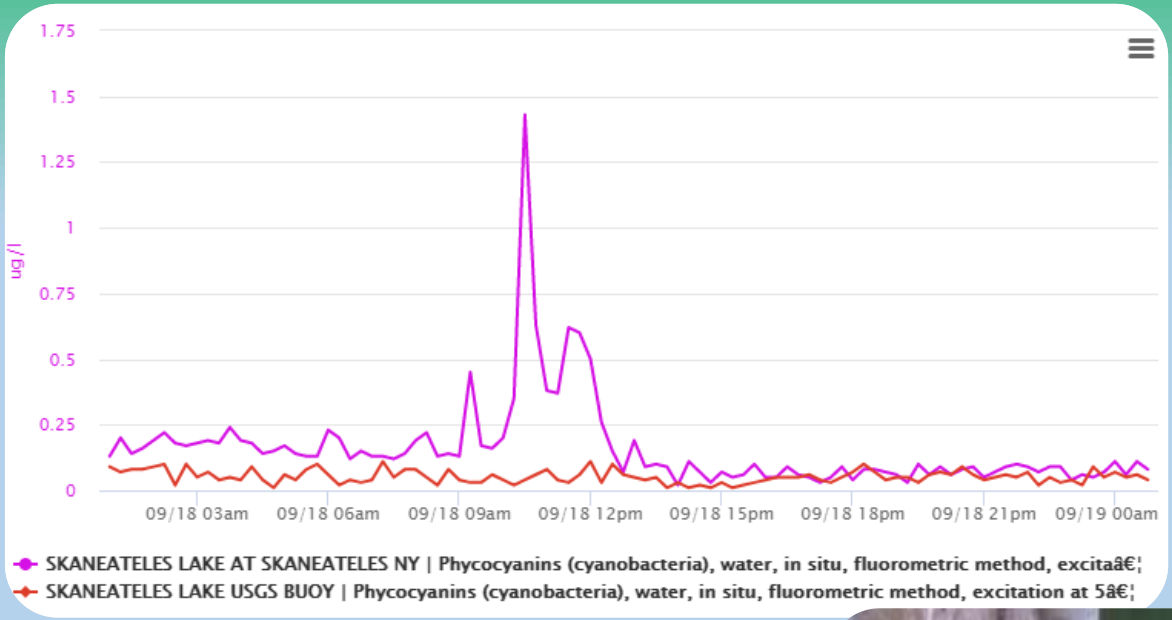
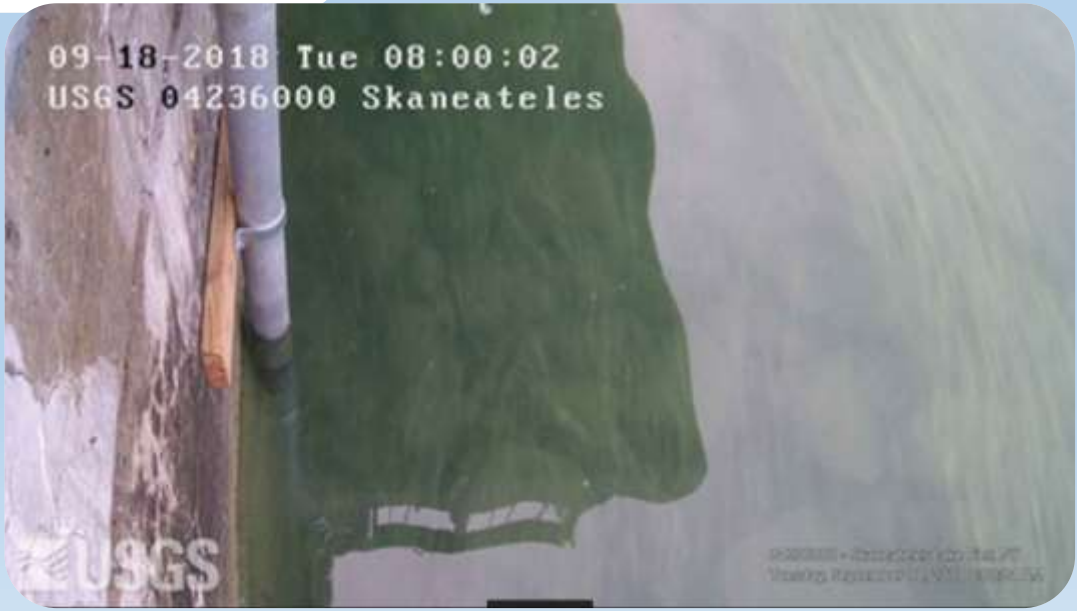


Photo Credit: J. Wernly, USGS

https://ny.water.usgs.gov/maps/habs/

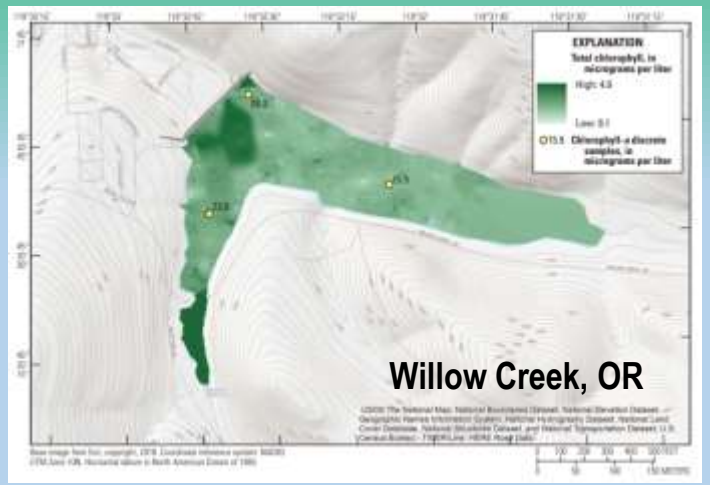
Photo Credit: J. Wernly, USGS



USGS science for a changing world

Courtesy of G. Foster, USGS

Mobile Sensor Arrays Allow High Resolution Spatial Data Collection to Characterize Bloom Severity and Extent



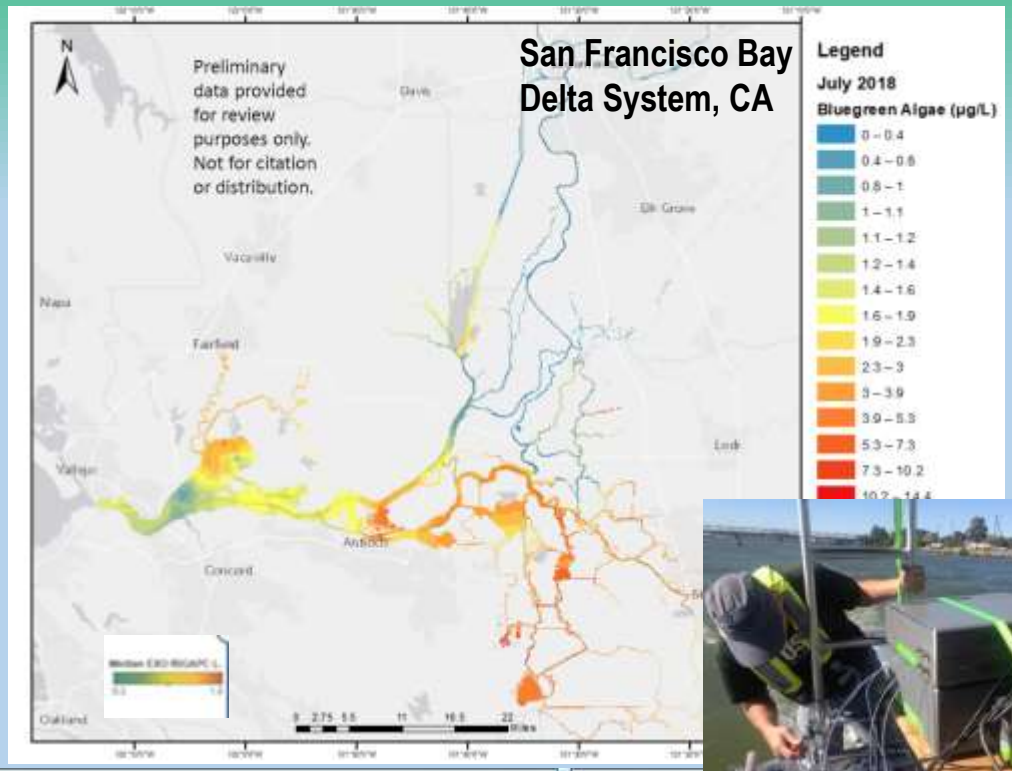


Photo Credit: B. Bergamaschi, USGS

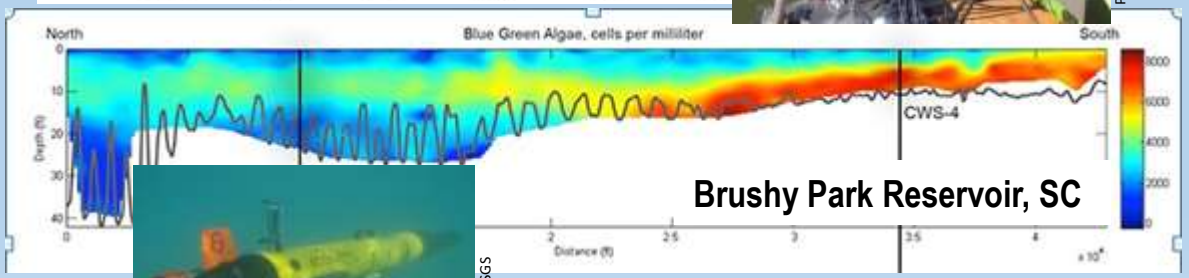
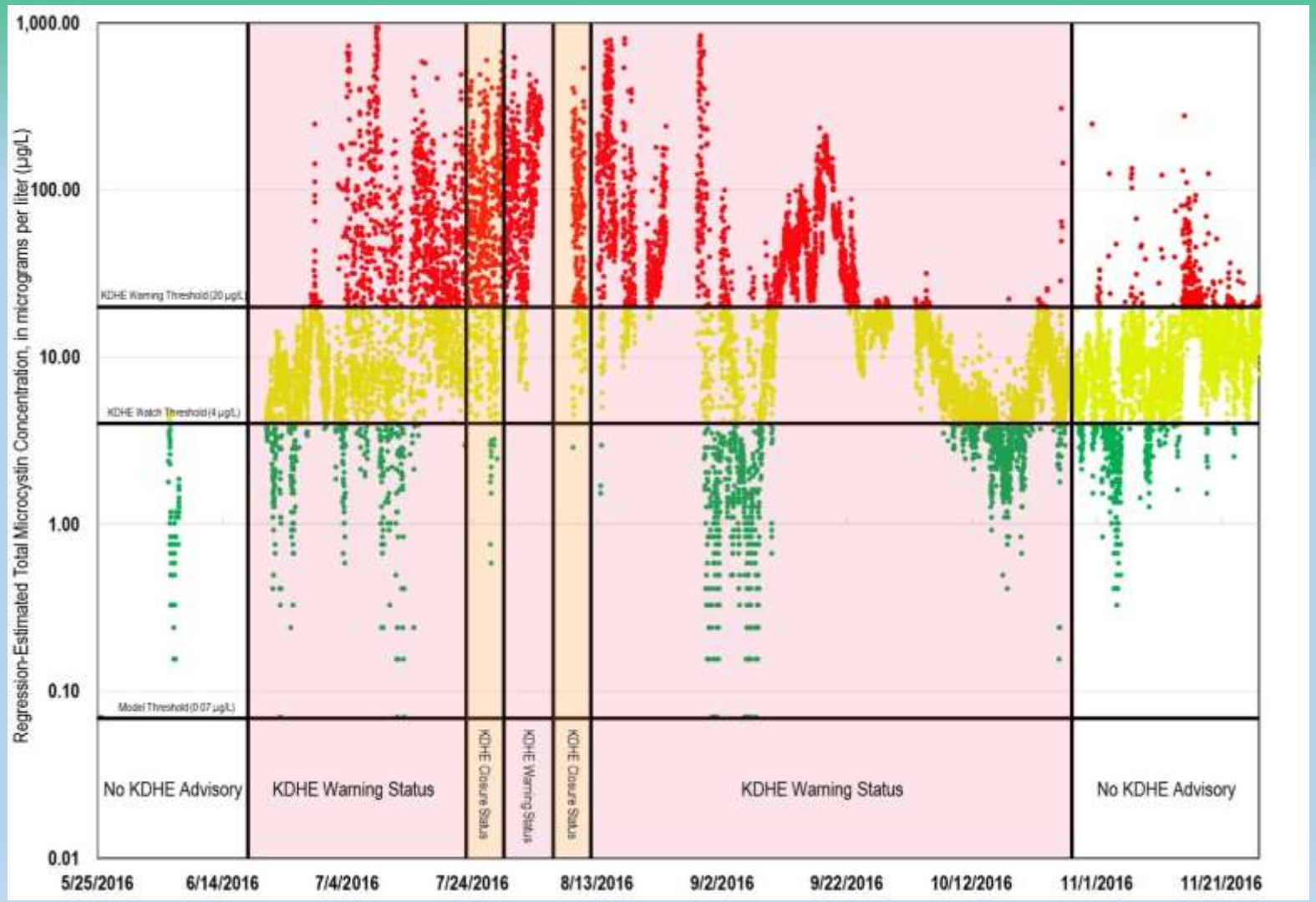


Photo Credit: USGS

USGS
science for a changing world

Courtesy of B. Bergamaschi, C. Journey, and C. Smith, USGS

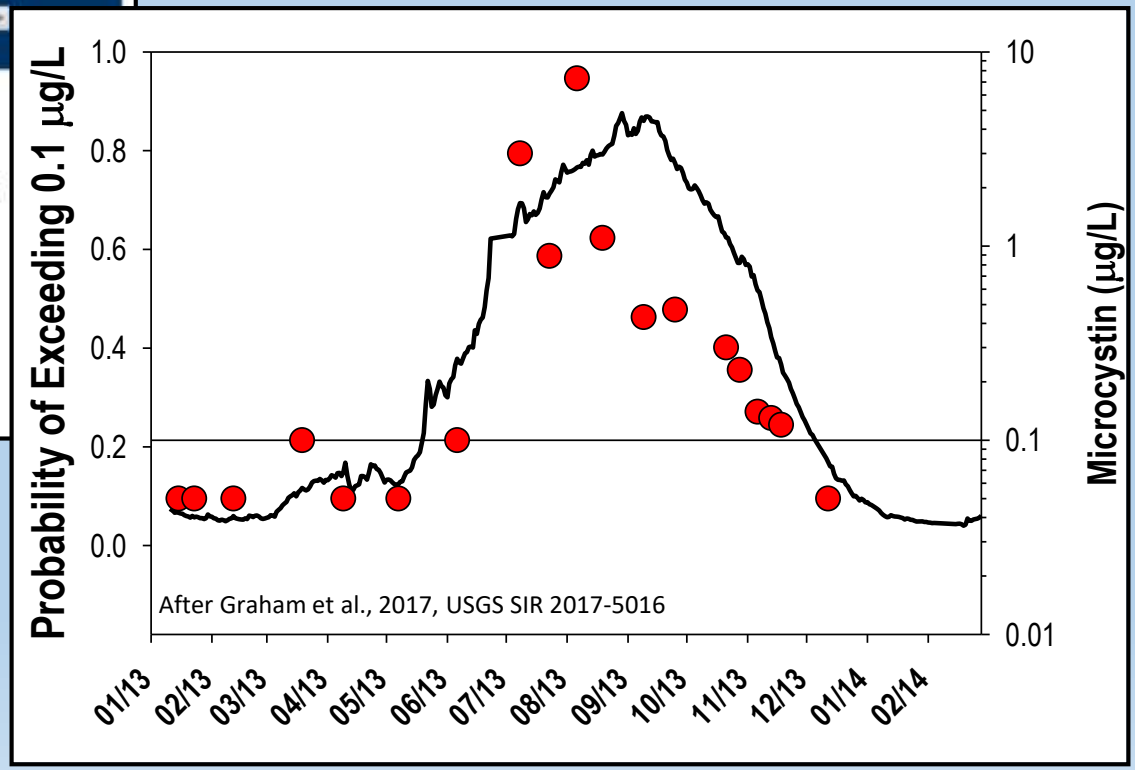
Sensor Data Can Be Used to Develop Models to Estimate Cyanotoxin Concentrations in Real Time



USGS science for a changing world

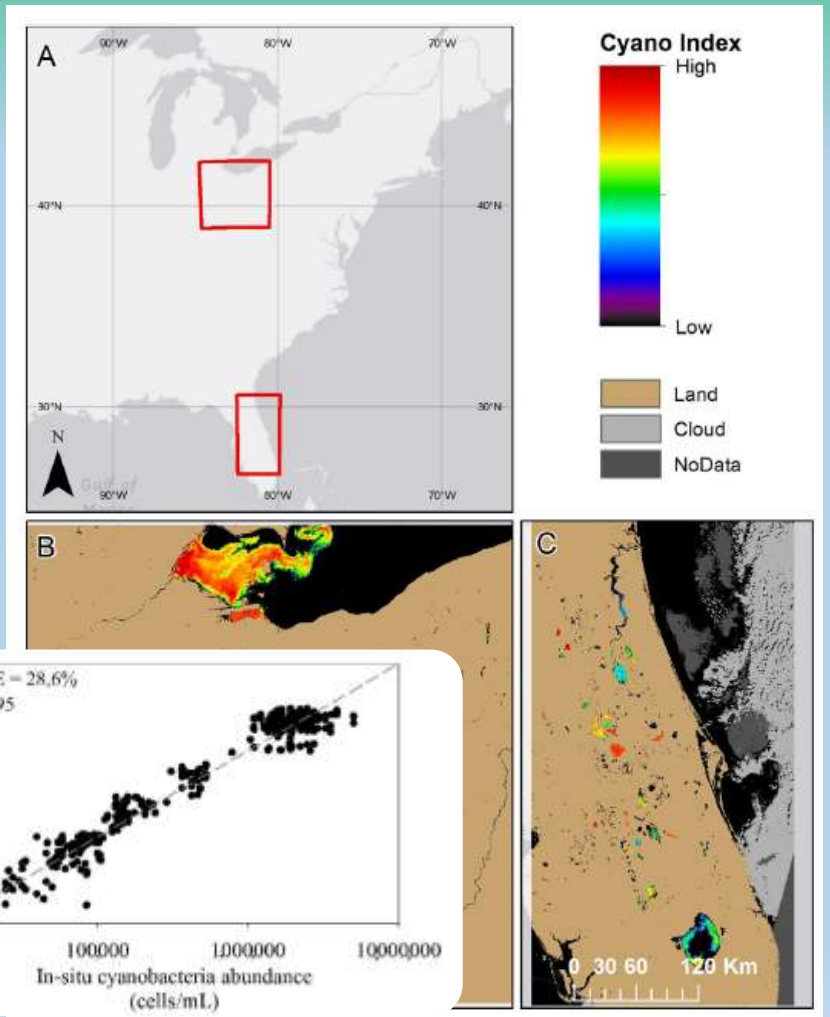
After Foster et al., 2018, USGS SIR 2018-5166

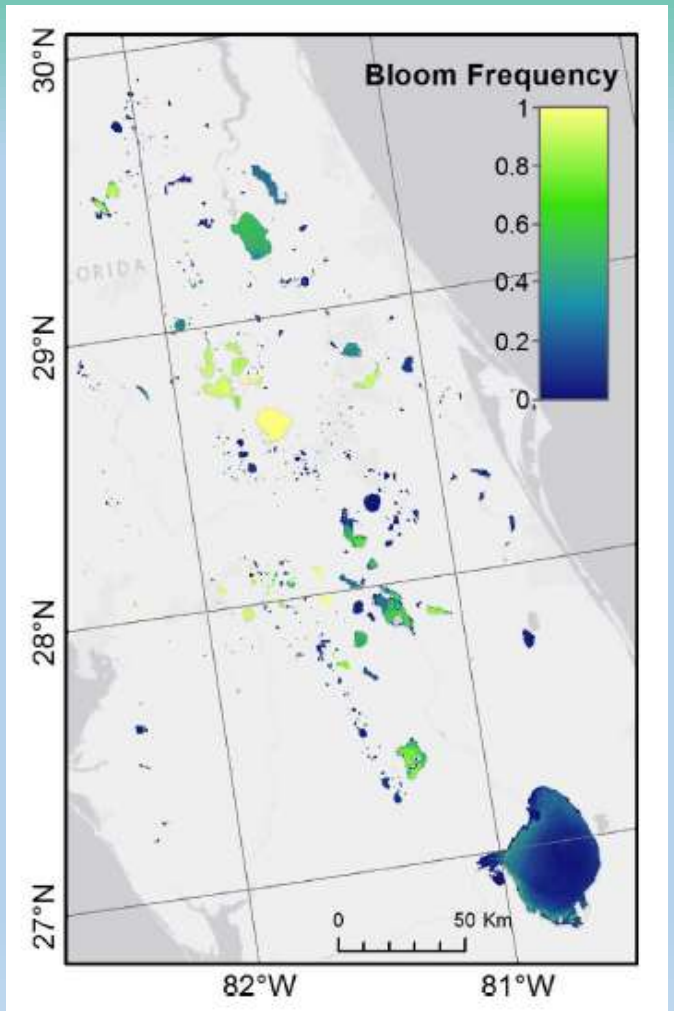
Sensor Data Can Be Used to Develop Models to Compute Probability of Cyanotoxin Occurrence



USGS
science for a changing world

Satellite Imagery May Capture Spatial and Temporal Variability Across a Regional Scale





After Clark and others, 2017, Ecological Indicators

USGS science for a changing world

Imaging Technology May Provide Near Real-Time Notification of the Presence of Potentially Harmful Algae

Photo Credit: M. Broshnahan, WHOI

Photo Credit: McLane Research Laboratories, Inc.

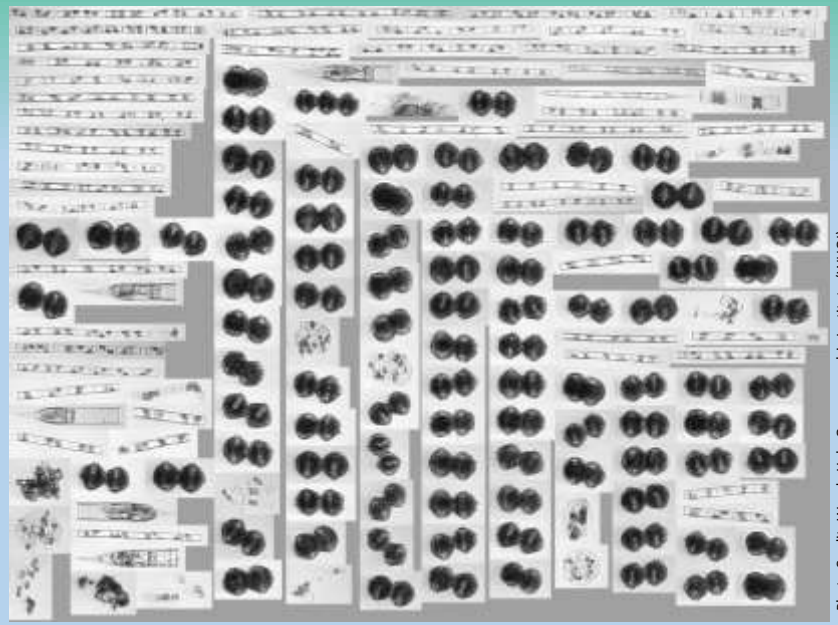
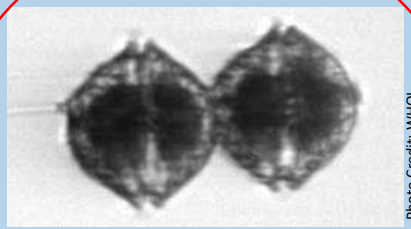


Photo Credit: Woods Hole Oceanographic Institute (WHOI)



Alexandrium fundyense

Photo Credit: WHOI

USGS science for a changing world

https://hablab.whoi.edu/sp

Courtesy of C. Culberson, USGS

Environmental Sample Processors

- Cyanotoxins
- Cyanotoxin synthetase genes
- Testing in Lake Erie - Collaboration between NOAA, MBARI, WHOI, OSU

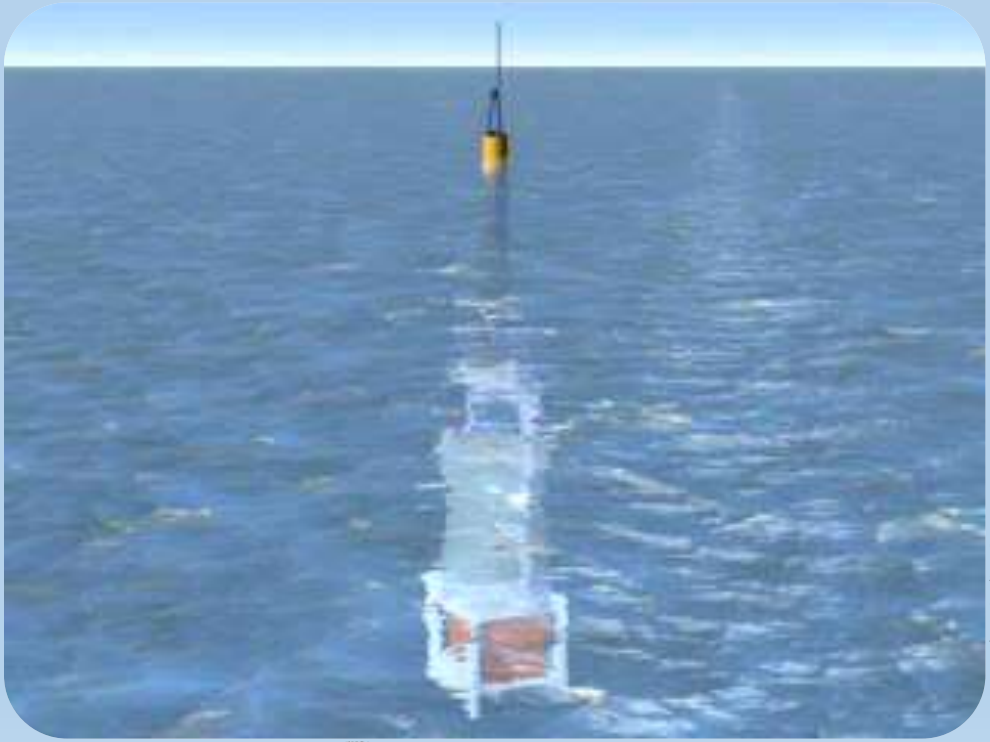


Photo Credit: NOAA

Photo Credit: NOAA

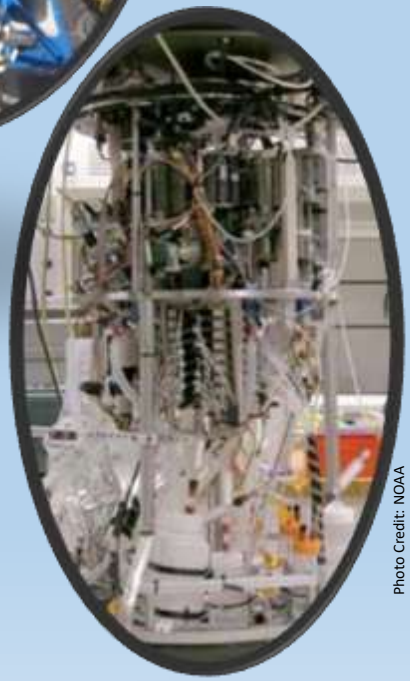


Photo Credit: NOAA

USGS science for a changing world

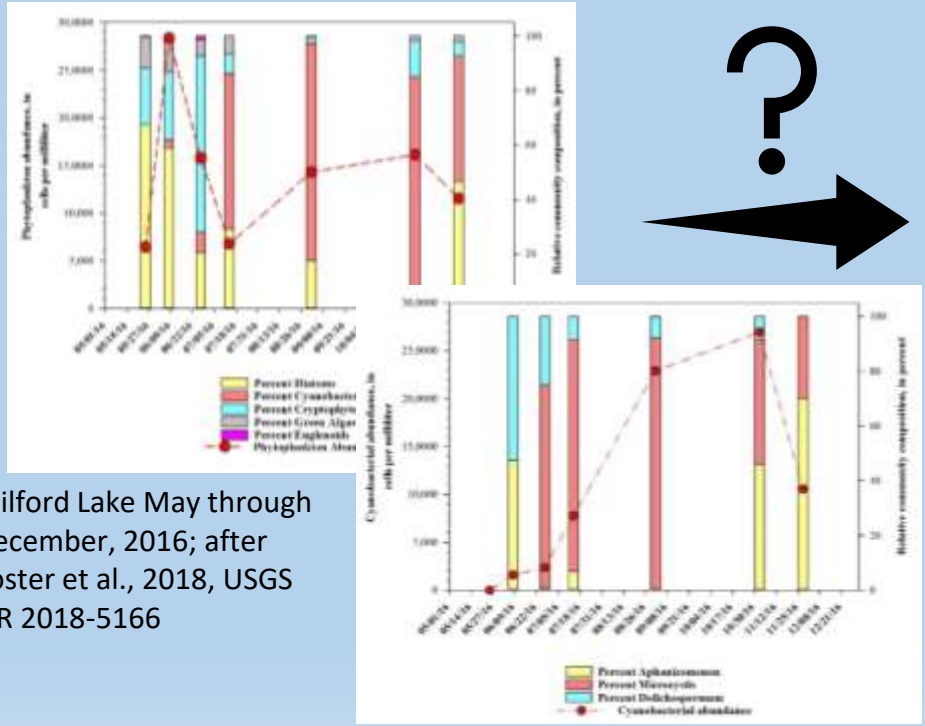
NOAA

CILER Cooperative Institute for Limnology and Ecosystems Research

Courtesy of T. Davis, Bowling Green State University

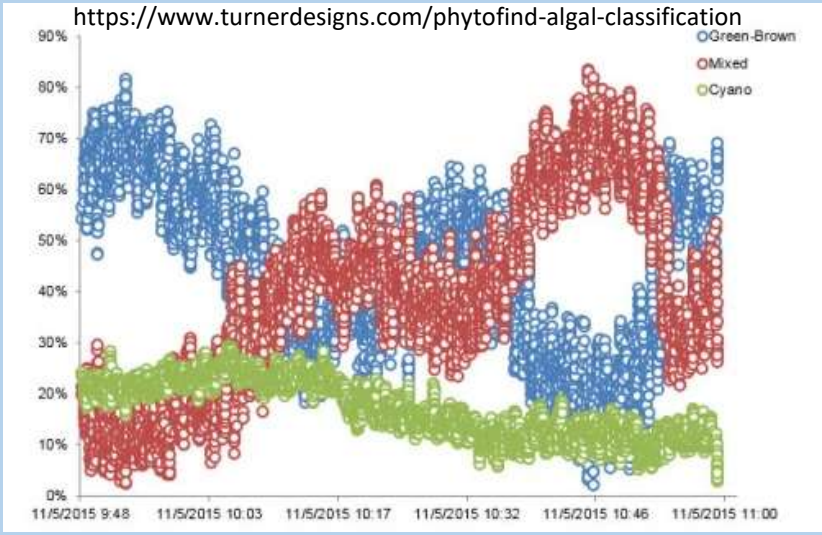
Multichannel Fluorometers Have Potential to Measure Phytoplankton Community Composition

Photo Credit: L. Nystrom, USGS



Milford Lake May through December, 2016; after Foster et al., 2018, USGS SIR 2018-5166

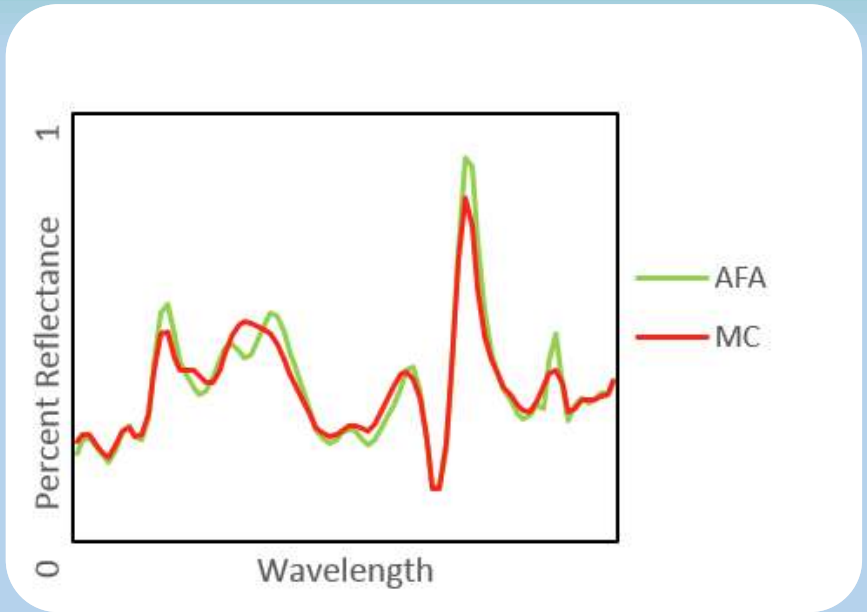
https://www.turnerdesigns.com/phytofind-algal-classification

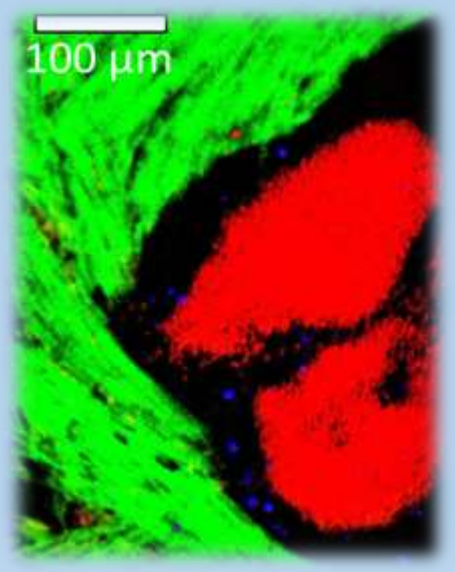


Courtesy of G. Foster, USGS

USGS science for a changing world

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





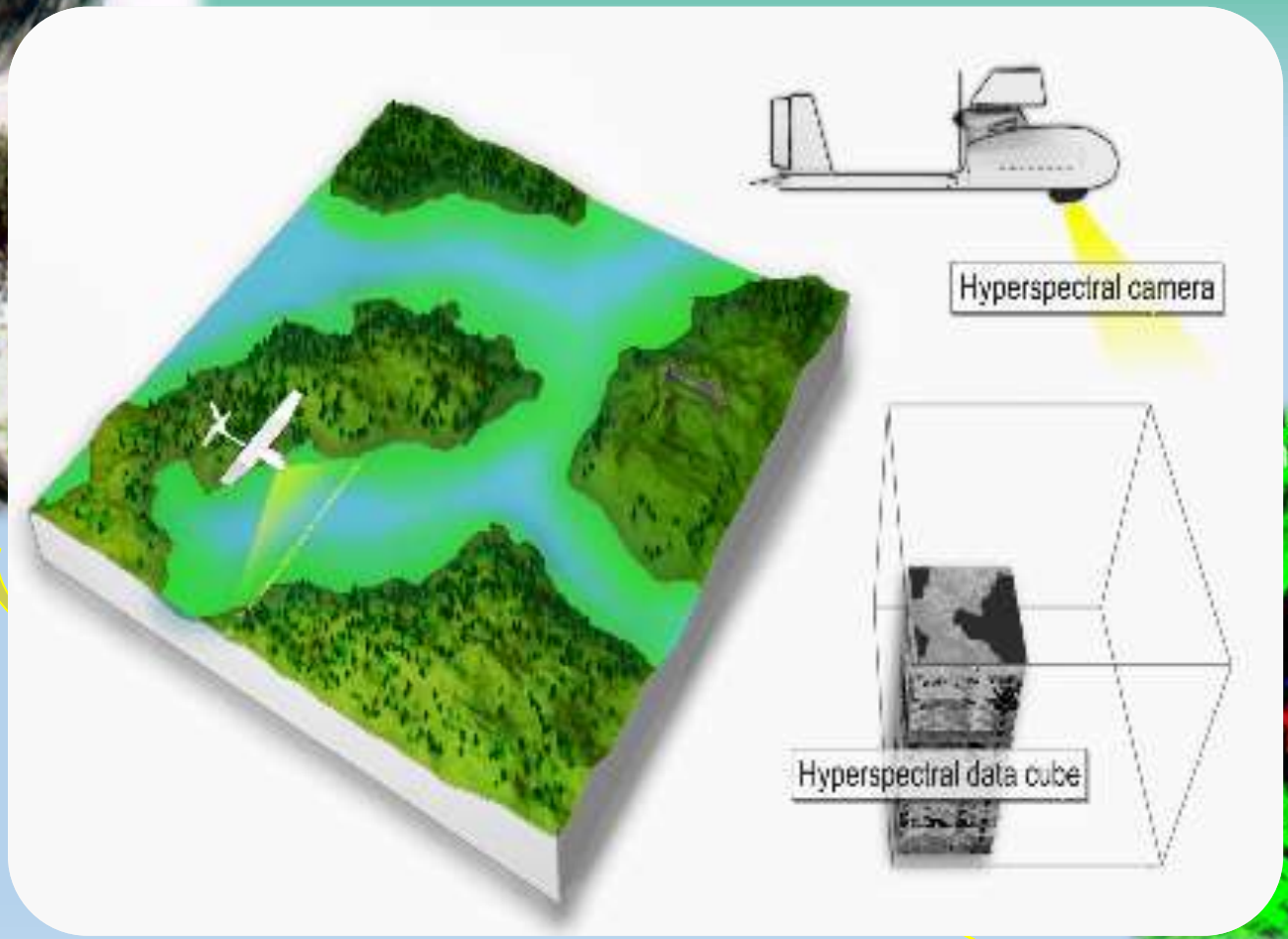
USGS science for a changing world

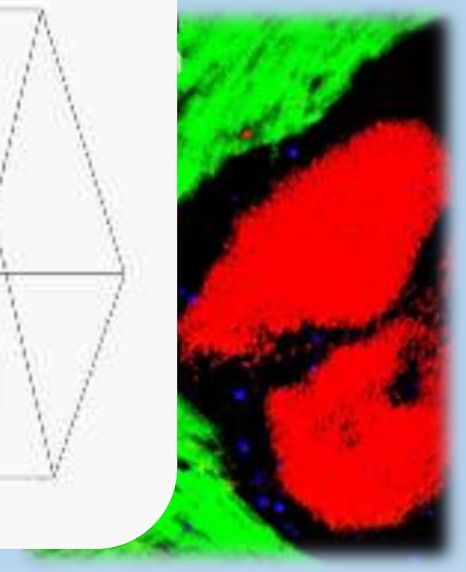
PML

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

Paine et al, 2018, Journal of Applied Remote Sensing

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





USGS science for a changing world

PML

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

Paine et al, 2018, Journal of Applied Remote Sensing

Citizen Science is Becoming an Increasingly Important Resource for Harmful Algal Bloom Monitoring

Submit your images

1) take pictures of cyanobacteria found in your sample, 2) upload the images and relevant info on iNaturalist.org

NOTE: Be sure include basic information about where and when the sample was collected.

NOTE: If not sure what cyanobacteria you have, that's fine! Go ahead and upload your image.

To submit your images, sign in or register at:

CYANOSCOPE ON INATURALIST

bloomWatch

Welcome to bloomWatch!

Crowdsourcing to find and report potential cyanobacteria blooms

bloomWatch Updated to Version 2.8

Jasper Hobbs | bloomwatch

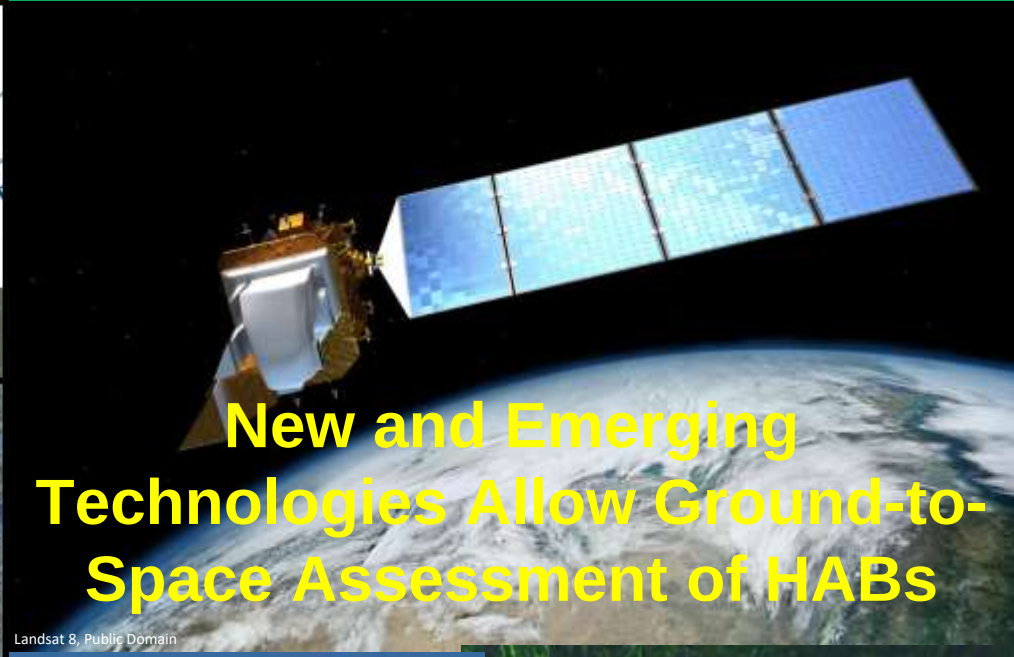
A new version of the bloomWatch app in the app store for iPhone and the Google Play store for Android. Version 2.8 features even more states listed, allowing the users to send their bloom reports directly to relevant state agencies.

GET BLOOMWATCH ON IOS

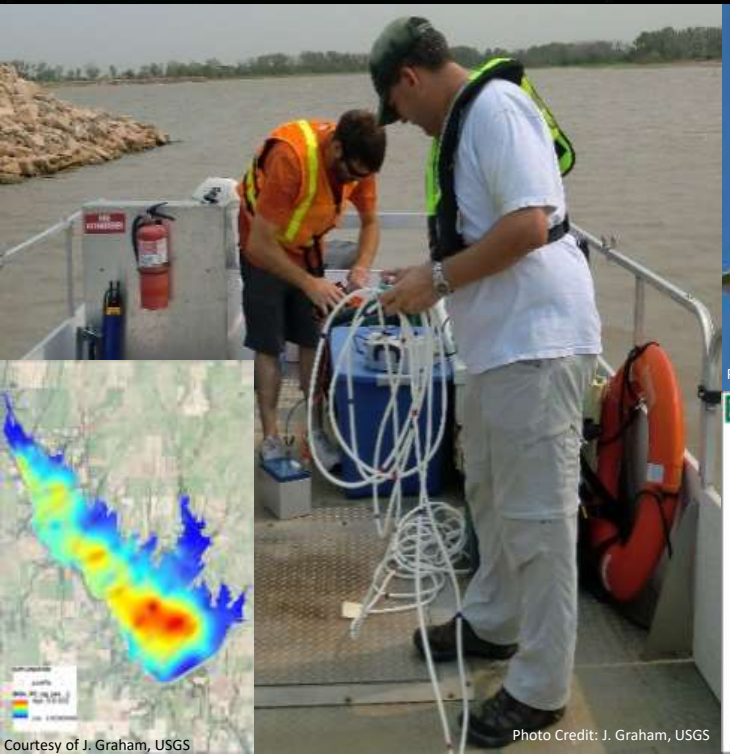
GET BLOOMWATCH ON ANDROID

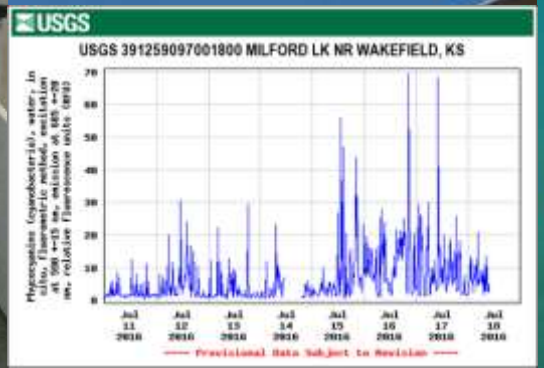
USGS science for a changing world

https://cyanos.org/



New and Emerging Technologies Allow Ground-to-Space Assessment of HABs





Integrated Approaches are Needed to Understand, Quantify, and Predict Harmful Algal Blooms

- Individual systems are unique.
- Spatial and temporal variability present challenges to data collection, analysis, and interpretation.
- A range of sensor-based applications have been developed to quantify harmful algal bloom occurrence and severity.
- A variety of tools for early warning and prediction are being developed and used.

Photo Credit: J. Graham, USGS

Photo Credit: L. Nystrom, USGS


Photo Credit: B. Brink


Photo Credit: D. Obrecht, University of Missouri


Photo Credit: K. Loftin, USGS


Photo Credit: J. Graham, USGS


Photo Credit: J. Graham, USGS


Photo Credit: B. Brink

jlgraham@usgs.gov
518-285-5706

USGS
science for a changing world