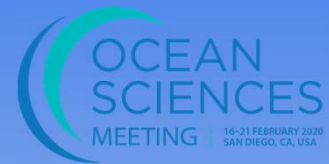




Satellite remote sensing of Cyanobacteria:
Success stories of management taking
action and the CyAN data sharing app.

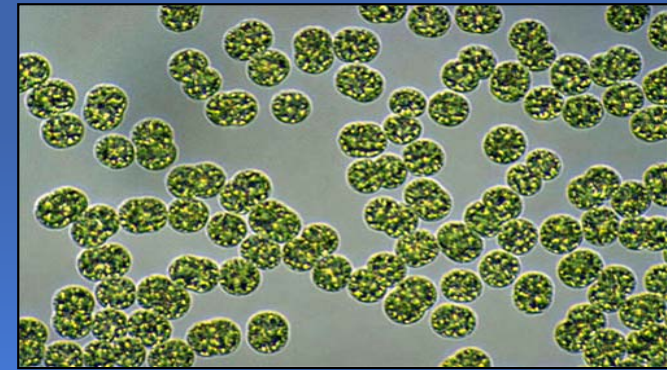
Bridget N. Seegers, Blake A. Schaeffer,
P. Jeremy Werdell, Richard P. Stumpf





Landsat 8

CYAN



Photograph by Dave Zapotosky



Photograph by David Ruck

Will This Toxic Algae Bloom Eat Florida?

| EWWW |

The Daily Beast, July 2016

A thick, toxic guacamole-like algae is choking Florida's beaches—and experts say we'll only see more of it in the years to come.

WADING INTO DANGER

Growth of toxic algae could make California's lakes unsafe

San Gabriel Valley Tribune, June 2016

Algae Can Poison Your Dog

Dogs have become fatally ill after frolicking in water infused with the toxic algae, owners said.

New York Times, Aug 2019

WATER

Toxic algae bloom closes Utah lake, sickens more than 100 people

The Guardian, July 2016

ENVIRONMENT

Poisonous Algae Blooms Threaten People, Ecosystems Across U.S.

August 29, 2016 · 4:21 PM ET

Heard on All Things Considered



After boy sickened, pets killed, Minnesota warns of toxic blue-green algae in lakes

MPCA warns beachgoers about foul water that has killed 2 pets and sent a boy to the hospital.

Star Tribune, July 2015

TOXIC ALGAE POSES DANGER ON LOCAL LAKES

Idaho

August 13, 2019 at 5:00 am | By KAYE THORNBRUGH Hagadone News Network





Cyanobacteria Assessment Network (CyAN)

Multi-agency project EPA, NOAA, USGS, NASA

GOAL: Support the environmental management and public use of U.S. lakes by detecting and quantifying algal blooms and related water quality indicators using satellite data records.

Approach

Remote Sensing

Uniform and systematic approach for identifying cyanobacteria blooms.
Strategy for evaluation and refinement of algorithms across platforms.

Information Distribution

Bring the technology to EPA, states and tribal partners. Provide notifications and decision support

Economics

Behavioral responses and economic value of the early warning system.

Environment

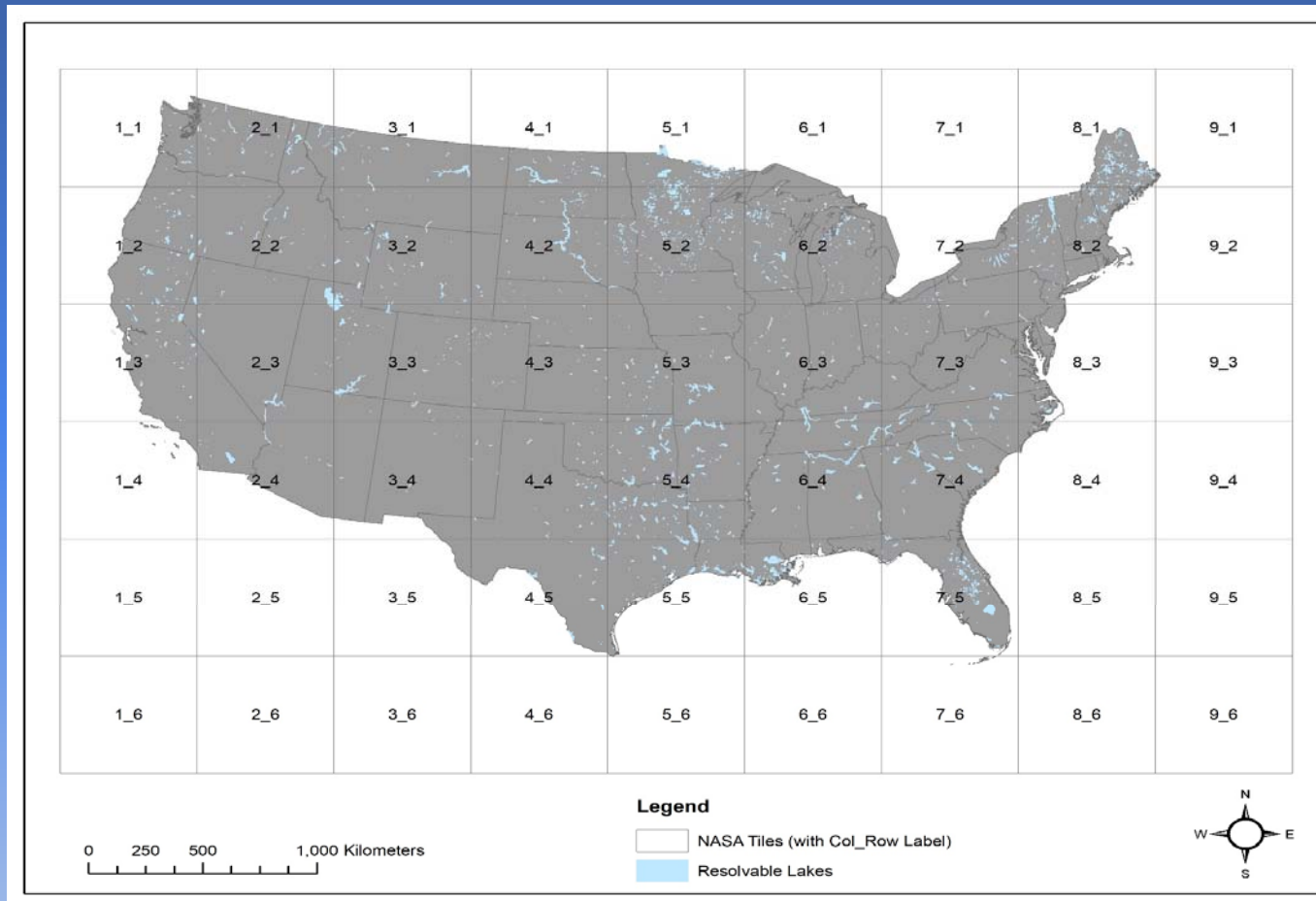
Identify landscape linkages causes of chlorophyll a and cyanobacteria.

Health

Exposure and human health effects in drinking and recreational waters.



Contiguous US (CONUS) tiles



MERIS (2002-2012) and OLCI (2016-) Full resolution (300 m)
1862 Resolvable lakes (3x3 pixel) <1% of lakes resolved 33% of surface intakes
A single pixel data for 15,545 lakes (5.6%) resolved 57% of surface intakes



Cyanobacteria
Assessment Network

Florida Tile

Mapped @300m

Jan 28, 2011 1 day image

Cyanobacteria Index (CI)

MERIS Image

Spatial 300m

Temporal 2-3 days

MERIS (2002-2012)

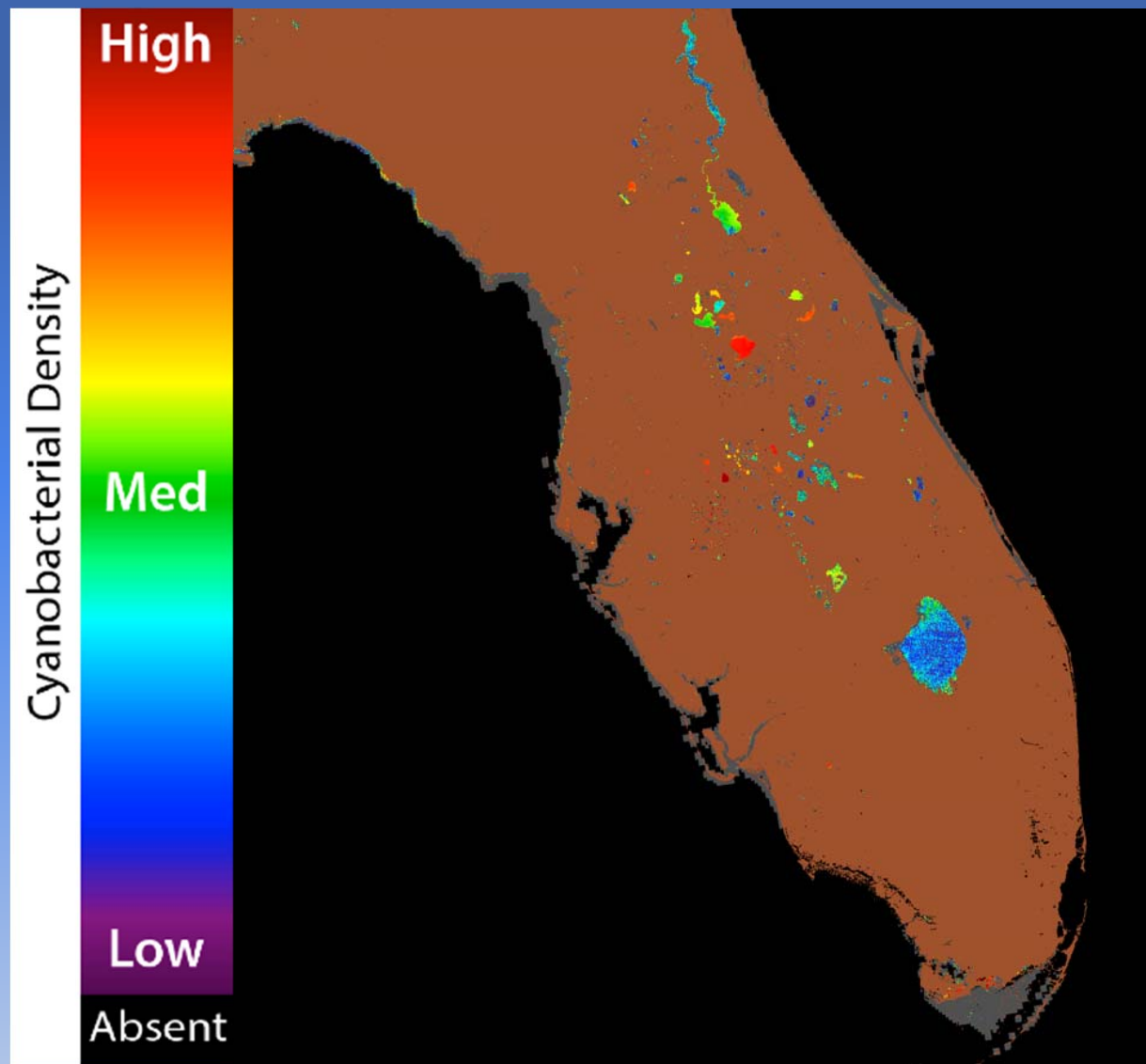
OLCI (2016-)

OLCI Images

from ESA satellite Sentinel 3a (soon 3b)

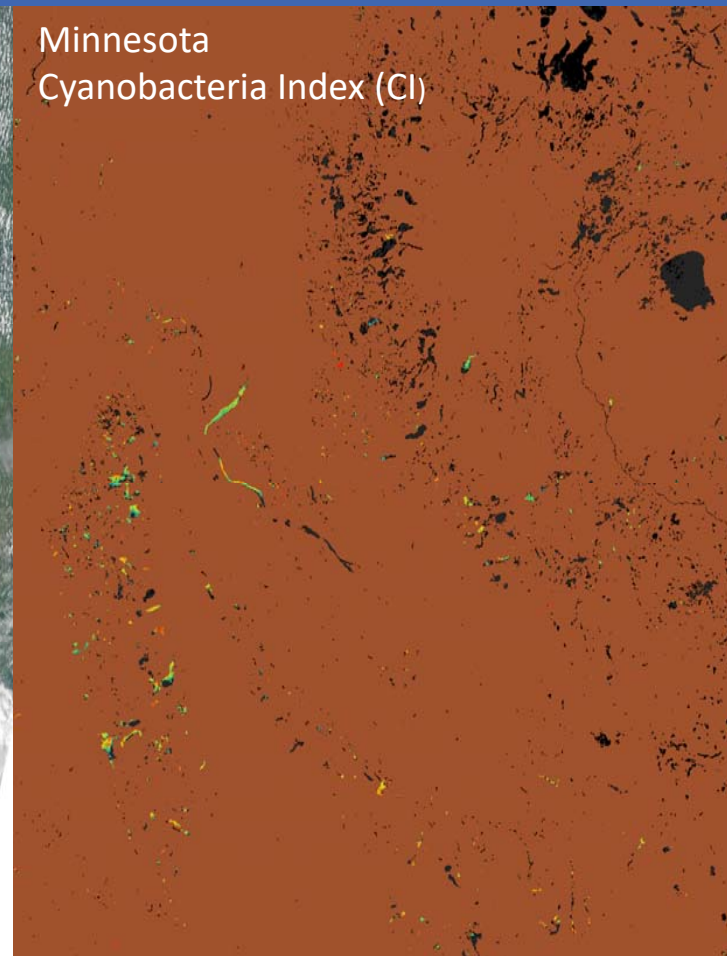
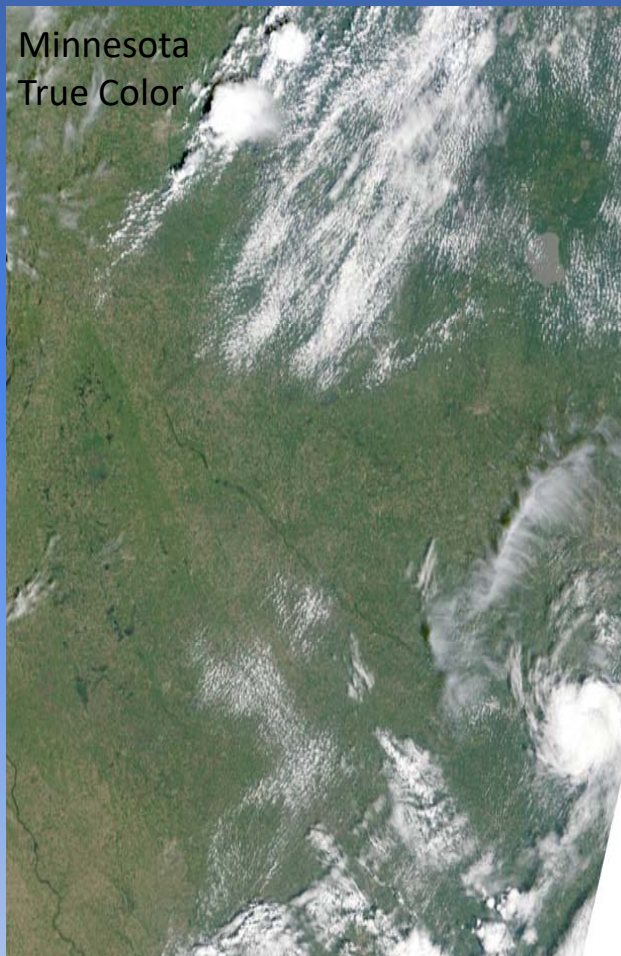


Cyanobacteria
Assessment Network



OLCI Images from ESA Sentinel 3 satellites

Cyanobacteria Index (CI). Spatial 300m Temporal 2-3 days



cells/ml
~ 6 million

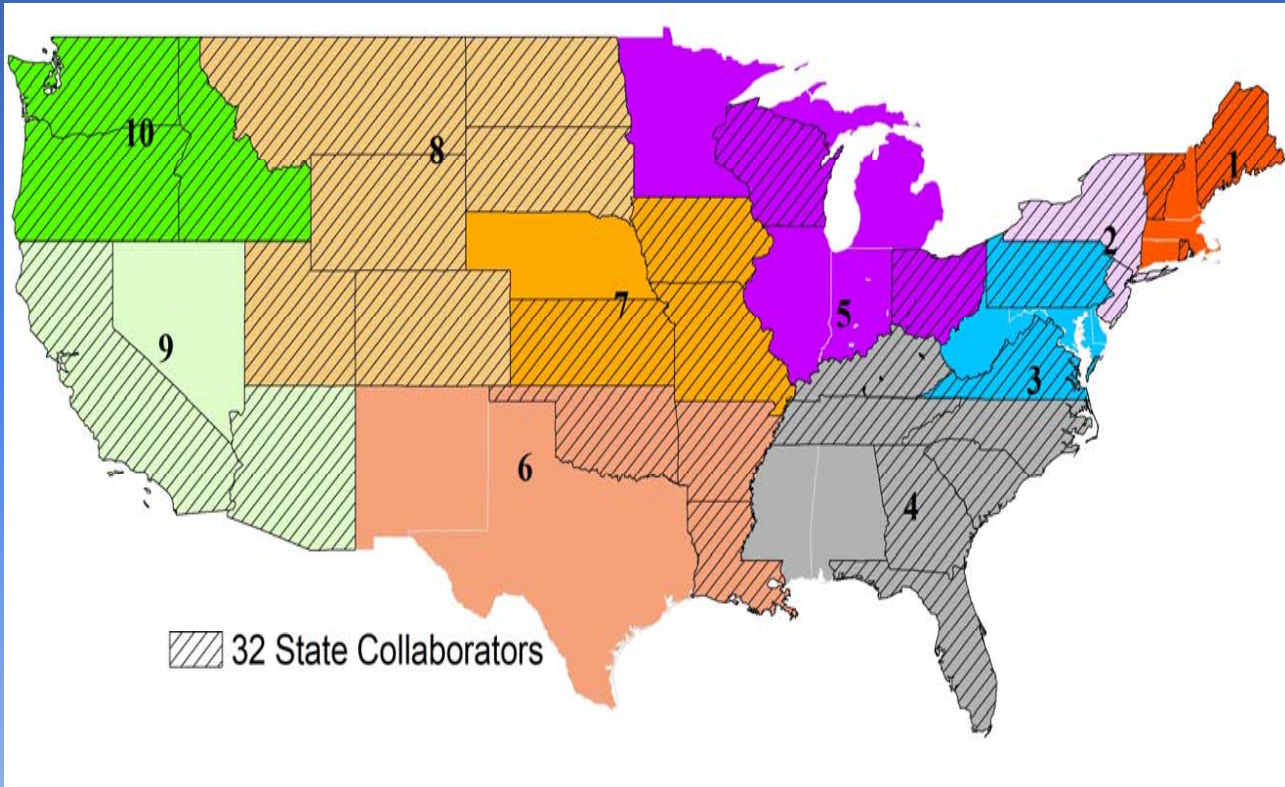


~10,000

- Information on
- Spatial extent
 - Severity
 - Duration



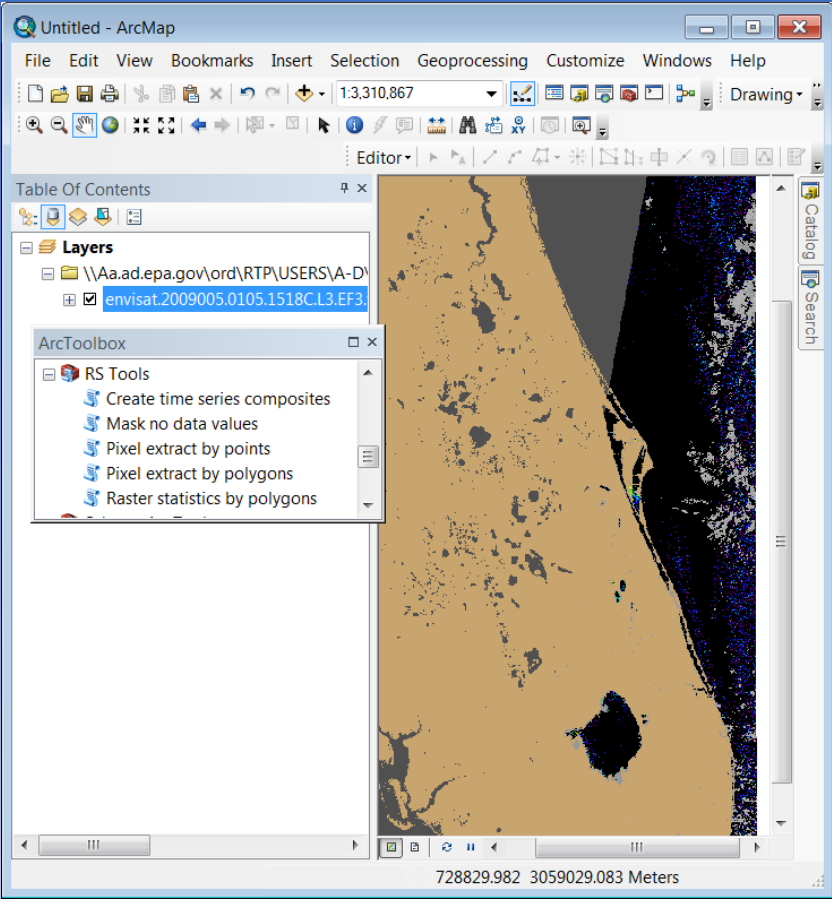
CyAN Collaborators and End Users



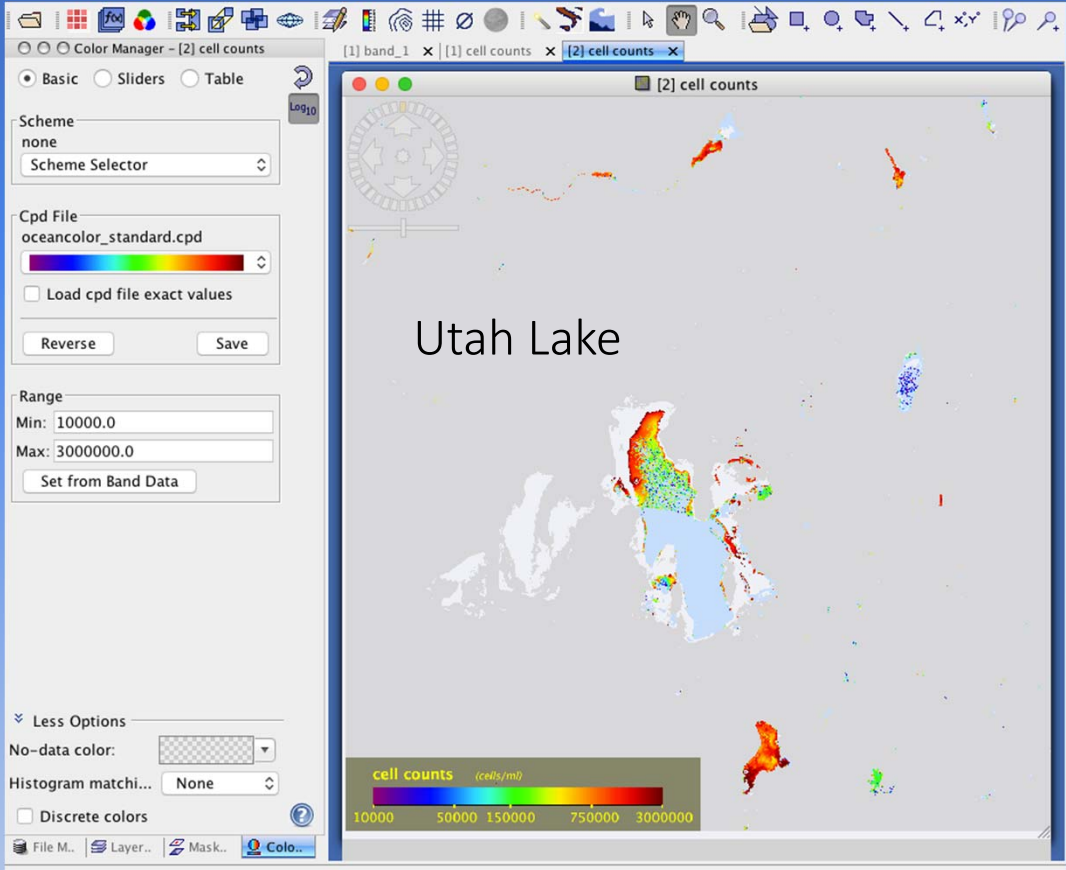
www.epa.gov/cyanoproject

Trainings and Software

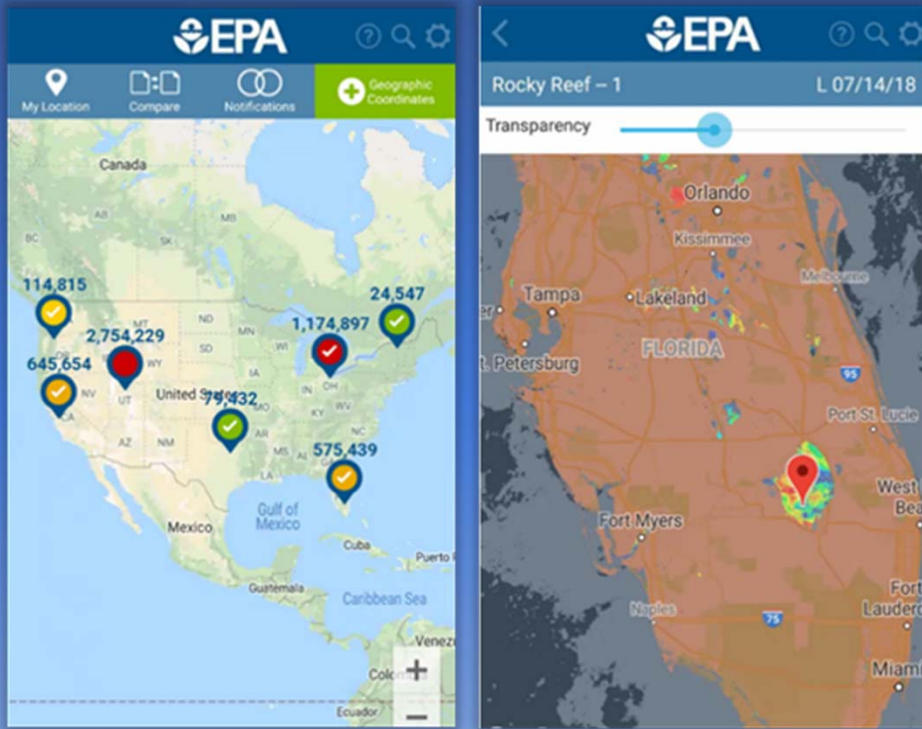
RSTools for ArcGIS



SeaDAS software



CyAN App



App makes it possible to

- easily share data and information with large numbers of people
- focus on individual lakes, current conditions and historic
- compare lakes of interest



(12) **United States Patent**
Schaeffer et al.

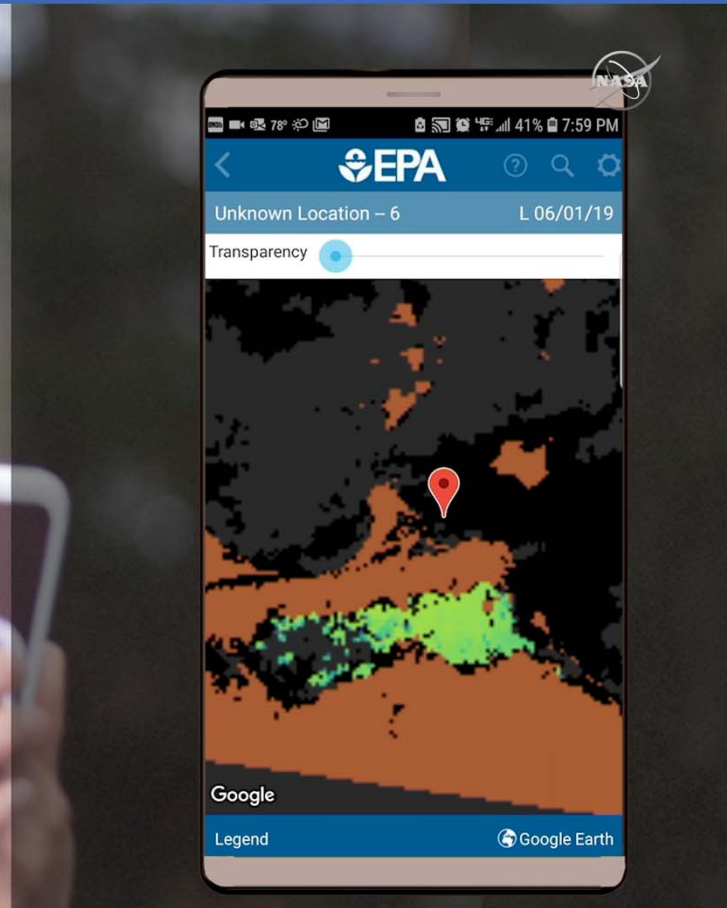
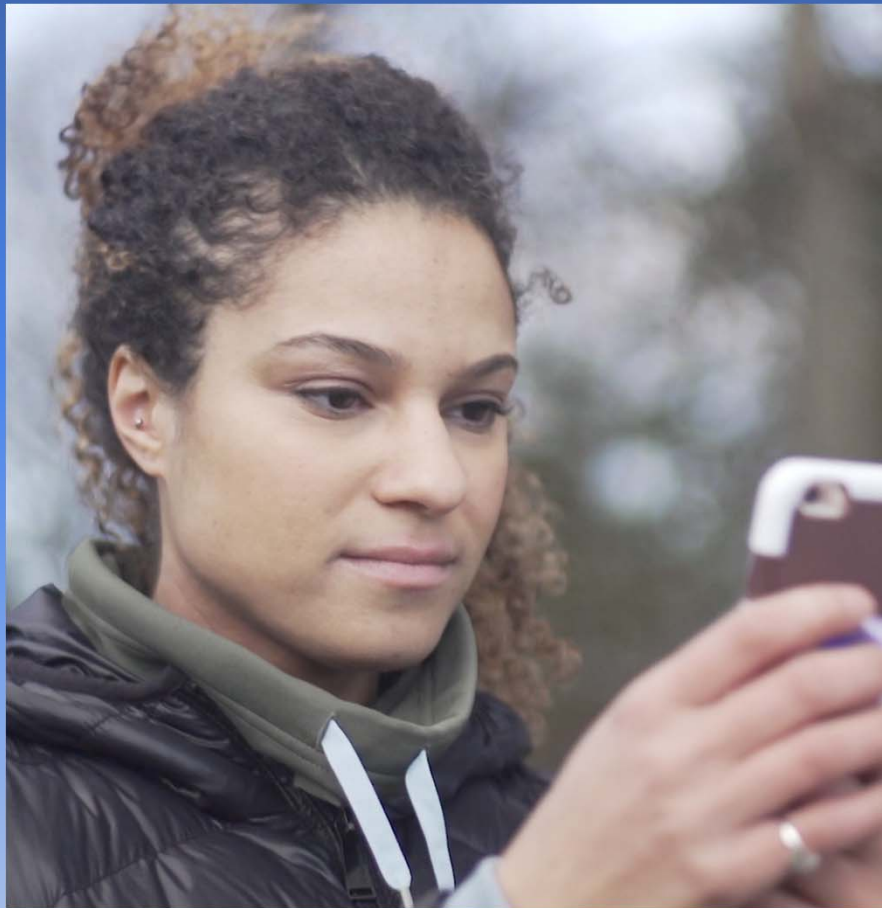
(10) **Patent No.:** US 10,290,089 B2
(45) **Date of Patent:** May 14, 2019

(54) **CYANOBACTERIA ASSESSMENT
NETWORK**

H04W 4/02 (2018.01)
G06F 16/9537 (2019.01)
H04L 29/08 (2006.01)

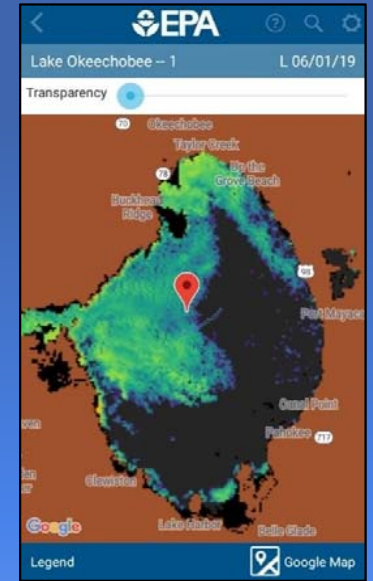
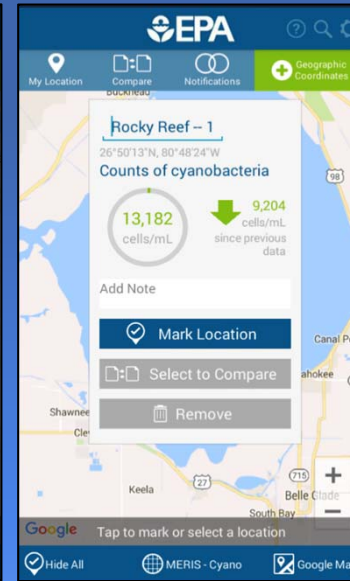
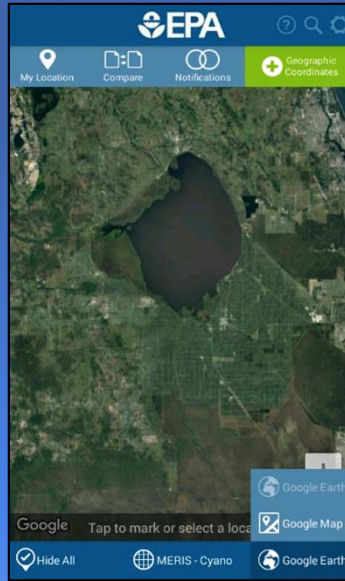
CYAN App

App uses weekly images



CYAN App

Look at lake of interest



Compare lakes and locations



Android only
Web interface coming

CyAN App Love



Aaron Borisenko, State of Oregon Department of Environmental Quality:

“... using CyAN app as an early warning system.”

Benjamin Holcomb, Utah Department of Water Quality:

“... allows UDWQ to better target field sampling and more efficiently use our limited resources to protect public health...”

Angela Shambaugh, Vermont Department of Environmental Conservation:

“... visualize that patchiness and provides additional context...”

Bart Johnsen-Harris, Environment America:

“...CyAN has proved to be a uniquely helpful tool.”

Lenard Long, Lake Cascade Citizen Scientist Monitoring Group:

“...enhance the community's ability to rapidly respond to and manage the growing threat posed by toxic algae...the CyAN app helps us do that...has been extremely useful....”

Success Stories

Data being used Operationally

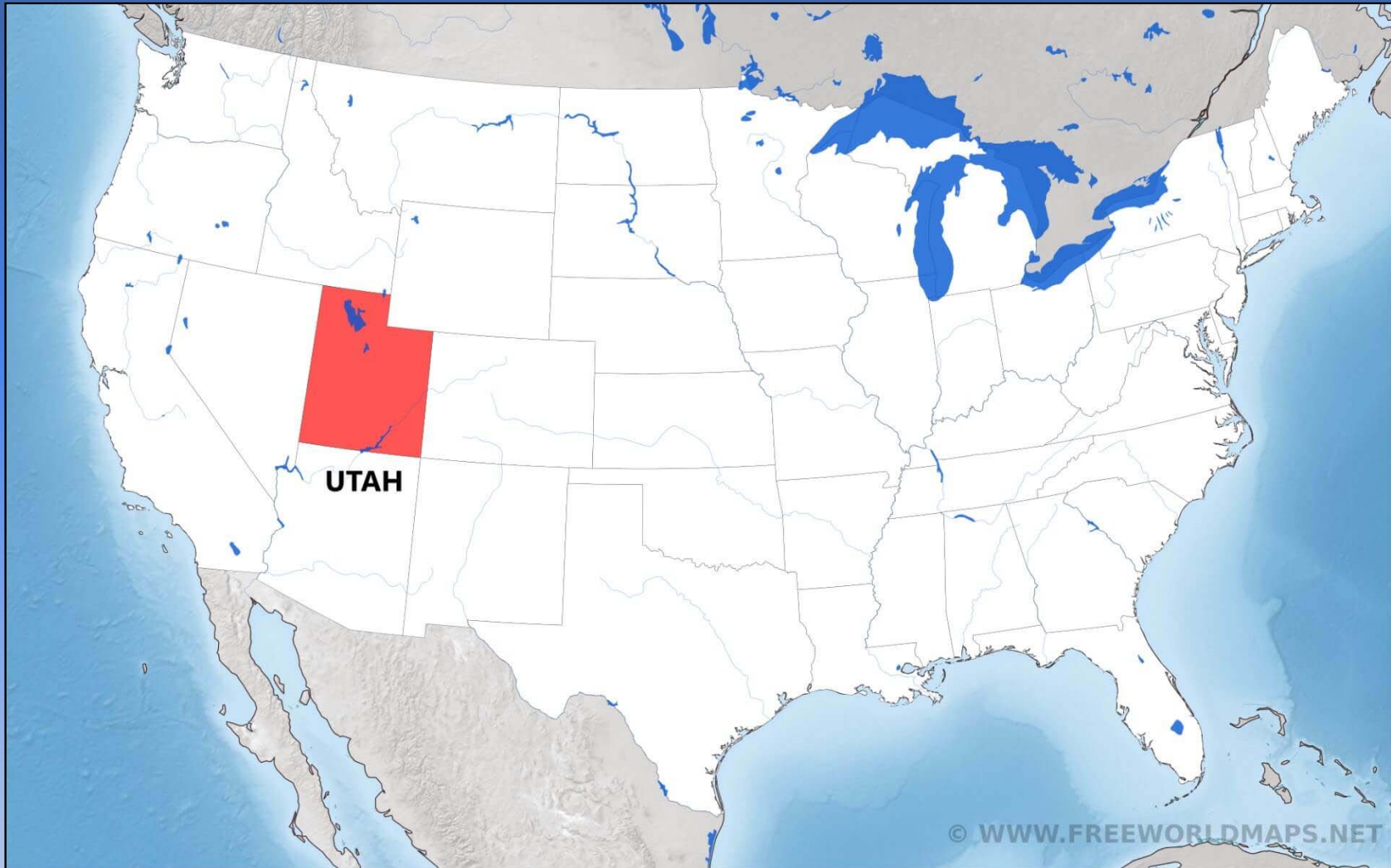
Collaborations for better science

Publications

Outreach to get data into the hands of the public



Early Warning Success.
Utah Lake



**Early Warning Success.
Utah Lake**



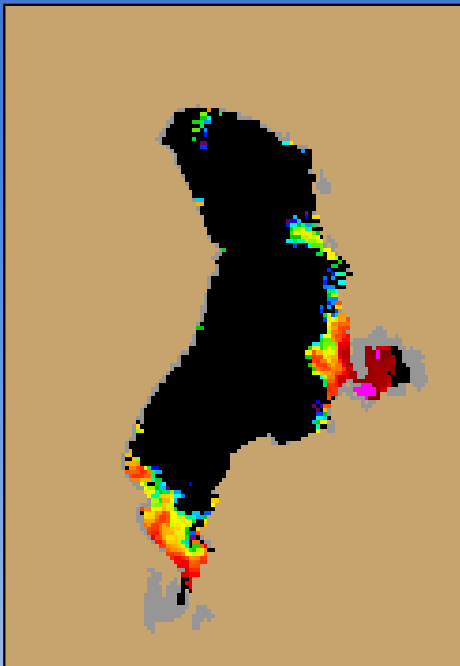
Early Warning Success.
Utah Lake



Photo by Rick Egan

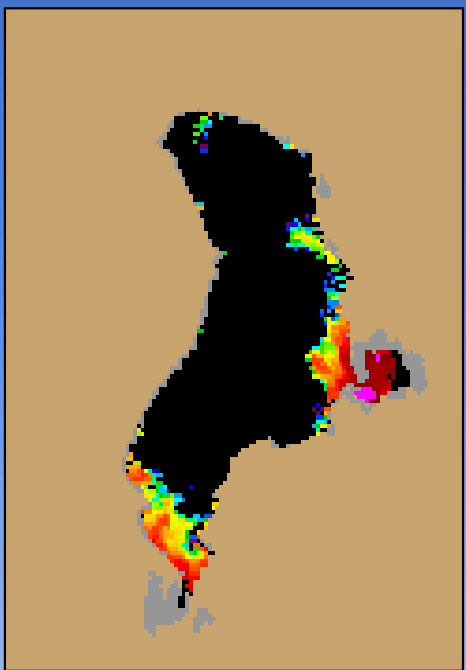
Early Warning Success. Utah Lake Summer 2017

June 18

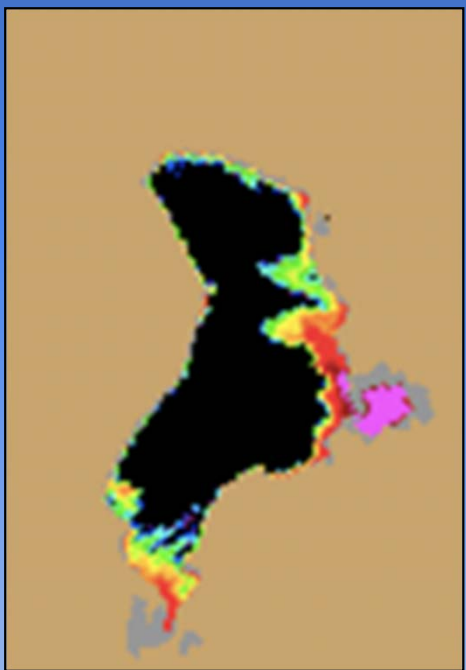


Early Warning Success. Utah Lake Summer 2017

June 18



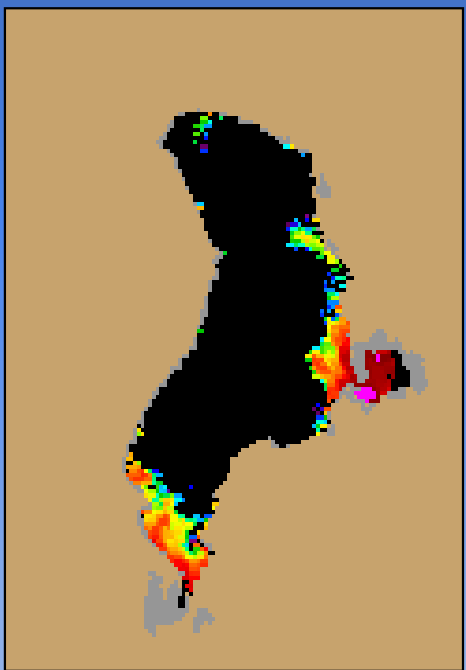
June 25



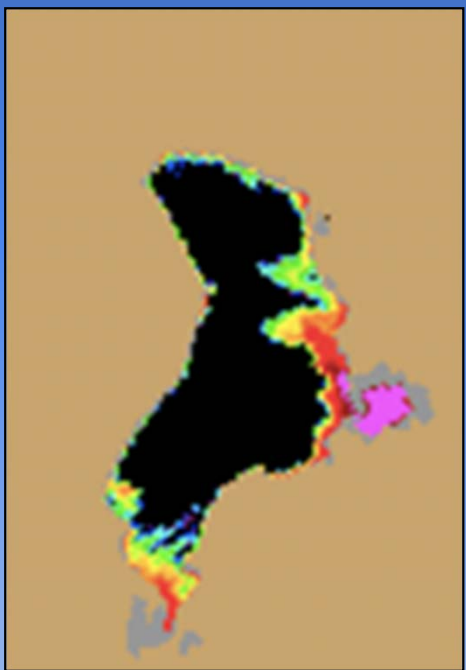
Shows where the bloom originated and the extent.
Data from ESA Sentinel-3 OLCI and processed by NOAA.

Early Warning Success. Utah Lake Summer 2017

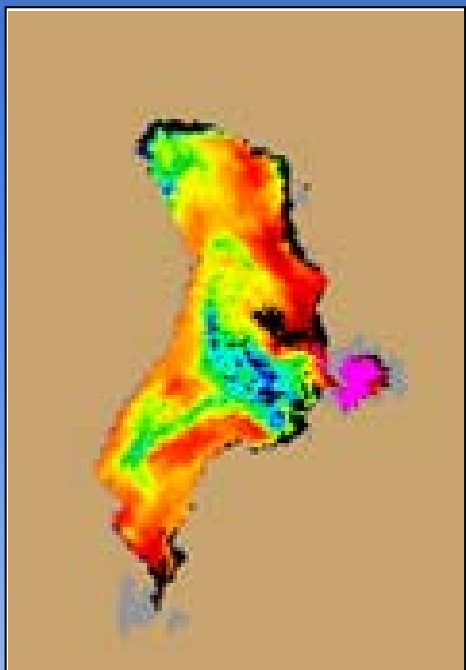
June 18



June 25



July 3



Shows where the bloom originated and the extent.
Data from ESA Sentinel-3 OLCI and processed by NOAA.

Early Warning Success. Utah Lake

Effective Response



- Utah Department of Environmental Quality (DEQ) sent out a water quality team
- DEQ issued an advisory, warning the public and pets to stay out of water.
- Many potential harmful encounters with toxic water were avoided



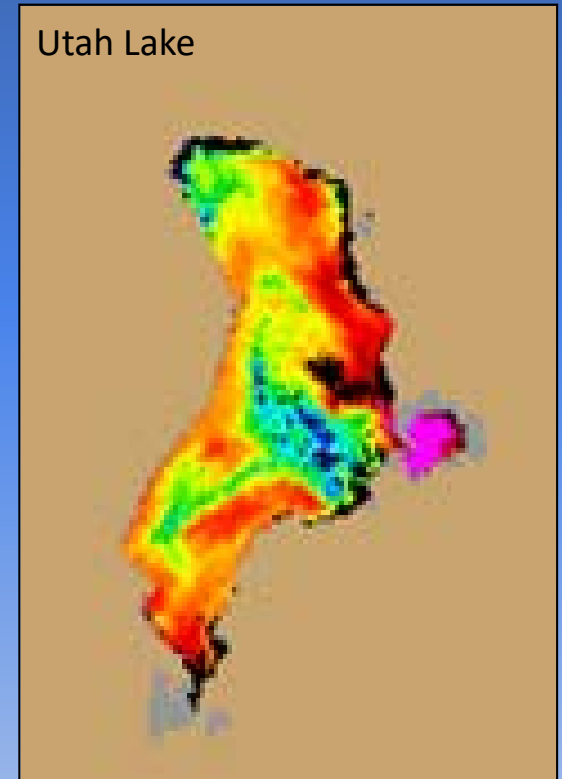
Cyanobacteria warning signs posted at Utah Lake June 2017
Photo by Chris Detrick of The Salt Lake Tribune

Early Warning Success. Utah Lake

Praise of CI product given by a
Utah Dept. Environmental Quality staff

“...to better target field sampling and more efficiently use
our limited resources to protect public health.”

“...images are easily shared with response agencies as a
useful visual communication aid.”



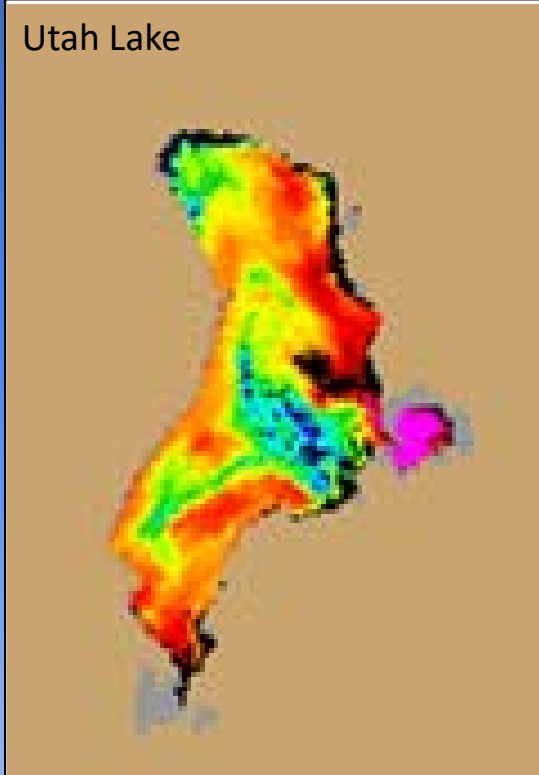
Early Warning Success. Utah Lake Summer 2017

Impacts

UT DEQ Health Advisories

\$368k total societal costs avoided for one advisory.

Stroming et al., *In Prep*. Quantifying the Human Health Benefits of Using Satellite Information to Detect Cyanobacterial Harmful Algal Blooms and Manage Recreational Advisories in U.S. Lakes. *GeoHealth*.



Wyoming HAB Action Plan

Wyoming Dept of Environmental Quality is exploring the use of satellite imagery to detect HABs issued Health Advisories and Recreational Use Advisories



Keyhole Reservoir: Harmful Cyanobacterial Bloom (HCB) Recreational Use Advisory

On September 4, 2019, satellite imagery from the [Cyanobacteria Assessment Network \(CyAN\)](#) identified elevated densities of cyanobacteria covering a large portion of Keyhole Reservoir. The Wyoming Department of Environmental Quality visited the reservoir on September 9, 2019, and collected water samples at Wind Creek Cove. Cyanobacteria densities exceeded the 20,000 cells/mL recreational use threshold identified in Wyoming's [HCB Action Plan](#). Cyanotoxin results are pending.

Oregon Law



Oregon Rule 333-061-0510 (2018)

“The Authority determines the source is susceptible based on the characteristics of the source, including, but not limited to...satellite imagery...or other relevant information.”

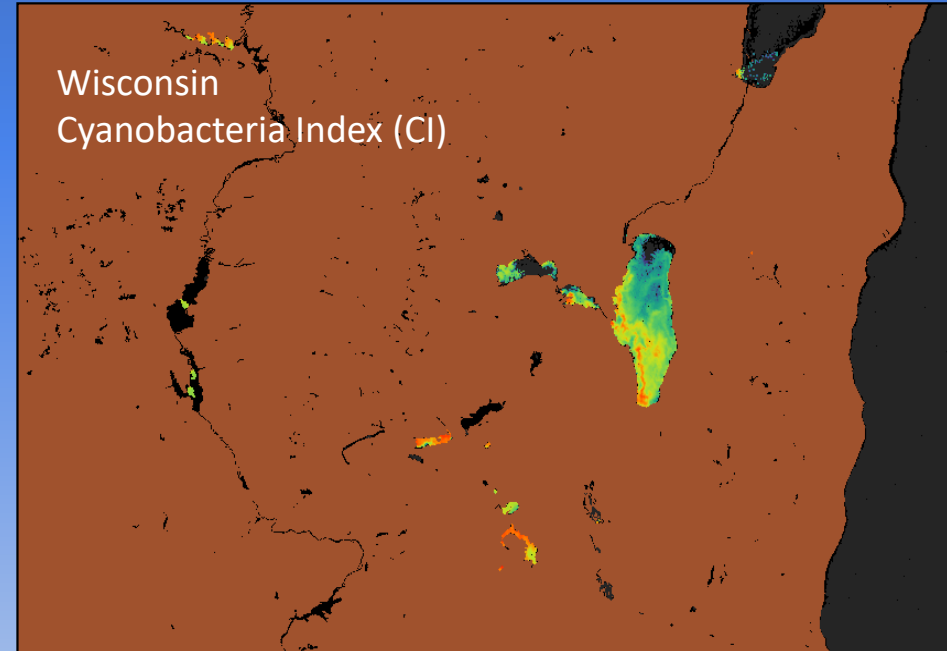


Collaborators: Wisconsin DNR Research Scientists Daniela Gurlin and Gina LaLiberte

Funded Project: "Lake Winnebago Region Harmful Algal Bloom Spectral Analysis and Bloom Characterization to support the Cyanobacteria Assessment Network (CyAN)"



Credit: Rob McLennan, WDNR



Questions about Bloom conditions over time

- Frequency
- Trends



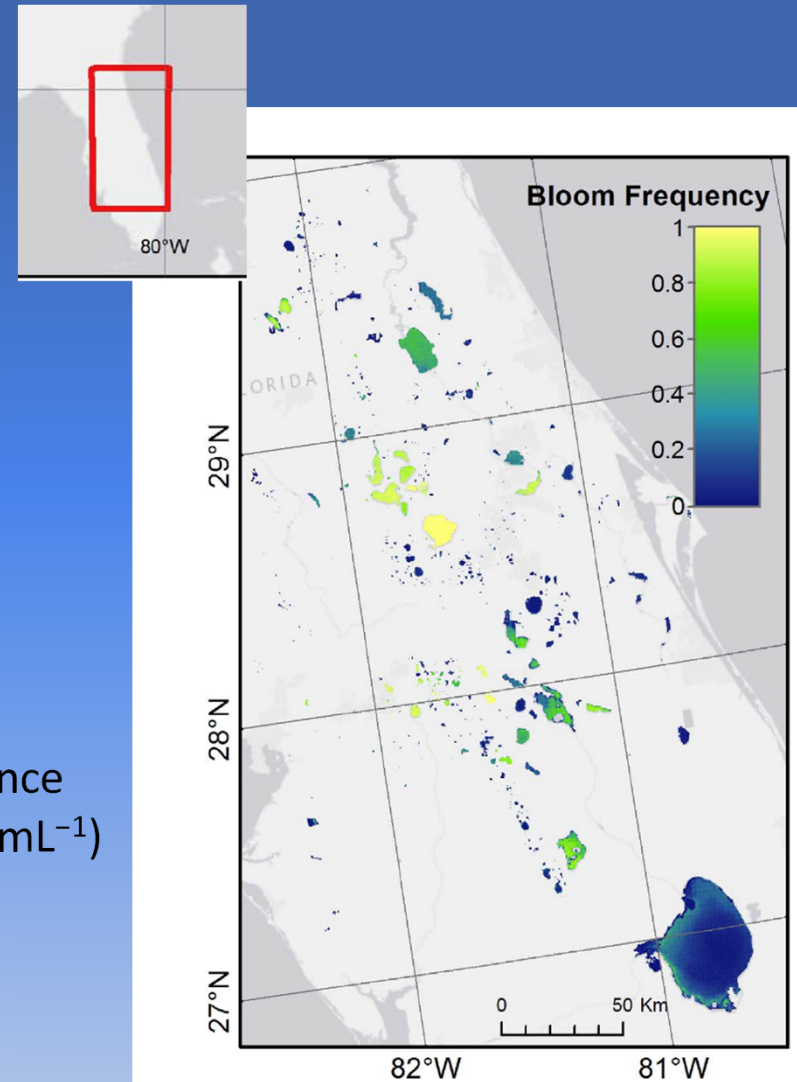


Original Articles

Satellite monitoring of cyanobacterial harmful algal bloom frequency in recreational waters and drinking water sources

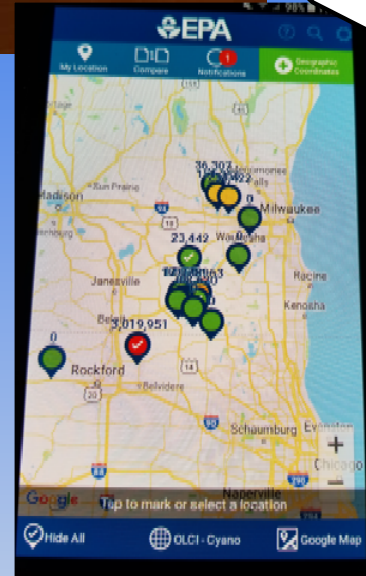
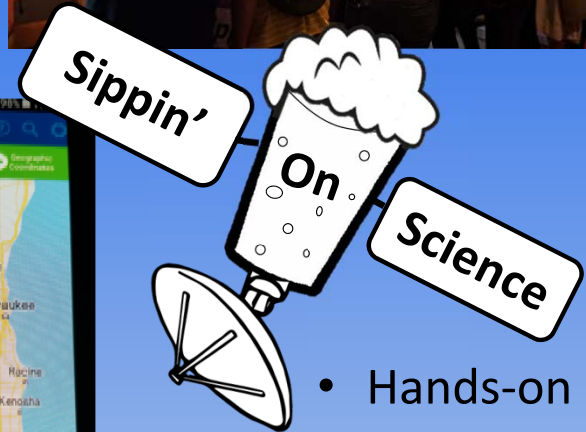
John M. Clark^a, Blake A. Schaeffer^{b,*}, John A. Darling^b, Erin A. Urquhart^a, John M. Johnston^b, Amber R. Ignatius^a, Mark H. Myer^a, Keith A. Loftin^c, P. Jeremy Werdell^d, Richard P. Stumpf^e

Frequency of observed cyanoHAB occurrence above WHO high threshold (100,000 cells mL⁻¹) from 2008-2011 at the pixel level.



Sippin' on Science

Public Outreach in Small Towns Pubs



- Hands-on Science
- Presentation
- Trivia
- CyAN App Demos
- Small town focus

Summary

- Satellites are a good way to monitor
- End-user engagement early
 - trainings (product and software)
 - product feedback
 - success stories
- Easy Data Access and Interface
- Outreach

Thank you!

Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government. The views expressed are those of the authors and do not necessarily reflect the views or policies of the U.S. Government."



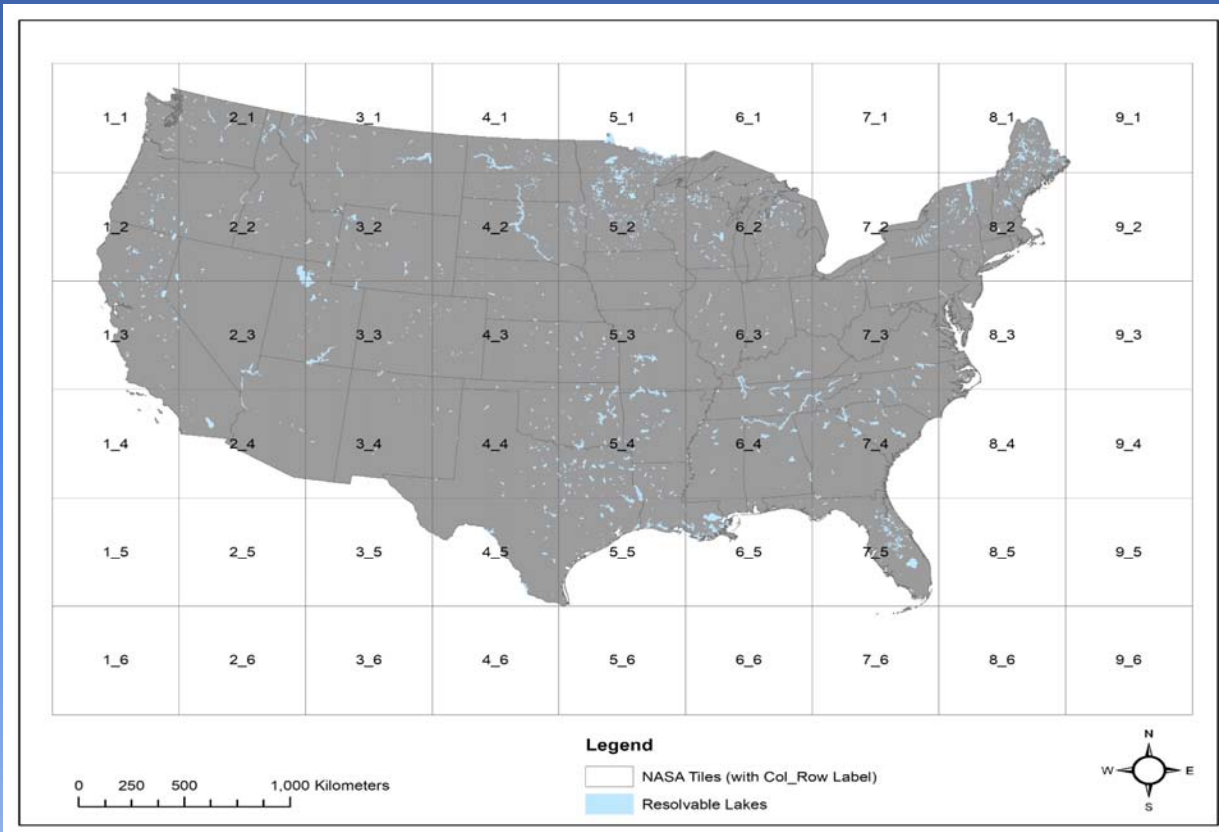
BONUS SLIDES

First Hour explore science table

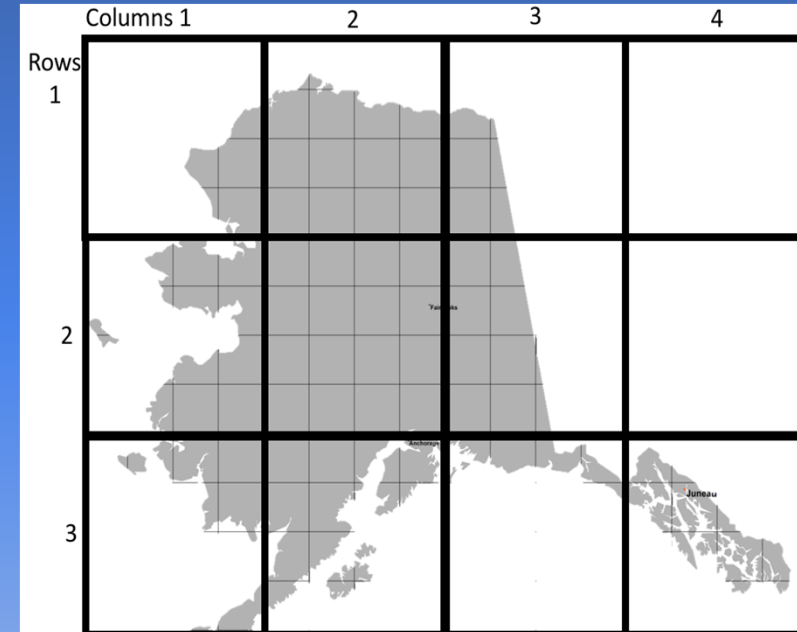
- Chat
- Cyan App
- Chlorophyll Fluorescence
- Light and water
- Microscope
- Free stuff



Contiguous US (CONUS) tiles



Alaska tiles



Cyanobacteria
Assessment Network

MERIS (2002-2012) and OLCI (2016-) Full resolution (300 m)

Impact

- Office of Water N-STEPS Program
 - Technical capability
 - Idaho DEQ
 - Coeur d'Alene Tribe
 - Oklahoma

- Potential avoided costs using remotely sensed chlorophyll-a values ~\$3.4 (S3) to \$146 (L8) million annually

Impact

EPA Office of Water N-STEPS Program

Nutrient Scientific Technical Exchange Partnership & Support

- Technical capability
 - Idaho DEQ
 - Coeur d'Alene Tribe
 - Oklahoma

Life in a drop of lake water on the microscope

