We will begin shortly

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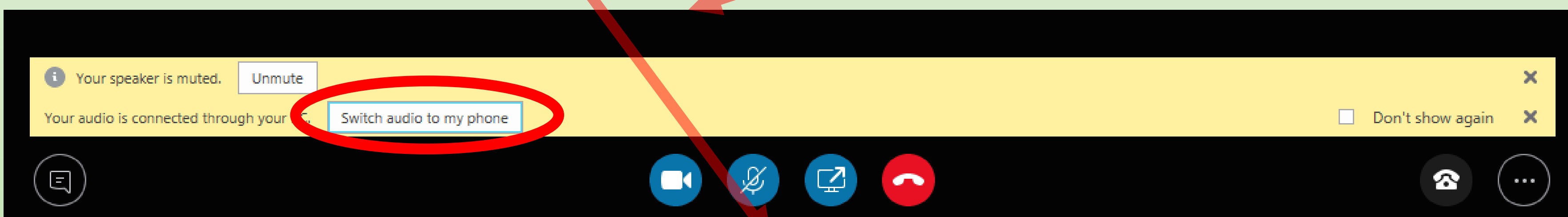
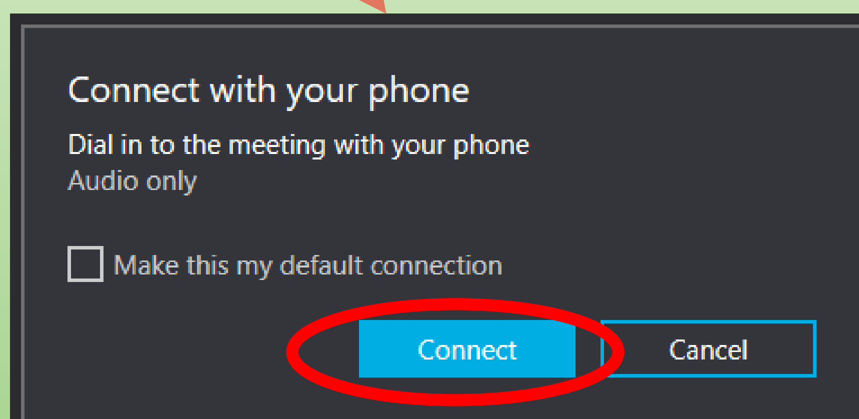
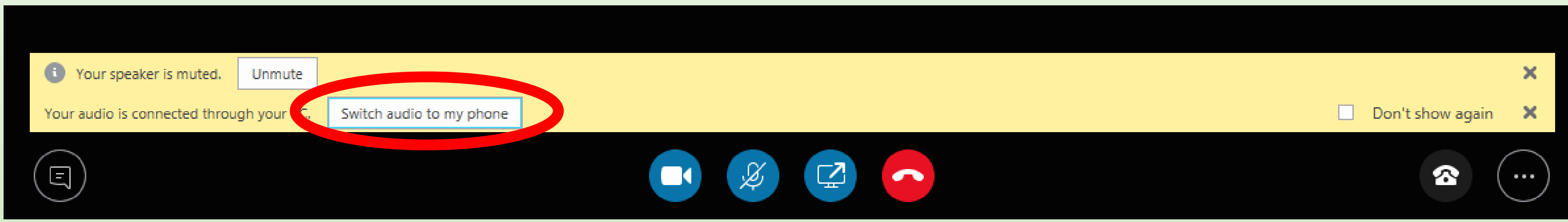




Current and Emerging Technology in the Great Lakes

November 14, 2017

Audio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Your audio is connected through your
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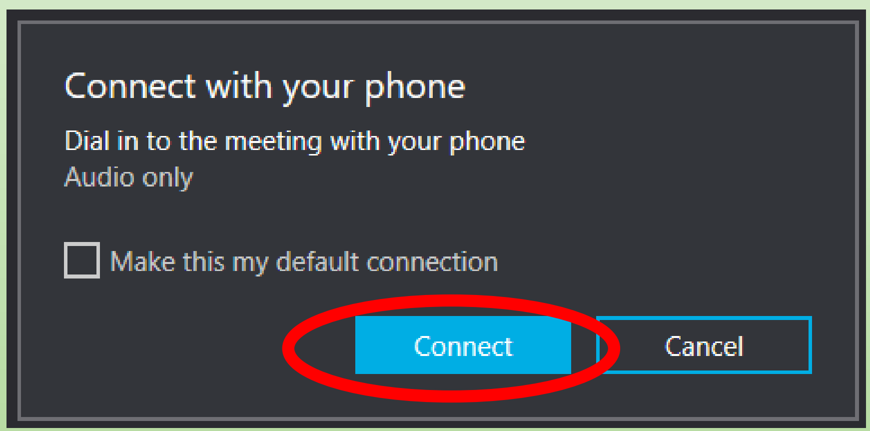
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Dial in to the meeting with your phone
Audio only
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Connect
Cancel

Questions

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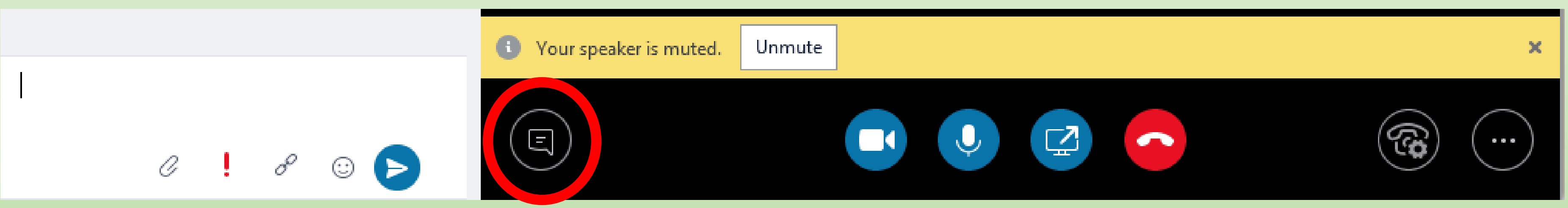


Speakers

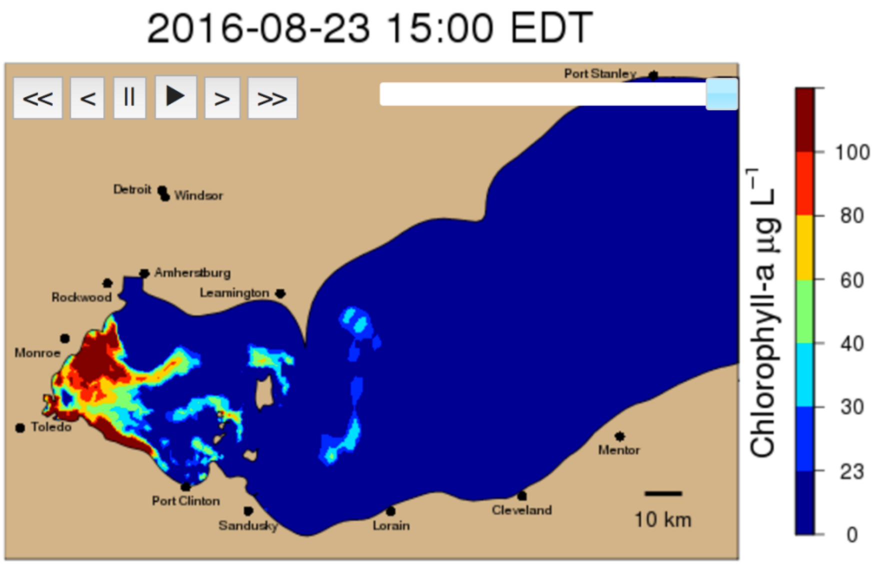
- Tom Johengen, NOAA-GLERL
- Ed Verhamme, LimnoTech
- Christian Moldaenke, bbe Moldaenke
- Jason Deglint, University of Waterloo
- Adam Schroeder, University of Toledo

New Technologies to Enhance GLERL-CIGLR HABs Monitoring and Forecasting

Tom Johengen
Research Scientist
CIGLR, University of Michigan
(representing dozens of collaborators)

Overview of Advanced Observing

- In –Situ Toxin Detection
  - ESPniagra plus 2 new ESP
  - 3G-ESP in mobile platform
- Vertical Profiling
- Underway surface mapping
- Hyperspectral Fly-overs

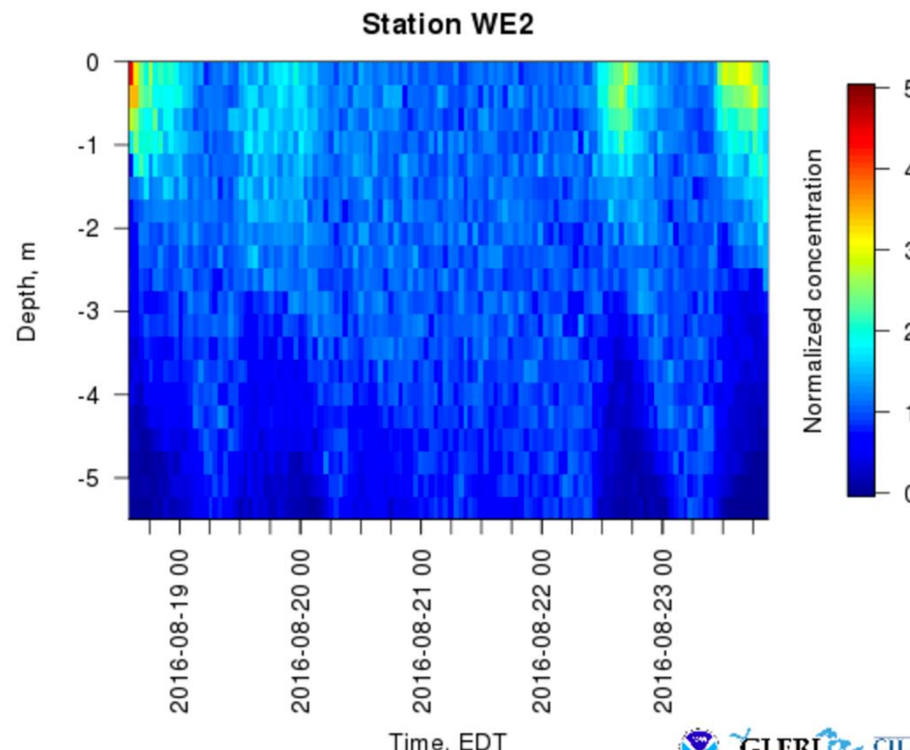


HAB Tracker

Chlorophyll Concentration (ug/l)

Mixing Model

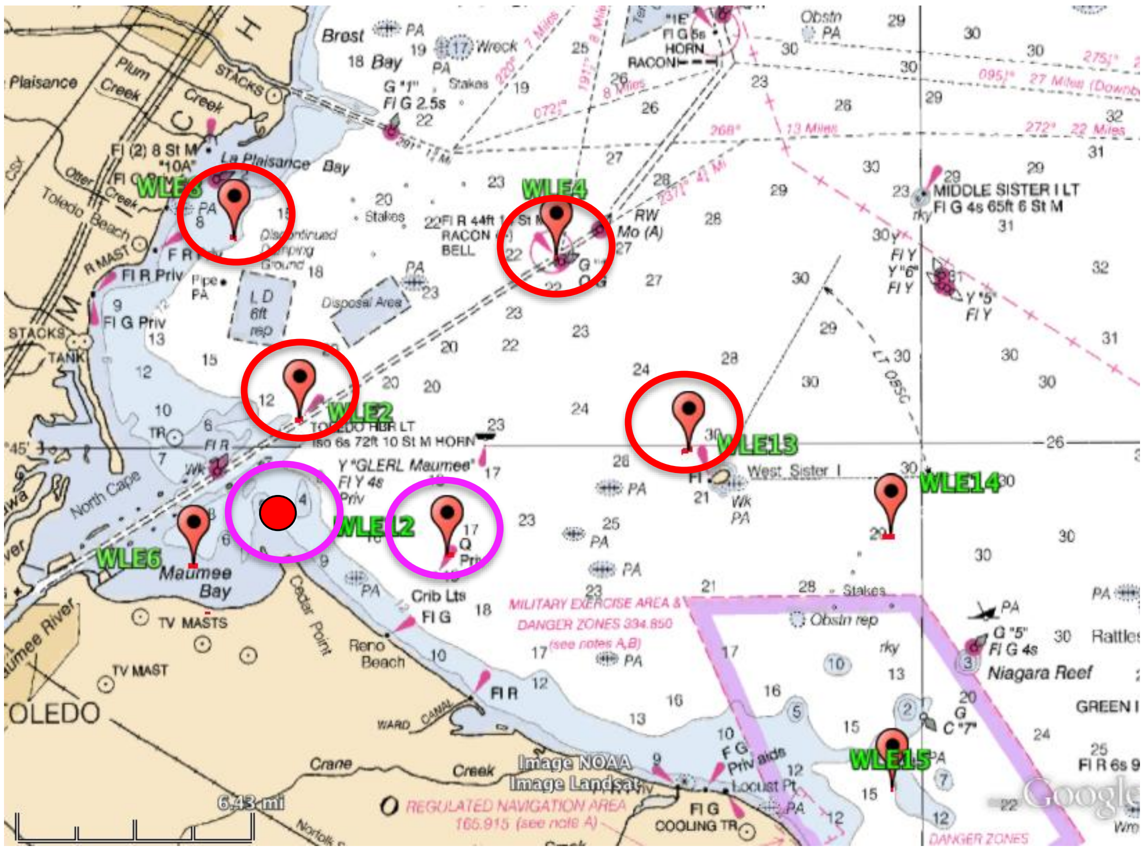
MC Vertical Distribution



TOXIN Model ??????

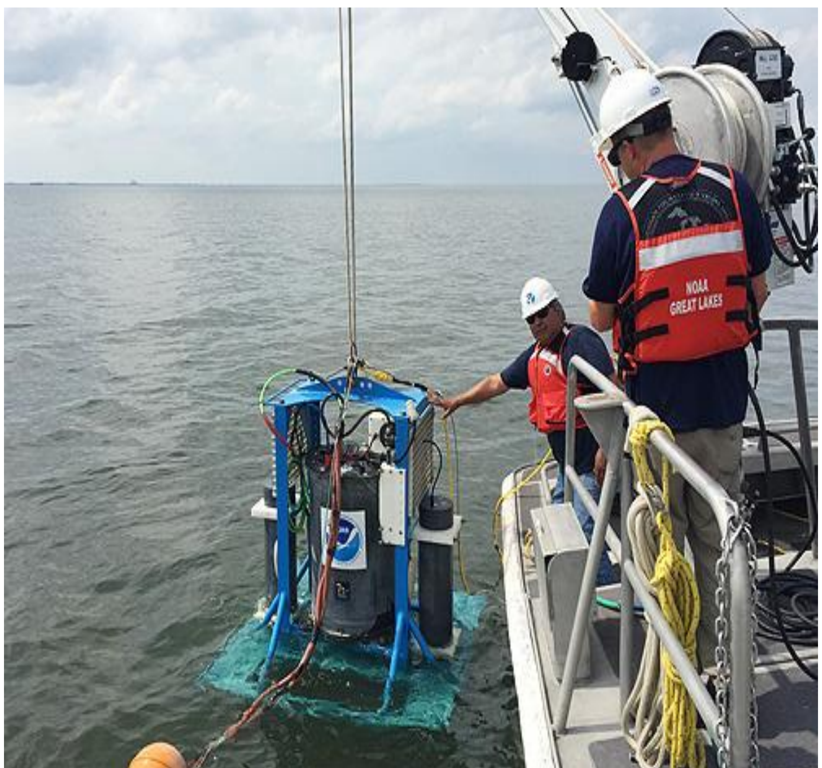
Establishing a Western Lake Erie Monitoring Capacity

Johengen, Palladino, Miller, Davis, Ruberg



ESPniagara

- Sealed pressure housing integrated on custom-designed lander
- Modified for deployment in shallow, freshwater environment & detecting cyanobacterial toxins



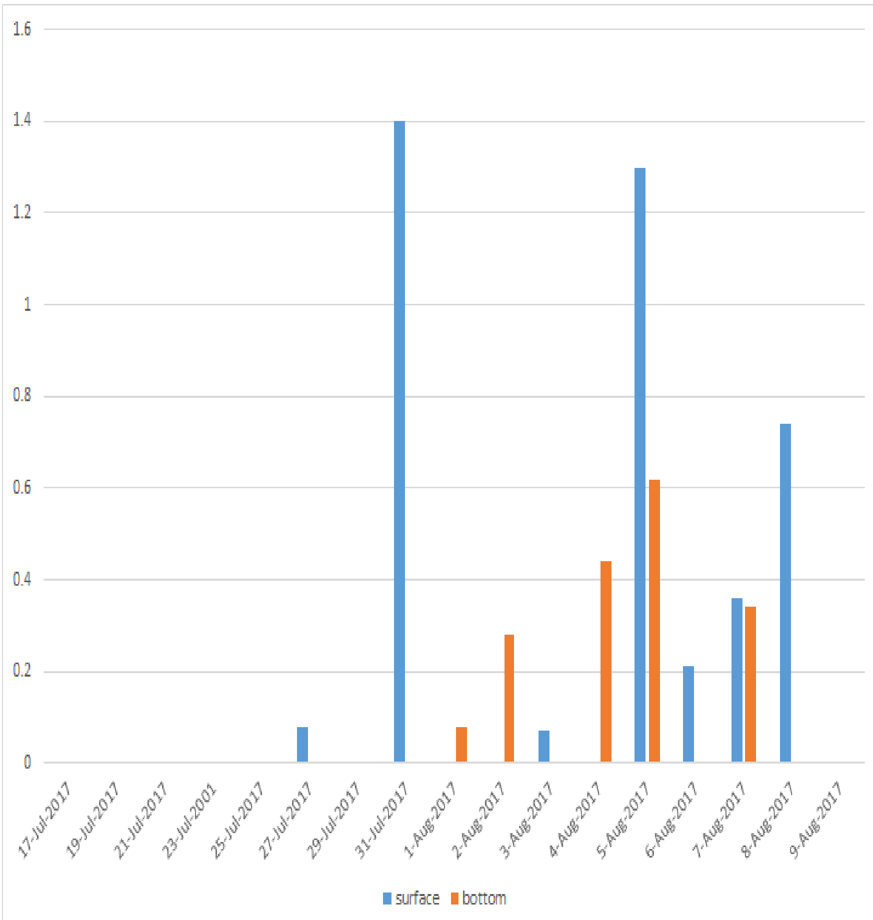
- Acquires samples at surface & bottom
- Performs ELISA for toxin (MCY) detection
  - employs Abraxis ADDA-specific antibody
  - chemistry controls included with each test
  - toxin quantified based on calibration curve
- Flexible, adaptive sampling schedule over a ~4-6 week-long deployment
- Data transmitted in near-real time

Image courtesy of MBARI

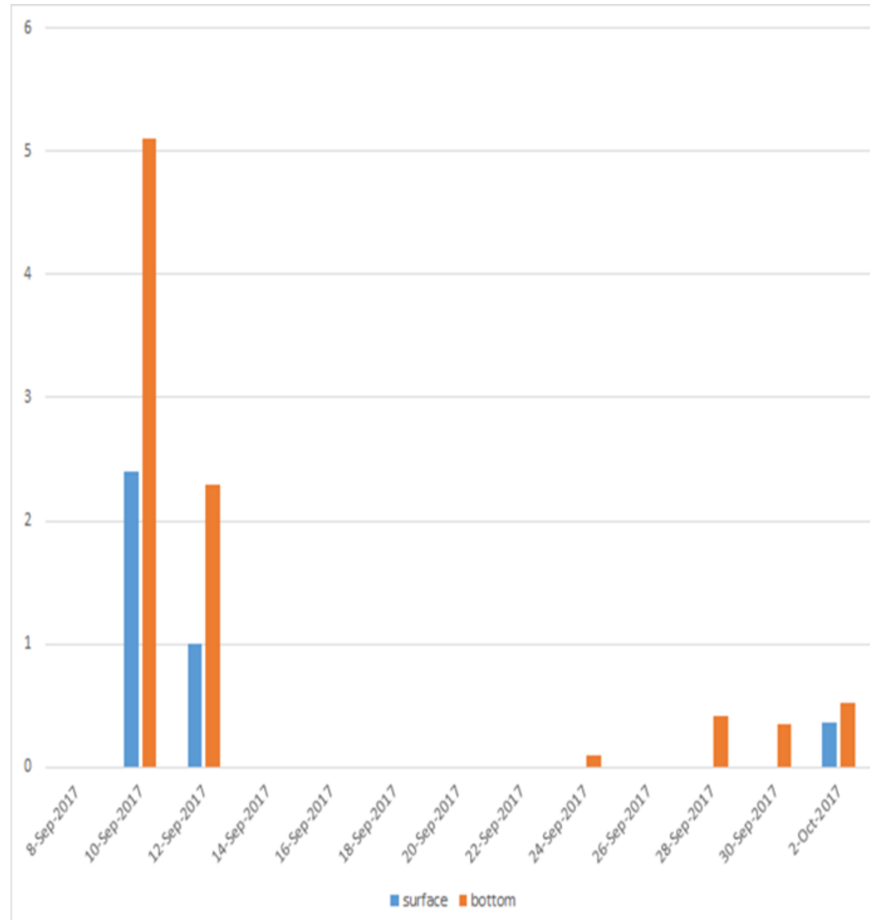
2017 deployments

ug microcystins/L

July 11 – Aug 8



Sep 8 – Oct 3

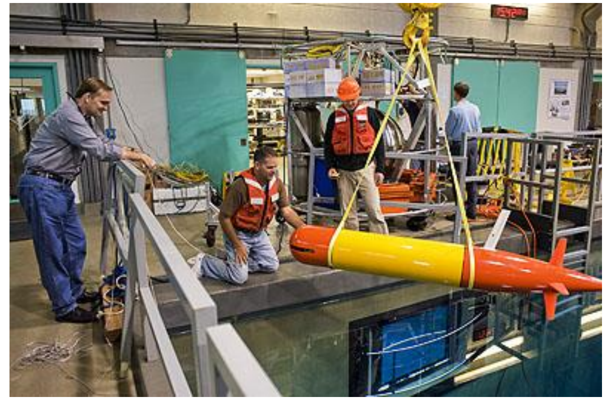


Build-out of in-situ toxin monitoring network

1. Purchase of new additional 2G ESP’s
   - IOOS-OTT proposal: *Upgrading and planning for the transition of the Lake Erie HABs Early Warning System to a sustainable operational form*
     - Collaboration with GLOS and LimnoTech
     - Purchase in 2018 and Deploy in 2019
   - GLERL GLRI proposal: *Harmful algal bloom monitoring program to inform ecological forecasting and decision support tools*
     - Extension of current collaboration with CIGLR
     - Purchase in 2019 and Deploy in 2020

2. Development of Mobile 3G ESP
   - NOAA-OAR Tech Development proposal: *Advancement of Mobile, In-situ HAB Toxin Warning and Genomic Observation for Great Lakes Decision Support Tools*
     - Collaboration with MBARI, NOS and CIGLR
     - MBARI and NOS-CCEHBR development in 2017 and Field test planned for 2018

3G ESP



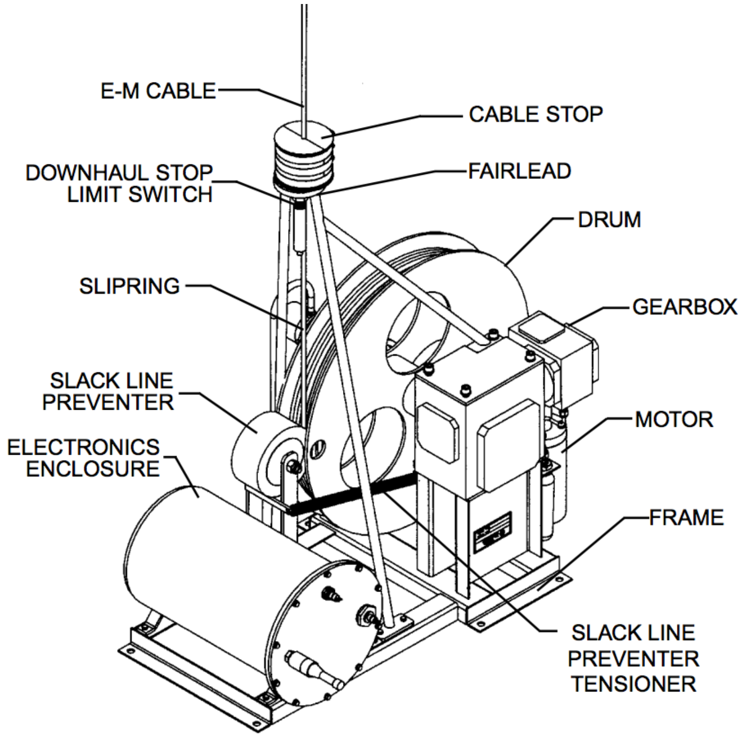
Goals

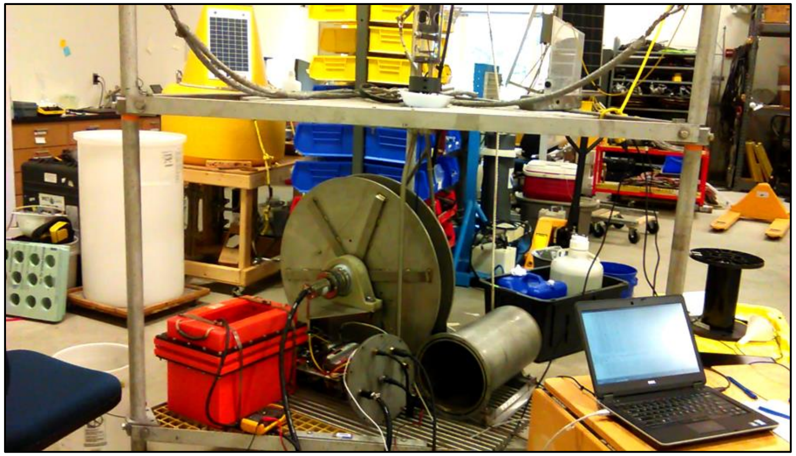
- Address critical gaps in NOAA’s autonomous technology capabilities by improving spatio-temporal resolution of in-situ toxin and ‘omics measurements
- Advance algal toxin sensor miniaturization and automation
- Providing critical near-real time data for integration into Lake Erie CHAB toxicity forecasting products

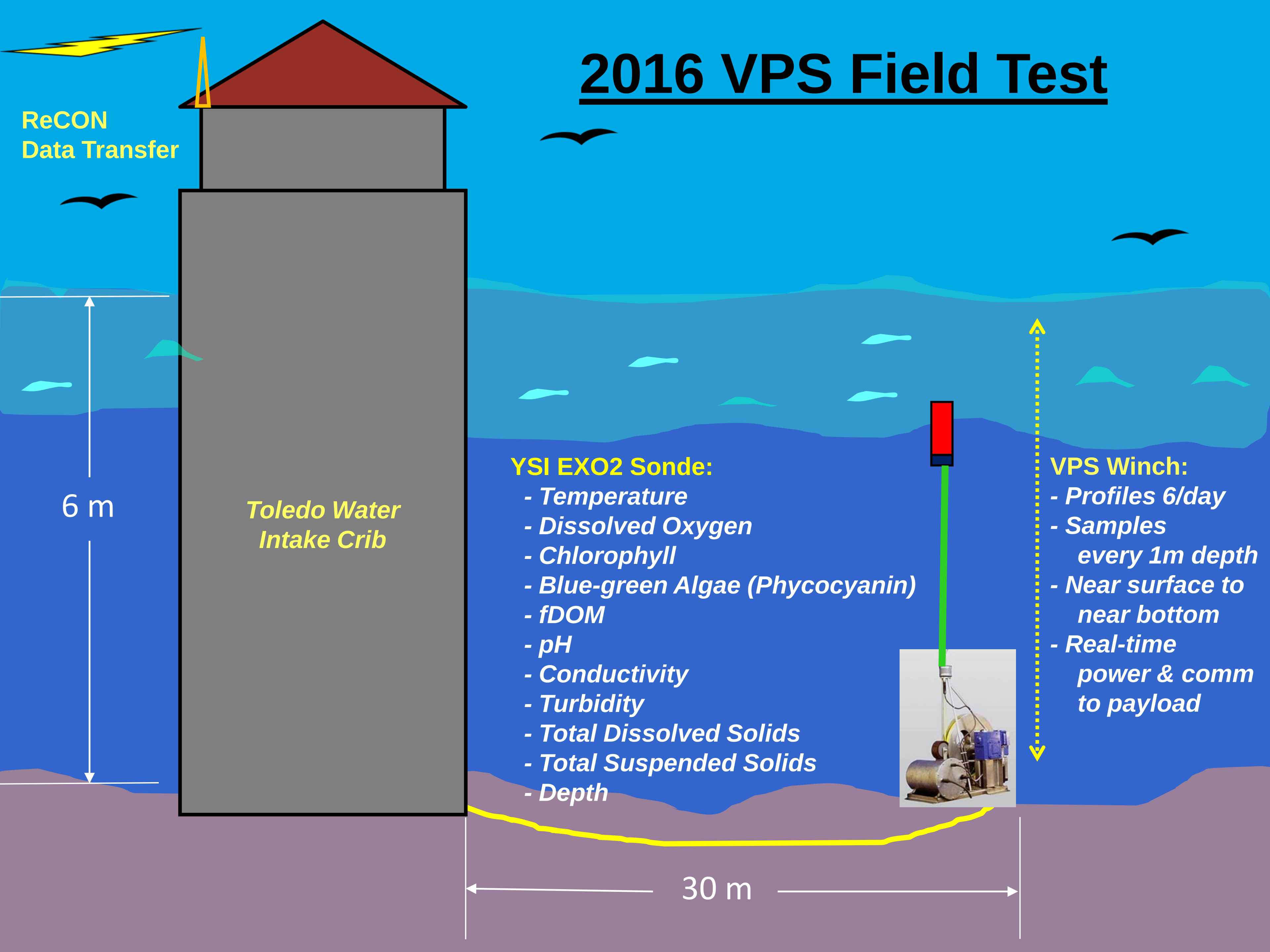
Activities

1. developing/validating an extraction protocol and surface plasmon resonance (SPR)-based sensor for particulate MC using a bench-top 3G ESP system;
2. conducting the first field deployment of the eAUV in western Lake Erie demonstrating newly developed in-situ MC detection capability in parallel with DNA archival and recovery protocols
3. analyze Lake Erie DNA extracts for CHABs and overall microbial community composition to enhance understanding of bloom dynamics

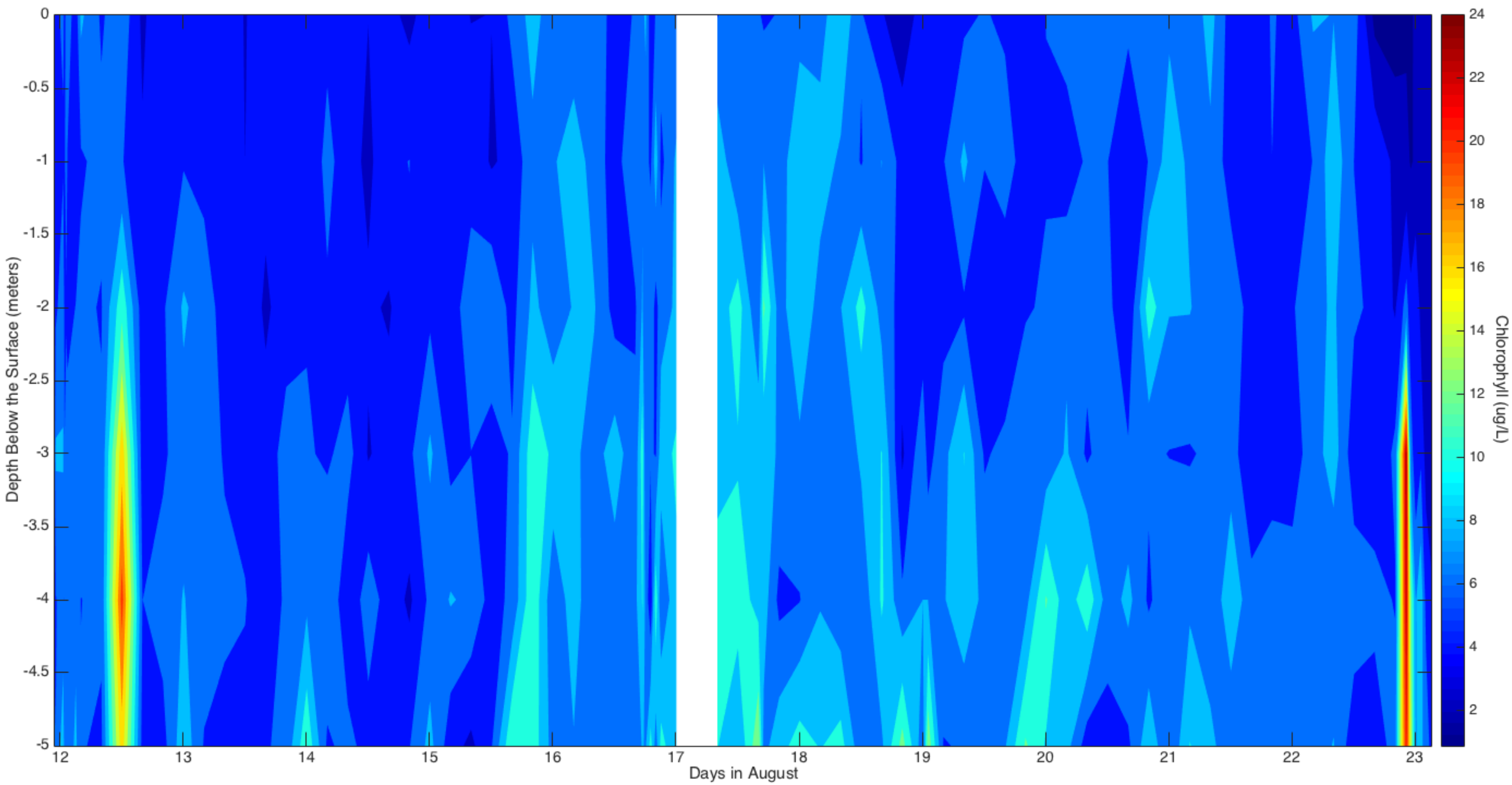
Vertical Profiling System



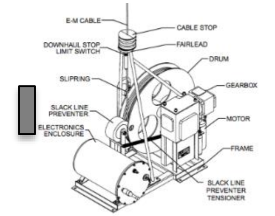


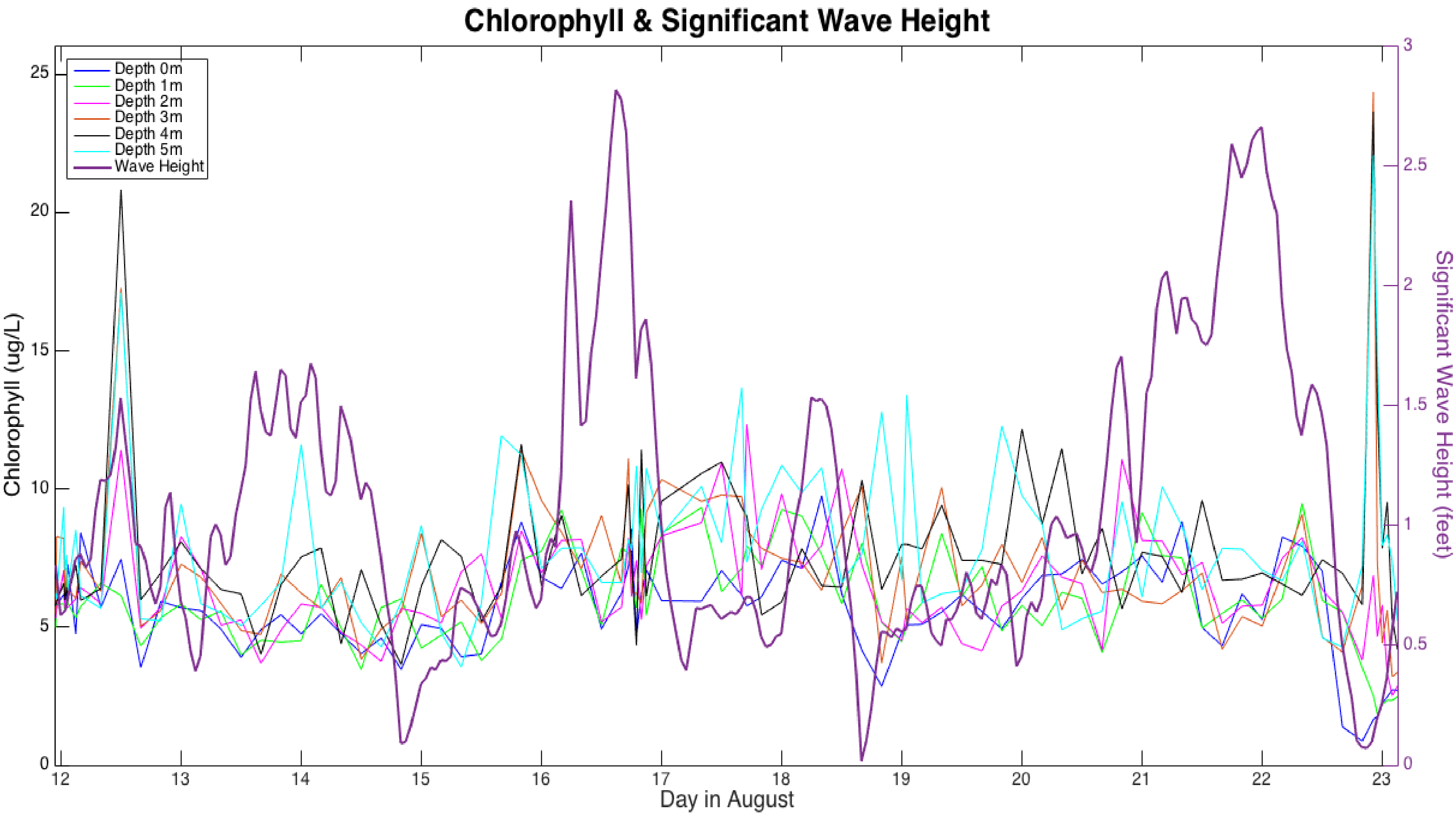

2016 VPS Field Test
ReCON
Data Transfer
6 m
Toledo Water
Intake Crib
YSI EXO2 Sonde:
- Temperature
- Dissolved Oxygen
- Chlorophyll
- Blue-green Algae (Phycocyanin)
- fDOM
- pH
- Conductivity
- Turbidity
- Total Dissolved Solids
- Total Suspended Solids
- Depth
VPS Winch:
- Profiles 6/day
- Samples
every 1m depth
- Near surface to
near bottom
- Real-time
power & comm
to payload
30 m

2016 Contoured Chlorophyll Profiles



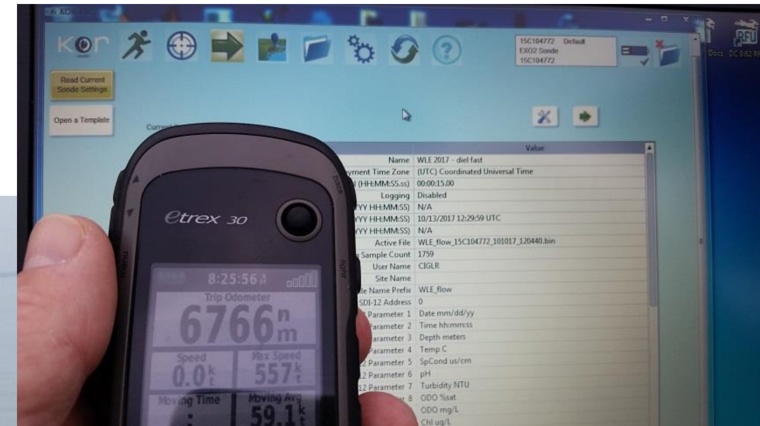
Chlorophyll Profiles Near Toledo Water Intake



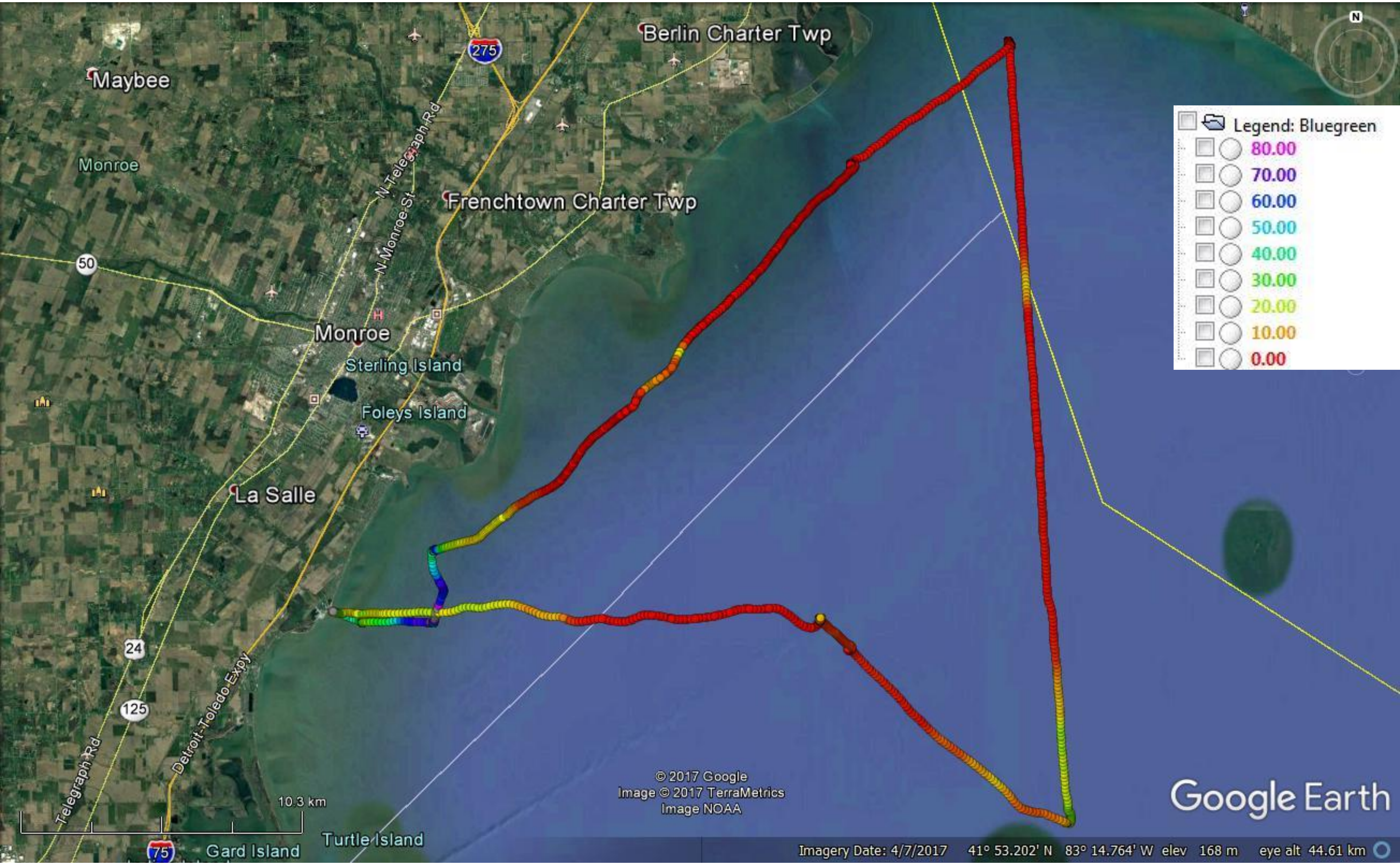


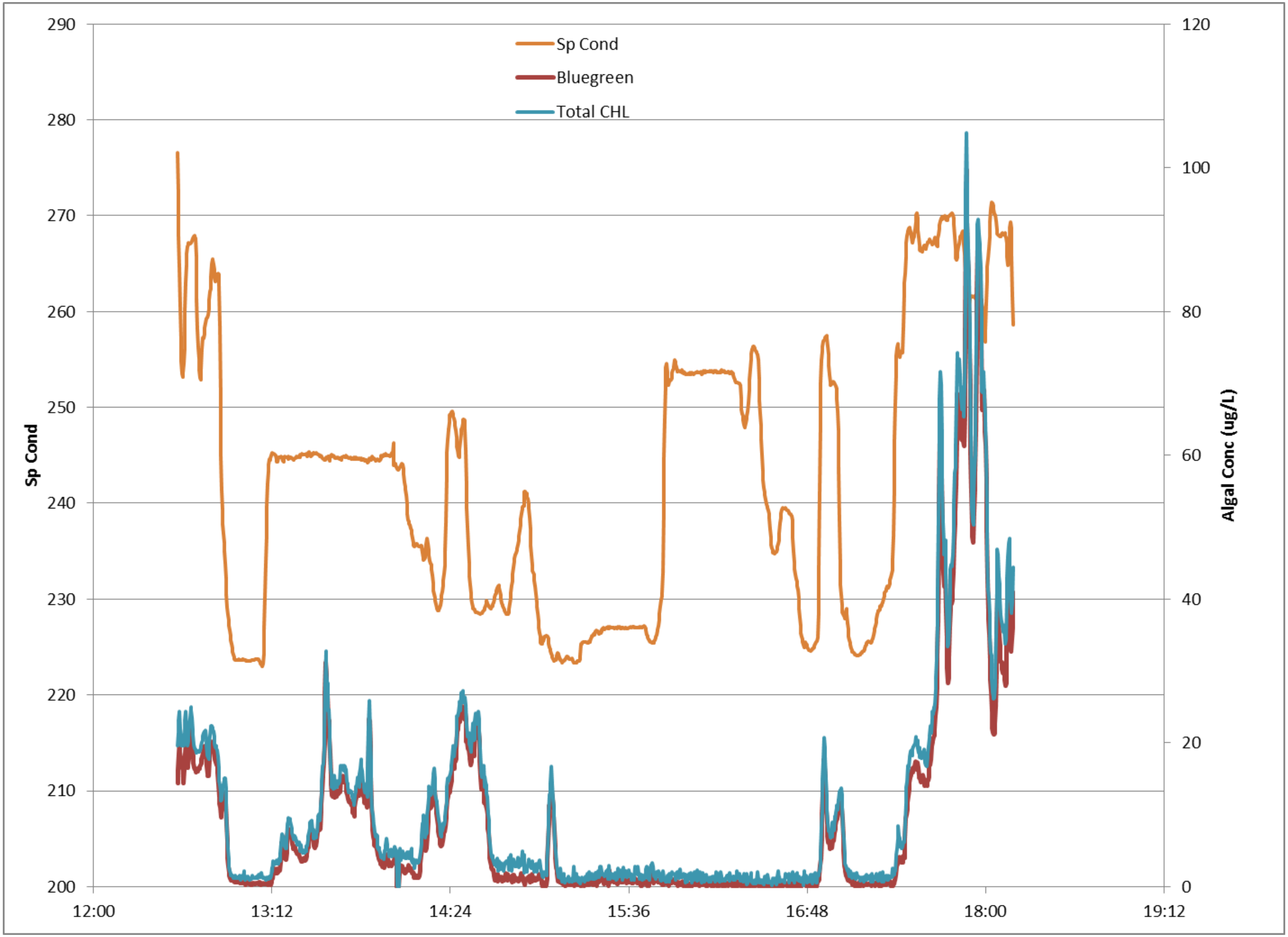
Surface Underway Mapping

- Integrate a YSI EXO2, BBE Fluoroprobe, and GPS into a flow-through system
- Conduct continuous underway monitoring at 15 sec intervals during monitoring and buoy servicing cruises



Underway surface mapping in WLE on October 13, 2017




Sp Cond
Bluegreen
Total CHL
290
280
270
260
250
240
230
220
210
200
Sp Cond
120
100
80
60
40
20
0
Algal Conc (ug/L)
12:00
13:12
14:24
15:36
16:48
18:00
19:12

Hyperspectral RS

AC9 and BBS

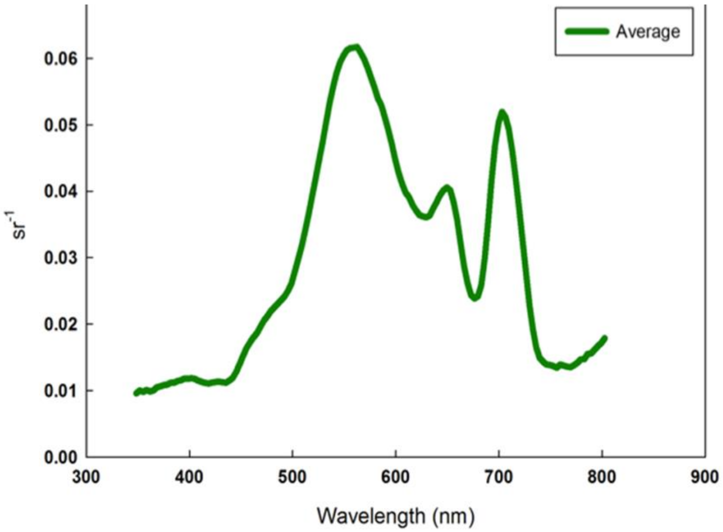
- Applications
  - Hand-held measurements in conjunction with monitoring surveys
  - Aerial over-flights
  - Inherent Optical Properties
- Objectives
  - Improved characterization of Cyanobacteria
  - Functional group maps of Lake Erie with a combination of absorption and backscatter spectra
  - Improved algorithm development

Satlantic hand-held remote sensing reflectance with Scum spectra

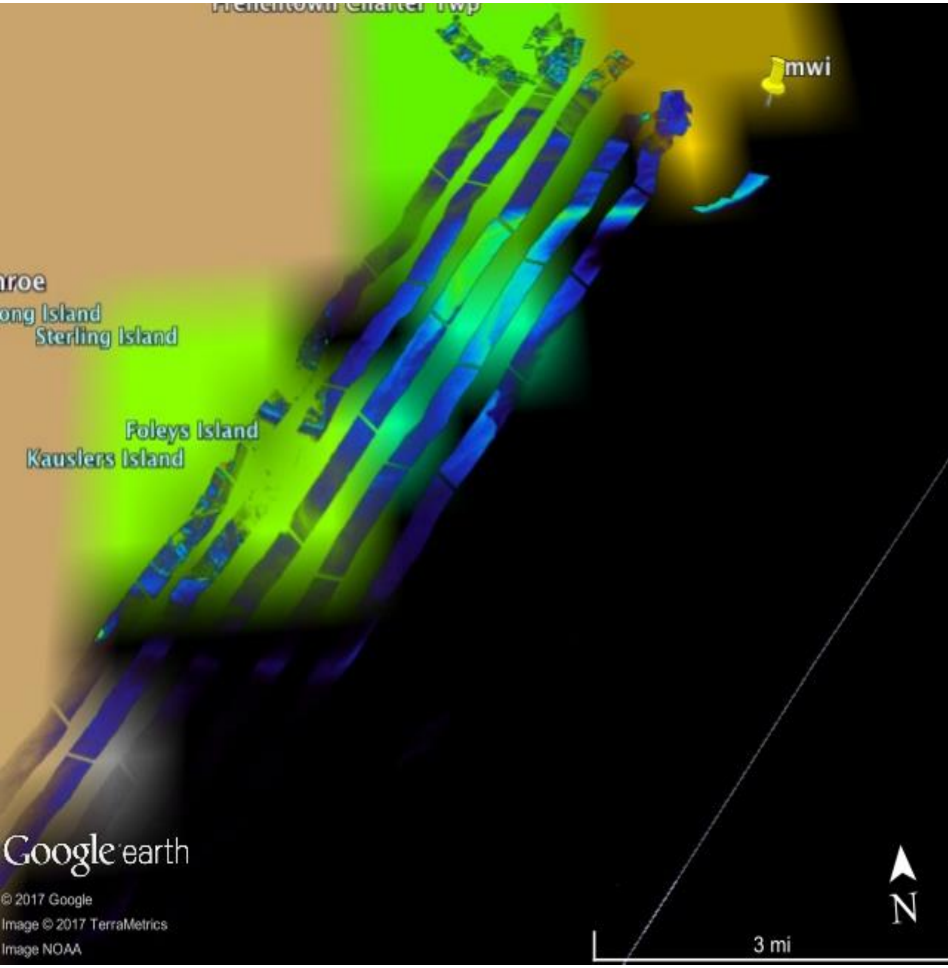
Resonon PIKA II

Spectral Range	400-900 nm
Spatial Resolution	2.1 nm (depending on altitude)
Number of channels	240
Field of View	16°

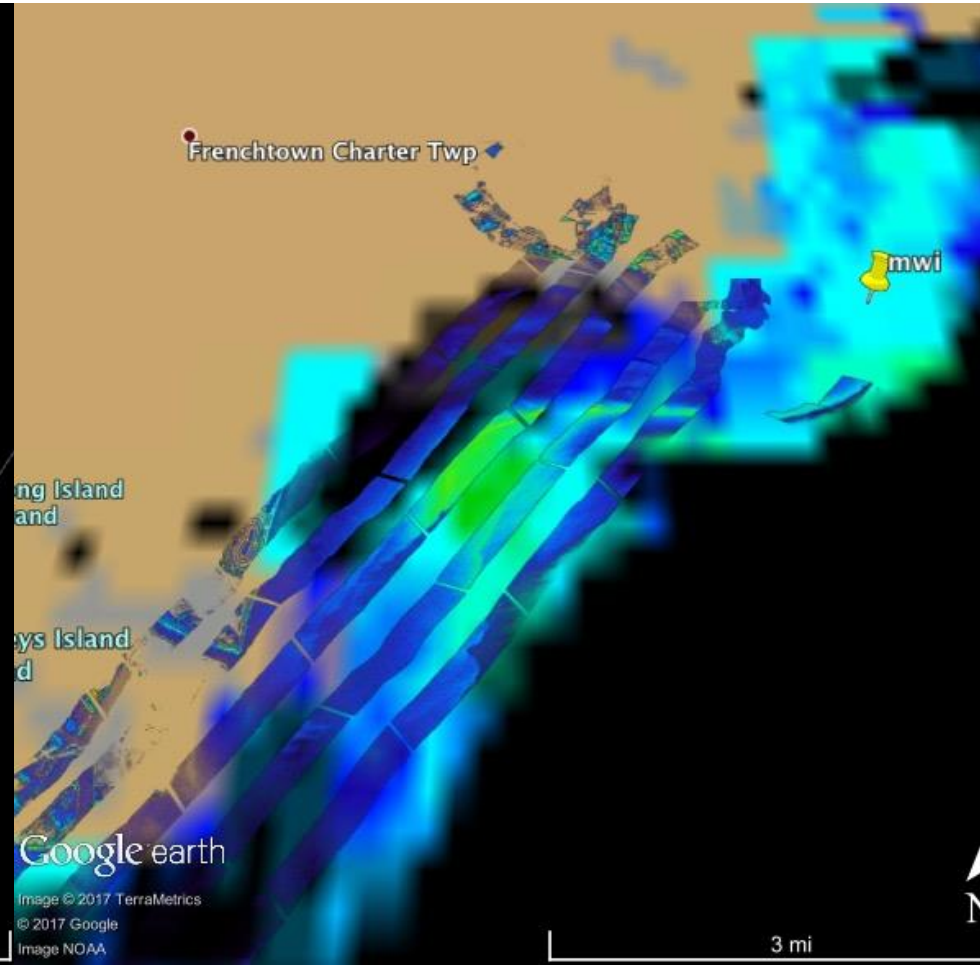
Spatial Resolution ~1m



October 19, 2017 Hyperspectral Flyover with Satellite Derived NOAA HAB bulletin Monroe Water Intake - Cyanobacteria Index



MODIS



Sentinel 3

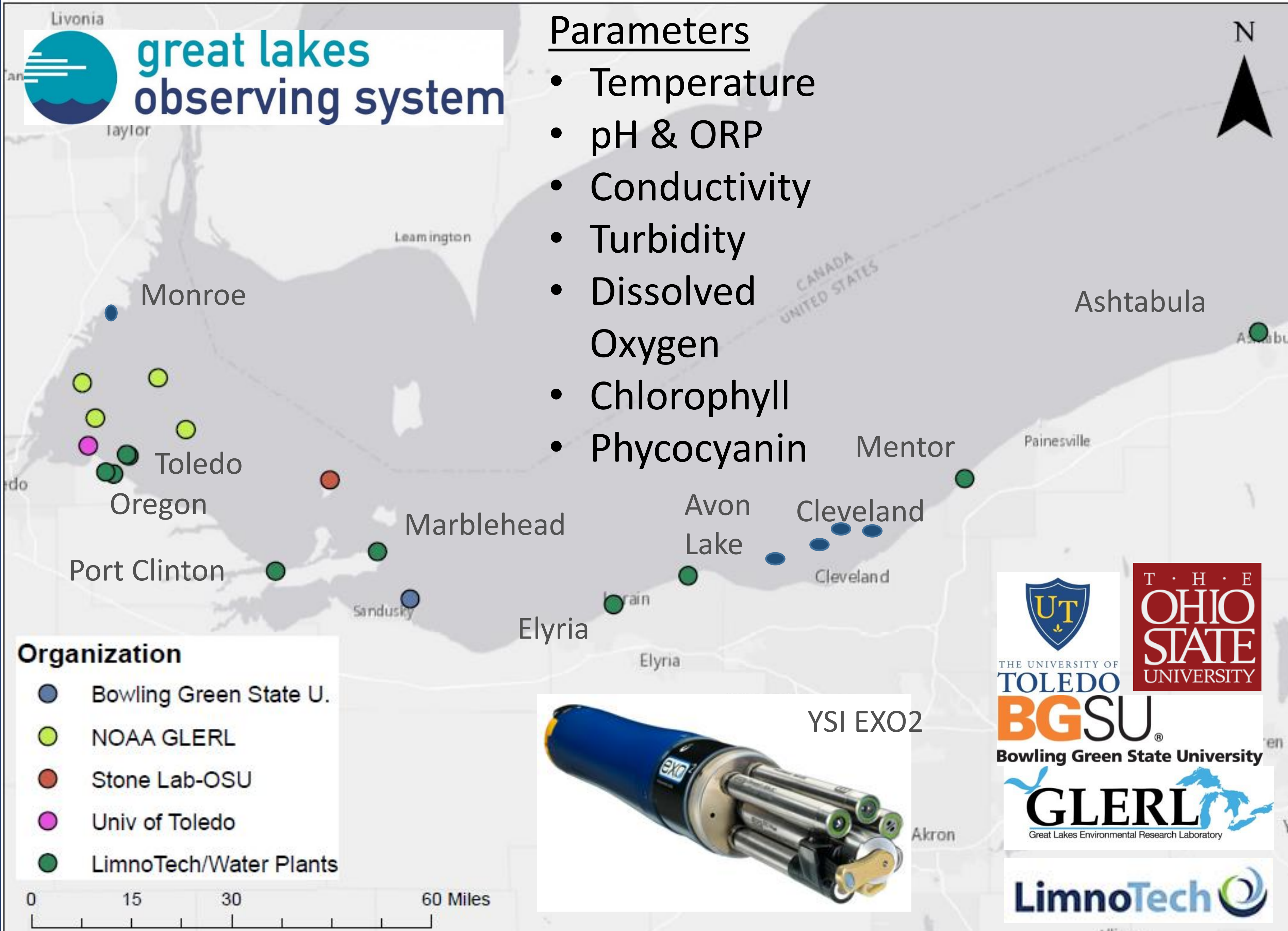
HABs: Technology and data management drive decisions

Ed Verhamme, LimnoTech


DO NOT
DRINK TAP
WATER!

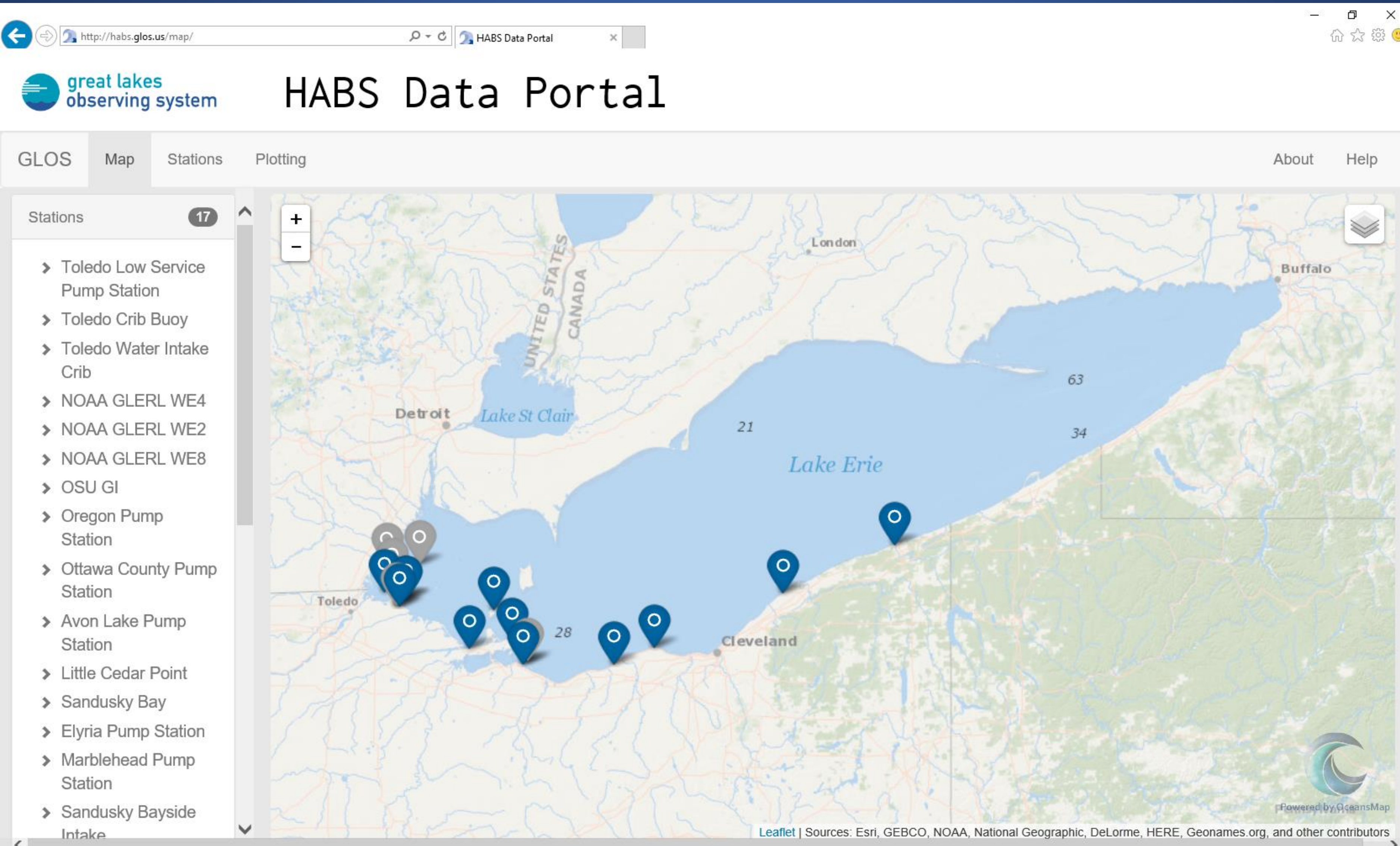
Parameters

- Temperature
- pH & ORP
- Conductivity
- Turbidity
- Dissolved Oxygen
- Chlorophyll
- Phycocyanin



YSI EXO2

GLOS HABs Data Viewer

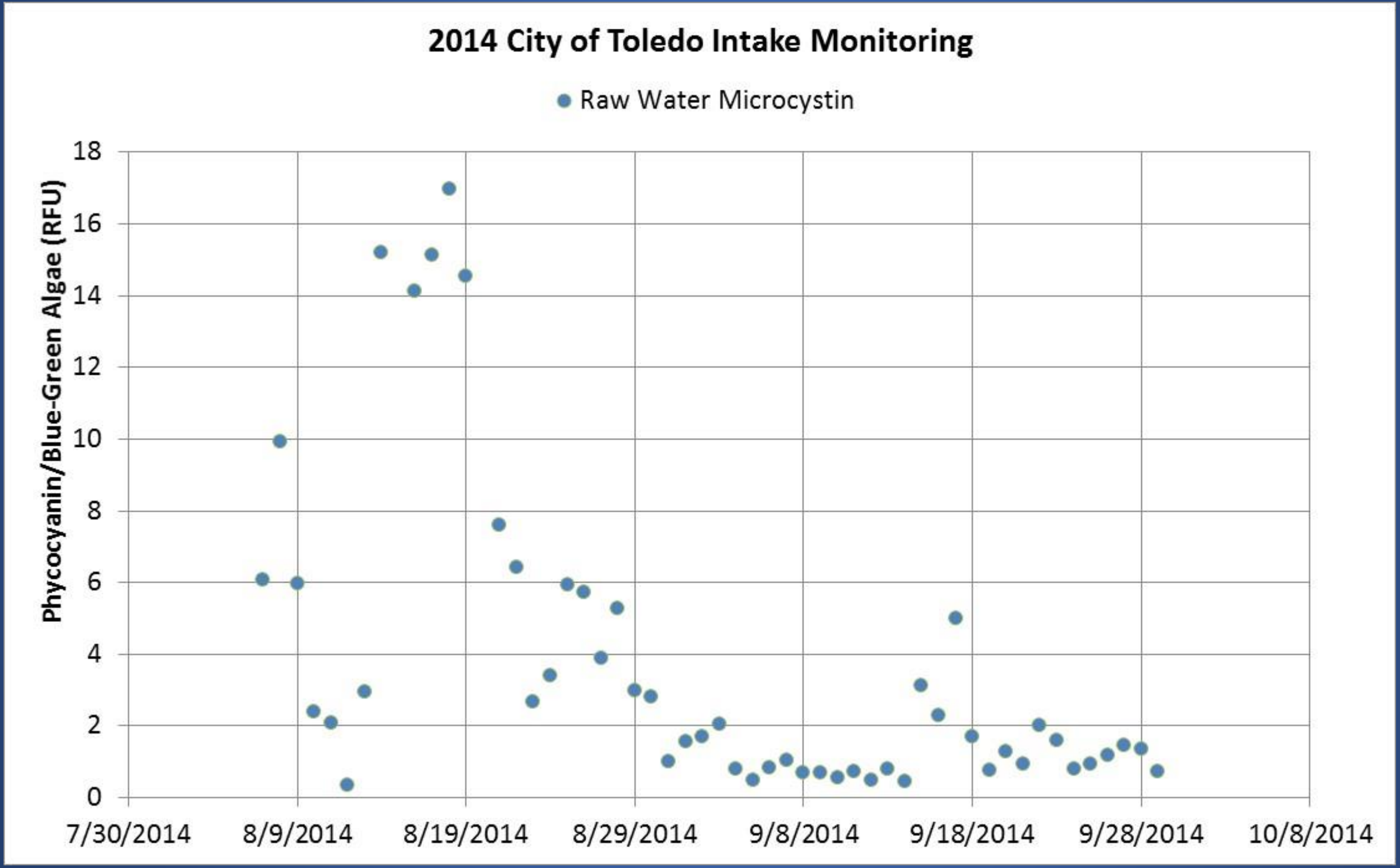


http://habs.glos.us

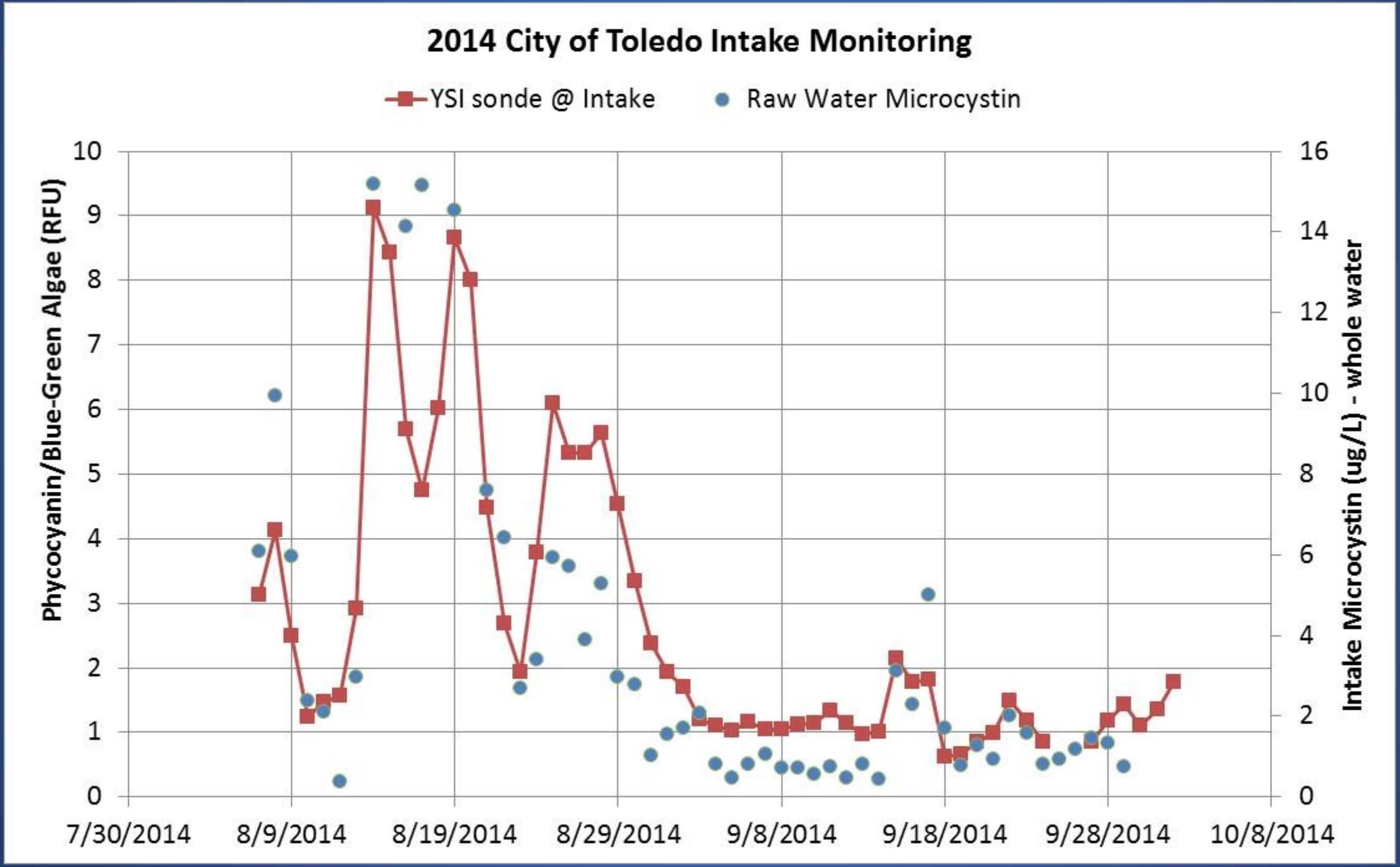
City of Toledo Sensors

Crib Buoy – wind, waves, current, YSI, webcam
Crib Sensor – YSI & webcam
Pump Station - YSI

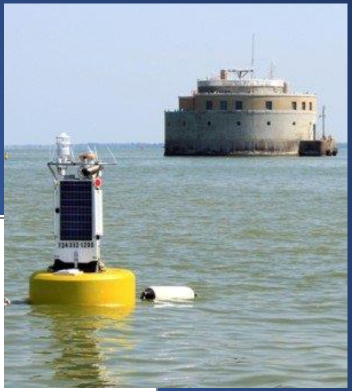
2014 City of Toledo Lake Monitoring

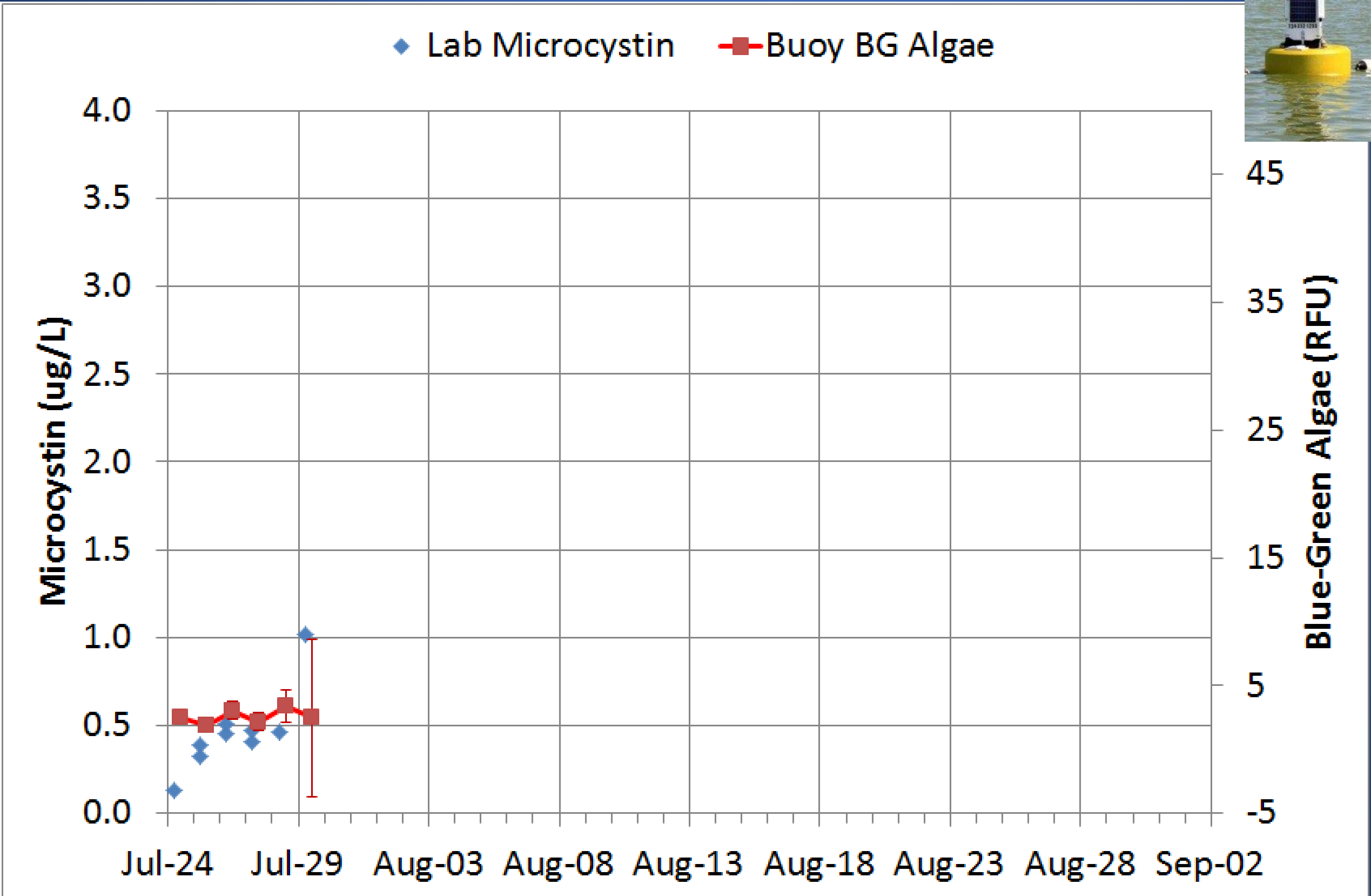


2014 City of Toledo Lake Monitoring

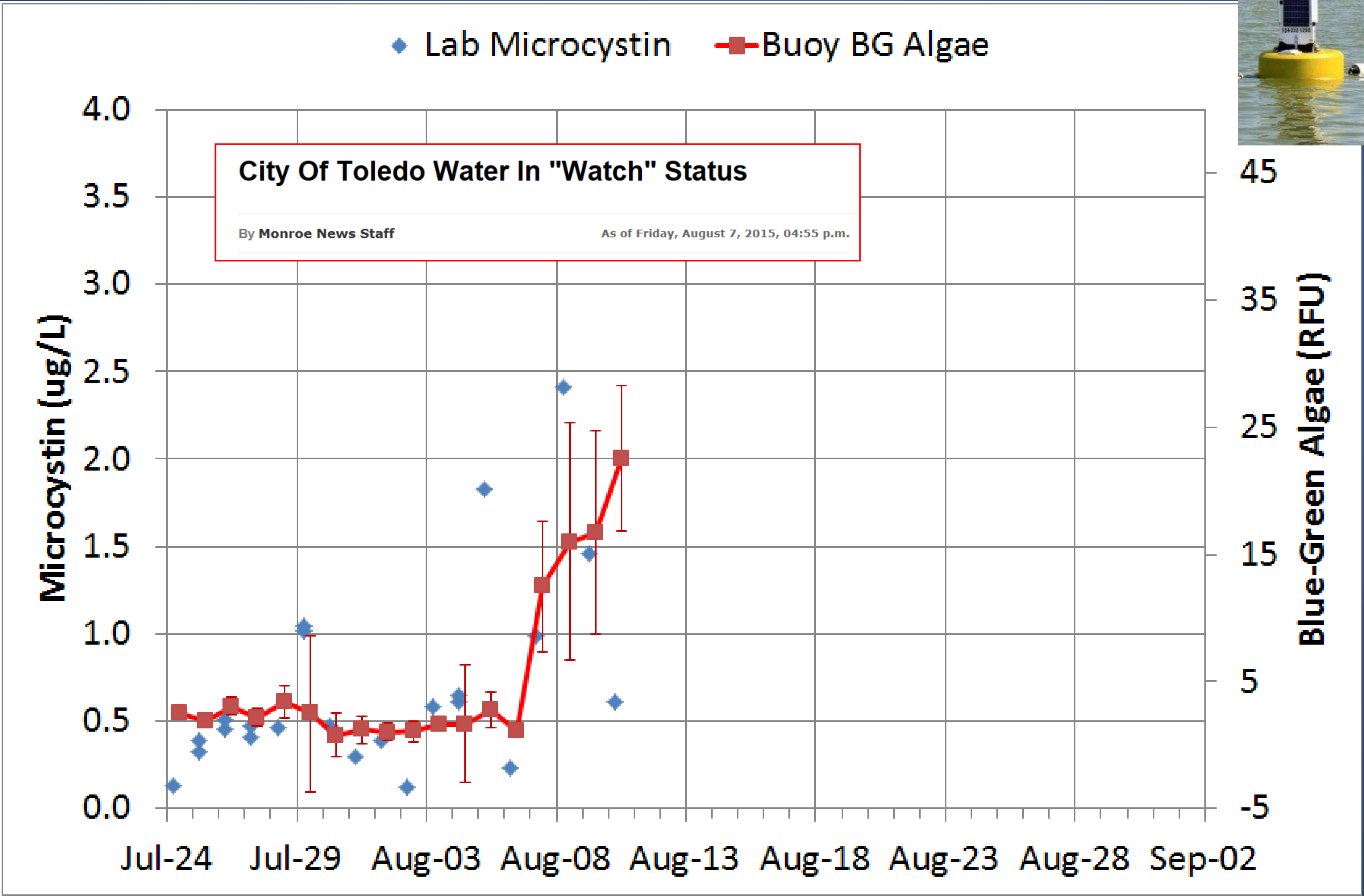


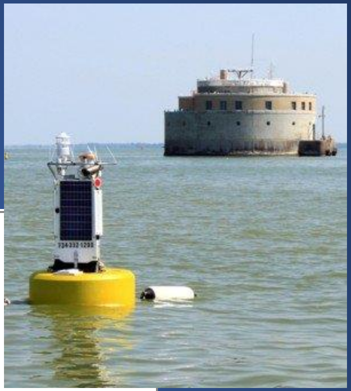
(Near Real-Time) Data → Decision





(Near Real-Time) Data → Decision





(Near Real-Time) Data → Decision

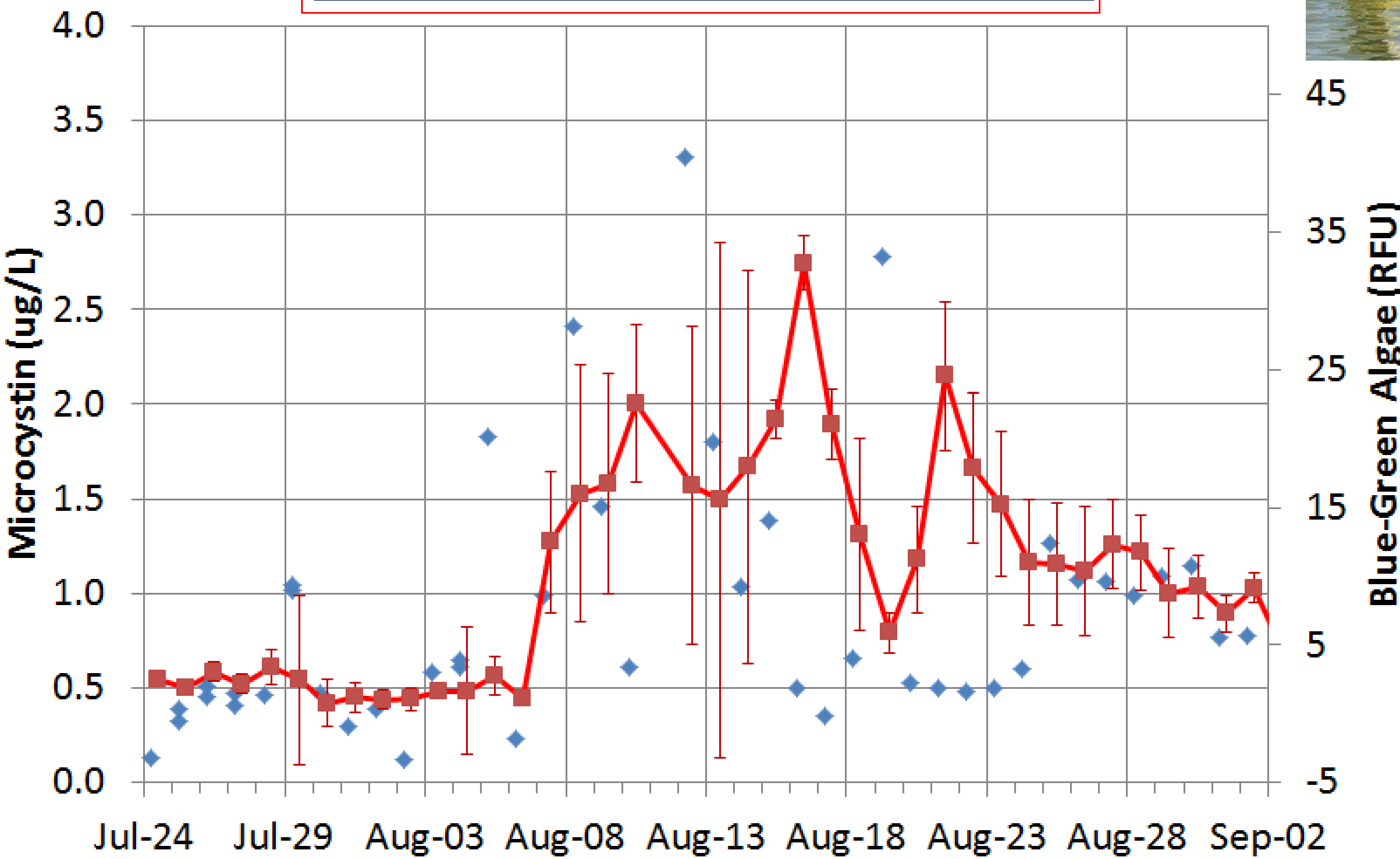
Published: Saturday, 10/3/2015 - Updated: 2 days ago

BUDGET SHORTFALL

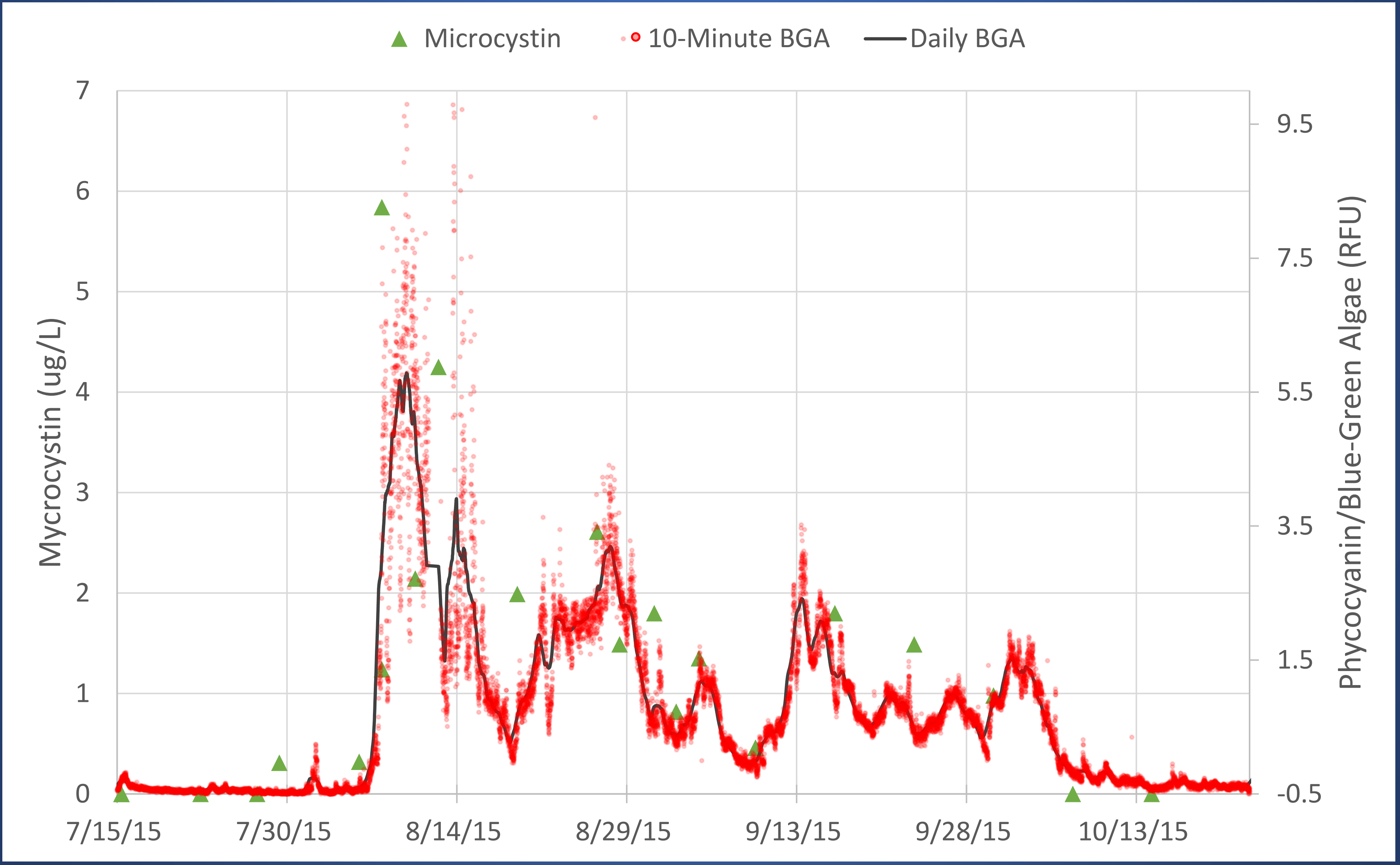
Treating water costing extra $3M

Spring thaw, storm blamed

BY IGNAZIO MESSINA
BLADE WRITER STAFF



City of Oregon Raw Water



How to share data?

- Install a radio or cellular modem
  - Cellular modem directly at sonde site (very cost effective)
  - Isolate outside connection from SCADA system
- Choose data management partner/method
  - Lake Erie – Great Lakes Observing System
  - Other local/regional data partner (USGS, watershed group, etc..)
  - Hosted solution (e.g. Fondriest Environmental, Campbell Scientific, etc..)
- Decide on best method for others to view data
  - Website
  - Recent data, recent trends, and historical data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Sonde Inter-calibration

- LimnoTech
- Bowling Green State University
- University of Toledo
- Ohio State University - Stone Lab
- NOAA GLERL
- Fondriest
- Water Treatment Plants
    - Toledo, Oregon, Port Clinton, Marblehead, Elyria, Avon, Cleveland, Mentor, Ashtabula

Meet 2x per year @ UT Lake Erie Center
~ 20-25 EXO2 per event

Robert Czachorski
@H2OmetricsNews

Following

Team GLASS wins #internetofh2o challenge!! @GEscience @OHMadvisors @CLEH2OAlliance @TrimbleCorpNews

9:36 AM - 27 Oct 2017

Green Eyes Environmental Observing Systems

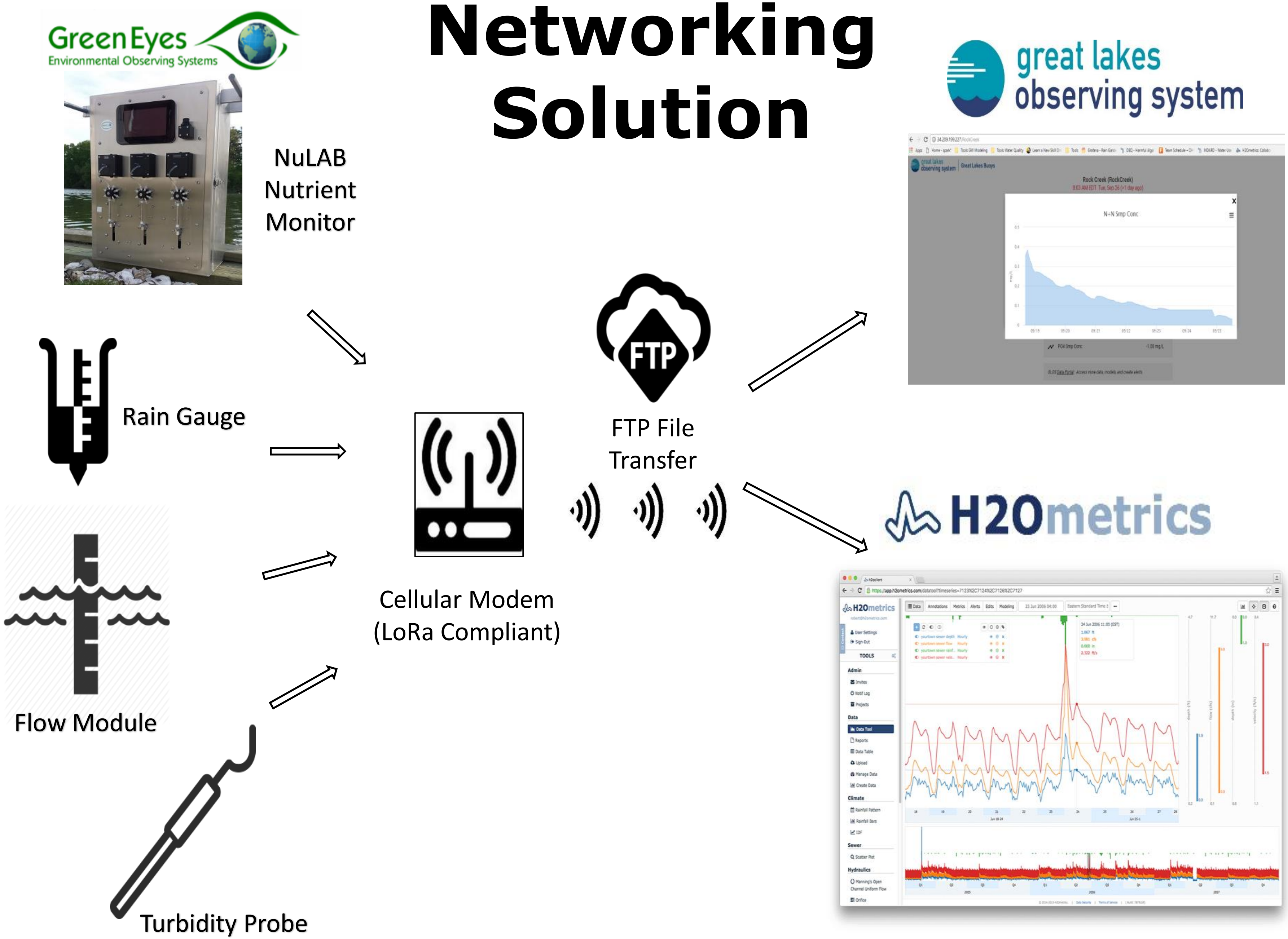
NuLAB

- Wet-chemical methods for N+N, Nitrite, Phosphate, Ammonium, Silicate
- Field deployment with 12v battery
- High level of accuracy
- LOW COST Reagents!
- 1mo to 3mo deployments possible

http://gescience.com

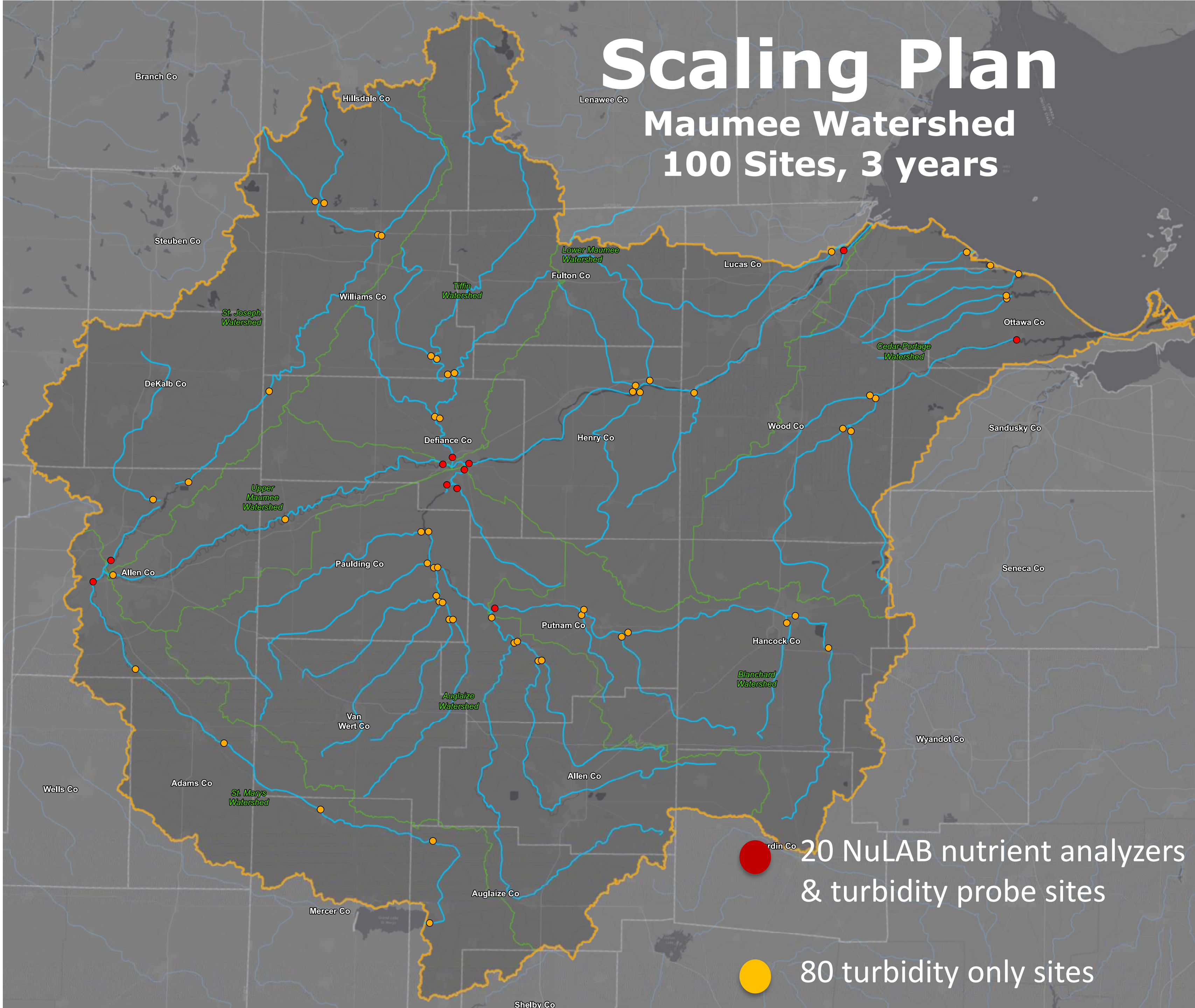
Vince Kelly
Director

Networking Solution



Scaling Plan

Maumee Watershed
100 Sites, 3 years



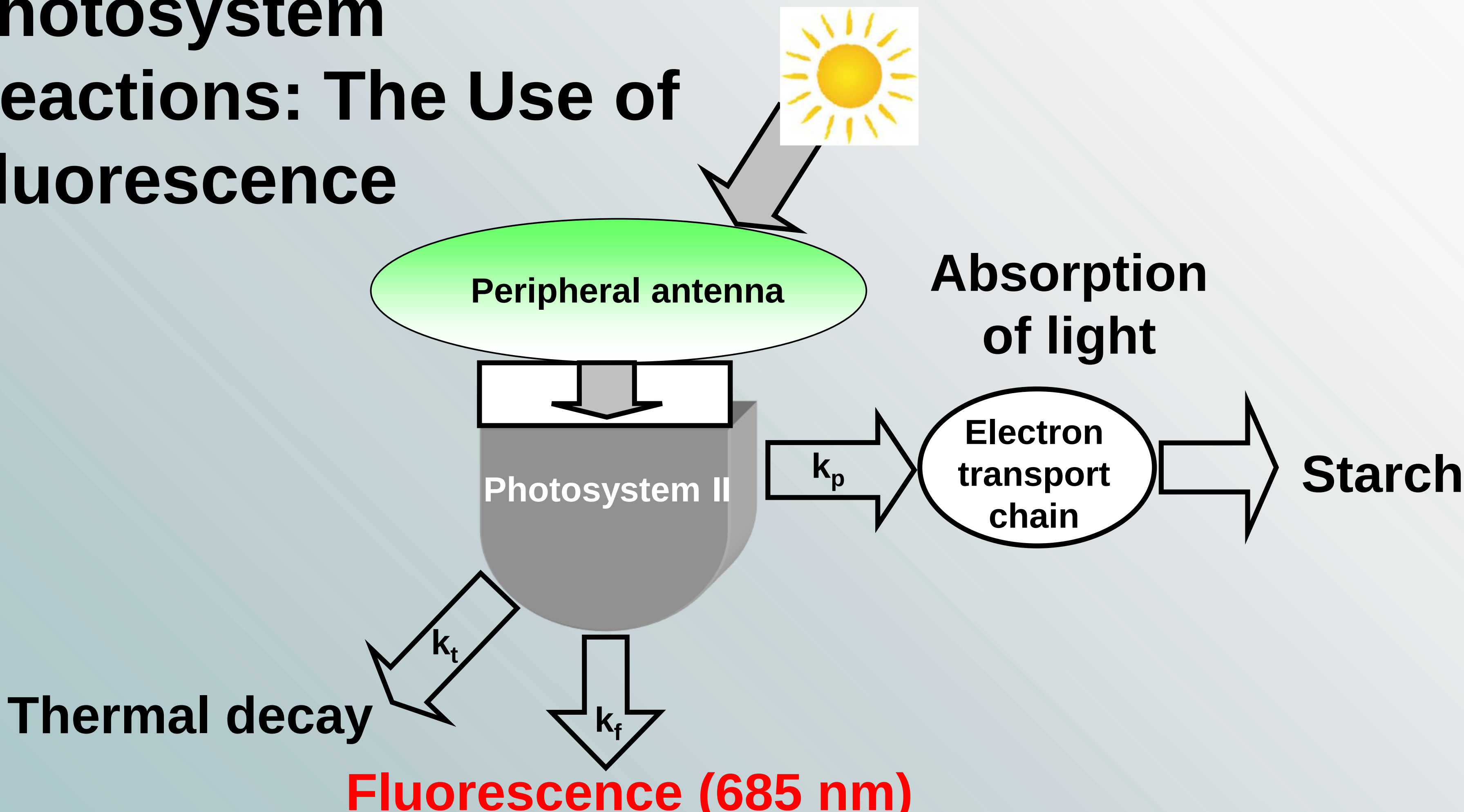
20 NuLAB nutrient analyzers & turbidity probe sites

80 turbidity only sites

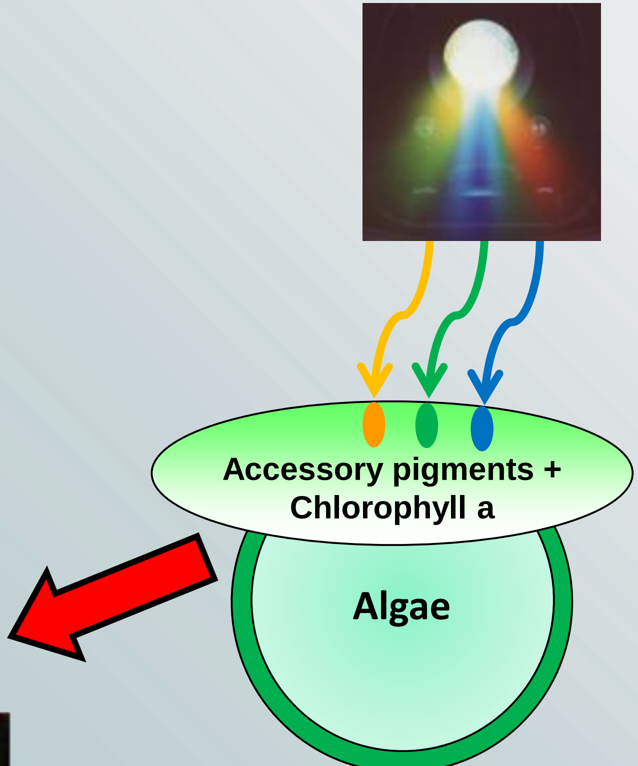
New Fluorometer Uses the Parameter ‘Unbound Phycocyanin‘ as an Early Warning System for Cyanobacterial T&O Compounds and Cyanotoxins

Christian Moldaenke,
bbe Moldaenke GmbH

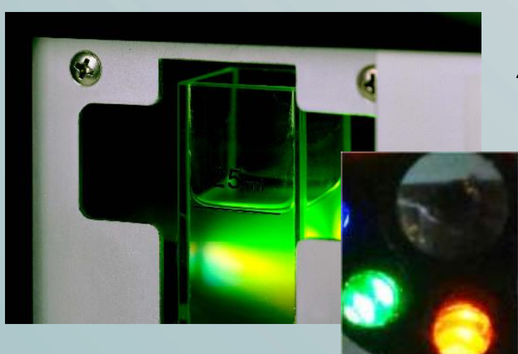
Photosystem Reactions: The Use of Fluorescence



Multicolor Excitation



Algae have a color …
We use that fact



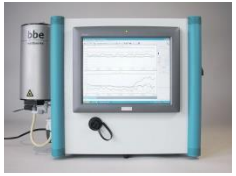
Determination of chlorophyll fluorescence

biological · biophysical · engineering

bbe moldaenke

Classification of Phytoplankton

Spectral Group	Green	Blue	Brown	Red	Mixed
Peripheral Antenna	Chlorophyll a/b-Xanthophyll	Phycobilisomes (Phycocyanin)	Chlorophyll a/c-Xanthophyll	Phycobilisomes (Phycoerythrin)	Chlorophyll a/c-Phycobiliprotein
Division	Chlorophyta	Cyanophyta Glaucophyta	Heterokonto-phyta Haptophyta Dinophyta	Rhodophyta	Cryptophyta



biological · biophysical · engineering

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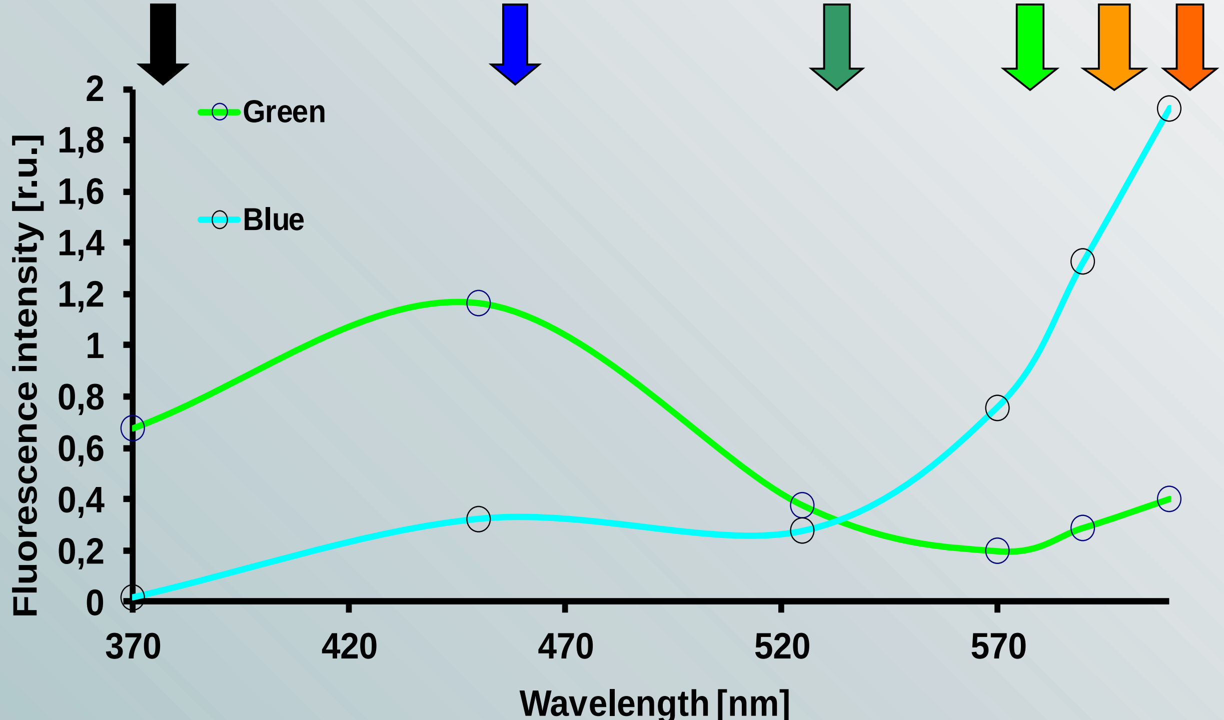
Algae Excitation Spectra (Fingerprints)…



…enables to calculate the quantity

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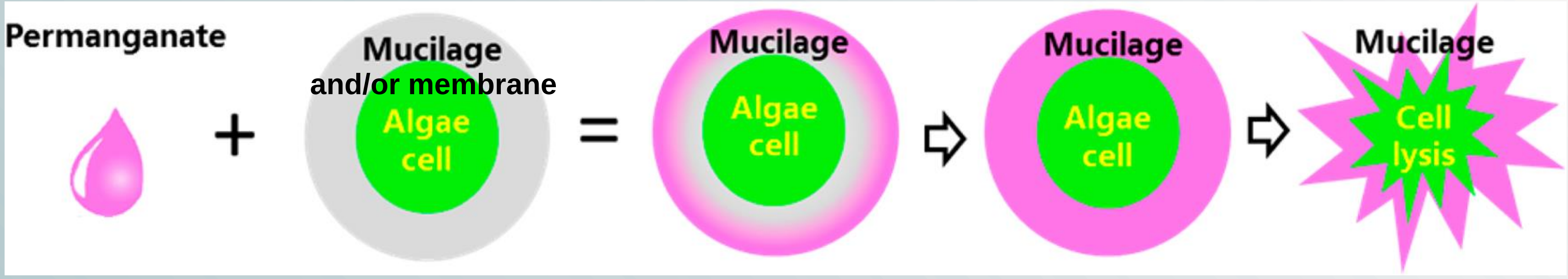
The Treatment of Cyanobacteria in Water Works



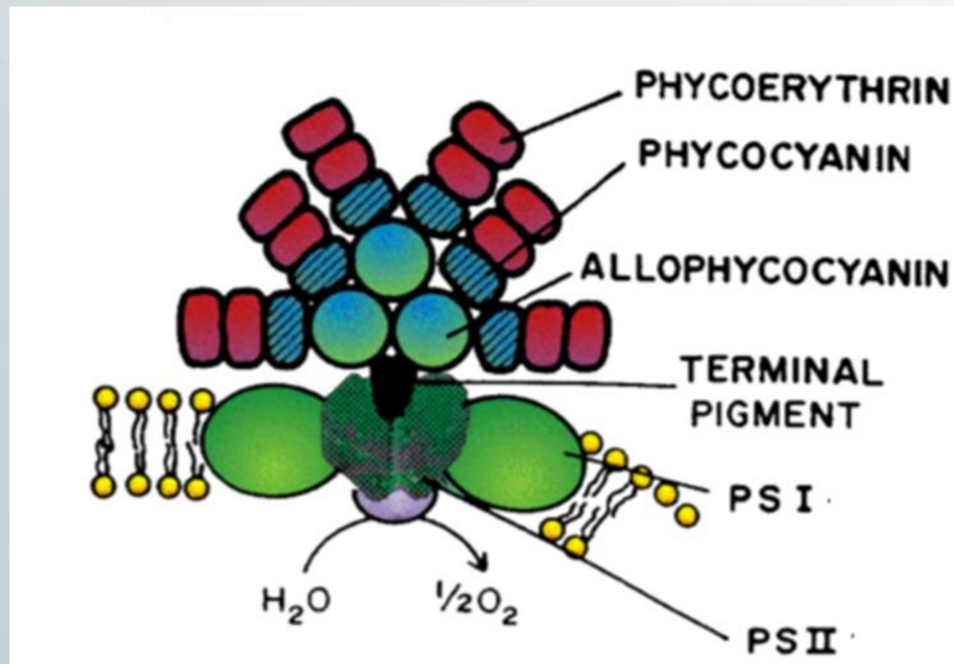
Permanganate destroys toxins in the water but may also cause algal cells to rupture (lyse) – releasing more toxin into the water.

Goal : Add enough permanganate to destroy dissolved toxins but not enough to lyse algal cells (removed later).

Problem: How to identify when cells are lysing?

Answer: We identified a new spectrum - “unbound phycocyanin” - which is released when cells begin to lyse and can be measured by a fluorometer.

“Unbound” or “Free” Phycocyanin



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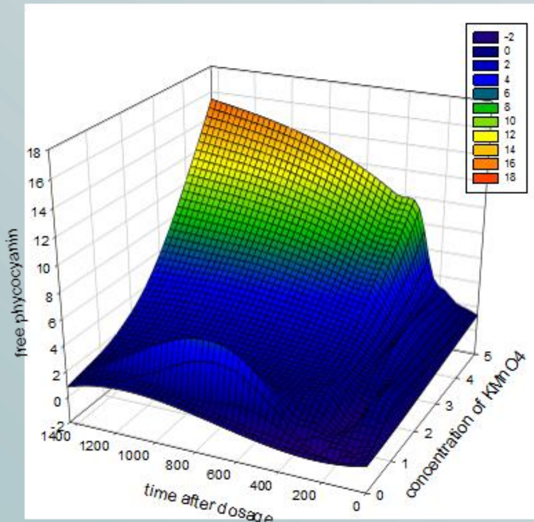
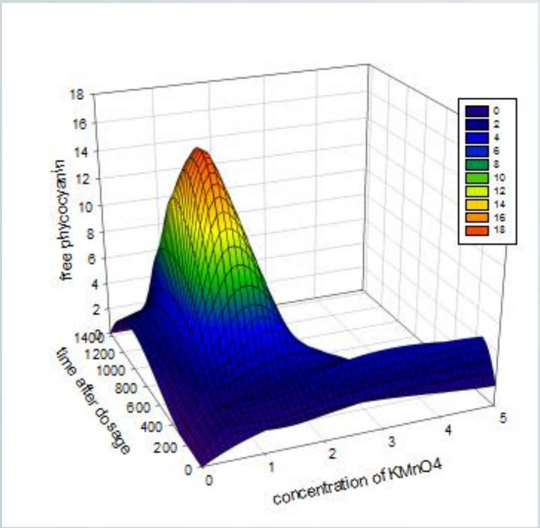
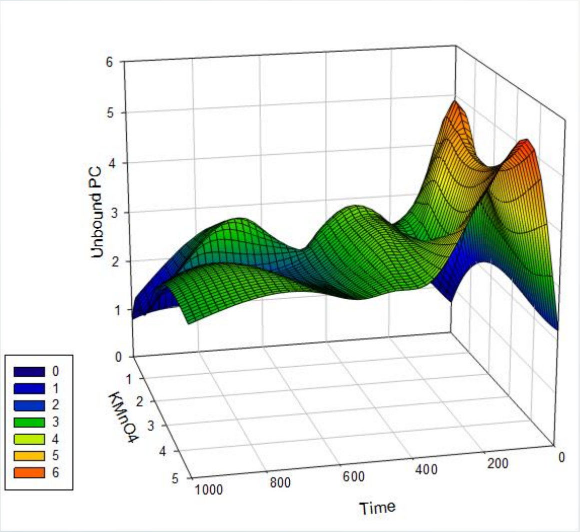
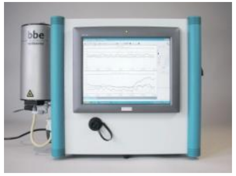
The Effects of Permanganate under Different Conditions







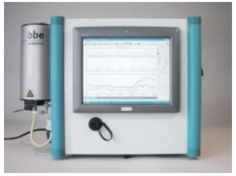
The lysis of cyanobacteria by permanganate is measured by the release of “free” phycocyanin. The effects of permanganate on cyanobacteria is demonstrated under 3 different conditions (Fig. left: inclusively yellow substances, middle: without yellow substances, right: cyanobacteria colonies).





Lake Erie Samples and Simulation of Toledo Water Works Processes

02. Sep 17			
		toxins by Abraxis strips	free phycocyanin r.u.
raw water	total	>5ppb	0
	dissolved	**0.5 ppb**	0
addition of permanganate	total	>4 ppb	**1.4**
	dissolved	>2 ppb	**0.2**
08. Sep 17			
raw water	total	>5ppb	0
addition of permanganate	total	**>4 ppb**	**1.9**
	dissolved	>1 ppb	**0.4**
13. Sep 17			
raw water	total	>5ppb	0
addition of permanganate	total	>4 ppb	1.1
	dissolved	>4 ppb	0.13





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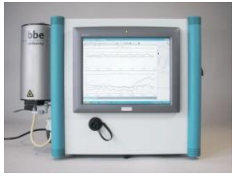
Interpretation of the Toxin Data

		toxins by Abraxis strips	free phycocyanin r.u.
raw water	total	>5ppb	0
	dissolved	**0.5 ppb**	0
addition of permanganate	total	>4 ppb	**1.4**
	dissolved	>2 ppb	**0.2**

Cells did not lyse (raw water)

Cells lysed (addition of permanganate)

Permanganate caused cells to lyse and dissolved toxins to increase.
The cell lysis was detected by free phycocyanin



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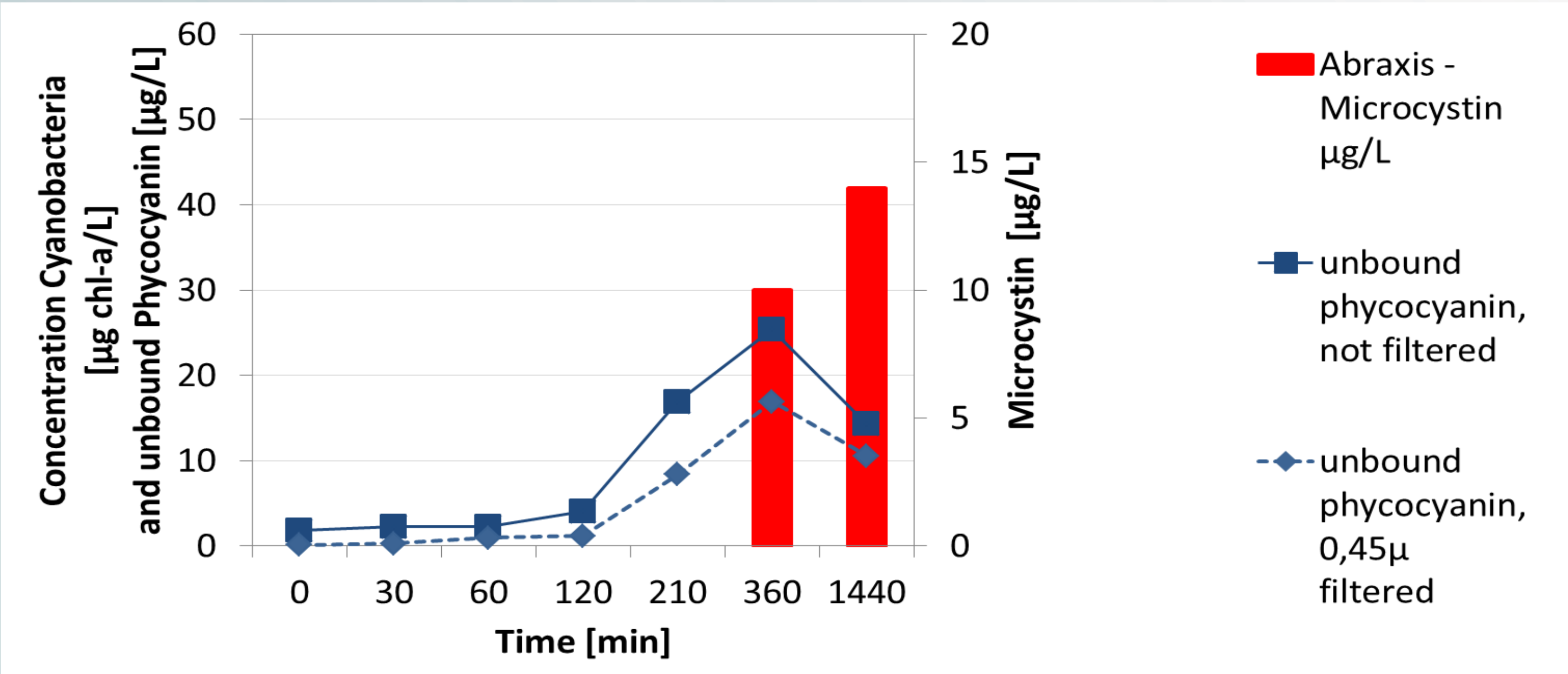
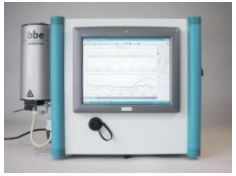
Effect of the pre-oxidation chemical



Application of 4mg/l $KMnO_4$ on a solution containing 50 µg/l chlorophyll (microcystis). Cell lysis allows the detection of unbound PC and extracellular microcystins.





Measuring free phycocyanin can help water utilities better understand when cells begin to lyse under different dosages of permanganate and different yellow substance concentrations.

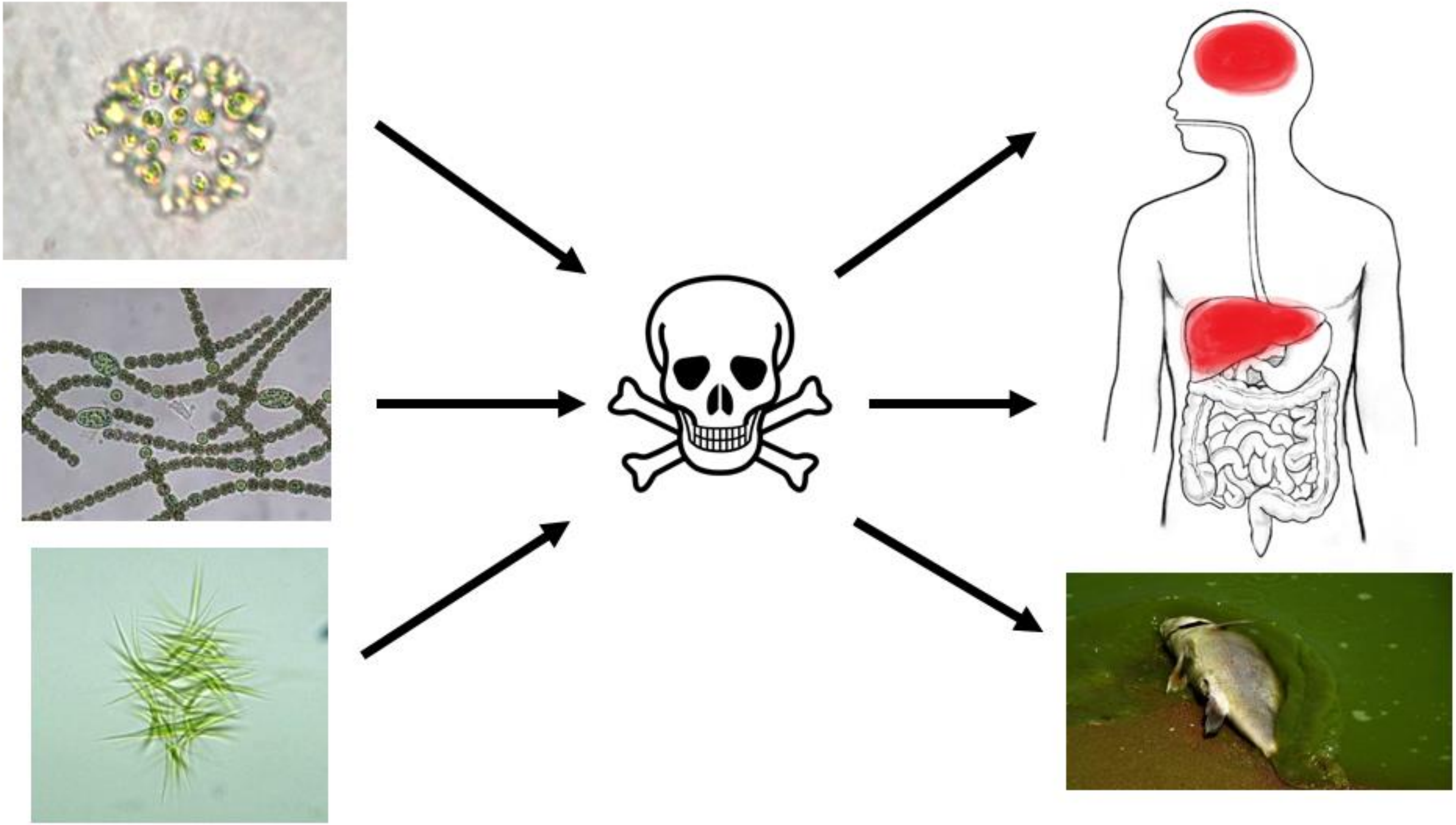
Therefore free phycocyanin may become a powerful tool in helping water utilities fine-tune their treatment procedures

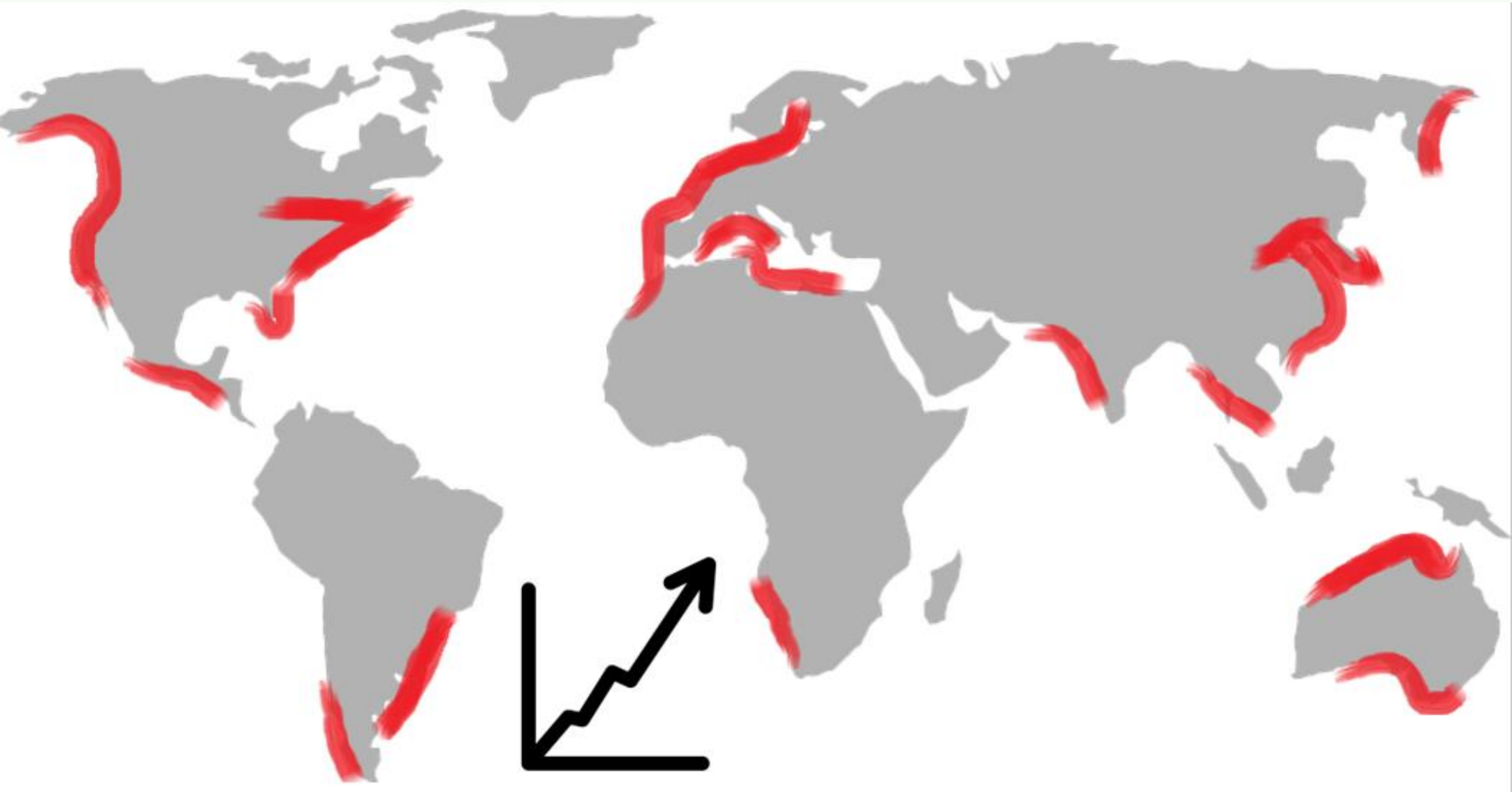

Thank you

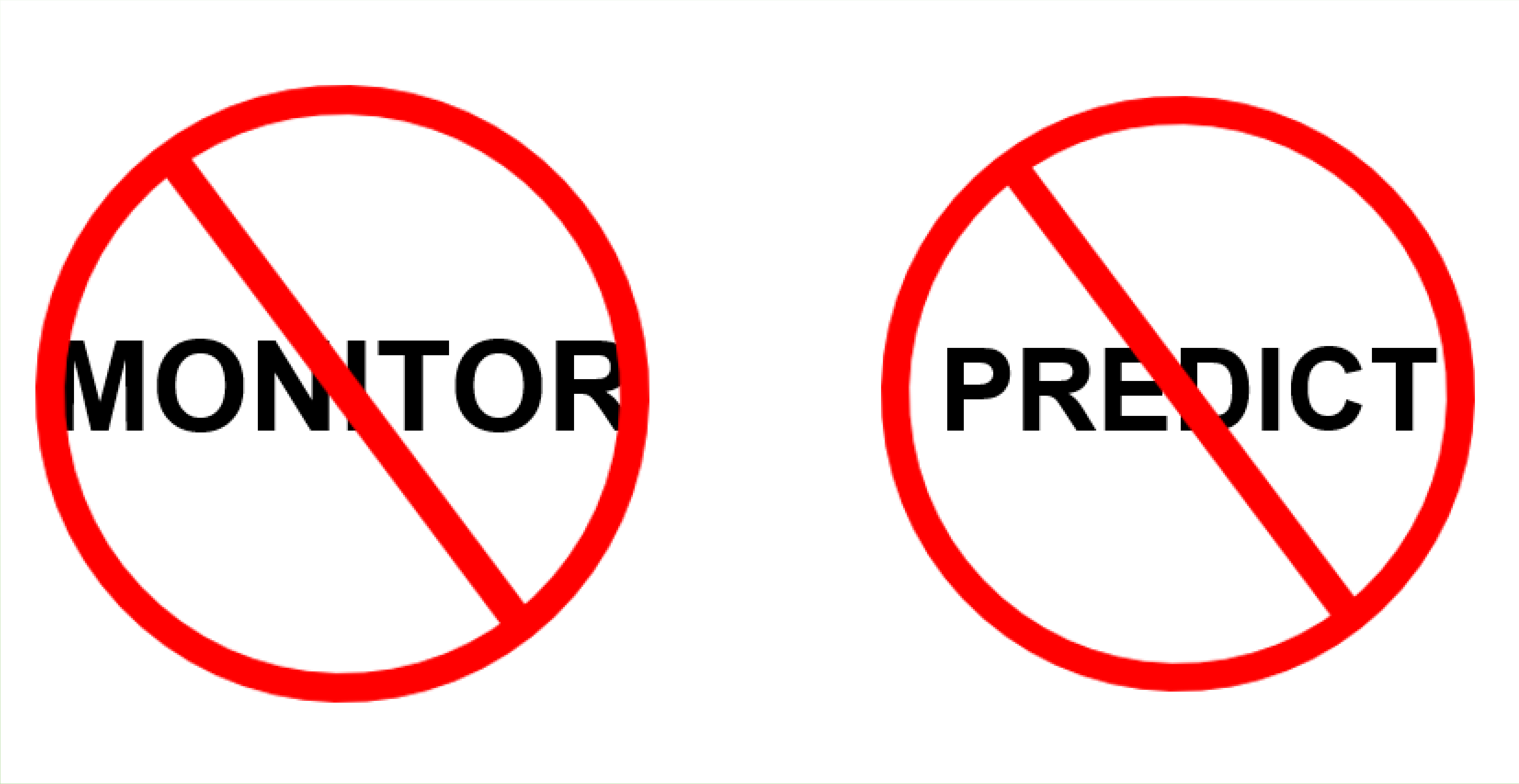
SIM LABS

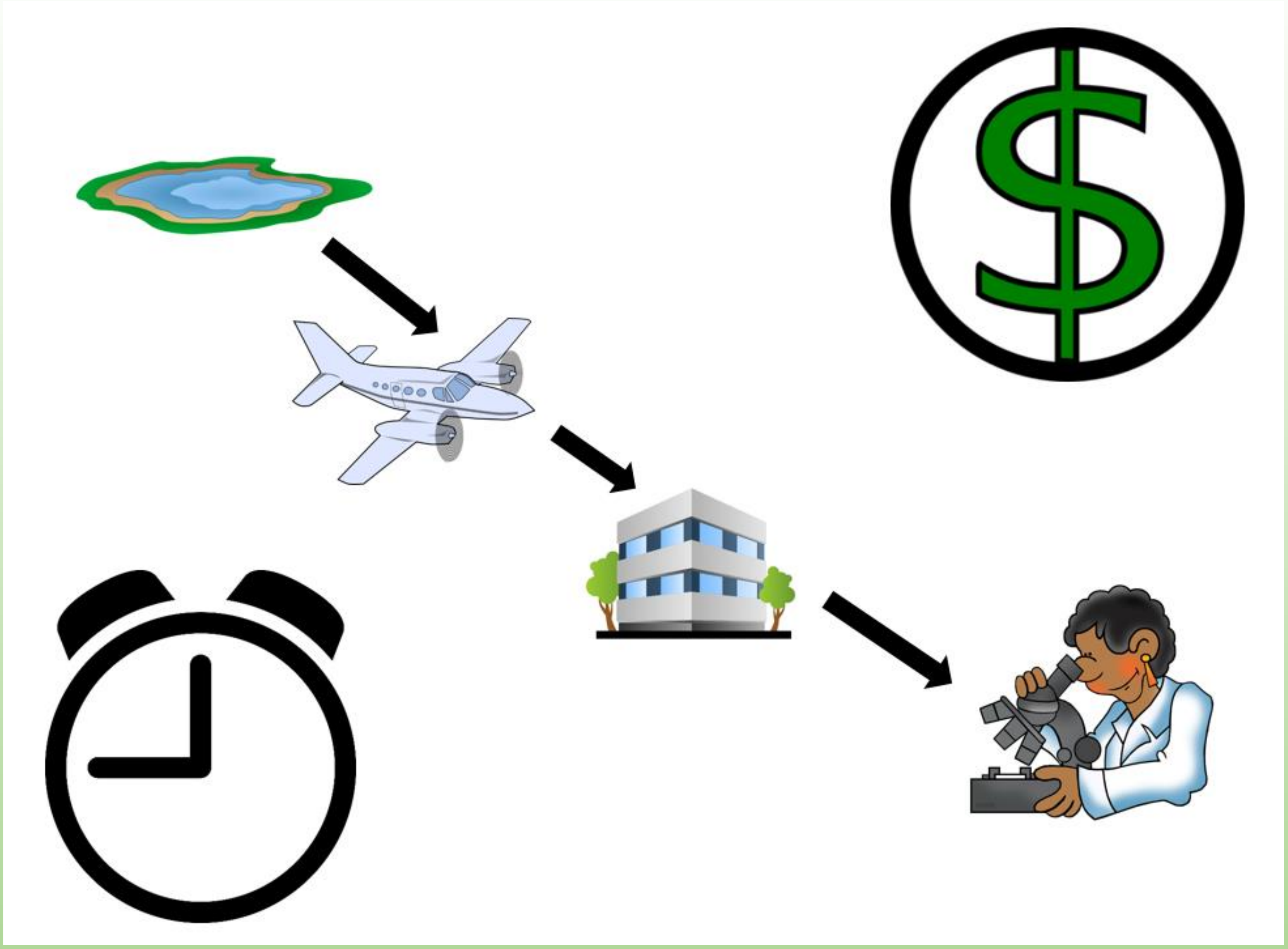
Jason Deglint
PhD Student
University of Waterloo
jdeglint@uwaterloo.ca

Harmful Algae Blooms (HABs)






MONITOR
PREDICT



Systematic Intelligent Monitoring (SIM)

MONITOR ✓ **PREDICT** ✓

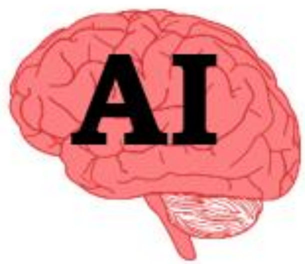
Systematic Intelligent Monitoring (SIM)

UNIQUE WAVELENGTH LEDs

OFF THE SHELF COMPONENTS

CAMERA

+



ARTIFICIAL NEURAL NETWORKS

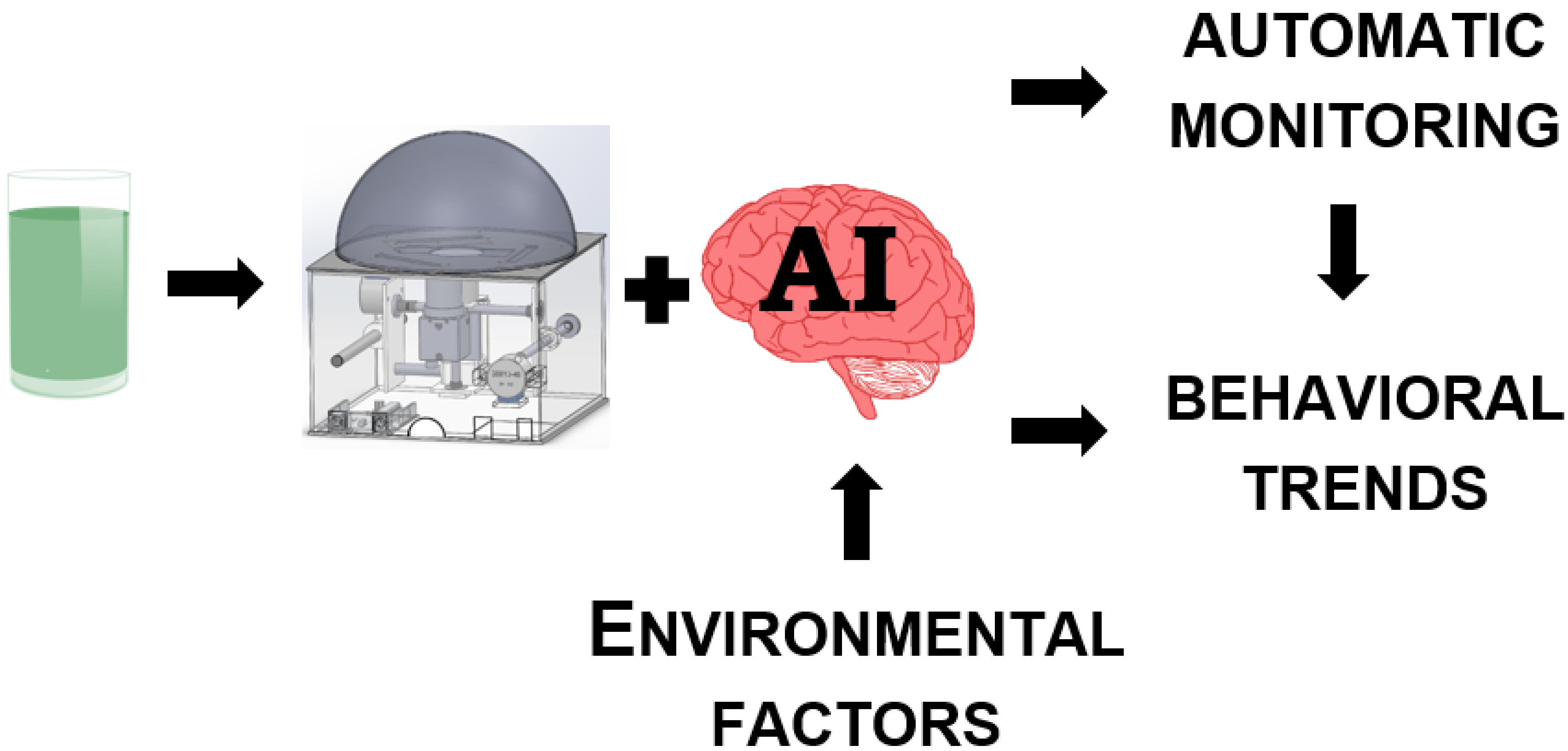
COMPUTER VISION

STATISTICAL MODELS

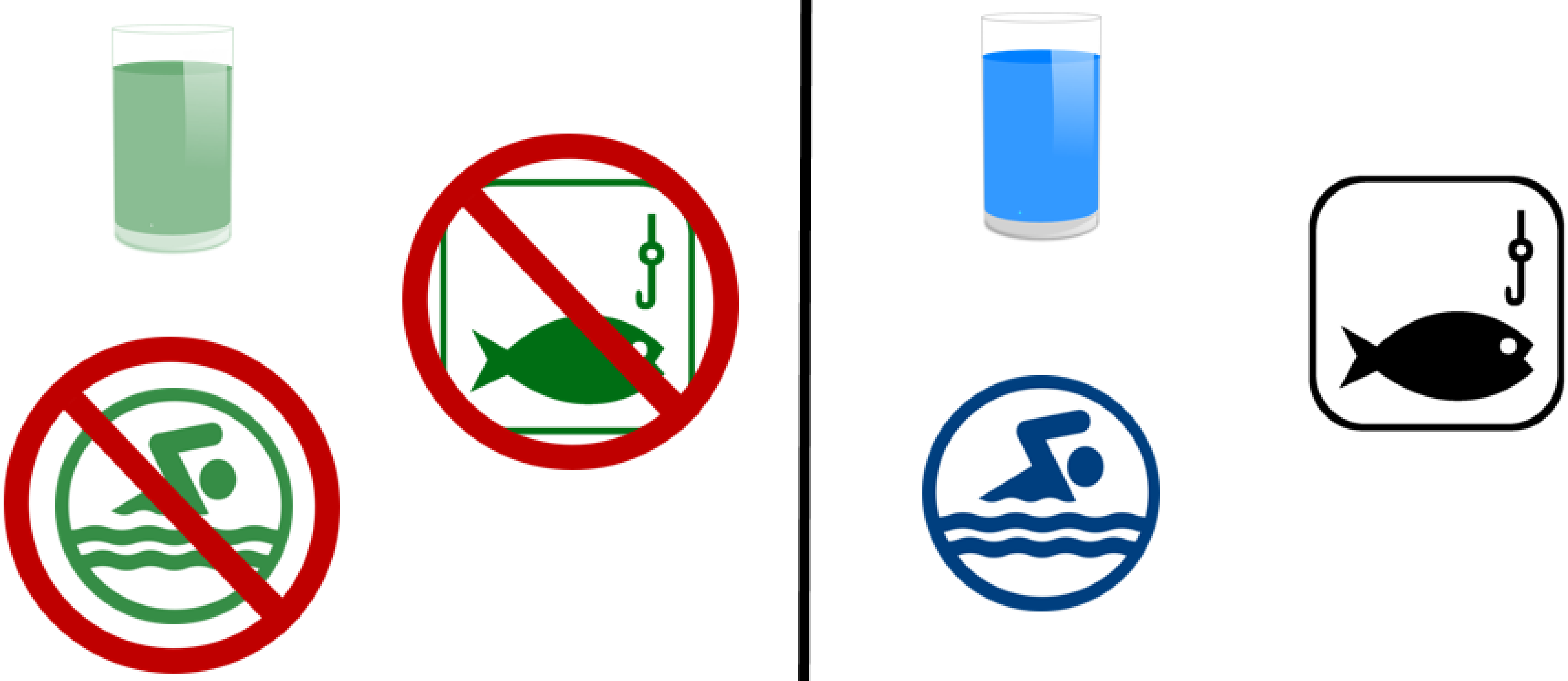
MACHINE LEARNING

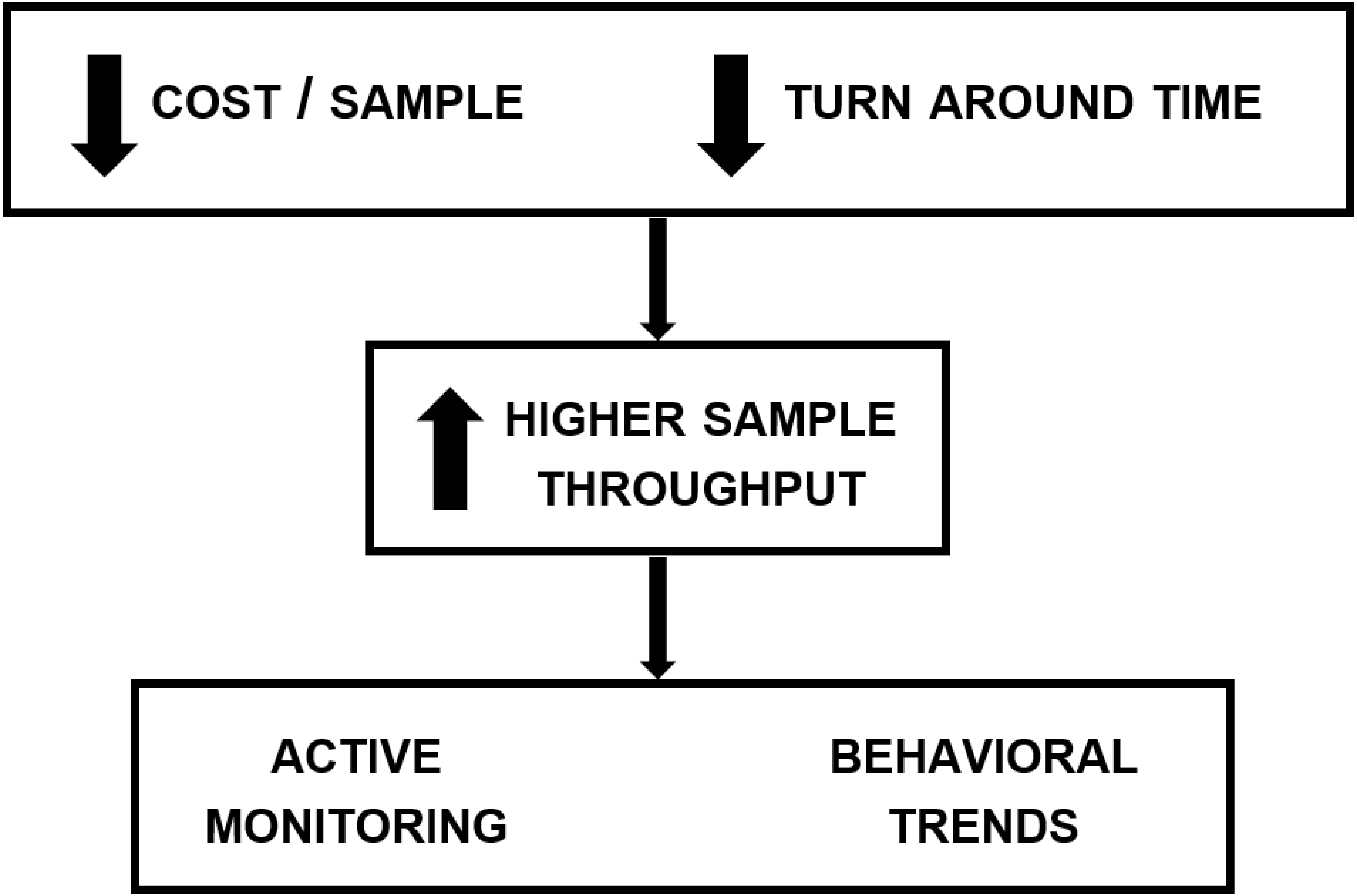
OPTIMIZATION

Systematic Intelligent Monitoring (SIM)



REACTIVE | PROACTIVE




COST / SAMPLE
TURN AROUND TIME
HIGHER SAMPLE THROUGHPUT
ACTIVE MONITORING
BEHAVIORAL TRENDS

Jason Deglint

Systems Design

Engineer

Dr. Alexander Wong

Artificial Intelligence

Expert

Dr. Chao Jin

Water Treatment

Expert

Kevin Thomason

Business Advisor

&

Environmentalist

UNIVERSITY OF WATERLOO

VELOCITY


1ST
PRIZE
SIM Labs

SIM LABS

SIM LABS

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Robot Swarms, Filter-feeding Fish, and Tethered Balloons

Adam Schroeder
PhD Adviser: Dr. Brian Trease
University of Toledo
14 November 2017

Part 1: Swarm Robotics

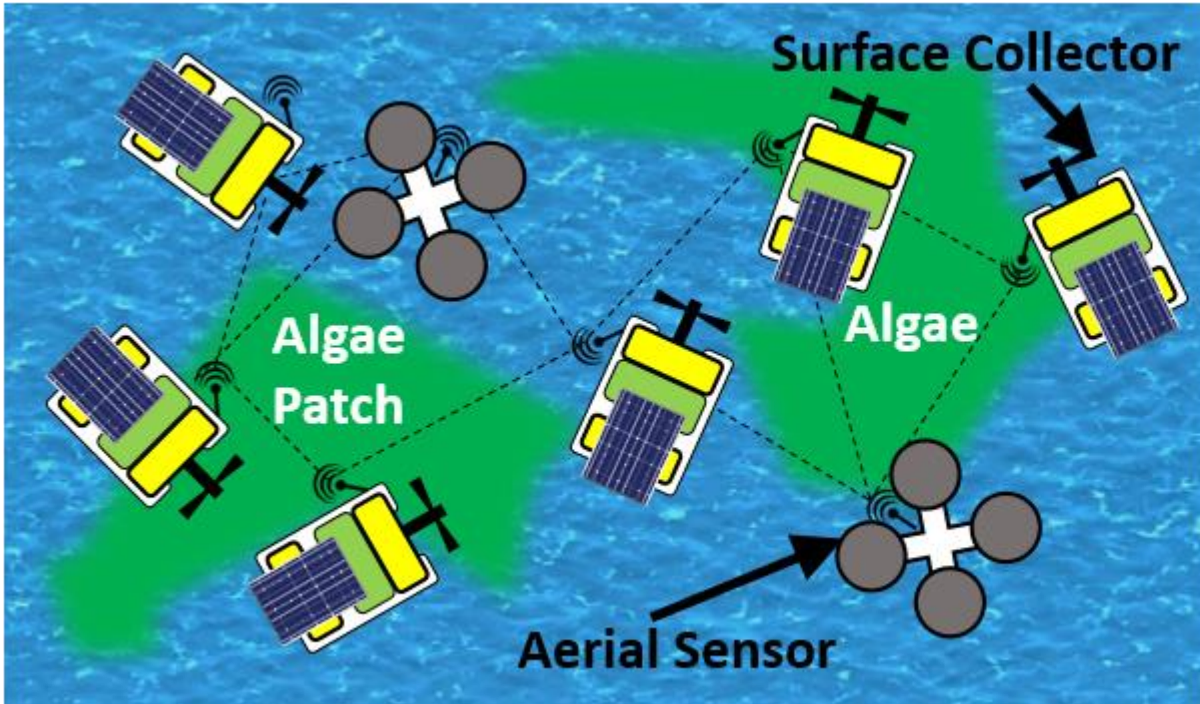
Big Idea: Use a heterogeneous swarm of robots to monitor and physically collect harmful algae.

Robot Swarms (inspired by swarm intelligence)
- *Massively* scalable
- Robust to loss of individual agents
- Each agent requires minimal sophistication

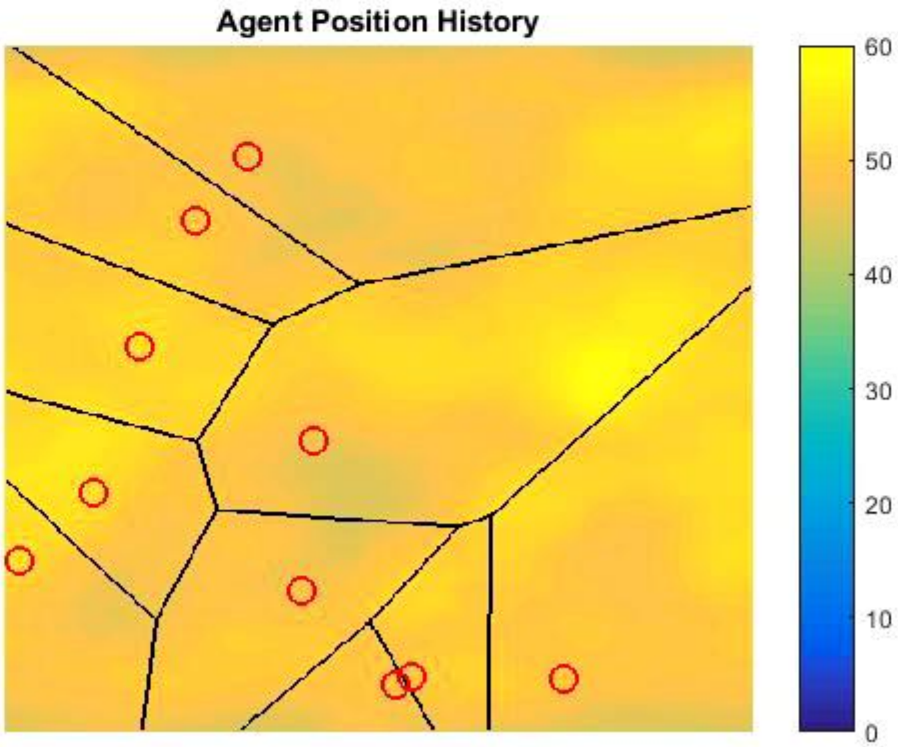
High-Level Goals

Establish feasibility of constructing full swarm

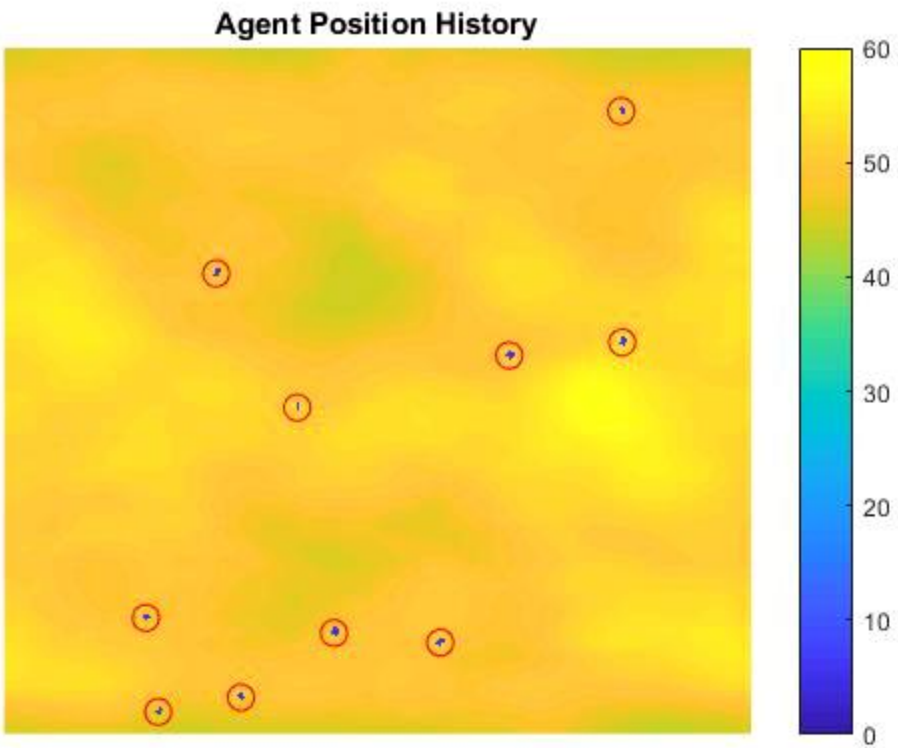
1. At what rate can a single agent collect algae?
2. How much would (i) an individual agent and (ii) an ensemble swarm cost?
3. What major technology roadblocks exist?



Part I: Swarm Algorithms

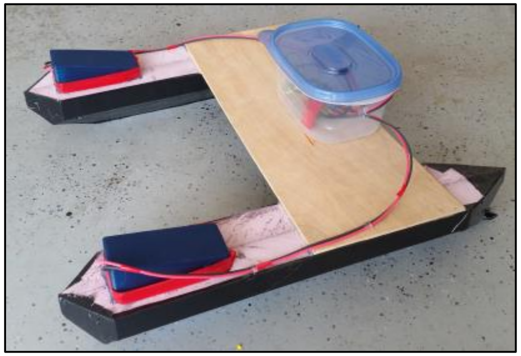


Partitioned

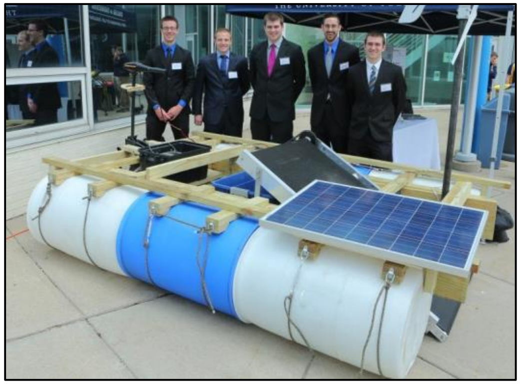


Non-Partitioned

Part I: Swarm Platforms



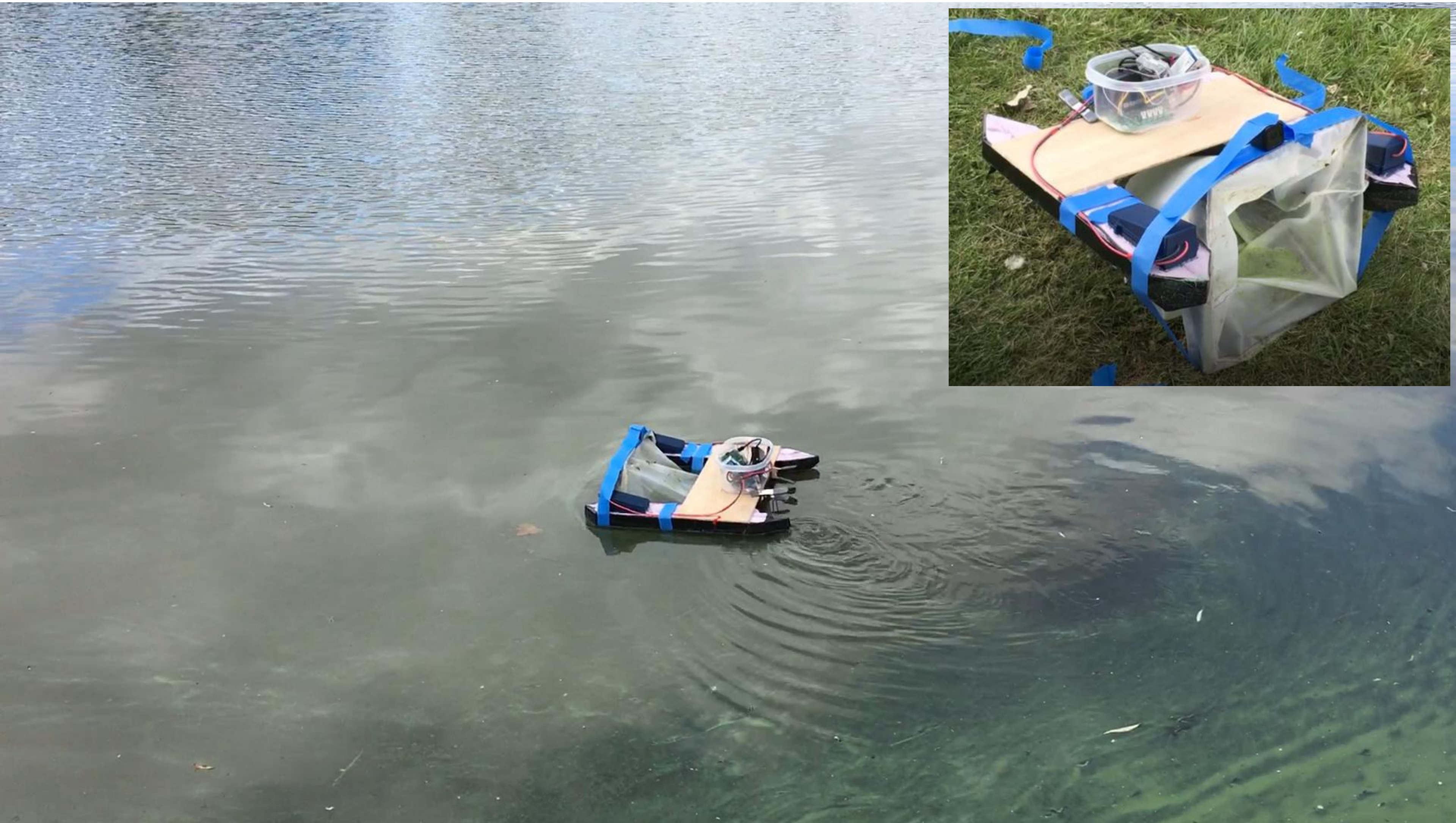
1st generation boat had only conveyor for collecting surface scum



Platform initially built by undergraduate senior design team. Modifications made by undergraduate Robert Longfield.

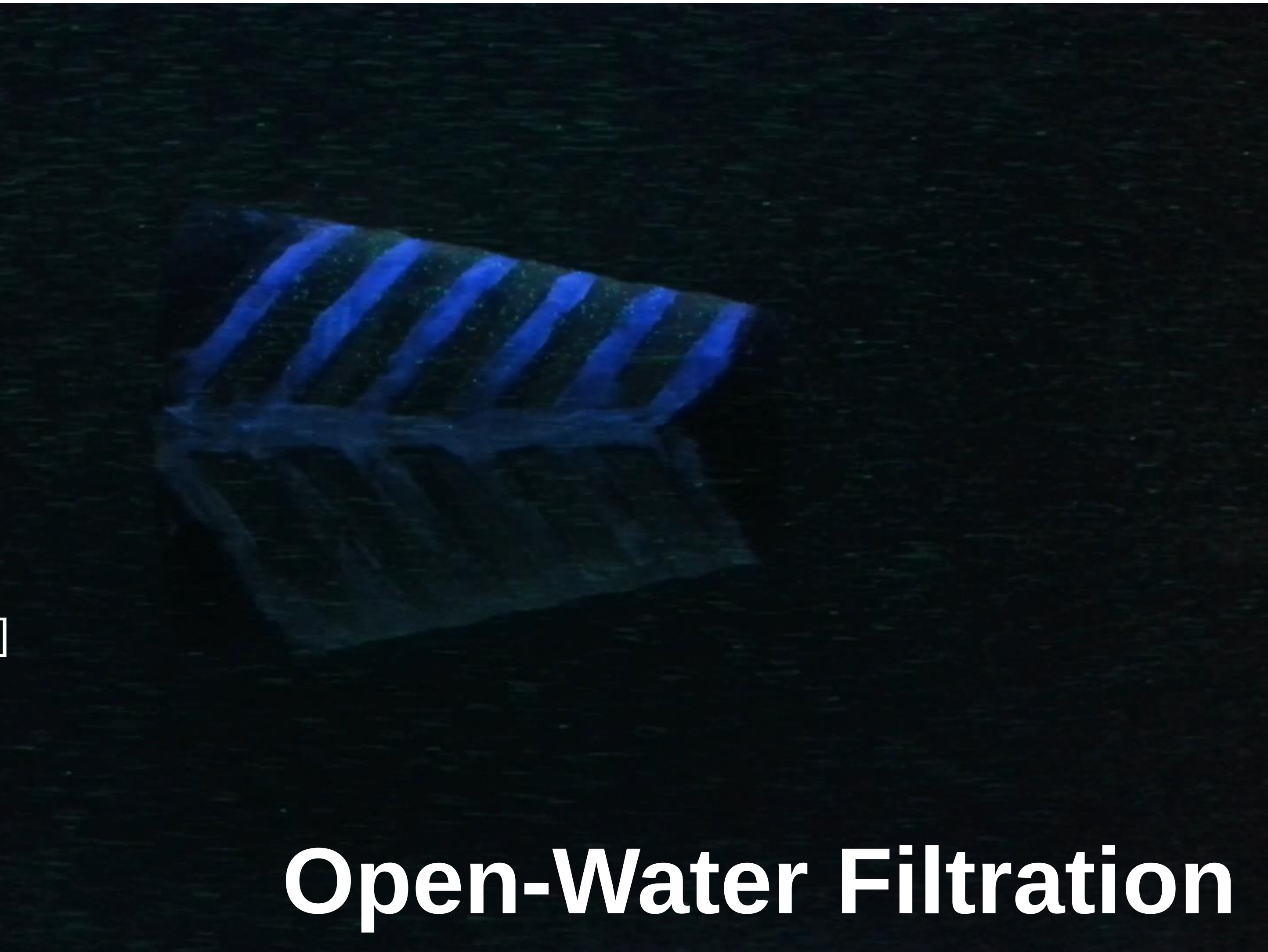
Part II: Filtering Algae

Open-Water Filtration



Part II: Collecting Pseudo Algae

Bioinspired Cross-Flow Filter



Paddle Fish

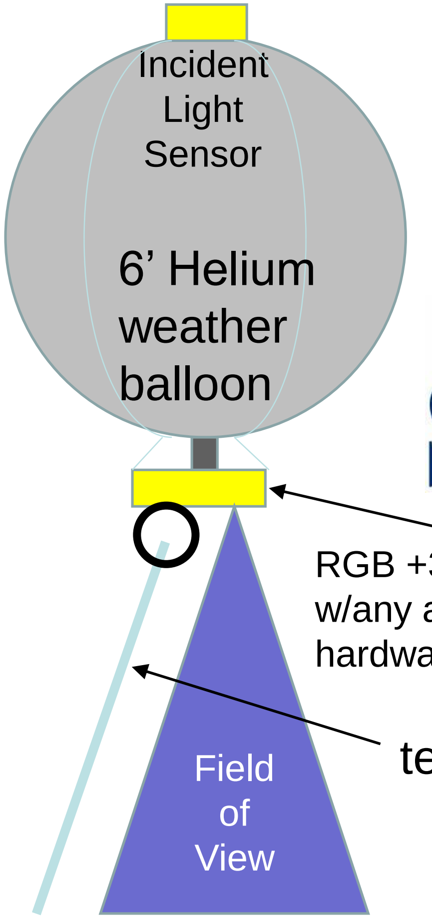
[Sanderson et al 2016]

Basking Shark

Open-Water Filtration

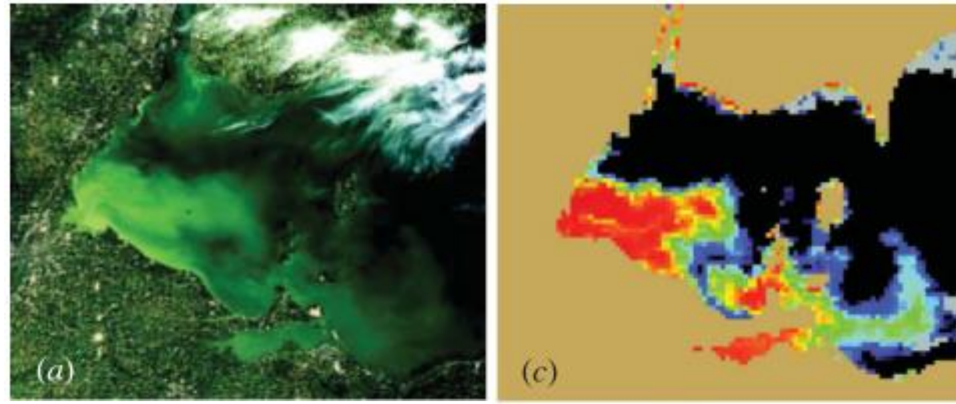
Part II: Collecting Real Algae

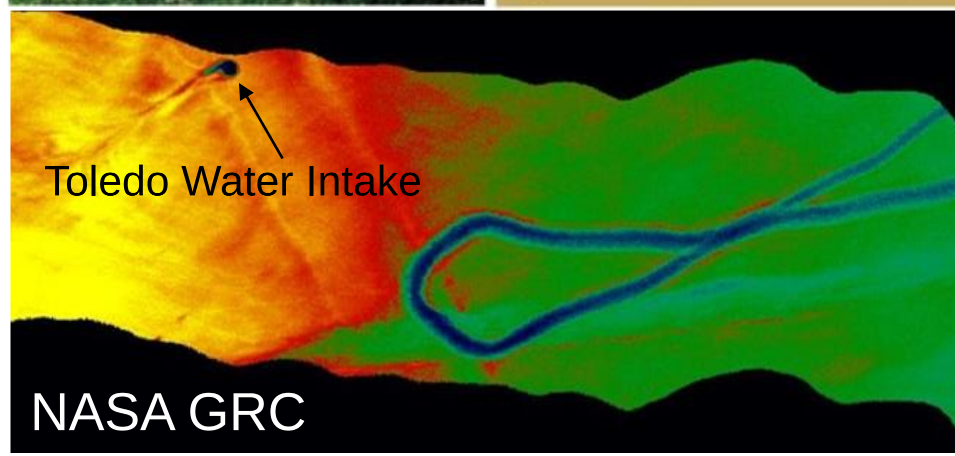
Part II: Remote Sensing



Sea Grant

True Color CI$_{MERIS}$





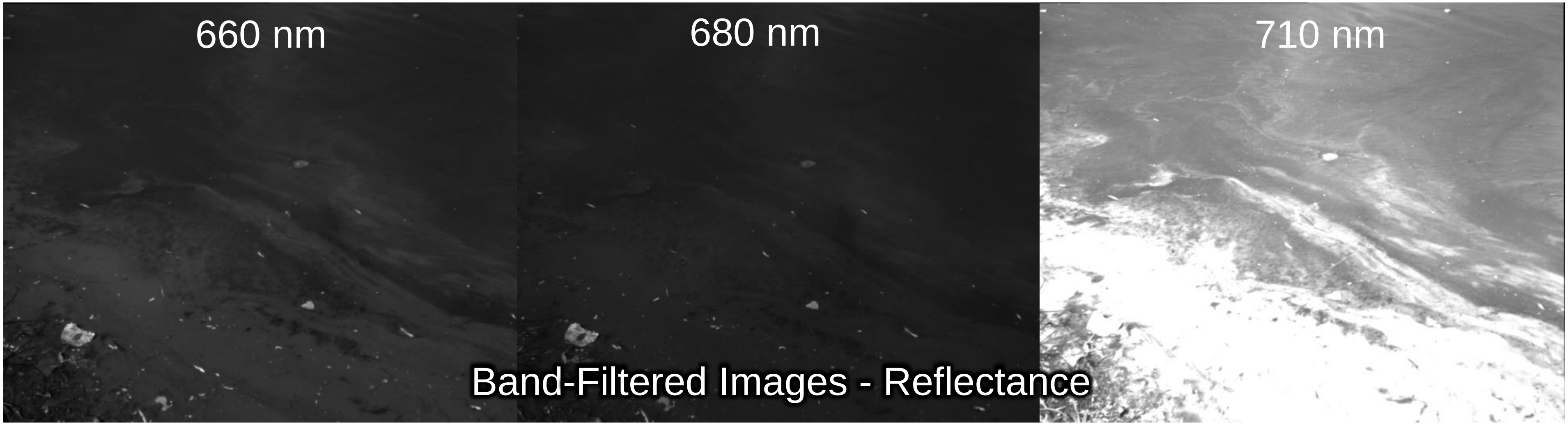
Enables New Science

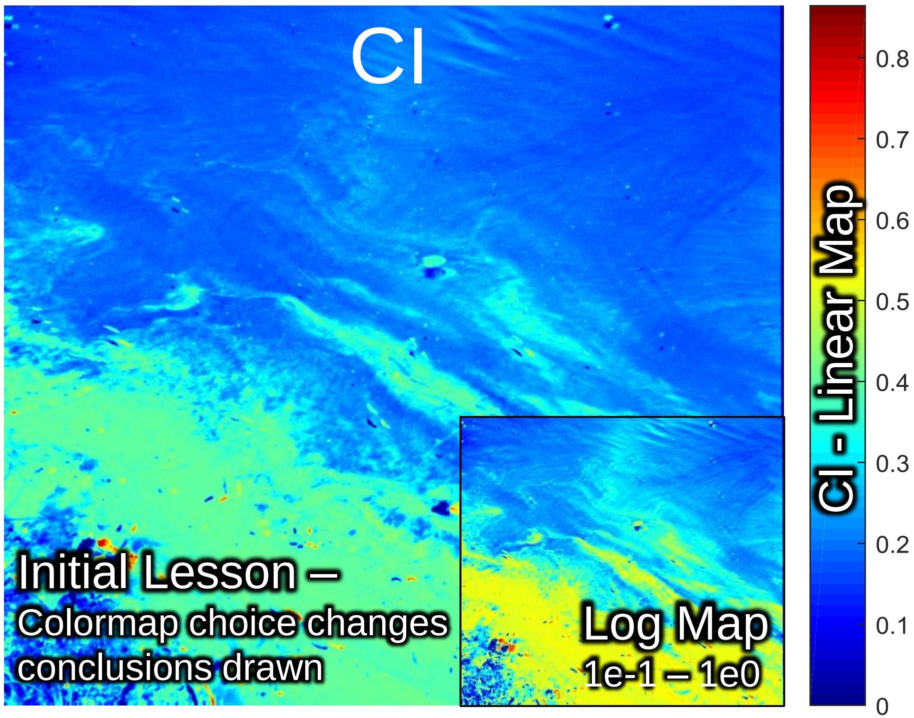
- ‘Sub-pixel’ information and lakes smaller than 1km (without aerial flyover)
- Observe real time migration and investigate bloom heterogeneity at new scale

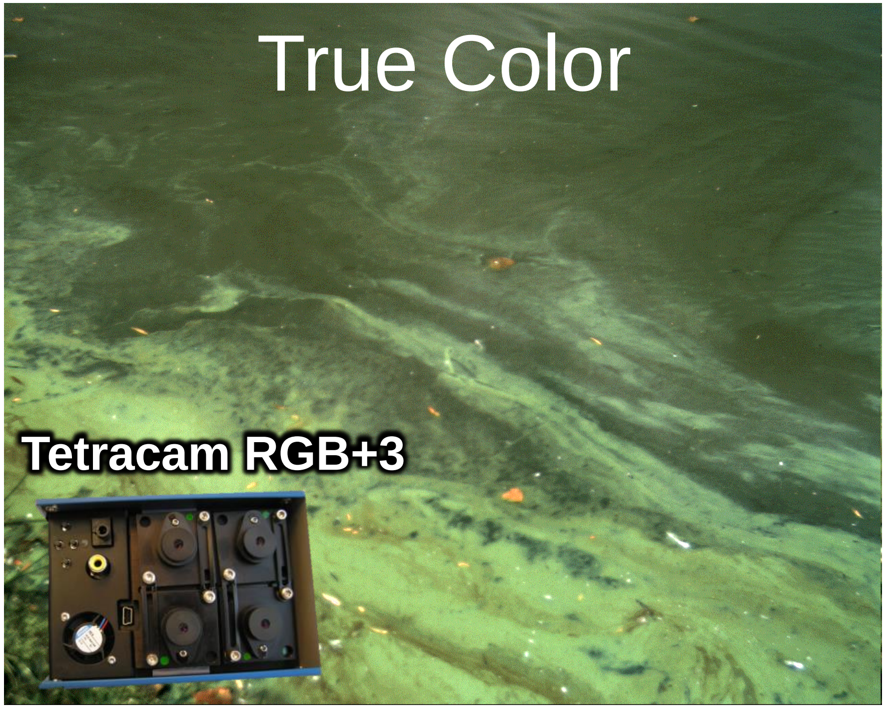
Unlocks Water Management Data

- Water treatment managers can get real time algal concentration near water intake
  - More comprehensive than single fluorometer

Part III: Initial Multispectral Data



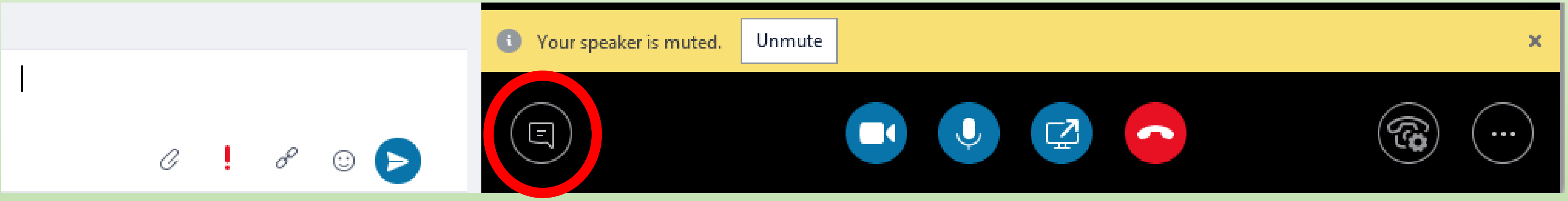




Adam.Schroeder@rockets.utoledo.edu

Questions

Submit your question using the chat box.



Thank you!

A recording will be posted at:

http://www.glc.org/work/habs-collaboratory