



Sigura™



***Applied
Biochemists.***

Toxigenic Cyanobacteria and Rapid Response Plans

Dr. Doug Pullman

Senior Aquatic Scientist

Benthos

Plants

Algae

Cyanobacteria (Blue Green Algae)

Fungi

Bacteria

Viruses

Plankton

Zooplankton

Algae

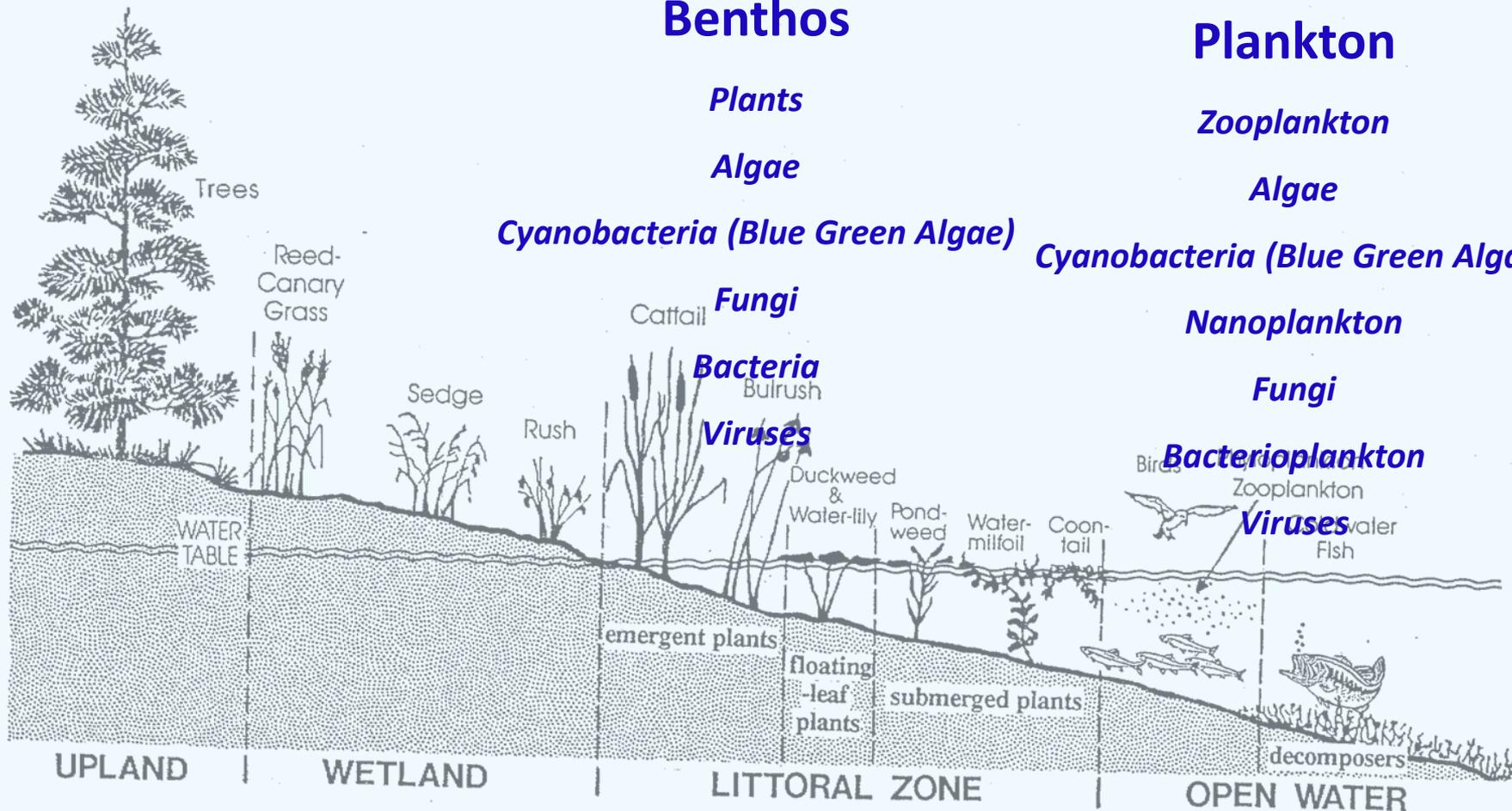
Cyanobacteria (Blue Green Algae)

Nanoplankton

Fungi

Bacterioplankton

Viruses



Aquatic Ecosystems = Many Different Interactive Systems

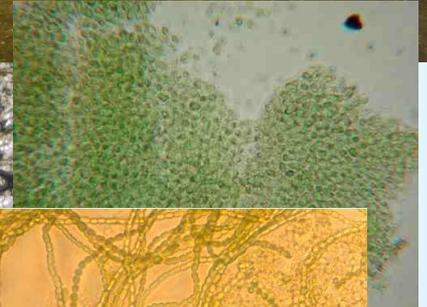
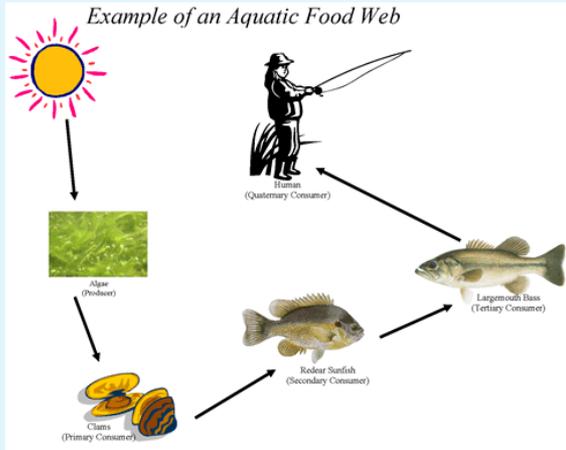
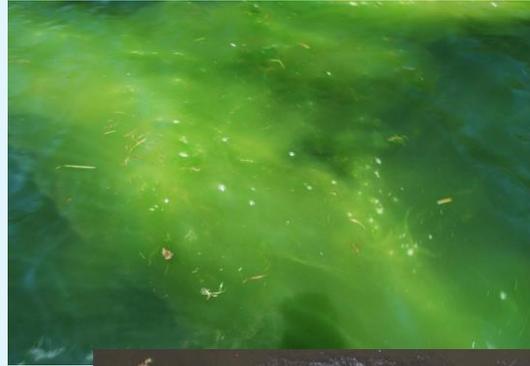
Primary Producers (Plants) – the Good the Bad and the Ugly

Phytoplankton

Algae

Cyanobacteria (Blue Green Algae)

Nanoplankton

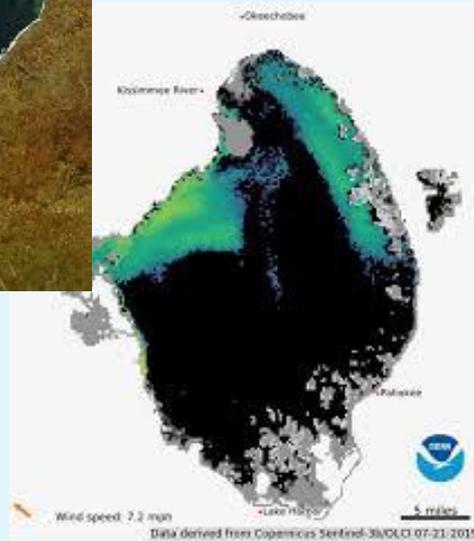


Toxigenic Cyanobacteria Bloom Response and Mitigation

Cyanobacteria Blooms are More Common, are Receiving More Attention, and are an Emerging Critical Public Health Issue



Lake Erie



Drinking Water Guidance – mid 1980's
WHO Recreational Water Guidance 2003
USEPA Recreational Water Guidance 2019
No enforceable Standards
As of 2019, 29 States have established guidance levels

Lake Okeechobee

Toxigenic Cyanobacteria Bloom Response and Mitigation

Cyanobacteria Blooms are Not New and Historically – the Impacts can be Very Significant



They've even been implicated in mass extinction events!

Kornei, K. (2018), Tiny algae may have prompted a mass extinction, *Eos*, 99, <https://doi.org/10.1029/2018EO102539>. Published on 11 July 2018.

Castle, J.W. and J.H. Rodgers, Jr. 2009. Hypothesis for the role of toxin-producing algae in Phanerozoic mass extinctions based on evidence from the geologic record and modern environments. *Environ. Geosci.* 16: 1–23.

Toxigenic Cyanobacteria Bloom Response and Mitigation

Cyano Toxins – Acute and Chronic Toxicity - TBD



Source: healthvermont.gov

Acute Exposure Outcomes

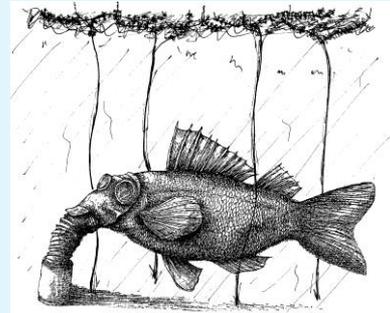
Gastrointestinal Distress, Rash - Do we recognize symptoms?

Chronic Exposure Consequences

Neurodegenerative disease, cancers, respiratory complications

Ecological Consequences

Fisheries, Macroinvertebrates, Zooplankton,
Phytoplankton, Plants,
Microbiome



Toxigenic Cyanobacteria Bloom Response and Mitigation

Many Toxins – Answers are Still Coming



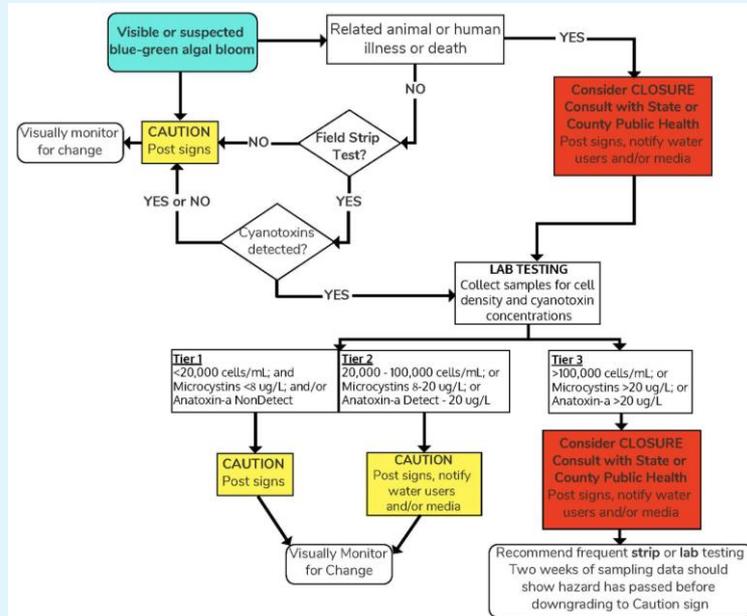
Source: healthvermont.gov

Toxin group ¹	Primary target organ in mammals	Cyanobacterial genera ²
<i>Cyclic peptides</i>		
Microcystins	Liver	<i>Microcystis</i> , <i>Anabaena</i> , <i>Planktothrix (Oscillatoria)</i> , <i>Nostoc</i> , <i>Hapalosiphon</i> , <i>Anabaenopsis</i>
Nodularin	Liver	<i>Nodularia</i>
<i>Alkaloids</i>		
Anatoxin-a	Nerve synapse	<i>Anabaena</i> , <i>Planktothrix (Oscillatoria)</i> , <i>Aphanizomenon</i>
Anatoxin-a(S)	Nerve synapse	<i>Anabaena</i>
Aplysiatoxins	Skin	<i>Lyngbya</i> , <i>Schizothrix</i> , <i>Planktothrix (Oscillatoria)</i>
Cylindrospermopsins	Liver ³	<i>Cylindrospermopsis</i> , <i>Aphanizomenon</i> , <i>Umezakia</i>
Lyngbyatoxin-a	Skin, gastro-intestinal tract	<i>Lyngbya</i>
Saxitoxins	Nerve axons	<i>Anabaena</i> , <i>Aphanizomenon</i> , <i>Lyngbya</i> , <i>Cylindrospermopsis</i>
<i>Lipopolysaccharides (LPS)</i>	Potential irritant; affects any exposed tissue	All

Source: WHO

Toxigenic Cyanobacteria Bloom Response and Mitigation

As an Emerging Critical Public Health Issue = But, there is way more to consider!



State Plan Guidance

Observation

Detection

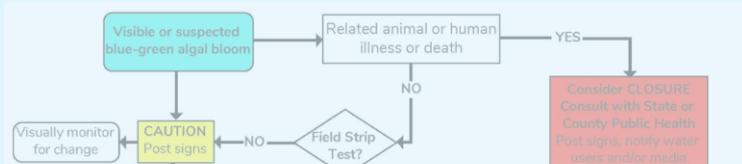
Notification

Communication

Most plans end with monitoring and "Caution" or "Closure" Statements

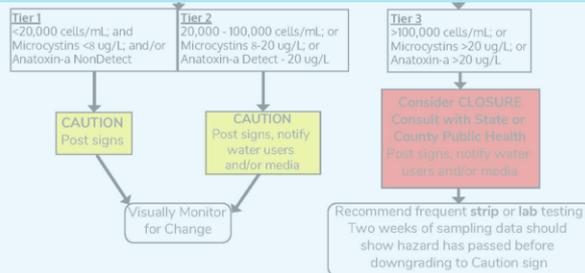
Toxigenic Cyanobacteria Bloom Response and Mitigation

As an Emerging Critical Public Health Issue = It is way more to consider!



Typical State Guidance
Observation
Detection

When we know how to mitigate – Do we not have a responsibility to protect the public health?



The Three Pillars of Toxigenic Cyanobacteria Bloom Response

When we know what we can do – Do we not have a responsibility to protect the public health?



Toxigenic Cyanobacteria Bloom Response and Mitigation

As an Emerging Critical Public Health Issue = Much more to consider!



MONITORING TRIGGER POINTS

- Observation** Residents (sentinels) observed blooms that are obvious for more than 5 days? Weeks?
- Detection** ELSIA reveals toxin higher than guidance levels when “obvious” worsen
- Notification** Lake Management Authorities and Changing Conditions
- Mitigation & Verification** Assessment of treatment outcomes

As Always ... Hope for the Best – But, Plan for the Worst

Toxigenic Cyanobacteria Bloom Response and Mitigation

Case Study and Lessons Learned

10 Days from Cyanotoxin Detection to Mitigation!

Toxigenic Cyanobacteria Bloom Response and Mitigation

Observation



Citizen Volunteers

Photos were taken in July, but blooms intensified 19 August 2019.

Observations were recorded for predetermined observation sites (AROS) for efficient communication.

Consultant notified - collected samples and smart phone photos 19 August 2019. Consultant notifies State

Toxigenic Cyanobacteria Bloom Response and Mitigation

Monitoring

Abraxis "Sticks"

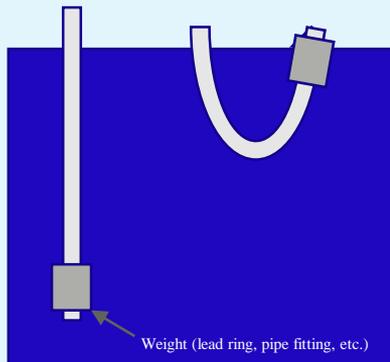


Sampling

Composite Tube Sample from Middle of North End (Obvious Bloom) of the lake 19 August 2019 by Consultant

Surface Water Sample Analyzed by ELISA ("dip stick")

And Water Sample Collected for Lab analysis by State 20 August 2019



Surface Water Sample



Tube Sampler

Source: Applied Biochemists and Abraxis Systems

<u>Dip Sample Site</u>	<u>20-Aug-19</u>
Windward Side of Lake (No Obvious Bloom)	
Southwestern Shore (No Obvious Bloom)	6.60 μ /L
North Western Shore 1 (Heavy Bloom)	3,700.00 μ /L
North Western Shore 2 (Heavy Bloom)	610.00 μ /L
<u>Composited Tube Sample Site</u>	<u>19-Aug-19</u>
North Part of Lake (Obvious Bloom)	458.00 μ /L

Toxigenic Cyanobacteria Bloom Response and Mitigation

Messaging

Various Notifications were issued between 20 August and 29 August 2019

Consultant Assumed Responsibility for Coordination of Notifications:

Lake Association – Issued an email warning to all lakeside residents, posted shoreline near obvious bloom in NW corner of lake

Lake Board or District (SAD) – Prepared a separate warning that was distributed by media outlets through County Health Dept.

County Health Department – Issued public notifications that were coordinated with efforts taken by the Lake Board and Drain Office

County Water Commission or Drain Office – Handled communications for Lake Board

State Water Quality and Aquatic Nuisance Control Units – Continued to monitor lake conditions

Aquatic Herbicide Application Company Posted Treated Shoreline

Toxigenic Cyanobacteria Bloom Response and Mitigation *Communications!*

One of the More Challenging Aspects of a Rapid Response

Wording of Message

Consistent messaging from residents to State agencies

Difficulty with reentry statements (what is safe for reentry?)

How to negotiate issue with electronic media?



Source: New York, health.ny.gov



Source: VA DoH



Source: Ohio EPA



Toxigenic Cyanobacteria Bloom Response and Mitigation

Develop Mitigation Plan

Mitigation Criteria - Large-Scale, Selective, Depth/Volume Targeted Application of Phycomycin® SCP



Treatment Design

Bottom 2 Acre Feet (9' – 11') in Lake Center

Weighted Hose Treatment

Shoreline Treatment of Obvious Blooms by surface spray

Toxigenic Cyanobacteria Bloom Response and Mitigation

Verification of Outcome: PTOX Cyanobacteria Treatment with Phycomycin®

<u>Dip Sample Site</u>	<u>20-Aug-19</u>	<u>29-Aug-19</u>	<u>10-Sep-19</u>	<u>19-Sep-19</u>	<u>22-Sep-19</u>	<u>2-Oct-19</u>
Windward Side of Lake (No Obvious Bloom)		12 µ/L	0.94 µ/L			ND µ/L
Southwestern Shore (No Obvious Bloom)	6.60 µ/L	180 µ/L	51 µ/L	<0.50 µ/L	34 µ/L	ND µ/L
North Western Shore 1 (Heavy Bloom)	3,700.00 µ/L	190 µ/L	20 µ/L	0.94 µ/L		ND µ/L
North Western Shore 2 (Heavy Bloom)	610.00 µ/L	240 µ/L	9 µ/L	8.4 µ/L	12 µ/L	1-5 µ/L
	Pre-Treatment		Post-Treatment			

<u>Composited Tube Sample Site</u>	<u>19-Aug-19</u>	<u>31-Aug-19</u>	<u>5-Sep-19</u>
North Part of Lake (Obvious Bloom)	458.00 µ/L		0.36 µ/L
South Composite (No Obvious Bloom)		1.00 µ/L	0.45 µ/L
	Pre-Treatment	Post-Treatment	

PTOX Cyanobacteria Present in Samples

<u>Composited Tube Sample Site</u>	<u>31-Aug-19</u>
North Part of Lake (Obvious Bloom)	Microcystis
South Composite (No Obvious Bloom)	Microcystis, Dolichospermum

Toxigenic Cyanobacteria Bloom Response and Mitigation



Pre-Treatment

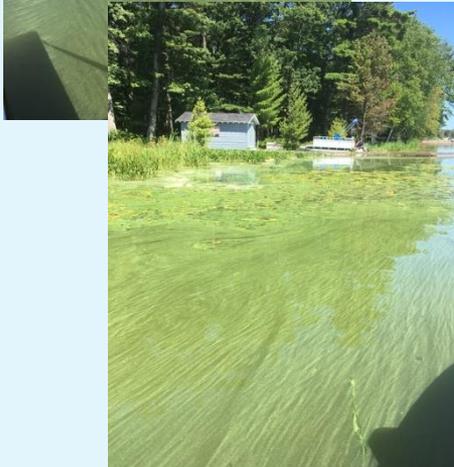


Post-Treatment

Dramatic decline in Microcystin levels to sub-guidance levels after treatment

Small patches of floating blooms persisted in leeward areas, cyanotoxins greater than guidance levels – too small to warrant treatment?

Toxigenic Cyanobacteria Bloom Response and Mitigation



Lessons Learned

1. Mitigation (lower microcystin levels) can be achieved within 10 days of cyanotoxin detection – but could be quicker!
2. Communications and notifications may have been the most difficult part of the response. Many parties and agencies make this more difficult and wording must be precise.
3. Professionals may be required to do sampling because of the inherent complexity of the process. There was loss of data in this case due to absence of formal sampling and monitoring response plan.
4. Selective PTOX cyanobacteria management is generally considered to be a more desirable approach than non-selective means of prevention or control when communicated with regulators and other stakeholders.

As Always ... Hope for the Best – But, Plan for the Worst

Plan Ahead

(Those who fail to plan, should plan to fail)

Access Risk: Identify what species in your lake could cause blooms and where blooms might form (inlets, sediments, etc.).

History of blooms?

Form your observation and monitoring teams NOW and establish lines of communication (names, phone numbers, local and state resources)

Develop a monitoring and sampling plan and secure services of trained monitoring/sampling persons (where, when, how often?). Secure supplies and sampling devices. Records?

Develop messaging and messaging plan NOW - so it's ready if needed (Consult ML&SA, State, Attorney)

Create an expert, targeted, and species selective Cyanobacteria Mitigation Plan: Algae challenge testing (ACT), find an applicator, develop an outcome assessment plan.





Dr. G. Douglas Pullman
Senior Aquatic Scientist
doug.pullman@sigurawater.com
810-516-6830