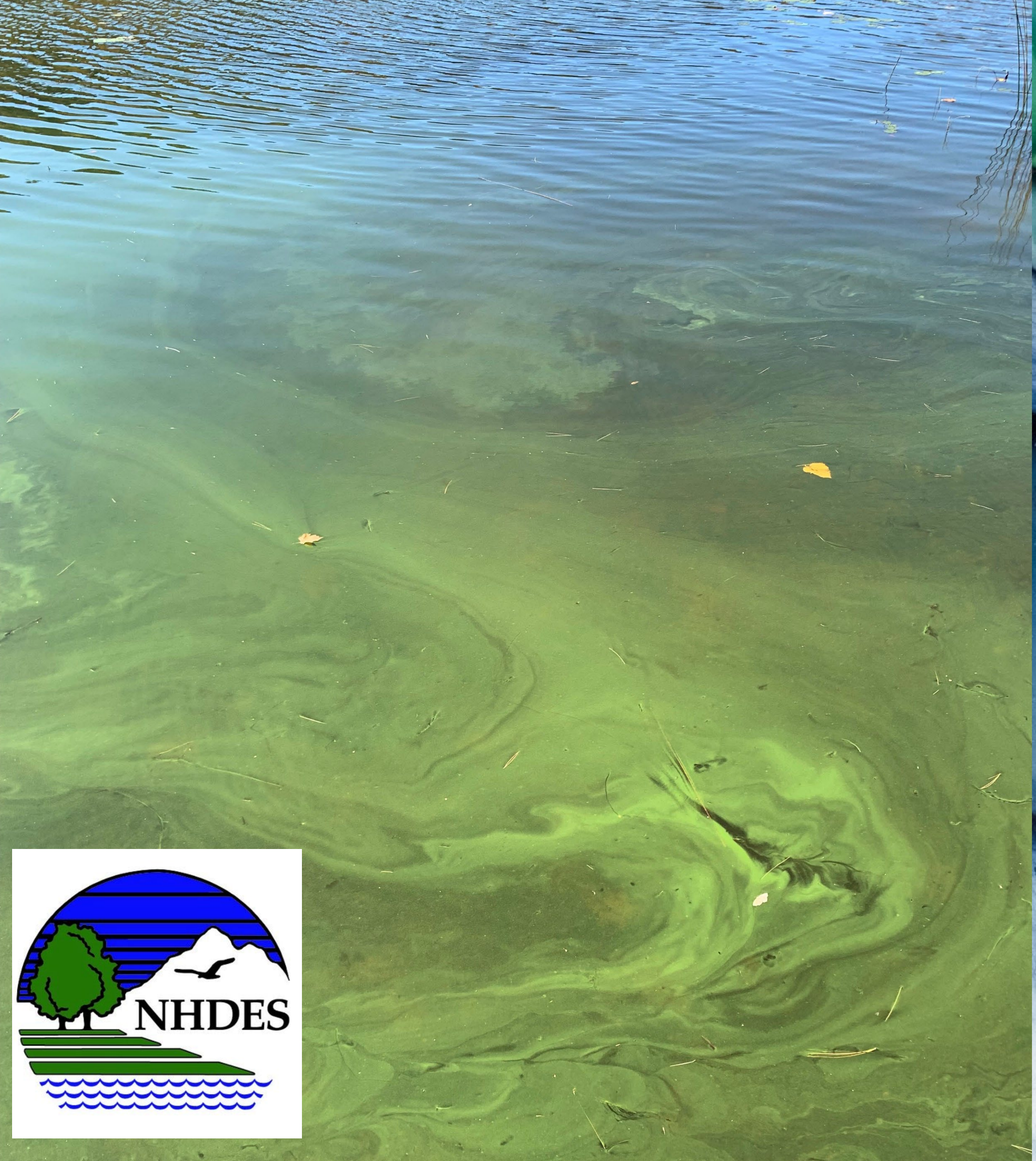


CYANOBACTERIA

Amanda McQuaid

Cyanobacteria Study Commission

HB1066

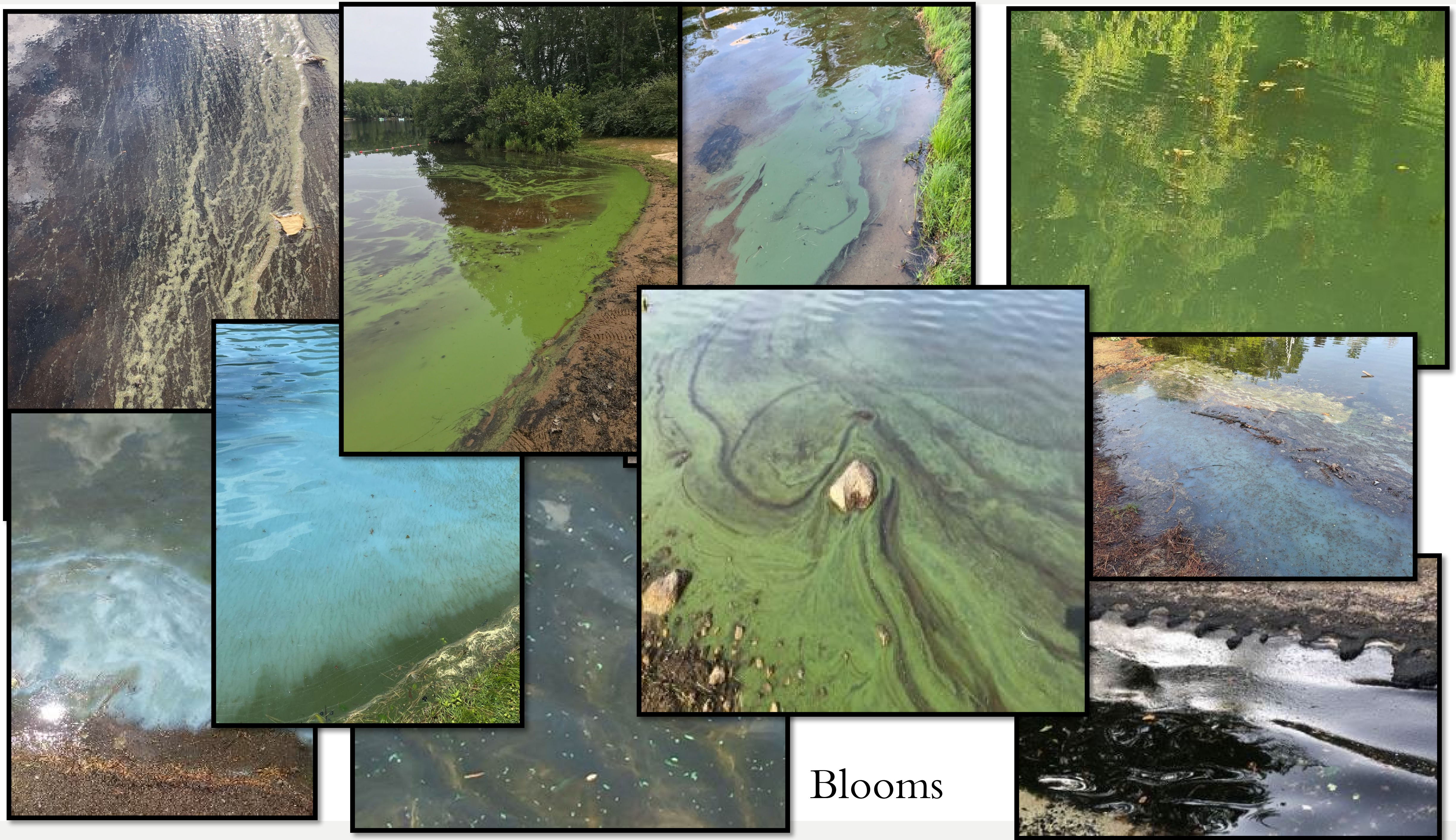
10/13/22

Cyanobacteria…

- Formerly known as "Blue-Green Algae"
- Photosynthetic bacteria, they are not actually algae

Inhabitants of Earth for over 3.5 billion years

- Thousands of species and hundreds of toxins
- Ubiquitous in the environment and globally



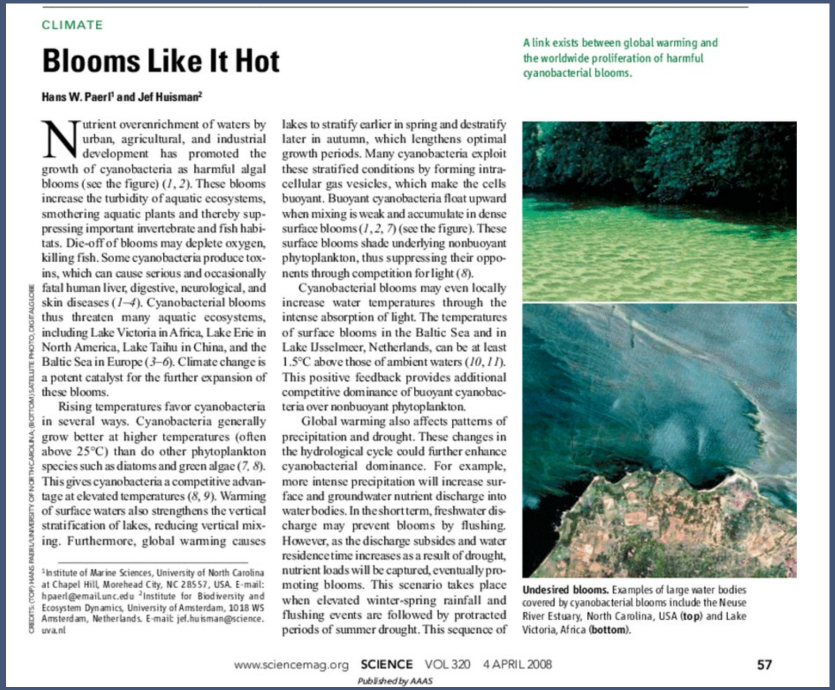
Blooms

"Blooms Like it Hot"

A link exists between global warming and the worldwide proliferation of harmful cyanobacterial blooms. Hans Paerl (Science 2008)

Cyanobacteria Dominance promoted by:

- Nutrients (high levels of phosphorus followed by low)
- Warm Temperature (grow best in warmest summers)
- Thermocline Stability (stratification increases w/ temp)
- Low Light (low water clarity)



CLIMATE

Blooms Like It Hot

A link exists between global warming and the worldwide proliferation of harmful cyanobacterial blooms.

Hans W. Paerl[1] and Jef Huisman[2]

Nutrient overenrichment of waters by urban, agricultural, and industrial development has promoted the growth of cyanobacteria as harmful algal blooms (see the figure) (*1*, *2*). These blooms increase the turbidity of aquatic ecosystems, smothering aquatic plants and thereby suppressing important invertebrate and fish habitats. Die-off of blooms may deplete oxygen, killing fish. Some cyanobacteria produce toxins, which can cause serious and occasionally fatal human liver, digestive, neurological, and skin diseases (*1*–*4*). Cyanobacterial blooms thus threaten many aquatic ecosystems, including Lake Victoria in Africa, Lake Erie in North America, Lake Taihu in China, and the Baltic Sea in Europe (*3*–*6*). Climate change is a potent catalyst for the further expansion of these blooms.

Rising temperatures favor cyanobacteria in several ways. Cyanobacteria generally grow better at higher temperatures (often above 25°C) than do other phytoplankton species such as diatoms and green algae (*7*, *8*). This gives cyanobacteria a competitive advantage at elevated temperatures (*8*, *9*). Warming of surface waters also strengthens the vertical stratification of lakes, reducing vertical mixing. Furthermore, global warming causes lakes to stratify earlier in spring and destratify later in autumn, which lengthens optimal growth periods. Many cyanobacteria exploit these stratified conditions by forming intracellular gas vesicles, which make the cells buoyant. Buoyant cyanobacteria float upward when mixing is weak and accumulate in dense surface blooms (*1*, *2*, *7*) (see the figure). These surface blooms shade underlying nonbuoyant phytoplankton, thus suppressing their opponents through competition for light (*8*).

Cyanobacterial blooms may even locally increase water temperatures through the intense absorption of light. The temperatures of surface blooms in the Baltic Sea and in Lake IJsselmeer, Netherlands, can be at least 1.5°C above those of ambient waters (*10*, *11*). This positive feedback provides additional competitive dominance of buoyant cyanobacteria over nonbuoyant phytoplankton.

Global warming also affects patterns of precipitation and drought. These changes in the hydrological cycle could further enhance cyanobacterial dominance. For example, more intense precipitation will increase surface and groundwater nutrient discharge into water bodies. In the short term, freshwater discharge may prevent blooms by flushing. However, as the discharge subsides and water residence time increases as a result of drought, nutrient loads will be captured, eventually promoting blooms. This scenario takes place when elevated winter-spring rainfall and flushing events are followed by protracted periods of summer drought. This sequence of

Undesired blooms. Examples of large water bodies covered by cyanobacterial blooms include the Neuse River Estuary, North Carolina, USA (**top**) and Lake Victoria, Africa (**bottom**).

CREDITS: (TOP) HANS PAERL/UNIVERSITY OF NORTH CAROLINA; (BOTTOM) SATELLITE PHOTO, DIGITALGLOBE

[1]Institute of Marine Sciences, University of North Carolina at Chapel Hill, Morehead City, NC 28557, USA. E-mail: hpaerl@email.unc.edu [2]Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam, 1018 WS Amsterdam, Netherlands. E-mail: jef.huisman@science.uva.nl

Published by AAAS

Rastogi et al. Bloom Dynamics of Cyanobacteria and Their Toxins: Environmental Health Impacts and Mitigation Strategies. December 2015. Frontiers in Microbiology 6(456):1254. DOI: 10.3389/fmicb.2015.01254

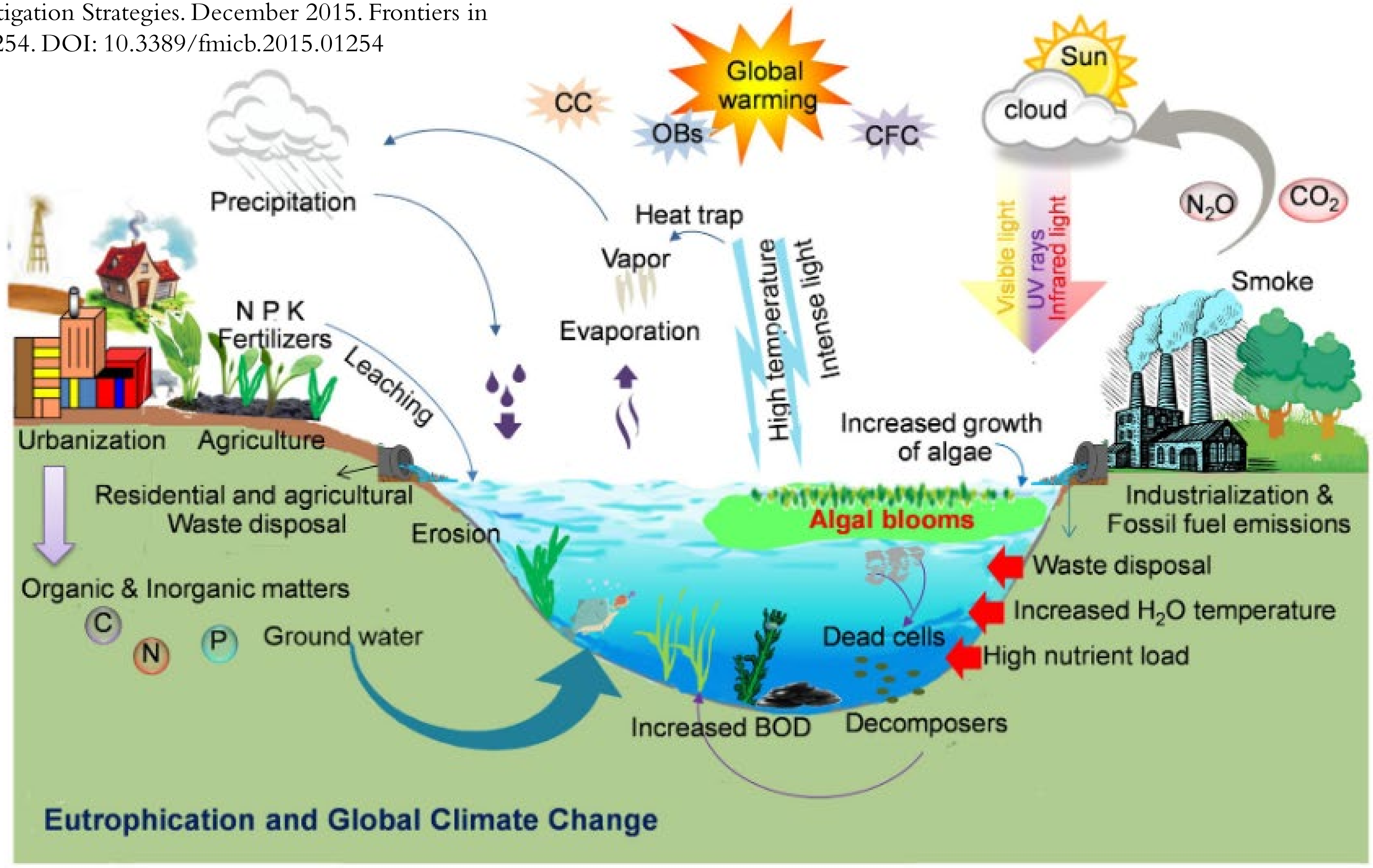


FIGURE 2 | Formation of cyanobacterial blooms: Schematic illustration showing the key factors such as anthropogenic eutrophication, global climate change such as increased temperature and light or global warming due to an increase in ozone depleting substances (e.g., CO_2, N_2O, etc.), and other biotic and abiotic factors responsible for the worldwide bloom incidence (Illustration by R. P. Rastogi).

Health effects vary from skin irritations to death

More biomass, more toxic?

Hepatotoxic

Genotoxic

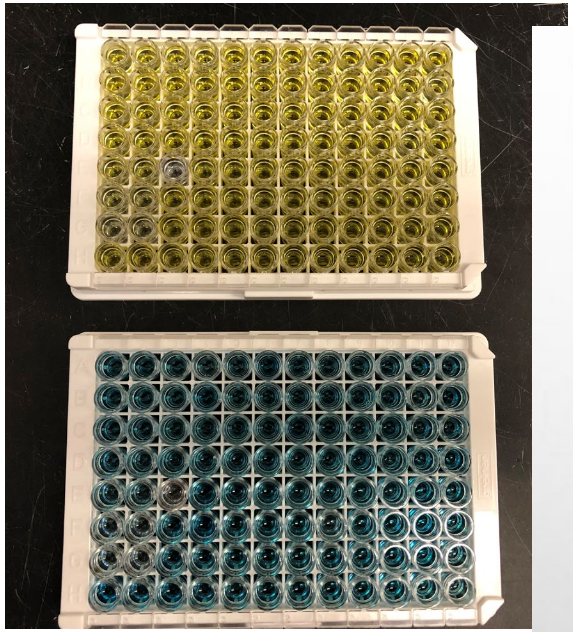
Neurotoxic

*this is not a complete list of the secondary metabolites and/or toxins produced by cyanobacteria.

Very narrow view of cyanotoxins…

Cyanotoxin	Mode of action and/ or symptoms
Microcystins (nearly 100 variants)	Hepatotoxic, targets the liver and digestive organs, tumor promoting, inhibition of protein phosphatases. Acute gastroenteritis, chronic tumor promotion.
Nodularins (similar in structure to microcystins)	Similar to microcystins, but not as toxic and common in brackish or marine systems.
Anatoxin-a	Neurotoxic, inhibits acetylcholine receptors (neurotransmitter). Fast-acting and may cause seizures or death (i.e. common for dogs or others animals to ingest and die).
Anatoxin-a (S)	Neurotoxic
Saxitoxins	Neurotoxic, blocking voltage gate of sodium ion channels. More common to marine organisms.
Cylindrospermopsin	Toxic to multiple organs, neurotoxic and genotoxic, affecting neurons and genes.
Lyngbyatoxins	Tumor promotion
BMAA/DAB	Neurotoxic, chronic exposure may be linked to neurodegenerative diseases such as ALS. (Though individuals may have a genetic precursor).

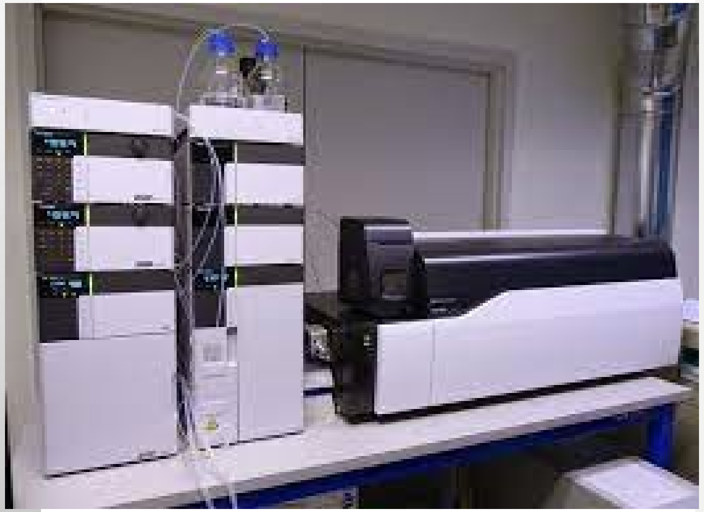
(ELISA) Enzyme-linked Immunosorbent Assay



ELISA versus LC/MS/MS

	ELISA	LC/MS/MS
Characteristics	Measure groups of variants	Measure individual variants
Quantitation	Semi-quantitative	Quantitative
Sample volume	<0.5 ml	<0.5 ml
MRL	0.15 µg/L	0.1 µg/L
Turn-around time	Fast	longer
Instrumentation	Inexpensive	costly
Level of expertise	Easy	High
Other	Kits available commercially	EPA Methods 544 (microcystins) and 545 (Cylindrospermopsin)

Abraxis ADDA-specific kit



(LC/MS/MS) Liquid Chromatography Mass Spec.

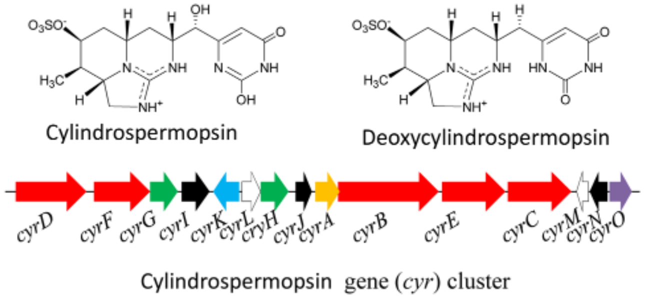


FIGURE 6 | Chemical structure of cylindrospermopsin and its biosynthetic gene (*cyr*) cluster in the cyanobacterium *Cylindrospermopsis raciborskii* AWT205. Red – PKS/NRPS, green – uracil ring, black – tailoring, blue – transport, white – transposase, orange – amidinotransferase, purple – regulator (Adapted from Mihali et al., 2008).

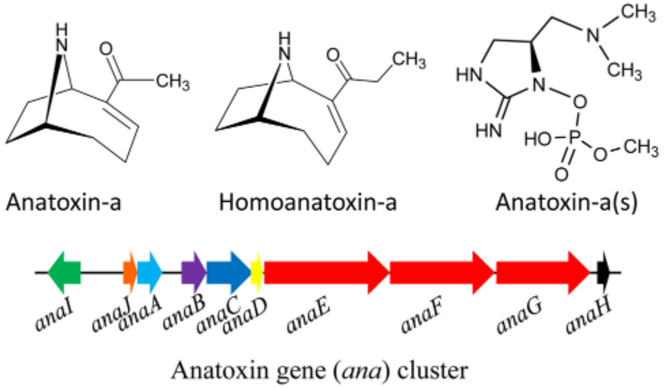
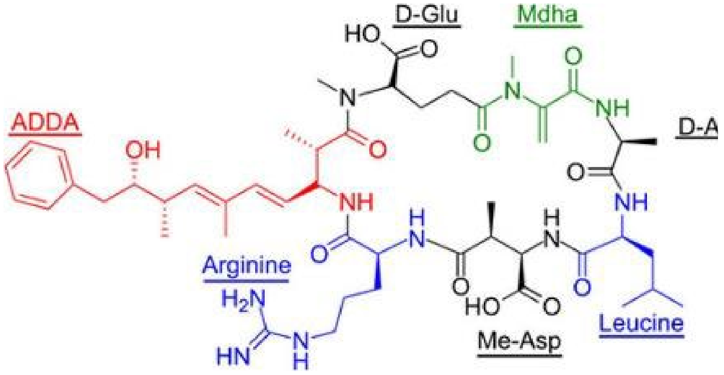
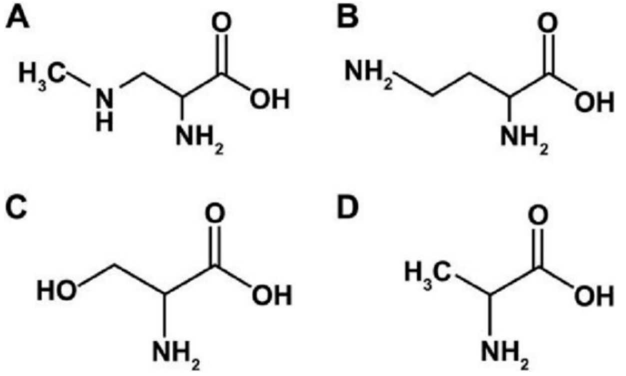


FIGURE 4 | Chemical structure of anatoxins and its biosynthetic gene (*ana*) cluster in the cyanobacterium *Oscillatoria* sp. PCC6506. Green – transporter, orange – cyclase, light blue – thioesterase, purple – oxidase, blue-adenylation protein, yellow – acyl carrier protein, red – polyketide synthase, black – transposase (adapted from Rantala-Ylinen et al., 2011; Méjean et al., 2014; Gene cluster not drawn to scale).



Microcystins

BMAA



Figure

Caption

Figure 1. Chemical structures for BMAA and similar amino acids A. β-N-methylamino-L-alanine (BMAA); B. 2,4-diamino butyric acid (DAB); C. serine; D. alanine.

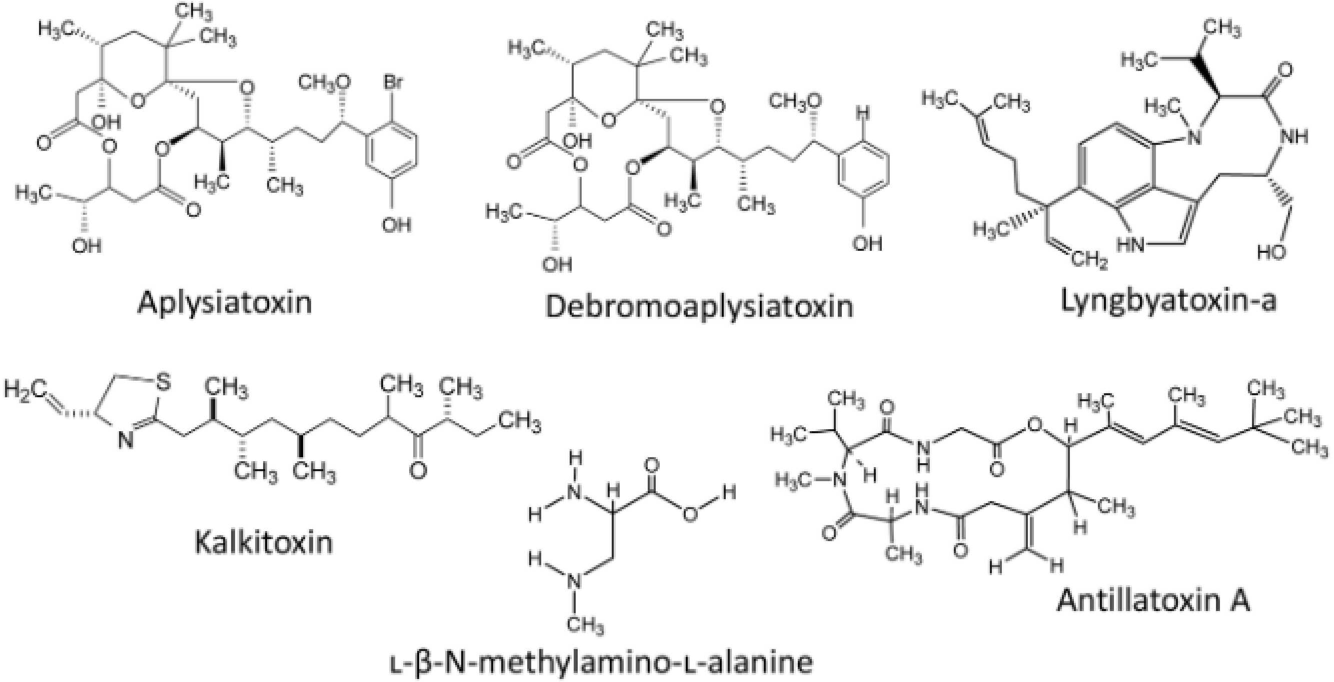


FIGURE 7 | The chemical structure of some common cyanotoxins reported in diverse cyanobacteria.

Rastogi et al. 2015

Genetic regulation and stability

https://www.researchgate.net/publication/284019974_Bloom_Dynamics_of_Cyanobacteria_and_Their_Toxins_Environmental_Health_Impacts_and_Mitigation_Strategies

Toxigenic Cyanobacteria vary World-Wide

Cyanotoxin Guidelines Limited

BMAA / DAB
Anatoxin–a (S) /Guanitoxin
Nodularin
Homoanatoxin–a
Antillatoxin
Kalkitoxin
Saxitonin
Gonyautoxin
Jamaicamides
Lyngbyatoxin
LPS
Aplysiatoxin
Cyanopeptolin

Table 3. EPA's 10-day health advisory guidelines (for recreational and drinking water) for microcystins and cylindrospermopsin.

Cyanotoxins	Recreational Water	Drinking Water (Children under 6)	Drinking Water (Adults, children 6+)
Microcystins	8 ppb	0.3 ppb	1.6 ppb
Cylindrospermopsin	15 ppb	0.7 ppb	3.0 ppb

Table 4. Modified from Table 5.1 in Chorus & Welker's 'Toxic Cyanobacteria in Water' (2nd ed. 2021).

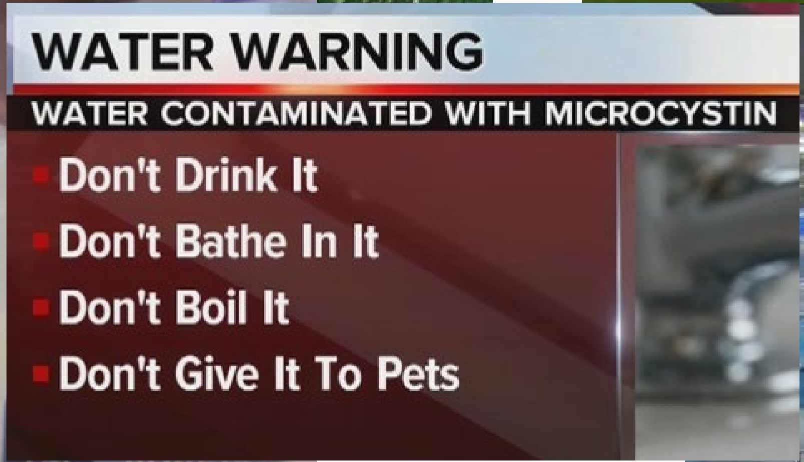
Provisional guideline values for selected cyanotoxins and exposure scenarios.	Exposure	Value (µg/L or ppb)
Microcystin-LR	Drinking-water, lifetime	1
Microcystin-LR	Drinking-water, short term	12
Microcystin-LR	Recreational	24
Cylindrospermopsin	Drinking-water, lifetime	0.7
Cylindrospermopsin	Drinking-water, short term	3
Cylindrospermopsin	Recreational	6
Anatoxin-a	Drinking-water, acute	30
Anatoxin-a	Recreational	60
Saxitoxin	Drinking-water, acute	3
Saxitoxin	Recreational	30

"Anatoxin–a(S) is the most potent natural neurotoxin produced by freshwater cyanobacteria. It is also the least understood and monitored." Rastogi et al. 2015


algae
Lake Erie
Toledo
water intake
algae


Toledo
Lake Erie
FULTON CO.
LUCAS CO.
WOOD CO.
OHIO
WARNINGS
Don't drink water
Don't let children bathe
Boiling water increases toxins


HEALTH ALERT
GOOD MORNING MARYLAND
DAY 3 WITHOUT SAFE DRINKING WATER
TOLEDO, OH
CURRENTS LOCAL POLICE ARE LOOKING FOR
5:19 64°


WATER WARNING
WATER CONTAMINATED WITH MICROCYSTIN
Don't Drink It
Don't Bathe In It
Don't Boil It
Don't Give It To Pets


DEVELOPING STORY
TOLEDO WATER SUPPLY CONTAMINATED; AFFECTING PARTS OF MONROE COUNTY

2014

The Washington Post

The toxin that shut off Toledo’s water? The feds don’t make you test for it.

By Todd C. Frankel
August 11, 2014 at 6:09 a.m. EDT

A sample glass of Lake Erie water is photographed near the Toledo water intake crib in Lake Erie. (Haraz N. Ghanbari/Associated Press)

Salem, Oregon - Drinking Water Communication

Lacey Goeres-Priest *Water Quality Supervisor, Salem Oregon*

Oregon's First Public Water System Algal Toxin Advisory – 2018 Communication Lessons Learned

Salem, Oregon

EPA Guidance Values				
Source	**Microcystin** (ppb)	**Cylindrospermopsin** (ppb)	**Saxitoxin** (ppb)	**Anatoxin-a** (ppb)
Recreational Waters	4	8	4	8
Dog guidance	0.2	0.4	0.02	0.4
Drinking Water – 10 Day Health Advisory				
Adults	1.6	3	1.6	3
Vulnerable population	0.3	0.7	0.3	0.7

Vulnerable population – infants, young children under the age of 6, pregnant women, nursing mothers, those with pre-existing liver conditions, those receiving dialysis treatment, the elderly and other sensitive populations.

10-Day Health Advisory – Cyanotoxin levels in drinking water less than or equal to which adverse human health impacts are unlikely to occur when exposed to these levels over a 10-day time period. These are NOT a federally enforceable regulatory limit.

Canine Cyanotoxin Poisonings in the United States (1920s–2012): Review of Suspected and Confirmed Cases from Three Data Sources

Lorraine C. Backer, Jan H. Landsberg, Melissa Miller, Kevin Keel, and Tegwin K. Taylor

"reported 67 suspected or confirmed cases of canine intoxications associated with HABs. Of these 67 cases, 58 (87%) followed exposure to fresh waters and 1 (1%) followed exposure to marine waters."

"…duration of illness ranged from <1 day to 6 weeks."

Canine "mine canaries" of lakes

We identified 231 discreet cyanobacteria harmful algal bloom (cyanoHAB) events and 368 cases of cyanotoxin poisoning associated with dogs throughout the U.S. between the late 1920s and 2012. **The canine cyanotoxin poisoning events reviewed here likely represent a small fraction of cases that occur throughout the U.S. each year.**

"Dog's death fuels lake cyanobacteria scare"

http://www.burlingtonfreepress.com/story/news/local/2015/08/12/death-dog-heightens-cyanobacteria-concerns/31555091/

One Health Harmful Algal Bloom System (OHHABS)

Print

The One Health Harmful Algal Bloom System (OHHABS) collects information to help CDC and partners better understand harmful algal blooms (HABs) and help prevent human and animal illnesses caused by HABs.

OHHABS ONE HEALTH Harmful Algal Bloom System

What Is OHHABS?

OHHABS is a voluntary **reporting system available to state and territorial public health departments** and their environmental health or animal health partners.

Communication Resources

Cyanotoxins- case studies and evidence for toxicity – pervasive and variable…

- 1998 Hemodialysis, Brazil incident (picocyanobacterial- *Aphanocapsa*)
- 2018 Florida incident (synergistic toxicity of marine and fresh HABs)
- Aquatic food web bioaccumulations
  - Fish - biomagnification and accumulation to tissues
  - Shellfish - especially in digestive systems (hepatopancreas)
  - Bottom feeders - crayfish
- Crops- surface and uptake to fruits and leaves, sprayed on surfaces and difficult to remove
- Dissolved toxins (extracellular) release from cyanobacteria
- Air- aerosolized cells and toxins
- ALS and other neurodegenerative diseases (BMAA)
- Avian illness- top predatory birds affected by toxins –related to avian vacuolar myelinopathy (AVM)
- Fish death- depletion of oxygen and side effects of toxins
- Disorientation and death of marine mammals
- Otter deaths of San Fran Bay
- Cattle/livestock deaths – "Bovine Blue-Green Algae Toxicosis"
- Dog deaths…

https://www.youtube.com/watch?v=s9WdqTv7vUw

Catastrophic red tide and blue-green algae hit Florida, killing wildlife and harming businesses
24,848 views May 10, 2019

Freshwater sources contaminating marine bays…

Toxic Algae Killing Sea Otters

2010: "A potent toxin produced by bright-green blooms of freshwater bacteria has been flowing into the ocean and poisoning sea otters, according to a team of investigators led by scientists at the California Department of Fish and Game (DFG) and the University of California, Santa Cruz."

RESEARCH ARTICLE

Hunting the eagle killer: A cyanobacterial neurotoxin causes vacuolar myelinopathy

STEFFEN BREINLINGER, TABITHA J. PHILLIPS, BRIGETTE N. HARAM, JAN MAREŠ, JOSÉ A. MARTÍNEZ YERENA, PAVEL HROUZEK, ROMAN SOBOTKA, W. MATTHEW HENDERSON, PETER SCHMIEDER, [...] SUSAN B. WILDE +12 authors Authors Info & Affiliations

SCIENCE • 26 Mar 2021 • Vol 371, Issue 6536 • DOI: 10.1126/science.aax9050

A FATAL FOOD CHAIN

By studying the diet of the Chamorro people of Guam, ethnobotanist Paul Cox unlocked clues that could lead to future treatments of diseases like Alzheimer's.

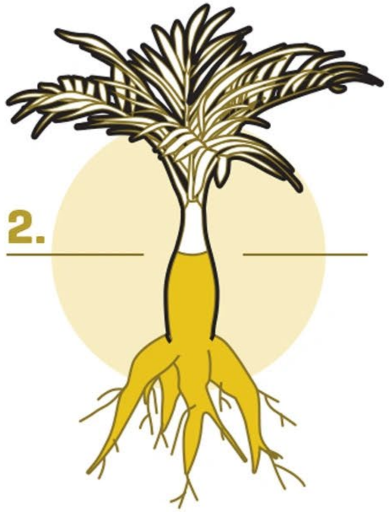
1.

Cyanobacteria, often called **blue-green algae,** contain many toxins, including BMAA, which interferes with amino acids crucial to brain development.

BMAA CONCENTRATION:

0.3 UG/G

2.

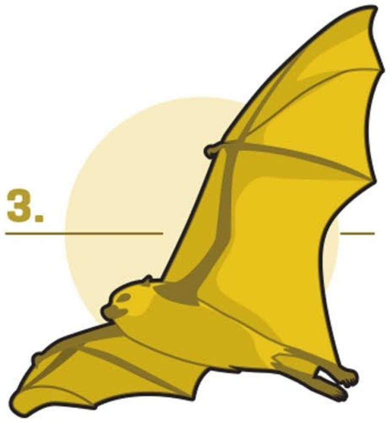


On Guam, algae accumulate in shallow pools. BMAA from the algae leaches into **cycad trees** via their roots and accumulates in their seeds.

BMAA CONCENTRATION:

37 UG/G

3.



Flying foxes, huge bats with three-foot wingspans, eat the cycad seeds. BMAA accumulates in high quantities in their fat.

BMAA CONCENTRATION:

3,556 UG/G

4.

Flying fox stew, a prized delicacy among the Chamorro, exposed those who ate it to massive doses of BMAA. In the mid-20th century, **the Chamorro were 100 times as likely as others to develop neurodegenerative symptoms**.

5.

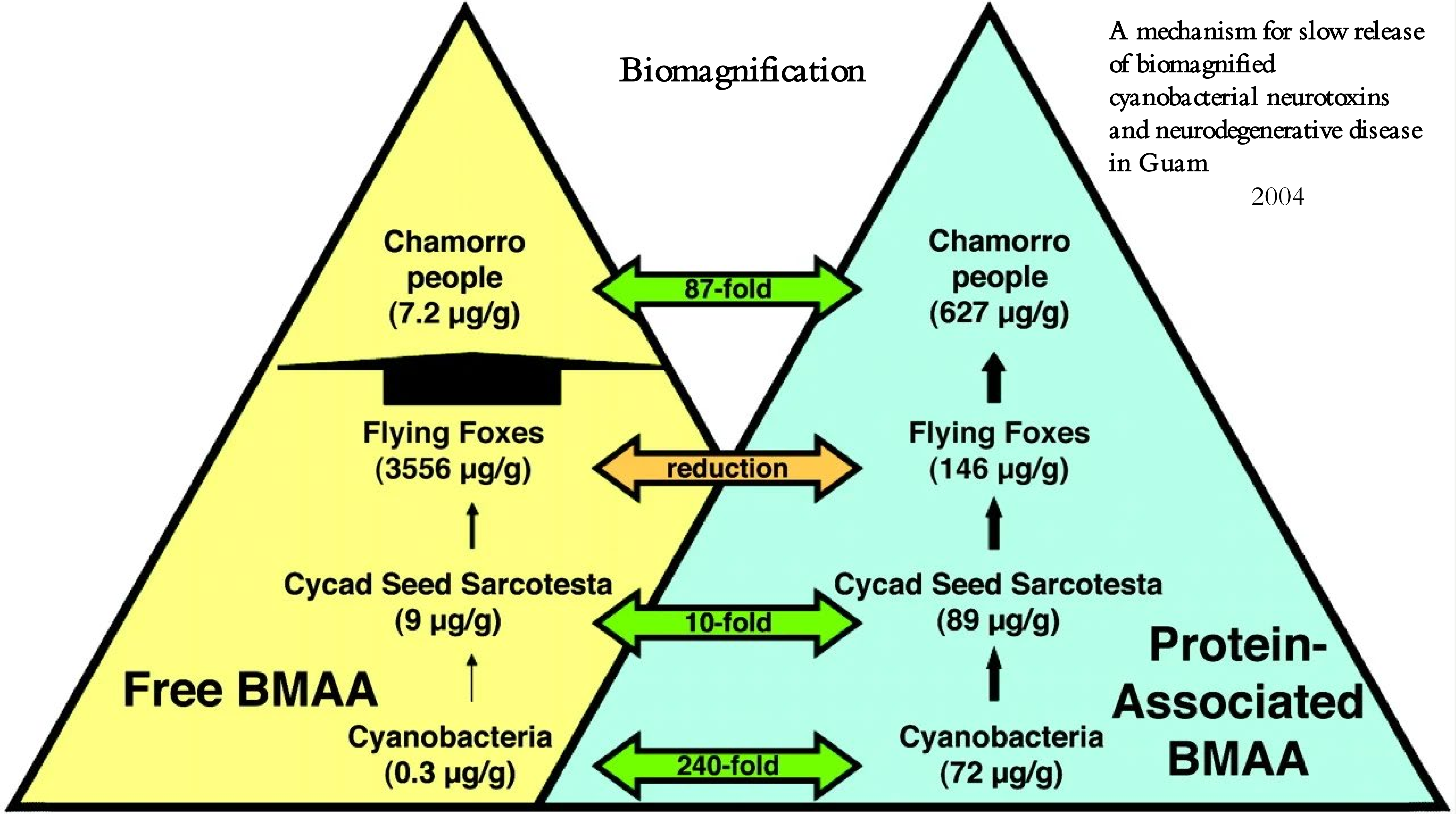
After the flying fox is hunted to extinction, the rate of neurodegenerative disease plummets among the Chamorro. But **research has linked BMAA to clusters of brain disease** in other parts of the world.

https://fortune.com/longform/alzheimers-disease-cure-breakthrough/

Biomagnification

A mechanism for slow release of biomagnified cyanobacterial neurotoxins and neurodegenerative disease in Guam

2004



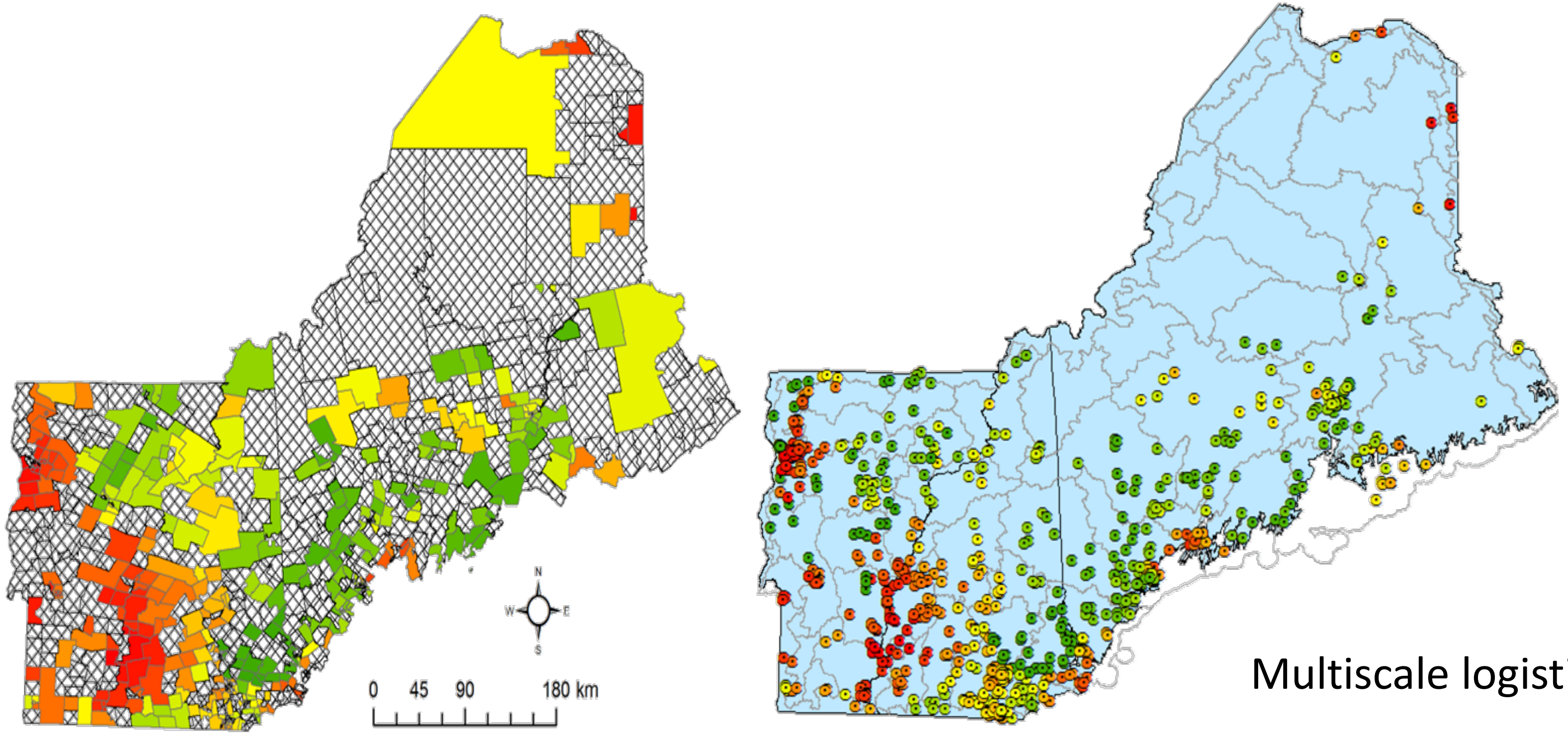
Toxins in the air/dust?

Cyanobacteria and BMAA exposure from desert dust: a possible link to sporadic ALS among Gulf War veterans.

Cox PA[1], Richer R, Metcalf JS, Banack SA, Codd GA, Bradley WG. 2009.

Cyanobacterial crusts and mats are widespread in the deserts of Qatar, occupying up to 56% of the available area in some microhabitats.

Satellite Images: Eco-epidemiological risk modeling



Multiscale logistic regression model

Risk of belonging to a localized cluster of “higher than expected” ALS counts and ALS patient location based on water quality parameters associated with cyanobacteria

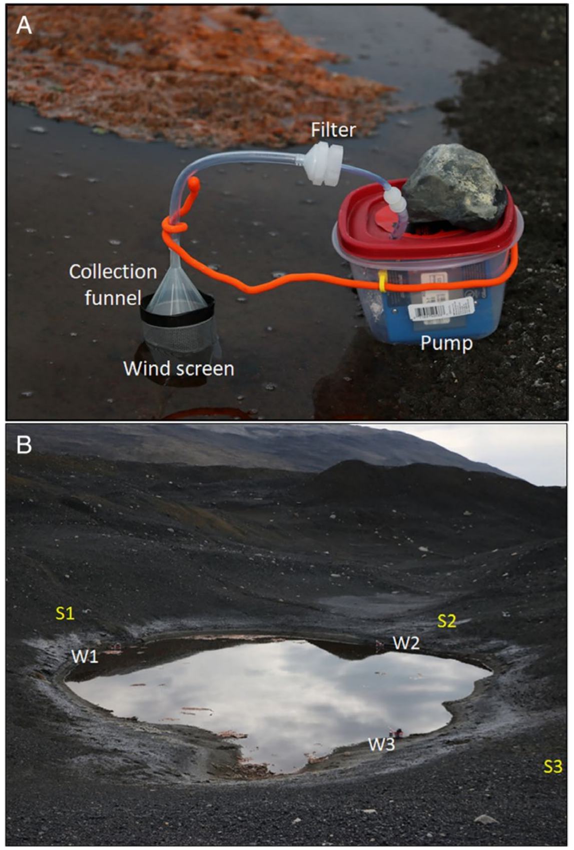
- increasing average SD within a radius of 30 km decreases odds by 59%
- increasing average TN within a radius of 30 km increase odds by 167%
- increasing average Chl-a within a radius of 10 km increased odds 35%

Slide from J. Haney

Torbick et al 2014

Stommel- Dartmouth-Hitchcock

Picocyanobacteria in the air?



Trout-Haney et al. 2020

environmental microbiology reports

Applied Microbiology International

Brief Report

Picocyanobacterial cells in near-surface air above terrestrial and freshwater substrates in Greenland and Antarctica

Jessica V. Trout-Haney, Ruth C. Heindel, Ross A. Virginia

First published: 05 March 2020 | https://doi.org/10.1111/1758-2229.12832 | Citations: 2

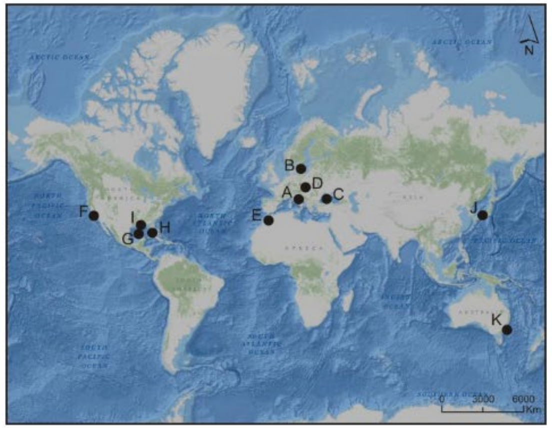
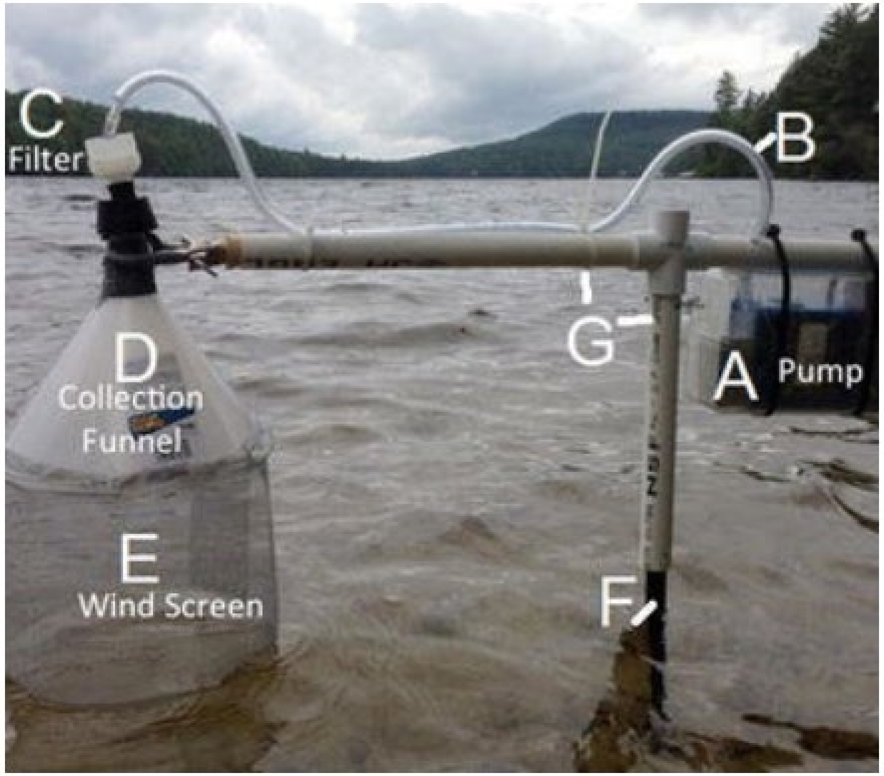


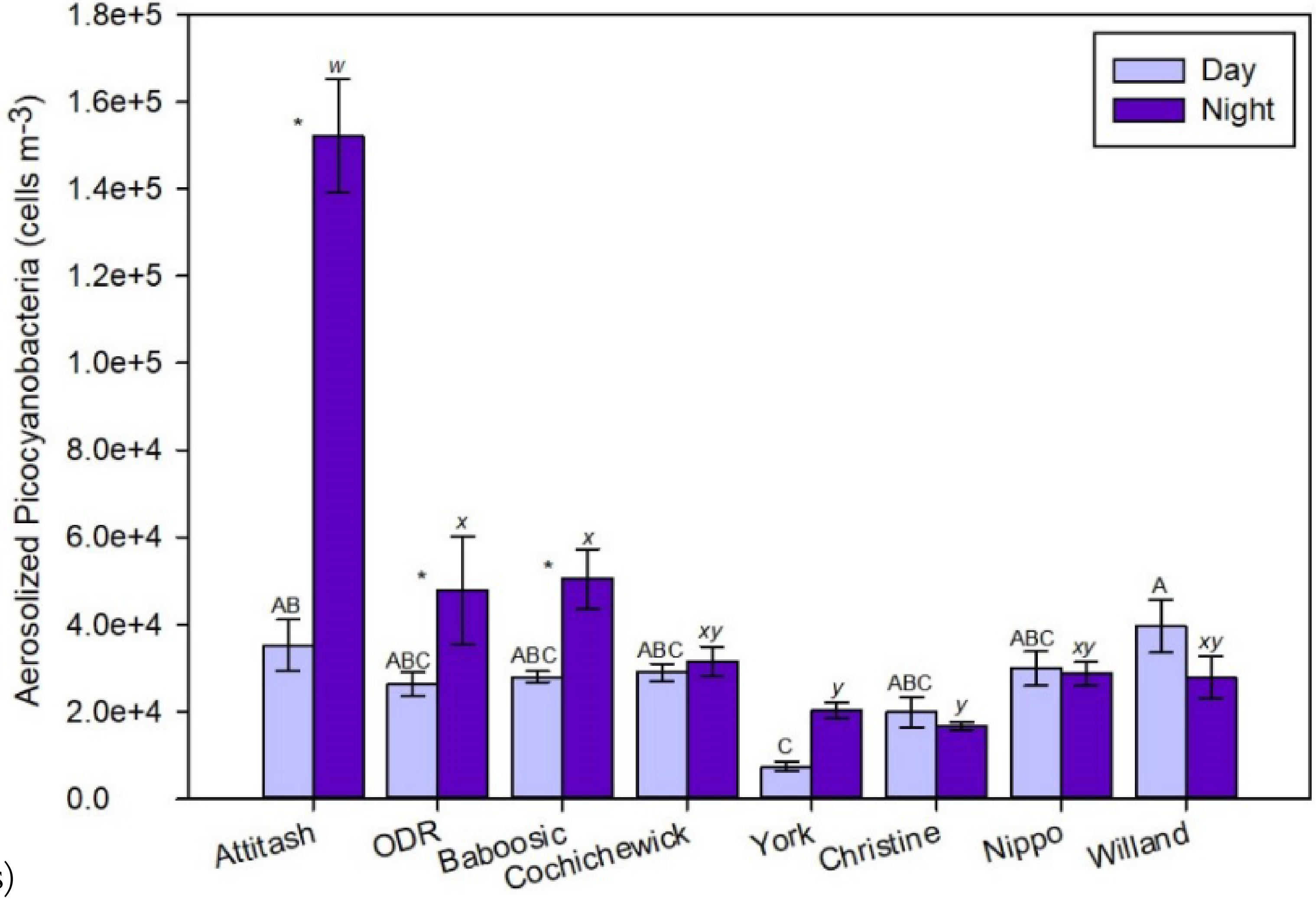
Figure 4. Water reservoirs in which mass occurrence of picoplanktonic cyanobacteria was Mediterranean Sea (A), Baltic Sea (B), Black Sea (C), Hungarian lakes (D), ponds of Moroc Francisco Bay (F), Gulf of Mexico (G), Florida Bay (H), Pensacola Bay (I), Seto Inland Sea (J) and Gippsland Lakes (K).



Murby and Haney 2015

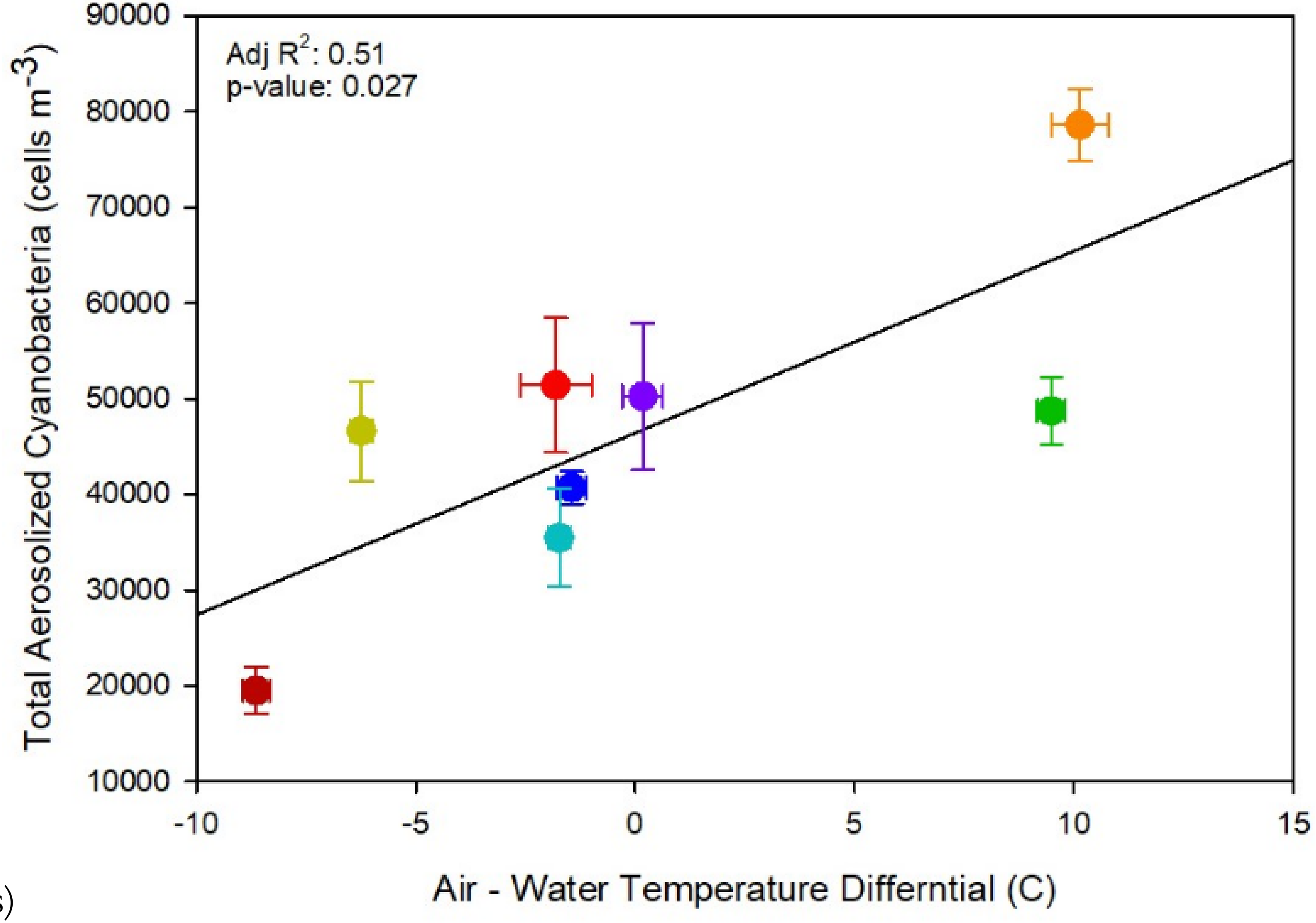
Allelopathic and Bloom-Forming Picocyanobacteria in a Changing World

Sylwia´Sliwi´nska-Wilczewska et al. (2018)



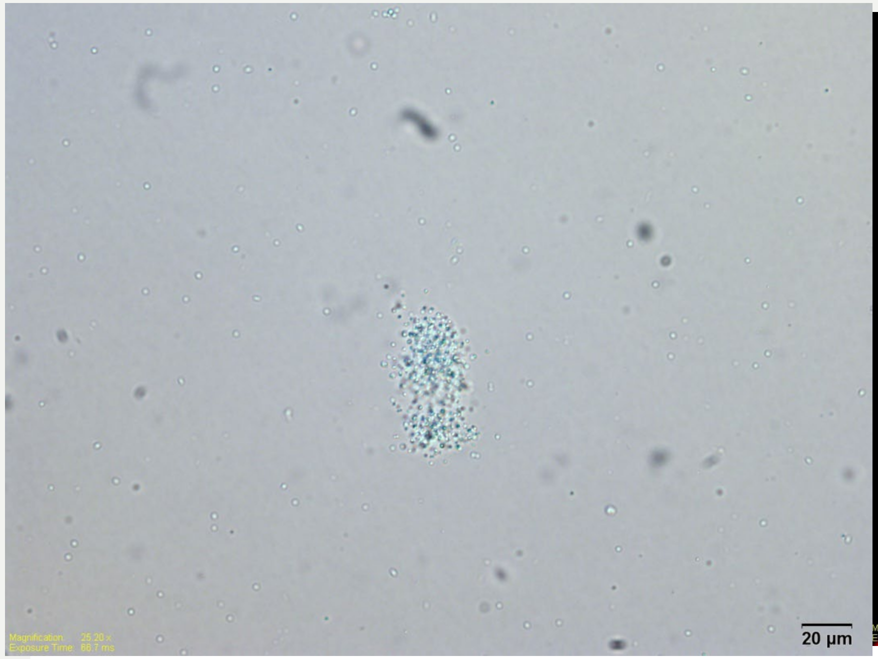
Kate Langley (Hastings)
2019

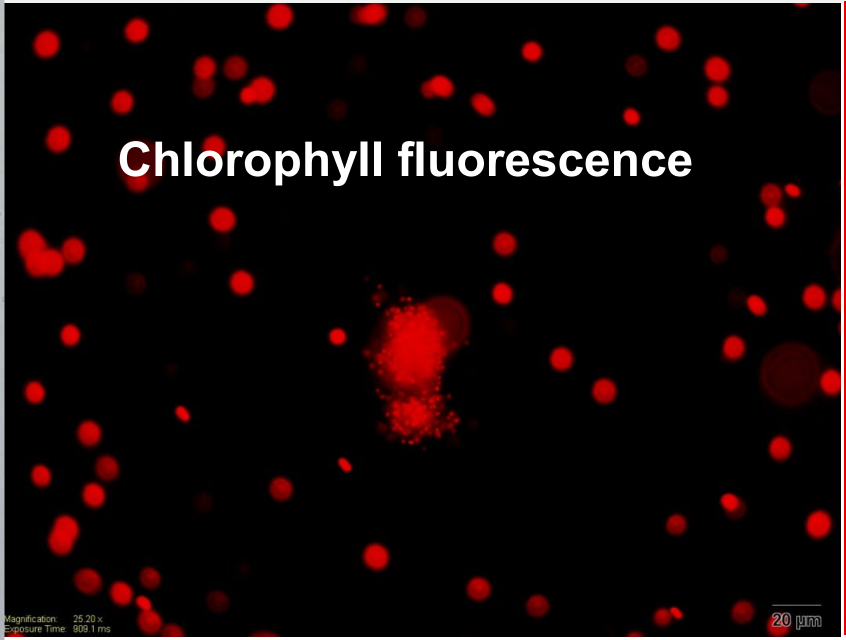
Figure 15. Picocyanobacteria (0.2 – 2 µm) aerosolized from lakes and time of day differences. Picocyanobacteria show different trends than the total aerosolized cyanobacteria. Five lakes had higher levels of aerosolized picocyanobacteria at night. This difference was statistically significant in Lake Attitash, Old Durham Reservoir and Baboosic Lake. Error bars are ± 1 standard error. The effect of time of day on aerosolized picocyanobacteria varied depending on the lake (two-way ANOVA time of day × lake interaction $p < 0.001$). Significant differences between lakes are indicated by letters A - C for day, and w-y for night ($p < 0.05$). Significant differences between day and night within a lake are indicated with asterisks.

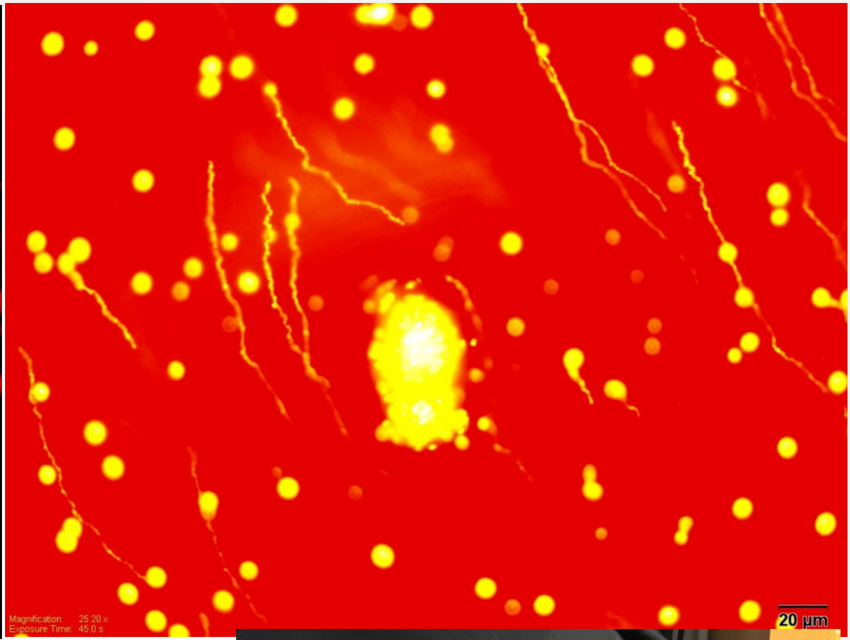


Kate Langley (Hastings)
2019

*Figure 20. Total aerosolized cyanobacteria cells during the day predicted by the temperature differential between air and water. As the air becomes increasingly warmer than the water, there are increasingly more aerosolized cyanobacteria. Error bars are ± 1 standard error. Refer to Figure 17 for color key. Equation: Total Aerosolized Cyanobacteria (cells m^{-3}) = 46472.76 (± 4133.26) + 1900.57 (± 658.62) * Air-Water Temperature Differential (C).*



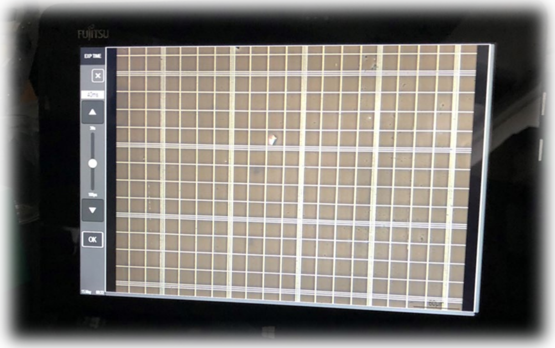




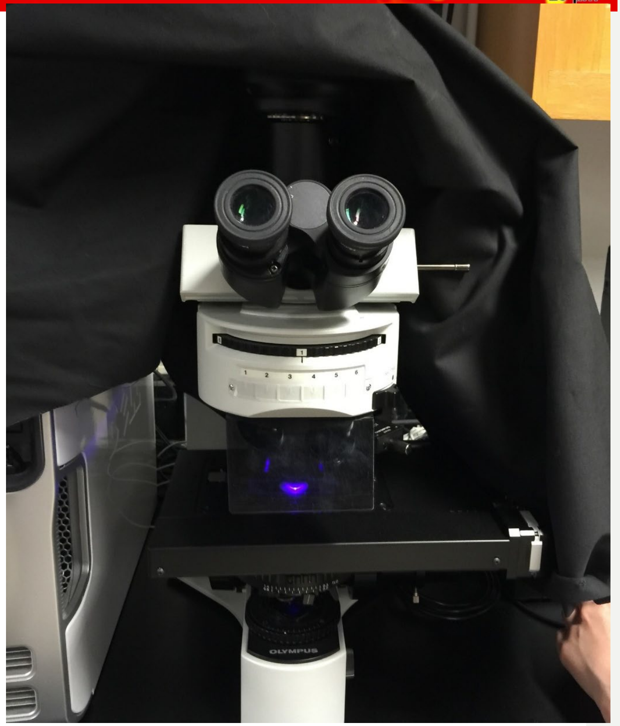
Picocyanobacteria - *Aphanocapsa*

pigment response by epifluorescence

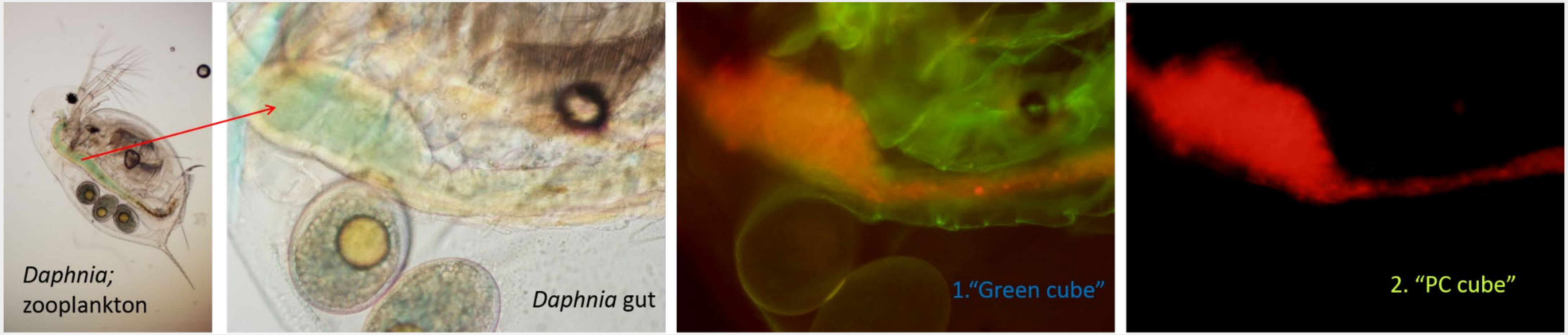
Picocyanobacteria can also be detected through pigments responses via fluorometery



Cell can be enumerated with a hemocytometer



Picocyanobacteria abundance and toxicity were seasonally variable in both lakes, and toxic PCY may be available year-round for grazers such as *Daphnia* spp.



Murby 2019

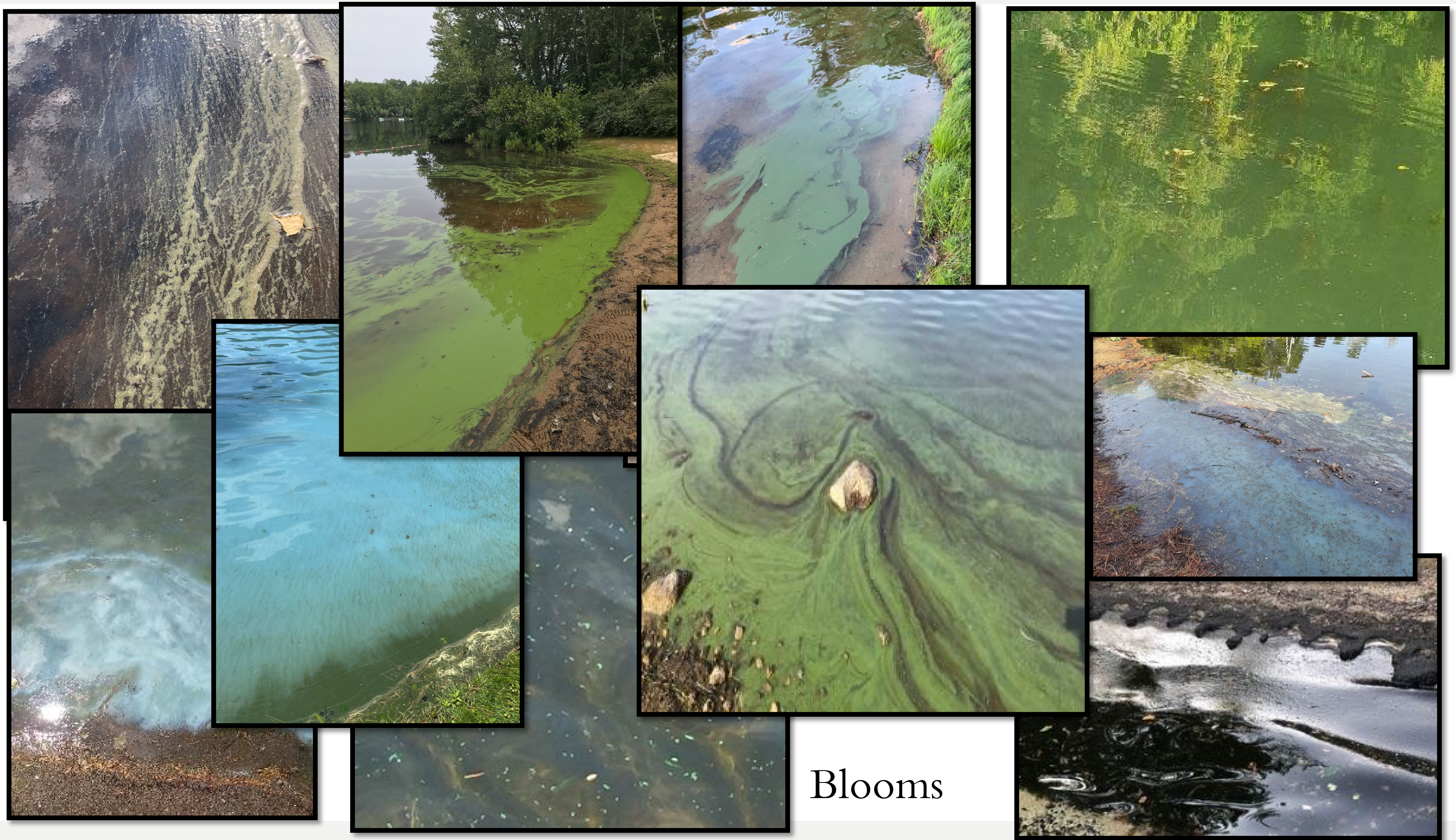
- Bioaccumulation of cyanotoxins to higher trophic organisms…

?

Bioaccumulation through food…?

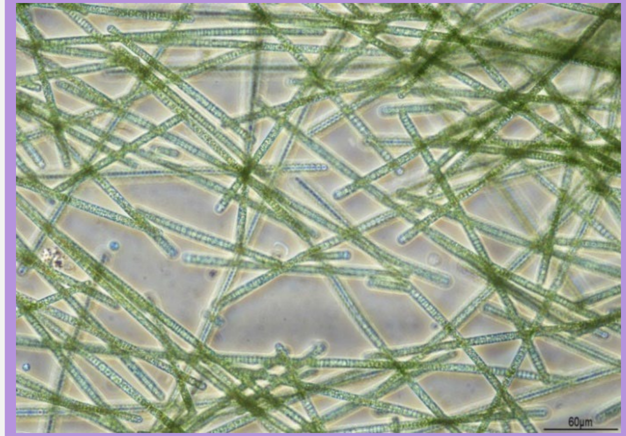
Every Lake is Unique

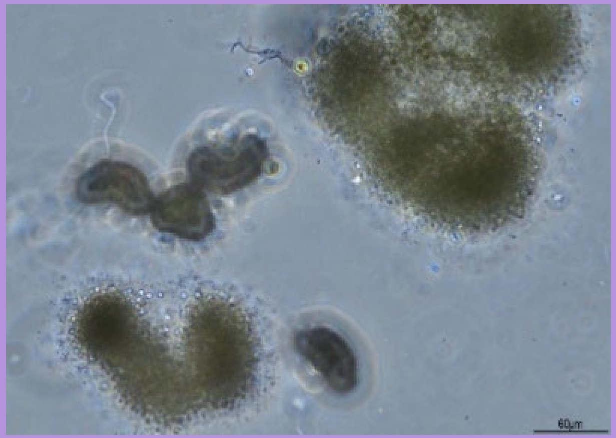
You cannot immediately tell if a lake bloom is toxic … it will also rapidly change over time

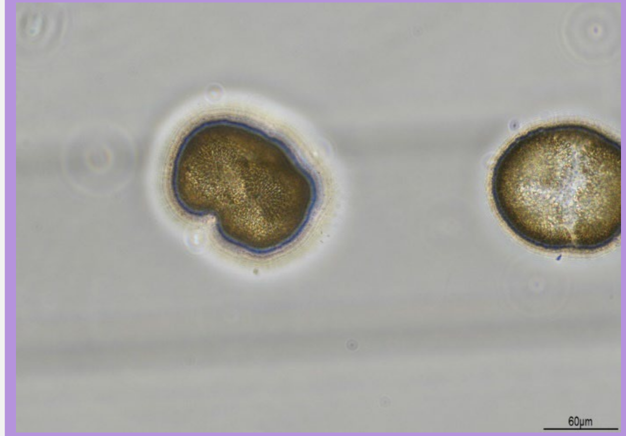


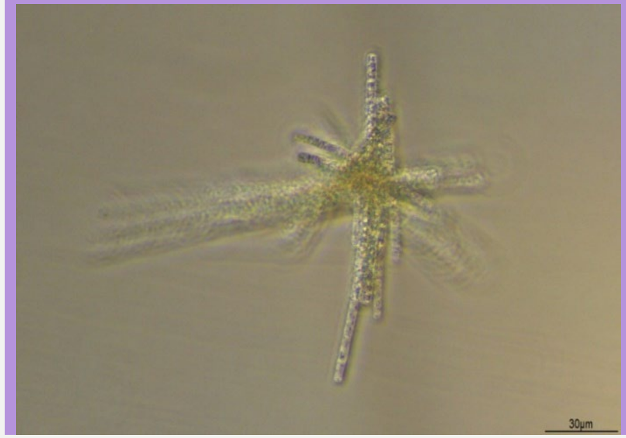
Blooms

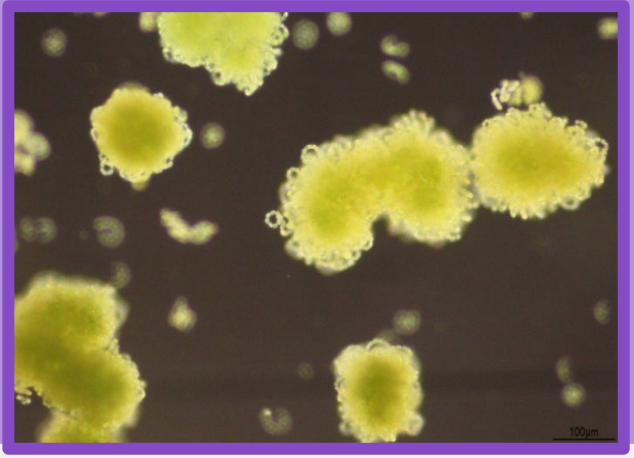
NHDES

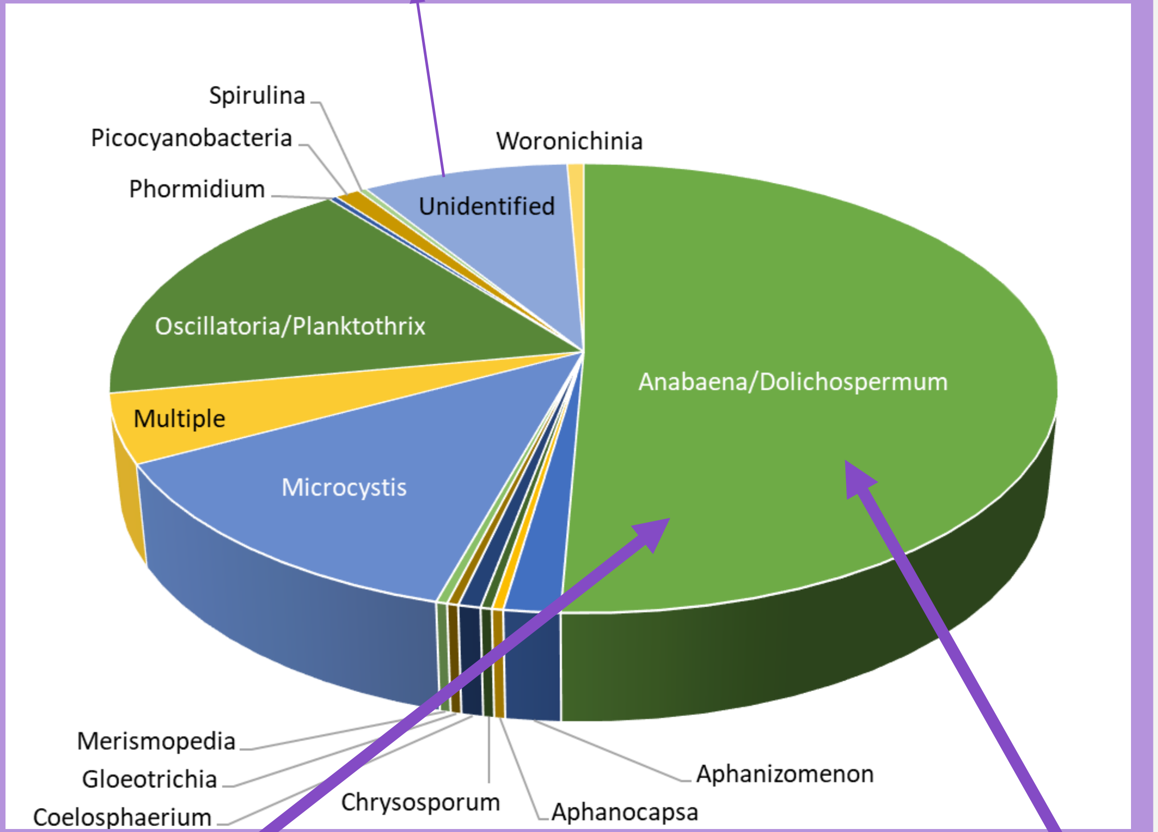












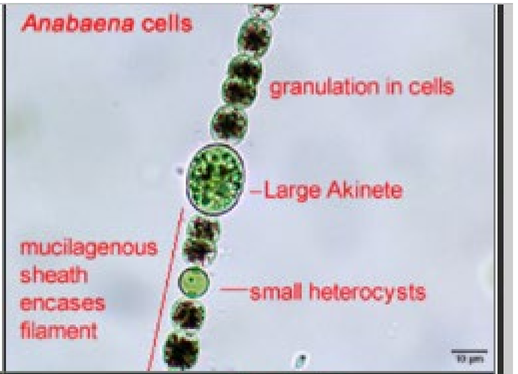
Dolichospermum lemmermannii

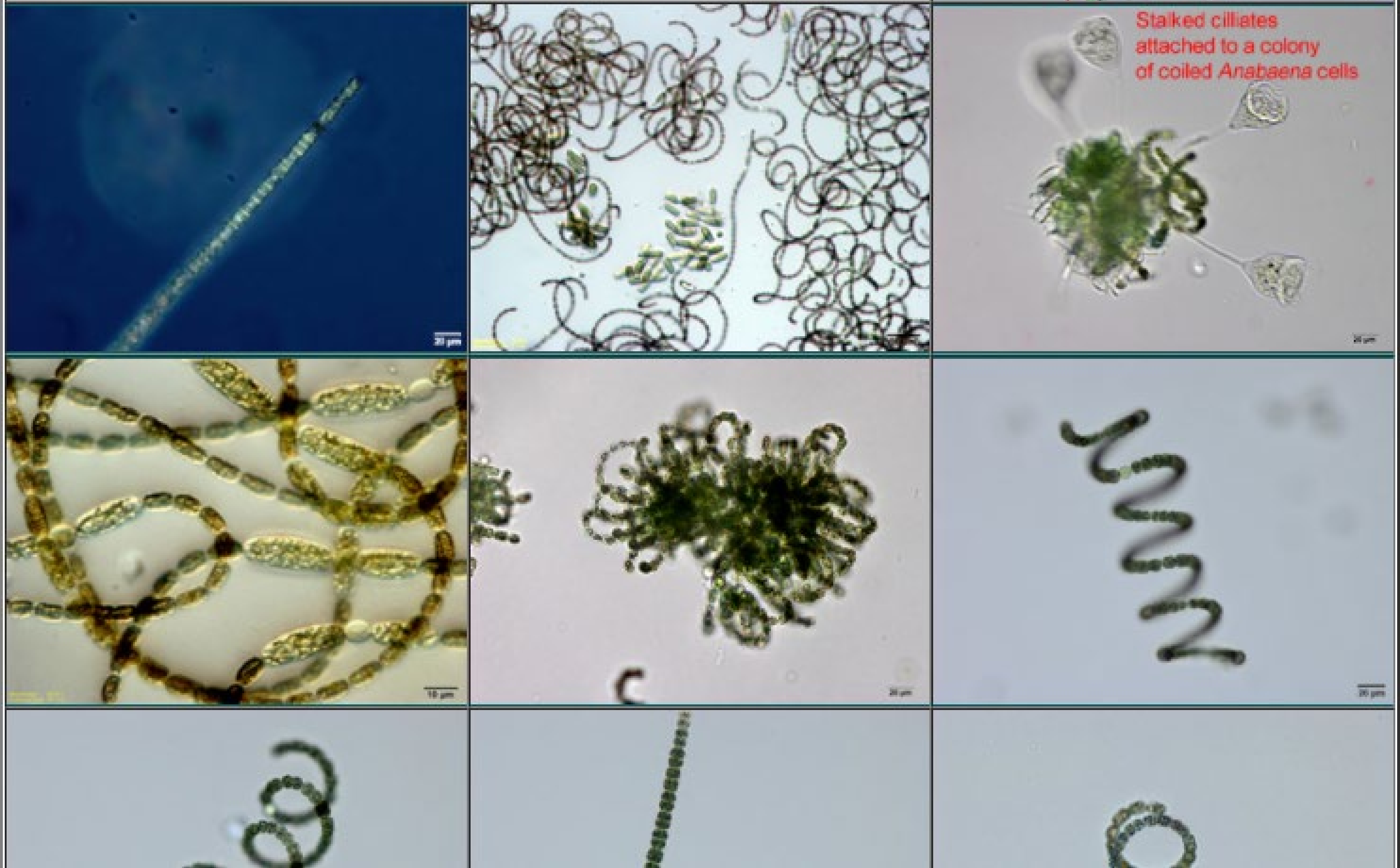
Dolichospermum/Anabaena

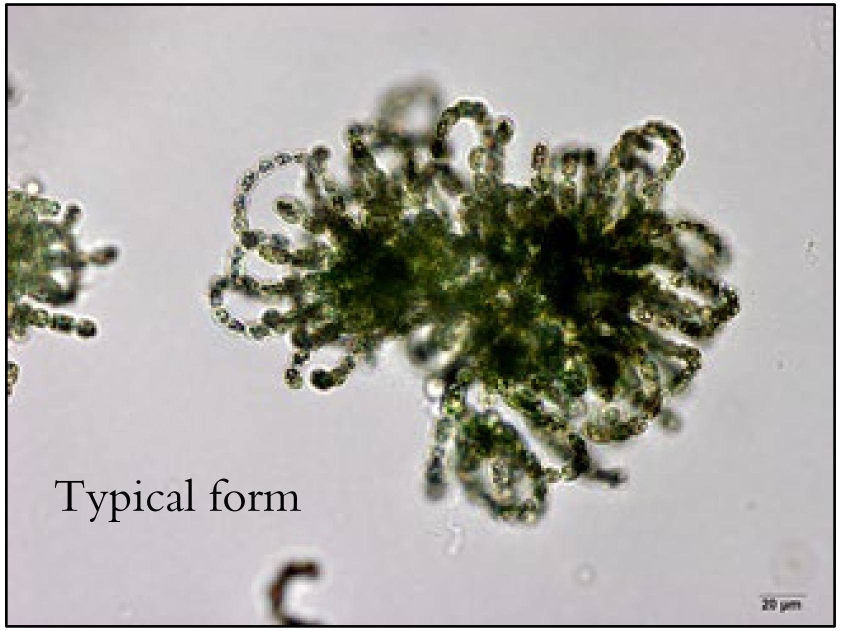
[*Anabaena* (unh.edu)]

General Description

- *Anabaena* cells are usually arranged in filaments or chains and can be straight, spiralled, coiled or spring-like and often dscribed as "beaded"
- Filaments also have specialized cells called heterocysts and akinetes, used for fixing nitrogen and regenerating cells for future colonies
- A mucilagenous sheath surrounds the cells of the filament





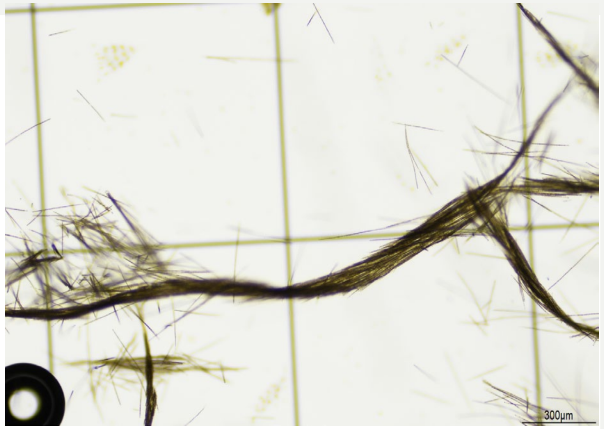


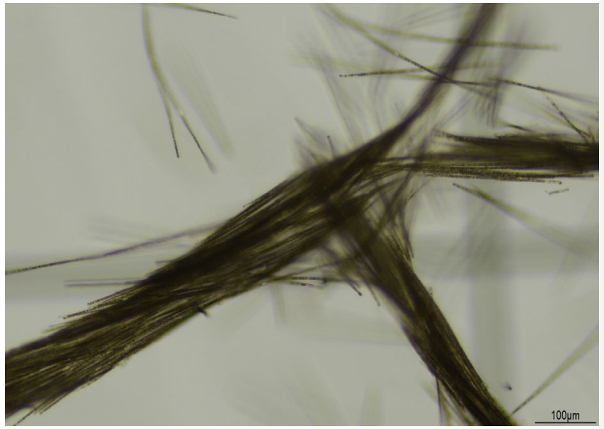
[*Aphanizomenon* (unh.edu)]

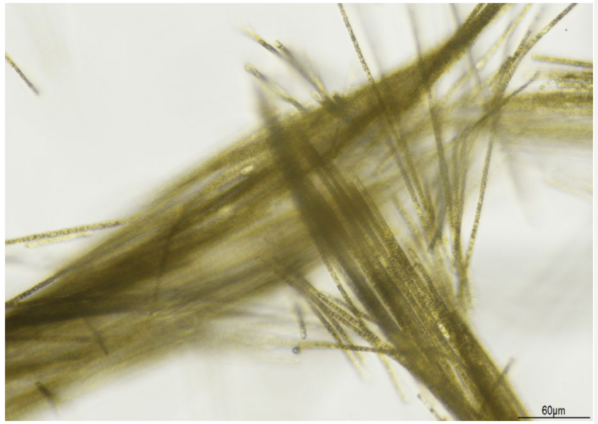
Aphanizomenon

General Description

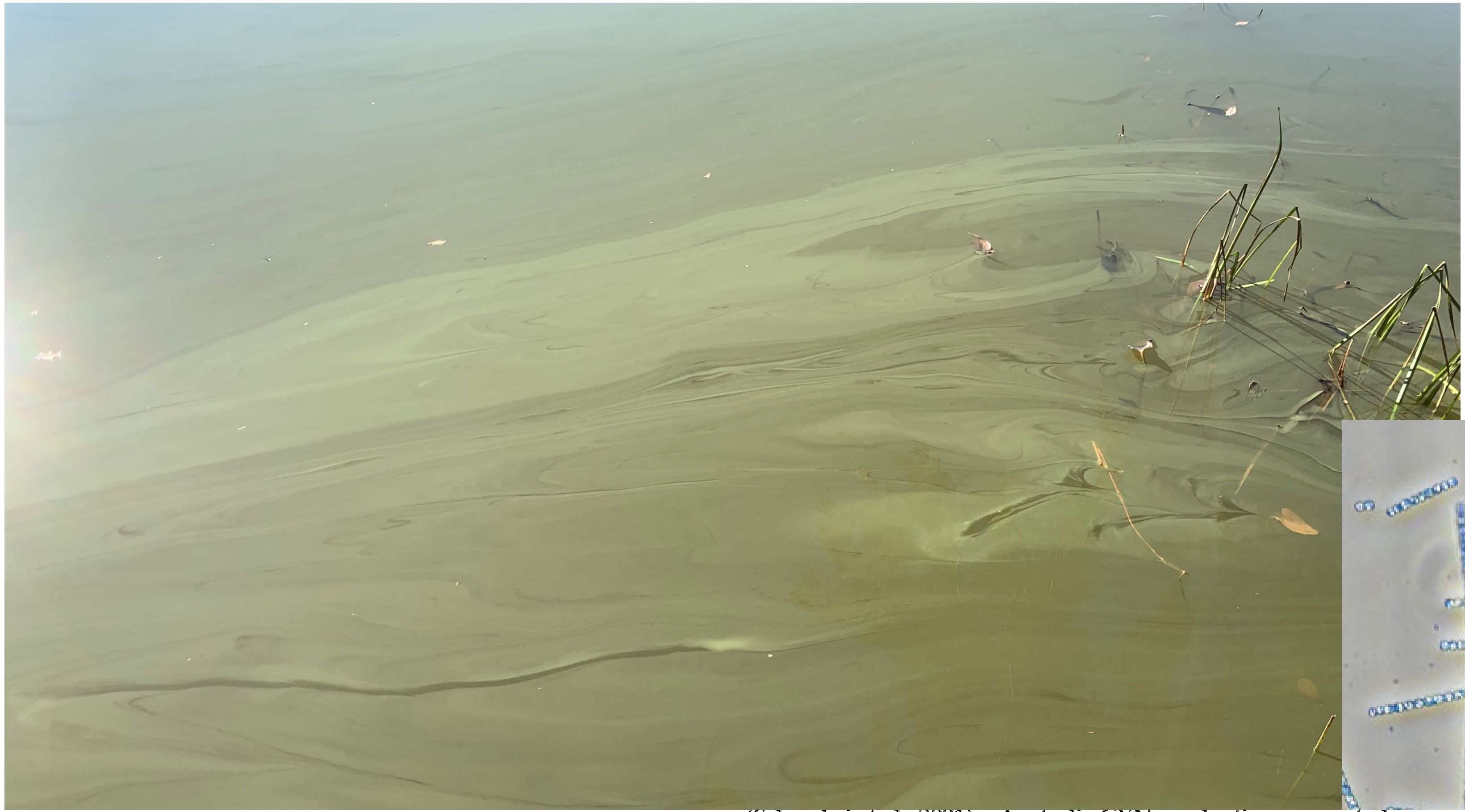
- *Aphanizomenon* are small filaments with cells arranged parallel or rafted to each other
- The length of cells are equal or greater than the width
- Heterocysts and akinetes may or may not be present depending on the species
- Individual filaments of *Aphanizomenon* are much smaller than *Anabaena*, but rafted together create a larger cyanobacteria colony







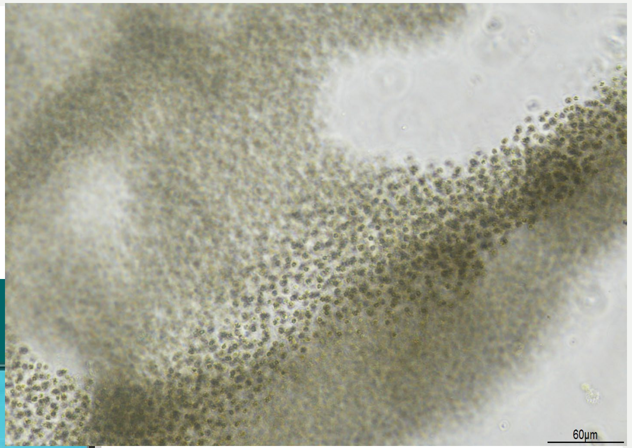
Chrysosporum (formerly Anabaena and Aphanizomenon)



Chrysosporum bergii (previously *Anabaena bergii*)	Cylindrospermopsin Microcystins?	(Schembri et al., 2001)—Australia CYN production supported with molecular work & LC-MS/MS Anecdotal microcystin observation (by Adda ELISA) in bloom dominated by *C. bergii* in a Texas Lake – Field Collection
Chrysosporum ovalisporum (previously *Aphanizomenon ovalisporum)*	Cylindrospermopsin	(Yilmaz et al., 2008)—US-FL isolates confirmed using LC-MS/MS, ELISA and molecular work (Akcaalan et al., 2014)—Turkey; blooms confirmed LC-MS/MS (Banker et al., 1997)— Lake Kinneret, identified using UV, MS & NMR

https://www.researchgate.net/publication/332079468_GreenWater_Laboratories_Potentially_Toxigenic_PTOX_Cyanobacteria_List?channel=doi&linkId=5ed3bd8945851529452209ce&showFulltext=true

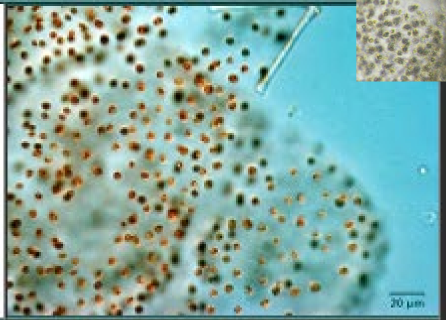
Microcystis (unh.edu)

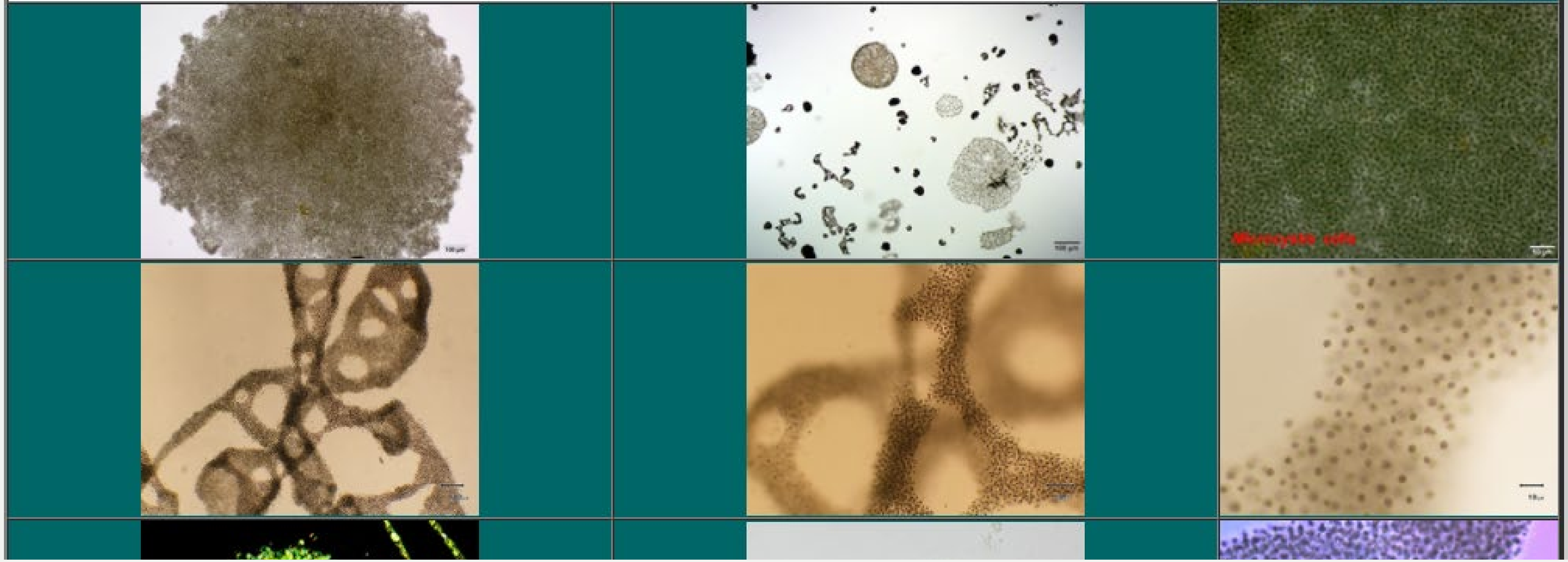


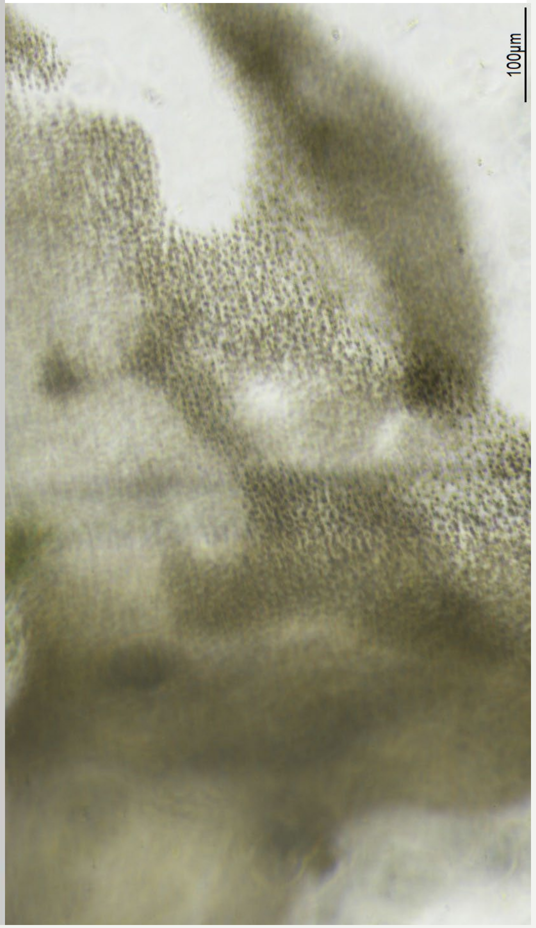
Microcystis

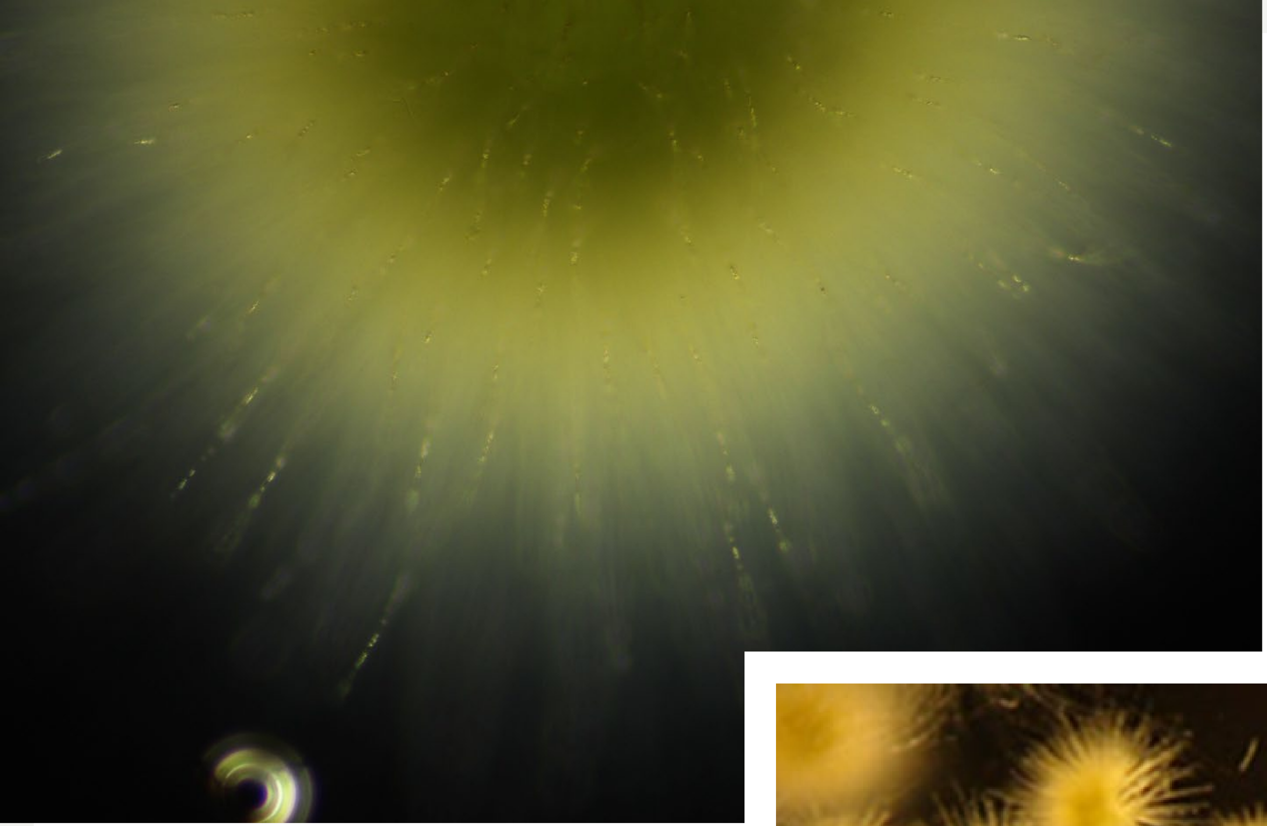
General Description

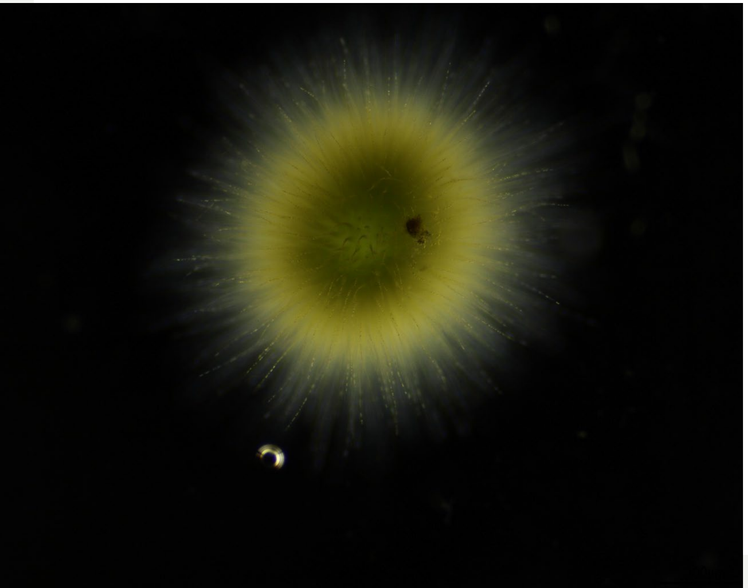
- *Microcystis* is one of the most common and diverse of the cyanobacteria, known for its production of hepatoxic, microcystins
- Cells are granular and sometimes released from the colony and mucilagenous sheath
- Cell-size and colony-shape vary by species, typically cells are about 4-5 micrometers









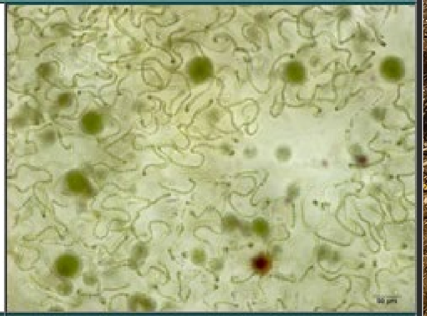



Gloeotrichia

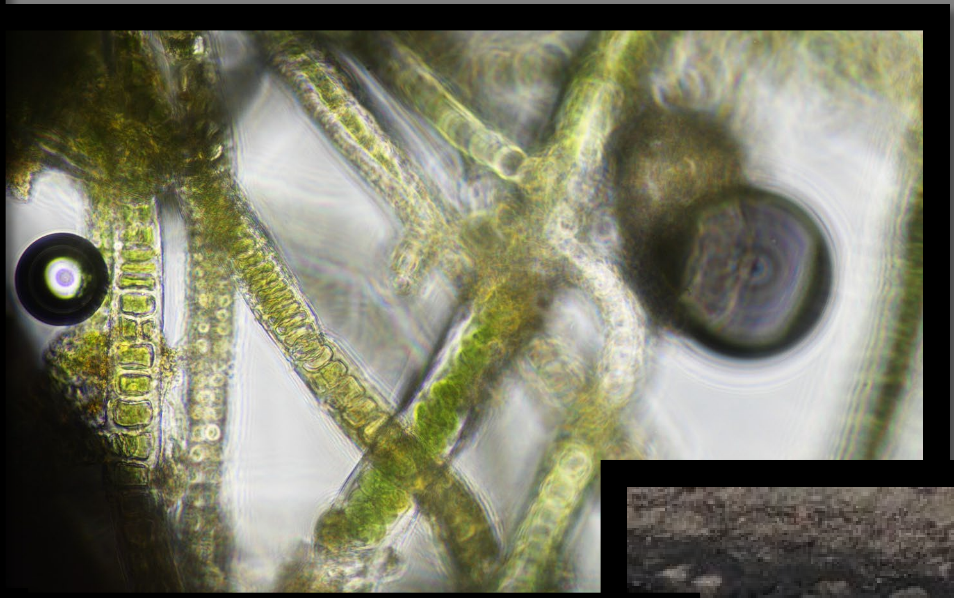
Nostoc

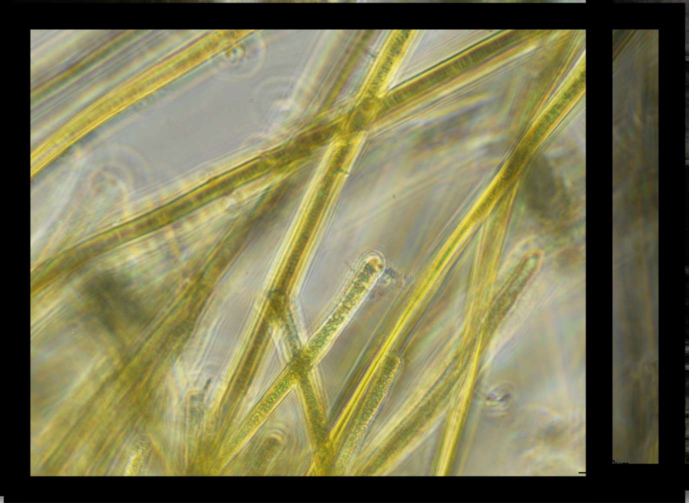
General Description

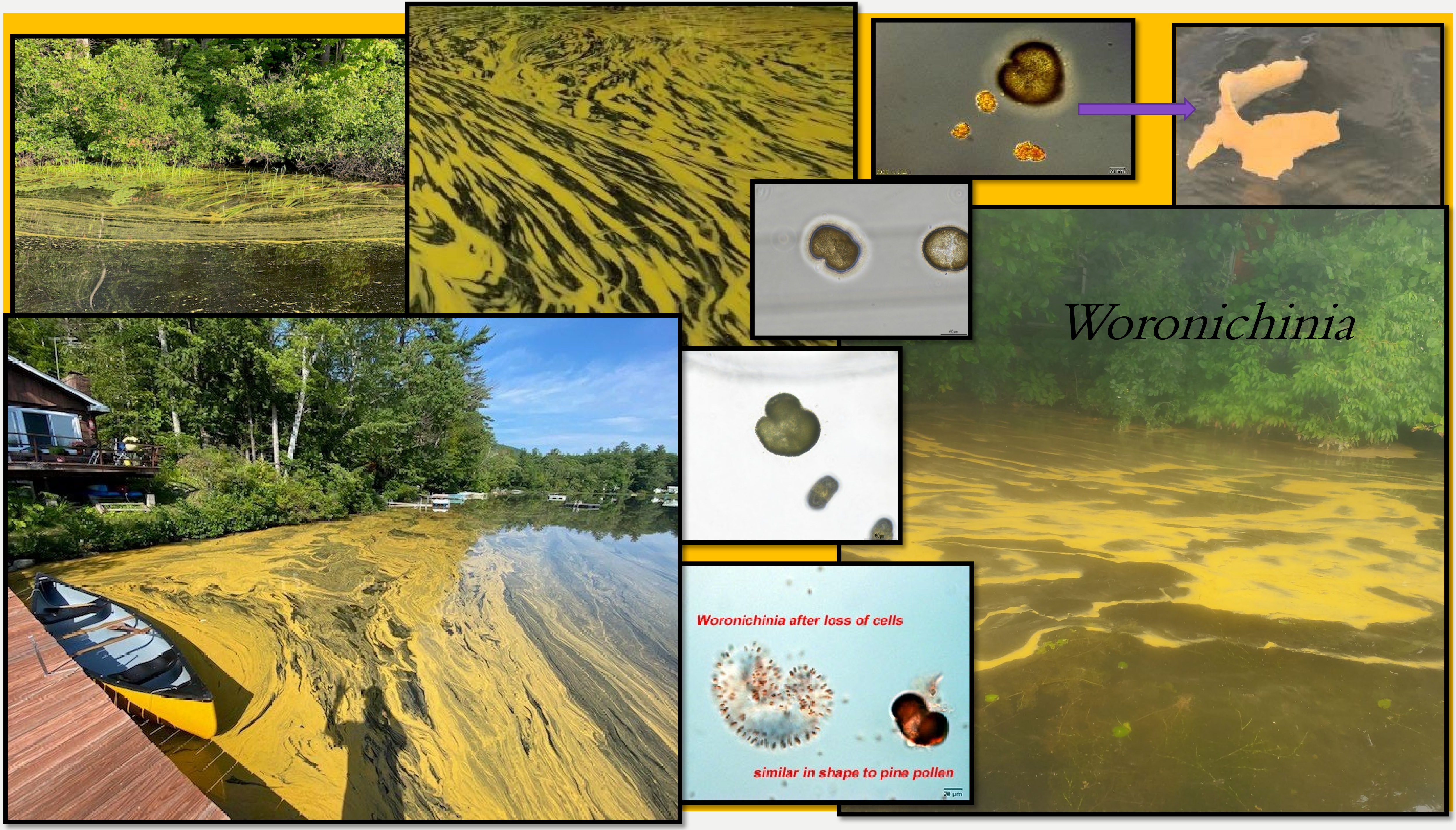
- *Nostoc* cells are similarily arranged as *Anabaena*, but often found within a thick-mucilagenous ball referred to as "the sea tomato"
- The filaments appear kinked and have heterocysts
- Cells are shorter in length than in width



Stigonematales and other benthic mats of cyanobacteria






Woronichinia
Woronichinia after loss of cells
similar in shape to pine pollen
20 µm

Oscillatoria / Planktothrix (unh.edu)

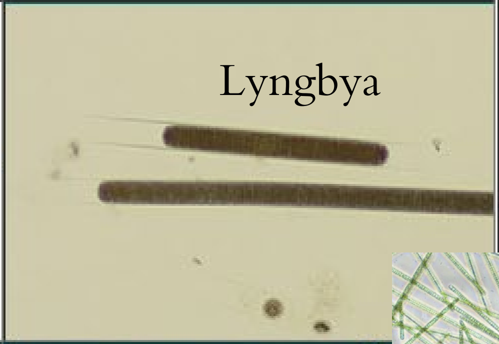
Oscillatoriales

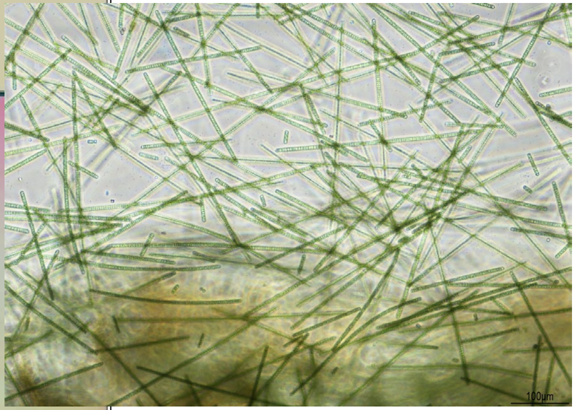
Oscillatoria / Planktothrix

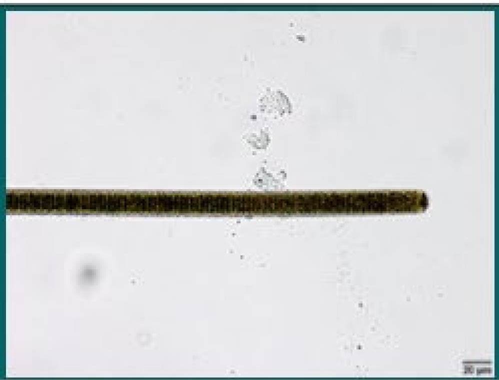
General Description

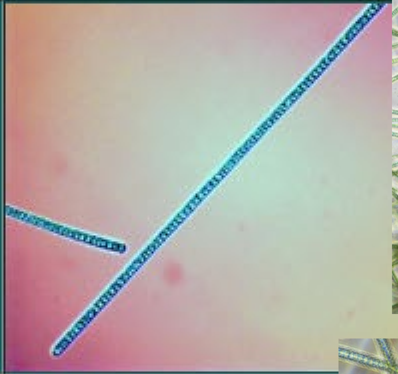
- *Oscillatoria* and *Planktothrix* are arranged as long, cylindrical filaments
- These filaments do not contain heterocysts. Sometimes, short vegetative segments of these can be seen, these are referred to as horomogones or trichomes
- Cells are rigidly divided and m ay or may not have a gelatinous sheath
- *Planktothrix rubescence* formerly known as *Oscillatoria*
- Colors vary from red, blue-green, yellow-brown, purple (some photos here are polarized and not the true color)

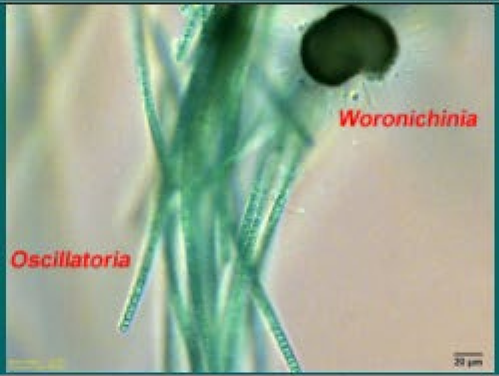
Lyngbya

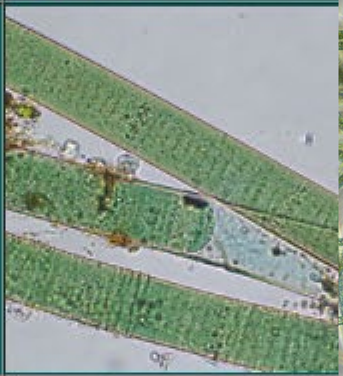


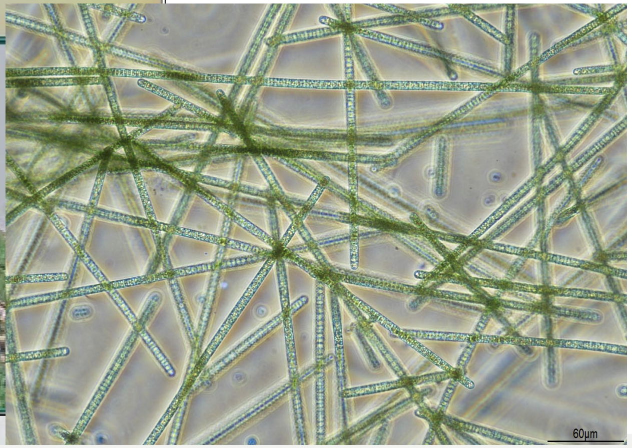




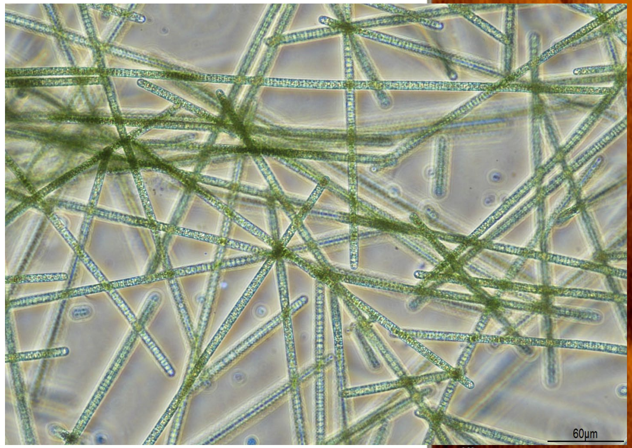


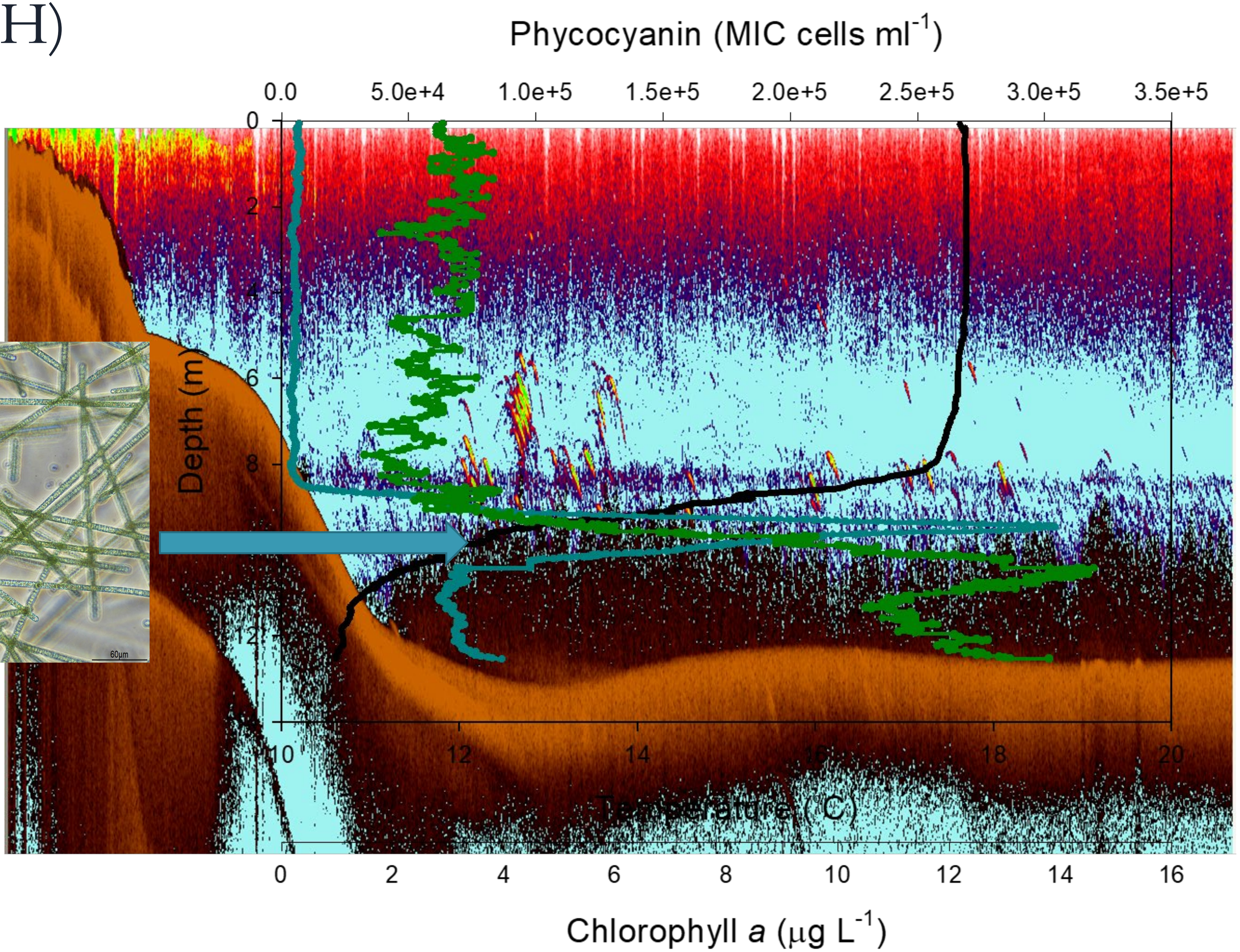




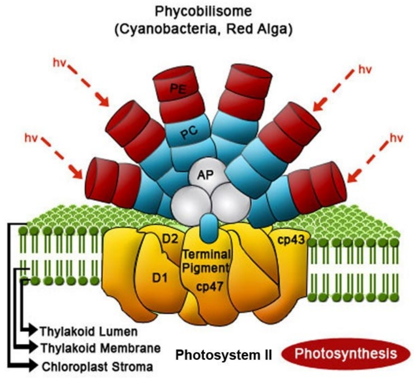


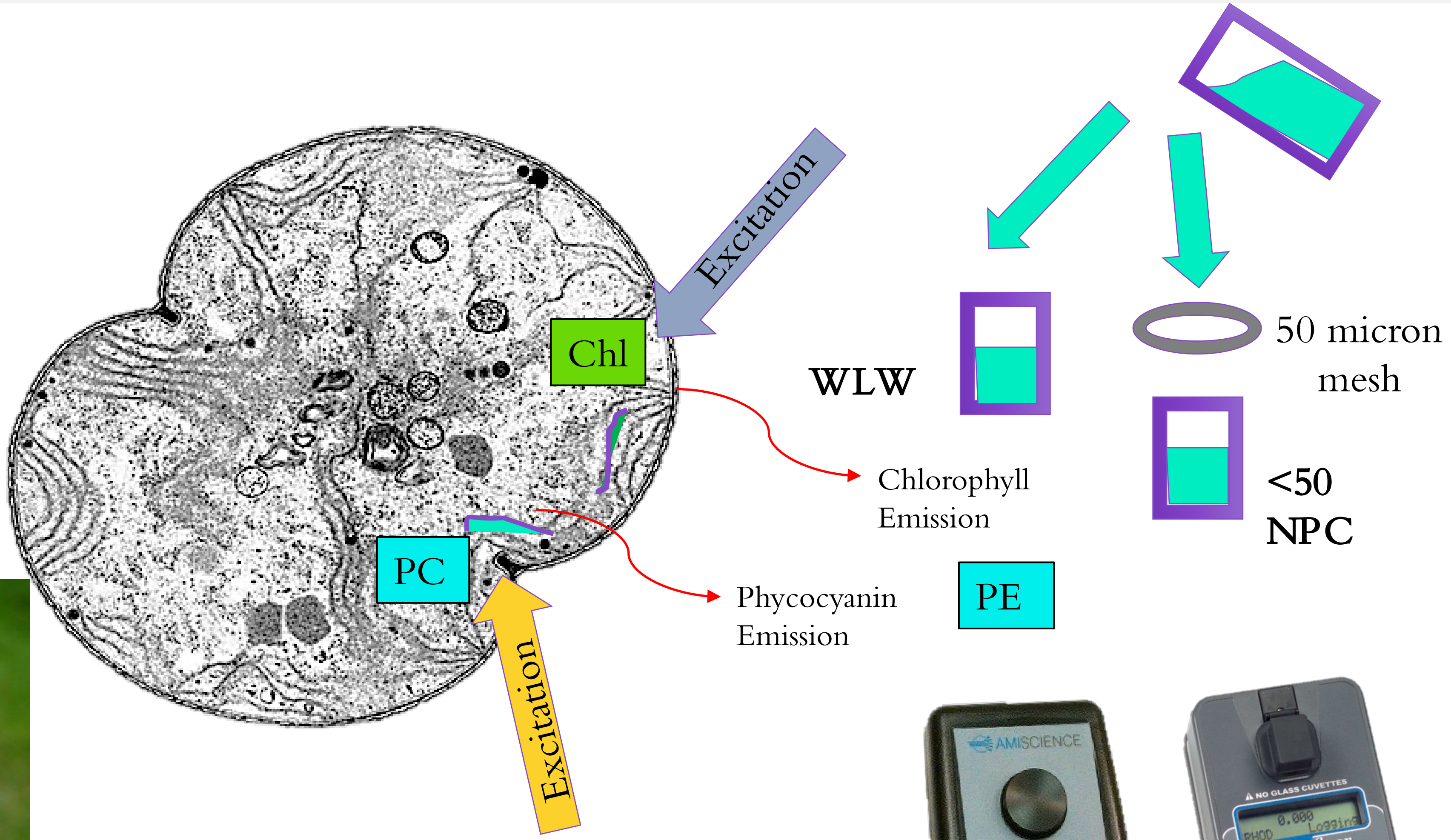
Mirror Lake (NH)





Murby and Haney 2007





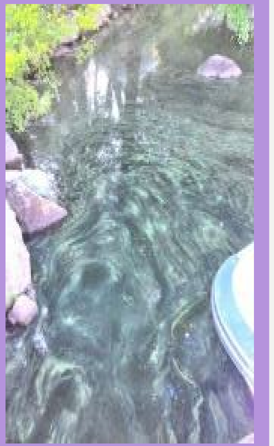
Detection of Cyanobacteria by fluorescence

Hand-held fluorometers

Cyanos.org

EPA Approved QAPP and SOPs guide citizen scientists to a tiered monitoring approach

Volunteer/Student Involvement

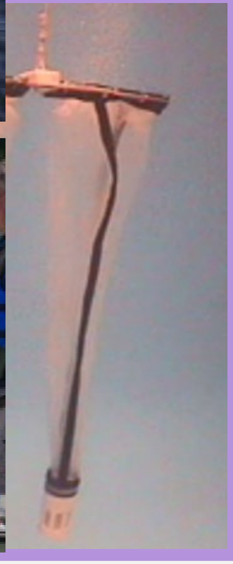


bloomWatch

- General public
- No connection to established VM/CBM program
- Good for tracking blooms
- Generating awareness

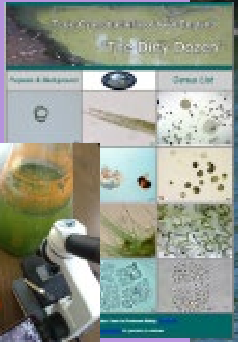
cyanoMonitoring

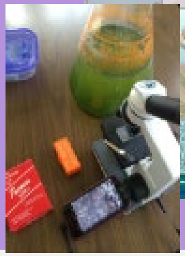
- Best if involved with established VM/CBM program
- Experienced volunteers
- Easy to train for sample collection
- Need an organization for processing/analysis



cyanoScope

- Interested/dedicated individuals
- University education/research
- Agencies, water suppliers

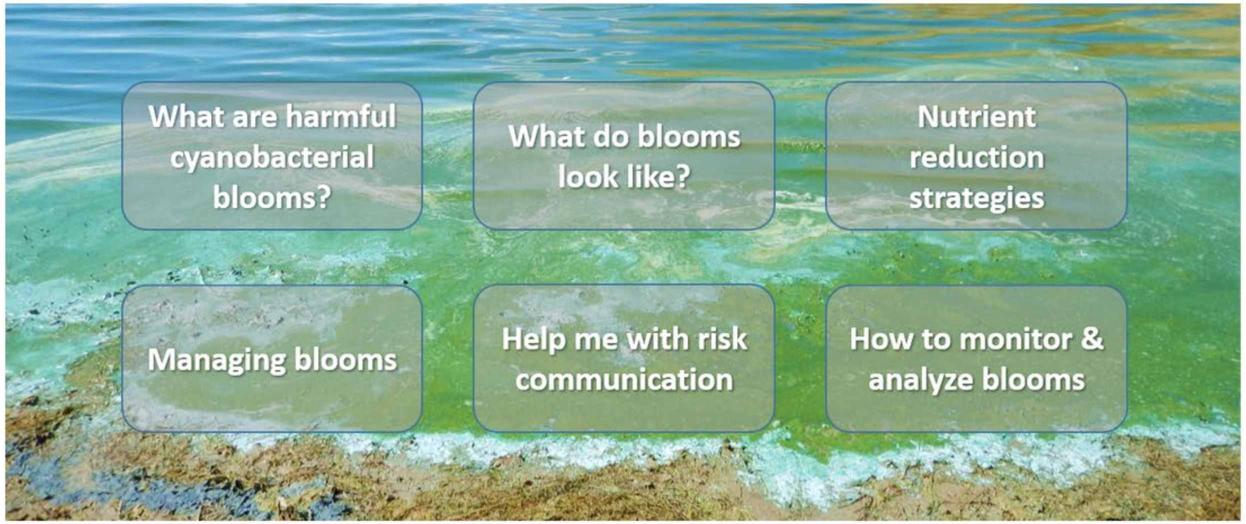




Slide credit to EPA Region 1 (Hilary Snook): Cyanos.org

Strategies for Preventing and Managing Harmful Cyanobacterial Blooms (HCB-1)

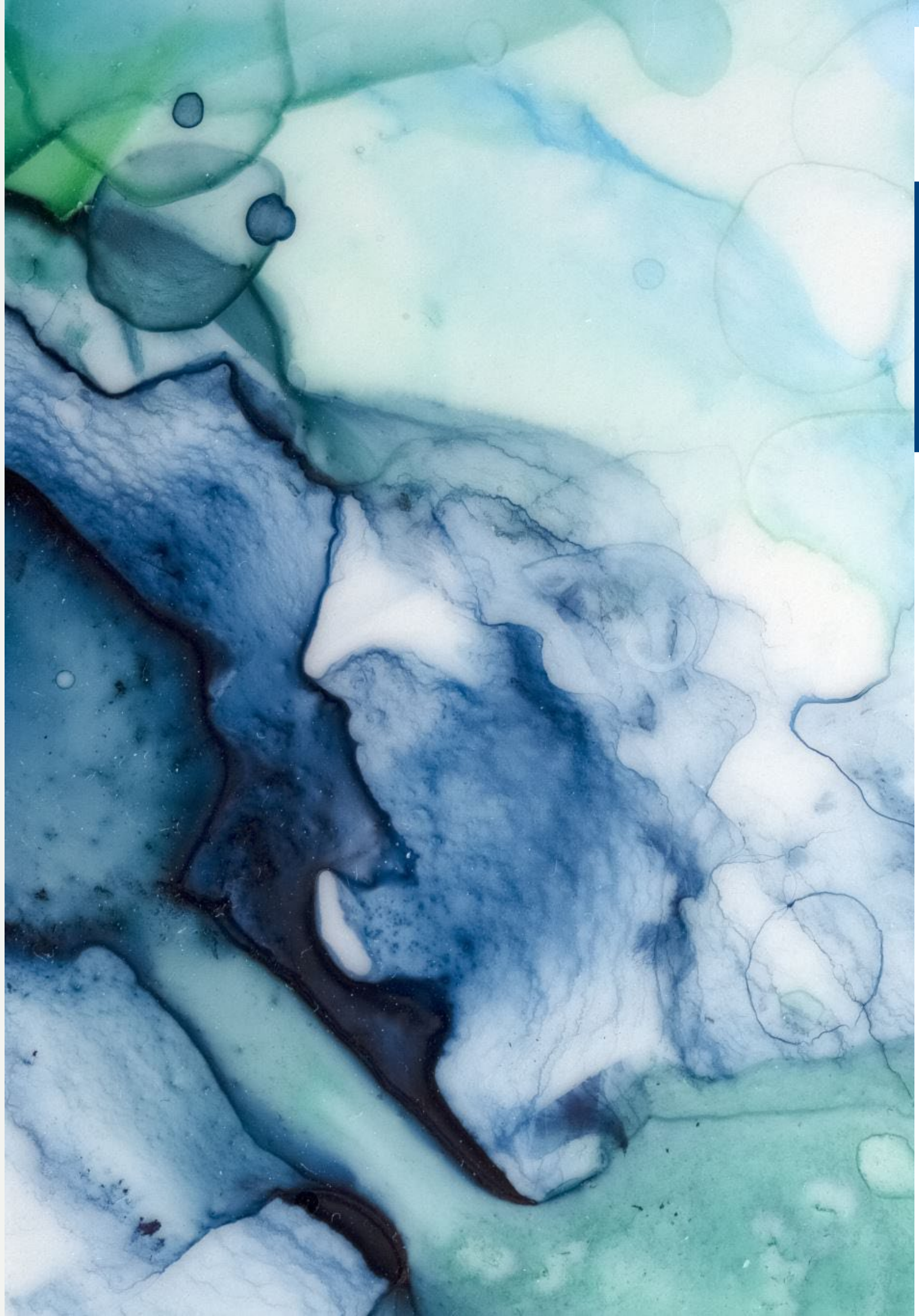
- Visit HCB-2 Website
- Home
- Interactive Tools
- 1. Overview
- 2. Using this Guidance for Cyanobacterial Bloom Response
- 3. Introduction to the Cyanobacteria
- 4. Monitoring



Source: Wyoming DEQ

Cyanobacteria are microscopic, photosynthetic organisms that can be found naturally in all aquatic systems. Under certain conditions, cyanobacteria can multiply and become very abundant, discoloring the water throughout a water body or accumulating at the surface. These occurrences are known as blooms. Cyanobacteria may produce potent toxins (cyanotoxins) that pose a threat to human health. Cyanobacteria can also harm wildlife and domestic animals, aquatic ecosystems, and local economies by disrupting drinking water systems and source waters, recreational uses, commercial and recreational fishing, and property values.

https://hcb-1.itrcweb.org/



Strategies for Preventing and Managing Harmful Cyanobacterial Blooms (Benthic)

The goal of this project team is to enhance the **ITRC HCB technical and regulatory guidance document** developed by the original HCB team with more detailed information focused on benthic cyanobacteria. The project team will produce a companion technical regulatory guidance document (and subsequent training) focused on:

- Introduction to benthic cyanobacteria and connection to existing HCB document
- Field screening and sampling for benthic cyanobacteria
- Analytical toxin testing methods for mat samples
- Toxin Thresholds - All cyanotoxins in mats; Neurotoxins and dermal toxins in water
- Communication and Response Planning - Specific advisory signage and messaging
- Specific considerations for Prevention and Management and Control Strategies

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What's happening now, in October, in NH Lakes?

Fall Turnover

Nutrients (cyanobacteria "seeds" fall to bottom and over-winter)

Cyanobacteria bloom surfacing/decaying - Advisories ongoing

External loading vs. Internal loading?

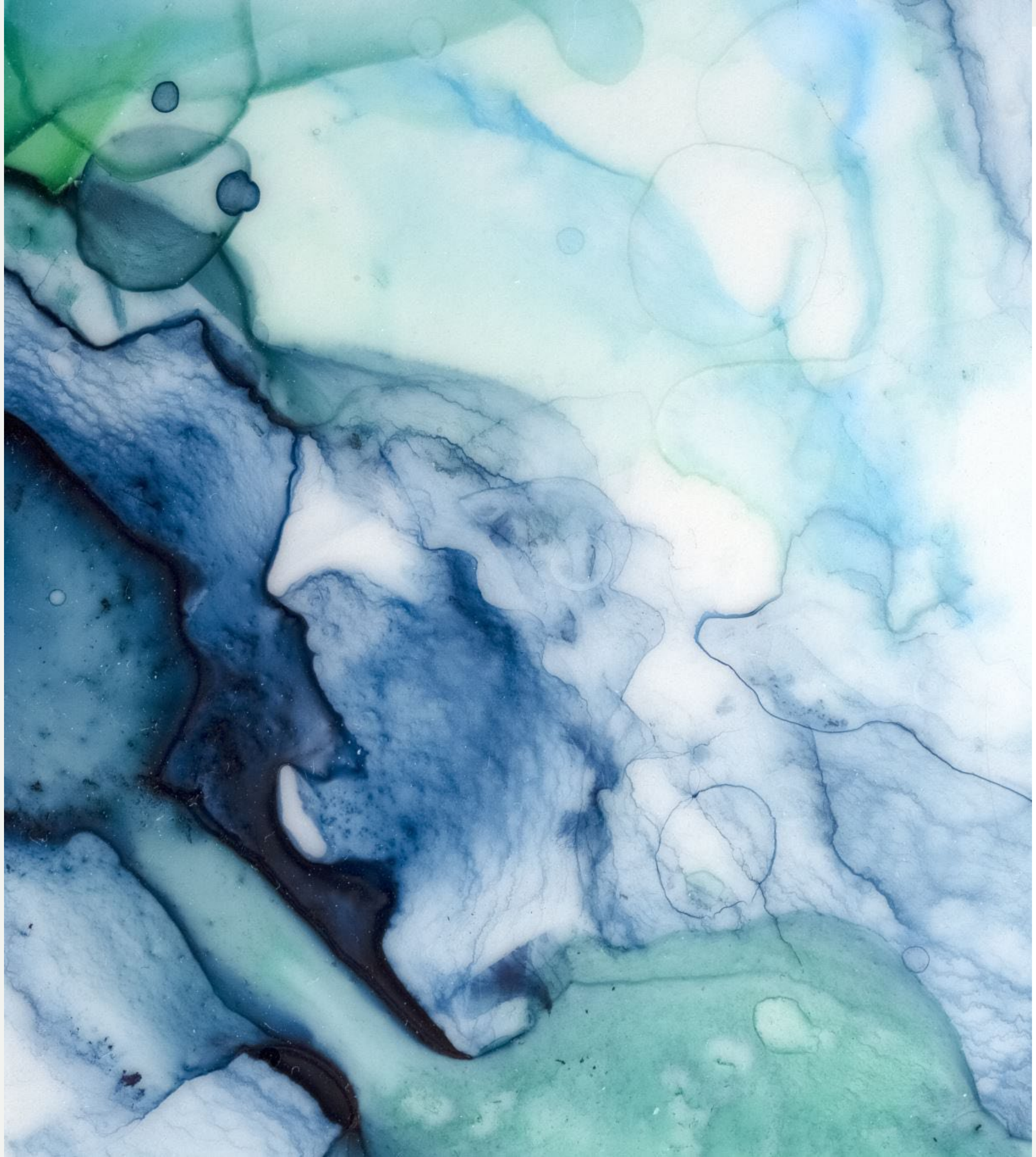
N:P ratio changes?

Sediment elements?

Limiting macro and micronutrients?

Temperature changes?

Flow?



Thank you

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