# Cyanobacteria

Dr. Amanda McQuaid

November 1, 2023

**Silver Lake**
and the
CYANOBACTERIA PROBLEM

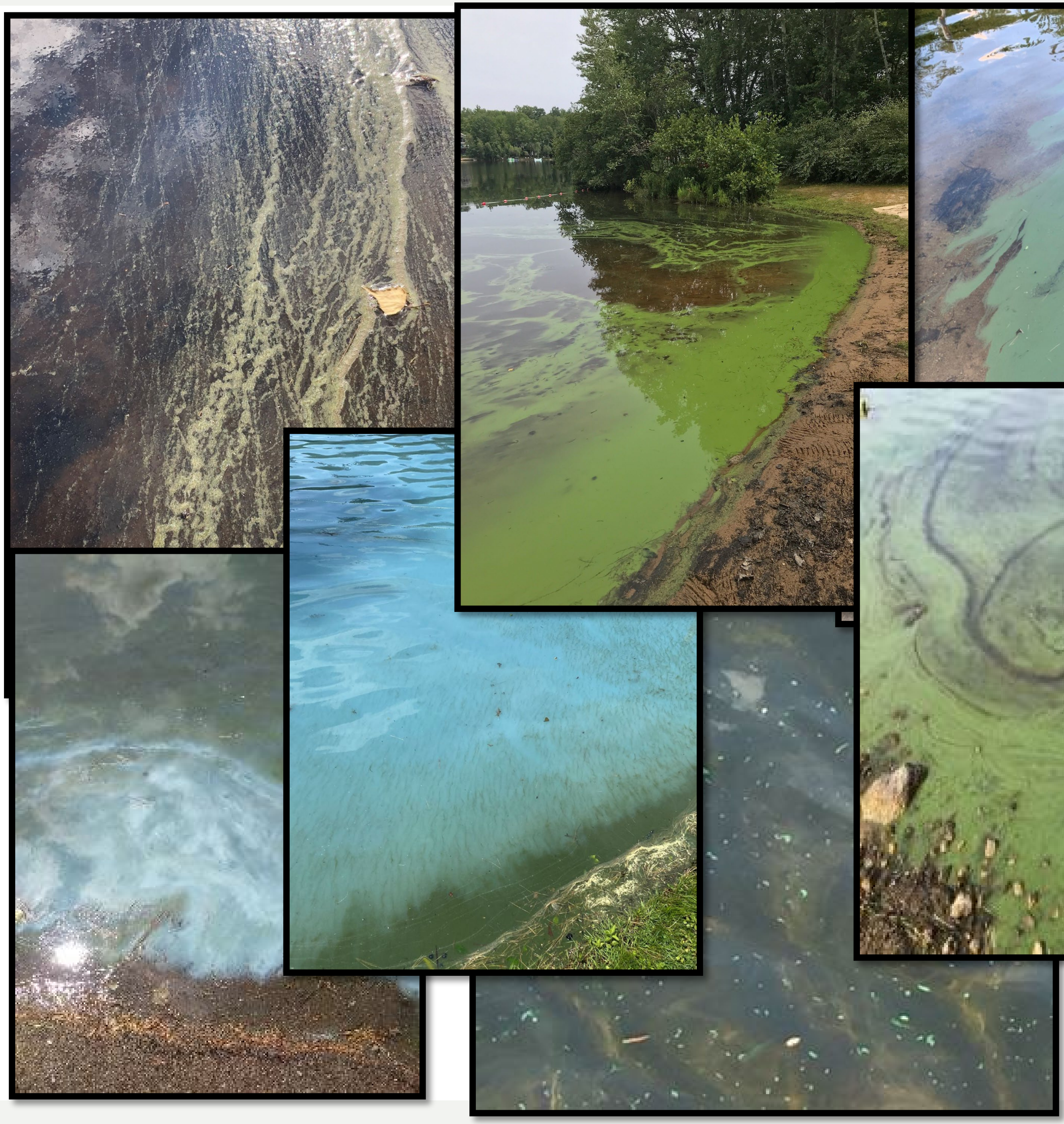
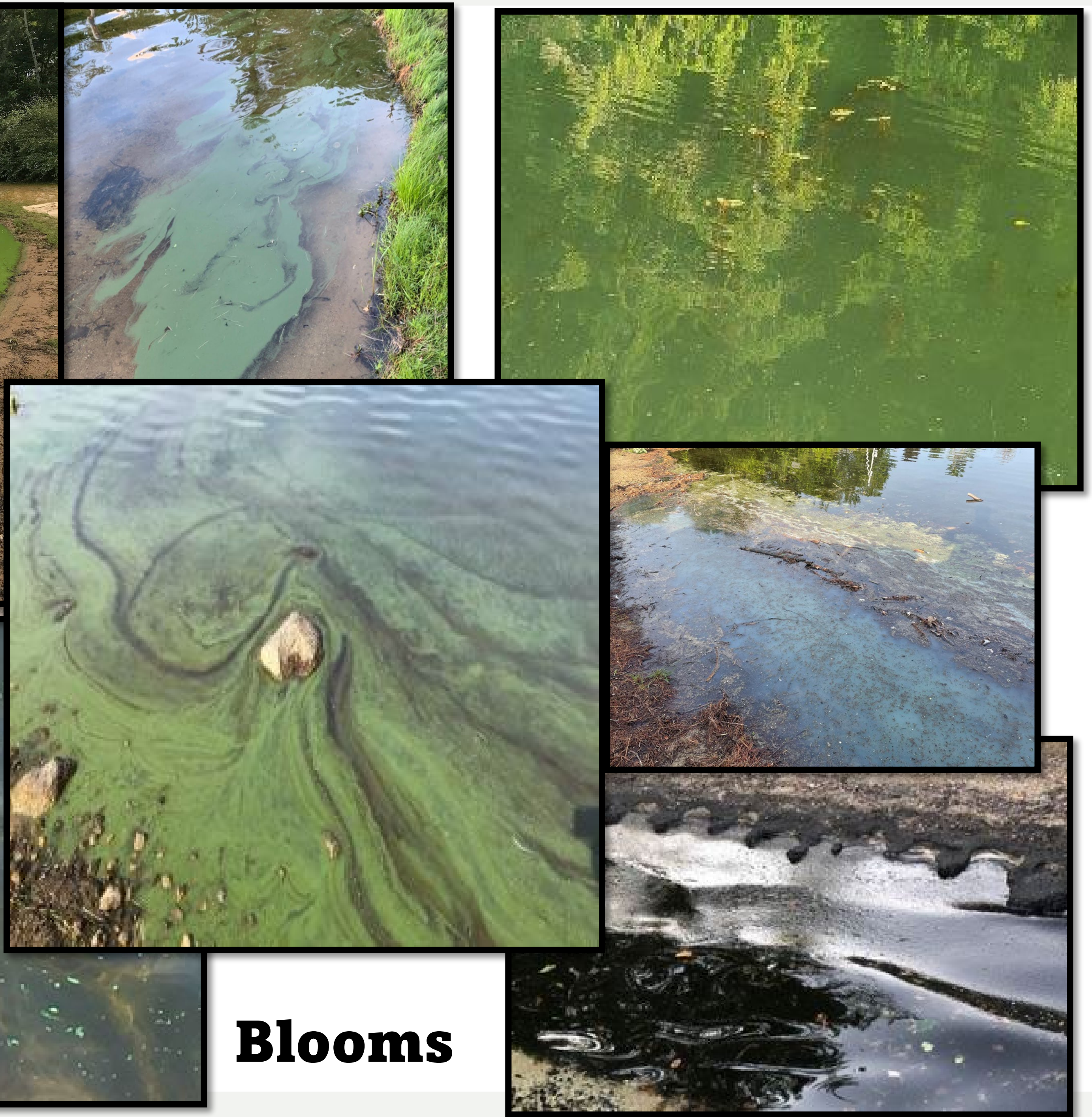
Hollis
Conservation
Commission

# 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 → rapid growth

# 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)

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

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

[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

**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

# Public and scientific interest has focused on surface blooms


Surface bloom in China: Hans Paerl

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

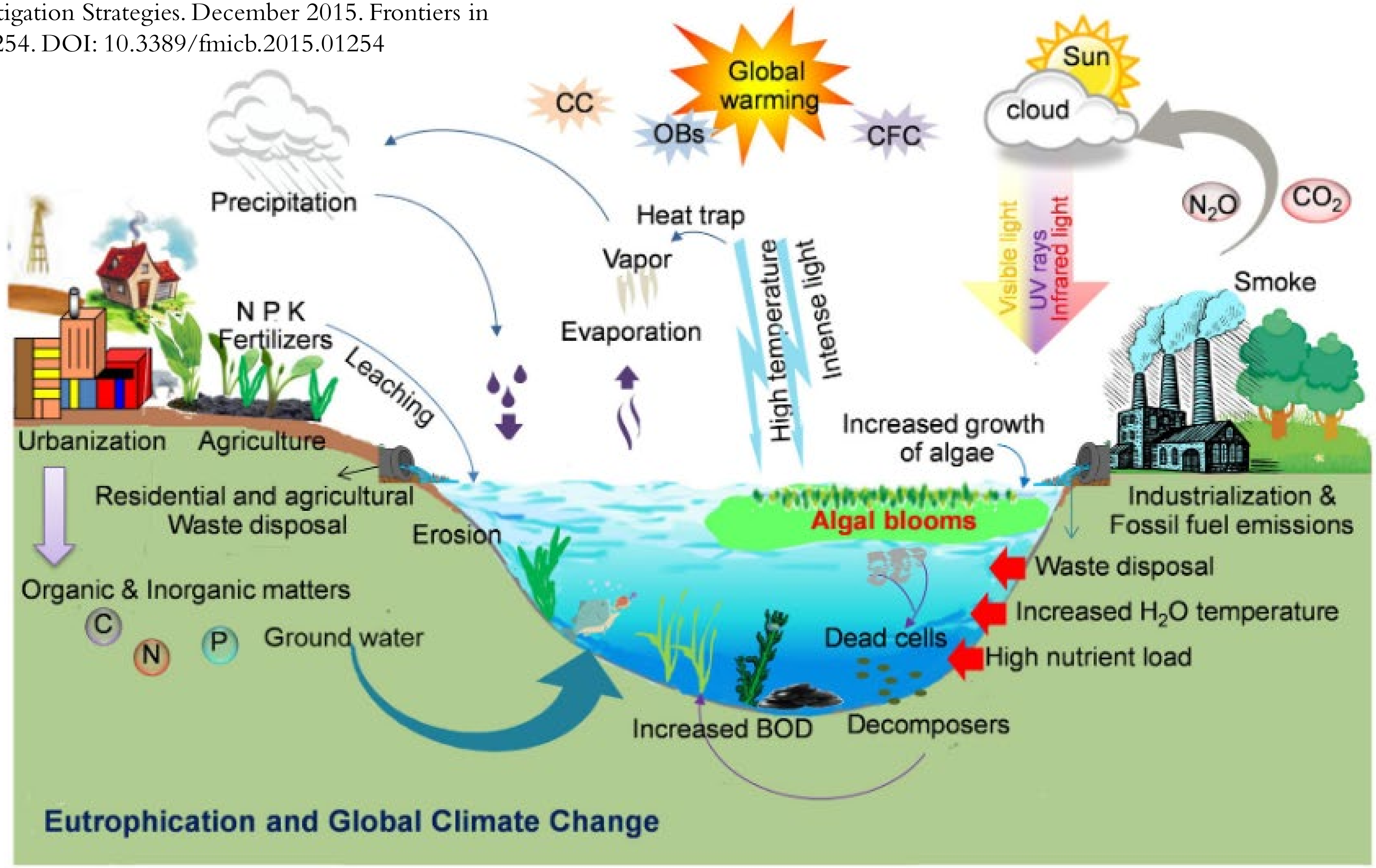



**FIGURE 2 | Formation of cyanobacterial blooms: Schematic illustration showing the key factors such as anthropogenic eutrophication, global climate change such as increased temperature and light or global warming due to an increase in ozone depleting substances (e.g., $CO_2$, $N_2O$, etc.), and other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

## What is a BMP?

# Best Management Practices….

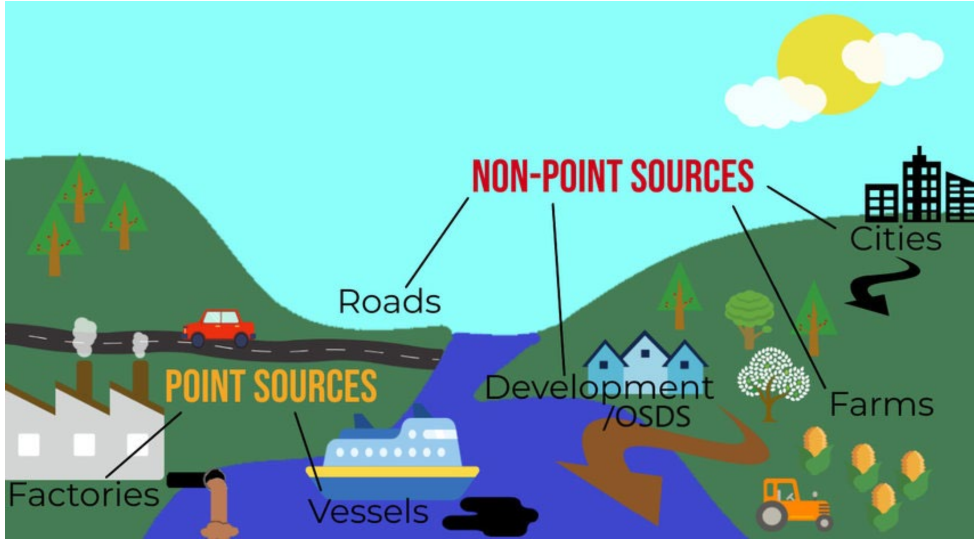
Control the delivery of Non-Point Source pollutants to water bodies in (at least) the following three ways:

1. source reduction by minimizing pollutants available in the first place;

2. reduce the transport of pollutants by reducing water transported or by retaining pollutants; and

3. remediating or intercepting the pollutants before or after they are delivered to the water resource by chemical or biological transformation.

https://www.des.nh.gov/sites/g/files/ehbemt341/files/documents/2020-01/wd-03-42.pdf



## Welcome to LakeSmart Start

Today, you can do one easy thing to protect your lake! Take the LakeSmart Start survey and join the hundreds of others, just like you, who are learning about simple steps they can take to live in a lake-friendly way.

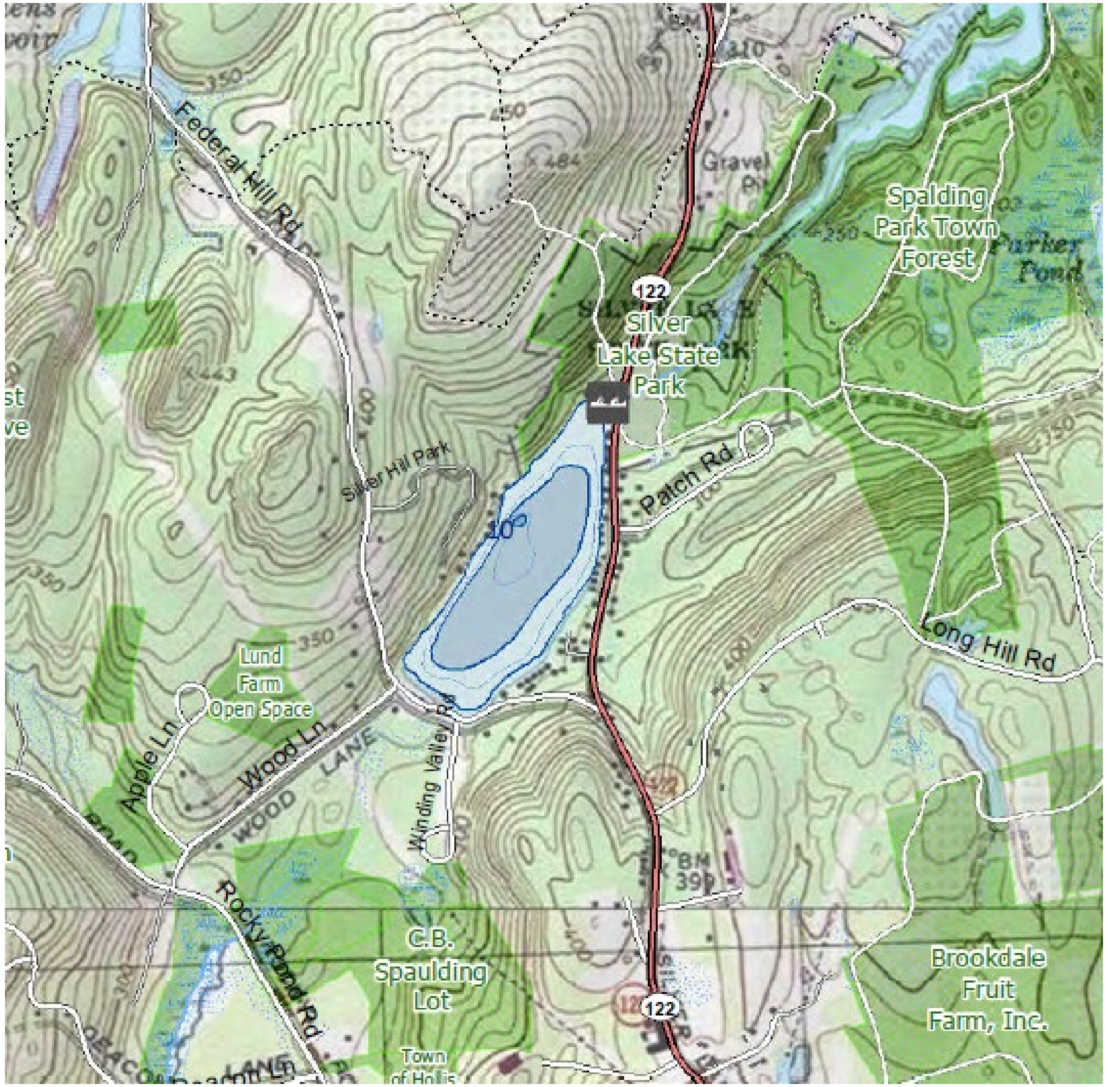
It is FREE, confidential, and only takes 15 minutes. And, after answering a few simple questions, you will receive a custom step-by-step plan with lake-friendly ideas for your property!

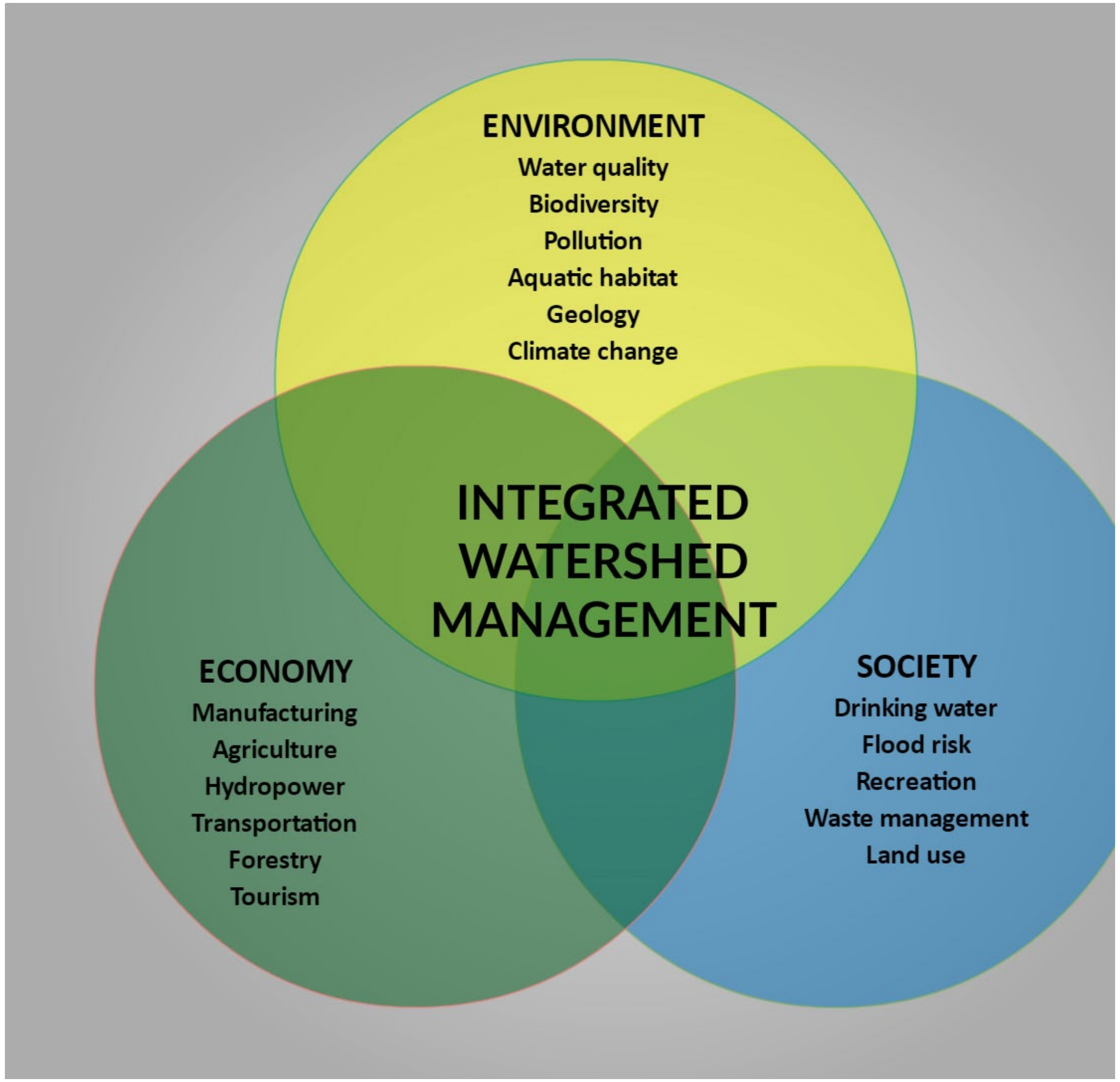
Are you ready to learn how to keep the lake you love clean and healthy for future generations?

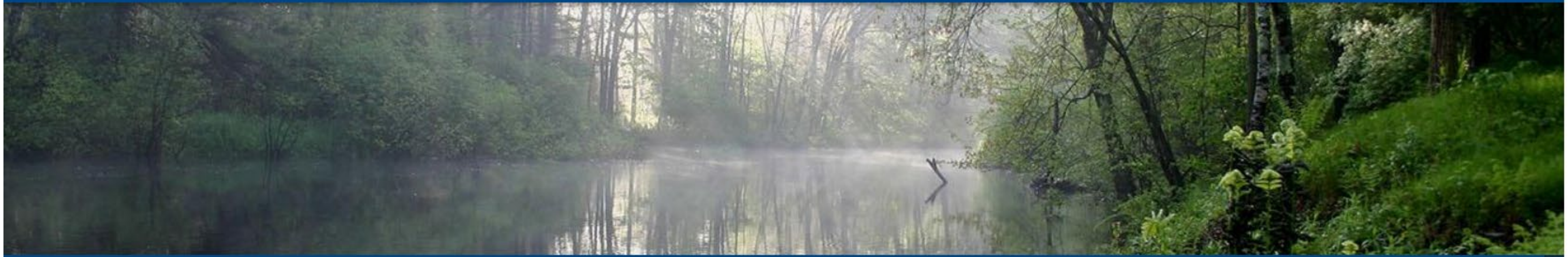
START

# What is a Watershed Management Plan?

a strategy and an achievable plan to reach water resource goals that provides assessment and management information for a geographically defined watershed.







https://www.des.nh.gov/water/stormwater

# Stormwater

***Managing stormwater to protect the state's water resources and balance a healthy environment with social and economic growth.***

Stormwater is water from rain or melting snow that does not soak into the ground. All across New Hampshire, communities, businesses and property owners are experiencing the challenge of managing stormwater to protect the state's water resources and to balance the need for a healthy environment with the need for social and economic growth.

Unlike pollution from industry or sewage treatment facilities (i.e. point source pollution, which is caused by a discrete number of sources that are easily identified), stormwater pollution is caused by the daily activities of people everywhere. Most of the water quality problems in lakes and rivers are the result, in some part, of stormwater runoff. Because of this, the responsibility of managing stormwater falls on everyone.

## Related Content

- Clean Water SRF
- Section 401 Water Quality Certification
- State Revolving Fund
- NPDES Permits and Compliance
- Watershed Assistance Grants
- Salt Reduction

# Watershed Assistance

***Working with partners and stakeholders to protect and restore surface water in New Hampshire.***

The NHDES Watershed Assistance Section works with local organizations, statewide nonprofits, municipalities, regional planning commissions, other programs within NHDES, EPA New England, and other state agencies to improve water quality in New Hampshire at the watershed level by implementing the New Hampshire Nonpoint Source Management Program Plan.

At the heart of this plan is the protection and/or restoration of surface waters in New Hampshire enabled by far-reaching collaboration with a diverse portfolio of watershed management stakeholders throughout the state.

**Resources for Watershed Assistance Grants and Loans ›**


**Salt Reduction Program and Green SnowPro Certification ›**

# Lakes Management is Dependent on…

Cooperation Among Governing Agencies and Organizations

Technical Assistance

Policies and Rules

Stakeholder and Public Interest

Funding and Support

# 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).**

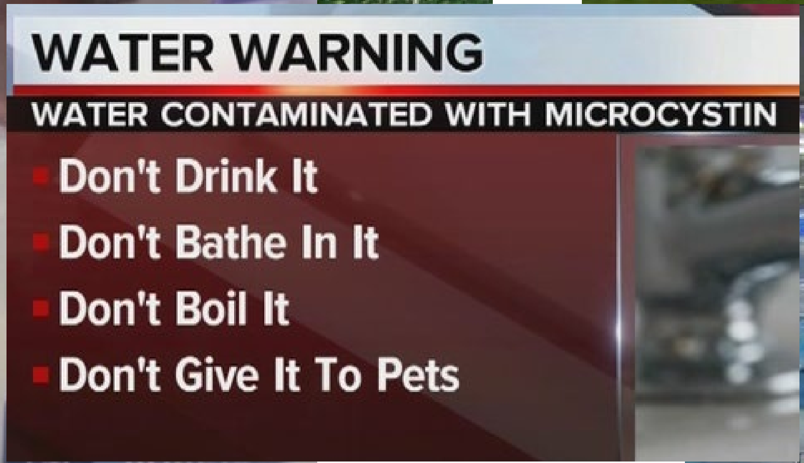
| Provisional guideline values for selected cyanotoxins and exposure scenarios. | Exposure | Value (µg/L or ppb) |
|---|---|---|
| Microcystin-LR | Drinking-water, lifetime | 1 |
| Microcystin-LR | Drinking-water, short term | 12 |
| Microcystin-LR | Recreational | 24 |
| Cylindrospermopsin | Drinking-water, 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
abc 2
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)

# Health effects vary from skin irritations to death…

More biomass, more toxic?

**Hepatotoxic**

**Genotoxic**

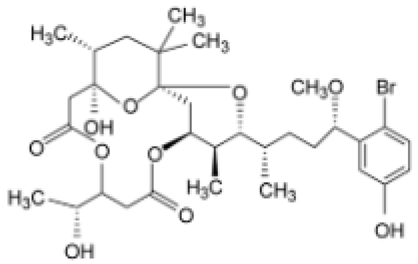
**Neurotoxic**

| 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). |

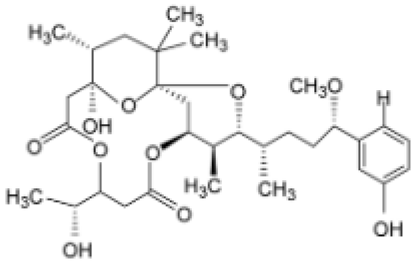
*this is not a complete list of the secondary metabolites and/or toxins produced by cyanobacteria.

Very narrow view of cyanotoxins…

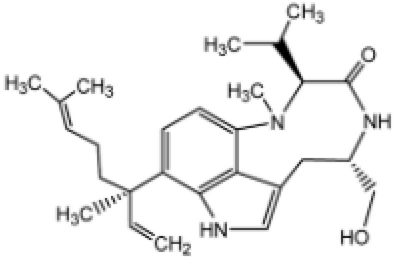
# Cyanobacteria Toxins



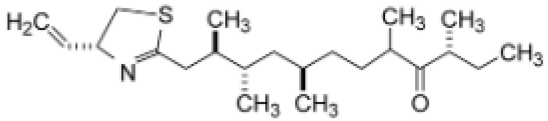
Aplysiatoxin



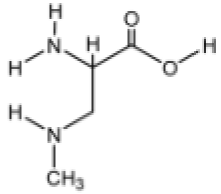
Debromoaplysiatoxin



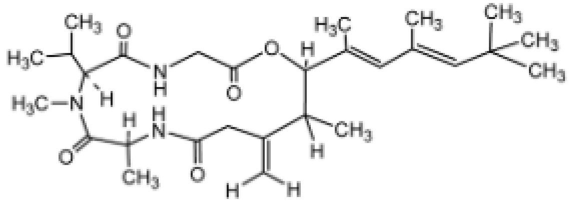
Lyngbyatoxin-a



Kalkitoxin



ʟ-β-N-methylamino-ʟ-alanine



Antillatoxin A

## HEPATO-TOXINS

**Microcystins**

(protein phosphatase blockers)

- Most cyanobacteria species
- Most widespread
- Over 100 analogs (hence plural)

**Cylindrospermopsin**

- liver and kidneys; tropical/subtropical (now in NH)

**Nodularins**

- *Nodularia*: brackish water species
- Close analog of microcystins

## NEURO-TOXINS

**Anatoxins**

- *Anabaena/Dolichospermum*

**Neosaxitoxins** (saxitoxin=marine red tide)

- *Aphanizomenon*

**BMAA** (beta-methylamino-L-alanine)

- Produced by most cyanobacteria groups
- possible link to neurological disorders (ALS, Alzheimer's)

# How toxic are microcystins?

| Method of administration | Toxicity | Species | Value |
|---|---|---|---|
| Intraperitoneal | LD50 | Rat | 0.05 mg/kg |
| Intraperitoneal | LD50 | Mouse | 0.03 mg/kg |
| Intravenous | LD50 | Mouse | 0.06 mg/kg |

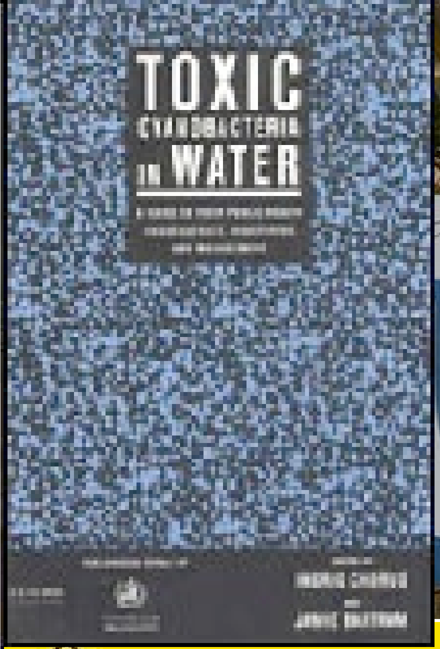
$LD_{50}$= Lethal Dose for 50% of test population

Hook-nosed seasnake (*Enhydrina schistosa*)
Highly venomous snakes (Indo-Pacific)
Mouse LD50 (mg/kg) : 0.02

**Which has the highest $LD_{50}$?**
**Which has the lowest $LD_{50}$?**

| Toxicant | $LD_{50}$ (mg/kg) |
|---|---|
| Ethyl alcohol | 10,000 |
| Salt (sodium chloride) | 4,000 |
| Iron (Ferrous sulfate) | 1,500 |
| Morphine | 900 |
| Mothballs (paradichlorobenzene) | 500 |
| Aspirin | 250 |
| DDT | 250 |
| Cyanide | 10 |
| Nicotine | 1 |
| Black Widow Spider venom | 0.55 |
| Rattle Snake venom | 0.24 |
| Tetrodotoxin (from fish) | 0.01 |
| Dioxin (TCDD) | 0.001 |
| Botulinum Toxin | 0.00001 |

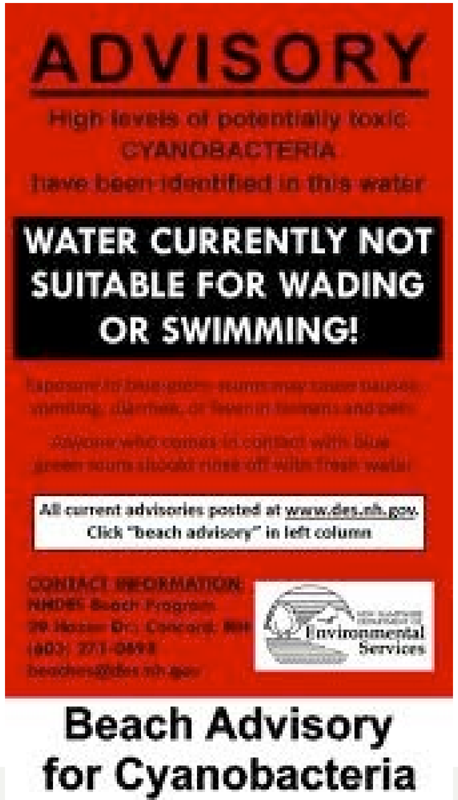

WARNING
August 25, 2009
This area may be hazardous to people and animals. The Douglas County Sheriff's Office is recommending that people stay out of this area while they investigate a potential hazardous substance that may be causing harm to animals.


TOXIC
CYANOBACTERIA
IN WATER


Warning!
kia tupato!
If you see toxic algae
Don't touch it
Don't let your dog scavenge in or near the river
What to look out for
HAWKE'S BAY


CAUTION
TOXIC ALGAE MAY BE PRESENT
Lake may be unsafe for people and pets
Until further notice:
• Do not swim or water ski in areas of scum.
No nade o practique el esquí acuático en áreas con espuma o verdín.
• Do not drink lake water.
No tome el agua del lago.
• Keep pets and livestock away.
Mantenga alejados las mascotas y el ganado.
• Clean fish well and discard guts.
Limpie bien el pescado y deseche las tripas.
• Avoid areas of scum when boating.
Evite las áreas con espuma o verdín cuando ande en lancha.
Call your doctor or veterinarian if you or your animals have sudden or unexplained sickness or signs of poisoning.


CAUTION
POSTED ______________: Based on counts of the cyanobacteria (blue-green algae), MDPH thresholds for recreational waters have been exceeded.
• Water which looks like the pictures above may contain algae capable of producing toxins that can be dangerous to humans and pets.
• People and pets should avoid contact in areas of algae concentration
• Do not swallow water and rinse off after contact
For further information call:
MA Department of Public Health at 617-624-5757


ADVISORY
High levels of potentially toxic CYANOBACTERIA have been identified in this water
WATER CURRENTLY NOT SUITABLE FOR WADING OR SWIMMING!
All current advisories posted at www.des.nh.gov.
Click "beach advisory" in left column
CONTACT INFORMATION:
Environmental Services
Beach Advisory for Cyanobacteria


Lake Erie algae bloom, August 2011

Tom Archer, Michigan Sea Grant

# Acute toxicity

http://www.dogsnaturallymagazine.com/blue-green-algae-risks-to-dogs/

**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/

https://www.bbc.com/news/world-africa-54234396

# Botswana: Mystery elephant deaths caused by cyanobacteria

September 2020

Toxins made by microscopic algae in water caused the previously unexplained deaths of hundreds of elephants in Botswana, wildlife officials say.

Botswana is home to a third of Africa's declining elephant population.

The alarm was raised when elephant carcasses were spotted in the country's Okavango Delta between May and June.

Officials say a total of 330 elephants are now known to have died from ingesting cyanobacteria. Poaching has been ruled out as a cause of death.

# 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.**

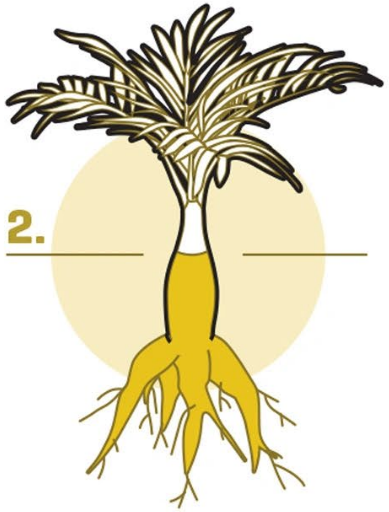
1.

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.

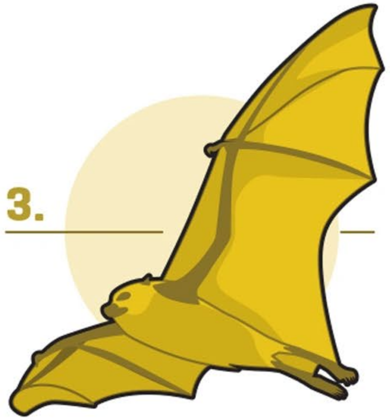


On Guam, algae accumulate in shallow pools. BMAA from the algae leaches into **cycad trees** via their roots and accumulates in their seeds.

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**.

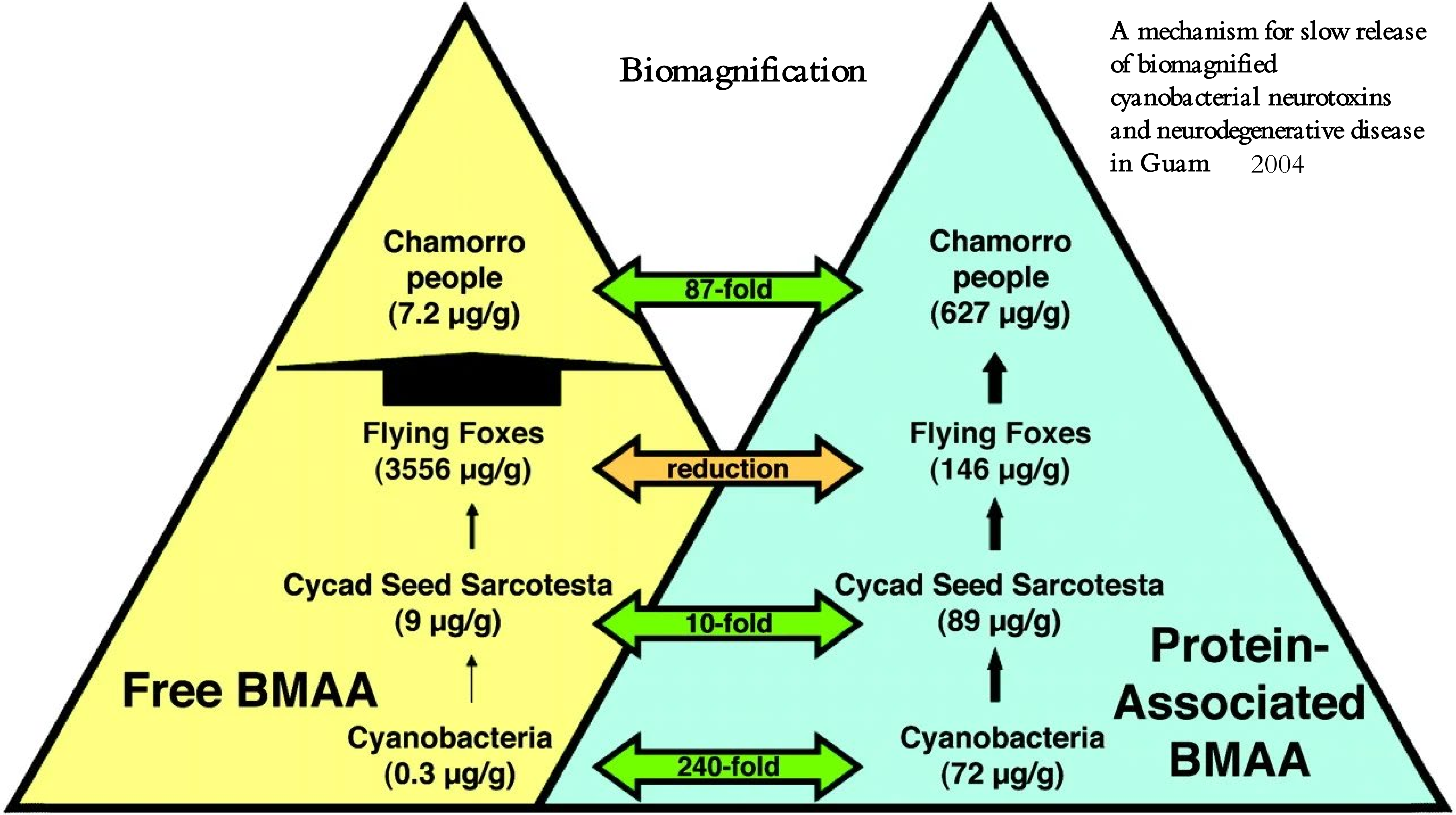
5.

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






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

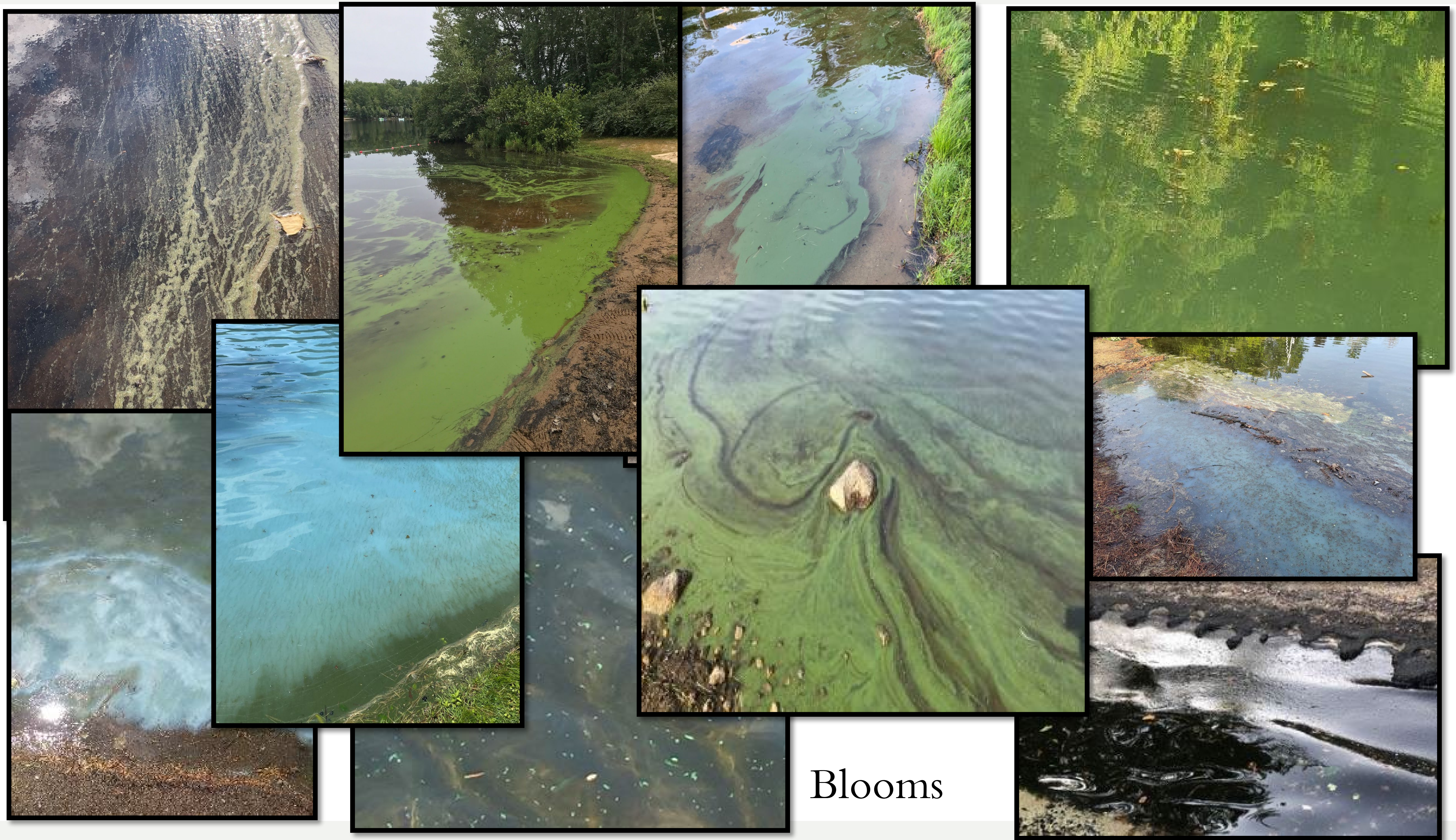
- Bioaccumulation of cyanotoxins to higher trophic organisms…

?

Bioaccumulation through food…?

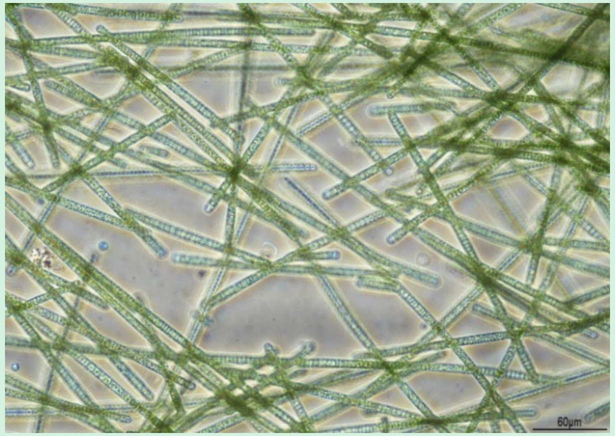
# Every Lake is Unique

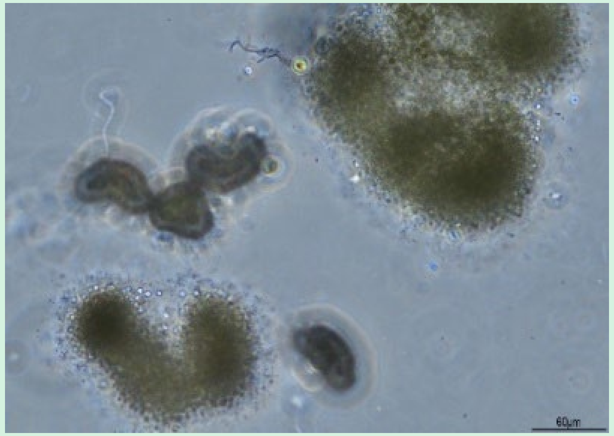
You cannot immediately tell if a lake bloom is toxic … it will also rapidly change over time

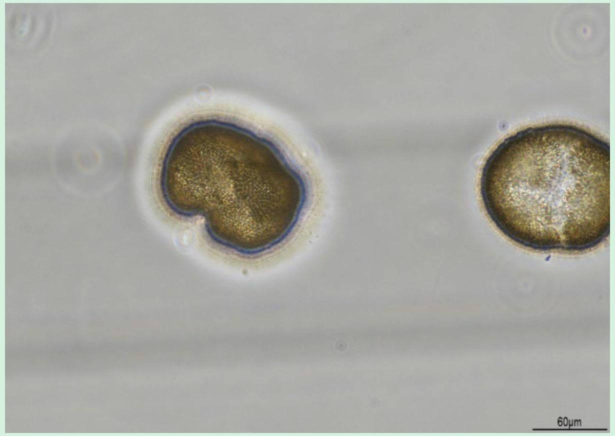


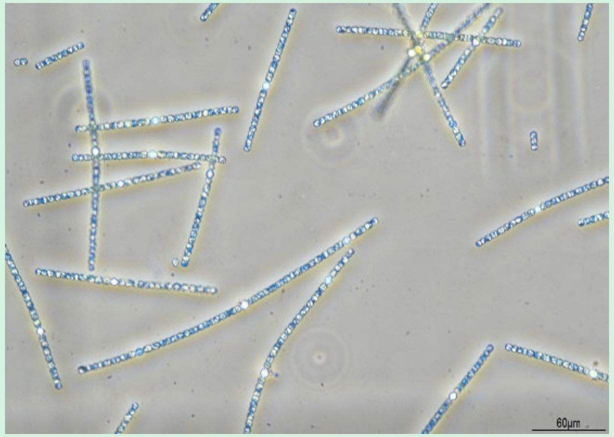
Blooms

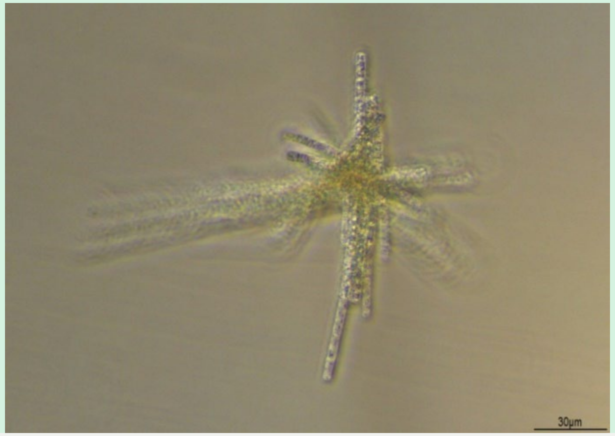
NHDES

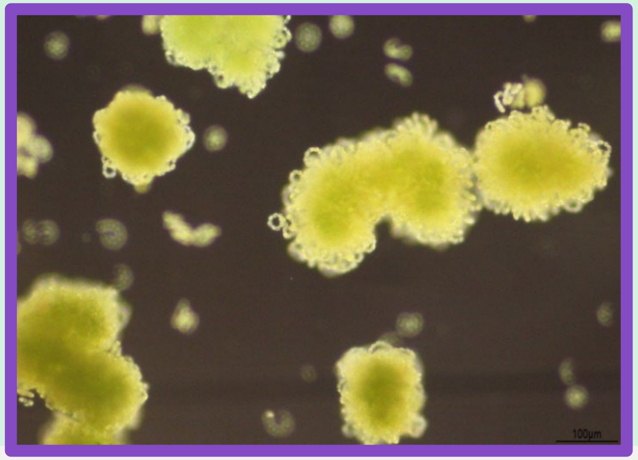


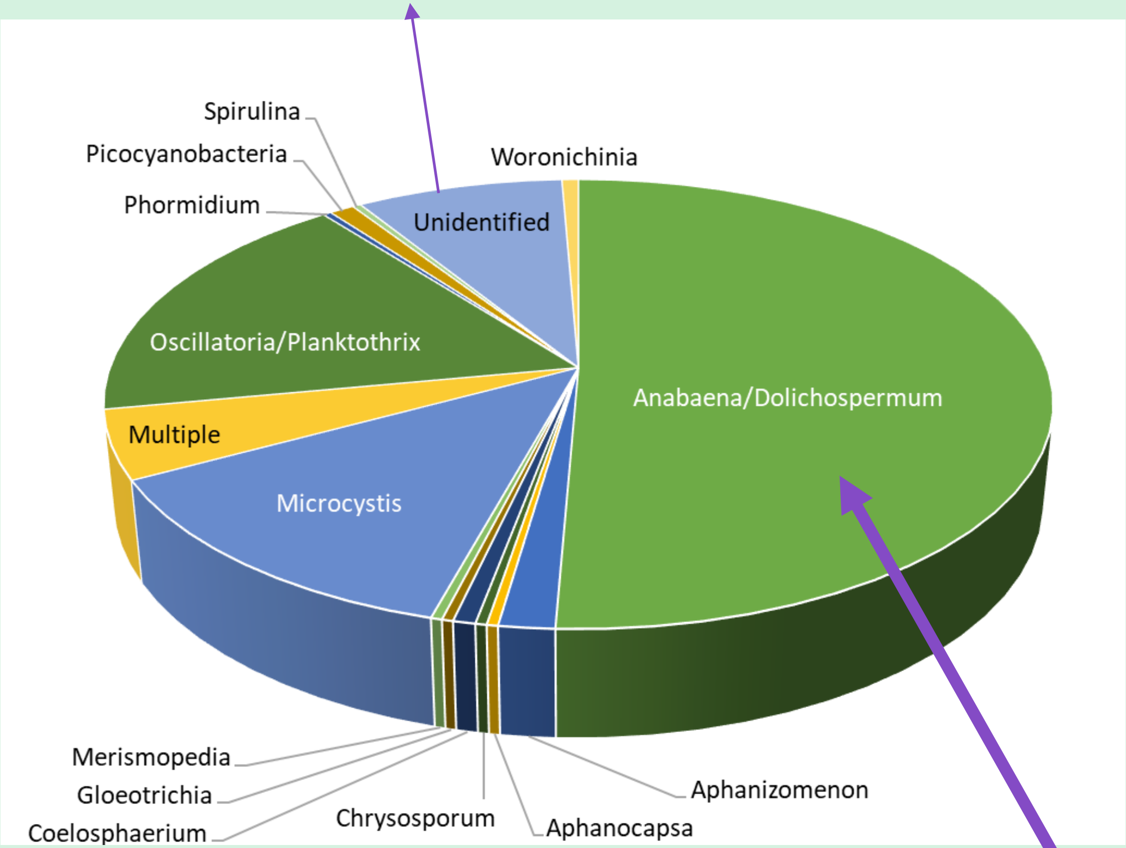


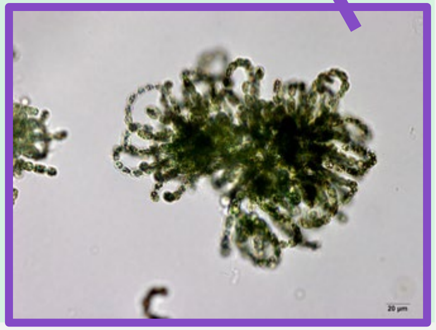










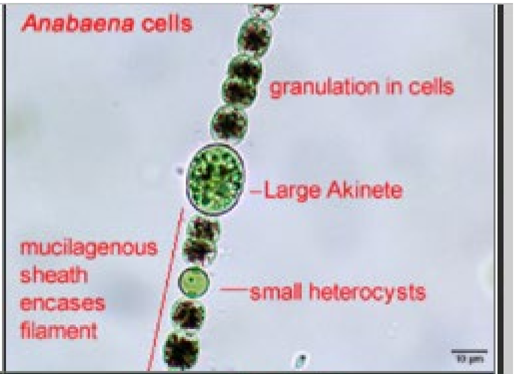
*Dolichospermum lemmermannii*

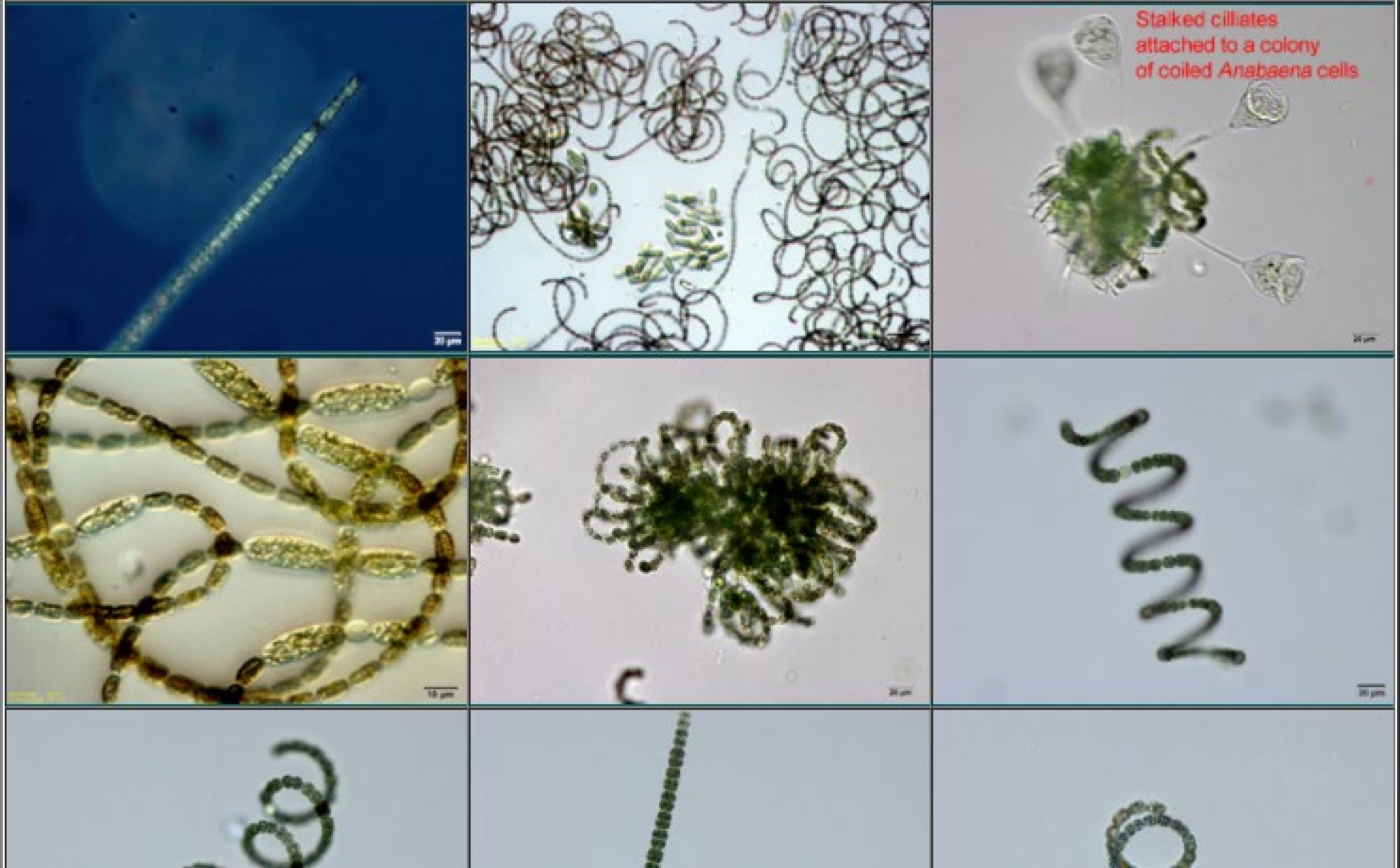
*Anabaena (unh.edu)*

# *Dolichospermum/Anabaena*

## General Description

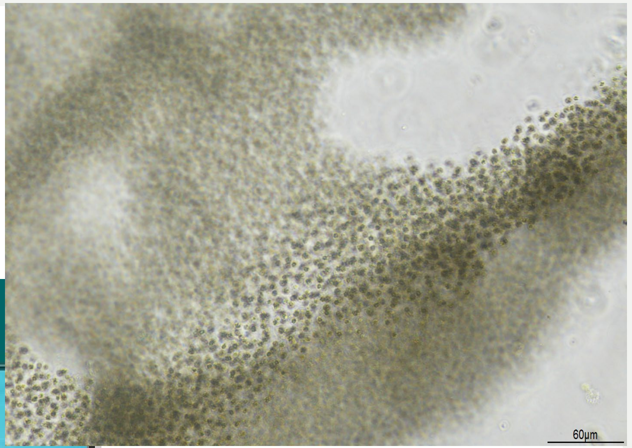
- *Anabaena* cells are usually arranged in filaments or chains and can be straight, spiralled, coiled or spring-like and often dscribed as "beaded"
- Filaments also have specialized cells called heterocysts and akinetes, used for fixing nitrogen and regenerating cells for future colonies
- A mucilagenous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





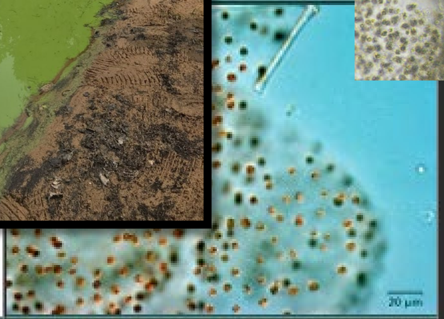
# *Microcystis* (unh.edu)

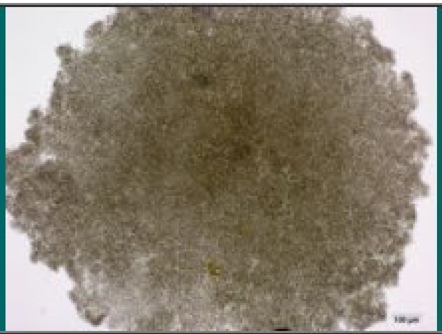


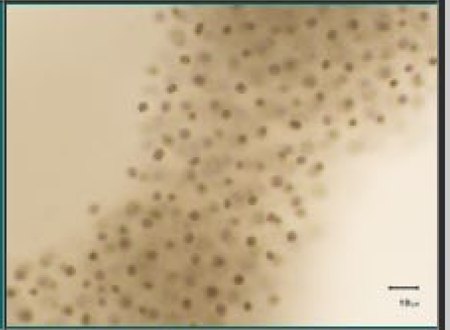

## *Microcystis*

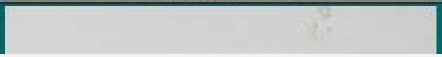
### General Description

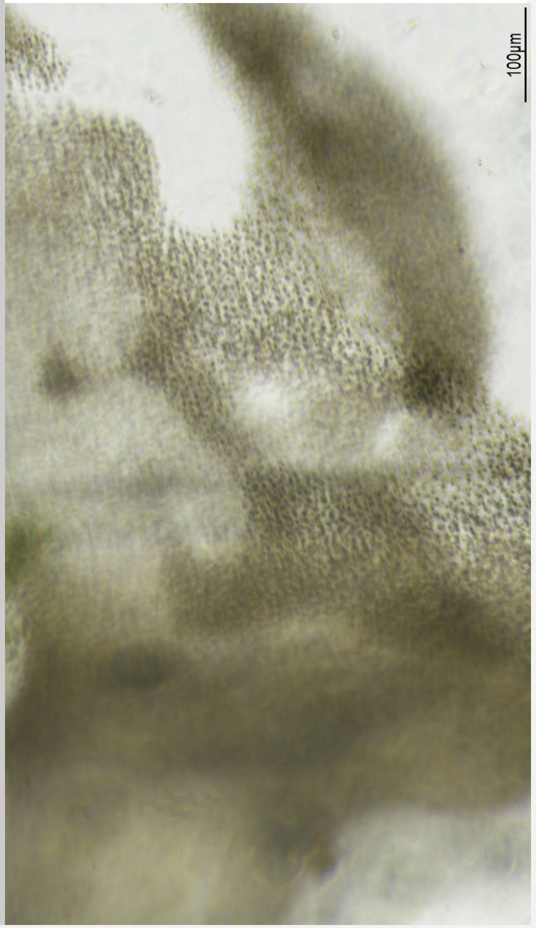
- *Microcystis* is one of the most common and diverse of the cyanobacteria, known for its production of hepatoxic, microcystins
- Cells are granular and sometimes released from the colony and mucilagenous sheath
- Cell-size and colony-shape vary by species, typically cells are about 4-5 micrometers



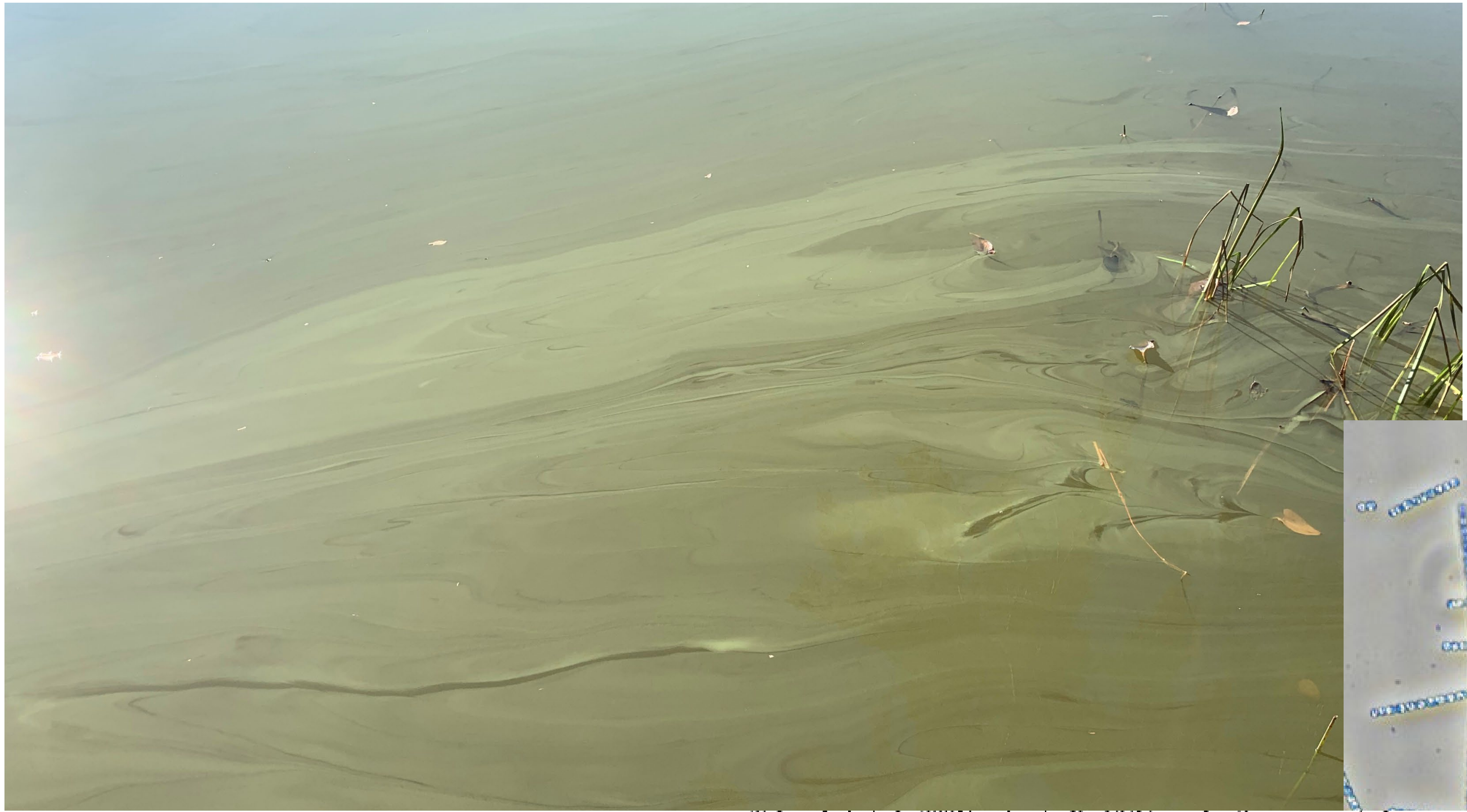





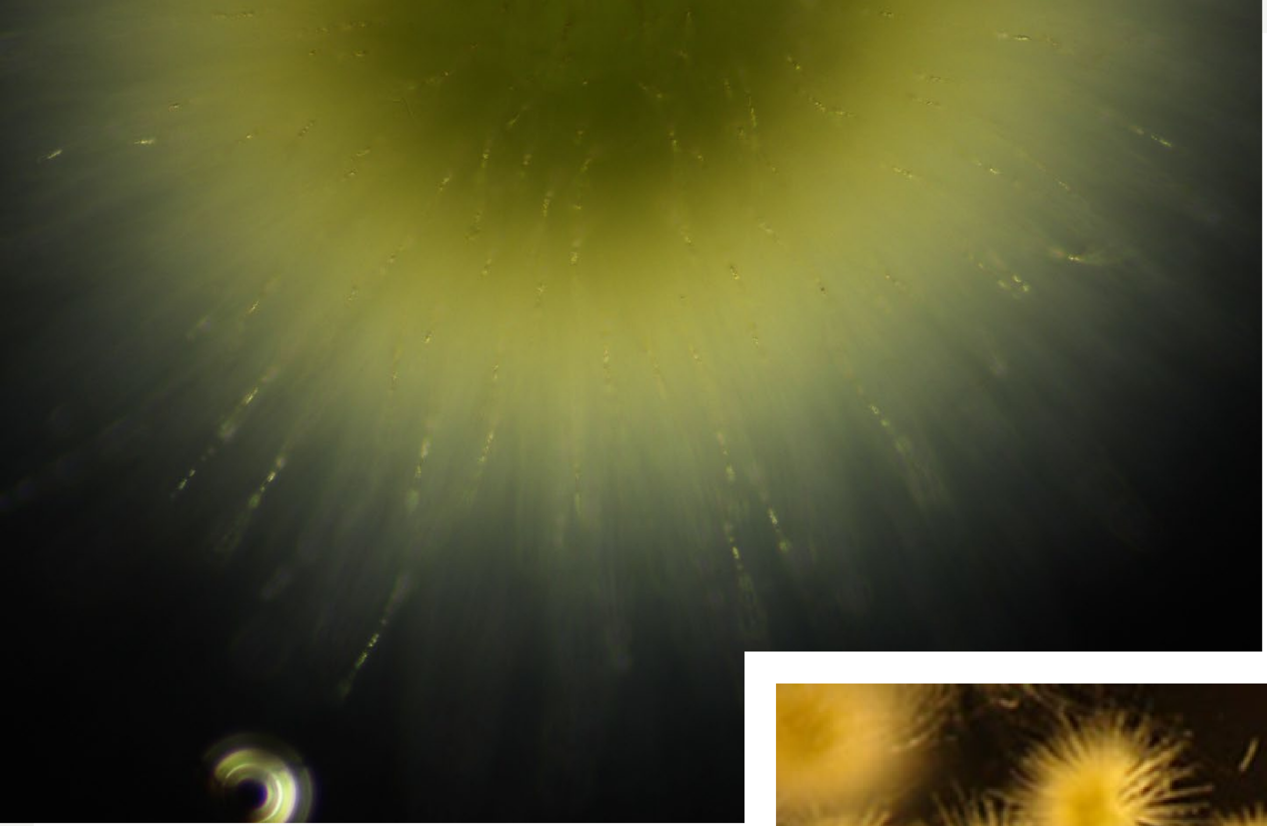


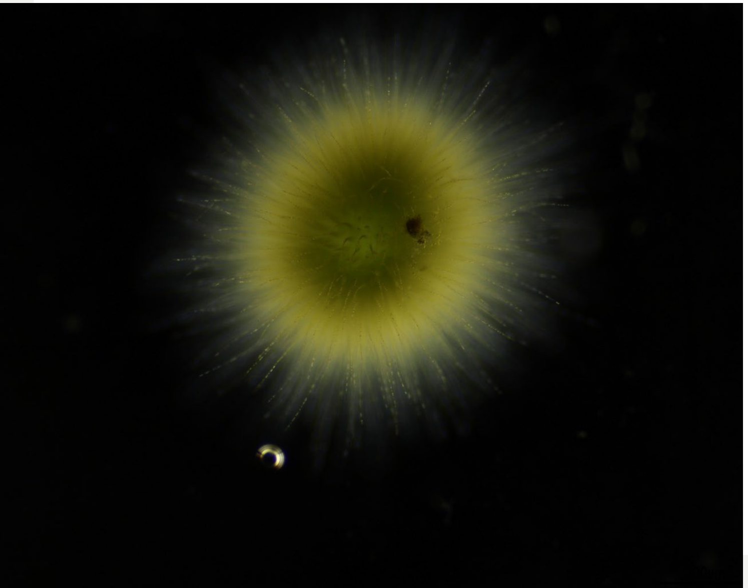
# *Chrysosporum (formerly Anabaena and Aphanizomenon)*




| | | |
|---|---|---|
| *Chrysosporum bergii* (previously *Anabaena bergii*) | Cylindrospermopsin<br>Microcystins? | (Schembri et al., 2001)—Australia CYN production supported with molecular work & LC-MS/MS<br>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<br>(Akcaalan et al., 2014)—Turkey; blooms confirmed LC-MS/MS<br>(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





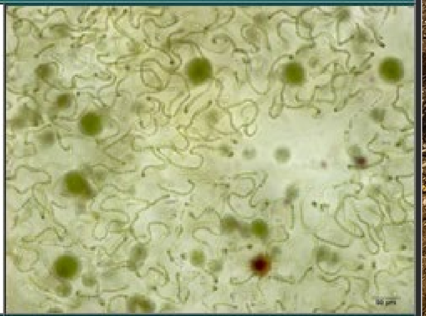

Gloeotrichia

# Nostoc

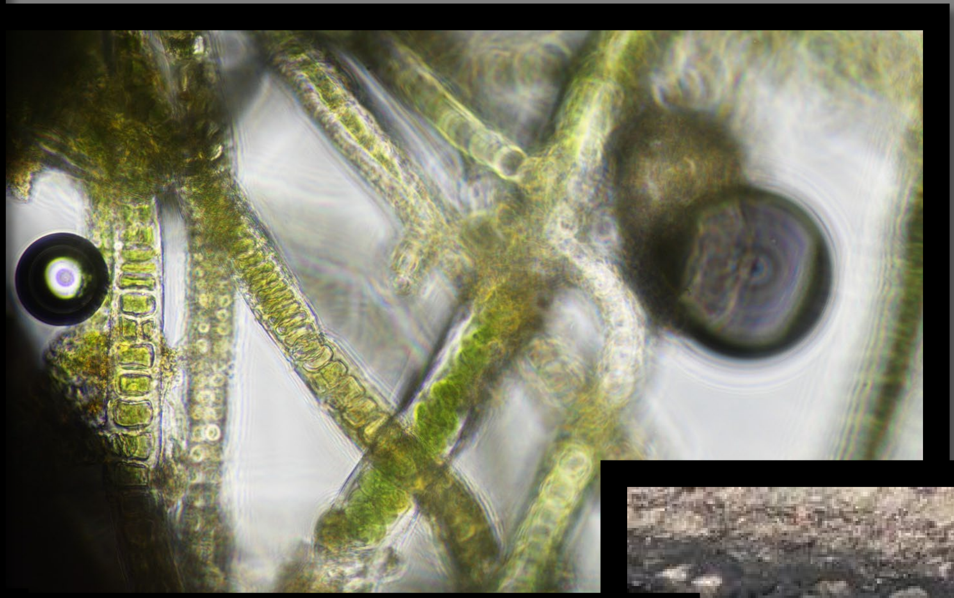
## *Nostoc*

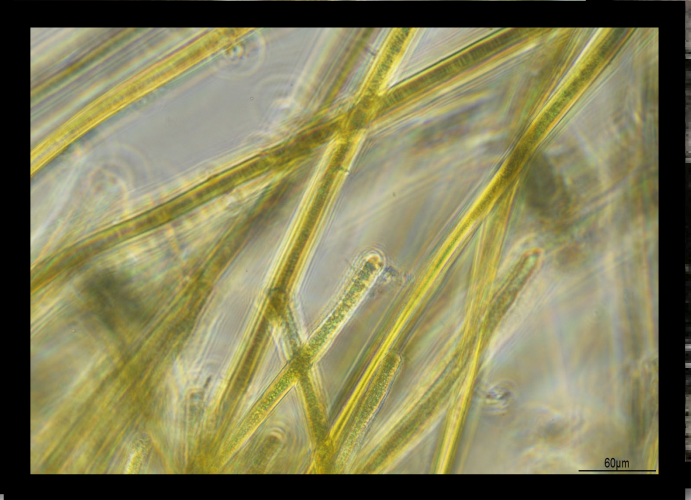
### General Description

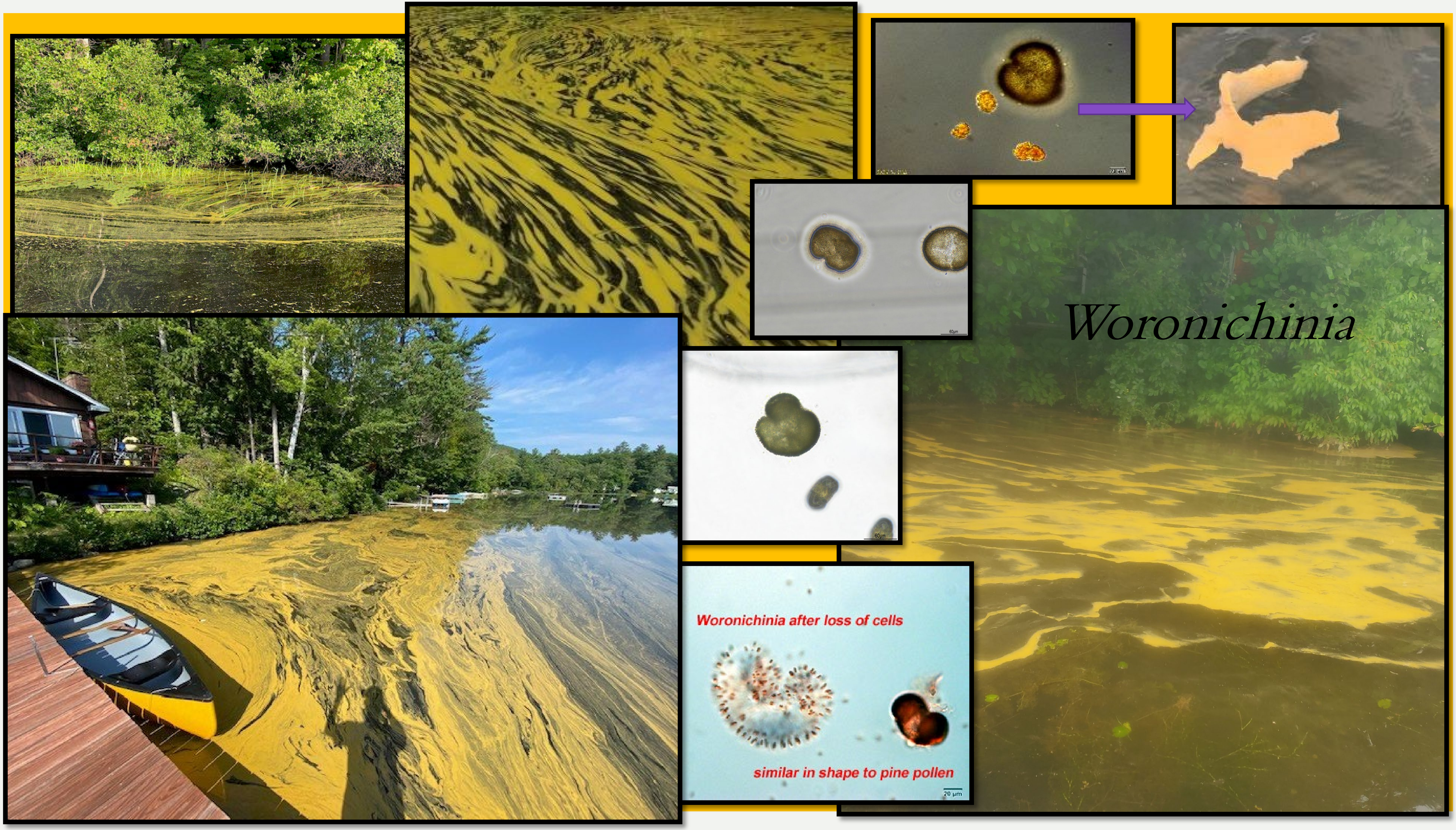
- *Nostoc* cells are similarily arranged as *Anabaena*, but often found within a thick-mucilagenous ball referred to as "the sea tomato"
- The filaments appear kinked and have heterocysts
- Cells are shorter in length than in width




# 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)

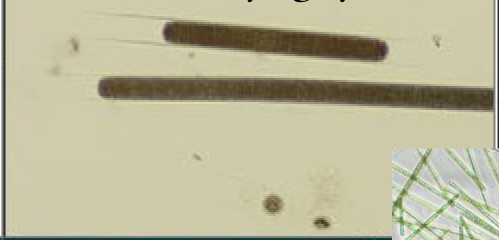
Oscillatoriales

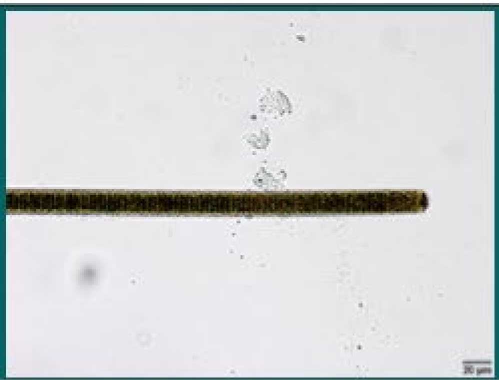
## *Oscillatoria / Planktothrix*

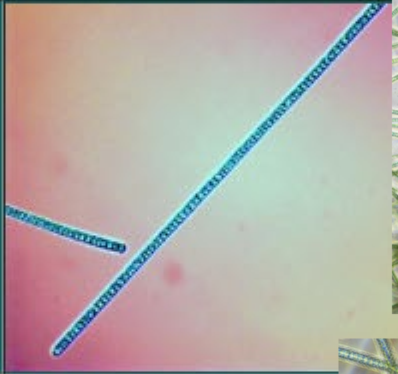
### General Description

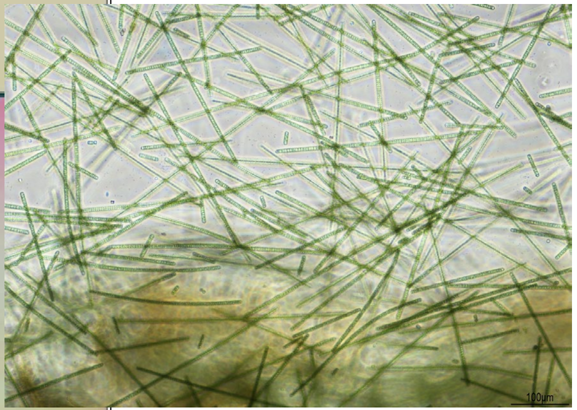
- *Oscillatoria* and *Planktothrix* are arranged as long, cylindrical filaments
- These filaments do not contain heterocysts. Sometimes, short vegetative segments of these can be seen, these are referred to as horomogones or trichomes
- Cells are rigidly divided and m ay or may not have a gelatinous 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)

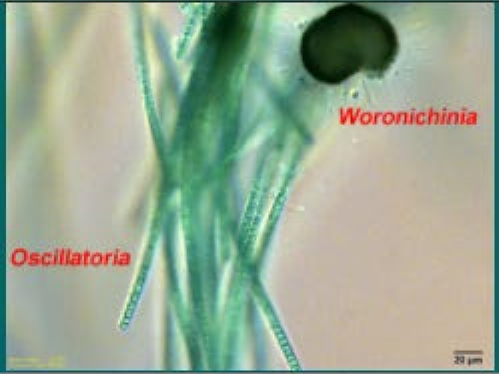
Lyngbya

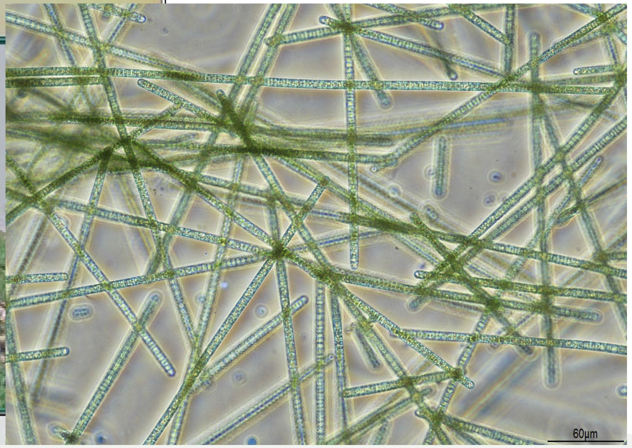


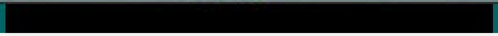











For fishing regulation information, please refer to the NHFGD Freshwater Fishing Digest.

Contact: NHFGD Region 4 (Southwest NH), Keene
E-mail: reg4@wildlife.nh.gov Phone: 603-352-9669

# SILVER LAKE
## Hollis

FISHERY: ACRES: 39
TROPHIC LEVEL: OLIGO
AVG. DEPTH: 9 MAX. DEPTH: 24
SPECIES:

ADDITIONAL INFO: speed limit

ACCESS: Cartop

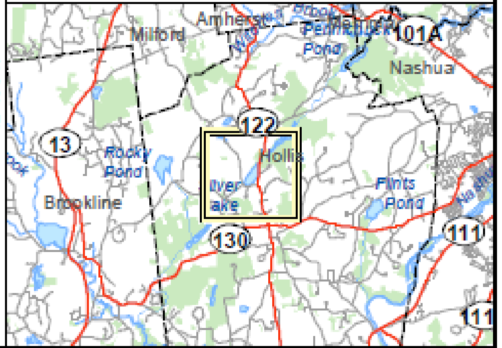
Please contact NH Dept of Safety, Marine Patrol for info. on water body/boat/motor restrictions: (603) 293-2037 www.nh.gov/safety


Public Water Access site
- Canoe/cartop
- Shorebank
- Ramp
- Bathymetric contour (feet)

Bathymetry provided by the NH Department of Environmental Services, Watershed Mgt Bureau

- Town boundary
- Primary Route
- Road or Street
- Trail or other
- Stream or Shoreline
- Surface Water
- Wetland
- Conservation or Public land
- Restricted Access Conservation

Cleared
Forest
Contour
Building
Source: USGS



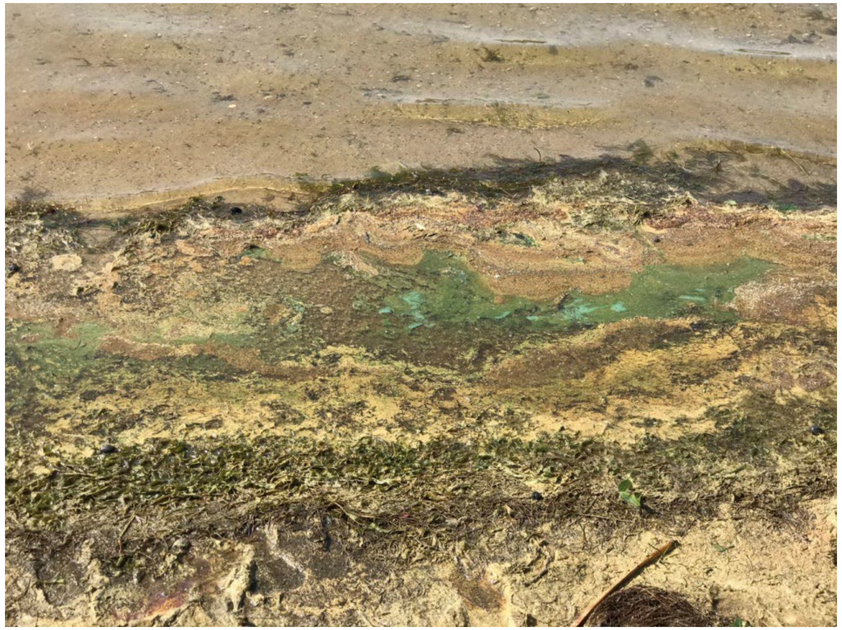

N
0 1,000 2,000 Feet
0 0.2 0.4 Miles

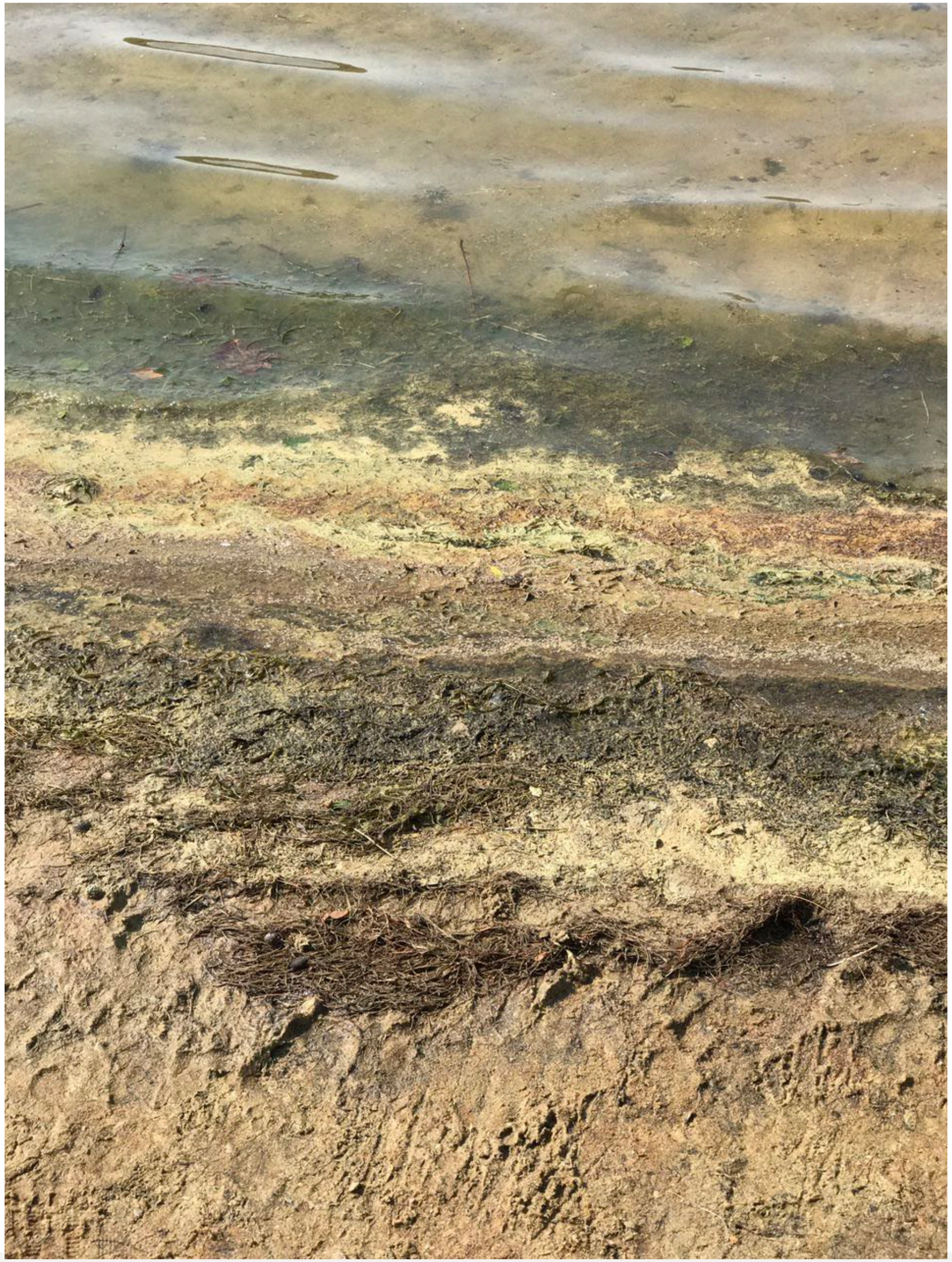
Base map data from NH GRANIT at Earth Systems Research Center (UNH) and Open Street Map contributors. UNH, NH Fish & Game and the cooperating agencies make no claim as to the validity or reliability or to any implied uses of these data. NOT INTENDED FOR BOAT NAVIGATION.

Directions: Rt 122

- Persistent Blooms
- Fish deaths
- Musty, bloom-decay odors

Silver Lake, Hollis : June 13, 2017





Silver Lake, Hollis : June 18, 2017

- Some bloom accumulation and decay along shoreline

Silver Lake, Hollis : June 20, 2017
ADVISORY
High levels of potentially toxic CYANOBACTERIA have been identified in this water
WATER CURRENTLY NOT SUITABLE FOR WADING OR SWIMMING!
Exposure to blue-green scums may cause nausea, vomiting, diarrhea, or fever in humans and pets
Anyone who comes in contact with blue-green scum should rinse off with fresh water
All current advisories posted at www.des.nh.gov Click "beach advisory" in left column
CONTACT INFORMATION:
NHDES Beach Program
29 Hazen Dr.; Concord, NH
(603) 271-0698
beaches@des.nh.gov
Environmental Services

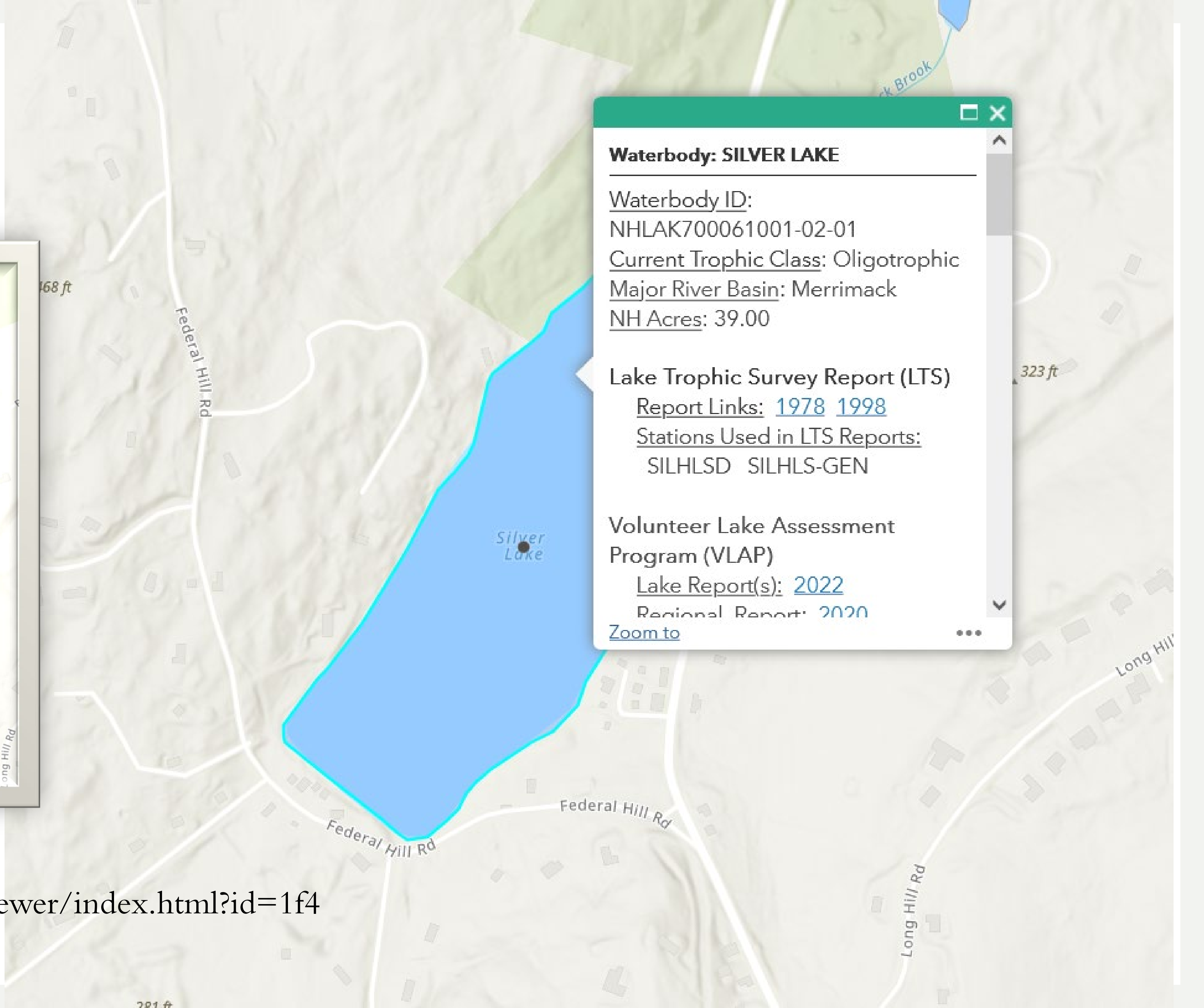
Silver Lake, Hollis : June 23, 2017


Silver Lake, Hollis : June 28, 2017

Silver Lake, Hollis : July 15, 2017


August 11, 2017

Silver Lake, Hollis : July 15, 2017


https://www.arcgis.com/apps/webappviewer/index.html?id=1f45dc20877b4b959239b8a4a60ef540

TROPHIC CLASSIFICATION OF N.H. LAKES AND PONDS

NAME Silver Lake TOWN Hollis CO Hillsborough RIVER BASIN Merrimack

# I. POTENTIAL FOR NUTRIENT ENRICHMENT

## A. NATURAL PHYSICAL FACTORS

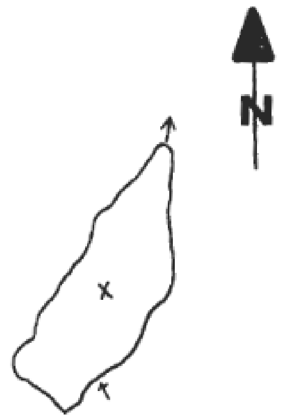
1. Area (ha) 13.65
2. Max. depth (m) 7.5
3. Mean depth (m) 2.7
4. Elevation (ft) 274
5. Shore length (m) 1,800
6. Volume ($m^3$) 370,500
7. Volume/shore length 205
8. % Stratification 0
9. Watershed area (ha) 124.1
10. $\frac{\text{Watershed area}}{\text{Volume}}$ 4
11. Bottom slope 1.8
12. Shore config. 1.37
13. Flushing rate 1.7
14. Water renewal time 0.6
15. Drainage density -
16. % Watershed ponded 0
17. Phos. retent. coeff. R 0.68

3. Summer Data:

Date August 29, 1978 Weather Sunny; light breeze 28°C

| | Mid-ep | Mid-therm | Mid-hyp |
|---|---|---|---|
| Depth (m) | 3.0 | 7.0 | 7.5 |
| pH (units) | 6.5 | 6.7 | 6.2 |
| Alkalinity | 7.0 | 9.0 | 11.0 |
| $PO_4$-P | 0.008 | 0.003 | 0.002 |
| Total-P | 0.016 | 0.015 | 0.021 |
| $NO_2+NO_3$-N | <0.05 | <0.05 | <0.05 |
| Kjeld-N | 0.35 | 0.37 | 0.36 |
| Total Residue | 68 | 68 | 72 |
| Color (units) | 15 | 15 | 20 |
| Turb. (NTU) | 5.1 | 4.8 | 5.5 |
| Spec. Conduct. (µMhos/cm) | 153 | 154 | 156 |
| Tot. Org. Carbon | <5 | - | - |
| Chloride | 28 | 32 | 27 |
| Mg | 1.11 | - | - |
| Ca | 5.2 | - | - |
| Na | 15.0 | - | - |
| K | 1.4 | - | - |
| [Mg+Ca] / [Na+K] | 0.38 | - | - |
| Tot-N/Tot-P | - | - | - |
| $NO_2+NO_3$-N/$PO_4$-P | - | - | - |

Station Location




Bottom: Depth 7.5 m D.O. 0.8 % Sat. 9

Epilimnetic alkalinity decrease

$PO_4$-P ratio: epi/hyp 4.0

Total-P ratio: epi/hyp 0.76

Secchi disk transparency (M) 3.5

% organic Matter sediment -

Vascular Plants Sparse

Dom. Vasc. Plants: 1.

2.

3.

Ash-Free Dry Weight

Chlorophyll a 8.10 ($mg/m^3$)

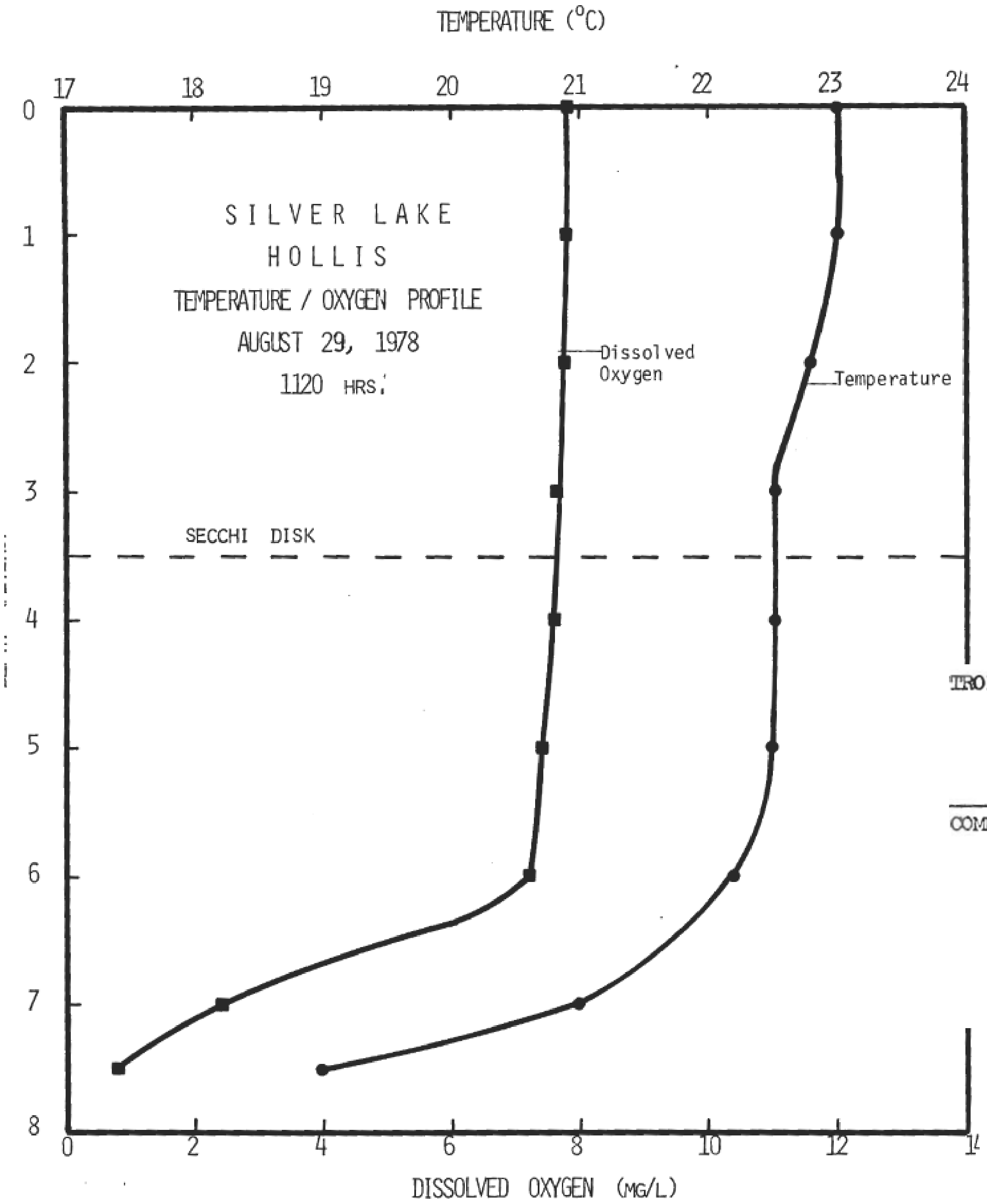
Tot. Zoopl. Cnts. 122 (cells/liter)

Dom. Phytopl. 1. Chrysosphaerella - 60%

2. Anacystis - 40%

Dom. Zoopl. 1. Diaptomus - 35%

2. Cyclops and Nauplius - 20%




TROPHIC CLASSIFICATION 1978 :

| | D.O. | S.D. | Vasc. Plants | Chl a | Total | Class. |
|---|---|---|---|---|---|---|
| Classification Points: | - | 2 | 0 | 1 | 3 | Oligo. |

COMMENTS:

1. Water somewhat murky; clumps of Anacystis visible in water.
2. Cottages close together and right on shore along northeast shoreline.
3. No summer temperature stratification was present when sampled.

DEPARTMENT of ENVIRONMENTAL SERVICES
Water Division - Watershed Management Bureau

LAKE TROPHIC DATA

MORPHOMETRIC:

| | | | |
|---|---|---|---|
| Lake: | SILVER LAKE | Lake Area (ha): | 13.64 |
| Town: | HOLLIS | Maximum depth (m): | 7.3 |
| County: | Hillsborough | Mean depth (m): | 2.8 |
| River Basin: | Merrimack | Volume ($m^3$): | 387000 |
| Latitude: | 42°45'25" N | Relative depth: | 1.8 |
| Longitude: | 71°35'54" W | Shore configuration: | 1.37 |
| Elevation (ft): | 274 | Areal water load (m/yr): | 9.14 |
| Shore length (m): | 1800 | Flushing rate ($yr^{-1}$): | 3.20 |
| Watershed area (ha): | 248.6 | P retention coeff.: | 0.56 |
| % watershed ponded: | 0.0 | Lake type: | natural w/dam |

| BIOLOGICAL: | | 2 February 1999 | 10 September 1998 |
|---|---|---|---|
| DOM. PHYTOPLANKTON (% TOTAL) | #1 | NO WINTER PLANKTON | COELOSPHAERIUM 95% |
| | #2 | ANALYZED | |
| | #3 | | |
| PHYTOPLANKTON ABUNDANCE (units/mL) | | | |
| CHLOROPHYLL-A (µg/L) | | | 3.27 |
| DOM. ZOOPLANKTON (% TOTAL) | #1 | | NAUPLIUS LARVA 37% |
| | #2 | | CYCLOPOID COPEPOD 35% |
| | #3 | | |
| ROTIFERS/LITER | | | 20 |
| MICROCRUSTACEA/LITER | | | 166 |
| ZOOPLANKTON ABUNDANCE (#/L) | | | 185 |
| VASCULAR PLANT ABUNDANCE | | | Sparse |
| SECCHI DISK TRANSPARENCY (m) | | | 3.4 |
| BOTTOM DISSOLVED OXYGEN (mg/L) | | 13.6 | 6.2 |
| BACTERIA (E. coli, #/100 ml) | #1 | | |
| | #2 | | |
| | #3 | | |

SUMMER THERMAL STRATIFICATION:

not stratified

Depth of thermocline (m): None
Hypolimnion volume ($m^3$) : None
Anoxic volume ($m^3$) : None

CHEMICAL:

Lake: SILVER LAKE
Town: HOLLIS

| | 2 February 1999 | | 10 September 1998 | | |
|---|---|---|---|---|---|
| DEPTH (m) | 1.0 | 2.0 | 1.0 | | 3.0 |
| pH (units) | 6.9 | 6.9 | 7.4 | | 7.3 |
| A.N.C. (Alkalinity) | 15.4 | 17.0 | 12.9 | | 12.8 |
| NITRATE NITROGEN | 0.10 | 0.08 | < 0.05 | | < 0.05 |
| TOTAL KJELDAHL NITROGEN | 0.40 | 0.40 | 0.40 | | 0.50 |
| TOTAL PHOSPHORUS | 0.008 | 0.010 | 0.007 | | 0.009 |
| CONDUCTIVITY (µmhos/cm) | 182.2 | 190.1 | 177.5 | | 177.1 |
| APPARENT COLOR (cpu) | 11 | 12 | | | |
| MAGNESIUM | | | 1.37 | | |
| CALCIUM | | | 6.8 | | |
| SODIUM | | | 24.5 | | |
| POTASSIUM | | | 1.28 | | |
| CHLORIDE | 43 | 46 | 43 | | 41 |
| SULFATE | 8 | 8 | 6 | | 6 |
| TN : TP | 63 | 48 | 57 | | 56 |
| CALCITE SATURATION INDEX | | | 2.0 | | |

All results in mg/L unless indicated otherwise

TROPHIC CLASSIFICATION: 1998

| D.O. | S.D. | PLANT | CHL | TOTAL | CLASS |
|---|---|---|---|---|---|
| ** | 2 | 0 | 0 | 2 | Oligo. |

COMMENTS:

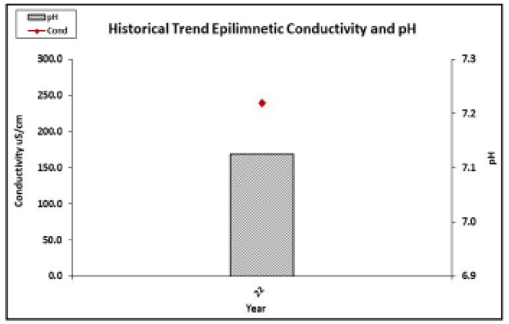
1. aka Long Pond.
2. Silver Lake was previously surveyed and classified in 1978 and was rated oligotrophic in both years. Despite the oligotrophic rating, Silver Lake has had episodes in the past of clumps of blue-green algae visible in the water column. A bluegreen alga (*Coelosphaerium*) was dominant in 1998 but did not form clumps or scums -- and the overall abundance was low.
3. Conductivity, sodium and chloride levels suggest some road salt runoff into the pond.
4. Heavily developed along the eastern shoreline and Silver Lake State Park is located adjacent to the outlet (northern end).

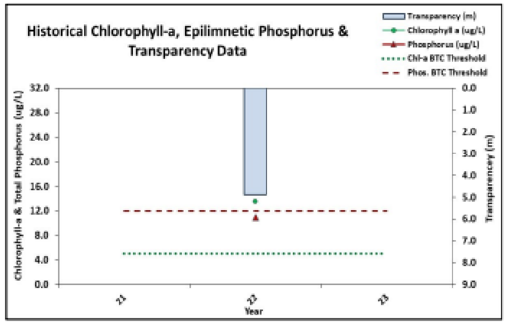
# Volunteer Lake Assessment Program Individual Lake Reports
## Silver Lake, Hollis
## 2022 Data Summary

**Recommended Actions:** Welcome to VLAP! We're excited to work with the lake association to build a baseline water quality data set that will allow us to assess current lake conditions and build an historical data record to assess water quality trends. Hypolimnetic phosphorus levels were elevated and indicate an internal load from bottom sediments under anoxic conditions. This phosphorus is readily available for uptake by algae and cyanobacteria and often results in cyanobacteria blooms, as occurred throughout the summer. Keep an eye on the lake for any future signs of cyanobacteria and alert NHDES' Harmful Algal Bloom Program if observed. In addition to an internal load of phosphorus, stormwater runoff is the leading cause of nutrient (phosphorus) pollution to our lakes. Educate watershed residents on ways to reduce stormwater runoff from their properties. NHDES' NH Homeowner's Guide to Stormwater Management is a great resource. Other sources of nutrient pollution to lakes are septic systems, waterfowl and irresponsible boating practices. NHDES has several fact sheets to educate watershed residents on these issues and best practices to reduce nutrient pollution. We look forward to gathering more data on lake conditions in the future. Lake chloride levels indicate negative impacts from application of winter de-icing materials and also potentially home water softener systems. Green Mountain Conservation Group's Salt Responsibly initiative is a great resource for educational materials. Contact the VLAP Coordinator in the spring to schedule a biologist visit to refresh sampling skills.

### Historical Water Quality Trend Analysis

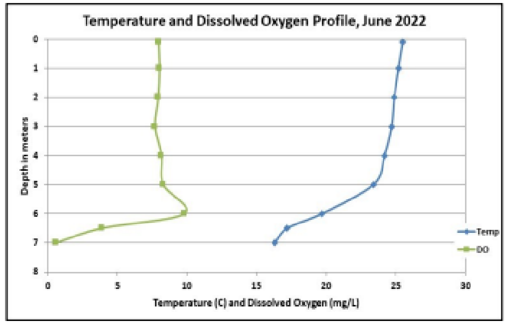
| Parameter | Trend | Parameter | Trend |
|---|---|---|---|
| Conductivity | Stable | Chlorophyll-a | Stable |
| pH (epilimnion) | Stable | Transparency | Stable |
| | | Phosphorus (epilimnion) | Stable |

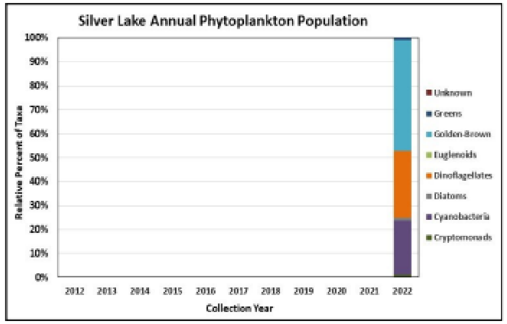



### Dissolved Oxygen and Phytoplankton

(Note: Information may not be collected annually)






2022-silver-hollis.pdf (state.nh.us)



Volunteer Lake Assessment Program Individual Lake Reports
Silver Lake, Hollis
2022 Data Summary

**Observations** *(Refer to Table 1 and Historical Deep Spot Data Graphics)*

- **Chlorophyll-a:** Chlorophyll level was greatly elevated in June due to a thick layer of Dinoflagellate algae, decreased significantly to a slightly elevated level in July, and decreased to a low level in August. Average chlorophyll level was greater than the state median and the threshold for mesotrophic lakes.
- **Conductivity/Chloride:** Epilimnetic (upper water layer) and Hypolimnetic (lower water layer) conductivity levels were elevated and much greater than the state median. Epilimnetic and Hypolimnetic chloride levels were also elevated and much greater than the state median, yet less than the state chronic chloride standard.
- **Color:** Apparent color measured in the epilimnion indicates the water was lightly tea colored, or light brown, from June through August.
- **Total Phosphorus:** Epilimnetic phosphorus level was within a low range in June, decreased slightly in July, and increased slightly in August. Average epilimnetic phosphorus level was approximately equal to the state median and was slightly less than the threshold for mesotrophic lakes. Hypolimnetic phosphorus level was elevated in June and increased to a greatly elevated level by August indicating release of phosphorus from bottom sediments under anoxic (low dissolved oxygen) conditions, a process called internal loading.
- **Transparency:** Transparency measured without the viewscope (NVS) was high (good) in June, remained stable in July, and decreased (worsened) slightly in August. Average NVS transparency was higher (better) than the state median. Viewscope (VS) transparency was higher (better) than NVS transparency and remained relatively stable from June through August.
- **Turbidity:** Epilimnetic turbidity level was stable and low from June through August. Hypolimnetic turbidity levels fluctuated within a slightly elevated to elevated range due to algal growth and organic compounds formed under anoxic conditions.
- **pH:** Epilimnetic and Hypolimnetic pH levels were within the desirable range 6.5-8.0 units.

| Station Name | Table 1. 2022 Average Water Quality Data for SILVER LAKE - HOLLIS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Alk. (mg/L) | Chlor-a (ug/L) | Chloride (mg/L) | Color (pcu) | Cond. (us/cm) | Total P (ug/L) | Trans. (m) | | Turb. (ntu) | pH |
| | | | | | | | NVS | VS | | |
| Epilimnion | 20.1 | 13.51 | 53 | 30 | 239.8 | 11 | 4.89 | 5.44 | 0.64 | 7.12 |
| Hypolimnion | | | 58 | | 231.2 | 71 | | | 5.68 | 6.56 |

**NH Median Values**

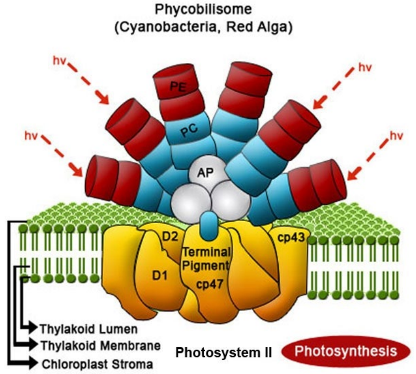
Median values generated from historic lake monitoring data.

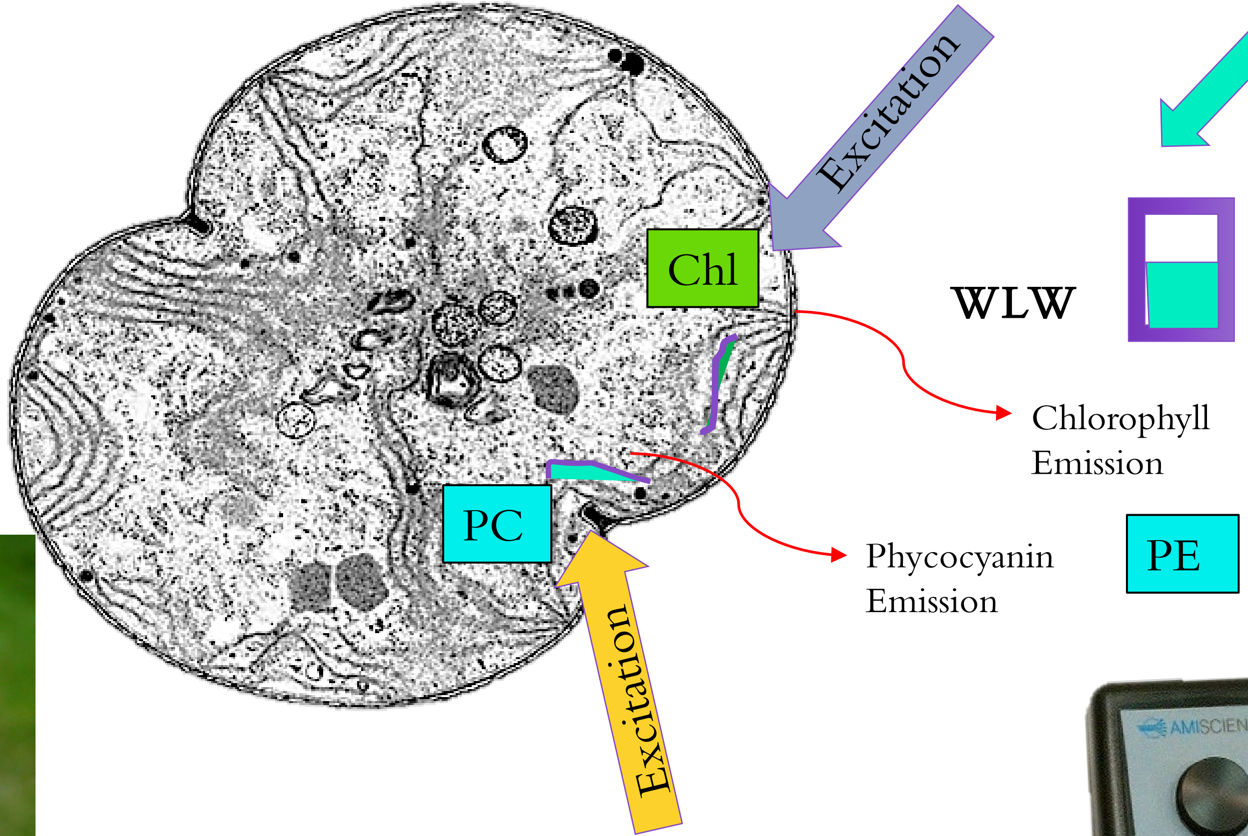
**Alkalinity:** 4.5 mg/L
**Chlorophyll-a:** 4.39 ug/L
**Conductivity:** 42.3 uS/cm
**Chloride:** 5 mg/L
**Total Phosphorus:** 11 ug/L
**Transparency:** 3.3 m
**pH:** 6.6

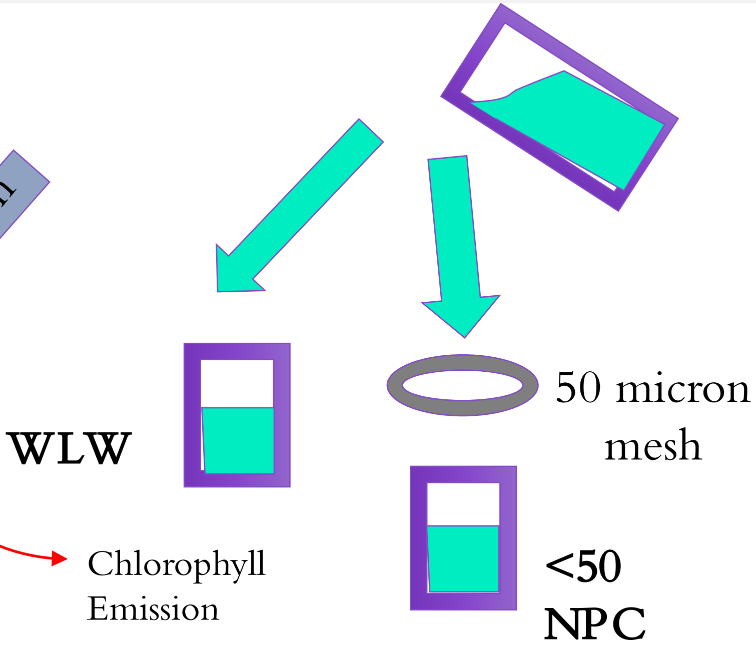
**NH Water Quality Standards**

Numeric criteria for specific parameters. Water quality violation if thresholds exceeded.

**Chloride:** > 230 mg/L (chronic) **Turbidity:** > 10 NTU above natural
**E. coli:** > 88 cts/100 mL (beach)
**E. coli:** > 406 cts/100 mL (surface waters)
**pH:** between 6.5-8.0 (unless naturally occurring)





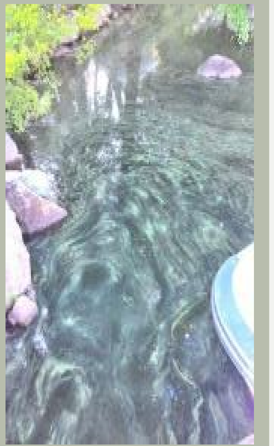
# Detection of Cyanobacteria by fluorescence


Hand-held fluorometers

# Cyanos.org


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

# Volunteer/Student Involvement

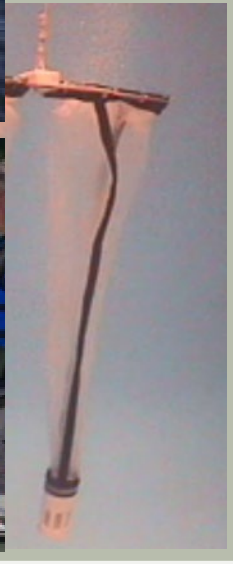


## bloomWatch

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

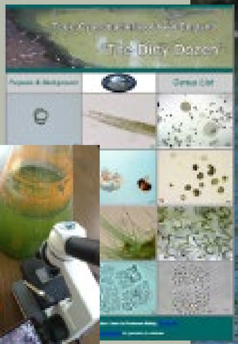
## cyanoMonitoring

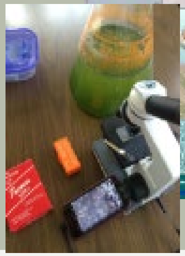
- Best if involved with established VM/CBM program
- Experienced volunteers
- Easy to train for sample collection
- Need an organization for processing/analysis



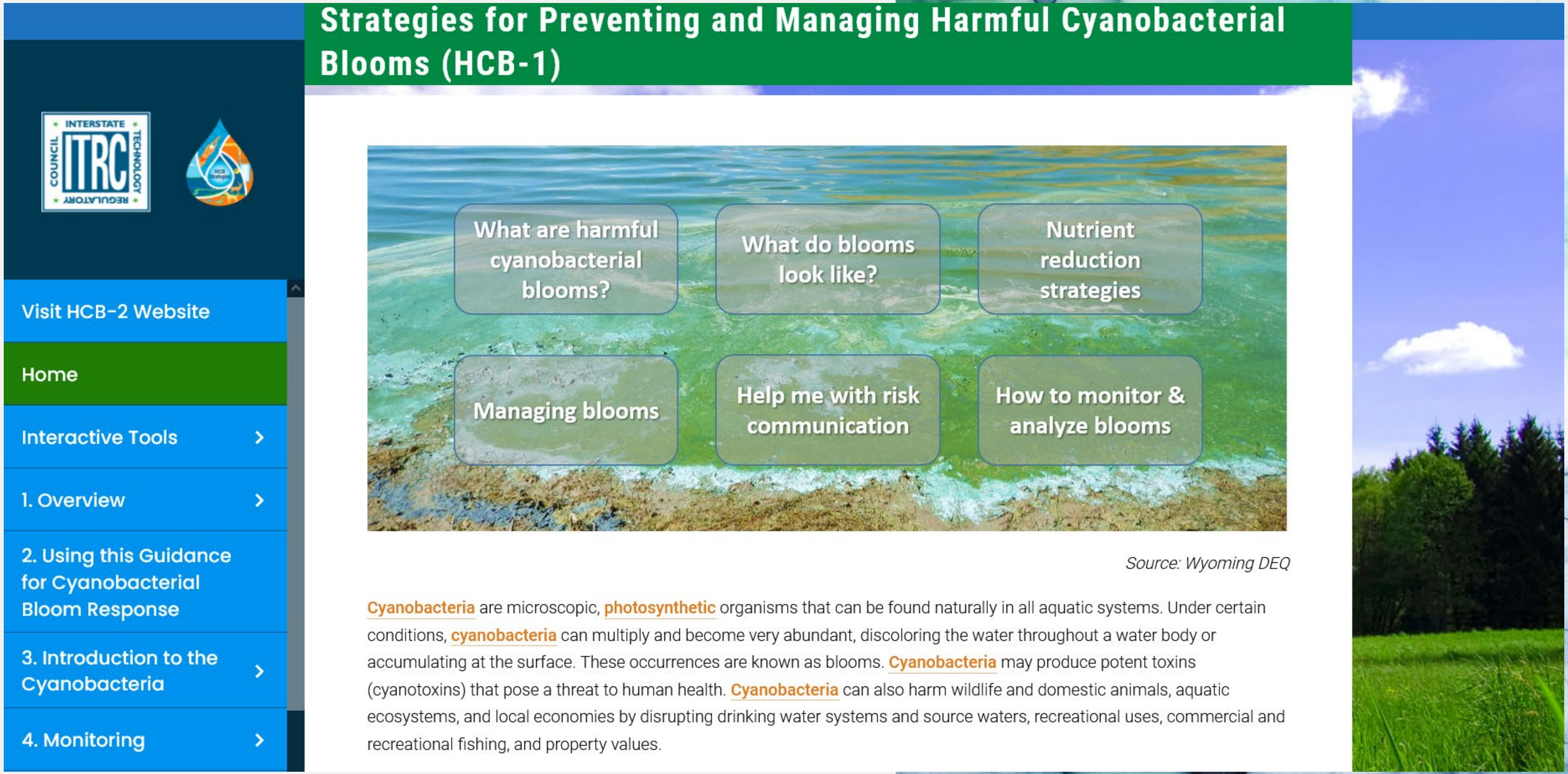
## cyanoScope

- 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

What are harmful cyanobacterial blooms?

What do blooms look like?

Nutrient reduction strategies

Managing blooms

Help me with risk communication

How to monitor & analyze blooms

*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/

https://www.des.nh.gov/about/boards-and-committees/cyanobacteria-plan-advisory-committee



NEW HAMPSHIRE DEPARTMENT OF Environmental Services

LIVE FREE OR DIE

# Cyanobacteria Plan Advisory Committee

***Preparing a statewide cyanobacteria strategy for New Hampshire.***

The Cyanobacteria Plan Advisory Committee was created in response to legislation in 2022 mandating NHDES to prepare a statewide cyanobacteria strategy by November 1, 2023.

HB 1066 calls for NHDES to "prepare a plan to prevent the increase of, and eventually control, cyanobacterial blooms in New Hampshire's lakes and other waters. Such plan shall be supported by scientific data and shall include measurable milestones. The commissioner shall determine the organizational structure, foci, personnel, and resources needed to execute the plan. The commissioner shall also coordinate with appropriate stakeholders as may be required to execute the plan. [...] The plan shall be submitted in writing to the governor, the speaker of the house of representatives, and the president of the senate no later than November 1, 2023."

List of committee members.

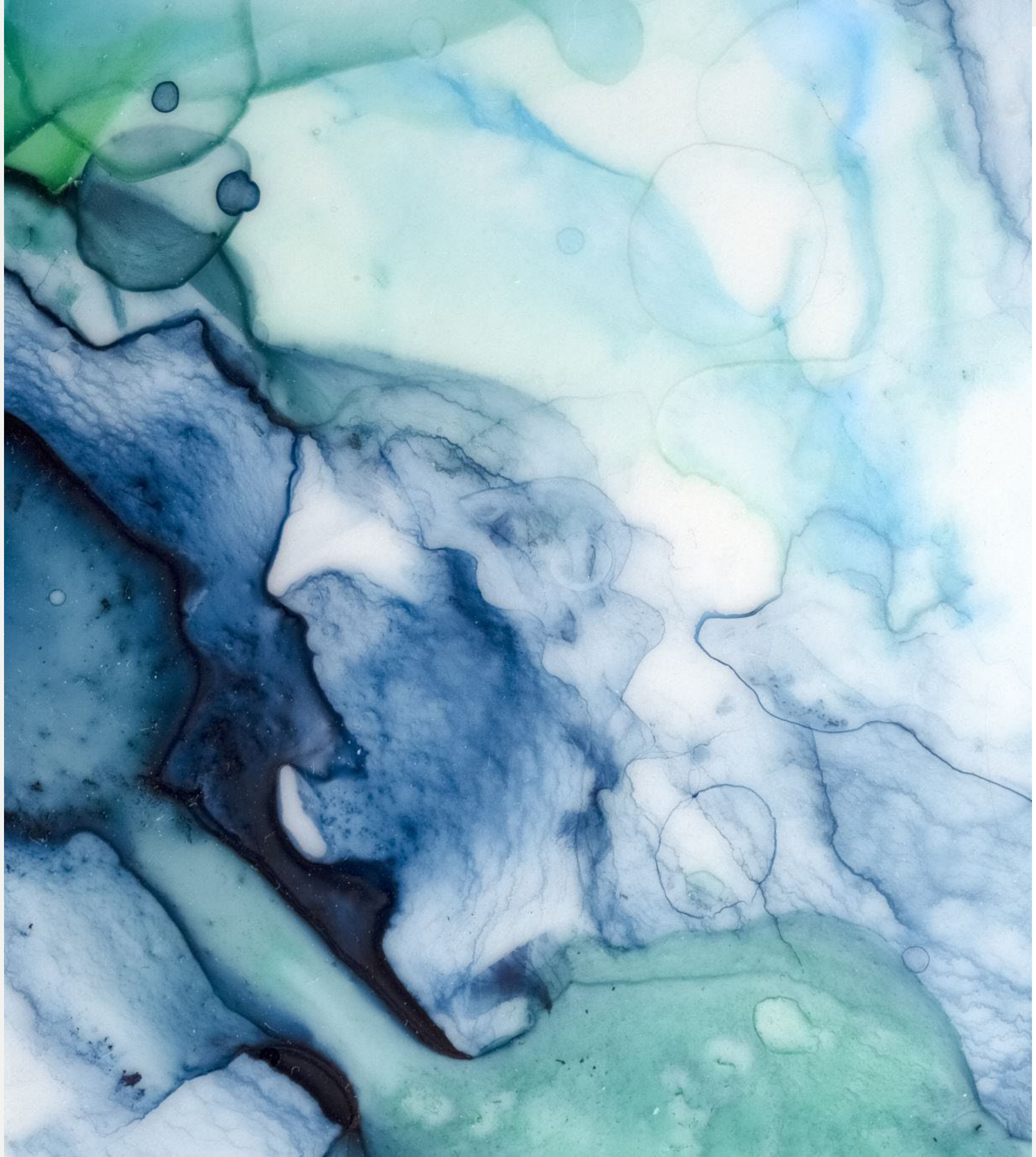
For more information about the committee, contact Dave Neils at david.e.neils@des.nh.gov or (603) 271-8865.

## Cyanobacteria Resources

This page is for meeting announcements and resources for the Cyanobacteria Advisory Committee. Members of the public looking for information about cyanobacteria should go to the links below. If you see a suspected cyanobacteria bloom, report it to NHDES (link below) and keep kids and pets away from the water. Remember, when in doubt, stay out.

Report a Bloom

NHDES Harmful Algal Bloom Program



Thank you!

Amanda Murby McQuaid
University of New Hampshire
Cooperative Extension/Dept. of Biological Sciences
Amanda.McQuaid@unh.edu