

Cyanobacteria Blooms of New Hampshire

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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

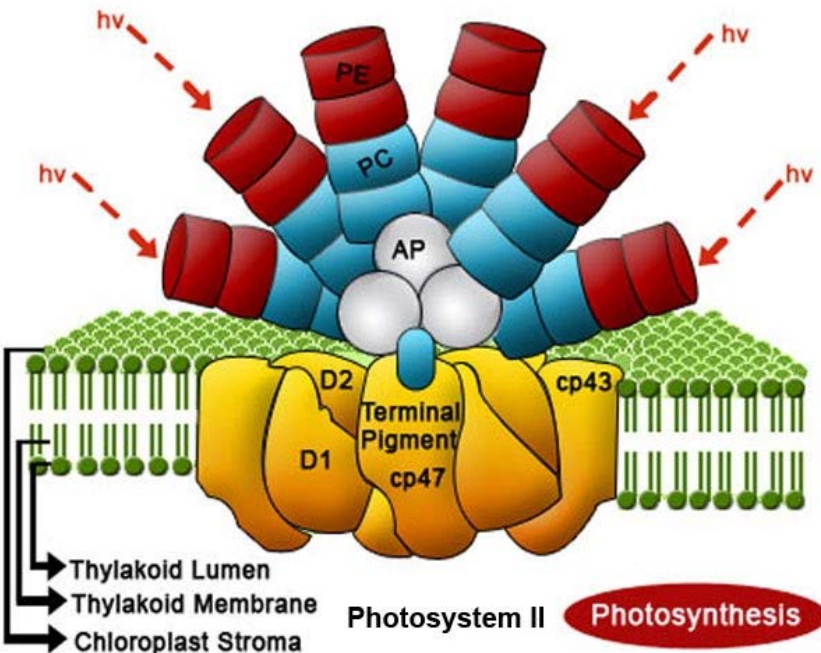


Antennal Pigments (of the Phycobilisome) branch off of the Chloroplast

Phycobillins: Phycocyanin (PC), Phycoerythrin (PE), and Allophycocyanin (AP)

Zeaxanthin (studied with marine picocyanobacteria also)

Phycobilisome
(Cyanobacteria, Red Alga)



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, similar to anatoxin-a (S)
Saxitoxins	Neurotoxic, blocking voltage gate of sodium ion channels. More common to marine organisms.
Cylindrospermopsins	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. (Individuals can have a genetic precursor).

This is not a complete list of the cyanotoxins

Cyanotoxins- case studies and evidence for toxicity in various compartments....

- 1998 Haemodialysis, Brazil incident (*Aphanocapsa*)
- 2018 Florida incident (synergistic toxicity of marine and fresh HABs)
- Aquatic food web bioaccumulations
 - Fish - biomagnifications and accumulation to tissues
 - Shellfish - especially in digestive systems (hepatopancreas)
- Crops- surface and uptake to fruits and leaves, sprayed on surfaces and difficult to remove
- Dissolved toxins (extracellular) release from blooms
- 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
- Dog deaths...



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

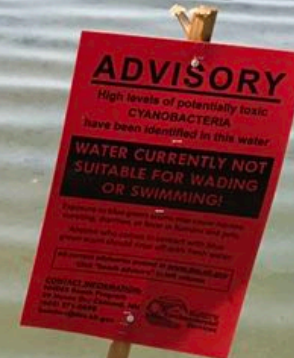
“reported 67 suspected or confirmed cases of canine intoxications associated with HABs. Of these 67 cases, 58 (87%) followed exposure to fresh waters and 1 (1%) followed exposure to marine waters.”

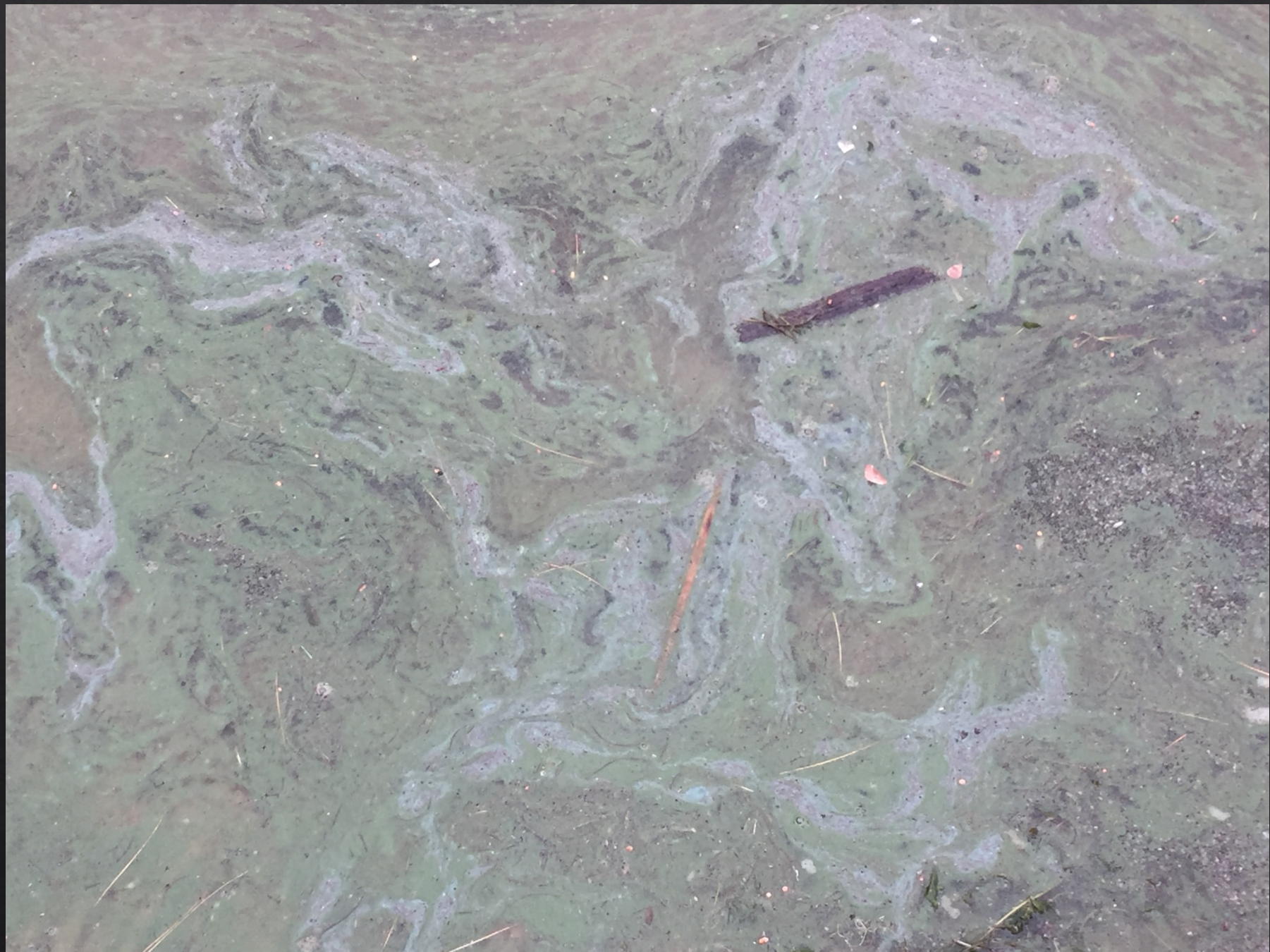
“...duration of illness ranged from <1 day to 6 weeks.”



“Dog's death fuels lake cyanobacteria scare”

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

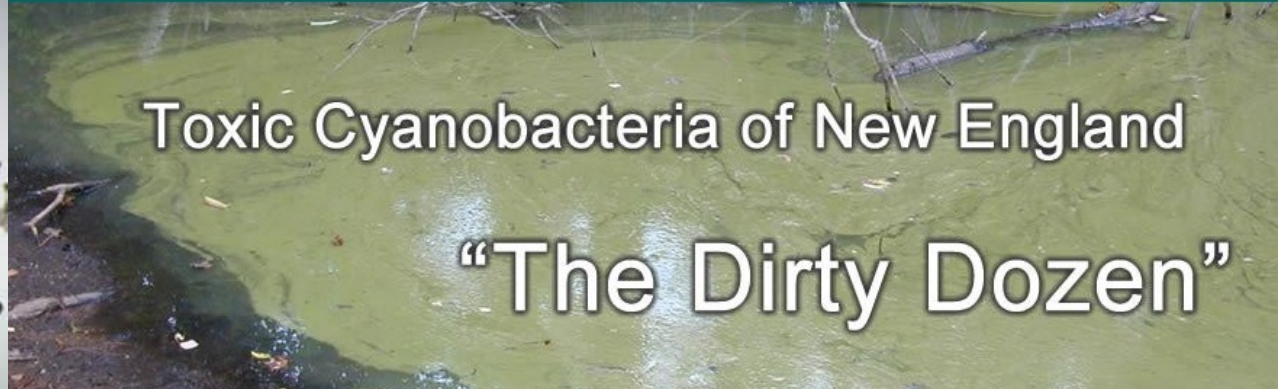




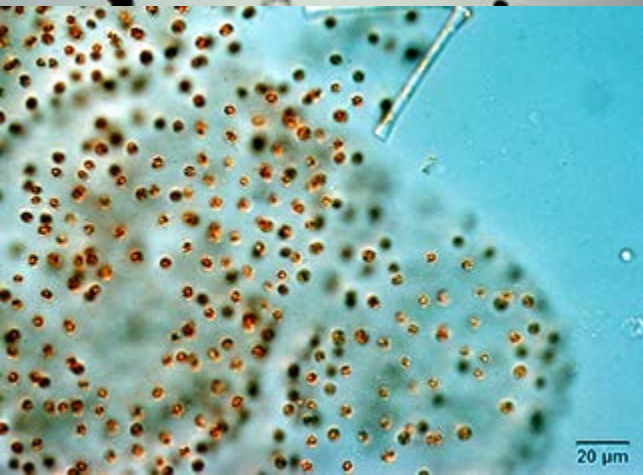




Microcystis



Toxic Cyanobacteria of New England
“The Dirty Dozen”



Aphanizomenon



Oscillatoria



Anabaena

Woronichinia



Planktothrix



Gloeotrichia

Normal microscope illumination

Picoplankton (picocyanobacteria)

Identification by epifluorescence

Magnification: 25.20 x
Exposure Time: 60.7 ms

20 μ m

Chlorophyll fluorescence illumination

Magnification: 25.20 x
Exposure Time: 909.1 ms

20 μ m

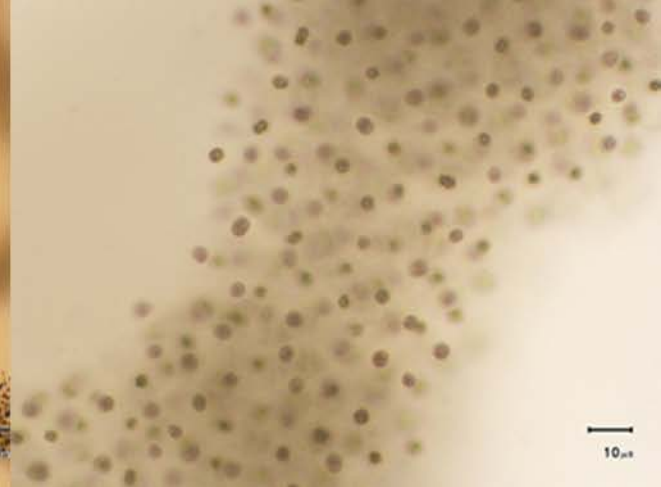
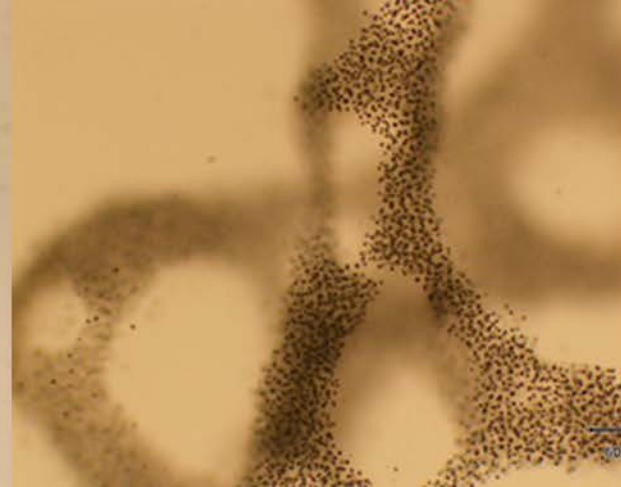
Phycocyanin fluorescence illumination

Magnification: 25.20 x
Exposure Time: 45.0 s

20 μ m

Common Cyanobacteria Genera of New Hampshire	Typical Form Observed	Associated or Known Toxins
Anabaena/Dolichospermum	Filaments	Microcystins, Anatoxin-a, Anatoxin-a (S), Saxitoxins, Cylindrospermopsin
Anabaenopsis	Filaments	Microcystins
Aphanizomenon	Rafts of Filaments	Anatoxin-a, Anatoxin-a (S), Saxitoxins, Possibly Microcystins
Aphanocapsa/Aphanothece	Colonies or Single Cells	Microcystins
Coelosphaerium	Colonies	Microcystins
Chroococcus/Gloeocapsa	Colonies	Possibly Microcystins
Gloeotrichia	Macroscopic Colonies	Microcystins
Lyngbya/Phormidium	Benthic Filaments	Microcystins, Lyngbyatoxins, Anatoxin-a
Merismopedia	Rafts of Colonies	Microcystins
Microcystis	Variations of Colonies	Microcystins, Anatoxin-a
Nostoc	Macroscopic Colonies	Microcystins, Nodularins
Oscillatoria/Planktothrix	Filaments	Microcystins, Cylindrospermopsin
Spirulina	Filaments	Microcystins
Synechococcus/Synechocystis	Single Cells, Rarely Colonial	Microcystins and Saxitoxins
Woronichinia	Dense Colonies	Microcystins

BMAA produced by all?



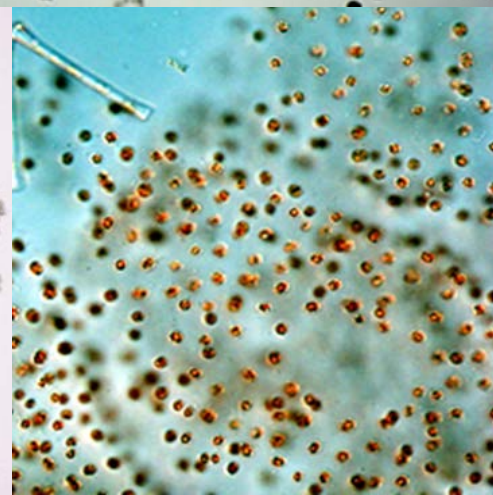
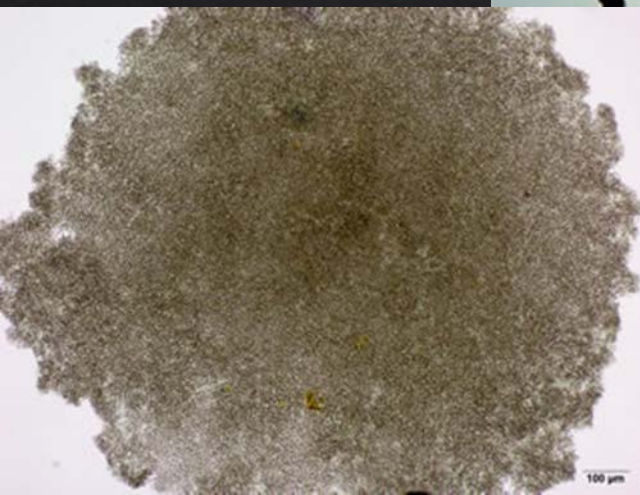
Colonies...

- Vary in shape and size



Cyanotoxins...

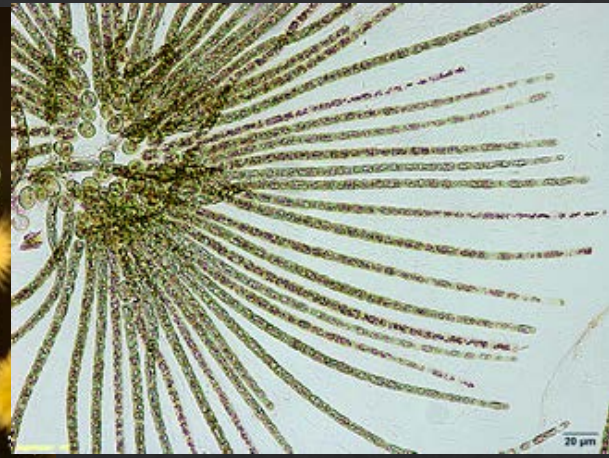
- Packaged in each cell



Unique Cyanobacteria

◇ Gloeotrichia

- ◇ Lake Winnepesaukee
- ◇ Lake Sunapee



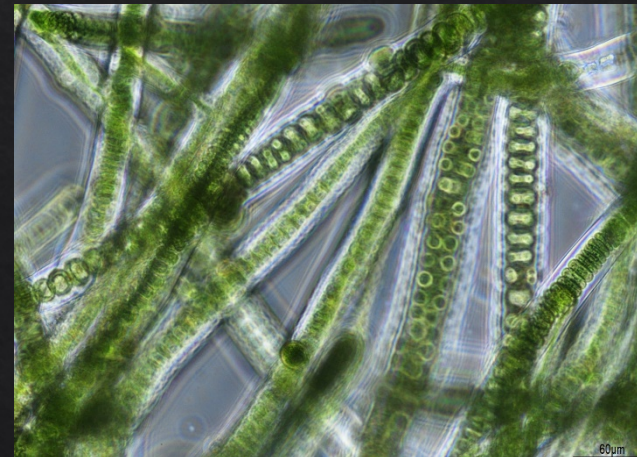
◇ Nostoc

- ◇ Pawtuckaway

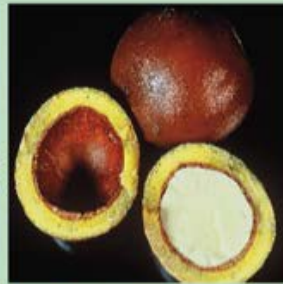


◇ Stigonematales

- ◇ Lake Winnepesaukee









Humans?

Top carnivores
(large fish, birds, mammals)

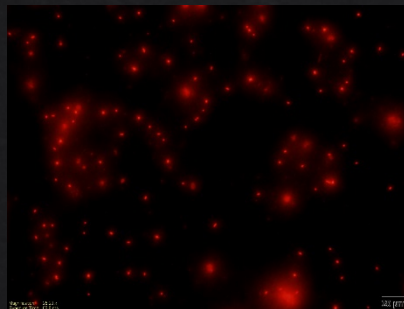
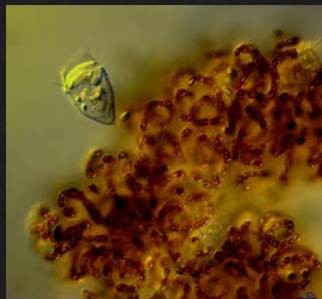
Tertiary consumers/ carnivores
(medium fish)

Secondary consumers/
carnivores
(predatory zooplankton,
small fish)

Primary consumers/
herbivores
(zooplankton and
herbivorous fish)

Primary producers
(cyanobacteria,
algae)





Top carnivores
(large fish, birds, mammals)

Tertiary consumers/ carnivores
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Secondary consumers/
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(predatory zooplankton,
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Primary consumers/
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Primary producers
(cyanobacteria,
algae)

Bioaccumulation
of cyanotoxins

- BioMagnification?
- BioDilution?

Chronic exposure?

Acute recreational exposure?

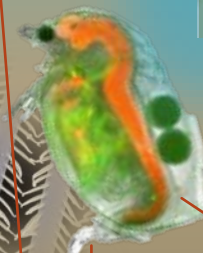
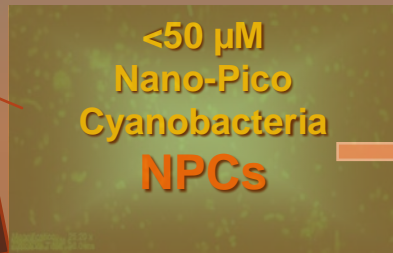
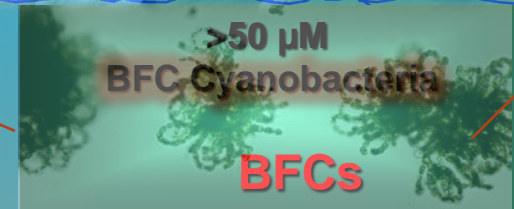
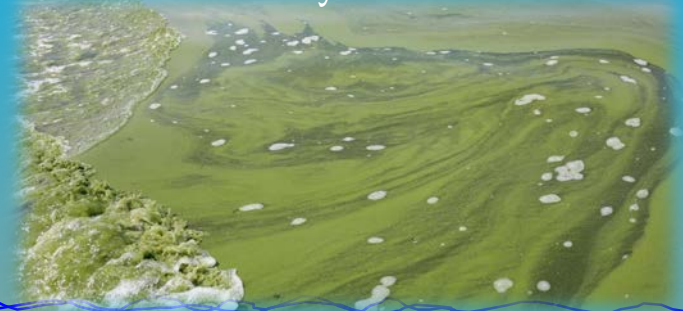
Humans

Inhalation

Drinking water

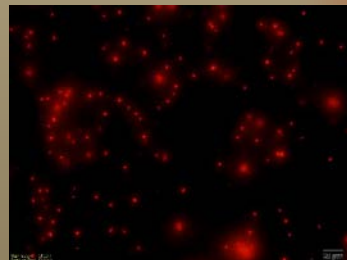
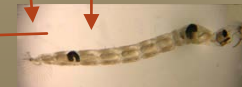
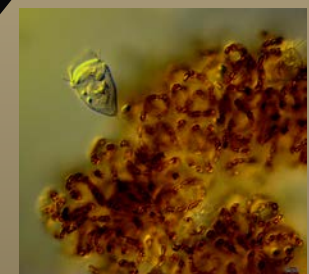
Food Chain

HCB Harmful Cyanobacteria Blooms



Spring

Winter



Nano-Pico Cyanobacteria (NPC)

- a. High growth rate
- b. rapid transfer within and outside lake

L a k e S e d i m e n t

Bloom-forming Cyanobacteria (BFC)

- a. Low growth rate
- b. Slow transfer within and outside lake

Cyanotoxins in the Lake Food Web

Every Lake is Unique





Blooms may occur...

- On beaches
- At boat launches
- Along inaccessible shorelines
- In front of private residences
- As patches around the lake surface
- As benthic mats
- Attached to rocks or substrates
- Deep within the water column
- Anywhere on the lake!

Photos are critical in spreading awareness...

- Shoreline accumulations rapidly change
- Weather, wind and currents may shift
- Water disturbance from boats
or other recreational activities
can alter the conditions of the
reported bloom sighting.

Please report what you are seeing!
603-848-8094

NH Cyano Hotline- 603-848-8094

Sampling is not encouraged. Please avoid blooms!

Call NHDES and text (or email) a photo if possible!
and we will coordinate sampling....

Download the BloomWatch app (Cyanos.org)

Bloom details should include:

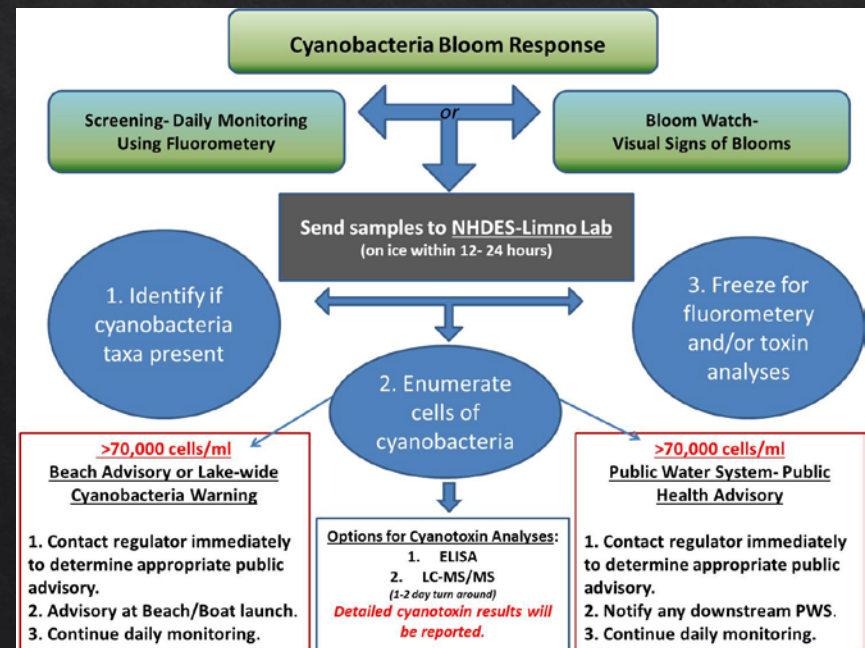


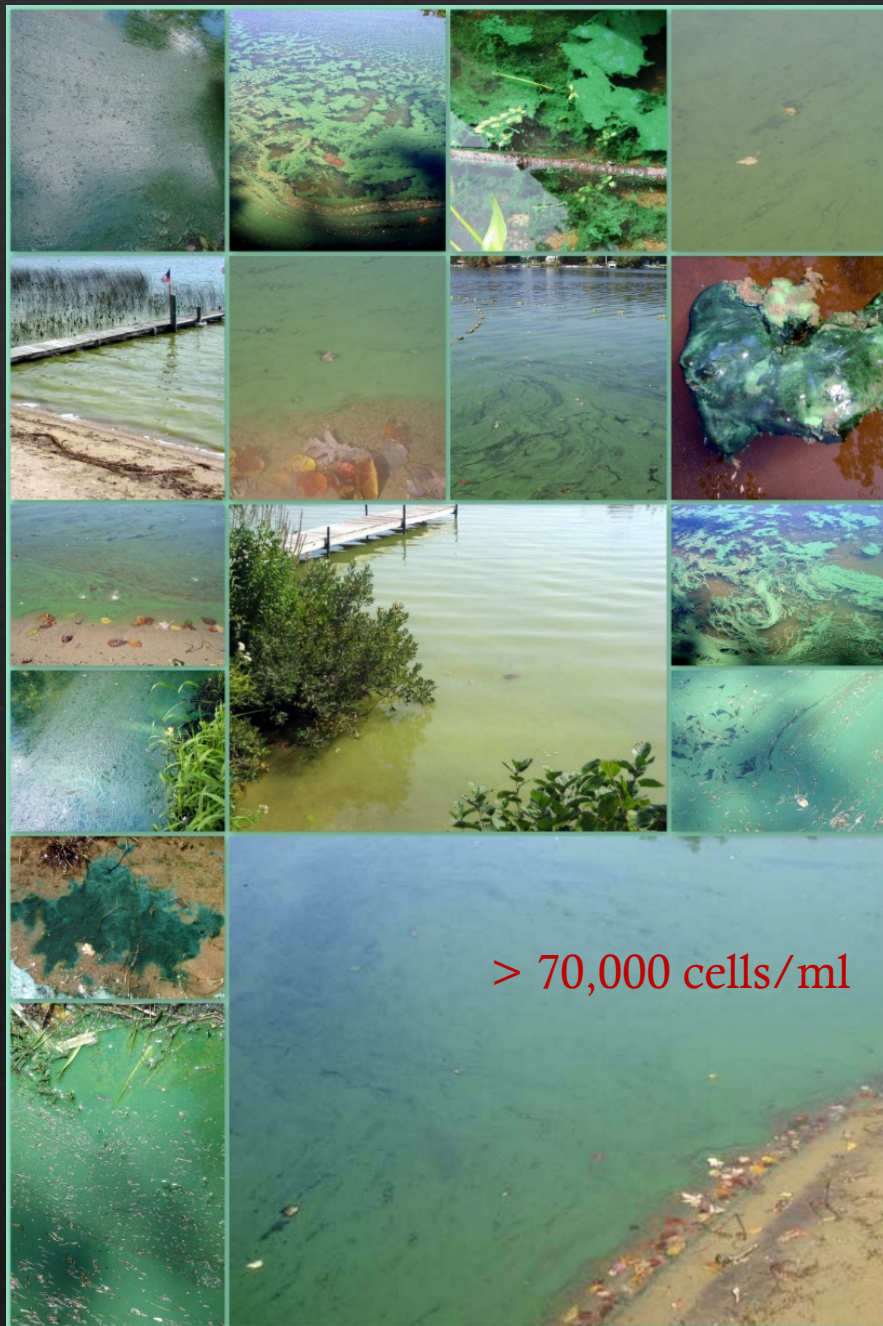
- Name and contact info
- Waterbody Name
- Waterbody Town
- Station ID and/or description
- Latitude/Longitude
- Date, time, weather conditions
- Photo or description of severity and dimensions of scum
- Water conditions and notes if possible (e.g. clarity, level, & temperature if possible)

1. Identify
2. Enumerate
3. Freeze for Cyanotoxin Analyses
4. Cyanobacteria Advisory

- **>70,000 cells/ml**

- Town notified
- Sign posted
- Press Release
- Map
- Social Media





> 70,000 cells/ml

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



<http://des.nh.gov>

A A A

an official NH



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Beach Advisory
Drinking Water Advisory



DES News

May 12, 2009

Municipal Officials, Interest Groups Express Concerns About The Future Of Water Resources In New Hampshire

Concord, N.H. – The impact of development on water quality in the Granite State tops the list of concerns voiced in a series of public meetings being held across the state by the New Hampshire Department of Environmental Services. [more...](#)

May 8, 2009

Lawn Watering A Costly Use Of Precious Drinking Water

Concord, N.H. – The New Hampshire Department of Environmental Services wants to encourage residents to be water wise by adopting proven water conservation practices that will reduce water losses, waste, or use. [more...](#)

May 7, 2009

DES And NH Association Of Natural Resource Scientists Sign Partnership Agreement Agreement Signed As Part Of DES Partners Program

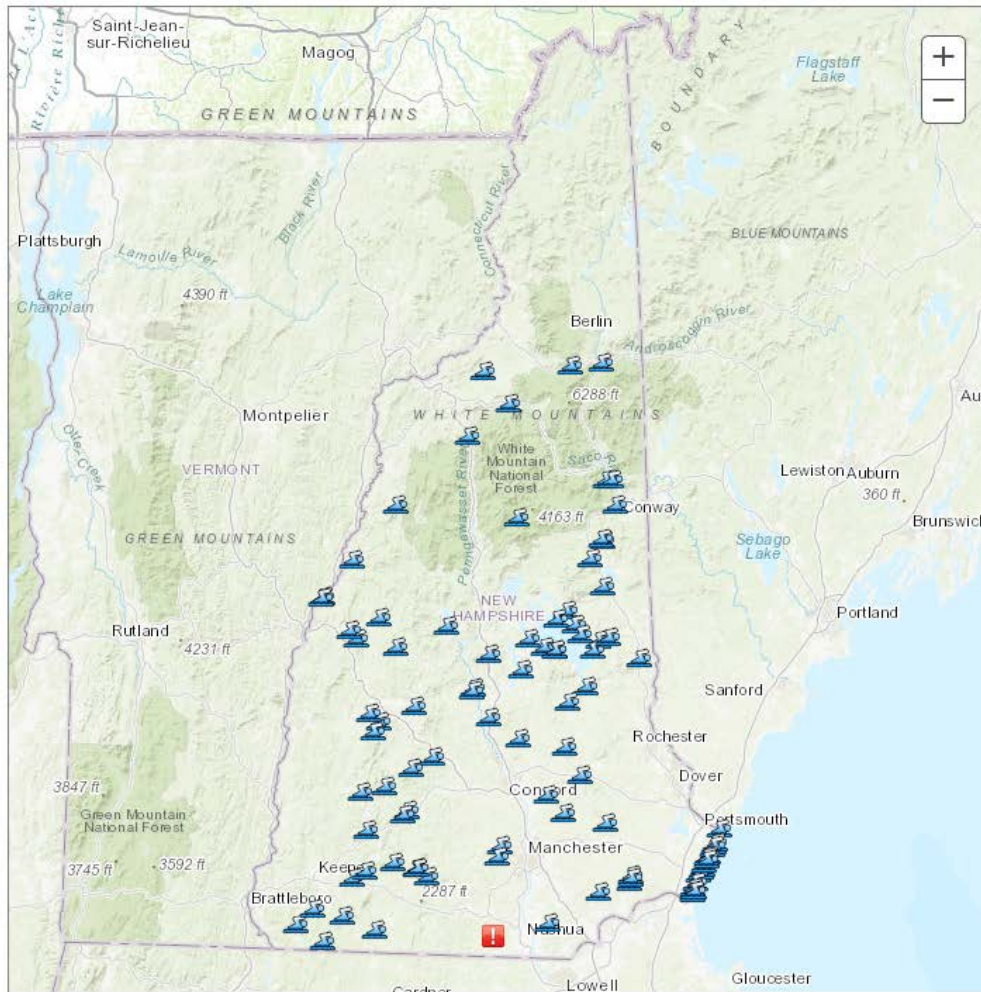
Concord, NH – The New Hampshire Department of Environmental Services and NH Association of Natural Resource Scientists (NHANRS) today signed a partnership agreement [more...](#)

What's New

- NH DES's American Recovery And Reinvestment Act Resources
- DES/UNH Workshop - Cyanotoxins In New Hampshire's Lakes (May 15)
- Title V Operating Permit For PSNH Merrimack Station
- Aquatic Resource Mitigation Funds For Merrimack River Watershed Request For Proposals

Wednesday, May. 29, 2019

Current Beach Advisories as of May 29, 2019



Legend

- ☒ Most Recent Samples Meet Standards
- ☒ Cyanobacteria Advisory

[Return to Full Extent](#)

Note: The map may not display accurate icons for a short time after any update. The [charts below](#) listing advisories and warnings are updated instantly by DES Beach Program staff.

Warnings are typically issued during the “swim season”, between Memorial Day and Labor Day. Extended until blooms subside, often occurring into late Fall.



Current Beach Advisories

Advisories are updated daily during the swim season. Beaches are only listed here if the most recent fecal bacteria or cyanobacteria sample analysis exceeded state standards. Results are available through the [OneStop database](#).

Beach sampling/monitoring is conducted between Memorial Day and Labor Day.

For beach and advisory details, sampling results, and yearly reports, conduct a OneStop search.

Summary reports of monitoring seasons are also available at: http://des.nh.gov/organization/divisions/water/wmb/beaches/beach_reports/index.htm.

Follow the NHDES Beach Advisories Twitter Feed. [NHDES Beaches Advisories Twitter Feed](#).

To receive future Beach Advisory Newsletters, join the NHDES E-Mail List. <https://www.des.nh.gov/media/enews/index.htm>.

For explanations about advisories and procedures, please visit the Beach Advisories page: <http://des.nh.gov/organization/divisions/water/wmb/beaches/advisories.htm>.

There are currently no beaches with fecal bacteria warnings issued in the State of New Hampshire.










Cyanobacteria Lake Warnings

Lakes without designated beaches or areas of a lake away from a designated beach are issued [cyanobacteria](#) lake warnings when a large algae bloom is observed. Lakes with cyanobacteria warnings are re-inspected weekly.

Date of Warning	Description of Warning
10/6/2017	STATEWIDE - The beach advisory and lake warning system for fecal and cyanobacteria implemented by the New Hampshire Department of Environmental Services (NHDES) has ended for 2017 as the formal swim season is over. The NHDES will resume monitoring and updating this site in May 2018.

Lakes are resampled every week during an advisory until the bloom has dissipated and cyanobacteria concentrations are below the state threshold of ~70,000 cells/ml.

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Media Center
FOR IMMEDIATE RELEASE
DATE: September 21, 2018
CONTACT: Amanda McQuaid (603) 271-0698 (O), 848-8094 (C)
des.nh.gov
twitter.com/NHDES

State REMOVES Cyanobacteria Warning for Winter Harbor on Lake Winnepesaukee in Wolfeboro, NH

Concord, NH – The New Hampshire Department of Environmental Services (DES) has REMOVED a cyanobacteria warning for the Winter Harbor area of Lake Winnepesaukee. The warning went into effect on August 30, 2018, and was removed on September 21, 2018.

Lake volunteers were tracking the *Gloeotrichia* bloom daily by visual observations. Samples were also collected for analyses using CyanoScope, a monitoring approach set out by the Environmental Protection Agency (Cyano.org). The bloom was not observed on Carry Beach, though was accumulating in various private coves in the area. Samples were collected August 29, September 5, September 6 and September 13. Several reports by lake residents from various towns across Lake Winnepesaukee were also submitted. Samples were not collected from other areas of Lake Winnepesaukee as low concentrations were observed and reported. The most significant concentrations were reported from Winter Harbor on September 5, 2018. NHDES analyzed these samples for the identification and enumeration of the bloom. Concentrations of *Gloeotrichia* exceeded 70,000 cells per milliliter from samples collected along coves and shorelines of Winter Harbor. Since that time, daily observations have been made that the bloom has slowly dissipated from the area. Please continue to monitor your individual shorelines for changing conditions.



Gloeotrichia – Large, deep NH lakes (such as Lake Winnepesaukee and Lake Sunapee) have been found to contain a unique cyanobacteria bloom called *Gloeotrichia*. Each colony of *Gloeotrichia* may contain approximately 5,000 cells. The colonies look like very small, fuzzy balls in the water. They can appear either green or sometimes brownish-yellow by eye. Often these cyanobacteria do not accumulate to large concentrations and may go unnoticed. These types of cyanobacteria do not typically form green surface scums, however they can quickly accumulate along shorelines and coves. Various NH researchers are studying the *Gloeotrichia* cyanobacteria to learn more about these unique blooms.

To learn more, follow the links:
www.lakesunapee.org/research/sites/dartmouth.edu/CottinghamLab/category/gloeotrichia-project/cfb.unh.edu/CyanoKey/Gloeotrichia.html


Cyanobacteria are natural components of water bodies worldwide, but blooms and surface scums may form when excess nutrients are available to the water. Some cyanobacteria produce toxins that are stored within the cells that can be released upon cell death. Toxins can cause both acute and chronic health effects that range in severity. Acute health effects include irritation of skin and mucous membranes, tingling, numbness, nausea, vomiting, seizures and diarrhea. Chronic effects include liver and central nervous system damage.

NHDES advises lake users to avoid contact with the water in areas experiencing elevated cyanobacteria cell conditions typically where lake water has a surface scum, green streaks, blue-green flecks, or even clouds of tiny balls like these. Changes in water color or clarity, though typically aggregating along the shore, may also be signs of cyanobacteria growth. NHDES advises pet owners to keep their pets out of any waters that have a cyanobacteria bloom in order to avoid consumption of cyanobacterial-contaminated lake water.






NHDES routinely monitors public beaches and public waters of the state for cyanobacteria. Once a cyanobacteria lake warning or beach advisory has been issued, NHDES aims to return to affected waterbodies on a weekly basis until the cyanobacteria standards are again met.

Air Quality
Beach Advisory
Drinking Water Advisory



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NHDES Calendar

				1			2			3		
4	5	6	7	8	9	10						
11	12	13	14	15	16	17						
18	19	20	21	22	23	24						
25	26	27	28	29	30							



Gloeotrichia under compound light microscopy at 100x.



[Full-screen Snip](#)

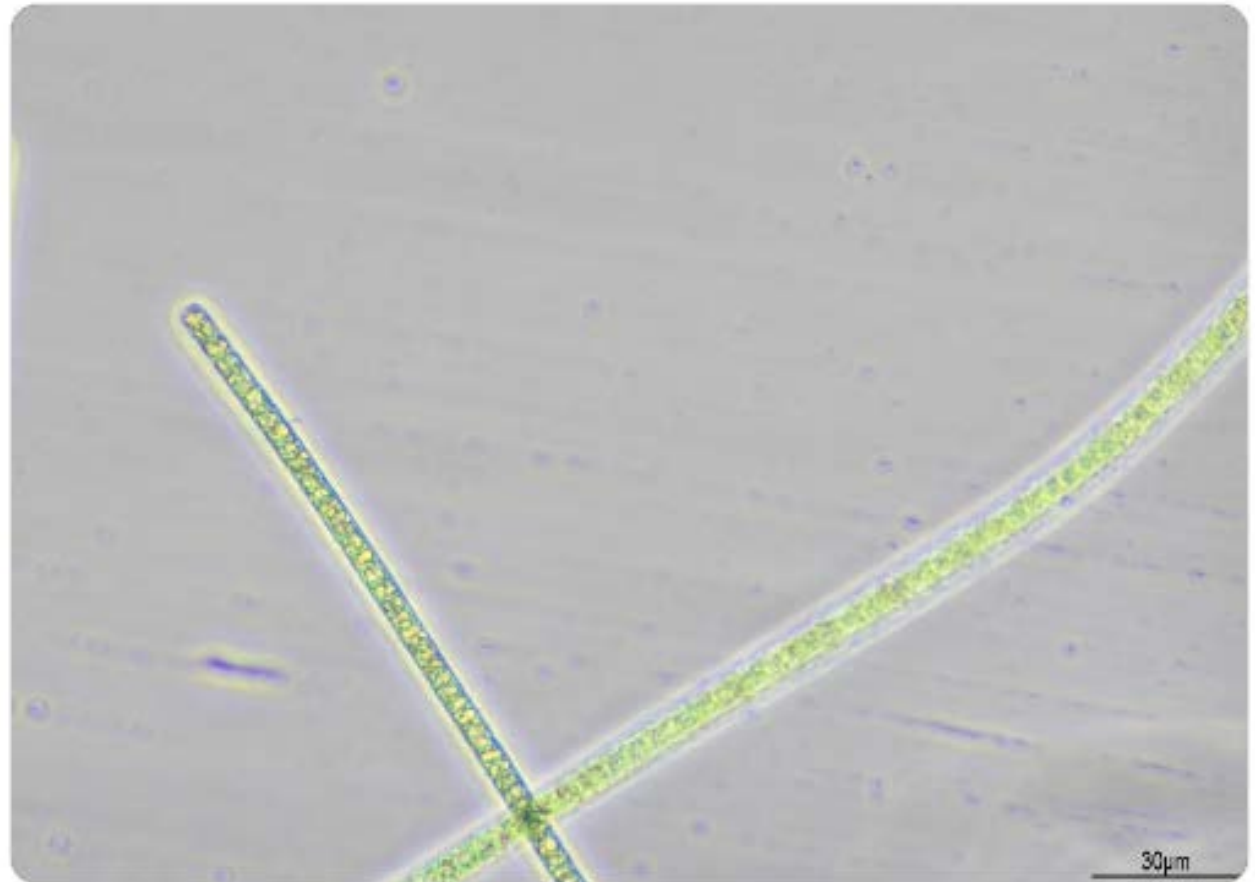


Twitter @NHDES_Beaches



NH Beach Inspector @NHDES_Beaches · May 20

#Oscillatoria are good at regulating buoyancy. They can survive deep in the #water unseen. Once the ice is out and the water column begins to warm, #cyanobacteria could surface. Look out for cyanobacteria #blooms this #summer. Report to the Beach Program! #MicroscopeMonday @NHDES



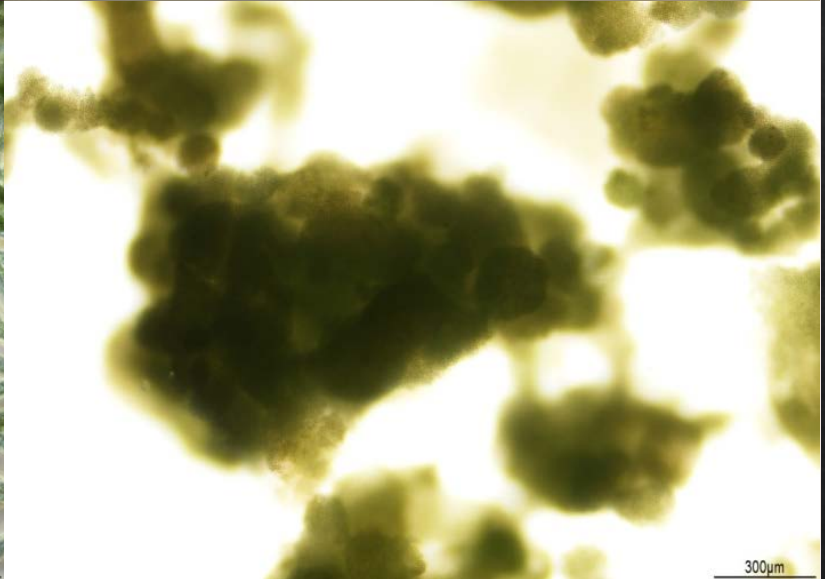
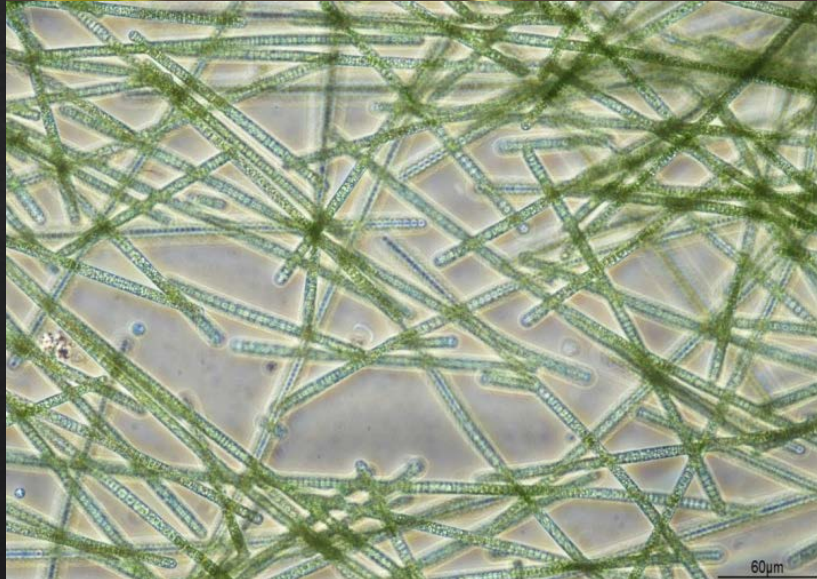
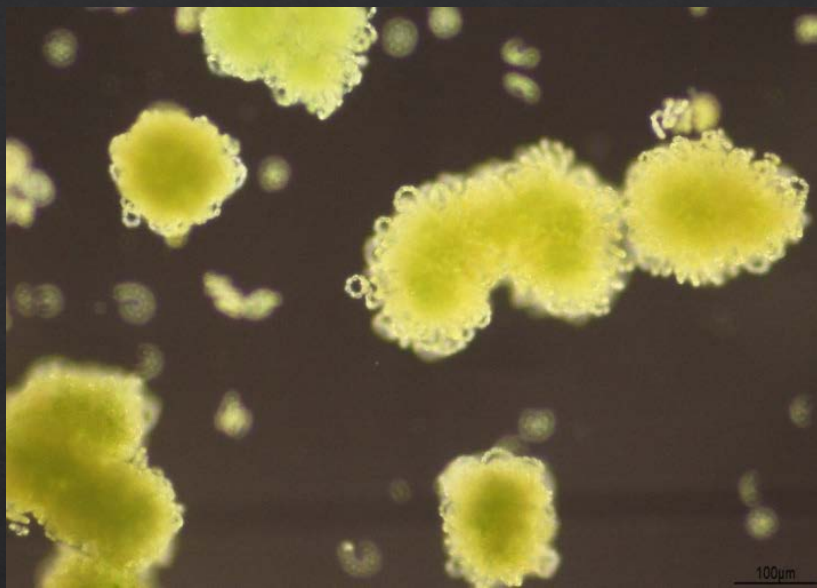
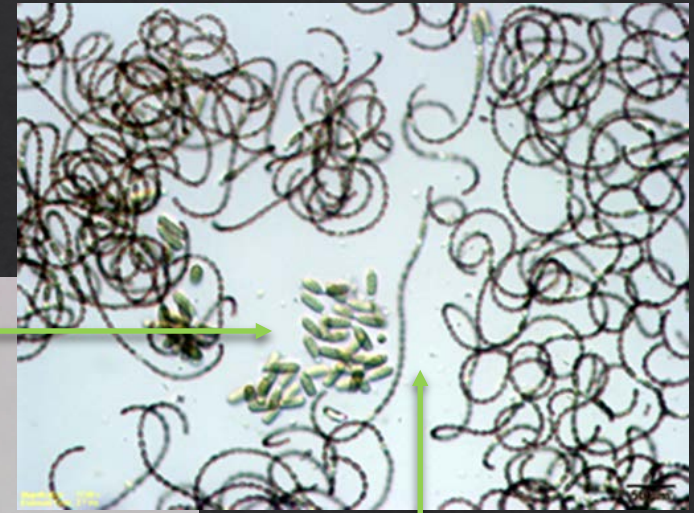


Figure. The most common cyanobacteria found in New Hampshire are *Dolichospermum* (aka *Anabaena*), *Aphanizomenon*, *Oscillatoria* (aka *Planktothrix*) and *Microcystis*. Left to right, top to bottom.

Anabaena (Dolichospermum)

Fall blooms-mixed assemblages, though
akinetes begin to settle for future growth

Early in the summer (June)-
Anabaena dominant



*Often smells musky,
earthy, like dirt*

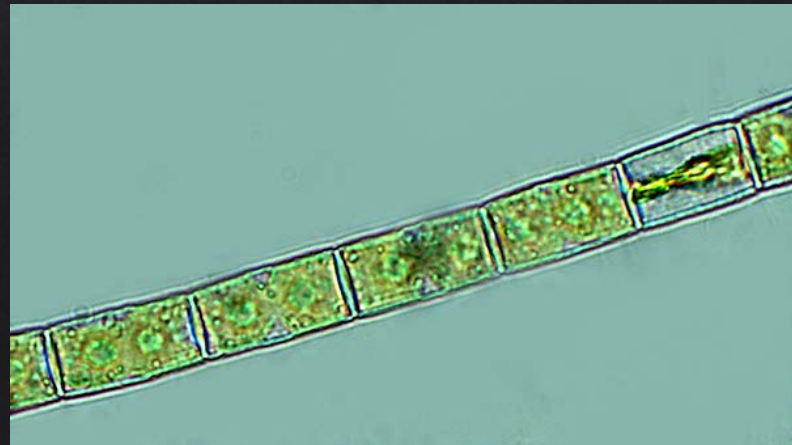
Average cell count/colony-
~250 cells
~diameter of colony (um)



Other “bloom” complaints -Non-cyanobacterial

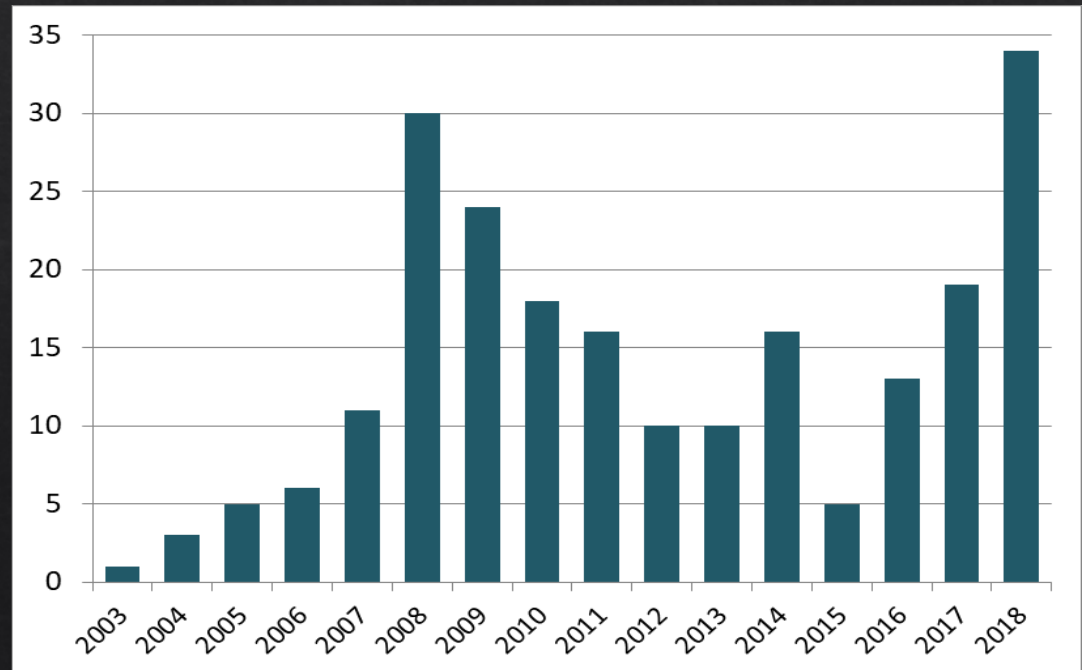
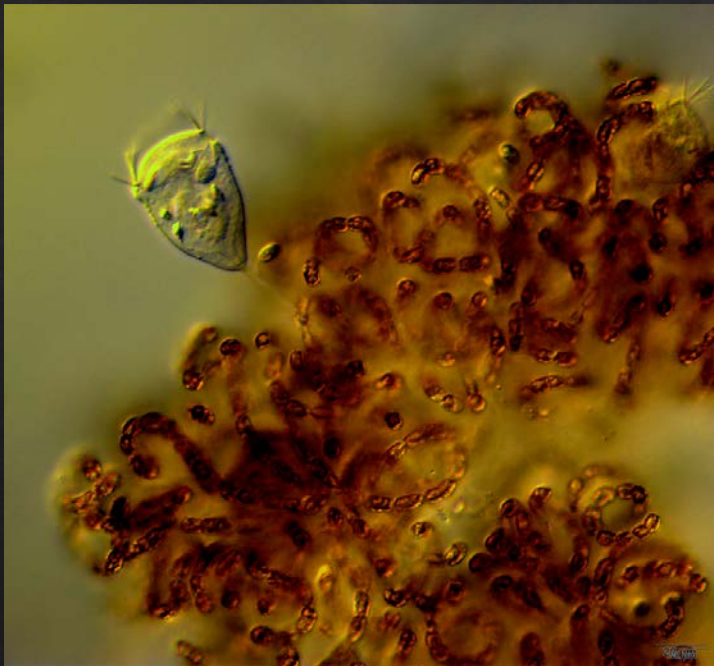
- Most common- filamentous green algae such as *Mougeotia* or *Spirogyra*.
- Sometimes appear slimy, foamy, bright green-yellow
- Slimy mats or clumps can surface or hover in the water column, just beneath the surface.
- Also found along the shoreline or in shallow water.
- Mats can contain a diverse range of other organisms including phytoplankton (sometimes a few strands of cyanobacteria), protists and zooplankton mixed within it.

Try the “stick test”



2018

- 350 samples analyzed- over 70 % of samples were confirmed to contain cyanobacteria (2017 and 2018).
- There were 34 cyanobacteria advisories at 29 different waterbodies.
- Only 12 of those were also reported at a public beach.
- The earliest reported bloom was May 23, 2018
- The latest reported bloom was November 2, 2018.
- The total number of cyanobacteria advisory days was 884 (up from 285 days in 2017).
- The average length of an advisory was 26 days, ranged from 3 - 89 days.



Increased public awareness has likely caused more blooms to be reported in recent years.

Harmful Cyanobacteria Blooms

Producing an array of toxins...



NHDES is only currently testing for Microcystins (MCs)

ELISA testing $\sim LOD \sim 0.1 - 2.0$ ppb (*High sensitivity kit with lower range ~ 0.05*)

Drinking water guideline = 0.3 ppb

Recreational guideline = 8 ppb (previously 4 ppb)

~ 350 samples, $\sim 50\%$ of samples with detected MCs (0.096-3.8 ppb)

Increased sensitivity further by speed vac ($\sim LOD$ 0.005 ppb) on select samples

Eight samples from four waterbodies above 4 ppb

Two samples from one waterbody was above 20 ppb

Three public water systems with MCs in lake water

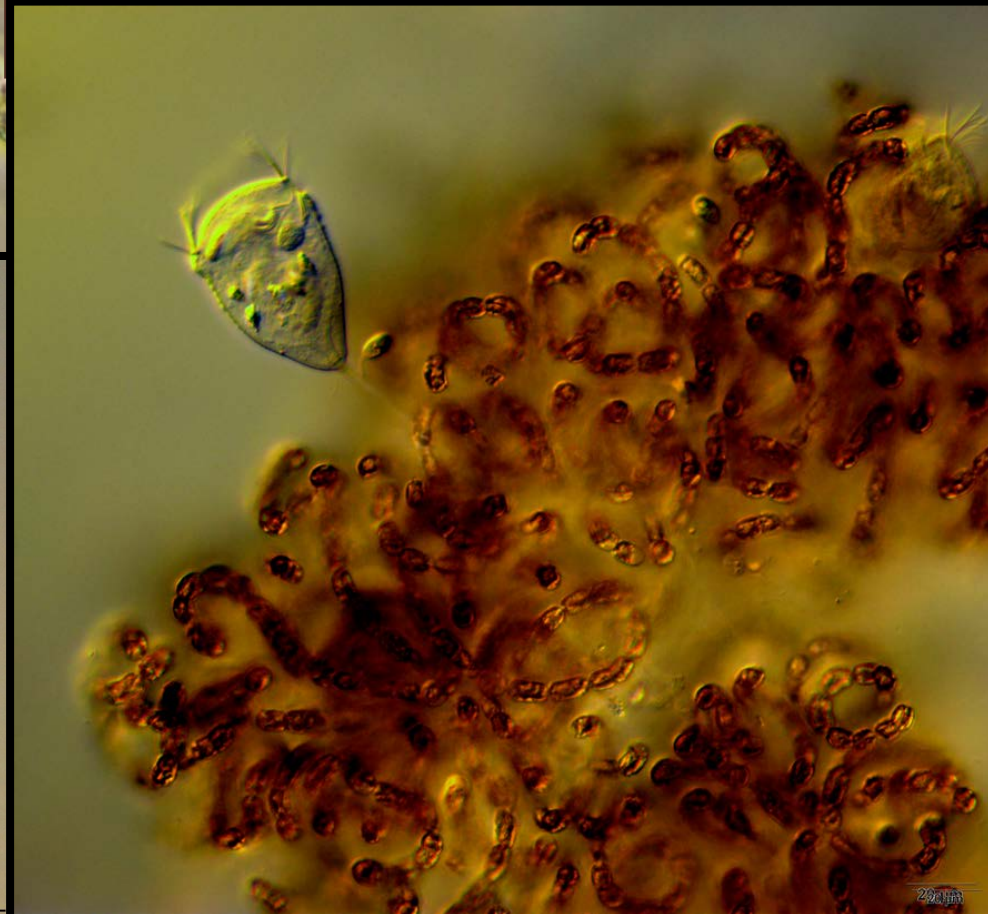
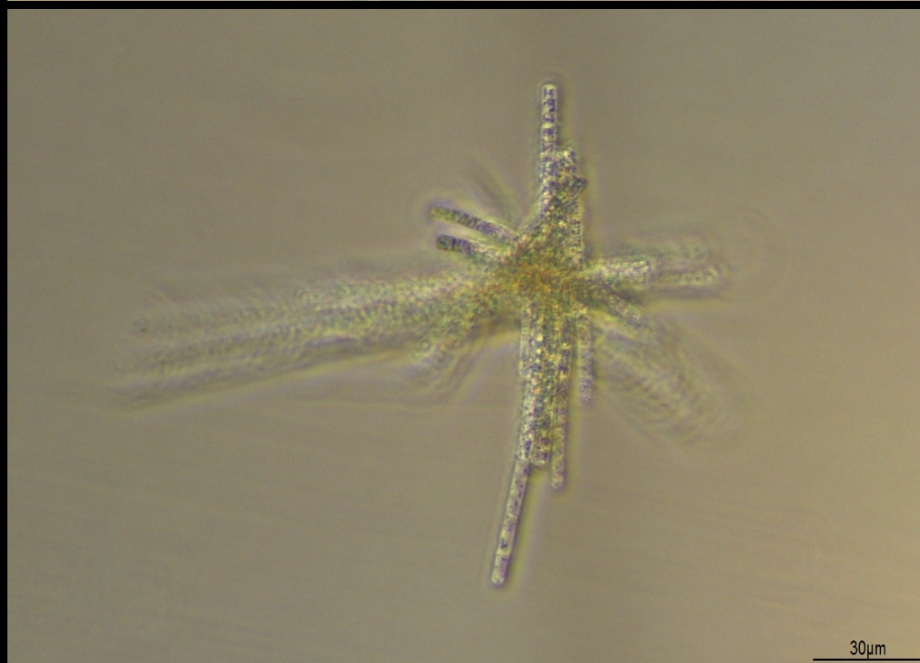
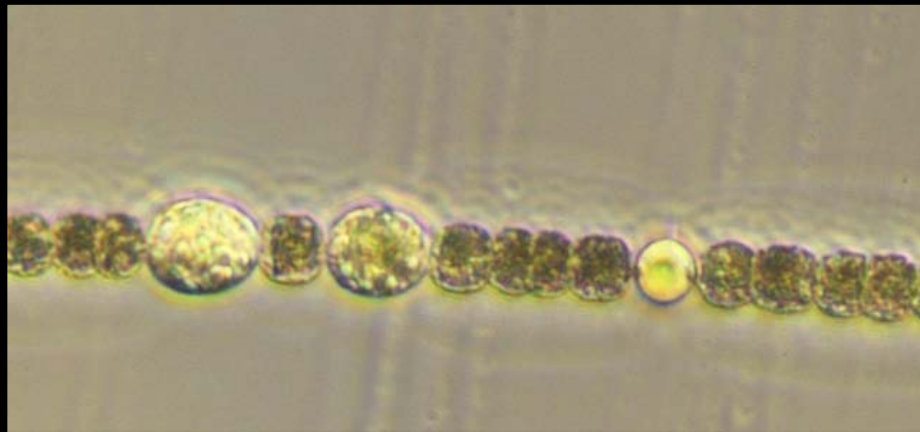
Hothole Pond, Loudon, NH

Anabaena/Dolichospermum blooms are typical

- Microcystins were below detectable levels (BDL) during initial Bloom advisory, 194,000 cells/ml of Anabaena.
- When *Microcystis* increased in dominance and cell count, MCs were highest on 9/25.

Date	Total Cyano cell count (cells/ml)	% of Cyano population was <i>Microcystis</i>	% of Total sample is Cyano	Microcystins (MCs) (ppb or ug/L)	<i>BDL= below detectable limits</i>
10/29/2018	4562	0	6.25	BDL	
9/25/2018	37132	43.5	32.22	0.012534	
8/27/2018	39280	1.2	51.32	BDL	*8/15 Anabaena Bloom event 194,000 cells/ml BDL MCs
7/30/2018	49558	0	32.09	BDL	
6/25/2018	5672	10.7	5.67	0.005392	
6/13/2018	25992	0	38.4	0.005056	
5/14/2018	0	0	0	BDL	
4/12/2018	1635	66.7	2.59	BDL	very low cell count and small percentage of total phyto pop.

Adding other cyanotoxins, such as
Anatoxin, may be trialed on blooms
in the future at NHDES



(NE) Cyanobacteria Monitoring Collaborative

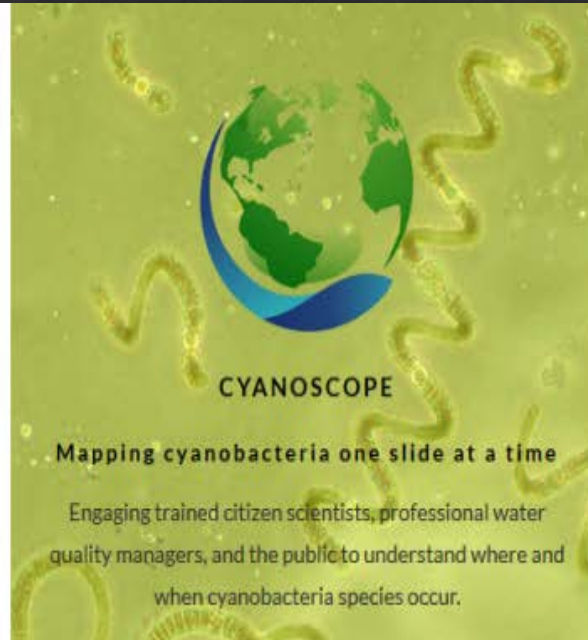
www.cyanos.org



BLOOMWATCH APP

Crowdsourcing to find and report potential cyanobacteria blooms

Engaging citizens to keep eyes on our lakes and determine where and when potential cyanobacteria blooms appear.



CYANOSCOPE

Mapping cyanobacteria one slide at a time

Engaging trained citizen scientists, professional water quality managers, and the public to understand where and when cyanobacteria species occur.



CYANOMONITORING

Professionals and trained citizen scientists monitoring freshwaters for cyanobacteria

Monitoring lakes and rivers for signs of cyanobacteria to determine the environmental factors that cause blooms

Multi-Tiered Approach to (Citizen Science Based) Cyanobacteria Monitoring

Cyanos.org

[OVERVIEW](#)[BLOOMWATCH](#)[CYANOSCOPE](#)[MONITORING](#)[NEWS](#)

CYANOBACTERIA MONITORING COLLABORATIVE

THREE COORDINATED MONITORING PROJECTS TO LOCATE AND UNDERSTAND
HARMFUL CYANOBACTERIA

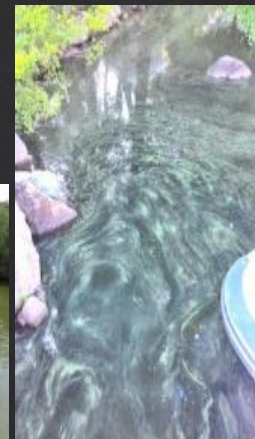
[GET INFORMED](#)[GET INVOLVED](#)[GET IN TOUCH](#)

Volunteer Involvement



bloomWatch

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



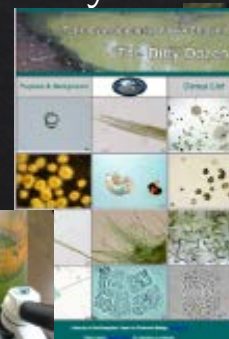
cyanoMonitoring

- 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



(NE) Cyanobacteria Monitoring Collaborative

www.cyanos.org

Bloom Watch

Multi-Tiered Approach to
(Citizen Science Based) Cyanobacteria
Monitoring

View Data

Submit Data

Resources

Media

Feedback

Questions

Analyses

Forum

Wiki

Observations

Map

Locations



Legend

Project Headquarters

Single Observation

Many Observations

Search by Observation Name:

Example: Site 1

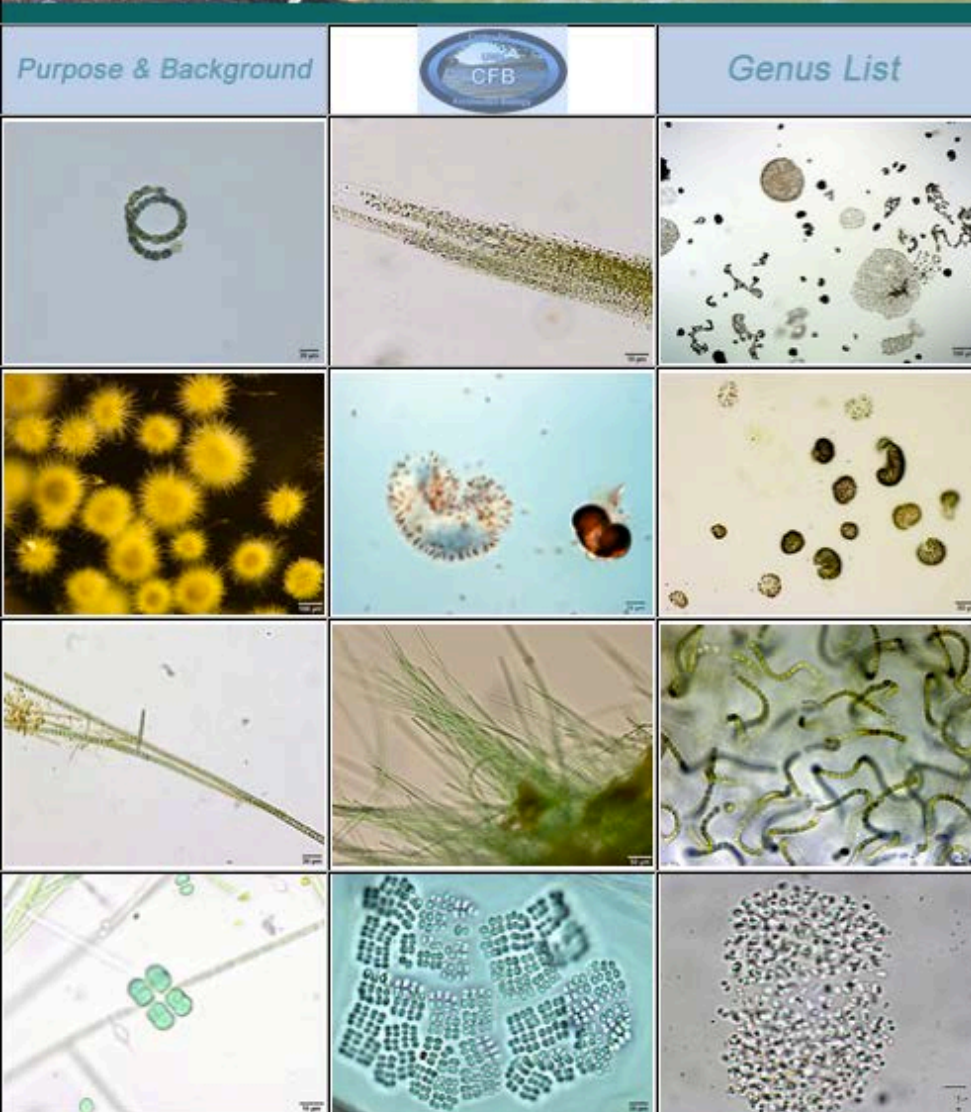
Search

Reset Map

Toxic Cyanobacteria of New England

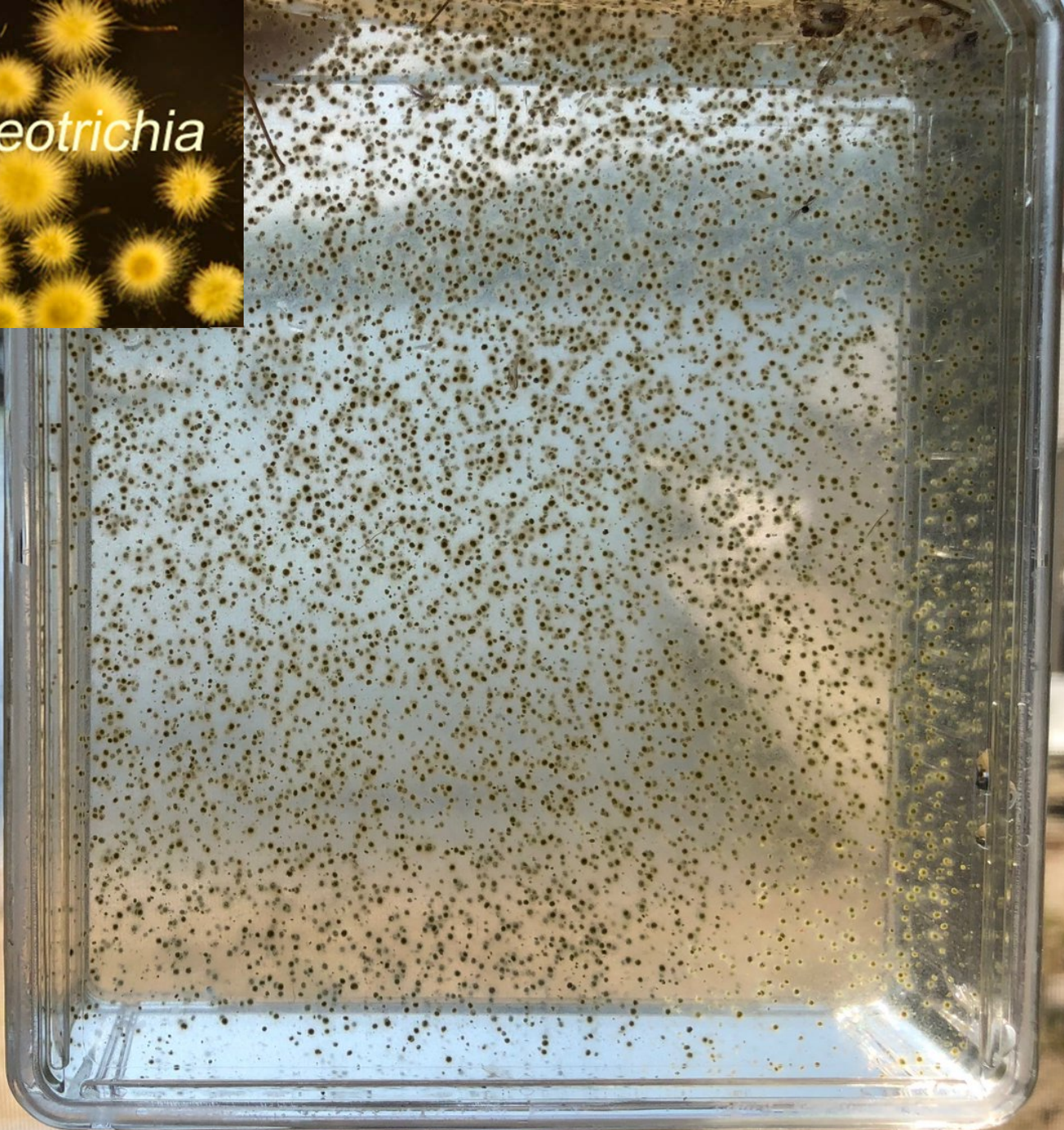
"The Dirty Dozen"

cyanoScope



On-line Key to Bloom-Forming Potentially-Toxic Cyanobacteria

<http://www.cfb.unh.edu/CyanoKey/indexCyanoQuickGuide.html>



Public awareness and citizen-science on the rise!



NH LAKES

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