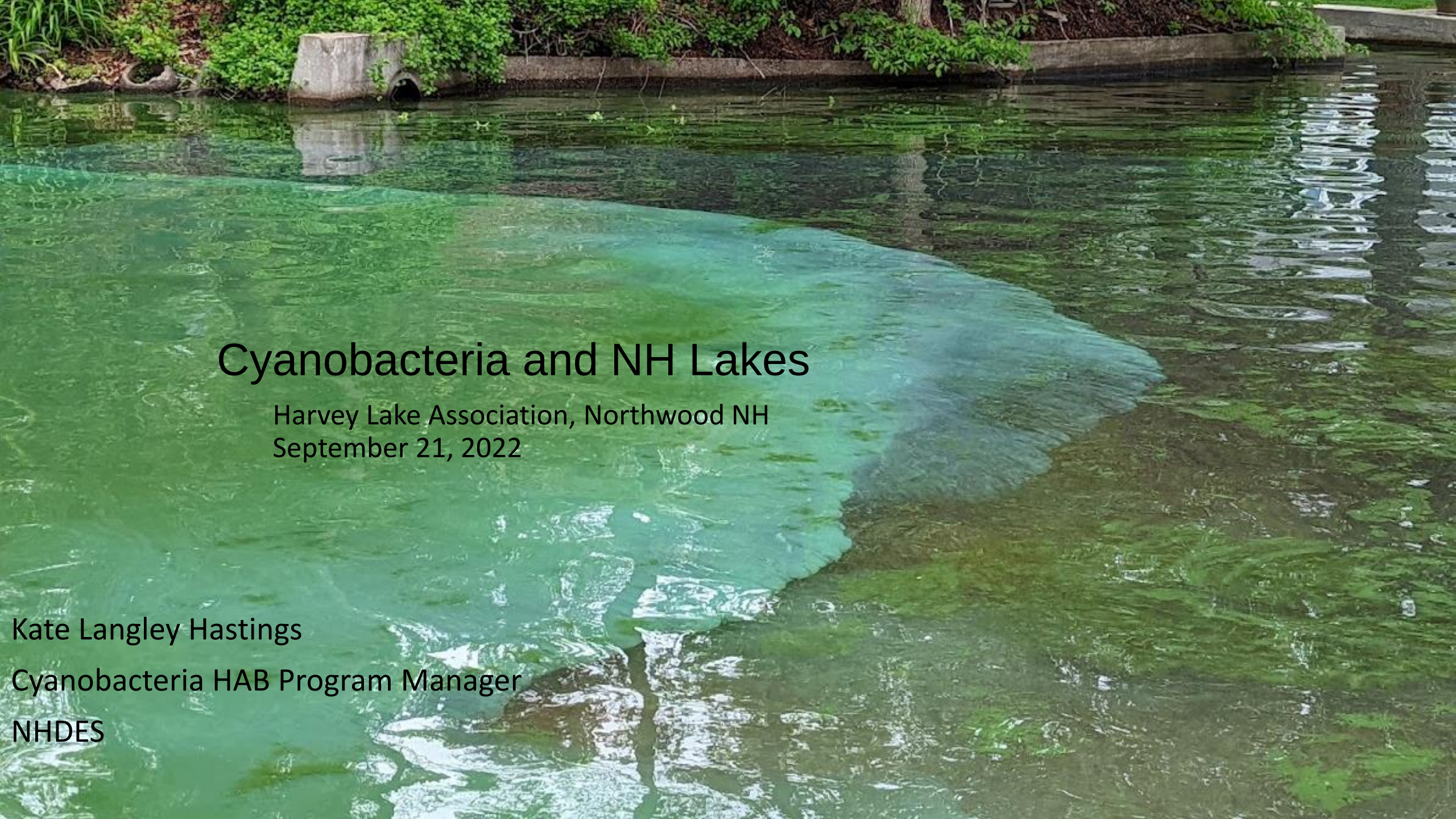


Cyanobacteria and NH Lakes

Harvey Lake Association, Northwood NH
September 21, 2022

Kate Langley Hastings

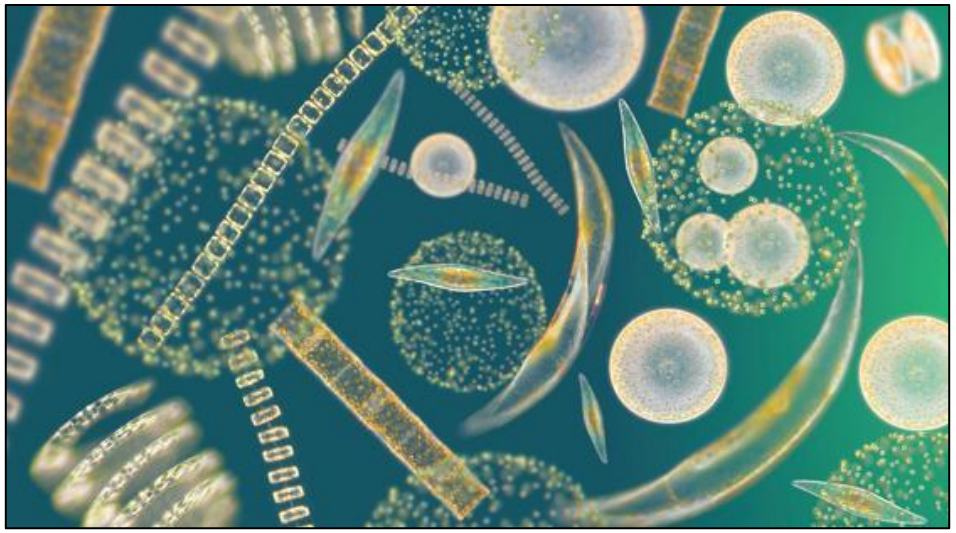
Cyanobacteria HAB Program Manager

NHDES

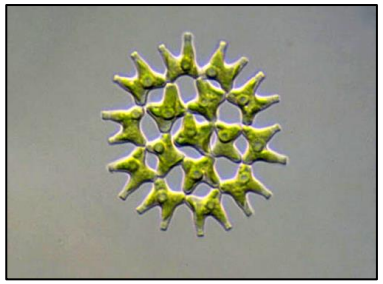
Kate Langley Hastings
NHDES, Cyanobacteria HAB Program
kate.l.hastings@des.nh.gov
Reporting cyanobacteria: hab@des.nh.gov
603-848-8094

Phytoplankton

- Greek for “plant” “drifter”
- Photosynthetic
- Basis of aquatic ecosystems

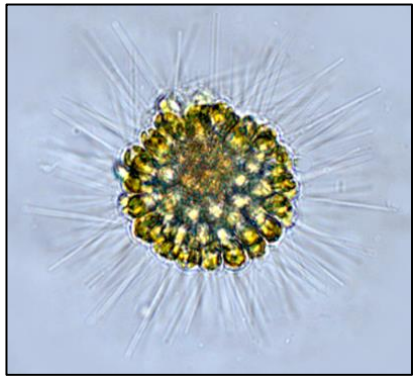


Green algae



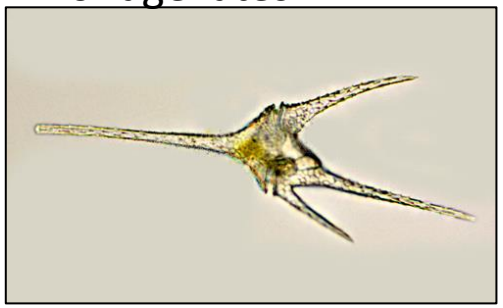
Pediastrum

Golden-brown algae



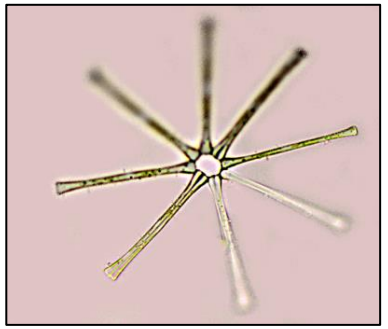
Chrysosphaerella

Dinoflagellates



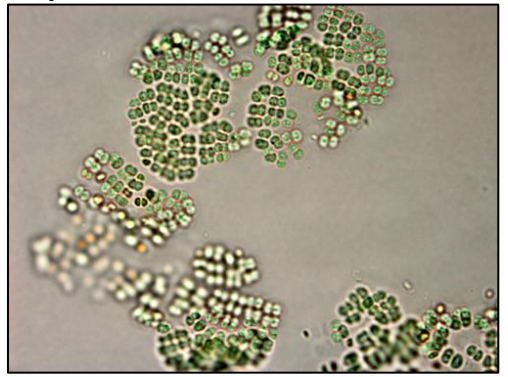
Ceratium

Diatoms



Asterionella

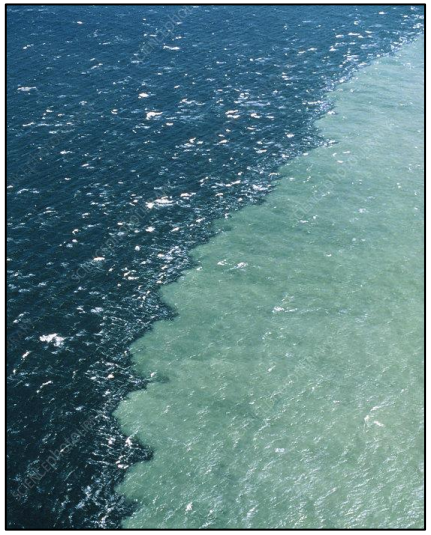
Cyanobacteria



Merismopedia

Cyanobacteria

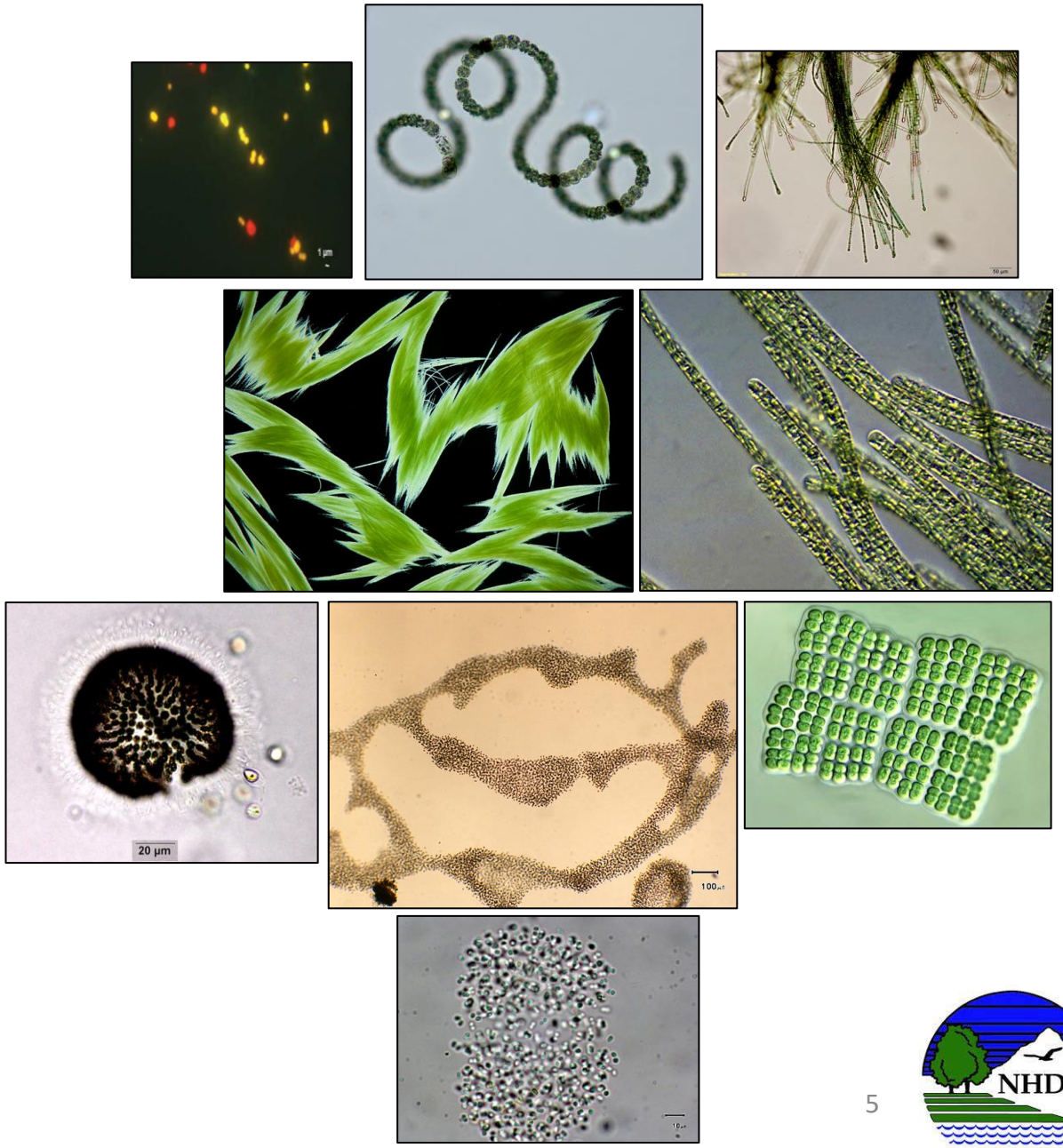
- Originated ~3.5 billion years ago
- Oxygenated the planet with the byproduct of photosynthesis
- Are ubiquitous in aquatic and terrestrial ecosystems
- Diverse group of organisms



The Diversity of Cyanobacteria

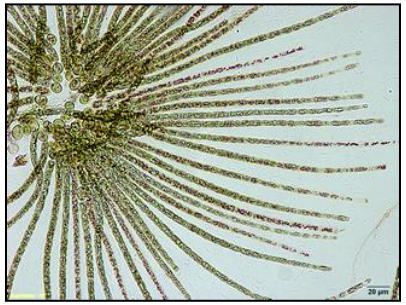
Common Cyanobacteria Genera of New Hampshire	Typical Form Observed	Associated or Known Toxins
Anabaena/Dolichospermum	Filaments	Microcystins, Anatoxin-a, Anatoxin-a (S), Saxitoxins, Cylindrospermopsin
Anabaenopsis	Filaments	Microcystins
Aphanizomenon	Rafts of Filaments	Anatoxin-a, Anatoxin-a (S), Saxitoxins, 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

Credit: Amanda McQuaid



Unique Cyanobacteria

Gloeotrichia
Lake Winnipesaukee
Lake Sunapee

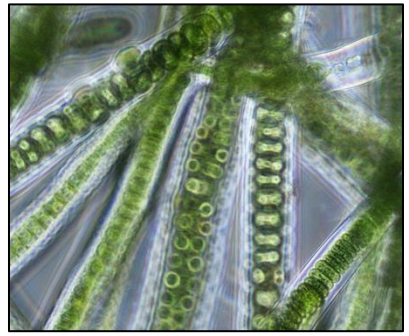


Macroscopic Colonies

Nostoc
Pawtuckaway

Benthic Mats

Stigonematales
Lake Winnipesaukee



Credit: Amanda McQuaid

Cyanobacteria Blooms

- Rapid growth
- Rise to surface and create scums

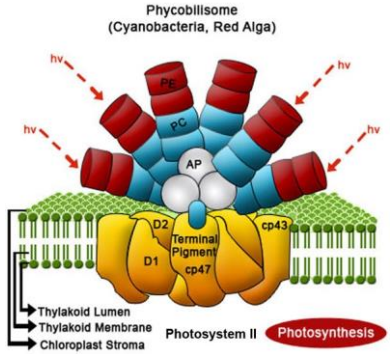
- Blooms are very dynamic
  - Surface during calm mornings, then resuspended in the water column
  - Move to another part of a water body
  - Can last for a single day, to a full summer

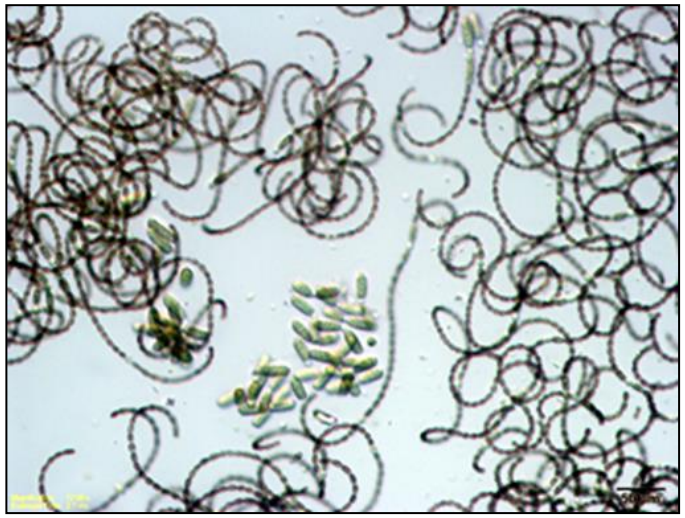
- Unsightly, displeasing
- Ecological damage
- Toxicity of blooms
  - Elevated concentrations can pose a threat to public health
  - Toxicity (type of toxin and amount) can change rapidly over the course of a bloom

Cyanobacteria competitive advantages

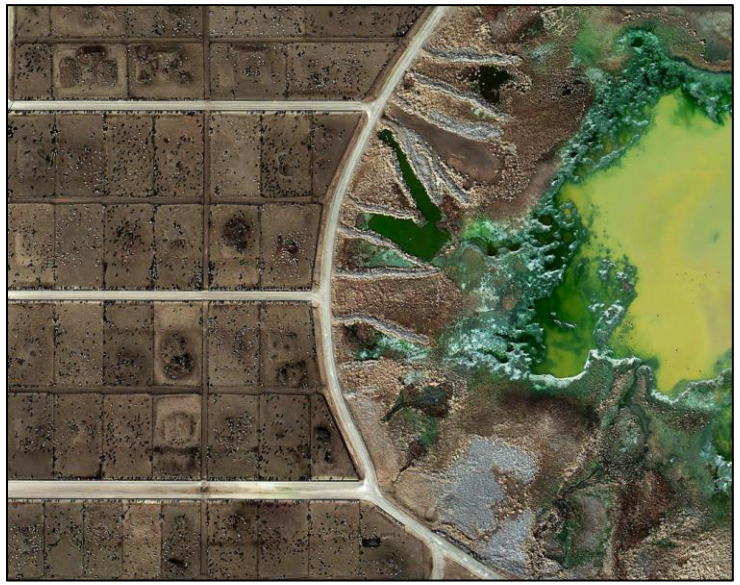
- Phycobilins: Accessory pigments on chlorophyll
  - Expand the range of light the chlorophyll can harvest
  - Phycocyanin (PC), Phycoerythrin (PE), and Allophycocyanin (AP)

- Fix atmospheric nitrogen through special structures called heterocysts
- Akinetes, resting cells that can survive undesirable conditions
- Regulate their buoyancy
  - Move towards nutrients and light





Increasing cyanobacteria blooms



- Eutrophication
  - Excess nutrients from watershed
    - NHDES Fact Sheet on Phosphorus
  - Agriculture, fertilization, land-use changes, urbanization
    - Poorly maintained septic systems
    - Runoff from roads, roofs, lawns, driveways
    - Removing trees and native shoreline vegetation
- Climate change
  - Warmer temperatures, shorter periods of ice cover, longer periods of stratification
  - Extreme weather, different rain patterns
- Increased awareness

Cyanotoxins

Cyanotoxins

- Range of toxins with various modes of action and resulting symptoms
  - Neurotoxins
  - Hepatoxins (liver)
  - Tumor promoters
  - Toxic to multiple organs

- Acute and chronic toxicity in humans, wildlife and pets
  - Individuals with compromised immune systems may have worse reactions

- Documented cyanotoxicity symptoms
  - Dermal irritations, eye and nose irritations, general malaise, fever
  - Nausea, vomiting, diarrhea, gastroenteritis
  - Tingling, numbness, seizures
  - Nervous system and organ failure
  - Death

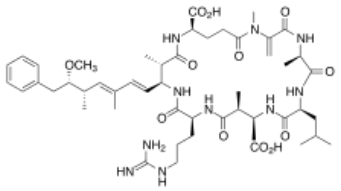
Cyanotoxin	Mode of action and/ or symptoms
★ Microcystins (over 200 variants)	Hepatotoxic, targets the liver and digestive organs, tumor promoting, inhibition of protein phosphatases. Acute gastroenteritis, chronic tumor promotion.
Nodularins (similar in structure to microcystins)	Similar to microcystins, 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
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. (Though individuals may have a genetic precursor).

Notes:

- **This is not a complete list of the cyanotoxins.**
- **Exposure can occur through drinking, food, dietary supplements, inhalation, and/ or by dermal contact, and has occurred by haemodialysis (with contaminated water). Dermal-toxins, causing rashes on skin may occur. Synergistic effects of the cyanotoxins may also occur.**
- **Cyanotoxins may have varying effects on individuals with higher implications for those with a compromised immune system.**

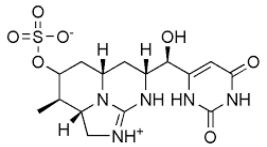
Credit: Amanda McQuaid

NHDES



Microcystins

- Most common cyanotoxins found worldwide, and in NH
- Potent hepatotoxin and tumor promoter
  - Acute and chronic toxicity
- MCs are extremely stable compounds (4-14 days)



Cylindrospermopsin

- Not found as frequently in NH freshwater
- Toxic to multiple organs, neurotoxic and genotoxic
  - Toxicity exerted on kidney, spleen, thymus, heart and gastrointestinal tract
- Not always cell bound – released into the water column during cell growth
- Stable in the environment

Table. Recommended magnitude for cyanotoxins.

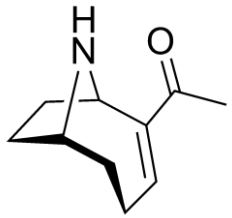
Microcystins	Cylindrospermopsin
8 µg/L	15 µg/L

(EPA, 2019)

Cyanotoxin	Drinking Water Health Advisory (10-day)	
	Bottle-fed infants and pre-school children	School-age children and adults
Cylindrospermopsin	0.7 µg/L	3.0 µg/L
Microcystins	0.3 µg/L	1.6 µg/L

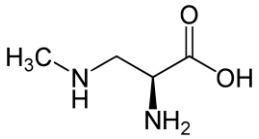
(EPA, 2019)

(Zhang 2015)



Anatoxin-a and anatoxin-a(S)

- Acute toxicity: Very fast death factor
  - Potent neurotoxin
  - Inhibits acetylcholine receptors (neurotransmitter)
  - Seizures and death (common for dogs and other animals to ingest and die)
- Not stable compounds



BMAA

- Non protein encoding amino acid
  - Potentially disrupts protein folding
- Chronic toxicity
  - Potentially leads to ALS and other neurodegenerative diseases
- Bioaccumulates through the food web

Routes of exposure to cyanotoxins

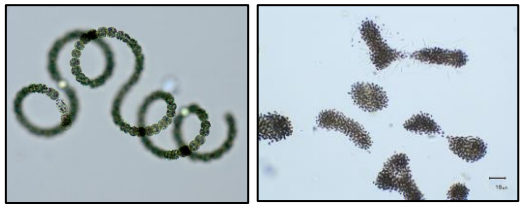
- Ingestion
  - Drinking water
  - Unintentional ingestion via swimming
  - Food
    - Fish
    - Shellfish
    - Supplements
    - Crops – surface and uptake to fruits and leaves
- Inhalation
  - Recreation
  - Showering
  - Living near a lake

Plus some extra on Harvey!

NH Cyanobacteria Advisory Trends Over Time

Microscopic Analysis

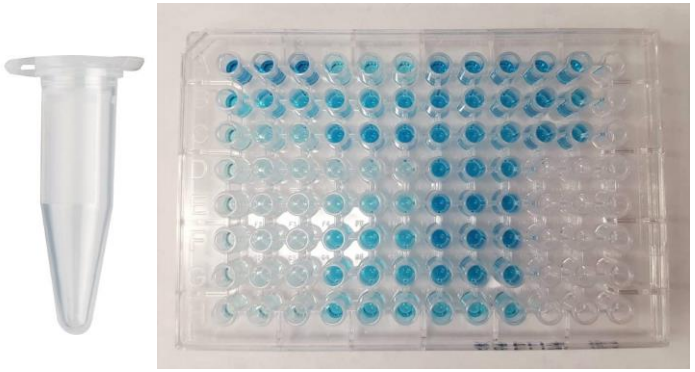
Microscopic Identification and Enumeration



< 70,000 cyanobacteria cells/mL **ALERT** may be issued

> 70,000 cyanobacteria cells/mL **ADVISROY** issued

Toxin Analysis



- Subsamples are taken for future toxin analysis via ELISAs

Table. Recommended magnitude for cyanotoxins.

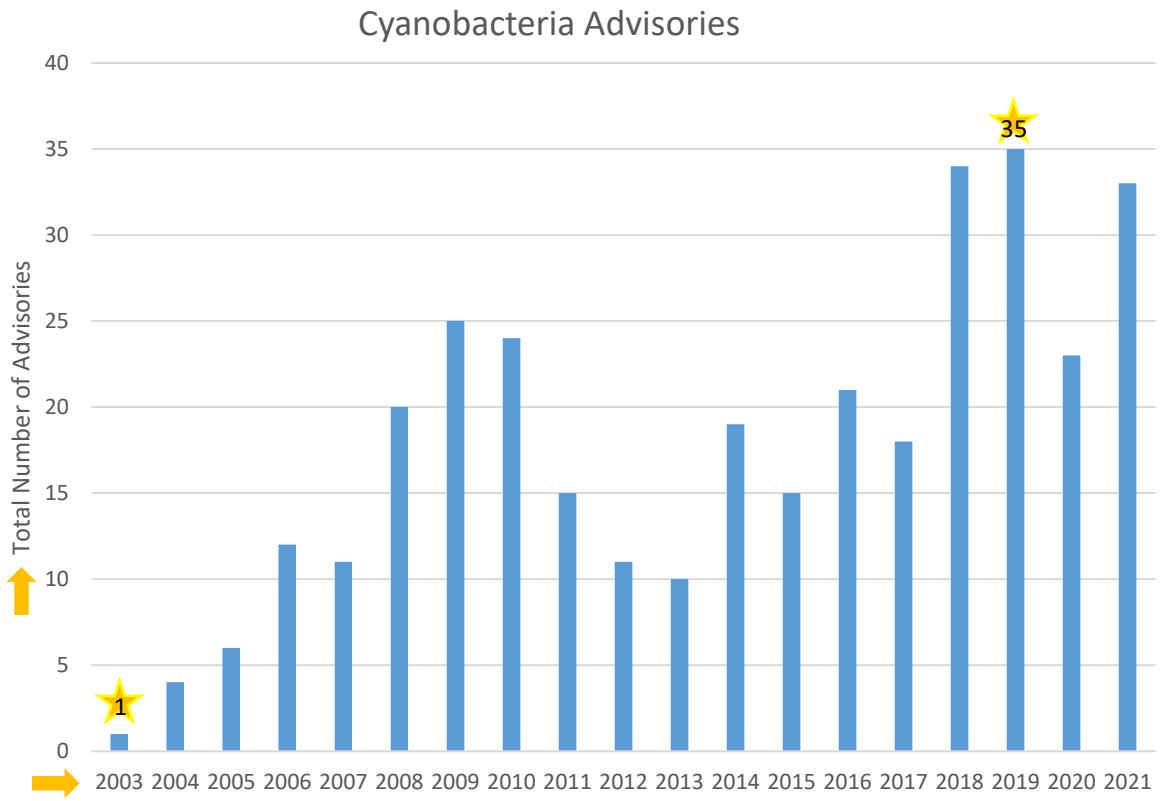
Microcystins	Cylindrospermopsin
8 µg/L	15 µg/L

(EPA, 2019)

70,000 cells/mL

- Limitations: expensive, time intensive, delayed results, many different cyanotoxins

Cyanobacteria Advisories Over Time



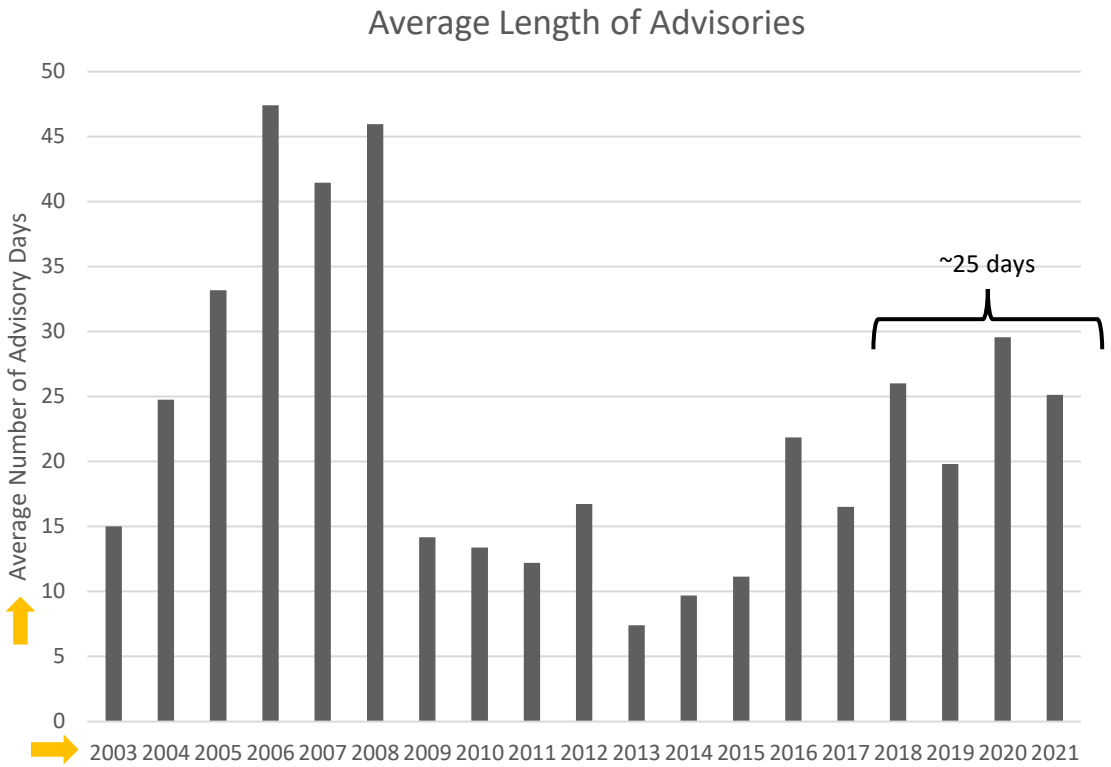
(2022, 42 advisories, 33 waterbodies)

- Some water bodies have multiple advisories per year
  - 2021, 33 advisories, 27 waterbodies
- While there has been an increase in total advisories over time, there is not a significant increase in advisory days since 2003
- Reaction-based program
  - Samples are primarily collected when they're reported
  - Increased public awareness
  - More reports = more advisories
- Advisories keep people and pets safe!

Date Adivsory Issued	Dominant Taxa	Total Cell Count (cells/mL)
6/8/2009	*Dolichospermum*	> 70,000
9/9/2020	*Chrysosporum*	375,000
8/9/2021	*Microcystis, Woronichinia, Dolichospermum*	2,230,000
9/8/2021	*Microcystis, Woronichinia*	>70,000
8/19/2022	*Chrysosporum, Woronichinia, Dolichospermum*	129,600

"How long is this going to last"

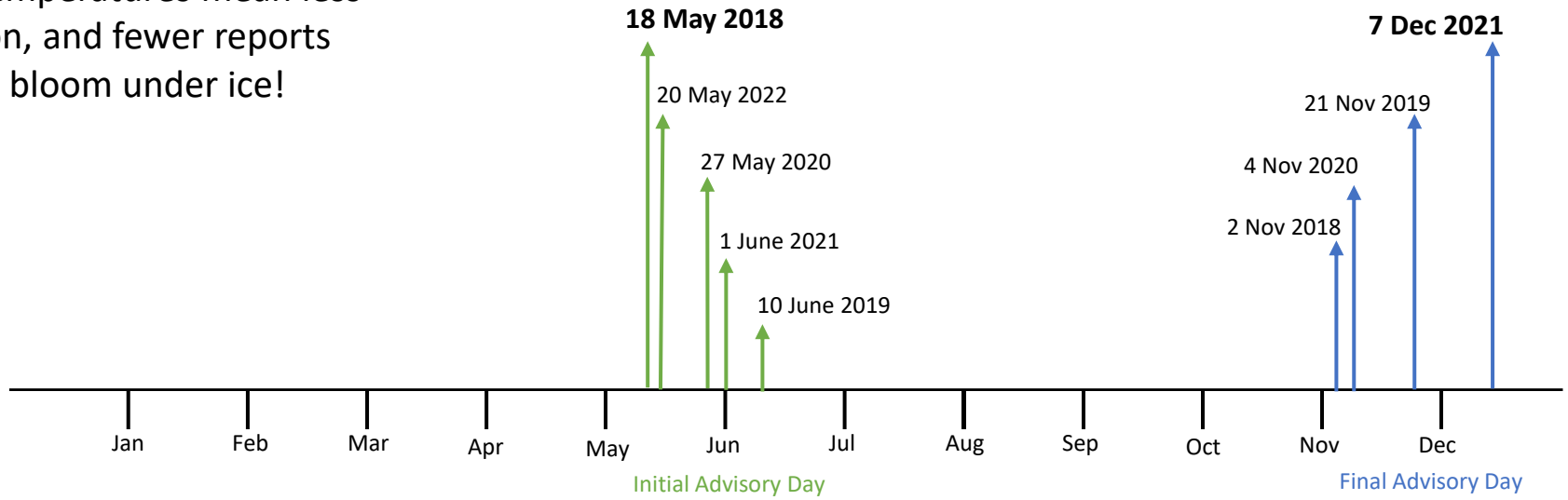
- Depends on many factors
  - Water body, nutrient inputs, weather, etc.
- In the last four years:
  - Shortest advisory was 2 days
  - Longest advisory was 132 days



Date Adivsory Issued	Dominant Taxa	Total Cell Count (cells/mL)	Number of Advisory Days
6/8/2009	*Dolichospermum*	> 70,000	8
9/9/2020	*Chrysosporum*	375,000	58
8/9/2021	*Microcystis, Woronichinia, Dolichospermum*	2,230,000	25
9/8/2021	*Microcystis, Woronichinia*	>70,000	47
8/19/2022	*Chrysosporum, Woronichinia, Dolichospermum*	129,600	33 days so far

Seasonality of Advisories

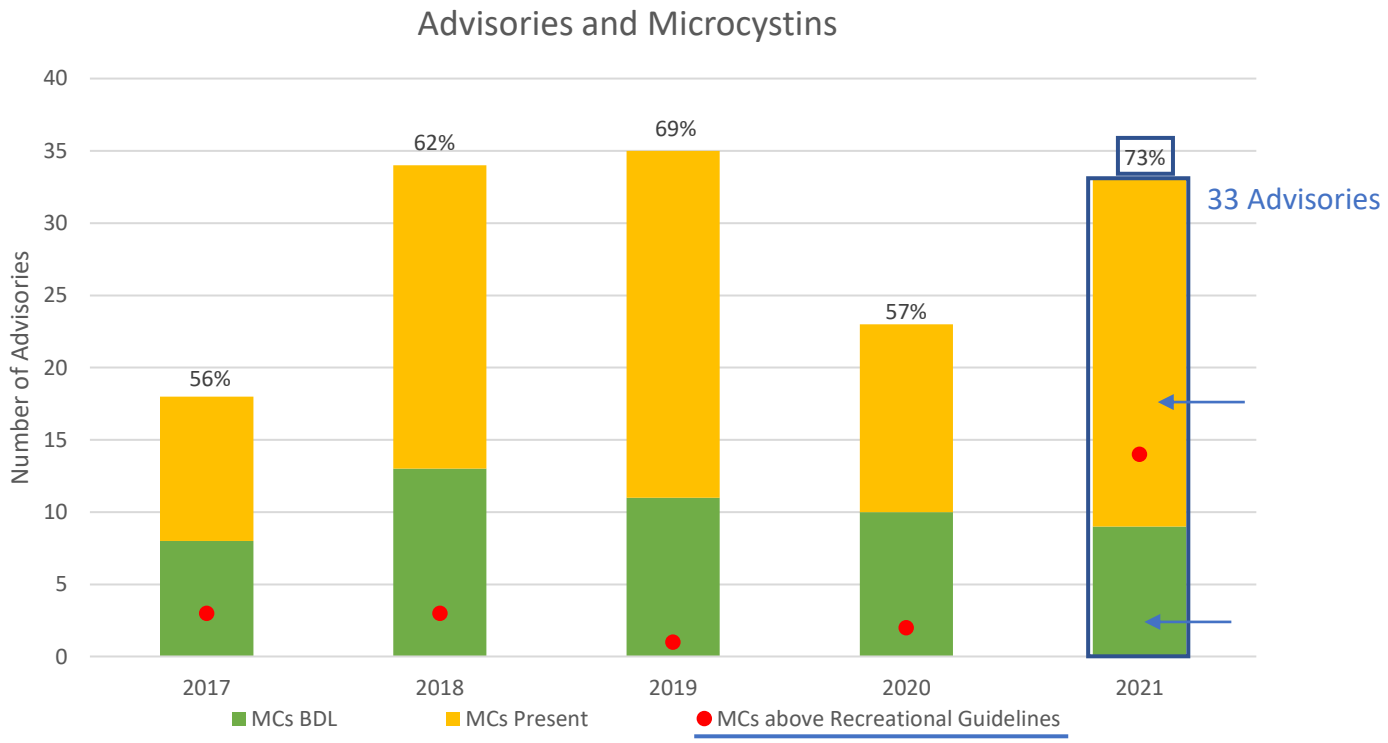
- NHDES has issued cyanobacteria advisories from May through December
  - Primarily during the typical growing season
  - Colder temperatures mean less recreation, and fewer reports
  - They can bloom under ice!



Date Adivsory Issued	Dominant Taxa	Total Cell Count (cells/mL)	Number of Advisory Days	Date Adivosry Removed
6/8/2009	*Dolichospermum*	> 70,000	8	6/16/2009
9/9/2020	*Chrysosporum*	375,000	58	11/6/2020
8/9/2021	*Microcystis, Woronichinia, Dolichospermum*	2,230,000	25	9/3/2021
9/8/2021	*Microcystis, Woronichinia*	>70,000	47	10/25/2021
8/19/2022	*Chrysosporum, Woronichinia, Dolichospermum*	129,600	33 days so far	Ongoing

Microcystins (MCs) in NH Cyanobacteria Blooms

*** Types and **levels** of cyanotoxicity can vary unpredictably



- Percent of advisories with detectable MCs varies per year
  - 56% to 73%
- Number of advisories with toxin levels above the 8 µg/L recreational limit varies
  - 1 to 14

Microcystins are not the only cyanotoxin. . .

2020 Cyanotoxin Analysis

*** **Types** and levels of cyanotoxicity can vary unpredictably

Below Detectable Level
Toxin Present
Toxin above Recreational Guideline (MCs and CYN only)
Not Tested

Advisory Number	Dominant Cyanobacteria Taxa	Date Advisory Issued	# of Advisory Days	MCs (ppb)	CYN (ppb)	ATX (ppb)	BMAA (ppb)
1	*Anabaena/Dolichospermum, Microcystis, Woronichinia*	5/27/2020	14				
2	*Dolichospermum (D. lemmermannii)*	6/2/2020	8				
3	*Dolichospermum (D. lemmermannii)*	6/3/2020	7				
4	*Microcystis, Woronichinia*	6/9/2020	10				
5	*Anabaena/Dolichospermum, Woronichinia, Oscillatoria*	6/17/2020	2				
6	*Anabaena/Dolichospermum*	6/19/2020	5				
7	*Microcystis, Woronichinia, Dolichospermum*	6/29/2020	52				
8	*Planktothrix, Aphanocapsa, Pseudoanabaena*	7/10/2020	66				
9	*Woronichinia*	7/10/2020	132				
10	*Planktothrix*	7/16/2020	47				
11	*Chrysosporum, Planktothrix, Spirulina*	7/16/2020	61				
12	*Anabaena/Dolichospermum, Microcystis, Aphanizomenon*	7/20/2020	10				
13	*Planktothrix*	7/30/2020	46				
14	*Dolichospermum (D. lemmermannii)*	7/30/2020	6				
15	*Anabaena/Dolichospermum*	8/12/2020	14				
16	*Anabaena/Dolichospermum, Microcystis*	8/17/2020	37				
17	*Planktothrix*	8/18/2020	24				
18	*Anabaena/Dolichospermum, Microcystis*	8/18/2020	17				
19	*Microcystis wesenbergii*	9/4/2020	19				
20	*Chrysosporum*	9/9/2020	58				
21	*Scytonema, Stigonema, Tolypothrix, Lyngbya*	9/10/2020	27				
22	*Microcystis, Aphanizomenon, Woronichinia, Dolichospermum*	9/29/2020	10				
23	*Woronichinia, Microcystis, Dolichospermum*	10/14/2020	8				

No toxins present

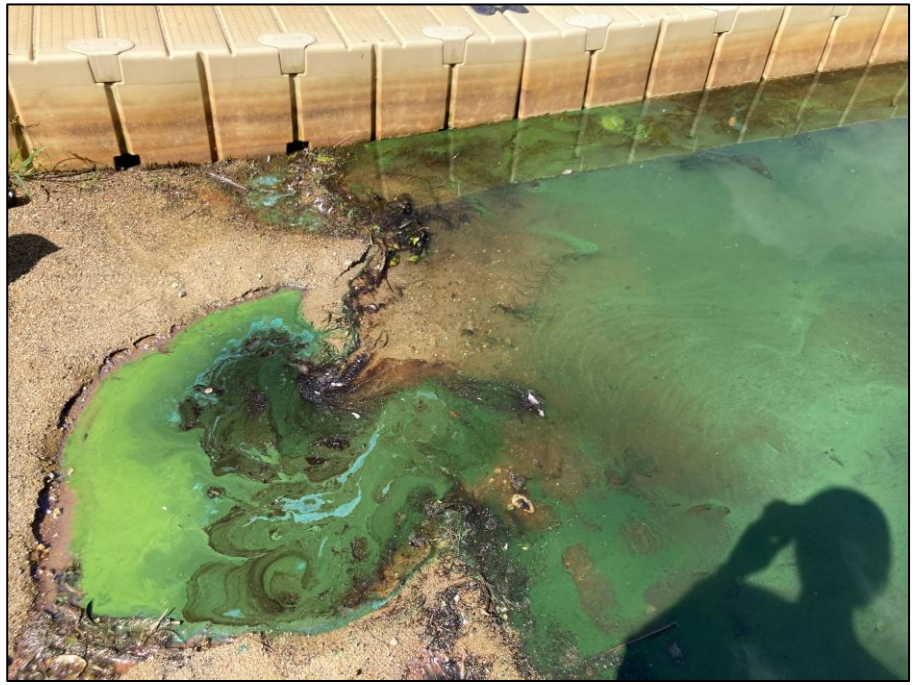
All toxins present

Majority have a mix of toxins

Cell counts help standardize our response, instead of focusing on just one toxin.

Credit: Amanda McQuaid

NHDES



Cyanobacteria Management and Prevention

How do you manage cyanobacteria blooms?

- No quick fix
  - Removing cyanobacteria through chemical treatment
    - Temporary solution

Watershed Management plans
- Long term solution
- Identify sources of nutrients and other pollutants
- Describe actions required to address those sources
- Support funding applications to implement the plans restoration and protection actions

Projects
- Replacing septic systems
- Protecting land
- Changing road grading
- Fixing culverts
- Revegetating shorelines
- Actions to reduce runoff (permeable pavers)
- Outreach – educate landowners, municipal officials, lake users about water quality

What can you do to help prevent Cyanobacteria HABs

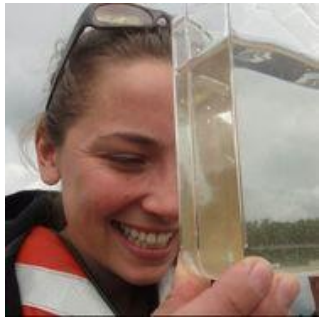
- Avoid phosphorus fertilizers
- Lake-friendly landscaping
- Septic systems inspected annually, pumped every two to three years

Programs to Help

- NH Lakes LakeSmart program
  - Free, voluntary, non-regulatory program
  - Evaluate structures, yard, driveway etc and give recommendations
  - Contact NH LAKES
- Soak Up the Rain
  - Guidance on DIY projects to protect your property and reduce nutrient runoff
  - Contact lisa.loosigian@des.nh.gov

Credit: Amanda McQuaid

Thank you!



NH LAKES

Questions?

Report a bloom by emailing photos and a description to: HAB@des.nh.gov

General cyanobacteria information on our website:
https://www.des.nh.gov/water/healthy-swimming/harmful-algal-blooms
Current Beach Advisories Map:
https://www4.des.state.nh.us/WaterShed_BeachMaps/
Cyanobacteria Advisories History:
https://nhdes.maps.arcgis.com/apps/webappviewer/index.html?id=1f45dc20877b4b959239b8a4a60ef540

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NHDES