Cyanobacterial growth on Cayuga Lake: what we do and don’t know about “HABs”

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Outreach and Programs Coordinator
Cayuga Lake HABs Monitoring Program Coordinator
Community Science Institute (CSI)
Community Science Institute’s Mission

To partner with community-based volunteer groups to better understand and protect local streams and lakes by collecting and disseminating scientifically credible, regulatory-quality data that inform long-term, sustainable management strategies.
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Outline

What is a “harmful algal bloom”?  
- Types of HABs  
- Cyanobacteria

Impacts of freshwater HABs
- Impacts on humans  
- Impacts on aquatic life

HABs on Cayuga Lake
- CSI’s Cayuga Lake HABs Monitoring Program  
- Cayuga Lake HABs patterns

Photo by Jeanne Sullivan, CSI HABs volunteer
What is a “Harmful Algal Bloom”?

“Harmful algal bloom” is largely a misnomer!

Marine “harmful algal blooms”
Aka “red tides”

Freshwater “harmful algal blooms”

Dinoflagellates

Diatoms

Cyanobacteria

Photo by Flickr User AJC1

Photo by Joni Dropkin, CSI HABs volunteer
What is a “Harmful Algal Bloom”?

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Marine “harmful algal blooms”
Dinoflagellates
Diatoms

Freshwater “harmful algal blooms”
Cyanobacteria

Impacts of Freshwater HABs
HABs on Cayuga Lake
What is a “Harmful Algal Bloom”?

Cyanobacteria

Photos by Holly Davidson and Joni Dropkin, CSI HABs volunteers

What is a Harmful Algal Bloom?  Impacts of Freshwater HABs  HABs on Cayuga Lake
What are cyanobacteria?
A LITTLE HISTORY LESSON
How cyanobacteria changed the world

~4.5B YEARS AGO
A LITTLE HISTORY LESSON

How cyanobacteria changed the world

~4.5B YEARS AGO

~3.8B YEARS AGO
A LITTLE HISTORY LESSON

How cyanobacteria changed the world

~2.7B YEARS AGO
A LITTLE HISTORY LESSON
How cyanobacteria changed the world

~4.5B

~3.8B

~2.7B

~2.4 - 2.1B YEARS AGO

What is a Harmful Algal Bloom?  Impacts of Freshwater HABs  HABs on Cayuga Lake
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~4.5B
~3.8B
~2.7B
~2.4 - 2.1B
~1B
~>1B
~200M YEARS AGO
~480M YEARS AGO
~250,000 YEARS AGO

What is a Harmful Algal Bloom?  Impacts of Freshwater HABs  HABs on Cayuga Lake
Cyanobacteria

Part of a healthy, balanced, normal freshwater ecosystem
When do they become “harmful”?

A “HAB” is an explosive population growth of these cyanobacteria, which may produce toxins.
What causes blooms?
What is a Harmful Algal Bloom?

Impacts of Freshwater HABs

HABs on Cayuga Lake
What is a Harmful Algal Bloom?

Impacts of Freshwater HABs

HABs on Cayuga Lake

- sunlight
- increased temperature
- still conditions
What is a Harmful Algal Bloom?

- Impacts of Freshwater HABs
- HABs on Cayuga Lake

- Sunlight
- Increased temperature
- Still conditions
- Nutrients

[Diagram showing sunlight, increased temperature, still conditions, and nutrients affecting harmful algal blooms.]
What is a Harmful Algal Bloom?

Cyanobacteria

First photosynthesizers

Grow in certain conditions

Photo by Joni Dropkin, CSI HABs volunteer
Who cares if their populations are exploding?
Cyanobacteria produce chemical compounds

<table>
<thead>
<tr>
<th>Beneficial compounds</th>
<th>Harmful compounds (“cyanotoxins”)</th>
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<td>• Anti-cancer drugs</td>
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Namikoshi and Rinehart 1996, Singh et al. 2011
Impacts on humans

What is a Harmful Algal Bloom?

Impacts of Freshwater HABs

HABs on Cayuga Lake
Broad impacts on the ecosystem

Anoxic conditions

Out-competing other primary producers

Carmichael and Boyer 2016, Bownik 2016, Babica et al. 2006
### Cyanobacteria produce chemical compounds

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What is a Harmful Algal Bloom?  
Impacts of Freshwater HABs  
HABs on Cayuga Lake

Namikoshi and Rinehart 1996, Singh et al. 2011
Cyanotoxin / Zooplankton interactions

Microcystin’s possible impacts:
- Mortality
- Decreased digestion
- Decreased motility

What is a Harmful Algal Bloom?
Impacts of Freshwater HABs
HABs on Cayuga Lake
Cyanotoxin / crustacean interactions

Mollusks and crustaceans seem to be more tolerant of microcystin concentrations, but this is variable.

red swamp crawfish
Cyanotoxin / Amphibian interactions

Microcystin’s possible impacts:
• Altered enzyme activity
• Delayed hatching
• Susceptibility to parasites

the green frog

Buss et al. 2019, Mehinto et al. 2021
Cyanotoxin / Fish interactions

Microcystin’s possible impacts:
• Skeletal malformations
• Oxidative stress
• Increased heart rate

Brown trout
Rainbow trout

Mehinto et al. 2021, Best et al. 2001, Gélinas et al., 2012
Impacts of Freshwater HABs

Cyanotoxins

Threats to humans

Threats to wildlife

What is a Harmful Algal Bloom?  Impacts of Freshwater HABs  HABs on Cayuga Lake
CSI’s Harmful Algal Bloom Monitoring Program

- 5 years and counting
- 146 volunteers
- Most thorough HABs monitoring in New York State

CSI’s publicly available Cayuga Lake HABs map – updated in real time
What is a Harmful Algal Bloom? > Impacts of Freshwater HABs > HABs on Cayuga Lake

**HAB "HARRIER" DUTIES**

- **See a HAB?**
  - **No**
    - Report "No Bloom" to CSI
  - **Yes**
    - Collect a sample and deliver to CSI lab

**Flowchart Description**

- **Weekly HAB shoreline survey**
- **Wait for the following week**

Note: "harrier" comes from the verb harry, to harass or attack repeatedly. As in "a harrier hawk attacks small game." This term was applied to our HABs volunteers to describe their vigilance.
What is a Harmful Algal Bloom?

Impacts of Freshwater HABs

HABs on Cayuga Lake

*Chlorophyll $a$ can stem from organisms besides cyanobacteria, making this a rough estimate of bloom density.

**Microcystin is only one of the possible cyanotoxins generated by cyanobacteria. It is a measure of toxicity from microcystin toxin, not of toxicity overall.
HABs on Cayuga Lake: data collected

Data from volunteers:
- Location
- Time and date
- Photos
- Descriptions

Data from CSI lab:
- Cyanobacteria composition
- Chlorophyll $a$ concentration
- Microcystin toxin concentration

<table>
<thead>
<tr>
<th>Bloom Sample Code</th>
<th>Microscopy</th>
<th>Total Chlorophyll $a$</th>
<th>Microcystin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Description</td>
<td>Analysis Date</td>
<td>Result in ug/L</td>
</tr>
<tr>
<td>22-3456-B1</td>
<td>sparse/medium Dolichospernum</td>
<td>7/22/2022</td>
<td>117</td>
</tr>
<tr>
<td>22-3480-B1</td>
<td>dense Microcystis, sparse/medium Dolichospernum, Pseudosanabaena present</td>
<td>8/7/2022</td>
<td>2448</td>
</tr>
<tr>
<td>22-3458-B1</td>
<td>dense Microcystis, sparse/medium Dolichospernum, sparse Limnolobus, Pseudosanabaena</td>
<td>8/11/2022</td>
<td>2065</td>
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A note about chlorophyll $a$ and microcystin toxin

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<td>$&lt;$ 0.30</td>
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<tr>
<td>22-3475-B3</td>
<td>sparse Microcystis, sparse Oscillatoria, sparse Merismopedia, Pseudoanabaena present</td>
<td>8/8/2022</td>
<td>21.8</td>
<td>8/8/2022</td>
<td>4.58</td>
<td>8/19/2022</td>
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<tr>
<td>22-3402-B3</td>
<td>dense Microcystis, sparse/moderate Dolichospermum, Pseudoanabaena present</td>
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<td>2448</td>
<td>8/8/2022</td>
<td>916.00</td>
<td>8/12/2022</td>
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<tr>
<td>22-3458-B4</td>
<td>dense Microcystis, sparse/moderate Dolichospermum, sparse Limnoraphis, Pseudoanabaena</td>
<td>9/11/2022</td>
<td>2905</td>
<td>9/12/2022</td>
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Non-bloom chlorophyll $a$ levels: $\leq 25 \, \mu g/L$
A note about chlorophyll $a$ and microcystin toxin

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Microcystin limits (set by NY State Dept. of Health):
- Drinking water limit: ≤0.3 µg/L
- Contact recreation limit: ≤4 µg/L

It is NEVER safe to swim in a bloom! Always keep pets and children away from blooms!
What is a Harmful Algal Bloom?

Impacts of Freshwater HABs

HABs on Cayuga Lake

Number of recorded HABs decreases in 2022 for the first time

<table>
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<th>Monitoring Year</th>
<th>Number of Cyanobacteria Blooms (HABs)</th>
<th>Concentration of microcystin toxin</th>
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<tr>
<td>2018</td>
<td>40</td>
<td>Greater than 4.0 μg/L: 22 (55%)</td>
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<td></td>
<td></td>
<td>Between 0.3 μg/L and 4.0 μg/L: 2 (5%)</td>
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<td>Less than 0.3 μg/L: 9 (23%)</td>
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<tr>
<td></td>
<td></td>
<td>Not Tested for Microcystin: 7 (17%)</td>
</tr>
<tr>
<td>2019</td>
<td>67</td>
<td>Greater than 4.0 μg/L: 28 (42%)</td>
</tr>
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<td></td>
<td></td>
<td>Between 0.3 μg/L and 4.0 μg/L: 8 (12%)</td>
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<td>Less than 0.3 μg/L: 24 (36%)</td>
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<td></td>
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<td>Not Tested for Microcystin: 7 (10%)</td>
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<td>2020</td>
<td>78</td>
<td>Greater than 4.0 μg/L: 55 (71%)</td>
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<td>Between 0.3 μg/L and 4.0 μg/L: 15 (19%)</td>
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<td>2021</td>
<td>102</td>
<td>Greater than 4.0 μg/L: 60 (59%)</td>
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<td>Between 0.3 μg/L and 4.0 μg/L: 16 (16%)</td>
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<td>Greater than 4.0 μg/L: 42 (58%)</td>
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<td>Between 0.3 μg/L and 4.0 μg/L: 10 (14%)</td>
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Dolichospermum sp.
What is a Harmful Algal Bloom?  

Impacts of Freshwater HABs  

HABs on Cayuga Lake

Microcystis sp.
Cayuga Lake Cyanobacteria

*Dolichospermum* sp. and *Microcystis* sp. are Cayuga Lake’s most common bloom-forming cyanobacteria.
What is a Harmful Algal Bloom?

Impacts of Freshwater HABs

HABs on Cayuga Lake

Cayuga Lake HABs – cyanobacteria

July

August

= Dolichospermum sp.

September

= Microcystis sp.
Cayuga Lake HABs – cyanobacteria

= Dolichospermum sp.

= Microcystis sp.
Cayuga Lake HABs – cyanobacteria

- July
  - = *Dolichospermum* sp.

- August
  - = *Microcystis* sp.

- September
  - = *Microcystis* sp.
What is a Harmful Algal Bloom?

Impacts of Freshwater HABs

HABs on Cayuga Lake

Cayuga Lake HABs – cyanobacteria

July

August

September

= Dolichospermum sp.

= Microcystis sp.
In Microcystis-dominated blooms, chlorophyll $a$ and microcystin toxin are highly correlated.
Spatial Patterns

microcystin toxin recreation limit: ≤4 µg/L
Spatial Patterns

- ~50%
- ~75%

>4µg/L = high in microcystin toxin
62% of **all HABs** observed occur north of Sheldrake Point

80% of HABs high in microcystin toxin occurred north of Sheldrake Point

>4µg/L = high in microcystin toxin
44% of all HABs observed occur in the northern ¼ of Cayuga Lake

64% of HABs high in microcystin toxin occurred in the northern ¼ of Cayuga Lake

>4µg/L = high in microcystin toxin
Why are Cayuga Lake HABs different on the northern vs. southern end?
Why are Cayuga Lake HABs different on the northern vs. southern end?

Potential explanations:
- Nutrients
- Shallow water
  - Warmer water
  - Higher density of *Microcystis*

O’Leary et al. 2019
Plankton Net Surveys

8 locations are regularly surveyed during non-bloom conditions.

Surveys demonstrate denser populations of *Microcystis* sp. at the north end of the lake.
HABs on Cayuga Lake

HABs are (mostly) increasing

Main cyanobacteria:
- Microcystis sp.
- Dolichospermum sp.

CSI volunteers!

Cayuga Lake’s northern portion sees worse HABs
HABs Database

Coming soon...March 2023
Sources


Ways to support CSI

- Donate
- Join our online community
- Volunteer
- Purchase CSI apparel
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Email us at info@communityscience.org to become a volunteer!

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