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HABs Formation: Beyond Nutrients and Temperature (Inland low nutrient lakes edition)

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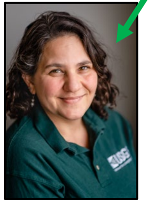
U.S. Department of the Interior
U.S. Geological Survey

Owasco Lake
Photo courtesy of NYSDEC



Upper Saranac Lake
Photo courtesy of NYSDEC

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Two approaches for study of HABs in low nutrient lakes:

1. USGS/DEC Finger Lakes CyanoHABs Advanced Monitoring Pilot
2. USGS Adirondack CyanoHABs projects

How can we measure cyanoHABs in deep, low nutrient lake systems?

- Phytoplankton enumeration
- Cyanotoxin analysis
- Cyanotoxin synthetase genes
- 16S RNA (Omics)
- Chlorophyll
- Akinetes
- Algal Pigments
- Passive toxin trackers
- Satellite/hyperspectral imagery


Photo courtesy of USGS


Photo courtesy of NYSDEC

Where can we measure cyanoHABs in deep, low nutrient lake systems?

- At the surface
- Throughout the water column
- Along the shoreline
- Drinking water intakes
- In the sediment
- From space

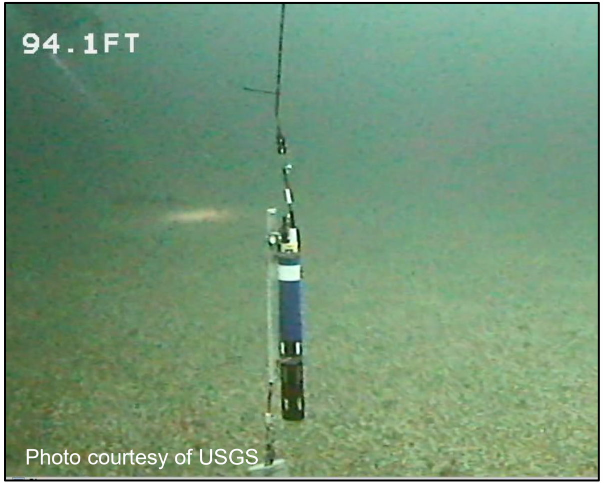

Photo courtesy of USGS

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If a cyanoHAB occurs in the woods…

- Known rates of cyanoHAB occurrence are constrained by monitoring/reporting programs.
- Anecdotal evidence of toxin-producing blooms in low nutrient systems don't fit the paradigm
- Blooms are sometimes sparse and short-lived.
- Lots of unknowns regarding causes and transport in stratified lakes.

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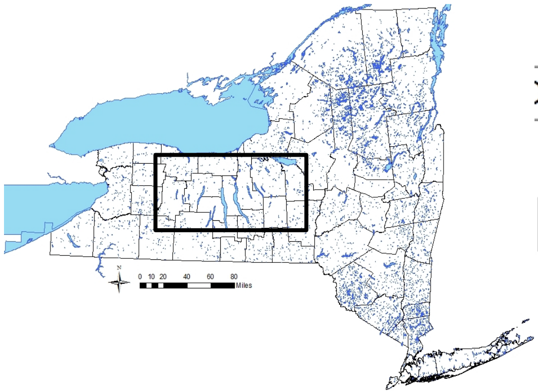
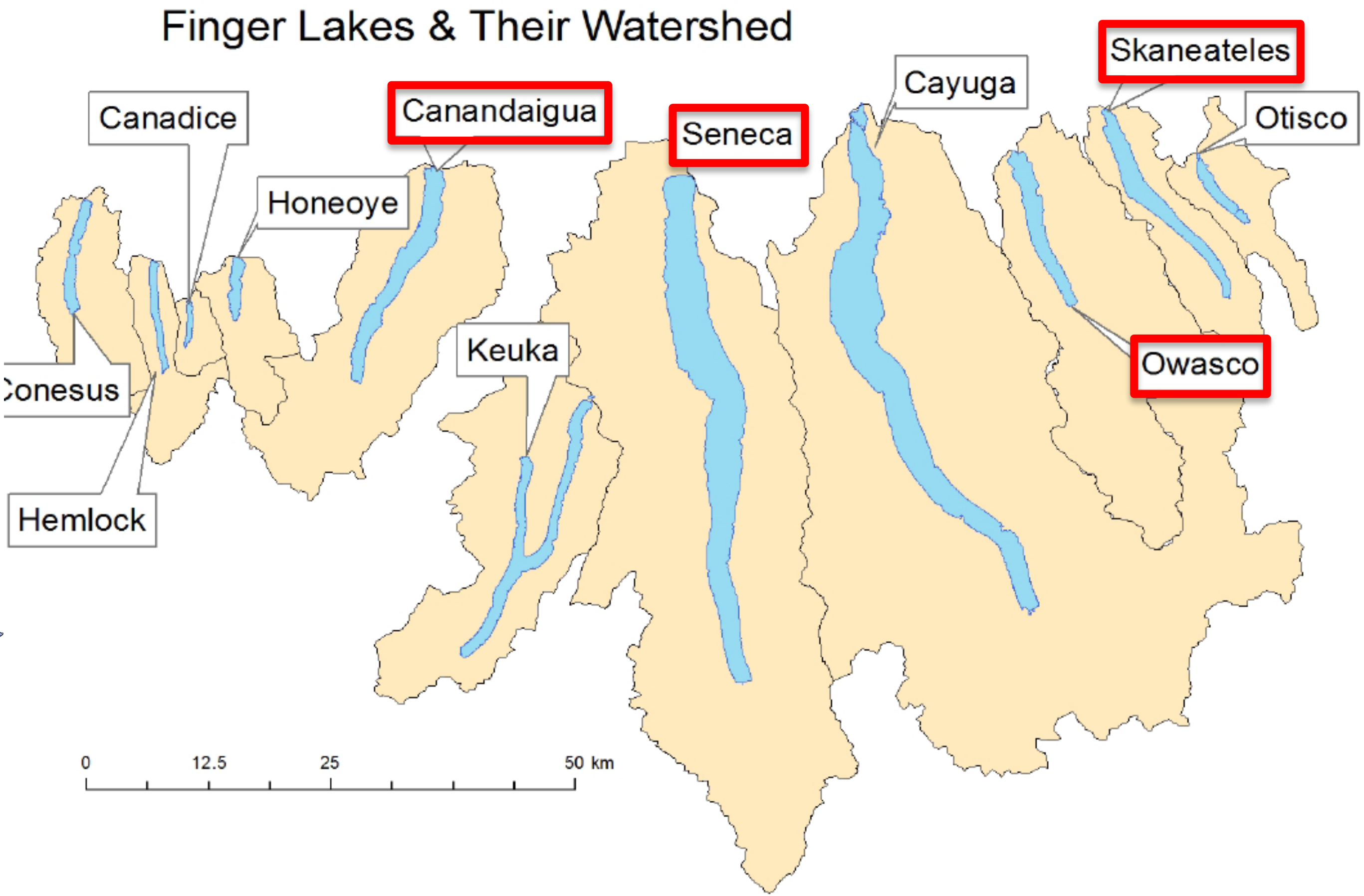
Mean Annual Water Quality of study lakes (per NYSDEC)

- TP: 0.005 – 0.011 mg/L
- Chl a: 1.1 – 5.2 µg/L





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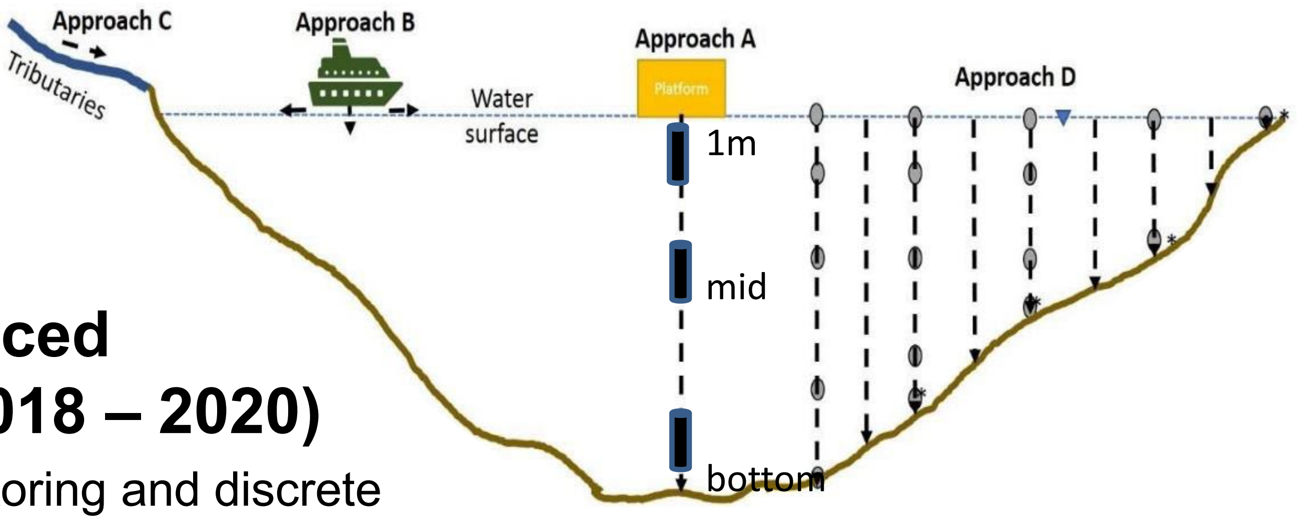

CyanoHABs Advanced Monitoring Pilot (2018 – 2020)

A) In-lake continuous monitoring and discrete sampling (USGS)

B) Tributary discrete sampling and shoreline mapping (USGS)

C) Intensive water-quality sampling of tributaries upstream of the lakes (NYSDEC)

D) Intensive lake characterization (NYSDEC)

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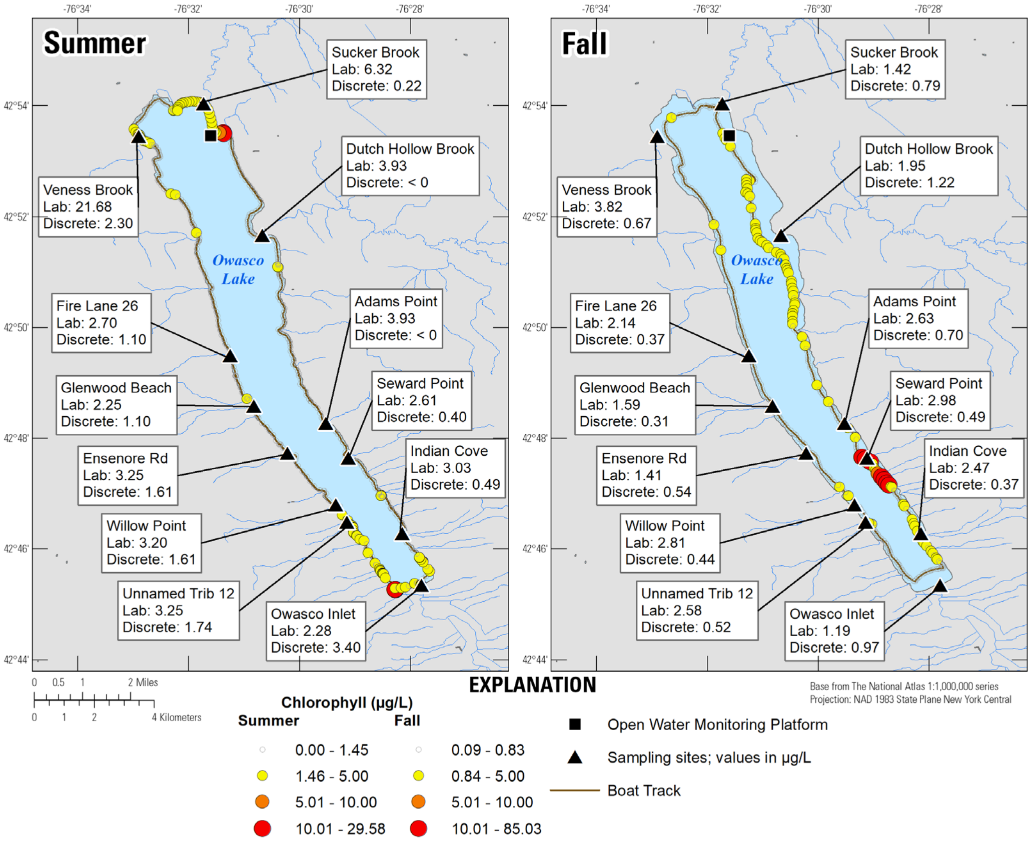
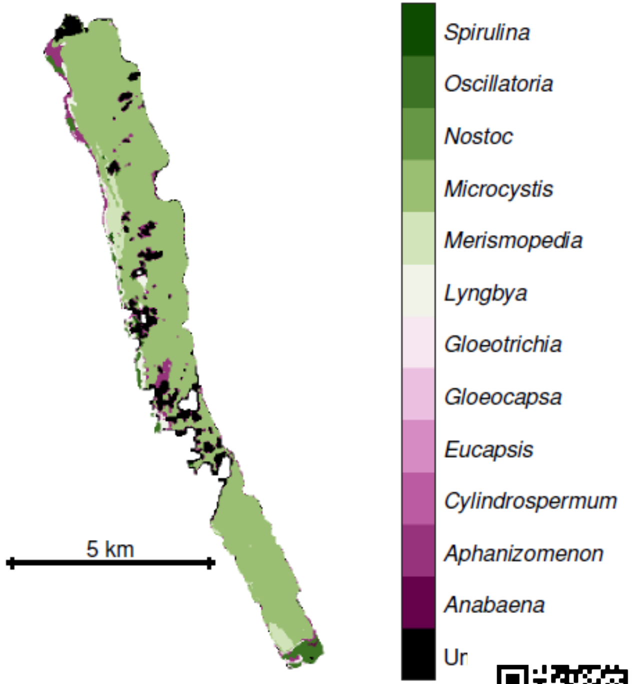
Photo courtesy of USGS

Lake Surface Conditions





Multiple endmember spectral mixture analysis-based classification of algal genera derived from a DESIS image. From Legleiter et al., 2022

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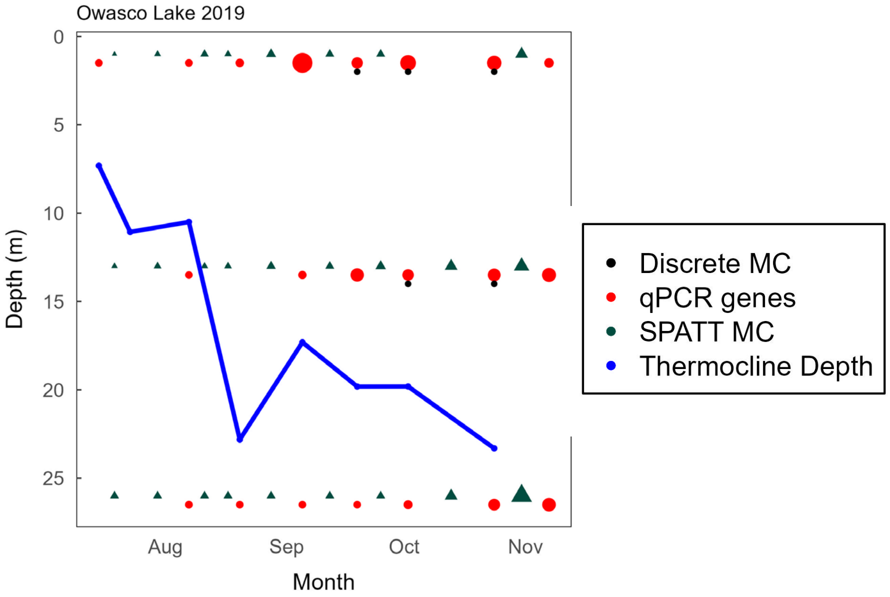
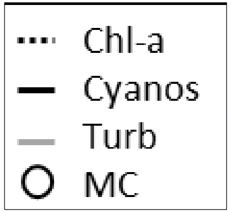
Preliminary Information-Subject to Revision. Not for Citation or Distribution.

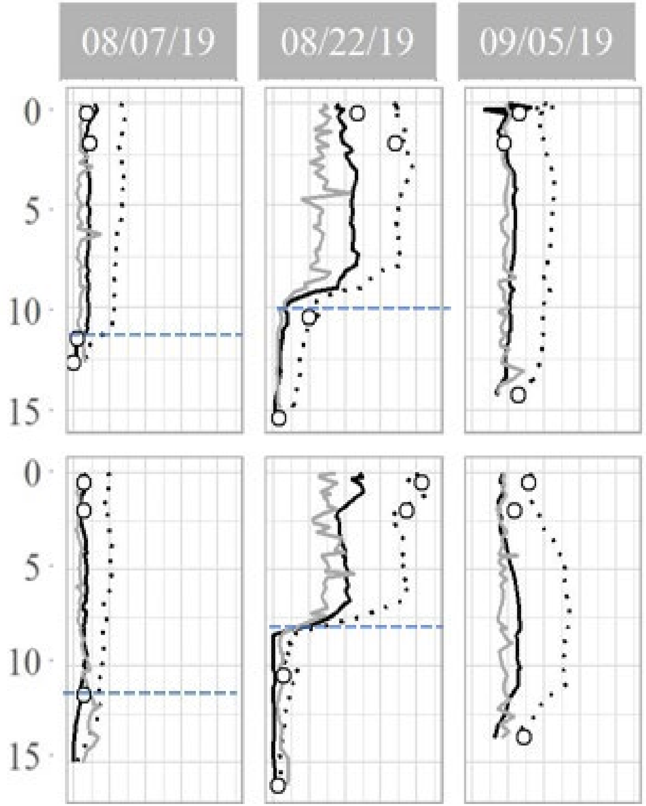
Water Column Conditions

- Cyanos & microcystin (MC) are present mid lake first, then move to the shore, and eventually downward.



Canandaigua Lake 2019





From Prestigiacomo et al., 2023.

Findings

- Low nutrient, ephemeral cyanoHAB lakes are boring most of the time
- Advancements: Evaluated novel sensors, compared phytoplankton enumeration methods, interpretation of hyperspectral imagery, use of passive samplers and much more
- Able to correlate sensor data to discrete water-quality samples
- No silver bullet for nutrients

Dissemination as of 1/18/2024
Several USGS & DEC Publications:

Type	Number
Peer Reviewed Journal Article	4
USGS Series Publication	6
USGS Data Release	8
MS Thesis	1

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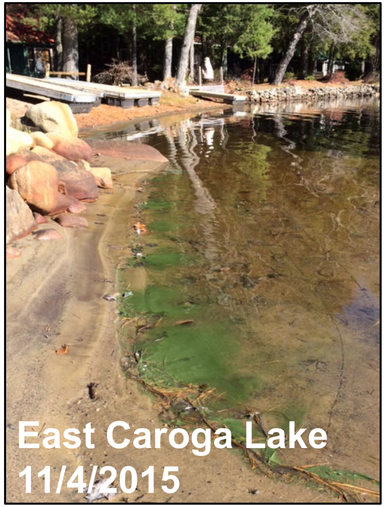
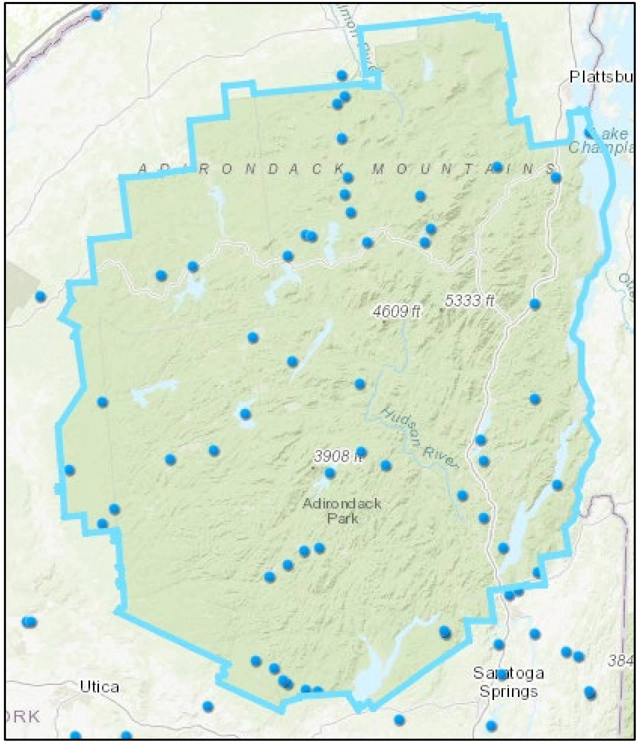
Adirondack Region

- Adirondack Park was created in 1892, in part to protect water quality
- Largest publicly protected area in the lower 48 states; ~6 mil. acres
- Approximately 2,770 lakes
- Recovering from a long period of acidification

Are HABs getting worse in the ADKs?





Locations that with Confirmed HAB reports (2012-2021); map and photos courtesy of NYS DEC.

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Why are cyanobacteria blooms occurring in oligotrophic (low nutrient) lakes?

- How does the cyanobacteria community compare in lakes without (**HAB No**) and those with (**HAB Yes**) observed & reported blooms?
- New(er) Methods:
  - Akinetes (resting stages of cyanobacteria) in sediment
  - Polymerase Chain Reaction (qPCR) to quantify cyanotoxin synthetase gene copies

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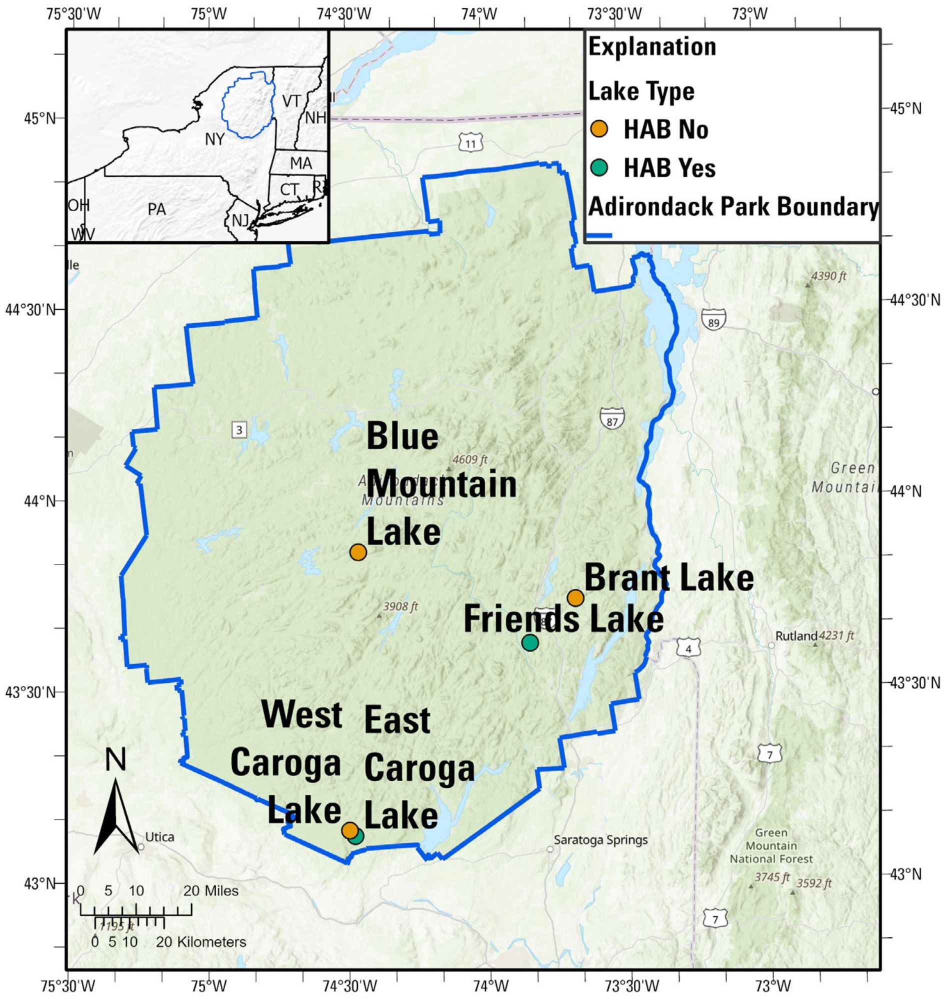
Study Design

- Selected for:
  - ✓ Inside Adirondack Park
  - ✓ History of oligotrophic conditions
  - ✓ Ongoing water quality monitoring
  - ✓ Lake pairs: **HAB No** ↔ **HAB Yes**
- Surface Water
  - Volunteer monitoring of basic WQ parameters
  - Vertical profiles, phytoplankton, qPCR
- Bottom Sediment
  - Akinetes, qPCR



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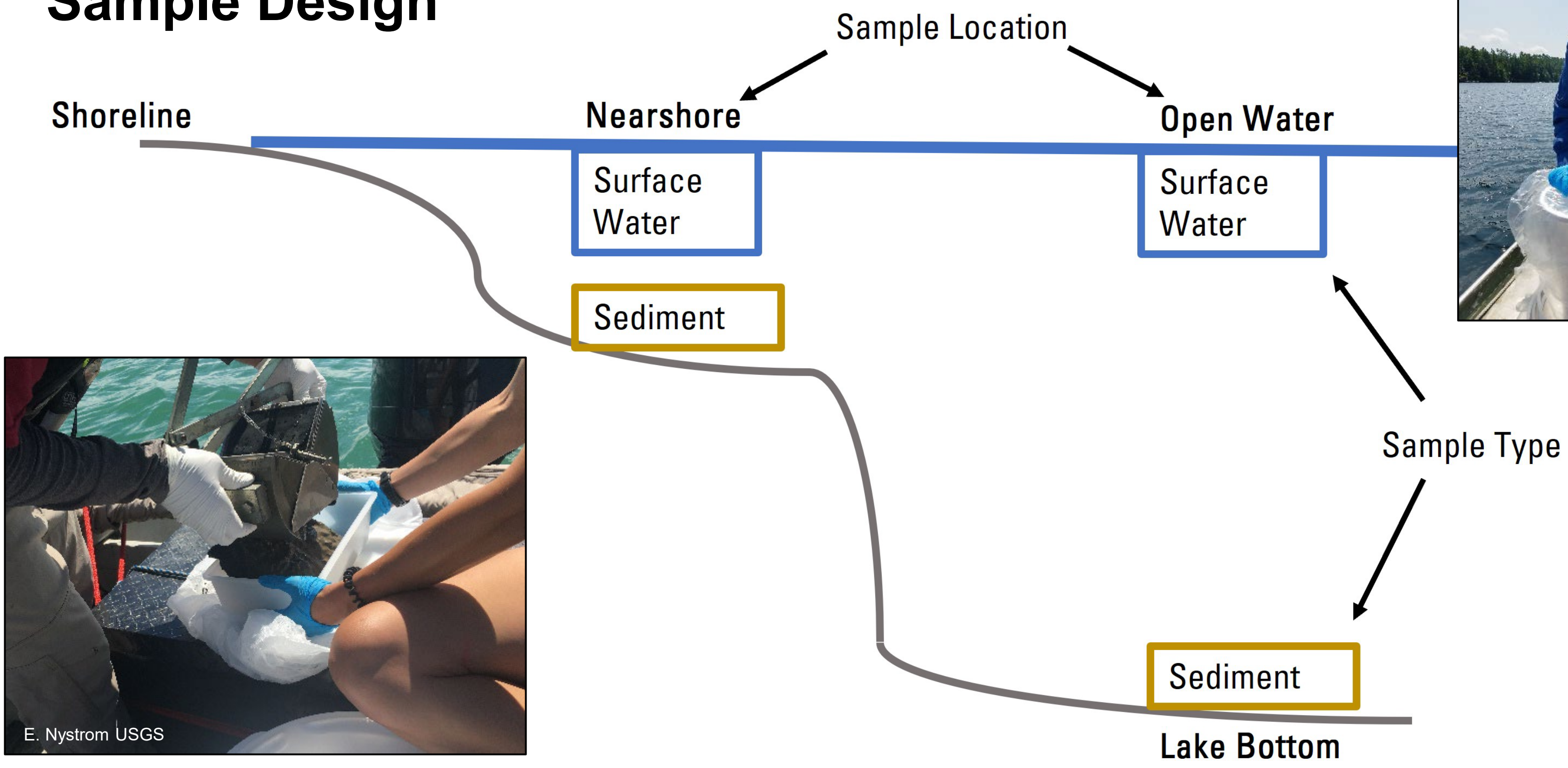
Sample Design



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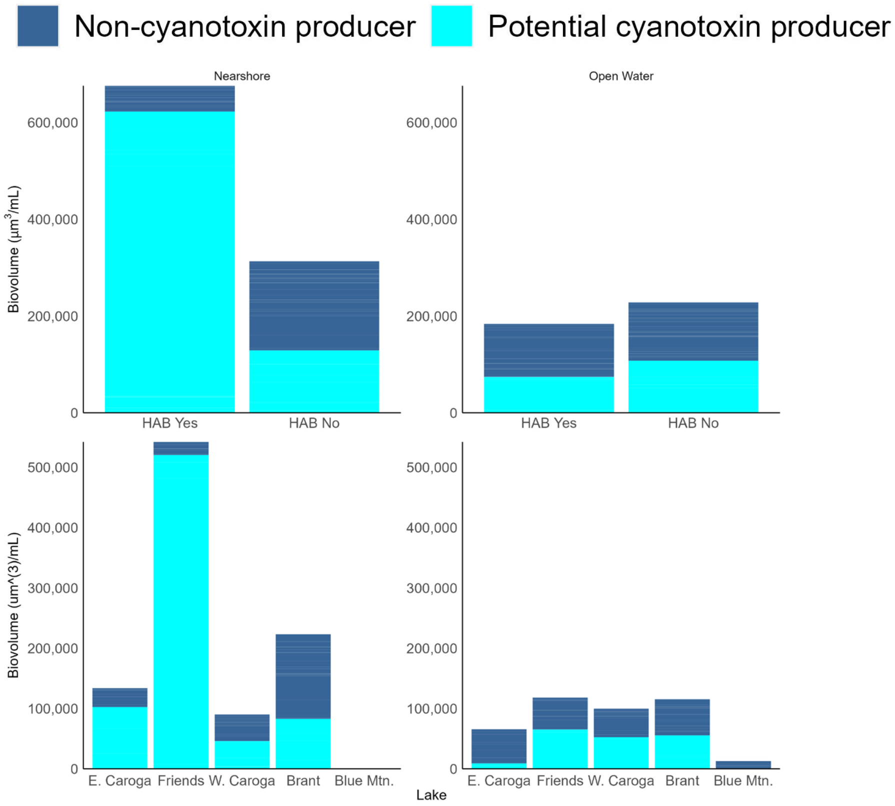
Cyanobacteria community composition



- In the nearshore, HAB Yes lakes dominated by toxin-producing taxa.
- In the open water, more cyanobacteria was present at HAB No lakes and community composition was similar.

Akinetes (resting stages) in sediment

- More Akinetes in **HAB Yes** systems
- Detected several cyanobacteria genera in **HAB No** lakes as well as **HAB Yes** lakes

Cyano Genus	Brant Lake	Friends Lake	West Caroga Lake	East Caroga Lake	Blue Mountain Lake*
Anabaena	Y	Y	Y	Y	Y
Aphanizomenon	Y	Y		Y	
Calothrix	Y	Y	Y	Y	
Dolichospermum	Y	Y	Y		
Gloeotrichia	Y	Y	Y	Y	
Microcystis				Y	

* Note: Only 1 sample collected in Blue Mountain Lake compared to 6 in other lakes

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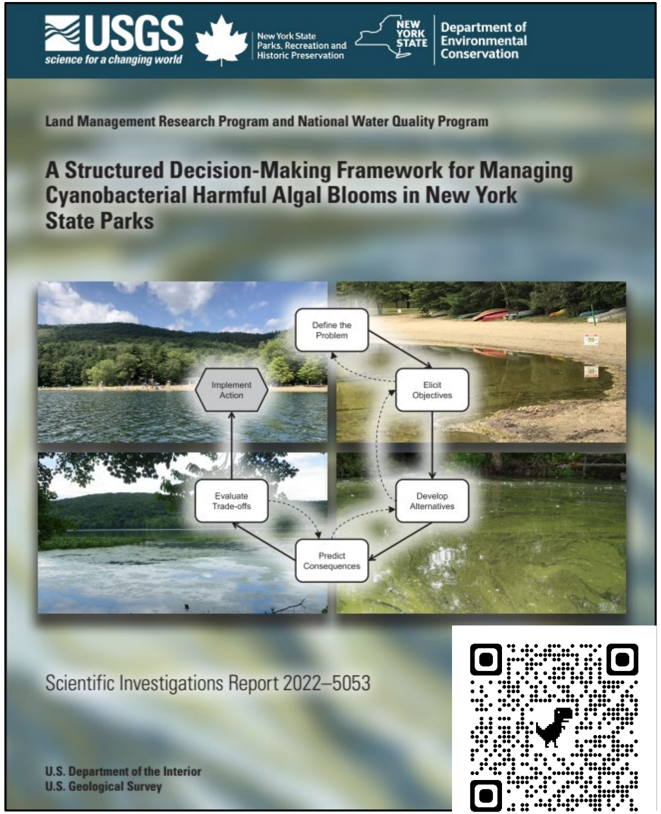
Are CyanoHABs a new phenomenon in these systems?



- Structured Decision-Making process for Moreau Lake, a low-productivity, oligotrophic lake:
  - Secchi disk clarity = 7.4 m
  - TP = 0.006 mg/L
  - Chl a = 1.6 µg/L
- What changed to lead to *Gloeotrichia* blooms and beach closures?
- How to communicate system changes to visitors?

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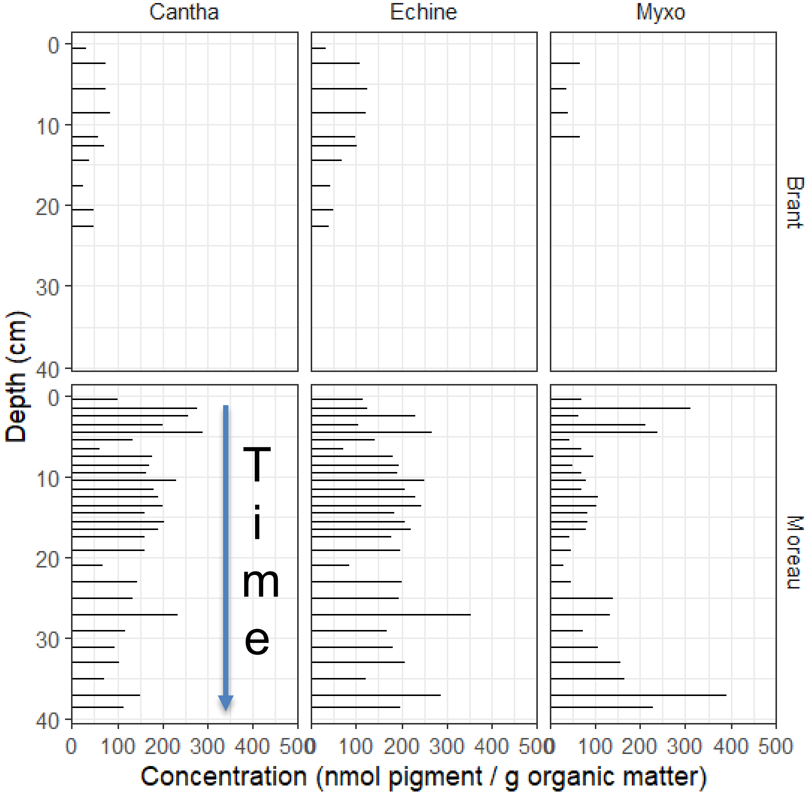
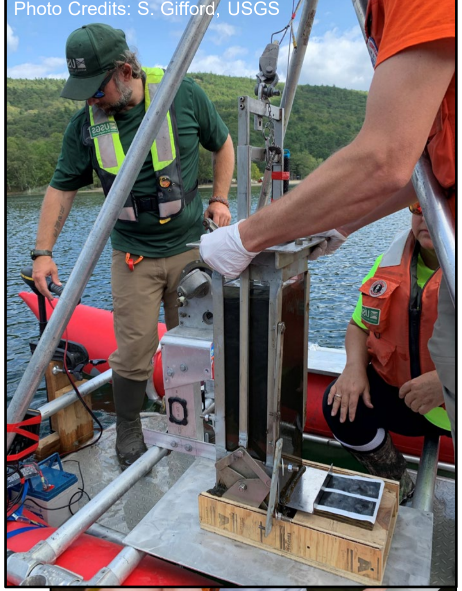
Paleolimnology - Lake Sediments

- Took a single core (Sept. '22) from the deep spot of each lake using a box corer. Age dating back to over 170 years.





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Conclusions & Next steps

- Adirondack lakes were more similar than we hypothesized. Several lines of evidence that cyanos are plentiful (or have the potential to be) in lakes without reported blooms.
- Finger Lakes cyanoHABs were ephemeral and complex in multiple dimensions. Better understanding of representativeness across new methods.
- Further publications and new projects coming soon.

Questions?

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Join our session at ASLO Madison, WI in June! Email me for more info.

Acknowledgements:

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