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A Paleolimnological Approach to Understand the History of Cyanobacterial Occurrence in Oligotrophic Adirondack Lakes

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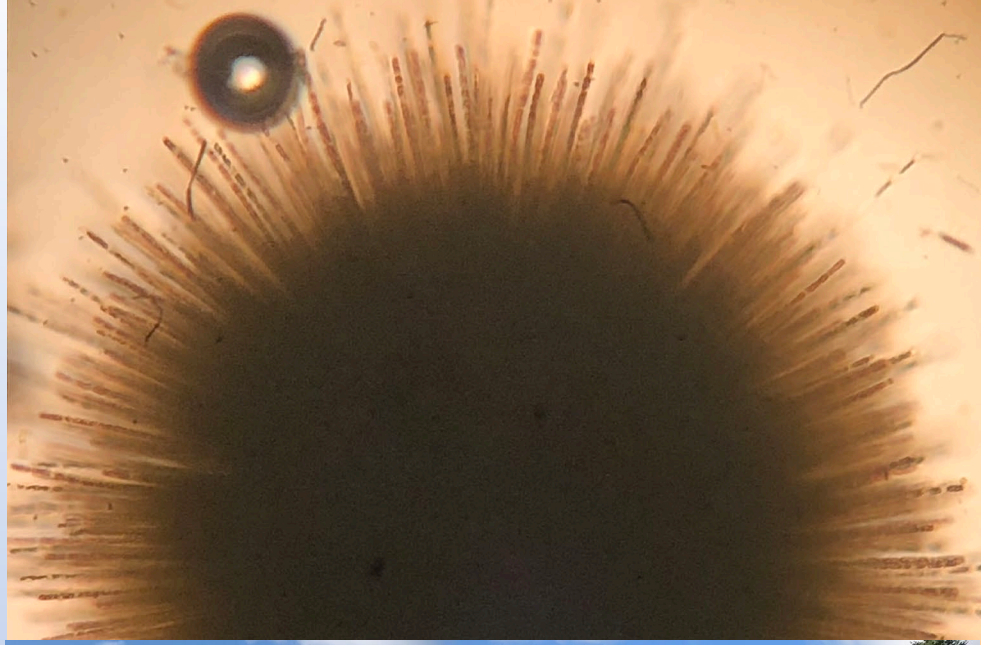
Problem

- Oligotrophic (low nutrient) lakes in New York sometimes experience cyanobacteria blooms
- Moreau Lake has been experiencing annual summer *Gloeotrichia* blooms since 2018 with no cyanobacteria blooms reported before that year
- Causes a loss of recreational opportunities at a state park



Beach Closure due to *Gloeotrichia* Bloom on Moreau Lake
September 2022 Photo Credit: Sabina Gifford

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Structured Decision Making

- USGS hosted a workshop focused on mitigating Cyanobacterial Harmful Algal Blooms at Moreau Lake
- Found that they couldn’t decide on which management approach to take based on critical uncertainty surrounding the cause of the CyanoHABs at Moreau

Photo Credit: New York State Parks, Recreation, and Historic Preservation

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Structured Decision Making Workshop - Moreau

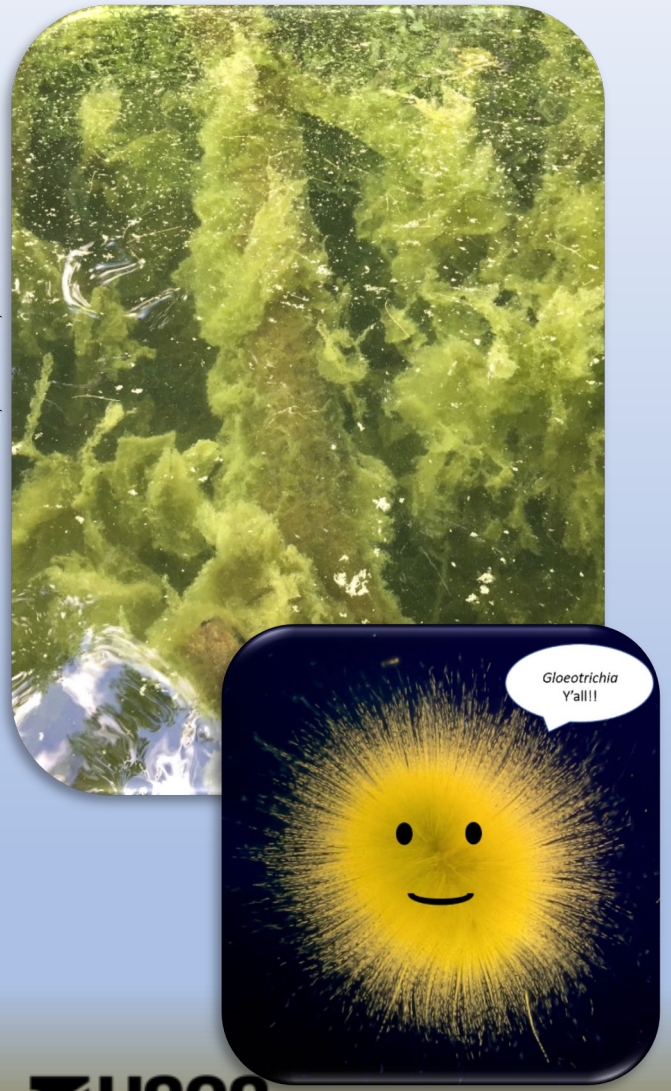

Photo Credit: New York State Parks, Recreation, and Historic Preservation

Photo Credit: B. Rosen, USGS

- Evaluation of the alternatives against the objectives may depend on the cause of the blooms
- Potential hypotheses:
  - HABs are part of a natural pattern → Alternative 1
  - HABs are part of a new norm driven by climate change → Alternative 2
  - Historic activities changed flow patterns and aquatic community → Alternative 3
  - One-time combination of events allowed establishment of HABs → Alternative 4

This study

- First crack at answering some of the critical uncertainty
- Using paleolimnological proxies to look back in time at cyanobacteria populations
- Focusing on Moreau Lake but also collected a core in Brant Lake for comparison
  - *Gloeotrichia* akinetes were found in the sediment during a previous USGS study
  - No blooms have been reported at Brant

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Tangent: *Gloeotrichia* are super cool

- Common bloom former in Oligotrophic Lakes (and eutrophic lakes)
- Can store nutrients, specifically P within the colony
- Recruits/rises from the sediments into the water column in the summer
- May be an important contributor to phosphorus cycles in stratified lakes
- Known toxin producer – Microcystin, a hepatotoxin
- But as with most understudied species of cyanobacteria, it's still unclear how often or how much they produce toxins

Photo Credit: John Dufresne - UNH

Study Sites

- Brant Lake (557 ha) has a mean depth of 9.1 m and is a reservoir that was created in the early 1900's via damming.
- Moreau Lake is smaller (52 ha), has a mean depth of 9.8 m, and is a glacial kettle lake. Moreau lake has no inlet stream, being almost exclusively fed by groundwater

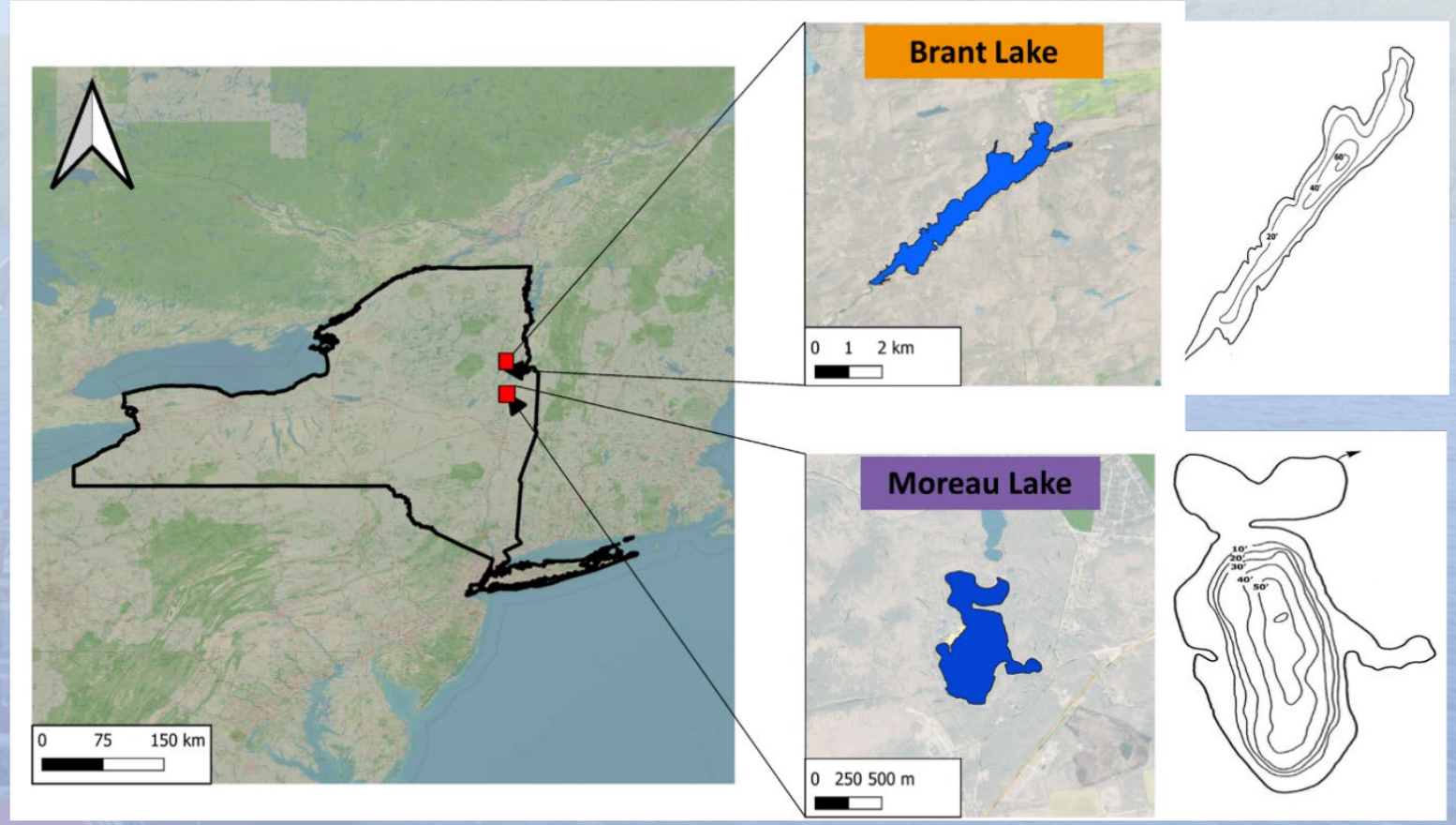

Figure 1: Locations of Brant Lake and Moreau Lake in New York, USA.

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Gloeotrichia from Moreau Lake Sep 2022 Photo Credit: Sabina Gifford

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Sample Processing

- Process/subsample core on shore
  - In the shade where possible to prevent degradation of the pigments
  - With additional QA/QC measures to limit contamination of genetic material from one core section to the next.

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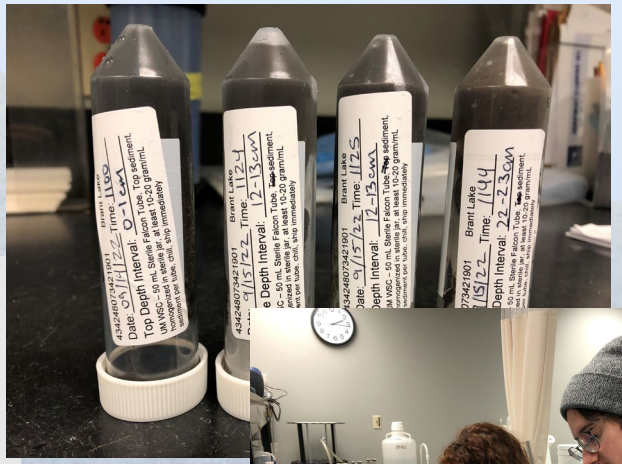
Lab Analyses

- Radionucleotide age dating
- Akinete enumeration
- Algal pigment analysis
- Cyanobacteria genus specific 16S genetic analysis
- Algal culturing and metabarcoding
- *%Carbon, %Nitrogen*
- *DOM Optical Property Analysis*



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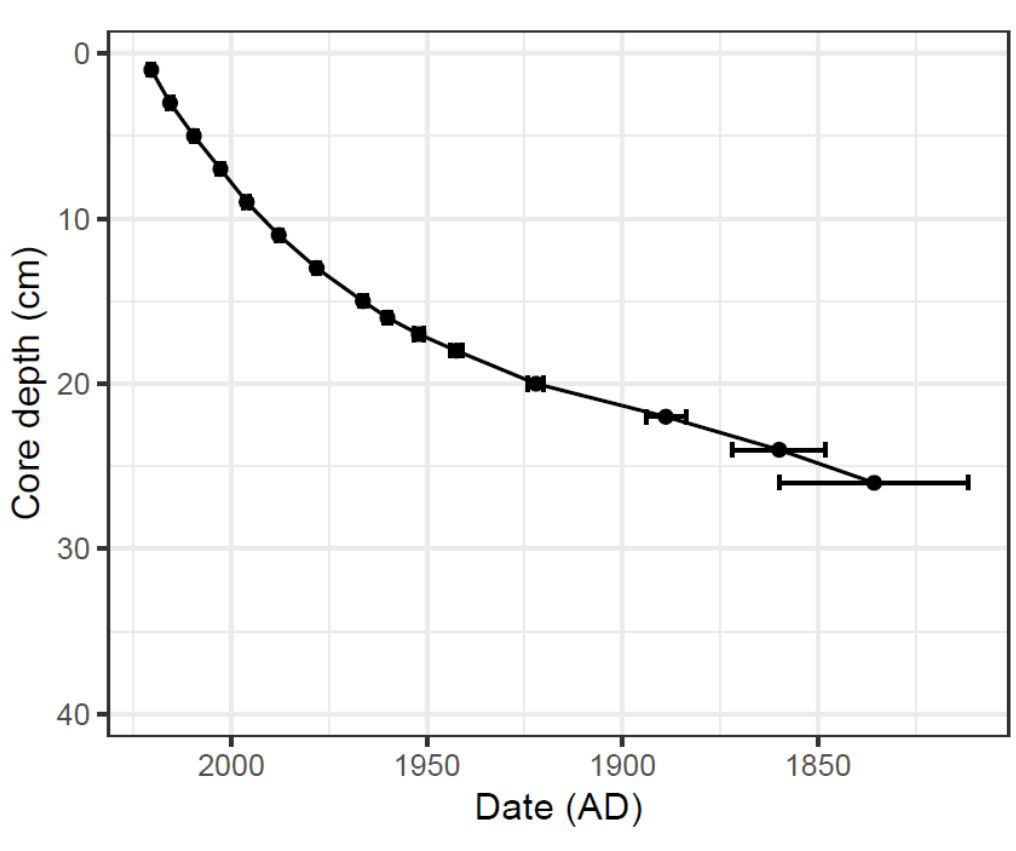
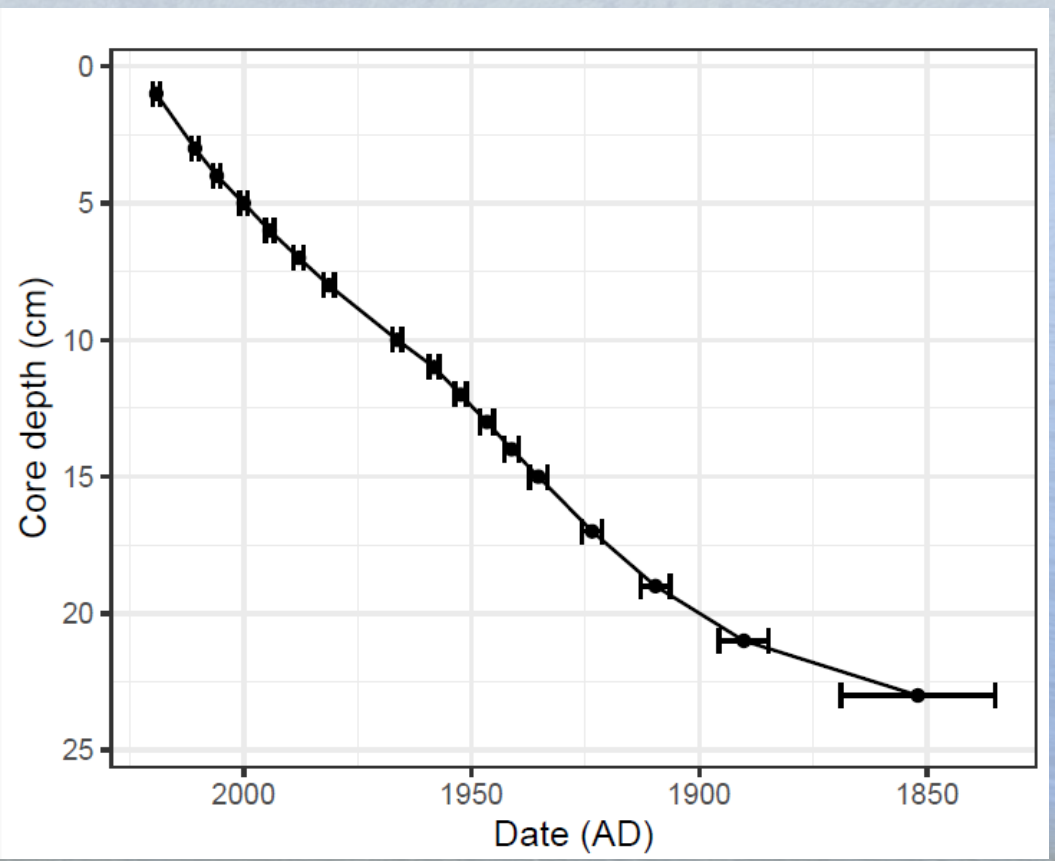
^{210}Pb Age Dating Data

Moreau



Brant



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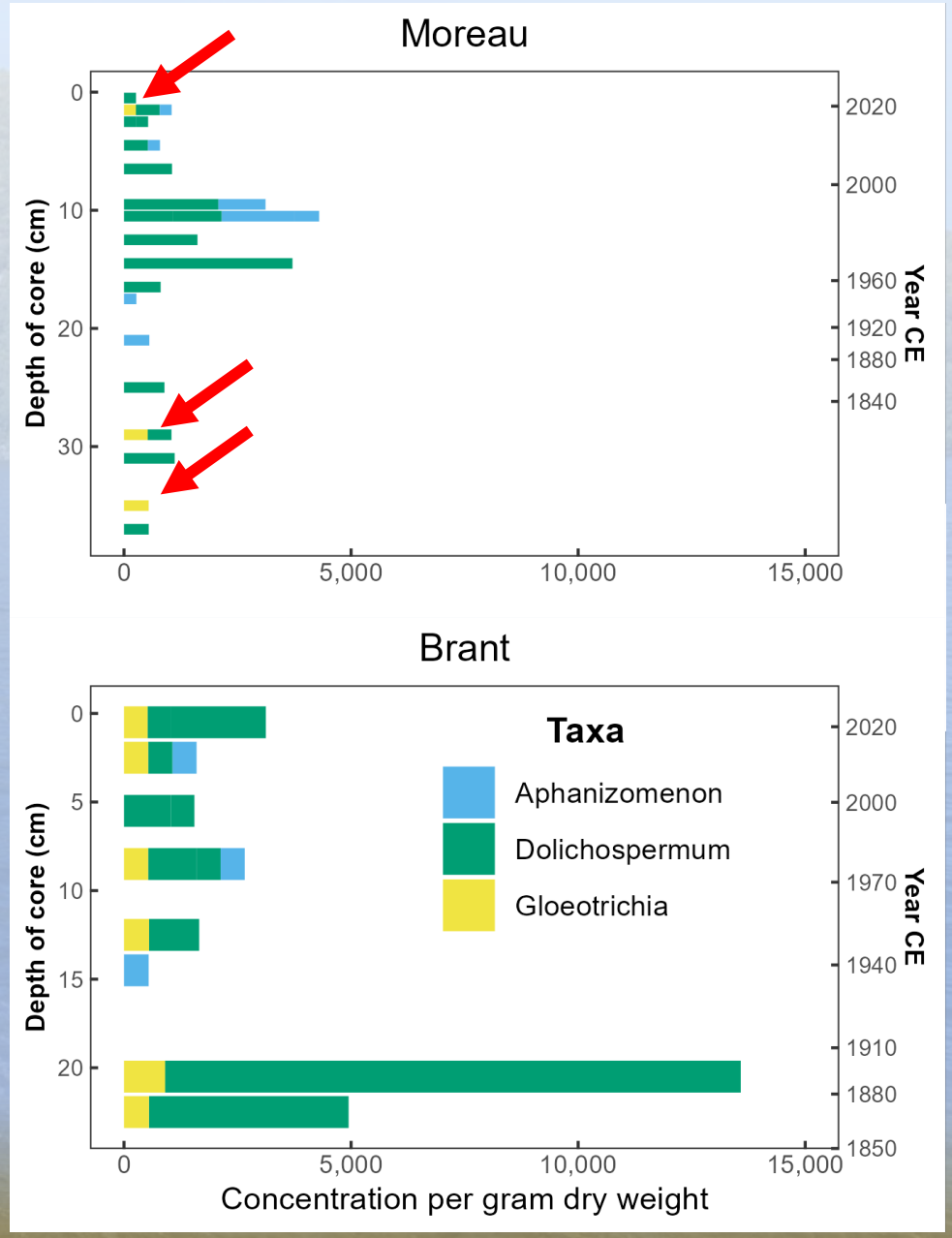
Cyanobacterial Akinete Data

- *Gloeotrichia* are identifiable remnants, not true akinetes
- More consistently prevalent throughout the Brant core than Moreau
- In Moreau they are present in the surface during the period of documented blooms and not again until before 1840
- Does not support a recurring pattern of *Gloeotrichia* blooms in Moreau



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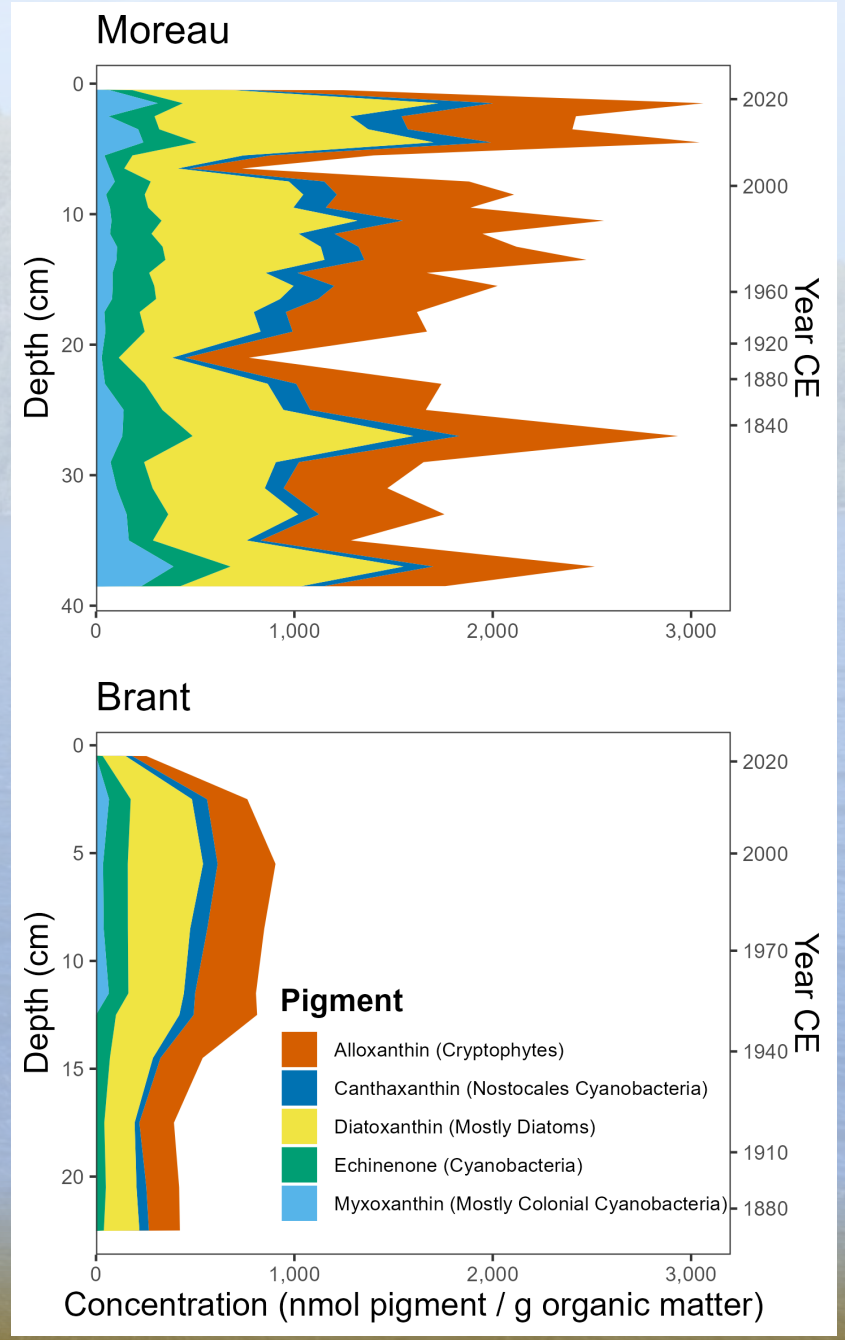
Algal Pigment Data

- Moreau has more activity than Brant
  - Mostly due to algal groups other than cyanobacteria (cryptophytes and diatoms)
- Suggests cyanobacteria populations present and stable (with some noise) in both lakes throughout history captured by core
- Does not suggest history of recurring blooms, but also does not capture recent history of blooms



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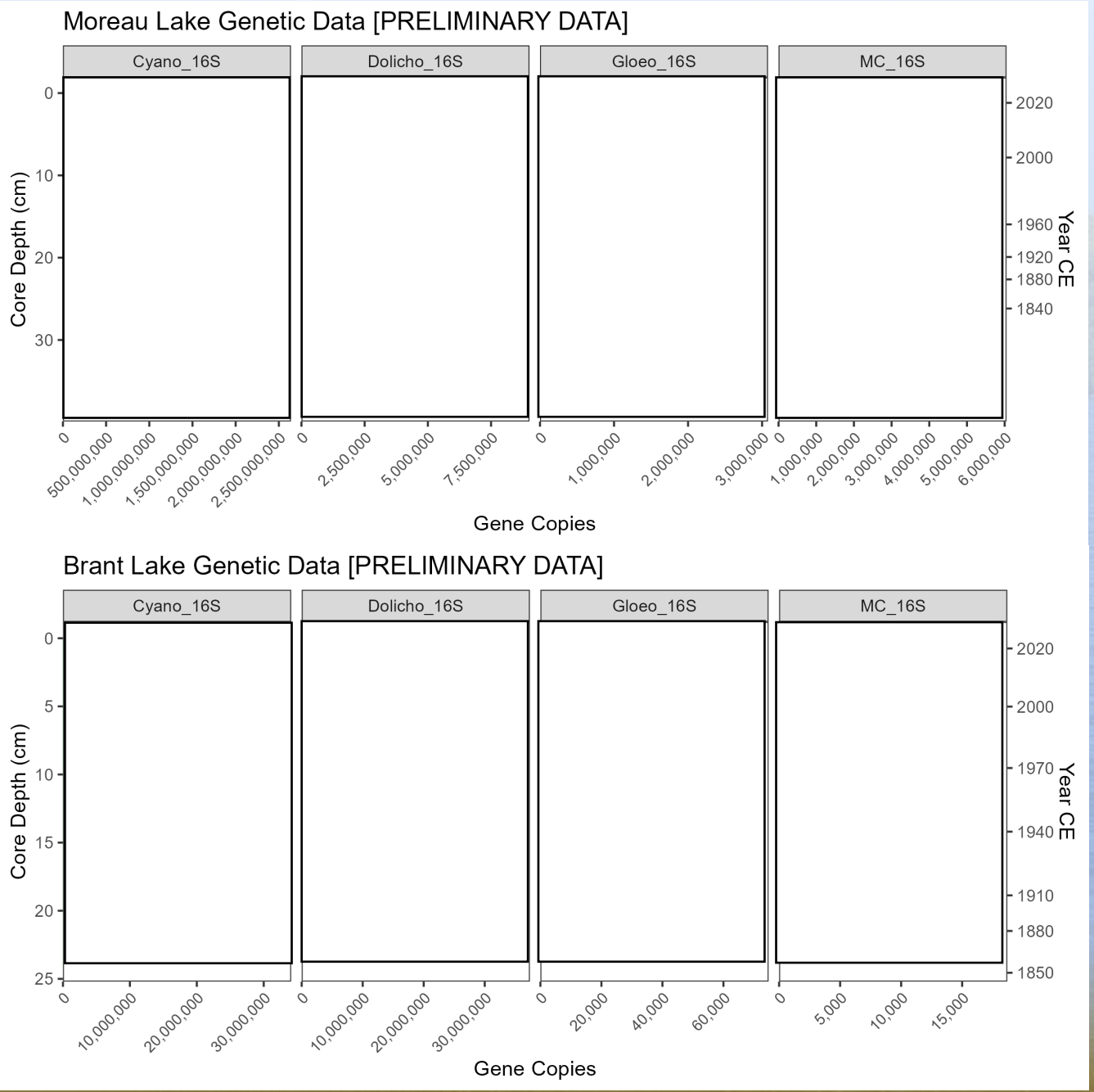
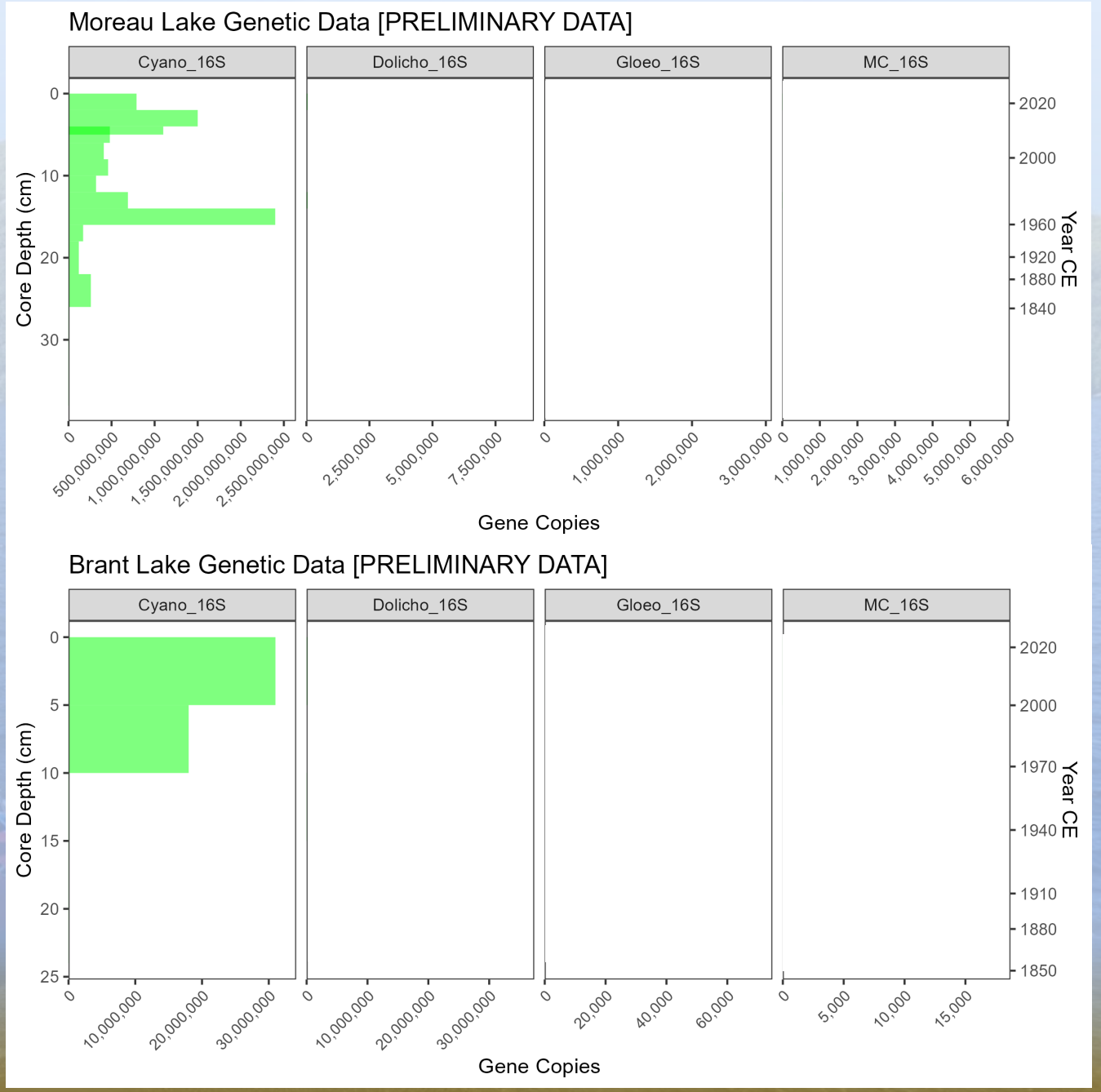
Genetic Results

- Both lakes stratify and go anoxic in the summer – expected to be adequate systems for retrieving cyanobacterial archives
- Samples were composited, every 2 cm for Moreau and every 5 cm for Brant
- No *Planktothrix* 16S detected in either lake



Genetic Results

- Moreau had much higher general Cyanobacteria 16S signal than Brant
- Detections consistent through age resolved core in Moreau, only detected in top two composite samples in Brant
- *Gloeotrichia* 16S assays run on all composited samples, detected only in surface composite sample at Moreau and Brant
- *Dolichospermum* 16S and *Microcystis* 16S run on top middle and bottom of each lake, detected in top and middle samples from Moreau, only top from Brant.
- *Gloeotrichia* may be a new player in the community - New assay, could be some lingering questions about DNA degradation rates and potentially spatial variability



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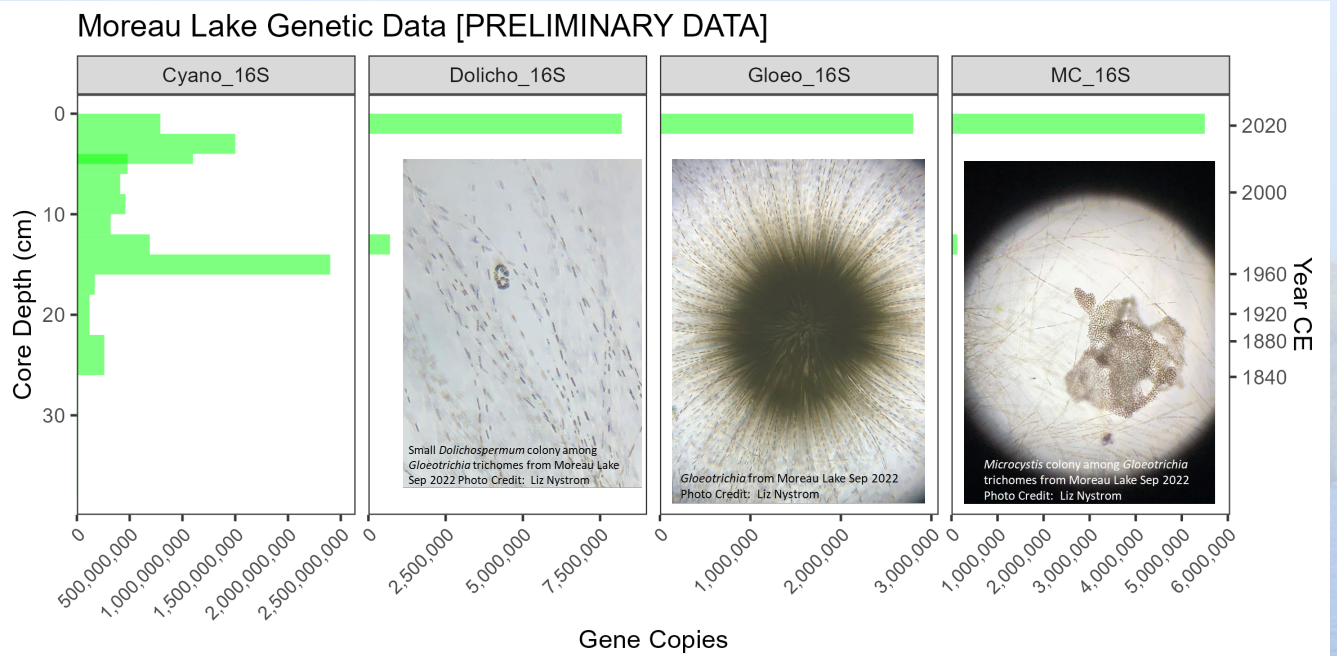

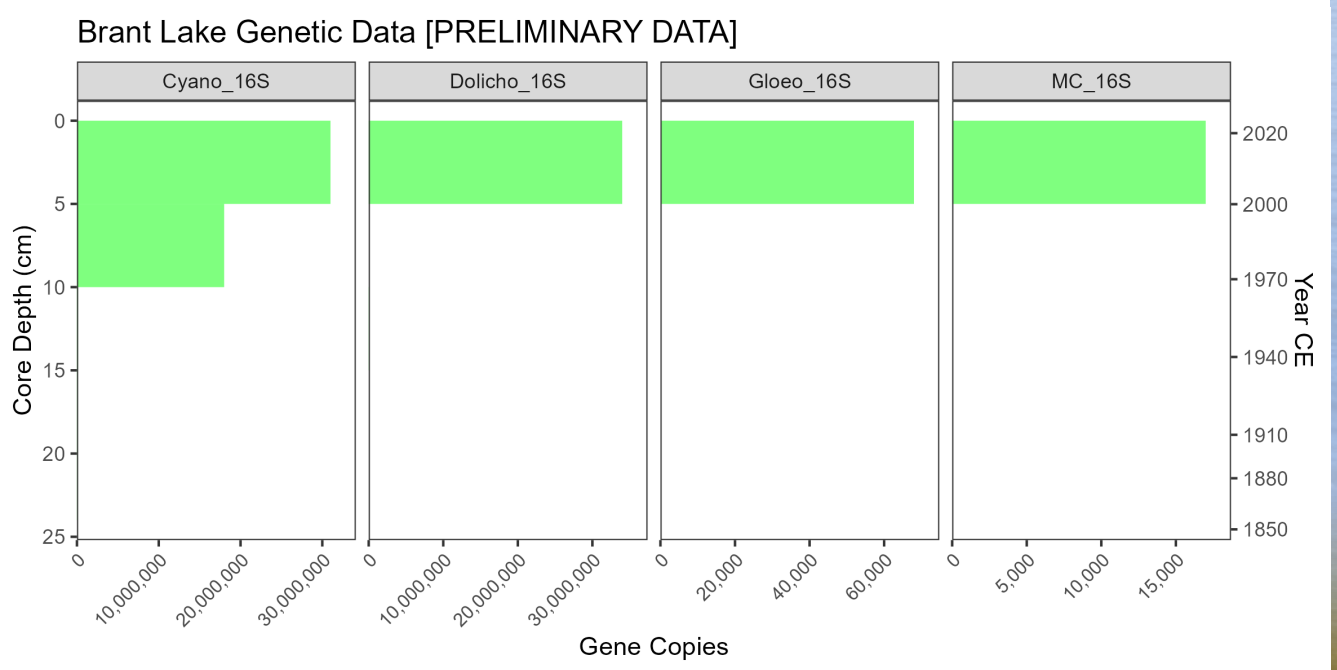

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Preliminary Information-Subject to Revision. Not for Citation or Distribution.

Conclusions

- HABs are part of a natural pattern
  → Alternative 1
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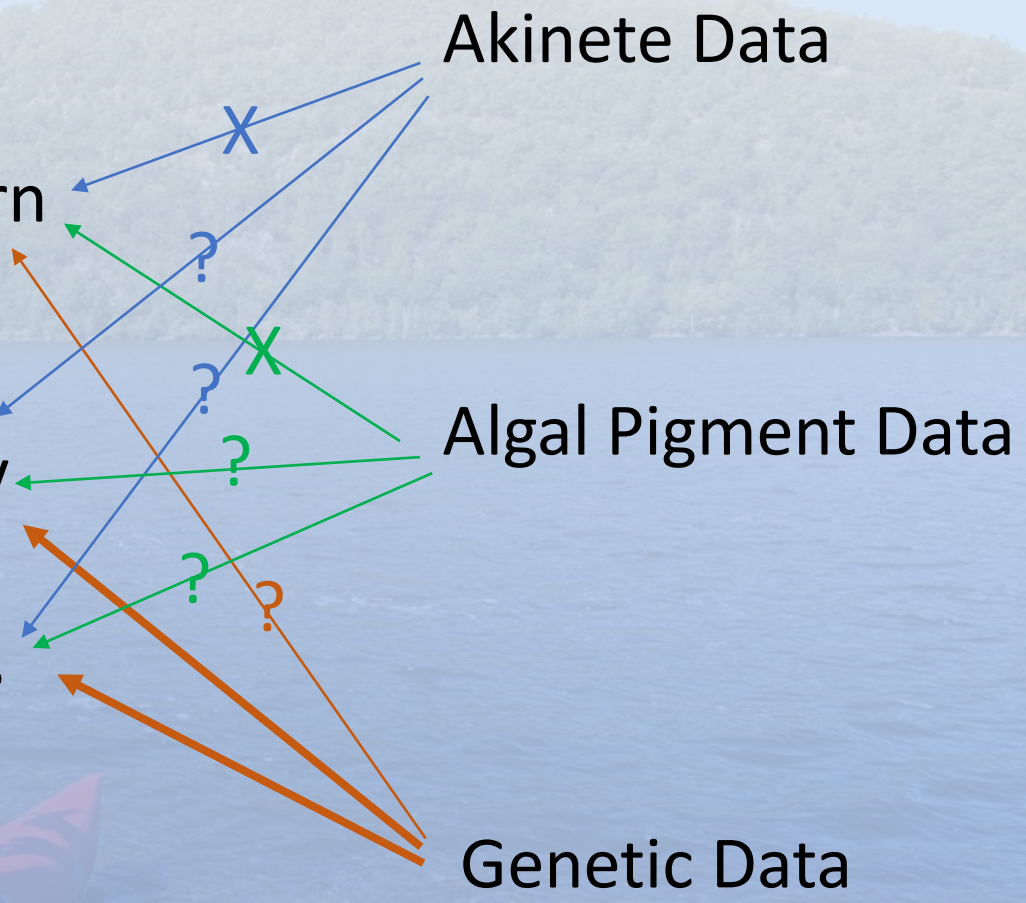

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Conclusions continued

- Cyanobacteria are present in these lakes and have been for a long time – they have the potential to bloom
- Gloeotrichia may be a new player in the cyanobacteria community in Moreau or at least potentially one that hasn't been seen for 150 years
- Triggers/causes of blooms in Moreau still unknown
- Multiple lines of evidence are fun
- Future research could be done to determine spatial representativeness of patterns within each lake, DNA degradation rates in these lakes

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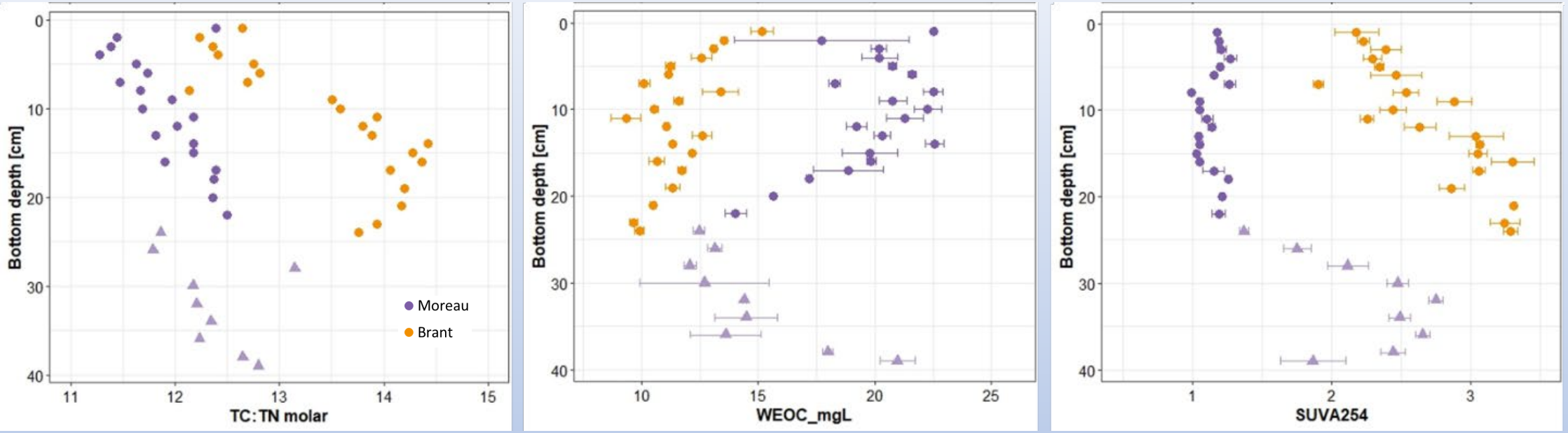
Questions?

Contact: Sabina Gifford (srgifford@usgs.gov)

Bonus: DOM Optical Characterization



- All parameters show differences between lakes: Moreau (purple), Brant (orange)
- C:N ratio of bulk sediment indicates increased C in shallow sections or N is preferentially depleted in deeper/older deposits, potentially due to microbial degradation
- More carbon can be extracted (WEOC) in shallow core sections, consistent with point above
- SUVA = absorbance at 254 nm/DOC (think of this as color normalized to DOC). SUVA increases with depth. Higher SUVA indicates more color per unit DOC which is typically more aromatic and of higher molecular weight (i.e., vegetation/terrestrial/allocthonous). Lower SUVA is typically indicative of lower molecular weight DOC, autochthonous, microbial/algal derived.
- The overall dynamics of these parameters over time/depth respond to the evolution of lake processes and environmental change (hydrologic/geomorphic differences and logging/acidic deposition). We are in the process of interpreting this dataset including other parameters (fluorescence). Alex's thesis chapter publication.

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