# Water in a Complex World: Educating Students to Understand and Assess Harmful Algal Blooms

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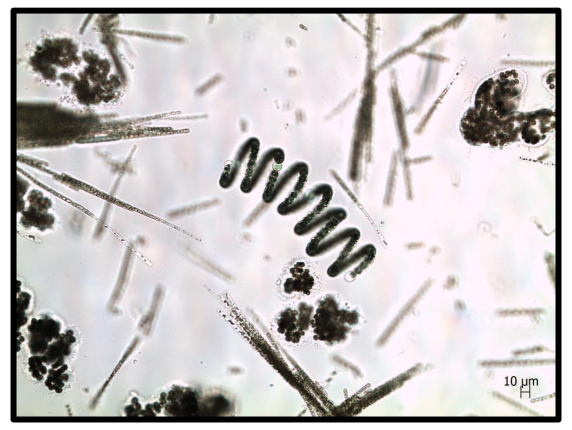


## Introduction

**Harmful Algal Blooms (HABs):**

- Climate warming and nutrient pollution, key drivers of ecological change in freshwaters, can change the structure and function of algal and cyanobacterial assemblages. Warm, nutrient-rich conditions can promote the growth of nuisance and toxin-producing cyanobacteria that can harm humans and other biological organisms, and disrupt the economy.
- Gaps in knowledge of harmful algal bloom (HAB) ecology by scientists and global citizens challenge strategies to effectively track and monitor our freshwaters and limit scientific efforts to inform policy. Technologies like fluid-imaging particle analyzers may help track and monitor HABs.
- Educating students, and other global citizens on HABs and monitoring methods will strengthen efforts to keep our freshwaters healthy in our complex, rapidly changing world.
- We present an educational case study based on an urban lake in MN, where students use light microscope and fluid-imaging particle analyzer (**Fig. 1**) data to determine if mitigation efforts improved lake water quality.

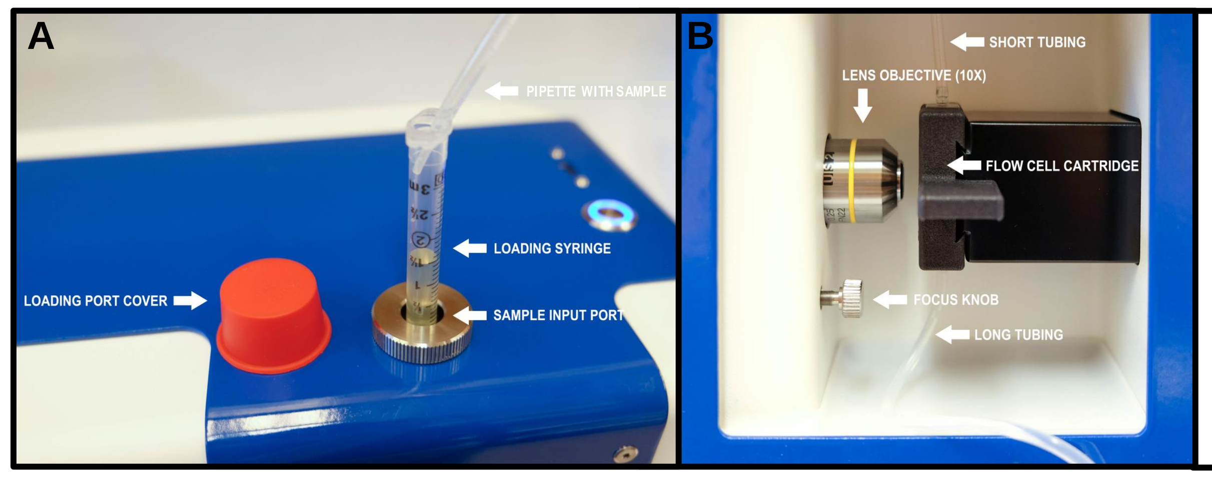



**Fig. 1.** FlowCam 5000® close up. (**A**) Loading input port with a filtered sample. (**B**) Image capture point with objective, focus, and flow cell.

**Case Study:**

- To teach students about HABs and how to use the FlowCam®, we developed a case study built around HABs in Como Lake, MN.
- Students apply data generated by the FlowCam® to assess the success of a recent HABs treatment in Como Lake.

**More specifically, by the end of the case study students:**

- Learn about HABs, their causes, and why they are of concern.
- Learn and identify common freshwater cyanobacteria taxa that form HABs
- Learn the basics about how to use the FlowCam 5000® (**Fig. 1**)
  - ➢ Watch a run demo, then complete a 'run' based on saved raw images
  - ➢ Create image libraries of common genera or groups (**Fig. 3**)
  - ➢ Build a sorting filter using libraries to separate out groups of interest.
  - ➢ Use and run a sample classification scheme based on filters of the major groups of algae and cyanobacteria to generate data
  - ➢ Export data to build relative abundance figures (**Fig. 4**), then compare changes from early to late summer and with historical data. Students discuss if water quality improved.

## Case Study: Como Lake, MN

- Urban lake with a significant history of HABs events during the summer (**Fig. 3**).
- Consistently high chlorophyll-*a* and shallow Secchi depths indicate high phytoplankton densities. (**Table 1**).
- Total phosphorus (TP) levels in Como Lake (173 ug/L TP) regularly exceed standards set for shallow lakes (60 ug/L TP; **Table 1**) to contribute to HABs.
- Numerous interventions to stop internal and external P loading most recently include the introduction of alum, a phosphorus binding agent.


**Fig. 3.** Como Lake and surrounding neighborhood. The color change of the water shows the transition from (**A**) an early spring - pre-bloom state to (**B**) a mid-summer bloom of harmful cyanobacteria. (**C**) View of a cyanoHAB in Como Lake, MN, 2021.

**Table 1.** Minnesota state shallow lake nutrient standards compared to the 1984-2018 Como Lake growing season average (May – September).

| *MN Eutrophication Standards versus Como Lake* | | | |
|---|---|---|---|
| | **Total phosphorus (ug/L)** | **Chlorophyll-*a* (ug/L)** | **Secchi depth (m)** |
| **Standards** | ≤ 60 | ≤ 20 | ≤ 1.0 |
| **Como Lake** | 174 | 34.2 | 1.4 |

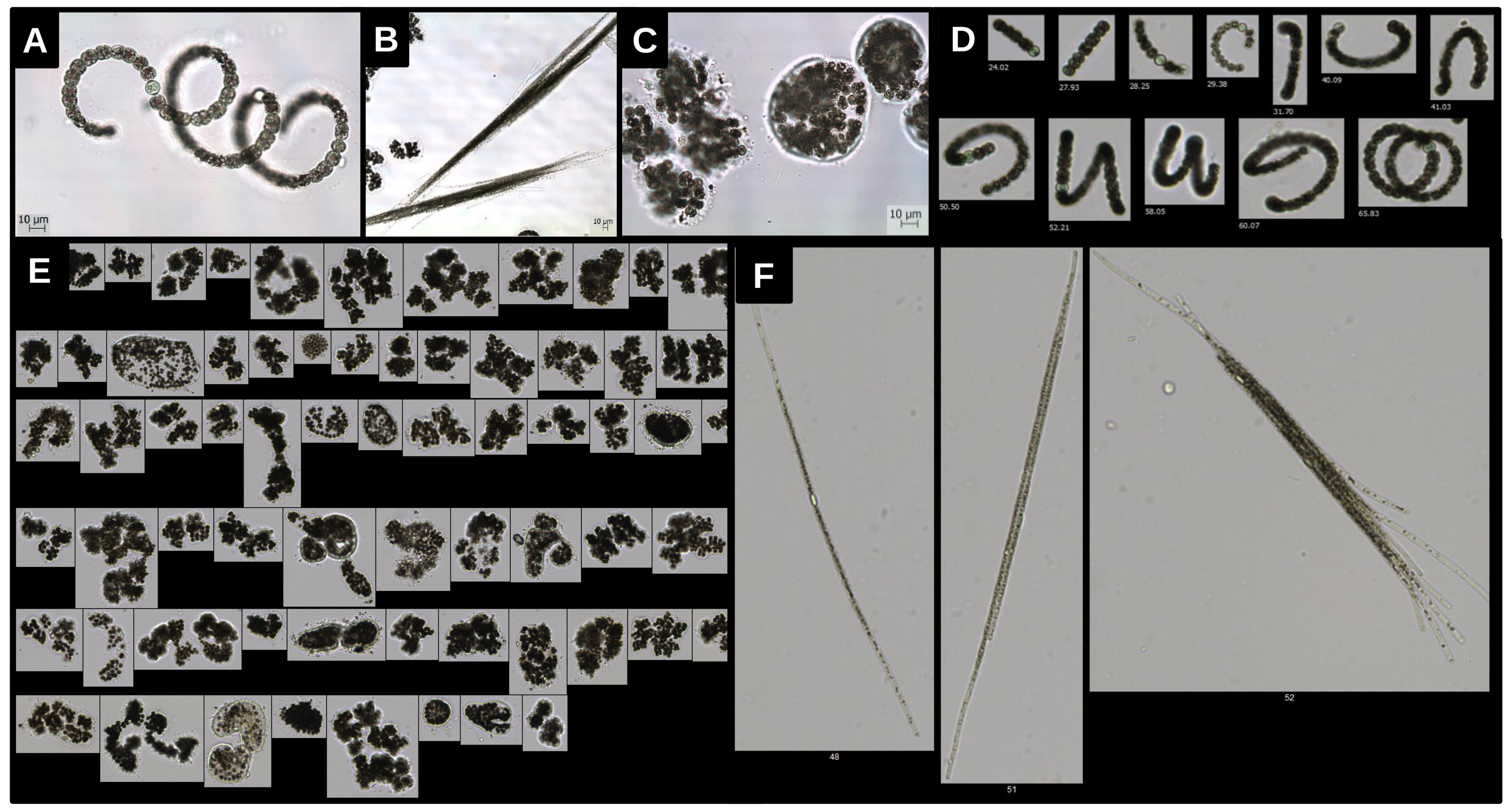



**Fig. 4.** (**A-C**) Light microscope images of some HAB-forming cyanobacteria in Como Lake. (**D-F**) Image libraries of taxonomic groups or genera developed in Visual Spreadsheet®. (**D**) *Dolichospermum* (Ralfs ex Born. et Flah.) P.Wacklin, L.Hoffm. & J.Kom., (**E**) *Microcystis Lemmerm.* and *Woronichinia* A.A.Elenk.; (**F**) *Aphanizomenon* Morr. ex Born. et Flah..

## Case Study Goals

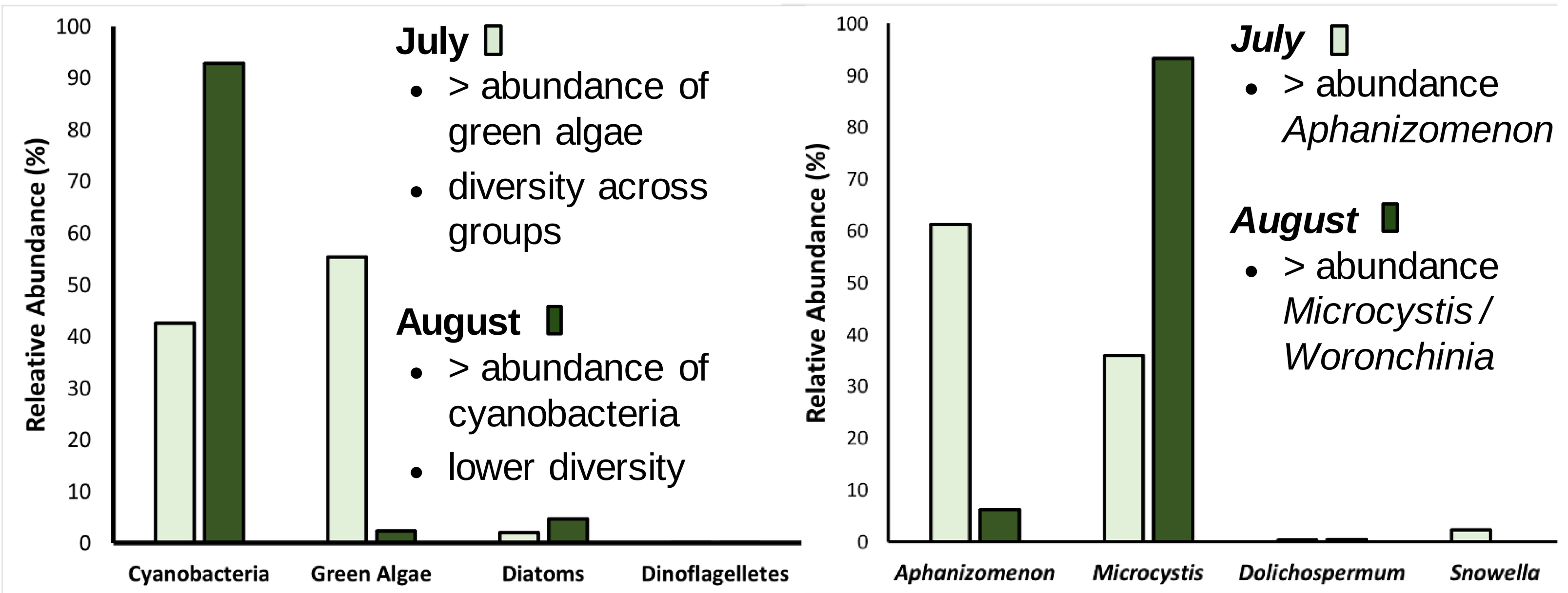
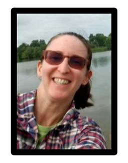



**Fig. 2.** Example student generated figures illustrating relative abundance data of algal and cyanobacteria groups from FlowCam® data to compare changes from July to August.

## Future Revisions to the Case-Study

- Feedback generated by students working through the case study in the an undergraduate Algal Ecology (St. Catherine University, fall 2021) generated ideas to improve the case content and student experience:
- The longer length of time needed to learn to build unique libraries, filters, and a classification, meant students lost the purpose of the case. Future edits will provide shorter learning tasks, for example:
  - Students could build a unique library set for one taxon (rather than all) – e.g., for different morphologies of *Dolichospermum*. That library set could then be used to build a practice filter for that taxon.
  - Students could then use a pre-made set of libraries, filters, and classification to generate the data to assess the case.
  - Students could manually sort the algae into the classification using sorting features that highlight particle properties like length, density, edge gradient. -- making corrections as they learn more about algae.
  - Future edits aim to set up some modular flexibility to allow more or less time for each component given learning goals /course needs.
- Students used learnings from the case to take on a semester-long exploration of a water body of their choice. Students regularly referenced the how-to sequences of the case study to complete their analyses.



**Want to chat more? -- Send an email to Paula Furey or come find her in person at the JASM meeting.**

St. Catherine University

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