Monitoring Blue-Green Algae Dynamics and Water Quality in Two Eutrophic Water Systems – Shelburne Pond and Missisquoi Bay

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Background

- Freshwater systems have natural cyanobacteria blooms during the warmest months of the year, which are affected by nutrient inputs, temperature, and wind (Paerl and Huisman, 2009).
- Cyanobacteria or blue-green algae blooms are characterized by the appearance of a thick surface scum that may produce harmful toxins.
- Monitoring water quality through the collection of high-frequency data and traditional sampling provide information about different factors that change in concert with cyanobacteria concentrations in different systems.
- Understanding bloom patterns and their relationship to climate may provide insight into water management strategies, and adaptation to and mitigation for climate change.

Methods

- We worked on two water bodies in Vermont: eutrophic Missisquoi Bay, Lake Champlain, and hyper-eutrophic Shelburne Pond (Fig. 1).
- Both systems share a history of periodic fish kills during cyanobacteria blooms.

Missisquoi Bay, Lake Champlain

- Missisquoi Bay is a large (70 km^2), shallow (~3 m) bay located in the northeastern part of Lake Champlain (Fig. 1).

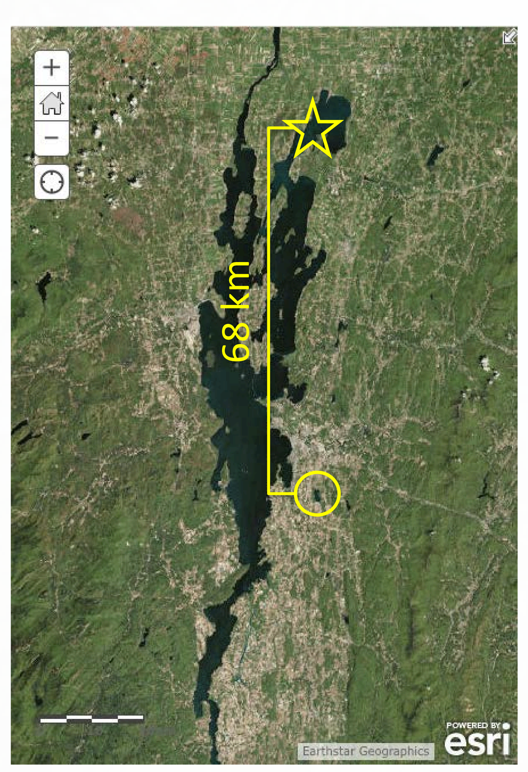


Figure 1. Location of Missisquoi Bay (star) and Shelburne Pond (circle; see Fig. 3).

- The bay has been monitored since 2012 with a buoy that contains a weather station and three ISCO 3700 C Portable Automatic Water Samplers, and a YSI 6600 V2 4 multi-parameter water quality sonde (Fig. 2a, b, c).
- During June and July 2014, weekly manual samples were collected along with the monitoring of other parameters, including water transparency (Secchi disk).

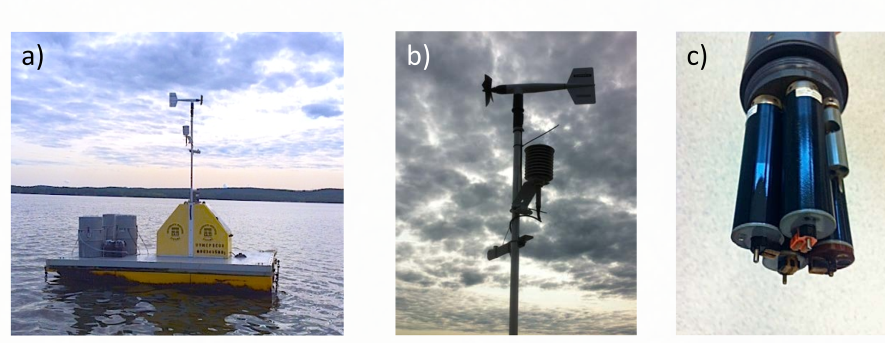


Figure 2. Buoy system on Missisquoi Bay (a) that contains automatic samplers for water, weather station (b) and YSI Sonde (c).

- The installed YSI sonde measures temperature, conductivity, pH, oxidation-reduction potential, dissolved oxygen concentration, chlorophyll-a and phycocyanin fluorescence, and turbidity.
- The weather station measures wind speed and direction, air temperature, atmospheric pressure, solar radiation, and relative humidity.

Methods (continued)

Shelburne Pond

Figure 3. Circle indicates location of thermistor chain buoy on Shelburne Pond.

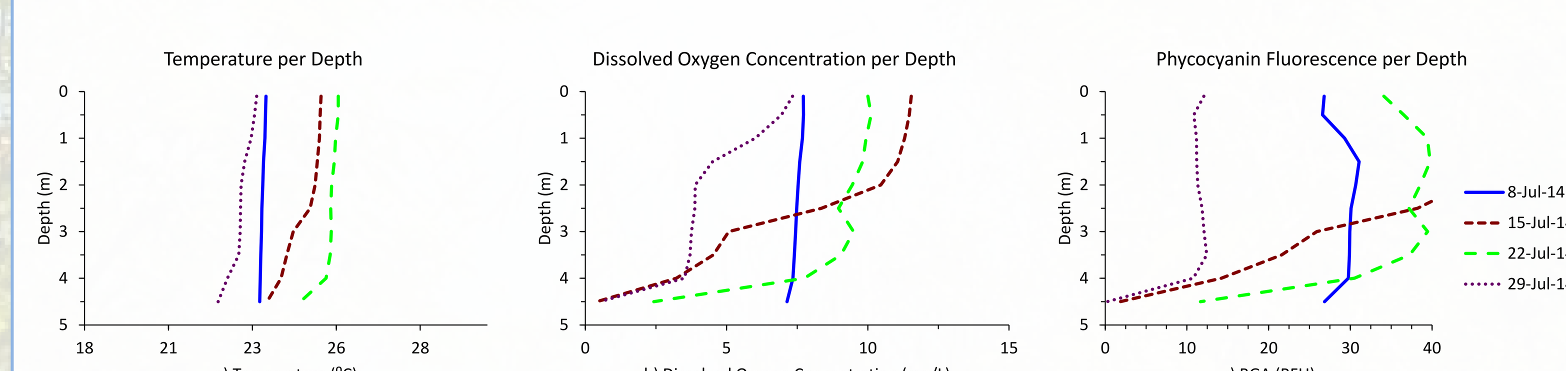
- Shelburne Pond (Fig. 3) is a small (1.8 km^2), shallow (~4 m) pond in the Lake Champlain watershed. It is is part of the University of Vermont's Natural Areas Program.
- Monitoring of Shelburne Pond began in March 2014 (Fig. 4a) with weekly manual sampling and the installation of a thermistor chain buoy (Fig. 4a, b) that records water temperature at different depths every 30 minutes.
- The same YSI Sonde was used in this water system during the manual sampling.

Figure 4. a) The thermistor chain comprises five temperature HOBO® Water Temp Pro v2 u22-001 loggers and was installed when the pond was still frozen. b) Temperature HOBO® Water Temp Pro v2 u22-001 loggers (top), and HOBO® Waterproof Shuttle data downloader (bottom). c) Collecting Photosynthetically Active Radiation during weekly sampling. d) Documented cyanobacteria bloom on June 17, 2014.

Results

- Despite similar temperatures (Fig. 5 Left Column), dissolved oxygen profiles (Fig. 5 Middle) were more variable in Shelburne Pond than Missisquoi Bay in July 2014.
- Cyanobacteria concentrations were more variable and much higher in Shelburne Pond than Missisquoi Bay in July 2014 (Fig. 5 Right).

Shelburne Pond



Missisquoi Bay

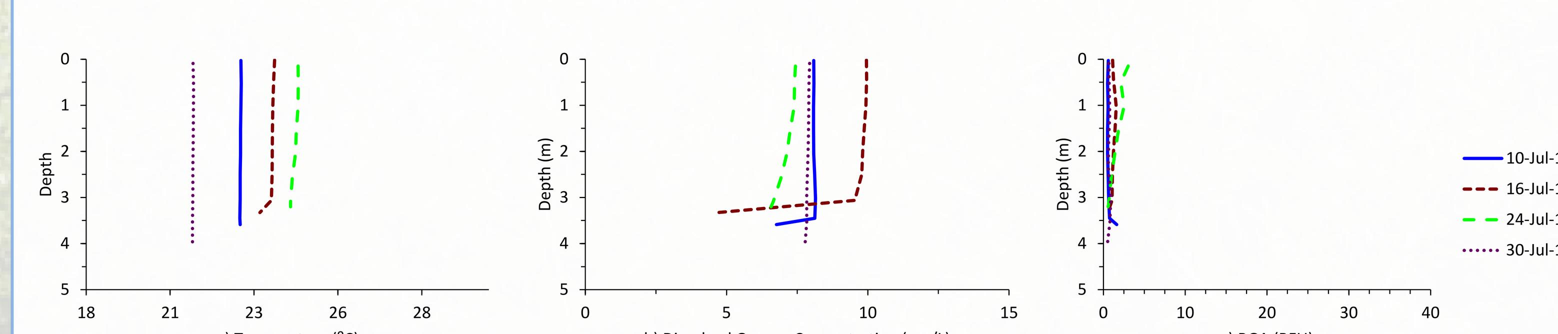


Figure 5. Comparison of temperature, dissolved oxygen, and phycocyanin fluorescence (a relative measure of cyanobacteria (BGA(RFU))) depth profiles in Shelburne Pond and Missisquoi Bay on four sampling dates in July 2014.

References

- Paerl, H. W. and Huisman, J. (2009). Climate change: a catalyst for global expansion of harmful cyanobacterial blooms. *Environmental Microbiology Reports*, 1: 27–37. doi: 10.1111/j.1758-2229.2008.00004.x

Results (continued)

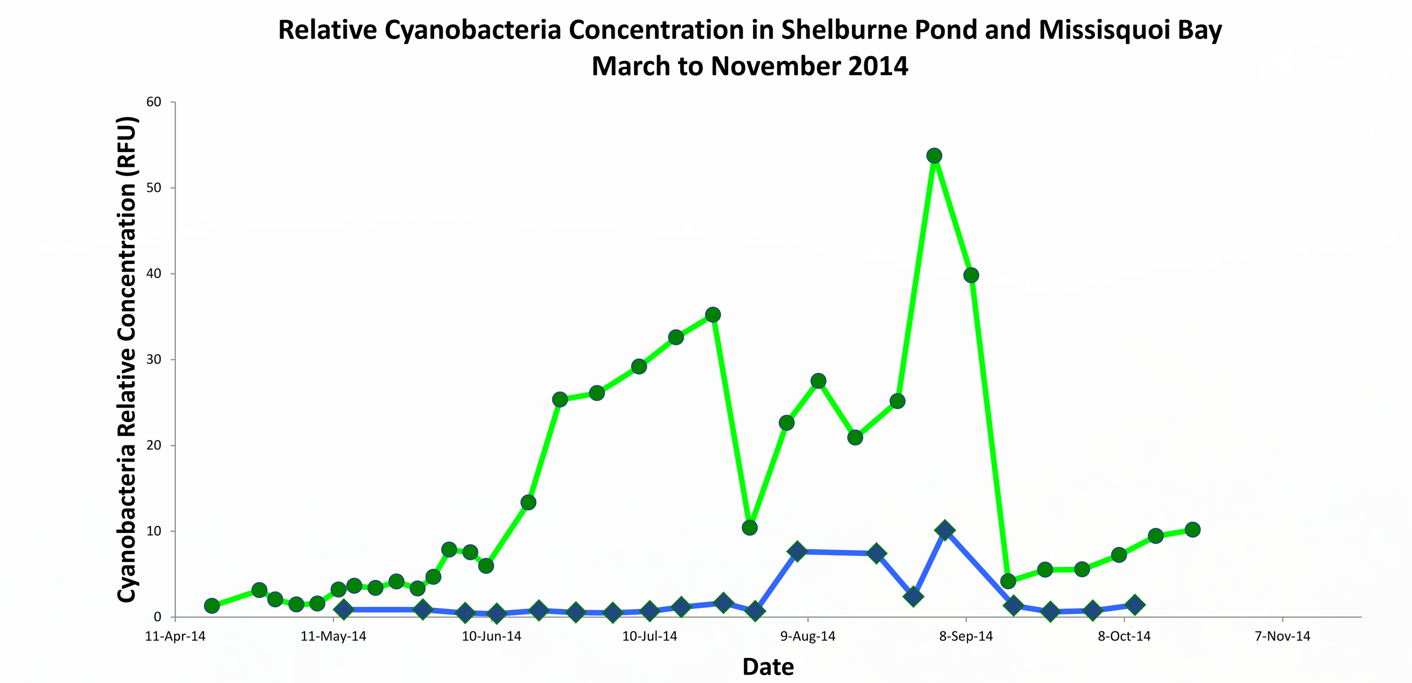


Figure 6. Relative concentration of cyanobacteria in Shelburne Pond and Missisquoi Bay from April 18 to October 10, 2014.

Discussion

- Shelburne Pond and Missisquoi Bay are located in the same region (Fig. 1) and provide opportunities to compare and contrast cyanobacteria blooms and the factors that influence them.
- Shelburne Pond was warmer and had lower dissolved oxygen than Missisquoi Bay (Fig 5).
- Cyanobacteria blooms started in early summer and followed a high growth trajectory in Shelburne Pond (Figs. 5, 6), whereas cyanobacteria remained relatively low in Missisquoi Bay (Fig. 6).
- A large drop in relative concentration was documented on July 29, 2014 in Shelburne Pond, of which the main cause may be a high precipitation event two days before the data were collected.
- For both systems, the highest cyanobacteria concentration values were recorded at the beginning of September 2014, after which there was an evident drop (Fig. 6) after a week of unseasonably cold weather.

These patterns suggest a connection between cyanobacteria blooms and weather, but further analysis with larger sample sizes are needed. Even though Missisquoi Bay blooms developed during the month of August, the relative concentration did not surpass Shelburne Pond levels.

Next Steps

- Compare and contrast Shelburne Pond and Missisquoi Bay in more detail to identify common and disparate drivers of blooms in each system.
- Extend comparisons to winter time when very little is known about how under-ice biogeochemical and limnological processes may impact summer blooms.

Acknowledgements

This research was possible with the help of Vermont EPSCoR, the Rubenstein Ecosystem Science Laboratory, and the University of Vermont. Dr. Jason Stockwell provided training, resources, and mentorship to carry out this project. Bradley Roy was the field technician for Shelburne Pond. Peter Isles provided valuable training and data from Missiquoi Bay. Funding was generously provided by NSF Grant EPS-1101317.

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