Summary of Leech Lake Phytoplankton Data, 2017-2022

Ceratium hirundinella
photo credit: Adam Heathcote, St. Croix Watershed Research Station

Field gear covered in zebra mussels
photo credit: MNDNR

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Summary

The goal of this report is to summarize the phytoplankton datasets from Leech Lake, ranging from 2017-2022. This project is a collaborative effort between the Leech Lake Association, Cass County Soil and Water Conservation District and the Minnesota Department of Natural Resources. This report will build on a similar report from 2021, which described patterns in the phytoplankton community during the summers (typically May-September) of 2017-2021. While the length of the dataset does not allow for analyses of long-term trends, it is documentation of the lake food web early in the infestation of zebra mussels. The zebra mussel population grew noticeably during 2022, and is now widespread.

Consistent with previous years, the algal community underwent a pattern of seasonal succession, a replacement of algal species through the summer, driven by changing environmental conditions. Unlike other years in this study, there was a large bloom of the dinoflagellate, *Ceratium hirundinella*, in the main basin of the lake during May. This dinoflagellate was replaced by other species into the summer but maintained a small population into August. Cyanobacteria (blue-green algae) with the capability to produce toxins (although they do not always make those toxins) were present in both the main basin of the lake and Walker Bay in 2022, something that is worth noting due to their potential to make toxins with negative impacts to human and other animal health.

Introduction

After confirmation of zebra mussels in Leech Lake in 2016, phytoplankton samples have been collected during the open water season each year (2017-2022). Phytoplankton are sensitive to changes in aquatic system, and the community composition and abundance can rapidly respond to changes in light, temperature, nutrient concentrations, invasive species, and turbidity (Dodds and Whiles, 2019). While the phytoplankton community is a good indicator of changes in a lake, the identification of organisms requires technical expertise.

Invasive species are a major threat to Minnesota lakes and lake food webs. One of the most widespread and impactful invasive animals in Minnesota lakes are zebra mussels (*Dreissena polymorpha*). As of late January 2023, 582 Minnesota waters were listed as infested with zebra mussels (MNDNR 2023). Zebra mussel populations can grow to high densities and are known to increase water clarity, alter nutrient cycles, change the distribution of organisms in a lake, and reduce growth of age-0 walleye (Sousa et al. 2009, Higgins and Vander Zanden 2010, Hansen et al. 2020).

This report is a summary of the results of phytoplankton analyses for two sampling locations on Leech Lake, from 2017-2022. This is a continuation of a report produced by the same author in 2022, which summarized the 2017-2021 datasets.

Methods

Phytoplankton samples were collected once a month in the summer of 2022 in both the Main Basin and Walker Bay, Leech Lake, Minnesota, by volunteers with the Leech Lake Association. The samples were collected from the top 2 m of the lake surface and sampled with glutaraldehyde. Phycologists at PhycoTech (St. Joseph, Michigan) used methodology developed by the Minnesota Pollution Control Agency to subsample and identify organisms from the samples (Swain and Dindorf 1989, Lindon and Heiskary 2007). The data collected using this method are relative abundance, instead of absolute abundance data. The algal taxa can be grouped to simplify plots, and in this effort they were grouped into seven categories based on their function and morphology (St. Amand 2015) and are described in Table 1. We added an "other" category this year, as on one date, the taxonomists found organisms that did not fit into any of the existing categories. There was not enough information in the dataset for further description of this group.

Table 1: Phytoplankton functional group classification and brief description. Adapted from St. Amand (2015).

Functional Group	Description
BG	Non-toxin forming cyanobacteria (blue-green algae)
CP	Cryptomonads and dinoflagellates; common in systems with stained water, regardless of nutrients
CP1	*Ceratium hirundinella*; a dinoflagellate that blooms when other dinoflagellates do not
DY	Planktonic diatoms and chrysophytes
G	Green algae
HAB	Toxin-forming cyanobacteria (blue-green algae)
O	Other

Results

The phytoplankton community shows seasonal patterns of succession, the replacement of species through time, which is typical of mesotrophic lakes, in both sampling locations (Figures 1 and 2). In general, the spring/early summer community of diatoms (DY), green algae (G), and chrysophytes (DY) are replaced by cyanobacteria (BG), including some species that are capable of producing toxins (HAB), although they do not always do so. Both groups of cyanobacteria (BG and HAB) persist through the end of the summer. The timing and relative abundance of this shift in species varies among years due to environmental conditions, including temperature, precipitation, nutrient inputs, and light.

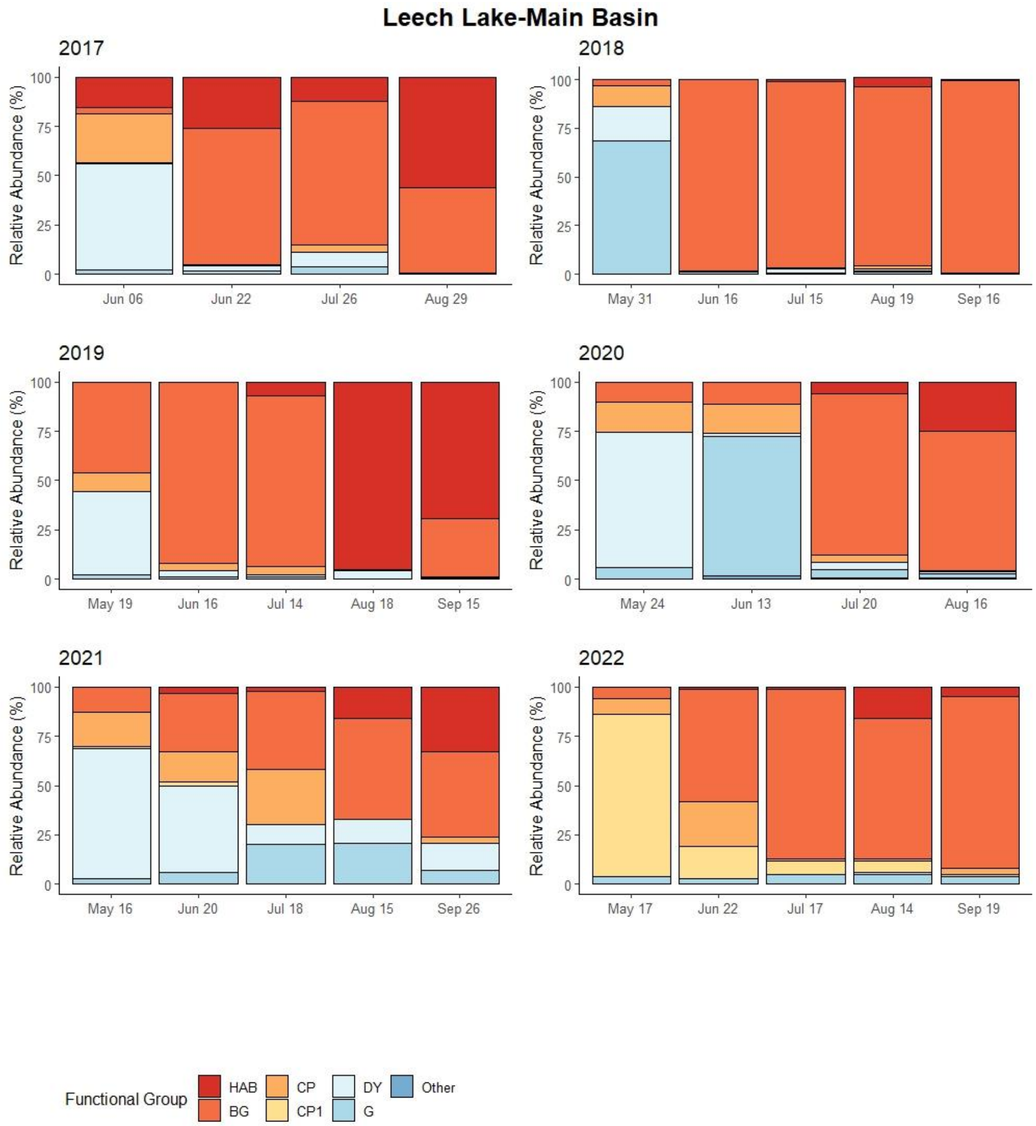

Figure 1: Bar graph showing the relative abundance of major phytoplankton functional groups in the Main Basin of Leech Lake, MN, from monthly samples (May-Sep) in the summers of 2017-2022 Note: BG = non-toxin forming cyanobacteria; CP = cryptomonads and dinoflagellates; CP1 = *Ceratium hirundinella*; DY = diatoms and chrysophytes; G = green algae; HAB = toxin-forming cyanobacteria; and Other = taxa not fitting in any of the previous groupings.

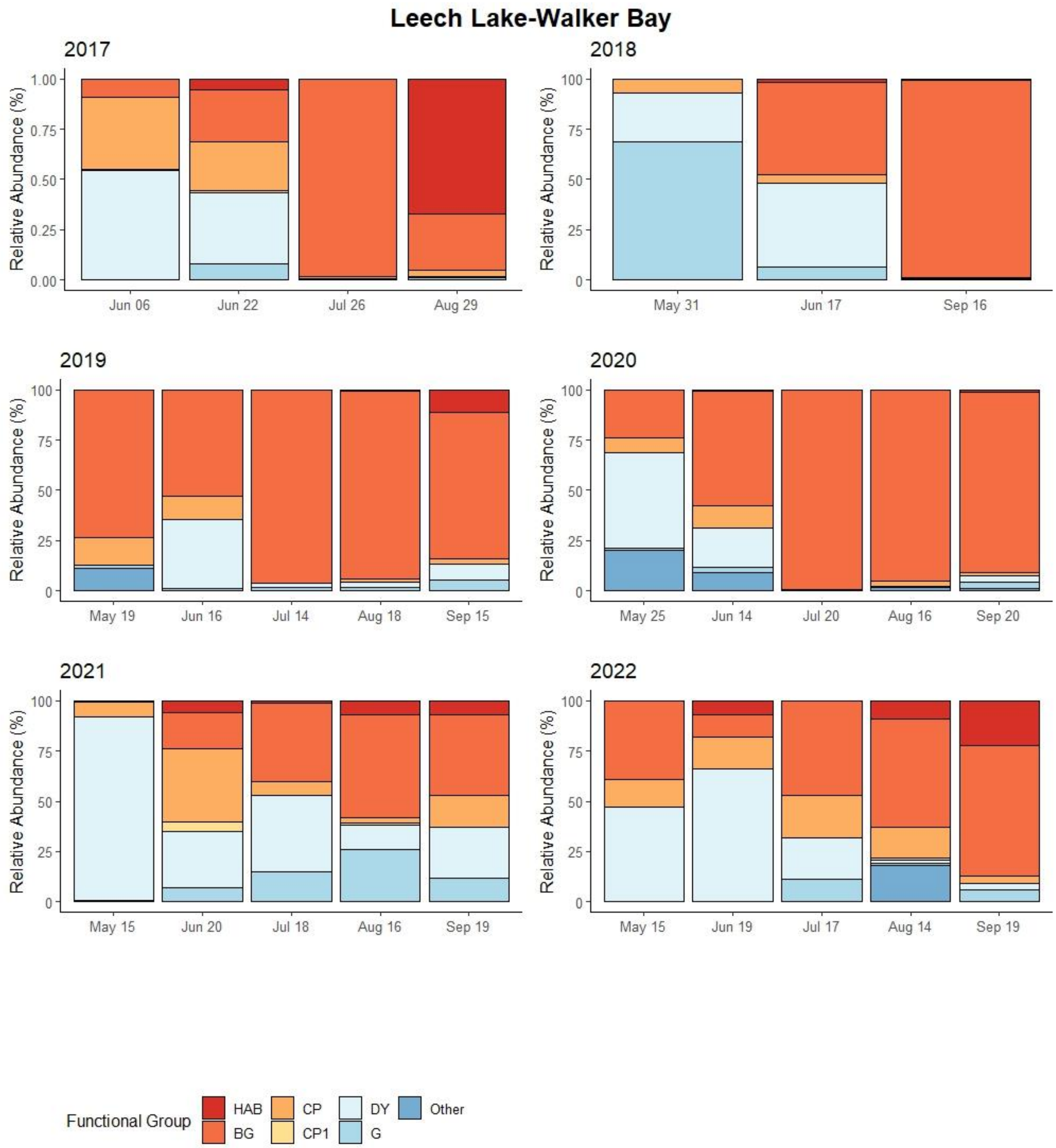

Figure 2: Bar graph showing the relative abundance of major phytoplankton functional groups in the Walker Bay, Leech Lake, MN, from monthly samples (May-Sep) in the summers of 2017- 2022. Note that only May, June, and September were sampled in 2018. Note: BG = non-toxin forming cyanobacteria; CP = cryptomonads and dinoflagellates; CP1 = *Ceratium hirundinella*; DY = diatoms and chrysophytes; G = green algae; HAB = toxin-forming cyanobacteria; and Other = taxa not fitting in any of the previous groupings.

The seasonal patterns we observed in the 2022 phytoplankton dataset vary between the Main Basin of the lake and Walker Bay. The sequence of algae in Walker Bay is typical to what we would expect based on historic conditions. The bloom of *Ceratium hirundinella* has not been observed in the lake during the period of monitoring and is noticeably different than other years.

The dinoflagellate, *C. hirundinella*, is found ubiquitously in temperate lakes. This alga is motile, and it favors calm conditions that allow it to move vertically in the water column to access specific light, temperature, and oxygen conditions (Heaney and Talling 1980). Interestingly, this alga is not edible by zooplankton (Conde-Porcuna et al 2022), possibly due to its large size and shape (see cover image). Zebra mussels, however, are able to filter *C. hirundinella* from the water column, and appear to selectively expel the alga (Naddafi et al 2007).

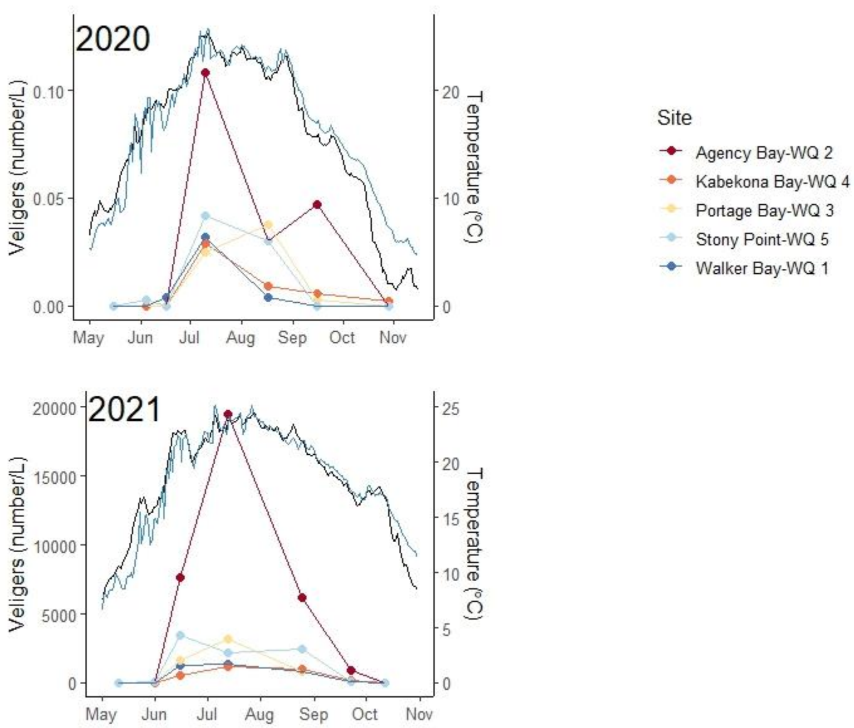

Figure 3: Plot of densities (number L^{-1}) of larval zebra mussels (veligers) from five stations in Leech Lake from May-October 2020 and 2021 and time-series plots of average annual daily temperature (black line = Main basin, blue line = Walker Bay) during the same time periods. Note the scale of the y-axis in 2021 is two orders of magnitude larger than the 2020 plot. Data from MNDNR.

Reports of harmful algal blooms (HABs, caused by toxin-forming cyanobacteria, also called blue-green algae) in Minnesota, and around the world, have been increasing.

These algae like warm, calm, nutrient-rich water, and have the ability to produce toxins that are harmful to human and other animal health, although they do not always form these harmful substances. In 2022, there was an increase in toxin-forming algae (HABs on Figures 1 and 2) during the late summer in both the Main Basin and Walker Bay. That said, the presence of these algae in Leech Lake is not an indicator of algal-derived toxins in the lake. Tests for specific toxins are required to confirm the presence of those substances. However, the algae capable of toxin production were detected in Leech Lake in 2022, and are most years.

Work from Michigan found that inland lakes with zebra mussels and low total phosphorus (<20 µg/l), there is an increased likelihood of increased concentrations of the algal toxin microcystin (Knoll et al. 2008). In 2022, *Microcystis,* the alga that produces the toxin microcystin was found in Walker Bay in June and the Main Basin in August and September.

Algae respond rapidly to changing environmental conditions, both within a summer, among summers, and over long time scales. The current dataset allows us to see both differences within and among summers. To access the impacts of zebra mussels to the lake, continued monitoring is needed.

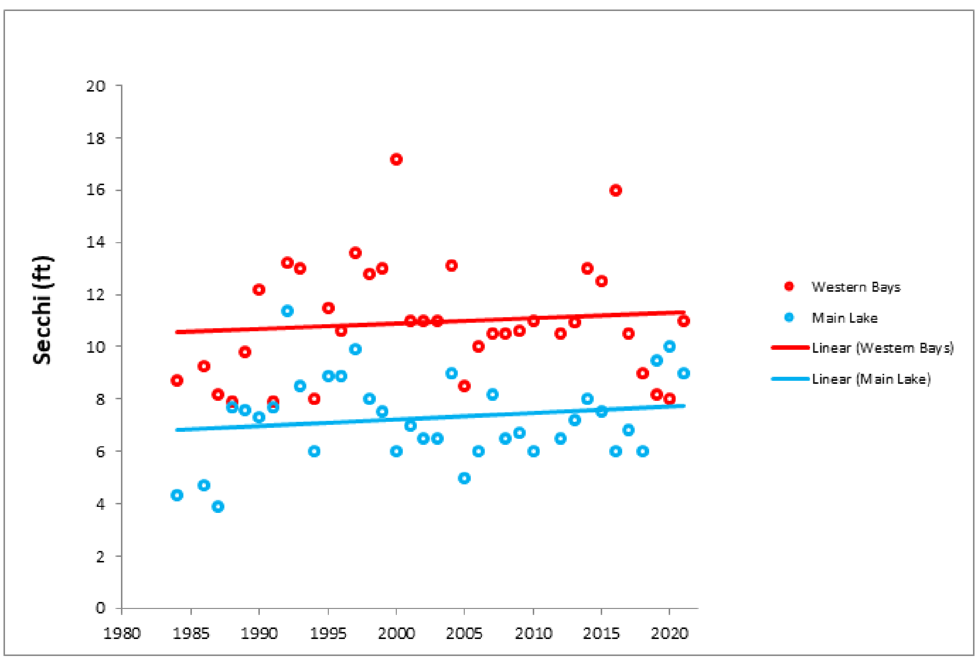

Figure 4: Time-series plot of average annual Secchi disc reading (ft) in the Main Basin (blue) and Western Bays (red) of Leech Lake from 1984-2022. Data from Minnesota Pollution Control Agency.

Phytoplankton communities are sensitive to changing environmental conditions at multiple temporal scales (i.e. seasonal, inter-annual, long term). To detect long-term trends in the community due to invasive species, land cover change, warming water, or other stressors, additional years of data are needed. MNDNR data from Leech Lake suggest that the zebra mussel population in the lake is still growing, as the number of veligers (larval zebra mussels) collected from water column sampling were higher in 2021 than in 2020 (Figure 3). The timing of the highest densities of larval zebra mussels coincides with peaks in water temperature (black and blue lines in Figure 3).

It appears that zebra mussels have increased water clarity in the Main Basin of Leech Lake, but those impacts are currently not evident in the western basins of the lake (Figure 4).

Soon, zebra mussels will likely continue to make major changes to the physical characteristics (e.g., light penetration, structure of the lake bottom, location of animal biomass) of Leech Lake, until zebra mussel population growth stabilizes. As phytoplankton respond quickly to the changing conditions, they are effective indicators of system-wide change. Continuing to monitor the phytoplankton community will help lake and fisheries managers understand the magnitude of change in Leech Lake.

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Patterns in zooplankton and phytoplankton communities in Minnesota Lakes

UM Extension Blue-Green Algae Website

Read more about harmful algal blooms in Minnesota on the MPCA HAB website and Minnesota Department of Health website

Find out more about current research in Minnesota on harmful algal blooms being done by the St. Croix Watershed Research Station