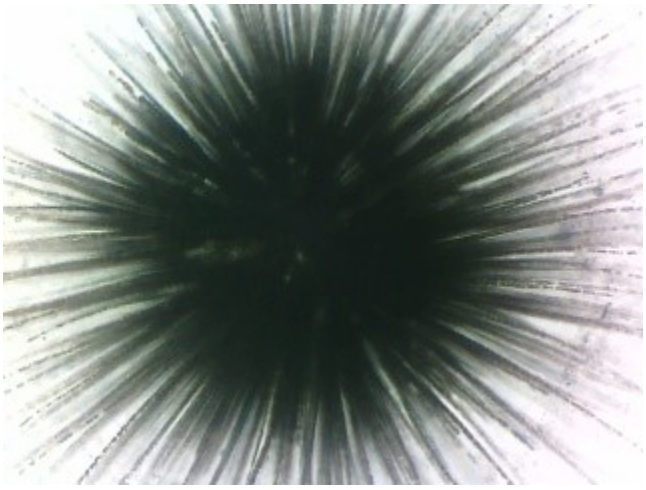
2015
Gloeotrichia echinulata Monitoring Report

February 1, 2016



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Project Summary

A total of 30 sites on 24 lakes and ponds were monitored in the summer of 2015 for the blue-green algae known as *Gloeotrichia echinulata*, or "Gloeo". Twenty sites were sampled once in late July or early August. The remaining ten sites were sampled 4 times, or roughly once per week, between July 15th and August 19th, with the exception of Moose Pond (main basin), which was sampled 5 times. The sites sampled more than once were on Long Lake (4 sites), Keoka Lake, McWain Pond, Moose Pond, Peabody Pond, Crystal Lake, and Middle Pond. The highest level of Gloeo recorded in 2015 was 192.4 colonies per liter in Moose Pond. The highest level in 2014 was 72.4 colonies per liter in Keoka Lake, and in 2013 it was 16.6 colonies per liter in Moose Pond. Moose Pond and the Harrison sample site on Long Lake's north shore both saw large increases in Gloeo abundance in 2015 over previous years. However, the concentrations at other sampling sites were similar or even less than in previous years. A late spring and slow warm-up in water temperatures may have affected Gloeo growth in 2015.

Factors that Affect Gloeo Abundance

Light

Like many other species, Gloeo take biological cues from the intensity and duration of sunlight. Gloeo can only grow on sediments that are exposed to light. Lake bathymetry (the shape and contours of the lake bed) will control the area of the lake that is shallow enough for light to reach (known as the "littoral zone"). Lake clarity and color also impact how deep light can penetrate. Low clarity and/or high color mean that less of the lake bottom is exposed to light.

Temperature

Cyanobacteria, including Gloeo, have higher optimum temperatures than other algae types. Comparison of the Gloeo population peak and seasonal temperature peak suggest that high temperatures trigger Gloeo to rise into the water column. Climate change is causing temperatures to rise over time, which could help explain why Gloeo seems to be becoming more prevalent. It is also troubling because it means that Gloeo could be more abundant and harder to control in the future as temperatures keep rising.

Nutrients

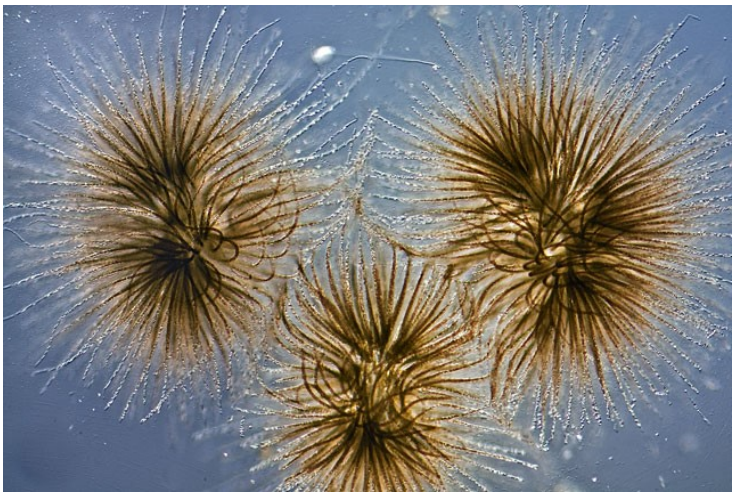
Because Gloeo grow on lake sediments, they are not as constrained by water column phosphorus levels as many other algae species. Instead, they get their nutrients from the bottom of the lake. Lake sediments often contain high levels of phosphorus, which Gloeo are able to uptake and store. A lack of nutrient-rich sediment in areas with adequate light and temperature levels would be likely to limit Gloeo growth. Lakes may have rocky or sandy sediment with little phosphorus or may not have much "free" phosphorus available for Gloeo to use.

Introduction and Background

Gloeotrichia echinulata ("Gloeo") is a colonial cyanobacterium. Each colony is made up of many individual cells with long, hair-like filaments. Under a microscope they look like round, spiky balls. The tiny colonies, which are about 1-3 mm in diameter, tend to be free-floating in the water column, and only form surface scums at extremely high concentrations. The term "cyanobacterium" refers to the type or category of algae that Gloeo fits into. Cyanobacteria, also known as blue-green algae, are the type of algae that cause harmful algal blooms. They are more persistent than other types of algae, often gaining a competitive advantage over other species. Many cyanobacterial species are capable of producing toxins that are harmful to animals and humans. Gloeo is able to take up phosphorus from sediments (unlike most algae, which get their phosphorus from the water), which may be a key to why it is gaining a foothold in low-nutrient lakes in this region.

Algal blooms are a sign of water quality problems in lake systems. They tend to affect lakes in warmer climates or in heavily developed or agricultural areas. The fact that Gloeo has appeared relatively recently in western Maine, and in other temperate, low-nutrient lakes in the northeast, is one of the reasons LEA is monitoring this species. Cyanobacteria have specific light, temperature, and nutrient requirements. Higher water temperatures, caused by climate change, may be allowing Gloeo populations to expand.

Dormant Gloeo cells will survive in harsh conditions for long periods of time. Once favorable conditions are present, they will grow and divide on the sediment in shallow areas of the lake. While phosphorus levels may be low in the water column of this region's lakes, the sediment is a phosphorus sink and harbors large amounts of the nutrient. Gloeo take advantage of this and uptake the phosphorus from the sediment before becoming buoyant and floating into the water column. In this way they are not limited by the low nutrient levels within the water column. The Gloeo die after 2-4 weeks, releasing their stored phosphorus, which could potentially increase other algae growth in the water column and contribute to algal blooms.



Three Gloeo colonies magnified by a microscope

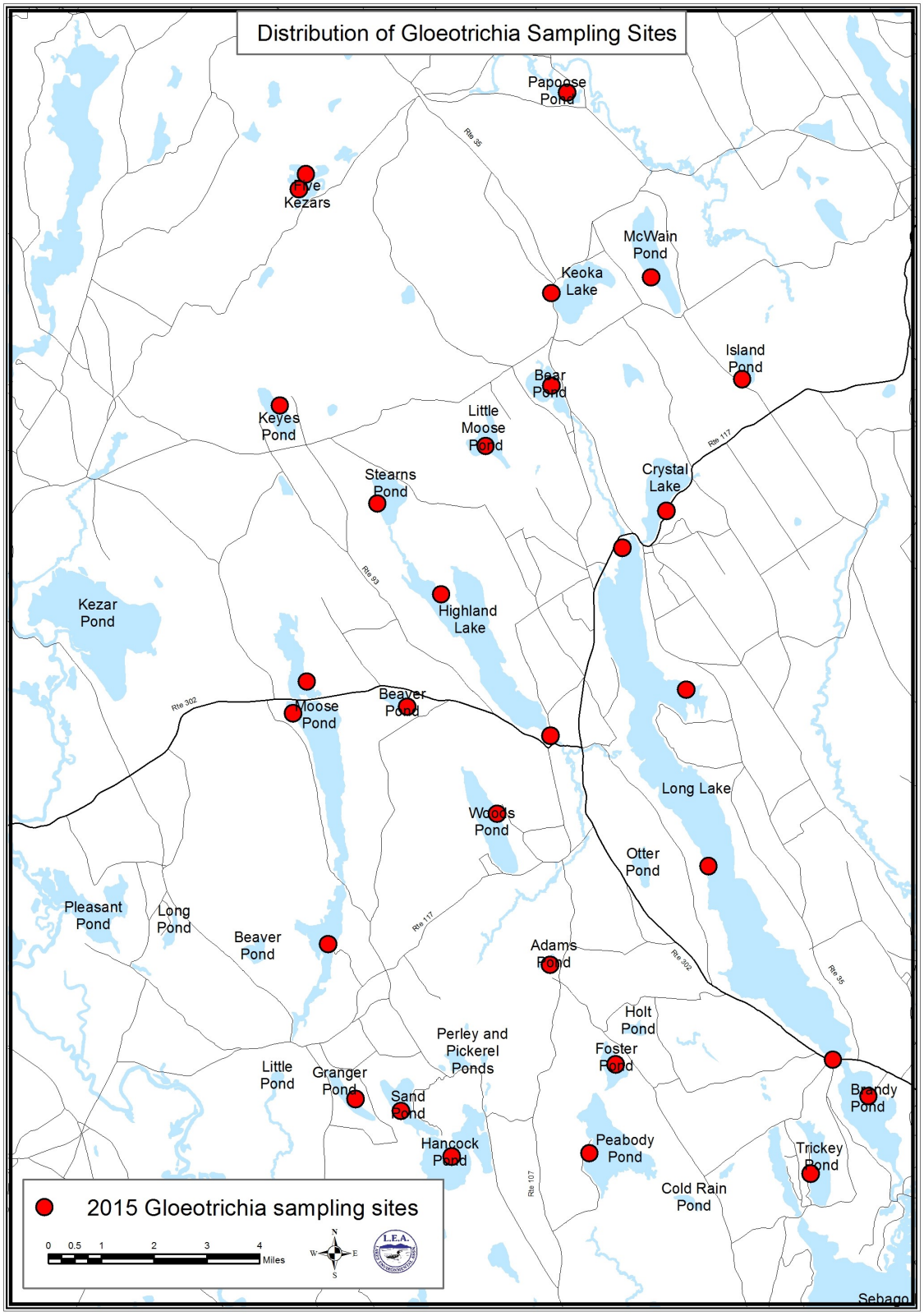


Figure 1. Map of 2015 *Gloeotrichia* sampling sites, located on lakes and ponds in the towns of Demark, Naples, Bridgton, Sweden, Waterford, and Harrison, Maine.

Sampling Methods

Ten sites on seven lakes and ponds in the western Maine Lakes Region were sampled roughly every week (for a total of 4 samples at each site) in July and August of 2015. Sample scheduling was intended to coincide with the peak in Gloeo population, which was determined based on data from the 2013 and 2014 sampling seasons and previous studies. The sites sampled included Long Lake (4 sites), Keoka Lake, McWain Pond, Moose Pond, Peabody Pond, Crystal Lake, and Middle Pond. These lakes, with the exception of Middle Pond, had the highest Gloeo concentrations in 2013 and 2014 and were therefore sampled multiple times.

Eighteen additional lakes in the region were sampled once during the anticipated peak in Gloeo abundance in late July/early August. These included Adams Pond, Back Pond, Bear Pond, Beaver Pond (Bridgton), Brandy Pond, Foster Pond, Granger Pond, Hancock Pond, Highland Lake (2 sites), Island Pond, Keyes Pond, Little Moose Pond, Moose Pond (north and south basins), Papoose Pond, Sand Pond, Stearns Pond, Trickey Pond, and Woods Pond (see Figure 1 on previous page). These sites had little to no Gloeo when sampled in previous years.

Samples were collected using a plankton net with 80 µm mesh. The sites where samples were collected remained consistent throughout the season and between years. All sites were located in shallow areas between 2 – 3.5 meters in depth. Two 1-meter deep tows were collected for each sample and rinsed into a 125 mL opaque bottle, then preserved with approximately 2 ml of Lugol's solution. Samples were counted using a stereomicroscope at 10 – 30x magnification. A total of 61 samples were counted.

Collecting a sample using a plankton net.

Table 1. Comparison of peak Gloeo concentrations in all lakes tested from 2013—2015, as well as the number of samples collected during the 2015 season.

Lake Name	Max. 2013 colonies/L	Max. 2014 colonies/L	Max. 2015 colonies/L	Number of Samples taken in 2015
Adams Pond	Not tested	0	0	1
Back Pond	0.1	0	0	1
Bear Pond	Not tested	0.3	0.2	1
Beaver Pond (Bridgton)	Not tested	0	0	1
Brandy Pond	Not tested	2.1	4.1	1
Crystal Lake	2.3	3.3	1.2	4
Foster Pond	Not tested	0	0	1
Granger Pond	0	0	0	1
Hancock Pond	0	0	0	1
Highland Lake, Public Launch	0	0	0.1	1
Highland Lake, Highland Point	0	0	0	1
Island Pond	0	0	0	1
Keoka Lake	6.1	72.4	5.5	4
Keyes Pond	0	0	0	1
Long Lake (Harrison)	2.4	33.9	42.2	4
Long Lake (Cape Monday)	1.9	17.5	6.1	4
Long Lake (Bridgton)	8.0	20.6	5.3	4
Long Lake (Naples)	6.9	16.3	4.1	4
Little Moose Pond	Not tested	0	0	1
McWain Pond	9.4	26.3	12.8	4
Middle Pond	Not tested	0	0	4
Moose Pond (North Basin)	Not tested	0.9	1.4	1
Moose Pond (Middle Basin)	16.6	16.2	192.4	5
Moose Pond (South Basin)	Not tested	1.5	1.7	1
Papoose Pond	Not tested	0	0	1
Peabody Pond	1.9	2.4	2.2	4
Sand Pond	Not tested	0	0	1
Stearns Pond	0	0	0	1
Trickey Pond	0	0	0	1
Woods Pond	0	0	0	1

Results

The highest concentration of Gloeo found in 2015 was 192.4 colonies per liter (col/L) on August 19th in Moose Pond. This is the highest level of Gloeo counted on any lake in this region since monitoring began in 2013. At this level, the algae were prevalent and clearly visible in the water column. The Harrison site on Long Lake, which is near the north shore of the lake, also had a high concentration of Gloeo, at 42.2 col/L on August 13th. Gloeo concentrations at the other sites—Keoka Lake, McWain Pond, the three remaining Long Lake sites, Crystal Lake, and Peabody Pond—either fell or stayed relatively similar to 2014 levels (see Table 1 on the previous page and Figure 4 on Page 9).

Of the 18 additional lakes sampled, Brandy Pond and the north and south basins of Moose Pond were the only sites with greater than 1 col/L of Gloeo present. Levels were still low at 4.1, 1.4, and 1.7 col/L respectively. Highland Lake and Bear Pond both had measureable levels lower than 1 col/L, while the rest of the sites that were sampled once contained 0 col/L of Gloeo.

The date of the "peak" in concentration for most lakes was difficult to determine, due to the relatively low levels of Gloeo and the small number of samples taken at each site. The last sample taken at the Harrison site on Long Lake had the highest Gloeo concentration (Figure 2, below), but we don't know if the population kept increasing after that because no samples were collected. Similarly, the last sample collected on Moose Pond, on August 19th, had the highest concentrations of the season. However, based on these two sites, the peak in concentration appears to have occurred later than in 2013 or 2014, when the peak occurred near the beginning of August.

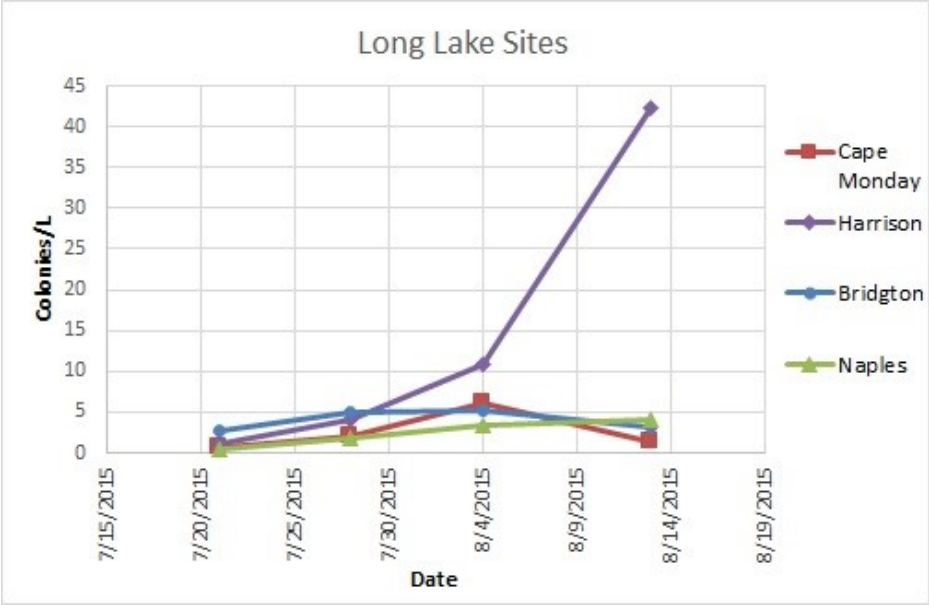


Figure 2. Results of 2015 Long Lake Gloeo sampling. The Cape Monday, Bridgton, and Naples sites remained consistently low in Gloeo (below 10 colonies/liter). The Harrison site started with levels similar to the other sites in July, however by August concentrations were much higher than at the other sites.

Results

Figure 3 shows individual sample results as well as season averages for the 10 sites that were tested multiple times in 2015. The only sites that had any individual samples with concentrations above 10 colonies per liter were McWain Pond, Long Lake (Harrison site), and Moose Pond (main basin).

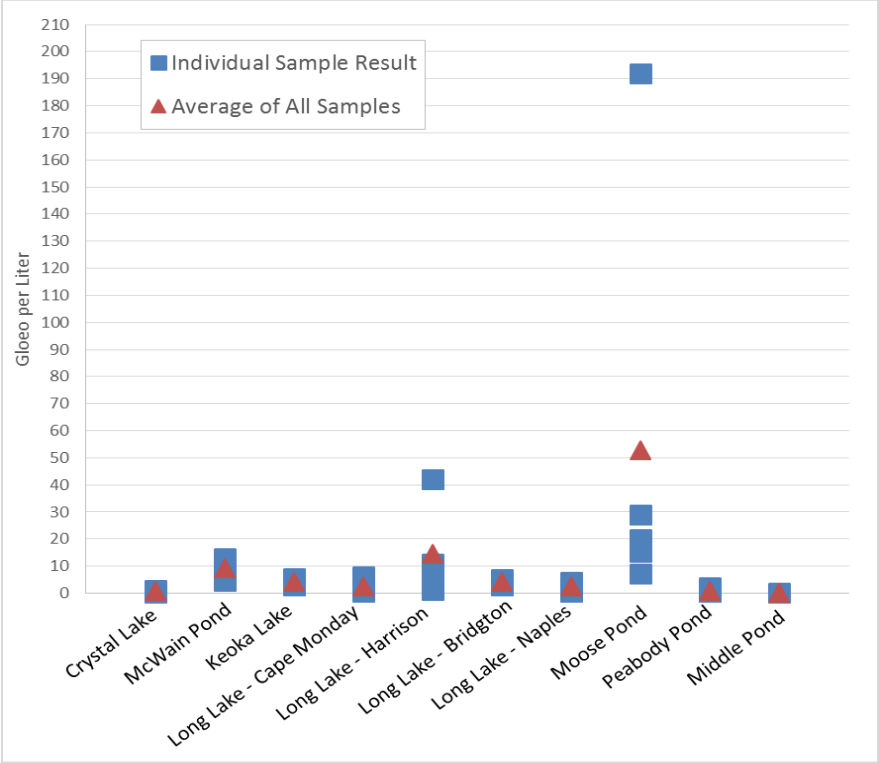
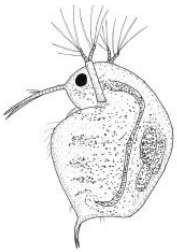
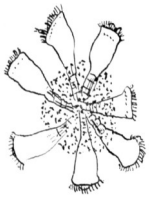


Figure 3. Gloeo concentrations at sampling sites with 4 or more samples taken over the season (each sample is marked by a blue square), as well as the average concentration at each site (red triangles).

Samples counted for Gloeo also contained a variety of other plankton species, which come in two types. Phytoplankton are the various types of algae that live in water and use photosynthesis to grow. They include green algae, metaphyton, cyanobacteria, dinoflagellates, and diatoms, among others. Zooplankton are small, insect-like organisms that swim in the water column and eat phytoplankton. They include copepods, bosminids, and rotifers, among others. There were a variety of plankton seen in the Gloeo samples, although most of the ones noted were fairly large due to the low magnification used to count samples.



Copepods were common in all of the samples. Long Lake appeared to have the highest number and variety of plankton, with large amounts of copepods in most samples. Keoka Lake was dominated by copepods, particularly in the samples collected in July. Metaphyton algae clumps, which had been common in Long Lake in the past two years, were most common in McWain Pond in 2015. Most samples from Moose Pond contained a large number of conochilus, a type of colonial rotifer. Bosminids were also very common in many lakes.



Results

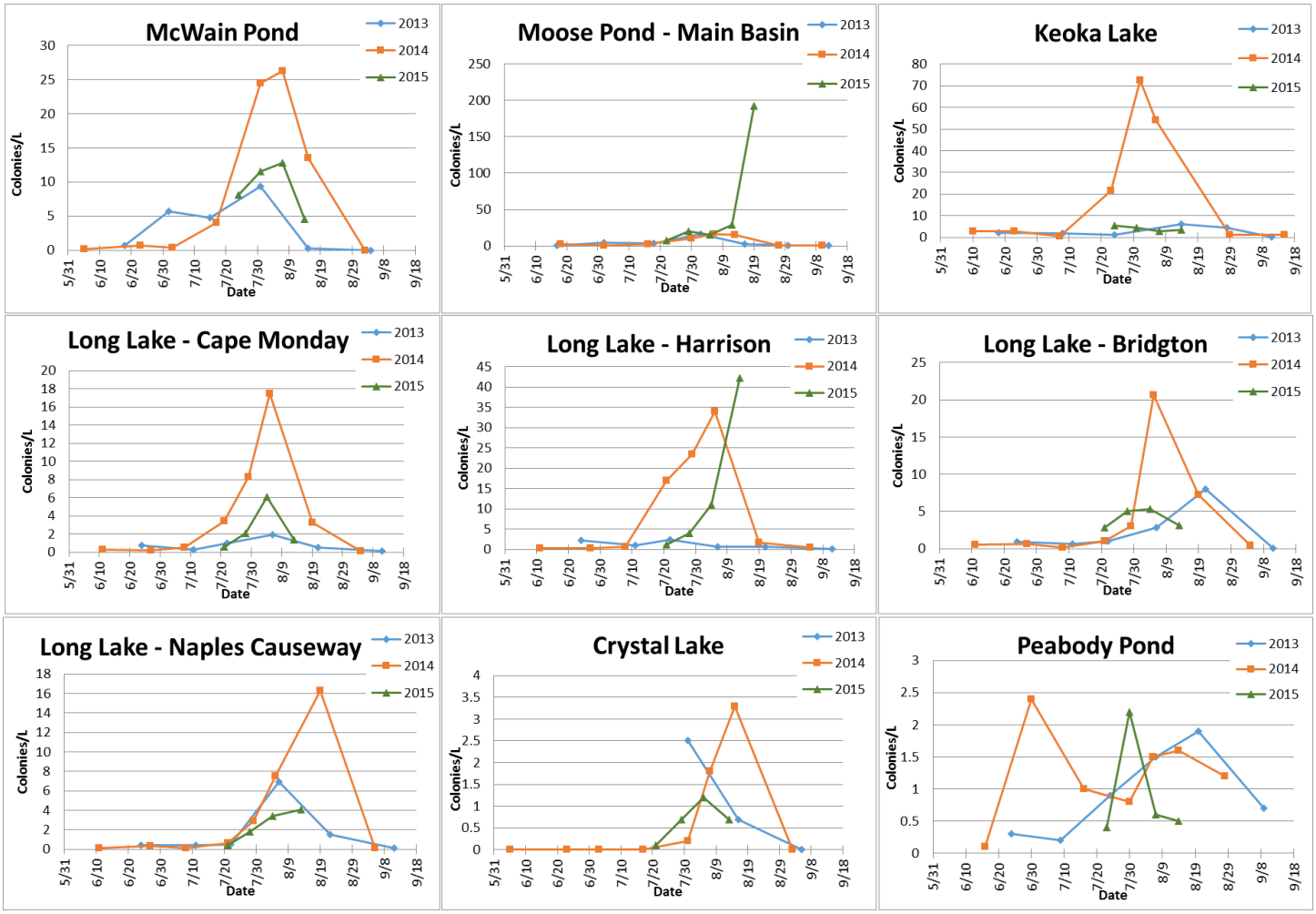


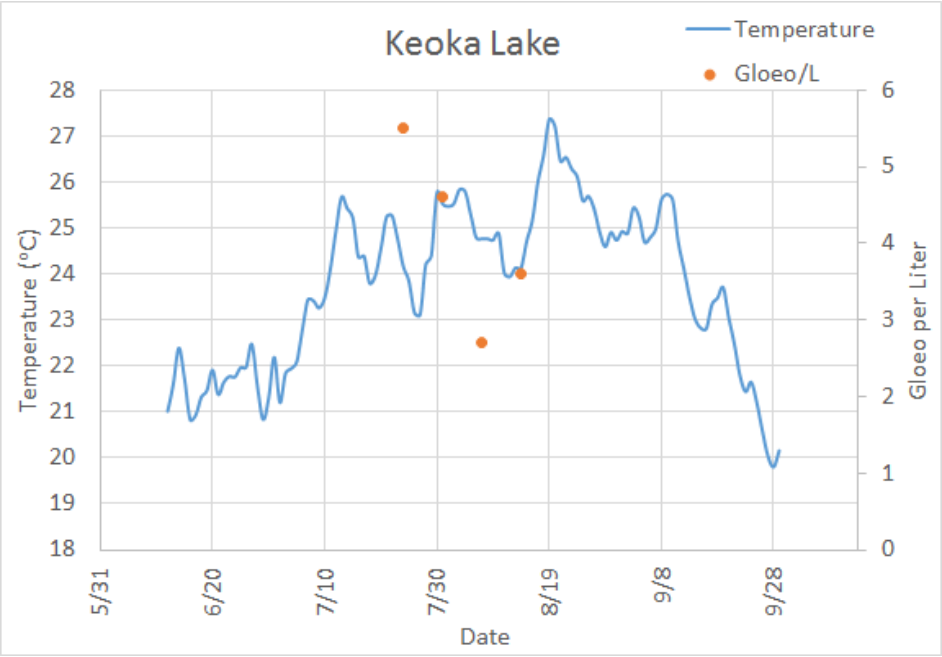
Figure 4. All data from 2013-2015 Gloeo monitoring at sites where samples were taken more than once per season. Please note that the scale on the Y-axis (vertical axis), which depicts the concentration level, differs greatly between individual graphs.

The above graphs display all of the data collected in 2013, 2014, and 2015 on each of the lakes and ponds which were sampled for Gloeo more than once per year. Some sites—such as Long Lake's Cape Monday site and McWain Pond—seem to have predictable peaks in concentration based on the three years' worth of data. At other sites, the patterns are less clear.

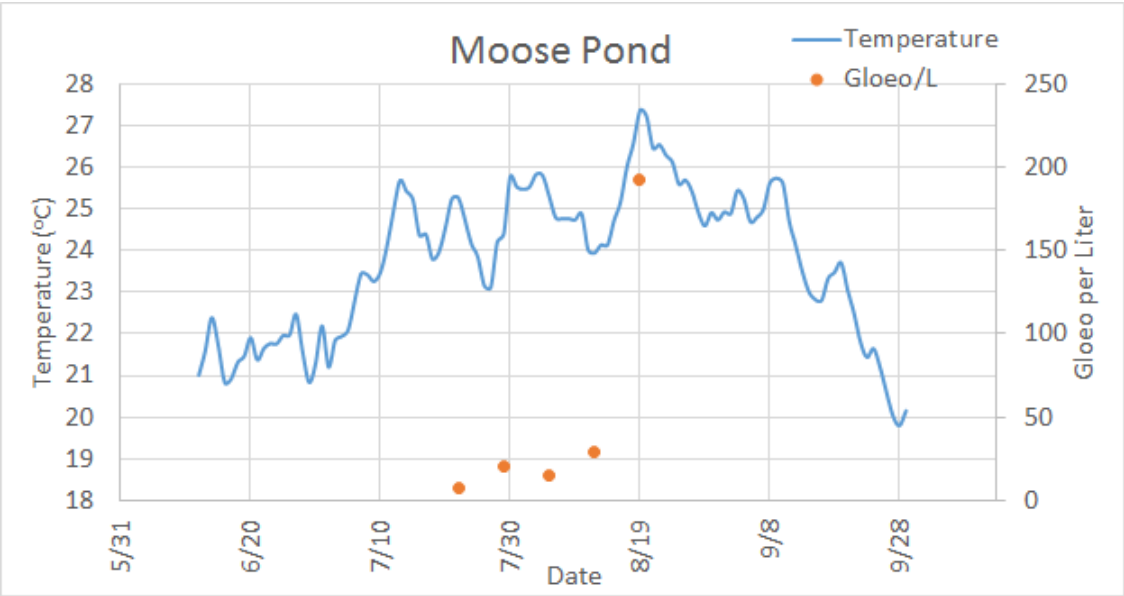
Moose Pond's 2015 high of 192.4 col/L dwarfs the previous two years' curves, which both peaked around 16 col/L. Populations peaks were difficult to discern in 2015 due to the low number of samples and often low concentrations of Gloeo. With the exception of Long Lake's Harrison site and Moose Pond, all of the sites saw their highest levels in 2014, with 2015 concentrations being somewhat lower.

Results

The highest recorded temperature for the year on most lakes occurred between August 18th and 20th. This is almost a month later than in 2014, where the high took place on July 23rd or 24th in most lakes. Because temperatures took longer to warm up than anticipated, Gloeo samples were collected before the peak in temperature occurred (Figure 5) — with the exception of Moose Pond, which was sampled at the same time as the temperature peak on August 19th. (Figure 6).



Figures 5 and 6. Comparison of 2015 summer daily average surface water temperatures and Gloeo concentrations in Keoka Lake and Moose Pond, showing that the peak in temperature occurred after Gloeo samples had been collected on Keoka Lake (above) and the high level of Gloeo on Moose Pond the day of the temperature peak (below). Note the difference in scale on the secondary Y-axis of each graph.



Discussion

Putting the Results in Context

Moose Pond had the highest Gloeo level recorded in the region with 192.4 col/L. However, about 60% of the 30 sites we sampled had little to no Gloeo this year and in the previous 2 years of sampling. Thirteen sites on 7 lakes have had levels above 1 col/L. The good news is that most of these sites have stable, relatively low Gloeo populations. Only Keoka Lake, Long Lake, Moose Pond, and McWain Pond have had Gloeo levels high enough to be a worry in the three years LEA has been monitoring this algae.

Due to the algae's size, concentrations of Gloeo as low as 1 col/L or less can be seen easily in the water column.

An important thing to remember is that Gloeo is fairly large compared to most other algae, and although it can be easily seen, its presence does not necessarily mean there is a water quality problem. There are often more numerous algae in lakes, but they are so tiny that their existence goes unnoticed. Concentrations of Gloeo as low as 1 col/L can be seen easily in the water column, but this level of Gloeo is not a concern.

Other lakes in Maine have experienced higher levels of Gloeo than the lakes of the Lakes Region. The Belgrade Lakes area has seen levels as high as 250 colonies per liter. Lake Auburn and Panther Pond also have significant Gloeo populations. Indeed, Lake Auburn had some very high levels of Gloeo sampled in 2015. Levels well over 1000 colonies per liter have been reported in high nutrient systems in other areas of the world.

Collecting a Gloeo sample on Long Lake, July 2015

Discussion

Some Observations from 2015 Sampling

Gloeo populations are hugely variable both over time and spatially across lakes. This makes it very difficult to accurately assess Gloeo concentrations in any particular portion of a lake. Because of this, our sampling only provides a "snapshot" of how much Gloeo is in a certain place at a certain time.

Daily fluctuation in concentration at a given site can be attributed to a number of causes, though wind and water currents are likely the main drivers. A strong easterly wind will "push" the water toward the western shore. These winds will cause lake currents to become stronger, which may result in the small, suspended Gloeo colonies accumulating downwind. To test the effect of wind and currents on Gloeo concentrations, sites on different sides of a lake could be sampled during various wind conditions and compared. Having multiple sample sites per lake increases our knowledge of Gloeo dynamics greatly.

However, collecting and counting samples is very time consuming, so taking large amounts of samples becomes unfeasible eventually. This year we tried to make it more manageable by only collecting four samples near the date we assumed the collective population would peak. Perhaps because of the cool spring and late warm-up in water temperatures, populations were quite low compared to samples collected at the same time in 2014.

Our results from 2013 and 2014 showed that Gloeo concentrations peaked between 8 and 13 days after water temperatures peaked. Because we didn't collect samples after the temperature peak, we can't say whether or not this was true in 2015. What is clear is that temperature is only a part of the picture when it comes to Gloeo abundance. The cooler temperatures may have caused concentrations to be lower in many lakes during the time we sampled. The two high levels in Long Lake and Moose Pond occurred later than we expected based on the timing of 2013 and 2014 peaks. However, the Long Lake spike occurred before the peak in temperature.

Based on anecdotal data, it did not appear that concentrations increased greatly after the temperature spike in mid- to late- August. LEA staff are regularly on these lakes throughout August and September and did not note any large blooms of Gloeo. Smaller amounts were still present on a number of lakes into September, which is consistent with previous years' observations.

Discussion

Possible Explanations for Results

One of the biggest questions that remains unanswered after three years of monitoring is, "Why are Gloeo seen in certain lakes and not in others?" An interesting observation is that many of the lakes with Gloeo levels above 1 col/L – with the exception of Moose Pond and Peabody Pond – are part of the same chain of lakes and are therefore directly connected to each other. In 2013, we looked at water quality and lake characteristics versus Gloeo concentrations and did not find any strong connections. Part of the reason for this is that many of the lakes in the Lakes Region have very similar water quality.

The main reason for the (mostly) lower populations of Gloeo in 2015 seems to be the colder spring and slower warm-up of lake waters. The delay in the temperature peak coincided with delays in many of the lakes' peak Gloeo concentrations. However, the warmer waters toward the end of the season don't appear to have caused a large increase in the population in most lakes. This may be because of competing effects from other factors such as light availability.

A few sites bucked the trend: Long Lake's Harrison site on the north shore of the lake reached an all-time high of 42.2 col/L about one week before the temperature reached its yearly maximum. This level is not much higher than at this site in 2014, yet all of the other sites were much lower than their 2014 levels. The concentration in Moose Pond was 11 times higher than in the previous two years. Our plant survey team reported a larger than normal amount of Gloeo on Moose Pond early in the season, before our sampling detected higher concentrations. Lake Auburn, which we do not sample, reportedly had record high levels this year as well. From these examples, it is clear that temperature is not the only measurement that predicts Gloeo abundance.

There are a number of factors which we know affect Gloeo populations generally – light, temperature, and nutrients being the main three. Scientific research suggests a number of other reasons why some lakes contain higher levels of Gloeo than others. Sediment mixing and strength of stratification both appear to affect Gloeo populations. More lake mixing and deeper epilimnion depth were associated with higher numbers of Gloeo colonies being released into the water column (Carey et al., 2014). Another study found that sediment disturbance, such as through wave action, increased the amount of Gloeo in a similar way (Karlsson-Elfgren et al., 2004).

Also, while Gloeo populations can fluctuate greatly from year to year, lakes that have already had high concentrations (such as Long Lake) are the most vulnerable to future high concentrations. This is

Discussion

because over the course of the summer, some of the Gloeo colonies present in the lake become dormant and settle out of the water column. These "resting cells" can persist until conditions are favorable for growth again, with each being able to produce multiple new colonies. The more Gloeo there are in the lake to begin with, the more dormant cells there will be, creating more potential for Gloeo growth the next summer.

It is very difficult to tease out the dominant drivers behind Gloeo population growth in lakes due to the large amount of factors that affect this growth. It is also important to remember that each lake is only sampled 4 times during the season, once per week from mid-July to mid-August. A typical bloom of Gloeo lasts approximately 2 weeks at the most (Fey et al., 2010). Because we cannot continuously monitor, there is still uncertainty as to what the "true" peak in concentration was. And because the level can fluctuate dramatically across a lake, the site we sample may not represent the lake as a whole.

Future Testing

Continued, regular monitoring is an essential part of understanding how Gloeo affects lakes. LEA is committed to monitoring those lakes with the highest levels of the algae. One of the issues we have to consider is the balance between time and resources and the amount and quality of the data we collect. This is why we concentrated on a shorter timespan for 2015 sampling. In 2016, we will likely expand the timeframe for testing again to include earlier and later dates, in order to capture more of the season.

In the future, we would like to investigate how Gloeo move in lakes by measuring the magnitude of the influence of wind speed and direction on Gloeo abundance at different sites on a lake. Another topic of interest is learning if there are sediment "hot spots" with ideal conditions for growth. This could be studied using sediment traps. Determining what percentage of each lake's bottom is viable for Gloeo production could indicate risk and help us to better understand why certain lakes have more Gloeo than others. The influence of color and organic matter on abundance and the monitoring of similar cyanobacterial species would also provide valuable insight.

For more information about our Gloeo program, please visit our website, www.mainelakes.org.

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McWain Pond Association
Moose Pond Association

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and all of our members

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