Echo Lake

WATER QUALITY REPORT

2023

30 Mile River Watershed Association
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www.30mileriver.org

2023 Echo Lake Water Quality Report

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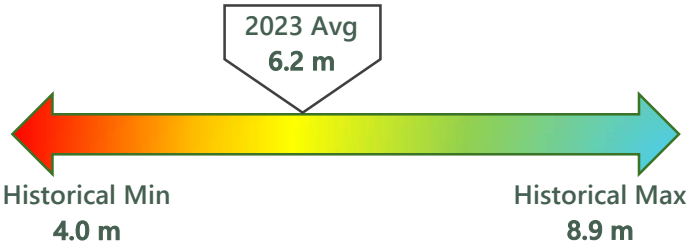
2023 Water Quality Summary[1]

Monitoring on Echo Lake occurred on ten (10) dates between June and October 2023 by Whitney Baker and Silas Mohlar of 30 Mile River Watershed Association (30 Mile) and local volunteer water quality monitor Gary Philip of Echo Lake Association (ELA).

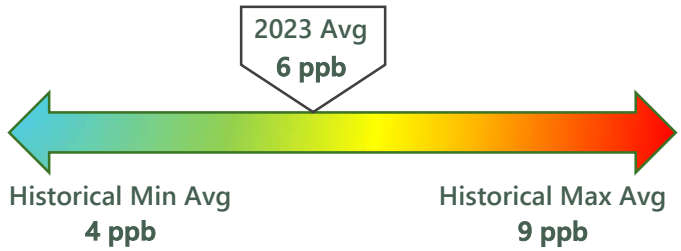
Water clarity readings in 2023 ranged from 5.30 meters (July 5th) to 6.65 meters (October 11th) with an annual average of 6.2 meters. 14 readings in total were collected in 2023.

Water Clarity (m)	
2023 Water Clarity Average	6.2
Historical SDT Average	6.6
Maine Lakes SDT Average	4.8



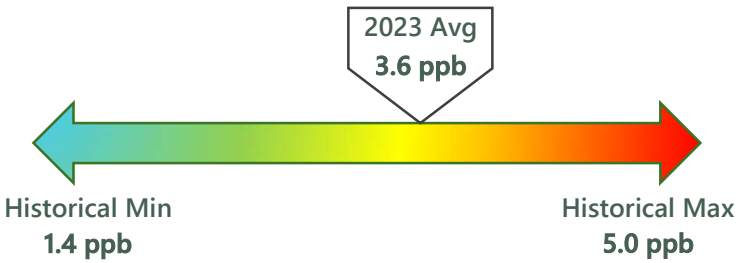
Five (5) samples were collected and analyzed for **Total Phosphorus**. Laboratory results ranged from 5 ppb (parts per billion) to 7 ppb with an average of 6 ppb.

Total Phosphorus (ppb)	
2023 TP Average	6
Historical TP Average	6
Maine Lakes TP Average	12



Chlorophyll was measured five (5) times in 2023. Results ranged from 2 ppb to 5 ppb with an annual average of 3.6 ppb.

Chlorophyll-a (ppb)	
2023 Chl-a Average	3.6
2023 Peak Chl-a	5.0
Historical Chl-a Average	2.5
Maine Lakes Chl-a Average	5.4



Ten (10) **Dissolved Oxygen (DO)** profiles were collected in 2023. Anoxia (DO <2 ppm) was first encountered at 8 meters (within the metalimnion) and again at 35 meters (in the deepest waters of the hypolimnion) on September 1st. A strong metalimnetic oxygen minima was observed in 2023, with anoxia encountered in the shallower water range of 8-10 meters from September through the end of the monitoring season in October.

[1] Scale bars illustrate the range of data collected for each parameter over the historical monitoring record for general comparison with the 2023 monitoring results. The blue end represents the historical minimum (best), and the red end represents the historical maximum (worst) of all monitoring data collected.

Echo Lake (Crotched Pond) has a surface area of 1,109 acres and is located in the towns of Fayette, Mount Vernon, and Readfield in Kennebec County, ME. Echo Lake has a maximum depth of 34 m (111 ft) and an average depth of 7 m (22 ft). The direct watershed area draining to the pond is relatively small at roughly 8 square miles. However, the lake has a rather large upstream/indirect watershed of 35 square miles that includes the upstream drainages of Taylor Pond, Minnehonk Lake, David Pond, Parker Pond, Flying Pond, and several other smaller ponds and tributaries flowing into each of the above. Water from Echo Lake flows to a single outlet located at the south end of the southwest basin, where it flows south into Lovejoy Pond.

Various water quality monitoring on Echo Lake has been ongoing since 1976 by Maine DEP and other state agencies, volunteers monitors certified through Lake Stewards of Maine, and more recently, 30 Mile River Watershed Association (30 Mile).

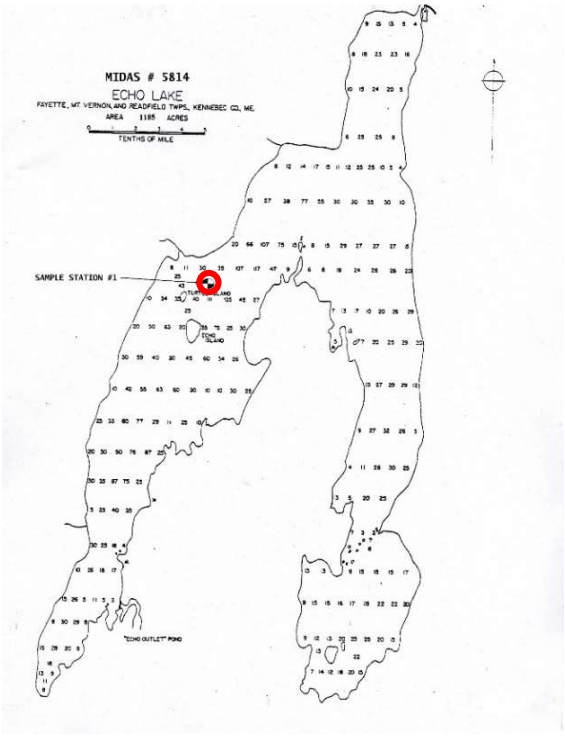
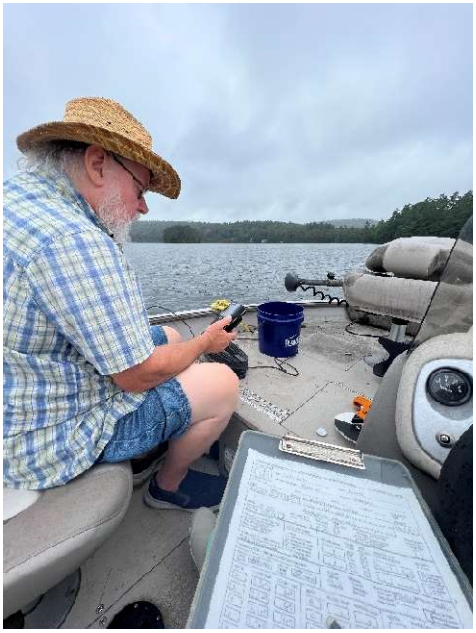


Figure 1. Station 01, Echo Lake, Mount Vernon & Readfield, ME.

Water Quality Monitoring in 2023



ELA volunteer water quality monitor, Gary Philip checks for a dissolved oxygen reading during a monitoring trip in September.

In 2023, 30 Mile River collaborated with Echo Lake Association (ELA) volunteer water quality monitor, Gary Philip to monitor water quality inEcho Lake on a bi-weekly schedule between June and October, collecting a varitey of parameters including secchi disk transparency (SDT), dissolved oxygen, and temperature. Water samples, collected monthly, were analyzed for Total Phosphorus (TP) and Chlorophyll (chl-a). An additional water sample was collected once in August and analyzed for pH, Alkalinity, Color, and Conductivity. All water samples were analyzed at the Health and Environmental Testing Laboratory (HETL) in Augusta, ME. Monitoring on Echo Lake takes place at the deepest spot in the lake - aka Station 01 (Figure 1).

Secchi Disk Transparency (Water Clarity)

Secchi disk transparency (SDT) is an indicator of water clarity. To measure water clarity, a black and white disk is lowered into the water and the reading is taken at the depth at which it is no longer visible. Factors that affect water clarity include algal growth, zooplankton densities, natural water color, and suspended silt or sediment particles.

Water Clarity (m)	
2023 Water Clarity Average	6.2
Historical SDT Average	6.6
Maine Lakes SDT Average	4.8

Water clarity readings in 2023 ranged from 5.30 m (July 5th) to 6.65 m (October 11th) with an annual average of 6.2 m. 14 total readings were collected in Echo Lake over 10 monitoring days in 2023 (Figure 2).

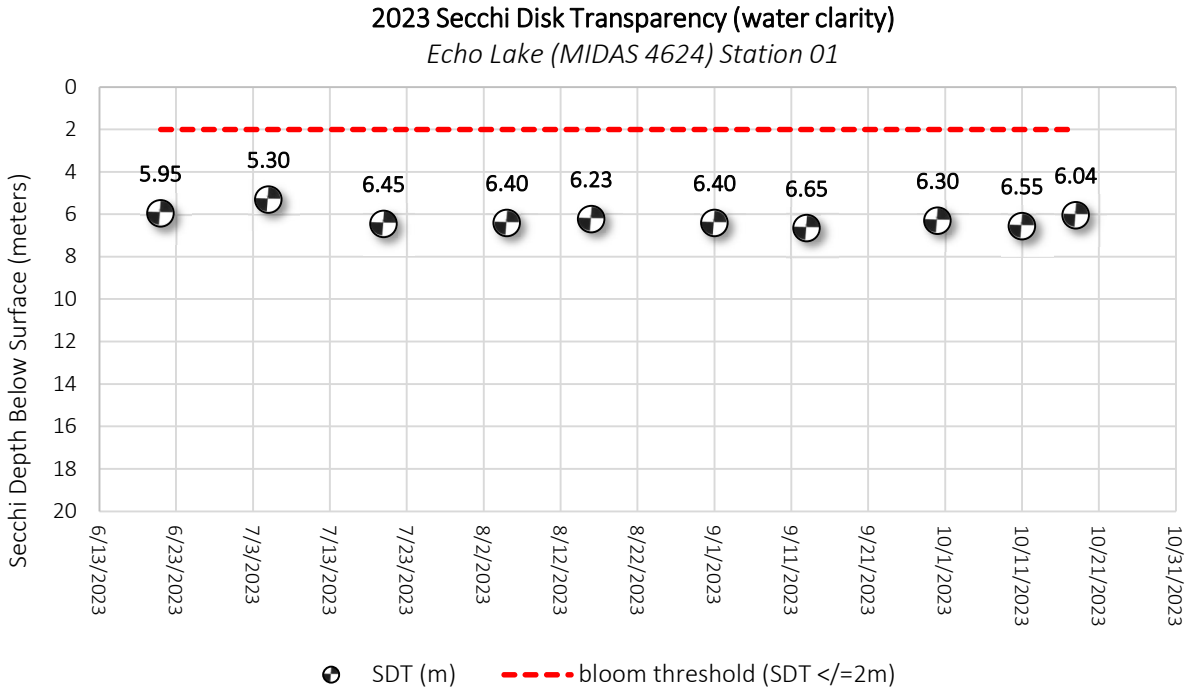


Figure 2. 2023 Secchi Disk Transparency, Daily Averages, Station 01

SDT data has been collected during 44 years throughout the historical monitoring period spanning the past 47 years. SDT readings in Echo lake have ranged from 4.0 m (1978 and 1983) to 8.9 m (2018) with a historical average of 6.6 m (Figure 3).

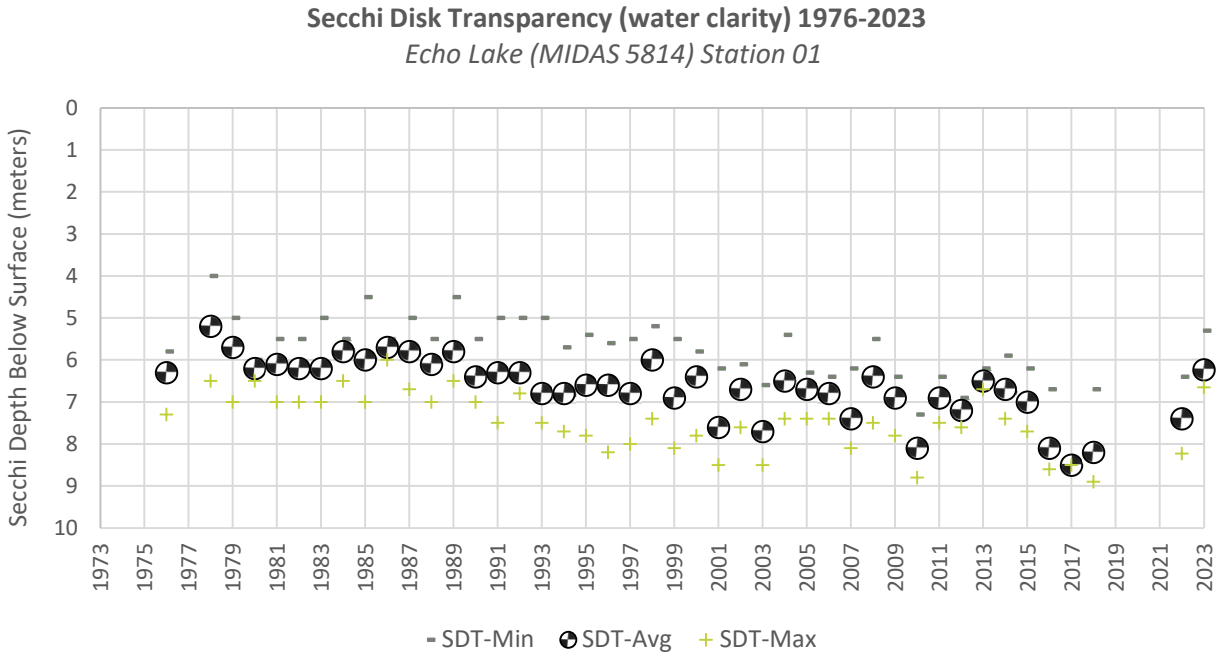


Figure 3. Historical Secchi Disk Transparency, Station 01, 1976-2023

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) is a critical indicator of the health of the lake system. DO is produced through photosynthesis, consumed during respiration and decomposition, and is influenced by wind, wave action, weather events, and lake productivity. A good supply of oxygen is essential for fish and other aquatic species, with most fish species requiring a DO concentration of 5 mg/L or more. *Anoxia* can occur when DO drops below 2 mg/L. As lake water is warmed during the summer, deep lakes will form three distinct temperature layers. There is a warm layer at the surface (epilimnion), a thin transitional layer (metalimnion or thermocline), and a deep cold layer (hypolimnion). The change in water temperature and density at the metalimnion acts as a physical barrier that prevents mixing of the upper and lower layers for several months during the warm summer months.

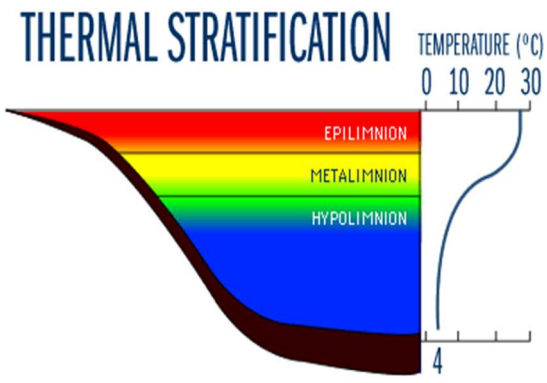


Figure 4. Thermal stratification in a deep lake. Image source: www.watertheweb.org.

As lakes become more biologically productive in the summer, oxygen can decline as decomposition occurs in deep areas of the lake. While oxygen loss at the bottom of a deep lake is common in the summer months, excessive loss of oxygen may indicate a stressed and changing ecosystem. Monitoring the pattern and extent of oxygen loss in deep areas of Echo Lake is important to understanding changes between the years and throughout a single season and is particularly important for Echo Lake

because may be more vulnerable for internal phosphorus loading due to unique lake sediment chemistry.[2]

Ten (10) DO and temperature profiles were collected in 2023 (Figure 5). Along with anoxic conditions (DO < 2 mg/L) observed in the deep waters of the hypolimnion, an isolated zone of anoxic water, called a metalimnetic oxygen minima (MOM), was also documented in waters between 7 meters and 10 meters deep. A MOM is an isolated area of anoxic water within the lake's metalimnion or thermocline. This can be the result of algae die-off in the upper waters of

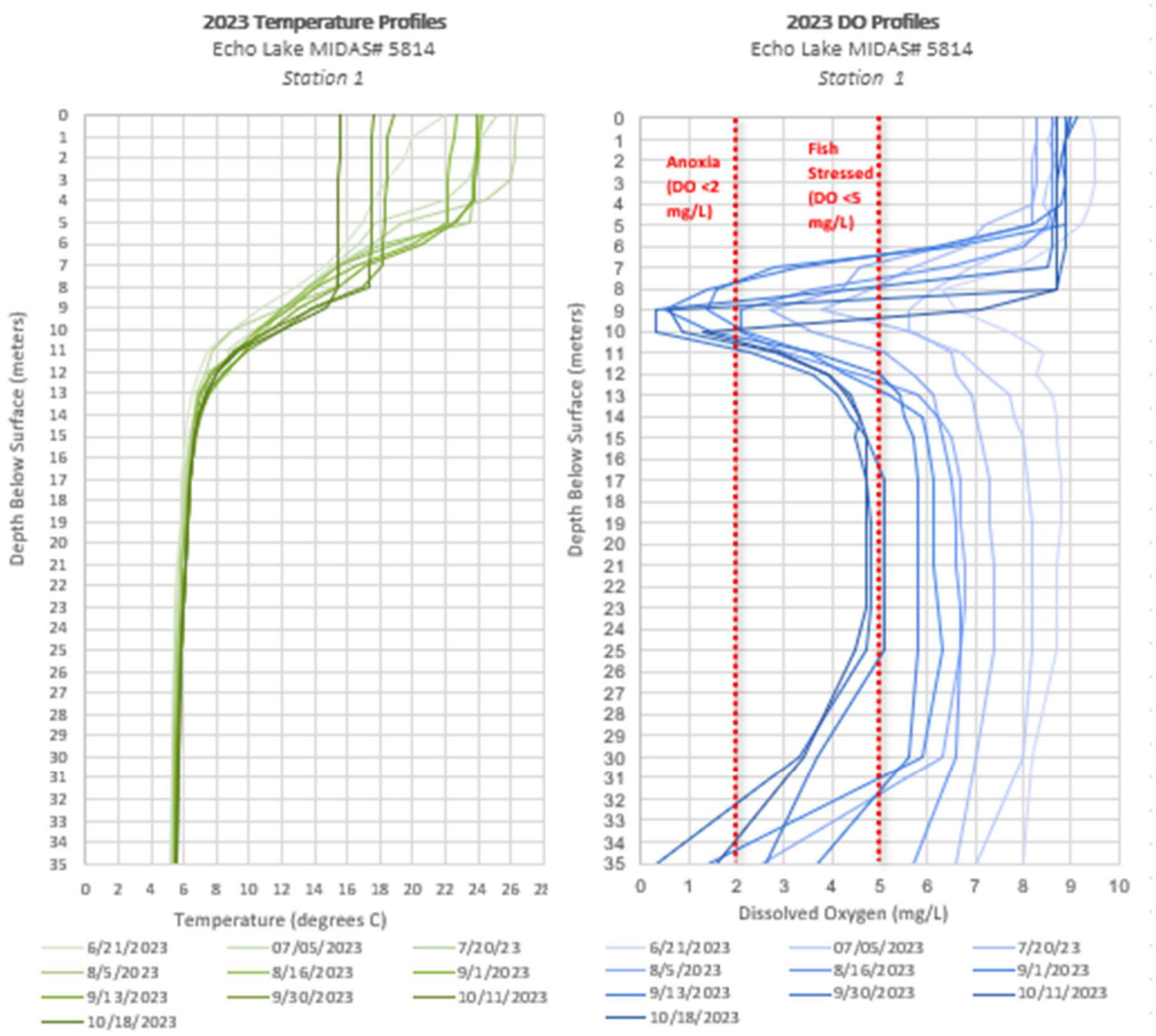


Figure 5. 2023 Dissolved Oxygen and Temperature Profiles, Station 01

[2] Echo Lake appears on Maine DEP's list of "Threatened Lakes" on the NPS Priority Watersheds List (https://www.maine.gov/dep/land/watershed/nps_priority_list/NPS%20Priority%20List%20-%20Lakes20.pdf) due to its sediment chemistry. Sediment results suggest that Echo Lake may be more vulnerable to internal phosphorus loading, a phenomenon that can occur when deep waters become anoxic (DO loss <2 mg/L) resulting is phosphorus release from the bottom sediments exposed to anoxic waters.

the lake with decomposition consuming oxygen, or an increase in zooplankton productivity with respiration consuming oxygen, or both of these two things occurring simultaneously.

DO <5 mg/L was first documented on July 20th in waters 8 and 9 meters deep (within the metalimnion or thermocline). This was the onset of a metalimnetic oxygen minima that persisted throughout the entire monitoring season in waters between 8 meters and 10 meters deep, eventually becoming anoxic (DO <2 mg/L) in early September.

In the hypolimnion, DO <5 mg/L was first documented in only the deepest part of the lake at a depth of 35 meters in early August, but this zone of low DO slowly grew to include all waters 9 meters and deeper By October. Anoxia (DO <2 mg/L) in the hypolimnion was only observed in the very bottom meter of the lake. Anoxic conditions at the lake bottom is of most concern when determining the potential of internal phosphorus loading. However, at this time, the summertime anoxic zone at the bottom of Echo Lake appears is confined to a very small area of lake bottom and appears to be stable.

Total Phosphorus (TP)

Total Phosphorus (ppb)	
2023 TP Average	6
Historical TP Average	6
Maine Lakes TP Average	12

Phosphorus is the nutrient that most influences the growth of algae in lakes. Because its natural occurrence in lake water is very small, phosphorus "limits" the growth of algae in lake ecosystems. Even small increases in phosphorus in lake water can cause substantial increases in algal growth, which hinders not only the overall health of the lake system, but also the economic, recreational, and aesthetic values. Tracking in-lake phosphorus levels over time is another way of monitoring change in lake water quality trends. Generally speaking, in-lake phosphorus concentrations less than 10 ppb are ideal. Lakes with in-lake phosphorus concentrations of ~13 ppb or more are known to sustain algal blooms, and blooms become more frequent as average concentrations approach 20 ppb.

In 2023, five (5) water samples were collected from the upper waters of Echo Lake using an integrated core sampler. These are referred to as "epilimnetic core samples". 2023 results ranged from 5 ppb to 7 ppb with an average of 6 ppb. Epilimentic core samples have been collected from the upper waters of Echo Lake since 1979 during 11 of the past 44 years. Annual average epilimnetic phosphorus concentrations have ranged from 4 ppb (1979 & 1985) to 9 ppb (1988) with an overall historical average of 6 ppb (Figure 6).

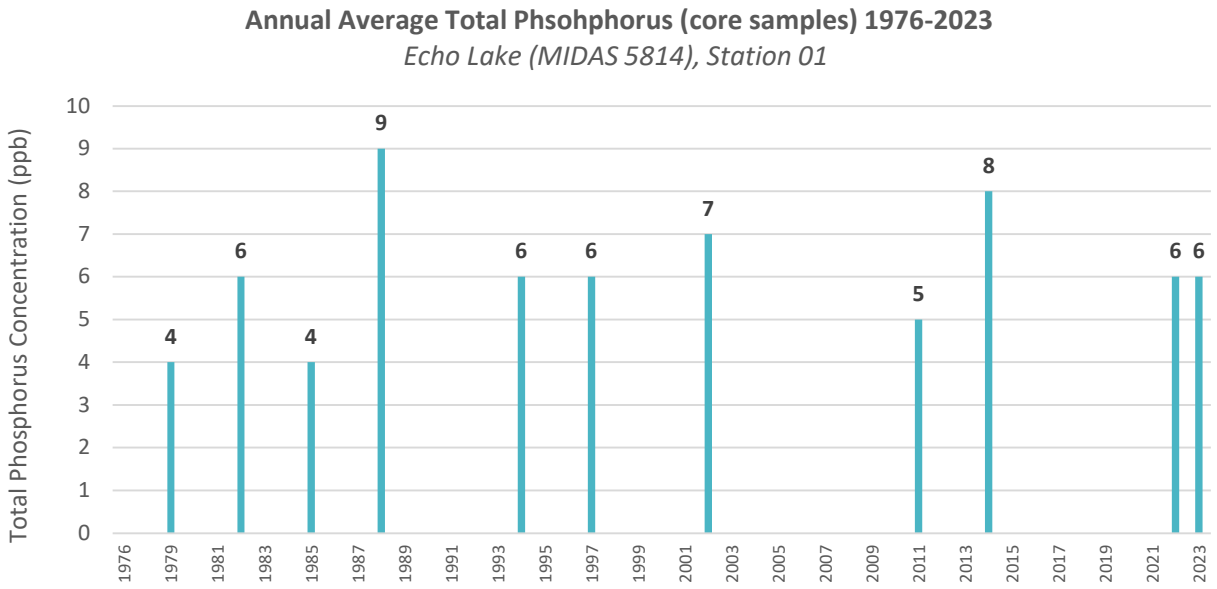


Figure 6. Annual Average Total Phosphorus (epilimnetic core samples), Station 01, 1979-2023

In 2023, two (2) TP samples were collected from the bottom of Echo Lake using a Kemmerer grab sampler; this type of sample is known as a "bottom grab". Bottom grabs are collected when anoxia is encountered anywhere in the dissolved oxygen profile, and help us determine if there is active phosphorus release from bottom sediments exposed to anoxic conditions. Lab results for the two bottom grab samples collected in 2023 were 17 ppb (September 13th) and 15 ppb (October 11th) (Figure 7).

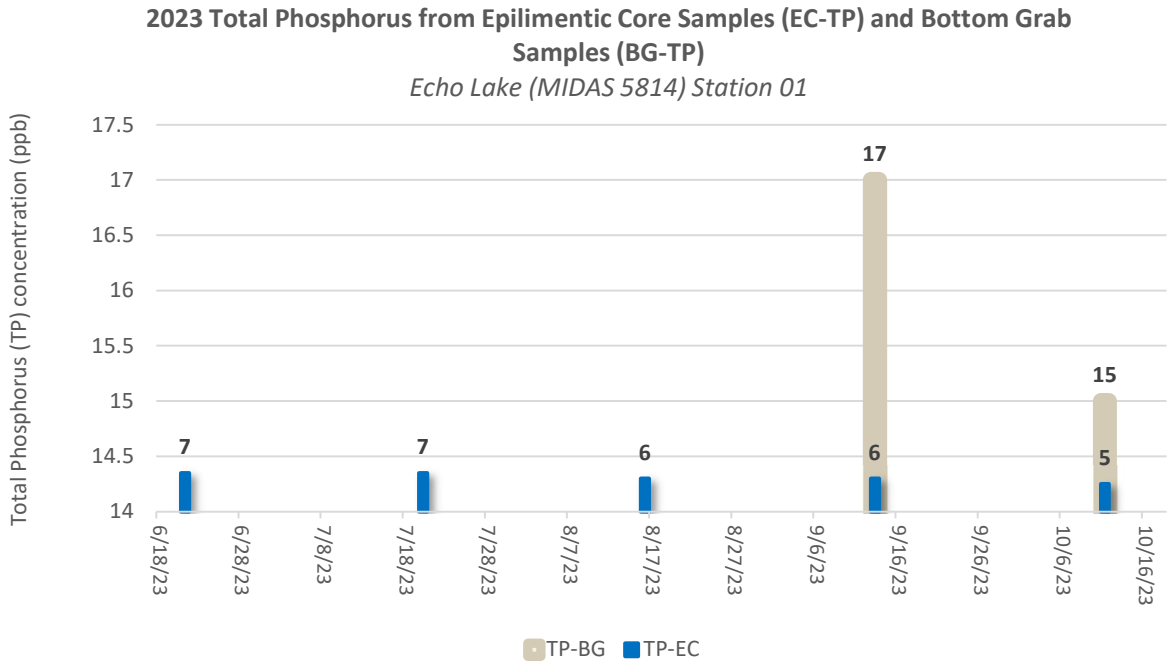


Figure 7. 2023 Total Phosphorus (epilimnetic core samples), Station 01

Bottom grab data is quite limited – collected during just seven (7) years throughout the 47-year monitoring record in 1979, 1982, 1985, 1988, 2002, 2022, and 2023. The historical annual average bottom grab TP concentration ranges from 4 ppb (1979) to 16 ppb (2023) with a historical average of 9 ppb. Though bottom phosphorus data is limited, the highest documented bottom TP concentration was observed in 2023.

Chlorophyll (Chl-a)

Chlorophyll is found in plants, including algae, and is used to convert sunlight into energy. Measuring the concentration of Chlorophyll in lake water helps us estimate the algae population in the lake. Chlorophyll was measured five (5) times in 2023.

Chl-a (ppb)	
2023 Chl-a Average	3.6
2023 Peak Chl-a	5.0
Historical Chl-a Average	2.5
Maine Lakes Chl-a Average	5.4

Chl-a samples have been collected from the upper waters of the lake (epilimnion) since 1979 during just nine (9) of the past 44 years. Annual average chl-a concentrations have ranged from 1.4 ppb (1997) to 5 ppb (2023) with an overall historical average of 2.5 ppb. The results from the five (5) epilimnetic core samples collected in 2023 ranged from 2 ppb (June 21st) and 5 ppb (October 11th) for an annual average of 3.6 ppb. The highest chl-a concentration ever recorded in Echo Lake was collected in 2023.

pH

pH helps determine which plant and animal species can live in the lake, and it governs biochemical processes that take place. The pH scale ranges from 0-14, with 7 being neutral. Water is increasingly acidic below 7, and increasingly alkaline above 7. A one unit change in pH represents a tenfold change in acidity or alkalinity. The pH scale is the inverse log of the hydrogen ion concentration.

pH	
2023 pH	7.1
Historical pH Average	7.2
Maine Lakes Average	6.44

One sample taken on August 16th was analyzed for pH and had a result of 7.1. Historically, pH has only been analyzed just eight (8) years since 1979, ranging between 6.4 (1988) and 7.3 (2007) with a historical annual average result of 7.2.

True Color

True color refers to the concentration of natural dissolved organic acids. This includes natural tannins and lignins dissolved in the water, often resulting in "tea" or "root beer" colored water in very colored lakes. “True Color” is measured in Platinum Cobalt Units (PCU) after all particulates (including algae cells) have been filtered out of the sample. Colored lakes (>25 PCU) can have reduced transparency

Color (PCU)	
2023 Color	16
Historical Color Average	14
Maine Lakes Color Average	21

readings and increased phosphorus values. However, this does not mean the lakes produce more algae. The dark color simply reduces the transparency such that the reading is not a good measure of algal biomass. Chlorophyll-a (Chl-a) is the best indicator of algal productivity in colored lakes and should be used if possible.

One sample taken on August 18th was analyzed for true color and had a result of 16 PCU. Historically, true color has been analyzed four years (2002, 2007, 2014, and 2023) and results range between 9 PCU (2007) and 17 PCU (2014), with a historical average of 14 PCU.

Conductivity

Conductivity (µMHOS/cm)	
2023 Conductivity	61
Historical Conductivity Average	47
Maine Lakes Conductivity Average	51

Conductivity measures the ability of water to carry electrical current and is directly related to the dissolved ions (charged particles) present in the water. Fishery biologists can use conductivity values to calculate fish yield estimates because conductivity will generally increase if there is an increase of pollutants entering the lake or pond. Stormwater runoff from developed areas and roadways is the most common pollutant in Maine lakes that can raise conductivity values. Conductivity is measured in micromhos per centimeter (µMHOS/cm).

One sample taken on August 18th was analyzed for conductivity and had a result of 61 µMHOS/cm. Historically, conductivity has been analyzed nine (9) years (1979, 1982, 1985, 1988, 1997, 2002, 2007, 2014, and 2023) of the 47-year monitoring period, ranging between 36 µMHOS/cm (1985) and 61 µMHOS/cm (2023) with a historical annual average of 47 µMHOS/cm. The highest conductivity value recorded in Echo Lake was observed in 2023.

Alkalinity

Alkalinity (mg/L)	
2023 Alkalinity	12
Historical Alkalinity Average	12
Maine Lakes Alkalinity Average	12

Alkalinity is also referred to as "buffering capacity." It is a measure primarily of naturally available bicarbonate, carbonate, and hydroxide ions in the water and is measured in milligrams per liter (mg/L). Measuring alkalinity is important to determining a lake's ability to neutralize acidic pollution from rainfall or snowmelt. Lakes with alkalinity values >20 mg/L are considered well buffered against pH changes over time. Lakes with low or zero alkalinity may have more variation in pH levels that can sometimes result in damage to aquatic life.

One sample taken on August 18th was analyzed for alkalinity and had a result of 12 mg/L. Historically, alkalinity has been analyzed during eight (8) years of the 47-year monitoring period, with a historical annual average of 12 mg/L.

Gloeotrichia echinulata (Gloeo)

Gloeotrichia echinulate – a.k.a. "Gloeo" (pronounced "glee-oh") is a type of cyanobacteria (blue-green algae) that lives suspended in lakes during the summer, sinks to the lakebed in a state of dormancy over the winter, then rises back up into the water column when the water warms in the spring. Unlike other bloom-forming cyanobacteria species that rely on nutrients in the water to fuel growth (like the bloom in Androscoggin Lake), Gloeo rely on lakebed sediments for their nutrient source. For this reason, reports of Gloeo blooms in pristine, low-nutrient lakes in the northeastern US, such as Echo Lake, have been on the rise in recent years.

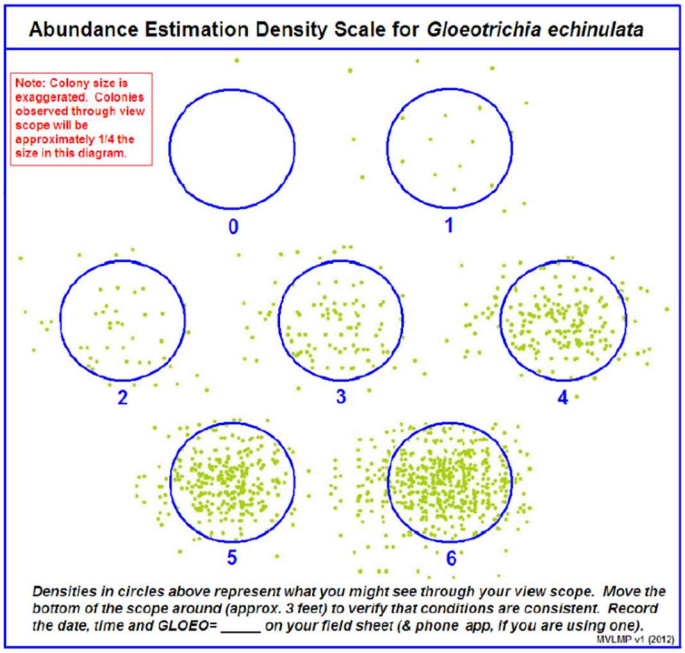


Figure 8. Abundance Estimation Scale used for assessing Gloeotrichia echinulata

New research has suggested that Gloeo may play a role in declining water quality of otherwise healthy lakes and that Gloeo may be increasing nutrient levels and algae growth within these lakes by moving phosphorus from the sediments at the lake bottom up into the water column, where it can be used by other algae. Anecdotal data indicates an overall increase in Gloeo abundance in recent decades, with the effects of climate change potentially accelerating growth.

During each monitoring session, the abundance of Gloeo is noted in Echo Lake. In 2023, Gloeo abundances ranged from 1 – 5 (refer to the *Abundance Estimation Scale* above) and was present during 6 of the 10 monitoring dates. Historically, Gloeo has been present in Echo Lake and in 2022, Gloeo was present during 3 of the 8 monitoring dates, with abundances ranging from 2-3. 30 Mile will continue to monitor Gloeo abundance to help identify Gloeo patterns and trends in Echo Lake.

Discussion

Data presented in this report includes all monitoring data collected on Echo Lake through 2022, submitted to Maine DEP by both volunteer monitors and state agencies, that has undergone a thorough QA/QC process. All data collected in 2023, presented in this report, was collected by 30 Mile staff, and collaborating volunteer monitors.

2023 was 30 Mile's second year of supporting water quality monitoring on Echo Lake, and the first full season collecting both baseline *and* advanced water quality parameters. One observation to note was the presence of a very strong metalimnetic oxygen minima (MOM) in 2023. This is an area of low oxygen and anoxia (no oxygen) in the metalimnion. Though a slight metalimnetic minima has commonly been observed in DO and temperature profiles collected in the past, severe oxygen loss in the metalimnion has not been as severe as what was observed in 2023. In fact, anoxia (DO <2 mg/L) was not observed in the metalimnion at all in 2022 – only in the deepest waters of the hypolimnion. Prior to 2022, anoxic conditions had not been observed at any depth in the water column of lake since 2013. Before 2013, anoxic conditions were observed in both the metalimnion and in the deep waters of the hypolimnion in late summer and early fall DO profiles collected during six years between 2004 and 2009.

The 2023 season was a particularly wet one, with an unprecedented rainstorm in early May delivering a large amount of polluted stormwater runoff into the lake. This likely increased the mass of algae in the lake this year, which resulted in more biological productivity and decomposition – processes that consume oxygen in the water. This also makes it difficult to compare this year's data to that collected years prior, which saw a lot less precipitation.

Five years of regular data collection for any given parameter will provide a baseline condition of the lake. 10 years of regular data collection is needed to meet the minimum data thresholds for determining trends over time. This effort will continue to develop a robust dataset that can help the community identify and address water quality trends.

Next Steps

1. Work with ELA volunteer water quality monitor, Gary Philipp, to complete a second full season of baseline monitoring between May and October in 2023.

2. Begin to work with the Echo Lake Association to build a LakeSmart team deliver LakeSmart programming on the lake, providing education to shorefront property owners about polluted stormwater runoff, phosphorus, and the effects that watershed development can have on lake water quality.