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Sunset Lake
Historical Water Quality Data
January 2020

Historical water quality data collected at Sunset Lake from 2013 through 2019 are summarized in the attached spreadsheet. As we continue to collect water quality samples for laboratory analysis and take physical measurements, these historical data will help determine longer-term trends as well as assist in lake management efforts, most notably the control of nuisance weeds and algae.

Most of the historically collected water quality data reflect limited "snapshots" of lake conditions at a deep-water location in the center of the lake and a shallower location in Christmas Cove. In June 2018, we began more frequent (monthly) data collection at these two stations. Beginning in May 2019, we began taking physical measurements at several additional locations across the lake as well as additional water quality samples at key inlets to the lake, including where: the confluence of Bluefield Brook and Bear Meadow Brook[1] discharges into the lake on the northeast; an unnamed tributary discharges into the cove west of Lollipop Beach on the north; and Estes Brook discharges into the lake on the northwest. These samples will help us better quantify the introduction of nutrients and pollutants from stormwater runoff from the surrounding watershed.

A brief explanation of the water quality analysis results and physical measurements as well as a preliminary interpretation of the results is provided below.

E. coli

Coliform bacteria are naturally occurring in lakes; a subset of these bacteria, fecal coliform, is associated with the presence of human and other animal wastes. *Escherichia coli* (abbreviated as *E. coli*) is a large and diverse group of fecal coliform bacteria indicative of the presence of fecal matter from warm-blooded animals. Although most strains of *E. coli* are harmless, others can make you sick. Elevated levels of *E. coli* indicate the potential presence of pathogens.

[1] Some topographic maps denote the Millers River beginning at the confluence of Bluefield and Bear Meadow brooks, while others denote the Millers River beginning at the confluence of the outfalls from Sunset Lake and Lower Naukeag Lake.

Limited *E. coli* data have been collected since 2013. Samples were taken at two nearshore stations in 2013, and a few subsequent samples were taken at the deep-water station in the center of lake. The latter samples are not particularly instructive as elevated *E. coli* concentrations would only be expected proximate to a source, such as a failed septic system.

The highest concentrations of *E. coli* observed at Sunset Lake were 10 organisms per 100 milliliters (ml). *E. coli* concentrations less than 235 organisms per 100 ml are generally considered acceptable for swimmable waters.

We currently do not plan on taking additional *E. coli* samples unless there has been a reported or suspected release from a failed septic system.

Phosphorus

Phosphorus is an essential nutrient for all plant and animal life. It is usually the nutrient in the least supply, or the "limiting nutrient," in most freshwater ecosystems in this region. Therefore, elevated phosphorus concentrations can stimulate excessive plant and algae growth in lakes. We measure two different forms of phosphorus, total and dissolved, the latter being more readily available for plant uptake.

Total phosphorus concentrations have been measured as high as 0.095 milligrams per liter (mg/L) in Christmas Cove and 0.034 mg/L at the deeper center-lake station. Concentrations as low as 0.03 mg/L can support algal blooms, and this value is typically considered an upper threshold for lakes. The very high reading above (May 2019) may have been an outlier; nevertheless, it is likely that more frequent sampling would reveal periodic exceedances of the 0.03 mg/L threshold.

Dissolved phosphorus, sometimes called "bioavailable" phosphorus, is the portion of total phosphorus that is most readily available for uptake by plants. Dissolved phosphorus concentrations have been recorded as high as 0.081 mg/L, although this value is believed to be an outlier. All other observed concentrations have been less than 0.035 mg/L. Dissolved phosphorus concentrations greater than 0.01 mg/L are considered elevated and may contribute to excessive plant and algae growth. It is expected that this threshold is routinely exceeded in the lake.

Both dissolved and total phosphorus samples will continue to be collected in 2020.

Total Suspended Solids

Total suspended solids (TSS) is one measure of water clarity, with higher clarity generally reflective of better water quality. TSS concentrations are affected by fine sediment inputs from sources such as stormwater runoff from roads.

Historical TSS levels in the lake have been less that 5 mg/L, which is considered low. Nevertheless, water clarity in the lake is low due to the presence of tannic acid, creating a tea-like color. This is a natural condition given that Sunset Lake was created by flooding wetlands, and its watershed contains considerable forested wetlands and bogs that release tannins. The presence of tannic acid in Sunset Lake helps control growth of rooted aquatic plants because the tea color of the water limits light penetration.

Due to the historically low concentrations, we currently do not plan on taking additional TSS samples in 2020 unless physical parameter monitoring (discussed in more detail below) indicates that levels may have increased.

Nitrogen

Nitrogen is an essential nutrient in lakes for aquatic plants and algae. Nitrogen in lakes is present as ammonia (NH_3), Total Kjeldahl Nitrogen (TKN), nitrates (NO_3), and nitrites (NO_2).

Ammonia is an intermediate product of the degradation of proteins and other nitrogen-containing molecules. High levels of ammonia can be an indicator of eutrophication (excessive richness of nutrients, which can cause dense growth of plant life and depletion of oxygen). Concentrations of the limited ammonia samples taken were less than 0.1 mg/L, which is considered low.

TKN is a measure of elemental nitrogen that is bound up in organic molecules, such as proteins and amino acids. These molecules are released as plants and animals are decomposed in the water. Historical TKN concentrations in the lake have been less than 0.85 mg/L, below the generally accepted maximum desirable threshold of 1.0 mg/L.

Nitrates are an essential source of nitrogen for plants and elevated levels may contribute to excessive plant and algae growth. Primary sources of nitrates in lakes include fertilizers, animal waste, and septic systems. Nitrates break down to form ***nitrites***, which in high concentrations can have serious human health impacts. Nitrates and nitrites were first sampled in 2018 and have not exceeded detection limits.

We plan on continuing TKN sampling in 2020. However, unless we observe high TKN levels, we do not plan on testing for ammonia, nitrates, or nitrites.

Alkalinity

Alkalinity is a measure of carbonate, bicarbonate, and hydroxide ions dissolved in the water column, usually reported as milligrams of calcium carbonate per liter (mg $CaCO_3$/L). These dissolved ions help buffer the water against fluctuations in pH (a measure of how acidic the water is, discussed in more detail below). Large pH fluctuations from acidic precipitation can kill fish and other aquatic organisms. Alkalinity values greater that 20 mg $CaCO_3$/L are generally considered desirable in lakes. Limited sampling has demonstrated that alkalinity levels are considerably lower than this value, which indicates that Sunset Lake, like most lakes in the region, is not well buffered against pH fluctuations.

We currently do not plan on taking alkalinity samples in 2020 unless we observe unusual pH readings.

Turbidity

Turbidity is a measure of light attenuation caused by suspended particles in the water column. Higher turbidity values reflect greater amounts of dissolved solids. Most lakes in the region have turbidity values less than 5.0 Nephelometric Turbidity Units (NTU). Limited turbidity measurements for Sunset Lake have ranged from 2.7 to 3.1 NTU, reflecting a relatively low amount of suspended material in the water column.

We currently do not plan on taking turbidity samples in 2020 unless physical parameter monitoring (discussed in more detail below) indicates that levels may have increased.

Color

Color is measured in two ways, apparent color and true color. Apparent color is the color of the water as seen by the human eye, which can be affected by suspended or dissolved solids and other factors such as the color of the lake bottom, water depth, sky reflections, etc. True color is the color of the water resulting from dissolved substances only (suspended solids are filtered out). When lake management professionals talk about color, they are generally referring to true color. Color is measured on the platinum-cobalt color scale (called Color Units).

Especially clear lakes have true color readings less than 10 Color Units. Lakes that are extremely dark have true color readings of 500 Color Units or higher. True color readings taken at Sunset Lake have ranged from 30-60 Color Units. As previously discussed, naturally occurring tannic acid affects Sunset Lake's water color.

We currently do not plan on continuing to take color samples in 2020 unless physical observations suggest that samples are warranted.

Physical Parameters

In-situ water profile measurement parameters include: ***temperature; dissolved oxygen; pH; specific conductivity; and Secchi depth*.** Unlike the previously discussed data that reflect water samples analyzed in the laboratory, profile measurement parameters are field measured, enabling development of water depth profiles. This allows us to track stratification in the water column throughout the year.

Stratification is the separation of lake water layers based on water density. Warmer water is less dense and rises to the top of the water column, while cooler, more dense water is found at the bottom. When a lake is stratified, it is more resistant to mixing. This can result in water near the bottom becoming anoxic (low to no oxygen) due to the decomposition of dead plants and animals.

Stratification can also cause water temperatures near the surface to exceed tolerances of various fish species. The portion of the lake where fish will reside is between these two depths (below where it is too hot, but above where there isn't enough oxygen). If that zone becomes too narrow, the lake will not be able to support a healthy fish population. Summertime water temperatures in Sunset Lake are generally too high to support most cold-water species, such as trout, as at times no portion of the water column that is cool enough for these species would at the same time have sufficient oxygen for them to survive. However, warm-water species such as bass currently have ample usable habitat.

Sunset Lake "turns over" at least twice per year. During fall, surface water temperatures will fall to levels lower than the underlying water. Since warm water rises, the deeper warmer water will rise above the cooler water, effectively mixing the water column. This replenishes the depleted oxygen at the bottom, but also mixes up nutrients found in the sediments into the water column, making them readily available for aquatic plant uptake.

The process is repeated in the spring when the ice melts and the melt water is colder than the deeper underlying water.

A generally accepted desirable threshold for dissolved oxygen to support fish and wildlife is 6.0 mg/L, while levels below 2.0 mg/L are generally too low to sustain a healthy aquatic community. Dissolved oxygen levels in Sunset Lake routinely fall below these levels near the bottom.

pH is a measure of the concentrations of hydrogen ions in the water. It is measured as the negative logarithm of the hydrogen ion concentration on a scale of 1-14, with 7 being "neutral." Levels less than 7 are acidic; levels higher than 7 are basic. Measured pH levels indicate that Sunset Lake, like nearly all lakes in the Northeast, is acidic. pH levels lower than 5 can be toxic to fish. Summertime pH levels have been recorded below this value in the lower half of the water column.

Specific conductivity is a measure of the ability of the water to conduct electricity. High conductivity is an indicator of high concentrations of dissolved solids. As such, conductivity is a good parameter to track since increases over time can mean there has been an increase in nutrient (or pollutant) loading. Specific conductivity has hovered around 50 microsiemens per centimeter (µS/cm), which is indicative of low concentrations of dissolved solids.

Secchi depth is a measure of water clarity, specifically how deep a Secchi disk (a round disk with standard white and black markings) can be lowered into the water column and still be visible. Secchi depths greater than 4 feet are desirable for swimming. Secchi depths measured in Sunset Lake are typically greater than this value, with only one reading below 4 feet (3.5 feet in July 2014) and values as high as 6.5 feet measured in 2018.

We expanded the in-situ water profile measurements to include additional sampling locations in 2019 and will continue to collect in-situ data at these stations in 2020.