Skiff Lake
2018-2022

Acknowledgements

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Skiff Lake & the Lake Association

Skiff Lake

Skiff Lake is located at the headwaters of the St Croix river catchment. The lake is relatively small and shallow: It has an area of 6.3 km^2, a max depth of 17 m and a mean depth of ca 7 m. To put those numbers into some context you can compare the size of Skiff with that of nine other NBALA lakes in Fig. 10.

There are two smaller regions of deeper waters, found in the northeast and northwest parts of the lake. There are several smaller inlets to the lake, and it drains in the south into Palfrey Stream.

The association monitors water quality at 7 stations in Skiff Lake. The results in this report are based on five years of data (2018 - 2022) from the seven stations seen in Figure 1.

Skiff Lake Cottage Owners Association

The Skiff Lake Cottage Owners Association Inc. (SLCOA) mission is to protect Skiff Lake's water quality by promoting Healthy Lake initiatives that protect the Lake's water now, and for future legacies while also ensuring safety so all may enjoy.

It works to achieve this mission through a number of goals, objectives, and activities (including water quality monitoring) that can be found at skifflake.org

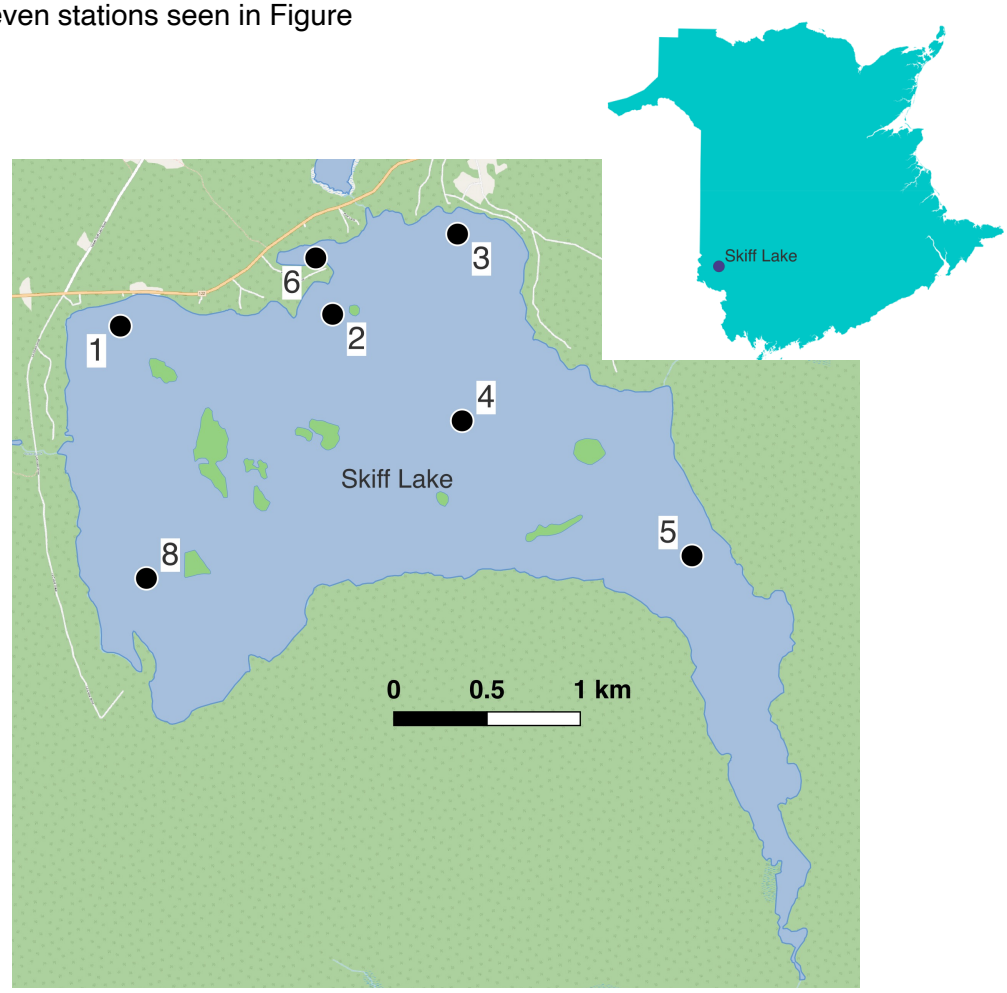


Fig. 1 Skiff Lake and the location of the SLCOA sampling stations

Summary

What can the monitoring results tell us about the health of Skiff lake?

Skiff Lake is small and, apart from in a couple of areas in the northeast and northwest, not very deep. During some of the years of monitoring thermal stratification developed at a relatively shallow depth (around six metres) dividing the lake into a warmer upper layer and a cooler layer found below seven metres.

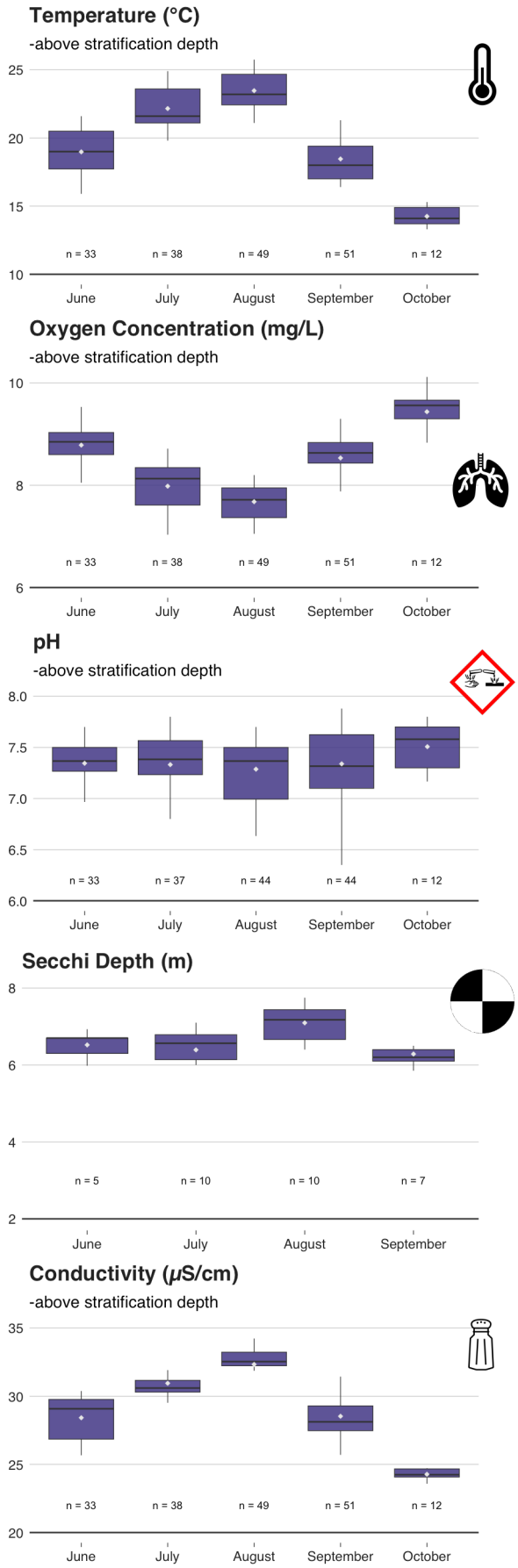
None of the monitored parameters give any real reason for concern. Apart from a couple of oxygen values in the deeper parts of the lake available guidelines provided by the Canadian Council of Ministers of the Environment (CCME) were never exceeded. Oxygen levels were on average low but most likely adequate for most species.
The only other noteworthy result is that temperature above the thermal stratification could possibly become stressful for some species during late summer.

…and what are they not telling us?

To really be able to see if there are any problems in the lake a wider suite of parameters would have to be investigated. For example, it would be pertinent to investigate concentrations of metals, commonly found toxic substances, and the nutrient status of the lake. Going one step further, the monitoring of plants and animals can show if human activities have significant effects on the inhabitants of the lake.

But as more data are gathered by the SLCOA the certainty of what the available parameters can tell us will get better!

Seasonality in Skiff Lake



The figures on the left show data from all stations and years grouped by month. The purpose with this presentation is to give an idea of how the monitored parameters vary over the growth season of plants animals in the lake and what "normal" values look like in Skiff Lake.
To avoid variation caused by the presence or absence of a thermal stratification, only data from the top five metres of the lake was combined per station and date before averaging per month.

The parameters that fluctuate the most over the season in Skiff lake are conductivity, temperature and oxygen.
Both temperature and conductivity increase during summer up until August and then decrease again. Oxygen does the opposite, decreases from spring through summer and then increase again during fall.
Secchi depth and pH remain more or less the same throughout the monitoring season.

What are those boxes in figure 2? -and what are they telling me?

In stead of just showing the average of each parameter for each month, I chose to present the data in a so-called "box plot". The strength of these are that they not only show an average value, but they also give you an idea of the variation around this value. The purpose of this is to give you a data-driven idea of what "normal" looks like in your lake!

To put it in terms that are in no way scientific but may be a useful rule of thumb: if during future years you find, for example, temperatures that fall outside of the box region for that month, you could refer to that as a "warmer than normal month". And if the temperature falls outside of the whisker region, it is fair to say that it is "extremely" or "unusually" warm or cold!

To learn more about how to interpret the boxplots, check out the glossary at the end of this report.

Fig. 2 Seasonal patterns of the investigated parameters in Skiff Lake.

Stratification

Warm water is lighter than cold water.

During summer, the sun warms the surface of the lake. In lakes that are deep enough the lighter warm water forms a layer (epilimnion), separated from the cold, heavy water near the bottom (hypolimnion). Between these layers there is a transition zone where the temperature shifts drastically, the ”metalimnion”.
At what depth this metalimnion separates the two zones depends on how clear the lake is and the amount of wind mixing the water in the lake.

Why is this important?

A stratification acts as a barrier, so there is almost no transfer of nutrients and gasses, like oxygen, between the two layers. This means that the lake now has two habitats with very different temperature and potentially different chemistry.
The presence of cool bottom waters can be advantageous to cold water species. However, In nutrient rich lakes, oxygen can be depleted at depth due to decomposition processes.

To account for variation caused by stratification, the sampling data in this report are often divided into shallow water (0-5 metres depth) and deep water (more than 7 metres depth).

Skiff Lake stratifies, but not all years!

Skiff Lake is relatively small and although the average depth is rather shallow there are a smaller areas in the northeast and northwest corners with enough depth to allow for thermal stratification.
It appears that although stratification does occur in the lake it does not do so reliably every year. This is exemplified by the graphs below showing two consecutive years with very different vertical temperature profiles. When stratifications do form, they are not always long-lived enough to for oxygen to get consumed under the thermocline, but occasionally oxygen concentration does drop in the hypolimnion (see Fig 5). By September, the cooler water usually prevents any stratification.

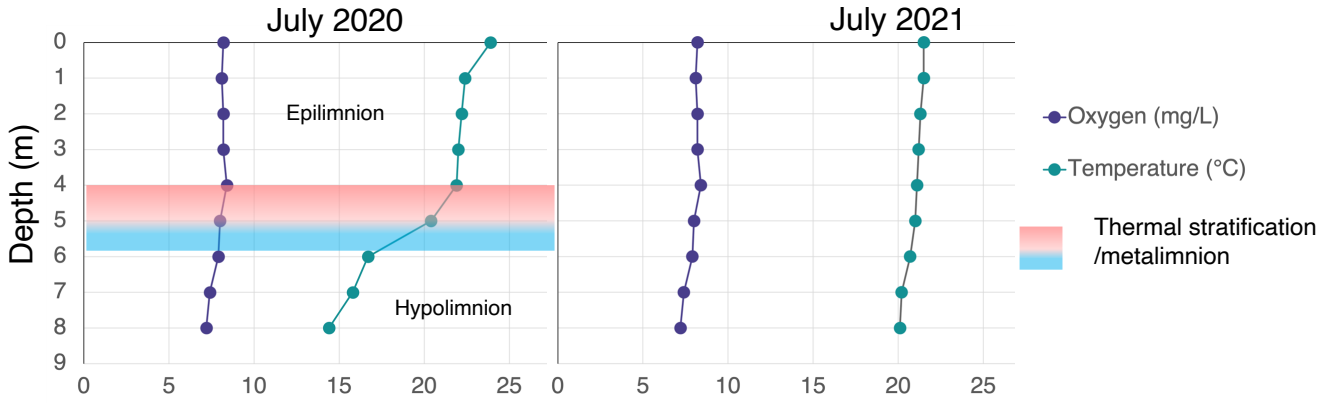


Fig .3. Example of thermal stratification in Skiff Lake

Temperature

Temperature affects biological activity in a multitude of ways.

It influences for example, rates of chemical reactions and how well oxygen dissolves in water. Temperature also directly influence growth, respiration and even the behaviour of lake organisms. All plants and animals have a range of optimal temperatures in which they thrive. Cold water fish like salmonids are stressed already at 20 °C and when temperatures reach 23-25 °C prolonged exposure may lead to deaths. Fish like yellow perch also struggle in warm water while other species, like smallmouth bass do well at 25 °C. Another risk at higher temperatures is that some common harmful bloom-forming cyanobacteria like members of the genus Microcystis have optimum growth at temperatures over 25 °C.

Temperature in Skiff Lake

Temperatures in Skiff lake get moderately high most years but not enough to raise any serious concern (Fig 4).
During periods of warmer water temperature organisms like fish that can move around the lake may seek refuge in deeper, cooler waters under the thermal stratification. However, the lake doesn't always stratify and sometimes the oxygen levels under the metalimnion may be too low for the deep waters to be a viable refuge from heat stress.

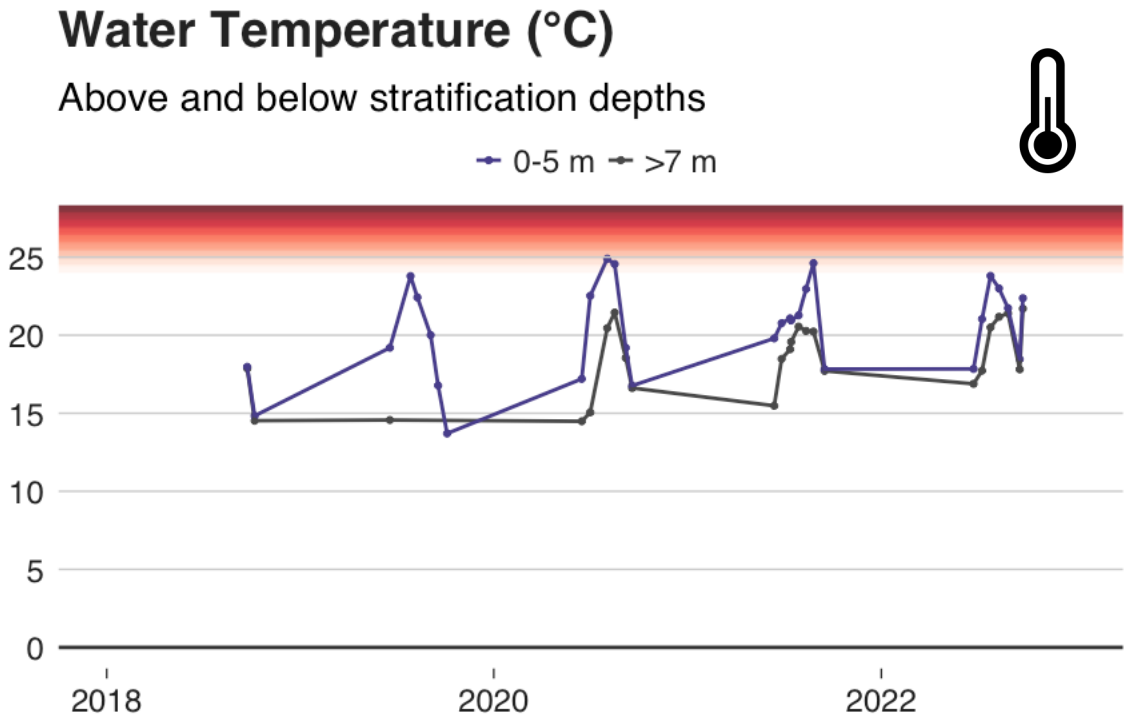


Fig. 4 Water temperature in Skiff Lake from 2018 to 2023. The red gradient signifies increased risks associated with higher temperatures. No CCME guidelines are available.

Oxygen

Most organisms need oxygen to survive!

Even plants that produce oxygen need it during nights for respiration. Some species are more sensitive than others, and certain animals are adapted to life in environments with almost no oxygen.

Oxygen in the air dissolves in the water of a lake. How much oxygen that can be dissolved is influenced by the temperature of the water and the salinity. Colder water can hold more oxygen and salty water holds less. Oxygen can also be produced and consumed within the lake. For example, oxygen is produced by plants, algae and cyanobacteria in the lake, and it's consumed by respiration by animals and microorganisms.

Dissolved Oxygen in Skiff Lake

Concentrations of dissolved oxygen (hereafter referred to as oxygen) in the top five meters of Skiff Lake are never high but stay above the CCME guidelines throughout the five years. These shallow waters receive oxygen from the air and from photosynthesis by plants and algae in the water.

The deeper parts of the lake rarely see oxygen concentrations below the levels of concern, but it does happen during years when a stable stratification forms. Oxygen does, however, never seem to get completely depleted during such episodes.

Low oxygen concentrations in the hypolimnion are caused by the continuous consumption of oxygen by respiration and decomposition processes.

In summary, oxygen concentrations do not present any reason for concern in Skiff Lake.

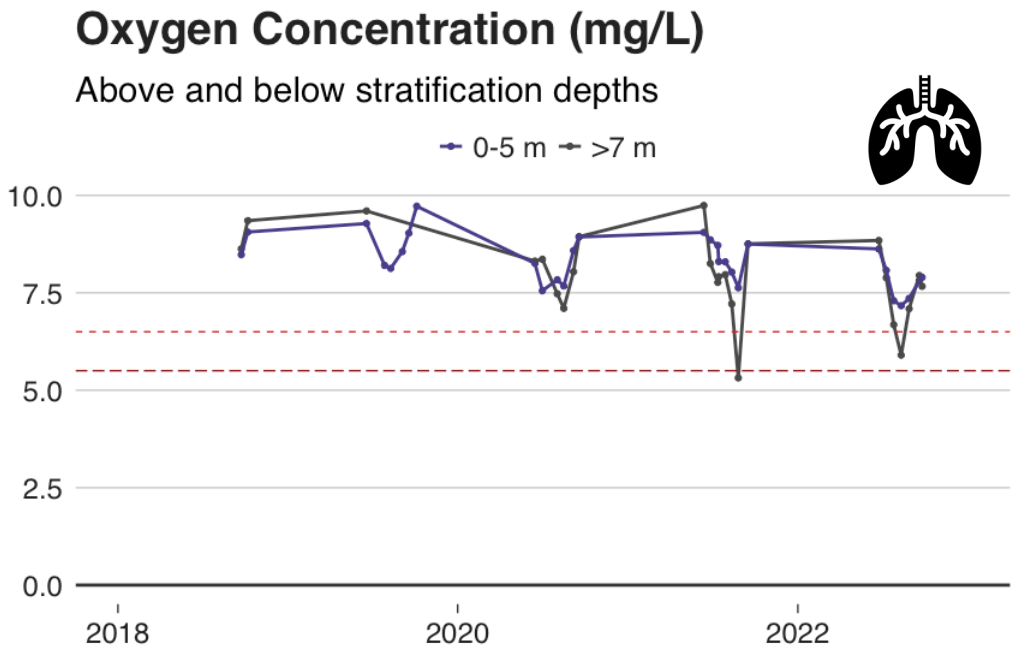


Fig .5 Dashed lines in the figure indicate lowest acceptable concentrations of oxygen for cold- (6.5 mg/L) and warm (5.5 mg/L) water species (CCME). Eggs and young individuals are generally even more sensitive.

Light
(Secchi depth)

What does Secchi depth tell us about a lake?

Measuring secchi disk depth is an easy way to get an estimate of the light climate in a lake. Light is important because it is the source of energy for the plants and algae that make up the foundation of a lake ecosystem. It is also the primary source of heat in a lake. Lakes with many particles, algal blooms or high concentrations of humic matter washed in from the surrounding watershed all have reduced light conditions. The Secchi disk depth will not tell you the reasons for light attenuation but gives an estimate of how deep light penetrates. Generally, photosynthesis is found down to roughly 2-3 times the secchi depth.

Secchi readings in Skiff Lake

There is no CCME guideline for aquatic life for Secchi disk depth, but Health Canadas guidelines for Canadian recreational water quality suggest that Secchi depth should be more than 1.2 metres in waters used for recreation.
Skiff Lake mostly has a relatively clear water, well exceeding CCME guidelines. This means that light can reach the bottom of most of the lake allowing for the potential of rooted plants in many areas.

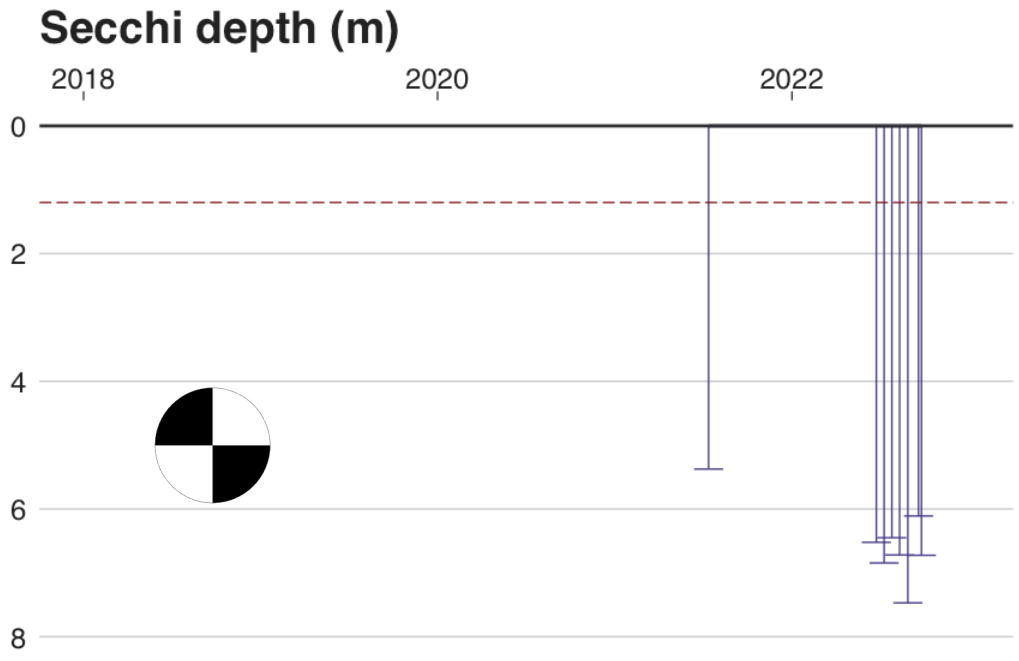


Fig. 6. Secchi depth in Skiff Lake. Hatched line indicate level of concern according to CCME guidelines for recreational waters.

pH

Acidity, or alkalinity, is measured on the pH scale.

The lower the pH, the more acidic it is. The pH is a logarithmic scale so for every step in the scale, there is a tenfold difference. This means that pH 4 is 10 times more acidic than pH 5, and a 100 times more acidic than pH 6! If the pH is too high, or too low it has detrimental effects on lake plants and animals.
High pH can damage fish skin, eyes and gills of fish and increase the toxicity of ammonia. Acidification below pH 6 can directly harm organisms and lead to increased levels of dissolved aluminum & increased aluminum toxicity to fish.

pH in Skiff Lake

The pH of the water in Skiff Lake, both above and below the thermal stratification, remains neutral or slightly alkaline throughout the investigated period. The pH is always within the upper and lower limits recommended by the CCME. In conclusion I see no reason for concern in the pH data from Skiff Lake.

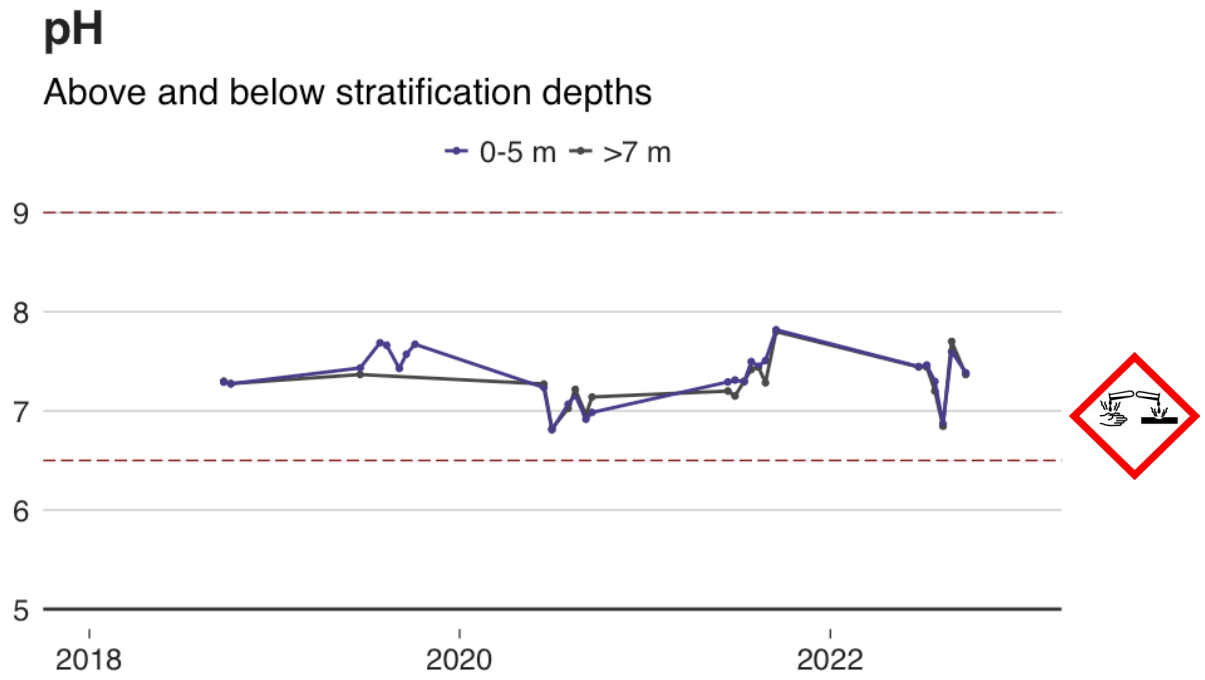


Fig. 7. pH in Skiff Lake. Hatched lines indicate upper (pH 9) and lower (pH 6.5) levels of concern according to CCME guidelines.

Conductivity

Conductivity is an estimate of the total concentration of dissolved salts in a lake.

Conductivity is estimated by testing how well the water can conduct an electrical current. Higher concentrations of dissolved salts (ions) passes more electrical current. Elevated conductivity could indicate contaminated runoff. For example, runoff containing road salts can increase the salinity to levels where it is harmful for aquatic life.

Conductivity in Skiff Lake

There are no CCME guidelines for conductivity and without knowing historical levels, it is impossible to say with absolute certainty if conductivity in Skiff Lake is elevated from natural conditions.

However, conductivity in Skiff Lake is quite low, in the lower part of the range of background levels and does not give cause for concern.

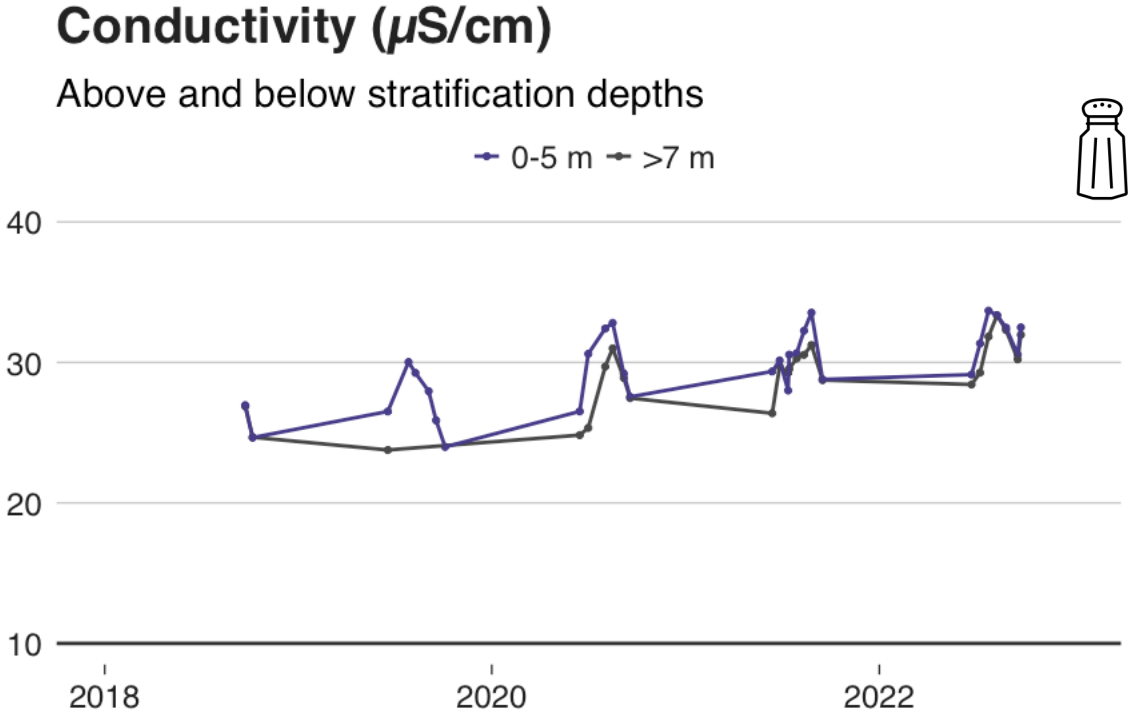
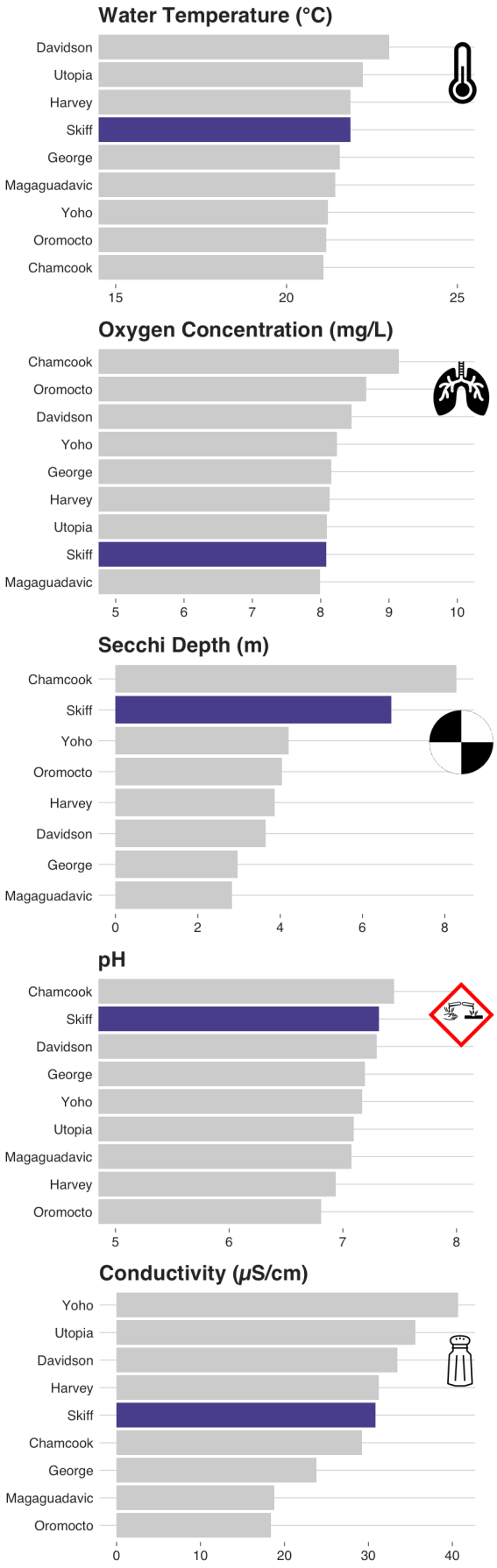


Fig. 8. Conductivity in Skiff Lake. No CCME guidelines are available.

A comparison of NBALA lakes



Is this a lot? …or little?

Most of us check the weather each day and have a reference system in our heads for what is considered a warm or a cold day. But very few spend every day looking at water chemistry data and thus have a hard time conjuring any sense of proportion when faced with a conductivity value.

This page is here to give some reference. As with many other things, what is considered extreme depends on what you compare with! Here I present the overall averages of the parameters monitored in the nine NBALA lakes analyzed in this project[1]. These lakes may not be representative for the full range found in New Brunswick lakes, but they will give you an idea of what you can expect in this part of the country and how your lake compares to the other NBALA lakes.

Skiff lake is relatively small but still one of the deeper of the nine lakes It has one of the highest secchi depths and one of the lower average oxygen levels but overall, none of the values are extreme.

[1]Average of values from depths above stratification for all data found within the period 2013-2022.

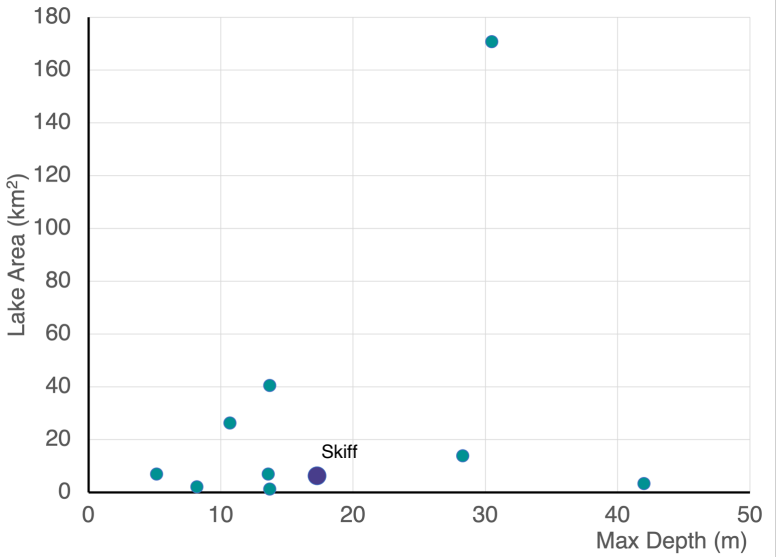


Fig. 10. The surface area and maximum depth of ten NBALA lakes. Skiff Lake is highlighted.

Fig. 9. Comparison between nine NBALA lakes for all investigated parameters.

Monitoring Strategies

Nature is in constant flux.

An ever-present question in all monitoring programs is whether to spend money and time on monitoring more often or to monitor more stations but not as frequently. There is no fits-all-sizes answer to this question. It depends on what parameter you are monitoring, in which ecosystem, and what the purpose of the program is.

Monitoring programs need to take into account that the lake environment changes. It changes from day to night, between days due to e.g., weather, between months due to seasonal changes and so on. The organisms living in the open water are also important in shaping the lake chemistry. Most of these are short-lived, fast growing, and abundances can change quickly.
When we monitor lakes, we take snapshots in time and space, hoping that samples will give us a good estimation of what's really going on.

Monitoring results vary between places in the lake (spatial variation), and they will vary over time in the same place (temporal variation). These two sources of variation may not be equally important. The two extremes would be that if there is no variation in space (everything is exactly the same in all parts of the lake), it makes no sense to monitor several locations. Or, if there is no change over time, it makes no sense to monitor more often.

Which brings me back to the initial question. If the SLCOA wants to improve upon their estimates, Is it possible to give advice on whether they should sample more often or in more places?

Monitoring in Skiff Lake

The SLCOA monitors seven stations in the lake that have been visited around four times per year. This is a good body of data that can be evaluated to give some tentative suggestions about future efforts.
I have made a preliminary analysis of spatial and temporal variation found in the SLCOA monitoring results. For each parameter I calculated the spatial and temporal variation expressed as the coefficient of variation (CV), see the glossary page for a brief explanation of methods.
The main conclusion is that for all parameters, except maybe pH the data vary more between dates than it does between stations (Fig. 11). This indicates that getting better coverage by sampling more often may give better estimates, or that maybe not all stations need to be sampled.
This is just a preliminary analysis. I would recommend a more careful look at the data and to consider what is practical for the volunteers before moving forward.

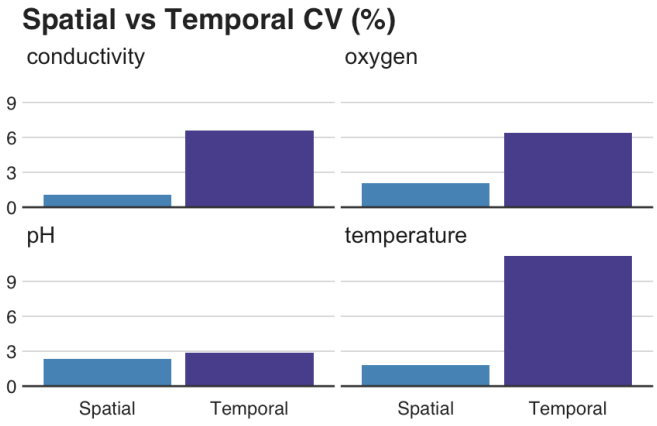


Fig. 11. Comparison of the relative variation between stations at any given date and the variation between dates for any given station.

Glossary

Catchment (area) the region around the lake that drains into the lake. (almost) Synonymous to watershed.
Coefficient of Variation is calculated by dividing the standard deviation by the mean. This gives a "relative" standard deviation that allows you to compare variation between parameters that have different units and ranges. It is often expressed as a percentage of the mean.
Epilimnion the warm, wind-mixed layer above the thermocline during thermal stratification..
Hypolimnion the layer of cooler water found under the thermocline during thermal stratification.
Metalimnion the layer between the epilimnion and hypolimnion where a rapid change in temperature is found with increasing depth.
Primary production the conversion of sun energy and carbon dioxide into organic compounds by plants, algae and cyanobacteria.
Standard Deviation is a measure of how large the variation is around a mean. A low standard deviation means that most data are close to the mean whereas a high standard deviation means that there is more spread out.
Thermocline synonym with metalimnion, sometimes referring to the depth where the maximum rate of change in temperature occurs.

Method description: analysis of spatial and temporal variation

I estimated the spatial variation by calculating the CV between stations for each date. I estimated the spatial variation per station by calculating the CV between dates within the period June-August. I then averaged both measures.
I limited the analysis to data data from years where at least three stations were visited at least three times (a bare minimum required to get an estimate of the standard deviation).
I also limited the analysis to data from the epilimnion because some NBALA lakes do not stratify, and the ones who do, typically only have data from the hypolimnion at one or two stations which is not enough. Finally, I excluded the secchi depth, because in many lakes it can not be measured properly at all stations, and there was not time to properly quality-control all secchi data.