Long Lake

2021-2023 Summary Report

Release Date

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Level of Study

Level 3

Volunteer Monitoring

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Photo 1 – Long Lake (source: Linda Brooymans).

The BC Lake Stewardship Society (BCLSS) and the Ministry of Environment and Climate Change Strategy (ENV) partner with local volunteers and stewardship groups to characterize lake water quality through the **BC Lake Stewardship and Monitoring Program (BCLSMP)**.

The BCLSMP's focus is on understanding water clarity, temperature, oxygen, and nutrients as these provide a basic understanding of lake processes and influence biological productivity. Concerns about productivity are common, specifically because high productivity can affect recreation and drinking water due to harmful algal blooms and can also impact aquatic organisms, such as fish.

Raw data collected for Long Lake can be accessed through the BCLSMP Interactive Map: https://arcg.is/1G9LG40

BC Lake Stewardship and Monitoring Program

BCLSS

The Importance of Long Lake & its Watershed

Long Lake is a small urban lake located within the northwest region of the City of Nanaimo on the traditional and unceded territory of the Coast Salish Peoples, the traditional territory of the Snuneymuxw First Nation (ISC, 2024). Refer to **Table 1** for a summary of physical lake characteristics.

The primary inflow to Long Lake is from an unnamed stream out of Brannen Lake. The stream flows roughly 2.3 km through several major structures, including under two highways before entering the western end of Long Lake. The lake also receives drainage from residential, commercial, and park land surrounding the lake. The primary outflow is a heavily channelized watercourse that flows underneath Island Highway 19A and Shenton Road to Diver Lake approximately 500 m to the south (ENV, 2011).

According to the Freshwater Atlas, Long Lake's watershed (a land area that moves water it receives to a common water body) drains an area of 3.96 km^2. Roughly 86.8% of the watershed has been developed for residential, commercial, and industrial uses and approximately 13.2% remains in a natural state (waterbody and riparian) or as greenspace (**Figure 1**). Primary access is from Loudon Park on the south side of the lake where there is a boat launch, walking trails, swimming beach, and a small fishing dock.

Long Lake is popular with local anglers and has been stocked with trout for several decades. The earliest record in the Freshwater Fisheries Society of BC stocking report is from 1932. Since the late 1980s, the lake has been stocked with mainly rainbow trout (*Oncorhynchus mykiss*) at catchable size multiple times per year (FFSBC, 2024).

Table 1. Physical Characteristics of Long Lake (BC Habitat Wizard, 2024).

Lake Name	Long Lake
Elevation	111 masl
Surface Area	33.6 m^2
Perimeter	3780 m
Maximum Depth	14 m
Mean Depth	6 m
Ice Over	N/A
Biogeoclimatic (BEC) Zone	Coastal Douglas-fir
ENV Region	Vancouver Island
Watershed Code (Trimmed)	920-395400-65000

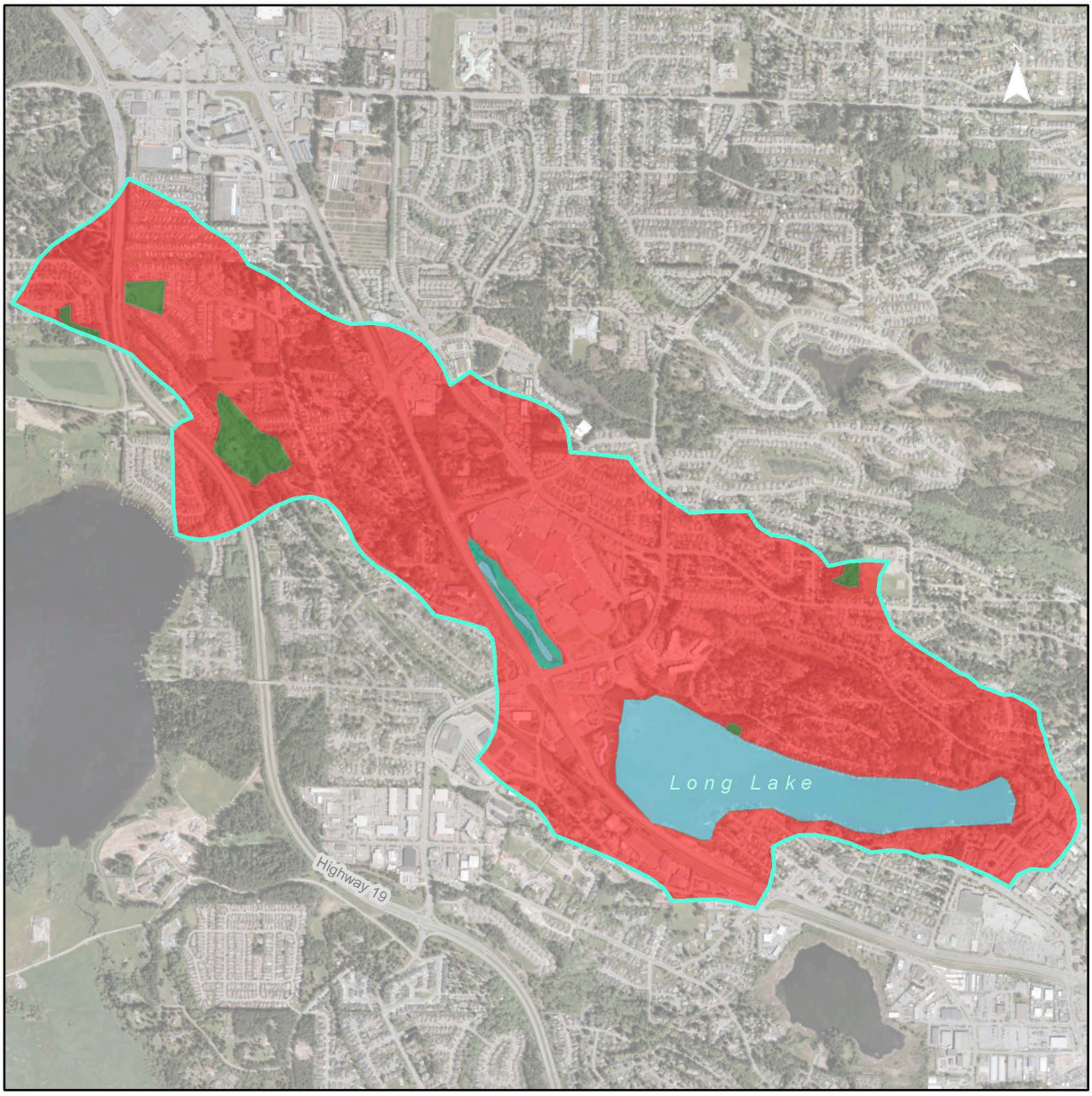


Figure 1. Map showing Long Lake watershed and associated land uses.

Monitoring Approach

Long Lake monitoring was conducted at a Level 3 BCLSMP study level from 2021 to 2023. A Level 3 BCLSMP study is typically conducted at the deepest lake location, and includes monitoring of dissolved oxygen, temperature, water clarity, algal productivity, and nutrient levels (e.g., phosphorus). Information on these parameters is collected at least twelve times during the open water season for three years to characterize the temporal variability typical of lake systems and can help to identify issues such as summer oxygen depletion, internal nutrient loading, and times of high algal productivity.

Level 3 water quality information was collected from Long Lake Deep Station, Environmental Monitoring Systems (EMS) ID: E323551 (**Figure 2**). Overall, 36 sampling events occurred with 12 sampling dates occurring each year between April and September. Water samples were collected for chemical analyses at three depths (1 m below surface, mid-depth, and 1 m above bottom) from this station during each sampling event.

Water samples were submitted to an accredited laboratory for analysis of phosphorus (all three depths) and chlorophyll-*a* (shallow samples only). At each sampling event, full temperature and dissolved oxygen profiles were collected (i.e., data was collected at 1 m depth intervals throughout the water column). Secchi depth was also recorded as a measure of water clarity during all sampling visits.

Historical water quality records are available at Long Lake Center (EMS: 1130030), a sampling station approximately 180 m west of the deep station. Available data includes a single shallow sample analysed for nutrients in August 1996. There is also nutrient and chlorophyll-*a* data available for both shallow and deep-water samples from six sampling events occurring in February in 1998, 2000, 2004, 2008, 2011, and 2017.

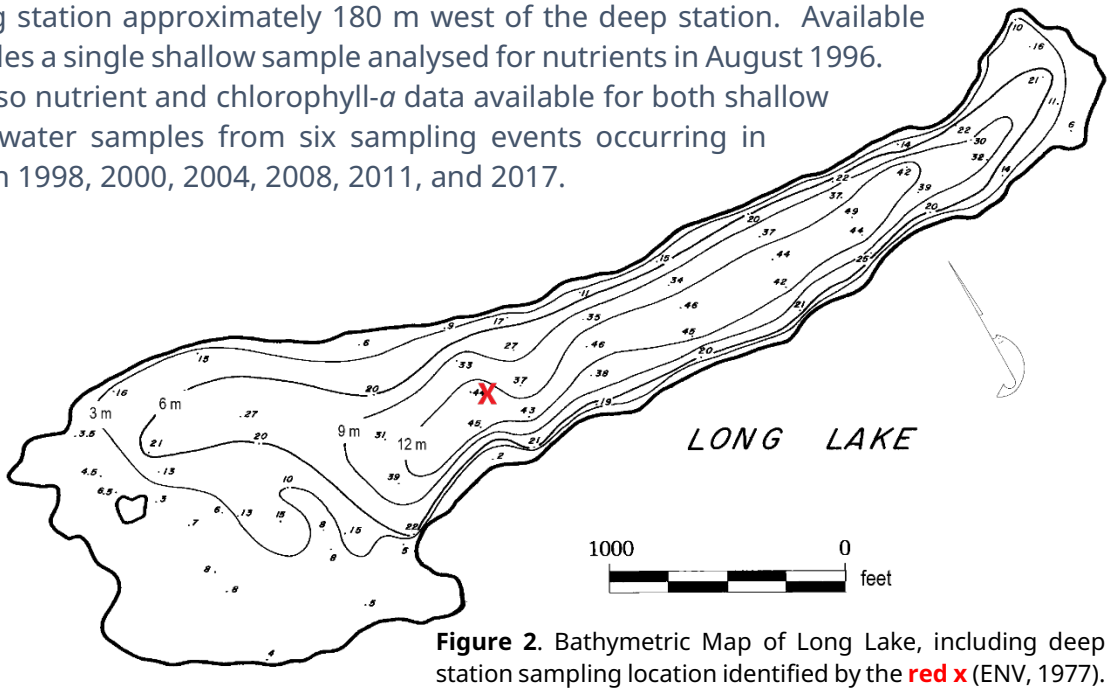
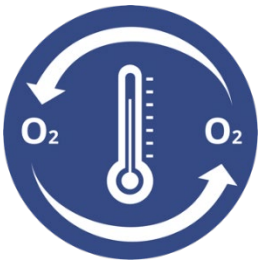


Figure 2. Bathymetric Map of Long Lake, including deep station sampling location identified by the **red x** (ENV, 1977).

Temperature and Dissolved Oxygen



Temperature and dissolved oxygen (DO) strongly influence physical, chemical, and biological processes in lakes. Annual temperature and oxygen patterns vary depending on local climate, lake shape, prevailing wind direction and lake depth (BCLSS, 2022). Water is most dense and therefore heaviest at 4°C and less dense (i.e., lighter) at both colder and warmer temperatures. During the summer, lakes more than 6 m deep usually experience a layering effect called stratification, with the warmer, less dense water sitting on top of the cooler and heavier water. Stratification keeps bottom cool water isolated from top warmer water which traps nutrients released from bottom sediments until the layers mix in the fall. This mixing is also called lake overturn and can occur one to multiple times per year. During the mixing process, the bottom waters get recharged with oxygen, and nutrients are brought up to the surface.

Temperature and DO data collected at the Long Lake Deep Station in 2021, 2022 and 2023 indicate stable summer stratification. The samples collected from April to early June for all years were successful at capturing the spring mixed conditions (full depth of lake profile seen as one colour, **Figure 3**). Samples were not collected late enough in the season for all years to capture fall overturn (**Figure 3**).

From May to September distinct layers of warm and cold water formed in Long Lake in all three sampling years, with peak surface temperatures ranging from 24.7 ºC to 26ºC, from July to August. The lake remained stratified throughout the summer months, with no intermittent mixing events observed.

The DO levels in Long Lake were influenced by the seasonal temperature stratification (**Figure 3**). The highest DO (11.92 mg/L to 12.5 mg/L) concentrations were observed to exist above the thermocline (approximately 7 m) and persisted through the summer months. The thermocline is a transition layer between the warmer mixed water at the surface and the cooler deep water below. During the sampling season DO concentrations in Long Lake did not drop to less than 4 mg/L until below a depth of 7 m.

Both temperature and DO results show that Long Lake has limited suitable habitat for fish when the lake is stratified. Many fish species, especially salmonids, show signs of stress at temperatures greater than 18ºC and dissolved oxygen concentrations less than 4 mg/L (Truelson, 1997). In all years the data suggests that the only area in Long Lake where there is enough DO for sensitive fish during this time is also too warm (approximately 7-4 m depth).

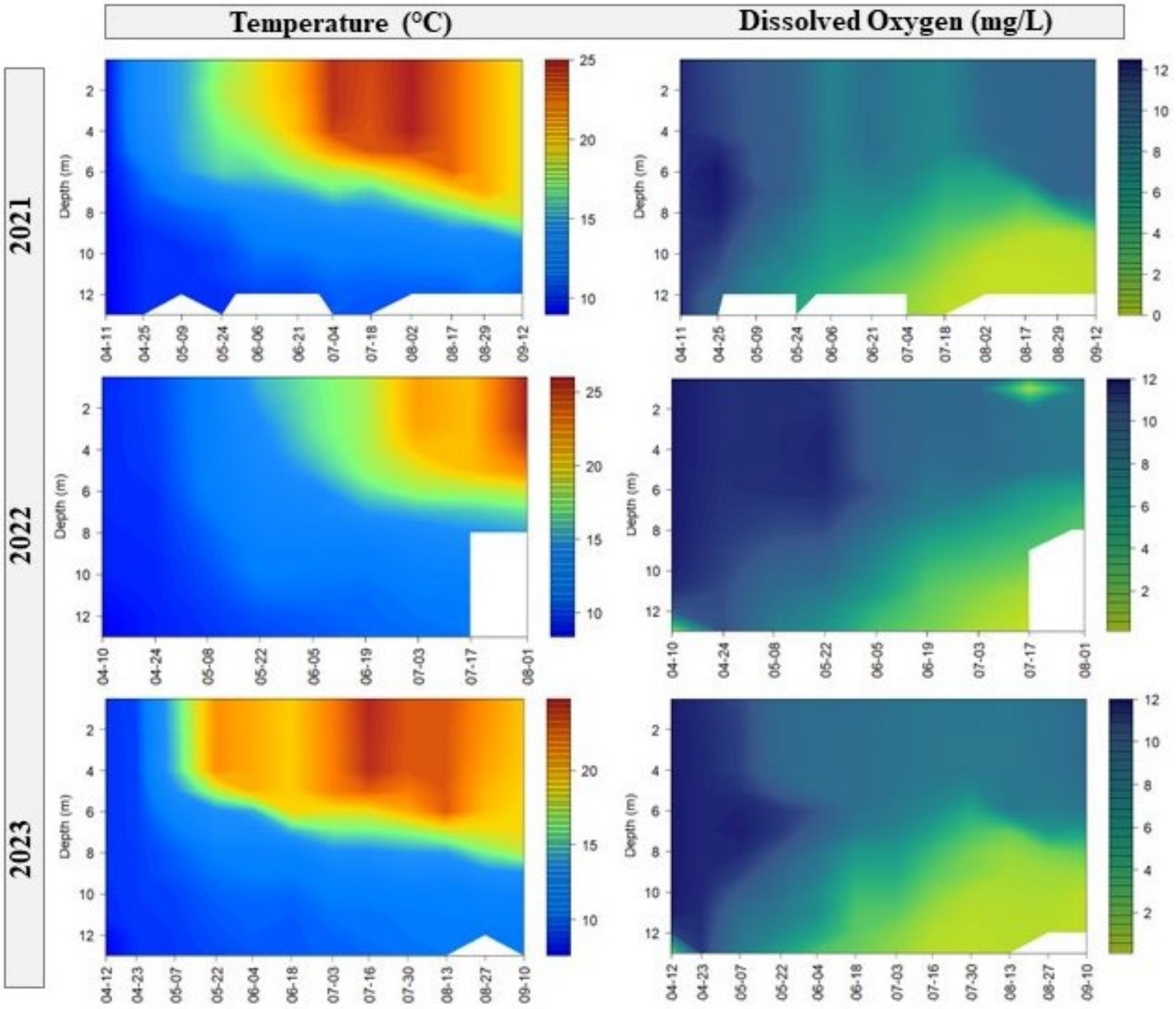


Figure 3: Temperature and DO results at the Long Lake Deep Station in 2021, 2022 and 2023. The coloured contours display patterns of warming/cooling and increasing/decreasing concentrations of DO.

Water Clarity and Algal Biomass

Water clarity is an indicator of algae, suspended sediments, and other particles in the water. It is measured using a Secchi disc to see how far light can penetrate through the water column. Chlorophyll-*a* is a common pigment found in almost all plants. It captures light energy and drives the process of photosynthesis. In open water areas of lakes, it occurs in free-floating microscopic algae (phytoplankton), which are important parts of the lake food-web. Chlorophyll-*a* in lake water is an indicator of the algal biomass present in the water. In highly productive systems, algal biomass can become excessive, causing aesthetic concerns, and impacting water quality.

The average Secchi depth in Long Lake for all three years was 4.2 m. The deepest (clearest water days) occurred in April of 2021 and May of 2022 and 2023 (April 25, 2021 = 7.5 m; May 8, 2022 = 5.2 m; May 7, 2023 = 6.05 m), whereas the most shallow (least clear water days) values were during summer for all years (July 4, 2021 = 3.4 m; August 1, 2022 = 2.7 m; August 13, 2023 = 2.7 m).

Water clarity is typically greatest following the spring overturn, but before summer algal growth peaks. Elevated concentrations of chlorophyll-*a* corresponded with shallower spring Secchi depth readings in all years, showing that poorer water clarity in Long Lake was due in-part to increased algal biomass (**Figure 4**). The maximum values captured for chlorophyll-*a* were observed between mid-April and mid-May (5.26 µg/L & 7.06 µg/L) which is a common time for early spring algae blooms to occur because of nutrients and oxygen being brought to the surface waters of the lake with spring mixing.

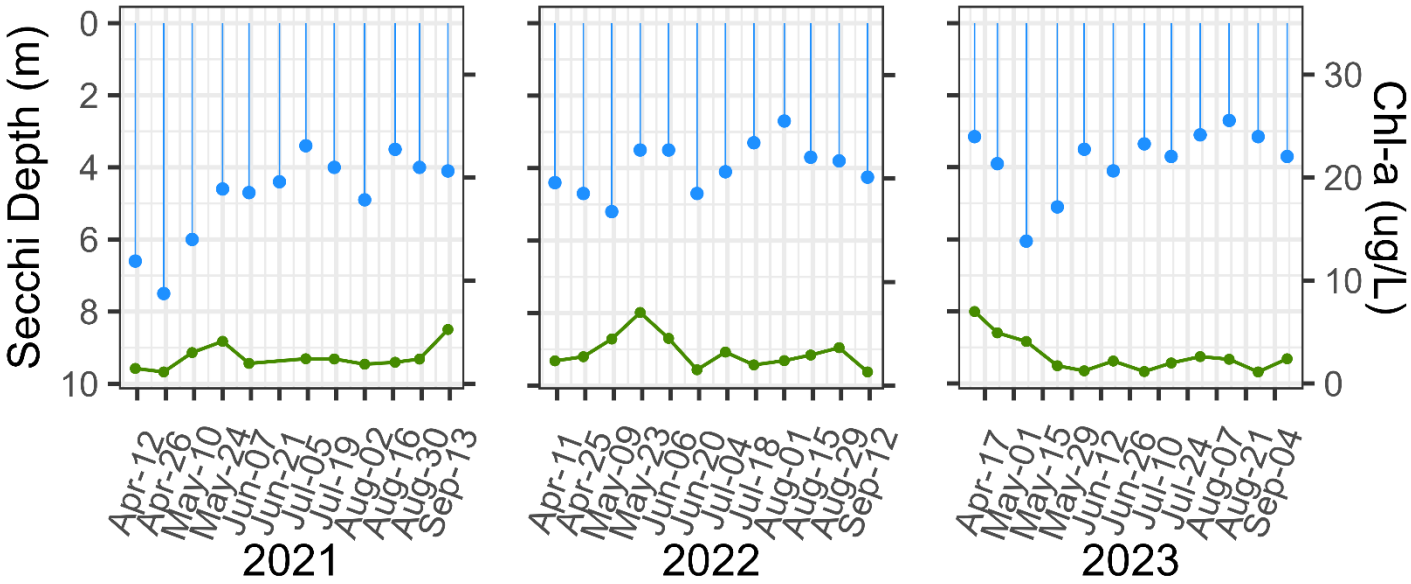
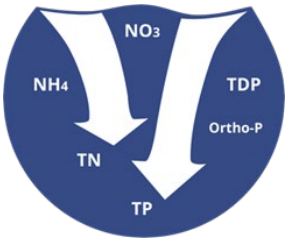


Figure 4. Secchi depth (blue lines with circles, scale on the left) and chlorophyll-*a* (green line, scale on the right) measured at the Long Lake Deep Station from 2021 to 2023.

Phosphorus



Phosphorus is typically the limiting nutrient for most lakes in BC, meaning that phosphorus concentration strongly influences biological production in aquatic environments (BCLSS, 2022). Nitrogen is also an important nutrient in aquatic environments but is generally second to phosphorus as the most limiting nutrient. There are several forms of phosphorus present in lake water. Dissolved phosphorus in the form of ortho-phosphate (PO_4) is the most readily available form of phosphorus for algae and aquatic plants. Total phosphorus (TP), stored in sediments and organic matter, can be converted to PO_4 in low oxygen conditions. Total dissolved phosphorus (TDP) is another bioavailable form of phosphorus. Monitoring the different forms of phosphorus is helpful towards understanding how much is available for plant growth. Phosphorus (TP, TDP, and Ortho-P) concentrations from the Long Lake Deep Station collected at the three sampling depths are listed in **Table 2** and shown by year in **Figure 5**.

Table 2. Minimum, maximum, and average phosphorus results from samples collected from 2021 to 2023 in Long Lake.

			Phosphorus		
Station	**Depth Sampled (m)**	**Summary Statistics**	**Total Phosphorus (µg/L)**	**Total Dissolved Phosphorus (µg/L)**	**Ortho-Phosphate (µg/L)**
Long Lake @ Deep Station	Shallow (0-1 m below surface)	Min	4.8	2	1
		Max	29.1	23.8	17
		Average	7.8	3.97	1.61
	Mid (1-8 m below surface)	Min	3	2	1
		Max	17.4	4.9	1.5
		Average	6.86	2.83	1.03
	Deep (8-14 m)	Min	2	2	1
		Max	22.4	6.8	2.1
		Average	7.77	2.64	1.06

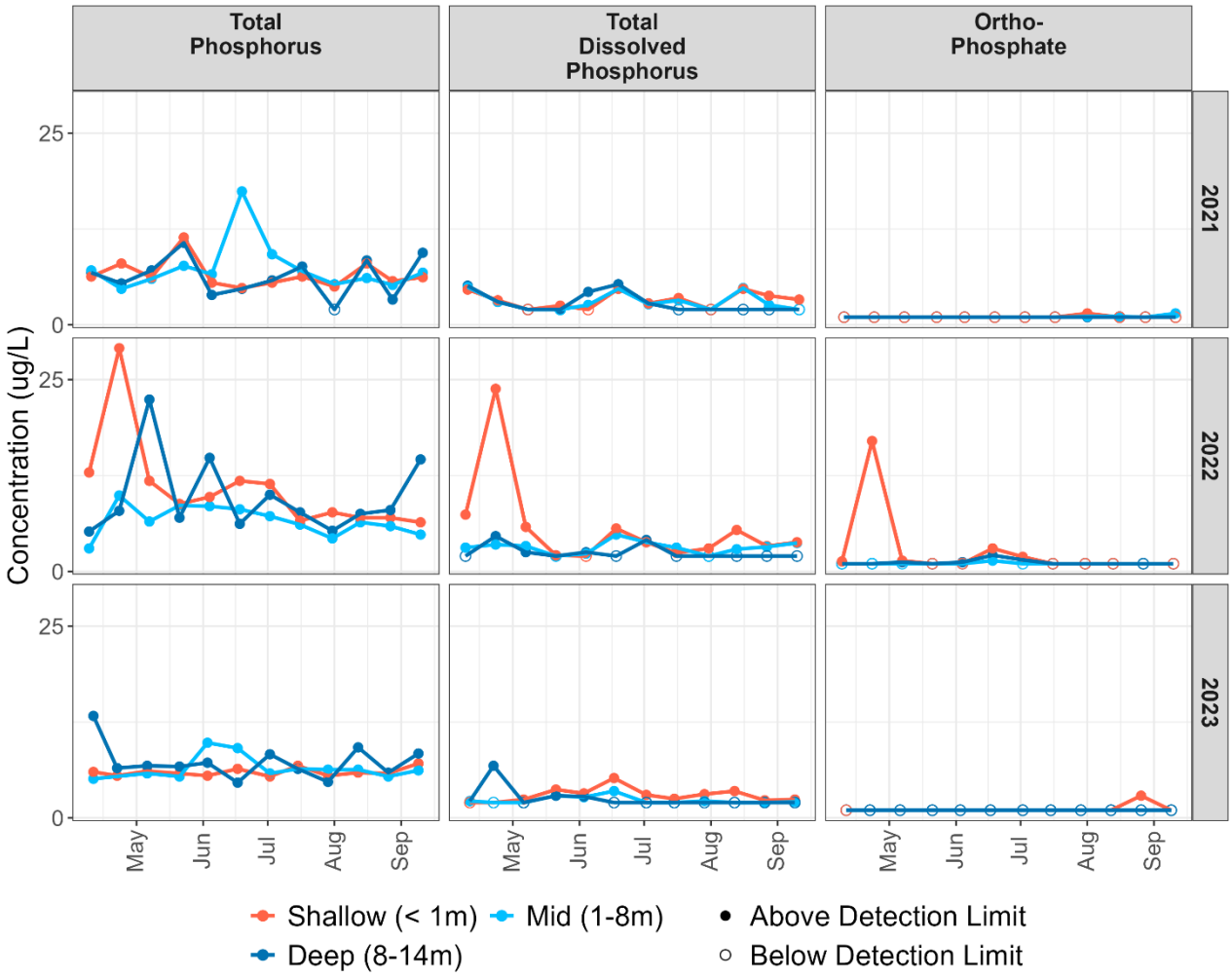


Figure 5. Long Lake 2021-2023 total phosphorus (TP), total dissolved phosphorus (TDP), ortho-phosphate (PO_4) results.

There are several large data spikes in the values impacting the overall averages. In 2021, the data collected at the mid-depth spiked in mid-June for TP. In 2022, the data collected at the shallow depth spiked in late-April for all phosphorus forms; there is also a spike in the deep sample for TP early May and early June. In 2023, the data collected for all sample depths and for all forms of phosphorus stayed relatively stable.

In 2021 a record-breaking heat wave occurred across BC in late June to mid-July. In 2023 atmospheric temperatures were unseasonably high early in the spring. This was followed by a summer long drought and one of the worst fire years on record for the province (WLRS, 2024). These factors would contribute to a more intensely stratified lake (**Figure 3**), and therefore greater oxygen depletion at the bottom of the lake. Bottom oxygen depletion would result in more phosphorus being released from the sediments, which is called internal nutrient loading. Also potentially contributing to the high TP values observed in spring of 2022 is the high chlorophyll-*a* values seen in the same years, since algal cells contain phosphorus which will add to the TP measured.

Trophic Status

Trophic status describes the level of biological productivity within a waterbody and is measured by using Secchi depth, chlorophyll-*a*, and total phosphorus concentrations (Nordin, 1985). Low productivity lakes are called *oligotrophic* and tend to have clear water and sufficient oxygen for aquatic life throughout the year. Lakes with moderate productivity are called *mesotrophic*. *Eutrophic* lakes have high productivity and often have high densities of aquatic plants and/or algae. Algal blooms may occur in these lakes frequently, reducing recreational opportunities and potentially impacting aquatic habitat.

The results show that Long Lake is moderately productivity depending on the trophic indicator (**Table 3**). Summer water clarity (i.e., Secchi depth) and chlorophyll-*a* concentrations for all years suggests the lake is mesotrophic. The total phosphorus concentrations during spring for all years, however, place Long Lake in the oligotrophic to low-mesotrophic range.

Table 3. Long Lake trophic indicator results (as per Nordin, 1985).

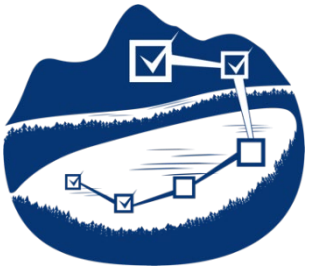
Parameters	Trophic Categories			Long Lake		
	Oligotrophic	Mesotrophic	Eutrophic	2021	2022	2023
Secchi Depth (m)[1]	>6.0	3.0 - 6.0	<3.0	4.1	3.7	3.4
Chlorophyll-a (µg/L)[1]	0 - 2	2 – 7	>7	2.5	2.7	2.6
Total Phosphorus (µg/L)[2]	1 - 10	10 - 30	>30	7.3	11.1	6.6

[1]Summer (June to September) average, [2]Spring (March to May) mixed conditions.

Summary

The key results of this study indicate that Long Lake is stratified between mid-May to early June and late-September (inferred). There is limited habitat available for fish during this time, as cooler bottom waters are low in oxygen, while shallower more oxygenated waters are too warm. Key parameters (i.e., chlorophyll-*a*, water clarity, and phosphorus concentration) suggest that Long Lake is a moderately productive system (mesotrophic) that may be prone to experiencing more productive years under certain climatic conditions, such as heat waves and longer periods of high temperatures. Years when the lake surface is warmer for longer (i.e., earlier in the spring and/or later in the fall) will result in more intense (longer and stronger) lake stratification, greater oxygen depletion at the bottom and more nutrients released from the sediments.

Going Forward



There is strong evidence that climate change is exacerbating existing issues in lakes that are already experiencing problems. One climate change impact already observed in many northern hemisphere lakes is earlier onset and longer periods of stratification, which may make internal nutrient loading more problematic (Woolway et al., 2020). If there is volunteer interest and capacity, continued monitoring at a less intense BCLSMP study level (e.g., Level 1: regular temperature and Secchi depth measurements at Long Lake Deep Station from spring to fall overturn) would be beneficial to help understand variability in Long Lake stratification and productivity. These data are important for long-term lake condition records and will provide early warning signs of deterioration in water quality. It is also recommended that monitoring include ice-on and off dates. A follow up Level 3 study can be conducted again in 5-10 years to track potential changes in lake water quality.

Lake Monitoring Resources and Education

See links under Monitoring Resources on: www.gov.bc.ca/lakestewardshipmonitoring, including tips to keep your lake healthy.

BCLSS's LakeKeepers Manual, a guide to lake stewardship and ecology in British Columbia: https://www.bclss.org/programs#lake-keepers-manual

Find lake monitoring resources, educational resources for youth, stewardship resources, funding information, stewardship community and more in the BCLSS library: https://www.bclss.org/document-library

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