BC Lake Stewardship and Monitoring Program

Cowichan Lake 2005-2020

A partnership between the BC Lake Stewardship Society and the BC Ministry of Environment and Climate Change Strategy

The Importance of Cowichan Lake & its Watershed

British Columbians want lakes to provide good water quality, aesthetics, and recreational opportunities. When these features are not apparent in recreational lakes, questions arise. People begin to wonder if the water quality is getting worse, if the lake has been affected by land development, and what conditions will result from more development within the watershed.

The BC Lake Stewardship Society (BCLSS), in collaboration with the Ministry of Environment and Climate Change Strategy (ENV), has designed a program, entitled *The BC Lake Stewardship and Monitoring Program*, to address these concerns. Through regular water sample collections, we can come to understand a lake's current water quality, identify the preferred uses for a given lake, and monitor water quality changes resulting from land development within the lake's watershed. There are different levels of lake monitoring and assessment. The level appropriate for a particular lake depends on the funding and human resources available, as well as the historic data or conditions, if available, and potential impacts to the system. Information on the levels of lake monitoring can be found on the BCLSS website. This report gives the 2005-2020 results of a Level II monitoring program for Cowichan Lake which includes volunteer collected bi-weekly Secchi and surface temperature data combined with spring profile and nutrient data collected by ENV from 2018-2020. The Cowichan Lake and River Stewardship Society collected the extensive set of Secchi depth and temperature data, contributing 982 volunteer hours from 2005-2020.

The BCLSS can provide communities with both lake-specific monitoring results and educational materials on general lake protection issues. This useful information can help communities play a more active role in the protection of the lake resource. Finally, this program allows government to use its limited resources efficiently with the help of local volunteers and the BCLSS.

A **watershed** is defined as the entire area of land that moves the water it receives into a common waterbody. The term watershed is misused when describing only the land immediately around a waterbody or the waterbody itself. The true definition represents a much larger area than most people normally consider. The Cowichan Lake watershed is 588 km^2. Watersheds are where much of the hydrologic cycle occurs and play a crucial role in the purification of water. Although no "new" water is ever made, it is continuously recycled as it moves through watersheds and other hydrologic compartments. The quality of the water resource is largely determined by a watershed's capacity to buffer impacts and absorb pollution.

Every component of a watershed (vegetation, soil, wildlife, etc.) has an important function in maintaining good water quality and a healthy aquatic environment. It is a common misconception that detrimental land use practices will not impact water quality if they are kept away from the area immediately surrounding a waterbody. Poor land use practices in a watershed can eventually impact the water quality of the downstream environment.

Human activities that impact water bodies range from small but widespread and numerous *non-point* sources throughout the watershed to large *point* sources of concentrated pollution (e.g., waste discharge outfalls, spills, etc.). Undisturbed watersheds have the ability to purify water and repair small amounts of damage from pollution and alterations. However, modifications to the landscape and increased levels of pollution impair this ability.

Cowichan Lake is located 31 km west of Duncan, in the Cowichan Valley, on Vancouver Island and lies in the traditional territory of the Cowichan Nation. The Cowichan Lake region includes the villages of Honeymoon Bay, Youbou, Marble Bay, Caycuse, Mesachie Lake, and the town of Lake Cowichan.

Cowichan Lake is the second largest lake on Vancouver Island. It has a surface area of 62 km^2, a perimeter of 109 km and lies at an elevation of 164 m. The average depth of the lake is 50 m and the maximum depth is 152 m (FIDQ, 2020). It supplies drinking water to the town of Lake Cowichan and the Cowichan Valley Regional District and there are also numerous domestic drinking water licenses for both Cowichan Lake and the Cowichan River (Epps & Phippen, 2011).

The lake contains anadromous bull trout (*Salvelinus confluentus*), atlantic salmon (*Salmo salar*), brown catfish (*Ameiurus nebulosus*), brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*Oncorhynchus kisutch*), cutthroat trout (*Oncorhynchus clarkii*), dolly varden char (*Salvelinus malma*), kokanee (*Oncorhynchus nerka*), pacific lamprey (*Entosphenus tridentatus*), prickly sculpin (*Cottus asper*), rainbow trout (*Oncorhynchus mykiss*), steelhead (*Oncorhynchus mykiss*), threespine stickleback (*Gasterosteus aculeatus*), Cowichan Lake lamprey (*Entosphenus macrostomus*), and cutthroat/rainbow hybrids (BCLSS, 2014). Cowichan Lake lamprey are only known to occupy two lakes, Cowichan and Mesachie, and are considered threatened under the Species at Risk Act (SARA) (Fisheries and Oceans Canada, 2016). Lake stocking has not occurred since 1939 (FIDQ, 2020).

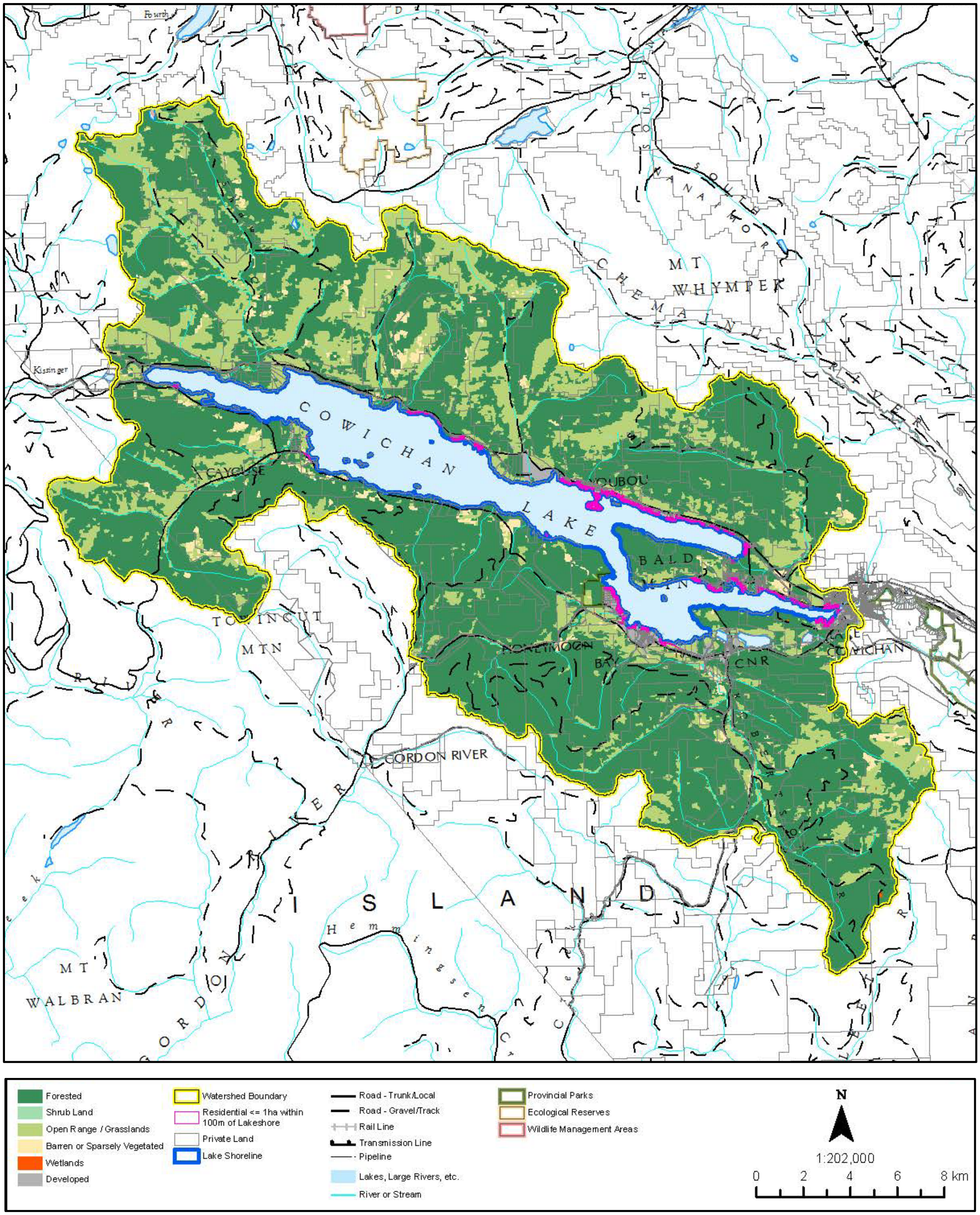
Cowichan Lake has 80 inlet streams (Thom, 2014) and one outlet, the Cowichan River, which is designated as a Heritage River. A weir at the Cowichan River outlet, controlled by Catalyst Paper, has been in operation since 1957. The control of the outflow provides water for both environmental flows and industrial use. With changing weather patterns, decreased snowpack, and longer, drier summers, the weir no longer meets the demand of increasingly frequent critically low summer flows in the Cowichan River (Cowichan Lake Weir, 2020).

The Cowichan Watershed can be characterised as having high precipitation/recharge, high storage, and low population/demand in the western and upper half of the watershed, contrasted with low precipitation, low storage, and high population and high demand in the eastern and lower half. Supply and demand are not matched regionally, and the supply-demand gap is pushed to extremes in the late summer and early fall (Cowichan Watershed Board, 2014). Due to the seasonal pattern of high precipitation in winter and low precipitation in summer, and limited ability to increase water storage on the lake without affecting lakeshore properties, providing sufficient flows in the downstream Cowichan River during the summer and autumn for salmonid passage, habitat maintenance, and spawning access has become a major issue (Nordin 2014).

Almost all the land surrounding Cowichan Lake is privately owned. Land use activities at Cowichan Lake include residential, recreational, logging, and historical mining activities (Epps and Phippen, 2011). The communities of Lake Cowichan, Youbou and Honeymoon Bay rely on tourism to support their economies. Several campgrounds are located along the shores of Cowichan Lake. Additionally, the Cowichan Lake Outdoor Education and Conference Centre is located on 44 hectares of forested foreshore west of the town of Lake Cowichan. The lake is popular for camping, hiking, fishing, swimming, paddling (canoes, kayaks, SUPs) and boating.

The map below shows the Cowichan Lake watershed and its associated land uses. Land use includes forested (64%), open range/grasslands (21%), water (10%), barren/sparsely vegetated (2%), and developed (1%).

Cowichan Lake Land Use Map



Map provided by Ministry of Forests, Lands, Natural Resource Operations and Rural Development, 2020.

Non-Point Source Pollution and Cowichan Lake

Point source pollution originates from municipal or industrial effluent outfalls. Other pollution sources exist over broader areas and may be hard to isolate as distinct effluents. These are referred to as non-point sources of pollution (NPS). Shoreline modification, urban stormwater runoff, onsite septic systems, agriculture, and forestry are common contributors to NPS pollution. One of the most detrimental effects of NPS pollution is phosphorus loading to water bodies. The amount of total phosphorus (TP) in a lake can be greatly influenced by human activities. If local soils and vegetation do not retain this phosphorus, it will enter watercourses where it will become available for algal production.

Stormwater Runoff

Lawn and garden fertilizer, sediment eroded from modified shorelines or infill projects, oil and fuel leaks from vehicles, snowmobiles and boats, road salt, and litter can all be washed by rain and snowmelt from properties and streets into watercourses. Phosphorus and sediment are of greatest concern, providing nutrients and/or a rooting medium for aquatic plants and algae. Paved surfaces prevent water infiltration to soils, and are potential sources of hydrocarbon and metal contamination, which can runoff into lakes during storm events.

Boating

Oil and fuel leaks are the main water quality concerns of boat operation on lakes. However, boating activities can also cause shoreline erosion from large wakes and churn up sediment and nutrients in shallow water from propeller wash. Other problems include the spread of aquatic invasive plants/animals and the dumping of litter.

Forestry

Timber harvesting can include clear cutting, road building, and land disturbances, which alter water flow and the ability for nutrients to remain stored (sequestered) in soil, potentially increasing sediment and phosphorus inputs to water bodies.

Atmospheric Deposition

Gases and particulates released to the atmosphere from combustion sources such as motor vehicle emissions, slash burning, and industrial sources contain nitrogen, sulphur, and metal compounds which eventually settle to the ground as dust or fall to the earth in rain and snow. These contaminants can fall directly into a waterbody, filter slowly into groundwater, or be washed into surface waters with runoff.

Onsite Septic Systems and Grey Water

Onsite septic systems can effectively treat human wastewater and wash water (grey water) as long as they are properly located, designed, installed, and maintained. When these systems fail, they can become significant sources of nutrients and pathogens to water bodies. Poorly maintained pit privies, used for the disposal of human waste and grey water, can also be significant contributors. Properly located and maintained septic tanks do not pose a threat to the environment, however, mismanaged or poorly located tanks have the potential to result in a health hazard and/or excessive nutrient loading.

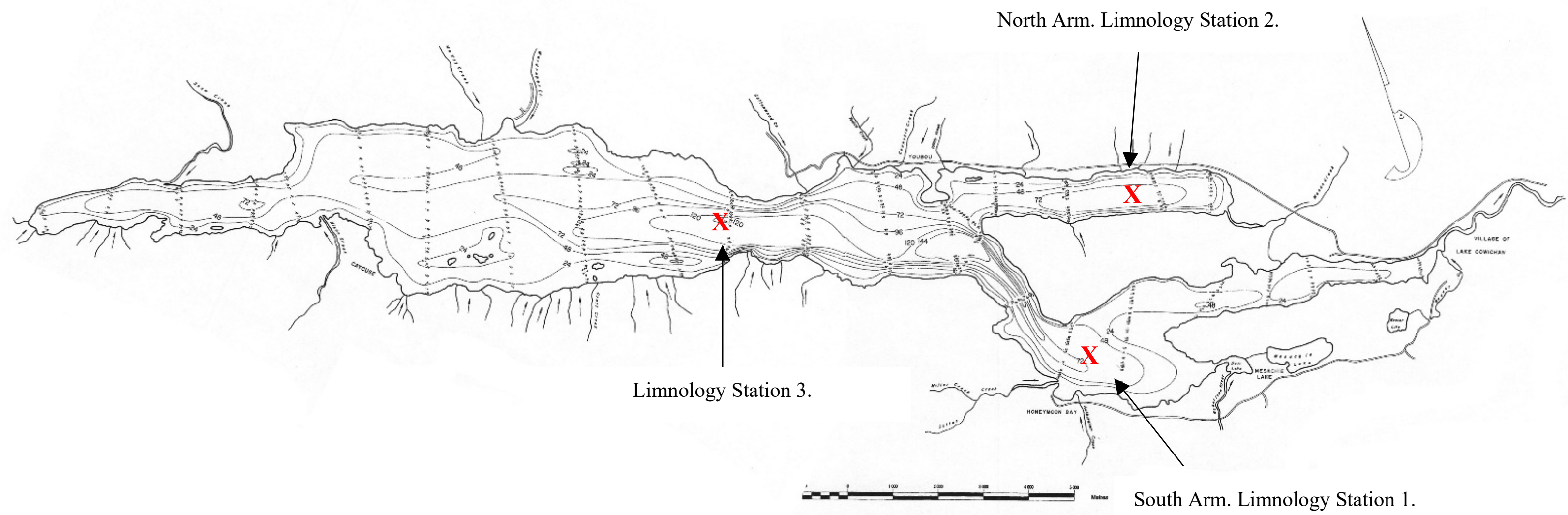
Agriculture

Agricultural production of crops and livestock, along with mixed farming activities, can alter water flow and increase sediment and chemical/bacterial/parasitic input into water bodies. Potential sources of nutrients (nitrogen & phosphorus) include chemical fertilizers, manure, and improperly situated winter-feeding areas. Significant amounts of total phosphorus can be transported by sediment inputs when riparian areas are not well maintained near agricultural activities and become degraded. The Code of Practice for Agricultural Environmental Management outlines requirements to minimize the impacts of agriculture on local waterways, including the distances structures and agricultural activities should be kept away from a watercourse (Government of BC, 2020). A Group-based Environmental Farm Plan has been established for dairy farmers in the Cowichan Lake watershed to identify best management practices and support for agriculture education and nutrient management upgrades is ongoing (Cowichan Watershed Board, 2020).

Internal Nutrient Loading

Lake sediments themselves can be a major source of phosphorus. Deep-water oxygen can become depleted (i.e., anoxic), causing a chemical shift in bottom sediments. This shift can cause sediment to release phosphorus to overlying waters. This *internal loading* of phosphorus can be natural but is often the result of external phosphorus addition through NPS entering the lake over a long time period. Lakes displaying internal loading have elevated algal levels and generally lack recreational appeal. Internal nutrient loading can be a significant source of nutrients to the overlying water and is very difficult and complicated to manage/remediate.

Cowichan Lake Bathymetric Map



Lake Characteristics

Area: 62.04 km^2
Max Depth: 152 m
Mean Depth: 50.1 m
Shoreline Perimeter: 109.7 km
Elevation: 164 m

X = Monitoring site

Map obtained from FIDQ. Lake surveyed in 1960.
Not to be used for navigational purposes.

What's Going on Inside Cowichan Lake?

Temperature

Lakes show a variety of annual temperature patterns based on their location and depth. Most interior BC lakes form layers (stratify), with the coldest water near the bottom. Because colder water is denser, it resists mixing into the warmer, upper layer for much of the summer. When the warmer oxygen rich surface water distinctly separates from the cold oxygen poor water in the deeper parts of the lake, it is said to create a thermocline, a region of rapid temperature change between the two layers.

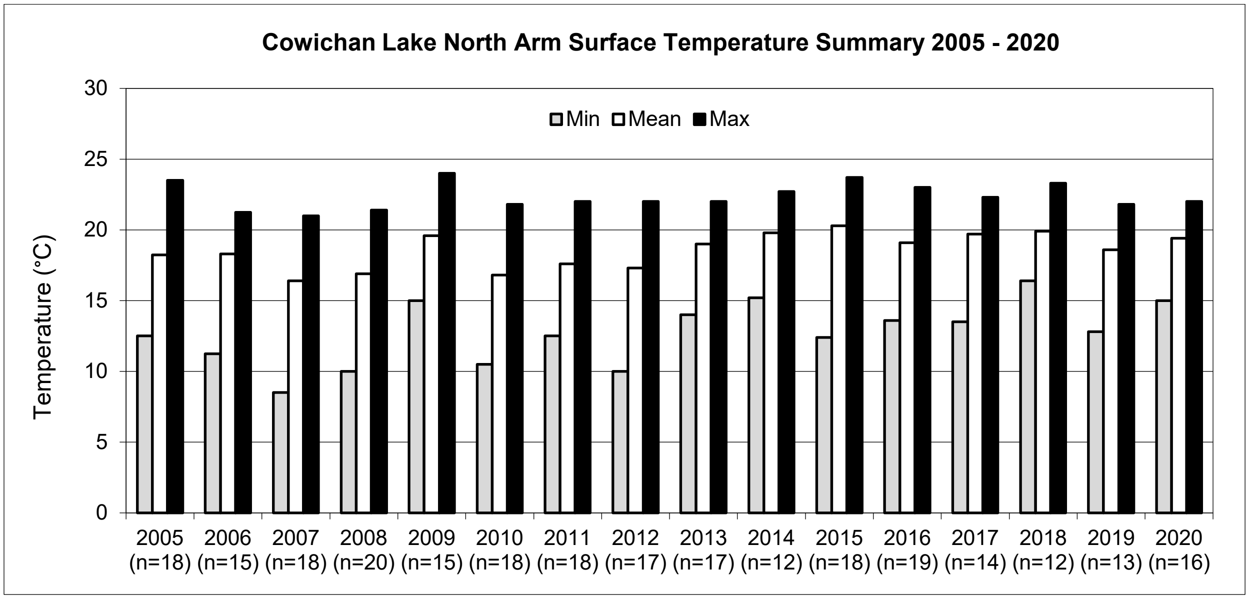
In spring and fall, these lakes usually mix from top to bottom (overturn) as wind energy overcomes the reduced temperature and density differences between surface and bottom waters. In the winter, lakes re-stratify under ice with the densest water (4°C) near the bottom. Because these types of lakes turn over twice per year, they are called dimictic lakes. These are the most common type of lake in BC.

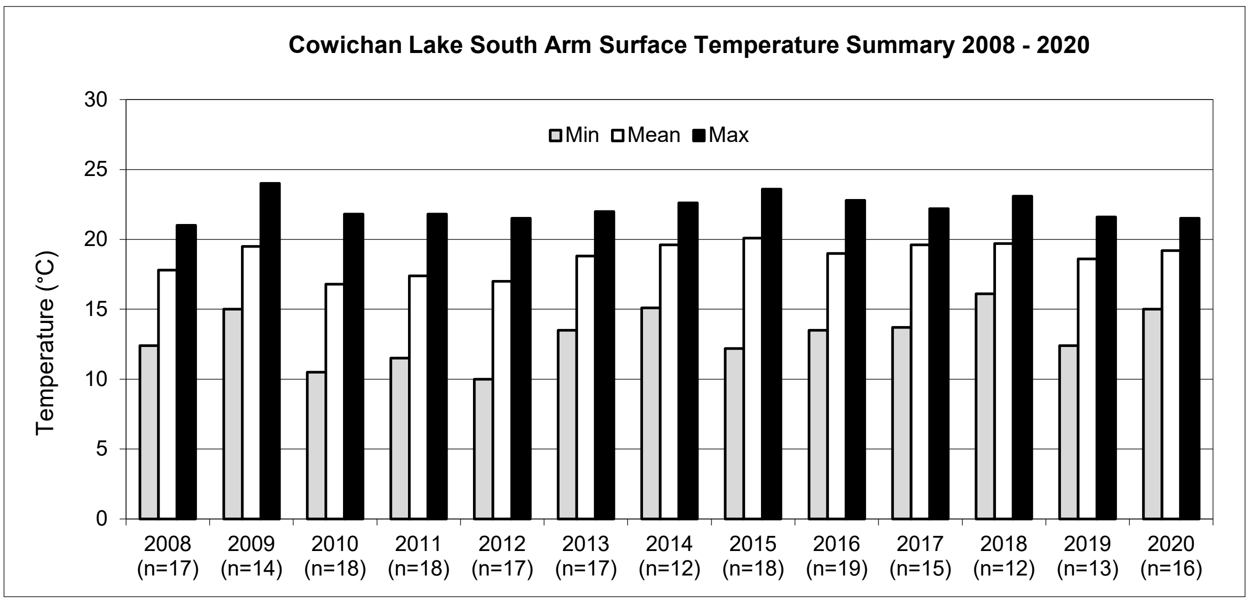
Coastal lakes in BC are more often termed warm monomictic lakes because they turn over once per year. These lakes have temperatures that do not fall below 4°C. Warm monomictic lakes generally do not freeze and circulate freely in the winter at or above 4°C and stratify only in the summer. Cowichan Lake is classified as a warm monomictic lake.

Ice-on and ice-off dates for BC lakes are important data for climate change research. By comparing these dates to climate change trends, we can examine how lake are being affected. Residents report that Cowichan Lake rarely freezes.

Volunteer monitoring took place at two sites on Cowichan Lake: the North Arm deep site (Limnology Station 2) and the South Arm deep site (Limnology Station 1). The North Arm data set is from 2005-2020 and the South Arm data set is from 2008-2020. The Ministry of Environment and Climate Change Strategy data were collected at these two sites as well as a Central deep site (Limnology Station 3). Monitoring site locations are shown on the bathymetric map on page 5.

Surface temperature readings serve as an important ecological indicator. By measuring surface temperature, we can record and compare readings from season to season and year to year. The surface temperature summary for the North and South Arms are shown below. Winter readings (January - early April) were removed from the North Arm 2012 dataset since monitoring did not take place until late April or early May in all other years.



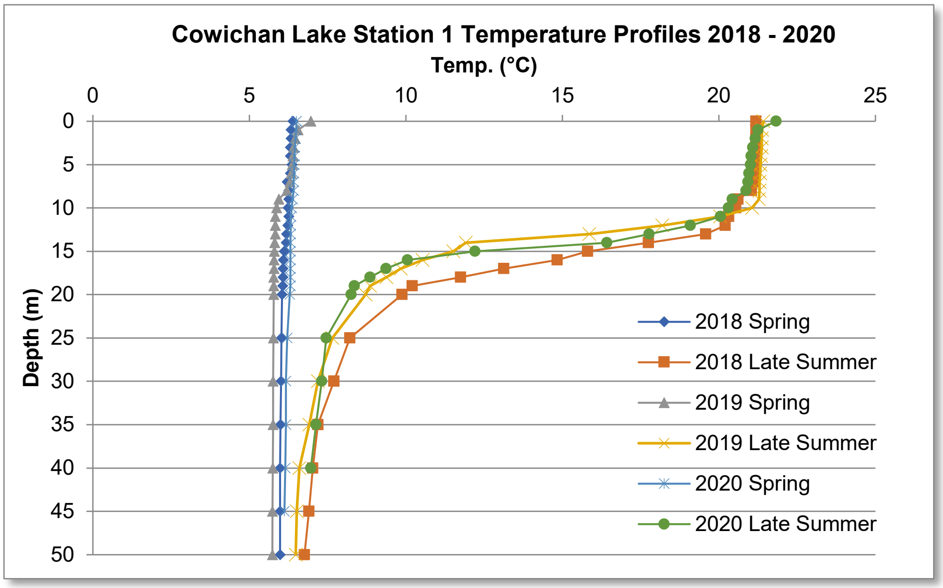


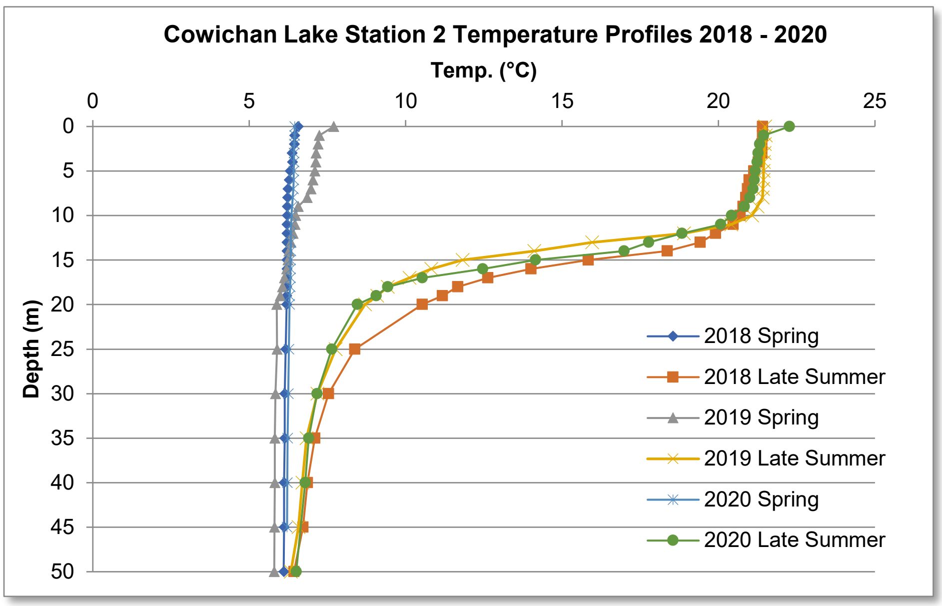
Temperature stratification patterns are also very important to lake water quality. They determine much of the seasonal oxygen, phosphorus, and algal conditions. When abundant, algae can create problems for lake users.

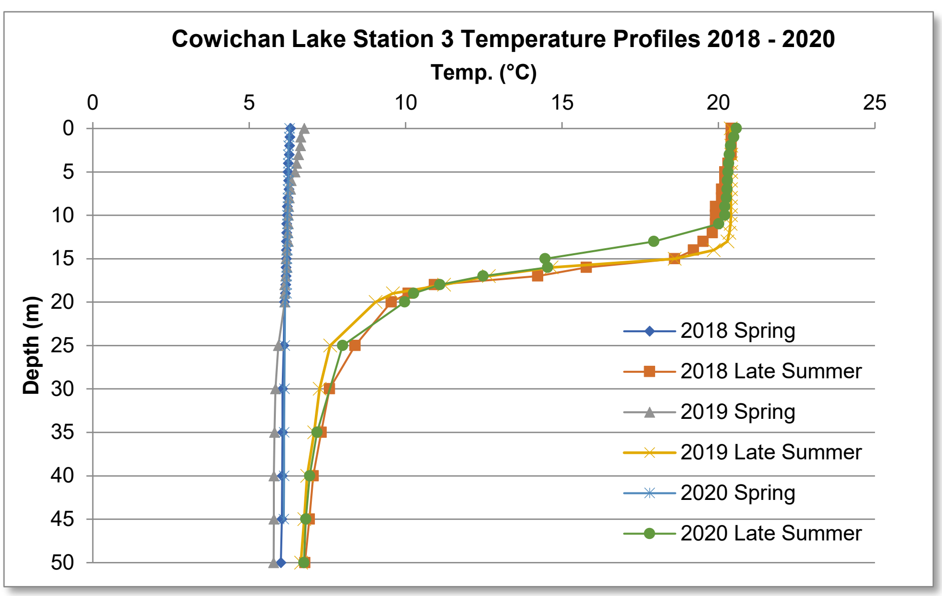
Spring and late summer temperature (T) profiles are collected by ENV on an ongoing basis at Cowichan Lake under the BC Lake Monitoring Network. The profiles collected at the three stations from 2018-2020 are shown on the following page. Spring profiles were taken March 12, 2018, March 20, 2019, and March 10, 2020. Late summer profiles were taken August 29, 2018, August 19, 2019, and August 26, 2020.

Spring overturn profiles show that all sites were thermally mixed at the time of sampling with fairly uniform temperatures throughout the water column. Capturing spring overturn conditions (i.e., fully mixed water column) allows for a better estimate of the lake's trophic conditions.

Late summer temperature profiles for 2018-2020 indicate that Cowichan Lake was thermally stratified at the time of sampling. A thermocline is evident in all profiles for each year from approximately 10-20 m.


Cowichan Lake Station 1 Temperature Profiles 2018 - 2020
Temp. (°C)
0
5
10
15
20
25
Depth (m)
0
5
10
15
20
25
30
35
40
45
50
2018 Spring
2018 Late Summer
2019 Spring
2019 Late Summer
2020 Spring
2020 Late Summer


Cowichan Lake Station 2 Temperature Profiles 2018 - 2020
Temp. (°C)
0
5
10
15
20
25
Depth (m)
0
5
10
15
20
25
30
35
40
45
50
2018 Spring
2018 Late Summer
2019 Spring
2019 Late Summer
2020 Spring
2020 Late Summer


Cowichan Lake Station 3 Temperature Profiles 2018 - 2020
Temp. (°C)
0
5
10
15
20
25
Depth (m)
0
5
10
15
20
25
30
35
40
45
50
2018 Spring
2018 Late Summer
2019 Spring
2019 Late Summer
2020 Spring
2020 Late Summer

Dissolved Oxygen

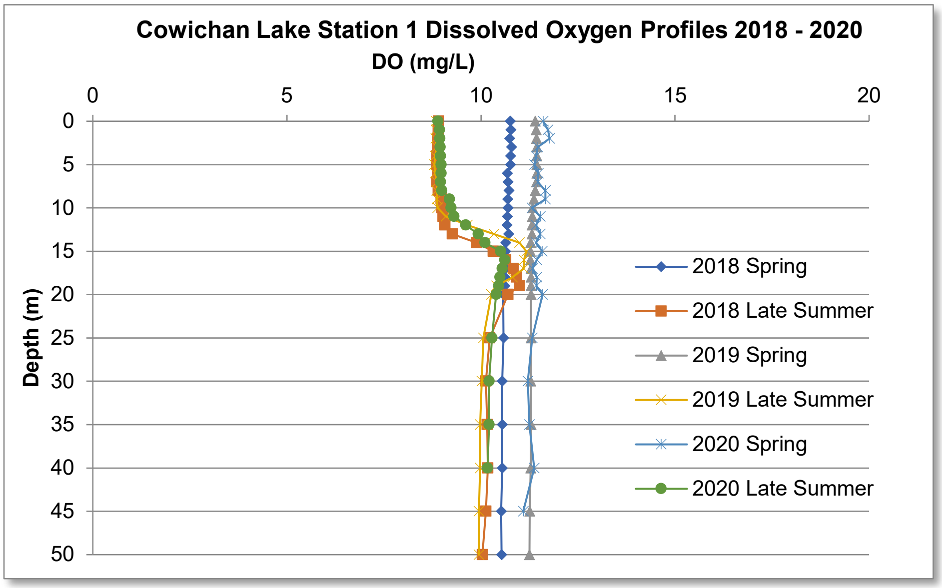
Dissolved oxygen (DO) is essential to aquatic life in lakes. Oxygen from the atmosphere dissolves and mixes into the water's surface and is also released from plants and algae during photosynthesis. Oxygen is consumed by respiration of animals and plants, including the decomposition of dead organisms by bacteria. A great deal can be learned about the health of a lake by studying oxygen patterns and levels.

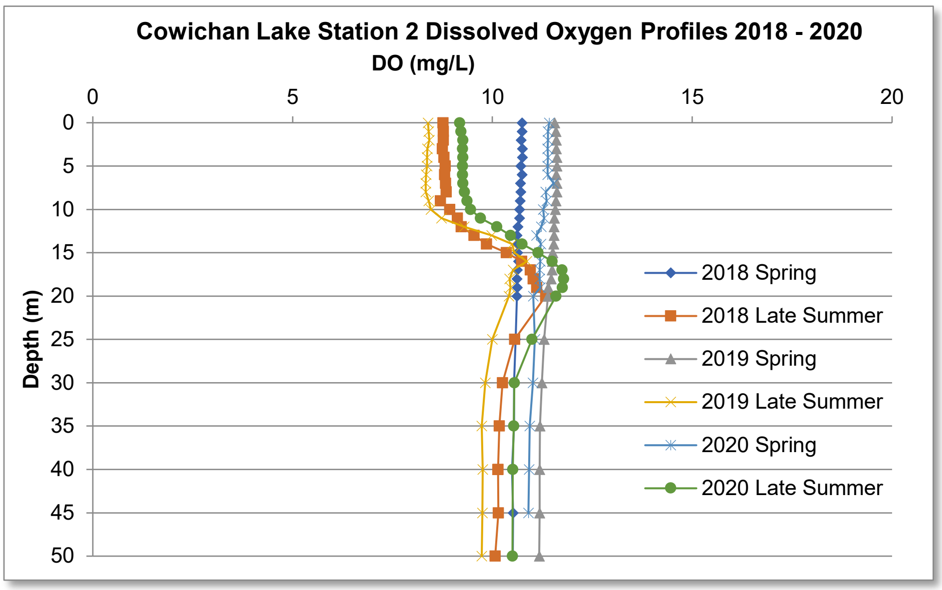
Generally, lakes that are lower in nutrients and algae production will have sufficient dissolved oxygen to support life at all depths through the year. As lakes become more nutrient and algae rich, it leads to increased plant and animal respiration and decay, resulting in more oxygen consumption. This is especially true near the bottom of the lake, where organic matter can accumulate, and oxygen is depleted more rapidly. Stratified lakes, with low oxygen concentrations in the isolated bottom layer, can impact the behaviours and locations of fish residing within the lake. Fish can become stressed when oxygen concentrations fall below 4 mg/L and begin to show avoidance behaviours at these levels, moving to areas of the lake with higher dissolved oxygen (BC Ministry of Environment, 1997). Fish kills can occur when decomposing or respiring algae use up the oxygen supply. In summer, this can happen on calm nights after an algal bloom, but most fish kills occur during late winter or at initial spring mixing.

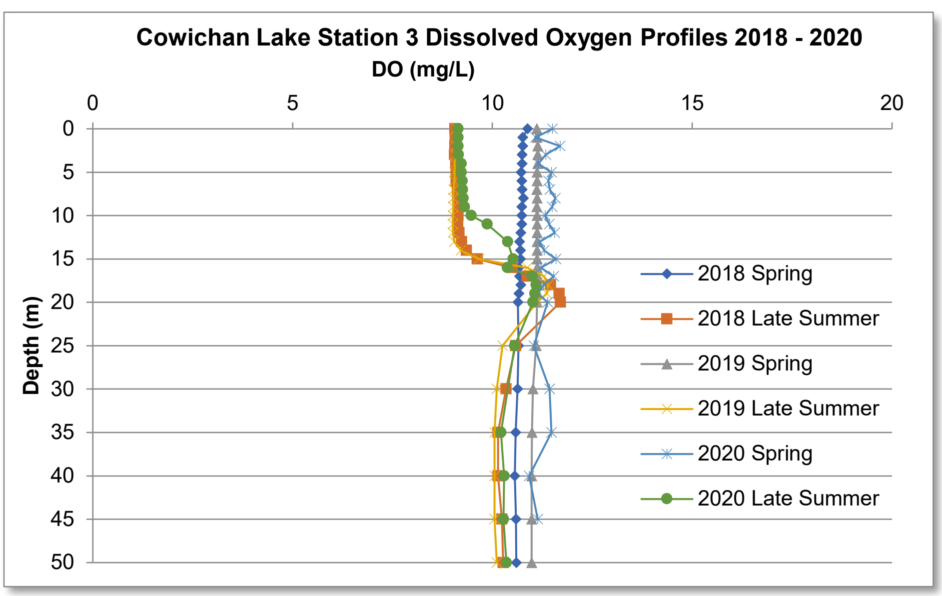
Spring and late summer dissolved oxygen (DO) profiles are collected by ENV on an ongoing basis at Cowichan Lake under the BC Lake Monitoring Network. The profiles collected at the three stations from 2018-2020 are shown on the following page. Spring profiles were taken March 12, 2018, March 20, 2019, and March 10, 2020. Late summer profiles were taken August 29, 2018, August 19, 2019, and August 26, 2020.

The Cowichan Lake spring profiles show that dissolved oxygen was fairly uniform to 50 m at all sites, with values ranging between 10.5 mg/L to 11.8 mg/L.

Late summer profiles for all sites show an increase in DO at approximately 10 m, which is a result of decreasing surface temperature. Water is able to hold more oxygen at lower temperatures. Late summer profiles indicate that DO was between 9.7 mg/L and 10.4 mg/L at 50 m depth. There is no evidence of oxygen depletion in bottom waters in late summer and this would not be expected in this oligotrophic lake (Wetzel, 2001).


Cowichan Lake Station 1 Dissolved Oxygen Profiles 2018 - 2020
DO (mg/L)
Depth (m)
2018 Spring
2018 Late Summer
2019 Spring
2019 Late Summer
2020 Spring
2020 Late Summer


Cowichan Lake Station 2 Dissolved Oxygen Profiles 2018 - 2020
DO (mg/L)
Depth (m)
2018 Spring
2018 Late Summer
2019 Spring
2019 Late Summer
2020 Spring
2020 Late Summer


Cowichan Lake Station 3 Dissolved Oxygen Profiles 2018 - 2020
DO (mg/L)
Depth (m)
2018 Spring
2018 Late Summer
2019 Spring
2019 Late Summer
2020 Spring
2020 Late Summer

Trophic Status

The term *trophic status* is used to describe a lake's level of productivity and depends on the amount of nutrient available for plant growth, including both floating algae (phytoplankton) and rooted plants (macrophytes). Algae are important to the overall ecology of a lake because they use nutrients to produce organic matter and are consumed by zooplankton, which in turn are food for other organisms, including fish. Macrophytes provide important habitat to many fish species and are the base of littoral zone (shallow water near shore) production.

In most BC lakes, phosphorus is the nutrient in shortest supply relative to need and thus limits the production of aquatic life. When in excess, phosphorus accelerates growth and may artificially age a lake. Total phosphorus in a lake can be greatly influenced by human activities.

Lakes with low levels of phosphorus usually support limited biological production and, thus, contain low concentrations of the photosynthetic pigment chlorophyll *a*, which is found in both algae and aquatic plants. These lakes are called *oligotrophic* and tend to have clear water and sufficient oxygen throughout the year to support fish and other aquatic organisms. *Mesotrophic* lakes have moderate levels of phosphorus and support greater biological production and therefore contain greater concentrations of chlorophyll *a*. Water clarity in mesotrophic lakes is moderate, but there is an increased probability of oxygen depletion in the deepest areas. *Eutrophic* lakes contain even greater concentrations of phosphorus and chlorophyll *a* and can experience extended periods of poor water clarity and low oxygen levels.

Mesotrophic and eutrophic lakes experience higher densities of macrophytes and algae. Surface accumulations or 'blooms' of algae may occur during the warmest months, particularly in eutrophic lakes, where lack of water transparency can significantly reduce recreational activities. Mesotrophic to slightly eutrophic lakes support productive fisheries, so are desirable for those seeking good fishing lakes. As a result of higher productivity, these lakes also tend to draw in wildlife and waterfowl in larger numbers.

The trophic status of a lake can be determined by looking at concentrations of different chemical and biological variables. Nordin (1985) defined values for these variables in British Columbia lakes, which are shown in the following table.

	Trophic Categories		
	Oligotrophic	Mesotrophic	Eutrophic
Chlorophyll-a (µg/L)[1]	0 - 2.0	2.0 - 7.0	>7.0
Total Phosphorus (µg/L)[2]	1.0 - 10.0	10.0 - 30.0	>30.0
Total Nitrogen (µg/L)[2]	<100	100 - 500	500 - 1000
Clarity - Secchi Disc (m)[1]	>6.0	3.0 - 6.0	<3.0

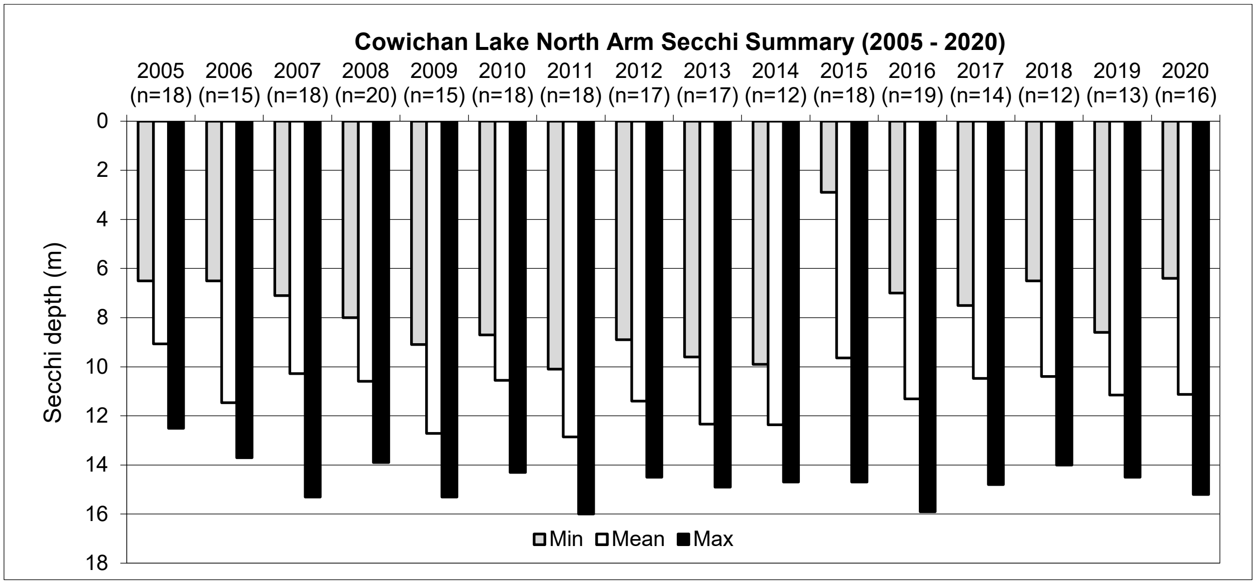
[1]Growing season average, [2]Spring mixed conditions.

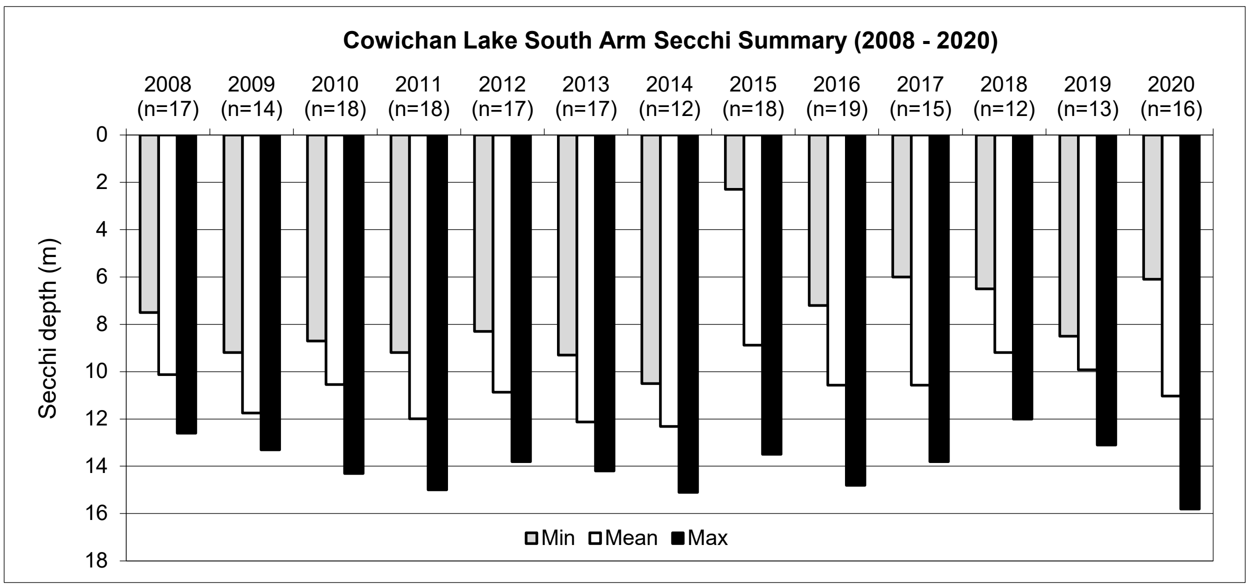
Water Clarity

As mentioned in the previous section, one method of determining productivity is water clarity. Secchi depth is a measure of water clarity and can be used as an indicator of the presence of algal cells in the water column. This can be assessed by using a Secchi disc, a 20 cm diameter black and white disc that measures the depth of light penetration. The disc is lowered into the water until it is no longer visible, and this depth is recorded. The disc is then dropped lower and then pulled up until it becomes visible again. The average of these two readings is known as the Secchi depth.

A deeper Secchi depth suggests clear water and fewer algal cells, while a shallow Secchi depth suggests less clear water, which may be caused by the presence of a large number of algal cells. In years where precipitation is much higher, this relationship can be confounded by additional debris and particulates from overland flow causing shallower Secchi depths.

The graphs below show the minimum, average and maximum Secchi depths recorded at the North Arm from 2005-2020 and South Arm from 2008-2020, as well as the number of readings each year (n). The minimum data requirements of 12 readings over the sampling season were met for all years. Winter readings (January - early April) were removed from the North Arm 2012 dataset since monitoring did not take place until late April or early May in all other years.

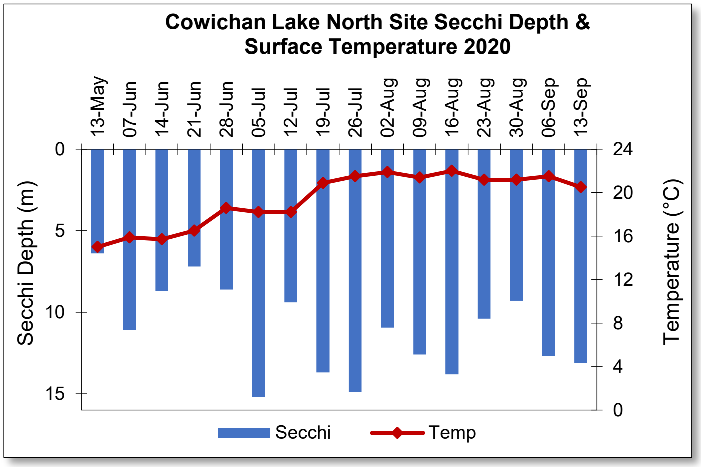


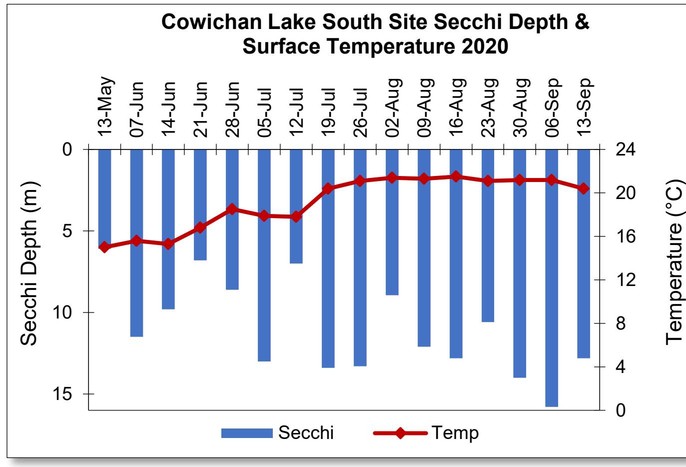


The maximum reading for the North Arm was 16.0 m (September 11, 2011) and the minimum was 2.9 m (May 10, 2015). The maximum reading for the South Arm was 15.8 m (September 6, 2020) and the minimum was 2.3 m (May 2, 2015). An algae bloom was reported in early May 2015 when the minimum readings were recorded.

The average Secchi depth measurements for the North arm ranged from 9.1 m (2005) to 12.9 m (2011) and for the South Arm from 8.9 m (2015) to 12.3 m (2014). Based on these summer average Secchi values, Cowichan Lake was exhibiting oligotrophic (>6 m Secchi depth) conditions (Nordin, 1985). Secchi disc depth doesn't appear to be increasing or decreasing over the monitoring period.

Natural variation and trends in Secchi depth and temperature not only occur between years, but also throughout one season. The figures below show the seasonal Secchi and temperature patterns at the North and South Arm sampling sites in 2020.



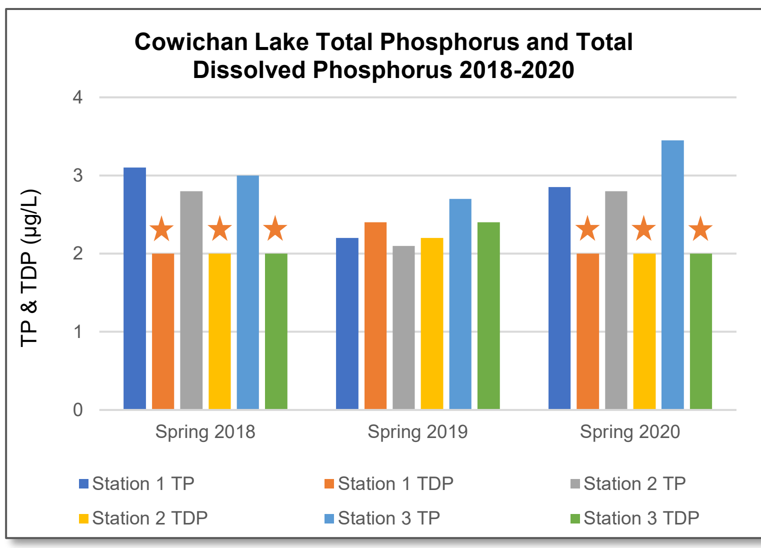


Phosphorus

The trophic status of a lake is characterized, in part, by the spring concentrations of total phosphorus. Phosphorus concentrations measured during spring overturn can be used to predict summer algal productivity. Productivity is dependent on the amount of nutrients (phosphorus and nitrogen) in a lake, which are essential for plant growth, including algae. Algae are important to the overall ecology of a lake because they are the food for zooplankton, which in turn are the food for other organisms, including fish. In most lakes phosphorus is the nutrient in shortest supply and thus acts to limit the production of aquatic life. When in excess, however, phosphorus accelerates growth and artificially ages a lake. Total phosphorus (TP) in a lake can be greatly influenced by human activities. Measuring total dissolved phosphorus (TDP) is also important as this form is more bioavailable for primary productivity than total phosphorus.

Spring TP and TDP values were averaged from the upper and lower sampling depths since the temperature profiles indicate that the water column was mixed. Capturing spring overturn conditions (i.e., fully mixed water column) allows for a better estimate of the lake's trophic conditions. The adjacent figure shows Cowichan Lake TP and TDP for 2018-2020.

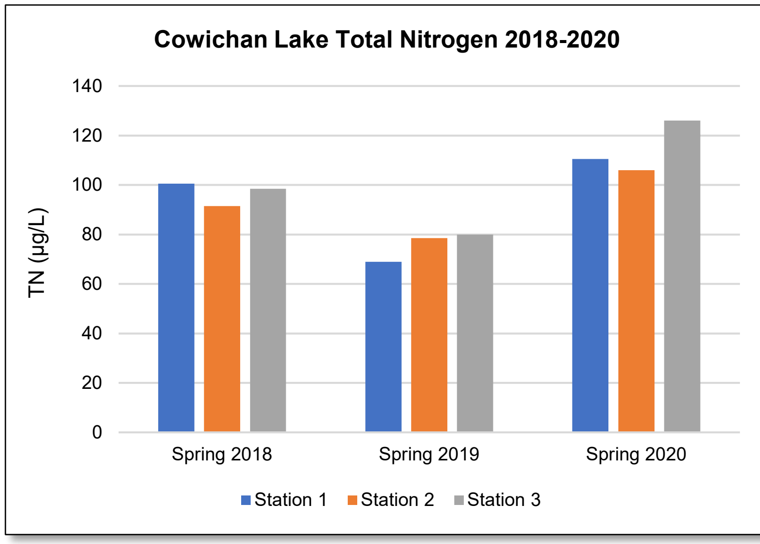
Spring TP concentrations for the monitoring period range between 2.0 ug/L and 3.4 ug/L, which indicate oligotrophic (TP 1-10 µg/L) conditions (Nordin, 1985). Total dissolved phosphorus is also relatively low, often below the detection limit (DL). This is consistent with TP and a further indication of oligotrophic conditions.



★ Value below detection limit

Nitrogen

Nitrogen is the second most important nutrient involved in lake productivity. Nitrogen in water is present in several forms including organic nitrogen, and inorganic forms of nitrogen (i.e., ammonia, nitrite, nitrates, nitrogen gas). Generally, major sources of nitrogen compounds are municipal and industrial wastewater, onsite sewage systems, urban and agriculture runoff, atmospheric precipitation, groundwater, and nitrogen fixation. In B.C. lakes, nitrogen is rarely the limiting nutrient for algal growth (phosphorus limitation is much more common). In most lakes, the ratio of nitrogen to phosphorus is well over 15:1, meaning excess nitrogen is present. In lakes where the N:P is less than 5:1, nitrogen becomes the limiting nutrient to algal growth, and can have major impacts on the amount and species of algae present.

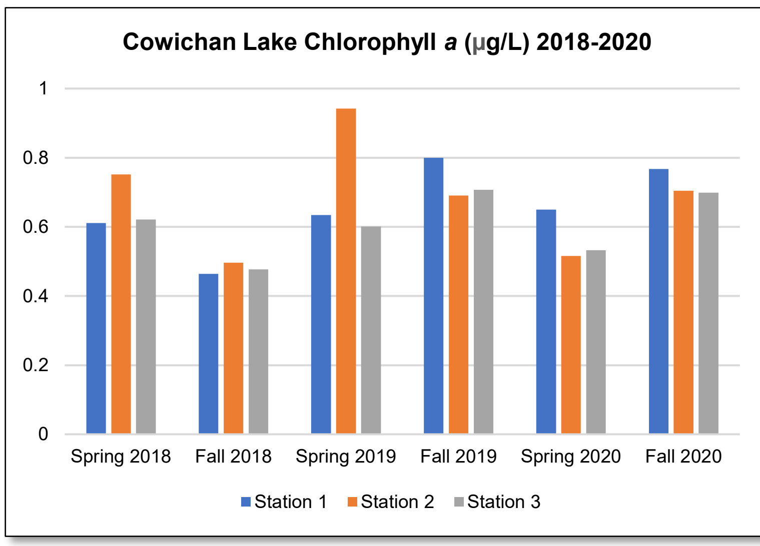


The Spring N:P ratios for Station 1 (South Arm) were 32:1, 31:1, and 39:1; for Station 2 (North Arm) were 33:1, 49:1, and 38:1, and for Station 3 were 33:1, 30:1, and 37:1 for 2017, 2018, and 2019, respectively. This indicates that Cowichan Lake is a phosphorus limited system.

Spring nitrogen concentrations ranged between 69 µg/L and 126 µg/L (see adjacent figure). Nitrogen values indicate oligotrophic conditions (TN <100 µg/L) in 2018 and 2019 and slightly mesotrophic conditions (TN 100-500 µg/L) in 2020.

Chlorophyll *a*

Chlorophyll *a* is the common green pigment found in almost all plants. In lakes, it occurs in plants ranging from algae phytoplankton) to rooted aquatic forms (macrophytes). Chlorophyll captures the light energy that drives the process of photosynthesis. While several chlorophyll pigments exist, chlorophyll *a* is the most common. The concentration of chlorophyll *a* in lake water is an indicator of the density of algae present in that same water. The spring and late summer chlorophyll *a* concentrations ranged between 0.464 µg/L and 0.942 µg/L (see adjacent figure).



As chlorophyll *a* concentrations were only sampled at spring and fall, it is difficult to draw conclusions about the trophic status as single point samples do not account for seasonal variation. To determine trophic status using chlorophyll *a*, multiple samples would be required throughout the growing season to calculate mean chlorophyll *a*. However, the chlorophyll *a* concentrations are relatively low and are indicative of oligotrophic conditions.

Aquatic Plants

Aquatic plants are an essential part of a healthy lake. They play an important role in the lifecycle of aquatic insects, provide food and shelter from predators for young fish, and also provide food for waterfowl, beavers, and muskrats. Factors that affect the type and amount of plants found in a lake include the level of nutrients (i.e., phosphorus), temperature, and introduction of invasive species.

Aquatic plants were surveyed in Cowichan Lake (Warrington, 1980) and include: *Myriophyllum exalbescens* Fern., *Myriophyllum quitense* H.B.K., *Myriophyllum verticillatum* L., *Potamogeton robbinsii* Oakes, *Potamogeton zosteriformis* Fern., *Potamogeton natans* L., *Potamogeton alpinus* Balbus., *Potamogeton pectinatus* L., *Potamogeton praelongus* Wulf, *Potamogeton amplifolius* Tuck., *Potamogeton pusillus* L., *Sparganium angustifolium* Mich., *Utricularia intermedia* Hayne, *Callitriche hermaphroditica* L., *Elodea canadensis* Rich., *Elodea richard, Lobelia dortmanna* L., *Scheuchzeria palustris* L., *Sium sauve walt., Veronica scutellate* L., *Typha latifolia* L., *Myosotis laxa* Lehm., *Myosotis scorpioides* L., *Dulichium arundinaceum* (L.) Britt., *Scirpus subterminalis* Torr., *Lemna trisulca* L., *Ranunculus flammula* L., *Callitriche heterophylla* Pursh., *Najas flexilis* (Willd.) R. & S., *Polygonum hydropiper* L., *Subularia aquatica* L., *Oenanthe sarmentosa* Presl, *Mimulus guttatus* D.C., *Lysimachia thyrsiflora* L., *Eleocharis palustris* (L.) R. & S., *Fontinalis antipyretica* L., *Potamogeton crispus* L., *Potamogeton perfoliatus* L., *Potamogeton gramineus* L., *Potamogeton obtusifolius* Mertens & Koch, *Utricularia vulgaris* L., *Ranunculus aquatilis* L., *Nuphar polysepalum* Engelm., *Ceratophyllum echinatum* Gray, *Equisetum fluviatile* L., *Menyanthes trifoliata* L., *Veronica americana* Schw., *Iris pseudacorus* L., *Potentilla palustris* (L.) Scop., *Juncus supiniformis* Engelm., *Scirpus lacustris* L., and *Carex* L. A number of plants were identified to the genus level.

Aquatic plant species can spread between lakes via boaters. Be sure to check for and remove all organic material and mud from boats, trailers, and equipment (boots, waders, fishing gear). Drain onto land all items that can hold water (buckets, wells, bilge, and ballast) and dry all items before launching into another body of water (ISCBC, 2020).

Should Further Monitoring Be Done on Cowichan Lake?

Generally, trophic status is based on a combination of parameters such as clarity (Secchi depth), nutrients, and chlorophyll *a*. The volunteer data (Secchi depth and surface temperature) collected from 2005-2020 indicate that the water quality has remained stable throughout the sampling years. Average annual Secchi readings and spring TP values place the lake in the oligotrophic classification. This classification is supported by the available chlorophyll *a* and spring nitrogen values.

	Trophic Categories			Station 1			Station 2			Station 3		
	Oligotrophic	Mesotrophic	Eutrophic	2018	2019	2020	2018	2019	2020	2018	2019	2020
Chlorophyll *a* (µg/L)[1]	0 - 2.0	2.0 - 7.0	>7.0	N.A.[3]	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Total Phosphorus (µg/L)[2]	1.0 - 10.0	10.0 - 30.0	>30.0	3.1	2.2	2.9	2.8	1.6	2.8	3.0	2.7	3.5
Total Nitrogen (µg/L)[2]	<100	100 - 500	500 - 1000	101	69	111	92	79	106	99	80	126
Clarity - Secchi Depth (m)[1]	>6.0	3.0 - 6.0	<3.0	9.2	9.9	11.0	10.4	11.2	11.1	N.A.	N.A.	N.A.

[1]Growing season average, [2]Spring mixed conditions. [3]N.A. = data not available.

In order to maintain and protect the water quality in Cowichan Lake, ambient water quality objectives were set for temperature, dissolved oxygen, water clarity (Secchi depth), total phosphorus, chlorophyll *a*, turbidity, total organic carbon, and E. coli. In addition, turbidity and total suspended solids objectives were recommended for the tributaries to Cowichan Lake (Epps & Phippen, 2011). Attainment monitoring took place in 2013 and 2014 and the reporting of results is pending.

Cowichan Lake is also part of ENV's BC Lake Monitoring Network (BCLMN). Program information and up to date summaries, graphs and raw data are available on ENV's BCLMN website and web mapping portal: www.gov.bc.ca/lake-monitoring. In addition, the public now has the opportunity to contribute to tracking of algae bloom information for BC lakes on ENV's Algae Watch website: www.gov.bc.ca/algaewatch.

A thorough dataset of Secchi depth and temperature has been established by volunteers over a period of 15 years. Volunteers could continue to collect Secchi and surface temperature readings to complement attainment monitoring and the long-term data collected by ENV.

Tips to Keep Cowichan Lake Healthy

Yard Maintenance, Landscaping & Gardening

- Minimize the disturbance of shoreline areas by maintaining natural vegetation cover.
- Minimize high-maintenance grassed areas.
- Replant lakeside grassed areas with native vegetation. Do not import fine fill.
- Use paving stones instead of pavement.
- Stop or limit the use of fertilizers and pesticides.
- Do not use fertilizers in areas where the potential for water contamination is high, such as sandy soils, steep slopes, or compacted soils.
- Do not apply fertilizers or pesticides before or during rain due to the likelihood of runoff.
- Hand pull weeds rather than using herbicides.
- Use natural insecticides such as diatomaceous earth. Prune infested vegetation and use natural predators to keep pests in check. Pesticides can kill beneficial and desirable insects, such as lady bugs, as well as pests.
- Compost yard and kitchen waste and use it to boost your garden's health as an alternative to chemical fertilizers.

Agriculture

- Locate confined animal facilities away from waterbodies. Divert incoming water and treat outgoing effluent from these facilities.
- Limit the use of fertilizers and pesticides.
- Construct adequate manure storage facilities.
- Do not spread manure during wet weather, on frozen ground, in low-lying areas prone to flooding, within 3 m of ditches, 5 m of streams, 30 m of wells, or on land where runoff is likely to occur.
- Install barrier fencing to prevent livestock from grazing on streambanks.
- If livestock cross streams, provide graveled or hardened access points.
- Provide alternate watering systems, such as troughs, dugouts, or nose pumps for livestock.

- Maintain or create a buffer zone of vegetation along a streambank, river or lakeshore and avoid planting crops right up to the edge of a waterbody.
- Ranchers are encouraged to have an Environmental Farm Plan for their operation (contact the Ministry of Agriculture).

Onsite Sewage Systems

- Inspect your system yearly, and have the septic tank pumped every 2 to 5 years by a septic service company. Regular pumping is cheaper than having to rebuild a drain-field.
- Use phosphate-free soaps and detergents.
- Do not put toxic chemicals (paints, varnishes, thinners, waste oils, photographic solutions, or pesticides) down the drain because they can kill the bacteria at work in your onsite sewage system and can contaminate waterbodies.
- Conserve water: run the washing machine and dishwasher only when full and use only low flow showerheads and toilets.
- Use biodegradable household cleaners instead of bleach or other hazardous products (which will kill the good bacteria in your system).
- Avoid planting trees or shrubs near the drain-field because their roots can damage or plug the pipes.

Auto Maintenance

- Use a drop cloth if you fix problems yourself.
- Recycle used motor oil, antifreeze, and batteries.
- Use phosphate-free biodegradable products to clean your car. Wash your car over gravel or grassy areas, but not over sewage systems.

Boating

- Do not throw trash overboard or use lakes or other waterbodies as toilets.
- Use biodegradable, phosphate-free cleaners instead of harmful chemicals.
- Conduct major maintenance chores on land.
- Use 4 stroke engines, which are less polluting than 2 stroke engines, whenever possible. Use an electric motor where practical.
- Keep motors well maintained and tuned to prevent fuel and lubricant leaks.
- Use absorbent bilge pads to soak up minor oil and fuel leaks or spills.
- Recycle used lubricating oil and left over paints.
- Clean, Drain, Dry. Clean off all organic material and mud from boat and equipment (boots, waders, fishing gear). Drain onto land all items that can hold water (buckets, wells, bilge, and ballast). Dry all items completely before launching into another body of water (ISCBC, 2020)
- Leading by example is often the best method of improving practices - help educate fellow boaters.

Docks

- Do not use metal drums in dock construction. They rust, sink, and become unwanted debris. Use blue or pink closed-cell extruded polystyrene billets or washed plastic barrel floats. All floats should be labeled with the owner's name, phone number, and confirmation that barrels have been properly emptied and washed.
- Untreated cedar is the best choice for dock construction. In some places, pressure-treated wood is banned for waterfront use because it can leach chemicals into the environment.

Who to Contact for More Information

The BC Lake Stewardship Society
1257 Erskine Street Coquitlam, BC V3B 6R3
Phone: 604.474.2441
Email: info@bclss.org
Website: www.bclss.org

Cowichan Lake and River Stewardship Society
www.cowichan-lake-stewards.ca/

BC Ministry of Environment and Climate Change Strategy
Kirsten McNeill, Aquatic Stewardship Coordinator
Public Feedback Welcomed
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Website:
https://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/lake-monitoring/volunteer-lake-monitoring

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