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Lakewatch

Calling Lake

The Alberta Lake Management Society
Volunteer Lake Monitoring Report

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And you really live by the river? What a jolly life!"

"By it and with it and on it and in it," said the Rat. "It's brother and sister to me. What it hasn't got is not worth having, and what it doesn't know is not worth knowing." *Kenneth Grahame The Wind in the Willows*

"The world's supply of fresh water is running out. Already one person in five has no access to safe drinking water." *BBC World Water Crisis Homepage*

A note from the Lakewatch Coordinator Preston McEachern

Lakewatch has several important objectives, one of which is to document and interpret water quality in Alberta Lakes. Equally important are the objectives of educating lake users about their aquatic environment; enhancing public involvement in lake management; and facilitating a link between aquatic scientists and lake users. The Lakewatch Reports are designed to summarize basic lake data in understandable terms for a lay audience, and are not meant to be a complete synopsis of information about specific lakes. Substantial additional information is generally available on the lakes that have participated in Lakewatch and readers requiring more information are encouraged to seek these sources.

The 2002 Lakewatch Report has undergone a substantial change in format from previous years. I am no longer the author as much as an editor including text and figures from others who have done an excellent job describing lakes throughout Alberta. I have attempted to give due credit to these outstanding people and apologize for blatant plagiarism where it occurs. As editor, feel free to castigate me for errors. I have included easily accessible information that is likely to have been updated in recent years and readers are encouraged to help update these reports by sending new information to me.

I would like to thank all people who share my love for aquatic environments and particularly those who have helped in the Lakewatch program. These people prove that ecological apathy can be overcome and give us hope that water will not be the limiting factor in the health of our planet.

Acknowledgements

The Lakewatch program is made possible through the dedication of its volunteers and Alberta Environment employees. Mike Bilyk, John Willis, Doreen LeClair and Dave Trew from Alberta Environment were instrumental in funding, training people and organizing with Lakewatch data. Comments on this report by Dave Trew were appreciated. Alberta Lake Management Society members and the board of directors helped in many facets of water collection and management. Without the dedication of these people and the interest of cottage owners, Lakewatch would not have occurred.

Calling Lake

Calling Lake is part of the Calling Lake Provincial Park located in the Municipal District of Opportunity No. 17, approximately 200 km north of the city of Edmonton on Secondary Road 813. The hamlet of Calling Lake and the St. Jean Baptiste Gambler Indian Reserve No. 183 are located on the lake's eastern shore (Mitchell and Prepas 1990). The 1986 census estimated the hamlet's population to be 408 permanent residents and 720 seasonal residents, while the reserve has a population of 93, members of the Bigstone Cree Indian Band (Alberta Native Affairs 1986; Calling Lake Planning Committee et al. 1988). The remainder of the shoreline is Crown land.

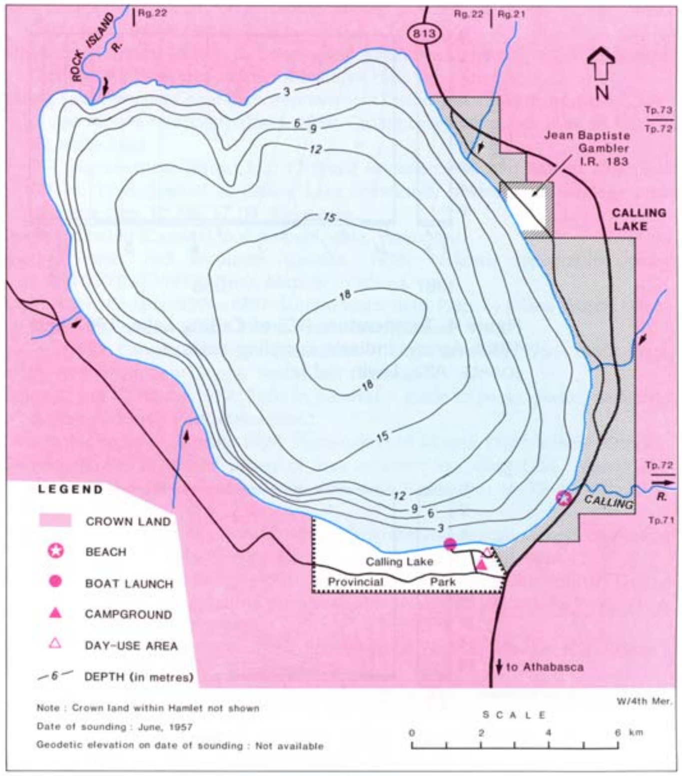


Fig. 1: Bathymetry of Calling Lake (Mitchell and Prepas 1990).

The lake's name is a translation of the Cree word which refers to the loud noises heard when the lake freezes over (University of Calgary Press 2001). The Calling Lake area has been inhabited for thousands of years; archaeological digs have discovered remnants of a hunter-gatherer band dating back as far as 6000 B.C. (Athabasca Historical Society et al. 1986). In recent history, the area was inhabited by the Woodland Cree and early fur traders who used the lake to catch their winter supply of fish (Finlay and Finlay 1987). Calling Lake Provincial Park was established in 1971 on 741 ha of land on the southern shore of the lake (Mitchell and Prepas 1990). Today, the park is a popular summer vacation area used for camping, fishing, motor boating, swimming and canoeing.

Calling Lake has a large drainage basin covering an area of 1,090 km2, mostly to the north of the lake (Mitchell and Prepas 1990). The main outlet, the Calling River, flows from the southeast end of the lake to the Athabasca River, approximately 25 km downstream. Calling Lake has a surface area of 138 km2, making it one of Alberta's larger lakes with a maximum depth of 18.3m in the center of the basin (Mitchell and Prepas 1990). Although this lake is moderately deep, it remains well mixed and shows only weak thermal stratification in the summer. Anoxic conditions can occur in the deeper water in both summer and winter, but there are no records of fish kills (Alberta Forestry, Lands and Wildlife n.d.). The most abundant phytoplankton species include *Rivularia* sp., *Stephanodiscus* sp. and an unidentified filamentous green alga (Miller and Macdonald 1949). Macrophytes and invertebrates have not been examined in this lake. The main sport fish are northern pike, yellow perch and walleye, and there is a small commercial fishery for whitefish.

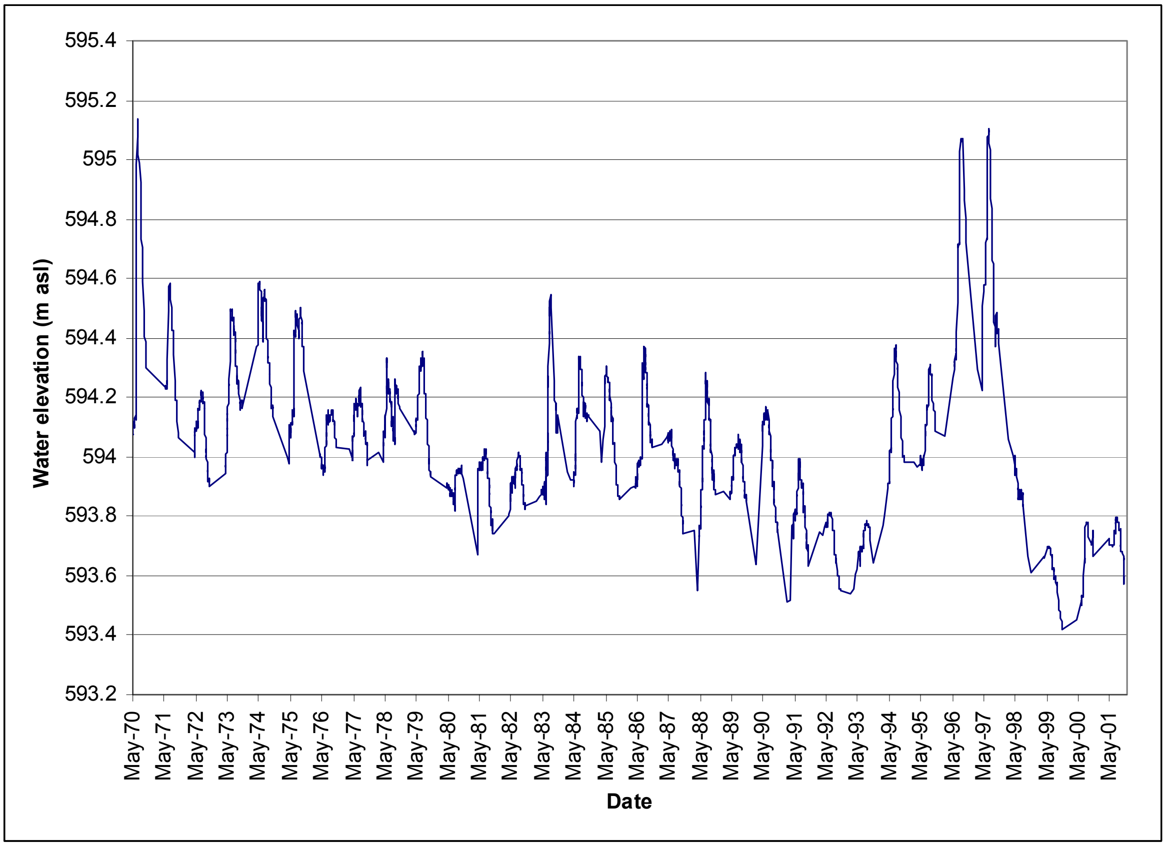
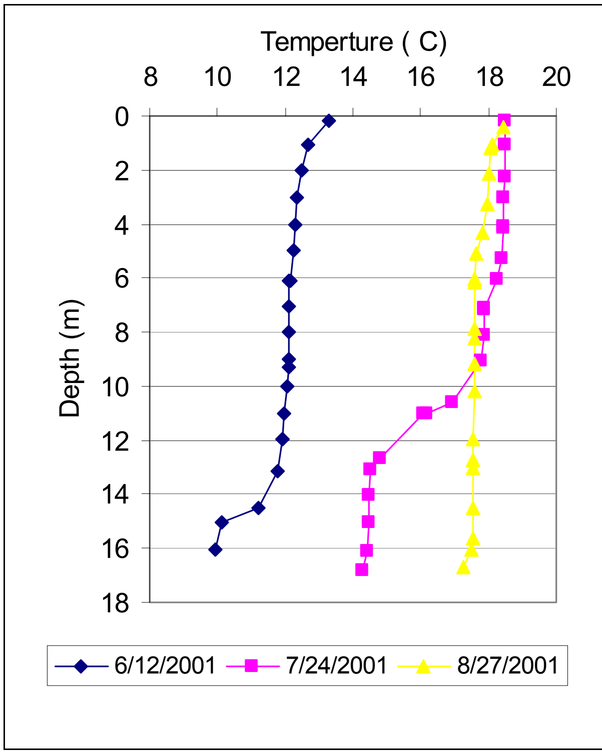
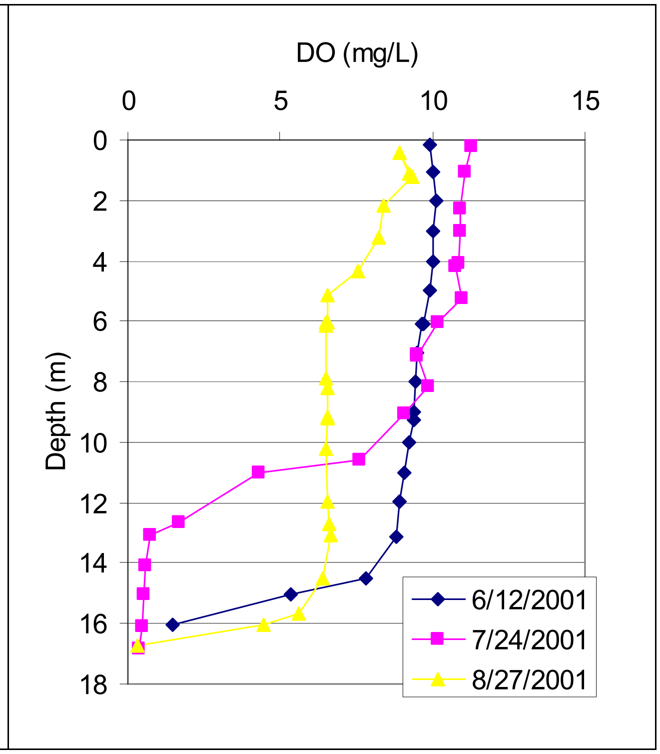


Fig. 2: Water levels in Calling Lake for the period of record from 1970 through 2001.

Water Levels

Water levels in Calling Lake fluctuate over a 0.2 to 0.6 m range within years (Fig. 2). These annual fluctuations are superimposed on the influence of climate trends occurring over the last three decades that brought water levels up to their maxima (1970, 1996, 1997) and their lowest (1999) that were 1.7 m apart. Fortunately, Calling Lake has a relatively steep littoral zone; changes in water level of a meter do not translate into large changes in surface area of the lake. Water levels rose in 2000 but declined in 2001. Data from 2002 are not available, but it is expected that these may also be low compared to the historic mean of 594.05 m.





Figs. 3 & 4: Temperature and dissolved oxygen profiles for Calling Lake for the summer 2001.

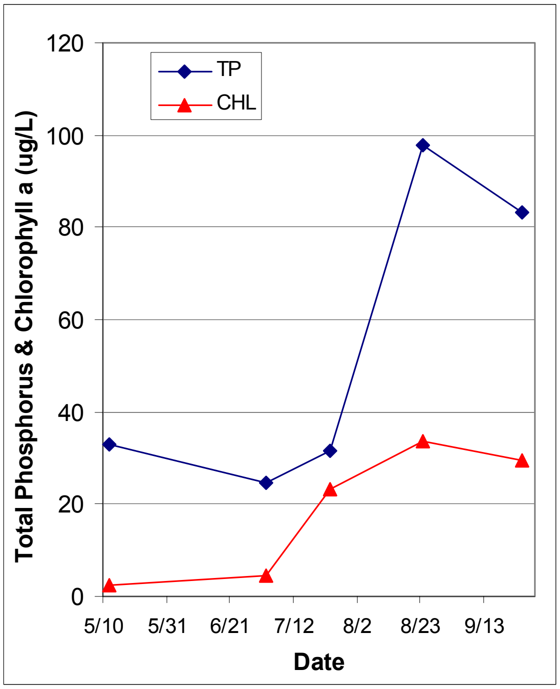
Results

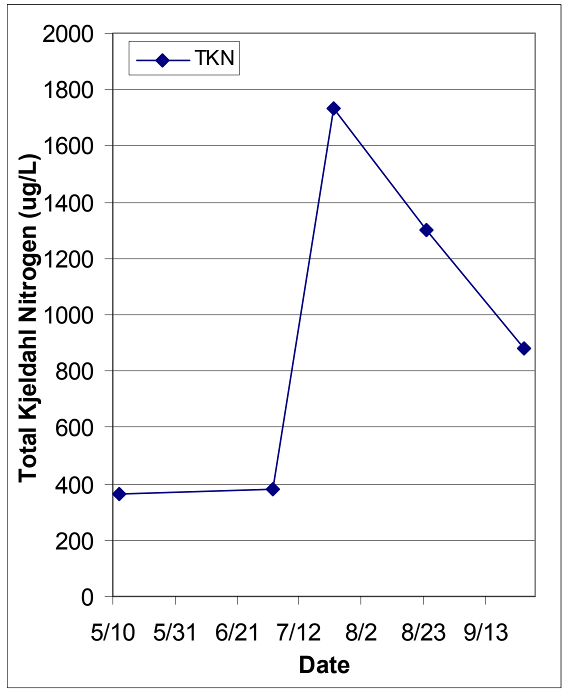
Water Temperature and Dissolved Oxygen

Calling Lake is considered dimictic, a term describing lakes that stratify and mix twice per year. During early spring, surface waters warm from 0° C and eventually reached the same temperature as deeper waters (around 4° C). This period of uniform temperature induces a spring mixing event often referred to as spring turnover. In mid June the lake was only stratified at the bottom 4 m of lake depth, meaning lake water could still mix through much of the water column. By late July, stratification was well developed at 10 m depth. The lake returned to isothermic conditions in August which would have allowed nutrient rich waters near the lake sediments to mix through the water column and stimulate algal growth. Dissolved oxygen concentrations declined below the 10 m thermocline in July and remained low through a majority of the water column following the breakdown of stratification in August (Fig. 4).

Water clarity and Secchi Depth

Water clarity is influenced by the suspended material, both living and dead, as well as some coloured dissolved compounds in the water column. The most widely used measure of lake water clarity is the Secchi depth. After ice and snowmelt a lake can have low clarity due to spring runoff and suspended sediments in the lake. Lake water usually clears in the late spring but then becomes less clear as algae grow through the summer. During mid June through early July, Calling lake had high transparency with Secchi depths of 3.5 m. As the summer progressed and algal growth increased, Secchi depth declined to 2.5 m in late July and continued to decline to 1.5 m in late August.





Figs. 5 & 6: Total phosphorus, chlorophyll *a* and Kjeldahl nitrogen for Calling Lake, summer 2001.

Table1: Mean values from summer 2001 samples compared to values from those reported in the Atlas of Alberta Lakes.

Parameter	1988	2000	2001
TP ($\mu g \bullet L^{-1}$)	50	55	54
TDP ($\mu g \bullet L^{-1}$)	19	15.7	18
Chl ($\mu g \bullet L^{-1}$)	19.1	20.6	19
Secchi (m)	2.7	2.7	2.7
TN ($\mu g \bullet L^{-1}$)	777	656	937
$NO_{2+3}N$ ($\mu g \bullet L^{-1}$)	<7	2.2	6
NH_4^+ N ($\mu g \bullet L^{-1}$)	33	14.2	31
Ca ($mg \bullet L^{-1}$)	22	22	23
Mg ($mg \bullet L^{-1}$)	6	6	6
Na ($mg \bullet L^{-1}$)	5	5	5
K ($mg \bullet L^{-1}$)	2	2	2
SO_4^{2-} ($mg \bullet L^{-1}$)	4	3.6	4
Cl^- ($mg \bullet L^{-1}$)	1	0.6	1
Total Alkalinity ($mg \bullet L^{-1}$ $CaCO_3$)	82	84	85
Conductivity (µS/cm)	168	173.3	170
Si (mg/L)	-	3.4	1
pH	7.4-8.5	8.6	9
Colour (mg/L Pt)	<14	12.15	10
TSS (mg/L)	-	5.0	6

Water chemistry

Calling Lake is eutrophic according to mean summer phosphorus, chlorophyll a and transparency criteria. Eutrophic lakes are common in Alberta and are distinguished by high algal growth and low water clarity. Occasionally, algal growth may reach nuisance levels and detract from recreational aesthetics of this lake. Total phosphorus concentrations averaged 54 $\mu g \bullet L^{-1}$, similar to values recorded in 1988 and 2000. Total phosphorus was at its highest during the late summer corresponding to peak algal growth (Fig. 5). The sharp increase in phosphorus was likely related to the loss of thermal stratification in August. The loss of stratification would have caused nutrient-rich water near the lake sediments to mix into the surface layer of lake water. Total nitrogen averaged 937 $\mu g \bullet L^{-1}$ and increasing sharply in July (Fig. 6). This contrasted with 2000 when nitrogen increased gradually through the summer. TN:TP ratios averaged 14 and only dropped below 10 in September.

Chlorophyll *a* concentrations were low during the spring and through to mid-July (Fig. 5), given the amount of phosphorus available during the same period. Algal growth accelerated by mid-July likely corresponding to warming of the lake, the development of a thermocline, and reduced vertical mixing of water. By mid-August algal growth produced a large quantity of chlorophyll. To residents, this would have appeared as a large decline in water quality as Calling Lake switched from mesotrophic to hypereutrophic over a three week period. While this change from clear to green water would have been dramatic it was within expected natural nutrient and chlorophyll parameters for the lake and does not necessarily represent recent pollution. Almost identical patterns were observed in 2000, except the peak in chlorophyll was even higher at 45 $\mu g \bullet L^{-1}$.

Major ion concentrations did not fluctuate appreciably through the summer but were low for a eutrophic lake. Mean values for calcium (23 $mg \bullet L^{-1}$), magnesium (6 $mg \bullet L^{-1}$), sodium (5 $mg \bullet L^{-1}$), and potassium (2 $mg \bullet L^{-1}$) were identical to those reported for 1988 in the Atlas of Alberta Lakes. Sulfate concentrations were low (4 $mg \bullet L^{-1}$) and consistent with concentrations of other ions. Total alkalinity, a measure of the ability for a lake to neutralize acidity, was 84 $mg \bullet L^{-1}$. The low, and relatively consistent, ion concentrations prevailing over the last two decades are reassuring that development pressures have not influenced local hydrology.

A brief introduction to Limnology

Indicators of water quality

Water samples are collected in Lakewatch to determine the chemical characteristics that characterize general water quality. Though not all encompassing, the variables collected in Lakewatch are sensitive to human activities in watersheds that can cause degraded water quality. For example, nutrients such as phosphorus and nitrogen are important determinants of lake productivity. The concentrations of these nutrients in a lake are impacted (typically elevated) by land use changes such as increased crop production or livestock grazing. Elevated nutrient concentrations can cause increases in undesirable algae blooms resulting in low dissolved oxygen concentrations, degraded habitat for fish and noxious smells. A large increase in nutrients over time may also indicate sewage inputs which in turn may result in other human health concerns associated with bacteria or the protozoan *Cryptosporidium*.

Temperature and mixing

Water temperature in a lake dictates the behavior of many chemical parameters responsible for water quality. Heat is transferred to a lake at its surface and slowly moves downward depending on water circulation in the lake. Lakes with a large surface area or a small volume tend to have greater mixing due to wind. In deeper lakes, circulation is not strong enough to move warm water to depths typically greater than 4 or 5 m and as a result cooler denser water remains at the bottom of the lake. As the difference in temperature between warm surface and cold deeper water increases, two distinct layers are formed. Limnologists call these layers of water the **epilimnion** at the surface and the **hypolimnion** at the bottom. The layers are separated by a transition layer known as the **metalimnion** which contains the effective wall separating top and bottom waters called a **thermocline**. A thermocline typically occurs when water temperature changes by more than one degree within one meter depth. The hypolimnion and epilimnion do not mix, nor do elements such as oxygen supplied at the surface move downward into the hypolimnion. In the fall, surface waters begin to cool and eventually reach the same temperature as hypolimnetic water. At this point the water mixes from top to bottom in what is often called a **turnover** event. Surface water cools further as ice forms and again a thermocline develops this time with 4° C water at the bottom and near 0° C water on the top.

In spring another turnover event occurs when surface waters warm to 4° C. Lakes with this mixing pattern of two stratification periods and two turnover events are called **dimictic** lakes. In shallower lakes, the water column may mix from top to bottom most of the ice-free season with occasional stratification during periods of calm warm conditions. Lakes that mix frequently are termed **polymictic** lakes. In our cold climate, many shallow lakes are **cold monomictic** meaning a thermocline develops every winter, there is one turnover event in spring but the remainder of the ice free season the lake is polymictic.

Dissolved Oxygen

Oxygen enters a lake at the lake surface and throughout the water column when produced by photosynthesizing plants, including algae, in the lake. Oxygen is consumed within the lake by respiration of living organisms and decomposition of organic material in the lake sediments. In lakes that stratify (see temperature above), oxygen that dissolves into the lake at the surface cannot mix downward into the hypolimnion. At the same time oxygen is depleted in the hypolimnion by decomposition. The result is that the hypolimnion of a lake can become **anoxic**, meaning it contains little or no dissolved oxygen. When a lake is frozen, the entire water column can become anoxic because the surface is sealed off from the atmosphere. Winter anoxic conditions can result in a fish-kill which is particularly common during harsh winters with extended ice-cover. Alberta Surface Water Quality Guidelines suggest dissolved oxygen concentrations (in the epilimnion) must not decline below 5 $mg \bullet L^{-1}$ and should not average less than 6.5 $mg \bullet L^{-1}$ over a seven-day period. However, the guidelines also require that dissolved oxygen concentrations remain above 9.5 $mg \bullet L^{-1}$ in areas where early life stages of aquatic biota, particularly fish, are present.

General Water Chemistry

Water in lakes always contains substances that have been transported by rain and snow or have entered the lake in groundwater and inflow streams. These substances may be dissolved in the water or suspended as particles. Some of these substances are familiar minerals, such as sodium and chloride, which when combined form table salt, but when dissolved in water separate into the two electrically charged components called **ions**. Most dissolved substances in water are in ionic forms and are held in solution due to the polar nature of the water molecule. **Hydrophobic** (water-fearing) compounds such as oils contain little or no ionic character, are non-polar and for this reason do not readily dissolve in water. Although hydrophobic compounds do not readily dissolve, they can still be transported to lakes by flowing water. Within individual lakes, ion concentrations vary from year to year depending on the amount and mineral content of the water entering the lake. This mineral content can be influenced by the amount of precipitation and other climate variables as well as human activities such as fertilizer and road salt application.

Phosphorus and Nitrogen

Phosphorus and nitrogen are important nutrients limiting the growth of algae in Alberta lakes. While nitrogen usually limits agricultural plants, phosphorus is usually in shortest supply in lakes. Even a slight increase of phosphorus in a lake can, given the right conditions, promote algal blooms causing the water to turn green in the summer and impair recreational uses. When pollution originating from livestock manure and human sewage enters lakes not only are the concentrations of phosphorus and nitrogen increased but nitrogen can become a limiting nutrient which is thought to cause blooms of toxic algae belonging to the cyanobacteria. Not all cyanobacteria are toxic, however, the blooms can form decomposing mats that smell and impair dissolved oxygen concentrations in the lake.

Chlorophyll a

Chlorophyll *a* is a photosynthetic pigment that green plants, including algae, possess enabling them to convert the sun's energy to living material. Chlorophyll *a* can be easily extracted from algae in the laboratory. Consequently, chlorophyll *a* is a good estimate of the amount of algae in the water. Some highly productive lakes are dominated by larger aquatic plants rather than suspended algae. In these lakes, chlorophyll *a* and nutrient values taken from water samples do not include productivity from large aquatic plants. The result, in lakes like Chestermere which are dominated by larger plants known as macrophytes, can be a lower trophic state than if macrophyte biomass was included. Unfortunately, the productivity and nutrient cycling contributions of macrophytes are difficult to sample accurately and are therefore not typically included in trophic state indices.

Secchi Disk Transparency

Lakes that are clear are more attractive for recreation, whereas those that are turbid or murky are considered by lake users to have poor water quality. A measure of the transparency or clarity of the water is performed with a Secchi disk with an alternating black and white pattern. To measure the clarity of the water, the Secchi disk is lowered down into the water column and the depth where the disk disappears is recorded. The Secchi depth in lakes with a lot of algal growth will be small while the Secchi depth in lakes with little algal growth can be very deep. However, low Secchi depths are not caused by algal growth alone. High concentrations of suspended sediments, particularly fine clays or glacial till, are common in plains or mountain reservoirs of Alberta. Mountain reservoirs may have exceedingly low Secchi depths despite low algal growth and nutrient concentrations.

The euphotic zone or the maximum depth that light can penetrate into the water column for actively growing plants is calculated as twice the Secchi depth. Murky waters, with shallow Secchi depths, can prevent aquatic plants from growing on the lake bottom. Conversely, aquatic plants can ensure lakes have clear water by reducing shoreline erosion and stabilizing lake bottom sediments. In Alberta, many lakes are shallow and bottom sediments contain high concentrations of nutrients. Without aquatic plants, water quality may decline in these lakes due to murky, sediment laden water and excessive algal blooms. Maintaining aquatic plants in certain areas of a lake is often essential for ensuring good water clarity and a healthy lake as many organisms, like aquatic invertebrates and insects, depend on aquatic plants for food and shelter.

Trophic state

Trophic state is classification of lakes into four categories of fertility and is a useful index for rating and comparing lakes. From low to high nutrient and algal biomass (as chlorophyll) concentrations, the trophic states are; **oligotrophic**, **mesotrophic**, **eutrophic** and **hypereutrophic**. A majority of lakes in Alberta contain naturally high levels of chlorophyll *a* (8 to 25 µg/L) due to our deep fertile soils. These lakes are usually considered fertile and are termed eutrophic. The nutrient and algal biomass concentrations that define these categories are shown in the following table, a figure of Alberta lakes compared by trophic state can be found on the ALMS website.

Trophic status classification based on lake water characteristics.

Trophic state	Total Phosphorus ($\mu g \bullet L^{-1}$)	Total Nitrogen ($\mu g \bullet L^{-1}$)	Chlorophyll a ($\mu g \bullet L^{-1}$)	Secchi Depth (m)
Oligotrophic	< 10	< 350	< 3.5	> 4
Mesotrophic	10 - 30	350 - 650	3.5 - 9	4 - 2
Eutrophic	30 - 100	650 - 1200	9 - 25	2 - 1
Hypereutrophic	> 100	> 1200	> 25	< 1

Note: These values are from a detailed study of global lakes reported in Nurnberg 1996. Alberta Environment uses slightly different values for TP and CHL based on those of the OECD reported by Vollenweider (1982). The AENV and OECD cutoffs for TP are 10, 35 and 100; for CHL are 3, 8 and 25. AENV does not have TN or Secchi depth criteria. The corresponding OECD exists for Secchi depth and the cutoffs are 6, 3 and 1.5 m.

References

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