Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Mink Lake

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2004 Report

Completed with support from:

Alberta Lake Management Society

LICA Lakeland Industry & Community Association

Alberta Environment

Alberta Lake Management Society's Lakewatch Program

Lakewatch has several important objectives, one of which is to collect and interpret water quality on Alberta Lakes. Equally important is educating lake users about their aquatic environment, encouraging public involvement in lake management, and facilitating cooperation and partnerships between government, industry, the scientific community and lake users. 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. Additional information is available for many lakes that have been included in Lakewatch and readers requiring more information are encouraged to seek these sources.

ALMS would like to thank all who express interest in Alberta's aquatic environments and particularly those who have participated in the Lakewatch program. These people prove that ecological apathy can be overcome, and give us hope that our water resources will not be the limiting factor in the health of our environment.

Acknowledgments

The Lakewatch program is made possible through the Lakewatch Chairs, Théo Charette, Ron Zurawell and Preston MacEachern, and the individual volunteers who dedicate their personal time. The 2004 summer field technician Heather Jones was a valuable and hard-working addition to the program. Numerous Alberta Environment staff also contributed to successful completion of the program. Shelley Manchur was the Technical Program Coordinator, responsible for planning and organizing the field program. Technologists Mike Bilyk, Brian Jackson and John Willis were involved in the logistics and training aspects. Doreen LeClair was responsible for data management. Théo Charette (ALMS President) was responsible for program administration and planning. ALMS gratefully acknowledges Alberta Environment, the Lakeland Industry and Community Association (LICA) and Lakeland County for their financial support of the Lakewatch program.

Mink Lake

Mink Lake is a small water body located approximately 12 km west of Stony Plain on Highway 29 in the North Saskatchewan River Basin. The Mink Lake Resort is located at the south end of the lake - except for two road easements all remaining land around the lake is privately owned, with the main land use being agricultural. Access is via a private road at the south end.

The lake is located in rolling land that typifies the low boreal mixedwood ecoregion (Table 1). With no permanent inlet or outlet, water levels are primarily influenced by surface runoff, precipitation and groundwater inputs. Much of the overstory along the south and west shores has been cleared for agricultural purposes, and vegetation is absent where a railbed right-of-way abuts the lakeshore to the north. The lake itself is divided into two main basins: a larger one to the south topped by a smaller north basin. A 1987 fisheries inventory found primarily Northern pike, and to a lesser extent yellow perch as well as brook stickleback and Iowa darter (R.L.and L. Environmental, 1987). The same survey noted that the littoral zone makes up over 46% of the lakebed with an average depth of less than 3.1 m (Figure 1, Table 2). Vegetation

Table 1. Summary of details describing the low boreal mixedwood in which Mink Lake is situated (adapted from Strong and Leggat, 1992).

Low Boreal Mixedwood Characteristics*		
Vegetation	Aspen, succeeding to White Spruce	
Summer	Average Temp.	13.8 C^0
	Average Min. Temp.	7 C^0
	Average Max. Temp.	20.4 C^0
	Month of Max. Precip.	July
	Total Summer Precip. (mm)	235.0
Winter	Average Temp.	-10.5
	Average Min. Temp.	-15.8
	Average Max. Temp.	-5.3
	Total Winter Precip. (mm)	61.0
Total Annual Precipitation (mm)		**380.0**

*precipitation numbers are median values

Table 2. Physical characteristics of Mink Lake (www.anglersatlas.com).

Lake surface area	0.72 km^2
Drainage basin	n/a
Mean depth	3.3 m
Maximum depth	approx. 8.5 m

throughout the lake is extensive and includes both emergent and submergent varieties.

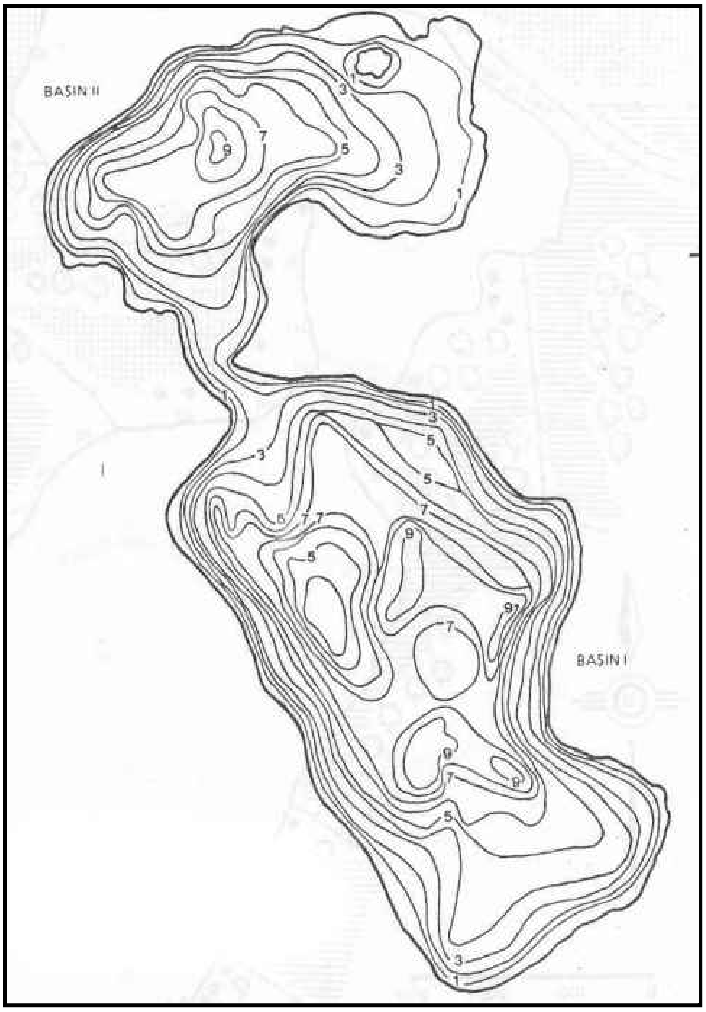

Figure 1. Bathymetric map of Mink Lake. Alberta Environment Historical Library.

Other than the fish inventory and a single sampling event in 1983, Mink Lake has not been studied until Lakewatch monitoring in 2004. During the fish inventory, some basic water chemistry was collected. It was noted that nutrient levels were high for both nitrogen and phosphorus and that the lake was saline and considered eutrophic (R.L. and L Environmental, 1987).

Methods

Lakes monitored under the Alberta Lake Management Society's Lakewatch program are all monitored using standard Alberta Environment procedures: composite samples are collected from numerous sites around the lake and water is profiled at the deep water spot in each lake once per month through the warmer months. This usually results in 4 sampling trips per open-water season. On each trip, the deep-water profiles include measurements for temperature and dissolved oxygen recorded from lake surface to lake bottom, as well as maximum depth. A Secchi depth is also measured, from which the range of the euphotic zone is estimated. Once the euphotic zone depth is known, the composite samples are collected for lab analyses. After the water has been analyzed, results are examined for trends and summarized.

Water Levels

Water levels on Mink Lake have been monitored from 1968 to present (Figure 2). Over this period, the lake's surface has ranged from a high of 736.745 m above sea level (asl) on July 12, 1983, to a low of 735.412 m asl on October 5, 1970. The average water level during this time was 736.205 m asl. At the lake's deepest point, this translates into a depth range of about 8.5 to 9 m, with an average depth closest to 8.5 m most often. Without a permanent inflow, this lake is very susceptible to evaporative water loss during dry periods.

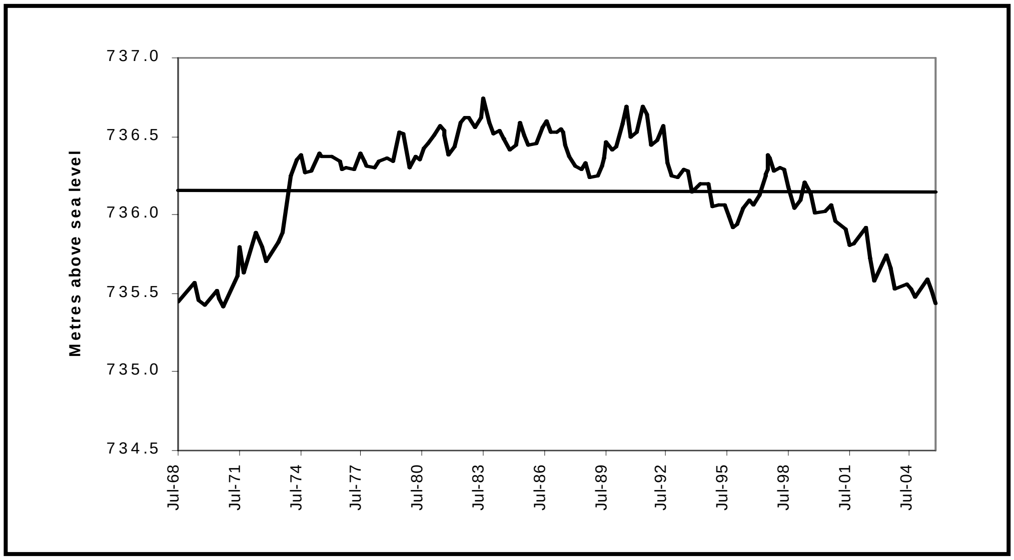

Figure 2. Historical water levels for Mink Lake. Alberta Environment data.

Temperature and Dissolved Oxygen Profiles

Temperature-wise Mink Lake would be good for swimming although the aquatic plant life might get in the way. The lake's shallowness and exposure to wind result in the water column remaining fairly mixed throughout the summer. This is reflected in the temperature profiles (Figure 3) which have only gradual slopes downwards instead of steep drops. Although wind action can contribute oxygen to open water, in this lake the dissolved oxygen (DO) profiles imply a greater effect from algae. The DO numbers are at the low end of a normal range at the start of the summer, which is expected since warm water holds less oxygen than cold. By early August, even though the lake water is almost 5 degrees warmer at the surface, there is even more dissolved oxygen present.

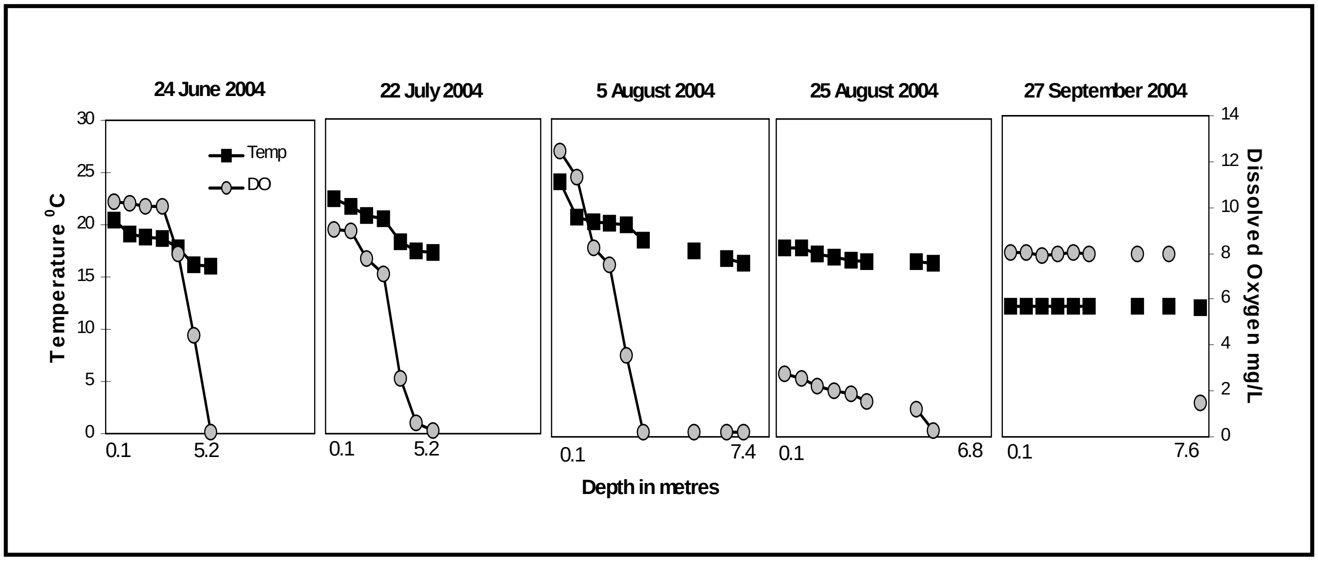

Figure 4. Temperature and dissolved oxygen profiles of Mink Lake for summer 2004. Alberta Environment data.

This suggests that a sizeable algal bloom is enhancing DO levels. By the end of August, levels have dropped greatly, indicating that the bloom has crashed and oxygen is being consumed from the water column by bacteria busily decomposing dead cells. In September the water has cooled, mixed, and the dissolved oxygen levels have begun to recover.

Water Clarity

Mink Lake is very productive and during peak blooms is easily hypereutrophic (Figure 4). Summer 2004 produced a large bloom, during which water clarity dropped dramatically to less than 1 m visibility in the water column (Figure 5). Although levels for both phosphorus and nitrogen were high, it is the nitrogen numbers that the chlorophyll *a*

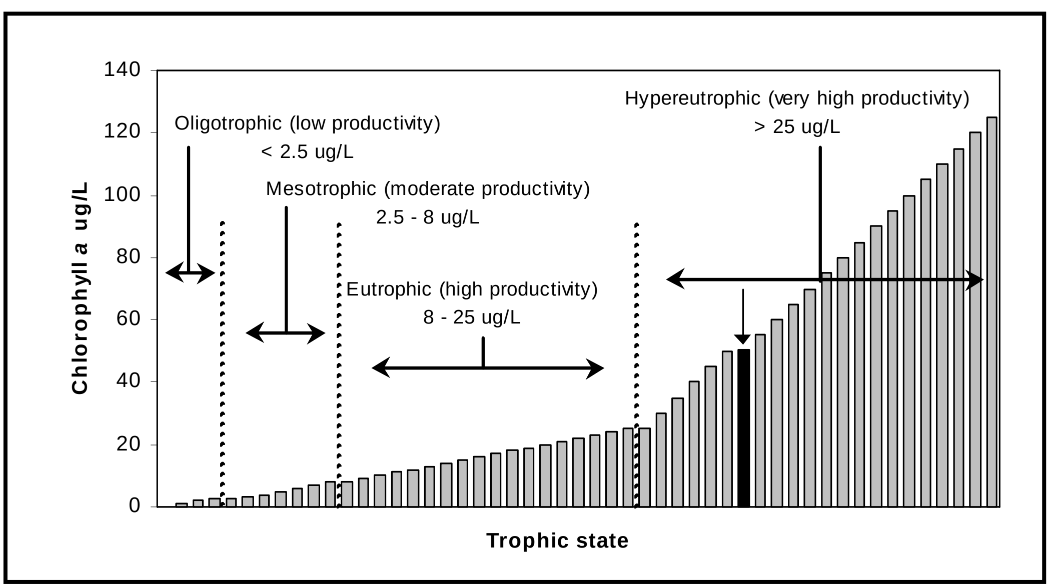

Figure 4. The black bar below the down arrow represents average chlorophyll *a* concentration for Mink Lake from summer 2004. Adapted from Mitchell, 1994.

numbers seem to follow closest (Figure 6). This suggests that the bloom that formed in mid-summer may have been cyanobacteria for the greater part as opposed to algae. This is of note to lake users as cyanobacteria can occasionally produce toxins that are released into the water when their cells die. It is unclear when and why toxins will be produced in a bloom or how to predict an occurrence – water can only be tested for their presence after the fact. Lake water should not be consumed by small children or pets during or after heavy blooms as a matter of precaution.

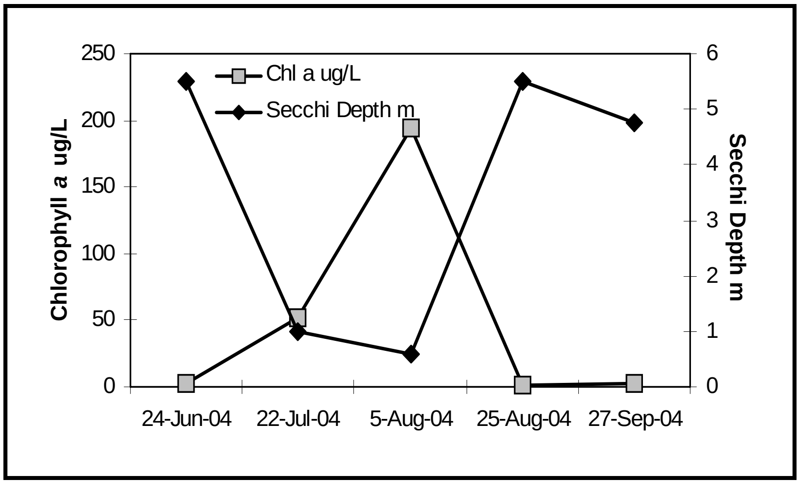

Figure 5. Lakewatch data from summer 2005. A heavy bloom, measured as chlorophyll *a* concentrations, created a drastic decrease in water clarity, measured as Secchi depth.

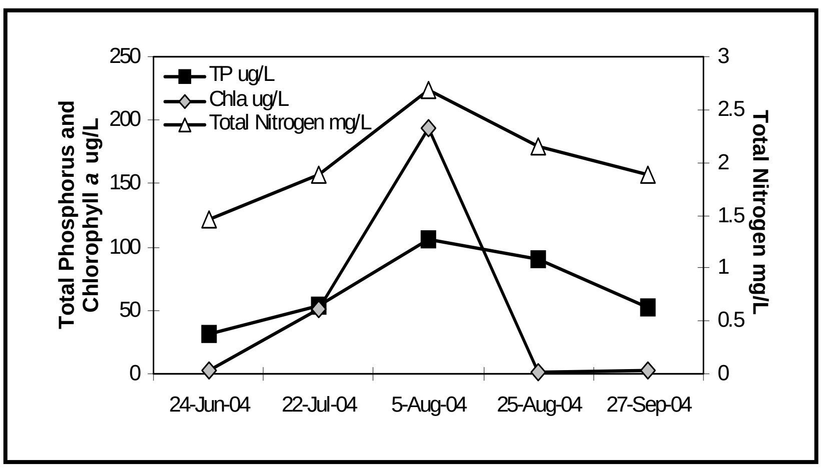

Figure 6. Numbers suggest that plenty of nutrients fueled a dramatic bloom in Mink Lake for summer 2004.

Water Chemistry

Unfortunately, the single sampling effort that preceded Lakewatch 2004 efforts was not as detailed, so historical comparisons are limited. The 2004 values do agree with written material from the 1987 fisheries inventory – Mink lake is still very productive and still has a total dissolved solids level that places it in the moderately saline range (Table 3). The water in Mink Lake has a fairly low alkalinity but is also very hard, reflected by the very high values for calcium and magnesium (Table 3). In Alberta lakes, alkalinity and hardness usually parallel one another. In the case of Mink Lake, the alkalinity is moderately low probably because of extremely high sulphate levels, which in this instance are also contributing to the high levels of hardness. Mink Lake thus has the dubious distinction of having low alkalinity relative to very high hardness values.

Table 3. Mink Lake cation concentrations place the lake in the moderately saline range. Adpated from Atlas of Alberta Lakes.

Salinity Range	**Average Cation Concentrations mg/L**			
(based on Total Dissolved Solids mg/L)	Sodium	Potassium	Calcium	Magnesium
Low salinity (<500)	20	5	29	15
Slightly saline (500-1000)	113	29	31	59
Moderately saline (1000-5000)	379	34	21	46
Mink Lake (1326.7)	**46.0**	**33.4**	**124.3**	**144.7**

Salinity has increased dramatically from the sample taken in 1983 relative to the Lakewatch 2004 values. This is very likely due to the lake's lack of a permanent inflow - any decrease in precipitation will affect the lake much more so in comparison to lakes with established inlets. This is also the probable cause of the high zinc levels noted in Appendix II.

Results for other water quality measurements averaged from 2004 are summarized in Appendices I and II, as well as historical values where available.

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Appendix 1. Summary of historical and summer 2005 averages for various water quality parameters. 1983 represents a single sampling effort. Where L occurs next to a value it means 'less than'.

Parameter	**1983**	**2004**
Total Phosphorus ug/L	146	66.8
Total Dissolved Phosphorus ug/L		34.4
Total Dissolved Solids mg/L	148	1326.7
Chlorophyll a ug/L		50.46
Secchi depth m		3.47
Total Nitrogen mg/L	2.70	2.01
Nitrate + Nitrite mg/L	L0.05	0.029
Ammonium mg/L	0.024	0.326
Calcium mg/L	38	124.3
Magnesium mg/L	9	144.7
Sodium mg/L	3	46.0
Potassium mg/L	2.4	33.4
Sulphate mg/L	15	909
Chloride mg/L	L1	9.8
Alkalinity mg/L as $CaCO_3$	132	102
Carbonate mg/L		5
Bicarbonate mg/L	161	121
pH	7.3	8.17
Conductivity uS/cm	293	1716.67

Appendix II. Summary of metals, non-metals and metallic elements analyses. Where L occurs next to a value it means 'less than'.

Parameter	**1983**	**2004**	**Guideline Values**
Aluminum ug/L		16.1	100
Antimony ug/L		0.2115	6 [1]
Arsenic ug/L		3.7	5
Barium ug/L		37.9	1000 [1]
Beryllium ug/L		L0.003	100
Bismuth ug/L		0.0022	
Boron ug/L		198	5000 [1]
Cadmium ug/L		L.002	0.085
Chlorine mg/L		10.03	
Chromium ug/L		0.34	
Cobalt ug/L		0.06	1000 [2]
Copper ug/L	0.11	2.11	4
Fluoride mg/L	1.81	0.34	1.5
Iron mg/L		0.023	300
Lead ug/L		0.0374	7
Lithium ug/L		182	2500 [3]
Manganese mg/L		265	200 [3]
Mercury ug/L		0.1385	
Nickel ug/L		L0.005	150
Selenium ug/L		L0.1	1
Silver ug/L		0.0019	0.1
Strontium ug/L		1320	
Thallium ug/L		0.062	0.8
Thorium ug/L		0.0168	
Tin ug/L		0.031	
Titanium ug/L		1.105	
Uranium ug/L		0.2495	100 [1]
Vanadium ug/L		0.3315	100 [2]
Zinc ug/L		**8.29**	1.5

[1]Canadian Drinking Water Quality guideline value
[2]Canadian Guideline for Agricultural Use (Livestock watering)
[3]Canadian Guideline for Agricultural Use (Irrigation)

A brief introduction to Limnology

Indicators of water quality

Water samples are collected in Lakewatch to determine the water quality of lakes. 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

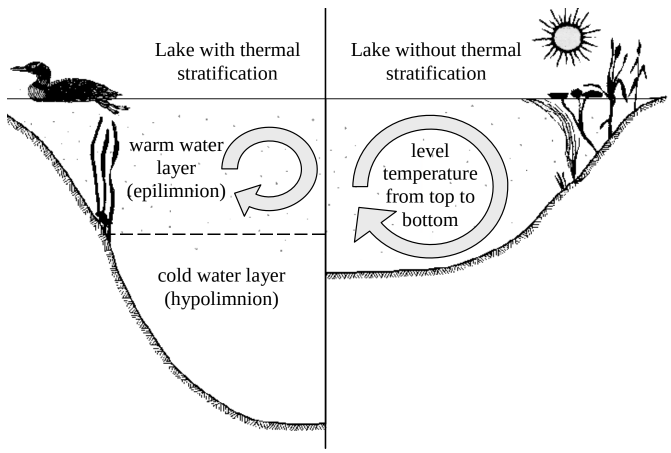

Fig. 1: Difference in the circulation of the water column depending on thermal stratification.

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 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 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/L and should not average less than 6.5 mg/L over a seven-day period. However, the guidelines also require that dissolved oxygen concentrations remain above 9.5 mg/L 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, known as macrophytes, rather than suspended algae. In these lakes, chlorophyll *a* and nutrient values taken from water samples do not include productivity from large aquatic plants. As a result, lakes like Chestermere which are dominated by macrophytes can be at 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 Depth

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. Secchi disk depth is the oldest, simplest, and quickest quantitative measure of water clarity. A Secchi disk is a black and white disk that is lowered down through the water column until it can no longer be seen. Secchi disk depth is the midpoint between the depth at which it disappears when lowered and reappears when it is pulled up again. The Secchi disk depth in lakes with high algal biomass will generally be shallow. However, Secchi disk depth is not only affected by algae. 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 shallow Secchi disk depths despite low algal growth and nutrient concentrations.

The euphotic zone, calculated as twice the Secchi disk depth, is the portion of the water column that has sufficient light for aquatic plants to grow. Murky waters, with shallow Secchi depths, can prevent aquatic plants from growing on the lake bottom. Aquatic plants are important because they ensure clear lake water by reducing shoreline erosion and stabilizing lake bottom sediments. Many lakes in Alberta are shallow and have bottom sediments with 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 fish, depend on aquatic plants for food and shelter.

Trophic state

Trophic state is a classification system for lakes that depends on 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**. 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. A majority of lakes in Alberta are meso- to eutrophic because they naturally contain high nutrient concentrations due to our deep fertile soils. Thus, lakes in Alberta are susceptible to human impacts because they are already nutrient-rich; any further nutrient increases can bring about undesirable conditions illustrated in Fig 2.

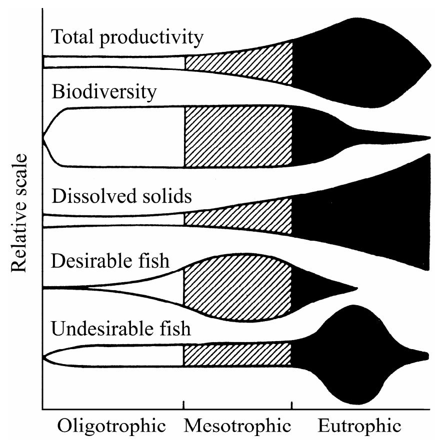

Fig. 2: Suggested changes in various lake characteristics with eutrophication. From “Ecological Effects of Wastewater”, 1980

Trophic status based on lake water characteristics.

Trophic state	Total Phosphorus (µg/L)	Total Nitrogen (µg/L)	Chlorophyll a (µg/L)	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.

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