Lakewatch

THE ALBERTA LAKE MANAGEMENT SOCIETY
VOLUNTEER LAKE MONITORING PROGRAM

2011 Jackfish Lake Report

COMPLETED WITH SUPPORT FROM:

Alberta Government

Alberta Lake Management Society's LakeWatch Program

LakeWatch has several important objectives, one of which is to collect and interpret water quality data 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 those 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.

Acknowledgements

The LakeWatch program is made possible through the dedication of its volunteers. We would like to thank Steve Zelych for his assistance with sampling and arranging volunteers for each of our sampling trips. We would also like to thank Jessica Davis and Pauline Pozsonyi who were summer interns with ALMS in 2011. Program Coordinator Bradley Peter was instrumental in planning and organizing the field program. Technologists Shelley Manchur and Brian Jackson were involved in the training aspects of the program. Doreen LeClair, Chris Rickard, and Lisa Reinbolt were responsible for data management. The 2012 report was prepared by Bradley Peter and Arin Dyer. Alberta Environment, the Beaver River Watershed Alliance (BRWA), and the Municipal District of Wainwright were major sponsors of the LakeWatch program.

JACKFISH LAKE:

Jackfish Lake, likely named so for northern pike which were the target of a sport fishery, is a popular recreational lake in the North Saskatchewan River Basin in the County of Parkland[1]. Approximately 60 km west of the city of Edmonton, Jackfish Lake is small, with a surface area of only 2.39 km^2, and shallow, with a maximum depth of nine meters (Figure 1)[1]. However, due to its irregular shape, the lake has a long, highly developed shoreline of 18.1 km. The drainage basin for Jackfish Lake is small compared to the size of the lake, approximately 12.6 km^2, or five times the size of the lake, and lies in the Moist Mixedwood Subregion of the Boreal Mixedwood Ecoregion[2]. Due to its proximity to both Edmonton and Spruce Grove, Jackfish Lake is heavily used for boating, fishing, and water skiing.

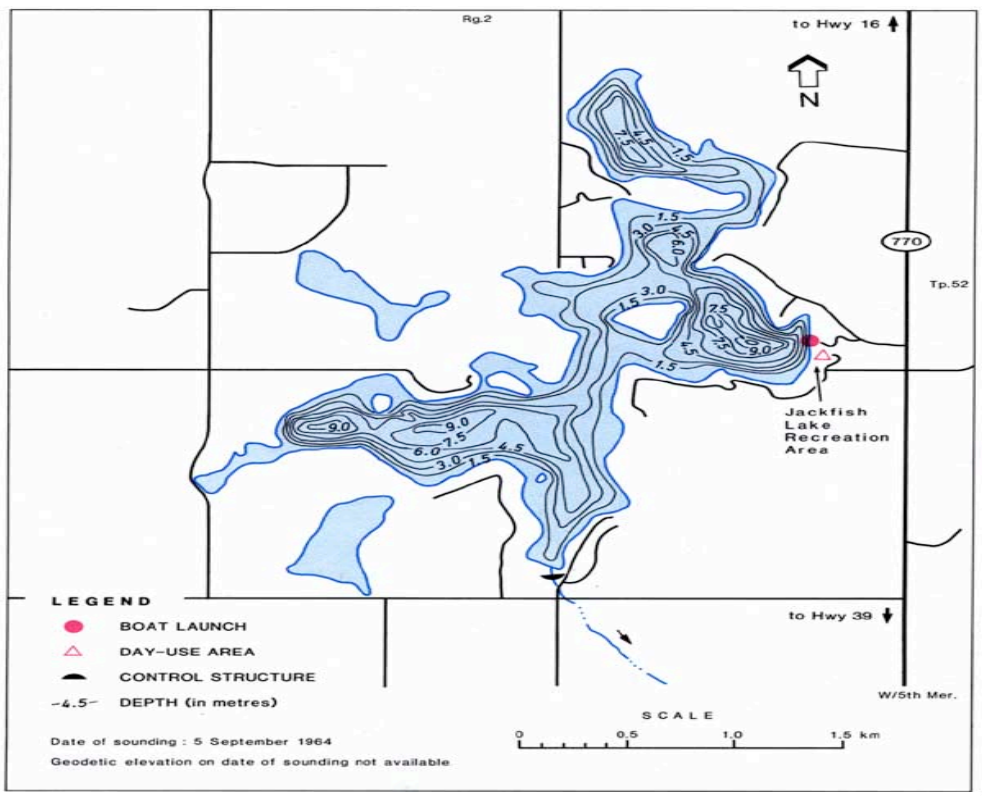

Figure 1 – Bathymetric map of Jackfish Lake measured in 1964. Source: Alberta Environment.

[1] Mithcell, P. and E. Prepas. 1990. Atlas of Alberta Lakes, University of Alberta Press. Retrieved from http://sunsite.ualberta.ca/projects/alberta-lakes/

[2] Strong, W.L. and K.R. Leggat. 1981. Ecoregions of Alberta. Alta. En. Nat. Resour., Resour. Eval. Plan. Div., Edmonton.

WATER LEVELS:

There are many factors influencing water quantity. Some of these factors include the size of the lakes drainage basin, precipitation, evaporation, water consumption, ground water influences, and the efficiency of the outlet channel structure at removing water from the lake.

Water levels at Jackfish Lake have been recorded since 1968 (Figure 2). From 1968 until 1983, water levels have shown an increasing trend, reaching a historical maximum of 730.132 meters above sea level (m asl) in 1983. Concern over rising water levels during the 70's prompted Parkland County to re-establish an outflow, which included the construction of a weir designed to allow output above levels of 729.72 m asl. However, since 1983, water levels have shown a declining trend, reaching a historical minimum of 728.44 m asl in October of 2010. With no permanent streams flowing into the lake, run-off and groundwater are important factors affecting Jackfish Lake's water quantity.

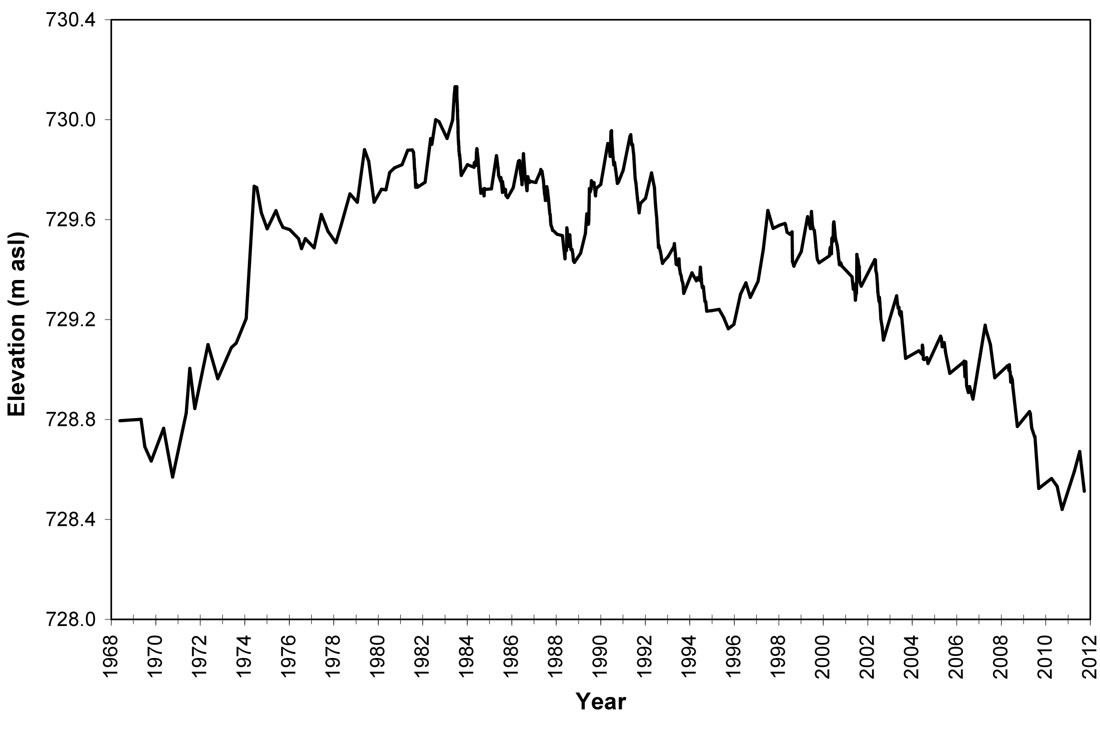

Figure 2 – Water levels from 1968-2011 for Jackfish Lake measured in meters above sea level (m asl). Data obtained from Alberta Environment.

WATER CLARITY & SECCHI DEPTH:

Water clarity is influenced by suspended materials, both living and dead, as well as dissolved colored compounds in the water column. During the melting of snow and ice in spring, lake water can become turbid (cloudy) from silt transported into the lake. Lake water usually clears in late spring but then becomes more turbid with increased algal *growth as the summer progresses. The easiest and most widely used measure of lake water clarity is the Secchi disk depth.*

Average Secchi disk depth was 2.16 m during the summer of 2011 (Table 1). Secchi disk depth was measured five times throughout the course of the summer, measuring a maximum of 3.50 m on June 28th and a minimum of 1.25 m on August 26th. Deeper Secchi disk depths are common early in the season as algal blooms have not yet become dense enough to impair water clarity. The 2011 average is slightly lower than the historical average of 2.48 m obtained from years 1980, 1981, 2001, and 2007.

WATER TEMPERATURE AND DISSOLVED OXYGEN:

Water temperature and dissolved oxygen profiles in the water column can provide information on water quality and fish habitat. The depth of the thermocline is important in determining the depth to which dissolved oxygen from the surface can be mixed. Please refer to the end of this report for descriptions of technical terms.

Water temperature at Jackfish Lake remained relatively uniform with depth throughout the summer (Figure 3a). At the surface, water temperature ranged from 19.04 °C on June 28th to 21.56 °C on August 12th. At the lakebed, water temperature ranged between 16.47 °C on June 28th and 17.49 °C on August 26th. Weak stratification was observed from June-August, as a narrow thermocline was present near the bottom of the lake. The presence of a thermocline is an important factor in the development anoxia near the lakebed, though the pattern of the thermocline seen at Jackfish Lake is the typical pattern expected in a dimictic lake.

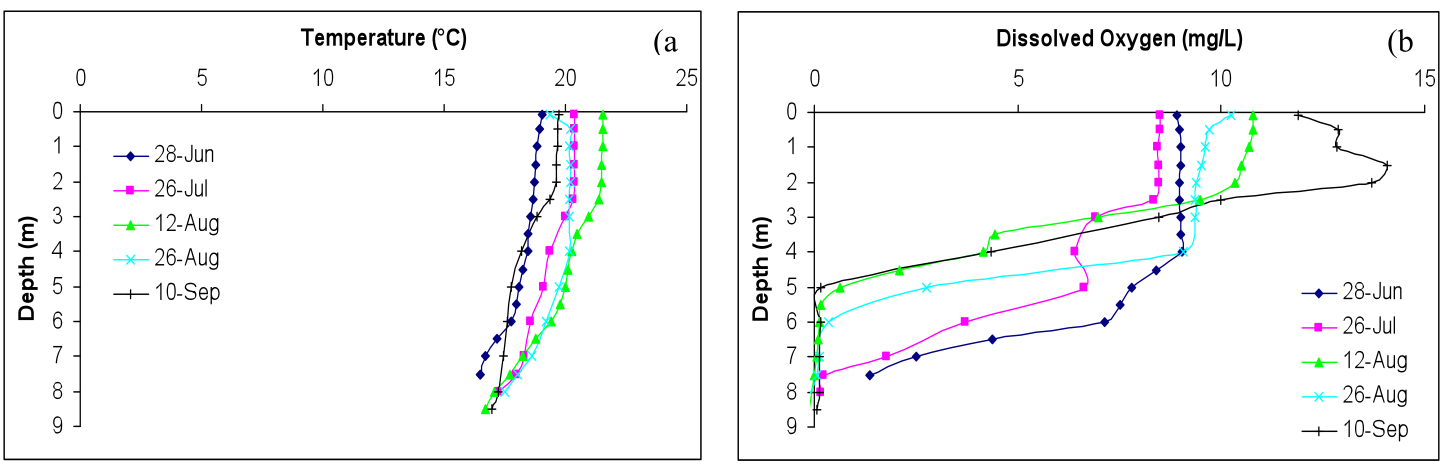

Figure 3. a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for Jackfish Lake in 2011.

At the surface, Jackfish Lake was well oxygenated, with measurements ranging between 8.50 mg/L to 11.88 mg/L (Figure 3b). Algae, which photosynthesize during the day, tend to elevate surface dissolved oxygen throughout the summer. However, when these blooms sink and decompose, oxygen is consumed near the lakebed. This is evident at

Jackfish Lake, as oxygen depletion was rapid through the water column, often reaching anoxia at ~5.0 m. The Canadian Council for Ministers of the Environment recommends 6.5 mg/L of dissolved oxygen for the Protection of Aquatic Life. The pattern of dissolved oxygen depletion seen in 2012 is extremely similar to the profiles collected by ALMS in 2001.

WATER CHEMISTRY:

ALMS measures a suite of water chemistry parameters. Phosphorous, nitrogen, and chlorophyll-a are important because they are indicators of eutrophication, or excess nutrients, which can lead to harmful algal/cyanobacteria blooms. One direct measure of harmful cyanobacteria blooms are Microcystins, a common group of toxins produced by cyanobacteria. See Table 1 for a complete list of parameters.

Based on average Total Phosphorous measured in 2011 (44.4 μg/L), Jackfish Lake is classified as eutrophic, or nutrient rich (Table 1). Total phosphorous fluctuated greatly throughout the summer, ranging from 22 μg/L on June 28th to 62 μg/L on August 12th. (Figure 4).

Similarly, average concentration of chlorophyll-*a* in Jackfish Lake (22.89 μg/L) falls into the eutrophic classification. Chlorophyll-*a,* an indirect measure of the amount of algae in the lake, ranged from 2.95 μg/L on June 28th to 48.4 μg/L on September 10th. Increasing algae concentration throughout the summer is common as warmer temperatures and increased nutrients allow for greater algal growth. The 2011 concentration of chlorophyll-*a* was higher than that measured in 1981 (9.2 μg/L) and 2001 (12.0 μg/L). This may be due to high concentrations of total phosphorous, potentially caused by heavy run-off in the spring of 2011. Because residents noticed large blooms of blue-green algae during the summer, microcystin producing algae may have made up a large portion of the algae community.

Finally, average concentration of Total Kjeldahl Nitrogen (TKN) was 1442 μg/L. This concentration of nitrogen falls into the hypereutrophic (highly productive) classification. Throughout the summer, levels of TKN Nitrogen ranged from 1200 μg/L on June 28th to 1720 μg/L on September 10th.

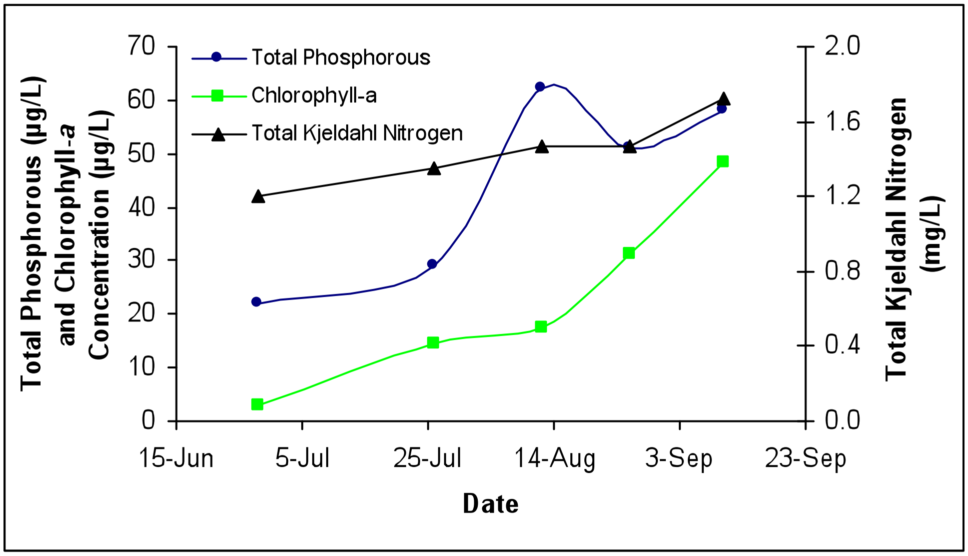

Figure 4 – Chlorophyll-*a* (µg/L), total phosphorous (µg/L), and total Kjeldahl nitrogen (mg/L) measured over the course of the summer in 2010.

Average pH measured at Jackfish Lake was 8.12 (Table 1). Higher than neutral, this pH level is common in Alberta due to large amounts of carbonate rich soils and falls within the Canadian Council of Ministers of the Environment (CCME) guideline for the protection of aquatic life (6.5-9.0). High levels of calcium and bicarbonate contribute to a high alkalinity (107.2 mg/L $CaCO_3$) which helps buffer the lake against changes in pH. Sulphate levels were quite high (431.7 mg/L), which suggest ground water inputs may be important to Jackfish Lake.

Table 1 – Average Secchi disc depth and water chemistry values for 1980, 1981, 2001, and 2011 at Jackfish Lake.

Parameter	1980	1981	2001	2011
TP (µg/L)	/	39	25	44
TDP (µg/L)	/	/	/	12.6
Chlorophyll-*a* (µg/L)	12.6	9.2	12	22.9
Secchi depth (m)	3	2.4	2.73	2.16
TKN (µg/L)	1259	1174	853	1442
NO_2 and NO_3 (µg/L)	<5	<3	5	4.2
NH_3 (µg/L)	41	64	45	17.8
DOC (mg/L)	/	/	/	12.7
Ca (mg/L)	76	/	76	102.1
Mg (mg/L)	49	/	56	66.8
Na (mg/L)	15	/	22	28.3
K (mg/L)	20	/	20	23.3
SO_4^{2-} (mg/L)	346	/	392	431.7
Cl^- (mg/L)	2	/	4	4.97
CO_3 (mg/L)	/	/	/	0.5
HCO_3 (mg/L)	/	/	/	131
pH	/	/	/	8.12
Conductivity (µS/cm)	/	/		1099
Hardness (mg/L)	/	/	/	530
TDS (mg/L)	/	/	/	721
Microcystin (µg/L)	/	/	/	0.081
Total Alkalinity (mg/L $CaCO_3$)	98	/	77	107.2

Note: TP = total phosphorous, TDP = total dissolved phosphorous, Chl-*a* = chlorophyll-*a*, TKN = total Kjeldahl nitrogen. NO_{2+3} = nitrate+nitrite, NH_4 = ammonium, Ca = calcium, Mg = magnesium, Na = sodium, K = potassium, SO_4 = sulphate, Cl = chloride, CO_3 = carbonate, HCO_3 = bicarbonate, / = absence of data.

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:

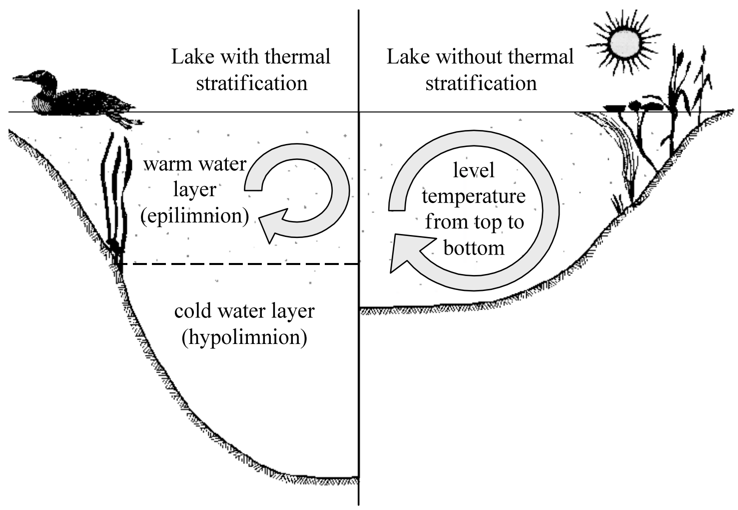

Figure A: Difference in the circulation of the water column depending on thermal stratification.

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 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 (Table 2)**.

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.

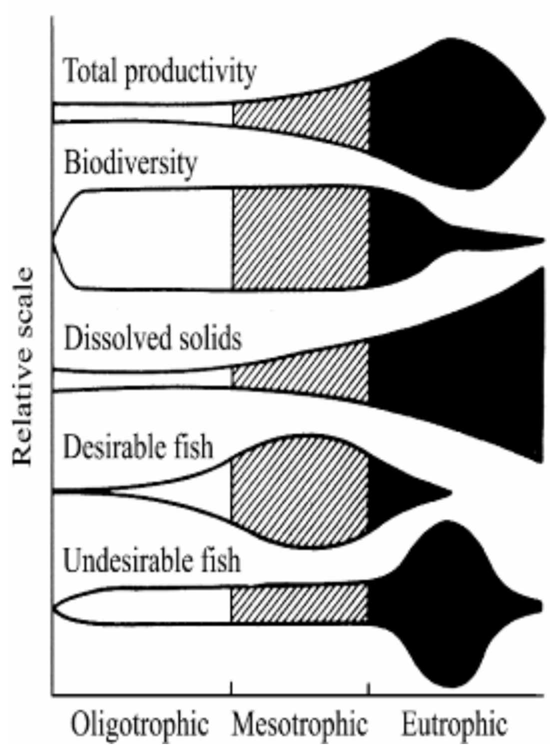

Figure B: Suggested changes in various lake characteristics with eutrophication

Table A - Trophic status classification based on lake water characteristics.

Trophic state	Total Phosphorus (µg•L^{-1})	Total Nitrogen (µg•L^{-1})	Chlorophyll a (µg•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