Lakewatch

THE ALBERTA LAKE MANAGEMENT SOCIETY
VOLUNTEER LAKE MONITORING PROGRAM

2012 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 volunteer Steve Zelych for his assistance with coordinating volunteers and his dedication to sampling Jackfish Lake. We would also like to thank Randi Newton and Erin Rodger who were summer technicians with ALMS in 2012. Program Coordinator Bradley Peter was instrumental in planning and organizing the field program. Technologists Trina Ball and Brian Jackson were involved in the training aspects of the program. Doreen LeClair, Chris Rickard, and Lisa Reinbolt were responsible for data management. Théo Charette, Ron Zurawell, Lori Neufeld, and Sarah Lord prepared the original report, which was updated for 2012 by Bradley Peter and Arin Dyer. Alberta Environment and the Beaver River Watershed Alliance (BRWA) were major sponsors of the 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.

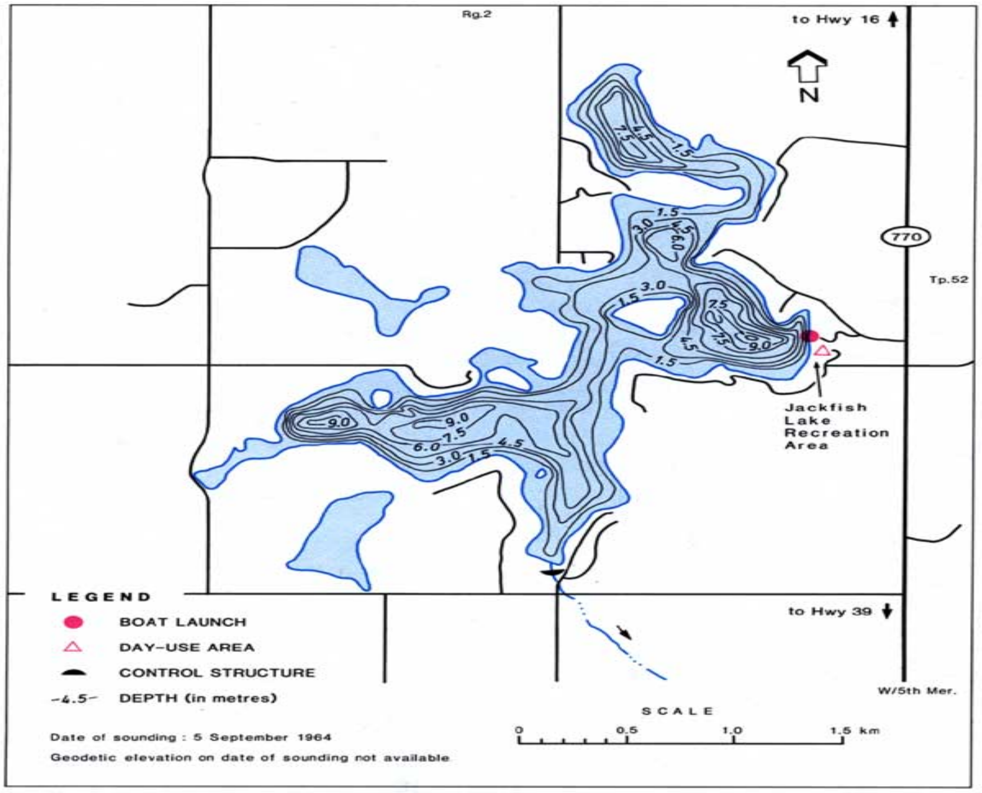

Figure 1 – Bathymetric map of Jackfish Lake measured in 1964. Source: Alberta Environment.

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

[2] Nat. Regions Committee, 2006. Nat. Regions and Subregions of AB. Compiled by D.J. Downing and WW Pettapiece. GoA Pub. No. T/852

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 showed 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.

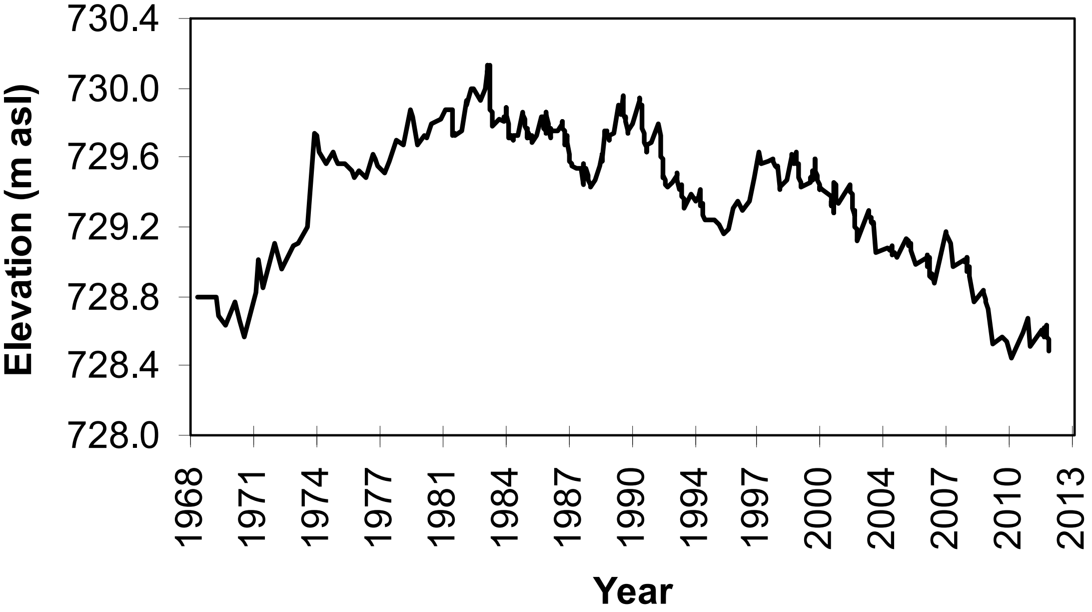

Figure 2 – Water levels from 1968-2012 for Jackfish Lake measured in meters above sea level (m asl). Data obtained from Alberta Environment.

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 measured at Jackfish Lake during the summer of 2012 was 2.30 m, slightly higher than the average measured during 2011 (2.16 m; Table 1). Throughout the summer, Secchi disk depth ranged from a minimum of 1.25 m on both August 17th and September 4th, to a maximum of 5.0 m on June 22nd. Secchi disk depth corresponded closely with chlorophyll-*a* concentrations, suggesting that algae/cyanobacteria blooms are the primary factors affecting water clarity at Jackfish Lake. Total suspended solids (2.76 mg/L) likely had less of an impact on water clarity, though may be much higher during periods of heavy boat use (Table 1).

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.

Surface water temperature at Jackfish Lake changed greatly throughout the summer of 2012 (Figure 3a). On September 4th surface water temperature was at a minimum of 16.87 °C, while on July 13th surface water temperature measured a maximum of 24.50 °C. Strong thermal stratification was observed during the first four sampling trips – by September 4th, temperatures had dropped enough to allow a complete mixing of the water column, resulting in uniform temperatures. This mixing of the water column occurred earlier than it did in 2011, when the lake was still thermally stratified on September 10th and surface water temperatures were still 19.72 °C. Thermal stratification may lead to reduced oxygen levels in deeper portions of the water column.

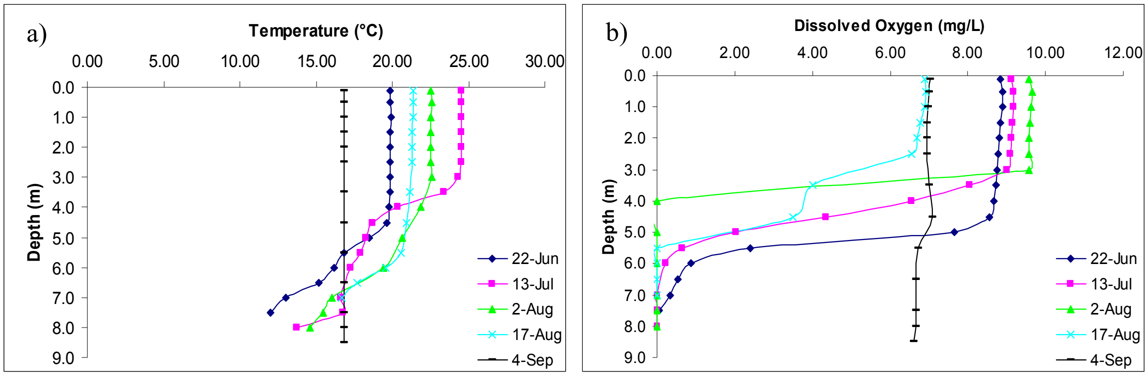

Figure 3 – a) Water temperature (°C) and b) dissolved oxygen concentration (mg/L) measured five times at Jackfish Lake during the summer of 2012.

Dissolved oxygen levels were greatly reduced below the thermocline at Jackfish Lake (Figure 3b). On the first four sampling trips dissolved oxygen concentrations proceeded towards anoxia at relatively shallow depths – only 4.0 m on August 2nd. The observed anoxic conditions are likely a result of the separation from surface waters by the thermocline and the decomposition of organic material on the lakebed which is an oxygen-consuming process. On both August 17th and September 4th dissolved oxygen concentrations in the upper portion of the water column appeared reduced, measuring only slightly above the Canadian Council for Ministers of the Environment (CCME) guidelines for the Protection of Aquatic Life of 6.5 mg/L. On September 4th, as with temperature, dissolved oxygen concentrations appeared uniform throughout the water column.

WATER CHEMISTRY:

ALMS measures a suite of water chemistry parameters. Phosphorus, 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.

Average total phosphorus (TP) at Jackfish Lake measured 36 µg/L in 2012 (Table 1). This value falls into the eutrophic, or nutrient rich, classification, and is lower than the value measured in 2011 (44.4 µg/L). Over the course of the summer, TP fluctuated between a minimum of 31 µg/L and a maximum of 45 µg/L (Figure 4).

As with TP, chlorophyll-*a* concentrations were also reduced compared to 2011. An indicator of algae/cyanobacterial biomass, chlorophyll-*a* levels measured an average of 12.76 µg/L in 2012 versus an average of 22.89 µg/L in 2011. While algae/cyanobacteria growth is strongly influenced by concentrations of phosphorus, other factors, such as ambient light and temperature, may also impact growth.

Finally, total Kjeldahl nitrogen (TKN) measured an average of 1340 µg/L in 2012. This value falls into the hypereutrophic, or extremely productive, classification. As with TP and chlorophyll-*a* concentrations, the 2012 average is slightly reduced compared to 2011 (1442 µg/L).

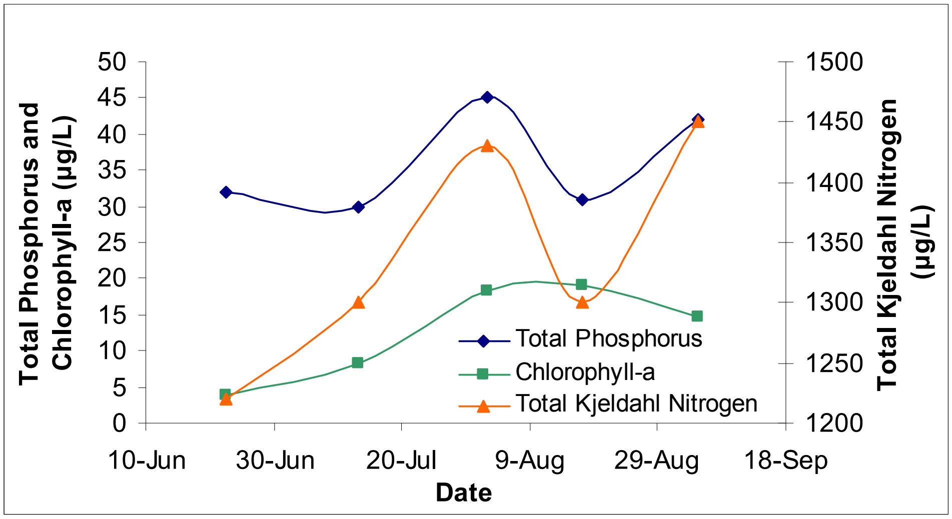

Figure 4 – Total phosphorus (µg/L), chlorophyll-*a* (mg/L), and total Kjeldahl nitrogen (µg/L) measured five times over the course of the summer at Jackfish Lake.

Average pH measured at Jackfish Lake in 2012 was 8.122, slightly above neutral. Though Jackfish Lake has high enough alkalinity (119.5 mg/L $CaCO_3$) and bicarbonate concentrations (145.4 HCO_3) to help buffer changes to pH, compared to other lakes in the region, these concentrations are relatively low. Dominant ions in Jackfish Lake include calcium (100.5 mg/L), magnesium (63.2 mg/L), and sulphate (461.3 mg/L). High levels of sulphate may contribute to a decrease in a lakes pH. Metals were measured twice over the summer at Jackfish Lake, and all values fell within their respective guidelines (Table 2).

Table 1 – Average Secchi disk depth and water chemistry values for Jackfish Lake. Previous years averages are provided for comparison.

Parameter	**1980**	**1981**	**2001**	**2011**	**2012**
TP (µg/L)	/	39	25	44	36
TDP (µg/L)	/	/	/	12.6	14.6
Chlorophyll-*a* (µg/L)	12.6	9.2	12	22.9	12.762
Secchi depth (m)	3	2.4	2.73	2.16	2.3
TKN (µg/L)	1259	1174	/	1442	1340
NO_2 and NO_3 (µg/L)	<5	<3	5	4.2	10.3
NH_3 (µg/L)	41	64	45	17.8	75.2
DOC (mg/L)	/	/	/	12.7	13.1
Ca (mg/L)	76	/	76	102.1	100.5
Mg (mg/L)	49	/	56	66.8	63.2
Na (mg/L)	/	/	22	28.3	27.2
K (mg/L)	/	/	20	23.3	24.1
SO_4^{2-} (mg/L)	/	/	392	431.7	461.3
Cl^- (mg/L)	/	/	4	4.97	5.43
CO_3 (mg/L)	/	/	/	0.5	0.5
HCO_3 (mg/L)	/	/	/	131	145.4
pH	/	/	/	8.12	8.12
Conductivity (µS/cm)	/	/	/	1099	1106.2
Hardness (mg/L)	/	/	/	530	511
TDS (mg/L)	/	/	/	721	753.7
TSS	/	/	/	5.68	2.76
Microcystin (µg/L)	/	/	/	0.081	0.089
Total Alkalinity (mg/L $CaCO_3$)	/	/	77	107.2	119.4

Note: TP = total phosphorus, TDP = total dissolved phosphorus, Chl-*a* = chlorophyll-*a*, TKN = total Kjeldahl nitrogen. NO_{2+3} = nitrate+nitrite, NH_3 = ammonia, Ca = calcium, Mg = magnesium, Na = sodium, K = potassium, SO_4 = sulphate, Cl = chloride, CO_3 = carbonate, HCO_3 = bicarbonate. A forward slash (/) indicates an absence of data.

Table 2 - Concentrations of metals measured in Jackfish Lake on July 13th and September 4th 2011. Values shown for 2012 are an average of those dates. The CCME heavy metal Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated) are presented for reference.

Metals (Total Recoverable)	**2012**	**Guidelines**
Aluminum µg/L	16.15	100[a]
Antimony µg/L	0.115	6[e]
Arsenic µg/L	2.365	5
Barium µg/L	81	1000[e]
Beryllium µg/L	0.0015	100[d,f]
Bismuth µg/L	0.00325	/
Boron µg/L	159	5000[ef]
Cadmium µg/L	0.00275	0.085[b]
Chromium µg/L	0.183	/
Cobalt µg/L	0.01265	1000[f]
Copper µg/L	1.4	4[c]
Iron µg/L	24	300
Lead µg/L	0.0436	7[c]
Lithium µg/L	111	2500[g]
Manganese µg/L	157.7	200[g]
Molybdenum µg/L	0.1375	73[d]
Nickel µg/L	0.0025	150[c]
Selenium µg/L	0.05	1
Silver µg/L	0.0023	0.1
Strontium µg/L	892	/
Thallium µg/L	0.000425	0.8
Thorium µg/L	0.013525	/
Tin µg/L	0.04465	/
Titanium µg/L	0.6135	/
Uranium µg/L	0.455	100[e]
Vanadium µg/L	0.2905	100[f,g]
Zinc µg/L	1.79	30

Values represent means of total recoverable metal concentrations.

[a] Based on pH ≥ 6.5; calcium ion concentrations $[Ca^{+2}] \geq 4$ mg/L; and dissolved organic carbon concentration [DOC] ≥ 2 mg/L.

[b] Based on water Hardness of 300 mg/L (as $CaCO_3$)

[c] Based on water hardness > 180mg/L (as $CaCO_3$)

[d] CCME interim value.

[e] Based on Canadian Drinking Water Quality guideline values.

[f] Based on CCME Guidelines for Agricultural use (Livestock Watering).

[g] Based on CCME Guidelines for Agricultural Use (Irrigation).

A forward slash (/) indicates an absence of data or guidelines.

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:

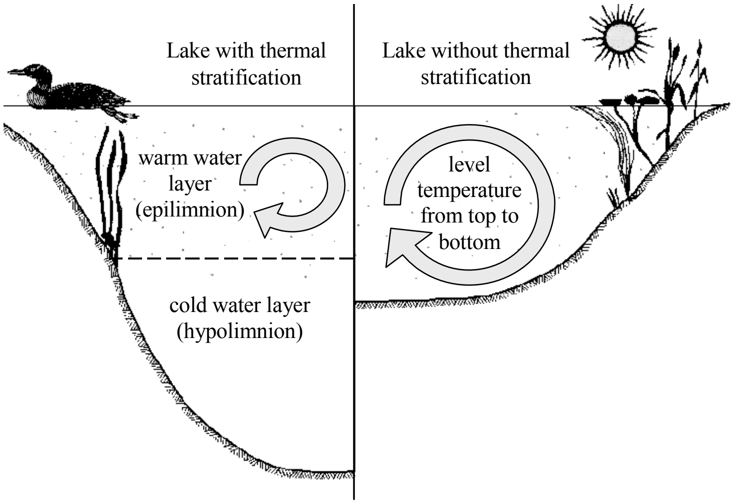

Figure A: Difference in the circulation of the water column depending on thermal stratification.

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.

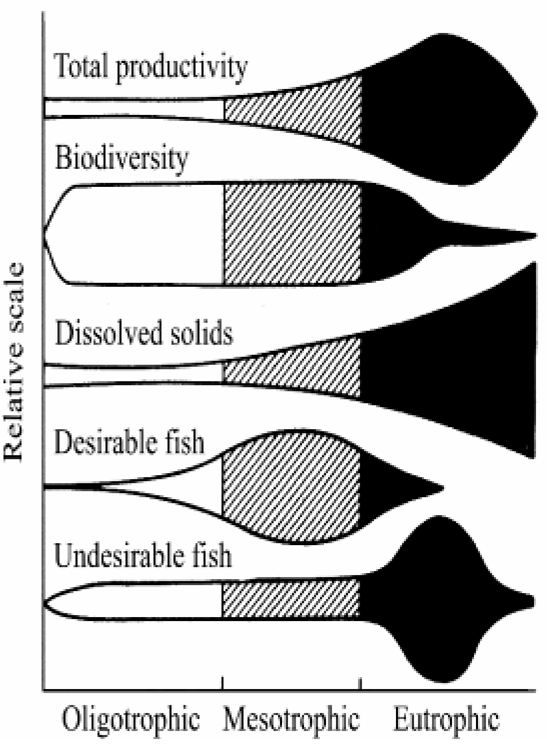

Figure B: Suggested changes in various lake characteristics with eutrophication. From “Ecological Effects of Wastewater”, 1980.

Table A - 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