Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Island Lake

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2005 Report

Completed with support from:

Alberta Lake Management Society

Baptiste, Island, and Skeleton Watershed Management & Lake Stewardship Council

Alberta Environment

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> *Water is integral to supporting and maintaining life on this planet as it moderates the climate, creates growth and shapes the living substance of all of Earth's creatures. It is the tide of life itself, the sacred source.* David Suzuki (1997). The Sacred Balance.

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.

Acknowledgements

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Island Lake

Island Lake is topographically interesting, in that it has many island and bays. The lake is located in the County of Athabasca, about 20 km northwest of the town of Athabasca. The west side is accessible from Highway 2, which passes north through Athabasca from Edmonton then along the west shore of the lake enroute to the town of Slave Lake (Fig. 1). Public access at Island Lake is available at several locations on the west side within the summer villages. Boats may be launched at most of these sites.

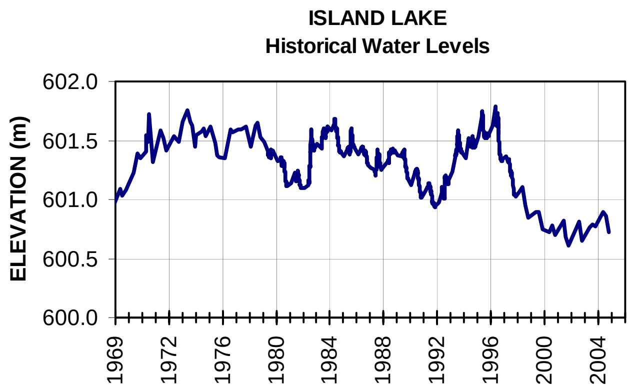
Homesteads in the region were first established in about 1908 (Alta. Mun. Aff. 1980). Seasonal cottage development on Island Lake began with subdivision of land on the west side in 1956; the summer village of Island Lake was incorporated the following year. In 1983, a second summer village, Island Lake South, was incorporated. Almost all residential development around the lake is located on the west shore within the two summer villages.

Island Lake is a medium-sized water body with a surface area of 7.81 km^2. The main basin is shallow: the maximum depth is about 12 m, but most of the basin is less than 6 m deep. The deepest part of the lake is in the north basin; it reaches a depth of 18 m. The main basin of Island Lake is fairly shallow. A smaller, deeper northern basin is connected to the main basin by a narrow channel. Shallow areas in the main basin support dense beds of aquatic vegetation. Groundwater inflow was measured by University of Alberta researchers in 1986 (R. Shaw and Prepas 1989). Groundwater was estimated to contribute 4% of total water inflow.

Island Lake's drainage basin is about 8 times the size of the lake. The main inflow drains from Ghost Lake and the northwestern portion of the drainage basin. Several intermittent streams carry runoff to the lake from other portions of the drainage basin. The outflow, Island Creek, flows from the east side of the lake southeast for about 5 km to the Athabasca River. Island Creek is choked with aquatic plants and has limited flow. About 27% of the drainage basin has been cleared, including areas of land around the south and west sides of Island Lake; most of the northern and northwestern regions remain forested. The soils around Island Lake have severe to very severe limitations for agriculture. The most abundant trees are trembling aspen, balsam poplar, white spruce, balsam fir and white birch. Black spruce grows on poorly drained areas. Mature stands are rare because of past fires and clearing. Mature mixed stands can be found on the large islands and in patches along the north shore of island Lake. There are extensive areas of Crown land near the lake, including most of the islands. Several of these areas have been reserved for recreation.

Water Levels

Water levels in Island Lake have been monitored by Environment Canada since 1969 under the joint Federal-Provincial Hydrometric agreement. Until recently, water levels have been fairly stable over the length of record; the maximum difference is less than 1.5 m. Water levels increased slightly during the early 1970's and were then quite stable until the early 1990's, when they began to decrease. Water levels increased again to reach a historical maximum in 1997, a year with record precipitation. Since then, water levels have decreased to a historical minimum in 2002 and remain low today. Over the period of record, the lowest water level occurred in October 2002 when it dropped to 600.608 m, and the highest water level was recorded in May 1997 at 601.791 m.



Results

Water Temperature and Dissolved Oxygen

Water temperature and dissolved oxygen profiles in the water column can provide information on water quality and fish habitat. Please refer to the end of this report for descriptions of technical terms.

Weak thermal stratification was evident in Island Lake over 2005 (Figure 3). The lake was thermally stratified at a depth of about 5 m in early June; however, by late June the lake had mixed again. This was followed by a period of stratification in July. By August the lake was once again destratified and remained mixed in September. Dissolved oxygen concentrations were consistently high from the surface to a depth of 7 meters (Figure 3). When the lake was stratified, oxygen concentrations dropped rapidly below the thermocline (i.e. depth of greatest water temperature and density change). When the lake was mixed, oxygen concentrations were essentially uniform with depth; sometimes within the last meter of the bottom, oxygen remained depleted. This may reflect the depletion of oxygen via bacterial decomposition at the lake bottom. Despite this, the water column of Island Lake remained well aerated.

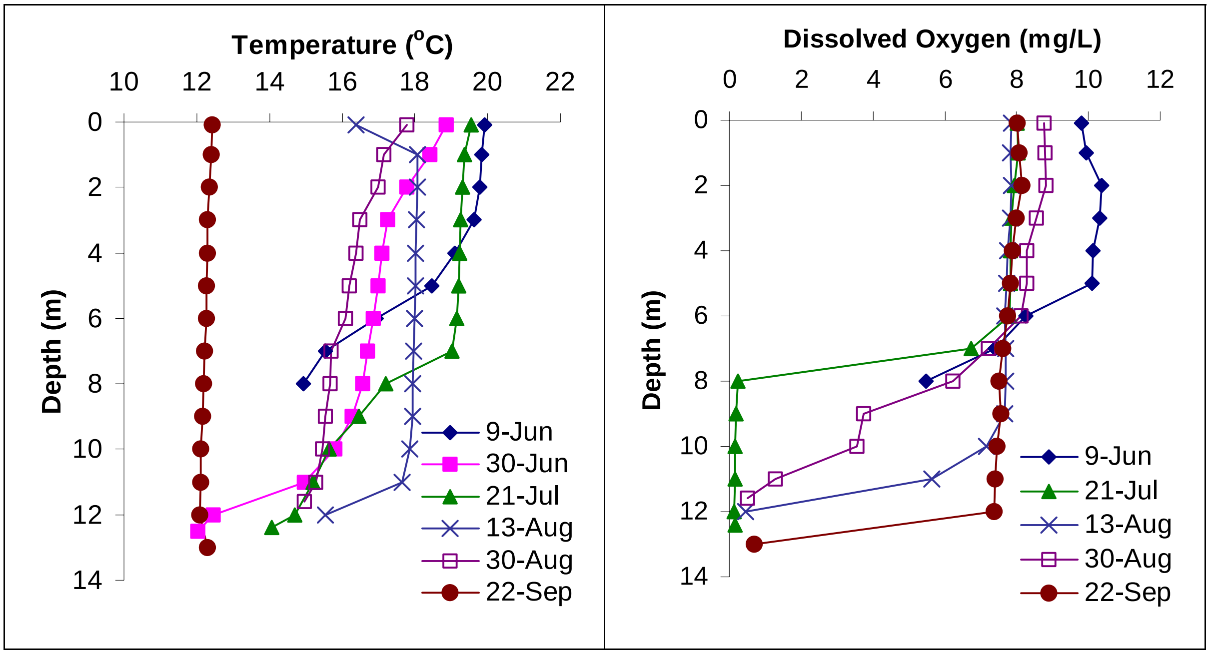


Figure 3. Temperature and dissolved oxygen concentrations with depth in Island Lake, summer 2005

Water clarity and Secchi Depth

Water clarity is influenced by suspended materials, both living and dead, as well as dissolved coloured 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 biomass as the summer progresses. The easiest and most widely used measure of lake water clarity is the Secchi disk depth.

In 2005, Island Lake's water was reasonably clear with an average Secchi disk depth of 3.1 m. Water clarity generally followed patterns in water greenness, or the chlorophyll *a* concentration (Figure 4). Water clarity was lowest in early August and late September and was highest in early June.

Water chemistry

Island Lake contained high nutrient concentrations and algal biomass compared to lakes throughout Canada, and is considered highly productive, or *eutrophic* (*see details on trophic status classification at end of this report*). In the Alberta context, although the lake is *eutrophic*, the water quality of Island Lake is generally quite acceptable for recreation. In 2005 both total phosphorus and algal biomass increased from early June to late September (Figure 4). Island Lake follows the typical pattern in Alberta lakes of an increase in nutrients and algae over the summer due to the release of nutrients from underlying sediments. Nutrients (i.e., total N and P) and water greenness appear to have increased over the past two decades (Table 1). However, it is important to realize that this observation is based only on 2 years and a proper statistical examination of trends requires at least 10 years of data.

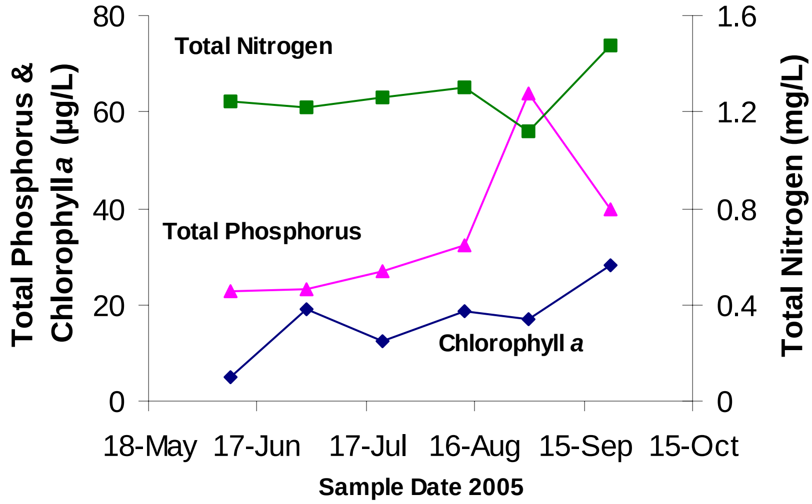


Figure 4: Total phosphorus, total nitrogen and chlorophyll-*a* (amount of algae) concentrations, summer 2005

Island Lake is well protected from acidification; its pH of 8.6 is well above that of pure water (i.e., pH 7). Bicarbonate, sodium, magnesium, and calcium are the dominant ions in Island Lake. Over the last two decades, the conductivity (or the saltiness) of Island Lake has increased. The major ions that have increased over the last two decades include bicarbonate, chloride, sodium, and magnesium. It is not clear whether changing hydrological conditions or external inputs from residential, agricultural and industrial activities have contributed to the moderate increase in ion concentrations observed in Island Lake over the past two decades. Given that water levels have decreased recently, dry climate is likely the culprit.

Table 1: Mean values from summer 2005 samples compared to 1984.

Parameter	1984*	2005
TP (µg/L)	26	35
TDP (µg/L)	12	11
Chla (µg/L)	8	17
Secchi (m)	3.4	3.1
TKN (µg/L)	1150	1265
NO_{2+3} (µg/L)	11	5.4
NH_4 (µg/L)	29	30
Ca (mg/L)	26	22
Mg (mg/L)	16	20
Na (mg/L)	27	40
K (mg/L)	8	9.8
SO_4 (mg/L)	7	6.3
Cl (mg/L)	2	7.7
HCO_3 (mg/L)	226	246
CO_3 (mg/L)	8	10
Total Alkalinity (mg/L $CaCO_3$)	199	219
Conductivity (µS/cm)	377	420
pH	8.1-8.6	8.6

Note: TP = total phosphorus, TDP = total dissolved phosphorus, Chla = chlorophyll *a*, 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, ND = no data
* Water Quality Report for Long Lake, Long Lake Provincial Park 2006

A Brief Introduction to Limnology

Indicators of water quality

The goal of **Lakewatch** is to collect water samples necessary to determine the water quality of lakes. Though not all encompassing, the variables measured in **Lakewatch** are sensitive to human activities in watersheds that may cause impacts to 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 affected (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 fish habitat and production of noxious odors. Large increases in nutrients over time may also indicate sewage inputs, which in turn, may result in other human health concerns such as harmful bacteria or protozoans (e.g. *Cryptosporidium*).

Temperature and mixing

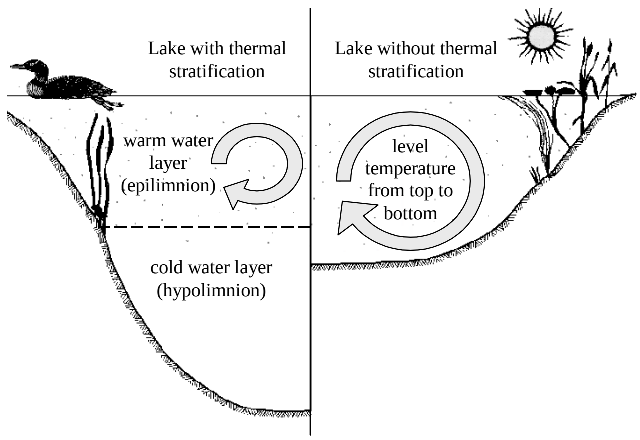


Figure 5: Difference in the circulation of the water column depending on thermal stratification.

Water temperature in a lake dictates the behavior of many chemical parameters responsible for water quality (Figure 5). 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. A third layer, known as the metalimnion, provides an effective barrier between the epi- and hypolimnion. The metalimnion reflects a rapid transition in water temperature known as the **thermocline**. A thermocline typically occurs when water temperature changes by several degrees within one-meter of depth. The thermocline acts as an effective physico-chemical barrier to mixing between the hypolimnion and epilimnion, restricts downward movement of elements, such as oxygen, from the surface 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 state 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 terrestrial plants and plants and algae of tropical lakes, phosphorus is usually in shortest supply in temperate 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. Larger aquatic plants, known as macrophytes, rather than algae, dominate some highly productive lakes. 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, reflect lower-nutrient trophic states than would otherwise result if macrophyte-based chlorophyll were 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 low. Secchi disk depth, however, is not only affected by algae, high concentrations of suspended sediments, particularly fine clays or glacial till common in plains or mountain reservoirs of Alberta, also impact water clarity. 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.

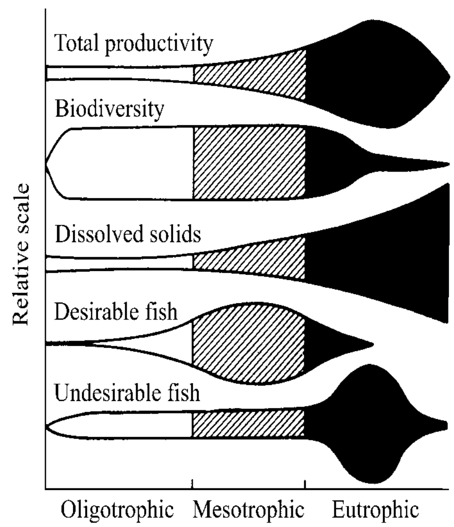


Figure 6: Suggested changes in various lake characteristics with eutrophication. From "Ecological Effects of Wastewater", 1980.

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-a) concentrations, the trophic states are: oligotrophic, mesotrophic, eutrophic and hypereutrophic. The nutrient and algal biomass concentrations that define these categories are shown in Table 2 and a graph 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 Figure. 6.

Table 2: 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 and Kerekes (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

Nurnberg, G.K. 1996. Trophic state of clear and colored, soft and hardwater lakes with special consideration of nutrients, anoxia, phytoplankton and fish. Lake and Reservoir Management 12(4):432-447.

Vollenweider, R.A., and J. Kerekes, J. 1982. Eutrophication of Waters. Monitoring, Assessment and Control. Organization for Economic Co-Operation and Development (OECD), Paris. 156p.

Welch, E.B. 1980. Ecological Effects of Waste Water. Cambridge University Press.