ALMS
Alberta Lake Management Society

Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Big Lake

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2006 Report

Completed with support from:

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

The Lakewatch program is made possible through the Lakewatch Chairs, Théo Charette and Ron Zurawell, and the volunteers. Stuart Loomis and Dave Burkhart were the volunteers for Big Lake. They made sampling possible through the dedication of their time. Our summer field technicians and volunteer coordinators, Amanda Crowski and Megan Mclean, were valuable additions to this year's program. Numerous Alberta Environment staff also contributed to successful completion of the 2006 program. Project Technical Coordinator, Shelley Manchur was instrumental in planning and organizing the field program. Technologists, Mike Bilyk, Brian Jackson and John Willis were involved in the logistics planning and training aspects of the program. Doreen LeClair was responsible for data management. Zofia Taranu, Jesse Vermaire and Erika Brown prepared this report. Alberta Environment and Lakeland Industry and Community Association (LICA) financially supported the Lakewatch program.

Introduction:

Big Lake is just northwest of the city of Edmonton and southwest of the community of St. Albert. As the name suggests, Big Lake has a large surface area and at its widest point is about 3 km wide and 8 km long. This lake however is very shallow with Lakewatch members reporting a maximum depth of roughly 0.75 m during the 2006 summer sampling. We unable to locate a bathymetric map for Big Lake suggesting that it has not recently been sounded.

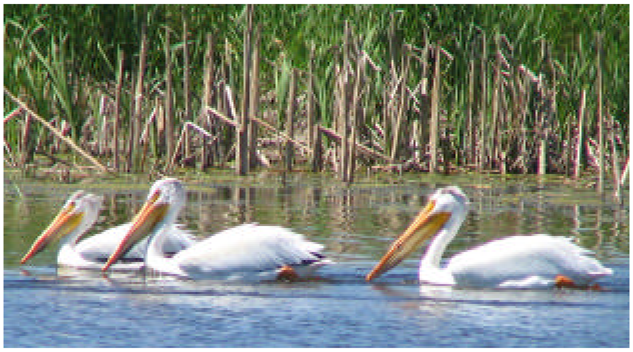

Figure 1: Photo of pelicans on Big Lake courtesy of Jim Price

Figure 2: Photo of a Greater Yellowleg in Big Lake courtesy of Dave Burkhart.

Big Lake is a nutrient rich and productive lake. Fish species found in the lake include Walleye, Stickleback, and Northern Pike. In the region Big Lake is probably best known for supporting a wide variety of birds (Figures 1 & 2). Over 235 bird species have been recorded at Big Lake and nearly 180 species are regularly spotted from year to year (BLESS). Because of the plant and animal richness of this lake Alberta Fish and Wildlife considers it to be one of the 20 most important habitat areas in Alberta. In an effort to protect the Big Lake ecosystem the Alberta Government created the Big Lake Natural Area in 1999, and in 2005 protected Big Lake as a portion of the Lois Hole Centennial provincial park.

Water levels

No long-term water level monitoring was found for Big Lake. The closest lake for which there is long term water level monitoring is for Lac la Nonne, roughly 70 km to the northwest of Big Lake. Water levels in Lac la Nonne have declined nearly 1.5 m since the mid 1990s (Figure 3). Although this does not mean that water levels at Big Lake have behaved the same, a general pattern of declining water levels has been noted in Alberta lakes over the last 20

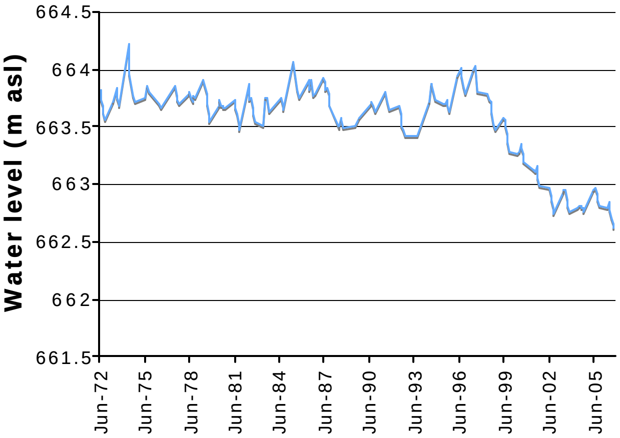

Figure 3: Water level data for Lac la Nonne measured as meters above sea level (m asl) of the surface of the lake.

years. Declining water levels are of particular concern for Big Lake because it is very shallow. The maximum depth of the lake measured during the Lakewatch 2006 sampling program was roughly 0.75 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.

Big Lake is a "polymictic" lake, meaning that the water column mixes completely several times throughout the summer (Figure 4). Because of the frequent mixing of the water column the water temperature and dissolved oxygen concentration is relatively the same at all depths (Figure 4). The water column was well-aerated and dissolved oxygen concentrations were above the provincial guidelines for the protection of aquatic life throughout the summer.

Water clarity and Secchi Depth

Suspended materials, both living and dead, influence water clarity, as well as some coloured dissolved compounds in the water column. During the melting of snow and ice in spring, lake

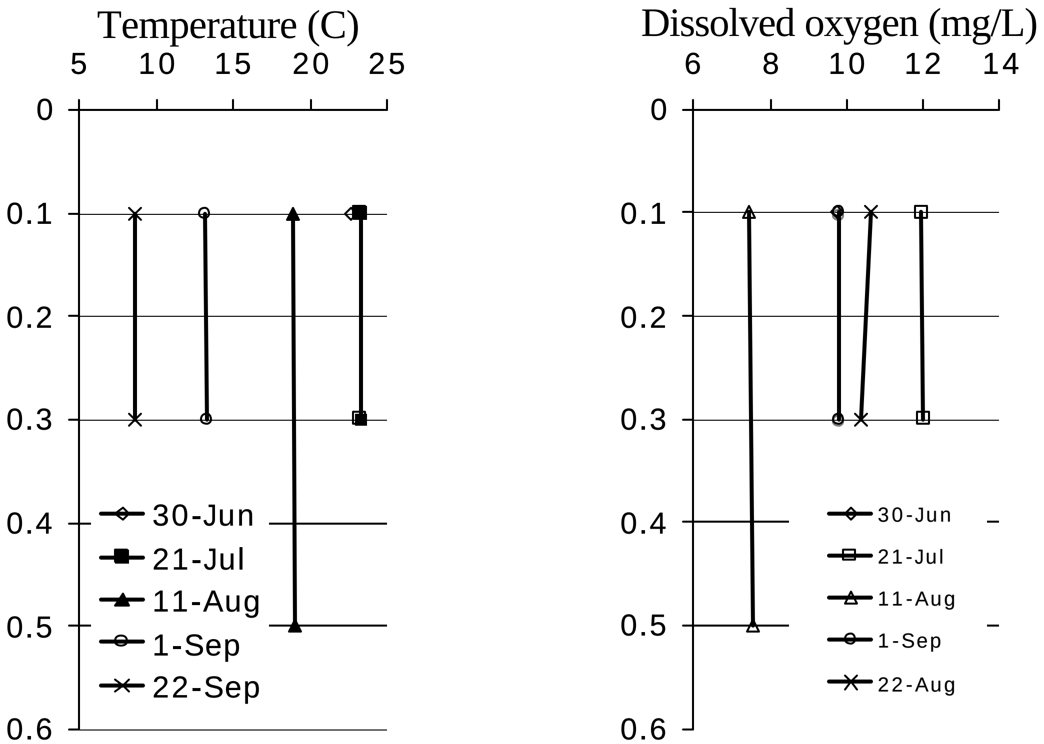

Figure 4: Water temperature and dissolved oxygen profiles fro Big Lake during the summer of 2006.

water can become 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.

Big Lake had low water clarity in 2006 with a mean secchi disk depth of 0.62 m. The greatest water clarity occurred during the June 30th sampling date with a secchi disk depth of 0.8 m. Low water clarity is common in nutrient rich lakes because algae blooms turn the water green and reduce water clarity.

Water chemistry

Big Lake has high nutrient concentrations and algal biomass compared to lakes throughout Canada, and is therefore considered hypereutrophic (very nutrient rich; *see details on trophic status classification at end of this report*). Alberta lakes are naturally nutrient rich, however Big lake does have greater than average nutrient and algae concentrations, even for Alberta. Nutrient concentrations are often higher in polymictic lakes because nutrients in the sediment can be resuspended in the water column. Also, waterfowl are likely a large source of nutrients to this lake. In 2006, total phosphorus, total nitrogen, and consequently, algal biomass, all increased throughout the summer declining in late September (Figure 5).

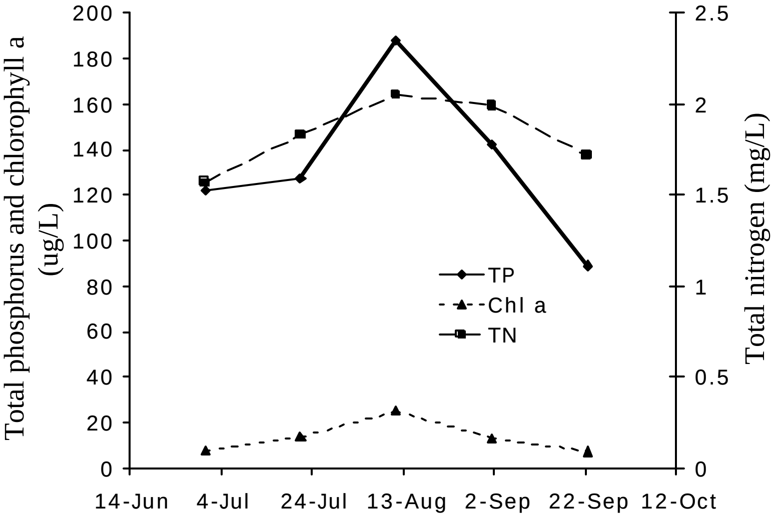

Figure 5: Total phosphorus, total nitrogen and chlorophyll *a* (algae biomass or water greenness) measurements for Big Lake during the summer of 2006.

Big Lake is well protected from acidification; its pH of 9 (Appendix 1) is well above that of pure water (i.e., pH 7). This is typical for most of northern Alberta lakes, on account of the parent material of the soils. Bicarbonate, sulphate, sodium, and magnesium are the dominant ions in Big Lake. Because there is only one year of data in Big Lake, we cannot make any comments on changes over time.

Appendix 1

Table 1. Average chemical characteristics of Big Lake during the summer of 2006.

Parameter	**2006**
Total P (µg/L)	133.6
TDP (µg/L)	47.6
Chla (µg/L)	13.4
Secchi (m)	0.62
Total N (mg/L)	1.83
NO_{2+3} (µg/L)	17
NH_4 (µg/L)	54.8
Ca (mg/L)	30.8
Mg (mg/L)	21.4
Na (mg/L)	70.1
K (mg/L)	8.4
SO_4 (mg/L)	108.7
Cl (mg/L)	40.9
CO_3 (mg/L)	15.7
HCO_3 (mg/L)	154
TDS (mg/L)	372
Conductivity (µS/sec)	618
pH	9
Total Alkalinity (mg/L $CaCO_3$)	152

Note: TDP = total dissolved phosphorus, Chla = chlorophyll a, TN = total nitrogen, NO_{2+3} = nitrate+nitrite, NH_4 = ammonium, Ca = calcium, Mg = magnesium, Na = sodium, K = potassium, SO_4 = sulphate, Cl = chloride, HCO_3 = bicarbonate, CO_3 = carbonate, Cond = conductivity, TDS = total dissolved solids.

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

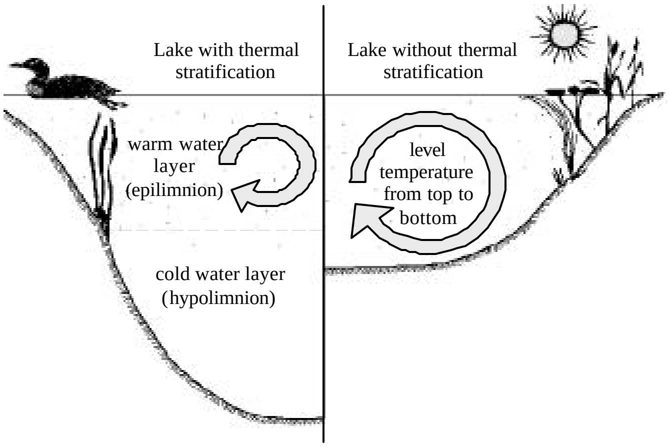

Figure 6: Difference in the circulation of the water column depending on thermal stratification.

Water temperature in a lake dictates the behavior of many chemical parameters responsible for water quality (Figure 6). 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. 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, can exist 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-*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 7.

Figure 7: Suggested changes in various lake characteristics with eutrophication. From “Ecological Effects of Wastewater”, 1980.

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 (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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