VOLUNTEER CITIZENS' LAKE MONITORING PROGRAM (1989)

SKELETON, BUFFALO AND CAPT. EYRE LAKES

by:

Patricia Mitchell
Environmental Quality Monitoring Branch
Environmental Assessment Division
Alberta Environment

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INTRODUCTION

The Volunteer Citizens' Lake Monitoring Program, which began in 1988 as a pilot study on Lac Ste. Anne and Pigeon Lake, has three main objectives: 1) to provide an opportunity for lakeshore property owners to learn first hand about water sampling procedures related to lake management; 2) to improve the existing water quality database for a particular lake, and 3) to encourage environmental responsibility among lake users.

The program was conceived largely as a response to concerns expressed by lakeshore property owners that the water quality of their lake was deteriorating. There is a common belief that human activities in and around these lakes are contributing pollutants that lead to excessive algal growth, murky water and weeds. By actively participating in water quality monitoring of their lake, citizens increase their own environmental awareness and that of others, through discussions with relatives and friends. This in turn may lead to individual action to reduce pollutant loading, as well as recognition of the detrimental activities of others. In addition, the data accumulated during the study provides initial baseline data (as for Capt. Eyre Lake) or enhances the existing database on lakes that would likely not be sampled that year. The high sampling frequency (weekly) during the summer is particularly useful for assessing seasonal trends in algal populations.

The focus of the sampling program was on water collection from the main, open part of the lake. It is much easier to assess and evaluate the overall status of a lake's water quality with composite samples collected from the open water, rather than with individual samples collected from localized shoreline areas. The shoreline is very variable in terms of the amount of terrestrial and aquatic vegetation, effects of development, wind and wave effects, and presence of inflowing creeks. An open water sample represents a blending or synthesis of all these effects.

BACKGROUND: INDICATORS OF LAKE WATER QUALITY

Phosphorus

The poor water quality that occurs in many prairie and parkland area lakes usually results from excessive quantities of available nutrients in the water. Aquatic plants - algae and the large water plants that people call weeds - need the same kinds of nutrients that are supplied for farm crops or lawns. However, phosphorus rather than nitrogen is often in shortest supply for plants that live in lakes. This means that the algae that turn the water green in summer can grow only in proportion to the amount of phosphorus available. When the amount of phosphorus dissolved in the water is low, the water may not turn green at all. But in many lakes there is enough phosphorus to allow considerable growth of algae. Sources of phosphorus to these lakes include: 1) streams and small ditches that run through cottage subdivisions, agricultural land, and areas of natural vegetation; 2) rain, snow and dust that falls directly onto the lake; 3) effluent from faulty or poorly placed sewage systems; 4) ponds or lakes upstream, and 5) the mud or sediment at the bottom of the lake. The bottom sediments, in particular, may be a very large source of phosphorus to shallow lakes.

Chlorophyll

This is the pigment in all green plants. It is easily extracted from the algae suspended in a water sample, and therefore it can be measured and used to indicate the amount of algae in the water.

Secchi Disk Transparency

The 20 cm. black and white metal plate called the Secchi disk has been used for over 100 years to indicate lake water quality around the world. Lakes that are clear are the most attractive for recreation, whereas those that are turbid or murky are considered by lake users to have poor water quality. Often, the turbidity in the water is caused by masses of suspended algae. Related to this is euphotic depth, the depth of light penetration. Algae need light to grow, and therefore an actively growing population of algae will be found above this depth. The euphotic depth has been calculated to be about twice the Secchi depth, based on studies on several Alberta lakes in which a light meter was used to measure light penetration.

THE LAKES STUDIED IN 1989

Three recreational lakes were involved in the Volunteer Citizens' Lake Monitoring Program in 1989. Buffalo Lake is located east of the city of Red Deer, near the town of Stettler. Capt. Eyre Lake (locally spelled Capt. Ayre) is located west of the town of Provost and southeast of the village of Czar. Skeleton Lake is located 160 km northeast of Edmonton near the village of Boyle.

Buffalo Lake

Buffalo Lake is the largest and shallowest of the three lakes (see Table 1). It has an irregular shoreline that divides the lake into three bays (Fig. 1). The main basin (Main Bay) is the largest and deepest. The bottom is sandy near shore, and there are extensive sand beaches along the south and east sides of the main basin. Secondary Bay has a maximum depth of 2.5 m, whereas Parlby Bay is only about 1 m deep. The lake is spring-fed, and quite salty. There are no major inlet creeks, and the outlet has not flowed since 1929. The water level has declined since 1975. Alberta Environment is investigating the possibility of stabilizing the lake.

There are four public recreational areas on the lake, including Rochon Sands Provincial Park on the south shore, and two summer villages, White Sands and Rochon Sands.

Capt. Eyre Lake

Capt. Eyre Lake is a tiny, attractive lake located in rolling prairie in east-central Alberta (Figure 2). The lake has not been sounded, so a bathymetric map and several physical variables are unavailable. According to the Fish and Wildlife Division of Alberta Forestry, Lands and Wildlife, the lake has a maximum depth of 8 m.

There is a municipally-owned campground on the lakeshore, and a few cottages are present.

Skeleton Lake

Skeleton Lake is the deepest of the three lakes in the volunteer program in 1989. It is divided into two basins, which are

Table 1. Physical characteristics of Buffalo, Capt. Eyre and Skeleton lakes.

	Buffalo	Capt. Eyre*	Skeleton
Area of lake (km^2)	93.5	approx. 0.2	7.89
Volume (m^3)	248×10^6	-	51.4×10^6
Maximum depth (m)	6.5	approx. 8	17
Average depth (m)	2.8	-	6.5
Shoreline length (km)	126	approx. 1.5	24.7
Drainage basin area (km^2)	1440	-	31.7
Elevation (m) above sea level	779.98	approx. 680	623.77

* Capt. Eyre Lake has not been sounded

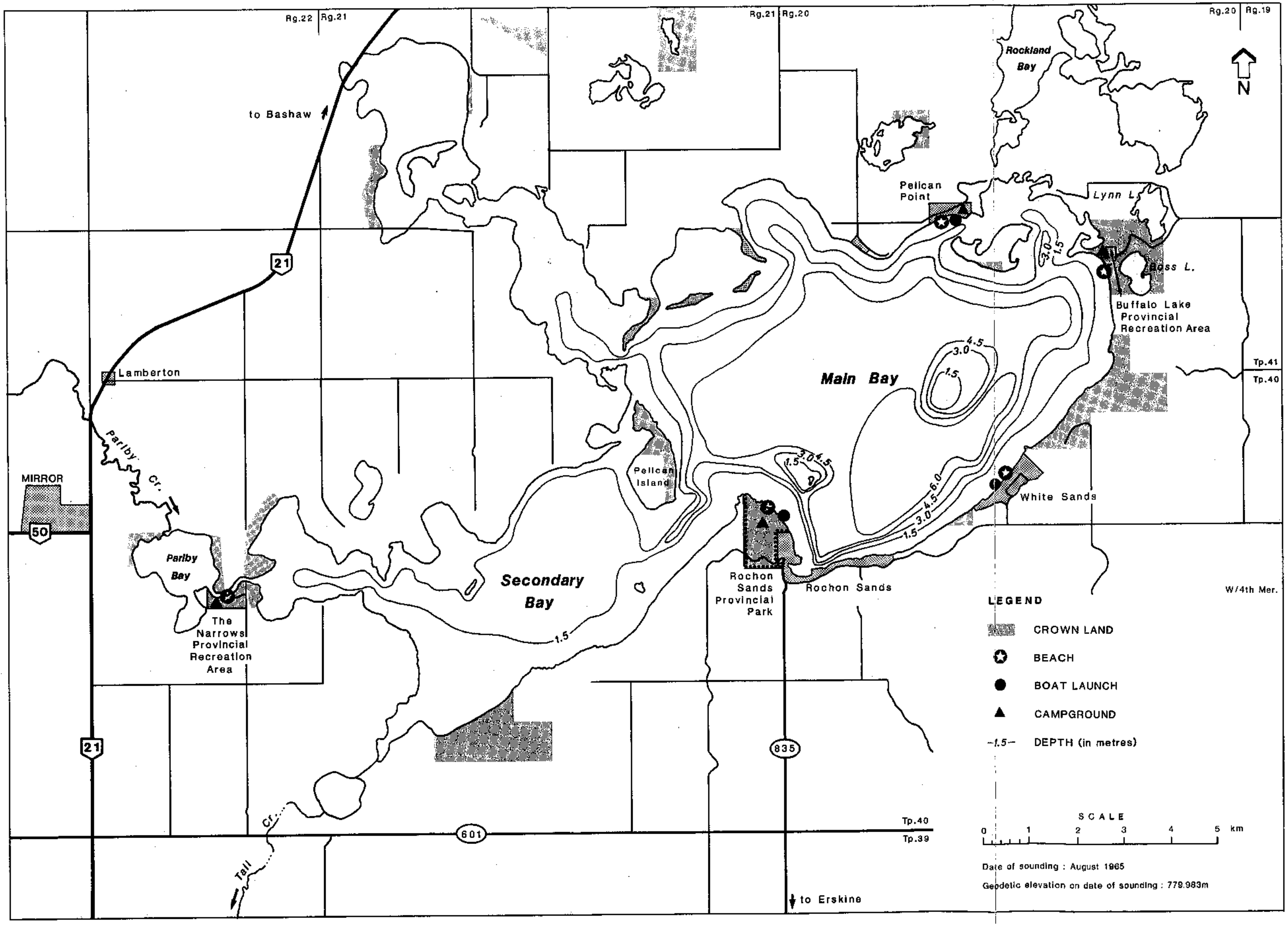

Figure 1. Bathymetric map of Buffalo Lake

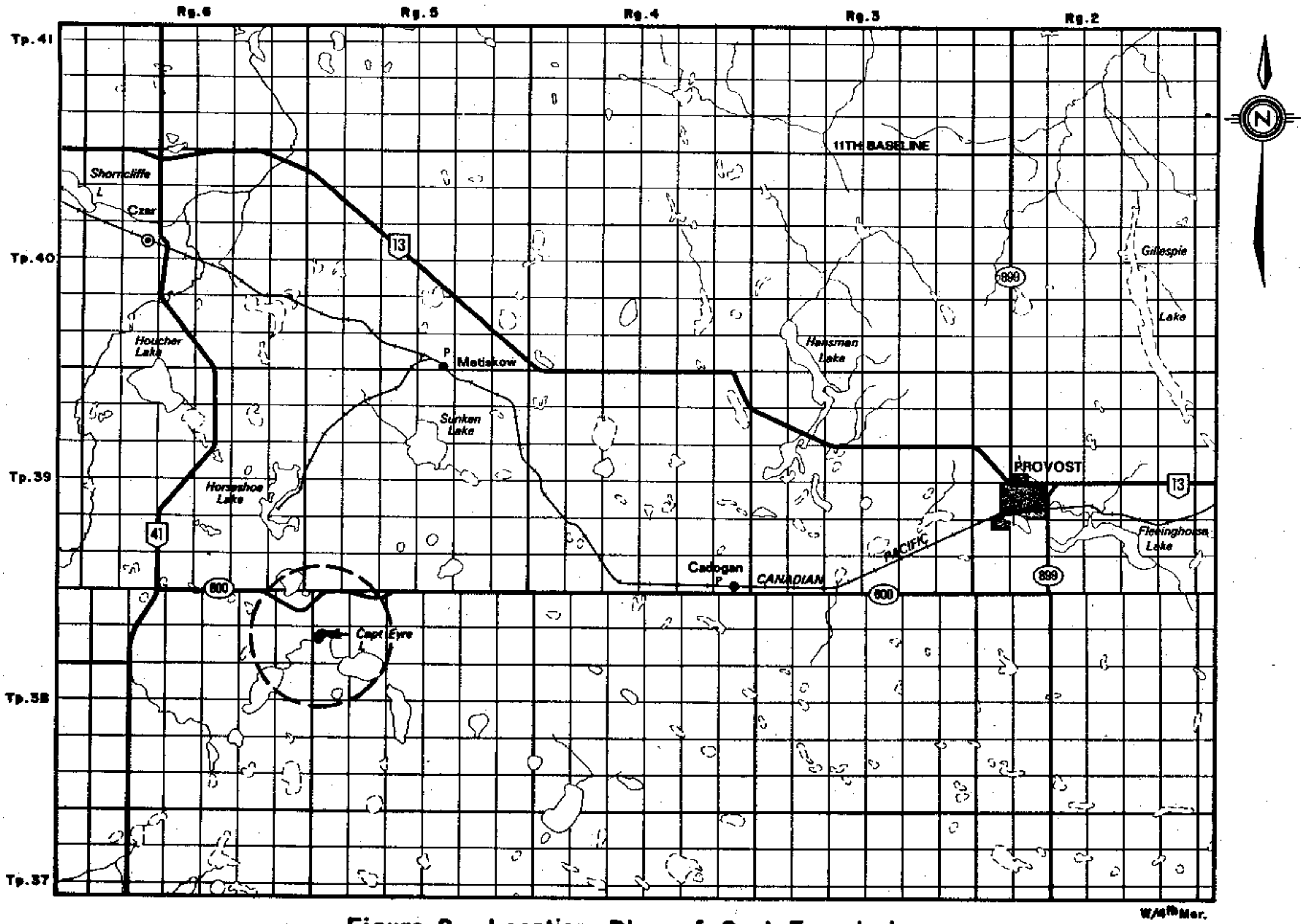

Figure 2. Location Plan of Capt Eyre Lake.

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separated by a shallow, weedy narrows (Fig. 3). The north basin is deepest, whereas the south basin slopes gradually to a maximum depth of 11 m. Several intermittent streams flow into the lake. The outlet creek flows toward Amisk Lake to the east, but the creek is often blocked by beavers.

Skeleton Lake is heavily developed compared to most Alberta lakes. Besides the two summer villages, there is a boy scout camp, a golf course, several day-use areas and two commercial campgrounds.

METHODS

In mid-May the project biologist from the Environmental Quality Monitoring Branch (EQMB) conducted training sessions for the volunteers. One person on each lake agreed to coordinate their program. Each lake's coordinator, with assistance from one or more volunteers, conducted the sampling program. Sampling frequency was weekly or every two weeks, depending on weather conditions or preferences of the volunteers. Sampling on Capt. Eyre Lake began at the end of May, while sampling began on the other two lakes in mid-June. The program ended in the second or third week of August. Nine samples were collected on Buffalo Lake, six on Skeleton and six on Capt. Eyre.

On each sampling day, volunteers in their own boats went to the deepest area of the lake and anchored. The Secchi disk was lowered into the water by means of a line marked in quarter-meter intervals. The precise depth that the disk disappeared from view was noted, and then it was raised until it could just be seen again, and this depth noted. An average for the two readings was the Secchi depth for that day.

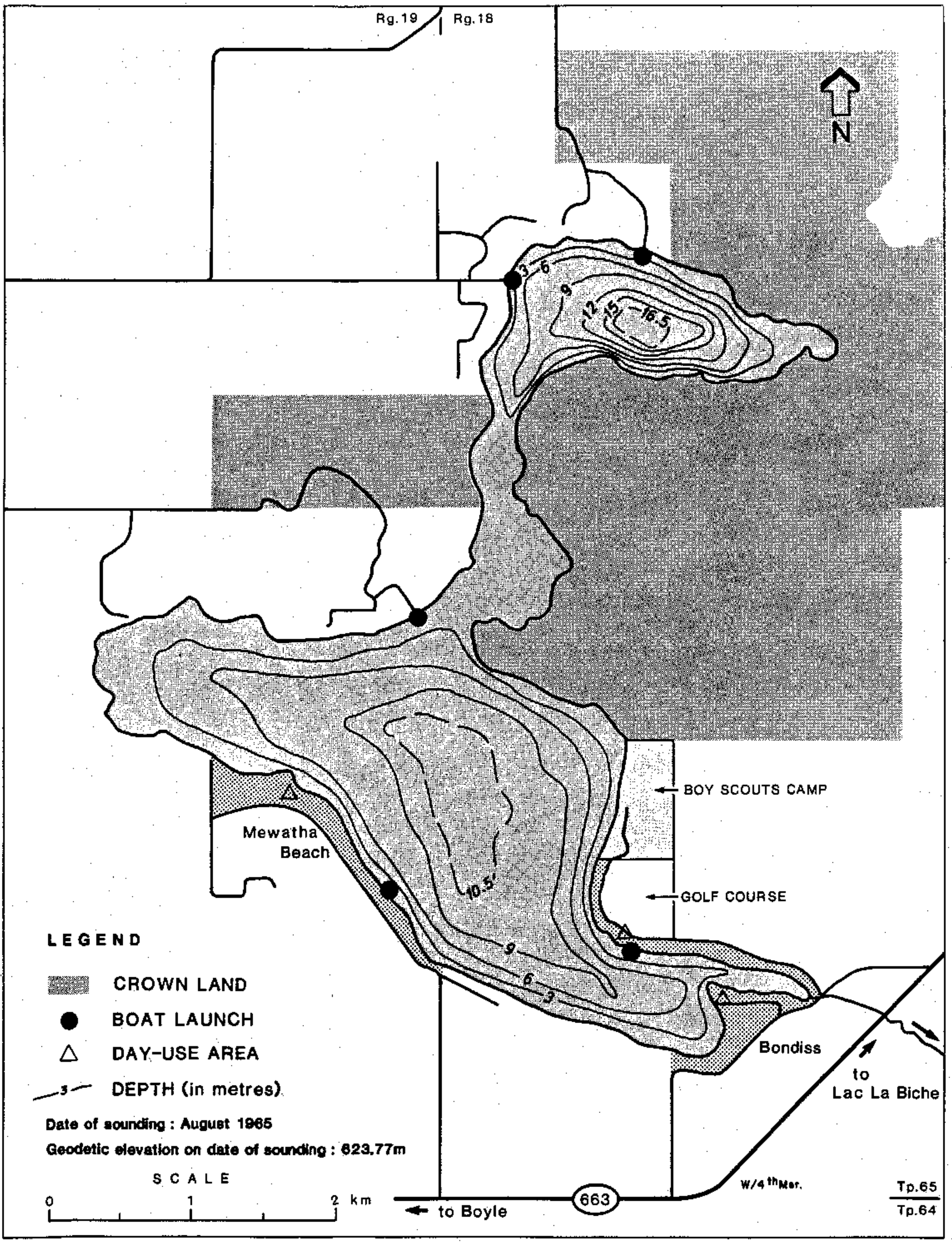

Figure 3. Bathymetric map of Skeleton Lake.

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It has been estimated for Alberta lakes that sufficient light for algal photosynthesis penetrates to about twice the Secchi depth. This depth of light penetration is called the euphotic depth, and is estimated by multiplying the Secchi depth for a particular day by two.

Water samples were collected with a long clear plastic tube marked in one-meter intervals. At each of approximately 10 random locations over the lake surface, the tube was lowered to the euphotic depth. A foot-valve in the end of the tube closed it off and the water in the tube was poured into a clean, rinsed plastic jug. Thus, for each sampling day, the jug contained a composite of 10 tube-hauls of lake water, or 20 if it was necessary to collect two hauls at each site.

The jug of sample water was brought back to the coordinator's cottage or other location. The jug was agitated, and water was poured into two plastic bottles. Three additional subsamples of water were poured off. Each of these subsamples was filtered to collect the algae from a known volume of lake water. The three filters and the two bottles of water were returned to the EQMB in Edmonton for further processing and analysis. The filters were put into a solvent which extracted the chlorophyll a from the algae on the surface of the filter. One bottle of lake water was submitted to the Alberta Environmental Centre in Vegreville for analysis of the salt content, and the other bottle was retained by EQMB staff for analysis of phosphorus, an important plant nutrient.

In addition to lake samples collected by the volunteers, EQMB staff visited each lake on one occasion. Using Hydrolab equipment, they measured temperature, dissolved oxygen, conductivity and pH at 1 m intervals from the surface to the bottom of the lake.

RESULTS AND DISCUSSION

Buffalo Lake

Buffalo Lake is moderately saline - it has a fairly high salt content. The dominant salts, or ions, are sodium, sulfate and bicarbonate. Table 2 lists average values of the major ions and related variables for the main basin of Buffalo Lake and the other lakes in the volunteer citizens' program in 1989. The likely reasons for Buffalo Lake's moderate salinity are saline groundwater inflow and evaporative concentration of salts. Data collected during studies in previous years indicate that the main basin of the lake has the highest salt concentration, whereas Parlby Bay is lowest and Secondary Bay is intermediate in concentration. This gradient is the result of the influence of Parlby Creek, which has relatively fresh water.

Lake surface to bottom profile measurements for temperature, pH, dissolved oxygen and conductivity were conducted on September 19, 1989 (Fig. 4). On this day the temperature was uniform from top to bottom (11°C) indicating that the lake was well-mixed. Dissolved oxygen concentrations declined slightly, but the lake water was well-oxygenated. Historical data for Buffalo Lake suggest that the water is oxygenated even in winter, so that there is little danger of fish kills.

Total phosphorus concentrations peaked in July (Fig. 5), whereas chlorophyll continued to increase through August. The increase

Table 2. Average concentrations of major ions, nutrients, chlorophyll a and other variables for Buffalo, Capt. Eyre and Skeleton lakes in 1989. Units are mg/L unless indicated otherwise.

	Buffalo	Capt. Eyre	Skeleton
pH (range), pH units	9.2-9.4	9.1-9.3	8.3-8.8
conductivity, µS/cm	2890	1537	339
total dissolved solids	1961	1005	183
calcium	6.0	8.5	24.8
magnesium	85	74	20
sodium	616	254	14
potassium	42.4	17.5	9.1
sulfate	482	282	4
chloride	15	7.4	1.9
bicarbonate	1031	546	207
carbonate	208	94	7.5
total hardness as $CaCO_3$	364	326	144
total alkalinity as $CaCO_3$	1193	604	182
silica	1.1	3.1	1.8
fluoride	0.28	0.26	0.13
iron	0.22	<0.02	<0.03
number of samples	5	6	5
total phosphorus, mg/m^3	82	32	37
chlorophyll a, mg/m^3	15.0	9.0	13.9
number of samples	9	6	6

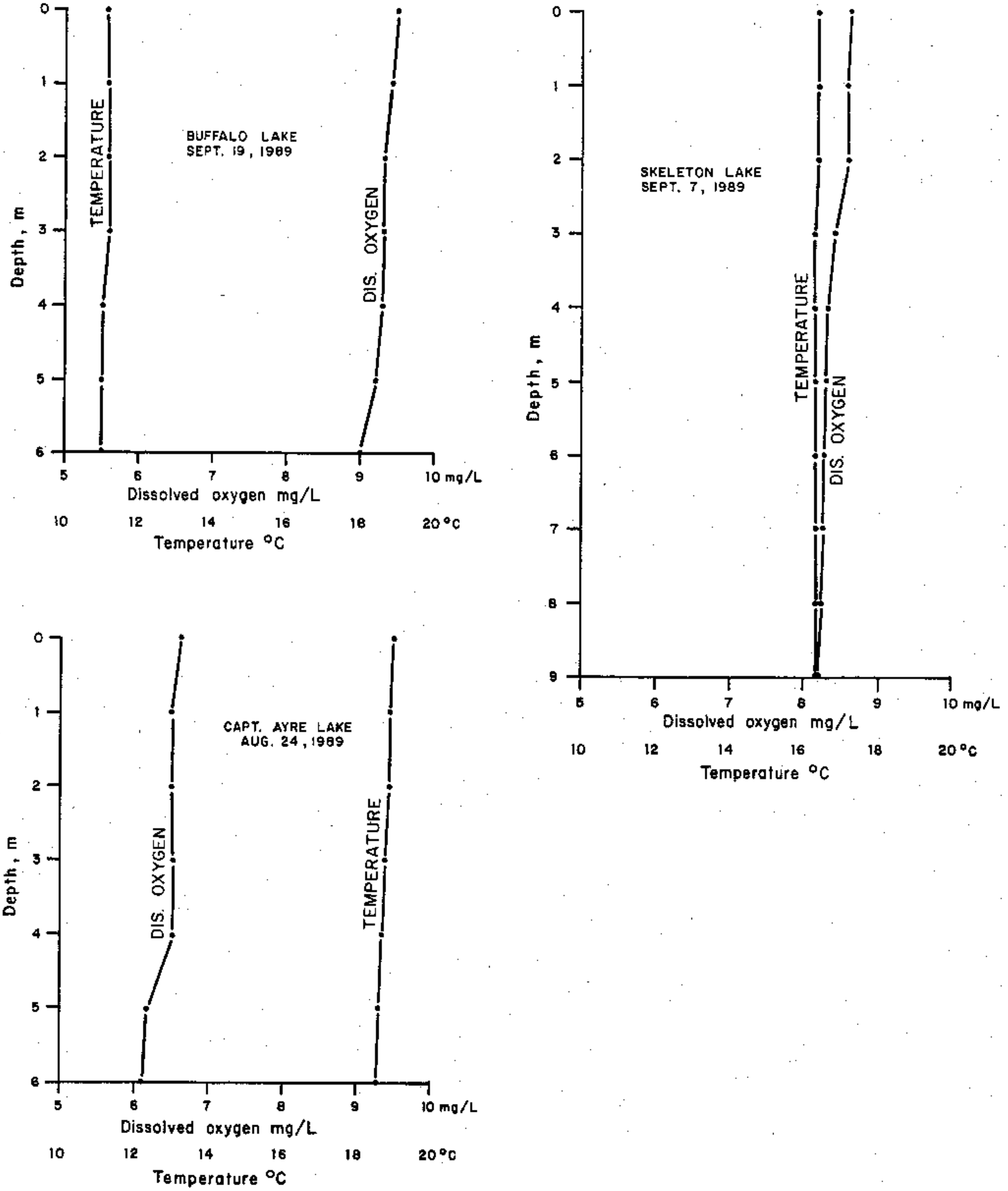

Figure 4. Profiles of temperature (°C) and dissolved oxygen concentration (mg/L) in Buffalo, Capt. Eyre and Skeleton lakes, 1989.

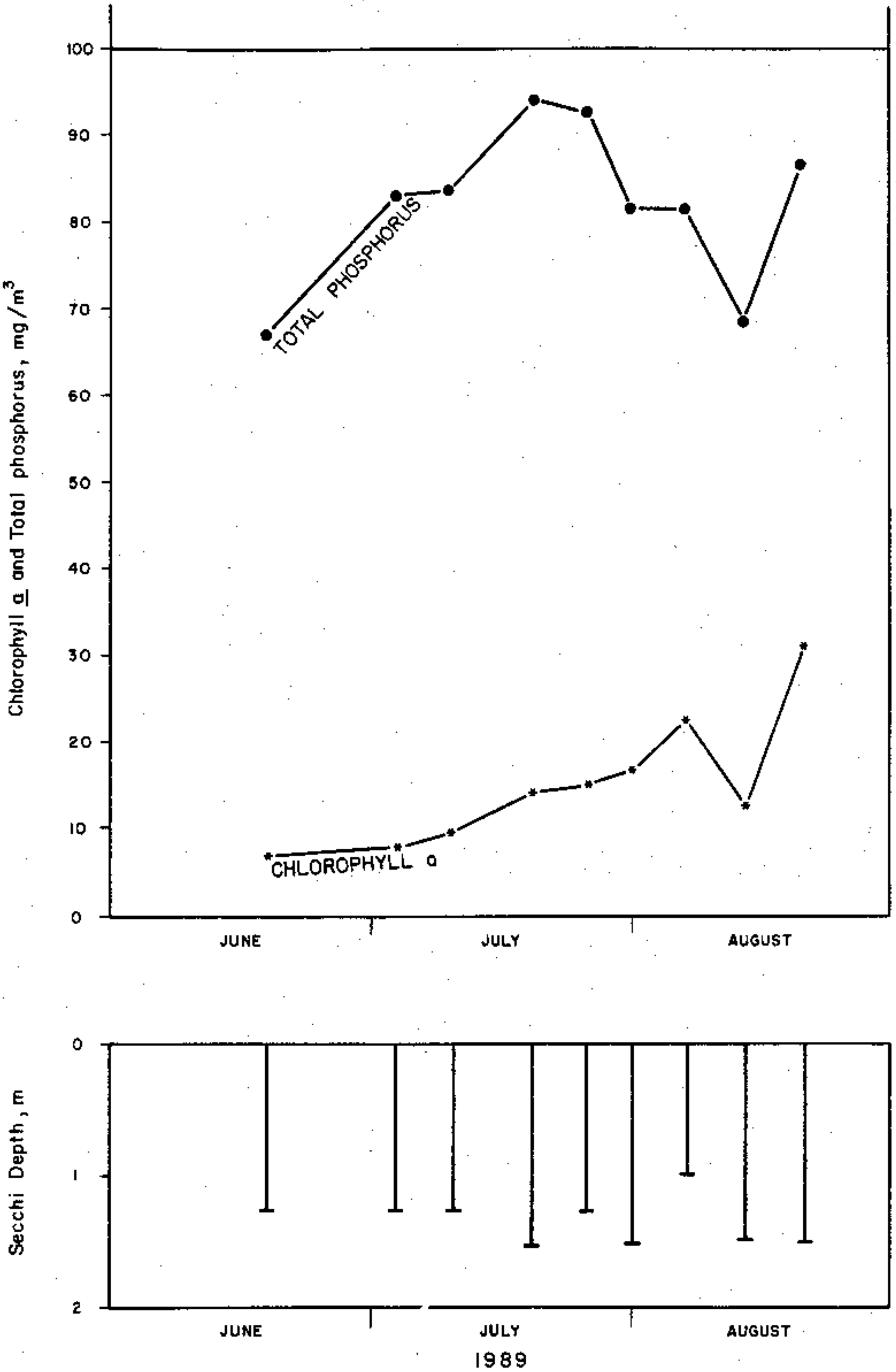

Figure 5. Concentrations of total phosphorus and chlorophyll a, and Secchi depth in Buffalo Lake, 1989.

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in phosphorus levels in mid-summer probably result from a release or recycling of phosphorus from the bottom sediments. Most prairie lakes have a large supply of phosphorus stored in the bottom sediments; these sediments and their associated phosphorus have been accumulating since the lake formed 10,000 or so years ago. Under certain conditions, the stored phosphorus moves into the overlying water and provides a natural fertilizer for the algae growing in it. The high chlorophyll concentrations in Buffalo Lake in August reflect this increase in phosphorus.

In most lakes, transparency (Secchi depth) declines when algal populations are high. However, in Buffalo Lake there was little relationship between the amount of chlorophyll and transparency. This may be because wind action continually resuspends bottom material, which reduces transparency even when the amount of algae is low, as in June and early July.

With an average chlorophyll of 15.0 mg/m^3, Buffalo Lake would be considered eutrophic in 1989 (see Fig. 6), but the historical average chlorophyll is lower. The volunteer lake monitoring data are likely higher because the program is conducted during the warmest (and greenest) part of the summer. The phosphorus level in the lake is quite high, relative to chlorophyll, suggesting a hyper-eutrophic lake. The high salinity of Buffalo Lake suppresses the growth of algae somewhat. If the lake were fresher, denser algal growth would be expected.

Capt. Eyre Lake

The water of Capt. Eyre Lake has higher levels of salts than that of many Alberta lakes, and the total salt content (estimated as

APPROXIMATE TROPHIC CATEGORIES FOR ALBERTA LAKES BASED ON AVERAGE SUMMER CHLOROPHYLL a CONCENTRATIONS

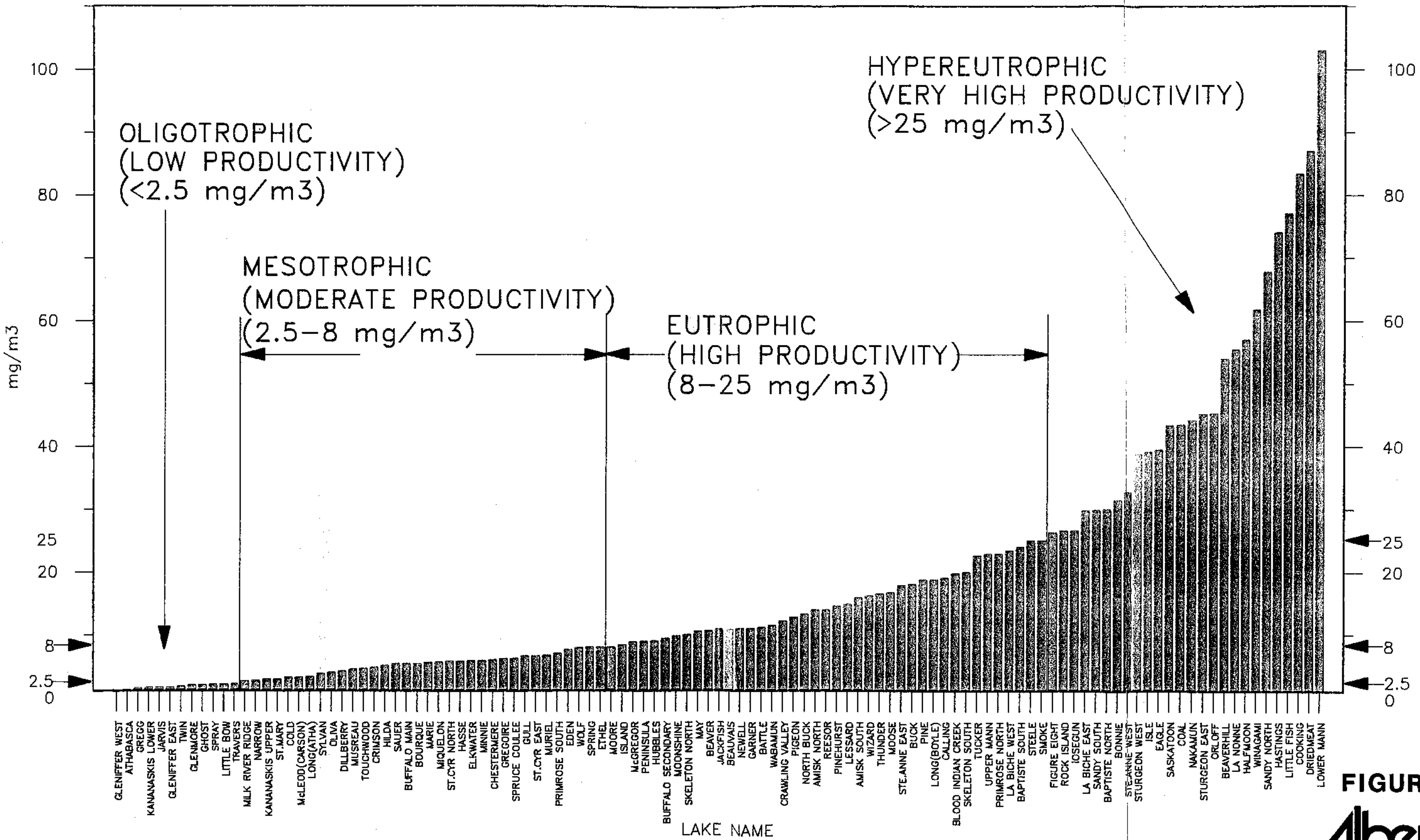

FIGURE 6

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total dissolved solids) indicates it is borderline saline (see Table 2). However, it has lower salinity than Buffalo Lake. The dominant salts, or ions, are sodium, sulfate and bicarbonate.

On August 24, 1989, temperature, pH, conductivity and dissolved oxygen concentrations were measured at 1 m intervals from the surface of the lake to the bottom at 6 m. The temperature ranged from 19°C at the top to 18.6°C at the bottom (Fig. 4), indicating that the lake was well-mixed. The dissolved oxygen concentration was nearly uniform through the water column, as indicated by the vertical line on the graph. Data collected in previous years by staff of Fish and Wildlife Division in winter and summer indicate that the lake maintained reasonable oxygen levels most of the time.

Total phosphorus concentrations were fairly uniform over the summer (Fig. 7). There was a slight increase on the last sampling date, but it is not possible to predict whether there would be a build-up of phosphorus in the water at the end of summer.

Chlorophyll concentrations (amount of algae) remained fairly low throughout the sampling period, and transparency (Secchi depth) was quite uniform as well. Based on the one summer's sampling, it appears that Capt. Eyre Lake does not develop the intense algal blooms characteristic of many Alberta lakes.

In comparison to most Alberta lakes, Capt. Eyre Lake has good water quality. Figure 6 ranks over 100 lakes that have been studied by the Environmental Quality Monitoring Branch and the University of Alberta. The ranking is based on average chlorophyll concentration for

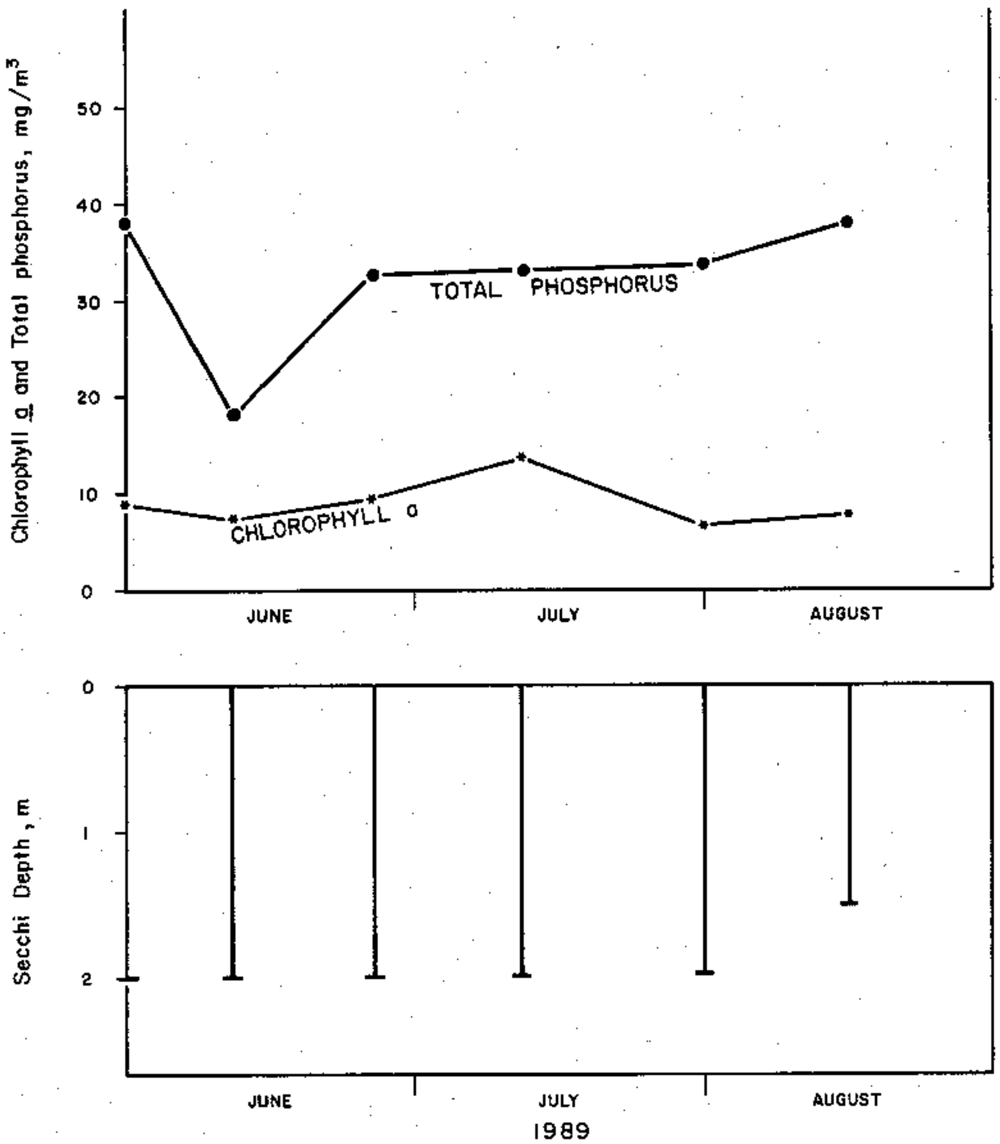

Figure 7. Concentrations of total phosphorus and chlorophyll a, and Secchi depth in Capt. Eyre Lake, 1989.

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one or two summers. Capt. Eyre Lake, with an average summer chlorophyll a concentration of 9.0 mg/m^3 for 1989 falls into the low end of the eutrophic range. However, the average concentration for 1989 did not include samples collected in May or September, as did most of the other lakes on this chart. Therefore, the ranking of Capt. Eyre Lake is tentative. Phosphorus levels in the lake indicate it is of relatively low productivity in terms of algal growth, however, and a full open-water period average chlorophyll would likely be lower than the June - August average.

Skeleton Lake

Skeleton Lake is a freshwater lake, meaning that levels of dissolved salts are relatively low. The salts with the highest concentration are bicarbonate, calcium and magnesium (Table 2). Levels of salts in the lake are well within the concentration range that the native species of fish prefer.

Data on temperature and dissolved oxygen from the lake surface to the bottom provide information about mixing patterns and the suitability of the lake to overwinter fish. Previous studies on Skeleton Lake indicate that the deep, protected north basin forms distinct temperature layers during the summer. Warm, wind-circulated water forms a layer that extends from the lake surface to about 8 m deep. Below this, the water is cool and static - it does not circulate with the upper layer, and there is little or no oxygen in this zone. The main basin of the lake is shallower, however, and these distinct layers form only temporarily during the summer. The bottom layer of water is relatively warm, and on windy days the two layers mix together.

On September 7, 1989, EQMB staff measured the temperature and dissolved oxygen at 1 m intervals from the lake surface to the bottom in the main basin of Skeleton Lake (see Fig. 4). On this day there was a 25 - 30 km/hr wind blowing from the northwest, and the lake was well-mixed and therefore well-oxygenated. This is indicated by the vertical lines on the graph. Data collected in previous years indicate that on calm, hot days in mid-summer, when the water is green with algae, there would be little oxygen in the deepest water. This condition is quite typical of many fertile lakes in Alberta.

Phosphorus and chlorophyll a concentrations provide information on the fertility or productivity of the lake. Algal growth is the most obvious manifestation of fertility in lakes, and chlorophyll a concentration is an indicator of this growth. The graphs in Figure 8 show how total phosphorus, chlorophyll a and Secchi depth changed over the summer. These measurements indicate that the amount of phosphorus and chlorophyll in the water and its transparency, was fairly constant. In other years, there has been a chlorophyll peak in August; for example, the chlorophyll a concentration in late August 1978 was over 60 mg/m^3. The amount of algal growth in this lake appears to vary considerably from year to year.

The average chlorophyll a concentration in 1989 places the lake in the eutrophic or highly productive range (Fig. 6), although it is lower on the scale than in other years. One may conclude from these data that Skeleton Lake had fairly good water quality in 1989.

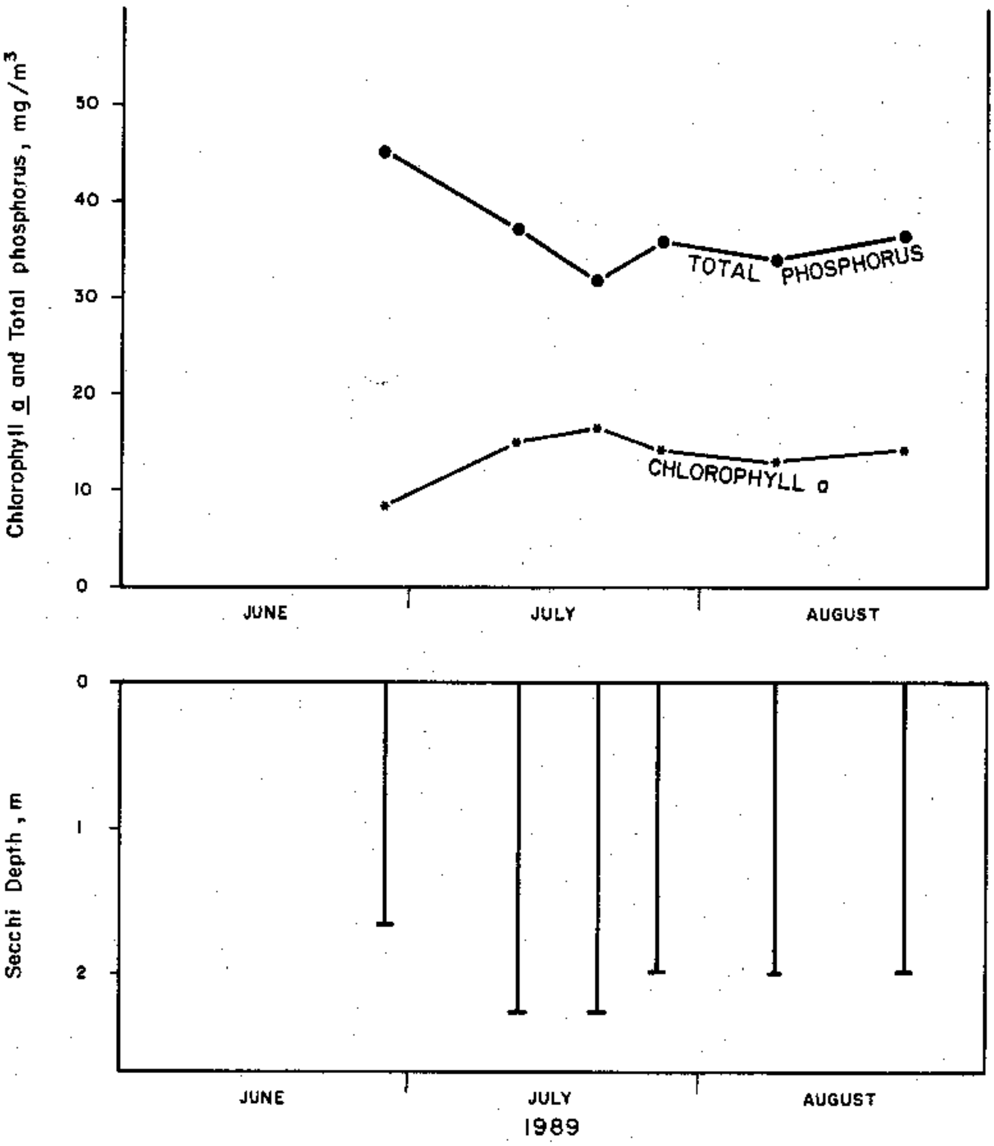

Figure 8. Concentrations of total phosphorus and chlorophyll a, and Secchi depth in Skeleton Lake, 1989.

SUMMARY

The Volunteer Citizens' Lake Monitoring Program was conducted on Buffalo, Capt. Eyre and Skeleton lakes in 1989. The sampling period included weekly or twice monthly samples during June, July and August. The focus of the sampling program was on indicators of fertility - chlorophyll a, total phosphorus and Secchi depth.

Buffalo Lake had the highest phosphorus and chlorophyll a concentrations and it is also the most saline (salty). Capt. Eyre Lake was the least productive of the three, and is intermediate in salinity. All three lakes were well-mixed and well oxygenated from the lake surface to the bottom. These lakes are eutrophic.

The program was very successful, and the volunteers did an outstanding job with the sample collection. The data from Capt. Eyre Lake is particularly useful, because it is the first set of monitoring data for nutrients and chlorophyll from this lake. Data from the other two lakes contributes to the long-term database for two heavily-used recreational lakes.