Volunteer Citizens' Lake Monitoring Program (1992)

Shorncliffe, Goose and Islet Lakes

by:

Patricia Mitchell

Environmental Quality Monitoring Branch
Environmental Assessment Division
Alberta Environmental Protection

July 1993

voluntr.pam

ACKNOWLEDGEMENTS

The Volunteer Citizens' Lake Monitoring Program was coordinated this year by Cecil Yarmoloy on Islet Lake, Terry Beck and John Sullivan on Shorncliffe Lake, and Gene Lefebvre and George Bowler on Goose Lake. John Willis of the Environmental Quality Monitoring Branch conducted the program for Alberta Environmental Protection, and Morna Hussey of the Branch undertook phosphorus and chlorophyll *a* analysis. Dr. Fred Dieken's group at the Alberta Environmental Centre in Vegreville analyzed samples for major ions and other constituents. Survey Branch provided water level and flow information.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The volunteer citizen's lake monitoring 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 to recognize the detrimental activities of others.

The program has three main objectives:

- To provide an opportunity for lakeshore property owners to learn first hand about water sampling procedures related to lake management.
- To improve the existing water quality database for a particular lake.
- To encourage environmental responsibility among lake users.

The Environmental Quality Monitoring Branch (EQMB) began the program in 1988 as a pilot study on Lac Ste. Anne and Pigeon Lake, and it has continued to the present with the following lakes:

1989 - Skeleton, Capt. Eyre, Buffalo lakes
1990 - Lac la Nonne
1991 - Buck Lake
1992 - Islet, Shorncliffe, Goose lakes

The focus of the sampling program each year is an assessment of the lake's fertility. The fertility of a lake, as with the fertility of soil on a farm, is its ability to grow plants. But in a lake, the plants of concern are the algae that turn the water green in summer. To assess this, samples are collected 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 samples collected from the open water, rather than with individual samples collected from localized shoreline areas. Conditions along the shoreline vary from day to day and even from daylight to dark. One area of a shoreline may be very different from another area because of the amount of terrestrial and aquatic vegetation, effects of development, wind and wave action, and presence of inflowing creeks. An open water sample represents a blending or synthesis of all these effects. We recognize, however, that lake users are very concerned about the impact of various activities on the section of lakeshore near their cottage. They have particular concerns about the amount of weed growth along the shoreline and possible bacterial contamination of swimming areas from sewage. These issues are valid, and Alberta Environmental Protection conducts specific studies on certain lakes to address shoreline issues. These studies are not done routinely, however, because they involve considerable manpower and expense.

The samples collected by volunteer citizens provide background information that can be used to assess future impacts and enhance the existing database on lakes that could not be sampled that year. The high sampling frequency (weekly or twice monthly) during the summer is particularly useful for assessing seasonal trends in algal populations in the lakes under study.

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 to farm crops or lawns. These are chemical elements like phosphorus, nitrogen, potassium and sulfur. But crops on land usually need added nitrogen, whereas aquatic plants may be deficient in phosphorus. 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. In many Alberta lakes, however, there is enough phosphorus (and nitrogen) to allow considerable growth of algae. Sources of nutrients to these lakes include:

- streams and small ditches that run through cottage subdivisions, agricultural land, and areas of natural vegetation,
- rain, snow and dust that falls directly onto the lake,
- effluent from faulty or poorly placed sewage systems,
- ponds or lakes upstream

- groundwater
- mud or sediment at the bottom of the lake

Of these, runoff over various types of land use is usually the largest source outside of the lake. But the bottom sediment may provide an even larger supply of phosphorus to the lake water in summer. Throughout the history of these lakes, the bottom mud has accumulated phosphorus by binding chemically with it. Under certain conditions, particularly when the lake is warm in summer and oxygen levels near the bottom are low, the phosphorus moves out of the sediments and into the overlying water. Algae living in the water respond by producing the thick growths known as algal blooms. The algae responsible are usually a type called **blue-green algae**.

Chlorophyll *a*

Chlorophyll *a* is a photosynthetic pigment found 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. The amount of chlorophyll *a* is used directly to indicate a lake's fertility level or **trophic status**. **Eutrophic** is a technical term used to describe a lake with a high level of fertility. A eutrophic lake is green most of the summer, but it may not develop the noxious algal blooms that people call "pea soup". When a lake is very highly fertile, so that recreational pursuits are limited, it is termed **hyper-eutrophic.** Lakes that are lower in fertility than either of these categories are called **mesotrophic** (moderately fertile) or **oligotrophic** (infertile). In Alberta, there are very few oligotrophic lakes outside of the mountains, but there are a small number of mesotrophic ones. They tend to be excellent for recreation.

Secchi Disk Transparency

The 20 cm diameter black and white metal plate called the Secchi disk has been used around the world for over 100 years as an indicator of lake water quality. It measures the clarity of the water. 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.

The depth that light can penetrate decreases as the turbidity of the water increases. The **euphotic depth** is the maximum depth that light penetrates on a particular day to reach actively growing plants. Beyond this depth, there is insufficient light for plants to grow. The euphotic depth in Alberta lakes has been calculated to be about twice the Secchi depth, based on studies on several lakes in which a light meter was used to measure light penetration. The light meter measures only the wavelengths of light that plants need for photosynthesis.

General Water Chemistry

Water in lakes is never "pure". It always has various chemical substances dissolved or suspended in it that have been picked up in rain and snow or have entered the lake in groundwater and inflow streams. Some of these substances are familiar, such as sodium and chloride, which when combined are table salt, but when dissolved in water separate into the two chemicals. Chemicals that separate like this into electrically charged particles are called **ions**. All the ions in a particular lake sample make up its salinity, or saltiness, and this is measured as **total dissolved solids (TDS)** or **specific conductance**. Within individual lakes, ion concentrations vary from year to year depending on the amount and mineral content of the water entering the lake. This year to year variation is very small compared to the variation from lake to lake across Alberta.

When a lake is very saline, game fish and other organisms may not be present, and the amount of algae in the water may be less. A lake that is low in total dissolved solids is said to have fresh water, whereas a lake that has between 500 and 1000 mg/L TDS is said to be slightly saline. Water that has over 1000 mg/L but less than 5000 mg/L TDS is considered moderately saline. Very few Alberta lakes have TDS concentrations higher than 5000 mg/L. Sea water has a TDS concentration of about 35,000 mg/L.

GENERAL CHARACTERISTICS OF THE LAKES SAMPLED IN 1992

Goose Lake

Goose Lake is a small, attractive lake located about 20 km west of Ft. Assiniboine, Alberta. It has an average depth of 4.5 m, and a maximum depth of 6 to 7 m (Table 1, Figure 1), and therefore it may be considered a shallow lake. The watershed area surrounding the lake is very large compared to its surface area (about 40 to 1), so that the calculated inflow volume and yearly flushing rate are quite high.

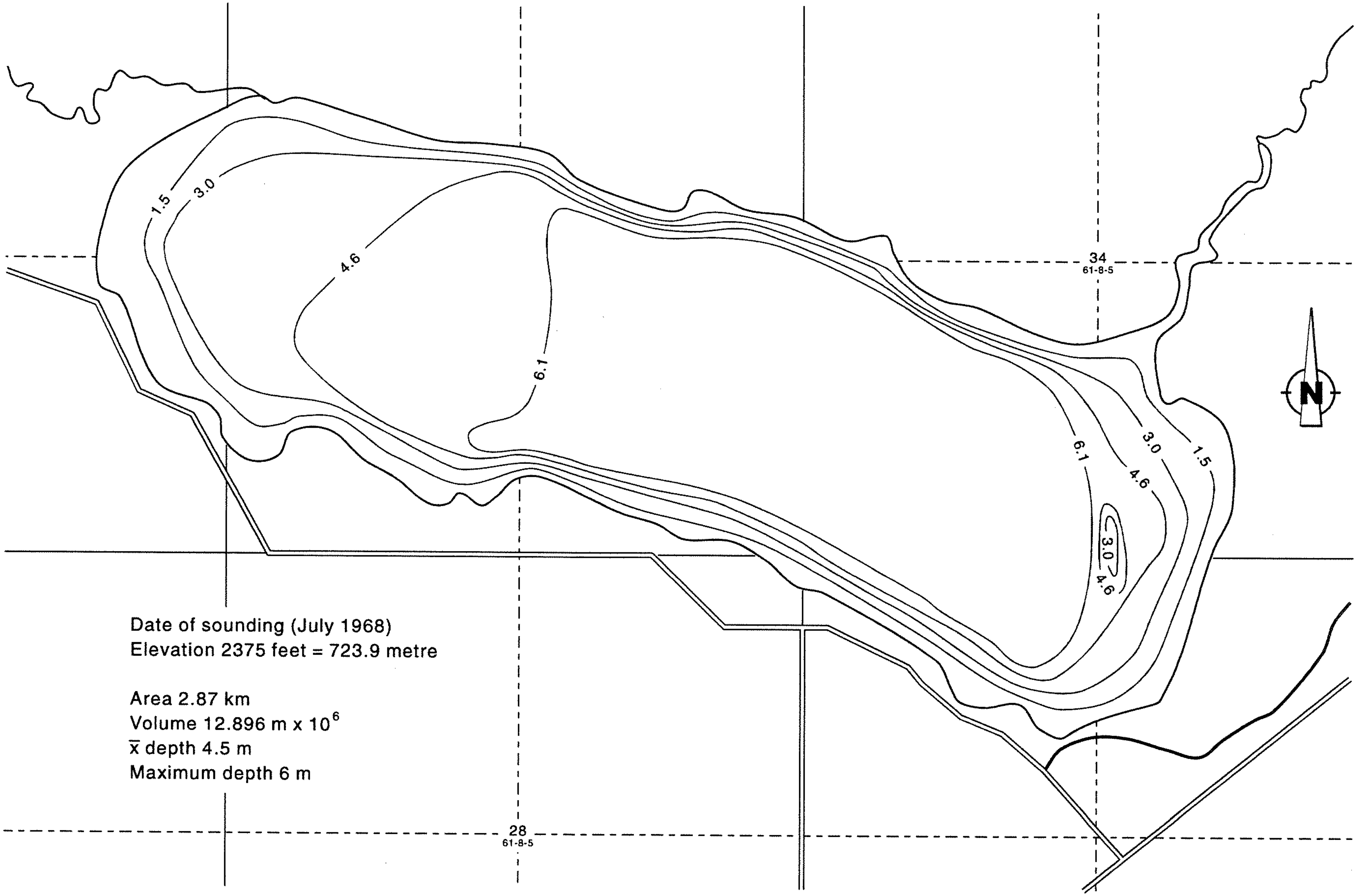


Figure 1. Hydrographic survey of Goose Lake

Table 1. Physical characteristics of the lakes.			
	GOOSE	ISLET	SHORNCLIFFE
Lake Area, km^2	3.03*	1.31**	about 2.5
Volume, m^3 **x** $\mathbf{10^6}$	12.896*	3.31**	unknown
Max. depth, m	6 - 7*	4.15**	< 4
Average depth, m	4.5*	2.5**	< 2
Drainage basin area, km^2	116.45	11.11	---
Elevation (m) above sea level	723.9*	approx. 739 m	---
Water residence time, years	1.4	>100	---

* on date of sounding, July 1968
** at 100.4 m assumed elevation on date of sounding, March 9-12, 1992 (Samide Eng. 1992)

In 1992, a study began to determine whether flushing through the lake could be improved by removing beaver dams upstream of the lake, and opening the weir on the outlet in mid-summer. The objective was to reduce nutrient concentrations in the lake over the long term, to improve water quality.

The main inflow stream to Goose Lake is located on its western end, and the outflow is on its eastern end. Both the inflow and outflow are called Goose Creek. The outflow creek eventually drains to the Athabasca River. There are several other small drainage channels to Goose Lake, but by far the largest surficial source of water to the lake is Goose Creek. The lake may also be fed by groundwater, but the extent and volume are unknown.

A weir was put on the outlet in 1976, and since then water level has been relatively stable. However, the structure has heaved somewhat, so that the sill elevation now is estimated to be 724.29 m, rather than the design elevation of 723.91 m. In 1992, the elevation of the outlet with stop logs in place was estimated to be at about 724.51 m. A beaver dam downstream of the weir controlled the lake elevation in 1992, but it was removed. The dams were re-built by 1993, so it is likely that this will be an on-going problem.

The lake's inflow was also controlled by beaver dams until 1992, but these were removed as well. However, there was insufficient rain during the summer of 1992 to allow water trapped behind the dams to move into Goose Lake.

Much of the watershed surrounding Goose Lake is undeveloped, with trees and shrubs in upland areas and willow swamp in low-lying areas. Some of the land area near the lake has been cleared for agricultural purposes or recreation, but this forms a very small percentage of the total watershed area.

Shorncliffe Lake

Shorncliffe Lake is a shallow, elongate lake set in farmland and grassland of eastern Alberta. It is located southeast of Hughenden and northwest of Czar, in the Provost area. There is very little information available about the physical characteristics of this lake, as it has not been sounded and water level readings are not taken. The lake is shallow, perhaps in the 3 to 4 m range. The drainage basin appears to be quite large compared to the size of the lake. Shorncliffe Creek flows into the lake from the south and west (Figure 2), and the lake outflow joins Ribstone Creek, which flows into the Battle River.

On the east end of the lake there are a number of cottages and a popular Municipal park managed by the Shorncliffe Lake Park Association. Farming in the watershed includes cereal crops, primarily wheat and barley, and tame hay. About 40% of the area around the lake is cultivated, 40% is in tame hay and 20% is natural grassland. There are about 250 head of cattle on the hay and grassland surrounding the lake, although this varies from season to season (Sullivan and Beck, pers. comm.).

Islet Lake

Tiny Islet Lake is located in the Cooking Lake moraine east of Edmonton and south of Elk Island National Park. It is a lovely, natural body of water frequented by wildlife and people who enjoy watching them. The lake is irregular in shape, with one large island in the centre and several small islands around the edge (Figure 3). The physical characteristics of the lake are presented in Table 1. There are no permanent inflow streams to Islet Lake, but the outflow usually runs. Beavers control the outlet stream, which drains toward Wakinagan Creek and Beaverhill Lake (Samide Eng. 1992). Groundwater probably plays a role in the lake's water balance. Water level records are not available. The watershed is largely undeveloped, although there are cottages along the south shore. On the east shore is the Islet Lake Staging Area in the Cooking Lake-Blackfoot Provincial Recreation Area.

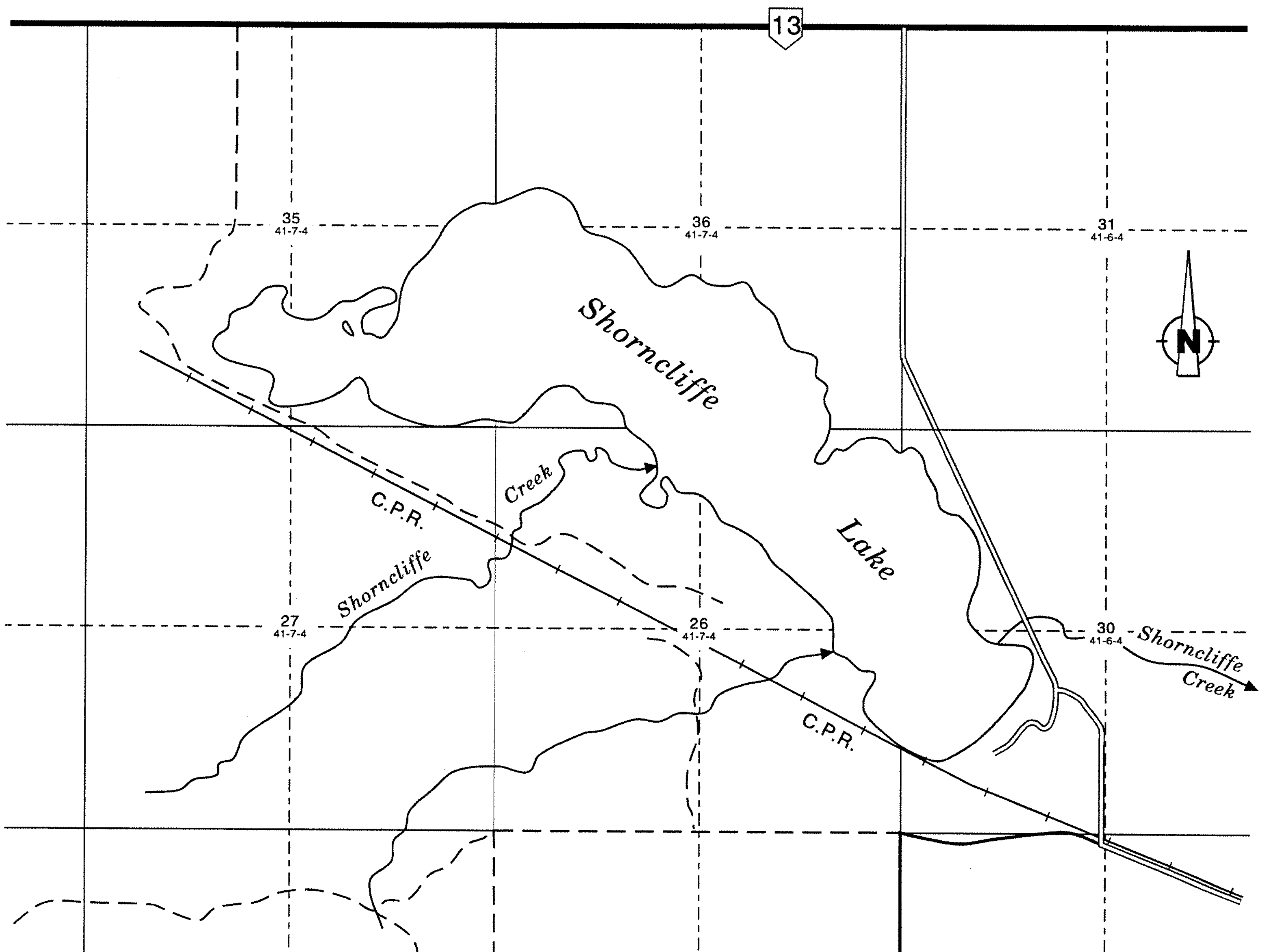


Figure 2. Map of Shorncliffe Lake

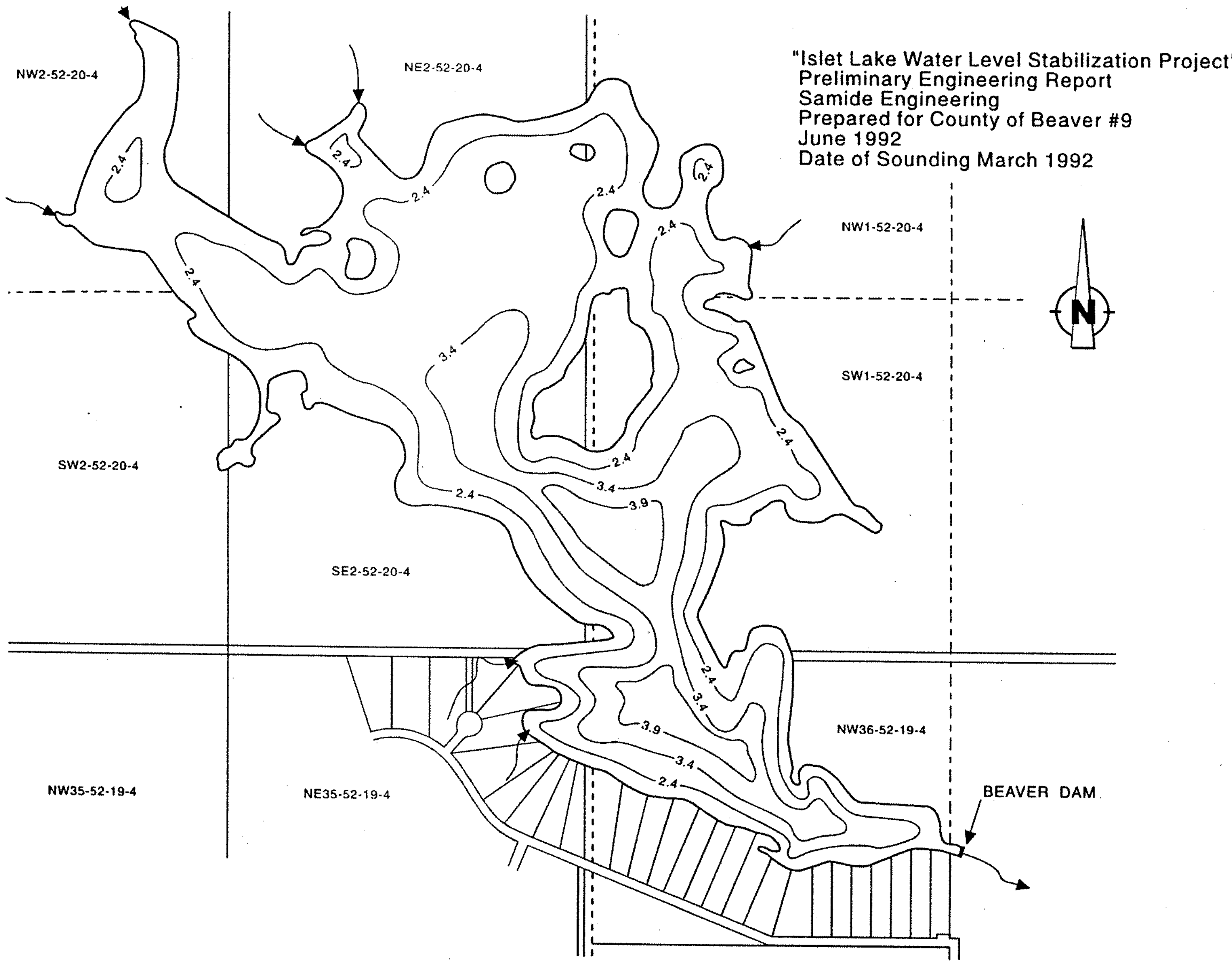


Figure 3. Hydrographic survey of Islet Lake

METHODS

In early May, the volunteers at each lake were trained by EQMB staff, and samples were collected from Goose and Shorncliffe. The monitoring program was coordinated by Cecil Yarmoloy on Islet Lake, Gene Lefebvre and George Bowler on Goose Lake and Terry Beck and John Sullivan on Shorncliffe Lake. Sampling frequencies are listed in Table 2. In addition, EQMB staff conducted profile measurements of dissolved oxygen, temperature, specific conductance and pH in mid-summer on each lake.

On each sampling day, volunteers in their own boat 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-metre 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. The euphotic depth was 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-metre 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.

Table 2. Frequency of sampling in the volunteer lakes 1992.

GOOSE	SHORNCLIFFE	ISLET
May 6 - T, G	May 7 - T, G	May 14 - T, G
May 24 - T, G	May 14 - T	May 24 - T
June 8 - T, G	May 27 - T, G	June 1 - T
June 21 - T	June 1 - T	June 21 - T, G
July 5 - T, G	June 8 - T, G	July 5 - T
July 12 - T	June 15 - T	July 16 - T, G
July 16 - P	June 23 - T	July 31 - T
July 19 - T	June 29 - T	August 5 - T, G, P
July 29 - T	July 7 - T, G	August 12 - T, G
August 6 - T, G	July 20 - T	August 24 - T
August 19? - T	July 28 - T, G	September 10 - T, G
August 30 - T, G	August 10 - T	October 21 - T, G
September 17 - T, G	August 17 - T, P	
	August 24 - T, G	

T = Chlorophyll, Secchi, Phosphorus G = general chemistry P = Profile

The large jug of sample water was brought back to the coordinator's cottage or other location. The jug was agitated, and the water was poured into several plastic bottles for analysis of nutrients and major ions. 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 bottles of sample water were kept cold and returned to the EQMB facility in Edmonton for further processing and analysis. In the lab, the filters were put into a solvent which extracted the chlorophyll *a* from the algae on the surface of the filter. This extract was read in a fluorometer to determine the concentration of chlorophyll *a*. One bottle of lake water from the composite sample was submitted to the Alberta Environmental Centre in Vegreville for analysis of major ions, and the remaining bottles were retained by EQMB staff for analysis of phosphorus , an important plant nutrient.

RESULTS AND DISCUSSION

Goose Lake

Goose Lake is a freshwater lake. Table 3 indicates average concentrations of major ions in Goose Lake in 1992, as measured in the "routine" samples submitted by the volunteers. The dominant ions are bicarbonate and calcium, as is typical of many lakes in central Alberta. During the summer, a heavy rainstorm on the lake diluted substances dissolved in the water, lowering concentrations of many of the major ions. Concentrations gradually increased again over the latter part of the summer as evaporation concentrated these substances.

Temperature, conductivity, pH and dissolved oxygen were measured at one-metre intervals from the lake surface to the bottom on July 16, 1992. Temperature and dissolved oxygen profiles are illustrated in Figure 4. Goose Lake is relatively shallow, and therefore the water mixes from the surface to the bottom on windy days. Thus, the the temperature is fairly uniform, although protected bays would likely be warmer in summer. The dissolved oxygen profile indicates that there is a large amount of oxygen in the water near the surface, but somewhat less at the bottom. Such depletion of oxygen near the bottom is typical of highly productive lakes. Decomposition by bacteria and respiration by the abundant plant and animal life use up the oxygen, particularly at night. Summer kill of fish, which may occur rarely in Goose Lake, is caused by such

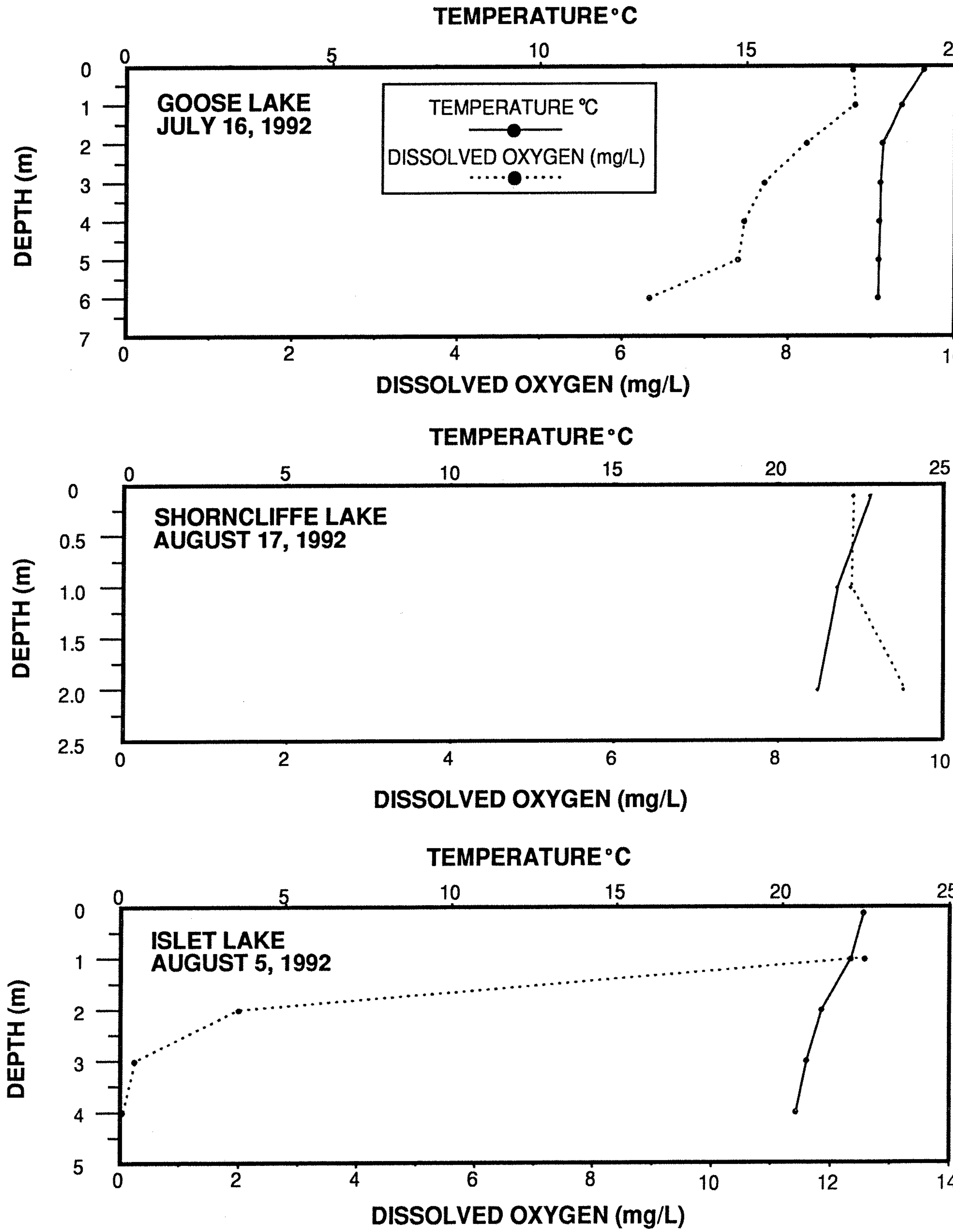


Figure 4. Vertical profiles of temperature and dissolved oxygen in Goose, Islet and Shorncliffe Lake.

Table 3. Average concentrations of major ions, nutrients, chlorophyll *a* and other variables for Goose, Shorncliffe and Islet lakes in summer 1992. Units are mg/L unless indicated otherwise.

	GOOSE	SHORNCLIFFE	ISLET
pH (range), pH units	8.06 - 9.24	9.00 - 9.29	7.99 - 9.23
Conductivity, uS/cm	279	3567	323
Total Dissolved Solids	153	2240	175
Calcium	34	13	41
Magnesium	11	151	16
Sodium	11	596	8
Potassium	2.4	26.1	11.3
Sulphate	<3	510	4
Chloride	0.7	522	3.1
Bicarbonate	179	621	190
Carbonate	3	116	7.4
Total Hardness, $CaCO_3$	130	655	150
Total Alkalinity, $CaCO_3$	152	684	168
Iron	0.06	0.03	0.05
Silica	4.9	2.4	14.4
Total Phos., mg/m^3	71	71	174
Chlorophyll *a*, mg/m^3	28.1	9.11	114
Secchi depth, m	3.1	1.75	1.4

oxygen depletion. The highest risk of this is at the end of a cycle of rapid algal growth and when the weather is calm and hot.

Total phosphorus and chlorophyll *a* concentrations varied considerably over the summer in Goose Lake (see Figure 5). In May and June, the water was quite clear as is seen by the 4 to 5 m Secchi depths and the low chlorophyll concentrations. By mid-July, the amount of algae in the water had increased, and in August the lake was very green. Transparency was greatly reduced, as might be expected when the lake looks like "pea soup". By the end of August, the amount of algae (chlorophyll) was much less, even though there were still high concentrations of total phosphorus. Stop-logs in the weir had been taken out in early August, and it was noted that large amounts of algae were passing out of the lake via the outflow. However, it is unlikely that this removed much algae because the outflow ran for only two weeks, and the highest concentration of chlorophyll occurred after the stoplogs were replaced on August 17.

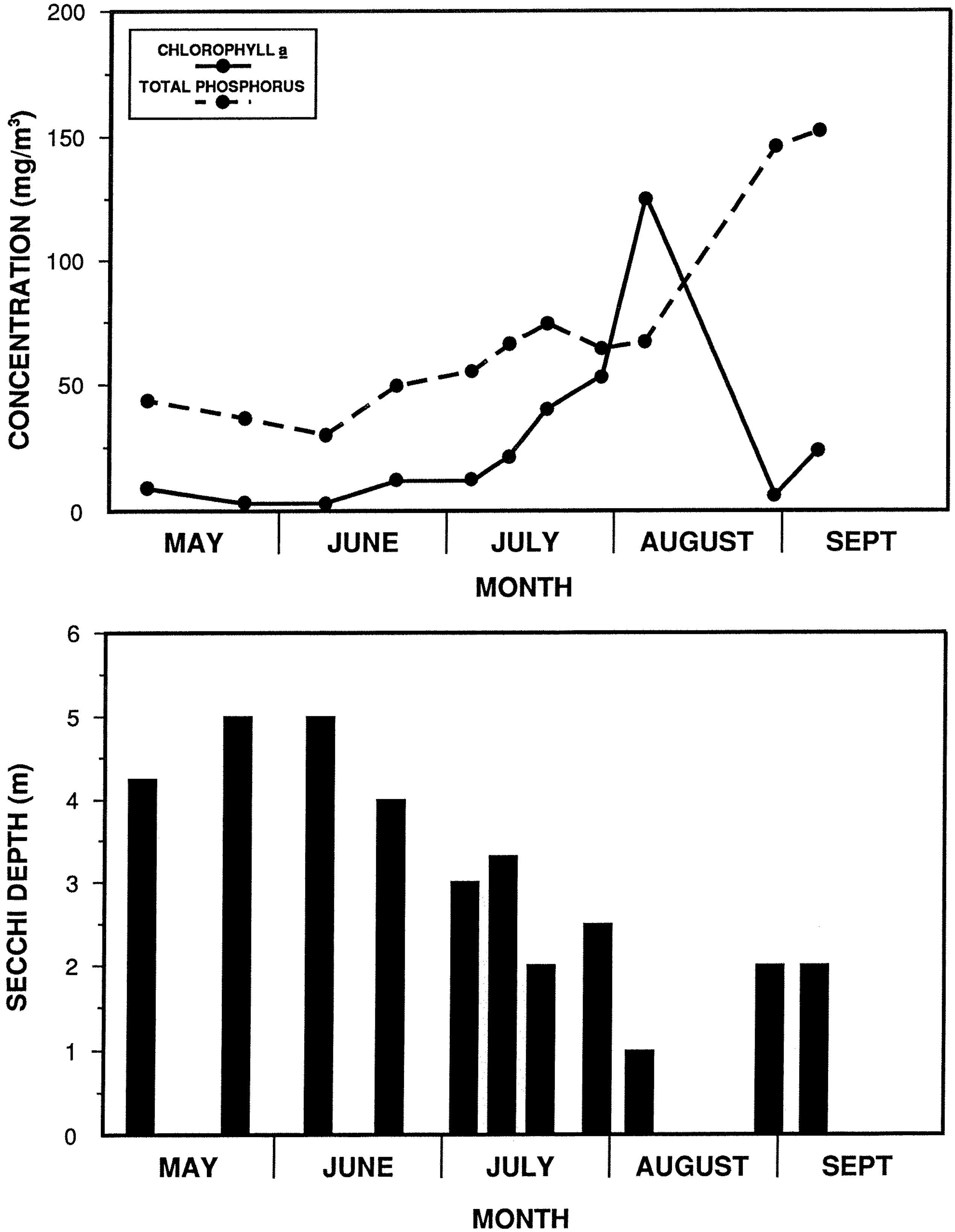


Figure 5. Secchi depth and concentrations of chlorophyll a and total phosphorus in Goose Lake, summer 1992.

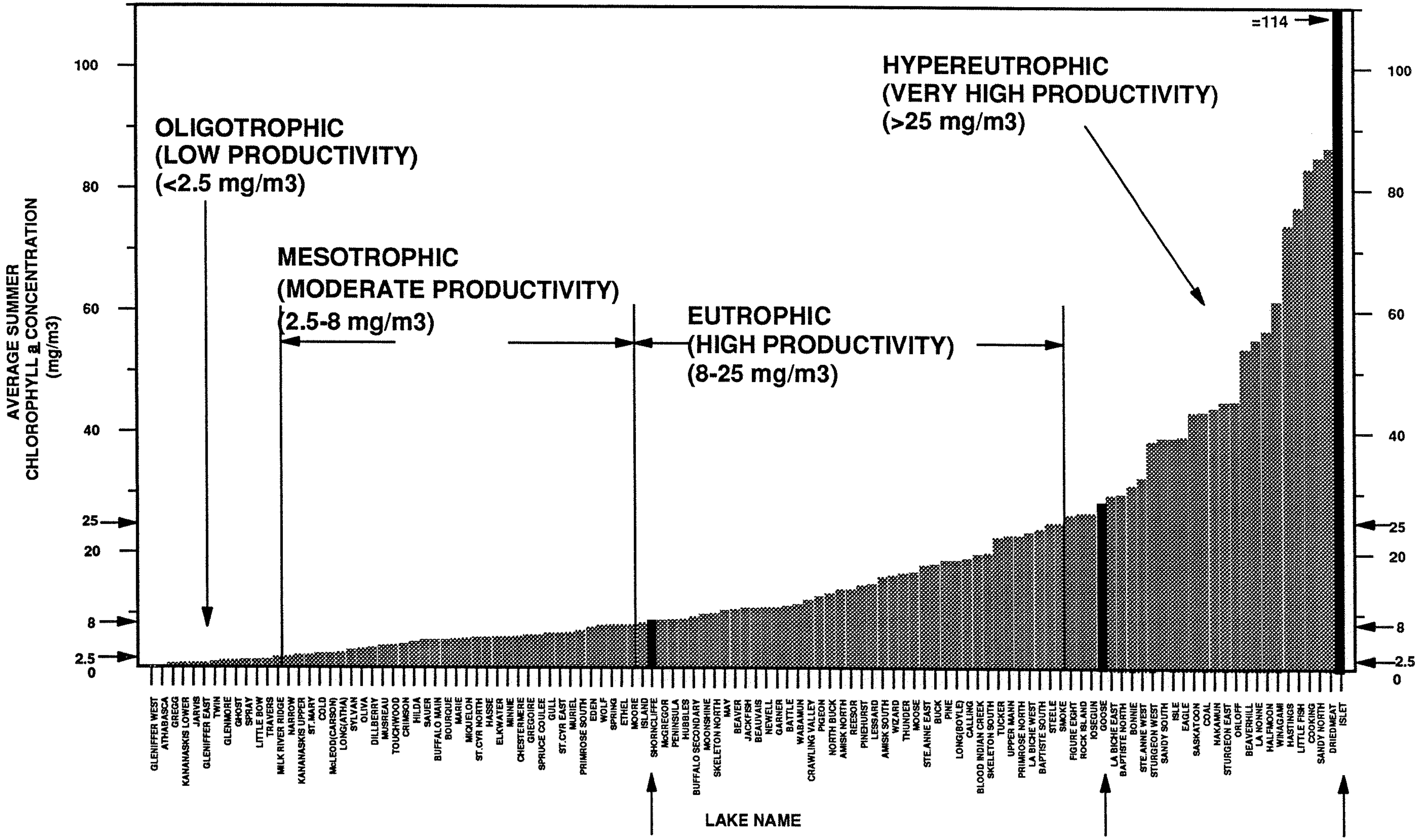
In Table 4, the water quality data gathered in 1992 are compared with those from the last time the lake was monitored, in 1988 and 1989. There appears to have been a decline in average phosphorus and chlorophyll concentrations and the water was slightly clearer in 1992. This is likely a response of the lake to climatic conditions, rather than a long-term improvement in water quality, but additional years of sampling will be needed to determine this.

Average chlorophyll and phosphorus concentrations provide an indication of a lake's fertility or trophic status. For Goose Lake, the average chlorophyll *a* concentration for all three study years falls into the hyper-eutrophic, or very high productivity, range (Figure 6).

The purpose of the 1992 study on Goose Lake was to determine whether water quality could be improved by increasing flushing during the period when phosphorus levels were highest. It was hoped that the amount of phosphorus in the lake could be reduced by removing a portion each year, and this in turn should reduce the amount of algae in the water. It is estimated that 243,000 m^3 of water passed through the outlet in August, and the average measured phosphorus concentration in this water was 100 mg/m^3, for a total loss of 24,300,000 mg of phosphorus, or 24 kg. This is a small amount compared to the calculated quantity in the lake at the time, 1300 kg, or the internal load over the summer, 1500 kg. Unfortunately, precipitation over the summer was below normal, and there was no inflow, in spite of removal of beaver dams along Goose Creek above the lake. It must be assumed that the enhancement operations conducted in 1992 would have very little benefit for the long-term.

Table 4. Secchi depth and concentrations of total phosphorus and chlorophyll *a* in Goose Lake, 1988, 1989 and 1992. Averages, May through September.

	1988	**1989**	**1992**
Secchi Depth, m	2.6	3.0	3.1
Total Phosphorus, mg/m^3	209	118	71
Chlorophyll *a*, mg/m^3	43.2	32.7	28.1



* Amount of algae estimated by Chlorophyll a concentrations

Figure 6. Amount of algae* in Shorncliffe, Goose and Islet Lake compared with other Alberta lakes.

<u>Shorncliffe Lake</u>

Shorncliffe Lake had not been sampled before the volunteers sampled it in 1992. Therefore nothing was known about its water chemistry or biology. The sampling program revealed that the lake is moderately saline; that is, the water contains fairly high concentrations of dissolved substances. This condition is natural, and a number of other lakes in the area are saline as well. Shorncliffe Lake has a different proportion of major ion concentrations than the other two lakes in Table 3. Note that sodium, sulphate, chloride and bicarbonate are high, but calcium and magnesium are relatively low. Calcium joins with bicarbonate/carbonate and precipitates out of the water as calcite or marl. The high concentrations of other minerals are probably a result of groundwater inputs, runoff through local soils, and evaporation, which removes water but not the mineral salts. Concentrations of these major ions will vary somewhat from year to year, and seasonally, depending on the amount of rainfall and runoff from snowmelt and evaporation over the summer.

Dissolved oxygen, temperature, pH and conductivity were measured at 1 m intervals from the lake surface to the bottom on August 17, 1992. Figure 4 shows that this "profile" for temperature and dissolved oxygen was fairly uniform from top of the lake to the bottom. Water temperature tends to reflect air temperature in lakes that are as shallow as Shorncliffe. Note that there was more oxygen at the bottom in Shorncliffe than in the other two lakes. Those lakes had considerably more algae in the water, which would lead to oxygen depletion at the bottom. The high level of oxygen at the bottom provides further evidence that Shorncliffe Lake has relatively good water quality.

Total phosphorus and chlorophyll *a* concentrations in a lake are direct evidence of its water quality. The top graph in Figure 7 shows variations in phosphorus and chlorophyll over the summer and the bottom graph shows variations in transparency (Secchi depth). The transparency of the water was greatest in June, and chlorophyll *a* concentrations were lowest. As the amount of algae increased in July and August, transparency declined somewhat. Phosphorus concentrations varied over the summer, but did not increase dramatically in July and August as it does in many lakes. Even so, the average phosphorus concentration for the summer is fairly high. It is the same as that in Goose Lake, but the average chlorophyll concentration is very different in the two lakes. Goose Lake has nuisance growths of blue-green algae throughout the summer, whereas

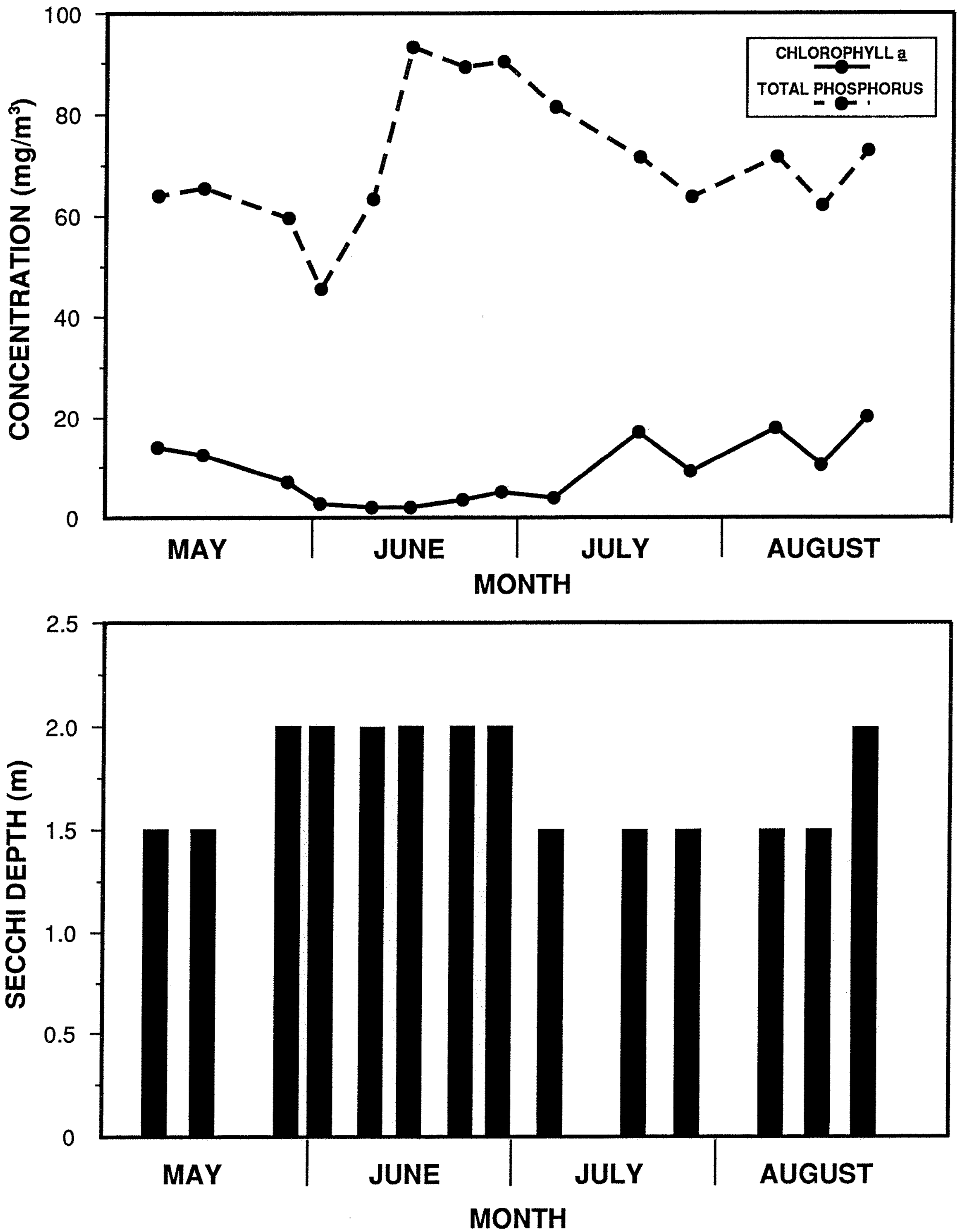


Figure 7. Secchi depth and concentrations of chlorophyll a and total phosphorus in Shorncliffe Lake, summer 1992.

nuisance algal blooms occur sporadically in Shorncliffe Lake. The salinity in Shorncliffe Lake may suppress the growth of algae somewhat, as has been found in other saline lakes in Alberta.

The average chlorophyll data collected during the summer of 1992 are compared with those of other Alberta lakes in Figure 6. Shorncliffe Lake falls into the eutrophic range, but at the low end. This indicates that the water quality is quite good.

Islet Lake

Islet Lake is another lake which had not been sampled previous to the 1992 program. It is a freshwater lake, with relatively low concentrations of total dissolved solids (TDS). Table 3 provides average concentrations of major ions and other chemical characteristics analyzed in the "routine" sample submitted by the volunteers. The dominant ions are calcium and bicarbonate; this is true of in Goose Lake and many other freshwater lakes in Alberta. Note how different Islet Lake's concentrations and proportions of ions are from those of Shorncliffe Lake, which is saline. Concentrations of ions may be expected to vary slightly from year to year and over the summer, depending on the amount of rainfall, evaporation and input from groundwater. The concentrations measured in Islet Lake are within typical ranges for support of aquatic life.

Dissolved oxygen and temperature data were collected all summer at Islet Lake (Table 5). When there was an abundance of algae in the water, dissolved oxygen concentrations exceeded 12 mg/L at the surface, but were much lower at the bottom. This was also true when the profile sampling was done on August 5 (Figure 4). Highly productive lakes like Islet often show this dramatic change in oxygen concentrations from the surface to the bottom of the lake. Oxygen is produced by growing algae near the surface, but respiration and decomposition remove oxygen near the bottom faster than it is replenished, and concentrations decline. At the surface, oxygen may become supersaturated, as it was on August 5, with 200% saturation.

Islet Lake is one of the most productive lakes ever sampled in the province. Its chlorophyll *a* concentration increased 50-fold from the beginning of June to the beginning of August (Figure 8). Heavy blue-green algal blooms occur during the summer, and it is likely that game fish could not survive in this lake because of critical declines in oxygen concentrations, both summer and winter. In spite of this, animal life is abundant,

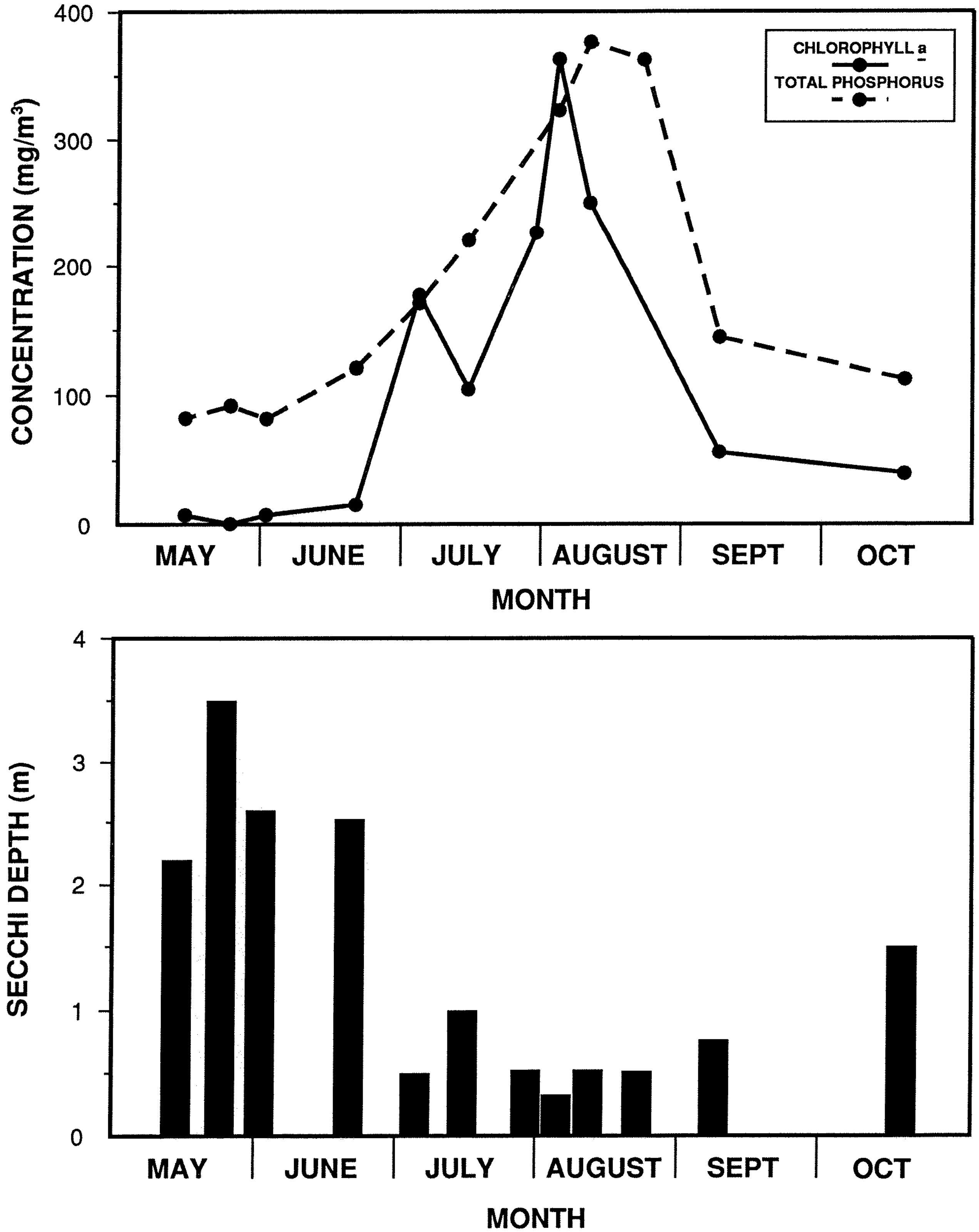


Figure 8. Secchi depth and concentrations of chlorophyll a and total phosphorus in Islet Lake, summer 1992.

Table 5. Dissolved oxygen (mg/L) and temperature (°C) in Islet Lake, 1992.

	DEPTH	DISSOLVED OXYGEN	TEMPERATURE
May 14	Top	6	12
May 24	0 m	6	11
	3.5 m	6	11
June 1	0 m	6	20
	3 m	6	16
June 21	0 m	6	20
	2.5 m	6	20
	3.5 m	4	20
July 5	0	12+	20
	2.5 m	12+	20
	3.5 m	9	20
July 16	0 m	12+	20
	2.5 m	12+	18
	3.5 m	8	18
	4.5 m	6	18
July 31	0 m	-	24
	1 m	12+	22
	4 m	4	20
August 12	0 m	12+	23
	1 m	12+	20
	3.75 m	3	20
August 24	0 m	6	13
	1 m	6	13
	3.5 m	6	-
Sept. 10	0 m	8	15
	1.5 m	8	12
	3.5 m	-	12
October 21	0 m	10	3
	3.5 m	10	10

including the hardy fathead minnow and stickleback. The increase in phosphorus and chlorophyll from early to late summer is typical of many shallow, productive lakes in Alberta. Note that the transparency, as measured by the Secchi disk, declined as the amount of algae in the water increased.

The average chlorophyll level in Islet Lake in 1992 is compared with that of other lakes in Figure 6. The lake is termed **hypereutrophic**, or very highly productive. If average phosphorus values were compared in a similar way, Islet Lake would also fall into the hypereutrophic category, but it is not at the top of the scale as with average chlorophyll. Several Alberta lakes have average phosphorus values that exceed 200 mg/m^3.

The highly eutrophic condition of Islet Lake is likely a result of natural factors, as well as human activities in its watershed. Islet Lake has probably been very productive for thousands of years, but it may be more productive now. The bottom sediments, which have accumulated phosphorus throughout the lake's history, undoubtedly contribute a large portion of the nutrient supply to the lake each summer. This recycling of phosphorus from the bottom of the lake may govern its water quality. Many of the lakes in the area are highly productive without obvious major sources of nutrients from human activities. Although many people object to lakes of this nature, they provide homes for an astonishing and harmonious diversity of plant and animal life.

CONCLUSIONS

The Volunteer Citizens' Lake Monitoring Program was conducted on three lakes in 1992: Islet, Shorncliffe and Goose. The focus of the program was on each lake's level of fertility, or trophic status. The indicators used were concentrations of total phosphorus and chlorophyll *a*, and Secchi depth. Shorncliffe Lake proved to be eutrophic, whereas Goose and Islet lakes are hypereutrophic.

Water quality in these lakes are governed by both natural factors and from human activities. The bottom sediments appear to contribute large quantities of phosphorus to the lake water in both Goose and Islet lakes, but much less so in Shorncliffe Lake. Such recycling of phosphorus from the bottom sediments seems to be important in many Alberta lakes, but it is not known how the effects of human activities influence the magnitude of the phosphorus supply from the sediments. Recent evidence suggests that when the supply of phosphorus from the watershed is large, the sediment supply is also large.

Examples of human activities that could increase the phosphorus supply to the lake, and thereby contribute to degradation of water quality, include:

* Conversion of forest or grassland to farmland, parks or cottage development
* Construction of roads, buildings (erosion of soil)

* Livestock in watershed, particularly with access to inflow streams or the lake

* Faulty or poorly maintained septic systems along lakeshore

* Fertilizer application near streams or lake, excessive use of fertilizers before heavy rain

Some or all of these activities may be found within the watersheds of all three volunteer lakes. The volunteers and other people closely associated with their particular lake can help protect water quality by identifing major sources of nutrients to the lake, and then working towards reducing the phosphorus supply from those sources. Unfortunately, the effects of nutrient reduction efforts would probably not be observed in the lake for several years. Our slow-flushing lakes change very slowly, whether in response to increased nutrient loading or to a reduced nutrient supply. But there is no other way to protect water quality in these lakes.

All of the volunteers who participated in the 1992 program did a superb job. The samples were collected regularly throughout the summer, and the number of samples collected was above average for the program. The data are invaluable to establish baseline conditions for Shorncliffe and Islet lakes, and to provide essential information for the enhancement investigation for Goose Lake.