Alberta Lake Management Society
Lakewatch 1999
Report.

Preston McEachern
G208 BioSci Bldg. University of Alberta, Edmonton, AB T6G 2E9
(780) 492-6304

Table of Contents

1. List of Tables

2. List of Figures

3. Acknowledgements

The Lakewatch program is made possible through the dedication of its volunteers and Alberta Environment employees. Mike Bilyk, John Willis, Doreen LeClair and Pat Mitchell from Alberta Environment were instrumental in both funding, training people and dealing with lakewatch data. Alberta Lake Management Society members Paula Siwik, Michael Agbeti, Lorelie Marks, Ron Zurawell, Jay White, Craig Taylor and Preston McEachern trained lake volunteers and collected samples. Without the dedication of these people and the interest of cottage owners, Lakewatch would not have occurred. Special thanks to Al Sosiak for providing editorial comments.

4. Introduction

Alberta's volunteer lake monitoring program known as Lakewatch has been an important source of water quality data for Alberta Environment and lake associations. In 1999, volunteers from lake associations, the Alberta Lake Management Society (ALMS) and Alberta Environment employees collected water samples bi-monthly from Burnstick Lake, Chestermere Lake, Driedmeat Lake, Gull Lake and Hastings Lake. This report outlines the Lakewatch program and results from the 1999 water quality survey of these five lakes.

Why have a volunteer lake monitoring program?

Volunteer lake monitoring programs are intended to accomplish four primary objectives for lake management: (i) They act as a platform for educating lake users about the aquatic environment; (ii) they foster and enhance public involvement in lake management; (iii) they facilitate a link between aquatic scientists and lake users; and (iv) they can provide reliable water quality data that, in the present era of funding constraints, can result in cost-saving to government programs.

Volunteer monitoring programs have been implemented in several provinces in Canada and states in the U.S., where one or two of these objectives have been emphasized, but usually all four are achieved in part. In Alberta, the volunteer program known as Lakewatch has operated for eight years and collected data from 22 lakes. Volunteer programs elsewhere have become so successful that they have expanded into a principle source for lake quality data. For example, in the United States, the Missouri Volunteer Monitoring Program involves 33 volunteers monitoring 15 lakes annually. The resulting volunteer dataset was independently tested using professionally collected data and was considered highly accurate for its summer mean representation of individual lakes. The utility of volunteer programs in collecting reliable and inexpensive water quality data has been recognized by the EPA to the point that they maintain a web site with access to manuals, data reporting, and data access at http://www.epa.gov/OWOW/monitoring/

How does Lakewatch help Albertans?

Much concern has been raised over the 'pollution' of Alberta lakes. It is a common belief that human activities, including industry, urbanization, forestry, agriculture, and residential dwellings contribute pollutants to lakes causing excessive algal growth, weeds and murky water. Lakewatch allows people to be involved in determining lake water quality so that they can make informed decisions at council meetings regarding developments that may impact their lakes.

5. Indicators of water quality: Sampling for what?

Water samples are collected in Lakewatch to determine basic chemical characteristics that characterize general water quality. Though not all encompassing, the variables collected in Lakewatch are sensitive to human activities in watersheds that can cause degraded water quality. For example, nutrients such as phosphorus and nitrogen are important determinants of a lake's potential productivity. The concentrations of these nutrients in a lake are impacted (typically elevated) by land use changes such as increased agricultural activity or livestock grazing. Increased nutrient concentrations can cause increases in undesirable algae blooms resulting in low dissolved oxygen concentrations, degraded habitat for fish and noxious smells. A large increase in nutrients over time can also warn of sewage inputs resulting in other human health issues such as increases in the protozoan *Cryptosporidium*.

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 containing livestock and human sewage enter 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. Trophic state is based on phosphorus, nitrogen, and chlorophyll concentrations and is a useful index for rating and comparing lakes.

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. Chlorophyll *a* can be used to estimate a lake's fertility or trophic status. Lakes with high levels of chlorophyll *a* (26 to 75 µg/L) are usually considered fertile and are termed eutrophic. Highly productive or fertile lakes are termed hyper-eutrophic, while moderate to low productive lakes are termed mesotrophic and oligotrophic, respectively. Some highly productive lakes are dominated by larger aquatic plants rather than algae. In these lakes, chlorophyll *a* and nutrient values taken from water samples do not include productivity from large aquatic plants. The result, in lakes like Chestermere which are dominated by larger plants known as macrophytes, can be a lower trophic state than if macrophytes 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 Transparency

Lakes that are clear are more attractive for recreation, whereas those that are turbid or murky are considered by lake users to have poor water quality. A measure of the transparency or clarity of the water is performed with a Secchi disk. To measure the clarity of the water, the Secchi disk is lowered down into the water column and the depth where the disk disappears is the Secchi depth. The Secchi depth in lakes with a lot of algal growth will be small while the Secchi depth in lakes with little algal growth can be very deep. Low Secchi depths are not caused by algal growth alone. High concentrations of suspended sediments, particularly fine clays or glacial till, are common in plains or mountain reservoirs of Alberta. Mountain reservoirs may have exceedingly low Secchi depths despite low algal growth and nutrient concentrations.

The euphotic zone or the maximum depth that light can penetrate into the water column for actively growing plants is calculated as twice the Secchi depth. Murky waters, with shallow Secchi depths, can prevent aquatic plants from growing on the lake bottom. Maintaining aquatic plants in certain areas of a lake is often essential for ensuring good water clarity and a healthy lake as many organisms, like aquatic invertebrates and insects, depend on aquatic plants for food and shelter.

General Water Chemistry

Water in lakes is never 'pure'. It always contains various chemical 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, such as sodium and chloride, which when combined form table salt, but when dissolved in water separate into the two electrically charged components. Chemicals that separate like this into electrically charged elements are called ions. All the ions in a particular water sample make up its salinity, or saltiness, and this is measured as total dissolved solids (TDS), specific conductance or total ions. 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 amount of precipitation and other climate variables as well as human activities such as fertilizer application.

6. Methods

Lakewatch determines the need for a lake to be included in the sampling program based on the following three priorities:

Priority 1. The highest priority is to lakes where little or no baseline data are available.
Priority 2. The second priority is lakes where data exist but is more than five years old.
Priority 3. The lowest priority is lakes where data exist within the last five years. Despite the low priority of this group, some lakes in this category have been sampled (e.g. Burnstick Lake) because monitoring agreements have been negotiated with Alberta Environment.

A pool of eligible lakes is formed each year from interest expressed by lake associations at the annual ALMS general meeting. Representation at ALMS general meetings is a basic requirement for inclusion in Lakewatch. Time and locations for ALMS meetings are posted at : http://www.biology.ualberta.ca/alms/home.htm
or can be obtained by calling Preston McEachern at (780) 492-6304. The program was limited to five lakes for 1999 by funding constraints. The selected lakes were Burnstick Lake, Chestermere Lake, Driedmeat Lake, Gull Lake and Hastings Lake which were routinely sampled every two weeks over the open water months for physio-chemical variables.

The sampling protocol was taught to the volunteers at the initial training session held at each of the lakes in May. The volunteers were organized ahead of time by the lake association coordinator who made the arrangements for the training session at the lake. At this meeting the coordinator was provided with a recent morphometric map of the lake, a copy of the “Lake sampling Procedures Manual” (Alberta Environmental Protection, 1995) and the equipment necessary to collect and prepare water samples for analysis. The equipment included a Secchi disk, integrating water sampling tube, filtering pump and apparatus, water collection carbouy, pre-labeled and coded sample bottles, standard record sheets, cold pack and cooler chest.

The number of volunteers at these training sessions ranged from 2 to 12 individuals. Training included an informal lecture style presentation of the theory and practical aspects of water quality and monitoring, boating and water safety issues, and an “on-the-lake” demonstration of equipment and sampling procedures. Training sessions concluded on land with a demonstration of sample preparation. The volunteers all had an opportunity to master the procedures at each stage of the sampling process before the session ended.

The main sampling site and 9 additional locations representative of the different water qualities exhibited around the lake were selected. These sites were selected on the basis of morphometric data and information on land use and water quality provided by the volunteers. The deepest location in the lake was chosen as the main sampling site because current theory suggests that such locations best represent the dominant open-water environment of the lake. The ten sites were marked on the morphometric map for future reference and a laminated copy was later provided to the lake coordinator.

On the training day and on each sampling day the volunteers - in their own boat(s) - anchored at the main sampling site of the lake. All pertinent meteorological, lake activity, and Secchi depth data were measured according to the method outlined in the procedures manual (Alberta Environmental Protection, 1995). The euphotic depth was estimated by multiplying the Secchi depth by a factor of 2.0.

Integrated water samples from the surface to the bottom of the euphotic zone were collected at each site with the sampling tube into a clean, rinsed carbouy. When multiple samples were collected, the same number of samples were taken at each site to maintain an equal and consistent representation from all ten sites.

The integrated water sample(s) of the euphotic zone were collected at each of the remaining nine sites and combined with the sample from the main site. Determination of the sampling depth was based on the estimate of the euphotic depth from the main site. Where water column depth was less than the euphotic depth the water sample was collected from approximately 0.5m above the bottom, without disturbing the bottom sediment. Effort and care was required to eliminate contamination of the water samples.

The samples were brought back to a suitable location on land and the samples were prepared for analysis. The sample carbouy was shaken vigorously and whole water samples were poured off into several water chemistry bottles used to estimate, among other variables, phosphorus and selected chemical ions. Triplicate whole water samples were individually filtered for chlorophyll analysis through a 0.4 um glass-fiber filter. Sample volume was determined subjectively from information on algal density noted during sampling. The filters were sprinkled with $MgHCO_3$ to reduce chlorophyll *a* degradation, folded so as to retain its contents inside a pouch and wrapped in aluminum foil. All samples were prepared under subdued light conditions to prevent photo-oxidative breakdown. The samples were placed in a thermally insulated cooler with freezer packs to keep the temperature of the samples as close to $4^{o}C$ as possible. Arrangements were made to transport the samples for analysis within 24 hours of being collected.

Samples for routine chemical analyses, including major anions and cations, alkalinity, hardness and ionic balance, were contracted out to Maxxam Analytics Inc., Edmonton. Analyses for total phosphorus and chlorophyll a were carried out at the AEP Water Quality Laboratory.

The Water Quality Section of AEP administered the data collected in 1999. A copy of the results as they became available was sent to the Alberta Lake Management Society for inclusion in the annual Alberta Lake Watch Report for 1999.

Water column profiles were carried out monthly when an ALMS representative was at each lake. On these occasions depth profiles of specific conductance, pH, % O_2 saturation, dissolved oxygen, and redox potential provided additional information on water quality conditions at the main lake sites.

7. Results

General characteristics for each lake.

Appendix 1 contains two figures summarizing lake mean chlorophyll *a* and total phosphorus concentrations for lakes in Alberta. These figures are provided as a relative reference for Lakewatch lakes against other lakes in Alberta.

Burnstick Lake

Burnstick Lake is considered dimictic, a term describing lakes that stratify and mix twice per year. During early spring, surface waters warm from 0° C and eventually reached the same temperature as deeper waters around 4° C. This period of uniform temperature was a spring mixing event and allowed sediments from the lake bottom to rise in the water column. The lake appeared “dirty” at this time, however, this spring sediment load was entirely natural and did not affect later water clarity. Surface waters continued to heat, the lake stratified at about 4 m depth and solids suspended in the water began to settle from the water column. The strength and depth at which stratification occurred increased until July when the thermocline stabilized at 6 m. The lake continued to clear during this period reaching a maximum transparency of 9.3 m.

Burnstick Lake is oligotrophic according to mean summer chlorophyll *a* and transparency criteria and mesotrophic by phosphorus criteria. This means the lake contains generally clear water and is rated highly for recreational enjoyment but may experience periodic declines in transparency under conditions that promote algal growth. Occasional periods of low transparency occurred at the beginning of the summer following spring turnover. Total phosphorus concentrations averaged 14 $\mu g \bullet L^{-1}$. Total phosphorus was at its highest in early spring corresponding to lake mixing and declined through the early summer (Fig. 2). Total nitrogen averaged 374 $\mu g \bullet L^{-1}$ and increased from a spring low through the early summer but decreased markedly by August (Fig. 3).

Chlorophyll *a* concentrations were highest during the spring (Fig. 4) as would be expected given this was the period of highest phosphorus concentration. Because algal growth is highly dependent on phosphorus, chlorophyll *a* concentrations dropped through the early summer following the trend for phosphorus. Phosphorus concentrations increased slightly during late July and through August which were similarly reflected in increased chlorophyll *a* through the same period. These patterns are consistent with natural conditions in temperate dimictic lakes. Several factors coincide during later summer months to bring about these increases. As the lake warms decomposition increases and causes increased release of phosphorus from organic matter and shallow water sediments. Warm, calm conditions are also optimal for accelerated growth of certain algae that can incorporate dissolved nitrogen gas (N_2), float at the surface in large colonies and cause reduced transparency. Water levels also decrease during this period, an observation that caused some concern among Burnstick cottagers. Loss of water is a natural occurrence for Alberta lakes during summer months because evaporation and outflow to groundwater is greater than summer inflows. As long as water levels return to a “normal” high during spring snow melt there is little reason for concern. When water quality variables from 1999 are compared with those from 1995 (Table 1), Burnstick Lake has remained unchanged and there is no evidence of a decline in water quality.

Major ion concentrations did not fluctuate appreciably through the summer. Mean values were characteristic of oligotrophic lakes for calcium (29 mg•L^{-1}), magnesium (11 mg•L^{-1}), sodium (2 mg•L^{-1}), and potassium (0.5 mg•L^{-1}). Sulfate concentrations were low (3.4 mg•L^{-1}) and consistent with concentrations of other ions. Concerns over sulfate loading from petroleum resource activities in the area do not seem warranted at this time. Total alkalinity, a measure of the ability for a lake to neutralize acidic ions such as sulfate, was 127 mg•L^{-1}. This indicates that it is relatively protected from acidification consistent with other lakes in this region of Alberta.

Gull Lake

Gull lake is intermediate in depth (8 m). However, the lake is polymictic during open water, mixes at least once possibly many times through the spring and summer. This type of mixing occurs in Gull Lake because it has a relatively large surface area compared to its depth. Like a dimictic lake (see Burnstick Lake above) surface waters warm during the summer; however, mixing by wind action at the surface forces warm water to deeper depths. As a result, no true thermocline existed in Gull Lake. Weak stratification may occur occasionally in Gull Lake during hot calm weather. Such conditions did not occur during our monthly sampling.

The importance of temporary stratification events is that if they last several days they allow the reduction of dissolved oxygen concentrations in deeper water and the release of phosphorus into the water column when the temporary stratification breaks down. Cottage owners at Gull Lake should make an effort to document the occurrence of hot calm weather and the response in water colour and algae growth following hot spells. Presently these temporary events are not represented in our data. The Lakewatch data suggests bloom conditions were rare in 1999.

Low oxygen concentrations [DO] during winter are possible. However, Gull Lake remained well oxygenated through the summer. Dissolved oxygen was always above 8 mg·L^{-1} at all depths except at the sediment surface where oxygen concentrations were still remarkably high (5 mg·L^{-1}). A severe winter with long ice-cover would be required to significantly lower winter oxygen concentrations. Dissolved oxygen concentrations would quickly return to acceptable levels after ice melt.

Gull Lake is eutrophic based on nutrient, chlorophyll and transparency criteria. This means the lake water, like most lakes in Alberta, is generally green with limited visibility, may undergo occasional blooms of noxious algae and could have low winter oxygen concentrations with a potential for winter fish-kill. Total phosphorus concentrations (TP) increased through the summer (Fig. 2). Increasing TP is indicative of internal phosphorus loading which either supports the probable occurrence of temporary stratification or continuous enrichment from warm sediments. Chlorophyll *a* concentrations likewise increased from a low in early spring to eutrophic conditions (>10 µg•L^{-1}) by late July. Total nitrogen concentrations in Gull Lake appear high (>1300 µg•L^{-1}). However, both nitrate and ammonium concentrations were relatively low (Table 1) indicating that the observed total nitrogen concentrations were likely of low concern and perhaps even desirable. Total nitrogen averaged 32 times that of phosphorus similar to the ratio observed in oligotrophic Burnstick Lake. Inputs from animal and human sewage (such as feed lots) contain N:P ratios less than 5. Gull Lake is at less risk of toxic algal blooms, if low N:P ratios are indeed the driving force in their occurrence.

Concentrations of base cations were not high for calcium (11 mg•L^{-1}), but were relatively high in magnesium (65 mg•L^{-1}), sodium (205 mg•L^{-1}) and potassium (20 mg•L^{-1}). Chloride concentrations were low for a eutrophic lake (4.8 mg•L^{-1}) and on an ion equivalent basis were less than 2% of sodium concentrations. The low chloride to sodium ratio indicated human and animal sewage were not as likely a source as local geology for the ion concentrations observed. Like many lakes in open watersheds, Gull Lake cations were dominated by sodium and potassium (> 60% of ion equivalents). This is indicative of high evaporative loss both in the watershed and from the lake. Stream data are currently being collected from Gull Lake and will be instrumental in determining the water budget for this lake. A reduction in the amount of water derived from a watershed is an unavoidable consequence of our recent (decade) dry climate and extensive agriculture.

Driedmeat Lake

Driedmeat Lake is shallow (3 m) and thus its water column has a uniform vertical temperature throughout the summer. High water inflow from the Battle River also helps maintain mixed conditions. Continual mixing maintained adequate dissolved oxygen concentrations, except during June sampling when the entire water column contained between 5 and 6 mg·L^{-1} [DO]. Unlike Gull Lake, the shallow depth of Driedmeat Lake makes disturbance of sediments from the lake bottom during wind events likely. Sediment suspension causes reduced water clarity and large releases of phosphorus into the water column. As a result of this and loading from a large agricultural watershed (7220 km^2), Driedmeat ranked as one of the most phosphorus - rich lakes in Alberta between 1980 and 1993 when mean TP was 425 µg•L^{-1}. The summer of 1999 was interesting for Driedmeat because nitrogen and phosphorus concentrations declined by 2.5 and 4-fold over historic levels (Table 1). Phosphorus concentrations fluctuated around a much lower mean (108 µg•L^{-1}) with a large peak in late August (Fig. 2). Reduced nutrient concentrations in 1999 were a result of high water flow through Driedmeat Lake. Given the large decrease in TP, land use changes and better management of agricultural runoff in the Driedmeat watershed may be occurring. Chlorophyll concentrations increased through the summer with cyclic blooms. Total nitrogen concentrations fluctuated around the mean (1252 µg•L^{-1}). The nitrogen : phosphorus ratio averaged 11 which should be of concern as this would stimulate the growth of noxious algae. However, nitrate and ammonium concentrations averaged 56 and 76 µg•L^{-1}, respectively indicating ample available inorganic nitrogen was present during the summer of 1999. When inorganic nitrogen is available some of the advantages that allow toxic algae to dominate in a lake are reduced. Concern is warranted because Driedmeat is known for the occurrence of toxic algal blooms.

Ion concentrations were similar to previously recorded data in Driedmeat Lake. Magnesium (18 $mg \cdot L^{-1}$), sodium (58 $mg \cdot L^{-1}$) and potassium (10 $mg \cdot L^{-1}$) concentrations were unchanged from values reported in the Atlas of Alberta Lakes for 1984 (Mitchell & Prepas 1990). Calcium (46 $mg \cdot L^{-1}$) was 11 $mg \cdot L^{-1}$ higher than reported for 1984. Mean chloride concentration was 16.2 $mg \cdot L^{-1}$, though high this was similar to concentrations reported in 1984 and was more than 3-fold lower than sodium concentration. Human sources such as road salt and sewage are not usually indicated until chloride : sodium equivalent ratios exceed 0.5 and approach unity.

Chestermere Lake

Like Driedmeat Lake, Chestermere is shallow over most of its depth. During original surveying by Alberta Environment, Chestermere Lake was more than 7 m deep. During 1999 we were only able to sample to depths of 3 m. Without bathymetric data we cannot determine if this represents low water levels in 1999 or an inability by the volunteers to locate the deepest site. Chestermere is currently facing two conflicting management issues, its designed use as a water balancing reservoir for irrigation and its development as a recreational resource and cottage community. Undoubtedly, the solution that is achieved between the active Chestermere Association and the Alberta Government will act as a precedent for how cottage associations will approach their specific management conflicts of watershed protection, shoreline development and water use.

Aquatic weeds are a problem in Chestermere Lake. Weed growth in Chestermere is extensive because of its shallow depth which is reduced to less than 2 m during winter months and has about 50% of its depth under 2 m during its highest water levels (assuming 7 m max depth). The prevailing theory on weed growth is that weeds dominate in shallow lakes that contain relatively clear water. Some shallow lakes have poor water clarity either because of excessive algal growth or because of suspended sediments. These lakes tend to have few weed problems no matter how shallow they are. Among shallow lakes these two states, turbid but weed free versus clear but weed dominated exist as two stable possibilities for the same lake. The current evidence suggests that a lake can be pushed from weed dominated to weed free by a single event causing high suspended sediments. Turbid and algae dominated conditions then persist because the stability of both the water column and bottom sediments provided by the rooted plants disappears. Chestermere Lake receives a large volume of water during summer months, enough to replace the entire lake volume in 11 days. Inflow of this magnitude may actually contribute to maintaining water clarity in Chestermere Lake and thus the success of weeds compared to lakes of similar depth in Alberta.

It is important to note that water bodies less than 2 m deep are considered wetlands by Canadian and U.S. classification criteria. This is not to detract from the beauty of Chestermere but simply to acknowledge the reality that a large portion of Chestermere should be dominated by aquatic plants. Chestermere is vital to local recreational use and requires a strong educational drive to increase awareness that a fringe of reeds followed by floating leafed and submerged vegetation may be unavoidable. At the same time depth must be maintained in the lake to provide weed-free areas. Aggressive weed removal by mechanical methods will provide respite from the weeds but will be required on a continuous basis.

Despite the shallow depth of Chestermere Lake, mixed conditions in June and July turned to stratification between 2 and 3 m by early August. As a result, dissolved oxygen concentrations which were above 8 $mg \cdot L^{-1}$ throughout the lake in June and July declined from 8.4 to 5.5 $mg \cdot L^{-1}$ below 2 m in August.

Total phosphorus concentrations averaged 39 $\mu g \bullet L^{-1}$ but the possibility that the mean was artificially inflated by a sediment contaminated sample on July 27 was likely (Fig. 2). TP from this date (81 $\mu g \bullet L^{-1}$) was likely erroneous because Secchi depths were high (indicating low suspended sediment) and chlorophyll concentrations were low. Without this date included, mean TP was 32 $\mu g \bullet L^{-1}$. Total nitrogen concentrations averaged 335 $\mu g \bullet L^{-1}$ and also fluctuated widely (Fig 3). Mean TP was within the range cited for 1983 and 84 while TN was lower than previously reported in 1983 and 84. The average nitrogen : phosphorus ratio was 11 and the same caution regarding algal blooms outlined above for Driedmeat Lake should be noted here. Chlorophyll concentrations remained relatively stable through June and July at mesotrophic levels (Fig. 4). A large algal bloom was observed in late August along with at least a doubling in TP and increase in chlorophyll from 5 $\mu g \bullet L^{-1}$ to 27 $\mu g \bullet L^{-1}$. A similar event may have occurred following a July increase in TP, however, it is more likely that the 81 $\mu g \bullet L^{-1}$ TP recorded on July 27 was a result of sampling error because at least residual indications of a bloom should have been detected on August 11. The algal bloom observed on August 25 was still apparent September 8.

Ion concentrations were similar to previous years. Calcium (37 $mg \cdot L^{-1}$), Magnesium (15 $mg \cdot L^{-1}$) and potassium (1 $mg \cdot L^{-1}$) were similar to values reported for 1983 in the Atlas of Alberta Lakes (Mitchell & Prepas 1990). Mean sodium (15 $mg \cdot L^{-1}$) and chloride (7 $mg \cdot L^{-1}$) concentrations were double that reported for 1983. Sodium and chloride are often contributed by de-icing salt from roads or other human contributions. While the observed concentrations of sodium and chloride are not high, levels of chloride should be monitored until it is determined if concentrations are rising.

Hastings Lake

Hastings Lake is intermediate in depth with a maximum of 7.5 m. The 1999 data suggest Hastings Lake is dimictic with only one summer thermocline and a fall overturn. However, like Gull Lake, Hastings Lake is polymictic in some years meaning the water column stratifies in winter with a spring overturn and possibly several stratification and mixing events through the summer. Water temperatures in Hastings Lake quickly rose through May and June until the entire water column was more than 16° C. By early August, a very strong thermocline was established around 2 m depth. The surface waters rose to 22° C while water below the thermocline remained close to 17° C. The strong thermocline was an effective barrier to downward mixing and diffusion of dissolved oxygen which declined to less than 2 $mg \cdot L^{-1}$ at 5 m depth. The lake was anoxic by 7 m depth.

Mean total phosphorus concentrations and the pattern of increase in phosphorus over the summer were similar in Hastings and Driedmeat Lakes. In May, TP concentrations were 67 $\mu g \bullet L^{-1}$ and rose with some fluctuation through to late August when TP peaked at 160 $\mu g \bullet L^{-1}$ (Fig. 2). Compared to the other lakes, Hastings Lake contained high concentrations of nitrogen with TKN ranging from 2.1 to 3.3 $mg \cdot L^{-1}$, with a mean of 2.5 $mg \cdot L^{-1}$ (Fig. 3). Nitrate-nitrite concentrations exceeded 50 $\mu g \bullet L^{-1}$ with a summer mean of 171 $\mu g \bullet L^{-1}$. There are no specific water quality criteria limits on nitrate concentration for aquatic life. Chlorophyll *a* concentrations initially declined after spring overturn but rose sharply through July and August finally peaking in mid September at 112 $\mu g \bullet L^{-1}$. This was the highest CHL concentration for lakes sampled in 1999 by more than 3-fold. Though the mean CHL was only one third of the highest mean observed in Alberta lakes listed in Appendix 1, the September peak value ranks with the mean for Cardinal Lake the second most CHL rich lake in Alberta. During bloom conditions, peak CHL concentrations in Alberta lakes can exceed 500 $\mu g \bullet L^{-1}$. The high chlorophyll concentrations observed in September were likely the result of a late August breakdown in stratification. The return of isothermic conditions in late August or early September allowed the more than 160 $\mu g \bullet L^{-1}$ of phosphorus observed in August to circulate through the water column and produce more algal growth. The CHL : TP ratio in September (1.12) was in keeping with strong bloom conditions. Though undesirable from a recreational perspective, blooms of this type are not uncommon in eutrophic lakes. Should the frequency of algal blooms increase in Hastings Lake to the point that they interfere with summer recreation, management options do exist that reduce TP concentrations.

Cation and anion concentrations were not remarkably high and except for Ca^{2+}, were similar to values reported for 1987 in the <u>Atlas of Alberta Lakes</u> (Mitchell and Prepas 1990). Calcium concentrations were elevated from 1987 (29 $mg \cdot L^{-1}$) to 36 $mg \cdot L^{-1}$. Hastings Lake was intermediate between values observed in Driedmeat Lake and Gull Lake. Like Driedmeat Lake, sodium and potassium comprised close to 50% of total cations. Chloride concentrations were less than 10% of sodium concentrations. Ion concentrations in Hastings Lake indicate a system dominated by evaporation rather than human influence. The runoff coefficient (amount of water received per m^2 of watershed) was estimated at less than 0.001, therefore Hastings receives little water from its 278 km^2

watershed. What water it does receive has undergone extensive evaporation from Cooking Lake and other open water upstream from Hastings Lake. Evaporation rates have been estimated at 664 mm compared to an annual precipitation of 466 mm indicating that a significant groundwater contribution must occur to maintain water levels.

Fecal coliforms were sampled in Hastings Lake and found to be low. From spring through fall, total coliforms were four colonies per 100 mL except on July 20 and Oct. 12 when 8 colonies per 100 mL were observed. Guidelines for recreational use suggest values should not exceed 200 colonies per 100 mL when five samples are collected within 30 days. Coliforms were not sampled with the required frequency nor were they sampled at many sites around Hastings Lake. However, given the low observed coliform counts, animal and human sewage does not appear to be a concern in Hastings Lake.

Cyanobacterial Addendum (written by Ron Zurawell, University of Alberta):

Hastings Lake has a long documented history of the occurrence of severe cyanobacterial blooms. Furthermore, several bloom-forming species of cyanobacteria common to Alberta’s productive lakes are known to produce potent liver toxins. Local residents and lake users may become concerned for their health and safety resulting from recreational activities (for example, swimming, water skiing, fishing etc.) on Hastings Lake. Consequently, a joint project with Capital Health (Strathcona County Public Health Centre) was established in order to determine the potential health risks relating to these toxins. As mentioned above, Hastings Lake experienced several severe surface accumulations of cyanobacteria. These blooms were most often dominated by *Aphanizomenon flos-aquae*. While this species of cyanobacteria is known to produce potent neurotoxins in several regions of the globe, there are no documented cases of toxin production in eutrophic Alberta lakes. However, *A. flos-aquae* is often accompanied by *Microcystis aeruginosa* as well as *M. flos-aquae*. Together, these species account for the majority of toxic episodes within Alberta’s mildly eutrophic to hypereutrophic lakes, ponds and reservoirs. Hastings Lake was no exception, as liver toxins (known as microcystins) produced by *Microcystis* were detected in both phytoplankton and raw water samples. Microcystin within the phytoplankton was detected soon after ice-out (May 20; Fig. 5). This likely resulted from resuspension of a large dormant population of *Microcystis* cells that overwintered on the sediment from the previous autumn. While toxin was detectable in phytoplankton samples throughout the spring and summer, concentrations remained quite low through to the end of July (Fig. 5). In contrast, large increases in microcystin levels within the phytoplankton occurred throughout August and September. Peak toxins levels (313.74 ug/g) were reported on August 6 and accompany increasing concentrations of both CHL and TP (Fig. 4 and 2, respectively) and decreasing Secchi disc depths (Fig. 1). Microcystin is considered to be an endotoxin, that is, it normally remains within healthy living cyanobacterial cells. However, at the end of their life cycle cyanobacteria may release toxin into the surrounding water. Thus, increasing microcystin within raw water indicates senescence of the cyanobacteria population. Toxin concentrations in water samples from Hastings Lake increased as early as June 10. While levels decreased at the end of July, concentrations peaked a few weeks later on

August 6 at 0.11 ug/L. Considering the newly established Health Canada guideline for microcystin in drinking and recreational waters is 1.5 ug/L, recorded values in Hastings Lake appeared relatively innocuous.

8. Summary

Data from the five Lakewatch lakes sampled in 1999 do not indicate a reduction in water quality from historical data. Gull, Chestermere and Burnstick demonstrated little to no change in the common quality variables of total chlorophyll *a*, Secchi depth, nitrogen and phosphorus while Driedmeat and Hastings demonstrated considerable improvement; however, these latter two lakes are highly productive and may demonstrate considerable variation in quality from year to year.

Cottage owners from each of the sampled lakes have concerns about perceived problems on their lake. For example, Driedmeat has experienced severe algal blooms in the past. Chestermere has a problem with excessive weed growth and occasional blooms. We have attempted to address these problems with current data. In the case of Driedmeat for example, cottagers can expect a reduction in the frequency and severity of algal blooms if the current trend of decreasing nutrient concentration continues. The Lakewatch program is not designed to provide solutions to aquatic weed problems, however, we have attempted to discuss some of the issues surrounding weed growth and the balance in shallow lakes between high water quality and weeds versus poor water quality and weed-free conditions.

Ion concentrations were largely unchanged from previous records, indicating that the water balance had not shifted greatly to evaporative loss compared to the previous decade. If reduced inflow volumes and heightened evaporation had occurred we would have expected higher ion concentrations in 1999 than in previous years. For Burnstick, local concern over sulfate deposition from gas activities does not appear to be warranted.

Smaller points have been raised such as noting trends in N:P and Na:Cl ratios. Most importantly, cottage owners should note the occurrence of water quality declines in the form of algal blooms or high turbidity along with notation for recent climate conditions and their feeling on why the problem occurred. These concerns can be submitted to the Lakewatch page (preston@ualberta.ca) and will be posted to maintain a directory of problem events. Simply measuring lake surface temperature and Secchi depth on a daily or weekly basis could vastly improve our understanding of lakes in Alberta.

It is important to note the costs of the Lakewatch program. The five lakes sampled in 1999 cost Alberta Environment $3600 for sample analysis and shipping and an additional $2000 for equipment some of which can be reused. ALMS spent an additional $1231 while many of the volunteers did not claim expenses and assumed about $500 each in costs using their own vehicles to train, collect samples and provide support for the individual lakes. The time contributed by the volunteers and Alberta Environment staff probably exceeds these totals.

Finally, 1999 was a successful year for Lakewatch. Training, sample collection, processing and the quality of final data was remarkable. This was the first year of a new program structure and it proceeded without difficulty largely due to the expertise and dedication of Alberta Environment staff and the volunteers. Due to the success of 1999, Lakewatch expanded to include eight lakes during the summer of 2000. The work is currently underway and has met with similar success. On behalf of ALMS and Alberta Environment, I look forward to the continued cooperation of all the parties that support Lakewatch and hope it continues to expand for the benefit of all lake communities in Alberta.

9. References

Most **historic data** was obtained from:

The Atlas of Alberta Lakes, Mitchell P. and E. E. Prepas (eds) © 1990 University of Alberta Press, Edmonton.

Additional Reading

Most scientific information can be found in journals For example the following reference summarizes the why **macrophytes** dominate in some lakes and not in others:

Scheffer, M., S. H. Hasper, M-L Meijer, B. Moss, & E. Jeppesen. (1993). Alternative equilibria in shallow lakes. TREE 8(8) 275-279.

The journal article was written by the authors: Scheffer, M., S. H. Hasper, M-L Meijer, B. Moss, & E. Jeppesen. and published in 1993. It can be found in the journal titled TREE volume number 8, issue number 8 at pages 275-279. To find this article one must look in a library that contains journals. College and university libraries may contain the journal TREE.

An alternate and excellent source for additional reading on **macrophyte growth and importance in lakes** is:

The Structuring Role of Submerged Macrophytes in Lakes. E. Jeppesen, M. Sondergaard, M. Sondergaard and K. Christoffersen (eds.) © 1998 Springer, N.Y.

Eutrophication of lakes

Eutrophication: Causes, consequences, Correctives. Edmondson, W. T. (Ed.) © 1969 Washington D.C., National Academy of Sciences.

Schindler, D. W. (1975). Whole lake eutrophication experiments with phosphorus, nitrogen, and carbon. Verh. Internat. Verin. Limnol. Stuttgart **9:** 3221-3231.

Trophic state

Canfield, D. E. Langeland, K. A., Maceina, M. J., Haller, W. & J. R. Jones (1983). Trophic state classification of lakes with aquatic macrophytes. Can. J. Fish. Aquat. Sci. **40:** 1713-1717.

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

Toxic algae

Kotak, B. G., S. L. Kenefick, D. L. Fritz, C. G. Rousseaux, E. E. Prepas & S. E. Hrudey (1993). Occurrence and toxicological evaluation of cyanobacterial toxins in Alberta lakes and farm dougouts. Wat. Res. **27(3):** 495-506.

Table 1: Mean values from summer 1999 and historic values reported in the Atlas of Alberta Lakes.

Lake	TP (µg•L^{-1})	CHL (µg•L^{-1})	Secchi (m)	TN (µg•L^{-1})
Gull 1983	36	7.3	2.9	1540
Gull 1999	44	8	1.9	1528
Driedmeat 1984	453	87	1.5	3133
Diredmeat 1999	108	13	1.6	1252
Chestermere 1984	28	6.5	2.7	482
Chestermere 1999	32	9	2.6	335
Burnstick 1994	16.3	2.7	5.8	-
Burnstick 1999	14	2.6	6.1	374
Hastings 1987	116	72.5	0.9	3730
Hastings 1999	96	44	2.1	2514

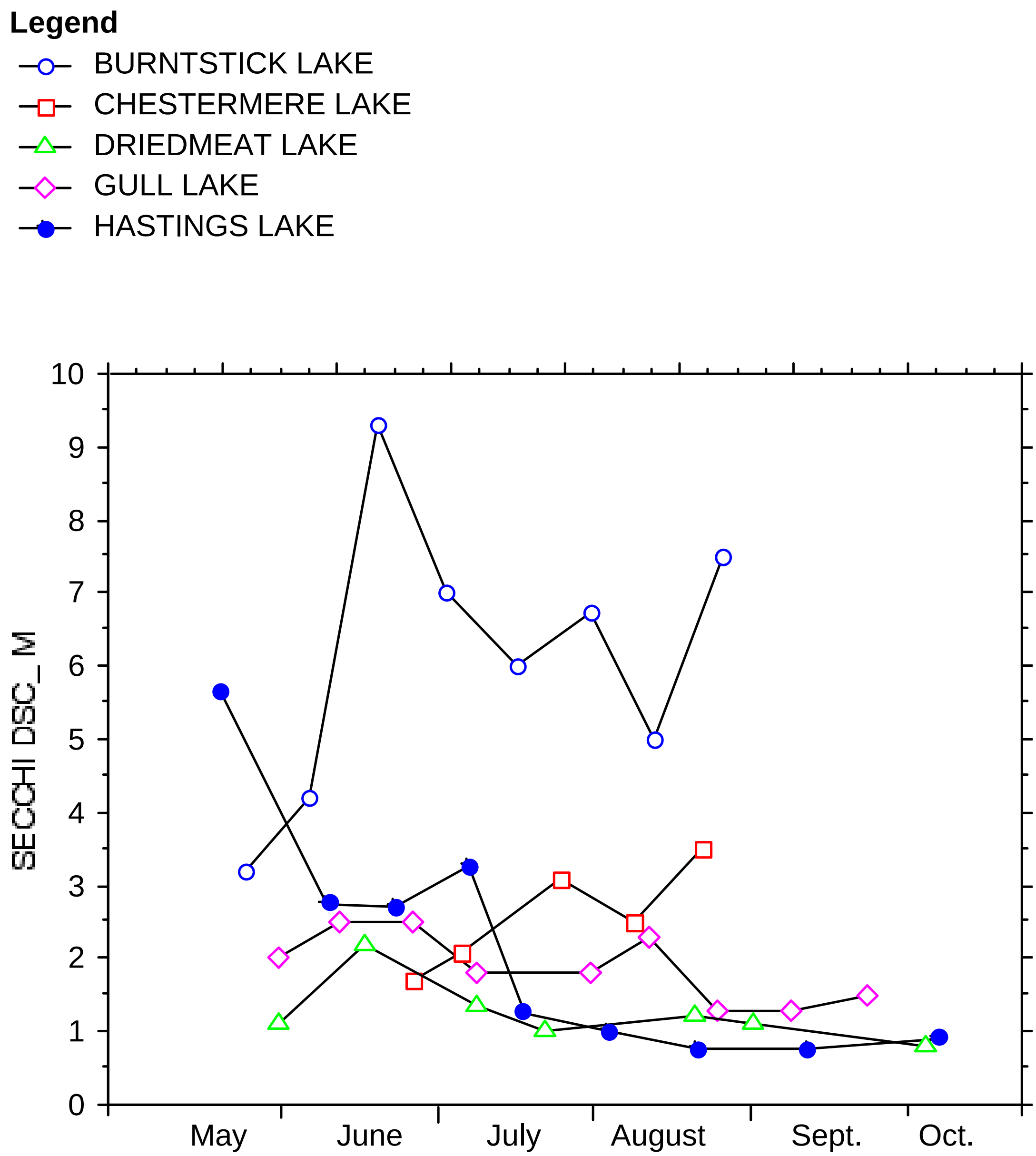

Fig. 1: Secchi Disc depth for each lake through the summer of 1999. Higher numbers represent increased water clarity.

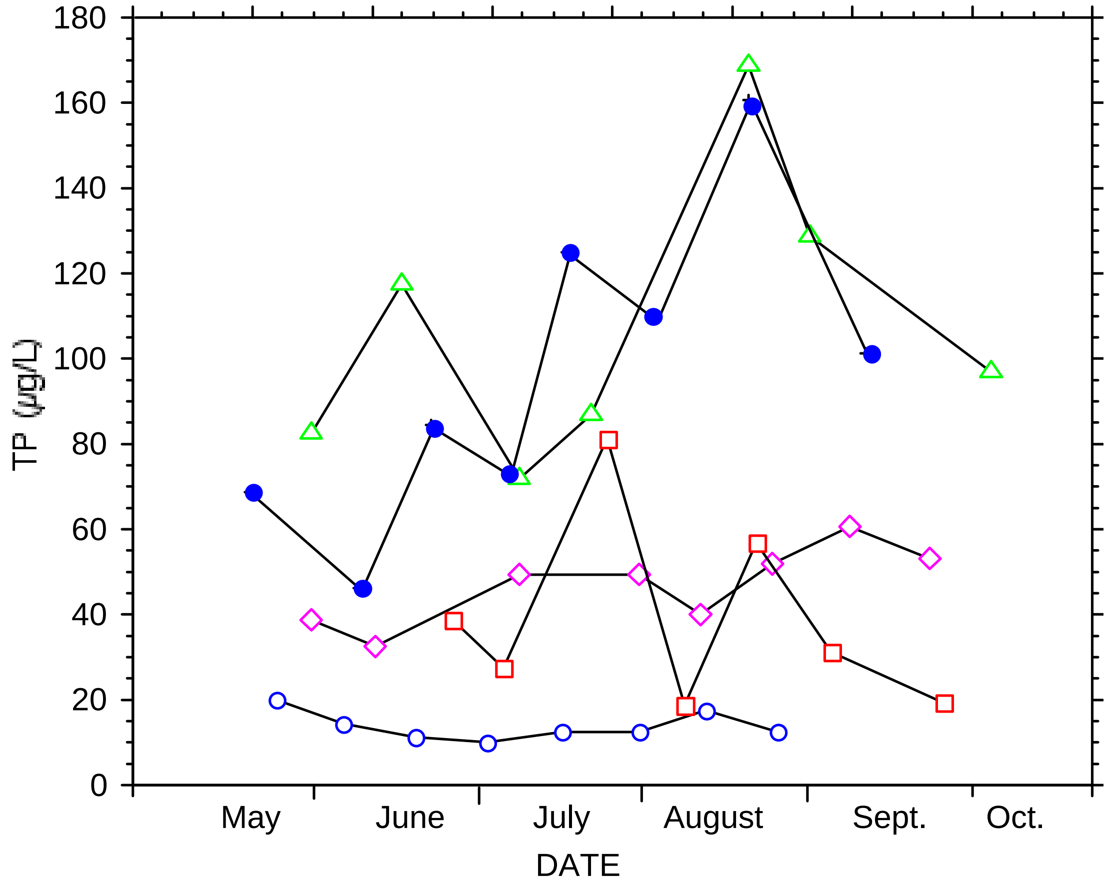

Fig. 2: Total phosphorus concentrations for each lake through the summer of 1999. Symbols are the same as in Fig. 1.

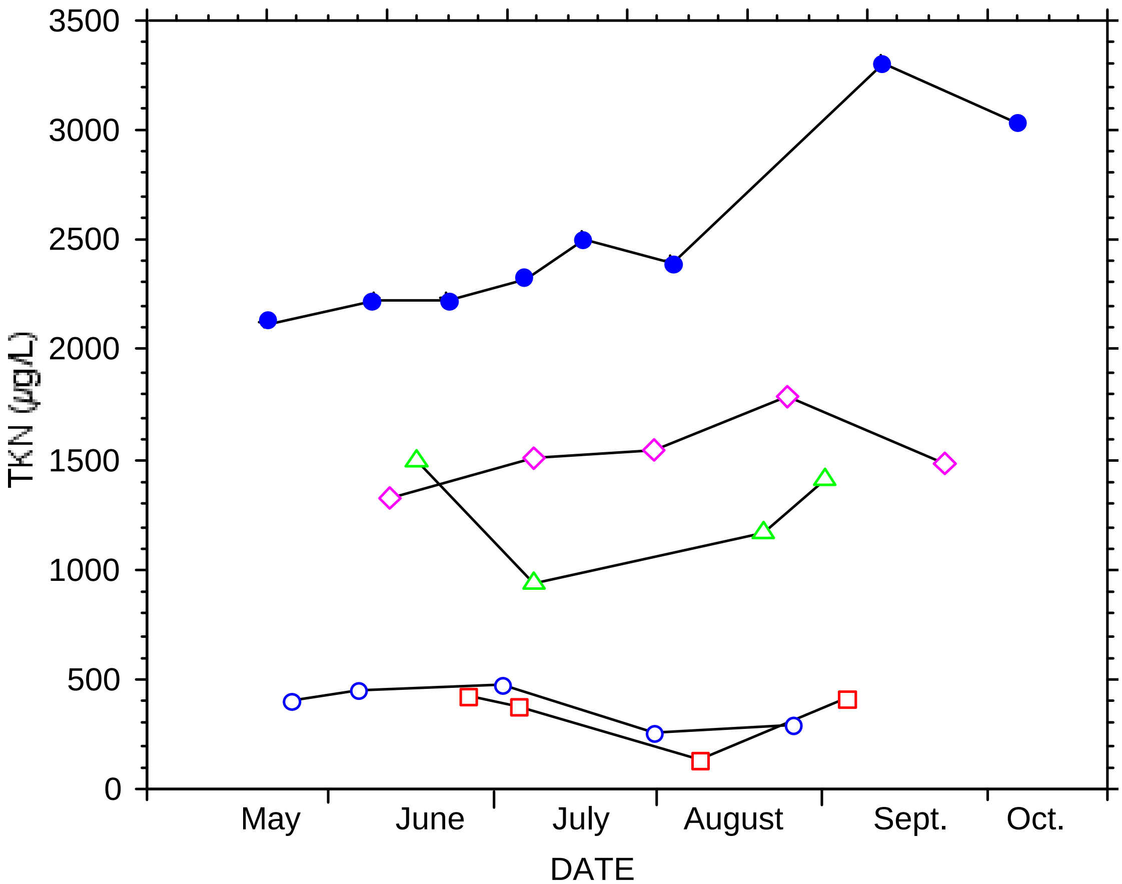

Fig. 3: Total Kjeldahl nitrogen concentrations (TKN) for each lake through the summer of 1999. Symbols are the same as in Fig. 1. Fewer samples were collected for this parameter because fluctuations in TKN are of less importance than total phosphorus.

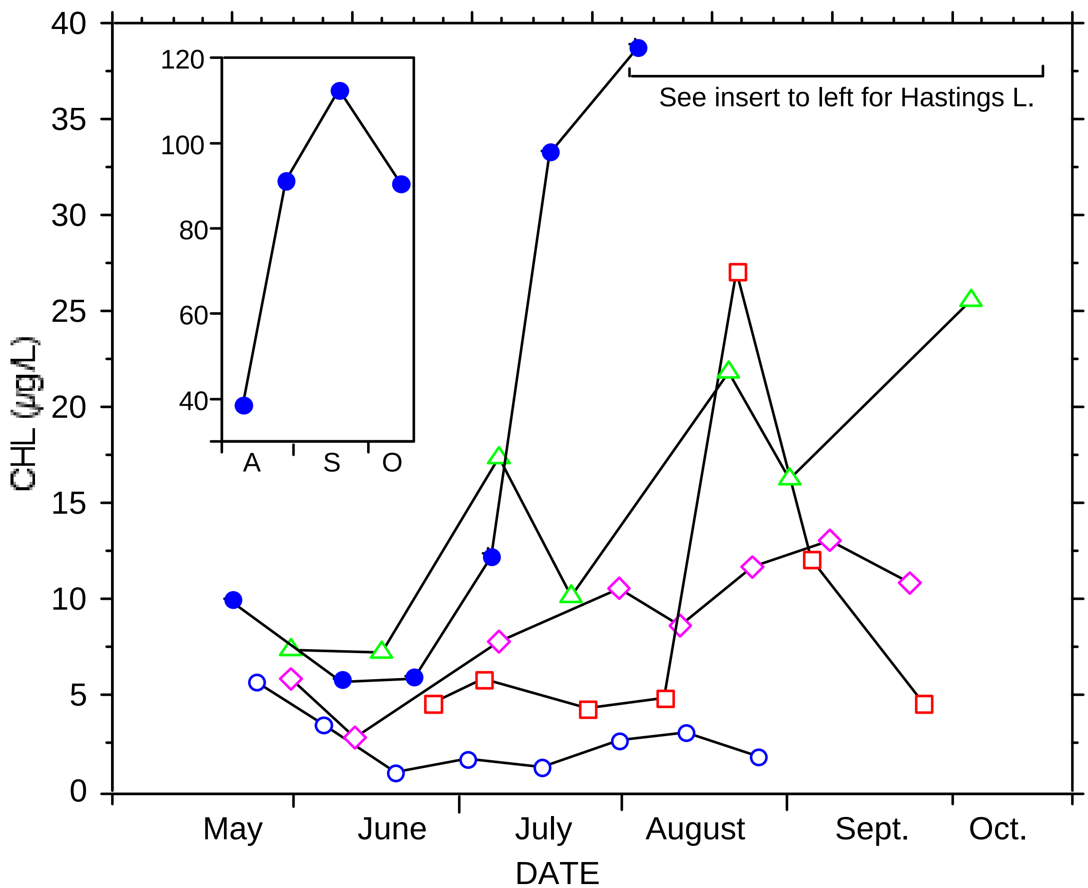

Fig. 4: Total chlorophyll a concentrations (CHL) for each lake through the summer of 1999. Symbols are the same as in Fig. 1. Hastings data for mid-August through October are shown in the inset.

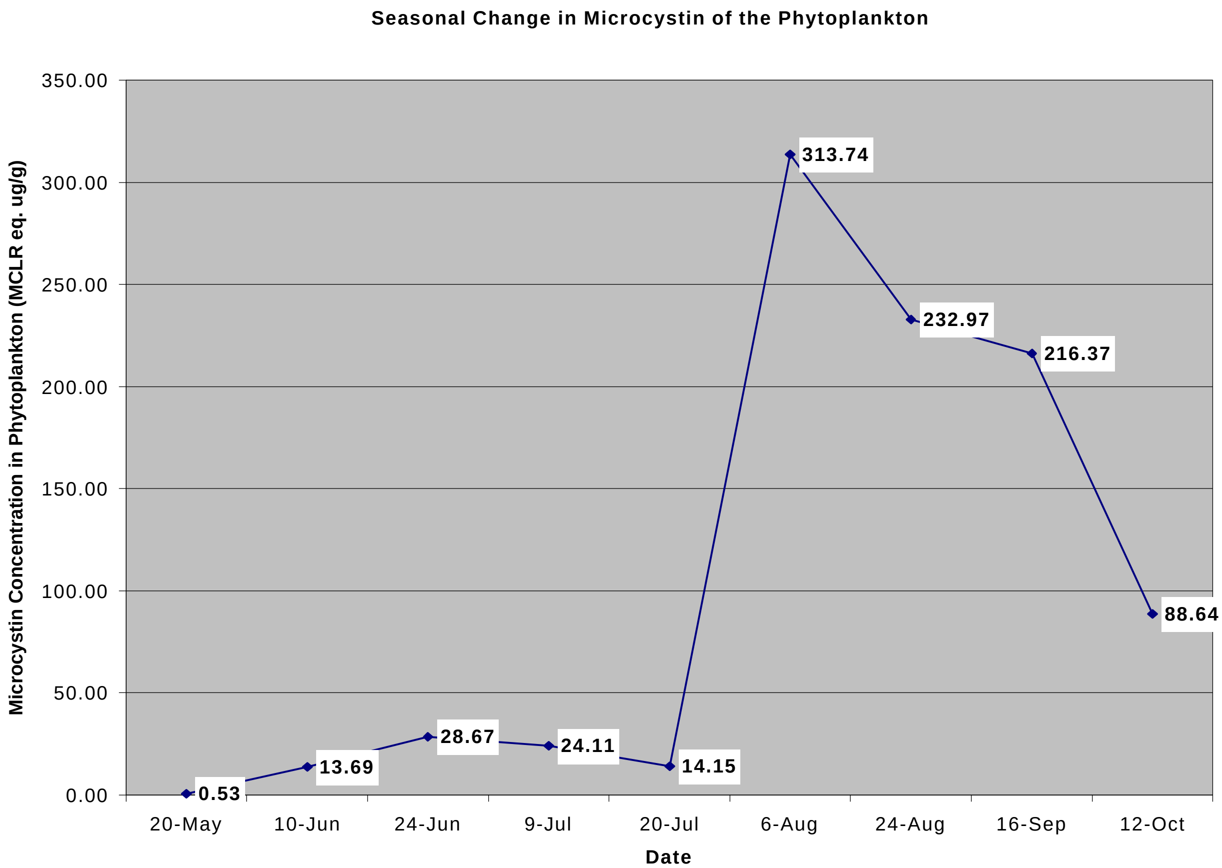

Fig. 5: Seasonal change in microcystin concentration within phytoplankton samples from Hastings Lake. Toxin concentrations expressed as ug Microcystin-LR (MCLR)

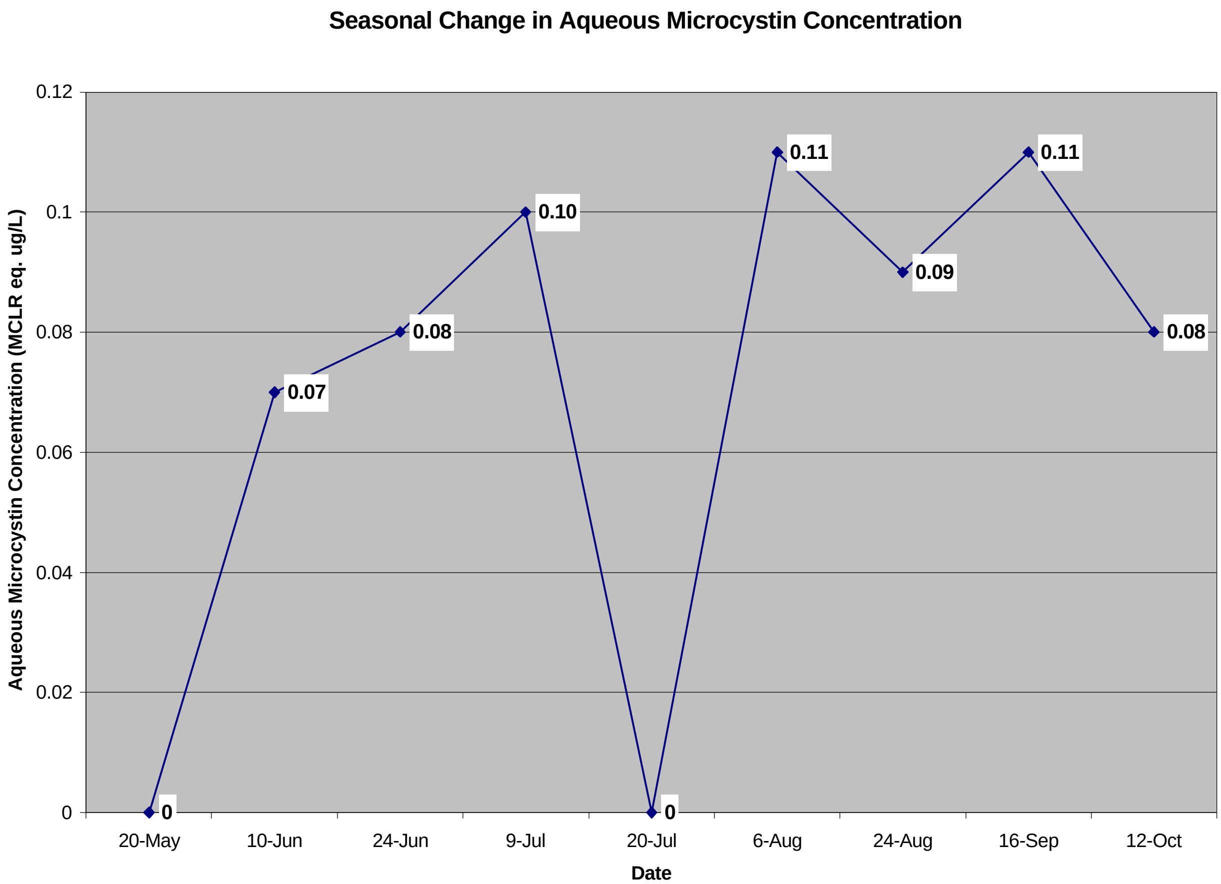

Fig. 6: Seasonal change in microcystin concentration within raw water samples from Hastings Lake. Toxin concentrations expressed as ug Microcystin-LR (MCLR) equivalents/g phytoplankton.

Appendix 1: Total Chlorophyll *a* and phosphorus concentrations for selected lakes in Alberta. Data collected by Alberta Environment May-September 1980-1993