Leonard Lake Water Quality

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Introduction - The Dorset Environmental Science Centre (DESC) is a part of the Ministry of the Environment and Climate Change's (MOECC) Environmental Monitoring and Reporting Branch. DESC's mandate is to monitor and report on the effects of multiple stressors (including climate change) on the water quality and quantity of lakes and streams located on Ontario's Precambrian Shield. Our work will help ensure the sustainable use of the services that these aquatic ecosystems provide to the people of Ontario.

History - A group of Muskoka/Parry Sound/Haliburton lakes with varying degrees of shoreline development were selected for the Lakeshore Capacity Study that began in 1976. The purpose of the study was to understand and quantify the impacts of shoreline development on the trophic (nutrient level) status of Precambrian Shield lakes. Leonard Lake is an oligotrophic (nutrient poor) lake of moderate size (195 hectares), with a maximum depth of 17.5 meters and a mean depth of 6.8 meters that, in the late 1970's, was selected for the Lakeshore Capacity study.

In 1979 the Acid Precipitation in Ontario Study (APIOS) was initiated to determine the effects of acid deposition on aquatic and terrestrial ecosystems. APIOS has concluded and the focus has shifted to climate control, while the Lakeshore Capacity work continues. The data from more than thirty years of monitoring lake water gives us the unique ability to look at the effects of multiple stressors, including climate change, the long-range transport of pollutants and the impact of invading species, on the water quality and biology of lake ecosystems.

Leonard Lake is one of a set of 26 extensively monitored lakes and has been sampled during spring, shortly after ice-out sporadically from 1979 to 1998 and annually since 1998.

Methods Overview - Staff at the MOECC's Dorset Environmental Science Centre sample Leonard Lake for water quality every spring, shortly after ice-out, while the lake is mixed, so that a single composite sample is representative of the entire lake's water chemistry. Water samples are collected at the deepest part of the lake (see bathymetric map, page 15). On each visit, air temperature, wind speed and direction, cloud cover and surface water condition are noted. Secchi depth, a measure of lake water transparency, is measured and an oxygen/temperature profile is developed by measuring oxygen concentration and temperature at the surface and at every meter to the bottom of the lake. A profile of sunlight penetration into the water column is also produced.

Using a peristaltic pump and weighted hose, predetermined, measured volumes of water are collected from each odd depth of the lake and are poured through an 80µm filter into a jug (to remove plankton and particulate matter which could alter the chemical composition of the sample when analyzed) to create a composite sample. The sample is then poured into a variety of sample containers which are submitted to the chemistry laboratory at DESC for analyses.

MOECC staff also visit Leonard between September 1st and 15th to measure late summer oxygen and temperature in profile from surface to sediment at each meter.

Results - The following are plots and descriptions of some of the key parameters monitored at Leonard Lake. MOECC analyzes water samples for many parameters and most have shown similar trends over time. Note that most parameters are measured as concentrations and are presented in mg/l (milligrams per litre (parts per million)) or ug/l (micrograms per litre (parts per billion)).

Acid Precipitation - Sulphur dioxide (SO_2) released into the atmosphere creates sulphuric acid that falls to earth in the form of acid precipitation causing stress on our lakes. With the reduction in SO_2 emissions in Eastern North America over the last twenty-five years we have seen lower sulphate levels in the surface waters of our lakes. Figure 1 shows the decrease in annual spring whole lake sulphate concentrations in Leonard Lake while Figure 2 shows a corresponding rise in pH (i.e. decline in lake acidity) over the same time period.

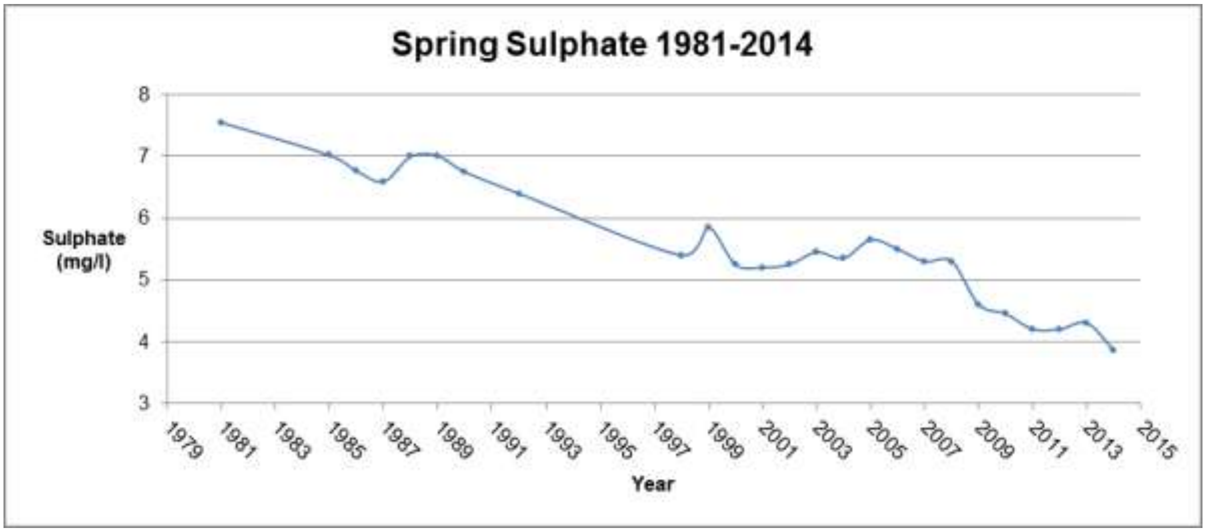


Figure 1. Annual spring whole lake sulphate for Leonard Lake, 1981 – 2014.

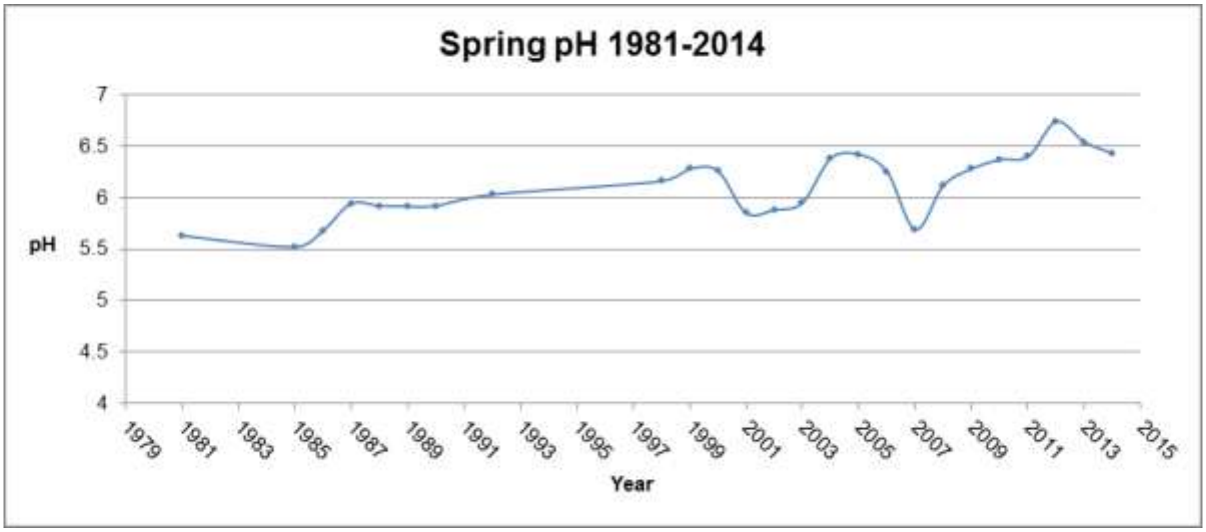


Figure 2. Annual spring whole lake pH for Leonard Lake 1981 – 2014.

Nutrients - Phosphorus is the nutrient that most often limits the growth and biomass of flora (including algae) in lakes on the Precambrian Shield. Phosphorus reaches lakes from the atmosphere, from the watershed via streams and overland flow, and from groundwater. Lake concentrations of phosphorus are influenced by local geology, land-use activities, soil depth and chemistry in the watershed, the shape and size of the lake, and human activity (e.g., septic systems). . Leonard Lake is at the low end of the 6 – 8ug/l phosphorus range (see figure 4 below), the range in which the largest percentage of Lake Partner monitored lakes fall. A surprising trend in many cottage-country lakes has been a gradual decline in total phosphorus over the past three decades, despite increases in shoreline residential development in some lakes. Interestingly, this decline is occurring in lakes with and without cottages, suggesting that a regional stress is the cause. This is an area of on-going research at DESC.

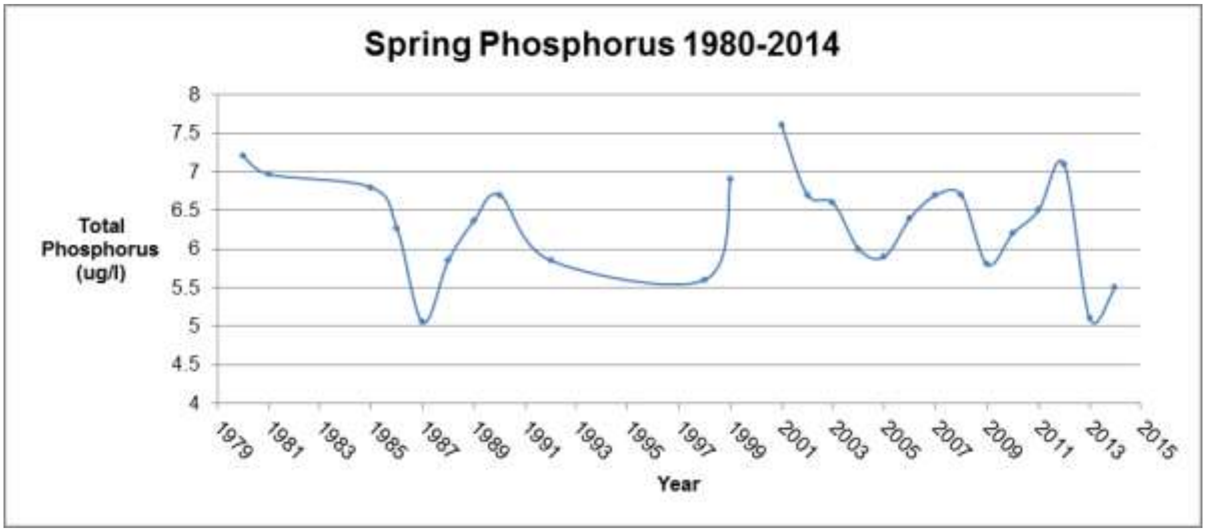


Figure 3. Annual spring whole lake total phosphorus for Leonard Lake 1980 – 2014.

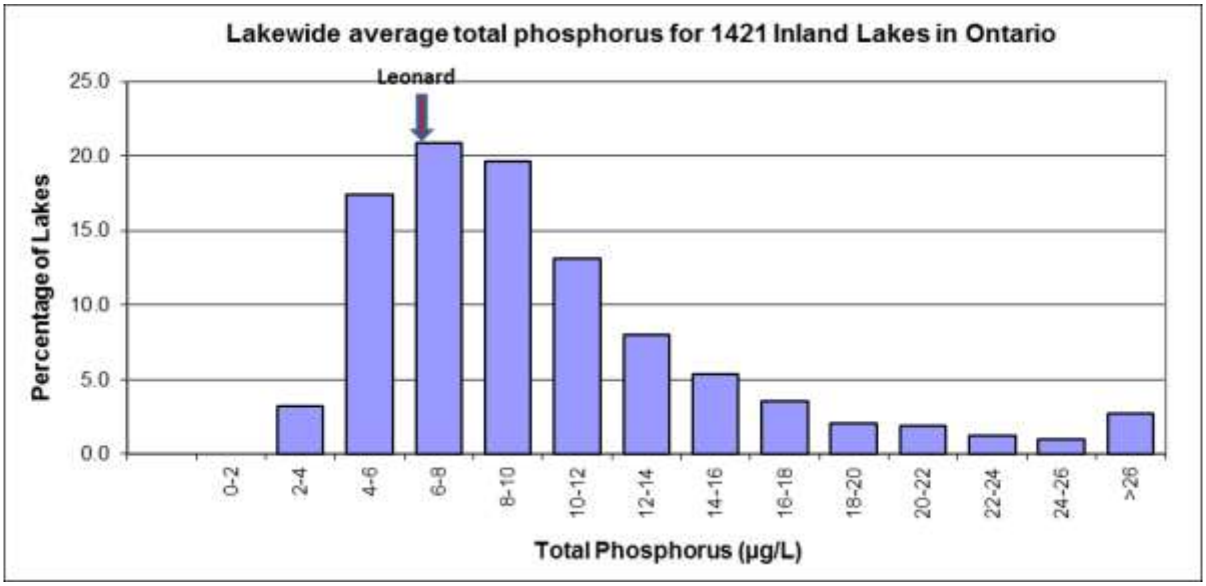


Figure 4. Average phosphorus in 1421 lakes monitored by the Lake Partner Program across Ontario (unpublished Lake Partner Program data).

Obtaining duplicate phosphorus samples

Nitrogen can be found in lake water in many forms including ammonia (NH_4), nitrites (NO_2) and nitrates (NO_3). Sources of nitrogen include precipitation, inflows, groundwater and organisms (cyanobacteria (blue-green algae)) with the ability to fix atmospheric nitrogen (convert atmospheric nitrogen to a usable form (NH_4)). No long term trend in nitrogen is evident at Leonard Lake.

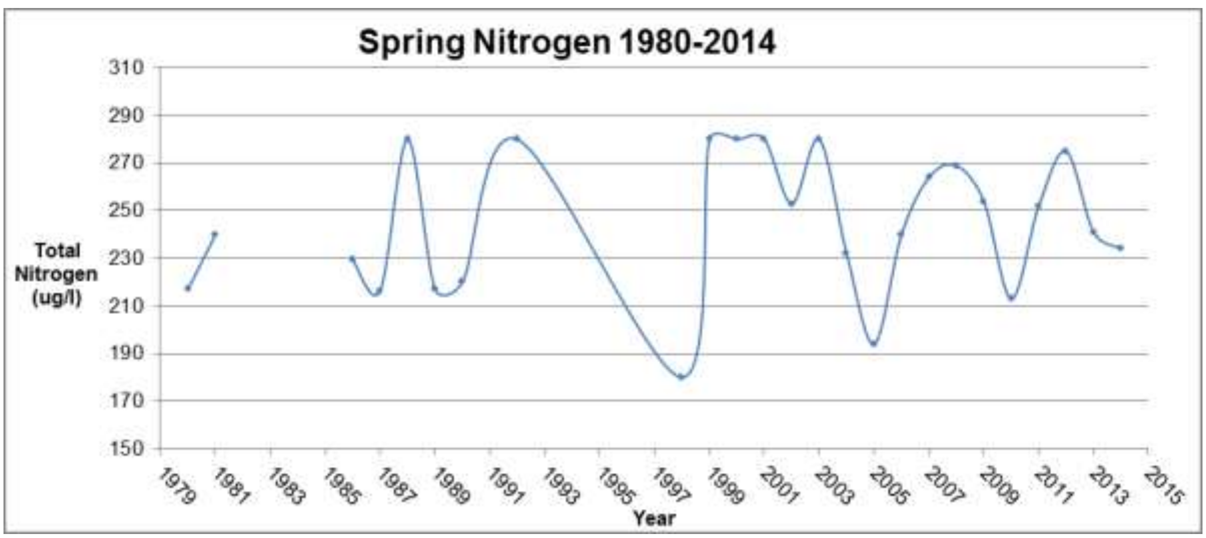


Figure 5. Annual spring whole lake total nitrogen for Leonard Lake 1980 – 2014.

A typical set of water sample containers

Dissolved Organic Carbon and Water Clarity - Dissolved organic carbon (DOC) is composed of dissolved compounds found in water that result from the decomposition of organic materials (e.g. decomposing plant matter). Often referred to as humic or tannin substances, DOC gives lake water its colour. High DOC lakes are often referred to as tea stained (the water is moderate to dark brown) while low DOC lakes have little or no colour. The slight increase in DOC concentration at Leonard is a trend we are seeing in many lakes in Ontario (see figure 7) and is a result of increased decomposition associated with warmer temperatures and decreasing acidity (Keller et al. 2008, Palmer et al. 2011). As temperature increases, the release of DOC from soils, as well as the production and decomposition of organic matter, increase and are moved into lakes by runoff from rain events.

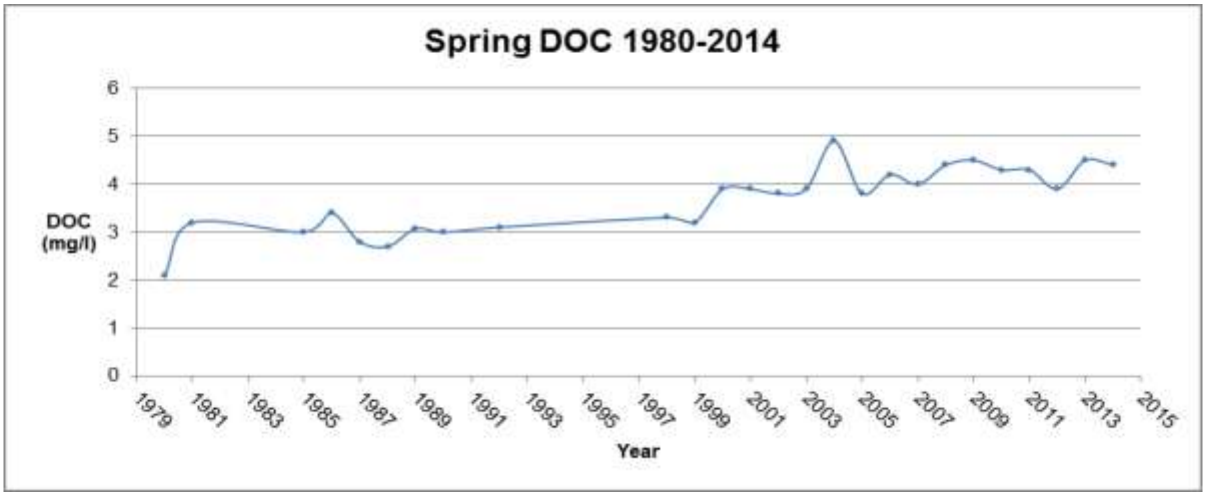


Figure 6. Annual spring whole lake dissolved organic carbon for Leonard Lake 1980 - 2014.

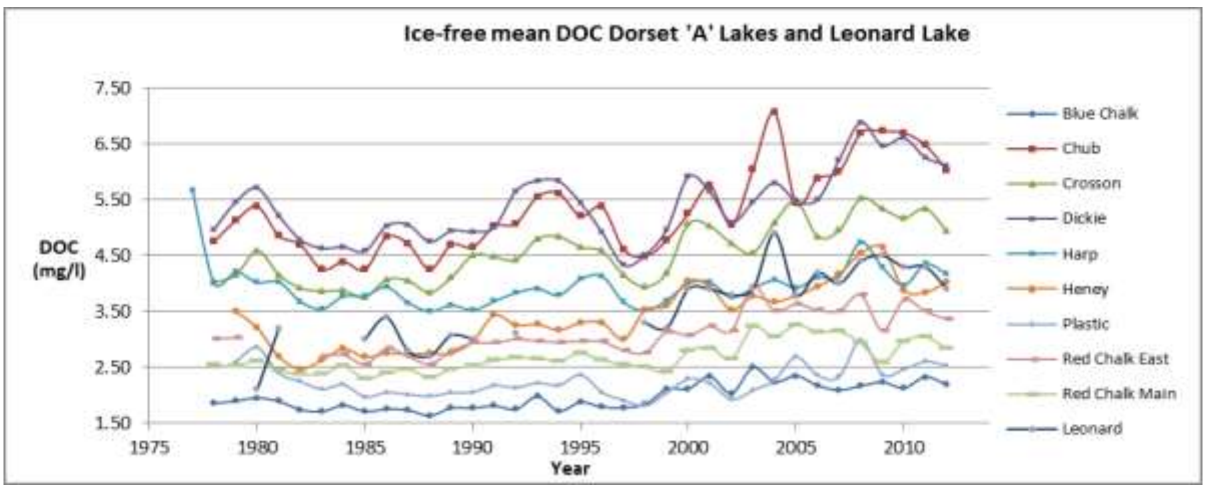


Figure 7. Annual mean DOC in the Dorset 'A' Lakes and Leonard Lake.

Dissolved organic carbon in water samples

Secchi - A Secchi disk is a 20 cm disk with four sections that alternate black and white. The Secchi disk is lowered into the water until it just disappears from view. The depth at which the disk disappears is termed Secchi depth, a measure of the transparency of the water. Transparency can be affected by the colour (DOC) of the water, the presence of algae, and turbidity. Cloud cover and wave action can also affect Secchi determination on any given day. Note that while DOC in Leonard increased, there is a small corresponding decrease in water clarity (Secchi depth) over the monitoring period.

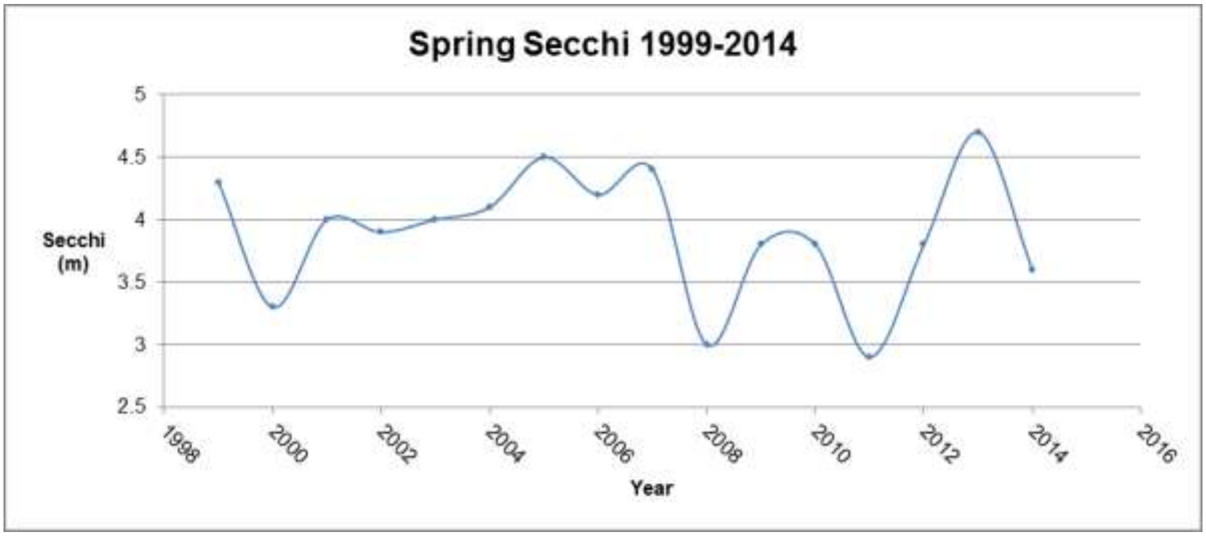


Figure 8. Annual spring Secchi (water transparency) for Leonard Lake 1999 – 2014.


Secchi depth determination

Calcium - Calcium influences the growth of freshwater flora and fauna. Most calcium enters our lakes through weathering of rock or atmospheric deposition. As most Precambrian Shield rock is granite, the weathering process is slow. Acid deposition causes a loss of calcium from surrounding soils and surface water and the rate of loss may exceed the rate of replenishment. Just as calcium is important to human health, it is important to both flora and fauna in our lakes. The implication(s) of long term calcium decline is currently being studied at the Dorset Environmental Science Centre. Calcium has remained relatively constant in Leonard through the study period.

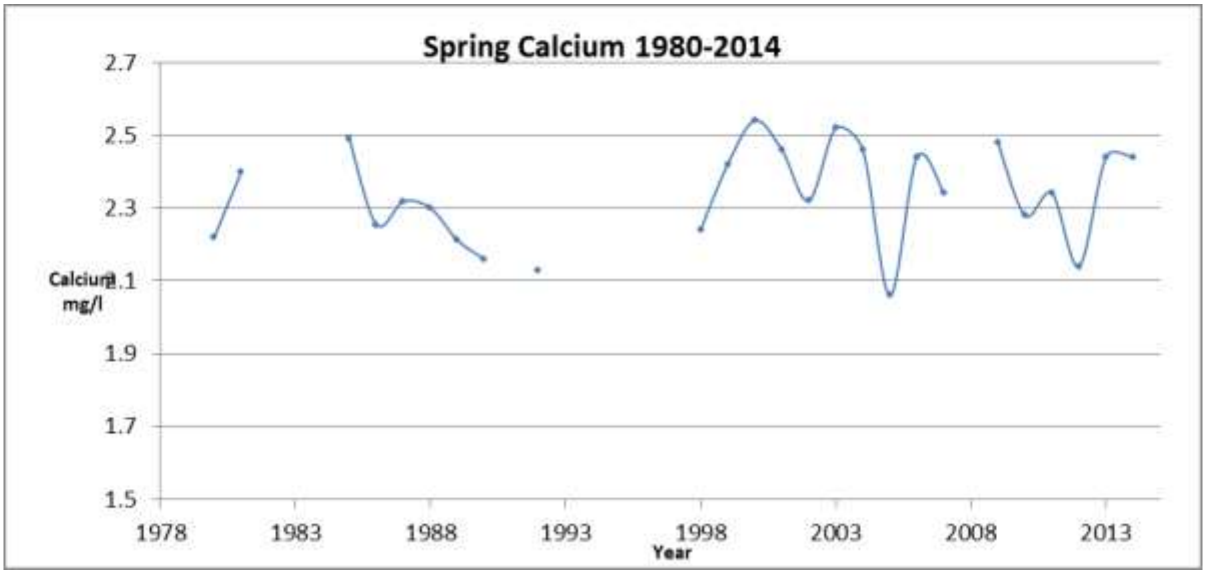


Figure 9. Annual spring whole lake calcium for Leonard Lake 1980 – 2014.

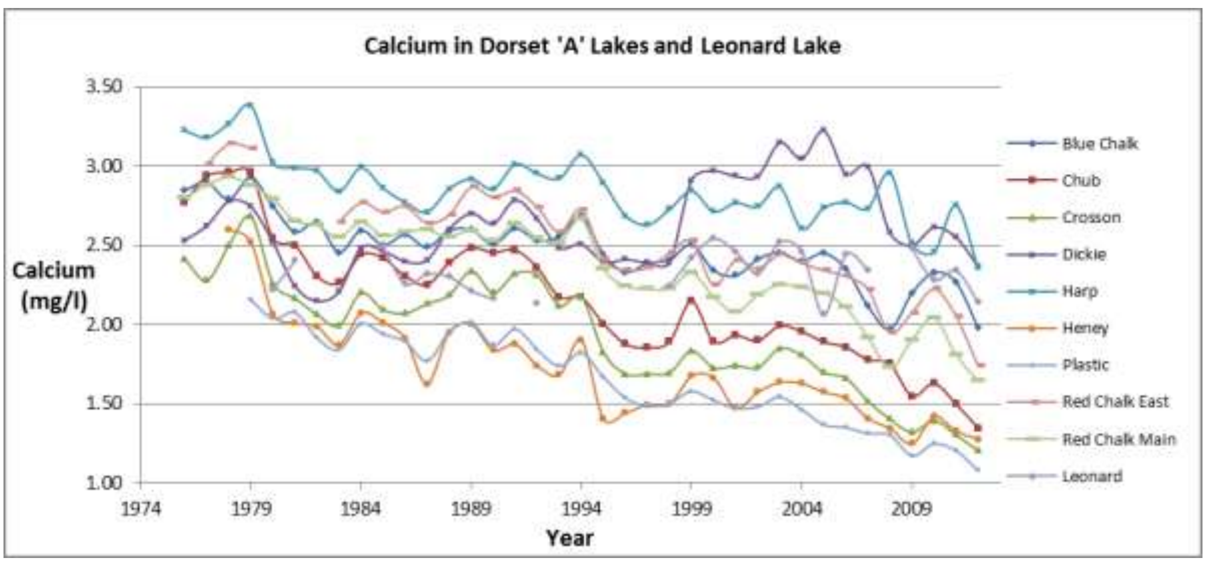


Figure 10. Annual ice-free calcium in Dorset 'A' Lakes and Leonard Lake (note that Dickie Lake is an exception and has seen an increase in calcium due to the use of calcium chloride dust suppressant on area roads).

Sodium - While sodium and chloride have remained relatively constant in many lakes there has been an increase in the concentration of both parameters in lakes that are near year round roads. Blue Chalk, Chub, Crosson, Heney, Plastic and Red Chalk lakes are not in the area of year round roads and both sodium and chloride have remained relatively constant through the monitoring period. The use of road salt locally contributes significantly to the increase in sodium and chloride concentrations in lakes like Dickie, Harp and Leonard which are in close proximity of year round roads.

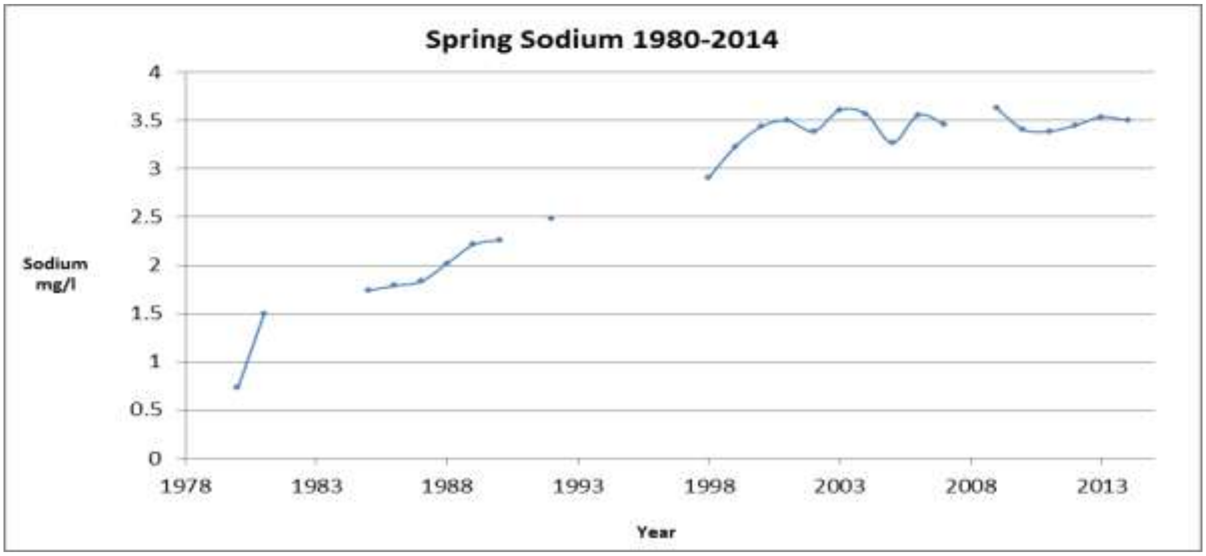


Figure 11. Spring sodium in Leonard Lake.

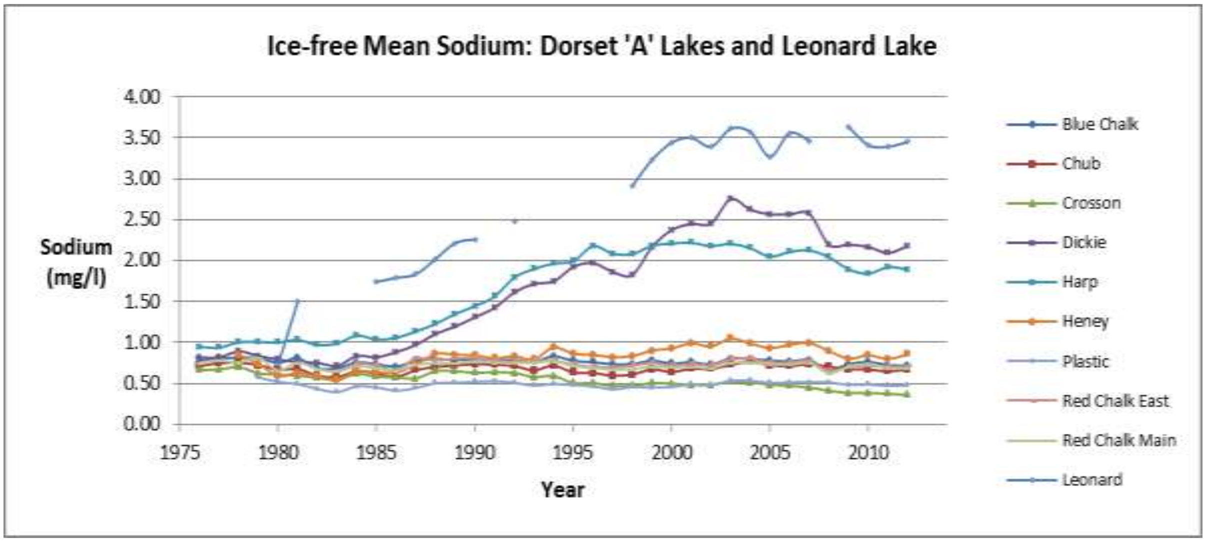


Figure 12. Sodium in Dorset 'A' Lakes and Leonard Lake. Note that lakes far removed from year round roads have not seen an increase in sodium.

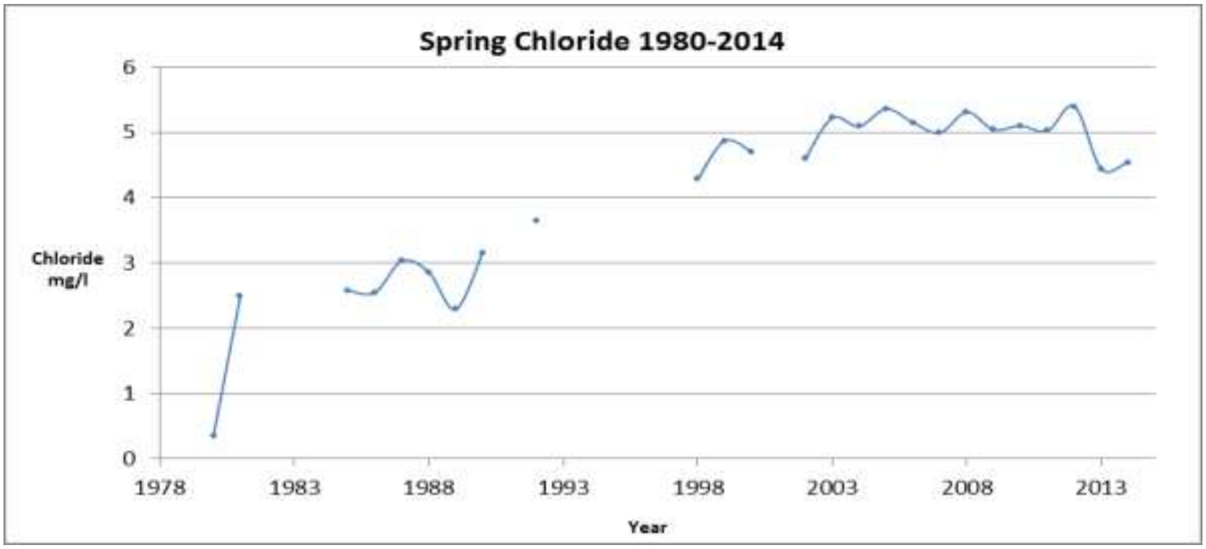


Figure 13. Spring chloride in Leonard Lake.

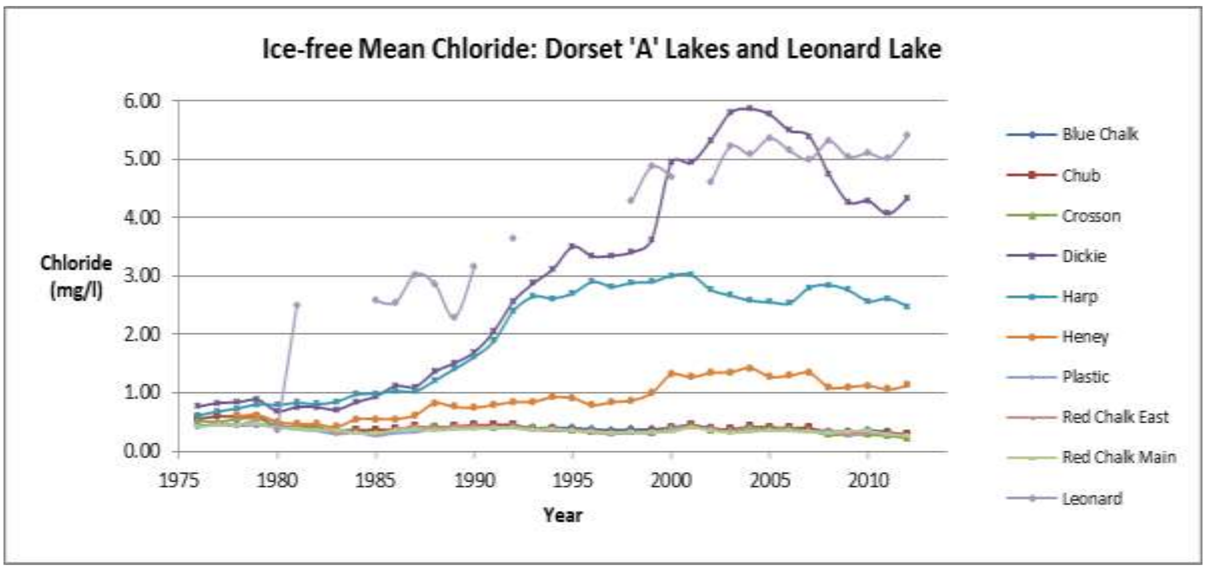


Figure 14. Chloride in Dorset ‘A’ Lakes and Leonard Lake.

Temperature and Oxygen

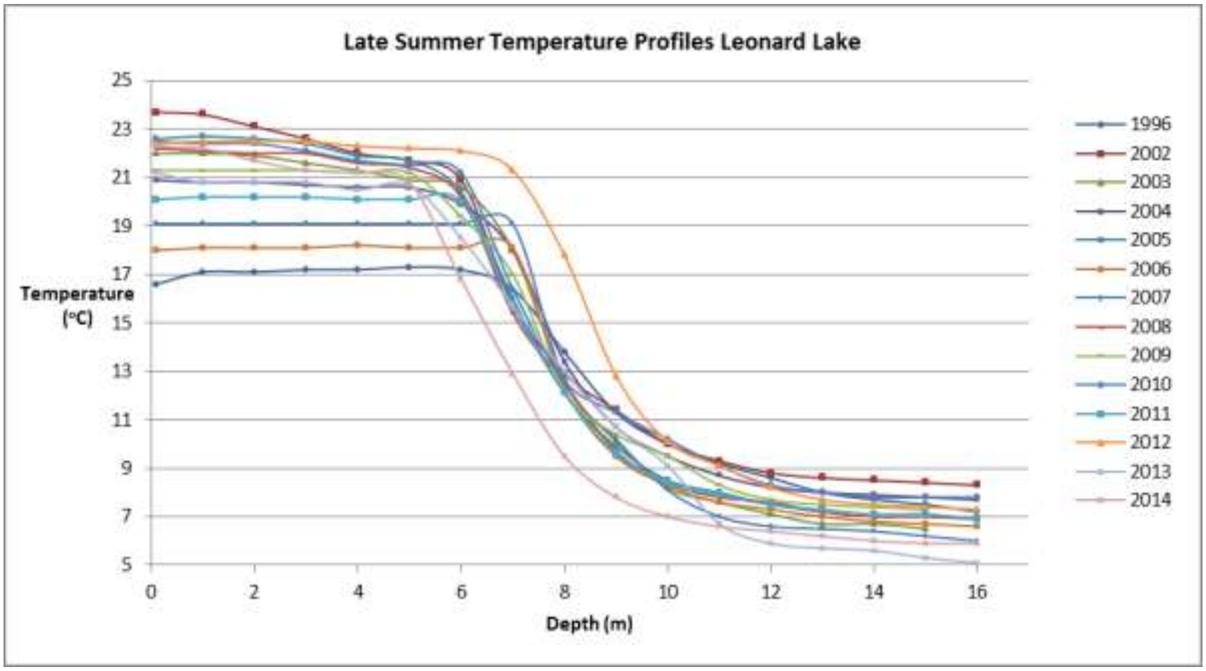


Figure 15: Late summer temperature profiles from Leonard Lake 1996-2014

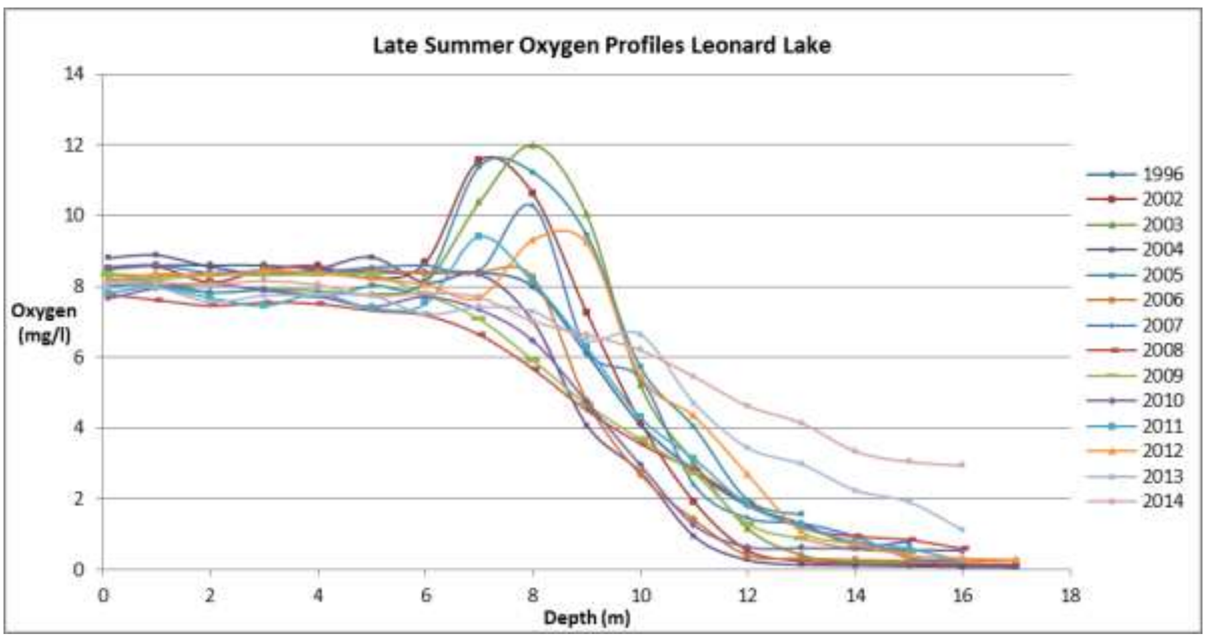
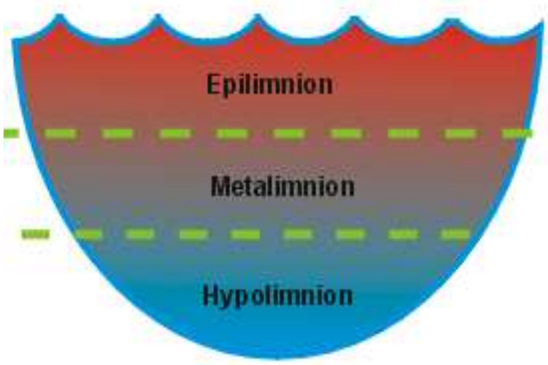


Figure 16: Late summer oxygen profiles from Leonard Lake 1996-2014

Temperature/Oxygen: In the above oxygen/temperature profiles note that typical epilimnetic water (uppermost and warmest layer of a stratified lake; see Figure 15) of Leonard Lake contains 7.5 to 8.8 mg/l oxygen in late summer. The metalimnion is the middle layer (typically 6 – 9m in September) and is the layer through which the greatest temperature change occurs. The hypolimnion is the bottom and coldest layer of a stratified lake. Late summer hypolimnetic water in Leonard Lake sees a decline in oxygen, at times to levels below 1mg/L. Stratification prevents introduction of new oxygen to the hypolimnion and combined with decomposition of organic matter can reduce dissolved oxygen in low or no light depths of a lake resulting in hypoxia (reduced oxygen) or anoxia (oxygen depletion). Note that there is a peak in oxygen at about 7-8 meters (Figure 16). During late summer the epilimnion is warm and as water increases in temperature, oxygen solubility decreases. At the same time oxygen is being depleted in the isolated hypolimnion. Algae that do well in low light, low temperature conditions are found in the metalimnion and those algae produce oxygen that results in the highest concentrations of oxygen found in Leonard during the late summer.



Depth	Temperature	Layer
0.1	20.9	Epilimnion
1	20.8	
2	20.8	
3	20.7	
4	20.6	
5	20.6	
6	19.9	
7	18	Metalimnion
8	13.4	
9	10.7	
10	9.5	
11	8.7	Hypolimnion
12	8.2	
13	8	
14	7.9	
15	7.8	
16	7.7	
17	7.6	

Figure 17: Diagram of a stratified lake and example of a temperature profile.

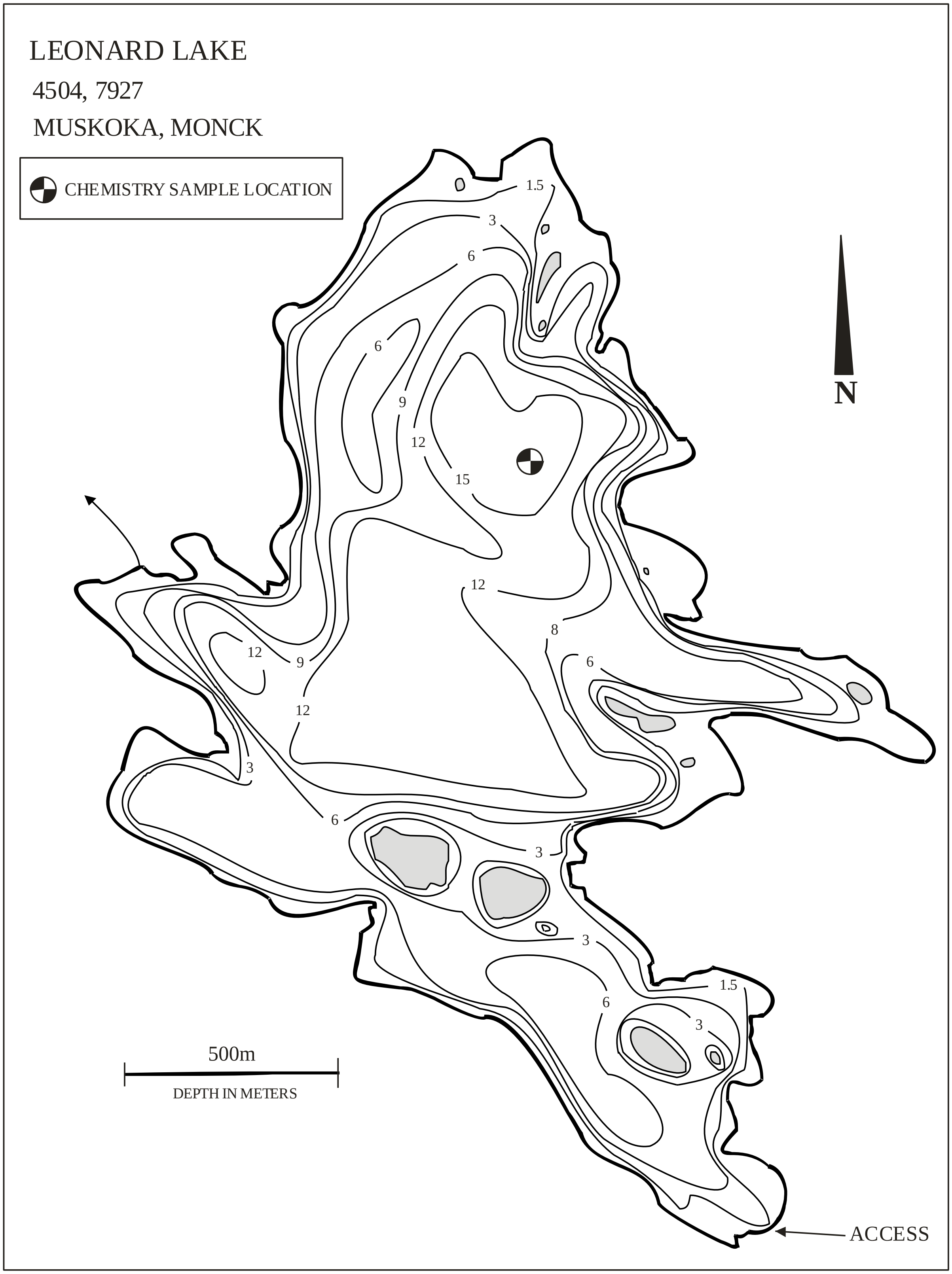
Conclusion:

Over the monitoring period there has been a reduction in sulphate and a corresponding rise in pH. DOC has increased very slightly over the monitoring period and with the small increase in DOC there is a small decrease in Secchi depth. Phosphorus has decreased slightly, a trend common to shield lakes. While calcium concentrations are decreasing in many shield lakes it has remained relatively constant in Leonard. Sodium and chloride have risen in Leonard as they would in any lake in close proximity of a year round road that receives road salt in winter.

For Leonard Lake most parameters follow similar trends to the majority of our long term monitored lakes.

Leonard Lake topographic map

Leonard Lake bathymetric map



For further information, see:

Canadian Journal of Fisheries and Aquatic Sciences, May 2008 - Dorset Special Issue: Thirty years of aquatic science at the Dorset Environmental Science Centre.
Web address: http://pubs.nrc-cnrc.gc.ca

History of chemical, physical and biological methods, sample locations and lake morphometry for the Dorset Environmental Science Centre (1973 - 2006)
Web address: http://www.ene.gov.on.ca/publications/6588e.pdf

Ingram, R.G., R.E. Girard, B.J. Clark, A.M. Paterson, R.A. Reid and J.G. Findeis. 2014. Dorset Environmental Science Centre: Lake sampling methods. Ontario Ministry of the Environment. Technical Report. 101pp.
Web address: http://desc.ca/node/30

Keller, W.B., A. M. Paterson, K.M. Somers, P.J. Dillon, J. Heneberry and A. Ford. 2008. Relationships between dissolved organic carbon concentrations, weather and acidification in small Boreal Shield lakes.
Web address: http://desc.ca/node/130

Palmer, M.E., N. D. Yan, A.M. Paterson and R.E. Girard. 2011. Water quality changes in south-central Ontario lakes and the role of local factors in regulating lake response to regional stressors.
Web address: http://desc.ca/node/363