A FOCA Guide to Community Science at the Lake

FOCA Federation of Ontario Cottagers' Associations

 https://foca.on.ca

Contents

1. WHY MONITOR YOUR WATERBODY

First and foremost, lake association members are worried about the water. We all love our lakes and want to ensure that the activities and experiences today will be possible for future generations.

Water monitoring is an under-appreciated public service, and the time has come to 'pay it forward' by carrying out the monitoring that must be done today in order to serve the needs of future generations.

Community scientists and lake stewards are essential in helping to improve and maintain the quality of Ontario's lakes. Having dedicated people who are able to take the time to measure physical characteristics of their lake, understand biological communities and assess chemical properties will play a vital role in keeping Ontario's lakes healthy.

> "A lack of comprehensive national monitoring systems, analysis capacity, and capacity to develop reliable predictive models based on common principles all hinder this [comprehensive national water assessment]."
>
> *– Schuster-Wallace C.J. and Sandford, R. 2015.*
> *Water in the World We Want. United Nations University for Water, Environment and Health and United Nations Office for Sustainable Development.*

Ongoing monitoring has benefits for our future. Long-term data is useful because it allows a baseline and trends to be understood for a particular watershed. They also allow outliers or changes to be identified, as results can be checked against data from previous years. From a community science standpoint, long-term monitoring creates a sense of community by keeping locals informed on changes to the health of their watershed, as well as giving the community a sense of place and values to understand and appreciate in the natural environment.

This ***Guide to Community Science*** is intended to provide lake stewards (or citizen scientists) with the tools they need to monitor their own lake.

This guide is intended to answer the questions, "**Should I be sampling?**" as well as "**How do I sample?"** and "**What should I sample for?**"

The guide includes:

- Information about how to classify your lake (see **Chapter 2**)
- how to design your own water sampling program (see **Chapter 3**)
- a description of various lake water quality parameters you might measure (see **Chapters 4 -8**)
- an overview of some existing monitoring programs across Ontario (see **Appendix A**) that you might choose to join
- an introduction to invertebrate sampling and identification (see **Chapter 7** and **Appendix B**)

Throughout the guide, look for sections titled '**Sampling Considerations**' to learn how to collect sound and meaningful data, how to interpret your results, and how to recognize when there may be a problem.

2. TYPES OF LAKES IN ONTARIO

The hard, slow-weathering granitic bedrock of the Canadian Shield was formed 1.5 billion years ago through geological processes such as upheaval. The glacial meltwater from the Laurentide Ice Sheet (approximately 10,000 years ago) provided source water to the depressions left by the glaciers, which now represent more than 200,000 of the province's inland lakes. Due to the hard, slow-weathering nature of the bedrock of the Canadian Shield, the overlying lakes tend to be very low in nutrients clear and generally long lived. Alternatively, lakes in Ontario that are located off the Canadian Shield tend to be shallower and more biologically productive than Shield lakes (Minns et al. 2008).

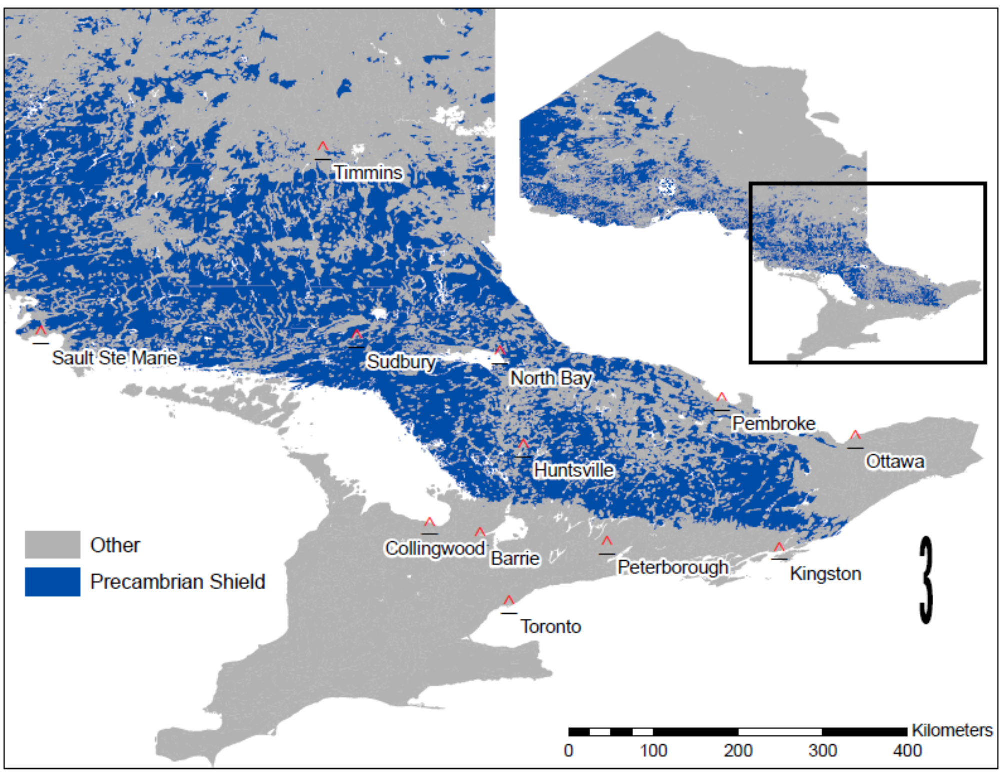


Figure 1: Map showing the distribution of the Precambrian Shield in Ontario *(figure credit: C. Anstey)*

The water quality and ecology of Ontario's inland lakes reflect watershed geology and vegetation, but human settlement, land-use change, climate, invasive species and chemical pollutants can modify these characteristics. For example, aquatic ecosystems can be vulnerable to climate change, with impacts that include declining lake water levels, increased susceptibility to invasive species and strain on native fish and aquatic insect populations. Human influences, such as industrial emissions, wastewater release and land use practices (i.e. deforestation, shoreline modifications, agriculture) can exacerbate problems by affecting physical and chemical parameters in aquatic ecosystems.

Many limnologists (scientists who study inland waters) place lakes into three broad categories with respect to nutrient status. Lakes with less than 10 μg/L total phosphorus (TP) are considered oligotrophic. These are dilute, unproductive lakes that rarely experience nuisance algal blooms. Lakes with TP between 10 and 20 μg/L are termed mesotrophic and are in the middle with respect to trophic status. These lakes show a broad range of characteristics and can be clear and unproductive at the bottom end of the scale or susceptible to moderate algal blooms at concentrations near 20 μg/L. Lakes over 20 μg/L are classified as eutrophic are highly productive, and may exhibit persistent, nuisance algal blooms.

Trophic status is an indicator of how much growth or productivity occurs in a lake. The availability of nutrients is the limiting factor in determining trophic status and may be different between water bodies due to the geology, nutrients and the surrounding land uses.

The key characteristics below may provide guidance in determining your lake's status:

2.1 Oligotrophic

In Latin "oligo" means few or very little. In general, oligotrophic lakes have lower levels of nutrients, including TP. As a result of the nutrient content, oligotrophic lakes have low primary productivity (low algal production). Primary productivity is the process of green plants converting solar energy, carbon dioxide, and water to glucose and eventually to plant tissue.

Generally deep with low algae concentrations, oligotrophic lakes are colder and therefore can hold a considerable amount of dissolved oxygen throughout the water column. This is why we often find that oligotrophic lakes provide suitable habitat for cold water fish species such as lake trout and lake whitefish.

2.2 Mesotrophic

In Latin “meso” means medium or mid. In mesotrophic lakes, intermediate levels of productivity result in a combination of clear water areas and beds of submerged aquatic plants. Mesotrophic lakes are able to support an abundance of fish – some of which include muskellunge, walleye, perch and smallmouth bass.

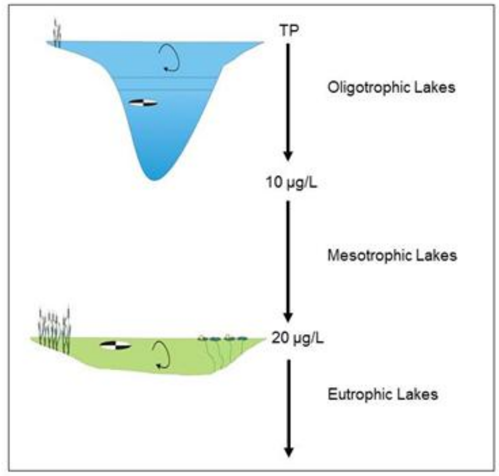


Figure 2: Total Phosphorus ranges by lake type.

2.3 Eutrophic

In Latin “eutrophic” means well nourished. Eutrophic lakes have high levels of nutrients. As a result of this, eutrophic lakes have increasing biological activity and can support an abundance of aquatic plants and algae. Higher phosphorous levels support increased levels of primary productivity (algal growth).

Typically eutrophic lakes are shallower and may have murky water due to the increased biological activity. The lake bottom is mucky and soft. Due to the abundance of biomass and decomposition, eutrophic lakes have a considerably lower dissolved oxygen content. This may create anoxic (low or no oxygen) conditions at the bed of a lake during certain times of the year resulting fish mortality (aka, “fish kills”). However, certain species of hardy fish are able to thrive in lower levels of dissolved oxygen, these species include fish such as carp and catfish.

It is important to remember that there are exceptions to these classifications that community scientists need to be aware of. For example, some lakes have naturally occurring turbidity or colour. This decreased clarity could be mistakenly attributed to algal growth. This is why participating in community science and the collection of long-term monitoring data will provide an overall picture of what is “normal” for your lake.

3. DESIGNING YOUR SAMPLING PROGRAM

Environmental monitoring is defined as a time series of measurements of physical, chemical and/or biological variables that are designed to answer questions about environmental change (Lovett et al., 2007). This reminds us that monitoring has a specific purpose, which is to answer questions or support research objectives. Well-designed monitoring programs form the basis of defensible management and policy when based upon (comprehensive) research questions and objectives.

Long-term monitoring is an important source of trend information, and allow us to validate our sampling methods and designs, generate data for modeling of future scenarios, and understand natural variability over time.

As community scientists, we can monitor our water resources to better understand and protect the health of our lakes. The objective of long-term monitoring of lake water conditions is to better understand what is “normal” between-year variation in water quality, and identify possible changes that may be occurring over time and possible causes. The development of a high quality, long-term monitoring program requires consideration of several key aspects, including the development of specific research questions.

After the key research questions and data gaps have been identified, key parameters can then be monitored over time to track the long-term health of your inland lake, and answer the proposed research questions (Rainy-Lake of the Woods State of the Basin Report 2nd Edition, 2014).

The key water quality parameters that a community scientist in Ontario may be interested in monitoring (and why) are described in Chapters 4 through 8.

Things to Think About

Often, sampling sites are determined by local uses, for example where lots of people will be exposed to water such as a public beach. Most rural lakes in Ontario are in good health, and their diminished health comes from many non-point sources, rather than a single obvious or large source.

Trying to assess the health of an entire lake can be very difficult especially for large water bodies. Therefore, it is very important that community scientists take samples that can appropriately represent the entire water body as opposed to just one or two locations.

It is critical to take samples at several different locations (as mentioned in the above paragraphs) as well as different depths. Using a depth finder or a bathometric map, the deepest and shallowest spots within a lake can be determined. Samples should be drawn from both locations as well as some intermediate locations in order to best represent the entire lake.

The location of each sample needs to be diligently recorded in order to capture any site-specific conditions or results. (Rainy-Lake of the Woods State of the Bain Report 2nd Edition, 2014)

Important considerations must be made if you plan to implement and design a new long-term monitoring program:

(Rainy-Lake of the Woods State of the Basin Report 2nd Edition, 2014)

1. What are your questions and what is the best way to answer them? Design the monitoring program around compelling scientific questions taking into consideration the interests of the many stakeholders (other lake residents etc.) within the basin.
2. What are your resources and how to decide the best way to use them? Allow flexibility to review, provide feedback on, and adapt to the monitoring design as

research questions evolve. This could be done on a rotating basis of 3-5 years. This allows for a refocusing of scientific objectives.

3. Choose variables with a future in mind. A core set of variables should include basic measures of lake health that are of interest to the general public and resource users, as well as those that are sensitive indicators of change. These variables should be monitored over space and time. Lessons learned from other monitoring programs can be used to refine the monitoring design. These measurements should be as inexpensive as possible, because cost can determine the long-term sustainability of the program.
4. Maintain quality and consistency of the data. Sample collections should be rigorous, repeatable, well document and employ acceptable methods. A quality assurance-quality control program should be initiated at the beginning of a new monitoring program, since field and analytical methodologies may vary among agencies and laboratories.
5. Make the data accessible over the long-term through proper archiving. This should include detailed information on sampling methodologies that can be made publically accessible.

4. WATER QUALITY

Water quality refers to the chemical, physical and biological characteristics of water. It is a measure of the condition of water relative to the requirements of the ecosystem as well as any human need or purpose.

Under the prospect of a changing climate, it is particularly important to watch for changes, and preserve the health of our lakes. Aquatic ecosystems can be vulnerable to a changing climate, with effects that include declining lake water levels, increased susceptibility to invasive species, longer ice-free seasons, increasing water temperatures and strain on native fish and aquatic insect populations. Human influences, such as industrial emissions, wastewater release and land use practices (i.e. climate warming, deforestation, shoreline modifications, and agriculture), can combine to exacerbate problems by collectively affecting physical and chemical parameters in aquatic ecosystems.

As concerned communities, we can monitor our water resources to better understand and protect the health of our lakes. Our lakes and rivers can be monitored for several key parameters. Lakes have distinct natural characteristics based on bedrock mineralogy, biological activity, precipitation, temperature and inflow/outflow patterns. The objective of long term monitoring of lake water conditions is to more readily recognize possible causes of environmental concern and apply positive remedial practices where possible.

Before taking water samples from your lake it is important to have a basic understanding of the parameters for which you are sampling and the proper sampling and monitoring considerations.

This next section provides a basic background on water chemistry monitoring, to prepare communities to effectively contribute to maintaining the health of their lakes.

4.1 Total Phosphorus

Phosphorus is an essential nutrient that is needed for growth and metabolic reactions in plants and animals, and occurs naturally in lake water. Phosphorus can be found throughout the terrestrial and aquatic environments largely based on the weathering of rocks and minerals containing phosphorus. Phosphorus can be found in degraded animal waste and plant matter that sink to the bottom sediment of lakes, as well as in dissolved and suspended particulate forms.

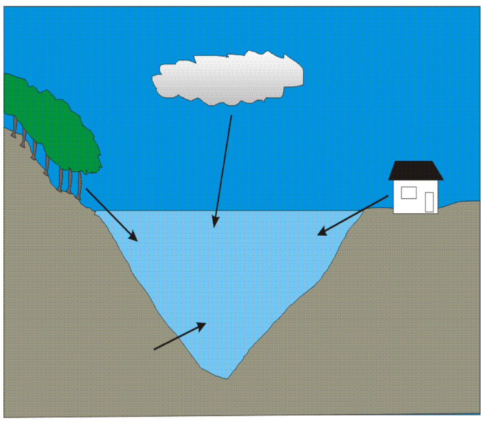


Figure 3: Sources of phosphorus

In Ontario, we frequently manage our lakes based on total phosphorus. The parameter ***total phosphorus*** (TP) defines the sum of all phosphorus compounds that occur in various forms. TP concentrations are ideally used to interpret lake nutrient status since phosphorus is the element that controls the growth of algae in most Ontario lakes.

Human-caused changes can influence the natural cycling of phosphorus. Excess phosphorus is known to come from human wastes (septic systems and wastewater treatment plants), decomposing organic matter, fertilizers and laundry detergents.

In addition to being an essential element for aquatic systems and organisms, phosphorus is a limiting nutrient for plant growth and therefore controls the growth of algae in most Ontario lakes. Increases in phosphorus may stimulate algal growth, resulting in reduced water clarity and deep-water oxygen concentrations, affect the aesthetics of the lake, and/or cause taste and odour problems in the water and in extreme cases, cause algal blooms that may produce toxins.

An algal bloom is a rapid increase or accumulation in the population of algae in freshwater systems. As algal blooms age and decay, bacterial processes consume oxygen, which may in turn reduce the oxygen available for other aquatic organisms. This may result in increased fish mortality or declining fish species or other organisms that have higher oxygen requirements (see Chapter 8.0 for more on algae).

It is important to note that many lakes in Ontario are “tea-stained” by tannins, which are contributions from wetlands in the watershed, which have a high humic content. These “dystrophic” lakes contain humic substances that can form compounds with phosphorus, which studies show can reduce phosphorus availability to algae. However, TP includes all forms of phosphorus that have been liberated from compounds containing strong phosphorous oxygen bonds such as phosphate (PO_4^{3-}) which is required for all forms of life and it forms part of the structural framework of DNA and RNA.

Sampling and monitoring considerations

TP concentrations are used to infer a lake’s capacity for algal growth, or trophic status, as described above. TP monitoring is the focus of FOCA’s long-term water quality monitoring partnership with the Ontario Ministry of Environment and Climate Change’s Lake Partner Program. This free, voluntary program provides volunteers with the tools they need to monitor lake TP, in addition to water clarity and calcium. Each year, approximately 650 volunteers monitor nearly 550 inland lakes at over 850 sampling locations. About 85% of volunteers sample lakes on the Canadian Shield, and these volunteers collect one water sample in the spring each year. The remaining 15% of volunteers sample once per month during the ice-free season for lakes off the Canadian Shield. These water samples are used to monitor long-term trends in a lake’s trophic status, TP and calcium concentrations.

Other TP monitoring factors

When designing a sampling program for TP, there are several important factors to consider (from Clark et al., 2011 and MOECC, unpublished data):

1. A mid-lake deep spot sample is the best to describe whole-lake conditions; samples taken from elsewhere in the lake should consider if the location is near a tributary or another source that may cause the phosphorus reading to be outside the norm.

2. Spring only samples are necessary to characterize ice-free season TP for most Shield-lakes, whereas off-Shield lakes should be sampled once per month during the ice free season to observe any increases in TP during the end-of-summer months, which may contribute to algal blooms.
3. Water samples should be filtered with an 80-um (micrometer) mesh on site to remove large zooplankton or other debris that could contaminate the sample and cause erroneously high TP readings.
4. Obtaining a composite water sample from a depth of 1 times the Secchi depth (see Chapter 4.2 for more on Secchi sampling methods) to the surface is sufficient to characterize the TP concentration of the upper layer of the water column (euphotic-zone). Samples taken from lower depths may enter the lower, stratified layers. Consistency is important. To identify if there is a load of TP entering the lake from the sediment, hypolimnetic (bottom layer of water in a thermally-stratified lake) samples will be necessary.
5. Data quality, analytical method, and precision of data, must be considered for lakes that are naturally low in phosphorus. You need precise, high quality data in order to observe between-year differences in TP over the long-term.
6. Replicate TP samples will improve confidence in the data.
7. Identification of outliers in both replicate samples, and within the long-term dataset also improves data integrity.

It is important to be consistent.

When taking phosphorus samples it is particularly important to avoid contamination. Since phosphorus is present in lakes in only trace quantities it is very easy for phosphorus to be transferred into your sample from your hands or even dust from the air without you realizing. Glass sample bottles provided from the lab have been cleaned diligently with chemicals that do not contain phosphorus and should be used to collect samples. Prior to collecting the sample it is important to rinse the sample bottle with your sample water three times. Nitrile gloves are recommended when collecting the phosphorus samples however they are not necessary as long as a community scientist is taking the proper precautions. The sample should immediately be capped/sealed and stored in a cooler until they are delivered to the lab for analysis.

4.2 Water Clarity

Water transparency, or water clarity, is easily measured with a piece of equipment called a Secchi disk.

Secchi depth (or water clarity) is directly related to the depth at which light can penetrate into the lake. Light penetration in a lake can be controlled by dissolved organic carbon (DOC), biological turbidity (e.g., algae) and non-biological turbidity, which can influence the colour of the lake. Water clarity readings are valuable to track changes in the lake that might be occurring that would not be noticed by monitoring TP concentrations alone, such as impacts from invading species (e.g., zebra mussels), climate change effects, or other watershed disturbances.

Figure 4: Using a Secchi disk.

The ability of light to penetrate into a water column is affected by the angle of incidence (at what angle the sun's rays hit the surface of the water) and materials that are suspended in the water such as algae, sediments and rock flour. All these things create turbidity in the water. Increased suspended sediment decreases the clarity of water and the amount of light that can reach certain depths within a column of water.

Secchi disk depths are correlated with two important lake measurements: the amount of chlorophyll in the water and the compensation point. The amount of chlorophyll is reflective of algal growth in the water body; therefore, a lake that has high algae growth would likely have a lower (smaller) Secchi depth. The compensation point is the depth within a water column where there is not enough light penetration to support high levels of growth, in other words respiration exceeds photosynthesis. The area above this compensation point is called the photic zone, where there is lots of available light and high levels of growth are possible.

Recorded Secchi depths can also be used as a somewhat reliable estimate of lake trophic status, as trophic status generally refers to the amount of plant nutrients available. However, in nutrient poor lakes, light penetration is controlled by Dissolved Organic Carbon (DOC) or non-biological turbidity. Therefore, Secchi disk measurements are a better estimate of land use alterations, changes due to climate warming, and invasive species introductions. For example, the appearance of the invasive zebra mussel can often be seen in long-term Secchi disk data due to a sudden increase in water clarity following invasion. This is a result of the mussels filtering high volumes of water, thereby enhancing water clarity.

Table 1: Typical Secchi depths by lake trophic status (Gertrud Nurnberg, 1996).

Trophic Level	Secchi Depth (metres)
Oligotrophic	2-4m
Mesotrophic	1-2m
Eutrophic	less than 1m

Sampling and monitoring considerations

Secchi depth measurement should be taken at the deep spot of the lake or bay, on the shady side of the boat between 10:00 a.m. and 4:00 p.m. (sunglasses should be removed). The Secchi disk should be weighted so that it sinks in the water column, and attached to a rope that has been marked every 10 cm (tenths of a metre) with an indelible marker. To take a Secchi depth measurement, the sampler lowers the Secchi disk until it disappears from view, and records this value; the sampler then raises the Secchi disk until it reappears, and records this value. The average (midpoint) of these two depths is the Secchi depth. The Secchi disk rope should also be re-calibrated at the start of each sampling year, since certain types of rope can stretch over-time, thereby providing inaccurate depth readings.

4.3 Temperature and Dissolved Oxygen

Temperature

We are all familiar with temperature as a physical parameter. Less intuitive is the role temperature plays in aquatic ecosystems and lake water quality. Warmer waters increase rates of photosynthesis for primary producers (algae and aquatic plants) as well as the metabolic rates of aquatic organisms. As discussed earlier (see page 8), warmer water can hold less oxygen than colder waters. High temperatures as well as the resultant oxygen depletion can stress aquatic organisms (i.e., certain fish species). This can ultimately have an effect on aquatic ecosystem biodiversity.

The primary source of heat to lakes is light from the sun. Inflow of warmer or cooler waters (i.e., streams and rivers) may also affect the temperature of a lake. Tributaries to lakes can be warmed or cooled by natural processes, but also by human influences. Thermal pollution from paved surfaces or industrial cooling processes can be sources of water released to freshwater systems at elevated temperatures. The removal of trees along the shores of waterbodies can also influence the water temperature by removing this important source of shade.

Sampling and monitoring considerations

Temperature measurements are quick and easy to make. This is fortunate because more temperature data is required to construct a meaningful dataset based on fluctuations throughout the day as well as variability with weather. The ease with which temperature is measured makes it possible to monitor more often than other parameters (monthly or weekly measurements). Samples should be distributed so that they are representative of different aspects of the lake, including significant stream/river inflows. A thermometer may be used for temperature measurements. Alternatively, most probes for dissolved oxygen, conductivity and pH also come equipped with a temperature sensor.

The location, depth and consistency of temperature measurements depend on what you would like to know. A community may just want to know the surface temperature of the water for recreational purposes or they may be interested in creating a temperature profile of the lake over different seasons. Creating temperature profiles once per season can tell you more about Lake Turnover rates in your lake. If this is the case temperature measurements need to be taken at regular depth intervals.

Dissolved Oxygen

The Earth's atmosphere is composed of approximately 21% oxygen (O_2). The oxygen in the atmosphere interacts with lakes resulting in oxygen being dissolved in the lake water. Dissolved oxygen is used by many aquatic organisms, including fish who use their gills to breathe oxygen from lake water. Different fish populations require different oxygen levels to survive, so the amount of dissolved oxygen in a lake is an important consideration for aquatic ecosystem health.

Dissolved oxygen in lakes is influenced by a number of factors. Temperature has an inverse relationship with oxygen solubility, meaning that at higher temperatures there is less dissolved oxygen in lake water. Biological processes include photosynthesis and respiration that function to produce and consume oxygen, respectively. Humans can influence the amount of dissolved oxygen in water through the discharge of wastewater rich in organic matter (i.e. agricultural runoff, wastewater discharges and sewage leakage). This organic matter can increase biological productivity and plant growth, which eventually results in bacteria thriving as it 'chews' on decaying plant matter. Bacteria use oxygen that would otherwise be available to larger aquatic organisms, putting stress on insect and fish populations.

Sampling and monitoring considerations

Dissolved oxygen monitoring is important, especially if the characteristics of your lake appear to be changing. For instance, if parts of your lake are shifting towards eutrophic status it would be worth sampling for dissolved oxygen at the areas of concern as well as the surrounding waters. Significant changes in water colour/clarity, extent of plant growth and biodiversity are all potential red flags where changing dissolved oxygen levels are concerned. Since dissolved oxygen changes with temperature, it is important not to mistake natural fluctuations based on the season or time of day with larger scale changes in aquatic ecosystem structure. This must be taken into account when comparing dissolved oxygen levels among lake samples or even planning where and when to take the samples. If a dissolved oxygen meter is not available, and/or you are unfamiliar with the use of this equipment, an environmental scientist skilled in sampling natural waters should do the sampling.

It is worth noting that the extent and frequency that we sample our lakes is largely based on the time and resources available. When sampled for, the parameters listed here in Chapter 4.0 can provide a valuable repository of data. For instance, monthly dissolved oxygen measurements for a lake over the span of several years could be indicative of trends or correlated with variability in other parameters. This depth of sample collection may not be realistic for community scientists at particular lakes. Seasonal sampling (i.e. spring, summer and fall) is less laborious, but could still make a valuable contribution to the long term monitoring of lake water chemistry. Sample location, collection methods and dates should be consistent and diligently recorded.

4.4 Dissolved Organic Carbon

Observing the colour of the water in your lake is a quick and easy way to determine conditions in your lake, (or if there is a potential problem). Certain colours are associated with different chemicals, organic matter and sediments, therefore, it is a good visual indicator of water quality.

Dissolved organic carbon (DOC) generally describes the organic material dissolved in water. Organic carbon is a result of the decomposition of plant or animal material. Organic carbon present in soil or water bodies may then dissolve when contacted by water.

Lakes with low Dissolved Organic Carbon concentrations tend to have high water clarity and appear bluer in color. High-DOC lakes have brown water because of the high concentrations of light-absorbing humic and fulvic acids. The large variation in DOC and color observed among lakes is determined by relative rates of loading, in-lake transformations, and losses of water in the system (Engstrom 1987; Dillon and Molot 1997; del Giorgio et al. 1999).

Tea stained lakes are naturally occurring and often appear darker and browner in colour. They get this colour from increased levels of dissolved organic carbon and tannins. One feature common among all tea stained lakes is the proximity, number and size of wetlands that are within the watershed. The wetlands act as a “tea bag” as water runs through them as it picks up darker colours from the excess dissolved organic carbon and tannins that wash out from the wetland plants. This water then enters the lake and stains it a darker colour of brown.

Making Observations

When taking a sample of lake water for colour analysis a white container should be used so the colour can be observed easily. Alternatively, a clear container can be used and white piece of paper can be held behind it to observe if there is a ‘tea-stained” colour.

However, to obtain a more accurate measurement of the amount of dissolved organic carbon present in your sample, it should be sent to a credited laboratory for analysis.

4.5 pH & Alkalinity

pH is expressed across a scale of 0 to 14. pH of 7 is considered neutral, whereas pH values less than 7 are acidic, and pH values greater than7 are basic. pH is key indicator of lake health, as many aquatic organisms thrive only within a narrow pH range. Conditions too acidic or basic can be detrimental to general health and reproductive efficiencies of fish and other organisms.

Natural features of a lake largely influence pH. Geology underlying and surrounding the water body determines the types of chemicals released to the water during the weathering of minerals, and can determine whether a lake is more sensitive or resistant to acidification. The balance between photosynthetic and respiration processes can also influence pH.

Human caused changes to pH of lakes include the release of sulfur and nitrogen oxides to the atmosphere as part of industrial emissions. These pollutants combine with water vapour in the atmosphere to form sulfuric and nitric acids, or “acid rain”. The resultant precipitation is influenced by these strong acids and the pH is consequently lowered (more acidic). Conversely, soaps and detergents from wastewater effluent may result in waters with higher pH values (more basic).

Sampling and monitoring considerations

Lake pH is of importance to the overall health of an aquatic ecosystem and should be monitored. pH measurements would ideally be made monthly or seasonally and taken at sampling sites distributed across diverse aspects of the lake. For instance, representative samples from the deep portion of the lake, areas closer to the shoreline, inflows/outflows and any areas of potential environmental concern should be taken.

If a pH meter is available, pH measurements can be made in the field immediately following sample collection. The pH probe is submerged in the lake water sample, swirled and allowed to reach a stable pH reading. This value is then recorded to the appropriate number of decimal places. Alternatively, capped sample bottles containing lake water samples can be stored in a cooler until they are delivered to an environmental lab for analysis. Note: Litmus paper “strips” can be used but may provide highly variable or imprecise results.

5. OTHER WATER QUALITY PARAMETERS TO CONSIDER

5.1 Calcium

Calcium is found naturally in the environment. It is found in deposits of limestone and is generally present in all natural waters at levels which depend on the amount of contact with specific geological formations (i.e. limestone, dolomite, gypsum and gypsiferous shale). Calcium enters a body of water through the leaching of soils, weathering of rocks and effluents from other point sources.

Calcium is an essential element for all life forms. It promotes proper teeth and bone formation in animals and enhances growth in plants. *Daphnia,* for example, are very sensitive to declining calcium levels. *Daphnia* are tiny organisms called zooplankton and are a primary food source for many fish. *Daphnia* use calcium in the water to form their calcium-rich body coverings. Mollusks, clams and crayfish are other examples of other aquatic animals that rely on calcium. Daphnia is also an important source of food for fish. (Lake Partner Program Report Card, 2015).

Calcium is especially important to monitor in Canadian Shield lakes, as calcium concentrations in these lakes are in decline. Studies have shown that calcium loss is an important stressor for many aquatic species, especially when combined with lower food availability and warmer temperatures.

Sampling and monitoring considerations

Calcium monitoring guidelines are comparable to those of total phosphorus detailed in the preceding section. It is recommended that the sampler should wear nitrile gloves and collect samples in pre-cleaned bottles provided by the environmental lab to minimize the likelihood of cross-contamination. The sample bottle should be rinsed three times with the sample (i.e. lake water) prior to filling the sample bottle one final time. After the filled sample bottle has been capped and sealed it should be placed in a chilled cooler until it is delivered the lab for analysis.

5.2 Nitrates

The Earth's atmosphere is composed of ~78% nitrogen (N_2). Nitrogen (N) is an essential nutrient for plant growth and animal health. Bacterial processes convert nitrogen through a number of different chemical forms that are taken up by plants, mainly ammonia/ammonium and nitrates. Excess nitrate concentrations can cause spikes in algae growth, which can cause problems in aquatic ecosystems. Similarly to total phosphorus, high nitrate concentrations have the potential to develop eutrophic conditions and depleted levels of oxygen for fish and aquatic insect populations. A milky yellow/green water colour could be a sign that a water body has elevated total phosphorus and/or nitrate concentrations and is at risk of becoming eutrophic. Clumps of decaying algae may be seen washing up on shore.

Nitrates are found in soil, plants, animals and natural waters. In addition to these natural sources, nitrates may enter lakes from human activities. For instance, nitrate-containing fertilizers are applied to farmlands to promote plant growth. Precipitation events can cause stormwater runoff from farmlands to deliver water containing high nitrate levels to rivers and lakes. By the same mechanism manure and wild animal excrement (particularly ducks and geese) can deliver heavy loads of nitrates to natural water bodies. Finally, sewage from wastewater treatment plants and poorly installed/maintained septic systems can be a human source of nitrates to rivers and lakes especially during and following heavy rainfall events.

Sampling and monitoring considerations

Nitrate monitoring guidelines are comparable to those of total phosphorus detailed in the preceding section. These nutrients are monitored largely to identify changes in lake trophic status (*Chapter* 2). The sampler should wear nitrile gloves and collect samples in pre-cleaned bottles provided by the environmental lab to minimize the likelihood of cross-contamination. The sample bottle should be rinsed three times with the sample (i.e. lake water) prior to filling the sample bottle one final time. After the filled sample bottle has been capped and sealed it should be placed in a chilled cooler until it is delivered the lab for analysis.

5.3 Turbidity

Turbidity measures the clarity of water based on the ability of a beam of light to pass through a sample of the water. At high levels of turbidity particulate matter such as clay, silt, algae, sewage and other inorganic materials reduces the ability of light to pass through the water. When it comes to drinking water, we want a glass of clear and colourless water devoid of suspended solids. In lakes high levels of turbidity makes the water appear murky and/or cloudy. The suspended solids in turbid waters can have an effect on fish populations by clogging their gills and reducing their respiration efficiencies. Suspended solids in turbid waters may also settle to the water bottom where they can cover and smother fish eggs or the larvae of aquatic insects. Turbidity levels can also affect the depths at which sunlight penetrates the water column, which influences aquatic ecosystem structure and oxygen demands.

In deep waters turbidity is largely attributed to the presence of microorganisms, such as algae and phytoplankton, in the upper portion of the water column. Towards the shoreline, suspended solids can also accumulate based on soil erosion and waste discharge. These mechanisms can be exacerbated with modified shorelines, increased storm water runoff or floods, as well as the agitation of bottom sediments by strong currents, large wakes, or high winds. Suspended solids may also enter a waterbody from shoreline sources such as construction, forestry and agriculture. It is therefore important to consider proximal land uses when assessing potential impact to the quality of natural waterbodies and appropriate management practices to minimize environmental risk.

Sampling and monitoring considerations

Turbidity can provide insights into lake health and can be monitored monthly or seasonally. When collecting a water sample for a turbidity measurement, the main challenge is ensuring that the sample is representative of the natural turbidity. For instance, wading into a water body can stir up the bottom sediment and compromise the quality of the sample collected. Care must be taken to avoid other situations where the sediment has become re-dispersed, such as areas of recent boating or swimming activity. Turbidimeters can be used in the field to obtain measures of turbidity.

Measurements are made in nephelometric turbidity units (NTU), where high NTU values correspond to high turbidity, or elevated light scatter off surfaces of suspended solids in the water sample. If you do not have access to a turbidimeter or are not comfortable using this equipment, an environmental scientist skilled in sampling natural waters can do these tests.

6. MICROBIOLOGY

Contaminated water can present a serious health risk, even in healthy lakes.

Bacteria exist naturally in surface water and (generally) will not pose a threat to human health, however, bacteria present in fecal (animal or human) contamination may cause infections in humans. Large quantities of bacteria can make their way into surface water indirectly through storm water runoff (nonpoint source) or may be discharged directly into a stream, river or lake from something such as a water treatment plant (point source).

It is important to remember the presence of fecal coliforms in small amounts is not necessarily a bad thing in a lake environment. Observing the quantity of *Escherichia coli (E. coli)* is an obligatory test for drinking water sources, such as wells, but is not usually part of routine sampling programs for inland lakes.

Since coliforms can be ubiquitous (ever-present), it is recommended that you never drink untreated surface water from any source.

Under the Safe Water Program, Boards of Health are required to conduct surveillance of public beaches and assess associated risk factors (bacteria) and emerging trends related to illnesses and injuries. Boards of Health are also required to respond to complaints and reports of adverse events related to recreational water use at public beaches. This response is required within 24 hours of notification and includes determining the level of potential impact and the appropriate corrective response (MOHLTC, 2014).

The following section describes the different types of bacteria that are naturally present in lake water, but in high enough quantities, may pose a risk for swimming.

6.1 Coliform Bacteria

Coliforms are a group of bacteria that are commonly found in the environment in soil or vegetation, as well as the intestines of mammals, including humans. Results for total coliform bacteria may not cause adverse health effects, but their presence indicates that your water supply may be vulnerable to contamination by more harmful microorganisms. The bacteria, *E. coli* is the only member of the total coliform group of bacteria that is found only in the intestines of mammals, including humans. The presence of *E. coli* in water indicates recent fecal contamination and may also indicate the possible presence of other disease-causing pathogens, such as bacteria, viruses, and parasites.

6.2 Fecal Coliforms

Fecal coliforms can be used as indicator bacteria in water testing. The presence of fecal coliform means that there is the possibility that other infectious disease organisms or pathogens are present as well. A person who is swimming in water with high counts of fecal coliforms is at a greater risk of getting sick from swallowing these disease causing organisms or from pathogens entering their body through open cuts in the skin, nose, mouth or ears.

Fecal coliforms occur naturally in the intestines of warm-blooded animals and actually aid in the digestion of food. The presence of these bacteria in a sample may suggest that the water source has been in contact with some form of waste contamination. Sources of waste contamination may include septic system infiltration, storm water runoff or direct waste from humans or animals.

Some monitoring agencies test water for *E. coli* rather than fecal coliforms. *E. coli* is a specific species of fecal coliform bacteria, and is an indicator of fecal contamination.

It is also important to note that there may be small levels of these bacteria present in the body of water already and it is not necessarily an indicator of a contamination. However, drinking water systems require regular tested for total coliform and/or *E. coli*.

The Ministry of Environment and Climate Change advises against consuming untreated lake surface water. The safe amount of colony forming units (CFU's) for drinking water is zero (*Safe Drinking Water Act*, O. Reg. 169/03, 2016). Contact your local health unit for more information on safe drinking water guidelines and testing. **This document only deals with bacteria in open water for swimming purposes.**

Sampling considerations and Resources

First consider: what is the goal of your bacteria monitoring program? For most community scientists, it is simply to educate themselves and others on the lake and to promote clean water practices.

Your monitoring plan should include the location of your sample sites, frequency of sampling, timing and duration of sampling, and sampling parameters and analysis methods.

The simplest fecal coliform test and perhaps the most appropriate for inland lakes is to note only the presence or absence of the bacteria. This may be helpful to a degree, however, depending on what you intend to do with the results, more specific information may be required. Certain tests require culturing a water sample in petri dish and obtaining a concentration of fecal coliforms in number of colonies per 100 ml of water. This work is done in a laboratory setting.

The most important thing to remember when out in the field collecting a sample to test for fecal coliforms is to not contaminate the inner surfaces of your sampling equipment. Most equipment used for testing fecal coliforms, such as jars and petri dishes, comes in a sterilized pack. Therefore, to prevent your sample from becoming contaminated, avoid touching the inner side of your equipment with bare hands, or wear gloves.

It is important to sample for bacteria where the most recreational activity (and thus human exposure) takes place. It may also be important to sample areas near known or likely point sources of pollution (sewage pollution, storm water inputs etc.). If you suspect an area in the lake where the levels of fecal contamination might be elevated, it may be worthwhile to collect a “Dry-weather” and “Wet-weather” sample. A “Dry-weather” sample is collected on a sunny day when there has been no recent rain events. A “Wet-weather” sample is taken during and immediately following a precipitation event. Comparing the concentration of fecal coliforms between the different samples may give more insight as to whether or not the contamination is related to storm water runoff.

Samples should be taken at the same time of day each time, preferably in the morning before the sun degrades the bacteria. For recreational water bodies such as public beaches it is recommended that a bacteria sample be taken once a week. There is no standard for other bodies of water (Center for Watershed Protection, 2016).

Bacteria samples should be tested in a laboratory setting. Therefore, **it is recommended that you find a credited laboratory to send your samples to be tested.** SGS Canada Inc. located in Lakefield, Ontario is just one example:

SGS Canada Inc. began in 1948 as a specialist provider of services for the agricultural industry. Today, their operations across Canada have rapidly evolved into highly technical service provision, conducting precise and accurate analytical testing, such as testing water samples for bacteria, phosphorous, turbidity and nitrogen among several other parameters. For more information: http://www.sgs.ca/en/Our-Company/About-SGS/SGS-in-Brief/SGS-in-Canada.aspx

Finding Licenced Laboratories

Local Health Units usually rely exclusively on *E. coli* as a measure of fecal contamination in drinking and recreational water. For a more comprehensive list of laboratories in Canada that perform *E. coli* testing, visit: https://www.ontario.ca/page/list-licensed-laboratories

7. INVERTEBRATES

Our lakes are home to many biota which are all part of a complex food chain. Invertebrates are species with no backbone (in=no, vertebrate=backbone). If your lake has tributaries, it can be important to take inventory of the types of invertebrates that reside in that aquatic ecosystem, because some invertebrates are considered indicator species of good water quality, or alternatively poor water quality.

It may be particularly important to be aware of the quality of any rivers or streams entering your lake because if the quality of water in the river or stream depletes or is depleted, your lake could be affected as well.

This chapter describes sampling techniques for collecting invertebrates, as well as a description of the important indicator species that are common to Ontario.

Sampling considerations and Devices

When taking samples of invertebrates in and along your water body, it is important to remember that a sample collected at one point in time will not represent an entire stream or body of water. Bottom differences, water quality difference and fast water environments vs. slow water environments all play a role in where invertebrates reside. Therefore, a community scientist must remember to take several samples at different stations to accurately represent the area.

Invertebrate sampling is relatively easy and fun to do – the harder part is ensuring you correctly sort, identify and classify your sample in order to understand your findings. There are two primary methods for collecting invertebrate samples. The primary method to use is an active sampling method where you physically stir up invertebrates and then analyze the sample the same day. Other methods are more passive where the sampler would try to create a device that imitates their natural habitat. This type of device is then removed several weeks after placement to be analyzed.

Remember: when approaching the sample area it is important to approach the site from downstream to avoid disrupting the area before you are ready to collect your sample (Mitchell and Stapp, 2008).

Commonly Used Active Sampling Devices:

D-Frame Nets

D-Frame Nets are relatively easy to obtain or construct yourself. They work well because the shape of the net rests comfortably against the bottom of a stream and prevents the organisms from escaping beneath the net. You collect your sample by facing the open side of the net upstream or against the current. The sampler then kicks the substrate at the bottom of the river dislodging organisms in the process. These organisms then become trapped in your net as you sample the cross section of a river or stream.

Kick-Screens

Kick-Screens are similar to D-Frame Nets; however, they are able to cover a larger area at one time. They are best for sampling in riffle sequences of a river – which can be identified as a more shallow area with higher turbulence. A Kick-Screen is made by stretching screening material between two poles and can be made at home by using window screening and two wooden poles. Sampling is completed by driving the two poles into the substrate until the netting rests at the bottom of your sample area. Organisms are then dislodged and captured by kicking the bottom of the stream and allowing the current to carry invertebrates towards the netting.

Square-Foot Sampler

This type of sampler is simply placed in the stream while you disturb the substrate in front of it by picking up rocks and rubbing them against one another. The net is held open by a square-foot frame that is attached to another frame of the same size. The cloth material attached to the frame allows the current to flow into and through the net as invertebrates get trapped in the material.

Dredge or Grab Samplers

These types of samplers are generally used for deeper rivers and can be used in lakes as well. The sampler is deployed from a boat or bridge and it uses a spring-released tension mechanism to collect a sample of substrate. This substrate can then be analyzed for invertebrates.

Commonly Used Passive Sampling Devices:

Hester-Dendy Sampler

This sampler is made of stacked plates with a rough texture. These plates are separated by washers or smaller plates and are suspended in the stream. This type of sampler must be left in place at least four to six weeks to allow invertebrate populations to colonize the structure.

Basket Sampler

This type of sampler consists of a wire mesh basket filled with rocks. In a deep river, this type of sampler should be suspended at approximately a three foot depth below the surface in the zone where light can still penetrate and promote aquatic plant growth. Alternatively in shallow rivers and streams, the basket can be placed on the bottom. This type of sampler must be left in place at least four to six weeks to allow invertebrate populations to colonize the structure.

Leaf Pack Sampler

A leaf pack sampler works by imitating the natural tendency of leaves to collect in a riffle and become compacted together. You can create one by filling a small mesh bag with leaves and submerge it in the riffle of a stream or river. Depending on the conditions, this sampler can be tied to a rock or remain held in place with a weight such as a brick. Because this type of sampler uses organic material, it should be monitored weekly and removed from the water within three to four weeks of placement in order to prevent the complete decay of the leaves inside it.

7.2 Sorting and Counting your Samples

When you are done collecting your sample carefully bring the net or device to a flat area of a bank next to your sample sight. Your sample can be emptied into a pan or plastic tub for analysis. A white shower curtain or plastic table cloth is a handy tool to put beneath your inspection in order to catch any invertebrates that fall to the ground.

Next you must sort, identify and classify your sample. A dichotomous key for invertebrates is useful for identifying organisms based on their characteristics, structure and behaviour. You may also want to bring along ice cube trays and petri dishes for sorting as well as tweezers and spoons.

Once you have sorted, identified and classified all the organisms in your sample you can then calculate the Pollution Tolerance Index. Organisms get classified into one of four categories based on their tolerance to pollution. Each group is given an index value which then can be tallied to give the sample area an overall score. This type of sampling also sheds light on the overall richness (number of different species) and abundance (how many species found overall) of your sample area (Mitchell and Stapp, 2008).

Examples of pollution intolerant invertebrates include caddisflies, mayflies and stoneflies; while examples of pollution tolerant species include aquatic worms, blood midges and planorbid snails.

Please refer to **Appendix B** for more information about different species and sampling procedures.

8. ALGAE

Algae are naturally occurring and critical to the life within our lakes. Algae are the base of a lake ecosystem food chain. They convert nutrients to organic matter and oxygenate the water. **Without algae there would be no fish.** Algae engage in photosynthesis which supplies oxygen to the fish and biota which inhabit our waters.

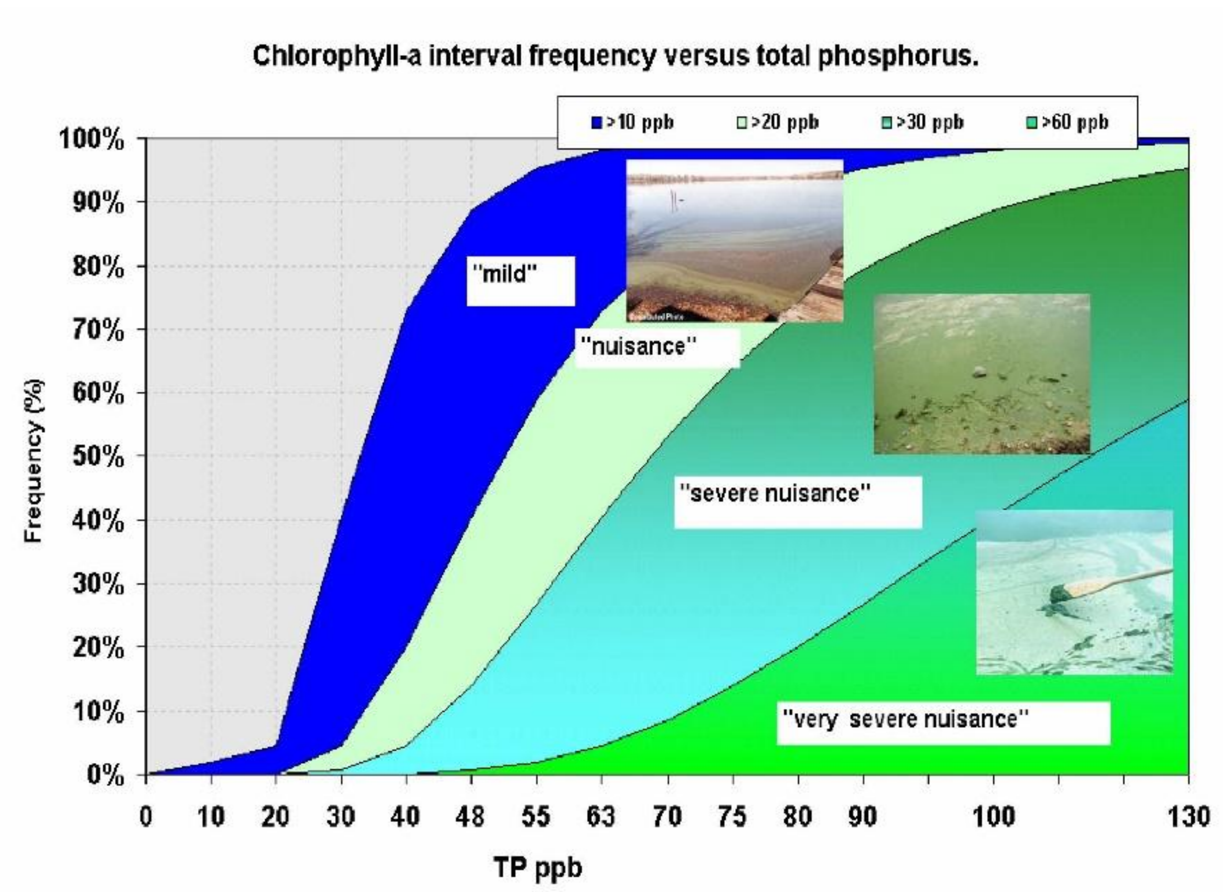


Figure 5: Frequency of blue-green algal blooms as TP concentration increases (figure credit: Minnesota Pollution Control Agency)

Algae can become a problem when excess nutrients and increased lake temperature cause algal blooms. Excess nutrients (in particular phosphate) can cause algae and other aquatic plants to proliferate. This can result in thick mats of algae or a scum-like appearance at the surface of the water. Algae is short lived and therefore an algal bloom will eventually result in high concentrations of dead organic matter in the water body. This organic matter eventually decays, a process that consumes dissolved oxygen from the water. The result is depleted dissolved oxygen concentrations that may lead to aquatic animals and plants dying off due to the lack of available oxygen.

An algal bloom can also affect the appearance of a water body, clog water intake pipes, provide a habitat for unwanted bacteria and can produce unwanted tastes and odours. Some forms of blue-green algae produce harmful toxins which can be detrimental to the health of you and/or your pets.

Several thousand species of algae live in Ontario's waters. Algae are extremely diverse in form, colour, habit, and habitat. They can live in water or on land.

The descriptions below relate to types of algae found in fresh water in Ontario.

There are 4 general groups: (Huynh, M. and N. Serediak. 2006)

Green Algae can be filamentous or free-floating. **Filamentous greens** (or attached algae) range from several millimetres to a metre in length. They have the potential to develop into large colonies of floating or attached mats, and they can cause odours in water and clog filters. Examples of filamentous green algae include *Spirogyra*, *Mougeotia*, and *Cladophora*. **Free-floating green algae** are important in the aquatic food chain and help to maintain oxygen levels. Examples of free-floating green algae include *Chlorella*, *Pediastrum,* and the desmids.

Diatoms are food for many aquatic microscopic animals. Diatoms have silicon cell walls that do not decompose. This is the group of algae most likely to clog filters. Some diatoms produce tastes and odours in the water. Examples include *Asterionella*, *Fragilaria*, and *Cyclotella*.

Flagellated Algae possess one or more flagella, whip-like 'tails' that act as propellers. These algae can sometimes produce strong tastes and odours in water supplies. For example, *Synura* can impart a cucumber odour to water even when present in low numbers. Other examples include *Dinobryon* and *Euglena*.

Blue-Green Algae, commonly known as pond scum, range in colour from olive-green to red. Some forms are gelatinous floating masses of various shapes. Sometimes, when a bloom of blue-green algae decomposes pigments are released, giving the water a bluish or pinkish colour. They have a pleasant grassy odour while healthy, but this may change to an unpleasant odour as they decompose.

8.1 Algal Growth

There are a number of environmental factors that influence the growth of algae in our lakes. The major factors that determine the type and amount of algae in your lake are:

- the amount of light that is able to penetrate through the water column
- the concentration of nutrients in the water
- water temperature
- grazing on the algae by microscopic animals or fish
- parasitism by bacteria and fungi
- competition from aquatic plants for available nutrients.

Sampling considerations

The procedure for collecting an algae sample can vary depending on the results you are looking for. If you are strictly interested in the <u>type</u> of algae in your water body, it would be appropriate to scoop a small sample of algae that you can clearly see. If you are interested in the <u>quantity</u> of algae in your water body, or if it is present at a particular location at all, you must take random samples near the surface. In this case, do not look for the algae and collect it as this would create results that are biased. A small vial of water collected near the surface of the water should provide more than enough material to be analyzed under a microscope.

Please be well aware that some surface scums that form in nutrient rich waters may be toxic, therefore the use of latex gloves while collecting a sample—or just avoiding contact with the water all together—is always good sampling practice.

Blue-Green Algae Microcystin (toxin) Testing				
Laboratory	Phone	Drinking Water	Surface Water	Cost
Central Ontario Analytical Laboratory (COAL)	705 326 8285	✓	✓	$50/sample; requires 1 litre of water; sample only on Thursdays; results are known on Fri
City of Hamilton	905-546-2424	✓	✓	$495.91/sample
Near North Laboratories	(705) 497-0550	✓	✓	$120 + HST
Testmark Laboratories	(705) 693-1121	✓	✓	$180 + HST
York-Durham Regional Environmental Laboratory	(905) 686-0041	✓	✓	$74 algae only $150 toxins only $224 for both algae and toxins + HST
SGS Lakefield Research	(705) 652-2000		✓	$170 + HST

Table 2: Ontario Laboratories that perform Blue-Green Algae testing. (Peterborough Public Health Unit, 2015)

Reporting Algal Blooms

Individuals can report suspected algal bloom sightings by contacting:

Spills Action Centre*:* 1-800-268-6060

If it is the first bloom of the year, the Ministry of Environment and Climate Change will take a sample of the algae to identify whether it contains cyanobacteria. They will also test the toxin level from a dense area of the bloom, but generally will not return to confirm that the bloom or the toxin levels have dissipated. Subsequent blooms will not be individually identified. (Peterborough Public Health Unit, 2015)

9. HEALTHY SHORELINES AND WATERSHEDS

Aside from monitoring your water body, a concerned individual who owns waterfront property should strive to maintain a healthy shoreline. A healthy shoreline provides water quality benefits that contribute to maintaining a healthy and functional ecosystem.

For improved water quality, it is important to have a natural shoreline with the vegetation intact. Natural vegetation along shorelines catches rainwater runoff and sediment, and absorbs the pollutants it carries.

Plants act as a physical barrier, slowing water flow and redirecting it to percolate into the soil column where plant roots filter excess nutrients and other pollutants. **Mowed areas and other hard surfaces allow for fast rainwater run-off, which carries polluted unfiltered water directly into the lake or river.**

Preventing erosion

Natural shoreline vegetation is also your first line of defence against soil erosion. The plants' extensive root systems hold the soil, keeping it where it belongs. Your property remains intact, and fish spawning beds remain clear. Natural shorelines adjust to natural disturbances and are remarkably stable. Shallow-rooted species, like turf grasses, do not prevent erosion.

Septic system considerations

Know how to maintain your septic system to keep it functioning properly. Have your septic system inspected and pumped every 3 to 5 years or as required by a licensed contractor.

About fertilizers

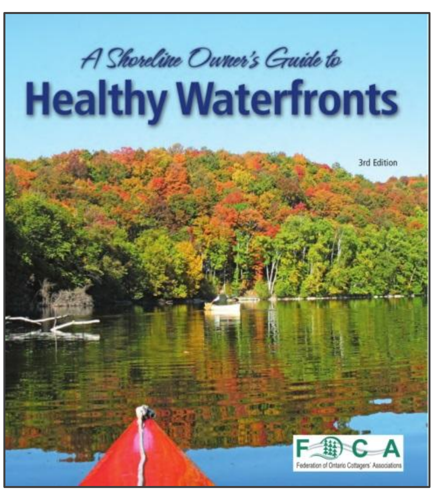
Natural shorelines don’t need fertilizing. Nutrients from lawn and garden fertilizer can be a significant cause of algal blooms, and can increase nuisance aquatic plants. Too much algae blocks the sun from reaching organisms at lower depths. Massive weed beds can clog waterways. And the decay of so much organic material lowers the water’s dissolved oxygen level, which affects fish and other aquatic wildlife.

Natural is best

Poor water quality and nuisance weeds affect swimming, fishing, and boating. A natural shoreline helps maintain water quality and control weeds and algal blooms.

More than 90 per cent of life in the lake begins or lives part of its life along the shore. Your natural shoreline will provide shelter, travel corridors and food for wildlife such as dragonflies, frogs, turtles, fish and water birds.

Just rely on nature and relax. Native plants are adapted to your area. They require little or no maintenance. That means you can eliminate the need to use fertilizers and pesticides on your land. You save money and the environment.



For more about all these “healthy shoreline” topics, consult FOCA’s booklet, **“A Shoreline Owners’ Guide to Healthy Waterfronts”** available here: https://foca.on.ca/shoreline-owners-guide-to-healthy-waterfronts/.

Appendix A:

An Overview of Ontario Community Science Monitoring Programs

Lake Partner Program

The Lake Partner Program is a province-wide, volunteer-based, water-quality monitoring program. Volunteers collect total phosphorus samples and make monthly water clarity observations on their lakes. This information will allow the early detection of changes in the nutrient status and/or the water clarity of the lake due to the impacts of shoreline development, climate change and other stresses.

https://foca.on.ca/lake-partner-program/

Breeding Bird Atlases

Breeding Bird Atlas projects engage thousands of volunteer community scientists to gather information that is used to map breeding bird distribution and relative abundance, within a defined geographic area. Atlases are typically five-year projects, designed to be repeated at regular intervals (usually every twenty years), that provide a standard assessment of the current status of breeding birds and lay the framework for evaluating long-term changes.

http://www.bsc-eoc.org/volunteer/atlas

Canada Lakes Loon Survey

The Common Loon is Canada's most iconic and beloved inhabitant of our lakes. But this ancient predator is undergoing systemic and increasing human pressure; pressures great enough that loons may someday be unable to maintain their current population levels. Canadian Lakes Loon Survey participants have worked since 1981 to track Common Loon reproductive success by monitoring chick hatch and survival.

Participants dedicate at least three dates, visiting their lake once in June (to see if loon pairs are on territory), once in July (to see if chicks hatch) and once in August (to see if chicks survive long enough to fledge).

https://www.birdscanada.org/bird-science/canadian-lakes-loon-survey/

Project Feeder Watch

At regular intervals from November to April, thousands of Feeder Watchers count the kinds and numbers of birds at their feeders, and then submit their observations to Project Feeder Watch. The information helps scientists study winter bird populations. Participants receive a full-colour bird poster and calendar, a FeederWatch Handbook and Instruction Book, access to the data entry portion of the FeederWatch website, and the chance to contribute to a continent-wide bird research project. Project FeederWatch is a joint program of Bird Studies Canada and the Cornell Lab of Ornithology. In Canada, you must be a member of Bird Studies Canada (BSC) to participate.

http://feederwatch.org/

FrogWatch Ontario

Starting in late March each year, participants in the FrogWatch Ontario Programme are out in full force, listening for frog and toad calls in their local wetlands. Male frogs and toads will typically start to call in March in Southern Ontario, and into April/May in Northern Ontario. Spring peepers, wood frogs, and chorus frogs are usually the first species to make their presence known in the spring, but larger frogs like the bullfrog may call as late as June/July. By participating in this program you will help to increase knowledge of frogs and toads in Ontario, which are an important part of local biodiversity, the amazing variety of life around us. FrogWatch is part of NatureWatch.

https://www.naturewatch.ca/frogwatch/ontario/

Ontario Turtle Tally

The purpose of this program is to collect, record, and store location and species information about Ontario turtles, including species at risk. Turtles are most often seen in June when they are traveling to reach their nesting sites. The information that is collected in this database will be submitted to the Natural Heritage Information Centre and will be used to learn more about turtle distributions in Ontario.

Report sightings online here: https://report.adoptapond.ca/

Ontario Reptile and Amphibian Atlas Program

Ontario's reptiles and amphibians are becoming increasingly rare. In fact, three quarters (18 of 24) of Ontario's reptile species are listed as species at risk. Reptiles and amphibians are collectively known as herpetofauna and are a unique part of Ontario's biodiversity. Volunteers are needed to submit their observations of reptiles and amphibians found throughout Ontario. All reporting after December 2019 goes via:

https://www.inaturalist.org/projects/herps-of-ontario

Great Lakes Marsh Monitoring Program

The Great Lakes Marsh Monitoring Program (MMP) is a wildlife monitoring program for coastal and inland marshes. Its success has been fuelled by the energy and contributions of volunteers. MMP surveyors record information about marsh birds, habitat, and (in some regions) frogs and toads. Survey information helps track long-term trends in species diversity, and guides conservation, restoration, and management programs for marshes and their bird and amphibian inhabitants.

https://www.birdscanada.org/gl_mmp/

FOCA Aquatic Invasive Species Prevention and Monitoring Programs

Over the past several years, FOCA in partnership with the Ontario Ministry of Natural Resources and Forestry (OMNRF), has led several aquatic invasive species prevention & monitoring programs. These volunteer programs help lake associations and their members to prevent the introduction of invasives, to monitor for aquatic invasive species (AIS) on their waterbody, and mitigate their spread. Learn more here: https://foca.on.ca/invasive-species/

Secchi Dip-In Program of the North American Lake Management Society

The Secchi Dip-In is a demonstration of the potential of volunteer monitors to gather environmentally important information on our lakes, rivers and estuaries. The concept of the Dip-In is simple: individuals in volunteer monitoring programs take a transparency measurement on one day during the month of July. Individuals may be monitoring lakes, reservoirs, estuaries, rivers, or streams. These transparency values are used to assess the transparency of volunteer-monitored lakes in the United States and Canada. https://www.nalms.org/secchidipin/

The Neighbourhood Bat Watch

"The Neighbourhood Bat Watch" encourages members of the public to report the locations of bat colonies in Ontario, Manitoba and Quebec. As bats are often found in cottages, Lake and Cottage Associations are an important means of reaching people who can help with this program.

www.batwatch.ca

NatureWatch

NatureWatch is your home page for fun, easy-to-use environmental monitoring programs that encourage you to learn about the environment while gathering the information that scientists need to monitor and protect it. NatureWatch monitoring program are suitable for all levels and interests, designed to develop your scientific observation and data collection skills so that you can actively contribute to scientific understanding of Canada's environment.

https://www.naturewatch.ca/

IceWatch

IceWatch is part of the NatureWatch suite of national volunteer monitoring programs designed to help identify ecological changes that may be affecting our environment. By analyzing community records, scientists have found that the cycles of Northern water bodies are changing. IceWatch encourages Canadians of all ages to participate by recording annual freeze and thaw dates of lakes and rivers.

https://www.naturewatch.ca/icewatch/

Appendix B:

Invertebrate Identification and Sampling Notes

Note: Several of these organisms are described on the following pages.

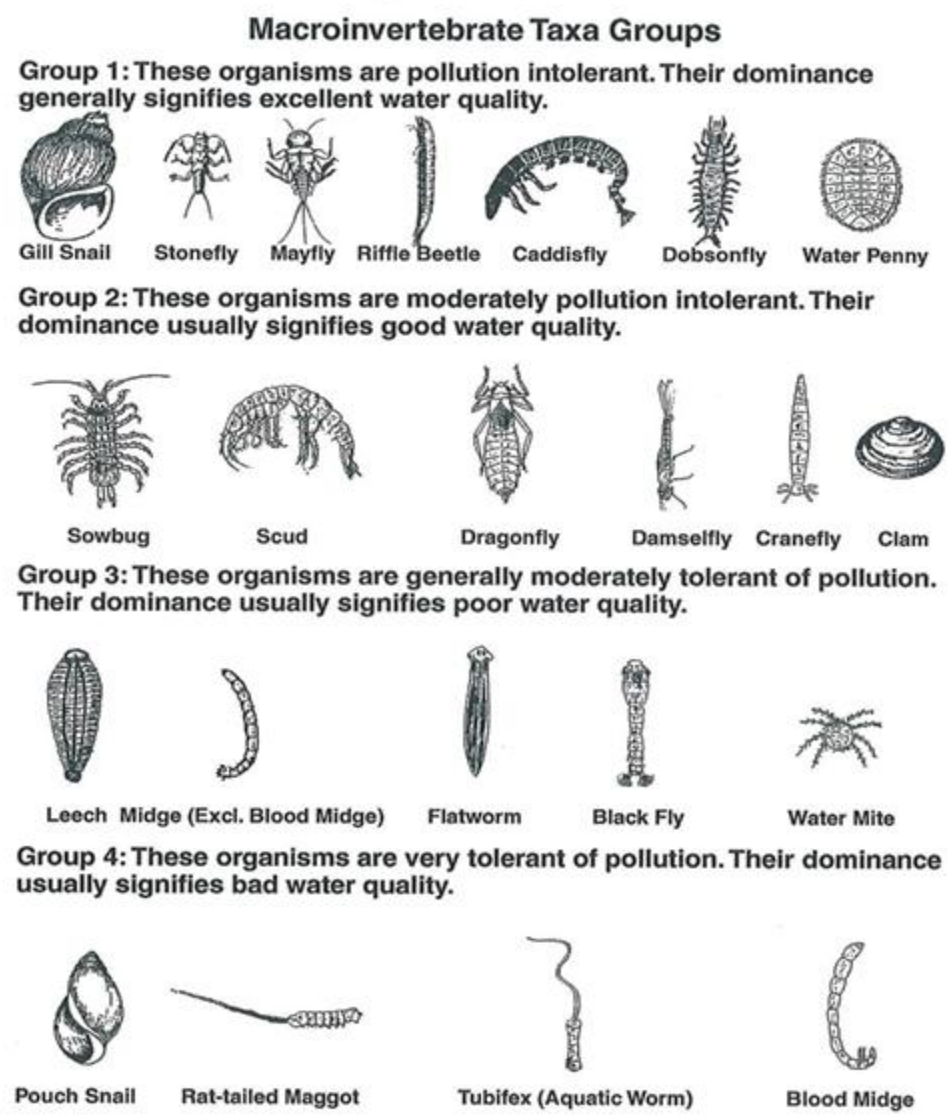


Figure 7.1. *Macroinvertebrate* ***taxa*** *groups.*

Field Manual for Water Quality Monitoring

(figure credit: Mitchell, Mark K., Stapp, William B. 2008. Field Manual for Water Quality Monitoring 13th Edition.)

Pollution Intolerant Invertebrates:

> dominance of these species implies **excellent water quality**

Gill Snail (Class *Gastropoda*)

Gill Snails have a spiral shell that opens on the right side (meaning the pattern spirals to the right). Gill snails breathe through their gills (as their name suggests). This method of breathing makes them sensitive to changes in water quality. The presence of gill snails in a sample is therefore indicative of excellent water quality.

Caddisflies (Order *Trichoptera*)

Caddisflies make up a large portion of benthic communities. Some live in protective cases from bits of plant matter, sand grains and pebbles while others are free living. Most species of caddisflies prefer highly oxygenated environments and therefore are very susceptible to the effects of pollution. Therefore the presence of caddisflies in your sample is indicative of excellent water quality as they are extremely resistant to changes in the condition of the water.

Mayflies (Order *Ephemeroptera*)

Mayflies thrive in highly oxygenated water. They are also a good source of food for salmonids. Abundance of mayflies is a good indicator of excellent water quality as they are intolerant of disturbance to their habitat.

Stonefly (Order *Plecoptera*)

Stoneflies are algae scrapers that are most commonly found in headwater streams that are highly oxygenated. They are good indicators of water quality because they are very intolerant to changes in their habitat. Therefore the presence of stoneflies in a sample is indicative of excellent water quality.

Dobsonflies, Alderflies and Fishflies (Order *Megaloptera*)

Insect larvae of the Megaloptera order are usually found in clean rivers with rocky bottom sediments. These larvae are some of the largest (approximately 1.5-3.0 inches) and they prey on other aquatic larvae. They have a moderate ability to survive in low oxygen conditions however they are intolerant of pollution and must live in clean water. The presence of these species in your sample indicates excellent water quality.

Moderately Pollution Intolerant Invertebrates:

> dominance of these species implies **good water quality**

Clams (Class *Bivalvia*)

Clams feed by filtering the water they live in. This means that they will accumulate large amounts of toxins if they live in poor water quality. The presence of clams in a sample may indicate good water quality as they are moderately intolerant to pollution.

Sowbugs (Order *Isopoda*)

Sowbugs are usually found on rocks in slower-moving water. To an extent, they are able to survive in water with low dissolved oxygen concentrations that typically arise due to sewage or agricultural runoff. Sowbugs are an important source of food for fish. An abundance of Sowbugs in a sample indicates good water quality.

Scuds (Order *Amphipoda*)

Scuds feed by scavenging for fine particulate organic matter in benthic environments. They are important source of food for fish and can exist in a wide variety of waters. They are not common in severely polluted waters therefore, an abundance of Scuds in your sample indicates good water quality.

Dragonflies (Suborder *Anisoptera*) **and Damselflies** (Suborder *Zygoptera*)

Dragonflies and damselflies are both benthic predators; meaning they eat other insects that reside in the lowest level of a waterbody. Their larvae are typically found in slower moving streams and the presence of these larvae in a sample indicates good water quality.

Craneflies (Family *Tipulidae*)

Craneflies are the preferred food choice for several different fish species. Some species of Craneflies have also adapted to withstand extremely dry conditions. Craneflies represent one of the largest family of flies and are moderately intolerant of pollution. Presence of Craneflies in a sample indicates good water quality.

Moderately Pollution Tolerant Invertebrates:

> dominance of these species implies **poor water quality**

Leeches (Subclass *Hirudinea*)

Leeches are known to be blood suckers and scavengers. They attach to their host and usually remain attached until they are full. Leeches are able to tolerate a wide range of conditions in their habitat, therefore a dominance of leeches in your sample in relation to other aquatic organisms may indicate poor water quality.

Midges (Order *Diptera*)

Midges are abundant in polluted streams. Midges differ from worms as they have legs and their body is not segmented. They often appear to be in a "C" or an "S" shape. An abundance of midges in a sample indicates poor water quality as they are able to thrive in polluted streams.

True Flies (Order *Diptera*)

True flies include several families with aquatic or semi-aquatic larvae. Common true flies in Ontario are black flies, horse flies and deer flies. The larvae of these species are able to survive in water with excess nutrients. Therefore, an abundance of these larvae means there are too many nutrients present and the water quality is poor.

Pollution Tolerant Invertebrates:

> dominance of these species implies **bad water quality**

Aquatic Worms (Subclass *Oligochaeta*)

Aquatic Worms look very similar to terrestrial (ie. Land-based) Earthworms. Aquatic Worms are able to easily break down fine particulate organic matter from the physical and biological fragmentation of things such as wood, leaves, soil organic matter and so on. They are also able to bioaccumulate or absorb metals and the majority are found in areas of high silt and organic pollution. Therefore, a dominance of Aquatic Worms in your sample may be indicative of bad water quality.

Planorbid Snails (Class *Gastropoda*)

Planorbid Snails have important functions in freshwater environments. They eat by scraping bottom surfaces and breaking down wastes; they also play a vital role in algae control. Seeing an abundance of planorbid snails in relation to other aquatic organisms may indicate bad water quality as they can be very resistant to toxins.

Blood Midge (Order *Diptera*)

Blood Midges differ slightly from other midges. They have hemoglobin which allows them hold onto oxygen and survive in extremely oxygen depleted conditions. Therefore, an abundance of blood midges in a sample is indicative of bad water quality.

Pouch Snail (Class *Gastropoda*)

Pouch Snails have a spiral shell that opens on the left (i.e., pattern spirals to the left). They have the ability to breathe air—enabling them to survive in poor water quality—since pouch snails possess lungs that certain families of snails do not. An abundance of pouch snails, in relation to other aquatic invertebrates, indicates bad water quality.

Rat-tailed Maggots (Family *Syrphidae*)

The larvae of Rat-tailed Maggots occur in highly nutrient enriched and poorly oxygenated environments. They are able to breath at the surface of the water using a terminal abdominal tube. An abundance of Rat-tailed Maggots in a sample indicates bad water quality.

Common Invasive Invertebrates Zebra Mussel (Family *Dreissena polymorpha*)
and Quagga Mussel (Family *Dreissena rostriformis*)

Zebra Mussels and Quagga Mussels are both invasive species to Ontario's freshwater ecosystems. Both species were believed to have been introduced in the late 1980's through ballast water from ships carrying veligers (larvae), juveniles or adult mussels. These mussels are known to clog pipes and create oligotrophic conditions in lakes by filtering high multitudes of algae out of the water.

Sample Pollution Tolerance Index Data Sheet

Quick Reference

Pollution Tolerance Index (PTI)
Data Sheet Example

Evaluator: West Middle School Date: October 23, 2008

Site: Hardy Creek

Circle the name of each organism you found at your monitoring site. Then record abundance on the line before each organism by noting C for common (more than 10 organisms found) or R for rare (fewer than 10 organisms found).

Count the number of types of organisms you found in each group and multiply by the weighting factor for that group. Add all the group totals together for your PTI score. Use the scale at the bottom to determine water quality based on macroinvertebrates.

Group 1 (Weighting factor 4.0)

R Gill snail
R Stonefly
C Mayfly
___ Riffle beetle
___ Dobsonfly
___ Water penny
C Caddisfly

# of Group 1 organism types = 4 × 4 = 16

Group 2 (Weighting factor 3.0)

___ Sowbug
C Scud
R Dragonfly
___ Damselfly
R Cranefly
___ Clam

# of Group 2 organism types = 3 × 3 = 9

Group 3 (Weighting factor 2.0)

R Leech
___ Midge
___ Flatworm
___ Blackfly
___ Water mite

# of Group 3 organism types = 1 × 2 = 2

Group 4 (Weighting factor 1.0)

___ Pouch snail
___ Rat-tailed maggot
___ Tubifex (Aquatic worm)
C Blood midge

# of Group 4 organism types = 1 × 1 = 1

PTI 28

Excellent = 23 or more Good = 17–22 Fair = 11–16 Poor = 10 or less

Conducting Water Quality Monitoring: Sampling Macroinvertebrate Communities

(figure credit: Mitchell, Mark K., Stapp, William B. 2008. Field Manual for Water Quality Monitoring 13th Edition.)

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