Benthic Macroinvertebrate Monitoring

Monitoring bottom-dwelling aquatic invertebrate communities has been part of the District Municipality of Muskoka's Lake System Health Biological Monitoring Program since 2003. In biological monitoring, composition of the aquatic-invertebrate community, the pattern of abundances of different species collected, indicates the health of the ecosystem.

Aquatic invertebrates, such as worms, mollusks, insects, crustaceans, and mites, are common indicators in biological-monitoring programs. These animals are sensitive indicators of the health, or condition of lakes and streams, and different species have different sensitivities to environmental changes such as pollution or habitat alteration. Aquatic invertebrates live between 1 and 3 years and are in constant contact with lake sediments. Contamination and toxicity of sediments affects those animals that are sensitive. For example, lake acidification is accompanied by both a decline in the total number of species present, and an increase in the abundance of those species able to tolerate acidity.

Reference-Condition Approach

One of the challenges of biological monitoring is that the composition of healthy invertebrate communities varies from place to place, and from time to time. We therefore have to understand natural variability to be able to make reliable conclusions about whether or not the community that we find in a given lake is normal or not. One way to determine what normal looks like is to sample *reference sites*. Reference sites are locations where human impacts (such as pollution, shoreline alteration, and development) are minimal and the aquatic ecosystem is considered to be in the best condition found in Muskoka.

Biological-monitoring assessments can make judgments about the condition of lakes by comparing samples from a given lake of interest (a test lake) against a set of samples from reference lakes. In short, reference lakes define what normal Muskoka invertebrate communities should look like in the absence or near-absence of human influence. Atypical sites, which are biologically different from reference sites, warrant further study to determine why their communities are unusual.

Because we need information from minimally-impacted reference sites before we can evaluate our lakes, much of the focus of our biomonitoring program to-date has been on sampling reference sites. Since reference sites are assumed to be in excellent condition, it doesn't make sense to *report* their condition; however, because their communities act as a benchmark for assessing other lakes, it is informative to understand invertebrate-community composition in reference lakes, and to watch for changes in reference lake composition over time. This report serves to characterize reference lake community structure, and gives a preliminary assessment of local test lakes.

Data analysis

Biological monitoring programs yield large data tables. You can envision such tables as columns of numbers, each column representing the counts of different species collected at a given location. It is very difficult to pick-out ecological patterns in such complex datasets, so it is common practice to simplify data tables into a manageable number of indices that represent meaningful ecological patterns. This is similar to the way stock-market performance is measured using indices like the TSX or the Dow Jones Industrial Average. The District of Muskoka uses several indices to simplify bioassessments, as described in Table 1.

Table 1: Indices used to summarize aquatic invertebrate composition in Muskoka.

Indicator	What it tells us
Number of taxa collected (Richness)	The number of taxa is a measure of biological diversity. Richness increases with increasing habitat diversity, suitability, and water quality; therefore, the healthier a site's community, the greater its number of taxa.
Percent of collection made-up of mayflies, dragonflies, damselflies, and caddisflies (% EOT)	Ephemeroptera (mayflies), Odonata (dragonflies and damselflies), and Trichoptera (caddisflies) are very sensitive to pollution and habitat alteration. They should be prominent in healthy ecosystems, but their numbers will decline in response to stress imposed by human activities.
Percent of collection made-up of midges (% Chironomidae)	Midges (true flies in the family Chironomidae) are tolerant of pollution and habitat changes so their dominance indicates water quality problems.
Percent of collected animals that are predators (% predators)*	In a healthy ecosystem, the numbers of predators and prey are maintained within a narrow range. Extreme fluctuations in this balance signify that the ecosystem is sick.
Percent of collected animals that are adapted to feeding on coarse plant matter (% shredders)*	Shredders are a group of plant eaters adapted to breaking down leaves, wood, and other plant matter that originates on land but gets transported into waterbodies. Such animals should be abundant if there is a good connection between a lake and its watershed. In addition to recycling nutrients, shredders are food for other animals.
Percent of collected animals that are adapted to feeding by collecting small pieces of organic matter (% collector/gatherers)*	Collector-gatherers feed on small pieces of organic matter that arise from the processing activities of shredders (described above). Their presence indicates a good population of shredders, which provide them with food. Like shredders, these animals perform a vital role in energy cycling, and are prey for other animals.
Organic pollution score (Hilsenhoff index value)	The Hilsenhoff index combines information about the abundances of different types of animals collected at a site with information about those animals' sensitivities to sewage pollution, farm wastes, and other sources of nutrients like phosphorus, nitrogen, and carbon. High values of this index indicate pollution; low values indicate good water quality.

* In healthy ecosystems, the proportion of the aquatic-invertebrate community that is made-up of predators, shredders, collector/gatherers, and other animals is maintained within a narrow range. Marked divergences in abundances of any type of animal signifies a stressed ecosystem.

How do your local sites fare?

For a preliminary evaluation of your lake, refer to the attached Aquatic Invertebrate Data Sheet. If your sites are reference lakes, assumed to reflect the best ecosystem conditions in Muskoka, no assessment is warranted. For test locations, assessments can be made by comparing test-site index values against the averages for Muskoka reference lakes, which are provided in the shaded box at bottom right.

In general,

1. Richness should be high (close to the average for Muskoka or above).
2. % EOT will decrease and % Chironomids will increase over time with water quality impairment.
3. % Predators should be less than the other types of benthos (shredders, collector/gatherers) and these percentages should remain relatively constant over time.
4. The Hilsenhoff Index value should be close to the average for Muskoka or less, as a lower value indicates healthier water.

Even though most of the lakes in Muskoka are quite similar, no two lakes are identical and there are various factors that play a role in determining the relative abundances of different types of aquatic invertebrates. Comparing your lake's data to the rest of the lakes in Muskoka is not definite, but it can give you an idea. If there is a trend in all the types of indices and data, either above or below normal, it may indicate your lake's overall quality.