CHAPTER 3 – BENTHIC MACROINVERTEBRATES IN MUSKOKA

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BENTHIC MACROINVERTEBRATES – WHAT ARE THEY?

Benthic macroinvertebrates, or benthos, is a grouping of small animals living in aquatic habitats. These creatures are small but large enough to see with the naked eye (macro), have no backbone (invertebrate) and live on the bottom of lakes and rivers (benthic). They include aquatic worms, mites, amphipods, and more. Many of the species sampled are in their larval or nymph stage of life, such as dragonflies, mosquitoes, and mayflies. Benthic macroinvertebrates generally live between 1 and 3 years and are in constant contact with lake sediments. They live in lakes and rivers crawling over rocks, logs, sticks and vegetation, or burrowed into the substrate.

WHY DO WE SAMPLE FOR BENTHIC MACROINVERTEBRATES?

Benthos is used as a biological indicator of water quality and habitat conditions. They are important indicators because they spend the majority of their lives in the same area of water, they are easy to sample, and different species have different tolerances to disturbances and pollution. For these reasons, the benthic data collected is a result of local water conditions. A great example of this is spilling gas into a lake: a fish can swim away from the polluted area, however, since benthos are not as mobile, only pollution-tolerant species of benthos will be present after the spillage. So, when we collect samples, we can tell what the biological water quality is like by the presence or absence of various benthic species.

WHY ARE THEY IMPORTANT IN MUSKOKA?

Sampling for benthos is important in Muskoka because of the vast waterbodies present in this region. Benthic invertebrate communities vary due to distinct natural and anthropogenic habitat conditions of each lake. It's important to monitor the biological communities in these lakes to ensure the natural integrity and state of the lake is maintained, especially if the shorelines are developed. Healthy conditions of a lake support high species richness and abundance. If the samples show low diversity and predominantly pollution-tolerant species, the waterbody could be impaired. Biological conditions of the water also reflect both chemical and physical components of the lake. For example, lake acidification is often accompanied by a decline in the total number of species present as well as an increase in the abundance of those species able to tolerate acidity.

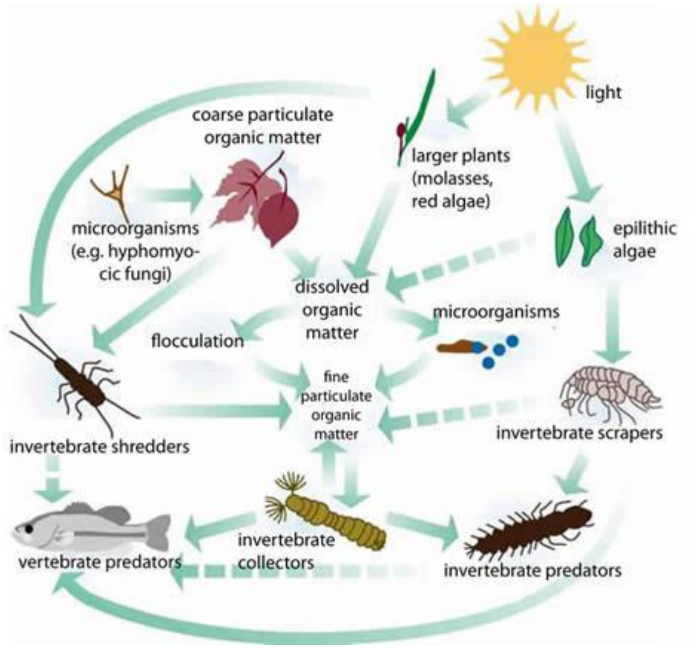

Figure 7. The role of benthic macroinvertebrates in aquatic food web (Source: USDA).

Benthos is important because they play a key role in the food web. Many fish rely on them as a food source, while some benthos help decompose organic matter that falls into the lake. Some make a meal out of other benthos, like dragonflies and fishflies.

HOW ARE BENTHOS BEING MEASURED AND REPORTED IN MUSKOKA?

Benthic macroinvertebrates in Muskoka are reported as the percentage of pollution sensitive species found in each sample per lake in the last ten years. These species include larval mayflies *(Ephemeroptera)*, dragonflies and damselflies *(Odonata),* and caddisflies *(Trichoptera)*. Most species within these taxonomic groups, referred to as EOT, are very sensitive to pollution and habitat alterations. Their abundances should be prominent in healthy ecosystems, but their numbers will typically decline in response to stress imposed by human activities. Consequently, the relative abundance of these taxonomic groups, %EOT, is used as an indicator of pollution level. %EOT is one of the metrics used to evaluate ecological status (e.g., Bohmer et al., 2014). It is the sum of the number of organisms belonging to EOT groups divided by the total number of benthic organisms in the sample, multiplied by 100:

%EOT = (#mayflies + #dragonflies + #damselflies + #caddisflies)/total #benthics x 100

For instance, in a large-scale study, Bohmer et al. (2014) quantified the %EOT in central Baltic lakes, including lakes from Belgium-Flanders, Estonia, Germany, Lithuania, the Netherlands, and UK. They found that the lakes with *reference* and *good* ecological status had an %EOT typically greater than 50%. The lakes with *bad* status had a %EOT around 9.8% (median value).

Mayfly larvae thrive in cool, oxygen rich and unpolluted lakes and streams, feeding primarily on algae and detritus. They can be identified by their three-pronged tail and gills that insert on the upper surface of the abdomen. Once mature, mayflies will extend their wings and become terrestrial.

Dragonflies thrive in cool, clean bodies of water and are unable to tolerate poor water quality and habitat disturbances. Dragonfly nymphs can often be found near aquatic vegetation in calm water. They are carnivores that feed on other insects such as mosquitoes and midges. In their nymph stage, they can be identified by their large head and big eyes, along with their large body.

Caddisfly larvae are also indicators of excellent water quality because they are sensitive to polluted waters and low oxygen levels. They can be found in a variety of aquatic habitats including cool or warm-water streams, lakes, marshes, and ponds. Caddisfly larvae have a unique mode of protection, in which they make cases of small stones or pieces of wood to wear, held together by silk they secrete.

DATA ANALYSIS

The District Municipality of Muskoka (DMM) works with local lake associations to monitor benthos through the DMM Biological Monitoring Program using the protocol developed by the Ontario Benthos Biomonitoring Network (OBBN) (Jones et al., 2005). The OBBN protocol recommends the collection of three 100-count sub-samples for each site using a traveling kick method. From 2012 to 2020, benthos samples comprised three 100-count sub-samples. To determine the %EOT, these three sub-samples were pooled into a single sample. However, starting in 2021, benthos samples collected at each site consisted of only one 100-count sample.

To date, DMM has continuously sampled 43 lakes across the watershed. Scientists at the Dorset Environmental Science Center (DESC) provided additional benthic data from sampling efforts undertaken since the mid 1970's through the Long-term Ecosystem Science Program. This program focuses on headwater lakes and streams located in south-central Ontario and are representative of tens of thousands of lake catchments on the Canadian shield. Through this program, benthos are collected from 19 lakes and 14 streams in the Dorset area once per year.

%EOT metric was used to classify each lake sampled into three categories; Potential Concern (PC), Typical (T), and Insufficient Data (ID). The mean of %EOT from 2012-2022 was calculated for each lake. Some lakes have only one sample site whereas larger lakes usually have more than one sample site. The value 9.8% from the central Baltic lakes study (Bohmer et al., 2014) was used as a threshold to differentiate T lakes (%EOT $\geq$ 9.8%) from PC lakes (%EOT < 9.8%). Due to the high inter-annual variability in benthic invertebrate sampling (Jones 2018), lakes with less than 3 samples were classified as ID lakes.

PC indicates that the ecosystem of the lake is probably stressed at least in some parts. The cause of stress may result from point and/or non-point pollution. For example, shoreline development and associated activities can alter substrates and remove riparian vegetation that causes the degradation of benthic invertebrate habitat for EOT species. Acidic lakes (pH <6) that have minimally developed watersheds will also be classified as PC lakes. The acidity of these lakes, caused by historical acid deposition, prevents the establishment of sensitive EOT taxa.

RESULTS

Little Lake-Severn River Watershed (6 lakes sampled, 4 with sufficient data): Three of four lakes sampled with sufficient data are classified as PC lakes. These lakes are; South Muldrew Lake, Loon Lake, and Little Lake (Figure 8). Their %EOT range from 6.1-7.89% (Table 11). South Muldrew Lake-Paterson's Bay was classified as T (%EOT=19.5%). Turtle Lake had insufficient data (n=2) because it was added to the DMM monitoring program in 2018. North Muldrew Lake also has insufficient data (n=1) because it was only sampled in 2022.

Lake Rosseau Watershed (7 lakes sampled, 6 with sufficient data): Three of the lakes sampled with sufficient data are classified as PC lakes; Stewart Lake, Bruce Lake, and Bass Lake (Figure 8) Bruce Lake had the lowest mean %EOT (5.44%) (Table 11). Three Mile Lake, Lake Joseph, and Ada Lake (Figure 8) are classified as T lakes. Clark Pond was added to the DMM monitoring program in 2022 and has insufficient data (n=2).

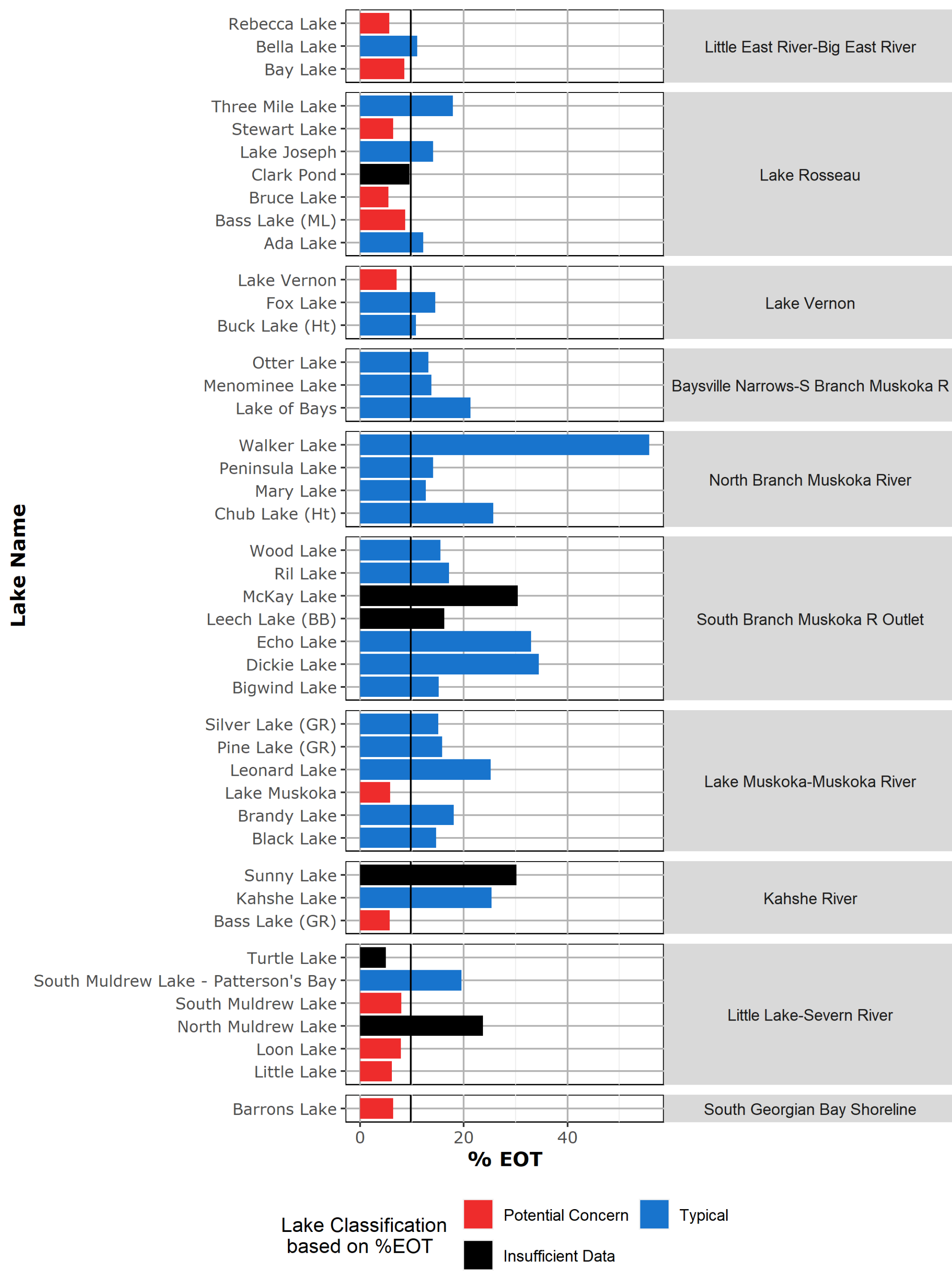

Figure 8. Mean %EOT for benthic invertebrate samples from 2012-2022. Black line corresponds to the 9.8% threshold for potential concern. Lakes with less than 3 samples were classified as insufficient data.

Only six of the 27 lakes sampled in other watersheds gave results indicating potential concern (Figure 8) %EOT was of potential concern for Lake Vernon, Lake Muskoka, Bay Lake, Rebecca Lake, Bass Lake (GR), and Barron's Lake (Figure 8). Overall, sampling has been conducted at relatively few sites within certain lakes. The number of lakes sampled in some watersheds was limited, including the South Georgian Bay Shoreline and the Little East River-Big East River Watershed.

While the data suggest most sites had typical composition of benthic macroinvertebrates, those sites that appear atypical suggests further attention to those sites, and additional sites within PC lakes will be needed to decide the true status of each lake. Our analyses have shown that the collection of benthic macroinvertebrates can be a useful way of characterizing sites, but the intensity of sampling, both number of samples per site and number of sites per lake has not been sufficient to draw firm conclusions.

Table 11. Summary of lakes sampled for benthic invertebrates from 2012-2022 with mean and standard deviation (SD) of %EOT and number of samples (n).

Lake	Mean % EOT	SD %EOT	n	# of Sites	Classification
Ada Lake	12.1	8.99	9	5	T
Barron's Lake	6.4	2.04	6	1	PC
Bass Lake (GR)	5.7	2.81	3	1	PC
Bass Lake (ML)	8.72	7.53	5	2	PC
Bay Lake	8.57	4.83	5	3	PC
Bella Lake	11	2.05	3	2	T
Bigwind Lake	15.2	12.4	5	3	T
Black Lake	14.7	8.02	4	2	T
Brandy Lake	18.1	8.17	8	2	T
Bruce Lake	5.44	3.78	6	2	PC
Buck Lake (HT)	10.8	5.63	5	3	T
Chub Lake	25.7	9.29	7	3	T
Clark Pond	9.5	4.25	2	2	ID
Dickie Lake	34.4	14.9	5	3	T
Echo Lake	33	10.4	4	2	T
Fox Lake	14.5	7.21	9	2	T
Kahshe Lake	25.4	10.3	4	3	T
Lake Joseph	14.1	4.04	3	2	T

Lake	Mean % EOT	SD %EOT	n	# of Sites	Classification
Lake Muskoka	5.78	3.65	8	2	PC
Lake of Bays	21.3	13.4	3	2	T
Lake Vernon	7.01	5.15	12	4	PC
Leech Lake (BB)	16.2	NA	1	1	ID
Leonard Lake	25.2	12.4	5	2	T
Little Lake	6.1	6.19	3	2	PC
Loon Lake	7.89	3.51	4	3	PC
Mary Lake	12.7	15.1	6	2	T
McKay Lake	30.4	NA	1	1	ID
Menominee Lake	13.7	3.66	7	4	T
North Muldrew Lake	23.7	NA	1	1	ID
Otter Lake	13.2	3.01	5	2	T
Peninsula Lake	14.1	11.3	6	2	T
Pine Lake	15.8	7.39	4	2	T
Rebecca Lake	5.6	1.72	4	2	PC
Ril Lake	17.1	5.87	10	4	T
Silver Lake	15.1	2.73	4	2	T
South Muldrew Lake	7.93	2.92	8	2	PC
South Muldrew Lake - Patterson's Bay	19.5	11.2	7	2	T
Stewart Lake	6.4	2.65	7	2	PC
Sunny Lake	30.2	10	2	1	ID
Three Mile Lake	17.9	16.4	7	2	T
Turtle Lake	4.97	5.05	2	1	ID
Walker Lake	55.8	15	9	3	T
Wood Lake	15.5	13.8	4	3	T

BB (Bracebridge) *HT (Huntsville)*

GR (Gravenhurst) *ML (Muskoka Lakes)*

WHAT DOES IT ALL MEAN?

Most of the lakes sampled (68%) have benthic invertebrate communities that are composed of a *typical* percentage of the sensitive EOT taxa. The remaining 32% of sampled lakes are classified as *potential concern* because of their low %EOT (< 9.8%) at sampled sites and should be further examined to identify potential stressors and clarify the extent to which the lake is atypical.

Shoreline development is a stressor for numerous lakes classified as *potential concern* in this study. By decreasing the structural complexity of aquatic habitats, shoreline development alters the community composition of benthic invertebrates (Urbanič et al., 2012). These changes can be signaled by a decrease or a low %EOT. Bass Lake (Gravenhurst, GR), Bruce Lake, Stewart Lake, Loon Lake, Lake Muskoka-Muskoka Bay, and Lake Vernon have >30% altered riparian areas (backlots). South Muldrew Lake and Rebecca Lake have moderate levels of altered riparian area (18.51-19.95%) but a high number of shoreline modifications (e.g., docks) that also impact benthic invertebrate habitat quality. Bass Lake (Muskoka Lakes, ML), Little Lake, and Bay Lake did not have shoreline surveys completed but, nonetheless, appear to have moderate levels of altered shoreline.

Other stressors could be at play in certain lakes, such as low concentrations of nutrients, low pH and high salinity from road salt application within the watershed. For instance, Barron's Lake has %EOT below the 9.8% threshold, despite having mostly natural riparian areas. Barron's Lake had a chloride concentration greater than 20 mg/L which indicates a potentially harmful level of chloride for sensitive aquatic life.

WHAT CAN YOU DO?

More data is always needed, especially in quaternary watersheds with few lakes sampled. You can get involved in monitoring the benthic macroinvertebrates in your lake through DMM's Biological Monitoring Program. District staff are available to work with lake associations and other community organizations to collect benthic data by providing expertise and equipment, while the association provides volunteers. Learn more about the Biological Monitoring Program at http://www.muskokawaterweb.ca/lake-data/muskoka-data/biological-monitoring-data.

Thank you to those lake associations involved with benthic monitoring.