Bob Lake Benthic Macroinvertebrate Health Assessment 2022/2023

Prepared for U-Links and the Bob Lake Association

Avery Scott, Carrie McDonald, and JulieAnn Prentice

ERSC 3160H – Community Based Resource Management

Faculty Supervisor: Tom Whillans

Host Supervisor: Dr. Jim Hyland

U-Links Supervisor: Sadie Fischer

Table of Contents

Acknowledgments

Thank you to Dr. Jim Hyland and the Bob Lake Association for providing samples and data from their Lake. Additionally, the workshops, guidance, and support of Sadie Fischer of the U-Links organization made this project possible. Lastly, many thanks to Tom Whillans and Jenna Snelgrove of Trent University for direction, laboratory support, and materials.

Abstract

Bob Lake is an inland lake located in Minden, Ontario, that is home to the Bob Lake Association. We completed a benthic macroinvertebrate assessment of the lake following Ontario Benthic Biomonitoring Network (OBBN) protocol using samples collected in the fall of 2022. The goal of this assessment is to contribute to a 5-year study establishing the baseline conditions of Bob Lake and the benthic invertebrate communities that inhabit it. Only one year has been completed prior to the submission of this report, which accounts for the second year. The results of this research will contribute to lake monitoring data and advise the Bob Lake Association on future lake management decisions. Using the random teaspoon sampling method, we identified 100 invertebrates from each replicate of the three sites sampled. We then evaluated the results of each site using several indices of species diversity and richness. Our evaluation shows that the lake conditions are within a normal range for the Haliburton area, but the remaining three years of this study must be completed to effectively confirm these results.

Introduction

Benthic macroinvertebrates (benthos) are small organisms who live at the bottoms of water bodies (TRCA, 2011). Benthic macroinvertebrates spend all or part of their lives in the water, and therefore are affected by the cumulative water quality during their time in the water (TRCA, 2011). They display a range of sensitivities to organic pollutants and disturbances. For instance, mayflies (Ephemeroptera) are sensitive and may indicate good water quality (U-Links & WWEW, 2022). In contrast, scuds (Amphipoda) are not sensitive and can sometimes indicate poor water quality and/or contamination (U-Links & WWEW, 2022). However, species richness and diversity must also be considered, as having only one species of benthic invertebrate, even if it is a sensitive species, does not usually indicate good water quality. Scientists choose to study benthic macroinvertebrates because they are cheap, easy to collect, relatively easy to identify, and they are a valuable food source for other aquatic life (TRCA, 2011). In combination with water chemistry measurements, benthic macroinvertebrates make an excellent indicator of water quality or health. The aim of this report is to analyze water chemistry and benthic macroinvertebrate community data in Bob Lake, located in Minden, Ontario. The Bob Lake Association (BLA) was founded by the community in 2017 (BLA, n.d), with the aim of protecting the lake by enhancing the natural shoreline, reducing water contaminants, and increasing the use of kayaks or canoes instead of fuel powered boats (Pyke, n.d).

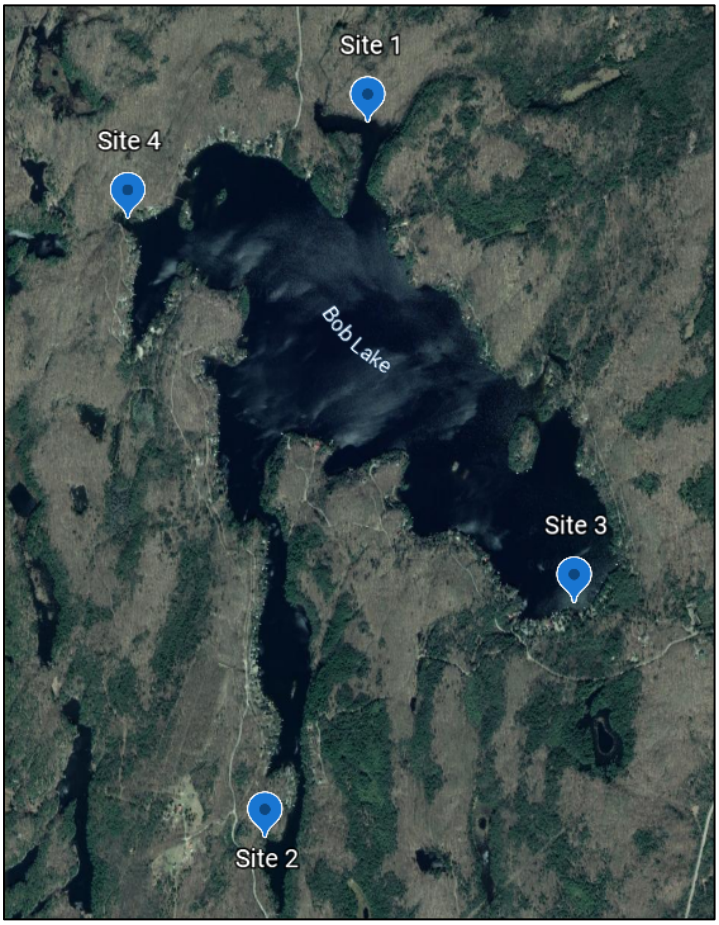

Figure 1: Bob Lake Benthic Macroinvertebrate Sampling Sites

Lake History

Bob Lake is located on the traditional land of the Mississauga and the Anishinabewaki nations. Currently this lake is approximately 2.5 km long and 1.2 km wide with an average depth of 18.3m and a maximum depth of 64m (BLA). The first three cottages were built on Bob Lake around 1926, and there are roughly 230 cottages in the present day (Pyke, n.d). Bob Lake was stocked with fish species such as trout between approximately 1950 and 1990 (BLA, n.d.). Today, there are four roads that provide cottagers and tourists with access to Bob Lake (Pyke, n.d).

Bob Lake had a significant relationship with the local fur trade and the logging industry. Around 1870, both the fur trade and the logging industry were prominent in the area (Pyke, n.d). The fur trading ended around the 1900's, but the logging industry continued in full force. Most logging took place in the winter months along the lake and surrounding rivers. During the 1920's the logging industry slowed down and eventually the last log drive occurred in 1929. As this industry shift took place, the Minden area grew and with that came an influx of cottagers (Pyke, n.d). In 1931, the old logging dam was replaced with the Big Bob dam and became a reservoir for the Trent canal. Bob Lake was finally formed in 1961 after three separate lakes connected due to the rising water levels from the dam construction (Pyke, n.d).

In more recent years there were attempts to combine various lake associations, and in 2017 the Bob Lake Association was formed to fulfill this goal. This can be attributed to the closure of the public boat launch in 2016 (Pyke, n.d), which prompted cottagers to join forces in the interest of restoring boat access. The Bob Lake Association wants to establish lake stewardship efforts to help address the changes noticed in the lake, specifically the blue-green algal blooms. In 2020, Bob Lake experienced their first recorded algae bloom, which was tested and found to be low in toxicity (BLA, n.d). This is concerning for the community regardless, as once there is one algal bloom, it is very likely more will occur in the future.

Purpose

The purpose of this project is to create a baseline composition of the benthic macroinvertebrate communities within Bob Lake. This baseline will be used by Bob Lake Association for long-term lake monitoring and future management decisions and

may also be compared with historic data from the lake. This is year two of the five required to develop a proper baseline composition.

Methodology

U-Links staff, Canadian Conservation Corps Interns, and Bob Lake Association volunteers went to 4 sites by boat to conduct sampling. Site 1 was inaccessible due to water levels being too low and was therefore not sampled in 2022. Site features and information about the vegetation and substrate in and around the sample areas were recorded in accordance with standardized protocol. Prior to sampling, information regarding the site's vegetation and any downed woody debris was recorded. Ontario Benthos Biomonitoring Network (OBBN) kick-and-sweep protocol was then followed at sites 2- 4 to collect benthic macroinvertebrates. For each site, a minimum of two replicates were collected. The sample was then placed in a jar with non-toxic antifreeze to preserve the specimens. Students from Trent University then conducted sample picking in February 2023 and identified the benthos to the 27-family level using the teaspoon method under a microscope in the lab. Next, benthic invertebrate community composition was analyzed using the following indices.

Percent Composition

To gain a greater understanding of the make-up of the benthic macroinvertebrate community, the identified organisms were sorted into six categories: worms, Malacostraca, Mollusca, %EOT, Diptera, and other. Worms and Diptera are known to be tolerant, malacostraca are tolerant to higher temperatures, and Mollusca prefer high suspended solids levels (U-Links & WWEW, 2022). In contrast, Ephemeroptera, Oligochaeta, and Trichoptera (%EOT) are more sensitive. The percent that each group represented overall in the Bob Lake samples was then determined.

Modified Hilsenhoff Family Biotic Index (mHBI)

To determine the modified Hilsenhoff family biotic index, species were grouped and given a corresponding tolerance score based on their pollution tolerance and abundance. The scores found for the Bob Lake benthos community were then added and divided by the total abundance to determine the index value of each site. An index score can range from ‘0’ which is considered pollution intolerant, to a score of ‘10’ is considered pollution tolerant (U-Links & WWEW, 2022). However, this calculation is only suitable for river environments, not for lakes, so it is simply be used to compare yearly data (U-Links & WWEW, 2022).

Percent Ephemeroptera, Oligochaeta, and Trichoptera (%EOT)

The percent of mayflies, dragonflies, damselflies, stoneflies, and caddisflies (%EOT) was calculated by determining the abundance of EOT species at each site and dividing by the total abundance. EOT species are sensitive to temperature changes and dissolved oxygen levels (U-Links & WWEW, 2022). A benthic community is categorized as typical when the %EOT is from 4.18% to 37.12% (U-Links & WWEW, 2022). Atypical

conditions range from 2.62% to 4.18% or 37.12% to 54.41% (U-Links & WWEW, 2022). An extremely atypical %EOT would be less than 2.62% or greater than 54.41% (U-Links & WWEW, 2022).

Simpson's Index

Simpson's index accounts for a community's diversity and abundance, so the number of species and total individuals in the community were counted. Then the individuals per species was divided by the total individuals in the community using the following equation:

$$D = 1 - \frac{\sum n(n-1)}{N(N-1)}$$ *Where: n = the individuals per group*

and N = the individuals in the community

Results can range from '0' to '1': no diversity to infinite diversity (U-Links & WWEW, 2022).

Hill 0, 1, 2

Hill numbers conveniently summarize all three types of biodiversity using a single expression, and consider species richness, Shannon's diversity index and the Simpson index (Broms et al., 2015). Hills diversity is considered a more comprehensive method for evaluating species diversity, evenness, genetic diversity, and differentiation among communities. (Roswell et al., 2021).

Hill numbers are interpreted as the 'effective number of species' or 'species equivalents", which are the number of equally abundant species that would be needed to give the same value of a diversity measure (Chao et al., 2014). Hill 0 indicates the overall species richness in a sample, Hills 1 indicates the number of

common species in a sample, and Hills 2 indicates the number of very common species in a sample (Peet, 1974).

Results

Note: *2021 averages were based off 4 sites, while 2022 averages were only based off 3 sites.*

Percent Composition

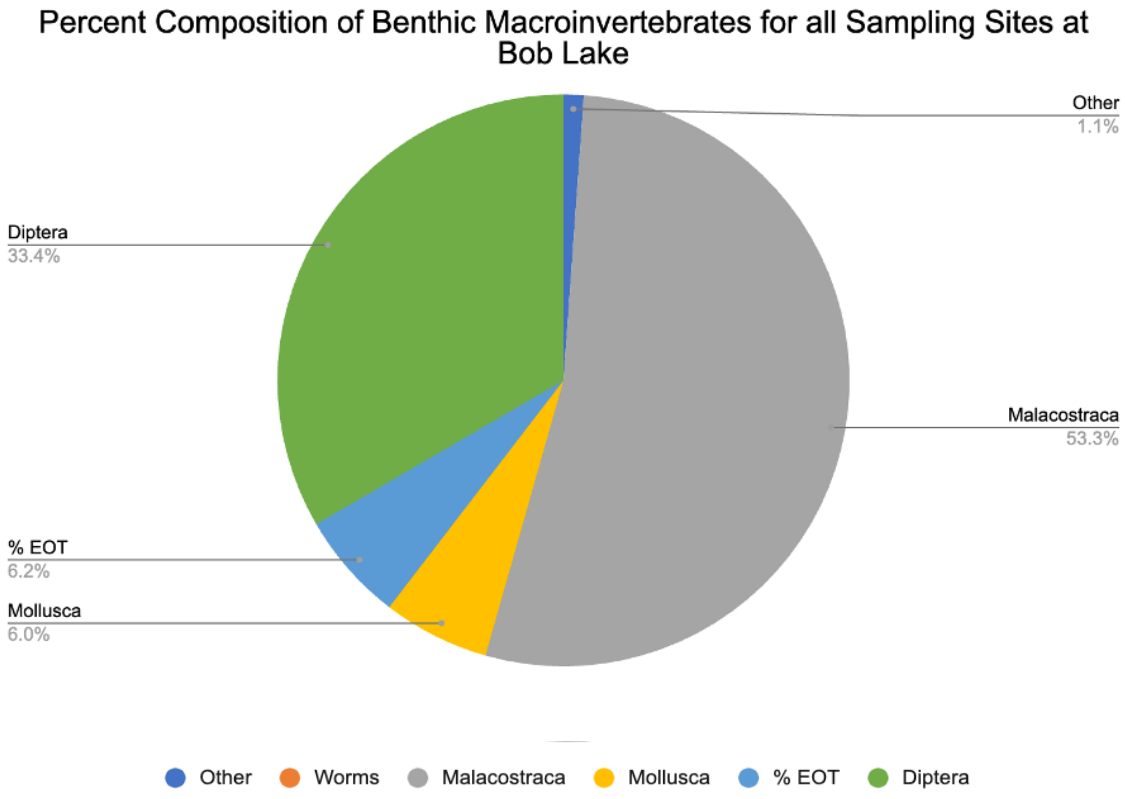

Figure 2: Overall Percent Composition of the Bob Lake Benthic Macroinvertebrate Community at all Sampling Sites

Percent composition is valuable to show the community in simple terms. As shown, the dominant group was Malacostraca (subphylum Crustacea, phylum Arthropoda), the largest class of Crustaceans.

Modified Hilsenhoff Family Biotic Index (mHBI)

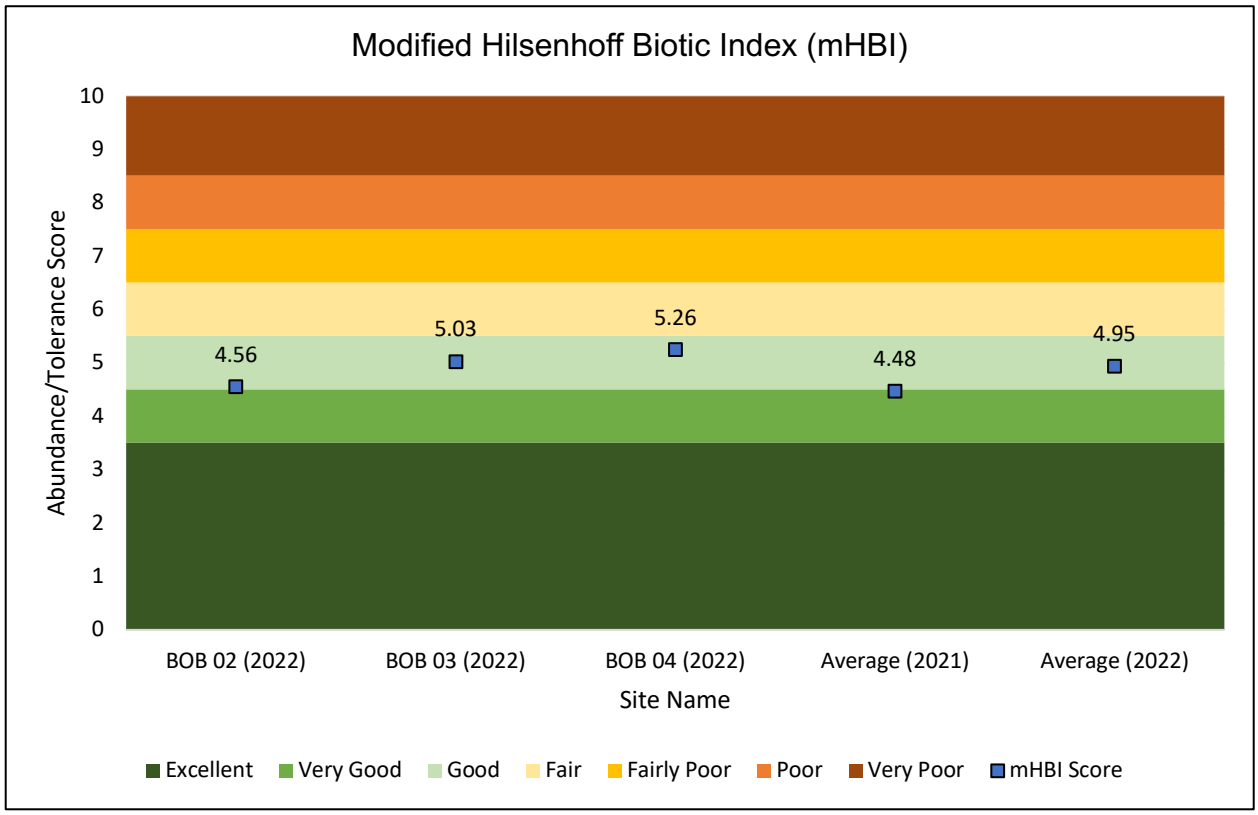

Figure 3: Average Modified Hilsenhoff Family Biotic Index (mHBI) at Bob Lake

The Average Modified Hilsenhoff Family Biotic Index is designed to evaluate organic and nutrient pollution using arthropods collected from a riffle in a stream environment (Hilsenhoff, 1977). It should be noted that we are using this index to evaluate a lake, which cannot support benthos that require stream conditions such as riffles. Therefore, the results should be considered as part of the bigger picture rather than independently.

Percent Ephemeroptera, Zygoptera (Odonata), Anisoptera (Odonata), and Trichoptera (%EOT)

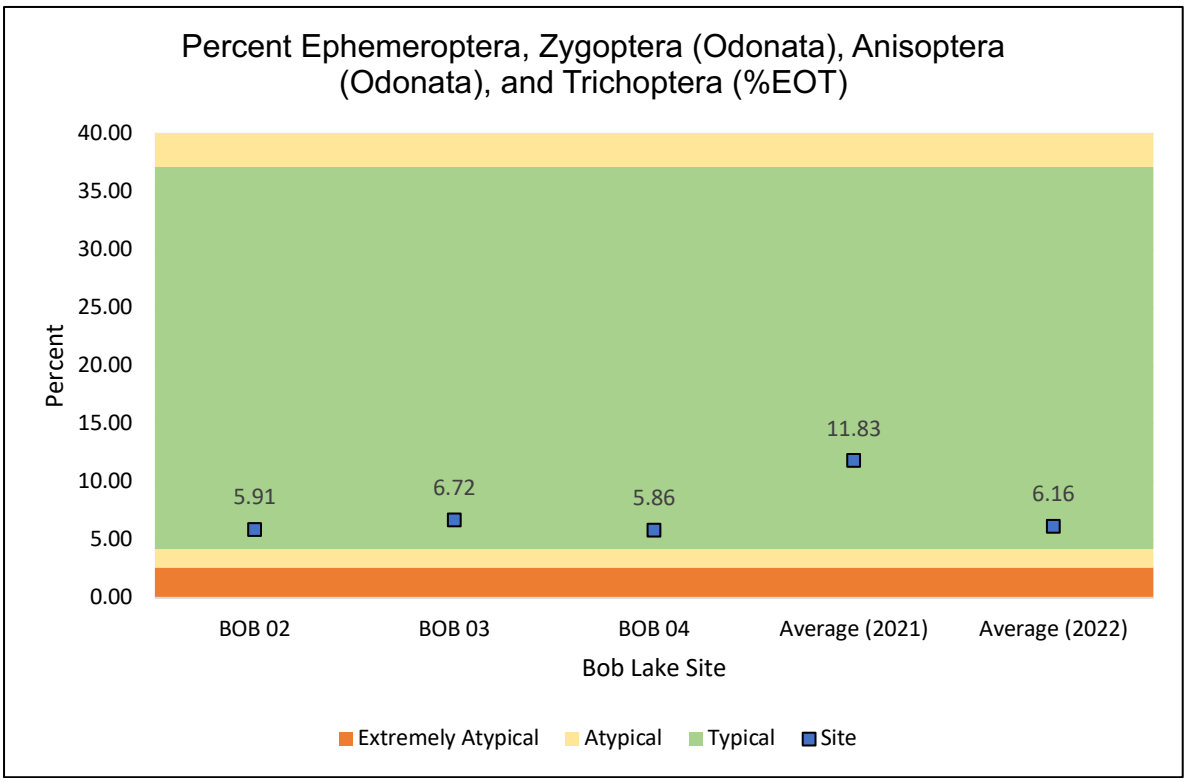

Figure 4: Average Percent Ephemeroptera, Zygoptera (Odonata), Anisoptera (Odonata), and Trichoptera (%EOT) at Bob Lake

Ephemeroptera, Odonata, and Trichoptera (EOT) are very sensitive to pollution and disturbance, making them strong indicators of ecosystem health.

Simpson's Index

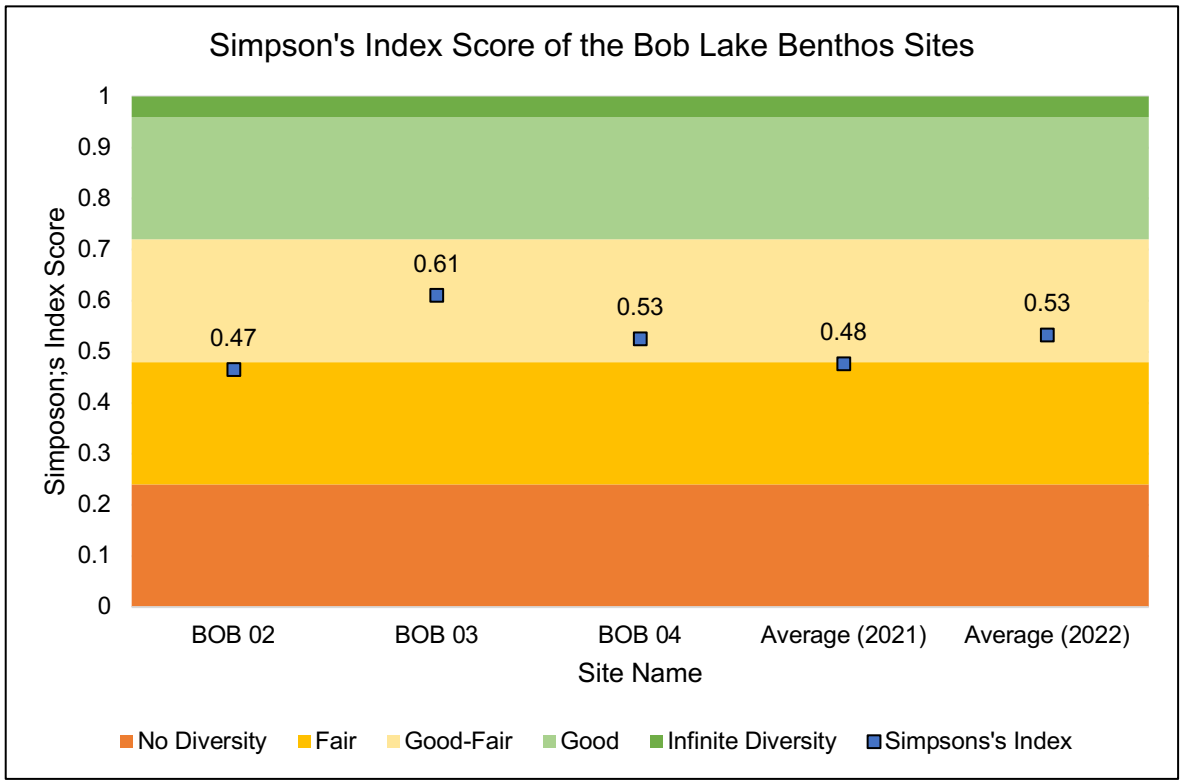

Figure 5: Average Simpson's Index Scores of Each Bob Lake Benthos Site

The Simpson's index considers diversity and abundance, and ranges from no diversity (0) to infinite diversity (1) (U-Links & WWEW, 2022).

Hills Diversity Numbers 0, 1, & 2

Table 1: Hills Score of Benthic Macroinvertebrate Communities Found at Bob Lake

Indices	BOB-02 R1	BOB-02 R2	BOB-03 R1	BOB-03 R2	BOB-04 R1	BOB-04 R2
Hills 0	6.00	6.00	7.00	9.00	6.00	3.00
Hills 1	2.39	2.52	2.75	4.40	2.91	2.04
Hills 2	1.76	2.00	2.01	3.54	2.51	1.81

Hills diversity is an advanced mathematical index that combines various diversity metrics, with a focus on species richness and modified versions of the traditional Shannon and Simpson indices. Hill 0 indicates the overall species richness in a sample, Hills 1 indicates the number of common species in a sample, and Hills 2 indicates the number of very common species in a sample (Peet, 1974).

Water Chemistry and Vegetation

All sites and replicates sampled during 2022 had detritus, submergent macrophytes, and attached algae present to varying degrees of abundance. BOB-02 and BOB-04 had the most abundant detritus and submergent macrophytes. BOB-03 had very little vegetation in or around the sample site. Detritus, submergent plants, and filamentous and attached algae were all noted as being present but not abundant. BOB-02 and BOB-04 also have an abundance of woody debris in and around the sample site while BOB-03 had none. BOB-02 is the only site noted to have emergent macrophytes and floating algae present. It is noted that there were low water levels during sampling. The average water temperature for the sites was 12.1 degrees Celsius, with BOB-04 having the highest temperature at 13.5° and BOB-03 having the lowest temperature at

10.5°. The sites had an average dissolved oxygen of 9.77 mg/L and an average pH of 8.22. BOB-03 does have higher pH and dissolved oxygen than the other sites with respective values of 8.58 and 9.76 mg/L. The difference between the sites is not large, but it is important to note that BOB-03 does have the highest pH and dissolved oxygen but also has the least vegetation by the site.

Discussion

Early on during the sample picking process it became clear that the dominant families present were Amphipoda (scuds) and Chironomidae (midges). Snails and mayflies were the next most abundant families, but they were a minority compared to the number of scuds and midges. Historic OBBN data from Bob Lake had similar results, so this was not unexpected. It should also be noted that the % EOT of each site in Bob Lake fell within the typical range for Haliburton lakes. While our results may have appeared concerning initially, background knowledge confirms the results are in an expected range. The 2021 report on Bob Lake showed similar species composition and diversity scores.

Average Modified Hilsenhoff Family Biotic Index is an index designed to evaluate stream environments, but we chose to include it in our evaluation as a component of the broader picture. Even though sampling took place in a lake, each site fell in the “good” range, and some sites were close to the “very good” range. This is a positive indication for Bob Lake. Percent EOT (Ephemeroptera, Odonata, and Trichoptera), which are considered the most sensitive groups to pollution, fell into the low end of the typical range for Haliburton County lakes. The average percentage at each site for 2022 did fall below the average from the 2021 assessment by just over 5%, but this isn’t something

that can be considered a concern so early in the 5-year assessment process. Values from the Simpsons index ranged from 0.47 to 0.61, which fall in the “fair” to “good-fair” range. This index accounts for species diversity and abundance, and mid-range values

There were a few miscellaneous findings made during sample picking that are worth noting. What appeared to be empty cases from Trichopterans (caddisflies) were seen in some samples, but because no insect was present within the cases they could not be counted. The main hypotheses that could explain this are that the samples were not preserved to their fullest extent. We did notice some insects appeared desiccated while still identifiable, but certain soft bodied species are more prone to decomposition. A higher number of caddisflies would have positively affected the EOT ratio and indicated higher water quality, so if these species were present but unidentifiable this may have skewed our results.

Additionally, what appeared to be metal particles were present in the sediment from site 3. When using tweezers to sort through the sediment, small black particles were sticking to and building up on the metal which had to be wiped off frequently- these particles were visible on a paper towel (Figure 21).

Without more advanced data on the water chemistry of the lake, it is difficult to speculate much further about the quality of the ecosystem. Our benthic data certainly does not indicate that the lake is unhealthy, but additional chemical data would be valuable regardless.

Conclusions and Recommendations

More sampling is required, as only 2 years of 5 have been completed to create the baseline composition data. Adding additional sites may be beneficial as one site

became inaccessible during the 2022 sampling period, and this may reoccur in the future. A site located near an additional busy road could be of interest. Additionally, it is recommended that further research and surveying be conducted regarding the metallic particles found in samples BOB-03-R1 and BOB-03-R2. This site should be examined further to determine a potential source of the metal particles, and ideally their composition should be determined to rule them out as a contaminant of concern. However, as the lake appears to be relatively healthy when compared to reference sites, no serious changes in management are urgently required.

Water chemistry analysis of Bob Lake has been focused on evaluating pH, dissolved oxygen, and temperature. Placing additional monitoring technologies such as a semipermeable membrane device (SPMD) may give some insight on potential organic contaminants of concern. An SPMD uses triolein oil to collect lipophilic contaminants and accumulate them in the same way the fat cells of a fish would. These devices can be made and deployed inexpensively, and the results could be evaluated onsite at Trent University. This contaminant data may be able to fill in gaps of knowledge present at the conclusion of this study.

Appendix A: Excel Sheets

BOB-02 R1					
27 OBBN Groups	Abundance	Tolerance Value	Tolerance Score	H Calc	D Calc
Coelenterata		5	0	#NUM!	0
Platyhelminthes		4	0	#NUM!	0
Nemata		5	0	#NUM!	0
Oligochaeta		8	0	#NUM!	0
Hirudinea		10	0	#NUM!	0
Isopoda		8	0	#NUM!	0
Bivalvia	2	8	16	-0.077094620	0.0001941370
Amphipoda	75	4	300	-0.226091691	0.5387303436
Decapoda		8	0	#NUM!	0
Hydrachnidia		6	0	#NUM!	0
Ephemeroptera	5	5	25	-0.147820338	0.0019413706
Anisoptera		5	0	#NUM!	0
Zygoptera		7	0	#NUM!	0
Plecoptera		1	0	#NUM!	0
Hemiptera		5	0	#NUM!	0
Megaloptera		4	0	#NUM!	0
Trichoptera	1	4	4	-0.045342870	0
Lepidoptera		6	0	#NUM!	0
Coleoptera	2	4	8	-0.077094620	0.0001941370
Gastropoda		7	0	#NUM!	0
Chironomidae	17	6	102	-0.298626578	0.0264026402
Tabanidae		6	0	#NUM!	0
Culicidae		8	0	#NUM!	0
Certopogonidae		6	0	#NUM!	0
Tipulidae		3	0	#NUM!	0
Simuliidae		6	0	#NUM!	0
Other Diptera		7	0	#NUM!	0
Totals	102	156	455	-0.872070718	0.5674626286
Meterics	Calculated Values:	Integrity Rating:			
Modified Hilsenhoff Family Biotic Index	4.46	Very Good			
%EOT	5.88	Typical			
Simpson's Index	0.43	Fair			
Hills 0	6.00				
Hills 1	2.39				
Hills 2	1.76				

Figure 6: BOB-02 Replicate 1 Excel Count Data

BOB-02 R2					
27 OBBN Groups	Abundance	Tolerance Value	Tolerance Score	H Calc	D Calc
Coelenterata		5	0	#NUM!	0
Platyhelminthes		4	0	#NUM!	0
Nemata		5	0	#NUM!	0
Oligochaeta		8	0	#NUM!	0
Hirudinea	1	10	10	-0.045694262	0
Isopoda		8	0	#NUM!	0
Bivalvia		8	0	#NUM!	0
Amphipoda	67	4	268	-0.272264050	0.4378217822
Decapoda		8	0	#NUM!	0
Hydrachnidia	1	6	6	-0.045694262	0
Ephemeroptera	6	5	30	-0.167724418	0.0029702970
Anisoptera		5	0	#NUM!	0
Zygoptera		7	0	#NUM!	0
Plecoptera		1	0	#NUM!	0
Hemiptera		5	0	#NUM!	0
Megaloptera		4	0	#NUM!	0
Trichoptera		4	0	#NUM!	0
Lepidoptera		6	0	#NUM!	0
Coleoptera		4	0	#NUM!	0
Gastropoda	1	7	7	-0.045694262	0
Chironomidae	25	6	150	-0.345605121	0.0594059405
Tabanidae		6	0	#NUM!	0
Culicidae		8	0	#NUM!	0
Certopogonidae		6	0	#NUM!	0
Tipulidae		3	0	#NUM!	0
Simuliidae		6	0	#NUM!	0
Other Diptera		7	0	#NUM!	0
Totals	101	156	471	-0.922676378	0.5001980198
Meterics	Calculated Values:	Integrity Rating:			
Modified Hilsenhoff Family Biotic Index	4.66	Good			
%EOT	5.94	Typical			
Simpson's Index	0.50	Fair			
Hills 0	6.00				
Hills 1	2.52				
Hills 2	2.00				

Figure 7: BOB-02 Replicate 2 Excel Count Data

BOB-03-R1					
27 OBBN Groups	Abundance	Tolerance Value	Tolerance Score	H Calc	D Calc
Coelenterata		5	0	#NUM!	0
Platyhelminthes		4	0	#NUM!	0
Nemata		5	0	#NUM!	0
Oligochaeta		8	0	#NUM!	0
Hirudinea		10	0	#NUM!	0
Isopoda		8	0	#NUM!	0
Bivalvia		8	0	#NUM!	0
Amphipoda	72	4	288	-0.262713718	0.4592991914
Decapoda		8	0	#NUM!	0
Hydrachnidia		6	0	#NUM!	0
Ephemeroptera	7	5	35	-0.179459458	0.0037735849
Anisoptera		5	0	#NUM!	0
Zygoptera	1	7	7	-0.043994708	0
Plecoptera		1	0	#NUM!	0
Hemiptera		5	0	#NUM!	0
Megaloptera		4	0	#NUM!	0
Trichoptera	1	4	4	-0.043994708	0
Lepidoptera		6	0	#NUM!	0
Coleoptera		4	0	#NUM!	0
Gastropoda	4	7	28	-0.123665839	0.0010781671
Chironomidae	20	6	120	-0.314661664	0.0341419586
Tabanidae		6	0	#NUM!	0
Culicidae		8	0	#NUM!	0
Certopogonidae	1	6	6	-0.043994708	0
Tipulidae		3	0	#NUM!	0
Simuliidae		6	0	#NUM!	0
Other Diptera		7	0	#NUM!	0
Totals	106	156	488	-1.012484806	0.4982929021
Meterics	Calculated Values:	Integrity Rating:			
Modified Hilsenhoff Family Biotic Index	4.60	Good			
%EOT	8.49	Typical			
Simpson's Index	0.50	Good-Fair			
Hills 0	7.00				
Hills 1	2.75				
Hills 2	2.01				

Figure 8: BOB-03 Replicate 1 Excel Count Data

BOB-03-R2					
27 OBBN Groups	Abundance	Tolerance Value	Tolerance Score	H Calc	D Calc
Coelenterata		5	0	#NUM!	0
Platyhelminthes		4	0	#NUM!	0
Nemata	2	5	10	-0.077662838	0.0001980198
Oligochaeta		8	0	#NUM!	0
Hirudinea		10	0	#NUM!	0
Isopoda		8	0	#NUM!	0
Bivalvia	2	8	16	-0.077662838	0.0001980198
Amphipoda	41	4	164	-0.365975113	0.1623762376
Decapoda		8	0	#NUM!	0
Hydrachnidia		6	0	#NUM!	0
Ephemeroptera		5	0	#NUM!	0
Anisoptera	2	5	10	-0.077662838	0.0001980198
Zygoptera	2	7	14	-0.077662838	0.0001980198
Plecoptera		1	0	#NUM!	0
Hemiptera		5	0	#NUM!	0
Megaloptera		4	0	#NUM!	0
Trichoptera	1	4	4	-0.045694262	0
Lepidoptera		6	0	#NUM!	0
Coleoptera		4	0	#NUM!	0
Gastropoda	27	7	189	-0.352679787	0.0695049505
Chironomidae	23	6	138	-0.336944603	0.0500990099
Tabanidae		6	0	#NUM!	0
Culicidae		8	0	#NUM!	0
Certopogonidae	1	6	6	-0.045694262	0
Tipulidae		3	0	#NUM!	0
Simuliidae		6	0	#NUM!	0
Other Diptera		7	0	#NUM!	0
Totals	101	156	551	-1.457639383	0.2827722772
Meterics	Calculated Values:	Integrity Rating:			
Modified Hilsenhoff Family Biotic Index	5.46	Good			
%EOT	4.95	Typical			
Simpson's Index	0.72	Good-Fair			
Hills 0	9.00				
Hills 1	4.30				
Hills 2	3.54				

Figure 9: BOB-03 Replicate 2 Excel Count Data

BOB-04-R1					
27 OBBN Groups	Abundance	Tolerance Value	Tolerance Score	H Calc	D Calc
Coelenterata		5	0	#NUM!	0
Platyhelminthes		4	0	#NUM!	0
Nemata		5	0	#NUM!	0
Oligochaeta		8	0	#NUM!	0
Hirudinea	1	10	10	-0.044997368	0
Isopoda		8	0	#NUM!	0
Bivalvia		8	0	#NUM!	0
Amphipoda	44	4	176	-0.363337199	0.180087569
Decapoda		8	0	#NUM!	0
Hydrachnidia		6	0	#NUM!	0
Ephemeroptera	7	5	35	-0.182735260	0.0039977155
Anisoptera		5	0	#NUM!	0
Zygoptera		7	0	#NUM!	0
Plecoptera		1	0	#NUM!	0
Hemiptera		5	0	#NUM!	0
Megaloptera		4	0	#NUM!	0
Trichoptera	2	4	8	-0.076535569	0.0001903674
Lepidoptera		6	0	#NUM!	0
Coleoptera		4	0	#NUM!	0
Gastropoda	1	7	7	-0.044997368	0
Chironomidae	48	6	288	-0.355818863	0.2147344375
Tabanidae		6	0	#NUM!	0
Culicidae		8	0	#NUM!	0
Certopogonidae		6	0	#NUM!	0
Tipulidae		3	0	#NUM!	0
Simuliidae		6	0	#NUM!	0
Other Diptera		7	0	#NUM!	0
Totals	103	156	524	-1.068421631	0.3990100895
Meterics	Calculated Values:	Integrity Rating:			
Modified Hilsenhoff Family Biotic Index	5.09	Good			
%EOT	8.74	Typical			
Simpson's Index	0.60	Good-Fair			
Hills 0	6.00				
Hills 1	2.91				
Hills 2	2.51				

Figure 10: BOB-04 Replicate 1 Excel Count Data

BOB-04-R2					
27 OBBN Groups	Abundance	Tolerance Value	Tolerance Score	H Calc	D Calc
Coelenterata		5	0	#NUM!	0
Platyhelminthes		4	0	#NUM!	0
Nemata		5	0	#NUM!	0
Oligochaeta		8	0	#NUM!	0
Hirudinea		10	0	#NUM!	0
Isopoda		8	0	#NUM!	0
Bivalvia		8	0	#NUM!	0
Amphipoda	28	4	112	-0.355659883	0.0748514851
Decapoda		8	0	#NUM!	0
Hydrachnidia		6	0	#NUM!	0
Ephemeroptera	3	5	15	-0.104450739	0.0005940594
Anisoptera		5	0	#NUM!	0
Zygoptera		7	0	#NUM!	0
Plecoptera		1	0	#NUM!	0
Hemiptera		5	0	#NUM!	0
Megaloptera		4	0	#NUM!	0
Trichoptera		4	0	#NUM!	0
Lepidoptera		6	0	#NUM!	0
Coleoptera		4	0	#NUM!	0
Gastropoda		7	0	#NUM!	0
Chironomidae	70	6	420	-0.254096725	0.4782178218
Tabanidae		6	0	#NUM!	0
Culicidae		8	0	#NUM!	0
Certopogonidae		6	0	#NUM!	0
Tipulidae		3	0	#NUM!	0
Simuliidae		6	0	#NUM!	0
Other Diptera		7	0	#NUM!	0
Totals	101	156	547	-0.714207347	0.5536633663
Meterics	Calculated Values:	Integrity Rating:			
Modified Hilsenhoff Family Biotic Index	5.42	Good			
%EOT	2.97	Typical			
Simpson's Index	0.45	Fair			
Hills 0	3.00				
Hills 1	2.04				
Hills 2	1.81				

Figure 11: BOB-04 Replicate 2 Excel Count Data

Appendix B: Tally Sheets

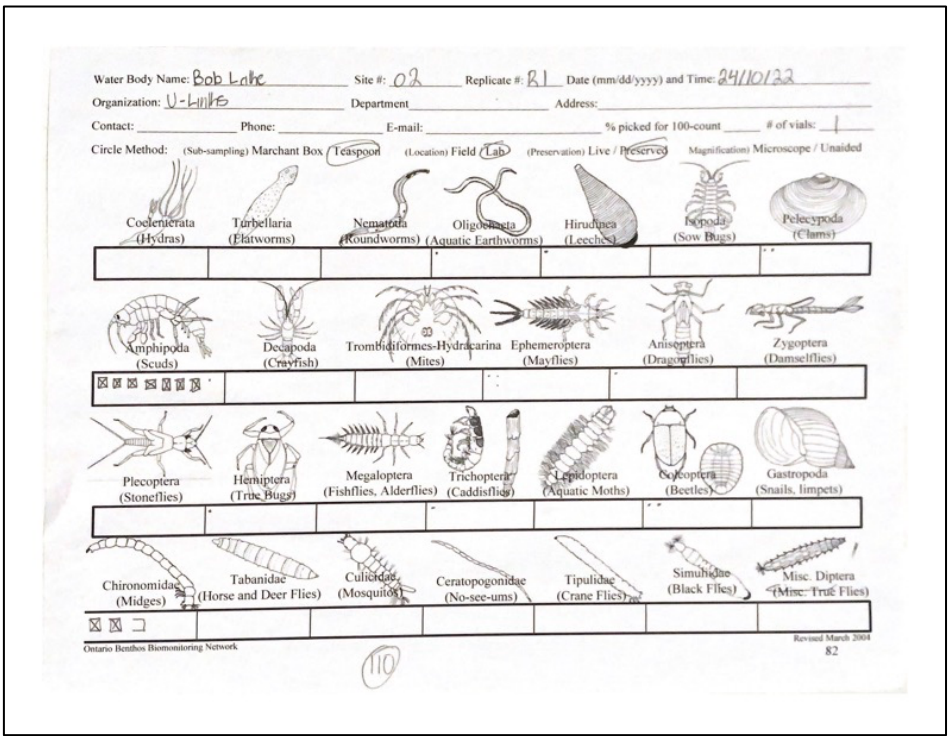

Figure 12: BOB-02 Replicate 1 Tally Sheet

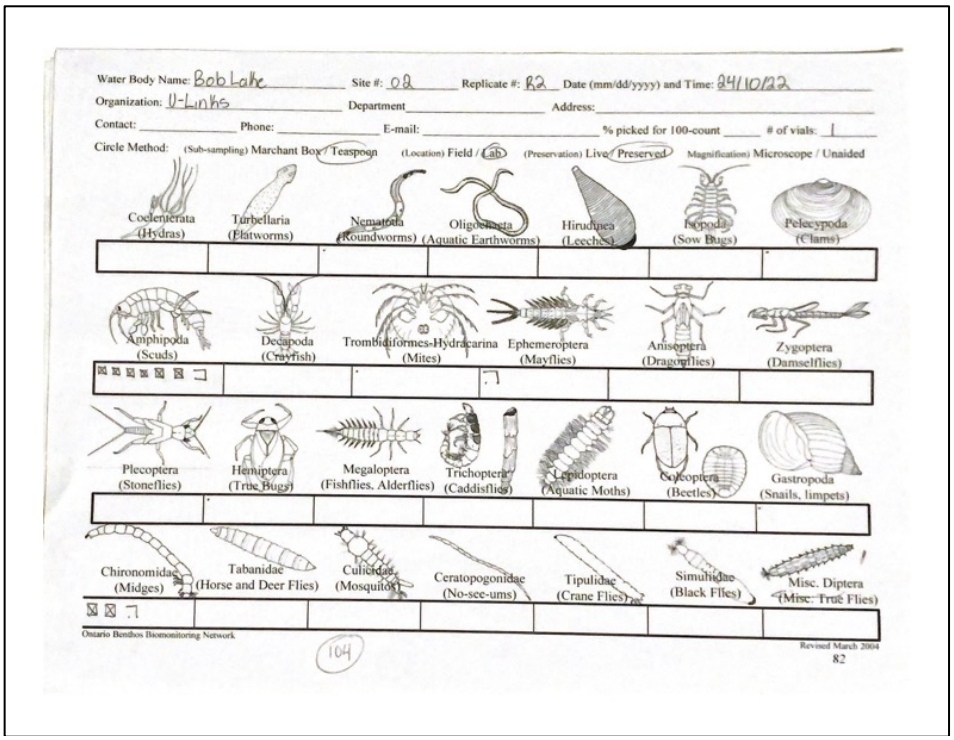

Figure 13: BOB-02 Replicate 2 Tally Sheet

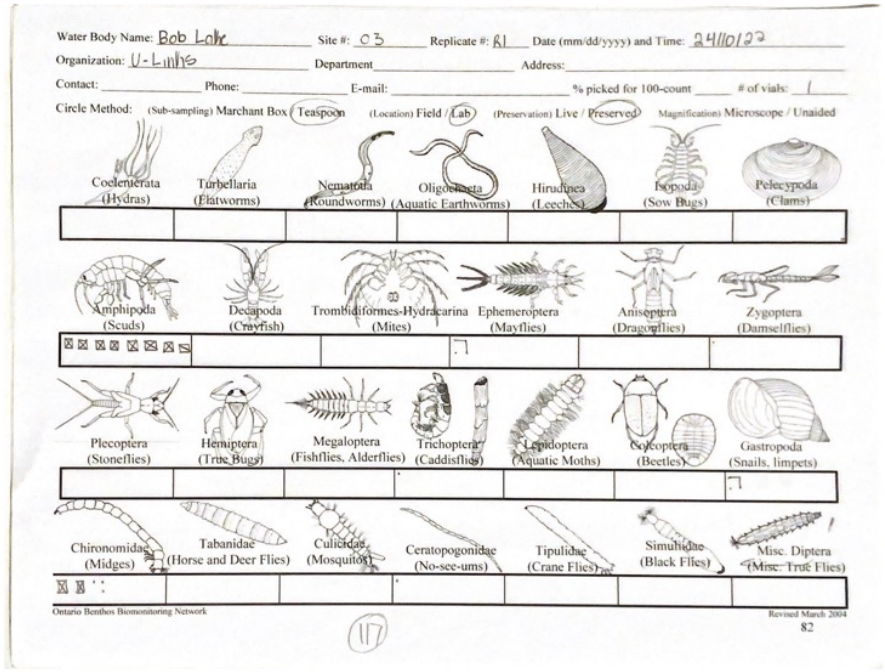

Figure 14: BOB-03 Replicate 1 Tally Sheet

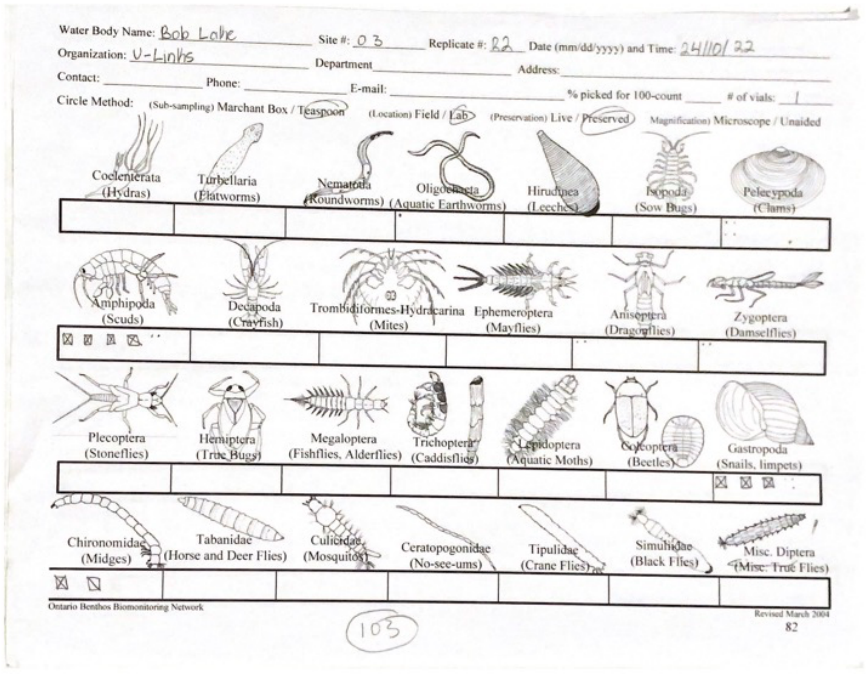

Figure 15: BOB-03 Replicate 2 Tally Sheet

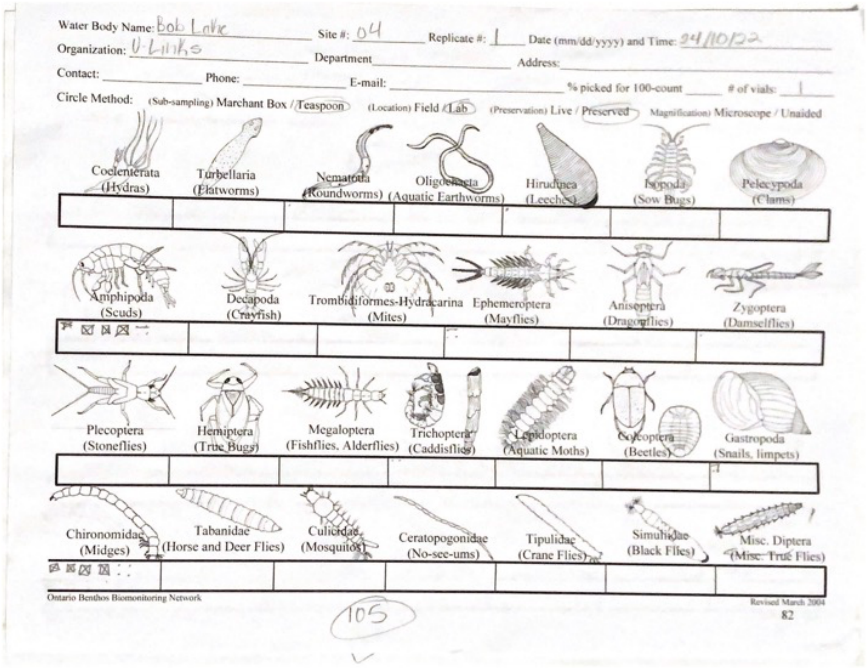

Figure 16: BOB-04 Replicate 1 Tally Sheet

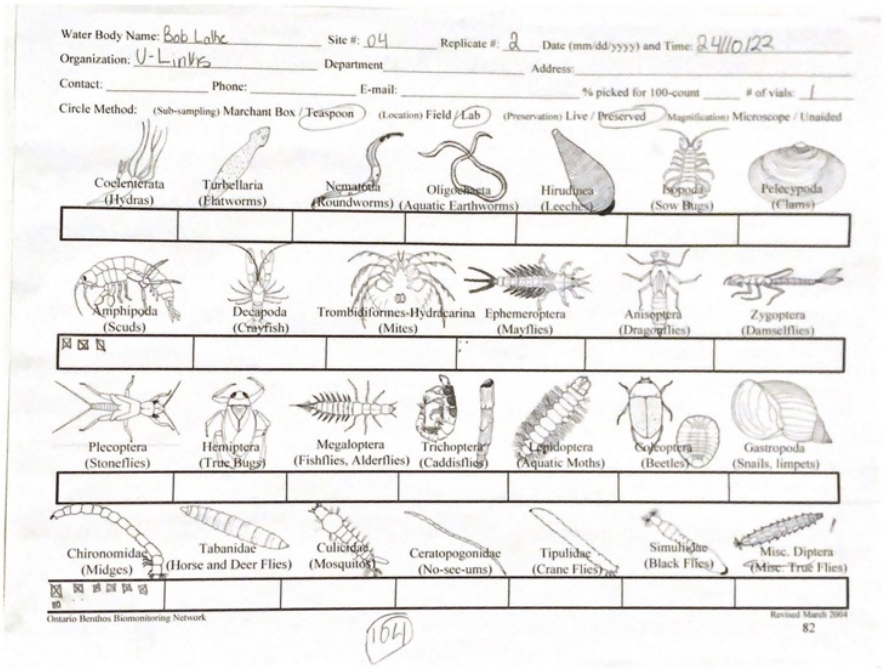

Figure 17: BOB-04 Replicate 2 Tally Sheet

Appendix C: Sampling Photographs

Figure 18: Bob Lake Damselfly (Zygoptera/Odonata) Specimen

Figure 19: Bob Lake Dragonfly (Anisoptera/Odonata) Specimen

Figure 20: Paper Towel with Metal Particles

References

BLA. (n.d.). Bob Lake Fishing. *Bob Lake Association.* https://boblakeassociation.ca/fishing/

Broms, K. M., Hooten, M. B., & Fitzpatrick, R. M. (2015). Accounting for imperfect detection in Hill numbers for biodiversity studies. *Methods in Ecology and Evolution*, *6*(1), 99–108. https://doi.org/10.1111/2041-210X.12296

Chao, A., Gotelli, N. J., Hsieh, T. C., Sander, E. L., Ma, K. H., Colwell, R. K., & Ellison, A. M. (2014). Rarefaction and extrapolation with Hill Numbers: A framework for sampling and estimation in species Diversity Studies. Ecological Monographs, 84(1), 45–67. https://doi.org/10.1890/13-0133.1

Hilsenhoff, W.L. (1987). An Improved Biotic Index of Organic Stream Pollution. *Great Lakes Entomologist, 20*, 7.

Ma, Z. S., & Li, L. (2018). Measuring metagenome diversity and similarity with Hill Numbers. *Molecular Ecology Resources*, *18*(6), 1339–1355. https://doi.org/10.1111/1755-0998.12923

Native Land Digital. (2021). Mapbox powered by WordPress, hosted by Pressable. https://native-land.ca/

Peet, R. K. (1974). The Measurement of Species Diversity. Annual Review of Ecology and Systematics, 5(1), 285–307. https://doi.org/10.1146/annurev.es.05.110174.001441

Pyke, G. (n.d.). The Bob Lake History. *Bob Lake Association.* https://boblakeassociation.ca/history/the-bob-lake-history/

Roswell, M., Dushoff, J., & Winfree, R. (2021). A conceptual guide to measuring species diversity. Oikos, 130(3), 321–338. https://doi.org/10.1111/oik.07202

TRCA. (2011). Regional Watershed Monitoring Program: Benthic Macroinvertebrate Summary 2001-2008. Watershed Monitoring and Reporting Section Ecology Division. *Toronto Region Conservation for The Living City.* https://trca.ca/app/uploads/2016/10/BMI-2001-2008-Report-FINAL.pdf

U-Links & WWEW. (2022). Introduction to Benthic Analysis Techniques [PowerPoint slides]. Provided for ERSC 3160H: Community Based Resource Management. Trent University.