BES 316 Spring 2010

**STREAM BENTHIC MACROINVERTEBRATE SAMPLING:**

**INDICATORS OF STREAM QUALITY**

**Goals for Today**

1. To practice identification and sorting of stream benthic macroinvertebrates (BMI)
2. To learn about and practice data analysis approaches for the BMI data
3. To compare BMI data from North Creek with that of Little Bear Creek

**SCHEDULE for MAY 20, 2010**

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| **Time Period** | **Activity** |
| 8:45 – 12:00 | Sorting benthic macroinvertebrate samples and summarizing data |
| 12:00 – 1:05 | Calculations of stream health indices |

**Overview**

Benthic macroinvertebrates (BMIs) are important components of stream ecosystems. Many BMIs are sensitive to the physical, chemical, and biological conditions of the stream environment but the degree of sensitivity to specific environmental factors varies among different BMI taxa. Thus, BMIs are often used as indicator species of certain stream environment conditions. Scientists have developed indices of stream quality based on the types, diversity, and relative abundance of BMIs found in a site.

Today we will analyze the samples from North Creek and Little Bear Creek. As a comnparison, the Little Bear Creek watershed is less urbanuized than North Creek. Within your group of four, you will work in two pairs, with each pair analyzing (1) your North Creek subsample and (2) a subsample provided from Little Bear Creek. Your group of 4 will use the two subsamples (one from each pair of students) from each site to calculate replicate indices from each site that are reflections of stream health. See Figure 1 at the end of this handout for an overview of the experimental design!

**Identification and Sorting of BMIs**

* Label 12 Petri dishes, one for each of the 12 general BMI taxa that we will recognize:
* Mayflies
* Stoneflies
* Caddisflies
* Dobsonflies/ alderflies / fishflies
* Dragonflies / damselflies
* True flies
* Midges
* Beetles
* Crustaceans
* Snails / clams
* Worms / leeches
* Others
* Pour your BMI sample from your sample jar into the sieve. Rinse the sample with water to wash off the ethyl alcohol. Wash the sample from the sieve into the white sorting tray with water. Put about 1 cm of water into the tray to help disperse your sample material.
* Remove each BMI from the sample and identify it using the dichotomous and pictorial keys provided (from Murdoch and Cheo 1999). You may need to use a magnifier or dissecting microscope to help in identification. These keys will allow you (when possible) to identify specific types of organisms within the 12 general taxanomic categories of BMIs. Knowing more specifically which types of mayflies, for instance, are present will allow you to draw more conclusions about the stream. At the end of this lab is a table that summarizes the pollution tolerance values of specific types of organisms within these groups.
* After each organism is identified, record the type and tally it using the data sheets provided in this lab.
* Place each identified and tallied organism into one of the Petri dishes for the 12 general taxa.

You may wish to examine a helpful online BMI identification guide for our region before class

(<http://www.seanet.com/~leska/Online/Guide.html>).

**Calculating Indices of Stream Health based on the Data on Macroinvertebrates**

Once we have sorted the samples into distinct groups, we will calculate a series of indices, specifically chosen for use in this brief laboratory exercise. Many of these are taken from Murdoch and Cheo (1999). A more complete set of indices is presented for your general information in the appendix to this laboratory handout.

You should calculate the following indices for each of your group’s subsample and the two subsamples you sorted from Little Bear Creek (see Fig. 1):

**Total Taxa Richness**: Count the total number of taxa, as presented in the above list of 12 taxanomic groups (thus the taxa richness will vary from 0 to 12). The biodiversity (and richness) of a stream often declines as flow regimes are altered, habitat is lost, chemicals are introduced, energy cycles are disrupted, and alien taxa invade.

**Ephemeroptera (Mayfly) Density**: Asess the number (density) of mayflies in your samples. The diversity of mayfly taxa is a better indicator of disturbance than density but requires identification of mayflies to at least genus – a time-consuming procedure that we will not have time to complete for this lab. Instead you should simply count the number of mayflies in your sample. Mayfly diversity declines in response to many types of human influence. Many mayflies graze on algae and are particularly sensitive to chemical pollution that interferes with their food source. Mayflies may disappear when heavy metal concentrations are high while caddisflies and stoneflies are unaffected. In nutrient-poor streams, livestock feces and fertilizers from agriculture can increase the numbers and types of mayflies present. If many different taxa of mayflies are found while the variety of stoneflies and caddisflies is low, nutrient enrichment may be the cause.

**Plecoptera (Stonefly) Taxa Richness:** Asess the number (density) of stoneflies in your samples. Stoneflies are the first to disappear from a stream as human disturbance increases. Many stoneflies are predators that stalk their prey and hide around and between rocks. Hiding places between rocks are lost as sediment washes into a stream. Many stoneflies are shredders and feed on leaf litter that drops from an overhanging tree canopy. Most stoneflies, like salmonids, require cool water temperatures and high oxygen to complete their life cycles.

**Trichoptera (Caddisfly) Taxa Richness:** Asess the number (density) of caddisflies in your samples. As with mayflies, the diversity of caddisfly taxa is a better indicator of disturbance than density but requires identification of mayflies to at least genus – a time-consuming procedure that we will not have time to complete for this lab. Instead you should simply count the number of mayflies in your sample. Different caddisfly species (or taxa) feed in a variety of ways: some spin nets to trap food, others collect or scrape food on top of exposed rocks. Many caddisflies build gravel or wood cases to protect them from predators; others are predators themselves. Even though they are very diverse in habit, taxa richness of caddisflies declines steadily as humans eliminate the variety and complexity of their stream habitat.

**EPT / Midge Ratio:** This is the ratio of the individuals in two categories: (1) EPT = Mayflies + Stoneflies + Caddisflies; (2) Midges (family Chironomidae). In general, midges are more tolerant of pollution than EPTs. Thus, the higher the EPT/Midge ratio, the better the water quality. A community with a ratio below 0.75 is considered strongly disturbed.

**Taxa Composition and Dominanace:** Calculate the fractional composition (in %) of each taxa in the total BMI sample. This data will allow you to examine the relative dominance of each taxa in your sample. As a general rule, samples that are dominated by one or just a few taxa are not as indicative of as healthy a stream as samples that have a greater diversity of taxa.

**Family Biotic Index (FBI):** This index is a quantitative reflection of the pollution tolerance and relative abundance of different BMI families. Values of pollution tolerance are provided for common BMI taxa in the table attached to this lab handout. The FBI is calculated as:

(Tolerance value x number of individuals)

**Σ**

FBI =

Total number of individuals

In the numerator a separate value is calculated for each specific taxa (as shown in the attached tolerance value table). These values are summed for all taxa in your sample to provide the numerator value. Below is a table with an example calculation of a mini-sample.

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| --- | --- | --- | --- |
| **Taxa** | **Number of Individuals** | **Tolerance Value** | **Number x Tolerance Value** |
| Common stoneflies | 8 | 1 | 8 |
| Perlodid stoneflies | 12 | 2 | 24 |
| Armored mayflies | 14 | 3 | 42 |
| Primitive Minnow mayflies | 10 | 7 | 70 |
| Narrowwinged damselflies | 22 | 9 | 198 |
| Biting midges | 15 | 6 | 90 |
| **TOTAL (SUM)** | 81 |  | 432 |
|  |  |  |  |
| **FBI** | 432 / 81 = 5.3 |  |  |

A rough scale developed for interpreting the FBI is referenced in Murdoch and Cheo (1999):

0 – 4: Stream unimpacted

4 – 6: Stream slightly impacted

6 – 8: Stream moderately impacted

> 8: Stream severely impacted

**Sources**

Murdoch, T and M Cheo. 1999. Streamkeepers field guide. The Adopt-a-Stream Foundation.

**Other Resources**

There are some fabulous websites on this stuff these days, including our county and the Puget Sound Stream Benthos project websites:

<http://www.kingcounty.gov/environment/data-and-trends/monitoring-data/stream-bugs/links.aspx>

<http://www.pugetsoundstreambenthos.org/>

I recommend perusing these sites and getting more famliar with the topic, as well as sampling and interpretation issues.

**Products**

On May 25 you will be expected to give an oral (Powerpoint) presentation on BMI results. You may give a group or individual presentation, though group presentations are encouraged. Once I know how many presentations there will be I will assign the amount of time each presentation may have. In general, I expect each presentation will have 15-30 minutes. You are required to provide me with an electronic copy of your presentation for grading purposes.

The presentation should include (1) a brief introduction to the topic and purpose of the study; (2) a brief overview of the methods; (3) results; (4) discussion. Statistical analyses are not expected for this lab.

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| **Example Data Sheet (for 1 sample)** |  |  |  |
| **Taxa** | **Number of Individuals** | **Tolerance Value** | **Number x Tolerance Value** |
| **MAYFLIES** |  |  |  |
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| **STONEFLIES** |  |  |  |
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| **CADDISFLIES** |  |  |  |
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| **MIDGES** |  |  |  |
| **TRUE FLIES** |  |  |  |
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| **Example Data Sheet (cont.)** |  |  |  |
| **Taxa** | **Number of Individuals** | **Tolerance Value** | **Number x Tolerance Value** |
| **DOBSON-, ALDER-, and FISH FLIES** |  |  |  |
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| **BEETLES** |  |  |  |
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| **DRAGONFLIES AND DAMSELFLIES** |  |  |  |
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| **CRUSTACEANS** |  |  |  |
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| **SNAILS** |  |  |  |
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| **CLAMS, MUSSELS** |  |  |  |
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| **WORMS, LEECHES** |  |  |  |
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| **OTHER** |  |  |  |
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***From Murdoch and Cheo (1999)***

**Tolerance Index 1.tif**

**Tolerance Index 2.tif**

**APPENDIX**

**Calculating Indices of Stream Health based on the Data on Macroinvertebrates**

More complete analyses employing BMIs are used to calculate a multi-metric index known as the Benthic Index of Biotic Integrity (B-IBI). The metrics used in combination to derive the B-IBI are described below and in more detail for our region at: <http://pugetsoundstreambenthos.org/About-BIBI.aspx>. The concept of creating an IBI was developed by Jim Karr (who is now professor emeritis here at UW) in the early 1980s. He noted that ecological health was not always well reflected by chemical composition of streams, and felt that the organisms surviving within might better provide an integrated reflection of stream status. He worked to develop a multi-metric index that incorporated many of the individual health indices that were already being used. The concept has been thoroughly tested, and is used throughout the US, adapted to suit variations in the ecology of different regions (see: <http://www.epa.gov/bioindicators/html/invertebrate.html>).

There are ten metrics that are used in the Puget Sound Lowlands B-IBI, which draw from richness data for different taxa, and a calculation on community dominance and percent tolerant taxa. The ten metrics are as follows:

**Total Taxa Richness**: The biodiversity of a stream declines as flow regimes are altered, habitat is lost, chemicals are introduced, energy cycles are disrupted, and alien taxa invade. Total taxa richness includes all the different invertebrates collected from a stream site (list above).

**Ephemeroptera (Mayfly) Taxa Richness**: The diversity of mayflies declines in response to many types of human influence. Many mayflies graze on algae and are particularly sensitive to chemical pollution that interferes with their food source. Mayflies may disappear when heavy metal concentrations are high while caddisflies and stoneflies are unaffected. In nutrient-poor streams, livestock feces and fertilizers from agriculture can increase the numbers and types of mayflies present. If many different taxa of mayflies are found while the variety of stoneflies and caddisflies is low, nutrient enrichment may be the cause.

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**Intolerant Taxa Richness:** Animals identified as intolerant to the range of human impacts are the most sensitive taxa; they represent approximately 5-10% of the taxa present in the region. These animals are the first to disappear as human disturbance increases.

**Clinger Taxa Richness:** Taxa defined as clingers have physical adaptations that allow them to hold onto smooth substrates in fast water. These animals typically occupy the open area between rocks and cobble along the bottom of the stream. Thus they are particularly sensitive to fine sediments that fill these spaces and eliminate the variety and complexity of these small habitats. Clingers may use these areas to forage, escape from predators, or lay their eggs. Sediment also prevents clingers from moving down deeper into the stream bed of the channel.

**Long-Lived (Semi-Voltine) Taxa Richness:** These invertebrates require more than one year to complete their life cycles; thus, they are exposed to all the human activities that influence the stream throughout one or more years. If the stream is dry part of the year or subject to flooding, these animals may disappear. Loss of long-lived taxa may also indicate an on-going problem that repeatedly interrupts their life cycles.

**Percent Tolerant Taxa:** Tolerant animals are defined as those present at most stream sites, but as disturbance increases, they represent an increasingly large percentage of the assemblage. Invertebrates designated as tolerant represent the 5-10% most tolerant taxa in a region. In a sense, they occupy the opposite end of the spectrum from intolerant taxa.

**Percent Predator Taxa:** Predator taxa represent the peak of the food web and depend on a reliable source of other invertebrates that they can eat. Predators may have adaptations such as large eyes and long legs for hunting and catching other animals. The percentage of animals that are obligate predators provides a measure of the trophic complexity supported by a site. Less disturbed sites support a greater diversity of prey items and a variety of habitats in which to find them.

**Percent Dominance:** As diversity declines, a few taxa come to dominate the assemblage. Opportunistic species that are less particular about where they live replace species that require special foods or particular types of physical habitat. Dominance is calculated by adding the number of individuals in the three most abundant taxa and dividing by the total number individuals in the sample. The larger the resulting fraction, the more dominated an assemblage is.

Specifically, scores for each metric are given as 1 (very poor), 3 (fair), or 5 (excellent), and are accorded to the different richness or dominance scores as follows: <http://www.pugetsoundstreambenthos.org/BIBI-Scoring-Types.aspx> .

**Figure 1. Experimental design.**

**Results for 2 subsamples from Bear Creek**

**Results for 2 subsamples from North Creek north site**

**Results for 2 subsamples from Bear Creek**

**Results for 2 subsamples from North Creek south site**

**Data for oral presentation**

**Collecting BMI sample**

**Calculating BMI indices**

**Indices for Bear Creek subsample**

**Indices for North Creek north site subsample**

**Indices for Bear Creek subsample**

**Indices for North Creek north site subsample**

**Indices for Bear Creek subsample**

**Indices for North Creek south site subsample**

**Indices for North Creek south site subsample**

**Indices for Bear Creek subsample**

**STUDENT GROUP 2**

**Students 7 & 8**

**Students 5 & 6**

**Take 1 BMI subsample of North Creek north site**

**Take 1 BMI subsample of North Creek north site**

**Sorting & identifying BMIs**

**Sort Bear Creek subsample**

**Sort North Creek south site subsample**

**Sort Bear Creek subsample**

**Sort North Creek south site subsample**

**Students 3 & 4**

**Take 1 BMI subsample of North Creek south site**

**Sort Bear Creek subsample**

**Sort Bear Creek subsample**

**Sort North Creek south site subsample**

**Sort North Creek south site subsample**

**STUDENT GROUP 1**

**Students 1 & 2**

**Take 1 BMI subsample of North Creek south site**