ASSESSING ENVIRONMENTAL HEALTH USING MACROINVERTEBRATES: Sampling aquatic insects in local streams

OVERVIEW

The main objectives of this project are to:

• introduce you to one of many practical uses of biological diversity
• give you hands-on experience using a biological assessment tool
• encourage you to look carefully and critically at complex data to uncover a “big picture”
• give you more practice writing up research into a formal scientific paper
• give you practice putting your research into the context of a broader base of scientific knowledge

To facilitate the process of meeting these objectives, this project is broken down into a series of discrete but interconnected steps:

• Week 7: Coordination of Sampling
• Week 8: Part 1: Sampling; Draft of Introduction due (20 pts)
• Week 9: Part 2: Sorting samples in lab
• Week 10: Part 3: Data analysis workshop & finish sorting samples; Draft of Material & Methods due (20 pts)
• Week 11: on your own Data analysis
• Week 12: Draft of Results due (30 pts)
• Week 15: Final Paper due (80 pts)

So, let’s begin …

INTRODUCTION & BACKGROUND

Reading


• Additional Background Reading
  Monitoring stream health has become an important tool for assessing and tracking environmental health. Early assessments of stream health focused on concentrations of certain pollutants. These measures, though very useful, are often difficult and/or expensive to make, and do not provide a broad measure of stream health. For instance, streams might not harbor the specific pollutants assayed, but might still be lacking in life for other reasons.
  Different measures of biodiversity have been used to assess community and ecosystem health because organisms are great integrators of community health, especially when one can examine and quantify entire communities. An example of this type of monitoring is aquatic macroinvertebrate monitoring in streams and rivers. You have read the paper, Sustaining Living Rivers by Ellen Chu and Jim Karr that explains the rationale behind the B-IBI (benthic index of biological integrity) measure that we will be using later this semester when we look at our samples. In the excerpt from the journal Wings (11/96) below, Karr describes why benthic invertebrates are, in his opinion, the best monitoring tool for assessing watershed health.
Aquatic Invertebrates: Sentinels of Watershed Condition: by James R. Karr (11/96)

**Note: this is not a scientific article**

“An aquatic ecosystem is an interactive mosaic of environments, extending from headwater streams and wet meadows through mainstem rivers to the sea. Invertebrates and other living components of aquatic ecosystems tell us about the health of these landscapes.

Unfortunately, the laws governing water deny that our basic biological heritage has any relevance to societal needs. This denial, and resource degradation resulting from it, continues even though the Clean Water Act specifically mandates efforts to "restore and maintain the biological integrity of the nation's waters." In the arid West, water is allocated on a first-come, first-served basis. Nationwide, the Clean Water Act is implemented as though crystal-clear distilled water running down concrete conduits were the ultimate goal.

Two hundred years of treating water like a commodity rather than a community has led to serious ecological decline. Human activity affects five attributes of watersheds and streams--water quality, habitat structure, stream flow patterns, sources of energy and nutrients, and biotic interactions. To protect the biota of streams, we must plan for these five factors in a comprehensive way. In the Pacific Northwest, we have contributed to the decline of Northwest salmon populations by degrading water quality with chemical pollutants; altering habitat structure by removing woody debris or destroying pools; disrupting flow patterns with dams; removing organic material from the riparian corridor; and changing relationships among species by overharvesting for sport or commerce, or by introducing exotic species.

Living systems provide the most direct and effective measure of the condition of watersheds and water bodies, as well as information critical to charting a course for federal and state programs to protect both the economic and ecological interests of society. Yet despite the efficacy of biological monitoring, chemical monitoring dominates water resource programs.

Biological monitoring detects changes in species composition, including the identity and number of species present; changes in ecological processes, such as nutrient dynamics and energy flow through food webs; and health of individuals, which is likely to influence species survival and reproductive rates. Water use and watershed alteration inevitably has unanticipated effects; in contrast to chemical monitoring, biological monitoring enables managers to detect change sooner, rather than later.

Biological evaluations can be used to diagnose and identify chemical, physical, and biological impacts as well as their cumulative effects; they can serve many kinds of environmental and regulatory programs when integrated with chemical and toxicity testing; and they are cost effective. Furthermore, because living systems respond to all impacts of human activity, they are less likely than chemical measures to underprotect water resources. When combined with strictly chemical assessments of water resources, assessments using biological criteria typically find double the proportion of stream miles that violate water quality standards.

Fish and benthic (bottom-dwelling) invertebrates are particularly effective indicators of the condition of waterways and watersheds. Invertebrates are abundant and easily sampled, and the species living in virtually any water body represent a diversity of morphological, ecological, and behavioral adaptations to their natural habitat. As humans alter watersheds, changes in the benthic invertebrate fauna signal the consequences of our actions.

The ecological integrity of water bodies rests on the well being of all their biological components, not just the size of commercially important populations. Failing to protect phytoplankton, zooplankton, insects, plants, bacteria, or fungi ignores the key contributions of these groups to healthy biotic communities. The ability of a water body to support healthy living systems directly determines its ability to support human goals. No species, including those important to humans, can persist outside the biological context that sustains it.

Past water policy has ignored these biological realities to the detriment of water resources and human society. Policy that is refocused on protecting the biological integrity of waterways would offer a means for real protection of these resources. Let us adopt a broader concept of water; forge partnerships among scientists, policymakers, resource managers, and other citizens; revise the fragmented legal framework guiding water resource policy; redouble our efforts to protect existing waters, and restore those that are degraded. Programs to protect aquatic resources should be broadly conceived and explicitly biological.

Chemically clean waterways are good; living waterways are better.”
We will be sampling macroinvertebrates from 3 local streams during week 8 of the course.

a) **Hylebos Creek** is an urban stream, which runs through southern King and northern Pierce County and drains into Commencement Bay. Much of it is surrounded by development and pavement (it runs through Federal Way, Milton and Fife). It used to be one of the best salmon streams in the region. Remarkably, salmon still return to Hylebos Creek, albeit in much smaller numbers than historically.

Over the past few years a citizen’s group, The Friends of the Hylebos, has dedicated itself to the task of restoring the Hylebos to some semblance of its former self. They are doing restoration work and monitoring along the length of the watershed (replanting and stabilizing streamside habitat, replacing culverts, buying land for riparian buffers). Volunteer teams have collected B-IBI data on the stream for the past few years. We are joining this effort by collecting macroinvertebrate data from one locality. Friends of the Hylebos is interested in seeing whether their efforts improve B-IBI and if the B-IBI is correlated with the number of salmon returning to the stream. An example of the data they previously collected can be found on their web site: [http://www.hylebos.org](http://www.hylebos.org). Go to the *State of the Hylebos* report. If you are interested in volunteering for the organization you can call them at (253) 929-1519.

b) **Swan Creek** is in east Tacoma and runs into the Puyallup River. It is the largest of the three streams and currently supports the largest salmon population. Information on the restoration efforts can be found at [http://www.darp.noaa.gov/northwest/cbay/swan.html](http://www.darp.noaa.gov/northwest/cbay/swan.html).

c) Mason Creek is being restored by the Puget Creek Restoration Society. At one time, it had a small salmon run of mostly chum and silver salmon but currently does not have salmon. However, salmon have begun returning to nearby Puget Creek in small numbers.

**PRE-LAB**
(DUE IN LAB WEEK 8)

*Definitions: Please define the following terms in writing (If you obtain your information from sources other than Campbell or lecture, please cite your sources)*

- benthic
- biota & biotic
- riparian
- fauna
- watershed
- macroinvertebrate

*Perspective: Please briefly answer these questions in writing (Please cite sources)*

- What exactly is the Clean Water Act? When was it put in place? What level of government created it?
- What exactly is the Benthic index of biological integrity (B-IBI)?
- Swan Creek, Mason Creek, and Hybelos Creek are all currently undergoing restoration efforts. Where are Swan Creek, Mason Creek, and Hybelos Creek? Look up additional background information on these creeks on the Web (no need write anything).
**PART 1: SAMPLING**

**IMPORTANT:** Sampling from streams can get VERY WET and VERY COLD and we will have to go out regardless of the weather. Dress in warm clothes (layers) that you don’t mind getting wet and dirty ... this includes shoes since you must stand in the stream to take samples. Rubber boots are highly recommended.

**Rationale:**

Biological assessment is an integral part of water quality monitoring. The use of biota, particularly macroinvertebrates, for assessing the health of a stream has numerous advantages over conventional water chemistry measurements. Macroinvertebrate species vary widely in their tolerances to stressors. They are relatively long-lived, thus are sensitive to both short- and long-term pollution. Episodic, acute pollution events are likely to go undetected by water chemistry surveys. These types of intermittent events, however, are often reflected by macroinvertebrate assemblages tolerant of stress. Aquatic organisms integrate habitat and chemical disturbance over time, thus providing a useful measure of ecosystem health.

The advantages of using macroinvertebrates as indicators of water quality include:
- They are easy and inexpensive to collect.
- They do not migrate or move large distances.
- They inhabit every type of aquatic environment.
- Because their life cycles require one year or more to complete, their populations can detect short-term as well as long-term disturbances.

The major disadvantage is that different types of invertebrates can be difficult to identify precisely. However, some indication of stream health can be derived from analyses at the level of macroinvertebrate family or order. Finally, aquatic communities are more tangible and easier to communicate to the public than water chemistry. Plus, there are some very cool bugs to see.

The purpose of this lab exercise is to familiarize you with a common method used to collect macroinvertebrates and introduce you to the taxa that you would expect to find in most streams in our region. We will model our procedure after those established by the Washington Department of Ecology (WA DOE) as part of the Freshwater Ambient Biological Assessment Program. This week, we will work in teams to collect and preserve macroinvertebrates at 4 sites (one per group) at a local stream. Next week (and later on your own), we will take a closer look at these organisms in lab, examine what we can about their biology from their structure, and sort them into taxonomic groups. Once we have them separated into groups, we will use several measures of biotic integrity to assess the health of our streams.

**Objectives:**
- Examine an urban stream and think about watershed health
- Collect samples for measuring B-IBI later in the semester
- Practice following a field sampling protocol
- Examine the diversity of aquatic invertebrates and get outside

**Products of Part 1:**

**Due at end of lab:**
- Sample jar containing invertebrates in alcohol
- Site description

**Materials needed per group:**

<table>
<thead>
<tr>
<th>Surber sampler</th>
<th>50m tape measure</th>
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<tbody>
<tr>
<td>sorting pan</td>
<td>meter stick</td>
</tr>
<tr>
<td>rinsing cup or squirt bottle</td>
<td>bobber/corks</td>
</tr>
<tr>
<td>ethanol</td>
<td>stopwatch</td>
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<tr>
<td>forceps</td>
<td>thermometer</td>
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<tr>
<td>pencil and sharpie pen</td>
<td>magnifying glass</td>
</tr>
<tr>
<td>labeling tape</td>
<td>towel</td>
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</tbody>
</table>
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Procedures:
Samples will be collected in riffle habitats. Riffles are typically rocky, shallow areas with medium to fast currents. The water surface is typically rough and broken. We want to try to standardize habitats among our collections. At each selected site, each team should describe the site qualitatively, measure stream characteristics, and collect a Surber sample. Washington Department of Ecology samples four riffles within an approximately 150 m stretch (reach) to characterize a stream.

Each group should
1. Survey the habitat – What is the surrounding vegetation? How much cover is there over the stream (estimate what percentage of the overhead view is vegetation as opposed to blue sky)? What is the width of the stream at your riffle? What is the substrate in the stream? How large are the pebbles or rocks? Do a stream profile by placing your tape perpendicularly across the stream and measuring the stream depth in 4 equally spaced intervals across the stream.
2. Assess the surface water quality – Do a qualitative assessment of water clarity (turbidity) and measure temperature at your site
3. Measure the rate of streamflow – Using your tape measure and a stopwatch use a small cork and measure how long it takes the cork to travel a meter through your riffle. Repeat 3 or more times and take the average. Units of slow should be in meters/second.

After you have completed your habitat survey and measured water quality and streamflow each group can collect their insect sample with the Surber sampler.

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Below are instructions for using the Surber sampler
(Modified from Mary Ball, for the Association for Biology Laboratory Education website at http://www.zoo.utoronto.ca/able/volumes/vol-12/5-ball/5-ball.htm.)

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Using a Surber Stream-bottom Sampler (After Brewer and McCann, 1982)
In General: Work as a team. Apportion tasks to be efficient, but also to be sure that everyone is involved. Before starting, everyone should read the instructions carefully. You might have a couple of people at the Surber, someone at the trays, and somebody taking notes.

1. Select a riffle deeper than the frame of the Surber sampler (just a bit of the net has to be in the water).
2. Wade to the site from downstream (avoid disturbing upstream of where you are sampling)
3. Position the sampler firmly on the bottom with the mouth facing upstream.
4. Pick up all rocks from within the frame and pass them to shore, where two or more persons are to gently dislodge and remove insects for collection using the scrubber or forceps.
5. Stir up the substrate in the framed area with a trowel for 2 minutes and try to get 4 – 6 inches deep. Float organisms into the net.
6. Remove the Surber sampler from the stream. Carefully and thoroughly inspect the net, rinsing the net and working all organisms down into the collecting end, (or pick them off into the sample trays). Use your fingers, forceps, rinse bottles, or whatever works, to make sure you get all the organisms.
7. Pour the sample into a plastic beaker. Pour the organisms on top into the white collecting tub (the pebbles sand and silt will be on the bottom). Add more water to the beaker and pour it into the other beaker. Again, pour off organisms into the tub. Repeat this pouring back and forth (like panning for gold) until you have all the organisms from your sample.
8. Replace the rocks into the sampled area of the streambed.
9. Write a description of your site. Describe the substrate within the Surber frame, the approximate depth, and any general observations about the area that you think may be relevant such as size of the rocks.
10. use a “Sharpie” to write a label with:
   Location, including location of your group relative to other groups, Date of collection, and the initials of all the individuals in your group.
   Put it on a jar and transfer your sample with as little water as possible into the jar with 95% ethanol.
11. Once you’re finished, return to the van with all equipment. Check to make sure nothing is left behind. Once we return to the lab each team should hand in:
   ✓ All equipment used.
   ✓ Their jar containing invertebrates and labels (in alcohol)
   ✓ A copy of the site description. Indicate the date and group number on your site descriptions. Include all members’ names of your group.

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DRAFTS OF
INTRODUCTION (DUE WEEK 8 IN LAB)
&
MATERIAL & METHODS (DUE WEEK 10 IN LAB)

Introduction:
• The Introduction should focus on the QUESTION that you are addressing, not on the METHOD (i.e., the I-BIB) that you are using to address your question.
• You need to incorporate outside sources into your introduction as a way to justify the importance of your study. To get the most useful feedback from this draft, I suggest that you find (and read!) all or your outside sources by week 7 so that you can effectively incorporate them into this draft.
• The minimum requirement for outside sources is:
  ✓ 1 primary journal article (you may use Morley and Karr 2002)
  ✓ 1 other primary journal article (either a review paper or a data paper)
  ✓ 1 book
  ✓ 1 credible web page (ending in either .gov or .edu)

Note: the excerpt from the Wings article will not count toward these minimum sources, since it is not a scientific article.

Material & Methods:
• A common mistake in Materials and Methods is to list all the materials. Include the important elements (those that are critical for replicating your study) in paragraph form. See the example provided in Knisely.
• IMPORTANT: In your paper, you will be combining data from all lab groups for all three streams. Thus, you will want to write the Material & Methods section so that it applies to all sites even though you only collected from one site. This is an instance where it is appropriate and correct to use the passive voice.
• Examples of elements that ARE NOT critical for replicating your study include: the names or numbers of people who helped you collect the sample; how you got to the collecting site; the fact that you used tape to label your sample jars; etc.).
• Examples of elements that ARE critical for replicating your study include: the date and times the samples were collected; how and how long the sediment was stirred up; how the collecting sites were chosen; what streams were sampled & where they are located; etc.)
• The M&M section should describe the sampling procedure, how the macroinvertebrates were identified, and how the data were analyzed. This means that you must describe both field sampling and lab sorting. Make sure that you cite the keys that you use in the lab.

General Guidelines:
• Use your writing handbook (Knisely) for a complete list of things you need to consider when writing this report. For each of the sections use Knisely as your guide. Check your draft to make sure that it conforms to Knisely’s suggestions. Look at her sample lab report. The only place where I differ with Knisely is her suggestion that passive voice is better than active voice in some situations. Use active voice whenever possible, but ultimately to make the prose more readable, you will end up using a mix of active and passive voice.
• Remember that scientific papers differ in content, tone, and type of evidence from papers in many other disciplines. Knisely has some excellent advice on both content and style. You can also discuss these topics with your TA or with me. Remember to be precise and concise with your wording! I want everyone to do well on this project and strongly encourage you to take advantage of the plethora of writing resources available to you on campus.

Format:
• Drafts must be word-processed
• 12-point font
• normal margins
• double spaced (it’s easier for me to comment)
• No cover page (this looks nice but it wastes paper)
• Stapled (pages are easily lost if it is not stapled)