Macroinvertebrate Discovery

Purpose

To determine the diversity of benthic (bottom dwelling) macroinvertebrates at your Hydrology Study Site and to investigate the correlations between macroinvertebrates and water chemistry measurements.

Overview

Students will establish a diversity index for benthic macroinvertebrates by sorting and counting organisms collected from the site, and in the process become familiar with many taxa of macroinvertebrates. They will then investigate the relationship between the taxa they found and their water chemistry measurements.

Time

One class period to do the practice exercise

One class period to collect sample and one class period to do the counts and calculate the index

Level

All

Key Concepts

- Species diversity is related to water chemistry
- Species have different habitat requirements
- Random sampling can be used to determine species diversity

Skills

- *Calculating* a diversity index
- *Performing* a random sample
- *Building* tools
- *Identifying* taxa
- *Discovering* species habitat parameters
- *Taking* water chemistry measurements

Materials and Tools

For Practice Activity

- Shallow, white tray or pan (such as a styrofoam meat tray) - about 60 X 40 cm
- Black marker
- Ruler
- Small candies, cake decoration confetti, or other items of varying colors or shapes to sample
- Macroinvertebrate Work Sheet
- Ice cube tray for sorting taxa
- Small pieces of paper numbered from 1-50 for drawing random numbers

For Field Activity

- Sorting and sampling kit (3 sets needed)
  - Shallow white pan for sorting, about 30 x 20 cm
  - Shallow white tray for counting, about 60 x 40 cm
  - Black permanent marker
  - Ice cube tray for sorting taxa
  - 10-20 mL bulb basting syringe (end should be approximately 5 mm diameter)
  - Large plastic forceps
- Magnifying glass
- 3 mL Pasteur pipette (eye dropper) (end should be approximately 2 mm diameter)
- 4-L sample container with lid (or 4 1-L containers)
- Set of numbered tiles or paper
- Bucket for pouring water through net
- Additional containers with lids if macroinvertebrates are to be brought back to the classroom
- Macroinvertebrate Work Sheet

And either:
kick screen (for running water, rocky bottom sites)
91 x 122 cm nylon screen(2 mm mesh size)
2 poles (122 cm long, 1-2 cm dia)
staples
2 pieces of denim or other heavy fabric (8 x 122 cm each)
needle and thread or heavy waterproof tape
or
D-net (for muddy bottom, still water)
2 pieces of nylon window screen (36 x 53 cm)
3 wire coat hangers
Heavy denim or fabric (8 x 91 cm)
Needle and thread or heavy waterproof tape
152 cm pole (e.g. broom or rake handle)
4 cm pipe clamp

Preparation

Make or buy appropriate net.

Copy Macroinvertebrate Work Sheets.

Collect materials for Sampling Kits.

Collect pictures or books illustrating local macroinvertebrates.

Prerequisites

Students should begin collecting GLOBE water chemistry data.

Background

Benthic macroinvertebrates are small, spineless animals that can be seen without a microscope, generally larger than one mm, which live in the mud or gravel in the bottom of water bodies. These include many larva of insects such as mosquitoes, dragonflies and caddisflies which begin their lives in the water then become land-dwelling insects when they mature. Other examples of common benthic macroinvertebrates include crustaceans such as crayfish, snails, and worms and leeches. These creatures populate the mud or gravel at the bottom of ponds or streams in amazing numbers - often thousands in a square meter. They are often an important part of the food chain.

Macroinvertebrates can tell us a lot about the conditions within a water body. Many macroinvertebrates are sensitive to changes in pH, dissolved oxygen, temperature, salinity, and other habitat parameters. A particular organism requires a consistent water quality to live its full life span.

For the *Macroinvertebrate Discovery* activity we want to establish a diversity index for your hydrology site. Biological diversity is a measure of the number of different kinds of organisms in an ecosystem. It is not a measure of the total number of organisms in the system. For example, you might have an equal number of organisms in a stream with low pH as in a stream with a more neutral pH. But because some types (taxa) of macroinvertebrates would not survive in the low pH stream, the diversity, or total number of different taxa, would be less. You might simply have a larger number of the organisms within each of the taxa which were tolerant of low pH.

What to Do and How to Do It

There are a number of good resources for identifying and researching macroinvertebrates. You will find some of these listed at the end of this activity.

1. Have students investigate the conditions under which different macroinvertebrates live. They may use their own observations, outside references, or the tables at the end of this investigation.
2. Have students form hypotheses on what macroinvertebrates they may find at their water site during the current season. Have them record their research, hypotheses and justification in their GLOBE Science Notebooks. They may want to sketch some of the common macroinvertebrates in their notebooks with notes on identification for field reference.

Calculating the Diversity of Macroinvertebrates in the Field

Preparation

Gather materials for sampling and doing the diversity index. If necessary, make a sampling net using the instructions given at the end of this activity. Note: There are two methods to collect your macroinvertebrate sample, depending upon your water site. If you have a rocky/gravel substrate with a current then you should use a Kick Screen. If you have a site with a muddy bottom with virtually no current then you should use a D-Frame net.

Students should do the Practicing the Diversity Index Activity at the end of this activity before they go into the field. This will give them practice in going through the exercise and help them to understand the concept of random sampling.

Collecting Your Sample

Collect the water chemistry measurements for your site. Note: Be sure the water is safe to enter and follow appropriate safety procedures with the students in the water.

Using a kick screen to collect sample:

1. Divide class into groups of 3-4 students and give each group a pail, net, and sampling kit.
2. Have each group identify a sample site. Sites should be within a few meters of each other, but represent different regions of the stream; for example a weedy area and a rocky area.
3. Beginning with the group farthest downstream, have one or two people from each group use either their feet and hands or a stick to disturb the bottom material, while 2 people hold the net 1-2 m downstream from the disturbance. The kicking or stirring should last for at least a minute. Also overturn and scrape the undersides of rocks. For safety reasons, if the area of collection is deeper than one-half meter, do not stand in the water.
4. Lift the net from the water by moving the bottom of the net forward along the bottom of the stream in a scooping motion so that nothing escapes from the net. Using 100-200 mL of water from the site, rinse material from the net into the sorting pan.
5. Have two people from each group pick out organisms using basting syringe or forceps and put them into containers filled with sample water.
6. Repeat steps 3-5 for each student group in order to collect a representative sample. Note: If sample area is shallow enough, try to get samples from all the way across the area.

Using a D-frame net to collect sample:

1. Divide class into groups of 3-4 students and give each group a pail, net, and sampling kit.
2. Have each group identify a sample site. Sites should be within a few meters of each other, but represent different regions of the stream; for example a weedy area and a rocky area.
3. Have the first group put the net into the water until it reaches the bottom substrate. Use the net to disturb the substrate for about 30 cm. Glide the net across the bottom of the disturbed area for about 30 cm and then bring it back up to the surface.
4. Pull the net out of the water so that nothing falls out. Using 100-200 mL or water from the site, rinse material from the net into the sorting pan.
5. Have two people from each group pick out organisms using basting syringe or forceps and put them into containers filled with sample water.
6. Repeat steps 3-5 for each student group in order to collect a representative sample. Note: If sample area is shallow enough, try to get samples from all the way across the area.

Calculating the Diversity Index:

1. Draw a grid on your counting tray of 4 cm squares.
2. Number the squares consecutively.
3. Pour your sample onto the tray more or less equally distributed across the grid in about 1 mm of water.
4 Have one student draw a number.
5. Have another student find that number on the grid and remove one organism using the Pasteur pipette or forceps. Place this organism (organism 1) in a bowl with water. Note: if there is nothing in the square drawn, draw another number.
6. Put an X on your Work Sheet to represent organism 1.
7. Pick organism 2 from the same square, or if there is nothing else in that square draw another number and sample from the new square.
8. Place organism 2 next to organism 1 in the bowl.
9. If organism 2 is the same as organism 1, put an X on the Work Sheet. If organism 2 is different from organism 1, put an O on the Work Sheet.
10. Put organism 1 into one compartment of the ice cube tray or taxa bowls.
11. Pick organism 3 from the same square, or draw a new square if needed.
12. Place organism 3 next to organism 2.
13. If organism 3 is the same as organism 2, put down the same mark on the Work Sheet as you used for organism 2 (X or O). If organism 3 is different from organism 2, put the opposite mark.
14. Place organism 2 into the ice cube tray. If it is the same as organism 1, put it with organism 1. If it is different, put it into a new compartment.
15. Continue to draw random numbers and take samples, recording each sample as X or O, then sorting the taxa into compartments until 50 samples are taken.
16. Count the number of 'runs' on your Work Sheet (see example below) and record.
17. Divide the number of runs by the number of organisms counted (50) and record the number on your Work Sheet.
18. Count the number of different taxa in your sample and record.
19. Multiply the two numbers, and record. This is the diversity index.
20. Have students try and identify as many taxa as possible.

Work Sheet Example:

X X O O O X O O X

1——2———3 4——5

In this particular example, there are 5 runs

Further Investigations

1. Students should identify as many macroinvertebrates as possible from their sample.
2. Compare their hypotheses with the actual taxa they identified.
3. Formulate hypotheses on what conditions may cause certain taxa to exist unexpectedly, or why some common taxa may be missing.
4. Use the GLOBE data server to find schools with a hydrology study site similar to your own. Begin by searching for schools within your watershed or at the same latitude and elevation with similar pH, temperature, dissolved oxygen and salinity levels.
5. Use GLOBEMail to contact these schools and ask about the macroinvertebrates they are finding.

Habitat Parameters for Selected Macroinvertebrates

*pH Range for Selected Macroinvertebrates**

TAXA	1	2	3	4	5	6	7	8	9	10	11	12	13	14
mayfly							XXXX							
stonefly							XXXX							
caddisfly							XXXX							
snails							XXXXXXXXX							
clams							XXXXXXXXX							
mussels							XXXXXXXXX							

* pH ranges 1-6 and 10-14 are unsuitable for most organisms

Temperature Range for Selected Macroinvertebrates

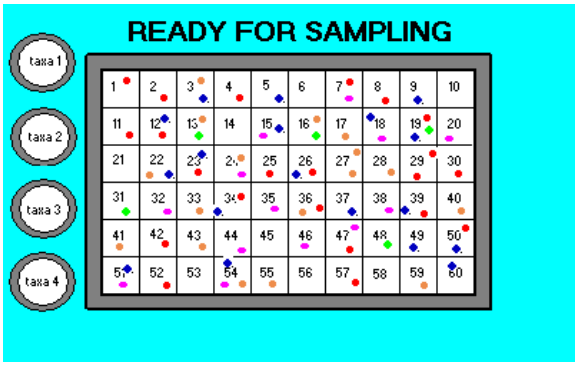
TAXA	Cold Range < 12.8° C	Middle Range 12.8-20° C	Warm Range > 20° C
caddisfly	x	x	x
stonefly	x	x	
mayfly	x	x	
water pennies	x		
water beetles		x	
water striders		x	
dragonfly		x	x

Minimum Dissolved Oxygen Levels for Selected Macroinvertebrates

TAXA	High Range 8 - 10 ppm	Medium Range 4 - 8 ppm	Low Range 0 - 4 ppm
stonefly	X		
water penny	X		
caddisfly	X	X	
some mayflies	X	X	
dragonfly		X	
true bugs		X	
damselfly		X	
mosquito			X
midge			X
tubiflex worm			X
pouch/lung snails			X
rat-tailed maggot			X

Practicing the Diversity Index Activity

1. Draw a grid on your tray of 4 cm squares.
2. Number the squares consecutively.
3. Scatter your sample onto the tray more or less equally distributed across the grid.
4. Have one student draw a number.
5. Have another student find that number on the grid and remove one piece. Place this piece (Sample 1) on the table. If there is nothing in the square, draw another number.
6. Put an X on your Work Sheet to represent Sample 1.
7. Pick Sample 2 from the same square, or if there is nothing else in that square draw another number and sample from the new square.
8. Place Sample 2 next to Sample 1 on the table.
9. If Sample 2 is the same as Sample 1, put an X on the Work Sheet. If Sample 2 is different from Sample 1, put an 0 on the Work Sheet.
10. Put Sample 1 into one of the taxa bowls or cube compartments.
11. Pick Sample 3 from the same square, or draw a new square if needed.
12. Place Sample 3 next to Sample 2.
13. If Sample 3 is the same as Sample 2, put down the same mark on the Work Sheet as you used for Sample 2 (X or 0). If Sample 3 is different from Sample 2, put the opposite mark.
14. Place Sample 2 into a taxa bowl. If it is the same as Sample 1, put it with Sample 1. If it is different, put it into a new taxa bowl.
15. Continue to draw random numbers and take samples, recording each sample as X or 0, then sorting the taxa into bowls until 50 samples are taken.
16. Count the number of 'runs' on your Work Sheet. (See example below.)
17. Divide the number of runs by 50 (your sample number).
18. Multiply this number by the number of different taxa. This is your diversity index.



Further Practice

Have students calculate a Diversity Index using fewer number of taxa or a different distribution of numbers within the taxa. Compare the results.

Work Sheet Example

Record— XX 0 0 0 X 0 0 X

Sample # 1 2 3 4 5 6 7 8 9
Run 1—2——-3 4—5

The example above shows that Sample 1 and 2 were alike. Sample 3 was different from 2. Samples 4 and 5 were like Sample 3. Sample 6 was different from Sample 5, etc. There are 5 runs.

Resources for Research on Freshwater Benthic Macroinvertebrates:

Caduto, M.J. (1990).*Pond and Brook: A Guide to Nature Study in Freshwater Environments*. 2nd ed. Prentice-Hall, NJ.

Cromwell, Mare et al. (1992) I*nvestigating Streams and Rivers.* GREEN, University of Michigan, Ann Arbor.

Maitland, Peter S. (1990). *Biology of Fresh Waters.* Blackie, Glasgow and London.

Merrit, R.E. and K.W. Cummins (1988). *An Introduction to the Aquatic Insects of North America.* Kendall-Hunt Publishing Co., Dubuque, Iowa.

Mitchell, Mark K. and Stapp, William B. (1996). *Field Manual for Water Quality Monitering,* Ann Arbor, Michigan 48104.

McCafferty, P.W. (1981). *Aquaticentomology: The Fishermen's and Ecologist's Guide to Insects and Their Relatives*. Jones and Barlett Publishers, Inc. California.

Needham, James G (1962). *A Guide to the Study of Fresh-Water Biology.* Holden-Day, Inc. San Francisco.

Pennok, Robert. (1973). *Freshwater Invertebrates of the United States.* Ronald Press, NY.

River Watch Network, 153 State St., Montpelier, Vermont 05602.

Save Our Streams, The Izaak Walton League of America, 1800 North Kent Street, Suite 806, Arlington, Virginia 22209.

Video (17 min): *Identification of the Benthic Macroinvertebrates;* Edward A Deschuytner, Northern Essex Community College, Elliott Way, Haverhill, MA 01830-2399.

Instructions for Making Macroinvertebrate Nets

Making the Kick Screen

1. Fold one 8 x 122 cm strip of fabric over one of the long screen edges and sew, reinforcing the edge.
2. Repeat for the other long edge.
3. Attach screen to poles with staples, making the poles even with the bottom of the screen and extending to form handles at the top.
4. Wrap screen around poles several times and staple again to reinforce the edges.

Making the D Net

1. Cut a net shape from the two 36 x 53 cm pieces of nylon screen (see diagrams) and sew them together.
2. Edge the open end of the net with heavy fabric, leaving an opening to form a casing to insert the hanger.
3. Cut hooks from hangers and untwist the wires.
4. Use duct tape to tape the hangers together to make your frame heavier.
5. Insert a wire through the casing and twist ends back together at opening.
6. Drill a hole in the tip of the wooden handle large enough to insert the ends of the hangers. Insert the ends of the hangers into the hole in the pole. Secure the net to the pole by using the hook you cut from the hanger and using the pipe clamp or duct tape to secure the hook to the pole.

Figure HYD-L-14: Making the Kick Screen

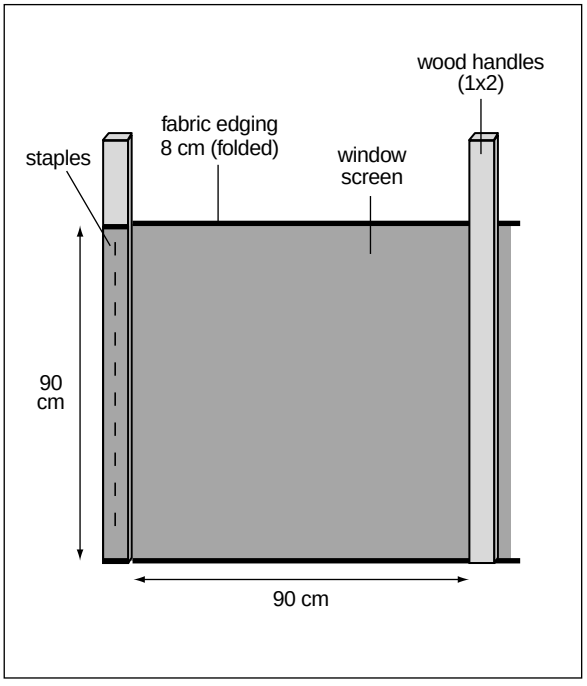
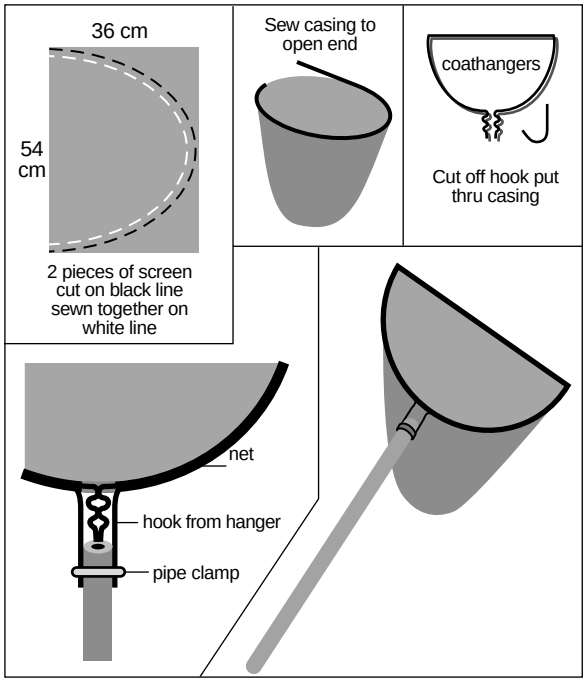


Figure HYD-L-15: Making the D Net



Hydrology Investigation

Macroinvertebrate Activity Work Sheet

Station name:_____

GPS coordinates: Latitude: _____ Longitude: _____

Collector's name(s): _____

Sample Collection: Sample #: _____ Date: _____ Time (UT): _____

Analyst's name(s): _____

Analysis (calculation of diversity index): Date: _____ Time (UT): _____

Collecting Method: _____ D net _____ Kick Screen

Calculation of # of runs:

Grid Number

X or 0

Grid Number

X or 0

Total # of Runs _____

Total # of Runs / # Sampled (50) = _____ (Run Index)

Total # of taxa: _____

(Run Index) x (Total # of Taxa) = _____ (Diversity Index)

Check Type of Macroinvertebrates Found, if known

Caddisfly (Trichoptera)	Stonefly (Plecoptera)
Mayfly (Ephemeroptera)	True Bugs (Hemiptera)
Worms & Leaches	Snails
Dragonfly/Damselfly (Odonata)	Dobsonfly, Fishfly, Alderfly (Megaloptera)
Beetles (Coleoptera)	Blackfly, Midge, Crane fly, Mosquito (Diptera)
Mites (Arachnids)	Crustaceans (e.g. Sowbug, Scud)

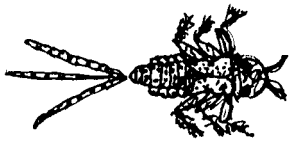
Notes: (water depth, recent rain, rocky, weedy, etc.)

Examples of Macroinvertebrates

1. dragonfly nymph

2. damselfly nymph

3. mayfly nymph



4. stonefly nymph

5. caddisfly larva

6. whirligig beetle larva

7. aquatic sowbug

8. blackfly larva

9. dobsonfly larva

10. midge larvae

11. crane fly larvae

12. water penny beetle larva

13. mosquito

14. scud