



Estimating Water Quality by Macroinvertebrate Sampling

Grade Level(s): 9-12

Author(s): Tulpehaking Nature Center

Course(s) and School(s)/School District: Abbott Marshlands

Overview/Summary:

Review how populations of aquatic organisms may change in response to organic pollution entering clean water. Introduce sampling techniques for determining the kinds and quantity of aquatic organisms. Form small sampling groups and have each group gather the equipment they will need on the field trip. On the field trip, students sample, identify and categorize the organisms found in the water. They then calculate the water quality rating using the weighting scale. The groups compare their results. Students make a map and graph of water quality differences in the areas sampled.

Standards/CPIs and 21st Century Themes:

HS LS2-2 Use mathematical representations to support explanations based on evidence about factors affecting biodiversity and populations in ecosystems.

HS LS2-6 Evaluate the evidence that complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

HS LS2-7 Design, evaluate and refine a solution for reducing impacts of human activities on the environment and biodiversity.

LS2-A Interdependent Relationships in Ecosystems

LS2-C Ecosystem Dynamics, functioning and Resilience

LS4-D Biodiversity and Humans

Interdisciplinary Connections and Technology Integration:

- Analyzing and interpreting data.
- Using mathematics and computational thinking.
- Engaging in argument from evidence.

Essential Questions:

- How can populations of aquatic organisms indicate water quality?
- What is a valid procedure for carrying out a biosurvey of aquatic organisms?
- How are captured aquatic organisms identified and grouped?

Enduring Understandings:

- Some aquatic organisms are sensitive to pollution while others are not.
- High species diversity usually indicates clean water.
- High populations of organisms not sensitive to pollution and low populations of sensitive organisms may indicate organic pollution.

Student Learning Outcomes:

Students will ...

- Use a variety of sampling methods to capture organisms in the variety of habitats found in the lake.
- Use a key to identify the taxa of the aquatic organisms and sort them into three categories.
- Calculate the water quality index based on the sensitivity category of the organisms.

Teaching and Learning Activities (Including Differentiation Strategies) with Timeline:

The Abbott Marshlands is a preserve of diverse aquatic habitats including lake, stream, and freshwater tidal marsh. Sampling sites for sampling around Spring Lake are abundant and the lake can be compared to samples from the nearby marsh.

Lesson 1- PRETRIP

1. Review possible sources of organic pollution in water. What would be the effect of the pollution on the populations of invertebrates in the water? What would be some kinds of invertebrates in the water? If the invertebrates are large enough to see with the naked eye, they are called macroinvertebrates.
2. Some invertebrates are very tolerant of organic pollution and some are very sensitive to the pollution and will either move out of the polluted area or die. Some can tolerate medium levels of pollution. How could determining the populations of these categories of organisms be used to find the water quality?
3. Review the sampling methods that will be used on the field trip. Have students review images of macroinvertebrates via internet or identification key. Divide the class into small groups and have each group gather equipment needed for the trip.

Lesson 2 -Sampling for Macroinvertebrates:

1. Assign the student groups to sampling sites around Spring Lake. Students should record a description of their site before starting to sample.
2. Students collect macroinvertebrates, sort them into 3 categories, identify and count the organisms. After the data are recorded, the invertebrates should be returned to the lake.

Lesson 3- Calculation and Interpretation:

1. Using the weight system, students calculate and score the water quality.
2. Groups share their site locations and graph the results.
3. Discussion. What is the overall water quality of the lake? Are there any areas where there is a marked decrease in quality? What might cause this?

ent and Assessment Strategies (Formative and Summative), Activities, and Rubrics:

group will prepare a short report detailing a description of the sampling sites, procedure used for sampling, and the group's data, and calculations. The report include a comparison of results of the water quality calculations to other groups ferent sites.

group will speculate on the causes of differences in the class findings and ble activities that would improve water quality in the areas tested.

Rubric

	4	3	2	1
Student correctly sorts and identifies 80% of organisms.	Student correctly sorts and identifies 70% of organisms.	Student correctly sorts and identifies 50% of organisms.	Student correctly sorts and identifies less than 40% of organisms.	
Given a data table student correctly calculates the water quality rating in 4 samples.	Given a data table student correctly calculates the water quality rating in 3 samples.	Given a data table student correctly calculates the water quality rating in 2 samples.	Given a data table student correctly calculates the water quality rating in 1 sample.	
Student correctly interprets water quality from data on 8 sampling sites.	Student correctly interprets water quality from data on 6 sampling sites.	Student correctly interprets water quality from data on 4 sampling sites.	Student correctly interprets water quality from data on 2 or less sampling sites.	

Supplies and/or Equipment Needed:

For the class: see appendices

For each student: see appendices.

Resources:

www.stroudcenter.org : Since 1967, Stroud™ Water Research Center has been focused on one thing – fresh water. Website provides background material, on-line key and curriculum support.

<http://www.nj.gov/dep/watershedrestoration/outreach.html> : Watershed education resources and outreach resources

<http://www.dep.wv.gov/WWE/getinvolved/sos/Pages/MacroID.aspx>: Online activity for macroinvertebrate identification.

Supplied in separate files (provided by Karen Harrison, Bordentown High School):

1. Sampling instructions and data sheet
2. Macro invertebrates key
3. Invertebrate key

Student and Teacher Reflection:

Analysis of student performance and learning (both group and individual).

What were the results of the assessments?

To what degree did the results match the expectations for student learning and performance?

What worked well, what didn't work as well as anticipated?

What, if any, modifications should be made for the next time this unit is taught?

What needs to be done now to help the students who have not yet mastered the objectives and to extend the learning of those that have?

What have we learned that will improve our own planning and classroom practice in the future?

Appendices A, B, and C follow.

Estimating water quality by macroinvertebrate sampling (grades 9-12)

Notes for teachers

A major concern for environmentalists is the level of organic pollutants in aquatic ecosystems. Many chemical tests are available to quantify different possible pollutants, but it is simpler (and more fun for students) to estimate water quality by the species of macroinvertebrates that are able to thrive there.

This Biosurvey is based on the simple macroinvertebrate sampling approach developed and used by the Ohio Department of Natural Resources and the Izaak Walton League of America's Save Our Streams program and adapted by many volunteer monitoring programs throughout the United States. It is modified from the EPA water monitoring and assessment protocols.

It centers around a macroinvertebrate survey in which organisms are collected according to specific protocols, identified in the field (generally to taxonomic order, a key is provided), and are then released back into the stream.

For the identification process, students group macroinvertebrates into three categories based on their pollution tolerance or sensitivity. Students then calculate a water quality index by counting the specimens in each sensitivity category and determining whether they are rare, common, or dominant; multiplying the number of taxa in each category by a weighting factor; adding all the scores; and comparing results to a water quality rating scale that has been determined by knowledgeable biologists/ecologists.

Estimating water quality by macroinvertebrate sampling

Student instructions

You will need the following equipment for macroinvertebrate collection:-

- Buckets (2)
- Hand lens, magnifying glass, or field microscope
- Tweezers, eyedropper, or spoon
- Plastic bag

- Large, shallow, white pans, such as dishpans (2)
- Spray water bottle
- Plastic ice cube tray
- Taxonomic key to aquatic organisms
- Calculator
- D-frame net (a dip net with a frame 12 inches wide with a fine nylon mesh, usually about 500 μm , attached to the frame).

Sampling Method

- Sample vegetated bank margins by jabbing vigorously, with an upward motion, brushing the net against vegetation and roots along the bank. The entire jab motion should occur underwater but the sampling can be done from the bank.

- - To sample snags and logs, hold the net with one hand under the section of submerged wood you are sampling. With the other hand (which should be gloved), rub about 1 square foot of area on the snag or log. Scoop organisms, bark, twigs, or other organic matter you dislodge into



Collecting a sample from a log
 Volunteer rubs the log with one hand and catches dislodged organisms and other material in the net.

your net. Each combination of log rubbing and net scooping is one jab (Fig. 4.11).

- To sample aquatic vegetation beds, jab vigorously, with an upward motion, against or through the plant bed. The entire jab motion should occur underwater.
- To sample a silt/sand/gravel substrate, place the net with one edge against the stream bottom and push it forward about a foot (in an upstream direction) to dislodge the first few inches of silt, sand, gravel, or rocks. To avoid gathering a netful of mud, periodically sweep the mesh bottom of the net back and forth in the water, making sure that water does not run over the top of the net. This will allow fine silt to rinse out of the net.

When you have completed all 20 jabs, rinse the net thoroughly into the bucket. If necessary, pick any clinging organisms from the net by hand and put them in the bucket.

Sorting the macroinvertebrates

Pour the contents of the bucket (water, organisms, and organic material) into a large, shallow, white pan and fill the ice cube tray with clean stream water. Using tweezers, eye dropper, or spoon, pick through the leaf litter and organic material looking for anything that swims, crawls, or seems to be hiding in a shell (like a snail). Look carefully; many of these creatures are quite small and fast-swimming. Sort similar organisms into the plastic ice cube tray.

Identifying Macroinvertebrates

1. Identify the collected macroinvertebrates. Using the hand lens or magnifying glass and the aquatic organism identification key, carefully observe the collected macroinvertebrates. Refine your initial sort so that like individuals are placed in the same section(s) of the ice cube tray. If you cannot identify an organism, place one or two specimens in the alcohol-filled vial and forward it to your program coordinator for identification.
2. On your field data sheet, note the number of individuals of each type of organism you have identified (Section 3 of the field data sheet).

When you feel that you have identified all the organisms to the best of your ability, Assign one of the following abundance codes to each type of organism. Record the code next to the actual count on the field data sheet. Return the macroinvertebrates to the stream.

R (rare) =if 1-9 organisms are found in the sample

C (common) =if 10-99 organisms are found in the sample

D (dominant)=if 100 or more organisms are found in the sample

Your field data sheet should be organized to help you sort macroinvertebrates into three groups based on their ability to tolerate pollution.

Generally, the three tolerance groups are as follows:

- Group I
(sensitive organisms) includes pollution- sensitive organisms such as mayflies, stoneflies, and non net-spinning caddisflies, which are typically found in good-quality water.
- Group II
(somewhat sensitive organisms) includes somewhat pollution-tolerant organisms such as net-spinning caddisflies, crayfish, sowbugs, and clams, found in fair-quality water.
- Group III
(tolerant organisms) includes pollution-tolerant organisms such as worms, leeches, and midges, found in poor-quality water.

2 Calculating the stream quality rating

The stream water quality rating takes into account the pollution sensitivity of the organisms and their relative abundance. This is accomplished through use of a weighting system.

The weighting system acknowledges the most desirable combinations of pollution sensitivity and abundance by assigning these extra weights within a 5, 3, and 1 point scale. Pollution-sensitive organisms receive a weighting factor based on a 5-point scale.

Somewhat sensitive organisms are weighted on a 3-point scale, and tolerant organisms are weighted on a 1-point scale. As can be seen in Table 4.2, a sample's ideal combination of organisms would be "sensitive" and "somewhat sensitive" organisms in common abundance (10-99 organisms), and pollution "tolerant" organisms in rare abundance (less than 10 organisms). This is because it is never ideal for any given type of organism to dominate a sample, and because it is best to have a wide variety of organisms including a few pollution-tolerant individuals.

1. Add the number of R's, C's and D's in each of the 3 pollution tolerance groupings. Then, for each grouping, multiply the total number of R's, C's and D's by the relevant weighting factor..

Weighting scales and Calculations

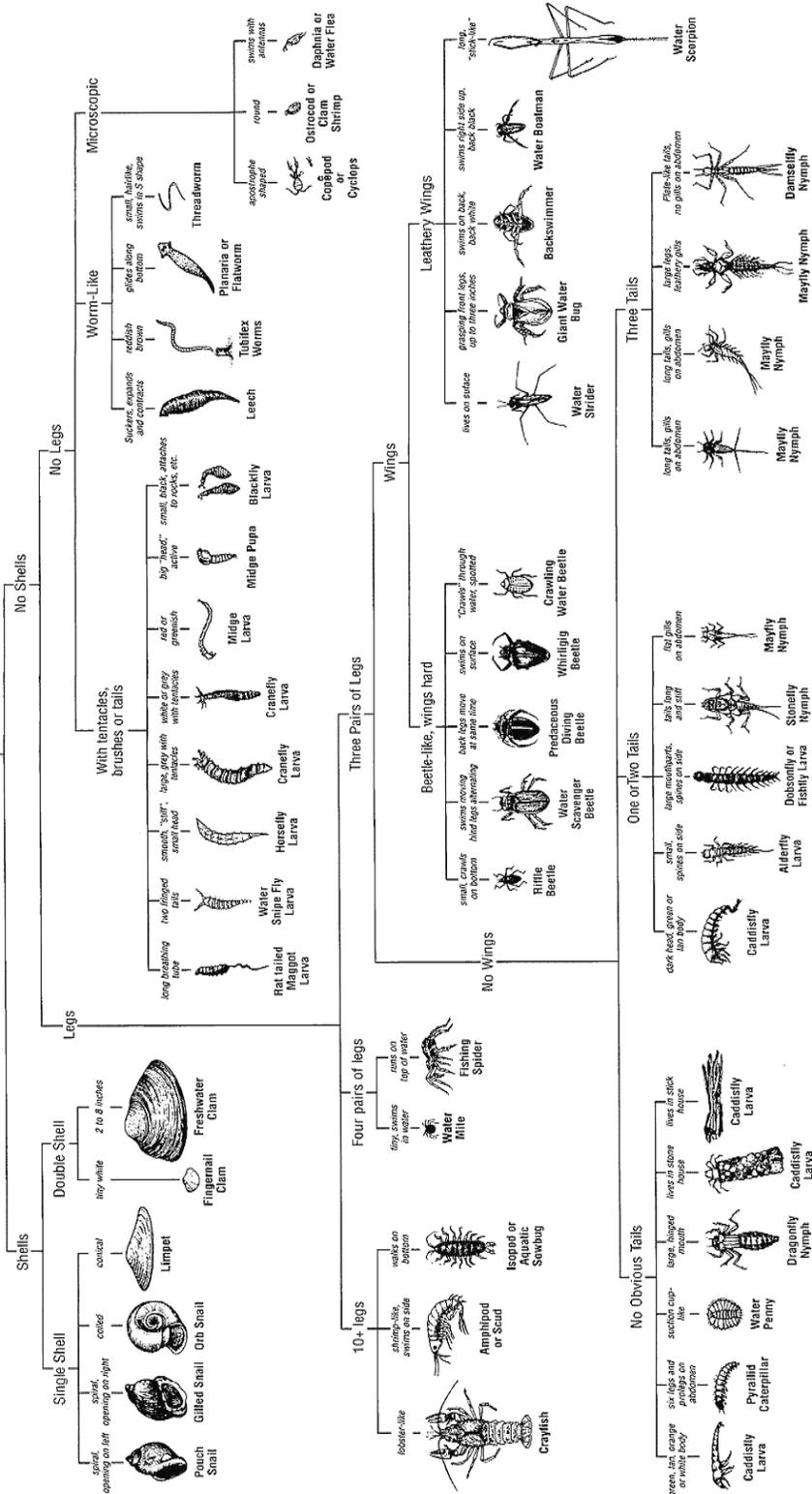
Abundance	Weighting Factor			Weighting factors used in calculating water quality ratings
	Group I Sensitive	Group II Somewhat Sensitive	Group III Tolerant	
Rare (R)	5.0	3.2	1.2	
Common (C)	5.6	3.4	1.1	
Dominant (D)	5.3	3.0	1.0	

Group I Sensitive	Group II Somewhat Sensitive	Group III Tolerant
(No. of R's) x 5.0 =	(No. of R's) x 3.2 =	(No. of R's) x 1.2 =
(No. of C's) x 5.6 =	(No. of C's) x 3.4 =	(No. of C's) x 1.1 =
(No. of D's) x 5.3 =	(No. of D's) x 3.0 =	(No. of D's) x 1.0 =
Index Value for Group I =	Index Value for Group II =	Index Value for Group III =

Score	Rating
>40	Good
20-40	Fair
<20	Poor

Estimated water quality is _____

Key to Macroinvertebrate Life in the River



Developed by University of Wisconsin-Extension in cooperation with the Wisconsin Department of Natural Resources. May be reproduced for educational, non-profit purposes. For information contact UWEX Environmental Resources Center 608/292-0020.



Macroinvertebrate Identification Key

GROUP 2

TOLERATE SOME POLLUTION

<p>Dragonfly larva</p>  <p>15-50mm</p>	<p>Damselfly larva</p>  <p>10-50mm</p>	<p>Water beetle larva</p>  <p>2-6mm</p>	<p>Whirligig beetle</p>  <p>3-15mm</p>	<p>Riffle beetle adult</p>  <p>2-4mm</p>
<p>Dragonfly nymph</p>  <p>30-50mm</p>	<p>Damselfly nymph</p>  <p>10-50mm</p>	<p>Water beetle</p>  <p>3-40mm</p>	<p>Whirligig beetle larva</p>  <p>3-12mm</p>	<p>Water strider</p>  <p>10-25mm</p>
<p>Dragonfly adult</p>  <p>17-200mm</p>	<p>Damselfly adult</p>  <p>25-55mm</p>	<p>Backswimmer</p>  <p>5-16mm</p>	<p>Waterboatman</p>  <p>5-16mm</p>	<p>Crane fly larva</p>  <p>10-25mm</p>
<p>Scud (amphipod)</p>  <p>5-21mm</p>	<p>Crayfish</p>  <p>10-150mm</p>	<p>Water scorpion</p>  <p>20-43mm</p>	<p>Sowbug</p>  <p>5-22mm</p>	<p>Freshwater clam</p>  <p>30-270mm</p>

Macroinvertebrate Identification Key

GROUP 3

TOLERATE POLLUTION

<p>Blackfly larvae</p>  <p>3-12mm</p>	<p>Midge larva</p>  <p>2-15mm</p>	<p>Mosquito larva</p>  <p>1-6mm</p>	<p>Flatworm (planaria)</p>  <p>1-6mm</p>	<p>Freshwater worm</p>  <p>1-30mm</p>
<p>Blackfly adult</p>  <p>2-5mm</p>	<p>Midge adult</p>  <p>3-4mm</p>	<p>Mosquito adult</p>  <p>6-13mm</p>	<p>Leech</p>  <p>5-40mm</p>	<p>Water snail</p>  <p>2-70mm</p>

PHOTO CREDITS

Water penny, Mayfly nymph, Hellgrammite: Ohio Department of Natural Resources

Freshwater clam: Center for Biodiversity, Illinois Department of Natural Resources

Freshwater mussel: Illinois Natural History Survey

Caddisfly larva: © 1999 McKensie

Alderfly adult: © 1999 Thomas Ames Jr.

Fishfly larva: © 2000 Wellfleet Bay Wildlife Sanctuary

Riffle beetle adult, Crayfish, Leech, Water snail: © Jones & Bartlett Publishers

Stonefly nymph, Alderfly nymph, Pouch snail: Illinois Department of Natural Resources

Stonefly adult, Water strider, Waterboatman, Mosquito larva: Bastiaan Drees, Extension Entomology, Texas A&M University

Mayfly adult: Extension Entomology, Texas A&M University
Caddisfly adult: © 1996 Blair Nikula, Extension Entomology, Texas A&M University

Scud: museum Victoria

Backswimmer: Peter J. Bryant

Dragonfly adult: Bruno Manunza

Dragonfly larva: © 1997 Forrest Mitchell, The Texas Agricultural Experiment Station

Damselfly nymph: © 2001 D.J. Hollingworth, Department of Animal and Plant Sciences, The University of Sheffield

Water beetle larva: Gerard Visser

Water beetle: © 2000 Cedar Creek Natural History Area, University of Minnesota

Cranefly larva: Jim Rathert

Midge larva, Sowbug: Cliff White

Blackfly larvae: University of Alberta, Department of Biological Sciences

Blackfly adult: Robert Burns, Texas Agricultural Extension Service

Mosquito adult: US Navy Disease Vector Ecology and Control Center

Whirligig beetle: © 2000 Singapore Zoological Gardens Docents

Whirligig beetle larva: Illinois River Watch