Essential Question 5

How Can Biotic Parameters Indicate the Health of Lake Winnipeg?

Essential Question 5: How can biotic parameters indicate the health of Lake Winnipeg?

Introduction

The biological condition of an aquatic environment is an indicator of watershed health. Aquatic organisms and communities reflect the cumulative conditions of watershed components. Healthy aquatic ecosystems reflect healthy watershed conditions. A biotic condition assessment for identifying healthy watersheds examines the presence, numbers, and condition of aquatic organisms and communities in a body of water. Environmental toxicologists, ecologists, and limnologists have used the biota of an area to indicate the health of the ecosystem. The lake ecosystem is no different. The presence of invasive species, the absence of toxin-sensitive invertebrates, the presence of low-oxygen tolerant macroinvertebrates, and population increases in toxin-tolerant macroinvertebrates are indications that an aquatic ecosystem has been disturbed. Some species are sensitive to specific toxins, and can be used as indicators for these poisons.

Resources to Plan Your Teaching

- CIER Species-at-Risk Tool Kit

Macroinvertebrates Keys

- Carlson, W., N. Trautmann, & the Environmental Inquiry Team. *Watershed Dynamics, Student Edition.* NSTA Press: Arlington, VA, 2004.
- Protocol 6 Simplified Stream Biota Test (SSBT) and Protocol 7: Index of Biotic Integrity using Aquatic Invertebrates are two analytical tools that can be used to evaluate the water quality of a stream.
- Ducks Unlimited Canada. *Key to Common Wetland Invertebrates; Marsh Monsters posters.* Winnipeg, MB: Oak Hammock Marsh Interpretive Centre/ Ducks Unlimited. Available online at <www.ducks.ca/ohmic>.
- Project WET (Macroinvertebrate Mayhem activity)
- Manitoba Waterways Project. Available online at <http://home.cc.umanitoba.ca/~lewthwai/mwp>. (information included on pp. 26–29)
- Arizona Water Education for Teachers. Healthy Water, Healthy People: Water Quality Educators Guide. "Benthic Bugs and Bioassessment," pp. 154–162; "Invertebrates as Indicators," pp. 174–180.

- **Fort Whyte Alive Centre**
- Beyond Books Institute of Alberta. "How to Monitor Aquatic Invertebrates," 1999–2001.
- "Key to the Major Invertebrate Species of Stream Zones." North Dakota Wetlands Discovery Guide, Photocopy booklet, USDA Soil Conservation Service, Figure B-11.
- "Protocols for Measuring Biodiversity: Benthic Macroinvertebrates in Fresh Waters" by D.M. Rosenberg, I.J. Davies, D.G. Cobb, & A.P. Wiens. Winnipeg, MB: Department of Fisheries and Oceans, Freshwater Institute.
- "Water on the Web." Available online at <www.waterontheweb.org>.
- "Freshwater Macroinvertebrates Protocol." GLOBE, 2003.
- Sharpe, William E., William G. Kimmel, & Anthony R. Buda. "Biotic Index Card." Penn State Sustainable Forestry Teacher Resource Center.
- "The Alabama Watershed Demonstration Project—Biotic Indicators of Water Quality." Available online at <www.aces.edu>.
- Volunteer Stream Monitoring Partnership. "Guide to Volunteer Stream Monitoring." University of Minnesota Water Resources Center.
- University of Wisconsin. "Water Action Volunteers—Volunteer Monitoring Factsheet Series." University of Wisconsin, 2003.

Lesson: Prokaryotes in Lake Winnipeg

Specific Learning Outcomes

- **SLO C9:** Analyze data or observations in order to draw conclusions consistent with the available results of an investigation, and identify the implications of these results. *Examples: cause and effect relationships, alternative explanations, support for or rejections of a hypothesis or prediction statement…*
- **SLO C15:** Use bibliographic and electronic research tools to collect information on a selected topic. *Examples: keyword searches, search engine navigation, databases…*

Objectives

Students will describe the characteristics of cyanobacteria by completing an Internet scavenger hunt.

Teacher Background

Cyanobacteria, sometimes called blue-green algae, are a domain of prokaryote. They lack a cell nucleus. Unlike plants, where photosynthesis takes place in specialized organelles called chloroplasts, cyanobacteria photosynthesis takes place inside the cytoplasm. Some of the filamentous cyanobacteria contain specialized heterocysts, which can fix nitrogen directly from the air.

Cyanobacteria may be single-celled or multicellular. Multicellular cyanobacteria can form filaments, sheet, or hollow balls. Certain types of cyanobacteria may produce toxins.

In Lake Winnipeg, cyanobacteria cause problems with recreation activities such as swimming and commercial activities such as fishing.

Good Internet sources for definitions include the report *State of Lake Winnipeg: 1999 to 2007 Highlights,* issued in June 2011, and the definition of cyanobacteria in the *New World Encyclopedia*.

Resources to Plan Your Teaching

- Lockhart, Lyle. "Algal Blooms in Lake Winnipeg." *Lake Winnipeg Foundation Newsletter,* November 2005. Available online at <www.lakewinnipegfoundation.org>.
- Hiriart-Baer, Véronique. "Tracking the phosphorus sources in Lake Winnipeg: A possibility?" *Lake Winnipeg Foundation Newsletter,* Fall 2007. Available online at <www.lakewinnipegfoundation.org>.

- Levésque, Lucie, & Elaine Page. *State of Lake Winnipeg: 1999 to 2007 Highlights.* Winnipeg. MB: Environment Canada, Manitoba Water Stewardship, June 2011. Available online at <www.gov.mb.ca/waterstewardship/water_quality/state_lk_winnipeg_report/pdf/state_of_lake_winnipeg_rpt_technical_low_resolution.pdf>.
- New World Encyclopedia. "Cyanobacteria." Available online at <www.newworldencyclopedia.org/entry/Cyanobacteria#Health_risks>.
- Lake Winnipeg Research Consortium. "What's So Special about Blue-Greens?" *Lake Winnipeg Research Consortium Newsletter* 1.1, March 2008. 7. Available online at <www.lakewinnipegresearch.org/pdf%20files/LWRC_enews_Mar08_final.pdf>.

The Three A's

Activate: Play a cyanobacteria matching game. Create pairs of matching cyanobacteria cards using pictures obtained from the following website: <www-cyanosite.bio.purdue.edu/images/images.html>.

Distribute the cards randomly around the classroom, and ask students to find their matching cyanobacteria. Have pairs examine the pictures, and discuss how cyanobacteria share characteristics of both bacteria and plants.

Acquire and Apply: Have students read 'So what's so special about blue-greens?" on page 7 of <www.lakewinnipegresearch.org/pdf%20files/LWRC_enews_Mar08_final.pdf>.

Provide an overview of the morphology of a generalized cyanobacteria. Point out the characteristics of cyanobacteria that make it a prokaryote. Highlight how bacteria cells differ from other cell structures because they do not have a nucleus. Because of this, genetic material is loose in the cell in the gel-like cytoplasm. Except for the protein-producing ribosomes, bacteria do not have organelles (specialized cell structures that have specific functions).

However, bacteria do have cell walls and cell membranes. Cyanobacteria harvest the energy contained in sunlight and turn it into food (sugars) using the same process of photosynthesis found in higher plants.

Have students complete the Cyanobacteria Scavenger Hunt.

Assessment

Assessment *for* Learning: Collect student responses to the cyanobacteria scavenger hunt, and provide feedback.

See <www.cyanosite.bio.purdue.edu/images/images.html>.

Distribute the cards randomly around the classroom, and ask students to find their matching cyanobacteria. Have pairs examine the pictures, and discuss how cyanobacteria share characteristics of both bacteria and plants.

Student Handout: Cyanobacteria Scavenger Hunt

Answer the following questions about cyanobacteria using the recommended web resources.

1. Create a biologically accurate picture of one species of cyanobacteria. Identify the magnification of the diagram. You can find images of cyanobacteria at the following website: www-cyanosite.bio.purdue.edu/images/images.html

2. What are the causes of the overproduction of cyanobacteria in the Lake Winnipeg ecosystem? You can find an overview of the cause of algae blooms at the following website: http://dunnottar.weebly.com/overview.html

(continued)

3. How do cyanobacteria harm an aquatic ecosystem? You can find information on harmful algal blooms at the following website: www.cdc.gov/nceh/hsb/hab/default.htm

4. What morphological qualities do cyanobacteria have that help them out-compete phytoplankton in high nutrients in low light conditions? You can find information on the health risks of cyanobacteria at the following website: www.newworldencyclopedia.org/entry/Cyanobacteria#Health_risks

5. What is a cyanoHAB? You can find information on cyanoHAB at the following website: www.cdc.gov/nceh/hsb/hab/default.htm

Lesson: Understanding Algae

Specific Learning Outcomes

- **SLO C5:** Select and use scientific equipment appropriately and safely. *Examples: volumetric glassware, microscopes, balances, test kits, probeware…*
- **SLO C6:** Estimate and measure accurately using Système International (SI) and other required standard units. Include: SI conversions, interconversion of units, significant figures.

Objectives

Students will identify the morphological differences between cyanobacteria and algae by comparing biological diagrams.

Teacher Background

Algae are non-vascular, aquatic plants that are capable of photosynthesis. Algae includes seaweed and many unicellular organisms. Many species of algae can be found floating or swimming as plankton in the water column, and macroscopic algae can often be found in the sand on beaches, but some algae are plants that grow together and form areas of thick vegetation that can look like underwater forests.

We can also eat some types of algae, and many commercial products contain forms of algae. The following are four of the most common algal products used in commercial products:

1. **Agar:** Agar is a gelatin-like substance that can solidify liquids that was first used in China in the 17th century. It is used as a thickener in foods like soup, yogurt, and ice cream.
2. **Diatomaceous earth:** This is a product that is made from diatoms, which are fossils of planktonic algae. It can be used as a filtering agent, an abrasive, and even as a pesticide-free ant killer.
3. **Carrageenan:** Carageenan is a colloid made from brown algae that is used in dairy and bakery products as a stabilizer or emulsifier.
4. **Alginic acid:** This is found in kelp plants along the Pacific coast, and is also used as a stabilizer or emulsifier in a variety of products, such as table syrup, orange drinks, and ramen noodles.

The Three A's

Activate: Bring in some food products that contain algae products (anything that contains agar would do, as it is a product of red algae). Show students each of the products one at a time, and then ask them what they have in common. Tell them they all contain algae. Have students discuss the natural environments in which they have observed algae, and describe what they looked like.

Acquire and Apply: Explain to students the different divisions of phytoplankton present in freshwater systems.

Explore the morphology of sample species in each of the different divisions. Assign students different freshwater algae species, depending on the slides you have available, or have each student observe algae species in a prepared culture. Have students prepare a large-scale drawing of their assigned algae. Students can compare the morphology of algae to the cyanobacteria studied previously using a compare and contrast frame.

Have students conduct the identification and quantification of a phytoplankton lab.

Identification and Quantification of Phytoplankton

This laboratory exercise is courtesy of Kent Simmons, University of Winnipeg.

Introduction

While it is useful to examine a few representative species within each group of algae, that exercise will not acquaint students with the difficulties of identifying algae collected in water samples from lakes, rivers, and streams. Also, knowing the algae is only half the problem. The other half is being able to quantify the number of algae in a known volume of water. This lab is designed to teach students how to recognize the major algal groups and to demonstrate one quantifying method.

Objectives

1. To illustrate techniques in identifying freshwater phytoplankton to family.
2. To develop student skills in reporting algal morphology.
3. To demonstrate one method of quantifying algae.

Phytoplankton Identification

This portion of the lab will concentrate on algal identification. The criteria you will use are sometimes based on the characteristics of algal divisions. Just

as often, they are based on the following: morphological traits that are true most of the time; colour that only indirectly reflects pigment composition; and developing a sense of logic and a process of elimination to help you in your identifications. In this lab, we will only classify the algae to family (where possible). Once you are able to get the organism to the level above genus, generic recognition is usually straightforward but species determination can be extremely difficult. Although there are several classification schemes available, we will use the scheme outlined by G.W. Prescott in *The Algae of the Western Great Lakes Area*.

You will be provided with a taxonomic key of all the divisions (classes, order, and families) of freshwater phytoplankton found in central and southern Manitoba. As well, each group of students will have a water sample. The first exercise will be to devise a relative abundance profile for the algae in your sample. Each student should make a wet mount of the water sample and record the numbers of algal/family present in the sample. Before submitting the results of your work, you should combine your results with those of the rest of the group. The results should be reported in the form of a histogram. This is a qualitative description of what is in your sample. You are not describing how many algae are present in a known volume of water, only how many are present relative to the other algae present.

Algal Morphometry

This section of the lab exercise involves determining some of the morphological features of the algae that may be important in estimating such parameters as lake productivity. This exercise may appear tedious, but it is issued on a regular basis in labs associated with determining water quality. There are three portions to this part of the lab:

a. Calibration of an ocular micrometer
b. Drawing two algae to scale
c. Calculating the surface area, volume, and surface-to-volume ratios of the cells

a. Calibration of an Ocular Micrometer

The ocular micrometer is a disc of glass upon which is ruled a series of equally spaced lines. Compound microscopes have ocular micrometers; however, the scale on the ocular micrometer changes with total magnification, and thus has no absolute value. Therefore, the ocular micrometer does not have units, and it needs to be calibrated prior to use. To determine the actual size of each unit on the scale, we must first calibrate the ocular micrometer with a stage micrometer. The stage micrometer is a microscope slide with a scale etched on it. The distance between the lines of the scale is exactly 10 microns.

When it is mounted on the stage, one can determine the number of microns represented by one scale division of the ocular micrometer.

- Remove the left ocular lens and insert the ocular micrometer (have the 10x objective lens in place). Look through the ocular and observe the scale.
- Place a stage micrometer on the stage. Focus on the scale using the right ocular.
- Using both oculars, rotate the left ocular until its scale is superimposed on the stage micrometer scale. Line up the tops of both scales at the same point.
- How many divisions of the ocular scale correspond to 1 division (10 microns) on the stage scale? What is the diameter of the field of view (microns)? Complete the calibration chart for your microscope.
- Remove and clean the stage micrometer.

b. Drawing Algae to Scale

- Once you have calibrated the ocular micrometer, you can now draw algae to scale. On the next two pages are grids and data tables. Make a wet mount of your lake sample, select two algae, and complete each page with a diagram and description of each alga.
- Using the calibrated micrometer, estimate the long axis of your alga in microns. Make an entire side of the grid slightly larger than the length of the alga. For example, if you determined the alga to be 12 microns long, then designate the grid scale to be 15 microns. Each subunit on the grid would then be 15 divided by the total number of subunits (19) or 1.4 microns.
- Draw the alga to fit the scale.
- Calculate the magnification of your drawing: $\frac{\text{drawing size (microns)}}{\text{actual size (microns)}}$
- Select the most appropriate geometric configuration, and calculate the surface area, volume, and surface-to-volume ratio. Complete the table that accompanies the grid.

c. Quantitative Estimate of an Algal Population

In the first exercise, you determined the type and relative abundance of an algal population. This may be all the information you are asked to obtain but generally it is insufficient. What you are missing is the number of algae per volume (usually mL) of water. This information is essential if you wish to know the productivity status of the lake. If slightly more sophisticated techniques are applied, quantitative information may also be obtained. In this portion of the lab, you will use one technique to determine the number of cells/mL. The technique employs a Palmer counting chamber. This chamber, when covered with a cover slip, holds exactly 0.1 mL of water.

Method:

Place a clean cover glass in position over the counting chamber, and slightly tilt the slide. Be certain there is firm contact between the chamber and the cover slip.

With a Pasteur pipette, add the sample via the lower entry port.

The total area of the chamber is 250 mm^2. Determine the area of the field of view from your calibration chart.

Count the number of algae (in each family) in 10 different fields of view (at 10x). Determine the average number of algae/family/field of view.

The density of each family of algae (D) in the water sample can be determined as:

$$D = N \times \frac{\text{area of chamber}}{\text{area of field of view}} \times \frac{1.0}{0.1}$$

$$D = N \times \frac{2500}{A}$$

A is the area of the field of view (in mm^2), where D is the number of cells of each family/mL of water, N is the average number of organisms/field in each class after 10 fields were counted. A is the area of the field of view (in mm^2).

Report your results in the form of a histogram (bar graph) in which the y-axis is the number of cells/mL.

Assessment

Assessment *for* Learning: Provide students with feedback on their use of the microscope and creation of wet mounts.

Algal Record

Sample Number_____ Sample Date_____

Sample Location _____

_____

Organism Identification_____

Organism Dimensions (microns) _____

Cell Volume _____ Cell Area_____ SA: Volume ratio _____

Magnification _____ Name of Identifier_____

Lesson: Lake Productivity

Specific Learning Outcomes

- **SLO C1:** Identify questions to investigate what arises from practical problems and issues.
- **SLO C2:** Clarify problems and refine testable questions to facilitate investigation. *Examples: develop a testable question appropriate to circumstances; define and delimit the kind and number of inquiry pathways…*
- **SLO C3:** Design and conduct an investigation to answer a specific scientific question. *Examples: materials necessary, independent/dependent variables, controls, testable hypothesis or prediction, methodology, safety considerations, appropriate sampling procedures…*
- **SLO C4:** Demonstrate work habits that ensure personal safety, the safety of others, and consideration of the environment. *Examples: application of WHMIS, proper disposal of chemical or biological specimens…*
- **SLO C5:** Select and use scientific equipment appropriately and safely. *Examples: volumetric glassware, microscopes, balances, test kits, probeware…*
- **SLO C6:** Estimate and measure accurately using Système International (SI) and other required standard units. Include: SI conversions, interconversion of units, significant figures.
- **SLO C7:** Evaluate the relevance, reliability, and adequacy of data and the methods used to collect data. Include: discrepancies in data, sources of systemic error, precision versus accuracy.
- **SLO C8:** Interpret patterns and trends in data, and infer and explain relationships. *Examples: line of best fit, regression equations, statistical analysis, modes of representation (visual, numerical, graphical, symbolical)…*
- **SLO C9:** Analyze data or observations in order to draw conclusions consistent with the available results of an investigation, and identify the implications of these results. *Examples: cause and effect relationships, alternative explanations, support for or rejections of a hypothesis or prediction statement…*
- **SLO C10:** Identify new questions or problems that arise from an investigation.

Objectives

Students will investigate ways to measure the primary productivity of a lake by conducting a simulation experiment.

The Three A's

Activate: Show students a jar of water and a second jar that is filled with algae. Ask them how we could measure the difference in algal growth between the two jars. Then ask students to imagine the two jars are lakes, and ask them how we could compare the difference in algal growth between the two lakes.

Acquire and Apply: Explain eutrophication to students, and tell them how it is a measure of the productivity of a lake. Discuss some issues associated with eutrophication that are specific to Lake Winnipeg.

The Measurement of Primary Productivity

This laboratory activity was provided courtesy of Kent Simmons, University of Winnipeg.

Teacher Background

The Winkler method is often used to measure biological oxygen demand. Biological oxygen demand (BOD) is a measure of the oxygen used by microorganisms when breaking down the organic material in a water source. When there is a large amount of organic waste in a water source, the BOD will be high because there is a large amount of bacteria in the water. As the waste material decreases, so will the BOD. When the BOD is high, there is also less dissolved oxygen in the water because the bacteria are consuming the oxygen. Low dissolved oxygen will affect fish and other aquatic animals that cannot survive in low oxygen environments.

The following lab is an exploration of the effect light limitation has on the biological oxygen demand of a water source. This is especially important in the Lake Winnipeg context because of the highly turbid water in the southern basin. Cyanobacteria can adjust to low light conditions because they have a vacuole that helps them navigate the water column. Thus, under high turbidity, cyanobacteria can move to better light conditions and out-compete other species of algae.

The beauty of the Winkler method is that once students have an idea on how it measures biological oxygen demand in a water source and they have conducted one guided experiment to explore the effect of light limitation on BOD, they can then design their own experiment to look at other parameters that may affect BOD by changing some of the variables.

Resources to Plan Your Teaching

The Manitoba Waterways project also has a description of the Winkler method that is not so detailed or as complicated. Students can follow this method and then submit their findings to the Waterways site.
http://home.cc.umanitoba.ca/~lewthwai/mwp/mainpage.html#contents

Laboratory

How does the productivity of a water column change with depth?

Procedure

Day 1

1. Divide students into groups of five, and have each person obtain a 300 mL glass bottle (you can use an Erlenmeyer flask or other glass bottle that can be sealed) and rinse well with distilled water. Obtain at least 2.5 litres of the sample water (this will be either water collected from a field trip or a culture created by your teacher to simulate Lake Winnipeg water).
2. Carefully siphon the water into the glass bottles. Place the siphon on the bottom of the bottle and fill it so it is overflowing. Place a stopper on the bottle, and turn it upside-down to get rid of excess water in the well. Set the bottles up as follows:

Bottle	Treatment
1	Fill with water, initial sample
2. Dark	Fill with water, cover with aluminum foil
3. Light	Fill with water

3. Place the dark and the light bottles in front of a light source, as directed by your teacher, and leave them overnight.
4. Remove the stopper from the initial sample bottle and pipette 2 mL of manganous sulfate into the sample. Be sure to insert the tip of the pipette below the surface of the sample.
5. Pipette 2 mL of alkaline iodide into the same sample. Again, be sure to insert the tip of the pipette below the surface of the sample. A manganous hydroxide precipitate will immediately form.
6. Stopper the bottle and shake the sample by inverting the bottle several times. Keep all three sample bottles at the same temperature.
7. Make a wet mount slide of the sample water used for the experiment, and draw and identify some of the organisms that you observe.

Day 2

8. Obtain your bottles. Fix the dark and light bottles by following steps 4, 5, and 6.
9. Determine the absolute amount of dissolved oxygen in all the samples by filling a burette with a standardized thiosulphate working solution (or PAO), and obtain a bottle of starch solution.

10. Remove the stopper from the BOD bottle and **CAREFULLY** pipette 2 mL of concentrated sulphuric acid (H_2SO_4) into the sample. **YOUR TEACHER WILL PERFORM THIS STEP FOR YOU. CONCENTRATED SULPHURIC ACID IS EXTREMELY CORROSIVE! YOUR TEACHER SHOULD BE WEARING GLOVES AND EYE PROTECTION.**

11. Stopper the bottle and shake the sample by inverting the bottle several times. The precipitate will dissolve and the sample will turn a clear yellow-gold as free I_2 is formed.

12. Using a graduated cylinder, remove a 50-mL sample and pour it into a 250 mL Erlenmeyer flask.

13. Titrate this sample with the thiosulphate solution in your burette until a pale straw colour is reached. Remember to continually swirl the solution in your Erlenmeyer flask during the titration process. Also, set the flask on a sheet of paper to enhance the colour change.

14. To help you accurately identify the endpoint of this titration, introduce one or two drops of starch solution into the straw-coloured sample. The sample should turn purple in colour.

15. Continue to titrate, **drop by drop**, until the purple colour disappears. At the endpoint in your titration, all the free iodine has been converted to sodium iodide by the addition of sodium thiosulphate. The volume of sodium thiosulphate (in mL) used to titrate your 50-mL sample is approximately equivalent to the concentration of dissolved oxygen (mg/L) in your original sample. Your teacher will show you how to convert mg/L to mL/L.

16. Calculate the gross and net productivities and the respiration rate for your samples using the following equations:

    Gross Productivity =
    [Light Bottle (mL O_2/L)—Dark Bottle (mL O_2/L)]/time in hours.

    Net Productivity =
    [Light Bottle (mL O_2/L)—Initial Bottle (mL O_2/L)]/time in hours.

    Respiration rate =
    [Initial Bottle (mL O_2/L)—Dark Bottle (mL O_2/L)]/time in hours.

    Gross Productivity =_____ (mL O_2/L)/hr

    Net Productivity =_____ (mL O_2/L)/hr

    Respiration =_____ (mL O_2/L)/hr

17. Plot the net productivity (mL O_2/L)/hr versus light intensity (%) for the samples.

Probing Questions

What was the effect of light limitation on biological oxygen demand? How would this finding be important in the Lake Winnipeg situation?

Extension

Now that the students have the basic procedure for the Winkler method, they can design their own experiment using their own questions. Have students, in pairs or groups, develop a testable question they would like to explore.

Examples

How does the temperature affect biological oxygen demand?

How does the pH affect biological oxygen demand?

From the testable question, students can now develop a procedure that would examine a different parameter other than light and dark.

Assessment

Assessment *for* Learning: Provide students with feedback on their lab skills using a checklist.

Assessment *of* Learning: Assess the lab report using a rubric.

Notes

Lesson: Macroinvertebrates as Indicators of Water Quality

Specific Learning Outcomes

- **SLO C2:** Clarify problems and refine testable questions to facilitate investigation. *Examples: develop a testable question appropriate to circumstances; define and delimit the kind and number of inquiry pathways…*
- **SLO C3:** Design and conduct an investigation to answer a specific scientific question. *Examples: materials necessary, independent/dependent variables, controls, testable hypothesis or prediction, methodology, safety considerations, appropriate sampling procedures….*
- **SLO C4:** Demonstrate work habits that ensure personal safety, the safety of others, and the consideration of the environment. *Examples: application of WHMIS, proper disposal of chemical or biological specimens…*
- **SLO C5:** Select and use scientific equipment appropriately and safely. *Examples: volumetric glassware, microscopes, balances, test kits, probeware…*
- **SLO C6:** Estimate and measure accurately using Système International (SI) and other required standard units. Include: SI conversions, interconversion of units, significant figures.
- **SLO C7:** Evaluate the relevance, reliability, and adequacy of data and the methods used to collect data. Include: discrepancies in data, sources of systemic error, precision versus accuracy.
- **SLO C8:** Interpret patterns and trends in data, and infer and explain relationships. *Examples: line of best fit, regression equations, statistical analysis, modes of representation (visual, numerical, graphical, symbolical)…*
- **SLO C9:** Analyze data or observations in order to draw conclusions consistent with the available results of an investigation, and identify the implications of these results. *Examples: cause and effect relationships, alternative explanations, support for or rejections of a hypothesis or prediction statement…*
- **SLO C11:** Synthesize information obtained from a variety of sources.

Objectives

Students will identify macroinvertebrates found in local water sources, and determine water quality based upon their presence or absence.

Teacher Background

Assessment of water quality for life can be done by looking at the macroinvertebrates that are found in a body of water. Tolerance to conditions in and of the water varies from species to species, and the relative abundance of different groups is a good general indicator of water quality.

Students can collect benthic invertebrate samples from small streams in an area. Samples could be collected from upstream and downstream reaches of a

creek or stream and benthic invertebrate abundance, community composition, and diversity could be compared among all sites. The benthic invertebrate data would complement any water quality information (i.e., DO, pH, water clarity, temperature, nutrients, ions) that the students may be collecting at the same locations along the stream of interest. The organisms can be easily identified by types and often by species. There are many good invertebrate resources available and keys that are relatively simple to use.

Resources to Plan Your Teaching

Macroinvertebrates Keys

- Carlson. W., N. Trautmann, & the Environmental Inquiry Team. *Watershed Dynamics Student Edition.* Arlington, VA: NSTA Press, 2004. Protocol 6 Simplified Stream Biota Test (SSBT) and Protocol 7: Index of Biotic Integrity using Aquatic Invertebrates are two analytical tools that can be used to evaluate the water quality of a stream.
- Ducks Unlimited Canada: Key to Common Wetland Invertebrates; Marsh Monsters posters—Oak Hammock Marsh Interpretive Centre/ Ducks Unlimited
  www.ducks.ca/ohmic
- Project WET (Macroinvertebrate Mayhem activity)
- Manitoba Waterways Project
  http://home.cc.umanitoba.ca/~lewthwai/mwp/
  (information included on pp. 26–29)
- "Benthic Bugs and Bioassessment" (pp. 154–162), "Invertebrates as Indicators" (pp. 174–180): Healthy Water, Healthy People Water Quality Educators Guide"
- FortWhyteAlive
- "How to Monitor Aquatic Invertebrates." Beyond Books Institute of Alberta, 1999–2001
- "Key to the Major Invertebrate Species of Stream Zones." *North Dakota Wetlands Discovery Guide—Photocopy Booklet*, USDA Soil Conservation Service, Figure B-11
- "Protocols for Measuring Biodiversity: Benthic Macroinvertebrates in Fresh Waters" by D. M. Rosenberg, I.J. Davies, D.G. Cobb & A.P. Wiens. Winnipeg, MB: Department of Fisheries and Oceans, Freshwater Institute
- "Water on the Web"
  www.waterontheweb.org
- "Freshwater Macroinveretebrates Protocol" GLOBE, 2003

- "Biotic Index Card" by William E. Sharpe, William G. Kimmel, & Anthony R. Buda. Penn State Sustainable Forestry Teacher Resource Center
- "The Alabama Watershed Demonstration Project: Biotic Indicators of Water Quality"
  www.aces.edu
- "Guide to Volunteer Stream Monitoring" Volunteer Stream Monitoring Partnership, University of Minnesota Water Resources Center
- "Water Action Volunteers—Volunteer Monitoring Factsheet Series" Spring 2003 University of Wisconsin

The Three A's

Activate: Using web resources, create a matching game where students must try to match adult macroinvertebrates with their larval stage.

Acquire and Apply: Have students look at the key to identify the macroinvertebrates present in a water source. Using the samples collected from a local water source, have students practise by identifying different macroinvertebrates.

Discuss the importance of each macroinvertebrate as an indicator of water quality, and design a plan on how your class could quantitatively evaluate the water quality using macroinvertebrates (e.g., the class could decide that each group must use the same amount of sample and count the number of different organisms in 10 different fields of view, and then average them).

Alternately, the class could use protocol 6 or 7 in *Watershed Dynamics*. (Carlson W., N. Trautmann, & the Environmental Inquiry Team. Watershed Dynamics Student Edition. Arlington, VA: NSTA Press, 2004. Protocol 6 Simplified Stream Biota Test [SSBT]).

Based upon the class results, have students write their own conclusions.

Assessment

Assessment *for* Learning: Provide students with feedback on their participation in the discussion.

Assessment *of* Learning: Collect the individual conclusions students draw to the results collected by the class.

Notes

Lesson: Fish Populations

Specific Learning Outcomes

- **SLO C11:** Synthesize information obtained from a variety of sources.
- **SLO C13:** Quote from or cite sources as required, and reference sources according to an accepted practice.
- **SLO C14:** Communicate information in a variety of forms appropriate to the purpose, audience, and context. Include: technical science writing (*e.g., proposals, laboratory reports, research reports…*); popular science writing (*e.g., magazine articles, comics, short stories, poetry…*).
- **SLO C15:** Use bibliographic and electronic research tools to collect information on a selected topic. *Examples: keyword searches, search engine navigation, databases…*

Objectives

Students will identify some of the fish species found in Lake Winnipeg, explain the habitat and food web of one species, and discuss the impact of nutrient loading on their selected fish species.

Teacher Background

There are 56 fish species found in Lake Winnipeg. They all have their own habitat parameters, and thus will be affected differently by different stressors on the lake. Students will be responsible for selecting one fish species from the lake, and conducting a research project that examines the habitat requirements of the fish and how high nutrient levels in the lake may affect it.

The Three A's

Activate: Ask students to name as many fish species they know to exist in Lake Winnipeg.

Acquire and Apply: Choose one fish species, and provide an overview of how that species may be affected by high nutrients in Lake Winnipeg.

Provide students with the following scenario:

A Grade 8 class is currently studying the Lake Winnipeg ecosystem and the effect high nutrient levels could have on the different organisms in the lake. The class does not have time to cover the fish species in the lake, and the teacher would like the class to create a web page, *PowerPoint* presentation, or bulletin board about the different species found in the lake and how they could be affected by high nutrient loading. Your job is to contribute

to the presentation by selecting one fish species to research, and creating a presentation providing the following information:

- Fish species common name
- Fish species biological name
- Description of habitat requirements
- Description of where this fish fits in an aquatic food web
- Description of sensitivities to fluctuations in the environment

Lesson Modification: If you are in a First Nations community, have students visit the Centre for Indigenous Environmental Resources website (see <www.ppw.ca>). The First Nations Fish Habitat Program has a number of resources. Using this workbook allows students to take a modified but proactive and local approach to the lesson above (see <www.ppw.ca/WorkArea/showcontent.aspx?id=1848>).

Assessment

Assessment *of* Learning: Assess the presentation using a rubric.