HOW HEALTHY IS THE IPSWICH RIVER ECOSYSTEM?

This lesson primarily focuses on teaching students about the animals within a river ecosystem. Students will gain knowledge through learning about the connections the animals have with the environment in which they live in.

RET Project Connection: The Environmental Biotechnology lab in the Civil Engineering Department at Northeastern University is focusing on Nitrogen and Phosphorous removal in wastewater treatment. This summer, as an RET intern, I have been participating in three of the main experiments being conducted in the lab. Each of the experiments involve manipulating a lab scale wastewater treatment system. The first of these three experiments is testing to see which influent (MicroC, Acetate, and Methanol) is more effective in removal of Nitrogen removal. In a second experiment, an Integrated Fixed-Film Activated Sludge (IFAS) reactor is being tested for various parameters to optimize the amount of phosphorus removing bacteria in the system. The third experiment involves a single tank sequencing batch reactor specifically set up to try and isolate the bacteria mainly responsible for optimal P removal.

Incorporating what I have learned this summer, I would like to teach my students about the bacteria that specifically remove P and N from water and relate it to eutrophication. The lesson I have designed is specifically geared for my upperclassmen zoology students. The goal is to have students understand the ramifications of eutrophication, which can occur due excess N and P entering an aquatic system. In addition, the background knowledge I have gained in the lab will be used to enhance my teaching of the Nitrogen Cycle to my freshman biology students.

RET Teacher:	Katelyn Carrette
School:	North Reading High School
Town/District:	N. Reading, Massachusetts
Subject(s) Taught:	Biology, Zoology
Subjects Covered:	Ecology, Scientific Design, Invertebrate Zoology, Chemistry of Life (Nutrient Cycling)
Grades Appropriate:	11, 12
Lesson Duration:	Two months

Fundamental Topics:

- Nutrient Cycling
- River Ecology
- Biodiversity
- Eutrophication
- Vertebrate Zoology

Goals/Objectives: (Student will)

Students will be able to:

1. Determine the health of the Ipswich River Ecosystem based on knowledge of the invertebrate life and amount of N and P present in the system.
2. Understand the ramifications of too much N and P present in an aquatic system.
3. Conduct field research: collect invertebrates and take water quality measurements (Ipswich River Park, North Reading, MA and MA Audubon, Tewksbury, MA)
4. Collect data: test pH, nitrogen (ammonia, nitrate, and nitrite) phosphorus in aquarium and Ipswich River.
5. Make observations: observe invertebrates that are collected from two sites of Ipswich River.
6. Conduct research: research the Ipswich River Watershed; research the parameters needed for a healthy river ecosystem; research the effects of increased levels of nitrogen and phosphorus in river systems.
7. Make predictions as to whether or not the Ipswich River Watershed is a thriving ecosystem.

Background Information:

Zoology is the study of animals and the environment in which they live in. It is a discipline that is typically taught through a course that thoroughly defines the major invertebrate and vertebrate phyla, from simple to complex. I have found that high school students have difficulty learning about the phyla in this fashion, often losing interest after learning about all the invertebrate phyla. My goal is to teach students about the animal kingdom through real life connection. This unit lesson intends to put students through a lab process that will allow them hands on experience in working with invertebrates. Learning about the river ecosystem and the ramifications of eutrophication, teaches students what animals need to survive. Students also make connections

to determine what can be done to keep a river system healthy.

Essential Questions:

1. How is the health of an ecosystem be determined?
2. What are the ramifications of eutrophication?
3. Does wastewater influence freshwater and coastal ecosystems?
4. How can we protect the animal life within a river ecosystem?

Links to National Frameworks:

Content Standard A:
- ✓ Abilities necessary to do scientific inquiry
- ✓ Understandings about scientific inquiry

Content Standard C:
- ✓ Structure and function in living systems
- ✓ Populations and ecosystems
- ✓ Diversity and adaptations of organisms

Content Standard F:
- ✓ Personal health
- ✓ Populations, resources, and environments
- ✓ National hazards

Content Standard G:
- ✓ Nature of Science

Links to Massachusetts Math Frameworks:

Massachusetts (MA) Scientific Inquiry Skills Standards- High School

SIS1. Make observations, raise questions, and formulate hypotheses.
- •Pose questions and form hypotheses based on personal observations, scientific articles, experiments, and knowledge.

SIS2. Design and conduct scientific investigations.
- •Articulate and explain the major concepts being investigated and the purpose of an investigation.
- •Select required materials, equipment, and conditions for conducting an experiment.

SIS3. Analyze and interpret results of scientific investigations.
- •Present relationships between and among variables in appropriate forms.
- •Use results of an experiment to develop a conclusion to an investigation that addresses the initial questions and supports or refutes the stated hypothesis.

SIS4. Communicate and apply the results of scientific investigations.
- •Develop descriptions of and explanations for scientific concepts that were the focus of one or more investigations.
- •Review information, explain statistical analysis, and summarize data collected and analyzed as the result of an investigation.

MA Biology High School Standards

1.1 Recognize that biological organisms are composed primarily of very few elements. The six most common are C, H, N, O, P, and S.

2.3 Use cellular evidence (such as cell structure, cell number, and cell reproduction) and modes of nutrition to describe six kingdoms (Archaebacteria, Eubacteria, Protista, Fungi, Plantae, Animalia). Additionally addresses most of the Scientific Inquiry Skills Standards.

5.2 Describe species as reproductively distinct groups of organisms. Recognize that species are further classified into a hierarchical taxonomic system (kingdom, phylum, class, order, family, genus, species) based on morphological, behavioral, and molecular similarities. Describe the role that geographic isolation can play in speciation.

6.2 Analyze changes in population size and biodiversity (speciation and extinction) that result from the following: natural causes, changes in climate, human activity, and the introduction of invasive, non-native species.

6.3 Use a food web to identify and distinguish producers, consumers, and decomposers, and explain the transfer of energy through trophic levels. Describe how relationships among organisms (predation, parasitism, competition, commensalisms, and mutualism) add to the complexity of biological communities.

6.4 Explain how water, carbon, and nitrogen cycle between abiotic resources and organic matter

in an ecosystem, and how oxygen cycles through photosynthesis and respiration.

Local Frameworks:

North Reading High School Zoology Curriculum Standards:

1. Unit on Animals and their Environments: Students will understand that all life is confined to the area on the earth's surface known as the biosphere. Within the biosphere there can be found a necessary supply of energy from the sun, water, suitable temperature and other resources that make life possible. The condition of these resources and the life they support have co-evolved over time.

2. Unit on Invertebrates: Students will understand that the simplest forms of animal life known to man are called the invertebrates, which comprise several varied phyla with greatly different characteristics. An understanding of these animals will allow students to more deeply understand the tremendous complexity associated with "higher" animals.

3. Unit on Classification: Students will understand that Biologists group animals according to their evolutionary relationships. The number of animal species named to date are believed to be only a fraction of all the living animals that exist or have existed.

Materials Required:

Materials for invertebrate collection:

- Waterproof boots (optional)
- Nets
- Collection buckets
- Tweezers and plastic spoons for picking up animals
- Small Vials
- Latex gloves (if the streamwater quality could be poor)
- Personal flotation devices (PFDs) if the stream is not uniformly shallow
- Ethanol (for preserving)
- Stream Invertebrate Identification sheet (pp. 81–84) and other identification materials
- Dissection Microscopes
- Observation Dishes

Aquarium Set-up:

- Fish Tank
- Air Pump
- Rocks
- Bio Filter
- Guppies
- GloFish (Carolina Scientific)

Water Quality Analysis:

- pH and Total Alkalinity Water Test Strips
- Nitrate and Nitrite Nitrogen Water Test Strips
- Phosphorus, Orthophosphate (reactive) Test Strips

Additional Unit Materials:

- Lab Assignment Outline
- Handout: "There's Something Fishy- the Nitrogen Cycle" curriculum unit, as developed by Jennifer Cosgrove and Julie Ertmann at the University of Missouri-St. Louis (copyright: 2002)
- Argonne National Laboratory's Human Fact Sheet on "Nitrate and Nitrates" (copyright: 2005)
- Access to computer lab with internet access
- PBS single episode: "Rivers of Destiny" http://www.pbs.org/journeytoplanetearth/about/purchase.html
- Handout: Protocol for Collecting Freshwater Invertebrates. National Science Teachers Association

Lesson Development:

Begin by having students set up a freshwater aquarium in the classroom. Students will be responsible for learning about all of the working components of the system and determine what parameters are needed in order to keep the fish in the aquarium alive. An overall explanation of

how nutrient (Water, N, P) cycling will be given. Over the course of the semester students will be expected to monitor the aquarium and care for the fish that live in it. They will be expected to use their knowledge of how fish live in the aquarium in their research of the Ipswich River.

Days 1 and 2:

- Lesson on Nutrient Cycling: Ask students to write what they know about how nitrogen, water, and carbon cycle through an ecosystem. Place students in four groups and have each group work together to diagram out how their assigned nutrient cycles through a system (each group will be given a different nutrient to consider).
- Students carry out the "There's Something Fishy- the Nitrogen Cycle" curriculum unit, as developed by Jennifer Cosgrove and Julie Ertmann at the University of Missouri-St. Louis (copyright: 2002).
- Students read Argonne National Laboratory's Human Fact Sheet on "Nitrate and Nitrates" (copyright: 2005).
- Students read online “Water on the Web” (http://www.waterontheweb.org/under/waterquality/oxygen.html) date last updated: Friday December 07 2007

Day 3:

- Field Study: Students walk to Ipswich Rriver Park (N. Reading, MA) and are introduced to the field of study, how to collect invertebrates and take initial measurements of water quality.
- Nitrogen levels, Phosphorus levels, and pH of river water are recorded in student lab notebooks.

Day 4:

- Lesson on invertebrates: students review powerpoint presentation on major invertebrate phyla (Phylum Annelida; Phylum Arthropoda; Phylum Cnidaria; Phylum Echinodermata; Phylum Mollusca; Phylum Nematoda; Phylum Platyhelminthes; and Phylum Porifera).
- Students are introduced to the Lab assignment that will be due in sections throughout the quarter (See Handout). Have students review sample scientific lab outlines online: Monash University Scientific Lab Outline, (http://www.monash.edu.au/lls/llonline/writing/science/5.xml); “How to write a biology lab report”, Union College (http://www.union.edu/PUBLIC/BIODEPT/ResearchReports.html)

Day 5:

- Questions are posed to the class: What is an ecosystem? What components are needed for a healthy freshwater ecosystem? Students work in groups to brainstorm for answers and later share their answers with the class.
- Students watch the PBS video "Rivers of Destiny" and respond to comprehension questions.
- Homework: Have students refer to the riverventure.org website. Riverventure: Copyright © 2006-2008 ETV Commission

Day 6:

- Introduction to freshwater invertebrates and collection. Powerpoint presentation on the freshwater invertebrates common to the Northeast.
- Introduction to dichotomous keys: Class discussion on “How are these invertebrates identified? “
- Lesson How to use a dichotomous key. Students construct a dichtomous key that keys out five shoes.

Day 7:

- Field Trip to MA Audubon - Students canoe down the ipswich river, sample for invertebrates and learn about basic river ecology from a MA Audubon guide. Students should use this experience as a comparison study.

Day 8:

- Students are given time in the computer lab to work on "Part I" of their lab report and begin research for their "background research" sections.

Day 9:

- Visit to Ipswich River Park-students collect invertebrates to bring back to the lab for analysis; students take water quality measurements.

Day 10:

- Students observe invertebrates under the dissection microscopes. Sketches are made in lab notebooks.

Days 11-20:

- Students continue to work on analysis in the lab and conduct research on the internet. Part II, III, and IV of the lab will be due at different points of the semester.

Concerns: 1. Some schools may not have access to a computer lab, or freshwater field site. In these cases, the lab can be condensed to fit the needs of the classroom.

2. Often students have little experience in working in the field and working with live specimen. Safety and proper field etiquette should be reviewed prior to the start of the lab.

Extension: If resources are available, students set up a second aquarium in which nitrogen levels can be manipulated. Predictions should be made as to how altering the N levels will affect the life in the tank. Nitrogen, Phosphorus and pH should be monitored on a regular basis. Observations should be made to determine how the health of the fish and plant life in the tank are affected based on the levels of nitrogen in the water. This part of the lab can be ongoing throughout the school year. End of the year discussion and analysis can conclude the course.

References: National Science Standards (http://newton.nap.edu/html/nses/6e.html)

Massachusetts Curriculum Frameworks: http://www.doe.mass.edu/frameworks/current.html

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