NATIONAL ESTUARINE RESEARCH RESERVES LESSON PLAN

Natural Laboratories

Theme

National Estuarine Research Reserve System (NERRS)

Links to Overview Essays and Resources Needed for Student Research

http://oceanservice.noaa.gov/topics/coasts/reserves/

Subject Area

Life Science/Earth Science

Grade Level

9-12

Focus Question

How are estuarine research reserves used as "natural laboratories" to improve our understanding of estuarine systems?

Learning Objectives

- Students will describe the National Estuarine Research Reserve System, and will explain how to obtain information on the 26 sites in the System, including the research projects undertaken at these sites.
- Students will explain how a biological organism can be used to detect excess nutrient inputs to estuaries.
- Students will interpret technical data to make predictions about the distribution of nutrients in specific estuaries.

Materials Needed

- (optional) Computers with internet access; if students do not have access to the internet, download copies of materials cited under "Learning Procedure" and provide copies of these materials to each student or student group
- Copies of "NERRS Worksheet" found at the end of this lesson plan, one copy for each student or student group

Audio/Visual Materials Needed

None

Teaching Time

One 45-minute class period, plus time for student research

Seating Arrangement

Classroom style if students are working individually, or groups of 3-4 students

Maximum Number of Students

30

Key Words

Estuary
National Estuarine Research Reserve System
Nutrient
Eutrophication
Nutrient Pollution Indicator

Background Information

Estuaries are water bodies and adjacent wetlands found in areas where rivers flow into much larger bodies of water, and include bays, sounds, marshes, inlets, lagoons, and sloughs. Most estuaries are formed where a river meets the sea, but there are also freshwater estuaries where rivers flow into much larger bodies of freshwater (such as the Great Lakes). Estuaries provide many benefits, including:

- essential spawning and nursery areas for many species, including fish and shellfish important to commercial and recreational fisheries;
- protection for upland areas from flooding and shoreline erosion; and
- habitat and food for estuarine species as well as species that live in other habitats.

Unfortunately estuaries (and the benefits they provide) are threatened by impacts from human activities such as coastal erosion, water pollution, and habitat destruction, as well as a variety of natural disturbances such as winds, waves, heavy rainfall, and severe storms.

The National Estuarine Research Reserve System (NERRS) is a network of 26 estuaries that was established to represent different biogeographical regions of the United States and support long-term research, education, and stewardship of estuarine resources. Within each reserve, field staff work with local communities and regional groups on issues such as nonpoint source pollution, habitat restoration, and how best to cope with invasive species. For more information on these topics, see:

- *http://nerrs.noaa.gov/Background_Bioregions.html*
- *http://oceanservice.noaa.gov/education/kits/pollution/*;
- *http://oceanservice.noaa.gov/education/classroom/lessons/09_coast-manag_point.pdf*;
- *http://oceanservice.noaa.gov/education/classroom/lessons/08_restor_fixit.pdf*;
- *http://oceanservice.noaa.gov/education/classroom/lessons/06_coastal_alien.pdf*;
- *http://oceanservice.noaa.gov/education/kits/estuaries/*; and
- *http://oceanservice.noaa.gov/education/stories/lionfish/*.

Many researchers working in NERRS are supported through the Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET), a partnership between NOAA and the University of New Hampshire. The CICEET Web page (*http://www.ciceet.unh.edu/*) includes a searchable database of more than 100 projects to develop and apply innovative technologies for understanding and reversing the impacts of coastal and estuarine contamination and degradation.

This activity is intended to introduce students to some sources of information about the National Estuarine Research Reserve System and applied research projects that are part of NERRS. In addition, students will gain practice in reading and interpreting scientific reports.

Learning Procedure

1.

Preparation: If students do not have access to the internet, download and copy:

- Introductory essay on National Estuarine Research Reserves (*http://oceanservice.noaa.gov/topics/coasts/reserves/*);

- Pages on Great Bay Reserve, New Hampshire: Site Description, Flora, Endangered Species, Tidal Range, and "Geology & Soil Types" (linked from *http://www.nerrs.noaa.gov/GreatBay/Overview.html*);
- Project Profile and Final Report for the project "Eelgrass as an Indicator of Nutrient Over-Enrichment in Estuaries" (from the CICEET Project Explorer Web page, *http://ciceet.unh.edu/searchprojects.html*, click below the Project Explorer icon, then enter Short in the Coordinator box, select Nutrient Enrichment in the Issue box, select Great Bay in the NERR box, then press the Search button. "Early Detection of Nutrient Over-Enrichment Using Eelgrass Community Response" should appear in the Title box. Click on this title to display the Project Profile and a link to the Final Report (note that the Final Report is 59 pages long and the file size is approximately 5.5 MB).

2.

Briefly review the concept of estuaries. You may want to have students review the tutorial in the "Estuaries Discovery Kit" (*http://oceanservice.noaa.gov/education/kits/estuaries*, and complete portions of the self-test in the Discovery Kit Lesson Plan section. Introduce the National Estuarine Research Reserve System, and tell students that they will be investigating one of these reserves and one of the many research projects that use these reserves as natural laboratories. Provide each student or student group with a copy of the "NERRS Worksheet," as well as copies of the materials downloaded in Step 1 if students do not have access to the internet.

3.

Lead a discussion of students' answers to worksheet questions. The following points should be included:

- Stewardship, research, and education are the three primary purposes for which National Estuarine Research Reserves are established.

- The eight habitats found in the Great Bay Reserve include upland forest, upland field, salt marsh, mudflats, tidal creek, rocky intertidal, eelgrass beds, and channel bottom/subtidal.

- The Great Bay Wildlife Refuge has the greatest diversity of habitats within the Great Bay NERR.
- *Spartina alterniflora* and *Spartina patens* dominate saltmarsh habitats.
- The Great Bay Reserve region is characterized as a transition zone between deciduous forest and coniferous forest.
- The Great Bay Reserve estuary is critical to the wintering of the American bald eagle.
- Tidal flow dominates over freshwater influence in the Great Bay Reserve estuary throughout most of the year.
- Large outcrops of slate provide an important source of stable substrate for macroalgal attachment and contributes to the beaches in the Great Bay Reserve.
- The Great Bay Reserve estuary is representative of a drowned river valley.
- Marsh soils bordering streams within the Great Bay Reserve generally contain high amounts of organic matter and sulfur-containing minerals.
- Man-made loading from coastal watersheds is the major cause of excessive nutrients in estuarine and coastal waters.
- It is difficult to directly measure excessive nutrients in estuaries because they become diluted and dissipate through tidal and current action, as well as plant uptake.
- Dr. Short used eelgrass, *Zostera marina*, as an indicator of nutrient over-enrichment.
- In addition to Great Bay, Narragansett Bay (RI) and Waquoit Bay (MA) were used as research sites for Dr. Short's project.
- Plant morphology and nutrient content of leaf tissue were used to create an early indicator of nutrient over-enrichment.

- Plant morphology and nutrient content were combined to provide a single measurement of early nutrient over-enrichment by calculating the ratio of leaf tissue nitrogen content to leaf mass. This ratio is called the Nutrient Pollution Indicator (NPI).

- Leaf mass is negatively related to leaf tissue nitrogen content; so, higher concentrations of nitrogen in leaf tissue correspond to a reduction in leaf mass. This is a good opportunity to distinguish between correlation and causality: This research shows that a reduction in leaf mass coincides with higher tissue nitrogen concentrations, but does not show that one response causes the other.

- Dr. Short's project developed an interactive CD-ROM to explain the step-by-step procedures for determining gradients of nutrient over-enrichment within estuaries; monitoring long-term changes in nutrient over-enrichment at specific sites; identifying sources of non-point nutrient pollution; and comparing the nutrient status of different estuaries.

- In samples from Waquoit Bay, leaf mass was highest in plants from down-estuary, while tissue nitrogen was highest in plants from up-estuary.

- Between April 1998 and April 2000, leaf nitrogen content in plants from Great Bay Estuary was highest during the spring.

The Bridge Connection

www.vims.edu/bridge/ – Click on Ocean Science Topics in the navigation menu to the left, then Habitats, then Estuary.

The "Me" Connection

Have students write a brief essay describing three ways in which estuaries are personally important (e.g., recreation, fishing, source of seafood, protection from erosion caused by storms, etc.), and how they might directly benefit from the National Estuarine Research Reserve System.

Extensions

1. Have students select other NERRS estuaries or projects in the CICEET project database, and prepare brief reports about these systems or projects.

2. Visit *http://oceanservice.noaa.gov/education/kits/estuaries/* and *http://nerrs.noaa.gov/Education/Curriculum.html* for more information and activities related to estuaries.

Resources

http://oceanservice.noaa.gov/education/kits/estuaries/ – NOAA's Estuary Discovery Kit, with a tutorial, roadmap to resources, and lesson plans on estuaries

http://nerrs.noaa.gov/Education/k12Educators.html – Information on education programs offered at National Estuarine Research Reserve sites, including curricula, Powerpoint presentations, and lesson plans

http://ciceet.unh.edu/searchprojects.html – The CICEET Project Explorer, which provides a visually-stimulating and user-friendly way to experience the CICEET project database.

www.ocrm.nos.noaa.gov/pdf/NERRLessonsLearned.pdf – Polluted Runoff: Lessons Learned from the National Estuarine Research Reserve System

http://www.epa.gov/owow/estuaries/kids/ – Games and activities about estuaries produced through the National Estuary Program

http://www.onr.navy.mil/focus/ocean/ – Oceanography site from the Office of Naval Research including online quizzes and activities. See the Habitats section for information and activities about estuaries.

http://www.ncnerr.org/education/estnet/index.html – Estuary-Net Project; an online project for grades 9-12 to help solve non-point source pollution problems in estuaries and their watersheds

National Science Education Standards

Content Standard A: Science as Inquiry
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard C: Life Science
- Interdependence of organisms

Content Standard D: Earth and Space Science
- Geochemical cycles

Content Standard E: Science and Technology
- Understandings about science and technology

Content Standard F: Science in Personal and Social Perspectives
- Personal and community health
- Population growth
- Natural resources
- Environmental quality
- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

Links to AAAS "Oceans Map" (aka benchmarks)

5D/H3 – Human beings are part of the Earth's ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems.

NATIONAL ESTUARINE RESEARCH REVERVES WORKSHEET

NERR Worksheet

Begin research for the following questions at *http://oceanservice.noaa.gov/topics/coasts/reserves*.

1. What are three primary purposes for which National Estuarine Research Reserves are established?

2. What are eight habitats found in the Great Bay Reserve?

3. Which area within the reserve has the greatest diversity of habitats?

4. Saltmarsh habitats are dominated by which plant species?

5. Are forested areas within the Great Bay Reserve classified as deciduous forests or coniferous forests?

6. The Great Bay Reserve estuary is critical to the wintering of what protected species?

7. Does tidal flow or freshwater flow have the dominant influence on water movement in the Great Bay Reserve estuary throughout most of the year?

8. What geological formation provides an important source of stable substrate for macroalgal attachment and contributes to the beaches in the Great Bay Reserve?

9. The Great Bay Reserve estuary is representative of what type of geological formation?

10. Marsh soils bordering streams within the Great Bay Reserve generally contain high amounts of what substances?

One of the major sources of water pollution in the United States is contaminated runoff. Estuaries in the National Estuarine Research Reserve System provide natural laboratories for studying this problem. From 1997 to 2000, Dr. Frederick Short of the University of New Hampshire led a research program to develop a biological method for detecting excess nutrient inputs to estuaries. Use the CICEET Project Explorer (*http://ciceet.unh.edu/searchprojects.html*) to answer the following questions. (Hint: the Project Profile and Final Report for Dr. Short's project contain all the information you need).

11. What is the major cause of excessive nutrients in estuarine and coastal waters?

12. Why is it difficult to directly measure excessive nutrients in estuaries?

13. What biological species did Dr. Short use as an indicator of nutrient over-enrichment?

14. In addition to Great Bay, what other NERRS sites were used in this project?

15. What responses of the indicator organism were used to create an early indicator of nutrient over-enrichment?

16. How were these responses combined to provide a single measurement of early nutrient over-enrichment?

17. Is the mathematical relationship between these responses positive or negative?

18. Dr. Short's project developed an interactive CD-ROM to explain the step-by-step procedures for what four types of investigation?

19. In samples from Waquoit Bay, were leaf mass and tissue nitrogen highest in plants from the mouth of the estuary (down-estuary) or near the head of the estuary (up-estuary)?

20. During what season was leaf nitrogen content highest in plants from Great Bay Estuary between April 1998 and April 2000?