Unraveling the Mystery of the Marsh: Training Students to be Salt Marsh Scientists

By Mary Carla Curran, Ph.D. and Tara Fogleman

Salt marshes serve as natural buffers that protect coastal *communities from hurricanes and storm surges and provide an important habitat for many commercial species. With increasing coastal development and other alterations that affect these areas, including the threat of increased hurricane activity due to possible global warming, it will become important for students to be aware of the benefits of protecting our salt marsh ecosystems. In these activities, high school students will learn about the characteristics of a salt marsh by visiting a field site and collecting data for several parameters, including stem density, porewater salinity, and soil temperature. The students will then analyze data collected by scientists affiliated with the Georgia Coastal Research Council (GCRC) to determine trends related to the recovery of a salt marsh exhibiting dieback characteristics.*

BACKGROUND INFORMATION

Salt marshes are intertidal habitats that form in protected areas such as the edges of estuaries and the back sides of barrier islands. These areas are flushed by the tides as water from the ocean rises and recedes. During high tide, the marsh is flooded with salty water from the ocean. This influx of water stirs up the bottom sediments and provides nutrients for marsh plants as well as phytoplankton, which are plant-like organisms that float with the tides and currents. Incoming water during high tides can also bring animals to the estuary, as currents bring larval forms of many species, including crabs and fishes. When the tide goes out towards the ocean, the receding water removes debris and decaying material from the salt marsh, therefore providing food and nutrients to nearshore environments.

One species of salt marsh plant is *Spartina alterniflora* or smooth cordgrass. Smooth cordgrass is a salt-tolerant plant characterized by long, narrow leaves and strong, spreading roots that help to stabilize the soggy sediment during high tides and river flooding. Cordgrass plants vary in height, with stems reaching up to two meters (Reidenbaugh 1983). Like other salt marsh plants, smooth cordgrass displays cyclical changes in height according to season, with peaks occurring during the months of September and October (Reidenbaugh 1983; Morris and Haskin 1990).

Though the salt marsh may appear to be a vast expanse of nothing but grass, mud, and water, many animals inhabit this productive area that offers abundant food and protection from predators. Organisms living in the salt marsh have adapted to survive in a tidally influenced habitat. Because of the daily tides, changes in rainfall, and seasonal changes, the plants and animals of the marsh experience cyclical fluctuations in salinity, temperature, and air exposure. Tidal currents and the removal or deposition of sediment also lead to cyclical changes in the marsh environment.

Since the 1990s, scientists have discovered several areas of salt marsh dieback in several coastal states in the eastern and Gulf coasts of the U.S., including Georgia, Louisiana, Florida, Virginia, Connecticut, Massachusetts, and South Carolina. These sites, which were once heavily vegetated by smooth cordgrass and black needlerush (*Juncus roemerianus*) became open mudflats with little or no vegetation. Some dieback areas persisted through a number of seasons and were often surrounded by healthy vegetation.

Salt marsh dieback may be associated with a variety of factors. Many scientists from the Georgia Coastal Research Council (GCRC) believe that the dieback in coastal Georgia could be related to a four-year drought that ended in 2002. Researchers are currently studying dieback sites to determine the presence of characteristics related to drought-like conditions, including temporary soil desiccation, a decrease in water availability, and an increase in fungal communities, toxic metals, or soil salinity. Scientists are also recording changes in live and dead plant densities and the abundance of invertebrate species, including mussels, fiddler crabs, and snails. By monitoring dieback sites over a period of several years, researchers hope to discover a pattern that will help identify what is causing the loss of marsh vegetation.

In 2003 and 2004, GCRC scientists monitored the physical, chemical, and biological characteristics of healthy marsh and areas of marsh dieback. Scientists visited three sites (Melon Bluff, Jerico River, and Isle of Wight) on a quarterly basis at low tide. At each site, scientists assessed replicate quadrats in healthy and dieback areas. Data were collected for the number of live plants, the number of dead plants, the heights of the five tallest plants, the number of snails, and the number of crab holes. Other factors, such as soil temperature (°C), porewater pH, and porewater salinity (ppt), were also recorded. Soil temperature was measured using a soil thermometer that was inserted into the sediment outside of the quadrat. Scientists dug a hole outside of the quadrat to obtain porewater, which seeped into the hole during the course of a few minutes. Salinity was measured using a refractometer and pH was measured using a handheld meter.

It is important we protect salt marshes because they provide numerous benefits for the coast and its inhabitants. Salt marshes filter both surface water and groundwater, and these wetlands protect adjacent areas from damage created by waves, storms, and floods. Estuaries and the surrounding salt marsh also provide a habitat and feeding area for many marine species, including several commercially important organisms such as blue crabs, oysters, and species of shrimp.

ACTIVITY I: VISITING THE SALT MARSH

In this lesson, students collect data to assess the health of a local salt marsh ecosystem, including measurements of plant height and abundance, sediment temperature, porewater salinity, and the abundance of periwinkle snails. This activity fits well with the National Science Content Standards for Life Science for students in grades 9-12 because it addresses the interdependence of organisms found in the salt marsh. The activity also addresses the concept that the ocean supports a great diversity of life and ecosystems, which is one of the ocean literacy principles outlined by the Ocean Literacy Network.

GRADE LEVEL

Grades 9-12: Biology, Ecology, or Environmental Science

TEACHING TIME

2 hours (plus travel time) for field component and 1 hour for analysis of data

LEARNING OBJECTIVES

The student will be able to collect data to assess salt marsh health.

The student will be able to graph and analyze the data collected during the field study.

MATERIALS

- 0.25 meter squared quadrats made of PVC pipe
- Measuring tape
- Meter sticks (one per group)
- Data collection sheets (one per group)
- Pencils (at least one per group)
- Clipboards (one per group)
- Soil thermometers (maximum of one per group)
- Refractometers (maximum of one per group)
- Plastic pipette or eyedropper (one per group)

PROCEDURES

1. Talk with your local government agency to select an appropriate field site that can be accessed easily. Many agencies require teachers to submit a formal request to use a site, so ensure that appropriate paperwork has been completed before bringing students to the site.
2. Prior to visiting the site, students should view a map of the area, including nearby waterways and landmarks. Explain that students will be comparing quadrats according to distance from the waterway. It may be helpful to draw the marsh site and the location of the quadrats on the board for students to see. Students should also be aware that they must not remove or damage any item from the marsh while visiting. Review all applicable safety procedures with the students before visiting the site.
3. When students first arrive at the site, have them assist you in placing the quadrats in three lines parallel to the waterway (see Layout of Quadrats on the NMEA website at http://www.marine-ed.org/current). Use the measuring tape to place quadrats correctly. Remind students to avoid walking in the quadrat area and/or damaging any of the marsh life.
4. For a sample quadrat, demonstrate all data collection techniques as indicated on the Field Study Methods handout (see p. 30). Answer any questions that the students have about the data collection.
5. Divide students into groups of 2 or 3 students. Assign groups to specific quadrats. If there is a large number of groups, have 2-3 groups assess the same quadrat.
6. After recording the quadrat number (such as 1A or 3B), students should collect data for all parameters listed on the Field Study Data Collection handout (total number of live stems, heights of the five tallest stems, total number of snails, porewater salinity, and sediment temperature). This sheet can be accessed and printed by visiting the NMEA website at http://www.marine-ed.org/current.
7. After student groups have finished collecting data for the assigned quadrat, direct students to move to another quadrat. After student groups have collected data for at least three quadrats, collect data sheets and return to the classroom.
8. Compile data for students to graph and analyze. It might be best to list all data entries in a spreadsheet using Microsoft Excel or comparable software. Visit the NMEA website at http://www.marine-ed.org/current and view Sample Spreadsheet for tips.

9. Students should use the data provided by the teacher to generate graphs using Microsoft Excel or comparable software. Using these graphs, the students should complete the Field Study Data Analysis handout. This sheet can be accessed and printed by visiting the NMEA website at http://www.marine-ed.org/current.

ASSESSMENT

Collect Field Study Data Analysis sheets and grade to ensure that the students have met the learning objectives.

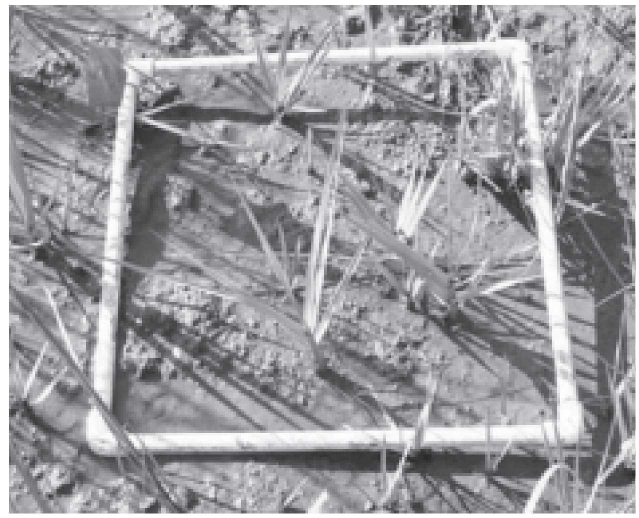
EXTENSIONS/MODIFICATONS

Have the students write a journal entry about their experience in the salt marsh. Did it look like they had expected? What did the student see? What did the mud look and feel like? What other plants and animals did the student observe? Include a sketch with the entry.

This activity can be modified to survey other suitable habitats if a salt marsh habitat is not easily accessible. For example, the students could assess changes in plant density, stem height, or species diversity in relation to distance from a creek, river, or road. For those in coastal habitats, students could assess changes in shell distribution and size in relation to distance from the water.

ACTIVITY II: ANALYZING DATA

Marsh dieback was reported in several coastal states, including Georgia, Louisiana, Florida, and South Carolina, between 1999 and 2003. Dieback sites were characterized by open mudflats with little or no vegetation, and many of these areas persisted through a number of seasons and were often surrounded by



During this activity, students use frames built from PVC pipes to mark specific areas of salt marsh for their study.

healthy vegetation. In this activity, high school students will use data collected by scientists affiliated with the Georgia Coastal Research Council (GCRC) to determine trends related to the recovery of a salt marsh exhibiting dieback characteristics. This activity fits well with the National Science Content Standards for Life Science for students in grades 9-12 because it addresses the interdependence of organisms found in the salt marsh. The activity also addresses the concept that the ocean supports a great diversity of life and ecosystems, which is one of the ocean literacy principles outlined by the Ocean Literacy Network.

GRADE LEVEL

Grades 9-12: Biology, Ecology, or Environmental Science

SAVE THE DATE FOR NMEA 2008!!!

The Georgia Association of Marine Education (GAME) graciously invites you to spend a week in coastal Georgia with marine education enthusiasts from around the nation, July 21-24, 2008. Come learn, explore, and dance with us!

One World, One Water: NMEA 2008, will team cutting-edge research with innovative education. Come celebrate the exciting field of marine science and Georgia's take on marine education and collaboration. Plunge into Ocean Literacy, The International Year of the Reef, southeastern estuarine ecosystems, and local fisheries. Fresh and salt water mingle where land meets sea in Savannah. Experience the Georgia coast as the locals do. Breathe in the sweet salt marsh and go with the flow of the tides. Paddle a tidal creek or cast net for wild Georgia shrimp. Experience the broad sandy beaches of nearby Tybee Island. Explore Georgia's wild barrier islands or stroll through historic downtown Savannah.

This will be a one of a kind conference with hundreds of your colleagues, old friends, and new acquaintances. Check out GAME's website at www.gamarine-ed.org, for conference details, tentative conference overviews, hotel information, and more. Or, please email Mare Timmons at mare@uga.edu for preliminary details.

One World • One Water • 2008 NMEA • SAVANNAH • GEORGIA • United in Marine Education

TEACHING TIME

Two 45-minute class periods

LEARNING OBJECTIVES

The student will be able to identify characteristics of marsh dieback.

The student will be able to identify potential reasons for marsh dieback.

The student will be able to analyze data on marsh dieback and determine trends related to the recovery of the salt marsh.

MATERIALS

- Data set (from GCRC website, see link below)
- Pencil

PROCEDURES

1. Instruct students to find the appropriate graphs by visiting the GCRC website at www.gcrc.uga.edu/MarshDieback/nov04_plots.pdf
2. Direct students to use the graphs to complete the following (either on paper or during a class discussion):
    - What are some of the characteristics of an area of marsh dieback? How do dieback (affected) sites compare to areas of healthy (reference) marsh?
    - Explain any differences between the number of dead plants in the healthy marsh as compared to the areas of dieback during the first half of the study. Were there any changes in this pattern towards the end of the study?
    - Write a statement that indicates when plant heights are tallest and when they are shortest for a healthy marsh site.
    - What would you assume to be the dominant type of vegetation at Melon Bluff and Jerico River? What plant species is the dominant type of vegetation at Isle of Wight?
    - What might cause porewater salinity measurements to be higher during specific times of the year?
    - Do you think that the dead marsh is recovering? Support your answer with data from the GCRC graphs.
    - How might dieback affect the organisms that live in the salt marsh?
    - What are some other research questions that come to mind when reviewing the salt marsh data?
    - What other ecosystem or habitat could you sample using a similar sampling design? Are there any modifications that would have to be made to the procedures? List possible research questions that could be answered using this sampling method.

This shows a marsh die-back site.

If the students participated in the visit to the salt marsh (as presented in Activity I), encourage them to draw from their personal observations during that visit when answering these questions. Students may also be interested in information about marsh dieback found at these websites: www.gcrc.uga.edu/FocusAreas/marsh_dieback.htm and www.gcrc.uga.edu/MarshDieback/marsh_newsarticles.htm.

ASSESSMENT

If the students answer the above questions on paper, a formal assessment can be made. Informal assessment can be made of student understanding by evaluating student responses given during a class discussion of the data.

MODIFICATIONS/EXTENSIONS

If computers with internet access are not available, the teacher can print the data prior to the lesson for student use. The graphs are best printed in color.

Have students write a request for an imaginary grant for funds to continue research on marsh dieback. The request should include information from the current study (including any trends that the students observed during the exercise), the amount of financial assistance needed to complete the project, and ideas for further research.

REFERENCES

Curran, M.C. 2003. Learning the metric system: Calculating fish distributions, densities, and means using candy fish. *Current: The Journal of Marine Education* 18:28-31.

Fogleman, T. 2006. *Georgia's estuaries: A teaching unit for students, an investigation of the accuracy of student-collected data and a case study of terrapin habitat.* Master's Thesis. Savannah State University.

Fogleman, T and M.C. Curran. 2006. Save our salt marshes! Using educational brochures to increase student awareness of salt marsh ecology. *Current: The Journal of Marine Education* 22:23-35.

Morris, J.T. and B. Haskin. 1990. A 5-yr record of aerial primary production and stand characteristics of *Spartina alterniflora*. *Ecology* 71:2209-2217.

Reidenbaugh, T.G. 1983. Tillering and mortality of the salt marsh cordgrass, *Spartina alterniflora. American Journal of Botany* 70:47-52.

ACKNOWLEDGMENTS

The authors would like to thank Janice Flory and Merryl Alber of the GCRC and the University of Georgia for their assistance in the editing of this manuscript, and the 2005 and 2007 Marine Science classes of St. Andrew's School for participating in the design and testing of these activities. Tara Fogleman would also like to thank Dr. Joe Richardson and Venetia Butler for their assistance during the development and editing of these teaching activities. Funding for the development and presentation of this project was provided by Georgia Sea Grant and a NOAA/Living Marine Resources Cooperative Science Center grant.

TARA FOGLEMAN obtained her Master of Science degree in Marine Sciences from Savannah State University. She currently teaches high school biology and marine science at St. Andrew's School in Savannah, Georgia.

DR. MARY CARLA CURRAN obtained her Ph.D. in Biological Oceanography from the Joint Program of the Woods Hole Oceanographic Institution and the Massachusetts Institute of Technology. Dr. Curran has designed K-12 activities using data from her shrimp, fish, and marsh studies.

RELATED BRIDGE RESOURCE PAGES:

The Blue Crab's Chesapeake Journey:
http://www.vims.edu/bridge/index_archive1102.html

Be A Bay Investigator:
http://www.vims.edu/bridge/index_archive0699.html

New Jersey Marine Science Consortium Lesson Plans:
http://www.njmsc.org/Education/Lesson_Plans/Lesson_Plans.htm

Marsh Munchies:
http://www.njmsc.org/Education/Lesson_Plans/MarshMunchies.pdf

Natural History of Nova Scotia Topics & Habitats–Tidal Marsh:
http://museum.gov.ns.ca/mnh/nature/nhns/h2/h2-5.htm

FIELD STUDY METHODS

Name ______________________________ Date ____________________

PROCEDURE:

1. Record the quadrat number above the data table (see the NMEA website for other handouts).

2. Push the soil thermometer into the ground immediately outside a corner of the quadrat. Don't record the temperature now—allow the thermometer to adjust to the correct temperature while you are assessing your quadrat.

3. Count the total number of live stems (stems with any green on them) in your quadrat. Write that number in the box next to "Total number of live stems."

4. Examine the live stems to determine the five tallest stems. Measure them using the meter stick. Ensure that you are recording height to the nearest 0.1 cm. Gently pull the stem upwards so that you measure the full height of each stem. Record the five heights, average the heights, and place the average height in the bolded box.

5. Count the total number of snails in your quadrat, including the snails on the surface of the mud and those crawling on the stems or creases of the plant. Small snails can often be found hiding between the leaves and the stem, so peel back the outermost leaves to check for them. Record the number of snails in the appropriate box.

6. Record the soil temperature in degrees Celsius (°C).

7. Use the pipette to collect water that has pooled in a nearby footprint or the hole left by the thermometer. Place a few drops of the water on the refractometer and look through the viewer to find the salinity, ensuring that the refractometer is level. If the numbers are hard to read, you may be able to focus the eyepiece. Look for where the white and blue meet and record the number located on the scale to the right at this delineation point. If it is fuzzy, your sample may be too muddy and you may need to rinse off the lens with more sample water and try again. Take this measurement two or three times to ensure that a reliable value was observed.

Note: It is not necessary to rinse the refractometer between samples. Be sure that you have allowed enough of your sample to flush out the previous water that was placed on the refractometer.