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Enhancing Climate Education for a Changing Chesapeake Bay

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The Chesapeake Bay National Estuarine Research Reserve in Virginia (CBNERR), located at the Virginia Institute of Marine Science (VIMS), coordinates *Climate Education for a Changing Bay* (*CECB*), a program providing meaningful watershed educational experiences (MWEEs) that are fully integrated and systemic into the classroom curriculum for ninth grade students in Gloucester and Mathews County, Virginia. *CECB* also provides interrelated professional development opportunities for teachers in the region. The overall objective of *CECB* is to improve climate literacy within local high schools by advancing the use of locally relevant environmental data and information in classroom curriculum, field experiences, and professional teacher training. Students have three experiences with CBNERR Education staff: a classroom visit will be the students' initial exposure to climate change science and the impacts that it will have on natural ecosystems, coastal communities, and local issues; a field experience on the schoolgrounds outlined in the activity; and a field experience at VIMS. Throughout the program, salt marshes are used as a model ecosystem to study the impacts of climate change.

BACKGROUND

The impacts of climate change on coastal areas will be seen across a diverse suite of physical and chemical variables including changes in air, water, and soil temperatures; water chemistry (e.g., pH, dissolved oxygen, and inundation of saltwater); the quantity, timing, and intensity of precipitation; the intensity of storm events; and changes in sea level. Understanding changes in sea level and inundation, and the associated responses of critical habitats and coastal communities are all key to the Chesapeake Bay region. Relative sea level rise rates and associated impacts within the southern Chesapeake Bay region represent some of the highest rates and threats reported along the U.S. Atlantic coast (Boon et al. 2010). Coastal wetlands are highly valuable and productive ecosystems, which have long adapted to changing sea levels. There is a heightened level of concern about the impacts of sea level rise. However, concern is justifiably given that current and projected rates of sea level rise reflect a greater increase over what we experienced during the last century. Salt marshes are a key habitat to the coastal area, and one that faces immediate impacts due to sea level rise.

Salt marshes provide many ecosystem services. They provide feeding, spawning, and nursery habitats for fish, shellfish, and birds. Furthermore, salt marshes and upland forests

Figure 1. Goodwin Island, part of the National Estuarine Research Reserve in Virginia, is a study site for the data used in this lesson. Courtesy of CBNERRVA Stewardship Program

associated with estuaries act as filters to remove excess nutrients and contaminants from storm water runoff. Marshes also help with flood and erosion control, acting as sponges and stabilizing the sediment. Many people also benefit from the marsh, whether recreationally through fishing, crabbing, and boating; or economically through a related career, such as environmental consulting, environmental education, or the seafood industry. Organisms living in the salt marsh face many environmental parameters on a daily basis, such as tides, waterlogged soils, temperature, and salinity. While some animals and plants have unique adaptations that allow them to thrive in this environment, ultimately elevation determines the zonation of the marsh paired with competition for space. Marshes have different zones based mainly on elevation, and different plants and animals characterize each of the zones. Over time, sediment builds up, and the marsh begins to grow vertically, leading to the development of zones.

While marshes can grow vertically through sediment build up, there is concern whether the deposition of sediment is keeping up with the rate of sea level rise. Marsh plants

are expected to respond to sea level rise by migrating toward high elevations. This process is being monitored at Sentinel Sites and by the National Estuarine Research Reserves (NERRS). Surface elevation is an important structural component of low-lying coastal areas (Scott and Hensel 2007). NERRS scientists are using Surface Elevation Tables (SETs), portable measuring instruments deployed atop wetland vertical benchmarks, to measure millimeter-level changes in surface elevations over time (see https://www.youtube.com/watch?v=KRRKWnmOHwo). Housing, infrastructure, and other human modifications are expected to limit the space of this potential marsh plant migration. Coastal counties continue to grow, placing more stress on their surrounding ecosystems. Not only does development impact marsh regression, development can also cause a significant amount of sediment to runoff, increasing the turbidity. As people become more aware of climate change and its associated impacts, hopefully we can reduce our impact on the environment.

ACTIVITY

EXAMINING SEA LEVEL RISE SCENARIOS THROUGH MOCK MARSH TRANSECTS

Students will work in groups to survey a mock, locally relevant, marsh habitat that includes dominant plant community types. Students use elevation data to construct and interpret a profile of the mock landscape. Students will understand local vegetative species found in each marsh zone, and how sea level rise may impact the marsh habitat. Students will be able to interpret elevation and elevation changes in a real world, hands-on example. This activity fits well with the National Science Content Standards for Earth Science students in grades 9 to 12. The activity also addresses the concept that the ocean and humans are inextricably interconnected, which is one of the literacy principles outlined by the Ocean Literacy Network. The activity highlights three Climate Literacy principles: Life on Earth depends on, is shaped by, and affects climate; human activities are impacting the climate system; and climate change has consequences for the Earth system and human lives.

OBJECTIVES

- Explain the difference between tidal elevation, storm surge, and sea level rise due to climate change.
- Measure the impacts of sea level rise on marsh communities.
- Construct a marsh transect following a set of instructions (this is measurable).

TEACHING TIME

One 90-minute class period

Figure 2. Scott Lerberg, Stewardship Coordinator for CBNERR, demonstrates his SET work. Courtesy of Jaclyn Beck

LEARNING PROCEDURE

1. Hand out instructions and corresponding questions to each group (See Example Student Worksheet on page 11).
2. Explain to the groups that they are creating a marsh transect, and they need to imagine that they are starting at the water's edge and working away from the water toward a high elevation.
3. All groups should work parallel to each other with their transect line running in the same direction.
4. Students are divided into three groups: Tides, Storm, and Sea Level Rise. Each group follows similar instructions to create a different transect line.
   a. Run the transect line out 12m along the length of the schoolyard.
   b. Every 1.5m along the transect line hammer a stake into the ground roughly 1 inch deep. Be sure the stake is secure and standing up straight.
   c. Place the PVC pipes on top of the stakes. The mud painted on the pipes should increase in elevation as you get further away from your starting point, and should be placed so that the mud is touching the ground.
   d. Current mean high tide is 0.33m above sea level. Measure from the ground up to 0.33m and place a piece of blue duct tape on the PVC pole at that location. Do this on all of the poles until that elevation is no longer above the mud.

FIgure 3. Students place PVC poles along their transect line to show marsh elevation increasing with distance from the water's edge. Courtesy of Kristen Sharpe

e. Use blue rope and connect it along the poles at the locations with the duct tape. If there is no duct tape at the pole, then drop the rope there. The blue rope represents high tide.

f. Now, attach the three marsh plants (Smooth cordgrass, *Spartina alterniflora;* Saltmeadow hay, *Spartina patens; and* Marsh elder, *Iva frutescens*) to a pole or zone that they are most likely to thrive in.

g. Note: each group will have different instructions for this step.

Tides: During a spring tide, water level is 0.46m above mean sea level. Measure from the ground up to 0.46m and place a piece of white duct tape on the PVC pole at that location. Do this on all of the poles until that elevation is no longer above the mud. Take your white rope and connect it along the poles at the locations with the duct tape. If there is no tape at the pole, then drop the rope at the last pole with tape. The white rope represents spring tide.

Storms: During Hurricane Isabel, the water level reached 1.9m above sea level. Measure from the ground up to 1.9m and place a piece of green duct tape on the PVC pole at that location. Do this on all of the poles until that elevation is no longer above the mud. Take your green rope and connect it along the poles at the locations with the duct tape. If there is no tape at the pole, then drop the rope at the last pole with tape. The green rope represents the water level during Hurricane Isabel.

Sea Level Rise: By the year 2050, sea level is projected to be 0.5m above current mean sea level. Measure from the ground up to 0.5m and place a piece of red duct tape on the PVC pole at the location; do this on all of the poles until the elevation is no longer above the mud. Take your red rope and connect it along the poles at the location with the duct tape. If there is no tape at the pole, then drop the rope at the last pole with tape. The red rope represents 2050 sea level. With an accelerated rate, by the year 2050, sea level is projected to be 0.86m above current mean sea level. Measure from the ground up to 0.86m and place a piece of red duct tape on the PVC pole at that location. Do this on all of the poles until that elevation is no longer above the mud. Take your other red rope and connect it along the poles at the location with the duct tape. If there is no tape at the pole, then drop the rope at the last pole with tape. This red line represents the accelerated projection of sea level in 2050.

h. Change the location of your plants, if needed, based on the changes to your water level.

5. Take a step back from your transect and make some observations about what you see.

6. Answer the questions on the Example Student Worksheet about your transect alone.

7. Once all of the groups have created their mock transects and answered the attached questions, bring everyone together on one side of the activity to review.

8. Have students explain their observations. Point out the different sea levels and changes in elevation throughout the poles. Have students tell you the water level represented by the different colored ropes.

9. Ask students the following questions:

- What is a spring tide? What happens during a spring tide?
- How did you decide where to place your plants?
- What influences marsh zonation?
- What is the highest water level represented? What are some impacts that were faced during this storm?
- Why are there two different water levels showing projected sea level by the year 2050? How do scientists get these numbers?
- What are some impacts we could face in 2050 due to a higher mean water level?
- What will the marsh do as sea level rises?
- How can we reduce our impact on climate change?

Figure 4. Student placing smooth cordgrass (*Spartina alterniflora*) along the marsh transect line. Courtesy of Kristen Sharpe

Figure 5. Three transect lines are completed to show marsh elevation and sea level during Hurricane Isabel, high tide, spring tide, and projected sea level rise in the year 2050. Courtesy of Sarah Nuss

EXTENSION

Create a long vertical ruler and have students place known elevations on the ruler (i.e., water levels from the activity, known area elevations within the community, such as school elevation, main street elevations, etc.). A good place to look for basic elevation information is Google Earth. This allows students to see how all of the elevations relate to each other within vertical space. Please visit our website for a complete listing of activities, as well as the VIMS site at www.vims.edu/cbnerr.

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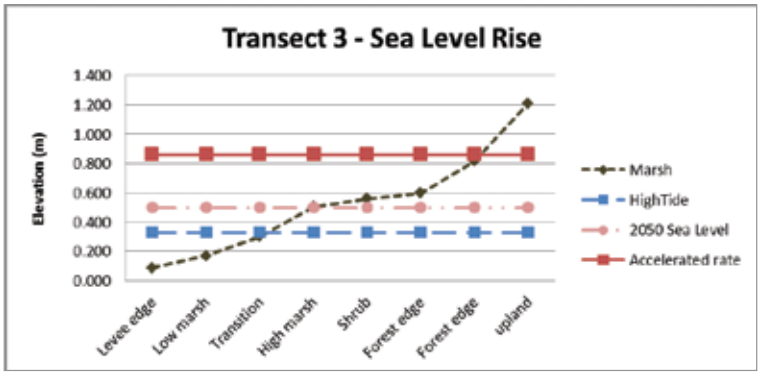
EXAMPLE STUDENT WORKSHEET
GROUP 3 – SEA LEVEL RISE MEMBERS

Your group will be completing a mock transect of a marsh habitat. You may use this graph as a reference when completing your transect. The numbers that you will use are listed below. For this activity, "0" represents current mean sea level.

High Tide Elevation: 0.33m

Projected Sea Level by 2050: 0.5

Accelerated rate Sea Level by 2050: 0.86m.



1. Run the transect line out 12m along the length of the school yard, walking towards the woods, away from the benchmark.

2. Every 1.5m along your transect line, hammer a stake into the ground roughly 1 inch deep (*use caution, group members involved in this step must wear gloves, the hammer is to be used ONLY on the stakes*). Be sure that the stake is secure and standing up straight.

3. Place the PVC pipes on top of the stakes, the mud painted on the pipes should increase in elevation as you get closer to the woods. See the graph above for an example, the brown line represents the elevation of the mud. *Check to make sure you are correct before moving on!*

4. Current mean high tide is 0.33m above mean sea level. Measure from the ground up to 0.33m and place a piece of blue duct tape on the PVC pole at that location. Do this on all of the poles until that elevation is no longer above the mud. Don't press tape down all the way!

5. Take your blue rope and connect it along the poles at the location with the duct tape. If there is no tape at the pole, then drop the rope there. The blue rope represents high tide.

6. Now Velcro the three plants on to the pole or zone that they are most likely to thrive in. Remember smooth cordgrass can be regularly inundated, saltmeadow hay is irregularly inundated, and marsh elder is rarely inundated.

7. By the year 2050, sea level is projected to be 0.5m above current mean sea level. Measure from the ground up to 0.5m and place a piece of red duct tape on the PVC pole at that location; do this on all of the poles until that elevation is no longer above the mud.

8. Take your red rope and connect it along the poles at the location with the duct tape. If there is no tape at the pole, then drop the rope at the last pole with tape. The red rope represents 2050 sea level.

9. With an accelerated rate, by the year 2050, sea level is projected to be 0.86m above current mean sea level. Measure from the ground up to 0.86m and place a piece of red duct tape on the PVC pole at that location. Do this on all of the poles until that elevation is no longer above the mud.

10. Take your other red rope and connect it along the poles at the location with the duct tape. If there is no tape at the pole, then drop the rope at the last pole with tape. This red line represents the accelerated projection of sea level in 2050.

11. Change the location of your plants should you need to based on the water levels from sea level rise.

12. Everyone take a step back from your transect and make some observations about what you see on a sheet of paper. (Find the complete list of questions and student worksheets for the full activity posted on the **website**.)

13. Please answer the questions based on your transect alone.