Examining Sea Level Rise Scenarios Through Mock Marsh Transects

Grade Level: 9th-12th

Subject Area: Earth Science, Environmental Science, Oceanography

Virginia Standards of Learning: ES. 1, ES. 2, ES. 11

Objectives:
Students will:

- Differentiate between tidal elevation, storm surge, and sea level rise due to climate change
- Construct a mock marsh transect displaying different sea level scenarios
- Discuss the impact of sea level rise on marsh communities
- Make inferences about climate change from the constructed lesson and displayed data

Summary:
Students will work in groups to survey a mock, locally relevant, marsh habitat that includes dominant plant community types. Students will 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.

Vocabulary: elevation, inundation, sea level rise, climate change, transect, marsh

Materials:

14 - 5' PVC poles (¾-inch diameter)
10 - 7' PVC poles (¾-inch diameter)
3 metric transect lines
3 metric tape measures
3 sets of printed plants
3 clipboards
3 blue duct tape rolls
1 white duct tape roll
1 red duct tape rolls
1 green duct tape roll
3 Blue ropes
1 White rope
1 Green rope
2 Red ropes
3 sets of printed plants
Printed instructions and questions
PVC bases

Procedure:

**Please read the background information and follow the set-up instructions in Appendix1, prior to doing the activity with your students. PVC poles will need to be cut and painted accordingly. **

Compiled in 2014 by education staff at the Chesapeake Bay National Estuarine Research Reserve in Virginia for use in the B-WET *Climate Education for a Changing Bay* program.

Introduction

1. Prior to going outside, give a brief introduction of a salt marsh. Discuss with students how salt marshes are zoned, identifying a few dominant plants in each zone.

2. Students should discuss the importance of salt marshes and create a list as a class.

3. Explain how marshes may respond to sea level rise, both current sea level rise scenarios, as well as projected sea level rise with climate change. Make sure everyone understands the basic mechanisms behind climate change and what could be affected as a result of climate change.

4. Show the SET video to further explain and enhance your class discussion (Appendix 2).

Set up

1. Divide students into three groups: 1) Tides 2) Storm 3) Sea level rise, and explain that they will be surveying a mock marsh habitat, to make predictions about how the marsh will respond to sea level rise.

2. Show the students what supplies each group will have (these should already be separated as follows):

Tides – Group 1
8 PVC bases
7 - 5ft. PVC poles
1 - 7ft. PVC pole
Blue duct tape roll
White/clear duct tape roll
Blue rope
White rope
Metric transect line
Metric tape measure
Set of printed plants
Tide group instructions and questions
Clipboard
Pencil

Storm – Group 2
8 PVC bases
8 - 7ft. PVC poles
Blue duct tape roll
Green duct tape roll
Blue rope
Green rope
Metric transect line
Metric tape measure
Set of printed plants
Storm group instructions and questions
Clipboard
Pencil

Sea level rise – Group 3
8 PVC bases
7 - 5ft. PVC poles
1 - 7ft. PVC pole
Blue duct tape roll
Red duct tape roll
Blue rope
2 – Red ropes
Metric transect line
Metric tape measure
Set of printed plants
Sea Level Rise group instructions and questions
Clipboard
Pencil

Activity

1. Hand out instructions and corresponding questions to each group (See Appendix 3).

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 towards a high elevation in a marsh.

3. All groups should work parallel to each other with their transect line running in the same direction.

4. Briefly review the outlined instructions so that everyone is clear on what to do.

a) Students will run the transect line out 12m along the length of the school yard.

b) Every 1.5m along the transect line place a PVC base.

c) Place the PVC pipes into the base. The brown paint on the pipes should increase in length as you get away from the starting point, with the paint at the bottom of the pole.

d) Students will use tape and colored rope to represent the water level on their PVC poles at their assigned elevation numbers, noted on their worksheet.

e) Once water levels are placed, students will add plants at the appropriate elevation along their transect (Appendix 4).

f) Students will take a step back from their transect line and make observations about what they saw and answer questions on their worksheet.

5. Once the students begin, periodically check in with each group to be sure they understand the provided instructions, activity, and questions.

6. Check to make sure students work corresponds to the correct line on the graph. A graph has been completed to show the whole transect activity in Appendix 5.

Wrap Up

1. Once all of the groups have created their mock transect and have answered the attached questions, bring everyone together on one side of all three transects to review. Have students explain their observations.

2. Point out the different sea levels and changes in elevation throughout the poles. Have students tell you the water level represented by the different color ropes.

3. Ask your students the following questions:

a) What is a spring tide? What happens during a spring tide?

b) How did you decide to place your plants where they were?

c) What influences marsh zonation?

d) What is the highest water level represented? What are some impacts that were faced during this storm?

e) Why are there two different water level showing projected sea level by the year 2050? How do scientists get these numbers?

f) What are some impacts we could face in 2050 due to a higher mean water level?

g) What will the marsh do as sea level rises?

h) How can we reduce our impact on climate change?

4. Students should clean everything up and leave the area as it was when they arrived for the next class.

**Extension: Create a long vertical ruler and have students place known elevations on the ruler, i.e. Water levels from the above activity, and known areas within the community such as school elevation, main street elevations. A good place to look for basic elevation information is Google Earth. This will allow students to see how all of the elevations relate to each other within vertical space.

Background Information

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 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.

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 justified 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 is facing 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 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 allowing 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, different plants and animals characterize each of the zones. Over time, sediment builds up, and the marsh begins to grow vertically which leads to the development of

zones. The low marsh is closest to the water's edge and has the lowest elevation. This zone is flooded daily by tides, which bring in nutrients making this zone fairly productive. Life here deals with rapid changes in temperature, salinity, and dissolved oxygen levels, so there is limited resident and species diversity. There is however a very high bio-mass which is predominately made up of *Spartina alterniflora*, Smooth Cordgrass. This plant is adapted to being regularly inundated with water, it has salt glands and therefore is salt tolerant (a halophyte.) Inundation is the covering over of water. This plant has smooth, leathery, flat and narrow leaves and grows in monocultures, meaning large uniform patches.

As elevation increases in the marsh, the dominant plant in each zone changes. The high marsh is noted for having sandier soils and is only flooded with the highest tides. The high marsh has a greater plant and animal diversity than the low marsh. One of the dominant plants in this zone is *Spartina patens*, Saltmeadow Hay. *Spartina patens* is a short, wiry grass that forms dense carpet like patches with weak stems. *Iva frutescens*, Marsh Elder, is a shrub that grows on high spots in the march and marks the transition zone from high marsh to upland, also known as the shrub zone. This zone is rarely inundated with water. Marsh Elder has fleshy leaves which are arranged in pairs opposite each other along the stem.

Marshes are exposed to varying water levels on a daily basis. The low marsh is inundated twice daily by the high tides. During a spring tide, the time when high tides are the highest and low tides are the lowest, sea level can reach well into the high marsh zone, during the highest tide. Not only do marshes experience sea level changes daily, but they are also exposed to rising water level depending on current weather situations, whether that is a high wind day, a nor'easter, or hurricane. With climate change, one of the local impacts that we will face is a rise in sea level.

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 a critical structural component of low-lying coastal areas. 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. Housing, infrastructure, and other human modifications are expected to limit the space of this potential marsh plant migration. Coastal counties continue to grow, putting more stress on their surrounding ecosystems. Not only does development impact marsh regression, development can also cause a significant amount of sediment to run-off increasing the turbidity. As people become more aware of climate changes and its associated impacts, hopefully we can reduce our impact on the environment.

Appendix 1 - PVC Set-Up

1) Cut ¾" PVC poles into 14, 5' poles and 10, 7' poles. (PVC can be purchased in 10' or 5' sizes)

2) Divide the poles up into the following three groups:
   Group 1) 7 - 5ft. poles and 1 - 7 ft. pole
   Group 2) 8 - 7ft. poles
   Group 3) 7 - 5ft. poles and 1 - 7ft. pole

3) Use brown paint to paint the following marsh elevations on each of the poles for each group. For Group 1 and 3, be sure to paint the highest elevation (1.210m) on the 7ft. pole.
   - 0.088m
   - 0.169m
   - 0.304m
   - 0.506m
   - 0.560m
   - 0.598m
   - 0.816m
   - 1.210m
   -

4) Once the paint has dried the poles are ready to be used with your class. You should have 3 sets of 8 poles for a total of 24. Group 1 is the tides group. Group 2 is the storm group. Group 3 is the sea level rise group.

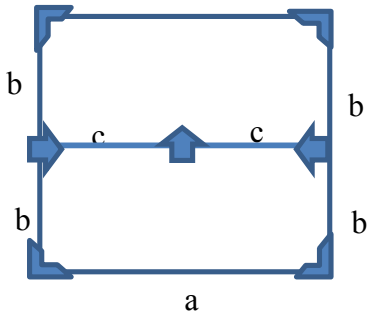
5) You may wish to add Velcro to the poles for students to attach printed plants.

PVC Bases

1) Start with 24, 5ft. long ¾'' PVC poles, 96 ¾'' PVC corner connectors, and 72 ¾'' PVC T piece connectors.

2) Cut a PVC pole into the following dimensions
   a. 2 - 1 ft. long pieces
   b. 4 - 1/2' long pieces
   c. 2 - slightly less than ½' long pieces

3) Use the corner connectors to create a square with the cut PVC. Two sides opposite of each other should have a T piece in the middle to connect their side. Use the smallest pieces to create a line through the middle of the square using the final t connector to complete the line. See the diagram below:



4) Complete steps 2 and 3 for all of the remaining poles.

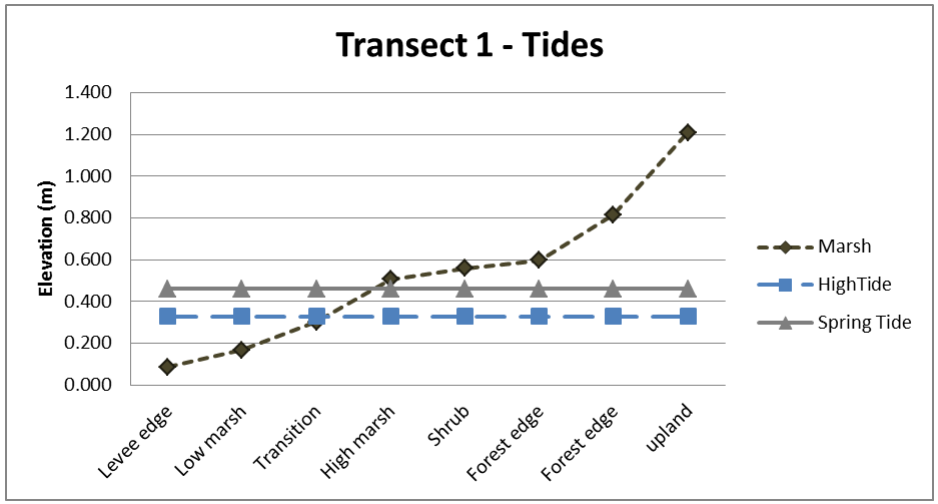
5) The center T connector is to be pointed upwards and used as the connection for the painted transect PVC poles.

Appendix 2- SET Video and Resources

- Surface Elevation Table Video and Explanation
  https://www.youtube.com/watch?v=KRRKWnmOHwo

- Surface Elevation Table Description
  http://www.pwrc.usgs.gov/set/theory.html

- Sentinel Site Information
  http://www.vims.edu/cbnerr/CBSSC/index.php



Appendix 3- Field Data Sheets and Instructions

Group 1 – Tides Group

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 Spring Tide Elevation: 0.46m

1) Mark a starting point. This represents the water's edge. Run the transect line out 12m along the length of the school yard away from your starting point.
2) Every 1.5m along your transect line, place a PVC base.
3) Place the PVC pipes into the PVC bases, with the painted sections at the bottom. The shortest painted sections begin at the water's edge, your starting point, and increase in length as you move down your transect. 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 first PVC pole. Do this on all poles until that elevation hits the mud/painted part of the pole. Don't press tape down all the way!
5) Take your blue rope and connect it along the poles using 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(s) or zone(s) 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) 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 first PVC pole. Do this on all poles until that elevation hits the mud/painted part of the pole. Don't press tape down all the way!
8) Take your white rope and connect it along the poles using 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.
9) Change the location of your plants should you need to.
10) Everyone take a step back from your transect and make some observations about what you see on attached sheet.
11) Please answer the following questions based on your transect alone.

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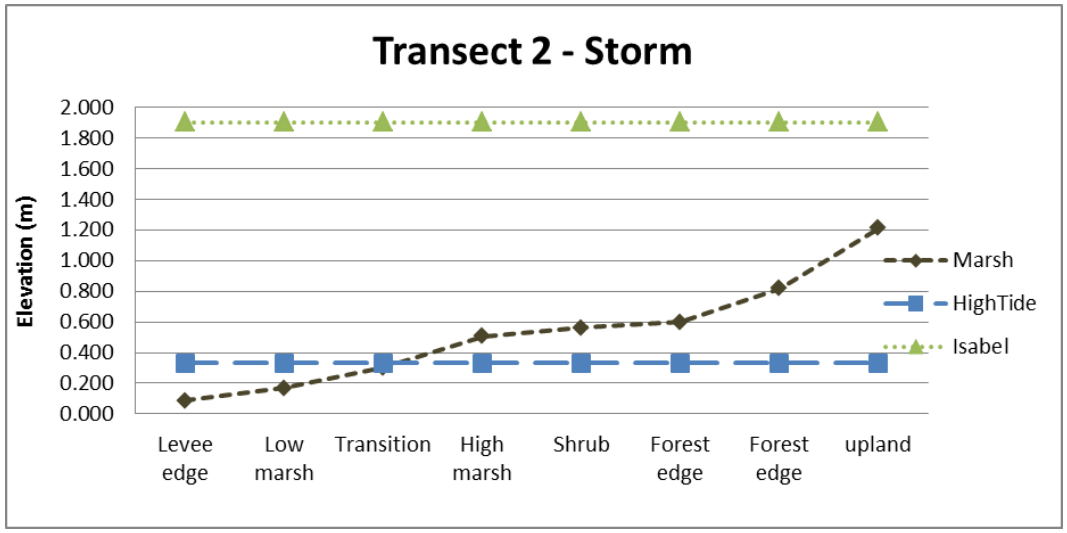

Group 2 – Storm Group Members:

_____

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 Isabel Elevation: 1.9m

1) Mark a starting point. This represents the water's edge. Run the transect line out 12m along the length of the school yard away from your starting point.
2) Every 1.5m along your transect line, place a PVC base.
3) Place the PVC pipes into the PVC bases, with the painted sections at the bottom. The shortest painted sections begin at the water's edge, your starting point, and increase in length as you move down your transect. 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 first PVC pole. Do this on all poles until that elevation hits the mud/painted part of the pole. Don't press tape down all the way!
5) Take your blue rope and connect it along the poles using 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(s) or zone(s) 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) During Hurricane Isabel, water level reached 1.9m above mean sea level. Measure from the ground up to 1.9m and place a piece of green duct tape on the first PVC pole. Do this on all poles until that elevation hits the mud/painted part of the pole. Don't press tape down all the way!
8) Take your green rope and connect it along the poles using 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.
9) Change the location of your plants should you need to. Remember that this storm was a singular event.
10) Everyone take a step back from your transect and make some observations about what you see on attached sheet.
11) Please answer the following questions based on your transect alone.

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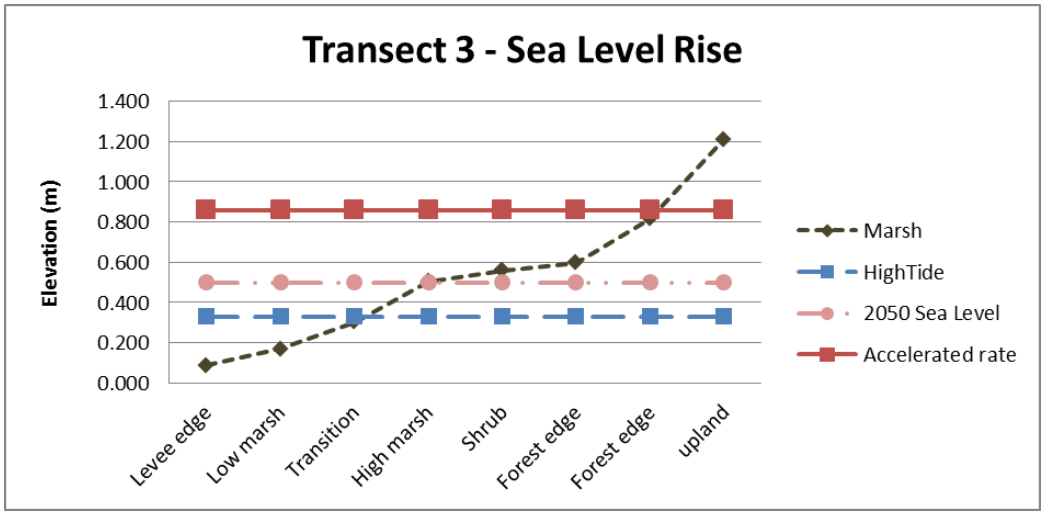

Group 3 – Sea Level Rise Members:

_____

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: 0.5m
Accelerated rate Sea Level by 2050: 0.86m.

1) Mark a starting point. This represents the water's edge. Run the transect line out 12m along the length of the school yard away from your starting point.
2) Every 1.5m along your transect line, place a PVC base.
3) Place the PVC pipes into the PVC bases, with the painted sections at the bottom. The shortest painted sections begin at the water's edge, your starting point, and increase in length as you move down your transect. 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 first PVC pole. Do this on all poles until that elevation hits the mud/painted part of the pole. Don't press tape down all the way!
5) Take your blue rope and connect it along the poles using 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(s) or zone(s) 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 first PVC pole. Do this on all poles until that elevation hits the mud/painted part of the pole. Don't press tape down all the way!
8) Take your red rope and connect it along the poles using 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 first PVC pole. Do this on all poles until that elevation hits the mud/painted part of the pole.
10) Take your other red rope and connect it along the poles using 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 attached sheet.
13) Please answer the following questions based on your transect alone.

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Group 1 -TIDES

OBSERVATIONS…

1.

2.

3.

4.

QUESTIONS

1. What plant did you place nearest the water's edge? How did you decide where to place your plants in your mock marsh habitat?

2. What is the difference in elevation between the mean high tide line and the spring tide line?

3. What do you know are some of the local impacts that we see when we have very high tides or spring tides?

4. If mean high tide is to be at the spring tide level in the future, what would this mean for the marsh plants? Would you expect their placement to move?

Group 2 - STORM

OBSERVATIONS…

1.

2.

3.

4.

QUESTIONS

1. What plant did you place nearest the water's edge? How did you decide where to place your plants in your mock marsh habitat?

2. How much higher was the water level during Hurricane Isabel than the high tide line?

3. What were some of the local impacts from Hurricane Isabel that you know about or may have heard your families discuss?

4. What role do marshes play during storms?

Group 3 - SEA LEVEL RISE

OBSERVATIONS…
1.

2.

3.

4.

QUESTIONS

1. When you first placed your plants, what plant did you place nearest the water's edge? How did you decide where to place your plants in your mock marsh habitat?

2. What is the difference in elevation between the mean high tide line and sea level projection for 2050, and for the accelerated rate by 2050?

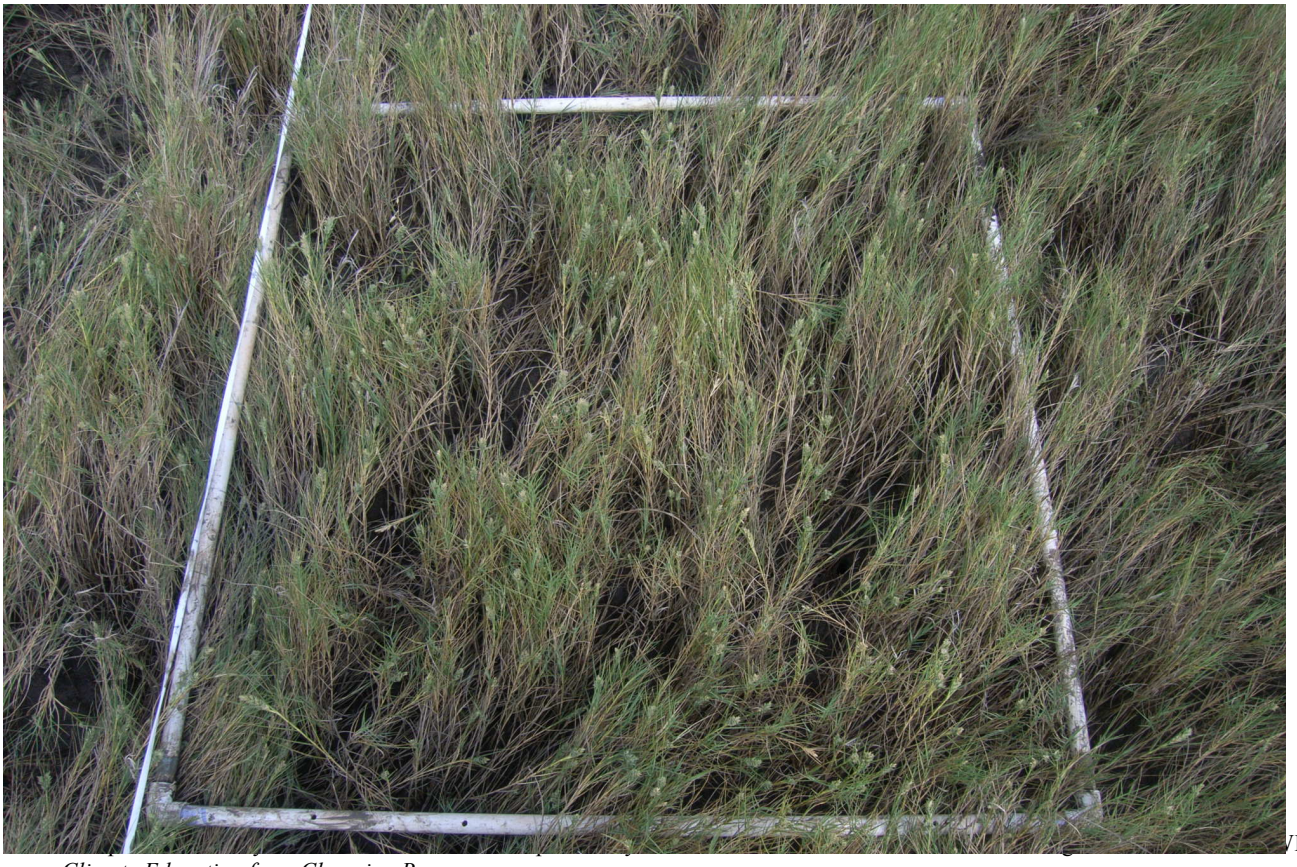
3. When you moved your marsh plants where did you decide to place them and why?

4. What happened to the marsh as a result of sea level rise?

Appendix 4 – Marsh Plants

1) *Spartina alterniflora*, Smooth Cordgrass

2) *Spartina patens*, Saltmeadow Hay



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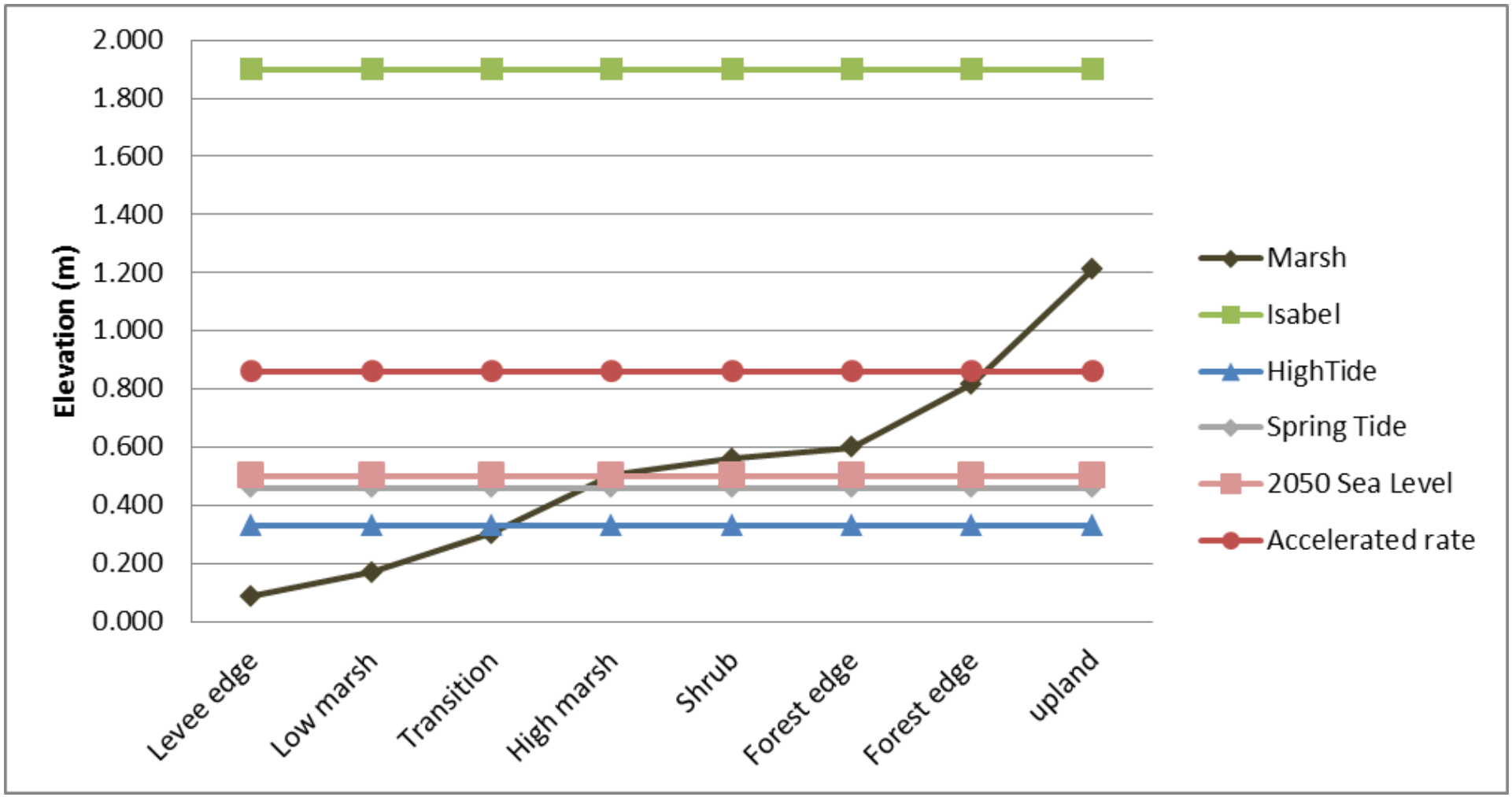
3) *Iva frutescens*, Marsh Elder

Appendix 5 – Completed Transect Graph



Appendix 6 – Answer Key

Group 1 -TIDES

QUESTIONS

1) What plant did you place nearest the water's edge? How did you decide where to place your plants in your mock marsh habitat?

Saltmarsh cordgrass should be placed nearest the water's edge because it can withstand the most saltwater inundation, followed by saltmeadow hay, and marsh elder. Saltmeadow hay can withstand some inundation, and should be placed where saltwater would reach it only during an extreme high tide. Marsh elder cannot withstand regular inundation, and should be placed where saltwater would not reach it.

2) What is the difference in elevation between the mean high tide line and the spring tide line?

The mean high tide (.33m) and the spring high tide (.46m) differ by 0.13m.

3) What do you know are some of the local impacts that we see when we have very high tides or spring tides?

During very high tides or spring tides, we may see some road flooding, ditches filled with water, and higher tide lines along the coast including marshes.

4) If mean high tide is to be at the spring tide level in the future, what would this mean for the marsh plants? Would you expect their placement to move?

If the mean high tide will be the current spring tide level, marsh plants would need to migrate further back away from the water's edge in order to survive. This would be a long term change, and would happen slowly over time, if marsh migration is allowed (meaning there is not development or something else blocking its retreat).

Group 2 – STORM

QUESTIONS

1) What plant did you place nearest the water's edge? How did you decide where to place your plants in your mock marsh habitat?

Saltmarsh cordgrass should be placed nearest the water's edge because it can withstand the most saltwater inundation, followed by saltmeadow hay, and marsh elder. Saltmeadow hay can withstand some inundation, and should be placed where saltwater would reach it only during an extreme high tide. Marsh elder cannot withstand regular inundation, and should be placed where saltwater would not reach it.

2) How much higher was the water level during Hurricane Isabel than the high tide line?

The water level during Hurricane Isabel was 1.9m, and the high tide line is at 0.33m. Hurricane Isabel was 1.57m higher than the high tide line.

3) What were some of the local impacts from Hurricane Isabel that you know about or may have heard your families discuss?

High winds, high storm surge, flooding of roads and some houses.

4) What role do marshes play during storms?

Marshes help to protect the coast by absorbing energy from waves, trapping sediment before it reaches the water, and soaking up flood waters to help reduce the amount of flooding.

Group 3 – SEA LEVEL RISE

QUESTIONS

1) When you first placed your plants, what plant did you place nearest the water's edge? How did you decide where to place your plants in your mock marsh habitat?

Saltmarsh cordgrass should be placed nearest the water's edge because it can withstand the most saltwater inundation, followed by saltmeadow hay, and marsh elder. Saltmeadow hay can withstand some inundation, and should be placed where saltwater would reach it only during an extreme high tide. Marsh elder cannot withstand regular inundation, and should be placed where saltwater would not reach it.

2) What is the difference in elevation between the mean high tide line and sea level projection for 2050, and for the accelerated rate by 2050?

The mean high tide line is at .33m, the projected sea level for 2050 is 0.5m, and the accelerated rate of sea level rise by 2050 is 0.86m. The difference between the highest projection and the mean high tide currently is 0.53m.

3) When you moved your marsh plants where did you decide to place them and why?

When we moved our marsh plants, we kept them in the same order as originally, but moved them further back away from the water's edge so that they were still in a zone of inundation that they can survive in.

4) What happened to the marsh as a result of sea level rise?

The marsh was forced to migrate further away from the water's edge.