2.1 Tides and Wetlands

AGE RANGE
9th—12th grade

TIME REQUIRED
90 minutes

ACTIVITY OVERVIEW
Engage: NERR Image

Explore: NOAA Tides

Explain: Discussion

Elaborate: Salt Marsh Profile

Evaluate: Discussion

MATERIALS
Computers
Graph Paper
Wetland Plant Cards
Tape

BASED ON:
"Water Going Up, Water Going Down" from NERR TOTE & Mock Marsh

LESSON TOPIC: Wetlands and wetland plants

ACTIVITY SUMMARY: Exploration of local tidal patterns and the distribution of northern Gulf of Mexico wetland plants.

OBJECTIVES:

Students will be able to explain that:

- Estuaries are dynamic ecosystems with variability in physical and biological components.
- Estuaries support an abundance of life and a diversity of habitat types.
- Salt marshes are dominated by a variety of plant species and influenced by tides.
- Plants that live in salt marshes tolerate different levels of flooding and this tolerance level determines where the plant lives in the marsh.
- Rising sea levels may change the plant species distribution and composition in salt marshes, impacting the entire marsh ecosystem.

LESSON BACKGROUND:

TIDES

Tides are caused by the gravitational attraction of the moon and sun on water in the ocean and in very large lakes. Tides originate in the ocean and move toward coastlines as very long-period waves, giving the appearance of regular rise and fall of the sea surface. High tide occurs when the highest part of the wave, the crest, reaches the coast, and low tide occurs when the lowest part, the trough, reaches the coast. The gravitational pull of the moon is greater than the sun, and the moon plays a larger role in producing tides.

The position of the moon and the sun in relation to Earth cause variations in the heights of tides. During new moon and full moon, the sun, moon, and Earth form a line and we experience the

greatest tidal amplitude with highest high and lowest low tide. This is termed “spring tide.” When the position of the moon is at a right angle to the Earth and sun we experience “neap tide” with tides with the least amplitude. Spring tide and neap tides occur twice each month.

The physical geography of the coastline influences tidal patterns in different locations. There are three basic tidal patterns: semi-diurnal, mixed semi-diurnal, and diurnal. Semi-diurnal means that there are two high tides and two low tides each day. Mixed semi-diurnal means that the high and low tides differ in height. Diurnal means that there is only one high tide and one low tide each day. Along the Mississippi and Alabama coasts, we experience diurnal tides.

ESTUARIES

Estuaries are the transition zone between freshwater environments and marine environments. Estuaries are fed by one or more freshwater rivers or streams and are open to the ocean, and the water is a mixture of fresh and salt water - often termed “brackish.” Wetland habitats might be present in estuaries. A salt marsh is a type of wetland that is flooded and drained by salt water brought in by tides. Tides affect the height of water within estuaries and salt marshes since they are open to the ocean.

Plants that live in salt marshes are affected by abiotic factors including water level and salinity, as well as competition among plant species. Marshes generally have three vegetation zones: low marsh, high marsh, and upland edge. The plants that grow in each zone are determined by their ability to tolerate water level and salinity. The more flooding-tolerant plants are located in the lower marsh zones.

With sea-level rise, wetlands and marshes will erode. High water levels will flood farther inland and new wetlands can form. However, the rate of new wetland growth may be less than the rate of wetland loss as many developed areas with hard structures like bulkheads and roads prevent the marsh from moving inland.

Understanding coastal processes allows for the use of natural systems to reduce flooding and sea-level rise impacts in coastal to urban areas. Wetlands and coastal marshes along the northern Gulf of Mexico provide many natural solutions. Wetlands act as speed bumps for storms, slowing the storms as they come ashore, 15 ft of marsh can absorb 50% of incoming wave energy. One square mile of salt marsh stores the carbon equivalent of 76,000 gal of gas annually. Marshes trap sediments from tidal waters, allowing the marsh to grow in elevation as sea level rises.

VOCABULARY:

Abiotic	A nonliving condition or thing, as climate or habitat, that influences or affects an ecosystem and the organisms in it.
Biomass	Organic matter derived from living, or recently living organisms.
Biotic	Biotic components, or biotic factors, can be described as any living component that affects another organism or shapes the ecosystem.
Carbon Sink	Anything that absorbs more carbon that it releases.
Carbon Storage	Capture and storage of carbon dioxide before release to the atmosphere (also known as 'carbon sequestration') through natural and/or anthropogenic (i.e., human) processes in order to mitigate climate change.
Diurnal Tide Cycle	An area has a diurnal tidal cycle if it experiences one high and one low tide every lunar day. Many areas in the Gulf of Mexico experience these types of tides.
Dynamic	Characterized by continuous action or change.
Ecosystems	All the living things in a particular area as well as components of the physical, non-living environment with which they interact (e.g., air, soil, water, and sunlight).
Elevation	Height above or below a fixed reference point.
Estuary	Estuaries and their surrounding wetlands are bodies of water usually found where rivers meet the sea. A mixture of fresh water draining from the land and salty seawater.
Forestry	Science and practice of planting, managing, and caring for forests.
Inundation	To flood; cover or overspread with water.
Invasive Species	Introduced, non-native organism (e.g., disease, parasite, plant, or animal) that rapidly expands its range, displacing other species, and causes harm to the environment, the economy, or to human health.
Mixed Semidiurnal Tide Cycle	An area has a mixed semidiurnal tidal cycle if it experiences two high and two low tides of different size every lunar day. Many areas on the western coast of North America experience these tidal cycles.

Salt Marsh	A salt marsh or saltmarsh, also known as a coastal salt marsh or a tidal marsh, is a coastal ecosystem in the upper coastal intertidal zone between land and open saltwater or brackish water that is regularly flooded by the tides.
Seagrass	Seagrasses are flowering plants which grow in marine environments.
Sediment	Fragmented organic and inorganic material, typically occurring due to erosion or weathering, that is easily transported by water, wind, or ice.
Semidiurnal Tide Cycle	An area has a semidiurnal tidal cycle if it experiences two high and two low tides of approximately equal size every lunar day. Many areas on the eastern coast of North America experience these tidal cycles.
Sequestration	The net removal of CO2 from the atmosphere by plants and micro-organisms and its storage in vegetative biomass and in soils.
Subsidence	Sinking of the ground due to underground movement or soil compaction and/or degradation; most often caused by the removal of water, oil, natural gas, or mineral resources from the ground by draining, pumping, fracking, or mining activities.
Tide	Tides are the rise and fall of sea levels caused by the combined effects of the gravitational forces exerted by the moon and the sun, and the rotation of the Earth.
Transect	A transect is a line across a habitat or part of a habitat. It can be as simple as a string or rope placed in a line on the ground. The number of organisms of each species along a transect can be observed and recorded at regular intervals.
Wetland	Wetlands are areas where water covers the soil, or is present either at or near the surface of the soil all year or for varying periods of time during the year, including during the growing season.
Wetland Change	When coastal wetlands, especially estuarine and marine wetlands, are naturally or unnaturally altered by high energy events such as erosion and inundation from sea level rise and storms.

ENGAGE:

Watch with students the introductory video "What is an estuary?" (2 minutes) about estuaries and the National Estuarine Research Reserves (NERRs):
https://oceanservice.noaa.gov/facts/estuary.html

Display a map of the NERRs and show Weeks Bay NERR in Alabama and Grand Bay NERR in Mississippi. Ask students what estuaries might be stressed by given their location on the coast next to the Gulf of Mexico. Answers to highlight: storms, tides, sea-level rise.

Alternative: Show students the short video of rapid erosion at Grand Bay NERR:
https://www.youtube.com/watch?v=S6TGEmu9dcA (1 minute 25 seconds)

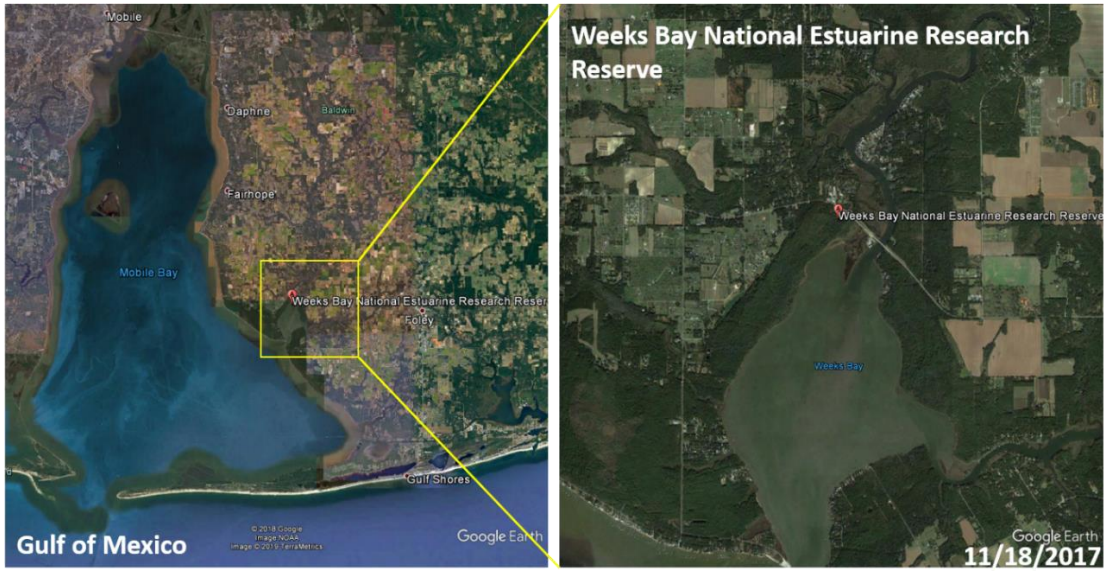


Image: Google Earth image of Weeks Bay NERR in Alabama.

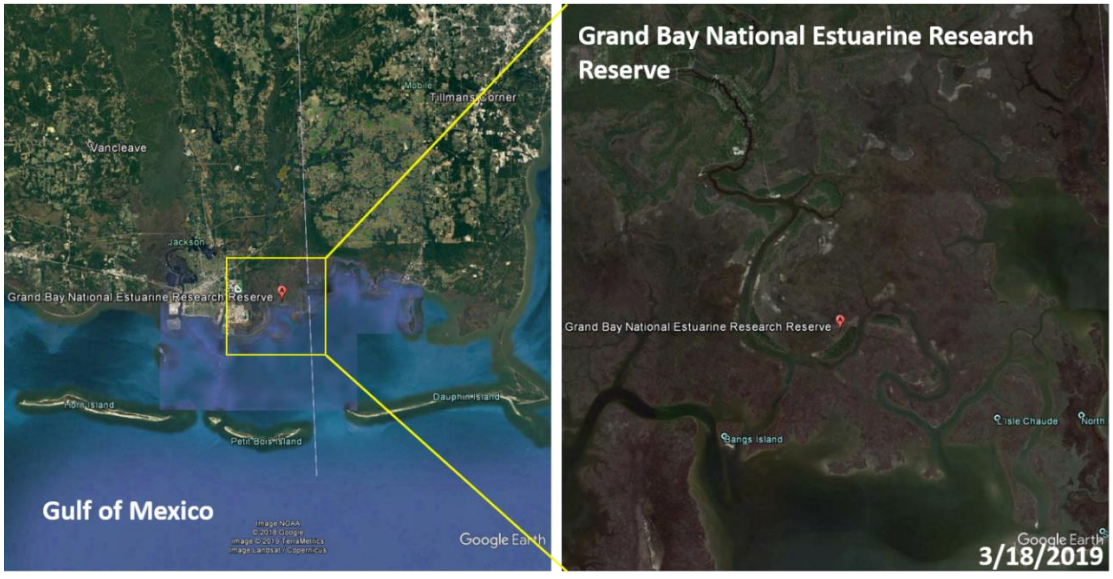


Image: Google Earth image of Grand Bay NERR in Mississippi.

EXPLORE:

Activity description: students will use NOAA's Tides and Currents website to explore tidal data from tide stations in Alabama and Mississippi.

Materials: access to computers with internet access and graph paper.

Procedure:

1. Open NOAA's Tides and Currents website: http://tidesandcurrents.noaa.gov/. Click on a state to be directed to local tides and currents information.
2. In the Legend on the right side make sure only "Water Level and Met" and "Water Levels" pins are checked. Locations in Alabama and Mississippi are given below, but students may work on stations located on other United States coasts. Ensure that at least one student group has selected a location outside of the northern Gulf of Mexico to allow for comparisons at the end.

Alabama:
Weeks Bay, Mobile Bay, AL;
Dauphin Island, AL;
Dog River Bridge, AL;
East Fowl River Bridge, AL;
Coast Guard Sector Mobile, AL;
Mobile State Docks, AL;
Chickasaw Creek, AL;
West Fowl River Bridge, AL;
Bayou La Batre Bridge, AL.

Mississippi:
Grand Bay NERR, Mississippi Sound, MS;
Pascagoula NOAA Lab, MS;
Bay Waveland Yacht Club, MS

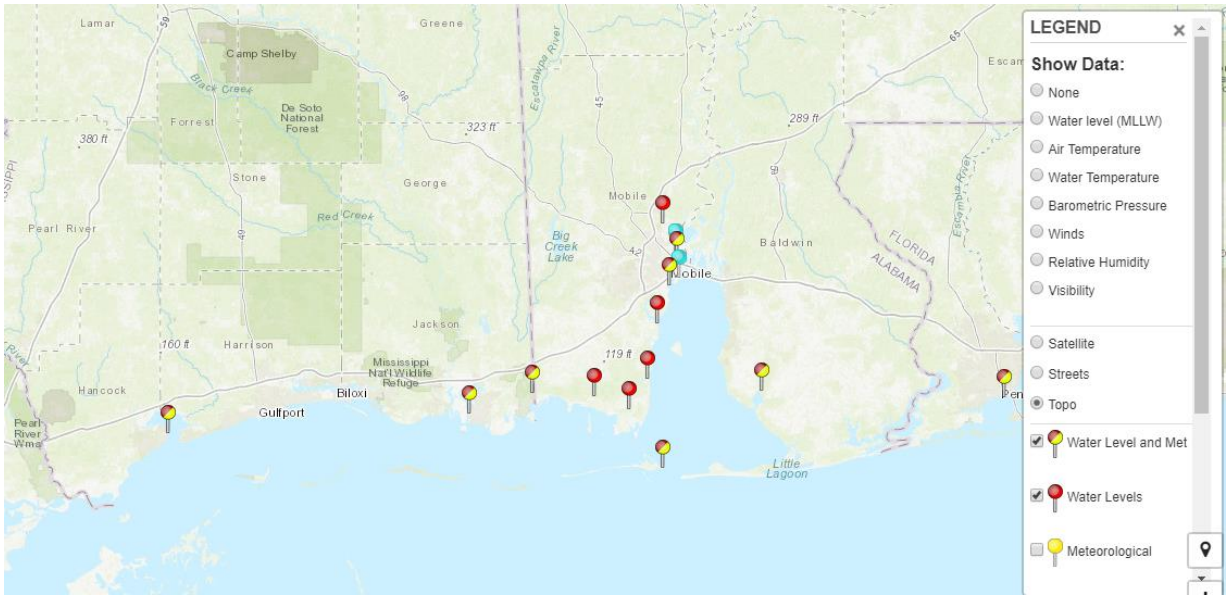


Image: Mississippi and Alabama display from NOAA Tides and Current website. Source: https://tidesandcurrents.noaa.gov/map/index.html

3. Students can access the tidal height data by clicking on the pin, then clicking on "More Data" in the dialog box that opens, and clicking on "Water Levels."

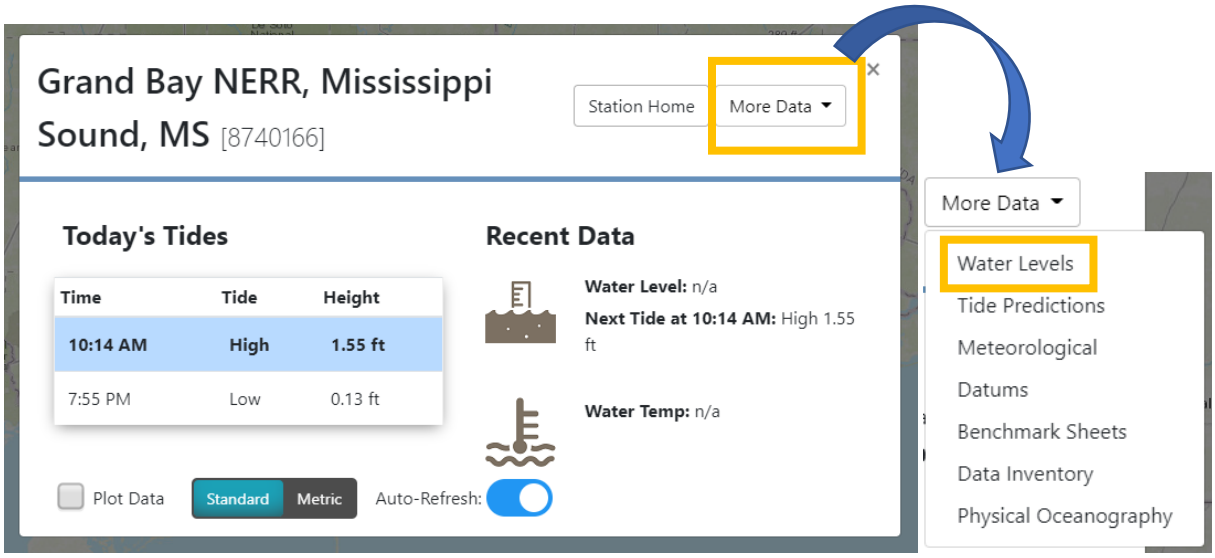
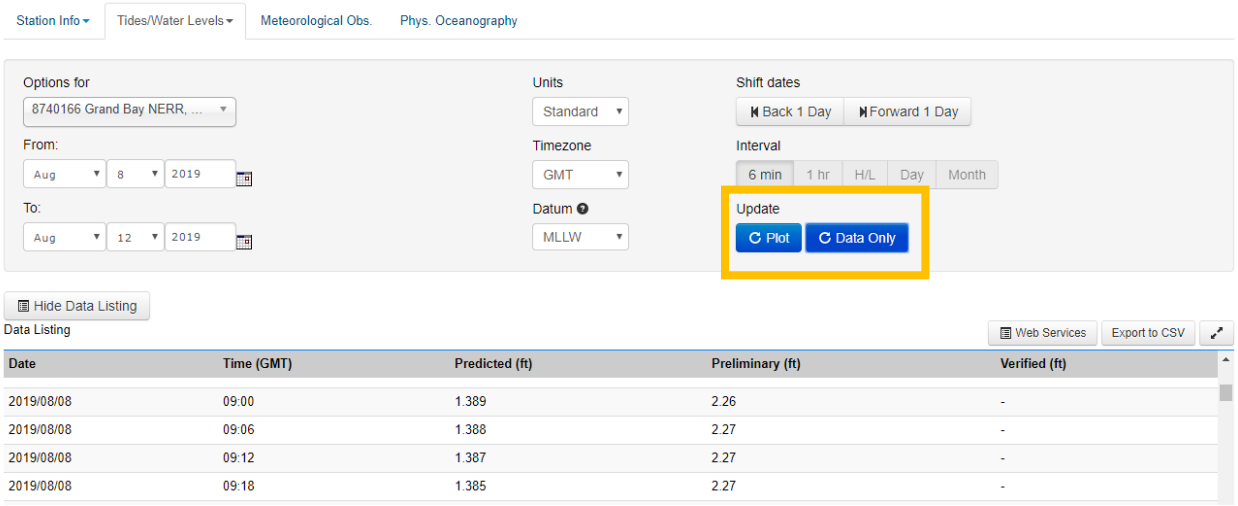


Image: The dialog box that opens when a tidal gauge pin is clicked. Source: https://tidesandcurrents.noaa.gov/map/index.html

4. Have students examine a range of time with tide data for their station. They select the range of time using the date selection and access the data by clicking the "Data Only" button.



5. Using the graph paper have students create a line graph of the tidal change at their location. Record the water height every two hours for at least a three-day length of time.
6. Have students calculate the tidal range - this is the difference in tide height from the low tide to the high tide.

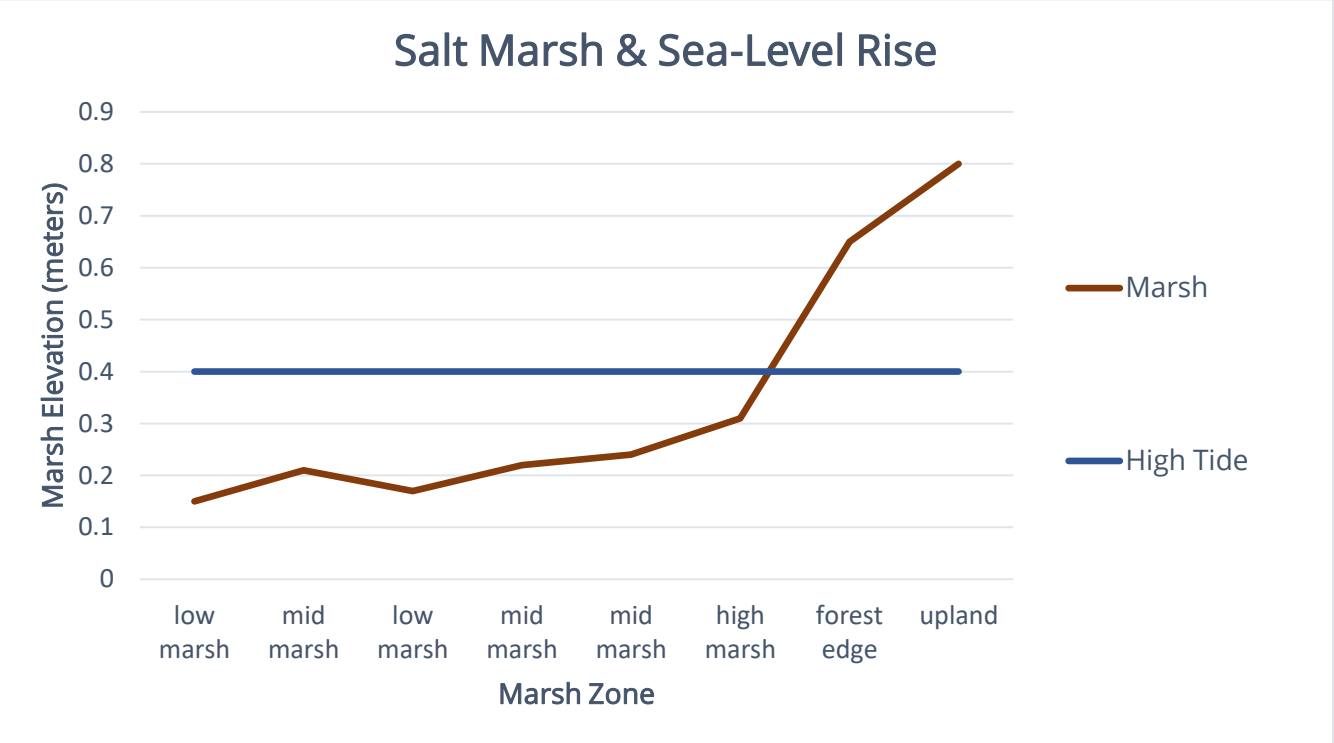
EXPLAIN:

Discuss the trends in tides that students found from graphing the tidal range. Compare graphs from locations with diurnal and semi-diurnal tides. In the Gulf of Mexico, we have a small tidal change, but the east coast has relatively large changes in their tides.

Guide students into thinking about how tidal changes might influence coastal wetland habitats.

Note: at this point the lesson can be paused for the day.

Across the board, or along one wall with string, create the graph below showing high tide, and marsh elevation. This could also be projected onto the wall.



This is a mock transect of a northern Gulf of Mexico marsh.

- The marsh elevation follows the brown line
- Current High Tide Elevation: 0.4 meters
- Current Sea-Level: 0

ELABORATE:

Materials: Enlarged version of the Salt Marsh Profile, Preserved specimens or cutout copies of the "Coastal Wetland Restoration Plant Fact Sheets"
http://extension.msstate.edu/sites/default/files/publications/publications/p3356.pdf

This activity will have students exploring the plants commonly found in salt marshes in Mississippi and Alabama and understanding the marsh zones.

Procedure:

1. Discuss the different vegetation zones of the marsh and have students brainstorm what might impact where plants can grow in a marsh (low marsh = plants have to withstand more or constant flood inundation of salt water; high marsh and upland edge = plants will rarely be exposed to water inundation from incoming tides).
2. Ask students what kind of adaptations they think plants living in a salt marsh might have. This can include things like the ability to excrete, exclude or sequester the salt, rhizomes, or developed aerenchyma to channel to get air to the roots.
3. Using identification cards or preserved specimens, have students identify the common salt marsh plants. Common name in regular text, scientific name in italics.
    a. Low marsh: smooth cordgrass *Spartina alterniflora,* Black needlerush *Juncus roemerianus*
    b. High marsh: Black needlerush *Juncus roemerianus,* Saltmeadow cordgrass *Spartina patens,* Bulrush *Schoenoplectus americanus,* Salt grass *Distichlis spicata*
4. Discuss with students the adaptations that each plant has that allows it to survive in the marsh and determine the marsh zone the plant is located.
5. After discussing the salt marsh plants, place them in the marsh zone displayed on the graph, using the below image for marsh zone reference.

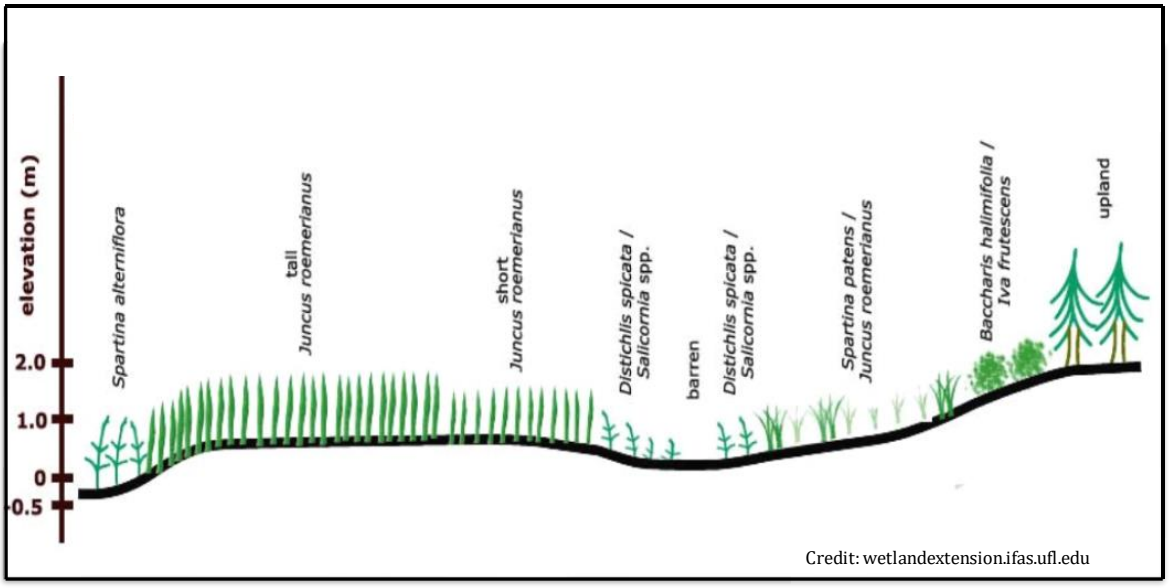
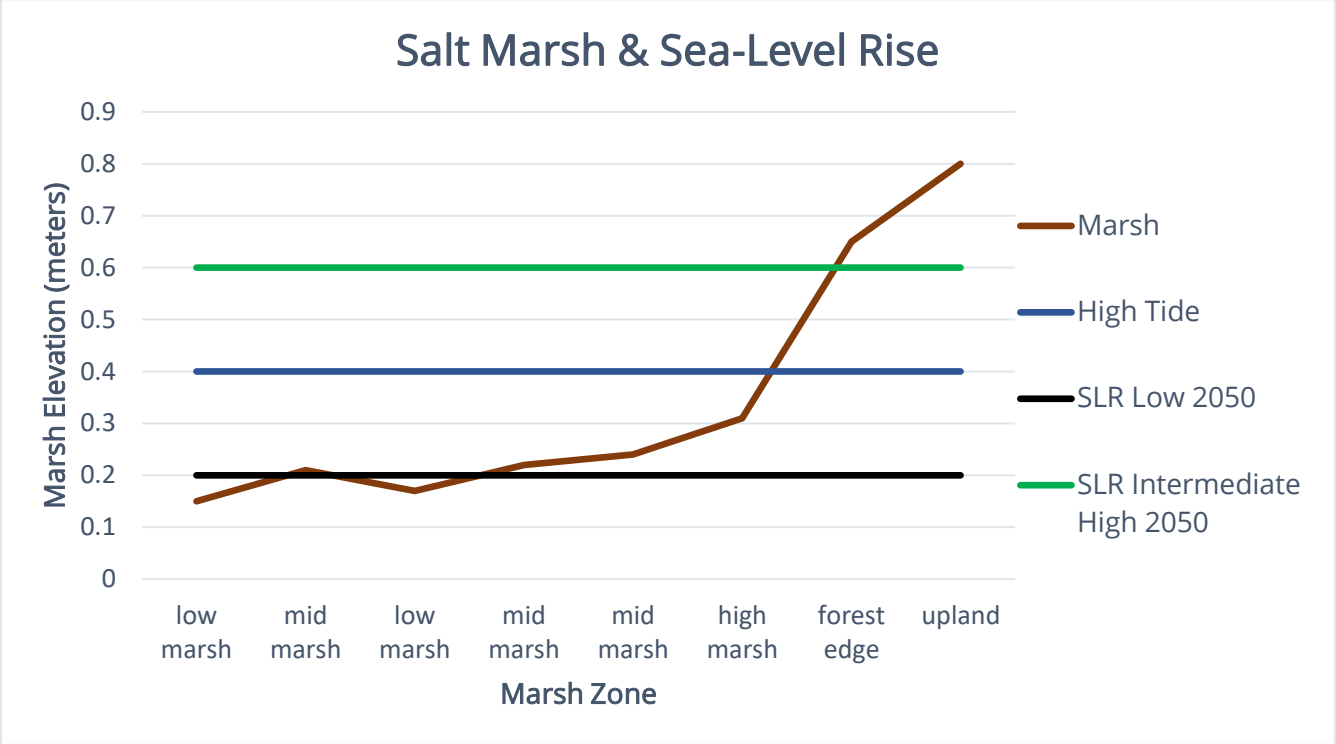


Image: Marsh profile showing elevation gradient graphic. Source: UF/IFAS Wetlands Extension.

7. Once all the plants have been placed, display the graph below with additional lines showing the projected sea-level rise by 2050 under the Low and Intermediate High scenarios. These sea-level rise projections show the change in low tide.
8. If needed, change the location of the plants based on the water levels from sea-level rise.
9. Students can use corresponding worksheet for notes.



- The marsh elevation follows the brown line
- Current High Tide Elevation: 0.4 meters
- Current Sea-Level: 0
- Sea-Level under the Low Scenario in 2050: 0.2 meters
- Sea-Level under the Intermediate High Scenario in 2050: 0.6 meters

Sea-level rise poses a challenge for marsh plants. Greater and more frequent inundation of the marshes leads to flooding stress and brings salt water into the higher marsh zones. In the northern Gulf of Mexico, we are experiencing sea-level rise at rates greater than the global average, so our marshes are being faced with this challenge now. The plants living in salt marshes have two options for keeping pace with sea-level rise: landward migration or vertical accretion. For landward migration, salt marsh plants move upslope into upland habitat. For vertical accretion, salt marsh plants trap sediment and vertically build up the land to stay above water with sea-level rise. Both of these pathways are relatively slow processes.

Landward migration is a process where the marsh zones shift upslope. However, landward migration is limited by steep slopes or barriers like human-built sea walls, parking lots, roads, or houses. This creates “coastal squeeze”, where the natural movement of the coastal habitat is prevented by physical barriers on the upslope side (see image below). Vertical accretion allows salt marshes to move up vertically as sea-level rises. This process occurs as salt marsh plants physically reduce the speed of water, which allows sediment particles to settle out and accumulate around the base of marsh plants. However, vertical accretion is limited by changes in marsh plant abundance and sediment supply; as plant biomass decreases there are less plants to slow the water velocity and accumulate sediment.

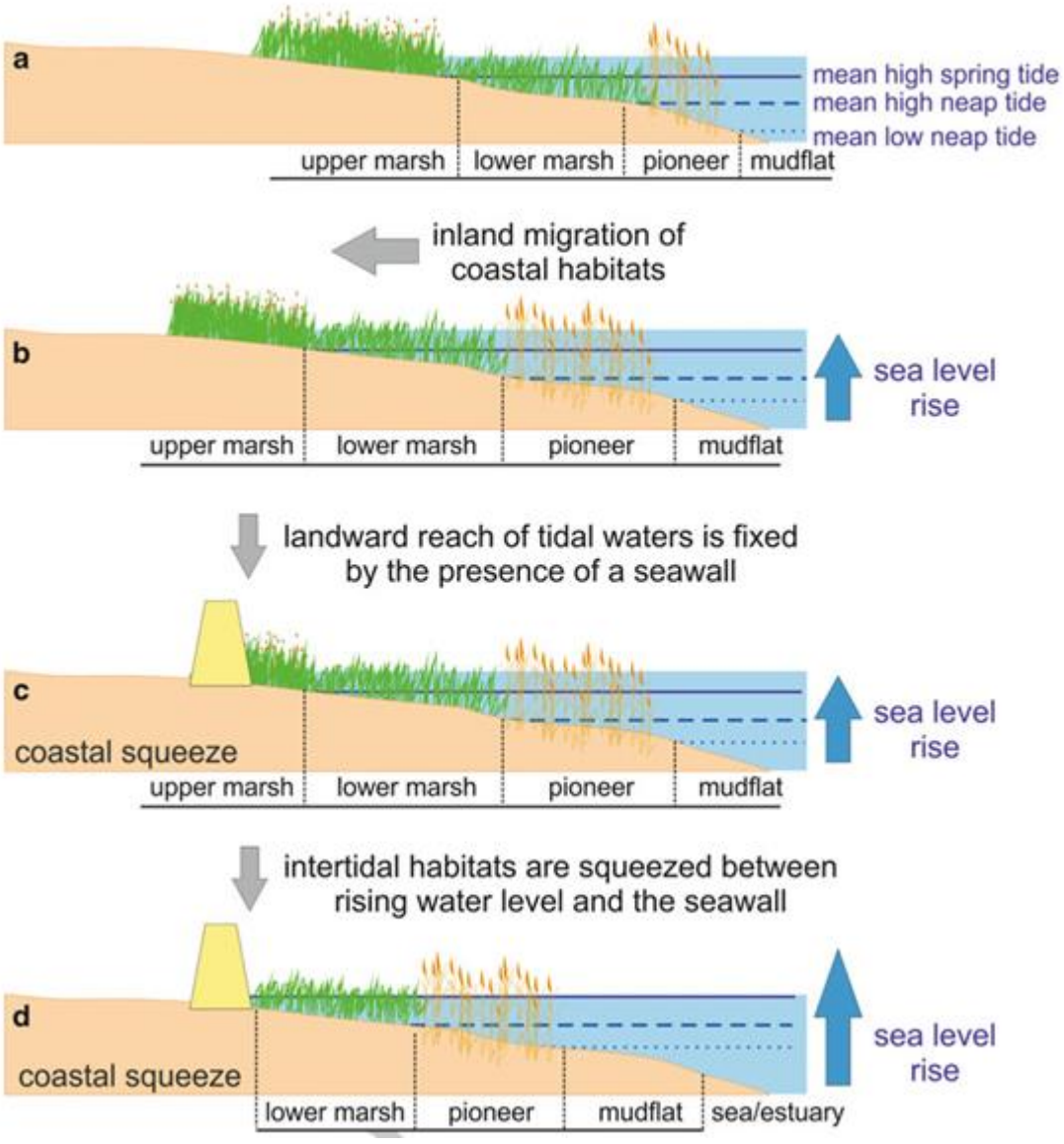


Image: The elevation in relation to the tidal range is one of the key factors determining the type of intertidal habitat that may develop in a particular location (a). Natural habitats tend to migrate inland as a response to rising sea levels (b). As a result of this migration the intertidal area may

expand or reduce depending, for example, on the coastal topography. Hard engineering structures will invariably fix the landward limit of intertidal areas (c), which will be reduced in extent as sea levels rise and more land becomes permanently inundated (d). The loss of coastal habitats due to rising sea levels in front of artificially fixed shorelines is known as coastal squeeze. Image source: Esteves, L.S., 2015. Coastal squeeze. *In*: Kennish, M.J., ed. *Encyclopedia of Estuaries 2016 ed.* Dordrecht: Springer.

As marsh plants try to adapt to sea-level rise, many human-made stressors can reduce their ability to adapt. With wetland restoration and resilient sea-level rise actions, we can provide pathways for marshes and the animals that rely on them to keep pace with sea-level rise and continue to provide flood protection and other valuable services.

EVALUATE:

Ask: How does the tide influence salt marshes and the plants that grow there?

The incoming tide floods the marsh with brackish water, which is a mixture of salt and fresh water. Most plants cannot tolerate being regularly flooded or exposure to salt water, so salt marsh plants must have special adaptations that allow them to grow there. The frequency and duration of tidal inundation will determine where certain species of plants can grow.

Ask: How might sea level rise impact the marsh zones and subsequently the plants that grow there?

As marshes become more frequently flooded or hold more standing water, plants that are less salt or flood tolerant may die back and be replaced by the very few tolerant species that inhabit the low marsh.

Introduction to Estuaries and Wetlands

Along the Gulf of Mexico, we have many areas that provide habitat for animals. An estuary is the area where freshwater meet the saltwater ocean. The mixture of fresh and salt water is often called "brackish" water. Since estuaries are located along the coast, they are impacted by tides. As the water level of an estuary rises and falls, the water level and chemistry changes create a wide range of habitats. The marsh and seagrasses along the coast slow the moving water, allowing sediment and food particles to settle to the bottom. The maze of grasses provide many hiding places to small fish and crabs, giving estuaries the name "nursery of the sea."

Types of coastal estuaries include brackish or freshwater marshes, salt marshes, seagrass beds, and oyster reefs. Some coastlines may only have a soft shoreline of sand. Wetlands are what their name implies, areas of land that are wet enough to influence the plants and soils. Wetlands can be found inland or along the coast.

A salt marsh is a type of wetland that is flooded and drained by salt water brought in by tides. Tides affect the height of water within estuaries and salt marshes since they are open to the ocean. Plants that live in salt marshes are affected by abiotic factors including water level and salinity, as well as competition among species. Marshes generally have three vegetation zones: low marsh, high marsh, and upland edge. The plants that grow in each zone are determined by their ability to tolerate flooding (or inundation) and salt water. The more flood tolerant plants will be located in the lower marsh zones. The high marsh and upper marsh edge are generally only flooded by the tide during spring tides or during storms. Sometimes the high marsh area has a high salt concentration due to evaporation, which can lead to the formation of salt pannes.

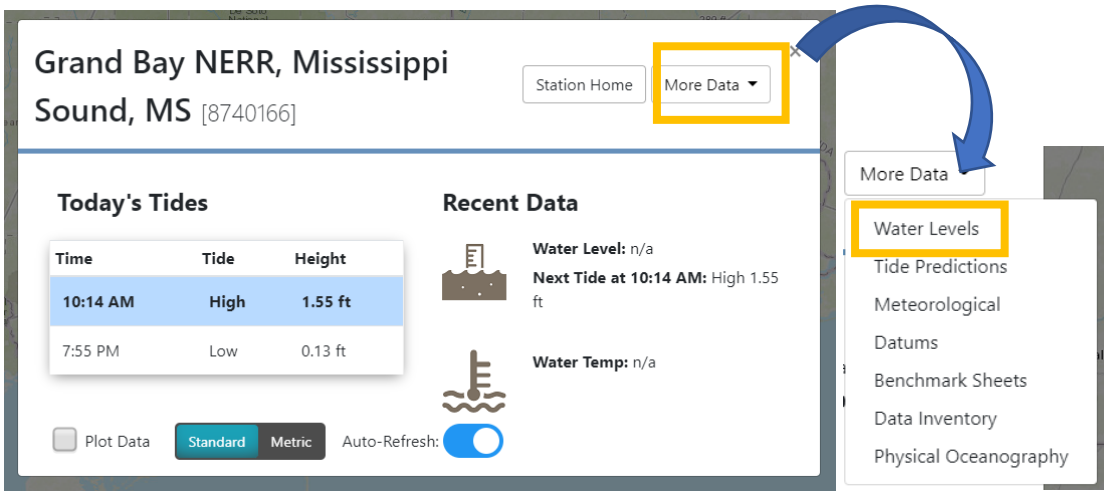
Most plants have one of three adaptations to deal with the salt from tidal influences: excrete the salt through specialized glands, exclude the salt at the roots, or sequester the salt in its leaves. Black needlerush (*Juncus roemerianus*) is the most common salt marsh plant in Mississippi and Alabama and has adaptations to handle anaerobic (i.e., no oxygen) conditions, as well as wide ranges of pH fluctuations. Saltmarsh cordgrass (*Spartina alterniflora*) thrives in the lower elevations of the marsh and alongside tidal creeks because of its tolerance to a high level of salinity. It excretes the excess salt onto the blades of the grass, which you can see as small crystals. Most salt marsh plants have an underground system of stems called rhizomes. These send out shoots, anchor the plant in unstable sediment, and help the plants survive in the harsh conditions of a salt marsh.

An essential component of a salt marsh is peat, the 'ground' of a marsh, providing the foundation for plants and animals living there. Often several feet thick, waterlogged, and composed of decomposing plant material, peat is low in oxygen, leading to a condition known as hypoxia. Certain bacteria thrive in hypoxic conditions, emitting the characteristic rotten egg smell associated with salt marshes. Examining a handful of peat shows the abundance of organic matter as well as its capacity to hold water. This ability of peat to act like a sponge means that marshes play a vital role in soaking up excess water during storm events, resulting in diminished flooding along the coast.

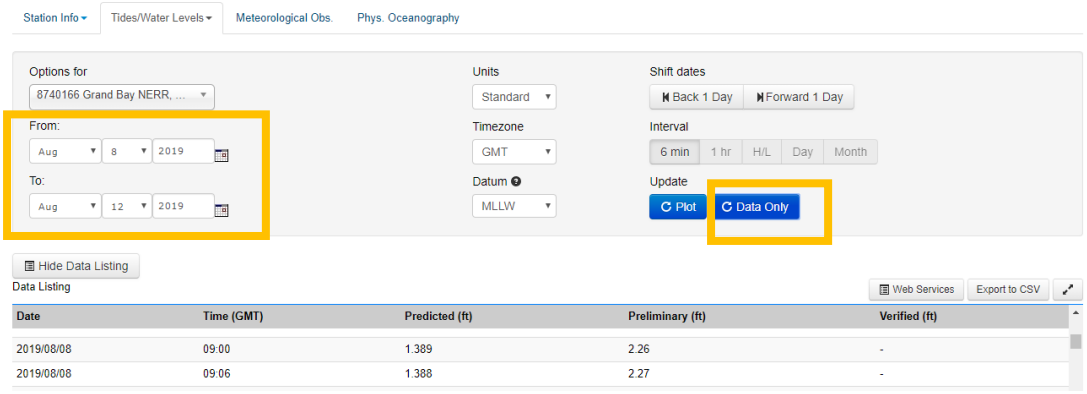
NOAA's Tides and Currents Investigation

What is your assigned tide station? _____

1. Go to http://tidesandcurrents.noaa.gov/ and search for your tide station by checking the "Water Level Met" and "Water Levels" pins in the right-side Legend.
2. Access the tidal height data by clicking on the tide station pin.
3. Click on "More Data" in the dialog box that opens, then click "Water Levels."



4. Select a range of time (at least 3 days) and click the "Data Only" button.



5. On graph paper record the water height every two hours for at least a three-day length of time. Create a line graph of the tidal change.
6. Calculate the tidal range:
    a. What is the height of the **high tide**? _____
    b. What is the height of the **low tide**? _____
    c. Tidal range = High tide minus low tide → _____

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Answer the following questions based on the marsh plant and sea-level rise activity.

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?

5. How might marshes be able to adapt to sea-level rise?

6. What management activities could we do to allow marshes to adapt to sea level rise?

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DO NOW:

Draw a coastline.

EXIT TICKET:

How does sea-level rise impact coastal wetlands in undeveloped and developed areas?