## Who is Restoring the Marsh?



SUBJECT:
Math
GRADE LEVEL:
6th
TIMEFRAME:
45 minutes MATERIALS:

O Students will need paper and pencils for activity


## ACTIVITY SUMMARY:

This lesson serves as an introduction to the importance of conserving and restoring Galveston Island's coastal prairie and wetland ecosystems. The Galveston Bay system has lost over 8,0oo+ acres of saltwater wetlands and 80,000+ acres of freshwater wetlands in the past 20 years through habitat degradation (Galveston Bay Foundation). Students will construct a restoration area using geometry and algebra principles, as well as follow a budget to complete a marsh restoration project.

## LEARNING OBJECTIVES:

- Students will build off of existing knowledge of coastal prairies and wetland ecosystems Students will learn about the organizations actively doing restoration in Galveston
- Students will utilize geometry and algebra to think like a restoration scientist and play a role in


## ALIGNMENT:

TEKS:
6.3.(D) add, subtract, multiply and divide integers fluently
6.3.(E) multiply and divide positive rational numbers fluently
6.8.(D) determine solutions for problems involving the area of rectangles, parallelograms, trapezoids, and triangles and volume of right rectangular prisms where dimensions are positive rational numbers.

Ocean Literacy Principles:
1 Ocean has one big ocean with many features
2 The ocean and life in the ocean shape the features of Earth
4 The ocean makes Earth habitable
6 The ocean and humans are inextricably interconnected

## VOCABULARY:

- Breakwater - A barrier built out into a body of water to protect a coast or harbor from the force of waves
- Berm - A flat strip of land, raised bank, or terrace bordering a river or canal
- Food Web - A system of interlocking and interdependent food chains
- Geotube Textile - A large, tube-shaped bag made of porous, weather-resistant geotextile and filled with a sand slurry, to form an artificial coastal structure such as a breakwater, dune, or levee
- Intertidal Zone - The area where the ocean meets the land between high and low tides
- Mangrove - A tree or shrub that grows in tropical coastal swamps that are flooded at high tide
- Marsh - An area of low-lying land which is flooded in wet seasons or at high tide, and typically remains waterlogged at all times
- Restoration - The act of returning something to a former owner, place, or condition
- Seagrass - A grass-like plant that lives in or close to the sea
- Turbidity - The quality of being cloudy, opaque, or thick with suspended matter; the measure of relative clarity of a liquid
- Ecosystem Services - Any positive benefit that wildlife or ecosystems provide to people


## BACKGROUND INFORMATION:

Salt marshes, sea grass beds, and mangrove marshes are extremely important areas. The ecosystem services these areas provide are the following:

1. Provide nursery habitat for fish, shrimp, and crab
2. Temporarily store water during a flood event and release it slowly like a sponge
3. Act as a filter to clean the water, trap pollutants, and break down pollutants over time
4. Reduce erosion to upland areas by slowing down wave energy
5. Stores carbon through plant photosynthesis and by acting as sediment traps for runoff
6. Provide nutrients which are the basis of the food web

Natural coastal habitat can be altered by both natural events and human factors. Waves such as the ones produced by tropical storms and hurricanes can erode coastlines increase turbidity and permanently or temporarily change the shape of the coastline. Waves are the result of wind on earth's surface caused by the sun unevenly heating the earth's surface.

The strength of the wind, combined with the length of time that it blows, the water depth and the size of area over which the wind can blow unimpeded in one direction will determine how large the three waves become. While most of the waves along the Texas Gulf Coast are small, waves produced by tropical storms and hurricanes can be quite large.

Human factor, such as draining, filling and construction of channels, or subsidence (sinking of land) caused by the removal of groundwater and oil also changes these habitats. Mangroves cannot tolerate extremely cold weather or low salinities. Seagrass beds become choked out when draining filling and construction deplete the water clarity. Once a marsh has been altered consequences can include increased flood damage, loss of nutrients in the ecosystem, loss of natural water filters and increased erosion. Restoration projects are undertaken with the goal of regaining the "ecosystem services" of these habitats provide.

Restoration projects vary from large scale operations requiring the cooperation of federal, state, and local entities and costing billions of dollars (such as projects in the Florida Everglades and the Mississippi River Delta regions) to smaller community-based projects led by local organizations like the wetlands plantings at the Coastal Heritage Preserve with Artist Boat.

Many restoration projects seek to raise the elevation of a site that has subsided or eroded to allow for growth of vegetation that only survives in the intertidal zone. Terraces, or marsh mounds, are long linear mounds of soil that are planted with native grasses such as Spartina alterniflora (smooth cordgrass). Terraces help to control the shoreline by reducing wave energy, trapping sediments, providing habitat for organisms, and increasing water clarity.


## PREPARATION:

Begin class with photos (either printed or projected) of marsh restoration examples. Break students into small groups and provide each student group with a copy of the restoration information sheet and a restoration site map.

## Who is doing the restoration?

- Artist Boat
- Coastal Heritage Preserve - Artist Boat is striving to preserve and restore 1,400 contiguous acres from beach to bay
- Elementary students from GISD have restored over 24 acres of coastal prairie at Galveston Island State Park since Hurricane Ike in 2008 through Artist Boat's Habitat Restoration Adventures
- Galveston Bay Foundation
- Galveston Bay Foundation has restored over 950 acres of vital coastal habitat through various restoration programs
- NOAA Fisheries - Office of Habitat Conservation
- Focus on protecting and restoring habitat to sustain fisheries, recover protected species, and maintain resilient coastal ecosystems and communities.


## INTRODUCTION:




Habitat Conservation
Protect. Conserve. Restore.
NOAA works to protect and restore marine and coastal habitat to sustain fisheries, recover protected species, and maintain resilient coastal ecosystems and communities.


Our Work



## GUIDED PRACTICE:

## PROMPT:

You are part of the Spanish Cove Homeowner's Association. You and your neighbors are concerned that there is increasing habitat loss of marsh and seagrass beds near your subdivision and will result in the loss of your property and yard space. Your Homeowner's association has decided to spend your dues on a marsh restoration project.

## ACTIVITY:

1. Introduce concept of marsh restoration - explain functions of wetlands
2. Review / provide more depth to the examples of restoration and the organizations who are actively doing restoration work in Galveston
3. Read through the habitat restoration information packet with your students
4. Go over the synopsis and parameters
5. Each student group will then decide how to do the restoration within budget.

## INDEPENDENT PRACTICE:

Student groups create their restoration plan using the attached worksheets.


## ASSESSMENT OF LEARNING:

Monitor groups by asking about their budgets and decision-making process. Each group can read their paragraph and show the restoration project they created.

## CLOSING:

As you teach lessons linked to the Galveston Bay Watershed and the Gulf of Mexico, you can use the "I Wonder" Board as a closure assignment.

You might ask what else the students want to learn about marsh restoration. Students may ask about types of plants, the laws regarding marshes, planting depth or locations of projects in our community. All of their questions (even the ones asked multiple times) will go on the "I Wonder" Board. If a question was answered in the lesson, it can still be placed on the board.

Students may even have follow-up questions after these lessons that could be added to the board The goal is to have a place for all questions about the Galveston Bay and the Gulf of Mexico in one place.

## EXTENSION:

Students might research the true costs of plants and soil in our community to determine how much it would cost to actually complete their planned restoration. For more information on marsh restoration go to the Tides and Currents article by NOAA https://tidesandcurrents.noaa.gov/marsh.html

## NOTES:

## Restoration Information Guide (TEACHERS - KEY)

Terrace size


- To calculate the number of plants needed for planting, the area of the top needs to be added to the area of the sides of the slopes. Area is measured in square feet.
- Area $=$ length x width
$>\mathrm{Top}=50 \mathrm{ft}$ long x 4 ft wide $=200 \mathrm{ft}$
> Sides $=50 \mathrm{ft}$ long x 6 ft wide $=300 \mathrm{ft}$
$>$ (Two sides, so $300 \mathrm{ft} \times 2=60 \mathrm{oft}$ )
- Area $=\mathbf{2 0 0}+\mathbf{3 0 0}+\mathbf{3 0 0}=\mathbf{8 0 0}$ feet $^{2}$
- 80o square feet of the terrace needs to be planted!


## Soil

- Soil is needed to create the terraces. Soil costs $\$ 20$ per cubic foot.

Volume of top $=\mathbf{1 , 0 0 o f t}$
$50 \mathrm{ft} \times 4 \mathrm{ft} \times 5 \mathrm{ft}=1,000 \mathrm{ft}$
Volume of side $=\mathbf{7 5 0 f t}$

- $50 \mathrm{ft} \times 3 \mathrm{ft}=150 \mathrm{ft}$
$150 \mathrm{ft} / 2=75 \mathrm{ft}$
$75 \mathrm{ft} \times 5 \mathrm{ft}=375 \mathrm{ft}$
$375+375=750 \mathbf{f t}$
- Volume $=$ center + side $1+$ side 2
- Volume $=$ lwh $+2(1 / 2$ base area * height $)$
- Volume $=\mathbf{1 0 0 0}+750$
- For this scenario above: $1750 \mathrm{ft}^{\mathbf{3}} \mathbf{x} \mathbf{\$ 2 0}$ per cubic foot $=\$ 35,000$ for the soil


## Vegetation

- Vegetation like Spartina alterniflora should be planted 3 feet apart on the exposed sides of the terrace.

To find how many plants are needed, divide the area to be planted by 3 square feet.

- 800 square feet need to be planted $/ 3^{2}=88.89$
$>800$ sq. ft / $9=88.89$
- So, 89 plants are needed.
- Each plant costs $\$ 2$ per stem. If 89 plants are needed, then $89 \times 2=\boldsymbol{\$ 1 7 8}$ for the plants


## Breakwaters

- Geotextile tubes will cost $\mathbf{\$ 2 0 0}$ per linear foot. The distance planned will change the cost for the group.
- Rock barriers will cost $\mathbf{\$ 3 5 0}$ per linear foot. The distance planned will change the cost for the group.


## Restoration Information Guide (Students)



## Terrace size

- Most terraces will be built to a uniform size, but then molded and bent to fit the shape of the land.
- To calculate the number of plants needed for planting you need the surface area of the terrace. Area is measured in square feet.


## Soil

- Soil is needed to create elevation of the terraces.
- You will need to know the volume of the terrace.
- Soil costs $\$ 20$ per ft ${ }^{3}$


## Vegetation

- In order to prevent erosion of your newly created terrace and provide habitat for native wildlife, the terrace must be planted with native vegetation, like Spartina alterniflora (smooth cordgrass)
- The cordgrass should be planted 3 feet apart on the top and sides of the terrace.
- Number of plants needed= surface area/3 ${ }^{2}$
- Plants cost $\$ 2$ per stem.


## Breakwaters

- Breakwaters are constructed to reduce wave energy so that terraces or mounds of material can be placed and planted behind for protection. If terraces are built without a breakwater of some sort to protect them from waves, the constant impact of the waves will cause the terraces to erode.
- Geotextile tubes are synthetic fabric tubes that are filled with soil and are used to break waves in areas of medium to high intensity. They are stable and require little maintenance. Bird feces can strip away the uv protectant on the tube and the material can become vulnerable to tears. These will cost \$200 per linear foot.
- Rock barriers are used to break waves in areas of high intensity like you would find near boat traffic areas. They are very stable and require very little maintenance. They can also provide reef type structure and habitat for animals and plants living in the area. These will cost $\$ 350$ per linear foot.


## Restoration Parameters



- You are restoring three acres.
- The area is in an area of high and medium intensity wave action due to the intercoastal waterway and will require a breakwater.
- The restoration will require the construction of terraces.
- Neighbors want the restored marsh to be attractive and provide habitat to native wildlife right away.
- You have \$500,000 to work with and not a penny more.

$100 \mathrm{ft} \pi$
Restoration Area site map with the wave energy areas marked
Coastline is 500 ft long


## Restoration Budget Breakdown

## Teacher Key:

- Budget = \$500,000
- Terraces $=50 \mathrm{ft}$ long
- 500 ft of coastline $/ 50 \mathrm{ft}=$ 10 terraces
- Geotubes = \$200 per ft
- Rocks $=\$ 350$ per ft



## Teacher Key:

- Soil = \$35,000
- Cost of plants $=\$ 178$
- Area $=800 \mathrm{ft}^{2}$
- Volume $=1750 \mathrm{ft}^{3}$
- Number of plants $=89$
- Number of terraces $=10$

Soil + cost of plants $=\$ 35,178$
$\$ 351,780 \times 10$ terraces $=\$ 351,780$
$\$ 500,000-\$ 351,780=\$ 148,220$

You will want to use a pencil so you can erase and change your budget as you modify your plan.

## Total budget

$\mathbf{\$ 5 0 0}, \mathbf{0 0 0}$ Length of geotube breakwater installed___ at a total cost of ___

Length of rock breakwater installed $\qquad$ at a total cost of $\qquad$

Total amount spent on breakwaters $\qquad$

Budget amount left for terraces $\qquad$

Number of terraces installed $\qquad$ at a total cost of $\qquad$

Money left over from the budget $\qquad$

Left over money spent on $\qquad$

## Restoration Conclusion

How did your project go? Was it a straight forward process, or did you have to negotiate and change your plan? Write five sentences to talk about your thought process on what you designed.

## Restoration Budget Breakdown



You will want to use a pencil so you can erase and change your budget as you modify your plan.
Total budget
$\$ 500,000$

Length of geotube breakwater installed $\qquad$ at a total cost of $\qquad$
Length of rock breakwater installed $\qquad$ at a total cost of $\qquad$

Total amount spent on breakwaters $\qquad$

Budget amount left for terraces $\qquad$

Number of terraces installed $\qquad$ at a total cost of $\qquad$

Money left over from the budget $\qquad$

Left over money spent on $\qquad$

## Restoration Conclusion

How did your project go? Was it a straight forward process, or did you have to negotiate and change your plan? Write five sentences to talk about your thought process on what you designed.

## Restoration Project Worksheet



You must design the restoration location to meet the parameters set out by the Homeowner's Association and stay within budget.

## Part 1:

Determine the size of the site.
1 acre $=43,560 \mathrm{ft}^{2}$
3 acres = $\qquad$

Part 2:
Determine type and length of breakwater needed.
Your breakwater needs to be between 100 and 150 ft from the shoreline. Draw a line on your restoration map for where the breakwater should be located and then measure how much is in each of the wave zones.

Length of breakwater needed in the low energy zone $\qquad$
Length of breakwater needed in the medium energy zone $\qquad$
Length of breakwater needed in the high energy zone $\qquad$

Now, you need to make some decisions. Use your guide sheet to determine the cost of installing geotube or rock or a combination of both. Many projects spend $1 / 3$ of the budget for breakwaters and $2 / 3$ of the budget on terraces, but it is your project, and you can decide how to spend the budget.

Cost to put in geotube: $\qquad$
Cost to put in rock barriers: $\qquad$
Total cost for your breakwater: $\qquad$
(transfer these numbers to your overall budget)


## Part 3:

Determine the cost of each terrace.
Surface area of your restoration area

- To calculate the number of plants needed for planting, you start by finding the surface area of the terrace.
- Remember that the area of top needs to be added to the area of the side slopes.
- But surface area alone won't get you there. Remember that the plants need to be 3 feet apart.


## Total Surface Area for planting = top area + side slope 1 area + side slope 2 area

## Number of plants you need to purchase for each terrace = Surface area of terrace $/ \mathbf{3}^{\mathbf{2}}$

Now you know how many plants you need, but you need to include the cost of plants in your budget, not the number of plants needed.

Number of plants needed $x$ cost of plants = cost per terrace for plants

## Volume of your restoration area

- To calculate the volume of one terrace you can assume that the two side slope sections are the same size.
- Total volume of the terrace $=$ center + side $1+$ side 2

How much soil will you need to build one terrace?
Volume of terrace x cost of soil = cost per terrace for soil

Total cost per terrace is the cost of soil + cost of plants

## Part 4:

How many terraces will you build?
Now that you know how much money is left after putting in breakwaters and the cost of each terrace, you can figure out how many terraces to build.

Money left after cost of breakwaters/ total cost per terrace = number of terraces you can put in.

Did it work out perfectly or did you have a decimal? $\qquad$
Round down to the nearest whole number and figure out the total cost of your terraces.
Total cost of terraces $=$ cost per terrace $x$ number of terraces
(transfer these numbers to your overall budget)

## Part 5:

## Leftover money

If you have money left, you can plant a partial terrace (you will need to figure out the cost per linear foot to build it), you can add some length to your breakwater. Or you could do something else with the money that would benefit your neighborhood. Signage? Save the fees for other projects? Record your thoughts and math here and then transfer your final plans to your overall budget sheet.

## Part 6:

## Draw your terracing map

Return to the terrace map and draw in your terraces and breakwaters based on what you purchased. Create a key so your installation team knows what should go where. Remember that terraces are 50 feet in length, but do not have to be built straight. They should look naturally occurring.

