CH∆NGES

Student Notebook

Estuary Module

Student Number

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Grand Bay National Estuarine Research Reserve

The National Academies of SCIENCES ENGINEERING MEDICINE

GULF RESEARCH PROGRAM

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What's this CH∆NGES program anyway?

The Grand Bay National Estuarine Research Reserve (GNDNERR) is home to a retrograding river delta, which requires constant application of management, monitoring, and restoration. Marshes in the estuary are subject to erosion through wave action and sediment loss and the introduction of invasive species. Through the employment of management practices, the GNDNERR seeks to restore functions to these unique ecosystems.

This project, Conceptualizing Human Alteration and Natural Growth in Estuaries and Savannas (CH∆NGES), will use these unique habitats and current management applications as a platform to educate students about ecological processes and applicable restoration practices. Students will be introduced to the GNDNERR savannas through immersive educational experiences. Students will use research instruments to collect data and map invasive species using GPS and GIS technology. Activities and simulations will help familiarize students with restoration practices associated with each environment. Students will observe and participate in monitoring processes from experimental design planning and data collection, to data entry and manipulation. They will identify differences between natural and anthropogenic change, discuss pros and cons of efforts to restore the ecosystem to a previous functional state, and assess ecosystem responses to weigh the benefits of each decision. In short, they will gain direct exposure to the real-world work of natural resource managers at the GNDNERR.

Figure 1. Grand Bay Estuary from Bangs Island. Photo by: Dr. Eric Sparks, 2018

This project is funded through The National Academies of Sciences, Engineering, Medicine Gulf Research Program's Capacity Building Grants.

Lesson 1: What's an estuary?

Concept Map

First, let's see what you think we'll be learning about estuaries! Using the word bank, create a concept map. A concept map shows relationships between a number of concepts. Use the word bank below to complete the map. The relationship between concepts should be shown with a directional arrow that is clearly labeled. There can be more than one relationship between concepts. *Hint: a concept map should not be linear! We have started a concept map for you with the words "salt marsh estuary."

Word Bank:

Deposition   Erosion   Monitoring   Restoration   Salt marsh estuary   Structure

Salt marsh estuary

In a few sentences, explain what your concept map is showing. ________________________

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Introduction

Speaking in terms of geological time, Estuaries only last for a short period. Most of the estuaries on earth are "young" systems in geological and evolutionary terms. They were formed at the end of the last ice age, about 6-10,000 years ago.

Most estuaries are places where rivers meet the sea. Here there is a mixing of freshwater and saltwater to become known as **brackish water**. Usually an estuary is partially enclosed by land. This protects them from the full force of wind and waves from the ocean.

Figure 2. Grand Bay Estuary.

Estuaries are some of the most biologically productive ecosystems on the planet. Here water circulation traps plant nutrients and stimulates **primary production**. Freshwater floats on top of saltwater, forming a distinct layer. Where they meet, the flow of freshwater along with the tides, winds, and waves cause the two types to mix along with nutrients carried with the water. This can cause estuaries to be more productive than either of the habitats from which the water flows. As a matter of fact, estuaries can be more productive than the most plentiful farmland.

The Grand Bay estuary is a naturally **retrograding river delta**. The Escatawpa River (to the north of the Reserve) was captured by the Pascagoula River (to the west) 3000-5000 years ago. Because of this, there is no direct flow of fresh water from a major river into the Grand Bay system. Freshwater inflows are limited to rainwater runoff and small creeks. Without a major source of sediment, erosion from storm surges and wave action is outcompeting sediment **accretion** in the Grand Bay NERR marshes. This has led to heavy erosion of the **headland areas** of Point aux Chenes Bay and the Grand Batture Islands. These areas are shifting from enclosed brackish waters to more open **saline environments** (Grand Bay NERR, 2007).

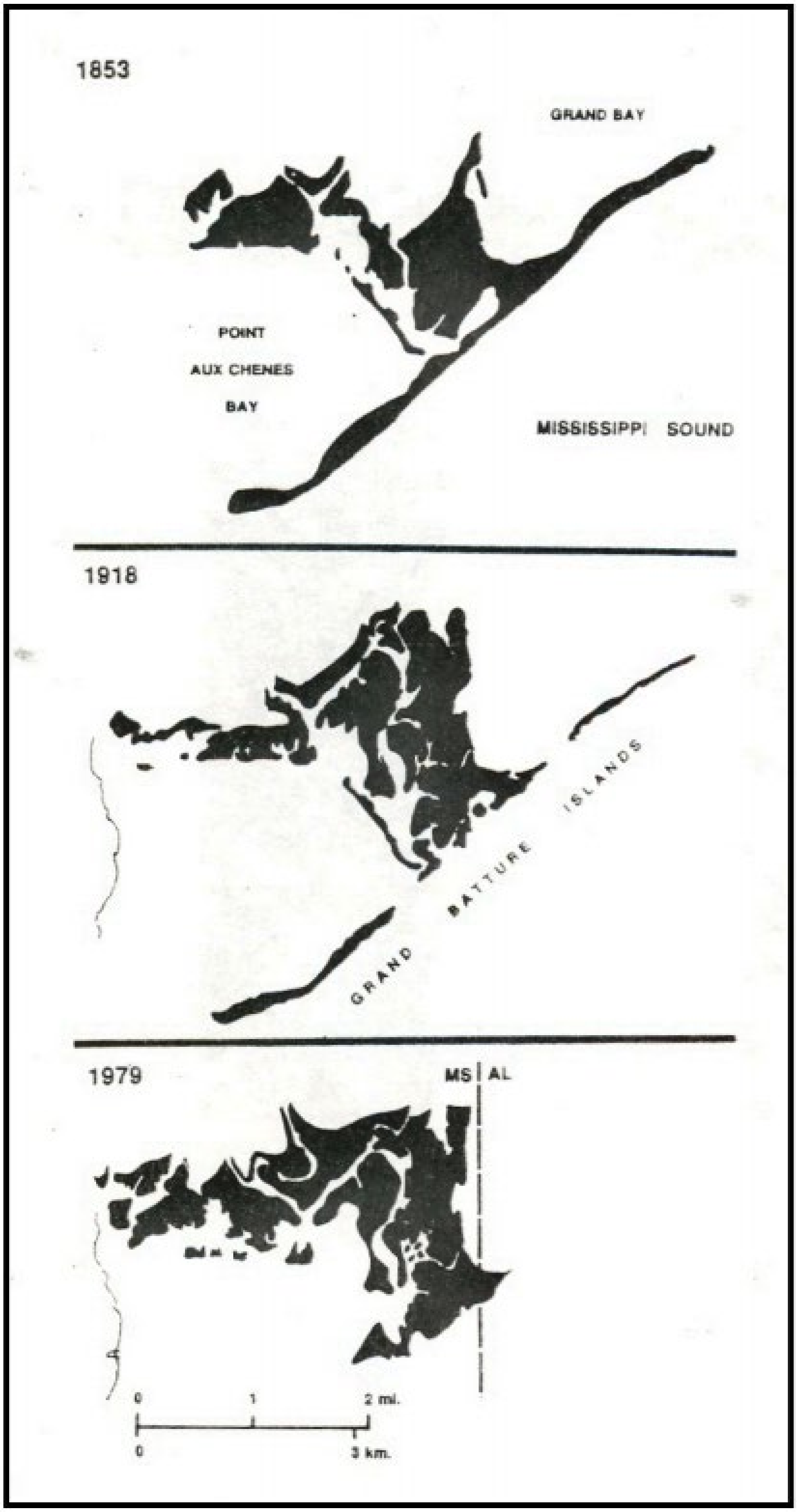

Figure 3. Over time, the Escatawpa delta plain and the Grand Batture marsh islands disintegrate. Figure from Otvos (1991), found in Grand Bay NERR Site Profile (2007).

In the 1930s construction began on a canal to connect Nine-Mile Lake to the Grand Bay Estuary. This waterway, called the Nine-Mile Canal, was built primarily to reconnect a source of freshwater and nutrients to the estuary in an attempt to increase growth of oysters.

An article from 1928 states that historically, the Dog River (a local name for the Escatawpa River) flowed into the estuary through an outlet in Nine-Mile Lake, but the outlet was filled with sediment following logging activities in the late 1800s and early 1900s.

This effort was designed to re-establish the connection. While little information is available about the success of the project, this is among the earliest documented ecological restoration efforts in the area. Historical records indicate that the canal was designed to be five feet wide at the bottom and 25 feet wide at the top and would permit a constant flow of water from Nine-Mile Lake to Bayou Cumbest. The total project cost was $2,080.20.

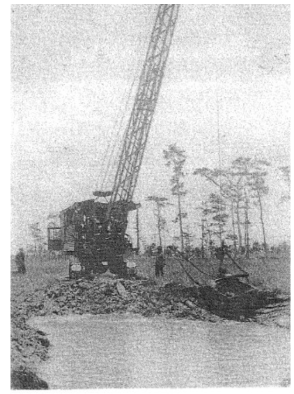

Figure 4. Photo of constructing the Nine-Mile Canal. Photo by: Marion Brown.

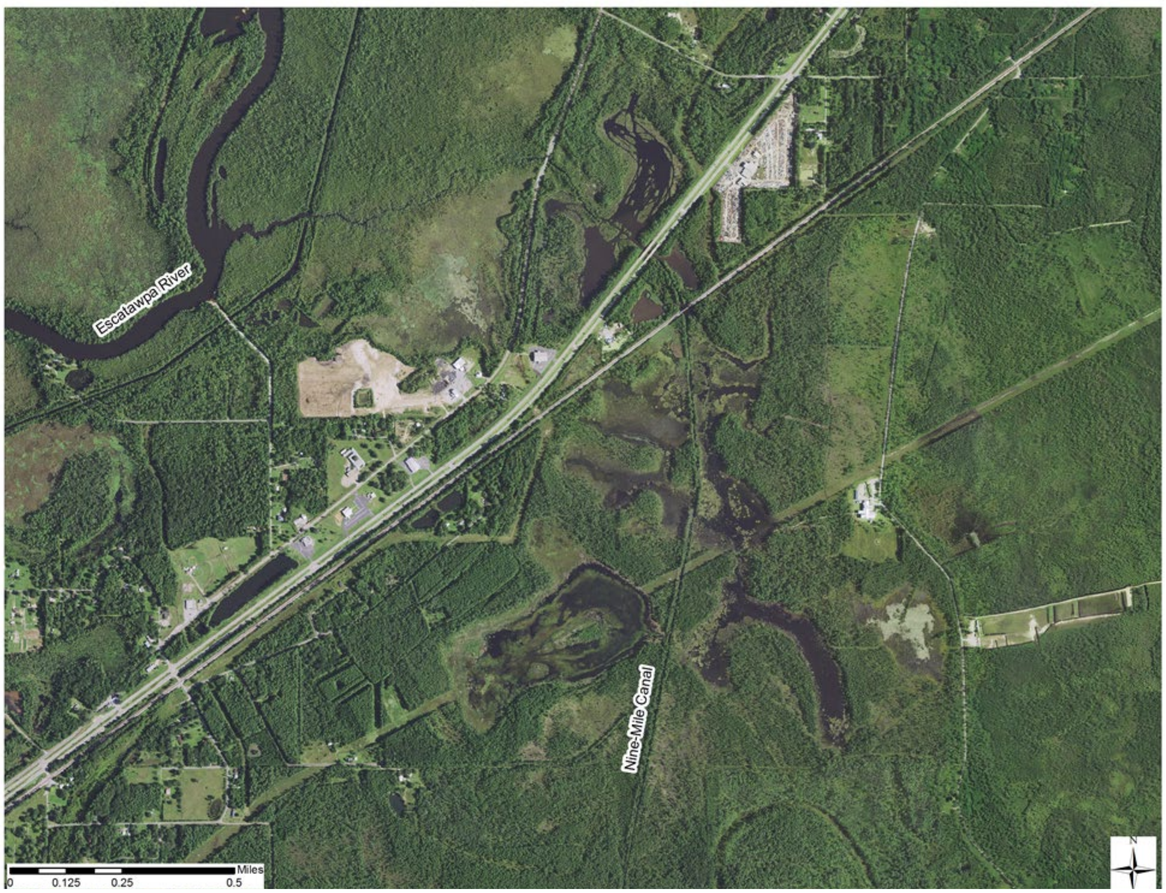

Figure 5. Aerial imagery of Nine-Mile Canal and how it was built to connect the Escatawpa River to the Grand Bay Estuary. Image obtained from Dr. Jonathan Pitchford, 2018.

1-1. *Connecting Past to Present:* How much do you think restoration efforts like the one to build the Nine-Mile Canal would cost in present day? How would you find out that information?

Structure- What makes up an estuary?

The Grand Bay Estuary is comprised mostly of **salt marsh**. These coastal wetlands are characterized by substrate made of deep mud and **peat** and influenced by saltwater tides. There are three distinct zones divided by minor elevation changes: low, mid, and high marsh. The low marsh lies at the lowest elevation and is dominated by smooth cordgrass (*Spartina alterniflora*). *S. alterniflora* is a **halophyte**, or salt-loving plant that only grows in areas exposed to saline water.

The low marsh zone is usually completely submerged - or **inundated** - during high tide, or is exposed during the low tide. This area goes from one extreme to another, and organisms that live in the low marsh zone must be adapted to harsh extremes.

The mid-marsh occurs above the average high tide mark and isn't regularly flooded. This zone is dominated by black needlerush (*Juncus roemerianus*). The high marsh lies at the highest elevation in the salt marsh and can support more diverse vegetation communities than the other zones comprised of plants like salt meadow cordgrass (*Spartina patens*), marsh elder (*Iva frutescens*), and yaupon holly (*Ilex vomitoria*). These areas are only covered with saltwater during unusual high water events like hurricanes and **king tides**.

Figure 6. Photo of salt marsh estuary.

Other types of habitat occur in the saltmarsh as well. **Salt pannes** can be found in some of the mid-marsh zones. Depressions are formed after saltwater pools during a spring or flood tide. Once the water evaporates, salt is left behind to create a **hypersaline environment**. This forms a barren habitat where most plants are unable to grow. Halophytes, like pickleweed or glasswort (*Salicornia virginica*), are the only vegetation that are able to survive in these areas.

Figure 7. Racoon tracks on a salt panne. Photo by Dennis McGrury, 2016.

Figure 8. Shell midden on Bangs Island. Photo by Sandra Huynh, 2018.

Shell middens are large mounds of oyster shells found in the Grand Bay marshes that support their own unique vegetation communities. Hardwood trees and woody shrubs are able to grow on these mounds because of the higher elevation and calcium rich soil. Shell middens are not naturally occurring phenomena. The mounds were formed from thousands of years of discarded oyster shells. Native Americans would once harvest and smoke oysters in the Grand Bay marshes. Once the oysters were consumed, they were discarded eventually piling up and forming large mounds. Over time Native Americans would discard other items here as well. Archaeologists have discovered tools, pottery, various types of animal bones, and even burials dating some of these items to about 4,000 years ago.

Seagrass beds are another habitat found in the Grand Bay Estuary. These beds are dominated by a single species in Grand Bay, widgeon grass (*Ruppia maritima*). *R. maritima* prefers low salinity waters in Mississippi. The beds can range from very small, <1 **hectare** (about 2.5 acres), to almost 100 hectares. Altogether they add up to a total of 147 ha. They are found on shallow muddy bottoms next to marshes. The seagrass needs to remain submerged during low tides. Seagrass beds provide food and shelter for many organisms.

Figure 9. Ruppia maritima *dominates seagrass beds in the Grand Bay Estuary. Photo by Chris May.*

Species Highlight

Black needle rush (*Juncus roemerianus*) and smooth cordgrass (*Spartina alterniflora*) are the two dominant plants found in the salt marshes of Mississippi. These plants are also good indicators of elevation. *S. alterniflora* can be found in the low marsh that is regularly inundated, or covered with water. It also is a halophyte, or salt loving plant that only grows in areas exposed to saline water. *J. roemerianus* grows at slightly higher elevations, is irregularly inundated, and can grow in freshwater marshes as well.

Figure 10. Photo of Spartina alterniflora *(greener plants on the left) and* Juncus roemerianus *(browner plants on the right). Photo by Sandra Huynh.*

Black Needle Rush (*Juncus roemerianus*)

The needle-like tips that are the namesake of this **perennial** actually consist of leaves rolled into sharp points. The stems of the plant are tipped with groups of flowers, called **inflorescences**, that are responsible for sexual reproduction. *J. roemerianus* is also capable of **vegetative reproduction** where new stems sprout from the spreading **rhizome**, or root system. *J. roemerianus* provides valuable habitat and protection for many animals that inhabit the salt marsh. Scientists have discovered that *J. roemerianus* is also able to help wetlands rid themselves of hazardous materials, a process known as **phytoremediation**. Studies have shown that this amazing plant will even enhance oil degradation and reduce the amount of hydrocarbons in contaminated wetlands.

Smooth Cordgrass (*Spartina alterniflora*)

This plant is covered with saltwater most of the year. While some other species wouldn't be able to tolerate this, *S. alterniflora* excretes the salt it takes in from glands on its leaves. These leaves and the algae that grow upon them provide food for grazers, like the periwinkle snail. In the fall, *S. alterniflora* dies and creates **wrack**. The wrack is transported by waves, tides, and currents and eventually breaks down. The nutrients are released back into the estuary. This **nutrient recycling** adds to the productivity of the system. *S. alterniflora* is also a good way to control erosion. The **root mats** and rhizomes will help stabilize soil, and the stalks will lessen the waves' impact by breaking up energy.

Function- What does an estuary do?

Estuaries have many ecological functions. One of the most important is that they are **habitat** for many species. The shallow waters and sheltered tidal creeks create perfect **spawning and nursery** conditions for many fish and shellfish species. These areas provide protection, in contrast to more open-water environments, and an abundant source of food. Most commercial fish species spend some part of their life cycle in an estuarine ecosystem. Other animals also seek out wetland habitats for shelter, like migratory birds. Many bird species use estuaries as a **"rest-stop" on their migration routes**. While breaking from long exhausting flights, the birds are also provided with a plentiful food source by the estuary. In addition to temporary residents estuaries are also full of animals that live there perpetually.

Estuaries also play a role in **cleansing our waters**. They are capable of filtering pollutants from **nonpoint sources**, like roads. First, certain plants, like smooth cordgrass (*S. alterniflora*), remove pollutants such as pesticides, excess nutrients, and heavy metals. Second, sediment absorbs and buries pollutants minimizing their effects on the environment.

When our coastlines are pummeled with large storms, like hurricanes, or inundated with flood waters, estuaries provide **buffer zones**. Estuaries can soak up the excess water from flooding or storm surges. These extensive vegetated areas also act like natural shoreline stabilizers to protect coastal lands from erosion caused by excessive hurricane winds and waves. Estuaries and surrounding wetland areas are responsible for preserving and protecting many coastal communities around the world.

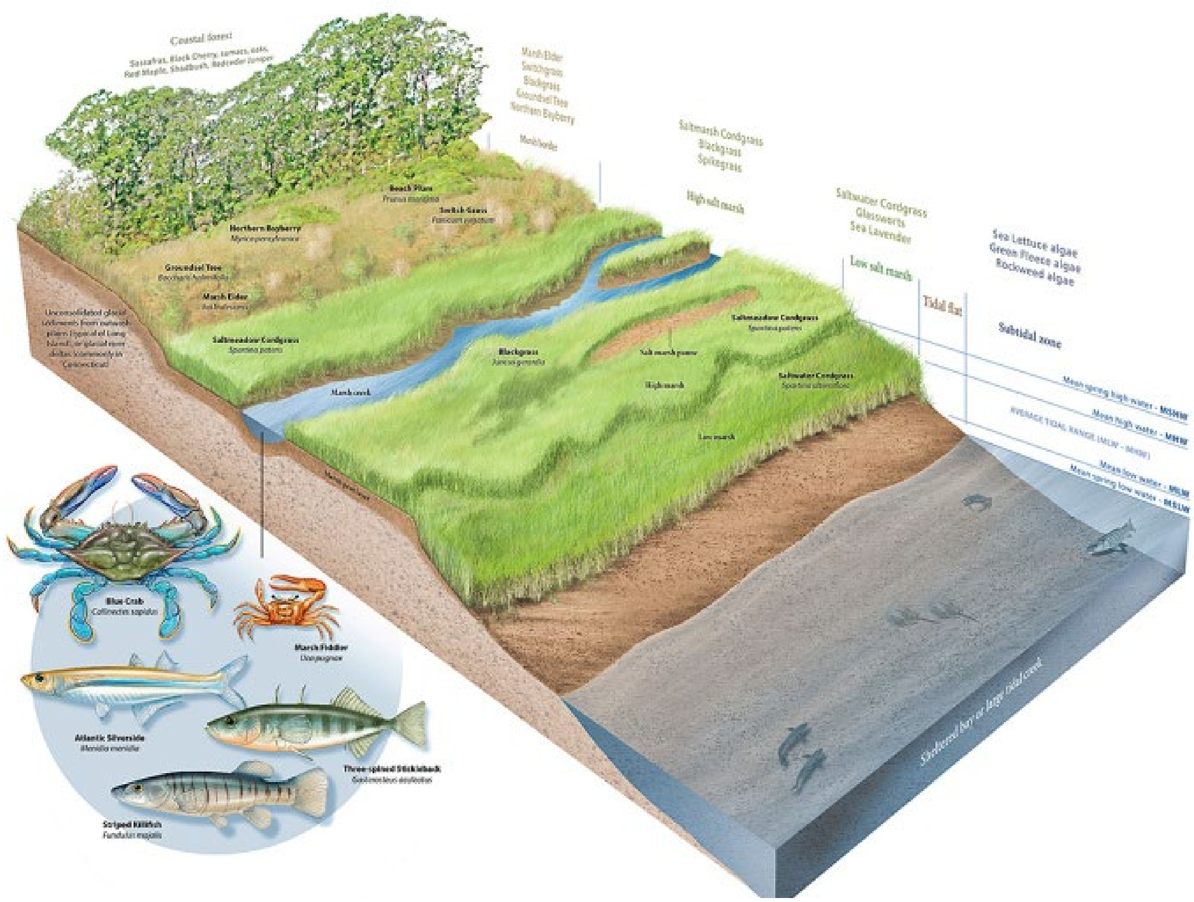

Figure 11. Illustration depicting the structure of a salt marsh by Patrick Lynch, 2017.

Ecosystem Services

An **ecosystem service** is a benefit that humans get from a functioning ecosystem. These can be natural resources that we consume like food and water, support natural cycles like the nutrient cycle and primary production, help with regulating things like waste and pests, and provide cultural services from spiritual to recreational, to education and therapy. At Grand Bay NERR, we estimate that our estuarine habitats (82.1% of the Reserve) and their ecosystem services are valued at $137,010,265.60 per year! The Grand Bay NERR has been a Reserve for 20 years, so calculate that number! ____.

1-2. List some of the ecosystem services of an estuary below: ____________________________

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1-3. What might be some ecosystem services in other areas of the Grand Bay NERR, like the upland pine savannas? ____

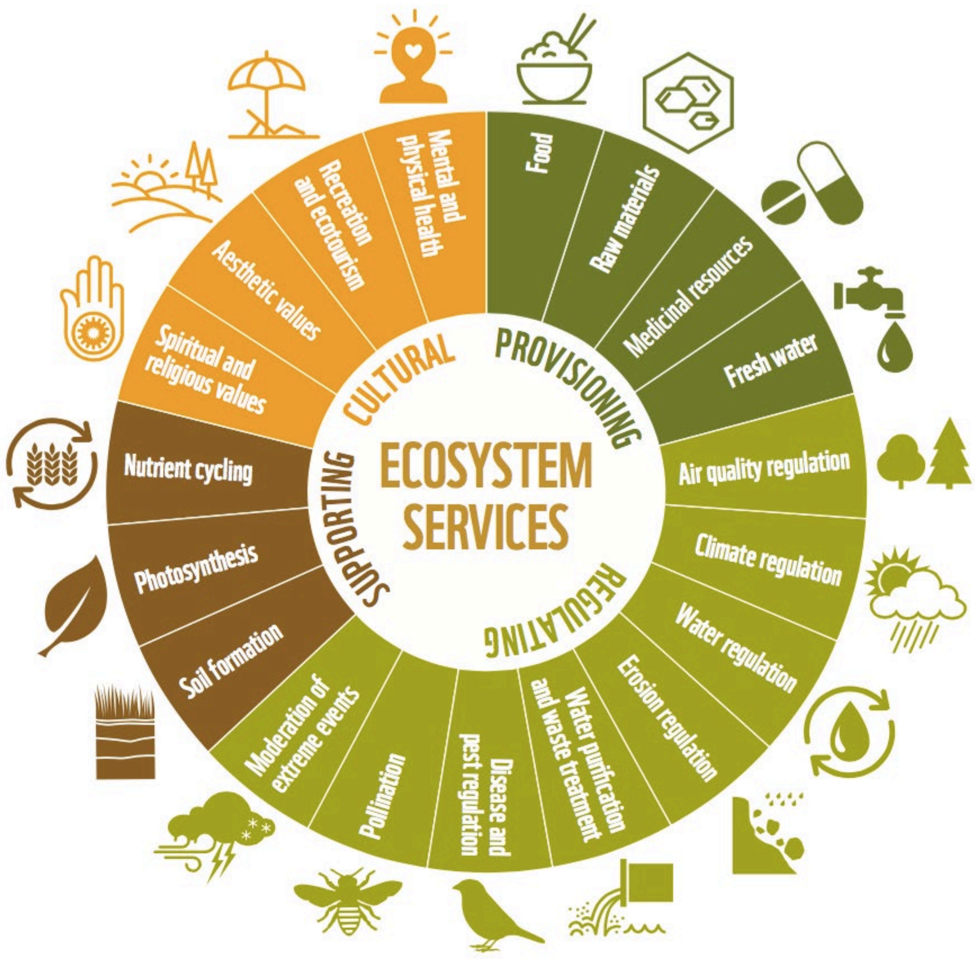

Figure 12. Ecosystem services. Figure by: WWF Living Planet Report 2016

Biodiversity- What lives in an estuary?

Biodiversity is the amount of different species of organisms in a specific area. Areas that are closer to the equator tend to have higher levels of biodiversity. In other words, tropical areas that stay warm year-round are high in biodiversity, whereas temperate regions have lower biodiversity because they have fluctuations in their climates (e.g. warm summers and cold winters). Areas with extreme conditions have the lowest biodiversities on the planet, such as deserts and arctic regions.

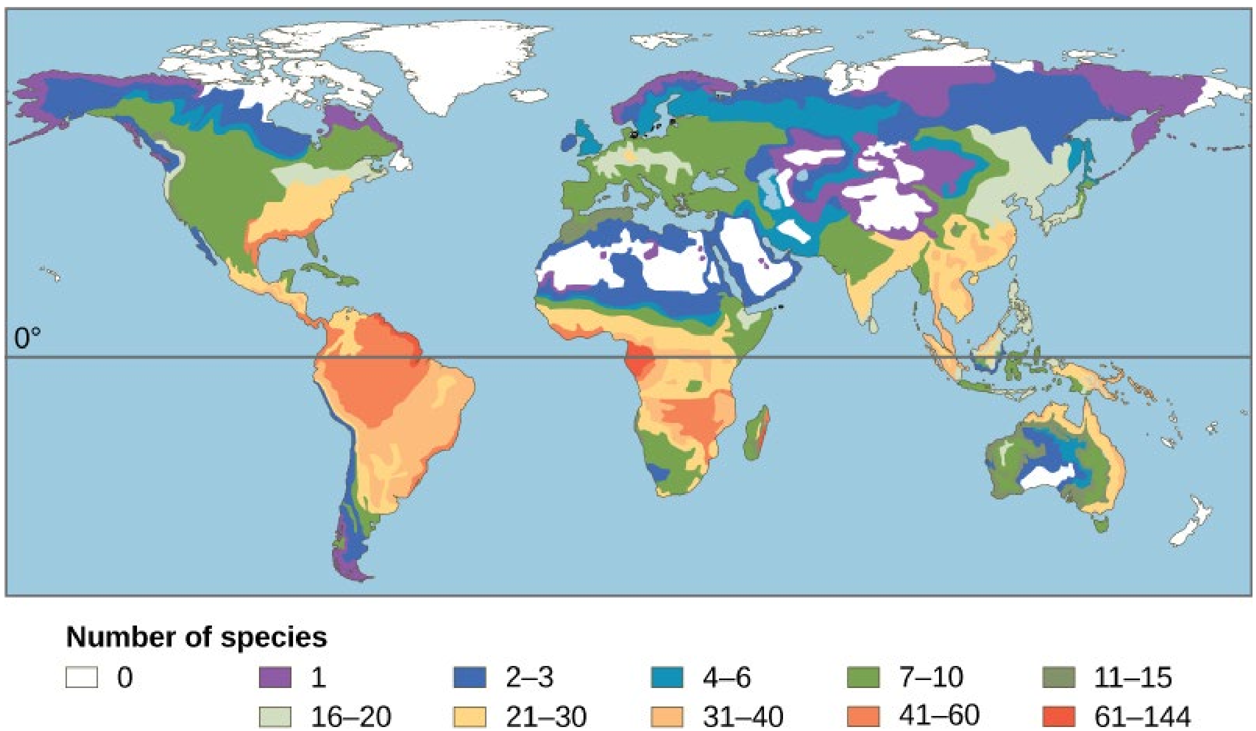

Figure 13. This figure from Fisher (2018) shows that biodiversity tends to be higher at lower latitudes (towards the equator). This map depicts the number of amphibian species around the world, but similar patterns of biodiversity occurs with most plant and animal groups.

Ecosystems around the planet with the highest levels of biodiversity and high numbers of **endemic species** (species that exists nowhere else on the planet) are considered "biodiversity hotspots." While biodiversity among vegetation is low and mostly consists of *J. romerianus* and *S. alterniflora* in the low and mid-marsh, other organisms thrive. High biological productivity in the saltmarsh allows this habitat to sustain many different species. There are many species that spend at least part of their lives in an estuarine environment. The estuary offers protection but also a food source. From plankton and fish to birds and reptiles, these habitats are diverse ecosystems with complex food webs.

Data and Observations Tip: As we venture into our field trips at Grand Bay NERR, you can observe and note examples of different species you encounter in your field journaling or notes pages at the end of this notebook.

Ecological Processes

Figure 14. Photo of eroding marsh in Grand Bay Estuary.

Erosion is the gradual process of removal of soil, rock, or sediment from one place and depositing it in another. Erosion can be caused by wind, water, or glacial activity. In the estuary, erosion is the weathering of soil from a beach or marsh area by water. This is usually facilitated by wave action and **longshore currents**. In Grand Bay there is no major supply of sediment, like from a river, to replenish the eroded sites. This can be problematic in that much shoreline can be lost, sometimes several meters a year.

Erosion also creates sediment. Some research that is going on right now at several erosional edges in Grand Bay is looking at the relation between shoreline erosion and **sediment deposition** on the marsh surface. Findings are somewhat preliminary, but they do suggest that (not surprisingly) these erosional edges are providing sediment for the marshes to keep pace with **sea level rise** (SLR). This is something to keep in mind when considering options for shoreline restoration. Protecting one shoreline could actually reduce the marsh's ability to keep up with SLR via sediment deposition, especially in areas like Grand Bay with minimal sediment input from upland sources.

Deposition is when sediments, soil and rocks are added to a landform or land mass. When discussing deposition in Grand Bay NERR, we focus on sediment deposition (the settling of material onto a marsh surface) and **accretion** (the net balance between deposition and removal processes).

Figure 16. Surface elevation table (SET) in the marsh. Photo by Grand Bay NERR Stewardship Staff.

Surface elevation tables consist of a steel rod driven far into the ground and equipped with a cemented attachment head for the measuring arm. The rod and concrete block ensure that the measuring head is stable and secure. Once the measuring arm is in place, pins are dropped down to the marsh surface and the height of each rod above the arm is measured. These measurements are taken quarterly and over time will be used to detect any increase (accretion) or decrease (**subsidence**) in the surface of the marsh. Since the SET measuring arm detects both accretion and subsidence, **marker horizons** are used to measure accretion only. This helps us determine the amount of accretion and/or subsidence happening at each site. Accretion is measured as the height of detritus and sediment accumulated on top of the white horizon layer.

Figure 15. Feldspar (the white mineral layer) is placed on soil and sediment and serves as a marker horizon to measure accretion. Photo by Grand Bay NERR Stewardship Staff.

Tides are influenced by the gravitational pull of the moon and the sun (although the pull from the sun is weaker because of its further distance from the earth). Tides are long-period waves that roll around the earth. This occurs because the moon, and the sun, "pull" the ocean as they move around the earth. Tides are also affected by landforms, like along the MS Gulf Coast. Here we only have one low tide and one high tide per day, or **diurnal**. In most other parts of the world, like the Atlantic coast, there are two high and two low tides per day, or **semidiurnal**. This is mainly because the Gulf of Mexico is like a giant bowl that the "long-period waves" slosh around in and cause the irregularities.

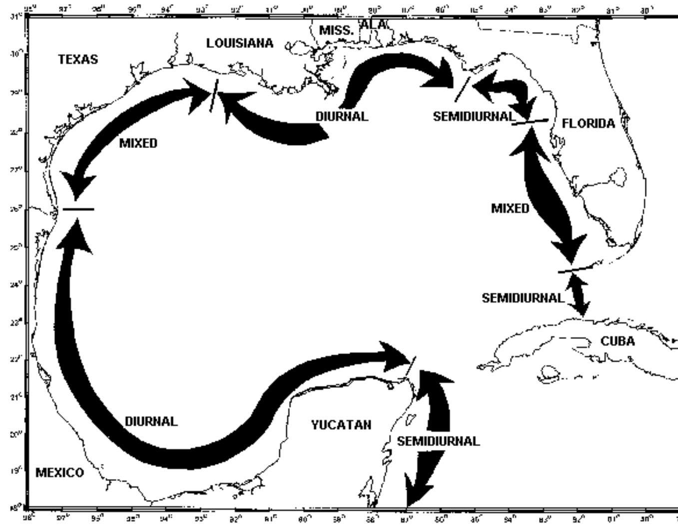

Figure 17. Tides in the Gulf of Mexico. Diagram by Gulf Coast Research Lab.

The two times a month when there is the greatest difference between high and low tide water levels (or the highest high tide and lowest low tide) are known as **spring tides**. This occurs during a full moon (earth is between the moon and the sun) or new moon (moon is between the earth and the sun) when the gravitational pull from the sun is added to the gravitational pull from the moon on the earth. When the sun and moon are at right angles, it is known as a neap tide. This arrangement will result in the least difference between high and low tides.

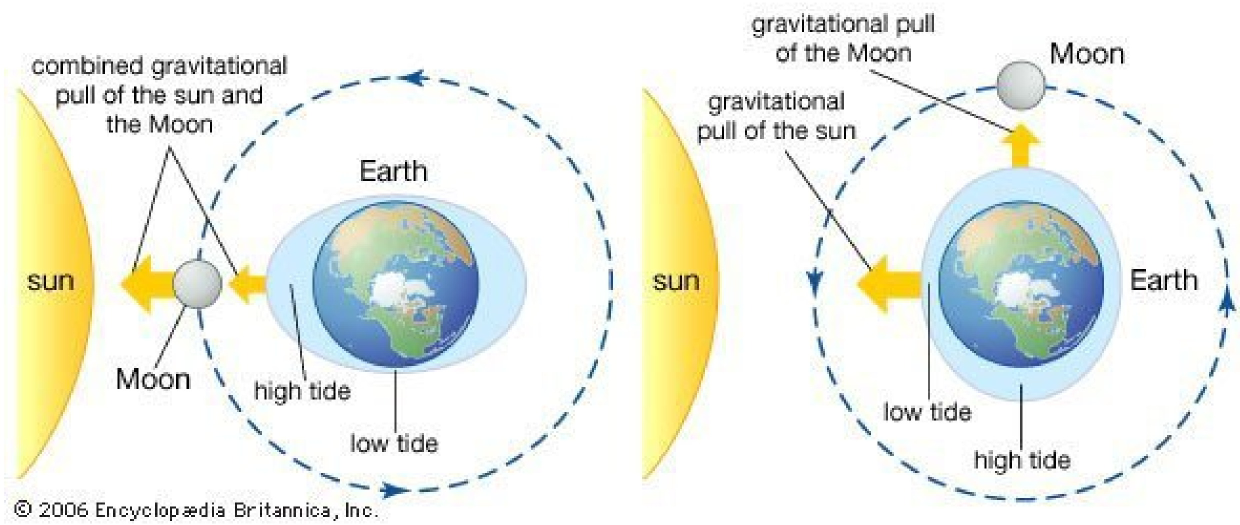

Figure 18. Illustration depicting how tides work. Image from: Encyclopedia Britannica, Inc.

Knowledge Checkpoint: Wetland Metaphors

Choose five of the following words. How do each of them relate to an estuary?

Sponge	Pillow or bed	Whisk	Crib
Strainer	Coffee filter	Antacid	Garden
Soap	Zoo	Baby food	Playground

1.______________________________

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2.______________________________

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3.______________________________

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4.______________________________

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5.______________________________

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Lesson 2: Methods and Technology

Welcome to the Grand Bay NERR! We're excited to have you onsite today, and we have a lot of activities to cover. Each component of today's field trip will help inform your Day 5 Restoration Plan that you'll design and present with a group.

Today's activities will introduce you to monitoring, management, restoration practices, and various impacts to the environment. We'll also explore some of the scientific instruments and methods our scientists at the Grand Bay NERR use to manage and monitor our Reserve.

Here's what to expect today:

- Group work: Our scientists and resource managers hardly work alone to accomplish a task, especially in the field where conditions could be extreme (very hot, in the wilderness). We also work in groups to help each other carry equipment and help with the data collection process. You will be working in small groups for the same reasons our scientists do.

- Handling equipment: Scientific equipment is meant to be durable, but they can also be very expensive. While you're in the field, be sure to take good care of any equipment you handle. When equipment is in good, working condition, you know that your data is reliable.

- Outdoors: At some point today, you will be working outside. Make sure to wear proper protective gear like boots, sunscreen, and/or bug spray, or a jacket in case the weather changes. We'll be doing a lot of walking, so be sure to watch where you're going and follow a path if there is one to reduce disturbing the land. If you're on the boat, make sure to always keep your life jacket on and wear closed-toed shoes.

- Writing in your notebook: Scientists are always writing, whether they are quick notes from observations, or writing down numbers or other types of data neatly so they can read it later, or creating a more formal report or scientific paper to explain the work they conducted and what it means to the scientific (and local) community. Keep your notebooks and something to write with handy. We'll be referring to it quite often.

- Information: Today will be packed with activities and information, and the best way for everyone to learn is to participate and be actively involved in what's going on. Active participation also means active listening! The way to succeed today is to pay attention and become familiar with the concepts, technology, and how they work together to help you do your best science.

Impacts Grid Activity

Environmental impacts come in a variety of forms, whether they are natural or **anthropogenic** (human-influenced), or whether they are good or bad for the environment. For this activity, we're going to explore some environmental impacts and see how you might classify them on a grid.

First, we need a large area to create our grid and for us to be able to move around. A "large area" maybe a courtyard or grassy spot at your school, or maybe the gym or classroom if you move things around. At the Grand Bay NERR, we're going to use the amphitheater outside by the front door. In the middle of the amphitheater, we'll create a life-sized grid with two axes coming together in the middle like a cross. On one axis, let's say the x-axis, we'll make a scale that goes from "human" to "natural" for the *type* or *source* of the environmental impact. On the y-axis, we'll make a scale that goes from "positive" to "negative." Label these axes with a sign, so everyone can remember which way to go.

2-1. *Draw it out: Use this space to draw out the grid we'll be creating in the amphitheater based on the example above. *Hint: Think math classes.*

Your class will start at the origin, or (0, 0) on the grid. A moderator (who could be NERR staff or maybe your teacher), will call out an "impact" and you have to move on the grid where you think it falls. *Hint: Think for yourself! Even if your teacher is participating, don't assume that he or she is correct. In fact, some of these impacts don't necessarily have a "right" or "wrong" answer.

Next, look around to see who else is standing by you and talk about why you chose to stand there. The moderator will ask for volunteers to tell the entire group why they chose to stand where they did.

You won't need your notebook with you for this activity, but when you come back or have time later, fill out the table on the next page and jot down your notes on environmental impacts from this activity.

IMPACT	**Where did you stand? (Label your axes first!)**	**DISCUSSION- What did you discover about this particular impact?**
invasive species		
flooding		
hurricanes		
eutrophication		
fragmentation		

2-2. *Let's pause:* There really isn't a right or wrong answer for some of these impacts. Understand that impacts are different based on who or what is affected. Thinking back to the estuary, how might we understand or know what is affected by impacts? How will we know what's the most appropriate restoration practices are for the environment that needs to be restored or managed?

Responding to Coastal Impacts: What can be done?

As sea level rises, the salt marsh naturally migrates inland. This allows the marsh to remain and function properly. The plants and animals will adapt to the rising water levels over time. If there is a barrier, natural or man-made, the marsh cannot migrate. Instead it is eroded at the seaward edge and squeezed against the barrier reducing its size and function. This is known as **coastal squeeze**.

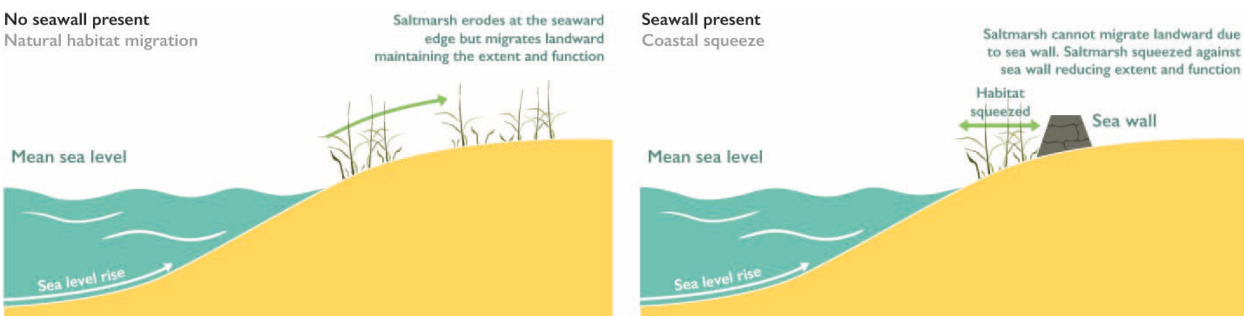

Figure 19. Illustration depicting coastal squeeze. Figure from: Eastern Solent Coastal Partnership.

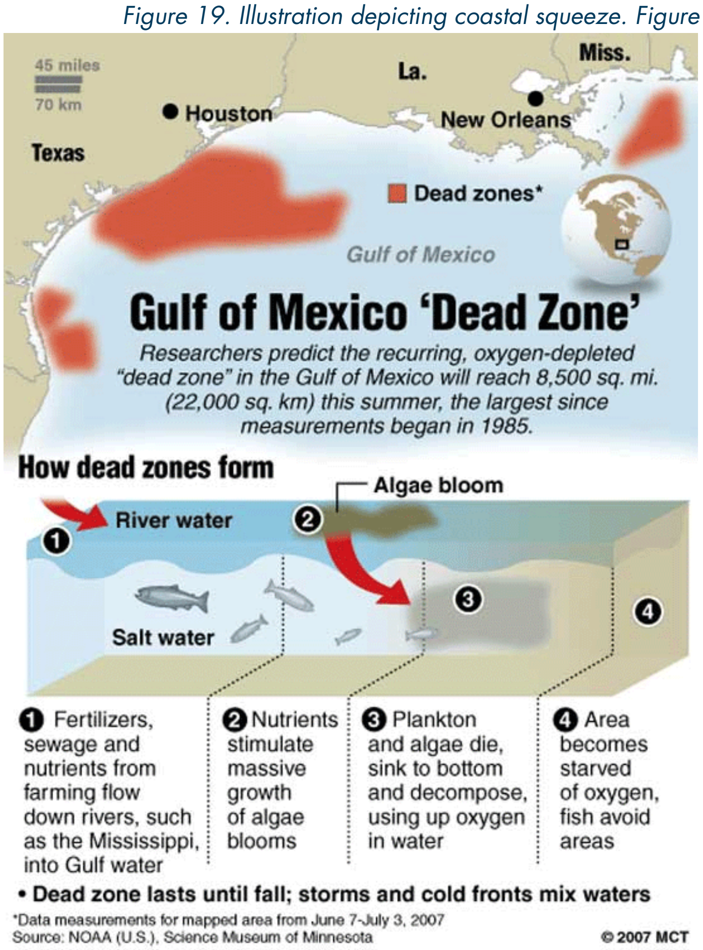

Figure 20. Infographic showing the Gulf of Mexico Dead Zone. Image by: Science Museum of Minnesota, 2007.

Eutrophication is a process that results in an excessive amount of nutrients in a body of water, like an estuary. One of the major ways these nutrient levels "load up" is through stormwater runoff. Once this nutrient charged rainwater enters a stream or lake, an explosive growth of algae occurs. Once this algal bloom dies, the waters become hypoxic, or oxygen poor, and organisms like crabs and fish begin to suffocate and die.

There are some things that we can do to prevent this. Like, use less fertilizer on our lawns, and if we do use it, don't put it on before a storm. Compost your grass clippings and raked leaves. Pick up your pet's waste so it doesn't enter storm drains. Recycle household chemicals. Plant native plants to provide ground cover. Finally, support wetland restoration projects, because they can naturally filter our waters.

Restoration Practices

management: replacing or augmenting missing or damaged natural processes, while using the least amount of manipulation to achieve a maximum benefit to wildlife or ecosystem health and function through active human intervention and action.

monitoring: processes and activities that take place to assess environmental conditions and ecosystem health by helping scientists establish current status and determine environmental trends. It is used to inform management.

System Wide Monitoring Program (SWMP) - Water quality is important in determining ecosystem health of the estuary. Monitoring scientists use SWMP station data loggers to record water quality assessments every 30 minutes. This data is uploaded to the NERRS SWMP database via satellite. The data is used to measure short and long-term changes in estuarine environments. Monitors at Grand Bay NERR have been able to capture significant water quality events like a chemical spill in Bangs Lake and storm surge from Hurricane Katrina at Bayou Cumbest.

Living shorelines - Living shorelines are a natural alternative to hardened shorelines for protecting marsh areas from erosion and wave energy. Organic materials like oyster shell, sand, wetland plants and coir fiber logs are used in creating living shorelines. By using these materials, a gradual slope is created which becomes an effective habitat for wildlife and a stable shoreline more successfully protected from erosion.

Sentinel Site Program (SSP) - There are five Sentinel Sites throughout GBNERR. The NERRS SSP was established to better understand climate change impacts such as changes in sea level, temperature, water chemistry, precipitation, and intensity of storm events. Currently the system wide SSP is examining the impacts of sea level change on coastal habitats by studying vegetation change over time.

Nourishment - Beneficial dredge use programs like MDMR's utilize dredge taken from projects such as widening shipping channels and use it to build up shorelines and islands that experience heavy erosion from high energy wave environments.

Hardened shoreline - (e.g. bulkheads) structures that reinforce shorelines and protect them from erosion

Artificial reef - habitat created for marine organisms. These reefs are made of oyster shells, rocks, and unwanted structures (bridge spans and derelict vessels)

Note: Often the cheapest management options are the ones that are the most practical. However, if a fast result is desired and money is no object, scientists may choose a different path. These practices are meant to imitate natural processes, which is usually the best option but not always ideal.

The Topobox- Geology and Watersheds

Topographic maps show how the land rises and falls. Topographic maps, like some hiking trail maps, help you visualize the terrain. Bathymetry is the underwater version of topography, where "bathus" is Greek for "deep." So, bathymetry looks at the depth of water in oceans and lakes. We'll be using the Topobox, a special interactive projection, to learn about topography, bathymetry, and the processes that affect both in an estuary.

2-3. Put one finger in the box and draw a line. How did the projection change? ______________
____

One way to classify estuaries is by its geology and its geologic processes, and how the landform shapes what goes on. Another way to classify estuaries is by its water circulation. We'll explore both using the Topobox. Ultimately, it leads to how we study water movement on the surface or below the surface of the earth. This is called hydrology. Sometimes hydrologic processes are interrupted or altered, which changes the flow of water. At Grand Bay NERR, the hydrology has changed due to fragmentation with construction.

2-4. Let's demonstrate fragmentation in the Topobox. When it "rains" or "floods," what happens to the hydrology? Where does the water go? ____
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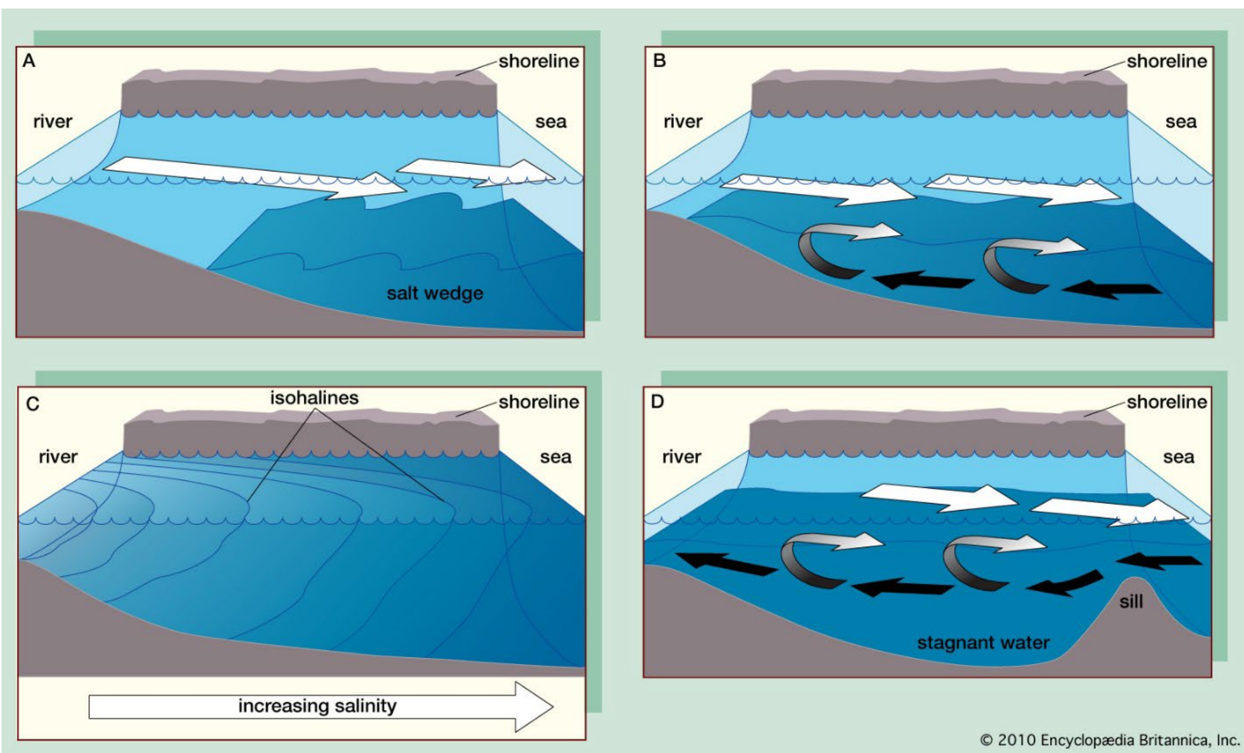


Figure 21. Illustration depicting four main types of estuaries classified by water circulation. A) salt wedge estuary, (B) partially mixed estuary, (C) vertically homogeneous estuary, and (D) fjord (black arrows indicate salt water and white arrows fresh). Image from: Encyclopedia Britannica, Inc.

Salinity and Stratification

An estuary is a very dynamic environment, and this is largely due to the daily changing salinity of the estuarine waters. Since it is where freshwater and saltwater meet, you can imagine daily salinity changes like a watery tug-of-war. Sometimes there may be larger tides or marine activity coming from the Gulf of Mexico, bringing in more saltwater. Other times there may be a big rainstorm that dumps a lot of freshwater on top of the saltwater.

As you can imagine, one of the things a National Estuarine Research Reserve does is keep track of the salinity of the estuary. **Salinity** is the amount of dissolved salts in water. Typically, salinity is measured in parts per thousand (ppt) or practical salinity units (psu). In essence, they're about the same thing.

2-5. What do you think is the salinity of freshwater? ______________ (Don't forget to include units!)

2-6. What do you think is the average salinity of the ocean? ________________

On the boat, you will be measuring the salinity of the water at various places in the estuary using a handheld YSI (equipment used to measure some water quality parameters, like salinity) and using a refractometer. First, we're going to learn how to use the refractometer. Pay attention to the instructor's demonstration before moving on with this activity.

Supplies: refractometer, food coloring, pitchers with fresh and salt water, salt, droppers, plastic cups, sticky notes

In front of you, you have two cups of water. Without tasting it, figure out which cup is freshwater and which cup is saltwater, and use a refractometer to determine this.

2-7. What are your initial thoughts or observations? ____________________________________

____

2-8. In cup A, do you think it's freshwater or saltwater? __________ Refractometer reading _______

2-9. In cup B, do you think it's freshwater or saltwater? __________ Refractometer reading _______

Here's a fun part! Pick a color to dye one of your cups of water. Color _____________________

The instructor will come around with food coloring to color the saltwater. Take your plastic dropper to mix the color in the cup. Then, fill your dropper with colored salt water, and carefully drop some colored saltwater into the freshwater cup.

2-10. What's happening? ____

____

____

2-11. Okay, now mix the water really well, and take a sample to measure in the refractometer. What does it read? ______________________

2-12. Thinking back to the mixing diagrams for classifying estuaries by water circulation, which scenario demonstrated a highly stratified estuary? ______________________________________

2-13. Which demonstrated a well-mixed estuary? ______________________________________

In the actual estuary, stratification occurs when there are bodies of water that have different salinities. Sometimes temperature differences in the water also stratifies the estuary (e.g. cold water sinks to the bottom, warm water is at the surface). Both salinity and temperature affect the density of the water, which is why water layers separate. An estuary stays stratified when there is no mixing occurring, but some things that might promote mixing include: some sort of external environmental disturbance (think about your dropper when you mixed the water in the cup), currents, wind, storms, animals swimming, or if a water mass hits an obstruction (like waves breaking at a sandbar that might mix water).

During your boat time, you'll be measuring the salinity of the Grand Bay Estuary to help illustrate what's going on in the water. Be sure to take a lot of field notes and jot things down like the weather or other environmental conditions that might affect the ever-changing salinity of the estuary.

Figure 22. Grand Bay NERR's Research and Education vessel, Miss NERR. Photo by Sandra Huynh, 2018.

Plankton

Plankton is a living organism and is anything that can't swim against a current. We're going to do a quick activity to help us understand the importance of plankton in our estuarine ecosystems.

2-14. Reflection: After the activity, jot down the most interesting facts you learned about plankton and its importance. ____

____

____

Next, we're going to look at some plankton samples under microscopes and try to identify what they are. Depending on time, we may have this set up for you, or we may ask you to set up your own station to see what is entailed in setting up a laboratory space to do this work. On a separate sheet that's not in the notebook, write or draw what you see, and try to identify the plankton using the provided identification guides.

Plankton Impacts

How we might affect plankton is by overfishing and polluting our water. If something is off in the system, it can create a cascade or chain reaction of consequences. For instance, if we had too much nutrients from our fertilizers that get washed from land into our water, you might have a really big **phytoplankton** or **algae bloom**. While phytoplankton make oxygen, they still also use oxygen. And with a lot of one thing using oxygen, other living things in the water won't have enough. This happens off the coast of Louisiana because runoff that enters the Mississippi River and drains into the Gulf of Mexico creates something called a "**dead zone**" where there's just too much algae taking up oxygen, and nothing besides algae can grow there.

Something we do at Grand Bay is monitor our water quality for things like oxygen and nutrients, so we can predict what's going on in our estuary. We know when it's healthy and when it's not healthy.

Plants and Salt

Some plants you'll have seen in the estuary are special, mostly because of their adaptations to surviving in extreme conditions like changing salinities and tidal inundation. This next activity will have you thinking of the adaptations by looking at and feeling the specimens. They'll be presented to you outside of its native habitat, and you'll have to see if you can figure out where this plant lives or what conditions it might face to need the adaptations you've identified. Each class participating in this program may get different plants, so just pay attention to the instructor and jot down your notes in the space below. If you need extra space, there are notes pages in the back of the notebook.

Species Survey- Science in a Seine

In order to properly manage an area, you must know what species can be found there. Some species may require special conditions or may be sensitive to some management practices. Endangered species can also be of great concern when considering management applications.

Monitoring fish communities is important in implicating restoration practices in estuarine environments. A community is two or more populations of different species living in the same area during the same time. Coastal ecologists at Grand Bay Reserve selected 14 sites to monitor fish communities between 2005 and 2014.

The sites consisted of 3 of each of the following habitats: erosional edge, shell midden, depositional edge, and seagrass. Beach sites were also sampled but only consisted of two sites. These sites were sampled 4 times a year, once during each season. The fish were collected using a seine net.

Table 1. The following table shows abundance at each habitat type of the species that were most commonly caught.

Habitat	Depositional Edge	Seagrass	Shell Midden	Beach	Erosional Edge
Anchoa hepsetus	472	1410	896	141	349
Anchoa mitchilli	6949	10751	1166	819	6026
Bairdiella chrysoura	356	1119	48	40	1142
Brevoortia patronus	530	382	445	525	7498
Lagodon rhomboides	412	2866	157	42	111
Leiostomus xanthurus	2085	1361	538	571	8727
Menidia beryllina	3171	1092	5988	816	1080
Micropogonias undulatus	11	58	1	6	7143
Mugil cephalus	315	149	370	843	2447
Mugil curema	102	22	440	1946	589

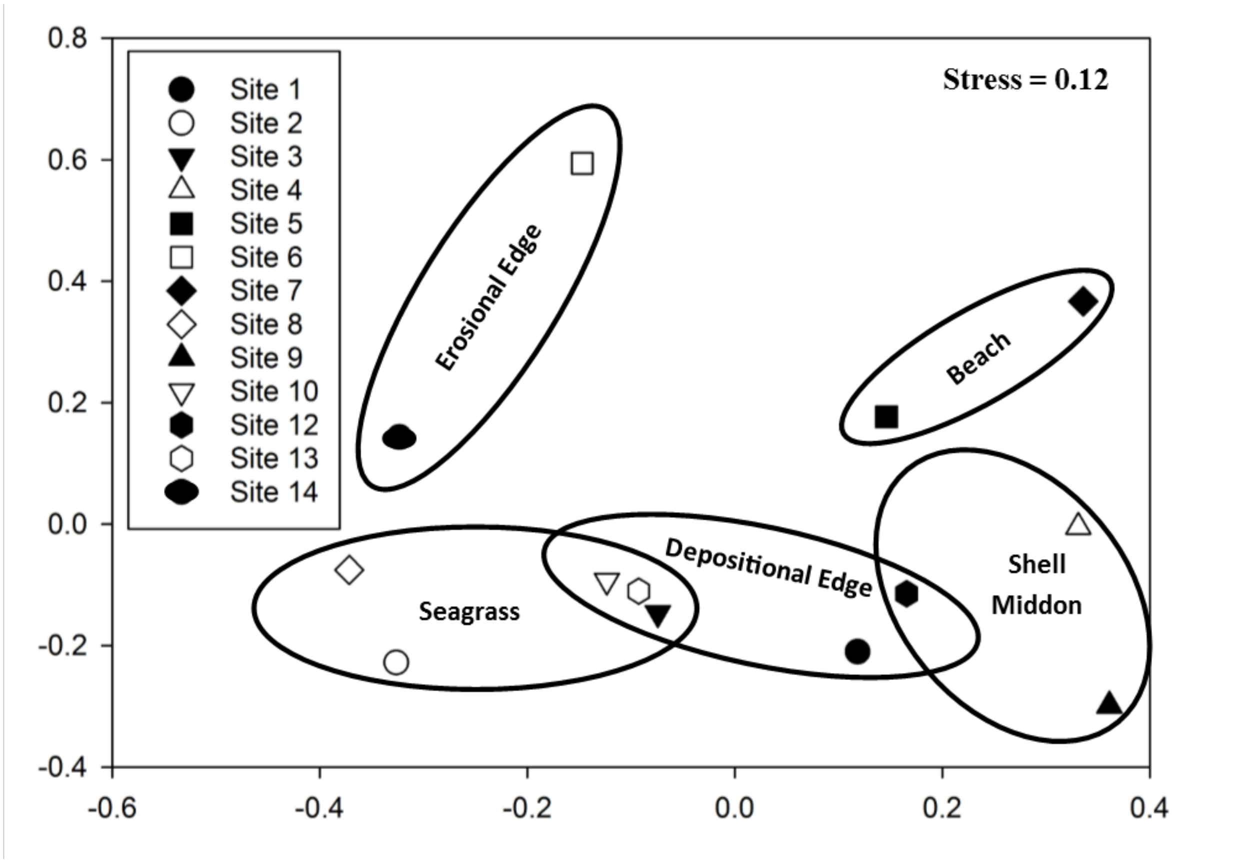


Figure 23. The graph was derived using a matrix created from these species. The closer the symbols are to each other the more alike the fish communities are within those sites.

2-15. What information can we gather from the graph concerning the relationship between fish species and habitat type? ______________________________

____

____

____

2-16. How could this influence restoration efforts on the erosional edge habitat?

____

____

____

2-17. Why did scientists choose to sample 3 different sites of the same habitat type when designing the study protocol? ______________________________

____

____

____

2-18. Do you think habitat diversity is important? Why or why not? ________________________

____

____

____

2-19. What are some reasons why fish may select one habitat over another? ________________

____

____

____

If you could add a plant or animal to monitor at the Grand Bay NERR, what would it be? How would you monitor it? ____

____

____

Meet the Scientist

Name:
Kim Cressman

Career:
Research Coordinator – Grand Bay NERR

Education:
-Bachelor of Science in Biology at Truman State University
-Master of Science in Marine Biology at University of North Carolina - Wilmington
-Master of Applied Statistics at Colorado State University

Research: Kim's primary focus is on long-term monitoring data. What can collecting the same data for many years tell us about changes in our estuaries?

Notes:

Kim grew up in Missouri, and got a lot of funny looks when she told people she wanted to be a marine biologist. She went to college in northeast Missouri, but came here to Ocean Springs one summer to take classes at Gulf Coast Marine Laboratory! Regular trips out into the Mississippi Sound and to the barrier islands cemented her interest in marine field work. Kim went on to graduate school in coastal North Carolina, where she became interested in oyster reefs and their effects on the water around them. Oysters, clams, and other shellfish are **filter feeders**: they eat floating particles in the water. They pump a lot of water through their bodies every day, which can make the water less **turbid** (more clear). It also means, however, that any contaminants in the water get concentrated in their tissues, a process known as **bioaccumulation**. If there are enough contaminants near oyster reefs, the reefs will be closed to shellfishing so that eating oysters won't make people sick. The water matters to oysters in other ways too – they need a certain range of **salinity** and **pH** to survive and grow well. Just like us, oysters need oxygen to breathe! Because they have gills, they get their oxygen from the water; so the level of **dissolved oxygen** in the water is also important. All of these things also matter to other marine and estuarine critters: fish, crabs, **benthic** animals (animals that live on or in the sediment).

Since her North Carolina days, Kim has moved around the southeast, collecting water quality data (usually including all of those **parameters**: salinity, turbidity, pH, and dissolved oxygen) for various research projects and monitoring programs. Before becoming the Research Coordinator, she was in charge of water quality and weather data collection and management for the System-Wide Monitoring Program (SWMP). Grand Bay is one of 30 NERRs that collect data for SWMP; all reserves use the same methods, and all of the data goes to the same place (www.nerrsdata.org). The goals of this program are to identify **short-term variability** (what happens after a big rain storm, for example?) and **long-term change** (over decades, as people move into an area, is the water quality different?). Knowing what the water is like, and how it affects things like oysters, can help us protect our coastal resources. Kim's role is to make sure we collect – and understand – this basic information about our estuary.

Lesson 3: Monitoring the Estuary

Today we will visit sites in the estuary. During this field component, we're going to observe some similarities and differences among the sites we visit as well as collect samples and data.

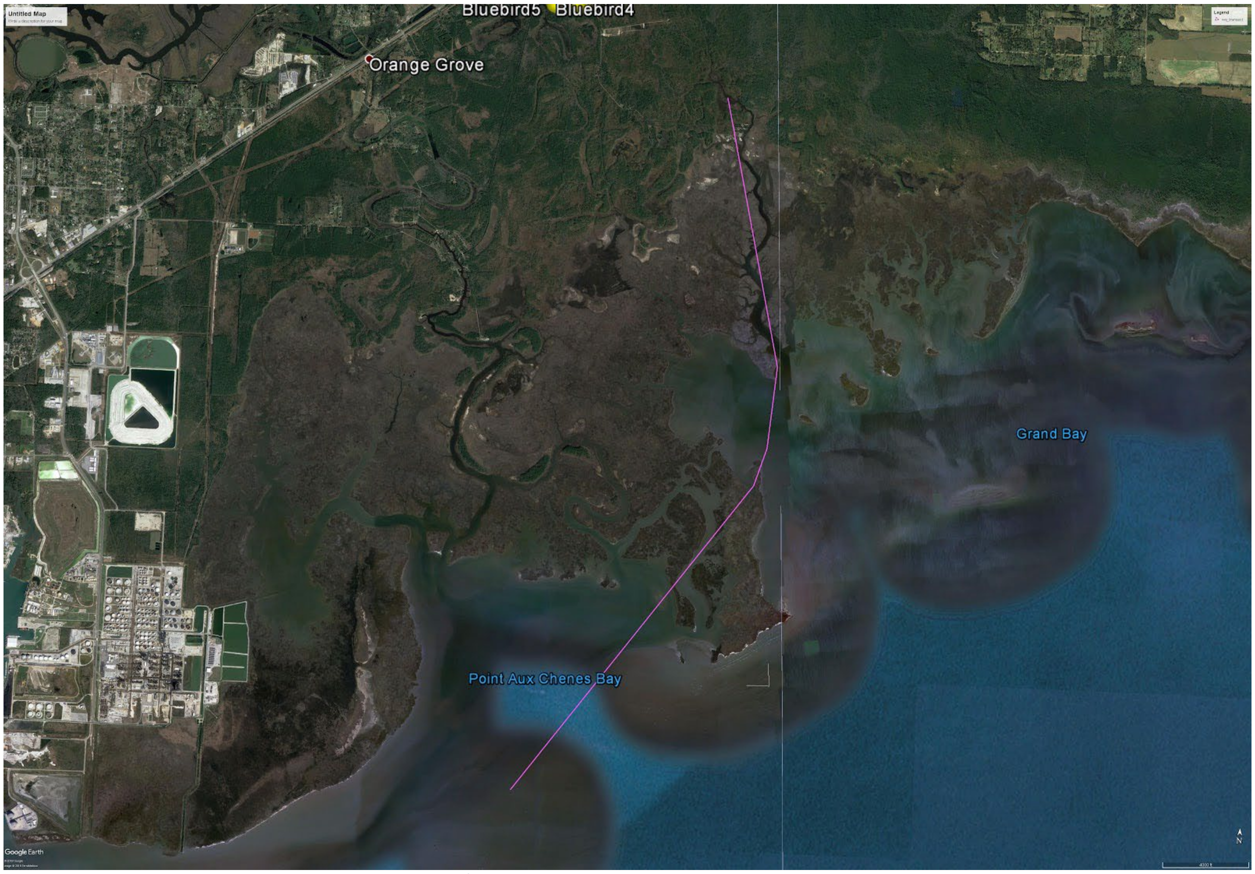


Figure 24. Photo of the transect we plan to make during the boat trip.

In this space provided, keep a list of the sites we stop at by listing "Site 1, Site 2" and so forth. Next to each site, jot down the GPS coordinates using the Trimble Nomad.

Plants and Salt

Because of elevated levels of salinity, plants have evolved various strategies to survive in the saltmarsh. While you are in the field today look for the following plant species and record your observations about each species in the table below. We will revisit this and discuss which adaptation each species has developed to deal with salt.

	Salicornia virginica	*Spartina alterniflora*	*Ilex vomitoria*
Observations:			
Salt Adaptations:			

Data Collection Tip

Instead of writing the entire scientific name of species, scientists and resource managers might abbreviate the names to save some time when writing in their field notebooks or spreadsheets. For example, *Salicornia virginica* (pickleweed/glasswort) might be abbreviated using the first two letters of each name: **SAVI**. *What are the abbreviations for smooth cordgrass and yaupon holly?*

____________________________ ____________________________

Erosion Monitoring

Erosion monitoring is important to determine how much and at what rate erosion is occurring at certain sites in the Grand Bay Estuary. Without a steady supply of sediment to replenish these marshes, erosion is outcompeting accretion. Restoration scientists take GPS points along the shoreline then compare those to points taken from the same site collected throughout the previous years. Today you will do the same at three sites in the estuary.

Once you arrive at the site, proceed to the shore and find the predetermined transect line. Use the Trimble Nomad to record data points. Use the line function on the Nomad to take a series of points on the shelf that has been eroded. Continue until you reach the end of the transect. Save the data points in the GPS. Record any other evidence of erosion you discover or any assumptions you may have.

Figure 25. Satellite imagery of our erosion sites on our boat trip.

Erosion Site 1: TIME________________

Observations ____

____

Weather/Environmental Notes:

Did you record your data points on the Trimble Nomad? ◻

Sketch the erosional edge and be sure to indicate North:

Erosion Site 1: TIME________________

Observations ____

____

Weather/Environmental Notes:

Did you record your data points on the Trimble Nomad? ◻

Sketch the erosional edge and be sure to indicate North:

Erosion Site 1: TIME________________

Observations ____

____

Weather/Environmental Notes:

Did you record your data points on the Trimble Nomad? ◻

Sketch the erosional edge and be sure to indicate North:

Assessing Water Quality

We will measure water quality along a transect from Bayou Heron, our freshest site, to Point Aux Chenes. We will record dissolved oxygen, salinity, and temperature using the YSI. Your group will record salinity, turbidity, and pH readings using a refractometer, secchi disc, and pH strips, respectively. Record this data below in the chart.

Site & Coordinates	Time	**YSI** Salinity (ppt)	Temp (C)	DO (mg/L)	**Refractometer** Salinity (ppt)	**Secchi Disc** Turbidity (m)	**pH Strip** pH
1							
2							
3							
4							
5							

3-1. Looking at the data, what can you say about the different sites we sampled?

____

____

____

____

3-2. Are there any differences in the salinity measured by the YSI versus the refractometer? Why or why not? ____

____

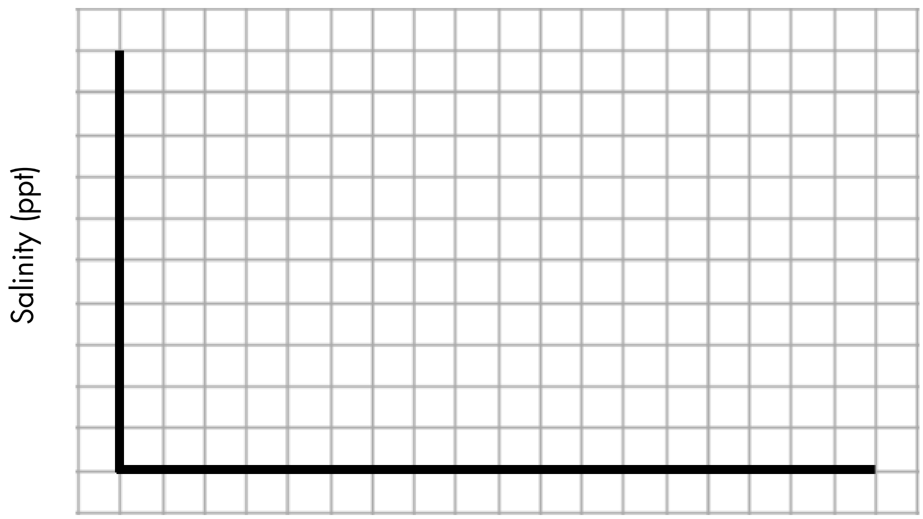
____

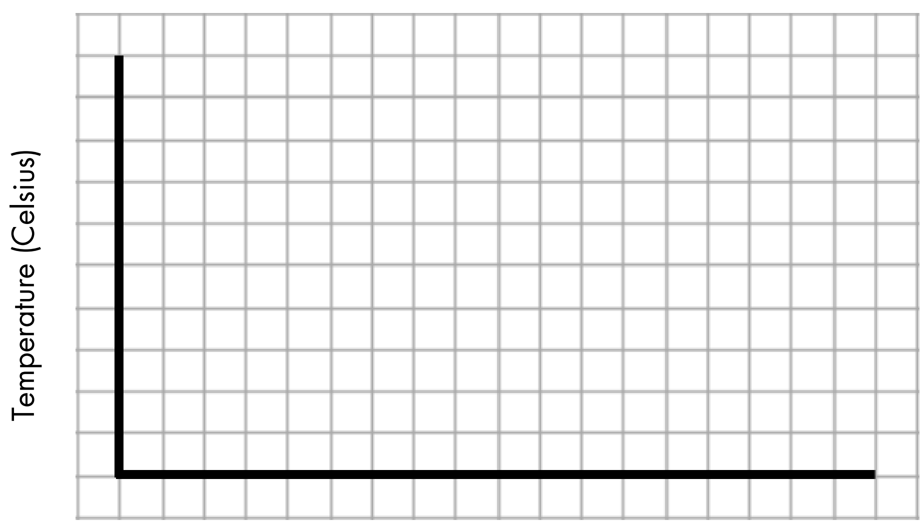
____

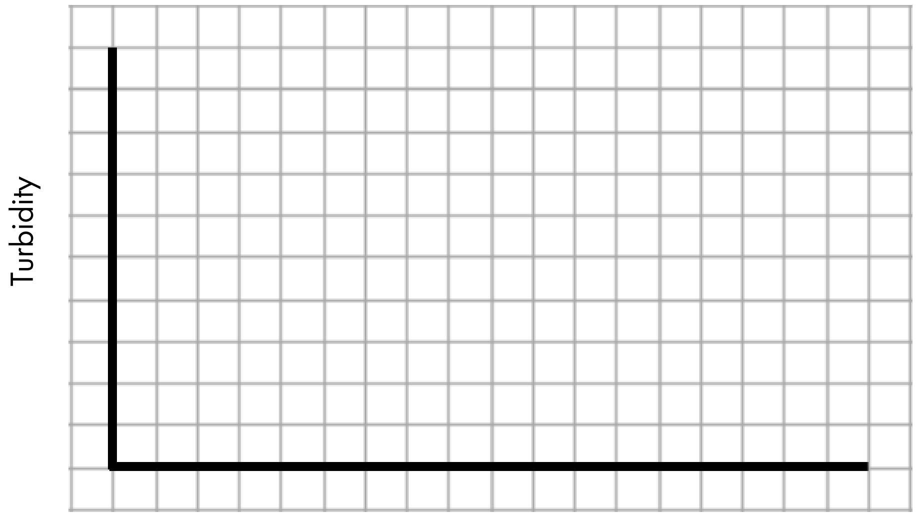
Lesson 4: Data Comparison and Analysis

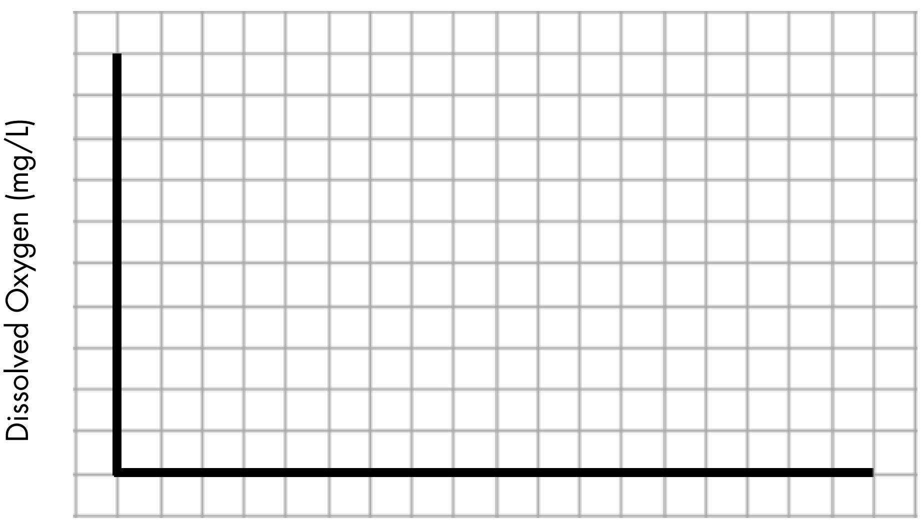
Creating an Estuary Profile

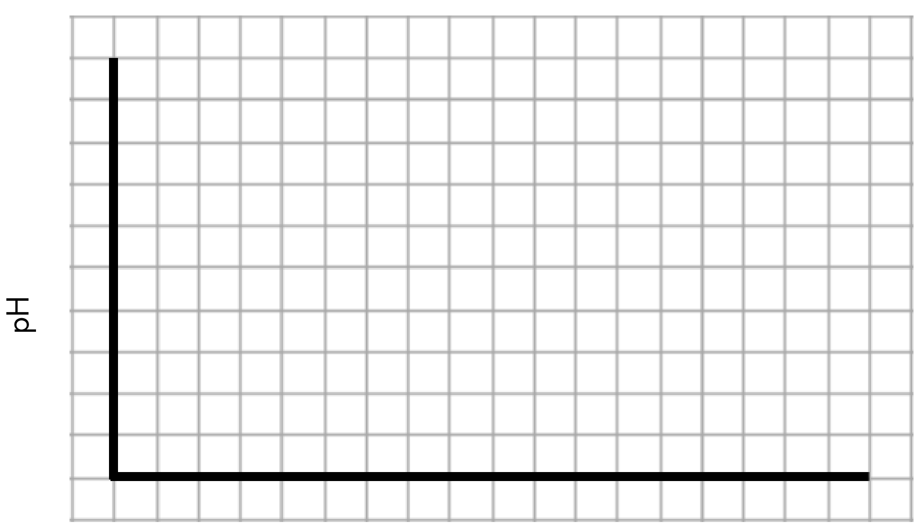
For this exercise, we're going to visualize our data we collected by graphing it. The axes have been drawn for you, so next is looking at your data and labeling the x-axis, figuring out the intervals for the y-axis, and labeling each graph with a title. What we're trying to do is see how each parameter differs at each site. How will you label the x-axis if we want to see all the sites along the transect?






Turbidity


Dissolved Oxygen (mg/L)


pH

4-1. Choose one site and discuss the relationships among the parameters at that specific site.

Site & Coordinates	Time	YSI Salinity (ppt)	Temp (C)	DO (mg/L)	Refractometer Salinity (ppt)	Secchi Disc Turbidity (m)	pH Strip pH
1							

What do you think is happening at that site? Was there anything from your field notes that you wrote down that might be an indicator for the activity going on at that site? (E.g. Were there birds fishing? Was it really windy? Did it rain recently?

Comparing Your Data to Real Time Data

Compare your data to SWMP's real time data through the Centralized Data Management Office (CDMO)'s website (http://cdmo.baruch.sc.edu/dges/) or using our printouts (if your class doesn't have enough computers to access). While a few of the SWMP stations are not currently transmitting data to the website, we can look at Bayou Heron's SWMP station and the Crooked Bayou Weather Station.

4-2. Were your water quality measurements similar to or different from what was collected by the SWMP station(s)? Explain.

____

____

____

Remember, we may not have been sampling near a SWMP station, so try to create a big picture of what was happening around the estuary that day.

4-3. What parameters do the Crooked Bayou weather station collect that's different from the Bayou Heron water quality station?

____

____

____

Here is an excerpt from the Grand Bay NERR Site Profile (2007) about Salinity in the Reserve:

> *Unlike many estuarine systems, the Grand Bay NERR has no major freshwater inflow, hence the rapid changes in salinity are due to local runoff and possibly groundwater seepage. Salinity in the reserve can range from near zero to about 25 psu at the more inshore stations, Bayou Heron and Bayou Cumbest, to values of 10 to near 30 psu at the more seaward stations, Bangs Lake, Crooked Bayou and Pt. aux Chenes. The lowest salinities are found landward during the summer wet season where salinities of 0 to 10 psu dominate during June and July (Bayou Heron and Bayou Cumbest). Shorter depressions in salinities are observed at all stations due episodic rain events. Tidal shift in salinity is also observed at all stations. The most extreme changes in salinity were measured at the most landward station, Bayou Heron (0 to 21 psu). Winter shifts in salinity were more dramatic than those during the summer likely due to winter storm winds that push water out of the Grand Bay NERR.* (pg. 83)

4-4. Given what you just read that occurs at Grand Bay NERR, and reading your field notes on the weather and environment, what do you think is affecting the salinity you found during our sampling?

____

____

____

____

____

____

____

Exploring Data from Other NERRS

4-5. Choose another reserve through the CDMO website and list it here: ______________________.

4-6. How does that reserve's data compare to Grand Bay NERR? ______________________________

____

____

____

Evaluating SWMP Data

A. A category 1, Hurricane Nate made landfall two times; first near the mouth of the Mississippi River and second near Biloxi. Hurricane Nate moved quickly, as it is the fastest moving storm that has ever been tracked in the Gulf of Mexico, but still not fast enough to escape the amazing data collection capabilities of our weather station and SWMP monitors. On the next page you will find a graph showing barometric pressure, wind speed, depth, and salinity. Notice the drastic changes to the data on October 8th.

4-7. Based on the graphs, when did Nate make landfall? ______________________________

4-8. What was the maximum wind speed? ______________________________

4-9. What was the maximum depth? ______________________________

4-10. What was the maximum barometric pressure? ______________________________

4-11. What was the lowest Salinity? ______________________________

4-12. What are the implications of depth and salinity? What is this data telling us?

____

____

____

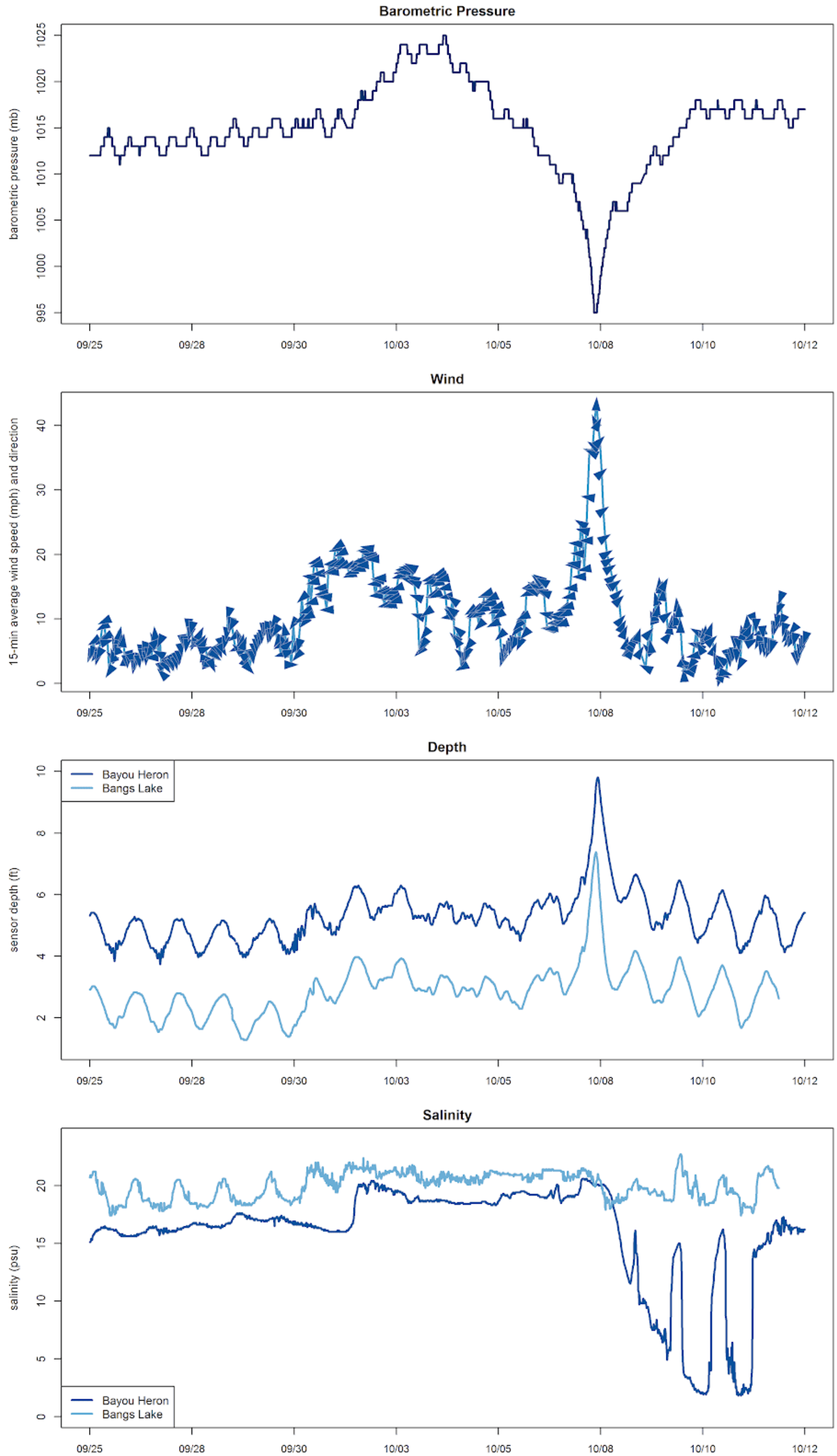


Figure 26. SWMP data at Grand Bay NERR during Hurricane Nate (2017)

B. Our SWMP coordinator, Kim Cressman, noticed something interesting when checking depth data from our Bayou Heron sonde. She was able to see some of the 2017 hurricanes.

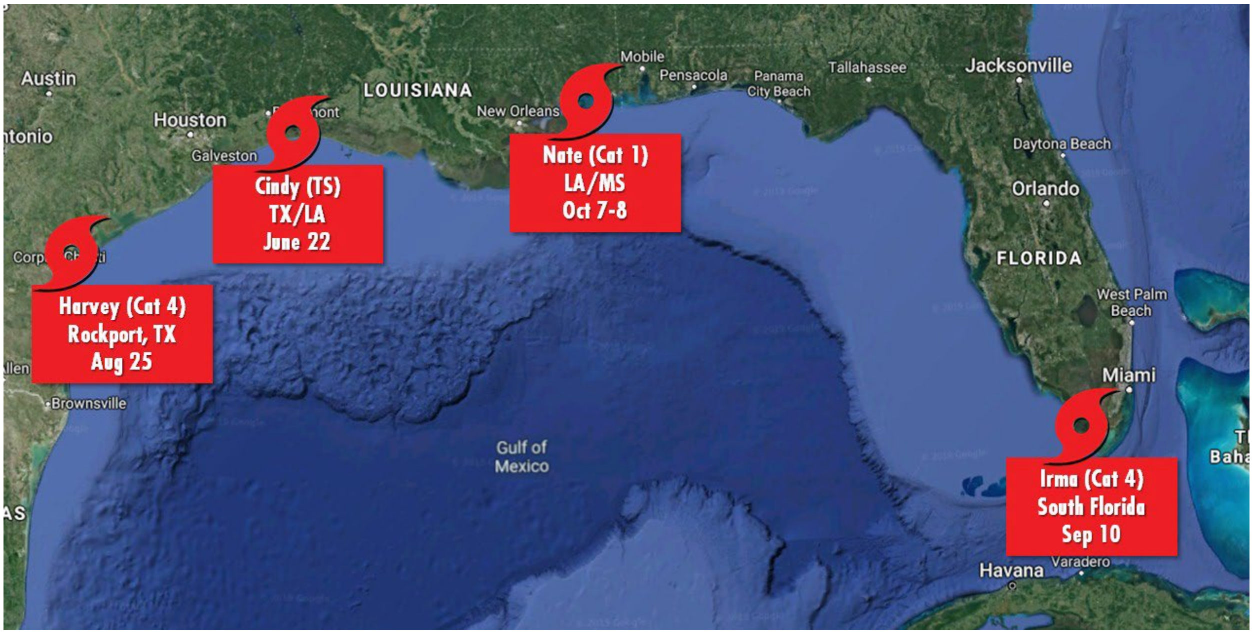


Figure 27. 2017 Hurricane and tropical storm landfalls in the United States.

Hurricane Harvey was a major hurricane that hit Texas. It was nowhere near us, but an increase in water depth was still noticeable. **Hurricane Irma** sucked the water out when she moved by (remember the pictures of stranded manatees in FL? Similar thing, but less extreme in the Northern Gulf). **Tropical Storm Cindy** and Category 1 **Hurricane Nate**, though weaker storms in terms of wind – which is how they're classified – had bigger impacts on our water levels because they were closer to us. Nate made landfall just 30 miles away!

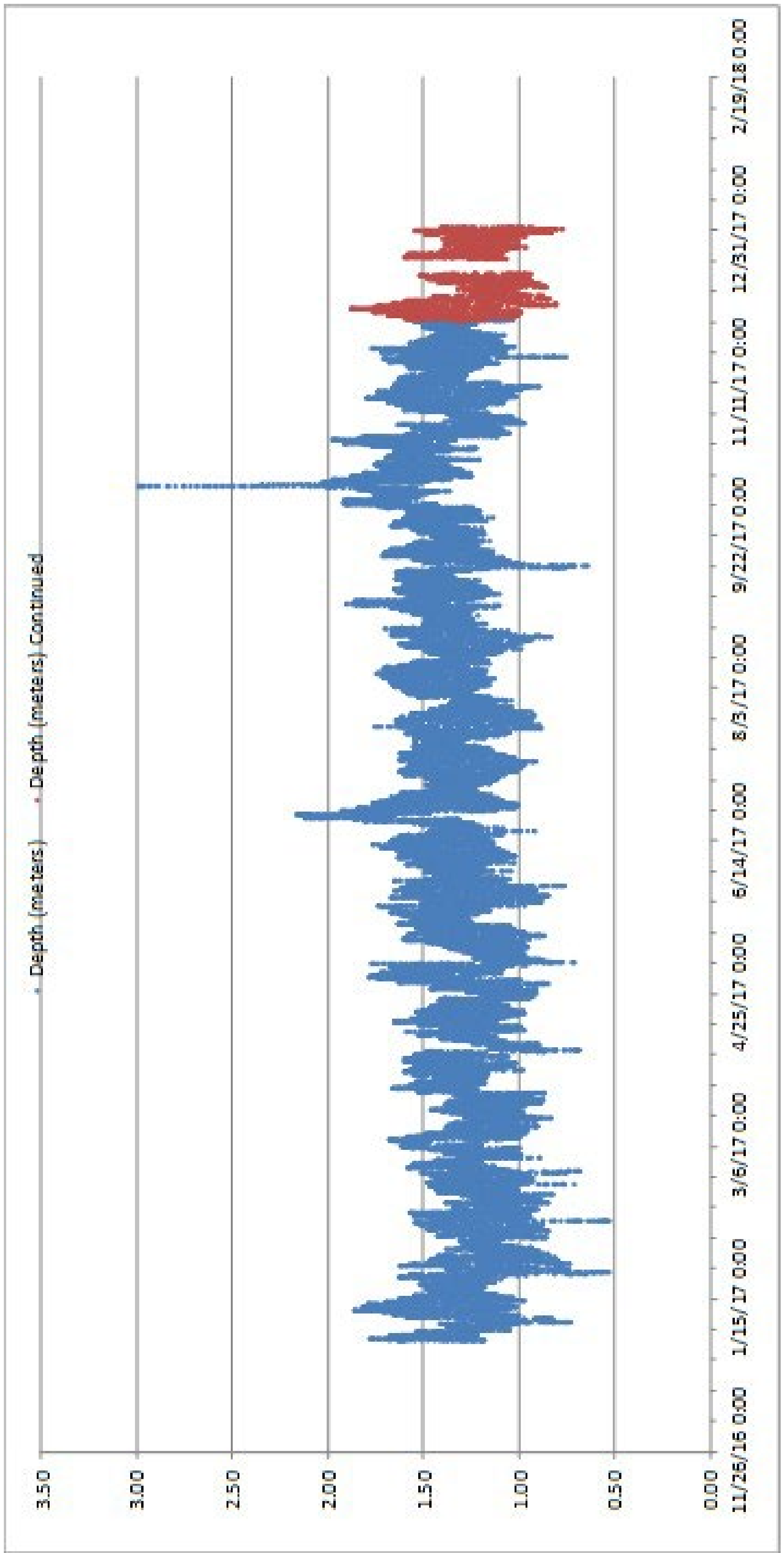
4-13. On the next page, label the graph with the hurricanes and tropical storm that are influencing the data.

Hurricane Harvey

Hurricane Irma

Tropical Storm Cindy

Hurricane Nate



Depth (meters)
Depth (meters) Continued
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
11/26/16 0:00
1/15/17 0:00
3/6/17 0:00
4/25/17 0:00
6/14/17 0:00
8/3/17 0:00
9/22/17 0:00
11/11/17 0:00
12/31/17 0:00
2/19/18 0:00

Erosion Monitoring Data

To analyze our erosion data, we will look at our points collected during erosion monitoring on Google Earth.

4-14. Do they line up with the shoreline on the map? Why or why not? ______________________

____

____

4-15. Look at these points on a map from 1920. What do you see? Why? __________________

____

____

____

4-16. Now we will use the polygon function to measure the area lost. Record the area in the table.

Site	1	2	3
Area Lost			

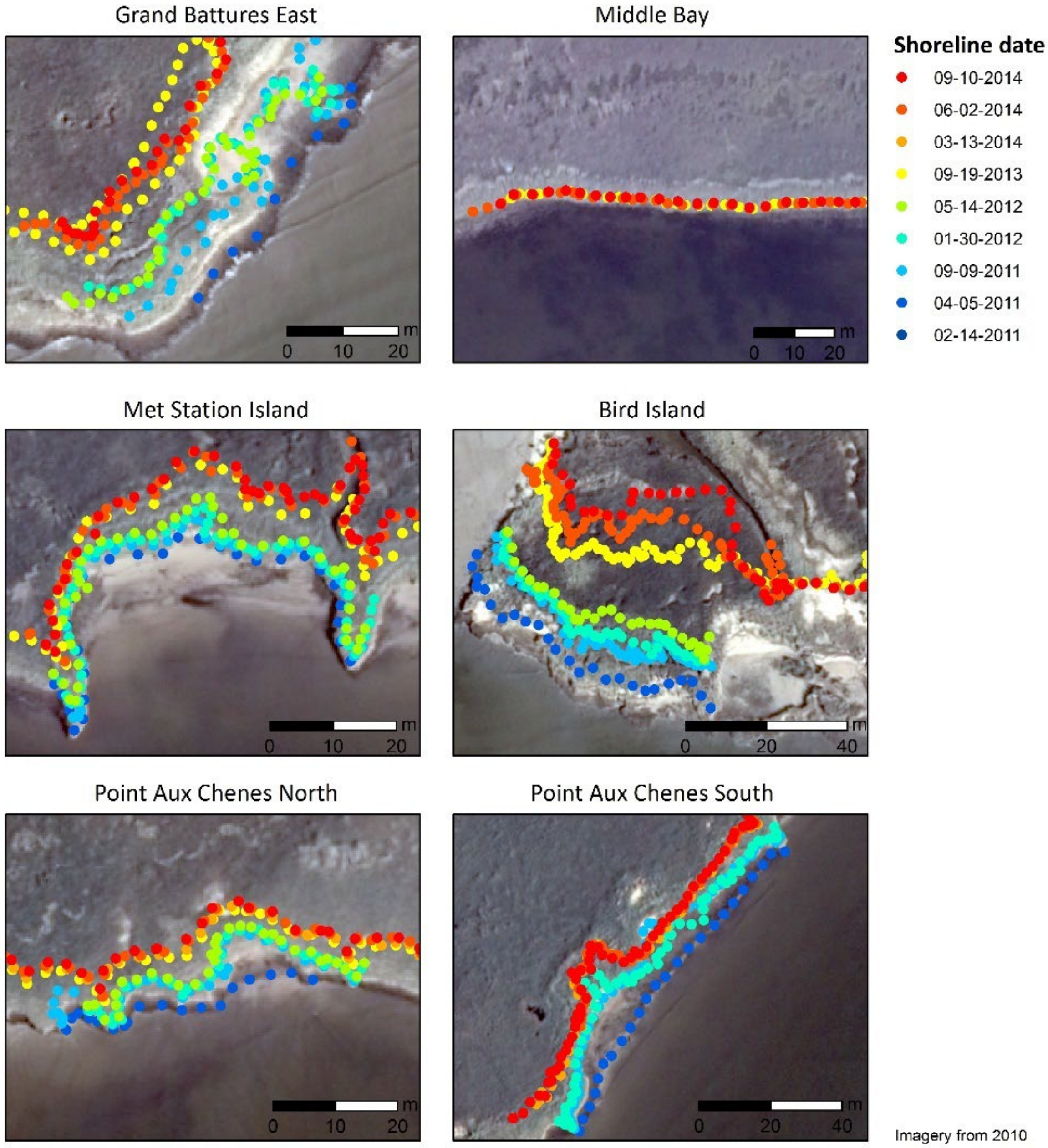
4-17. Do you think the area lost is significant? Why or why not? ______________________

____

____

____

On the next page, let's look at some erosion monitoring data taken at different locations throughout the Grand Bay Estuary from 2011 to 2014.



What can we say about erosion at the Middle Bay site? ______________________________

____

____

What about at Bird Island? ______________________________

____

____

Lesson 5: Designing a Restoration Plan

You will further develop your collaboration skills with your peers by creating a restoration/management plan using one of the scenarios we will assign to you. You'll be using information and knowledge gained from the previous days in the CHANGES program to help you formulate a well-informed sequential plan. Each scenario has a different issue, but the steps you plan might sound similar. While you're developing your plan, consider costs, sociological factors, and possible repercussions for both natural and human aspects.

This exercise requires you to do a good bit of critical thinking and brainstorming. Although we've discussed and demonstrated a lot of different methods and processes, some of these scenarios could have management practices that we didn't talk about. Meaning, you'll have to do some critical thinking to find some feasible solutions. If you don't have access to a computer for this assignment, write down some questions you may ask or searches you would need to do to get to your answer. While the scenarios each have one page of questions, this is not limiting your plan; it is only providing some guiding questions and space for an outline and brainstorming.

What we are looking for in your restoration plans are ways you and your group have incorporated the science and methods learned from our lessons and activities. We are also looking for questions you might ask or methods you may employ that we didn't discuss in the CHANGES program. The beauty of restoration is finding ways to improve your practice or approach a problem, with the least harmful impact as possible.

Crucial to this process is also communicating with your group. What may help is having roles for each person. At the end of this, you'll be presenting your group's restoration plan in front of your classmates, so be sure to check out the rubric found in your reference pages. Your classmates will be expected to ask questions and give your group constructive feedback.

As you have experienced from our program, restoration requires many working parts and needs effective communication to make sure everything runs properly and is working for the betterment of the habitat and the potential ecosystem services they provide.

Depending on the time your teacher has allotted, you may be writing a simple outline, or you may be developing a full-on plan. Regardless, you must work with your group and communicate your plan to the class. Presentations should be between 3-5 minutes long, so take a little bit of time if you can to practice! Also be prepared for questions after your presentation.

Good luck!

Managing for Boat Waves

A large portion of a salt marsh has been lost to erosion. It is located in an area that experiences heavy boat traffic. The waves created from boats have washed away much of the low marsh and some of the mid marsh. Some of the semi aquatic animals are having difficulty moving from the water to the banks of the marsh. How would you manage this area of marsh for the erosion caused by boat waves?

Which professionals will be involved in your management plan? See the list on page 54 for ideas.

____

____

____

Outline your monitoring process?

____

____

____

____

____

What steps should be taken to begin restoration efforts, especially knowing that you're managing for an area of marsh that often has human activity?

____

____

Create a restoration plan based on what you've learned.

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Stabilizing a Quickly Eroding Edge

In an estuary with low sediment input, erosion is outcompeting accretion. While erosion is taking sediment from some areas, it is being deposited in other areas of the estuary. These erosional edges are supplying sediment for this estuary to keep up with sea level rise. A large section of marsh located on the south end of the estuary is disappearing at an alarming rate. A group of conservationists want to do something to stabilize the shoreline, but they want the estuary to remain resilient.

Which professionals will be involved in your management plan? See the list on page 54 for ideas.

Outline your monitoring process?

What steps should be taken to begin restoration efforts?

Create a restoration plan based on what you've learned.

Island Users

An island about a mile off the coastline of Mississippi is losing one meter of shoreline off the east end every year. This is due to the strong longshore currents that run parallel to the shore picking up sediment on the east end and sweeping it offshore (meaning, it's not being deposited on the west end of the island). The east end of this island is also an important nesting beach for many shorebirds. This island is a great place for recreation and bird watching, but recreational fishermen complain that they never catch anything while fishing there or the waters surrounding it. The local municipality wants to do something to preserve the island. They feel it is valuable and contributes to a considerable percent of their recreation and tourism industry.

Which professionals will be involved in your management plan? See the list on page 54 for ideas.

Outline your monitoring process?

What steps should be taken to begin restoration efforts?

Create a restoration plan based on what you've learned.

Water Chemistry and Seagrasses

A chemical plant located next to an estuary is having problems with its outflow system. It has been releasing unusually high levels of phosphates into the waters connected to the estuary for months. The high levels of phosphates have promoted growth of algae. The dense algal mat is blocking sunlight from reaching seagrass causing a die-off. This along with the death of the algae has led to hypoxic conditions in the water. What can be done?

Which professionals will be involved in your management plan? See the list on page 54 for ideas.

____

____

____

Outline your monitoring process?

____

____

____

____

____

What steps should be taken to begin restoration efforts?

____

____

Create a restoration plan based on what you’ve learned.

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Fragmentation by Highway

A wetland was altered with the introduction of a highway. It was constructed to increase tourism in the local area, which boosts the economy. It's also a great way for more people to see the wonders and beauty of the local wetland, something they may not have seen before without public access the highway created. However, one side of the highway floods a lot more when it rains because the wetland becomes oversaturated with water and has nowhere to naturally drain, and it's causing people that have built houses there to either learn how to adapt and protect their homes or move away from the area. A major restoration effort to remove the road will cost a lot of money and is likely to make local homeowners unhappy, but there is an opportunity to restore a section of the wetland habitat where there aren't as many people.

Which professionals will be involved in your management plan? See the list on page 54 for ideas.

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Outline your monitoring process?

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What steps should be taken to begin restoration efforts?

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Create a restoration plan based on what you've learned.

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Jobs for Restoration Plan Scenarios

The following "jobs" are examples of positions/people that might be needed for a restoration plan. While each "job" is general, be sure to specify what they do or study in your plan (e.g. botanist who specializes in native wildflowers instead of just "botanist").

Restoration specialist- specializes in restoration practices and knows how to balance natural processes with human impacts. https://www.agcareers.com/career-profiles/restoration-specialist.cfm

Monitoring specialist- this person might spend most of their field work monitoring different things to assess ecosystem trends. https://www.environmentalscience.org/career/environmental-monitor

Wildlife Biologist- study and survey animals and can specialize in certain types of animals (e.g. birds or small mammals) or animals belonging to a specific ecosystem (e.g. all animals that live in a grassland). https://www.environmentalscience.org/career/wildlife-biologist

Botanist- study and survey plants and can specialize in certain types of plants (e.g. carnivorous plants or mosses) or plants belonging to a specific ecosystem (e.g. all plants that live in a grassland). https://www.environmentalscience.org/career/botanist

Conservationist- generic term for someone who works to preserve the environment. For these scenarios, it may help to focus on a conservation group such as The Nature Conservancy. https://www.environmentalscience.org/career/conservationist

Contractor- miscellaneous "contract" jobs you may need to specify in your restoration plan (e.g. civil engineering contractor for road project)

City planner- someone who determines best practices and ways to use a city's resources, including land. They may take part in zoning and regulations, and study land use and the city's population to help their planning process. They deal with a lot of stakeholders. https://study.com/articles/City_Planner_Job_Description_Duties_and_Requirements.html

Other: if you feel the need to bring another "job" for your restoration plan, be sure to describe who they are and what they do. Most importantly, detail *why* they've been added to your plan.

Communicating Your Science

Communicating your science is a college class on its own, but here are a few tips and tricks for sharing your science knowledge with someone.

First, who is your **audience**? This is probably the most important part about communicating, because talking science with a kindergartener is quite different than talking with a parent.

Next, what's your **topic**? Do you think your audience will be receptive to your topic? How can you make it engaging enough to where your audience might learn something? For example, if your topic is about a sunflower, you may focus on things like "flower" or "colors" for a small child, but to an adult you may talk about whether or not the sunflower is an annual or perennial, something you can grow in your garden, or see as wildflowers. Or if you're talking about a blue crab, you may act out how it moves with a child, but talk about seafood recipes or crab fishing with an adult.

You always want to identify a few **takeaway points**. It's a good rule of thumb to have at least three, just in case your audience is varied. Let's take the blue crab example, for instance. You might want to highlight things like the difference between male and female blue crabs and how to identify them. Or you may want people to know that they're part of a group of crabs that are called swimming crabs! Or you might talk about crab traps and ways you can help unwanted animals escape the traps.

Now that you have an idea of what you're talking about and who you're talking to, here are some ways professionals communicate in science:

Poster presentation
Oral presentation with slide show
Discussion/expert panel
Webinar
Demonstration
Video/Vlog
Web post/blog
Social media posts
Science exhibits/displays

Can you think of other types of presentations or ways to communicate scientific messages?

Elements of a good presentation:

- Appeal to senses (see, touch, smell, hear, taste)
- Visuals (photos, videos, real specimens, fake specimens)
- An activity (something you can demonstrate, something the audience can do with you, or something they can do later)
- Hitting your takeaway points- you want your audience to leave learning something new
- Finding a balance of too little information and too much information

Think about presentations you've seen and enjoyed. How did those appeal to you? How were they engaging? When crafting your presentation, think of these things and incorporate them!

Communication Rubric

Restoration Scenario: ____ Time 3-5 mins? Y N

Presentation	4	3	2	1	Score
Content (See presentation handout)	*All* of the necessary information was included.	*Most* of the necessary information was included.	*Some* of the necessary information was included.	*None* of the necessary information was included.	
Delivery (Eye contact, audibility, body language, etc.)	The speaker did an *excellent* job delivering the information in the presentation.	The speaker did a *good* job delivering the information in the presentation.	The speaker did a *fair* job delivering the information in the presentation.	The speaker did a *poor* job delivering the information in the presentation.	
Comprehensibility (Quality of presentation, how well information is taught)	The presentation was *exciting and really made me understand* the purpose and results of the scientist's work.	The presentation was *somewhat exciting and helped in my understanding* of the purpose and results of the scientist's work.	The presentation *was not very exciting and I did not get a clear understandin g* of the purpose and results of the scientist's work.	The presenter *did not demonstrate an understanding* of the purpose and results of the scientist's work.	
Creativity (Thought of ways to solve problem outside of the box, creative presentation/ communication.)	The speaker did an *excellent* job with thinking outside the box.	The speaker did a *good* job with thinking outside the box.	The speaker did a *fair* job with thinking outside the box.	The speaker did not think outside the box.	
Reference (All references cited on the last slide of the presentation)	*All* of the references were included.	*Most* of the references were included.	*Some* of the references were included.	*None* of the references were included.	
				Presentation Score (Average)	

Comments:

Concept Map

Word Bank:

Deposition Erosion Monitoring Restoration Salt marsh estuary Structure

In a few sentences, explain what your concept map is showing. ___________________________

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Geocaching Grand Bay

The Trimble Nomad is an important tool used to collect geospatial data. Tools like this one are used by NERR restoration specialists to effectively monitor plant communities in the savanna.

The Nomad will be necessary to collect monitoring data for the next lesson. The following activity was designed to familiarize you with this tool. *Note: The Nomads are on an Android operating system.

Use the Nomad to navigate to the following points and record the identity of the object. The photos are meant to be clues of the objects you are meant to find. Write down the identity of the object in the lines below. If you don't know what that object is, describe it as best as you can.

	1. 30.429333, -88.427372		2. 30.429782, -88.427568
	3. 30.429702, -88.427760		4. 30.429963, -88.427752
	5. 30.430593, -88.427715		6. 30.430302, -88.428361
	7. 30.429677, -88.428455		8. 30.429332, -88.429572
	9. 30.429388, -88.428701		10. 30.429152, -88.427994

Using the line function on the Nomad, draw a line along some of the boundaries around the Coastal Resources Center. Record your group members' names in the note section.

Find a few boundaries around the Coastal Resources Center, like the area around the flagpole, sidewalks, or parking lots. Pick a spot to start and record a line on the Nomad and walk for 50 steps and stop recording. Include the location's description and coordinates on the lines below.

1.____

2.____

3.____

4.____

5.____

Careers Pages

The following scientists are highlighted in our both our savanna and estuary module notebooks for the CHANGES program and will give students a look at various jobs.

Generally, scientists begin their career development right out of high school when they choose to attend college, whether it's a community college or 4-year university. During their time in college, they also look for volunteer opportunities or internships to gain experience. Science is a broad field, and each scientist's adventure to where they are today is different for each person we've highlighted below. Take a look at some Mississippi natives, Mississippi transplants (people who were born somewhere else and moved here), and other scientists that come from across the country and the world, chose their careers. They may have some good advice that speaks to you!

Mai Dang- Mississippi Department of Marine Resources

Marine Fisheries Technician

Mai Dang is a Marine Fisheries Technician of Seafood Technology Bureau (2007-Present). She works in the Office of Marine Fisheries with the **Mississippi Department of Marine Resources**. She came from a family who are members of the Shrimp Industry of Mississippi and Louisiana. Her mother worked for several shrimp factories since arriving in **Biloxi, MS**. Both parents came from **Vietnam** and had fishing experience where they came from. Mai was born in California, where her parents were first processed. Before long, they transferred to Mississippi to work in the boats. She grew up with knowledge of shrimp processing in factories and on the shrimp boats. She spent her summers working almost 90 hours every week at the shrimp processing factory. She chose her career field in Marine Fisheries because of the influence of her background and greater knowledge and understanding of her people's needs. She is continuing to help by using her mastery in speaking English and Vietnamese. It is way to form a bridge of understanding between parties in the **seafood industry**.

Mai has an Associate Degree in Applied Science in Business. She also has the following certifications: Basic Seafood Hazard Analysis Critical Control Point Plan, Sanitary Control Procedures on Seafood Processing, Serve Safe Certification.

A Marine Fisheries Technician can do many things. Mai assists in administrative, regulatory, and education and outreach tasks for her job. She collects bi-annual water quality sampling and maintains projects/grants financial status and budgetary needs. She maintains database of Statistical Data Landings and regulatory inspection data. She assists regulatory inspections of processing plants, research surveys, validation and verification experiments of processing procedures and on -going regulatory technical assistance helping the Vietnamese community by acting as interpreter and preparing brochures and educational materials in stewardship education especially for the Vietnamese members of the Seafood industry. She co-authored the publication "How to Start a Seafood Business" guide. Mai also assists in seafood safety outreach and education, and mentors trainees and interns in the Seafood Technology Bureau at MDMR.

Dr. Peter Edwards – Coral Reef Conservation Program (NOAA)

Economist & Social Science Coordinator

I was and raised in Jamaica, which is a tropical island in the Caribbean. As a child, much of my summers were spent at the beach and with my grandparents in the rural inland areas. This influenced my career path as you can see from my academic training. My career has evolved over time from specializing in **biology, tropical ecology and marine sciences and coastal management** to my present vocation as an **environmental economist and social scientist**. In recent years, my primary driver has been the need to improve the link between biological and ecological sciences and the human dimension – that is, social science, the **science and policy link**.

Our natural resources, including oceans, coasts and atmosphere, have been impacted over time by humans. So while it is critical to devote time and money to better understand the processes and changes that are occurring in these environments, we **also need to understand the impact that society and human beings have on our natural resources** as well as understand how these threats or changes will affect society. If we are aware of people's preferences, their motivations for their behavior, and their level of information about oceans and coastal issues, then agencies such as NOAA can improve how we inform and educate the public as part of our natural resource management strategies. For example, we do need to continue biological monitoring of coral reefs, however if we don't monitor what people are doing to impact the reef, and if we don't understand why or how best to communicate with the public, then biological scientists may simply be monitoring reefs as they slowly disappear. My decision to focus on being trained as a natural resource economist was also due to a need to acquire these skills in order to demonstrate that there are elements in nature that actually have an economic value. This is because if we ignore these economic benefits of nature then we will continue to over exploit these precious natural resources.

I most enjoy the **interdisciplinary** nature of my work. My formative background as a marine scientist and now as a social scientist/economist means I am able to work across various disciplines to try and fuse ecological and social sciences together. I also enjoy **working with various teams** of committed individuals both domestically and internationally.

I would advise [students] to **follow their passion**! For this kind of work I would recommend having a **good grounding in science and biology** as well as **some social sciences**. This will help to improve their understanding of the importance of the ocean and coastal environment and the role they play in human existence. You may start out as a biologist, chemist, economist or philosophy student but you never know where you'll end up! **I believe the future of conservation will require interdisciplinary approaches**, including being able to relate to other disciplines, i.e., economists, biologists, atmospheric scientists, natural resource managers and even lawyers. But most importantly: follow your passion!

BSc., Zoology, University of the West Indies, Mona Campus, Jamaica
M.Phil., Marine Sciences, University of the West Indies, Mona Campus, Jamaica
Ph.D., Marine Studies, University of Delaware, College of Marine and Earth Sciences

Dr. Ana Spalding – Oregon State University Assistant Professor of Marine and Coastal Policy

After I finished my **BA** in **Economics** and **International Relations** at the University of Richmond, in Virginia, I returned to Panama (my home country) and spent a week in Bocas del Toro. This is an archipelago on the Caribbean NW of Panama, where most of our time was spent on boats between islands, [where the] vulnerability of oceans and people so visible. Originally interested in providing lasting solutions to economic development issues in Latin America, I figured that working towards better understanding and saving our marine spaces would be a good place to start. Studying **marine policy** seemed a good way to work in development AND spend more time by the ocean.

Research interests? In practice, I focus on **contemporary and emerging issues** faced by our **global oceans**. I am interested in the evolution of marine policy and ocean governance. As an intellectual exercise, this draws from my training as a development **economist** (undergrad), **marine affairs and policy specialist** (Masters), and **critical political ecologist** (PhD). I basically want to understand what we have done, what the threats are, and how to make it better for all of us.

I want to emphasize my interest and **commitment to diversity, equity, and inclusion**. I have started to explore what this means to my own identity and how I navigate an institution and state where being "different" (in my case, a woman of color) is super obvious. I would much rather be in a place where there are more people like me (of color or other types of diversity). So, I started out learning about myself, and am starting to try to work in support of others (primarily students) who are working to navigate the challenges of being women, people of color, international students, in a very homogeneous town and institution.

Advice for students? Be brave! There is no clear path (YET!). So, talk to everyone about what they do on a daily basis, what path they took, what are some of the challenges they face. Learn to speak the language of other disciplines that are more "prominent" in ocean-related studies and **work really hard on your own communication skills** to make sure that you also don't alienate others with your jargon. **Find your own voice** and **develop confidence** around it.

Tate Thriffley – De Soto National Forest Ecologist

I grew up in **Bay Saint Louis, MS**. I spent a lot of time down along the shores of the Bay and the Mississippi Sound. I always felt connected to the waves and the water. There were several acres of wooded areas near my home as well, and I spent many days playing in the woods, climbing trees, playing hide and go seek, building forts of natural materials, etc. I attended a week-long **marine biology camp** at the University of Southern Mississippi Gulf Coast Campus when I was 13 and also attended a vision quest program in a terrestrial nature setting at La Terre Bioregional Center in south Mississippi **when I was 16**. In college, I took as many **field biology courses** as I could to diversify my knowledge of biology and ecology. In **graduate school**, my primary focus was **plant ecology**. Two great biology professors showed me how rewarding the study of biology could be and I realized that somehow it could be a profession for me.

After 5 years of field work on De Soto National Forest while in graduate school, I secured a job as a National Environmental Policy Act Coordinator for the Mississippi Army National Guard. I learned about legal aspects of conservation and protection for state and federal lands during this time. My education, field work, and understanding of environmental protections and processes prepared me for the job as **Ecologist on De Soto National Forest**, a job I have done for over 16 years. In addition to my regular duties, I often work with groups of children and adults, giving field tours and making presentations about ecosystem types, ecosystem management, and ecosystem restoration.

My advice to young people is to **spend quiet time in nature when you can**. Open up and hold space for your own conservation ethic to rise from within and be realized. Use that passion to fuel the journey toward reaching your goals.

Scott Wiggers – US Fish and Wildlife Service Botanist

I grew up around water, spent a lot of time fishing with my grandfather, and have been interested in science and conservation for as long as I can remember. I went to **college** intending to study freshwater and fish, but quickly became interested in plants when I took an **introductory botany course** taught by a professor who had an infectious passion for wetlands and fire ecology. I caught the plant bug and took most of the plant courses my college offered, while also taking a wide variety of related courses in **geology, chemistry, environmental science, math, and statistics**.

After college, **I wasn't 100% sure what I wanted to do**, so spent several years bouncing around the country working internships through the Student Conservation Association and other entry-level work. During this time, I gained experience in vegetation monitoring, prescribed fire and fire ecology, public outreach, outdoor environmental education, invasive species control, air quality monitoring, geographic information systems (GIS), and scientific research, among other things. I then went to **graduate school** and studied **fire ecology and plants** in the longleaf pine ecosystem. After grad school, I worked for a land trust and helped private land owners protect and conserve their land before starting with the **U.S. Fish and Wildlife Service as a botanist**. I'm now able to help conserve plants in Mississippi and throughout the Southeast, by working with a wide variety of partners and collaborators, while putting to use my knowledge of plants and their habitats, science, and policy.

Glossary

accretion	the process of an increase in growth (usually vertically) by the gradual accumulation of detritus and sediment on the marsh surface.
anthropogenic	influenced, caused by humans
artificial reef	an underwater structure built by humans to imitate a reef by providing habitat or controlling erosion.
benthic	organisms that live in the bottom layer of a body of water
bioaccumulation	the accumulation of a substance, usually chemical in nature, in the tissues of a living organism
biodiversity	amount of different species of organisms in a specific area
brackish water	water that is a mix of fresh and saltwater with lower salinity than seawater and higher salinity than freshwater
coastal squeeze	process by which saltmarsh cannot migrate upland because of some sort of barrier, like a seawall or woody vegetation. The saltmarsh is then "squeezed" between the water and said barrier.
dead zone	a rapid increase in the population of algae in a water system
dissolved oxygen	the amount of oxygen dissolved in the water
diurnal tides	areas that have only one tidal cycle per day
ecosystem service	a benefit that humans get from a functioning ecosystem
endemic species	species that exist nowhere else on the planet
erosion	the removal of sediment from an area by wind, waves, or glacial activities and moving it to another
eutrophication	the ecosystem's response to the addition of an abundance of artificial or natural nutrients
filter feeders	animals that feed by straining suspended matter and food particles from water
halophyte	salt loving plant species that grow in areas of high salinity and have adaptations that allow them to survive there
headland areas	a narrow piece of land that projects from a coastline into the water
hectare	an SI unit used to measure land. 1 hectare is equivalent to 2.47 acres.
herbarium	collection of preserved plant specimens used for scientific study
hypersaline environment	harsh environments that have salt concentrations much greater than that of seawater, often close to or exceeding salt saturation
inflorescences	a group or cluster of flowers
inundated	flooded
king tides	an especially high tide
living shorelines	a gradual sloping shoreline built by humans with natural materials to protect areas from erosion.
longshore currents	an ocean current that moves parallel to shore
long-term change	changing trends to water quality parameters over long periods of time

management	approach that recognizes the full array of interactions within an ecosystem, including humans, rather than considering single issues, species, or ecosystem services in isolation.
marker horizons	method used by monitoring specialists to determine accretion and subsidence levels. A layer of feldspar is deposited on the surface of the marsh, it can then be measured to determine the amount of sediment lost or gained
monitoring	processes and activities that take place to assess environmental conditions and ecosystem health by helping scientists establish current status and determine environmental trends. It is used to inform management.
nonpoint sources	pollution impacts and inputs occurring over a wide area and are not easily attributed to a single source
nourishment	sediment from recycled dredge deposited on an area affected by erosion
nutrient recycling	process by which organic material is broken down and its nutrients are released back into the environment
parameters	a measurable factor of a set that defines a system
peat	partially decayed vegetation and other organic matter
perennial	a plant that lives longer than two years usually with no woody growth
pH	a numeric scale used to specify the acidity or basicity (alkalinity) of an aqueous solution
phytoplankton	plankton species that photosynthesize
phytoremediation	the removal, stabilization, or degradation of pollutants or waste by certain plant species
plankton	a group of organisms living in the water column that cannot swim against the current
primary production	the production of chemical energy by organisms
refractometer	a device used to determine salinity
rhizome	a modified plant stem located under the soil that produces roots
root mats	a dense mass of plant roots
saline environments	environments that contain salt
Salinity	the amount of salt in the water
salt marsh	a coastal ecosystem in the upper coastal intertidal zone between land and open salt water or brackish water that is regularly flooded by tides
sea level rise (SLR)	the phenomenon of ocean levels rising several millimeters per year
seagrass beds	colonies of flowering marine plants
sediment deposition	the buildup of sediment carried by wind, water, or ice
semidiurnal tide	areas that have two high tides and two low tides per day
Sentinel Site Program (SSP)	a national program established to better understand climate change impacts such as changes in sea level, temperature, water chemistry, precipitation, and intensity of storm events.

shell middens	a mound of oyster shells and other unwanted items deposited by humans from during pre-settlement times
short-term variability	changes to water quality parameters during a short period of time
spring tides	tides occurring during a new or full moon when the difference between high and low tide is the greatest
subsidence	the process of a gradual settling or a decrease in the top layers of detritus and sediment on the marsh surface.
surface elevation tables (SETs)	a device consisting of a steel rod driven far into the ground and equipped with a cemented attachment head for the measuring arm. Pins are dropped down from the arm to the marsh surface and the height of each rod above the arm is measured. These measurements are used to detect any increase or decrease in the surface of the marsh
System Wide Monitoring Program (SWMP)	a system of monitors set up around the country to measure water quality
tides	the rise and fall of the ocean levels caused by the gravitational pull of the sun and the moon
turbid	the level of cloudiness of water due to suspended material
vegetative reproduction	process by which new plants arise without production of seeds or spores, a form of asexual reproduction
wrack	debris, such as dead plant material, that is deposited on the shore by waves
zooplankton	plankton that cannot produce their own food

Other words you may not have known and needed to define:

Species Reference Pages

Diamondback Terrapin (*Malaclemys terrapin*)

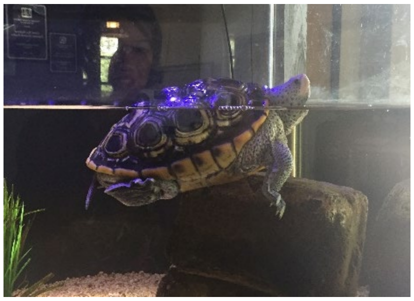

Figure 28. Peterson Field Guide to Reptiles and Amphibians, pg 166.

Diamondback terrapins are the only turtles in North America that live primarily in brackish water. Diamondback terrapins exhibit sexual dimorphism, meaning the males and females display different characteristics besides differences in sexual organs. In the case of these turtles, there is a difference in size. The females grow much larger than the males. The average midline carapace (shell) is 7 1/4 inches for females and 4 3/4 inches for males. Another dimorphic characteristic is the head size where females have larger heads than the males. At the Grand Bay NERR, we actually have the Mississippi diamondback terrapin subspecies (*Malaclemys terrapin pileata*), which can be found from Louisiana through the Florida panhandle (dark blue section on the map).

Osprey (*Pandion haliaetus*)

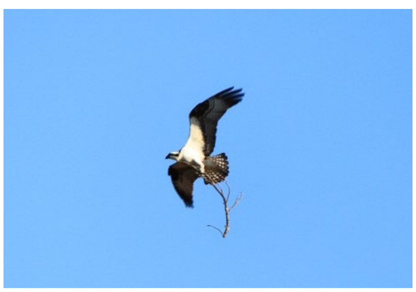

Figure 29. Field Guide to the Birds of North America, pg. 126.

The osprey is a permanent resident at Grand Bay NERR. You can find them here year-round flying over the bays and bayous in search for its favorite meal of fish. You will find their large nests on top of power line towers near the Grand Bay NERR Coastal Resources Center. This bird is a staff favorite and is even an element of the Grand Bay NERR's logo.

Eastern oyster (*Crassostrea virginica*)

Figure 30. Photo by Erika Zambello.

Figure 31. http://www.fao.org/fishery/species/2669/en

The eastern or American oyster is a bivalve mollusk common in the shallow, brackish waters of the Mississippi Gulf Coast. They are filter feeders, meaning they consume plankton and algae by pumping water through their gills and separating their food from it. By opening and closing its shell, a single oyster can filter and clean 50 gallons of water per day. This is one of the reasons that oyster reefs are so important to our environment. These reefs also provide habitat and feeding grounds for many organisms. They are also natural shoreline stabilizers, reducing wave energy before it reaches the shore. Oysters are also economically important. They can fetch a fair price on the seafood market.

Pickleweed (*Salicornia virginica*)

Pickleweed is one of many halophytic, or salt-tolerant plant, species that flourish at the reserve. It gets its common name from the fact that it's edible and tastes like a pickle. *Salicornia* produces seeds that contain 32% oil, which is an important component in biofuel production. Some of the main problems when producing biofuel is that traditional sources, such as corn, require large amounts of fresh water and occupy land that food crops could accommodate. Because *Salicornia* can be irrigated with saltwater from the ocean and can grow in areas where food crops cannot, scientists are looking to this plant to fill the gap and even create biofuel for jet engines.

Figure 32. https://plants.usda.gov/core/profile?symbol=SADE10

Blue crab (*Callinectes sapidus*)

Blue crabs are common on the Mississippi Gulf Coast, especially in our estuaries. In fact, salinity is a factor in how they live. For instance, larval planktonic stages of blue crabs need ocean salinity (~30 ppt), and as they grow through their life cycle, they return to the estuary and live there as adults. Because larval crabs need high salinity water, female adult crabs swim offshore before releasing her eggs. If you've ever been fishing offshore and saw a swimming blue crab, it's likely a female blue crab! In the estuary, blue crabs follow the salinity gradients of the incoming and outgoing tides, so if you plan to go crabbing, it's best to look at a tide chart to catch crabs as they move. Blue crabs are also economically important all over the coasts they're found.

Figure 33. http://www.fao.org/fishery/species/2632/en

Fiddler crab (*Uca spp.*)

Fiddler crabs can be seen scurrying across the mudflats on the Reserve. The males have a large claw that is only used for territorial displays and mating rituals. This is actually a disadvantage when it comes to feeding. This enlarged claw cannot be used to feed. So, in order to consume the same amount of food, the males must work twice as hard with only one claw adapted for feeding than the females with their two. In this sense, the females have "one claw up" on the males.

Figure 34. https://www.fiddlercrab.info/u_minax.html

Marsh periwinkle (*Littorina irrorata*)

Figure 35. www.marinespecies.org/aphia.php?p=taxdetails&id=419566#distributions

The marsh periwinkle can be found in the salt marshes of the Mississippi Gulf Coast living on the grasses above, or right at, the water level. This can be a very harsh environment for a snail to live. To keep from drying out when the tide is low, the periwinkle will withdraw into its shell. The shell provides protection from the sun and can remain dry for hours at a time. When the temperature of the water becomes high enough to reduce the levels of oxygen, the periwinkle will simply climb up the grasses, which will also keep the snails safe from predators like diamondback terrapins.

Gulf saltmarsh snake (*Nerodia clarkii clarkii*)

Figure 36. Peterson Field Guide to Reptiles and Amphibians, pg 299.

The gulf saltmarsh snake is a salt marsh specialist. It can be found in saltwater wetland environments from Texas to Florida. These snakes will usually hide in places like crawfish burrows or wrack lines during the day and hunt for mostly fish at night. The gulf saltmarsh snake doesn't drink saltwater. It obtains the water it needs to survive from the animals it consumes or drinking rain water.

American alligator (*Alligator mississippiensis*)

Figure 37. Photo by Dennis McGrury.

Figure 38. https://nhpbs.org/natureworks/americanalligator.htm

The American alligator is a remarkable predatory reptile with many adaptations to facilitate its survival. One of those is teeth that can regenerate. Alligators replace each tooth about once a year. Alligators have a third eyelid known as a nictitating membrane. It is a transparent membrane that can be drawn over the eye, horizontally, acting like a pair of swim goggles. It gives the alligator's eye protection and better vision under the water. From the eyes and nose positioned on the top of its head acting like a periscope and snorkel to its dark brown camouflage, the alligator is adapted for an ambush hunting style.

*All photos by Sandra Huynh except Eastern oyster and American alligator.

Field Journaling:

<table>
<tr><td colspan="3">Name:</td><td colspan="2">Date:</td><td>Time In:</td><td colspan="2">Time Out:</td></tr>
<tr><td>State:</td><td>County:</td><td>City:</td><td colspan="5">Specific Location:</td></tr>
<tr><td colspan="8">Coordinates:</td></tr>
<tr><td colspan="7">Weather:</td><td>Temp:</td></tr>
<tr><td colspan="8">Observations:</td></tr>
<tr><td colspan="8">Notes:</td></tr>
</table>

Field Journaling:

<table>
<tr><td colspan="3">Name:</td><td colspan="2">Date:</td><td>Time In:</td><td colspan="2">Time Out:</td></tr>
<tr><td>State:</td><td>County:</td><td colspan="2">City:</td><td colspan="4">Specific Location:</td></tr>
<tr><td colspan="8">Coordinates:</td></tr>
<tr><td colspan="7">Weather:</td><td>Temp:</td></tr>
<tr><td colspan="8">Observations:</td></tr>
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Herbarium

An **herbarium** is a collection of preserved plant specimens used for scientific study. The plants are usually pressed and then dried for several days. The oldest herbarium dates back to Italy in the 1500s. Today, herbariums are kept to preserve a record of the types of plants in an area. While you're outside and in the field, observe some plants that you might like for starting your own herbarium.

The simplest way to press plants is by using a book. At Grand Bay NERR, we also have plant presses your class can use, and we can bring the completely pressed plants back to your classroom on the last day of the program, with your teacher's permission.

Figure 39. Here is an example of plants from Grand Bay NERR before (left) and after (right) they were pressed for about a week in April 2018. Photos by: Sandra Huynh

After pressing plants, you want to attach your plants to archival, acid-free paper and label each page with the species' common name and scientific name. It also helps to write down when and where you obtained your specimen.

Press and display your own plant species on the following pages.

Common name: ____________________

Scientific name: ____________________

Location: __________________________

Date: _____________________________

Common name: ____________________

Scientific name: ____________________

Location: ____________________

Date: ____________________

Common name: ____________________

Scientific name: ____________________

Location: ____________________

Date: ____________________

Notes Pages

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