A Classroom Course in Community Resilience

Understanding the impacts
of climate change on communities
and solving real-world challenges

TABLE OF CONTENTS

FOREWORD

A Classroom Course in Community Resilience (CR) was inspired by the components of a National Oceanic and Atmospheric Administration (NOAA) Meaningful Watershed Education Experience (MWEE). A MWEE is a series of activities designed to make students more aware of watersheds as systems that connect land to sea and shows how actions in all parts of a watershed affect each other. The MWEE incorporates a series of strategies shown by research to be effective. Essential elements that describe student activities in a MWEE include: issue definition, outdoor field experiences, synthesis and conclusions, and stewardship. Supporting practices that describe teacher activities include: sustained support of student learning throughout the MWEE, integration of MWEE activities into existing classroom instruction, place-based lessons focused on local context, and MWEE sustainment over multiple classes with successive activities building on each other. For more information about how to create or conduct a MWEE visit: https://www.noaa.gov/education/explainers/noaa-meaningful-watershed-educational-experience.

School district and teacher involvement were key to the development of this MWEE. Initially it was designed to address Marine and Environmental Science course content standards. However, with new teacher involvement, it expanded to include additional courses ranging from middle school to high school. Teachers incorporated previously published resources for use with the original lessons created by the Marine Education Center Staff. Some are streamlined with references cited, while others are linked directly for complete use as appropriate to the lessons. Weblinks for content information can be found in the references section of this document. Links needed for mini lessons are found in the body.

Our goal for this curriculum is to provide teachers with the content background they need to teach for conceptual understanding of climate change and how it looks in communities. Students who gain understanding on a deep level will be able to develop innovative solutions and not become discouraged by the magnitude of challenges stemming from climate change. **Suggested citation:** Kastler, J.A., Sempier, T., Blackmon, L. and Capers, S. (2021) A classroom course in community resilience. https://www.usm.edu/marine-education-center/watershed-education.php

Document Designed by Diana Reid, The University of Southern Mississippi
and Samantha Capers, USM Marine Education Center

Supplemental information and additional resources are available on the Web at
https://www.usm.edu/marine-education-center/watershed-education.php

This project was funded through a series of grants from the National Oceanic and Atmospheric Administration B-WET program: NA16NMF4630052, NA18NMF0080173.

This document is a Mississippi-Alabama Sea Grant Consortium publication. MASGP-21-066.

INTRODUCTION

The purpose of this curriculum is to provide teachers with a simple and effective method of teaching community vulnerability and resilience. This curriculum was designed to complement the Coastal Community Resilience Index (CRI) created by the Mississippi-Alabama Sea Grant Consortium (MASGC).

VULNERABILITY is the potential for harm to the community and relates to physical assets, social capital and political access. Also, how sensitive a population may be to a hazard or to disruptions caused by the hazard.[1]

RESILIENCE is the ability to prepare and plan for, absorb, recover from and more successfully adapt to adverse events.[1]

The CRI is a self-assessment tool that communities can use to evaluate the strengths and weaknesses in their community and identify areas where the community might become more resilient (http://masgc.org/ri)[2]

This curriculum provides teachers with a meaningful approach to community resilience and supporting concepts. Authors designed activities to connect students to natural processes at work in their home communities, explore changes and challenges using existing web-based tools and work as teams to address real-world problems. In addition, the curriculum presents mini lessons that develop student understanding of concepts related to climate change. Teachers have the freedom to select any or all of the resilience mini lessons to integrate the content into their own instruction.

The goal of this curriculum is to empower students, teach them to use problem solving skills to tackle real world problems their communities will face and develop innovative solutions. By exposing them to these issues through a lens of hope and not defeat, they will be equipped to make a difference in their communities.

CLIMATE CHANGE

CLIMATE is the long-term weather in a specific area. In addition to the accumulation of precipitation and the atmospheric conditions, climate is also the measure of the type, severity and frequency of severe weather events.[3]

All communities face the uncertainty of natural disasters. Over the years, many lessons have been learned from past natural disasters. Using this information, MASGC developed a tool to help communities measure their ability to bounce back after a natural disaster. This tool allows community leaders to consider the possible hazards and develop response plans that will protect residents, businesses and ecosystems in their communities.[2] In order to best prepare for natural disasters, communities must learn what is causing them. The human impact on global temperatures is causing an increase in severe weather events that will affect communities.[3]

Climate change is the deviation from typical weather patterns, including the possibility of an increase in frequency and severity of regularly occurring natural events.[3] A global increase in temperature is changing the weather patterns across the globe. Humans are causing this increase by fossil fuel consumption, deforestation and farming practices. In combination, these practices raise greenhouse gases that trap the sun's radiant energy and cause an increase in the temperature.[4]

Mini Lesson: Greenhouse Effect

Since the industrial revolution in the 1800s, humans have been burning fossil fuels at an ever-increasing rate. The combustion of fossil fuels releases CO_2 into the atmosphere. When CO_2, methane, nitrous oxide and fluorinated gases collect in the atmosphere, they stop heat energy from being released back into space. While these gases exist naturally, human activities concentrate them in the atmosphere.[4]

1. Ask the students to explain what a greenhouse is and what it is used for.
2. Distribute the Student Video Reflection Sheet found on page 22.
3. Show one or more of the following videos to your students.
    a. Video 1: https://www.youtube.com/watch?v=SN5-DnOHQmE. (This video is appropriate for middle and high school. It describes the greenhouse effect in simple terms and is easy to understand.)[5]
    b. Video 2: https://youtu.be/_Qmq73RYBi4.(NOAA video that explains the human impact on the greenhouse effect and the comparison of the climate data from different climate centers.)[6]
    c. Video 3: https://youtu.be/K9kga9c0u2I. (NASA Earth Minute on carbon dioxide.)[7]
4. Discuss the impact of increased greenhouse gases and how they end up trapped in the atmosphere.

Mini Lesson: CO_2 Concentration and Human Impact

Scientists have been actively monitoring the CO_2 in the atmosphere since the 1950s.[8] Using ice cores, scientists can estimate the atmospheric CO_2 levels prior to 1950. Using the information from the ice cores, we can see that since the beginning of the industrial revolution the amount of CO_2 has greatly increased.[9]

1. Distribute the Ice Core Video Study Sheet found on page 23.
2. Have the students visit the following website to see how ices are harvested, stored and analyzed. https://icecores.org/about-ice-cores .
3. Ask the students: Why are scientists examining ice cores? What information does this provide?
4. Have the students complete the video study based on the ice cores website (videos can be found if you scroll to the bottom or click the “Videos” link in the navigation menu.)
    a. Student instructions for video study: After reading the article about how ice cores are collected, scroll to the video gallery at the bottom of the page.
    b. Watch the videos listed on the video study sheet and answer the questions.
5. When the students have finished the video study, discuss the following: How does the ice capture the climate data? Where do the ice cores come from? What information about CO_2 do the ice cores give us? How can cores collected in places where there are no humans tell us about an increase in CO_2 caused by humans? Where does the CO_2 in the ice cores from unpopulated areas come from?
6. Have the students discuss and answer the questions they came up with for each video.

Did you know? You can have students answer and post discussion questions in your online classroom. This will allow any virtual students to interact and participate.

EFFECTS OF CLIMATE CHANGE

Temperature changes caused by humans have consequences. Increased temperatures on land disrupt weather patterns. Increased temperatures in the ocean melt ice caps and cause thermal expansion. These changes impact coastal shorelines and the fragile ecosystems that exist there.[10]

Mini Lesson: Mapping Severe Weather Events

Climate change can cause changes in the frequency, intensity and location of many severe weather events.

How to Create a Severe Weather Events Spreadsheet

1. Go to https://ncdc.noaa.gov/stormevents/.
2. Select year and event type.
3. Select [--All--] for the counties.
4. Click search.
5. Download as a .csv file

*You will need to format the spreadsheet to make it easy for students to read See the handouts section for examples

1. Ask the students: What is the worst weather event you can remember? What is the most common weather event that we experience as a community? Discuss the change in frequency of severe weather as an indicator of climate change.
2. Students complete the Mapping Severe Weather Events activity using the instructions below:
   a. Assign each student a year and a severe weather event.
   b. Provide them with spreadsheet containing the data from the NOAA Severe Storm Database (examples can be found in the Student Handout section).
   c. Have students record the information on the Mapping Sever Weather Data Sheet found on page 24
3. Using the Mapping Sever Weather Poster Handout, the students put tick marks in the counties that experienced a severe weather event that year.
4. Once they have finished identifying the counties have the students use a colored pencil to lightly shade in all of the counties that had a severe weather event.
5. On their poster handout have the students record the amount and severity of the storms.
6. Analyze the severe weather data following the instructions below:
   a. Display student maps by year.
   b. Have the students do a gallery walk and make observations about each of the event types.
   c. Ask the students if they can identify if a particular county is at more risk than others? Do they see any patterns of events?
   d. Rearrange the maps by year or groupings of years.
   e. Have the students do a gallery walk and make observations about each year/grouping of years.
   f. Ask the students if they can identify if a particular year is more active than others? Do they see any patterns of events?
7. Discuss the student observations. Discuss the impact that climate change has on weather events. Help students make the connection between the severity of the events and the change over time.

Mini Lesson: Disappearing Ice Caps

NASA has been using satellite technology GRACE (Gravity Recovery and Climate Experiment) since 2002 to track changes in the polar ice sheets. Using the change in gravity caused by shifting water, GRACE can identify how the ice is changing.[12]

SEA ICE is ocean water that freezes, grows and melts in the ocean.[35]

ICE CAPS are mound shaped masses of ice that completely cover huge areas of land.[35]

1. Ask students: What is the difference between sea ice and ice sheets? Clarify that we are referencing the polar ice sheets that are found on land.
2. Distribute the Disappearing Land Ice Observation Sheet to your students found on page 25.
3. Following the instructions below, show the two animations to your students: https://gracefo.jpl.nasa.gov/science/ice-sheets-and-glaciers/.

   Greenland Ice Mass Loss Animation
   a. Pause the animation and point out that the center where the ice was the thickest had little change, but the areas around the perimeter experienced up to 3 meters of ice loss.
   b. Give students a visual representation by setting up 3-meter sticks or by taping the height on the wall.
   c. Scroll to the next animation on the page.

   Antarctic Mass Change from GRACE derived Gravity Observations
   a. Pause the animation to explain that the blue areas show an increase in thickness and red areas show a decrease in thickness.
   b. Have the students make comparisons and determine if there was more loss or gain in Antarctica from 2004-2014.
4. Discuss: Why is the change in the thickness of ice important? Where does the water go if there is a decrease in thickness of the ice? What impact does the thickness of the ice have on the ecosystems that border the ice? Do you think the amount of change is enough to affect the volume of the ocean?

Did you know?

Land ice, ice cap, ice sheet, iceberg, ice shelf and glacier all refer to ice that formed on land![35]

Mini Lesson: Thermal Expansion

The oceans absorb the majority of the heat energy that is reflected to Earth by the atmosphere. This creates an increase in water temperature, which causes water molecules to spread and take up more space. Warm salt water has more volume than cold salt water.[10]

1. Ask students: What happens to most materials when they are heated? What covers most of the surface of the Earth?
2. Have students complete the Thermal Expansion activity (see page 26) using the instructions below.[13]
    a. Fill a disposable plastic water bottle completely with water and add 5 drops food coloring.
    b. Insert a clear plastic straw and a probe thermometer into the water bottle.
    c. Seal the bottle with clay. Be sure to surround the thermometer and the straw. Be sure the water can move freely up and down the straw, and the thermometer is not touching the bottom of the bottle.
    d. Mark the water level on the straw and record the water temperature.
    e. Turn on a heat lamp and place the bottle 20 cm away from the lamp. Make sure the lamp is directed toward the middle of the bottle. Wait 5 minutes.
    f. Mark the water level. Record the temperature and measure the amount of change in water level.
    g. Place the bottle 15 cm away from the lamp. Wait 5 minutes.
    h. Mark the water level. Record the temperature and measure the amount of change in water level.
    i. Place the bottle 10 cm inches away from the lamp. Wait 5 minutes.
    j. Mark the water level. Record the temperature and measure the amount of change in water level.
3. Discuss: How much did the water level increase? Why did it increase? How does this apply to the ocean?

DID YOU KNOW?

Demonstrations like this one often have different results due to error. This is a great opportunity to talk with your students about error and variables.

MODELING

Models help us predict the world around us., models "Describe, explain and predict natural phenomena and communicate scientific ideas."[30] When we are teaching concepts that are related to climate change, using models can help students see the impact on both global and local scales. The NOAA Investigating Sea Level Using Real Time Data Module uses numerical models that are based on data to allow students to make predictions based on the information from the past. Accurate data collection is essential for these models to work. Increasing accuracy and adding to existing data lead to more accurate predictions by models.[31]

Mini Lesson: NOAA Data in the Classroom

Models can be created to show many different scientific phenomena. The students will complete the Investigating Sea Level Using Real Data Module to develop an understating how models are used to predict local conditions related to climate change. This activity is provided by NOAA Data in the Classroom.[31]

1. Ask the students to give examples of models. Have them explain the differences or similarities between the examples. Explain to the students that models use data to predict natural phenomena, like the height and times of tides.
2. Show the introduction video for this module, found on the website below: https://noaa.maps.arcgis.com/apps/MapSeries/index.html?appid=bc85d84410054ad5b314a2a8e417fd63. Answer any questions the students have.
3. Distribute the student worksheet (see page 27) or upload the fillable student PDF into your online classroom. Student documents are located in the Module Resources section: https://dataintheclassroom.noaa.gov/content/sea-level/teacher
4. Have the students go to the following website and complete levels 1-4. https://noaa.maps.arcgis.com/apps/MapSeries/index.html?appid=bc85d84410054ad5b314a2a8e417fd63
5. After the students have completed the first four levels, they are going to design their own investigation. Using the information found in the teacher's guide, go over the tools and the data sets that the students can use to complete the investigation. This level is best completed by student pairs. Have the students present their findings after they complete their investigations.

DID YOU KNOW?

The NOAA Data in the Classroom has 5 online modules that can be easily integrated into your online classroom. The teacher's guide also includes hands-on activities to extend student learning.

SEA LEVEL RISE

The volume of water in the ocean is increasing and is creating an alarming situation for coastal communities. Sea level rise causes increased nuisance flooding and storm surges. With seawater flooding low-lying coastal areas more frequently, saltwater intrusion is becoming an issue. Communities are faced with troubleshooting these hazards in a way that is best for their citizens and the local ecosystems.[14]

NUISANCE FLOODING, which refers to low levels of water, can disrupt day-to-day activities but does not pose a major threat to public safety.

Mini Lessons: Sea Level Rise Viewer

The sea level rise viewer is a tool that city officials can use to identify issues that will be made worse in the future due to sea level rise. Using a web-based mapping system that was created by NOAA, city planners can input hypothetical data and develop plans to mitigate nuisance flooding, storm surge or other flooding scenario.[15]

1. Ask the students: What are the most important places in a community? What would happen to these places in the event of a flood? Where are our important places located? Is there any area that experiences nuisance flooding in our area? Why is it useful for city planners to identify areas that could be impacted by future sea level rise?
2. Show students the About the Tool video found on the website: https://coast.noaa.gov/digitalcoast/tools/slr.html.
3. Have the students complete the Guided Tour of the Sea Level Rise Viewer.
    a. Have the students go the following website: https://coast.noaa.gov/slr/.
    b. Have the students complete the Guided Tour of Sea Level Rise Viewer chart (see page 28-31).
4. Discuss with the students: what part of the Sea Level Rise Viewer was the easiest to figure out? Explain the importance of each focus area designated with the clickable buttons. Explain that city planners and communities use this tool to determine locations for essential businesses and infrastructure.

Mini Lesson: Nuisance Flooding

Many of today's low-lying areas were not at risk of nuisance flooding 50 years ago.[18] These streets and businesses were built above the high tide mark for that time, when it would have taken a significant amount of water to cause flooding. However, the high tide line has risen with the sea level. Many of these areas now flood at high tide and during rain events.[19]

1. Ask the students if they have ever seen any local flooding? What caused it? Is there any location nearby that is impacted by tidal flooding?
2. Have the students listen to the NOAA Diving Deeper: Episode 63 Nuisance Flooding podcast found here: https://oceanservice.noaa.gov/podcast/oct15/dd63-nuisance-flooding.html.[19]
3. Discuss the different scenarios that the oceanographer mentions. Explain that nuisance flooding is a nationwide issue that is increasing in severity and frequency. The greatest impact is when there is a vulnerable population. Do we have protections in place to prevent nuisance flooding? Discuss the impact sea level rise has on nuisance flooding.
4. Have the students complete the following nuisance flooding activity (see page 32) using the sea level rise viewer.
5. Discuss the impacts of nuisance flooding on the citizens in the community. If flooding keeps police from responding in an emergency, or if the hospital becomes inaccessible, how are residents affected?

Mini Lesson: Saltwater Intrusion

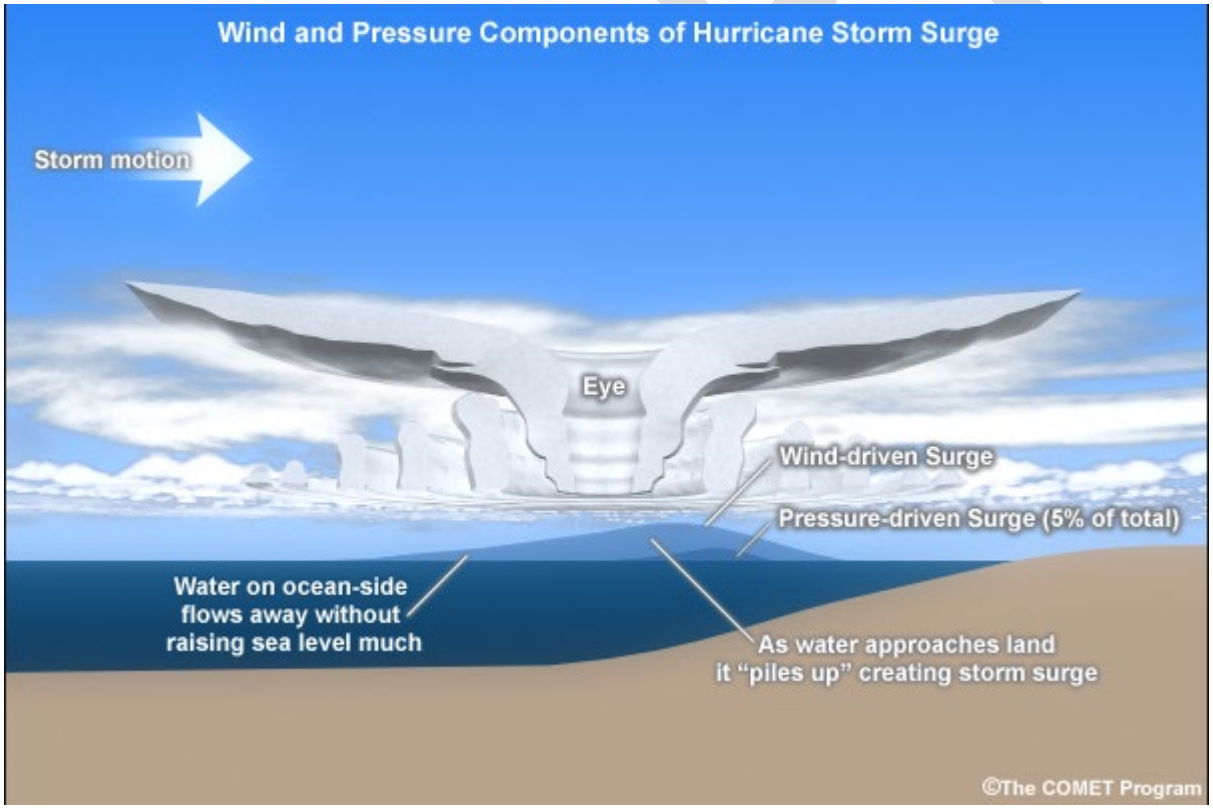
Saltwater intrusion occurs when salt water replaces the fresh water in a coastal aquifer. As more fresh water is pumped from aquifers for human consumption, saltwater coming from the coast will replenish the aquifer. This saltwater intrusion can put a community at risk especially if they only have one way to obtain drinking water.[20]

1. Ask the students where their drinking water comes from. What is an aquifer? Can we drink salt water? Do our water treatment centers have the ability to remove salt from our drinking water? How can we remove salt from seawater to make it potable?
2. Have students complete the following activity adapted from Water Education Today (see page 33 for handout).[21]
   a. Give students a clear container, a thick milkshake straw and some sand.
   b. Have the students place the straw upright near the back of the container touching the bottom.
   c. Next pour sand around the straw being careful not to get any in the straw.
   d. This straw represents the pipe from the well.
   e. Moisten the sand with water. This will represent the groundwater that is absorbed. Continue adding water until you can see it in the straw.
   f. Drain any standing water from the container using a paper towel or washcloth but leave any that is in the pipe.
   g. Create a slope at the edge of the sand farthest from the straw. This will represent the ocean area.
   h. Mix several drops of blue food coloring into a separate container of water.
   i. Have the students add the blue water slowly and in small increments only to the ocean end of the container.
   j. The students will watch the straw and make any observations about the color change of the water in the straw.
3. Explain that the salt water was represented by the blue water. When the fresh water in an area is pumped out it is replaced with salt water. This is a major concern because of sea level, salt water is nearing the inland location of municipal water pumps. The pumping of water disrupts the natural seaward flow and causes saltwater intrusion.

Mini Lesson: Storm Surge

Hurricanes and other maritime storms cause coastal flooding. Water is moved by wind and pressure, and it changes as it approaches the shoreline. Low air pressure at the centers of storms raises the water surface, and wind pushes the water on shore. Storm surges associated with intense storms can cause water levels to increase 20 feet or more. Areas subjected to flooding from increased storm surge will flood even deeper during a storm surge, which can destroy public infrastructure and private property.[22] Higher water levels from rising sea levels can raise storm surges even higher.

1. Ask which students have been on the coast during a hurricane? What are some of the threats that a hurricane presents? What is the storm surge? Where does this water come from?
2. Students will complete the Storm Surge Game created by Dauphin Island Sea Lab (see page 34).[23]
3. Discuss what the relationship between storm intensity and storm surge is? Where is the greatest amount of storm surge in relation to the eye of the hurricane? How would an increase in sea level cause a change in the storm surge? Explain that Austal is one of the largest employers in Mobile, so a storm surge could cause damage and have an economic impact that is just as relevant as the police or power plant being flooded.



A Storm Surge Overview. [34]

WATERSHEDS

Our focus considers sea level rise impacts to watersheds. Watersheds are areas of land that drain water, sediment and dissolved materials to a common receiving body or outlet. The water includes surface and groundwater. All land is part of a watershed. The watershed includes both upland and coastal areas which are inextricably linked by the water flow, habitats, transportation and flooding. Storms upstream lead to downstream flooding. These areas already have several low-lying spaces that are affected by nuisance and tidal flooding. An increase of salt water in these areas can create issues that impact the local community. Since the watershed also includes the ground water, saltwater intrusion can contaminate the communities' drinking water supply. All these issues create an additional stress on emergency management crews while they are trying to handle a crisis.[24]

WATERSHEDS are systems of connected habits. For example, a watershed could contain a forest and a marsh both connected by flowing water. [25]

Mini Lesson- Watersheds

The topography of an area determines the way water flows and defines the different watersheds in a region.

1. Show the students the Watershed presentation from Sturgeon in the Watershed MDEQ RESTORE. https://www.usm.edu/marine-education-center/sturgeon-restore-project.pdf [25]
2. Ask students which watershed do you live in? Is it a part of a larger system? What activities occur in our watershed?
3. Have the students complete the Let's Make Our Own Watershed Activity adapted from Sturgeon in the Watershed MDEQ RESTORE.[25]
    a. The students will need a blank sheet of paper, colored pencils, blue and green washable markers.
    b. Turn the paper so that the short sides are facing the student (portrait).
    c. Fold the bottom 2 inches and make a crease.
    d. Below the crease, using a black colored pencil draw a coastal shorelines. Don't forget to include any barrier islands if your state has them.
    e. Color the coastal body of water (sound, bay, ocean…) blue.
    f. On your paper using colored pencils draw in housing and industrial areas as well as agricultural fields.
    g. Using your green washable marker, draw an X over the tops of these locations.
    h. Gently crumple the top portion of your paper. Not too much, just enough to create divides!
    i. Outline the tops of these creases blue. These blue lines represent the divides in the watershed. Remember elevation determines how water moves.
    j. Prop the crumpled end of your paper on an elevated surface to create differences in elevation between upland and sea level.
    k. Gently spray water on your paper.
    l. The markers will show the path the water takes to reach the ocean. The green marker shows the path of the pollutants.
4. Discuss how watersheds are impacted by climate change. Increased precipitation in some regions can lead to a higher volume of water moving through a watershed from upstream drainage, which can create challenges for the people who live in that area in the form of pollution and flooding. Human disruption of the watershed can increase the effects of nuisance flooding and storm surge impacts.

CHANGE DETECTION ANALYSIS

Scientists use a variety of techniques to monitor and analyze the processes that impact watersheds. Some of these changes are related to climate change and are happening at an alarming rate. Coastal monitoring is the periodic measurement of the factors that affect the use and quality of coastal resources. [32] Data regarding water quality, biological processes and meteorological events provide a snapshot of the coastline. NOAA has 28 different monitoring systems to collect this data. NOAA's Coastal Change Analysis program (C-CAP) uses satellite images from the same location on different dates to detect changes in the type of structures and vegetation that appear along the coastline. Sometimes the changes result from human activity. Natural processes like erosion or succession also cause change.

GROUND TRUTHING is the process of visiting a site to make sure interpretations of aerial images match what is observed on the ground.

Mini Lesson: Change Detection Analysis

This lesson comes from the archived NOAA Ocean Service lesson: Do you Have Change? [32]

1. Have the students brainstorm events that could cause land changes in coastal areas. Explain that some of these events are natural and others are caused by humans.
2. Distribute student handouts found of page 35-37.
3. Explain that NOAA C-CAP uses satellites to determine the changes in land cover. These changes are ground truthed and can then be mapped by the types of land use. The data are individual pixels that can be tabulated to interpret change. Each pixel represents an area. Its size depends on the resolution of the sensor used to capture the image.
4. Distribute the Land Use Change sheet. Show the students that each pixel has a letter based on the row and a number based on the column. Instruct the students to complete Table 1.
5. Using Table 1, fill in Table 2. Table 2 is a matrix, so the students are recording the number of pixels of a specific land use (rows) that change to another land use (columns) from 1990 to 1995.
6. Have the students make observations about the land use changes from 1991 to 1995. Point out that the central diagonal boxes show how many pixels did not change from 1990 to 1995.
7. Discuss the impact of high-density development along coastal shorelines. Encourage the students to explore relationships between the sea level rise impacts and the types of land cover along shorelines.

Mini Lesson: Ecosystems

ECOSYSTEMS are community of living things interacting with each other and with the non-living factors in their environment.

HABITATS are the environment that meets an organism's needs for food and shelter.

Many diverse types of ecosystems can be found in the watershed. These ecosystems overlap and vary based on the location of unique features found within the watershed. Humans modify ecosystems in ways that change how different parts work together. This can impact fisheries and other industries that humans depend on. These habitat changes can have lasting impact on the organisms and the humans that depend on them. Watersheds include both land and aquatic ecosystems.[26]

1. Ask the students what ecosystems are present in our local area (forest, tundra, desert, grassland, freshwater, saltwater, wetland)? What are the different types of habitats can be found in a forest ecosystem? What type of ecosystem would be vulnerable to changes in salinity or could be destroyed by storms?
2. Review the types of Wetland Classifications with the students.
3. Complete the Sea Level Rise viewer activity on wetland ecosystems (see page 38) and see the impact of sea level rise on these ecosystems.

Habitat Descriptions

Habitat Type	Description	Dominant Species
Upland*	Any area that is not covered by water and host a variety of trees, shrubs and grasses.	long leaf pine, white oak, laurel oak, post oak, water oak, hickory[29]
Freshwater Forested Wetland	Tidal and non-tidal wetlands were woody vegetation greater than 5 meters covers more than 20% of the land.	red maple, American elm, black gum, tupelo gum, bald cypress, red bay, sweet bay, loblolly pine [29]
Freshwater Shrub Wetland	Tidal and non-tidal wetland containing mostly woody vegetation that is less than 5m tall. Total vegetation cover is greater than 20%.	marsh elder, willows, button bush, red osier dogwood, honey cup, coastal sweetbells, fetterbush[29]
Freshwater Emergent Wetland	Tidal and non-tidal wetlands dominated by emergent vascular plants, emergent mosses or lichens. Total vegetation cover is greater than 80%.	cattail, reed grass, arrow arum, pickerel weed, marsh mallow[29]
Brackish/ Transitional Marsh	Experiences flooding with saltwater that is not tidal but maintains low salinity due to its distance from saltwater source and freshwater inflow. Primary vegetation is rushes and grasses.	awl-leafed arrowhead, welsh mudwort, eastern grasswort, hooded arrowhead, swamp smartweed, tidal marsh amaranth[29]
Saltwater Marsh	Experiences tidal flooding with saltwater of a moderate salinity level. Primary vegetation is grasses and rushes depending on the elevation.	needlerush, saltmarsh cordgrass, smooth cordgrass, sea purslane, sand cordgrass, saltgrass, saltwort[29]
Unconsolidated Shoreline* (Beach)	Contain sand, gravel and silt that are often inundated and redistributed due to wave action. Most substrates lack vegetation. Pioneering plants can be established during brief periods of favorable growing.	

*These descriptions were compiled based on NOAA C-CAP regional land cover classification scheme. [33]

RESILIENCE AND VULNERABILITY

The beauty of diverse communities is the variety of people that live, work and experience life in the same place. Some of this population would not be able to leave or adequately prepare for a natural disaster if one were to strike. These vulnerable populations don't have the ability to plan for, respond to and recover from natural disasters. A community's vulnerability can be measured using a variety of socioeconomic factors. In addition to race and income, factors such as age, access to hospitals, employment status, and housing type are all factors that are used to determine vulnerability.[27] A community can be resilient in many ways; socially, economically, environmentally, etc. Cities and towns use the Coastal Community Resilience Index (CRI) to evaluate the impacts of a disaster and project the time and cost of recovery. The CRI allows city leaders and emergency management teams to evaluate six different priority areas related to resilience. After completing this process communities can make changes to prepare for the next natural disaster.[2]

Mini Lesson: Vulnerability

Identifying vulnerable populations allows communities to determine where to focus their resources and efforts to increase resilience after a natural disaster. Using data from the census, NOAA and the University of South Carolina Hazards and Vulnerability Research Institute created the Social Vulnerability Index to provide a visual representation of vulnerable populations.[27]

1. Ask students what type of natural hazard we are likely to experience. Are there any areas of our community that would have a hard time recovering financially from a disaster? What about any specific group of people (elderly, home health, etc.) that would be at risk if a disaster struck? What are the locations of emergency services and critical infrastructure in the community? Is this important?
2. Use the Sea Level Rise Viewer to determine the location of critical infrastructure and evaluate the city's vulnerability (see page 39-40). * Note: you can use any coastal cities you would like for this activity.
3. Discuss with the students. After we have identified these areas of most concern, list the groups and agencies that provide disaster relief. Which specific places do relief groups target? What would happen if the emergency services were not able to do their jobs? What would happen to the vulnerable population if they didn't have access to water and power?

Mini Lesson: Waffle House Index

When we look at the images of storms damage on the coast, we may often see the infamous Biloxi Beach Waffle House picture. https://www.loc.gov/resource/highsm.04857/. The Waffle House Index designates the degree of damage left by a storm.
GREEN: full menu – restaurant has power and damage is limited or no damage at all.
YELLOW: limited menu – no power or only power from a generator, or food supplies may be low and choices will be limited.
RED: the restaurant is closed – severe damage or severe flooding.
Disaster responders, starting with FEMA (Federal Emergency Management Agency), use this index as an informal way of gauging conditions on the ground before they arrive on the scene.
While many people approach this topic jokingly, Waffle House is well known for its ability to bounce back in the face of a crisis. They have a systematic plan and the entire restaurant can be run efficiently with minimal staff and resources. The goal is the same for many communities after a storm. They are forced to run as efficiently as possible with limited city employees and resources that were damaged by a storm.[28]

1. Distribute activity sheet found on pg 41. Have students read the article and answer the questions.
2. Discuss with students why they think Waffle House is good at getting reopened quickly after a disaster? Why are local businesses important to the resilience of a community? What are the issues that would

cause a Waffle House to close completely? Why would Waffle House serve a limited menu? What other businesses reopen quickly after a disaster?

Mini Lesson: Exploring the CRI

Many communities use tools created by experts to help guide them in the process of determining the best way to use their resources. The CRI was created to help communities make tough decisions while planning for future resilience. [3]

1. Ask the students if they have ever gotten advice about a tough question from a friend? Where would community leaders look to get help planning for a disaster before it happens?
2. Have the students go to the Mississippi Alabama Sea Grant website to find the CRI http://masgc.org/assets/uploads/publications/662/coastal_community_resilience_index_2021.pdf.
3. Instruct the students to complete the scavenger hunt (see pg 42-43) to find out what the Coastal Resilience Index is and how communities can use this tool. [3]
4. Discuss with students that a community has a high level of resilience if it has a healthy economy, healthy environment and a healthy society. The CRI provides communities a way to evaluate the health of each of these three sectors and see where they can improve. Consider your own community. What industries do you have? Are you getting new businesses? Are businesses staying open for many years? Do you have several vacant store fronts? What is the economic health of your community? What nature areas does your community have? What coastal planning projects does your community support? What is your community's environmental health? What social systems (ex: churches, ethnic communities, civic groups…) do you have in place in your community? Do you have growing schools? Do you have gyms and parks? Are utilities like water supply, trash pick-up and electricity functioning well and providing quality service? Do the residents have insurance? Does your community have a large number of rental properties? What kinds of social resources does your community have? (gyms, places for entertainment etc.)? After all of these topics have been discussed, explain to the students that communities will prioritize, and address issues based on availability of funds.

COMMUNITY RESILIENCE PROJECT

As a culmination of the discussed topics, the students will demonstrate their understanding of how human activities impact climate change and increase the severity of natural disasters. Each team of students will be given a scenario to evaluate and produce a solution to help build resilience.

Community Resilience Project Timeline	
Review and Evaluate Scenario	Group students into teams Assign them a scenario The students will: -Review the page in the CRI that correlates with their scenario -Determine the topics they will need to research -Google any unfamiliar concepts -List the specific requirements the solution must have
Individual Research Component	The student will: -Research the connection between climate change and the scenario -Name the community stakeholders that can offer different perspectives about the solution -List resources needed to solve the problem -Suggest possible solution to the problem - Be creative when coming up with ideas! - Consider implementation challenges
Team Planning Discussion	The team will: -Based on independent research, formulate an answer to the question; "How does your problem result from climate change?" -Use the SLR Viewer to determine what year your scenario will occur -How is your problem related to sea level rise *Discuss solutions and choose 4 to reference in your presentation *Evaluate the pros and cons for 2 of the solutions *Develop a best solution, it can be a combination of suggested solutions
Presentation Creation	The team will: -Create a visual presentation and assign a speaking part to each team member The presentation will include: -Cite references on individual slides -How the scenario is related to climate change (and/or sea level rise) -The community stakeholders whose perspectives were considered -A list of potential solutions -Two solutions that were evaluated -A statement of the ideal solution that explains * How this solution solves the problem * Implementation requirements * The risks and drawbacks
Class Presentation	The class presentation will be for the students to share their research findings with the class, practice their presentations in front of their peers, and receive feedback from other students and instructors.
Class Stewardship Summit Video	The top team from each class will record a competition quality video to send to the MEC for the Stewardship Summit.
MEC Stewardship Summit	The MEC will host a Stewardship Summit and team presentations/ videos will be judged by community stakeholders and winners will be awarded based on the judges' rubric.

Resilience Index Scenarios	
Section 1: Critical Infrastructure and Facilities	
Saltwater Intrusion Your community has experienced an increase in population causing more freshwater to be removed from your local groundwater aquifer. Due to your community's close proximity to the ocean and increasing sea levels, water monitoring is showing increased salinity levels indicating salt water intrusion. In the next 5 years the sea level is predicted to rise by 3 m causing water quality degradation. It is your responsibility to address this vulnerability by coming up with feasible adaptation strategies that can be implemented at the local level.	**Critical Record Storage** After the last intense storm of record (Hurricane Katrina 2005), your community lost many important paper documents such as birth certificates, death certificates, elevation certificates, city ordinances, etc. Since that time, the city has started using a digital system to keep electronic files of these types of critical records. However, the server that houses these documents is still located at City Hall, which happens to be in a Special Flood Hazard Area. It is your responsibility to determine how the city can ensure these documents are safe before another disaster strikes.
Section 2: Transportation Issues	
Debris Removal After a storm, debris (trees, wrack) lines the roads and main transportation thoroughfares in your community. Your community calls on all of its resources from the police, fire, and community development departments to utilize city vehicles to push the debris to the side of the road so they are passable within a one-week period. This is a practice that has always worked in the past. However, city leaders have determined that if a storm of greater magnitude hits the community, it is likely that the resources of the city will not be enough to clear the roads of debris. To make matters worse, it is likely a neighboring community will not be able to assist you because they will be dealing with similar issues. What will you do to prepare for debris removal before the next storm hits your community?	**Evacuation/Reentry** Your community has two evacuation routes that are accessible to citizens. One of the roads is a long bridge that connects the coastal zone to the upland area with shelters. The bridge was operational after the last storm of record, however the base of the bridge floods, rendering it impassable for evacuation before the arrival of the storm. Before the next storm approaches you must create an evacuation management plan. Include a traffic control strategy to allow traffic flow out of the community in a manner that does not put residents at risk, an evacuation management plan for vulnerable populations in your community who are unable to evacuate by themselves, and a detailed post-storm re-entry arrangement that focuses on the safety of all residents and community workers.

Resilience Index Scenarios (continued)	
Section 3: Community Plans and Agreements	
Early Flood Warning System Your mayor is considering the purchase, installation and monitoring of an early flood warning system to help warn the citizens of your community of nuisance flooding threats. The mayor believes this early warning system will allow city officials and residents to prepare, and will reduce property damage by evacuating low-lying areas, moving vehicles, mechanical preparations and security plans. Other municipalities have been successful in their implementation of early flood warning systems and have also given their residents a discount on their flood insurance. You will create an early flood monitoring system. The mayor and city council will need the following information so they can make an informed decision. The cost to implement, monitor and analyze the data, flood monitoring location sites in your community, and ways to alert the citizens of potential flooding.	**Memorandums of Understanding (MOU)/ Memorandums of Agreement (MOA)** During the last storm, your region experienced widespread damage to roads, bridges, homes, critical infrastructure, and businesses. Your city was unable to offer support to neighboring communities because you did not have fuel for your city vehicles, water for your residents, or even power (other than a few generators). Due to the large-scale nature of the disaster, companies you typically call on for assistance were busy helping other municipalities. In the future, how can your community ensure you will have the assistance necessary to get back up and running? How will you coordinate with other communities and municipalities to provide adequate emergency responders, debris removal, and other critical services to the community? How will you ensure there are enough city staff trained in response and recovery?
Section 4: Mitigation Measures	
Mitigation Options Now that storm season has passed, your city has begun to focus on how to prevent property damage in the event of future coastal storms. The city is interested in participating in the National Flood Insurance Program's Community Rating System which offers insurance discounts for going beyond minimum required standards to protect life and property. Your team has been asked to identify flood mitigation options the community can implement in order to be better prepared for future hurricanes and flood damage. What options will you recommend? How will these be financed? Which ones provide a "win-win" opportunity for your city and residents?	**Erosion Control** During the last storm, an area has become critically eroded due to storm surge and immediate action is necessary to prevent infrastructure from being compromised. In this same area, there are sensitive coastal habitats and ecosystems that provide homes to endangered wildlife. Therefore, any erosion control options must take into consideration the protection of these organisms. This area of high erosion sits within a high hazard area (V-zone) and there are strict limits on how you are allowed to manage the eroding area. What kind of shoreline restoration projects will your team propose to prevent further erosion and stabilize the coastline, while also protecting critical wildlife habitat?

Resilience Index Scenarios (continued)	
Section 5: Business Plans	
Business Equipment/Plans Businesses in your community are an essential part of recovery after a major disaster. Your job is to compile a guide for community and business leaders that can assist them with providing the needed supplies and resources to the community. This will need to include essential businesses and the good/services they provide, the vulnerability of these essential businesses, business continuity of operations plans they may have developed, and the immediate support these businesses can provide to citizens. You will also create a way to get this information into the hands of the city leaders and businesses that need it.	**Restocking/Bringing Staff Back** Immediately after a storm, many businesses have resources needed to help residents, but no workforce due to the impact of the storm. Additionally, storms can disrupt supply chains causing stocking limits. Your task is to come up with a staffing plan that will allow businesses to meet their staffing needs post-storm, including ways to compensate employees who return to work even if the basic utilities like power and internet are not restored, cross-training and remote work to reduce the number of staff required to operate a business, and any ideas to circumnavigate supply chain issues.
Section 6: Social Systems	
Neighborhood Associations Your community has strong neighborhood associations that assist residents before and after disasters. These neighborhood associations work with experts and the city to create well informed citizens. After the last storm, the city had issues with residents re-entering the community when it was unsafe to do so due to flooding and unstable roadways. This put the citizens in danger and placed undue stress on the emergency management team. The primary reason for their early return was that they wanted to know the condition of their property and to protect their belongings from looters. Your team will put together a solution that addresses the concerns of the citizens and prevents them from putting themselves in harm's way. What pre-planning measures must be taken and how will you communicate with the individual property owners the state of their homes without them being there in person to see it?	**Faith-Based Networks/Cultural Identity** After the last storm your community received generous donations from many churches and nonprofit organizations. There was no organization of the food and supplies, and the distribution centers were all located on one side of town. This left many people without access to the donated food and water. The non-English speaking community was organized and able to provide assistance if it had been given the appropriate resources. However, it was unable to receive supplies, partially due to the language barrier. English speaking residents were unable to communicate the location of distribution centers effectively. Your team will propose a solution that connects these networks and ensures adequate resources can reach residents equally, including the populations that are most vulnerable. Who are the people that would need to be involved in this process?

Judging Rubric	1 Poor	2 Adequate	3 Average	4 Above Average	5 Exceptional	Total Score
Communicating the issue: Helping audience to understand the problem at hand.						
Knowledge of the issue: Understanding the problem well enough to communicate it to the audience.						
Explanation of the proposed solution: Helping audience to understand how the proposed solution would solve the problem at hand.						
Originality of proposed solution: Going beyond existing standard procedures.						
Reality of proposed solution: Could the proposed solution be implemented?						
Pros & cons of solution:						
Quality of presentation: Content, visuals, participation, organization.						
Length of presentation: Adequate to explain the issue and solution without exceeding limit.						
Use of the CRI criteria:						
Identification of sources: References listed throughout the presentation for all photos and information that not the students' ideas or thoughts.						
Creativity: The creativity in the presentation style						
Notes:						

Team Name: _____

STUDENT HANDOUTS

The following handouts were designed for teachers to use with the accompanying mini lessons. They may be adapted to fit the need of the teacher specific to their class.

GREENHOUSE EFFECT
STUDENT VIDEO REFLECTION SHEET

As you watch the following videos record 3 key terms and 3 important facts from each video.

Student Name:	Key Terms	Important Facts
Video 1: What is the Greenhouse Effect?	* * *	* * *
Video 2: How Do We Know That the Climate is Changing?	* * *	* * *
Video 3: NASA Earth Minute: Gas Problem	* * *	* * *

ICE CORE VIDEO STUDY

Visit the following website: https://icecores.org/about-ice-cores. After reading the article about how ice cores are collected, scroll to the video gallery at the bottom of the page. Watch the videos selected and listed on this worksheet and answer the questions.

Student Name:	What does the video say about ice cores and climate change?	What were two things that you found interesting about the video?	Make up a question about the video for your classmates.
Antarctic Ice Core Research at National Ice Core Lab			
CO_2 in the Ice Core Record			
NSF-ICF Core Processing Line			
Time History of Atmospheric Carbon Dioxide (Showing Ice Core Data)			
How Do Ice Cores Allow Researchers to Look at Global Climate Change?			

MAPPING SEVERE WEATHER EVENTS

Using the provide spreadsheet record the required data in the table below. Use the data table to complete the Mapping Severe Weather Poster

Student Name:	Year:	Weather Event Type:
Strength or Magnitude	**Date**	**Counties impacted**
F3	1/19/2019	Leake, Rankin, Neshoba

DISAPPEARING ICE CAPS

Go to the NASA GRACE-FO Satellite web page: https://gracefo.jpl.nasa.gov/science/ice-sheets-and-glaciers/. Watch the animations and answer the questions below.

Student Name:	
Green land Ice Mass Loss Animation	What was the first year that had a 3m loss of land ice?
	What was the first year to not show any accumulation of land ice (light blue color)?
	What year had the greatest loss of land ice?
Artic Mass Change from GRACE Derived Gravity Observations Animation	Between what 2 months do you see the largest change in land ice?
	What month had the largest accumulation of land ice?
	What is the total amount of lost land ice in gigatons over the years included in the animation?

THERMAL EXPANSION ACTIVITY

Procedures:

1. Fill a disposable water bottle to the top with water and add 5 drops of blue food coloring.
2. Insert a straw and a thermometer into the water bottle and seal completely with modeling clay.
3. Plug in a heat lamp and place a mark at 20 cm, 15 cm, & 10cm.
4. Mark the starting height of the water in the bottle (if it is not visible put the mark at the clay).
5. Starting at the 20cm, place the bottle on the mark and wait 5 min.
6. Mark the change in water height in the straw.
7. Measure the change in water height.
8. Record the temperature and the change in height on the table below.
9. Repeat these steps for each interval.

Student Name:	Distance from Lamp	Temperature	Change in Water Level

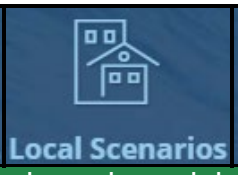
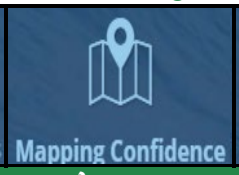
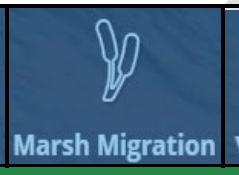
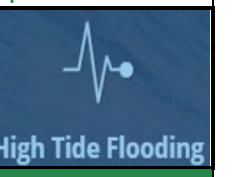
NOAA DATA IN THE CLASSROOM

NOAA Data in the Classroom Student handouts can be downloaded from the following website:
https://dataintheclassroom.noaa.gov/sites/default/files/ditc_sea_level_worksheets_pdf_forms_l1-l5.pdf

GUIDED TOUR OF SEA LEVEL RISE VIEWER

Student Name:	Go to https://coast.noaa.gov/slr/. Maximize your web browser so that the Sea Level Rise tools are all accessible.
Read the Disclaimer under the green "Get Started" button.	- What do the maps in the tool show us? - What variables are not taken into account? - What are the water levels relative to?

On the start sceen click the blue circles above the green "Get Started" button to answer the question below

					
What concept is shown by each button?					

Click the green "Get Started" button, then click each of these 5 buttons.

Sea Level Rise

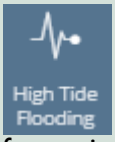
MEAN HIGHER HIGH WATER (MHHW) is the average daily highest tide height.

INUNDATION is the amount of water that occurs above normally dry ground as the result of flooding. This happens when water level exceeds MHHW height.

Click the Sea Level Rise icon on the left side of the screen.  Click the information icon at the bottom of the screen. 	- If an area is hydrologically connected to the ocean what color will it be? - What features do green areas have? * *
 Look at the water level scale on the left side of your screen	- What is the maximum amount of water above MHHW that the slider shows? - What are the two different units that the slider uses? * *

Click on the Legend Toggle in the top right corner. 	- What do the following represent? - Light Blue Areas - Dark Blue Areas - Green Areas - Blue Drop -
Local Scenarios	
Click the Local Scenarios icon on the left side of the screen.  Click the information icon at the bottom of the screen 	- What are the two views you can choose from? * * - How many sea level rise scenarios are there? - In what year do the scenarios begin? - What do these scenarios take into account? * * * * * - Why don't they show the low scenario?

Mapping Confidence	
Click the Mapping Confidence icon on the left side of the screen.  Click the information icon at the bottom of the screen 	- What are three unknowns of mapping future conditions? * * * - What percentage is considered high confidence?
Click on the Legend Toggle in the top right corner 	- What does blue mean? - What does orange mean?
	Click the question mark next to "Leveed Areas" in the legend to answer the questions.
	- What type of levees were assumed high enough and strong enough to protect against inundation? - When is flooding behind levees shown in the sea level rise viewer?
	Click the x in the top right corner to close the disclaimer.
Marsh Mitigation	
Click the Marsh Mitigation icon on the left side of the screen.  	- What are the three ways we can view the changes in marsh? * * *
ACCRETION is the gradual and imperceptible accumulation of land by natural causes.[17]	
Click the information icon at the bottom of the screen 	- What are the potential distributions of the wetland type based on? * *

Click on the Legend Toggle in the top right corner 	- What wetland types are represented? * * * * * - What feature is bright blue? - What does the aqua drop represent?
Vulnerability	
Click the Vulnerability icon on the left side of the screen.  Click the information icon at the bottom of the screen 	- What two pieces of data are placed on a map to determine vulnerability? * * - Where does this data come from?
Click on the Legend Toggle in the top right corner 	- What color represents high risk populations? - What color represents low risk populations?
High Tide Flooding (Nuisance Flooding)	
Click the High Tide Flooding icon on the left side of the screen.  Click the information icon at the bottom of the screen 	- Where is high tide flooding the greatest? - What impact does sea level rise have on high tide flooding?
Click on the Legend Toggle in the top right corner 	- What does the teal drop represent? - What color are the areas that experience shallow coastal flooding?

NUISANCE FLOODING SEA LEVEL RISE VIEWER

Student Name:

Go to the Sea Level Rise Viewer website: https://coast.noaa.gov/slr/

Click the high tide flooding tab.  Enter your home address in the search bar.  Click enter.	- Is there any red near your home address? - Do you live in or near a leveed area?
Enter your school address in the search bar.  Click enter.	- Is there any red near your school address? - Is your school in or near a leveed area?
Enter your nearest hospital's address in the search bar.  Click enter.	- Is there any red near your local hospital address? - Is your local hospital in or near a leveed area?
Enter your nearest police station address in the search bar.  Click enter.	- Is there any red near your local police station address? - Is your local police station in or near a leveed area?
Zoom out until you see a teal drop that represents a tide gauge  Click on the one closest to your home address.	- What year(s) have the most flood days? - What year(s) have the least flood days? Record the number of flood days for the following years. Then average the number of days for each column (hover over the bar on graph).

1983:	2016:
1984:	2017:
1985:	2018:
1986:	2019:
1987:	2020:
Average # of flood days:	Average # of flood days:

What is the difference in the two data sets?

SALTWATER INTRUSION

Procedure:

1. Person 1 secure holds a large plastic drinking straw against the bottom of a clear plastic container.
2. Person 2 slowly pours sand around the straw while person 1 is making sure no sand is getting into the straw.
3. Moisten the sand with water. This will represent the groundwater that is absorbed. Continue adding water until you can see it in the straw.
4. Drain any standing water from the container using a paper towel or washcloth but leave any that is in the pipe.
5. Create a slope at the edge of the sand farthest from the straw. This will represent the ocean area.
6. Mix several drops of blue food coloring into a separate container of water.
7. Have the students add the blue water slowly and in small increments only to the ocean end of the container.
8. Record observations below.

Student Name:	Observations
Observations before the addition of sea water	
Observations after the addition of sea water	

STORM SURGE GAME

Student Name:	
Go to https://www.disl.edu/assets/storm_surge_gmaps/client/StormApp.html Click on the intensity selector. **Choose Low intensity (Cat 2).** Drag the hurricane Icon until it's centered over **Pascagoula**. Click **Max Surge Inundation** on the visualization menu in the upper left	- If the storm hits Pascagoula, what 3 communities are going to receive the greatest amount of storm surge? * * * - What side of the storm, East or West has the greatest storm surge threat? - Use the + bottom to zoom in to Mobile, what is the storm surge depth at Austal USA (near Govt. St. and I-10)? - What is the storm surge depth at the Mobile County Sherriff Offices (near Canal St. and I-10)? - Drag the map to view Pascagoula, use the + to zoom in and locate Mississippi Power. Is there any storm surge impact there?
Click reset on the left menu bar	
Click on the intensity selector. **Choose High intensity (Cat 4).** Drag the hurricane Icon until it's centered over **Pascagoula**. Click **Max Surge Inundation** on the visualization menu in the upper left	- If the storm hits Pascagoula, what 3 communities are going to receive the greatest amount of storm surge? * * * - What side of the storm, East or West has the greatest storm surge threat? - Use the + bottom to zoom in to Mobile, what is the storm surge depth at Austal USA (near Govt. St. and I-10)? - What is the storm surge depth at the Mobile County Sherriff Offices (near Canal St. and I-10)? - Drag the map to view Pascagoula, use the + to zoom in and locate Mississippi Power. What is the storm surge at Mississippi Power?
Does the path of the storm change the threat of storm surge for different locations? Does the intensity of the storm change the storm surge threat?	

CHANGE DETECTION ANALYSIS

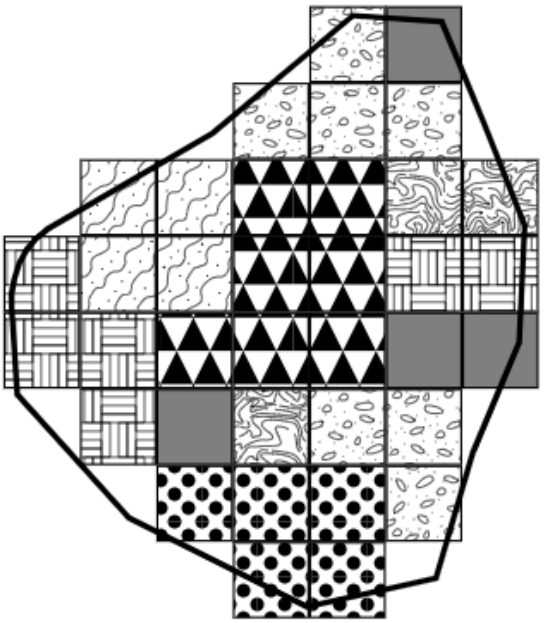
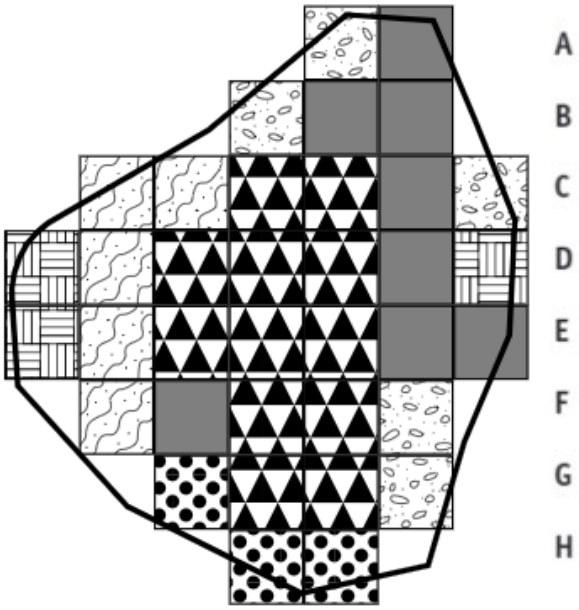
Land Use Change Sheet	
Student Name:	
Figure 1 Hokey Island Land Use, 1990 1 2 3 4 5 6 7 A B C D E F G H 	Figure 2 Hokey Island Land Use, 1995 1 2 3 4 5 6 7 A B C D E F G H 
Developed High Density (DH)	Developed High Density (DH)
Maritime Forest (MF)	Maritime Forest (MF)
Wetland (WL)	Wetland (WL)
Grassland (GS)	Grassland (GS)
Agriculture (AG)	Agriculture (AG)
Developed Low Density (DL)	Developed Low Density (DL)
Bare Land (BA)	Bare Land (BA)

TABLE 1: Land Cover

Pixels	1990 Land Cover	1995 Land Cover
A5		
A6		
B4		
B5		
B6		
C2		
C3		
C4		
C5		
C6		
C7		
D1		
D2		
D3		
D4		
D5		
D6		
D7		
E1		
E2		
E3		
E4		
E5		
E6		
E7		
F2		
F3		
F4		
F5		
F6		
G3		
G4		
G5		
G6		
H4		
H5		

TABLE 2: Land Use Change

To 1995 ⇨ / From 1990 ⇩	DH	MF	WL	GS	AG	DL	BA	Total Acres
DH								
MF								
WL								
GS								
AG								
DL								
BA								
Total Acres								

SEA LEVEL RISE IMPACT ON WETLAND ECOSYSTEMS

Student Name:				
Click the Marsh Migration icon on the left side of the screen. Click the information button. Sea Level Rise viewer must be full screen to work correctly.				
Complete the Marsh Mitigation Tutorial				
In the search bar type in one of the coastal cities: Eureka, CA Imperial Beach, CA Houma, LA High Island, TX Hudson, FL Milton, FL Beaufort, SC Stumpy Point, NC Deal Island, MD Sommers Point, NJ	- What is the nearest body of open water to your city? - With the MHHW slider all the way down what are the top 3 the most prominent land coverings? * * *			
1. Scroll out until you see the aqua teardrops. Click the one nearest to the city you selected above.	2. Click the following settings: View by scenario Mid Accretion rate (4mm/yr.)	3. Place the bubble with the arrow on the slider on Intermediate High.	4. Scroll back into the city you selected above.	5. Move the MHHW slider to the following increments and answer each set of questions.
The legend is in the top right corner to identify the land coverings.				
1ft	2ft	3ft	4ft	
What are the top 3 land coverings? * * *	What are the top 3 land coverings? * * *	What are the top 3 land coverings? * * *	What are the top 3 land coverings? * * *	

- What do you think will happen when you have moderate development (gray) next to open water (dark blue)?
- What type of wetland had the most loss?
- What type of land covering seemed to increase the most with sea level rise?
- What impact does this have on the interconnected ecosystems?

VULNERABILITY ANALYSIS USING SEA LEVEL RISE VIEWER

Student Name:

Sea Level Rise Viewer must be full screen to work correctly.

1. Click the Vulnerability icon on the left side of the screen.
2. Click the base map icon and change the map to street view.
3. Copy the address for each critical location in the search bar and press enter.

*The site will be in the center of the screen.

4. Record the information about each site.
5. Adjust the MHHW slider to 5ft.
6. Record the new information for the site.
7. Reset the slider before moving to the next location.
8. Fill out the chart completely and answer the analysis questions.

Galveston, Texas		
	Current MHHW	5ft of sea level rise
Water Treatment 5200 Old Port Industrial Rd, Galveston, TX, 77551	What is the vulnerability of the location?	Is the area flooded or near flooding?
Power Plant 585 El Dorado Blvd, Webster, TX, 77598	What is the vulnerability of the location?	Is the area flooded or near flooding?
City Hall 823 Rosenberg St, Galveston, TX, 77550	What is the vulnerability of the location?	Is the area flooded or near flooding?
Police 601 54th St, Galveston, TX, 77551	What is the vulnerability of the location?	Is the area flooded or near flooding?
Fire 823 26th St, Galveston, TX, 77550	What is the vulnerability of the location?	Is the area flooded or near flooding?
Hospital 815 Market St, Galveston, TX, 77550	What is the vulnerability of the location?	Is the area flooded or near flooding?
Friendswood, Texas		
	Current MHHW	5ft of sea level rise
Water Treatment 1306 Deepwood Dr, Friendswood, TX, 77546	What is the vulnerability of the location?	Is the area flooded or near flooding?
Power Plant 12100 Hiram Clarke Rd, Houston, TX, 77045	What is the vulnerability of the location?	Is the area flooded or near flooding?
City Hall 910 S Friendswood Dr, Friendswood, TX, 77546	What is the vulnerability of the location?	Is the area flooded or near flooding?
Police 1600 Whitaker Dr, Friendswood, TX, 77546	What is the vulnerability of the location?	Is the area flooded or near flooding?
Fire 2605 W Parkwood Ave, Friendswood, TX, 77546	What is the vulnerability of the location?	Is the area flooded or near flooding?

Hospital 500 W Medical Center Blvd, Webster, TX, 77598	What is the vulnerability of the location?	Is the area flooded or near flooding?
League City, Texas		
	Current MHHW	5ft of sea level rise
Water Treatment 703 N Wisconsin Ave, League City, TX, 77573	What is the vulnerability of the location?	Is the area flooded or near flooding?
Power Plant 36th St N, Texas City, TX, 77590	What is the vulnerability of the location?	Is the area flooded or near flooding?
City Hall 300 W Walker St, League City, TX, 77573	What is the vulnerability of the location?	Is the area flooded or near flooding?
Police 555 W Walker St, League City, TX, 77573	What is the vulnerability of the location?	Is the area flooded or near flooding?
Fire 601 2nd St, League City, TX, 77573	What is the vulnerability of the location?	Is the area flooded or near flooding?
Hospital 2530 Gulf Fwy, League City, TX 77573	What is the vulnerability of the location?	Is the area flooded or near flooding?

By the year 2080 the sea level is projected to rise 5ft.

- Which communities have critical infrastructure that is vulnerable to sea level rise in 2080?

- Which city is most vulnerable to damage from storm surge greater than 5ft (hint: look at the 5ft column above)?

- What infrastructure locations from the vulnerable city are the most at risk of a storm surge?

- Based on this analysis, what city is the **most** vulnerable to water inundation hazards?

WAFFLE HOUSE INDEX

After reading the article explain each level of the Waffle House index an answer the discussion question below.

Student Name:	
Code Green	
Code Yellow	
Code Red	
What do you think makes waffle house so resilient?	

COASTAL COMMUNITY RESILIENCE INDEX SCAVENGER HUNT

Student Name:	
What is disaster resilience?	
What is resilience?	
What is the goal of the CRI?	
What are the resilience index ratings?	
How do community leaders select a bad storm?	
How much worse is the future storm than the bad storm?	
On the critical facilities and infrastructure page, what may you need to use to find the location of the facilities?	
Name two things considered critical infrastructure?	* *
What are two things considered critical facilities?	* *
What is the time limit given for having pre-storm level of service on the transportation issues page?	
What do some communities use as transportation or evacuation routes?	

Name three types of plans, personnel, or agreements that a community can have?	* * *
Name two mitigation measures a community can put in place.	* *
What resources/ equipment might businesses have that can help after a disaster?	
What is one of the social systems communities depend on?	
If a community has a LOW rating in a category, what should they do?	
After completing the CRI, what does a community do next?	
Name one of the communities that piloted this tool.	
To whose memory is the CRI dedicated?	
What organizations helped develop this tool?	

ACKNOWLEDGMENTS

Great thanks are extended to Dr. Wei Wu for her contribution to the many phases of this project that were based on her research modeling the effects of accelerated sea level rise on coastal habitats in Mississippi.

Marine Educators Aaron Lamey, Summer Dorcik, and Ben Weldon developed and assembled materials to create the original MWEE lessons and taught them during the first grant project. We thank them for this. Particular thanks to Aaron, who conducted logistical arrangements for the increasingly efficient operation of the Stewardship Summit as it changed through this and other projects.

Many thanks to Leslie Salter who facilitated interactions with Pascagoula-Gautier School District teachers. Leslie also placed the MWEE I activities into the framework for Marine and Environmental Science classes. Finally, appreciation is extended to the master teachers, Cooper Kimbrell, Noel Lamey, and Hale Switzer. Their knowledge and willingness to implement this program added great value to the project.

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