Sturgeon in the Watershed

MDEQ's Sea Grant Education and Outreach Grant Program (RESTORE)

Photo provided by
M. Andres or M. Peterson

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- Obstacles/Advantageous Situations cards (optional)
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- Day 1, Activity 1- Sturgeon in the Watershed
- Day 1, Activity 2- Surging Sturgeon Migration
- Day 1, Activity 3- Sturgeon Habitat Survey

PROJECT SUMMARY

There's a Marine Biologist in My Classroom: A visiting educator program of The University of Southern Mississippi, Gulf Coast Research Laboratory's Marine Education Center

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This curriculum was produced through a grant, *Watershed Connections and Restoration (Restoration MWEE),* from the Gulf Coast Ecosystem Restoration Council via the Mississippi Department of Environmental Quality Sea Grant Education and Outreach Program. It is part of a larger watershed education program developed at the USM GCRL MEC through the sponsorship of several previous grants from the NOAA B-WET program, and the EPA Gulf of Mexico Program.

This curriculum addresses learning content standards, such as watershed awareness, and cultivates stewardship. It consists of lessons conducted over three days. Three lessons taught on Day One introduce content. Day Two is an educational field experience. During the grant period, the field experience took place at the MEC. A similar experience could be organized by classroom teachers unable to take their students to the MEC. Day Three is a review of content and a discussion of stewardship, including both a description of what it is and a brainstorming session during which student's list ways they can become better environmental stewards.

The content refers to watersheds of the Mississippi Coast, primarily the Pearl and Pascagoula Rivers and the Mississippi Sound. Goals are to:

- Convey watershed concepts
- Introduce a fish that lives in the watershed (Gulf Sturgeon) and how it uses the watershed
- Discuss how changes in watersheds can affect residents
- Define and give examples of habitat restoration,
- Introduce ways research can assist in restoration planning
- Cultivate stewardship

LESSON PLAN
DAY 1

Takes place at the school — 3 hours
Three separate groups of students rotate through three one-hour lessons.

Lesson 1
AN INTRODUCTION TO WATERSHEDS AND THE LIFE HISTORY OF GULF STURGEON
PowerPoint Presentation

Educational objectives:

- Students will understand all parts of watersheds are connected and changes happening in one part of the watershed affect other parts of the watershed.
- Students will be able to find and label these locations on a map: Pascagoula River Watershed, Mississippi Coastal Watershed, Lower Pearl River Watershed, Mississippi Sound, and Horn and Ship Islands.
- Students will become familiar with the life history of Gulf Sturgeon.
- Students will learn Gulf Sturgeon are native to the Gulf Coast, and migrate annually between the Pascagoula River and Mississippi Sound to use different habitats for spawning and feeding.
- Students will be able to define the terms watershed, divide, migration, anadromous, and restoration.

This PowerPoint presentation introduces major concepts of the curriculum that will be considered in later activities. Auxiliary activities include a simple watershed demonstration that uses a single piece of paper, markers and water, and consideration of sturgeon anatomy using a toy sturgeon or a preserved specimen.

Lesson 2
SURGING STURGEON MIGRATION BOARD GAME
Educational objectives:

- Students will learn processes that cause change in watersheds (pollution, floods, dredging, damming), and distinguish between human and natural agents of watershed change.
- Students will understand how changes in watersheds (human and natural) affect Gulf Sturgeon.

Students play a board game during which they navigate a series of obstacles and advantageous situations to move between their spring spawning grounds along the Pascagoula River, and their fall/winter feeding grounds in the Mississippi Sound and near the barrier islands. Through competition in this game, students learn habitat requirements of Gulf Sturgeon, and how the fish uses the watershed and estuary during its annual migration.

Lesson 3
STURGEON HABITAT SURVEY
Educational objectives:

- Students will learn tagging techniques GCRL scientists use to conduct research on Gulf Sturgeon use of the watershed.
- Students will explore maps of Gulf Sturgeon migration patterns in the coastal watershed.
- Students will create graphs of tagged fish and data receiving buoys.
- Students will discuss habitat changes and restoration.

Students explore watershed changes caused by natural processes and human activity. They learn how GCRL scientists are studying the effects of habitat changes on sturgeon migration patterns. They plot data collected from buoys and tagged fish by GCRL scientists. By mapping location data, and graphing occurrence data, students distinguish between migratory paths followed by different life stages. Students consider the effects of watershed changes and restoration activities on these paths. Then they create bar graphs representing how many times each fish encounters a specific buoy, plotting each buoy on the x-axis and the number of times each fish swam by that buoy (or detection count) on the y-axis.

DAY 2

Takes place at the MEC — 4 hours, including one hour for lunch
Three groups rotate through three one-hour stations.

FIELD TRIP TO THE MARINE EDUCATION CENTER

Educational objectives:

- Students will explore tidal creek food webs, measure water quality parameters, and record weather observations.
- Students will measure and discuss changes in water quality parameters and understand different water quality changes that affect sturgeon.
- Students will identify watershed features in the field and on maps.
- Students will discuss community resilience.

Students travel to the MEC for a morning of activities outside. These include a tour of Davis Bayou aboard the *Miss Peetsy B*, during which students pull a trawl to examine fish and invertebrates and collect water quality data from several stations. Students conduct a full water quality analysis in a classroom and compare results from different locations. During a tour of the MEC Exhibit Hall students use the Watershed Exhibit produced for this project to identify their watershed, and explore watersheds and resilience with other exhibits including the Topo-Box and the NOAA Science on a Sphere. As they walk between buildings, students pause several times to consider resilience through exploring the new MEC facility, which exemplifies building for storm resilience and environmental sustainability. They see examples of watershed features and habitats while walking along a trail and between MEC buildings.

DAY 3

Takes place at the school — 1 hour
Three groups participate separately in a one-hour session.

STURGEON STEWARDSHIP – REFLECTION AND REVIEW

Educational objectives:

- Students will review curriculum content.
- Students will synthesize information about watersheds and how sturgeon use them.
- Students will learn the term stewardship.
- Students will brainstorm actions they can take to become better stewards of their watershed, and pledge to take one action to become a better steward.

Educators help students construct a more complete understanding of the geography, habitats, residents, changes, and restoration efforts by leading a Jeopardy-type review game with the following topics: watershed, sturgeon, restoration, stewardship, and a hodge-podge category.

After the term 'stewardship' is defined, students consider ways they can change their behavior to become better stewards. Students record a stewardship pledge on a paper sturgeon "scute" to remember how they can best help their watershed. All of the scutes are placed on a large piece of paper with a sturgeon outline. This paper is hung on the wall in the students' classroom, so they can remember the lesson and their pledge.

DAY 1
LESSON 1

AN INTRODUCTION TO WATERSHEDS AND THE LIFE HISTORY OF GULF STURGEON

This presentation provides the introduction to and summarizes content of a Meaningful Watershed Educational Experience created for a MASGC RESTORE MDEQ project, Watershed Connections to Restoration." The full MWEE includes three 45-50 minute lessons in a school classroom on day one, followed on day two by a field experience at the USM, Gulf Coast Research Laboratory's Marine Education Center in Ocean Springs, MS. Day three takes place back at the school and includes a review of previous information and a discussion of watershed stewardship.

The curriculum has been used with fifth graders in the three coastal counties of Mississippi, but can be modified for other levels of development. Materials used in the full curriculum can be found at: http://gcrl.usm.edu/mec/mec_resources.php

If you would like to have this curriculum conducted with your students by our experienced marine education staff (for a fee), please review this page: http://gcrl.usm.edu/mec/marine.biologist.in.my.classroom.php

Otherwise, you may use the materials on your own.

WHAT IS A WATERSHED?

SLIDE 2

An area of land that drains into a specific body of water. The term includes surface and groundwater.

A. Vicente, U.S. Forest Service.
https://www.fs.fed.us/rm/boise/research/techtrans/projects/scienceforkids/watersheds.shtml

When rain falls on the top of a hill or mountain, where does the water go?

- To the bottom of the hill.
- Some will flow into one body of water. On the other side of the hill water will flow into another body of water.

Water that falls anywhere within the boundary connecting the high points of all the hills is the watershed for this river. And the river flows into the ocean, so this land is part of the watershed of the ocean.

It's important to learn about watersheds, because what happens in one part of the watershed affects all the other parts of the watershed as the water flows down to the ocean.

What does water do when it moves?

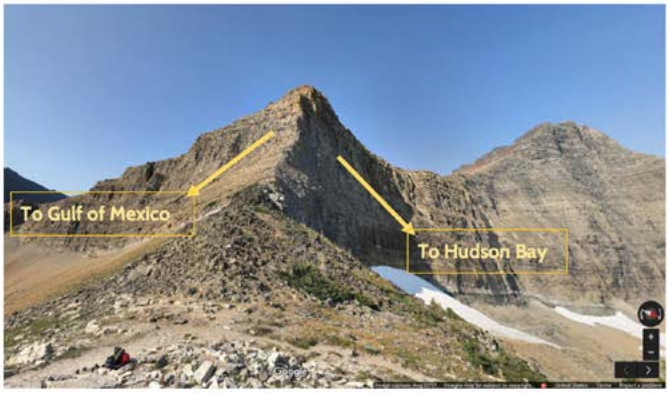
- It picks up things and carries them to the river.
- Things like what?
  - Fertilizers
  - Pesticides
  - Trash, etc.

If water flows down toward the ocean, is there anything that might move from the ocean toward the higher land of the watershed?

- People and animals
- Storms and the water they push onto land as storm surge.

WATERSHEDS

SLIDE 3



This photograph shows the Triple Divide Peak, which is located at the blue star on the map.
You are standing to the East of the blue star looking West.
The Gulf of Mexico is to your Left;
Canada and Hudson Bay are to your Right.

3

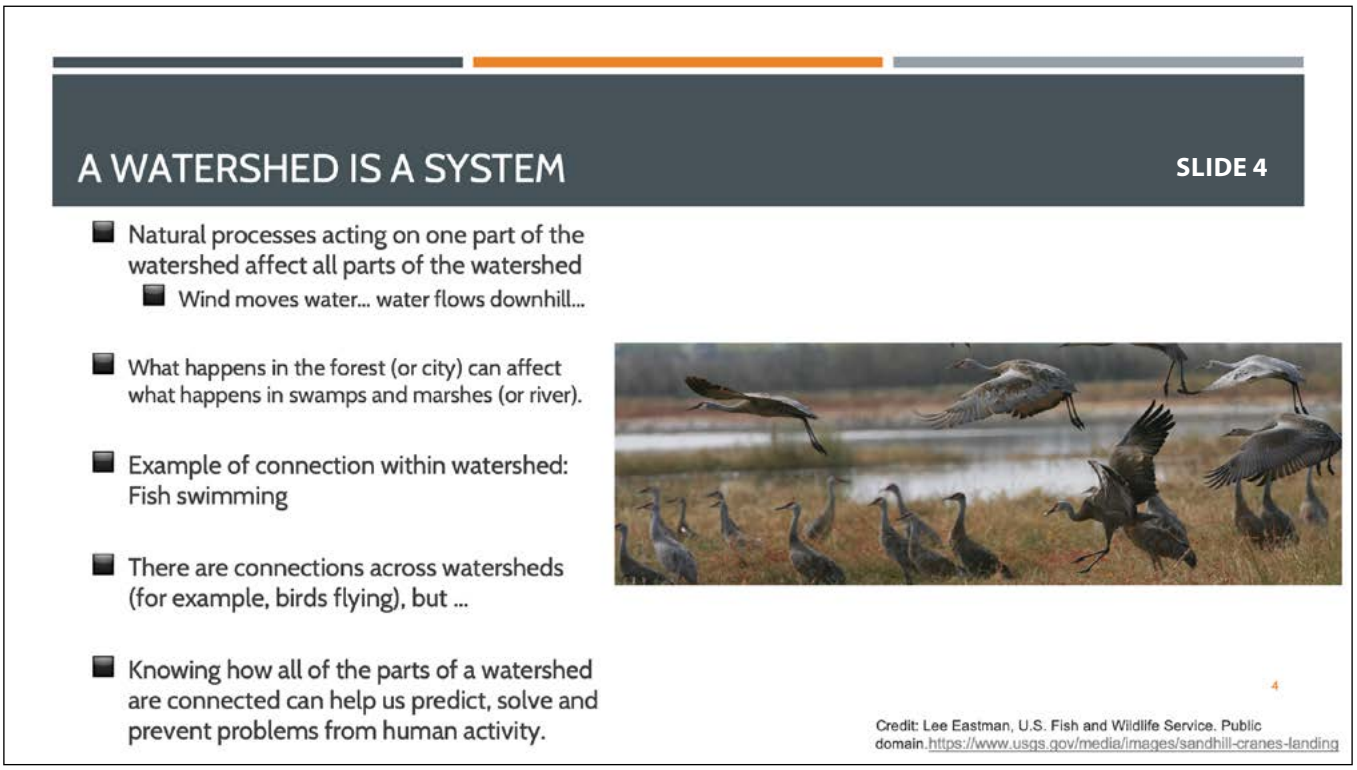
By Pfly - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=12131177

Stephane Champoussin,

A watershed starts at the highest point on the landscape, like a mountain peak or ridge. Water flows in different directions on either side of this high point. This peak or ridge is the dividing line between watersheds.

The fictional line connecting all of the high points of elevation is called the divide.

Here the solid lines are divides that separate watersheds of the Gulf of Mexico, the Atlantic, the St. Lawrence River, the Pacific, the Arctic, and Hudson Bay.



What does it mean to say a watershed is a system?

- Watershed boundaries are determined by water flow and many of the natural processes acting on parts of the watershed affect all parts of the watershed.
  - Wind moving water… water flowing downhill…
- Many animal activities stay within a watershed. Fish may swim into tributaries and for long distances along a river without ever leaving the watershed – because the water they are swimming in is geographically separate from other water bodies. There is a variety of habitats within a watershed, for example forests, ponds, swamps and marshes. These habitats are connected by water flowing downhill. They are separate geographically from marshes in the next watershed.

Here is an example of how different parts of a watershed are connected.

Fish swim into tributaries and for long distances along a river without leaving the watershed. That water is geographically separate from other water bodies.

However, here is an example of how there can be connections between separate watersheds.

- Birds fly from one watershed to the next. Food they eat is taken from the watershed where they ate it, which affects other parts of the food web. Waste they leave is added to the food web in the watershed where they left it.

HUMAN DELINEATIONS & BOUNDARIES

SLIDE 5

- What are some human boundaries?
  - Roads
  - Dams
  - Agricultural fields
  - State, county, country lines
- How can these affects watersheds?
  - Physical barriers change how water flows and what water carries. They inhibit animal travel through watershed
  - Laws changes with state lines. A deer might be protected in one place and fair game a few hundred yards away.

U.S. Secretary of Agriculture Sonny Perdue surveying agricultural damage from Hurricane Harvey, from Houston to El Campo, Texas, on September 21, 2017.
Photo via Good Free Photos

WATERSHEDS

SLIDE 6

- Divide
- River
- Estuary
- Ocean
- Runoff
- Pollution
- Dam

A. Vicente, U.S. Forest Service.
https://www.fs.fed.us/rm/boise/research/techtrans/projects/scienceforkids/watersheds.shtml

These are the parts of a watershed (which is land).

- Divide
  - Line connecting high points that outlines a watershed
  - Water flows away from the divide to separate watersheds
- River
  - The waterbody to which a watershed drains
  - We will consider
    - The Pascagoula River
    - The Pearl River
    - between those two rivers are a bunch of smaller rivers/bayous that are lumped together as the Mississippi Coastal Watershed
- Tributaries (feed into rivers)
- Estuary (Mississippi Sound)
- Ocean (Gulf of Mexico)
- Runoff - water (from precipitation or river flooding) that flows across land (not confined in a channel) from high to low points as surface water instead of being absorbed into the ground or evaporating. It flows into ditches and rivers and ultimately into the ocean.
- Pollution - substance in the environment that has harmful effects.
  - Litter, especially plastic.
  - Chemicals from a factory.
  - Runoff from yards and farms, parking spots, construction sites.
- Dam - a barrier built to hold back river water and raise its level. The water collects upstream from the dam forming a reservoir used to generate electricity or as a water supply.

WATERSHEDS

SLIDE 7

https://commons.wikimedia.org/wiki/File:Mississippi_watershed_map_1.jpg
Jon Platek [CC BY-SA 3.0 (https://creativecommons.org/licenses/by-sa/3.0)]

Here is the Mississippi River Watershed.

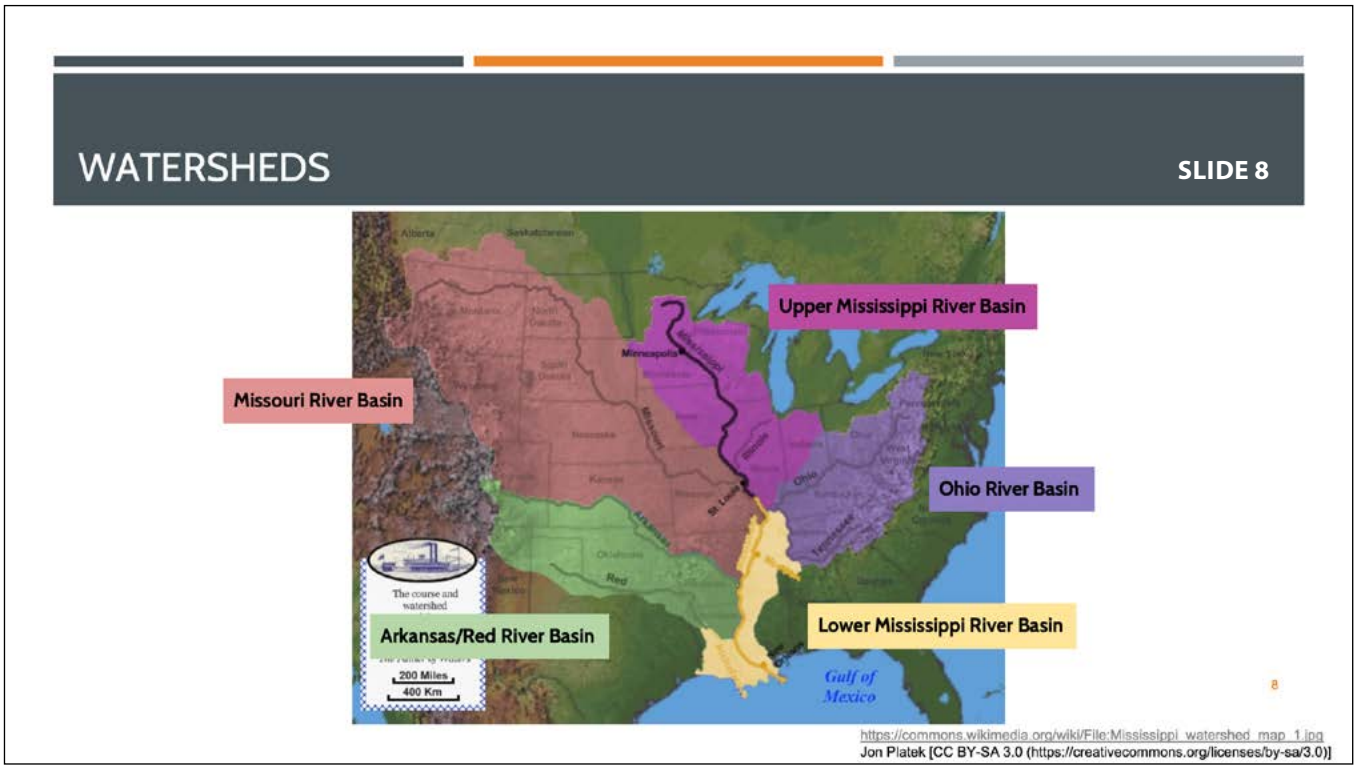
- It is a part of the Gulf of Mexico Watershed. Where does it drain to? Into the Gulf of Mexico.
- It covers about 40% of the United States and includes all or part of 32 states and 2 Canadian provinces

Why do you think they call it the Mississippi River watershed?

- All of the land within that boundary flows into the Mississippi River

What keeps water outside of this area from flowing into the Mississippi River?

- Mountains divide the land. On this side of the mountain, any water that lands as rain or melts from snow, flows to the Mississippi River. Water on the other side flows outward to the East or West.
- To the West are the Rocky Mountains. Water flowing to the East of the highest peaks flows to the Mississippi. Water flowing to the West flows to the Pacific Ocean.
- To the East are the Appalachian Mountains. Water flowing to the West of the highest peaks flows to the Mississippi. Water flowing to the East flows to the Atlantic Ocean.
- Please note: not all land that falls to the east of the Rockies and to the west of the Appalachians flows into the Mississippi River Watershed. South of the watershed boundary, the water flows to the Gulf of Mexico.



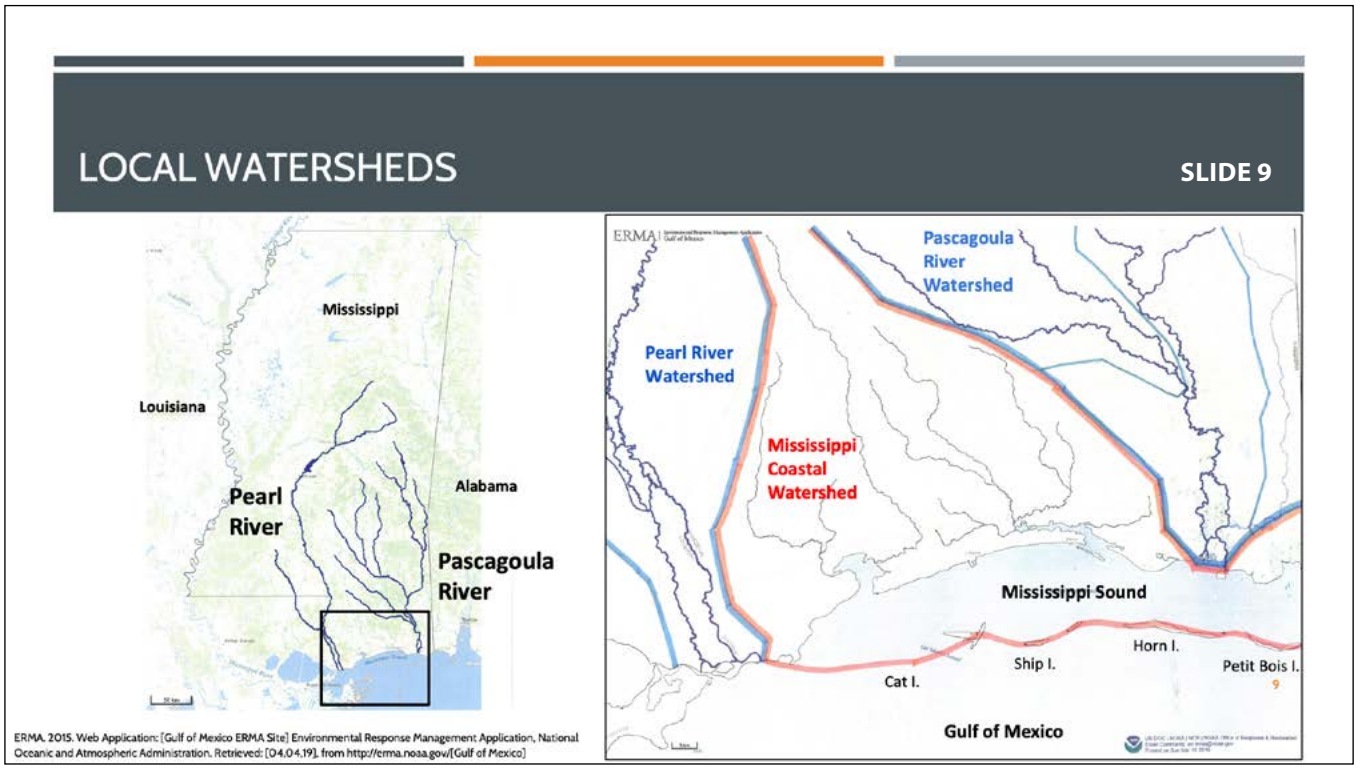
Mississippi River Watershed.

- Arkansas-White and Red River Basin
- Missouri River Basin
- Upper Mississippi River Basin
- Ohio River Basin
- Tennessee River Basin
- Lower Mississippi River Basin
-

Watersheds on the Mississippi Gulf Coast:

- - Pascagoula River
- - Wolf River
- - Pearl River
- - Black River
-

Which watershed do you live in? Is it part of a larger watershed system?



Most of the area between the Mississippi River and Mobile Bay drains to the Mississippi Sound through one of these watersheds.

Point out these features.

- Pearl River
- Pascagoula River
- The Pearl River Watershed
- The Pascagoula River Watershed - Several smaller watersheds – HUCs - see note below
- The Mississippi Coast Watershed
- Mississippi Sound
- Horn and Ship Islands
- Gulf of Mexico
- Lake Pontchartrain

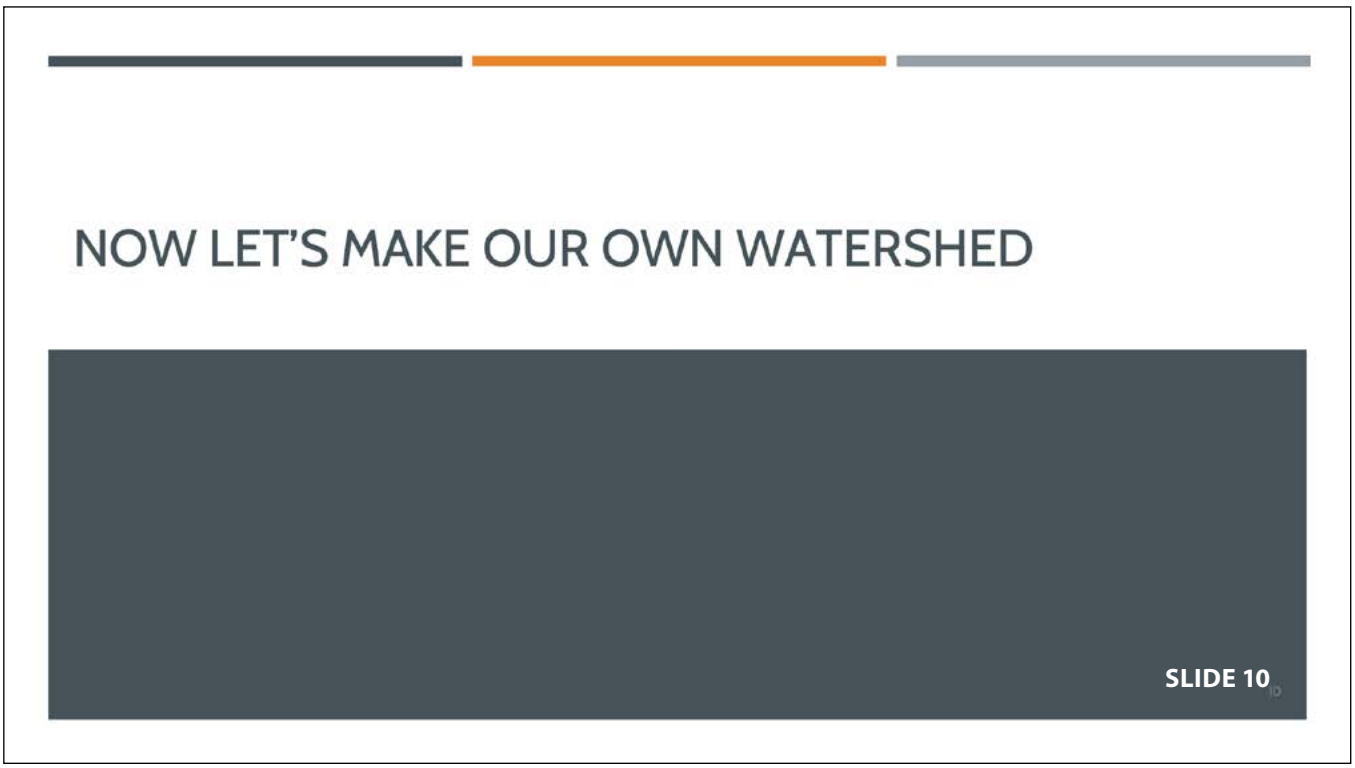
Which watershed do you live in? Do you know the name?

- Optional FYI – Hydrologic Unit Codes (HUCs) - these are designations used by the US Geological Survey for monitoring conditions in local water bodies. Big watersheds are divided into smaller watersheds that act independently of each other while contributing to the larger watershed. Maybe one small hydrologic unit is adjacent to another within the larger watershed, or maybe it is upstream. The divides between the smaller HUs are not always easily distinguished, especially from upstream to downstream.

03180004 Lower Pearl River watershed

03170009 MS Coastal watershed

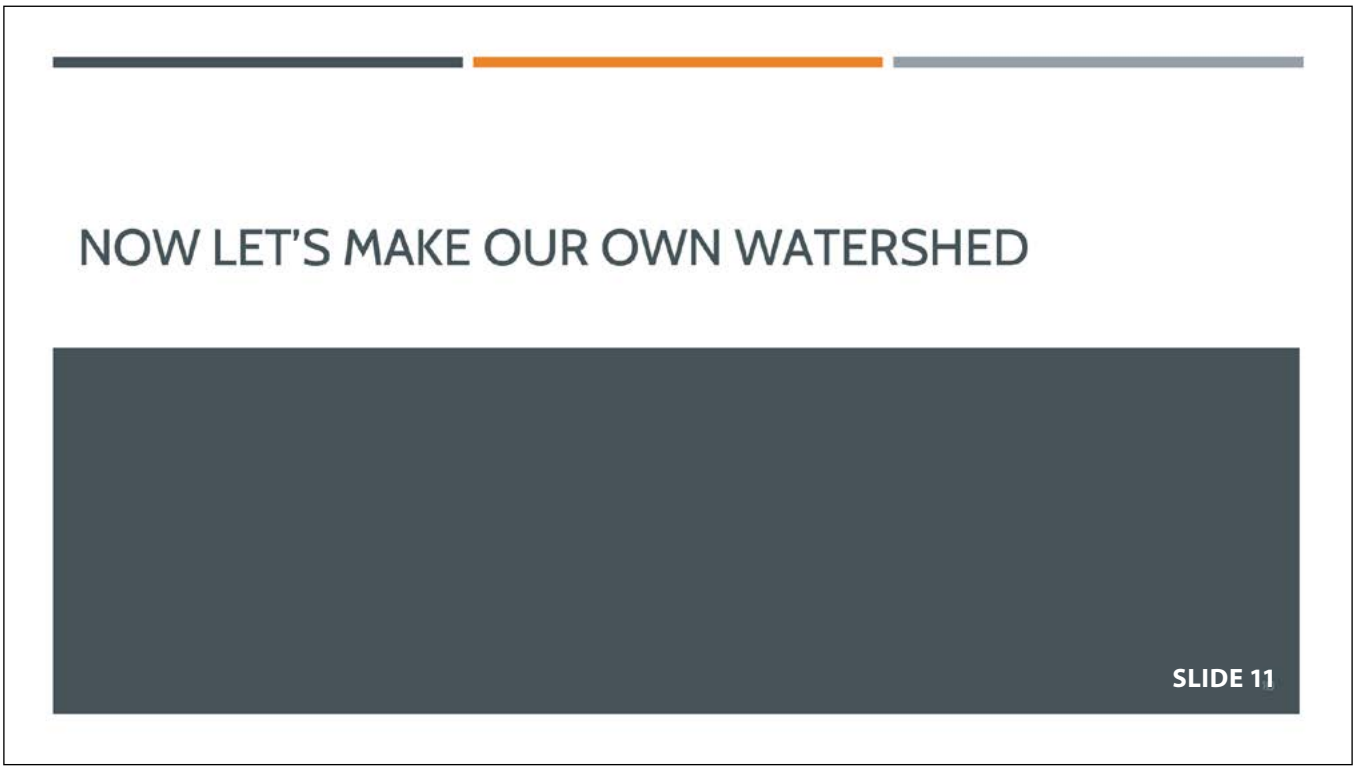
03170006 Pascagoula River watershed



Which watershed do you live in? Do you know the name?

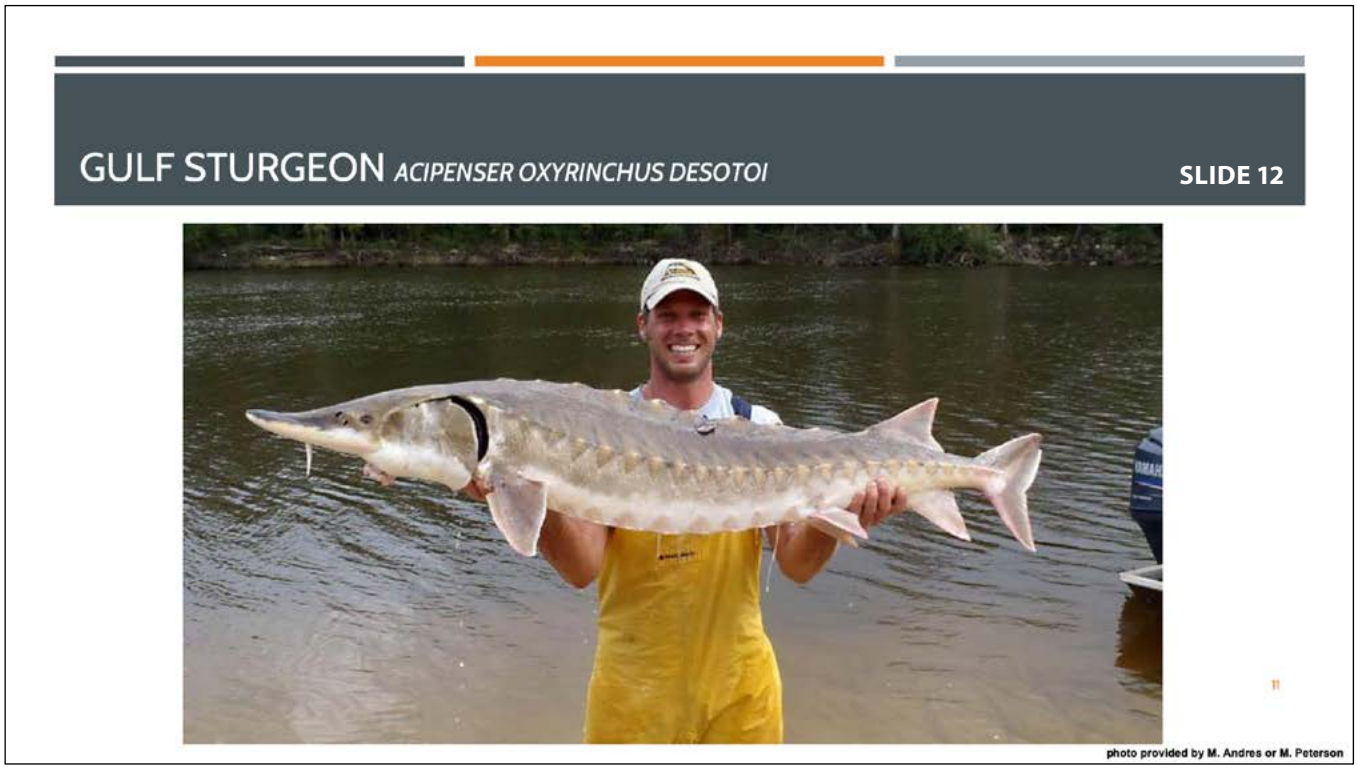
Include your watershed, and a map of your watersheds system.

Marine Education Center:
Ocean Springs, MS - Mississippi Coastal Watershed



Students work together in groups on this. A different student will complete each successive step.

1. Fold the bottom ¼ of the paper and draw the coast line and barrier islands with black
2. Color the sound blue
3. Crumple the top ¾ of the paper
4. Outline creases with blue marker
5. Draw agriculture field, industry, houses in black
6. Draw dots or x's in green around those areas.
7. Spray water at top.
    - Water will flow down the creases/tributaries
    - The color of the pens will be carried with the water showing the path pollutants take as they travel to the ocean.



The Gulf Sturgeon is an interesting resident of rivers draining into the Mississippi Sound (and across the northern Gulf Coast)

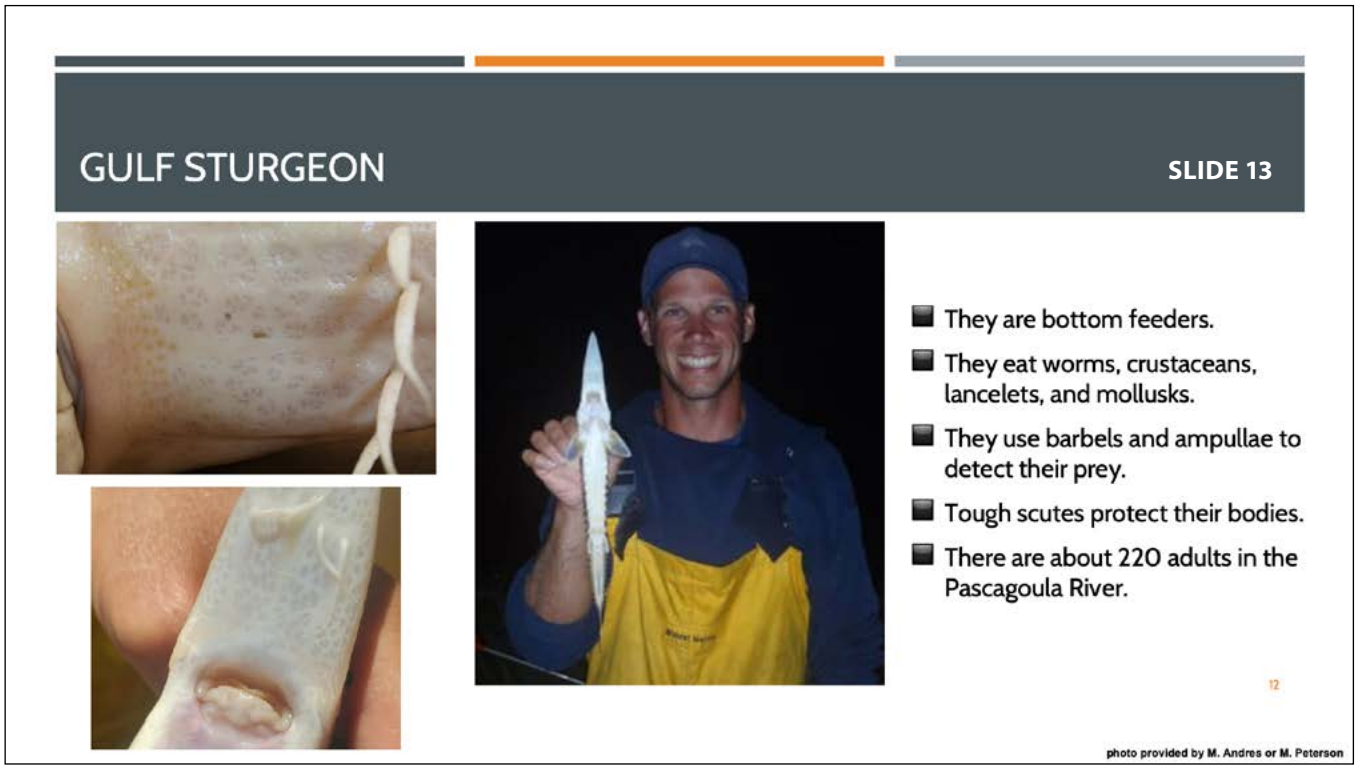
Why are we talking about Gulf Sturgeon today?

- The health of a sturgeon population can tell you a lot about the health of a watershed.

Scientists at the Gulf Coast Research Lab are studying them to understand how changes in the watershed may affect their population.

FYI:
The order first appeared in the fossil record over 200 MYA; the family about 160-145 MYA; and A. oxy diverged from *A. sturio* (another North Atlantic anadromous species) about 50 MYA.)

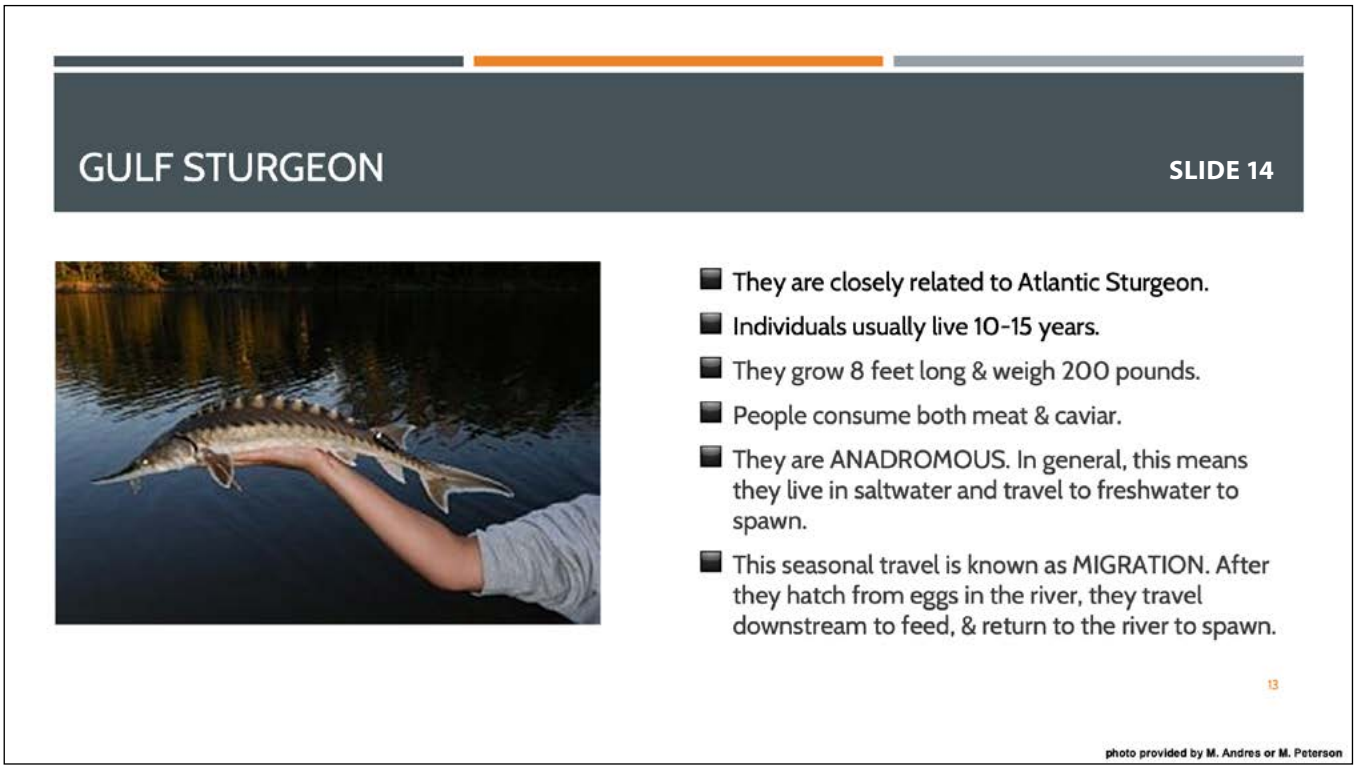
Gulf Sturgeon = *Acipenser oxyrinchus desotoi*, Atlantic Sturgeon = *Acipenser oxyrinchus*



They have scutes; tough, leathery skin with dermal denticles, and ossicles.

dermal denticles = a tough type of scale, which is common to shark and ray families, and is structurally similar to vertebrate teeth

ossicles= inner ear bones



Gulf Sturgeon are anadromous. Who can tell me what that is?

It means they live primarily in salt water and travel to freshwater to spawn.

In the case of Gulf Sturgeon they "feed" in saltwater, and travel to freshwater to spawn or "hold."

What's another type of fish that does that?

- Salmon.
- Locally, we have some anadromous species of shad as well.

GULF STURGEON – MIGRATION

SLIDE 15

- Eggs hatch & juveniles live in freshwater rivers for 9 months.
- They migrate to saltwater during Fall & Winter to feed above the soft (sandy & muddy) sediment of the Mississippi Sound.
- They return upstream in Spring to spawn on the hard bottom (gravel, pebbles) of the river where they were spawned.
- Adults spawn every few years.
- Gulf Sturgeon are unusual in that they return to their river whether or not they will spawn in a given year.
- If they are not spawning, they hold (rest) in the cool water. They do not eat in the river.

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photo provided by M. Andres or M. Peterson

Spring to spawn on the hard bottom (gravel, pebbles) of the river where they were spawned. Adults spawn every few years.

Gulf Sturgeon are unusual in that they return to their river whether or not they will spawn in a given year. If they are not spawning, they hold (rest) in the cool water. They do not eat in the river.

WHERE DOES THE GULF STURGEON LIVE?

SLIDE 16

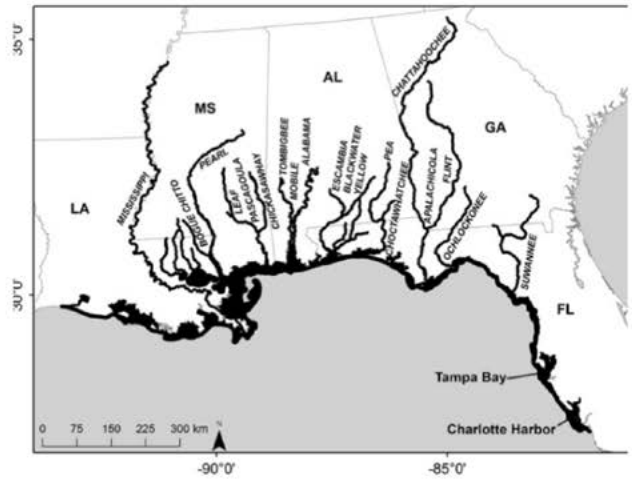

Fig. 2. Contemporary geographic range of the Gulf Sturgeon (excluding rare extralimital records from Texas and from Florida Bay). See several map figures that follow for detail of contemporary and historical distributions within individual natal rivers

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Sulak, K.J.; Parauka, F.; Slack, W. T.; Ruth, R. T.; Randall, M. T.; Luke, K.; and Price, M. E., "Status of scientific knowledge, recovery progress, and future research directions for the Gulf Sturgeon, Acipenser oxyrinchus desotoi Vladykov, 1955" (2016). USGS Staff -- Published Research. 1055. http://digitalcommons.unl.edu/usgsstaffpub/1055

This is the full geographic range of Gulf Sturgeon as we currently understand it.

TOC

GULF STURGEON

SLIDE 17

ENDANGERED THROUGHOUT RANGE (6/2019)

- Sturgeon have been harvested in the past for both meat and caviar.
- However, their status as threatened/endangered results largely from changes in their habitat.

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photo provided by M. Andres or M. Peterson

What are rules for harvest of sturgeon?

Do they differ from MS (endangered) to federal (US) waters?

That would be an example of how boundaries imposed by humans are inconsistent with natural systems boundaries like watershed divides.

GULF STURGEON

SLIDE 18

ENDANGERED THROUGHOUT RANGE (6/2019)

- **Pollution** can harm their health.
- **Dredging** can remove or bury animals they eat, make noise that scares them away, & destroy their habitat.
- **Dams** block their migration.
- **By-catch:** Fishing for others species destroys some individuals (primarily trawls & trotline).

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photo provided by M. Andres or M. Peterson

STURGEON IN MISSISSIPPI WATERSHEDS

SLIDE 19

- Both the Pearl & Pascagoula Rivers are historic spawning sites for Gulf Sturgeon.
- The Pearl River has been highly modified. Structures people have built to aid navigation have disrupted sturgeon migration.
- The Pascagoula River has experienced less human activity. It is the largest undammed river in the continental United States.

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ERMA. 2015. Web Application: [Gulf of Mexico ERMA Site] Environmental Response Management Application. National Oceanic and Atmospheric Administration. Retrieved: [04.04.19], from http://erma.noaa.gov/[Gulf of Mexico]

STURGEON IN MISSISSIPPI WATERSHEDS

SLIDE 20

Where are the sturgeon during the year?

- Spring, Summer (Spawning, Holding)
  - Hard bottom (gravel, pebbles)
  - Cool water
- Fall, Winter (Feeding)
  - Soft bottom (sandy, muddy)
- Year-round (Migrating)
  - **Unobstructed waterways**

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ERMA. 2015. Web Application: [Gulf of Mexico ERMA Site] Environmental Response Management Application. National Oceanic and Atmospheric Administration. Retrieved: [04.04.19], from http://erma.noaa.gov/[Gulf of Mexico]

WATERSHED CHANGE
CHANGING WATER FLOW PATTERNS

SLIDE 21

Natural

- Shoreline Erosion
- Storms
- River Flooding
- Forest Fires, Volcanoes, Glaciers Moving

Human Action

- Shoreline Erosion
- Dredging
- Construction: Dams, Roads, Houses, Parking Lots
- Navigation
- Timber Harvest

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USGS, https://www.usgs.gov/news/study-links-major-floods-north-america-and-europe-multi-decade-ocean-patterns

CCO Public Domain, https://www.publicdomainpictures.net/en/view-image.php?image=89500&picture=dredger

WATERSHED CHANGE
CHANGING WATER FLOW PATTERNS

SLIDE 22

Changing how water flows can make it hard for a sturgeon to migrate.

- Does that matter?
  - Can anything be done about it?
  - Should anything be done about it?
- These questions are worthy of consideration.
  - What can be done?

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Hagerty, Ryan, U.S. Fish and Wildlife Service, mailto:nctcimages@fws.gov, https://www.fws.gov/panamacity/gulfsturgeon.html

RESTORATION

SLIDE 23

We can make changes if habitats have been damaged.

- Human action to return a changed habitat to its previous condition
  - Remove a dam
  - Reshape a dredged channel
  - Reconnect a barrier island split by hurricane flooding
- Scientists study restoration to see if it:
  - Benefits different organisms
  - Changes sturgeon feeding & migration

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USGS https://soundwaves.usgs.gov/2009/03/2ShipHorn2LG.jpg

Restoration = the study of renewing a degraded, damaged, or destroyed ecosystem through active human intervention

STEWARDSHIP

SLIDE 24

What is Stewardship?

- an idea that a person is responsible for a place, a church, a community, and resource.
- the responsibility humans accept to protect natural habitats through conservation and sustainable practices. Restoration is a form of stewardship.

What can you do to be a good steward?.....

- Teach others how to be stewards
- Reduce the amount of plastic you use
- Clean up a river or park
- **What else.....?**

WHO?

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Mississippi Watershed Restoration Projects

Two examples and how they affect sturgeon

SLIDE 25

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SLIDE 26

WATERSHED CHANGE

CHANGING WATER FLOW PATTERNS

Pearl River Navigation Canal

Lower Head Dam, Pearl River

Regional Map

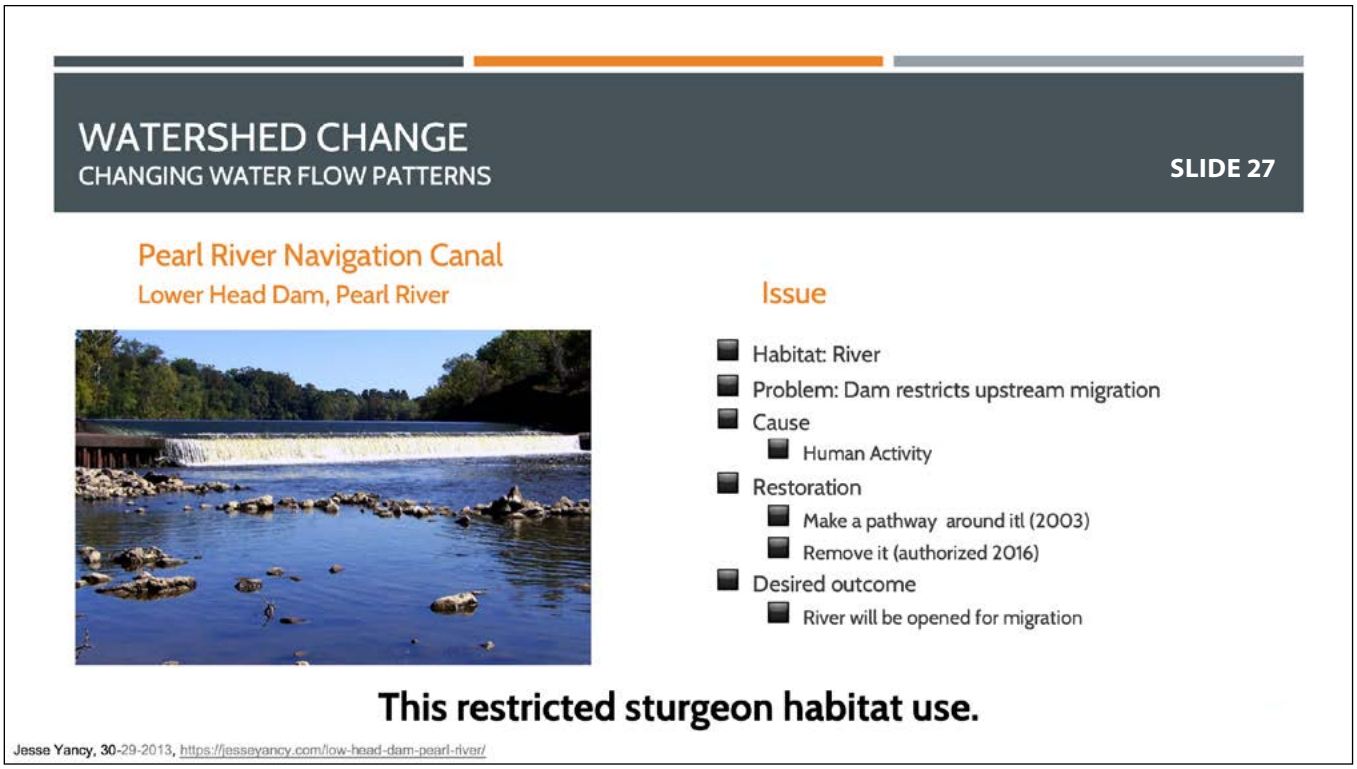
Jesse Yancy, 30-29-2013, https://jesseyancy.com/low-head-dam-pearl-river/

Dams raise the water level upstream

- Fishing
- Water supply
- Navigation
- Power generation
- Protection

Effects

- Emplaces hard barriers
- Changes flooding patterns
- Changes substrate (slope, vegetation, sediment)



The flow of the Pearl River has been impeded by sills built for navigation aids. A small restoration project took place in 2003 and the complete removal was authorized in 2016. This will allow sturgeon to access spawning grounds all the way to Jackson, MS. *https://web.archive.org/web/20050215155824/http://www.gulfmex.org/crp1003.html; https://healthygulf.org/blog/pearl-river-restoration-gives-hope; https://blog.marinedebris.noaa.gov/restoring-fish-habitat-pearl-river*

Sills

- HUMAN ACTIVITY
- A sill is a barrier placed below the surface that crosses the Pearl River. There are three between Bogalusa and the mouth of the river to ease boat traffic.
- This construction reduced the ability of sturgeon to migrate. Vessel traffic has declined greatly in recent years and people increasingly worry about the sturgeon because its population has been reduced to the point that it is threatened with extinction.
- In 2003 there was an effort to make a pathway around one of the sills. This project improved the sturgeon access to spawning grounds, but there were still two barriers. In 2016 a project was approved by Congress that decommissioned the Pearl River Navigation Canal, so the sills can be removed or the area otherwise restored.

WATERSHED CHANGE
Island Cutoff

SLIDE 28

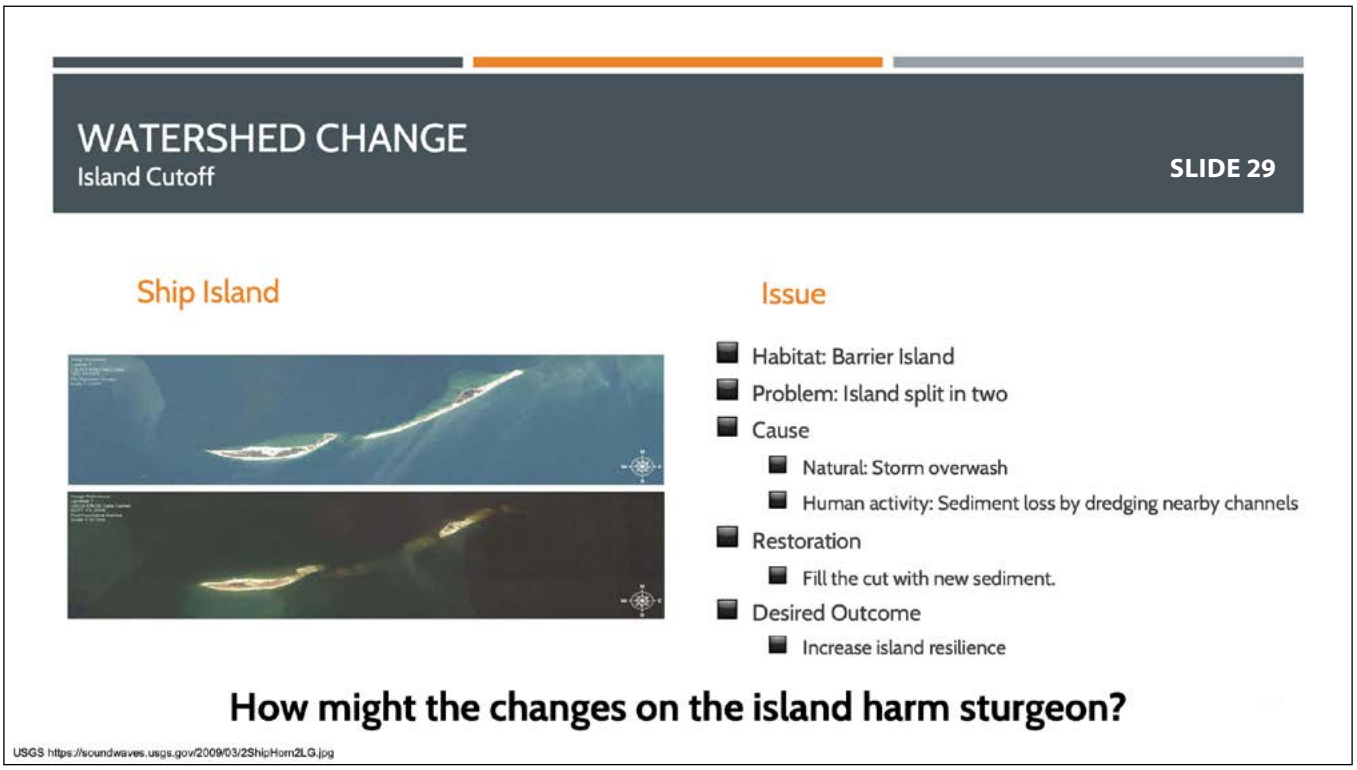
Ship Island

Regional Map

USGS https://soundwaves.usgs.gov/2009/03/2ShipHorn2LG.jpg

Ship Island – Camille Cut

- NATURAL PROCESSES – research shows that natural storms are causing erosion of all Mississippi barrier islands.



ALSO

HUMAN ACTIVITY – dredging of the Gulfport Ship Channel

- When Hurricane Camille struck the Mississippi Coast in 1969 it cut Ship Island into two pieces. Fair weather waves were moving sand to fill in the gap when Hurricane Katrina hit in 2005 and cut the island apart again. Scientists determined that the island might have been able to close the gap on its own if it had not been for the loss of sediment to dredging in Gulfport Harbor.
- The National Park Service decided to restore the area as a protection for the mainland against future storms. https://www.nps.gov/guis/learn/nature/mscip.htm; https://www.nps.gov/subjects/climatechange/upload/CAS_Case_Study_14.pdf;

Changes to the island might disrupt feeding patterns. But we don't know. That's why the scientists are collecting data.

WATERSHED CHANGE
Island Cutoff

SLIDE 30

Ship Island

USGS https://soundwaves.usgs.gov/2009/03/2ShipHorn2LG.jpg

Issue

- Habitat: Barrier Island
- Problem: Island Split in Two
- Cause:
  - Natural: Storm overwash
  - Human activity: Sediment loss by dredging nearby channels
- Restoration: Fill the cut with new sediment.
- Desired Outcome: Increased island resilience

Is there any evidence this has hurt sturgeon?

Changes to the island might disrupt feeding patterns. But we don't know. That's why the scientists are collecting data.

TAKE HOME MESSAGE 1

SLIDE 31

- Much of the rain water in Mississippi flows into the Mississippi Sound, including waters of the Pearl, Pascagoula and Coastal Watersheds.
- **Watersheds** are **systems.**
- Flowing water connects all of the habitats in the ecosystem.

A. Vicente, U.S. Forest Service.
https://www.fs.fed.us/rm/boise/research/techtrans/projects/scienceforkids/watersheds.shtml

TAKE HOME MESSAGE 2

SLIDE 32

- **Gulf Sturgeon** use different parts of the watershed during yearly **migrations**.
- **Spring spawning** occurs on hard bottom upstream in the freshwater of Pascagoula River.
- During **winter** they **feed** on soft bottoms in the Mississippi Sound, often near the barrier islands.

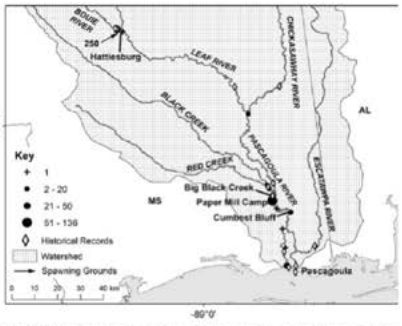


Fig. 16. Map of the Pascagoula River system, showing the known distribution of the Gulf Sturgeon, including individual historical records (pre-1993) and total scientific sampling records by location, 1977–2008. Known Bouie River spawning ground at rkm 250 is identified with an arrow

Sulak, K.J.; Parauka, F.; Slack, W. T.; Ruth, R. T.; Randall, M. T.; Luke, K.; and Price, M. E., "Status of scientific knowledge, recovery progress, and future research directions for the Gulf Sturgeon, Acipenser oxyrinchus desotoi Vladykov, 1955" (2016). USGS Staff -- Published Research. 1055. http://digitalcommons.unl.edu/usgsstaffpub/1055

TAKE HOME MESSAGE 3

SLIDE 33

- **Changes in watersheds** can cause problems for resident organisms.
  - Dams disrupted sturgeon migration in the Pearl River.
  - Ship Island was cut into two island by hurricanes.
- **Restoration** addresses such changes.
  - A new law allows for removing dams to restore habitat.
  - Filling the gap with sediment made East & West Ship into one island again.
- GCRL scientists conduct research on how restoration projects **affect** the sturgeon.

Jesse Yancy, 30-29-2013, https://jesseyancy.com/low-head-dam-pearl-river/

TOC

TAKE HOME MESSAGE 4

SLIDE 34

- When humans make changes in the watershed, we need to consider how the changes will affect resident organisms.
- We can use this information to help us decide whether to make the changes.
- We are stewards of our ecosystems

USGS https://soundwaves.usgs.gov/2009/03/2ShipHorn2LG.jpg

THE END

ACTIVITY

Let's Make Our Own Watershed

Students work together in groups on this. A different student will complete each successive step.

1. Fold the bottom ¼ of the paper and draw the coast line and barrier islands with black
2. Color the sound blue.
3. Crumple the top ¾ of the paper.
4. Outline creases with blue marker.
5. Draw agriculture field, industry, houses in black.
6. Draw dots or x's in green around those areas.
7. Spray water at top.
    - Water will flow down the creases/tributaries.
    - The color of the pens will be carried with the water showing the path pollutants take as they travel to the ocean.

DAY 1
LESSON 2

SURGING STURGEON MIGRATION BOARD GAME

Students play a board game during which they navigate a series of obstacles and advantageous situations to move between their spring spawning grounds along the Pascagoula River, and their fall/winter feeding grounds in the Mississippi Sound and near the barrier islands. Through competition in this game, students learn habitat requirements of Gulf Sturgeon, and how the fish uses the watershed and estuary during its annual migration.

Educational objectives:

Students will learn processes that cause change in watersheds (pollution, floods, dredging, damming), and distinguish between human and natural agents of watershed change.

Students will understand how changes in watersheds (human and natural) affect Gulf Sturgeon.

Introduction

A watershed is an area of land that drains to a common receiving waterbody. When rain or snow falls on a mountainside and into a valley, it flows downhill to a river. That river might meet and flow into a bigger river, which becomes an estuary when it nears the ocean and starts mixing with saltwater. All of the land the water flows over on its way to the estuary is the watershed. All parts of the watershed are connected by the water flowing through it. As the water flows downhill, it picks up sediment and other debris and carries them along. The dirt, leaves, chemicals, and sometimes trash are carried to the ocean unless they are caught along the way.

Many processes can change how the water flows and what it carries. Floods. Storms. Dams. Dredging. Pollution. The processes might have a beneficial result for some watershed residents. A big flood from the river might move debris downstream, opening a path to make it easier for your neighbor's boat to get from one point to another. However, that might block the path you were using. Building a dam might make it possible for humans to store fresh drinking water. However, this change might cause problems for a non-human watershed resident. For example, that dam might block

off the path of a fish that needs to migrate upstream. Scientists study how changes in watersheds affect animals living there.

The environment can be resilient to many of these processes. Resilience is the ability of an environment or organism to recover from a disturbance. Disturbance may be natural or man-made. Humans may try to help this process by restoring an area. Restoration is a human activity taken to renew a degraded, damaged, or destroyed ecosystem. Everyone can help with restoration by being a good steward to the environment.

A Gulf Sturgeon is a large fish that begins its life in one of the freshwater rivers that empties into the Mississippi Sound. During the fall when it gets to be about 9 months old, the sturgeon swims to salt water and spends winter feeding near the barrier islands in the Mississippi Sound. In spring it returns to the river where it was spawned. It is anadromous. That means it is hatched in freshwater, travels into salt water for part of its life, and returns to fresh water as an adult to spawn. Movement between the freshwater and saltwater parts of the estuary is called migration. Gulf Sturgeon are unusual among sturgeon in that all of them migrate annually. Some sturgeon will spawn, or lay eggs, on the hard bottom. Others will just rest in the fresh water until fall, when it is time to begin the migration again.

Scientists from USM's Gulf Coast Research Lab are currently studying Gulf Sturgeon to learn how sturgeon approach challenges in their habitat. In this game, *Surging Sturgeon,* you will play the role of a sturgeon**show game piece**. You will start at either your spawning grounds in the Pascagoula River or your feeding grounds in the Mississippi Sound. With every roll of the dice, you take another step in your migration across the board to your other seasonal home. Once there, you take care of your seasonal business (feeding or spawning) then turn around to complete the yearlong cycle back where you started.

Listen to the story of your life up to now:

In your summer habitat, you hatched from a tiny egg and grew up in the cool, deep river. After nearly a year, you grew large enough to begin your migration to salt water to find food.

As a sturgeon migrating through a river, you swim between your summer spawning grounds and winter feeding grounds. These areas provide different habitats. Both are part of the estuary where freshwater from the Pascagoula River mixes with saltwater from the Gulf of Mexico. The spawning grounds are upstream in the river. Waters here are cooler and fresher, and the riverbed has a hard surface of pebbles. You spend summers here.

The feeding grounds are downstream in the Mississippi Sound, between the mainland and the barrier islands. These waters are saltier and can get too warm for you during the summer. Nevertheless, the soft sandy and muddy bottom are home to the worms and crustaceans you eat. You spend winters here.

You migrate every year. The journey is perilous and exhausting. It is filled with challenges you meet to grow, find food, and spawn. You might encounter dams, nets, or a lack of food, *OH NO!* You must use your sensory system **point out barbels** to navigate the water bodies along your route, and meet different challenges a Gulf Sturgeon might face.

Once you arrive in salt water, you cruise between the mainland and the barrier islands finding food all winter long. You only eat during the winter, but you eat so much food that the energy lasts you the rest of the year. When the spring arrives and water begins to warm up, you return to your native river to meet other sturgeon. Some of you will spawn and produce the next generation.

You take this journey every year, encountering many challenges: finding food, navigating waterways, dealing with temperature changes, and human interactions. There are many dangers that make it difficult for a sturgeon to survive this intense journey. Good luck to each of you, have a safe trip home.

Refer to the Game Board and Cards in Appendix 1, pages 72-90.

Rules

1. Each player will start at a number (1-3) on the spawning or feeding side of the board.
2. Roll the dice to see who goes first.
3. On your turn, roll the dice and move that number of spaces.
4. Draw a card for the path you land on (if you land on a dark blue square, pick up a dark blue card). Read the card. Follow the directions to continue your journey.
5. Once you are finished, the next player takes a turn.
6. Each sturgeon migrates to the other side of the board and back. If you start at the feeding grounds, journey to your spawning area and back. If you start in the spawning area, journey to the feeding grounds and return to the RIVER WHERE YOU STARTED.
7. The first sturgeon to return to its starting site is the winner.

Questions

1. What challenges did you face as a sturgeon? What kinds of situations assisted you in reaching the end of your migration?
   Make columns labeled "obstacles" and "advantages." Students call out factors that influence migration success. As each factor is named, students put it in the appropriate column. Which of these include being a good steward of your environment?
2. What characteristics does a sturgeon need in its watershed habitat?
   a. Cool water for resting and spawning
   b. Hard bottoms for spawning
   c. Muddy/sandy bottoms for feeding on small organisms that burrow
   d. Unimpeded access around the estuary between the watershed and the ocean.
3. What are some processes that might damage the ability of the habitat to provide what the sturgeon needs?
   a. Natural…
   b. Human…
4. What can we do to repair this damage?
   Restore…
5. What do we have to watch out for when we conduct restoration?
   Unintended consequences

Stewardship possibilities

Be prepared to tell why each of these counts as stewardship

a. Teach your family and friends about being good stewards
b. Turn off the water when you brush your teeth
c. Turn off the lights when you're not in a room
d. Reduce the amount of plastic you use
e. Use reusable grocery bags

f. Recycle your bottles, cans, and paper

g. Grow a garden

h. Clean up a river bank or park

i. Read about the earth

j. Make a compost pile

DAY 1
LESSON 3

STURGEON HABITAT SURVEY

Students explore watershed changes caused by natural processes and human activity. They learn how GCRL scientists are studying the effects of habitat changes on sturgeon migration patterns. They plot data collected from buoys and tagged fish by GCRL scientists. By mapping location data, and graphing occurrence data, students distinguish between migratory paths followed by different life stages. Students consider the effects of watershed changes and restoration activities on these paths.

Then they create bar graphs representing how many times each fish encounters a specific buoy. Each buoy is on the x-axis and the number of times each fish swam by that buoy (or detection count) is on the y-axis.

Educational objectives

- Students will learn tagging techniques GCRL scientists use to conduct research on Gulf Sturgeon use of the watershed.
- Students will explore maps of Gulf Sturgeon migration patterns in the coastal watershed.
- Students will create graphs of tagged fish and data receiving buoys.
- Students will discuss habitat changes and restoration.

Introduction

A watershed is an area of land. What defines this land as a watershed and determines how far it extends is that every drop of water falling on it or flowing under it drains to the same water body. The water flow in the watershed connects all parts of the watershed, and what happens in one part of the watershed can have an impact somewhere else.

The separation between two different watersheds is based on elevation. When water falls on a place that is higher than its surroundings, you can watch which way the water falls to find the watershed boundaries. Sometimes humans conduct activities according to human boundaries. Sometimes human activities and jurisdictional boundaries do not follow these watershed boundaries. Natural processes are not stopped by human determined lines. As a result, they can be disrupted by human activities.

Watersheds change all the time. Changes can occur naturally, such as when big waves wash over a beach during a storm. These processes are eroding the shoreline of the Hancock County Marsh. Humans can also cause changes, such as building barriers across in the Pascagoula River to aid boat traffic, or dredging the east branch of the Pascagoula River. Some combination of natural and human activities caused changes.

Changes can keep happening over time and sometimes their impact increases. A big storm washing out a beach may destroy nests of shore birds like tern or pelicans. This is devastating to the animals affected and to many of us also, but it is natural for things to change. However, sometimes the changes that get started and continue to happen have much greater impacts that extend to many species and over great distances. The impacts may not show up for a long time. If that beach continues to erode, the marsh it was protecting erodes. Then the waters behind the marsh become

saltier and waves get bigger as the area becomes more exposed to the Gulf of Mexico. Waves and saltier water can damage the oysters that marshes previously protected. This would threaten the animals that live on the oyster reef, including the oysters, reducing the number of oyster available for our tables, and potentially damaging the local economy.

When humans start to notice effects, we wonder what we can do to fix these things. That is where restoration comes in.

Environmental Restoration

Habitats are resilient to many changes that occur. We use the term 'resilience'. Restoration is the process people undertake when they decide a problem caused by change in a habitat is so disruptive they have to make a change. The habitat may be able to recover through resilience, however that is not always the case. Through restoration, humans try to correct damages and return the habitat to its original condition. Science guides restoration. During decades of research, scientists have learned that sturgeon need unrestricted waterways to migrate. A restoration project might remove a dam to restore flow in a waterway. Restoration projects try to reach a balance of protecting the natural environment and making if functional for humans to use.

Here are some areas where big changes have happened. In some of these cases, restoration is being or has been considered. Point out each location on a map:

- **Pearl River**
  - The Pearl River, like the Pascagoula, provides spawning grounds for Gulf Sturgeon. The flow of the Pearl River has been impeded by sills built for navigation aids. A small restoration project took place in 2003. Complete removal of the sill was authorized in 2016. This will allow sturgeon to access spawning grounds all the way to Jackson, MS. https://web.archive.org/web/20050215155824/http://www.gulfmex.org/crp1003.html; https://healthygulf.org/blog/pearl-river-restoration-gives-hope; https://blog.marinedebris.noaa.gov/restoring-fish-habitat-pearl-river

  – Sills
    - HUMAN ACTIVITY – a sill is a barrier placed below the surface that crosses the Pearl River. There are three sills between Bogalusa and the mouth of the river to ease boat traffic.
    - This construction reduced the ability of sturgeon to migrate, which has become increasingly worrisome as the sturgeon population has declined.
    - Vessel traffic has been reduced greatly in recent years.
    - In 2003 there was an effort to make a pathway around one of the sills. This project improved the sturgeon access to spawning grounds.
    - In 2016 Congress approved a plan to decommission the Pearl River Navigation Canal, so the sills can be removed or the area otherwise restored.

  – Hancock Marsh
    - NATURAL PROCESS as described previously in the example of the marsh erosion.
    - This project does not directly affect sturgeon. However, when a restoration plan for the erosion was developed, it was scrutinized to make sure the process ***does not impede*** sturgeon or sea turtle movement in area.
    - https://www.gulfspillrestoration.noaa.gov/sites/default/files/wp-content/uploads/Living_ShoreFINAL12_1_13.pdf

- **Pascagoula River – East Branch Port**
  - HUMAN ACTIVITY
  - The Pascagoula River is the largest undammed river in the continental US.
  - It was dredged to maintain vessel passage since the 1800s when 1 million bales of cotton were transported from agricultural fields to other parts of the Gulf Coast and beyond (http://portofpascagoula.com/port-history.html).
  - Dredging removes the transitional edge of river that provides habitat for a variety of animals and plants. It results in a uniformly deep channel that may not provide the full complement of habitat animals need.
- Ship Island – Camille Cut - Ship Island is part of the Gulf Islands National Seashore
  - NATURAL PROCESSES – research shows that natural storms are causing erosion of all Mississippi barrier islands.
  - HUMAN ACTIVITY – dredging of the Gulfport Ship removes sediment that might be transported to the island.
  - When Hurricane Camille struck the Mississippi Coast in 1969, it cut Ship Island into two smaller islands. Fair weather waves were moving sand to fill in the gap when Hurricane Katrina hit in 2005 and cut the island apart again. Scientists determined that the island might have been able to close the gap on its own if it had not been for the loss of sediment to dredging in Gulfport Harbor. The National Park Service decided to restore the area as a protection for the mainland against future storms. https://www.nps.gov/guis/learn/nature/mscip.htm; https://www.nps.gov/subjects/climatechange/upload/CAS_Case_Study_14.pdf;

Sturgeon Habitat Use and Migration

Sturgeon move throughout Mississippi Gulf Coast watersheds and the Mississippi Sound estuary. Their spawning grounds are the hard bottoms covered with gravel upstream in the rivers. After the eggs hatch, juveniles live in the river, sometimes drifting downstream, for about 9 months. At that point they migrate from the river to spend the winters feeding on soft, sandy and muddy bottoms in the Mississippi Sound. Unlike many animals that migrate only when they spawn (like Atlantic Sturgeon), Gulf Sturgeon of all ages return to the river where they were spawned, whether they are spawning or not. The animals do not generally feed in the rivers during the summer.

Both the Pearl River and Pascagoula River are historic spawning sites of Gulf Sturgeon. The Pearl River has been highly modified by human structures that have disrupted their migration, while the Pascagoula River is the largest undammed river in the continental US and continues to provide habitat for sturgeon.

Sturgeon Research

GCRL scientists Dr. Mike Andres and Dr. Mark Peterson tag Gulf Sturgeon in the Pascagoula River to understand how changes in the watershed and estuaries might affect sturgeon migration. They position **acoustic buoys** at various places around Mississippi Sound to collect data on the movements of individual fish. Acoustic buoys use sound waves to detect the tag of an animal as it passes a buoy.

Once they deploy the buoys, the researchers capture, tag, and release individual fish in the Pascagoula River. They place gillnets across the river to catch the sturgeon. Gillnets are long pieces of mesh held vertical in the water with floats at the top and lead sinkers at the bottom. The nets have openings of different sizes to catch fish of different ages as they swim along the channel. When a sturgeon is brought aboard the research vessel for tagging, a blood sample is collected, and each fish is measured, weighed, and checked for parasites.

Three different tags are attached to each fish. Acoustic tags comes in two sizes. The small acoustic tag attaches to the base of the dorsal fin of a juvenile fish. The large acoustic tag is inserted on the ventral side of sub-adult and adult fish. The two other tags, T-bar tags and PIT tags (microchip) are backups to identify a fish in case the acoustic tag falls off or the battery dies. Each acoustic tag costs $330. Receivers cost $1,500.

Every time a fish with an acoustic tag swims within 500 meters of a buoy, it generates a **ping** in a **receiver** attached to the buoy. Drs. Mike and Mark place several dozen acoustic buoys at stations in Mississippi Sound to record how many times each tagged fish swims near a buoy.

The researchers catch and tag Gulf Sturgeon during the summer and fall months when sturgeon are migrating The buoys collect data during the winter months when sturgeon are feeding. Sturgeon are not caught in spring, during pupping season.

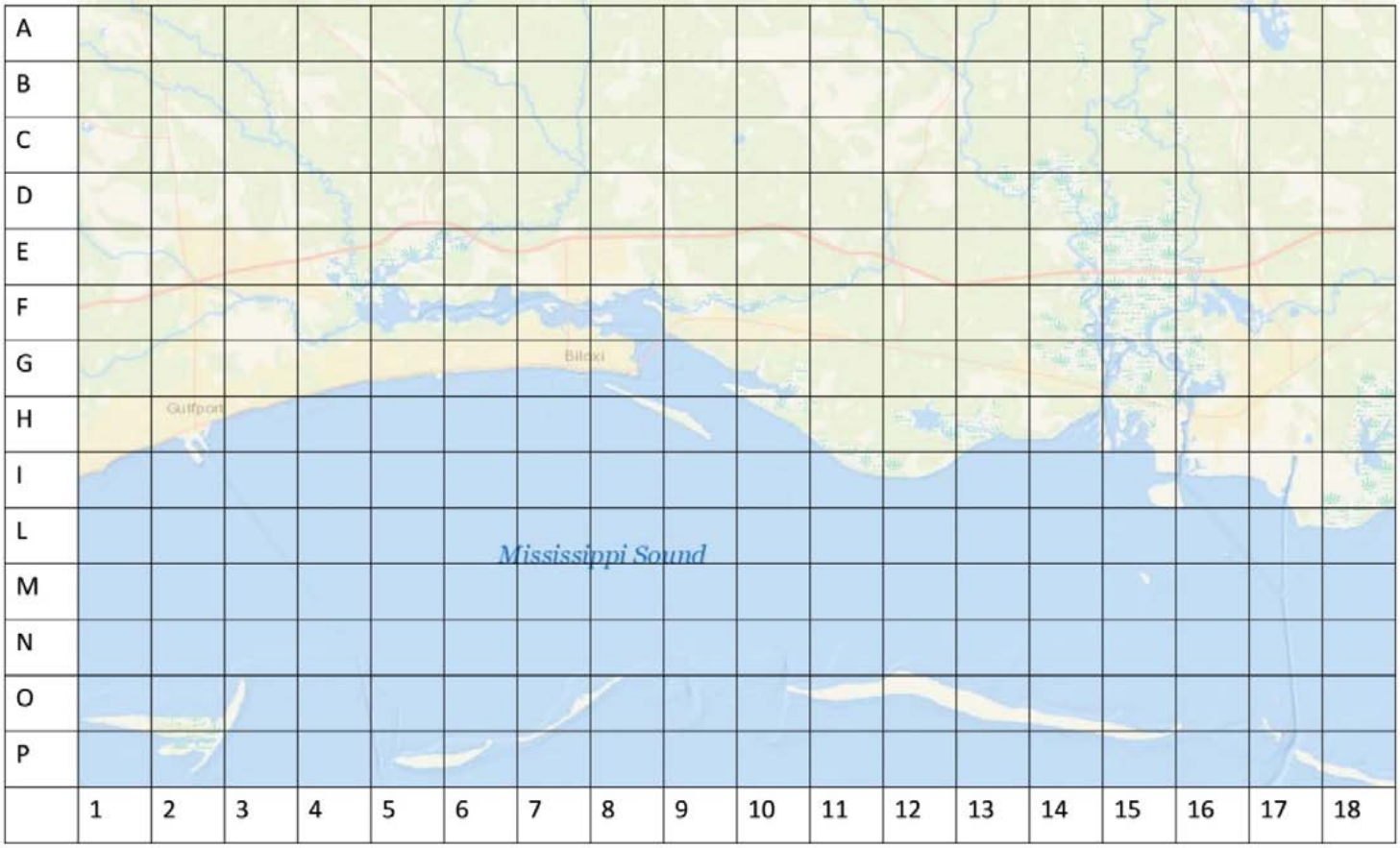
Drs. Mike and Mark collect data for three life stages, juveniles, sub-adults, and adults. The number of pings at each buoy for each fish shows researchers which habitats fish use most along their migration pathways. The researchers use this information to assess the effects of both habitat changes and restoration projects.

Activity

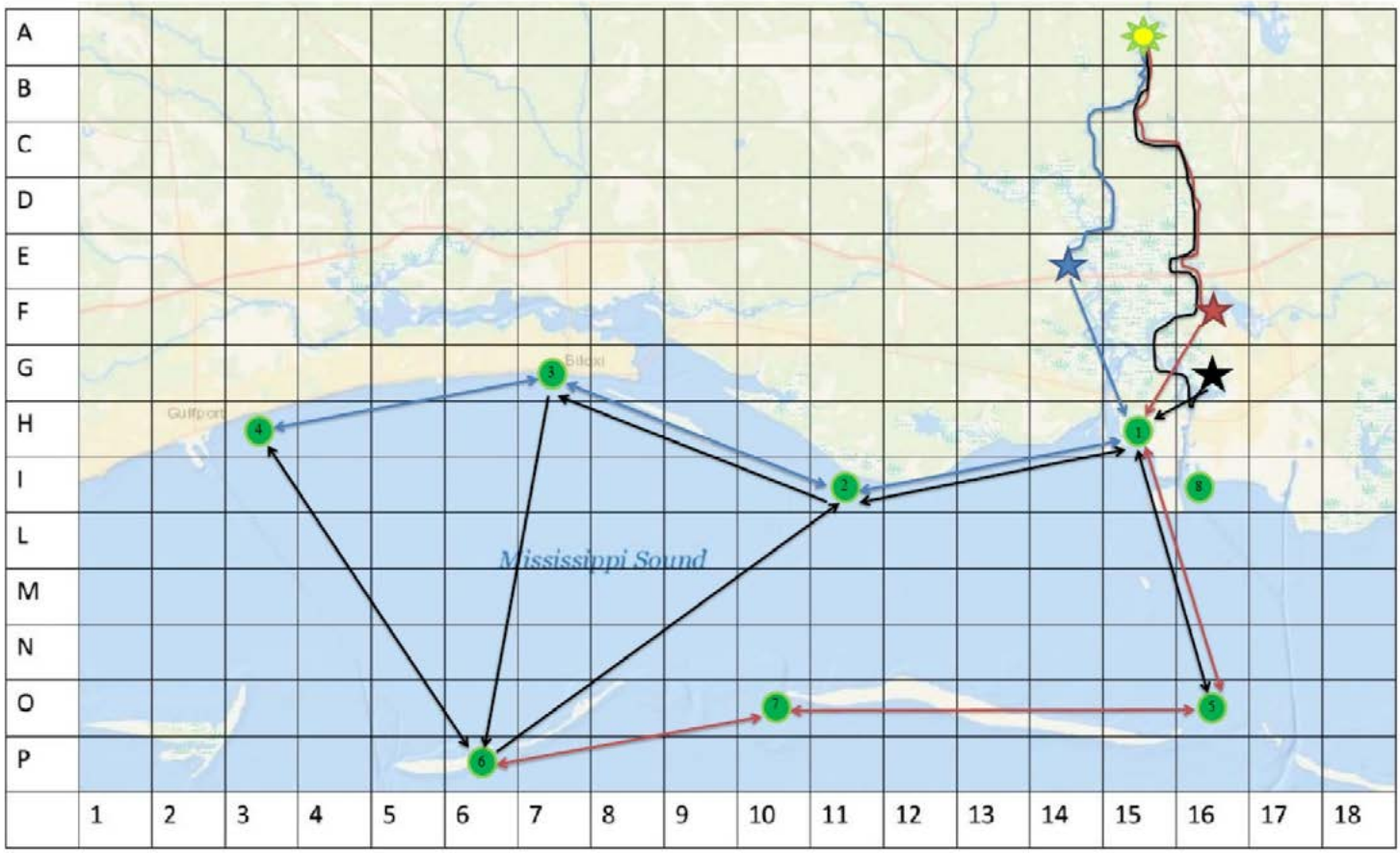
- The teacher divides the students into pairs or small teams, and provides pens and a copy of data sheets, map, and graph forms. Each team needs a clipboard if the room does not have a table or desks. Each team will be assigned one of the three fish (juvenile, sub-adult, adult).
- Each team plots the locations of the spawning site, the acoustic buoys at the feeding site, and the tagging location of their fish.
- The teacher shows where spawning site and buoys are located on the large map, making sure all teams start in accurate locations. S/he also makes sure the individual fish locations are in the correct general location (downstream, but still in the river).
- Each team writes a hypothesis describing the annual migration pathway of their assigned fish. The hypothesis should include the full migration, including spawning site, migratory route, feeding site. The prediction lies in each team's statement about which of the buoys the fish will visit in the feeding area. They should record why they selected the buoys they selected.
- The teacher calls the class to attention to check in, fish by fish, to discuss hypothesized migration pathways. No answer is wrong at this stage (if the path starts at the spawning site, visits any of the buoys in any order, and returns to the spawning site). Each team should have a hypothesis and a justification.
- Each team plots the path for their sturgeon. Students use this information to plot the annual migration pathway of their sturgeon, making sure the pathway passes near all buoys that detected any pings for that fish. The teacher moves around the room making sure teams are on task and on target.
- The teacher calls the students to attention, shows the map of the Mississippi Sound, points out the locations of spawning site and acoustic buoys, and goes through results for each fish, one by one.
  - For each fish, the teacher (or the teacher invites a team to) shows which buoys are visited by the fish, using a marker (with color specific to that life stage) to write the number of pings near each buoy (this part may be confusing – use your discretion). With guidance from the students, the teacher uses the same marker to draw the migratory pathway of that fish.
  - The teacher repeats this process three times to record data and plot a pathway for fish of each life stage.
- Each team can then create a bar graph of the number of pings (acoustic detections) from each sturgeon picked up at each buoy.
  - Observing which buoys each sturgeon used will demonstrate their habitat preferences as well as note that some buoys are not used.

- Questions for discussion
  - What is different between the different pathways?
  - What causes the differences? What might be different about the habitat needs of a fish at each life stage?
  - Which fish went to buoy 5 on the east branch of the Pascagoula River? Why did no fish visit buoy 5?
    It is possible the fish do not visit the site because of historic dredging that removed the natural habitat. I do not think there are any data to support that statement and that should definitely be made clear to the students. However, it is worth a conversation. What sort of research could be done to determine whether the dredging is responsible for the dearth of pings at that buoy?
    This conversation is speculative. STUDENTS SHOULD LEARN THAT IT IS OK NOT TO KNOW THE ANSWER TO ALL QUESTIONS: Collecting data is a good way to find answers. In addition, it usually generates more questions. Scientists take all these questions and consider what data they can collect to answer them.
  - A restoration project recently dredged sediment to connect East and West Ship Islands. What will that do to the sturgeon visits to Ship Island?
    Any answers are conjecture and should be couched as a discussion of possibilities. Consider habitat needs of the fish in their feeding grounds (sandy, muddy); what the fish actually eat (crustaceans and worms that live in the sand are likely not to be in newly placed sand immediately. I am not sure where the dredged material for this project came from – in future I think it will be from Gulfport Ship Channel, but dredged areas are likewise lacking in resident food items.
  - How would you go about determining the effect of the restoration on habitat use by sturgeon? This discussion is also conjecture. However it is a discussion going on now, because the restoration just took place. If this case, Drs. Mike and Mark received funding in the past to collect baseline data of how often sturgeon visit the restoration area. The data being collected right now are being analyzed to see if there is a difference. Answering this question is a main objective of the GCRL researchers.
  - How can we be good stewards and help our ecosystem?
  - What are goals of restoration? Return habitat to original condition and functioning. This includes improving resilience.

Sturgeon Habitat Survey



Sturgeon Habitat Survey - *Completed migration paths*



TOC

MAPPING STURGEON HABITAT SURVEY

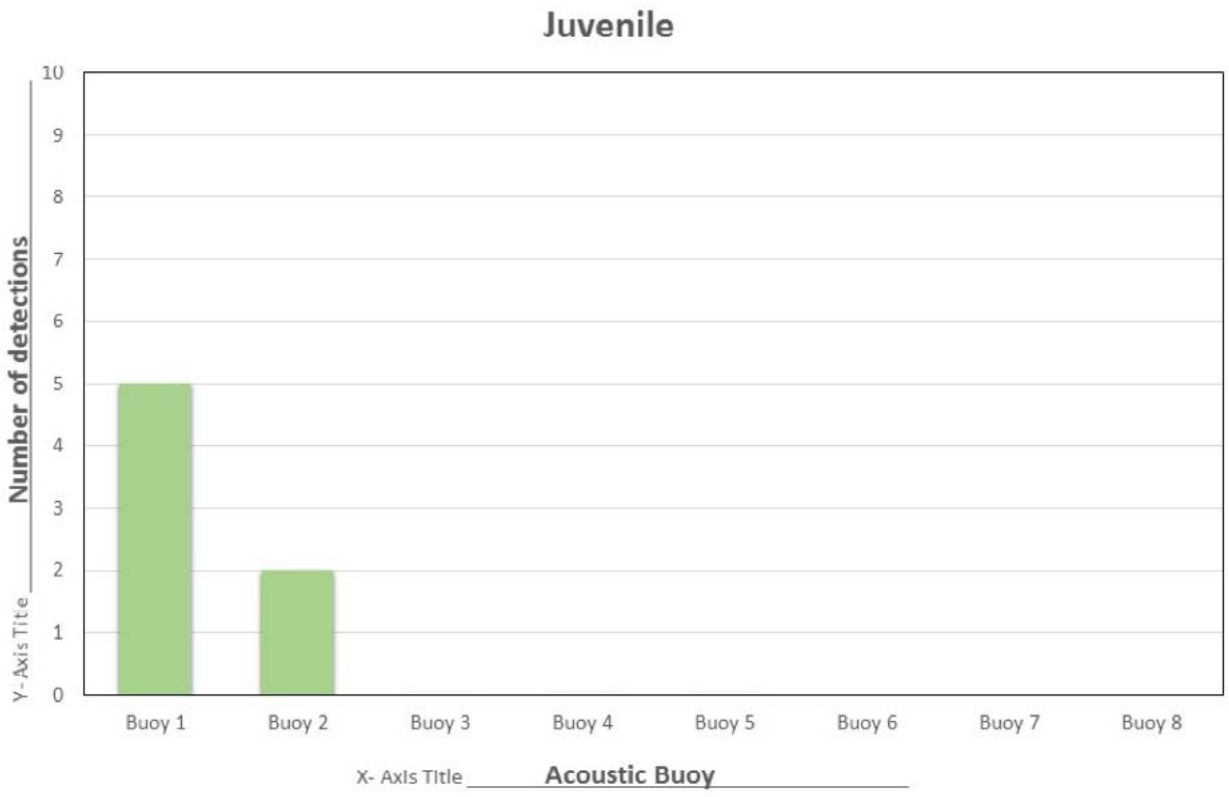
1. Plot these points on the map.
    - Feeding Site Acoustic Buoys
        - Buoy 1: (15,H)
        - Buoy 2: (11, I)
        - Buoy 3: (7, G)
        - Buoy 4: (3, H)
        - Buoy 5: (16, O)
        - Buoy 6: (6, P)
        - Buoy 7: (10,O)
        - Buoy 8: (16, I)
    - Sturgeon Tagging Locations
        - Juvenile: (14, E)
        - Subadult: (16, G)
        - Adult: (16, F)
    - Spawning Site
        - SS: (15, A)
2. Describe each buoy's location as upstream, downstream, coastal, or barrier islands.
    - Buoy 1:
    - Buoy 2:
    - Buoy 3:
    - Buoy 4:
    - Buoy 5:
    - Buoy 6:
    - Buoy 7:
    - Buoy 8:
    - Spawning Site:
3. Write a hypothesis describing the yearly migration path of your assigned fish. Your hypothesis should include the full migration, including spawning site, migratory route, feeding site. Which buoys does your sturgeon swim by? Why would the sturgeon migrate along the path you suggest?
4. Map the path of your sturgeon, as determined by GCRL scientists.
    - Juvenile: (15, H), (11, I), (7, G), (3, H), (7, G) , (11, I), (15, H)
    - Subadult: (15, H), (16, O), (15, H), (11, I), (7, G), (6, P), (3, H), (6, P), (11, I), (15, H)
    - Adult: (15, H), (16, O), (10, O), (6, P), (10, O), (16, O), (15, H)

5. Create a bar graph of each sturgeons' ping count at each buoy.

Table: Number of pings (acoustic detections) from each sturgeon picked up at each buoy

	Buoy 1	Buoy 2	Buoy 3	Buoy 4	Buoy 5	Buoy 6	Buoy 7	Buoy 8
Juvenile	5	7	4	3	0	0	0	0
Subadult	7	5	7	5	2	1	0	0
Adult	3	0	0	0	7	8	7	0

Example graph:



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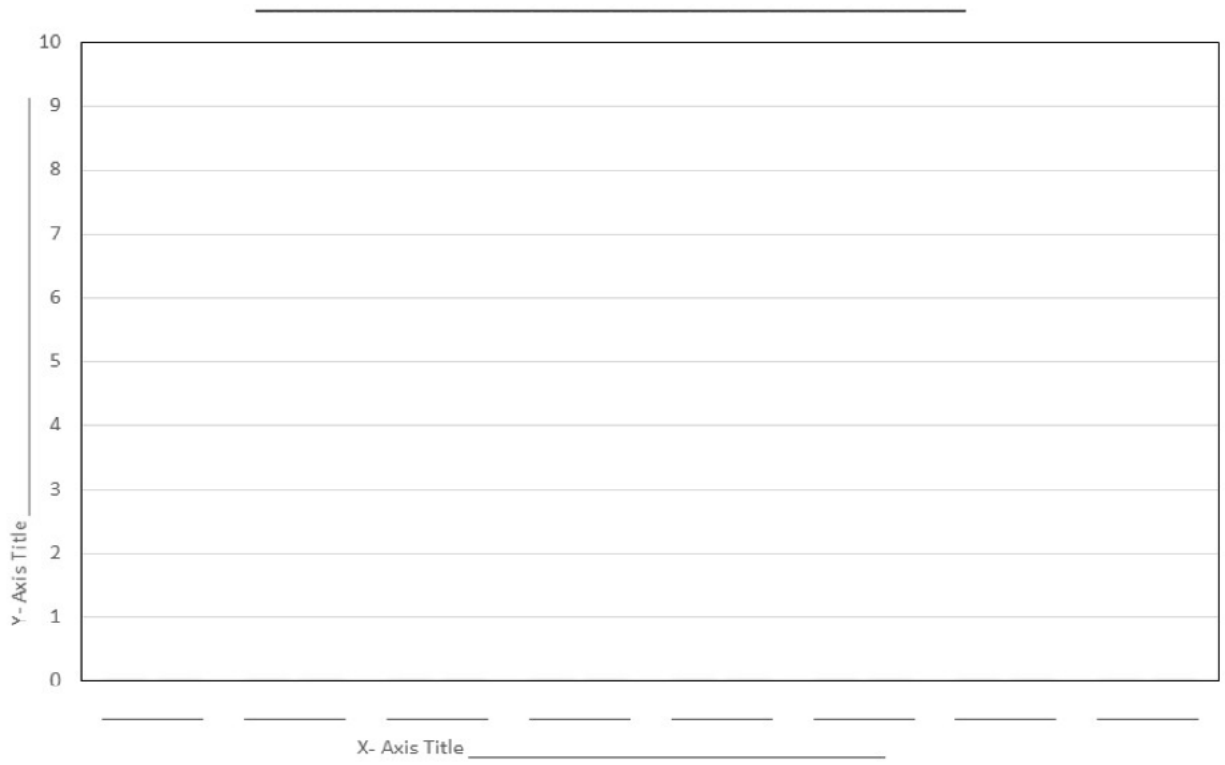
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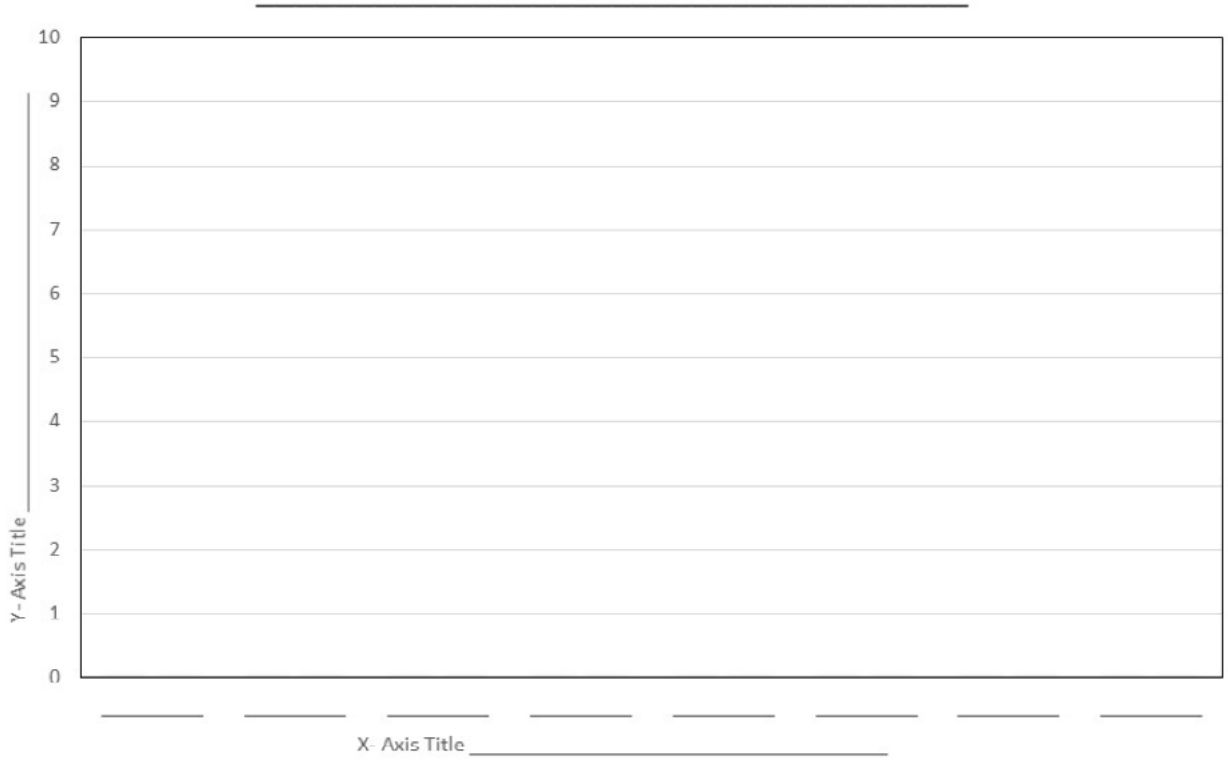
X- Axis Title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DAY 2

FIELD TRIP

Takes place at the Marine Education Center
4 hours, including one hour for lunch
Three groups rotate through three one-hour stations.

Students travel to the MEC for a morning of activities outside. These include a tour of Davis Bayou aboard the *Miss Peetsy B*, during which students pull a trawl to examine fish and invertebrates and collect water quality data from several stations. Students conduct a full water quality analysis in a classroom and compare results from different locations. During a tour of the MEC Exhibit Hall students use the Watershed Exhibit produced for this project to identify their watershed, and explore watersheds and resilience with other exhibits including the Topo-Box and the NOAA Science on a Sphere. As they walk between buildings, students pause to consider resilience through exploring the new MEC facility which exemplifies building for storm resilience and environmental sustainability. They see examples of watershed features and habitats while walking along a trail and between MEC buildings.

Educational objectives:

- Students will explore tidal creek food webs, measure water quality parameters, and record weather observations.
- Students will measure and discuss changes in water quality parameters and understand different water quality changes that affect sturgeon.
- Students will identify watershed features in the field and on maps.
- Students will discuss community resilience.

Station 1

Watershed and estuarine ecology aboard the *Miss Peetsy B*

Educational objectives:

- Students will observe a trawl and identify and record local species.
- Student will understand the dynamic water quality changes in the Mississippi Sound through collecting and testing water quality using a YSI ProDSS at two stations.
  - Observations, weather, and water parameters (top and bottom) will be collected for comparison.
- Students will understand the importance of estuaries.

Students undertake an educational cruise through Davis Bayou aboard the *Miss Peetsy B*. They observe local species, estuarine waters, and measure water quality. Students use a trawl to sample and identify local organisms. They collect data, including field observations, weather, and water quality (temperature, dissolved oxygen, salinity) from two different stations for comparison. The instructor introduces concepts including water parameters, and local environmental factors such as salt wedges, temperature gradients, and the importance of estuaries.

Educator Narration:

Collect water samples at stations 1 and 2, then pull trawl.

Students collect water quality using the PRO DSS probe at two stations. Different students take turns recording data and collecting data including: Top and bottom temperature, salinity, dissolved oxygen concentration, Secchi depth, and water depth.

Discuss what each measurement means and expected values, including the temperature and salinity gradients and salt wedge if one is present. Discuss the importance of the estuary.

Students observe trawl tow and investigate organisms collected. They count and identify organisms, recording

appropriate information on the data sheet

Discuss any possibilities for stewardship that might come up, for example, litter removal.

Station 2

MEC Exhibit Hall and Osprey Point Nature Trail

Educational objectives:

- Students will understand resilience.
- Student will observe and locate the watershed in which they live on the map.
- Students will understand that watersheds are systems.
- Students will recognize watersheds of the Gulf of Mexico, the Mississippi River and the Mississippi Gulf Coast.

Students tour the exhibit hall and nature trail discussing resilience and their watershed. Students observe and identify their watershed and the areas that make up the Gulf of Mexico watershed. Interaction at the topo-box provides a hands-on experience to let students create their own simulated watershed and adjust factors to watch how water movement can be impacted. The NOAA Science on a Sphere projection program rotates through a display of different influences on local watersheds.

The nature trail is a particularly good place to discuss resilience and stewardship. Topics include:

- What it takes to rebuild a house after a storm (as many of their parents might have done after Hurricane Katrina).
- Visible litter. A lack of litter is also noteworthy. You know people drop stuff unintentionally. Who picks it up?
- Volunteers assist in maintaining the vegetation. They are not using pesticides because we do not want to hurt anything living here.
- Bird feeders encourage resident and migratory songbirds.

Stewardship contributes to resilience.

- The most sensitive habitat on site is the bayhead wetland. We were concerned it would be damaged by children walking down the hill and across the small stream that is present most times of the year. So we invested in this amazing bridge. The bridge protects the wetland. This protection makes the wetland more resilient to other stresses, such as those that might be caused by rising sea level in the future.

Educator Narration:

Exhibit 1: Watershed exhibit

Ask them if they have seen this before (referring to the Mississippi River Watershed). Does anyone know the name of this watershed? Mississippi River Watershed. This watershed covers about 40% of the US. Why would it not have water from the eastern and western parts of the US? Because of the divides. What's a divide? The west has the Rocky Mountains and the East has the Appalachian Mountains. Remember that water flowing East of the Rockies and West of the Appalachians may flow South of the Mississippi River Watershed into the Gulf of Mexico by other pathways.

Watersheds can be very large, like this one or the Gulf of Mexico Watershed (which draws water into the Gulf from Canada, the US, and Mexico), and very small, all the way down to a neighborhood level, and you can have watersheds within watersheds within watersheds. The Mississippi River Watershed can be subdivided into the sections shown as different types of wood on this collage. Each section represents a large river system:

- Arkansas-White and Red River Basin (basin is the same as watershed)
- Missouri River Basin
- Upper Mississippi River Basin
- Ohio River Basin
- Tennessee River Basin
- Lower Mississippi River Basin

Are we in the Mississippi River Watershed? We are not. But let's look at the watersheds in our area. Remember that everything within a watershed is connected through water flow. Here is where we are in the Mississippi Coast Watersheds. We may see impacts of human activities (road-building, dam-building, timber-harvesting) and processes (storm surge and river floods) in the watersheds north (upstream) and south (downstream) of us in the Mississippi Coast Watersheds. We are located East the Mississippi River Watershed. The watersheds in our local area include the Lower Pearl, and the Pascagoula. The Mississippi Coast Watersheds includes the smallish watersheds of the Biloxi River, the Wolf River, Fort Bayou, and Davis Bayou. They are individual watersheds that flow separately to the Mississippi Sound and are considered together because they are so much smaller than the Pearl and Pascagoula River Watersheds.

As we see with the Missouri River Basin and the Mississippi River Watershed, watersheds are connected to watersheds upstream or downstream by water flowing through them, and by water flooding across the watershed within its divide (e.g., river flooding). Watersheds not connected by water flow upstream, downstream and across the watershed between divides are not generally connected hydrologically. That CAN change. For example, in the event of a major hurricane, the sub-watershed of the Wolf River might be linked to Pearl River watershed when flood water surpasses the divide between the watersheds.

Watersheds within the inset:

- Pearl River Basin
- Pascagoula River Basin
- Wolf River Basin
- Pearl River Basin
- Black River Basin

Exhibit 2: Topo Box

The Augmented Reality Topo Box can be used to explore a variety of concepts. Focus here on talk about divides and how watersheds are separated by elevation changes. First start with a large hill maybe with different peaks etc. Make it rain on top and show where the water goes. That will help demo divides and how watersheds are separated.

Get the students to recreate our coastline and use this as a way to discuss the different habitats and their the significance, barrier islands, etc.

Exhibit 3: Science on a Sphere (SOS)

- Focus attention on the following datasets. Presenter notes for each are included in the information section on the tablet, and at the following websites:
- *Watershed Dataset: Dams and Reservoirs Mississippi River 1800-2010.* https://sos.noaa.gov/datasets/dams-and-reservoirs-mississippi-river-1800-2010/
- *Sea Level Rise: 10m increments* https://sos.noaa.gov/datasets/sea-level-rise-10m-increments/

- *Sea Level Rise: Impact of 6 meter (red)*
  https://sos.noaa.gov/datasets/sea-level-rise-impact-of-6-meter-red/
- *Hurricane Season – 2005*
  https://sos.noaa.gov/datasets/hurricane-season-2005/
- *Flood Events – 2000 – 2009*
  https://sos.noaa.gov/datasets/flood-events-2000-2009/
  This one is not very exciting on the sphere, but the narrative that goes with it is appropriate to the topic

Station 3

Water Quality Classroom

Educational objectives:

- Students will understand water quality and parameters that influence local watersheds.
- Students will learn how to measure water quality parameters: temperature, salinity, dissolved oxygen, and turbidity.
- Students will discuss changes in each of the parameters and understand different water quality changes that affect Sturgeon.
- Students will learn about the different water quality parameters they measured or will measure on the bayou cruise and compare measurements.
- They will collect a water sample off the dock and measure each parameter using appropriate meters for comparison to the YSI ProDSS results.

Students collect water alongside the pier in order to investigate how abiotic factors affect the surrounding environments and organisms. As a class, students measure temperature, salinity, dissolved oxygen, and turbidity, and discuss how each compares to values they observed on the boat and why we have different methods to test these parameters. Discuss the dynamic estuarine environment, water quality fluctuations, and their impacts on organisms.

Educator Narration:

Introduction:

Parameters

1. Dissolved oxygen
    a. Concentration of dissolved oxygen (mg/L) introduced into the water by various processes, including photosynthesis, mixing by wind, and diffusion.
    a. Method: Winkler titration kit
    a. Amount of free oxygen in the water is directly proportional to the amount of sodium thiosulfate added (ml).
    a. < 2 mg/L = anoxic, <3 mg/L = hypoxic, 5-6 mg/L = sufficient oxygen (up to 8 mg/L).
    There might be some variation in what various people call hypoxia. I am most familiar with hypoxia being defined at <2 mg/L. I have heard of people using 3 mg/L as a cutoff, but not usually on the Gulf Coast.
    a. When I talk about anoxia, I just say anoxic water contains no dissolved oxygen. The USGS defines anoxic waters as containing <5mg/L.5-6mg/L is adequate, 8 mg/L is likely to happen on a clear, cold day. Higher values have been observed (~10mg/l) in cold water, clear, and windy days, when the water is supersaturated with oxygen.

2. Salinity
    a. Concentration of dissolved salts in a body of water (ppt).
    b. Method: Refractometer
    c. Drinking water – Salinity <0.5 ppt
    d. Freshwater – Salinty < 1.0 ppt
    e. Brackish water – Salinity 1.0-10.0 ppt
    f. Salt water – Salinity > 1.0 ppt
    g. Along Mississippi's coast, salinity ranges 27-33 ppt.
    h. The average salinity in the open ocean is ~35 ppt.
    i. https://water.usgs.gov/ogw/gwrp/brackishgw/brackish.html
3. Temperature
    a. The degree of hotness or coldness in a body or environment (°C).
    b. Method: Enviro-safe thermometer (uses alcohol, kerosene, or some other liquid that is not as damaging to the environment as mercury).
    c. Temperature offers information about resident organisms and where they are in migration or breeding seasons.
4. Clarity/Turbidity
    a. The amount of suspended particles in the water (cm).
    b. Method: Secchi disk (created by Angelo Secchi in 1865).
    c. Suspended particles may be phytoplankton, pollutants, or a variety of bacteria etc.
    d. Waves caused by wind can suspend sediment particles, increasing the turbidity and consequently decreasing clarity.
    e. High photosynthetic activity can create a plankton bloom that would also increase turbidity and decrease clarity.

(Adapted from Douglas, E. Water Quality Lesson)

DAY 3

STURGEON STEWARDSHIP – REFLECTION AND REVIEW

Takes place at the school

~1 hour

Three groups participate separately (one after another) in a one-hour session.

Educational objectives:

- Students will review curriculum content.
- Students will synthesize information about watersheds and how sturgeon use them.
- Students will learn the term stewardship.
- Students will brainstorm actions they can take to become better stewards of their watershed, and pledge to take one action to become a better steward.

Jeopardy Content Review

Categories (100-500 points)

1. Restoration
2. Sturgeon
3. Watershed
4. Stewardship
5. Hodge Podge

***Restoration**:*

100 – An example of a something **natural** that would cause change in a watershed

- What is rain or river flooding?
- What is movement of sand to and from a barrier island during a hurricane?

200 - Example of a watershed change caused by **humans**

- What is dredging?
- What is building a dam?
- What is pollution?

300 – A human activity that attempts to return a modified ecosystem to its original condition

- What is restoration?

400 - Sturgeon behavior that is disrupted by dams

- What is migration?

500 – The type of bottom required for sturgeon to lay eggs

- What is hard bottom, or gravel, or pebbles?

Sturgeon:

100 - Location in the water where sturgeon find and eat clams, worms, and other creatures?

- What is 'on the bottom?'

200 - A group of organisms, like the sturgeon, whose population has fallen so low that it may become extinct in an area (or globally)

- What is a threatened species?
- What is an endangered species?

300 - Seasonal pattern of movement the sturgeon take between feeding and egg-laying grounds

- What is migration?

400 – A term describing: a fish that is born in fresh water and migrates to salt water during part of its life

- What is anadromous?

500 - Hard structures that cover a sturgeon's body for protection

- What are scutes?

Watershed:

100 - The whole area of land that drains into one specific body of water

- What is a watershed?

200 - An imaginary line that connects high points of elevation around a watershed. On one side of the line, the water goes to one body of water; on the other side, the water goes to another body of water.

- What is a divide?

300 - The place in the watershed where sturgeon lay eggs and hatch

- What is the river?
- What is upstream?
- What is fresh water?

400 - Water from rain or snow that drains the land of a watershed, carrying any pollution present into the water body

- What is runoff?

500 – The largest undammed river in the lower 48 United States

- What is the Pascagoula River? (The Pascagoula carries the greatest volume. The Yellowstone is actually longer).

Stewardship:

100 – What are the characteristics of a good environmental steward?

- Acts to take care of their environment
- Feels a personal connection to natural resources
- Shares their knowledge with peers and others
- Wants to help future generations and the earth

200 – Resilience is the ability of an environment or organism to recover from a disturbance, What kinds of process can disturb and environment?

- What is a storm, flood, or other accurate natural process?
- What is channel dredging, dam building or other specific (and accurate) human activity

300 - Reducing the amount of water you use; picking up litter; or telling people how watersheds work

- What are acts of stewardship?

400 - Replacing sediment that was carried away with a similar type of sediment, in a natural slope and planted with natural vegetation is a way to restore after this activity

- What is dredging?
- What is pretty much any natural or human change to a waterside habitat? But they should give a specific example.

500 – The name of your watershed, where you can practice stewardship

- What is the Pascagoula River Watershed? OR
- What is the Pearl River Watershed? OR
- What is the Mississippi Coastal Watershed

Hodge-Podge

100 - Plastic and acoustic versions of these are attached to sturgeon to track their movements

- What are tags?

200 - Any property you can measure to tell you whether a water body will provide good habitat for a specific organism

- What is temperature?
- What is dissolved oxygen?
- What is salinity?
- What is clarity?

300 - The part of the watershed where adult sturgeon feed

- What are the barrier islands?

400 - A structure that might be built to collect river water into a lake

- What is a dam?

500 - The waterbody into which Davis Bayou and the Pascagoula, Pearl, Wolf, and Biloxi Rivers all flow

- What is the Mississippi Sound?

Final Jeopardy question

The act of taking care of, protecting, and being responsible for the environment in a way that benefits both humans and animals?

What is STEWARDSHIP

Watershed Resilience Discussion

<u>Educator Narration (suggestions):</u>

We share the Mississippi Gulf Coast habitat with a variety of animals

- Name some animals besides the sturgeon that live here.

As we go about our day, we do things that affect those other animals. Some of these actions make it difficult for the animals to survive.

- Name some activities we do that can cause problems for the animals that live here?
  - Building dams
  - Dredging
  - Polluting

What can we do to help the animals?

- Restore habitats
  - Could be by removing a dam, or filling in a dredged area - BUT we can't always do that
  - Could just be by making the remaining habitat better for them.

Restoration usually takes place in a big place, with big machines, and a whole community. **What can kids do?**

- Tell people that what happens in one part of the watershed affects what happens in the other parts of the watershed.
  THIS IS A VERY IMPORTANT ROLE THEY CAN PLAY. THEY SHOULD KNOW THAT THEY MAKE A DIFFERENCE BY TALKING TO THE ADULTS THEY KNOW.
- Ask questions about how changes that they see might affect the animals that live in the watershed.
  - Where do the animals go when the tree they live in is cut down?
  - What happens when all the trees are cut down?

Are there smaller changes you can make on your own that will make the watershed safer for the other animals that live here?

FOCUS on a few of these examples and talk about how they might specifically make a difference for the animals in their shared habitats.

- don't litter, pick up trash
- use less water
- use less plastic
- use less electricity

The Stewardfish

Discuss with class. Either:

1. Have the students decide together on one specific action the class can take. One member of the class writes down a pledge that all members of the class will follow. Each kid signs his or her name to a scute and places the scute on the fish.

OR

2. Have each individual kid decide one action they want to take on their own. Have them write their action and their name on a scute to make the pledge. Glue or tape the scutes on the fish. Hang the Stewardship on the wall as a reminder or their pledge.

EVAULATION

RESTORE Evaluation Circle one: Pretest / Posttest

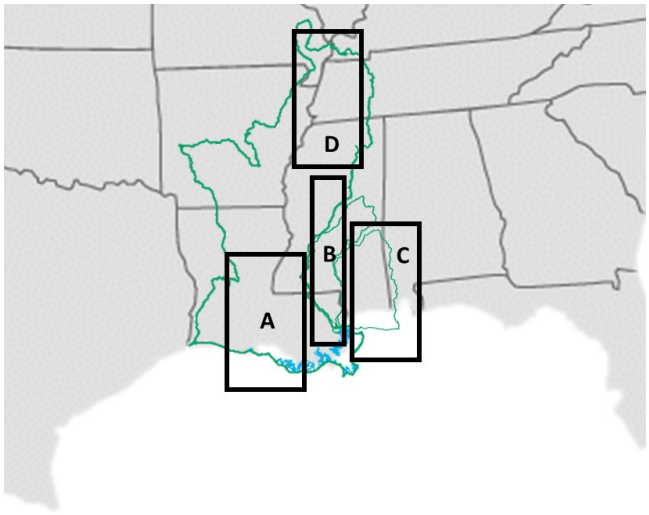
Name_____Date_____

School_____

1. What is a watershed
    a. A building at a water treatment plant
    b. An area of land that drains into a specific body of water
    c. A significant pollution event
    d. Another name for a river or stream

2. Which of these statements is FALSE? Watershed boundaries …
    a. Hardly ever change; they are nearly permanent
    b. Can sometimes be changed by the actions of people
    c. Can sometimes be changed by natural processes
    d. Are constantly altered by both human activities and natural processes

3. Which box includes the Pascagoula River Watershed?
    a. A
    b. B
    c. C
    d. D



4. Sturgeon are anadromous fish. This means they_____?
    a. Live only in fresh water
    b. Live only in salt water
    c. Are born in fresh water and migrate between salt and fresh water during their adult life
    d. Are born in salt water and migrate to freshwater in their adult life

5. Name the protective body part of the sturgeon that covers.

6. Mapping… When mapping your sturgeon where do the adults feed?
    a. At the barrier islands
    b. Up river
    c. Along the coastline
    d. In deep water out in the Gulf of Mexico

7. What is stewardship?
    a. Serving a kingdom
    b. The responsibility and management of some resource
    c. A large boat used to study rivers
    d. An act of kindness

8. What is the name of the watershed where you live?

9. What can you do to be a better watershed steward?

Choose one answer for each statement.

	Not at all	A little	A lot	Not sure
I like to learn about the Mississippi Sound	❍	❍	❍	❍
I search for information to learn about the Mississippi Sound	❍	❍	❍	❍
I want to explore the Mississippi Sound	❍	❍	❍	❍
I care about the Mississippi Sound	❍	❍	❍	❍

	No	Yes	Not sure
Make predictions or hypotheses?	❍	❍	❍
Analyze the data and figure out what it means?	❍	❍	❍
Make conclusions about what you found out?	❍	❍	❍
Present to others what you found out about your science question?	❍	❍	❍

How much do you know about each of the following things?

	Nothing	A little	A lot	Not sure
Changing water flow patterns	❍	❍	❍	❍
Key factors in deciding whether to restore a habitat	❍	❍	❍	❍
The loss of important habitats such as rivers and islands	❍	❍	❍	❍
Changes of habitats sturgeon use	❍	❍	❍	❍

Demographics

In science, do you usually get...

- ❍ Mostly A's?
- ❍ Mostly B's?
- ❍ Mostly C's?
- ❍ Mostly D's or below?
- ❍ Our school does not give this type of grades
- ❍ I prefer not to answer

Do you identify as (check all that apply):

- ❑ Hispanic or Latino
- ❑ American Indian or Alaska Native
- ❑ Asian
- ❑ Black or African American
- ❑ Native Hawaiian or other Pacific Islander
- ❑ White
- ❑ Other
- ❑ I prefer not to answer

Do you mostly speak English at home?

- ❍ No
- ❍ Yes
- ❍ I prefer not to answer

Are you ....

- ❍ Male
- ❍ Female
- ❍ I prefer not to answer

Zint, M. and A. Kraemer. 2012. NOAA B-WET Evaluation System Plan: Student Item Bank. Bay Watershed Education and Training Program, National Oceanic and Atmospheric Administration, Washington, D.C.

PRETEST/POSTTEST- Answers

RESTORE Evaluation Circle one: Pretest / Posttest

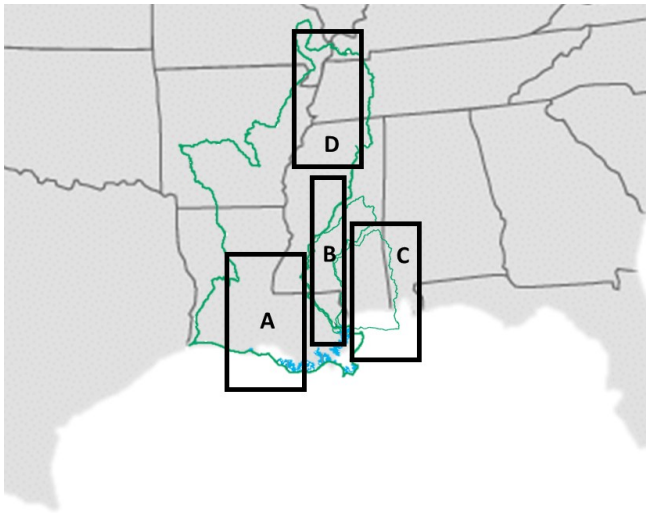
Name_____Date_____

School_____

1. What is a watershed
   a. A building at a water treatment plant
   b. An area of land that drains into a specific body of water
   c. A significant pollution event
   d. Another name for a river or stream

2. Which of these statements is FALSE? Watershed boundaries …
   a. Hardly ever change; they are nearly permanent
   b. Can sometimes be changed by the actions of people
   c. Can sometimes be changed by natural processes
   d. Are constantly altered by both human activities and natural processes

3. Which box includes the Pascagoula River Watershed?
   a. A
   b. B
   c. C
   d. D



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   d. Are born in salt water and migrate to freshwater in their adult life

5. Name the protective body part of the sturgeon that covers.

   Scutes

6. Mapping… When mapping your sturgeon where do the adults feed?
   a. **At the barrier islands**
   b. Up river
   c. Along the coastline
   d. In deep water out in the Gulf of Mexico

7. What is stewardship?
   a. Serving a kingdom
   b. **The responsibility and management of some resource**
   c. A large boat used to study rivers
   d. An act of kindness

8. What is the name of the watershed where you live?

   Pascagoula River or Mississippi Coastal Watershed

   ……Depends on your location

9. What can you do to be a better watershed steward?

   Don't litter, pick up trash
   Use less water
   Use less plastic
   Use less electricity
   Teach others about watersheds and stewardship

APPENDIX I: SUPPLEMENTARY MATERIALS

Vocabulary words:

Anadromous
Fish who are born in fresh water and migrate between salt and fresh water during their adult life.

Bycatch (in the fishing industry)
An individual fish (or other marine organism) that is caught unintentionally while catching target species and sizes of fish, shrimp, crabs, etc.

Dam
A structure built in a stream to prevent the flow of water.

Divide
An imaginary line that connects high points of elevation around a watershed. On one side of the line, the water goes to one body of water; on the other side, the water goes to another body of water.

Dredging
The removal of sediments and debris from the bottom of lakes, rivers, harbors, and other water bodies.

Estuary The body of water where a river meets the sea, characterized by brackish water. An example is the Mississippi Sound.

Gulf sturgeon- *Acipenser oxyrinchus desotoi*
A threatened species of fish. Individuals hatch from eggs spawned in fresh water and migrate between salt and fresh water during their adult lives.

Migration
A pattern of seasonal travel in which an animal moves between one location and another.

Mississippi Sound
The estuary bordered by the mainland between eastern Louisiana and western Alabama and the Mississippi barrier islands, which separate it from the Gulf of Mexico.

Ocean
The salty body of water that covers nearly three fourths of the surface of the earth.

Pollution
Pollution is a substance in the environment that has harmful effects. It includes litter (especially plastic), chemicals from a factory, and runoff from yards and farms, parking spots, and construction sites.

River
One of the types of waterbody to which a watershed can drain.

Resilience
The ability of an environment or organism to recover from a disturbance.

Restore (restoration)
The process of renewing a degraded, damaged, or destroyed ecosystem through active human intervention.

Runoff
Water (from precipitation or river flooding) that flows across land (not confined in a channel) from high to low points into ditches, rivers, and ultimately, into the ocean.

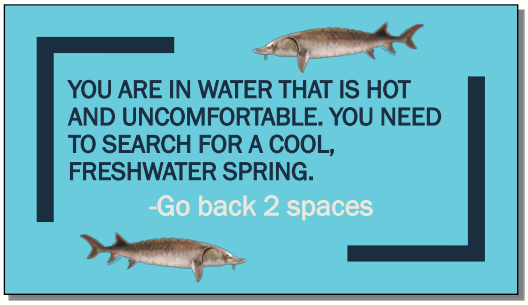
Stewardship
The act of protecting and being responsible for the environment.

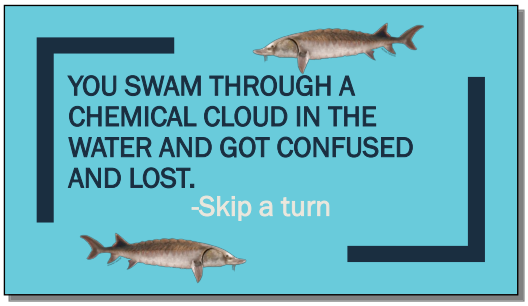
Spawning
The act or process of producing or depositing eggs.

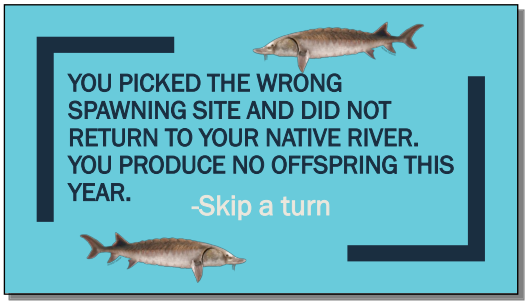
Watershed
An area of land that drains into a single body of water.

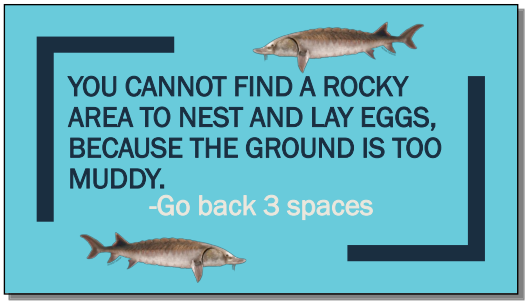
GAME BOARD – Surging Sturgeon
Migration Board Game

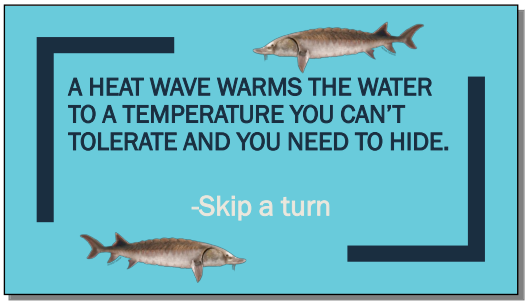
GAME CARDS – Surging Sturgeon Migration Board Game











Spawning

Spawning

Spawning

Spawning

Spawning

Spawning

A FARMER WAS COLLECTING YOUR EGGS TO EAT AS CAVIAR, BUT YOU ESCAPED AND CARRIED YOUR EGGS TO YOUR NEST.

-Go forward 1 space

HUMANS RESTORED YOUR NESTING SITE! YOUR HOME IS SAFE FOR JUVENILE STURGEON

- Go forward 3 spaces

YOU SURVIVED THE EGG STAGE AND GREW INTO AN ADULT STURGEON.

-Go forward 2 spaces

YOU NAVIGATED BACK TO THE STREAM WHERE YOU WERE SPAWNED.

- Go forward 3 spaces

1% OF YOUR EGGS SURVIVED TO ADULTHOOD.

-Go forward 3 spaces

YOU BUILT A NEST AND LAID EGGS TO START THE NEXT GENERATION.

- Go forward 4 spaces


YOUR RESILIENT NESTING AREA STAYED STRONG DURING A TROPICAL STORM.
- Move forward 3 spaces

Spawning

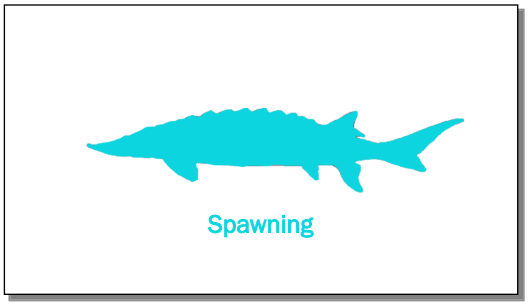
Spawning

Spawning

Spawning

Spawning

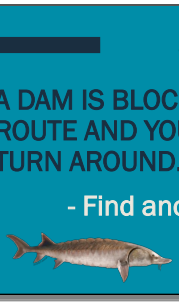
Spawning



Spawning

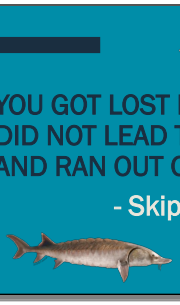
A DAM IS BLOCKING YOUR ROUTE AND YOU NEED TO TURN AROUND.

- Find another route



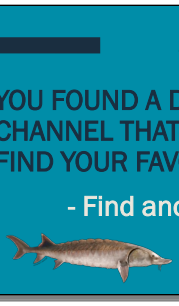
YOU GOT LOST IN RIVERS THAT DID NOT LEAD TO THE OCEAN, AND RAN OUT OF ENERGY.

- Skip a turn



YOU FOUND A DREDGED CHANNEL THAT IS TOO DEEP TO FIND YOUR FAVORITE FOOD.

- Find another route

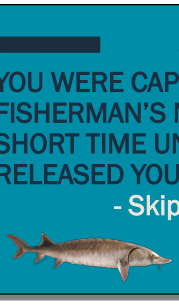


HUMAN TRASH LOOKED LIKE FOOD AND YOU HURT YOUR MOUTH TRYING TO VACUUM IT UP.

- Go back 3 spaces

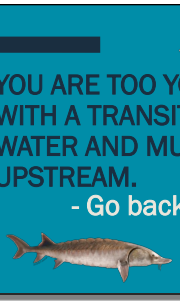
YOU WERE CAPTURED IN A FISHERMAN'S NET FOR A SHORT TIME UNTIL THEY RELEASED YOU.

- Skip a turn



YOU ARE TOO YOUNG TO DEAL WITH A TRANSITION TO SALT WATER AND MUST RETURN UPSTREAM.

- Go back 3 spaces



Migration

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Migration

A DAM IS BEING RESTORED, WHICH IS STRESSFUL, BUT YOU FOUND A WAY TO CONTINUE.

- Go forward 1 space

YOU JUMPED OUT OF THE WATER TO CLEAN OFF PARASITES AND MADE YOUR SCUTES LESS IRRITATED.

- Go forward 3 spaces

A GOOD STEWARD REMOVED AN ABANDONED FISHING NET FROM THE RIVER.

- Go forward 2 spaces

YOU SUCCESSFULLY SWAM FROM FRESH TO SALTWATER.

- Go forward 3 spaces

YOU WERE CAUGHT, MEASURED, TAGGED, AND RELEASED UNHARMED BY RESEARCH SCIENTISTS.

- Go forward 2 spaces

DATA YOU PROVIDED TO SCIENTISTS HELP YOUR POPULATION.

- Go forward 4 spaces


A GOOD ENVIRONMENTAL STEWARD PICKED UP TRASH THAT WAS BLOCKING YOUR PATH.
- Go forward 4 spaces

Migration

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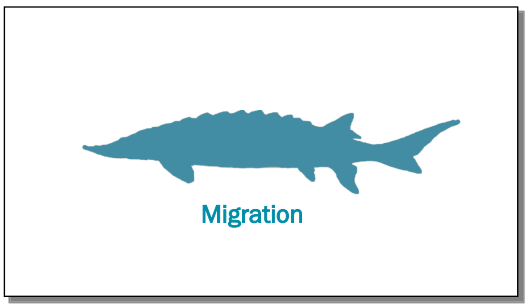

Migration

ROUGH SAND ON THE OCEAN FLOOR RUBS AND INJURES YOUR SCUTES.

- Go back 2 spaces

HUMANS RESTORING THE BARRIER ISLANDS TEMPORARILY BLOCKED YOUR ROUTE. YOU MUST SEARCH FOR A NEW PATH TO YOUR FEEDING AREA.

-Find another path or turn around

A HURRICANE HITS THE BARRIER ISLANDS AND DISRUPTS YOUR FEEDING AREA, MAKING IT DIFFICULT FOR YOU TO FIND FOOD.

- Go back 3 spaces

YOUR TAG FALLS OFF AND YOUR MIGRATION CANNOT BE RECORDED BY SCIENTISTS.

- Go back 3 spaces

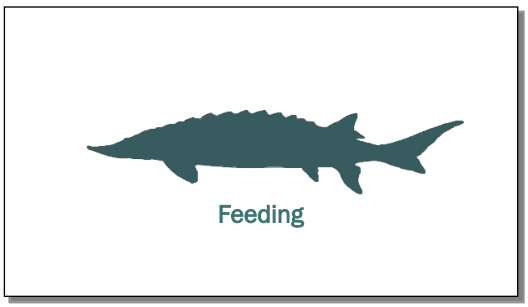
A BOAT PASSES BY AND THE PROPELLER HITS YOU.

- Go back 4 spaces

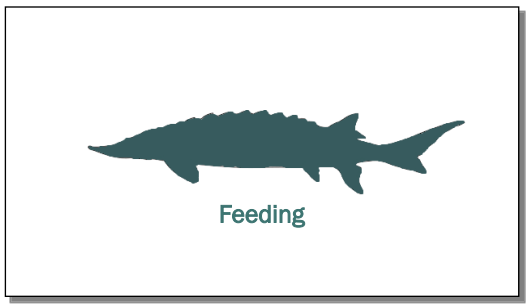
A WARM SPELL INCREASES PLANKTON GROWTH, ULTIMATELY USING ALL THE OXYGEN IN THE WATER. YOU NEED TO REST IN AN AREA WITH MORE OXYGEN.

- Skip a turn

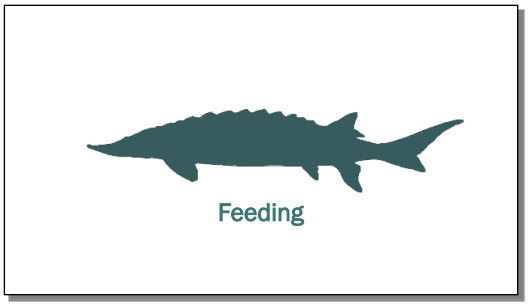

THE LOCAL FISHING PIER WAS NOT RESILIENT AND ROTTED IN A FLOOD. FALLEN WOOD IS BLOCKING YOUR PATH.
- Find another route



Feeding



Feeding



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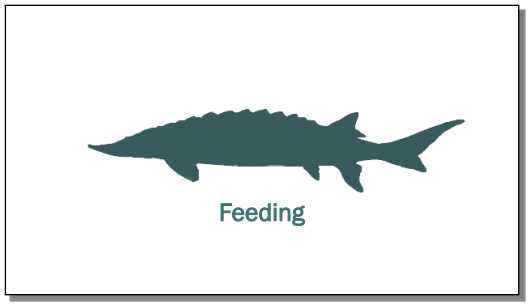

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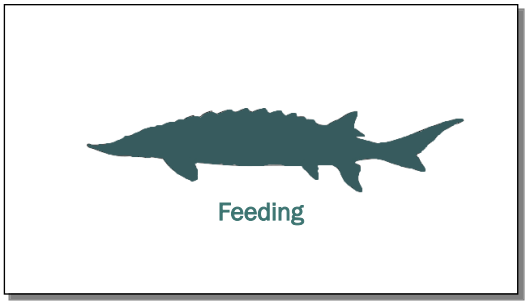

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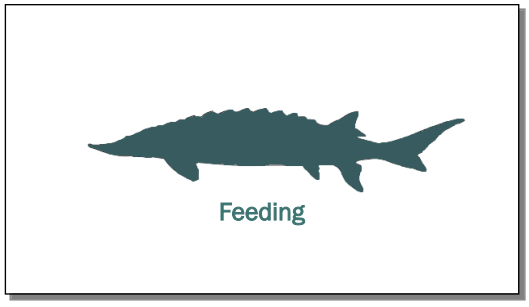

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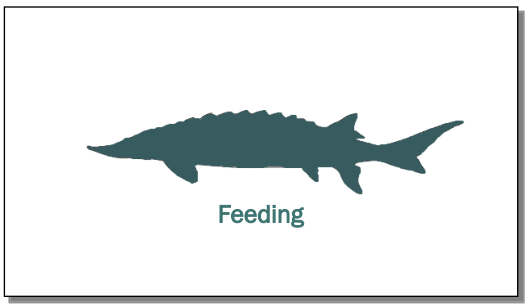


Feeding

YOU USED YOUR FOUR BARBELS TO FIND WORMS TO EAT.

- Go forward 3 spaces

YOU HAVE LIVED A LONG AND SUCCESSFUL LIFE OF OVER 20 YEARS.

- Go forward 4 spaces

USING YOUR TUBULAR VACUUM MOUTH YOU FOUND AND SUCKED UP SOME CRABS.

- Go forward 2 spaces

IT TOOK YOU A LONG TIME, BUT YOU'VE GROWN TO 10 FEET LONG.

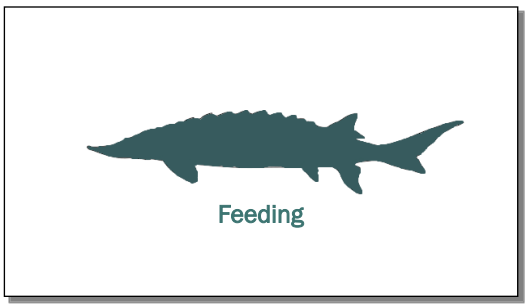
- Go forward 3 spaces

YOU WERE ABLE TO FIND A PARTNER TO SUCCESSFULLY PRODUCE NEW YOUNG STURGEON.

- Go forward 3 spaces

WHILE SWIMMING AROUND THE ISLANDS, YOUR TAG SIGNALS SEVERAL BUOYS AND HELPS SCIENTIFIC RESEARCH.

- Go forward 3 spaces



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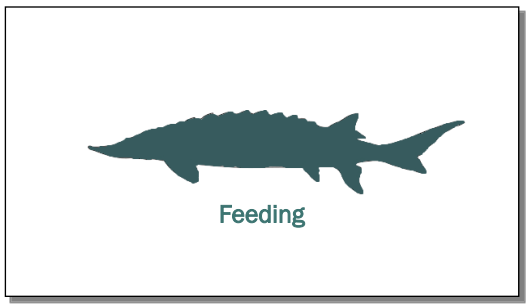

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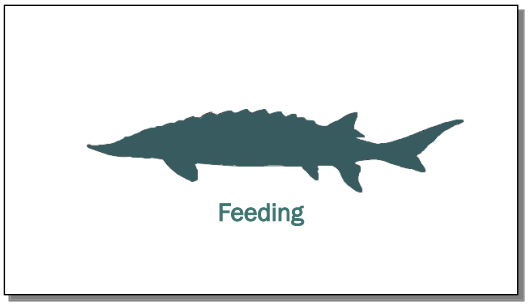

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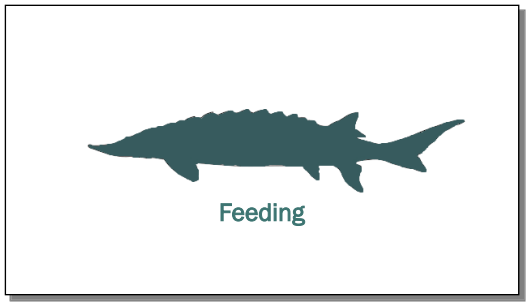
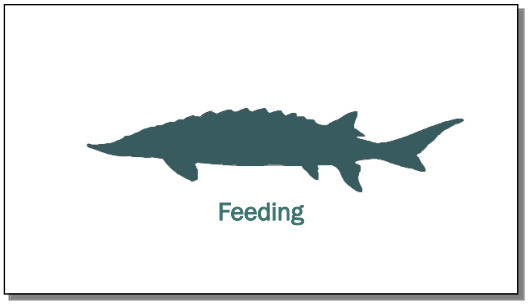
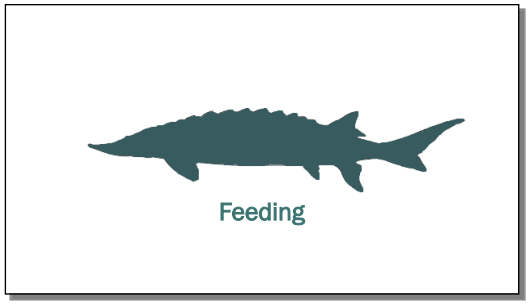


Feeding



Feeding



Feeding

OBSTACLES/ADVANTAGOUS SITUATIONS CARDS (optional):

Option to increase font size and cut out

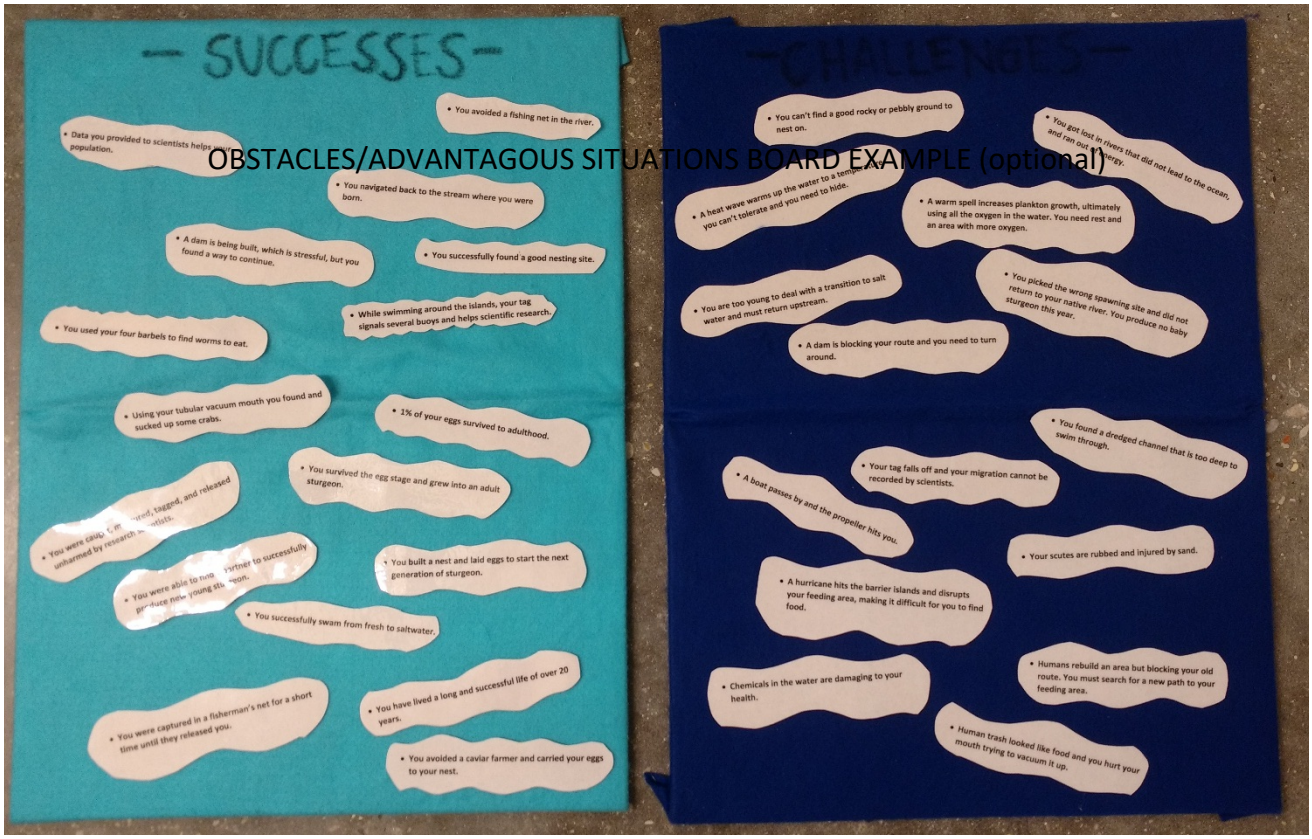
OBSTACLES:

- **The water is hot and uncomfortable. You need to search for a cool, freshwater spring.**
- **You can't find a good rocky or pebbly ground to nest on.**
- **Your scutes are rubbed and injured by sand.**
- **Chemicals in the water are damaging to your health.**
- **You picked the wrong spawning site and did not return to your native river. You produce no baby sturgeon this year.**
- **A heat wave warms up the water to a temperature you can't tolerate and you need to hide.**
- **A dam is blocking your route and you need to turn around.**
- **You found a dredged channel that is too deep to swim through.**
- **You were captured in a fisherman's net for a short time until they released you.**
- **Human trash looked like food and you hurt your mouth trying to vacuum it up.**
- **You are too young to deal with a transition to salt water and must return upstream.**
- **You got lost in rivers that did not lead to the ocean, and ran out of energy.**
- **Rough sand on the ocean floor rubs and injures your scutes.**
- **A hurricane hits the barrier islands and disrupts your feeding area, making it difficult for you to find food.**
- **A boat passes by and the propeller hits you.**
- **Humans rebuild an area but blocking your old route. You must search for a new path to your feeding area.**
- **Your tag falls off and your migration cannot be recorded by scientists.**
- **A warm spell increases plankton growth, ultimately using all the oxygen in the water. You need rest and an area with more oxygen.**
- **Local fishing pier was not resilient and rotted in a flood. Fallen wood is blocking your path.**

ADVANTAGOUS SITUATIONS:

- **You avoided a caviar farmer and carried your eggs to your nest.**
- **You survived the egg stage and grew into an adult sturgeon.**
- **1% of your eggs survived to adulthood.**
- **You successfully found a good nesting site.**
- **You built a nest and laid eggs to start the next generation of sturgeon.**
- **You navigated back to the stream where you were born.**
- **A dam is being built, which is stressful, but you found a way to continue.**
- **You avoided a fishing net in the river.**

- **You successfully swam from fresh to saltwater.**
- **Data you provided to scientists helps your population.**
- **You were caught, measured, tagged, and released unharmed by research scientists.**
- **You jumped out of the water to clean off parasites and made your scutes less irritated.**
- **You used your four barbels to find worms to eat.**
- **Using your tubular vacuum mouth you found and sucked up some crabs.**
- **You were able to find a partner to successfully produce new young sturgeon.**
- **You have lived a long and successful life of over 20 years.**
- **It took you a long time, but you've grown to 10 feet long.**
- **While swimming around the islands, your tag signals several buoys and helps scientific research.**
- **A good steward removed an abandoned fishing net from the river. (replacing the avoided a fishing net in the river card)**
- **An environmental steward picked up trash that was blocking your path.**
- **Your resilient nest didn't get destroyed in the tropical storm.**
- **Humans restored your nesting site! Your home is safe for new young sturgeon.**



OBSTACLES/ADVANTAGOUS SITUATIONS BOARD EXAMPLE (optional)

Sturgeon Game Pieces - Surging Sturgeon Migration Board Game

Lake Sturgeon Toy Fish model

Purchased from: https://www.ebay.com/itm/122971969677

Sturgeon, stuffed animal - Surging Sturgeon Migration Board Game

Purchased from:
https://www.amazon.com/dp/B01DTZKFRU/ref=pe_2640190_232748420_TE_item

Water Quality Data Sheets

School name:	
Date:	
Project Name:	

Top Water

Station #:		
Lat/long		
Time:		
Clarity:		
Salinity:		
Temperature:		
Dissolved Oxygen:		

Bottom Water

Station #:		
Time:		
Salinity:		
Temperature:		
Dissolved Oxygen:		
Depth:		

School:	
Date:	
Project Name:	

Trawl Data:

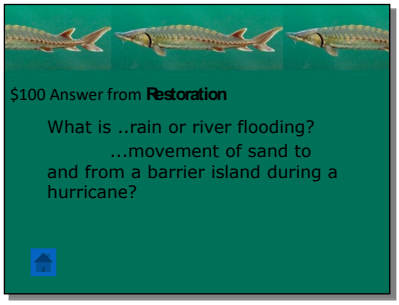
Date:	Time in	Time out	Latitude	Longitude	Species	Number

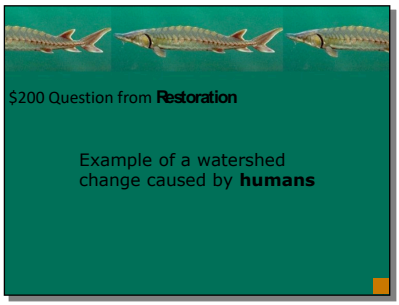
School:	
Date:	
Project Name:	

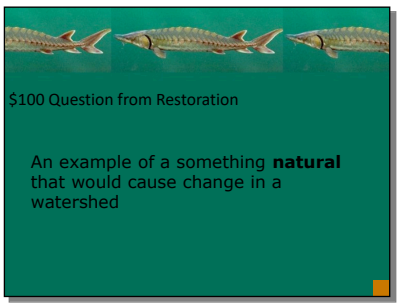
Site Description:

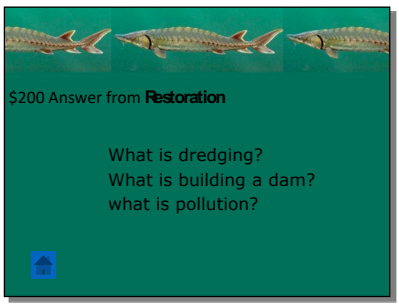
Site	**Station 1**	**Station 2**
Time:		
Description: **Be sure to address** **1) Weather (clouds, wind, temperature)** **2) Water (color, transparency, motion)** **3) Landscape (grasses, mud, trees)** **4) Fauna (birds, mammals, inverts)**		

JEOPARDY PRESENTATION









$300 Question from **Restoration**

Human activity that attempts to return a modified ecosystem to its original condition

$400 Answer from **Restoration**

What is migration?

$300 Answer from **Restoration**

What is restoration?

$500 Question from **Restoration**

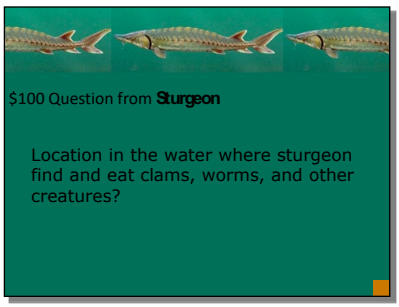
The type of bottom required for sturgeon to lay eggs

$400 Question from **Restoration**
DOUBLE JEOPARDY

Sturgeon behavior that is disrupted by dams

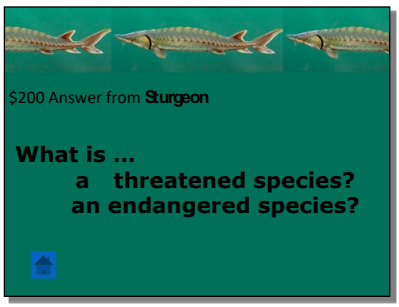
$500 Answer from **Restoration**

What is hard bottom, or gravel, or pebbles?



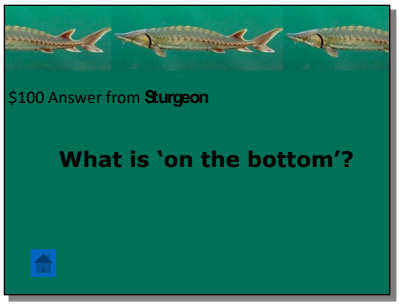
$100 Question from **Sturgeon**

Location in the water where sturgeon find and eat clams, worms, and other creatures?



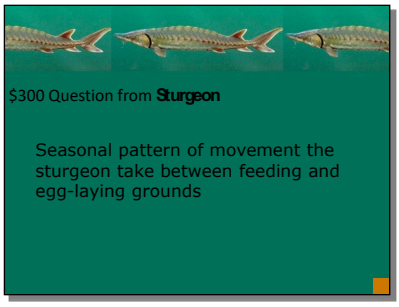
$200 Answer from **Sturgeon**

What is …
a threatened species?
an endangered species?



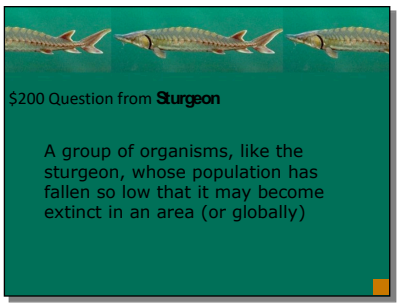
$100 Answer from **Sturgeon**

What is 'on the bottom'?



$300 Question from **Sturgeon**

Seasonal pattern of movement the sturgeon take between feeding and egg-laying grounds



$200 Question from **Sturgeon**

A group of organisms, like the sturgeon, whose population has fallen so low that it may become extinct in an area (or globally)

$300 Answer from **Sturgeon**

What is migration?

$400 Question from **Sturgeon**

A term describing: a fish that is born in fresh water and migrates to salt water during part of its life

$500 Answer from **Sturgeon**

What are scutes?

$400 Answer from **Sturgeon**

What is anadromous?

$100 Question from Watershed
DOUBLE JEOPARDY

The whole area of land that drains into one specific body of water

$500 Question from **Sturgeon**

Hard structures that cover a sturgeon's body for protection

$100 Answer from **Watershed**

What is a watershed?

$200 Question from **Watershed**

An imaginary line that connects high points of elevation around a watershed. On one side of the line, the water goes to one body of water; on the other side, the water goes to another body of water.

$300 Answer from **Watershed**

What is the river?
What is upstream?
What is fresh water?

$200 Answer from **Watershed**

What is a divide?

$400 Question from **Watershed**

Water from rain or snow that drains the land of a watershed, carrying any pollution present into the water body

$300 Question from **Watershed**

The place in the watershed where sturgeon lay eggs and hatch

$400 Answer from **Watershed**

What is runoff?

$500 Question from **Watershed**

Largest undammed river in the lower 48 United States

$100 Answer from **Stewardship**

Who is each and every one of us

$500 Answer from **Watershed**

What is the Pascagoula River?

The Pascagoula carries the greatest volume. The Yellowstone is actually longer

$200 Question from **Stewardship**
DOUBLE JEOPARDY

Resilience is the ability of an environment or organism to recover from a disturbance, What kinds of process can disturb and environment?

$100 Question from Stewardship

Who is responsible for environmental stewardship?

$200 Answer from **Stewardship**

What is a storm, flood, or other accurate natural process?

What is channel dredging, dam building or other specific (and accurate) human activity

$300 Question from **Stewardship**

Reducing the amount of water you use; picking up litter; or telling people how watersheds work are examples of…..

$400 Answer from **Stewardship**

- **What is dredging?**
- **What is pretty much any natural or human change to a waterside habitat?**

-give a specific example.

$300 Answer from **Stewardship**

What are acts of stewardship?

$500 Question from **Stewardship**

The name of your watershed, where you can practice stewardship

$400 Question from **Stewardship**

Replacing sediment that was carried away with a similar type of sediment, in a natural slope and planted with natural vegetation is a way to restore after this activity

$500 Answer from **Stewardship**

What is the Pascagoula River Watershed?

OR

What is the Pearl River Watershed?

OR

What is the Mississippi Coastal Watershed?

$100 Question from Hodge-Podge

Plastic and acoustic versions of these are attached to sturgeon to track their movements

$200 Answer from **Hodge-Podge**

What is temperature?
What is dissolved oxygen?
What is salinity?
What is clarity?

$100 Answer from **Hodge-Podge**

What are tags?

$300 Question from **Hodge-Podge**

The part of the watershed where adult sturgeon feed

$200 Question from **Hodge-Podge**

Any property you can measure to tell you whether a water body will provide good habitat for a specific organism

Be specific

$300 Answer from **Hodge-Podge**

What are the barrier islands?

$400 Question from **Hodge-Podge**

A structure that might be built to collect river water into a lake

$500 Answer from **Hodge-Podge**

What is the Mississippi Sound?

$400 Answer from **Hodge-Podge**

What is a dam?

Final Jeopardy

The act of taking care of, protecting, and being responsible for the environment in a way that benefits both humans and animals?

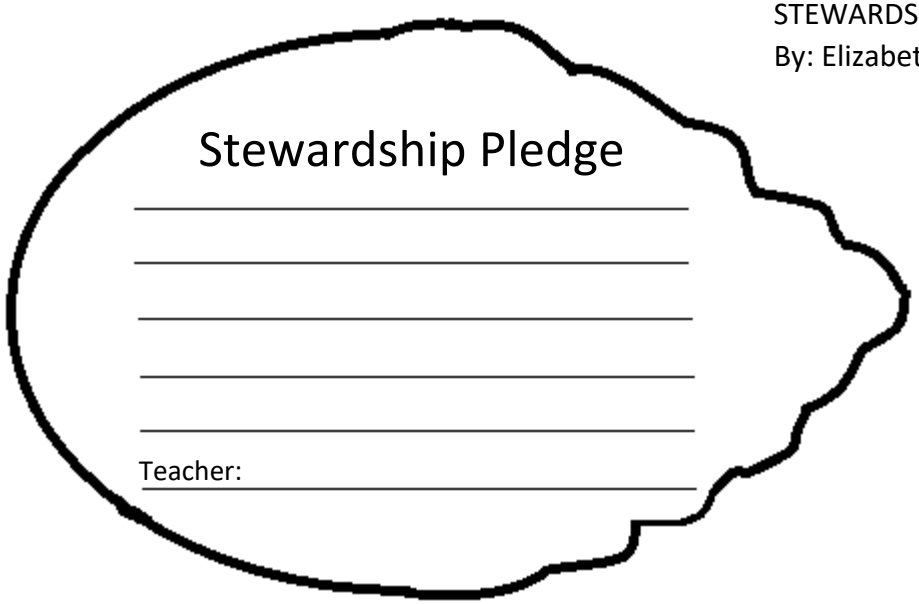
$500 Question from **Hodge-Podge**
DOUBLE JEOPARDY

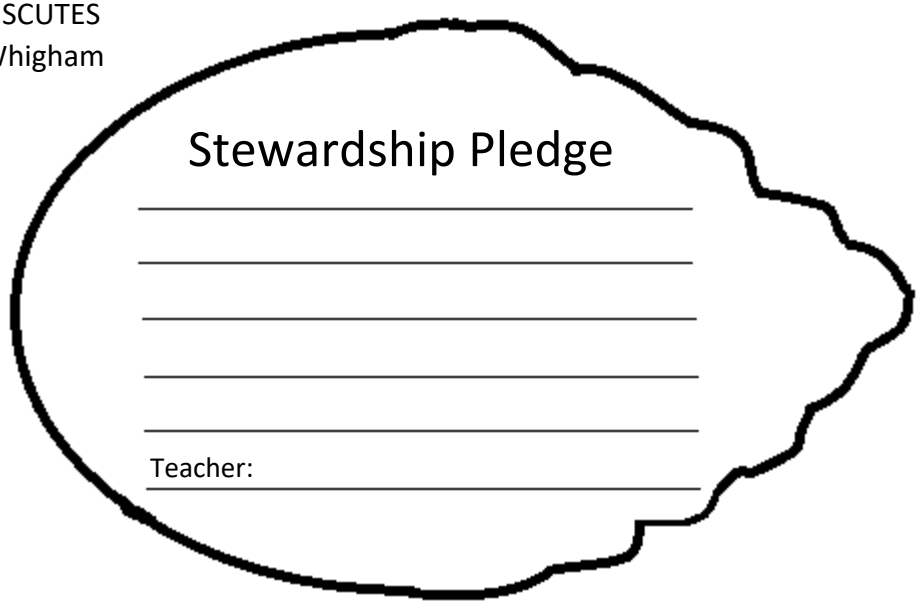
The waterbody into which Davis Bayou and the Pascagoula, Pearl, Wolf, and Biloxi Rivers all flow

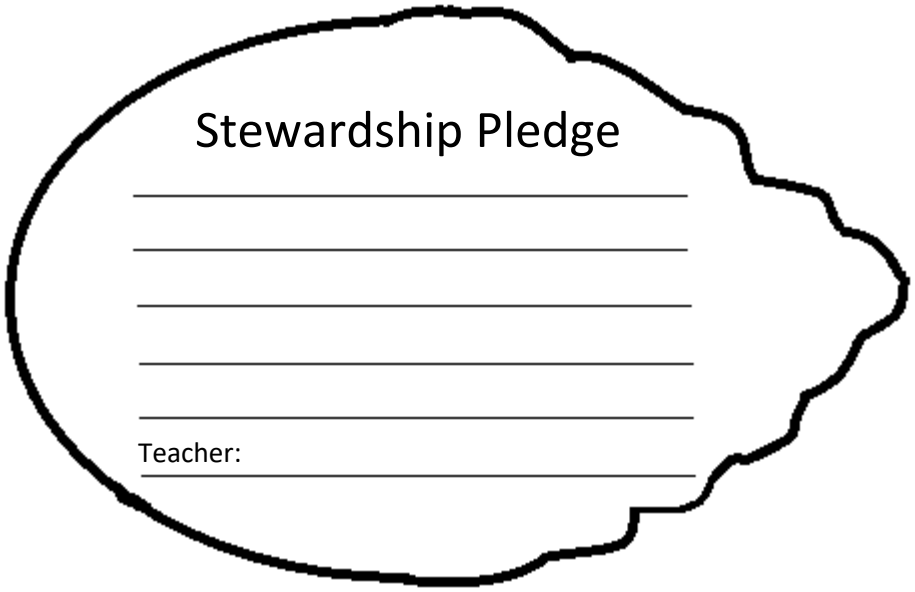
Final Jeopardy Answer

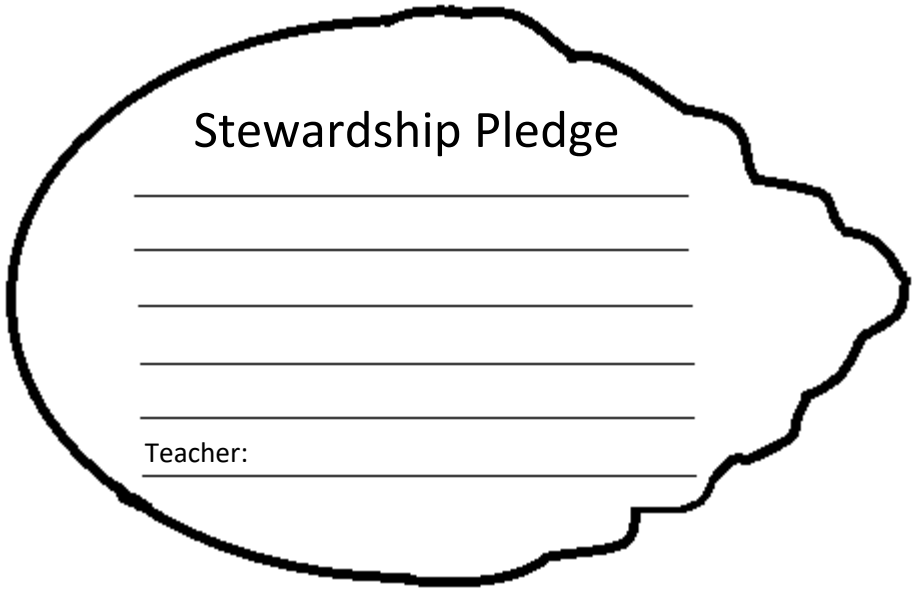
STEWARDSHIP

STEWARDSHIP SCUTES
By: Elizabeth Whigham



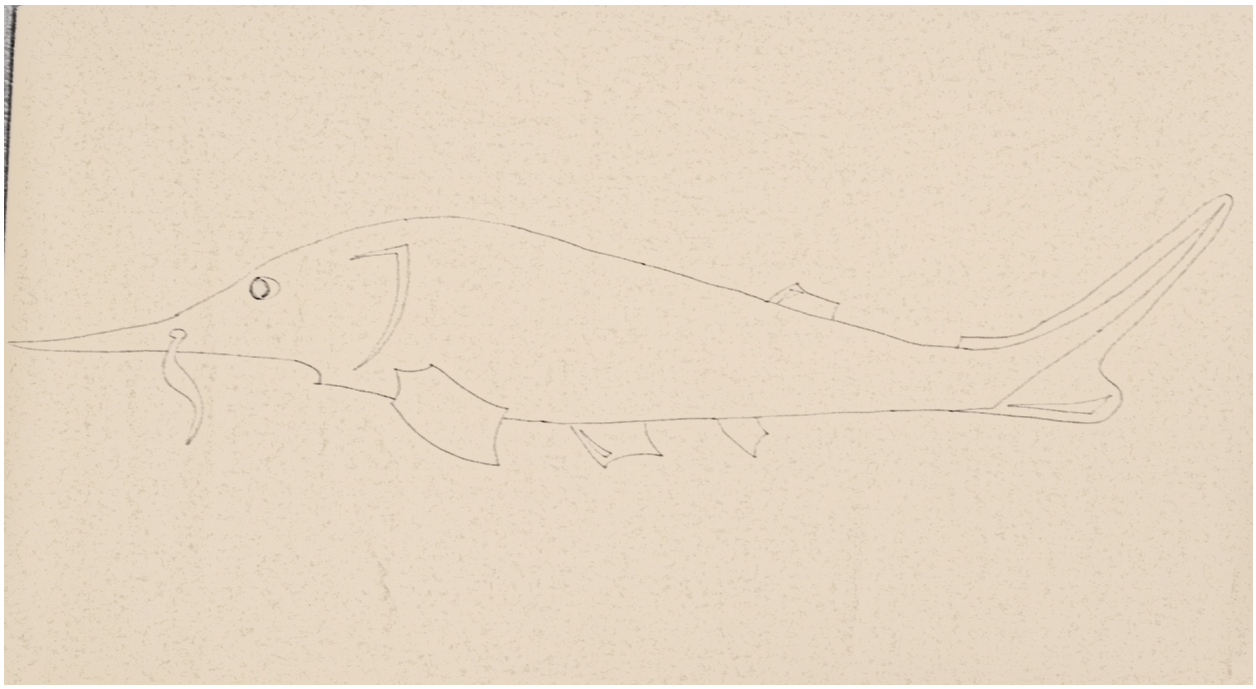






STEWARDSHIP STURGEON OUTLINE

Measurements: ~ 58 x 36 inches (sturgeon is 57 x 13 inches),
[~ 148 x 92 cm (sturgeon is 148 x 33 cm)]



APPENDIX II: CHECKLIST OF SUPPLIES FOR EACH LESSON

Day 1, Lesson 1 - *An Introduction to Watersheds and the Life History of Gulf Sturgeon*

- ☐ *Sturgeon in the Watershed* lesson, activity instructions and PowerPoint slides
- ☐ Pre-tests
- ☐ Flash drive w Presentation – *There's a Sturgeon in My Watershed*
- ☐ Washable markers: variety of colors (blue, black, green, and two more colors)
- ☐ Paper
- ☐ Spray bottle + water
- ☐ Pencils

Day 1, Lesson 2 - *Surging Sturgeon Migration Board Game*

- ☐ Game narration
- ☐ Board game: board, dice, sturgeon pieces, cards
- ☐ Obstacles and advantages cutouts (optional)
- ☐ Obstacles and advantages boards (optional)

Day 1, Lesson 3 – *Sturgeon Habitat Survey*

- ☐ *Sturgeon Habitat Survey* lesson
- ☐ Large laminated map
- ☐ Activity sheets
- ☐ Dry-erase maps
- ☐ Dry-erase markers
- ☐ Dry-erase erasers
- ☐ Markers
- ☐ Sturgeon stuffed animal

Day 2 – Field Trip

Station 1 *Miss Peetsy B*

- ☐ Pro DSS YSI
- ☐ Secchi disc
- ☐ Data sheets
- ☐ Pencils
- ☐ Clipboards
- ☐ Identification key/sheet (Optional)

Station 2 Exhibit tour

- ☐ IPad for SOS

Station 3 Water quality classroom

- ☐ Water quality lesson kit (thermometer, refractometer, oxygen kit, Secchi disk, measuring tape)
- ☐ Data sheets

Day 3 – *Sturgeon Stewardship – Reflection and Review*

- ☐ Jeopardy questions/presentation
- ☐ Mini white boards for each group
- ☐ Dry-erase markers
- ☐ Dry-erase erasers
- ☐ Markers
- ☐ Large sticky notepad
- ☐ Sturgeon Stewardfish poster (with USM sticker)
- ☐ Stewardfish scutes
- ☐ Tape/glue
- ☐ Pencils
- ☐ Posttests

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