



Teacher Guide—Earth Science Module

Activity 1: Observing Estuaries



Featured NERRS Estuary:
Weeks Bay NERR (Alabama)
<http://www.nerrs.noaa.gov/Reserve.aspx?ResID=WKB>

Activity Summary

In this activity, students investigate landforms and features associated with estuaries. They begin by taking a journey down a river to an estuary system where the river empties into the Gulf of Mexico near Weeks Bay National Estuarine Research Reserve (NERR) to investigate how landforms differ between uplands and riverine/estuarine environments. Student teams then use Google Earth and other resources to engage in a scavenger hunt to locate and identify landforms and features of estuaries.

Learning Objectives

Students will be able to:

1. Describe differences between upland non-estuarine and estuarine landforms and features.
2. Visually identify and describe various landforms and features associated with estuarine environments, including salt marshes, barrier beaches, peninsulas, headlands, spits, mud flats, fjords, deltas, coves, harbors, sounds, and others.

Grade Levels

9-12

Teaching Time

3 (55 minute) class sessions + homework

Organization of the Activity

This activity consists of 3 parts which help deepen understanding of estuarine systems:

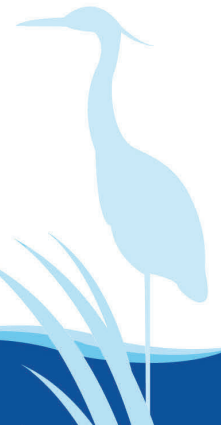
What is an Estuary?

A trip down the Alabama River

Estuary Landforms and Features—Scavenger Hunt

Background

The Alabama River, in the state of Alabama, is formed by the Tallapoosa and Coosa Rivers, which unite about 10 km above Montgomery. The river flows west to Selma, then southwest until it is about 72 km from Mobile where it unites with the Tombigbee River, forming the Mobile and Tensaw



The river flows west to Selma, then southwest until it is about 72 km from Mobile where it unites with the Tombigbee River, forming the Mobile and Tensaw Rivers. Both rivers discharge into Mobile Bay.

The Alabama River meanders a lot. It is 502 km long and varies in width from 200 to 300 m, and its depth ranges from 1 to 2 m. The river crosses the richest agricultural and timber districts of the state, and railways connect it with the mineral regions of north central Alabama.

See the PowerPoint *Estuary Landforms and Features* for more background information on the major landforms and features of estuaries.

Download and prepare to present the PowerPoint *Estuary Landforms and Features*.

Preparation

Download [Google Earth](#) and install it on your classroom computer(s) or computer lab machines. To find a tutorial for using Google Earth, please check the box on the next page.

Preset the locations of your school and the beginning of the Alabama River trip (31° 08' 53.46 N, 87° 56' 56.46 W; altitude 4 km) in Google Earth. Refer to *Using Google Earth to Explore Estuaries* for a brief how-to guide. (See side-box for instructions on how to access this tutorial.)

In Google Earth, choose a starting point for students' Part 3 exploration of a coastal area and determine an address or location name to enter that will zoom in on this starting place. For example, if you want your students to begin exploring the coast of the Gulf of Mexico, a starting location might be Port Isabel, Texas. Or select one of the National Estuarine Research Reserves for students to investigate.

Browse the coastal area that you want your students to examine and identify potentially confusing borders or areas with only low-resolution imagery available.

Materials

Students

- Need to work in a computer lab or with a computer and projector
- Copy of the *Student Reading Observing Estuaries*
- Copy of the *Student Worksheet Observing Estuaries*
- Copy of *Student Reading Introduction to Weeks Bay NERR*
- Copy of Student Worksheet — Scavenger Hunt*
- Copy of *Student Reading Using Google Earth to Explore Estuaries* (assuming you have computer access)

Teachers

- Download [Google Earth](#)
- If you wish to use hardcopy materials instead of Google Earth, obtain topographic or other types of maps for students to use in Part 2 of the activity
- PowerPoint *Estuary Landforms and Features* (available on the [Estuaries.noaa.gov](#) site, click under Curriculum, High-School Curriculum, Earth Science, and find the presentation under Supporting Materials, Activity 1)

Equipment:

- Computer lab or
- Computer and Projector



Alternatives

If you want to use a local river and estuary instead of the Alabama River, produce an alternate river trip for Part 1 using Google Earth.

If you wish to use hardcopy materials instead of Google Earth, obtain topographic or other types of maps for students to use in Part 2 of the activity.

Procedure

Part 1 — What is an Estuary?

1. Begin by asking students what they know about estuaries.
2. Have students each sketch or describe what it might look like where the river meets the ocean. Select students to hold up their diagrams and describe what they drew. Emphasize the variety of estuaries and the fact that different types exist.
3. During the discussion, ask the following questions to get students to think more deeply about these places where fresh water from rivers and streams run into ocean water:
 - How big are these places?
 - How can you tell where the fresh water ends and ocean water starts? Can you see it clearly, like a waterfall into the sea or is it a little less obvious, like a hose underwater in a swimming pool?
 - What do you know about where fresh water meets the ocean? What landforms or features may be present?

National Science Education Standards

Content Standard A: Science as Inquiry

A3. Use technology and mathematics to improve investigations and communications.

A4. Formulate and revise scientific explanations using logic and evidence.

A6. Communicate and defend a scientific argument.

Content Standard C: Life Science

C4. Interdependence of organisms

Content Standard E: Science and Technology

E1. Identify a problem or identify an opportunity

E6. Understandings about science and technology

Content Standard F: Science in Personal and Social Perspectives

F4. Environmental quality

F5. Natural and human-induced hazards



Google Earth

This activity *requires* the use of Google Earth. If students have computer access, the use of [Google Earth](http://earth.google.com/) (<http://earth.google.com/>) can help them develop spatial skills.

Find the Tutorial “*Using Google Earth to Explore Estuaries*” in Estuaries.noaa.gov, click under Curriculum, and then the sub-tab titled “Tutorials”.

Part 2 — A Trip Down the Alabama River

4. Explain to students that they will now take a trip down a river in Alabama to investigate one type of estuary and the kinds of features that are present when a river meets the sea.
5. Show students an image of their school in Google Earth at an altitude of 4 km. Ask students if they recognize the image and its location. You may have to point out a few familiar landmarks.
6. Ask students to describe the environment around their school, pointing out the specific landforms and features they see. (*Ponds, rivers, streams, lakes, hills, canyons, and valleys are commonly mentioned, or there may only be city streets.*)
7. Demonstrate how to zoom in and out, move left and right, and up and down using Google Earth. Also show students how to leave a place mark on a Google image. Distribute *Student Reading — Using Google Earth to Explore Estuaries*.
8. Click on the placeholder for the beginning of the Alabama River trip if you have marked it or go to: 31° 08' 53.46 N, 87° 56' 56.46 W. Ask students what kinds of features they see in the image. (*Sand bars, farmland, forests, and a tributary flowing into the Alabama River*)
9. Hand out *Student Worksheet — Observing Estuaries*. Instruct students to explore the Alabama River, following the directions and answering the questions on the worksheet.

Part 3 — Estuary Landforms and Features Scavenger Hunt

10. Divide your class into teams and hand out the *Student Worksheet — Scavenger Hunt*.
11. Show the *Estuary Landforms and Features* PowerPoint presentation so students have a basis for selecting features in the scavenger hunt.
12. In Google Earth, have the teams go to your pre-selected starting point and challenge them to locate as many of the features as they can in 30 minutes.
13. Have teams exchange lists and verify the objects on each other's lists. Have students place question marks on features that they either cannot find or those they feel are misidentified.
14. Have students answer the summary questions.

Check for Understanding

Discuss the following:

- How do the terrain and types of landforms change as you travel down a river toward a source of salt water?
- Which of the landforms and features on your scavenger hunt list were fairly common?
- Which landforms were not present at all?

Have students sketch an imaginary estuary system on a piece of paper. Direct them to draw and label as many landforms and features on their diagram as possible. Collect and evaluate them for accuracy, clarity, and the number of landforms correctly identified.

Optional Extension Inquiries

Have students create a travelogue that documents a trip down a river that flows into another NERRS estuary.

Have students make a PowerPoint presentation that describes the differences between the geological landforms and features in upland versus estuarine environments.



Teacher Worksheet with Answers

Activity 1: Observing Estuaries

Part 2 — A Trip Down the Alabama River

2a. Use the vertical slider in the upper right-hand corner of the screen to zoom towards the river. What kinds of land and terrain border the river? Use the navigation buttons to survey the area. Can you locate farms or other signs of human habitation or industry?

Answer: Students will see a few patches of farmland and mostly flat, forested riverbanks. They will also notice sandbars on the inside of each curve of the river.

2b. Use the slider in the upper right-hand corner of the image to set your viewing altitude at 4 kilometers (2.4 miles). For the rest of your journey, zoom back to this altitude before moving further downriver. As you travel downriver, what signs of human interaction with the river (industry, towns, ships, etc.) do you see?

Answer: Large freighters, bridges, and large-scale mining operations can be seen as students go downriver.

2c. When you reach a fork in the river, take the west channel. When you reach Whitehouse Bend (31° 00' 07.06) on the river, you will see a large brown feature. Zoom in and explore this region. What do you think this feature is?

Answer: The feature at Whitehorse Bend appears to be a large borrow pit or surface mining operation.

2d. After you cross highway I-65, you will see two large areas on both sides of the river. Zoom in and zoom out to explore this area. Can you identify what type of terrain these areas consist of?

Answer: The terrain on both sides of the river consists of extensive bayous and swamps.

2e. Follow the river to Twelve Mile Island. How do you think this island formed? What kind of terrain surrounds the island?

Answer: Twelve Mile Island was formed by the river changing course. Bayous flank the river on both sides.

2f. When you reach Bear Creek, a channel of the Alabama River empties into a larger body of water. What is it?

Answer: The tributary of the Alabama River empties into Grand Bay.

2g. When you arrive at Blakely Island Reach in Mobile, Alabama, how has the terrain on both rivers changed?

Answer: Industrial sites line both sides of the river. No vegetation exists.



2h. Center the river and fly south until you see Gaillard Island. Find latitude 30° 30' 31" (on the right shoreline of the island) and zoom in. Describe what you see.

Answer: Students should point out the estuarine environment formed by a fresh water river flowing into a long linear lagoon. The barrier beach that forms the eastern shore of the island forms the lagoon.

2i. Move back to 4 km of altitude, and fly directly south from Gaillard Island to Mobile Point. Zoom in and describe the terrain you see.

Answer: Mobile Point has many beaches and salt marshes behind them. There are a few ponds situated toward the center. There is an old fort (star-shaped formation) there as well.

2j. Now fly east and explore the region to the north of the beach area beginning with Navy Cove. Describe the types of features and terrain you find there.

Answer: Headlands, coves, bays, bayous, inlets, ponds, and barrier beaches occur in this vicinity.

2k. Now fly directly north across the bay until you reach **Weeks Bay National Estuarine Research Reserve**. Can you identify a sediment plume at the mouth of the bay? Identify other features in the neighborhood of the estuary reserve.

Answer: Yes, a sediment plume is evident. Other features include a peninsula, wetlands, forested areas, beaches, and salt marshes.

2l. In your journey, you traveled from an upland region to an estuarine environment (Mobile Bay) to a coastal area. In general, how did the types of terrain change in each region as you made your way downriver?

Answer: The terrain changes dramatically as you travel downriver—from forested areas with occasional farmland to a complex of bayous, deltas, beaches, and salt marshes.

2m. How does the water change as you move down the river? What evidence can you give for any changes you see?

Answer: Students should notice that many different kinds of bodies of water increase the complexity of the river system as it moves towards the sea (inlets, bays, streams, bayous, wetlands, salt marshes, etc.). Evidence includes seeing sediment plumes and sand bars as streams and rivers empty into larger bodies of water.

2n. Describe how different human activities affect the nature of the river and the terrain on both sides of it.

Answer: Large-scale industrial activity on both sides of the river has in some cases diverted the flow of the river and certainly has contributed to waste products being washed into the river.



Part 3 — Estuary Landforms and Features Scavenger Hunt

3a. Which landforms and features were easiest to find?

Answer: Students' answers will vary depending on which section of coastline they are investigating.

3b. Which landforms or features were the most difficult to find?

Answer: Students' answers will vary. In particular, students may have difficulty finding reefs unless they search in tropical climates.





Student Reading—1

Activity 1: Observing Estuaries

An estuary is a partially enclosed body of water, and its surrounding coastal habitats, where saltwater from the ocean mixes with fresh water from rivers, streams, or groundwater. In fresh water, the concentration of salts, or salinity, is nearly zero. The salinity of water in the ocean averages about 35 parts per thousand (ppt). The mixture of seawater and fresh water in estuaries is called brackish water.

Estuaries are transitional areas that connect the land and the sea, as well as freshwater and saltwater habitats. The daily tides (the regular rise and fall of the sea's surface) are a major influence on many of these dynamic environments. Most areas of the Earth experience two high and two low tides each day. Some areas, like the Gulf of Mexico, have only one high and one low tide each day. The tidal pattern in an estuary depends on its geographic location, the shape of the coastline and ocean floor, the depth of the water, local winds, and any restrictions to water flow. For example, tides at the end of a long, narrow inlet might be heightened because a large volume of water is being forced into a very small space. However, the change in sea level for tides in wetlands composed of broad mud flats might appear to be rather small.

While strongly affected by tides and tidal cycles, many estuaries are protected from the full force of ocean waves, winds, and storms by reefs, barrier islands, or fingers of land, mud, or sand that surround them. The characteristics of each estuary depend upon the local climate, freshwater input, tidal patterns, and currents. Truly, no two estuaries are the same.

Landforms that occur on or near the coast are shaped by wave and wind erosion and glacial transport. Headlands are composed of the very hard rock left behind as

softer rocks are eroded away by relentless wave action occurring over thousands of years. In contrast, sand bars, spits, and even entire beaches can form, or be completely obliterated, in a single severe storm. Estuary features such as salt marshes, bayous, and mangrove forests form in the areas protected by barrier beaches, islands, and strips of coastal land.

Besides the constant erosional forces of water and wind, coastal landforms and features are influenced by other large, long-term geologic events. Glaciers retreating during the last ice age sculpted the northeast coastline of the United States. One look at the peninsulas of Maine clearly shows the direction of retreat of the mile-thick ice sheets. Only the hardest rock was left behind to form the islands and the peninsulas of the coast. During this period, the entire bulk of Long Island was left behind by the forward edge of a massive glacier, deposited like a load of dirt from a huge dump truck. Long Island Sound formed in the gouge behind the rubble.

In this activity, you will explore how landforms and features change as you travel from the interior of our country to the place where rivers empty into the sea—estuaries. Then, you will explore coastal regions from above using Google Earth or other resources to identify landforms and features associated with estuarine and coastal environments.





Student Reading—2

Activity 1: Introduction to Weeks Bay NERR

The Weeks Bay National Estuarine Research Reserve (NERR) includes over 6,000 acres of coastal wetlands that provide rich and diverse habitats for a variety of fish, crustaceans and shellfish, as well as many unique and rare plants. Weeks Bay is a small estuary, about 8 km², receiving freshwater from the Magnolia and Fish rivers, and draining a 500 km² watershed into the lower portion of Mobile Bay. This sub-estuary of Mobile Bay averages just 1.5 meters in depth and is fringed with salt marshes dominated by black needle rush and cordgrass, as well as extensive swamps with pine, oak, magnolia, maple, cypress, bayberry, and tupelo trees.

The Weeks Bay ecosystem contains many freshwater and marine fish and invertebrate species. Collectively, these species support large commercial and recreational fishing industries. Weeks Bay is especially a critical nursery for shrimp, bay anchovy, blue crab and multitudes of other fish, crustaceans and

shellfish. The Reserve lands also include upland and bottomland hardwood forests, freshwater marsh, submerged aquatic vegetation, and unique bog habitats. Many of these areas are especially important to the large number of trans-Gulf migratory birds as a resting and feeding area.

Additionally, the Weeks Bay NERR is home to many threatened or endangered species, including the West Indian manatee, eastern fox squirrel, red-cockaded woodpecker, wood stork, Alabama red-bellied turtle, gopher tortoise, and Alabama sturgeon.

Although the Reserve is relatively undisturbed, increasing development pressure and population growth within areas of the Weeks Bay watershed has resulted in increasing sources of pollution. These include storm water runoff from parking lots, industrial sites, leaking septic tanks, and landfills, as well as, agricultural runoff. Input of excessive nutrients and sediments from this runoff can have detrimental affects on estuary life including reduction in submerged aquatic vegetation, increase in algal blooms which cause fish kills, and accumulation of toxic substances within shellfish.

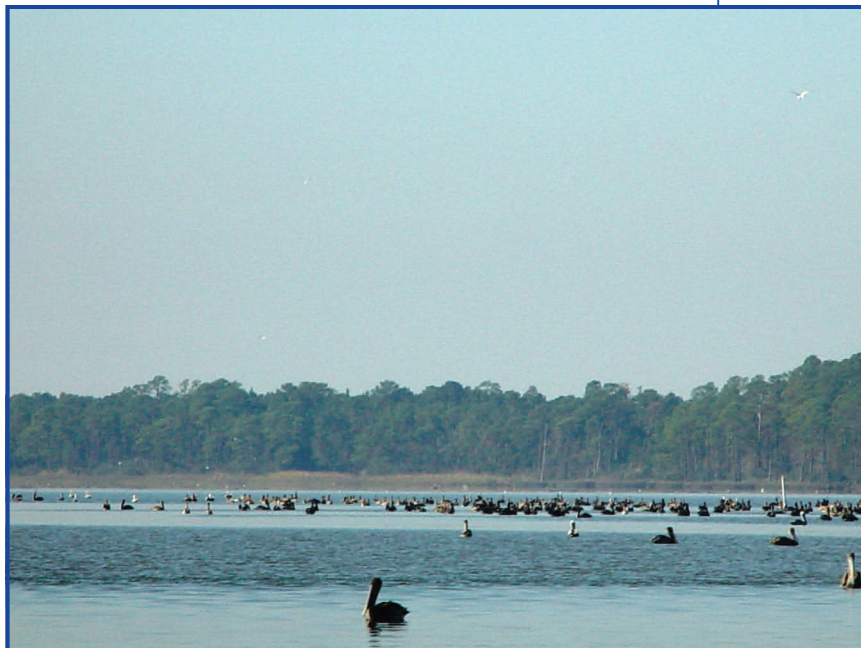


Figure 1. Weeks Bay NERR is home to many species of plants and animals.

Location of Weeks Bay Reserve



Figure 2.
Location of Weeks Bay Reserve



Student Worksheet - 1

Activity 1: Observing Estuaries

Student Name: _____

Part 1 — What is an Estuary?

1. Use a blank piece of paper to sketch what you think an estuary looks like.

Part 2 — A Trip Down the Alabama River

Take an aerial tour of a section of the Alabama River in Alabama, following the river's course from a point in the south-central portion of the state, through to Mobile Bay where it empties into the Gulf of Mexico. To begin:

1. Open Google Earth
2. Click on the *Fly To* button, and enter these coordinates (31° 08' 53.46 N, 87° 56' 56.46 W).
3. Under the Layers menu, click on Terrain, Geographic Web, Places of Interest, and Roads



Figure 3.
The Alabama River in Alabama—the starting point for your tour.

2a. Use the vertical slider in the upper right-hand corner of the screen to zoom towards the river. What kinds of land and terrain border the river? Use the navigation buttons to survey the area. Can you locate farms or other signs of human habitation or industry?

2b. Use the slider in the upper right-hand corner of the image to set your viewing altitude at 4 kilometers (2.4 miles). For the rest of your journey, zoom back to this altitude before moving further downriver. As you travel downriver, what signs of human interaction with the river (industry, towns, ships, etc.) do you see?

2c. When you reach a fork in the river, take the left channel. When you reach Whitehouse Bend ($31^{\circ} 00' 07.06$) on the river, you will see a large brown feature. Zoom in and explore this region. What do you think this feature is?

2d. After you cross highway I-65, you will see two large areas on both sides of the river. Zoom in and zoom out to explore this area. Can you identify what type of terrain these areas are?

2e. Follow the river to Twelve Mile Island. How do you think this island formed? What kind of terrain surrounds the island?

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- 2g. When you arrive at Blakely Island Reach in Mobile, Alabama, how has the terrain on both rivers changed?
- 2h. Center the river and fly south until you see Gaillard Island. Find latitude $30^{\circ} 30' 31''$ (on the right shoreline of the island) and zoom in. Describe what you see.
- 2i. Move back to 4 km of altitude, and fly directly south from Gaillard Island to Mobile Point. Zoom in and describe the terrain you see.
- 2j. Now fly east and explore the region to the north of the beach area beginning with Navy Cove. Describe the types of features and terrain you find there.
- 2k. Now fly directly north across the bay until you reach **Weeks Bay National Estuarine Research Reserve**. Can you identify a sediment plume at the mouth of the bay? Identify other features in the neighborhood of the estuary reserve.



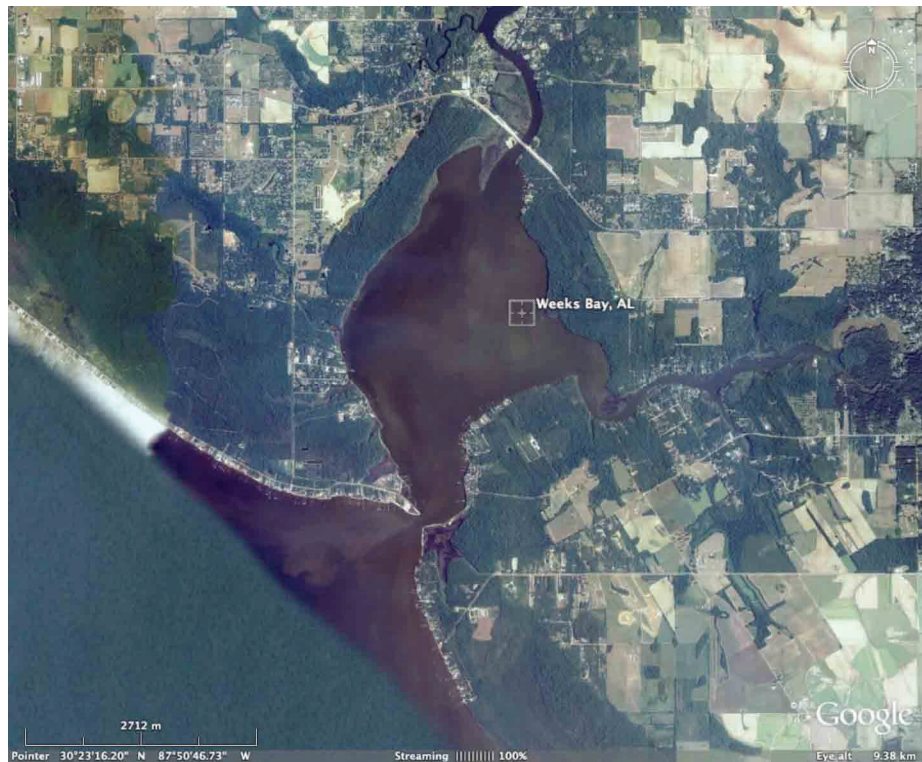


Figure 4. The end point of your Alabama River trip in the Weeks Bay NERR

2l. In your journey, you traveled from an upland region to an estuarine environment (Mobile Bay) to a coastal area. In general, how did the types of terrain change in each region as you made your way downriver?

2m. How does the water change as you move down the river? What evidence can you give for any changes you see?

2n. Describe how different human activities affect the nature of the river and the terrain on both sides of it.

Part 3 — Estuary Landforms and Features Scavenger Hunt

View the *Estuary Landforms and Features* PowerPoint presentation and take notes about the various structures and features.

Using Google Earth, explore regions of coastline and find as many landforms and features as you can on the *Student Worksheet — Scavenger Hunt*.

Your teacher may start you in a particular coastal region. You may then “fly” to other coastal areas and search for missing landforms and features if time allows.

Exchange your list with another team and check that team’s results by flying to each location they recorded to verify whether the landforms and features have been correctly identified.

3a. Which landforms and features were easiest to find?

3b. Which landforms and features were the most difficult to find?





Student Worksheet - 2

Activity 1: Scavenger Hunt

Team Member Names: _____

When you identify a landform or feature in Google Earth, give the name if provided, and the exact coordinates (latitude and longitude). NOTE: You may not find all landforms and features in a particular stretch of coastline or estuarine region.

Landform	Name/Location (latitude and longitude)
barrier beach	_____
bay	_____
bayou	_____
cove	_____
delta	_____
harbor	_____
headland	_____
lagoon	_____
mangrove forest	_____
peninsula	_____
slough	_____
sound	_____
reef	_____
salt marsh	_____
tidal or mud flats	_____

