

Bays and Estuaries

Texas bays and estuaries provide vital ecosystems and nursery habitat for most important Gulf species, feeding and resting places for migrating birds, and billions of dollars to the Texas economy.

Chapter 11

Grade Levels/Courses

6th, 7th, 8th, Aquatic Science, Environmental Science

Chapter Objectives

Students will:

1. Locate bays on a map of Texas.
2. Identify the importance of bays and estuaries.
3. Use a Venn diagram to compare estuaries and freshwater wetlands.
4. Read the student guide and answer the questions.
5. Compare and contrast bays and estuaries.
6. Identify the importance of freshwater inflow to bays and estuaries.
7. Define *hypersaline*, and identify a hypersaline body of water in Texas.
8. Determine the kinds of plants found in estuaries.
9. Compare adaptations of closely related species.
10. Define tides.
11. Explain how tides may differ in different places in bays and from bay to bay.
12. Identify why the Texas coast is important to birds.
13. Explain the importance of conservation of water inland to healthy ecosystems and the production of seafood on the Texas Coast.
14. Synthesize information to develop a public information/media presentation educating the public about important issues concerning estuaries.
15. Conduct an investigation to observe the ways that saltwater and freshwater mix.
16. Draw a diagram showing how freshwater and saltwater mix in an estuary.
17. Play a game to model changing conditions in an estuary and the consequences for fish or other organisms living in the estuary.
18. Draw conclusions based on what they learn from the model.

19. Use the model to experience biotic and abiotic changes to which organisms react in an ecosystem.
20. Model how drought affects an estuary.
21. Model the effects of human activity on groundwater and surface water.
22. Model how organisms respond to external stimuli.
23. Describe predator and prey relationships in their model.
24. Describe how organisms depend on biotic and abiotic factors in the estuary.
25. Describe how short and long-term changes affect organisms.
26. Explain the model showing changing populations in an estuary and its limitations.
27. Identify and evaluate factors that affect aquatic populations.
28. Predict how species extinction may alter the food chain and affect existing populations in an estuary.
29. Identify the land uses of humans and affects of those uses of the land on an estuary.
30. Synthesize what they learned from the game/model in a 3-paragraph essay on affects of changes in an estuary.
31. Work cooperatively to learn information about ecosystem services to teach others the concepts.
32. Classify ecosystem services into appropriate categories.
33. Synthesize information on ecosystem services to write a television news story.
34. Describe how biotic and abiotic parts of the ecosystem contribute to ecosystem services.
35. Describe how biodiversity contributes to the sustainability of an ecosystem.
36. Describe how short and long term environmental changes affect organisms and traits in subsequent populations.
37. Describe how organisms and populations in an ecosystem depend on and may compete for biotic and abiotic parts of the ecosystem.
38. Describe human dependence on ocean systems and explain how human activities have modified these systems.
39. Explain how human activity is affecting aquatic viability in the Texas bays and estuaries.

Texas Essential Knowledge and Skills in Science

6.1 A, B; 6.2 C, D, E; 6.3 C; 6.4 A; 6.12 E; 7.1 A, B; 7.2 C, D, E; 7.3 C; 7.5 A; 7.8 A; 7.10 A, B; 7.11 B; 7.13 A; 8.1 A, B; 8.2 C, D, E; 8.3 C; 8.4 A, B; 8.7 C; 8.11 A, B, C, D
 Aquatic Science: 1 A, B; 2 F, G, H, J; 4 A; 9 A; 10 B, C; 11 B; 12 A, B, C, D
 Environmental Science: 1 A, B; 2 F, G, I, K; 3 B, G; 4 B, D; 5 A, B; 8 A, B; 9 A, D, E

Materials Needed

Activity 11.1

Map of Texas showing bays:

<http://www.tpwd.state.tx.us/publications/learning/aquaticscience/maps.pdf>

Science journals

Pencils/pens

Activity 11.2

Student Guide

Science journal

Pencils/pens

Activity 11.3

Student journals

Pencils/pens

For each pair of students

Water

Graduated cylinder or measuring cup

Salt

Scale

2 clear cups or beakers

Blue food coloring

Red food coloring

Spoon

Eyedroppers (optional)

Activity 11.4

Science journals

Pencils

For each team of 4 players

1 sheet of blue construction paper to represent the estuary

Goldfish Colors crackers or other tokens (approximately 40)

1 set of game cards found at the end of the activity

Activity 11.5

Copies of *Ecosystem Services Cards*

Science journals

Pencils/pens

Vocabulary

- Artificial reef
- Barrier island
- Bay
- Cultural
- Ecosystem services
- Estuary
- Fertilizer
- Freshwater
- Habitat
- Hypersaline
- Inflows
- Migratory
- Pesticide
- Pollution
- Provisioning
- Regulating
- Salinity
- Saltwater
- Supporting
- Tides

Enrichment

Project Aquatic Wild

- Wetland Metaphors
- Marsh Munchers

Video

The State of the Gulf

from Texas Parks and Wildlife Department

Activity 11.1: What Do We Know about Bays and Estuaries?

Essential Concept

Bays and estuaries are important to the environment. Estuaries have some similarities to freshwater wetlands, but also have important differences.

Objectives

1. Students will find bays on a map of Texas.
2. Students will identify the importance of bays and estuaries.
3. Students will use a Venn diagram to compare estuaries and freshwater wetlands.

TEKS

6.2 C; 6.12 E; 7.2 C; 8.2 C

Aquatic Science: 2 J; 9 A

Environmental Science: 2 K

Estimated Time

1 class period

Materials

Map of Texas showing bays:

<http://www.tpwd.state.tx.us/publications/learning/aquaticscience/maps.pdf>

Science journals

Pencils/pens

Procedures

1. Importance of Bays and Estuaries

An estuary is a partly enclosed body of water along the coast where one or more streams or rivers enter and mix freshwater with seawater. We've learned about wetlands in the last chapter. Now we will look at a particular kind of wetlands which may occur in estuaries. An estuary may or may not contain wetlands, but along the Gulf coast there usually are extensive areas of wetland associated with estuaries. You can have an estuary that is mostly mud bottoms and bare, low-lying mud islands. More typical are estuaries that are a mix of wetlands and bare areas. It's the mixing of freshwater and saltwater in a transition zone that defines an estuary, not the wetlands. Wetlands are defined by the presence of plants.

Estuaries may occur at river deltas where the river extends out into the Gulf, or at bays that are partially enclosed by land, but open directly to the ocean.

- **Where might we see a delta type estuary?** (Most students will think of the Mississippi River delta.)
- **Do any Texas rivers form deltas?** Look on *Google Maps*, satellite view, and see if you can find a delta where a river in Texas enters the gulf.
- **Can you think of some bays along the Texas Gulf Coast?**

If students have difficulty coming up with names of bays, give out Texas road maps to each group and allow students time to find the bays along the Texas coast. They should look for the seven major bays. (Sabine Lake, Galveston, Matagorda, San Antonio, Aransas, Corpus Christi bays, and the Laguna Madre) There are other smaller bays, which they might also notice, but these are the larger bays.

Ask students to write down the names of the seven major bays in their science journals.

Ask each group to make a list in their journals of the things that they think are important for the environment about the bays and the estuaries. (**Examples:** Bays and estuaries are important to fish and shellfish as safe nurseries for their young, help maintain climate through absorption of carbon dioxide, provide habitat for a wide variety of organisms from bacteria to birds, etc.)

2. Sharing Ideas

Have students share their groups' thinking about the importance of bays and estuaries to the environment. Write students' ideas on the board. Each group should give one contribution to the class list. The teacher may call on each group to continue to add new ideas until all ideas are on the board. Provide opportunity for discussion among class members. Have students add new ideas to their group's list in their science journals.

3. Comparing Estuaries to Freshwater Wetlands

Ask students to make a Venn diagram to compare estuaries and freshwater wetlands.

- **How are estuaries like freshwater wetlands?**
- **How are they different from freshwater wetlands?**

Vocabulary

- Bay
- Estuary
- Freshwater
- Saltwater

Activity 11.2: Reading and Research

Essential Concept

Bays and estuaries provide for widely diverse ecosystems that require adequate freshwater inflow to maintain the necessary conditions for supporting uniquely adapted plants and animals.

Objectives

1. Students will read the student guide and answer the questions.
2. Students will compare and contrast bays and estuaries.
3. Students will identify the importance of freshwater inflow to bays and estuaries.
4. Students will define *hypersaline*, and identify a hypersaline body of water in Texas.
5. Students will determine the kinds of plants found in estuaries.
6. Students will compare adaptations of closely related species.
7. Students will define tides. Students will explain how tides may differ in different places in bays and from bay to bay.
8. Students will identify why the Texas coast is important to birds.
9. Students will explain the importance of conservation of water inland to healthy ecosystems and the production of seafood on the Texas Coast.
10. Students will synthesize information to develop a public information/media presentation educating the public about important issues concerning estuaries.

TEKS

6.2 C; 2.12 E; 7.2 C; 7.11 B; 8.2 C; 8.7 C; 8.11 C

Aquatic Science: 2 J; 4 A; 9 A; 10 B; 12 A, C

Environmental Science: 2 K; 5 B; 8 A; 9 A, E

Estimated Time

1 class period

Materials

Student Guide

Science journal

Pencils/pens

Procedure

1. Read the Chapter

Have students read *Chapter 11: Bays and Estuaries*. Introduce vocabulary terms as needed.

2. Questions to Consider

Assign the *Questions to Consider* as homework or use them in a cooperative learning activity.

1) How do bays differ from estuaries? How are they similar?

Bays are bodies of water partially enclosed by inward curving land that are directly open to the ocean. In Texas many bays are also estuaries. Estuaries are partly enclosed bodies of water along the coast where one or more streams or rivers enter and mix freshwater with seawater. There is not always a clear point at which the estuaries end and the bays begin. Some estuaries extend out into the Gulf where there are no bays. These places are called river deltas. Bays and estuaries are similar in that they are both partially enclosed bodies of water. They are different in that estuaries may occur where there are no bays and bays are open directly to the ocean.

2) Why is freshwater inflow important in bays and estuaries?

Freshwater inflows create salinity gradients that expand and contract with seasons, droughts, tides, and floods. Life in the estuaries has adapted to normal rainfall patterns inland. Estuaries receiving freshwater inflow from East Texas rivers are adapted to higher amounts of freshwater inflow than estuaries in South Texas, which are fed from rivers farther west that receive far less rainfall. Texas' estuaries need higher freshwater inflows during late spring and early summer. Along with freshwater, the inflows bring nutrients and sediments that support fish, wildlife, invertebrates, plankton, and wetland plants.

3) What is a hypersaline bay?

A hypersaline bay is a bay where salinity frequently exceeds that of seawater. Example: the Laguna Madre, which is technically a lagoon because it is separated from the ocean by a barrier island, is considered a hypersaline bay. It has higher salinity than the Gulf of Mexico.

4) What kind of plants are there in coastal wetlands?

As salinity increases, seagrasses replace the freshwater grasses as cover and places for animals to feed. In addition other plants in estuaries have special adaptations to survive in saturated and salty soils and water such as *Spartina* and *salicornia*.

5) *How do closely related species adapt differently to life in bays and estuaries?*

Because conditions may be very different in different bays, closely related species can have very different adaptations to survive. For example: Sea trout use the food-rich cover of seagrass beds and oyster reefs as long as the shallow waters are warm enough. When it gets too cold, seatrout move into the Gulf and wait for the bays and estuaries to warm back up. Red drum, on the other hand, stay in Texas bays and estuaries until they become mature when they move into the Gulf of Mexico and live there the rest of their lives, usually staying within about five miles of shore.

6) *What are tides? How can tides differ from place to place in a bay, and between different bays?*

Tides are the alternating rise and fall of sea level produced by the combined gravitational attraction of the moon, sun, and Earth on our oceans.

Tides differ from place to place because gravitational forces that cause tides are constantly changing and have varying effect depending on where you are located, and because of differences in the size and shapes of bays and inlets, and local wind and weather patterns.

7) *Why would you go to the Texas coast to bird watch? Why is the Texas coast important to a bird that nests in Canada or Venezuela?*

Coastal barrier islands and wetlands provide habitat and protection from storms for millions of migrating waterfowl, shorebirds, and songbirds from throughout the western hemisphere, providing rich opportunities for observation of a wide variety of birds. Texas is the winter home for many species that nest in northern areas.

3. What Is the Economics? Debate the costs and benefits to the economy of oil production versus the tourist industry, and the fishing industry.

Ask students to do some Internet research of the costs and benefits of oil production, the tourist industry, and the fishing industry in a coastal city or town of Texas. Ask each group to select a Texas coastal town or city and research the local economy. Allow 2 days of homework for research. Students should take notes in their science journals of information they discover. Students should choose what they think is the most beneficial industry for the citizens, the city, and the environment.

On the third day ask students to debate which industry is most important to the local economy oil production, the tourist industry, or the fishing industry.

4. How is the seafood we catch and eat from the Texas Coast related to water conservation in places like Dallas, Austin, Houston, and San Antonio?

Ask students to discuss the question in small groups and write down their ideas. Meet as a class and share the ideas generated.

(Cities influence the amount of inflow of fresh water to bays and estuaries, because of their large populations and therefore large water use. When they conserve water, it increases freshwater inflows providing a better mix of saltwater and freshwater for various organisms that have nurseries in bays and estuaries.)

5. Cast Beyond Tomorrow Question

Ask the class to think about this question in light of the discussion in the activity above.

- **How can you help maintain healthy coastal ecosystems in Texas?**

No matter where we live in the state, what we do affects the coastal waters. So if we conserve and maintain the quality of water in our area we are also helping conserve and maintain healthy coastal ecosystems.

6. Spreading the Word

Choose one important issue from the chapter and work with your group to develop, and present to the class, a brochure, PowerPoint slide presentation, TV public service announcement, poster, jingle or rap, or other media to help the general public learn about the importance of bays and estuaries.

Remember, these need to be short, eye catching, colorful, and entertaining as well as educational to meet the goal of keeping the attention of people and informing them of important issues.

Your group will present your project to the class. Use the *Rubric for Projects and Presentations* to help you develop and present your project.

Vocabulary

- Barrier island
- Bays
- Estuaries
- Hypersaline
- Inflows
- Migratory
- Tides

Rubric for Projects and Presentations

- I. Organization** **Total 20 points**
1. Title
 2. Clear, concise, and easy to understand information
 3. Organized in a logical way
 4. Includes photos or illustrations
- II. Appearance** **Total 10 points**
1. Neat, clean, attractive
 2. Easy to read and colorful
- III. Accuracy** **Total 20 points**
1. Includes all information
 2. Uses web sites and at least 1 book for references
 3. Information is correct and communicated appropriately
 4. Correct writing and spelling
- IV. Critical Thinking** **Total 15 points**
1. Conclusions are based on logical inferences and generalizations related to data collected on websites and in books
 2. Sources are noted.
 3. Reasons for conclusions are stated.
- V. Group Skills** **Total 20 points**
1. Works cooperatively with others
 2. All students took part in doing the tasks and in the presentation
 3. Student is willing to provide leadership and/or share ideas freely
 4. All members of the group are heard and all ideas are respected
- VI. Originality and Motivation** **Total 15 Points**
1. Project is appealing to the senses
 2. Project inspires understanding of the importance of bays and estuaries
 3. Project motivates action to protect the environment

Possible Grand Total **100 points**

Activity 11.3: Salinity

Essential Concept

Estuaries have freshwater inflows, which mix with salt water from a bay or the Gulf of Mexico. This mixture of freshwater and saltwater creates a wide variety of salinities in which many organisms can find a niche in which to survive.

Objectives

1. Students will conduct an investigation to observe the ways that saltwater and freshwater mix.
2. Students will make a diagram showing how freshwater and saltwater mix in an estuary.

TEKS

6.1 A, B; 6.2 C, D, E; 6.4 A; 6.12 E; 7.1 A, B; 7.2 C, D, E; 7.10 A; 13 A; 8.1 A, B; 8.2 C, D, E; 8.4 A, B; 8.11 B, C

Aquatic Science: 1 A, B; 2 F, G, H, J; 4 A; 9 A; 10 B, C

Environmental Science: 1 A, B; 2F, G, K; 4 B, D

Estimated Time

1 class period

Materials

Student journals

Pencils/pens

For each pair of students

Water

Graduated cylinder or measuring cup

Salt

Scale

2 clear cups or beakers

Blue food coloring

Red food coloring

Spoon

Eyedroppers (optional)

Procedure

1. Salinity

Because estuaries have differing amounts of freshwater flowing into them, the salinity of each estuary is different. We call these mixtures of freshwater and saltwater *brackish water*. In addition, depending on how close one is to the freshwater inflow, and how much mixing is going on due to winds and inflow amounts, the salinities in any one estuary will vary from location to location. All of these variables create many niches in which different types of organisms can find a home.

- **How does all this mixing of freshwater and saltwater occur?** (Students may have various ideas. Write all ideas on the board.)

Today we are going to mix freshwater and saltwater in various ways to see what happens.

2. Investigating Saltwater and Freshwater Mixtures

Use the graduated cylinder to measure 250 ml (1 cup) of water into a clear container (beaker or cup). Add 54 g (3 Tablespoons) of salt and stir until completely dissolved. Add 4 drops of yellow food coloring. This will represent salty seawater.

Measure another 250 ml of water into another clear container and add 4 drops of blue food coloring. This represents freshwater inflows.

Pour half of the saltwater into a clean, clear container. Very slowly and gently add 4 teaspoons of freshwater down the side of the cup into the salt water. Wait a few minutes for the water to settle. Be sure to observe the cup with your eye at the same level as the water. (Don't jiggle or pick up the cup. It will mix the freshwater and saltwater.)

Write your observations in your science journal.

- **What do you observe? Why do you think this happens?** (You will see 2 layers. The yellow layer on the bottom is the saltwater. It stays on the bottom because saltwater is denser than freshwater. The fresh water will mix with some of the salt water and turn from blue to green.)

Repeat the experiment, but this time, find at least 2 different ways to put the freshwater and saltwater together. (Slowly pour saltwater into freshwater, drip saltwater into freshwater, or drip fresh water into saltwater or any other ideas students may have.)

- **What do you observe?** (Answers will vary and may include one color [all green] 2 colors [green and yellow] or 3 colors blue on the top green in the middle and yellow on the bottom.)
- **Why would this layering of saltwater and freshwater be important in an estuary?** (Organisms have adapted to different salinities so having various salinities provides more kinds of places for organisms to live.)
- **What other things happening in an estuary would provide a variety of salinities to provide more places for organisms to live?** (The location in relation to the freshwater inflow and the saltwater tides—Closer to freshwater will be lower salinity and closer to the saltwater will be higher salinity. Together with the larger and smaller amounts of freshwater coming into the estuaries and along with the layering effect, many different habitats are possible. Also some

organisms are able to survive in changing salinities, which happen with each change in the tides and changes in seasons and climatic conditions such as drought.)

3. Using What You Learned

Make a diagram showing how the different salinities might occur in an estuary and **label the parts**. Be sure to include the freshwater inflow source and the saltwater source. Show the different layers. **Label your diagram showing where higher and lower salinities might occur.**

For High School

Research adaptations of 3 organisms that can survive in an estuary. Explain how these adaptations help the organism survive. Compare these adaptations to the adaptations of organisms in a freshwater environment.

Vocabulary

- Inflow
- Salinity

Activity 11.4: The Ups and Downs In an Estuary

Essential Concept

Conditions in estuaries are constantly changing.

Objectives

1. Students will play a game to model changing conditions in an estuary and the consequences for fish or other organisms living in the estuary.
2. Students draw conclusions based on what they learn from the model.
3. Students use the model to simulate biotic and abiotic changes in an ecosystem to which organisms react.
4. Students model how drought affects an estuary.
5. Students model the effects of human activity on groundwater and surface water.
6. Students model how organisms respond to external stimuli.
7. Students describe predator and prey relationships in their model.
8. Students describe how organisms depend on biotic and abiotic factors in the estuary.
9. Students describe how short and long-term changes affect organisms.
10. Students will explain the model of changing populations in an estuary and its limitations.
11. Students will identify and evaluate factors that affect aquatic populations.
12. Students will predict how loss of a particular species in a habitat may alter the food chain and affect existing populations in an estuary.
13. Students will identify the land uses of humans and affects of those uses of the land on the estuary.
14. Students will synthesize what they learned from the game in a 3-paragraph essay on affects of changes in an estuary.

TEKS

6.2 E; 6.3 C; 6.12 E; 7.2 E; 7.3 C; 7.5 A; 7.8 A; 7.13 A; 8.2 E; 8.3 C; 8.11 A, B, C

Aquatic Science: 2 F, H, J; 11 B; 12 B, C, D

Environmental Science: 2 F, I, K; 3 G; 5 A; 8 A, 9 E

Estimated Time

1 class period

Materials

Science journals

Pencils

For each team of 4 players

1 sheet of blue construction paper to represent the estuary

Goldfish Colors crackers or other tokens (approximately 40)

1 set of game cards found at the end of the activity

Special Instructions

Copy, cut and laminate a set of game cards for each group

Procedure

1. Changing Conditions

Each day conditions change in an estuary.

- **What changes can you think of that might happen in a bay or estuary?**
(Allow students to brainstorm some changes. They may come up with things like: A drought resulting in too little inflow of freshwater raising salinity, pollution from nearby farms fertilizing, fishing by humans, predators catching prey, a big hurricane, eutrophication causing red tide, boaters spilling gasoline/oil, new wildlife sanctuary, tidal changes, etc.)
- **How do you think these changes would affect organism that live in the bay or estuary?** (Some things will bring positive changes, enhancing life in the environment and some will bring negative changes that kill off some of the organisms.)

2. Playing *Ups and Downs in an Estuary*

Today we are going to play a game that simulates some of these changes and how those changes affect the populations of organisms in the estuary.

Give out the materials and the rules. Each team should begin with 24 goldfish, 6 of each color, in their estuary. Players shuffle the cards and put them in a pile in the middle of the desk, and take turns drawing a card from the pile and carrying out the instructions. Each player will use a different color of *Goldfish* to represent a different species in the estuary. When a player has no more *Goldfish* in the estuary, their species has died off and they are out of the game. Students should keep a record in their science journals the conditions that caused them to lose fish.

For High School

Instead of using 24 fish in the estuary, give each player 10 of one species of fish. (a total of 40 fish in the estuary) Keep a data table for your species. Write down the number of

fish of your species that are in the estuary for each round. Figure the mean, median, and range for your data.

Each group should discuss the fate of their estuary. If all the fish are taken out of the estuary, conditions changed to make life impossible. Look at the notes on each round of the game in your science journal. Discuss what caused the problems that killed off all of your species of fish. **Was it just one thing or did several things contribute to the disappearance of your species?**

3. Class Discussion

- **Did your estuary remain a viable habitat? Did you end with fewer fish or more fish than when you started?**
- **If you gained fish, what changes helped you add fish to your estuary?**
- **What other kinds of changes did your estuary experience?**
- **What were the results of those changes?**
- **What predator/prey relationships did you experience?**
- **How did drought affect the estuary?**
- **What were the effects of human activity on the estuary?**
- **How did organisms respond to external stimuli in the estuary?**
- **What biotic and abiotic factors that organisms depend on to survive were changed in the estuary? What were the consequences of these changes?**
- **What short and long term changes happened and how did they affect organisms in the estuary?**
- **What role did human recreation, fishing, and transportation activities have on the estuary?**
- **What role did humans have in eutrophication in the estuary? How was land use related to this change? What are the costs and benefits of using fertilizer for farming? Is the trade-off worth it? Are there other methods that could be considered?**
- **What factors affected the aquatic population of your estuary and which of those factors was the most important in determining the final population?**
- **What was the cumulative effect of humans on the estuary?**
- **If all of your fish population was taken out and your species were gone from the estuary, how might that alter the food chain and affect existing populations in the estuary?**
- **How is this model like a real estuary?**
- **How is this model different from a real estuary?**
- **What are the limitations of our model?**

4. Using What We Learned

Ask students to write a 3-paragraph essay in their science journals summarizing what happened in their estuaries illustrating the effects of change and answering these questions. You may wish to use the game cards as your data for writing your essay. Classify each card by the type of change it represents (predator, freshwater inflow changes, human pollution, human conservation, human recreation, etc.) Further categorize the cards by classifying each set you have made as either short-term or long-term changes. Examine each category to see the impact of these kinds of changes. Use this information to help you draw some conclusions about the effects of changes in an estuary.

Paragraph 1

- **Were there many changes in the estuary? What were some of them?**
- **What caused the changes?**
- **Was there one big thing that caused the most problems? Or were there many things that contributed to any problems in the estuary?**

Paragraph 2

- **Is there anything that you learned that you could do that would help the estuary? What would that be and how would it help?**

• **Paragraph 3**

- **What conclusions can you draw about the effects of changes in the estuary from what you learned in the *Ups and Downs in an Estuary* game?**

Vocabulary

- Artificial reef
- Estuary
- Fertilizer
- Habitat
- Inflows
- Pesticide
- Pollution

Rules for Ups and Downs in the Estuary

You will need:

- 1 sheet of blue construction paper to represent an estuary
- 24 Color Goldfish (6 of each color) in your estuary
- 30 extra Goldfish
- A set of cards

- 1) **Put your estuary in the middle of the desk and add 12 goldfish. Each player will represent one color (or species) of fish.**
- 2) **Assign one person to be the aquatic biologist and keep the rest of the fish at the fish hatchery.**
- 3) **Shuffle the cards and put them in the middle of the desk next to your estuary.**
- 4) **Take turns drawing a card from the stack and completing the action on the card, adding or taking away fish as directed. You can only take out your own fish. The aquatic biologist can add fish to any species that still has fish in the estuary.**
- 5) **You are out of the game when your fish are all gone from the estuary.**
- 6) **The game continues until all cards have been drawn or your estuary has no fish left.**

Read the following information:

Estuaries and bays are transition zones between the land and the ocean along the coast. This is where rivers meet the ocean, mixing freshwater that has travel from far inland with the saltwater of the Gulf of Mexico. We call this *brackish* water. Conditions are always changing in an estuary.

Life in estuaries has adapted to receiving freshwater inflow bringing water, nutrients, and sediments that nourish fish, wildlife, invertebrates, plankton, and wetland plants. This shallow water is the nursery for many aquatic organisms including fish, shrimp and crabs. Estuaries often have a high biodiversity.

Sometimes pollution also comes with the inflow of water. This pollution may include fertilizers that cause algae to grow and too much algae can cause loss of light and result in death of the algae. Decay of the algae can use up all the oxygen in the water. When there is not enough oxygen, fish and other organisms can die.

Sometimes people can come to clean up trash in the water or set aside habitat for wildlife or they just follow the rules for catching only the appropriate number and size of fish. This helps species survive.

Many things can happen in a bay or estuary. Lets find out what happens in your estuary.

Ups and Downs in the Estuary Game Cards

<p>Spotted Seatrout closes in on a school of smaller fish.</p> <p>TAKE OUT 3 FISH</p>	<p>Mr. Farmer sprayed pesticide for insects in his field on the edge of the waterway. When it rained, the runoff killed 3 fish</p> <p>TAKE OUT 3 FISH</p>
<p>The Legislature just passed legal protection for your fish species.</p> <p>ADD 5 FISH</p>	<p>Volunteers do a “Clean the Wetland” day in the estuary.</p> <p>NO FISH LOST</p>
<p>Mrs. Gardner fertilized her tomato crop. Extra algae grew in the water. Fish die.</p> <p>TAKE OUT 2 FISH</p>	<p>Drought has limited freshwater inflow. Salinity is very high. The fish nursery has lost 3 fry.</p> <p>TAKE OUT 3 FISH</p>
<p>3 Fish are caught by vacationers</p> <p>TAKE OUT 3 FISH</p>	<p>Seagrasses hold soil, stop erosion, and create places for organisms to take cover</p> <p>Add 3 fish</p>
<p>A new marina just opened and attracts 20 old boats that leak oil to stay in the estuary.</p> <p>LOSE 3 FISH</p>	<p>Rain in the watershed increases freshwater inflows to help keep the habitat healthy</p> <p>ADD 3 FISH</p>
<p>A boater spilled a can of gasoline in the water and 3 fish died.</p> <p>TAKE OUT 3 FISH</p>	<p>A seagull flies over and eats a fish for dinner.</p> <p>TAKE OUT 1 FISH</p>

<p>The estuary is left undisturbed.</p> <p>ADD 2 FISH</p>	<p>New fry hatch.</p> <p>ADD 3 NEW FISH</p>
<p>Industrial pollution in the water kills fish.</p> <p>TAKE OUT 6 FISH</p>	<p>A vacationing family went fishing. Mr. and Mrs. Thompson, little Tim, and Tina. They caught 4 fish and released one.</p> <p>TAKE OUT 3 FISH</p>
<p>Plants conduct photosynthesis adding more oxygen to the water for more fish.</p> <p>ADD 2 FISH</p>	<p>Someone builds a new dock without a permit. Fish are killed when pilings damaged their habitat.</p> <p>TAKE OUT 2 FISH</p>
<p>The area becomes a protected wildlife area and fishing is prohibited.</p> <p>ADD 5 FISH</p>	<p>A big algae bloom due to over fertilization of a golf course. No oxygen left in the water.</p> <p>TAKE OUT 8 FISH</p>
<p>A fish ate a plastic bag that Mr. Thompson lost while fishing. The fish dies.</p> <p>TAKE OUT 1 FISH</p>	<p>Oyster shells are recycled to build an artificial reef. New habitat for fish.</p> <p>ADD 3 FISH</p>
<p>A fish ate a piece of plastic foam floating in the water and dies.</p> <p>TAKE OUT 1 FISH</p>	<p>Seagrasses restored making new nurseries.</p> <p>ADD 5 FISH</p>

Questions to Answer in your Essay

Directions

Write 3 paragraphs in your science journal summarizing what happened in your estuary illustrating the affects of change and answering these questions.

Paragraph One:

- **Were there many changes in the estuary? What were some of them?**
- **What caused the changes?**
- **What effect did these changes have on the organisms in the estuary?**
- **Was there one big thing that caused the most problems? Or were there many things that contributed to any problems in the estuary?**

Paragraph Two

- **Is there anything that you learned that you could do that would help the estuary? What would that be and how would it help?**

Paragraph Three

- **Based on the model in the *Ups and Downs in an Estuary* game, what conclusions can you draw about the effects of changes in an estuary?**

Activity 11.5: Ecosystem Services

Essential Concept

Bays and estuaries provide ecological services that benefit everyone by providing resources and processes to help maintain a healthy environment.

Objectives

1. Students will work cooperatively to learn information about ecosystem services.
2. Students will classify ecosystem services into appropriate categories.
3. Students will teach others about the ecosystem service which their group studied.
4. Students will describe how biotic and abiotic parts of the ecosystem contribute to ecosystem services.
5. Students will describe how biodiversity contributes to the sustainability of an ecosystem.
6. Students will describe how short and long-term environmental changes affect organisms and traits in subsequent populations.
7. Students will describe how organisms and populations in an ecosystem depend on and may compete for biotic and abiotic parts of the ecosystem.
8. Students will describe human dependence on ocean systems and explain how human activities have modified these systems.
9. Students will explain how human activity is affecting aquatic viability in the local bay and estuary.
10. Students will synthesize information on ecosystem services to write a TV news story.

TEKS

6.2 C; 6.12 E; 7.2 C; 7.10 B; 8.2 C; 8.11 B, C, D

Aquatic Science: 2 J; 3 B; 12 A, B, D

Environmental Science: 2 K; 3 B; 8 B; 9 A, D

Estimated Time

1 class for jigsaw and writing, with possible homework to finish writing assignment,
1 or 2 class periods for presenting news stories and discussion depending on size of class

Materials

Copies of *Ecosystem Services Cards*

Science journals

Pencils/pens

Special Instructions

Copy, cut apart, number from 1-8 on the back, and laminate the *Ecosystem Services Cards*.

Procedure

1. Jigsaw

Ask students to number off from A to D. Ask each group (Group A, etc.) corresponding to each of the ecosystem service categories below, to move to different corners of the room. These will be the *Expert Groups*. Each *Expert Group* will receive one type of *Ecosystem Service Cards* to learn about one of the 4 types of ecosystem services with some concrete examples. These cards should all be one category of ecosystem service, but the teacher will not tell them which ecosystem service category they have.

Put the definitions of the ecosystem service categories on the board and ask students in each group to discuss their cards and decide which ecosystem service their group is discussing.

Ecosystem Service definition:

Ecosystem services are **resources** and **processes** that are supplied by ecosystems, generally grouped into four broad categories:

- **Group A, Provisioning Services:** providing products from the ecosystem such as food, fiber, and water.
- **Group B, Regulating Services:** services that maintain climate, and disease control such as improving water and air quality.
- **Group C, Supporting Services:** materials needed for production of all other ecosystem services including nutrient cycles, oxygen and carbon cycles, erosion control and habitat preservation.
- **Group D, Cultural Services:** including intangibles such as artistic inspiration, spiritual renewal, education, and recreation.

Each member of the group will receive a numbered ecosystem service card.

Group members will share their information with each other so that all learn about the particular ecosystem service category. The group should talk about their cards and decide what ecosystem service the group is learning about and find the best way to teach all of the information about their ecosystem service category to other students. Students should take notes in their science journals to help them teach other members of the class. These experts will disperse and reform in **new groups based on the numbers on their numbered ecosystem service cards**. All the ones together, all the twos, threes, and fours, etc. will form new groups in which they will teach the other members of the new group about their ecosystem service, and learn about each of the other group member's ecosystem services. (This will give 8 groups each with one member from the original 4 groups.) All students should make notes on what they learn from the other group members to use later in synthesizing what they have learned.

2. Using What We Learned

When each student has learned about all four types of ecosystem services, students will go back to their desks and work in pairs or individually (their choice) to **research and write a television news story (3–5 minutes long: NO MORE THAN 5 MINUTES LONG)** about ecosystem services in a bay front community. (Give your community a name.) The student should choose one question from each of the 3 categories and answer these questions in their news story. Be sure that all questions are covered by at least 1 of the news stories. **Note: Category 1 only has one question, which is required.**

Category 1: Required

- **How do these ecosystem services contribute to the community economy, health, character?**

Category 2

- How do biotic and abiotic parts of an ecosystem contribute to ecosystem services?
- How does biodiversity contribute to the sustainability of an ecosystem?
- How do short and long term environmental changes affect organisms and traits in subsequent populations?
- How do organisms and populations in an ecosystem depend on and compete for biotic and abiotic factors in the ecosystem?

Category 3

- How are humans dependent on ocean systems and how have human activities modified these systems?
- What is the result of human activities on the ability of bays and estuaries to provide the ecosystem services needed by the community?
- How is human activity affecting aquatic viability in the local bay and estuary?
- How does the community plan and implement conservation?

3. TV News Story Presentations

Provide time for each group or (in some cases) individuals to present their news story. Allow a few minutes for questions from the class or discussion of issues with each story.

4. Summary Paragraph

At the end of the presentations, ask the class to summarize what they have learned about ecosystem services in a paragraph in their journals.

Vocabulary

- Cultural
- Ecosystem services
- Provisioning
- Regulating
- Supporting

ECOSYSTEM SERVICES CARDS

PROVISIONING SERVICES

<p>Seagrasses</p> <p>Ecosystem Service: Production of oxygen</p> <p>Benefit: Oxygen essential for life.</p>	<p>Healthy Plants and Animals</p> <p>Ecosystem Service: Food Production</p> <p>Benefit: Sustains life. Estuary nurseries are critical to continued supply of fresh seafood.</p>
<p>Oyster Reefs</p> <p>Ecosystem Service: Food Production</p> <p>Benefits: Maintains life Economic benefits</p>	<p>Spotted Seatrout</p> <p>Ecosystem Service: Food Production</p> <p>Benefit: Maintains life Economic benefits</p>
<p>Red Drum</p> <p>Ecosystem Service: Food Production</p> <p>Benefit: Sustains life, enhances the economy.</p>	<p>Crabs</p> <p>Ecosystem Service: Food Production</p> <p>Benefit: Maintains life. Economic benefits</p>
<p>Oyster Reef</p> <p>Ecosystem Service: Filters water</p> <p>Benefit: Clean water for people and the ecosystem. Maintains life.</p>	<p>Shrimp</p> <p>Ecosystem Service: Food Production</p> <p>Benefit: Maintains life. Economic benefits</p>

CULTURAL SERVICES

<p>Beauty of Nature</p> <p>Ecosystem Service: Recreation Motivation</p> <p>Benefit: Exercise and relaxation such as walking, camping, fishing, hunting, swimming, nature study, photography, birding.</p>	<p>Natural Sounds and Sights</p> <p>Ecosystem Service: Spiritual Renewal</p> <p>Benefit: Find inner peace, become one with nature.</p>
<p>Biodiversity and Abiotic Cycles</p> <p>Ecosystem Service: Education</p> <p>Benefit: Learning about cycles, patterns, and functions of nature. Learn about and participate in conservation.</p>	<p>Beauty and Complexity of Nature</p> <p>Ecosystem Service: Arts Inspiration</p> <p>Benefit: Aesthetic response in artistic ideas in various forms including painting, photography, sculpture, writing, and music.</p>
<p>Beauty, Warmth, Peace of Nature</p> <p>Ecosystem Service: Recreation</p> <p>Benefit: Attracts people to find winter homes for those who live in colder climates. Economic benefits</p>	<p>Beauty and Peace of Nature</p> <p>Ecosystem Service: Recreation</p> <p>Benefit: Vacation spots for families, seniors, and students to relax and get away from day to day responsibilities. Economic benefits</p>
<p>Endangered Species</p> <p>Ecosystem Service: Recreation</p> <p>Benefit: Eco-tourism. Brings many birders, enhancing the economy.</p>	<p>Abundant Aquatic Species</p> <p>Ecosystem Service: Recreation</p> <p>Benefit: Many opportunities for fishing and observing wildlife. Economic benefits</p>

SUPPORTING SERVICES

<p>Freshwater Inflows</p> <p>Ecosystem Service: Habitat</p> <p>Benefit: Freshwater mixing with saltwater provides varying salinities for a variety of niches. Provides food, shelter, water, and space for fish, plants, and other aquatic organisms.</p>	<p>Photosynthesis</p> <p>Ecosystem Service: Gas Regulation</p> <p>Benefits: Clean, breathable air, and dissolved oxygen in water for living things.</p>
<p>Wetlands and Barrier Islands</p> <p>Ecosystem Service: Protection from storms for people and nature</p> <p>Benefit: Helps prevent damage and flooding</p>	<p>Plants</p> <p>Ecosystem Service: Nutrient Cycling</p> <p>Benefit: Help maintain nitrogen balance.</p>
<p>Seagrasses</p> <p>Ecosystem Service: Erosion Control</p> <p>Benefit: Retain soil and take sediments out of the water. Maintains cleaner water.</p>	<p>Abiotic and Biotic Cycles</p> <p>Ecosystem Service: Habitat</p> <p>Benefit: Maintain biodiversity and a healthy ecosystem. Provides food, water, shelter and space for a wide variety of organisms including migratory birds, shore birds, and songbirds.</p>
<p>Seagrasses</p> <p>Ecosystem Service: Nursery Habitat</p> <p>Benefit: Helps maintain the numbers of shrimp, fish, and shellfish. Increased nursery area increases catch for fishermen. Provides employment and economic activity.</p>	<p>Oyster Reefs</p> <p>Ecosystem Service: Habitat.</p> <p>Benefit: Increases places for fish, invertebrates and other organisms to live.</p>

REGULATING SERVICES

<p>Plants</p> <p>Ecosystem Service: Absorb carbon dioxide</p> <p>Benefit: Clean air and helps maintain healthy climate.</p>	<p>Gulf of Mexico</p> <p>Ecosystem Service: Sink for carbon dioxide.</p> <p>Benefit: Maintain healthy climate.</p>
<p>Oyster Reefs</p> <p>Ecosystem Service: Filters wastes from industry.</p> <p>Benefit: Help provide clean water to prevent disease.</p>	<p>Soils</p> <p>Ecosystem Service: Absorb water and capture waste products.</p> <p>Benefit: Soils help clean water to prevent disease.</p>
<p>Wetland Organisms</p> <p>Ecosystem Service: Cycling biotic and abiotic materials.</p> <p>Benefit: Helps maintain healthy ecosystems to prevent disease.</p>	<p>Wind off of the Water</p> <p>Ecosystem Service: Brings clean air onshore</p> <p>Benefit: Improves air quality to prevent disease.</p>
<p>Ocean</p> <p>Ecosystem Service: Evaporation for the water cycle</p> <p>Benefit: Keep freshwater inflows coming into estuaries and bays keeping them healthy and functioning to maintain climate and prevent disease.</p>	<p>Wetland Plants</p> <p>Ecosystem Service: Treating municipal waste.</p> <p>Benefit: Clean water and prevent disease.</p>

Rubric for Stories

I. News Story for Television 25 points

1. The beginning gets the reader's attention.
2. The story has local interest.
3. The purpose of the story is clear and provides details.
4. The story is no longer than 5 minutes.

II. Organization 25 points

1. Information is clear and concise.
2. The story has a beginning, middle, and end.
3. Ideas for video footage to illustrate important points is included.

III. Accuracy 25 points

1. Includes all 4 types of ecosystem services.

Answers at least one question from each of the following categories:

Note: Category 1 only has one question, which is required.

Category 1: Required

1. How do these ecosystem services contribute to the community economy, health, character?

Category 2

1. How do biotic and abiotic parts of an ecosystem contribute to ecosystem services?
2. How does biodiversity contribute to the sustainability of an ecosystem?
3. How do short and long term environmental changes affect organisms and traits in subsequent populations?
4. How do organisms and populations in an ecosystem depend on and compete for biotic and abiotic factors in the ecosystem?

Category 3

1. How are humans dependent on ocean systems and how have human activities modified these systems?
2. What is the result of human activities on the ability of bays and estuaries to provide the ecosystem services needed by the community?
3. How is human activity affecting aquatic viability in the local bay and estuary?
4. How does the community plan and implement conservation?

IV. Grammar and Punctuation

25 points

1. Stories should be neatly written.
2. Story uses complete sentences.
3. Story uses appropriate punctuation.
4. Story uses correct spelling.

Chapter 11: Assessment

Directions

Select the best answer for each of the following multiple-choice questions.

Seagrasses have special roots that let them live in the somewhat salty water where rivers meet the ocean. These roots collect sediments, debris, and mud. Seagrasses also provide shelter for wildlife.

- 1. The high winds of hurricanes often destroy seagrasses. The destruction of these plants most likely affects ecosystems by _____ .**
 - A Reducing beach erosion in sea-turtle nesting areas.
 - B Reducing the amount of saltwater flowing into lakes.
 - C Forcing aquatic organisms to find other places for nurseries.
 - D Causing pollution in inland rivers and streams.

- 2. How does freshwater inflow affect bays and estuaries?**
 - A Provides freshwater for plants.
 - B Provides for many niches in an estuary ecosystem.
 - C Provides nutrients to feed fish, wildlife, and invertebrates.
 - D B and C.

- 3. Tides are:**
 - A Variable, but predictable.
 - B Heights and timings vary daily.
 - C Produced by the gravitational attraction of the Moon, Sun, and Earth on our oceans.
 - D All of the above.

Use the following data to answer question number 4.

A marine biologist does an investigation into the salinity of bays in Texas to study optimum salinities for oyster reefs. Salinity is measured in parts per thousand (ppt).

Source of Sample	Salinity Reading
Seawater	35 ppt
Bay 1	19 ppt
Bay 2	38 ppt
Bay 3	15 ppt

4. Based on the data of the biologist, which bay is hypersaline?

- A Bay 1
- B Bay 2
- C Bay 3
- D None of the above

5. Seagrasses:

- A Are related to algae.
- B Have strong supportive stems.
- C Provide nurseries for young organisms and reduce erosion.
- D Are not affected by extreme currents.

4. Why are oysters important?

5. What are some adaptations that help spotted seatrout and red drum to survive in bays and estuaries?

Chapter 11: Assessment Answer Key

Directions

Select the best answer for each of the following multiple-choice questions.

- 1. The high winds of hurricanes sometimes destroy seagrasses. The destruction of these plants most likely affects ecosystems by _____ .**
C Forcing aquatic organisms to find other places for nurseries.
- 2. How does freshwater inflow affect bays and estuaries?**
D B and C
- 3. Tides are:**
D All of the above
- 4. Based on the data of the biologist, which bay is hypersaline?**
B Bay 2
- 5. Seagrasses:**
C Provide nurseries for young organisms and reduce erosion.

Chapter 11: Assessment Answer Key

1. How do bays and estuaries contribute to the economy of Texas?

One third of the oil and gas production in the United States takes place on the Texas coast providing many jobs contributing to the Texas economy. Texas also has 10 large seaports and 420 miles of the Gulf Intracoastal Waterway providing opportunities for shipping for industry. Texas estuaries produce up to \$250 million per year in seafood. Tourism is the third largest industry in Texas after oil and gas, and agriculture, providing \$5.4 billion in economic activity.

2. What kinds of changes happen in an estuary and what are the affects on organisms that live there?

Changes occur in the amount of freshwater inflow, which can provide variation in salinity that may provide more habitat choices for organisms.

Photosynthesis increases oxygen in the water increasing the number of organisms that can survive.

Seagrasses hold soil and stop erosion and create places for organisms to take cover.

New organisms hatch providing more populations of species.

People can improve habitat in the estuary when they volunteer to clean up the wetland, restore oyster reefs and seagrass beds, leave the estuary undisturbed or protect a wildlife area. Legislation can protect various threatened or endangered species.

People also can damage habitat by using pesticides and fertilizers or allowing industrial pollution that can run off into the estuary causing eutrophication and fish kills. People also cause death of organisms when they leave behind litter and plastic and inedible baits or fishing line, or spill gasoline or oil into the water.

Increasing human use by building new docks or marinas increases pollution, which can cause deaths of organisms.

Fishing without paying attention to size and number limits reduces fish populations.

Predators eat some organisms to continue the food web.

3. What are some examples of ecosystem services of bays and estuaries and why are they important?

Treating municipal wastes and diluting industrial discharges, are ecosystem services of bays and estuaries.

Wetlands also protect communities from storm surges.

There are four types of ecosystem services:

- 1) Provisioning services such as food and fiber production and water.
- 2) Regulating services such as control of climate and disease, and water and air quality.

- 3) Supporting services such as nutrient cycles, erosion control, habitat provision, and crop pollination.
- 4) Cultural services such as spiritual, educational, and recreational opportunities.

Ecosystem services are important, because they help us clean up our environment, produce materials we need, keep our ecosystems going and help maintain a stable climate. For humans to carry out all these tasks would be very expensive and difficult, requiring intense research, effort, time, and expense.

4. Why are oysters important?

Oysters are important because they provide essential habitat and nursery areas for important seafood species. They help clean up pollution by filtering water through their gills. They are also one of our most important seafoods. As such oysters provide jobs that are an important part of the coastal economy.

5. What are some adaptations that help spotted seatrout and red drum to survive in bays and estuaries?

Spotted seatrout spawn in coastal bays, estuaries, and lagoons in shallow grassy areas where eggs and larva have cover from predators. They prefer to remain near seagrass beds and oyster reef throughout their lives, but they have adapted to move into the Gulf of Mexico if this shallow water gets too cold in the fall and winter. As water temperatures warm in the spring and summer, they return to the bays and estuaries.

Red drum adults live in the Gulf of Mexico. However they spawn in high salinity waters near an entrance to a bay where high tidal current flow will carry the eggs and larval fish into the bay and estuary. These young red drum live in the shallow water where there are seagrass beds. They are also found around other structures, such as along jetties and pier pilings. They stay in Texas' bays and estuaries until they become mature. Then they move into the Gulf of Mexico and live there the rest of their lives, usually staying within 5 miles of shore.