Ups and Downs in an Estuary
Whooping Crane Dilemma

Modified from Texas Aquatic Science and Estuaries in the Balance Curriculum

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
- You will need to have some 3-dimensional small objects that represent food resources for the whooping crane:
  - 60 crabs
  - 100 wolfberries
  - 100 bugs and small fish
  - Ideas for these symbolic foods are: poker chips, large beads, small craft pom poms, marbles, small toy insects, cotton balls, q-tips, packing peanuts, etc.
- 1 set of cut out and shuffled model cards found at the end of the activity.
- Internet access to watch the video “Bays and Estuaries” from Texas Aquatic Science, Chapter 11. http://texasaquaticscience.org/bays-estuaries-aquatic-science-texas/#!prettyPhoto
- One bird beak puppet per student. Students can fold and create the puppets themselves, use chopsticks, or clothespins. However, you may choose to make sock puppets or have students imagine that they are whooping cranes by using their hands to symbolize crane beaks, instead.

Lesson Objectives

1. Students will interactively 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 whooping crane and other estuary populations.
12. Students will predict how loss of a particular species in a habitat may alter the food chain and effect existing populations in an estuary.
13. Students will identify the land uses of humans and effects of those uses of the land on the estuary.
14. Students will synthesize what they learned from the model in a 3-paragraph essay on effects of changes in an estuary.

**Important Vocabulary**

- **Salinity** – the amount of salt content in a body of water. The more salt, the higher the salinity.
- **Estuary** – the body of water where freshwater from rivers and streams meets saltwater bays and oceans. This area has lower salinity levels than the ocean.
- **Fertilizer** – nutrients added to vegetation to encourage healthy growth. However, when fertilizer from the land flows into bodies of water, it can create an overpopulation of algae. Eventually, the algae will die, and be consumed by bacteria. This bacteria becomes over populated, consuming the available oxygen in the water (dissolved oxygen). Many aquatic organisms then die due to the lack of oxygen.
- **Habitat** – The type of shelter, food, space, and water availability needed for a species.
- **Freshwater inflows** – The freshwater that flows into a bay or ocean from a river or stream.
- **Pesticide** – A chemical that kills pests, such as insects that eat crops, sprayed often on lawns and farmland.
- **Pollution** – A substance introduced into the environment that is harmful or poisonous to organisms in that environment.
**TEACHER PAGE**

**Engagement and Lesson Procedure Overview**

**Engagement:** Ask students what they know about bays and estuaries. You might ask them, if they are unsure, what they know about the Gulf of Mexico, Texas beaches, or oceans, depending on their backgrounds. Write their comments on the board.

**Video:** Have students watch the Texas Aquatic Science Chapter 11 Bays and Estuaries film clip: [http://texasaquaticscience.org/bays-estuaries-aquatic-science-texas/](http://texasaquaticscience.org/bays-estuaries-aquatic-science-texas/)

Discuss with the students whether or not they learned anything new about bays and estuaries, and ask them to write down a question they may have about them. Ask them to determine if their question is answered by the end of the activity.

**Playing *Ups and Downs in an Estuary***

- Explain to the students that they are going to participate in a model that simulates changes in an estuary and how those changes affect the populations of organisms in the estuary. Each day conditions change in an estuary.

- Have students read the following information about estuaries and whooping cranes provided in the “Student Pages”. Strategies for this may include creating literacy groups to work in for synthesis of the information.

Estuaries and bays are transition zones between the land and the ocean along the coast. This zone is where rivers meet the ocean, mixing freshwater that has traveled from far inland with the saltwater of the Gulf of Mexico. The mixed salt and fresh water is called brackish water. Conditions are always changing in an estuary. Freshwater flows from San Antonio River and Guadalupe River into the saltwater of San Antonio Bay. The process is called freshwater inflows and decreases salinity levels.

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

Blue crab populations, like many estuarine organisms, thrive on highly variable degrees of salinity in the estuary. However long, sustained periods of lack of fresh water inflows into the bay, usually due to drought in the watershed, might negatively impact the population. Like many of the estuary organisms, blue crab are also negatively impacted by pollutants, over fishing, and human population growth and building development.

A population of whooping cranes, which is a species of bird that is critically endangered, migrates from Wisconsin and Canada to the bays and estuaries near San Antonio Bay, in the winter. The whooping crane’s primary foods in the estuary are blue crabs and wolf berries, which is a small red berry. When these foods are readily available, the whooping crane can store the energy needed to fly north in the summer. Whooping cranes can eat other foods, such as bugs, acorns, and small fish, but as a last resort.
Teacher Page

- Give out the whooping crane puppets, 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.

- Students should keep a record in their science journals the conditions that caused them to lose whooping crane food resources.

- When there are no more cards to read, students should discuss the fate of their whooping crane population. Discuss what caused the problems and solutions that impacted the blue crab, the wolf berries, and whooping crane.
Teacher Page

*Class Discussion* – Once the model is finished, review the following questions in a class discussion. Ideas for teaching strategies for this discussion include Philosophical Chairs and Think-Pair-Share.

- Did your estuary remain a healthy habitat? Did you end with fewer whooping cranes or more whooping cranes than when you started?
- If you gained blue crab, what changes helped you add blue 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 whooping crane and food source 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? Why would certain positive of negative impacts have a larger value than others?
- 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?
Rules for Ups and Downs in the Estuary Model

You will need:
1 large space representing the estuary
60 “blue crabs”
100 “wolf berries”
100 “other foods”
1 origami beak per student to pick up “food”
1 small bag / student to represent a crane’s “stomach”

*The more difficult it is to place objects in the bag, the better. This will slow the game down for a better model.

A set of estuary cards, printed, cut, shuffled and stacked.

Teacher Set-up:

1.) Select one area of the estuary to scatter the blue crabs. Select a different area to scatter the “wolf berries” and another to scatter “other foods.”
2.) Students are to imagine they are a whooping crane, with the optional origami beak and small bag or bowl representing their stomachs.
3.) One winter season is represented by a 15 second period in which the “cranes” will need to forage and consume (or collect into small bags) a total of 9 energy points to survive, migrate, and return to the estuary the next winter. They will need a total 12 to reproduce over the summer.

1 Blue Crab = 5 energy points
1 Wolf Berry = 2 energy points
1 Other Food = 1 energy points

4.) Assign one person to be the aquatic biologist. This student will be the person drawing and reading from the cards.
5.) Divide the class into 3rds. One-third of the class will represent the founding population of whooping cranes and report to the “estuary.” The remaining two-thirds are waiting to be a new generation of whooping cranes if members of the founding population are successful in gathering 12 energy points.

Modeling the Whooping Crane Population – remind students that this is not a game, but a model. At times, a whooping crane might perish. While it is up to the teacher to determine the best way to resolve which “cranes” will have to come to the side line, it is advisable to ask students who would be willing to volunteer to leave the population ahead of time with an incentive.

1.) Begin the model by having the founding whooping crane population report to the estuary. Take note on the board how many cranes are in the estuary.
2.) Tell them that 15 seconds represents one winter season before the population flies to Canada for the summer to reproduce.
3.) Tell them **1 Blue Crab = 5 energy points, 1 Wolf Berry = 2 energy points, and 1 Other Food = 1 energy points** (This can be written on the classroom board).

4.) Tell them the goal is to determine what positively and negatively impacts whooping crane populations. Explain that to survive they will need to “consume” (or pick up and put in their “stomach”) at least 9 energy points to be a survivor until the next season and 12 energy points to reproduce. If a crane is successful at consuming 12 or more points, then one more crane will be allowed into the estuary representing reproduction of offspring. If they do not obtain at least 9 points, they perish, and return to the sideline.
   a.) Food items not in the “stomach” do not count.
   b.) As the model progresses there is a chance that a crane that has perished will return to the estuary as a new offspring in the population if another crane is successful at reproducing.

5.) Start the timer and tell students to commence foraging. After 15 seconds, cranes will stop and count the points in their “stomachs”, determine if they were successful survivors or reproducers, and proceed accordingly. Record the number of cranes after each round.

6.) Students will then return the contents of their stomachs to the areas of the estuary that they collected them from, to prepare for the next season.

7.) Repeat steps 1-6 twice more. This will have represented 3 years of a normal, healthy estuary, free of human impact.

8.) The aquatic biologist will draw a card from the stack and read the action on the card, adding or taking away food items as directed. Be sure to record the number of cranes in the population after each round.

9.) Students are to keep playing until the whooping crane population is either extinct or the cards run out.

10.) Once the model is completed students will discuss the questions provided.

**Alternative set-up for younger or special needs groups:**

1.) Have all the students begin the model as whooping cranes all at once.

2.) Start the timer and tell students to commence foraging. After 15 seconds, cranes will stop and count the points in their “stomachs”, determine if they were successful survivors.

3.) If they “survived”, they may participate in the next round.

4.) The aquatic biologist will draw a card from the stack and read the action on the card, adding or taking away food items as directed. Be sure to record the number of cranes in the population after each round.
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 model 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* model?
The San Antonio Bay

Estuaries and bays are transition zones between the land and the ocean along the coast. This zone is where rivers meet the ocean, mixing freshwater that has traveled from far inland with the saltwater of the Gulf of Mexico. The mixed salt and fresh water is called \textit{brackish} water. Conditions are always changing in an estuary. Freshwater flows from San Antonio River and Guadalupe River into the saltwater San Antonio Bay. These are called freshwater inflows and the process decreases \textit{salinity} levels.

Estuaries often have high \textit{biodiversity}. Life in estuaries has adapted to receiving freshwater inflows that bring water, nutrients, and mineral 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.

\textit{Blue crab} populations, like many estuarine organisms, thrive on highly variable degrees of salinity in the estuary. However long, sustained periods of lack of fresh water inflows into the bay, usually due to drought in the watershed, might negatively impact the population. Like many of the estuary organisms, blue crab are also negatively impacted by pollutants, over fishing, and human population growth and building development.

A population of \textit{whooping cranes}, which is a species of bird that is critically endangered, migrates from Wisconsin and Canada to the San Antonio Bay area in the winter. The whooping crane’s primary foods in the estuary are blue crabs and wolf berries, which is a small red berry. When these foods are readily available, the whooping crane can store the energy needed to fly north in the summer.

Many things can happen in a bay or estuary. Let’s find out what happens in your model estuary!
**Vocabulary**

- **Biodiversity** - the variety of life found in an area; how many different organisms are found in an area. For example, an area with 15 different species would have greater biodiversity than an area with 12.

- **Estuary** – the body of water where freshwater from rivers and streams meets saltwater bays and oceans. This area has lower salinity levels than the ocean.

- **Fertilizer** – nutrients added to vegetation to encourage healthy growth. However, when fertilizer from the land flows into bodies of water, it can create an overpopulation of algae. Eventually, the algae will die, and be consumed by bacteria. This bacteria becomes overpopulated, consuming the available oxygen in the water (dissolved oxygen). Many aquatic organisms then die due to the lack of oxygen.

- **Freshwater inflows** – The freshwater that flows into a bay or ocean from a river or stream.

- **Habitat** – The type of shelter, food, space, and water availability needed for a species.

- **Pesticide** – A chemical that kills pests, such as insects that eat crops, sprayed often on lawns and farmland.

- **Pollution** – A substance introduced into the environment that is harmful or poisonous to organisms in that environment.

- **Salinity** – the amount of salt content in a body of water. The more salt, the higher the salinity.
Using What We Learned

Write a 3-paragraph essay in your science journals summarizing what happened in the model estuary evaluating the effects of change by answering the questions below. You may wish to use the model cards as your data for writing your essay.

For example, it may help to classify each card by the type of change it represents (predator, freshwater inflow changes, human pollution, human conservation, human recreation, etc.) Or 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 Model*?
### Ups and Downs in the Estuary Game Cards

- **The estuary is left undisturbed.**
  - Add 2 handfuls of crabs and a handful of wolfberries.
  - Adult blue crab return to the estuary.
  - Add one handful of crabs

- **Industrial pollution from a factory on the San Antonio River flows into the estuary. Wildlife dies.**
  - Remove 4 handfuls of crab.
  - A vacationing family went crabbing and caught 10 blue crab, but released the females.
  - Remove 1 handful of crab.

- **Three hundred acres of sea grass areas provides more oxygen into the water through photosynthesis.**
  - Add 2 handfuls crab.
  - Someone builds a new beach house with a dock in areas used by whooping cranes, destroying areas of wolf berries, blue crab habitat. The whooping crane pair is forced to move.
  - One whooping crane dies. Remove approximately 3 handfuls of crab.

- **1000 acres of estuary becomes protected wildlife area.**
  - Add 5 handfuls of crab and 2 handful of wolf berries.
  - A golf course near the estuary uses too much fertilizer which gets washed away into the bay after a storm. A big algal bloom occurs, eventually leaving no oxygen in the water.
  - Remove 4 handfuls of crab.

- **A whooping crane gets caught in a fishing line.**
  - One crane dies.
  - A fresh water pond is created to provide fresh water to the terrestrial (land-based) wildlife, including the Whooping Crane.
  - No loss.

- **A young whooping crane mistakes a piece of plastic foam for food.**
  - One crane dies.
  - 100 acres of sea grasses are restored creating nursery habitats.
  - Add 2 handful of crab.
<table>
<thead>
<tr>
<th>Event</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe and long-term drought keeps plants like oak and wolfberry from producing fruits and seeds.</td>
<td>Remove 4 handfuls of the wolfberries.</td>
</tr>
<tr>
<td>A nearby agriculturalist sprayed pesticide for insects in their field which is close to the estuary. When it rained, the pesticide washed into the estuary.</td>
<td>Remove 4 handfuls of crab.</td>
</tr>
<tr>
<td>Legislation passed further legal protection for the whooping crane resources.</td>
<td>Volunteers do a “Clean the Wetland” day in the estuary.</td>
</tr>
<tr>
<td>1 more whooping crane pair are able to make it for migration and reproduce.</td>
<td>Add 3 handfuls of wolfberries.</td>
</tr>
<tr>
<td>Add 2 cranes.</td>
<td></td>
</tr>
<tr>
<td>A hunter accidentally shoots a whooping crane, mistaking it for a goose.</td>
<td>Severe and long-term drought has limited the amount of freshwater coming from the Guadalupe River into the San Antonio Bay estuary. While the organisms in the estuary depend varying salinity to be survive and reproduce, the salinity is too high for too long.</td>
</tr>
<tr>
<td>One crane dies.</td>
<td>Remove one handful of crab.</td>
</tr>
<tr>
<td>Visitors come to view the whooping crane population from a safe distance. Donations to their conservation include buying and protecting more estuary.</td>
<td>A neighborhood gets built nearby. The increased impervious surface allows pet waste to be carried to the estuary when it rains. Bacteria on the waste kills crabs.</td>
</tr>
<tr>
<td>Add 2 handfuls of crab and 2 handfuls wolf berries.</td>
<td>Remove 3 handfuls of crab.</td>
</tr>
<tr>
<td>Rain further north in the watershed increases the freshwater that flows into the bay, called freshwater inflows. The estuary responds positively with more plant growth, and blue crab spawning.</td>
<td>A boat spills 50 gallons of oil into the estuary.</td>
</tr>
<tr>
<td>Add 2 handfuls of crab and 2 cups of wolf berries.</td>
<td>Remove 3 handfuls of crab and 2 handfuls of the wolfberries.</td>
</tr>
<tr>
<td>A nearby school builds a rain garden and installs a rain barrel, keeping pollution from traveling to the estuary.</td>
<td>Add 3 handfuls of crab.</td>
</tr>
<tr>
<td>Students, government agencies, environmental organizations, and businesses work together to educate watershed community members on how to protect the estuary. The community creates and implements plans for its further protection.</td>
<td>Add 6 handfuls of crab.</td>
</tr>
</tbody>
</table>