

ACTIVITY 11

The Great Oyster Mystery

Estuary Principle

Ongoing research and monitoring is needed to increase our understanding of estuaries and to improve our ability to protect and sustain them.

Research Question

How is ongoing research and monitoring of oysters increasing our understanding of estuaries?

Introduction

Oysters are a valuable part of estuary ecosystems. They help purify the water and control erosion. Oyster reefs provide habitat for numerous other species. However, oysters can also be an "indicator species." Like a canary in a coal mine, oyster health and oyster abundance can tell us about changing conditions in an estuary. Studying the response of oysters to changing conditions over the short term can help scientists predict how long-term changes, such as climate change, may impact oysters in the future.

A few years ago, something odd happened to the oysters in the Mission-Aransas Estuary in south Texas, a valuable oyster-growing area. In the first half of 2007, young oyster populations within the estuary's Copano Bay and Aransas Bay were normal. But then, the numbers of young oysters mysteriously decreased, only to dramatically increase again the next year. To oyster researchers, this was a mystery. Now your students can look for clues using the same data that researchers used to solve the Great Oyster Mystery.

Table of Contents

Teacher Guide.....	2
Exercise 1: <i>Clues in the Numbers</i>	4
Exercise 2: <i>A Salty Tale of Intrigue</i>	11
Exercise 3: <i>Cracking the Case with Data</i>	15

This curriculum was developed and produced for:

The National Oceanic and Atmospheric Administration (NOAA) and The National Estuarine Research Reserve System (NERRS)

1305 East West Highway NORM/5,
10th Floor
Silver Spring, MD 20910

www.estuaries.noaa.gov

Financial support for the Estuaries 101 Middle School Curriculum was provided by the National Oceanic and Atmospheric Administration via grant NA06NOS4690196, administered through the Alabama Department of Conservation and Natural Resources, State Lands Division, Coastal Section and Weeks Bay National Estuarine Research Reserve. Support was also provided by the Baldwin County Board of Education.



Permission is hereby granted for the reproduction, without alteration, of the activities contained in the Estuaries 101 Curriculum on the condition that proper attribution is given to the National Oceanic and Atmospheric Administration and the National Estuarine Research Reserve System (NERRS) as the source, and cite the following URL: <http://www.estuaries.noaa.gov>.



TEACHER GUIDE

The Great Oyster Mystery

Research Question

How is ongoing research and monitoring of oysters increasing our understanding of estuaries?

Content Objectives

Students will understand that:

- Environmental conditions, such as salinity, have a direct influence on estuary organisms.
- Testing hypotheses through scientific investigation helps answer questions about the natural world.
- Monitoring the responses of estuary organisms to changing environmental conditions helps scientists make predictions about the potential impact of long-term changes, including climate change.

Exercises

Exercise 1: Clues in the Numbers

Students read oyster abundance graphs to describe how young oyster abundance in Aransas and Copano bays responded to short-term environmental changes.

Exercise 2: A Salty Tale of Intrigue

Students access and print monthly average salinity and rainfall data for a two-year period during which oyster abundance in Aransas and Copano bays declined and then rebounded.

Exercise 3: Cracking the Case with Data

Students describe and interpret the relationship between several abiotic and biotic conditions in the estuary, including salinity, rainfall, oyster abundance, and the abundance of parasites and predators that attack oysters.

Assessment Questions

Assessment questions based on content covered in *The Great Oyster Mystery* can be downloaded on the web page for this activity in the Middle School Curriculum section of the Estuary Education website at estuaries.noaa.gov.

Vocabulary

Abiotic – the nonliving, physical components of the environment. Some abiotic components that impact oysters include salinity, temperature, and dissolved oxygen level.

Abundance – how much of something that can be found in a particular place. Example: The abundance of people is high in New York City.

Biotic – a component of the environment that is or was once alive. Some biotic components that impact oysters include predators, such as the oyster drill and stone crab.

Dermo – a parasite that infects and kills oysters.

Hypothesis – a prediction or statement that can be tested and that is based on prior knowledge, new information, and / or observation.

Predator – an organism that preys on (hunts, kills, and eats) other organisms. Oyster drills and stone crabs are predators that eat oysters.

ppt – means parts per thousand.

Range – all that is found between the upper and lower limits. All living things have a range of conditions in which they thrive. Oysters, for instance, thrive best within a salinity range of 14 ppt to 28 ppt.

Salinity – a measure of the amount of salt in solution. The salinity of the ocean is about 35 ppt.

Acknowledgement

We thank Dr. Jennifer Pollack, Assistant Professor at Texas A&M University - Corpus Christi, for providing the data for this activity. Dr. Pollack and her colleagues published the results of their oyster research in a paper entitled, “Role of Flood Disturbance in Natural Oyster (*Crassostrea virginica*) Population Maintenance in an Estuary in South Texas, USA.” This publication may be accessed [online](#):

http://tamucc.academia.edu/JenniferPollack/Papers/314707/Role_of_Flood_Disturbance_in_Natural_Oyster_Crassostrea_virginica_Population_Maintenance_in_a_n_Estuary_in_South_Texas_USA

EXERCISE 1

Clues in the Numbers

Estuary Concept

Environmental conditions have a direct influence on estuary organisms, such as oysters.

Focus Question

How did young oyster abundance change during 2007 and 2008 in the Aransas and Copano bays?

Performance Tasks

Students will:

- Observe oyster abundance graphs from two locations and describe how young oyster abundance in those bays changed over time.

Teacher Background

Since the activity is presented to students as a mystery, be careful to not reveal the cause of the oyster decline and rebound that is described next.

Over a two-year period, researchers examined the effects of flood disturbance on the eastern oyster in the Mission-Aransas Estuary of south Texas. Researchers collected oyster samples each month from 2007 through 2008. During July 2007, El Niño related storms sent large amounts of fresh water into Copano Bay and Aransas Bay via the Aransas and Mission rivers. Researchers found that these 2007 fresh water surges caused short-term reductions of salinity in the estuary, which in turn resulted in lower oyster abundance. However, in just one year, the oyster population recovered beyond the pre-flood level. The researchers concluded that although oyster abundance decreased dramatically after the floods, the retention of freshwater in the estuary resulted in salinity levels that were too low to support large populations of predators and disease causing parasites. The reduction in parasites and diseases allowed the oyster population to rebound beyond pre-flood levels. Other researchers suggest that oysters respond to some disease-causing parasites by attempting to “outrun” the parasites by reproducing at a faster rate.

Overview

In this activity, students are asked to solve an “Oyster Mystery.” As they complete the three exercises in this activity, students will learn that environmental conditions have a direct influence on estuarine organisms because an estuary is a system. A change in one component of that system can have repercussions on other components and in the way the whole system works.

In Exercise 1, students will look at maps and graphs of real scientific data to describe an event that happened in a valuable oyster-growing area in Texas, where a decline and then an increase in oysters abundance took place over a two year period. Students are challenged to discover what caused the oysters to disappear and then dramatically reappear the next year.

Time required

One 45-minute class period

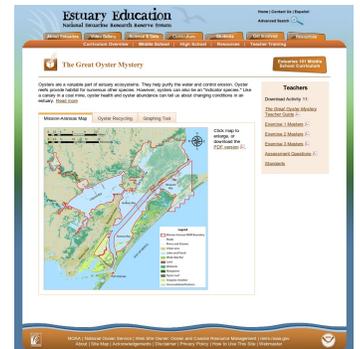
Teacher Preparation

1. Download and view the presentation *Oyster Recycling* (available as a PDF document), on the web page for this activity.
2. Download the image of the Mission-Aransas Estuary found on the web page for this activity.
3. Copy Student Master: *Clues in the Numbers*, including the *Oyster Abundance Graphs*.

Procedures

1. Show your students the presentation slideshow, *Oyster Recycling*, which you downloaded from the web page for this activity on the Estuary Education website. This slideshow describes reasons why oysters are an important estuary species and discusses threats to the oysters from both humans and other sources.
2. Project the image of the Mission-Aransas Estuary found on the web page for this activity. Point out the locations of Aransas Bay and Copano Bay within the Mission-Aransas Estuary. Also point out the locations where the Aransas and Mission rivers enter Copano Bay. Show your students how to use the map legend to locate oyster reefs in Aransas and Copano bays. Tell students that they are going to solve a real life oyster mystery that happened several years ago in this estuary. Tell your students that the oyster populations of both Aransas Bay and Copano Bay fell in 2007. Researchers and oyster farmers were worried. But in 2008, the oyster population rebounded significantly. Estuary researchers wanted to know why this happened. Tell the students that Dr. Jennifer Pollack and her fellow researchers are asking them to join the hunt for answers. Your students' challenge is to try and solve this real-life oyster mystery and to suggest reasons why the oyster populations changed, using real data.
3. Divide your students into teams of two to four students each. Students will work in the same teams for all three exercises in this activity. Distribute copies of the Student Master: *Clues in the Numbers*. This Master includes young oyster abundance graphs for both Aransas Bay and Copano Bay.
4. Using the PDF file containing the Exercise 1 Masters, project the images of the young oyster abundance graphs from Aransas and Copano bays on a screen. Review with your students how to read the bar graphs. Tell students that the purpose of these graphs is to show changes in the numbers of young oysters over time. Ask students if they can find the time period on the graph. Students should see that the horizontal axis of both graphs goes from January 2007 to December 2008.
5. Ask the students what they think the numbers on the vertical axis indicate. Based on the graphs, do they think the numbers represent all oysters or just young oysters? Do the numbers represent all young oysters in the entire bay or just an average of how many young oysters were found in one area? Student answers will vary. You should tell them that the researcher was only counting young oysters and reporting the average numbers found within a limited sample. So the bar graphs show the mean (average) number of young oysters each month in samples taken from the Aransas and Copano bays.

You'll find multimedia and other resources on the web page for this activity in the Middle School Curriculum section of the Estuary Education website: <http://estuaries.noaa.gov>.



Materials

- Presentation: *Oyster Recycling*
- Student Master: *Clues in the Numbers*

6. Now have student teams examine the Aransas and Copano Bay oyster abundance graphs and complete the clues and questions on the Student Master. Team members should discuss with each other how the abundance of young oysters in the two bays changed during 2007 and 2008. Students should see that from January 2007 through October 2007, oyster abundance was low in both bays. Since students cannot see data for 2006, they will not know how to interpret the beginning parts of the graphs. So you should tell your students that these numbers in early 2007 represent what is normal for these two bays. What happens next is not normal. From November 2007 through May 2008, the graphs show no evidence of young oysters. Then from June 2008 through November 2008, there is a high abundance of young oysters.

Clues, Questions and Possible Answers

Clue one: “Abundance of young oysters in Aransas Bay was normal from January 2007 to October 2007. Young oysters were absent from October 2007 to May 2008. Following their disappearance, young oyster abundance was high from June 2008 to November 2008.”

Clue two: “Abundance of young oysters in Copano Bay was normal from January 2007 to October 2007. Young oysters were absent from November 2007 to May 2008. Following their disappearance, young oyster abundance was high from June 2008 to November 2008.”

- Q1. Are there any similarities between the abundance or lack of abundance of young oysters in Aransas Bay and Copano Bay during 2007 and 2008? If so, what are the similarities?**

Graphs from the two different bays are similar. Both sites had normal abundance of young oysters in the first half of 2007. Both sites then saw a decline in young oyster abundance in late 2007 and into 2008. Then both bays saw a dramatic increase in young oysters in mid-2008.

- Q2. Does one of the bays seem to have more oyster growth than the other? What evidence do you see to back up your observation?**

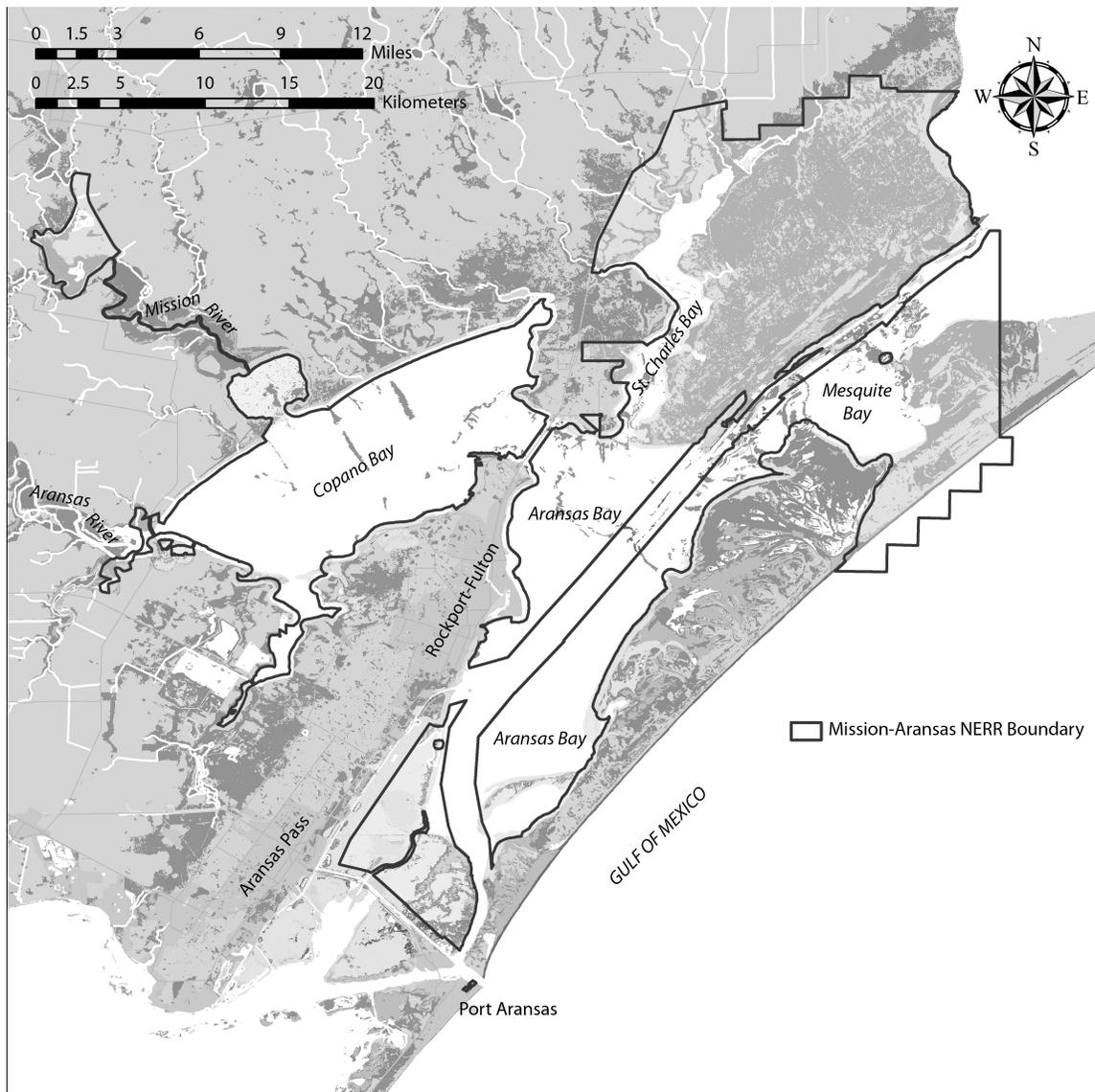
Copano Bay seems to have a greater increase in young oyster abundance than Aransas Bay. In Copano Bay, there was a consistently high abundance of young oysters between June 2008 and December 2008, when compared to the 2007 data. Aransas Bay saw a higher initial spike in young oysters, but then the numbers dropped normal more quickly than in Copano Bay.

- Q3. Have you solved the oyster mystery or do you need more clues?**

Students should say that they do not have enough information at this point to solve the mystery.

STUDENT MASTER

Clues in the Numbers



Oysters are a valuable part of estuary ecosystems. They help purify the water and control erosion. Oyster reefs provide habitat for numerous other species. However, oysters can also be an “indicator species.” Like a canary in a coal mine, oyster health and oyster abundance can tell us about changing conditions in an estuary. Studying the response of oysters to changing conditions over the short term can help scientists predict how long term changes, such as climate change, may impact oysters over the long term.

A few years ago, something odd happened to the oysters in Mission-Aransas Estuary in south Texas, a valuable oyster-growing area. In the first half of 2007, young oyster populations within the estuary’s Copano Bay and Aransas Bay were normal. But then, the numbers of young oysters mysteriously decreased, only to dramatically increase again the next year. To Dr. Jennifer Pollack, an oyster researcher at Texas A&M University, this was a real mystery. Now you can look at some of the data researchers used to solve the great oyster mystery.

Think of yourself as an armchair sleuth. You must mount a virtual research expedition to Aransas and Copano bays in the Mission-Aransas Estuary to collect data that will help you answer the following research question:

“What caused oysters to decline in 2007 and why did the population rebound so dramatically the following year?”

Along the way, you will look at maps and graphs of real scientific data and have the opportunity to gather your own data online. There’s no rest until you find out what happened! It’s time to get your first clues.

Procedure

1. In this exercise, you will be using two bar graphs showing the abundance of young oysters in samples taken by researchers in Aransas Bay and Copano Bay, which are both located within the Mission-Aransas Estuary.
2. Look at the Aransas Bay Young Oyster Abundance Graph. Decide what the bars on the graph indicate and what the data tells you about the young oyster abundance in Copano Bay at different times. Use the Aransas Bay Young Oyster Abundance Graph to fill in the statement below:

Clue one: “Abundance of young oysters in Aransas Bay was normal from January 2007 to October 2007. Young oysters were absent from _____ (month and year) to _____ (month and year). Following their disappearance, young oyster abundance was _____ (high, low, or normal) from _____ to _____ (months and year).”

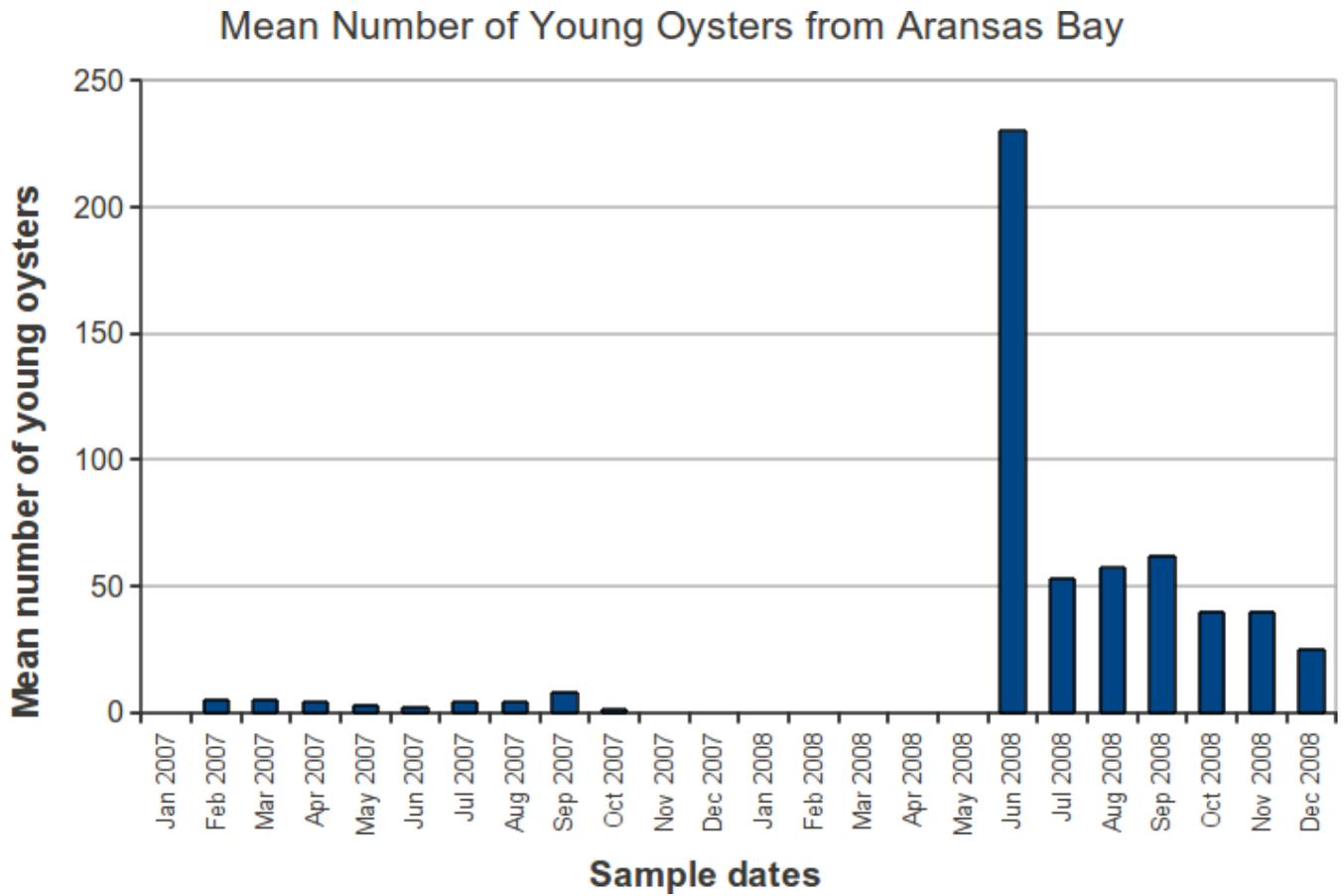
3. Now look at the Copano Bay Young Oyster Abundance Graph. Use this graph to in the statement below:

Clue two: “Abundance of young oysters in Copano Bay was normal from January 2007 to October 2007. Young oysters were absent from _____ (month and year) to _____ (month and year). Following their disappearance, young oyster abundance was _____ (high, low, or normal) from _____ to _____ (months and year).”

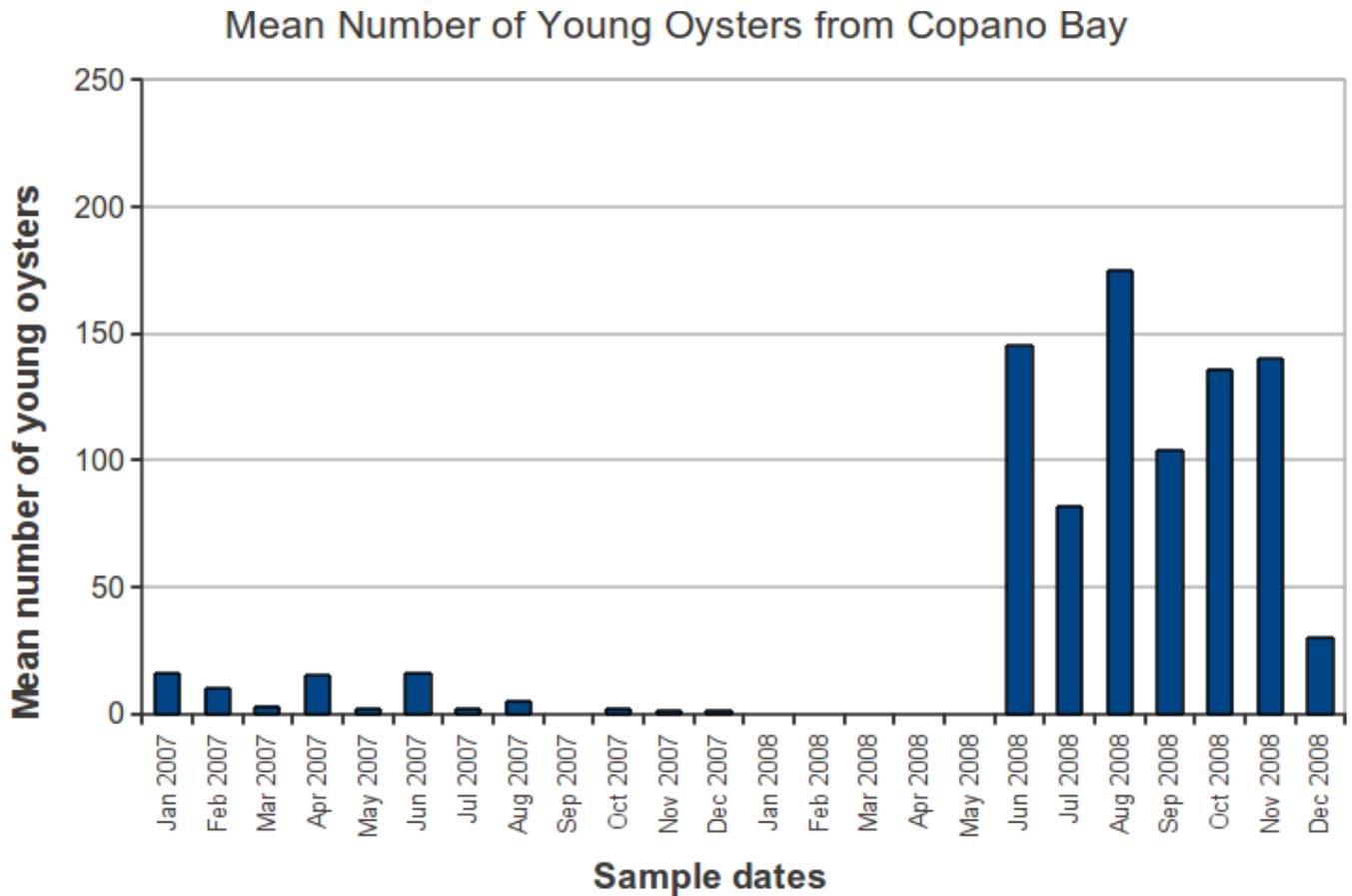
Questions

- Q1. Are there any similarities between the abundance or lack of abundance of young oysters in Aransas Bay and Copano Bay during 2007 and 2008? If so, what are the similarities?
- Q2. Does one of the bays seem to have more oyster growth than the other? What evidence do you see to back up your observation?
- Q3. Have you solved the oyster mystery or do you need more clues?

Oyster Abundance Graphs



Oyster Abundance Graphs



Notes on the data

What do the above graphs tell you about the abundance of young oysters in Aransas and Copano Bays? The “young” oysters counted by researchers are the spat — larval oysters that have attached to bigger oysters. Researchers dredged oyster samples from the bottom of the bays. They picked out five oysters from whatever they dredged up and counted the number of spat on those five oysters. The counts were then averaged to give the monthly numbers you’re seeing above. Since the same method was used for the entire period of time, you can compare months and know that what you see should represent actual increases or decreases in larval oysters in that bay over time. And because the same sampling method was used in both bays, the numbers can be compared with each other.

EXERCISE 2

A Salty Tale of Intrigue

Estuary Concept

The National Estuarine Research Reserve System Wide Monitoring Program (SWMP) can provide real data for research on abiotic factors that affect oysters, such as salinity and precipitation.

Focus Question

How can graphs of real data be generated to collect information about salinity and precipitation?

Performance Tasks

Students will:

- Access and print real salinity and rainfall data from a two-year period during which oyster abundance in the Mission-Aransas estuary declined and then rebounded.

Teacher Background

In this exercise, students will access real data from the NERRS System wide Monitoring Program (SWMP). SWMP is used to monitor the health of the reserves. It measures changes in estuarine waters to record how human activities and natural events affect coastal habitats. Data-collecting instruments are located at over 100 data stations (about 4 stations at each reserve).

SWMP data stations collect data on a variety of factors. There are stations that record water quality data, including pH, salinity, oxygen saturation, and other abiotic factors. Other stations record weather data, such as temperature and precipitation. Still other stations record factors relating to biology, such as dissolved nutrients and concentration of chlorophyll in the water.

Your students will be accessing the SWMP data through the online graphing tool on [estuaries.noaa](http://estuaries.noaa.gov). They will create salinity graphs for Copano and Aransas bays and a precipitation graph for Copano Bay, to use in determining why oyster abundance declined in 2007 and then increased in 2008 in these bays.

Teacher Preparation

1. Watch the SWMP graphing tool tutorial at <http://coast.noaa.gov/swmp/tutorial/tutorial.html>
2. Visit <http://estuaries.noaa.gov/ScienceData/Graphing.aspx> to practice accessing and using the SWMP graphing tool before working with students in Exercise 2. See instructions in Student Master: *Clues in the Numbers*.
3. It is highly recommended that students go online to collect their own salinity and precipitation data. However, if this option is not available to you, you can generate the salinity and precipitation graphs for Aransas Bay and Copano Bay ahead of time and have students retrieve data from your graphs.

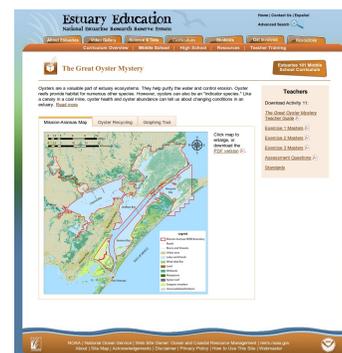
Overview

Students will access the NERRS System Wide Monitoring Program (SWMP) data on the Estuary Education website to investigate changes in salinity and rainfall patterns that occurred in Aransas and Copano bays during the study period. Students will need the collected data from this exercise to use in Exercise 3, which is the final part of this activity.

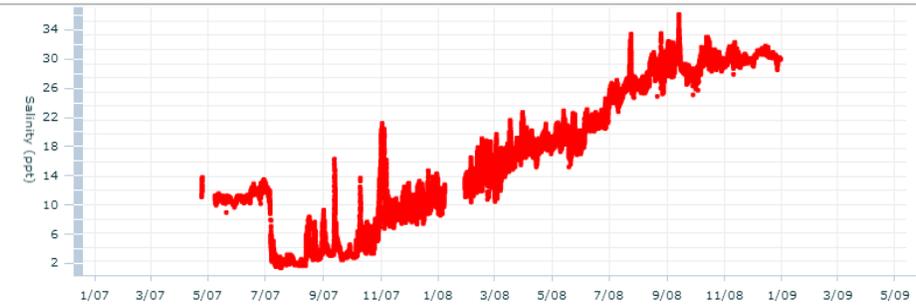
Time Required

Two 45-minute class periods

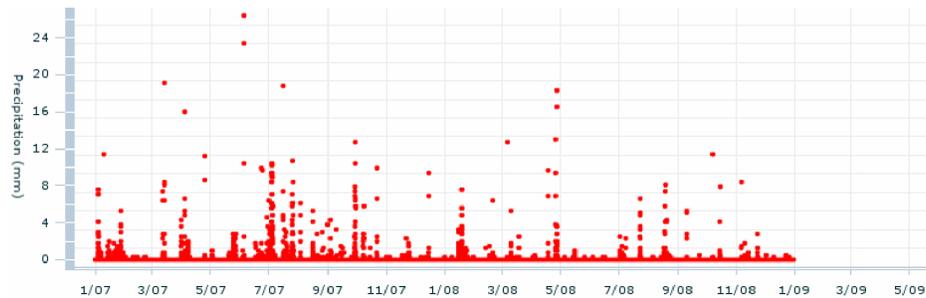
You'll find multimedia and other resources on the web page for this activity in the Middle School Curriculum section of the Estuary Education website: <http://estuaries.noaa.gov>.



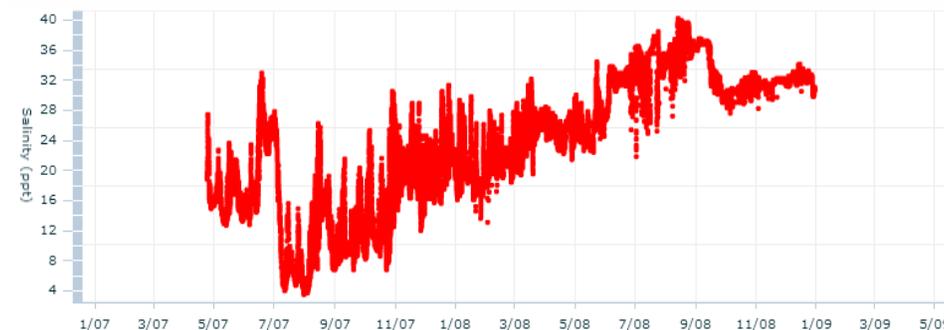
The generated graphs should look something like this:



Copano Bay Salinity



Copano Bay Precipitation



Aransas Bay Salinity

Procedure

1. Have each student team from Exercise 1 use a computer with Internet access to go online to gather data and create graphs in this exercise.
2. Give each student a copy of the Student Master: *A Salty Tale of Intrigue*. Students will follow directions on the master to create salinity and precipitation graphs for data in Aransas and Copano bays for the time interval January 1, 2007 to December 31, 2008.
3. Circulate among your students and help them with their efforts to use the online data tool.
4. Remind students to keep their graphs and all Masters from Exercises 1 and 2 organized and available to use in Exercise 3.

STUDENT MASTER

A Salty Tale of Intrigue

Clearly something affected oyster abundance in Aransas and Copano bays during 2007 and 2008. Perhaps it had something to do with the water in the bays. Let's start by looking at the water's salinity.

In this exercise, you will gather real salinity and precipitation (rainfall) data in both Aransas and Copano bays for 2007 and 2008. Could salinity be the smoking gun?

Procedure

1. Visit <http://estuaries.noaa.gov/ScienceData/Graphing.aspx> and click on the map where it says "Click here". This will open up the SWMP graphing tool.
2. The graphing tool application will open with a map of the United States. On the left hand side of the page will be Step 1 titled "Which Data". This section lists the various types of stations that gather data within Reserves around the United States.
3. Select the "Water Quality" button.
4. Specify a Date Range under Step 2. Enter a start date of "January 1, 2007" and an end date of "December 31, 2008."
5. Under Step 3 choose "TX>> Mission Aransas> >Copano Bay East" from the list of recording stations.
6. Now you need to select a type of water data to graph. Click on the "Which Parameter" pull-down found under Step 4. Select "Salinity" from the list of water data gathered at this site.
7. Select an output format for the data you want graphed. Click next to the "Graph" button. At the bottom of the page click on the blue "Get Data" button to generate your graph. There may be a delay in seeing your graph.
8. You may have to zoom out to see the whole two year period, but you will notice that some salinity data are missing because water quality data collection did not begin in Copano and Aransas bays until April 24, 2007. Note that date labels on the x-axis are for the first of the month. For example, 2/08 is February 1, 2008.
9. You may want to save the graph image to your local computer as a PDF or print the graph before moving on. (You can print a graph by clicking on the "Print Graph" button found in the bottom right hand corner of the graph.) Be sure to write in missing number labels on the vertical axis (salinity) if they do not print.
10. Use a ruler to draw a horizontal line across your graph equivalent to a salinity value of 17 ppt. Label the line "20-year average salinity." Any salinity value below this line is below average for water in Copano Bay over a 20 year period; any value above this line is above average, if we ignore seasonal effects.
11. Now let's get the precipitation data for Copano Bay. Beneath the graph, under "Second Data Type" select "Weather".
12. Select "TX>> Mission Aransas> >Copano East" from the list of recording stations.
13. Finally select "Precipitation" from the list of available weather data parameters gathered at this site.
14. Click the "Plot Graph" button and your results will appear on the graph in blue.
15. You may want to save the graph image to your local computer as a PDF or print the graph before moving on. (You can print a graph by clicking on the "Print Graph" button found in the bottom right hand corner of the graph.) Be sure to write in missing number labels on the vertical axis (precipitation) if they do not print.
16. Now create a salinity graph for Aransas Bay. Select "Water" data again. Follow Steps 3 through 7 above, except this time choose the "TX>>Mission Aransas>>Aransas Bay" station. Be sure to print or save your graph.



17. Use a ruler to draw a horizontal line across your graph equivalent to a salinity value of 20 ppt. Label the line “20-year average salinity.” Any salinity value below this line is below average for water in Aransas Bay over a 20 year period; any value above this line is above average.
18. There is no weather station data for Aransas Bay. You will be using the precipitation graph from Copano Bay East as an approximation of data in nearby Aransas Bay.
19. Here is one more piece of information that might be related to precipitation in the estuary during 2007 and 2008. These data comes from a United States Geological Survey (USGS) water data collection station on the Aransas River, near where the river empties into Copano Bay.

Stream Discharge Data for Aransas River south of Skidmore, Texas (USGS Station 08189700) Drainage area 247 square miles	
Month/Year	Monthly average river discharge (cubic feet per second)
January 2007	96
February 2007	9
March 2007	105
April 2007	17
May 2007	10
June 2007	29
July 2007	727
August 2007	17
September 2007	21
October 2007	8
November 2007	7
December 2007	7
January 2008	7
February 2008	6
March 2008	9
April 2008	6
May 2008	4
June 2008	4
July 2008	8
August 2008	58
September 2008	25
October 2008	5
November 2008	3
December 2008	3

Source: USGS Surface-Water Monthly Statistics for the Nation

20. Save your collected data to analyze in Exercise 3: *Cracking the Case with Data*.

EXERCISE 3

Cracking the Case with Data

Estuary Concept

A better understanding of estuarine processes can be gained when abiotic and biotic conditions are examined together.

Focus Questions

- What caused the changes in young oyster abundance during 2007 and 2008 in Aransas and Copano bays?

Performance Tasks

Students will:

- Analyze real data to explain variations in water salinity and abundance of oysters and oyster parasites/predators within Aransas and Copano bays.

Teacher Background

In order to answer the research question: “What caused the changes in young oyster abundance during 2007 and 2008 in Aransas and Copano bays?” students will need to examine the team-collected salinity and precipitation data from Exercise 2. They will also explore the types of enemies that attack oysters. One such enemy is the single-celled protozoan, *Perkinsus marinus*, a parasite that causes dermo disease in oysters. Other oyster enemies are the predators, oyster drills and stone crabs.

First, it is important to understand that the oysters live in bays found within the Mission-Aransas Estuary. In order to thrive in these locations — and estuaries in general — oysters must live within certain environmental ranges that contain upper and lower limits. As an example, oysters thrive best within a salinity range of 14 to 28 parts per thousand (ppt). If oysters are in water outside of this range at either end for too long, they will not thrive. At extreme levels outside of this range, the oysters will die. It is important that students understand the concept of salinity tolerance ranges, in order for them to predict what might happen to oyster populations if future climate change causes salinity levels to rise in South Texas estuaries. Students will be asked to make this prediction at the end of the activity.

Next, it is important to realize that the salinity of the water within the estuary does not always stay the same. Salinity is a measure of the amount of dissolved salts in water. In the open ocean, salinity varies little. Salinity in an estuary, however, varies according to location, tidal fluctuations, and the volume of freshwater entering the estuary, either via runoff or directly via precipitation. Overall salinity levels in many estuaries decline in the spring, when snow melt and spring rains produce elevated freshwater flows from streams and ground water. The added fresh water “dilutes” the water in the estuary, lowering salinity levels. In the Mission-Aransas Estuary, salinity is more likely to be lowered by large storms that send enormous surges of fresh water down into the bays via the

Overview

In this activity, students are asked to solve an Oyster Mystery. In this last of three exercises, students are asked to analyze the data they have gathered in the first two exercises. They are also asked to consider the impact of oyster enemies (parasites and predators) on oyster populations and whether or not those oyster enemies are also affected by the same abiotic factors (e.g., salinity) as the oysters themselves.

Time Required

Two 45-minute class periods

Aransas and Mission rivers.

Oysters are not the only organism with a salinity tolerance range. The protozoan that causes dermo disease has a salinity tolerance range. So do the oyster predators, the oyster drill and the stone crab. All of these organisms, oysters included, thrive best within specific ranges of salinity and cannot survive outside these ranges over the long term.

In this exercise, student teams are going to be asked to examine the salinity tolerance range of the oysters and organisms that affect oyster populations. Then students will attempt to synthesize their thoughts on salinity tolerance with data on oyster abundance (Exercise 1) and precipitation and salinity (Exercise 2) to solve the mystery of the great 2008 oyster revival in Aransas and Copano bays.

Teacher Preparation

1. Make copies of Student Master: *Cracking the Case with Data*.
2. Remind students that they will need their materials, graphs, etc., from Exercise 1 and Exercise 2 (especially the graph data they gathered online) in order to do Exercise 3 and solve the great oyster mystery.

Procedure

1. In teams, students will examine their collected salinity and rainfall graphs from Exercise 2 and compare them to the oyster abundance graphs from Exercise 1. Once students complete this task, ask if they see any patterns between the abiotic conditions of salinity and rainfall compared to the biotic conditions of young oyster abundance in Aransas and Copano Bays.
2. Distribute the Student Master: Cracking the Case with Data. Ask students to read the first page. Discuss what a “tolerance range” is with the whole class. Ask students to describe the salinity tolerance range that is needed to support oysters. While oysters thrive best within a salinity range of 14 ppt to 28 ppt, they can withstand a wider range of 5 to 40 ppt.
3. Have students work through the procedures outlined on the Student Master. Circulate among the teams and engage students in thinking carefully about the different sets of data they have and how to meaningfully compare data sets, looking for correlations, similarities, etc. You may want students to record their thoughts or answers to the questions raised in the procedure steps.

Materials

- Student Master: *Clues in the Numbers*
- Student-collected precipitation and salinity graphs from Exercise 2
- Student Master: *Cracking the Case with Data*

Questions and Possible Answers

Q1. Oysters grow and thrive best in water with what range of salinity?

Oysters can survive within a wide range of salinity, from 5 ppt. to 40 ppt. However, oysters do best within a salinity range of 14 ppt. to 28 ppt.

Q2. What do you think caused salinity to decline in Copano Bay and Aransas Bay during the summer of 2007?

Students should see that there were heavy rains in Copano Bay in January and April of 2007. However, the longest period of rains was in late June and early July. This corresponds to the drop in salinity in the bay. Students should also notice from the USGS stream discharge data that local heavy rains over the bay correspond to large increases in water flowing down the Aransas

River and into Copano Bay. Rain at one location isn't the main factor. In the summer, potentially as much water may evaporate from the bay as falls on it from precipitation. However, the rains that fall over the bay also fall on land that drains into the bay. The June and July 2007 rains sent a huge surge of fresh water into Copano Bay via the Aransas and Mission rivers. This surge of fresh water diluted the salty water in the bay, causing the salinity levels to fall.

Q3. What happened to oyster abundance in the two bays when salinity declined? What happened to oyster abundance in the two bays as salinity increased from fall 2007 and into 2008? Relate your observations to oysters' salinity tolerance range.

Young oyster abundance was low before the salinity declined. However, those were normal low numbers. After the salinity declined, the oyster abundance stayed mostly the same for another two months before falling to levels approaching zero. At first, there was no change in oyster abundance. Salinity increased steadily from July 2007 until December 2008. Oysters did not reappear until June 2008. However, when the young oysters did reappear, their numbers were at a higher level than before the salinity drop. Students may expect to see oyster numbers recover quickly once the water salinity reaches the oyster's tolerance range. However, what they will see in the data is a lag time of several months. This is probably due to the oyster's reproductive cycle, seasonal spawning events, etc.

Q4. If oysters have a lower limit of salinity tolerance than oyster enemies, what would you expect to see in a bay where salinity levels are increasing from near zero (almost fresh water) to 20 ppt. or greater? Do you see evidence of oysters recovering before oyster enemies or vice-versa?

As salinity levels increase, the organism with the lowest tolerance level will "feel comfortable" first and start to thrive before the organisms with higher lower limits. In the graph showing percent of market-size oysters infected with *P. marinus* in Copano Bay, it appears the protozoan that causes dermo started to revive at about the same time as the oyster.

Q5. Drawing Conclusions: What caused oysters to decline in the Mission-Aransas Estuary in 2007 and why did the population rebound so dramatically the following year? Describe what you learned and whether you think you've solved the "great oyster mystery."

Major storms in watersheds draining into the estuary caused temporary reductions in salinity. This decline in salinity is associated with observed reductions in young oyster abundance. Oyster populations generally recovered within one year's time as salinity levels increased back within the oyster's preferred tolerance range. Students may or may not feel they have solved the mystery. Some questions were answered by the data; some questions were not answered and would require more research.

Q6. Making Predictions: The data you examined in this study were collected over a relatively short period of time and reflect short-term responses of oysters to environmental change. Long-term climate change predictions for South Texas suggest that the region is likely to become warmer and receive less rainfall. Considering the salinity tolerance ranges of oysters, their predators, and their parasites, what effect might higher salinities have on oyster populations over the long term?

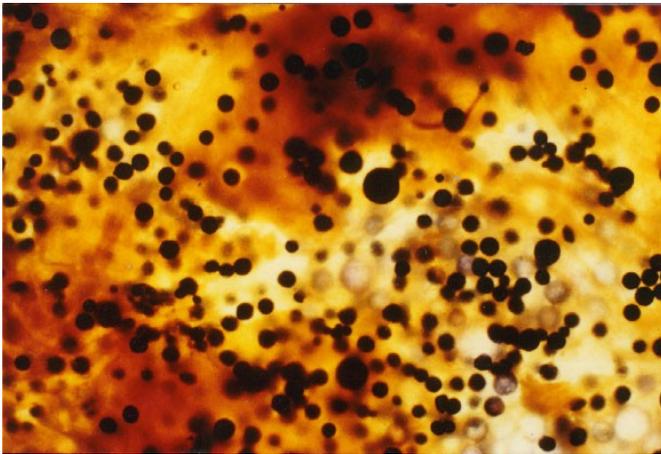
There could be a wide range of acceptable answers to this question. If there is a decrease in rainfall in South Texas, then less fresh water would enter the estuaries. Warmer temperatures would likely cause more evaporation from the estuaries. Both of these conditions would result in higher salinities in South Texas estuaries. As shown in this activity, oysters and other estuary animals require certain ranges of salinities, so their populations would be impacted by elevated salinity levels. If estuaries become hypersaline (e.g., above 40 ppt) oysters would probably not survive over the long term. There could be an added negative impact on oyster populations because their predators and parasites would not experience the setbacks that they currently do, when salinities decline due to heavy rainfall events.

STUDENT MASTER

Cracking the Case with Data



Stone Crab

Southern Oyster Drill
credit: Brittany Blomberg*Perkinsus marinus* (causes dermo disease)
credit: Dr. David Bushek. Used with permission.

Mature oyster shell covered with spat (young oysters).

What is a Tolerance Range?

All living things have a range of abiotic (non-living) environmental conditions in which they can live. For example, you need high quality air to breathe and you couldn't live in extreme temperatures without adequate shelter. Oysters are also affected by abiotic environmental conditions. For oysters to survive, they need water with specific ranges of salinity, temperature, water depth, and water clarity. A range means that there are upper and lower limits. Beyond those limits in either direction, the oyster will die.

Salinity is one of the abiotic conditions affecting oyster growth. Water salinity is measured in parts per thousand (ppt). A salinity of 1 ppt means that there is one gram of salts dissolved in 1000 grams of water. The average salinity of sea water is 35 ppt. The salinity of totally fresh water is close to 0 ppt. Oysters live in estuaries, where fresh water from rivers and streams mixes with salt water from the ocean. In terms of salinity, oysters thrive in areas that have a higher salinity than a freshwater stream, but a lower salinity than the open ocean.

The Oyster’s Enemies

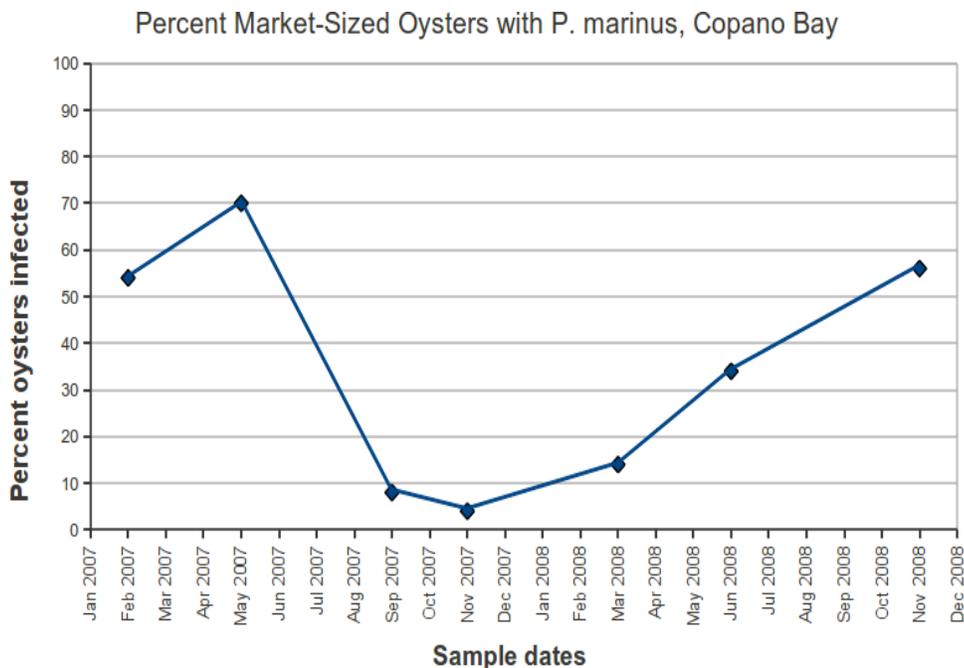
Oysters are able to tolerate lower salinity levels than many of their predators (oyster drills and stone crabs) and parasites (*Perkinsus marinus* that causes dermo disease). This is important because oysters cannot run away from their enemies and they have no way to defend themselves, except their protective shells, which oyster drills, stone crabs, and *Perkinsus marinus* can easily get into. The oyster’s tolerance for lower salinity levels means that freshwater inflow into oyster beds can help oysters thrive because it tends to lower the numbers of oyster predators and parasites.

Oysters can survive within a wide range of salinity, from 5 ppt to 40 ppt, but they do best within the range of 14 ppt to 28 ppt. Oyster drills and stone crabs cannot tolerate salinities less than 15 ppt for long periods of time and *Perkinsus marinus* does not tolerate salinities below 8 ppt. The table below shows the lower limits of salinity tolerances for oysters, oyster drills, stone crabs, and *Perkinsus marinus*.

Organism	Lower Limit of Salinity Tolerance
Oyster	5 ppt
Oyster Drill	15 ppt
Stone Crab	15 ppt
<i>Perkinsus marinus</i> (cause of dermo disease)	8 ppt

Procedure

1. Compare the salinity graphs for Copano Bay and Aransas Bay (from Exercise 2) with the young oyster abundance graphs (from Exercise 1). During what time period were oysters within their preferred tolerance range for salinity in each bay? Is there a relationship between when oysters were in their preferred salinity conditions and when young oysters were abundant?
2. Compare the precipitation graph for Copano Bay with the salinity graph for Copano Bay. Also, examine the stream discharge data for the Aransas River. Are there any clues in the precipitation graph and discharge data that suggest why salinity in Copano Bay and Aransas Bay fell so dramatically in July 2007?
3. Look at the graph below that shows number of “market-sized” oysters infected with *Perkinsus marinus* in Copano Bay during 2007 and 2008. Is there a relationship with the salinity graph? Is there a correlation with the young oyster abundance graph?



4. Use your observations and all of your data to answer the questions below.

Questions

Q1. Oysters grow and thrive best in water with what range of salinity?

Q2. What do you think caused salinity to decline in Copano Bay and Aransas Bay during the summer of 2007?

Q3. What happened to oyster abundance in the two bays when salinity declined in the summer of 2007? What happened to oyster abundance in the two bays as salinity increased from fall 2007 and into 2008? (Relate your observations to oysters' salinity tolerance range)

Q4. If oysters have a lower limit of salinity tolerance than oyster enemies, what would you expect to see in a bay where salinity levels are increasing from near zero (almost fresh water) to 20 ppt or greater? Do you see evidence of oysters recovering before oyster enemies or vice-versa?

Q5. Drawing Conclusions: What caused oysters to decline in the Mission-Aransas Estuary in 2007 and why did the population rebound so dramatically the following year? Describe what you learned and whether you think you've solved the "great oyster mystery."

Q6. Making Predictions: The data you examined in this study were collected over a relatively short period of time and reflect short-term responses of oysters to environmental change. Long-term climate change predictions for South Texas suggest that the region is likely to become warmer and receive less rainfall. Considering the salinity tolerance ranges of oysters, their predators, and their parasites, what effect might higher salinities have on oyster populations over the long term?