

ACTIVITY 2

Seasonal Swings

Estuary Principle

Estuaries are dynamic ecosystems with tremendous variability within and between them in physical, chemical, and biological components.

Research Question

What are the physical (geographic, weather and climate) factors that influence and regulate life in the estuaries?

Introduction

There is tremendous variability in the physical conditions between and within estuaries. Factors such as air and water temperature, water salinity, and dissolved oxygen can also vary seasonally at the same location. Students will learn about the NERRS System using an online map that has a brief description about each of the 28 Reserves. By comparing and contrasting specific data from two of those Reserves, students will come to understand that extreme air and water temperature differences found in the Reserve estuaries are related to their geographic location, particularly their latitudes relative to each other.

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TEACHER GUIDE

Seasonal Swings

Research Question

What are the physical (geographic, weather and climate) factors that influence and regulate life in the estuaries?

Content Objectives

Students will understand that:

- Weather can affect water properties.
- Seasonal changes in weather and a Reserve's proximity to the equator or the poles create conditions that cause variety amongst the nation's estuaries.

Exercises

Exercise 1: NERR and Far

Students compare and contrast data (weather and geographic location) from two sources to characterize Reserves. Students see that there are seasonal effects on air and water temperature and those estuaries at different latitudes experience different conditions.

Exercise 2: A Chilling Effect

Students use online tools to compare data from two Reserves at different latitudes. Students use the data to identify trends and establish connections between latitude and air temperature, air temperature and water temperature, and water temperature and dissolved oxygen concentration.

Assessment Questions

Assessment questions based on content covered in *Seasonal Swings* 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

Annual cycle – a cycle that happens each year.

Data logger – an instrument for measuring water quality parameters over time.

Direct relationship – a mathematical relationship in which two variables both increase or decrease together.

Dissolved oxygen – often referring to the oxygen content of water. The amount of oxygen dissolved in a given volume of water at a particular temperature and pressure. (Note: This is not the oxygen in H₂O, but rather separate oxygen molecules.)

Inverse relationship – a mathematical relationship in which one variable decreases while another increases.

Latitude – measure of distance north or south of the equator.

Longitude – measure of the distance east and west of the prime meridian.

Parameter – the thing that is being measured.

Precipitation – rain, snow, sleet, freezing rain, mist.

Salinity – the concentration of salts dissolved in salt water.

Taking It Further

How Far Away Is It? Have your students choose any two sites (e.g., cities, named mountains, etc.). Use an almanac or an online reference to look up the site locations. Write down the latitude and longitude of each site on a piece of paper (accurate to the minute). Calculate how many degrees east/west and how many degrees north/south there are between the sites.

EXERCISE 1

NERR and Far

Estuary Concept

Estuaries at lower latitudes have smaller annual temperature fluctuations than estuaries at higher latitudes.

Focus Question

- What influence does latitude have on air and water temperature extremes and ranges within the NERRS estuaries?

Performance Tasks

Students will:

- Integrate data (air temperature, water temperature, and latitude) from two locations to characterize estuaries in the National Estuarine Research Reserve System.

Teacher Background

The characteristic temperatures of the seasons — spring, summer, autumn, and winter — experienced at a given location are determined by the number of daylight hours and the height (altitude) of the sun at noon at that location. Both of these measurements are a function of the latitude of the observer and the relative position of Earth during its annual orbit around the Sun.

Because Earth is tilted on its axis, the Sun appears to change altitude from day to day. Changes in the Sun's altitude are less pronounced at locations close to the equator. Near the equator, the Sun always appears to pass nearly overhead at noon and daylight is always about 12 hours long. However, as you move toward the poles, there are more dramatic changes in altitude of the Sun at noon and in the length of daylight. For example, in the Arctic Circle, the length of daylight increases to 24 hours on the day of the summer solstice in the Northern Hemisphere. Then the length of daylight gets shorter through the fall and winter months. The Arctic Circle has 24 hours of darkness at the time of the winter solstice.

The overall amount of energy leaving the Sun and striking Earth is constant. But the heating effect of this energy at a location on Earth's surface — the solar insolation — depends on the latitude of the location and time of year. Near the equator, the length of daylight stays about the same and the sun beams down from nearly overhead at noon each day. So the solar insolation is always relatively high near the equator. But when sunlight strikes Earth at an angle, the energy is spread out over a larger area. The solar insolation is less. Therefore, the heating effect of the Sun's energy is more variable at higher latitudes because both the length of day and the altitude of the Sun at noon changes throughout the year.

Overview

In this exercise, students learn about the NERR System using an online map that has a brief description about each of the 28 Reserves. By comparing and contrasting specific data from two of those Reserves, students will come to understand that extreme air and water temperature differences found in the Reserve estuaries are related to their geographic location, particularly their latitudes relative to each other.

Time Required

Half of one 45-minute class session

Teacher Preparation

- Become familiar with using the Interactive Map of the NERR System, found on the web page for this activity in the Middle School Curriculum section of the Estuary Education website: <http://estuaries.noaa.gov>. The map features a variety of useful information about the 28 NERR sites.
- You may want to review with your students how to read lines of latitude and longitude on a world map or globe.

Procedures

1. Introduce the NERR System interactive map to your students. Show students what information and parameters are available on the map for each site (e.g., the State where the reserve is located, annual maximum and minimum air temperature, tidal range, etc.)
2. Distribute the Student Master: NERR and Far and the Data Sheet. Students will need to find information about 3 different Reserves. All students will choose the same Reserve as the one located closest to your school. Encourage different students to choose different Reserves for the “Far away” choice. As students locate the data for each Reserve, they should fill in the Student Master Data Sheet and then summarize their findings in the data tables on the Student Master: NERR and Far.
3. Have students use the data summarized in the two data tables to answer the questions on the Student Master. Possible answers to the questions are provided below.

Questions and Possible Answers

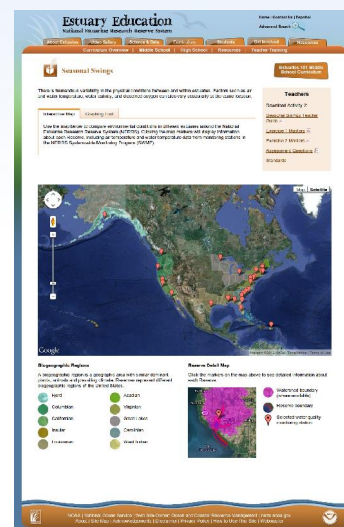
1. **Which Reserve has the highest high water temperature? Which Reserve has the lowest low water temperature? Which Reserve has the largest range of water temperature?**

Student answers will depend on the Reserves they have chosen to examine. The Reserve with the highest high water temperature should be the one located at the lowest latitude (i.e., closer to the equator). The Reserve with the largest range of water temperatures is likely to be the one located at the highest latitude (i.e., farthest from the equator).

2. **Are air temperatures at the two Reserves with the same or nearly the same latitude more or less similar to each other than they are to the “Far Away” reserve?**

Students should see that air and water temperatures at the two Reserves located close to the same latitude are more similar to each other than either of them is to the third Reserve at the more different latitude. It is important to note that there is not a perfect temperature (air and water) gradient from north to south.

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

- NERR System interactive map on the Estuary Education website
- Student Master: *NERR and Far*

3. Which Reserve has the largest range of air temperature? Is that Reserve closer to the equator (i.e., lower latitude) than the other Reserves or farther away (i.e., higher latitude)?

Student answers will depend on the Reserves they have chosen to examine. The Reserve with the largest range of air temperatures is likely to be the one located at the highest latitude (i.e., farthest from the equator).

Conclusions

At the end of this exercise, your students should know that:

- There are 28 National Estuarine Research Reserves around the country and that each Reserve has unique characteristics.
- The range of air and water temperature variation at a Reserve greatly depends on the latitude of the Reserve.
- Reserves that are closer to Earth's equator have smaller temperature ranges compared to Reserves that are farther from the equator.

STUDENT MASTER

NERR and Far

The National Estuarine Research Reserve (NERR) System has 28 amazing estuaries (or Reserves) located around the United States. Maybe there's a Reserve in your home state that you can visit. Even if there isn't, you can take a virtual trip to the estuaries and get your feet wet collecting data on any Reserve site, near or far. So jump right in! The water's warm...in some places.

Procedures

1. Use a computer to access the NERR System Interactive map. You will find it at <http://estuaries.noaa.gov> in the "Middle School Curriculum" section. Then select Activity 2: Seasonal Swings".
2. Use the map to find the Reserve that is closest to your school. Click on that Reserve's location on the map to see information on that Reserve.
3. Write down the Reserve name on the Student Master Data Sheet in the section labeled "Nearby."
4. Write down the Reserve's latitude, the annual maximum air temperature, the annual minimum air temperature, the annual maximum water temperature, and the annual minimum water temperature.
5. Calculate the annual air temperature range at this Reserve by subtracting the minimum annual air temperature from the maximum annual air temperature. Use the same method to calculate the annual water temperature range.
6. Now go back to the NERR System map. Find another Reserve on the map that is located at close to the same latitude as the first Reserve, but in a different time zone. Click on that Reserve's location on the map to see information on that Reserve. (NOTE: If you live in Alaska or Puerto Rico, you should choose the next closest Reserve.)
7. Write down this Reserve name on the Student Master Data Sheet in the section labeled "Along the Same Latitude Line."
8. Write down the Reserve's latitude, the annual maximum air temperature, the annual minimum air temperature, the annual maximum water temperature, and the annual minimum water temperature.
9. Calculate the annual air and water temperature ranges for this Reserve.
10. Again, go back to the NERR System map. Find another Reserve on the map that is located at a very different latitude (at least 20° north or south of the first two Reserves). The new Reserve may or may not be in the same time zone.
11. Write down this Reserve name on the Student Master Data Sheet in the row labeled "Far Away."
12. Write down the Reserve's latitude, the annual maximum air temperature, the annual minimum air temperature, the annual maximum water temperature, and the annual minimum water temperature.
13. Calculate the annual air and water temperature ranges for this Reserve.
14. Transfer data about the Reserves from the Student Master Data Sheet to the air temperature and water temperature data tables on your Student Master. Use the data in the data tables to answer the questions below.

Data Tables

Air Temperature

	Reserve Name	Latitude (°N)	Annual Maximum Air Temp. (°C)	Annual Minimum Air Temp. (°C)	Annual Air Temp. Range (°C)
Nearby					
Along the Same Latitude Line					
Far Away					

Water Temperature

	Reserve Name	Latitude (°N)	Annual Maximum Water Temp. (°C)	Annual Minimum Water Temp. (°C)	Annual Water Temp. Range (°C)
Nearby					
Along the Same Latitude Line					
Far Away					

Questions

- Which Reserve has the highest high water temperature? Which Reserve has the lowest low water temperature? Which Reserve has the largest range of water temperature?
- Are air temperatures at the two Reserves with the same or nearly the same latitude more or less similar to each other than they are to the “Far Away” reserve?
- Which Reserve has the largest range of air temperature? Is that Reserve closer to the equator (i.e., lower latitude) than the other Reserves or farther away (i.e., higher latitude)?

STUDENT MASTER

Reserves Data Sheet

Use this data sheet to record information about the Reserves you have chosen. When you are done, transfer information to the two data tables on the main part of the Student Master.

Nearby Reserve

What is the name of the Reserve that is located closest to your school?

What is the latitude of this Reserve?

The maximum annual air temperature at this Reserve is _____ (°C)

The minimum annual air temperature at this Reserve is _____ (°C)

The annual air temperature range at this Reserve is _____ (°C)

The maximum annual water temperature at this Reserve is _____ (°C)

The minimum annual water temperature at this Reserve is _____ (°C)

The annual water temperature range at this Reserve is _____ (°C)

Along the Same Latitude Line Reserve

What is the name of a Reserve located at approximately the same latitude as the “Nearby Reserve”?

What is the latitude of this Reserve?

The maximum annual air temperature at this Reserve is _____ (°C)

The minimum annual air temperature at this Reserve is _____ (°C)

The annual air temperature range at this Reserve is _____ (°C)

The maximum annual water temperature at this Reserve is _____ (°C)

The minimum annual water temperature at this Reserve is _____ (°C)

The annual water temperature range at this Reserve is _____ (°C)

Far Away Reserve

What is the name of a Reserve located at latitude that is far from the latitude of the “Nearby Reserve”?

What is the latitude of this Reserve?

The maximum annual air temperature at this Reserve is _____ (°C)

The minimum annual air temperature at this Reserve is _____ (°C)

The annual air temperature range at this Reserve is _____ (°C)

The maximum annual water temperature at this Reserve is _____ (°C)

The minimum annual water temperature at this Reserve is _____ (°C)

The annual water temperature range at this Reserve is _____ (°C)

EXERCISE 2

A Chilling Effect

Estuary Concept

Variations in weather and location influence water properties in an estuary.

Focus Questions

- How does air temperature affect water temperature?
- How does water temperature affect the amount of dissolved oxygen in the water?

Performance Tasks

Students will:

- Understand that weather (e.g., air temperature, precipitation) can affect water properties in an estuary.
- Identify trends by comparing data for two reserves, one that experiences freezing winters and one that does not.

Teacher Background

The Elkhorn Slough Reserve winds inland nearly seven miles from Monterey Bay to Watsonville, California north of Monterey. Its broad salt marsh is second in size in California only to San Francisco Bay. The Reserve's 1,439 acres include threatened habitats such as maritime chaparral, coastal prairie, coastal sage scrub, live oak woodlands, and grasslands. Elkhorn Slough is noted for its diversity: more than 550 species of invertebrates, 100 species of fish, and 135 species of birds have been identified, including six that are listed as threatened or endangered.

Kachemak Bay, Alaska is the largest reserve in the NERR system, encompassing over 370,000 acres of estuarine and upland habitats. Among Kachemak Bay's most spectacular features is the Homer Spit, which divides Kachemak Bay into an 'inner' and 'outer' bay. Glaciers provide much of the fresh water runoff that empties into the Bay. The 8.5 meter tidal range creates a wide band of intertidal habitats. The bay has beaches and tidal flats, mud flats, wetlands, glaciers, submerged aquatic vegetation, and open water. It supports large concentrations of marine mammals including whales, porpoises, sea lions, seals, and sea otters; as well as fish, king crabs, clams, and other fauna.

In addition to looking at water temperature in this exercise, students will also be looking at dissolved oxygen in the waters of the two Reserve estuaries. Why is dissolved oxygen important? Fish, crabs, oysters, and other aquatic animals need sufficient levels of dissolved oxygen (DO) in the water to survive. The amount of dissolved oxygen in an estuary's water is a major factor in determining the type and abundance of organisms that can live there. The more oxygen there is in the water, the healthier the marine ecosystem is.

How does oxygen get into the estuary's water? Oxygen enters the water through

Overview

Students will create air temperature versus water temperature graphs for a seasonally warm estuary (Elkhorn Slough, CA) and a seasonally cold estuary (Kachemak Bay, AK). Then students will create their own two parameter graphs and use those to examine: 1) water temperature versus latitude at Elkhorn Slough and Kachemak Bay; 2) water temperature versus oxygen concentration at Elkhorn Slough and Kachemak Bay.

Time Required

One 45-minute class session

two natural processes: diffusion from the atmosphere; and photosynthesis by aquatic plants. DO levels are also influenced by temperature and salinity. The solubility of oxygen, or its ability to dissolve in water, decreases as the water's temperature and salinity increase. DO levels in an estuary vary seasonally, with the lowest levels occurring during the late summer months when temperatures are highest.

Bacteria, fungi, and other decomposer organisms reduce oxygen levels in estuary water because they consume oxygen as they break down organic matter. Oxygen depletion may occur in estuaries when many plants die and decompose, or when wastewater with large amounts of organic material enters the estuary. Shallow, well-mixed estuaries are less susceptible to this phenomenon because wave action and circulation patterns bring in water that has plentiful dissolved oxygen.

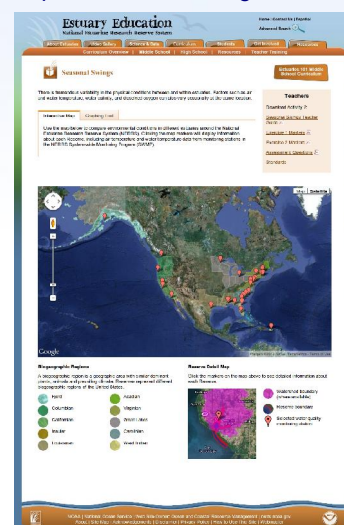
Teacher Preparation

1. If you aren't already familiar with it from Exercise 1: NERR and Far, get to know the Interactive Map of the NERR System. You will find it on the web page for this activity in the Middle School Curriculum section of the Estuary Education website at estuaries.noaa.gov. In particular, look at the location and available data for the two reserves highlighted in this exercise: Elkhorn Slough, CA, and Kachemak Bay, AK.
2. Data from the System Wide Monitoring Program (SWMP) can be retrieved and plotted using the Graphing Tool on the web page for this activity in the Middle School Curriculum section of the Estuary Education website at estuaries.noaa.gov. Practice using the SWMP data program to retrieve real-time data for Elkhorn Slough, CA and Kachemak Bay, AK. Follow Student Master: A Chilling Effect to learn how to get data.

Some tips

- The Science and Data section on estuaries.noaa.gov includes a tutorial for plotting and using SWMP data. Click on the "Graphing Tool Tutorial" tab under "Science & Data" to access the tutorial.
- If your students have trouble finding buttons referred to in instructions, remind them to scroll up or down.
- Graphs may take a couple of minutes to generate. If this is an issue, consider printing graphs ahead of time for class discussion.
- While looking at graphs still displayed on the NERRS data tool, actual 15 minute interval data will display if you hold your cursor over the data set.
- It's preferable to print graphs in color, but data sets can still be distinguished even in black and white copies.
- When looking for actual data values on the graphs, remind your students to make sure they're reading the correct axis for each parameter. Even if they are comparing like parameters (e.g. water temperatures in Part Two), the vertical scales for the two graph lines are not the same. In other words, parallel points on each axis don't share the same values!

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>.



Procedures

Part One: Air temperature versus water temperature

1. Begin Exercise 2: A Chilling Effect by having students locate Elkhorn Slough, CA and Kachemak Bay, AK on the NERR System Interactive Map on the Estuary Education website at estuaries.noaa.gov. Record the locations (latitude and longitude) on the board. Are both locations in the same hemisphere? Students should see that both Reserves are on the same side of the equator, putting them both in the Northern Hemisphere. Therefore, seasons at the two locations differ in length and onset, but follow the same annual cycle.
2. Clicking markers on the map will display photos and information about each reserve. Project the photo of Elkhorn Slough, CA on a screen for students to look at. Ask students what time of year they think the photo was taken.
3. Now show students the photo of Kachemak Bay, AK. Ask your students what time of year they think this photo was taken. Students will correctly guess that this photo of Kachemak Bay was taken in winter, as evidenced by snow and ice. Now show your students the photo of Elkhorn Slough again. Ask whether your students would be surprised to know that both photos were taken in the same season. Students may be surprised that the Elkhorn Slough photo was taken in winter until they stop to consider the latitude of the Reserve. The season is harder to distinguish in Elkhorn Slough because of the milder California climate.
4. Now show your students the two graphs of air temperature versus water temperature for Elkhorn Slough and Kachemak Bay. Ask students if they can see a relationship between air temperature and water temperature. Explain the difference between a direct and an inverse relationship. Is the relationship between air temperature and water temperature direct or inverse? Students should see that the graph demonstrates that, generally speaking, air temperature and water temperature parallel one another. They have a direct relationship. The relationship between air and water temperature is harder to see in the Elkhorn Slough graph since the two graph lines overlap so closely, but the trends of the data points can be seen to parallel one another rather than diverge from one another. Warmer air leads to warmer water; cooler air leads to cooler water. The reverse can also be true, where warm water can moderate the temperature of the overlying air.
5. If you can go online and project your computer screen for the class, you may choose to use the online Graphing Tool to create these two maps yourself rather than showing the existing graphs. If so, follow the general directions from Part 2 of the Student Master and choose air and water temperatures for the data parameters.
6. Have your students look at the year as a whole for each graph and observe the trends in air and water temperature data for Elkhorn Slough and Kachemak Bay. Ask students how the year-long data trends are similar for each site. Students should see that both Elkhorn Slough and Kachemak Bay share similar seasonal patterns. Both experience the coldest temperatures at the ends of the year and the warmest temperatures around the middle of the year. Both also show wider daily fluctuations in air temperature than water

Materials

- NERR System online map
- Student Master: *A Chilling Effect*

temperature. Now ask students how the year-long data trends are different for each site. Data from the two sites differ in three ways: 1) High and low temperatures are shifted seasonally slightly between the two sites: Elkhorn Slough has the coldest temperatures in December and January; Kachemak Bay has its coldest temperatures in December through March. Elkhorn Slough is warmest in July and August, Kachemak Bay is warmest in August and September; 2) Air and water temperatures at Kachemak Bay are generally colder relative to Elkhorn Slough temperatures; and 3) daily fluctuations in both air and water temperature (seen in the ‘thickness’ of the data line on the graph) are greater at Elkhorn Slough than at Kachemak Bay.

Part Two: Water temperature versus latitude

7. Distribute copies of Student Master: A Chilling Effect.
8. Refer your students to Part Two of the Student Master.
9. Tell students that they will practice using the online Graphing Tool to compare water temperatures at Elkhorn Slough and Kachemak Bay.
10. You may want to do Part Two as a class exercise before having students plot their own graphs in Part Three.
11. Have students answer the Part Two questions found on the Student Master. Student should be ready to discuss all of their data and answers to questions in class. Possible answers to Part Two questions are listed below.

Q1. Between which two dates did water temperatures not fall below freezing during 2010 at the Homer Deep station in Kachemak Bay, Alaska?

Water did not freeze between May and October of 2010.

Q2. Were there more or fewer days with freezing water temperatures at the Elkhorn Slough, CA station than at the Homer Deep, AK station?

There were many fewer days with freezing water temperatures at Elkhorn Slough than at Homer Deep in Kachemak Bay.

Q3. Did it ever get below freezing at Elkhorn Slough station in 2010?

Yes. There were a few days at the end of November 2010 when water temperatures reached freezing.

Part Three: Water temperature versus dissolved oxygen

12. Refer your students to Part Three of the Student Master: A Chilling Effect.
13. Tell students that they now must use the same online Graphing Tool to compare and contrast water temperature and dissolved oxygen concentration for the same two Reserve estuaries.
14. Have students answer the Part Three questions found on the Student Master. Student should be ready to discuss all of their data and answers to questions in class. Possible answers to Part Three questions are provided below.

Q4. Do you see a gap in the oxygen concentration data for Homer, AK? When does it occur? What might cause such a gap?

Yes, there is a data gap in July 2010. Sometimes data sets are incomplete because of environmental conditions, such as a large storm. Sometimes data logger equipment malfunctions. Either of these could cause a gap in data.

Q5. What happens to oxygen concentration when water temperature goes up? What happens to oxygen concentration when water temperature goes down?

Warm water cannot hold as much dissolved oxygen as cold water. When water temperature goes up, oxygen concentration tends to go down and vice versa.

Q6. Can you find a place on the Homer, AK graph when oxygen concentration relates differently to water temperature? What might explain this?

Students should notice a strange direct relationship between water temperature and oxygen concentration in March when both graphs drop sharply. This was probably due to a large storm, dumping cold, fresh water into the bay. In May, another unusual trend in the data also corresponds to the beginning of glacial rivers dumping their seasonal snowmelt runoff into the bay.

Q7. Do water temperature and oxygen concentration have the same relationship at Elkhorn Slough as they do in Kachemak Bay?

Yes, in both locations, the amount of dissolved oxygen goes down as water temperature increases. Neither parameter varies as much at Elkhorn Slough as it does in Kachemak Bay.

Q8. How do you think differences in temperature and dissolved oxygen affect animals and plants that live in estuaries?

Plants need certain minimum temperatures in order to grow, whether they live on shore or in the water. Animals need oxygen to breathe. Temperature and the amount of available oxygen in the water are tied to the seasons. The life cycles of plants and animals respond to these seasonal changes in their environment.

Extension: Salinity versus cumulative precipitation

15. As an optional whole-class extension, have students use the SWMP graphing tool to investigate the effects of freezing weather on salinity by comparing and contrasting cumulative precipitation and salinity data for Elkhorn Slough, CA (a “warm” estuary) and Kachemak Bay, AK (a “cold” estuary).
16. Review your class’s observations from the first three parts of this exercise on how latitude affects air temperature, how air temperatures affect water temperature, and how water temperature affects dissolved oxygen levels.
17. Distribute copies of the Student Master, Extension: A Chilling Effect. Students will follow directions on the Student Master to create precipitation versus salinity graphs for the two Reserves.
18. Check your students’ understanding by asking the following questions in class:

What happens to salinity at Elkhorn Slough during 2010? Why?

Salinity drops during precipitation spikes. Precipitation, falling as rain, dilutes the water in the estuary near the station, resulting in lower recorded salinity.

What happens to salinity at Kachemak Bay during 2010?

Salinity drops during precipitation spikes from May through November 2010, but remains relatively level during precipitation spikes from December through April 2010.

Are salinity trends the same for Elkhorn Slough and Kachemak Bay in 2010?

The trends are similar from May through November (although salinity only dips slightly at Elkhorn Slough during less extreme cumulative precipitation spikes in October and November 2010.) Trends are not similar in the two Reserves from December through April.

Can you find a reason why precipitation from December through April does not cause salinity to decrease at Kachemak Bay?

Air temperatures from December through April 2010 at Kachemak Bay were generally below freezing, so any precipitation that fell during that time did not fall as liquid rain. Snow that fell on land did not melt, or melted slowly, so melt water runoff didn't enter the bay and dilute the water, lowering salinity, until the spring thaw.

Conclusions

At the end of this exercise, your students should know that:

- Water temperature is directly related to air temperature.
- Locations at higher latitudes (farther away from the equator, such as Kachemak Bay, Alaska) have colder winters than locations at lower latitudes (closer to the equator, such as Elkhorn Slough, California).
- Dissolved oxygen in the water is inversely related to water temperature.
- Trends in weather and water quality data follow annual cycles related to the seasons. Although exact data values cannot be predicted, general seasonal data trends (e.g., the air will be colder in February than in June) can be predicted.
- Data sets can sometimes be incomplete, due to natural events or equipment malfunctions.

STUDENT MASTER

A Chilling Effect

Get ready to explore the world of data. Be a data detective and see what interesting facts you can find. But be careful. You'll be working with graphs that have two different sets of data shown on the same grid. The two graph lines share the same horizontal axis, which is time. But the vertical axis is different for the two different sets of data. Be sure you're looking at the correct axis for each set of data on your graph.

Water temperature versus latitude

1. Visit estuaries.noaa.gov and click on the "Science & Data" tab near the top of the page.
2. Click on "Data Graphing Tool" in the red bar beneath the "Science & Data" tab.
3. The graphing tool application will open with a map of the United States. The green pins indicate stations gathering water data within Reserves around the United States. If you click on Weather button at the bottom left, the pins will switch to blue. These pins represent stations recording weather data.
4. Select the "Water" button.
5. Choose "AK >> Kachemak Bay >> Homer Dolphin Deep" from the pulldown list of recording stations. The map view will change to a close-up view of the Kachemak Bay, Alaska location.
6. Now you need to select a type of water data to graph. Click on the "Add Data" button. A new "Choose Parameters" window will display.
7. Under Step 3: Pick Parameter label, use the pulldown list to select "Water Temperature" from the list of water data gathered at this site.
8. Finally, you will need to choose which range of dates to include in your graph. Under Step 4: Pick Date Range, specify a start date of "January 1, 2010" and an end date of "December 31, 2010."
9. Click on the "Add" button to generate your graph of 2010 water temperature at the Homer Dolphin Deep, AK station.
10. Look at the graph. The dark grey horizontal line in the middle of the graph represents 0 degrees Celsius, the temperature at which water freezes. Between what two dates did water temperatures not fall below freezing during 2010 at the Homer, AK station?
11. Let's compare the water temperature at the Homer, AK station with a station to the south in California. You can add a second set of data to the same graph. So click the "Add Data" button again.
12. The "Choose Parameters" window will open again. Change the station to "CA >> Elkhorn Slough >> South Marsh." Select "Water Temperature" for the parameter. The date range should already be selected as the same range as before. Click on the "Add" button to add the second set of data to your graph.
13. Look at the graph to answer the questions below. 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 right-clicking inside the graph area and choosing Print from the popup window.)

Questions

- Q1. Between which two dates did water temperatures not fall below freezing during 2010 at the Homer Deep station in Kachemak Bay, Alaska?

Q2. Were there more or fewer days with freezing water temperatures at the Elkhorn Slough, CA station than at the Homer Deep, AK station?

Q3. Did it ever get below freezing at the Elkhorn Slough station in 2010?

Water temperature versus dissolved oxygen concentration

14. Click Reset to start a new graph.
15. Select the “Water” button.
16. Choose “AK>>Kachemak Bay>>Homer Dolphin Deep” from the pulldown list of recording stations.
17. Click on the “Add Data” button. A new “Choose Parameters” window will display.
18. Under Step 3: Pick Parameter label, use the pulldown list to select “Water temperature” from the list of water data gathered at this station.
19. The date range should already be selected as the same range as your previous graph (January 1, 2010 to December 31, 2010). Click on the “Add” button to add this data to your graph.
20. Now use the graphing tool to compare the water temperature at the Homer, AK station with the oxygen concentration in the water at the same station. Click the “Add Data” button again.
21. A pop-up saying “Would you like to change the Y axis?” appears. Click “Yes.”
22. The “Choose Parameters” window will open again. Select “oxygen concentration” for the parameter. Again, the date range should already be selected as the same range as before. Click on the “Add” button to add the second set of data to your graph.
23. You may want to save the Kachemak Bay graph image to your local computer as a PDF or print the graph before moving on.
24. Click Reset to start a new graph. After you click on Reset, a pop-up saying “You have asked to Reset your graph....Would you like to continue?” appears. Click “Yes.”
25. Now repeat Steps 2 through 10 to create a water temperature versus oxygen concentration graph for the “CA>>Elkhorn Slough>> South Marsh” NERR.
26. You may want to save the Elkhorn Slough graph image to your local computer as a PDF or print the graph before moving on.
27. Look at the two graphs to answer the questions below.

Questions

- Q4. Do you see a gap in the oxygen concentration data for Homer, AK? When does it occur? What might cause such a gap?
- Q5. What happens to oxygen concentration when water temperature goes up? What happens to oxygen concentration when water temperature goes down?

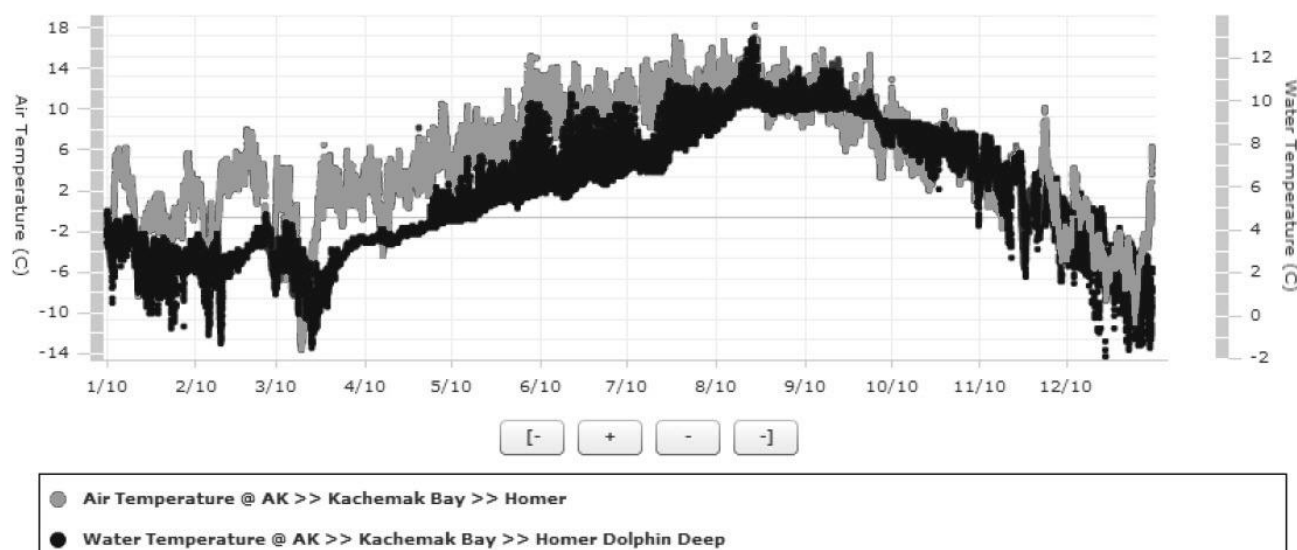
- Q6. Can you find a place on the Homer, AK graph when oxygen concentration relates differently to water temperature? What might explain this?
- Q7. Do water temperature and oxygen concentration have the same relationship at Elkhorn Slough as they do in Kachemak Bay?
- Q8. How do you think differences in temperature and dissolved oxygen affect animals and plants that live in estuaries?

EXTENSION

A Chilling Effect

Extension: Salinity versus cumulative precipitation

1. Return to estuaries.noaa.gov and access the Graphing Tool under the “Science & Data” tab.
2. Create a graph showing cumulative precipitation for “CA>>Elkhorn Slough>> Caspian Weather Station” from January 1, 2010 to December 31, 2010.
3. Then add a second set of data to the same graph. Add salinity at “CA>>Elkhorn Slough>>South Marsh” for the same date range.
4. Look closely at the Elkhorn Slough graph. Notice when precipitation changes the most. What happens to water salinity during the time when precipitation changes the most? Why?
5. Now repeat the process for the Kachemak Bay NERR. Plot cumulative precipitation at “AK>>Kachemak Bay>>Homer” from January 1, 2010 to December 31, 2010.
6. Then add a second set of data to the same graph. Add salinity at “AK>>Kachemak Bay>>Homer Dolphin Deep” for the same date range.
7. Look closely at the Kachemak Bay graph. Notice when precipitation changes the most. What happens to salinity during that time?
8. Look at both graphs together. Are the trends in precipitation versus salinity the same for Kachemak Bay and Elkhorn Slough?
9. Now look at the graph of 2010 air temperature versus water temperature for Kachemak Bay from earlier in this exercise:



10. Compare data in this graph with the salinity versus cumulative precipitation graph for the same estuary. Precipitation from December through April does not seem to cause salinity to decrease in Kachemak Bay? Can you find a reason why this might be the case?