

Monitoring Estuarine Water Quality

Summary

Five lessons at increasing levels of sophistication incorporate real data from NOAA to help students understand how water quality parameters are monitored and how these factors affect biological systems.

Grade Level: 6 - 8

Aligned to National Standards in Mathematics, Science, and Geography. See page 8.

This curriculum module was developed for the NOAA Ocean Data Education (NODE) Project by Caroline Joyce and Todd Viola under a contract with the National Marine Sanctuary Foundation and in collaboration with these offices of the National Oceanic and Atmospheric Administration: National Marine Sanctuary Program, National Estuarine Research Reserve System and National Oceanographic Data Center.

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NATIONAL
ESTUARINE
RESEARCH
RESERVE
SYSTEM

IOOS
INTEGRATED OCEAN OBSERVING SYSTEM

Introduction

Estuaries are an important component of complex and dynamic coastal watersheds. A partnership between NOAA and various coastal states, the National Estuarine Research Reserve System (NERRS) has established a network of coastal sites that are protected for long-term research, education, and stewardship. As part of the NERRS research mission, the System-wide Monitoring Program (SWMP) continually monitors an array of environmental factors throughout the reserve system.

Instruments called data loggers record a number of water quality parameters, while other instruments monitor meteorological conditions and nutrient data in a variety of coastal systems.

These lessons and accompanying online tools will introduce students to water quality monitoring using real data. First, students need to understand how to access and interpret water quality data, and how to look for patterns and changes over time. Ultimately, they will examine the impacts of physical water quality factors on species that live in a given environment, using the Atlantic sturgeon as an example. The lessons deal primarily with the following water quality parameters: water temperature, dissolved oxygen, and salinity. However, students can use the online tools to extend their investigations by examining other parameters as well. The goal is for students to experience different kinds of data and data accessing tools, so that, by the end of the module, they can continue to explore data sets driven by their own inquiry.

The curriculum is not designed to be a comprehensive unit on estuaries or on water quality measures. Rather, the focus is on data literacy as much as science, and the lessons are intended to help achieve important cross-curricular connections between science and mathematics.

Estuary Basics

An estuary is a partially enclosed body of water where two different water bodies meet and mix. In an estuary, fresh water from rivers or streams mixes with salt water from the ocean, or with the chemically distinct water of a large lake. Water quality in estuaries fluctuates naturally because of the dynamic mixing of fresh and salt water.

Web Links

For links to helpful Web sites about water quality parameters and monitoring programs, visit www.dataintheclassroom.org.

The physical water quality parameters within an estuary depend on the structure of the estuary and on the location being observed. Locations in inlets and open bays, for example, may see a tidal effect, as water moves in and out during the daily tide cycle. Farther up in the watershed, marshes and streams may see less tidal effect, but a greater effect from river input and runoff.

Estuaries are critically important ecosystems, because they provide habitat and breeding locations for a great number of aquatic species. Although human civilizations have historically depended on and benefited from estuarine resources, only recently have we recognized the effects of habitat disturbances.

Lesson Overview

Water quality is often taught as a field project in which students measure water quality at a local stream or aquatic site. If you routinely conduct such local studies with your students, this module can serve as a complement to give students more exposure to real data. However, because of the challenges involved with field trips and the fact that not all schools have access to field sites, this module is also designed to be used as a stand-alone lesson. In this case, you can treat the module as a “virtual” or electronic field trip, in which students use real data from the Internet to explore and monitor an aquatic environment without leaving the classroom.

This curriculum incorporates a scaled approach to learning. Each module offers activities at five different levels of student interaction, sometimes referred to as Entry, Adoption, Adaptation, Interactivity, and Invention. The early levels are very directed and teacher driven. They are important first steps, however, when learning something new. The levels of Adaptation through Invention are more student directed and open up opportunities to design lessons featuring student inquiry.

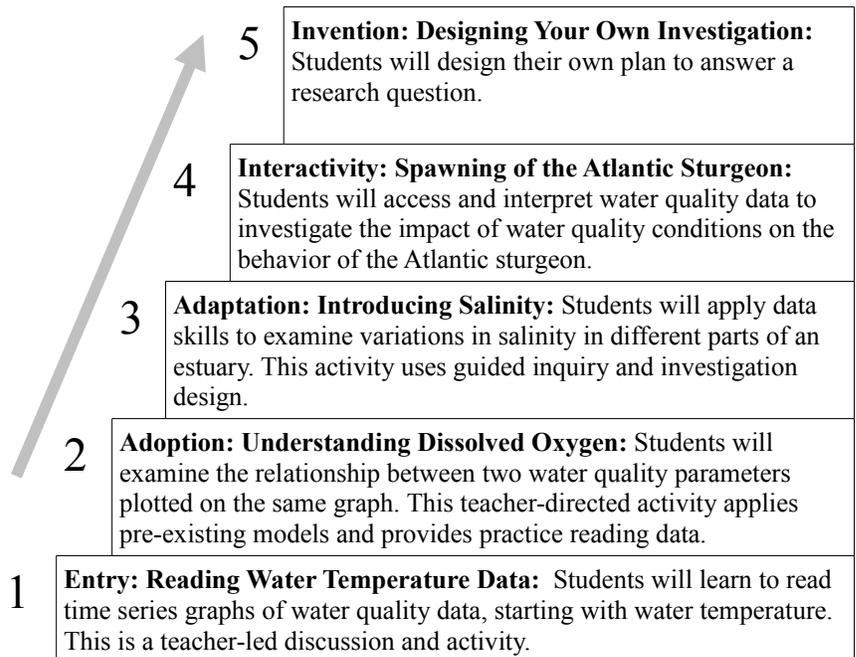
The levels serve a dual purpose. They are designed to engage students in increasingly sophisticated modes of understanding and manipulating data. They are also intended to help you, as a teacher, familiarize yourself with online tools for accessing data and to provide you with models for integrating the use of real data into your classroom practice.¹

¹ For more information about the research behind this approach, consult these papers:

Dwyer, D. C., Ringstaff, C., & Sandholtz, J. H. (1990). Teacher beliefs and practices, Part I: Pattern of change. ACOT Report # 8. Cupertino, CA: Apple Classroom of Tomorrow Advanced Technology Group, Apple Computer, Inc.

Bransford, J.D., Goin, L., Hasselbring, T.S., Kinzer, C.K., Sherwood, R.D., & Williams, S.M. (1999). Learning with technology: Theoretical and empirical perspectives. *Peabody Journal of Education*. 5-26.

The chart below illustrates the five levels of this module, Monitoring Estuarine Water Quality.



The levels provide a natural opportunity for you to adapt and customize the curriculum module as needed. For example, if students already have experience with the topic, you may find that you can skip the entry level activities.

Using the Technology

Teaching using technology presents some challenges. Because this curriculum demonstrates strategies for using real scientific data available on the Internet, it assumes that you and your students will have access to the Internet at some point during the investigation. Because the level and availability of Internet access varies widely from setting to setting, however, you may need to adapt the activities to suit your particular situation. To help you, the activities are designed with flexibility in mind.

For example:

- When access to real data is needed, the Preparation section describes steps that can be performed outside of class. Data and results can be saved for use in class.
- Data can be accessed through the dataintheclassroom.org Web site using special forms that have been designed for this project. While it is recommended that you familiarize yourself with how to access data using these tools, the early lessons also contain blackline masters of important maps, graphs, and other data products, which can be used in settings where live Internet access is not available.
- An important outcome of these activities, especially at the higher levels, is for students to learn how to access and manipulate data themselves. In the ideal case, students will access the Internet individually or in groups in order to generate maps and graphs using real data. In settings where this is not possible, the curriculum provides student masters, which can be reproduced and used in class. To fully explore the questions posed in the highest level activities, however, students in these settings will need to access the Internet in a library or computer center outside of class.

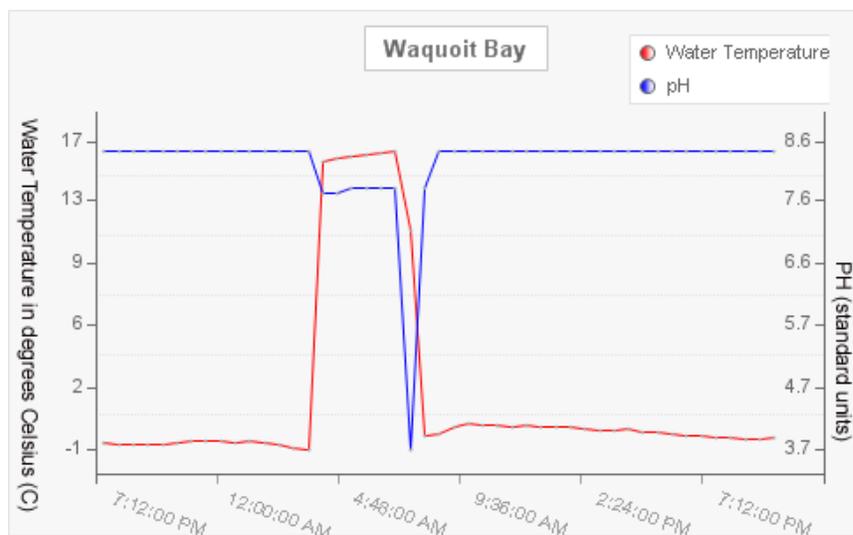
Note

The Web site for the NERRS Centralized Data Management Office (CDMO) contains the notice below. You may wish to read this notice to your students and discuss what it means, as they attempt to use real-time data themselves.

“All real time data reported on the CDMO website are considered provisional and have not been edited or reviewed. The reflected data may contain values that are missing or erroneous due to satellite transmission interruptions. Data out of instrument range have been removed through an automated quality control process.”

Emphasizing Critical Thinking

Data from the System-wide Monitoring Program (SWMP) are available through the NERRS Centralized Data Management Office (CDMO) in “real time.” This means that, for the sake of providing very current, up-to-the minute information, the data are made available without being checked for missing or erroneous values. Ultimately, data used by scientists in published research are carefully edited and reviewed using quality control procedures, which take time. Generally, data available through the CDMO that is older than two years have been reviewed. However, newer, real-time data may contain gaps or errors that have not been corrected yet. Therefore, when using any online data, students should use critical thinking to ask if the data make sense or may contain errors. For example, consider the graph below:



In this example from February 2007, the chart shows the water temperature increasing sharply from near freezing to 17°C (62°F) during a four-hour period one winter day in Massachusetts. Common sense says this is unlikely. At the same time, the recorded pH went from 8.5 to 3.7 (comparable to the acidity of grapefruit juice). Taking these measurements together, one suspects that they more likely indicate a temporary problem with the data logger instrument than the actual conditions at the site.

National Education Standards

This curriculum module is aligned with the national education standards in science, math, and geography for grades 5-8. The table below presents a list of core standards covered at the different activity levels. These standards-based activities are designed to be easily integrated into pre-existing school science and math curricula, not as “add ons” but as ways to enhance existing standards-driven curricula by using real-time data. The standards that support this curriculum facilitate learning by having students practice using real-time data within the context of a variety of standards- and inquiry-based activities.

	Mathematics ²	Geography ³	Science ⁴
Level 1	<ul style="list-style-type: none"> ■ Use tables, maps, and graphs to describe situations. ■ Statistics and Probability: Work with data in the context of real-world situations. 		<ul style="list-style-type: none"> ■ Technology is essential to science, because it provides instruments and techniques that enable observations of objects and phenomena that are otherwise unobservable due to such factors as distance and location. ■ The number of organisms an ecosystem can support depends on the resources available and abiotic factors such as temperature.
Level 2	<ul style="list-style-type: none"> ■ Use observations about the differences between two characteristics on the basis of maps, histograms, box plots, and scatter plots. 	<ul style="list-style-type: none"> ■ Explain how physical processes help to shape features and patterns on the Earth’s surface, for example, by comparing and interpreting maps and charts. 	<ul style="list-style-type: none"> ■ Make conjectures about possible relationships between sample characteristics on the basis of graphs/plots of data and approximate lines of fit.
Level 3	<ul style="list-style-type: none"> ■ Use observations about the differences between two characteristics on the basis of maps, histograms, box plots, and scatter plots. 	<ul style="list-style-type: none"> ■ Explain how physical processes help to shape features and patterns on the Earth’s surface, for example, by comparing and interpreting maps and charts. 	<ul style="list-style-type: none"> ■ Identify questions that can be answered through scientific investigations.

2 National Council of Teachers of Mathematics. (2001). *Principles and Standards for School Mathematics*. Washington, D.C.

3 Geography Education Standards Project. (1994). *Geography for Life: The National Geography Standards*. Washington, D.C.: National Geographic Society Committee on Research and Exploration.

4 National Academy of Sciences. (1996). *National Science Education Standards*. Washington, D.C.: National Academy Press.

	Mathematics	Geography	Science
Level 4	<ul style="list-style-type: none"> ■ Formulate questions that lead to data collection and analysis. 	<ul style="list-style-type: none"> ■ Demonstrate an understanding of the structure and systems of Earth and other bodies in the universe, and of their interactions. 	<ul style="list-style-type: none"> ■ All organisms must be able to obtain and use resources, grow, reproduce, and maintain stable internal conditions while living in a constantly changing external environment. ■ State what they have learned from investigations, relating their inferences to scientific knowledge and data they have collected. ■ Identify data sources and other sources of information, including their own records, to answer the questions being investigated.
Level 5	<ul style="list-style-type: none"> ■ Utilize questions that lead to data collection and analysis. ■ Compare several data sets to generate, test, and have the data dictate, confirm, or deny hypotheses. ■ Work with data in the context of real-world data situations. 		<ul style="list-style-type: none"> ■ Design and conduct investigations that provide reliable quantitative or qualitative data, as appropriate, to answer questions.

Ocean Literacy Essential Principles

This curriculum module also supports the following Essential Principles of Ocean Sciences.⁵

1. The Earth has one big ocean with many features.
 - f. The ocean is an integral part of the water cycle and is connected to all of the earth's water reservoirs via evaporation and precipitation processes.
5. The ocean supports a great deal of diversity of life and ecosystems.
 - f. Ocean habitats are defined by environmental factors. Due to interactions of abiotic factors such as salinity, temperature, oxygen, pH, light, nutrients, pressure, substrate, and circulation, ocean life is not evenly distributed temporally or spatially, i.e., it is "patchy." Some regions of the ocean support more diverse and abundant life than anywhere on Earth, while much of the ocean is considered a desert.
 - i. Estuaries provide important and productive nursery areas for many marine and aquatic species.
6. The ocean and humans are inextricably interconnected.
 - f. Coastal regions are susceptible to natural hazards (such as tsunamis, hurricanes, cyclones, sea level change, and storm surges).

⁵ Ocean Literacy Network (2005). *Ocean Literacy - The Essential Principles of Ocean Sciences K-12*. Washington, D.C.

Summary

Grade Level: 6 - 8

Teaching Time: 45 minutes

Activities:

- **Examine what estuaries are and where they are located in the NERRS System.**
- **Interpret graphs of water temperature data.**

Vocabulary

Data logger – an instrument used to measure water quality parameters.

Estuary – a body of water, partially enclosed by land, and connected to a river and an ocean, where salt water and fresh water mix.

NERRS – National Estuarine Research Reserve System

SWMP – System-wide Monitoring Program

Objective

This activity will define estuaries, describe where they are located, and present how real-time water quality measurements are collected.

Students will learn to read time series graphs of water quality data, starting with water temperature.

Students will look at two of the National Estuarine Research Reserve System (NERRS) sites, the Waquoit Bay NERR in Massachusetts and the Wells NERR in Maine.

Background

NOAA's National Estuarine Research Reserve System is a network of protected coastal areas around the United States. Water quality parameters are measured and recorded continuously throughout the NERRS using instruments called data loggers. These parameters include water temperature, salinity, dissolved oxygen, and pH.

Temperature is an important parameter to study, because it is a driving factor in the chemical and biological processes that determine how well an aquatic environment can support life. Scientists using System-wide Monitoring Program (SWMP) data to study coastal systems have found that temperature is the most important factor in determining the primary and secondary production of a community within the estuaries.⁶

6 Dionne, M. Physical Influences on the Biota. (2006.) *In* Site profile of the Wells National Estuarine Research Reserve. *Edited by* M. Dionne, C. Dalton, and H. Wilhelm. Wells National Estuarine Research Reserve, Wells, ME. 326 pp. 221.

To Display



Generate this image at
www.dataintheclassroom.org.

Preparation

If you have access to a computer and projector, you can display a color version of the Water Temperature Time Series for Webhannet Inlet at the Wells NERR in Maine (shown at left). Use the following steps:

1. Visit www.dataintheclassroom.org and find the Water Quality module.
2. Follow the link to “Get Data.”
3. Using the form, select “Water Quality” from the list under “Which data?”
4. Choose “Wells > Inlet” from the list of recording stations.
5. Choose “Water Temperature” from the list of available parameters.
6. Specify a start date of January 1, 2007. Select a duration of “1 Year.”
7. Leave “Graph” selected under “Specify an output format.”
8. Click the “Get Data” button.
9. You can print the graph for later use or use a screen capture utility to save the image to your local computer.

Materials

- Computer with Internet connection or overhead projector
 - Transparency of Teacher Master, Waquoit Bay National Estuarine Research Reserve
 - Transparency of Teacher Master, The National Estuarine Research Reserve System
 - Saved image or transparency of Teacher Master, Water Temperature Measured Over One Year
 - Copies of Student Master, Water Temperature Measured Over 24 Hours
-

Procedure

1. Display the Teacher Master, Waquoit Bay National Estuarine Research Reserve, on an overhead or computer screen. Explain the key features of the diagram:
 - Give the following definition of an estuary: an estuary is a body of water, partially enclosed by land, and connected to a river and an ocean, where salt water and fresh water mix.
 - Point out the river and the ocean as sources of fresh water and salt water.
 - Explain that Waquoit Bay is located in Massachusetts and is one of 27 National Estuarine Research Reserves around the United States.
 - Point out the photo of the data logger. Tell students that each reserve has instruments like this in at least four locations, to measure water quality parameters at 15-minute intervals.
2. Discuss how the structure of the estuary provides an opportunity for the water to mix.
3. Ask where the students think the water is the shallowest.

Possible answers: Near the shores of the bay; at the mouth of the river.

4. Ask where the water might be the coldest and the warmest.

Possible answer: The coldest water is probably near the ocean; the warmest water may be in shallow areas of the bay or river.

5. Explain that this activity will involve taking a “virtual” field trip. Using the Internet, students will be able to access data from data loggers all over the United States. By carefully examining water quality data from estuaries like Waquoit Bay, they can study the dynamics of the site without actually going there.

6. Next, display the Teacher Master, National Estuarine Research Reserve System (NERRS), on an overhead or computer screen. Explain that there are currently 27 reserves, indicated by white circles on the map. Black circles represent proposed reserves.
7. Point to Maine on the map, and explain to students that they are going to visit another site, the Wells NERR, to collect some temperature data.
8. Display the Teacher Master, Water Temperature Measured Over One Year, on an overhead or computer screen. Explain the key features of the graph:
 - X axis = time, marked at intervals from January 2007 through February 2008
 - Y axis = recorded water temperature in degrees Celsius
9. Discuss the way the water temperature varied over the course of the year. Ask students to describe the pattern of the graph.

Possible answers: The water temperature was lowest in the winter, then gradually rose to its highest level in late summer, before falling again the next winter.

10. Give each student a copy of the Student Master, Water Temperature Measured Over 24 Hours. Students should use the graph to answer the questions on the sheet.

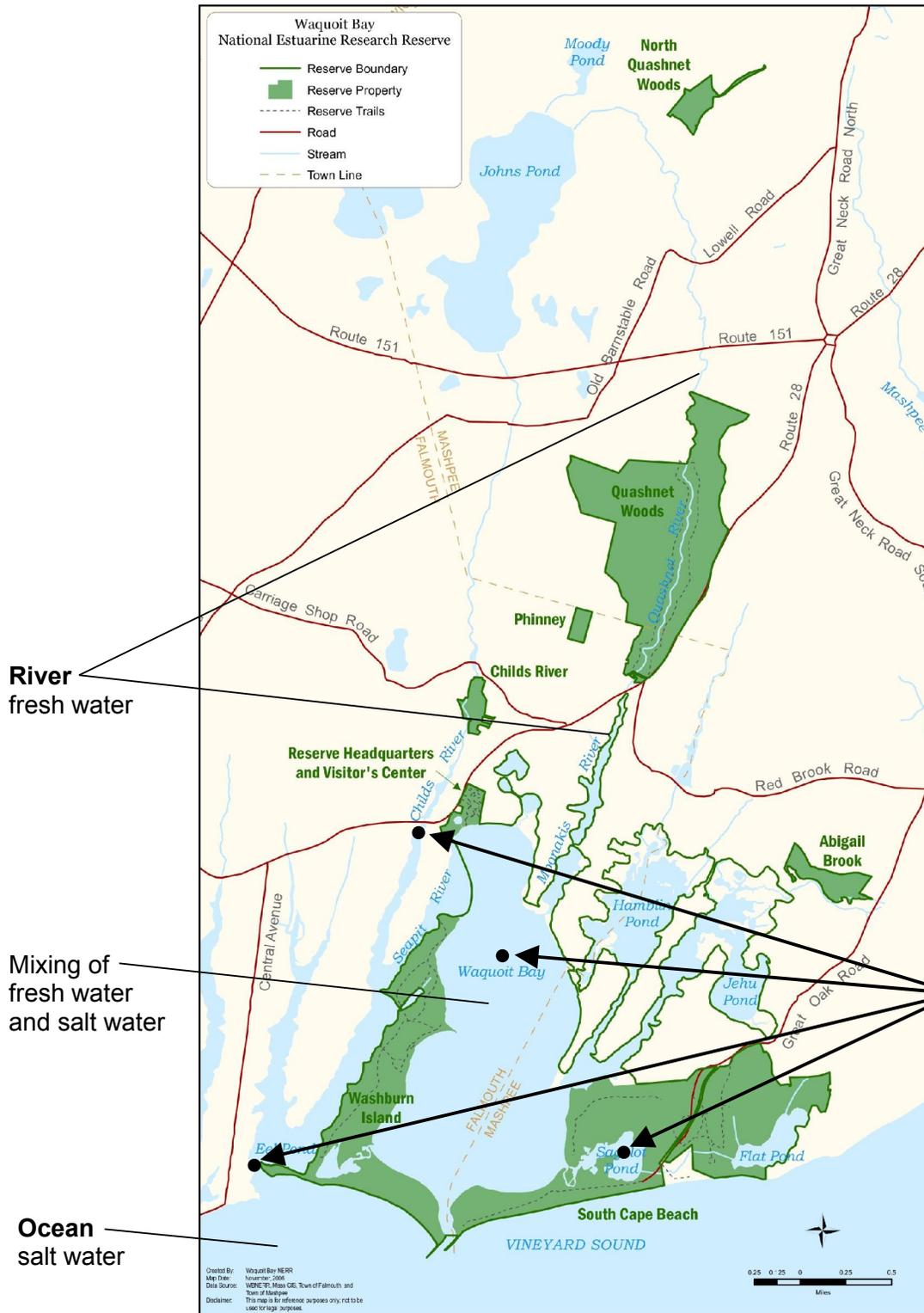
Answers:

1. c) About 15.4 °C
2. b) About 14 °C
3. Perhaps the daily high tides carried cold ocean water into the area near the data logger.

11. Once students are comfortable reading data from graphs, you can use the online tool to examine more data.

Teacher Master

Waquoit Bay National Estuarine Research Reserve



River fresh water

Mixing of fresh water and salt water

Ocean salt water

Typical YSI 6000 series data logger



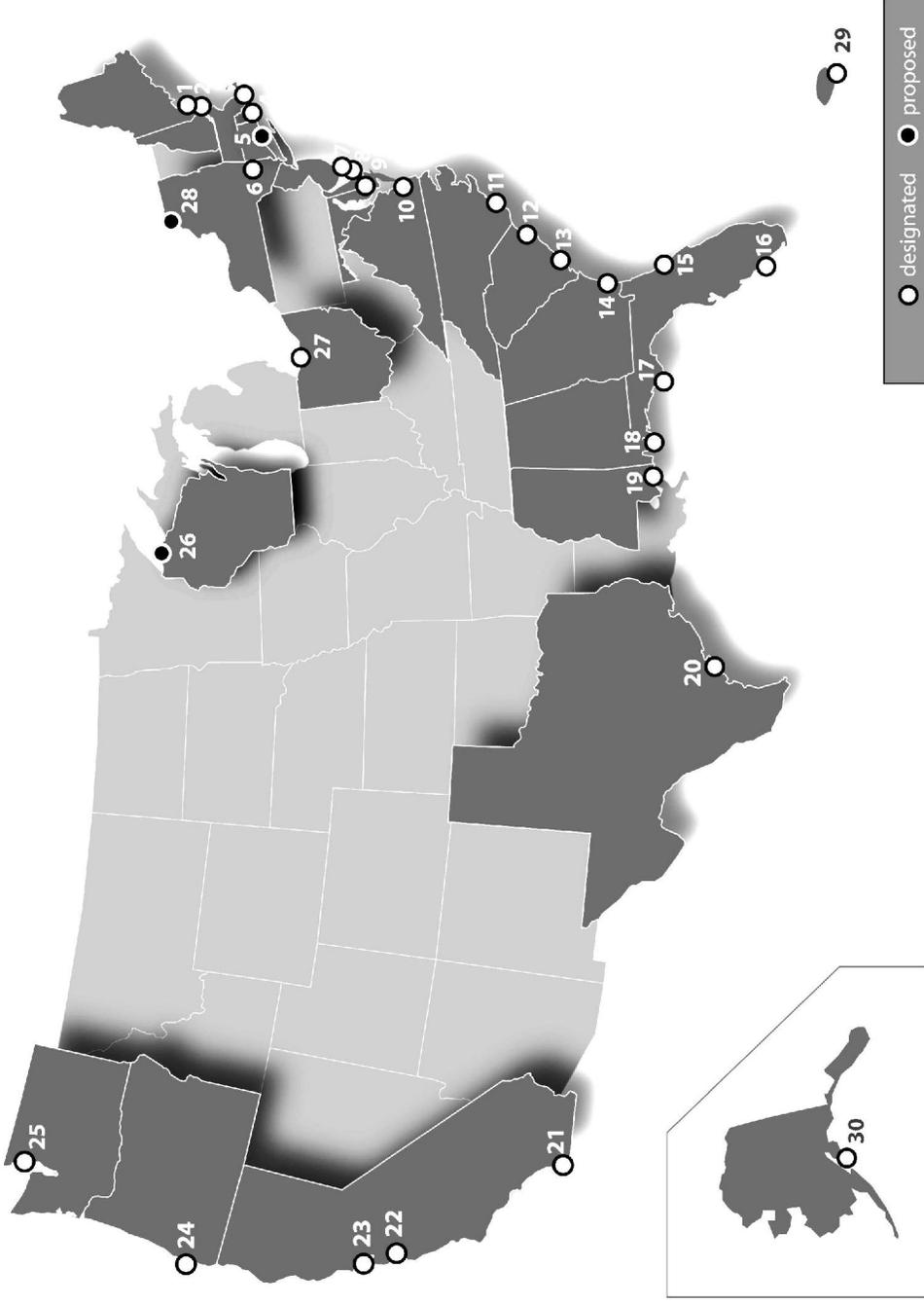
Data logger locations:

- Child's River
- Metoxit Point
- Menauhant
- Sage Lot

map: Waquoit Bay National Estuarine Research Reserve
 photo: North Carolina National Estuarine Research Reserve

Teacher Master

The National Estuarine Research Reserve System (NERRS)



1. Wells, Maine
2. Great Bay, New Hampshire
3. Waquoit Bay, Massachusetts
4. Narragansett Bay, Rhode Island
5. Connecticut*
6. Hudson River, New York
7. Jacques Cousteau, New Jersey
8. Delaware
9. Chesapeake Bay, Maryland
10. Chesapeake Bay, Virginia
11. North Carolina
12. North Inlet-Winyah Bay, South Carolina
13. ACE Basin, South Carolina
14. Sapelo Island, Georgia
15. Guana Tolomato Matanzas, Florida
16. Rookery Bay, Florida
17. Apalachicola, Florida
18. Weeks Bay, Alabama
19. Grand Bay, Mississippi
20. Mission-Aransas, Texas
21. Tijuana River, California
22. Elkhorn Slough, California
23. San Francisco Bay, California
24. South Slough, Oregon
25. Padilla Bay, Washington
26. Wisconsin*
27. Old Woman Creek, Ohio
28. St. Lawrence River, New York*
29. Jobs Bay, Puerto Rico
30. Kachemak Bay, Alaska

* Proposed Reserve

Teacher Master

Water Temperature Measured Over One Year

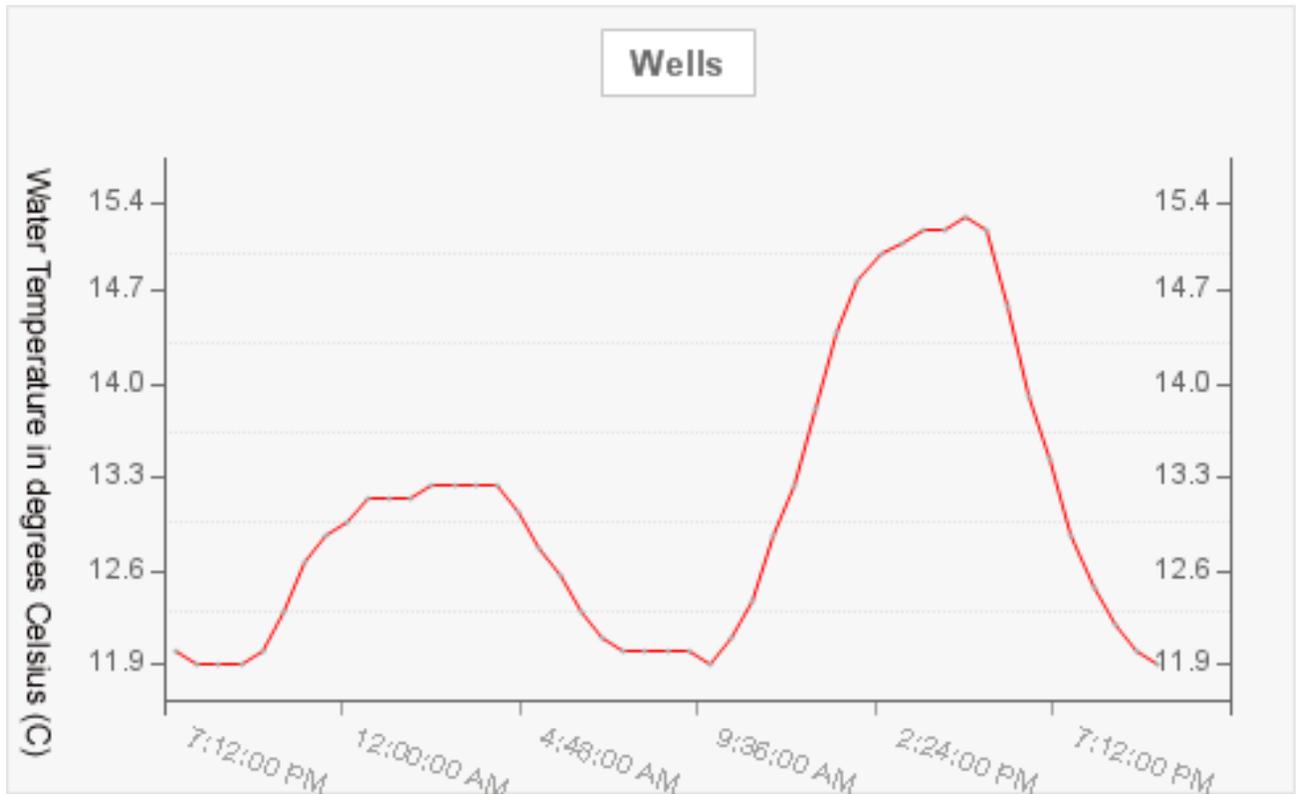
Wells NERR, Webhannet Inlet, January 2007 – February 2008



Student Master

Water Temperature Measured Over 24 Hours

Wells NERR, Webhannet Inlet, June 1, 2007



Questions

1. What was the highest temperature recorded on June 1?
 - a) About 11.9 °C
 - b) About 13.3 °C
 - c) About 15.4 °C

2. What was the recorded temperature around 12:00 noon?
 - a) About 13 °C
 - b) About 14 °C
 - c) About 15 °C

3. What are some factors that might explain the two “peaks” in water temperature that occurred approximately 12 hours apart?

Summary

Grade Level: 6 - 8

Teaching Time: 45 minutes

Activities:

- Explore two processes that influence dissolved oxygen concentrations.
- Use a graph to examine the relationship between water temperature and dissolved oxygen.

Vocabulary

Dissolved oxygen – oxygen from the surrounding atmosphere that is absorbed in water and supports aquatic life.

Objective

Students will examine the relationship between two water quality parameters plotted on the same graph.

Background

Although water molecules contain oxygen atoms, this oxygen is not accessible to fish and other organisms, because it is locked up in the water molecule. Instead, air from the surrounding atmosphere dissolves in the water, and it is this dissolved oxygen that supports aquatic life. Different factors influence the amount of dissolved oxygen in water. For example, fast-flowing water may absorb more dissolved oxygen than slower-moving water. Organisms in the water that use oxygen for respiration will also deplete oxygen levels.

In this activity, students will examine two processes that influence dissolved oxygen concentrations. The first is photosynthesis: primary producers in aquatic environments generate oxygen through photosynthesis. The second is the solubility of oxygen in water based on temperature. Because oxygen is a gas, it tends to escape from water when heated. As a result, cold water is capable of absorbing more oxygen than is warm water.

To Display



Generate this image at
www.dataintheclassroom.org.

Tip

If you have a dissolved oxygen test kit, you can prepare a demonstration to show students how DO is measured in the field.

Preparation

If you have access to a computer and projector, you can display a color version of the Water Temperature and Dissolved Oxygen graph from the ACE Basin NERR (shown at left). Use the following steps:

1. Visit www.dataintheclassroom.org and find the Water Quality module.
2. Follow the link to “Get Data.”
3. Using the form, select “Water Quality” from the list under “Which data?”
4. Choose “ACE Basin > Big Bay” from the list of recording stations.
5. Choose “Water Temperature” as the first parameter and “Dissolved Oxygen” as the optional second parameter.
6. Under “start date,” select Jun. 1, 2007. Select a duration of “1 Day.”
7. Leave “Graph” selected under “Specify an output format.”
8. Click the “Get Data” button.
9. You can print the graph for later use or use a screen capture utility to save the image to your local computer.
10. Repeat the procedure, but this time select a start date of Jan. 1, 2007, and a duration of “1 Year.”

Materials

- Graph screenshot saved to your computer or transparency of Teacher Master, Water Temperature and Dissolved Oxygen
 - Copies of Student Master, Water Temperature and Dissolved Oxygen
 - Dissolved oxygen test kit (Optional)
-

Procedure

1. Explain to students that dissolved oxygen (DO) enables living organisms to survive underwater, and describe some ways that oxygen is absorbed in water.
2. Remind students how photosynthesis works. Ask students whether they would expect oxygen levels to rise or fall on a sunny day.

Answer: Oxygen levels should rise as microorganisms photosynthesize and produce oxygen in the water.

3. Describe what happens when a gas like oxygen heats up. As temperature increases, the gas molecules have more energy and move faster. Ask students whether they would expect warm water to contain more or less dissolved oxygen than cold water.

Answer: Warm water would contain less DO than cold water.

Tell students they will look at the ACE Basin NERR in South Carolina to see what happens to DO when temperature changes.

4. Display the graphs of water temperature and dissolved oxygen from the ACE Basin NERR. Explain key features of the graphs:
 - X axis = time, marked at intervals from January 2007 through February 2008
 - Notice that the Y axis is marked with two different scales: degrees Celsius for reading water temperature on the left, and milligrams per liter for reading dissolved oxygen on the right.
5. Discuss the relationship between the water temperature and dissolved oxygen measurements in the graph. Point out that over the course of the year, when the water temperature is highest,

dissolved oxygen levels are lowest, and vice versa. Ask students to relate what they see in the graph to their earlier discussion of factors affecting dissolved oxygen.

6. Give each student a copy of the Student Master, Water Temperature and Dissolved Oxygen. Explain the key features of the graphs.
 - The first graph displays water temperature and dissolved oxygen on the same graph over a period of one day.
 - The second graph displays water temperature and dissolved oxygen at the same site, but over a period of a full year.
7. Students should study the graphs in order to answer the questions on the sheet.

Answers:

1. In the first graph (one day), dissolved oxygen and water temperature are both high at the same time. In the second graph (one year), they have the opposite relationship: when water temperature is high, dissolved oxygen is low.
2. Over one day, the change in water temperature is relatively small (less than 2°C). Therefore, the ability of the water to absorb oxygen doesn't change much over that range. Over one year, the water temperature changes at least 20°C, which impacts dissolved oxygen levels over time. At this longer time scale, the influence of temperature is more evident.
3. Dissolved oxygen is generated by microorganisms during photosynthesis. Just as water temperature is highest in the afternoon when the sun is high, perhaps dissolved oxygen is also high because there is more sunlight for photosynthesis.

Teacher Master

Water Temperature and Dissolved Oxygen

ACE Basin NERR, Big Bay, January 2007 – February 2008



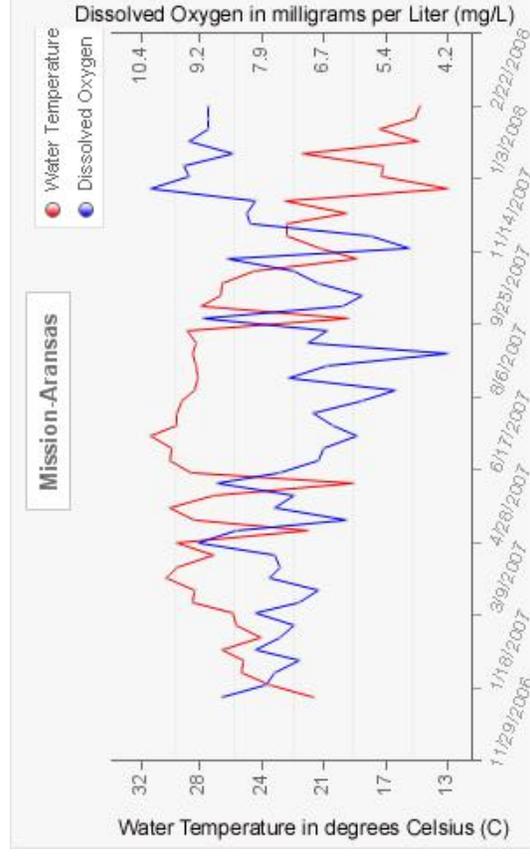
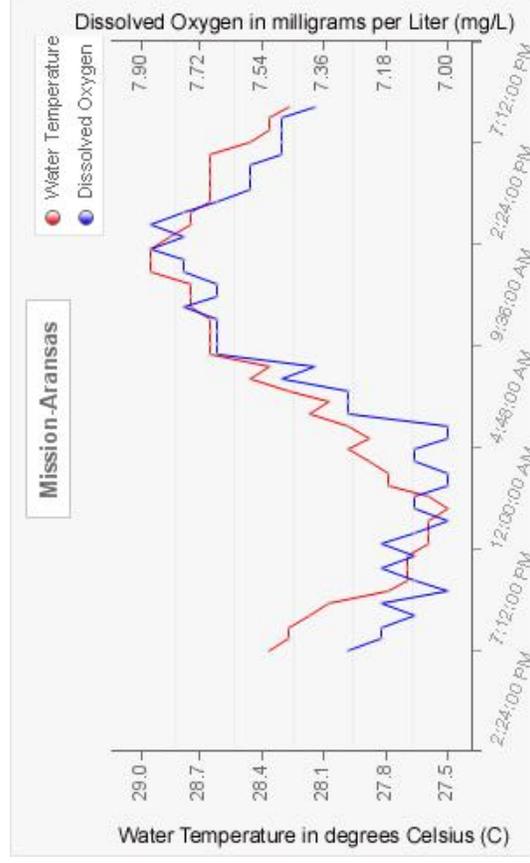
Student Master

Water Temperature and Dissolved Oxygen

Mission-Aransas NERR, Copano Bay East

Daily: June 1, 2007

Yearly: January 2007 – February 2008



Questions

1. How would you describe the relationship between temperature and dissolved oxygen in the two graphs?
2. What might explain the apparent difference in the relationship of water temperature and dissolved oxygen in the two graphs? (Hint: consider the different between the lowest and highest temperatures recorded over one day vs. one year.)
3. How might you explain the change in dissolved oxygen in the first graph (one day)?

Summary

Grade Level: 6 - 8

Teaching Time:

Two 45-minute periods

Activities:

- **Compare salinities at different locations within an estuary.**
 - **Interpret data from graphs to support or disprove a hypothesis.**
-

Vocabulary

Salinity – measure of the quantity of dissolved salts in seawater, expressed in parts per thousand (ppt).

Objective

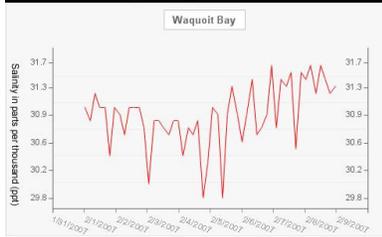
Students will apply data skills to examine variations in salinity in different parts of an estuary in order to support or disprove a hypothesis.

Background

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 runoff. Circulation and distribution of salinity are used to distinguish between different types of estuaries. Salinity may change from one season to another, depending on the amount of freshwater river flow or the change in weekly tides from spring to neap tides.

Salinity levels in estuaries are generally highest near the mouth of a river where ocean water enters, and lowest upstream where fresh water flows in. However, salinities at specific locations in the estuaries vary through the tidal cycle. Overall salinity levels in the estuaries decline in the spring, when snowmelt and rain produce elevated freshwater flows from streams and ground water.

To Display



Generate this image at
www.dataintheclassroom.org.

Materials

- Computer with Internet access or overhead projector
- Saved image or Transparency of Teacher Master, Waquoit Bay National Estuarine Research Reserve, p. 15.
- Copies of Student Master, Supporting a Hypothesis with Data
- Student access to computers with Internet connections

Preparation

If you have not done so already, be prepared to demonstrate for students how to access the dataintheclassroom.org Web site to generate maps and graphs. Using a computer and projector, walk students through the preparation procedure described in step 5 below.

Procedure

This activity uses guided inquiry to accomplish two objectives: 1) to use real data to examine salinity; and 2) to use real data in the form of graphs to support or disprove a hypothesis.

1. Remind students about the structure of an estuary, using Teacher Master, Waquoit Bay National Estuarine Research Reserve.
2. Define salinity as the amount of dissolved salts in the water. Ask students what factors might influence salinity in an estuary.

Possible answers: rainfall, evaporation, freshwater runoff, tides.

3. Pair up students into teams, and give each team a copy of the Student Master, Supporting a Hypothesis with Real Data.
4. Review the mission and hypothesis on the Master. Tell student teams they must design a plan using real data to support or disprove the hypothesis.
5. If you have not done so in earlier activities, use a computer and projector to demonstrate how to use the dataintheclassroom.org Web site to generate graphs of water quality parameters. Use Waquoit Bay, as an example.
 - a) Visit www.dataintheclassroom.org and find the Water Quality module.

- b) Follow the link to “Get Data.”
 - c) Using the form, select “Water Quality” from the list under “Which data?”
 - d) Using the map tools, drag and zoom the map until it is centered over Cape Cod, Massachusetts. Zoom in until you identify at least four separate stations at the Waquoit Bay Reserve.
 - e) Select “Waquoit Bay > Menauhant” from the list of stations.
 - f) Choose “Salinity” from the list of available parameters.
 - g) Under “start date,” select Feb, 1, 2007. Select a duration of “1 Week.”
 - h) Click the “Get Data” button.
 - i) You can print the graph for later use or use a screen capture utility to save the image to your local computer.
 - j) Repeat the procedure to generate salinity maps from the three other stations at Waquoit Bay.
6. Students will need access to the Internet to generate data graphs. Depending on the setting, this can be done in a computer lab or assigned as homework, assuming students have access to the Internet at a library or computer center.
7. In order to test their hypothesis effectively, students will ideally need to look at NERRS sites that have data loggers in several different locations.
8. Have student teams carry out their plans, then present their findings.

Assessment Reference

In assessing student performance, consider each team's use and explanation of data. Successful student reports may include such information as:

- A comparison of salinity data at more than one station location in the same reserve over the same period of time.
- Indication of high and low salinity levels for each location studied.
- A discussion of why salinity values may be different in different locations over the same time period.
- The identification of questions that would need to be answered to provide further explanation. For example, what was the weather like during the time period studied? Or, where were the locations situated in terms of the structure of the estuary?

Student Master

Supporting a Hypothesis with Data

**Your mission is to find evidence that supports or disproves this hypothesis:
Salinity concentrations vary at different locations within an estuary.**

Make your plan to support or disprove the hypothesis cited above. Choose one of the National Estuarine Research Reserves to study and plan your virtual fieldwork to collect the data you will need.

1. Visit www.dataintheclassroom.org and find the Water Quality module.
2. Follow the link to “Get Data.”
3. Using the form, select “Water Quality” from the list under “Which data?”
4. Using the map tools, drag and zoom the map until it is centered over one of the National Estuarine Research Reserves. Zoom in until you identify several separate stations at the same reserve.
5. Select one of the stations using the map or from the list of stations.
6. Choose “Salinity” from the list of available parameters.
7. Select a start date and duration to look at.
8. Click the “Get Data” button.
9. You can print the graph for later use or use a screen capture utility to save the image to your local computer.
10. Repeat as necessary to generate as many graphs as you need to support or disprove the hypothesis. Organize your findings in a brief report.

Hint: Can you support or disprove the hypothesis by looking at data from only one station? Zoom the map so that you can determine the location of each station within the reserve. Consider how the location of the station might impact the salinity.

Summary

Grade Level: 6 - 8

Teaching Time:

Two 45-minute periods

Activities:

- **Collect water quality data on several different parameters at a single location.**
 - **Interpret graphs of water quality data to answer a research question.**
-

Vocabulary

Euryhaline – able to live in water with a range of salinity, and therefore migrate between fresh water and oceans.

Migration – the movement from one locality or climate to another for the purpose of feeding and breeding.

Range – an open region over which an organism may travel and feed.

Spawning – to produce and deposit eggs and produce young.

Objective

Students will access and interpret water quality data to investigate the impact of water quality conditions on the behavior of the Atlantic sturgeon.

Background

Changes in water quality parameters have a big impact on organisms living in estuaries along the Atlantic coast. The Atlantic sturgeon is a large fish that depends on swiftly flowing estuaries with rough bottoms in which to feed and spawn. Atlantic sturgeon are euryhaline, meaning they do not spend a large part of their life in estuaries, but migrate between the ocean and fresh water. In this activity, the sturgeon are migratory fish. They move up and down the Atlantic coast, feeling most comfortable in water with a temperature between 2 and 25 °C. The Atlantic sturgeon's range extends from the Hamilton River in Labrador to southeastern Florida. In actuality, little is known about the Atlantic sturgeon's migratory patterns.

During this lesson, students will try to answer a research question: What water quality factors influence the Atlantic sturgeon to enter and leave estuaries during their yearly migration? To accomplish this task, students must collect real water quality data along the Atlantic coast, using data loggers at student-identified Atlantic NERRS sites, to determine if the water conditions can support spawning sturgeons.

Materials

- Computer with Internet access or overhead projector
 - Transparency of Teacher Master, Atlantic Sturgeon
 - Copies of Student Master, Research Project: Predicting the Return of the Atlantic Sturgeon
 - Copies of Student Master, Data Log Sheet
 - Student access to computers with Internet connections
-

Procedure

This activity challenges students to apply their skills in accessing and reading online data to a real scientific question. Working in teams, students must decide what data they need to collect to determine favorable time periods for Atlantic Sturgeon to return to an estuary to spawn.

1. Display the Teacher Master, Atlantic Sturgeon, on an overhead or computer screen. Use the Master to describe the Atlantic sturgeon and where it is found in the wild.
2. Explain that water quality conditions affect the health and behavior of organisms in many ways. This activity examines the spawning behavior of the Atlantic sturgeon. Scientists studying sturgeon have discovered that they respond to specific water quality conditions in deciding when to move from oceans into estuaries to spawn. These conditions are:

Water Temperature:	between 13°C and 17°C night and day
Turbidity:	low
Water Flow:	½ to 1 meter per second
Salinity:	33 parts per 1000
Dissolved Oxygen:	high (above 3.5 mg/L, and ideally above 5mg/L) ⁷

3. Have students form teams of two or three, and give each team copies of Student Masters, Research Project: Predicting the Return of the Atlantic Sturgeon and Data Log Sheet.

⁷ Atlantic Sturgeon Status Review Team. (2007). Status Review of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*). Report to National Marine Fisheries Service, Northeast Regional Office. February 23, 2007. 174 pp.

4. Ask each team to select a National Estuarine Research Reserve from the list provided. Following the instructions on the Master, each team will gather water quality data to identify a time period when conditions are right for sturgeon to return to their estuary to spawn.
5. Students will need access to the Internet to generate data graphs. Depending on the setting, this can be done in a computer lab or assigned as homework, assuming students have access to the Internet at a library or computer center.
6. After students complete their research, provide time for each team to report its findings to the class.
7. As a class, keep track of the time periods that students identified for each NERR. Discuss any patterns you might see in the findings. How do the time periods vary from north to south? Organize your findings as follows:

Region	NERR	Time Period
Northern region	Wells	
	Great Bay	
	Waquoit Bay	
	Narragansett Bay	
Mid-Atlantic	Hudson Bay	
	Jacques Cousteau	
	Delaware	
	Chesapeake Bay, MD	
	Chesapeake Bay, VA	
Southern region	North Carolina	
	ACE Basin	
	Sapelo Island	
	Guana Tolomato Matanzas	

Teacher Master

Atlantic Sturgeon

Acipenser oxyrinchus oxyrinchus

Diet: bottom invertebrates including mussels, worms, and shrimps

Average Lifespan: up to 60 years in the wild

Size: 4.25 meters (14 feet) max.

Weight: to 360 kilograms (800 lbs)

Atlantic sturgeon are found in the following NERRS Reserves: Wells (ME), Great Bay (NH), Waquoit Bay (MA), Narragansett Bay (RI), Hudson River (NY), Jacques Cousteau (NJ), Delaware, Chesapeake Bay (MD and VA), North Carolina, N. Inlet-Winyah (SC), ACE Basin (SC), Sapelo Island (GA), and Guano Tolomato Matanzas (FL).

Atlantic sturgeon respond to the following water quality factors when moving from the ocean into estuaries to spawn:

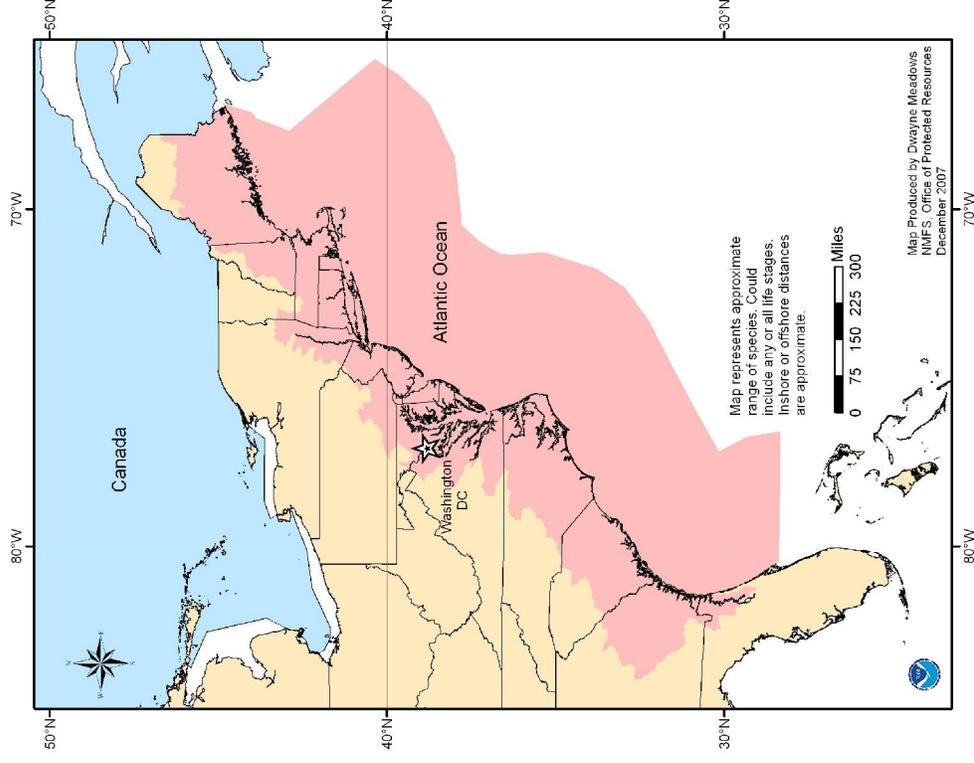
Water Temperature: between 13°C and 17°C night and day

Turbidity: low

Water Flow: ½ to 1 meter per second

Salinity: 33 parts per 1000

Dissolved Oxygen: high (above 3.5 mg/L, and ideally above 5mg/L)



Adapted from the Atlantic Sturgeon fact sheet, developed by Dwayne Meadows, Ph.D., Species of Concern National Program Coordinator, National Marine Fisheries Service.

Other water parameters courtesy of Dr. Fred P. Binkowski, Senior Scientist, Great Lakes Water Institute.

Photo: University of Maine.

Student Master

Research Project: Predicting the Return of the Atlantic Sturgeon

The problem: Population sizes and ranges of the Atlantic sturgeon have declined during the 20th century. Ocean-going Atlantic sturgeon return to estuaries in order to spawn and have their young. The location and timing of their return are of primary importance.

Your challenge: You and your team are ready to go on an electronic field trip to collect data to help predict when Atlantic sturgeon might leave their migration path on the Atlantic Ocean to move into estuaries.

Atlantic sturgeon respond to the following water quality factors when moving from the ocean into estuaries to spawn:

Water Temperature:	between 13°C and 17°C night and day
Turbidity:	low
Water Flow:	½ to 1 meter per second
Salinity:	33 parts per 1000
Dissolved Oxygen:	high (above 3.5 mg/L, and ideally above 5mg/L)

To predict when the sturgeon might return to your area to spawn, you will gather data to determine when conditions are favorable, based on the information above.

Planning your project:

1. Select one of the following National Estuarine Research Reserves to investigate. Atlantic sturgeon are found in all of these reserves: Wells (ME), Great Bay (NH), Waquoit Bay (MA), Narragansett Bay (RI), Hudson River (NY), Jacques Cousteau (NJ), Delaware, Chesapeake Bay (MD and VA), North Carolina, N. Inlet-Winyah (SC), ACE Basin (SC), Sapelo Island (GA), and Guano Tolomato Matanzas (FL).
2. Choose data to collect.
 - Which parameters will you need?
 - What time period(s) will you look at?

3. Go online and get data.
 - a) Visit www.dataintheclassroom.org and find the Water Quality module.
 - b) Follow the link to “Get Data.”
 - c) Using the form, select “Water Quality” from the list under “Which data?”
 - d) Choose your location from the list of recording stations or from the map.
 - e) Choose “Water Temperature” from the list of available parameters.
 - f) Select the start date and duration for one of the time periods you chose in step 2.
 - g) Click the “Get Data” button.
 - h) You can print the graph for later use or use a screen capture utility to save the image to your local computer.
 - i) Repeat this procedure for all relevant time periods and parameters, until you have collected all of your data.
4. Use the Data Log Sheet to keep a record of the data you select, so you can refer to it later. Begin by writing in the name of your reserve. The first row of data has been filled in as an example.
5. Analyze the data.
 - Can you identify a time period when the water temperature is within the range for the sturgeon to return?
 - What is the range of the other water quality parameters during that time period?
 - Can you identify a time period when all the conditions look right for the sturgeon to return to spawn?
 - Do the same conditions occur around the same time, year after year?
6. Report your findings.

Summary

Grade Level: 6 - 8

Teaching Time:

Two 45-minute periods

Activity

- **Develop a research question and hypothesis to examine effects of changes in water quality parameters on a species.**
 - **Design and carry out an investigation using real data.**
-

Objective

Students will develop a hypothesis to predict or describe how changes in water quality parameters might influence the health or behavior of organisms.

Background

Students have used real data to begin to understand abiotic water quality factors, and how these factors relate to one another and to the organisms that depend on them. Now, students will examine water quality on a larger scale by developing their own investigation or field experience using real data.

In this activity, students should be encouraged to develop their own research questions and hypotheses. Here are some examples:

Research question:

- Why are sturgeon populations declining?

Hypotheses:

- Increased sedimentation caused by development and land use practices can alter the freshwater habitats needed for sturgeon to spawn.
- There are some years when water quality conditions in estuaries are not ideal for sturgeon to spawn.

Materials

- Copies of Student Master, Designing Your Own Investigation
 - Copies of Student Master, Data Log Sheet
 - Student access to computers with Internet connections
-

Procedure

1. Distribute the Student Master, Designing Your Own Investigation.
2. Guide student selection of a research question (or allow students to make up their own) appropriate to their academic experience. Review student hypotheses to make sure they are appropriate, and that students will be able to support or disprove them using the data available to them.
3. Have students design a research project that will answer their questions.
4. Check each research project plan before students begin, to make sure the project aligns with the question and the resources available.
5. Assign students to use the tools at www.dataintheclassroom.org to access the data they need.
6. If necessary, help students identify areas where they may need to seek out additional sources of information. For example, to answer questions related to land use, students may need maps of land-use patterns for the area they are studying.
7. After students complete their research, provide time for them to present their findings to the class.

Student Master

Research Project: Designing Your Own Investigation

Planning your project:

- 1. Develop a research question. Then form a hypothesis to investigate.**

Be sure to review your hypothesis with your teacher before you begin.

Research question:

Hypothesis:

- 2. Design a plan to test your hypothesis and answer the research question.**

What do you need?

a) More information:

b) Specific data:

- 3. Go online and get data.**

a) Visit www.dataintheclassroom.org, and find the Water Quality module.

b) Follow the link to “Get Data.”

c) Using the form, select the locations and parameters you wish to look at.

d) Click the “Get Data” button.

- 4. Use the Data Log Sheet to keep a record of the data you select, so you can refer to it later.**

- 5. Collect and organize any additional sources of data.**

- 6. Analyze the data.**

- 7. Draw conclusions.**

Write down what you learned from your investigation. Use your data to help you decide whether your hypothesis is supported. If your hypothesis is not supported, think about other data you might need to collect.

