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 Next Generation Science Standards.

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.

2nd edition (2016): completed by Amy Dean.

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NOAA
NATIONAL MARINE SANCTUARIES
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 websites about water quality parameters and monitoring programs, visit dataintheclassroom.noaa.gov.

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]

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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.

5 **Invention: Designing Your Own Investigation:** Students will design their own plan to answer a research question.

4 **Interactivity: Spawning of the Atlantic Sturgeon:** Students will evaluate water quality data to identify the optimal timing of springtime spawning migrations of the Atlantic sturgeon. Students will identify latitudinal patterns in water quality data.

3 **Adaptation: Introducing Salinity:** Students will apply data skills to examine variations in salinity in different parts of an estuary. This activity uses guided inquiry and investigation design.

2 **Adoption: Understanding Dissolved Oxygen:** Students will examine the relationship between two water quality parameters plotted on the same graph. This teacher-directed activity applies pre-existing models and provides practice reading data.

1 **Entry: Analyzing Water Temperature Data:** Students will analyze water temperature data and identify daily and seasonal temperature patterns. This is a teacher-led discussion and activity.

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 website 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 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 online data tool 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 internet access.

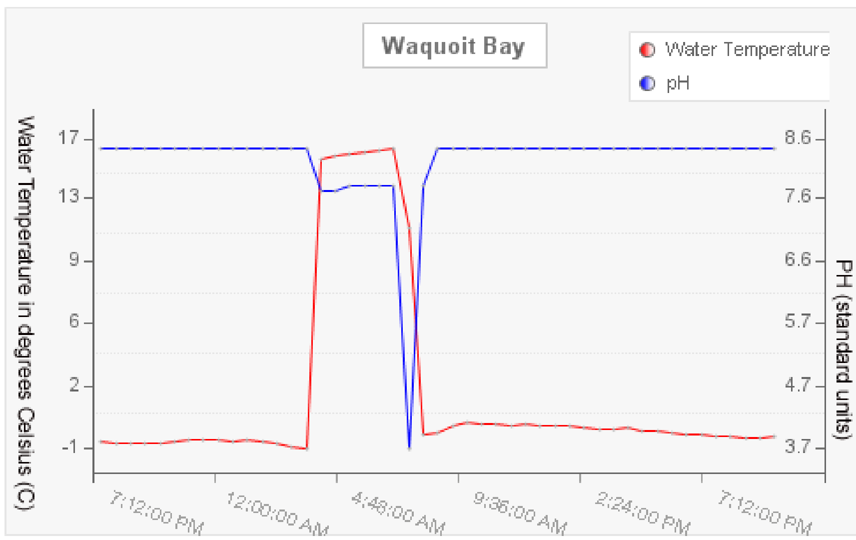
Note

The website 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 are 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.

Next Generation Science Standards

This module was developed to build data literacy, engaging students in increasingly sophisticated modes of understanding and manipulation of data. It was completed prior to the release of the Next Generation Science Standards[2] (NGSS) and, in 2016, was adapted to incorporate the innovations described in the NGSS where possible. An alignment document has been developed to help teachers and educators understand how the activities in this module align with the new standards. This document can be found by visiting the Water Quality section of the website, under ‘Downloads.’

Ocean Literacy Essential Principles

This curriculum module also supports the following Essential Principles of Ocean Sciences.[3]

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)

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2 NGSS Lead States. 2013. Next Generation Science Standards: For States, By States. Washington, DC: The National Academies Press. Next Generation Science Standards is a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the Next Generation Science Standards was involved in the production of, and does not endorse, this product.

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

Analyzing Water Temperature Data

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.

Objective

This activity will define estuaries, describe where they are located, and present how real-time water quality measurements are collected. Students will analyze water temperature data and identify daily and seasonal temperature patterns from one or more National Estuarine Research Reserves.

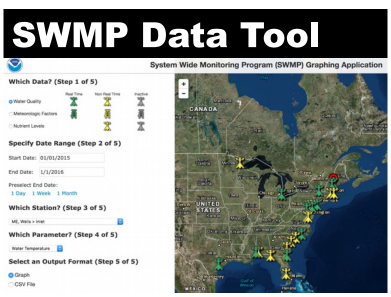
Background

Estuaries are bodies of water, partially enclosed by land, where fresh water mixes with salt water from the ocean. Estuaries are some of the most biologically productive ecosystems in the world. The health of estuaries around the world is seriously impacted by human activities. Pollution continues to be one of the most important threats to water quality in estuaries. Poor water quality affects most estuarine organisms, including commercially important fish and shellfish.

Special places within many of our nation's estuaries are protected, much like the public lands protected by our national park system. These protected areas are called National Estuarine Research Reserves. NOAA's National Estuarine Research Reserve System is a network of 28 protected coastal areas around the United States.

Water quality is continuously monitored in each of the National Estuarine Research Reserves using instruments called *data loggers*. These loggers collect data on water temperature, water depth, salinity, pH, dissolved oxygen and turbidity (cloudiness or clarity). Water quality monitoring data help scientists to understand how estuaries function and change over time. Data also help scientists understand how human activities and natural events impact estuarine ecosystems over days, weeks and years. This data is also made available to the public, through and online data tool called the System Wide Monitoring Program (SWMP) Graphing Application. Students will use this tool to access and analyze water quality data throughout the activities in this module.

Why study water temperature? The temperature of water in an estuary is an important indicator of the health of aquatic systems because of the direct relationship between water temperature and how much oxygen can be dissolved into the water. As the water temperature increases, the amount of oxygen that can dissolve in the water decreases. For example, fresh water at 0° C can contain up to 14.6 mg of oxygen per liter of water, but at 20° C, it can only hold 9.2 mg of oxygen per liter. Thus, seasonal water temperature (and dissolved oxygen) is an important indicator of habitat quality for many estuary species. The temperature of the water also determines what types of plants and animals are able to live in the estuary. All plants and animals have a range of temperatures in which they thrive. If the water in the estuary is outside the normal seasonal temperature range for which the local organisms are adapted, it is probably an indication that something is adversely affecting the health of the estuary.



Access water quality data at dataintheclassroom.noaa.gov.

Preparation

If you have a computer, internet access and a projector, follow the steps below to access the interactive water temperature graph to be used in this activity. If you do not have internet access, you can display the graph on page 18.

1. Visit dataintheclassroom.noaa.gov. Click on ‘Water Quality.’

2. Follow the link to ‘Get Data.’ Click on the main image to go directly to the SWMP Data Tool.

3. Under the page heading ‘Available Data,’ click on ‘Need help?’ and view the tutorial. Return to the data tool.

4. Complete steps 1-5 on the form.

- Step One: select ‘Water Quality’ from the list under “Which data?”
- Step Two: Specify a start date of January 1, 2015 and an end date of January 1, 2016.
- Step Three: Choose ‘Wells > Inlet’ from the list of recording stations.
- Step Four: Choose ‘Water Temperature’ from the list of available parameters.
- Step Five: Leave the default ‘Graph’ selected under ‘Specify an output format.’

5. Click the ‘Get Data’ button. A graph should appear in a new window. Note: As you move your cursor over the line on the graph, the values of each data point appear in a small text box.

6. Interested in learning about what types of guiding questions are useful when conducting data interpretation activities with your students? View the document *Guiding Questions for Interpreting Graphs*, available in the Water Quality section of the website, under ‘Downloads.’

Materials

- **Computer with internet connection or overhead projector**
- **Teacher Master, Waquoit Bay National Estuarine Research Reserve**
- **Teacher Master, The National Estuarine Research Reserve System**
- **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 (page 15). 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 estuary is located in Massachusetts and is one of 28 National Estuarine Research Reserves around the United States. The reserves are designated to protect and study estuarine ecosystems.
   - Point out the photo of the data logger. Each reserve uses automated instruments called data loggers to continuously monitor estuarine water quality. The data loggers measure water quality data, such as temperature and salinity, as well as nutrient data, weather, and biological data (chlorophyll a). Anyone can access this data online, enabling scientists and students alike to study the dynamics of an estuary.

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

5. Next, display an online interactive map showing the locations of the 28 National Estuarine Research Reserves (http://nerrs.noaa.gov). If you do not have internet access, you can display the Teacher Master on page 16. Use the map to explore some of the reserves, particularly the ones closest to your school.

6. Explain to students that they are going to take a "virtual" field trip to collect water temperature data within an estuary. On this field trip, they will visit an estuary located within the Wells National Estuarine Research Reserve in Maine. Locate the site on the interactive map.

7. Display the Teacher Master, Water Temperature Measured Over One Year (page 17). Explain the key features of the graph:

    - X axis = time, from January 2015 through January 2016
    - Y axis = recorded water temperature in degrees Celsius

8. Discuss the way the water temperature varied over the course of the year. Ask students to identify and explain patterns in the data.

    Possible answers: There is a seasonal temperature pattern. The water temperature was lowest in the winter, then gradually rose to its highest level in late summer, before falling again the next winter. Because estuaries are shallow bodies of water, great ranges in temperature can occur on a yearly basis.

9. Next, students will identify and explain variations in water temperature data over the course of a 24-hour period. Give each student a copy of the Student Master (page 18). Students should use the graph to answer the questions on the sheet.

    Answers: 1. 12 °C and 15.9 °C
    2. 4.0 °C

3. Because the data logger is positioned at the inlet of the estuary, it is likely that the increase and decrease in temperatures can be explained by the rise and fall of the tides. An incoming tide brings cold ocean water into the inlet. An outgoing tide will bring warmer water from the shallow interior of the estuary out towards the ocean.

10. If you have online access to the data tool, students may explore temperature data (at the same estuary or another estuary) across multiple days. Are there consistent daily temperature patterns that students can identify? Note: tidal currents, weather and water depth can have significant effects on daily and seasonal temperature variations in estuaries.

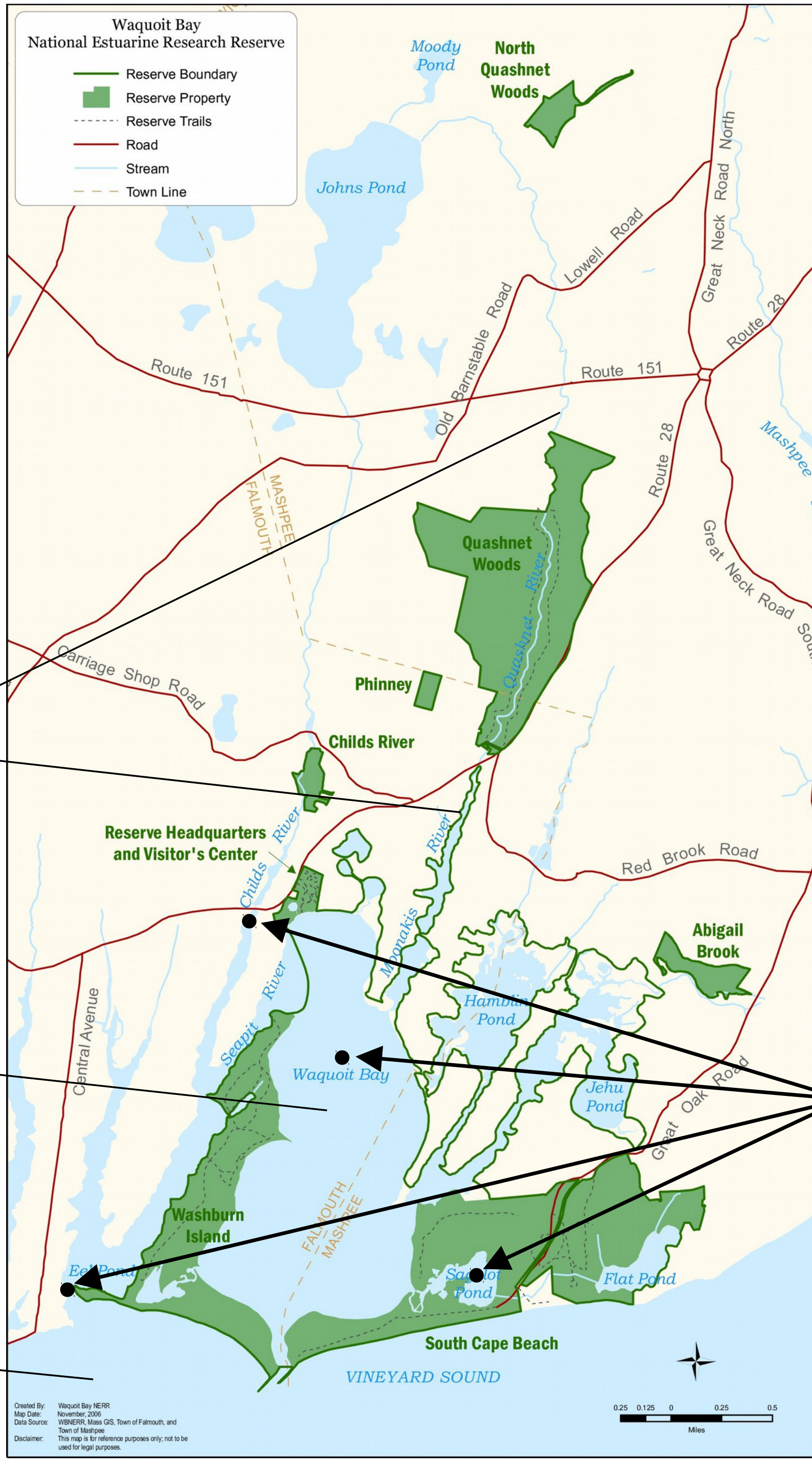
11. Check for Understanding: After completing Level 1, you may optionally use the Level 1 quiz on the website as an assessment tool.

Waquoit Bay National Estuarine Research Reserve

River
fresh water

Mixing of
fresh water
and salt water

Ocean
salt water



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

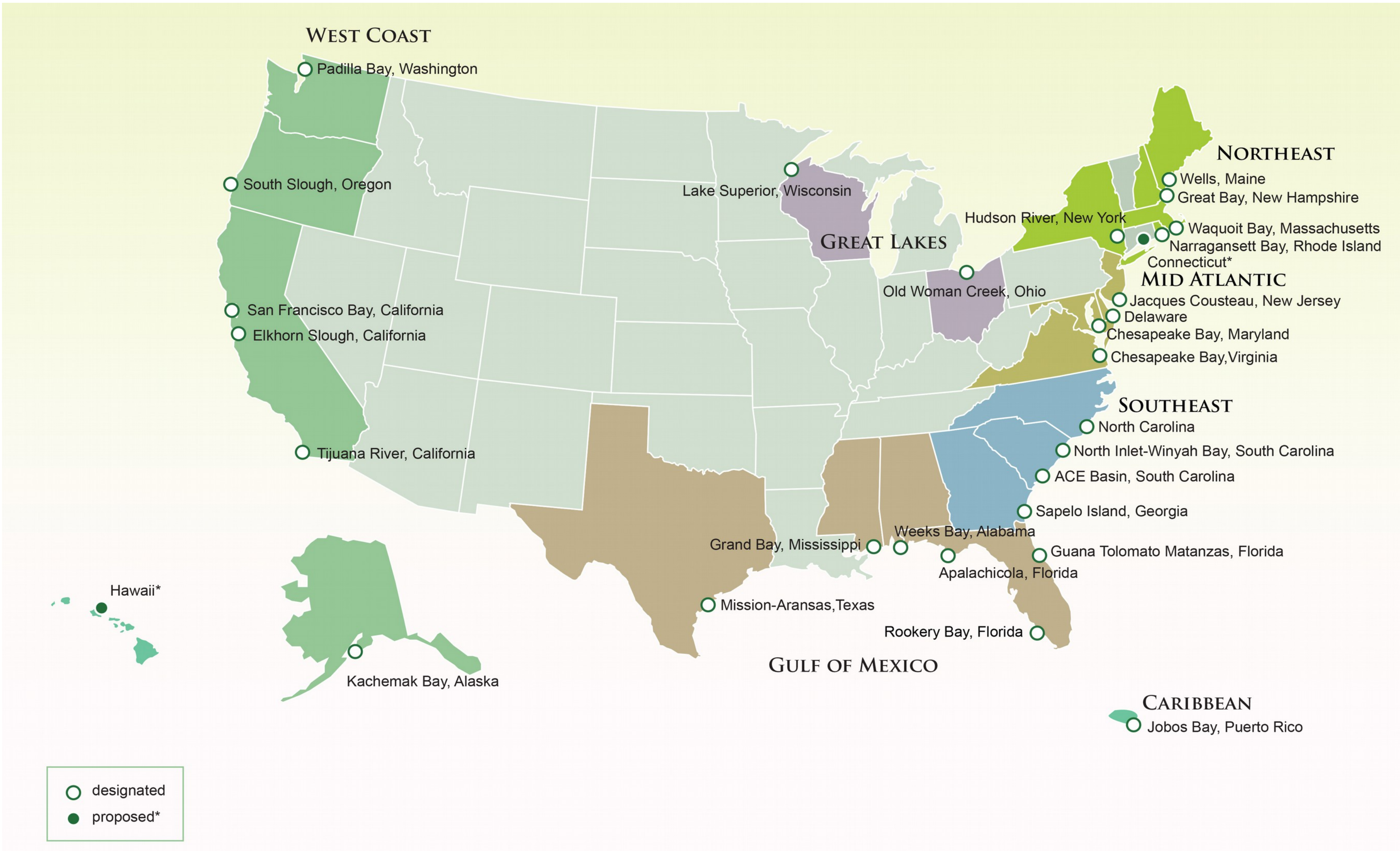
Typical YSI
6000 series
data logger

Data logger
locations:

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

Teacher Master

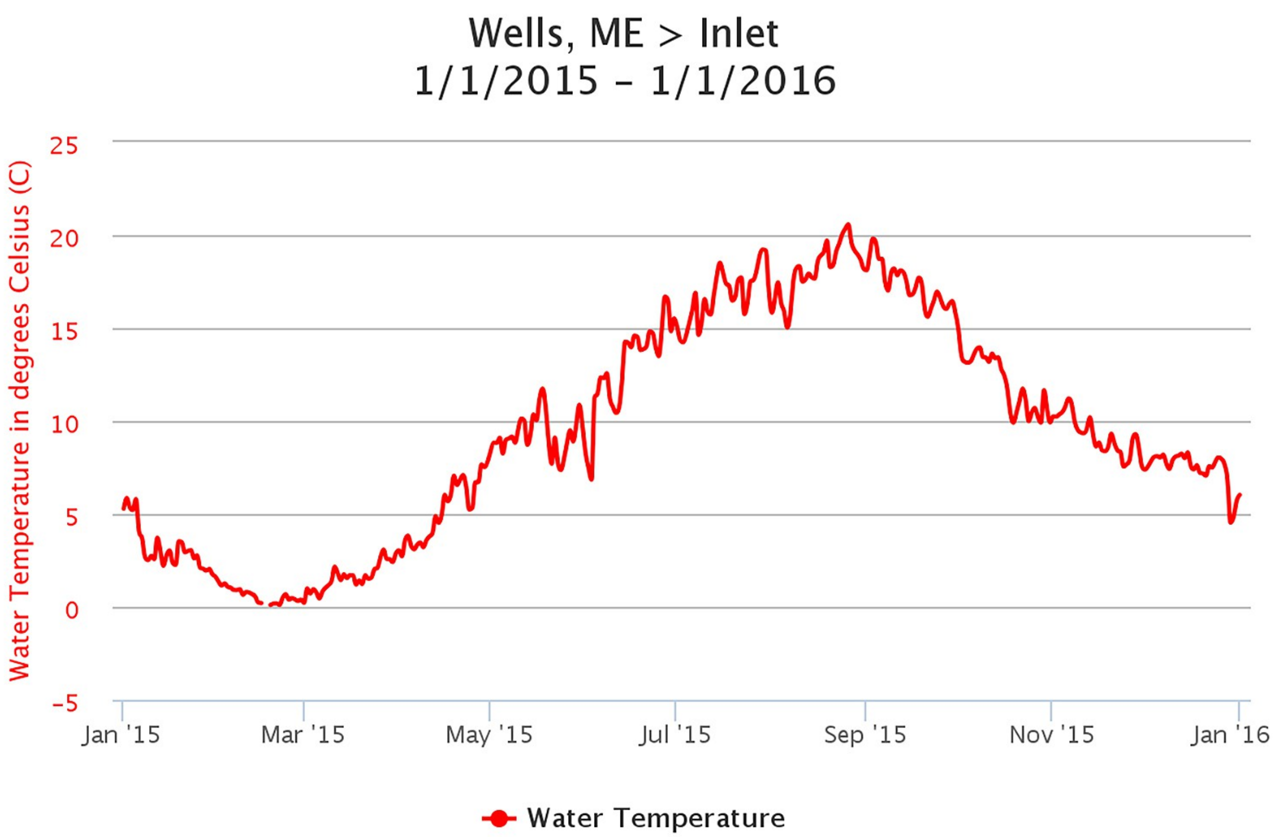
The National Estuarine Research Reserve System (NERRS)



Teacher Master

Water Temperature Measured Over One Year

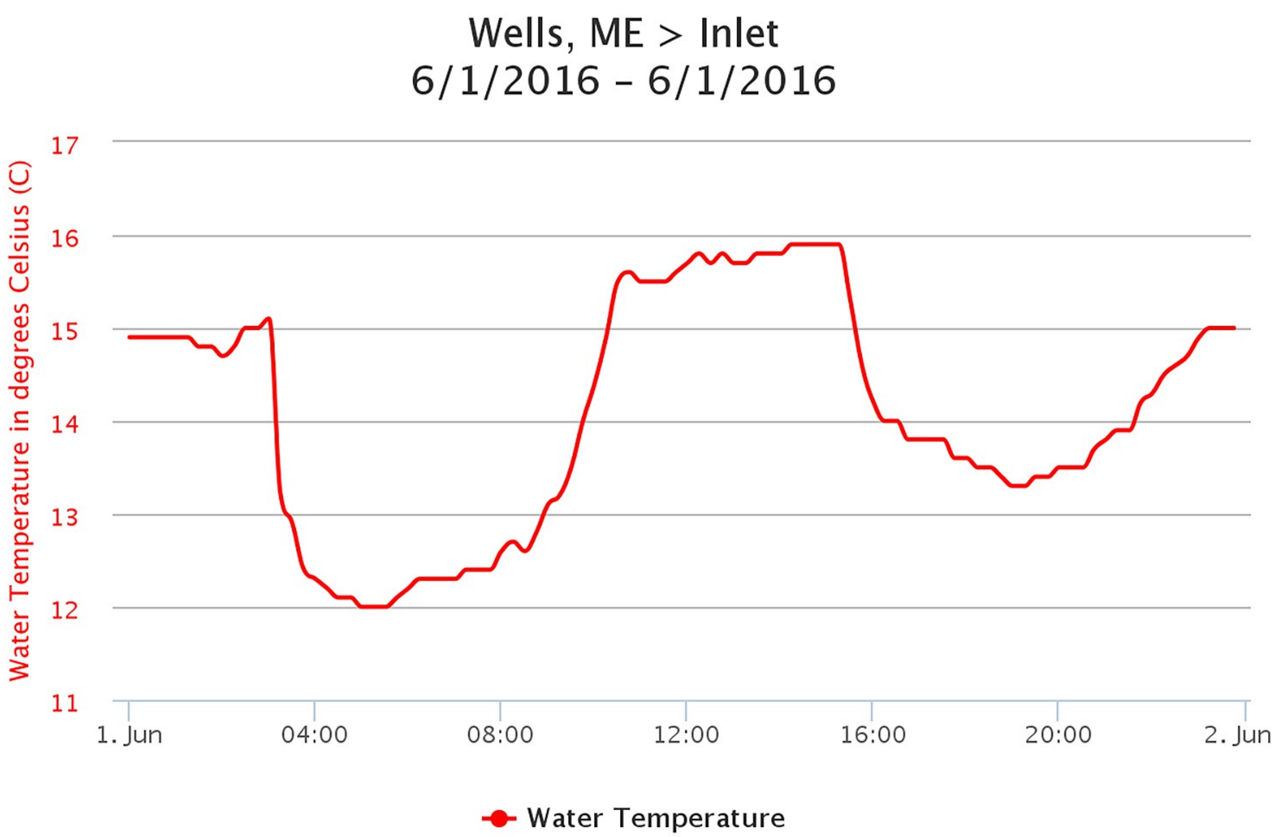
Wells NERR, Inlet, January 2015 – January 2016



Student Master

Water Temperature Measured Over 24 Hours

Wells NERR, Inlet, June 1, 2016



<u>Questions</u>

1. What were the lowest and highest temperatures recorded on June 1, 2016?
   a) 12 °C and 15.9 °C
   b) 13.5 °C and 15.1 °C
   c) 12 °C and 16.4 °C

2. Approximately how much did the water temperature change over the 24-hour period?
   a) 2.5 °C
   b) 3.0 °C
   c) 4.0 °C

3. What are some factors that might explain the pattern of increasing and decreasing water temperature that occurred over the 24-hour period?

Understanding Dissolved Oxygen

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.

Aquatic respiration – the process by which aquatic animals take up and use dissolved oxygen from the water.

Hypoxia – an environmental phenomenon where the concentration of dissolved oxygen in the water column decreases to a level that can no longer support living aquatic organisms.

Objective

Students will analyze dissolved oxygen data from estuaries around the United States to identify daily and seasonal patterns. Students will use data to examine the relationship between water temperature and dissolved oxygen.

Background

Although water molecules (H_2O) contain oxygen atoms, this oxygen is not accessible to fish and other organisms because it is locked up in the water molecule. *Dissolved oxygen* (DO) refers to the oxygen that is dissolved between molecules of water and is available to organisms for *respiration*.

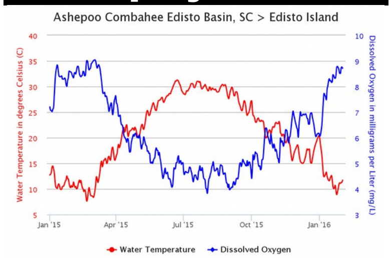
Oxygen enters the water through two natural processes: (1) diffusion from the atmosphere and (2) photosynthesis by aquatic plants. The mixing of surface waters by wind and waves increases the rate at which oxygen from the air can be dissolved or absorbed into the water.

The amount of dissolved oxygen in estuary waters varies naturally. Daily variations are due to changes in the tides, in temperature, and in the photosynthetic activity of plants. Oxygen levels typically peak during the daylight hours as plants are photosynthesizing. At night oxygen levels decrease because plants stop photosynthesizing and both plants and animals are respiring. Seasonal and monthly fluctuations in dissolved oxygen are related to the tides, day lengths, and temperatures.

Very high levels of dissolved oxygen in an estuary (supersaturation) can be harmful to fish, causing capillaries in fish gills to rupture or tear. Of greater concern in most estuaries are low levels of dissolved oxygen that create a condition known as *hypoxia*. Hypoxic conditions in an estuary (due primarily to nutrient pollution from agricultural runoff, sewage spills, the burning of fossil fuels) may cause die-offs of fish, shellfish, corals, and aquatic plants. In aquatic ecosystems, low oxygen usually means a concentration of less than 2-3 milligrams of oxygen per liter of water (mg/l). The number of U.S. estuaries experiencing hypoxia has greatly increased in recent decades, and over half of these exhibit hypoxic conditions in any given year. Students can investigate hypoxic conditions in estuaries around the United States in Level 5 of this module.

In this activity, students will examine two processes that influence natural dissolved oxygen concentrations in coastal ecosystems. 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 graph at dataintheclassroom.noaa.gov.

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 a computer, internet access and a projector, follow these steps to access the interactive water temperature and dissolved oxygen graph to be used in this activity. If you do not have internet access, you can display the graph on page 26.

1. Visit dataintheclassroom.noaa.gov. Click on 'Water Quality.'

2. Follow the link to 'Get Data.' Click on the main image to go directly to the SWMP Data Tool.

3. Under the page heading 'Available Data,' click on 'Need help?' and view the tutorial. Return to the data tool.

4. Complete steps 1-5 on the form to create a water temperature graph. Follow the instructions below.

   - Step One: select 'Water Quality' from the list under "Which data?"
   - Step Two: Specify a start date of January 1, 2015 and an end date of February 1, 2016.
   - Step Three: Choose 'SC, Ashepoo Combahee Edisto Basin > Edisto Island' from the list of recording stations.
   - Step Four: Choose 'Water Temperature' from the list of available parameters.
   - Step Five: Leave the default 'Graph' selected under 'Specify an output format.'
   - Click 'Get Data.' A water temperature graph should appear in a new window.

4. Next, plot dissolved oxygen data on the same graph. Follow these steps.

    - Below the graph, leave the default ‘Water Quality’ selected under ‘Second Data Type.”
    - Next, under ‘Second Station’, choose ‘SC, Ashepoo Combahee Edisto Basin > Edisto Island.’
    - Under ‘Which Parameter,’ choose ‘Dissolved Oxygen.’
    - Click ‘Plot graph.’
    - Your graph should look the same as the graph on page 26.
    - Note: As you move your cursor over the lines on the graph, the values of each data point appear in a small text box.

5. Interested in learning about what types of guiding questions are useful when conducting data interpretation activities with your students? View the document *Guiding Questions for Interpreting Graphs*, available in the Water Quality section of the website, under ‘Downloads.’

Materials

- **Graph 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 DO than cold water.

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

   Tell students they will look at the Ashepoo Combahee Edisto (ACE) Basin estuary in South Carolina to see what happens to DO when temperature changes.

4. If you have internet access, display the interactive water temperature and dissolved oxygen graph from the Ashepoo Combahee Edisto Basin estuary. See pages 21-22 for details. If you do not have internet access, display the Teacher Master on page 26. Explain key features of the graph:

   - X axis = time, marked at intervals from January 2015 through February 2016
   - 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 on page 27. Explain the key features of the graphs.

    - The first graph displays water temperature and dissolved oxygen on the same graph over a period of two days.
    - 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 and answer the questions.

    Answers:

    1. A) On both May 23 and 24, 2016, water temperature was highest at around 4:00 PM. B) Dissolved oxygen was highest at around 5:30 PM.

    2. A) There is a direct relationship between water temperature and dissolved oxygen during this 2-day time period. When water temperatures are high, dissolved oxygen levels are high. When water temperatures are low, dissolved oxygen levels are low. B) This may not be what the students expect, particularly after discussing the graph from Ashepoo Combahee Edisto (ACE) Basin estuary.
    C) 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.

3. A) Between January 2015 and February 2016, there is an inverse relationship between water temperature and dissolved oxygen. When water temperatures are highest, dissolved oxygen levels are lowest. When water temperature are lowest, dissolved oxygen levels are highest. B) Over the 2-day period, water temperature changes by approximately 6°C. The ability of the water to absorb oxygen may not change much over that range. Over one year, water temperature changes at least 15°C, which impacts dissolved oxygen levels over time. At this longer time scale, the influence of temperature is more evident.

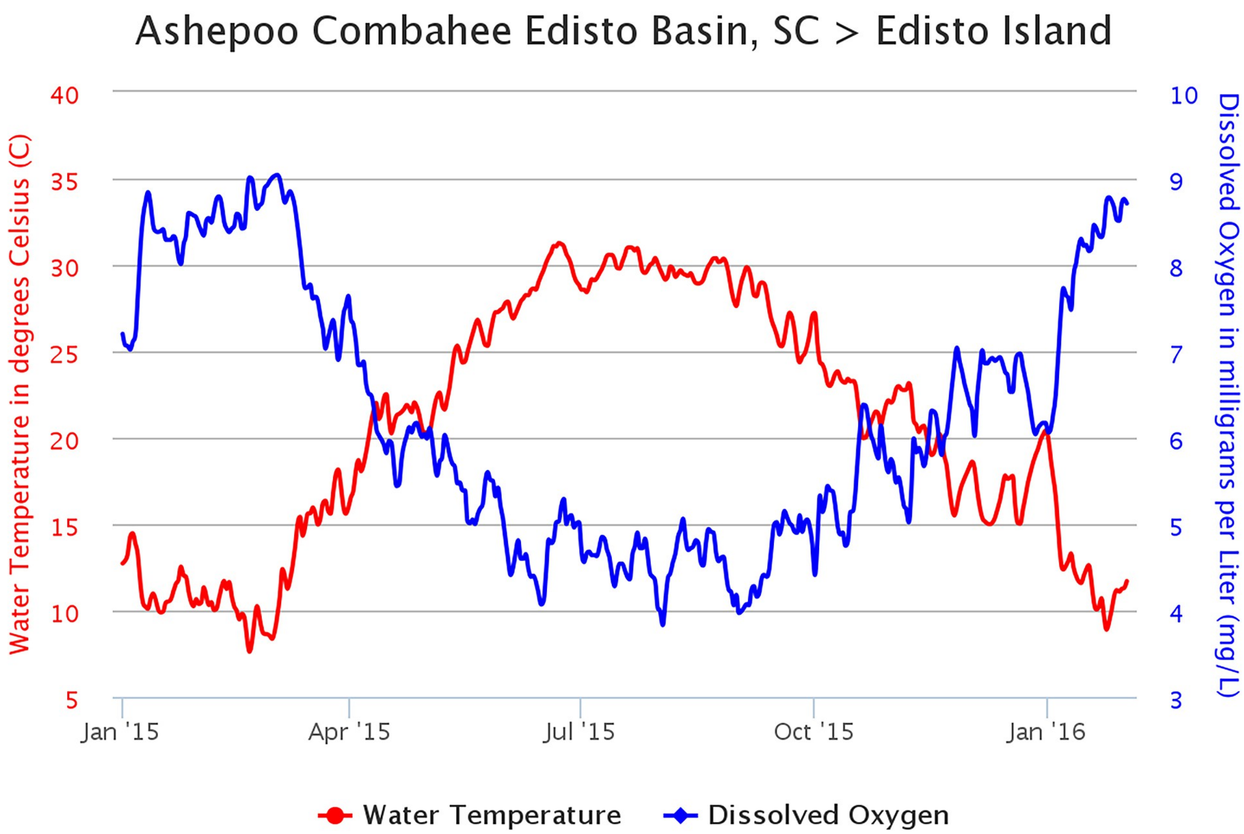
8. Check for Understanding: After completing Level 2, you may optionally use the Level 2 quiz on the website as an assessment tool.

Teacher Master

Seasonal Relationship: Water Temperature and Dissolved Oxygen

Location: Ashepoo Combahee Edisto Basin (Edito Island), South Carolina

Time range: January 2015 – February 2016

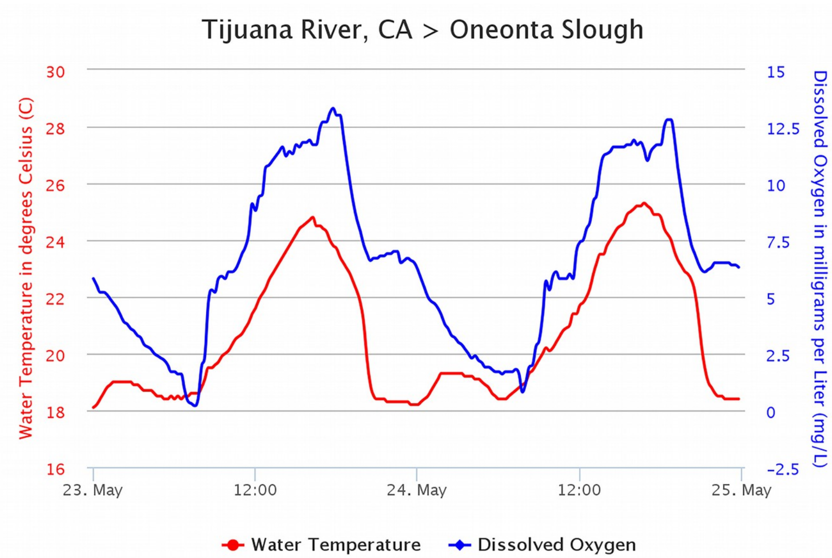


Student Master

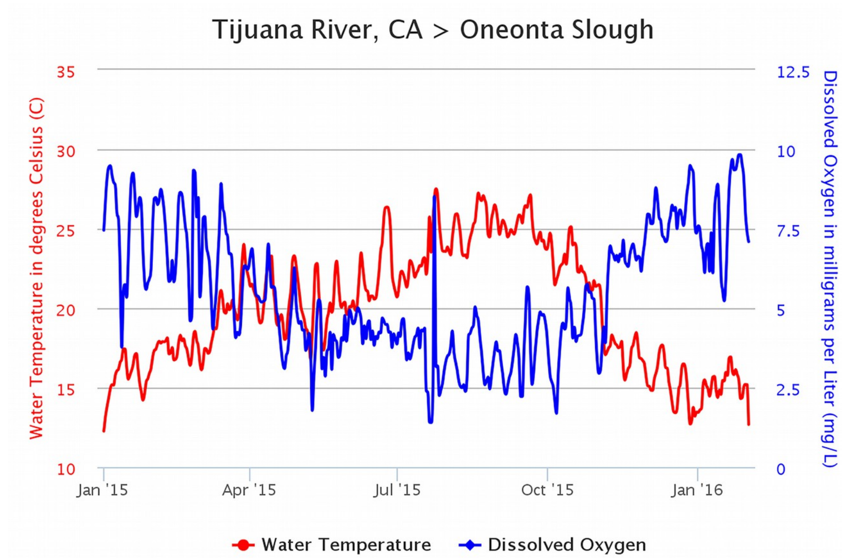
Comparing Daily and Seasonal Relationships: Water Temperature and Dissolved Oxygen

Location: Tijuana River Estuary (Oneonta Slough), CA

Daily: May 23 – 24, 2016



Yearly: January 2015 – February 2016



Questions

1. The first graph shows fluctuations of water temperature and dissolved oxygen over a 2-day period, May 23-24, 2016.
   A) On each day, what time of day was *water temperature* highest? B) What time of day was *dissolved oxygen* highest?
2. A) Describe the relationship between water temperature and dissolved oxygen in the first graph. B) Is this what you expected? Why or why not?
   C) Propose an explanation for the daily fluctuations in dissolved oxygen at Tijuana Estuary on May 23-24, 2016.
3. A) Describe the relationship between water temperature and dissolved oxygen in the second graph. B) What might explain the apparent difference in the relationship of water temperature and dissolved oxygen in the two graphs?

Introducing Salinity

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.**

Objective

Students will analyze data at various locations within an estuary to determine the extent to which salinity varies over time and space. Students will write a brief report supported by their data investigations that supports or disproves a hypothesis.

Background

Salinity refers to the amount of dissolved salts in seawater and is usually expressed in parts per thousands (PPT). In the open ocean, salinity varies little. Salinity in an estuary, however, varies daily, seasonally, by location, and with tidal cycles. Salinity levels in estuaries can rise on hot sunny days when evaporation removes fresh water and leaves behind the salt. The formation of sea ice can also raise salinity levels. On the other hand, salinity can be reduced by large amounts of rain or snow, which increase the flow of freshwater entering the estuary from rivers and creeks.

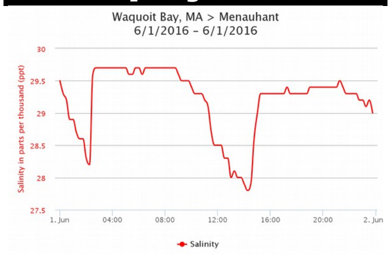
Salinity gradients exist throughout an estuary, from the river to the open ocean. Salinity levels are generally highest near the mouth of a river where the ocean water enters, and lowest upstream where freshwater flows in. However, salinities at specific locations in the estuaries vary through the tidal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

Vocabulary

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

Salinity levels greatly influence the organisms that inhabit an area. Typically, animals and plants that live in estuaries are able to tolerate a wide range of salinities. Cordgrass, pickleweed, oysters, blue crabs, bay anchovies and pipefish are examples of organisms that live in estuaries year round and are are able to cope with constantly changing salinities.

To Display



Generate this image at dataintheclassroom.noaa.gov.

Materials

- **Computer with internet access or overhead projector**
- **Teacher Master, Waquoit Bay National Estuarine Research Reserve**
- **Copies of Student Master, Supporting a Hypothesis with Data**
- **Student access to computers and internet**

Preparation

If you have not done so already, familiarize yourself with the website and online data tool. The step-by-step procedure for accessing and creating graphs in outlined below (see #5).

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 the Teacher Master, Waquoit Bay National Estuarine Research Reserve (page 15). This estuary is located on the southern shore of Cape Cod, MA. Point out the location of the ocean, as well as the streams and rivers that bring fresh water to the estuary.

2. Define salinity as the amount of dissolved salts in the water. Salinity is typically measured in parts per thousand (ppt). The average ocean salinity is 35 ppt and the average salinity in a river or stream is 0.5 ppt or less.

3. Point out the data logger that is located at the mouth of the Childs River, on the bottom left of the image. Ask the students to predict what the measured salinity might be at this location. How might tides influence salinity?

   Possible answers: This location is adjacent to the ocean. On a rising tide, the salinity might be close to 35 ppt. On a falling tide, the salinity might be lower (between 15 and 30 ppt.)

4. Ask students what factors might influence salinity in an estuary.

   Possible answers: Freshwater inflow from rivers and streams, precipitation, evaporation, tides.

5. Use a computer and projector to demonstrate how to use the online data tool to create salinity graphs.

   a) Visit dataintheclassroom.noaa.gov. Click on 'Water Quality.'

   b) Follow the link to 'Get Data.' Click on the main image to go directly to the SWMP Data Tool.

   c) Using the map tools, drag and zoom the map until it is centered over Waquoit Bay, located in Cape Cod, MA. Zoom in until the four separate monitoring stations are visible. Move your cursor over each of the four stations to see the station name, the 'active dates' (dates when data is available), and the water quality parameters measured at each location. Find 'Menauhant Station' and click on it.

   d) Complete steps 1-5 on the left side of the webpage. Follow the instructions below.

   e) Step One: select 'Water Quality' from the list under "Which data?"

   f) Step Two: Specify a start date and an end date. You may choose to look at data from yesterday.

   g) Step Three: Ensure that 'MA, Waquoit Bay > Menauhant' is selected from the list of recording stations.

   h) Step Four: Choose 'Salinity' from the list of available parameters.

i) Step Five: Leave the default ‘Graph’ selected under ‘Specify an output format.’

j) Click ‘Get Data.’ A graph should appear in a new window.

k) Point out the axes (x-axis = time, y-axis = salinity) and ask the students to summarize the data and propose explanations for the daily variations in salinity. Example: yesterday, the salinity of the water at this location ranged between 28 and 31 ppt. Explanations will vary.

6. Pair up students into teams, and give each team a copy of the Student Master, Supporting a Hypothesis with Real Data (pages 33-34). Students will need internet access to complete this activity.

7. 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.

8. In order to test their hypothesis effectively, students will ideally need to look at estuaries in the NERR system that have data loggers in 3 to 4 different locations. Good options include: Waquoit Bay (MA), Coos Bay (OR), Mission Aransas (TX), and Chesapeake Bay (VA).

9. For students to successfully compare salinity data across locations in their chosen estuary, they will need to know the range of dates when data is available at each site. To find out, students can hover their cursor over the station icon on the map and take note of the ‘active dates.’ In the example at left, data is available between 3/31/2001 and 6/21/2016.

Station Details

Menauhant Station
Waquoit Bay NERR (MA)

Active Dates
3/31/2001 to 6/21/2016

Type
Water Quality
Realtime: Yes
Active

Parameters
Chlorophyll a, Depth, Dissolved Oxygen, Percent Saturation, pH, Salinity, Specific Conductivity, Turbidity, Water Temperature

10. Have student teams carry out their plans, then present their finding to the class. In assessing student performance, consider each team's use and explanation of data. Successful student

reports may include:

- A comparison of salinity data at more than one station location in the same estuary over the same period of time.
- Indication of high and low salinity levels for each location.
- 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?

11. Quick Assessment for Level 3: After completing this activity, you may use the 'Level 3' quiz on the website as a reference and assessment tool for your students.

12. Assessment for Levels 1-3: After completing Levels 1-3 in this module, challenge your students by playing an interactive quiz (hosted by the online student learning tool – Quizziz). Learn more by visiting the 'Water Quality' section of the website.

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 estuaries within the National Estuarine Research Reserve system. Collect the data graphs that you will need.

1. Go to dataintheclassroom.noaa.gov. Click on 'Water Quality.' Click on 'Get Data.' Finally, click on the image of the map to reach the *System Wide Monitoring Program (SWMP) Graphing Application.*

2. Use the map tools to drag and zoom the map over an estuary that you are interested in studying. Zoom in and make sure that there are at least 3 water quality monitoring stations within the estuary. Record the name of each station on the Data Log.

3. Move your cursor over each of the station icons within the estuary. Record the 'active dates' for each station on the Data Log. The 'active dates' are the range of dates when salinity data is available at each site.

4. Do you plan to look at salinity at each station over a period of one week, one month, one year? Decide on a time frame. Make sure it is within the range (the active dates) when data is available for each station. Record your start and end dates on the Data Log.

5. Click on one of the monitoring station icons on the map. Create a salinity graph by completing Steps 1-5 on the form.

6. Read the graph to determine the lowest and highest salinity that occurred over the chosen time period. Complete the Data Log for the station.

7. Print the graph or save the image to your local computer.

8. Repeat for each of the sites within your chosen estuary. Complete the data log.

9. Organize your findings in a brief report. Does your data support or disprove the hypothesis?

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.

Student Master

Data Log Sheet

Name and location of estuary:

Hypothesis:

Station Name	Active dates: Range of dates when data is available	Start date	End date	Salinity Range (ppt):
Menauhant Station	3/31/2001 - 6/21/2016	6/1/2016	6/8/2016	26-30 ppt

Spawning of the Atlantic Sturgeon

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

Anadromous – migrating up rivers from the ocean to spawn.

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.

Spawn – to produce and deposit eggs and produce young.

Objective

Students will obtain and evaluate water quality data in East Coast estuaries to identify the optimal timing of springtime spawning migrations of the Atlantic sturgeon. Students will identify latitudinal patterns in data in estuaries from Maine to Florida.

Background

Estuaries are dynamic in nature. From prior data investigations in this module, students know that the water quality within estuaries, particularly temperature, salinity and dissolved oxygen, vary considerably over time. How do the changing physical conditions impact the animals that live in estuaries?

The Atlantic sturgeon is a very large and long-lived fish that can be found in estuaries from Maine to Florida. Like salmon and shad, the Atlantic sturgeon is an *anadromous* species. In the spring, adults *migrate* from the coastal ocean, where they spend most of their lives, to the upper reaches of estuaries and freshwater rivers to *spawn*. Sturgeon are sensitive to water conditions during periods of spawning. For example, research has shown that specific water temperature cues cause sturgeon in U.S. South Atlantic estuaries to migrate earlier than those in mid-Atlantic and New England portions of their *range*[3]. This occurs, in part, because waters warm to the Atlantic sturgeon's optimal range earlier in the spring in the Southern Atlantic, later in the spring in the mid-Atlantic and New England.

Because the sturgeon is dependent on estuarine and freshwater habitat,

3 Greene, K. E., J. L. Zimmerman, R. W. Laney, and J. C. Thomas-Blate. 2009. Atlantic coast diadromous fish habitat: A review of utilization, threats, recommendations for conservation, and research needs. Atlantic States Marine Fisheries Commission Habitat Management Series No. 9, Washington, D.C., pg 198.

habitat degradation and loss along the East Coast of the United States threatens this species. Other threats include water pollution, ship strikes, dredging, and potentially, warming temperatures associated with climate change. Atlantic sturgeon in the Chesapeake Bay, New York Bight, Carolina, and South Atlantic regions are currently listed as an endangered species. Atlantic sturgeon in the Gulf of Maine region are listed as threatened.

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. 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, projector and internet access**
- **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 and internet**

Procedure

This activity challenges students to apply their skills in accessing and reading online data to answer 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.

Note, depending on your location, you may wish to focus on a fish that is local to your area for the purpose of this investigation. The table at the end of this section (page 39) provides a list of alternate species and resources.

1. Display the Teacher Master, Atlantic Sturgeon (page 40). 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 ppt (parts per thousand)
Dissolved Oxygen:	high (above 3.5 mg/L, and ideally above 5mg/L)[4]

4 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.

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.

4. Ask each team to select an estuary within the National Estuarine Research Reserve system 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.

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 estuary. Organize findings in a table (see example table on the following page).

8. Discuss any patterns you might see in the findings. How do the time periods vary from north to south? How might populations of sturgeon in the different regions be affected by rising ocean temperatures associated with climate change?

   Possible answers: Students should find that optimal time periods for spawning in the northern regions are in late spring and early summer. Moving south, these time periods should shift to early spring. Rising water temperatures associated with climate change may affect the Atlantic sturgeon by impacting timing of spawning migrations, food availability, oxygen concentrations, and suitability of spawning habitat.

Example Table: Optimal time periods for spawning migrations of the Atlantic sturgeon.

Region	Estuaries	Time Period
Northern region	Wells, ME Great Bay, NH Waquoit Bay, MA Narragansett Bay, RI	
Mid-Atlantic	Hudson Bay, NY Jacques Cousteau, NJ Delaware Bay, DE Chesapeake Bay, MD Chesapeake Bay, VA	
Southern region	North Carolina, NC ACE Basin, SC Sapelo Island, GA Guana Tolomato Matanzas, FL	

Fish species that can be used as alternatives to the Atlantic sturgeon: Interested in focusing on a fish that is local to your area? Both fish species in the table below undergo spawning migrations to estuaries or rivers and can be use in this activity in place of the Atlantic sturgeon. Determine the specific water quality conditions that are optimal for spawning migrations by reviewing the fact sheet (link provided below). Modify the investigation on pages 41-43 as needed.

Species	Estuaries	Link to Fish Fact Sheet
Blueback Herring	All East Coast estuaries in the NERR system: from Wells, ME to Guana Tolomato Matanzas, FL	Blueback Herring Fact Sheet
White Sturgeon	South Slough, OR San Francisco Bay, CA Elkhorn Slough, CA	White Sturgeon Fact Sheet

Teacher Master

Atlantic Sturgeon

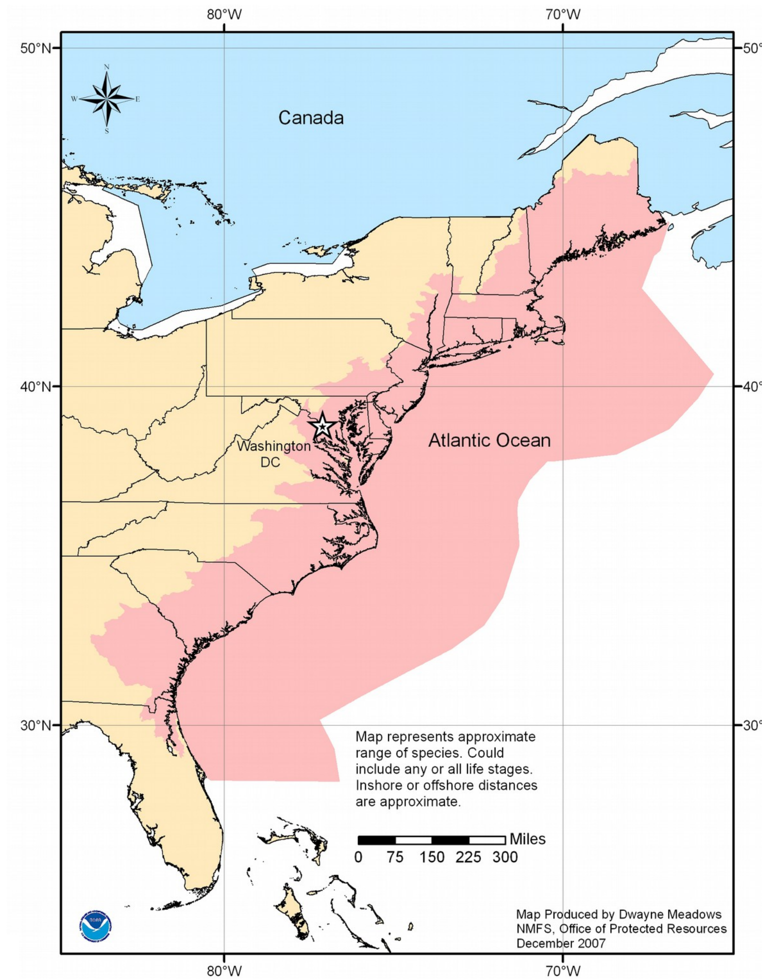
Acipenser oxyrinchus oxyrinchus

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 estuaries: 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 Guana Tolomato Matanzas (FL).

Atlantic sturgeon respond to the following water quality conditions 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 ppt (parts per thousand)**
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 conditions 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 ppt (parts per thousand)**
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 estuaries within the National Estuarine Research Reserve system to investigate. Atlantic sturgeon are found in all of these estuaries: 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 Guana 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) Go to dataintheclassroom.noaa.gov. Click on ‘Water Quality.’ Click on ‘Get Data.’ Finally, click on the image of the map to reach the *System Wide Monitoring Program (SWMP) Graphing Application*.

    b) Use the map tools to drag and zoom the map over an estuary that you are interested in studying. Select any of the real-time monitoring stations in the estuary, as indicated by the green icons.

    c) Complete Steps 1-3 on the form.

    d) For Step 4, choose ‘Water Temperature’ from the list of available parameters.

    e) Click the “Get Data” button.

    f) Print or save the graph.

    g) Repeat this procedure for all relevant time periods and water quality conditions, 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. Write a brief report. Use your data as evidence to predict when sturgeon will return to the estuary to spawn.

Student Master

Data Log Sheet

As you access online water quality data, keep a record of the parameters and dates you select on this data log sheet. Your data log will help you remember and keep track of the data you have looked at.

Name of National Estuarine Research Reserve: ______________________________

	Station	Parameter	Start Date	Duration	Notes
1	Blackbird Landing	Water Temperature	Apr 1, 2005	One Month	Temperature was between 13°C and 17°C throughout most of the month.

Designing Your Own Investigation

Summary

Grade Level: 6 - 8

Teaching Time:

Two 45-minute periods

Activity

- **Design and carry out an investigation using real water quality data.**

Objective

Students will ask questions that can be answered by gathering water quality data available through the SWMP data tool. Students will design their own investigations, collect and analyze data, and construct an argument that reasonably shows how data supports their conclusions.

Background

Students have used real data to begin to understand 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 using real data.

It may not be easy for students to develop their own questions that can be answered by gathering water quality data available through the SWMP data tool. Sample research questions with links to additional data and resources are available on ‘Level 5’ of the Water Quality section of the website.

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 dataintheclassroom.noaa.gov. 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

<u>Planning your project:</u>

1. **Develop a research question.**
   Be sure to review your question with your teacher before you begin.

   Research question:

2. **Design a plan to answer your research question.**
   What do you need?

   a) More information:
   b) Specific data:

3. **Go online and get data.**

   a) Go to dataintheclassroom.noaa.gov. Click on 'Water Quality.' Click on 'Get Data.' Finally, click on the image of the map to reach the *System Wide Monitoring Program (SWMP) Graphing Application.*
   b) Using the form, select the locations and parameters you wish to look at.
   c) 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 form conclusions. What additional data might you need to better evaluate your question?

Student Master

Data Log Sheet

As you access online water quality data, keep a record of the parameters and dates you select on this data log sheet. Your data log will help you remember and keep track of the data you have looked at.

Name of National Estuarine Research Reserve:____

	Station	Parameter	Start Date	Duration	Notes