Nature's Water Filter: Oyster Lesson Plan

Educator Activity Plan

Original lesson by Sarah Pedigo and E.V. Bell, S.C. Sea Grant Consortium

About This Activity

Target Grade Levels: 2, 3, 4, 5, 7, 8, 9-12

2021 South Carolina State Science Standards: 2-LS4-1; 2-LS4-1; 2-ESS3-1; 3-LS1-1; 3-LS4-3; 4-LS1-1; 4-ESS3-2; 5-LS2-1; 5-ESS3-1; 7-LS2-1; 7-LS2-2; 7-LS2-4; 7-LS2-5; 7-ESS3-3; 8-LS1-4; B-LS2-1; B-LS2-6; B-LS2-7; B-LS4-4; B-LS4-5; E-ESS3-2; E-ESS3-5; E-ESS3-6; E-ESS3-7

Ocean Literacy Essential Principles

#5 The ocean supports a great diversity of life and ecosystems.

#6 The ocean and humans are inextricably interconnected.

Focus Questions

- What are three characteristics of an estuary? How is an estuary different from the ocean?
- What are three physical and/or behavioral characteristics of oysters that help them to survive in estuaries?
- What is a keystone species? Why are oysters considered keystone species in estuaries?
- How are humans and oysters interconnected?

Objectives

- Describe the characteristics of an estuary.
- Explain the life cycle of the eastern oyster, *Crassostrea virginica*.
- Identify physical and behavioral characteristics that oysters have adapted to live in estuaries.
- Demonstrate an oyster's ability to filter particulate matter from a water body.
- Measure turbidity, temperature, pH, and salinity of estuarine water.
- Determine ways that oysters contribute to overall environmental health.

Activity Details

Group Size: individual, small group, or class (~30 students)

Time: Set up is approximately 1.5 – 2 hours; activity is approximately 2 – 3 hours

Materials

Pre-Procedure Set Up

Filtering Demonstration

- Two, clear containers (suggested size 5-10-gallon capacity)
- Access to seawater that is between 10-35 ppt (e.g., estuary, tidal creek, marina). An alternative option is to purchase Instant Ocean© and mix to a salinity between 10-35 ppt
- REED Mariculture Shellfish Diet® or algal paste (optional, to enhance turbidity if seawater is made using Instant Ocean©)
- Two, air stones or bubblers (one/tank)
- Oysters (dependent on size of container, obtain a number of oysters that will create a solid layer on the bottom. Clusters of oysters can be obtained from local markets from October - May or can be harvested with appropriate licenses from designated reefs during these months). To purchase a license, visit your state's department of natural/wildlife resources

Create a Secchi Disc

- Plastic bottle cap (white preferred)
- Penny (or small weight)
- Nylon string (2 feet)

- Black marker
- Hot glue/super glue
- Ruler (cm)
- Scissors

Procedure

- Secchi disc
- Hydrometer or refractometer to measure salinity in parts per thousand (ppt)
- pH strips or other method for measuring pH levels
- Aquarium thermometer
- Timer
- Student handout to record metrics (Water Quality Parameter Chart and Water Quality Parameter Graph)
- Markers, colored pencils, or crayons (various colors)

Directions: Pre-Procedure Set Up

Filtering Demonstration Set Up:

Note: *Set up should be timed appropriately for the duration of your lesson/class timeframe. The filtering demonstration will need to be prepped and started ahead of time to allow for oysters to acclimate to the new environment and begin filtering water. Comparable differences will not be evident until the demonstration has been operating for at least 1-1.5 hours.*

- Place the two containers on a level surface (e.g., table) ensuring they are side by side.
- Fill the containers with the same volume of seawater, ensuring that containers have enough water to measure turbidity (i.e., at least half full).
- Place an air stone or bubbler into each tank. Place oysters into tank. Let sit undisturbed.
- Record an initial turbidity measurement for each tank on the Water Quality Parameters Chart.

Create a Secchi Disc:

Florida Atlantic University Virtual Resources Program has demonstrated creation of a small secchi disc and can be found at this link. Protocol is listed below:

- Use the marker to divide the top of the bottle cap into four quadrants. Color two of the sections opposite each other fully black.
- Glue the penny to the underside of the bottle cap.
- Cut the nylon string to a length of one and a half feet. Tie a knot at one end. Starting at the knot, use the marker to place lines on the string at each centimeter.
- Glue the knot of the string to the center of the top of the bottle cap.

Directions: Procedure

Students in older grades should read the information provided in the Student Handout; for younger grades, the teacher can review some of the basic concepts provided in the Student Handout (e.g., life cycle). Review concepts of an oyster's anatomy, life cycle, habitat, and benefits to the environment. Describe what turbidity, temperature, pH, and salinity are and how they can be measured.

- Measure water quality metrics over a duration of time. Measurements should be recorded every 30 minutes on the Water Quality Parameter Chart.
- Graph the water turbidity, temperature, pH, and salinity in each container on the Water Quality Parameter Graph. Compare water quality in the containers as time elapses by plotting points (use two colors) on the graph for each water quality metric. At the end of the experiment, connect the points to make a line graph that distinguishes the metrics in the container with and without oysters.

Teacher Background and Student Handout

This handout is suitable for older students to read; for younger students, overarching concepts can be reviewed by the teacher.

Eastern Oyster: Species Profile

Taxonomy

Kingdom - Animalia
Phylum - Mollusca
Class - Bivalvia
Order - Ostreida
Family - Ostreidae
Genus - Crassostrea
Species – virginica

Habitat and Distribution

The eastern oyster, *Crassostrea virginica*, is a sessile invertebrate found in intertidal and subtidal estuarine environments. The eastern oyster is distributed from the Gulf of St. Lawrence, Canada, along the East Coast of the United States, the Gulf of Mexico, to the Yucatan Peninsula, Mexico.

Oyster Anatomy

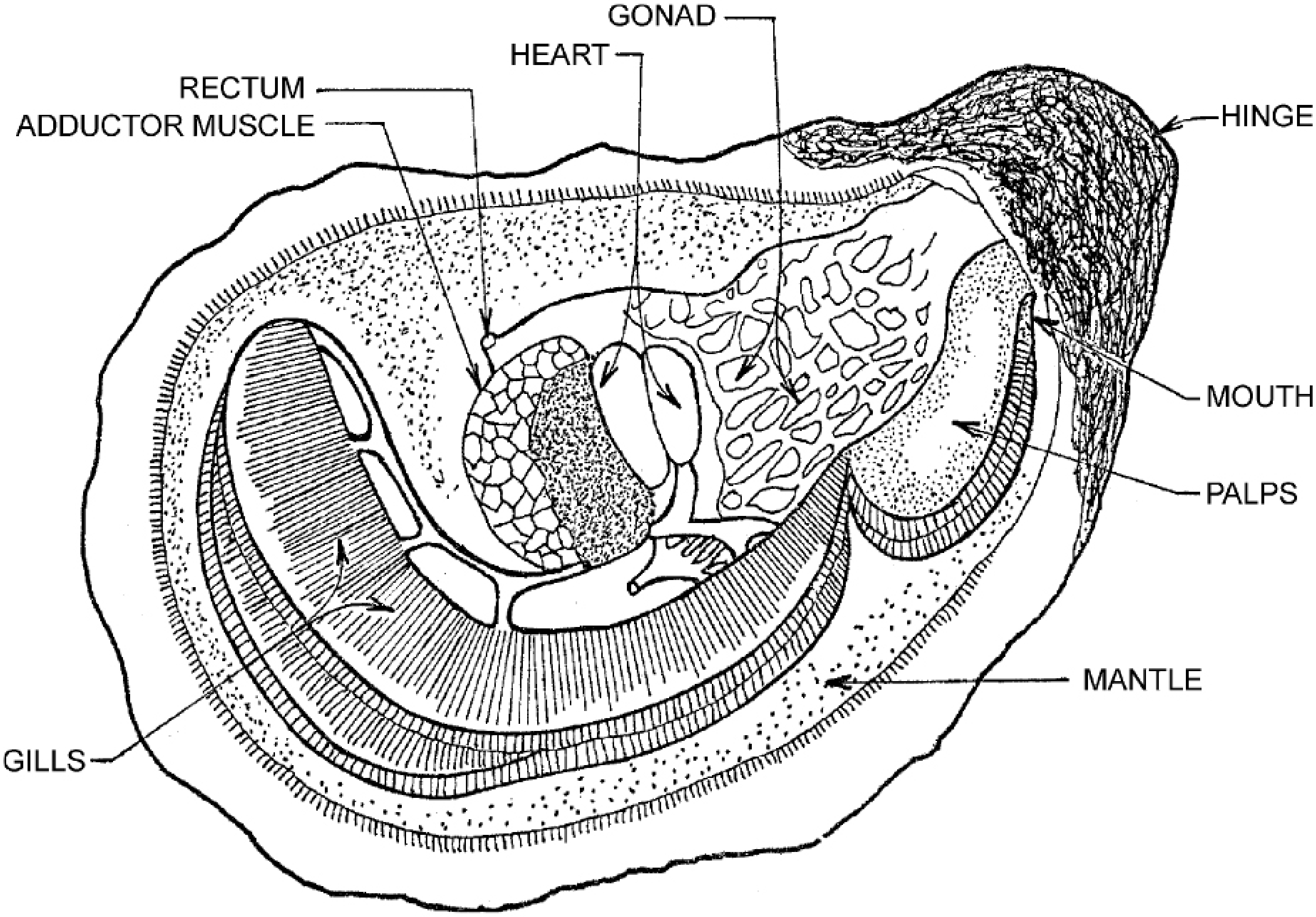


Figure 1: Internal oyster anatomy diagram. Credit: F. Wheaton, redrawn from Galtsoff, 1964.

Oysters are bivalve mollusks; they have an external two-part hinged shell or exoskeleton that covers the internal soft-tissue or body. The shell acts as a natural protection from low tide, predators, and environmental variations. An oyster can protect itself by shutting its two-valved shell, which the adductor muscle helps to open and close. When the oyster is in a safe environment, it will relax its adductor muscle, to open its shell and begin feeding. Oysters build their own shells using compounds and minerals taken in from the seawater. The mantle is the tissue that secretes calcium carbonate to build the external protective layers.

Oysters are filter feeders. They eat by pumping large volumes of water through their bodies to collect food particles from the water. Water is pumped through an oyster's gills by movement of cilia, small hair like projections on the gills. Algae or small plants that are food for the oyster are collected on the gills and passed to the mouth and stomach to be digested. Oysters will feed throughout the warmer months of the year when food (algae) is available in the water column. During winter, when food is not readily available, oysters slow their metabolisms and rest throughout the cold months.

Oyster Life Cycle

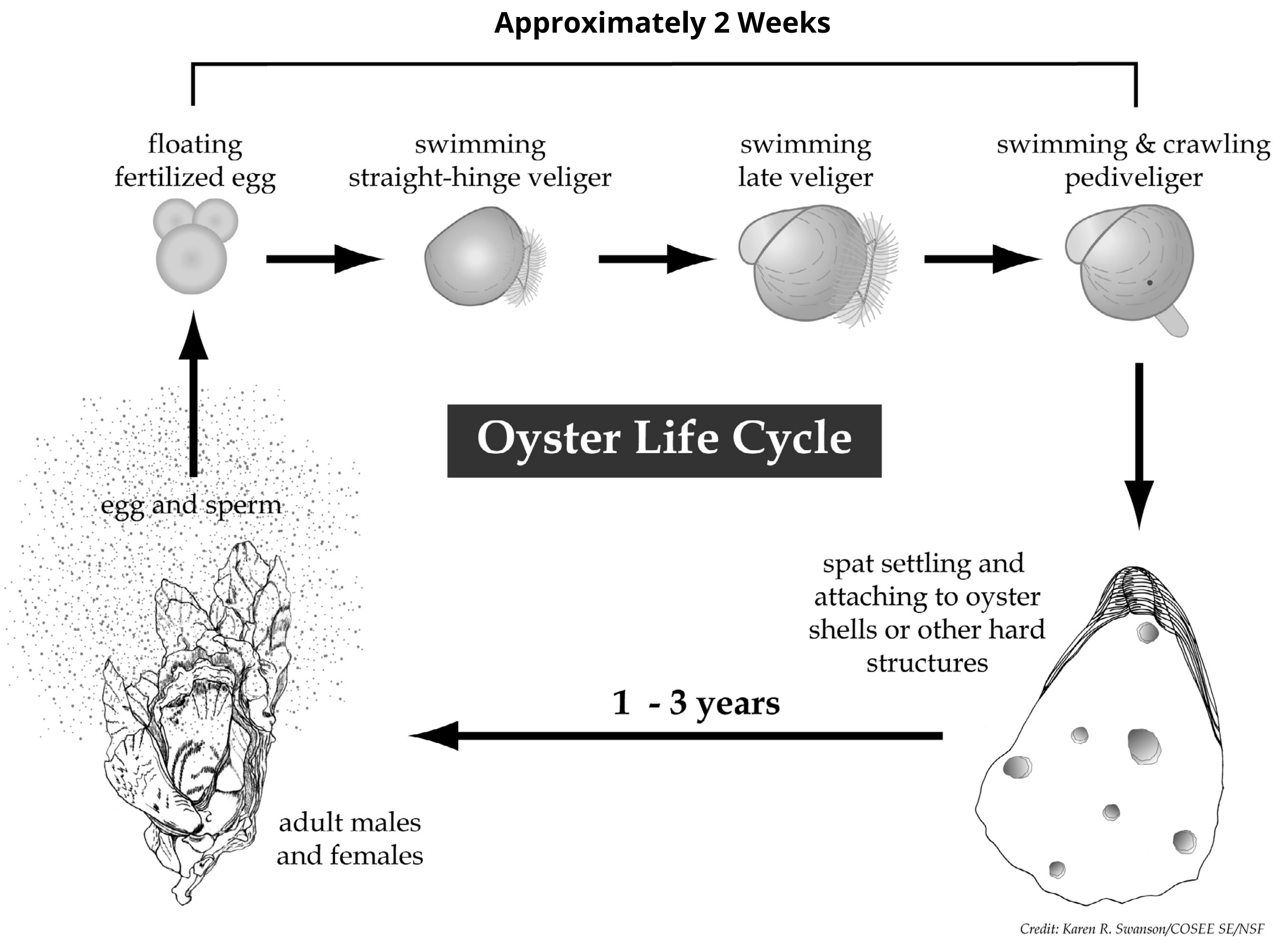


Figure 2: Life cycle diagram. Credit: Karen R. Swanson/COSEE SE/NSF.

Oysters are sessile organisms that attach to hard substrates in the environment, but they begin their lives as larvae swimming in the water column. Oysters are sequential hermaphrodites:

Most oysters begin life as a male and switch to female around two to three years of age. Oysters are broadcast spawners and will develop gametes internally throughout the winter and spring. Once oysters have produced ripe gametes, environmental cues (e.g., water temperatures rising above 20°C) will signal oysters to begin spawning. Oysters release unfertilized gametes into the water column, where eggs are fertilized and begin to develop into larvae. During gamete development, the female will create a nutrient reserve in the egg that will provide energy for embryo development. Within 24 hours after fertilization, the embryo develops into a trochophore. At this stage, the embryo is still relying on the nutrient reserves that were provided in the egg by the female. At two days' post-fertilization, the larva develops into a veliger, noted by the development of a velum, an organ that aids in locomotion and food intake. Around two weeks of age, the larva will develop a foot, marking the pediveliger stage. This is an indication that the larva is ready to find a hard substrate to settle, and metamorphose into the sessile portion of its life cycle. Larvae prefer to settle onto substrate that is much like their own composition and will often settle onto existing oyster reefs, which aids in replenishing and maintaining the reef. Within a year, the oyster will be developed to a point it can begin to reproduce, starting the whole cycle again.

Oysters and Water Quality

In lab environments, an adult oyster can filter up to 50 gallons of water a day! By filtering water, oysters remove organic and inorganic particulate matter from the water column. Oysters filter water to select and digest food particles, which include microalgae (small plants that thrive in warm, sunlit, nutrient-rich surface waters). While oysters are filtering large volumes of water, they selectively ingest desirable food particles and they also remove suspended solids from the water column that are less desirable for ingestion (sediment/detritus). These particles are packaged in a covering and expelled from the oyster, which aides in benthic-pelagic coupling: As these particles are deposited onto the reef or substrate, they can be processed by microbial organisms that can't reach them in the water column. Microbes are able to convert particles into useable forms of energy, aiding in nutrient cycling throughout the environment. Altogether these processes remove excess particles and nutrients (e.g., phosphorus, nitrogen) from the water column.

Today, many natural water bodies are polluted due, in part, to human activities such as increased development that can lead to higher levels of polluted runoff entering waterways.

When oysters filter the water they aid in lessening harmful impacts that would result from increased pollution (e.g., hypoxia, decreased light attenuation, eutrophication).

Ecosystems

Oysters are keystone species, which means that many other species are dependent on their existence in estuaries. Naturally, oysters are ecosystem engineers, building reefs that provide habitat for a high level of biodiversity. Crevices and expansive surface area of oyster reefs provides permanent habitat for mussels, barnacles, anemones, crustaceans, polychaetes and other bivalves. Fish species like gobies and blennies, seek dead oyster shells for a protected location to lay eggs. Other fish species may enter estuaries to spawn and oyster reefs act as nursery grounds for these juvenile finfish. In the Southeastern U.S. oyster reefs are mainly intertidal and form a protective barrier that mitigates wave action and limits erosion. Oysters are also a source of food for other invertebrates, fish, and humans. For humans, oysters support a culturally- and economically-valuable industry and also serve as a sustainable and nutrient-rich protein source.

Measuring Water Quality Parameters

Measuring Turbidity

Turbidity is the measure of clarity of a liquid. Water loses transparency due to the presence of suspended particles like silt, sand, and organic/inorganic matter. Turbidity of a water body may vary depending on velocity of flowing water, the volume of water, precipitation, and the water source. A spring flowing from an aquifer may be completely clear, whereas a tidal estuary may appear murky due to the constant resuspension of particles. During this lab, a secchi disc will be used to measure transparency of the water in the containers. Secchi discs are commonly used in field sampling to estimate turbidity at a sampling site. Direct measurements of turbidity quantify light reduction by evaluating the amount of light that is scattered by the particles suspended in the water. This measurement requires precise lab equipment.

Secchi Disc

A relative estimate of turbidity in a water body can be measured using a secchi disc. This black and white disc is lowered by a cable into the water until it is no longer visible from the surface, a point referred to as the secchi depth. Secchi depth is a measure of transparency of the water and is inversely related to turbidity. Markings on the cable are used to indicate the secchi depth.

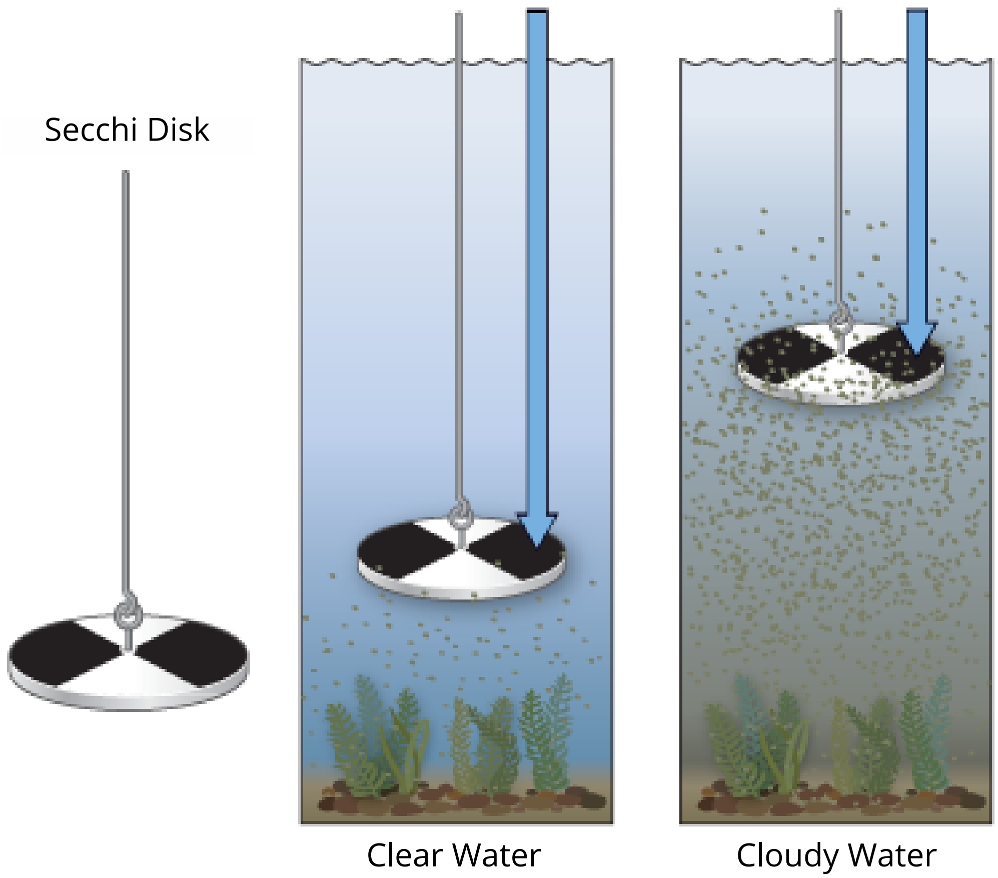


Figure 3: Measuring turbidity using a secchi disc, Credit: The Many Faces of Water.

Measuring Water Temperature

Temperature is referred to as the thermal energy of a substance. Water temperature can be measured using a thermometer. There are several factors that may influence the temperature of an estuary. These include the depth, season, degree of mixing (e.g., due to tide, wind, or storms), temperature and volume of other water sources flowing into estuaries, and human influences (e.g., pollution). Temperature is a vital parameter to measure in an estuary because it impacts many biotic and abiotic factors. As temperature increases, water has a lower capacity to hold dissolved oxygen. Temperature also influences metabolic rates of estuarine organisms and effects the rate at which primary producers photosynthesize. For many estuarine and marine species, like the oyster, their reproductive cycle is dependent on seasonal temperature cues.

Measuring pH

The pH is a measure of how acidic or basic a solution is. The pH of water can be measured by using litmus paper strips, which turn colors according to whether the water is acidic or basic. Other measurements of pH use meters with specific electrodes that measure hydrogen ion (H^+) or proton activity in a solution. The pH is measured on a scale from 0.0-14.0, with 7 being neutral, below 7 being increasingly acidic, and above 7 being increasingly basic or alkaline. Seawater systems like estuaries have an intricate carbonate to bicarbonate buffer system that maintains the pH within a neutral to slightly basic range (approximately 7-8). The pH of an estuary may be influenced by the types of minerals dissolved in seawater, chemicals in runoff, and biological activity (e.g., algal blooms). The pH of a water system dictates the survival of organisms. Most plants and animals would have difficulty surviving outside a pH range of 5-9. Drastic changes in pH will impact the ability of water to dissolve certain elements and may even present toxic conditions.

Measuring Salinity

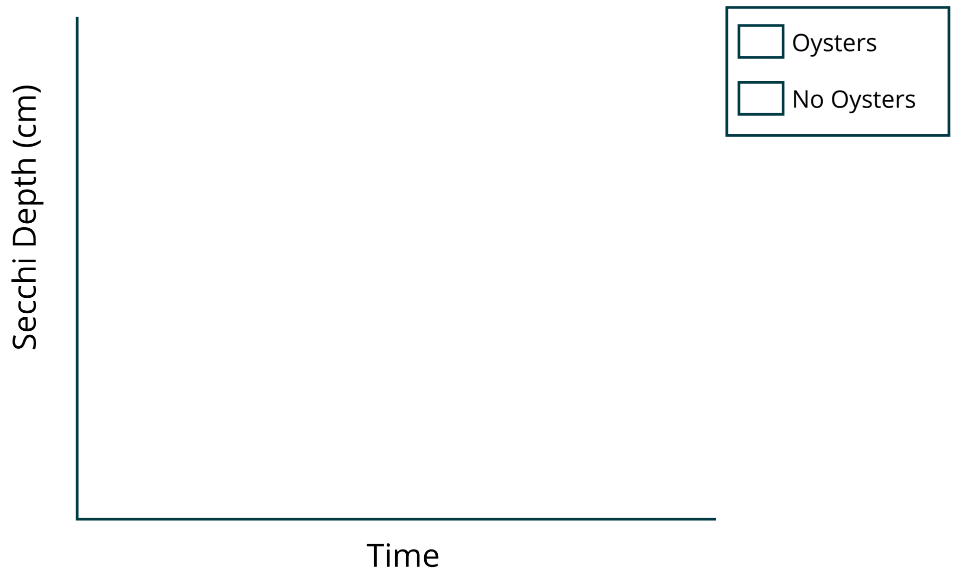
Salinity refers to the amount of salt that is dissolved in a body of water. Salinity can be measured using a refractometer, an instrument that measures the refractive index of a solution or how light bends and changes speed as it moves through the medium. Salinity can also be measured using a hydrometer, an instrument that uses specific gravity or density to determine the amount of salt dissolved in a solution. The salinity of an estuary or brackish environment can fluctuate depending on the amount of fresh water input (e.g., rivers, precipitation) and the amount of tidal influence or ocean water (approximately 35 ppt) that enters the estuary. Estuarine organisms, like oysters, are euryhaline, which means they can withstand a wide range of salinities.

Water Quality Parameter Chart

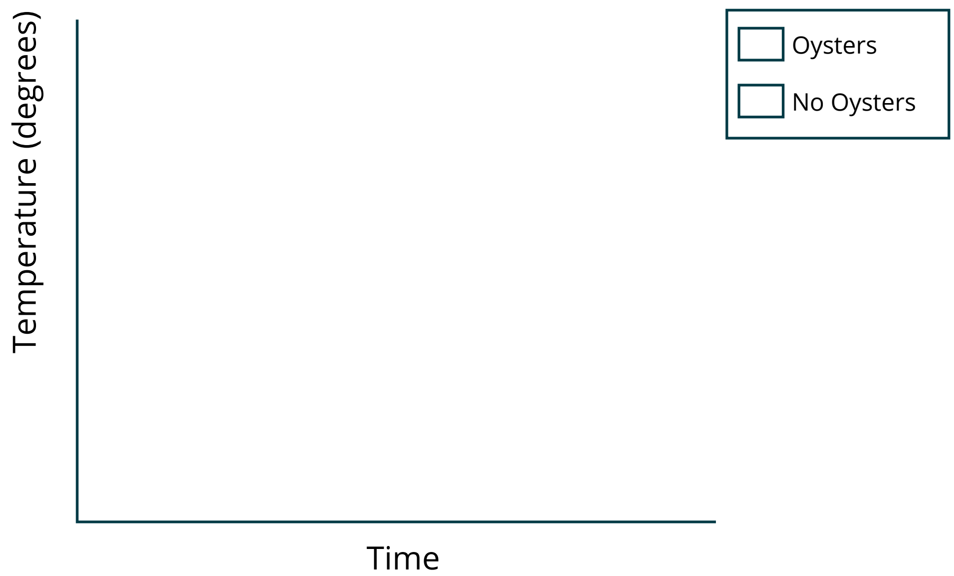
	Tank With Oysters				Tank With No Oysters			
Time	Secchi Depth (cm)	Temp (°C /°F)	pH	Salinity (ppt)	Secchi Depth (cm)	Temp (°C /°F)	pH	Salinity (ppt)

Water Quality Parameters Graph

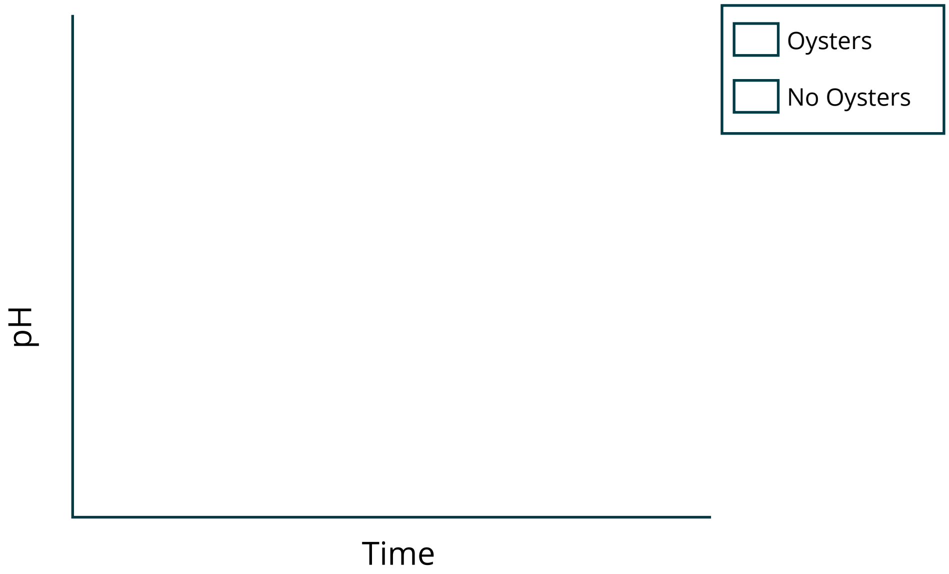
Secchi Depth Change Over Time



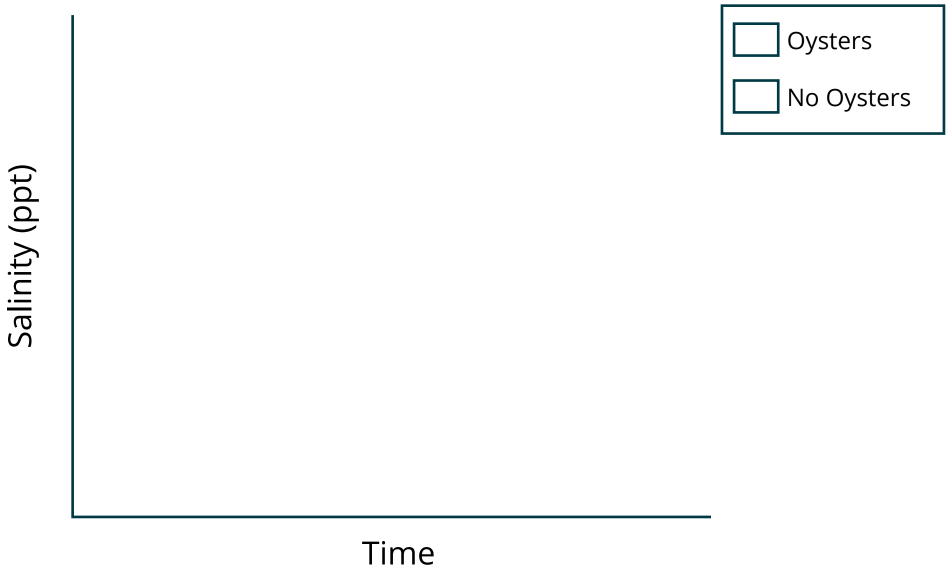
Temperature Change Over Time



pH Change Over Time



Salinity Change Over Time



Discussion Questions

- What did you observe about the turbidity measurements over time? Why do you think these changed/didn't change?
- What did you observe about the pH, temperature, and salinity measurements over time? Why do you think these changed/didn't change?
- In what ways do oyster impact water quality? Why is this important?
- Identify natural factors (daily/seasonal, hazards, etc.) and manmade factors that might impact water quality parameters. How might these impacts affect oysters?
- Describe what might happen if oyster populations become critically low or unhealthy.
- What can humans do to help keep oyster populations at a healthy and sustainable level?

Extensions

- Explore how climate change impacts might impact oyster populations. Factors to consider would be sea surface temperature changes, sea level rise, and ocean acidification. Suggested websites include: NOAA Climate and NASA Global Climate Change.
- Review the definition of watershed. Using Google Earth, a road map, or other source, identify the watershed where you live. What are the headwaters that flow into your area? What are the waterways downstream from you? Does your watershed include an estuarine/coastal location(s) and oyster reefs? If so, locate areas where water quality might become impaired along the watershed. What might that mean for salt marsh ecosystem and oysters? How might you help minimize negative water quality impacts along your area of the watershed?
- Discover ways in which to become good stewards of the salt marsh ecosystem. For example, some states have oyster recycling programs where volunteers help create new oyster habitat from oyster shells. Additionally, there are coastal cleanups that help remove harmful litter that could impair the water quality of an area. What are other ways that you can help oysters and the salt marsh environment?