The National Aquarium is a nonprofit organization whose mission is to inspire conservation of the world’s aquatic treasures.
Chesapeake Bay Explorations
A 45 minute program for Grades 4—8

PROGRAM DESCRIPTION
Students investigate the salinity and turbidity of water samples representative of four different locations in the Chesapeake Bay. Based on their data, students make recommendations about which location is most suitable to oysters.

PLANNING FOR THE PROGRAM
This Chesapeake Bay Explorations program fits into a unit on the Chesapeake Bay. Including your visit to the National Aquarium in Baltimore, this lesson should be covered in three days.

DAY 1
The day before your visit to the Aquarium read the Teacher Background information and share this information with your students. Complete Activity 1- The Oyster Reef.

DAY 2
At the Aquarium attend the Chesapeake Bay Explorations program in a classroom lab. Then look for various Chesapeake Bay exhibits located on Level 2 in the Main Aquarium building.

DAY 3
The day after your program, complete Activity 2– Developing Coastlines.

AAAS Benchmarks
1B-3-5#1: Scientific investigations may take many different forms, including observing what things are like or what is happening somewhere.

12D-3-5#3: Use numerical data in describing and comparing objects and events.

MD Voluntary Curriculum: Science
Grade 5 – 1.0 Applications of Science C.1. Apply scientific concepts to make decisions about a relevant science issue.

MD Voluntary Curriculum: Mathematics
Grade 5 – 3.0 Knowledge of Measurement - Measurement Tools B.1. Measure in customary and metric units.

MD Voluntary Curriculum: Social Studies
Grade 5 – 2.0 Geography A.4 Explain why people modify the natural environment and the impact of those modifications.

MD Voluntary Curriculum: English
Grade 5 – 1.0 General Reading Processes: Comprehension E.4. Use strategies to demonstrate understanding of the text (after reading).
SALINITY AND CIRCULATION
The Chesapeake Bay is the largest estuary in the United States. An estuary is a semi-enclosed body of water in which seawater freely enters and mixes with freshwater from rivers, creeks and streams. Because of the nature of the estuary, physical characteristics such as salinity and wind vary greatly within the body of water. Freshwater and saltwater, each with its own chemical and physical attributes, mix freely and create a wide variety of conditions within the estuary.

Salinity is a measure of the amount of salt dissolved in water. Salinity is measured in parts per thousand (ppt). The salinity of seawater is around 35 ppt. This means that if you had 1,000 kg of seawater, it would contain 35 kg of salt and 965 kg of freshwater. The salinity of freshwater is 0.5 ppt or less. Water that is between pure freshwater and pure saltwater is termed brackish. The water in the Bay ranges between 0-0.5 ppt at the top, near its freshwater sources, to 30 ppt at the mouth, where it mixes with pure ocean water. Salinity can also vary between the surface of the water and the bottom. Saltwater is heavier than freshwater; therefore, salinity increases with depth. Salinity changes seasonally as well. In the spring, melting snow or heavy spring rains can increase the amount of freshwater entering the estuary and cause a decrease in salinity. In the summer, as freshwater input decreases due to droughts, salinity increases.

The Bay is also affected by incoming tides from the Atlantic Ocean. A tide is a term used to define the changes in water level produced by the gravitational attraction of the moon and the sun. On most days in the Bay, there are two high tides and two low tides. The difference between high water and low water in the Bay varies between 2.8 feet at the mouth of the Bay in Virginia to 1-2 feet in Maryland.

TURBIDITY
Turbidity is a measurement of the clarity of water, or, alternatively, the amount of dirt in the water. It is usually measured with a Secchi disk, a circular plate that is divided into alternating black and white quarters and is tied to a rope. The Secchi disk is lowered into the water, usually from a boat or pier. When the cross, or X, of the disk is no longer visible, the depth is recorded using length measurements marked in increments along the rope. Secchi depth values that are high mean the water is clearer. Low Secchi depths indicate high turbidity, usually due to a large

Teacher Background

THE CHESAPEAKE BAY
The Chesapeake Bay is about 200 miles long. The average depth is less than 25 feet (7.6 meters). The Bay itself lies entirely within the states of Virginia and Maryland. However, the water from rivers and streams that drains into the Bay (known as the watershed) comes from a much larger area. The Chesapeake Bay watershed covers over 64,000 square miles and includes parts of Maryland, Virginia, Pennsylvania, New York, West Virginia, Delaware and Washington, DC. More than 16 million people live in the Chesapeake Bay watershed.

The Chesapeake Bay is one of this country’s greatest resources. The Bay is home to many plants and animals that interact in a complex ecosystem. Many species of fish that live in the ocean as adults spawn and mature in the Bay. In the winter months, it provides a much-needed resting place for migrating birds and waterfowl. For centuries, humans have reaped benefits from the Bay: we have eaten its animals, used it for commerce and shipping and participated in recreational activities along its beautiful banks. The Bay is home to one of the largest shipping centers on the East Coast, with more than 90 million tons of cargo traveling its waters each year. Millions of people head to the Bay every year to go boating, fishing, swimming, or to enjoy some other water-related activity. However, human pollution threatens to destroy the Bay’s value as a home for wildlife as well as a source of food and recreation.
amount of sediment and **phytoplankton** in the water. The presence of these materials in the water can block sunlight from reaching the Bay’s underwater grasses, or submerged aquatic vegetation, which provide oxygen to the water and serve as critical habitat for many fish and **invertebrate** species. Turbidity can also increase due to land runoff and shoreline erosion, pollution, dredging or during periods of elevated freshwater input from rivers and streams.

**HABITATS OF THE BAY**

In addition to physical limiting factors, especially with regards to salinity, organisms are also divided into the type of habitat in which they are found. A habitat describes the place where a particular species lives. Habitats are a part of ecosystems. An ecosystem is a community of living (biotic) and non-living things (abiotic) that interact. The depth of the Bay has a lot to do with this distribution. Shallow habitats close to shore, called **littoral zones**, will usually contain a wide variety of organisms, including invertebrates (such as shrimp and snails), waterfowl (such as ducks and swans) and underwater grasses (**SAV**). This habitat can act as a nursery for fish; the fallen tree limbs and SAV beds provide protection from predators. As fish mature, they will migrate into deeper water.

**Oyster reefs** can be found throughout the mid-Bay. These reefs, or bars, are formed because young oysters—called **spat**—settle on the firm surfaces of mature or dead oyster shells. The accumulation of oyster upon oyster results in the formation of clusters of oysters, creating refuges for small fish and invertebrates. Fish such as gobies, blennies and skilletfish live in and among the oyster reef community. The oyster shells offer a hard substrate onto which organisms such as barnacles, tunicates and anemones can attach. The natural ability of oysters to filter dirt from the water results in higher water clarity and light penetration in these areas.

**LIFE IN THE BAY**

Salinity and tides are factors that determine the variety and distribution of organisms in an estuary. Organisms that live where there are extreme changes in either of these factors have adapted to live with these variations.

Salinity is probably the most important factor in determining what types of animals live in the Bay. The Bay can be divided into salinity zones from top to bottom. The head of the Bay, near the Susquehanna River, is known as tidal freshwater and has a salinity of 0 ppt. The next zone extends from the Sassafras River to above the York River. The waters in this zone are brackish and range from 1-18 ppt salinity. The last zone extends from the York River to the mouth of the Bay. Here there is a large influx of saltwater from the Atlantic Ocean, producing a salinity of 18-30 ppt. The animals that live in the Bay must be able to adapt to a wide range of saltwater concentrations. Species that have a high tolerance for salinity changes are known as **euryhaline** species. There are certain freshwater species of animals in the Bay, such as yellow perch, that can spread into salinities as high as 10 ppt. And there are also saltwater species, such as Atlantic croaker, that can be found in upstream rivers where the water is nearly fresh.

In the tidal regions of the Bay, organisms have to tolerate being out of water during low tides or being covered by water during high tides. The salt marsh snail lives on estuarine plants above the water line. The snails move down the stems with the retreating tide to feed on the exposed mud and then move back up the stems to keep ahead of the advancing tide. Worms and other burrowing organisms retreat into their burrows to escape exposure when the tide is low. Air-breathing fiddler crabs do the opposite: when the tide is high, they retreat into their burrows and plug the entrance with mud. When the tide is low, these fiddler crabs move out across the exposed flats in search of food.
Open water, or the **pelagic zone**, is beyond the shallow water and oyster reefs. The depth in the open water is greater—sunlight does not always reach the bottom of the Bay. The underwater grasses cannot grow without the penetration of sunlight, resulting in a barer bottom with sediment that is much finer than that of shallower water. Striped bass, bluefish, American shad, blueback herring and Atlantic menhaden are just some of the fish that are found here; other animals include jellyfish, squid and blue crabs.

**OYSTERS**

American oysters, *Crassostrea virginica*, are classified in the following way:

- **Kingdom:** Animalia
- **Phylum:** Mollusca
- **Class:** Bivalvia
- **Subclass:** Pteriomorpha
- **Order:** Ostreoida
- **Family:** Ostreidae
- **Genus:** Crassostrea
- **Species:** Crassostrea virginica

Oysters are **mollusks** and are in the same phylum as octopuses, squid, conchs and snails. They are bivalves, which mean they have two shells held together by powerful adductor muscles. Oysters are dioecious, or have both sexes separate. Scientists believe oysters have the ability to change sex at least once in their lifetime. Spawning is the mass release of eggs by a female oyster. It is triggered by a rise in water temperature; Bay oysters are ready to spawn at the end of June. The millions of eggs and sperm released can turn the water a milky white. A fertilized egg will turn into different larval stages, and eventually the oyster larvae will use their foot to attach themselves to a firm substrate (usually another oyster) and will spend the rest of its life in the same spot, eventually fully developing two shells. In optimum conditions, an oyster will grow about 1 inch (2.5 cm) in one year.

The animal itself is a filter feeder, which means that the oyster draws in water through its gills and filters out its food—small plants called phytoplankton. Pollutants and sediments are also sucked in from the water column and packaged into tiny pellets, which are then expelled from the oyster to settle on the bottom of the Bay. An adult oyster can filter up to 50 gallons of water a day!

**OYSTERS IN THE BAY**

In the early days of European settlement, the colonists followed the native Powhatan’s lead and **harvested** oysters for food by plucking them by hand from the oyster bars. As the population of colonists rose, the demand for oysters rose as well. Boats were utilized more as the oysters within wading distance began to disappear. Oyster tongs, a tool with metal rakes on the end of scissor-like handles, were invented to aid in oyster harvesting. The tongs are held over the side of a canoe or skiff to scrape the oyster shells off the bottom.

As early as the 1850s, New England oysters off the coasts of New York and New Jersey began to show signs of overharvesting. Yankee watermen turned to the Chesapeake Bay for their harvest. With them they brought their latest innovation—the oyster dredge—and completely changed the Bay’s oyster fishery. Local watermen, who up until then had been dependent on the awkward, heavy tongs for their oyster catch, began turning to the dredge. The dredge combined an iron rake, used to scrape oysters from other shells, with a metal bag used to collect the oysters. When combined with steam-powered ships, this method could be used in much deeper waters and resulted in a far greater catch than tonging. Dredging proved to be far more destructive to oyster bars as well. Maryland passed laws as early as 1865 in order to protect its valuable oyster beds. The first law outlawed dredging from a boat that is powered by anything else but sails, resulting in a fleet of specially designed sailboats called skipjacks being used to **dredge** oysters from the Bay. With the improvement of railroads and refrigeration, the demand for oysters began to spread far and wide. As
Toxic substances – which include herbicides, pesticides, heavy metals and oil—enter the Bay in agricultural and urban runoff, industrial and sewage effluent, and from recreational and commercial boats and ships. These toxins tend to accumulate in the tissues of living organisms. Though these substances may not kill the oysters, they may affect the development of larvae into spat. Also contributing to the dwindling oyster population is the increasing amount of nutrients in the Bay, primarily nitrogen and phosphorous, which can promote the growth of phytoplankton. Although this increase in food supply may initially appear to benefit oysters, it is harmful in the long run. The increased phytoplankton growth reduces the amount of light reaching underwater plants and causes a decrease in dissolved oxygen levels when the phytoplankton die and decompose. The decrease in dissolved oxygen causes the death of aquatic organisms, including oysters. The sources of these nutrients include runoff from agricultural land, urban and suburban areas, as well as treated and untreated sewage released into the Bay.

The current oyster fishery in the Chesapeake Bay is threatened with extinction. Watermen whose livelihoods depend on the health of the Bay and oyster connoisseurs alike are demanding a solution to restore the Bay’s oysters without putting a suspension on harvesting them. The solution put forth by the Maryland Department of Natural Resources (DNR) is to regulate the industry. There are daily bushel limits, time limits, harvesting seasons, limited entries and periodic closures of harvesting sites. In addition, it is illegal to harvest oysters that are less than 3 inches in the Bay.

The plan to restore the Bay’s oysters also calls for rebuilding oyster reefs in certain areas of the Bay and establishing oyster sanctuaries where oysters will be protected from harvest. Also, the rebuilding of oyster reefs would allow hundreds of oysters to be close to each other. These oyster reefs would provide a suitable habitat for spat to adhere to and would aid in spawning. For the restoration plan to work, however, it requires time: time to rebuild the reefs, time for the oysters to grow to 3 inches and then time to see whether or not these large oysters will be immune to disease. However, time is something that the demanding oyster industry might not have.
WHAT YOU CAN DO FOR THE BAY

There are things that ordinary people can do to protect the Chesapeake Bay. Conserve water by turning faucets off when not in use and taking shorter showers instead of baths. Reducing the amount of water we use means that less water has to be treated in sewage treatment plants or in septic systems. Reducing the amount of water that needs to be pumped also conserves energy. Energy can be conserved by turning lights, radios and TVs off when not in use, running only full loads in the washing machine and dishwasher and replacing ordinary light bulbs with energy-efficient bulbs. Conserving energy will reduce the load on fossil fuel plants, thereby reducing the pollution they produce. Of course, the old adage “Reduce, Reuse, Recycle” is an important conservation concept for the Bay. In addition, it is important to reduce the amount of fertilizer and pesticides that are used in our gardens. Planting native trees and plants will provide habitat for indigenous animals and help reduce the amount of runoff from lawns. Even just picking up litter on the street will help. Remember, the Bay’s watershed extends over 64,000 square miles and covers six states, so make sure to ask everyone you know to do their part in helping the Bay!
Glossary

Brackish water – a mixture of salt and freshwater

Bushel – a basket in which crabs, oysters, and other shellfish are sold in; 1 bushel = 32 dry quarts

Dermo – a disease that affects oysters

Dredge – a metal cage with small spikes on one side that is attached to a boat and dragged along the bottom of the Bay to harvest oysters

Ecosystem – interrelationships among all living organisms in a given area and their relationships with the nonliving materials that make life possible

Estuary – a semi-enclosed coastal body of water connecting with the ocean, within which sea water mixes with freshwater

Euryhaline – capable of tolerating a wide range of salinity ranges

Harvest – collecting animals to sell for profit

Invertebrate – animal without a backbone

Littoral zone – shallow water habitat, close to shore

Mollusk – invertebrate with soft body covered by a thick membrane; can have 0,1,2, or 8 shells; examples of shelled mollusks include clams, oysters, snails, and scallops; octopuses and squid are examples of mollusks without an external shell

MSX – parasite disease that affects oysters

Oyster bar – another name for an oyster reef

Oyster reef – an aquatic reef consisting of individual oysters piled on top of each other; many other animals use the reef as habitat including oyster toadfish, skillet fish, and sea squirts

Oyster rock – another name for an oyster reef

Parts per thousand (ppt) – the unit used to measure salinity based on the relative weight of the salt to the total weight of the solution

Pelagic zone – open water habitat found beyond shallow water

Phytoplankton – small (generally microscopic) single-celled aquatic plants that drift with the currents; includes many kinds (phyla) of organisms called algae

Salinity – the measurement of the amount of salt in the water; measured in parts per thousand (ppt). Fresh water has a salinity of < 1 ppt while saltwater has salinity between 30-35 ppt

Secchi disc – a tool used today to measure turbidity; a weighted white disc with a black “X” on top attached to a calibrated line

Spat – juvenile, newly attached oyster; has only 1 shell

Submerged Aquatic Vegetation (SAV) – underwater plants that are an important habitat for many of the Bay’s animals

Turbidity – the measurement of the amount of dirt in the water or clarity of the water.
Resources

Maryland Sea Grant’s **Oysters and the Chesapeake in the Classroom** web site.
http://www.mdsg.umd.edu/oysters/

**Chesapeake Bay Program**’s web site has everything you need to know about the Bay, including how to get involved in restoring the Bay.
http://www.chesapeakebay.net/about.htm

**National Aquarium**’s web site provide information about the Aquarium Conservation Team and how to volunteer to help with Bay conservation projects.
http://www.aqua.org

**Life in the Chesapeake Bay** is an excellent resource book about the plants and animals of the Chesapeake Bay.
*Life in the Chesapeake Bay* by Alice Jane and Robert L. Lippson.

**Living Waters of the Chesapeake CD-ROM** is loaded with interactive learning activities for teachers and students about the Bay.
*Living Waters of the Chesapeake CD-ROM*, National Aquarium
Activity 1 — Oyster Reef

DESCRIPTION
In this activity, students will read an article about oyster reefs. Students will use the information to complete several activities.

PROCEDURE

1. Discuss oysters with students. Draw a K-W-L chart on the blackboard and discuss with your students what they:
   - **K**now about oysters
   - **W**ant to know about oysters
   - **L**earned about oysters (after the activity).

2. Distribute the article and worksheets to the students.
3. Have the students read the article carefully.
4. Once finished, students will complete the worksheets.
5. Discuss the answers as a class.
Activity 1 — Oyster Reef

STEP B
List three facts you learned about oysters from the Oyster article you read.

Fact #1
Answer may vary

Fact #2
Answer may vary

Fact #3
Answer may vary

STEP B
What does salinity mean? What tool is used to measure salinity?

Salinity is the amount of salt in the water. It is measured with a hydrometer.

What does turbidity mean? What tool is used to measure turbidity?

Turbidity is the amount of sediment in the water. It is measured with a hydrometer.
Activity 1 — Oyster Reef

STEP A
Read the following article:

THE OYSTER
Oysters are related to clams and mussels. They belong to a group of animals called mollusks. Mollusk means “soft bodied”. Two shells protect the oyster’s soft body. A powerful muscle connects the two shells.

The oyster’s shells open and close like a book. When the oyster is hungry it opens its shell. Gills pull water inside the shell through a siphon. The oyster filters drifting food and dirt from the water. One oyster can filter up to 50 gallons of water in a day.

Oysters live in brackish water in the Chesapeake Bay. Brackish water is salt water mixed with freshwater. The water in the Chesapeake Bay is very salty near the Atlantic Ocean. The amount of salt in the water is called salinity. Some scientists use a hydrometer to measure salt in the water. Salinity is measured in parts per thousand (ppt). Water with a salinity between 10 and 14 ppt is best for oysters.

Rivers carry dirt into the Bay. Too much dirt can kill young oysters. Dirt also blocks sunlight so underwater plants can’t grow. Oysters are important to the Chesapeake Bay because they filter the water and get rid of dirt and other materials. The amount of dirt and other materials suspended in the water is called turbidity. Some scientists measure turbidity using a turbidimeter.

Oysters live stuck together on an oyster reef. The reef provides habitat for many other animals in the Bay like crabs, worms, fish, snails, and shrimp.
Activity 1 — Oyster Reef

STEP B
List three facts you learned about oysters from the Oyster article you read.

Fact #1

Fact #2

Fact #3

STEP C
What does salinity mean? What tool is used to measure salinity?

What does turbidity mean? What tool is used to measure turbidity?
Activity 2 — Developing Coastlines

DESCRIPTION
Recently, your students performed salinity and turbidity tests on water samples. The students should understand how salinity and turbidity can affect oyster life in the Chesapeake Bay. Remind the students of what they have already learned. In this activity, students will read about runoff and design a piece of property that minimizes runoff into the Chesapeake Bay.

In this activity, students will read about runoff and design a piece of property that minimizes runoff into the Chesapeake Bay.

PROCEDURE
1. Brainstorm with the students regarding what they have learned about oysters, salinity, and turbidity. Some leading questions that might be asked are:
   a. Where do oysters live?
   b. What do oysters eat?
   c. What affects the health of oysters?
   d. What can change the salinity and turbidity of the water?
   e. What do you know about oyster habitats?
   f. What other animals live in the Bay in oyster habitats?
2. Distribute the Student Pages for Activity 2.
3. Have the students read the article, Uses of the Chesapeake Bay Watershed.
4. Break the class into groups of 2-4 students.
5. Assign each group one of uses of the land along the Chesapeake Bay that are mentioned in the reading “Uses of the Chesapeake Bay Watershed.” (Fishermen, Watermen, Seafood House, Beach, Park, Campground, Boat Marina, Home Owner, Hotel Owner, Neighborhood Developer, Shopping Mall, Office Building, Factory, Sewage Pant, Farm, School, Marsh, Bird Sanctuary).
6. Photocopy the plot of land template and hand out to each group.
7. Have each group draw on their paper how they would develop their piece of land to best suit their needs. Consider buildings, landscaping, parking structures, etc. You can show photographs of the Inner Harbor as an example of a location with many uses.
8. Each group should then write a paragraph about their drawing. The paragraph should include the reasons for the buildings or plants etc, how what they drew affects the land and water in the Chesapeake Bay, and solutions for potential pollution from their land.
9. Have each group present their drawing to the class. Each group should explain why using their land for their assigned purpose is useful to the people in the Chesapeake Bay watershed. Also, each group should mention any pollution that might come from their land, as well as their solution to solve that problem.
10. Collect each paper and tape the sides together. This creates the entire “coastline” of the Chesapeake Bay.
11. Tape the entire coastline to the walls in the classroom, chalkboard, or hallway.
12. Have the class examine their land and the adjacent properties. Make note of any properties that negatively affect their neighbors. (For example, factory pollution next to a bird sanctuary).
13. Discuss as a class any of the properties that would negatively affect their neighbors. Also, discuss possible solutions.
Activity 2 – Developing Coastlines

DIRECTIONS TO STUDENTS

STEP A

Read the following article:

The Chesapeake Bay watershed extends into six states: Maryland, Virginia, West Virginia, New York, Delaware and Pennsylvania as well as Washington, DC. There are more than 16 million people who live in the Chesapeake Bay watershed. Many of these people choose to live along or visit the coast of the Bay.

People use the land around the Chesapeake Bay for many reasons. There are fishermen and watermen who harvest seafood. There are recreation areas like beaches, parks, campgrounds and boat marinas. People also choose to live along the Chesapeake Bay in houses, apartments or condominiums. Or people visit the Bay and stay in rental houses or hotels.

There are also many businesses along the waterfront such as shopping malls, office buildings or even factories. Farmers also use the land near the Chesapeake Bay to grow crops or raise animals. There are even schools that are right next to the waters in the Chesapeake Bay. Finally, there are protected areas like marshes and bird sanctuaries.

STEP B

1. Your teacher will break your class into small groups and assign each group one use of the Chesapeake Bay that was mentioned in the reading “Uses of the Chesapeake Bay.”

2. Draw on your paper how your group would develop your piece of land to best suit your needs. Consider buildings, trees, grasses, docks, parking, etc.

3. In your group, write a paragraph to describe your drawing. Write why you drew each item. Also, write any way that your land might affect the water or land next to it (pollution, for example). Then, write a sentence about how you would solve the problem of pollution.
X - OYSTERS LIVE HERE