The Education Program at the
New Jersey Sea Grant Consortium
22 Magruder Road Fort Hancock, NJ 07732 732-872-1300 njseagrant.org

ESTUARIES AND OIL SPILLS

OVERVIEW

In this lesson, students will learn about estuaries, their importance in marine and coastal ecology, and how they are affected by oil spills. The nature of crude oil and its uses will also be discussed. Students will simulate an oil-contaminated environment in an effort to promote understanding of the difficulties involved with clean-ups. Finally, students will investigate the differences in estuarine salinities and discover the role these differences play in the dispersal of crude oil in a marine system.

OBJECTIVES

Following completion of this lesson, the students will be able to:

- Describe the important features of an estuary
- Simulate an oil spill in water
- Discover which materials will be most effective in cleaning up oil from water
- Compare density in water samples of different salinities
- Discover the influence of water salinity in the dispersal of oil

GRADE LEVELS

4^{th} -8^{th} grades

NJCC STANDARDS

SCIENCE: 5.1 Science Practices, 5.2.B Physical Science (Changes in Matter), 5.4.C. Earth Systems Science (Properties of Earth Materials), 5.4.E. Earth Systems Science (Energy in Earth Systems), 5.4.G. Earth Systems Science (Biogeochemical Cycles)

OTHER: 2.1.D. Comprehensive Health and Physical Education (Wellness: Safety), 2.2.B Comprehensive Health and Physical Education (Integrated Skills: Decision Making and Goal Setting), 4.5 Mathematical Processes, 6.3. Social Studies (Active Citizenship in the 21^{st} Century), 6.1.B. Social Studies (U.S. History: America in the World), 8.2 Technology Education, Engineering and Design

MATERIALS

- Plastic food container or wax-coated or Styrofoam bowl
- Enough water to fill the bowl halfway
- Bottle of “oil spill oil” (cocoa powder mixed with cooking oil)
- Small plastic pipette or dropper
- Forceps
- Straw
- Plastic spoon
- Popsicle stick
- Feather
- Pompom

- Cotton ball
- Small squares of nylon (1” x 1”; cut from old panty hose)
- Twine or string (cotton or other natural fiber)
- Human hair (collected from your local salon)
- Small (1” x 1”) squares of aluminum foil

PROCEDURES

Ask students what they already know about estuaries. You may use a pad or a white board to keep track of students’ answers. Lead students in a discussion about the characteristics and importance of estuaries to the natural environment and to people. Use a map of New Jersey to locate our state’s estuaries (New York/New Jersey Harbor Estuary, Barnegat Bay Estuary, Mullica River Estuary, and Delaware Bay Estuary) and categorize them (commercial/industrial, production or natural). Also discuss their importance to the state (centers of commerce and/or transportation, food production, recreation, tourism).

Ask the students if they know what oil is, where it comes from, and what it is made of. Use graphics (power point, posters, pictures, etc.) to show that oil is formed from dead marine microorganisms over millions of years and is usually found by digging and/or drilling. Discuss the reasons why crude oil is important to society (used to power vehicles, heat homes, etc.) and what types of products can be made from it (ink, crayons, dishwashing liquids, deodorant, eyeglasses, CDs/DVDs, tires, heart valves, etc.). Show the class a picture of an oil spill, stressing the fact that it is a form of pollution when it occurs at the hands of mankind but that it can also occur naturally through underwater seepages. Discuss the behavior of crude oil in a marine environment (spreading, evaporation, oxidation, emulsification, dissolution, biodegradation, dispersion and sedimentation). Explain how oil spills can occur (human activity such as factory waste and drilling/pipe laying in routine exploration), and stress that the biggest contributor is from motor oil deposited by cars and trucks on our streets. Discuss the adverse effects of an oil-spill to wildlife (inability to fly/swim, loss of thermoregulation abilities, internal organ failure due to ingestion, mortality) and the environment (fouling of beaches and estuaries) and list methods commonly used to clean up an oil spill (booms and skimmers, in-situ burning, chemical dispersants, bioremediation). Ask students for ways that they can help prevent oil spills, and lead them to suggest the exploration of alternative energies for common everyday use.

Have work stations set up with materials for the oil spill activity. Explain to the students that they will be working in small groups to simulate an oil spill using the disposable food container/bowl to represent the ocean/estuary. Before they begin, ask them to make a list of predictions about the action of oil mixed with water. Ask the following questions:

What will happen to the oil when you drop it on the water-- will it sink, float or mix with the water? Why do you think this will happen? Which materials will clean up the oil in the least amount of time and why?

Ask students to test each material supplied one by one to determine which absorbs the oil faster and more effectively than the others. Have the students record their observations on a chart (See Worksheet). After completing the activity, lead a discussion about which material(s) worked best and what factors could contribute to the speedy clean-up of an oil spill.

BACKGROUND

Estuaries are partially enclosed bodies of water that are formed along the coast where fresh water from rivers meets salt water from the ocean. Since they are partially enclosed by land, sand or reefs, estuaries are protected from the full force of ocean waves, winds and storms. Estuaries can protect adjacent land from storm damage by acting as buffer zones: sand bars cushion the impact of waves, while plants and shellfish beds anchor the shore against tides. Estuaries are important ecosystems that serve many functions such as flood control, coastal protection, sediment traps, pollution filters, biological production, habitat, recreation, aesthetics and education. Marshes, which frequently develop along the shores of estuaries, soak up heavy rain and release the water gradually into bays and rivers. The sheltered waters of estuaries are home to various plant and animal species that prefer to live in water that is part fresh and part salty (brackish). Typical residents are horseshoe crabs, ospreys, diamondback terrapins, mud snails and sea grasses. Hundreds of fish and shellfish species, such as scallops, shrimp and bass, live in estuaries at some point during their life cycle. With nutrient-rich, protected and calm waters, estuaries are ideal places for many types of marine life to lay eggs, hide, and rest, eat and grow. It is estimated that at least 65 percent of America's commercial seafood and nearly all saltwater sport fishes are vitally linked to estuaries. Estuaries help protect and improve water quality by filtering out dirt and pollution as river waters slow before reaching the ocean and are met by vegetation. Plants in estuaries also absorb carbon dioxide, a greenhouse gas, and produce atmospheric oxygen.

The formation of petroleum, natural gas and crude oil originated in the ocean millions of years ago as microscopic plankton died and fell to the sea floor. Over time, the natural process of sedimentation caused layers and layers of silt and sand to cover these dead organisms and push them farther down into the Earth's crust. This is the reason why oil is called a "fossil fuel." Due to the intense weight of these sediments and their proximity to the center of the Earth, the pressure and heat that resulted turned them into oil and gas. These reservoirs of oil and gas presently exist in rock formations deep in the Earth's crust. In order to harvest these reservoirs, humans must drill through layer upon layer of sand, silt and rock.

As a non-renewable energy source that powers our vehicles, heats our homes, and helps us travel from place to place, oil is a necessity in our lives. Many common products that we use every day are produced from petroleum such as ink, crayons, dishwashing liquids, deodorant, eyeglasses, CDs and DVDs, tires, ammonia, and heart valves, to name a few. Therefore, oil and petroleum-based products are of great importance in our society.

An oil spill is the release of petroleum hydrocarbon into the environment and is a form of pollution. Many of the noteworthy oil spills that most people are familiar with are catastrophes that have occurred due to human error (e.g., Exxon Valdez of March 1989, Deepwater Horizon of April 2010). However, it is important to note that there are also many naturally-occurring oil seepages in areas where oil reservoirs are prevalent (e.g., Gulf of Mexico); these seepages are not necessarily considered polluting occurrences. The volume of oil in an environment determines the degree of disaster, since a gallon of oil can spread over a square mile of ocean surface very quickly. Once in the marine environment, oil spreads to a thin slick that can be very difficult for humans to see. Natural processes cause the components of oil to degrade through evaporation into the atmosphere and undergo oxidation with atmospheric elements. Naturally-occurring bacteria cause biodegradation as oil molecules disperse throughout the water column and spread over the ocean's surface. Any particles that are left behind eventually succumb to sedimentation by falling to the sea floor.

Oil spills can occur when oil rigs leak or explode, when tankers pierce their hulls, when pipelines are laid, and when factories leak contaminants into water sources. However, the most common oil spill is the dispersal of motor oil on our roadways. Each day our cars and trucks can leak or drip oil, and when it rains this oil is flushed into storm drains and eventually fouls our waterways. When this occurs, it impacts wildlife and the environments in which they live. By tainting our beaches and spoiling our coastlines, oil spills not only create unsightly damage but unhealthy conditions as well. Birds are rendered flightless as oil penetrates their plumage, impairing their abilities to find food and escape predation. It reduces the insulating properties of feathers and makes birds less buoyant in water. As they preen, birds ingest oil. This causes kidney and liver damage and digestive tract irritation, eventually resulting in dehydration and even death. Similar effects are seen in marine mammals as well. The slick produced by oil spills limits sunlight penetration into the water column thus limiting photosynthesis of marine plants and phytoplankton. This factor has an adverse effect on marine food chains.

Cleaning and recovering from an oil spill is difficult and depends upon many factors, such as the type of oil spilled and environmental conditions in the contaminated area. Equipment such as booms (large floating barriers that enclose spills and lift up oil) and skimmers (machines that skim oil) are utilized to remove oil from the water's surface. At times in-situ burning techniques are employed to rapidly remove oil from a contained area, but can only be used when there is low or no wind.

Chemical dispersants spread by airplanes and helicopters break apart large molecules of oil, creating smaller droplets that degrade easily. Bioremediation accelerators can also be dispersed in a contaminated area to encourage indigenous hydrocarbon-consuming bacteria to bloom and break down the oil pollutants.

All of these endeavors are extremely costly and require the concerted efforts by countless individuals.

Oil spill prevention can be increased through more research in and use of alternative fuel energies. By decreasing our society's dependence on fossil fuels and increasing our use of alternative fuels, man-made oil spills could become more infrequent thus providing hope in maintaining healthy estuaries.

EXTENSION

One of the factors that could alter the nature of an oil spill and impede or contribute to a speedy clean-up is the varying salinity found in estuaries. To extend the *Estuaries and Oil Spills* activity, perform it 3 more times using water at various salinities. To begin, ask students if they know what "salinity" means (the amount of dissolved salt in a volume of water). Tell them that they are going to perform the same experiment 3 different times using water with various salinities (0 ppt for fresh; 15 ppt for brackish; and 35 ppt for ocean) to represent oil spills in rivers, estuaries and oceans. Remind them that salty (i.e., ocean) water is very dense and may have a different effect on the behavior of oil than fresh water, which is not as dense. Have the students record their observations on a data table (Appendix 1). Discuss and compare the results as a class.

Water temperature can also affect an oil spill. Another option could be to perform the oil spill activity twice with water at different temperatures in the container. For this option you can use warm and cold fresh water or warm and cold water at various salinities. Have students record their observations on a data table and then compare and discuss the results as a class.

A third option could be to explore absorption of oil using other types of materials, such as paper towels, cheesecloth, gauze, or even sand. Be sure to test the materials ahead of time and create a data table with the appropriate names of the materials you plan to use. Have students record their observations on the data table and discuss their results as a class.

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Check the box which describes your results the best. Write a description of your results in the space provided.

Name of clean-up item	**TRY IT! How well did it clean up the oil?**		**Describe your results**
	Cleaned up a little oil 	Cleaned up a lot of oil 	
1. pom-pom			
2. cotton ball			
3. twine			
4. feather			
5. nylon			
6. aluminum foil			