SciGuide lesson: Oil Spill Model

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Grade Level: 9–12

Subject Area: Earth and Space Science

SciGuide Resources: NOAA Ocean Service Education
http://oceanservice.noaa.gov/education/lessons/welcome.html
Get to the Point: Nonpoint Source Pollution
Where's the Point?: Watersheds and Polluted Runoff

http://oceanservice.noaa.gov/
education/tutorial_pollution/welcome.html

Standards Addressed:

Life Science

Human beings live within the world's ecosystems. Increasingly, humans modify ecosystems as a result of population growth, technology, and consumption. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems will be irreversibly affected.

Personal and Community Health

Humans have a major effect on other species. For example, the influence of humans on other organisms occurs through land use—which decreases space available to other species—and pollution—which changes the chemical composition of air, soil, and water.

Natural ecosystems provide an array of basic processes that affect humans. Those processes include maintenance of the quality of the atmosphere, generation of soils, control of the hydrologic cycle, disposal of wastes, and recycling of nutrients. Humans are changing many of these basic processes, and the changes may be detrimental to humans.

Time Required: Three 45-minute class periods.

Lesson Goal: The overall goal for this lesson is for students to model the dispersal of an oil spill and how the knowledge of tides and currents is used to help clean up the pollutants.

Learning Objectives:

- Students will be able to answer basic questions on what causes the spread of pollution in ocean surface and shorelines and how challenging clean-up effort can be after a pollutant disperses.
- Students will be able to create a model to simulate the spread of water pollution in the ocean.
- Students will be able to use their knowledge of tides and currents to design appropriate methods of containing the oil.

Prerequisite Knowledge:

Water Quality

Coastal waters are valuable resources. They provide food, recreational opportunities, commerce pathways, and solace. They are also home to countless marine and estuarine species. Since the passage of the Clean Water Act in 1972, we have made great strides in protecting our nation's waters by targeting point source pollutants—pollutants discharged directly from pipes, such as from a factory or sewage treatment plant. This is made exceedingly more difficult when the pollution occurs in the ocean and not on land. This is especially true of nonpoint source pollution, or pollution that is carried in the air and has proven more difficult to control.

Unlike point source pollution on land, which comes from a single usually stationary source, such as leaky pipes. Pollution in the ocean comes from many sources including stationary oil rigs and moving vessels all dumping ballast water, waste water, garbage.

"In one week, a typical cruise ship generates 210,000 gallons of black water (sewage), 1,000,000 gallons of gray water (shower, sink, dishwashing water), 37,000 gallons of oily bilge water, more than eight tons of solid waste, millions of gallons of ballast water containing potential invasive species, and toxic wastes from dry cleaning.
http://en.wikipedia.org/wiki/Ship_pollution

The major potential environmental effects from offshore drilling occur from the discharge of wastes, including drilling fluids (also referred to as drilling muds), drill cuttings and produced formation water. The decommissioning of platforms/rigs is also a potential environmental problem.
http://oils.gpa.unep.org/facts/extraction.htm

Tides and currents further disperse the pollutants and often are the controlling factors in the ability to limit the spread of the pollutant. The level of tolerance for toxic pollutants varies by species though most organisms can take only very limited exposure. Most time it is not direct contact with oil pollution by an organism but the indirect effects that are the most dangerous. Surface water oil slicks may block out light necessary preventing the ability of phytoplankton to photosynthesize and provide energy for consumer organisms. Surface oil also adheres to birds preventing their feathers from properly repelling water and insulating them from the cold. Any organisms that ingests oil also has a greater chance of developing health problems, especially when it interferes with a fish's ability to exchange oxygen in the water through its gills. Oil spills often provide the nutrients for algal blooms which rob the water of required dissolved oxygen. Raw oil also often congeals to form oil balls that

sink to the bottom and affect bottom feeding organisms, as well as shell fish, kelp, and sea weed beds.

Polluted water has been linked to a
loss of aquatic species diversity and abundance, including many important commercial and recreational fish species. In addition, many swimming and beach closures are attributed to pollution. As the Environmental Protection Agency's 2005 "National Coastal Condition Report" indicates,
the overall condition of U.S. coastal waters is fair but 28 percent of coastal waters are not suitable for aquatic life and 22 percent are not suitable for human use (such as fishing or swimming).

Once an oil spill occurs it is nearly impossible to contain or limit its spread since modern technology may provide for water skimmers and surface containment buoys but a 3 dimensional ocean allows for oil to flow deep under the surface and resurface hundreds of kilometers away, killing organisms along the way. Oil on the water surface may be unsightly and dangerous to birds but it is in the ocean depths where the real productivity occurs. A disruption to this area may impact large areas of the ocean and shorelines for years. Even without major spills occurring, oil balls commonly wash ashore on coastal beaches and in wetlands contaminating water and soil.

In Depth:
A Closer Look at nonpoint source pollution impacts on recreational beaches, shellfish beds, and coastal habitat.

Because almost everything we do in the coastal zone influences water quality, improving and maintaining coastal water quality is intertwined with many other coastal issues, including habitat, community development, and cumulative impacts. For example, coastal habitats such as wetlands or riparian areas (areas along streams and rivers and shorelines) play an important role in filtering pollutants from runoff. This includes pollutants which occur from ocean spills which are carried to wetlands by diurnal tides and long shore currents.

Since coastal wetlands are the nurseries for juvenile species any impact there affects future generations of fish, shell fish, and other organisms.

Managing the coastal zone to minimize, or at least mitigate, for these cumulative impacts is critical for protecting water quality. Visit these other coastal issue sections to gain a better understanding of how other coastal management efforts help address water quality issues.

Procedures/Instructional Strategy:

1. Divide the class into small groups of no more than four.
2. Explain the assignment.
3. Build an ocean table (see appendix A) -possibly one for each group though more than one group can work on the same stream table

See Appendix A for building an easy to use plastic ocean table

Three 45-minute class periods.

Period 1: Set up stream table

- Discuss if the location of the pollutant's source will affect its ability to contaminate large portions of the ocean?
- Discuss if the quantity of pollutant affects the level of contamination?
- Discuss how fast the pollutant might disperse with the introduction of tides and currents?

Period 2: Conduct experiments

- Add vegetable oil and food coloring (pollutant) one drop at a time on the surface at the predetermined locations chosen by students - at least one on the surface and one on the bottom (use a straw, dropper with long tube, or place your hand with the food coloring bottle under the water) and observe its movement.
- observe its direction and rate of movement, as well as any change in intensity of the color, the "rainbow effect" visible in the oil slick, and extent of water surface coverage.
- Time, plot 3-D extent of dispersal
- Vary depth of water the pollutant is introduced, and the direction and rate of flow, tide and currents have on the spread of the pollution.
- Repeat this a number of times at different locations and observe the spread of pollutant to the shoreline and water surface. Heavier "oils" (Karo Syrup and honey) can then be used and simulate the denser crude oils from many spills that sink and contaminate the ocean floor.
- Create waves and currents using the wooden boards to further disperse the oil. Tides can be produced by making minor changes to the height of one end of the stream table using the lever board.
- The pollutant can also be dispersed by blowing across the surface to simulate wind.
- Use cotton balls to try and remove as much oil as possible (place immediately in appropriate receptacle). Plastic straws can also be used to try and contain the spread of the pollutant on the surface (straws can be linked by threading a string through them creating chains).
- After the initial clean-up efforts, different natural materials can be used to "test" if any oil remains. Examples of natural materials that simulate potential marine organisms include fur, feathers, and plant leaves. By dipping them in the contaminated water, students can determine if oil is still present and how it impacts the ability of these materials to protect the organisms.

Period 3: Debrief (and possible repeat some experiments)

- How far did each drop of pollutant spread (its extent)?
- How did tides and current affect the distribution?
- What was the pattern of pollutant as it spread?
- How fast did the plume of pollution spread?
- How might the change in color (tint) indicate toxicity levels?
- How did the surface, under water, and shore pollution compare and contrast based on the location of the spill? Surface spill vs. bottom

spill from well-heads.

- How did knowledge of tides and current determine the timing, type, and ability of the clean-up effort.

Outcome/Assessment	Students will create a report that addresses all the criteria for an effective experiment on oil pollution and the ability to clean up the spills. They will evaluate others observations and receive feedback on their own experiments.
Extensions:	• Students can create poems, tales or images that share their thoughts, feelings, and visions about water pollution and how prevention is easier and more effective than clean-up efforts. • Collect and evaluate your own pollution data and understand how it relates to water awareness.
Classroom Resources:	• Computer access for students (group size will determine number of computers)

Other Teaching Resources Lesson Plan List:

The Dead Zone: Ecological Forecasting - The Gulf of Mexico Dead Zone
http://oceanservice.noaa.gov/education/lessons/dead_zone.html

Get to the Point: Nonpoint Source Pollution
http://oceanservice.noaa.gov/education/lessons/get_point.html
Where's the Point?: Watersheds and Polluted Runoff
http://oceanservice.noaa.gov/education/lessons/wheres_the_point.html

Dirty Mud: Contaminants in the Environment
http://oceanservice.noaa.gov/education/lessons/dirty_mud.html

Audio
Colorado School of Mines: Earth and Environmental Science, lecture pod cast #17: Water Pollution

Video
NOAA Ocean Service
Overview of NOAA's role in Spill Response
http://www.youtube.com/watch?v=JU6sYHpx4Co&feature=channel
http://www.youtube.com/watch?v=wY8sa3zfrbw&feature=related

Appendix A

Easy build/view Ocean table

Materials
1. Large rectangular clear plastic tray/tub ~2' x 3' though other larger size may be substituted (the tray should be at least 1' deep).
2. Hose and coupling to attach to tray
3. Water source- a tap is best though water can be added through a funnel and buckets of water.
4. 1, 20lb bag of aquarium sand
5. Small mesh screens or cheese cloth
6. Bucket or sink to collect drained water
7. Grease pencils
8. Video-still camera

Large rectangular clear plastic tub - one that is ~2' x 3' x 1' deep works well. Hoses for running water can be attached at both ends to help facilitate constant water flow. The down stream hose should be attached 1" from the bottom on one end of the plastic tub. A fine mesh screen or cheesecloth should be placed over the opening on the "out" hose to prevent sand from being washed out.

1. Fill tub with white sand along one of the short ends, as deep as possible (the sand will have a tendency to slide down. This will serve as the shoreline beach.

2. Use toy houses, cars, boats, or an oil rig for authenticity. Hint: a stream will form outward from the "in flow" hose.

3. Fill the bottom with 6 inches of water. The ocean end can be placed on a board that acts as a lever and allows you to lift the ocean end to simulate tides on the beach.

4. Slowly turn on hose and allow it to trickle water through the system. You can monitor the flow rate by observing how much water flows out of the system. The flow rate should be fast enough not to disturb the beach sand too much.

5. Once the tub is filled, use a dropper, filled with vegetable oil and red food coloring in one spot in the middle of the ocean. A clear plastic tub will allow students to view the side distribution of the pollution plume.

6. Dispersal of pollutants can be viewed through the side of clear plastic tubs, and marked with grease pencil. If the stream table is visible form the bottom then dispersal of pollutants can be viewed from that angle. Or a video camera or can be used to display the bottom of the tub.

7. A current will naturally be created by the water flow from the in flow to the out flow hose but to add additional currents a board, or even a dust pan can be used to circulate the

pollution plume in other directions. The pollution will eventually reach the beach through eddy currents forming on the sides of the tube induced by the natural current but an artificial long shore current can also be added by carefully pushing surface water parallel to the shoreline. Long shore currents can also be created by attaching an additional in flow hose on one side of the tub near the beach.

8. To generate waves that strike the beach, an additional floating piece of 2" x 4" wood in the ocean can be used. Note the additional changes that this action produces on dispersing the pollutants.

9. This model is a one-time use model. Once the sand and water become largely discolored and the water changes tint, you should empty, rinse and clean the sand (or replace) to get the same visual effects in subsequent experiments. Video-photographs-sketches of the progression of the pollutants will help post analysis.