Oil Spill in a Pan

Grade Level: 6-12
Length: 60-90 Minutes
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This lesson plan was adapted by Katie Gavenus from a compilation of several similar activities: by Bonnie Jason; by Kara Johnson, Prince William Sound Science Center; and adapted by Elizabeth Trowbridge from Alaska Science and Marine Science Project: FOR SEA Poulsbo, Washington, 98370 with background information provided by Bruce McKenzie, Alaska Clean Seas

NGSS Standards

HS-ETS1-1 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Crosscutting Concepts

Systems and System Models A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

Scale, Proportion, and Quantity In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

Overview

It is difficult and expensive to contain and clean up an oil spill.

Objectives

- Students will experiment with way to contain and clean an oil spill.
- Students will evaluate the challenges and efficiencies of various clean-up techniques.
- Students will compare the success of different technologies under different conditions.

Materials

- ☐ Vegetable Oil
- ☐ Black Oil Craft Paint
- ☐ Eye Droppers
- ☐ Clean Up Materials- an assortment of the following:
  - Nylon Net
  - Nylon Hose
  - Styrofoam
  - String
  - Straw or Sticks
  - Drinking Straws
  - Fur or Hair
  - Detergents
  - Seaweed/Pondweed
  - Absorbent Pads

Crosscutting Concepts (cont'd)

Stability and Change For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.

Related Resources

Worksheets Clean Up Response; Clean Up Cost Sheet

Notes

Materials (continued)

- Spoons, etc.
- Cotton Ball or Q-tips
- Large Disposal Container (coffee can, etc.)

☐ Habitat Materials:
- Grass
- Mud
- Rocks
- Sand
- Model Animals Appropriate to the Habitat (optional)

☐ Fan (optional)
☐ Saltwater
☐ Freshwater
☐ Worksheets: clean up response; clean-up cost sheet
☐ Pencils or Pens
☐ Newspapers
☐ Aluminum Pans or Plastic Bins (3 per group)
☐ Stop Watches
☐ Ice Cubes
☐ Hot Water

Background

This hands-on activity is meant to simulate the challenges of containing and cleaning up an oil spill. This version of the activity has been adapted from many sources and includes an economic component as well as habitat and climate comparisons. It can be simplified for use with younger students or shorter duration.

Many different clean-up techniques were used following the Exxon Valdez oil spill. Below a brief description of each technique is given. For more detailed information on various clean-up techniques and their merit, see references cited in the appendices. There are basically four ways to actively clean up oil spills: mechanical containment & recovery, application of dispersants, shoreline clean-up, and in-situ burning of oil. Another response, not always recognized, is "no response." After the Exxon Valdez oil spill, NOAA studied sites that were not actively cleaned up and documented considerable survival and recovery of marine life. None of these methods are perfect. Since the Exxon Valdez oil spill, and more recent BP Deepwater Horizon oil spill, there has been considerable debate about the best way to clean up a large oil spill. Different things may work more or less depending on the weather, water temperature, natural ecological community,

type of surface, surrounding human communities, and many other factors. However, since there is obviously no great solution to oil once it is spilled, extra care must be taken to prevent oil spills from occurring.

Mechanical skimming of oil is considered the response method least harmful to the environment. It requires large quantities of equipment and personnel, as well as fair weather. It is a multistage process: first you need to contain the oil, then you need to recover the oil, next you need to temporarily store and transport the oil, remove the water from the oil, and finally dispose of the oil. In each stage the oil is handled, so special safety equipment and training is needed. The process is time-consuming and can bottleneck at any stage, breaking down the system. Equipment used can include skimmers, booms, suctioning devices, and buckets.

Chemical dispersants are used to break oil into small droplets that spread out into the water column. This removes oil from the surface, potentially reducing impact on surface-feeding and -breathing animals. However, as the oil disperses through the water column and sea floor, it increases the impacts on other species. The dispersants themselves are highly toxic and also may be ineffective in cold waters. To be effective, dispersants must be applied soon after a spill, since weathered oils don't disperse. The right amount of mixing energy from wind and waves is also needed. Approval is required from the government before dispersants can be applied on a spill.

Shoreline clean-up involves the physical removal of oil from beaches. This is the most labor and equipment intensive response method. Techniques must be chosen carefully. Removal of oiled sediments and biotic materials can sometimes create environmental problems such as beach erosion. Pressurized hot water used to wash oil off of rocks can kill intertidal invertebrates. Running heavy equipment on shorelines can sometimes do more damage than the oil. A variety of shoreline clean-up methods are available. The one(s) used depends on the beach type, location, type of oil, and the equipment and manpower available. Citizen clean-up programs after the Exxon Valdez oil spill involved many different shoreline clean-up techniques, such as oiled seaweed pick-up on beaches. Seaweed is a natural oil collector so the more picked up meant less oil spread back out to bays and estuaries. Pom-poms made of oil-absorbent material were also used to pick up oil, and oil-adsorbent pads were used to wipe off individual rocks. A rock washing program was developed by tying rocks in special bags where they would be washed by the tidal action of the ocean. Once back in the ocean, the oil can be picked up by mechanical skimming.

Bioremediation, the use of fertilizer to increase populations of oil eating bacteria, was also tried. There is some evidence that bioremediation using oil eating bacteria is more effective in warmer climates.

In-situ burning is the technique of burning the spilled oil. It creates air pollution that poses a risk to people and animals exposed to the smoke. Unwanted fires can also happen, and controversy exists about this method's effectiveness and hazards. Burning works best on fresh oil before it has been emulsified with air and water. Specialized equipment and trained personnel are necessary.

Preparation

1. Set up this activity outside if possible. If not, use old newspapers to cover the floor. Mix vegetable oil and black paint and beat well to create pretend crude oil students can safely work with.
2. Fill two tubs per group with saltwater. Leave one tub as only water but include "habitat" materials along one side of the other tub to represent intertidal habitats such as marshes, sandy beaches, and rocky intertidal zones. Give each group a different type of intertidal habitat: rocky intertidal (large rocks), sandy beach (sand), salt marsh (grass), mud flats (mud/clay), cobble beach (small rocks/pebbles), etc. An alternative is to have students make their own habitats, especially if they can recreate a local coastal area they know. Let students select one or two plastic animals to include in their habitat if you have them.
3. Set up a clean-up material station at a table or counter on the side of your teaching space. This should include small piles of each clean up material, plus a printed-out cost list for materials and disposal.
4. Print out Clean Up Cost Sheets, one for each group, and Clean Up Response Worksheets, one for each student or group.

Introducing the Lesson

Introduce the lesson to students by explaining that you are going to create an oil spill in each pan. Their challenge is to investigate various containment and clean-up techniques. Discuss with them various clean-up products and methods, such as: skimmers and booms, dispersants (represented by detergents), oiled seaweed or pompoms, absorbent pads, suctioning (eye dropper),and collecting with buckets. Allow students to consider alternative methods and experiment with them during the clean-up based on the materials provided.

Each of these clean-up techniques comes with a cost: the cost of the material itself and the cost of disposal. Explain to students that each group has a $100,000 budget for their clean-up and oil disposal.

>>*Educator Tip: You should adjust the budget based on group size and duration of the clean up. Multiply the number of people in a group x the number of minutes the students will spend actively cleaning up. This will generally add up to about $80,000 for a group of 4, and having approximately $20,000 left for materials and disposal costs is an appropriate amount. If your groups are smaller groups or you will have significantly less time for the activity, decrease the budget accordingly.*

Their task within their group is to design a clean up response solution. In designing their clean up response they must be mindful of:

- Staying within financial constraints, given the costs of materials and disposal as well as human labor.
- Creating an effective solution that removes most, if not all, of the oil.
- Minimizing the negative impact on the environment.
- Minimizing the negative impact on human economies, cultures, and social practices that depend on that shoreline environment.

Activity

1. Break students into groups and have each group gather around a tub of open water and a tub with an "intertidal habitat." Before they begin, ask students to consider the aspects of this habitat that are important to a healthy ecosystem as well as support human economies, cultures, and social practices. Why are marshes important? What do people use sandy beaches for? What foods do we get from the rocky intertidal? Have students answer the first four questions of the worksheet, or put the prompts on the board and have them respond in their science notebooks.

>> *Educator Tip: If you have less time available, want to streamline the lesson, or the students need more scaffolding, you can instead do the "open ocean" clean up as a demonstration and then have each group work just on cleaning up an oil spill in their "intertidal habitat" tub.*

2. Give students approximately 3 minutes in their group to discuss different materials and techniques that they might use. This isn't a lot of time, but oil spill response almost always happens in a reactive rather than proactive mode.

3. Begin by placing a tablespoon of oil in the "open ocean." Start the timer for one minute. As you wait for the oil spill response to begin, explain to students that they are trying to contain and remove the oil from the open ocean bin. If oil touches the edge of the open ocean bin, then it has moved into intertidal habitat; when this happens, you will place 1 tablespoon of oil into the tub with intertidal habitat. The students' task is to contain, remove, and dispose of the oil as quickly as possible while staying within their $100,000 budget. If the oil cannot be contained and makes its way into the intertidal habitat, their task expands to include cleaning the habitat as best as possible.
4. After the minute passes, let the containment and clean-up begin! Students can send one representative per group to the materials station to pick up materials and note the purchase on their cost sheet.

>> *Educator Tip: An alternative is to skip discussing the budget in advance, but to require all groups keep all their clean up supplies throughout the activity, and then add up their costs at the end. The activity could be run a second time with the budget included. A second run-through also demonstrates how much students ("responders") learn by practice. Drills and exercises of spill response plans is an important part of the system.*

5. After two to three minutes, simulate a storm in each ocean tub by blowing or using a fan to move the oil around. Check tables to add a tablespoon of oil to the intertidal habitat bin as needed if the oil reaches the edge of their open ocean tub.

>> *Educator Tip: If any group is successful in containing and removing the open ocean oil before it reaches the edge of the tub, congratulate them on their efficiency, but still give them a new challenge by placing a tablespoon of oil in their intertidal habitat tub.*

6. Continue the activity for 20-25 minutes, or until groups have reached their limit of clean-up activities. Have groups tally up their clean-up cost and estimate what percent of the oil was removed from the open ocean and intertidal habitat bins. Students should record this data on their worksheet and answer questions 5-9.

Wrap-up

Have students share their data and record it on the board. As a group, discuss the following prompts:

- What containment and clean up techniques seemed to be most successful?
- Which ones were least successful?
- Which techniques seemed to clean or contain the most oil for the least amount of cost?
- Did different techniques work better in different habitats?
- Did students develop any new materials or techniques?

As a group, identify the three most successful techniques that worked across habitats. Have students briefly respond to question 10 on their worksheet.

Ask each student to evaluate the solution their group created compared to a solution another group created. Evaluations should consider:

- Staying within financial constraints, given the costs of materials and disposal as well as human labor
- Creating an effective solution that removes most, if not all, of the oil
- Minimizing the negative impact on the environment
- Minimizing the negative impact on human economies, cultures, and social practices that depend on that shoreline environment

Lead a class discussion, or have students further reflect in writing about their experience. Have them first summarize what they learned about oil spill clean-up and identify any major challenges that they faced. Were they realistic challenges? What environmental factors influence clean-up and oil composition?

In one paragraph, or through a guided discussion, ask students to state their opinion of the best techniques to clean up an oil spill. What trade-offs are made with each of these techniques? Are these techniques better than no response?

Finally, students should respond to the prompt, “How clean is clean enough?” This is an area of debate among scientists, agency representatives, and local people who disagree about what “clean” really is. Ask students to explain how they would determine if an area affected by a spill was sufficiently cleaned and restored. Another prompt can be, “What is the best way to avoid impacting habitat and wildlife with oil?” The answer, which should be obvious after students have seen how difficult it is to prevent the oil from reaching their mock beaches, is “To prevent spills from happening!”

Extension Activity

Change the climate and location of the spill. Allow each group to choose a new climate/location: warm saltwater with the same intertidal habitat type (80 degrees Fahrenheit), ice-filled seas (ice cubes), or a land-based spill (grass/dirt on either side of the tub with a freshwater river or lake in the middle). Spill 1 tablespoon of oil into each tub, wait one minute, and then let students begin the clean-up with a new $50,000 budget and 15 minutes of time (since they only have one tub to clean). Be sure to simulate another storm by blowing on the tubs or using a fan. In the terrestrial habitat, sprinkle freshwater to simulate rain.

Have students tally up their cost and estimate the percent of oil cleaned up. Share this data with the class. Were the same techniques successful in different climates and locations?

Assessment

Review written work for complete answers to questions during the lab. Listen during discussion for arguments based on evidence from their mock clean up or other sources. Evaluate discussion responses and/or written responses for clarity and completeness. Students who successfully meet the performance expectation will demonstrate an understanding of (1) how their clean up solution addressed key priorities, (2) how their design for a clean-up solution was affected by the given constraints and (3) which trade-offs they made in responding to the mock oil spill. Successful students will also make comparisons to other clean-up solutions, across these same categories.