LIKE OIL AND WATER

People and the Planet
Lessons for a Sustainable Future

INTRODUCTION

Today, over one-third of the energy used in the United States comes from oil.[1] Every day, Americans use an average of over 20 million barrels to power our vehicles, heat our homes, and to create various kinds of plastics.[2] Many major sources of oil are found deep under the ocean floor, and they must be drilled out. The process of extracting, processing, and transporting the oil can be hazardous and at times, spills occur. These spills can have devastating effects on marine wildlife, and it can take years for an ecosystem to recover even after the oil has been cleaned up.

When an oil spill first occurs in the ocean, experts try several methods to contain and clean the spill. Large, floating barriers called booms are sometimes put out to keep the oil from spreading further. Because oil is less dense than water, it floats on the surface, so boats called skimmers can remove the oil directly before it reaches a sensitive ocean ecosystem. Another method, which is more controversial, is called in situ burning. During in situ burning, oil is set on fire as it floats on the surface of the ocean. However, this only works in certain circumstances and can be dangerous and pollute the air.

Marine life can be affected by oil spills, and birds are especially sensitive to the negative impacts, as their ability to stay clean and dry is compromised when their feathers are covered in oil. To clean birds, rescue groups soak them in a specific concentration of detergent, thoroughly rinse them with sprayers, and then keep them in a rehabilitation pool to allow time for the birds' natural waterproofing oils to be restored.

As we continue to depend on oil to fuel our lifestyles, the risks and effects of spills will remain a reality. Future engineers and scientists will have the important task of finding safe and effective methods to clean up ocean oil spills and protect the marine ecosystems that are impacted.

CONCEPT
Oil spills pollute the ocean environment and can have devastating effects on marine wildlife.

OBJECTIVES
Students will be able to:

- Conduct a scientific investigation on the effects of oil spills.
- Make and record detailed observations to define a problem in need of solving.
- Use the engineering design process to propose a solution to the problem of oil spill clean-up and/or marine wildlife rehabilitation.
- Design and test prototypes that meet a specific environmental challenge.

SUBJECTS
Science (Earth and environmental, life), social studies

SKILLS
Collecting and analyzing data, observing, researching, engineering design, problem solving, identifying trends and patterns

METHOD
Students make observations about a simulated oil spill and then use the engineering design process to create and test potential solutions for cleaning up oil spills and rehabilitating marine birds.

MATERIALS

- Cooking Oil
- Cocoa powder (optional)
- Paper towels

For each Feathered Friends group:

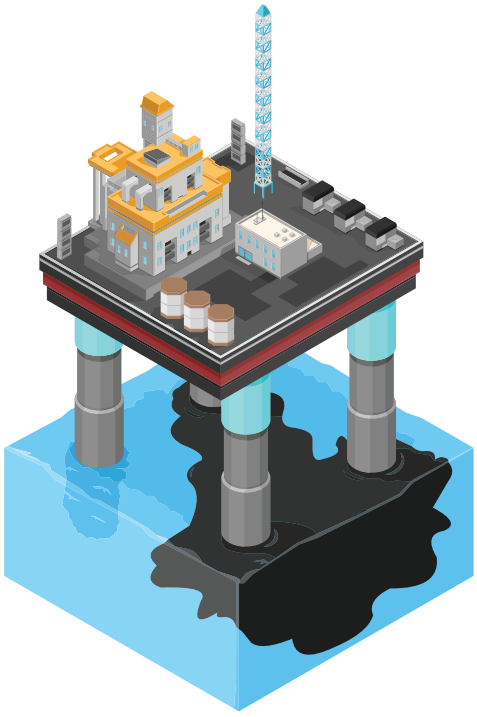
- Small plastic cup
- Shallow container of water
- 4 natural feathers*
- Student Worksheet 1

For each Seashore Superheros group:

- Small plastic cup
- Shallow container of water
- Larger clear plastic cup
- Straw
- Student Worksheet 2

Materials to use in clean-up efforts (suggested list): Cotton balls, cut-up pantyhose, paper towels, popcorn, cut-up sponges, sawdust, sand, bandage pads, rope/string, pipette or eye dropper, popsicle sticks, liquid detergent diluted in spray bottle, toothbrushes

**Find at a pet store or online*



PROCEDURE

1. Before class, color the cooking oil using the cocoa powder and divide it into the small plastic cups, one per group of 2-4 students. Make sure each cup is filled with the same amount of oil. You will also need to partially fill shallow containers with water, one per group of 2-4 students. Finally, for each large clear plastic cup, make a mark indicating the amount of oil placed in the small cup. (For example, if the small cups contain 2 ounces of oil, make a mark at the 2 ounce mark of the large cup.)

2. Give students a quick overview of the two lab options so they can decide which one they would like to do. Divide the class into groups of 2-4 students who have chosen the same lab. Give each group a shallow container partially filled with water, a small cup of vegetable oil, and the materials for their lab:

   a. Feathered Friends – four feathers and copies of the Feathered Friends Student Worksheet for all members.

   b. Seashore Superheroes – a straw, copies of the Seashore Superheroes Student Worksheet for all members, and a large clear plastic cup.

3. Have students follow the directions in Stage 1 of their Worksheet to complete the observation stage of their lab. They can then summarize their findings by answering the guiding questions in the "Define the Challenge" box.

4. Before students proceed to Stage 2, review the "Define the Challenge" sections for both Feathered Friends and Seashore Superheroes. Call on one student from each lab group to share out their answers with the class.

a. Feathered Friends – *Answers will vary. Highlight that healthy feathers repel water and have a fluffy appearance, with their "barbs" (the tiny offshoots from the shaft of the feather) evenly spread out. The feathers are used to protect the bird's skin from water, keeping it warm and dry. When the feathers are covered in crude oil, they aren't aligned correctly, so the bird may get wet, very cold, and sick.*

b. Seashore Superheroes – *Answers will vary. Students should mention the fact that oil floats on the surface of the water due to its low density relative to water. The oil moves around easily, especially when wind and waves are simulated. This could be a major problem because even a small spill spreads quickly, covering a large area and making the clean-up process even more difficult.*

5. Students should proceed to Stage 2, the design process. They will follow the directions to define the problem, create prototypes, and then test their prototypes.

   a. Feathered Friends – Their feather-cleaning solutions will be graded on a scale from 1-5 using a rubric on the worksheet. This includes the look of the feather and a few words describing its shape and ability to repel water.

      Note: Students may find that using a large amount of dish soap destroys the feather's natural oils and makes it less waterproof.

   b. Seashore Superheroes – Their spill clean-up solutions will be tested by how much of the oil they are able to collect and place in their large cup. If they take out water with the oil, that is considered a design flaw.

      Note: This is why it is helpful to mark a "fill line" on the large clear plastic cup before giving it to students, to aid in their estimates of percentage of oil removed.

6. While students are working, write or project the Discussion Questions on the board. Students should discuss these questions as they work on the design process and be prepared to share their answers with the class at the end of three prototype/test cycles.

7. Once the designs and tests are complete, assign students a partner who did the other lab and share with that person to prepare for the whole-class discussion. You may also ask students to write their answers on lined paper or in a science journal.

DISCUSSION QUESTIONS

1. Why was it important to make observations and collect data before you started designing the solution?

   You can't make the best solution possible if you're not completely sure what the problem is that needs solving. The more you learned about how the oil behaved in the water and on the feathers, the better you were able to design a way to clean it up.

2. Was there anything important you wrote during Stage 1 (data collection) that helped you during Stage 2?

   Answers may include: observations about the feather's ability to repel water or the behavior of the oil as it moved around the container of water.

3. What were some changes you made after your first official test? Did they help?

4. What were some challenges you faced when cleaning up the feather/water?

   Answers may include: the observation that dish soap can be harsh and remove natural oils on the feather or that the devices students create to clean up oil sometimes just spread it around more.

5. What additional challenges would you face if cleaning up live birds or an actual oil spill in the real world, compared to just this small test?

   Answers may include: the large size of the spill, the distance from shore, the importance of being gentle to the bird, and the number of birds affected. It may also be difficult to capture wild birds that are scared.

6. What was the most effective thing you tried? How could you scale your idea so that it could be used in real life?

7. In real life, scientists use methods such as booms (floating barriers to prevent further spreading), skimmers (boats that skim the oil from the surface), and in situ burning (setting it on fire on top of the water) to contain and clean up oil spills. Marine birds that have been affected by oil spills are soaked in a special concentration of dish detergent, rinsed with pressure sprayers, and then given time to restore their natural feather oils in a rehabilitation pool before release. Knowing these real life solutions, how does your solution compare?

ASSESSMENT

Review the completed Student Worksheets to determine student understanding of the concept and application of the engineering design process. Students complete a 3-2-1 list that includes: three new facts they learned about the process of cleaning oil spills; two ways they used their observations or testing data to improve their prototype; and one question they still have about oil spills and clean-up.

FOLLOW-UP ACTIVITIES

1. Have students research a recent large oil spill, such as the Deepwater Horizon spill of 2010 or another major event. Ask students to write an essay or newspaper article about the incident, including causes of the spill, extent of oil coverage, effects on the local environment, and efforts to contain and clean-up the spill.

2. Although this activity looked at how oil affects birds, other wildlife is also at risk from oil spills. Have students research how oil affects marine mammals, fish, and other organisms.

[1] U.S. Energy Information Agency. (7 May 2020). U.S. energy facts explained. Retrieved 8/26/2020 from https://www.eia.gov/energyexplained/us-energy-facts/

[2] U.S. Energy Information Agency. (27 April 2020). Oil and petroleum products explained. Retrieved 8/26/2020 from https://www.eia.gov/energyexplained/oil-and-petroleum-products/use-of-oil.php

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STUDENT WORKSHEET 1 – FEATHERED FRIENDS

Name: _____ Date: _____

Stage 1: Observations and Data Collection

Fill out the data table below as you follow the directions to make observations about your feather.

Feather Status	Detailed observations	Drawing
Clean, dry		
Clean, soaked in water		
Soaked in oil		

1. Set your feather on the table so both you and your partner can see it. Observe your feather while it is clean and dry. Write a detailed description of what you observe about its shape, feel, color, size, and other features. Make a drawing or sketch.

2. Carefully submerge the feather in the clean water for 10 seconds. Then remove it, place it on the table, and complete the observations and drawing again. Notice how the feather behaves. Does it repel water? Soak up water? Include this information in your notes about the clean, wet feather.

3. Raise your hand when you are ready to receive oil from the teacher. Dip your feather in the oil and then place the feather on the paper towel. Make your observations and drawing of the oil-soaked feather.

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STUDENT WORKSHEET 1 – PAGE 2

4. Complete the box below to summarize your findings from this part of the lab.

Define the Challenge! What were the qualities of a clean bird feather? Why do you think clean feathers are important – what do they do to help a bird? What are some possible problems with having oily feathers?

Stage 2: Design Process

State the challenge. Why is it a problem for marine birds when oil gets on their feathers?

_____

_____

Goal: Use the given materials to clean the oil from your feather and make it as healthy as possible, as measured by the scale below.

1 (Unhealthy)	2	3	4	5 (Healthy)
Barbs are completely flat Doesn't repel water and easily becomes soaked		Feather barbs clumped Slightly repels water		Barbs are fluffy and evenly spaced with no visible gaps Fully waterproof

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STUDENT WORKSHEET 1 – PAGE 3

Prototype and Testing Process: Using the materials provided, create a prototype of a method for cleaning off the feather. Each prototype can use no more than three different materials. To test your method, record its score from 1-5 based on the rubric on the previous page. Explain what you think went well/not so well, and then revise your prototype and try again. Each time, you should use a new feather freshly dipped in oil, so that each trial is fair.

	Sketch and Description of Cleaning Plan	Score on Rubric and Notes for Improvement
Prototype #1		
Prototype #2		
Final Version		

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STUDENT WORKSHEET 2 – SEASHORE SUPERHEROES

Name: _____ Date: _____

Stage 1: Observations and Data Collection

Fill out the data table below as you follow the directions to make observations about your oily ocean.

Ocean Status	Detailed observations	Drawing	Percentage of surface covered by spill
Immediately after spill			
After wind from the straw			
After waves			

1. Gently pour your cup of oil into your container of water to simulate an oil spill. Without touching the water or the container, record your observations about the color, shape, size, movement, and smell of the oil. Also record its buoyancy, or whether or not it floats. Make a drawing of your oil spill and estimate the percentage of the container's surface it covers.

2. Using your straw, gently blow on the surface of the water for a few seconds at a time to simulate wind on the ocean. You can do this three times. Then, record your observations, draw the spill, and estimate the percentage covered by the spill.

3. Using your hand, gently move the water and oil around in the container. You may also shake the container WITHOUT SPILLING to simulate waves. Then, dry off your hands and complete the data table.

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STUDENT WORKSHEET 2 – PAGE 2

4. Answer the questions in the box below to summarize your findings from this part of the lab.

Define the Challenge! Based on what you observed, is oil more or less dense than water? Did the wind and wave simulations affect the spread of the spill? How can a small amount of oil entering the ocean become a major problem for an ecosystem?

Stage 2: Design Process

State the challenge. How can a small amount of oil spilled into the ocean have a big effect?

_____

_____

Goal: Use the given materials to clean the oil from your container. Your goal is to collect as much oil as possible in the large cup, without taking out too much water with it.

Prototype and Testing Process: Using the materials provided, create a prototype of a method for cleaning your water. To test your method, you will have one minute to try out your prototype by using it to transfer as much oil as possible into the large cup. For each trial, after one minute, estimate the percentage of the spill you were able to collect in the large cup. To help you estimate, the mark on the large cup shows how full it would be if you got 100% of the oil. Record this in the data table and write notes about successes and problems with that prototype in the Testing Notes column. Note that if you are taking out large amounts of water with the oil, that is a problem! Then, revise your prototype and test again.

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STUDENT WORKSHEET 2 – PAGE 3

	Sketch with Labels	Percentage of Spill Collected in Cup and Notes for Improvement
Prototype #1		
Prototype #2		
Final Version		