JOURNEY TO PLANET EARTH

Dispatches from the Gulf

Educators Guide

Written by

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TABLE OF CONTENTS

NEXT GENERATION SCIENCE STANDARDS

"Dispatches from the Gulf" connects to the following Next Generation Science Standards Disciplinary Core Ideas:

LS1.B: **Growth and Development of Organisms**

- Genetic factors as well as local conditions affect the growth of the adult.

LS2.C: **Ecosystem Dynamics, Functioning, and Resilience**

- Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.

ESS3.A **Natural Resources**

- Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.

ESS3.B **Natural Hazards**

- Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events.

ESS3.C **Human Impacts on Earth Systems**

- Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

PS4.C **Information Technologies and Instrumentation**

- Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them.

Observing how scientists in the film gathered and interpreted data relates to the following "Connections to Nature of Science:"

Scientific Investigations Use a Variety of Methods

- Science investigations use diverse methods and do not always use the same set of procedures to obtain data.
- New technologies advance scientific knowledge.

Scientific Knowledge is Based on Empirical Evidence

- Science knowledge is based on empirical evidence.
- Science arguments are strengthened by multiple lines of evidence supporting a single explanation.

OVERVIEW

"Dispatches from the Gulf" examines the impact of the 2010 Deepwater Horizon oil spill upon the Gulf of Mexico and its environmental impact on humans, wildlife, and the ecosystem.

The film touches upon the serious effects the spill had on local communities, including the tourism industry, and especially the families who relied upon seafood such as shrimp and crabs for their livelihoods.

The opportunities for scientific research that came from this spill (the largest in U.S. history) are, however, the focal point of "Dispatches." Take an up-close tour on research ships, in research labs, and with submersible devices to find out what scientists are learning about the condition of the Gulf and its marine inhabitants since the spill, where the 200 million gallons of spilled oil went, and the effects of dispersants on oil.

Meet biologists, chemists, engineers, and oceanographers in action, to learn how these scientists go about finding answers to their questions, both in the field and in the lab. Discover the expected and unexpected lessons being learned and the questions that still need to be answered about the impacts of oil spills.

LEARNING OBJECTIVES

Students will be able to:

- Describe a variety of strategies for cleaning up oil spills.
- Identify the short-term and long-term impacts of oil spills.
- Explain how scientists set up studies to determine the environmental impacts of oil upon fish populations and other marine life.
- Design a research study to test oil spill cleanup strategies.
- Illustrate how oil is formed and compare natural oil seeps to accidental spills.

PRE-VIEWING ACTIVITIES

If students do not know the following locations, use a map to familiarize them with the geographical areas profiled in the film:

- Gulf of Mexico (including the sea floor)
- Mississippi
- Alabama
- Panhandle of Florida

The following terms are used in the film and may need to be introduced to students:

- **Aquarium trade** — a commercial industry dealing with live aquatic animals and customers who wish to purchase them.
- **Barnacle** — as adults, they are hard-shelled marine animals that attach themselves to hard surfaces such as rocks and even other living things such as whales. Feathery appendages reach out of their plated shell to feed on plankton.
- **Baseline data** — initial information gathered that is compared to data collected at a later time to see if changes or new trends have occurred.
- **Bile** — a yellowish-brown fluid produced by the liver that aids in the digestion of lipids (fats) in the small intestine.
- **Breeding stock** — a group of animals brought together for the purpose of breeding.
- **Dispersant** — a substance that, after an oil spill, breaks oil into smaller droplets. Smaller droplets are thought to more easily spread oil throughout a volume of water and make the oil more easily biodegraded by microbes.
- **Exponential growth** — in the context of population, exponential growth means that the original population increases at a consistent rate over time
- **Filter feeder** — animals that strain water for food using a special filtering structure. Clams, mussels, scallops, krill, some species of fish, and baleen whales are examples of animals that are filter feeders.
- **Invasive exotic** — a species that is introduced to a new geographical region where it outcompetes native species, becoming dominant and eliminating or diminishing native species. People can introduce these species knowingly or unknowingly.
- **Larval fish** — many fish species begin as eggs that go through a larval stage before becoming juveniles and adults. In the larval stage, fish are very small, don't swim well and often float in currents. They are also known as zooplankton.

- **Longline fishing** — a technique of fishing that uses a very long fishing line baited with fish at regular intervals. Commercial longlines hold several thousand baited hooks. Often, many lines are hooked together and spread out over many miles. Seabirds, sea turtles and other non-target species also get caught in these lines and are known as by-catch.
- **Mahi-mahi** — an open ocean fish found in waters around the world, including the Gulf of Mexico. Known for being acrobatic, mahi-mahi are a fast growing and valuable commercial fish.
- **Microbes** — microscopic single-celled organisms that include bacteria and archaea, as well as some fungi and some protists.
- **Mitigate** — to reduce or lessen
- **Oil seep** — a series of networks and cracks in the Earth's crust that allow oil to find its way to the surface. They are found on land as well as at the bottom of the ocean. These geologic features are natural, but the oil coming from them is released very slowly.
- **Otolith** — a structure made of calcium carbonate located behind the brain in fish. It helps fish with balance, sound-detection, and orientation.
- **Planktonic** — refers to a group of organisms that cannot swim against a current and instead drift with them. Usually microscopic, planktonic species do vary in size and include larger species such as jellyfish. Planktonic species play an important role in marine food chains.
- **Red snapper** — a fish species found in the southeast Atlantic coast of the U.S., but especially in the Gulf of Mexico. A prized food fish, the red snapper is also long-lived, living up to 50 years. It is associated with reef environments.
- **ROV** — remotely operated robotic device
- **Sea fan** — a marine organism closely related to coral that gets its common name from its shape — a flattened branching structure resembling a fan. This "fan" is made of colonies of polyps. Sea fans are classified as Cnidarians. They come in a variety of colors and are especially abundant in the Western Atlantic in and around the Gulf of Mexico.

To help students put the video in perspective, ask them the following questions:

- What oil spills have you heard about, both in your lifetime and in the past? What do you know about them?
- What do you know about the 2010 Deepwater Horizon oil spill in the Gulf of Mexico?
- What strategies did people use to clean up the oil spilled in the Deepwater Horizon spill?
- What do you think has happened to the 200 million gallons of oil spilled? Where do you think they went?
- What would you predict the impacts of this amount of oil to be on the marine environment in the Gulf of Mexico as well as on land and upon the people living in the Gulf coast area?
- In what ways could this oil spill be an opportunity for the scientific community?
- What technological innovations are you aware of that could help scientists study oil spills—their effects as well as how to best clean them up?

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VIEWING ACTIVITIES

Theme 1: What are the Effects of Oil on Fish?

Overview

When the Deepwater Horizon oil spill occurred, scientists saw an opportunity to study the effects of the oil spill on fish populations and fish growth. Several segments of the film follow scientists who are conducting research to learn about the short-term and long-term impacts of the oil spill on Gulf fish such as red snapper and mahi-mahi. Find out how scientists catch a representative sample of the fish community for study, what scientists can learn from fish tissues, and how researchers use an undersea robotic device to measure the length of fish and estimate their age and weight. You will learn what scientists have learned so far, as well as the questions that are still unanswered. Related film segments are described below.

Dispatch #1 (04:09-05:33) and **Dispatch #3** (08:25-11:00): Go aboard the 115-foot research vessel Weatherbird II to see scientists catch a representative sample of the fish community in the Gulf using a baited longline. By conducting similar samples in a wide variety of sites (200 different areas), both close to the site of the oil spill and far away, scientists can compare the fish populations. Their goal is to track the recovery and health of the fish in the Gulf of Mexico.

Post-viewing Discussion

1. What are the goals of the scientists on the Weatherbird II? (To collect and analyze fish samples in order to understand the long-term impacts of oil spills on fish.)

2. Why are scientists conducting fish samples in 200 different areas of the Gulf? (They want to get a representative sample of fish communities and be able to compare them, especially by comparing the fish populations near the spill to those farther away.)

Dispatch #4 (11:00-16:00): This segment demonstrates how technology can be put to use to gather vital information about fish populations without touching or harming the fish. A ROV (remotely operated vehicle or device) is lowered to take footage of life on the seafloor. A laser on the device is used to determine fish length, which also allows scientists to estimate the age and weight of the fish. What have scientists learned? View this segment to find out!

Post-viewing Discussion

1. Before the spill occurred, oceanographers had collected data on fish populations using the remotely operated device (ROV) in how many different sites? (27)

2. How does the ROV provide data on the length of fish? (Two parallel laser beams are set at 10 cm apart. Scientists can later analyze the footage using the red dots that appear on the fish to make a good estimate of fish length.)

3. What did these oceanographers determine about the fish since the spill? (While the population of reef fish predictably decreased immediately after the spill, it had rebounded a few years later. While the number of fish matched pre-spill levels, scientists noticed a significant difference: the fish were, on average, smaller than before the spill and weighed less. This indicated to scientists that their growth rate had slowed.)

4. What event has made their understanding of changes in the red snapper population more challenging? (Since the oil spill, the invasive exotic, lionfish, became a prominent species in parts of the Gulf. Eating the same food as red snapper, the lionfish are now a serious competitor and scientists have observed that red snapper stay away from reefs inhabited by lionfish, requiring the snapper to expend more energy obtaining food. This adds complexity to their analysis of data.)

Dispatch #5 (16:00-20:30) and **Dispatch #6** (20:30-28:40): These segments show how work in the lab can compliment the research done in the field. In Dispatch #5, find out how the otolith (part of the inner ear in a fish) is used to determine age so that scientists can estimate the abundance of each age group in a given fish species. Dispatch #6 shows the collection of mahi-mahi that will be used for breeding and studying in captivity. In tanks, scientists compare the swimming performance of healthy fish to that of healthy fish exposed to low concentrations of oil, and conduct research on the effects of oil on the larval stage of fish.

Post-viewing Discussion

1. What information do the otoliths (part of the inner ear) provide scientists? (When examined under a microscope in the lab, the otolith indicates the age of the fish.)

2. Why is determining age important to scientists trying to understand the effects of an oil spill? (By estimating the population of fish at each age, scientists can determine how successful reproduction of fish populations has been in the years since the spill. By examining tissues, scientists can also gather information about the levels of contamination in fish several years after the spill.)

3. Why do scientists study the muscle and liver tissue of fish in the Gulf of Mexico? (To determine the levels of contamination in fish and where in the fish body those contaminants are located.)

4. To be able to conduct their research, these scientists must kill fish in order to examine their tissues. What is your opinion about this and why?

5. What have scientists learned about the swimming ability of fish exposed to low concentrations of oil, and how might this affect fish? (Swimming performance goes down in fish exposed to oil. Since their ability to catch food successfully depends on sustaining a high-level of activity, scientists suspect these fish may not do as well in the wild.)

6. What effects does oil have on developing larval fish? (Oil exposure influences the heart, which affects the adults later in life because they are not able to sustain the highest level of activity when swimming. It is important to consider the effects of oil on all stages of fish development.)

Theme Two: Where did the Oil Go?

Overview

200 million gallons of oil spilled during the Deepwater Horizon event. While 23% of the oil washed up on beaches and into marshes, scientists have wondered where the rest of the oil went and what has happened to it since. During the spill, large amounts of oil dispersants were applied to oil on the surface of the Gulf as well as injected into the oil coming out of the Earth at the bottom of the Gulf, 1500 meters below the surface. What effect do dispersants have on oil and where it ends up? Meet some of the scientists exploring these questions and learn about their research.

Dispatch #8 (32:38-36:22): The use of dispersants upon oil has raised questions about whether they do more harm than good. After learning where the 200 million gallons of oil are estimated to have gone, this segment takes you to a wave tank at Johns Hopkins University where researchers simulate oceanic conditions and examine the influence of different sizes of waves upon oil that has been treated with dispersants.

Post-viewing Discussion

1. Where do government scientists estimate the 200 million gallons of oil to have gone? (25% burned or siphoned off; 23% reached salt marshes and beaches or stayed in the water; 52% evaporated into the air or was dispersed)

2. At the time of the Deepwater Horizon spill, little was known about dispersants and the effects of large amounts of them. What were some of the common concerns and questions that people had? (Did the chemicals do more harm than good? Could they be harmful to the environment or to people's health?)

3. How are scientists trying to learn about the ways oil and dispersants interact with the ocean? (Researchers at Johns Hopkins University are using a 20-foot wave tank to generate a wide variety of waves from non-breaking to very violent. When oil is applied to the surface, they can video how oil slicks are broken into small droplets. They can also simulate the application of dispersants beneath the water, which they want to study since dispersants were injected into the oil that was rising from the blowout at the bottom of the ocean.)

4. How will researchers use their findings in the future? (They will apply what they have learned to large-scale field models that try to predict the fate of oil in various kinds of spills.)

Dispatch #9 (36:22-40:10): How does nature deal with molecules of oil? Watch chemical oceanographer Chris Reddy walk beaches collecting oil samples from the 2010 spill. (Your image of a gingersnap cookie is likely to change forever!) In the lab, Ryan Rogers, an analytic chemist, analyzes these samples to find out how they have changed since the spill. You may be surprised by his findings!

Post-viewing Discussion

1. Why is Chris Reddy, a chemical oceanographer, collecting samples of oil that he finds on beaches? (He has the samples analyzed using a high field magnetic lab to see how the molecules have changed over time.)

2. What have Chris Reddy and Ryan Rogers learned? (The UV wavelengths in sunlight and bacteria are breaking down the petroleum molecules.)

3. What is surprising to Chris Reddy about these results? (This process is happening much faster than he anticipated. He expected the oil compounds to last a decade, but is finding that they last about a year. Some oil is still found on beaches, but in trace amounts.)

Dispatch #10 (40:10-46:00): Did you know that oil seeps naturally from ocean depths and that the ocean floor is teeming with wildlife nearby? Join microbial geochemist Mandy Joye to see some of these beautiful life forms. Then accompany her on the Alvin, a manned submersible, to the bottom of the Gulf to see what life forms she finds after the oil spill and to discover whether oil ended up there.

Post-viewing Discussion

1. What does oceanographer Mandy Joye and her research team typically find when they visit a natural oil seep at the bottom of the ocean? (Areas teeming with a wide variety of extraordinary marine species, including microscopic organisms that eat tiny droplets of oil.)

2. What did Mandy Joye and her team suspect happened to some of the oil from the spill? (Images from remotely operated equipment led the team to believe that some of the oil sank to the bottom, blanketing the ocean floor rather than rising to the surface.)

3. What did Mandy Joye learn when she visited the bottom of the Gulf two miles from the spill aboard the manned submersible known as Alvin? (Oil had sunk to the bottom, smothering corals and sea fans as well as other marine organisms.)

4. Why are corals, sea fans, and barnacles especially susceptible to dying when exposed to oil? (They feed by filtering the water, consuming whatever comes into their system. They are unable to be selective about what they take in from the water.)

5. How many dives has Mandy done to the bottom of the Gulf to observe the sea floor? (17. This is significant because scientists want to gather data from as many samples as possible, given time and financial resources.)

Dispatch #11 (46:00-52:05): Scientists on the Weatherbird II collect sediment samples from the bottom of the Gulf to better understand the connections between the oil contaminants in the sediments and the fish that live nearby.

Post-viewing Discussion

1. Why are scientists collecting sediment samples in the same places that the fish are sampled on the Weatherbird II research ship? (Scientists can look for relationships between the contaminants in the sediments with the changes they see in the fish over time.)

2. Why are sediment cores considered to be like a history book? (The further down you go, the older the sediments are, so sediment cores track the history of sediments gathered on the ocean floor over time.)

3. What have scientists discovered so far? (Tiny creatures living in the sediments ingested the oil and transferred it to small fish that ate them. The contamination moved through the food chain until it reached larger fish such as red snapper. Fortunately, the muscle tissue of fish—the part of fish that people eat—is not tainted.)

Theme Three: What's at Stake

Overview

Along the Gulf of Mexico, "everything and everyone is tied to the rhythms of the sea." This includes people who rely upon the Gulf for their livelihoods: the shrimpers and crabbers whose way of life was changed after the spill, as well as the commercial fisheries that provide 40% of the commercial seafood for the continental United States. Coastal wetlands provide a home to a wide variety of plants and animals and the $100 billion tourism industry relies upon clean waters and beaches. What is the balance between searching for new sources of oil and what can be safely provided? What would more oil spills mean for the Gulf of Mexico, the fish and marine creatures that live there, as well as the people who enjoy and rely upon its health?

Dispatch #2 (5:15-8:28): Meet watermen who rely on the Gulf of Mexico for a way of life and to make their living. Learn how much the tourism industry lost in the wake of the Gulf spill.

Post-viewing Discussion

1. Whose lives were especially affected by the oil spill in the Gulf of Mexico? (People in the fishing and tourism industries had their lives and income disrupted.)

2. What natural environment was of most concern by oil coming ashore? (The coastal wetlands that provide homes for many plants and animals and the nursery for many Gulf of Mexico marine species.)

Dispatch #7 (28:40-32:28): What lessons can we learn from past oil spills? The 1989 Exxon Valdez spill in Alaska appeared to spare the herring fishery, but four years after the spill, the herring fishery suddenly collapsed. Scientists have learned that some effects of oil spills can take years to show up.

Post-viewing Discussion

1. Why did the herring fishery collapse four years later rather than immediately after the Exxon Valdez spill? (Larval fish are much more susceptible to oil contamination than their adult counterparts. While adult herring could swim away from the spill, the larval young were negatively affected, and this showed up several years later when they should have reached adult age.)

Dispatch #12 (52:05-56:04): Our society is dependent upon energy and, at this time, we still rely heavily upon fossil fuels such as oil. As we continue to explore offshore environments for oil, we reach into deeper ocean areas, which puts us at risk for this new breed of oil spills. This concluding segment of the film raises the question: What is the right balance between searching for new sources of energy and what can be safely provided?

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SPECIAL PROJECTS

Project 1

In this activity, your students simulate an oil spill and evaluate various cleanup methods. Younger students can use an aluminum pie pan for their oil spill setting, half-filled with water to represent the ocean. Older students could use a larger aluminum pan. If you'd like to add complexity, a rock could be placed in the water to represent land and a small sample of an aquarium plant could represent wetland grasses. Depending on the size of the pan, use 1-4 Tablespoons of vegetable oil to represent the oil slick. You can also consider using Marvel Mystery oil for older students.

Ask your students to identify various strategies for cleaning up oil spills and preventing the oil from coming ashore (absorbing, containing, skimming, and dispersing the oil). Find images of these strategies to share with your students and then show them the aluminum pan in which they will simulate an oil spill. Ask them to make a list of common materials they could use to simulate the absorption, containment, skimming, and dispersing of oil. Possibilities include small (1") squares of absorbent paper towels, small pieces of sponge, cotton balls or cotton pads, small pieces of wool or other types of fabric, string, pipe cleaners, Popsicle sticks, and a few drops of liquid detergent.

For each cleanup strategy (absorption, containment, etc.), ask students to make a list of possible materials to use. For example, they could use Popsicle sticks, string, and pipe cleaners for containment. Younger students could make their lists by looking at materials you have provided. Older students could add additional ideas of their own. For each list, ask students to predict and record which materials they think will be most effective and why.

Run the various simulations as a class demonstration, or have students work in small groups. (Alternately, you could assign each group to focus on one clean up strategy. For instance, testing and comparing various absorption methods or a variety of containment methods.) For each cleanup strategy, ask students to evaluate which materials were most effective. For example, were Popsicle sticks, pipe cleaners, or string more effective at containing the oil and helping to keep it from hitting land and wetland plants? Were paper towels, cotton balls, or cotton rags more effective at absorbing oil? Students should record their results and descriptive observations. Then, ask them to reflect upon and describe what made some materials more effective than others. Could they use this information to design a better method for containing or absorbing oil? If possible, allow them to design and test their ideas and report back to the class.

To test dispersants, use a few drops of liquid dishwashing soap. What happens when it is first applied? What happens when the water is stirred up with a spoon? Ask students what other ways they could test dispersants that would simulate real-world conditions. For example, if they thoroughly mixed the oil and water using an immersion blender, what happens to the oil when the dispersant is added? After using the immersion blender and adding oil, test their original absorption or containment methods. Are the results the same or different? Ask students to summarize in writing what they learned from this lab, and what it makes them think about or wonder about, especially when they apply the lessons of the lab to a real-life oil spill scenario.

For older or advanced groups, extend the oil spill activity by using an oil- absorbing polymer. Oregon State University has designed an activity that you can use or adapt. Enviro-Bond 403 is an oil-absorbing polymer available through Flinn Scientific supplies.

Design this activity for the age of your students and your curricular goals. You can focus specifically on learning about oil spill cleanup methods; extend the lesson to allow students to use the process of science to test questions and make sense of results; or go even further to allow your students to use design thinking and engineering to test their own ideas. You can find a variety of oil-spill activities online. Here are several that might be helpful:

- **National Geographic**
  http://education.nationalgeographic.org/activity/simulate-oil-spill-cleanup/

- **TeachEngineering**
  https://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_enveng/cub_enveng_lesson01_activity1.xml

- **Flinn Scientific**
  http://www.flinnsci.com/media/980622/bf10058.pdf

- **NOAA**
  (This activity focuses on simulating an oil spill response team.)
  http://www.education.noaa.gov/Ocean_and_Coasts/Oil_Spill.html

Project 2

The National Oil Spill Response Test Facility is located in Leonardo, New Jersey. This facility is known as Ohmsett and stands for the Oil and Hazardous Materials Simulated Environmental Test Tank. The Ohmsett facility houses one of the largest concrete test tanks in the world where researchers can test oil containment and cleanup methods, new equipment, and cleanup training response methods. The large tank (203 meters long, 20 meters wide, and 3.4 meters deep) allows researchers to run tests with full-size equipment.

Older or advanced students could visit the Ohmsett website (http://www.ohmsett.com/) to become familiar with the specific features and capabilities of the equipment. Then, using what they've learned about oil spills, oil spill technology, the equipment at Ohmsett, and their understanding of the scientific process, students work in small groups to design sound research studies that could be done using the facilities at Ohmsett.

- What specific question would they like to test?
- What parameters do they need to control or measure using the available equipment?
- How would they go about setting up their methodology?
- What variables and controls would they have?
- What conditions would they test in?

Afterward, they can return to the website to browse through the research that is being done and that has been published to find any research related to their question. How did the research methodology they learned about compare to the methodology they developed. Each group then prepares a detailed presentation of their research methodology as well as any lessons learned from similar Ohmsett research that has been conducted.

Whether students prepare oral presentations or presentation boards, allow their classmates to provide feedback and to ask questions, much like the scientific community would do.

Project 3

Learning about oil spills provides a good opportunity for students to learn how oil forms. Many students may not know that oil formed more than 300 million years ago from ancient photosynthetic marine organisms called diatoms. These microscopic creatures were prolific and sank to the ocean bottom when they died. Over millions of years, these "fossil" organisms piled up and were covered by rock and other sediments that were the result of geologic activity. Pressed and squeezed by the weight and pressure placed on them, the diatoms became oil, with the carbon and chemical energy in the living diatoms still present. Over millions of years, Earth's crust has moved, collided, and folded, creating pockets of oil that are now located beneath the continental crust and ocean floor. Oil companies drill to find these pockets.

Ask pairs of students to search Internet sources (diagrams, simulations, and information) that tell the story of oil formation.

Each pair should design and illustrate its own colorful poster telling this story.

Each poster should include the timeline, the process, and the forces necessary to create oil. In addition, the posters should explain why oil is considered to be a "fossil" fuel.

Project 4

This activity helps students consider the widespread implications of oil spills. Write “Gulf of Mexico Oil Spill” on the board and draw a circle around it. From this central circle, ask students, either the entire class or organized in small groups, to draw out connecting circles, each with a “category of impact.”

Examples of categories include “Environmental Impacts,” “Economic Impacts,” “Health Impacts,” etc. From each of these circles, students continue to connect more and more specific consequences. For example, from environmental impacts, students could add “fish populations,” “wetland organisms,” “seabirds,” etc. Details for each of these topics are then added.

Eventually, encourage students to begin to connect specific details to other categories. For example, students might draw a connecting line from “decline in shrimp” to “economic impacts” (or a more specific related detail such as “fishermen lose jobs” or “fishermen lose way of life,” etc.).

Eventually, the students should end up with a complex web of connections illustrating cause and effect relationships that are mapped out by a series of “bubbles,” much like a concept map.

Ask students to reflect on what they learned and what questions the exercise makes them think about. You might begin by giving them a few minutes to write down their ideas in silence and then share them with the class.

Project 5

The film "Dispatches from the Gulf" discusses natural oil seeps. Students might be surprised to learn that natural oil seeps account for the greatest amount of oil released into oceans, and they may wonder what the concern is about accidental oil spills with so much oil naturally seeping from the ocean floor. This activity addresses this question.

Use the Internet to find a good diagram of an ocean floor oil seep to show your students. Pose the question—why are people concerned about accidental oil spills if oil naturally seeps from the ocean floor? Then, challenge students to research oil seeps and present their answer to this question. The Woods Hole Oceanographic Institution website is a good resource (http://www.whoi.edu/main/topic/natural-oil-seeps).

Ask each group to write a report of their findings.

After explaining what oil seeps are, groups should compare the following: the natural rates of oil seepage to that of an oil spill; and the life found around natural oil seeps compared to the effects of oil spills on living things. As part of their report, you also might ask them to research tar balls, the La Brea tar pits, and the origins of the word "asphalt."

RESOURCES

Additional educational content can be found at the following:

ACER: Alabama Center for Ecological Resilience
http://acer.disl.org/
The Alabama Center for Ecological Resilience (ACER) Consortium came together to investigate how biodiversity influences an ecosystem's ability to resist and recover from disturbance, specifically the ecosystems of the northern Gulf of Mexico to the 2010 Deepwater Horizon oil spill. Education and Outreach modules for university, K-12 school, and general communities are available on their website.

ADDOMx: Aggregation and Degradation of Dispersant and Oil by Microbial Exopolymers
http://www.tamug.edu/addomex/
ADDOMEx investigate the impacts of spilled oil and dispersants on the formation of an extracellular matrix called EPS (exopolymeric substances) formed by marine microbes that is thought to be instrumental in determining the fate of oil. EPS formed by marine microbes can aid in the formation of marine snow that is important in the self-cleansing capacity of natural waters. Education and Outreach modules for university, K-12 school, and general communities are available on their website.

American Institute of Biological Sciences Educational Programs
http://www.aibs.org/education/
AIBS is dedicated to improving biological science literacy at all levels of formal and informal education so that the public is able to make decisions informed by the biological sciences, particularly through an understanding of the process and nature of science and how biology informs societal issues. AIBS works with organizations in biology and across the scientific community to advance knowledge about issues and best practices to improve public understanding of science.

Center for Ocean Sciences Education Excellence (COSEE)
http://coseenow.net/blog/2010/08/oil-spill-resources/
This website provides PowerPoints and hands-on activities related to the Gulf of Mexico oil spill that teachers can use in the classroom.

CONCORDE: Consortium for Oil Spill Exposure Pathways in Coastal River-Dominated Ecosystems
http://www.con-corde.org/
CONCORDE conducts scientific studies of the impacts of oil, dispersed oil, and dispersant on the Gulf's ecosystem and public health. An important part of the scientific process—one as carefully planned as every experiment in a well-thought-out program—is how to share findings with the community who will benefit most from understanding them. The education program of CONCORDE addresses the level of public trust in science. Education and Outreach modules for university, K-12 school, and general communities are available on their website.

Congressional Research Service
https://www.fas.org/sgp/crs/misc/R41640.pdf
Read the Congressional Research Service's report on the economic impacts of the Deepwater Horizon spill on fisheries in the Gulf of Mexico.

CRGC: Consortium for Resilient Gulf Communities
http://www.rand.org/gulf-states/resilient-communities.html
How can communities build resilience to future adverse events like the Deepwater Horizon oil spill?
To find out, CRGC will study the public health, social, and economic impacts of the 2010 Deepwater Horizon (DH) oil spill in the Gulf of Mexico region. CRGC uses an interdisciplinary approach to research and outreach activities to address a major policy issue in this region with implications for the rest of the United States. Education and Outreach modules for university, K-12 school, and general communities are available on their website.

CARTHE: Consortium for Advanced Research on Transport of Hydrocarbon in the Environment
http://carthe.org/
CARTHE studies the oil spill and its impact on the Gulf's delicate ecosystems. Their scientific work is based on one of GoMRI's intellectual themes and focuses on the physical distribution, dispersion and dilution of petroleum, its constituents and associated contaminants under the action of physical oceanographic processes, air-sea interactions and tropical storms. Education and Outreach modules for university, K-12 school, and general communities are available on their website.

C-IMAGE: Center for Integrated Modeling and Analysis of Gulf Ecosystems
http://www.marine.usf.edu/c-image/
C-IMAGE studies the effects of oil spills on marine environments and will advance the understanding of the processes, mechanisms, and environmental consequences of marine oil blowouts. Education and Outreach modules for university, K-12 school, and general communities are available on their website.

C-MEDS: Consortium for the Molecular Engineering of Dispersant Systems
http://dispersant.tulane.edu/
C-MEDS is researching how dispersants can be part of the effective management and mitigation of large oil releases from deep ocean environments. In addition to its research mission, the C-MEDS has a strong education mission to train students in advanced science and technology related to the mitigation of oil spills, and an outreach mission to communicate and provide information on the role of dispersants in oil spills. Education and Outreach modules for university, K-12 school, and general communities are available on their website.

Consortium for Ocean Leadership
http://oceanleadership.org/
The Consortium for Ocean Leadership manages ocean research and education programs in areas of scientific ocean drilling, ocean observing, ocean exploration, and ocean partnerships.

CWC: Coastal Waters Consortium
http://cwc.lumcon.edu/
CWC is assessing the chemical evolution, biological degradation, and environmental stresses of petroleum and dispersant within Gulf of Mexico coastal and shelf ecosystems. CWC's Education and Outreach program translates research investigating the effects of the Deepwater Horizon Oil Spill on coastal ecosystems into understandable formats for all levels of society. Education and Outreach modules for university, K-12 school, and general communities are available on their website.

Deep-C: Deepsea to Coast Connectivity in the Eastern Gulf of Mexico
http://deep-c.org/
Deep-C is a long-term, interdisciplinary study of deep sea to coast connectivity in the northeastern Gulf of Mexico. The study is investigating the environmental consequences of petroleum hydrocarbon release in the deep Gulf on living marine resources and ecosystem health. Deep-C will examine the geomorphologic, hydrologic, and biogeochemical settings that influence the distribution and fate of the oil and dispersants released during the Deepwater Horizon (DwH) accident, and use the resulting data for model studies that support improved responses to possible future incidents. Education and Outreach modules for university, K-12 school, and general communities are available on their website.

DEEPEND: Deep-Pelagic Nekton Dynamics of the Gulf of Mexico
http://www.deependconsortium.org
DEEPEND is investigating deep-pelagic communities on short-term (sub-generational) and long-term (evolutionary) timescales to appraise extant recovery and potential future recovery of these communities, using a suite of integrated approaches. An integrated outreach program will disseminate DEEPEND consortium activities to scientific, educational, and public sectors. Education and Outreach modules for university, K-12 school, and general communities are available on their website.

DROPPS: Dispersion Research on Oil: Physics and Plankton Studies
https://sites.cns.utexas.edu/utmsi.dropps
DROPPS is studying the effects of oil spills in the Gulf of Mexico by examining the breakup of oil as well as the interactions of different planktonic and microbial species with oil. The information gathered from this research helps to predict the overall impact of oil spills, allowing for better protection of people and the environment. Education and Outreach modules for university, K-12 school, and general communities are available on their website.

ECOGIG: Ecosystem Impacts of Oil and Gas Inputs to the Gulf
https://ecogig.org/
ECOGIG is bringing together physical oceanographers, marine biologists, and chemists from 14 research institutions in a holistic effort to understand the impacts of natural seepage versus that of abrupt, large hydrocarbon inputs on coupled benthic-pelagic processes in deepwater ecosystems in the Gulf of Mexico, and to chart the long-term effects and mechanisms of ecosystem recovery from the Macondo well blowout. Education and Outreach modules for university, K-12 school, and general communities are available on their website.

Environmental Defense Fund (EDF)
www.edf.org
The EDF website has educational resources on Climate & Energy, Oceans, Ecosystems, and Health.

Environmental Protection Agency (EPA)
http://www.epa.gov/land-research/oil-spills-research
Visit this website to learn about the protocols that the EPA uses to conduct research on mitigating the effects of oil spills and to have access to their research report.

GISR: Gulf of Mexico Integrated Spill Response
http://gisr-consortium.org/
The vision of GISR (pronounced *Geyser*) is to understand and predict the fundamental behavior of petroleum fluids in the ocean environment. This capability is critical to inform decisions during response to oil spills and for development of mitigation plans, ultimately yielding significant environmental and financial savings. Education and Outreach modules for university, K-12 school, and general communities are available on their website.

Gulf Coast Ecosystem and Restoration Council
https://www.restorethegulf.gov/resources/education-resources/teachers-and-students
This website includes resources for teachers and students, including lessons provided by the Council, as well as links to educational materials at other sites.

Gulf of Mexico Research Initiative (GoMRI)
http://gulfresearchinitiative.org/
The Gulf of Mexico Research Initiative (GoMRI) will investigate the impacts of the oil, dispersed oil, and dispersant on the ecosystems of the Gulf of Mexico and affected coastal States in a broad context of improving fundamental understanding of the dynamics of such events and their environmental stresses and public health implications. The GoMRI will also develop improved spill mitigation, oil and gas detection, characterization and remediation technologies.

The ultimate goal of the GoMRI will be to improve society's ability to understand, respond to and mitigate the impacts of petroleum pollution and related stressors of the marine and coastal ecosystems, with an emphasis on conditions found in the Gulf of Mexico. Knowledge accrued will be applied to restoration and to improving the long-term environmental health of the Gulf of Mexico.

LADC-GEMM: Littoral Acoustic Demonstration Center – Gulf Ecological Monitoring and Modeling
http://www.ladcgemm.org/
Changes in marine mammal distribution and abundance, caused by environmental stresses or human activities, can have a major impact on the function of the entire deepwater ecosystem. This multidisciplinary consortium effort, which uses expertise from marine acoustics, biology, physics, engineering, mathematics, and computational predictive modeling, will equip scientists with an understanding of how the regional marine mammal population in the Northern Gulf of Mexico (GoM) has been affected by the Deepwater Horizon oil spill. Education and Outreach modules for university, K-12 school, and general communities are available on their website.

National Environmental Education Foundation (NEEF)
www.neefusa.org
NEEF works with a network of professions (teachers, weathercasters, health professionals, and land managers) to provide information, resources, and programs to thousands of households around the country. Sign up for their e-newsletter to receive updates on their programs, Environmental Education Week lessons, and more.

National Oceanic and Atmospheric Administration (NOAA)
http://www.education.noaa.gov/Ocean_and_Coasts/Oil_Spill.html
This website has a variety of helpful resources, including access to videos, lessons, fact sheets, and background information related to oil spills, especially the Gulf of Mexico spill.
—AND—
http://response.restoration.noaa.gov/oil-and-chemical-spills/oil-spills/spill-containment-methods.html
The link to this part of NOAA's website provides information on oil spill containment methods.

National Wildlife Federation (NWF)
http://www.nwf.org/What-We-Do/Protect-Habitat/Gulf-Restoration/Oil-Spill/Effects-on-Wildlife.aspx
Find out about the effects of oil spills on wildlife in the Gulf of Mexico.

NEED
www.need.org
The National Energy Education Development Project (NEED) site contains a wealth of information and educational resources for teaching about energy.

RECOVER: Relationship of Effects of Cardiac Outcomes in Fish for Validation of Ecological Risk
http://recover.rsmas.miami.edu/
RECOVER scientists are examining the detrimental effects of oil on two ecologically and economically important species of fish in the Gulf of Mexico: Mahi-mahi and Red drum. Education and Outreach modules for university, K-12 school, and general communities are available on their website.

SeaGrant
http://seagrant.noaa.gov/
Sea Grant's mission is to enhance the practical use and conservation of coastal, marine and Great Lakes resources in order to create a sustainable economy and environment. Environmental stewardship, long-term economic development and responsible use of America's coastal, ocean and Great Lakes resources are at the heart of its mission. A network of 33 Sea Grant programs in the coastal US States and territories carries out this mission through research, extension and education activities.

Smithsonian National Museum of Natural History
http://ocean.si.edu/slideshow/after-oil-spill-research-projects-gulf-mexico-gomri
Visit this site to learn about research projects in the Gulf of Mexico since the oil spill. The site relates to research studies funded by GoMRI (described above), but also includes photographs and an interactive map.

350.org
www.350.org
350.org is an international campaign that's building a movement to unite the world around solutions to the climate crisis. In addition to downloadable information explaining the science of carbon emissions, 350.org has guidelines on how to create a community Climate Action Plan and get community and local government involved in creating solutions to help reverse global warming.

Union of Concerned Scientists
http://www.ucsusa.org
The Union of Concerned Scientists puts rigorous, independent science to work to solve the planet's most pressing problems. Joining with citizens across the country, they combine technical analysis and effective advocacy to create innovative, practical solutions for a healthy, safe, and sustainable future. They have a plethora of educational tools for formal and non-formal education.

Woods Hole Oceanographic Institute
www.whoi.edu
Go to this website and visit the Climate and Oceans Section to view informative articles about a host of climate change research and data, especially as it relates to oceans.

World Resources Institute
http://www.wri.org
The World Resources Institute offers much demographic and environmental information on countries around the world, including charts and maps. Its focuses on six critical issues at the intersection of environment and development: climate, energy, food, forests, water, and cities and transport.

Worldwatch Institute
www.worldwatch.org
Worldwatch Institute is an independent research organization recognized for their fact-based analysis of critical global issues. Their focus is in three main areas: 1) Climate & Energy; 2) Food & Agriculture; and 3) Environment & Society.

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