MODEL BEHAVIOR | EDUCATOR

Links to Next Generations Science Standards |

MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

MS-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool or process such that an optimal design can be achieved.

MS-PS1-3: Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

S T E M

Supplement Video |
https://www.youtube.com/watch?v=FHuwpZDOGFE
https://vimeo.com/162371042 (password: exploration)

Pacing | 1-2 class periods (45 minutes each)

Background Needed | Basic knowledge of scientific modeling and graphing

Assessment | STEM Project & Task rubric provided

Materials/Resources |

- 4-6 large plastic clear tubs filled with water
- trays of ice
- salt
- several hot pots
- paper fans, straws or small battery operated fans with clips
- various types of cooking oils such as peanut, vegetable, canola, etc.
- plastic stirrers/spoons
- thermometers
- rulers, timers
- sediments such as sand, gravel, etc.
- laptops and graphing software such as Microsoft Excel (optional)

Overview

In this module, students will learn the importance of developing models to predict behaviors of substances such as oil in a marine environment and will develop a model to test one variable that would influence the behavior of oil molecules when dispersed in water. Students will then use their developed models to make connections to and ask questions about current research addressing these topics. This module could also serve as an introduction to scientific method and measurement.

Objectives & Learning Outcomes

- Students will understand impacts from hazardous events such as oil spills and the scientific efforts in place to better understand future events.
- Students will design a model to test a variable in a controlled setting.
- Students will collect and graph data using proper scientific techniques.
- Students will communicate their results to an appropriate audience.

Links to Common Core Standards |

CCSS.ELA-LITERACY.WHST.6-8.4: Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

CCSS.ELA-LITERACY.WHST.6-8.7: Conduct short research projects to answer a question, drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

Guiding Questions

- What are Earth's sources of oil and gas? Where are they found?
- How are cold seeps being utilized to study impacts of hazardous events such as oil spills?
- What factors contribute to a working model?
- How do the concepts in this lesson apply to a real scientific expedition?

Define the following terms:

Students will be able to understand and define the following concepts by completing this lesson.

Flux

✓ The rate of flow of a property per unit area.

Fossil Fuels

✓ Buried combustible geologic deposits of organic materials, formed from decayed plants and animals that have been converted to crude oil, coal, natural gas, or heavy oils by exposure to heat and pressure in the earth's crust over hundreds of millions of years.

Hydrocarbon

✓ An organic compound composed of two elements, hydrogen and carbon. Can consist of a few to hundreds or thousands of individual atoms that are linked together in a number of ways, including chains, circles, and other complex shapes; major component of petroleum.

Cold Seep

✓ An area of the ocean floor where hydrogen sulfide, methane, and other hydrocarbon-rich fluid and gas seepage occurs due to fissures on the seafloor caused by tectonic activity.

Methane

✓ A type of hydrocarbon which is the main component of natural gas and forms the basis of a cold seep ecosystem.

Set The Stage!

These materials may be helpful as you introduce the topics within this module:

2015 Expedition Overview (Cruises NA056- NA058)
http://nautl.us/22rx0QL

Article: MIT model accurately characterizes hydrocarbon intrusions observed at Deepwater Horizon oil spill
https://cee.mit.edu/onbalance/2011/november

Excerpts for Rock Talk Vol 7 No. 2, CO Geological Survey
http://nautl.us/1P5gV0Q

Blog: Why Do Bubbles Matter?
http://nautl.us/1sTEHTU

Grad Student Used Genetics to Explore Oil, Dispersant Effects on Deep-Sea Corals
https://nautl.us/2wazv4r

Pre-Lab Questions

1. What do we know about the behavior of oil in water?
   - ✓ **Possible answers**: It is non-polar, does not dissolve or mix with polar water molecules, oil is lighter which is why it floats.
2. Identify 2-3 negative impacts of oil spills on marine ecosystems or humans.
   - ✓ **Possible answers:** Although most oil by itself is not toxic, there are certain components of it that are toxic to fish, birds and other mammals. These components can cause cardiac distress, deformities and death. Oil can coat bird feathers and mammal fur affecting their ability to fly or swim. Oily residue on land, beaches or marshes causes habitat loss and decreases tourism revenue.
3. What is a variable?
   - ✓ **Possible answers:** Any factor, trait, or condition that can exist in differing amounts or types. An independent variable represents the inputs or causes during an experiment, may be changed by a scientist. A dependent variable represents the output or the effect.
4. Hypothesize two variables that could affect the dispersal of oil in a marine spill.
   - ✓ **Possible answers:** Wind or surface currents, deep water or density driven currents, weather events, geographical features including peninsulas, islands, etc.
5. Why is it important to develop models predicting the behavior of oil molecules during a spill? How would this help companies in charge of cleaning up a spill?
   - ✓ **Possible answers:** They can be useful in determining the mechanisms for oil behavior at various depths of water, can predict the direction of oil travel for quicker clean up efforts. Could save money in mitigation efforts.

Teacher Notes

- Groups can be pre-established with assigned roles based on individual strengths.
- Have materials set up in a central supply depot so students can observe and select what materials they would like to use for their model.

Extensions & Adaptations

Introductory | Students can use real feathers to cover with oil and note the differences between these feathers and normal feathers in water- tie in to avian ecology and marine ecosystem dynamics.

Advanced | Students can research the origins, production and components of various types of oil and the importance of hydrocarbon molecules to the function of oil as an energy source; students could create a report/school newspaper article/ presentation that identifies the importance of current research happening with hydrocarbon behavior in ocean environments.

Student Procedure- Day 1

1. Complete pre-lab questions and vocabulary terms individually or with a partner.
2. Get into small groups and decide individual roles such as materials & maintenance, technician, data recorder, recorder/videographer, reporter, etc.
3. Students choose a minimum of one variable they will test about oil behavior (effect of temperature, wind, currents, sediments, etc.) in water.
4. Students can develop a hypothesis for their chosen variable.
5. Students will come up with a plan for creating a model to test their hypothesis.
6. Students will come up with a plan for keeping track of data, graphing data and providing evidence of their model.

Student Procedure- Day 2

1. Students can gather their materials and test out their ideas, recording their data and observations.
2. Have students prepare a brief report to share out with the class.
3. Have students answer the post-lab questions either individually or with their group.

Post-Lab/Discussion Questions

1. What are 1-2 new pieces of information you learned today using your model (support by showing data)?
2. What were some of the difficulties your group had in designing this model? What were some of the strengths of the group?
3. How do you think scientists study the effects of oil spills without causing significant harm to the environment?
4. What are some components you would change/modify to make your model better?
5. What are some variables that were difficult to test in the classroom, but may influence oil behavior in the deep sea?

MODEL BEHAVIOR | STUDENT

Learning Goals

- Understand impacts from hazardous events such as oil spills and the scientific efforts in place to better understand future events.
- Develop a model to test a variable in a controlled setting.
- Collect and graph data, using proper scientific measuring techniques.

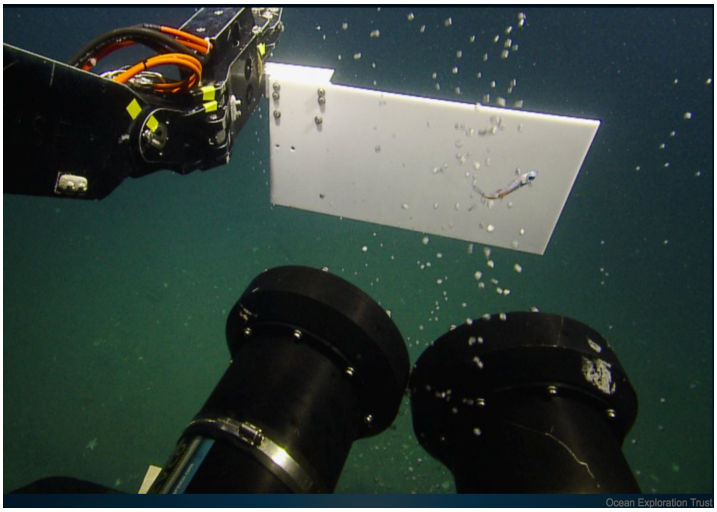
Visualizing Molecules

Look up images of water and oil molecules. What do you notice is different about the chemical structure between the two?

Introduction | Human-caused oil spills are a major threat to ecosystems, costing many millions of dollars in clean up and economic impact to those who depend on the sea. More poorly understood though, is the natural inputs of oil and natural gas that seep from the ocean's floor every day. Natural seeps are part of the normal ecosystem, but scientists don't have well-developed explanations for how this natural gas and oil behaves in the environment. Whether oil releases from the seafloor naturally or in a human-caused accident, it's important to understand how the oil will rise, sink, spread, diffuse into the atmosphere or be consumed by organisms. There are many factors that contribute to how hydrocarbons (oil and natural gas) disperse so scientists build computer models to combine the results of many studies and make informed predictions about how petroleum behaves in the water column. Every study helps develop more accurate models to educate stakeholders, engineers, and scientists how to best manage and mitigate future spills. In this module, you will develop a model to test one factor affecting oil behavior in water.

Background | Oil and water are both molecules made up of atoms. Water is a polar molecule- one side has a positive charge (hydrogen) and one side has a negative charged (oxygen). Polar molecules have asymmetrical electron. Oil is a lipid and it is non-polar due to the symmetrical electron distribution. Polar molecules are attracted to other polar molecules, but not attracted to uncharged molecules. Non-polar molecules are therefore insoluble, or will not dissolve, in water. The chemistry of oil and water molecules at a basic level informs scientists in understanding molecular behavior and oil mitigation.

In the picture shown at right, scientists aboard E/V *Nautilus* use specialized equipment to measure the size and velocity of methane bubbles moving through the water column in the Gulf of Mexico.



NAUTILUS NEWSFLASH

In April 2015, the Corps of Exploration partnered with scientists from GISR (the Gulf Integrated Spill response) to study the dynamics of hydrocarbons in the petroleum-rich Gulf of Mexico. Hydrocarbon inputs are a normal small-scale process throughout the Gulf, but scientists wanted to understand the behavior of petroleum when added in large-quantities to the complex marine environment. Learn more about the expedition!

- "Why Do Bubbles Matter?" http://nautl.us/1sTEHTU
- 2015 Expedition Overview (Cruises NA056- NA058) http://nautl.us/22rx0QL
- Exploring Methane Seeps Photo Album http://nautl.us/2eggBjH

Guiding Questions |

1. What are Earth's sources of oil and gas? Where are they found?

2. How are cold seeps being utilized to study impacts of hazardous events such as oil spills?

3. What factors contribute to a working model?

4. How do the concepts in this lesson apply to a real scientific expedition?

MODEL BEHAVIOR | STUDENT

SCIENTIST SPOTLIGHT

Dr. Scott A. Socolofsky
Texas A&M University
Lead Scientist,
GISR Cruise

"I recall how difficult it was to find the bubble plumes the first time—we couldn't see them until the ROV was within a few meters away! Luckily, the *Nautilus* technical staff recommended we use an acoustic sonar to find the plumes, and that proved to be invaluable. Probably the most exciting part of the 2015 cruise was when a sperm whale stopped by to check out the ROV. You can view a video of this encounter on YouTube. What you will not see in the video, though, is that we also had a fire in the ROV control van at the same time. It did not cause much damage, but made for a very exciting moment. For me, the best part of these cruises is that we captured the data we sought after, and made some of the first observations of this kind in the field, including high-speed stereoscopic imaging of the bubbles from the seafloor to high in the water column, and high-resolution chemistry measurements of the dissolved gases. My recommendations to anyone interested in STEM professions: follow what excites you and what you are most curious and interested about. I am very glad that I followed my interests and I now have a job where I study phenomena that I love."

Materials |

- 4-6 large plastic clear tubs filled with water
- trays of ice
- salt
- several hot pots
- paper fans, straws or small battery operated fans with clips
- various types of cooking oils such as peanut, vegetable, canola, etc.
- plastic stirrers/spoons
- thermometers
- rulers
- timers
- sediments such as sand, gravel, etc.
- laptops and graphing software such as Microsoft Excel (optional)

Student Procedure |

1. Complete pre-lab questions and vocabulary terms.
2. Break out into small groups and decide individual roles *[recommendations: materials & maintenance, technician, data recorder, recorder/videographer, reporter, etc].*
3. Choose a minimum of one variable you will test about oil behavior *[recommendations: effect of temperature, wind, currents, sediments]* in water.
4. Develop a hypothesis for your chosen variable as well as a data recording plan for how to prove or disprove your hypothesis.
5. Create a model to test your hypothesis.
6. Gather your materials and test your model, record data and observations.
7. Graph data.
8. Answer the post-lab questions either individually or with your partner(s).
9. Prepare a brief report to share out with the class.

Vocabulary |

Flux

Fossil Fuels

Hydrocarbon

Thoughts & Ideas

Vocabulary (continued) |

Cold Seep

Methane

Pre-Lab Questions |

1. What do we know about the behavior of oil in water?

2. Identify 2-3 negative impacts of oil spills on marine ecosystems and humans.

3. What is a variable?

4. List two variables that could affect the dispersal of oil in a marine spill.

5. Why is it important to develop models predicting the behavior of oil molecules during a spill? How would this help companies in charge of cleaning up a spill?

Worksheet One - Use this page to help organize your plans.

Group Member Name	Role & Responsibilties

Variable group will test:

_____

Hypothesis:

_____

_____

_____.

Model/Experimental Plan: Use the space below to summarize the materials and steps required to test your variable.

Worksheet Two

Data: Create a format (data tables, etc.) for keeping track of your data and associated qualitative or quantitative measurements. It may be helpful to incorporate pictures, diagrams or illustrations of your model.

Graph: Use a computer program like Microsoft Excel or graph paper to create a graph representative of your results.

Post-Lab Questions

1. What are 1-2 new pieces of information you learned today using your model (support by showing data)?

2. What were some of the difficulties your group had in designing this model? What were some of the strengths of the group?

3. How do you think scientists study the effects of oil spills without causing significant harm to the environment?

4. What are some components you would change/modify to make your model better?

5. What are some variables that were difficult to test in the classroom but may influence oil & gas behavior in the deep sea?

MODEL BEHAVIOR | ASSESSMENT

STEM Project & Task Rubric

OBJECTIVE	CRITERIA			
	4 Exemplary	3 Commended	2 Emerging	1 Developing
Knowledge & Understanding |	Student consistently, correctly and thoroughly answers all questions. Uses an abundance of relevant vocabulary and is able to explain relationships within the content using examples. Can apply the content to other topics or real life.	Student is able to consistently answer most questions correctly. Uses an adequate amount of relevant vocabulary. Can explain relationships within the content and can apply content to other topics or real life.	Student is able to answer some questions correctly. Uses some relevant vocabulary. Student does not elaborate on relationships within the content or make connections between the content and real life.	Student is able to answer a few questions correctly. Inconsistently uses relevant vocabulary. Student does not elaborate on relationships within the content or make connections between the content and real life.
Content Organization, Methodology & Analysis |	Student effectively organizes complex ideas, concepts, and information to make important connections and distinctions. This may include detailed, labeled and thorough procedures, data tables, graphs, diagrams and/or analyses.	Student is able to organize ideas, concepts, and information to make connections and distinctions. This may include mostly detailed, labeled and thorough procedures, data tables, graphs, diagrams and/or analyses.	Student attempts to organize ideas, concepts and information to make some connections and distinctions. Student is able to provide basic procedures, data tables, graphs, diagrams and/or analyses.	Student has difficulty organizing ideas, concepts and information to make connections and distinctions. Student is unable to provide basic procedures, data tables, graphs, diagrams and/or analyses.
Self-Directed Learner |	Student is actively engaged in the learning process; consistently contributes to class discussions and asks clarifying questions. Seeks out and shares additional resources with the class or teacher. Advocates for his/her learning needs.	Student is engaged in the learning process. Often contributes to class discussions and asks clarifying questions. Advocates for his/her learning needs.	Student is inconsistently engaged in the learning process. Sometimes contributes to class discussions or asks clarifying questions. Inconsistently advocates for his/her learning needs.	Student is weakly engaged in the learning process. Rarely contributes to class discussions or asks clarifying questions. Rarely advocates for his/her learning needs.
Technological Tools |	Use of digital resources is always appropriate for the task. Willing to learn and use technology for inclusion of charts, graphs, pictures, etc. to amplify the message.	Use of digital resources is appropriate for the task. Willing to use technology for inclusion of charts, graphs, pictures, etc. to amplify the message.	Use of digital resources is sometimes appropriate for the task. Inconsistent use of technology for inclusion of charts, graphs, pictures, etc. to amplify the message.	Use of digital resources is rarely appropriate for the task. Inconsistent use of technology for inclusion of charts, graphs, pictures, etc. to amplify the message.
Collaboration Skills |	Consistently works effectively and respectfully with a diverse group of learners. Actively checks with others for understanding and how he or she may be of help. Student listens when others speak and incorporates or builds off of the ideas of others.	Works effectively and respectfully with a diverse group of learners. Checks with others for understanding and how he or she may be of help. Student listens when others speak.	Sometimes works effectively and respectfully with a diverse group of learners. Sometimes checks with others for understanding and how he or she may be of help. Student listens when others speak.	Has difficulty working effectively and respectfully with a diverse group of learners. Rarely checks with others for understanding and how he or she may be of help. Student may talk over other students or does not listen when others speak.
Total Score:	**Comments:**			

How Large is Nautilus Nation?

Tracking the reach of Ocean Exploration Trust's education programs is essential in ensuring we are funded to continue making discoveries and inspiring the next generation of explorers.

Name: **My Community (City, State):**

Email Address:

School's Name:

Instruction date: **Grade level instructed:**

Subject area:

My education space is a...

- ❑ Classroom
- ❑ After school program / Club meeting
- ❑ Fair / Festival / Event
- ❑ Museum / Science Center
- ❑ Other. Tell us more:

Who did you engage in your teaching?

Students

Community Members

Select all the OET materials you used in your instruction:

- ❑ STEM Learning Modules. Which ones? _____
- ❑ Digital Resource Library materials. Which ones? _____
- ❑ Nautilus Live website: photo albums ❑ highlight videos ❑ live stream
- ❑ Meet the Team STEM mentor profiles
- ❑ Facebook (NautilusLive) ❑ Twitter (@EVNautilus) ❑ Instagram (@nautiluslive)
- ❑ Other. Tell us more: _____

_____

What made working with OET resources valuable to your instruction (select all that apply)?

- ❑ Hands-on activities ❑ STEM career connections
- ❑ Easy to use lessons ❑ Standards-based lessons
- ❑ Website resource access ❑ Real world application of curricula topics
- ❑ Excitement of cutting-edge discoveries / Unfamiliarity of deep ocean
- ❑ Another reason. Tell us more: _____

_____

Using OET resources increased my confidence in teaching my science, technology, engineering, or math subjects.	❑ Yes	❑ No
OET provided me with helpful and relevant teaching resources.	❑ Yes	❑ No
Using OET resources increased my awareness of STEM careers.	❑ Yes	❑ No
If yes, how so? How can we improve?		

Please scan this document or snap a picture of it with your phone. Email the feedback or questions to education@oet.org. You can also submit feedback online: http://nautl.us/2cp3PNu

Thank You For All You Do!