



Classroom Series – Module #2

An Oil Tanker Runs Aground Off the California Coast; Plan and Execute an Appropriate Warning and Cleanup Response.

Description of Activity

In this lesson, students will first consider how to properly respond to a hypothetical oil spill by reviewing online EPA emergency guidelines. Then, students will derive component vectors in order to gain an understanding of how HF Radar technology is used to generate maps of sea surface currents. Additionally, students will make calculations of average speed and direction of sea surface currents and then use these skills along with real time data from the CeNCOOS website (www.cencoos.org) to predict the movement and eventual location of a hypothetical off-shore oil spill that has occurred offshore of Drakes Bay (near Point Reyes National Seashore). Finally students will present their team's strategic response plans to the entire class for review.

Related Subjects and Grade Level

High School Physics, Mathematics, Oceanography.

Grades 9-12

California Science Content Standards Alignment

- Motion and Forces (Physics): 1j - resolve two-dimensional vectors into their components and calculate the magnitude of a vector from its components.
- Energy in the Earth System (Earth Sciences): 5a, b – differential heating and Earth's rotation produce the circular motion of ocean currents on earth

(Source: www.cde.ca.gov/be/st/ss/scmain.asp)

Prerequisite Prior Knowledge

Students should have had instruction in the following related topics prior to beginning this lesson:

- Objects in motion have a direction and speed that can be altered.
- The speed of an object can be calculated using $s = d/t$.
- The motion of an object can be represented graphically by vectors.
- The position of an object on earth can be determined using a system of coordinates in latitude and longitude (GPS).

- Have already completed CeNCOOS Classroom Series – Module #1: “An Introduction to the Integrated Ocean Observing System- IOOS” (recommended).

Time Required

Two 45-50 minute class periods

Specific Learning Objectives

Students will:

1. Locate and determine the magnitude (average speed) and direction of a vector from a surface current vector field chart.
2. Calculate the component vectors when given a resultant vector so as to understand how HF Radar measures average sea surface movement.
3. Apply their knowledge of vectors to calculate and predict the movement and eventual location of a hypothetical off-shore oil spill.
4. Analyze and track real-time ocean surface current data to confirm the validity of their initial prediction.

Materials

For each team (2-3 students per team):

- Printouts of Sea Surface Vector Field for the San Francisco Region
- Computer with internet access
- Metric ruler
- Calculator
- Pencil and pen
- Copy of the Student's Guide: “An Oil Tanker Runs Aground off the California Coast; Plan and Execute an Appropriate Warning and Cleanup Response”.

Description of Lesson and Related Activities

This lesson is best conducted after students have had the opportunity to work through CeNCOOS Classroom Series – Module #1: “An Introduction to Integrated Ocean Observing System - IOOS”. Doing so will give them a generalized introduction to the Integrated Ocean Observing System (IOOS) and the instruments and methods used to collect real-time oceanographic data.

Part 1: Oil Spill Research

First, students will be introduced to the scenario – the hypothetical oil spill - and will be directed to study the following recommended EPA resource links on oil spills:

<http://www.epa.gov/emergencies/content/learning/oiltech.htm>

<http://www.epa.gov/emergencies/content/learning/rescue.htm>

<http://www.epa.gov/emergencies/content/learning/crude.htm>

While students are studying this information, they will be required to respond to five questions which will be used to complete their final response plan. (See the Oil Spill Research Profile contained in the Student's Guide).

Part 2: Vector Analysis

Here, students will be analyzing the Sea Surface Vector Field for the San Francisco Region, CA and calculate the component vectors from a specific resultant vector (see Vector Analysis procedure in the Student's Guide). The resultant vectors (indicated as colored arrows on the chart) represent the average direction and magnitude (speed in cm/sec) of the current in that specific location (see "Technical Background – HF Radar" below). The students will need to carefully follow the procedure contained on the Vector Analysis in order to successfully calculate the component vectors as required. Be sure to assign a clear and distinguishable resultant vector for students, as this will aid in them being able to find the component vectors with less difficulty. You can also assign a different resultant vector to each team, allowing them to work more independently of one another.

Technical Background - HF Radar

One of the ways scientists can measure the movement of water at the surface of the ocean (that is, surface currents) is to use a system of high frequency (HF) Radar that produces radio waves which are emitted out over the ocean (as far as 70 km offshore) from radio antennas located along the coastline. These radio waves are scattered by the rough surface of the ocean. Some of this scattered energy returns to the receiving antenna (like an echo) after it "bounces" off the ocean surface. By measuring the change in frequency of the radio signal that returns (compared to that which was emitted), the HF Radar determines how fast the water is moving relative to the position of the antenna. Once combined with the measurements made from other HF Radar units, the

movement of water at that specific location can be represented by a *resultant vector* (an arrow that represents the sum of all forces acting on the object – in this case, that part of the ocean). Because this resultant vector represents the sum of all forces acting on that part of the ocean, we can derive the contributing forces, or *component vectors* from this single vector (Students do exactly this in Part 2 of this lesson). In order to make accurate measurements of sea surface motion, an array of HF Radar systems has been installed along the entire California coastline (see <http://cordc.ucsd.edu/projects/mapping/>). As a result, scientists are now able to acquire accurate, real-time sea surface current measurements around the clock.

For further information on HF RADAR technology, check out the following links:

http://www.cencoos.org/sections/conditions/currents/what_is_hfradar.shtml

http://marine.rutgers.edu/cool/education/class/josh/hf_radar.html

http://www.codaros.com/intro_hf_radar.htm

Part 3: Using Real-Time Data from CeNCOOS to Predict the Movement of the Oil Spill.

After students have completed Parts 1 and 2, they will be ready to conduct an analysis of a real-time sea surface vector field image in order to guide them in making their predictions as to the movement of the hypothetical oil spill. Because this lesson relies upon real-time data, it will be necessary to preview the sea surface current images on the day of the lesson (prior to beginning the activity) to familiarize yourself with the possible outcomes given that day's coastal sea surface features (go to: http://www.cencoos.org/sections/conditions/Google_currents/).

Also check out the animations at:

http://www.cencoos.org/sections/conditions/CENCAL_currents/sf_node.shtml

to see the projected paths an object will take over the next 24 hours. Students themselves will be comparing their results to these animations at the end of Part 3. The starting point of this hypothetical oil spill (the scenario is 40 km (~25 miles) offshore, due west of Drakes Bay (near Point Reyes National Seashore). You can choose other starting locations if you would like (e.g. Monterey, Bodega Bay, etc.) but they should be comparable to the area contained within the animation sequences for student reference.

Part 4: Present Your Team's Strategic Response Plan

This last part of this activity should be used to give students an opportunity to share their predictions and findings to the rest of the class. They can do this in any number of ways. You can have them make a formal written report, a PowerPoint presentation, a poster presentation, a public service announcement (or skit), etc. You may choose to award prizes for the team that provides the most compelling, accurate, or effective plan of all. Have fun!