Adrift

A Classroom Activity for Ocean Gazing Episode 18: The prince's predictions: Part II

Written by: *Liesl Hotaling (CIESE at Stevens Institute of Technology), Daniel Griesbach (Homdel High School), Paul Ludgate (Upper Township Middle School), Janice McDonnell and Eric Simms (IMCS-Rutgers University)*
Edited by: *Amy Pallant and Debra Kovacs (Turnstone Publishing)*
Reviewed by: *Michael Crowley, Dr. Scott Glenn, Dr. Josh Kohut, and Sage Lichtenwalner (IMCS-Rutgers University)*
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Grade Level: 7-8

Lesson Time: Three to four 45-50 minute sessions

Summary

In this lesson cluster, students will work with component and resultant vectors. They will learn that the motion of an object is a function of many different forces. Students will then graphically add vectors to determine the displacement of a boat adrift at sea. Through this task, the concepts of distance and displacement will be distinguished. Ultimately, students will use real-time CODAR data for sea surface currents to determine the drift rate of a ship in the ocean and predict its eventual location. Predictions will be compared in following days to the actual sea surface current data to assess the validity of the students' hypotheses.

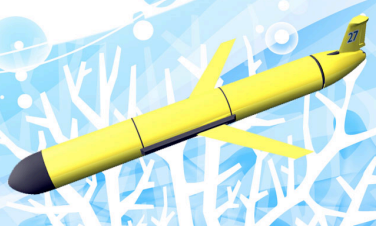
Objectives

- ✓ **Step #1: Learn the Tools Understanding Ocean Currents and CODAR.** Students visit the Control Room and background material what Coastal Ocean Radar (CODAR) is and how it works.
- ✓ **Step #2: Analyze Data Practice Analyzing CODAR Images.** Students will understand how surface currents are mapped and how to analyze data contained on the maps.
- ✓ **Step #3: Pracitce Calculations Adding Vectors.** Students will use both component and resultant vectors to solve a problem and understand the concept of vector addition
- ✓ **Step #4 and #5: Using Real-Time CODAR Data to Locate the Ship.** Students will use real-time CODAR data for sea surface currents to determine the drift rate of a ship in the ocean and predict its eventual location

Introduction

Navigation and ocean currents

If you have ever dropped something in the ocean, you have probably seen how the ocean tends to carry it away from you, and you've watched it bob up and down in waves. The movement of the object you've



seen is caused by the influence of the ocean's surface currents and waves on the object.

Boats on the ocean are able to travel with, or against, the currents on the ocean's surface by using oars, sails, or motors. However, if a boat loses its ability to move across the water, or is overcome by a storm, it will quickly find itself at the mercy of the wind, waves and currents. When boaters find themselves in trouble, they rely on the U.S. Coast Guard's Search and Rescue Unit to respond to their distress calls. If the Coast Guard knows how the surface currents are moving, they can locate boats and people more quickly.

But how can ocean scientists (and the Coast Guard) "see" how the currents on the surface of the ocean are moving? In this project, you will learn how to read vector images of real-time CODAR (Costal Ocean Radar) data. Then you'll use your knowledge to help locate a lost ship off the New Jersey coast!

Step 1: Learn the Tools; Understanding Ocean Currents and Coastal Ocean Radar (CODAR)

Learn about CODAR. Visit the CODAR page in the "What's COOL?" section to learn how CODAR is used to study ocean surface currents and conditions. Then use the Control Room CODAR tutorial and the CODAR Science Background to explore component and resultant vectors of motion and to learn for yourself how surface currents are measured. When you're done close the windows to continue with this project.

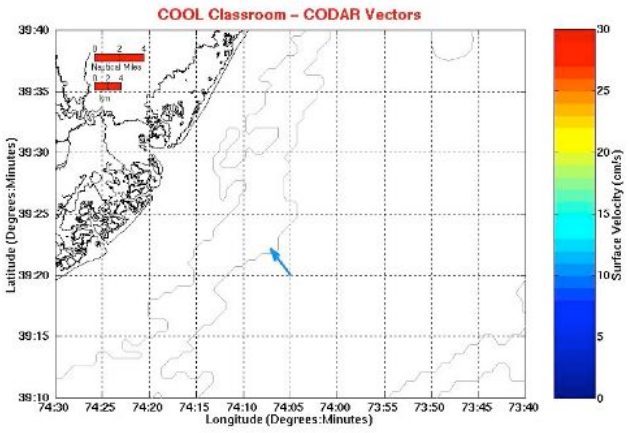
1. Read about CODAR in What's COOL.
2. Go to the Control Room and click on the CODAR lever to do the CODAR tutorial.

Based on what you've learned about CODAR, answer the following questions. Record the answers on the Adrift Activity Worksheet.

1. Download the "Adrift" Activity Worksheet.
2. Make a list of the different forces you think would affect the motion of a drifting boat under "Understanding Ocean Currents and CODAR."
3. Do you think it would be easy to determine the eventual motion of a drifting boat using all the forces you have listed so far? Why or why not?
4. Record your answers to the questions on the Adrift Activity Worksheet.

Step 2: Analyze Data; Practice Analyzing CODAR Images

Now let's apply your knowledge of vectors to some real CODAR images. In the following image, the CODAR system has produced a vector indicating the direction and speed of the surface current. The arrow you see is the combined, or resultant, motion for all the forces acting on the water at that point.



1. Examine the vectors.
2. Refer to the the "Adrift" Activity Worksheet to answers the questions

under "Practice Analyzing CODAR Images."

3. Determine the current velocity (cm/sec) using the color scale on the right of the graph.
4. Use the COOLroom "Speed Conversion" calculator to convert the velocity to km/hour. To get there, scroll down to the middle of the COOLroom's Ocean Surface Currents from Coastal Radars page. Close the window when done.
5. Use the map scale (km) to determine the distance between the starting point (the non-arrowed end) of the vector and the point on land reached by drawing a straight line from the vector (in the direction it is pointing) until you hit land. Use the following formula to determine how long it would take for a wave starting at the vector to reach shore.

   If you know that *Distance* = *Rate* (or *velocity*) x *Time*, you can rearrange the equation as:

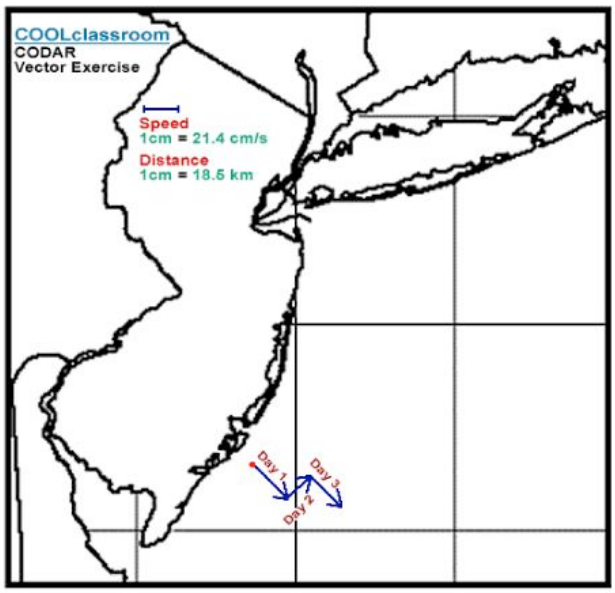
   Time = *Distance*/*Rate* (or *velocity*)

Be sure to record your answers on the Adrift Activity Worksheet.

Step 3: Practice Calculations; Adding Vectors

Imagine that a group of middle school students is taking a field trip aboard a research vessel off the coast of New Jersey. The vessel is caught in a sudden storm and the engine breaks down, leaving the students adrift at sea for three days before the Coast Guard can rescue them (don't worry – they have plenty of food!). The last known location of the vessel is 10 miles East of Ocean City, NJ. Record all your answers on the Adrift Activity Worksheet under "Adding Vectors."

The location of the boat is indicated on the map by a red dot approximately 10 miles off shore.



1. Look at the vector for Day 1. To determine how far the boat drifted in the first 24 hours, measure the length of the vector for Day 1 in centimeters (cm). Use the conversion of 1 cm = 21.4 cm/sec and convert to km/hr using the C.O.O.L. Room "Speed Conversion" calculator. Then multiply your answer by 24 hours to obtain the distance traveled on Day 1. Repeat the calculations for the vectors for Days 2 and 3.
2. Draw a straight line connecting the starting point on Day 1 to the ending point on Day 3. This line is the resultant vector. Measure the length of the vector in cm, and then use the scale 1 cm = 18.5 km to calculate the distance between the two points.

Analysis: Answer the following questions on the Adrift Activity Worksheet under "Adding Vectors."

1. Add the component vectors from each of the three days to determine the total distance the boat drifted.
2. How far from the starting point was the boat eventually located? How does this differ from adding the component vectors over the three days?

Step 4: Use Real-Time CODAR Data; Coast Guard Search

As a member of the Coast Guard Search and Rescue Unit, you have just received a distress call from a ship stranded at sea. You will now need to apply your knowledge of vectors, surface currents and the interaction of forces on ocean water to predict the expected location of the ship. You will do this by calculating the time it will take for the ship to reach a specified end point from a known starting point in the ocean. Record all of your answers on the Adrift Activity Worksheet under "Using Real-Time CODAR Data."

1. Examine real-time data:
   a. Go the Boaters section of the COOLroom at http://www.thecoolroom.org/boaters.htm and click on the link "Ocean Surface Currents from CODAR."
   b. Scroll down the page to the second map, which shows the area of the ocean off the coast of New Jersey from Brant Beach to Brigantine. The small blue square at the top of the map is the Brant Beach CODAR station, and the blue square further south along the coast is the CODAR station at Brigantine.
   c. Print the image.
   d. Discuss any differences between this map and the ones used in the previous activities.
2. Discuss the overall trends and patterns observed for this day:
   a. What is the general direction of the surface currents?
   b. What is the fastest current speed on the map?
   c. What is the slowest current speed on the map?
   d. In what direction would a bottle drift if you dropped it at latitude 39:25 and longitude 74:05?

Step 5: Predict Motion; Locate the Ship

1. Using latitude and longitude coordinates provided by the teacher, find the vector to be used as the starting point where the ship first sent a distress call. Based on the color of the vector, determine the speed (km/hour) of the surface currents at this location by comparing the color to the velocity scale to the right of the map.

2. Use the map scale (km) to determine the distance between the starting point (the non-arrowed end) of the selected vector and the selected end point. The end point is determined by drawing a straight line from the vector (in the direction it is pointing) until you hit land, or you reach the edge of the map (if the vector is pointing away from land).

3. Use the formula *Time* = *Distance* x *Rate* (or *velocity*), calculate the amount of time it would take for the ship to reach the selected end point. Do you predict that the ship will travel in a straight line to the end point? If not, why? Think back to the beginning of the unit when you hypothesized about the forces that would affect the motion of a drifting boat. Was the speed and direction of

the wind one of your factors? You may wish to check the real-time wind speed and direction of the wind from the Meteorological Tower at the Rutgers Marine Field Station (http://www.thecoolroom.org/boaters/boat_met.htm) to see how the wind might affect the movement of the currents.

4. Check the real-time CODAR data over the next two-three days (or for as long as the amount of time you calculated in Step 5). Answer the corresponding question on the Adrift Activity Sheet.

Sources

To access an online version of this activity, you can go to the following URL: http://coolclassroom.org/cool_projects/lessons/physics_middleschool/locatetheship.html

The related podcast episode for this activity can be found by going to the podcast section of www.oceangazing.org