CENTERS FOR OCEAN SCIENCES EDUCATION EXCELLENCE
BEST OF COSEE HANDS-ON ACTIVITIES

ALASKA
PEOPLE, OCEANS AND CLIMATE CHANGE
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Activity Title: Improving Oil Spill Response: Plotting the Currents in Prince William Sounds

Learning Objectives

Students find and use data from the Alaska Ocean Observing System (AOOS) to plot the tracks of drifters used by scientists as real-time data to compare with computer predictions during a field experiment to test a circulation model for Prince William Sound, Alaska. They interpret data to develop predictions about the path of an oil spill and to make inferences about what drives circulation in the Sound.

Focus Questions:

- How do scientists use drifters to study currents?
- How is data from drifters used in computer models to predict the direction and speed of currents?

Curricular Connections:

Boating Safety, Math, Language Arts (reading, speaking, library/information skills), Technology.

Alaska State Standards and Grade Level Expectations Addressed:

SA1 The student demonstrates an understanding of the processes of science by

[6][7][8] SA1.1 asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring and communicating.

SB1 The student demonstrates understanding of the structure and properties of matter by

[7] SB1.1 using physical properties (i.e., **density,** boiling point, freezing point, conductivity) to differentiate among and/or separate materials (i.e., elements, compounds, and mixtures)

[8] SB1.1 using physical and chemical properties (i.e., **density**, boiling point, freezing point, conductivity, flammability) to differentiate among materials (i.e., elements, compounds, and mixtures)

SG2 Students develop an understanding that the advancement of scientific knowledge embraces innovation and requires empirical evidence, repeatable observations, logical arguments, and critical review in striving for the best possible explanations of the natural world.

SG3 Students develop an understanding that scientific knowledge is ongoing and subject to change as new evidence becomes available through experimental and/or observational confirmation(s).

Essential Questions

- How do scientists study ocean surface currents?
- Why do scientists study ocean currents?

National Science Education Standards

A. Science as Inquiry
E. Science and Technology
H. History and Nature of Science

Ocean Literacy Principles:

1d -- Throughout the ocean there is one interconnected circulation system powered by wind, tides, and the force of the Earth's rotation (Coriolis effect), the Sun, and water density differences. The shape of ocean basins and adjacent land masses influence the path of circulation.

7d -- New technologies, sensors, and tools are expanding our ability to explore the ocean. Ocean scientists are relying more and more on satellites, drifters, buoys, subsea observatories and unmanned submersibles.

7e -- Use of mathematical models is now an essential part of ocean sciences. (Ocean Literacy Principle

Supplies and Materials

- PWS Field Experiment Newsletter also available @:

  www.aoos.org/wp-content/uploads/2011/10/AOOS-Summer-2009-Newsletter-PWS.pdf
- Map of Alaska
- *Worksheet "Where Did the Drifters Go?"* (included in this document)
- *Worksheet "Predicting the Path of the Drifter"* (included in this document)
- Videos (http://www.youtube.com/watch?v=OpQngP9HmKo and http://www.coseealaska.net/resources/index.cfm?CFID=5394370&CFTOKEN=45797631) and podcasts (http://www.aoos.org/prince-william-sound-region-page/field-experiment/pws-fe-media/)

Background

See procedure for background on the project.

Duration

3 classes of 45 minutes each

Audience

Grades 6-8

Procedure

Teacher Preparation

- Print copies or obtain copies in advance. Read through the newsletter and the key points, and explore the project website to become more familiar with the scientists, their blogs, and the project in general.
- Listen to the podcasts and view the video.
- Print copies of the student worksheet *"Where did the Drifters Go?"*
- Arrange for student internet access.
- Gather materials needed.

Engagement

Introduce the Prince William Sound Field Experiment by playing two podcasts: *The Prince's Predictions -Part 1 and Part 2* found at http://www.aoos.org/prince-william-sound-region-page/field-experiment/pws-fe-media/ (about 8 minutes each; the first podcast focuses on need for better predictions for oil spill response, safe boating, and search-and-rescue; the second on the drifter experiment).

Show the video *Overview of the Project* (http://www.aoos.org/prince-william-sound-region-page/field-experiment/pws-fe-media/) by scientist Scott Pegau (approximately 5 minutes). Distribute copies of the Sound Predictions 2009 Newsletter (also available @: http://www.aoos.org/wp-content/uploads/2011/10/AOOS-Summer-2009-Newsletter-PWS.pdf) to read and discuss as a class.

Discuss the experiment. Some key points for the discussion:

- Scientists conducted a large field experiment using drifters in Prince William Sound, Alaska, during the summer of 2009. (Use a map of Alaska to help students locate the Sound.)
- The study was led by the Alaska Ocean Observing System (AOOS), with partners from other agencies. They wanted to test predictions about weather, waves, and currents made by computer models to find out if the predictions were accurate enough to help people involved with oil spills, search and rescue, and fishing.
- It took five years to get ready for the experiment, and at least 65 scientists from eight states were involved.
- Drifters were used as part of the experiment, to measure current direction and velocity. Several different types of drifters were used to track currents at different depths. (The design and location of the drogue, the sail-like underwater structure of the drifter is main design feature related to the depth at which the drifter floats.)
- The experiment also used fixed weather stations, instruments mounted on ships, and drifters with underwater drogues to collect data on temperature, salinity, wave heights, chlorophyll and other properties of the water in Prince William Sound. (See the pictures of the different instruments on the back page.)
- All of the instruments together make up a system for observing the ocean. Scientists use mathematical models to forecast weather, waves, and ocean conditions, and the data collected by all of the instruments helps them to come up with better models and determine how well their predictions work.

- While other instruments collected data to help forecast weather, wind, and wave conditions and to study marine life, drifters were used mainly to help track ocean currents and then develop forecasts.
- Nearly 100 drifters were tracked during a two week period. The drifter track data was collected in "real time" and fed into the computer model so the predicted track of the drifter could be compared. (Point out the pictures in the middle of page 3 that compare the real path of the drifters with the predicted paths)
- The experiment was successful even though there were a lot of challenges. Challenges included bad weather, equipment malfunction, and difficulties in sending data from remote locations.

If possible, watch the other videos about the project (Search by "Sound Predictions" on the COSEE Alaska website (http://www.coseealaska.net/resources/index.cfm?CFID=5407796&CFTOKEN=31061775) and take time with the class to look at pictures, scientists' blogs, profiles of the scientists, and additional information about the Prince William Sound Field Experiment on the AOOS Website: http://www.aoos.org/prince-william-sound-region-page/field-experiment/. Use the website to answer any questions generated during the discussion.

Exploration

Activity 1. Where Did the Drifters Go?

Have your class do the following or demonstrate it with a projector:

Go to the NASA Jet Propulsion Laboratory (JPL) website. http://ourocean.jpl.nasa.gov/PWS09/

Demonstrate how they can find out what happened to drifters that were dropped into Prince William Sound during the experiment.

1. Choose dates from the calendar on the left hand side of the page. The dates in blue and underlined are the days that the experiment was going on.
2. Scroll down to the title "Drifter Trajectory" in the menu on the left hand side of the page.
3. Click the circle next to "Observation" under "Drifter Trajectory.
4. Click the circle next to one of the types of drifters.
5. Add drifters one by one by clicking the box next to the drifter number. You will see the trajectories they followed after they were dropped in the central part of the Bay. You may want to turn off all the drifters but one.

Individually or in small groups. Pass out the worksheet Where Did the Drifters Go? and have the students fill it out. Discuss their predictions.

Activity 2. Predicting the Paths of Drifters in Relation to Winds and Circulation.

The JPL site provides the opportunity for virtual drifter experiments - dropping virtual drifters into Prince William Sound which, based on how drifters actually moved during the experiments, will move as the model predicts they would have moved under the wind and current conditions that were present during the experiment. This demonstrates how models work - predictions are developed for future wind, wave, and current conditions based on past observations.

Have your class do the following or demonstrate it with a projector:

1. *Go to the NASA Jet Propulsion Laboratory (JPL) website at http://ourocean.jpl.nasa.gov/PWS09/*

Look at the calendar on the lefthand side of the page. The dates in blue and underlined are the days that the experiment was going on.

2. Scroll down to WRF, which is the name of the model that predicts wind speed and direction.

3. Click "wind" under "WRF"

4. Choose the dates July 26, 27, 28, 29, 30, and 31 in succession and look at the wind patterns and the strength of the winds for each day (the map will re-draw each time). What difference do you see between winds on July 26 – 28 and July 29 -31?

Individually or in Small Groups:
Pass out the worksheet Predicting the Path of a Drifter. Have the students write down a prediction for how a drifter would move from the center of the Sound (under the words "Prince William Sound" on the map) during the period July 26-28 compared to July 29-31.

Have the students follow the instructions on the worksheet and answer the questions. Discuss their answers as a class.

Elaboration

Connecting the drifter movement patterns for a circulation model requires that your students have a basic understanding about how differences in water temperature and salinity constitute differences in density that can drive current patterns because warm, fresher water flows over cold, salty water. (Understanding why water flows in a counterclockwise gyre in the Northern Hemisphere, however, requires an understanding about the Coriolis effect, which is better taught at high school level.)

You can show the students the salinity and current patterns in the Sound for the period by choosing "Salinity" under "ROMS nowcast" and clicking on each day in succession (the map will re-draw each time). The pattern is consistent with fresh water runoff "forcing" the counter-clockwise flow in the center of the Sound when the Sound was calm on July 29-31 and winds strong enough to overcome the forcing and move the drifters in a western direction on July 26-28.

ROMS stands for Regional Ocean Model. One of the important changes that the scientists made to the ROMS for Prince William Sound as a part of this project was to add the influence of the fresh water flow from the Copper River and surrounding mountains and glaciers. Because fresh water is less dense than salt water, its buoyancy creates a large counterclockwise gyre in the middle of the Sound which can only be dominated at the surface by currents driven by the winds. (In order to incorporate freshwater forcing into the PWS ROMS, the model takes into account air temperature and precipitation data, and glacier, snow storage, and melting processes.)

Extension
For career exploration, have students watch all of the videos featuring scientists and field technicians. Students can also choose one of the PWS scientists from the experiment and research their role in the experiment and their career online

Assessment

Have students develop experiments using the JPL data website simulation tool.

Assess student understanding using:

- Student responses during class discussions

- Written work on the worksheets

This lesson plan was provided by COSEE Alaska. For more information, please contact Marilyn Sigman at msigman@alaska.edu

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Predicting the Path of a Drifter
Student Worksheet

1. Write down your predictions for the path of a drifter dropped in the middle of Prince William Sound

Dropped on July 26 and picked up on July 28: Predicted direction it will travel:_____

Dropped on July 29 and picked up on July 31: Predicted direction it will travel: _____

2. Go to the website http://ourocean.jpl.nasa.gov/PWS09/ .

3. Look at the calendar on the lefthand side of the page. The dates in blue and underlined are the days that the experiment was going on.

4. Scroll down to the title "Drifter Trajectory" in the menu on the lefthand side of the page.

5. Click the circle next to "Prediction" under "Drifter Trajectory.

Prediction
a. Choose Single Drop.

b. Choose the dates "7/27/2009" as your starting date and "7/28/09" as your ending date.

c. Click on the map in the middle of the Sound under the words "Prince William Sound." (The latitude and longitude will be automatically calculated for the place you click on the map.)

d. Click on "Compute and Plot" below the map.

6. Click on "Clear," then repeat steps a-d, but use the 7/29/09 as your starting date and 7/31/09 for your ending date.

Were you right about your predictions?

How did the wind affect the drifters?

What influenced the direction of the drifters when the winds were calmer?

Where Did the Drifters Go?

Student Worksheet

How Drifters were used in the Prince William Sound Field Experiment

Drifters were deployed in groups that contained at least three of four different types of drifter. During the main study periods the drifters were released at three sites to provide a spread to check against what the model predicted the currents would do.

In an earlier experiment in 2004, drifters went in a counter-clockwise direction (cyclonic circulation) from where they were dropped off in the center of the Sound and then they drifted off from the northern and western edge of the circle. In 2009, the drifters were allowed to drift no more than 10 nautical miles away from the center of the circle whose center was the original drop point. If they went further, they were picked up and redployed from their original starting location.

The electronic signal give off by the drifter position was monitored by satellite as well as by hand-held receivers. Hourly drifter positions were reported each evening of the experiment before 10 p.m. ADST.

You can see how well the predicted route of the drifters (from the model) matched what actually happened (from the signals sent by the drifter).

1. Go to the website http://ourocean.jpl.nasa.gov/PWS09/ .

2. Look at the calendar on the lefthand side of the page. The dates in blue and underlined are the days that the experiment was going on.

3. Scroll down to the title “Drifter Trajectory” in the menu on the lefthand side of the page.

4. Click the circle next to “Observation” under “Drifter Trajectory.

Observation

5. Click the circle next to “Argosphere drifters.” These were used in the experiment because they would drift like oil spilled by the *Exxon Valdez* oil tanker on the surface of the water.

6. Add Argosphere drifters one by one by clicking the box next to the drifter number. See the trajectories they followed after they were dropped in the central part of the Bay.

You may want to turn off all the drifters but the one you are looking at.

7. After you have added all of the drifters, answer the following questions:

a) Why do some drifters follow different routes than the others?

b) Where would you predict that oil spilled at Bligh Reef during this period would go?

c) If you heard about an oil spill somewhere in the Sound in July or August, would you alert oil spill responders in Cordova or Whittier?

8. Add Self-locating Marker Buoy Drifters (SLMDB) drifters one by one by clicking the box next to the drifter number. This type of drifter was used in the experiment because they drift a short distance below the surface drift like an adrift boat or a person overboard. See the trajectories they followed after they were dropped in the central part of the Bay. You may want to turn off all the drifters but the one you are looking at.

9. After you have added all of the SLDMB drifters, answer the following questions:

a. How do you account for the zig-zag pattern for several of the drifters?

b. If you went overboard would you have a better chance of being found if you went in north or south of Bligh Reef?

SLDMB Drifter

Argosphere Drifter