Ocean in Motion 2: What Causes Ocean Currents and How Do We Measure Them?

A. Overview

1. The Ocean in Motion -- Circulation

In this program, students will learn about the driving forces responsible for ocean circulation. We will show a video clip showing sea level height and describe its connection to ocean circulation. Finally, we will look at different ways in which we can measure ocean currents.

2. Contents of package

Your packet contains the copies of the following activities:

I. Temperature-driven and Density currents
II. Salinity-driven and Density currents
III. Wind-driven currents
IV. Demonstrating the Coriolis Effect

B. Program Preparation

1. Focus Points

o Ocean Circulation:

a. uneven heating and cooling is largely responsible for circulation
b. two main classes of currents
   1. wind-driven currents
   2. density-driven currents
c. ocean circulation covers a wide scale of motion (space and time)
d. many different ways to measure the scales of motion
e. ocean motion can be tracked using dissolved chemicals acting as invisible dyes

C. Showtime

1. Broadcast Topics

This broadcast will link into discussions on ocean circulation, global water temperature and its effect, and changing seasons.

a. Driving Forces

Energy from the sun and tidal forces drive ocean currents. Wind-driven and density-driven currents are described.

Follow-up activities:

1. Temperature and Density-driven currents.
2. Salinity and Density-driven currents.
3. Wind-driven currents.

b. Resulting Circulation

A video clip from NASA’s Jet Propulsion Lab shows the modeled height of the global sea surface resulting from the forcing factors described. In general, water flows from 'high' level regions to 'low' level regions, with some circulation because of the earth's rotation.

Follow-up activity: 1. Demonstrating the Coriolis Effect

c. Measurement

Measurements over different space and time scales are appropriate to different problems. For example, to study how heat is moved by ocean circulation, satellite data can be used. Satellites are useful because heat circulation can take years, and heat distribution covers the entire ocean.

Satellite data are also useful on a much smaller scale to provide safe navigation in an estuary the size of Tampa Bay. One type of useful data are hourly current measurements at a single location to help predict navigation. Different instruments and techniques are used depending on the scale of the problem. Some of these are: current meters, satellites, 'Smart' drifters, and chemical tracers.

D. Activities

I. Temperature and Density-Driven Currents

Key Concepts:

a. ice versus water density

b. ocean waters near the equator are heated by the sun's rays

c. surface (warm) and bottom (cold) water currents

Materials:

- a tank, or wide-mouth glass jar
- ink or food coloring
- ground pepper
- water
- small containers, or an ice cube tray, to freeze water in
- prepared colored ice cubes

Objective: To demonstrate and observe the constant exchange of surface and bottom water currents as related to density.

Method: Fill the tank one-half full with warm fresh water. Sprinkle pepper grains into the water. These will settle to the bottom. Place a colored ice cube in the water.

Discussion Questions:

1. Where does the melting ice water go?

2. If the pepper grains represent material on the ocean bottom, what happens to them?

3. What happens to the cold water as it warms up?

Teacher's Guide for Discussion Questions:

A. **Unique water properties**

Among the unique properties of water are the facts that solid water (ice) is less dense than liquid water. Consequently, ice floats. Water is most dense at 4° Celsius, so be careful generalizing that cold water is denser than warm water. However the inky ice water (near freezing) is more dense than the surrounding warm water and so it sinks to the bottom. The sinking icy water moves the warm water ahead of it and causes a current that moves the pepper grains on the bottom of the tank.

B. **Relation to Ocean Motion**

The ocean waters near the equator are heated directly by the sun's rays. Waters at the poles receive less energy from the sun (they are tilted further away from the sun). Globes might be a helpful demonstration here. The heavier cold water at the poles sinks and flows along the bottom towards the equator as density currents. The warm surface waters at the equator move toward the poles in a constant exchange. Of course, surface currents are also affected by winds.

II. Salinity and Density-Driven Currents

Key concepts:

a. mixing of waters with different densities

b. location of different salinity waters in the worlds ocean

c. salinity as a water tracer

Materials:

- table salt
- two different colors of ink or food coloring
- tank or wide-mouthed glass jar
- 2 glasses of fresh water
- a teaspoon
- a stirring stick

Objective: To observe and determine how different salinity waters drive currents.

Method: In the first glass, dissolve a small pinch of salt and mix in a few drops of red ink. In the second glass dissolve 4 teaspoons of salt and mix in a few drops of blue ink. Pour the red (low salinity) water into the tank. Slowly and carefully pour the blue (high salinity) water into the tank.

Discussion Questions:

1. What happens to the high salinity water and why?
2. Where would you expect to find the saltiest waters in the ocean and why?

Teacher's Guide for Discussion Questions:

- The saltier water is denser than the less salty water so it sinks.
- Leave the tank for a few hours and notice whether the waters mix. Compare with the temperature experiment (salt mixes more slowly than temperature).
- The most saline waters are found at the ocean surface, in regions where the removal of fresh water (by evaporation) is greater than the input of fresh water (by precipitation).
- Differences in salinity can drive ocean currents. Usually there are temperature differences that enhance the density differences. Oceanographers use salinity as an ocean tracer.

III. Wind-Driven Currents

Key Concepts: Demonstrating the Coriolis Effect

a. Coriolis deflection

b. Sea surface flow

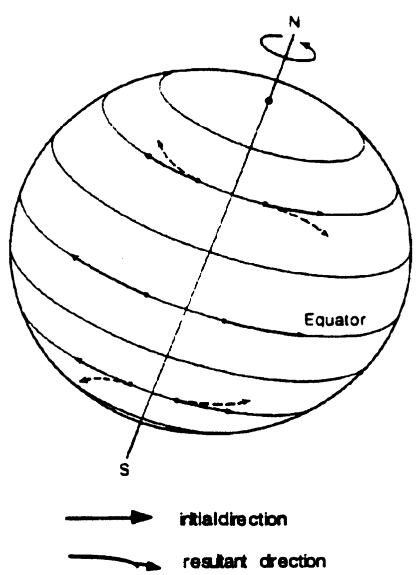
c. Ocean floor current flow

Materials:

- piece of paper cut into a circle (10" diameter)
- record player
- pencil

Objective: The rotation of the earth makes the direction of wind and water flow deflect to the right the Northern hemisphere, and to the left in the Southern Hemisphere. This deflecting force is called the Coriolis Force (Figure 1).

Figure 1.



Method: Place around sheet of paper over the record table. Draw a straight line on the paper. This represents the flow of water (or air) in the absence of the Coriolis force, because the earth (the record player) is non-rotating. Start the phonograph table rotating, to represent the rotating Earth. Now try and draw a straight line on the paper.

Discussion Questions:

1. What happens when you try and draw a straight line on the rotating table?

Teacher's Guide for Discussion Questions:

1. The straight line now becomes a curve as a result of the turning record player. This is the kind of deflection seen on the rotating earth. You may have to demonstrate this deflection on a globe using your finger moving downward in a 'straight' line, while the globe is rotating.