KIDS ENVIRONMENTAL LESSON PLANS

This lesson plan developed by:

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Density Currents

Overview:
This activity demonstrates the thermohaline circulation (Global Ocean Conveyor Circulation) throughout the world's oceans and the relative density differences between cold and warm ocean water.

Ocean Literacy Principles:

1. The Earth has one big ocean with many features
2. The ocean and life in the ocean shape the features of Earth
3. The ocean is a major influence on weather and climate
4. The ocean made Earth habitable
7. The ocean is largely unexplored

Key Concepts:

- Surface and deep waters are not well-mixed, however they do mix gradually over longer timescales.
- A major ocean circulation system called the thermohaline circulation plunges cool surface waters into the deep ocean, mostly in the North Atlantic and around Antarctica. The thermohaline circulation eventually raises some of the deep ocean water to the surface; mostly in the Pacific but also in the Indian Ocean.

Materials:

- rectangular container (glass dish, plastic shoebox or storage container)
- paper cup with pinholes in bottom
- tape
- food coloring

- crushed ice
- eye dropper
- small piece of paper (about ½ inch)
- warm tap water
- 4 small thermometers to fit in container (optional)

Set-up Prior to Activity:
If doing a single demonstration of ocean currents for the entire group, tape the cup in one corner of the rectangular container, about one inch from the bottom. Fill container with warm (room temperature) water so that the bottom of the cup is submerged. If you have equipment to do several setups (small groups of 3- 4 students), allow the students to set up their own containers.

Duration:
30-60 minutes without thermometers/ 2 hours with thermometers

Physical Activity:
Low

Background:
Cold deep ocean water is often much higher in essential mineral nutrients than surface waters because as organisms die, they sink and take their minerals with them to the bottom where the minerals are released by decomposers. Where ocean currents, climate and geography force deep water to the surface, primary production increases dramatically with the introduction of higher levels of mineral nutrients. This production supports entire food chains. This upwelling is caused by both geographic and climatic factors. It produces areas in the ocean where the fisheries are particularly rich, and thus, are of high interest to humans.

Complicating this issue of heat storage in the oceans is the fact that the oceans are not really just one big monolithic pool of water. From the surface, we tend to focus on the separations of the oceans in geographic terms; the Atlantic is distinct from the Pacific is distinct from the Arctic, and so on. From a heat reservoir and a "parcels of water with shared characteristics" perspective, a major distinction is between the surface ocean and the deep ocean.

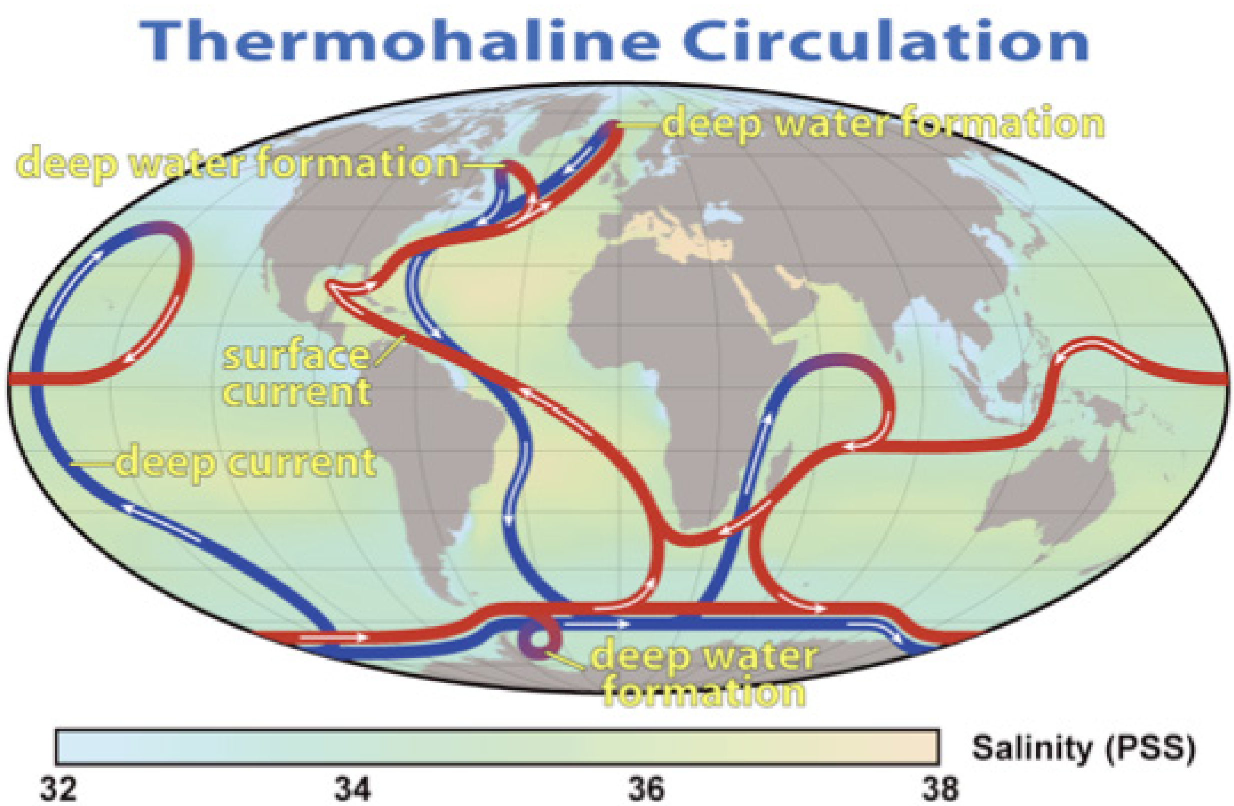
In the tropics through mid-latitudes, sunlight provides a lot of heat to the uppermost layers of the ocean. However, this warming sunlight only penetrates to depths of a few tens of meters. The stirring action of wind-driven surface waves and the tides keeps the uppermost layers of the oceans well mixed, so the heat provided by the Sun is effectively distributed throughout the top few hundred meters of ocean water. However, the deeper ocean, which contains about 90% of all ocean water, does not mingle much with the surface layers. Sea surface temperatures range from slightly below freezing near the poles to an annual average near 30° C in the tropics. Deep ocean temperatures span a much more narrow range, between about 0° C and 4° C, and are nearly uniform throughout the world's oceans. A fairly sharp transition between warmer surface waters and the colder deep waters, called the **thermocline**, exists at depths of a few hundred meters throughout most of Earth's oceans.

Density Currents (cont.)

Of course, although surface and deep waters are not well-mixed, they do mix gradually over longer timescales. A major ocean circulation system called the thermohaline circulation (Global Ocean Conveyor Circulation) plunges cool surface waters into the deep ocean, mostly in the North Atlantic and around Antarctica. The thermohaline circulation eventually raises some of the deep ocean water to the surface; mostly in the Pacific but also in the Indian Ocean. This round trip is not a quick one though; it generally takes at least a couple hundred years, and can last as long as 1,600 to 2,000 years for water that makes the longer journey to the Pacific.

Heat and dissolved chemicals (including carbon dioxide from the atmosphere that dissolves into sea water at the surface) do not necessarily have to travel with a parcel of water as it makes the long journey to the deep ocean and back, but in many cases they do. So warming (or cooling) of the deep ocean will likely occur on much longer timescales than is the case for the ocean's surface layers, and on much, much longer timescales than for the atmosphere. Global warming will heat the deep ocean very slowly; but the deep ocean's recovery once we "fix" the problem (presuming we do!) will also be extremely gradual, lasting many human generations.

Effects that began early during the industrial revolution in the 1800s are now being felt in the deep oceans. This time lag between climate forcings and the reactions of Earth systems to those forcings is a major feature of many aspects of global climate change that is of concern to scientists. Policies that attempt to prevent or account for further impacts from climate change need to take such lag times into account.



Activity:
If you have the time and equipment available, follow the 10 steps as outlined below. If you have limited equipment, and a short period of time, you can do this same activity as a simple demonstration, leaving out the thermometers and data collection, and simply observing the flow of the cold water current (colored by food dye) along the bottom of the container and the warm water current (with paper) on the surface. See Illustration at end of the activity.

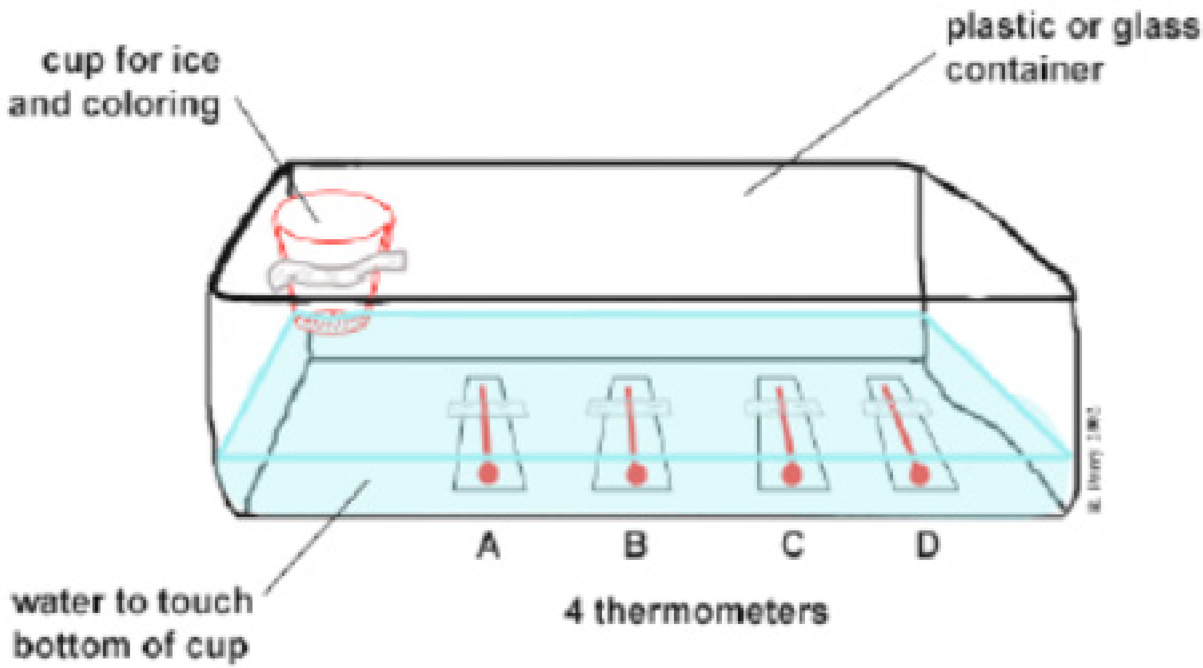
1. Divide class into small groups of 3 - 4 students. Have 1 student get supplies and equipment.
2. Students tape cup in one corner of rectangular container, about one inch from the bottom.
3. Tape 4 thermometers in bottom of dish, all oriented in same direction with equal spacing.
4. Add water to the container, so the bottom of the cup is covered. Let water settle.
5. Record the temperature on all 4 thermometers at start of the experiment, or time = 0.
6. Place ice in the cup and add 10 drops of food coloring.
7. Record the temperatures again every 5 minutes for 1/2 hour on the data sheet.
8. Observe what happens by looking though the side of the dish at table level. Record your observations by making a small sketch or diagram of what you see, and explain what you think causes what think causes this.
9. NOTE: If you cannot see a bottom current, heat the corner opposite the ice by placing a beaker of hot water in the dish.
10. At the end of 30 minutes, or when the food coloring has made its way most of the way across the container, place a small piece of paper (1/2 inch square) on top of the water in the corner opposite the ice. Observe what happens.

Discussion:
1. In which direction does the paper move? (Answer: It should move toward the ice)
2. What does the paper represent, a surface or deep current? (Answer: Surface)
3. Explain what happened to cause the colored water to move across the container; what caused the changes in the 4 thermometers' temperatures? (Answer: Cool water sank and flowed across the container while the warm surface water flowed toward the cup).
4. What can we learn from the movement of the colored water? (It traces the movement of the cold water current across the bottom)
5. What does the cup of ice imitate in the real world? (Polar sea ice)
6. How does cooling affect the density of water? (Cold water is denser than warm water).
7. Where would you find coldwater currents in the ocean? (Moving away from the polar regions in the deep ocean. See Thermohaline Circulation Illustration)
8. What significance does this separation between surface and deep ocean waters have for climate change? (Since the surface layer is exposed to the atmosphere, a warming atmosphere can effectively transfer heat to the upper layers of the ocean. Although water, due to its relatively high "thermal inertia", heats more slowly than air, we can expect that increasing air temperatures will lead to warmer surface waters over time scales of years to decades.)
9. What would happen if all the polar ice melted and no longer contributed cold water to the currents?

Density Currents (cont.)

If using thermometers:

1. Which thermometer showed the greatest change? (The one nearest the ice)
2. Which thermometer changed fastest? (Nearest the ice)
3. Did the thermometers get hotter or colder? (colder)
4. Which thermometer's temperature dropped last? (farthest from ice)
5. If a thermometer was placed at the surface, would it get hotter or colder? (hotter)



Equipment setup for Density Currents activity.

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