Comprehending Currents II

Density-Driven Ocean Currents

Adapted from NASA's "visit to an Ocean Planet" Curriculum
http://topex-www.jpl.nasa.gov/education/activities.html

Currents in the ocean are important because they transport heat and nutrients from one part of the ocean to another. Ocean circulation patterns influence climate and living conditions for plants and animals, even on land. Ocean currents affect everything from the routes taken by ships to the distribution of plants and animals in the sea. Currents move water north, east, south and west and up and down through the depths of the ocean.

There are two major types of currents in the ocean: **wind-driven currents** and **density-driven currents**. Most sub-surface (below ~ 100m) currents in the ocean are caused by density differences due to changes in water temperature and salinity. In these activities, we will explore why density differences drive currents.

Temperature and Deep Ocean Circulation

Materials - Activity 1 (per group of 4-5 students)

• Approx. 9 x 13 x 3 inch glass dish
• Tap water
• Hot tap water
• Small waterproof ziplock bags
• 2 Clothes pins (or small clamps)
• 2 Different colors of food coloring
• 2 Eye droppers
• Rock (or other weight)
• Ice cubes, or a chemical cold pack
• Laminated cardboard or plastic partition

Activity 1

1. Fill the glass dish with tap water. Let the dish rest for a few minutes while the water settles.
2. Place a rock in a plastic bag and fill the bag with hot water. Seal the bag, and use the clothes pin to clip it to one corner of the glass dish.
3. Fill another bag with ice cubes or the chemical cold pack, and clip the bag to the opposite corner of the pan.
4. Place the partition halfway between the cold bag and the warm bag.
5. Use one of the droppers to add four drops of food coloring to the water next to the bag of ice cubes and stir the water to mix in the color. Use the other dropper to add four drops of a different color of food coloring next to the bag of hot water and stir to mix. Remove the partition.

6. Observe the food coloring for several minutes. Where did the water sink? In what direction did the current flow along the bottom? Where did the water rise? Make a drawing of what you observed.

Materials - Activity 2 (per group of 4-5 students)

- Large clear container, such as a fish tank, large Tupperware, or pop bottle
- Warm tap water
- Ice cubes
- Food coloring

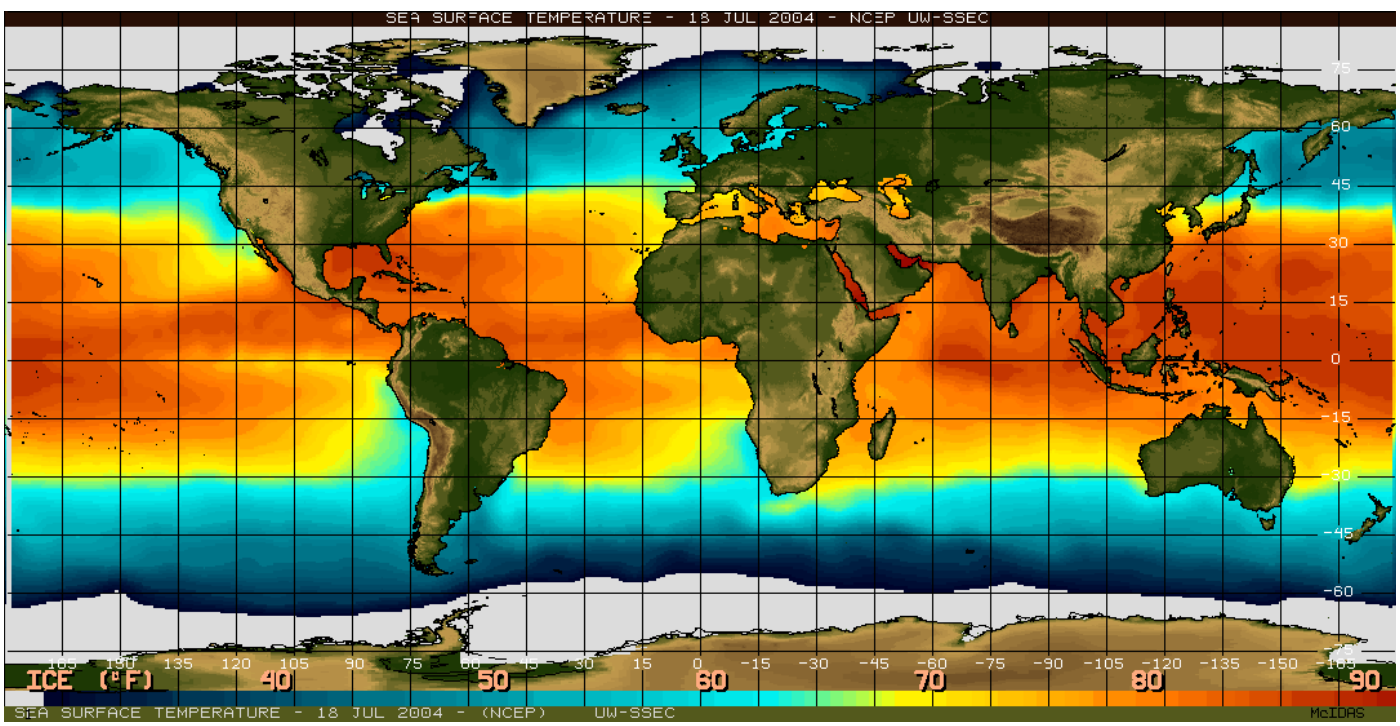
Activity 2

1. Fill the container with warm tap water. Let the water settle.
2. Place an ice cube at one end of the container. Place a drop of food coloring on top of the ice cube. Observe what happens to the colored water as the ice cube melts.
3. Observe the food coloring for several minutes. Make a drawing of what you observed. Why do you think this happened?

Temperature in the Ocean

Compare your model to the Earth's oceans by looking at the image below of global sea surface temperature. Think about the following questions:

- Where are the oceans the coldest? Where are they the warmest?
- What is the source of warm water in the ocean? Where does warm water go? What happens to it?
- Do you think that the direction of deep-water currents could be reversed?



Salinity and Deep Ocean Circulation

Materials (per group of 4-5 students)
• 4 Baby food jars (per group of 4-5 students)
• 2 Laminated cards or sponges*
• Table salt
• Food coloring
• Spill pan

* You can try this activity once using a sponge and once using a card as the results will be slightly different.

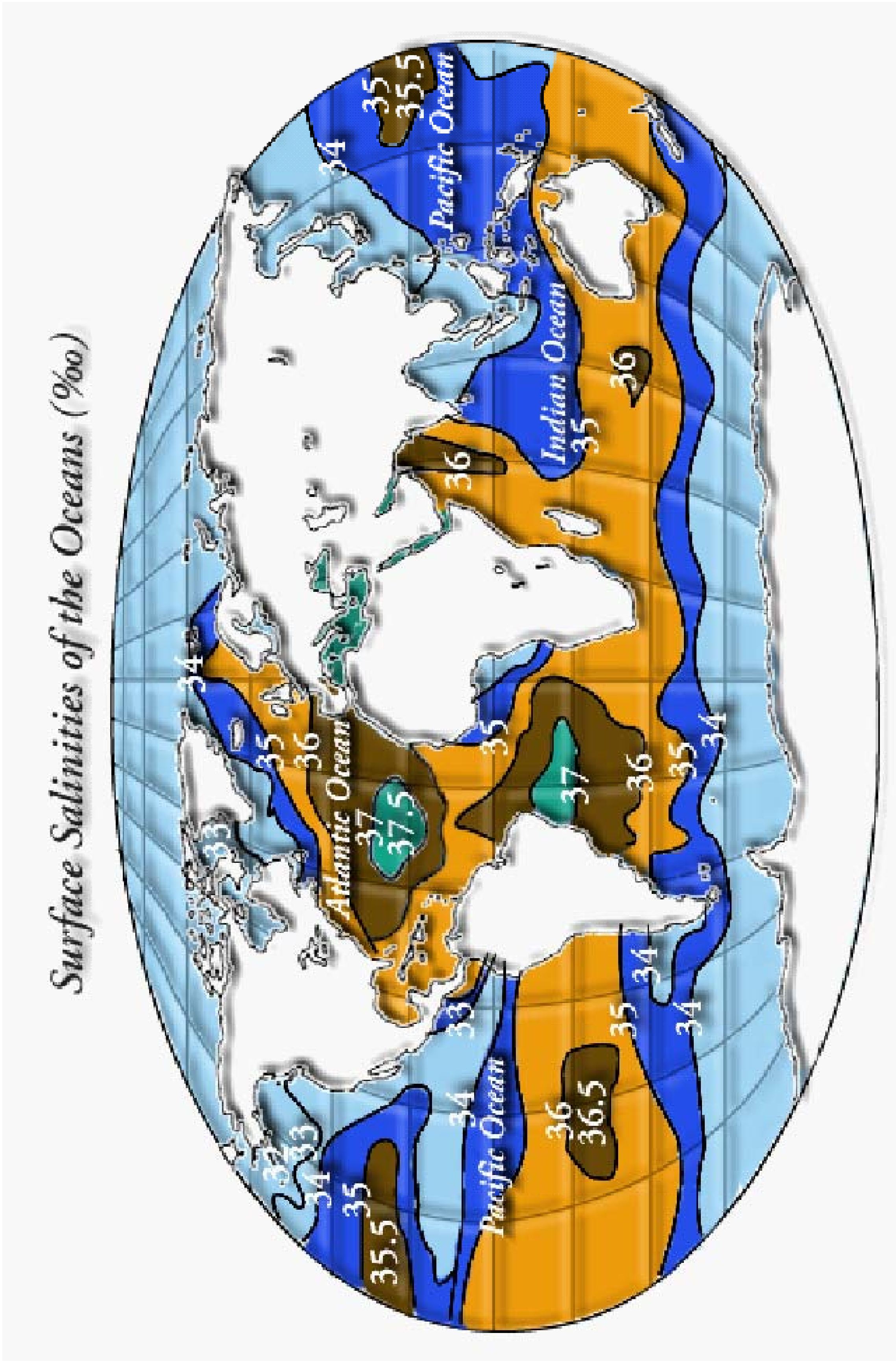
Activity

1. Fill two baby food jars with water. Dissolve the salt in one of the jars and add red food coloring. Label this jar "Salt Water." Add a drop of blue food coloring to the other jar and label it "Fresh Water."
2. Place the index card or sponge as a barrier on top of the salt water and carefully invert it. Place the salt water jar on top of the fresh water container and have someone carefully remove the card or sponge. Observe the results.
3. Use the second set of jars to repeat the experiment. This time, invert the fresh water jar over the salt water jar. Remove the barrier, and observe the results.
4. Take both sets of jars, turn horizontally, remove the barrier and observe the results.
5. Is the salt water heavier or lighter (higher or lower in density) than fresh water?

Salinity in the Ocean

Look at the map of ocean salinity on the following page. Think about the following questions:

- Where are the oceans the saltiest? Where are they the least salty?
- Can you explain the pattern of salinity in the ocean? What makes surface water more salty? What makes it less salty?
- Compare the map of sea surface temperature and salinity. Is there a relationship between salinity and temperature? How does this affect the density of seawater?


Surface Salinities of the Oceans (‰)
Pacific Ocean
Indian Ocean
Atlantic Ocean
Pacific Ocean

Thermohaline Circulation

The global effect of density-driven currents

Thermohaline circulation is the name for currents that occur when colder, saltier water sinks and displaces water that is warmer and less dense.

In Earth's equatorial regions, surface ocean water becomes saltier as the water, but not the salt, evaporates. However, the water is still warm enough to keep it from sinking. Water that flows towards the poles begins to cool. In a few regions, especially in the North Atlantic, cold salty water can sink all the way to the sea floor. It then travels in the deep ocean back towards the equator and rises to replace water which is moving away at the surface.

This whole cycle, called the *global conveyor belt* (shown in the figure below), is very important in regulating climate as it transports heat from the equatorial regions to polar regions of Earth. The full cycle can take a thousand years to complete.

An excellent animation of the global conveyor belt is available at http://sealevel.jpl.nasa.gov/gallery/videos.html , this is however a very large file and requires QuickTime so be sure to open it on a computer with a fast internet connection.