Deep Ocean Currents

Vanderbilt Student Volunteers for Science

Training Presentation

2018-2019 – VINSE/VSVS

Introduction to Ocean Currents

- There are two types of ocean currents:
  - Surface currents
    - Driven by the wind blowing over the ocean, the earth's rotation, and large land masses interrupting the flow.
    - Occur near the surface of the ocean.
    - Move in loops.
  - Deep ocean currents
    - Driven by the temperature and density of water.
    - Majority of ocean water (90%) is moved by these currents.
- Ocean water becomes denser when it is colder and when it has more salt dissolved in it

Density background and demonstration

- Density is how much mass there is in a given volume (D = m/V).
- **Demonstration**
  1. Show students jar with marbles in it. Tell students that the marbles represent water molecules.
  2. Pour salt into the jar.
  4. Explain to students that the salt packs around the water molecules in a similar way in salt water.
  5. Ask why is salt water denser than pure water?
     - Salt water has a higher mass per unit volume than pure water, and thus a higher density.

Poly-density bottle demonstration

- **Tell students that a liquid with low density will float on top of a liquid with a high density.**
- Demonstration:
  Shake the poly density bottle and then let the students observe what happens.
  - The two liquids will gradually separate.

  Ask students what happened, and why they think that it happened.
  - The two liquids have different densities.
  - One of the liquids is denser salt water (lies below the beads on the bottom).
  - The other liquid is less dense rubbing alcohol (lies above the beads on the top).
  - These 2 liquids do not mix, they form layers (salt water on the bottom & rubbing alcohol on the top)
  - The beads also have different densities:
    - The blue beads are more dense than the white beads and less dense than the salt water (they float on the salt water).
    - The white beads are less dense than the salt water and blue beads, but more dense than the rubbing alcohol (they float on the blue beads but not on the rubbing alcohol).

Saltwater in the Ocean

- How is ocean water different from fresh water?
  - Ocean water is salty; fresh water has no or very low salt content.
  - Ocean water is more dense than fresh water.
- Why does the ocean contain so much salt, but lakes, streams, and rivers do not?
  - Salt in the ocean comes from weathering of the earth's crust, volcanic emissions (when the earth was formed), ocean floor.
  - Rains and streams transport the salts to the sea.
  - As time has passed, the seas have gotten saltier.
- What kind of salts are in the ocean?
  - Seawater is very complex – contains salts made up of combinations of at least 72 elements! (Most in very small amounts).

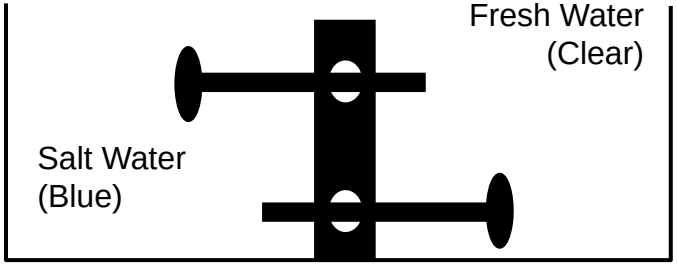
Saltwater experiment – set up

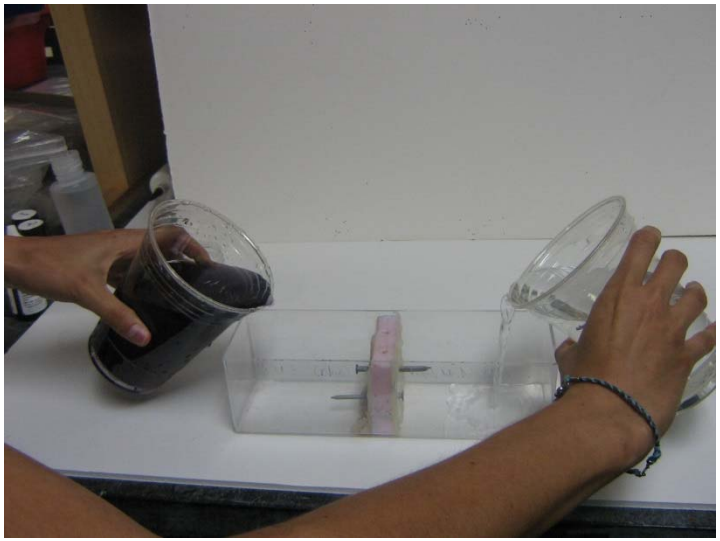
- Tell the students that they will make their own salt water and observe what happens when it meets fresh water.

1. Divide class into 10 groups (of 3).
2. Pass out materials to each group.
3. Fill the cups to the 250 mL mark with tap water.
4. Add 3 full spoons of salt to the water in ONE of the cups
5. Have a VSVS member add 15 drops (or one squirt) of blue food coloring to the SAME cup until the solution is **dark blue.**

Saltwater - predictions

4. **Make sure that the students understand the differences between the two waters.**
   - The salt water (blue) is more dense than the fresh water (clear).
5. **Draw a sketch of the container with the divider on the board.**
6. **Tell the students that they will be adding the salt water to the LEFT and fresh water to the RIGHT (but not yet!).**
   - Point out that the sides of the container are labeled.
7. **Ask the students to predict what will happen when the two waters are added.**
   - Accept ALL answers and write them on the board.
8. **Tell the students to pour the solutions into the correct sides.**





Saltwater experiment

9. Have the students remove both plugs simultaneously.
10. Have one VSVS member to go to each group and sprinkle pepper on the top of the water on BOTH sides.
    - The students should observe the water from the top over 5 minutes and record their observations on their observations sheets.

Saltwater experiment - discussion

- Ask the students:
  - What happens to the salt water?
    - It moves through the bottom hole underneath the clear fresh water.
  - What happens to the fresh water?
    - It moves through the upper hole and layers on the top of the blue salt water.
  - What did you observe when the pepper was added?
    - Pepper on the right didn't move much; pepper on the left is moving away from the hole and is circling.

Saltwater experiment - discussion

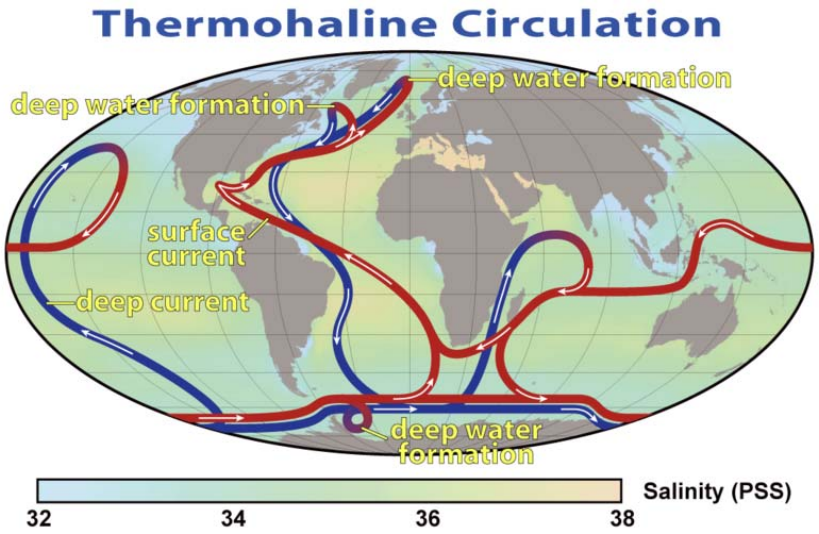
- Explain to the students that they have just created currents, similar to those in the ocean

- The blue salt water is more dense than the fresh water, so it acts like the colder/saltier water of the ocean while the fresh water acts like the warmer/less salty water of the ocean.

- Deep ocean currents are formed when denser water sinks/flows beneath less dense water, which in turn, flows on top of the denser water, as they observed in the experiment.

Where are the deep ocean currents?

- Tell the students to look at the map of ocean currents (pass this out)
- Have the students notice where deep water formation occurs.
  - 3 areas in the Arctic and Antarctic.
- Why?
  - These are very cold regions, so the water becomes very cold.



IIIB. Movement of Cold Water in the Ocean

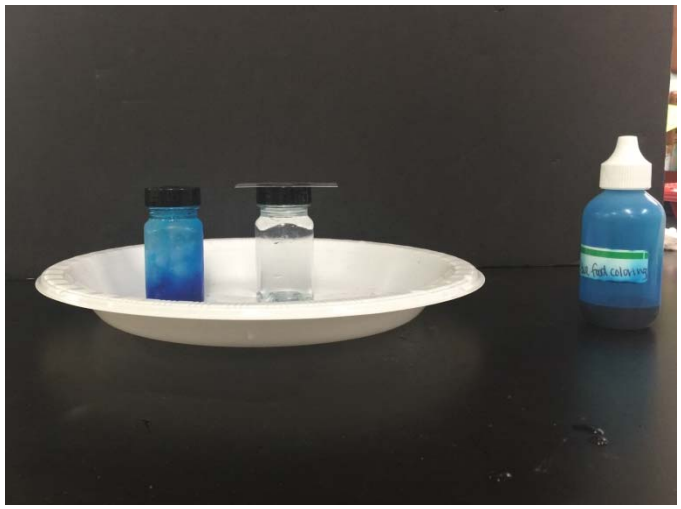
- VSVSers should have previously prepared 10 bottles with 2 drops of blue food coloring and packed with ice.

Set-up:

- Pour room temperature water into all (20) bottles so they are FULL. Replace all lids.
- Tell students that the blued water tells them that the water is COLD.

Pass out to each group:

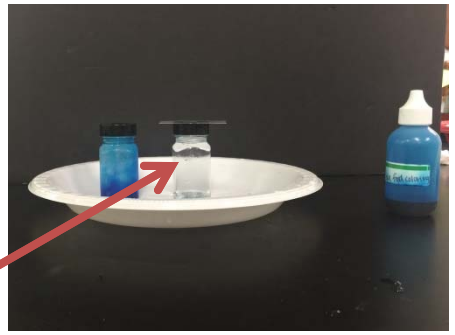
1 jar with blued ice water and 1 jar of room temperature clear water, 1 plastic plate and 1 clear plastic square

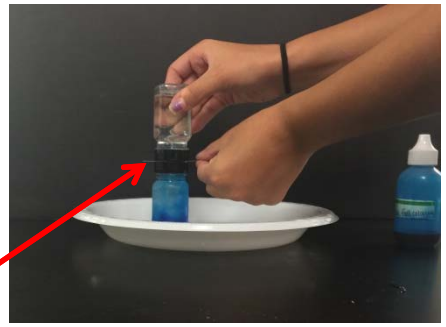


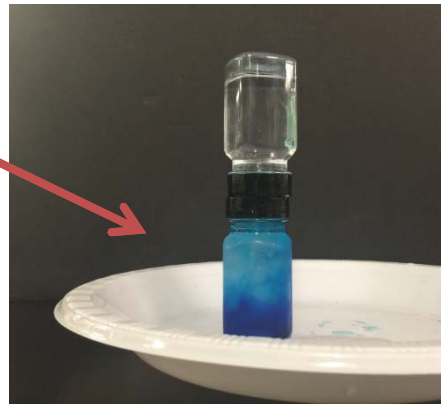
IIIB. Movement of Cold Water in Ocean Experiment

<u>Students must do the following in this order:</u>

1. Take one bottle of cold and one of room temperature.
2. Place the plastic square on top of the <u>ROOM TEMPERATURE</u> bottle.
3. Hold the square securely to keep water from pouring out, turn it upside down.
4. Place on top of a bottle of blue cold water. Once in place, have one member of the group (or VSVSer) hold the 2 bottles securely and slide the plastic square out. Observe what happens. *Not much!*
5. **Carefully slide the bottles apart and set upright. Top up the bottles with water so that they are FULL.)**

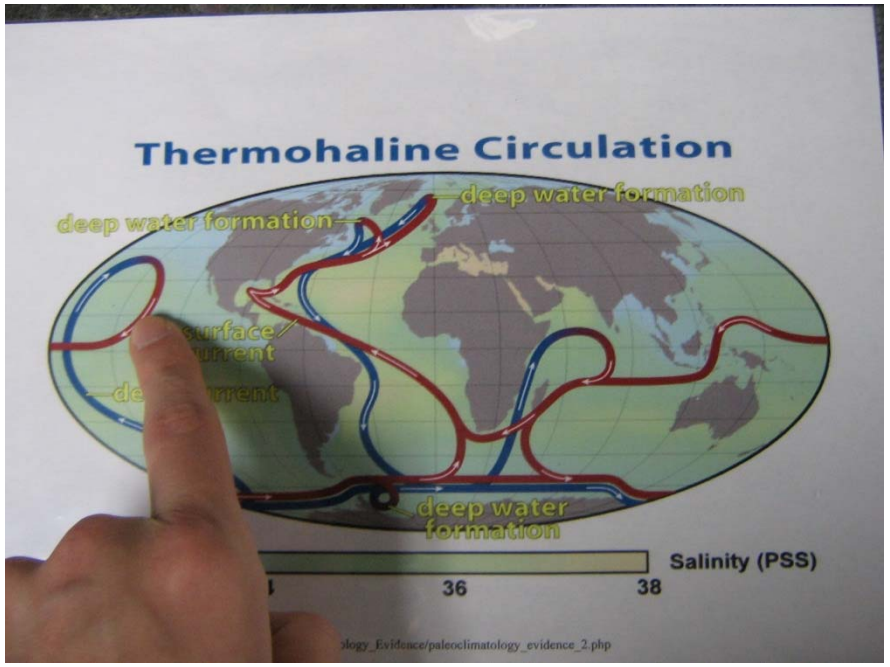






Where are the deep ocean currents?

- Have the students trace the paths of the current with their fingers, following the arrows. Start at the northern-most point.
  - Tell the students that the entire trip for the current to return to its starting point can take over 1000 years.
- Have students look at where the water appears to warm up (blue changes to red).
  - This happens in the warm areas of the world
  - When the blue line turns red, the water has become less dense by warming up and/or becoming less salty, and hence rises above the denser water.



Convection Currents in Gases

- Split the class into 4 groups
  - Each VSVS member will demonstrate the experiment for a group
- Hand out to each group

  1 Chimney Apparatus

  1 Thermometer Strip

  1 Styrofoam cup containing Dry Ice

  1 small bottle of water

  Observation sheets

Convection Currents in Gases (Cont.)

1. Give each group a cup of dry ice PLUS a very small amount of water (to increase the "fog"). **Tell them not to touch the ice – it's cold!** Have the students tilt the cup sideways so that they can see "fog" flowing out of the cup.

2. Explain that "Fog" = cold mixture of CO_2 gas, water vapor, and air. The white color is from the condensed water vapor.

3. Fog flows down toward the ground because it is colder and denser than the warm air surrounding it.

4. Set dry ice aside while steps 5-11 are completed.

Convection Currents in Gases (Cont.) 2

5. Place the metal box in the center of the table.
6. Insert chimneys into metal box.
7. Tell students to take the temperature **2 inches** above each chimney (look at the number that is dark blue) and to record this. **The thermometer strip should be held almost horizontal so that there is no danger of dropping the strip into the flame.**
8. VSVS members should light candle and place under left hand chimney.
9. Slide glass window into place.
10. Tell students to record the new temperatures **2 inches** above each chimney. Discuss any changes in temperature.
11. Remove the temperature strips as soon as it reaches maximum temperature.

Colliding Warm Air and Cold Air Masses

1. Ask students what they think will happen when cold air meets warm air?

2. Hold the dry ice cup 6 inches above the **left (hot) chimney.** What is the direction of the fog?

3. Lower the cup to 2 inches above the chimney. What happens now?

   -Rising warm air pushes cold air aside.

Colliding Warm Air and Cold Air Masses (Cont.)

1. Ask students what they think will happen when cold air is introduced to the right-hand chimney?

2. Hold the dry ice cup over the right hand chimney and “pour” cold air out of it.

3. What path does the fog take? What happens to the candle?
   - -Fog flows straight down the chimney.
   - -The Candle dims and may go out.

4. Tell the students that the denser cold fog sinks to the bottom. The fog contains carbon dioxide which does not support combustion (burning).

Review

- Have students look once more at water experiment to notice the layering effect of salt water and fresh water.
  - These layers will remain separated for several hours.
- Ask the students: Why is saltwater more dense than freshwater?
  - Saltwater has a higher mass than the same volume of freshwater.
- Ask students: What can we say about cold air versus warm air?
  - Cold air is more dense and sinks.
  - Warm air is less dense and rises.