P L E A S E   D O   N O T   W R I T E   A N Y W H E R E   I N   T H I S   P A C K E T !

Deep Water Currents Lab

Background:

Anyone visiting the seashore is struck by the constant motion of water traveling on the surface of the ocean in the form of waves. But beneath the ocean's surface, water is also moving in giant streams called currents. Some currents are very large in size and extend for thousands of kilometers. Others are smaller in scope and influence mainly nearshore regional areas. Regardless of size, all ocean currents are derived from the same major factors: wind patterns and differences in water density.

There are two principal types of currents: surface currents and deep currents. Surface currents usually have a depth of several hundred meters and are driven by global wind patterns. They may be termed either warm-water or cold-water currents depending on the temperature of the zone from which the current originates. The Gulf Stream is a well-known, warm-water, surface current. In contrast, deep currents move slowly at depth beneath the surface of the ocean and are driven mainly by differences in water density.

The water density, or mass per unit volume, is affected by changes in temperature and salinity. The large amounts of dissolved solids in ocean water make it more dense than pure freshwater, since the dissolved solids add mass to the water. Salinity is the term used to describe the amount of dissolved solids present in seawater, since most of these solids are in the form of salts. Salinity is expressed as a percent (‰) representing the number of grams of dissolved solids in a kilogram of ocean water. As salinity increases, so does the density of the water. The salinity for most of the surface waters of the world's oceans ranges from 33‰ to 36‰. Salinity can be locally affected by the amount of freshwater and salts added to the sea by rivers and runoff, and by the rate of evaporation or freezing. For example, as seawater at the poles is frozen in icebergs and pack ice, most of the salt is left behind in the unfrozen water. This increases the salinity, and therefore the density of the water.

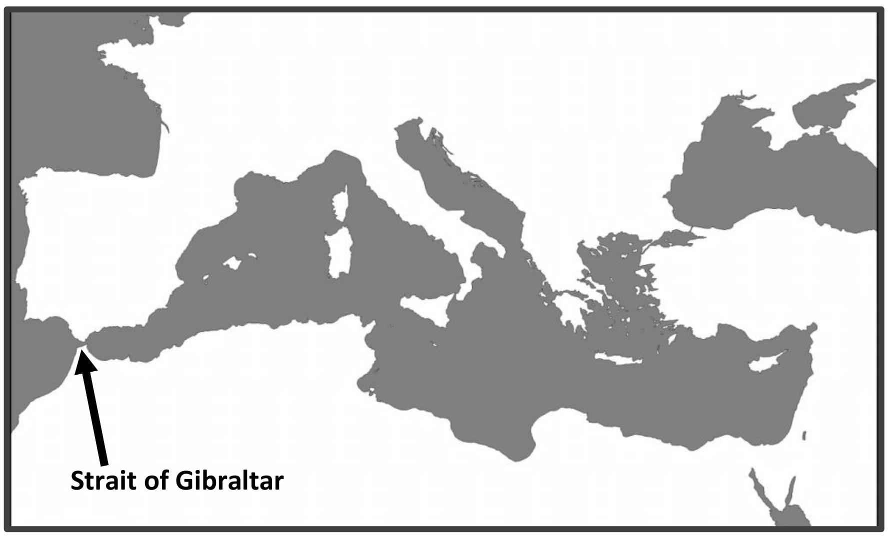
Temperature also affects the density of ocean water, with the density increasing as the water grows colder. When water is cooled, it contracts and its molecules are crowded more closely together. As a result, the water becomes more dense and sinks. The temperature of ocean water is basically determined by the amount of infrared radiation it receives from the sun. The densest ocean water is found in the cold temperatures of the polar regions, whereas waters in equatorial regions heat up, expand, and become less dense. These equatorial waters, driven by surface winds, tend to flow towards the poles. On their way there, the waters carried by surface currents return to the atmosphere a large portion of the heat accumulated in the tropics.

When large masses of water of unequal densities meet, they generally do not mix. Here deep currents are produced as cold, dense, polar water sinks and flows beneath the warmer, less dense ocean waters that originated near the equator. These deep currents move much more slowly and in a more diffuse manner than the surface currents. However, in general, the volume of water moving at depth from the poles towards the equator is equal to the volume of surface water moving from the equator towards the poles.

Typically, most deep ocean currents flow in a direction opposite that of surface currents flowing above them. For example, during the summer months, the waters of the Mediterranean Sea become increasingly saline and more dense as increased evaporation is accompanied by decreasing rainfall. During this time, a deep current is created as the denser water sinks and flows out along the ocean floor through the Straits of Gibraltar into the Atlantic. At the same time, less saline surface waters from the Atlantic flow into the Mediterranean at the ocean surface.

Another process whereby deep, ocean waters move upward to replace warmer surface waters is called upwelling. Upwelling is a common wind-induced vertical movement of water that occurs when winds blowing steadily parallel to a shoreline move ocean surface waters farther offshore. This allows deeper water to move up and replace the surface waters. This phenomenon is characteristically observed along the eastern shores of oceans, including the west coasts of North and South America and Africa

The Mediterranean Sea



I. Pre-Lab Questions: *Answer on a separate sheet of notebook paper.*

1) Define the three following terms **in your own words**:

    A. Surface current →
    B. Deep current →
    C. Upwelling →

2) What physical property causes something to sink or float? Use this property to explain why oil floats on top of water.

3) What symbols are used to represent percent and parts per thousand? What is the difference between these two types of units mathematically?

4) The average salinity of the Atlantic Ocean is about 35‰. What would be the breakdown of dissolved salt to water content in a sample of 1,000 grams of seawater? (In other words, how many grams of salt, and how many grams of water?)

5) Draw a diagram of the equipment used in the teacher demonstration. Beneath your diagram, write a caption that explains what was happening. Also, make sure to tell which part of the demo represented the surface current and which part represented the deep water current.

II. Procedures: *After your pre-lab questions, please number the following steps from 1 – 10 on your notebook paper. Using complete sentences, write out your predictions and observations as you go.*

1) Set up the clear plastic box as shown in Figure 5. Place the wood block at one end to incline the box.

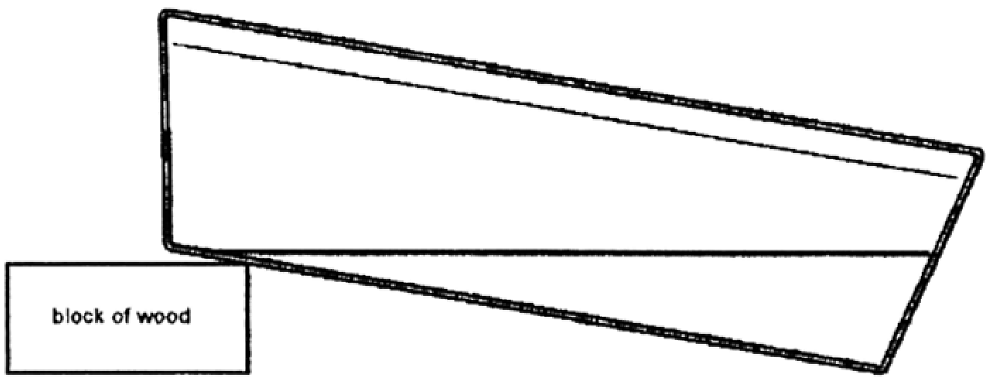


Figure 5

2) Add about 800 mL of room temperature water to the box. Let the water become calm before proceeding.

3) Next, place 25 mL of room temperature water in a small beaker. Add one level teaspoon of salt and one drop of yellow food coloring to the water and stir until the salt dissolves. Carefully and slowly pour the solution into the raised end of the box as shown in Figure 6. Position yourself at eye level along the side of the box and observe what happens to the solution. Describe what occurs.

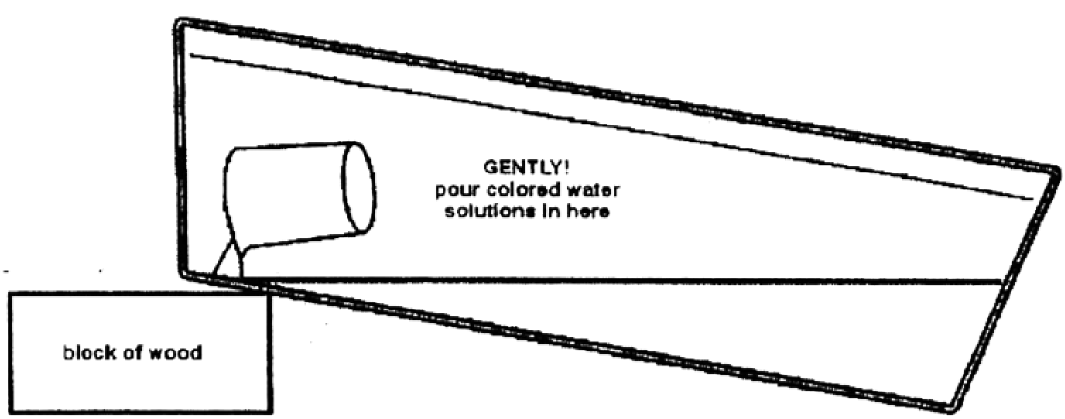


Figure 6

PLEASE DO NOT WRITE ANYWHERE IN THIS PACKET!

4) Place 25 mL of ice water in a beaker and stir in a drop of blue food coloring. DO NOT POUR IT INTO THE BOX YET! Predict below what will happen when you pour the blue ice water into the box.

5) Now, carefully and slowly pour the blue ice water into the raised end of the box. Describe what happens.

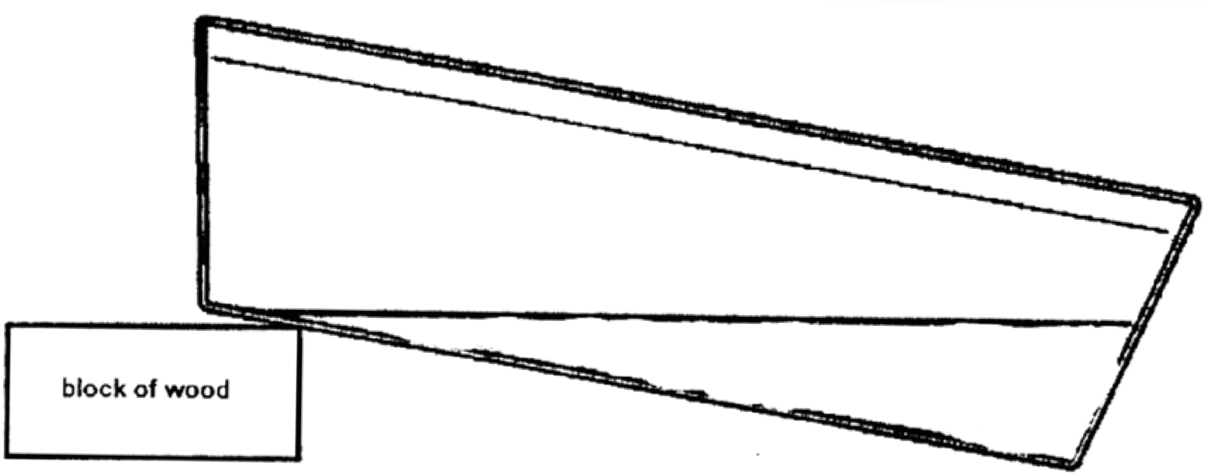
6) Rinse and refill your beaker with 25 mL of hot tap water and stir in a drop of red food coloring. Predict what will happen when this solution is poured into the box.

7) Carefully and slowly pour the hot water into the raise end of the box. Describe what happens.

8) From what you've observed so far, which solution has a higher density: Saltwater or water that isn't salty? Warm water or cold water?

9) Next, add a level spoonful of salt and a drop of green food coloring to 25 mL of ice water. Stir until the salt dissolves, and then carefully pour the solution into the box as you did with the other solutions. Describe what happens.

10) Trace (or sketch) the diagram below onto your paper. Use colored pencils to accurately show the relative positions of each of the solutions in the box after following steps 1 - 9.



Do not write anything on this page. Redraw the diagram and fill it in *on your own lab paper*.

III. Post-Lab Analysis Questions: *Answer in complete sentences on your lab paper. For full credit, please remember to* *<u>restate the question</u>* *as part of your answer.*

1) How would an **increase in evaporation** affect the density of ocean water?
2) Which sample would contain **more water molecules**: a beaker containing 100 mL of hot water or a beaker containing 100 mL of cold water? (*Think about the density.*)
3) Why does the density of liquid water increase as it cools? (*Describe what happens to the molecules*.)
4) The salinity of the Mediterranean Sea is about 40‰, whereas the salinity of the Atlantic Ocean is about 35‰. Why do you think the Mediterranean Sea is so salty?
5) Would it be easier for you to float in the Mediterranean, or in the nearby Atlantic Ocean? Explain why.
6) *Figure 7* below represents a profile of the Strait of Gibraltar between the Atlantic Ocean and the Mediterranean Sea. Explain how the high rate of evaporation causes the **surface current** to flow <u>into</u> the Mediterranean.

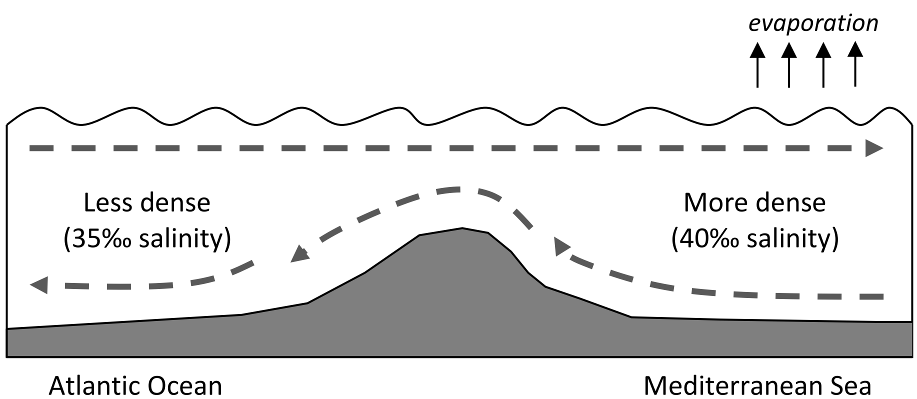


Figure 7

7) Looking at the same diagram above, explain what's happening to the deep water and why.
8) The movement of cold deep water up to the surface is called "upwelling". Why would wind blowing water away from the coast tend to cause upwelling? Describe how this happens. (*HINT → Try to visualize it, or draw a picture*.)
9) Why are there such good fishing conditions in areas of continual coastal upwelling? (*see p. 450 – 451*)
10) The global conveyor belt is critical in distributing dissolved oxygen from the surface to the deep. Explain what you think would happen if warming climate conditions caused Arctic water to stop sinking near the way it normally does (*see* Figure 8 *on p. 453*).

OVER →

IV. Honors Science Questions:

11) If a substance increases in density as it cools, how come ice floats on top of liquid water? Explain what must be happening to the molecules of water when it turns into solid form.

12) Water freezes at 0° C, yet Antarctic bottom waters may be as cold as -1.9° C. Name one condition or chemical property that might lower the freezing point of water in this case?

13) The yellow solution that you mixed during the lab contained 25 grams of water and about 7 grams of salt. What was the salinity of this solution in parts per thousand?

(*HINT: First you must think about how many grams of* ***salt water*** *there were total*.)