# Activity 37: The Varying Density of Sea Water

## Maine Geological Survey

### Objectives:

To demonstrate to students how water temperature and the concentration of dissolved and suspended solids affect the density of sea water.

### Time:

This activity will occupy one class period and an appropriate pre-activity discussion or lesson.

### Background:

Ocean currents are responsible for influencing such diverse things as food (plankton) distribution to the world's commercial fish species, the dispersal of pollutants, and the erosion or accretion of coastal land in all areas of the world. Surface waves from the winds and the influence of tides notwithstanding, the great majority of ocean currents are controlled by the varying densities of sea water.

So-called "normal" sea water contains 3.7% dissolved salts, mostly Family I chlorides, but a wide variety of other materials in small amounts as well. These dissolved materials, and locally suspended materials, give the water a density greater than that of 1, which is the accepted density of pure water at 4°Celsius. In reality the amount of dissolved and suspended materials varies widely. In tropical areas, where the water becomes partially or totally trapped in natural rock basins or lagoons, some of the water will evaporate, leaving more salts behind to be dissolved in a lesser amount of water;

this increases the density of the remaining water considerably, and creates such locally unique phenomena as the Sargasso Sea, where the water has one of the highest densities on earth.

In waters where a large amount of suspended sediments are present, the density also increases. This is most notable in major rivers such as the Nile, Mississippi, and Amazon. In the oceans, at the junction between the continental shelves and the continental slopes, large, dense, sediment laden waters form turbidity currents and flow down slope.

When water bodies with different densities contact each other, some mixing may occur, but it often occurs quite slowly or not at all. This can be observed where fresh water flows out into the ocean and remains on top of the denser sea water. Along ice caps and glacial margins, rivers of dense, cold water flow out and sink into the oceans relatively warmer (and therefore less dense) sea water. These are known as cold water currents. Many swimmers in lakes have experienced hot/cold spots in lakes and rivers where water of different density is entering the lake in a coherent manner as a current.

## Materials:

Each group of students will need the following:

- Three (3) paper cups of 8 ounce capacity
- Clock or watch with a second hand
- 25 ml graduated cylinder
- Two 100 ml graduated cylinders
- Ice-cold water (mixture of ice and water; drain off water when you need it)
- Red, blue, and yellow food color
- 125 ml of mineral oil
- 60 ml of tap water
- 1/2 teaspoon (2.5 ml) measure
- 1 medicine dropper
- Clay (do not use plasticene modeling clay, use a clay soil source instead; in desperation Kaopectate may be used)
- 15 grams of salt (sodium chloride)

## Procedure:

Students should work in groups of 2 or 3 using the various materials to create and test liquids of different density. Students need to make certain that materials are completely dissolved to create the greatest variation in density between liquids. See student sheet.

## Follow-Up:

Have students use 1 liter soda bottles and eye droppers to create the toy known as a Cartesian diver. After demonstrating a diver, ask students to explain how this toy works. To make a Cartesian diver, place enough oil (cooking oil) inside an eye dropper so that the eye dropper stays suspended in the middle of a plastic soda bottle filled with water. The capped bottle can then be squeezed making the "diver" alternately rise to the top and sink to near the bottom.

There are conflicting superstitions about bodies of drowned people or animals. One is the old adage "the sea never gives up its dead"; a second is the notion, handed down from Colonial times, of firing cannon directly over the surface of a lake to raise the body of a drowned person. Discuss these with your class from a density point of view.

Discuss the possibility of TRUTH to the rumors of divers seeing ghost ships floating mysteriously in the ocean, above the ocean floor, near the drowned city of Port Royal, in the Caribbean. How could these ships hover in the ocean water?

Collect a sample of sea water, distill it completely, and recover the salt. Using simple weight comparisons calculate the percent of dissolved salts in the water. (Weight of salts compared to weight of the entire salt water sample).

Have students look up the term "convection cell" as it applies to rock movement in the mantle. Compare the convection cell to an ocean upwelling; how are they alike? How are they different?

## References:

Activity adapted by Duane Leavitt from materials in the *Earth Science Source Book*, edited by John R. Carpenter (Center for Science Education, University of South Carolina, Columbia, South Carolina, 1987)

Name___________________________

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### Student Sheet

**Purpose:**

To learn how density of sea water is controlled by temperature and the amount of dissolved salts present in the water.

**Materials:**

Working in groups of two or three, each group will need the following: three 8-ounce capacity paper or plastic cups, a clock or watch with a second hand, a 25 ml graduated cylinder, two 100 ml graduated cylinders, ice-cold water, red, blue, and yellow food color, 125 ml of mineral oil, 60 ml of tap water, a 1/2 teaspoon (2.5 ml) measuring spoon, 1 medicine dropper, clay, and 10 grams of salt.

**Procedure:**

Follow the directions carefully and closely observe what happens after each part. Use these observations to answer the questions.

**Part I:**

1. Pour 20 ml of tap water at room temperature (21° C) into each of the three plastic cups; label the cups A, B, C.

2. To cup A, add 5 ml (1 level teaspoon) salt and two drops blue food color. To the cup labeled B, add 2.5 ml (1/2 level teaspoon) salt and two drops of yellow food color. Add no salt to the third cup, C, but do add two drops of red food color.

3. Stir all three cups until all salt is dissolved and the food color is evenly dispersed.

4. Put 100 ml of mineral oil into the 100 ml graduated cylinder.

5. Using the medicine dropper, squeeze out 2 drops of water, one at a time, from cup A BENEATH the surface of the mineral oil. Make certain that the tip of the medicine dropper is just below the surface before squeezing out the drops. With the stop watch, measure the amount of time it takes each blue drop to sink from the 100 ml mark to the 5 ml mark. Record the two values and the average time.

   Time for drop #1 ___________ Time for drop #2 ___________ Average ___________

6. Repeat the process using two drops of water from cup B.

   Time for drop #1 ___________ Time for drop #2 ___________ Average ___________

7. Repeat this process using two drops of water from cup C.

   Time for drop #1 ___________ Time for drop #2 ___________Average ___________

8. Which drops sank fastest? ____________________________________________________

   Which drops sank slowest? ___________________________________________________

Explain why the drops sank at different rates:

**Part II:**

1. Pour 20 ml of mineral oil from the 100 ml graduated cylinder into the second (empty) 100 ml graduated cylinder. To this second cylinder, with 20 ml of mineral oil in it, add the following. Holding the cylinder at a slant, slowly pour the water from cup A into the mineral oil. After the blue water has settled to the bottom, slowly pour the water from cup B into the mineral oil. After it settles, slowly pour the water from cup C into the cylinder. Return the cylinder to an upright position; sketch and label what you observe in the cylinder in the space below.

**Part III:**

1. Wash out one of the 100 ml graduated cylinders.
2. Put about 70 ml of water into the 100 ml graduated cylinder.
3. Make a thick suspension of clay and water by mixing 5 ml of dry clay into 20 ml of water in a cup. Mix the clay and water well. Without delay, slowly pour the muddy water suspension into the clear water. Describe what happens:

*Dispose of all materials and solutions as directed by your teacher.*

**Questions:**

1. Define density.

2. List three factors that can affect density of water.

3. Explain how each factor listed in number 2 above affects the density of sea water.

4. Assume that the rainfall decreases significantly for several years, but that evaporation continues to take place at its normal rate. What would be the effect of this situation on the salinity of the ocean?