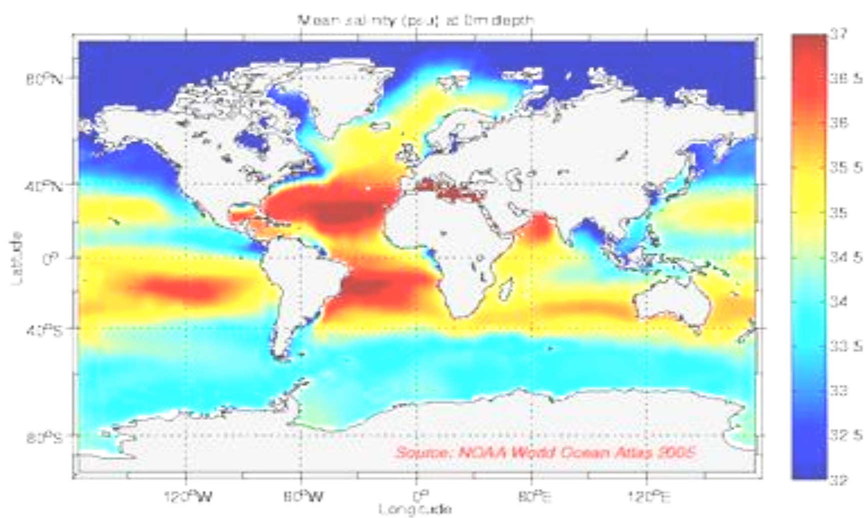
Floating in a Salty Sea

Background

If there is one thing that just about everyone knows about the ocean, it's that it is salty. The two most common elements in sea water, after oxygen and hydrogen, are sodium and chloride. Sodium and chloride combine to form what we know as table salt. If you allow the wind to dry your skin after swimming in the ocean, you will see a light coasting of salt that has been left behind when the water evaporated.

Salinity is a measure of how much salt is in the water. Sea water salinity is expressed as a ratio of salt (in grams) to liter of water. In sea water there is typically close to 35 grams of dissolved salts in each liter. Scientists describe salinity using Practical Salinity Units (PSU) which defines salinity in terms of a conductivity ratio, so it is dimensionless. Salinity was formerly expressed in terms of parts per thousand or by weight (written as ppt or ‰). That is, a salinity of 35 ppt meant 35 grams of salt per 1,000 ml (1 liter) of sea-water. The normal range of open ocean salinity is between 32-37 grams per liter (32‰ - 37‰).

Salinity affects **density**. Density is the mass per unit volume (mass/volume) of a substance. Salty waters are denser than fresh water at the same temperature. Both salt and temperature are important influences on density: density increases with increased salinity and decreases with increased temperature.



As you might expect, in the ocean there are areas of high and low salinity. Of the five ocean basins, the Atlantic Ocean is the saltiest. On average, there is a distinct decrease of salinity near the equator and at both poles, although for different reasons.

Near the equator, the tropics receive the most rain on a consistent basis. As a result, the fresh water falling into the ocean helps decrease the salinity of the surface water in that region. As one move toward the poles, the region of rain decreases and with less rain and more sunshine, evaporation increases.

Fresh water, in the form of water vapor, moves from the ocean to the atmosphere through evaporation. Only the water evaporates, leaving salts behind and resulting in higher salinity at the surface. Toward the poles, fresh water from melting ice is less dense than the salty, cold ocean water, so it mixes mostly at the surface, decreasing the surface salinity at high latitudes.

The saltiest locations in the ocean are the regions where evaporation is highest or in large bodies of water where there is little input of fresh water or outlet into the ocean. The saltiest ocean water is in the Red Sea and in the Persian Gulf region (around 40‰) due to very high evaporation and little fresh water inflow.

Activity

In this activity we will investigate how the density of an object and of the water affects whether the object will float or sink.

The Dead Sea, located between Israel and Jordan, is one of the saltiest bodies of water on the earth. Here is some information about the Dead Sea.

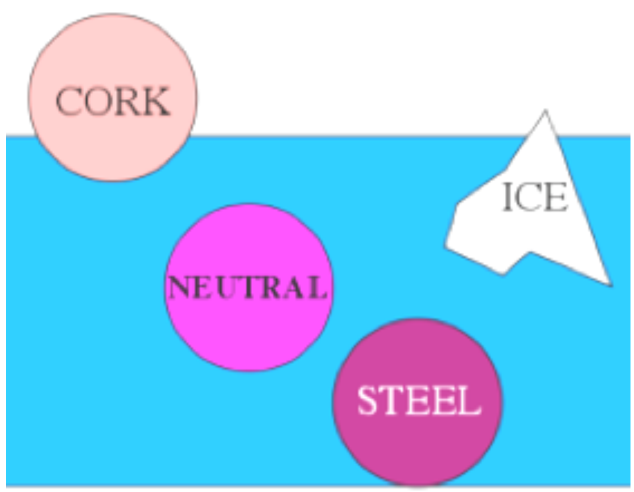
- Its shore is the lowest dry land on earth.
- Its salinity is about 37% or 10 times that of average ocean water salinity.
- It supports little life except for microbes due to the salinity.
- It lies along 2 tectonic plates that have been sliding by each other for the past 10 million years.

The Dead Sea is so salty because there is no outlet of water or mixing with water from larger seas or the ocean. All water leaving the sea is evaporated, a process which takes away the water, but leaves the salt behind. Because the Dead Sea is so salty, its water has a high density (mass/volume). People find it very easy to float when swimming in the Dead Sea. In this activity you will vary the salinity of water to make beads of various densities float.

Specific Gravity is the density of a substance compared to the density of water. Scientists have designated a specific gravity of 1.0 (no units) for pure fresh water at 4 degrees C. A substance that sinks in water (like iron or most rocks) will have a specific gravity greater than 1.0, and a substance that floats on water (like oil or a cork) will have a specific gravity less than 1.0.

The density and specific gravity of water increases as the salt content increases. We are going to experiment with changing the salinity of water so that an object that normally sinks in water will float. As part of this experiment, you will keep track of the water's salinity by carefully measuring the amount of water and salt you use. The following diagram shows some objects in fresh water and gives their specific gravity. How might the positions of the objects change if the water were salty, so that the water had a higher specific gravity?

Objects in pure fresh water



Specific gravity of
Pure fresh water = 1.0
Steel = 7.0
Cork = 0,24
Neutrally buoyant object = 1.0
Ice = 0.92

OBJECTIVE: To make a plastic bead float in the middle of a beaker filled with salt water.

Conversion units: 1 ml salt = 1.26 grams
28 ml salt = 35 grams
1 teaspoon salt = 6.2 grams
5 5/8 teaspoons salt = 35 grams
1 ml water = 1 g

Note: these conversions are close to the precise values but rounded for convenience

1. Place 400 ml of cold tap water in a 1000 ml beaker.
2. Add 28 ml (about 5 5/8 teaspoons) salt to small plastic cup (this represents the amount of salt that would be added to 1000 ml of water to approximate average ocean salinity; in this activity we are starting with only 400 ml of water)
3. Place a plastic bead in the 1000 ml beaker of fresh water and be sure it sinks to the bottom.
4. Add about 10 grams (about 1.5 tsp.) of salt to the water. Stir, and observe if the bead is still on the bottom (it should be).
5. Now, add salt **slowly** (about 1.5 g or 1/4 tsp. at a time) until you see the bead **just begin to float.** You do not want the bead to float all the way to the top. Keep track of how much salt you have added.
6. If the bead floats to the top, **slowly** add fresh water to the solution until the bead again begins to sink, but not all the way to the bottom. Keep track of the volume of water you add.
7. Stop when you have the bead suspended near the middle of your salt water solution.
8. Add all the volumes of salt you have added to the solution and convert it to grams using the values above.
9. Calculate the approximate salinity of the solution:
    a. Add the mass of all the water and salt you used to find total mass of your solution
    b. Divide the total number of grams of salt you added by the total mass
    c. Multiply by 1000 to get parts per thousand

    g salt + g water = total mass of solution

    g salt / g total x 1000 = salinity ‰

10. To find the density of the bead, find the temperature of the solution, then use the temperature and salinity to enter the reference table http://www.lumcon.edu/education/studentdatabase/SGTable.pdf to look up the specific gravity.

Questions:

1. Which has a higher specific gravity, the bead or the fresh water?
2. As you add salt to the water, are you increasing or decreasing the specific gravity of the water?
3. When you have the bead suspended in the water, how do the specific gravity of the bead and water compare?
4. The salinity of normal ocean water is about 3.5%. Would this bead sink or float in normal ocean water?
5. Look at data from the Aquarius satellite http://aquarius.nasa.gov/gallery-science.html . Is there an area in the ocean with salinity similar to your solution?

Adapted by Pat Harcourt pharcour@usc.edu from an activity by Ted Taylor. Background information from NOAA http://www.srh.noaa.gov/jetstream/ocean/seawater.htm and the Aquarius project http://aquarius.nasa.gov/techops.html .