Please Pass the Salt

A Weddell Seal at a breathing hole. Courtesy NOAA Corps Collection
Photographer: Giuseppe Zibordi. Credit: Michael Van Woert, NOAA NESDIS, OAR

"Antarctica is the coldest, driest, windiest continent on the planet. Temperatures can plummet to -58°F, which is 90°F below freezing…Antarctica is so cold that most of the ice there never melts; the continent is permanently covered in ice. Yet, Weddell seals can live there…because some water remains unfrozen, and they can dive and re-surface through these holes in the ice. How do these holes stay open?…The answer is, it's a joint effort between the seals and the properties of the water."

~ from the Web site of Dr. Terrie M. Williams, Professor, Ecology and Evolutionary Biology, University of California Santa Cruz http://bio.research.ucsc.edu/people/williams/teachers/intro.htm

What is the most obvious property of seawater? It's salty! But if you mix salt from your kitchen into a glass of water, it doesn't taste exactly like seawater. That's because seawater contains many other chemicals in addition to sodium chloride (which is ordinary kitchen salt), such as magnesium sulfate, magnesium chloride, and calcium carbonate. Scientists call the content of all dissolved salts in seawater "salinity," and measure it in parts per thousand (abbreviated ppt or ‰), which is equivalent to grams per kilogram. Freshwater has a salinity of 0‰; normal seawater has a salinity of about 35‰.

Salinity makes seawater very different from freshwater. Most animals have a specific range of salinities that they can tolerate, and cannot survive if the salinity is above or below their tolerance range. Changes in salinity can affect the circulation of the oceans, and may even affect climate. Because salinity influences our environment in many ways, NOAA keeps track of salinity in many places along the U.S. coasts and around the world. Here are some experiments you can do to discover some of the most important properties of seawater.

What You Will Do

Experiment to find some of the ways that salt changes the physical properties of water

What You Will Need:

- ❒ Salt
- ❒ Water
- ❒ Freezer
- ❒ Tablespoon measure
- ❒ Cup measure
- ❒ Spoon for stirring
- ❒ Five clear plastic cups, six ounces or larger
- ❒ One fresh egg
- ❒ Food coloring

How to Do It:

1. For your first experiment, dissolve three tablespoons of salt in one cup of water. Pour the salt solution into one of the plastic cups until the cup is about 3/4 full. Pour the same amount of fresh water into another cup. Place both cups in a freezer. Check the cups every half hour for two hours. Which solution freezes first? What has happened to the salt solution after 24 hours?

2. For the second experiment, dissolve three tablespoons of salt in one cup of water, and pour the salt solution into one of the plastic cups until the cup is about half full. Fill another cup about half full of fresh water, and add a few drops of food coloring. Now, carefully pour the colored fresh water into the cup of salt water, holding the edges of the cups together so that the fresh water flows down the inside of the cup containing the salt water. Do the two solutions mix, or does one float on top of the other? Which solution has the greater density?

An iceberg in Gerlache Strait, West Antarctica
Photographer: Rear Admiral Harley D. Nygren, NOAA Corps (ret.) Courtesy NOAA.

3. Finally, pour fresh water into a plastic cup until the cup is about 3/4 full. Carefully crack a fresh egg, and gently drop the contents of the egg into the cup. If your egg is fresh, the yolk will be a firm but flexible sphere that sinks to the bottom of the cup. If your egg is not-so-fresh, the yolk will break or ooze into the water and your experiment is over! Assuming the egg yolk is still intact, add two tablespoons of salt to the water, and gently stir with a spoon. Over the next few minutes, the salt will slowly dissolve. What has happened to the egg after ten minutes?

   Now, do you have an idea why holes the Antarctic ice stay open and don't immediately freeze over?

What's Going On Here?

Pure water freezes at 32°F (0°C), but adding salt lowers the freezing point of pure water. This is why salt is sometimes used to keep ice from forming on sidewalks. When water freezes, it forms crystal-like structures. When salt water freezes, only the water forms these structures; the salt is left out in unfrozen water. So as

salt water freezes, the water that is not frozen becomes saltier.

After 24 hours in your freezer, the cup containing fresh water should be frozen solid (if it isn't, your freezer isn't working!). The salt solution probably contains some ice, but it is not frozen solid. It may appear slushy, and you should have no trouble sticking your finger through whatever ice is in the cup.

Salt water is more dense than freshwater, so freshwater floats on top of salt water. The greater density of salt water also means that objects float more easily in salt water than in freshwater. Remember Archimedes' Principle, which says that an object in a fluid is buoyed up by a force equal to the WEIGHT of the fluid displaced by the object (see Page 11). One cup of salt water weighs more than one cup of fresh water, so its buoyant force is greater. So your egg (if it was fresh) sank in freshwater, but was bouyed up by the salt water.

Want to Do More?

1. Check out NOAA's National Ocean Service Discovery Kits at *http://www.oceanservice.noaa.gov/education/kits/estuaries/media/supp_estuar10c_salinity.html* and *http://www.oceanservice.noaa.gov/education/kits/estuaries/estuaries05_circulation.html* to find out more about salinity and how it affects coastal ecosystems.
2. Sea nettles are stinging jellyfish that are a major menace to summer recreational activities in the Chesapeake Bay. Visit *http://coastwatch.noaa.gov/seanettles/sn_salinity-model.html* to see how NOAA uses salinity to give a daily "nowcast" (like a forecast except it's what's happening NOW) that tells swimmers how likely it is that they will encounter sea nettles in the Bay.
3. Other NOAA programs that provide information on salinity include:
   - The Regional Ocean Forecast System (*http://polar.ncep.noaa.gov/cofs*), which provides real-time salinity measurements as well as 24-hr and 48 hr salinity forecasts
   - The National Oceanographic Data Center (*http://www.nodc.noaa.gov/General/salinity.html*) with records of global ocean salinity data
   - The National Estuary Research Reserve System (*http://nerrs.noaa.gov/Monitoring/WaterSalinity.html*) that uses automatic instruments to collect data on salinity and other physical features

NOAA wildlife biologists Mike Goebel and Birgitte McDonald get a Southern elephant seal ready for measurement and tagging, as part of the U.S. Antarctic Marine Living Resources research program that provides scientific information needed to conserve and manage marine living resources in the oceans around Antarctica. Courtesy NOAA/Scott Seganti