SEAWATER DENSITY & SALINITY

Introduction:

Water is an amazing solvent. It is able to retain large amounts of salts and other materials in solution. When this occurs, the salts change the properties of water. For example, when salt is dissolved in water the freezing point of water is lowered. Thus, fresh water freezes at 0° C., whereas normal seawater freezes at –1.9 degrees C. As ice forms in salt water, there is no room in the crystal for salt. Most of the salt is squeezed out of the ice structure and the resulting ice is less salty than when it began to freeze. In the polar regions, where seawater freezes to form sea ice, the ice is not as salty as the seawater from which it formed. Sea ice, which is different from icebergs, looks like flat ice "plates" floating at the surface in polar seas. In the Antarctic Ocean, most (perhaps 90%) of the sea ice forms anew each winter and melts the next summer, and it is seldom more than about one meter thick. In the Arctic Ocean, however, sea ice often does not melt each summer, but instead a new layer of ice is added each winter, producing multiyear sea ice that can become many meters thick. Icebergs, on the other hand, are formed on land, and thus glaciers are formed entirely of fresh water. Most icebergs are pieces of glaciers, which have broken off and floated away when the glaciers reached the sea. They are jagged chunks of ice that can take many shapes. Most of an iceberg is below the surface of the sea.

Seawater has a higher density than fresh water. Sea water contains many dissolved substances and these add mass to the water within which they are dissolved, thereby producing a greater mass per unit volume, or a density, higher than that of pure water. The amount of salts dissolved in water is called salinity. Salinity is measured in g per 1000 ml and a special symbol is used: 0/00 by weight. Open ocean water has an average salinity of about 35 o/oo (equivalent to 3.5%, if one were to use units of one hundred instead of one thousand for the amount of water. Scientists almost always use metric measurements, however, and express quantities of dissolved substances as grams per liter, or 1000 ml. Thus, we use parts per thousand to express salinity). Salinities near shore vary due to the addition of fresh water by rivers and rainfall. An estuary is a semi-enclosed body of water where incoming seawater is diluted with fresh water coming from the land. Because of differences in density between fresh and salt water, salt water will move upstream in the estuary along the bottom, while fresh water will flow downstream along the surface. Some mixing occurs at the interface where fresh and salt water meet. This is called brackish water. Local conditions of temperature and water circulation may also increase or decrease salinity. Salinities vary in different bodies of water. For example:

Red Sea	**=**	**40 ^{o}/oo**
Mediterranean Sea	**=**	**38 ^{o}/oo**
Average Seawater	**=**	**34.7 ^{o}/oo**
Black Sea	**=**	**18 ^{o}/oo**
Baltic Sea	**=**	**8 ^{o}/oo**

Scientists use a variety of instruments to determine the density of water. Hydrometers work on the principle that an object submerged in water must displace a weight of water equal to that of the object itself. Water (or any liquid) pushes on objects placed within them. If the object is lighter than the water it displaces, this force is directed upward and it is called buoyancy. Buoyancy counteracts the earth's gravitational force, which pulls the objects downwards, towards the center of the earth. Because the density of saltwater is greater than the density of fresh water, objects in seawater float higher than they do in freshwater. Buoyancy is why ships float. Ships float because the force of gravity pulling the ship down is less than the force of the water pushing the ship up. Empty ships ride high in the water. When loaded with cargo a ship rides lower in the water. It is important not to load too much cargo aboard or the ship will take on water and sink. A "Plimsoll mark" is found on all large ships. This mark shows proper loading in fresh or seawater. A ship can hold more cargo in seawater because it floats higher.

The relationship between density of a fluid, weight of an object, and buoyancy is an absolutely basic concept for all students of the sea or fresh waters, because density directly affects everything in the water. Scientific understanding of this basic science concept was first elucidated more than 2,000 years ago by Archimedes, a Greek scientist and middle school teacher (he was the private tutor for Alexander the Great). Archimedes was interested, among other things, in why things float. He answered this question by a series of careful experiments in which he weighed the water displaced by each of the objects he tried to float and then weighed the object. Archimedes found that the weight of the water displaced by the floating object is greater than or equal to the weight of the object.

Another quality of seawater is its ability to conduct electricity. When salts are dissolved in water they dissociate and become ions that carry positive or negative charges. It is the ions that are dissolved in water that conduct electricity. Conductivity increases as the amount of dissolved salts, or ionic content, increases. Oceanographers generally use conductivity meters to determine the salinity of seawater rather than hydrometers because conductivity meters are more sensitive.

A very important property of water, in both freshwater and in the sea, is the heat capacity of water. Heat capacity is the amount of heat needed to raise the temperature of 1 gram of a substance by 1 degree Centigrade, and this amount of heat, one Calorie, is used as the international standard against which all other substances are compared. Most substances, such as air, rock, iron, glass, etc., require less heat per gram to warm one degree C than water. Only liquid ammonia has a higher heat capacity than does water. Because of its high heat capacity, the ocean is refractory to sudden temperature changes. The ocean holds an enormous amount of heat, even at the poles. It is important to remember that temperature and heat are different. Heat is a quantity of energy, whereas temperature is how rapidly molecules are moving. The flame of a candle has a higher temperature than does a bucket of hot water, but the bucket of water contains more heat.

If seawater had different properties, such as a different heat capacity, the ocean currents would transport different amounts of heat around the globe, and the climate of the earth would be different. If water compressed when it froze (as does almost every thing else), ice would sink to the bottom of the sea bed and, in the absence of energy from the sun, it would never melt, ice would accumulate, and the world oceans would be in a solid phase rather than liquid water.

Lastly, when compared to many substances, water is relatively viscous, or sticky. Viscosity is important for rapidly swimming animals that must overcome the resistance of water in order to move rapidly forward during hunting, avoiding predators, or during long distance migrations. Streamlined morphology is far more important in the sea than it is in air (which has a low viscosity) for rapidly moving animals. Viscosity is also exceptionally important for very small animals, such as plankton. To a very small animal, like a copepod only 1 mm long, water is much like molasses. Copepods must exert lots of energy to move forward, and when they stop swimming, they do not glide forward, as we do in a swimming pool, but instead they stop instantly because of surface friction and the viscosity of water. Plankton also exploit viscosity to their advantage by the presence of spines and foliose appendages which increase their contact with the surrounding sea water and thereby increasing their resistance to sinking