Compared with most terrestrial environments, the ocean is a relatively stable medium in which to live. Conditions such as salinity, temperature, and amounts of dissolved gases typically only fluctuate only slightly over days or even seasons. Nevertheless, the variations that do exist, however subtle, are extremely important in determining the type and distribution of organisms that are found in particular areas.

**Density**

All types of matter, including water, possess density. Precisely defined, density is the ratio of the mass of a substance to its volume. The density of seawater varies from place to place in the ocean, depending on the amount of precipitation and inflowing water, evaporation, chemical composition, and water temperature. The density of water in which marine organisms live influences many aspects of their lives. For example, planktonic and nektonic organisms often rely on water for buoyancy; the denser the water, the more buoyant they are. And density differences between masses of water can cause currents which will distribute materials, including dissolved gases and nutrients.

When measuring the density of a substance you must have a standard for comparison purposes. Because the density of water varies depending on temperature and chemical composition, the standard is set for pure water at 4°C which is approximately the temperature at which water reaches its maximum density. By definition, one milliliter of pure water at 4°C weighs one gram and occupies one cubic centimeter (= 1 g/cm³). Above and below 4°C, the density of water decreases. Because the temperature of the ocean decreases significantly as depth increases, the deep ocean is layered with the densest water on bottom and the lightest water on top. Often, this gives rise to a pycnocline – a layer of water in which the density changes rapidly with depth. The pycnocline effectively divides the ocean into layers of separate density, temperature, and often chemical composition. For this reason, circulation in the depths of the ocean tends to be horizontal as water moves along the layers with the same density rather than vertically from shallow water to deep water or vice versa.

**Salinity**

Salinity is a measure of the total amount of dissolved salts in water. In oceanography, salinity is traditionally expressed as concentration in parts per thousand (ppt or ‰), which is grams of salt per liter of water. The average salinity of the ocean is 35‰. However, this value varies from place to place and from time to time. For example, the salinity at the mouths of rivers is almost 0‰ while the Dead Sea has
an average salinity of 345‰.

The density of water increases as salinity increases. And less dense water floats on top of denser water. If two layers of water have the same salinity, the warmer water will float on top of the colder water. And because temperature has a greater effect on the density of water than salinity does, a layer of water with higher salinity can float on top of water with lower salinity if the layer with higher salinity is warmer than the other layer.

**INTERACTION OF SALINITY AND TEMPERATURE**

The following diagram is used to determine how temperature and salinity interact to determine the density of sea water. Conversely, if you know density and either temperature or salinity, it can be used to determine the value of the missing parameter. Use this diagram to answer the following questions.

![Temperature-salinity-density (T-S-D) diagram](image)

**Figure 2.1** Temperature-salinity-density (T-S-D) diagram. Density values (in g/cm³) are represented by curved diagonal lines.

1. Off the coast of Cuba, the average salinity of the ocean is 36‰. Currently, the sea surface temperature in that area is approximately 26°C. What is the density of water in the ocean near Cuba?

   ______ g/cm³

2. Off the coast of Nova Scotia, the average salinity of the ocean is 34‰. Currently, the sea surface temperature in that area is approximately 12°C. What is the density of water in the ocean near Nova Scotia?

   ______ g/cm³

3. The Gulf Stream is a large mass of water that sweeps up the eastern coast of North America from the Caribbean towards the north Atlantic. Look at your answers to the first two questions and describe what happens to the depth of the Gulf Stream as it moves from south to north.
4. The average salinity of sea water on Earth is 35‰. If that water has a density of 1.027 g/cm³, what is its approximate temperature?

_______ °C

5. Go to this web page: http://www.wunderground.com/tropical. Where on Earth might you currently find sea water with a salinity of 35‰ and a density of 1.027 g/cm³?

6. Looking at that same image, you can see that the sea surface temperature off the coast of Venezuela is approximately 29°C. If the density of the water in that area is 1.021 g/cm³, what is its salinity?

_______ ‰

7. Think about how water flowing out of the Mediterranean Sea behaves when it encounters the water in the Atlantic Ocean. Because of excessive evaporation, the salinity in the Mediterranean Sea can be as high as 39‰. Near the Straits of Gibraltar (where the Mediterranean empties into the Atlantic), the Atlantic Ocean has a salinity of 36‰. In the summer, the temperature of the Mediterranean may be as high as 18°C while that of the Atlantic in that area is around 20°C.

What is the density of water in the Mediterranean under these conditions? _______ g/cm³

What is the density of water in this area of the Atlantic under these conditions? _______ g/cm³

So how will these two masses of water behave when they encounter one another?

8. What happens when a cold Alaskan river runs into the Bering Sea? Assume that the river has a temperature of 4°C and the Bering Sea has a temperature of 9°C. The river is pure water (salinity = 0) and the Bering Sea has a salinity of 33‰.

What is the density of water in the river under these conditions? _______ g/cm³

What is the density of water in the Bering Sea under these conditions? _______ g/cm³

So how will these two masses of water behave when they encounter one another?

This assignment is due by 5:00 p.m. on Monday, January 31st.