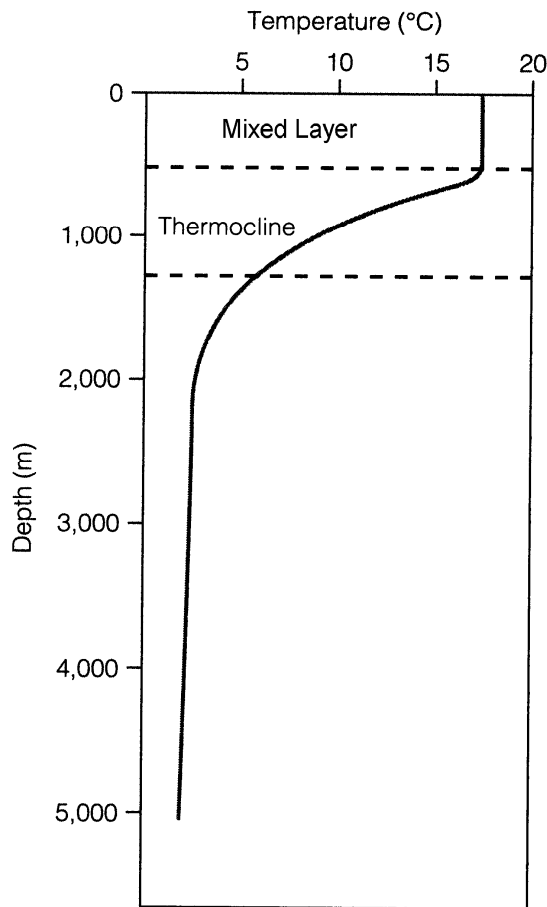


# Thermohaline Circulation

Introduction:

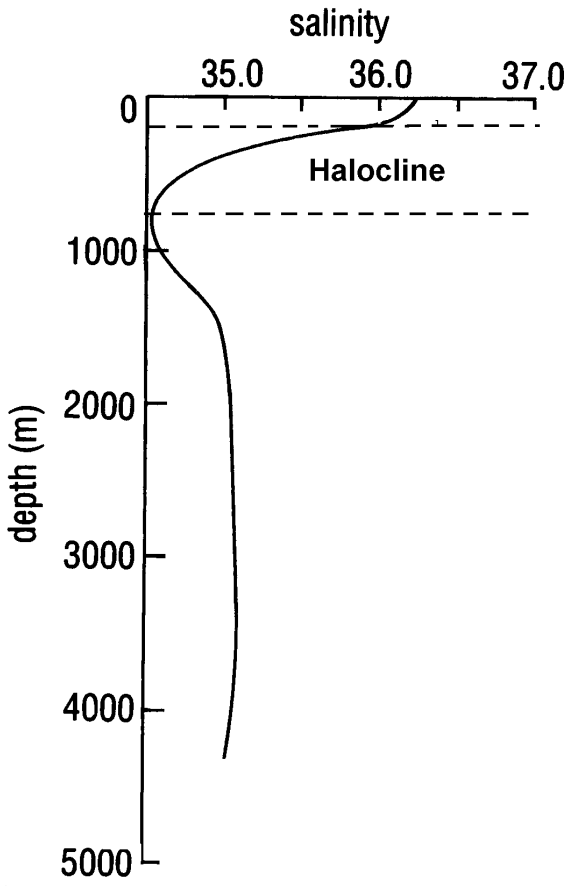
**Thermohaline circulation** is a term used to describe the movement of water in the ocean based on **temperature** (= thermo) and **salinity** (= haline). These two factors in combination affect the density of seawater. More dense seawater sinks below less dense seawater and thus the oceans circulate partially based upon their temperature and salinity.

Temperature of seawater is affected by heat input from the sun. Surface seawater gets more heat input near the equator than near the poles, and similarly more in the summer than in the winter.



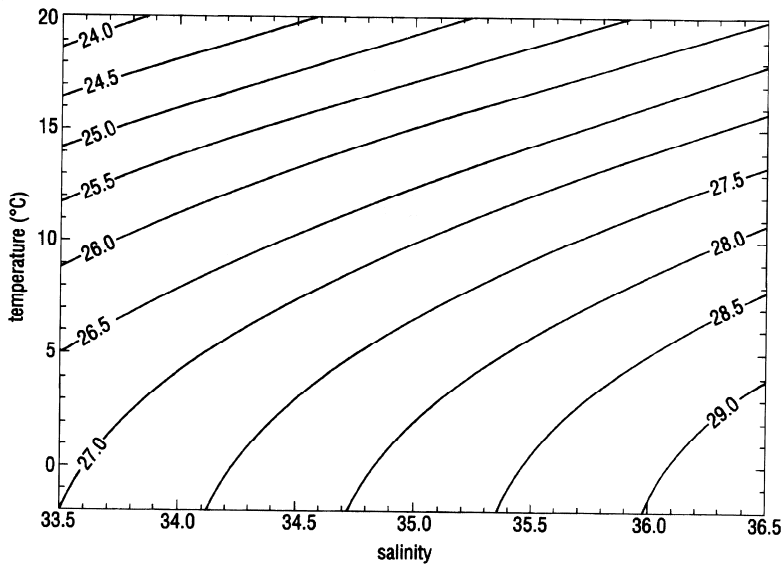
This figure represents a typical vertical profile of temperature in seawater. Note that a sharp change in temperature with depth is called a **thermocline**.

Salinity of seawater is affected by evaporation, precipitation, ice formation, and ice melting. Evaporation increases the salinity of seawater because when seawater evaporates, the salts are left behind, thus increasing their concentration. Precipitation and river input decrease salinity because the input of freshwater dilutes the salts in seawater, thus decreasing their concentration. Ice formation and melting behaves in a similar way. When ice forms, it occludes (leaves behind) the salt, thus increasing the salinity of seawater. When ice melts, the input of freshwater dilutes the salt content and reduces the salinity.

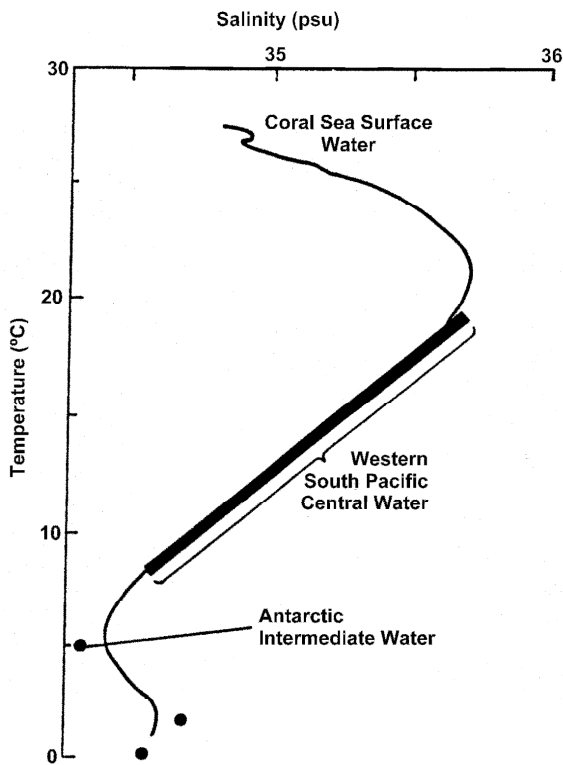


This figure represents a vertical profile of salinity in the ocean  
 A sharp change in salinity with depth is called a **halocline**.

The **density** of seawater depends on temperature and salinity. Higher temperatures *decrease* the density of seawater, while higher salinity *increases* the density of seawater. The following figure shows how density is affected by temperature and salinity. The lines through the figure are lines of constant density.



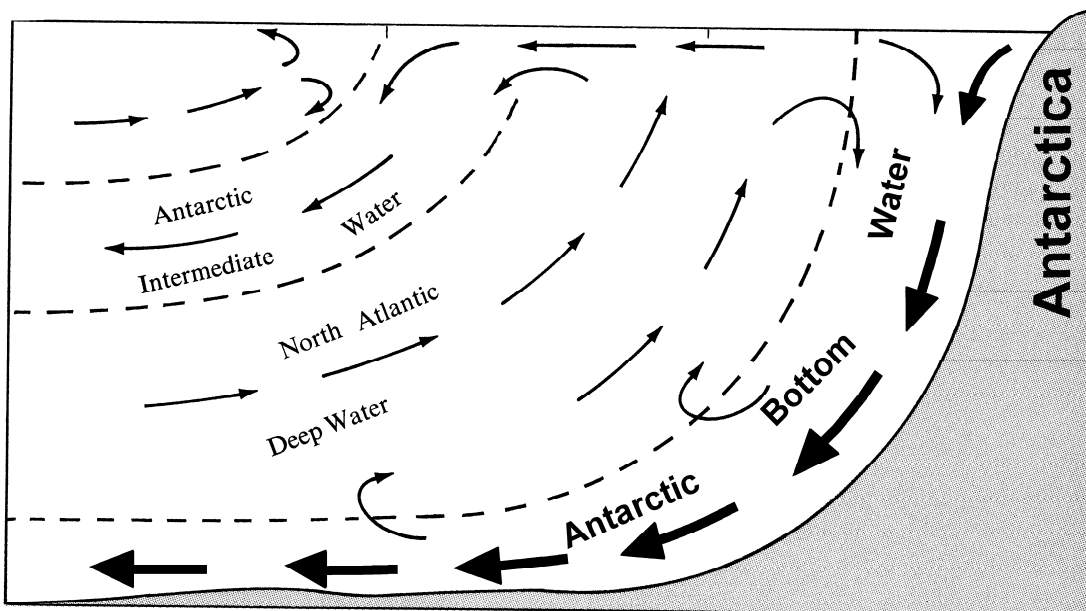
Seawater will become stratified with less dense water on the surface and more dense water below it.



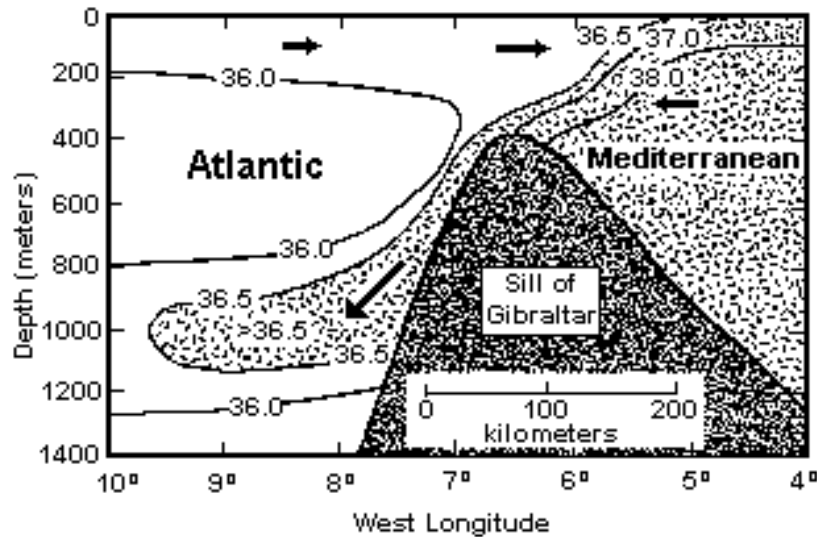
A **water mass** is a body of water that can be defined by its characteristic salinity and temperature range. Temperature vs. salinity plots (**T-S plots**) for a vertical column of water in the ocean can reveal what kind of water masses are present there. These water masses are often named for where they were formed. Water masses can be from a specific source, like Antarctic Bottom Water, or result from a mixture of water masses, like Western South Pacific Central Water.

Two characteristic examples of water mass formation are the Antarctic Bottom Water and the Mediterranean Water.

**Antarctic Bottom Water** is primarily formed in the Ross and Weddel seas of Antarctica. The formation of ice increases the salinity of water which increases the density of the seawater. This cold, dense water sinks and spreads out across the oceans as a bottom water mass, shown in this figure:



**Mediterranean water** forms because the Mediterranean Sea is relatively shallow and secluded from the Atlantic Ocean. The Mediterranean is in an area of extreme evaporation, which increases the salinity of the water. The water in the Mediterranean is more saline (salty) than the Atlantic so it is denser. This dense water "spills" over the sill of Gibraltar into the less dense Atlantic water as shown in the following figure:



Since the Mediterranean water is more saline, it will sink below the Atlantic surface water. However, it is also warmer than the Atlantic water so it will not sink to the bottom because it is of medium density. This is a good example of how the combination of temperature and salinity of seawater affect its density.

Water masses do not stay completely separated once they have been formed. They can mix together forming new water masses (you will see this in today's lab). Some general ways that seawater can be mixed are wind and turbulence. As you may guess, wind can only mix near the surface of the ocean. This layer will be relatively homogeneous with respect to temperature and salinity and is thus called a **mixed layer** (go back and look at the mixed layer in the first figure). Turbulence in water can be caused by currents, small scale features such as eddies, or just water masses being in contact with each other and mixing along the boundary (this is what you will see in your columns). Water mass features are also influenced by local aspects such as river input or storms.

In this lab, you will form water columns that are stratified with respect to salinity and temperature, and compare these to actual vertical profiles in the ocean.