Activity 2.3

Current basics

Figure 1. Global winds (red) and their corresponding surface currents (blue) in the North Atlantic Ocean.

density—mass per unit volume of a substance or object.

$$\text{density (kg/m}^3) = \frac{\text{mass (kg)}}{\text{volume (m}^3)}$$

Ocean waters are continuously moving, circling the ocean basins in powerful currents hundreds of kilometers wide, and in swirls and eddies as small as a centimeter across. The primary forces driving the large-scale motions are the sun's energy and Earth's rotation. Energy from the sun warms Earth's surface and atmosphere, generating winds that initiate the horizontal movement of surface water (Figure 1). Vertical movement between the surface and the ocean depths is tied to variations in temperature and salinity, which together alter the *density* of sea water and trigger sinking or rising of water masses. Together, the horizontal and vertical motions of water link the world's oceans in a complex system of surface and subsurface currents often referred to as the *Global Conveyor Belt* (Figure 2). This circulation system plays a vital role in transporting and distributing heat, nutrients, and dissolved gases that support life around the globe.

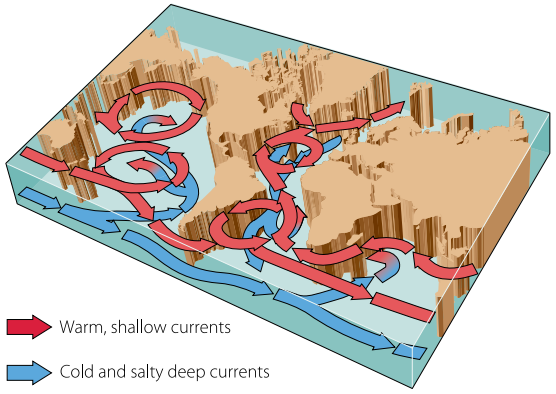

Figure 2. A highly simplified diagram of the *Global Conveyor Belt*.

Structure of the ocean waters

The oceans contain numerous *water masses,* which can be distinguished by their physical and chemical characteristics such as salinity, temperature, and density. The density of seawater depends on its temperature and salinity, as well as the amount of pressure exerted on it. Water expands as it warms, increasing its volume and decreasing its density. As water cools, its volume decreases and its density increases. Salinity, the amount of dissolved solids (like salts) in the water, alters density because the dissolved solids increase the mass of the water without increasing its volume. So, as salinity increases, the density of the water increases. Finally, when the pressure exerted on water increases, its density also increases.

Changing density

The density of water changes as its temperature or salinity (or both) change.

- If the temperature decreases and/or the salinity increases, the water becomes more dense.
- If the temperature increases and/or the salinity decreases, the water becomes less dense.

1. Rank the following types of ocean water from highest density (1) to lowest density (3).
   a. warm, salty water _____
   b. cold, salty water _____
   c. warm, fresh water _____

photosynthesis - Process by which organisms convert sunlight and carbon dioxide to carbohydrates (food) and oxygen (O_2).

The characteristics of a water mass typically develop at the ocean surface due to interactions with the atmosphere. Evaporation can increase salinity as fresh water is removed from the ocean and the salts are left behind. Precipitation has the opposite effect, decreasing salinity levels as fresh water is added to the ocean. Processes like *photosynthesis* and the exchange of energy and matter between the ocean surface and the atmosphere can affect the amounts of oxygen and other dissolved gases in the water.

Thermocline

The thermocline is a layer of the ocean in which the temperature decreases rapidly with depth. Above the thermocline, the temperature is fairly uniform due to the mixing processes of currents and wave action. In the deep ocean below the thermocline, the temperature is cold and stable.

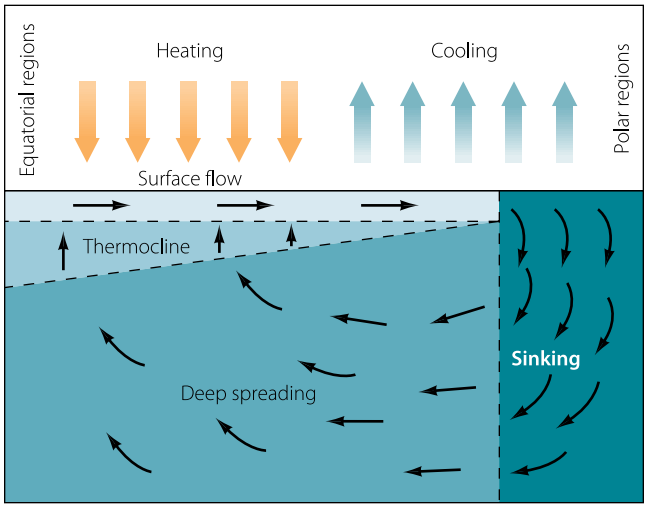

Figure 3. Schematic cross-section of ocean from equator to pole.

In addition, water temperature (and thus density) changes rapidly as surface currents transport water masses from the equator to the poles and vice versa. Although the sun's energy is very efficient at warming the upper 100 meters of the ocean, very little solar energy penetrates to deeper waters. Therefore, water temperature decreases rapidly between 100 and 800 meters depth. This region of decreasing temperature is called the *thermocline*, and marks the boundary between surface water circulation and deep water circulation (Figures 3 and 4).

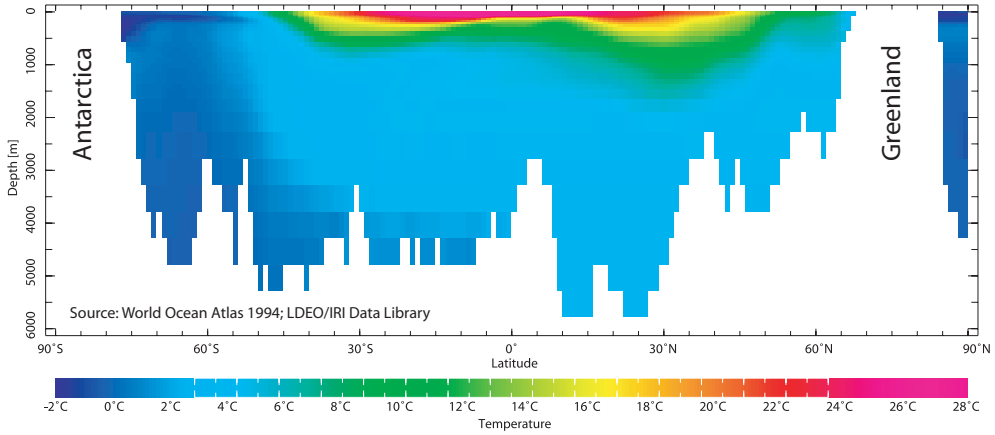

Figure 4. South-north temperature profile of the Atlantic Ocean basin at 32.5° W longitude. White represents the ocean floor and continents.

2. The water temperature at the base of the thermocline is around 5°C. Using this information, sketch and label the approximate location of the base of the thermocline on Figure 4.