Thermocline Graphing Activity

Background:

The thermocline is the transition zone between the upper and lower layers of the ocean, The sunlit and wind-driven upper layer of Earth's oceans rests on relatively colder and denser waters. At times, there is a distinct temperature difference between the wind-stirred **Surface Zone** and the quieter **Deep Zone** below. Although temperature generally decreases with depth, there is a layer where temperatures drop abruptly called the **Thermocline.** In this region, temperatures steadily drop over a depth of several hundred meters. The thermocline simply separates the upper and lower layers of the ocean, it is affected by factors such as seasonal variation, latitude and local conditions like tides and currents. With no external forces applied, the ocean would **stratify** into a simple layered structure based on its **density** (mass divided by volume). Factors that influence seawater's density are **temperature** and **salinity.**

When heated, seawater volume expands and density decreases. So, Sun-warmed surface waters generally float on top of colder, denser waters below. This leads to layering of water -- or stratification -- by temperature. However, **stratification can be "undone" by other forces including wind and tides.**

Objective:

To graph the data set of temperatures in the ocean waters at a mid-latitude location as they change with depth. Don't forget to include the important components to a scientific graph (title, x-axis label, y-axis label, correct neatness).

Depth (m)	Temp (°C)
0	10.2
125	10.2
250	10.1
375	10.0
500	8.7
625	7.5
750	6.5
875	5.8
1000	5.1
1125	5.0
1250	3.8
1375	3.2
1500	3.1
1625	3.0
1750	2.8
1875	2.6
2000	2.5

Temperature, Salinity and Density

Name: ______________________________

In oceans, the salinity varies over time and from place to place. Typical open ocean salinities vary between 33 and 36 PSU (Practical Salinity Units), equivalent to 33-36 parts per thousand. Two of the most important characteristics of ocean water are its temperature and salinity. Together they help govern the density of seawater, which is the major factor controlling the ocean's vertical movements and layered circulation.

The following activity investigates the role of temperature and salinity in determining seawater density. It does so by using a Temperature-Salinity (T-S) Diagram to examine the effect of mixing on density. Such mixing can be a significant factor in causing surface seawater to sink as part of vertical circulation. The T-S Diagram is a simple, but powerful tool used in studies of seawater density, mixing, and circulation. In a T-S diagram, temperature is plotted along the vertical axis in degrees Celsius and salinity is measured along the horizontal axis in PSU. Seawater density is illustrated in the diagram by curved lines of constant density.

Surface waters are mixed by winds and deep ocean water mixing is driven by density differences. Circulation in the depths of the ocean is referred to as thermohaline circulation. The deep ocean is layered with the densest water on bottom and the least dense water on top. Water tends to move horizontally throughout the deep ocean, moving along lines of equal density. Vertical circulation is limited because it is easier for water to move along lines of constant density (isopycnals) than across them.

Materials

- Pencil
- T-S (Temperature-Salinity) Diagram (below)
- Water Sample Table (below)
- Ocean Salinity map

Procedure:

1. On the T-S Diagram, each seawater sample is plotted as a dot (•) at the point determined by its temperature and salinity. Find the temperature and salinity for the two surface seawater samples labeled "A" and "B" and record these values in the Water Sample Table.
2. The density of seawater samples must be determined to several decimal places in order to detect significant differences. Read from the T-S Diagram the densities for the two surface seawater samples labeled "A" and "B" to the fourth decimal place. Record these values in the table. Note that their densities are the same.
3. If surface waters of the same density are brought together, they tend to mix. The temperature and salinity of the resulting mixture are somewhere between the temperatures and salinities of the original waters prior to mixing. Record in the table, the temperature and salinity of a water sample "C" that would result if equal volumes of samples "A" and "B" were mixed together. (Hint: Mixing one liter of 10°C water with one liter of 30°C water produces two liters of water at 20°C.)

Table 2: Water Sample Table

Sample	Temperature (^{0}C)	Salinity (PSU)	Density (g/cm^3)
A			
B			
C			

Analysis

A. As shown by the T-S Diagram, the density of seawater increases with (increasing) (decreasing) temperature and with (increasing) (decreasing) salinity.

B. Comparison of the seawater densities recorded in the table shows that the density of sample "C" is (less than) (equal to) (greater than) the density of samples "A" and "B" prior to mixing.

C. On the T-S Diagram, draw a straight line between the points representing samples "A" and "B". Any possible mixture of these seawater samples, including sample "C," would be represented by a point falling somewhere on the straight line. Regardless of the relative volumes of seawater samples "A" and "B" mixed together, the T-S Diagram shows the resulting mixture will always be (denser) (less dense) than either "A" or "B."

D. Comparison of the density of surface seawater samples "A" and "B" with the density of any resulting mixture of these original samples indicate that the mixed water will (remain at the ocean surface) (sink).

E. This investigation shows that mixing surface seawaters of the same density, but different temperatures and salinities, produces seawater of (greater) (equal) (lesser) density.

F. Using the global ocean salinity map http://aquarius.nasa.gov/pdfs/avg_salinity_global.pdf make predictions on where the World's high and low density oceans would be located.