

**THE VERTICAL THERMAL STRUCTURE OF THE OCEAN:  
TEMPERATURE vs DEPTH AT DIFFERENT LATITUDES. AND SEASONS**

**INTRODUCTION** Warm water is less dense and “floats” as a layer on the top of colder water when it is heated by the sun. Because cold water is more dense it sinks to the depths of the ocean. In between the warm and cold water is a third region in which the temperature changes most drastically within a narrow range of depth is called the thermocline. In this investigation we will consider the structure of the 3-layer temperature profile from the surface (0 meters) down to 2,000 meters, and compare water temperatures of the high latitudes in winter and summer, middle latitude waters during all four seasons and low latitude or tropical waters.

**PROCEDURES** The Excel file has 9 columns of data. You are to produce two graphs: On graph #1 you will use Excel to plot temperature curves for tropical and high-latitude waters. On graph #2 you will plot middle latitude temperature curves for each season. On graph #1 there will be 3 curves and on graph #2 there will be 4 curves. We will make scatter graphs with data points.

1. Create the first curve for graph #1 using the temperature data and the depth data in the far right column.  
Select Data - Click top cell Temp. Column >> Shift-Click bottom cell  
Ctrl-Click top cell of depth column (right one) >> Shift-Click bottom cell  
then Insert >> Scatter >> Select smooth lines with data points.
2. To add another line to the graph  
RIGHT CLICK on the graph  
Left Click Select Data on the menu that opens  
First rename the first curve you created then click "add"  
Name the new series, select the "x" values (temperature) and "y" values (depth).
3. Now modify the graph by enlarging, adding titles, changing curve colors, labelling curves and making it as user friendly as possible.
4. Do the same for graph #2 but be sure you have added all 4 season curves.
5. Follow the instructions below.

## ANALYSIS OF DATA

- Describe the general shape of the temperature depth curve:
  - at low latitudes
  - at mid latitudes in summer
  - at mid latitudes in winter
  - at high latitudes
- (a) Label the three temperature layers for each location: **Surface Layer, Thermocline, and the Deep Water Layer.** (b) Where is it difficult or nearly impossible to clearly label curves? Why?
- Which two curves indicated by your graphs might require that you use a wetsuit (or drysuit) to prevent hypothermia when swimming in the ocean at the location of the curve? Why?
- Approximately where (at what depth) is the primary thermocline:
  - at low latitudes
  - at mid latitudes in summer
  - at mid latitudes in winter
  - at high latitudes (winter and summer)
- Calculate the rate at which the overall temperature changes in  $^{\circ}\text{C}/\text{meter}$  for the top 125 meters, within the first of each water column:
  - at low latitudes
  - at mid latitudes in summer
  - at mid latitudes in winter
  - at high latitudes (winter and summer).[Hint: subtract the temperature at the surface from the temperature at 125m and divide by 125].
- Where is: (a) the most rapid temperature decline, and (b) the slowest temperature decline, and (c) a temperature increase within the upper 125 meters of the ocean?
- Calculate the rate at which the overall temperature drops in  $^{\circ}\text{C}$  per meter, between 750 and 1,750 meters (a 1,000 meter interval) in the water column:
  - at low latitudes
  - at mid latitudes in summer
  - at mid latitudes in winter
  - at high latitudes (winter and summer).[Hint: subtract the temperature at 750 meters from the temperature at 1750 meters, then divide by 1,000].
- Which regions (a) show the most rapid temperature decline, and (b) the slowest temperature decline, below 750 meters in the ocean?
- Extrapolate the data as depicted on your temperature profile graphs and predict the water temperature at a depth of 3000 m:
  - at low latitudes
  - at mid latitudes in summer
  - at mid latitudes in winter
  - at high latitudes (winter and summer).
- Write a short summary explaining what happens to the water temperature profile from the surface to 125 meters at various latitudes and tell why it happens.
- Write a short summary explaining what happens to the water temperature profile below 750 meters at various latitudes and why it happens,
- Explain the seasonal changes at middle latitudes starting with summer and progressing through spring. Be sure to explain why the autumn and spring curves are not identical.
- Compare or contrast polar waters and tropical waters. When and where is overturning most likely and least likely? Why does this happen? What does this mean for primary productivity?