Laboratory 4 Salinity, Temperature and Turbidity

★ red + blue Food Coloring works best

Introduction

The ocean is not a uniform body of salt water. In low to mid-latitudes, the sea is vertically stratified into layers that differ in density because of varying salinity and temperature. Density differences prevent the layers from easily mixing. The greater the density difference, the more stable and long-lived the stratification (layering).

When two or more bodies of water of different density come together, each water mass flows to occupy a position determined by its density. The least dense flows to the top and the densest sinks to the bottom.

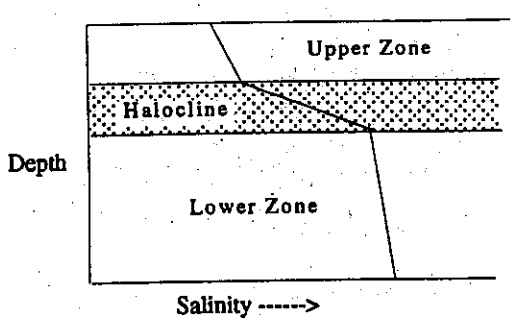
Density increases with increasing salinity and decreasing temperature to 3.98°C. Above and below 3.98°C, fresh water becomes less dense. Warmer or less saline water typically overlie colder or more saline water.

Turbidity currents are temporary water masses characterized by high density, resulting from a large amount of suspended particulate matter. Because turbidity currents are more dense than surrounding water, they flow along the bottom, down slopes and toward the ocean floor.

Salinity in the Sea

Salinity is a measure of the quantity of dissolved salts in water. Average salinity in the ocean varies from 33 parts per thousand (abbreviated **ppt**, or **o/oo**) to 37 ppt. In restricted areas salinity may range from almost 0 ppt (fresh water) to > 72 ppt, the salinity at which **evaporites** (salts) begin to crystallize.

Local changes in salinity can result from evaporation, precipitation (rainfall, snow, etc.) and the inflow of fresh water from rivers or springs. **Diffusion** is the slow, random motion of molecules and ions. Over long periods of time, diffusion will allow migration of dissolved salts from areas of high salinity to those of lower salinity, thereby changing the salinity of both.

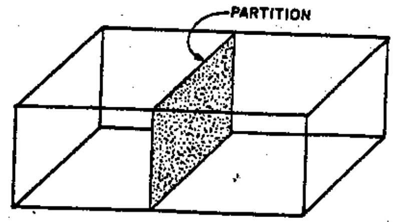


Lab Figure 4.1. Change in salinity with depth.

Most changes in salinity occur at or near the surface where the environment fluctuates frequently and rapidly. Below the surface, salinity is more stable. A graph plotting salinity versus depth demonstrates that salinity does not change uniformly with depth (Lab Fig. 4.1). Three distinct salinity zones can be recognized. The **upper zone** is marked by a gradual increase in salinity with depth. Below the upper zone is the **halocline**, a zone of mixing that is characterized by a rapid increase in salinity. The **lower zone** is marked again by gradual salinity increase. Depth to the halocline varies with the amount of mixing between the upper and lower zones (Lab Fig. 4. 1).

★ remove dividers slowly
★ need lots of clay

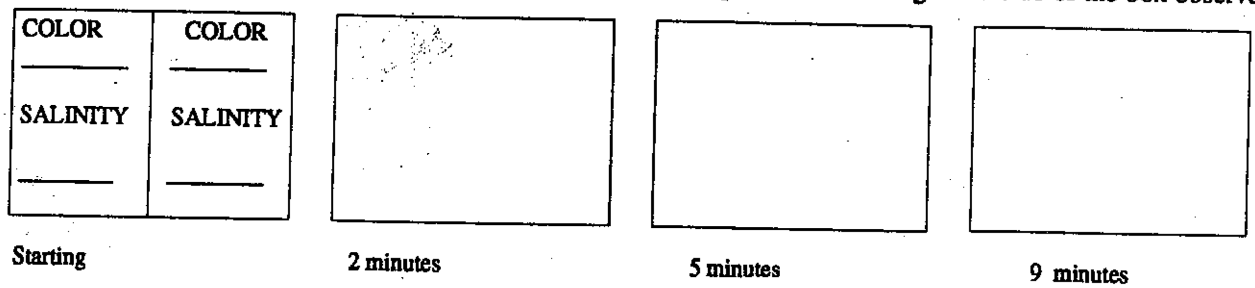
Exercise 1 Effect of Salinity on Water Stratification and Mixing



Lab Figure 4.2. Container with partition.

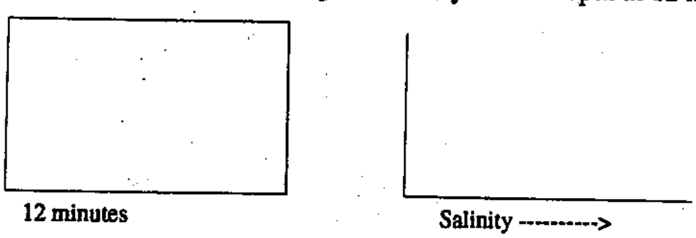
Procedure:

1. Install a partition firmly in place in the middle of the clear container or aquarium as shown in Lab Fig. 4-2. Seal the sides of the partition with a thin layer of modeling clay.
2. Fill a container with room-temperature salt water and another with room-temperature fresh water. Add food coloring to each container. Use color combinations such as blue and yellow or red and yellow. Do not make the solutions too dark. Record the color of each solution (Lab Fig. 4-3).
3. Simultaneously pour one colored solution on each side of the partition. Both sides of the container should be filled to the same height.
4. Allow the solutions to calm and then carefully remove the partition. Through the side of the box observe what occurs to the solutions as the partition is removed. It may help to hold a sheet of white paper behind the container.



Lab Figure 4.3. Changes in color with time as viewed through the side of the container.

5. In the area provided, draw the changes observed at the times suggested (See no. 6). Label colors and zones present (Lab Fig. 4-3). Measure and record thickness of and depth to each layer.
6. After 2.5 minutes, blow moderately hard *across* the water at a low angle to the surface along the length of the container for about 15 seconds. Observe what happens through the side of the container.
7. Blow across the surface again after 9 minutes.
8. After 12 minutes plot the change in salinity with depth. Label zones present (Lab Fig. 4.4). Graph relative change of salinity versus depth at 12 minutes.
9. Dispose of solutions when finished.



Lab Figure 4.4. Changes after 12 minutes.

Questions:

1. Briefly describe what occurred when the partition was removed.
2. What produced the motion described above?
3. Where could the mixing of fresh water and salt water occur in nature?
4. How is the zone of mixing identified in the experiment?

5. Describe what occurred when you blew across the surface the first time?

6. Does the zone of mixing become thicker or thinner after blowing across the surface? Why would you expect this?

7. From 2.5 minutes to 9 minutes the zone of mixing should be gradually becoming thicker, although you may not be able to easily observe this. What process is causing this slow mixing?

8. Does the zone of mixing appear thicker or thinner after blowing across the surface the second time (after 9 minutes)?

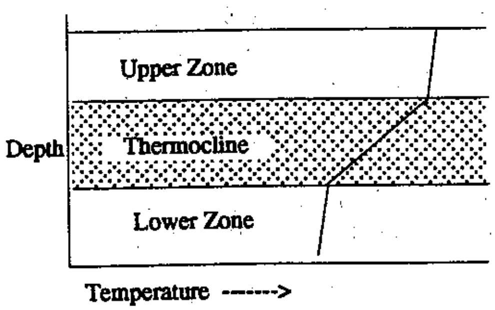
9. How permanent does stratification caused by differences in salinity appear to be?

10. Is the halocline a zone of rapid increase or decrease in salinity?

Temperature in the Sea

The Sun is the major source of heat for the oceans, but directly heats only surface waters. The deep ocean is isolated and maintains a constant temperature between 1 and 4°C. Because the lower latitudes receive the most direct solar radiation, tropical surface water is considerably warmer than surface water near the poles, where solar radiation is most diffuse. The average temperature of the ocean surface in the tropics is about 27°C. This produces very strong thermal stratification. No stratification exists near the poles because the bottom waters and surface waters are nearly isothermal. In the temperate region, stratification is seasonal.

A graph plotting temperature versus depth shows that temperature does not decrease uniformly from the surface to the ocean floor in the tropics and subtropics (Lab Fig. 4. 5). Three distinct temperature zones can be recognized. The warm upper zone is characterized by a gradual decline in temperature with depth. Underlying the upper zone is the **thermocline**, a zone of mixing characterized by a rapid change in temperature. The zone below the thermocline is marked by very cold water and a gradual temperature decline with depth.



Lab Figure 4.5. Changes in temperature with depth.

Exercise 2 Effect of Temperature on Water Stratification

Procedure:

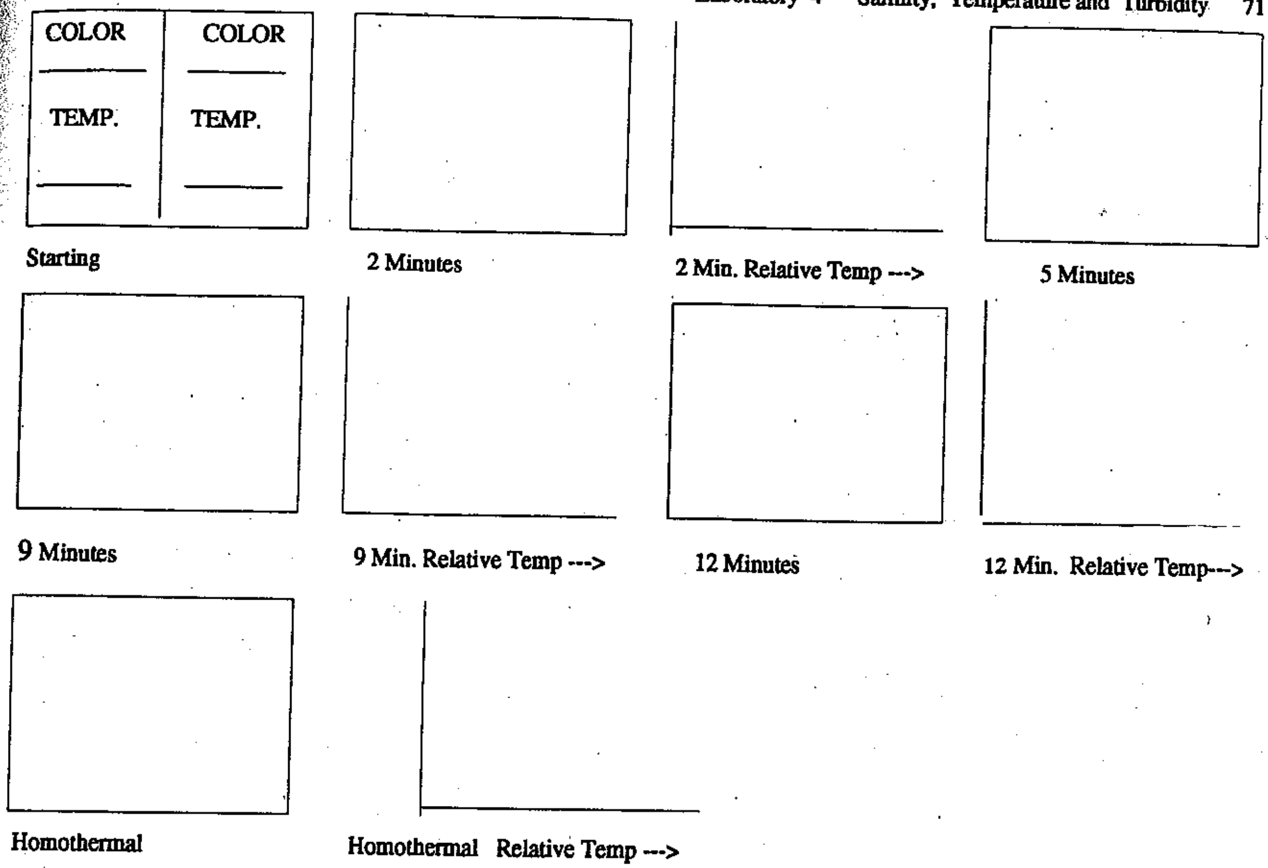
mix (pull pactition out) very slowly

1-4. Same as in Exercise 1, except use warm and cold freshwater. Graph the change in temperature with depth at the times requested. (Lab Figs. 4. 6).

5-7. Same as in Exercise 1.

8. Allow the solutions to become **homothermal** (also called **isothermal** and means all one temperature). Blow across the surface again and observe the changes.

9. Dispose of solutions.



Lab Figure 4.6. Changes in color with time as viewed through the side of the container.

Questions

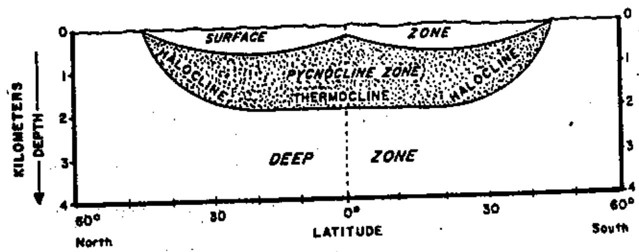
1. Briefly describe what occurred when the partition was removed.
2. What produced the motion described above?
3. Where could the mixing of warm and cold salt water occur in nature? Fresh water?
4. How is the zone of mixing identified?
5. Describe what occurred when you blew across the surface the first time.
6. Do the solutions appear to mix more easily as they become homothermal? When homothermal? Why?
7. How permanent does stratification from temperature appear to be?

Density of Sea Water

red + blue + yellow Food Coloring

Density of sea water is mainly controlled by salinity and temperature. As seen from the previous two experiments, density increases with increasing salinity and decreasing temperature. Because of variations in temperature and salinity in the ocean a density stratification extends from the equator into the temperate climates (Lab Fig. 4.7).

In the lower latitudes, temperature is the major factor producing stratification. In these areas the surface waters may become more saline than the deeper waters, but the small density difference from salinity is offset by the large density difference from temperature.
In the temperate regions where surface waters are cooler, high precipitation maintains stratification by lowering surface salinities.

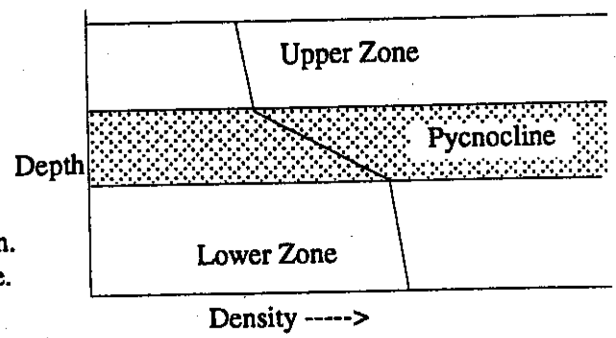


Lab Figure 4.7. Density layering in the ocean.

A graph plotting density versus depth shows three layers in the ocean (Lab Fig. 4.8). The upper zone is an area of gradually increasing density with depth. The underlying **pycnocline** is characterized by a rapid change in density. The lower zone displays a gradual increase in density with depth.

In the ocean, the upper density layer is called the **surface zone** (Lab Fig. 4.7). Waters in this zone are characterized as being warmer, less dense and highly variable because of precipitation, evaporation and seasonal changes in solar radiation. The surface zone extends to a maximum depth of about 100 m at about 30° north or south of the equator. It contains only 2% of the ocean volume and is well mixed by winds, waves and currents. Much of the organic production in the sea occurs in the surface zone. Water density gradually increases with depth.

The pycnocline is characterized by rapidly changing water density because of changes in temperature or salinity. It is thickest (> 1.7 kilometer) in the tropics where it coincides with the thermocline. The pycnocline zone thins to the north and south. Its base curves upwards and extends to the surface at about 45° N and S latitude, depending upon the season. In this area the pycnocline coincides with the halocline.



Lab Figure 4.8. Change in density with depth.

The deep zone is characterized by extremely cold water that increases in density with depth because of increasing pressure and declining temperature.
It contains over 80% of all water in the ocean, is homogeneous and extremely stable, and extends from the base of the pycnocline to the ocean bottom. In polar and subpolar areas the water at the surface varies only slightly from that of the deep zone.

Exercise 3 A Multiple-layer System

Because of the great thickness of the pycnocline in the tropics, it effectively isolates the deep zone from surface phenomena. The isolation of the deep zone can be studied in a multiple-layer system.

Procedure:

1. Obtain an additional partition. With the two partitions divide the container into thirds and seal the sides of the partitions with clay.
2. Fill one container with hot fresh water, a second container with room-temperature salt water and a third with cold salt water. Add food coloring as before.
3. Simultaneously pour each solution into a section of the container. Try to fill the container almost to the top. For the system to work best pour the room-temperature salt solution into the middle third.
4. Allow the solutions to calm and then remove both partitions at the same time. Through the side observe what occurs. In the area provided draw the changes seen at the times suggested (Lab Fig. 4.9). Label colors and zones present.
5. After 2.5 minutes blow moderately hard for about 20 seconds across the water surface along the length of the container. Observe what occurs to the lowermost solution.
6. After 10 minutes try blowing harder and longer and observe any changes.
7. Dispose of the solutions.

Color ______	Color ______	Color ______
Salinity ______	Salinity ______	Salinity ______
Tempt. ______	Tempt. ______	Tempt. ______

Starting

2 Minutes

Salinity---> Tempt.---> Density --->

5 Minutes

9 Minutes

Salinity---> Tempt.---> Density --->

Lab Figure 4.9. Changes in color with time.

Questions

1. What causes the various solutions to assume the positions they occupy?

2. What occurred to the bottom solution as you blew across the surface the first time?

3. What occurred to the bottom solution as you blew across the surface the second time?

4. Why would a difference be expected between the first and second time?

5. How protected was the lowermost layer by the multiple-layer system?

6. In the ocean why would you expect the thermocline to be most important in forming the pycnocline in the tropics, but the halocline to be more important in the temperate regions?

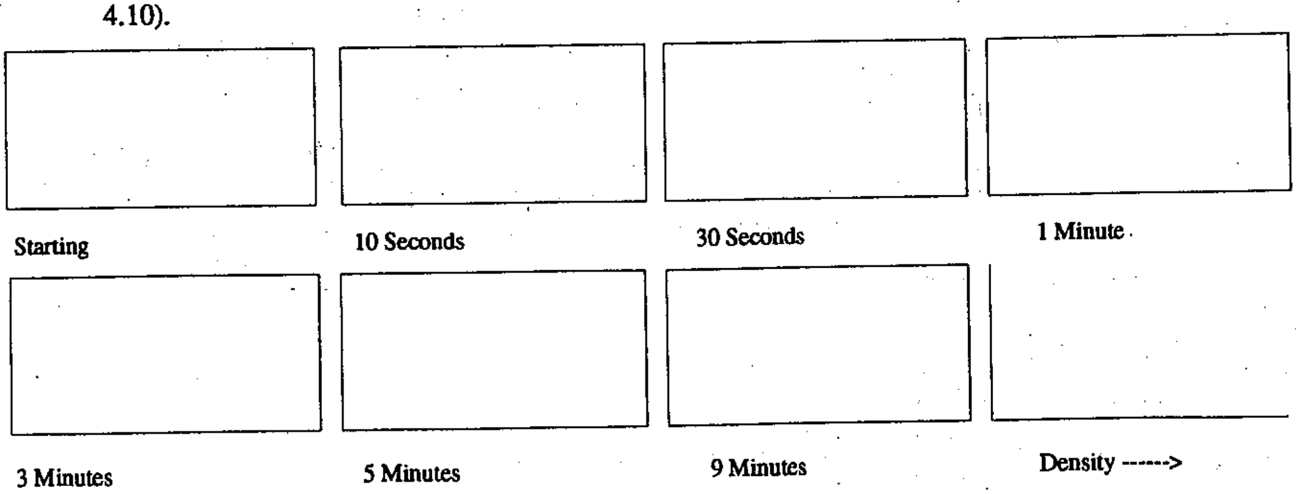
Turbidity Currents

Turbidity currents are temporary, flowing water masses characterized by extremely high density resulting from a large amount of suspended particulate matter (sediment). Because turbidity currents are dependent upon the suspension of sediment, they exist only as long as there is sufficient turbulence to retain the particles in suspension. The amount of turbulence is directly related to the steepness of the slope the current flows across. The steeper the slope, the faster the water flows and the greater the turbulence. As the slope declines, turbulence decreases and the sediment in the current begins to be deposited. In accordance with the Hjulstrom Diagram, largest particles are deposited first and smallest last. In the ocean, turbidity currents commonly begin on the shelf, flow rapidly down the slope, and die on the continental rise and the abyssal plains.

Exercise 4 Turbidity Currents

Procedure:

1-5. Same procedure as for Exercise 1, but use of cold clear fresh water and a turbid solution. Mix the turbid solution well. Do not add color to either solution. Draw and graph change in turbidity (Lab Fig. 4.10).



Lab Figure 4.10. Changes in density with time as viewed through the side of the container.

Questions

1. Briefly describe what occurred when the partition was removed.
2. What produced the motion described above?
3. What occurred to the turbid zone when you blew across the surface?
4. What happens to the dense turbid zone with time?
5. How permanent does stratification from turbidity appear to be [once the sediment is deposited, it is no longer a water layer]?

Exercise 5 Summary Questions

1. Rank temperature, salinity and turbidity in order of producing the most stable and long-lived stratification in these exercises? Why are some more stable than others?
2. Which variable would be most likely to produce the most stable and long-lived stratification in nature? Why?
3. How do the changes in turbidity with time differ from the changes observed for salinity and temperature?