Lake Stratification

Grade Level: 8-12
Subject Area: Physical Sciences
Duration: 50 minutes or less
Setting: classroom/lab
Skills: gathering, organizing, analyzing, and interpreting information
Vocabulary: stratification, density, reservoir, thermocline

Related State Content Benchmarks Objectives

- **Explain basic ecosystem concepts and processes**
- **Write and follow procedures in the form of step-by-step instructions, recipes, formulas, flow diagrams, and sketches**

Objectives

Students will be able to:

- explain why the red water layer lies below the blue water layer when mixed; and,
- explain the process of stratification in lakes

Materials

- blue food coloring
- red food coloring
- 2 pint Mason or similar jars (important that jar openings be the same size)
- reservoir of warm and reservoir of cold water
- edged baking pan
- 3 x 5 cards

Background

On the Schoolship, students record surface water temperature and bottom water temperature (often from 60-80 feet of water). In early May, these two values are often close (low 40ºF range). By the end of spring Schoolship, the sun has become more direct and air temperatures are on average much warmer. This leads to absorption of heat in the form of energy from the sun which warms the upper or surface water. The surface layer is called the **epilimnion** and because it is a warmer layer of water it is also less dense. Students who measure bottom water temperatures find relatively cold water; this is a more dense layer called the **hypolimnion**. The intermediate layer—between the warm epilimnion and the cold hypolimnion—is called the metalimnion or **thermocline**. By summer, Grand Traverse Bay is highly stratified. This has implications for organisms living in the bay. The differences in density mean that wind cannot physically mix atmospheric oxygen into the deeper parts of the bay. If enough oxygen-demanding material (organics) is present in bottom sediments these bottom areas can become oxygen deficient in summer.

There are also zones in the lake determined by the penetration of light. The "Common Lake Terms" diagram shows the **photic zone** and the **aphotic zone**. The photic zone is the depth to which light can penetrate in a lake (measured as 1 percent of the light on the surface). Students measure clarity or water transparency of the lake with a Secchi disk*. Of course, the photic zone supports photosynthesis (oxygen production) by algae and rooted aquatic plants. In clear, deep lakes, the photic zone may extend well into the hypolimnion. The aphotic zone extends below the photic zone to the lake bottom. Here, available light is too limited for photosynthesis.

The Activity

1. Fill first jar with cold water. Add **two** drops of red food coloring, making sure jar is filled to the brim.
2. Fill second jar with warm water. Add **two** drops of blue food coloring, again making sure jar is filled to the brim.
3. Place 3 x 5 card firmly over the mouth of the warm water jar, and **carefully** set the warm water jar on

top of the cold water jar—leave the 3 x 5 card between jars.
4. Students should predict what will happen when the card is removed.
5. CAREFULLY remove the 3 x 5 card between jars.
6. Observe the reaction.
7. Let stand for 15 minutes and observe any changes.
8. Repeat activity with the cold water on top.

Lake Stratification Activity

This activity is more advanced and is designed to demonstrate stratification in a lake.

Materials

- distilled water
- 25 x200 mL tube with screw cap (ideal) or a large container (important to limit surface area)
- large syringe or straw
- blue, yellow, and red food coloring
- poppy seeds

Preparation

- To make the dense "cold" hypolimnion, supersaturate 250 mL of water with salt. Keep adding salt (at least 20 g.) until the water will hold no more. Decant off the saltwater into a separate container.
- To make the thermocline or metalimnion: mix this salt solution with pure, distilled water (tap water will also work) ½ and ½.
- The surface layer or epilimnion consists of pure, distilled water.

The Activity

1. Begin with the dense salt water pouring this into the demonstration container (add several drops of blue food coloring).
2. On top of this salt water, **carefully** add the ½ and ½ solution using a syringe (this is colored with the yellow food dye).
3. Finally, add the clear top layer (drop red dye into). You should end up with a blue bottom band of water, a yellow middle band, and a red surface band.

Demonstration

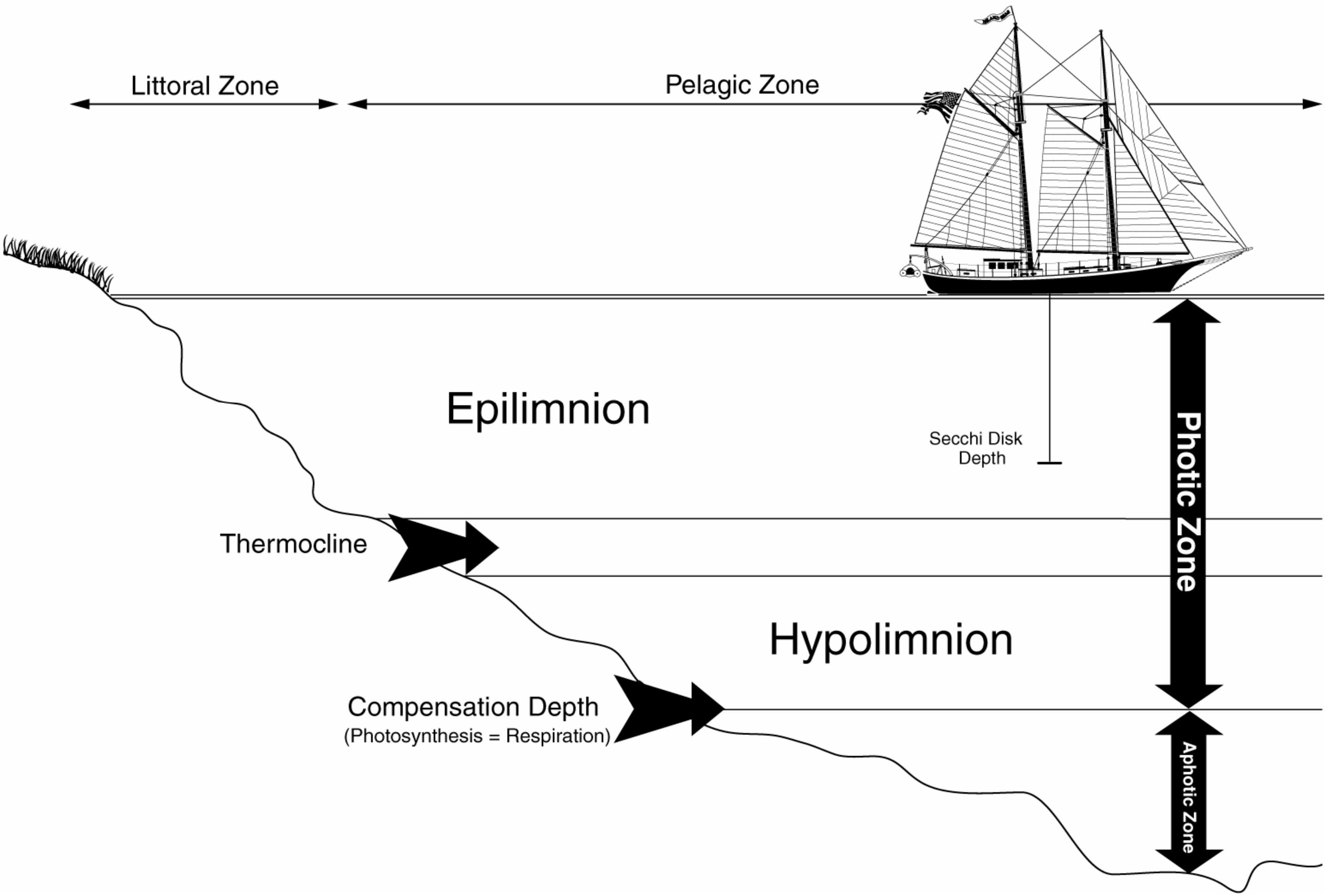
To demonstrate wind mixing, blow across the surface by using a straw. This shows that once a lake is stratified, wind and wave action don't usually cause mixing between the upper layer (epilimnion) and the cold, dense hypolimnion. Of course, this physical separation means that no or very little atmospheric oxygen is added through physical mixing of the surface water.

To demonstrate how phytoplankton congregate in the epilimnion and metalimnion, drop poppy seeds into the water. They should slowly sink through the epilimnion, but float just above the hypolimnion. Zooplankton are larger and motile and can move through the three layers.

Wrap-up

- Is warm water more dense (heavier/unit mass) or less dense (lighter/unit mass) than cold water?
- Where does most of the heating occur in a lake?
- How does this layering affect animals that live in the lake?

Common Lake Terms



Additional Resources

Horne, Alexander J. and Charles R. Goldman. *Limnology*. (2nd ed.) McGraw-Hill, Inc.

The Watercourse and Western Regional Environmental Education Council, 1995. *Project WET Curriculum and Activity Guide*.

A good related activity in this guide is called "Adventures in Density". This activity combines literature with science to understand water density in relation to heat and salinity.

*The **Secchi disk** has long been used as a tool of limnologists. It is a disk about 8 inches colored in alternating black and white quadrants. Students on the Schoolship lower this disk attached to a metered line. As the disk decends, students keep count of the meters. Students note the depth at which the disk just disappears. Then the disk is slowly raised and the depth of its reappearance is noted. The Secchi disk transparency depth is the average of the disappearance depth and the reappearance depth.

Visit the following website for an interesting history of the Secchi disk:
http://humboldt.kent.edu/~dipin/secchi.html