U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Marine Fisheries Service

Lesson 7: Ocean Layers II

Overview

Lesson 7 introduces students to the primary ocean layers, as well as relevant terminology (e.g., thermocline, pycnocline). In the activity, students graph ocean temperature data to determine how temperature-depth profiles vary by latitude and season.

Lesson Objectives

Students will:

1. Define three primary layers in the ocean
2. Explain the physical properties of these layers relating to temperature, density and depth
3. Define common terms related to these properties including thermocline and pycnocline

Lesson Contents

1. Teaching Lesson 7
    a. Introduction
    b. Lecture Notes
    c. Additional Resources
    d. Student activity
2. Student Handout
3. Mock Bowl Quiz

Standards Addressed

National Science Education Standards, Grades 9-12
Unifying concepts and processes
Science as inquiry
Physical science

Ocean Literacy Principles
The Earth has one big ocean with many features

DCPS, High School
Chemistry
C.2.1. Investigate and classify properties of matter, including density, melting point, boiling point, and solubility

Lesson Outline[1]

I. Introduction

If you didn't use the layering demonstration in the salinity lesson, you may want to create the following solution to remind students how layers form in the ocean:

1. Before class, fill a clear water bottle or beaker halfway with cool tap water. Add salt until it no longer dissolves. Fill another bottle or beaker with a smaller amount of tap water and a small amount of salt. Put a few drops of food coloring into this solution. When class starts, gently pour the colored solution into the clear solution so that the less dense, colored water forms a layer on top of the denser, clear water.

2. Tell the students that the clear layer has a lot of salt and the colored solution has only a little salt. Remind them that last time they learned that salinity affects density, and density causes layers to form in the ocean. Remind them that temperature also affects density.

3. Tell them that in today's lesson we are going to learn the specifics about ocean layers, and how temperature, salinity and density change with depth in each layer. Emphasize the importance of understanding all the relationships and terminology for the NOSB.

II. Lecture Notes

Use the PowerPoint for Lesson 7 (File: Lesson 7 – Ocean Layers II.ppt) to present the following information. Distribute the Student Handout before you begin for students to take notes on key information.

Last class we learned about salinity (slide 2)

1. The ocean forms layers because the water has different density throughout.

2. Water with higher density sinks to the bottom while water with lower density sits on the top.

3. Temperature and salinity both affect density. Low-density water tends to be warmer and less saline, while high-density water is generally cooler and more saline.

4. Pressure also affects seawater density, but only in the deepest parts of the ocean.

5. It is important to know about layering because it affects ocean currents. Deep water currents are part of the global circulation of the Earth's ocean. Knowing the general properties of ocean layers will make some of the information in the lessons about currents easier for your students to understand.

[1] Unless otherwise indicated, all websites provided or referenced in this guide were last accessed in November, 2010.

Let's take a journey down through the ocean layers (slides 4-8)

1. The ocean has three primary layers.

2. The layers are the surface layer (sometimes referred to as the mixed layer), the thermocline and the deep ocean.

3. The surface layer is the top layer of the water. This layer is also known as the mixed layer and is well stirred from the wind and other forces. This top ocean layer tends to be the warmest layer due to heating from the sun.

4. Below the surface layer is the **thermocline**, the layer between warm surface water and cold deep ocean. Its size varies based on latitude and season, but it will rarely occur deeper than 1,000m[2]. In this layer, temperature changes rapidly with depth. This layer often coincides with the **halocline**, the region where salinity changes sharply with depth.

5. Below the thermocline is the deep ocean. Water here is cold and dense. Temperature and salinity tend to remain relatively constant below the thermocline.

What is the pycnocline? (slide 10)

1. Some of the terminology in physical oceanography can be confusing. The **pycnocline** encompasses both the halocline (salinity gradients) and the thermocline (temperature gradients)refers to the rapid change in density with depth. Because density is a function of temperature and salinity, the pycnocline is a function of the thermocline and halocline.

2. Because temperature tends to be the dominant factor influencing seawater density, the depth range and base of both the pycnocline and thermocline often tend to be similar. Therefore, below the pycnocline or thermocline, temperature and salinity are relatively constant. This will be important to know for the bowl.

III. Additional Web Resources

Background information
http://www.windows.ucar.edu/tour/link=/earth/Water/temp.html

IV. Student Activity

The activity is included as a separate in the Lesson 7 folder (File: ThermoclineActivity.pdf). This activity is a UCLA OceanGLOBE lab exercise, used with permission from Bob Perry at the Ocean Globe Program[3].

[2] National Marine Educators Association. 2010. *Life on an Ocean Planet*. Current Publishing Corps, Santa Margarita, CA. 598pp.
[3]You can find other great marine science activities from UCLA OceanGLOBE on the web: http://www.msc.ucla.edu/oceanglobe/investigations.htm.

Tips for the Bowl – Ocean Layers[4]

Definitions
Write definitions and key concepts for these terms during your teacher's presentation.
Thermocline:

Halocline:

Pycnocline:

Facts about layering:

- The thermocline size and depth varies with season and latitude: in temperate zones, the thermocline will be most pronounced during the summer; in the tropics, it is more stable; in the polar regions it is weak or nonexistent.
- On average, though, the thermocline exists between 50-1,000m
- About 90% of the Earth's oceans exist below the thermocline (and pycnocline)

Know your water physics!
Some physical properties of water consistently come up on the Bowl. During your preparation with your friends and teammates, quiz each other about the following physical facts:

- The maximum density of pure water is 1gm/cm^3, it reaches this at about 4^{o}C
- At 0^{0}C pure water freezes into ice
- The freezing point of sea water depends on its salinity content (increase in salinity, decrease in freezing point)
- The maximum density of sea water occurs at its freezing point
- The density of ice is **less than** water, that's why ice floats
- Water temperature is often the dominant factor over salinity in determining ocean layers

Why does it matter?
The concepts you learn can be related to broader ecosystem function. Below are a few examples. Can you think of others?

- Ocean layers affect currents which, influence weather patterns, and movement of materials like nutrients through the ocean.
- The speed of sound in the ocean varies with temperature, pressure, and salinity and therefore will also vary in the different ocean layers.

[4] Reference text: National Marine Educators Association. 2010. *Life on an Ocean Planet*. Current Publishing Corps, Santa Margarita, CA. 598pp.

Ocean Layers II

1. Short Answer: The ocean layer where temperature changes most rapidly with depth is called:
   Answer: Thermocline

2. If you consider the ocean to have many different layers of water, where would you expect to find warm water heated by the sun:
   w. Near the ocean floor
   x. **Near the ocean surface**
   y. In a layer called the thermocline
   z. Between 500 – 1,000 meters

3. Short Answer**:** Why would warm water stay on the ocean surface?
   Answer: It is less dense than colder water and essentially "floats" on the denser layers

4. Which of the following best describes water beneath the thermocline:
   w. Highly variable in temperature
   x. Warmer than most surface waters
   y. **Relatively uniform and cold in temperature**
   z. Variable by latitude

5. Thermoclines are typically not found below this depth regardless of season and latitude:
   w. 10 meters
   x. 100 meters
   y. 500 meters
   z. **1,000 meters**

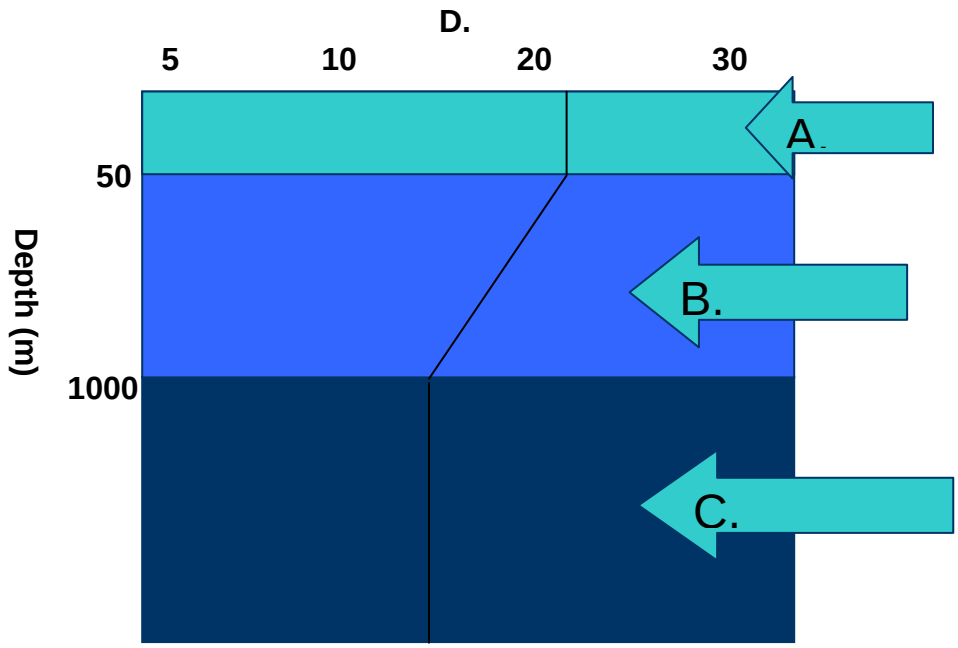
6. A pycnocline refers to a significant change in:
   w. **Density**
   x. Temperature
   y. Salinity
   z. Turbidity

7. If all else is equal, increasing the salinity of a seawater sample will also increase its:
   w. Temperature
   x. Pressure
   y. **Density**
   z. Turbidity

8. Short answer: In which oceanic layer is most of Earth's water located?
   Answer: Deep ocean (or below thermocline)

9. Which of the following represents the ocean layer which has the most rapid change of salinity with depth?
   w. Salinicline
   x. Pycnocline
   y. Thermocline
   z. **Halocline**

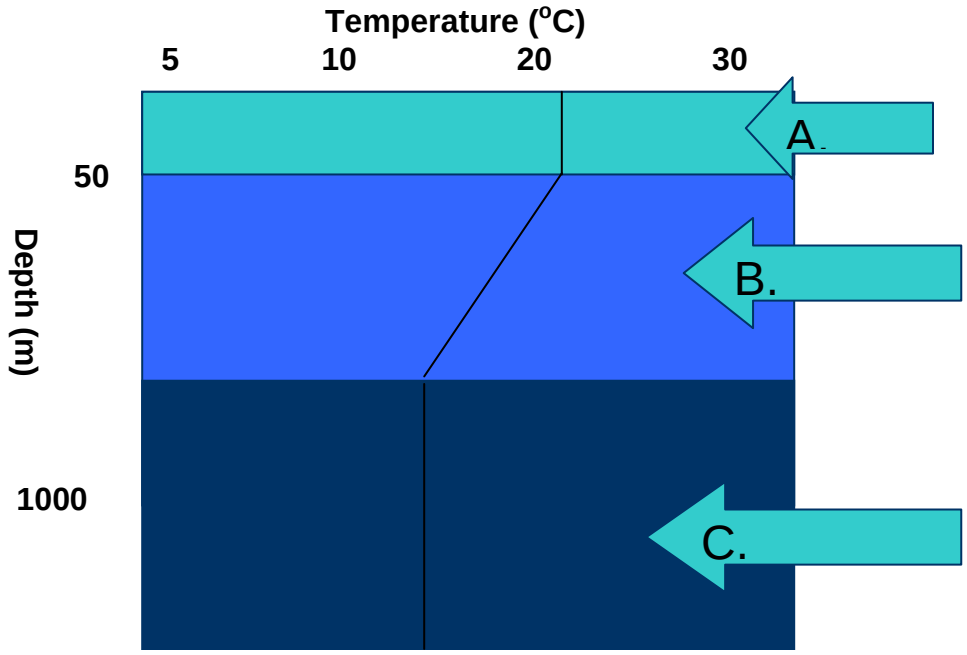
10. Team challenge question



1. Label boxes A-C according the name of the ocean layer. (3pt)

2. Looking at the shape of the curve displayed on the graph, what do you think the values on the x-axis (letter D) represent? Why? (2pt)

ANSWER



1. Label boxes A-C according the name of the ocean layer. (3pt)
   A: surface or mixed zone (or layer)
   B: thermocline
   C: deep ocean (1pt each)

2. Looking at the shape of the curve displayed on the graph, what do you think the values on the x-axis (box D) represent? Why? (2pt)
   The values represent temperature (1pt). You can tell because the line shows decreasing values with depth through the thermocline (1pt) and those numbers correspond most closely to the Celsius temperature scale.