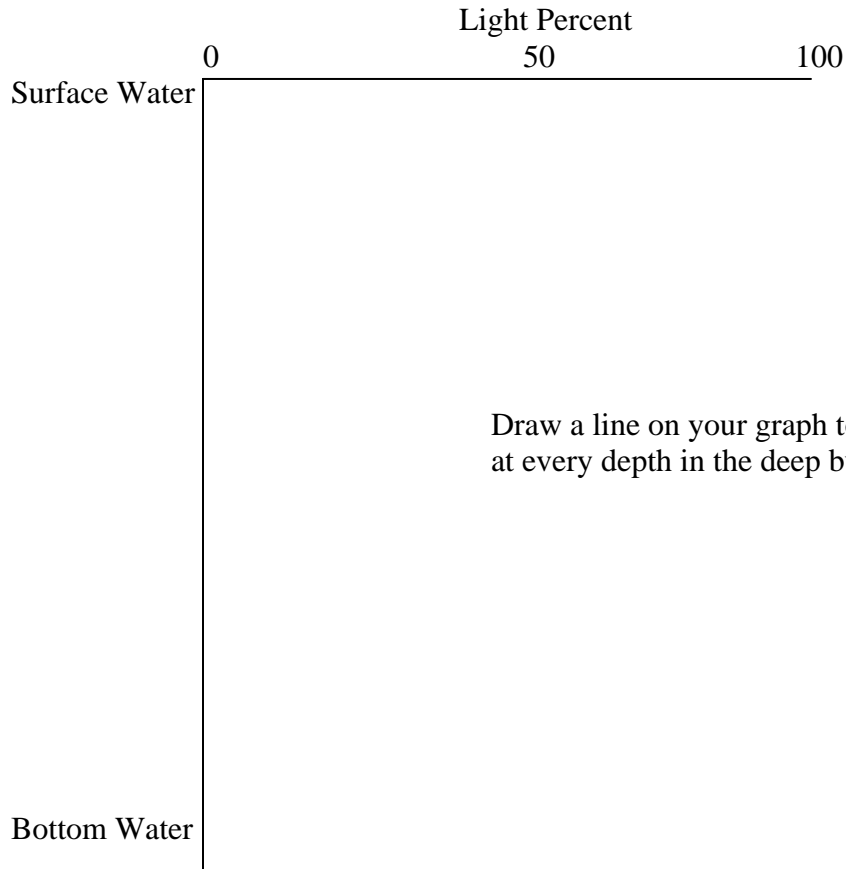


Two Layer Ocean – Structure of the Ocean and Properties of Seawater with regard to Light, Temperature, Dissolved Oxygen, Pressure and Salinity

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- 1. Thought Problem:** You have a bucket of water sitting in the sun. Draw a picture of a bucket of water in your journal. Copy questions **a.** and **b.** in your journal.
 - a. What can you tell me about light in the bucket of water; is the amount of light the same everywhere in the bucket? Is there more at the top than the bottom? Explain your answer using evidence from what you see in buckets, the bathtub, swimming pool or ocean.
 - b. You want to accurately measure the temperature of the water in the bucket. Is the whole bucket the same temperature? Does it matter where in the bucket you place the thermometer? Explain using an example from your experience.
- 2. Discussion:** How many of you have been swimming in a lake in the summer? Does that experience tell you anything about light or temperature in water? Write down, in a complete sentence, one important thing from the discussion.
- 3. Thought Problem:** Imagine that you have a very deep bucket of water. Draw a picture of a very deep bucket and a light meter in your journal. Copy the following question in your journal. Does the light change in the bucket, or is it the same everywhere in the bucket? Explain using evidence from your experience.

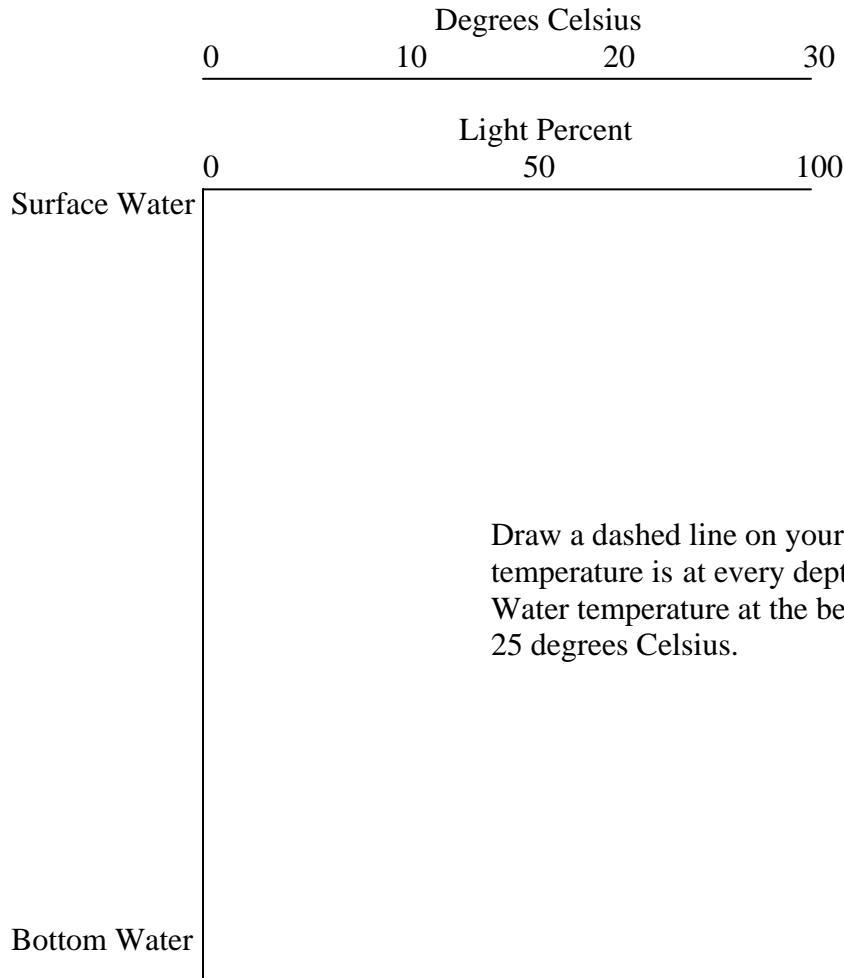
4. You will now draw a graph in your journal of light in the very deep bucket. Make the axes look like this:



Draw a line on your graph to show how much light there is at every depth in the deep bucket.

5. **Thought Problem:** (please copy the question) Does the amount of light affect the temperature of the water in the deep bucket? Explain using examples from your experience.

6. You will now add to your graph of light in the very deep bucket. Make a second X axis for temperature above the light axis. It should look like this:



7. Look at your graph of light and temperature. Please copy the following question. Are light and temperature distributed the same in the deep bucket? (are the lines parallel?) Explain using your own experiences where you expect to have the most light and temperature and the least light and temperature. If you think that light and temperature will be the same everywhere in the deep bucket, explain why using evidence from your experience.

8. Discussion: (please copy the questions **a.** and **b.**)

- a. Will your graph for the shallow bucket look the same as your graph for the deep bucket, why or why not? (write your answer following the discussion)
- b. Consider the ocean instead of the bucket. The ocean is 5000 meters deep (3 miles) or more in places. Will a graph for light and temperature in 5000 meters of ocean look like that for the deep bucket, why or why not?
- c. Is there any light at the bottom (5000 meters) of the ocean?

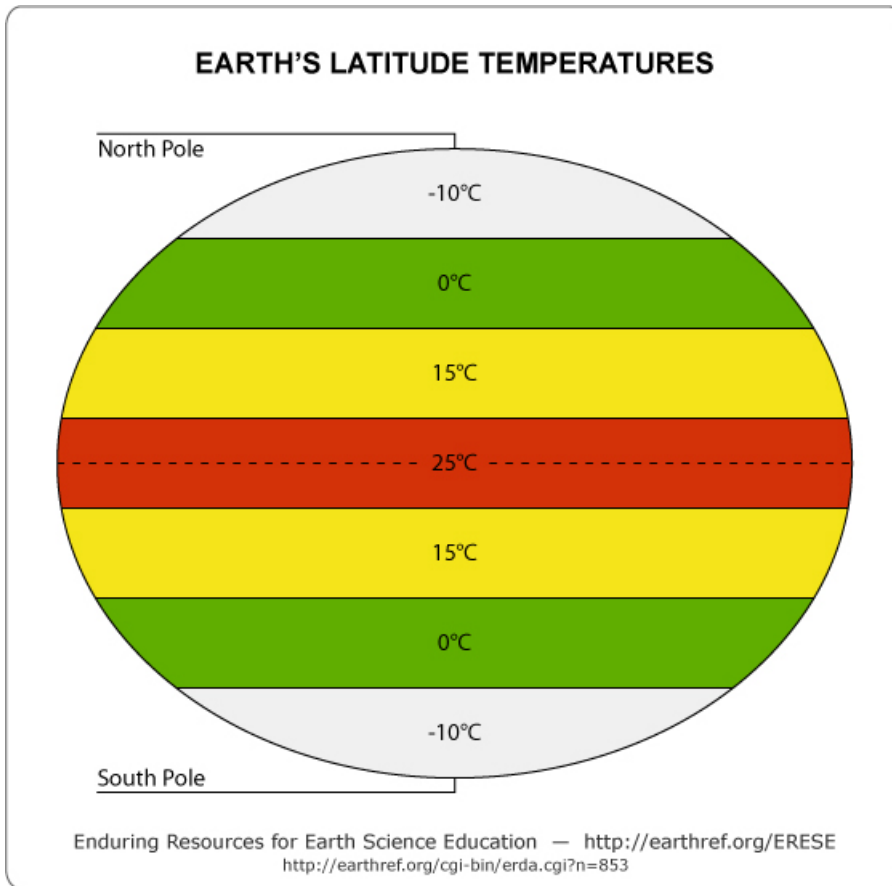
9. The surface of the ocean near where these scientists sampled is 26 degrees Celsius, predict the temperature of the ocean at 5000 meters depth.

10. Graph CTD Data: This is ocean data collected from near the submarine volcano Lo'ihi located on the deep underwater slopes of the big island of Hawaii. Lo'ihi is an active volcano that rises 4000 meters from the seafloor and will become the next Hawaiian island when it reaches the surface. The CTD cast was made at the deep edge of Lo'ihi in 5000 meters of water. Pick up a copy of the data table, a length of paper off the roll and 4 colored pencils. You may work with a partner, but you must each turn in your own graph. You will graph temperature and dissolved oxygen ($\mu\text{mol/Kg}$; "DO") against depth.

Discussion: Look at the data, what should be the maximum and minimum numbers on the axes be? What depth interval should we use for temperature and DO? Should it be the same all the way to 5000 meters or do we lose some information if we use too large an interval? Using what you know about dissolved oxygen why does DO go down in the warmest water, and why does DO go up in the colder water?

11. Add a third line and axis to your graph for pressure.

12. Add a fourth line and axis to your graph for salinity. The minimum for this axis should be 34.6 and the maximum should be 35.1. When you finish your graph compare it with those of other students to check your work. Which is easiest to read? Which is most accurate? When you are satisfied with your graph tape the top edge into the binding of your journal and fold it neatly into the journal.
13. How does pressure change with depth? (please copy the question; use numbers from the data in your explanation)
14. According to the data where is the warmest water? Where is the coldest? What is heating up the warmest water? (please copy the questions)
15. How are temperature and salinity related in the top 300 meters of the ocean? Explain the pattern from your graph and propose a possible explanation for the increase in salinity. (please copy the question; use numbers from the data in your explanation)
16. Why is the coldest water so cold? The average surface temperature on Earth is about 15 degrees Celsius. Propose an explanation for why the deepest water is so much colder than 15 degrees. (please copy the question; use numbers from the data in your explanation)
17. This is a diagram of the Earth showing how average surface temperature changes with latitude. Please sketch the diagram in your journal.



18. Looking at your diagram of the temperature of the Earth answer the following questions.

- a. Where on Earth do we find water as cold as water at 5000 meters depth?
- b. What does this tell us about where the deep water formed?
- c. Propose an explanation for the temperature of the deep water using this diagram.

The end of the lesson can be used to introduce the two layer ocean model. Students can then use the data and their graphs to discuss how the two layer model is supported or not supported by the data. The two layer ocean emphasizes the lack of primary productivity below the photic zone. This lesson is followed by a lesson on thermohaline circulation.