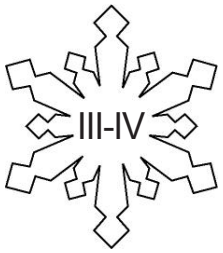
Saltwater Science

Levels



Grades 5-8

Overview:

In this hands-on lesson, students explore the effect of density on the oceans and the formation of sea ice through teacher demonstration and student investigation. (NOTE: This lesson may require more than one class period.)

Objectives:

The student will:

- conduct an investigation;
- collect and interpret data; and
- explain the connection between density and ocean circulation.

GLEs Addressed:

Science

- [5-8] SA1.1 The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring, and communicating.
- [5] SA1.2 The student demonstrates an understanding of the processes of science by using quantitative and qualitative observations to create inferences and predictions.
- [6] SD1.2 The student demonstrates an understanding of geochemical cycles by identifying the physical properties of water within the stages of the water cycle.
- [7] SB1.1 The student demonstrates an understanding of the structure and properties of matter by using physical properties (i.e., density, boiling point, freezing point, conductivity) to differentiate among and/or separate materials (i.e., elements, compounds, and mixtures).
- [8] SB1.1 The student demonstrates an understanding of the structure and properties of matter by using physical and chemical properties (i.e., density, boiling point, freezing point, conductivity, flammability) to differentiate among materials (i.e., elements, compounds, and mixtures).

Vocabulary:

density - the mass of a substance per unit volume <*density* expressed in grams per cubic centimeter>
salinity - the amount of salt in a given volume of water

Whole Picture:

When salt and other minerals from the earth dissolve in water, the water becomes very different than fresh water. A ship can carry more cargo in seawater than in a freshwater because it floats higher, and salt water won't freeze until its temperature drops a few degrees below freezing. Unfrozen salt water can be extremely salty and dense (heavier than fresh water), or it can be less salty and light, riding on top of saltier water. This mixing of really salty water with less salty water happens all the time off the coast of Alaska, where streams and rivers flow into the ocean and make the salt water near them less dense.

Materials:

- (4) 400-milliliter beakers
- Kosher salt
- Ice cube trays
- Food coloring: red, blue, green, and yellow
- Water
- Small clear cups (five per group)
- Clear straw (one per group plus one for demonstration)

- Small lump of clay or play dough (one per group plus one for demonstration)
- Tape
- Pipette (one per group)
- Salt
- 4 1-liter bottles, empty
- Tablespoon measure
- *Global Climate* Interactive DVD
- OVERHEAD: “Ocean Water Layering”
- STUDENT WORKSHEET: “Density Rainbow”

Activity Preparation:

1. The day before the lesson or sooner, mix together plain water and food coloring and pour into ice cube trays. Freeze.
2. Prepare water samples for the saltwater demonstration (Activity Procedure 1).
   a. In a 400-milliliter beaker, mix 1 tablespoon of salt into 200 milliliters of warm water. (NOTE: Warm water will help to dissolve the salt.) Label the beaker, “Demo A.”
   b. In a second 400-milliliter beaker, pour in 200 milliliters of water. Label the beaker, “Demo B.”
3. Prepare solutions for the “Density Rainbow” lab.
   a. Fill each of the 4 1-liter bottles three quarters full with warm water. You may cut the tops off to make this process easier, or use a funnel. (NOTE: Depending on your class size and the amount of water students use, more solution may be needed.)
   b. In one bottle, mix 18 tablespoons (equal to 1 1/8 cup) of salt and blue food coloring.
   c. In a second bottle, mix 11 tablespoons (equal to ½ cup plus 3 tablespoons) of salt and red food coloring.
   d. In a third bottle, mix 4 tablespoons of salt and green food coloring.
   e. In the last bottle, mix several drops yellow food coloring. There will be no salt in this solution.

Teacher’s Note: Add enough food coloring to make the water dark in color. Once poured in the straw, the color will be lighter and less easy to see. Depending on the class size, more salt solution may be needed. If more needs to be made, be sure to use the same proportions of salt and water. Warm water aids in the dissolving of the salt, but may result in more mixing of colors during the investigation. If possible, chill water prior to class.

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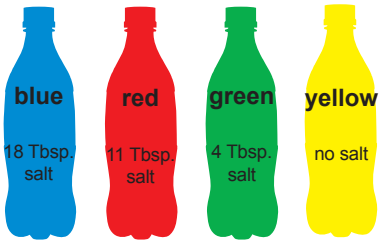
4. Prepare the water samples for Activity Procedure 15.
   a. Fill two 400-milliliter beakers with water.
   b. Stir 1 tablespoon of kosher salt into one of the beakers.
   c. Ensure that colored ice cubes are at an easy to reach freezer location.



Activity Procedure:

1. Place “Demo A” and “Demo B” (Activity Preparation 2) on a surface where all students can easily observe. Ask students to make observations about the two substances, but do not allow them to touch the beakers or their contents. List student observations on the board. Ask students what they think will happen if food coloring is added to each substance, but is not mixed in. List student predictions on the board. Place 4 drops of food coloring into each beaker; do not stir. Ask students to describe, in writing or orally, what happened and their ideas about why it occurred.
2. Explain the cause of the unusual behavior was because one beaker contained salt, while the other one did not. The addition of salt into the water in the beakers caused the density of that liquid to

increase. Since the food coloring is the same density as regular water, but less dense than saltwater, it mixed in with the regular water, but floated on the surface of the saltwater.

3. Ask students if sea ice in the ocean mixes or floats on the surface of the ocean. Ask them to explain their reasoning. If necessary, explain that density is a physical property of matter. Density depends on the mass of the atoms or molecules that make up a compound, and how tightly packed these atoms or molecules are. The more closely packed the individual particles, the more dense the substance. If one were to place two non-mixing liquids in a beaker, the denser liquid would sink to the bottom. An object, such as an egg, sinks in a liquid of lesser density and floats in a liquid that is denser.

Teacher's Note: Explain that the measure of density is the mass divided by the volume. For example, if solution A and solution B have the same volume, but solution A has a higher mass, then it is more dense than solution B.

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4. Explain that students will complete an investigation with various substances and demonstrate their understanding of density. Divide students into pairs or small groups.
5. Explain that in this activity, each group will try to determine which solution contains the most salt, based on their knowledge of density. Remind students that the denser solutions will sink to a lower level than the less dense solutions when they are layered in a straw.
6. Plug the bottom of the straw with a small piece of clay. Demonstrate how to layer a less dense solution on top of a more dense solution (such as yellow on blue). Use a pipette to remove a small amount of blue solution from its cup and let it drip down the side of the straw. Then, use the pipette to retrieve a small amount of yellow solution. Layer it very slowly by dripping it down the side of the straw over the blue solution.
7. Explain that if students layer slowly, and the colors mix, they have the wrong order and will need to start over. Demonstrate by repeating the demonstration in Activity Procedure 6 with the colors reversed; blue over yellow. The solution should turn green. (NOTE: Colors will mix a small amount where they contact, but will not completely mix if a less dense solution is poured over a more dense one.) Explain that the empty cup is for groups to pour out their straw when they need to start over.
8. Distribute the STUDENT WORKSHEET: "Density Rainbow."
9. Distribute a straw, empty cup, small lump of clay or play dough, pipette, and one cup of each prepared solution (green, blue, red, and yellow) to each group.
10. Direct students to begin the investigation by following the directions on their student worksheets. Tell students not to taste the prepared solutions at any point. Assist as needed. (NOTE: Student results should reflect the order of most dense to least dense solution: blue on the bottom, red above blue, then green, and finally yellow on the top.)

Teacher's Note: This activity may be adapted for younger students by replacing the straw and clay with a plastic graduated cylinder.

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11. Display the *Global Climate* DVD "Earth's Systems" Unit, Hydrosphere and Great Ocean Conveyor Belt pages. Discuss how the Great Ocean Conveyor Belt connects to the "Density Rainbow" lab.
12. Display OVERHEAD: "Ocean Water Layering." Explain that ocean water layers just like saltwater and regular water in a beaker. The entire ocean consists of saltwater, but different parts of the ocean have different concentrations of salt. Even in one particular geographical region, there can be variations.
13. These density variations result in a layering of ocean water. (NOTE: Density variations are also caused by temperature.) In general, there are three layers of water: the top layer, or surface mixed zone is the least dense and the least salty; the deep water zone has the highest concentration of salt; and the transition zone is in the middle and serves as a barrier between the surface mixed zone and

the deep water zone.

14. The surface mixed zone is where sea ice forms. The salt, in addition to making the water more dense, changes the freezing point of the water. The saltier the water the colder it has to get for the ocean water to freeze.

15. Place the two beakers of water and saltwater in a location where students can see. Explain that one beaker contains water and one beaker contains saltwater. An ice cube will be placed in the water, which should be at room temperature. Place one colored ice cube in each beaker and observe as the ice cubes melt.

16. Divide students into small groups and ask each group to use the information they just learned to explain why the ice in the two beakers behaved differently. After an allotted amount of time, ask students to share their explanations with the class.

17. Explain the heat from the water caused the ice to melt. As the ice in the regular water melted it mixed in with the freshwater. In the beaker with saltwater, the ice cube also melted. However, in this case, the denser saltwater resulted in the cold water staying at the top of the beaker, resulting in a slower melting rate. The difference can be seen in the coloring from the ice cube. In the regular water color is mixed throughout, in the saltwater it is all at the top.

18. Sea ice melts in much the same way. When ice crystals begin to form on the surface of the water, the salt in the water accumulates into droplets called brine. This brine is generally expelled back into the ocean. As salt is ejected into the ocean, the water's salinity increases. Because saltwater is heavier than freshwater, the density of the water increases and the saltwater sinks, just like in the demonstration at the beginning of the lesson, helping to drive ocean circulation.

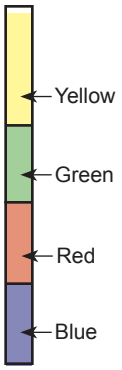
19. Sometimes the brine droplets become trapped in pockets between the ice crystals. These droplets are filled with salt, but the ice around them is not. Because of the high concentration of salt in these droplets, the freezing point is lowered and the brine stays liquid for a very long time. Eventually, from melting, gravity, or cracks in the ice, the brine finds its way back to the ocean.

20. When the ice melts in the summer, the cold freshwater mixes with the ocean surface saltwater to form the surface mixed zone.

CRITICAL THINKING ACTIVITY - Circle Discussion Method: Divide students into two groups. The groups should form concentric circles. Assign the interior circle the following topic to discuss: If sea ice did not form, how would ocean water be affected? Why should we care? Ask the other circle to listen. Then, have students reverse positions. Do not correct student misconceptions during discussion; however, if needed, remind students that cold dense water in the ocean sinks and is replaced by warmer water.

Extension Idea: Introduce students to the mathematical formula for density: mass ÷ volume. To demonstrate, measure the same volume of each salt solution (i.e., 50 milliliters), then weigh each solution on a gram scale that measures to the hundredth gram (.01 grams). Compare the weights, volumes, and densities in a chart and discuss. ([7] N-7)

Answers:

1. 

2. A. blue
   B. It was the most dense.

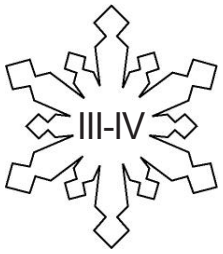
3. Deep Water Zone

Name:_____

Density Rainbow

Student Worksheet (page 1 of 2)

Levels



Background Information: The density of a substance (gas, liquid, or solid) depends on the mass of the particles that make up a substance and how tightly packed they are.

Directions:

STEP 1. Place the straw firmly into the clay. The clay will serve as a plug to hold in liquid and a base to hold the straw upright.

STEP 2. Use the pipette to add a small amount of a solution to the straw. Allow the solution to drip slowly down the side of the straw.

STEP 3. Use the pipette to add a small amount of a second solution to the straw. Allow the solution to drip slowly down the side of the straw.

STEP 4. If the colors mix, pour the mixed solution into the empty cup and repeat steps 2 and 3. If not, proceed.

STEP 5. Continue until there are four distinct layers in the straw.

STEP 6. Answer the questions below and on the following page.

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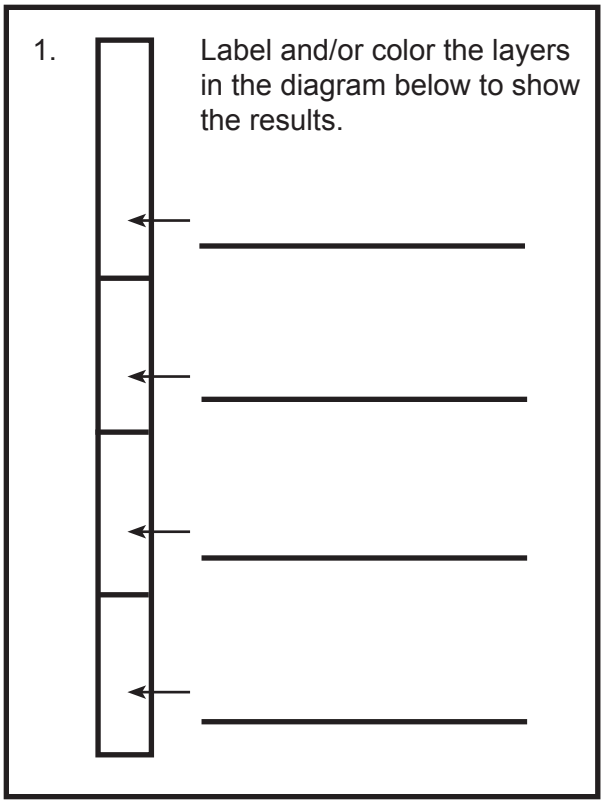
1. Label and/or color the layers in the diagram below to show the results.



Name:_____

Density Rainbow

Student Worksheet (page 2 of 2)

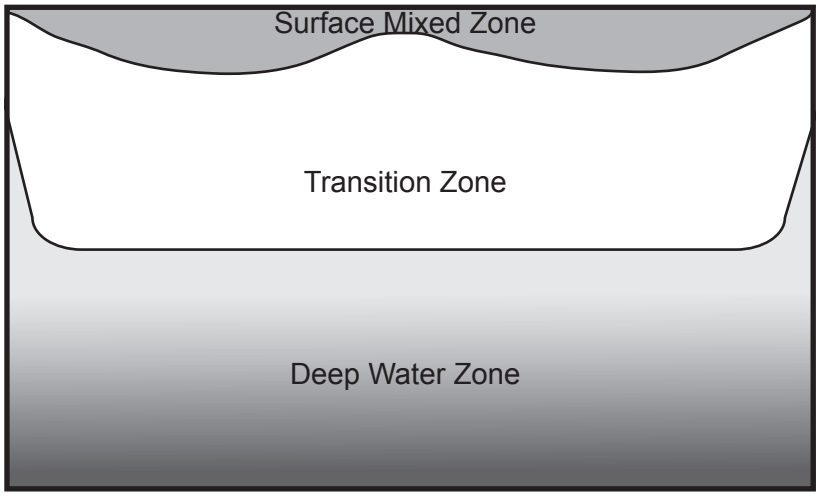
2A. Which color of salt solution contains the most salt?

_____

2B. How do you know? _____

3. Based on the diagram below and what you know about density, which is more dense: waters in the Deep Water Zone, or water in the Transition Zone? _____

Ocean Water Layering



Ocean Water Layering
Overhead