CURRICULUM SUPPLEMENT

STRATEGIC STRATIFICATION

A WATER STRATIFICATION SIMULATION

For use with the **Discovery** section of GULF WATCH ALASKA: THE MYSTERY OF THE BLOB

Overview: Students will discover how important the role of density is in determining ocean layer stratification or mixing. During the first of four activities, students will be introduced to the concept of density by observing a demonstration utilizing the buoyancy of some favorite sugary drinks. Then students will construct and observe a series of varying temperature and salinity activities to demonstrate that variations in density due to temperature and salinity drive stratification of the water column and ocean currents on a regional and global scale.

Learning Objectives:

The student will:

- *Understand and be able to explain* ***the role of temperature and salinity in determining the density*** *of a body of water.*
- *Analyze how the rate of movement of* ***molecules of water changes under varying temperature conditions****.*
- *Explore how the* ***density of sea water is the major factor governing its vertical movement****.*
- ***Develop models that compare the density of molecules in fresh and salt water*** *under varying conditions of temperature and density and make inferences about how this drives stratification and mixing in the ocean water column and regional and global water patterns.*

Standards Addressed:

Alaska Science GLEs:
https://education.alaska.gov/akstandards/standards/standards.pdf
5th: SA1.1, SA1.2, SA3.1
6th: SA1.1, SA1.2
7th: SA1.1, SA1.2
8th: SA1.1, SA1.2

Next Generation Science Standards:
https://www.nextgenscience.org/search-performance-expectations
MS-ESS2-1, building toward MS-PS1-4

Ocean Literacy Principles:
http://oceanliteracy.wp2.coexploration.org/ocean-literacy-framework/principles-and-concepts/
OP #1: The Earth has one big ocean with many features.

Materials/Location Needed:

- *Activity 1:*
  - *Large, transparent container, such as an old aquarium tank*
  - *Room-temperature tap water*
  - *An un-opened can of Diet Coke (or some other diet soft drink)*
  - *An un-opened can of Coke (or some other non-diet soft drink)*
- *Activity 2:*
  - *Table Salt, such as a can of Morton Regular Salt or Kosher Salt, for creating salt solutions*
  - *Large bucket for mixing (>1gallon)*
  - *Room-temperature tap water (if available, distilled water will work better because tap water often has minerals)*
  - *Tablespoon measurement*
  - *Mixing spoon*
  - *Liquid food coloring*
  - *Transparent plastic cups (2 per group)*
  - *Liquid pipette dropper (1 per group)*
- *Activity 3:*
  - *One, large transparent container for each group of 3-4 students*
  - *Room-temperature tap water*
  - *Hot tap water (not boiling)*
  - *2-3 colors of liquid food coloring*
  - *Freshwater ice cubes, enough for each group to cover the top of their container*
- *Activity 4:*
  - *Stopwatch or timer (1 per group)*
  - *Freshwater ice cubes (~4 per group)*
  - *Transparent plastic cups (2 per group)*
  - *Pre-mixed salt water solution (see Activity 2)*
  - *Room-temperature tap water*
  - *Liquid food coloring*

Teaching Time: 2-3, 40 min periods

Preparation Time: 40 minutes.

Background:

The density of water is affected by two factors: temperature, and the amount of dissolved material. The relationship between these two factors acts as the major governing force for the vertical movement of ocean water, leading to stratified layers and current exchange. While in liquid form, water molecules move around each other randomly. A decrease in temperature causes water molecules to slow down and get slightly closer together, now taking up a smaller volume and causing an increase in density. An increase in temperature causes water molecules to speed up and spread apart, now filling a larger volume that results in a decrease in density.

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Salt water is denser than fresh water because it contains dissolved minerals. The higher the salinity of a water mass, the greater its density. The temperature and amount of minerals dissolved in a water mass affects the way it will behave when it comes in contact with other, different water masses. When two water masses of differing salinity meet, the fresher, less-dense water floats above the saltier, denser water. When temperature and salinity are competing forces in a system, there are a number of factors that determine which is more important to the mixing and layering of the body of water. Stratification of water within a system is pivotal in determining the distribution of currents, nutrients, sediments, and organisms in the water column.

For further background information on mass, volume, and density, and how this lesson plan addresses MS-PS1-1, take a look at the following video:
http://www.middleschoolchemistry.com/lessonplans/chapter3/lesson6

Directions:

1. After completing the **Discovery** section of *Gulf Watch Alaska: The Mystery of the Blob*, explain to your class that they are going to discover the factors that go into organizing water below the surface of the ocean. The students will have a chance to build and observe water-layering simulations and utilize the scientific method to develop hypotheses and investigate how temperature and salinity affect the density of water.

2. **Activity One:** Fill a large, clear container with room-temperature tap water. Present the class with the two different cans of soda; pass them around and ask the students if the two cans feel like they have different weights. Ask the class if they think the cans will sink if you drop them into the container of water.
    a. If there is disagreement, ask the class if each can will do something different.
3. Once the class has come to a decision, place both cans in the water. Have the class observe what happens. The results will likely spark surprise and present an opportunity to discuss the difference between volume, mass, and density. This is where you can introduce the idea that not all liquids, specifically water, have the same density.

4. **Activity Two:** Prior to starting the lesson, make a salt water solution adding 11 tablespoons of salt to 1 gallon of room-temperature water, mix, and allow time for salt to dissolve. Prepare a second 1-gallon sample of room-temperature water (without salt) and mix in a visible amount of food coloring.
    a. To ensure the solution is dense enough, pour a small sample into a transparent cup and add a few drops of food coloring to the surface. The coloring should form a layer on top; if it sinks immediately, add more salt.
5. Provide small groups of students with a single transparent cup filled with the salt water solution. Additionally, give each group a single plastic dropper and a small sample of the colored fresh water.

6. Instruct students to fill the dropper with the colored freshwater and gently lower the dropper into the middle of the transparent cup filled with the salt water. Have them slowly squeeze the dropper to release the colored freshwater and observe what happens.

7. **Activity Three:** Have the students break up into small groups (3-4 students per groups). Prepare two freshwater samples – enough water for each group to perform the experiment in their containers; put a few drops of different food coloring in each so that the two have distinct coloration.
    a. One water sample at room temperature
    b. One hot water sample (not boiling)
8. Have students carefully pour some of each sample into an aquarium / tank to create two layers of different colored water. This represents a stratified or layered water formation found where the sun warms the upper layers of water and the colder, denser water sinks to the bottom.
    a. Either guide the students to put the coldest sample in first or let them work with the materials to solve the problem themselves.
9. Once the students have distinct water layers in the container, instruct them to add ice to the surface at one end of the container. As the ice melts into dense, cold water, they should see the cold water move toward the bottom, causing visible circulation patterns in the colored water layers.
10. Next, have the students compare this process with what happens when ice is covering the entire surface of the tank.

11. **Activity Four:** Within their small groups, students will now combine experimental ideas by utilizing density and temperature differences.
    a. On the worksheet, have students predict whether ice cubes would melt faster in salt water or faster in fresh water and provide their reasoning.
12. Pour an equal volume of salt water and fresh water into two transparent cups for each group of students. Mark the cups accordingly.
13. Place two fresh water ice cubes in each cup and observe and time / record the melting. When there is less than half of the ice remaining in each cup, place one drop of food coloring carefully onto the top of one of the ice cubes in each cup and observe what happens.

Assessment:

- Participation in classroom discussion and labs.
- Scientific reasoning demonstrated in explanations on worksheets.
- Accuracy of models in demonstrating and understanding of the relationship between density and temperature.

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Credits:

This lesson was adapted from the University of California Berkeley Communication Ocean Sciences course and the ACS Middle School Chemistry Lesson 3.6, on Temperature and Density. For further activities, worksheets, and videos on this topic, follow the link below:

http://www.middleschoolchemistry.com/lessonplans/chapter3/lesson6

STUDENT WORKSHEET

Name _____ Date_____Class_____

Activity #1:

1. What about the contents of the soda cans made them behave differently?

_____

_____

_____

Activity #2:

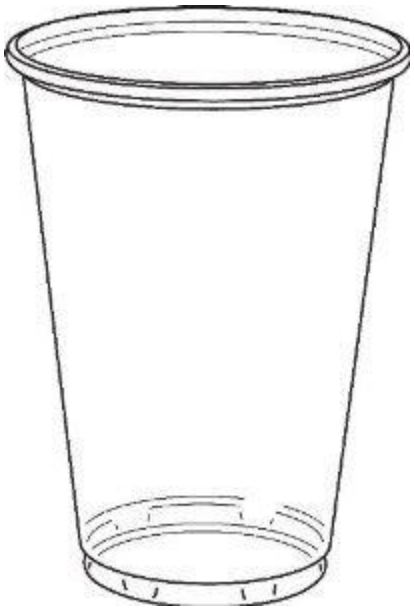
1. Predict what will happen when you place a small sample of fresh water in the middle of the salt water.

_____

_____

_____

2. Draw and label what you observed when you added the fresh water to the salt water.



3. Explain why the water moved the way it did within the cup.

_____

Is *salt* water **more dense**, **less dense**, or the **same** density as *fresh* water?

STUDENT WORKSHEET

Activity #3:

1. Is cold water **more dense**, **less dense**, or the **same** density as room temperature water?

   Is room temperature water **more dense**, **less dense**, or the **same** density as cold water?

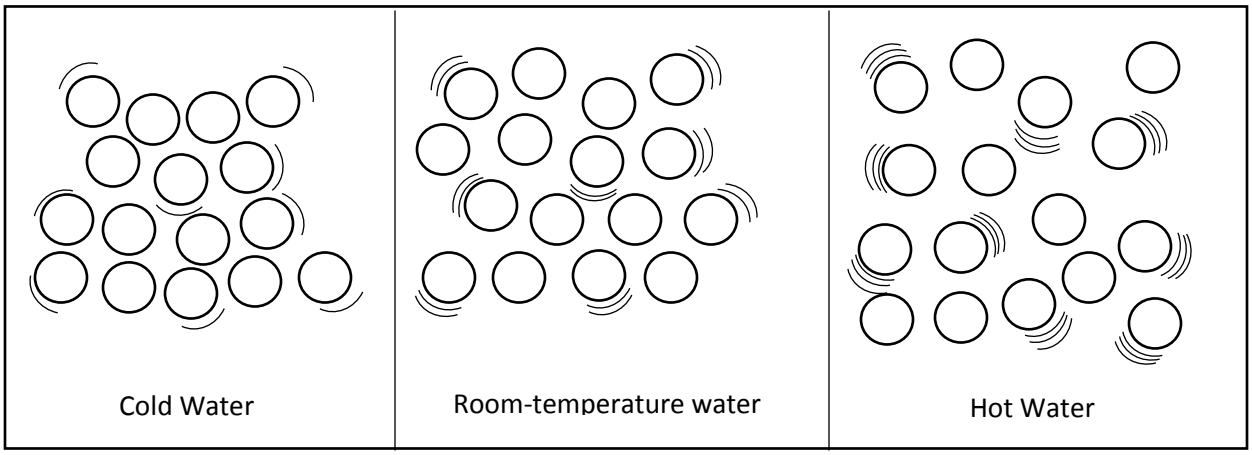
2. Compare and contrast placing a few ice cubes in the corner of the container to covering the whole surface with ice.

   _____

   _____

   _____

Look at the model of water molecules in the diagram below to help you compare the volume, mass, and density of cold and hot water.



Write *more, less,* or *same* in the chart to describe the volume, mass, and density of cold and hot water compared to room temperature water.

Comparing cold and hot water to room-temperature water		
	Cold Water	**Hot Water**
Volume		
Mass		
Density		

STUDENT WORKSHEET

3. Why does cold water sink in room-temperature water?

_____

_____

4. Why does hot water float on room-temperature water?

_____

_____

Activity 4:

1. Make a prediction: will the ice cubes melt faster in the salt or fresh water? Why?

_____

_____

2. Record how much time was required for half of the ice to melt in the salt and fresh water.

Salt Water	**Fresh Water**
_____	_____

3. Was your prediction correct? Explain what you observed.

_____

_____

_____

4. Draw a model of changes in the density of water molecules that occurred as the ice cube melted in salt water that explains what happened. (Hint: What happened around the ice cube?)

STUDENT WORKSHEET

5. Now that you've watched the animations and modeled how variations in temperature and salinity impact density and drive water currents, explain how the Blob affected the stratification of the Gulf of Alaska?

6. What do you think drives changes in densities of different water layers, thus stratification and currents in the Gulf of Alaska? What causes mixing after the Gulf has stratified into different layers? How do stratification and mixing affect marine life?