**The Dense Seas**

**Density and Deep Water Circulation**

**Timeframe:** 2 forty-five-minute sessions

**Target Audience:** 4th-6th Grade

**Suggested Materials and Cost Points:**

* Small clear plastic tubs
* Squeeze bottles
* Food dye
* Ice
* Table salt
* Water

**Description**

Utilizing a classic activity, students will learn how salinity and temperature affect the density of seawater. Students will then examine oceanographic maps to hypothesize where in the world seawater might be the densest. From there, students will learn about the importance of the deep-sea circulation.

**Objectives**

Students will learn:

* How temperature, pressure, and salinity affect density
* The importance of density for understanding deep sea circulation.
* How ocean currents control global climate and weather patterns

**Essential Question**

Why is density an important measurement to have when studying the ocean?

**Background Information**

The equation for density is mass divided by volume. Water is a little different though. Pressure, temperature, and dissolved particles in solution all alter the density of water. All of these factors are especially important to consider when calculating density in the ocean. **Density is not consistent in space and time within the ocean.**

Temperature affects salinity because it determines how spread out or condensed molecules are in space. If the temperature of water is warmer the water molecules are more spread apart (think of the transition from liquid to vapor). If water is colder the molecules are closer together (think of the transition from liquid to ice). When molecules are closer together there is more mass in a given volume. So colder water is more dense than warm water.

Salinity effects density because it adds mass into the given volume. Salinity is the amount of dissolved particles in solution. The more particles there are in a given volume, the greater the mass and the greater the density. This is why cold, salty water is more dense than fresh water.

As the ocean gets deeper, more pressure is placed on the seawater, condensing the volume and squeezing particles closer together, so density increases with depth.

The coldest, saltiest water is formed in the North Atlantic. This water then sinks and starts what is known as thermohaline (thermo= temperature, haline = salty) circulation or the “deep sea conveyor belt.” This conveyor belt is responsible for circulating ocean water all over the earth and ultimately ends in the North Pacific. Thermohaline circulation helps control ocean temperature and is a factor in global climate as it moves cold water to warmer parts of the globe and warm water to colder parts of the globe. Climate change might be slowing down thermohaline circulation as water warms up and less sinks to the bottom in the North Atlantic. Scientists are still uncertain but concerned about what this means for global climate.

**Preparation**

The day before prepare lukewarm water squeeze bottles. One will be fresh and the other will be salty. Make sure they are both different colors from one another. Let the squeeze bottles sit overnight so they are the same temperature the next day for the activity.

You can also prepare what will be the cold squeeze bottles the night before, but only fill up halfway. Add ice in the morning and keep in the fridge, or add ice an hour before class starts.

Fill tubs with water beforehand, or have student’s fill tubs with water during the experiment. Prepare the room as needed for water/wetness. Always a good idea to have rags and towels on hand.

**Activity 1: Create the Deep-Sea Conveyor Belt**

1. Utilize the accompanying powerpoint to introduce students to the concept of density.
2. Split students up into groups of 3-4
3. Give each group a kit with the following:

* 1 tub full of water
* Four Labeled squeeze bottles with dyed water
  + Luke warm fresh water dyed green
  + Luke warm salty water dyed red
  + Cold fresh water dyed yellow
  + Cold salty water dyed blue
    - Note: Color doesn’t matter, just make sure that each are different

1. Make sure students understand that colors should be all dripped on the same side of the tub and should be done one at a time
2. Hand out provided instructional worksheets for students to make observations for each squeeze bottle.
3. When students are done come back together as a group and discuss their observations

**Activity 2: Data Exploration**

1. Invite students to become oceanographer’s themselves and figure out where the most dense water in the world is based on the observations they made in the last activity
2. Hand out the appropriate worksheet to student groups
3. When students are done come back together as a class and talk about their answers
4. After the discussion show the following video:

* [**https://youtu.be/p4pWafuvdrY**](https://youtu.be/p4pWafuvdrY)

1. When the video is over offer the following prompt:

* *There is still a lot scientists are learning about ocean circulation. After watching that video, what are some questions you would like to answer about ocean circulation?*

**Expansion/Concerns**

1. Creating a whole class model of the mixing in the tub. This can be done by having individual groups/students offer up their three phase model, as the class creates a whole class model to explain and describe what happened in the tank and how that may or may not replicate deep ocean mixed.
2. Compile student questions and place students into groups based on similarity of questions. These groups can be research teams and go forth on an internet exploration to try and figure out if there is an answer to their questions or if scientists are still figuring the answer to their question out.
3. Weather Patterns and Ocean Currents. Creating a model for how the biosphere, geosphere, atmosphere and hydrosphere interact, specifically in the case of ocean and climate interactions is a major part of NGSS. This lesson may go well with other lessons looking at connections between earth systems.

**Density Observation Worksheet**

**Remember to squeeze solution on one side of the tub!**

1. **Squeeze a few drops of the room temperature/fresh water solution (\_\_\_\_\_\_\_\_\_)**

**What do you observe?**

1. **Squeeze a few drops of the room temperature/salty solution (\_\_\_\_\_\_\_)**

**What do you observe?**

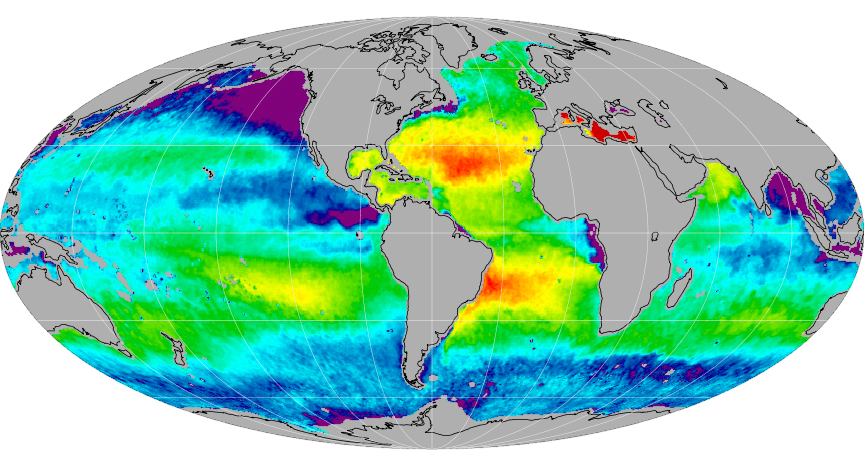
1. **Squeeze a few drops of the fresh/cold solution (\_\_\_\_\_\_)**

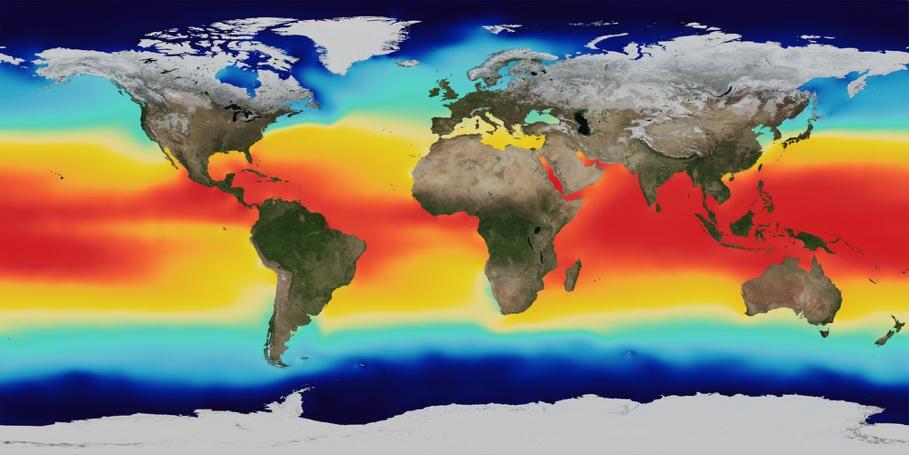
**What do you observe?**

1. **Squeeze a steady stream of the cold/salty solution (\_\_\_\_\_\_\_)**

**What do you observe?**

**Exploring Global Data**







**The images above are of sea surface salinity and temperature. Red colors indicate higher than average sea surface salinity and purple indicates lower than average sea surface salinity in the map on the left.**

**Red colors indicate high sea surface temperature and dark blue indicates low sea surface temperature in the map on the right.**

**Utilizing what you know about how salinity and temperature affect density, circle the parts of the ocean you think has the densest water on the map below:**

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