Water Density and the Ocean

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Topic: Explore the role of temperature and salinity in changing the density of water samples. Observe and discuss the impact of density differences in the ocean.

Audience: Grades 9 and up.

Length: 45 - 60 min

NJ State Standards: (scale with student's grade level)

- 5.1.A – Understand Scientific Explanations
- 5.2.A – Properties of Matter
- 5.4.G – Biogeochemical Cycles

Objectives:

- Establish some properties that define an ocean habitat.
- Observe interactions different water masses have with each other based on density.
- Learn techniques to determine water properties like salinity and temperature, calculate density of water samples.
- Use collected measurements and calculations to explain observations and support reasoning.

Introduction:
What can you tell me about ocean properties? Why do scientists care about, and measure properties like salinity and temperature? Ocean water properties such as salinity and temperature create a spectrum of different water masses and habitats in the ocean. We will focus this experiment on how different water masses interact with each other in the ocean. Different water samples will be prepared and experimented with, controlling variables of temperature and salinity.

Background:
The ocean can be divided into many different zones, depending on the water property being used. Light penetration can define photic zone, aphotic zone; as one example of this. The focus of this lesson will be the impacts of properties like temperature and salinity on seawater. The term water mass refers to a body of water that has consistent physical properties, such as salinity and temperature. There are multitudes of water masses in the ocean that are divided by density differences; they do not require a physical barrier to conserve their unique physical properties. The differences in density are one mechanism that drives vertical circulation of the ocean. The physical properties of the ocean are important to the biology as well; many marine animals either remain within a water mass favorable to their needs, or must adapt to changing water masses.

Materials:

- One 250mL volume beaker per student
- Several stirring rods
- 2 different colors of food coloring (i.e. red and blue)
- Salt – prefer kosher or aquarium salt (dissolves faster)
- One Small Petri dish or watch glass per 2 students plus a few extras

- One density tank per pair of students[1]
- Hot pot
- One 2L beaker (for ice water)
- Ice
- Ready supply of water
- Paper towels (in case of spills)
- Scales with maximum mass rating of at least 3000g
- Probe ware with conductivity and temperature probes.
- One 400mL beaker per Probe ware setup
- Student worksheets (WaterMass_Worksheet_High.pdf)

Procedure:

I. Preparation

1. Set up stations with scales
2. Set up stations with Probe ware, and rinse water in 400 mL beakers
3. Set out student beakers, density tanks, and other needed materials.
4. Pre-measure salt into small Petri dishes or watch glasses.
    a. Vary the quantity of salt in the dishes from a little to a lot.
    b. The largest quantity of salt available to students should still dissolve easily into their water sample.
5. Immediately before the lesson:
    a. Fill the 2L beaker with ice and top off with water.
    b. Fill hot pots with water, and turn on.

II. Activity

1. Instructor will introduce the lesson, and explain that students will work in pairs for this experiment. Explain all the steps of this experiment to students in the order they need to be performed in, and briefly explain how to use the density tank when they reach that step.
2. Pass out worksheet.
    a. Have students decide with their partner what kind of water sample they will make. Students each make their own water sample, but they MUST vary at least one variable from their partner's sample. They may choose hot or cold water, and fresh or salty water. They must also decide who will have red water, and who will have blue water (they must have two different colors between them).
    b. Have students record their water sample decision on their worksheet.
    c. Have students record their hypothesis on their worksheet.
3. Students will prepare the water samples as planned.
    a. Measure the mass of the empty beaker
    b. Add salt, if any, to the beaker, then fill to the 200mL line of beaker
        i. **For Hot Water Samples:** Instructor should fill to 125 mL mark from Hot Pot then dilute the temperature with tap water to the 200 mL mark. (This is to prevent burns to students, and make beakers comfortable to handle)
        ii. **For Cold Water Samples:** Fill 200mL beaker from the ice water. If ice water runs out, refill the 2L beaker with more water, the ice will chill it fast.
    c. Add several drops of food coloring. (Instructor may wish to do this step to prevent stains to clothes and skin)
    d. Use stirring rod to ensure sample is well mixed and salt, if any, dissolves.

[1] A density tank is a divided tank with moveable center barrier. Small versions of these can be purchased from science teaching supply catalogs, or instructions to make one can be found online. They are used to teach ocean and meteorological science concepts. We use: http://sciencekit.com/ig0029656/p/IG0029656/

    e. Measure the mass and volume of the filled beaker
    f. Use probe ware to measure conductivity and temperature.
4. Pass out density tanks to each pair of students; ensure the center barrier is in place.
5. Perform density experiment. (Instructor may need to demonstrate how to use the density tank).
    a. Students pour water samples into the tank simultaneously, one on each side of the divider.
    b. Once the water has stilled, pull out the divider in one smooth motion.
6. After observing the results, students will record their observations on the worksheet.
7. Perform the calculations listed on worksheet.
8. Students will record their conclusions about the relationship of density to the observed behavior of the water samples in the density tanks.

Evaluation:

Have students record whether their hypothesis was correct; why or why not? What affect does density have on the behavior of water in the density tanks? What can students think of that water density might impact in the ocean?

Extension:

Show visuals of real-time data of the New Jersey Coast displaying sea surface temperature and salinity. Display data collected by gliders of temperature and salinity at depth (along Rutgers University, Institute of Coastal Marine Studies IMCS endurance line*). See if students can explain any observed differences between the surface data, and that collected from depth. What impact do differences in water density have in the ocean? How would you relate the concepts of temperature, salinity, and density to ocean habitat?

Safety Precautions:

Hot water could cause burns; care should be exercised with this portion of the activity.

If salt water gets in eyes, flush immediately with plenty of fresh water. The salt should not be harmful to vision, but can sting.

Resources:

- Link to glider data: http://marine.rutgers.edu/cool/auvs/ including endurance line (eline project)

Name: _____

Measuring Water Samples

For Your Sample: Record the information requested in the table below.

For Partner's Sample: Copy the information your partner recorded and measured to fill out this table.

Water Sample Description (*circle*)	**Water Color**	**Mass of Empty Beaker (*Listed on glass*) (g)**	**Total Mass of Beaker and Water Sample (g)**	**Volume of Water Sample (mL)**	**Temperature (°C)**	**Conductivity (µS/cm)**
Your Sample: Hot / Cold Fresh / Salt						
Partner's Sample: Hot / Cold Fresh / Salt						

1. What do you hypothesize will happen when you perform the experiment in the density tank with your sample, and your partner's sample?

2. Record your observations of the density tank: write at least one sentence about what you observed happen within your density tank.

Name: _____

Calculating Water Density

Use the data you recorded, to support your observations. Perform the calculations below, then explain those observations with the results of these calculations.

3. Your Sample:

_____ g	-	_____ g	=	_____ g		
Total Mass of Beaker and Water Sample		Mass of Empty Beaker		Mass of Water Sample		
_____ g	/	_____ mL	=	_____ g/mL		
Mass of Water Sample		Volume of Water Sample		Density of Water Sample		

Fill in the table using your calculation, and your partner's.

Water Sample	Water Color	Density of Water Sample
Your Sample:		
Partner's Sample:		

4. Explain why you think your water samples behaved in your density tank the way they did, use your calculations to support your argument.

Name: _____

Comparing Water Properties

Use the data you recorded, to compare the properties of yours and your partner's samples. Perform the calculations below, and then answer the questions.

1. **Calculating Salinity:**

_____	(µS/cm)	X	0.00064	=	_____	PPT
Your Sample's Conductivity			Conversion Factor		Salinity of Your Sample	
_____	(µS/cm)	X	0.00064	=	_____	PPT
Partner's Sample Conductivity			Conversion Factor		Salinity of Partner's Sample	

2. **Salinity Differences**
   Calculate the difference in Salinity values between Your Sample, and Partner's Sample. To make the math cleaner, put the largest value from the calculations above on the first blank.

_____ PPT	-	_____ PPT	=	_____ PPT	
Larger Salinity Value		Smaller Salinity Value		Salinity Difference	

3. **Temperature Differences**
   Calculate the difference in Temperature values between Your Sample, and Partner's Sample. To make the math cleaner, put the largest measured value on the first blank.

_____ °C	-	_____ °C	=	_____ °C	
Larger Temperature Value		Smaller Temperature Value		Temperature Difference	

Water Sample	Temperature of Water Sample	Temperature Difference	Salinity of Water Sample	Salinity Difference	Density of Water Sample
Your Sample:					
Partner's Sample:					

4. Which water property (Salinity or Temperature) appears to influence density the most? *Use your data to support your answer.*