VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE

http://studentorgs.vanderbilt.edu/vsvs

Saltwater Density

Fall 2010

Goal: To demonstrate the concept of density using saltwater, and to share some information about the salinity of oceans.

Lesson Outline:

I. Introduction

A. Density Activity: Students will discover that saltwater is denser than fresh water by layering the two liquids in a test tube.

B. Density Background Information: VSVS team members will explain the concept of density.

C. Density Demonstration: VSVS volunteers will show students how salt packs around water molecules using a jar of marbles and salt.

D. Floating Solids Demonstration: Students will observe two vials one with saltwater and one with freshwater. A plastic bead will float in the saltwater but not in the freshwater, this illustrates the concept of floating. The poly density bottle also illustrates this concept.

II. **Separation Challenge**: Students will separate a mixture of beads using the concept of density. There are four types of beads with differing densities. As students add salt to the water, the density changes, the beads will float according to their densities.

III. **Estimation of Density Using a Graph**: Students will estimate the density of the blue beads and the yellow beads using a graph.

IV. **Saltwater in the Ocean:** The VSVS team will share some information about oceans with the students.

V. **Review**

Materials

17 ziploc bags containing:
- 1 dropper bottle of 20% saltwater solution (blue)
- 1 dropper bottle of distilled water
- 1 plastic test tube

1 jar with marbles
1 container of salt
8 bags containing
- 1 vial with saltwater and a plastic bead (#1)
- 1 vial with regular water and a plastic bead (#2)

1 poly density bottle
16 containers of salt
16 100 mL bottles water
16 50 mL cylinders
16 8 oz jars
16 Ziploc bags containing:
- 1 small plastic bag of assorted beads
- 1 taster spoon
- 1 Popsicle stick

16 plates
1 roll of paper towels

32 Observation Sheets
32 Instruction Sheets
32 Density Graphs
32 World Maps with Ocean Salinity

I. Introduction

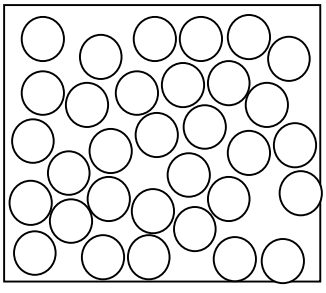
A. Density Activity

Materials:
16 test tubes
16 dropper bottles of saltwater (blue)
16 dropper bottles of regular water

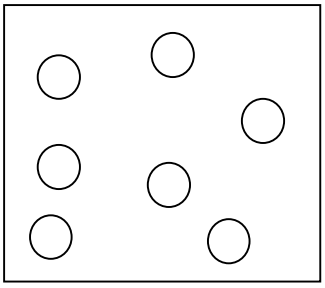
- Divide students into pairs.
- Demonstrate the following procedure for students.
    1. Fill the test tube half full with saltwater (blue) from the dropper bottle.
    2. Carefully tilt the test tube and slowly add the regular water (clear) to the saltwater using the dropper bottle. **It is important that the water go down the side of the test tube, otherwise the liquids might not layer.**
- Have the students perform the experiment.
- Ask students: What do you notice? *There are two separate layers, the saltwater is on the bottom and the regular water is on the top.*
- Ask students: Why do you think the two liquids layer? *Saltwater is more dense than regular water, so the regular water floats on top of the saltwater.*

B. Density Background Information

- Ask the students whether they know what density is. Tell them that they can think of density as how much mass there is in a given volume.
- In math terms, D (density) is equal to mass (m) divided by volume (v): D = m/v. Write this equation on the board, along with the definitions of the symbols (D, m, v).
- Sum up the difference between high density and low density with these generalizations:
    - **High density** means there is a **lot of material** in a **given space** (volume)
    - **Low density** means there is **little material** in a **given space** (volume).
- Have students look at the pictures on their Instruction Sheet. The circles represent material. Both pictures have the same space (area), but the high density picture has much more material (circles).



High density



Low density

Note: While one VSVS member performs the following demonstration, the other team members should assemble the materials for the next part. One VSVS member needs to fill the clear cups for the next part to the 50 mL line with water.

C. Density Demonstration
Materials:
1 2 oz cup of salt
1 glass jar containing marbles

- Show students the glass jar with marbles in it.
- Tell students that the marbles represent water molecules.
- Pour the container of salt into the jar.
- Explain to students that the salt packs around water molecules in a similar way in salt water.
- Ask students why they think saltwater is denser than regular water. *Saltwater has a higher mass because of the added salt, and hence is denser.*
- Share that density is a **property** of solids, liquids, and gases. We will be exploring the densities of **liquids**.

D. Floating Solids Demonstration
Materials:
1 poly density bottle
8 bags containing
1 vial with saltwater and a plastic bead (#1)
1 vial with regular water and a plastic bead (#2)

- Pass out the bags containing the vials with the beads to two pairs of students.
- Explain to students that solids that are less dense than a liquid will float in that liquid. Solids that are denser than a liquid will sink in that liquid.
- Have students take out the two vials.
- **Make sure that students do not remove the tops of the vials!**
- Tell students that the bead in all of the vials has the same density.
- Ask students why the bead floats in vial 1 but not in vial 2. *Vial one has saltwater which has a higher density.*
- Ask students if the bead is more or less dense than regular water. *More*
- Ask students if the bead is more or less dense than saltwater. *less*
- Tell students that each bead in the next experiment has a different density.
- Shake the poly-density bottle.
- Hold the bottle in place and ask students what happened? *The beads separate, with the white beads on the top, and the blue beads on the bottom.*
- Set the bottle down and at the end of the lesson, have the students look at the bottle and observe what has happened.

II. Separation Challenge

Materials:
16 small bags of beads (4 different densities)
16 containers of kosher salt
16 50 mL cylinders
16 taster spoons
16 Popsicle sticks

16 plates
16 clear 8 oz jars (fill with 50 mL water)
32 observation sheets

- Distribute to each **pair** of students:
  - 1 small bag of beads
  - 1 plate
  - 1 jar
  - 1 50mL cylinder
  - 1 taster spoon
  - 1 Popsicle stick
  - 1 observation sheet
  - 1 container of salt (tell them they need to share)
- Tell students to write down the different shapes and colors of beads they see in the bag on their observation sheet.
- Have the students add the beads to the water and stir using the Popsicle stick.
- Tell students to tap all of the floating beads gently to see which ones float and which beads sink to the bottom.

For VSVS information only: Share the following explanation with the students: some of the beads float initially because water has a high surface tension. This surface tension is mostly due to the high intermolecular forces between water molecules making it possible for some things that would normally sink to float. Tapping the bead exerts enough force to break the surface tension. Stirring the water may also break the surface tension.

- Tell students to mark down on their Observation sheets which beads are floating and which are at the bottom of the cup. *The round whitish beads should be the only ones floating at this point.*
- Ask students: How do you think we could separate the rest of the beads? *Since the beads have different densities, they can be separated by floating them in liquids that have different densities. We can gradually change the density of the water by adding salt to it.*
- Have students add one level taster spoon of salt and then stir the water until they can no longer see particles of salt. Tell students it is important to have a level teaspoon. Have the students record what happened.
  - Have any more beads floated to the top? *There shouldn't be any beads floating to the top, but this will vary depending on how much salt students add with the taster spoons.*
- Have students repeat this step. Record what happens after each teaspoon is added.
- Tell students we are going to use their data to estimate the density of the beads.

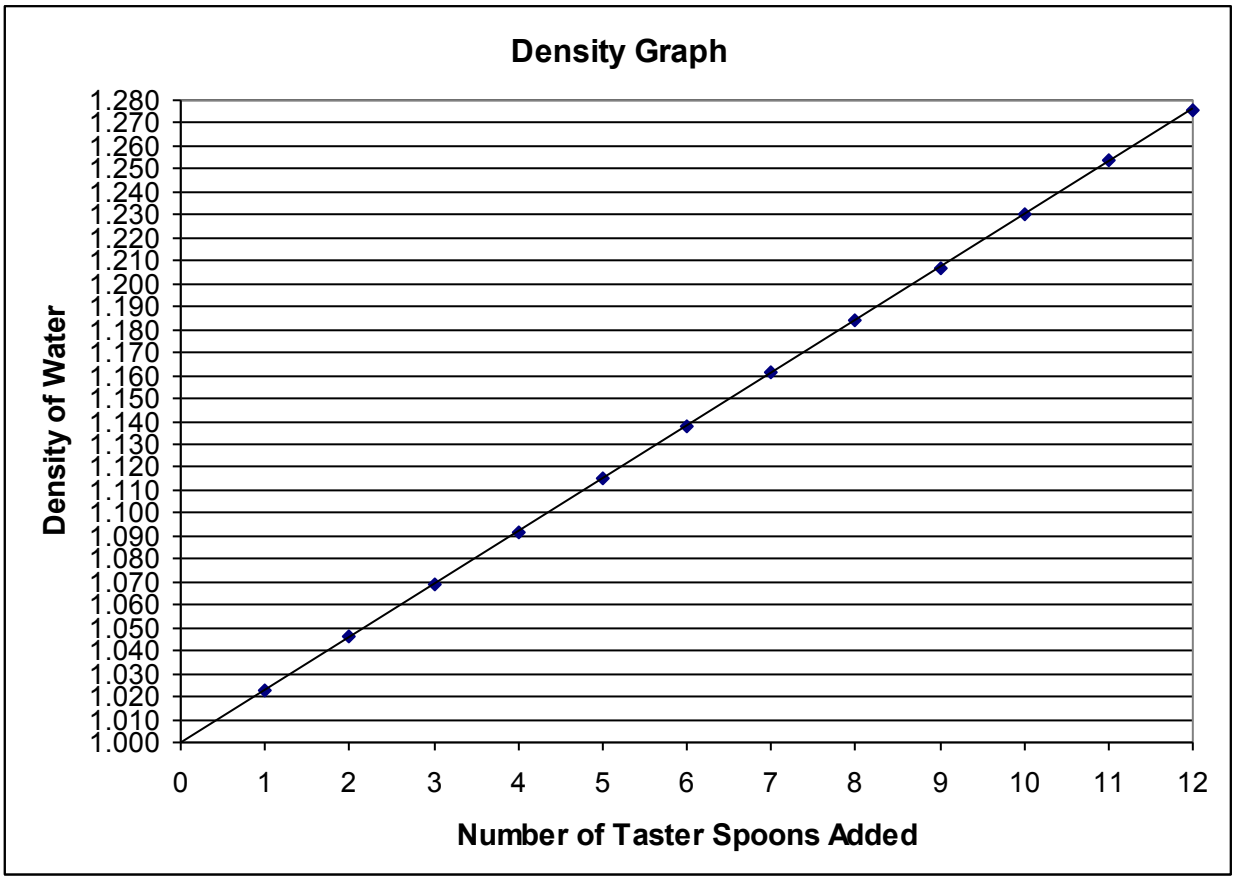
Note: In the lab, 2 taster spoons of salt were required for the blue beads to float, 6 additional taster spoons were necessary for the yellow beads to float. This may vary depending on students' "level teaspoons". The clear beads will not float at all. Students can add several more taster spoons; tell them not to go higher than 12 taster spoons of salt total.

III. Estimation of Density Using a Graph

Materials:
32 Density Graphs

- Hand out the Density Graph to each pair of students.
- Draw a rough representation of the graph on the board, making sure to label the x and y axes.

- Tell students that the density of the salt water has been calculated using a mass of 1.15 g for one taster spoon of salt and 50mL for volume. (Point to the mass/volume equation on the board.)
- The density of regular (fresh) water is 1g/mL.
- The density of the saltwater is calculated using:



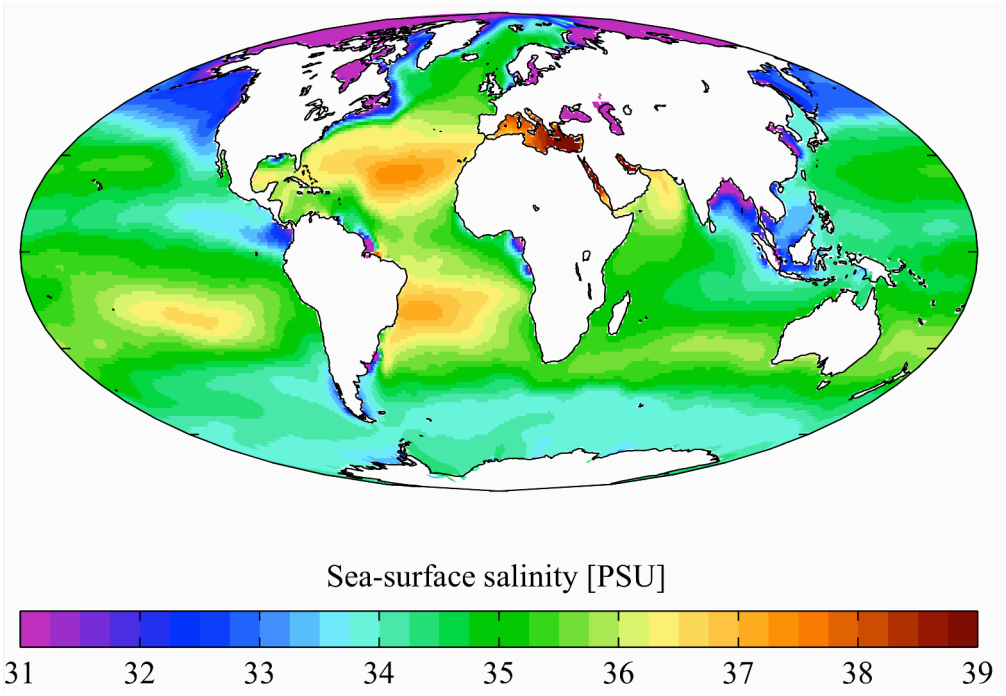
50g of water + (1.15 grams * # of taster spoons of salt added) / 100mL

- Tell students to locate the number of taster spoons of salt that were required to make the blue beads float. This number is on the x-axis.
- Tell students to draw a line from the x-axis to the corresponding value on the y-axis (show them this procedure on the board.) The value on the y-axis is the approximate density of the blue beads.
- Tell the students to repeat this procedure for the yellow beads.
- Have students write down the approximate density on their Observation Sheet.
- Ask students why this procedure does not work for the white beads or the clear beads. *The white beads floated initially, so all we know is their density is less than one. The clear beads never floated, so we can only say their density is greater than 1.276.*
- Ask students if they can think of a way to calculate the density of the white beads or the clear beads. *We could use different liquids that are less dense than water to see if the white beads float or sink in them. We could use liquids more dense than water for the clear beads.*

IV. Saltwater in the Ocean

- Oceans and seas contain considerably more salt than freshwater.

- Ask students if any of them have ever gone swimming in an ocean.
    - If some respond, ask if they remember if it was easier or harder to float in the ocean than in a swimming pool. *Hopefully they will say it is easier but if they don't, mention that it is easier to float in the ocean than in freshwater.*
- Ask students why it might be easier to float in saltwater than in freshwater. *Saltwater is more dense, so objects float in saltwater that would sink in freshwater.*
- If the salt in all of the earth's seas could be removed and spread evenly over the Earth's surface, it would form a layer more than 500 feet thick or 40 stories high!
- Ask students why they think the sea would contain so much salt but lakes, streams, and rivers do not have much at all.
    - The salt in the ocean comes from the gradual process of weathering and erosion of the Earth's crust, as well as the wearing down of mountains.
    - Rains and streams then transport the salts to the sea.
- As time has passed, the seas have actually gotten saltier.
- Seawater is actually really complex and contains at least 72 elements, most in very small amounts.
- Salinity is the total salt content of the ocean.
- Have students look at the map of the world that was included in their instruction sheet.
- The numbers in the key (at the bottom) are measures of salinity. 35 means 35 pounds of salt for 1000 pounds of water. The higher the number, the more salt that ocean contains.
- As students can tell from the map, the oceans vary widely in salt concentration.
- Ask students if they can point to the saltiest area. The saltiest water occurs in the Red Sea and the Persian Gulf.
- The average salinity of water in the ocean is 35.



http://en.wikipedia.org/wiki/Salinity

V. Review

- Ask students: what is one way to separate mixtures? *Density*
- Ask students: If a solid floats in a liquid, is it denser or less dense than the liquid, if it sinks? *Less, more*
- Ask students why saltwater is more dense than freshwater? *Saltwater has a higher mass as the same volume of freshwater.*
- Have students observe the poly density bottle, ask students what happened? *The white beads have floated down and the blue beads have floated up to meet in the middle*.
- Ask students why they think this happened? *There are two liquids of different densities; the beads also have different densities*.

VSVS background information: If there is enough time left, share this information with the students. The bottle contains a mixture of isopropyl alcohol and saltwater. The white beads have a lower density than the mixture of isopropyl alcohol and saltwater while the blue beads have a higher density than the mixture. As the two liquids separate (due to their different densities), the blue beads float to the top of the saltwater layer because they are less dense than saltwater, and the white beads float to the bottom of the isopropyl alcohol layer because they are more dense than the isopropyl alcohol.

References: Educational Innovations Mixture Separation Challenge
Educational Innovations Poly Density Bottle

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Michael Gootee, VSVS Lab Assistant

Additional Materials for 5-class Version

2 1-L Stock Bottles of 20% Salt Solution, dyed blue
8 8oz. Jars of NaCl
1 Bag Containing:
16 Popsicle Sticks
16 Taster Spoons
16 Small Plastic Bags of Assorted Beads (wash between classes)
16 Instruction Sheets (in sheet protectors)
1 Master Copy of the Observation Sheet
1 Strainer

Observation Sheet - Saltwater Density

I. Introduction

A. Density Activity

Which layer is on top (circle one): saltwater freshwater

D. Floating Solids

Is the bead more or less dense than freshwater? _____

Is the bead more or less dense than saltwater? _____

II. Separation Challenge

Describe the colors and shapes of the four different beads:

1.) _____

2.) _____

3.) _____

4.) _____

Write down the order that the beads floated and the number of taster spoons of salt required for the bead to float.

Number of Taster Spoons Added	Grams of Salt Added	Mass of 50mL of Water	Mass of Water Plus Salt	What Happened to the Beads?
0		50g		
1		50g		
2		50g		
3		50g		
4		50g		
5		50g		
6		50g		
7		50g		
8		50g		

Note: 1 taster spoon of salt is roughly 1.15 grams of salt.

III. Calculation of Density of the Beads

D=mass/volume. We need to calculate the density of the saltwater in which the beads float.

Calculate the mass of the water plus the mass of the salt for each addition of salt.

For the blue beads: Density=mass of 50mL of water plus mass of salt / 50mL

=_____ / _____ = _____g/mL

For the yellow beads: Density = mass of 100mL of water plus mass of salt / 50mL

=_____ / _____ = _____g/mL

Write down the approximate density for each of the beads:

Bead	Approximate Density

Observation Sheet Answers - Saltwater Density

I. Introduction

A. Density Activity

Which layer is on top (circle one): saltwater (freshwater)

D. Floating Solids

Is the bead more or less dense than freshwater? **More**

Is the bead more or less dense than saltwater? **Less**

II. Separation Challenge

Describe the colors and shapes of the four different beads:

1.) **Oval, white beads**

2.) **Blue, cylindrical beads**

3.) **Yellow, cylindrical beads**

4.) **Clear, cylindrical beads**

Write down the order that the beads floated and the number of taster spoons of salt required for the bead to float.

Number of Taster Spoons Added	Grams of Salt Added	Mass of 50mL of Water	Mass of Water Plus Salt	What Happened to the Beads?
0	0.00g	50g	50.00g	White Beads Float
1	1.15g	50g	51.15g	No Change
2	2.30g	50g	52.30g	Blue Beads Float
3	3.45g	50g	53.45g	No Change
4	4.60g	50g	54.60g	No Change
5	5.75g	50g	55.75g	No Change
6	6.90g	50g	56.90g	No Change
7	8.05g	50g	58.05g	No Change
8	9.20g	50g	59.20g	Yellow Beads Float

III. Calculation of Density of the Beads

D=mass/volume. We need to calculate the density of the saltwater in which the beads float.

Calculate the mass of the water plus the mass of the salt for each addition of salt.

For the blue beads: Density = mass of 50mL of water plus mass of salt / 50mL

=52.30g / 50mL = 1.046/mL

For the yellow beads: Density = mass of 50mL of water plus mass of salt / 50mL

=59.20g / 50mL = 1.184g/mL

Write down the approximate density for each of the beads:

Bead	Approximate Density
white, oval	**< 1.00g/mL**
blue cylindrical	**1.046g/mL**
yellow cylindrical	**1.184g/mL**
clear cylindrical	**> 1.276g/mL**

Instruction Sheet
Saltwater Density
Fall 2010

A. Density Activity

1. Watch carefully as the VSVS team demonstrates the procedure for this experiment.
2. Fill the test tube about half full with saltwater (blue) from the dropper bottle.
3. Carefully tilt the test tube and slowly add the freshwater (clear) to the saltwater.
4. **Make sure that the water goes down the side of the test tube!**

D. Floating Solids Demonstration

Do not remove the tops of the vials!

1. Note that the bead in all of the vials has the **same** density.
2. Why does the bead float in vial 1 but not in vial 2?
3. Is the bead more or less dense than regular water?
4. Is the bead is more or less dense than saltwater?

1. Each bead in the next demonstration has a **different** density.
2. Watch as the poly-density bottle is shaken.
3. What happened?
4. At the end of the lesson, look at the bottle and observe what has happened.

Separation Challenge:

1. Make a note of the color and shape of the beads you see in the bag and record it on your observation sheet.
2. Fill the 8 ounce plastic jar with 50mL of water, using the 50 mL cylinder.
3. Pour the beads into the water and gently tap them with the Popsicle stick. Note on your observation sheet which beads float and which ones sink.

<u>To change the density of the water, salt will be added</u>:

4. Fill your taster spoon with salt and then use the Popsicle stick to level off the top.
5. Add the taster spoon of salt to the 16 ounce jar of water and use the Popsicle stick to thoroughly stir in all the salt.
6. Observe and record what happens to the beads.
7. Repeat steps 5 and 6 (<u>adding one taster spoon of salt at a time</u>) and stir until all the salt is gone.
8. Be sure to observe what happens to the beads after every spoonful of salt you add, and record how much total salt has been added (see observation sheet).
9. If some of the beads of one color sink and some don't, tap them with your Popsicle stick to make sure there are no air bubbles.

Mark down all your observations in the table so you can use them for the next part of the lesson.

Instruction Sheet Version 2.

This version has students using a balance to weigh out their salt.
You will need 1 oz cups to use for weighing.
Separation Challenge:

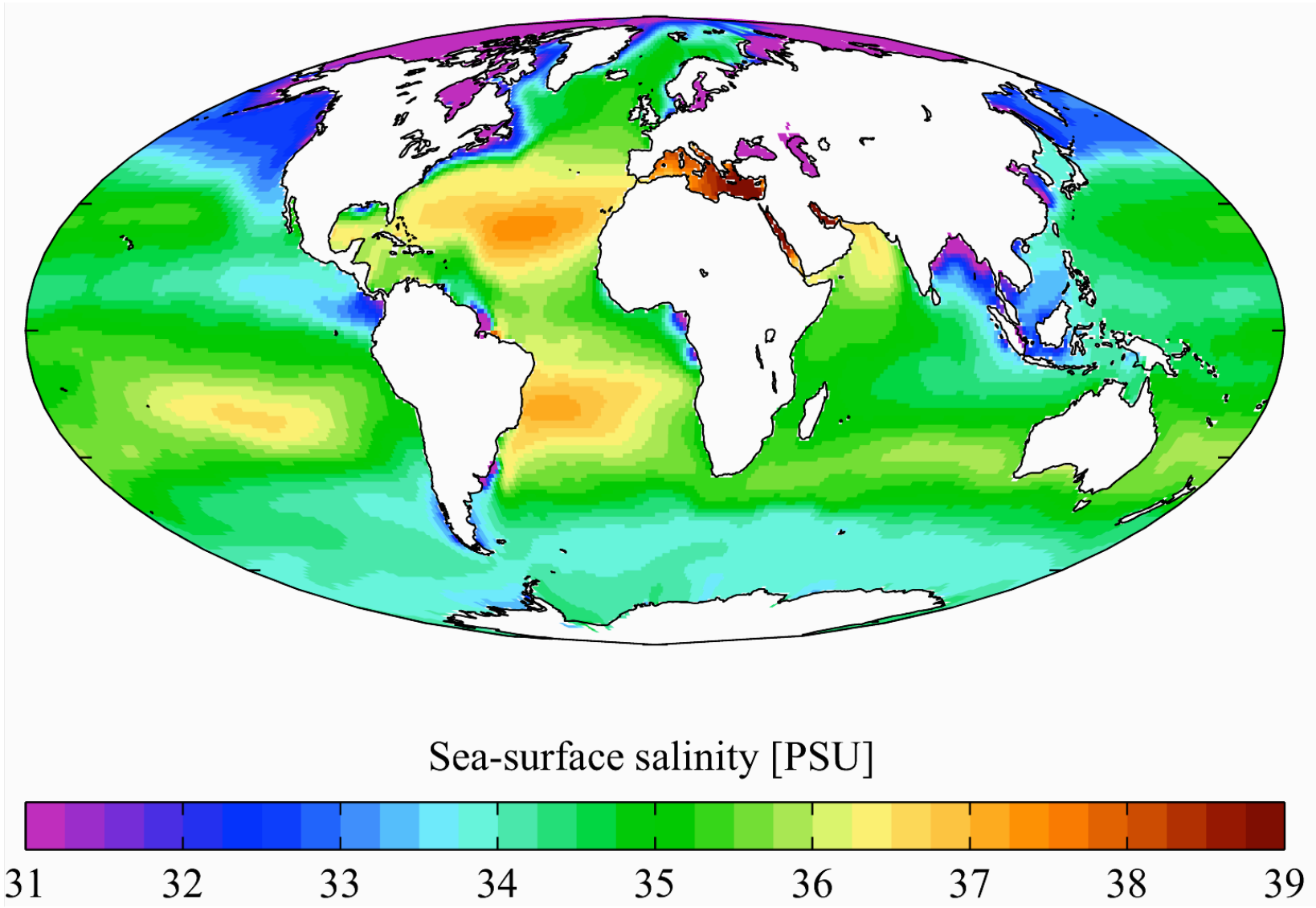
1. Make a note of the color and shape of the beads you see in the bag and record it on your observation sheet.
2. Fill the 8 ounce plastic jar with 100mL of water.
3. Pour the beads into the water and gently tap them with the Popsicle stick. Note on your observation sheet which beads float and which ones sink.

   To change the density of the water, salt will be added:

4. Place a 1 ounce cup on the balance and use your taster spoon to add 2.5 grams of salt to the cup.

(OR: Fill the taster spoon with salt and use your Popsicle stick to scrape it flat. Add 3 of these to your cup to get about 2.5 grams.)

5. Make a total of 6 of these cups before you begin the next part of the challenge.
   Note: For the VSVS classes, the salt is already measured out.
6. After you have all 6 cups with the 2.5 grams of salt in them, add one cup to the water in the jar and use your Popsicle stick to stir the water until there are no more salt particles left.
7. Observe and record what happens to the beads.
8. Repeat steps 6 and 7 (adding one cup of salt at a time) and stir until all the salt is gone.
9. Be sure to observe what happens to the beads after every cup of salt you add, and record how much total salt has been added (see observation sheet).
10. If some of the beads of one color sink and some don't, tap them with your Popsicle stick to make sure there are no air bubbles.
11. Mark down all your observations in the table so you can use them for the next part of the lesson.


Sea-surface salinity [PSU]
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