AQUARIUS

Education & Public Outreach

POTATO FLOAT

Unit: *Salinity Patterns & the Water Cycle* **| Grade Level:** *Middle* **| Time Required:** *30 min. (in class) after solutions are prepared by the teacher* **| Content Standard:** *NSES Physical Science, properties and changes of properties in matter* **| Ocean Literacy Principle 1e:** *Most of Earth's water (97%) is in the ocean. Seawater has unique properties: it is saline, its freezing point is slightly lower than fresh water, its density is slightly higher, its electrical conductivity is much higher, and it is slightly basic.*

Big Idea: *Seawater contains many dissolved substances and these add mass to the water producing a greater mass per unit volume, or density, than that of pure water. The relationship between the density of a fluid, weight of an object, and buoyancy is critical in understanding the ocean, because density has a direct influence on the way seawater and objects in seawater behave.*

Key Concepts:

- An object can both sink and float depending on its relative density to the surrounding fluid.
- There are two main factors that make ocean water more or less dense: the temperature and the salinity.
- Less dense water floats on top of more dense water.
- Generate hypotheses and make predictions.

Essential Questions:

- Why do some objects float in water and others don't?
- Why do some objects behave differently in salt water than in fresh water?
- If we can't detect density with any of our five senses, how do we know it exists?
- What is density a measurement of?
- Why does a ship float in the water and a paper clip sinks?
- Are fish "floating" when they are in the water, even though they are submerged?

Knowledge and Skills:

- Observe density by floating an object in variable density solutions and then in a solution that has layers of varying density.
- Examine the effect salinity has on the density of water.
- Predict what will happen to the potato in varying densities of water.
- Explain the role density has in buoyancy.

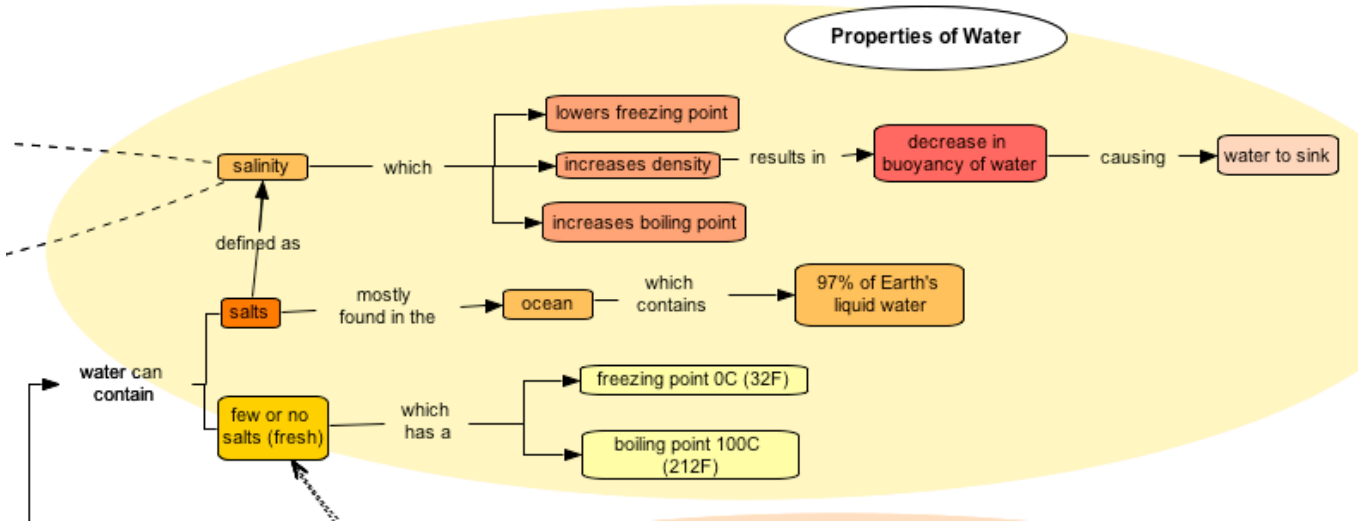
Prior Knowledge:

- Identify floating and sinking objects.
- Distinguish between mass, weight, volume, heaviness, and size.
- Describe attributes of matter, which are qualitative, such as color, smell, size, and texture.
- The extent to which a substance mixes into and throughout another substance is called its **solubility**. In discussions of solubility, the substance being added is called the **solute** and the substance the solute is placed in is called the **solvent**. If the solute mixes and spreads completely throughout the solvent so that the particles are so intermingled with those of the solvent that they will not settle out, then the substance has **dissolved** in the solvent.
- Salt has mass, and when mixed with water it does not change the volume of the water, however it does change the mass of the water.

Common Preconceptions:

- Objects float in water because they are lighter than water.
- Objects sink in water because they are heavier than water.
- Mass/volume/weight/heaviness/size/density may be perceived as equivalent.
- Wood floats and metal sinks.
- All objects containing air float.
- Liquids of high viscosity are also liquids with high density.
- An object that appears to be on top of the solution is not floating but it is held up by the solution's "skin".
- Objects that are completely submerged but freely suspended, such as fish or submarines are not buoyant.

Concept Map- Create a preliminary concept map with the class, to determine the level of student knowledge. See Assessment below to revisit the concept map as a form of evaluation. This lesson and activity relates to the branch "Properties of Water" from the comprehensive Aquarius Concept Map – *Water & its patterns on Earth's surface*.



Background

Seawater has a higher density than fresh water. Seawater contains many dissolved substances and these add mass to the water in which they are dissolved. This produces a greater mass per unit volume, or a density higher than that of pure water. The amount of salts dissolved in water is known as salinity. In waters where large amounts of suspended sediments are present, the density also increases. This most notable in major rivers such as the Nile, Mississippi, and Amazon. In the oceans, at the junction between the continental shelves and the continental slopes, large, dense, sediment water mixtures form currents. When bodies of water with different densities contact each other, some mixing may occur, but it often occurs slowly or not at all. This can be observed where fresh water flows out into the ocean and remains on top of the denser seawater. Along ice caps and glacial margins, rivers of dense, cold water flow out and sink into the oceans relatively warmer (and therefore less dense) seawater. Many swimmers, including your students, have experienced hot/cold spots in lakes and rivers where water of different density has formed.

The relationship between density of fluid, weight of an object, and buoyancy is a basic concept in understanding the behavior of seawater. Students often have difficulty identifying the factors that influence whether an object sinks or floats in a liquid. When deciding whether an object sinks or floats, they consider the object's mass, or volume instead of density. Different objects also have different densities, and depending on their relative densities to solutions, they will either sink or float.

Materials:
3 tall beakers or glass tumblers labeled A, B, C; water; salt (pickling salt works best to prevent cloudiness); spoon; knife; potato (cubed into 3 pieces that are equal sizes, experimentation with size of cube may be prudent to ensure flotation); balance; variety of smaller high-density objects (e.g., made of metal or glass) and larger low-density objects (e.g., made of wood or plastic); ruler; graduated cylinders if beakers or tumblers do not have marked volumes, data sheet

Preparation:
This activity described here is a demonstration. In Beaker A, mix salt and water until saturation, but try not to let the solution become cloudy or have salt crystals at the bottom. Fill Beaker B, with fresh water. In Beaker C, fill it half full with a saturated salt solution, then carefully pour in water so that the water is layered on top of the salt solution. Tip – to minimize mixing, pour the water down the side of the glass or use a spoon (or glass rod) to direct the stream against the side of the glass. The less dense pure water will float on the denser saltwater solution. In the third beaker, the saltwater solution should be clear enough to appear to be pure water. All three beakers are filled to the same level/volume. Prepare all of these solutions before students arrive in the class so they are not aware that there is a difference among solutions.

Activity –

- Ask students to describe their understanding of density. Record their thoughts on a chalk or white board. (*It is mass per volume.)* The demonstration they are about to see should help them better understand density. Handout the data sheet so that students have a place to record observations.
- Carefully place a cube of potato in Beaker A. You should expect the potato to float at the top of the liquid. Ask the students which has higher density – the potato or the liquid? (*The liquid.)*
- Carefully place a cube of potato in Beaker B. The potato will sink to the bottom. Ask the students which has higher density – the potato or the liquid? (*The potato.)*
- Ask students to hypothesize about what made the density (or mass) of each solution different. Ask them "What might one of the liquids be?" *(They will likely guess water*.) Based on their experiences with placing potatoes in water before boiling, can they guess which of the two liquids is water? (*The liquid in Beaker B.).* Ask the students "What might have been added to the liquid in the first beaker to increase its density? What experiments might you conduct to discover this 'secret ingredient'?" **Lab Safety Reminder** - Tasting the solution in the first glass would be effective but is not advised. If the students cannot guess correctly, then tell them they will learn the "secret ingredient" after the next step of the demonstration.
- Carefully place a cube of potato in Beaker C. The potato will sink to the middle of the glass. If, during the previous step, they didn't guess the composition of the solutions, identify the solutions in the first two beakers. (*The bottom layer is saltwater, the top layer is pure water.)* Then ask again why they think the potato sank only halfway in Beaker C. Recording the discussion on a whiteboard, lead them with questions to arrive at the conclusion that the solutions are layered in Beaker C. Following is a suggested line of questioning. Ask for a prediction about the potato's behavior in Beaker C. Student answers should vary --"sink," ""float," I don't know." Since this last demonstration is a bit of a trick, don't spend too much time on their guesses. When the potato sinks halfway in the beaker, ask, "What might be the cause?" Ask if they think it is possible for one liquid to float on top of another, like the potato floats on top of the water. Is it possible or likely that there is a smooth gradient of increasing density from the top to the bottom of the liquid? Again, a variety of answers, but lead them to realize that there are two different liquids of different densities layered in the beaker, and the density of the potato must be an intermediate between them.

Assessment Activities:

- Discuss the idea of density (i.e., mass per volume) with the students. Did the demonstration help them better understand the concept? Density is not the same as weight because it depends on an object's volume.
- Ask the students "Which beaker of solution would you predict weighs more?" *(The solution in the*

Beaker A.) To illustrate this point, show the amount of salt that went into the saltwater solution, explaining that the saltwater solution has the weight of the water plus that of the salt.

- Mass/volume/weight/heaviness/size/density can mistakenly be perceived as equivalent– unlike weight, mass is independent of the pull of gravity. Discuss with students this misconception, it may be helpful to review fundamentals with a definition of matter. Matter is anything that takes up space (has volume) and has mass. Recording on a whiteboard, ask students to generate a list of examples of matter. You may want to have a box of items containing some examples of matter: rocks (solid), water (liquid), air (gas), your desk, your arm, your shoe to display after they've had sometime to craft list. Then ask students to list examples of some things that are NOT matter (objects that do not take up space and do not have mass) - examples of "non-matter" things include heat, light, an idea. Because of its definition, matter has four general properties, that is, four measurable quantities that can always be assigned to it: mass, weight, volume, and density. Mass and weight are different, but related quantities. An object's mass is a measure of its inertia -- the more mass an object has, the more resistant it is to changes in motion. Weight is a measurement of the gravitational force acting on an object. So a big rock has more mass than a small rock. The big rock also weighs more than the little rock in the earth's gravitational field. If you took both rocks into the universe, outside of any gravitational field, both rocks would not have any weight -- but the big rock would still be more resistant to a change in motion than the little rock -- that is, the big rock still has more mass than the little rock, even though both rocks are "weightless". An object has the same mass on earth as it has on other planets, but its weight is very different. Visiting the website "*Your Weight on Other Worlds*" – www.exploratorium.edu/ronh/weight/ – is an additional resource to help illustrate this point.
- In cooperative teams of 3-5 have the students use the equation for density (mass divided by volume) to calculate the density of the two solutions – water and saltwater, and the density of the potato. They will need balances, rulers, and graduated cylinders or marked beakers to determine the mass and volume. The potato cubes should be measured (length x width x height) to determine volume. In their groups also ask them to choose among smaller high-density objects (e.g., made of metal or glass) and larger low-density objects (e.g., made of wood or plastic) to find two objects with the same weight but different volumes. Ask them which has the higher density when comparing.
- If the students are familiar with and the teacher is comfortable with concept maps, instruct the students to construct a concept map using the following concepts: **matter, mass, weight, volume, density, water, ocean, salinity, buoyancy, float**. Each concept should be identified in the map by having a circle around it. Lines with arrowheads (directional) are drawn between concepts that are related. One or a few words are written on the line to describe how the concepts are related. There will be no "right" answer per se. Each of the students will have a map that looks different. Encourage students to acknowledge all the relationships that seem important. The teacher can use the maps to identify persistent misconceptions or misunderstood relationships between concepts.

Wrap Up:

In their cooperative groups have students discuss and record thoughts on the following questions:

- How can knowing the density of solutions be useful in daily life?
- Why is density important to life in the ocean?
- How does temperature affect the density of water?

Have each group report out on their thoughts / answers to these questions.

Vocabulary

- **buoyancy:** In physics, an upward force on an object immersed in a fluid (i.e. a liquid or gas), enabling it to float or at least to appear to become lighter. If the buoyancy exceeds the weight, then the object floats; if the weight exceeds the buoyancy, the object sinks.
- **density:** Mass per given unit of volume.
- **mass:** The property of a body that causes it to have weight in a gravitational field.
- **volume:** The measure of three-dimensional space occupied by an object.

Original source: *Adapted from Mid-continent for Research and Education (McREL) and* ***Aquarius*** **Education & Public Outreach URL:** *http://aquarius.nasa.gov/*

****Lab Safety Reminders**** Students should never taste any chemical.

Potato Float Data Sheet

Student / Group Name:

Demonstration Data Sheet

Observations	Beaker A	Beaker B	Beaker C
Which has a higher density – potato or liquid?			
Identity of liquids			
Notes			

Density Calculation

Equation for Density (D)	Potato	Beaker A liquid	Beaker B liquid
D = mass / volume The unit of density is the mass (gram or kilogram) per cubic metre (kg/m3)	**Mass =** **Volume =** **Density =**	**Mass =** **Volume =** **Density =**	**Mass =** **Volume =** **Density =**
Place an X in the column of the material with the highest density			