

The Mystery of the Pirate's Booty- Salinity and Buoyancy

Buoyancy

If you've ever lain on your back in a swimming pool you have demonstrated the ability of an object to float in water. You float because **the water your body displaces weighs the same as your body**. In the pool, the water is pushing on your body's mass with a stronger force than gravity is pulling it down. This is called **buoyancy**, or the *ability of an object to stay afloat in water due to the displacement of its weight in water*. Simply put, if an object in water displaces its own weight in the water then the object will float. If the object is denser (heavier) than the water it displaces it will sink. Ships float because they are less dense than the surrounding water and so the force of gravity pulling on the ship is less than the force of water pushing the ship up.



Salinity

Approximately 98% of the Earth's water is found in the ocean. Ocean water contains large amounts of dissolved minerals such as *sodium chloride or common table salt*. This factor makes ocean water undrinkable for humans. Oceanographers use the term **salinity** to describe the concentration of salt in a given amount of water. Salinity or salt content is expressed in parts per thousand (ppt). This means one gram of salt mixed with one liter (1000 milliliters) of water is one part per thousand. The average salinity of ocean water is about 35 ppt that is 35 grams of salt per every liter or 1000 mL. This number can fluctuate depending on how much freshwater is available, usually between **32 and 37 ppt or approximately 3.5%**. Freshwater normally has a salinity of less than 0.5 ppt. Marine estuaries which are called brackish waters can have a salinity as high as 17 ppt. This is because brackish water is a mixture of freshwater (usually from a river) and ocean water.

Effects of the Density of Water on Buoyancy

Because most ocean water contains high amounts of dissolved minerals such as salt it is more dense or heavier than freshwater. The particles dissolved in the water create a greater mass per unit volume or a higher density. Because ocean water at ~35 ppt has more salt than freshwater ~0.5 ppt it is more dense, so objects in seawater will float higher and easier than they do in freshwater. Imagine the extra particles of minerals acting as "tiny little hands" pushing

you or a large cruise liner up while gravity is pulling down. The more “tiny little hands” there are to push the object up the easier it is for the object to float provided it weighs the same as the water displaced. **NOTE: A ship holding a given amount of cargo will float high in seawater.** When the ship arrives in less saline waters it will ride lower because there are less dissolved minerals in the water. The “**Plimsoll mark**” shows the maximum amount of cargo a ship can have in freshwater and seawater to ensure that a heavily loaded ship does not sink as it reaches freshwater.

The Problem:

Captain Jack Sparrow does not believe the old wives tale that a pirate ship heavily loaded with treasure and cargo will float lower in the water and possibly sink as it travels from the open ocean into a harbor at the mouth of river. You, being his trusty first mate, understand that something in the ocean water allows the ship to float better than if it was in freshwater. Your job is to convince the Captain that loading up in open ocean water and traveling towards the mouth of a river could mean death to the crew and the loss of all the buried treasure you have uncovered. Based on the background information you have about the relationship between salinity and buoyancy **conduct an experiment** using the following materials to determine if **salt concentration in water (salinity expressed in ppt)** has an effect on the ability of an object of a specific mass to float (buoyancy).

Task: Working in groups of two to three, you will **design and conduct your own investigation using the steps of the scientific method to determine the effects of salinity on the buoyant properties of ships.** Be sure to identify the independent and dependent variables as well as the control setup of your experiment.

Materials: *(NOTE: You do not have to use all the materials provided. If you require a material not on the list please see me before you start your experiment.)*

Pen/pencil
Lab notebook
Graph paper

Ruler Masking tape
Scissors
Clear plastic container (*volume of 2 L*)
Spoon/stirring rod
Graduated cylinder (*100 mL*)
Plastic drinking straw
Modeling clay
Tin Foil
Table salt
Water
Balance
Plastic vials w/ lids
Metal washers

Procedure: Begin your investigation by determining the following information. Be sure to answer these questions in complete sentences in your lab notebook. Your notebook will be the only source of information used when writing up your formal lab report to submit to the Captain.

What is your problem statement? (*Hint: What is it that you are trying to find out?*)

What are the variables being tested?

Independent variable? Dependent variable? Controlled variables?

What is your control setup?

What is your hypothesis? Write it in IF (independent variable), THEN (dependent variable) format.

Example: If I add, then ____ ____ will happen

What steps will you use to test your hypothesis? (*Be specific. Write each step like you are teaching someone how to bake cookies.*)

What observations did you make as you were conducting the experiment? What data did you collect? (**Data Table**)

What results did your experiment show? **(Include a data table and graph.)**

What can you conclude from your results? Be sure to **restate your hypothesis**. Was your hypothesis correct? **HINT: Include a discussion of your data and how confident you felt about your results.**

Analysis Questions:

Define the following in your own words: Buoyancy- Give an example.

Explain Salinity- How is it measured? What is the salinity of the ocean? What is the salinity of fresh water? What is brackish water-Where is it usually found?

Did changing the salinity of the water affect the buoyant properties of the “ship”? *In your own words explain how this occurred.*

Was Captain Jack right or wrong in disbelieving the old wives tale? Why? **Explain.**

Having completed your experiment and drawn your own conclusions about the relationship between salinity and buoyancy, **what would your argument to Captain Jack Sparrow be now?** Could you all die? **(Use the terms salinity, buoyancy or buoyant force, and gravitational pull in your discussion.)**

Why do you think fish don't float to the top of the water or sink to the bottom in ocean water?

Why do different fish swim at *different depths* in the open ocean?

Do you think freshwater fish would have trouble swimming in ocean water and saltwater fish have trouble swimming in freshwater? **Explain your answer.**

