**Pass the Salt**

**Investigating Global Ocean Salinity with Data**

**Timeframe**: 50-70 minute sessions

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

**NGSS Performance Expectations:**

3-ESS2-2. Obtain and combine information to describe climates in different regions of the world.

4-ESS2-2. Analyze and interpret data from maps to describe patterns of Earth’s features.

5-ESS2-2. Describe and graph the amounts of saltwater and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.

MS-ESS2-6. Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.

**Suggested Materials:**

* 250ml beakers (can make with clear cups)
* Tap water or DI water dependent on the mineral content of the water in your area
* Table Salt
* Handheld refractometer (may need to calibrate)
* Pipets
* Measuring spoons
* Stirring Utensil
* Spray bottle labeled “rain”
* Petri dish or ceramic mugs
* Pass the Salt Worksheets
* Access to images from: <https://salinity.oceansciences.org/smap-salinity.htm>

**Description**

Students will use a refractometer to measure salinity and perform several experiments to examine variables that can change salinity. Student’s will then utilize global sea surface salinity maps to determine physical conditions that impact sea surface salinity. The goal of this lesson is for students to learn that ocean saltiness is not constant in space and time.

**Objectives**

Students will:

* Learn how to measure and record ocean salinity
* Learn how earth cycles impact global ocean salinity
* Learn how to answer questions with data

**Essential Question**

How does the precipitation and evaporation impact global ocean salinity in space and time?

**Background Information**

On research vessels a common measurement scientist’s take is salinity or “how salty the ocean is”. While out at sea scientist’s usually do this with a “CTD” (the acronym stands for conductivity, temperature, depth) or a thermosalinograph (TSG). CTD and TSG data from research vessels adds more robust regional-specific data to NASA’s global salinity program in which NASA measures salinity with satellites. Satellites are great for capturing the big global picture, but CTD’s and TSG’s are excellent for examining small-scale details in a specific part in the ocean. NASA can use this data to check to make sure their satellite data is accurate.

Satellites are able to measure sea surface salinity using emissivity, which in its simplest definition is: “how much radiative surface emissions are different from that of a black body”. A black body is an idealized object that is able to absorb all electromagnetic radiation. Scientists compare the amount of energy being released by items (for example, a lake) to the theoretical black body. To simplify further, satellites are measuring how much radiation is being reflected off the surface of the ocean. Salinity affects the electrical conductivity of seawater and therefore affects how much energy (radiation) is emitted. The saltier the water is the less energy it emits. This is because salty water is much more conductive than freshwater, and therefore traps energy rather than releasing it.

Emissivity measured on a satellite is known as “brightness temperature” or the amount of energy being released from the surface of the ocean at a fixed temperature. The fresher the water is the higher the “brightness temperature” because it is releasing more energy than the saltier water.

In this exercise, students will use refractometers to measure salinity. Refractometers work similarly to satellites because they measure the angle in which light changes direction which it hits a substance (i.e. refraction). Different solution concentrations have different refractive indexes dependent on the concentration (or how much stuff is floating around in there). Ocean water typically has a salinity of 35 parts per thousand (ppt) and is primarily made up of sodium and chloride ions (dissolved salt). Estuary water can range between 0.5 ppt and 17 ppt because fresh water is mixing with salt water. Some parts of the ocean are saltier than others and can have salinity as high as 38 ppt (ex. The North Atlantic).

The reason why ocean salinity is variable is because of the wind and water cycles. Wind cycles in conjunction with earth’s rotation create gyres on the surface of the ocean which both trap and move seawater. Precipitation and evaporation in turn effect salinity in certain parts of the world. If you look at a NASA global salinity map you will see the Bering Sea is on average fresher than the rest of the ocean. This is due to high rates of precipitation and meltwater runoff from glaciers. The Mediterranean Sea contrasts the Bering Sea because there is little influx of fresh water from rivers and more sun exposure and evaporation. The equator is on average fresher than the rest of the ocean due to high rates of precipitation as a result of wind cells trapping rain clouds over this region in conjunction with a faster cycle of evaporation and condensation due to constant sun exposure.

The ocean is salty in the first place because rivers move minerals from the land into the ocean basins where it is trapped for longer periods of time than in a lake or river. Evaporation leaves minerals in the ocean basins and returns fresh water to clouds.

**Preparation**

Clear space on several tables for students to work in teams. Have enough kits ready for students to work in groups of 2-3. Each kit should have three 250ml beakers, a squeeze bottle with tap water in it, table salt, measuring spoons, a refractometer, a pipet, a stirring utensil, and a measuring spoon.

In a separate area set up squirt bottles and heat lamps for students to investigate how evaporation/precipitation affects salinity after the first experiment.

Have appropriate worksheets printed out and either print/laminate salinity maps from the NASA website or provide computers for students to investigate online.

**Activity Part 1: Hands-on Learning**

1. Use the “Pass the Salt” PPT to introduce students to what makes the ocean salty, global sea surface temperature, and global sea surface precipitation. Utilize the embedded videos to help students visualize global patterns. The videos can help you point out seasonal changes to sea ice and precipitation. Use the recommended guiding questions in the PPT to facilitate a discussion.
2. **Give Students the Following Scenario:** *Scientist’s on research vessels take regular measurements on ocean salinity while out at sea. These measurements can tell us a lot about the ocean and patterns that go on in the ocean. Today we’re going to make our own seawater and take our own salinity measurements. We’re also going to see how weather might affect salinity.*
3. Show students the refractometer and demonstrate how it works. Assign students into groups of 2-3 and give them kits with instructions. Be prepared to help students as needed.

* Students should start by calibrating the refractometer (they come pre-calibrated but this is an important step for all science). Students should add a few drops of DI water to the refractometer and make sure that the salinity measurement is zero. If it is not they should let you know and you can help them adjust with the dial.
* Students will measure out 100 ml of water into the beaker and then add as much salt as they think necessary to mimic the average ocean salinity of 35 ppt (let them know it’s no more than a tablespoon). Students can add water or salt as needed until they get a reading of 35 ppt on the refractometer.
* Students will add a couple drops of solution using a pipet to the refractometer and take a reading.
* Bonus challenge is for students to get 17 ppt, which is the average salinity of an estuary.

1. Once students are complete and have created a solution that is 35 ppt they can move onto testing how precipitation and evaporation affects salinity.

* Have students split their 35 ppt solution in half into two beakers
* Student’s will pour solution from one beaker into a petri dish or a ceramic mug. If you’re utilzizing petri dishes and it’s a hot day, have students place their petri dishes (labeled with a group name) outside in the sun. You can come back to measure salinity at the end of the day/class period or during the next day. Microwave is a little faster for demonstrating evaporation. Have students pour one half of the solution into a microwave safe container. Students should then microwave between 30 and 90 seconds to see how quick evaporation affects salinity.
* While the heat lamp is shining on the petri dish students can spray water over the other half to mimic rain. Students will then take measurements to see how rain affects the salinity of the solution. Student’s should record their measurement on a piece of paper
* Once this is complete students can remove the petri dish that has been sitting under the heat lamp. Remind students to give this solution a stir before using the refractometer to measure how the salinity was affected by evaporation.
* Have students write down the ppt measurement for the evaporated solution
* Come together as a class and write answers up on the board to compare and contrast differences.
* Students can discuss how the following might have affected their measurement
  + How much water did they spray to represent rain? Lots of squirts or only a couple squirts
  + How close was the heat lamp to their petri dish? Super close or far away?
  + How long did they leave the petri dish under the heat lamp?
  + Did they stir the solution before adding it to the refractometer?

1. Another bonus option is to have students graph the class ppt measurements against time spent under the heat lamp or number of squirts of rain added to the solution.
2. Once this is complete you can move onto investigating data.

**Activity Part 2: Investigating Data**

1. In this step students will use the provided worksheet to investigate data on global ocean salinity collected by NASA’s Aquarius satalite.
2. Have laminated print outs of ocean salinity maps for students or provide laptops with access to the following link: <https://salinity.oceansciences.org/smap-salinity.htm>
3. It’s good to have students compare December and July maps in order to examine how the coldest and hottest months of the year in the northern hemisphere affect salinity. **Blue-Purple means lower than average salinity and Orange-Red means higher than average salinity**. If your students are still working on global geography it might be good to go over a world map before diving into the data exploration.
4. Go through the slides and watch the mission videos about Aquarius.
5. When students have completed the worksheet in small groups you can then work through the answers as a class on the board.
6. Once the worksheets and findings have been shared, what the catching up with aquarius video!



**This color range represents how to read salinity on the NASA images.**

**Extension/Concerns**

1. Measure graphing density. Students can measure density using the refractometer. Salt water density will change during the experiment and positively correlates to salinity. The activity the Dense Seas expands on density and deep sea circulation and doing density in this activity prior to the Dense Seas can be very beneficial to students.
2. Try different amounts and taste them, based on locations. Refractometers are a great way to “ground” salinity in a tangible experience for students. Wikipedia has a well sourced list of salinity by location <https://en.wikipedia.org/wiki/List_of_bodies_of_water_by_salinity> and so does world atlas <https://www.worldatlas.com/articles/the-world-s-most-saline-bodies-of-water.html>.
3. The Dense Seas. The dense Seas expands on the relation of temperature, precipitation, salinity and ocean water to include density. Ocean water density plays a key role in deep sea circulation.
4. The later part of Activity 2 requires students to know geography and names of bodies of water, before starting this lesson it may be good to review the water cycle, states of water, and major bodies of water.
5. Weather Patterns, Ocean Currents, and their interactions. 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.

**Investigating Ocean Surface Salinity**

**Name three parts of the world from the December 2018 map that have the highest salinity (remember high salinity is red)**

**1.**

**2.**

**3.**

**List some reasons for why you think these three parts of the world have high salinity:**

**Do you think the reasons for why these parts of the world have high salinity is the same in each area?**

**Yes or No: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Why or why not?**

**Name three parts of the world from the December 2018 map that have the lowest salinity (remember low salinity is purple):**

**1.**

**2.**

**3.**

**List some reasons why these parts of the world have low salinity:**

**Examine the July 2019 map.**

**Has salinity changed anywhere since December? List below:**

**What are some reasons the salinity might have changed in these areas?**

**Investigating Ocean Salinity Example Answer Key**

**Name three parts of the world from the December 2018 map that have the highest salinity (remember high salinity is red)**

**1.** The North Atlantic Ocean

**2.** The Mediterranean Sea

**3.** The east coast of South America

**List some reasons for why you think these three parts of the world have high salinity:**

High rates of evaporation/more sunlight hitting these areas, low rates of precipitation or less rain, wind cycles blowing more sand into these areas, less freshwater runoff into these spaces, smaller volume of water than other parts of the world, freshwater getting trapped in glaciers during cold months

**Do you think the reasons for why these parts of the world have high salinity is the same in each area?**

**Yes or No: \_\_\_\_\_\_\_\_\_\_Yes\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Why or why not?**

Wind and weather patterns are different around the globe. Some places are bigger than others, some places get more sunlight, some have more terrestrial input.

**Name three parts of the world from the December 2018 map that have the lowest salinity (remember low salinity is purple):**

**1.** The Gulf of Alaska

**2.** The Pacific Equatorial region

**3. Southeast Asia**

**List some reasons why these parts of the world have low salinity:**

More rain in these areas, runoff from glaciers, more freshwater input from rivers and streams

**Examine the July 2019 map.**

**Has salinity changed anywhere since December? List below:**

The mouth of the Amazon, glacial regions

**What are some reasons the salinity might have changed in these areas?**

More precipitation causing runoff from the river. Glaciers freezing over in winter and melting in summer.