

# NOAA National Ocean Service Education: Hot, Cold, Fresh, Salty

*This lesson plan was developed by NSTA master teacher Jerry D. Roth through NSTA's partnership with NOAA.*

**Grade Level:**

9–12

**Subject Area:**

Primarily aimed at the geosciences, this is also valid with physical science and/or introductory chemistry.

**Standards Alignment-National Science Education Standards:**

- Earth Science
  - Structure of the Earth system
    - The Ocean has a major effect on climate because water in the ocean holds a large amount of heat.
- Earth Science
  - Structure of the Earth system
    - Deep ocean currents are caused by the density of ocean water.
- Earth Science
  - Structure of the Earth system
    - The temperature, density, and color of ocean water varies.
- Earth Science
  - Structure of the Earth system
    - Thermohaline circulation is the flow of water induced by differences in temperature (thermo) and salinity (haline). These differences in water properties lead to density differences.

**Time Required:**

The time required to complete this lesson is two single 40-minute class periods or one lab period of 80 minutes if the students are well prepared and work in groups. If you find students need more time, an extra 40 minutes is optional.

**Overall Lesson Goal:**

The student will observe the effects of the layering of warm and cold water and water that is more or less saline than the normal.

**Individual Learning Objectives:**

1. The student will create saline solutions that mimic ocean salinity, are more saline than ocean water, and are less saline than ocean water.
2. The student will carefully pour different solutions into a basin that shows how the different solutions can model layering in the ocean.
3. The student will observe that waters of different temperatures can layer according to their respective temperature, with hot water rising above colder water.
4. The student will observe that waters with different salinity will layer according to their respective salinity with more saline water being more dense than that of lower salinity.
5. The student will recognize that the effects of salinity and temperature are the root cause of thermohaline layering in the ocean.
6. The student will combine the results of the two separate exercises and predict which of the conditions might prevail.

**Prerequisite Knowledge; Misconceptions/Preconceptions:**

Cool water is denser than warm water and will sink below the warmer water. Water that is more saline is also more dense than water with lower salinity and thus will sink below the water of lower salinity. Interestingly, water temperature has more of an effect on water movement than salinity.

The student should have a good grasp of proper lab procedures.

Knowing about the effects of ocean temperature and salinity may help students have a better understanding of factors that influence weather and climate. Ocean currents have a major impact on climate, and a thorough explanation of surface currents can be found at “A CURRENT Is a

CURRENT by Any Other Name, But What is a Current?",  
[http://oceanworld.tamu.edu/students/currents/  
currents1.htm](http://oceanworld.tamu.edu/students/currents/currents1.htm).

It is important to note that this activity addresses both parts of what is called the thermohaline circulation: temperature and salinity. A good reference to begin your investigation deals with a Web site about the [Thermohaline Circulation](#). Another reference can be found at the JHU/APL Ocean Currents Web site, <http://fermi.jhuapl.edu/student/currents/index.html>. Sufficient background for the teacher and reference for the students is available in an easy-to-understand series of presentations.

*A special note: Following instructions closely will result in usable results. If solutions are not carefully combined, results will be difficult to observe.*

The students should mix their own solutions. I find it very important that students get practice, whenever possible to produce the solutions they use in a laboratory setting.

The concept of density is important for students. What appear to be minor changes with density differences caused by temperature and salinity may have a major impact in the oceans. Since the oceans do not have a constant temperature and a given area may be more saline than another, it is important for the student to understand factors that may contribute to observable layering and other differences within the oceans.

**Procedures/Instructional Strategy:** Before beginning this lab, it is best to have enough materials for all students to work in groups of two. Larger groups can be used but clever students tend to double up the work and thus share the results, meaning they may have only a cursory understanding of each of the trials.

### **Materials and Equipment:**

Materials and equipment shared by the entire class include triple-beam balances or other reasonably accurate scales, roughly a pound of table salt, and food dye in two colors. I recommend red or blue dye. Each pair of students should have a clear plastic shoebox. The plastic shoeboxes are readily available in most "Dollar Stores." They generally come with lids and I find them useful storage containers when not being used for this lab. Each pair of students also needs two 500 ml beakers for mixing and pouring their solutions. All students need a quantity of ice to chill their solutions and a source of hot water.

### **Step 1. Making the solutions:**

Mix 2 liters of saltwater solution and pour into the shoebox for the temperature test. If your shoeboxes are smaller, use less solution.

The saltwater solution is made by dissolving 35 grams of NaCl into a liter of room-temperature water. This roughly approximates the salinity of seawater at 3.5%. Additionally, each pair of students needs a minimum of one more liter of room-temperature solution for the experiment regarding water temperature.

## Step 2. Temperature Test

(a): The first test involves having students create 500 ml of hot and 500 ml of cold seawater. The cold water can be made by chilling a beaker of the “seawater” in an ice bath for 10 to 15 minutes.

(b): The warm seawater can be made by warming the solution on a hot plate or using hot tap water to make the solution.

While the solutions are changing temperature, ask the students to predict which of the waters will rise or sink when gently poured into the room-temperature solution and record their prediction in their lab notebook. This test is fairly direct and most students may predict that the warm water will rise over the colder water.

(c): Once the solutions have reached temperature, add a few drops of different colored food coloring to each solution. I prefer red for hot and blue for cold.

(d): Have the students gently pour the contents of each of their beakers into the opposite ends of their shoebox. Allow time for the solutions to settle.

**Caution: If the beakers are poured into the shoebox too quickly the solutions will mix. Otherwise, have the students note the layering that resulted and compare the layering results to their earlier predictions.**

Once the students have finished observing the layering and made notations in their notebooks regarding their observations, have them discard the solutions in the drain and rinse their shoebox for the next test.

Ask the students to list where in the ocean sources of warm seawater and cold seawater arise.

**Step 4. Salinity Test** - The second test is a little more complicated to predict.

(a): Have all of the students make a liter of “regular” (35 grams NaCl per liter of water) seawater and pour it into their shoebox.

(b): Have half of your groups make seawater that is  $\frac{1}{4}$  as salty as “normal” sea water by mixing 8.75 grams of salt per liter of water. I have students color this solution blue.

(c): Have the other half of the groups make seawater that is 4 times as salty by dissolving 120 grams of salt in a liter of water. Color this solution red.

(d): Ask the students to share half of their solutions with a group that has made the other solution. Make sure their solutions are clearly labeled.

Have the students record their predictions about which layer will rise to the top; the hypertonic (greater or more than) solution, the isotonic (same as) solution, or the hypotonic (under or less

than) solution. Have the students record the reasoning for their prediction regarding their prior knowledge of density.

Step 5: Direct the students to carefully pour the contents of the beakers of hyper and hypotonic solutions into opposite ends of their isotonic shoebox and observe the layering.

**Caution: If the beakers are poured into the shoebox too quickly the solutions will mix. Otherwise, have the students note the layering that resulted and compare the layering results to their earlier predictions.**

Does the layering match the predictions? Have the students offer a reasonable explanation as to why their predictions were right or wrong.

Ask the students to record where in the ocean water that is more salty than seawater may exist and where water that is less salty than “regular” seawater may exist.

Step 6: Finally the students should predict which is more important to the layering: temperature or salinity. Ask the students to propose a test that might determine which is more important. My recommendation is simple: Have the students test the temperature solutions with the solutions of different salinity. Ask them to report their results in a summary of the lab on the accompanying sheet.

### **Outcome/Assessment:**

A straightforward assessment of this activity involves students explaining what they observed during the lab. A formal write-up may be acceptable but the important factors in this lab are:

1. How does salinity affect ocean layering?
2. How does temperature affect ocean layering?
3. Which has a greater impact on the oceans, salinity or temperature?

If you would like the students to complete a followup to the lab, they should look to the website listed in the extension section, which contains a tutorial regarding the concept.

### **Extension:**

This lesson also directly applies to the theme regarding the sun and its effect on the ocean since it is primarily the sun that heats the oceans and not the Earth’s internal temperature. Because warm water rises to the surface and currents are affected by wind and the Earth’s rotation, the students should be able to see and perhaps understand the connection between deep ocean circulation and weather. [Variations in a Salty Ocean](#) contains an activity that allows the students to look at actual data and make their own predictions of the interactions of salinity and temperature.

### **Internet Resources:**

Deep Ocean Currents, Surface Ocean Currents are the keywords and the urls include:

- [A CURRENT is a CURRENT by ANY OTHER NAME, BUT WHAT is a CURRENT?](#)
- [Thermohaline Circulation](#)
- [Variations in a Salty Ocean](#)
- [JHU/APL Ocean Currents Website](#)

### **Classroom Resources:**

Provide a list of materials, consumables, and any physical equipment, including the total number of computers if using an entire lab, single computer station, LCD, speakers, etc., that a teacher looking to replicate your lesson would need. If your lesson also includes a hands-on component, please include all equipment necessary.

At least 4 scales to measure salt  
1 plastic shoebox for each pair of students  
1 lb of salt (table salt is adequate)  
2 colors of food coloring for comparing the different solutions  
One 1 l beaker and two 500 ml beakers per pair of students  
Sufficient quantity of ice to cool solutions  
Heat source to warm water or hot tap water.

### **Holt, Cold, Fresh, and Salty - Student Worksheet**

Name \_\_\_\_\_

Date \_\_\_\_\_

1. Write your predictions for the hot and cold water test:
2. Did your prediction match the observed results of the test?
3. Describe your results in terms of the density of the solutions.
4. Record your predictions for the salinity water test:
5. Did your prediction match the observed results of the test?
6. Describe your results in terms of the density of the solutions.
7. Plan and execute a simple experiment that attempts to show which of the factors, temperature or salinity, has more of an impact on ocean layering.

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