

## Family Fun

# Temperature and Salinity Investigation Part 1

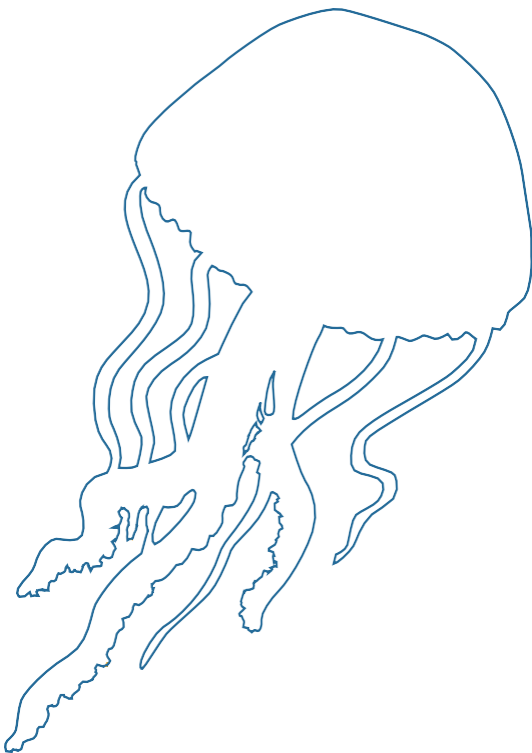
**Enduring Understanding:** The temperature and salinity of water impact its density.

### Materials

- Water
- Salt
- Food coloring or other dye (four colors)
- Refrigerator
- Microwave (optional)
- Glass cups
- “Temperature and Salinity Investigation” data sheets

### Setup:

1. Print the “Temperature and Salinity Investigation” data sheets.
2. Collect four batches of water (six to eight ounces of each kind).
3. Prepare each batch differently, as outlined below:
  - Mix two batches with salt until fully saturated, creating saltwater. You want to make them as saline (salty) as possible to exaggerate the effects of salinity on density.
4. Chill one batch of saltwater in a refrigerator, preferably overnight but for at least two hours. (NOTE: If you are short on time, you may also chill it for a short period of time in a freezer. Remove before water freezes.)
5. Heat one batch of saltwater in the microwave until warm. (NOTE: If you do not have access to a microwave, you may add salt to warm tap water.)
  - Two batches are freshwater
6. Chill one batch of freshwater in a refrigerator, preferably overnight but for at least two hours. (NOTE: If you are short on time, you may also chill it for a short period of time in a freezer. Remove before water freezes.)
7. Heat one batch of freshwater in the microwave until warm. (NOTE: If you do not have access to a microwave, you may use warm tap water.)
  - In the end you should have cold saltwater, warm salt water, cold freshwater, and warm freshwater.
  - Dye each sample with a different shade of food coloring (NOTE: Add a small amount of food coloring. Too much food coloring will turn the water opaque, making it difficult for students to discern the line between layers.
  - Label each type of water appropriately.
8. Gather eight glass cups: four for samples and four for layering.





## Setup continued:

9. Remove the chilled water from the refrigerator and warm the warmed water as close to the start of the lesson as you are able. If the chilled water must be out of the refrigerator for an extended period, add ice to keep it sufficiently cool.

## Program outline:

### Introduction

- Briefly discuss the concepts of temperature and salinity.
  - Temperature is a measure of heat, or the kinetic energy of the particles, within a given object. It is measured in degrees Celsius or Fahrenheit.
  - Salinity is the measure of the amount of dissolved salt in water. It is usually measured in parts per thousand (abbreviated ppt or ‰).
- Explain that you will be using four beakers (or cups) to layer two types of water together to see how water samples of different temperatures and salinities layer. You will only get four beakers, so the student must carefully choose the combinations they layer.
- Explain that there are four different type of water: cold saltwater, warm saltwater, cold freshwater, and warm freshwater.
- The students' goal is to layer the different types of water and construct an argument using their trials as evidence for the effect of temperature and salinity on the way the water layers.
- Pass out data sheets for recording results.

### Investigation

- The goal is for your student to work out both the logistical and content aspects of the lesson on their own, without you driving the instruction.
- If students have difficulty pouring the samples in a way that allows them to see how the samples layer, try to get them to figure out what they can do differently to make it easier. If they are unable to figure out an alternative procedure on their own, you may offer them these tips:
  - Pour the lighter color (for example, yellow) first and the darker color (for example, blue) second. This makes it easier to see the line between layers.
  - Pour a small amount of water slowly and carefully.
  - Tilt the beaker or cup while pouring the second sample.
  - Do not wait until you have finished pouring to watch what is happening with your samples. Watch what happens the instant the two samples hit. The longer they are in contact, the likelier they are to mix, making it too hard to tell which layer is on top.
- Students should record the results of their comparisons on their data sheets.
- Once they have completed their four comparisons, students should answer the other questions on their data sheets, constructing an argument from evidence about the implications of the findings.





## Program outline continued:

### Debrief

- Once your student has completed the investigation and constructed their argument from evidence, have them share their results and argument with you.
- Discuss students' findings and hypotheses as a group. What did they discover? What do they think the connection is between temperature, salinity, and the way water layers?
- Introduce the idea of density. Explain the connections among temperature, salinity, and density. These relationships explain the results of their investigation.

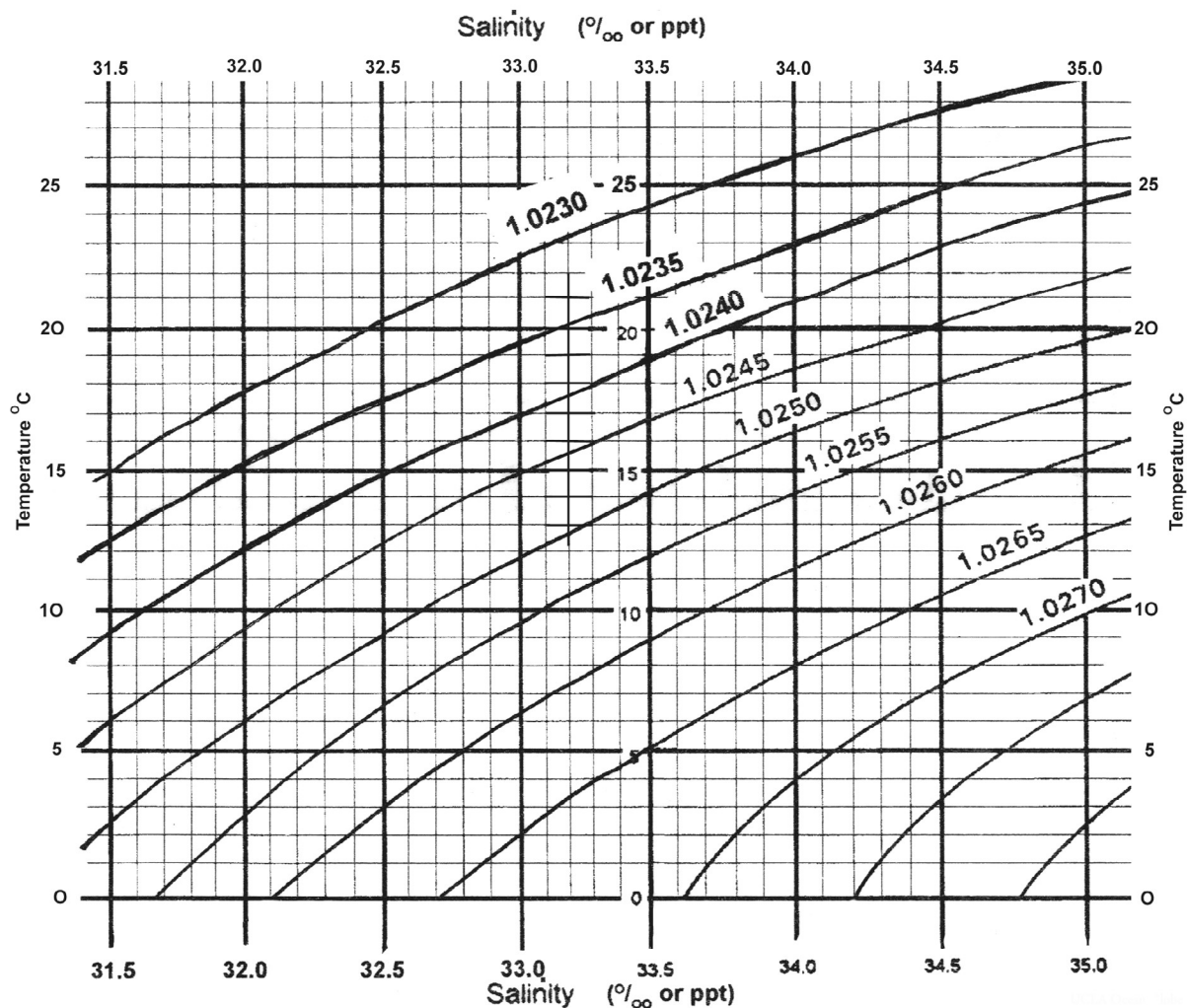




## Background information:

Temperature and salinity are two important characteristics of water that impact its physical properties, notably its density. The theoretical density of water is 1 gram per cubic centimeter. However, this is only the actual density of water when it is at certain temperatures and salinities; based on differences in temperature and salinity, the density of water varies widely. As temperature decreases, the density of water increases, meaning cold water is denser than warm water. This trend changes around 4°C, when water becomes less dense as it approaches freezing. Salinity has an even greater impact on the density of water. As salinity increases, density increases, meaning saltwater is considerably denser than Fresh water. The graph below demonstrates these relationships and how temperature and salinity work in concert to impact the density of water.

**Temperature Density Salinity Conversion Chart**





## glossary:

**Density:** Amount of matter in a given area; calculated by dividing mass by volume

**Salinity:** Measure of the amount of dissolved salt in water; usually measured in parts per thousand (ppt or ‰)

**Temperature:** Measure of the average kinetic energy of particles within a given object; measured in degrees Celsius, Fahrenheit, or Kelvin



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# Family Fun

## Temperature, Salinity, and Density Part 2

**Enduring Understanding:** The density of water is calculated as mass over volume and is influenced by both the temperature and salinity of the water.

### Materials

- “Temperature and Salinity Investigation” data sheets

### Setup:

1. Print the “Temperature, Salinity, and Density” worksheets.

### Program outline:

#### Why do the temperature and salinity of water matter?

- The temperature and salinity of water are important because they impact its physical and chemical characteristics, as well as its suitability for use, consumption, and habitat by humans and other organisms.
  - People and most land animals cannot survive by drinking saltwater. Most plants will die if watered with saltwater.
  - If you took an ocean-dwelling animal like a great white shark and put it in freshwater Lake Tahoe, it would not be able to survive. The same would apply if you took a goldfish and put it in the Pacific Ocean. The salinity of water, in part, determines what can live in it.
  - The same is true of the water’s temperature. A cold-water animal like a lion’s mane jellyfish or Chinook salmon cannot live in tropical waters; a warm-water animal like a staghorn coral or a clownfish could not survive in frigid Arctic waters.
- Density is one of the physical characteristics of water impacted by temperature and salinity.

#### What is density?

- Density is the amount of matter in a given amount of space.
  - It is calculated by dividing mass by volume.
  - Pure water’s density is about 1 gram/cubic centimeter, but it varies greatly based on a number of factors, including temperature and salinity.





## Program outline continued:

### **How is water's density impacted by its temperature and salinity?**

- Students will work in small groups to investigate this relationship using the “Temperature, Salinity, and Density” charts and filling out the worksheet.
- When students are done, gather them together to share their findings.
- Check for understanding.
  - Density is mass over volume.
  - As water's salinity increases, its density increases.
  - As water's temperature increases, its density decreases.



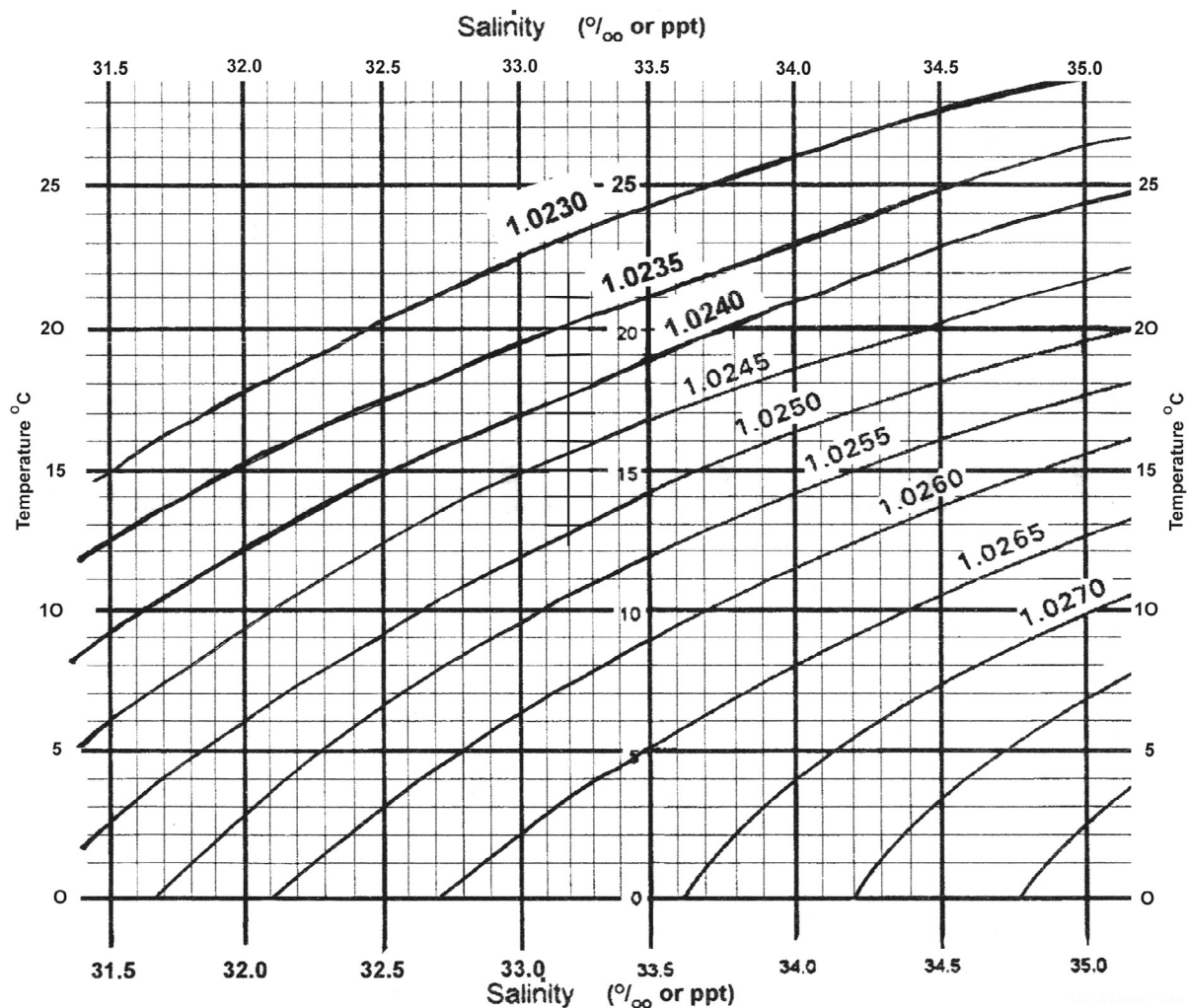


## Background information:

Temperature and salinity are two important characteristics of water that impact its physical properties, notably including its density. The theoretical density of water is 1 gram per cubic centimeter. However, this is only the actual density of water when it is at certain temperatures and salinities; based on differences in temperature and salinity, the density of water varies widely. As temperature decreases, the density of water increases, meaning cold water is denser than warm water. This trend continues until around 4°C, at which water is its densest.

Salinity has an even greater impact on the density of water. As salinity increases, so does density, meaning saltwater is considerably denser than freshwater. The graph below demonstrates these relationships, and how temperature and salinity work in concert to impact the density of water.

**Temperature Density Salinity Conversion Chart**





## glossary:

**Density:** Amount of matter in a given area; calculated by dividing mass by volume

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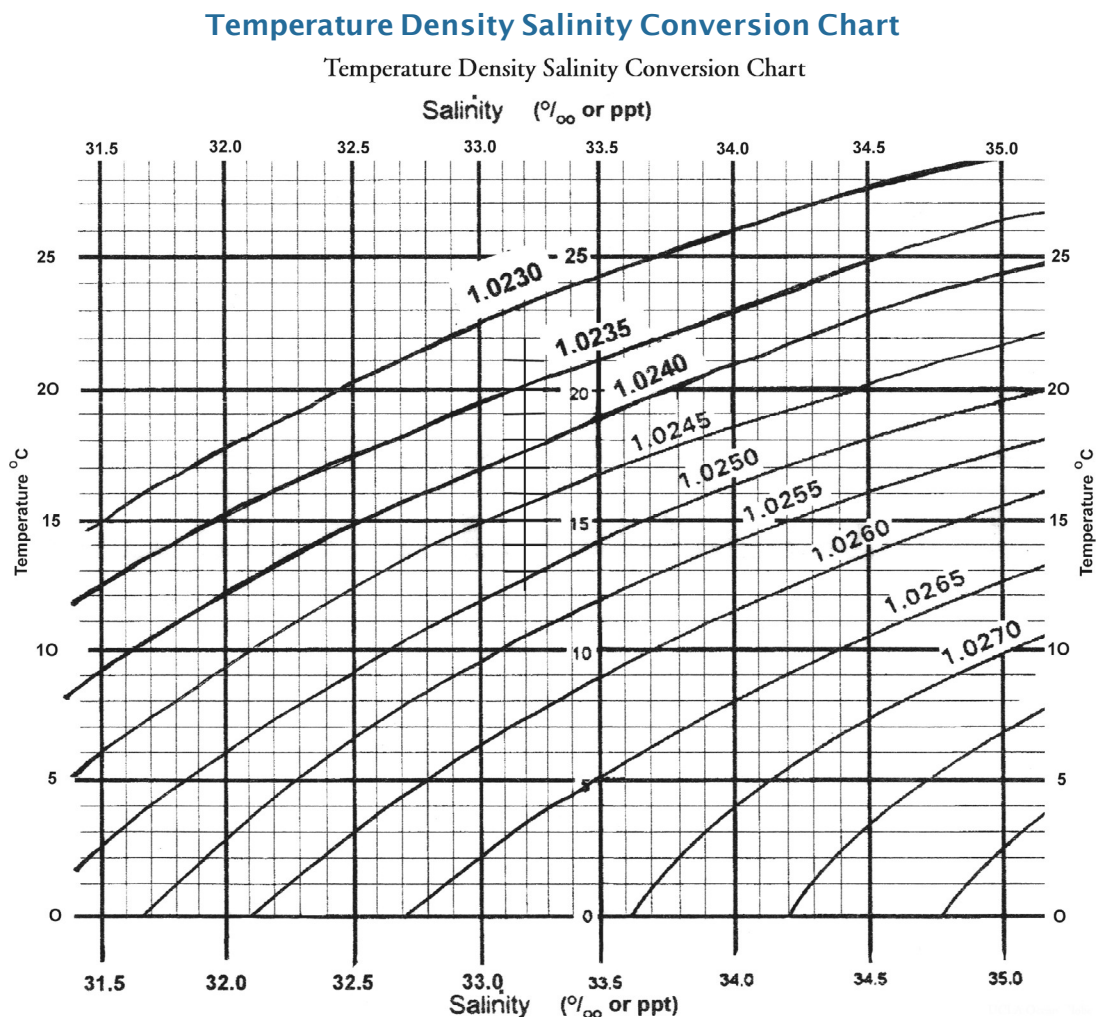
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## Temperature, Salinity, and Density

Temperature and salinity are two important characteristics of water. Temperature measures how much heat is in a given material. It is measured in degrees Celsius or Fahrenheit. Water is liquid between 0°C and 100°C. Below 0°C, water becomes solid ice. Above 100°C, water becomes gaseous water vapor. Salinity measures how much salt is dissolved in water. It is measured in parts per thousand (ppt or ‰). Freshwater has a salinity of 0‰, while ocean water is around 35‰. Temperature and salinity also influence another important characteristic of water: density. Density measures how much matter is in a given amount of space. It is calculated using the equation  $\text{Density} = \text{Mass}/\text{Volume}$ . Water's density is often measured in grams per cubic centimeter (g/cm<sup>3</sup>).

This graph shows how water's temperature, salinity, and density are related to each other.





## Temperature, Salinity, and Density continued



In the graph, the density of water is shown on the curved diagonal lines and is measured in g/cm<sup>3</sup>.

Use the graph and information above it to answer the following questions. Make sure to include units as needed.

1. As water's temperature increases, its density\_\_\_\_\_.
2. As water's salinity increases, its density\_\_\_\_\_.
3. If water is at 15°C and has a salinity of 33‰, its density is\_\_\_\_\_.
4. If water is at 3°C and has a salinity of 32.5‰, its density is\_\_\_\_\_.
5. If water is at\_\_\_\_\_and has a salinity of 33.5‰, its density is 1.024 g/cm<sup>3</sup>.
6. If water is at\_\_\_\_\_and has a salinity of 35‰, its density is 1.027 g/cm<sup>3</sup>.
7. If water is at 26°C and has a salinity of\_\_\_\_\_, its density is 1.023 g/cm<sup>3</sup>.
8. If water is at 9°C and has a salinity of\_\_\_\_\_, its density is 1.024 g/cm<sup>3</sup>.
9. Rank the following from least dense to most dense:
  - a. \_\_\_\_\_ Colder, saltier water
  - b. \_\_\_\_\_ Warmer, saltier water
  - c. \_\_\_\_\_ Colder, less salty water
  - d. \_\_\_\_\_ Warmer, less salty water
10. Would this graph be more useful if you wanted to find the density of water from the Sacramento River or from the Pacific Ocean? Why? \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_



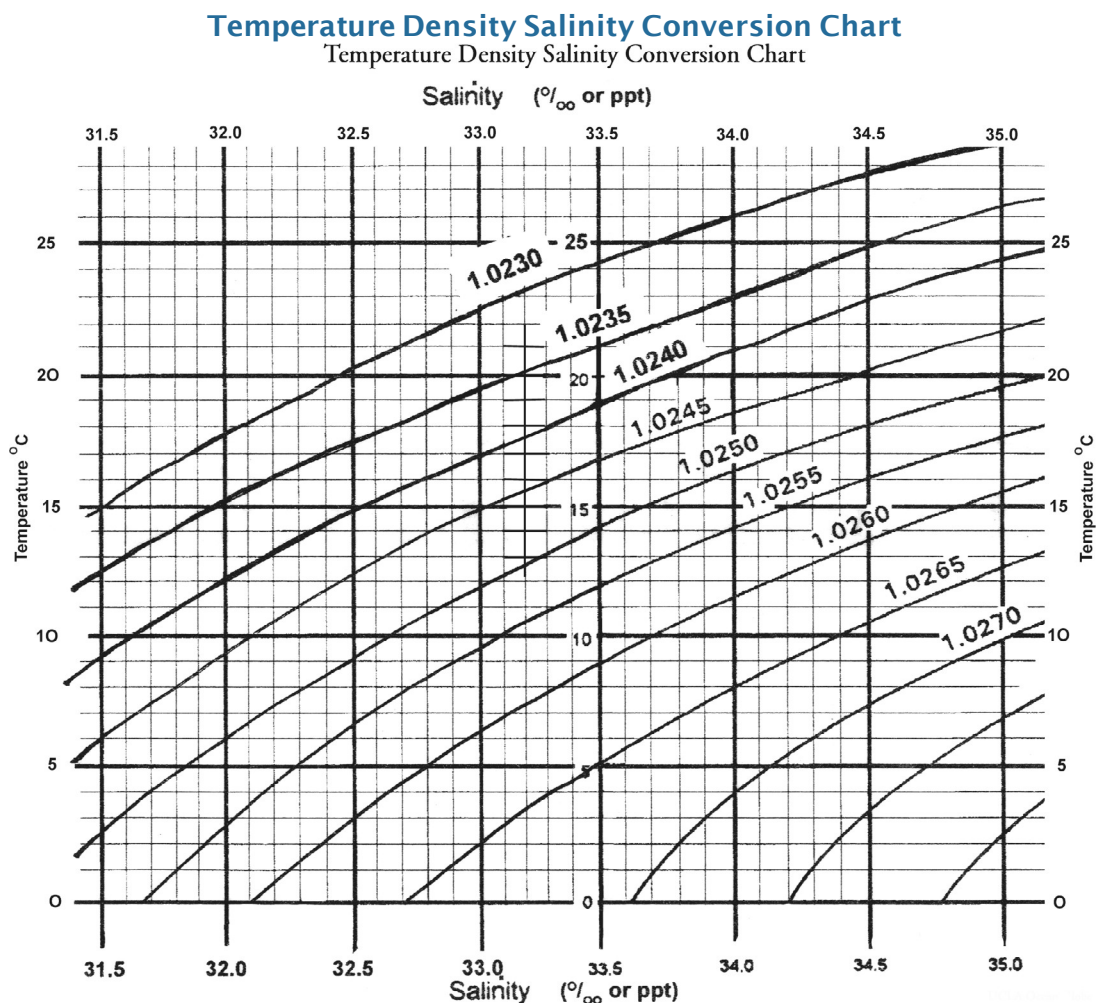
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This graph shows how water's temperature, salinity, and density are related to each other.





## Temperature, Salinity, and Density continued



In the graph, the density of water is shown on the curved diagonal lines and is measured in g/cm<sup>3</sup>.

Use the graph and information above it to answer the following questions. Make sure to include units as needed.

1. As water's temperature increases, its density decreases.
2. As water's salinity increases, its density increases.
3. If water is at 15°C and has a salinity of 33‰, its density is 1.0245.
4. If water is at 3°C and has a salinity of 32.5‰, its density is 1.0260.
5. If water is at 19° and has a salinity of 33.5‰, its density is 1.024 g/cm<sup>3</sup>.
6. If water is at 10° and has a salinity of 35‰, its density is 1.027 g/cm<sup>3</sup>.
7. If water is at 26°C and has a salinity of 34‰, its density is 1.023 g/cm<sup>3</sup>.
8. If water is at 9°C and has a salinity of 31.5‰, its density is 1.024 g/cm<sup>3</sup>.
9. Rank the following from least dense to most dense:
  - a. 4 Colder, saltier water
  - b. 3 Warmer, saltier water
  - c. 2 Colder, less salty water
  - d. 1 Warmer, less salty water
10. Would this graph be more useful if you wanted to find the density of water from the Sacramento River or from the Pacific Ocean? Why?

### Answers will vary. The key points are:

- The graph would be more useful for finding the density of water in the Pacific Ocean than in the Sacramento River.
- The graph only shows salinities between 31.5 and 35 parts per thousand, and the informational text explains ocean water, like the water in the Pacific Ocean, is roughly 35 parts per thousand, and freshwater, like the water in the Sacramento River, is 0 parts per thousand.
- This means the graph could be used on ocean water, but it does not cover anywhere near the salinity (0 parts per thousand) that would be expected in a freshwater river. Without the necessary data for salinity there would be no way to use the graph.



