Unit 3: The Nature of Seawater

Unit Focus

This unit explains the components of seawater and the differences in salinity throughout the world's oceans. Students will gain knowledge about factors such as precipitation, temperature, location, and evaporation, which affect salinity in the oceans.

Student Goals

1. Describe how the oceans became salty.
2. Define salinity.
3. Explain how precipitation, temperature, and evaporation affect the salinity of water.

Vocabulary

Study the vocabulary words and definitions below.

acid (acidic) .... a compound that joins with a base to form a salt; will cause blue litmus paper to turn red; high concentration of H^+ ions

base (basic) .... a compound that joins with an acid to form a salt; will cause red litmus paper to turn blue; high concentration of OH^- ions

brackish .... having a lower salinity than normal seawater; a mixture of freshwater and saltwater

buffer .... chemical compound that maintains pH level through chemical reactions

condense .... to change from a gas or vapor to a liquid

crystallization .... a method of desalination involving the freezing of water and then removing the ice crystals to produce freshwater

desalination .... a process by which salt is removed from seawater

distillation .... a method of desalination involving the evaporation of water with high heat and then condensing it by cooling

evaporate .... to change from a liquid into a gas or vapor

filtration .... a method of desalination which involves filtering water through special membranes or materials

hydrologic cycle .... the movement of water from the oceans and the land to the atmosphere and then back; also called the *water cycle*, nature's recycling of freshwater
Example: water evaporates into the air, condenses, and falls back to the ground as precipitation.

hypersaline .... water with high levels of salinity

ion .... an electrically charged atom or molecule formed by gaining or losing one or more electrons

pH .... a measure of the concentration of hydrogen ions (H^+) in a solution expressed as a scale, ranging from less than zero to more than 14, that in turn expresses the concentration of acid or base

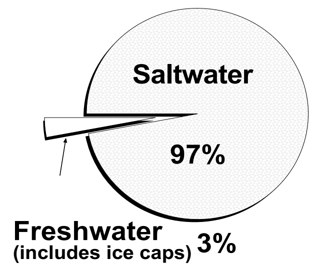
sodium chloride .... $NaCl$ (chemical formula); common table salt; the most common salt in seawater

thermocline .... a layer of water in the ocean where the temperature of the water changes rapidly

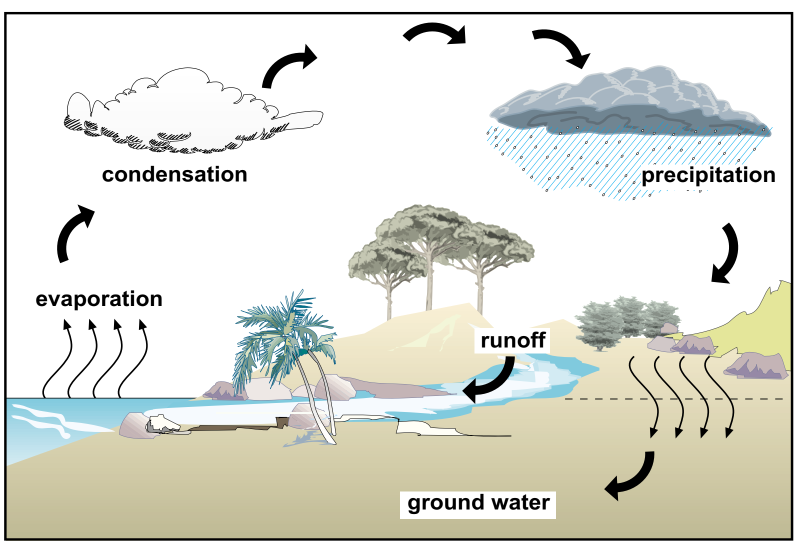
water vapor .... water in the form of gas

Introduction: The Nature of Seawater

Water appears on Earth in many different places and in many different forms. In oceans, rivers, and lakes, water most often appears as a liquid. Overhead, in banks of clouds drifting by, water has collected as a gaseous vapor. And in glaciers, icebergs, and snow packs, water is in solid form. (Some solid water or ice will melt and become liquid. Some, such as the ice in Antarctica, will never warm above the freezing point.) The *water cycle*, or **hydrologic cycle**, is the movement of water from the ocean and the land to the atmosphere and then back.



Over 97 percent of the water on Earth is too salty to drink! Through evaporation and then precipitation, water becomes purified and free of salt. On the diagram below, follow the pathway of water. One of the paths of the hydrologic cycle, or *water cycle*, is **evaporation**. During evaporation, liquid water turns into a gas. Water molecules at the water's surface move into the air as water vapor. Water vapor is water in a gaseous state. When molecules of water vapor come close enough together, a cloud is formed. The process of cloud formation is called *condensation*. Condensation is the part of the water cycle that typically comes after evaporation. When the clouds become *saturated*, or full, from so many water droplets condensing together, then the droplets fall to the Earth as *precipitation*. Precipitation may be in the form of rain, sleet, or snow.

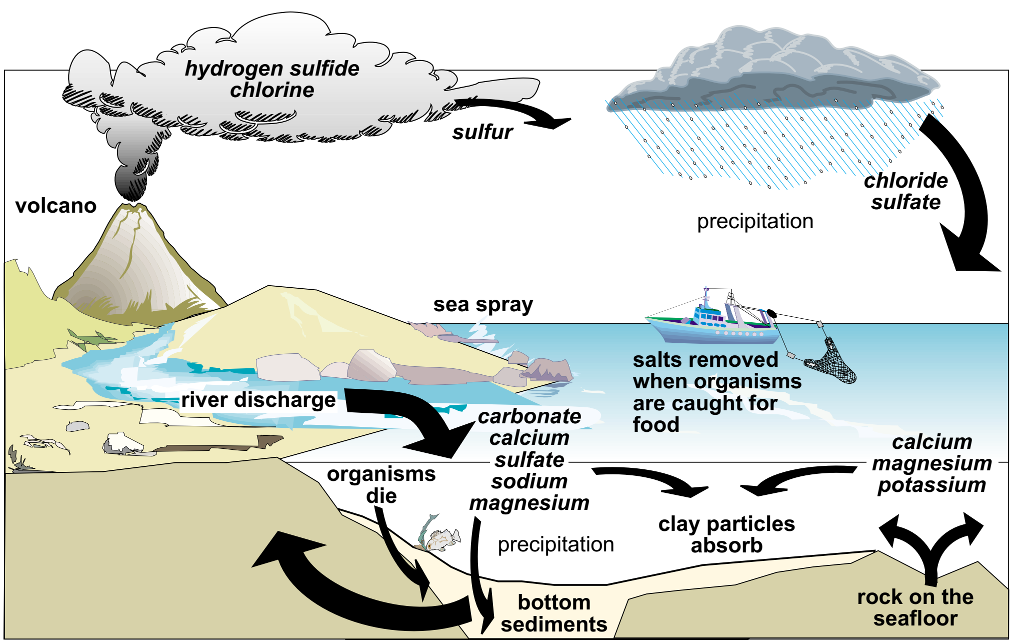


water cycle

Some of the water that returns to Earth will wash into the oceans, lakes, and rivers. This water is called *runoff*. The rest of the water soaks into the ground and becomes *groundwater*. Eventually, the groundwater will return to the ocean through underground channels, where it will continue in the water cycle.

Seawater: So Much to See, So Little to Drink

You may have accidentally swallowed some seawater while swimming in the ocean or gulf. This water, you instantly realized, was far different from *drinking* water. Salts in seawater make it virtually undrinkable. When salts dissolve in water, they form **ions**. Most of the salt in seawater is made up of sodium and chloride ions. Together, these two make up common table salt, or NaCl (**sodium chloride**). These and four other major ions make up a little more than 99 percent of the elements in seawater (see page 37-38). The four other ions are magnesium, sulfate, calcium, and potassium. Although seawater contains almost every element that exists in nature, the others are present only as *trace elements*, such as bicarbonate (HCO_3), and exist in very small quantities.



sea salt cycling - salts are constantly being added and removed from seawater

Where did these elements in the seawater come from? Why are the oceans salty? Well, as the rivers move to the ocean, they dissolve the rocks that they pass over. See the *sea salt cycle* above. The rocks on the riverbeds contain elements that eventually erode and dissolve into the water. This process takes a very long time! When water evaporates from the ocean and is returned to the land as rain, the dissolved elements are left behind in the ocean. This is why the oceans are salty. Some salts can be removed from the ocean when organisms, such as fish, are taken from the ocean. This percentage of salt loss is very small.

Salinity: Water and Salt

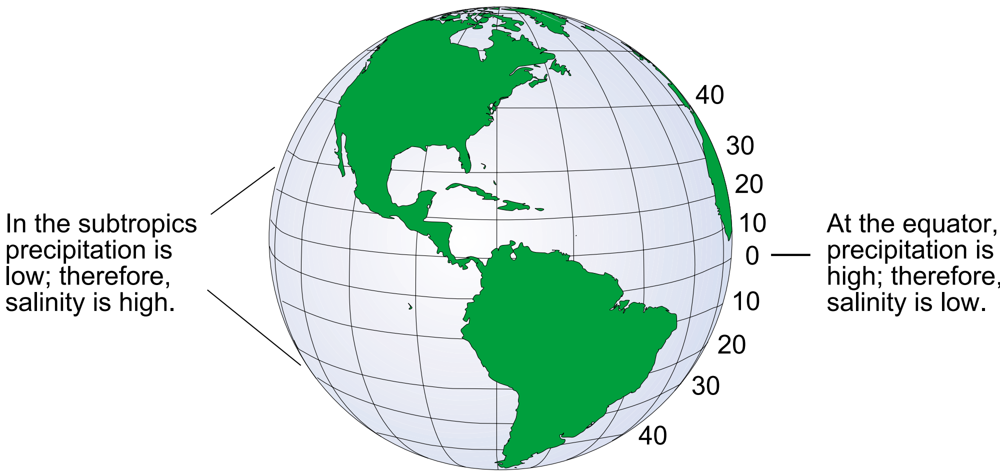
To better understand the composition of seawater, oceanographers measure the amount of dissolved salts in the ocean. Salinity, or the amount of dissolved salts in seawater, is measured in parts of dissolved salts per 1,000 parts of water—or parts per thousand ($\frac{0}{00}$). The average salinity of the ocean is 35 parts of salt per 1,000 parts of water or 35$\frac{0}{00}$.

Differences in Salinity

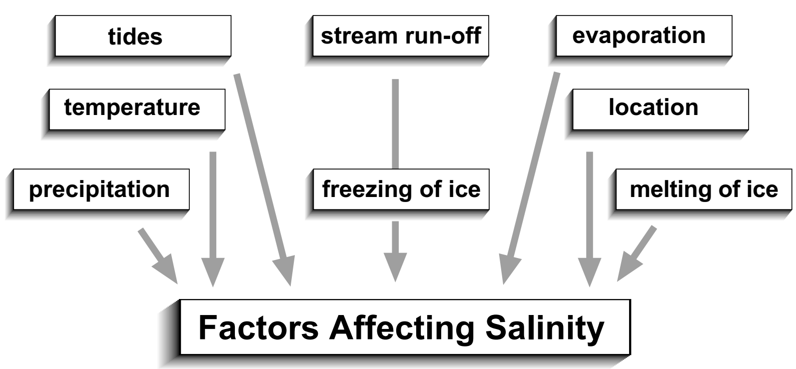
Salinity in the ocean differs from one location to the next. For example, the Red Sea has a salinity reading of 40 and 41 parts per thousand. The Mediterranean Sea has a salinity reading of 38 and 39 parts per thousand. Both these seas have high salinity readings. Bodies of water with high salinities are called **hypersaline**. The Red Sea and Mediterranean Sea are hypersaline because they are in hot, dry areas that have high evaporation and less precipitation than open oceans. Remember, when water evaporates from saltwater, the salt is left behind. Evaporation increases the salinity of saltwater. Other bodies of water which are hypersaline include the Dead Sea, the Persian Gulf, the Great Salt Lake in Utah, and areas around the Gulf of Mexico.

Dead Sea

Salinity of saltwater can also change according to latitude. Look at a globe or world map. Locate the area that is 20 degrees north latitude and 20 degrees south latitude. The salinity in this area is about 36 parts per thousand. The salinity at this latitude is higher than at zero degrees latitude or at the equator. Why do you think that the salinity is lower at the equator? If you answered because it rains more at the equator then you were right! Rain dilutes the water, making it less salty.



Coastal water typically has a lower salinity. Rivers and streams enter the oceans along the coastlines, providing freshwater to the oceans. This freshwater input lowers the salinity of the oceans. Rainwater runoff from the land impacts the salinity of the oceans near the coast as well. Water with a lowered salinity is called **brackish** water. Brackish water is a mixture of freshwater and saltwater.



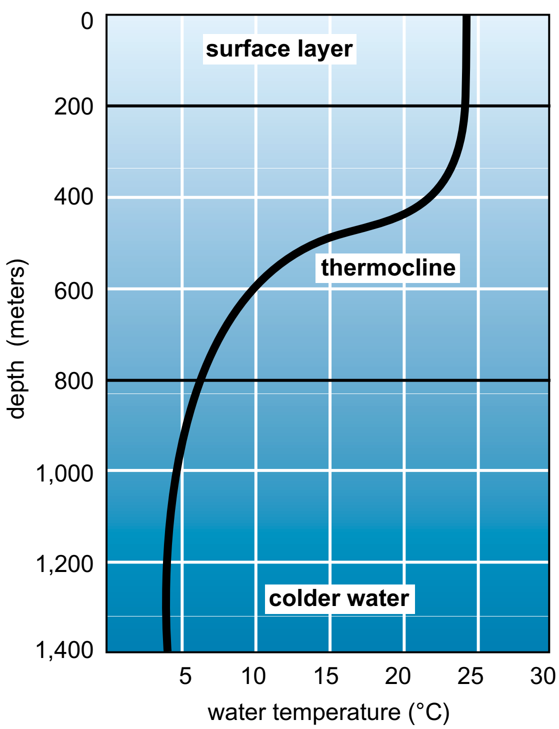
Salinity can also change as you go deeper in the ocean. The salinity at the bottom of the ocean is greater than at the surface. The change in salinity as you go deeper in the ocean is not uniform. In other words, as you go deeper, salinity does not increase but varies according to factors such as currents and temperature. There is a layer of water in the ocean called the *halocline*. The halocline shows a rapid change in salinity in a depth area between 100 and 200 meters. The change is an increase in salinity. Salinity increases in the halocline because the temperature of the water becomes

colder at these depths. Cold water contains molecules that are packed closer together. The salt molecules move closer together as well. The molecules moving closer together make salinity higher. In contrast, water at the surface of the ocean is warmer, and the molecules are farther apart, making the water less salty. Other factors besides precipitation, latitude, depth, and temperature affect salinity. These factors are shown in the diagram on page 64.

Temperatures of the Ocean: From Freezing to Warm

The surface temperature of the ocean varies depending on the latitude (its distance from the equator) and the season of the year. Seawater in the Antarctic Ocean during the winter is much colder than the waters in the South Pacific during the summer.

Water at lower depths in the ocean is always colder than water at higher depths and on the surface. On a warm day at the beach, the surface of the ocean, having been warmed by the sun, may feel warm to your skin. As you swim below the water, however, the temperature lowers, and continues to decrease the further down you go. As you'll remember from your reading in Unit 2, warm water is lighter and so remains on the surface, whereas cooler water more dense and sinks.

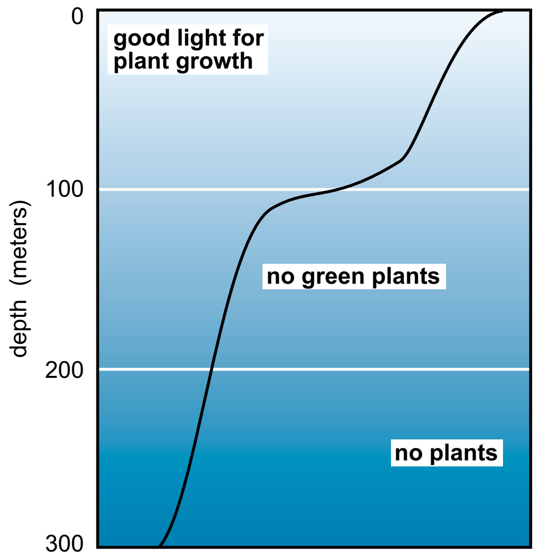


temperature of ocean water decreases with increasing depth

There is a layer of water called the **thermocline** beneath the surface of the ocean where temperature drops radically. If you were swimming through the thermocline, it would be like a sudden burst of cold. Once you passed through it, your body would begin feeling a more gradual drop in temperature as you continued your descent.

Light in Ocean Waters

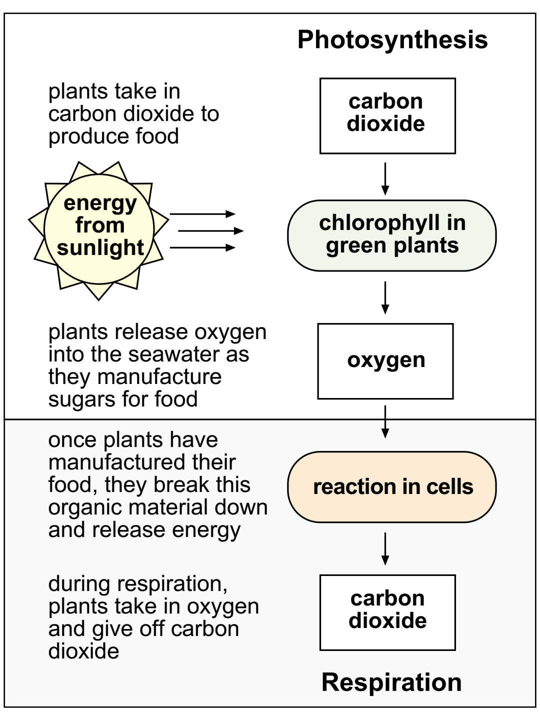
On average, light reaches to about 200 meters below the surface of the ocean, or the distance of two football fields. However, light is not adequate beyond about 100 meters to support photosynthesis (food-making) and plant growth. Beyond about 200 meters complete darkness prevails.



light in ocean waters

Dissolved Gases in Seawater

You've read about dissolved solids, such as salt, in seawater. In addition to solids, seawater also contains dissolved *gases* that come from mixing with air in the atmosphere. Nitrogen, carbon dioxide, and oxygen are the most common dissolved gases found in the ocean.



photosynthesis and respiration cycle

Both plants and animals play roles in removing and replacing gases in seawater. Plants take in and release both oxygen and carbon dioxide. In the process known as *photosynthesis*, plants use carbon dioxide to produce food. During this stage, plants release oxygen into the seawater as they manufacture sugars for food. Once plants have manufactured their food, they break this organic material down and release energy. This is called *respiration*. During respiration, plants take in oxygen and give off carbon dioxide—a reversal of the exchange of gases occurring during photosynthesis. Animals also undergo respiration as they burn oxygen to release energy from food.