Introduction: Measuring the Ocean—Collecting Information

Most oceanographers study the ocean with a specific purpose in mind. Some may study the chemical composition of seawater. Others may study its physical properties. For example, a *chemical oceanographer* may measure the amount of dissolved salts in seawater. This would help to detect changes that could affect different organisms. On the other hand, a *physical oceanographer* may want to discover the direction and speed of the ocean's currents. To collect this information, the oceanographer may use something as simple as a bottle with a message sealed inside it, which drifts across the ocean until someone along a coast discovers it. In contrast, a *geological oceanographer* may have to use complex instruments capable of bouncing sound waves off the ocean floor in order to chart the ocean's topography.

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The Ocean's Chemical and Physical Features and How They Are Measured

Salinity. **Salinity** is the measure of the amount of dissolved solids, or salts, in seawater. Water dissolves many materials. It's easy to see this when we spoon sugar into a glass of tea, but it's rare—in fact nearly impossible—to observe rainwater percolating through the soil and dissolving weathered rock and minerals. Whether we see it or not, that is what happens. After passing through soil, rainwater carries dissolved minerals (mostly salts) into rivers, and rivers then carry these minerals into the ocean.

Knowing the salinity of specific regions helps scientists determine the location of different organisms. Certain kinds of ocean life thrive in certain salinities. Interestingly, ocean water has a similar salinity to that of our own body fluids—about three percent.

Major Ions Found in Saltwater

Ion	Symbol	Percentage of Ions in Seawater by Weight
Chloride	Cl^-	55.07
Sodium	Na^+	30.62
Sulfate	SO_4^{2-}	7.72
Magnesium	Mg^{2+}	3.68
Calcium	Ca^{2+}	1.17
Potassium	K^+	1.10
trace elements*		.64
		100.00

* Elements in amounts less than on part per million.

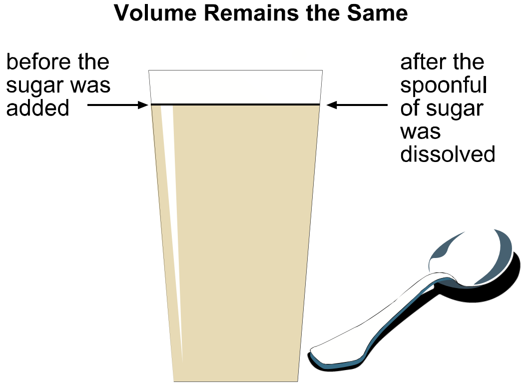
To measure salinity, oceanographers use several methods. One method is measuring the **ions** concentrated in the water sample (see previous page). When salts dissolve in water they form ions.

A total of six major ions are responsible for about 99% of the dissolved salts in the ocean. Some of these ions are sodium (Na) and chloride (Cl), the two ions that make up **sodium chloride** (NaCl), or salt. Other ions that can be measured are sulfate (SO_4), magnesium (Mg), calcium (Ca), and potassium (K). Other elements dissolved in seawater and present in concentrations less than one part per million are called *trace elements*. For example, bicarbonate (HCO_3) is a trace element found in seawater at .40 percent. By measuring these ion concentrations, oceanographers obtain the approximate salinity of seawater. Conductivity testing is another method used to determine salinity. An electrical current is passed through the water. The more NaCl ions there are, or the higher the salinity, the more easily the electrical current flows. Oceanographers also use a *refractometer* to measure the *refraction* (bending) of light through a sample of water. The change in angle of the light changes as the salinity changes.

Density. Recall a documentary you've seen on whales, or giant sea turtles. Remember how you watched them glide gracefully through the water, moving their thousands of pounds with seemingly little effort? Why didn't that blue whale weighing 150 tons sink to the bottom? Now remember a documentary or movie that depicted dinosaurs, or rhinoceros, or even elephants using their feet to walk over land. Note how much harder it is for huge land animals to travel. What accounts for the ease with which large animals can move through the water as compared to the large animals traveling on land?

Large land animals have to balance and support their own weight, carrying a thousand or so pounds across the ground. But ocean animals are assisted in carrying their weight by the **density** of ocean water. To understand the concept of density, carry out this simple experiment. First, pass your hand through air. Then pass your hand through water. Which movement took more effort? Which is more dense, air or water? As you've discovered, water is more dense than air. (In fact, water is 800 times more dense than air.) Now add to pure water all the salt that it collects as it heads towards the ocean, and you can see that seawater is much more dense than air.

To determine density, we measure the mass in a particular volume of space. Take, for example, a glass of tea. If you dissolve a spoonful of sugar in it, its volume—or the space it filled—does not increase. But its mass—or its amount of matter, does increase. The high mass of salts (or its salinity) in a particular measure of seawater, or its density, helps to support the giant blue whale on its travels through the ocean.



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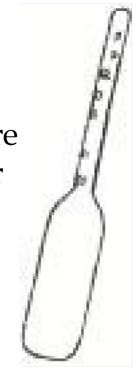
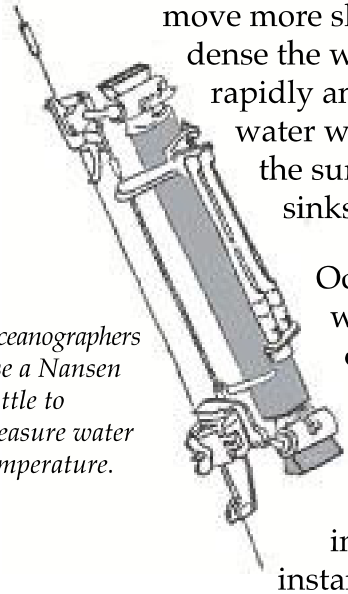
Less dense substances will remain above more dense substances. Air remains above water because it is less dense than water. Fresh water hasn't collected salts and minerals, so it will remain above heavier, salt-filled seawater. Oil, although it may seem more dense than ocean water, is actually less dense. Here's the proof. Remember pictures on the news of an oil freighter spilling its load? Remember seeing the oil floating across the ocean's surface—producing an oil slick? The oil floated and spread, like a poisonous blanket. If that oil had been more dense than seawater, it would have sunk.

To measure the density of a substance, oceanographers use a **hydrometer**. A *hydrometer* is a weighted glass tube that floats upright in water. It will float high in water that is heavy or more dense, such as seawater, and it will sink in water that is light or less dense, such as fresh water.



A hydrometer is a weighted glass tube that floats upright in water.

Temperature. Temperature also increases or decreases density. Heat is a form of energy. When heat is added to water, molecules move more rapidly and farther apart. When the water is cooled, the molecules move towards one another and consequently there will be more molecules per cubic centimeter. When water molecules move more slowly and remain closer together, the more dense the water will be. When molecules in water move rapidly and are, therefore, farther apart, the less dense the water will be. So warm water is lighter and remains on the surface, whereas cooler water is more dense and sinks.



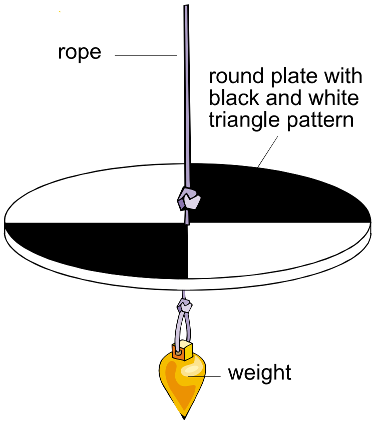
Oceanographers use a Nansen bottle to measure water temperature.

Oceanographers use a **Nansen bottle** to measure water temperature. They lower the bottle to different depths, collect some water, and measure its temperature. Then they bring the sample to the surface for further analysis.

Studying water temperature has raised some interesting questions about marine life. For instance, how do organisms keep from freezing to death in frigid water temperatures? The answer? Some organisms have a kind of *antifreeze* in their blood that protects them against freezing—just as the antifreeze in a car's radiator keeps the engine block from freezing in the winter.

How do organisms keep from freezing to death in frigid water temperatures?

Clarity. Marine plants, like nearly all plants on Earth, need light to produce food and survive. By studying how deeply light penetrates different regions of the ocean, oceanographers can determine where plant life could survive and where it could not survive.



secchi disk

Oceanographers use a **secchi disk** to measure **clarity**, or clearness, of water. The secchi disk is a round plate with a black and white triangle pattern painted on its surface. Oceanographers lower the secchi disk on a rope into the ocean until the black and white pattern can no longer be seen. By measuring the length of rope that's been submerged into the water, oceanographers can measure the number of meters light penetrates in a particular area of the ocean.

Composition. Take a look at a periodic table printed in Appen ix A. This chart includes every known element scientists have discovered up to now. Then imagine reaching down into the ocean and scooping up a few teaspoonfuls of water in the cup of your hand. In your hand you now hold almost all of the chemical elements that exist in nature.

Scientists have also discovered that the proportions of the major elements vary only slightly from one ocean to another. This finding supports the notion that seawater flows from one ocean to another. It may take thousands of years, but eventually a particular cup of water will circulate through all the oceans on Earth.

Three particular gases that chemical oceanographers test for in seawater are oxygen, nitrogen, and carbon dioxide. Each of these gases is used by plants and other organisms for particular processes. For example, oxygen is used by plants and animals during respiration. And carbon dioxide is used by plants during photosynthesis.

To determine the amount of these gases in seawater, oceanographers use a **titration apparatus**. A *titration apparatus* consists of pipettes, or tubes, which slowly drop a chemical indicator into seawater, allowing scientists to see if a chemical reaction will occur and how quickly. The nature of the chemical reaction indicates the amount of oxygen, nitrogen, and carbon dioxide the seawater contains.

Moving water is a powerful force and can carry marine life great distances.

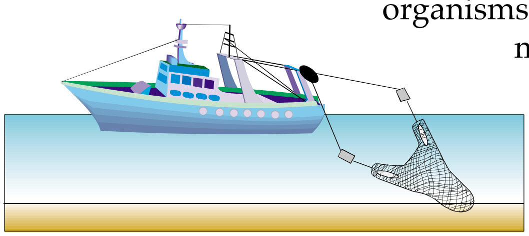
Currents. The movement of large masses of ocean water is called a *current*. The study of currents reveals both the direction and speed of ocean waters. Moving water is a powerful force and can carry marine life great distances. For example, some marine organisms begin their life near the shore, and then they are carried out to sea as eggs or larvae by currents. Some marine life that live near shore feed upon plants and organisms carried in by ocean currents.

We're all familiar with the cartoon of a man or woman stranded on an island who finds a message in a bottle. In fact, oceanographers use **drift bottles** to collect physical data about ocean currents. They release bottles (in the oceans) containing cards that ask the finder the date, time, and location of the discovery, and request that the finder return the card. Oceanographers use this information to chart ocean currents.

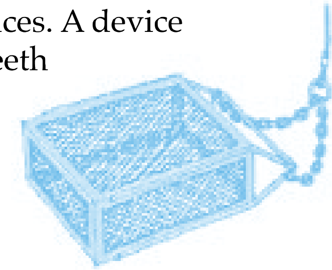
Sampling

The Ocean Floor. When we think of the ocean floor, it's easy to imagine a very dark and cold place with little life. But the ocean floor supports a large community of organisms. Some of these life forms, such as lobsters, crabs, and clams, even make their way to our dinner tables. The group of organisms that live in or on the ocean's bottom are known as *benthic organisms*.

Oceanographers are particularly interested in the life styles of benthic organisms because their food supply is limited. As you know, plants survive by using sunlight for photosynthesis. But light does not penetrate to all parts of the ocean floor, and so there are no plants for benthic organisms to feed on. Consequently, benthic organisms are dependent for food or organic materials from the surface that settle to the bottom. To study the benthos, the organisms that live in or on the ocean's bottom, oceanographers use **trawls**—large nets that are pulled along the bottom to capture animals.

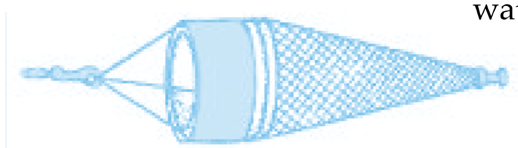

trawl net

Oceanographers also collect *sediments*—actual samples of the seafloor—to determine the *age* and *composition* of the ocean floor. Sediment samples are collected by mechanical devices. A device known as a **grab sampler** looks like a giant set of teeth which bites into the ocean floor. In its "mouth," it collects a sediment known as a *grab sample*. A **dredge**—a kind of giant scoop—collects rock samples as it is dragged along the ocean floor.


A dredge is a kind of giant scoop that is dragged among the ocean floor.

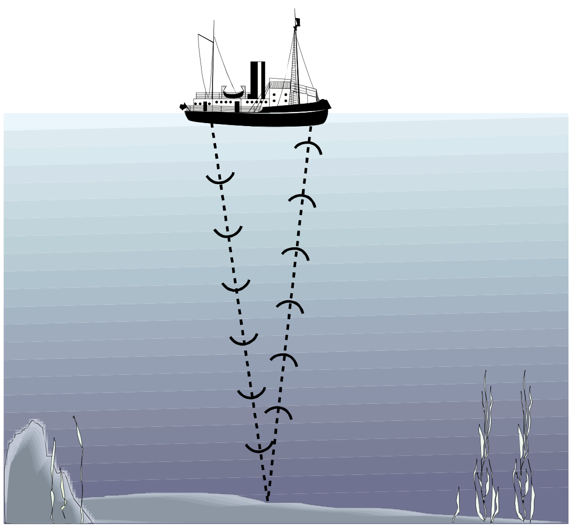
A device known as a **corer** also removes sediment samples from the seafloor. The corer works in the same way as an apple corer and drills a hole in the seafloor to collect a cylindrical or tube-shaped sample. From these core samples, oceanographers can study the changes in marine life populations over thousands of years and the rate at which sediment has accumulated on the ocean floor.

Above the Ocean Floor. All marine life depends in some way on a large group of plants and animals invisible to the human eye. These tiny organisms are called **plankton**. To gather these life forms for study, oceanographers tow a cone-shaped net called a **plankton net** through the water. To capture fish that travel in schools, oceanographers use stationary nets called **seine nets**. By setting these nets at particular depths, oceanographers can capture different kinds of fish.



plankton net

Depth. Just as the land we live on is uneven, ranging from deep valleys to high mountains, the depth of the ocean floor varies greatly from place to place. Until the 1920s, little was known about the *topography*—or rises and dips—of the ocean bottom. Scientists used to tie a weight on a rope and lower it until it reached bottom. This method, as you can imagine, was slow and imprecise.



The echo-sounding method sends sound waves through the water to the ocean floor and measures the time it takes for the sound wave to bounce off the ocean floor and (return) back to the ship.

In the 1920s, *sonar* (sound navigation and ranging) was invented. Sonar uses the **echo-sounding** method, sending sound waves through the water to the ocean floor. By measuring the time it takes for sound waves to bounce off the ocean floor and echo (return) back to the ship, oceanographers can chart the ocean bottom.

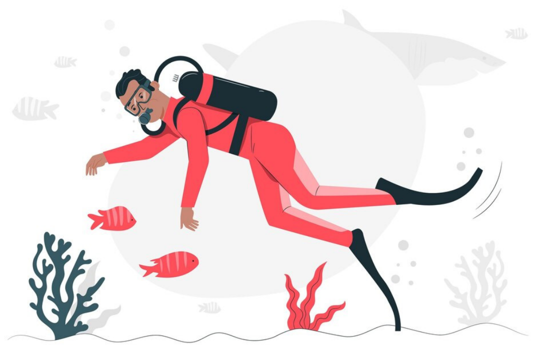
Interestingly, the use of submarines in warfare during World War II helped speed the refinement of sonar. Submarine personnel needed to remain aware of their surroundings in order to survive their “blind” travels through the ocean. In order to “see,” subs sent out sonar and were able to detect, among other things, enemy ships and subs. Some sea animals, for example dolphins and porpoises, use a system similar to sonar to “see” in their underwater worlds.

Seismic profilers and **side scan sonars** are two powerful types of echo sounding methods. **Seismic profiling** uses powerful sound waves produced by explosions. These waves reach below the surface of the seafloor and bounce off buried rocks. This method gives researchers a deeper geological profile of the ocean floor. Side scan sonars use sound waves to view a wide area of the seafloor. Sound waves are sent out to the sides of the ship and are received by an instrument towed behind the ship. Side scan sonars provide pictures of objects on the seafloor and can be used to locate shipwrecks and large schools of fish.

Satellites gather more data faster than ocean vessels with echo sounding can. Signals sent from a satellite are bounced off the ocean surface rather than the ocean floor. Utilizing ocean surface data to map the ocean floor works because the water level of the ocean varies. Water will pile up over undersea mountains and dip over undersea trenches. The dips and hills in the ocean level are revealed by accurate satellite measurements. These measurements are fed into a computer to produce a picture of the ocean floor.

Diving. Most of us have used diving equipment or have seen the air tanks divers strap to their backs to breathe underwater. These tanks are called *aqualungs* or **SCUBA** (**s**elf-**c**ontained **u**nderwater **b**reathing **a**pparatus). Scuba gear enables divers to spend up to an hour underwater exploring up close the marine life and habitats in the upper levels of the ocean.

Diving underwater does have its problems. Water pressure—or the force exerted by water—increases with depth. Divers using scuba tanks can withstand pressure to 36 meters (or approximately 118 feet) below the surface. Beyond 36 meters, divers need to wear pressure suits. At depths requiring equipment, divers must go through **decompression** very slowly as they swim to the surface. Most of the ocean floor is too deep for divers to explore without being harmed by extreme water pressure.



Summary

To fully understand Earth's oceans, oceanographers attempt to measure their physical features. Measuring salinity, density, temperature, clarity, composition, and currents, and sampling the ocean floor takes specific and often varied equipment.