Introduction: Ocean Currents—Moving Streams of Water

The previous unit discussed how the *gravitational pull* of the moon and sun cause the Earth's oceans to *rise* and *fall*. The sun also influences streams of water in the oceans to flow across the Earth's surface or move *horizontally*. These moving streams of water are called **currents** and follow a regular **course**, or path, as they travel the ocean. *Currents* can move along the surface of the ocean and at any depth below the surface.

The Ocean's Surface Currents: Blown by the Wind, Moved by Temperatures

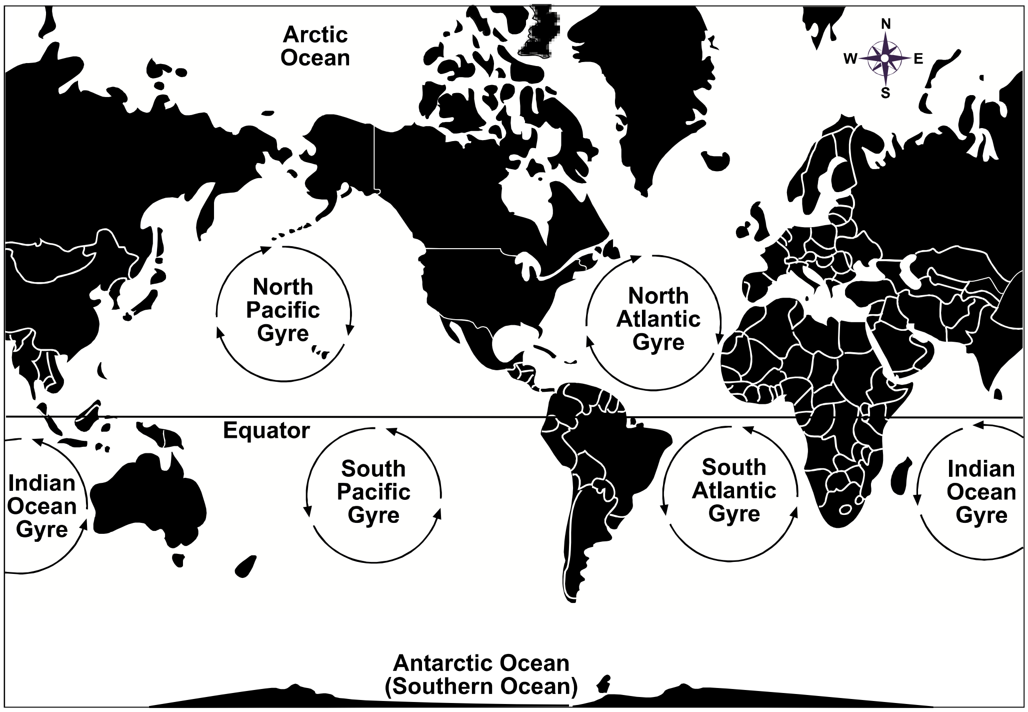
The friction of the wind, or moving air, against the surface of the water set the water in motion.

You've probably noticed the surface of the ocean set in motion by the wind when you've visited the coast. What you're witnessing is the transfer of energy from the wind to the surface of the ocean. The friction of the wind, or moving air, against the surface of the water set the water in motion. The greater the wind, the greater the friction, and, consequently, the stronger the surface currents. In short, on a windy day, the sea will be much choppier than on a calm day. (The next time you see the wind's effect on the ocean's surface, consider this: Wind friction is passed from the surface water to the water levels below. In some places, this transfer of energy continues, level by level, to 200 meters below the surface!)

Our study of the surface currents in the ocean begins with a discussion of wind. You may remember from your previous studies in science that some parts of the Earth receive more direct sunlight than other parts. Heated air expands and rises, while colder, more dense air sinks. If the Earth did not rotate on its axis, the air along the sun-drenched equator would heat and flow towards the north and south poles. At the poles, air would cool, become very heavy, and flow back to the equator where it would be heated again. The winds would move northerly and southerly along the Earth.

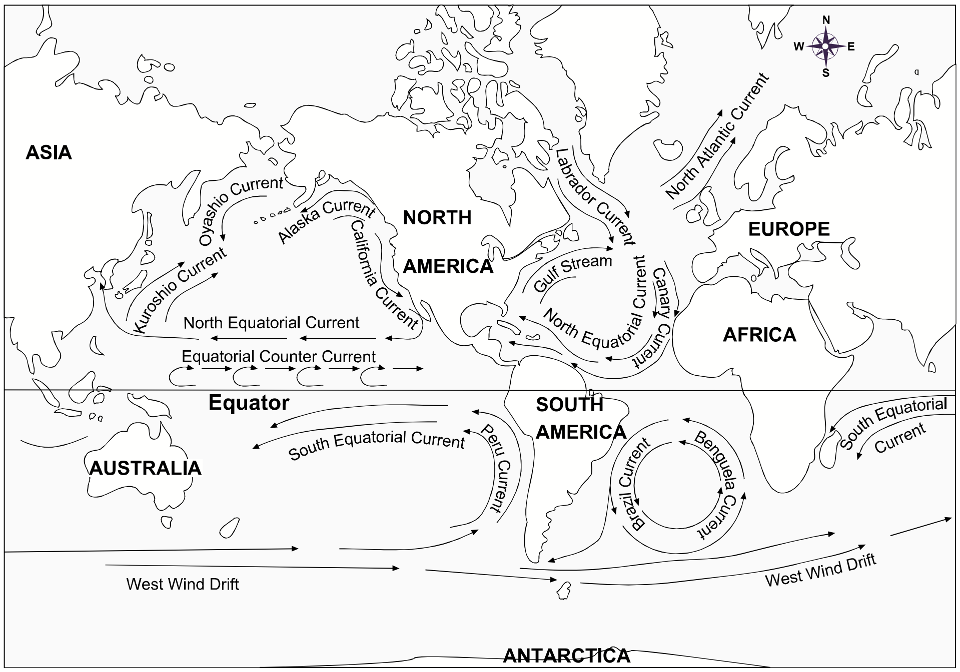
The Earth rotates and this feature produces a regular but complex wind pattern in the atmosphere. The result of the Earth's rotation is known as the **Coriolis effect**. In each hemisphere, the Coriolis effect produces three wind systems, or moving bands of air. These moving bands of air, called the *polar easterlies*, the *westerlies*, and the **trade winds** (which are easterlies), move the ocean's currents. The winds are named for the direction from which they come.

Air along the equator moves north or south. The waters move, consequently, in giant circular patterns called **gyres**. There are five major gyres or circulating patterns in the world's oceans. In the Northern **Hemisphere**, these gyres move in a *clockwise* direction, and in the Southern Hemisphere they move in a *counterclockwise* direction.



gyres of the world

The waters of the Earth have different temperatures. Because the sun is closest to the equator, currents at the equator are warm, whereas currents at the poles are cold. This difference in water temperatures creates **convection currents** in the ocean waters. The colder, more dense water sinks, and the warmer, less dense water rises above it. **Equatorial currents** carry warm water away from the equator toward the poles. **Polar currents** carry cold water away from the poles toward the equator.



currents of the world

Florida's Currents: The Gulf Stream

One of the most familiar currents to us in Florida is the **Gulf Stream**. The Gulf Stream is a warm-water current that flows from the Gulf of Mexico, around Florida and up the East Coast of North America. Its waters help to warm the water temperature of the eastern North Atlantic Ocean, making the water relatively warm (even in the winter) and moderating our climate.

Turbidity Currents: A Slide in the Ocean

The continental shelf and the slope sometimes have deep cuts that form valleys or canyons. Scientists hypothesize that these valleys and canyons were formed by **turbidity currents**. These are currents that are very thick and carry huge amounts of sediment down the **continental slopes** (see Unit 7). Turbidity currents form when landslides of sediments are pushed down the continental slopes. The landslides are possibly triggered by earthquakes. The speed at which the sediment slides down the continental slope erodes the slope, forming deep canyons.

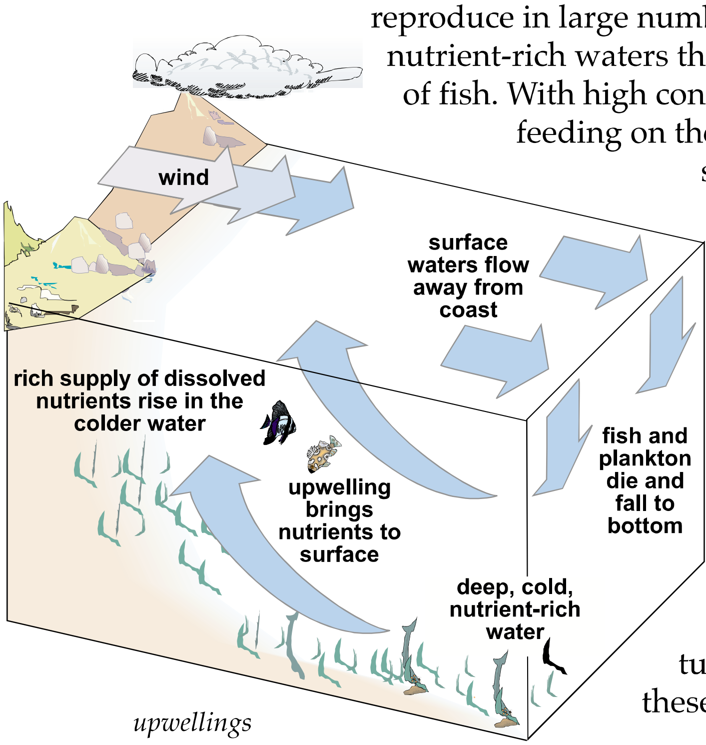
Making Use of the Currents

For hundreds of years we've observed the currents and used them to our advantage. For example, sailors have long used the currents to decrease their travel time. By moving in the same direction as fast-moving currents, ships save time and reduce fuel use. In some instances, traveling a longer distance along the currents take less time and fuel than traveling a more direct route.

Ships coming to the New World from Europe knew about currents and used them to their advantage. Ponce de Leon noted in 1513 the difficulty of sailing against the Gulf Stream along the coast of Florida. In 1770 Benjamin Franklin used sailors' records to draw simple maps of the currents in the North Atlantic Ocean, including the Gulf Stream.

Fishermen also use the currents to increase their catches. Ocean or wind currents can cause the surface water to flow away from the coast. Then a process called **upwelling** takes place: Deep, cold, nutrient-rich water—an upwelling—is brought to the surface by coastal currents. This upwelling replaces the surface water that has flowed away from the coast because of a water current or the wind. Whenever this occurs, a rich supply of dissolved nutrients rises in the colder water. *Plankton* (small, sometimes microscopic organisms that float or drift) use this nutrient source and reproduce in large numbers (see Unit 10). These nutrient-rich waters then attract large numbers of fish. With high concentrations of fish feeding on these nutrients or other sea life, these areas provide a rich catch for fishermen.

Upwellings are common on the west coasts of North America, South America, and Africa. Because of the abundance of fish, many major fisheries, such as anchovy and tuna, are located near these upwelling areas.



upwellings

Currents and the Availability of Nutrients

Marine and plant life are typically very abundant along coastal and shallow waters. Do you know why this is so? You may already know that bacterial decay occurs on the ocean floor and *photosynthesis* (the process plants and algae use to make their own food using the energy in sunlight) occurs in the surface waters of the ocean. Bacterial decay provides nutrients for marine plants and algae. Plant life in the surface waters provides food for marine life. But in the open ocean, most of the nutrients sink to the bottom of the ocean. Nutrients located at the ocean bottom are not available to the plant life at the ocean's surface. Therefore, a smaller amount of *phytoplankton*, or plant plankton, are produced in the open oceans (see Unit 9). How do you think limited phytoplankton production affects marine life in the open ocean? Upwelling in deep water brings important nutrients that have sunk to the ocean bottom back to the surface. Once these nutrients are at the ocean's surface, they become available to the phytoplankton. Upwelling and the availability of light play an important role in shaping *ecosystems* (systems formed by the interaction of a community of organisms with their environment) and the productivity of the ecosystem.

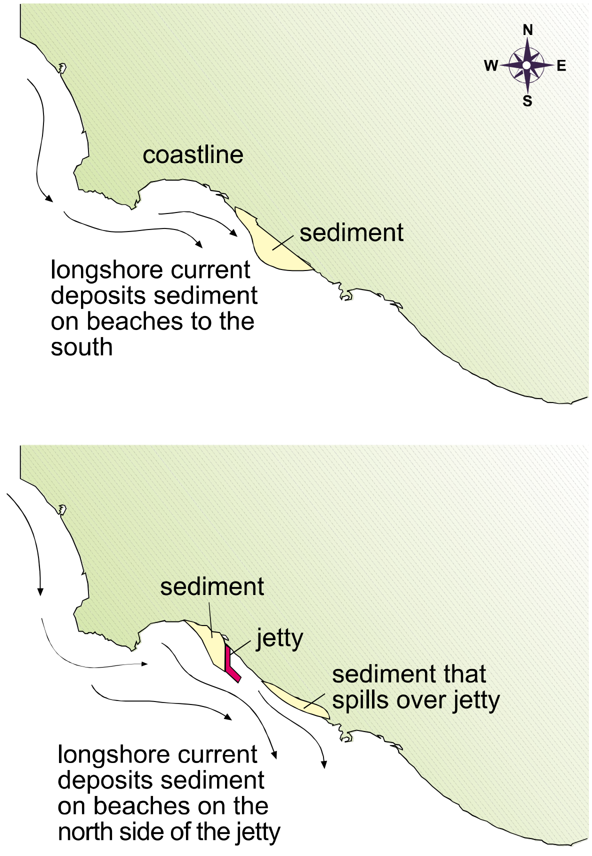
Beach Currents: A Possible Danger to the Ocean Swimmer

Not all currents are large ocean currents. Smaller currents occur near the shore. A **reversing current** is the movement of the water back toward the ocean. Most reversing currents have the same force as the wave striking the beach. However, when these currents are stronger, they can be dangerous and have caused swimmers to drown.

One of these dangerous reversing currents is the **rip current**. A rip current is a strong, narrow flow of water caused by water returning to the ocean after breaking on a shoreline. The speed and strength of this current depends on the wave and the steepness of the beach.

If you find yourself trapped in a rip current, don't panic and do not fight the current. Let the current carry you out a short distance until the pull has decreased. You can then swim to the beach, but do so diagonally to avoiding swimming into another rip current.

Another beach current is the **longshore current**. This type of current runs parallel to, or along, the beach. Longshore currents are formed when waves hit the beach at an angle. When you are carried away from your towel and beach umbrella while swimming, you have probably been caught in a longshore current. Do not try to swim against strong longshore currents. Simply swim or float directly to shore, then walk back to your starting point.



longshore currents

Longshore currents are responsible for the mass movements of sand and erosion along the beach. Many people try to stop longshore sand movement by building jetties. A *jetty* is a projecting structure made of rocks, concrete, or wood that protects the beach from the current or tide. The longshore current still moves the sand, but with a jetty in place, the sand is trapped. Eventually, however, the sand will spill over to the other side of the jetty. Although jetties can't stop longshore movements or erosion, they can slow it down.

Summary

Ocean currents are movements in the water caused by Earth's rotation (Coriolis effect), wind systems, and differences in water temperature (convection). Currents affect the movement of ships and marine life in the ocean, and carry warm water to the poles and cold water to the equator. You may have experienced currents along the beach, such as rip or longshore currents. These can cause harmful erosion and can be dangerous to a swimmer who gets caught and carried away from land.