Ocean Currents

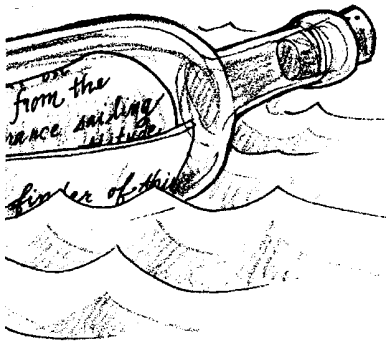
Lesson by Karen Mattick, Marine Science Center, Poulsbo, WA.

Key Concepts

1. Ocean currents are driven by wind and differences in density of surface and deep water.

2. Ocean currents move in large, circular gyres.

3. Ocean currents affect many human activities.



Background

The sun is a giant motor driving the waters of the oceans in huge, relatively well defined currents. The water masses move as a result of winds or because of differences in temperature and salt content between surface layers and lower water layers. Wind driven circulation primarily moves the water masses in a horizontal direction. Temperature and salt differences affect the density of sea water and account for vertical movements of water as well as for some horizontal movement. The persistent movements of ocean waters account for the fact that sea waters are remarkably well mixed and similar in spite of the vastly different inputs of fresh water found in different parts of the world.

Teaching Hints

This reading is fairly short and easy. For a much more detailed and challenging article, see the next article, "The Circulation of the Oceans".

Key Words

convection - the transfer of heat by the circulation or movement of the heated parts of a liquid or gas

current - in this case, a body of water moving in a certain direction within a larger body of water

density - mass per unit volume

friction - surface resistance to relative motion

gyre - a pattern made of four or five currents that dominate the circulation pattern of the ocean in each hemisphere, clockwise in the Northern Hemisphere, and counterclockwise in the Southern Hemisphere

salinity - a measure of the salt concentration in a solution

upwelling - the process by which warm, less-dense surface water is drawn away from a shore by offshore currents and replaced by cold, denser water brought up from subsurface

Answer Key

1. The two principal driving forces behind the currents are wind and differences in the densities of sea water in different areas.

2a. Hot water from power plants will tend to float on the layers of colder water below.

b. It is not likely that these outflows in their present numbers would have much of an effect on **global** ocean currents. They may, however, have a rather sizeable influence on **local** conditions.

3. Gyres are large circular patterns of water movement.

4. Plants do not grow in the deep sea because sunlight cannot penetrate through the water to provide the energy the plants need to photosynthesize.

5. Upwelling brings waters rich in oxygen and minerals to the surface. These waters provide for abundant growth of microscopic plants and animals. These organisms provide the base for a food chain that can support many different species. Upwelling, then, increases the numbers and variety of organisms in the area affected.

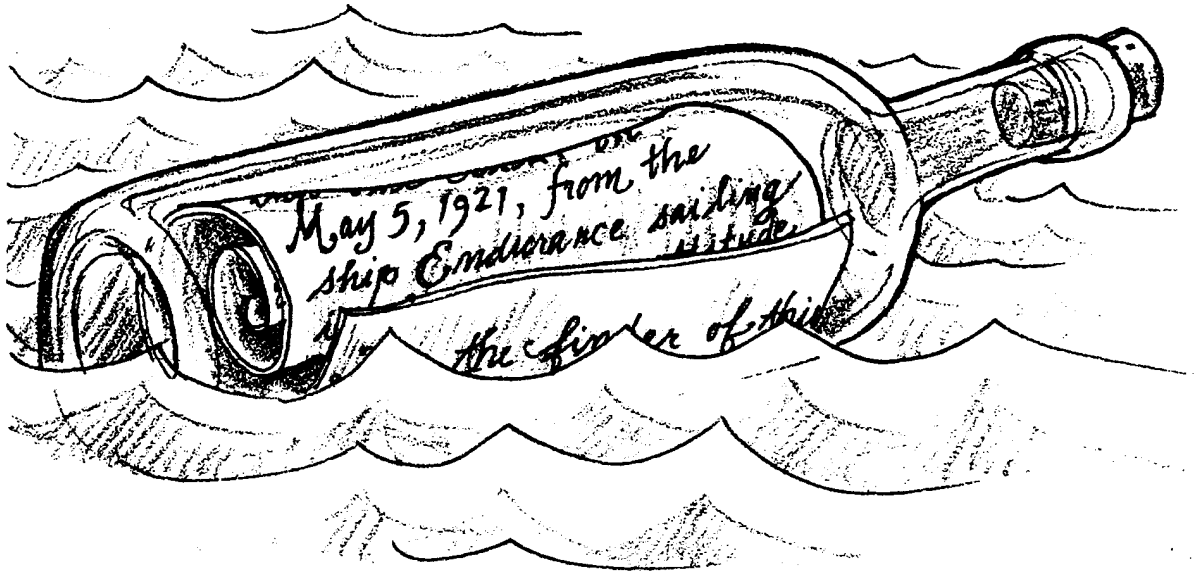
6. Students should label two currents where water has moved from the north or south pole along a continent. For example, upwelling occurs off the west coast of North America, the west coast of South America, and the west coast of Africa.

7. El Nino stops the upwelling of nutrient rich deep water off the coast of Peru. The phytoplankton do not have adequate nutrients supplies to flourish. The zooplankton that consume the plant plankton lack sufficient food supplies and their populations drop. The fish, then lack sufficient zooplankton stocks on which to feed and either die or move to richer waters.

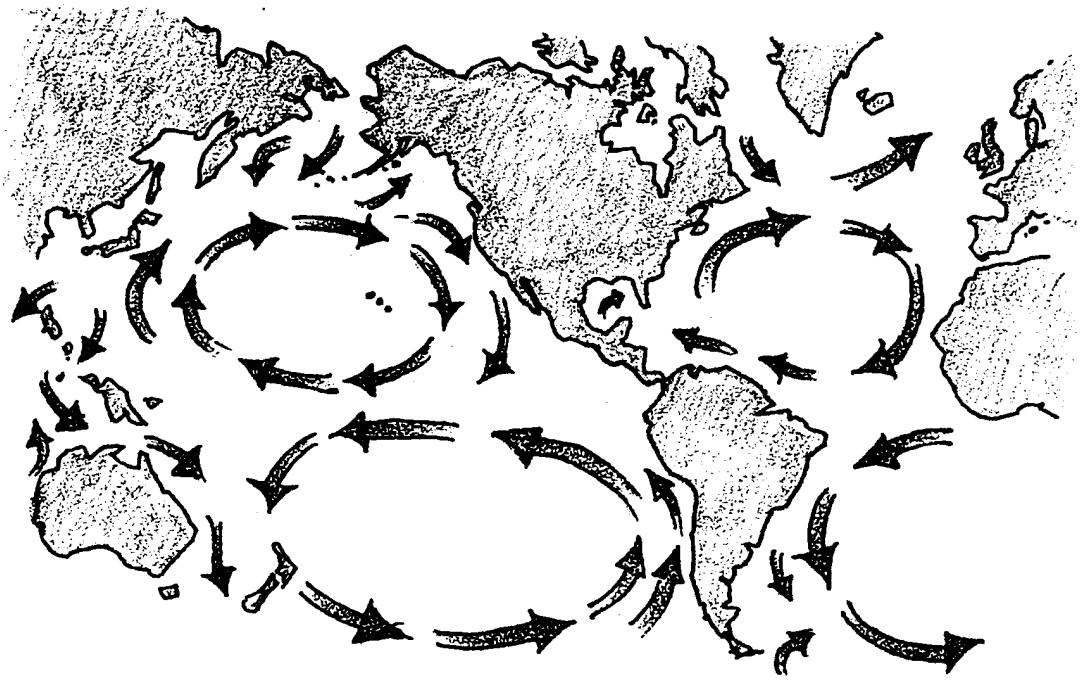
8. Ocean water is warmer in New England states because the Gulf Stream moves warm, equatorial water northward along the Atlantic coast.

9. The cold water carrying Labrador currents helps cause the severe winters in Nova Scotia.

Ocean Currents

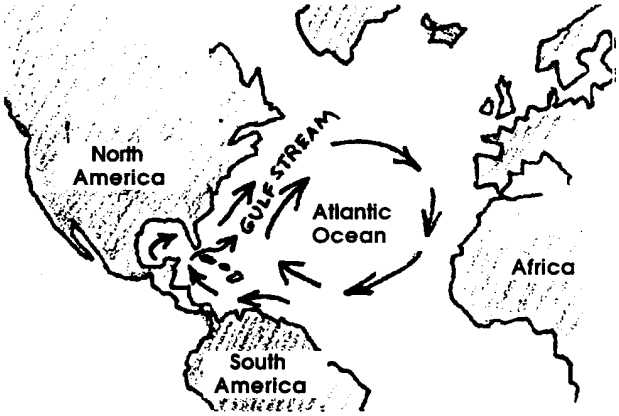


The waters of the sea are always in motion. In all of the oceans there are great rivers of salt water flowing in giant, circular currents.



Sailors have long recognized these currents as important forces in the oceans. In the late 1700's Benjamin Franklin wondered why American sailing ships took about two weeks less to cross the Atlantic than similar English ships. Franklin discovered that American captains were taking

advantage of a current running eastward across the North Atlantic at about three miles an hour. Returning from England, the American ships sailed to avoid the current as much as possible. Franklin named this current the "Gulf Stream". Today we know that the Gulf Stream is but one of many ocean currents.



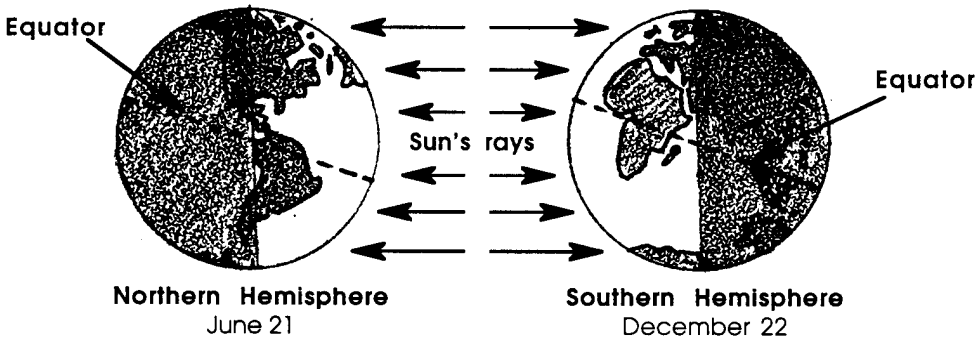
What causes the ocean currents we see? The currents appear to be caused by a combination of factors. The main driving force of the currents comes from the wind. The wind blows across the surface of the water causing the water particles to move. The second principal driving force comes from differences in the densities of sea water in different areas. Cold temperatures and high salt content are two factors that can make salt water more dense. More dense sea water sinks and less dense sea water floats. These movements create currents.

1. What are the two principal driving forces behind the currents?

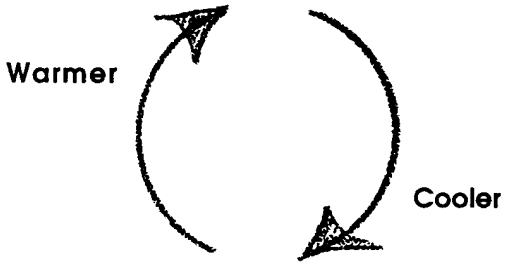
a.

b.

Wind forces are readily seen. Can we see the changes due to density differences? If you have ever dived into a swimming pool and felt colder water at the bottom, you will have little trouble believing that cold water is more dense than warm water and tends to sink. How can this observation help explain some of the currents? Let's look at the earth's position in relation to the rays from the sun.



Even though the earth is slightly inclined from the vertical, it isn't hard to see that the most direct rays from the sun strike the earth near the equator.



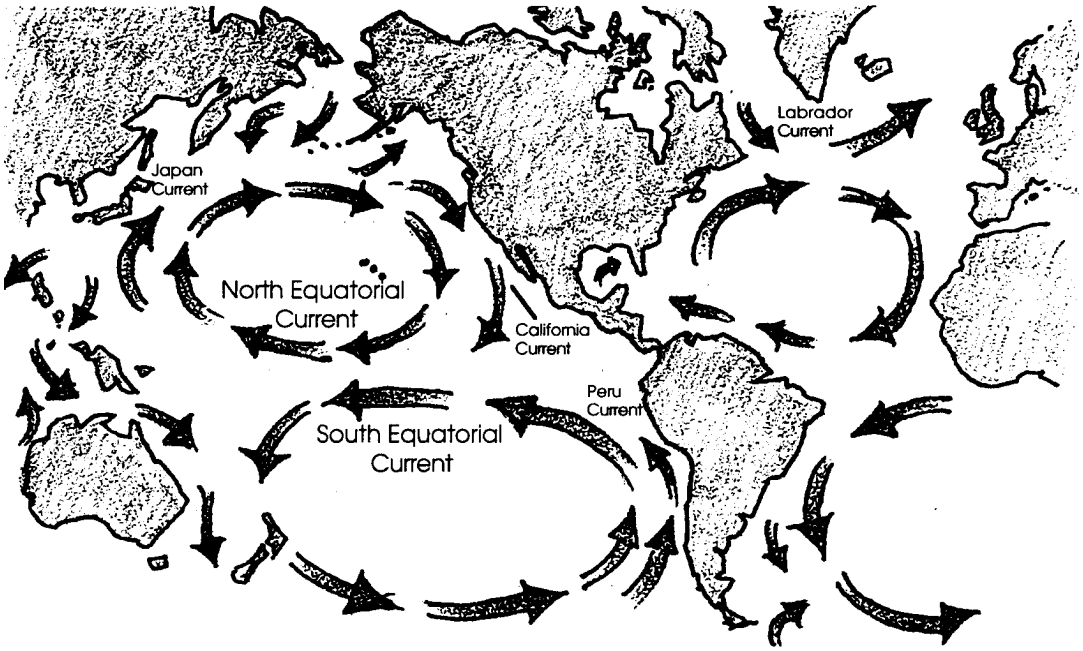
These direct rays produce more heat. Therefore, the surface waters near the equator will be warmer than the surface waters nearer the poles. As cool water warms near the equator, it rises. Cold, deep water flows in from the poles to take its place and it too warms and rises. This is a temperature caused current also known as a convection current.

Temperature is not the only thing that can change the density of water. The addition of salt makes water more dense. The sea is relatively uniform in salinity (salt concentration), but we find local differences which can help cause currents. For example, the ice caps around the poles are frozen fresh water. As icebergs melt, they tend to dilute the salt water. This water tends to stay near the surface. Conversely, as icebergs form, the surrounding sea water becomes very cold and more salty. This cold, dense water sinks and travels in bottom currents all the way to the equator. Differences in density due to salinity, then, can also cause currents.

2 a. Power plants often discharge hot, fresh water into the ocean. Will this water tend to sink or float?

b. Is it likely these outflows would have much of an effect on world ocean currents? Why or why not?

Look at the map of some of the ocean currents of the world.



The major currents flow in large circular patterns or gyres (jy - urz) caused by the spinning of the earth. These gyres tend to stay in either the Northern hemisphere or in the Southern hemisphere. If you look carefully you will notice that the currents move in different directions in the two hemispheres: clockwise north of the equator and counter-clockwise south of the equator. Currents that flow away from the equator are warm currents. Those that flow away from the poles and toward the equator carry cold arctic waters.

3. What are gyres?

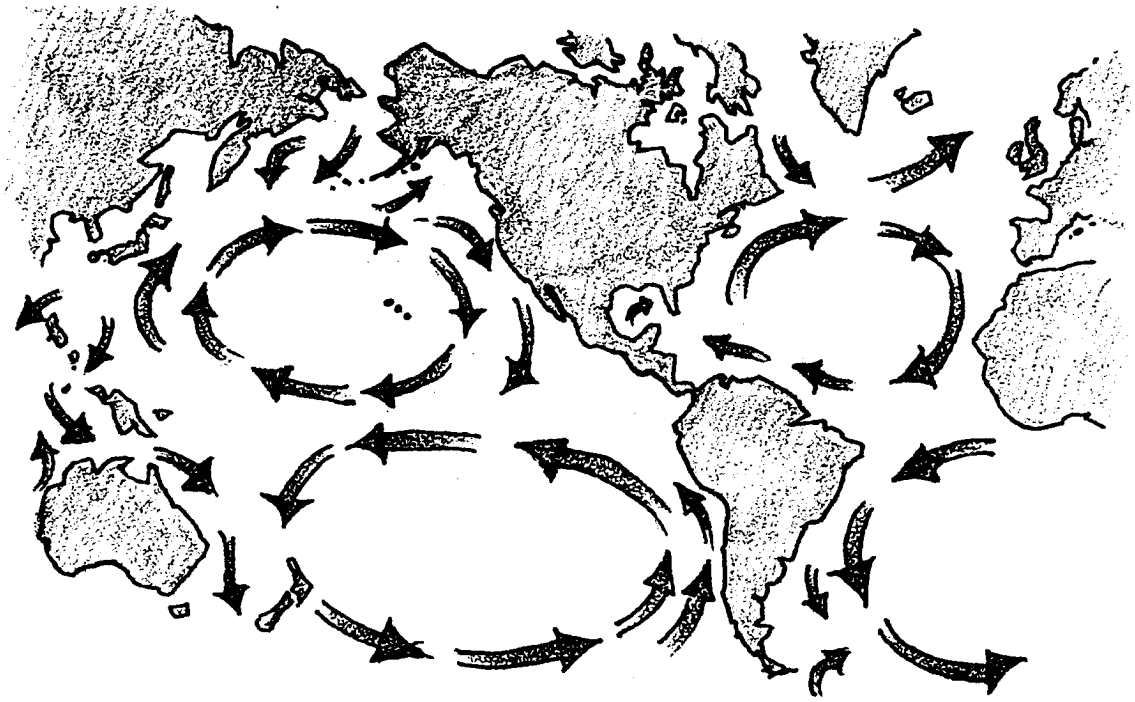
Surface currents have been studied since humans first went to sea. The study of deep water currents is much more recent and incomplete. The surface currents move the waters in the first 2,000 feet of the ocean. Deep currents run below the surface currents, moving the waters that lie between about 2,000 feet deep and about 10,000 feet deep.

The deep water currents, it turns out, provide important nutrients in the oceans. The cold, dark, deep waters gradually accumulate nutrients as wastes from plants and animals at the surface sink and decay. Wherever this deep water surfaces, it brings the nutrients to the lighted surface waters where the nutrients nourish a prolific bloom of tiny plants. The plants, in turn, support thriving fish populations. This upward movement of deep, cold, nutrient-rich water is known as upwelling.

4. Plants do not grow in deep ocean water even though the deep waters are rich with the nutrients that would fertilize the plants. Why don't plants grow in these areas?

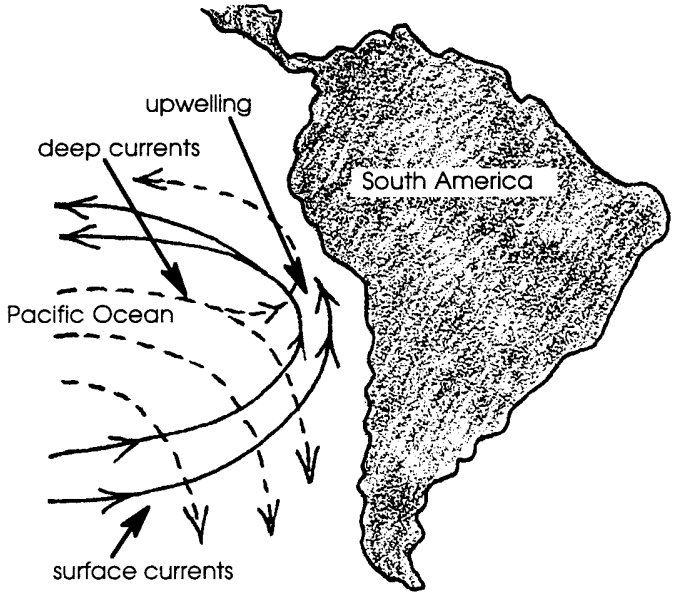
5. How does upwelling affect marine life in the surface waters?

A major upwelling occurs on the Pacific Coast of South America where water from the south pole surfaces along the coast of Peru.



6. Upwelling happens where cold water from the poles surfaces along a continent. Label on the world map two other locations that would have upwelling.

The Peruvian anchovy business depends upon this upwelling for success. The upwelling provides nutrients for plants which, in turn, feed tiny animals which, in turn, are food for fish such as anchovies.



Currents and Upwelling on the Coast of South America

Occasionally this upwelling current is disrupted in an event known as El Niño. The usual trade winds that drive the upwelling blow weakly in the opposite direction, blowing warm, equatorial water toward the Peru coast. The deep water is not able to surface. The anchovies disappear and other fish populations decline drastically. Nesting sea birds sometimes are forced to abandon their nests and fly to richer feeding grounds elsewhere because there are no fish off South America for them to feed their young.

7. How does El Niño cause a decline in fish populations?

How else have the currents influenced humans? Our climate is affected by the currents. The cool California current flows toward the equator along the Pacific coast. The warm Gulf Stream Current flows northward to about the New England States along the Atlantic coast. These currents affect the temperatures on the adjacent coasts.

8. Where would the ocean water be warmer for swimming, on the north Pacific coast in Washington and Oregon or on the Atlantic coast in the New England states? Why?

9. The New England states and Nova Scotia, Canada have very severe winters. Use the map of ocean currents to help explain this observation.