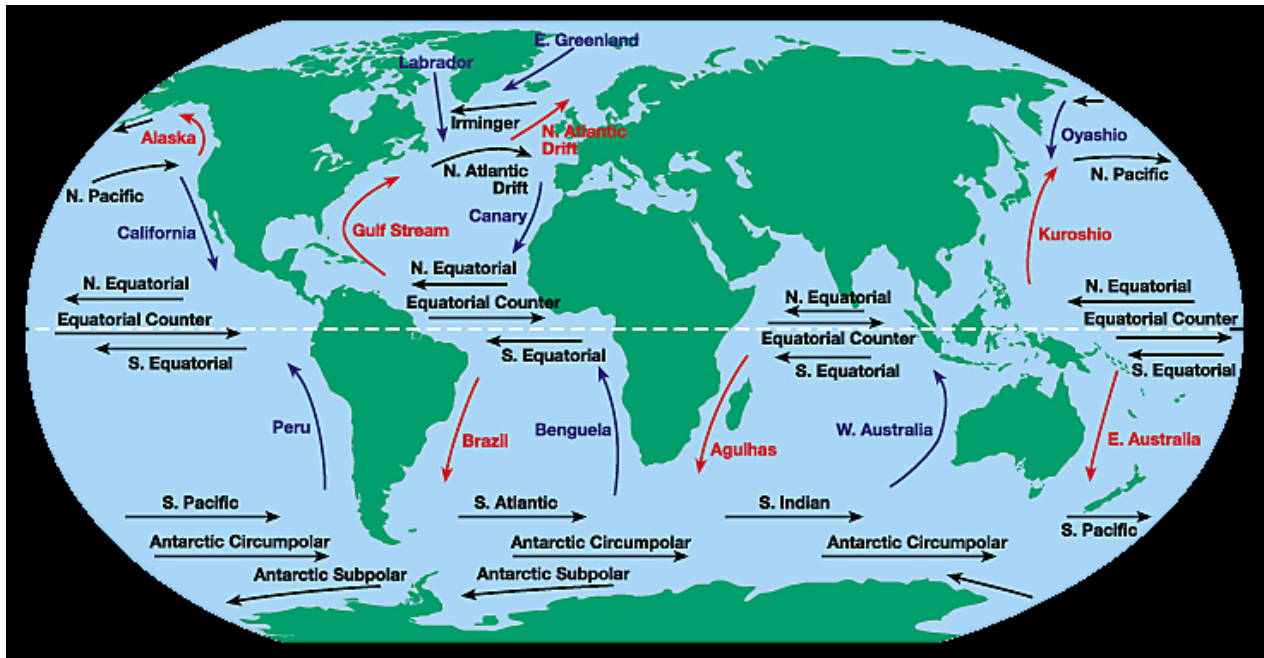


Ocean Surface Currents



The water at the ocean surface is moved primarily by winds that blow in certain patterns because of the Earth's spin and the **Coriolis Effect**. Winds are able to move the top 400 meters of the ocean creating surface ocean currents.

Surface ocean currents form large circular patterns called **gyres**. Gyres flow clockwise in Northern Hemisphere oceans and counterclockwise in Southern Hemisphere oceans because of the Coriolis Effect. Near the Earth's poles, gyres tend to flow in the opposite direction.

Surface ocean currents flow in a regular pattern, but they are not all the same. Some currents are deep and narrow. Other currents are shallow and wide. Currents are often affected by the shape of the ocean floor. Some move quickly while others move more slowly. A current can also change somewhat in depth and speed over time.

Surface ocean currents can be very large. The Gulf Stream, a surface current in the North Atlantic, carries 4500 times more water than the Mississippi River. Each second, ninety million cubic meters of water is carried past Chesapeake Bay (US) in the Gulf Stream.

Surface ocean currents carry heat from place to place in the Earth system. This affects regional climates. The Sun warms water at the equator more than it does at the high latitude polar regions. The heat travels in surface currents to higher latitudes. A current that brings warmth into a high latitude region will make that region's climate less chilly.

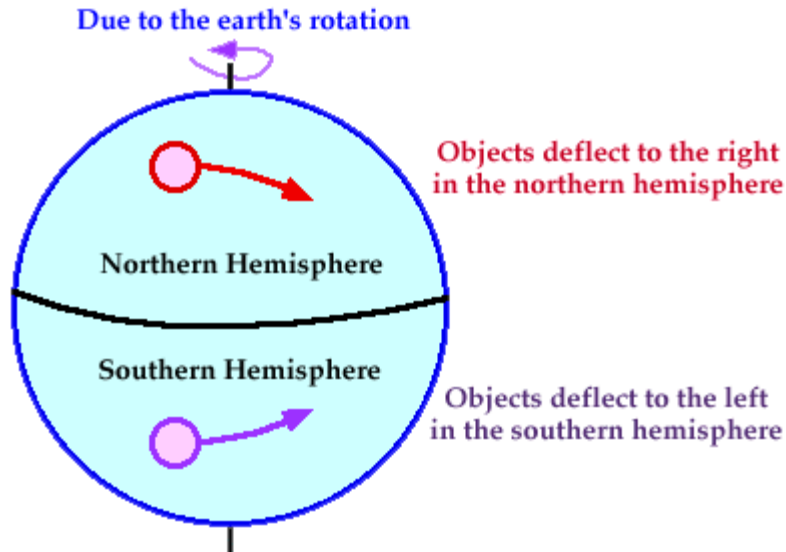
Surface ocean currents can create **eddies**, swirling loops of water, as they flow. Surface ocean currents can also affect upwelling in many places. They are important for sailors planning routes through the ocean. Currents are also important for marine life because they transport creatures around the world and affect the water temperature in ecosystems.

Ocean Current Questions

1. What is the primary mechanism which causes surface currents?
2. What are gyres and what is the difference between gyres in the northern hemisphere and southern hemisphere?
3. What large surface current runs along the east coast of the United States? Which direction does it travel?
4. How can climates of coastal regions be affected by surface currents?
5. List two ways currents affect life on earth.

Coriolis Effect

Once air has been set in motion by the pressure gradient force, it undergoes an apparent deflection from its path, as seen by an observer on the earth. This apparent deflection is called the "**Coriolis Effect**" and is a result of the earth's rotation.



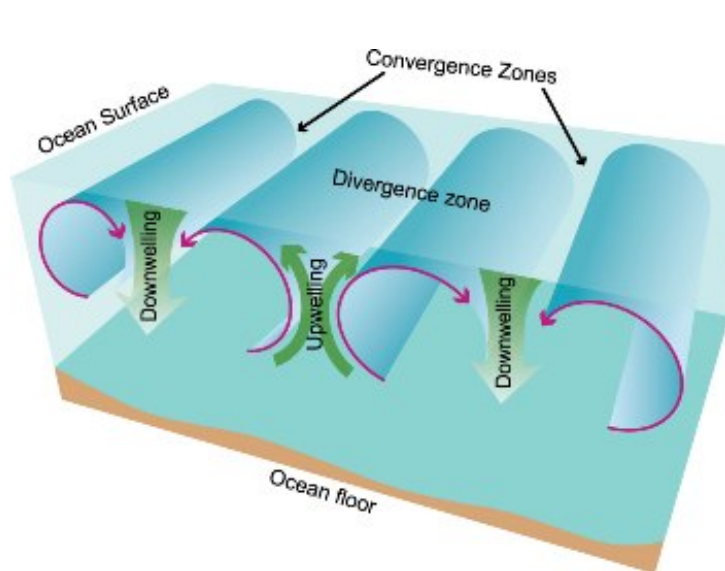
As air moves from high to low pressure in the northern hemisphere, it is deflected to the right by the Coriolis Effect. In the southern hemisphere, air moving from high to low pressure is deflected to the left by the Coriolis Effect.

The amount of deflection the air makes is directly related to both the speed at which the air is moving and its latitude. Therefore, slowly blowing winds will be deflected only a small amount, while stronger winds will be deflected more. Likewise, winds blowing closer to the poles will be deflected more than winds at the same speed closer to the equator. The Coriolis Effect is zero right at the equator.

6. Why are winds and surface currents deflected to the right in the Northern Hemisphere and to the left in the Southern Hemisphere?
7. What two factors determine the strength of the Coriolis Effect?
8. Why is the Coriolis Effect zero at the equator?

Upwelling and Downwelling

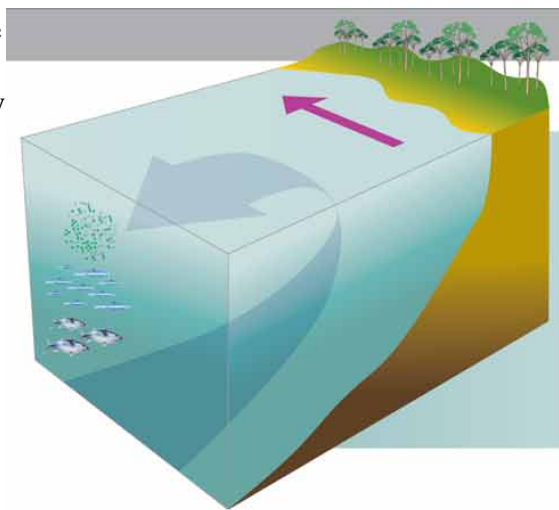
Upwelling and downwelling are important processes that describe mass movements of the ocean, which affect both surface and deep currents. These movements are essential to stirring the ocean, delivering oxygen to depth, distributing heat, and bringing nutrients to the surface. Stratification occurs when surface waters and deep waters are separated into layers by distinct differences in temperature and salinity. Think of swimming in the sea and how warm the top few centimeters feel compared with deeper waters. The top layer of ocean is called the “surface mixed layer”; it is often warm and without many nutrients.



Downwelling occurs when surface waters converge (come together), pushing the surface water downwards. Regions of downwelling have low productivity because the nutrients get used up and are not continuously resupplied by the cold, nutrient-rich water from below the surface. Upwelling is the movement of cold, deep, often nutrient-rich water to the surface mixed layer; and downwelling is the movement of surface water to deeper depths.

Upwelling occurs when surface waters diverge (move apart), enabling upward movement of water. Upwelling brings water to the surface that is enriched with nutrients important for primary productivity (algal growth) that in turn supports richly productive marine ecosystems.

Some of the most important upwelling regions are along the coasts of continents. In these coastal upwelling regions, surface winds push water away from the shore and create a divergence at the coast, which is replaced by water from depth. For coastal upwelling to occur, the wind must be parallel to the coast because water is deflected to the left of the wind in the southern hemisphere, and the right of the wind in the northern hemisphere. This deflection is due to the Coriolis force which causes objects travelling in a straight line appear to curve or deflect due to the rotation of the earth.



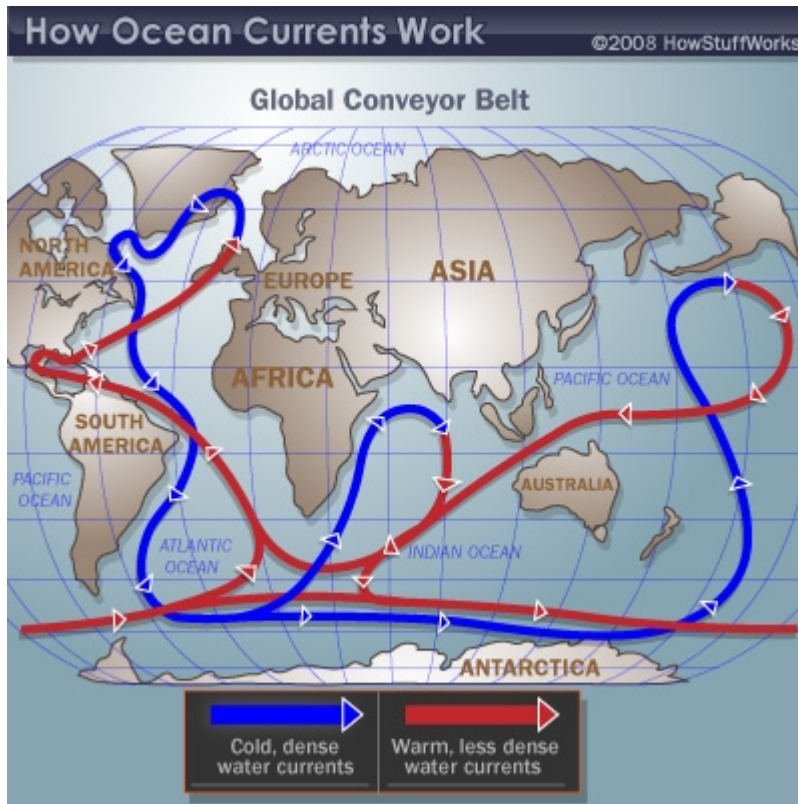
Upwelling regions are often measured by their productivity due to the influx of nutrients to the surface mixed layer and euphotic zone (sunlit layer) by upwelling currents. This drives photosynthesis of phytoplankton (tiny alga), which form the base of the ocean food web. Upwelling regions are less than 1 per cent of the world’s ocean by area, but account for greater than 20 percent of the global fish catch.

Most major upwelling regions are found along the west coasts of continents, such as off California, Peru, Namibia and South Africa. Large-scale upwelling off the west coast of Australia is suppressed due to the poleward-flowing Leeuwin Current. However, smaller-scale regional upwelling is found around the Australian coastline, including the largest and most predictable upwelling off the Bonney Coast in southeastern Australia.

Questions

1. What three ways do the stirring movements associated with upwelling and downwelling benefit life in the ocean?
2. Are many nutrients found in the surface (mixed) zone of the ocean? Why is this the case?
3. How does downwelling occur?
4. Why do regions of downwelling have low productivity?
5. How does upwelling occur?
6. Why do regions of upwelling have high productivity?
7. Where are most upwelling regions located?
8. What angle must wind hit the coast for upwelling to occur? Explain.
9. How is the ocean's food chain influenced by upwelling?
10. Name two specific regions where significant upwelling occurs.

Deep Ocean Currents (Global Conveyor Belt)



Invisible to us terrestrial creatures, an underwater current circles the globe with a force 16 times as strong as all the world's rivers combined. This deep-water current is known as the global conveyor belt and is driven by density differences in the water. Water movements driven by differences in density are also known as thermohaline circulation because water density depends on its temperature (thermo) and salinity (haline).

The global conveyor belt

Density refers to an object's mass per unit volume, or how compact it is. A heavy, compact bowling ball is obviously going to be denser than an air-filled beach ball. With water, colder and saltier equals denser.

At the earth's poles, when water freezes, the salt doesn't necessarily freeze with it, so a large volume of dense cold, salt water is left behind. When this dense water sinks to the ocean floor, more water moves in to replace it, creating a current. The new water also gets cold and sinks, continuing the cycle. Incredibly, this process drives a current of water around the globe.

The global conveyor belt begins with the cold water near the North Pole and heads south between South America and Africa toward Antarctica, partly directed by the landmasses it encounters. In Antarctica, it gets recharged with more cold water and then splits in two directions -- one section heads to the Indian Ocean and the other to the Pacific Ocean. As the two sections near the equator, they warm up and rise to the surface in what you may remember as upwelling. When they can't go any farther, the two sections loop back to the South Atlantic Ocean and finally back to the North Atlantic Ocean, where the cycle starts again.

The global conveyor belt moves much more slowly than surface currents -- a few centimeters per second, compared to tens or hundreds of centimeters per second. Scientists estimate that it takes one section of the belt 1,000 years to complete one full circuit of the globe. However slow it is, though, it moves a vast amount of water -- more than 100 times the flow of the Amazon River.

The global conveyor belt is crucial to the base of the world's food chain. As it transports water around the globe, it enriches carbon dioxide-poor, nutrient-depleted surface waters by carrying them through the ocean's deeper layers where those elements are abundant. The nutrients and carbon dioxide from the bottom layers that are distributed through the upper layers enable the growth of algae and seaweed that ultimately support all forms of life. The belt also helps to regulate temperatures.

Cinching Our Belt?

Many scientists fear that global warming could affect the global conveyor belt. If global warming leads to increased rain, as some believe it might, the added fresh water could decrease the salinity levels at the poles. Melting ice, another possibility of global warming, would also decrease salinity levels. Regardless of the means, the end scenario is the same: Warmer, less dense water won't be dense enough to sink, and the global conveyor belt could stop -- having far-reaching and devastating consequences.

1. What drives the global conveyor belt?
2. What is thermohaline circulation?
3. How are deep ocean currents generated in polar regions?
4. If thermohaline circulation begins near the North Pole, where does it travel to next?
5. How does thermohaline circulation repeat itself in a cycle?

6. How quickly does the global conveyor belt move? How does this compare with the velocity of surface currents?

7. How is the global conveyor belt important to the earth's food chain?

8. How could global warming influence salinity levels at the earth's poles?

9. How could a change in salinity affect the global conveyor belt?

10. In your opinion, what are one or two possible side effects that a disruption of the global conveyor belt?