

Encyclopedic Entry

ocean gyre

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An **ocean gyre** is a large system of circular ocean **currents** formed by global **wind** patterns and forces created by Earth's **rotation**.

The movement of the world's major ocean gyres helps drive the "ocean conveyor belt." The **ocean conveyor belt** circulates ocean water around the entire **planet**. Also known as **thermohaline circulation**, the ocean conveyor belt is **essential** for regulating **temperature**, **salinity** and **nutrient** flow throughout the ocean.

How a Gyre Forms

Three forces cause the circulation of a gyre: global wind patterns, Earth's rotation, and Earth's **landmasses**. Wind drags on the ocean surface, causing water to move in the direction the wind is blowing.

The Earth's rotation **deflects**, or changes the direction of, these wind-driven currents. This deflection is a part of the **Coriolis effect**. The Coriolis effect shifts surface currents by angles of about 45 degrees. In the **Northern Hemisphere**, ocean currents are deflected to the right, in a clockwise motion. In the **Southern Hemisphere**, ocean currents are pushed to the left, in a counterclockwise motion.

Beneath surface currents of the gyre, the Coriolis effect results in what is called an **Ekman spiral**. While surface currents are deflected by about 45 degrees, each deeper layer in the **water column** is deflected slightly less. This results in a spiral pattern descending about 100 meters (330 feet).

Earth's **continents** and other landmasses (such as **islands**) also influence the creation of ocean gyres. The **massive** South Pacific Gyre, for instance, includes hundreds of kilometers of open ocean. It is **bounded** only by the continents of Australia and South America, as well as the **Equator** and powerful **Antarctic Circumpolar Current (ACC)**.

In contrast, the northern Indian Ocean Gyre is a much smaller ocean gyre. Unlike the South Pacific Gyre, its **extent** is **determined** largely by landmasses. The Equator forms its southern **boundary**, but it is bounded elsewhere by the Horn of Africa, Sri Lanka and the Indian **subcontinent**, and the Indonesian **archipelago**.

Types of Gyres

There are three major types of ocean gyres: tropical, subtropical, and subpolar.

Subpolar gyres form in the **polar** regions of the planet. They sit beneath an area of low **atmospheric pressure**. Wind drives the currents in subpolar gyres away from coastal areas. These surface currents are replaced by cold, nutrient-rich water in a process called **upwelling**. The Northern Hemisphere has several subpolar gyres, bounded by islands such as Iceland, Greenland, and the Aleutians; and the northern reaches of **Scandinavia**, Asia, and North America.

Tropical gyres form near the Equator. The Coriolis effect is not present at the Equator, and winds are the **primary** creators of currents. For this reason, tropical gyres tend to flow in a more east-west (instead of circular) pattern. The Indian Ocean Gyre is actually two distinct tropical gyres—the northern and southern Indian Ocean Gyres.

Most of the world's major gyres are [subtropical gyres](#). These form between the polar and equatorial regions of Earth. Subtropical gyres circle areas beneath regions of high atmospheric pressure. These are [placid](#) ocean areas thousands of kilometers in diameter. Unlike coastal zones, these central regions are relatively [stable](#). The ocean water generally stays in one place while the currents of the gyre circulate around it.

Movement of Gyres

Gyres are [comprised](#) of ocean currents that link up as they follow the coastlines of the Earth's continents. Each gyre has a powerful western boundary current and a weaker eastern boundary current.

The North Atlantic Gyre begins with the northward flow of the [Gulf Stream](#) along the East Coast of the United States. The Gulf Stream is the western boundary current of the gyre. The gyre then becomes the North Atlantic Current, which flows across the North Atlantic to Europe. Still flowing in a circular pattern, the current flows south as far as the northwestern coast of Africa, where it is known as the Canary Current—the gyre's eastern boundary current. The gyre is completed as the North Atlantic Equatorial Current crosses the Atlantic Ocean to the Caribbean Sea. This entire circle and the water within it is the North Atlantic Gyre.

Most ocean gyres are very stable and [predictable](#). The North Atlantic Ocean Gyre always flows in a steady, clockwise path around the North Atlantic Ocean. Some gyres experience [seasonal](#) variation, however.

The Indian Ocean Gyre is a [complex](#) system of many currents extending from the eastern coast of Africa to the western coast of Australia. The northern part of the system [circulates](#) between the Horn of Africa and the Indonesian archipelago. It is sometimes called the Indian monsoon current.

The Indian monsoon current takes its name from the wind—the [monsoon](#)—that drives it. It is one of the very few currents in an ocean gyre that change direction. In the summer, the current flows clockwise, as the monsoon blows in from the southwestern Indian Ocean. In the winter, the current flows counterclockwise, as the wind blows in from the Tibetan [plateau](#) in the northeast.

The temperature in an ocean gyre depends on many [factors](#), including the current. The Gulf Stream and summer monsoon current are warm currents. They are heated by the warm tropical waters of the Caribbean Sea (Gulf Stream) and equatorial Indian Ocean (summer monsoon current). The North Atlantic Current and winter monsoon current are cool currents. They are cooled by [Arctic](#) winds and ocean currents (North Atlantic) and the winter monsoon blowing from the icy Himalayas (winter monsoon current).

Garbage Patches

Ocean gyres circle large areas of [stationary](#), calm water. [Debris](#) drifts into these areas and, due to the region's lack of movement, can [accumulate](#) for years. These regions are called garbage patches. The Indian Ocean, North Atlantic Ocean, and North Pacific Ocean all have [significant](#) garbage patches. The garbage patch in the North Pacific Ocean is sometimes called the Pacific trash [vortex](#) or the [Great Pacific Garbage Patch](#).

Garbage patches are created slowly. Marine debris makes its way into the Great Pacific Garbage Patch, for instance, from currents flowing along the west coast of North America and the east coast of Asia. Some of the debris is also dumped from [ocean vessels](#).

The circular motion of the gyre draws in the debris, mostly small [particles](#) of plastic. Eventually, the debris makes its way to the center of the gyre, where it becomes trapped and breaks down into a kind of plastic soup.

[Oceanographers](#) and [ecologists](#) are concerned about garbage patches. In particular, they are studying the [degradation](#), or breaking down, of plastics. Unlike natural substances, such as wood or metal, plastic does not [disintegrate](#) into [organic substances](#). It simply breaks down into smaller and smaller pieces of plastic. These tiny plastic particles are as small as the [algae](#) and [plankton](#) that form the basis of the entire ocean [food web](#). Species such as shrimp, birds, and fish consume these micro-plastics, which oftentimes kill them. The plastic chemicals can also be [absorbed](#) by [predators](#) of these species. The [concentration](#) of these chemicals increases through each [trophic level](#) of the [food chain](#), a process known as [biomagnification](#).

Garbage patches generally accumulate far from any country's coastline, and it is nearly impossible to track the **origin** of marine debris. The tiny plastic particles that make up most of the patches are also very difficult and **expensive** to **detect** and remove. Few **nations** have accepted the **responsibility** of cleaning up the ocean's garbage patches.

Life in a Gyre

Scientists are only beginning to understand the **biodiversity** of ocean gyres. Their calm centers have traditionally been regarded as **oligotrophic**, or nutrient-poor, because they have few concentrations of the organic chemicals that support **producers**, such as algae and plankton, in the ocean food web.

Researchers have recently discovered an expansion of oligotrophic regions in ocean gyres. They have **correlated** this expansion with increases in sea-surface temperatures—warm waters generally have far fewer nutrients than cold water.

The University of Hawaii is taking advantage of its position in the North Pacific Gyre to further study the gyre and factors that impact it. Scientists regularly study “the thermohaline structure, water column chemistry, currents, **optical** properties, primary production, plankton community structure, and rates of particle export” in this ocean gyre.

VOCABULARY

Term	Part of Speech	Definition
absorb	<i>verb</i>	to soak up.
accumulate	<i>verb</i>	to gather or collect.
algae	<i>plural noun</i>	(singular: alga) diverse group of aquatic organisms, the largest of which are seaweeds.
Antarctic Circumpolar Current (ACC)	<i>noun</i>	most powerful surface ocean current in the world, which rotates clockwise around the continent of Antarctica. Also called the West Wind Drift.
archipelago	<i>noun</i>	a group of closely scattered islands in a large body of water.
Arctic	<i>noun</i>	region at Earth's extreme north, encompassed by the Arctic Circle.
atmospheric pressure	<i>noun</i>	force per unit area exerted by the mass of the atmosphere as gravity pulls it to Earth.
biodiversity	<i>noun</i>	all the different kinds of living organisms within a given area.
biomagnification	<i>noun</i>	process in which the concentration of a substance increases as it passes up the food chain.
bound	<i>verb</i>	to limit or confine.
boundary	<i>noun</i>	line separating geographical areas.
circulate	<i>verb</i>	to move around, often in a pattern.
coast	<i>noun</i>	edge of land along the sea or other large body of water.
complex	<i>adjective</i>	complicated.
comprise	<i>verb</i>	to contain or be made up of.
concentration	<i>noun</i>	measure of the amount of a substance or grouping in a specific place.
consume	<i>verb</i>	to use up.
continent	<i>noun</i>	one of the seven main land masses on Earth.

Coriolis effect	<i>noun</i>	the result of Earth's rotation on weather patterns and ocean currents. The Coriolis effect makes storms swirl clockwise in the Southern hemisphere and counterclockwise in the Northern Hemisphere.
correlate	<i>verb</i>	to bring different sets of data into order, or establish a relationship or connection between them.
current	<i>noun</i>	steady, predictable flow of fluid within a larger body of that fluid.
debris	<i>noun</i>	remains of something broken or destroyed; waste, or garbage.
deflect	<i>verb</i>	to alter from a straight line.
degradation	<i>noun</i>	breaking down.
detect	<i>verb</i>	to notice.
determine	<i>verb</i>	to decide.
disintegrate	<i>verb</i>	to fall apart and disappear.
East Coast	<i>noun</i>	Atlantic coast of the United States.
ecologist	<i>noun</i>	scientist who studies the relationships between organisms and their environments.
Ekman spiral	<i>noun</i>	rotating column of water formed as ocean surface currents are deflected by the Coriolis effect, wind, and friction forces.
Equator	<i>noun</i>	imaginary line around the Earth, another planet, or star running east-west, 0 degrees latitude.
essential	<i>adjective</i>	needed.
expensive	<i>adjective</i>	very costly.
extent	<i>noun</i>	degree or space to which a thing extends.
factor	<i>noun</i>	element contributing to an event or outcome.
food chain	<i>noun</i>	group of organisms linked in order of the food they eat, from producers to consumers, and from prey, predators, scavengers, and decomposers.
food web	<i>noun</i>	all related food chains in an ecosystem. Also called a food cycle.
fund	<i>verb</i>	to give money to a program or project.
Great Pacific Garbage Patch	<i>noun</i>	area of the North Pacific Ocean where currents have trapped huge amounts of debris, mostly plastics.
Gulf Stream	<i>noun</i>	warm current that starts in the Gulf of Mexico and travels along the eastern coast of the U.S. and Canada before crossing the North Atlantic Ocean.
island	<i>noun</i>	body of land surrounded by water.
landmass	<i>noun</i>	large area of land.
marine	<i>adjective</i>	having to do with the ocean.
massive	<i>adjective</i>	very large or heavy.
monsoon	<i>noun</i>	seasonal change in the direction of the prevailing winds of a region. Monsoon usually refers to the winds of the Indian Ocean and South Asia, which often bring heavy rains.
nation	<i>noun</i>	political unit made of people who share a common territory.

Northern Hemisphere	<i>noun</i>	half of the Earth between the North Pole and the Equator.
nutrient	<i>noun</i>	substance an organism needs for energy, growth, and life.
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ocean conveyor belt	<i>noun</i>	system in which water moves between the cold depths and warm surface in oceans throughout the world. Also called thermohaline circulation.
ocean gyre	<i>noun</i>	an area of ocean that slowly rotates in an enormous circle.
oceanographer	<i>noun</i>	person who studies the ocean.
ocean vessel	<i>noun</i>	ship, boat, submarine, or other vehicle able to travel the ocean.
oligotrophic	<i>adjective</i>	having few nutrients and supporting little growth.
optical	<i>adjective</i>	having to do with vision or sight.
organic	<i>adjective</i>	composed of living or once-living material.
origin	<i>noun</i>	source or ancestry.
particle	<i>noun</i>	small piece of material.
placid	<i>adjective</i>	calm.
planet	<i>noun</i>	large, spherical celestial body that regularly rotates around a star.
plankton	<i>plural noun</i>	(singular: plankton) microscopic aquatic organisms.
plastic	<i>noun</i>	chemical material that can be easily shaped when heated to a high temperature.
plateau	<i>noun</i>	large region that is higher than the surrounding area and relatively flat.
polar	<i>adjective</i>	having to do with the North and/or South Pole.
predator	<i>noun</i>	animal that hunts other animals for food.
predictable	<i>adjective</i>	regular or able to be forecasted.
primary	<i>adjective</i>	first or most important.
producer	<i>noun</i>	organism on the food chain that can produce its own energy and nutrients. Also called an autotroph.
region	<i>noun</i>	any area on the Earth with one or more common characteristics. Regions are the basic units of geography.
responsibility	<i>noun</i>	being accountable and reliable for an action or situation.
rotation	<i>noun</i>	object's complete turn around its own axis.
salinity	<i>noun</i>	saltiness.
Scandinavia	<i>noun</i>	region and name for some countries in Northern Europe: Iceland, Norway, Sweden, Finland, and Denmark.
seasonal	<i>adjective</i>	likely to change with the seasons.
significant	<i>adjective</i>	important or impressive.
Southern Hemisphere	<i>noun</i>	half of the Earth between the South Pole and the Equator.

stable	<i>adjective</i>	steady and reliable.
stationary	<i>adjective</i>	unmoving.
subcontinent	<i>noun</i>	large section of a continent.
subpolar gyre	<i>noun</i>	circulating ocean current that forms at high latitudes beneath an area of low atmospheric pressure, where wind drives currents away from coastal areas.
substance	<i>noun</i>	physical material.
subtropical gyre	<i>noun</i>	circulating ocean current that forms between Earth's polar and equatorial regions, beneath an area of high atmospheric pressure.
temperature	<i>noun</i>	degree of hotness or coldness measured by a thermometer with a numerical scale.
thermohaline circulation	<i>noun</i>	ocean conveyor belt system in which water moves between the cold depths and warm surface in oceans throughout the world.
trophic level	<i>noun</i>	one of three positions on the food chain: autotrophs (first), herbivores (second), and carnivores and omnivores (third).
tropical gyre	<i>noun</i>	circulating ocean current that forms in equatorial regions and tends to flow mostly east-west.
upwelling	<i>noun</i>	process by which currents bring cold, nutrient-rich water to the ocean surface.
variation	<i>noun</i>	difference.
vortex	<i>noun</i>	column of rotating fluid, such as air (wind) or water.
water column	<i>noun</i>	area reaching from the sediment of a body of water to its surface.
wind	<i>noun</i>	movement of air (from a high pressure zone to a low pressure zone) caused by the uneven heating of the Earth by the sun.

For Further Exploration

Articles & Profiles

- Woods Hole Oceanographic Institution: Currents, Gyres, and Eddies
- EarthSky: Emanuele Di Lorenzo Explains Ocean Gyres

Instructional Content

- COMET Program: Introduction to Tropical Meteorology—Global Upper and Deep Ocean Circulation
- National Geographic Education: The Geography of Ocean Currents

Websites

- NASA Ocean Motion: Wind Driven Surface Currents
- NOAA Ocean Service Education: Currents



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