Ocean Currents



Global Conveyor Belt. While winds drive ocean surface currents, differences in the water's density, controlled by temperature (thermo) and salinity (haline), drives most of the ocean mass thousands of meters below in the deep ocean, this is called Thermohaline Circulation. In the Earth's polar regions ocean water gets cold, forming sea ice. The surrounding seawater gets saltier, its density increases, and it starts to sink. Surface water is pulled in to replace the sinking water, which in turn eventually becomes cold and salty enough to sink. When Artic ice melts, it releases fresh cold water to warmer salty water driven from the equator. Artic Ice Cap formation and melting drives the deep-ocean global conveyer belt.



Surface Currents. Tidal currents originate from tides, while surface currents are caused by wind and waves. Major ocean currents include the Gulf Stream, Kuroshio Current, Agulhas Current and Antarctic Circumpolar Current. Collectively, currents move enormous amounts of water and heat around the globe. This circulation significantly impacts global climate and the redistribution of pollutants including from surface into deep ocean. These currents create atmospheric rivers and locally El Nino and La Nina.



Ocean Gyres. Gyres are large systems of circulating ocean currents, slow-moving whirlpools. There are five named gyres: North Atlantic, South Atlantic, North Pacific, South Pacific, and Indian Ocean Gyres. While they circulate ocean waters, they're also drawing in pollution that we release in coastal areas, known as marine debris. The largest is the Great Pacific Garbage Patch in the North Pacific and growing.



Ocean Currents and Climate Change. New research reveals Earth's major ocean currents are slowing down, and though the consequences will not be as immediate or dramatic as in the Hollywood fiction movie, The Day After Tomorrow. There are real-world impacts for global weather patterns and sea levels. If the Atlantic overturning circulation breaks down all together, this will lead to a strong cooling around the northern Atlantic, especially into Europe, especially coastal areas of Britain and Scandinavia.

Ocean Science

The **world ocean** is single body of salt water which covers approximately 71% of the surface of the Earth and contains 97% of Earth's water. Separate names identify five different areas of the ocean: Pacific (the largest) Atlantic, Indian, Southern (Antarctic), and Arctic (the smallest). Seawater covers approximately 361,000,000 km² (139,000,000 sq mi) of the planet. The ocean is the principal component of Earth's hydrosphere, and therefore integral to life on Earth. Acting as a huge heat reservoir, the ocean influences climate and weather patterns. the carbon cycle and the water cycle.

Oceanographers divide the ocean into different vertical and horizontal zones based on physical and biological conditions. Water pressure increases dramatically with depth. The water column is categorized in zones depending on depth and on how much light is present. The photic zone includes water from the surface to a depth of 200 m, where photosynthesis can occur, creating a biodiverse environment. Below that the ocean is cold and dark. Photosynthesis by plants and microscopic algae (free floating phytoplankton) creates organic matter from water and carbon dioxide and emits oxygen for animal life. This upper sunlit zone is the food supply which sustains most of the ocean ecosystem.

Ocean temperatures depend on the amount of solar radiation reaching the ocean surface, more than twice as much as land. Water retains heat energy buffering climate change. Water expands with higher temperature, one of the causes of sea level rise. In the tropics, surface temperatures can rise to over 30 $^\circ$ C (86 °F). Near the poles where sea ice forms, the temperature in equilibrium is about -2 °C (28 °F). Deep seawater temperature is between -2 °C (28 °F) and 5 °C (41 °F) in all parts of the ocean. Since ice is less dense than liquid water, ice crystals forming in deep water float up so the deep ocean does not freeze solid.

Water continuously circulates in the oceans in the Global Conveyor Belt system, surface currents, and vertical movement of upwelling and downwelling near continents. These directed movements of seawater are generated by forces acting upon the water, including temperature and salinity differences, atmospheric circulation (wind), and the Coriolis effect (spinning ball physics). Outside of Earth's equatorial areas, weather patterns are driven largely by ocean currents. Currents are movements of ocean water in a continuous flow, cre ated largely by surface winds but also partly by temperature and salinity gradients, Earth's rotation, and tides. Major current systems typically flow clockwise in the northern hemisphere and counterclockwise in the southern hemisphere, in circular patterns that often trace the coastlines.

Ocean currents act much like a conveyor belt, transporting warm water and precipitation from the equator toward the poles and cold water from the poles back to the tropics. Thus, ocean currents regulate global climate, helping to counteract the uneven distribution of solar radiation reaching Earth's surface. Without currents in the ocean, regional temperatures would be more extreme, super hot at the equator and frigid to ward the poles, and much less of Earth's land would be habit-

Ocean water contains large quantities of dissolved gases, including oxygen, carbon dioxide and nitrogen. This gas exchange between air and water takes place at the ocean surface and solubility depends on the temperature and salinity of the water. The ocean absorbs over 30% of the human generated carbon dioxide and other gas pollutants, resulting in ocean acidification and toxic contamination.



Deformed shells Source: University of Maryland

Threats to **Our One & Only Ocean**

Summary

The ocean provides society with important environmental services, including climate regulation. It also offers a means of trade and transport of food and goods. Known to be the habitat of 230,000 species, it may contain far more, perhaps over two million species. Life started in the oceans and phytoplankton produce half of the atmospheric oxygen we breath.

Human activities are threatening its health. Tens of thousands of ships are responsible for more than 90 per cent of world trade, however, more than 80 percent of marine pollution comes from landbased activities.

Global warming is altering ocean chemistry, changing currents, causing sea level rise and threatening many species of marine animals that cannot cope with higher temperatures.

The list of **pollutants** entering the marine environment remains long with sewage, fertilizers, pesticides, industrial chemicals, and solid garbage. Plastics contamination poses the biggest threat with large amounts of plastic circulating in gyres and break down into microscopic pieces that are interfering with the food web.

From coral bleaching to sea level rise, entire marine ecosystems are rapidly changing. Overfishing is a serious problem in many parts of the world. Conservationists advocate creating expansive marine reserves to protect the biodiversity of the oceans.

Think Global, Act Local Reduce your Carbon Footprint

Climate Change

Imagine how poorly a fish in an aquarium would fare if we turned up the heat, dripped in acid, and pulled out the oxygen bubbler. Climate change arguably presents the greatest threat to ocean health. It is making oceans hotter, promoting acidification, and making it harder to breathe by reducing dissolved oxygen levels.

Increasing Temperature. The majority of radiation from the sun is absorbed by the ocean, particularly in tropical waters around the equator, where the ocean acts like a massive, heat-retaining solar panel. It also helps to distribute heat around the globe. The average global sea surface temperature of the upper few meters of the ocean has increased by approximately 0.13°C per decade over the past 100 years, with some areas warmer than others. Fish are migrating in different ways since cooler water holds more oxygen gas. The thinner layer of ocean at the Great Coral Reef off Australia is much warmer causing coral reefs to bleach and die. About 75% of the world's reefs are threatened.

Ocean Acidification is the continuing decrease of seawater pH caused by the absorption of carbon dioxide (CO2) from the atmosphere. The carbonic acid formed after reaction with water then chemically reacts with calcium carbonate, the main component of all sea shells, dissolving the shells of animals such as oysters, shrimp, and lobsters. This is having other widespread effects on marine life.

Sea Level Rising. Global warming is alarmingly increasing seawater levels. Ice on land in form of glaciers are melting faster than expected, particularly in Greenland, delivering a large flow of ancient fresh water to the oceans. Arctic ice floats so does not add extra water when it melts. Besides the additional fresh water from land, water expands from being heated, becoming less dense. This warmer water stays on surface. The annual rate of seawater rise during the past two decades has been 0.13 inches a year, which is around twice the average speed of rising over the preceding 80 years. Future sea level rise is expected to be 3 or more feet by midcentury resulting in coastal city flooding, wetland flooding, destructive erosion, agricultural land contamination, and a serious threat to the habitats of several plants, fishes and birds.

Solution: We can each reduce our own carbon footprint and help decelerate climate change by making smart choices about what we eat, how we live, and how we travel. In our businesses, we can join companies in going carbon neutral. With 7.6 billion people on the planet, these decisions add up.

Poster By John Shribbs

Sources: Wikipedia, National Geographic, Douglas McCauley, Marin Insight, Science Direct, NRDC, EPA, NO-AA, IFAW



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Pacific Ocean island beach.



Biological Threats to Ocean Life

Overfishing. Almost a third of global fish stocks are overfished. Fish that were once extremely abundant, such as bluefin tuna, are now becom ing increasingly endangered. Amount and size of large predatory fish like swordfish and merlin caught for food has declined over time. Illegal, unreported and unregulated fishing can cost the global economy up to \$23 billion annually. Restaurants and seafood markets in many areas routinely serve endangered seafood species that are the underwater equivalent o a rhino or a panda. New sustainable seafood Apps like Seafood Watch can help us steer clear of these endangered species and select sustainable and healthy seafood choices instead.

Government Subsidies of Fishing. Every year, governments spend \$35 billion on fisheries subsidies, the majority of which directly accelerate harmful overfishing. Subsidies lead to overcapacity in fishing fleets and allow vessels to fish harder for longer in an internationally shared resource. This is a prime example of "Tragedy of the Commons" when individuals compete for shared resource. We must urge our national leaders to reach an agreement to end subsidies and promote a healthy future for fish and fishermen in our global oceans. We also need to end commercial whaling entirely.

Dredging. Dredging of coastal waterways enhances marine transportation, but it can cause disturbance in marine ecosystems for many years.

Invasive species such as poisonous algae, cholera, and countless plants and animals have entered harbor waters and disrupted the ecological balance. Many of these were transported in ship ballast tanks and released with the ballast water when entering harbors.

Lack of Safe Zones for Breeding. Fishing fleets, large and small, can devastate the catch and bycatch population reducing the ability to breed. We all know that parks and protected areas on land help wildlife such as bears, deer and elephants thrive. The same is true for underwater protected areas. In addition to preserving charismatic and ecologically important marine wildlife, including sharks, dolphins, and corals, protected areas in the ocean can act like a savings accounts for fisheries. Fish inside such areas grow larger and generate more offspring. These then spill beyond the boundaries of the protected area, and are harvested by fisheries as a return on their investment in the park. Today, only 2% of our global oceans are included in strongly protected marine parks. We are behind the curve on setting up protected areas in the ocean. Scientists estimate we may need to protect 30% of the oceans to provide properly for the future of ocean wildlife and ocean health.

Solution: We need to back local, national and international efforts to set up more marine protected areas. Responsible travel also helps. The tourism industry can be both a key beneficiary and guardian of marine parks. We can reinforce these efforts by patronizing hotels that are financing marine park protection in their ocean backyards, by replanting corals and managing their footprint near these parks.

with stomach full of plastic trash.

Chemical Pollution

There are over 400 dead zones at river outlets due to chemical pollution.

Plastic Pollution. People around the world throw away almost four million tons of trash every day, of which 12.8% is plastic. More than five trillion pieces of plastic pollution are afloat in the oceans. Yearly, over 8 million tons of plastic waste are washed into the ocean. For every pound of tuna we are taking out of the ocean, we are putting two pounds of plastic back in. By 2050, at this rate, we would witness more plastic than fish. Plastic bags, fishing nets and other debris chokes tens of thousands of seabirds and sea turtles every year. Over 90% of seabirds may have plastic pieces in their stomachs. Plastic breaks down with sunlight and time and ingestion or microplastics by small and large organisms poses risk to their life as well as humans eating sea food.

Ocean Dumping. Dumping of waste materials from industries, ships and sewage plants into oceans has polluted the marine ecosystem to a great extent. These include sewage, chemicals, industrial waste, garbage, and other debris from the land. Mining companies across the world dump 220 million tons hazardous waste directly into our waterbodies every year.

Waste Pollution from Ships. Apart from other pollutants such as oil and gas, the waste and garbage generated on board ships poses a significant threat to the marine ecosystem. Both solid and liquid waste in form of ballast water, grey water, food waste, human waste, packing material, paper products and cleaning material and rags etc. pollutes seawater and badly affects marine lives.

Land Runoff. Surface runoff is a nonpoint source of pollutants including animal waste, fertilizers, and pesticides from agriculture and roof and street debris including oil, asphalt, cement, rubber, fertilizer, and trash from cities.

Air Pollution is responsible for almost one-third of the toxic contaminants and nutrients that enter coastal areas and oceans.

NOx and Sox. Nitrogen oxides (NOx) and Sulfur oxides (SOx), the two main pollutants found in shipping diesel engine emissions has badly affected both marine environment and ozone layer in a number of ways. It is estimated that in 2005, the water bodies around Europe witnessed 1.7 million tons of sulfur dioxide (SO2) emissions and 2.8 million tons nitrogen dioxide emissions from international shipping. Strict rules have been formed to reduce their levels in ship's emissions. The Sulfur limit applicable to all marine fuels used internationally will go from 3.5% to 0.5% since 2020.

Ozone Depleting Substances. Ozone-depleting compounds, such as CFCs, compounds containing chlorine (or bromine), fluorine, and carbon, including Halon for refrigeration, Methyl Chloroform cleaning solvent, Methyl Bromide fumigant, and other chemicals come directly from ships or from dissolving at ocean surface from air. Besides depleting ozone in the air they can cause harm to the marine environment in several ways.

Noise Pollution from Ships. Noise generated from shipping operations including engine noise and entertainment on cruise ships is harmful to marine organisms including hemorrhages, changed diving pattern, migration to newer places, and damage to internal organs and an overall panic response to foreign sounds. Intensity of noise pollution is higher in water than air since noise travels greater distances and some marine life is extremely sensitive. Whale song can travel thousands of miles. Military sonar can harm or kill whales and other marine mammals

Oil Spills. Disasters such as the Exxon Valdez Oil Spill and Deepwater Horizon etc. have resulted in the extreme pollution of the marine ecosystem, killing thousands of marine species. The oil spilt destroys the insulating ability of several marine species and also the water repellency of bird's feathers, exposing these creatures to life-threatening risks.

Entanglement in Fishing Gear. Marine animals, from whales, dolphins, and seals to turtles and seabirds, often become caught and trapped in nets and lines used by commercial fisheries. Whales have been known to drag lobster traps for thousands of miles during their annual migrations, adding extra weight and slowing them down and making it harder for them to feed which can lead to starvation and death. There are also solutions out there to reduce the risk of whales becoming entangled, such as switching to ropeless fishing gear.

