SAMPLE

Earth's Dynamic Systems: Ocean Currents

The Great Conveyor Belts

Aira Astralis

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Conclusion

This free sample contains the Introduction and Chapter 1. The complete book contains the full contents above.

Introduction

An ocean current is a continuous, directed movement of seawater generated by a number of forces acting upon the water, including wind, the Coriolis effect, breaking waves, cabbeling, and temperature and salinity differences. Depth contours, shoreline configurations, and interactions with other currents influence a current's direction and strength.

Ocean currents move both horizontally, on scales that can span entire oceans, as well as vertically, with vertical currents (upwelling and downwelling) playing an important role in the movement of nutrients and gases, such as carbon dioxide, between the surface and the deep ocean. Ocean currents are classified by temperature as either warm currents or cold currents. They are also classified by their velocity, dimension, and direction as either drifts, currents, or streams.

Drifts, such as the North Atlantic Drift Current, involve the forward movement of surface ocean water under the influence of the prevailing wind. Currents, such as the Labrador Current, involve the movement of oceanic water in a more definite direction at a greater velocity than drifts. Streams, such as the Gulf Stream, involve movement of larger masses of ocean water with greater velocity than drifts or currents. Ocean currents are patterns of water movement that influence climate zones and weather patterns around the world.

They are primarily driven by winds and by seawater density, although many other factors influence them, including the shape and configuration of the oceanic basin they flow through. The two basic types of currents - surface and deep-water currents - help define the character and flow of ocean waters across the planet. Ocean currents flow for great distances, and together they create the global conveyor belt, which plays a dominant role in determining the climate of many of Earth's regions.

Chapter 1: The Discovery of Ocean Currents

Another example is Lima, Peru, whose cooler subtropical climate contrasts with that of its surrounding tropical latitudes because of the Humboldt Current. The largest ocean current is the Antarctic Circumpolar Current (ACC), a wind-driven current which flows clockwise uninterrupted around Antarctica. The ACC connects all the oceanic basins together, and also provides a link between the atmosphere and the deep ocean due to the way water upwells and downwells on either side of it.

Ocean currents are driven by the wind, by the gravitational pull of the Moon in the form of tides, and by the effects of variations in water density. Ocean dynamics define and describe the motion of water within the oceans. Ocean temperature and motion fields can be separated into three distinct layers: mixed (surface) layer, upper ocean (above the thermocline), and deep ocean.

Ocean currents are measured in units of sverdrup (Sv), where 1 Sv is equivalent to a volume flow rate of 1,000,000 m3 (35,000,000 ft3) per second. There are two main types of currents, surface currents and deep-water currents. Generally surface currents are driven by wind systems and deep-water currents are driven by differences in water density due to variations in water temperature and salinity.

Surface oceanic currents are driven by wind currents, the large scale prevailing winds drive major persistent ocean currents, and seasonal or occasional winds drive currents of similar persistence to the winds that drive them, and the Coriolis effect plays a major role in their development. The Ekman spiral velocity distribution results in the currents flowing at an angle to the driving winds, and they develop typical clockwise spirals in the Northern Hemisphere and counter-clockwise rotation in the Southern Hemisphere.

In addition, the areas of surface ocean currents move somewhat with the seasons; this is most notable in equatorial currents. Deep ocean basins generally have a non-symmetric surface current, in that the eastern equator-ward flowing branch is broad and diffuse whereas the pole-ward flowing western boundary current is relatively narrow. Large scale currents are driven by gradients in water density, which in turn depend on variations in temperature and salinity. This thermohaline circulation is also known as the ocean's conveyor belt.

Ocean water also moves vertically. Where it rises toward the surface the process is called upwelling; where it sinks, downwelling. The deep engine behind much of that overturning is density — water made heavy by cold and salt — and the circulation it drives eventually took a hybrid name assembled

from those two ingredients.

The surface journey can end in sinking: currents flowing out of the tropics cool at high latitude, and where they grow dense enough they plunge — North Atlantic Deep Water being the classic case. From there the deep flow spreads through the basins for centuries before welling back up, most of it in the Southern Ocean but the most aged water far away in the North Pacific.

Along the way these moving masses redistribute heat, salt, dissolved gas and sediment, so the state of the overturning leaves its fingerprint on climate everywhere. Later chapters return to the system under its modern name, the meridional overturning circulation; popular accounts prefer the simpler image of a conveyor belt.

Since the 2000s an international program called Argo has been mapping the temperature and salinity structure of the ocean with a fleet of automated platforms that float with the ocean currents. The information gathered will help explain the role the oceans play in the Earth's climate. Ocean currents affect temperatures throughout the world.

For example, the ocean current that brings warm water up the north Atlantic to northwest Europe also cumulatively and slowly blocks ice from forming along the seashores, which would also block ships from entering and exiting inland waterways and seaports, hence ocean currents play a decisive role in influencing the climates of regions through which they flow. Ocean currents are important in the study of marine debris.

Upwellings and cold ocean water currents flowing from polar and sub-polar regions bring in nutrients that support plankton growth, which are crucial prey items for several key species in marine ecosystems. Ocean currents are also important in the dispersal and distribution of many organisms, including those with pelagic egg or larval stages. An example is the life-cycle of the European Eel. Terrestrial species, for example tortoises and lizards, can be carried on floating debris by currents to colonise new terrestrial areas and islands.

The continued rise of atmospheric temperatures is anticipated to have various effects on the strength of surface ocean currents, wind-driven circulation and dispersal patterns. Ocean currents play a significant role in influencing climate, and shifts in climate in turn impact ocean currents. Over the last century, reconstructed sea surface temperature data reveal that western boundary currents are heating at double the rate of the global average.

End of free sample. The full book is available at putrabooks.github.io

ABOUT THE AUTHOR

Aira Astralis is a science writer specializing in astronomy and space exploration. Her work spans the full breadth of humanity's relationship with the cosmos -- from the earliest naked-eye observations to the engineering marvels of modern space missions.

Her books are built on a foundation of primary sources: peer-reviewed research, mission archives, and direct engagement with the scientific community. She writes for readers who want to understand not just what we know about the universe, but how we came to know it.

She believes that the most important frontier is not out there but in the gap between what scientists discover and what the public understands. Her books exist to close that gap.