Oceanography

Oceanography covers a wide range of topics, including marine life and ecosystems, ocean circulation, plate tectonics and the geology of the seafloor, and the chemical and physical properties of the ocean.

Oceanography is an **interdisciplinary science** where math, physics, chemistry, biology and geology intersect. Traditionally, we discuss oceanography in terms of four separate but related branches: physical oceanography, chemical oceanography, biological oceanography and geological oceanography.

Study of the oceans is critical to understanding shifts in Earth's energy balance along with related global and regional changes in climate, the biosphere and biogeochemistry. The atmosphere and ocean are linked because of evaporation and precipitation as well as thermal flux (and solar insolation). Recent studies have advanced knowledge on ocean acidification, ocean heat content, ocean currents, sea level rise, the oceanic carbon cycle, the water cycle, Arctic sea ice decline, coral bleaching, marine heatwaves, extreme weather, coastal erosion and many other phenomena in regards to ongoing climate change and climate feedbacks. In general, understanding the world ocean through further scientific study enables better stewardship and sustainable

utilization of Earth's resources.[27] The Intergovernmental Oceanographic Commission reports that 1.7% of the total national research expenditure of its members is focused on ocean science.[28]

The study of oceanography is divided into these five branches:

- **Biological oceanography**[edit]

Main article: Marine life
See also: Marine biology
Biological oceanography investigates the ecology and biology of marine organisms in the context of the physical, chemical and geological characteristics of their ocean environment.

- **Chemical oceanography**[edit]

Main article: Chemical oceanography
Chemical oceanography is the study of the chemistry of the ocean. Whereas chemical oceanography is primarily occupied with the study and understanding of seawater properties and its changes, ocean chemistry focuses primarily on the geochemical cycles. The following is a central topic investigated by chemical oceanography.

Ocean acidification[edit]
Main article: Ocean acidification
Ocean acidification describes the decrease in ocean pH that is caused by anthropogenic carbon dioxide (CO_2) emissions into the atmosphere.[29] Seawater is slightly alkaline and had a preindustrial pH of about 8.2. More recently, anthropogenic activities have steadily increased the carbon dioxide content of the atmosphere; about 30–40% of the added CO_2 is absorbed by the oceans, forming carbonic acid and lowering the pH (now below 8.1[30]) through ocean acidification.[31][32][33] The pH is expected to reach 7.7 by the year 2100.[34]

An important element for the skeletons of marine animals is calcium, but calcium carbonate becomes more soluble with pressure, so carbonate shells and skeletons dissolve below the carbonate compensation depth.[35] Calcium carbonate becomes more soluble at lower pH, so ocean acidification is likely to affect marine organisms with calcareous shells, such as oysters, clams, sea urchins and corals,[36][37] and the carbonate compensation depth will rise closer to the sea surface.

Affected planktonic organisms include pteropods, coccolithophorids and foraminifera, all important in the food chain. In tropical regions, corals are likely to be severely affected as they become less able to build their calcium carbonate skeletons,[38] in turn adversely impacting other reef dwellers.[34]

The current rate of ocean chemistry change seems to be unprecedented in Earth's geological history, making it unclear how well marine ecosystems will adapt to the shifting

conditions of the near future.[39] Of particular concern is the manner in which the combination of acidification with the expected additional stressors of higher ocean temperatures and lower oxygen levels will impact the seas.[40]

- **Geological oceanography**[edit]

Main article: Marine geology

Geological oceanography is the study of the geology of the ocean floor including plate tectonics and paleoceanography.

- **Physical oceanography**[edit]

Main article: Physical oceanography

Physical oceanography studies the ocean's physical attributes including temperature-salinity structure, mixing, surface waves, internal waves, surface tides, internal tides, and currents. The following are central topics investigated by physical oceanography.

Seismic Oceanography[edit]

Main article: Seismic Oceanography

Ocean currents[edit]

Further information: Ocean current

Since the early ocean expeditions in oceanography, a major interest was the study of ocean currents and temperature measurements. The tides, the Coriolis effect, changes in direction and strength of wind, salinity, and temperature are the main factors determining ocean currents. The thermohaline circulation (THC) (*thermo-* referring to temperature and *-haline* referring to salt content) connects the ocean basins and is primarily dependent on the density of sea water. It is becoming more common to refer to this system as the 'meridional overturning circulation' because it more accurately accounts for other driving factors beyond temperature and salinity.

- Examples of sustained currents are the Gulf Stream and the Kuroshio Current which are wind-driven western boundary currents.

Ocean heat content[edit]

Oceans of Climate Change NASA

Further information: Oceanic heat content

Oceanic heat content (OHC) refers to the extra heat stored in the ocean from changes in Earth's energy balance. The increase in the ocean heat play an important role in sea level rise, because of thermal expansion. Ocean warming accounts for 90% of the energy accumulation associated with global warming since 1971.[41][42]

- **Paleoceanography**[edit]

Main article: Paleoceanography

Paleoceanography is the study of the history of the oceans in the geologic past with regard to circulation, chemistry, biology, geology and patterns of sedimentation and

biological productivity. Paleoceanographic studies using environment models and different proxies enable the scientific community to assess the role of the oceanic processes in the global climate by the reconstruction of past climate at various intervals. Paleoceanographic research is also intimately tied to palaeoclimatology.

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