

Introduction to Oceanography

Introduction to Oceanography

An overview of the science that studies the world's oceans, their processes, and their role in the Earth system.

1. What Is Oceanography?

Term	Definition
Oceanography	The interdisciplinary study of the physical, chemical, biological, and geological aspects of the ocean.
Marine Science	A broader term that includes oceanography plus related fields such as marine biology, fisheries, and coastal management.

Key Idea: Oceanography seeks to understand how oceans work, how they interact with the atmosphere and land, and how they influence climate, ecosystems, and human societies.

2. Major Branches of Oceanography

Branch	Focus	Typical Methods
Physical Oceanography	Circulation, waves, tides, heat transport, and ocean–atmosphere interactions.	Satellite altimetry, drifters, moored buoys, numerical models.
Chemical Oceanography	Composition of seawater, nutrient cycles, trace elements, and ocean acidification.	Water sampling, mass spectrometry, autonomous sensors.
Biological Oceanography (Marine Biology)	Distribution, abundance, and behavior of marine organisms; food webs.	Plankton nets, ROVs, DNA metabarcoding, acoustic surveys.
Geological Oceanography (Marine Geology)	Seafloor structure, plate tectonics, sedimentation, and past climate records.	Multibeam sonar, seismic reflection, core drilling, submersibles.

Many research projects integrate two or more branches (e.g., biogeochemical cycles).

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3. Why Study the Ocean?

1. **Climate Regulation** – Oceans store >90% of excess heat from greenhouse warming and transport it globally.
 2. **Carbon Sink** – Dissolved inorganic carbon and biological pumps remove CO₂ from the atmosphere.
 3. **Biodiversity Hotspot** – Home to ~50% of all known species, many of which are still undiscovered.
 4. **Resources** – Food (fish, shellfish), energy (tidal, offshore wind), minerals (manganese nodules).
 5. **Human Impact** – Shipping, pollution, and climate change affect coastal communities; ocean science informs policy and management.
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4. Fundamental Concepts

4.1. Ocean Structure

- **Surface Layer (Mixed Layer)** – Uniform temperature & salinity; depth 10–100m; driven by wind and heat fluxes.
- **Thermocline** – Zone of rapid temperature decrease with depth.
- **Deep Ocean** – Cold, dense water below the thermocline; relatively stable.
- **Bottom Boundary Layer** – Interaction with seafloor sediments; site of benthic habitats.

4.2. Salinity & Density

- **Salinity** measured in Practical Salinity Units (PSU) or ‰.
- **Density (ρ)** depends on temperature, salinity, and pressure ρ controls vertical stability and circulation (e.g., thermohaline circulation).

4.3. Ocean Circulation

- **Wind-driven gyres** (e.g., North Atlantic Gyre) – surface currents shaped by the Coriolis effect and continental boundaries.

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- **Thermohaline circulation** – Global “conveyor belt” driven by density differences; connects surface and deep waters.
- **Upwelling & Downwelling** – Vertical motions that bring nutrients to the surface or transport surface water to depth.

4.4. Waves & Tides

- **Surface gravity waves** – Generated by wind; characterized by wavelength, period,