Temperature, Salinity, and Water Density

![Temperature-Salinity-Density graph](image)

**Graph 1:**
- Temperature (°C) on the y-axis
- Salinity (‰) on the x-axis
- Density (g/cm³) labeled along the y-axis

**Graph 2:**
- Temperature (°C) on the y-axis
- Salinity (‰) on the x-axis
- Points A and B with corresponding densities and temperatures
- Mixing line indicated

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1. Image of graph 1.
2. Image of graph 2.
Key Ideas

- Ocean water circulates in currents.
- Surface currents are driven by wind and affect the uppermost 10% of the ocean.
- Circulation of the other 90% of the ocean is driven by gravity, as dense water sinks and less dense water rises.
- Upwelling and downwelling describe the vertical movement of water masses.

Surface Temperatures and Salinities Correlate with Latitude

Isotherms - lines of equal temperature
Isohaline - lines of equal salinity

Generally trend east-west except where deflected by currents.

- Ocean currents carry warm water poleward on the western side of ocean basins and cooler water equatorward on the eastern side of the ocean.
Salinity Variations With Latitude

- Due to variations in precipitation and evaporation
- Highest salinity - between 20-30° north and south of the equator (evaporation exceeds precipitation)
- Lower salinity - at equator and poleward of 30° (precipitation exceeds evaporation)
- Halocline may be present - zone of rapid change of salinity with water depth
- Water stratification (layering) - more pronounced between 40°N and 40°S

Salinity Variations with Latitude

![Diagram showing salinity variations with latitude](image-url)
Surface Salinities

Solar heating and surface water temperature vary with the season.

Ocean temperature is highest in the tropics (25°C) and decreases poleward.
Thermocline, Halocline, Pynocline

[Diagram showing the layers of water with thermocline, halocline, and pynocline marked at different depths and temperature changes.]
Structure of the Oceans

- Tropical and subtropical oceans are permanently layered with warm, less dense surface water separated from cold, dense deep water by a thermocline.
- Temperate regions have a seasonal thermocline and polar regions have none.
The Temperature-Salinity Diagram

A general temperature-salinity (T-S) diagram.
Density Structure of the Ocean

- **Surface zone** - upper layer containing the least dense water; about 2% of total ocean volume; most variable part of the ocean because it is in contact with the atmosphere.

- **Pycnocline** - zone in which density increases rapidly with depth; about 18% of ocean water.

- **Deep zone** – about 80% of all ocean water; little change in density; originates at the surface in high latitudes where it cools, becomes dense, sinks to the sea floor and flows equatorward across the ocean basin.
Thermohaline Circulation

A model of thermohaline circulation caused by heating in lower latitudes and cooling in higher latitudes.
The movement of water due to different densities is thermohaline circulation. The ocean is density stratified, with the densest water at the bottom. There are five common water masses:

- Surface water
- Central water
- Intermediate water
- Deep water
- Bottom water
DISTRIBUTION OF PHOSPHATE in the ocean varies with depth. Essentially all the phosphate in surface water is taken up by marine plants and falls into the deep sea in soft-tissue residues. Much of it is released into solution as the residues are decomposed by animals and bacteria, a process that takes place primarily at intermediate depths. Superimposed on this vertical variation there is an Atlantic-to-Pacific increase in the deep-water phosphate content. It results from the flow of newly sunken deep water, much of which now originates in the northern Atlantic and tends to purge the Atlantic of the products of decomposition. The horizontal gradient complicates attempts to reconstruct the chemical composition of the glacial ocean climatic events may have altered the deep-current pattern as well as the ocean's bulk chemistry.
Figure 2.18: (a) Generalized map of deep water flow. Dark blue and yellow water return to the surface. Large black dots denote sources of North Atlantic Deep Water (NADW) and Norwegian Bottom Water (NBW). Small blue circles indicate areas of ice-covered shallow water. (b) Generalized cross-section from the North Atlantic to the North Pacific, showing major surface flow patterns and ice-covered shallow water. NADW is not shown in this picture.
Summary

- Deep ocean circulation is density-driven (thermohaline).
- Surface currents are wind-driven; transport heat to higher latitudes.
- Winds and ocean currents are influenced by the Coriolis Effect.
- Upwelling brings nutrients back to the surface for use in biological productivity.