

# Upwelling And Sinking

# Introduction

**Upwelling** is an oceanographic phenomenon that involves wind-driven motion of dense, cooler, and usually nutrient-rich water towards the ocean surface, replacing the warmer, usually nutrient-depleted surface water. The increased availability in upwelling regions results in high levels of primary productivity and thus fishery production. Approximately 25% of the total global marine fish catches come from five upwellings that occupy only 5% of the total ocean area.

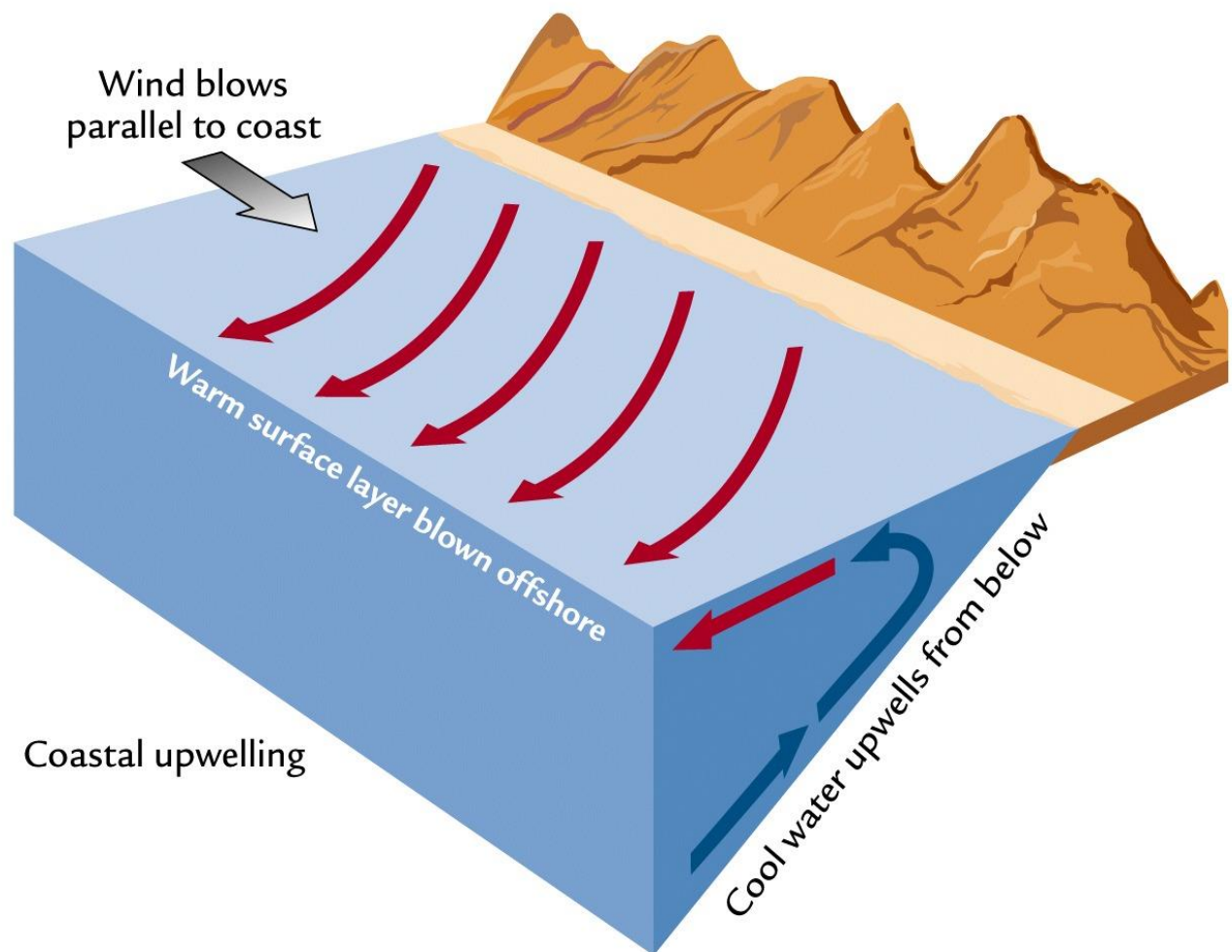
# Types

The major upwellings in the ocean are associated with the divergence of currents that bring deeper, colder, nutrient rich waters to the surface. There are at least five types of upwelling:

1. Coastal upwelling
2. Large-scale wind-driven upwelling in the ocean interior
3. Upwelling associated with eddies
4. Topographically-associated upwelling, and
5. Broad-diffusive upwelling in the ocean interior

# Coastal

Coastal upwelling is the best known type of upwelling, and the most closely related to human activities as it supports some of the most productive fisheries in the world. Wind-driven currents are diverted to the right of the winds in the Northern Hemisphere and to the left in the Southern Hemisphere due to the Coriolis effect. The result is a net movement of surface water at right angles to the direction of the wind, known as the Ekman transport. When Ekman transport is occurring away from the coast, surface waters moving away are replaced by deeper, colder, and denser water.



A Coastal upwelling

❖ Deep waters are rich in nutrients, including nitrate and phosphate, themselves the result of decomposition of sinking organic matter (dead/detrital plankton) from surface waters. When brought to the surface, these nutrients are utilized by phytoplankton, along with dissolved CO<sub>2</sub> (carbon dioxide) and light energy from the sun, to produce organic compounds, through the process of photosynthesis. Upwelling regions therefore **result in very high levels of primary production** (the amount of carbon fixed by phytoplankton) in comparison to other areas of the ocean. High primary production propagates up the food chain because phytoplankton are at the base of the oceanic food chain.

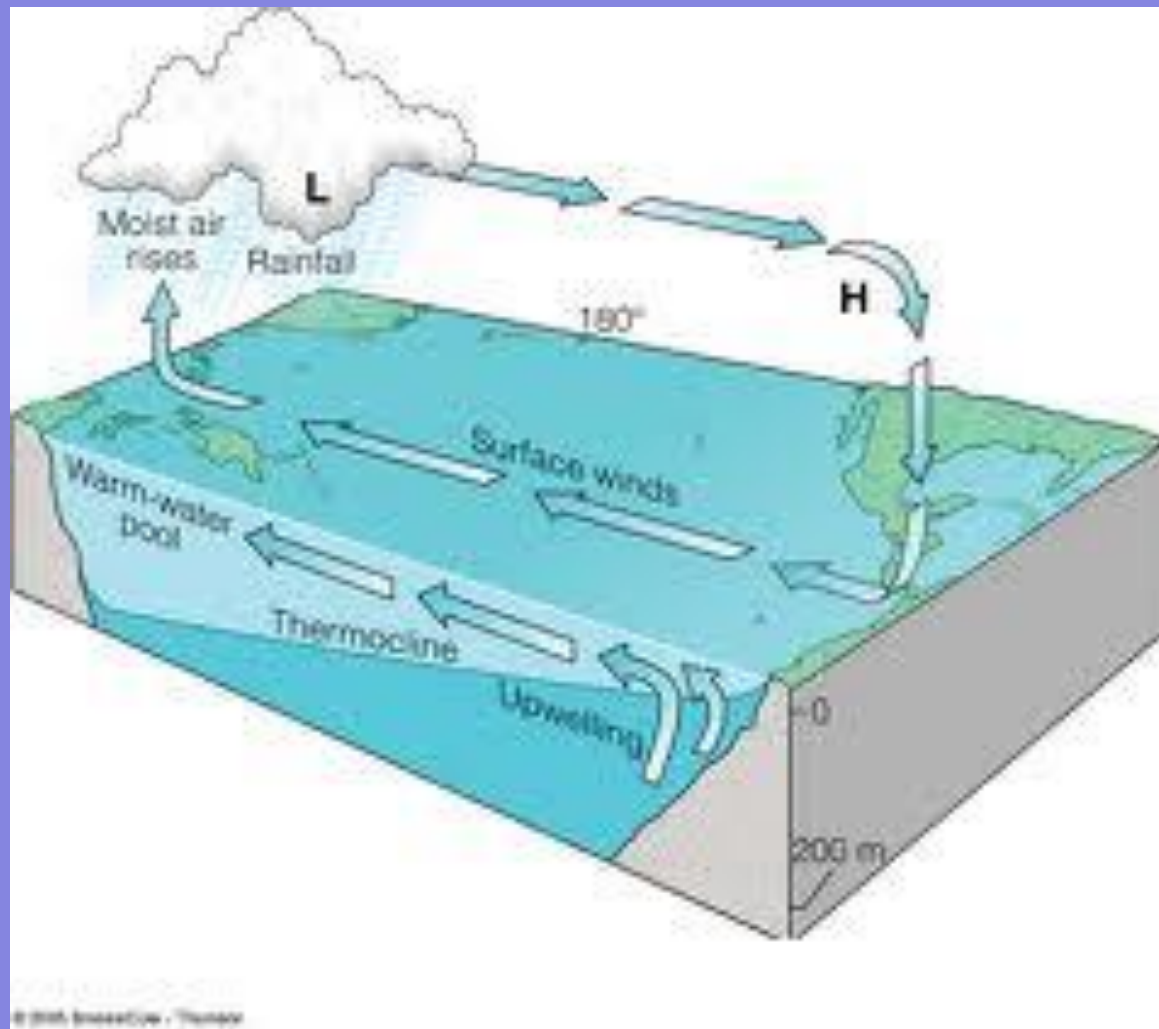
❖ Worldwide, there are five major coastal currents associated with upwelling areas:

1. The Canary Current (off Northwest Africa),
2. The Benguela Current (off southern Africa),
3. The California Current (off California and Oregon),
4. The Humboldt Current (off Peru and Chile), and
5. The Somali Current (off Western India).

# Equatorial

Upwelling at the equator is associated with the Intertropical Convergence Zone (ITCZ) which actually moves, and consequently, is often located north or south of the equator. If the ITCZ is displaced above the equator, the wind south of it becomes a southwesterly wind which drives water to its right or southeasterly, away from the ITCZ. Whatever its location, this results in a divergence, with denser, nutrient-rich water being upwelled from below, and results in the remarkable fact that the equatorial region in the Pacific can be detected from space as a broad line of high phytoplankton concentration.





**Upwelling** is often due to the divergence of surface currents

## Variations

- ❖ Upwelling intensity depends on wind strength and seasonal variability, as well as the vertical structure of the water, variations in the bottom bathymetry, and instabilities in the currents.
- ❖ In temperate latitudes, the temperature contrast is greatly seasonably variable, creating periods of strong upwelling in the spring and summer, to weak or no upwelling in the winter.
- ❖ In contrast, tropical latitudes have a more constant temperature contrast, creating constant upwelling throughout the year. The Peruvian upwelling, for instance, occurs throughout most of the year, resulting in one of the world's largest marine fisheries for sardines and anchovies.

- ❖ Upwelling is a seasonal phenomenon in the Indian Ocean because of the monsoon regime. During the southwest monsoon, upwelling occurs off the Somali and Arabian coasts and south of Java. It is most intense between  $5^{\circ}$  and  $11^{\circ}$  N, with replacement of warmer surface water by water of about  $57^{\circ}\text{F}$  ( $14^{\circ}\text{C}$ ).
- ❖ During the northeast monsoon, strong upwelling occurs along the western coast of India. Mid-ocean upwelling takes place at that time at  $5^{\circ}$  S, where the North Equatorial Current and the Equatorial Countercurrent run alongside each other in opposite directions.

# SINKING (Vertical Water Movement)

- ❖ Vertical movements of ocean waters are produced by upwelling and sinking processes. These processes tend to break down vertical stratification established by pycnocline. The physical processes that increase sea water density are affected by temperature and salinity results in sinking of water to subsurface and deeper areas. Sea water sinking from surface is usually highly oxygenated, so it transport dissolved oxygen to deep areas of ocean basin that would otherwise be deoxygenated.

❖ The chief areas of sinking are located in colder latitudes, where sea surface temperatures are low. After sinking this dense water continues to spread and flow horizontally very slowly. Time spans of a few hundred to a thousand years are required for water that sinks in the North Atlantic to reach the surface again in the southern hemisphere.

❖ In the arid climate of Mediterranean Sea, particularly at its eastern end, evaporation from the sea surface greatly exceeds precipitation and runoff. The resulting high salinity and high density water sinks and fills the deeper parts of the Mediterranean basin. The sinking of surface water provides substantial mixing and oxygen replenishment for the deeper water of the Mediterranean. Part of these dense water flows out of the Mediterranean over a shallow sill at Gibraltar and down into the Atlantic Ocean.