# Marine Water Microbiology

By- Dr Ekta Khare

Department of Microbiology,

Chhatrapati Shahu Ji Maharaj University, Kanpur

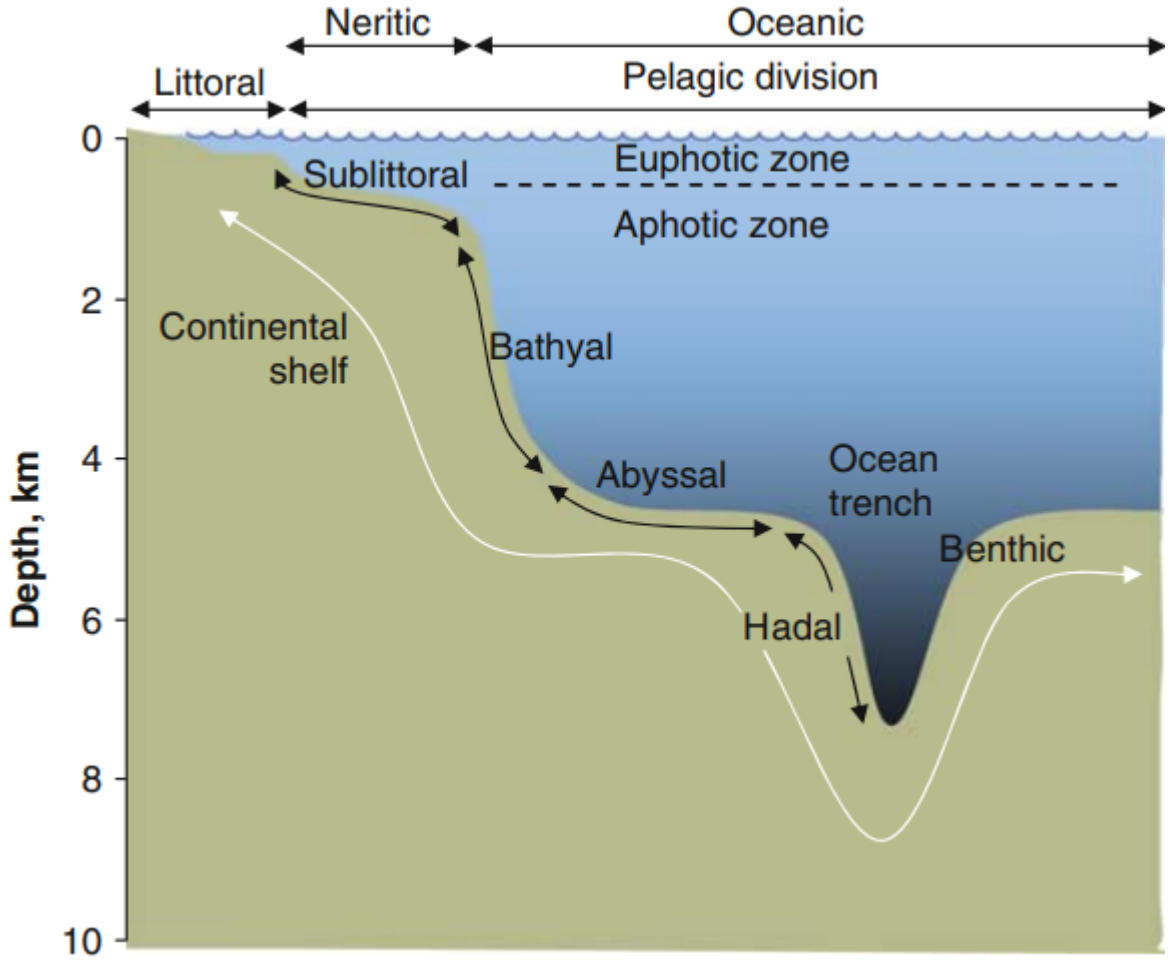
# Marine Environment

- In terms of sheer volume, the marine environment represents a major portion of the biosphere and contains 97% of the Earth's water.
- The ocean has been called a "high-pressure refrigerator," with most of the volume below 100 meters at a constant 3°C temperature.
- The ocean, at its greatest depth, is slightly more than 11,000 meters deep.
- The pressure in the marine environment increases approximately 1 atm/10 meters in depth, and pressures are in the vicinity of 1,000 atm at the greatest ocean depths.
- The greater the depth of the water, the less light can penetrate until below a certain depth there is no light whatsoever.
- This area of inky darkness, which occupies the great bulk of the ocean, is called the aphotic zone.
- The illuminated region above it is called the photic zone, within which are distinguished the euphotic (receives enough light for photosynthesis to occur) and disphotic zones (illuminated so poorly that rates of respiration exceed those of photosynthesis).
- Marine environments consist of water, or pelagic, environment and a bottom, or benthic, environment.

# … Marine Environment

- Within the pelagic environment, the waters are divided into the neritic province above the continental shelf, and the open oceanic waters.
- The pelagic water body is divided into several zones (epipelagic, mesopelagic, bathypelagic, and abyssalpelagic) according to depth.
- The intertidal, or littoral, zone ranges from the high-tide mark to the shallow, offshore waters.
- The sublittoral is the environment beyond the low-tide mark and is often used to refer to continental shelf (150–300 m).
- Beyond the continental shelf is the bathyal zone, which occurs at depths of 150 to 4,000 m and includes the descending continental slope and rise.
- The abyssal zone (between 4,000 and 6,000 m) represents a substantial portion of the oceans.
- The deepest region of the oceans (greater than 6,000 m) is the hadal zone of the deep-sea trenches.
- The trophic status of marine ecosystems depends on both the vertical and horizontal positions of a particular site.

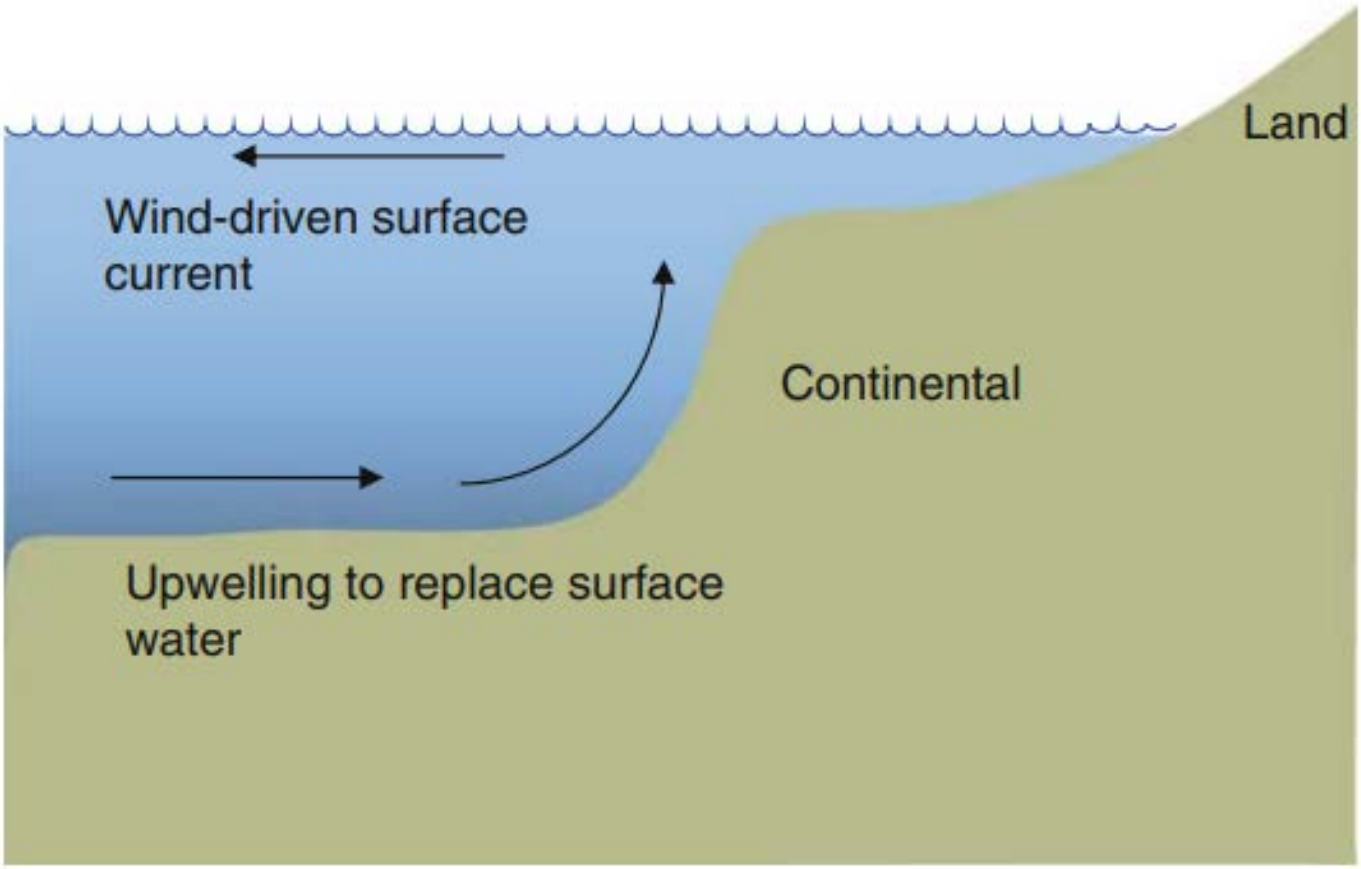
# Major vertical zones of an ocean profile



# Aquatic Environments and Microorganisms

- Probably, the majority of heterotrophic/saprotrophic marine organisms are limited by a supply of available organic substrates derived mainly from soluble exometabolites and the dead bodies of primary producers.
- The photosynthetic bacteria such as *Prochlorococcus* and numerous algae are limited mainly by mineral nutrients, among which are nitrogen, phosphorus and especially iron.
- Still in oceans, organic matter from the surface can sink to great depths, creating nutrient-rich zones where decomposition takes place.
- Gases and soluble wastes produced by microorganisms in these deep marine zones can move into overlying waters and stimulate the activity of other microbial groups.
- In most cases, a supply of substrates should be considered continuous with seasonal and diurnal fluctuations dependent on fluctuation of temperature and photone flux.
- The mixing and movement of nutrients, $O_2$, and waste products that occur in marine environments are the dominant factors controlling the microbial community.
- A significant increase in the nutrient level encourages circulation of oceanic waters and upwelling.
- The temperatures within which microorganisms function in aquatic environments can range from - 5 to - 15°C at the lower range, to at least 113°C in geothermal areas.

# Upwelling of deep ocean water along continental slope to replace surface waters driven offshore by wind



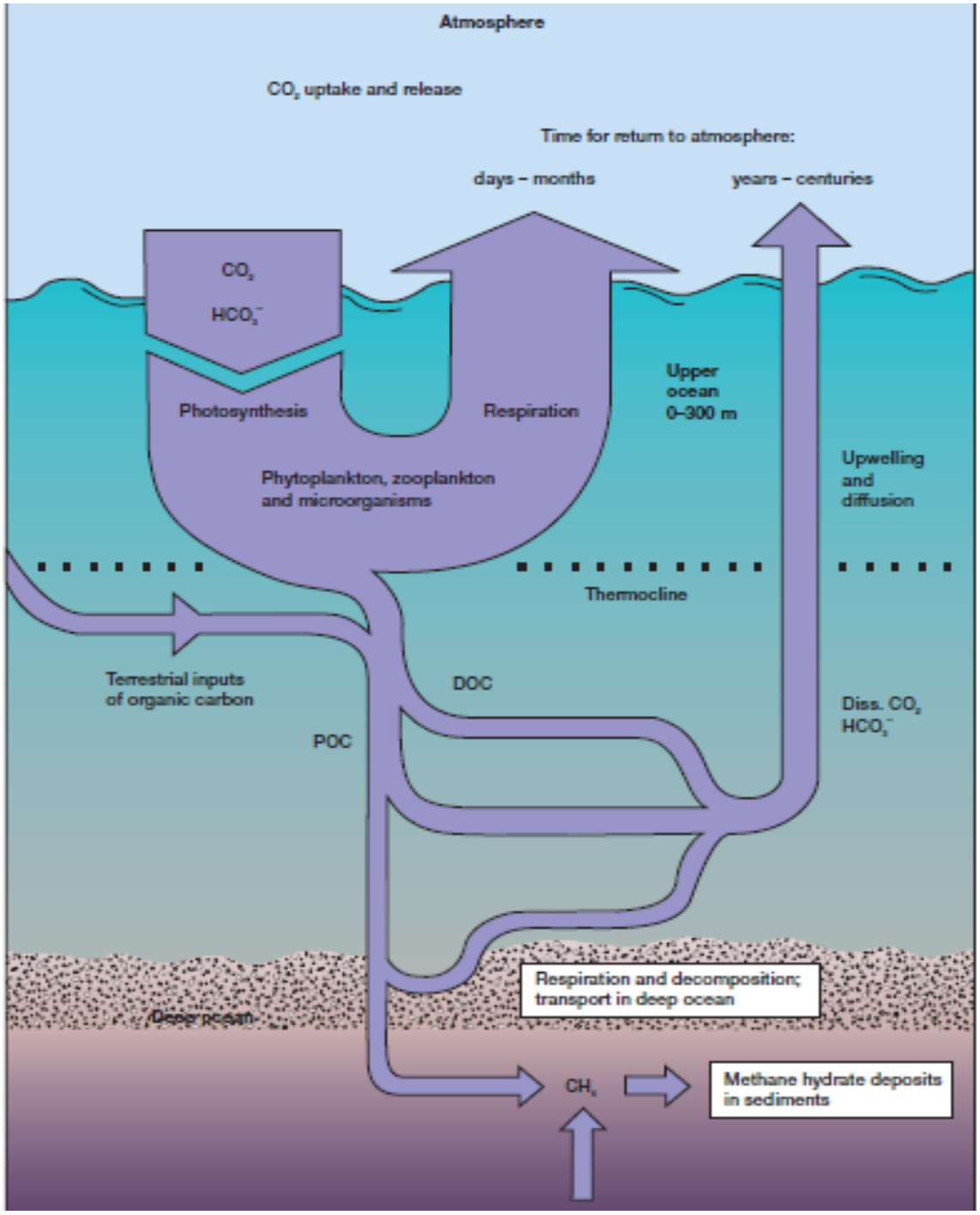
# Nutrients in Aquatic Environments

- Most nutrient cycling in oceans occurs in the top 300 meters where light penetrates.
- Light allows phytoplankton to grow and fall as a “marine snow” to the seabed. This “trip” can take a month or longer.
- Most of the organic matter that falls below the 300 meter zone is decomposed, and only 1% of photosynthetically derived material reaches the deep-sea floor unaltered. to grow under oligotrophic conditions becomes important
- In marine environments the turnover time for nutrient processing may range from hundreds to thousands of years.
- In contrast, marsh and estuarine areas may have rapid rates of nutrient turnover, and a complex, diverse microbial community of rapidly responding microorganisms is present.
- The nutrient composition of the water affects the final carbon-nitrogen-phosphorus (C:N:P) ratio of the phytoplankton, which is termed the **Redfield ratio,** named for the aquatic biologist A. C. Redfield.
- This ratio is important for following nutrient dynamics, especially mineralization and immobilization processes, and for studying factors that limit microbial growth, especially the sensitivity of oceanic photosynthesis to atmospheric additions of nitrogen, sulfur, and iron.

# Carbon cycle in marine environment

- The carbon cycle within the ocean environment is only poorly understood.
- It is estimated that the large amount of dissolved organic carbon (DOC) in the ocean has a mean age of greater than 1,000 years.
- Besides DOC, massive deposits of methane hydrate occur in ocean sediments.
- Under the low-temperature, high-pressure conditions microorganisms found at the ocean floor below 500 meters produce methane, that accumulates in lattice like cages of crystalline water.
- There may be up to 10,000 billion metric tons of carbon present as methane hydrate worldwide, 80,000 times the world's current known natural gas reserves.
- Archaea, as a part of complex microbial communities, appear to metabolize methane deposits at low hydrogen levels under sulfate reducing conditions. The process is called **reverse methanogenesis.**
- The procaryotes that consume these methane hydrates serve as a food source for ice worms, *Hesiocaeca methanicola.*

# Carbon Cycling in the Ocean Environment



# Nitrogen & Sulfur cycles

- Large volumes of the ocean's water have lower oxygen levels, leading to denitrification and a decrease in the nitrate-phosphate ratio in the water.
- As a consequence, nitrogen fixation may be favored and increase the nitrogen level in the water.
- The ocean sulfur cycle also has widespread effects on global processes.
- Dimethylsulfide (DMS), an algal osmolite, can be released to the atmosphere and comprises 90% of the volatile sulfur compounds in the sulfur cycle.
- When DMS is oxidized, its end products can influence the acidity of the atmosphere, as well as the Earth's temperature and cloud formation.

# Sea ice & Microorganisms

- Much of the marine environment is covered by sea ice that may comprise up to 7% of the world's surface at the winter maxima at the north and south poles.
- Microorganisms actually grow and reproduce at the interface between the ice and the seawater.
- The microbes that have been recovered from these ice cores: these include *Polaromonas, Marinobacter, Psychroflexus, Iceobacter, Polibacter,* and *Psychromonas antarcticus.*

# Anthropogenic activities

- Increased human populations and the urban development occurring in coastal areas around the world is taxing the seemingly inexhaustible ability of oceans to absorb and process pollutants.
- Coastal areas that have limited mixing with ocean waters (e.g., the Baltic Sea, Long Island Sound, Chesapeake Bay, the Mediterranean) are showing signs of nutrient enrichment and microbial pollution.
- In the Gulf of Mexico, at the Mississippi River delta, releases of nutrients from states that drain into this river have stimulated microbial growth and oxygen depletion.
- Another problem that relates to ocean waters and water mixing in coastal areas is the occurrence of red tides.
- Recently the occurrence of algal blooms and red tides in the Pacific Ocean off the central California coast has resulted in the die-off of dolphins.
- The major algal genus responsible for widespread loss of these aquatic animals is *Pseudo-nitzschia.*

# Questions

- Explain the marine environment in detail. Discuss the role of marine microorganisms in nutrient cycling.
- Write short note on microbiology of marine environment.