Glossary Marine Biology 1

Bioluminescence: Also called phosphorescence; production of light without sensible heat by living organisms as a result of a chemical reaction either within certain cells or organs or outside the cells in some form of secretion.
ATP-driven luciferin-luciferase metabolism generates light; in marine organisms either caused by mucus segregation containing bioluminescent bacteria or by chemical reaction in specially adapted tissue – usually spread all over the organisms body.
Many organisms (carnivorous) use their bioluminescent activity to attract potential prey; their highly developed eyes can detect flashbacks of a distance as far as 200m away.

Camouflage: Body shapes, colors, or patterns that enable an organism to blend in with its environment and remain concealed from danger.

- **Color Adaptation**: Benthic organisms can acquire the color pattern of the surrounding seafloor (e.g. flounder).
- **Scales**: Silvery guanine scales redirect incident light, making pelagic organisms almost invisible.

Continental Shelf: Zone adjacent to a continent or around an island, usually extending from the low-water line to the depth at which the slope increases markedly.
Atlantic C.S.: A slightly, but steadily falling slope.
Pacific C.S.: A sharp and steep drop within a few kilometers off shore.

Conveyor Belt System (CBS): The present flow of ocean water within and between ocean circulating at both the surface and at depth. Cold surface water sinks to the sea floor in the North Atlantic, then flows south to be further cooled by the Antarctic bottom water formed in the Weddel Sea (40°W 65°S). This deep water moves eastward around Antarctica, feeding into the surface layer of the Indian Ocean and also into the deep basins of the Pacific. A return flow of surface water from the Pacific and Indian Ocean flows north to replace the surface water in the North Atlantic.
Gulf Stream: Warm, well-defined, swift, and relatively narrow ocean current that originates north of Grand Bahama Island where the Florida Current and the Antilles Current meet. The Gulf Stream extends to the Grand Banks about 40°N, 50°W, where it meets the cold Labrador Current, and the two flow eastwards as the North Atlantic Current. The Florida-, North Atlantic Current, and Gulf Stream, together form the Golf Stream system.

- Eddies caused by the G.S.: The Gulf Stream is defined by sharp changes in current velocity and direction. Meanders form at this boundary after the stream leaves the US coast at Cape Hatteras. The amplitude of the meanders increases as they move downstream. Eventually the current flow pinches off the meander to form isolated rotating eddies of warm water which wander into the cold water (NW) rotating clockwise, while cells of cold water drift through the stream into the warm water (SE) rotating counter-clockwise.

Circulation: General term describing a water current flow within a large area; usually a closed circular pattern, and are essential in the plankton distribution throughout oceans and climatic patterns to bordering continents.
Types of Circulation:

- **Convection**: In general, mass motions within a fluid resulting in transport and mixing of the properties of that fluid. Convection, along with conduction and radiation, is a principle means of energy transport.
  Once the spring sun heats up the upper layers of seawater, convection results in a total exchange of water bodies, which swaps surface water of low nutrient content with bottom water of high nutrient content – similar to **c**onveyor **b**elt **s**ystem (CBS).
  Thermohaline C. (circulation): General term describing a water current flow within a large area; usually a closed circular patterns such as the North Atlantic.
- **Langmuir** C.: Vertical surface-water circulation causing a water vortex of several meters in diameter;
  Convergence: Situation in which waters of different origins come together at a point or, more commonly, along a line known as a convergence line (minor water level depression, often accumulating floating detritus and positively buoyant organisms such as zoo-plankton - nowadays plastics); often associated with down-welling. Along such a line the denser water from one side sinks under the lighter water from the other side. The recognized convergence lines in the oceans are the polar, subtropical, tropical, and equatorial convergence line.
  Divergence: Horizontal flow of water in different directions from a common center or zone; often associated with upwelling (minor water level elevation along a divergence line; aggregating negatively buoyant organisms such as phyto-plankton).

Currents: The horizontal movement of water (for global currents, see Conveyor Belt System);

Basic forces of C.: Physical and chemical forces have a major impact upon water displacement:

- **Bernoulli's** Effect: The pressure along any given streamline must decrease whenever the velocity of the fluid increases;
  all over pressure = hydrostatic + hydrodynamic pressure:
  $p_0 = \rho \cdot g \cdot y + \frac{1}{2} \cdot \rho \cdot v^2$ $[N/m^2] = [Pa]$

  ρ, density of liquid [kg/m^3]
  v, velocity of liquid [m/s]
  g, grav. accelerat. 9.81 [m/s^2]
  y, height [m]
- **Directive** F.: Earth rotation causes Coriolis effect and geo-morpholigical patterns redirect water currents.
- **Endogenic** Forces: Atmospheric influences (wind, solar radiation, etc.), gravitation, and interstellar mass attraction (by the sun and moon) shift large amount of water bodies.
- **Exogenic** Forces: Density gradients over time and space; temperature and salinity differences as well as con-/di-vergenic patterns cause a water body to shift.

Coriolis Effect: Apparent force on moving particles resulting from the earth's rotation. It causes moving particles (water as well as air) to be deflected to the right of motion in the northern hemisphere (resulting in a counter-clockwise circulation) and to the left in the southern hemisphere (clockwise rotation); the force is proportional to the speed and latitude of the moving particle and cannot change the speed of the particle.

Drift C.: Surface water transport perpendicular to the direction of the wind, along with the Coriolis effect causes the Ekman spiral; e.g. southern winds and the Humbolt current at the west coast of Chile and Peru.

Eddy: Circular movement of water usually formed where currents pass obstructions, between two adjacent currents flowing counter each other or along the edge of a permanent current; e.g.: Strait of Gibraltar: warm water bodies high in salinity, pass the threshold of the underwater peaks and sink rapidly downhill into the cooler Atlantic. These waters become separated and form islets of warm deep water, which later on gradually spread horizontally at a certain depth establishing thin sheets to finally integrate completely with Atlantic waters (see currents - Gulf Stream).

Ekman Spiral: Theory that a wind blowing steadily over an ocean of unlimited depth and extend and of uniform viscosity caused the surface layer to drift at an angle of 45° to the right of the wind direction in the northern hemisphere. Water at successive depths drift in directions more to the right until at some depth it moves in the direction opposite to the wind. Velocity decreases with depth throughout the spiral. The depth at which this reversal occurs is about 100m. Net water transport is 90° to the right of the direction of the wind in the northern hemisphere; vice versa in the southern hemisphere (see also Coriolis effect).

Longshore C.: Current running roughly parallel to the shoreline and produced by waves being deflected at an angle by the shore. According to the surface and shoreline conditions, the incoming wave-front results in a heading (wave-ray) always perpendicular to the wave front;

- Bay: Waves refracted by the shallow depths on each side of a bay deliver lower levels of energy inside the bay. The diverging wave-rays spread the energy over a larger volume of water, decreasing the energy per unit of wave crest as the wave height decreases; less erosive.
- Headland: Waves refracted over a shallow submerged ridge focus their energy on the headland; the converging wave-rays crowd the wave's energy into a smaller volume of water. Increasing the energy per unit length of wave crest as the height of the wave increases; very erosive.

Surface Water C.: See circulation - Langmuir; convergence / divergence

Tidal C.: Alternating horizontal movement of water associated with the rise (flood) and fall (ebb) of the tide caused by astronomical tide-producing forces (see tides).

Density of Seawater: See there.

Depth Zones: compare also light zones - light;

Abyssal: Refers to organisms of phenomena at depths between 4000 and 6000m, on the sea bottom.
Benthos: The community of plants and animals that live permanently in or on the sea bottom (see substrate).
Hadal: Refers to organisms or phenomena at depths greater than 6000m, living in mid water.
Litoral (intertidal zone): Benthic zone between high- and low-water marks; between the shore and water depths of approximately 20m; i.e. *neritic division* on top of the continental shelf. Rich in species diversity and number.

- **(Eu)Litoral**: - in-between the low and the high water line (intertidal); e.g.: settling area of certain sea anemones.
- **Sublitoral**: - below the low water line
  Bathylitoral: Depths of 180m and over.
  Circalitoral: Depths of 80 to 180m; representing the typical biologic active depth zone.
  Infralitoral: Zone below the low water line till 80m; typically for light-tolerating organisms (*Fucus sp*.).
- **Supralitoral**: - above the high water line; e.g.: *Cyanobacter* forming a black band on rocky shores.

Neritic Zone: Portion of the pelagial extending from low-water level to the approximate edge of a continental shelf
Pelagial: Thropic zonation of open water, marine environments; occurring in the water, away from the bottom; marine environment not in close proximity to continental land masses, also referred to as *oceanic division*, as the water body above the deep sea floor. Lower in species number and diversity than benthos.

- **Abyssopelacic** Zone: see above - abyssal.
- **Bathypelagic** Zone: Refers to organisms or phenomena at depths between 1000 and 4000m, in mid-water.
- **Mesopelagic** Zone: Refers to organisms and phenomena at depths between 200 and 1000m, in mid-water
- **Epipelagic** Zone: Portion of the oceanic province extending from the surface (pleuston, neuston, see marine environments) to depths of about 200m.

Dissolved **O**rganic **M**atter (DOM): Suspended organic material, such as carbohydrates, fatty acids, lipids, enzymes and vitamins; up to $1E^6$ - $1E^8$ bacteria/mL can be found there along with flagellates, ciliates, and other planktonic herbivores (copepods are the grazers of phytoplankton).

Ekman Spiral: See currents.

Estuary: A bay whose salinity is affected by river runoff; environment not suitable for stenohaline species.

Exclusive Economic Zone: A 200 nautical mile (360km) wide stretch that extends out under the ocean, containing a wealth of resources.

Food: Organic compounds used in the synthesis of new bio-molecules and as fuel in the production of cellular energy; i.e. carbohydrates (glucose), proteins (amino acids), starch, lipids (fatty acids), vitamins, and trace elements.
F. **Chain**: A sequence of organisms through which energy captured from sunlight by photosynthesis is transferred from one consumer (or trophic level) to the next; each organism in the chain feeds on a preceding species and itself is eaten by the following member of the sequence; there are seldom more than six links in a chain, with autotrophs at the bottom and the largest carnivores at the top.

- **Grazing Food Chain**: Phytoplankton is consumed by herbivores and in turn is eaten by planktivores, peaking by piscivores as the top predator (fish-eating fish); going up the pyramid, every consumer level represents a decline in biomass and energy by a magnitude of 10; this **positive correlation** implies that a huge biomass production at producer level results in a large population at the predator level and vice versa if the chain is still intact.

F. **Web**: Representation of feeding relationships in a community that includes all the links revealed by dietary analysis; it depends upon the number of species involved and their connectiveness, and characterizes competition between three major fluxes (grazing food chain, microbial loop, and sinking organic matter);

- **Microbial Loop**: Viruses, Bacteria and protozoans feed on released DOM (mainly in the form of DOC, i.e. carbon of phytoplankton, zooplankton, planktivores and herbivores) as metabolic byproducts: These substances are utilized by heterotrophic bacteria which in turn are consumed by protozoans to finally be eaten by larger zooplankton; the microbial loop interferes especially with the linear chain of consumers at the start of the food chain.
- **Sink**: Downward movement of organic matter beyond the euphotic zone (critical depth) into the mesopelagic zone, which represents a huge storage site of organic and other debris.

Gasses dissolved in Seawater: See seawater;

Gulf Stream: See current.

Light: The visible part of the electromagnetic spectrum of the sun.

Adaptation: According to autotrophic organism and its absorption spectrum found at certain depths suitable for photosynthesis; e.g.: *Rhodophyta* (red algae till 180m) found in the lower circalitoral zone; *Phaeophyta* (brown algae till 80m) within the infralitoral zone; *Chlorophyta* (green algae below waterline) within the sublitoral zone.

- **Chromatic** A.: ： Benthic organisms can acquire the color pattern of the surrounding seafloor (e.g. flounder); in general, eyes become more sensitive to the shorter wave spectrum, the deeper an organism lives.
- **Plasmatic** A.: (Gk. to mold, to shape) related to or like plasma.

Absorption: Certain surfaces and colors absorb the visible spectrum of light. Seawater easily absorbs the UV-spectrum (wavelengths <350nm) and the IR-spectrum (wavelengths >800nm), leaving the photosynthetic active spectrum almost untouched (400-750nm) – see PHAR.

Attenuation: Reduction in light intensity caused by the absorption and scattering of light energy in water; i.e.: a lessening of the amplitude of a wave with distance from the origin.

Attenuation (A) = $100 \cdot (1 - I_0/I_D)$ [%]suspended

I_0, max. light intensity

I_D, light intensity at a certain depth

Compensation Depth: The depth at which phyto-plankton receives just enough light, over a 24h-period, to enable its photosynthesis to produce exactly enough new carbohydrate to supply its own metabolic needs. The depth at which its photosynthetic production matches its respiratory or metabolic consumption.

Light Zones: compare also with depth zones;

- **Aphotic Zone**: Portion of the ocean waters where light is insufficient for plants to carry on with photosynthesis (equivalent to the bythypelagic and abyssal depth zone).
- **Euphotic Zone**: Layer of body of water that receives ample sunlight for photosynthetic processes of plants. Depth of this layer varies with the angle of incidence of the sunlight (reason why a day the waterline is always shorter than a day above water - see refraction), length of day, and cloudiness, but is usually 80m or more. 99% of sunlight is absorbed (equivalent to epipelagic depth zone).
- **Dysphotic Zone**: Twilight zone in the ocean, between euphotic and aphotic zone. 1% of sunlight reaches this zone (equivalent to mesopelagic depth zone).

PHAR (photosynthetic active radiation): The spectral range utilized for photosynthesis by plants; 380-710nm.

Refraction: The bending of an oblique ray of light when it passes from one transparent medium of one density to another with a different density, caused by a difference in the speed of light in those media. When the change in medium is abrupt (e.g., from air to water, the angle of incident is larger than the angle of refraction by an amount that depends on the relative speed of light in air and in water), the bending is abrupt; when the change in medium is gradual (from cool air to warm air), the bending is gradual, which accounts for mirages; the change from a dense medium to a denser medium (air-water line) bends light towards the perpendicular air-water line, whereas it is bent away from the perpendicular plane once light passes from a denser material to a less dense material (see critical angle)

- **Critical angle**: The minimum angle of incidence at which a light ray is totally reflected within a medium; causing a net shortage of sunlight hours under the water, compared to that one above the water line.
- R. **Index**: The refractive power of a medium compared with that of air, designated 1; $n_{diamond} = 2.4$; $n_{water} = 1.3$:
  $n = c_{vacuum}/v_{of\ light\ in\ medium}$
  $n_1 \cdot \sin\theta_1 = n_2 \cdot \sin\theta_2$

  c, speed of light $3 \cdot 10^8$ [m/s]
  n, index of refraction [-]
  f, frequency [1/s] [Hz]
  θ, angle in degrees [-]

Scattering of Light: Occurs when the scattering particles are much smaller than the wavelength of an incident light and have resonance at frequencies higher than the scattered light; the shorter the wavelength the more light is scattered, that's why daylight sky is blue (due to N_2, O_2-molecules). A red sunset on the other hand occurs when the sun is already low in the sky, therefore the path through the atmosphere is considerably longer than at midday; more blue is scattered, leaving more and more red; furthermore long-waves bend better than short waves, if the sun is about to vanish beyond the horizon, in reality its already past the horizon, just the bent red long waves give us this illusion that it is still there.

Scattering of light in water is due to SESTON (suspended material like plankton, sediment particles, and DPOM); the higher the primary production, the more light is scattered, the more turbid the water appears.

Marine Environment and its **Organisms**: based on open water or bottom dwelling activities.

Nekton: Pelagic animals that are active swimmers, such as most of the adult squids, fishes, and marine mammals.

Plankton: Passively drifting or weakly swimming organisms in marine and fresh waters. Members of this group range in size from microscopic plants to jellyfish measuring up to 2m across the bell and includes the eggs an larval stages of the nekton and benthos; e.g.: phyto-plankton, zoo-plankton.

- **Neuston**: The epipelagic zone few centimeter below the waterline; rich in DOM, and bacteria.
- **Pleuston**: Organisms or phenomena of the (epi-)pelagic zone considered to include the space a few centimeters above the waterline; e.g. floating organisms which utilize wind to get drifted over the ocean, *Physalia physalis* (Portuguese man-of-war).

Classes of P.: Based upon the autotrophic or heterotrophic aspect, grouped into :

- **Phytoplankton**: Planktonic plants, usually single celled, like diatoms, etc.
- **Zooplankton**: Animal forms of plankton. They include various crustaceans, such as copepods and euphausiids; jellyfish, certain protozoans, worms, molluscs, and the eggs and larvae of benthic and nektonic animals.

P. **Distribution**: According to its geographical distribution grouped as:

- **Neritic** P.: Benthic zone between high- and low-water marks (water depths of approximately 20m); e.g. autotrophic organisms (algae, cyanophyta, dinoflagellates, and other protists) larvae of echinoderms, polychaeta, tentaculata, etc.), filter feeders (molluscs, copepods, etc.), and predators (cnidaria, some protists, etc.).
- **Oceanic** P.: Belonging to the marine environment not in close proximity to continental land mass; autotrophic organisms (some flagellates etc.) filter feeders (copepods, krill, salps, thekosomes, gymnosomes, and predators (some protists, nudibranches, polychaetes, most fish, etc.).

P. **Lifecycle**: Only about 2% of all marine organisms are found in the pelagial zone; the majority (98%) is found at benthic level; out of these, up to 90% gather at the continental shelf (eulithoral zone).

Biphasic (planktotrophic): Organisms that spend their juvenile stage as planktortrophic larvae and become sessile once adult stage is reached, e.g.: porifera, cnidaria, echinoderms and others.

Holo-P.: Organisms that spend their entire lifecycle in the pelagial; e.g. copepods. Contrary to biphasic.

Hypo-(Typhozoo)-P.: Organisms living on or a few centimeters above the ocean bottom; e.g. *Protista, Mysidacea*.

Mero-P.:

P. **Movement**: Passive or active migration of plankton in the ocean.

Patchiness: Passive distribution mainly caused by Langmuir circulation; phyto- and zoo-plankton in the sea is primarily of a patched character, in which aggregations of phyto-plankton attract zoo-plankton; a pendelum-like oscillation of planktonic aggregations allows "overgrazed" phyto-planktonic sites to recover.

Vertical M.: Diurnal oscillation of phyto-plankton caused by the sun; as plankton sinks down at sunrise avoiding over-exposition, it creates a scattering layer at a certain depth (depth at which photosynthetic production matches respiratory or metabolic consumption; can be up to 800m deep; see light - compensation point, aphotic zone), which will cease to exist once the plankton drifts back to the surface at sunset.

Such vertical shifts are also present on a larger scale following seasonal patterns.

P. **Size**: According to its size, an indicator if its throphic position in the energy pyramid (see also food chain).

- **Ultranano**-P.: <2µm in size; plankton mainly constituting of bacteria;
- **Nano**-P.: 2-20µm in size; mostly phytoplankton (silico-flagellates);
- **Micro**-P.: 20-200µm; phytoplankton (dinoflagellates, diatoms) and zooplankton (ciliates, radiolaria);
- **Macro**-P.: 0.2-2mm; mostly zooplankton as herbi- and carnivores (foraminifers, copepods, cirripeds);
- **Mega**-P.: >2mm; mostly carnivores (chaetognatha, crustaceans, coelenterates, ctenophores, telosts);

Mediterranean Sea: This large body of salt water surrounded by land with a narrow opening to the Atlantic. The Italian peninsula divides it into a western and eastern basin. In general, the W-Mediterranean is far more productive than the eastern half (in species number as well as density by a factor of **two**). In recent times the E-Mediterranean is subject to great alterations caused by the Assuan Dam (lower nutrient influx) and the opening of the Suez Canal (migration of Red-Sea species known as ***Lessepian*** migration).

Microbial Loop: See food - food web;

Nutrient Cycle: Any inorganic or organic compound or ions cycling through the chain of life, mainly used in the nutrition of primary producers. N, P, and Si are the limiting nutritive factors regarding productivity of the sea (silicates are essential to diatoms). Vitamins such as B_{12} are essential to many algae.

Productivity: The rate at which biomass is produced per unit area by any class of organisms.

- **Gross Primary** P. (GPP): The amount of new carbohydrate material produced each day (or longer time interval) by the plants of an ecosystem.
- **Net Primary** P. (NPP): The excess material of GPP which is not consumed by its own metabolic process.

Phytal: Dense epibentic plant coverage of sea-grass beds (*Potamogetonacea*) or algal forests (*Kelp*); provide the structural habitat required for other flora and fauna; epizoa at the lower end, epiphyta near the canopy of the plant;

Plate Tectonics: Theory and study of the earth's lithospheric plates, their formation, movement, interaction, and destruction; also known as continental drift.

Convergent Zone: Seismically active spot at the edge of 2 global plates that collide or slide past each other.

Divergent Boundary: Edge of two global plates that are separating; i.e.: mid-ocean ridge.

Particulate Organic Matter (POM): Organic matter composed of particles that are not superficially bound together, such as phosphorous, or nitrogen.

Pressure: The ratio of force to the area over which it is distributed.

Water P.: Pressure increases at a rate of one atmosphere ($10 \cdot E^3$Pa) for each additional 10m of depth under water. Organisms capable of handling these pressures have to control their air spaces to avoid internal damages. Swimm-bladders of fish going beyond 600m contain oil fat rather than air. Myoglobin, a special oxygen storage protein, enables these organisms to extend diving intervals. Sperm whales can dive as deep as 2000m for up to 60mins, Seals to a depth of 600m for 3hs, Elephant Seals down to 1200m for up to 2hs.

Productivity: See nutrient cycle;

Salinity: Measure of the quantity of dissolved salts in seawater. It is formally defined as the total amount of dissolved solids in seawater in parts per thousands [‰] by weight when all the carbonate has been converted to oxide, the bromide and iodide to chloride, and all organic matter completely oxidized. In practice, salinity is not determined directly but computed from chlorinity, electrical conductivity, refractive index, or some other property whose relationship to salinity is well established. Average salinity level of seawater: 35‰. The equation presently used for determining salinity from chlorinity is:

Salinity (S) = $1.80655 \cdot Cl$ or more precisely: $S = (1.805 \cdot Cl) + 0.03$ both in [‰]

- **Brackish Waters**: Salinity levels between 0.5 - 30%.
- **Euhaline**: Salinity levels between 30 - 40%, euhaline organism can tolerate large fluctuations in salinity.
- **Hyperhaline**: Salinity levels >40%.

  Metahalin: Salinity levels between 40 - 70%, as observed in lagoons or closed water bodies.
- **Hypohaline**: Salinity levels <30%.
- **Limbic Waters**: Salinity levels <0.5%.
- **Stenohaline**: (Gk. steno, narrow, small) Tolerating only tiny fluctuations of salinity; e.g.: *Echinodermata*;

Effects of S.: Colligative properties of water like elevated boiling point (irrelevant for organisms), but:

- **Freezing point depression**: The lowering of the freezing point of a solution caused by the pressure of a solute; when the solution begins to freeze, only the solvent solidifies and solute is left behind in the solution, raising the concentration of the solute as well as further lowering the freezing point of the solvent; this effect renders marine ice inhomogeneous and lowers its firmness. Furthermore, "densified" water-bodies, due to their heavier weight rather sink than freeze, which facilitates convection.
- **Osmosis**: (Gk. osmos, impulse or thrust) The diffusion of water, or any other solvent, across a differentially permeable membrane; in the absence of other forces, the movement of water during osmosis will always be from the region of greater potential to one of lesser water potential.

  Homoi-o. Organism: Actively controlled osmotic balance (*Crustacea, Chondrichtyes, Osteichthyes*)

  Poikil-o. Org.: Adaptation to external salt-concentration (*Cnidaria, Polychaeta, Molusca, Echinodermata*).

  O. **Pressure**: The pressure needed to balance the flow of solvent through a semipermeable membrane; i.e. the pressure required to stop osmosis. Saltwater increases the osmotic pressure, resulting in a net sucking force from a water-body with no or lower level of salinity. Since salinity levels are all but constant, a changed osmotic pressure will have a beneficial or detrimental effect upon organisms.
- **Vapor Pressure Lowering**: The presence of a non-volatile solute raises the boiling point of the solvent, because it can block the escape of solvent molecules but has no effect on the rate of return of the solvent particles from the vapor to the solution.

Seawater: 96% of the global water reserves are stored in the oceans; only 4% are distributed as freshwater over landmasses; 2 out of the 4% are bound in polar ice-caps. 96% of global evaporation occurs over oceans. Only 78% are returned directly via precipitation, the remaining 18% over landmasses, which return via river run-offs.

Density: Ratio of the mass of any substance to its volume. In oceanology, density is equivalent to specific gravity and represents the ratio, at atmospheric pressure, of the weight of a given volume of seawater to that of an equal volume of distilled water at 4°C – thus dimensionless.

In general, water bodies with a higher salt concentration tend to sink since its density is slightly higher than less saltier waters; e.g.: estuaries of larger river systems (see circulation).

Gasses dissolved in SW.: Due to the air-water barrier gasses do not readily dissolve in water. Besides from other atmospheric gasses, oxygen and carbon dioxide are the most important gasses found dissolved in sea water. Seawater at 0°C may contain 50% more gasses (e.g. O_2) than seawater at 20°C; freshwater can hold an even larger amount of dissolved gases (less dense than seawater).

- **Carbon dioxide** (CO_2): Heavy, colorless gas; it is the fourth most abundant constituent of dry air; over 99% of terrestrial CO_2 is found in the oceans. Carbon dioxide is the major constituent of carbonate:
  I) $CO_2 + H_2O \leftrightarrow H_2CO_3$ (carbonic acid) $\leftrightarrow H^+ + HCO_3^-$ (bicarbonate) $\leftrightarrow 2H^+ + CO_3^=$
  II) $Ca^{2+} + CO_3^= \leftrightarrow CaCO_3$

Mineral Content: Apart from Na^+, Cl^-, which by far represents the largest ionic elements found in seawater, elements like N (NO_3^-, NO_2^-, NH_3), P ($H_2PO_4^-$, HPO_4^{2-}, PO_4^{3-}), and Si ($Si(OH)_4$, $SiO(OH)^-$, the most essential compound for both pelagic protozoa, and benthic organisms like *porifera* and *cnidarians*) are the so called minimum elements, which determine the overall growth of organic matter.

- **Carbonate** ($CO_3^=$): Planar structure of the carbonate ion in which the C atom forms 3 sigma bonds with the 3 O atoms. In addition, the $2p_z$ orbitals of the C and O atoms overlap to form delocalized molecular orbitals, so that there is also a partial pi bond between the C atom and each of the 3 O atoms.
  Carbonate deposits will not form at depths >4000m; due to the intense water pressure (>400atm) no precipitation reaction will occur any more; according to eq-II, the equilibrium rests on the left hand side of the equation (see chemistry - liquid). Carbonate is far more soluble in warmer waters, such as in the tropics than in cooler waters of the polar regions; this fact accounts for the 300-fold increase of carbonate in the tropics.

Salinity: See there;

Temperature Pattern: The high heat capacity of water constitutes for a quite stable, oceanic climate at landmasses surrounded by the sea (surface water). Average global water temperature equals 3.8°C; around the equator slightly higher, approx. 4.5°C (thermo-radiation from the tropical sun). These equatorial water bodies float on top of cooler water bodies, separated by a thermocline. Due to rotation of the earth, these equatorial water bodies accumulate around the equator in a more or less dense layer (like a sphere) and diminish in strength towards the poles. Warmer and cooler waters do not readily mix (diffusion would require 100s of years). Mixing of alternate water bodies of different temperature are mainly due to density differences (i.e. salinity), which are a main cause for eddies.

- **Thermocline**: Vertical negative temperature gradient in some layer of a body of water that is appreciably greater than the gradients above and below it; also a layer in which such a gradient occurs. The principal thermoclines in the ocean are either seasonal, due to heating of the surface water in summer or permanent (eddies).

Sediment: Particles of organic and inorganic matter that accumulate in a loose unconsolidated form of biogenous, lithogenous or cosmogenous origin; usually beyond the compensation depth (aphotic or mesopelagic zone);

S. of **Biogenous** Origin: Huge number of micro-organic debris that have slowly accumulated on the ocean floor; e.g. *foraminifera* (silica-made), *diatoms* (of cooler waters w/ silica housing), and others;

S. of **Hydrogenous** Origin: Precipitation from seawater or from interstitial water; e.g. Mg-nodules, anhydrite etc.

S. of **Lithogenous** Origin: Detrital products of disintegration of preexisting rocks and of volcanic ejecta. Transport by rivers, glaciers wind; redistribution through waves and currents; e.g. transport of desert sand by wind.

S. **Rock**: Rocks formed by the accumulation of sediment in water or from the air. The sediment may consist of rock fragments, the remains or products of animals or plants, the products of chemical action or evaporation, or mixtures of these material.

Substrate: Also bentos, the bio-geographic region at the bottom of a sea or ocean (the soil-water interface of an ocean, sea, or lake). Base on which organisms live; benthic organisms by far outnumber pelagic organisms.

Lithion: (Gk. stone) Hard rock bed; a community of plants and animals that live on (epi) or in (endo) the rock

Epi-L.: Organisms found on top of the hard substrate; they can either be sessile (permanently attached), hemi-sessile (sessile w/ limited capabilities to migrate), hemi-vagile (predominantly motile) or vagile (motile).

Endo-L.: Organisms that actively drill into the soft bed rock; often a successional lineage can be observed initiated by cyanophyta, followed by drilling *porifera*, *bivalvia*, and bony fish (*Blenniidea*) at the end.

- **Carbonate** S.: Soft calcerous substrate favor both epi- and endobenthic fauna and flora.
- **Silicate** S.: Predominantly granite, onto which only epibenthic organisms can settle.

Psammon: (Gk. resemblance or relationship to sand) A community made up of microscopic plants and animals that live in-between the grains of sand along sea shores and lake-shore areas.

Pelos: (Gk. related to clay, mud or ooze) Community made up of microscopic organisms that live on (epi-) or in (endo-) the muddy substrate.

Thermocline: See seawater;

Tide: Periodic rising and falling of the earth's oceans and atmosphere. It results from the tide-producing forces of the moon and sun acting on the rotating earth. Sometimes the periodic horizontal movements of the water along coastlines are also called tides, but these ate more correctly called tidal currents.

Neap T.: Tide of decreased range (45% below normal), that occurs about every two weeks when the moon is in quadrature (position of the phase cycle when the 2 principal tide-producing bodies (moon and sun) are nearly at a right angle to the earth; the moon is in quadrature in its first quarter and last quarter).

Spring T.: Tide of increased range (150% above normal), which occurs about every 2 weeks when the moon is new or full.

Tidal Current: Alternating horizontal movement of water associated with the rise (flood) and fall (ebb) of the tide caused by astronomical tide-producing forces.

Tidal Force(s): Slight local difference between the gravitational attraction of two astronomical bodies and the centrifugal force that holds them apart. These forces are exactly equal and opposite at the center of gravity of either of the bodies, but since gravitational attraction is inversely proportional to the square of the distance (see physics mechanics - gravity), it varies from point to point on the surface of the bodies. Therefore, gravitational attraction predominates at the surface point nearest to the other body, while centrifugal "repulsion" predominates at the surface point farthest from the body.

Tidal Terminology: Mean water levels recorded over a 19 year period;

- MHHW: Mean Higher High Water line, the upper water line at mixed tides of the MHW;
- MHW: Mean High Water line, the greatest height to which the tide rises on any day;
- MHWS: Mean High Water Spring tides, maximal water level occurring syzygy at MHW;
- MLW: Mean Lower Water Line, the lowest point to which the tide drops on any day (zero tide level);
- MLWS: Mean Low Water Spring tide, maximal depression occurring syzygy at MLW;
- MLLW: Mean Lower Low Water line, the lower water line at mixed tides of the MLW;
- MSL: Mean Sea Level, the average water level (statistical);
- MTL: Mean Tide Level, the water level averaging MHW and MLW;

Tidal Associations:

- **Amphidromic Point**: No-tide or nodal point on a chart of cotidal lines from which the cotidal lines radiate.
- **Amphidromic Region**: Area surrounding an amphidromic point in which the cotidal lines radiate from the no-tide point and progress through all hours of the tide cycle.
- **Cotidal Line**: Line on a chart passing through all points where high water occurs at the same time. The lines show the lapse of time, usually in lunar-hour intervals, between the moon's transit over a reference meridian (usually Greenwich) and the occurrence of high water for any point lying along the line.
- **Seiche**: Standing-wave oscillation of an enclosed (inland lakes)or semi-enclosed (Mediterranean Sea) water body that continues like a pendulum, after the cessation of the originating force, which may have been either seismic, atmospheric, wave-induced or tidal.
- **Syzigy**: Two points in the moon's orbit when the moon is in conjunction or opposition to the sun relative to the earth; time of new or full moon in the cycle of phases.
- **Tsunami**: A seismic sea wave; long-period sea wave produced by submarine earthquake or volcanic eruption. It may travel unnoticed across the ocean for 1000s of km from its point of origin and build up to great heights over shoal water.

Viscosity: Molecular property of a fluid that enables it to support tangential stresses for a finite time and thus resist deformation; water viscosity is important for very small objects.

Reynold's Number: The tendency of a flowing gas or liquid to become turbulent is proportional to its velocity and density and inversely proportional to its viscosity; it indicates the change from laminar to turbulent flow; with an increase of speed, a laminar flow sooner or later will change into turbulent one:

$R_N = \rho \cdot v_{AV} \cdot d/\eta$ [-]

v_{AV}, average velocity [m/s]
η, viscosity index [kg/s]
d, diameter [m]

Wave: (1) Disturbance that moves through or over the surface of a medium with speed dependent on the properties of the medium. (2) Ridge, deformation, or undulation of the surface of a liquid.

Critical W. **Depth**: Depth zones to which suspension-feeder orientates their tentacles or branches to obtain the best filtering effect:

- **1st** C.D.: Zone of shallow water waves, orientation parallel to wave front (1D-swinging wave motion) best for flat, raceme organisms;
- **2nd** C.D.: Depth at which the shallow water waves interfere with longshore current (2D-motion) best for racemous organisms;
- **3rd** C.D.: Depth at which the bottom currents are not uniformly orientated but rather turbulent (again 2D-motion) best for radially-symmetric, ramous organisms;

Fetch: (1) Area of the sea surface over which seas are generated by a wind having a constant direction and speed (also called generating area). (2) Length of the fetch area, measured in the direction of the wind in which the seas are generated.

F. **Dispersion**: Shooting out of wave trains generated by storms, earthquakes or other disturbances due to the variation of velocity with wavelength (velocity is proportional to the wavelength); longer waves travel faster than shorter waves do; this causes the waves with shorter period to fade out sooner, leaving the ones with longer period causing swell.

F. **Swell**: Ocean waves that have traveled out of their generating area. Swell characteristically exhibits a more regular and longer period and has flatter crests than waves within their fetch.

W. **Crest**: Highest point of the wave, in [m]

W. **Height** (h): Vertical distance between a wave crest and the preceding wave through, in [m].

W. **Orbit**: The moving wave form sets the water particles in motion. The diameter of a water particle's *orbit* at the surface is determined by wave height (h).

W. **Period** (T): Time required for 2 successive wave crests or throughs to pass a fixed point, in [1/s].

W. **Trough**: Lowest point of a wave form between successive wave crests, in [m].

W. **Steepness** (ζ): Ratio of wave height to wavelength; once the ratio decreases below 1/7, the wave becomes too steep and breaks (wave becomes unstable, cannot maintain shape, and collapses), equivalent to the angle formed at wave crests approaching 120°:

$\zeta = h/\lambda$ [-]

h, wave height [m]
λ, wavelength [m]

W. **Speed**: The inter-dependence of wavelength and period:

$C = \lambda/T$ [m/s]

T. period [1/s]

Wavelength (λ): Distance between corresponding points of 2 successive periodic waves in the direction of propagation, for which the oscillation has the same phase.

Deep Water W.: Below the surface, the diameter decreases and orbital motion ceases at a depth D equal to 0.5 the wavelength;

Shallow Water W.: When waves enter waters with a depth of less than 1/20 the wavelength. The orbits flatten (wave particles move in elliptical orbits) with depth due to interference from the seafloor. This interference changes both the speed and wavelength and height of the incoming wave:

$C = \sqrt{(g \cdot D)}$
$\lambda = \sqrt{(g \cdot D \cdot T)}$

g, gravity 9.81 [m/s^2]
D, depth [m]

Because the horizontal dimension of the orbit remains unchanged, but wavelength shortens along with increased height, the wave finally break when becoming too steep (when wave crest/D ≥ 3/4).

- **Plungers** (dumpers): Break over a short distance, pounding the beach with a great roar and splash of flying water and foam.
- **Spillers**: Roll in evenly and slowly (a surfers dream).