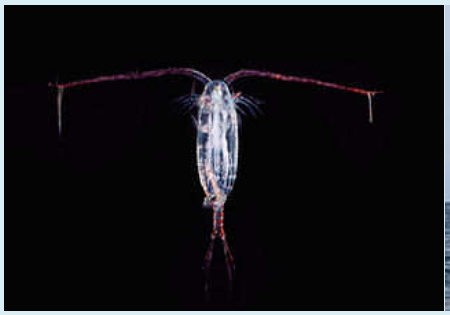
MARINE SCIENCE OF AUSTRALIA

MARINE BIOLOGY BASICS

THE BASIC PRINCIPLES OF MARINE BIOLOGY



MARINE SCIENCE OF AUSTRALIA

MARINE BIOLOGY BASICS

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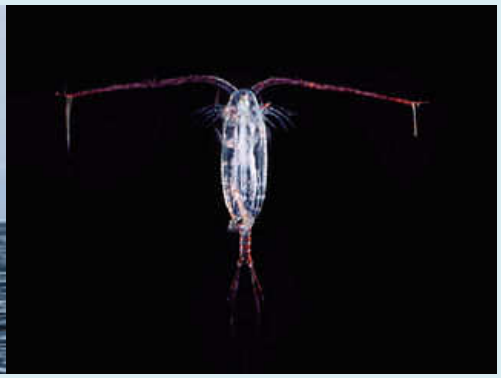
MARINE BIOLOGY BASICS

Marine biology is the scientific study of animal and plant life in the ocean or other marine or brackish bodies of water.

Marine biology covers a large array of organisms, from the microscopic, including most Zooplankton and Phytoplankton to the huge cetaceans (whales) which reach up to 30 metres in length.



HOW DOES MARINE BIOLOGY CLASSIFY LIFE?

In Biology many groups or phyla, families and genera have some species that live in the sea and others that live on land. Marine Biology differs from the traditional classification of Biology and classifies species based on the environment that they live in, rather than on the basis of shared characteristics or taxonomy.

Marine Biology also differs from Marine Ecology as marine ecology is focused on how organisms interact with each other and the environment, while Marine Biology is the study of the organisms themselves.

MARINE BIOLOGY BASICS

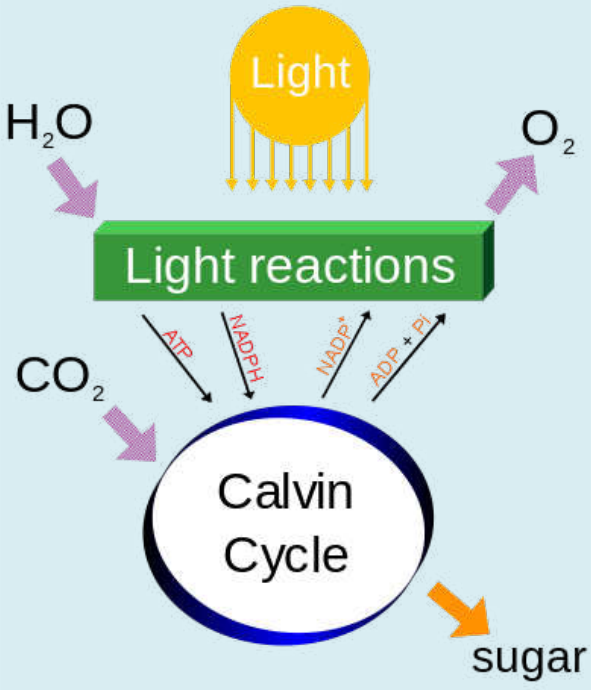
PRIMARY PRODUCTION: PHOTOSYNTHESIS

Photosynthesis is a process used by plants and other autotrophic organisms to convert light energy from the sun, into chemical energy that can be used to fuel the organism's activities. A pigment contained in the plant cells, chlorophyll, captures the light energy and transfers it to a chemical called adenosine tri-phosphate (ATP).

Carbohydrates, such as sugars, are synthesized from carbon dioxide and water during the process. Oxygen is also released, mostly as a waste product.

Most plants, most algae, and cyanobacteria perform the process of photosynthesis, and are called photoautotrophs.

Photosynthesis maintains atmospheric oxygen levels and supplies most of the energy necessary for all life on earth, except for chemotrophs, which gain energy through oxidative chemical reactions.



Plants and algae absorb light primarily using the pigment chlorophyll. The green part of the light spectrum is not absorbed but is reflected which is the reason that most plants and many algae have a green color.

MARINE BIOLOGY BASICS

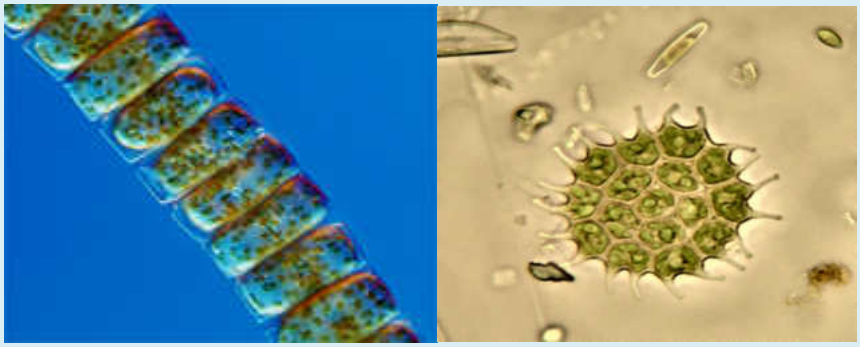
PRIMARY PRODUCTION: PHOTOSYNTHESIS

Photosynthesis occurs in two stages:
Stage (1) **light-dependent** reactions or light reactions capture the energy of light and use it to make the energy-storage molecules ATP and NADPH.
One molecule of the pigment chlorophyll absorbs one photon and loses one electron. This electron is passed to a modified form of chlorophyll called pheophytin, which passes the electron to a quinone molecule, starting the flow of electrons down an electron transport chain that leads to the ultimate reduction of NADP to NADPH.

Stage (2) during the second stage, the **light-independent** reactions use these products to capture and reduce carbon dioxide. In the light-independent (or dark) reactions, the enzyme RuBisCO captures CO_2 from the atmosphere and, in a process called the Calvin-Benson cycle, it uses the newly formed NADPH and releases three-carbon sugars, which are later combined to form sucrose and starch.

PRIMARY PRODUCTION: THE PHYTOPLANKTON

Phytoplankton are mostly microscopic free living algae that live near the water surface where there is sufficient light to support photosynthesis.

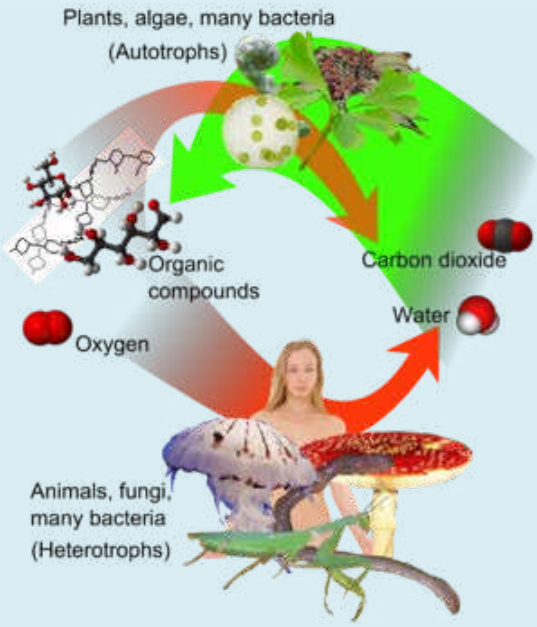


Phytoplankton are autotrophs or organisms that produce complex organic compounds (such as carbohydrates, fats, and proteins) from simple substances present in their surroundings. They generally use energy from; light through photosynthesis or from; inorganic chemical reactions through chemosynthesis. As autotrophs they do not need a living source of energy or organic carbon to feed on.

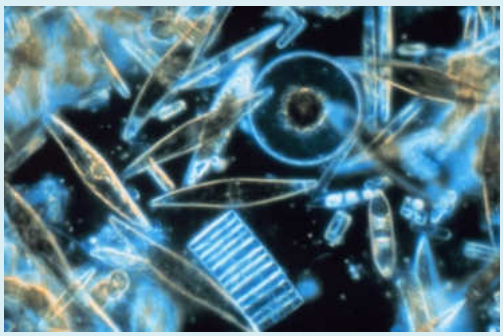
MARINE BIOLOGY BASICS

Primary Production: The Phytoplankton

Through photosynthesis the phytoplankton transform inorganic carbon in the atmosphere and in seawater into organic compounds, making them an essential part of Earth's carbon cycle. They generate about half the atmosphere's oxygen, as much per year as all land plants. Most phytoplankton are also phototrophs, a form of autotroph that convert electromagnetic energy from sunlight into chemical energy in the form of reduced carbon.



Phytoplankton form the basis of virtually every ocean food web, they make most other ocean life possible. They take energy from the environment in the form of sunlight or inorganic chemicals and use it to create energy-rich molecules such as carbohydrates. This mechanism is called primary production.



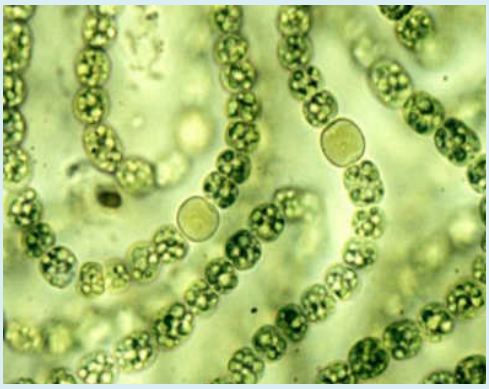
MARINE BIOLOGY BASICS

PRIMARY PRODUCTION: CYANOBACTERIA THE PRIMARY PRODUCERS OF THE OPEN OCEAN

Although the Cyanobacteria are informally referred to as blue-green algae, this usage is incorrect since they are regarded as bacteria. Cyanobacteria are a taxon of bacteria that conduct photosynthesis.

Cyanobacteria can be found in almost every terrestrial and aquatic habitat: oceans, fresh water, damp soil, temporarily moistened rocks in deserts, bare rock and soil, and even Antarctic rocks. They can occur as planktonic cells or form phototrophic biofilms.

Aquatic cyanobacteria are known for their extensive and highly visible blooms that can form in both freshwater and marine environments. The blooms can have the appearance of blue-green paint or scum. These blooms can be toxic, and frequently lead to the closure of recreational waters when spotted.



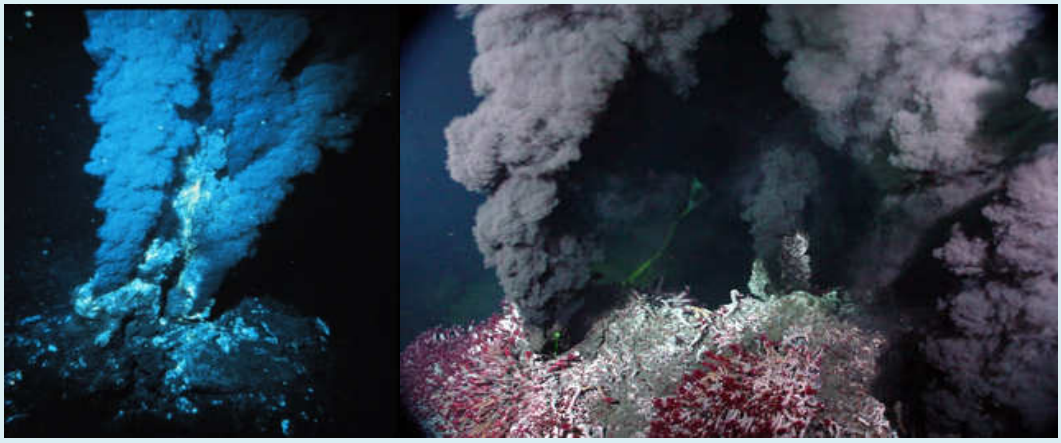
By producing gaseous oxygen as a by-product of photosynthesis, cyanobacteria are thought to have converted the early reducing atmosphere into an oxidizing one. This caused the "rusting of the Earth" and dramatically changed the composition of life forms on Earth by stimulating biodiversity and leading to the near-extinction of oxygen-intolerant organisms.

Chloroplasts, the organelles responsible for photosynthesis in green plants and algae, are considered to be cyanobacteria that have developed a symbiosis with green plants.

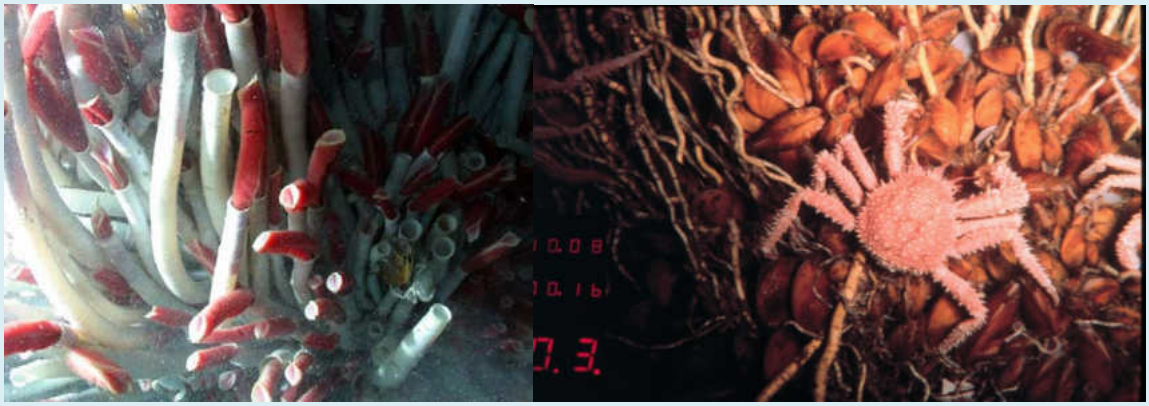
MARINE BIOLOGY BASICS

PRIMARY PRODUCTION: CHEMOSYNTHESIS AT HYDROTHERMAL VENTS

In the late 1970's, scientists on a routine study of the ocean floor in the Pacific made a discovery that would rock the entire scientific community. On the East Pacific Rise not far from the Galapagos Islands, nearly 2400 metres below the surface, was a strange alien landscape littered with what looked like chimneys expelling clouds of black smoke. Surrounding these chimneys was a unique type of ecosystem that had never been seen before.



Until this day, science had always assumed that all life on Earth obtained its energy from the Sun. The plants convert sunlight into energy through a process called photosynthesis. The plants, in turn, provide food for countless species of animals in a complex web of life. But here, facing the deep-sea submersible submarine, was a sight that challenged those assumptions. Here was proof for the first time that life could be sustained by the Earth itself.

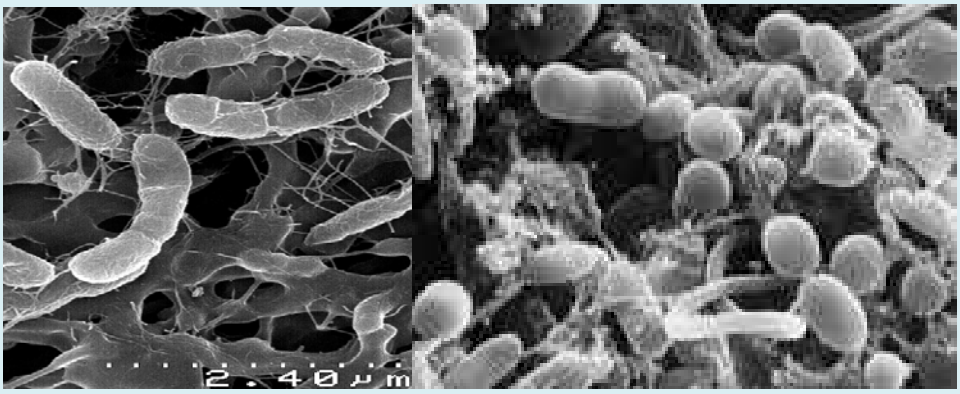


MARINE BIOLOGY BASICS

Primary Production: Chemosynthesis at Hydrothermal Vents

Most life on Earth is dependent upon photosynthesis. At hydrothermal vents in the deep ocean a unique ecosystem has evolved in the absence of sunlight and its source of energy is completely different. Chemosynthesis is the process by which certain microbes create energy by mediating chemical reactions.

So the animals that live around hydrothermal vents make their living from the chemicals coming out of the seafloor in the vent fluids, as they are a local food source, hydrothermal vents typically have high biomass. This is in stark contrast to the very sparse distribution of animals outside of vent areas in the deep oceans where animals are dependent on food dropping down from above.



Chemosynthetic microbes provide the foundation for biological colonization of vents. Chemosynthetic microbes live on or below the seafloor, and even within the bodies of other vent animals as symbionts. Where microbial mat covers the seafloor around vents, grazers such as snails, limpets, and scale worms eat the mat, and predators come to eat the grazers. Tubeworms flourish in small clumps, waving in the warm fluids.

A typical picture of an active hydrothermal vent is therefore one with shimmering warm hydrothermal fluids, tubeworms and many other vent species, all densely clustered around the vent, with white microbial mat material covering the surrounding area.

MARINE BIOLOGY BASICS

THE PLANKTON

Plankton are a diverse group of organisms that live in the water column of large water bodies, they are unable to swim against a current.

The term, plankton, doesn't define the organism but how the organism lives.

Plankton provide a crucial source of food to many larger organisms, such as fish and whales.

Plankton include drifting or floating bacteria, archaea, algae, protozoa and animals that inhabit the pelagic zone of oceans and seas. Essentially, plankton are defined by their ecological niche rather than any phylogenetic or taxonomic classification. Though many planktonic species are microscopic in size, plankton includes organisms covering a wide range of sizes, including large organisms such as jellyfish.

Plankton are primarily divided into three broad functional (or trophic level) groups:

1) ***Phytoplankton*** are autotrophic, prokaryotic or eukaryotic algae that live near the water surface where there is sufficient light to support photosynthesis. Among the more important groups are the diatoms, cyanobacteria, dinoflagellates and coccolithophores.

MARINE BIOLOGY BASICS

THE PLANKTON

2) ***Zooplankton*** are small protozoans or metazoans (e.g. crustaceans and other animals) that feed on other plankton and organisms such as some of the eggs and larvae of larger animals, such as fish, crustaceans, and annelids.

Copepods are microscopic zooplankton

3) ***Bacterioplankton*** are bacteria and archaea, which play an important role in re-mineralising organic material down the water column (note that the prokaryotic phytoplankton are also bacterioplankton).

MARINE BIOLOGY BASICS

MARINE HABITATS: WHAT IS A HABITAT?

A habitat is an ecological or environmental area that is inhabited by a particular species of animal, plant, or other type of organism. A place where a living thing lives is its habitat. It is a place where it can find food, shelter, protection and mates for reproduction. It is the natural environment in which an organism lives, or the physical environment that surrounds a species population.

The habitats studied in Marine Biology include everything from the tiny layers of surface water in which organisms may be trapped in surface tension between the ocean and atmosphere, to the depths of the oceanic trenches, sometimes 10,000 metres or more beneath the surface of the ocean.

THREE MARINE HABITAT TYPES

Marine habitats can be divided into three general categories, these are :

The Benthic zone

The Benthic zone is the ecological region at the lowest level of a body of water such as an ocean, sea or a lake, including the sediment surface and some sub-surface layers.

The Demersal zone

The Demersal zone is the part of the sea or ocean comprising the water column that is near to (and is significantly affected by) the seabed and the benthos. The demersal zone is just above the benthic zone. It can be significantly affected by the seabed and the life that lives there.

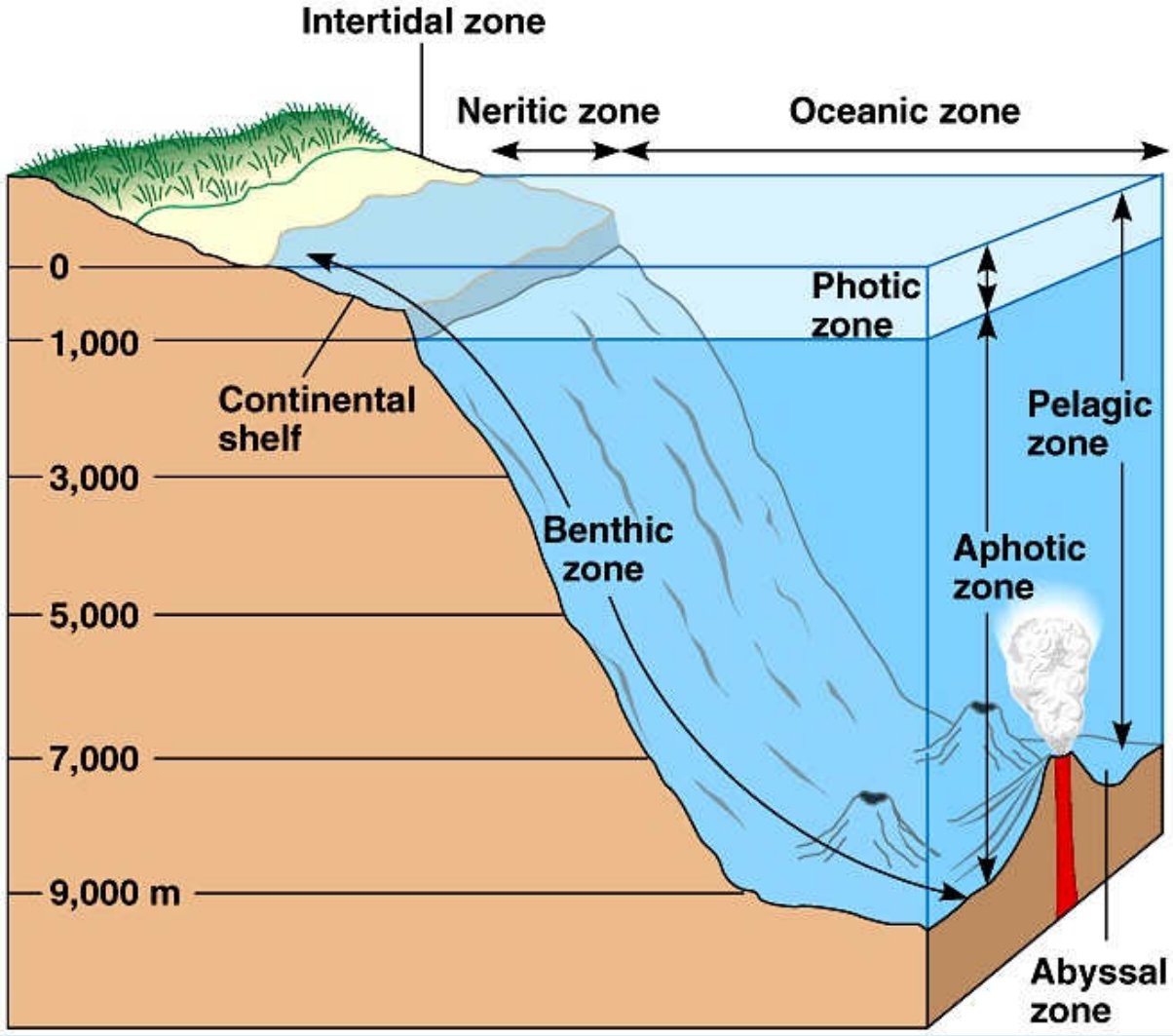
The Pelagic zone

The Pelagic zone is the part of the open sea or ocean that is not near the coast or sea floor. The pelagic zone can be thought of in terms of an imaginary cylinder or water column from the surface of the sea almost to the bottom.

MARINE BIOLOGY BASICS

MARINE HABITATS: THE BENTHIC ZONE

The Benthic zone is the ecological region at the lowest level of a body of water such as an ocean, sea or a lake, including the sediment surface and some sub-surface layers.
The benthic zone begins at the edge of the sea at the intertidal zone. From the intertidal zone it extends out along the continental shelf, and continues down the continental slope to the abyssal plain.



The Benthic zone extends thousands of metres below sea level and includes the entire seabed including down into the deep ocean trenches.

MARINE BIOLOGY BASICS

Marine Habitats: The Benthic zone

LIFE VARIES WITH DEPTH

The habitats of the benthic zone vary widely depending on how far below the water surface the bottom is.

Just beyond the intertidal zone, the shallow water receives ample sunlight and oxygen.

Continuing down along the continental slope, the environment becomes increasingly dark and cold, and the pressure increases. A remarkable variety of organisms live in these different habitats, each with specialized adaptations reflecting the conditions of their environment.

The environmental conditions within a habitat have a direct influence on the biology of resident organisms.

THE PHOTIC ZONE

Photic zone is the surface layer of the ocean that receives sunlight. The uppermost 80 m or more of the ocean, which is sufficiently illuminated to permit photosynthesis by phytoplankton and plants, is called the euphotic zone.

The thicknesses of the photic and euphotic zones vary with the intensity of sunlight as a function of season and latitude and with the degree of water turbidity. The bottommost, or aphotic, zone is the region of perpetual darkness that lies beneath the photic zone and includes most of the ocean waters.

Since the photic zone is where almost all of the photosynthesis occurs, the depth of the photic zone is generally proportional to the level of primary production that occurs in that area of the ocean. About 90% of all marine life lives in the photic zone.

MARINE BIOLOGY BASICS

Marine Habitats: The Benthic zone

The Benthos, life in and on the sea floor

Benthos are organisms that live in the Benthic Zone,

The Benthos can be divided into two categories:

(1) The **Epifauna** live on the surface of the ocean floor
Examples include:

Sea Stars

Corals

Sea Urchins

(2) The **Infauna** live within the ocean floor, they do this by building burrows and tubes into the sediment.
Examples include:

Bivalves

Gastropods

Tube Worms

MARINE BIOLOGY BASICS

Marine Habitats: The Benthic zone

THE BENTHOS, LIFE IN AND ON THE SEA FLOOR

FILTER FEEDERS

Filter feeders are animals that feed by straining suspended matter and food particles from sea water, typically by passing the water over a specialized filtering structure.
Filter feeders have adaptations such as specialised mouthparts, brush-like combs, or secrete a slime from their gills to capture planktonic food.
Filter feeders can play an important role in clarifying water, and are therefore considered ecosystem engineers.

Benthic organisms that are filter feeders include:

BIVALVES

Bivalves (a class of the phylum Mollusca) such as clams, oysters and mussels and some other molluscs that use their gills to filter food out of sea water as well as to collect oxygen and release carbon dioxide. They feed by drawing in sea water and sifting the plankton and nutritive particles out using a mucous coating on their enlarged gills.

Common Bivalves:

The bivalves are a highly successful class of invertebrates found in marine habitats throughout the world. Most are infaunal and live buried in sediment on the seabed. Bivalves have laterally compressed bodies enclosed by a shell in two hinged parts.
Bivalves have been an important source of food for humans at least since Roman times. Oysters, scallops, clams, mussels and cockles are the most commonly consumed kinds of bivalve.

MARINE BIOLOGY BASICS

Marine Habitats: The Benthic zone

The Benthos, life in and on the sea floor

FILTER FEEDERS: ASCIDIANS

Ascidians are commonly called sea squirts they are a sac-like marine invertebrate.

Ascidians feed by taking in water through an oral siphon. The water enters the mouth and pharynx where plankton are filtered from the water. Water then flows through mucus-covered gill slits into a water chamber called the atrium, then exits through the (atrial) siphon.

Common Ascidians (Sea Squirts):

Ascidians are members of the class Ascidiacea in the Tunicata subphylum of the phylum Chordata (or Chordates). The ascidian central nervous system is formed from a plate that rolls up to form a neural tube (a simple nervous system). The number of cells within the central nervous system is very small.

FILTER FEEDERS: SPONGES

Sponges belong to the phylum Porifera the most simple animal phylum, they stand out because of their bright color. The word Porifera means pore-bearing, this means that the sponges have pores, which can be used to absorb water.

Sponges have a unique cell type, called the collar cell, they don't have internal organs because the tissues are loosely organized. They have microscopic crystals or fibers that make up the internal skeleton.

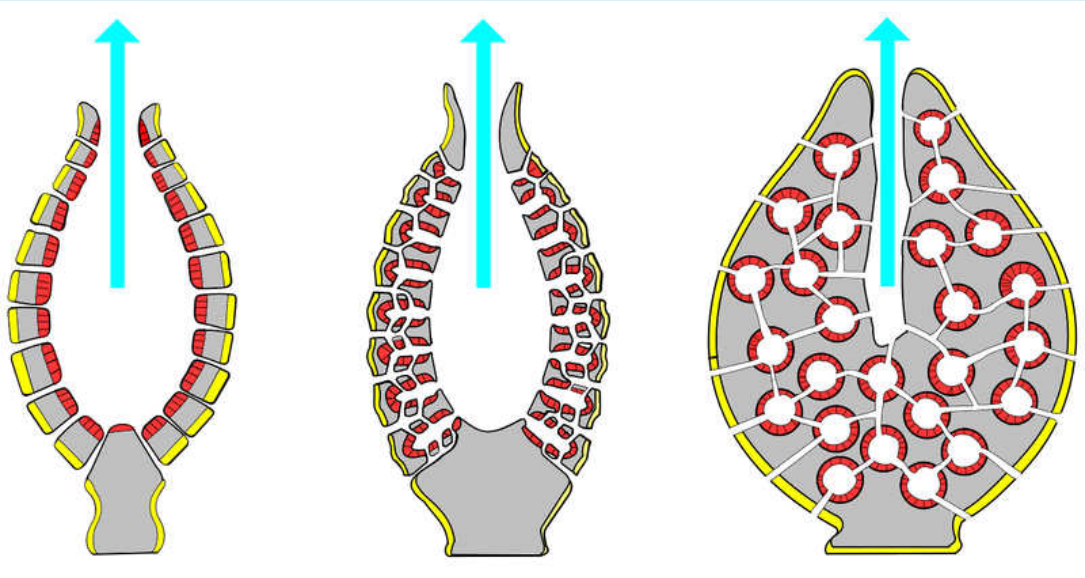
MARINE BIOLOGY BASICS

Marine Habitats: The Benthic zone

The Benthos, life in and on the sea floor

FILTER FEEDERS: SPONGES

Sponge Cell type and structure



Cell types: Yellow: pinacocytes, Red choanocytes, Grey: mesohyl, Pale blue: water flow
Structure types: Left: asconoid, Middle: syconoid, Right: leuconoid

Sponges have no true circulatory system; instead, they create a water current which is used for circulation. Dissolved gases are brought to cells and enter the cells via simple diffusion. Metabolic wastes are also transferred to the water through diffusion. Sponges pump remarkable amounts of water. Leuconia, for example, is a small sponge about 10 cm tall and 1 cm in diameter, water enters through more than 80,000 incurrent canals at a speed of 6 cm per minute.

Common Sponges:

MARINE BIOLOGY BASICS

Marine Habitats: The Benthic zone

The Benthos, life in and on the sea floor

DEPOSIT FEEDERS

For marine animals there is another source of food that is available to them that is not available to land animals. This is the thin layer of ooze called detritus which consists of bacteria and the remains of finely chopped up algae and decaying fragments of animals, as well as countless numbers of stranded microscopic, one-celled green plants which are called diatoms. Animals which eat detritus are called detritivores.

Detritus is a very rich food source and there are many types of marine and intertidal animal groups which are fully adapted to feeding upon it. These animals have special adaptations for dealing with detritus.

Deposit feeders pass sand, mud, water or sediment into their mouths using mucous-covered tentacles or arms, or by a mucous net. Organic material is then removed from the deposit and digested. The rest of the deposit simply passes through the gut of the organism.

Examples of deposit feeders are flounders, eels, haddock, bass, crabs, shellfish, snails and sea cucumbers.

MARINE BIOLOGY BASICS

Marine Habitats: The Benthic zone

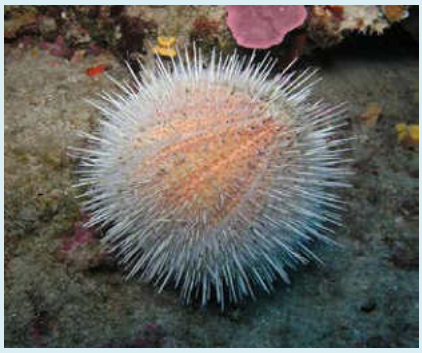
The Benthos, life in and on the sea floor

COMMON DEPOSIT FEEDERS:

Sea Cucumbers

Most sea cucumbers feed on detritus (dead plant and animal material) in the sand. The sand is taken in through the mouth, the detritus digested and the clean sand expelled through the anus. Others, like the beach-ball sea cucumber, use feather-like arms to filter food from the surrounding seawater.

Sea Urchins



Sea urchins or urchins, sometimes called sea hedgehogs, are small, spiny, globular animals which, with their close kin, such as sand dollars, constitute the class Echinoidea of the echinoderm phylum. Sea urchins are sensitive to touch, light, and chemicals. Although they do not have eyes or eye spots, recent research suggests their entire body might function as one compound eye.

Gastropods

The word Gastropod is derived from Ancient Greek words gastér "stomach", and pod "foot" hence stomach-foot. This is a misnomer, based on the fact that to humans it appears as if snails and slugs crawl on their bellies. In reality, snails and slugs have their stomach and digestive system in a hump on the opposite side of the body. In most gastropods this visceral hump is contained within the shell.

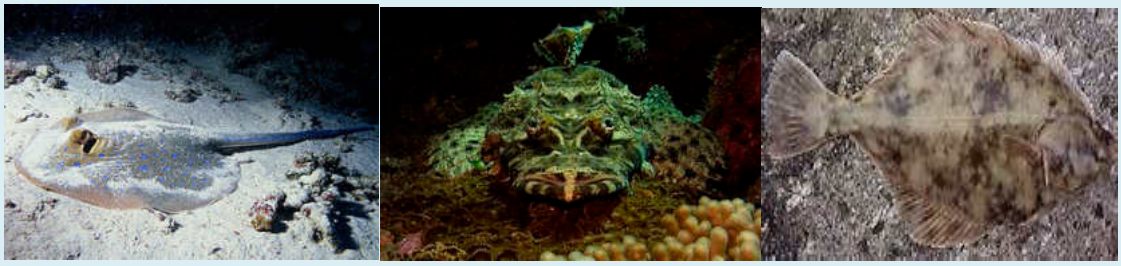
MARINE BIOLOGY BASICS

MARINE HABITATS: THE DEMERSAL ZONE

The demersal zone is the part of the sea or ocean comprising the water column that is near to (and is significantly affected by) the seabed and the benthos. The demersal zone is just above the benthic zone. It can be significantly affected by the seabed and the life that lives there.

Demersal Fish

Fish that live in the demersal zone are called demersal fish. Demersal fish can be divided into benthic fish, which are denser than water so they can rest on the bottom, and benthopelagic fish, which swim in the water column just above the bottom. Demersal fish are found by the seafloor in coastal areas on the continental shelf, and in the open ocean they are found on the continental slope and the continental rise.



Demersal fish are also known as bottom feeders and groundfish. Fish species that habituate the demersal zone are usually flat fish whose body shape has adapted to feeding on the ocean floor.

Primary demersal species of fish include halibut, plaice and turbot. Cod and haddock, although not flat fish, are usually found in the demersal zone as well. Crustaceans targeted by fisheries include lobsters, crabs, urchins and scallops.

MARINE BIOLOGY BASICS

MARINE HABITATS: THE PELAGIC ZONE

Any water in a sea or lake that is neither close to the bottom nor near the shore is said to be in the pelagic zone.

Any water in a sea or lake that is neither close to the bottom nor near the shore is said to be in the pelagic zone.

Pelagic fish live in the water column of coastal, ocean and lake waters, but not on the bottom. They can be contrasted with demersal fish, which do live on or near the bottom, and reef fish which are associated with coral reefs.

Marine pelagic fish can be divided into coastal (inshore) fish and oceanic (offshore) fish. Coastal fish inhabit the relatively shallow and sunlit waters above the continental shelf, while oceanic fish (which may well also swim inshore) inhabit the vast and deep waters beyond the continental shelf.

MARINE BIOLOGY BASICS

GLOSSARY

Abyssal: Of or relating to the region of the ocean bottom between the bathyal and hadal zones, from depths of approximately 2,000 to 6,000 meters

ATP: Adenosine triphosphate (ATP) is a nucleoside triphosphate used in cells as a coenzyme often called the "molecular unit of currency" of intracellular energy transfer

Autotrophic: An organism capable of synthesizing its own food from inorganic substances, using light or chemical energy. Green plants, algae, and certain bacteria are autotrophs

Algae: is an informal term for a large, diverse group of photosynthetic organisms which are not necessarily closely related

Aquatic: means relating to water, living in or near water or taking place in water

Annelid: a segmented worm of the phylum Annelida, such as an earthworm or leech

Benthic: of or relating to or happening on the bottom under a body of water

Benthos: the flora and fauna found on the bottom, or in the bottom sediments, of a sea or lake

Biodiversity: the variety of all living things; the different plants, animals and microorganisms, the genetic information they contain and the ecosystems they form

Biofilm: any group of microorganisms in which cells stick to each other and often these cells adhere to a surface

Bivalve: a class of marine and freshwater molluscs that have laterally compressed bodies enclosed by a shell consisting of two hinged parts

Brackish: slightly salty, as is the mixture of river water and seawater in estuaries

Carbohydrate: any of a large group of organic compounds occurring in foods and living tissues and including sugars, starch, and cellulose. They contain hydrogen and oxygen in the same ratio as water (2:1) and typically can be broken down to release energy in the animal body

Cetacean: order of wholly aquatic placental mammals including the whales and dolphins

Chemosynthesis: the biological conversion of one or more carbon molecules (usually carbon dioxide or methane) and nutrients into organic matter using the oxidation of inorganic (e.g. hydrogen gas, hydrogen sulfide) or methane as a source of energy, rather than sunlight, as in photosynthesis

Chemotroph: organisms that obtain energy by the oxidation of electron donors in their environments. These molecules can be organic (chemoorganotrophs) or inorganic

(chemolithotrophs). The chemotroph designation is in contrast to phototrophs, which utilize solar energy

Coccolithophore: is a unicellular, eukaryotic phytoplankton (alga)

Crustacean: a very large group of arthropods, usually treated as a subphylum, which includes such familiar animals as crabs, lobsters, crayfish, shrimp, krill and barnacles

Cyanobacteria: a taxon of bacteria that conduct photosynthesis

Demersal: the part of the sea or ocean (or deep lake) comprising the water column that is near to (and is significantly affected by) the seabed

Diatom: a major group of algae, and are among the most common types of phytoplankton

Dinoflagellate: a large group of flagellate protists that constitute the phylum Dinoflagellata

Ecology: the scientific analysis and study of interactions among organisms and their environment.

Environment: the surroundings or conditions in which a person, animal, or plant lives or operates

Epifauna: benthic animals that live on the surface of a substrate, such as rocks, pilings, marine vegetation, or the sea or lake floor itself

Eukaryotic: cells that have membrane-bound organelles, especially the nucleus, which contains the genetic material, and is enclosed by the nuclear envelope

Gastropod: a large taxonomic class within the phylum Mollusca, includes snails and slugs of all kinds and all sizes from microscopic to large

Gill: a respiratory organ found in many aquatic organisms that extracts dissolved oxygen from water and excretes carbon dioxide

Habitat: an ecological or environmental area that is inhabited by a particular species of animal, plant, or other type of organism

Hydrothermal: of or relating to hot water, used especially in the formation of minerals by hot solutions rising from a cooling magma

Infauna: aquatic animals, such as clams or burrowing worms, that live beneath the surface of a sea or lake floor

Inorganic: a compound that is not organic. Compounds that do not contain carbon, and do not consist of or derived from living matter

Intertidal: the area that is above water at low tide and under water at high tide

Invertebrate: an animal lacking a backbone, such as an arthropod, mollusc or annelid

Microscopic: so small as to be visible only with a microscope.

Metazoan: any of a group (Metazoa) that comprises all animals having the body composed of cells differentiated into tissues and organs and usually a digestive cavity lined with specialized cells

Ocean: a very large expanse of sea, in particular, each of the main areas into which the sea is divided geographically

Organic: relating to or derived from living matter

Organism: any living thing

Pelagic: of, relating to, or living in open oceans or seas rather than waters adjacent to land or inland waters

Pharynx: is an organ found in vertebrates and invertebrates, though the structure is not universally the same across the species. In humans: cone-shaped passageway leading from the oral and nasal cavities in the head to the esophagus and larynx

Photoautotroph: are capable of synthesizing their own food from inorganic substances using light as an energy source. Green plants and photosynthetic bacteria are photoautotrophs

Phototroph: organisms that carry out photon capture to acquire energy. They use the energy from light to carry out various cellular metabolic processes. It is a common misconception that phototrophs are obligatorily photosynthetic

Photosynthesis: a process used by plants in which energy from sunlight is used to convert carbon dioxide and water into molecules needed for growth

Phyla: of a phylum

Phylum: a primary grouping consisting of animals with a similar body plan, and thought to be evolutionarily related

Phytoplankton: all photosynthetic plankton, including unicellular algae and cyanobacteria.

Plankton: a diverse group of organisms that live in the water column of large bodies of water and that cannot swim against a current. Plankton includes organisms covering a wide range of sizes, including large organisms such as jellyfish

Prokaryotic: a prokaryote is a single-celled organism that lacks a membrane bound nucleus (karyon), mitochondria, or any other membrane-bound organelle.

Protozoan: the Protozoa are a diverse group of unicellular eukaryotic organisms defined as single-celled organisms with animal-like behaviors, such as motility and predation

NADPH: Nicotinamide adenine dinucleotide phosphate, abbreviated NADP+ is a cofactor used in anabolic reactions, such as lipid and nucleic acid synthesis, which require NADPH as a reducing agent. NADPH is used as reducing power for the biosynthetic reactions in the Calvin cycle to assimilate carbon dioxide

Symbiont: an organism living in symbiosis with another

Symbiosis: the close association between two or more organisms of different species, often but not necessarily benefiting each member

Taxonomy: the branch of science concerned with classification, especially of organisms

Terrestrial: on or relating to the earth

Trophic: the trophic level of an organism is the position it occupies in a food chain

Zooplankton: animal plankton