M

MAC →maximum allowable concentration.

macrobenthos bottom-living organisms larger than 1 mm, →benthos.

macronutrients those nutrients that constitute the main part of nutrition, such as organic molecules, phosphate (→phosphorous cycle), nitrate and ammonia.

macrophytes the larger, macroscopic, multicellular algae as opposed to single-celled, microscopic microphytes.

macroplankton large-sized (between 2 and 20 mm) planktonic organisms, →plankton.

Madreporaria (syn. **Scleractinia**) true or stony corals, order of the class Anthozoa (phylum Cnidaria). These corals are solitary or colonial, and have a heavy, external calcareous skeleton. They have relatively small polyps. Reef-forming colonies, coral reefs, are restricted to clear water in shallow tropical seas, but solitary corals can even be found in the deep sea.

madreporite →Echinodermata.

magma a hot silicate melt within the earth containing suspended crystals and dissolved gases. Rocks originating from the crystallization and solidification of magma are said to be magmatic. →lava.

magnetic (earth) field the earth's magnetic field is thought to derive from flow patterns in the liquid outer core (→earth's internal structure). Its mean field intensity at the surface is ca. 0.5 Gauss (equivalent to 50 10^{-6} Tesla). At any point on the earth, the total field intensity can be resolved in the intensity of the horizontal component and the intensity of the vertical component. The direction is described by the deviation from the north (declination) and the angle with the horizontal (inclination). The earth's magnetic field resembles for 90 % a dipole field with its axis declined 11° from the axis of rotation. The small additional nondipole field is responsible for irregularities of the field in distribution and time (secular variation). →magnetic anomaly and →magnetic polarity.

magnetic anomaly any departure from the theoretical magnetic (earth) field. The earth's magnetic field can be locally affected by induced or remanent mag-

H.(J.)G. Baretta-Becker et al. (eds.), *Encyclopedia of Marine Sciences*

netism of geological features, which then reveal themselves by magnetic anomalies.

magnetic polarity the converging of the magnetic lines of force in a dipole, with a magnetic north and a magnetic south pole. According to the convention that the northwards pointing end of a compass-needle is a magnetic north pole, the earth's dipole has its (attracting) magnetic south pole near the geographical north pole and its magnetic north pole near the geographical south. However, this polarity is not permanent. Studies of the remanent magnetism induced by the magnetic (earth) field in ferromagnetic rocks at the time of their formation reveal that **magnetic polarity reversals** have occurred many times in the geologic past. Based upon these reversals, a polarity time scale has been established.

magnetic polarity reversal →magnetic polarity.

magnetic tags →tagging.

magnetometer an instrument used for measuring earth magnetic field intensity. Magnetometers may measure the vertical component of the magnetic field, or the horizontal component sometimes the total field is measured. →magnetic (earth) field.

magnetostratigraphy stratigraphy based on paleomagnetic signatures. During sediment deposition or cooling of molten rock, ferromagnetic minerals orientate themselves according to the existing magnetic field. The last 4.5 million years include four magnetic epochs (chrons) from old to young: the **Gilbert** reversed, the **Gauss** normal, the **Matuyama** reversed, and the (present-day) **Brunhes** normal **epoch.** →stratigraphic hierarchy, magnetic polarity and magnetic (earth) field.

magnetotaxis orientation of organisms possessing magnetic crystals (some bacteria, dolphins, some birds) in the magnetic (earth) field.

Malacostraca class of the subphylum Crustacea (phylum Arthropoda), containing most of the Crustacea including woodlice, sandhoppers, crabs, shrimps, and lobsters. For general description of body structure →Crustacea. The body of the Malacostraca has basically 19 segments of which five compose the head, eight segments form the thorax (sometimes covered by the carapace), and the remaining six form the abdomen with telson. The segments each bear one pair of appendages. On the head are two pairs of antennae and a pair of stalked eyes. In the more primitive forms, all thoracic appendages are similar and used as walking legs; in others the first one, two or three pairs are changed into maxillipeds. The abdominal appendages are smaller, and adapt-

ed for swimming, burying, effectuating water currents for ventilation, or carrying eggs (in females). The Malacostraca include along the primitive Leptostraca, the superorders Syncarida (with no marine representatives), Hoplocarida, Peracarida and Eucarida.

mammals, marine different groups of originally terrestrial mammals that have returned to the sea over the last 80 million years, probably attracted by abundant food, or to escape from predators or climatic changes. They include **Cetacea** (**whales** and **dolphins**), pinnipeds (**seals**, sea-lions and walruses), sirenians (manatees, dugongs and Steller sea-cows) and mustelids (a few otters, and the extinct sea-mink) and sometimes the polar bear is included. Respiratory, circulatory, locomotory, thermo-regulating, and communicative systems are all significantly different from the typical terrestrial mammalian pattern. Man has used marine mammals as a source of food, fuel, and clothing for at least 5000 years; with extending size and range of hunting vessels man began to affect populations, some species being hunted to extinction: the Steller sea-cow was discovered in the Bering Sea in 1741 and eradicated about 30 years later, the bowhead and right whales were almost eradicated in the 18th and 19th centuries, the blue whale and humpback in this century.

manganese nodules (syn. **ferromanganese nodules**) spherical or semi-spherical or irregular concretions, largely consisting of oxides of iron (Fe) and manganese (Mn), but containing in addition metals like titanium, chromium, copper, nickel, cobalt, and zinc, often found on the surface of deep-sea marine sediments. Most likely of diagenetic origin. First reported during the Challenger Deep-Sea Expedition. These nodules form very slowly, over millions of years. →mineral resources.

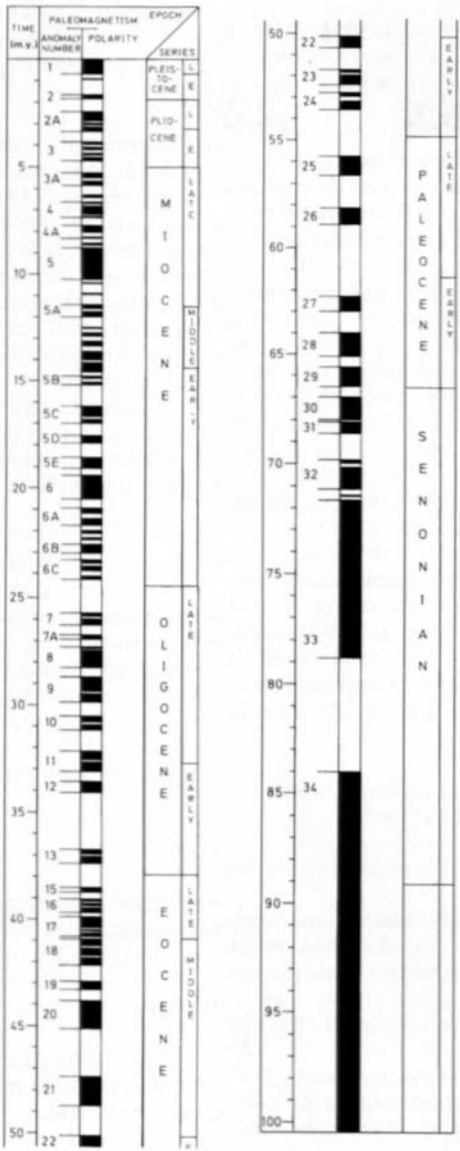
mangrove swamps (or mangal, also mangroves) salt marshes in the tropics covered by shrubs and trees. →salt marsh.

mantle (1) (biol.) →Mollusca; (2) (geol.) →earth's internal structure.

marginal basin (syn. **back-arc basin**) basin of intermediate (ca. 2000 m) to normal oceanic (ca. 4500 m) depth, behind island arc systems and separating the trenches and island arcs from continents or other (usually inactive) island arcs.

marginal seas more or less enclosed seas along the continents.

Mariana Trench the deepest point in the ocean (12–15° N; 143–147° E). At this depth an accurate measurement meets difficulties. The best available estimate is about 11 030 m depth. →bathyscaphe, →trench, →sea-floor topography.



Magnetostratigraphy. (After Lawrie and Alvarez 1981)

mariculture →aquaculture.

marine provinces →biogeography.

marine snow the flocs of suspended particles in the ocean, →flocculation.

marine terrace →terrace, marine.

marsh →salt marsh.

mass extinction →mass mortality.

mass mortality catastrophic dying of one or several species of organisms (usually not all species are affected) in a limited area. Mass mortality in the sea often coincides chiefly with red tides and is then due to blooms of poisonous algae (often Dinoflagellata). However, not all red tides coincide with mass mortalities and other causes of mass mortalities in sea are known, such as volcanism, earth- and seaquakes, sudden changes in salinity or temperature. **Mass extinctions** are large mass mortalities that occurred in the past, and worked over longer periods during which numerous species are exterminated, e.g., at the Cretaceous-Tertiary boundary, which marks the extinction of, e.g., dinosaurs and ammonites. On the causes of such mass extinctions we can only speculate, but usually worldwide extra-terrestrial causes are suggested. The current extinction of many organisms due to activities of man is probably the largest mass mortality ever. →extinction and →biohorizon.

mass spectrometry an analytical technique for the identification and quantification of unknown compounds. It is based on the determination of the mass/charge ratios of ionized molecules and ionized fragments of these molecules. The molecules are fragmentized and ionized by exposure to an excess of energy. The ionized molecules and fragments are then accelerated and fed into an ion-analysis device. Here the ions are separated according to their mass/charge ratios and detected by a spectrum recording system. The recorded fragmentation pattern contains specific and characteristic information on the molecule structure. Mass spectrometers are often combined with other analytical instruments (→gas chromatography). The combination of gas chromatograph, mass spectrometer, and data system is one of the most powerful analytical devices for the analysis of complex mixtures of unknown compounds.

Mastigophora (syn. **Flagellata**, flagellates) unicellular organisms distinguished by the presence of one or more flagella. Within the zoological classificaton this group was and is listed as a subphylum of the phylum Sarcomastigophora (→Protozoa). There are different autotrophic groups, together called the **Phy-**

tomastigophora or phytoflagellates, and heterotrophic groups, together the **Zoomastigophora** or zooflagellates. Within the five-kingdoms classification (→organisms) used throughout this book, the term Mastigophora becomes obsolete and is split up into different phyla, e.g., Euglenida, Dinoflagellata, Raphidophyta (autotrophic flagellates) and Zoomastigina (heterotrophic flagellates) of the kingdom Protoctista.

Matuyama epoch, - chron →magnetostratigraphy.

maxillipeds the first pair(s) of the thoracic appendages of the Crustacea with a feeding function.

maximum allowable concentration [**(MAC)**; syn. maximum permissible concentration **(MPC)**] the highest concentration of any (harmful) substance allowed by regulations to occur and not to be exceeded in any or a particular compartment of the environment. For the determination of MAC →bioassay.

maximum sustainable yield (MSY) maximum harvest which is currently compensated by the fish production of the system. →fishery science.

MBAL →minimum biologically acceptable level.

mean the average (arithmetic mean) value of a set of observations. →distribution.

meander originally a term indicating a bend in a river, but is by analogy also applied to large bends in ocean currents, such as the Gulf Stream.

mean sea level →sea level.

median the central value in a set of observations. →distribution.

mediterranean seas seas that are separated from the ocean by land masses or island chains and only connected with the ocean by more or less narrow straits. Apart from the Mediterranean proper, the Caribbean, the Red Sea, and the Arctic seas are considered mediterranean seas.

medusa (jellyfish) free-swimming reproductive life stage of Cnidaria. Bell- or umbrella-shaped body of which the rhythmic muscular contractions serve for propagation.

megabenthos large bottom-living organisms, →benthos.

megalopa pelagic developmental stage of crabs (→Malacostraca) which comes after the last larval stage or zoea. The megalopa has already the appearance of the

crab, although the abdomen is not yet folded under the body; it is also called the postlarval stage. After the megalopa stage the postlarvae settle on the seabed and become small crabs.

megaplankton planktonic organisms > 20 mm, →plankton.

megaripple cross-bedded sedimentary structure (with ripple shape) resulting from current powers higher than those necessary for small-scale ripples. Two types can be distinguished: (a) dunes, with a sinuous to lunate-shaped crest, and (b) **sand waves**, with a straight crest. The difference between the two types originates from the method of transport: for dunes, the major mode is transport by traction, for sand waves it is suspension transport.

meiobenthos (syn. **meiofauna**) group of animals of a size between roughly 50 μm and 1 mm living in the spaces between sediment grains. To this group belong for instance various genera of Copepoda, Nematoda, Polychaeta and Ciliata. →benthos and →interstitial.

meiofauna →meiobenthos.

membrane sheet-like structure separating the cell interior from the outside or separating intracellular spaces from each other. Membranes play a major role in controlling the transport of substances between various cellular spaces. In principle, membranes consist of lipid bilayers. As integral part of the membrane structure, or loosely attached to it, protein molecules may occur which function as carrier molecules for the transport of certain solutes across the membrane.

meristic characters characters in organisms that show repetition as a consequence of segmentation of the animals.

meroplankton temporary plankton consisting of pelagic stages of organisms which also have benthic stages. Mainly larvae of sedentary organisms. →plankton.

Merostomata class of the subphylum Chelicerata (phylum Arthropoda). The only living representatives are the five species of horseshoe crabs. These large marine animals have a strong rounded carapace that completely covers the appendages, with two compound eyes fixed on top of it. Further there is an abdomen, which bears leaf-like gills, and a long spiny tail. Most of the mouth appendages and walking legs have pincers (chelicerae). They live in shallow seas of southeast Asia and along the shores of the northwest Atlantic. Example: *Limulus*.

mesenterium (mesentery) (1) vertical partitions in coelenteron of Anthozoa; (2) in vertebrates: double layer of peritoneum attaching stomach, intestines, spleen etc. to dorsal wall of peritoneal cavity.

mesh size size of the openings in fishing nets or plankton gauze, measured according to standard methods. The gauze of plankton nets consists of single nylon fibers of a certain diameter, woven and melted together to form square pores that are stable in form. Mesh size of different plankton nets is given in μm length of the side of the square opening, irrespective of the diameter of the surrounding fiber, and ranges from 20 to 2000 μm with 50, 100, 200, 300, 500 and 1000 μm being the sizes most frequently used in plankton research. The nets used in fisheries are made of a great variety of natural and artificial fibers, which can be woven or knotted in many different ways into the netting. Since the mesh openings are not stable in form, and the fibers are sometimes elastic, mesh sizes are measured in a way standardized by the ICES (→fishery science). A measuring device is brought diagonally into the mesh opening and stretches it completely with a certain standard force, to measure the "stretched mesh size", the measure used in the minimum mesh size regulations for fisheries for the protection of young fish.

mesocosms in- or outdoor established experimental ecosystems on a mesoscale, i.e., having a volume of between 1 and 10^4 m^3 in pelagic systems and a surface area of > 1 m^2 in benthic systems. **Microcosms** or microecosystems refer to smaller experimental systems. Mesocosms provide realistic facilities for basic marine biological research, ecotoxicological testing, and aquaculture experiments and bridge the gap between laboratory experiments and field research.

mesoderm the middle tissue layer of an animal embryo, developing into tissues between gut and ectoderm: muscles, blood vessels, connective tissue, etc.

mesogloea the jelly-like more or less structureless mass, filling the space between the ectoderm and endoderm of the Cnidaria.

mesopelagic zone →zonation.

mesophile a term referring to organisms living in the temperature range around that of warm-blooded animals (→homeotherm).

mesoplankton planktonic organisms of intermediate body size between 0.2 and 2 mm, →plankton.

mesosphere →earth's internal structure.

mesotrophic →eutrophic regions.

Mesozoa small marine phylum of small, ciliated, multicellular parasites. They can be endoparasites of Turbellaria, Nemertina, Annelida, Bivalvia, Cephalopoda and Echinodermata. The larvae or the sexual stage can be free-living. Their very primitive appearance is probably secondary, and a result of parasitic adaptation.

Mesozoic →geological time scale.

Messinian →salinity crisis.

metabiosis cooperation of different organisms to degrade substances, e.g., refractory substances such as lignin or cellulose. These are first attacked by specialist microorganisms possessing enzyme systems for the decomposition of such substances and after that other microbes that can utilize the intermediate products follow. Thus the first create the pre-conditions for the development of the latter group of organisms, by whose activities an accumulation of harmful metabolic products is avoided. This kind of cooperation is widespread in nature.

metabolic diversity the overwhelming amount of morphologically different types of living organisms shows a remarkable unity in their biochemistry. Also in the metabolic processes of evolutionary different groups of organisms an impressive diversity exists. Especially among microorganisms a large variety of metabolic types can be found. On the basis of the energy source or the carbon sources used, organisms can be divided into various categories. If the energy source is chemical the organisms are **chemotrophs**. If they use light as energy source they are **phototrophs**. The chemotrophs can be divided into organisms that use the energy from reduced inorganic compounds (hydrogen, reduced S-compounds, reduced N-compounds, reduced Fe, or reduced Mn) the **(chemo)lithotrophs** and organisms that use the energy from organic matter the **(chemo)organotrophs**. The generation of energy must be separated clearly from the carbon source they use for building their biomass. If organisms use carbon dioxide as C-source they are autotrophs and if they use organic matter as C-source they are heterotrophs. So chemoorganotrophs are always heterotroph. But organisms such as the sulfate-reducing bacteria that use hydrogen as energy source and organic matter as C-source belong to the category **chemolithoheterotrophs**. The hydrogen bacteria using hydrogen as energy source and carbon dioxide as C-source belong to the **chemolithoautotrophs**. Phototrophs are mostly autotroph (**photolithotrophs** or **photoautotrophs**) but if they use organic matter as C-source they belong to the **photoorganotrophs** or **photoheterotrophs**. Metabolic diversity exists also in the way of oxidizing reduced inorganic or organic matter. The electron

acceptor can be oxygen, nitrate, iron, manganese, sulfate or carbon dioxide. In this way various aerobic and anaerobic respiration principles are possible. There are also different types of fermentations in the group of heterotrophic anaerobic organisms.

metabolism all the biochemical reactions in a cell or organism. Such reactions involve three major phases: first, the breaking down of organic compounds into smaller fragments (**catabolism** or destructive metabolism); second, the reactions of the intermediary metabolism; third, the reactions of the synthesis of building blocks and polymers for the composition of the various cell structures. These synthesizing reactions (constructive processes) are called **anabolism.** The metabolism of all the enzymatic reactions in a wide variety of living organisms have much in common. There is a fundamental similarity in carbohydrate, lipid and aminoacid metabolism, which gave rise of the dogma of the unity in biochemistry. On the other hand there is a wide diversity of reactions (→metabolic diversity), but they are not so diverse as they may first appear.

metameric repetition of a pattern of elements belonging to each of the main organ systems of the body, along the length axis of the body, or a comparative repetition along the axis of an appendage. Example: Polychaeta.

metamorphic water →juvenile water.

Metazoa multicellular animals in which there is at least some degree of cell differentiation. Include all taxa of the animal kingdom. The unicellular Protozoa, which formerly were included in the animal kingdom, are now assigned to the kingdom Protoctista.

Meteor Expedition (1925–1927) this German expedition marks the beginning of a new interest in oceanography which had strongly diminished after the heyday of expeditions around 1900. It sampled 14 sections across the Atlantic Ocean from 20° N to 65° S. Stations were closely spaced and subsurface observations made at standard depths down to the sea bottom. The central topic was deep-sea circulation and mixing processes in the entire Atlantic Ocean and led to G. Wüst's circulation model. For the first time the echosounder (→seismic instruments) was used, revealing a surprisingly irregular deep-sea bottom in all cross-sections. Due to the relatively sparse (because time-consuming) wire soundings of previous expeditions, the sea bottom was presumed to be far more uniform than it actually proved to be.

meteoric water →juvenile water.

methane bacteria (syn. methanogenic bacteria) a unique group among prokaryote organisms because they produce methane as a major product of anaerobic metabolism.

mica a group of platy, white-, green- or brown-colored minerals consisting of a 2:1 layer (→clay minerals) with the general formula: $(K,Na,Ca)(Mg,Fe,Li,Al)_{2-3}(Al,Si)_4O_{10}(OH,F)_2$. Micas are rock-forming constituents of igneous and metamorphic rocks.

Michaelis-Menten kinetics describe the rate of a biochemical process as a hyperbolic function of the concentration of the converted component. Originally derived from a mechanistic analysis of enzyme-catalyzed reactions by L. Michaelis and M.M.L. Menten in 1913: $V = V_{max}\, S/(K_m + S)$, where V is the actual rate at which the reaction proceeds, V_{max} is the maximum rate, S is the concentration of the converted component (often referred to as: substrate concentration) and K_m is a **half saturation constant** numerically equal to S at 0.5 V_{max}. Not only applied for enzyme kinetics but also for **nutrient-uptake kinetics**. At low concentrations the rate of the reaction is determined by the initial slope of the Michaelis-Menten curve. This slope, as S approaches zero, becomes equal to V_{max}/K_m. This ratio can be used to calculate the affinity of an enzyme for its substrate. In the application to the kinetics of microbial growth the equation is generally referred to as the Monod equation. With regard to microbial growth, the equation is written: $\mu = \mu_{max}\, S/(S+K_S)$ where the specific growth rate (μ) is a function of the concentration of the growth rate-limiting substrate S, the maximum specific growth rate μ_{max} which is observed when S becomes saturating, and K_S (half saturation constant for growth). The ratio μ_{max}/K_S is a measure of the competitive ability of a microorganism under conditions at which it has to compete for a limiting substrate at concentrations much lower than K_S.

Michael Sars Expedition (1910) in the North Atlantic, the Norwegians had already used the *Michael Sars* since 1900 for extensive oceanographical and fishery research in the Norwegian Sea. John Murray proposed to pay all expenses privately if the Norwegian government would lend the ship and its scientific staff for a four month's summer cruise. The scientific staff consisted of i.a. J. Murray, H.H. Gran, B. Helland-Hansen and Johan Hjort. Following Lohmann's suggestions (→Plankton Expedition) for the first time a motor-driven centrifuge was used to collect the nanoplankton, which passes plankton nets. Murray and Hjort's *The Depths of the Ocean* gives a general account of the expedition as well as an excellent overview of the knowledge of the oceans up to 1912.

microaerophilic requiring oxygen at very low concentrations.

microbenthos benthos consisting of the smallest animals, i.e., Protozoa. The arbitrary upper boundary of the animal size is generally set at about 100 μm, which is the lower limit for meiobenthos. →benthos.

microbes →microorganisms.

microbial decomposition the return of constituents of organic matter to ecological cycles by the activities of microorganisms, →biogeochemical cycles. This recycling of material is essential for life on earth.

microbial food web →microbial loop.

microbial loop (or **microbial food web**) term describing the complex of organisms and processes thought to be responsible for transferring back into the traditional grazing food chain dissolved organic matter "lost" from phytoplankton either by exudation, autolysis, or due to herbivorous feeding.

microbiology study of microorganisms.

microcosm microecosystem, →mesocosm.

microfauna microscopic animals roughly less than 0.1 mm in length. →microbenthos and microorganisms.

microflagellates a diversity of criteria has been used in classifying organisms as belonging to the microflagellates; photosynthetic cells have been alternately included and excluded. The concept has no systematic value and has been loosely applied to distinguish the smallest eukaryotic cells, often flagellated, from larger cells. Microflagellates are now split up into several phyla of the kingdom Protoctista. →Mastigophora.

microfossil fossil too small to be studied without the aid of a microscope. May be either the remainder of a microscopic organism or small part of a larger organism (examples of the last: otoliths and phytoliths). By size we distinguish micro- and **nanofossils**, the last being only visible at the highest light microscope magnification or with the aid of an electron microscope (e.g., coccoliths and discoasters). Several useful groups of microscopic organisms are studied, which can be divided on the basis of skeletal composition: calcareous (Foraminifera, coccoliths, discoasters, Ostracoda, Pteropoda, calpionellids), siliceous (Radiolaria, diatoms, Silicoflagellata) and organic-walled (spores, pollen, Dinoflagellata, Chitinozoa). →micropaleontology and →biostratigraphy.

micronutrient substance which an organism must obtain from its environment to maintain health, though necessary only in minute amounts, either vitamins or trace elements. →trace elements.

microorganisms (syn. **microbes**) organisms of very diverse groups including viruses, prions, viroids, Bacteria, Fungi, algae and Protozoa. The first three groups are all acellular and incapable of independent existence. The study of microorganisms is called microbiology.

micropaleontology the study of microfossils. The rapid evolutionary changes of microscopic organisms make micropaleontology an important biostratigraphical tool (→biostratigraphy), while the specific tolerances of microorganisms can be used for paleo-environmental interpretations. Once the relations have been established between the distributions of species and environmental parameters such as temperature, salinity, and water depth, this relationship can be used to reconstruct the geologic history, e.g., the history of the oceans by studying distributions of marine microfossils in the sediment (→facies). A major advantage of micropaleontology is that only small quantities of sediment are needed: often thousands of microfossils can be found in 1 g of sediment.

microphytobenthos small (usually unicellular) algae living on the (shallow) sea floor. Particularly abundant on tidal flats. →benthos.

microplankton small-sized (between 20 and 200 μm) planktonic organisms. →plankton.

microtektite small glassy object, usually droplet-shaped and less than 1 mm in diameter, found in some deep-sea sediments, and obviously strongly related to tektites.

mid-ocean ridge a broad, bilaterally symmetrical, elongate submarine ridge with sloping sides, 1 to 3 km in elevation, about 1500 km in width, and over 60 000 km in length. Mid-ocean ridges are formed at divergent plate boundaries and are not necessarily located in the middle of oceans. The new oceanic floor accreted there by volcanic activity sinks as each side moves laterally away and cools, which gives the ridge its form. Examples: Mid-Atlantic Ridge, East Pacific Rise, and Carlsberg Ridge. →plate tectonics.

migration periodical movement of organisms between alternative habitats, e.g., the area of reproduction and one or more areas of nonreproductive life, or between areas of foraging and areas used for other activities. Migrations occur at predictable times; in most cases they anticipate unfavorable conditions and are triggered by stimuli timed by biological clocks. Organisms capa-

ble of migration have a sense of direction (→orientation) and are able to move actively. Movements that do not include an obligatory return journey have been classed as dispersal, e.g., young that leave the area of birth and settle elsewhere (natal dispersal), or animals that have reproduced once in one area and use another area the next time (breeding dispersal). →orientation, →homing, and →scattering layer.

Milankovitch theory a theory of glaciation, formulated in 1941 by the Yugoslav mathematician Milutin Milankovitch (1879–1958). This theory states that climatic changes result from fluctuations in the geographic and temporary distribution of insolation, determined by orbital variations.

mile →nautical mile.

mimicry resemblance to organisms of other species, either to advertise an effective protective device that they possess in common with other species (Müllerian mimicry), or to "pretend" they possess such a device when they actually do not (Batesian mimicry). →coloration in (marine) animals.

mineralization the degradation of organic matter by organisms. During this process minerals (plant nutrients) become available again to the primary producers. →decomposition.

mineral resources because of technologic and economic limits the mining of marine resources is mainly restricted to the continental shelves. Hydrocarbons (oil and gas) make up almost 90 % of the current subsea mineral production. Other mineral resources of the continental shelves include heavy-mineral concentrates, gravel, shell, and lime mud mined by dredging in shallow water. Sulfur and salt are mined through drill holes. Phosphorite, potash, magnesium, fresh ground water, and geothermal energy (recoverable through drill holes) are other minerals that may be brought into production from the continental shelves in the future. The manganese nodules that occur on the deep ocean floor are an enormous potential source of manganese, copper, nickel, cobalt, zinc and other metals. Exploration of the nodules, however, is not economically feasible yet because the mining of land resources is much cheaper.

minimum biologically acceptable level (MBAL) value of spawning stock biomass above which there is no empirical evidence that recruitment is dependent on egg production. Below this level the probability of poor recruitment increases.

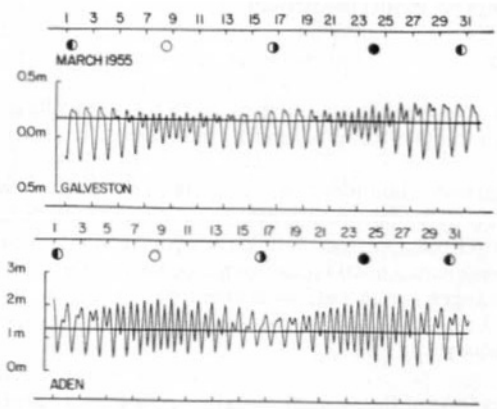
Miocene →geological time scale.

mitochondria cell organelles of eukaryotic organisms responsible for processes of respiration and electron-transport phosphorylation.

mixed fishery a fishery targeted at a mix of species. The demersal trawl fisheries for roundfish and flatfish provide typical examples. Management of these fisheries is faced with specific problems, because regulations with respect to one species have necessarily consequences for the others.

mixed layer water layer in which the vertical mixing is intense enough to give a homogeneous distribution of temperature and salinity as well as of other properties over its full depth. The term is mostly applied to the surface layer, where the air-sea exchange causes strong convection and/or turbulence. It may be bounded underneath by a pycnocline. Over large parts of the ocean the mixed layer varies seasonally and diurnally in depth.

mixed tides tides with an alternation of semidiurnal and diurnal tides, occurring in certain sea areas. →harmonic analysis of tides.



Mixed tides.
(After Scharnow 1978)

mixotrophs organisms able to assimilate organic compounds as carbon source while using inorganic compounds as energy source (as electron donor).

mode the most frequent value of a set of observations. →distribution.

models idealized representations of reality (the prototype). In oceanographic models the actual processes in the sea are simulated on the basis of underlying physical, chemical, and biological theories. They are used as a tool for further investigations and for predictions. Models are most advanced in physical oceanography but ecological models are more and more used. Models are formulated in the form of a set of mathematical expressions (mathematical models) that are either solved analytically, or in numerical models are solved in a grid and with discrete time steps. Furthermore there are analog models,

especially hydraulic models, in which by some scaling of the governing equations the relevant processes are reproduced on a smaller scale and where their development is much faster than in reality. An essential problem in numerical models is the way in which the mathematical model is discretized. In hydraulic models the scaling requires that the relation between the relevant parameters, as expressed in nondimensional variables, remains the same (→similarity theory). Models have to be calibrated by comparison with the observed past behavior of the prototype. In the calibration certain parameters governing the behavior of the model can be adapted to obtain an optimal result. By **sensitivity analysis** the response of different elements in the model to external influences is investigated. The reliability of models for prediction is investigated by **validation**, that is comparison with a set of independent observations of the prototype. Further development in modelling involves the regular incorporation of information from observations into the model (**data assimilation**) in order to improve model predictions.

Moho →Mohorovičič discontinuity.

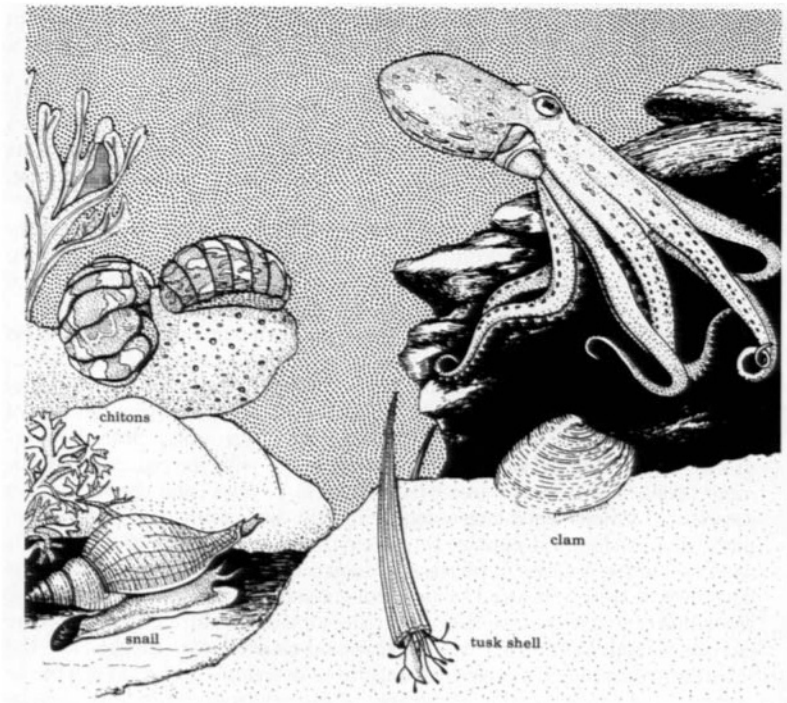
Mohole proposed deep bore hole through the earth's crust to the Mohorovičič discontinuity in order to obtain samples from the underlying mantle.

Mohorovičič discontinuity (abbr. **Moho**) boundary which separates the earth's crust and mantle, characterized by an abrupt increase in seismic wave velocity and an increase in density from approximately 2.9 to 3.2 g cm^{-3}. It is situated 25 to 40 km below continents, 5 to 10 km below the ocean floor, and 50 to 60 km below mountain ranges. →earth's internal structure.

molds filamentous fungi. →Fungi.

Mollusca (mollusks) phylum (one of the largest) containing the chitons, snails, slugs, clams and all other bivalves, squids, octopods and tusk shells. There are some 75 000 living species and 35 000 fossil species reaching back as far as the Cambrium. They occur in all marine habitats, in freshwater, and on land. The unsegmented, soft-bodied animals are characterized by a muscular foot (the surface on which they crawl), a calcareous shell secreted by two lobes of the skin called the **mantle**, and often by the feeding organ in the mouth called radula for scraping food. Between the mantle lobes and the body, a space called mantle cavity hides the "gills" or ctenidia. The Mollusca are divided into the classes Gastropoda (snails), Monoplacophora, the Polyplacophora (chitons), Aplacophora, the Bivalvia, Scaphopoda (tooth or tusk shells), and Cephalopoda (squids, cuttle-fish and octopods).

molting (syn. **ecdysis**) periodical renewal of the exoskeleton in Arthropoda, which allows these animals to change their body shape (during juvenile develop-



Mollusca. (After Keeton 1972)

ment), or to increase in size (growth). After an intermolt period, the cuticle loosens through the excretion of molting fluid from the hypodermis; is partly digested and softened, and thrown off. Then, the soft animal can change shape and/or increase in size, after which the new cuticle hardens.

momentum density momentum per surface area of a wave field. The momentum of the waves is found from the phase- and depth-averaged momentum that results from the orbital motion. Because of the Stokes drift there is an average momentum in the direction of the wave propagation. As a horizontal flux of momentum equals a stress, the flux of wave momentum gives a so-called **radiation stress**, which can raise the water level when waves are moving into shallower water.

momentum equation equation in hydrodynamics which formulates the equations of motion as a relation that expresses the conservation of momentum in a moving fluid subject to different forces.

Monera (syn. **Prokaryota**) one of the five kingdoms of living organisms. It includes the Archaebacteria, Bacteria and Cyanobacteria. These mostly unicellular organisms are characterized by their prokaryotic cell. Cyanobacteria can be multicellular.

monitoring the process of repetitive observation, for defined purposes, of one or more elements of the environment, according to prearranged schedules in space and time and using comparable methodologies for environmental sensing and data collection. Monitoring provides factual information concerning the present state and past trends in environmental behavior (this definition is based on the definition of monitoring accepted by the Governing Council of the United Nations Environmental Programme, UNEP). **Biological monitoring** has a public health objective (e.g., heart rhythm, activity of kidneys, lead concentration in human hair or finger nails). Both environmental and ecological monitoring are concerned with the natural environment (excluding human beings): its ecological, physical, and chemical characteristics. **Environmental monitoring** primarily deals with the recording of physical and chemical entities in the environment; sometimes the term is used for the registration of physical stress on biota or – by using indicators – the detection of trends induced by harmful substances. **Exposure monitoring**, the recording of total exposure to critical receptors, is therefore a member of the environmental monitoring family. **Ecological monitoring** is focused on the recording of changes in ecological entities to determine trends in pollution or the extent of contamination, geographical distribution, community composition etc. Two terms often used in connection with monitoring are bioassay and indicator.

monoclonal antibody an antibody secreted by immune cells derived from just one original antibody-forming cell. These cells are isolated and replicated by cloning techniques. The high specificity of monoclonal antibodies is used to detect the antigen isolated in e.g. sediment, water, cells or even fossils.

Monoplacophora class of the phylum Mollusca. Primitive snails that have retained some segmentation traces from a supposedly segmented worm-like ancestor. The nap-like shell is thin, and the few recent species known to men live in the deep sea. Example: *Neopilina*.

Monothalamia (syn. Monothalmida) Foraminifera with noncalcareous, single-chambered test. The pseudopodia are rarely reticulate and the protoplasma does not extend as a layer over the tests. Only some of the species are marine. Example: *Trichosphaerium*.

monsoon seasonal variation of the weather in the tropical Indian Ocean. Because of the heating during the summer of the Asiatic land mass to the north there is a variation in the pressure distribution that causes more or less a reversal of the normal trade wind pattern (→climate). As a consequence, during the (northern) summer westerly winds prevail north of the equator, and in response the circulation pattern in the ocean shows marked seasonal variations.

morphology the study of form, e.g., of organisms, the sea floor, coastal forms, land forms (geomorphology).

mortality (syn. **death rate**) the number of individuals of a population dying in a given period, →population parameters. In fishery research, **natural mortality** (death caused by natural factors such as predation) is distinguished from fishery mortality (caused by catches by man).

mother of pearl →nacreous layer.

MPC maximum permissible concentration, →maximum allowable concentration.

MSY →maximum sustainable yield.

mucoid feeder mechanisms mechanisms of collecting food by means of a structure made of mucus produced by the animal itself.

mucous glands generally unicellular glands which secrete mucin, a protein polysaccharide, which, with water, forms a lubricating solution called mucus.

mud slimy and sticky mixture of water and fine-grained particles with a consistency varying from that of a semifluid to that of a soft plastic sediment. Muds are generally described by color, e.g., black mud, gray mud, red mud.

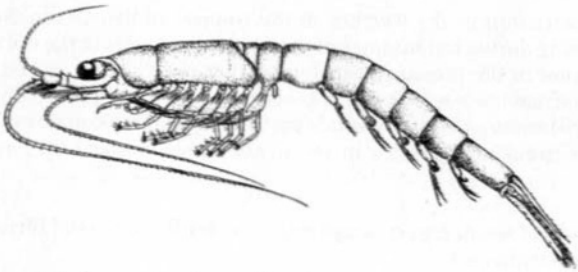
mud flat →tidal flat.

mudflow sediment-gravity flow in which more than 50 % of the solid fraction consists of particles smaller than 64 μm.

multi-net →nets.

mutualism →symbiosis.

Mysidacea (opposum shrimps, mysids) order within the Peracarida (class Malacostraca, subphylum Crustacea, phylum Arthropoda). Small, pelagic shrimp-like crustaceans of which the majority lives in the sea or in a brackish environment,



Mysidacea. (After Tattersall and Tattersall 1951)

with only a few in freshwater. The thorax has a carapace, which is not fused with the last four thoracic segments but covers them loosely. Most mysids also have as a characteristic a statocyst at both bases of the tail-legs (uropods). It is visible as a small black dot from the outside. The first one or two pairs of thoracic appendages are maxillipeds, the other six or seven are uniform and filamentous, and are used for swimming. Mysids live in large swarms along the seabed, and form an important food source for fish. They mostly feed on small suspended particles.