

Fig. 3.2 Some animals of the littoral zone of ponds 1. amphipod; 2. Pond snail; 3. Isopod; 4. Mosquitoe larva; 5. Mayfly nymphs; 6. Caddisfly larva; 7. Adult dysticus and; 8. Its larva; 9. Water scorpion, Ranatra. 10 and 11 Dragonfly nyphe

Secondary consumer (carnivores)

They are the carnivores which feed on the primary consumers (herbivores). These are chiefly insects and fish. Most insects as water beetles feed on zooplanktons. These are labeled as 'd' in the diagram.

Tertiary consumers (carnivores)

There are some large fish as game fish that feed on the smaller fish, and thus become the tertiary (top) consumers as shown in diagram.

Decomposers

They are also known as micro consumers, since they absorb only a fraction of the decomposed organic matter. They bring about the decomposition of complex dead organic matter of both — producers (plants) as well as the macroconsumers (animals) to simple forms, Thus they play an important role in the return of mineral elements again to the medium of the pond. *Rhizopus*, *Penicillium*, *Thielavia*, *Alternaria*, *Trichoderma*, *Circinella*, *Fusarium*, *Curvularia*, *Paecilomyces*, *Saprolegnia* etc. are most common decomposers in water and mud of the pond.

3.2.2 Reservoir Ecosystem

River water is usually running or flowing water. Construction of dam turns the section of the river immediately behind it into a lake, called reservoir or dam-lake, in which the lotic water of the upper reaches becomes lentic as water approaches the dam. (Fig. 3.8). Reservoir ecology is thus changed from the usual riverine ecology to lacustrine ecology with passage of time. This necessitates an entirely different type of fishery, called reservoir-fishery, in place of riverine fishery, to suit the ecology of the reservoirs. A reservoir, however, has its own special features in which it differs from natural lakes. But, unlike in natural lakes, the time for which 'cater is retained is relatively very short, and, since the water outflow may take place from deep water also, the hypolimnion is removed in temperate reservoirs. In reservoirs, in contrast to condition in lakes, water level is subject to great fluctuation.

The dam in some way interferes with the ecology of the upper reaches of the river. Migratory fishes are completely wiped out from the upper reaches. This often leads to disturbances in the ecosystem especially with advantage to the prey (in the absence of its predator - the migratory fish).

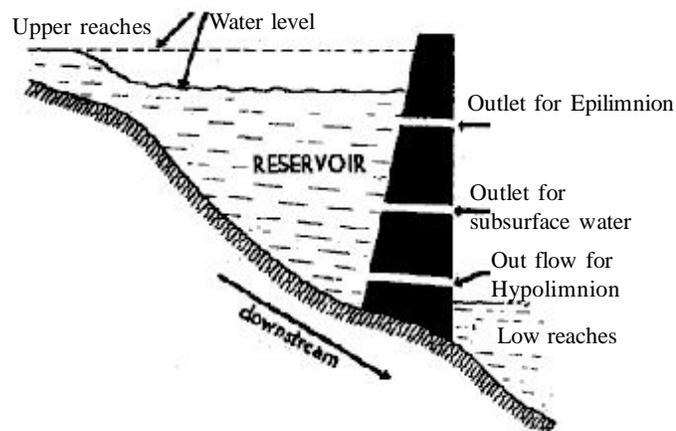


Fig. 3.3 Ecology of Reservoir

The reservoir itself may affect the ecology of the lower reaches of the river. Periodical discharge of sediments from the reservoirs may cause mud and silting in the lower reaches with serious consequences on the fauna. However, plankton is increased in the lower reaches due to drift from the reservoir, and turbidity is reduced. Reservoirs act as fertility traps reducing the amount of dissolved plant nutrients which would otherwise be freely arriving at the lower reaches. However, the tail-water released from the outlet often supports extensive fisheries in the stream below. If the discharge is from the hypolimnion, an excellent sport fishing for angling occurs for cold water species (trout etc.). If the discharge is from upper outlets, warm water fish species will largely support fishery.

3.2.3 Estuarine Ecosystem

An estuary is usually defined as a semi-enclosed coastal body of water having free connection with open sea. Thus, it comprises of both sea water and fresh water and occurs, usually near the river mouths, coastal bays and tidal marshes. Primarily it is a passage or inlet where tidal water comes in contact with a river current. In other words, it may be designated as a confined arm of the sea situated at the lower end / or mouth of a river. Generally, estuaries may be thought of as transition zones (or ecotones) between fresh water habitat and marine habitat. They consist of brackish water which may be either oligohaline, mesohaline or polyhaline on the basis of degree of salinity. They undergo seasonal organismal changes and thus belong to "fluctuating water-level ecosystem".

Kinds of Estuaries

On the basis of geomorphology, the estuaries are broadly classified into four categories. They are:

i. Drowned river valleys

These are very common along the coastlines and are characterized by low and wide coastal plains, e.g., Chesapeake Bay of the United States.

ii. Fjord type estuaries

They are deep, U-shaped coastal formations usually formed by glaciers, e.g., Norwegian fjords.

iii. Bar built estuaries

These are shallow basins along the seashores being partly exposed at low tide and surrounded by a discontinuous chain of barrier islands. The inlets between these barriers connect various estuaries with the sea, e.g., 'sea islands', salt marsh estuaries from Georgia.

iv. Tectonic Estuaries

These are formed as a result of local subsidence (sinking) of land or by some geological faulting along the coasts, e.g., San Francisco Bay.

v. Other kinds

Besides the above four categories, there are *river delta estuaries* present at the mouths of large rivers., e.g., Nile river.

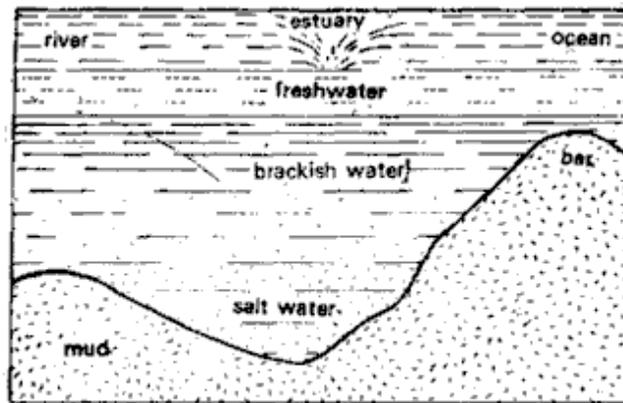


Fig. 3.4 Structure of Estuary

On the hydrographic basis, they are further classified into three categories.

a. High stratified estuaries

These are also called as salt-wedge estuaries, characterized by higher stratification of water. In it, flow of river water is dominant over sea water's tidal action with the result that fresh water overflows heavy salt water forming a sort of 'wedge' extending forward. Thus, two layered or stratified estuary is produced, e.g.: mouth of Mississippi River.

b. Moderately stratified estuaries

It is also termed as 'partially mixed' estuary, where fresh water and tidal inflow balance each other, e.g., Chesapeake Bay.

c. Vertically homogeneous estuaries

These comprise of "completely mixed" system in which tidal action is dominant and water mixes from top to bottom. Salinity is relatively higher, e.g., Bar-built estuaries.

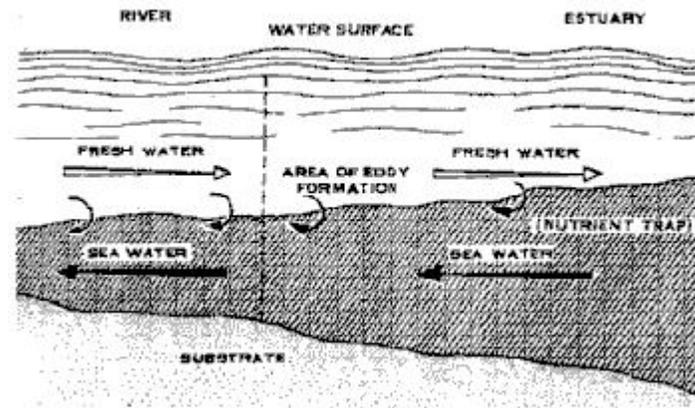


Fig. 3.5 Horizontal turbulence and formation of eddies

d . Turbulence in Estuaries

Generally, the amount of fresh water entering into the estuary at its upper end will vary with the seasonal changes. The flood tide volume of water entering a particular estuary may bring about an increased amount of longitudinal movement of water. Thus in salt-water estuary, a boundary is formed by the mass of fresh water current coming into contact with the underlying mass of salt water and at this boundary, there is great shearing force which causes horizontal turbulence resulting in *eddy formation*. These eddies contain most of the nutrients of the estuaries and some ecologists call them *nutrient traps*.

Abiotic Factors

i. Temperature

The temperature in the estuaries varies considerably diurnally and seasonally. The temperature of estuarine waters increases by solar radiation, tidal currents, and defect of high tide on the mud flats, etc.

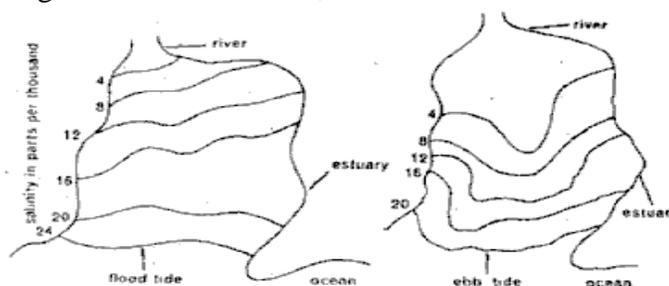


Fig 3.6 A) Isohaline lines across an estuary at flood tide. B) Isohaline lines at ebb tide

ii. Salinity in Estuaries

In shallow temperate water estuaries, salinity conditions are varied vertically, i.e., fresh water flowing from the river will be less dense than the sea water. Salinity conditions may be dependent on the flood tide and on the ebb-tide. The salinity fluctuates between 5 - 35‰.

Characteristics of Estuarine Biota

The organisms of estuarine waters must have the capacity to tolerate changing salinity conditions continuously which are mainly of tidal and seasonal nature. Thus euryhaline species are most common inhabitants on a permanent or semipermanent basis. Besides, silt content and turbidity of the water are limiting factors with regard to the distribution of biota. Increased silt contents adversely affect both flora and fauna of the estuary.

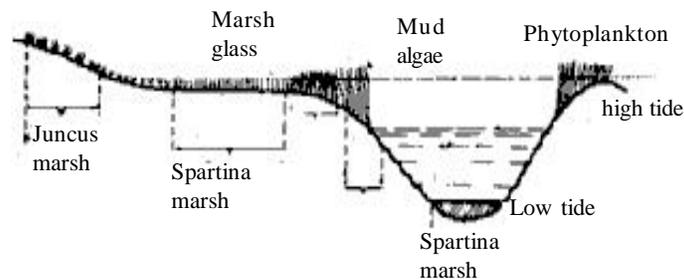


Fig.3. 7 Zones in marsh estuary

Estuarine species may be grouped into three categories.

(i) Marine species found along the outer limits of the estuary occasionally enter the estuary, e.g., Polychaetes (*Phyllodoce*, *Lanice*), Bivalve (*Abra*). (ii) Permanent estuarine animals found primarily in the estuaries but may also be found in certain marine areas if ecological conditions permit, e.g., Polychaete, (*Nephtys*), Gastropods (*Nerita*, *Littorina*) and Crustaceans (Crab). (iii) Strictly estuarine animals found only in estuarine environment and not in marine e.g., *Nereis*, Gastropods (*Neritina*, *Hydrobia*) and crustacea (*Cyathura*).

Biota and Productivity

The estuarine communities are usually composed of endemic species (i.e., those confined to estuarine zone) and movable species which come in from the sea, and also fresh water environment. Most of the estuarine biota is of marine origin. In addition to this, estuaries serve as very good nursery grounds for many fishes, plankton and organisms. Many shrimps pass their larval history in the estuaries, whereas adults inhabit the sea. Fishes like eels, mullets and salmon, etc., remain for a considerable period during the migrations.

3.2.4 Marine Ecosystem

The marine habitat constitutes a dynamic environment with continuous cycles, waves, tides and currents. The oceans and seas cover approximately 71 per cent of the earth's surface, an area of about 361 million square kilometres. The great stretches of salt water are termed as the oceans, while the smaller areas are referred to as seas.

There are five great oceans. These are the Pacific, Atlantic, Indian, Arctic and Antarctic oceans. The largest ocean of the world is the Pacific ocean. In spite of their vast size, all the oceans are connected with each other. In addition to the oceans, there are seas. Some of these, such as the Arabian sea and the Sargasso sea, are parts of oceans. Other seas are surrounded by continents, such as the Mediterranean sea, Red sea and the Black sea. Some shallow seas, such as the North sea and Baltic sea, are the flooded edges of continents. The largest of the worlds seas is the South China sea.

The oceans being connected with each other, form a single-phase environment, but the diversity is enormous with respect to temperature, salinity, physical nature, dissolved gases, dissolved organic and inorganic matter. The diversity, along with the circulatory pattern of the oceanic water masses and the nutrient concentration determines the distribution of organisms. The major difference between the fresh water and the sea is that the latter is highly saline, and organisms found here are not only adapted, but also use this characteristic to their own benefit. Some, such as the Dead sea are so salty that no plants or animals can live in it.

Structure of the Ocean Floor

i. Beach

Where the, land meets the oceans and seas it is called the seashore or beach. A beach is said to extend from the farthest point where sand has been carried by wave action to the depth beyond which wave action does not have sufficient force to move the sand particles.

ii. Sea Floor

Close to the beneath the sea is mostly shallow, the bottom shelving from the shore to a depth of about 200 metres. This coastal ledge of shallow sea-bottom is the continental shelf and its seaward margin is termed as the continental edge. Beyond the continental edge, the floor descends downwards steeply, and is known as the continental slope. The slope plunges into the floor of the ocean basin, often reaching a depth of 300 to 6000 metres or even deeper in some

places. The slope is often fissured by irregular gullies and steep-sided submarine canyons.

Zonation of the Sea

The marine environment can be classified into two major divisions, the pelagic and the benthic (Fig.3. 8).

i . Pelagic division

The pelagic division comprises the whole body of water forming the seas and oceans. The pelagic part can be divided into the following

ii .Neritic province

Consists of the shallow water over the continental shelf. This region has a more dynamic environment due to constant water movement and greater variations in the physical and chemical parameters.

iii. Oceanic province

The deep water beyond the continental edge constitute the oceanic province. This region is relatively stable with less fluctuations, water movement is very slow and conditions change with depth. The oceanic province is subdivided into three zones which are:

Epipelagic zone extends vertically downwards from the surface to a depth of 200 metres. In this zone, sharp gradients of illumination and temperature occur between the surface and deeper levels. Temperature gradients and thermocline is common, and marked diurnal and seasonal changes in light intensity and temperature occur. The effect of water movement (in the form of waves) is prominent, especially in the upper layers, and determines the conditions in the layers beneath.

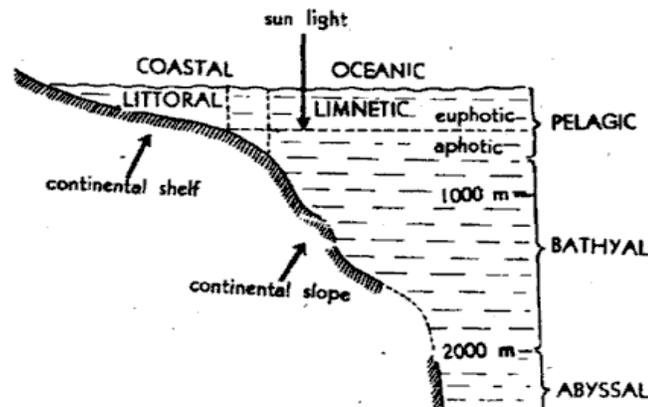


Fig. 3.8 Ecology of sea

Mesopelagic zone extends from 200 metres to about 1000 metres. Wave action does not reach here, and very little light is available.

The temperature gradient is more even and gradual, and there is very little seasonal variation. An oxygen-minimum layer is found here, along with maximum concentrations of nitrates and phosphates.

Bathypelagic zone extends from about 100 metres to the sea floor which is typically 3000 to 4000 metres in depth. Here darkness is virtually complete, except for bioluminescence. Temperatures are low and constant, and water pressure are enormous.

iv. Benthic division

The benthic division includes all the bottom terrain from the wave-washed shoreline at flood tide to the ocean abyss.

The benthic division is further classified into the littoral and the deep-sea zones which are:

v . Littoral Zone

The littoral zone extends from the high-tide level to a depth of 20 metres, that is, it includes the benthic region up to the continental edge. It has two subdivisions.

vi. Eulittoral Zone

It extends from the wave-splashed high tide level to a depth of about 40 to 60 metres. The lower border is set roughly at the lowest limit at which the more abundant attached plants can grow. In the upper part of the eulittoral zone is a well-defined tidal or intertidal zone that is bounded by the high and low-tide levels.

vii. Sublittoral Zone

It extends from the lower pit of the eulittoral zone down to a depth of 200 metres, or the edge of the continental shelf.

viii. Deep Sea Zone

The deep-sea zone includes the benthic region from the edge of the continental shelf to the ocean abyss which is usually at great depths. It has two zones, an upper archibenthic zone and a lower abyssal benthic zone.

ix. Archibenthic Zone

It extends from the sublittoral to a depth between 800 and 1100 metres.

x. Abyssal benthic Zone

It comprises all the deep-sea benthic system below the archibenthic zone. It is a region of relatively uniform environmental conditions with uniformly low temperatures (50 to -1 °C), with total darkness, and without seasonal changes.

Physical Characteristics of Sea

These are four general types of water movements in the oceans. They are, waves, subsurface currents, surface currents and tides.

i. Waves

The most common type of water movement in the seas and oceans are the waves. Waves are caused by the wind. Wind action does not move the water from place to place like currents or tides, but transmits energy into the water, setting it in orbital motion. Where waters are deep and wind velocities are low or moderate, water movements are smoothly progressive.

Surface waves do not mix the water to any great depth. Their motion falls off sharply with depth and at a depth equal to the wavelength of the waves, the water is virtually still.

ii. Ocean currents

The ocean waters are constantly moving in a great circulatory system that involves both horizontal and vertical transfers. These movements are initiated by the transfer of kinetic energy from the winds to the surface waters and by variations in the densities of waters resulting from differences in their temperatures and salinities. The resulting flows, involving huge volumes of water, help to transport heat from the tropical and subtropical zone of excess receipt of solar radiation to the poleward zones where the energy received from the sun is much lower. The movement is aided by the Coriolis force and produces clockwise currents in to the northern hemisphere and anticlockwise in the southern hemisphere.

iii. Tides

Nearly all shores of the open seas experience the distinct periodic rise and fall of sea-level known as the tides. The level of the sea or ocean rises twice in a day, water covers the shore and we say that the tide is in the level of water falls, Twice in a day the seashore is uncovered and we say that the tide is out.

Two important forces involved in a system, are responsible in tide generation: (i) the gravitational pull of the moon upon the earth, and (ii) the centrifugal reaction which necessarily accompanies the smaller revolution of the earth. The gravitational attraction decreases rapidly with increasing distance from the moon, and hence

it is significantly greater on the side of the earth nearest the moon than on the side opposite. That centrifugal reaction, on the other hand, is the same everywhere on the earth, for as the centre of the earth revolves in a circle around the centre of gravity of the pair, all points on the earth follow circular paths of the same size and move at the same speed.

At times of new moon and of full moon, the earth, moon, and sun are nearly in line, so that the lunar tides and the solar tides occur in the same places, and the height of the solar tides is added to the lunar tides. These causes the high tides of these periods to be unusually high and the intervening low water to be unusually low. These are the periods of spring tide, which occur every two weeks.

When the moon is at its first and third quarters, the earth-sun line is nearly at right angles to the earth-moon line. The solar tides then fall between, and detract from the lunar tides, causing the difference between low and high tides to be less pronounced than usual. These are the periods of neap tide, which also recur every two weeks.

iv. Temperature

Temperature changes with depth differ in different latitudes. In high latitudes, heat passes from the sea to the atmosphere. Surface waters usually have a temperature of 1.9°C ; there is an inversion around 500 metres, and below 1000 metres the temperature is almost uniform to the bottom.

At low latitudes,, a distinct thermocline is formed between 100 - 500 metres. The thermocline divides the waters into an upper warm thermosphere and a lower cold psychrosphere. The temperature decreases from about 25°C in the surface layers to about 0°C in the bottom layers.

In middle latitudes seasonal thermocline occurs during the summer months at a depth of 15 - 40 metres. In winter the thermocline disappears, being replaced by a slight permanent thermocline, below which the temperature decreases steadily to around 0°C .

v. Pressure and wind flow

Pressure differences are primarily important in wind generation which leads to the formation of surface currents, wind waves and swells. Major winds which have an influence on oceans are the winds in the equatorial region, the westerlies of the midlatitude, and the polar winds in the high latitudes.

Apart from these, pressure changes create cyclones and anticyclones. A cyclone has a low pressure centre, while an anticyclone has a high pressure

centre. Monsoonic winds are periodic and create local effects, such as the clockwise and anticlockwise gyre in the Bay of Bengal

vi. Light

Compared to the great depth of the oceans, light does not reach very far into the sea. Illumination of the surface layer varies with place, time and conditions depending upon the light intensity, transparency of the water and angle of incidence. The strength of the incident light varies diurnally, seasonally and with latitude, and is considerably influenced by cloud cover. Much of the incident light falling on the sea surface is reflected. Depending upon conditions some 3 - 50% of the incident light is usually reflected.

Most of the plants are restricted to the euphotic zone by their dependence upon light as the energy source. Animals too are most numerous at or near the surface layers because they derive their food, directly or indirectly from plants.

Below this zone, organisms depend largely on the rain of organic debris coming from the upper layers, and consists of carnivores and detritus feeders moving in complete darkness.

vii. Density

Pure water has its maximum density at 4°C, but for sea water the temperature of maximum density decreases with increasing salinity, and at salinities greater than 24.7% (parts per thousand) it is below the freezing point.

The distribution of density in sea waters is characterized by two features. In a vertical direction the stratification is generally stable, and in a horizontal direction differences in density exist only in the presence of currents. In every ocean region, water of a certain density which converges from the sea surface tends to sink to and spread at depths where a similar density is found.

viii. Hydrostatic pressure

Hydrostatic pressure increases with depth at approximately 1 atmosphere per 10 metres of depth. In the deepest ocean trenches, pressures may exceed 1000 atmospheres. Although water is only slightly compressible, such enormous pressures are sufficient to produce a slight adiabatic compression of the deep waters, resulting in a detectable increase in temperature.

ix. Evaporation and precipitation

The oceans have a major role in the hydrological cycle through the processes of evaporation and precipitation. For the oceans, the average annual evaporation is between 116 and 124 centimetres and the average annual precipitation is

between 107 and 114 centimetres. This system is controlled by a large number of factors, for instance, temperature, precipitation, evaporation, vapour pressure and relative humidity. All these can be combined to form a hydrothermal index (Hin).

Chemical Characteristics of Sea

Sea water is an extremely complex solution, its composition being determined by an equilibrium between dissolution and deposition, evaporation, precipitation and addition of fresh water as river run-off. Although it is not known as to what extent the composition of sea water has changed over the geologic period, but large-scale changes are definitely ruled out (Table 3.1).

Table 3.1. Major constituents of sea water at a salinity of 35 grams per kilo

Constituents	Concentration g/kg
Sodium	10.77
Magnesium	1.30
Calcium	0.409
Potassium	0.388
Strontium	0.010
Chloride	19.37
Sulphate	2.71
Bromide	0.065
Total inorganic carbon	0.023 - 0.027

i. Salinity

The amount of inorganic material dissolved in sea water expressed as its weight in grams per kilogram (parts per thousand) of sea water is termed as salinity. The salinity of sea water varies from place to place. The average salinity of the oceans as a whole is generally considered to be 35 g/kg of which the chloride ion constitutes about 19 gms per kilo and the sodium ion a little over 10 gms per kilo. The salinity is lower where large rivers enter the sea, but in areas where the influx from the land is negligible, and where surface evaporation is great. Surface salinity is closely related to the process of evaporation, by which the salts are concentrated and this varies with latitude.

ii. Dissolved Oxygen

The oxygen content of the sea water is seldom limiting for the occurrence of animals and plants, except in the deeper waters.

The oxygen content of the sea water generally varies between 0 and 8.5 mill, mainly within the range of 1 - 6. Higher values occur at the surface, due to diffusion and photosynthesis, especially in coastal areas where the phytoplankton and benthic algae are numerous. The process of diffusion is enhanced in wave-splashed shores. Oxygen is more soluble in cold water than in warm, the oxygen content of the surface water is usually greater at higher latitudes than nearer the equator, and the sinking of cold surface water in polar seas carries oxygen-rich water to the bottom of the deep ocean basins.

iii. Free and bound carbon

40 chemical elements (including four principal cations Ca^{++} , Mg^{++} , K^{+} and Na^{+}), gases excluded are dissolved in sea water. The abundance of these ions enables a considerable amount of carbon dioxide to be contained in solution in the form of bound carbon (CO_2 , HCO_3^- and HCO_3^-). In fact, the ocean serves as a major reservoir of carbon dioxide, containing about 50 times more CO_2 (47 ml/L) than the atmosphere and serves as a modulator of the atmospheric carbon dioxide.

iv. pH

The pH of sea water in free contact with the atmosphere normally varies within the range of 7.5 and 8.4. The higher values are found at or near the surface layers where CO_2 is withdrawn rapidly for photosynthesis. In general, there is a decrease of pH with depth to about the region of minimum dissolved oxygen, and then increases in deeper waters where respiration and decomposition become the dominant metabolic processes.

v. Nitrogen

Nitrogen in the combined form is present in sea water as nitrate, nitrite, ammonium ions and traces of nitrogen-containing organic compounds. Nitrogen-fixing bacteria such as Nitrocystis oceans are known to occur in the sea, but the amount fixed is negligible. Substantial quantities of nitrates, nitrites and ammonia enter the sea as river run-off.

vi. Phosphates

Phosphates are typically present in the sea water as orthophosphates. Like nitrates, large amounts of phosphates are brought to the sea through river run-off. Phosphates show much the same distribution in depth as nitrates (Fig.3.20),

and in broad outline, their seasonal and geographical variation approaches that of nitrate. Phosphates are present in much smaller concentration than the nitrates and appear to be an important limiting factor in the development of phytoplankton. Surface values of phosphate are in the range of 0 - 20mg per litre while at depths of 500 - 1500 metres it is 40 - 80 µg per litre. The ratio of nitrates of phosphates present in the sea roughly approaches a constant value of 7 : 1 by weight.

vii. Iron and other elements

The amount of iron present in sea water in solution is about 2 mg per litre, but there are appreciable amounts of iron in particulate form as colloidal micelles, mainly as ferric hydroxide. There is a continuous loss of iron from sea water and accumulation at the bottom due to sedimentation.

Manganese is a plant nutrient which, like iron, is probably present mainly in the particulate form as oxide micelles. The amount varies from 0.3 to 10mg per litre. These two elements along with copper, nickel and cobalt give rise to polymetallic nodules at the sea bottom.

viii. Silicate

Silicon is present in sea water chiefly as silicate ions. The concentration of silicates is usually low in surface waters but increases with depth to about 1- 5 mg/L.

ix. Dissolved organic matter

Varying quantities of organic matter are present in solution in sea water. Although the concentration is small, it has been estimated that there is on average about 15 kg of organic matter beneath each square metre of the ocean surface. The sources are diverse and include materials origination (from the break-down of tissues, excretory materials and organisms secretions).

Biotic Components of Sea

The marine community is diverse and diversification is a measure of the success of a species. In these terms, many marine groups are highly successful. The community is segregated into the range of environmental niches provided by the sea.

Regardless of their phylogenetic position, marine organisms can be placed in two large categories dependent on whether they live on the water mass (pelagic) or on the bottom sediments (benthic). A third category is made of those organisms which live in the air-water interface (pneustic). However, these categories are not rigidly defineable. Some species are benthic as adults but pelagic as larvae,

and a number of pelagic organisms may spend much time resting on or feeding at the sediment-water interface.

The biotic components of marine ecosystem are of the following orders:

i. Producers

These are autotrophs and also designated as primary producers, since they are responsible for trapping the radiant energy of sun with the help of dinoflagellates and some microscopic algae. Besides them, a number of macroscopic seaweeds, as brown and red algae (members of Phaeophyceae and Rhodophyceae), also contribute significantly to primary production. These organisms show a distinct zonation at different depths of water in the sea.

ii. Consumers

These all are heterotrophic macroconsumers, being dependent for their nutrition on the primary producers. They are:

- (a) Primary consumers. The herbivores, that feed directly on producers are chiefly crustaceans, mollusks, fish etc.
- (b) Secondary consumers. Still in the food chain, there are other carnivorous fishes like Cod, Haddock, Halibut etc. that feed on other carnivores of the secondary consumers level. Thus these are the top carnivores in the food chain.

iii. Decomposers

The microbes active in the decay of dead organic matter of producers and macroconsumers are chiefly bacteria and some fungi.

iv. Pelagic biota

The pelagic region has a larger group of organisms and includes all the species inhabiting the entire water column. These can be divided into two broad categories, the plankton and the nekton.

v. Plankton

The plankton of the sea includes a great variety of forms and exceeds that of fresh water, but differences in composition usually occur. The phytoplankton (Fig.3.09) population of the sea is dominated by the diatoms and the dinoflagellates also present and are occasionally important. The diatoms tend to dominate in higher latitudes, while dinoflagellates are predominant in the subtropical and tropical waters. As a group, the dinoflagellates are the most versatile of organisms, since they not only function as autotrophs, but some

species are facultative saprotrophs or phagotrophs. Some, such as *Gymnodiniumbrevis*, *Goiniauluxpolyedra* and *Exuviella baltica* give rise to red tides causing death of enormous number of fishes.

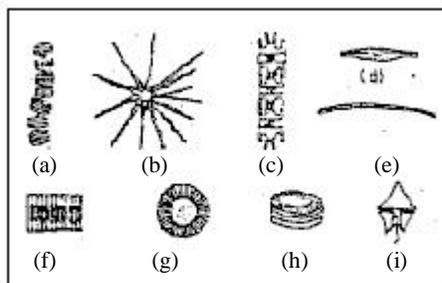


Fig 3. 09 Representative members of the phytoplankton
 (a) *Thalassiosira* (b) *Asterionella* (c) *Biddiuphia* (d) *Navicula*
 (e) *Thalassiothrix* (t) *Fragilaria*(g) *Planktoniella* (h) *Coscinodiscus*
 (i) *Peridinium*.

The animal plankton (Fig .3.10) are defined according to duration of the life cycle in the pelagic state. The planktonic eggs and larvae of the nekton and benthos constitute temporary plankton or meroplankton. These are especially abundant in the neritic waters and are composed mainly of the developmental stages of invertebrates, but also include the young of fishes.

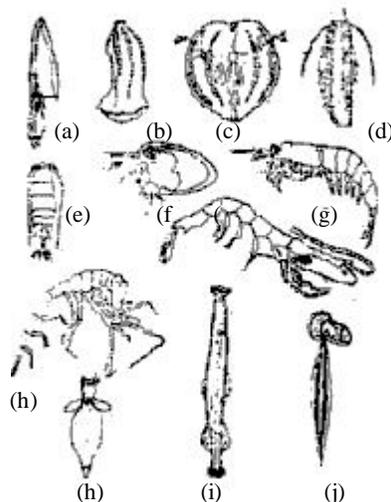


Fig. 3.10 Marine zooplankton
 (a) Siphonophore (b) Beroe (c) Pleuro brachi (d) Tompteris
 (g) Eupliansut (h) Amphipod (i) Lucifer (j) Chaetognath

vi. Nekton

The assemblage of organisms comprising this group are provided with efficient locomotory organs enabling them to swim against currents and waves, The large cephalopod molluscs (squid), crustaceans (prawn) and a great variety of vertebrates (fish, turtles, snakes, mammals Fig.3.11) comprise this group.

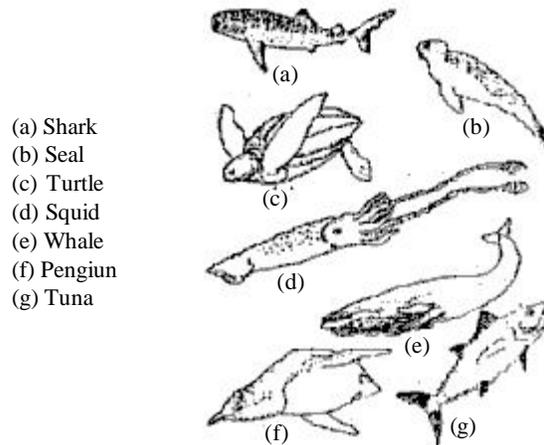


Fig. 3. 11 Representative members of the nekton

The locomotion efforts of nektonic organism are not only capable of being sustained for a considerable length of time, but the movement is also effectively directed towards pursuit of prey, escape from enemies, and instinctive migratory journey. Active swimming requires the development of muscular systems and often of relatively large size. They are the terminal consumers of the sea, mostly carnivorous, while a few are herbivores and even fewer take detritus.

vii. Benthic biota

The benthos consists of diverse group of organisms with specific adaptations and is zoned both horizontally and vertically. These zonations are based on their energy requirements and the physical and chemical factors to which they have adjusted. In the well-lit waters of the euphotic zone are to be found the phytoplankton; they extend down to the compensation zone and are graded at different levels based on environmental factors and community dynamics. The phytoplankton includes three categories of photosynthetic organisms; protists essentially similar to those of the phytoplankton but here associated with soft sediments, symbiotic within littoral animals such as corals, and occurring in various other microhabitats; larger, multicellular algae in a variety of forms but especially as the large, leathery sea-weeds of rocky outcrops (forming kelp beds) and the

finer, more filamentous species growing on the surfaces of coarser sea-weeds and rocks; and the community of marine tracheophytes consisting of sea-grasses, salt-marsh herbs, and mangrove- swamp shrubs and trees.

Beyond the euphotic zone the benthos lacks photosynthetic organisms and is replaced by chemosynthetic bacteria (nitrifying, sulphur, hydrogen methane, carbon monoxide, and iron bacteria) which occur in the benthic sediments, and fix their carbon dioxide by oxidizing ammonia, hydrogen sulphide, methane, and others. These regenerate nutrient materials for the photosynthetic forms.

Benthic animals are very abundant in the littoral zone and decrease in number with depth in the only scattered individuals are found in deep ocean trenches. These consist of sessile forms such as sponges, barnacles (Fig.3.27), mussels, oysters, crinoids, hydroids, bryozoans, and some worms; creeping forms such as crabs, lobsters, certain copepods, amphipods, crustaceans, snails, echinoderms, bivalves, and some fishes; and burrowing forms including mostly clams, worms, some crustaceans and echinoderms.

In the shore zone, organisms are characteristically zoned. This zone represents transition between the marine and terrestrial environments. The organisms living here have to withstand varying degrees of stress resulting from tides, waves, sea-spray, pounding of surf and the alternate inundation and exposure to air. Based on the type of substratum, the zone is classified into rocky and sandy shores. Each has its own peculiar feature and the organisms living in these environments have specific adaptations for the same.

3.3 Energy Flow in Ecosystem

The energy used for all plant life processes is derived from solar radiations. A fraction i.e. about 1/50 millionth of the total solar radiation reaches the earth's atmosphere. In this about 34% of the sunlight reaching the earth's atmosphere is reflected back into its atmosphere, 10% is held by ozone layer, water vapour and other atmosphere gases. The rest, 56% reaches the earth's surface.

Only a fraction of this energy reaching the earth's surface (to 5%) is used by green plants for photosynthesis and the rest is absorbed as heat by ground vegetation or water. In fact, only about 0.02% of the sunlight reaching the atmosphere is used in photosynthesis. Nevertheless, it is this small fraction on which all the organisms of the ecosystem depend.

The behaviour of energy in ecosystem can be termed energy flow due to unidirectional flow of energy. From energetics point of view it is essential to understand for an ecosystem (I) the efficiency of the producers in absorption

and conversion of solar energy, (ii) the use of this converted chemical form of energy by the consumers, (iii) the total input of energy in form of food and its efficiency of assimilation, (iv) the loss through respiration, heat, excretion etc. and (v) the gross net production.

Single - Channel Energy Models

The principle of food chains and the working of the two laws of thermodynamics can be better made clear by means of energy flow diagrams shown in Figure 3.12.

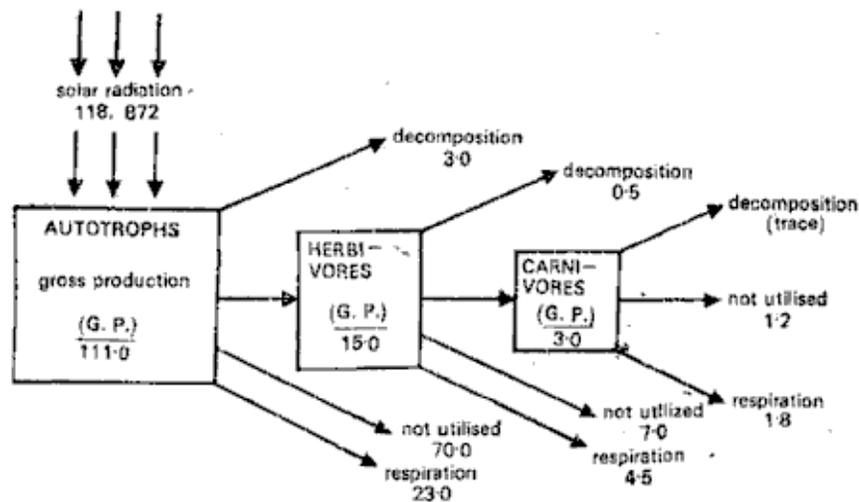


Fig. 3.12 Energy flow in a water body ($\text{g cal} / \text{cm}^2 \text{ yr}$)

From the energy flow diagram shown in Fig. 3.12, two things become clear. Firstly, there is one-way Street along which energy moves (unidirectional flow of energy). The energy that is captured by the autotrophs does not revert back to solar input; that which passes to the herbivores does not pass back to the autotrophs. As it moves progressively through the various trophic levels it is no longer available to the previous level. Thus due to one-way flow of energy, the system would collapse if the primary source, the sun, were cut off. Secondly, there occurs a progressive decrease in energy level at each trophic levels it is no longer available to the previous level. Thus due to one-way flow of energy, the system would collapse if the primary source, the sun, were cut off. Secondly, there occurs a progressive decrease in energy level at each trophic level. This is accounted largely by the energy dissipated as heat in metabolic activities and measured here as respiration coupled with unutilized energy.