ENVIRONMENTAL FACTORS AFFECTING THE LIFE IN THE OCEAN

TEMPERATURE

- Temperature is a measure of the condition caused by heat and it expresses the intensity of the warmth and is measured by oC.

- To be more precise, it is defined ‘as the energy in molecular motion and expresses the intensity of warmth, which is measured by o Celsius’.

Temperature is a factor of prime important in the marine environment because of its action.

1.Directly upon the physiological process of the animals especially upon the rate of metabolism and the reproductive cycle.

2.Indirectly through its influence on the other environmental factors such as gases in solution, viscosity of water and distribution.

The range of temperature in the sea varies from about –30 C to 420C depending on season and locality, but in the open ocean, the maximum temperature does not exceed 300C. (Whereas air temperature from –650 C to + 650 C may be found)

HEAT BUDGET IN THE OCEAN

	Heating		Cooling
1.	Absorption by radiation from sun and sky	1.	Back radiation from sea surface
2.	Conduction of heat from the ocean bottom	2.	Evaporation
3.	Transformation of kinetic energy to heat		
4.	Heating due to chemical processes		
5.	Condensation of water vapour		
6.	Convection of sensible heat from the atmosphere		

VERTICAL DISTRIBUTION OF TEMPERATURE IN TROPICAL OCEANS

Surface (Avg.)	-	26.0^0C
200 m	-	13.0^0 C
400 m	-	7.5^0C
1000 m	-	4.5^0C
2000 m	-	3.3^0C

The animals are commonly divided into large groups with reference to their tolerance to temperature namely,

- Stenothermic
- Eurythemic.

Within the temperature limits tolerated by an animals there are three fundamental categories.

- Optimum, minimum and maximum

Response of an organism to varying temperature in the marine environment can be described as

- Structural response
- Functional response
- Behavioural response

Structural Responses:

- There are much direct evidences that frequently cold water animals grow to a large size than the similar animals in warm water.

- Jesperson (1939) reports that *Calanus finmarchicus* in Greenland waters forms two size groups, larger being found particularly in waters of low temperature and the smaller size population in warmer surface layers.

Three explanations have been given for the increased size of the cold water planktonic form.

1.Lowered temperatures lengthen the time required for poikilothermal animal sexual maturity. Hence in cold water forms, the delay permits longer growing period with resultant large size at maturity.

2.It has been shown that, the oxygen consumption of certain non- locomotary warm water benthic species is higher than that of related colder water species and this difference in metabolism may have a bearing on the question.

3.Increased density and viscosity of cold waters enables large forms to keep afloat more successfully in cold than warm water.

FUNCTIONAL RESPONSES

Metabolism:

- The rate of metabolism (measured by O2 consumption and production of CO2) of all poikilothermic organisms is very much increased with rise in temperature.
- According to Vant-Hoff's rule, the increase is 2-3 times for each 10oC rise in temperature within favourable limits.
- Hence, it serves, as one of the factors in rapid and abundant production in warmer regions.
- During winter, when production is less, Calanus finmarchicus sinks down to deeper waters where the metabolic rate declines.

- Among the coastal forms Penilia and Evadne survive the low winter temperature as resistant resting eggs and are therefore able to appear suddenly in abundance in spring, when warming of water takes place.

- Therefore, parthenogenic activity in marine cladocerons is largely depend on temperature fluctuation.

- It could be noted that, the optimum temperature for life activity is considered to be nearer the maximum than the minimum limit, for which reason a small rise in the temperature from the optimum is more disastrous to cold blooded animals than is a greater lowering.

Calcium Precipitation:

- Temperature influences to a marked degree of which $CaCO_3$ can be precipitated by the animals in the formation of skeletal parts, shells and spicules.

- Therefore, organisms that utilize calcium compounds in their supporting, protective structures are notably abundant in warm water. Because of this, deep water molluscan shells is not large and heavy as in warm water.

- Calcium precipitating organisms are present in all seas, but their numbers are much reduced in the fauna of cold polar seas and the shells of these present are relatively more weakly constructed.

- Calcareous shelled species are replaced in cold northern waters by the arnaceous types, which build shells of sand, fragments of shells, spicules and so forth, cemented together with non calcareous cement. This type is characteristic of deepwater foraminifera.

- Low temperature is apparently a major cause of the limited production of calcareous structures, although a great hydrostatic pressure in deep water, may be of great importance.

- effect of temperature on biological deposition of $CaCO_3$ provides a key to the interpretation of temperature conditions and water depths that mush have prevailed.

BEHAVIOURAL RESPONSES

Bipolarity:

- It has long been known that the fauna's of the cold waters, the north and south latitude contain many elements in common.
- The animals or animal group that form these elements may be wanting in the intervening tropical region. A break of continuity of distribution of species is called 'discontinuous distribution'.
- This discontinuous distribution occurring in the meridonial direction resulting in the absence of species in the tropical belt is known as 'bipolarity'.

There are three hypotheses to support the theory of bipolarity.

(i) Theory of extinction: This hypothesis holds that the fauna were cosmopolitan and is now extinct along the tropical belt.

(ii) Theory of tropical submergence: This hypothesis is associated with the sinking of eurybenthic and eurythermic fauna to a greater depth along the tropical belt, thus involving discontinuous distribution.

(iii) Theory of Parallel Evolution: This hypothesis states that, the species of the fauna developed simultaneously along both the poles resulting in the presence of same species of the fauna and their absence in tropical belt.

SALINITY AS A BIOLOGICAL FACTOR

- Of the 109 elements occurring in nature till now, 74 have been determined analytically in sea water, it is to be expected that, around 15 elements are also present, probably they have not yet been detected because their concentrations are too small for our present analytical techniques.

- The abundance of major elements in sea water of 35 ppt salinity is subdivided into 5 cations, 6 anions together hydrogen and oxygen of the water, there are 13 major elements.

Elements	Quantity in gm/kg	
Sodium	10.750	Cations
Potassium	0.395	
Magnesium	1.290	
Calcium	0.410	
Strontium	0.008	
Chlorine	19.340	Anions
Bromine	0.066	
Fluorine	0.001	
Sulphate	2.700	
Bicarbonate	0.014	
Boric Acid	0.027	

Definition of Salinity:

- Salinity is defined as the total amount of dissolved material in gms per kg of sea water with an assumption of the organic matter is completely oxidized, the bromide and iodide are replaced by an equivalent amount of chlorine and all carbonates are oxidized.

- The physical property of seawater depends in general on 3 factors, temperature, salinity and pressure.

- In the open ocean, the surface salt content varies between 32 and 38 ppt. (one can take the mean value as 35 ppt). The considerable differences in surface salinities are caused by variations in the extent of evaporation, quantity of rain and inflow of freshwater. So the salinity fluctuation is seen from 0 to 41 ppt.

Density and Viscosity:

- Changes in salinity lead to respective changes in density and viscosity of the ambient water.
- This may be importance in regard to movement and maintenance of position in planktonic invertebrates.
- Variations in density can affect the amount of energy, which must be expended for migrations and other activities of planktonic communities.
- The density of the protoplasm of most marine invertebrates ranges between 1.0400 and 1.0500. This range lies slightly above the density of seawater (1.028 at 10°C and 35 ppt).

FUNCTIONAL RESPONSES

a) Tolerance:

- Animals, which can tolerate the wide range of salinity, are referred to as ‘euryhaline’ and those animals which have a limited salinity tolerance range are ‘stenohaline’.
- In marine invertebrates, the degree of tolerance to salinity variations often varies during the embryonic stages.
- Developing eggs and newly hatched larvae of some invertebrates may not tolerate extremely wide range of salinity.
- Eggs of shore crab develop normally in salinities between 28 ppt and 40 ppt, while adults tolerate salinity down to 4 ppt.

Metabolism and Activity:

- Rates of metabolism and activity are functionally correlated; changes in metabolic rate tend to alter the scope for activity.
- The amount of oxygen and carbon dioxide, which can be held in solution decreases in increasing salinity.

(1) Many aquatic invertebrates respire at most economic rates in salinities to which they are genetically adjusted or to which they have been acclimatized over longer time.

(2) Respiratory demands due to salinity stress can be reduced by reductions in muscular activity.

- Salinity may influence the metabolic rates in multiple ways.
- Ex. Via stimulation or diminution of locomotary activity, increases or decreases of water or salt contents of body fluids.

Reproduction:

- Salinity may effect decisively reproduction in areas where it undergoes pronounced changes .Changes in salinity have been shown to modify rates of reproduction and to bring about a shift from asexual to sexual reproduction.
- Amphipod lays more eggs in brackish water than in freshwater.
- Theodoxus sp. produces smaller egg capsules containing pure eggs than in freshwater.
- Salinity variations may also modify time and length of breeding season.
- Salinity may affect functional and structural response of invertebrates.

STRUCTURAL RESPONSES

- Among euryhaline animals, individuals living in reduced salinities frequently have smaller size than do those of the same species inhabiting more saline waters. Ex: oyster, Mytilus.

- It is very strange to note that, with few exceptions, marine animals from groups with fresh water representative and larger than the fresh water relative and usually size difference is enormous.

- Respiration is more difficult in fresh water hypotonic is another factor for which it has to spend energy more.

Light as a Biological Factor

- Light is defined as radiant energy roughly covering the range 380-780 nm (1 nm = 10-9m) which is capable of simulating a human eye so as to produce the sensation of vision.

- Further, the extent of scattering and absorption depends upon dissolved substances, suspended particles and molecular processes in the water.

- Light serves animals for visual orientation and stimulant for locomotion. In addition, there are other living processes that are controlled by light.

Light and Colour:

Colour changes in marine invertebrates are brought about for mainly three reasons.

1.To match the colour with the surrounding.

2.To scare the predator

3.To protect itself from harmful rays of the sun.

- The pigments of chromatophores produce degrees of shade and colour by the concentration or depression of pigments within the irregularly shaped chromatophores cells.
- The content of chromatophores are either activated directly by intensity of incident light or medicated through the eyes and nervous system in response to colour.

- I) On the open coast of California, Holothuriods are darkly pigmented, while specimens from Mytilus bed have very little body wall pigment. Interestingly darkly pigmented individuals do not contact when a strong light directed on their body, whereas, pale individuals are sensitive to strong light and move rapidly away.

- ii) Population of crab found on the white sandy beach of Oahu are pale in colour when compared to that of crabs found on the black sandy beaches of Hawaii. Hawaii beach crabs process approximately 12 times as many black chromatophores as Oahuan beach crabs.

- iii) In cephalopods, colour intensity may quickly shift from pale grey to rich chocolate as the mollusc passes over a lighter or darker surrounding. Here, light appears to be the stimulus activating the changes, but in addition nervous reaction related to feeding or presence of enemies may also produce the temporary colour changes in cephalopods.

- iv) Summer and Doudoroff showed that Guppy was nearly independent of the intensity of light, but was dependent upon albido of the background.

The responses of marine invertebrates towards light can be described as:

Functional Responses:

- Under laboratory conditions, calcium deposition in corals was higher in higher light intensity, while it was significantly less in lower light intensity.
- In several decapods, especially freshwater crabs, it was observed that darkness enhances the rate of moulting and promotes growth, while in constant light condition, the decapods enter into a irregular moulting leading to inhibition of growth
- In planktonic copepod, Calanus finmarchicus decreased in the heart rate and sharp increase in respiratory rate when exposed to light.

- The ascidian, Corella parallelograma which normally spawns during the early morning hours, can be induced to spawn after exposure to light for 2 mins. following a period of dark adaptation.

- Diurnal vertical migration of planktonic and benthic marine invertebrates represents one of the most widespread and conspicuous phenomenon in the oceans and coastal waters.

- Many of the benthic animals produce pelagic larvae, which are generally positive photo taxis. After the metamorphosis, they show negative response to light (negative photo taxis) during settlement at the bottom.

Structural Responses:

- Body size and form (i.e. sexual and asexual) in reef building corals depend primarily upon water movement and conditions of illumination.
- Ex: Gorgonia and Madreporaria produce more branches in colonies in calm and higher intensity of light.
- Ascidian growing under eel algae in shallow water grows smaller than that of the ascidian present in deeper waters. Similarly, Balanus belanoid grows bigger settle in shade than the one settle in high illumination.
- The absence of light indirectly plays a more remarkable stamp on structure than on colour.

- This is manifested by the strange and varied anatomical adaptations, especially of many abyssal fauna.

- These adaptations are concerned with structural modifications fitting the animals better to survive in utter perpetual darkness.

- They are mainly along three lines:

(1)Tactile structure

(2)Food procuring devices

(3)Light production

- Development of tactile devices is an important feature in numerous instances and is well illustrated in Macro pharynx. Sensory structures may involve modification of the whole body where by it is elongated and ends in disproportionately long thread like tail.

- The film rays grow to a length of several times that of the body.

- The prawns of deepwater also possess extremely long tactile antennae. Some of which may be 12 times the length of the body as in Aristeus sp.

- The food procuring devices of deep sea fishes consists commonly of an extraordinarily immense mouth in proportion to body size.

- The stomach and abdominal wall may be so elastic that it is possible for some of these Malanocetus, for ex swallow other fishes 3 times their own size and many times their own weight. In addition, they are provided with formidable teeth.

- As if these were not sufficient, some species of deep sea angler fishes possess a tectile organ, 'illicum' useful as rod and line and provided with terminal luminous lure, which in some cases be armed with hooks.

- The number of animal species emitting light distributed among such group has the radiolarians, dinoflagellates, hydroids, jelly fish, ctenophores, bryozoans, polychaetes, brittle stars, many crustaceans (ostracods, copepods and decapods), gastropods, cephalopods, protochordates and true fishes

- In many luminescent organisms, the light results from luminous slime secreted over parts of the body are thrown out as glowing cloud.

- Ex: Squids, which produces this secretion in a gland corresponding to ink sac.

- In many of the fishes and crustaceans highly specialized luminescent organs are present, which in some cases are under nervous control as in dinoflagellates, bacteria.

- There appears to be no possible utility, but in the higher forms those with specialized light organs capable of flashing under nervous control and arranged in a definite pattern and even specific colours, utility seems clear.

- Bioluminescence seems to be of greater significance in abyssal benthic animals.

- The biochemical activities involved in bioluminescence are only in part understood.

- It is highly efficient, since the light is practically devoid of heat and there being no infra and ultra violet rays.

- The light is produced by oxidation of substance, probably a simple protein known as luciferin, that is produced by a living cell.

- However, before light can be produced by union of oxygen, it is necessary that another substance luciferase be present as catalyst to accelerate the oxidation.