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MZOE-003: Aquaculture
Guess Paper-1

Q1. Discuss the trend of fish consumption in the context of India.

Ans. Consumption of fish as a stable source of protein supply in India over the past years has taken a steep rise in the proportion of population from 730 million to 966 million an increase by 32.34%.The trend to eating fish much more frequently is prominently shown by drop in occasional consuming population by 4.9% and increase of weekly interval consumption of fish population by 11.3%. In 2020, 5.95% of people eat fish daily, 34.8% once in week and 31.3% occasionally. The proportion of population in urban area eating fish once in a week constitutes 42.7% of the population and 39.8% in rural areas. This is an increase population of 9.55% in urban area and 11.85% in rural areas. It is further observed that 78.6% of the male population constitutes fish eaters while female constitutes about 65.5% of the female population. The consumption pattern based on wealth/income of the population shows an overall increase in all categories (highest, 4th, middle, 2nd, lowest). The lowest wealth category of the population showed a 20% increase, 14% for the second, middle category and 4th category with 8% and 1% for the highest wealth category. The consumption trends based on age of the individuals shows 42% fish eater in the age group of 30-39 years, 41% in 40-49 years, 40.9% in 20- 29 years and 37.3% within 15-19 years eats fish at least once a week.

In India, the per capita consumption of fish was highest in Andaman & Nicobar Island with 59.47 kg/capita/year followed by Puducherry (30 kg/capita/year), Tripura with 29.29 Kg/capita/year, Kerala (19.41 kg/capita/year), Manipur with 14.1 kg/capita/year, Odisha (13.79 kg/capita/year), and Assam with 11.7 kg/capita/year. The least fish consuming fish recorded include; Rajasthan (0.01 kg/capita/year), Punjab (0.4 kg/capita/year), Uttarakhand (0.49 kg/capita/year), and Sikkim with 1.14 kg/capita/year. However, the proportion of population eating fish was the highest in the state of Tripura (99.3%) followed by Northeastern states (Manipur, Nagaland, Tripura, Meghalaya, Assam, Mizoram, Arunachal Pradesh and Sikkim combined) with than 95% of the population. Similarly, more than 90% of the Kerala, Tamil Nadu and Goa population are fish eaters while states like Punjab, Rajasthan and Haryana constitutes the lowest proportion of fish consuming population with 26.4%, 22.5% and 20.5% respectively.

Q2. Compare the employment status and trend between Indian aquaculture and global aquaculture.

Ans. Indian aquaculture: Aquaculture as an avenue for income generation and socio-economic development has evolved as an indispensable sector with over 5.8 million individuals employed in global aquaculture and fisheries sector. According to 2020 data of Govt. of India, over 2.8 million individuals are engaged in inland and marine aquaculture activities. Close to half of the global population of people engaged in aquaculture related individuals are concentrated in India (48.2%). Approximately, 82.3% of the populations engaged in fishery activities are employed in inland sector while 17.6% are related to capture fisheries. The overall increase in employment in the sector has been estimated at 22-25% from the recent past decade.

Even though, aquaculture has reached industry status in India, the estimation of the human resources in the sector has not been accurately mapped. Nevertheless, the existing data suggests that the average age of fish farmers ranged from 38 years to 58 years settling for a national average age of 47 years. The nature of engagement in the sector differs across different states of the country. More than 85% of the population engaged in fish and fisheries activities work on a part time basis and unspecified status with a minimum activity period ranging between 17 man-days/ annum - 75 man-days/annum. While in others the activity ranges from 600 man-days/crop/ha in intense shrimp farming to 180 man-day/crop/ha in paddy field cultivation. At national scale, 1.6 million population of the sector are engaged as full time workers, 1.7 million as part time workers, 0.703 million as occasional and 5.3 million as unspecified.

Statistically, the state of Bihar has the highest population of individuals engaged in aquaculture activities employing 21.4% of the total fishermen population of the country which is followed by Uttar Pradesh (13.8%), West Bengal (11.5%) and Andhra Pradesh (5.3%). The participation of the genders in aquaculture of the country has been overwhelming with 1.3 million of males and 1.02 million female populations participating in the running of the sector. The distribution pattern of employment in the inland aquaculture sector and capture fisheries is almost similar with male's population at 56.2% and female at 43.7% for inland sector and 53.6% for male and 46.3% for female, respectively. The largest participation of female workers comes from Bihar (2.8 million) followed by UP (1.7 million), and WB (1.2 million) out of the total 10.1 million females workers in inland aquaculture.

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Global aquaculture: More than 58.5 million are employed currently in aquaculture and captured fisheries sector (FAO, 2022). The employment in the sector can be categorized as aquaculture and captured fisheries. The sector wise employment status in 2020 shows higher engagement of the population in captured fisheries (65%) than aquaculture sector (35 %). Further the workerscan be categorized as; full time, part-time and unspecified or occasional workers engaged in either aquaculture or fisheries.It is observed that nearly 40% of the employment population is unspecified, 25% of them are full time, 21% as part-time and the remaining engagement as occasional (14%). The gender composition of workers shows only 21% female and 79% male population. Out of the 21% female workers, the proportion of engagement directly in aquaculture sector accounts for only 28% population in aquaculture and 21% in fisheries. The remaining population are involved in processing sector. Overall nature of engagement status of the women workers in the sector accounts for 34 %, 27% and 15% as unspecified, part-time and full-time, respectively.

Asia has the highest numbers of fishers and fish farmers making up 84% of the total employment in the sector followed by Africa with 10%, 4% in Caribbean and Latin America. The remaining population is distributed in the region of North America, Europe and Oceania each with less than 1% of the total workers. The workers in aquaculture sector is dominated by Asia with whooping 93.5% of the total 20 million workers. Asia is followed by Africa with 3.1%, about 3% in Caribbean and Latin America, and the remaining small portion in North America, Oceania and Europe. In fisheries sector, 80% of the total 37.9 million are from Asia which is followed by 13% from Africa, Latin America and Caribbean with 5%, Oceania with about 1% and Europe with less than 1%.

Q3. Evaluate the constraining factors of aquaculture.

Ans. It is true that aquaculture holds immense potential for meeting our future requirements of proteinaceous food supply, but also besets with several constraining factors. These constraining factors should be given adequate focus while planning for an aquaculture project.

I. Possibilities of Disease Outbreak: Like all other animals, finfish and shellfish species raised under semi-intensive and intensive aquaculture systems are highly prone to stress from high density stocking, rough handling, feeding regime and inappropriate water quality management. Disease outbreaks in aquaculture are caused from combinations of multiple factors which increase the probability of susceptibility to disease outbreak. Therefore, a stringent monitoring of the above mentioned parameters/factors are required. Outbreak of disease in aquaculture farm leads to mass mortality causing huge financial loss.

II. Intensification of Land Use and Scarcity of Water: The expanding world population has already started weighing heavy on the availability of land for agriculture. Much of the current stagnation in agriculture production has been traced to population pressure and land degradation which are undermining agriculture's current condition and future prospects. The land resource available for aquaculture are perhaps more limited than previously expected. The situation obviously denotes that aquaculture is going to have to compete with the many other sectors to which land, water and nutrient resources involved, and as population pressure mounts it is to be expected that priority will be given to cereal crops and vegetable protein sources. Particularly, competition between irrigation and aquaculture for use of water is eminent. Availability of clean water is fast becoming one of the major limiting factors for life. Sooner or later, the onslaught is also going to fall on aquaculture too.

III. Feed Ingredients Supply Shortage: Aquaculture pursuits fall under two broad categories, one is culture of high value carnivorous fishes and shrimp and another is culture of lower value species. While aquaculture of former is based on supplies of fish meal and trash fish as aqua feed inputs, aquaculture of the low value species is largely based on locally available vegetable wastes. Fish meal and trash fish have already become commodities of scarce availability and in due course of time, it is definitely going to impact the progress of aquaculture especially the high value aquatic organisms. Feeds for the low food chain species, on the contrary, are more abundant. It, thus, implies that the best potential for future advances in aquaculture would be using lower food chain species such as carps and tilapias.

IV. Social and Economic Constraints: Experiences over the years have shown that social and economic constraints are among the most serious constraining factors to the goal of diversifying rural agricultural options. One such option is introducing aquaculture to areas where potential is good but practice is so far lacking. Some of the problems associated with it are:

- overcoming traditional land leasing patterns
- finding time for a new activity in already busy schedules
- influencing perceptions of risk and food security
- allocation of scarce financial resources for aquaculture

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- serious lack of knowledge and experience due to lack of training

Q4. Explain why water as a medium has advantage over other solvents?

Ans. All living organisms contain a large proportion of water, and life, as we know, would not have been possible if water did not have the special properties for sustaining life. As a medium to live in, water presents several advantages as given below.

Valuable Buffer: Water forms a valuable buffer against changing environmental temperature, both for the water within the organisms and for the aquatic environment.

Density: Pure water is the standard, with a maximum density of 1000 kg m3 . This property of water enables the bulky organisms to remain in suspension and to move with minimal expenditure of energy. Also, it reaches its maximum density at a temperature of 4ºC while its freezing point is 0ºC. This helps in preserving an ice free environment in a lake or a pond. If the surface water is frozen, underlying water remains unfrozen providing living environment for the aquatic fauna and flora.

Viscosity: The viscosity of water is 0.89 centipoise (cP) or 1.0016 millipascal second (mPa Sec) at 20 C. The low viscosity of water serves an immense advantage of having the property to flow easily. Higher viscosity of water compared with air means that there is increased frictional resistance which aids for locomotion of aquatic organisms through it. Furthermore, viscosity assumes greater importance for smaller organisms.

Heat Capacity: Water is capable of absorbing tremendous quantity of heat energy with relatively small rise in temperature due to high specific heat capacity (4.2 j/g at 25 C). Specific heat can be defined as the amount of energy required for changing the temperature of a substance. This results in a more stable temperature in water as compared to air since temperature changes much slower in water. This helps the aquatic organisms in maintaining their body temperature which they generally are not able to maintain. Most aquatic animals do not have physiological systems that can generate heat for compensating abrupt temperature changes of their immediate environment.

Specific Gravity: Small organisms often have a specific gravity close to that of water. They are, thus, close to neutral buoyancy and spend very little energy in counteracting the forces of gravity compared to terrestrial organisms. Even larger organisms, with dense skeletal material, obtain some buoyancy support from being immersed in the water, and are able to save energy which otherwise would be needed for counteracting gravity.

Q5. Explain with suitable illustration the characteristic zones of marine environment.

Ans. The oceans constitute nearly 71% of the earth's surface. And so as a habitat it provides an unusual stability in temperature, salinity and gaseous contents.

Characteristic of marine environment: The most characteristic feature of sea water is its high salt content (about 3 to 3.7 per cent). The salinity is relatively constant in different oceans. As the range of salinity in the open ocean is rather small, a salinity of 3.5% is taken as an average for all oceans. The consistency of composition in the different oceans is mainly due to the result of circulation and mixing up of water caused by oceanic currents.

Nearly 49 elements have been detected in sea-water and they are found to occur in dissolved state. The temperature range from the bottom to the surface is uniform in all the oceans. The pressure increases as one descends deeper and deeper into the ocean. While calculating the pressures in the ocean, the atmospheric pressure is neglected and the pressure at the surface is taken as zero. The light intensity varies from brilliant sunlight at the surface to absolute and perpetual darkness in the deeper layers. Light penetrates up to 200 meters normally. The water is in constant motion for the most part and this has several distinct advantages viz., (i) it helps in the dispersal of waste products produced by the animals as a result of catabolism; (ii) it helps in dispersal of nutrient materials; (iii) oxygen is carried to the depths; and (iv) it helps in the dispersal of eggs, larvae, spores etc. over wide area.

Classification of marine environment: Two major divisions of the ocean are recognized. They are the pelagic and the benthic zones or regions. The pelagic region includes the sunlit surface waters while the benthic zone includes the ocean floor (Fig.).

Pelagic region: The pelagic area of the sea can be distinguished into the neritic province and the oceanic province. The neritic province consists of water up to a depth of 200 meters and it is close to the land mass. It is considerably influenced by the facts of terrestrial environment. The oceanic province extends from the continental shelf to the archibenthic (about 1,100 meters) level. This oceanic province is free from the influences of terrestrial environment. The flittering surface waters of the ocean are known for their teeming abundance of living organisms. The most characteristic feature of all pelagic animals (animals which live at the surface) is their ability to keep themselves afloat.

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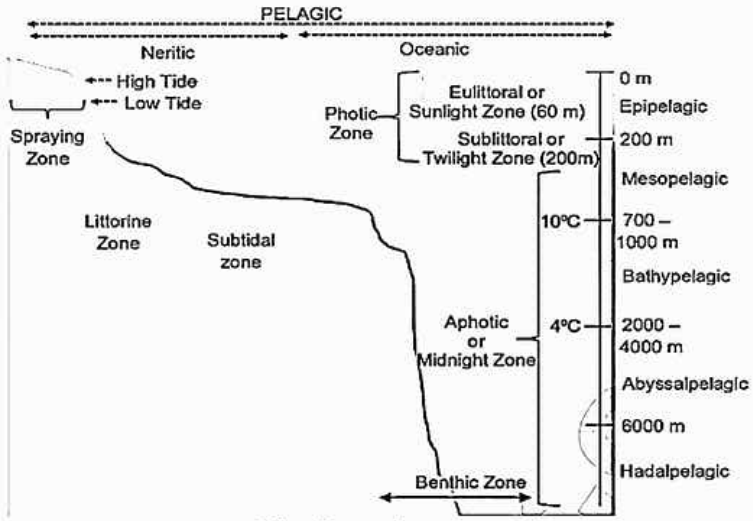

Fig.: Zones in ocean

Benthic region: The benthic biotic environment is concerned with ocean floor and forms two main zones (a) the lighted zone of littoral benthal which is more briefly referred to as littoral zone and (b) the lightless archibenthal or abyssal benthal forming the so-called deep sea systems. The line of demarcation has been fixed at 200 meters depth, to which light usually penetrates. The littoral zone extends from the high tide level to about 250 miles off the shore and roughly to about 200 meters depth up to the edge of continental shelf). This archibenthal zone extends from 200 meters to 1,000 meters depth. The abyssal zone covers the ocean bottom running upto 6,000 meters. From 6,000 to 10,000 meters the region is generally referred to as "Ocean-deeps".

The sea and its shores support a vast form of animal life. The littoral zone is further subdivided into two divisions (i) eulittoral and (ii) sublittoral. The eulittoral zone extends up to 40 to 60 meters and is known for its luxuriant vegetation. The sublittoral zone extends from this point to about 200 meters depth.

Eulittoral zone: The eulittoral zone includes the well known intertidal zone which is bound by high and low tide marks. Though the tidal zone is rather well defined, its vertical range varies in different parts of the world for it is dependent on the tidal range. The eulittoral zone gives rise to many biotopes dependent on the substrata such as the rocky, sandy and muddy zones. Unlike the open oceans which are known for the consistency of conditions, the eulittoral zone is known for its diversity of the physico-chemical conditions of the habitat. The shore provides three major habitats for animals to live in namely rocky, sandy and muddy shores. The changes in salinity coupled with seasonal and diurnal fluctuations of other environmental factors add to the variety of physico-chemical conditions that the animal life is subjected to. The most important of all the factors in the tidal zone is the tidal rhythm (the low and high tides).

The structural modifications of eulittoral animals are dependent on the type of substratum, the degree of exposure to the climatic conditions, depth and feeding habits. Their modes of life vary, some of them are adapted for crawling (worms and mollusks), some others are burrowing (crustaceans, mollusks and worms) and yet others are sessile (crinoids, bryozoans and corals). Thus the eulittoral animals, under the influence of the vagaries of environment, are generally very sensitive to sudden changes and hence quickly alter their behaviour accordingly.

The marine eulittoral zone biologically as well as ecologically can be divided into four main zones, viz. (i) Spraying zone (ii) Littorine zone (iii) Balanoid zone and (iv) Subtidal zone.

Spraying zone: It occurs nearer to the land mass and the animals living in this zone are exposed to the spray caused by the dashing of the tireless waves. This is the rocky part of the eulittoral zone. Only forms like isopods which can withstand adverse conditions are present in this zone. The littorine zone is the true intertidal zone and exposed either for long or short periods due to the ebbing of tides. This zone is characteristic of the sandy and muddy shores of the eulittoral zone. The balanoid zone is seen in rocky coast margins and are absent in the muddy and sandy shores. This zone is dominated by the barnacles and hence the name balanoid zone. The subtidal zone is clearly demarcated in the rocky coast margins, wherein are found the rocky pools. The animals living in rockpools are seldom exposed to the severity of atmospheric conditions. The temperature of the water is always greater than the sea. This zone is particularly noted for its richness of fauna e.g. Seaanemones, fishes, polychaetes and extension of coral reefs.

Sub-littoral zone: The sub-littoral zone extends from the low water tide mark to about 200 meters. The sublittoral bottom is of a soft consistency and is largely composed of sand, mud and clay in which a large number of benthic organisms (e.g.

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molluscan shells) are found. Plentiful supply of food and oxygen and the optimum conditions of temperature are responsible for the richness of the sublittoral fauna upto 100 to 120 meters wherein plant life exists that are chiefly calcareous seaweeds. The coral reefs form a distinct biotope in the sublittoral zone. The bottom fauna includes variety of sponges, foraminiferans, crustaceans, worms, star fishes, sea-urchins, sea-cucumbers, brittle stars, seafans, sea-pens, lobsters, crabs, mollusks and fishes.

Q6. What is thermal stratification?

Ans. Stagnant water bodies with well-defined basin, e.g. lakes show property of thermal stratification. In lakes or deeper ponds when the heat enters at the surface, the surface water gets heated faster than lower waters. In due course of time, waters of the upper stratum become considerably warmer than those of the lower stratum reducing the density of surface water. The surface water becomes so warm and light that it does not mix with the lower column of cool water establishing distinct layers of water in the water column. This phenomenon is known as thermal stratification. In a thermally stratified water body, the upper stratum is called the 'epilimnion' and lower stratum the 'hypolimnion'. The stratum between the two has a marked temperature difference and is termed 'metalimnion' or 'thermocline' (Fig.). A thermocline can thus be defined as a layer across which the temperature drops at a rate of at least 1ºC per meter. Temperature of the epilimnion in turbid waters is greater than those of clearer waters because of greater absorption of heat by particulate matter.

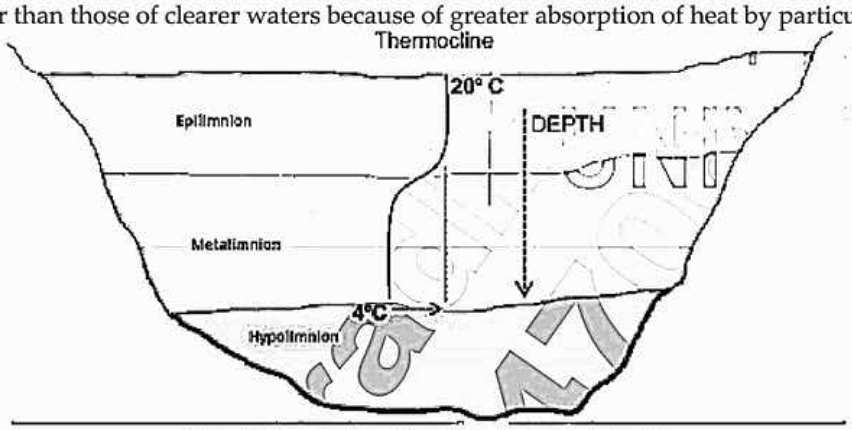

Fig.: Thermal Stratification in water bodies

The type of thermal stratification just described in Figure (Fig.) is a typical phenomenon occurring in summer. Therefore, this phenomenon is known as 'summer stagnation period'. Thermal stratification undergoes cyclic seasonal changes. In temperate lakes, summer stagnation period is followed by 'fall over turn' i.e. whole water column is mixed up, followed by 'winter stagnation period' and 'spring overturn' (Fig.). Various other modifications may occur either temporarily or permanently. The water bodies having larger inflow of cold mountain water and larger outflow show a 'partial or complete absence of thermal stratification'.

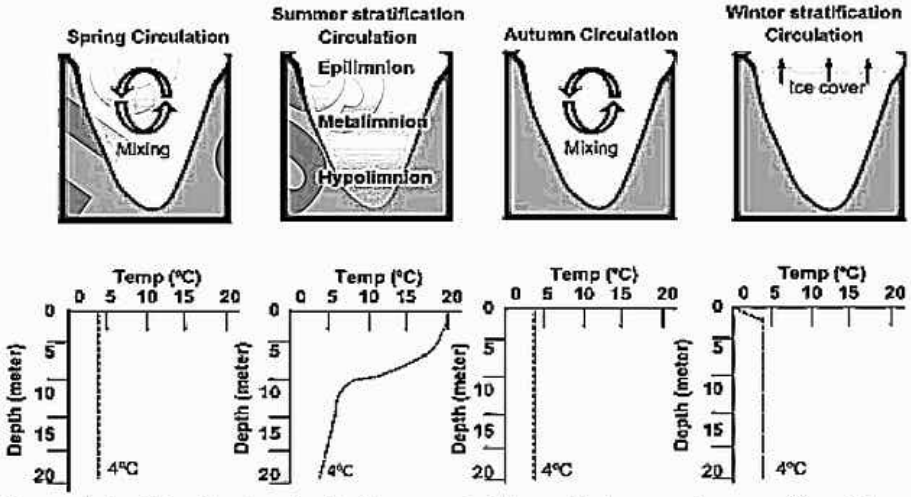

Fig.: Thermal stratification in a typical temperate lake with temperature profile of the water

Warm water fish grow best at temperatures between 25 o C and 32 o C. The water temperatures remains in this range the year around at low altitudes in the tropics, but in temperate regions water temperatures are too low in winter for rapid

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