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Fishery Oceanography

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The ocean in itself is not a homogeneous medium although it is a single phase environment. The temperature, the amount of dissolved organic and inorganic matter, the amount of dissolved gases and the physical nature of the ocean are subject to various changes seasonally and regionally. The climatic conditions of the atmosphere also affect the ocean and the exchange of energy between the sea and the atmosphere is also important in this respect. The *in situ* changes in the ocean affect the production of planktonic organisms which form the food material for the fish. The spatial differences in the mass distribution of the oceans which can be estimated from temperature and salinity, give rise to ocean currents, which help the transport of fish eggs and larvae and which affect the movements of adult fish also. Thus the fluctuations in the environmental conditions have a profound influence on the aperiodic and seasonal migrations and occurrence of fish. Furthermore, the conditions in the aquatic environment and their changes influence the recruitment, survival and growth of fish. The environment also interferes with such biological activities as spawning and growth. Thus, for instance, the survival and abundance of all the food specimens of fish are affected by the environmental factors most decisively. Oceanography, which deals with the study of the physics, chemistry, as well as the biology of the oceans, is thus indispensable for the study of fishery conditions in a particular region.

The pursuit of all oceanographic studies have had as its objective the exploitation of the resources of the seas for the benefit of mankind. It would be interesting to recall, curiously enough, that the studies started in the wake of charting sea routes for the fabulous riches of the east, when incidentally the ships sounded the depths of the sea. The first remarkable cruise solely devoted for oceanographic studies was that of the *CHALLENGER* in 1872 under the leadership of Sir Wyville Thompson. Since the beginning of this century there have been several more expeditions with more sophisticated equipments on board. Amongst these are those of the *VALDIVIA* sponsored by Germany; the *DISCOVERY I & II* and the *WILLIAM SCORESBY* into the Antarctic and in the near past *GALATHEA* visited our seas. By the close of the last century various nations had recognized the importance of oceanographic investigations and extensive researches were started in many of them. In this connection it is worth mentioning here the formation in 1901, of the International Council for the Exploration of the Seas with its headquarters in Charlottenlund near Copenhagen, to promote cooperation between the countries of Europe in the researches of the sea.

The first person to give a general feature of the surface conditions and pattern of circulation in the Indian Seas was the late Col. R. B. Seymour-Sewell. Hydrological studies were started in the Central Marine Fisheries Research Institute as early as in 1947, but the observations were restricted to localised shallow stations off Calicut, Bombay,

Cochin, Madras and Mandapam Camp. A hydrographic survey of the shelf waters was carried out along the east coast of India by Prof. E. C La Fond, during the years 1952–53 and 1956-57. But, detailed systematic studies along the west coast where nearly 80% of the marine fish catch is landed was initiated by the Central Marine Fisheries Rasearch Institute in September 1957, with the co–operation of the Indo–Norwegian Project, Ernakulam. The first vessel to be utilised for oceanographic research work was *M. O. KRISTENSEN*, but due to the unsatisfactory condition of the vessel it was condemned and replaced by *R. V. KALAVA*. The latter vessel was used till December 1961. During this period, observations were made in the area Cape Comorin – Mangalore, and the Laccadive region. The fully equipped research vessel *VARUNA* arrived in December 1961. This enabled an extension of the area of investigation and the duration of the research cruises. 674 oceanographic stations were worked out along the west coast in the Arabian sea by *M. O. KRISTENSEN* and *R.V. KALAVA* in 63 cruises, and nearly 2950 stations have been worked out by *R. V. VARUNA* in 104 cruises till now.

Of all the environmental factors temperature plays an important role to influence the behaviour of fish. The sense of temperature in fish seems to be well developed. There are tolerable limits of lowest and highest temperature, beyond which fish may no longer survive. Another thermal feature which affect the vertical migration of fish is the thermocline. The latter is defined as a layer within the sea where rapid decrease in temperature occur in the vertical, downwards. Above this thin layer, the waters are usually warm and also rich in dissolved oxygen content, which conditions are favourable for the pelagic fishes.

The major commercial fisheries like those of the sardine, mackerel and prawns along the west coast of India exist within the continental shelf. During post monsoon season and subsequent months the waters over the continental shelf are warm (temp. range 27–29°C roughly) and sardines generally appear along the west coast by the end of monsoon or the beginning of post monsoon. From a preliminary study it is observed that the fishery starts from the south, gradually proceeding northwards. The warm waters after the monsoon period seem to be favourable for these pelagic fishes and never is found a thermocline within the shelf during this period viz., November–May. These more or less isothermal waters are rich in oxygen content also. Such conditions are in general found to be favourable for these fisheries. The peak sardine fishery seems to be in November and December in the south generally, while December and January are the months in which peak fishery in the north occurs During late November and December it could be said that winter conditions exist along the west coast when the waters are cooler than the following summer. Sinking of the offshore waters over the continental shelf also occur, and this phenomenon defined as convergence cause dynamically a concentration of zooplankton and an accompanied concentration of fish. Figuratively, one may say that there is an accumulation of everything on the convergence zones, from plankton to fishermen. Drastic changes in temperature affect the fishes in an adverse manner and thus during the year 1962 a predominent failure in the sardine and mackerel fishery occurred. Considerable investigations have been done on this problem. However, the failure in the mackerel fishery may perhaps be due to an increase of the surface temperature which occurred during that year.

The demersal fisheries along the west coast after the monsoon are also good. R. V. *VARUNA* is regularly conducting bottom trawling along the west coast during the various seasons.

Now coming to the conditions existing during the monsoon and post monsoon periods the following points can be noted. From the year 1962 onwards, regular research cruises are conducted during the monsoon season also, along the west coast. During the above season a considerable amount of upwelling takes place along the entire west coast. This process can be primarily defined as the incursion of offshore subsurface waters into the continental shelf. Thus the temperature of the waters within the shelf is considerably reduced and the whole of the shelf (the major fishing zone) is filled with very cold oxygen-poor waters. Sometimes the intensity of the process is so high that a decrease of nearly 7°C occur at the upper layers, (5, 10, 20 m etc.) than the preceding summer. During the period of upwelling the demersal fishes will try to escape the oxygen poor cold waters, and either migrate to upper layers or to the shoreside waters inside 4–5 fathoms depth, where saturation takes place due to vertical mixing by wind and wave action. Similarly the pelagic fishes like sardine and mackerel are also found to escape the normal fishing zones.

The drastic decrease in the temperature of the environment can be attributed as a probable cause for the above phenomenon, combined with the depletion in oxygen content. The intense rough nature of the sea may also be a probable cause. The upwelling has been defined as vertical migration of the deeper waters, and this may produce vertical accelerations and this turbulence helps in the replenishment of the upper layers by nutrients from below. Preliminarily this may cause the formation of mud-banks along the coast, at localised areas. The fishery near the mud-banks during the monsoon also is good, and may be attributed to the calm conditions prevailing near the mud-banks and due to the oxygen enrichment due to the shallow depths.

Within the sea the temperature decreases depthwise and the nutrient contents (such as phosphate, nitrate, silicate etc.) generally increase. The nutrient contents are important for the primary production in the sea. As mentioned earlier, the upwelled nutrient rich water is thus fertilizing the coastal waters and form a feeding area for plankton organisms, which again form the food stock for the commercially important fishes. The monsoon period of the year 1962, gave pronounced upwelling between Beypore and Mangalore along the west coast. Thus one may expect the area mentioned to be the most productive regarding food stock and therefore, it should also be expected to give the best fishing possibilities in the post monsoon period by which time the aeration of the waters is complete. The intensity of upwelling and its duration will change from year to year and region to region. Thus, mechanized fishing operations in the area off Cannanore has proved to be better during the post monsoon period of the year 1962 than in the South Malabar coast during the same period.

The theory of the influence of upwelling has to be verified with observations during subsequent years and such regular studies are being conducted by the Central Marine Fisheries Research Institute. With a close follow up of the theories however, a valuable prediction of the fishing possibilities of the commercial fishing fleet may be

obtainable. In general it may be said that in the premonsoon period of the year 1962, shoals were mostly registered within a distance of approximately 10 nautical miles from the coast. During the monsoon period, considerable shoals of fish were observed at surface layers all along the coast, with the best registration in the area southwest of Alleppey and between Cochin and Calicut.

From the investigations carried out by R. V. *VARUNA* a large convergence zone has been found during the early winter (late November) along the 8°N latitude, around the 74°E meridian. As mentioned earlier, these convergence zones form suitable spawning grounds for the fishes and an area where zooplankton production may be high. The hypothesis based on catch data that sardines first appear in the south, may thus be primarily correlated with the above mentioned convergence zone, but more data is necessary to confirm the above.

The sunlight penetrating from the surface through various layers of the sea is important from the viewpoint of the fundamental production. It is by utilising the light energy, that the phytoplankton of the sea produce for themselves the carbohydrates by photosynthesis. The limitation of penetration of sunlight in the sea puts a natural limit to the primary production. The latter in oceanic waters is directly correlated with the optical nature of the water masses, optically clear water being less productive and the turbid water being highly productive. Light measurement studies of the Arabian Sea are being done on board R. V. *VARUNA* by the Central Marine Fisheries Research Institute, likewise primary production studies also using the radioactive isotope of carbon viz., ^{14}C.

It appears from observations that every species of fish has a particular optimum light intensity where the activity of the fish is at maximum. Fishing with different gear also is affected by conditions of light. It is due to the scattering of light from an object that the fish can perceive it. There must be sufficient day light for the bait of longline to be visible, to attract the fish in turbid waters. Fish like Tuna can avoid gill nets if they are visible.

The response of fish to currents depends upon the factors like the manoeuvara bility of the fish to resist movement, their swimming capacity and the stress of the current. Some observations on herrings in the high latitude waters suggest that they were stemming the current at the swimming speed of a few knots, although they were being carried along with the current. In light, fish swim against the current and in darkness they drift with it Large eddies keep the larvae and fish eggs concentrated at a particular locality. From the investigations done by the research vessels *KALAVA* and *VARUNA* around the Laccadives, it has been observed that around the islands there exist circulatory movements upto a notable depth (100-200 m from the surface and these help to maintain the highly productive waters in the vicinity of the islands, thus contributing to the rich fisheries that are found in the Laccadive area. Several fish species concentrate in the centres of eddies and this refers to spawning in some cases. It is observed that feeding pelagic fish usually move with the water masses. Along the west coast it is found that the currents are mainly southwards during the monsoon and postmonsoon seasons, and mainly northwards from December to February. This probably influences the movement pattern as well as regional intensity of

fishing of sardine as referred earlier. As a preliminary step, it may happen that the fish migrate along with the northward current and this may be the reason for the time lag in the sardine fisheries along the west coast. Now that the Central Marine Fisheries Research Institute has initiated tagging programme to study the migration of the pelagic fishes, this may throw more light on the fluctuation and the regionwise variation in the pelagic fishery.

The salinity variations mainly depend upon rainfall, run off from rivers and evaporation at the sea surface. These variations affect the buoyancy of the pelagic eggs and the osmotic regulations of the fish. The salinity maximum found along the west coast during the winter and summer seasons, may act as a buoyant barrier for the vertical migration of the eggs and fish. It is also observed that this salinity maximum layer usually coincides with the thermocline. The position of these two layers viz, the thermocline and the associated salinity maximum zone are important from the view point of the vertical distribution of the buoyantly floating eggs and larvae of the pelagic fish, which are affected by the vertical turbulence occurring in the mixed layer above the thermocline. This zone, so to say, is a barrier making it for some fish to pass through because of the temperature contrast of the water bodies within the thermocline, as well as the consequent density contrast which affect the buoyancy.

The pH observations from an important part in fishery oceanographic studies The pH generally encountered in the sea ranges from 7 5 to 8.4, that is the sea water is generally alkaline. pH below 7 indicates that the water is acidic, and pH 7 indicates neutral water. High pH values are associated with the photosynthetic removal of carbon dioxide. From observations made on board R. V. *VARUNA*, it has been observed that the mixed layer above the thermocline has always high pH ranging from 8 to 8. 3, during the period of summer. This range thus seems to be suitable for the pelagic fishes is general. The dis continuity in pH in the vertical, always coincides with the discontinuity in temperature-Fishes in general are able to detect slight changes in pH values and the actively migratory, fish such as sardine and mackerel are more efficient in this respect. Scientists in other countries have actually proposed an optimum pH range for particular species.

Thus the fishes and fisheries are very much influenced by the oceanographic conditions in the sea. During recent years the importance of oceanography in fisheries had come to be fully recognized. Several countries in the west and Japan in the east have by many decades of intensive research, come to a state when they could forecast the prospects of a fishery much ahead. In this respect we are still at the infant stage and much work has to be done in our waters to help solve the problems connected with two of our main fisheries viz., the oil sardine and the mackerel. More and more oceanographic as well as fishery data are being collected and intensive correlation studies are being made. The observations from the International Indian Ocean Expedition during the period 1961–1965 may also throw light on the fishery aspects of the Indian Ocean. The studies are in vogue in the Central Marine Fisheries Research Institute, on the west coast of India on all aspects of oceanography. Thus, fishery oceanography investigations are quite essential in any large scale fishery investigations and these studies have to be of a continuing nature, the sea being a dynamic aquatic environment.