THE SEASONAL DISTRIBUTION OF SOME OCEANOGRAPHIC PARAMETERS OFF SOUTHWEST COAST OF INDIA RELEVANT TO PELAGIC FISHERIES

A. V. S. MURTY AND M. N. VISHNUDATTA

Central Marine Fisheries Research Institute, Cochin-682018.

ABSTRACT

The temperature, salinity and oxygen distributions associated with the thermocline of the shelf and adjacent waters off the southwest coast of India are presented seasonwise. The seasonal differences in the location of the thermocline and the magnitude of the vertical temperature gradient within the thermocline are also presented and discussed. The commercially important pelagic fisheries of the waters are also discussed in the light of environmental conditions.

INTRODUCTION

Hydrographic conditions of the upper mixed layer play a dominant role in the behaviour of the pelagic fishes and hence their fisheries. Murty (1965) studied the behaviour of the mixed layer and thermocline off the southwest coast of India. Sharma (1966) correlated the seasonal changes of the level of discontinuity layer with vertical motions (upwelling and sinking). Banse (1968) reviewed the hydrography of the region with a view to detecting the influence of upwelling on the demersal fisheries. We make an attempt here to correlate the pelagic fisheries for oil sardine and mackerel with temperature, salinity and oxygen conditions of the waters associated with the thermocline off the southwest coast of India.

MATERIALS AND METHODS

The hydrographic data collected from R. V. VARUNA during 1964-70, from a stretch of about 100 nautical miles across the coast from Cape Comorin to Mangalore are utilised for the present studies. Since our interest is centered on the pelagic fisheries, the conditions of temperature, salinity and dissolved oxygen prevailing on the top of the thermocline are considered. In order to simplify the picture, the year is divided into three different seasons: spring (March-May), monsoon (June-September), and winter (November-February). The month of October is omitted as it forms the transition period between monsoon and winter. The location of the thermocline (the depth at which the top of the thermocline lies) and the intensity of the thermocline (the magnitude of the vertical gradient of temperature within the thermocline) are determined from the vertical distribution of temperature at different stations.

The published data on the oilsardine catches from the Calicut region for 1955-59 (Sekharan 1962) and mackerel catches for the different years from Vizhinjam, Calicut and Mangalore (C.M.F.R.I. Bulletin, No. 24, 1970) are taken into consideration in the present studies.

OBSERVATIONS AND DISCUSSION

Physical and chemical properties associated with thermocline

Fig. 1 shows the temperature and salinity conditions above the thermocline (upper mixed layer). The premonsoon (spring) period is characterised by moderate salinity values and high temperature. Relatively lower temperatures with wider salinity range are seen during monsoon season. By winter, the

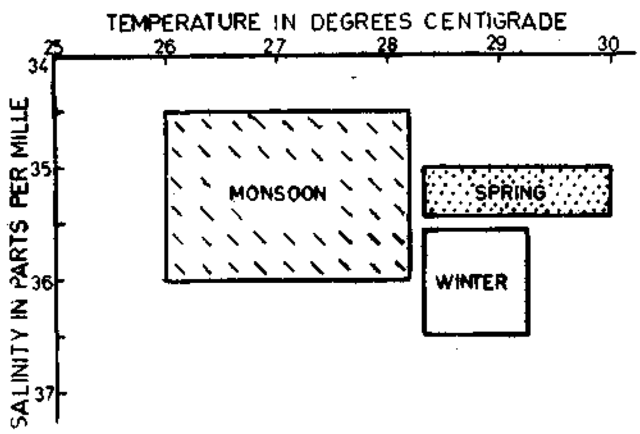

FIG. 1. Temperature and salinity conditions associated with thermocline.

waters assume moderate temperature and relatively higher salinity values. In Fig. 1, for the three seasons, the marginal overlappings of the three blocks are ignored for the sake of simplicity. However, it may be interesting to note that there is no considerable reduction of the spring temperature from 28°C. The monsoon temperatures may increase to 28.5°C. The winter temperatures may reach down to 27.5°C. The spring salinity values exceeding 35.5‰ are negligible. The winter salinities lower than 35.2‰ are also negligible. The influence of dilution due to rainfall and the effect of upwelling are responsible for the greater range of salinity during the monsoon season, while the lower temperature may be due to the combined effect of cloudiness and cooling caused by upwelling. The temperature spread of the spring may be the result of the influx of heat from the sun and atmosphere.

From the fishery oceanographic point of view, the depth of the thermocline is an important physical parameter, as the thermocline serves as a barrier between the warm, oxygenated, less-saline mixed layer and cooler, less-oxygenated, and more saline deeper waters. From the dynamics point of view, it is a boundary layer separating the less stable water from the more stable water. The intensity of thermocline, i.e., the rate of fall of temperature with depth within the thermocline, would be interesting for studies of stability of thermocline itself. The more intense is the thermocline, the stronger would be the barrier. Periodic fluctuations of the order of less than a day, which appear to be closely related to the internal tides, are observed in the magnitude of the vertical thermal gradient within the thermocline in the coastal waters (Cairn 1968). Sharp difference in the optical properties (e.g., irradiance) of the sea water is associated with the thermocline positions and intensity (Boden *et al* 1960). The isopleths of sound velocity follow closely the corresponding isotherms (Ramasastry and Ramamirtham 1960) with a sharp negative gradient of sound velocity with depth within the thermocline. Hence the location and intensity of thermocline find an application in sonic methods of fishing.

Fig. 2 illustrates the range of depth at which the thermocline begins and also its intensity during the three different seasons of the year. The thermocline is located very close to the surface during monsoon period and it is

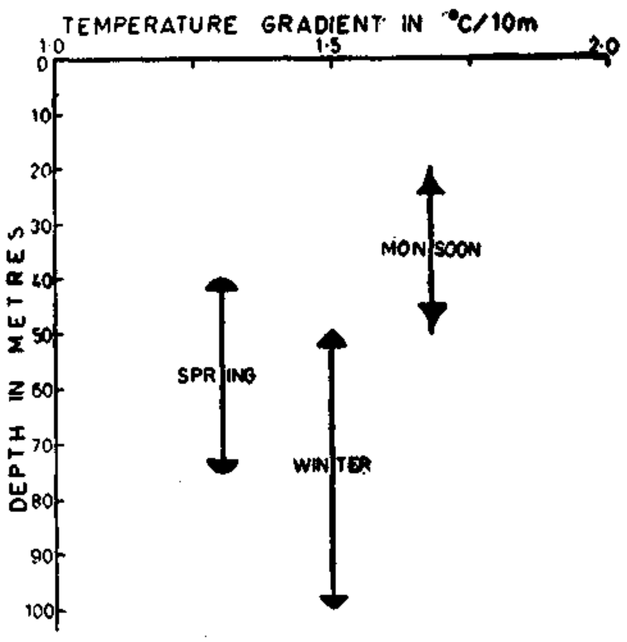

FIG. 2. Depth and intensity of thermocline.

deeply embedded during winter. The top of the thermocline is usually located at depths of 40-75 m during spring, 20-50 m during monsoon, and 50-100 m during winter. The thermocline intensity is about 1.3°C|10 m during premonsoon season. It attains greater stability in monsoon, with an intensity of about 1.7°C|10 m. The intensity is moderate, with 1.5°C|10 m, during winter.

From the analysis of the data of R. V. ATLANTIS, collected from the Arabian Sea during August-September 1963, Sastry and D'Souza (1970) found that the thickness of the surface mixed layer varied between 40 and 50 m off the west coast of India, which gradually increased to 100 m in the Central Arabian Sea.

From the Oceanographic Atlas of I.I.O.E. (Wyrtki *et al* 1971), where the computer-plotted maps of bi-monthly data of depth of mixed layer are given, it may be inferred that the mixed-layer depths in southeast Arabian Sea are 40-60 m during March-April, less than 20 m during July-August and about 60 m during Nevember-December. The intensities of vertical temperature gradients in the thermocline, per 10 m, during the above three bi-monthly periods are 3°C, 2-3°C, and 2-3°C or even less, respectively.

If the vertical temperature gradient of the thermocline is approximated by the temperature difference between the surface and 100 m minus one degree centigrade, as was attempted by Wooster *et al* (1967), in the data presented by them for the southeast Arabian Sea, the mean thermal gradient of the discontinuity layer would be 4.4°C, 5.5°C and 5.6°C, respectively, for the three seasons.

Sharma (1968) presented the vertical time sections of temperature from five different sections off the west coast of India. If 25°C isotherm may be chosen to represent the thermocline depth, the corresponding depths for the three bi-monthly periods of March-April, July-August and November-December are respectively 100 m, 20 m and 85 m. Further, from an arbitrary selection of vertical spacing between two isotherms of 25°C and 20°C, the vertical (negative) gradients of temperature in degree centigrade per 10 m within the thermocline are 1.4, 0.9 and 1.1, respectively, for three periods.

However, the comparative values of thermocline depth and intensity from the foregoing observations should be derived with caution as different authors have employed different methods in these observations.

Fig. 3 shows the percentage frequency of dissolved-oxygen concentrations in the mixed layer. Except in localities of strong upwelling, where the concentration of the dissolved oxygen gets depleted to a critical level, the oxygen concentration in the mixed layer, in general, will not be a limiting factor for occurrence of pelagic fishes. Oxygen concentrations as high as 4 ml|l, or even more, are commonly encountered in all the three seasons. The frequency distributions of oxygen concentration are amazingly identical in all the three seasons of the year, the range of distribution being 1.0-5.5 ml|l. The occurrence of values lower than 3.5 ml|l and above 5.0 ml|l are, however, insignificant, their frequencies being less than 10 percent.

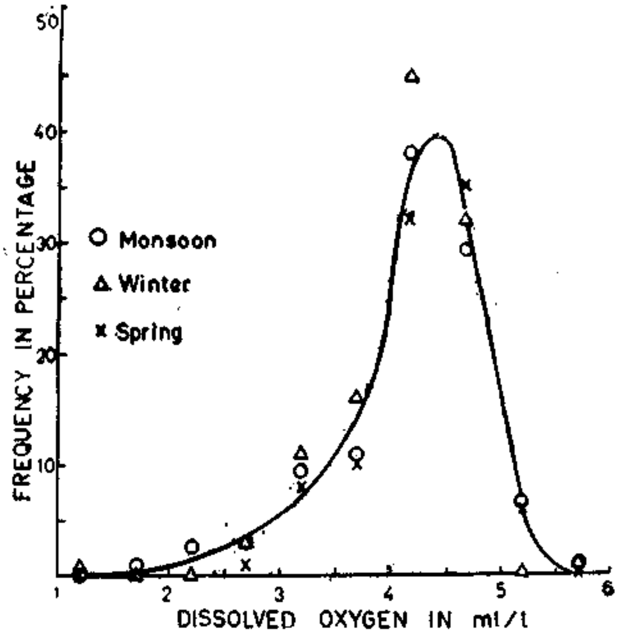

FIG. 3. Frequency distribution of dissolved oxygen.

Primary production

The rates of primary production in the waters off the southwest coast, between Karwar and Cape Comorin, are given as 1.54g C|m^2|day during monsoon, 0.32g C|m^2|day during winter and 0.09g C|m^2|day during spring. The monsoon productivity is as high as 5 times the winter productivity.

Based on the displacement volume of phytoplankton in the 75m-to-surface vertical hauls over the shelf and adjacent waters off the west coast of India during 1963-64, Subrahmanyam *et al* (1971) arrived at the values: 9.7 ml/m^2 during winter, 15.9 ml/m^2 during spring and 25.1 ml|m^2 during monsoon.

The oilsardine fishery

The annual distribution spectrum of oilsardine fishery is shown in fig. 4. The total annual catch is taken as unity and the catch corresponding to each month as fraction thereof (the actual annual landings were smoothed freehand and reduced to unity). The spectral distribution clearly shows the winter as the season of abundance and minimum catch or no catch during monsoon and spring. The monsoon is the period of spawning of oil sardine and the spawning activity is related to the intensity of rainfall (Antony Raja 1969). The lowered temperature and salinity conditions prevailing during the period may be the causative factors of spawning.

The behaviour of the oil content of oilsardine is interesting when viewed in relation to oceanographic conditions. Sen and Cheluvaiah (1968) and Sen and Revankar (1972) found that the fat content and body moisture are governed by an inverse relationship, namely, fat (per cent) + 0.9714 moisture (per cent) = 75.67. They have found that the fish have maximum fat (and minimum moisture) during monsoon. The seasonal variations of lipid content in the muscle of oilsardine were studied by Gopakumar (1965, 1973) and in his observation, the lipid content during winter is about 3 times to that of monsoon and during spring it is slightly less than that of monsoon.

Mackerel fishery

The spectral distribution of mackerel fishery (Fig. 4) is similar to that of oilsardine, with abundant catch during winter and minimal or no catch during monsoon and spring. The spectral distribution of mackerel dominates that of oilsardine during winter and a reverse situation happens during the premonsoon (spring) season, though it is identical during monsoon period.

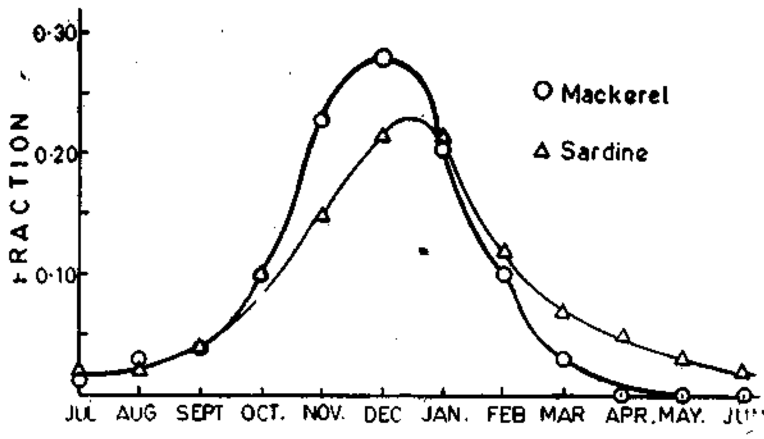

FIG. 4. Annual spectra of fisheries.

However, the spectral distribution of both the fisheries does not exceed 5% level during spring and monsoon. Regarding the spawning season of mackerel, different authors have different opinions (C.M.F.R.I. Bulletin No. 24, 1970). However, from the observations of George and Banerji (1967), mackerel attains an age between 1 to 5 months during monsoon, 6-10 months during winter and above 10 months during premonsoon. By extrapolating these observations, we may conclude that the premonsoon period (probably April-May) would be the spawning season of the mackerel.

CONCLUSION

The behaviour of the plankton, primary production, the fisheries of oil-sardine and mackerel, and the biochemical quality (fat|lipid content) of oil-sardine when viewed with the oceanographic conditions prevailing off the west coast of India in the background, it appears that the primary production is inversely proportional to the temperature. The oilsardine is rich in fat and lipid content in winter when the water has high salinity. The spawning of oilsardine and mackerel is nevertheless not associated with high salinity. The fisheries of these two pelagic fishes are associated with high salinity and moderate temperature, and deeper thermocline. In the light of the present observations, the dissolved-oxygen content of the mixed layer has identical distributions over the seasons and hence this parameter may be regarded ineffective of the changes in the pelagic fisheries. These conclusions are, however, of essentially a general nature, requiring confirmative evidence from carefully recorded observations on physiological behaviour of the fishes concerned in changing conditions of the environment.

ACKNOWLEDGEMENTS

The authors are grateful to Dr E. G. Silas, Director, C.M.F.R. Institute for his constant encouragement in this work.

REFERENCES

ANTONY RAJA, B. T. 1969. The Indian oilsardine. *Bull. cent. mar. Fish. Res. Inst.*, **16**: 32.

BANSE, K. 1968. Hydrography of the Arabian sea shelf of India and Pakistan and effects of demersal fishes. *Deep Sea Res.*, **15**: 45-79.

BODEN, B. P., E. M. KAMPA AND J. M. SNODGRASS. 1960. Underwater daylight measurements in the Bay of Biscay. *J. mar. biol. Ass. U.K.*, **39**: 227-238.

CAIRNS, J. L. 1968. Thermocline strength fluctuation in coastal water. *J. geophys. Res.*, **73**: 2591-2595.

GEORGE, K. C. AND S. K. BANERJI. 1967. Age and growth studies on the Indian mackerel, *Rastrelliger kanagurta* (Cuvier) with special reference to length-frequency data collected at Cochin. *Indian J. Fish.*, **11**: 621-638.

GOPAKUMAR, K. 1965. Seasonal variation in lipid composition of oil sardine (*Sardinella longiceps*). *Indian J. Fish.*, **12**: 1-5.

GOPAKUMAR, K. 1973. Studies on marine lipids. (Ph.D. thesis submitted to the University of Kerala.)

MURTY, A. V. S. 1965. Studies on the surface mixed layer and its association with thermocline off the west coast of India and the influences thereby for working out a prediction system of the pelagic fisheries of the region. *Indian J. Fish.*, **12**: 118-134.

NAIR, P. V. R., SYDNEY SAMUEL, K. J. JOSEPH AND V. K. BALACHANDRAN. 1973. Primary production and potential fishery resources in the seas around India. *Proc. Symp. Living Resources of the seas around India*, CMFRI spl. publ.

RAMASASTRY, A. A. AND C. P. RAMAMIRTHAM. 1960. Velocity of sound in the Arabian Sea along the south Malabar coast during postmonsoon season. *Indian J. Fish.*, **7**: 394-406.

RAO, K. V. NARAYANA. 1970. The exploitation. *In*: The Indian Mackerel. *Bull. cent. mar. Fish. Res. Inst.*, **24**: 55-77.

SASTRY, J. S. AND R. S. D'SOUZA. 1970. Oceanography of the Arabian Sea during south-west monsoon seasons. Part I Thermal Structure. *Indian J. Meteorol. Geophys.*, **21**: 367-382.

SEKHARAN, K. V. 1962. On the oil sardine fisheries of the Calicut area during the years 1955-1956 to 1958-1959. *Indian J. Fish.*, **9**: 679-700.

SEN, D. P. AND G. L. CHALUVAIAH. 1968. Seasonal variation in the amount of oil and characteristics of the oil sardine (*Sardinella longiceps*). *Fish. J. Fd. Sci. Technol.*, **5**: 117-122.

SEN, D. P. AND G. D. REVANKAR. 1972. Seasonal variation in the amount of oil of oil sardine (*Sardinella longiceps*). *Fish. J. Fd. Sci. Technol.*, **9**: 93.

SHARMA, G. S. 1966. Thermocline as an indicator of upwelling. *J. mar. biol. Ass. India*, **8**: 8-19.

SHARMA, G. S. 1968. Seasonal variation of some hydrographic properties of the shelf waters off the west coast of India. *Bull. Nat. Geophys. Res. Inst.*, 38: 263-276.

SUBRAHMANYAN, R., C. P. GOPINATHAN AND C. THANKAPPAN PILLAI. 1971. Phytoplankton of the Indian Ocean: Some ecological problems. Presented to the Symposium on Indian Ocean and Adjacent seas held at Cochin 12-18 January 1971 by the Marine Biological Association of India.

WOOSTER, W. S., M. B. SCHAEFER AND M. K. ROBINSON. 1967. Atlas of the Arabian sea for fishery Oceanography. University of California Institute of Marine Resources La Jolla California, 22 pp.

WYRTKI, K., E. BENNET AND E. J. ROCHFORD. 1971. *Oceanographic Atlas of the International Indian Ocean Expedition.* The National Science Foundation Washington, D.C., 531 pp.