Fish. Technol. (1980) 17, 79-86

Hydrography of Fishing Grounds of Arabian Sea off Mangalore

MATHEW M. MALIEL,* P. K. SALIAN, N. R. MENON** and H. P. C. SHETTY
University of Agricultural Sciences, College of Fisheries, Mangalore-575 002

Hydrographical parameters, namely temperature, salinity, dissolved oxygen and density of the fishing grounds off Mangalore extending over an area of *ca* 850 km² have been studied during March 1976–March 1977. Twelve stations along three transects up to 50 m isobath were located for sampling. The vertical distribution of temperature show three distinct phases, namely, a period of conspicuous variation, a short intermediary phase and a period of thermal stability. The dissolved oxygen of the bottom waters was drastically low during September. Salinity fluctuations were not considerable between months and depths. Dense waters existed over the shelf region, especially along the bottom during September and to a certain extent in October also. The distribution patterns of temperature, dissolved oxygen and density clearly indicate the movement of cold, dense, oxygen-poor bottom waters from greater depths to the upper reaches of the shelf during September.

Information on the hydrography of any area with reference to its direct bearing on fisheries should be an important aspect of fisheries hydrography. Probably, the work of Banse (1959) is an important step in this direction. His studies have shown that some direct correlations exist between the appearance and disappearance of demersal fishes and the hydrography of the west coast of India. Similarly, the importance of oxygen-minimum layer and its effect on the marine biology of the waters off the west coast of India were delineated by Carruthers *et al.* (1959). Pradhan & Reddy (1962) stressed the importance of temperature-salinity conditions to explain the fluctuations in the abundance of mackerel. Banse (1968), with documented evidence, tried to substantiate the concept that the hydrography of the Arabian Sea has a profound influence on the trawl fishery. Sankaranarayanan & Qasim (1968) found that the lowest fish and prawn catches in the Cochin area coincided with minimum temperature and oxygen content of the waters. Murthy (1969) attempted to work out a prediction system for pelagic fishery based on the mixed layer and the thermocline off the west coast of India. Noble (1972) observed a relation between the duration of mackerel fishery and surface temperature in the inshore waters off Karwar.

A few important works, although not directly treated under fishery hydrographic investigation, that could give detailed information on the hydrography of the west coast of India are those of Jayaraman *et al.* (1960), Ramamirtham & Jayaraman (1960), Neyman (1961), Ramamurthy (1963), Patil *et al.* (1964), Banse (1972), Sastry (1973) and Gangadhara Rao *et al.* (1974). These works provide information on hydrography in general, changes in the hydrographical structure brought about by the combined effects of monsoon and upwelling, distribution of oxygen-minimum layer in the surface waters and upsloping of isotherms.

Materials and Methods

The region explored covered 850 km² of the Arabian Sea along the coast of South Kanara, between Suratkal in the north and Someshwar in the south, extending up to 50 m isobath. The area investigated lies between long. 74′ 25°E & 74′ 51°E and Lat. 13°N & 12′45°N. Twelve sampling stations were distributed along three

---

Present address. *Australian National University
Canberra, Australia
**Asmara University
Asmara, Ethiopia

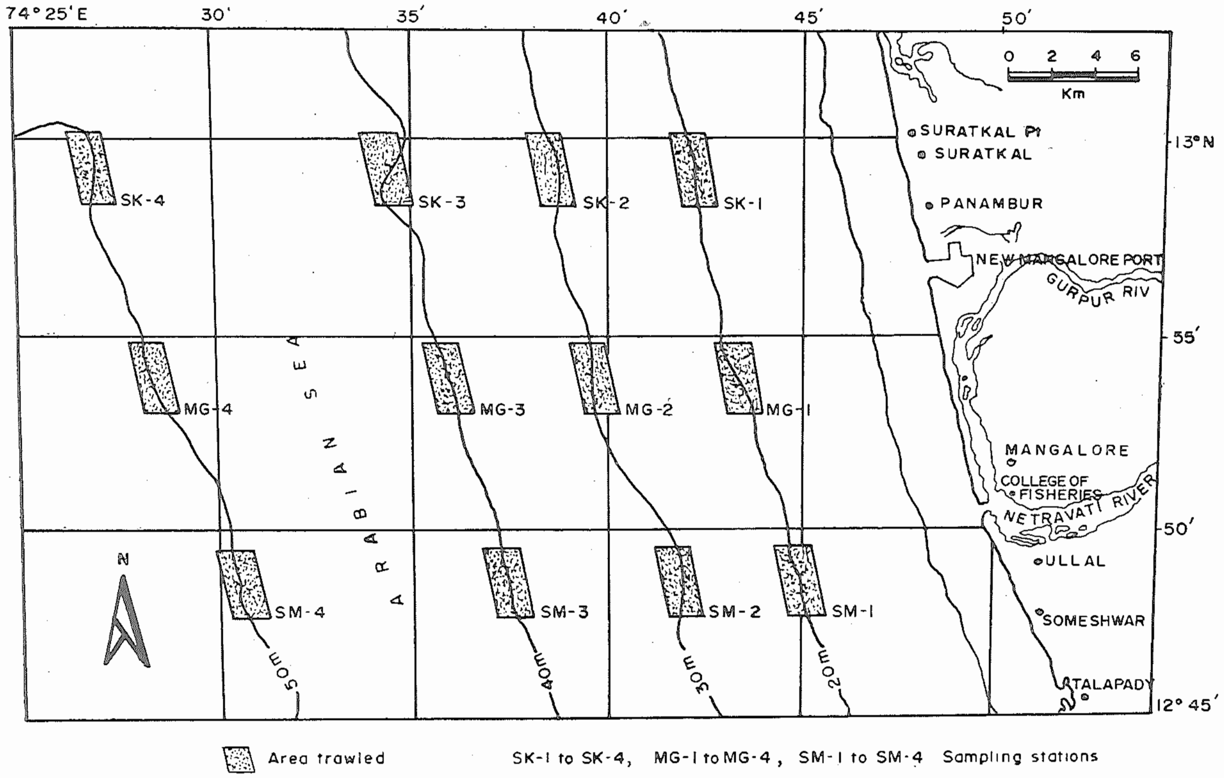

Fig. 1. Area of investigation showing the location of sampling stations

transects off Suratkal, Mangalore and Someshwar at four depth zones, namely, 20, 30, 40 and 50 m (Fig. 1).

The sampling started in March 1976 and concluded in March 1977. Owing to very rough weather, no sampling could be made during June, July and August. The 12 stations in the area were covered once in a fortnight by two sampling days. At each station water samples were drawn at 10 m intervals from surface to bottom. Subsurface water samples were taken with the help of a Nansen's reversing water bottle. Temperature was recorded with an ordinary mercury-in-glass thermometer immediately after tapping the water from the bottle. Salinity and dissolved oxygen were estimated following standard analytical procedures. Density of the water was computed.

Results and Discussion

Temperature of surface and columnar waters of the various stations distributed along the different transects is presented in Figs. 2a to 2c. It may be seen from the figures that comparatively cooler waters existed only during September. The lowest value recorded was 22.3°C at 20 m depth off

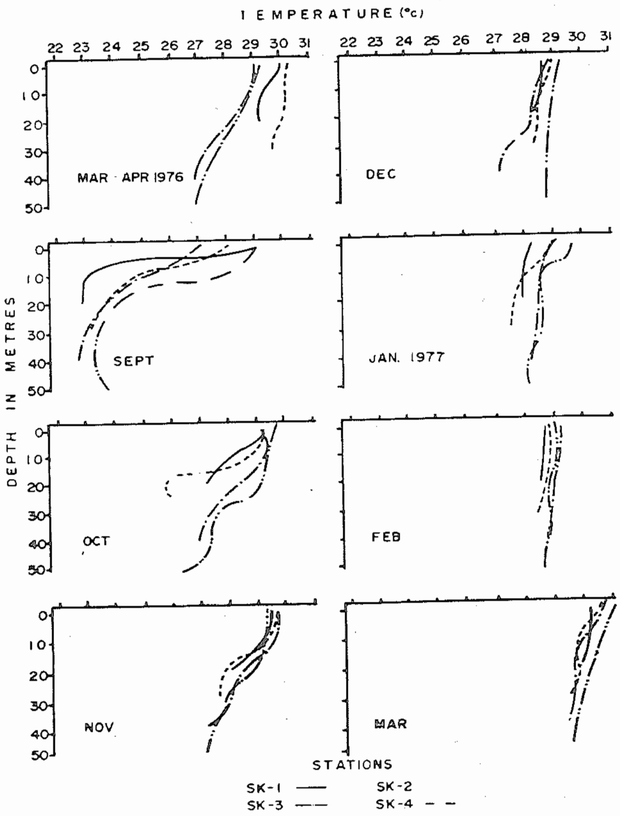

Fig. 2a. Vertical distribution of water temperature off Suratkal

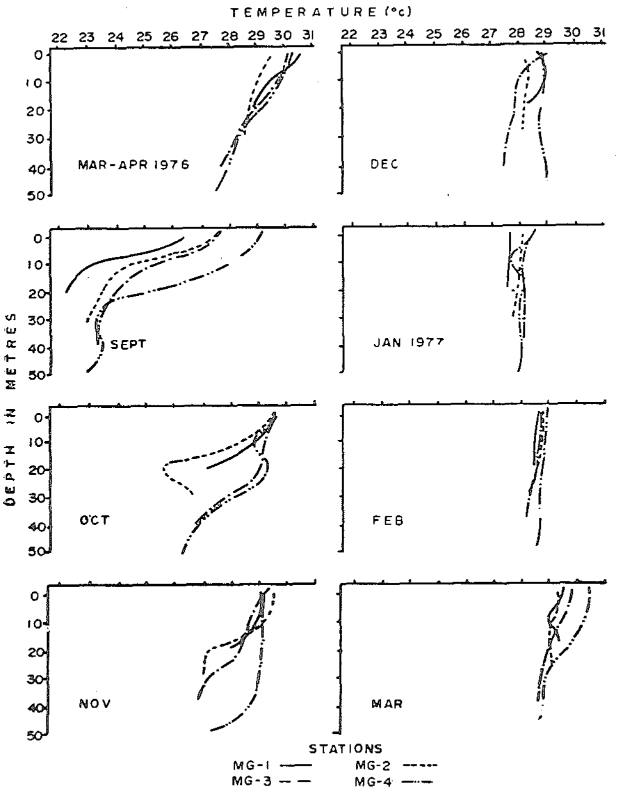

Fig. 2b Vertical distribution of water temperature off Mangalore

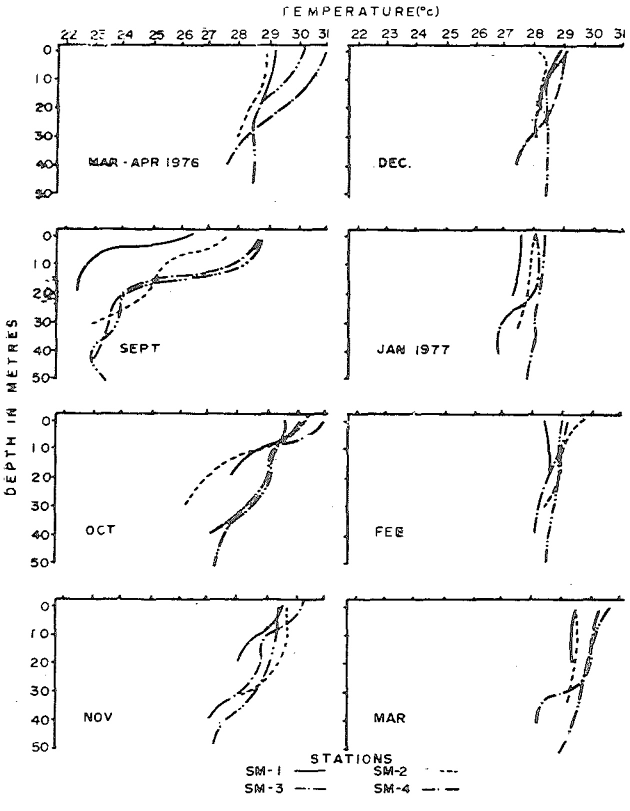

Fig. 2c. Vertical distribution of water temperature off Someshwar

Mangalore in September. The total fluctuation was 8.6°C which, considering the geographical location of the area, is conspicuous. It is clear from the figures that the premonsoon months showed very little fluctuation between stations or depths.

Distribution of salinity at the various depths along the three sections is presented in Figs. 3a to 3c. The surface waters of stations towards the coast showed only negligible reduction in salinity during September. A gradual increase in salinity was depicted towards the bottom. The nonmonsoon months experienced waters of higher salinity at all depths. It could be seen from the salinity figures that the premonsoon period, especially February, March and April, had lesser vertical gradient in salinity. Although the Mangalore and Someshwar sections are situated near the Gurpur-Netravati estuary, the freshwater run off does not seem to influence the salinity of deeper waters conspicuously.

Dissolved oxygen showed clear-cut seasonal and bathymetric variations is evident from Figs. 4a to 4c. The maximum range of variation was observed during September, when the bottom waters, particularly those beyond 20 m depth, had uniformly low values along all sections. In one instance during this month, a total lack of dissolved oxygen at 40 m depth off Suratkal was observed. The general reduction in oxygen at greater depths was found to continue at this area even after September. Oxygenation of deeper waters occurred only after a lapse of two to three months. The nonmonsoon months had well-oxygenated waters at various depths.

Denser waters were encountered at depths exceeding 10 m during September. The densities recorded for the various depths below the upper 10m during this month were decisively higher than those recorded for the rest of the period (Figs. 5a to 5c). The densities between the surface and deeper waters during October and November showed conspicuous variations at all the stations. The nonmonsoon months maintained a stable equillibrium evinced by less dense surface waters and denser bottom waters. Although variations in temperature was around 8°C and the salinity fluctuations were nearly negligible, the computed density

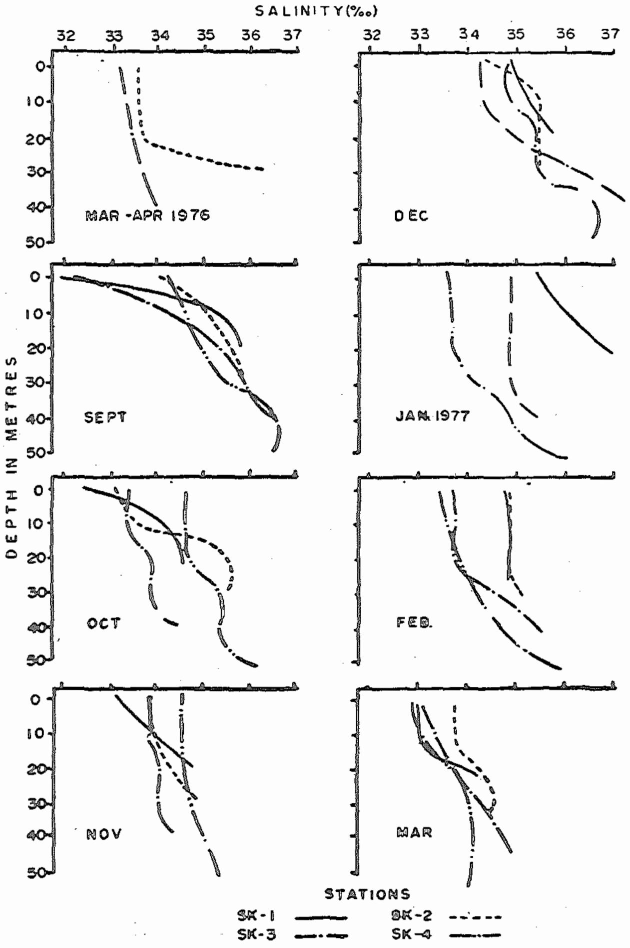

Fig. 3a. Vertical distribution of salinity off Suratkal

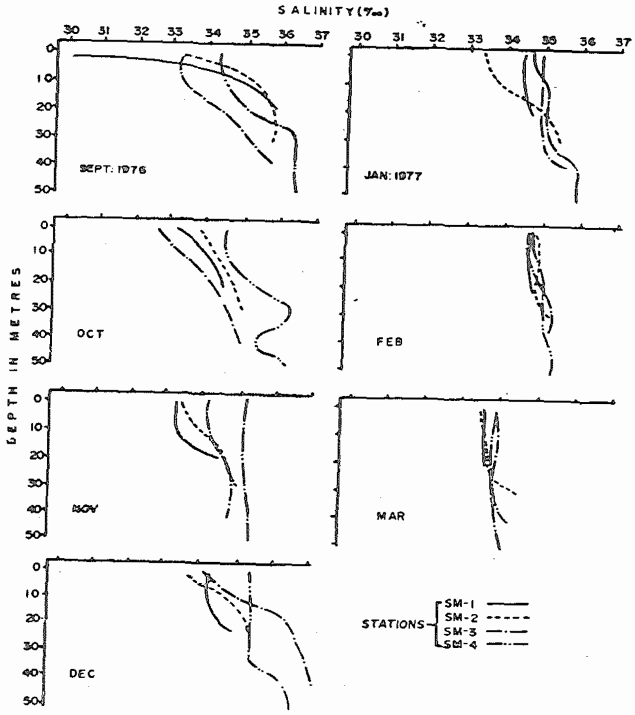

Fig. 3c. Vertical distribution of salinity off Someshwar

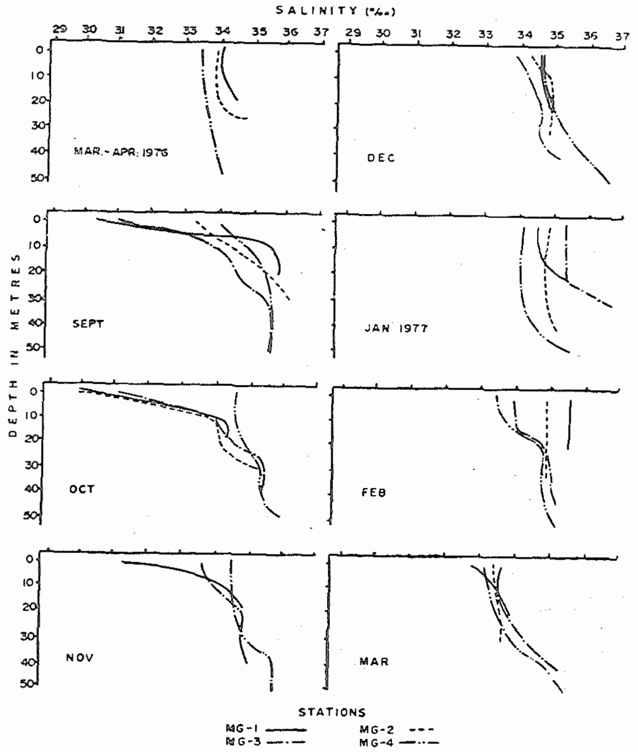

Fig. 3b. Vertical distribution of salinity off Mangalore

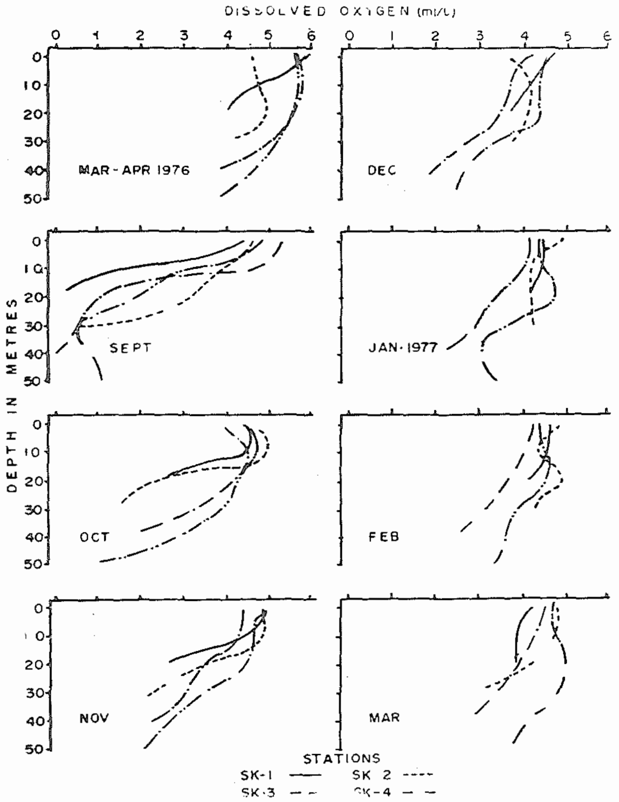

Fig. 4a. Vertical distribution of dissolved oxygen off Suratkal

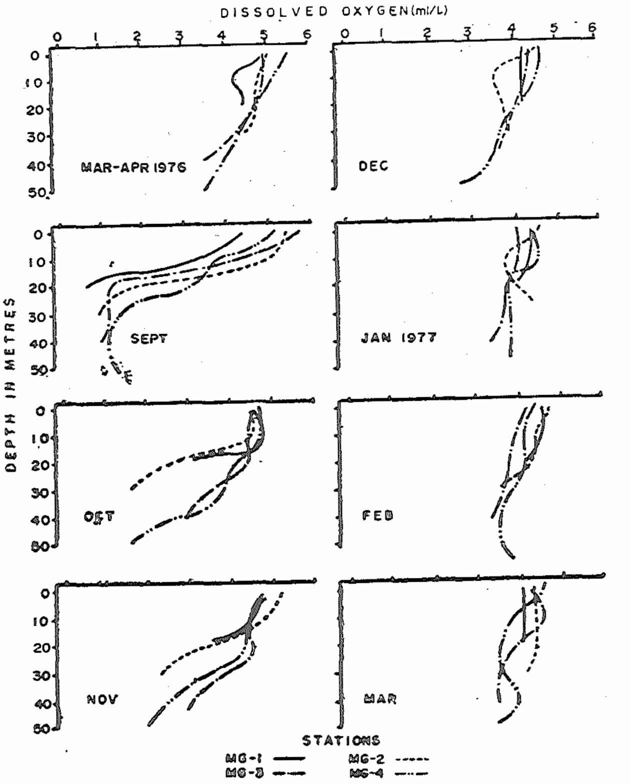

Fig. 4b. Vertical distribution of dissolved oxygen off Mangalore

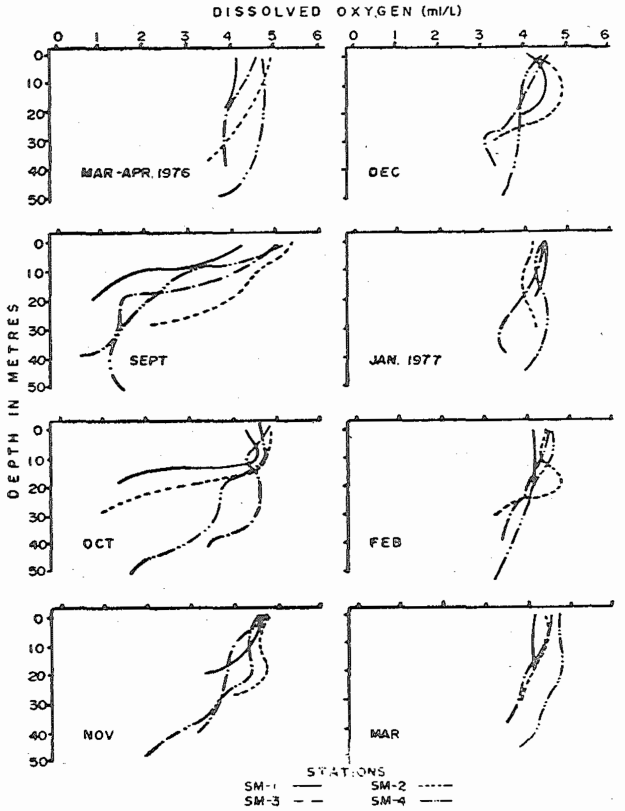

Fig. 4c. Vertical distribution of dissolved oxygen off Someshwar

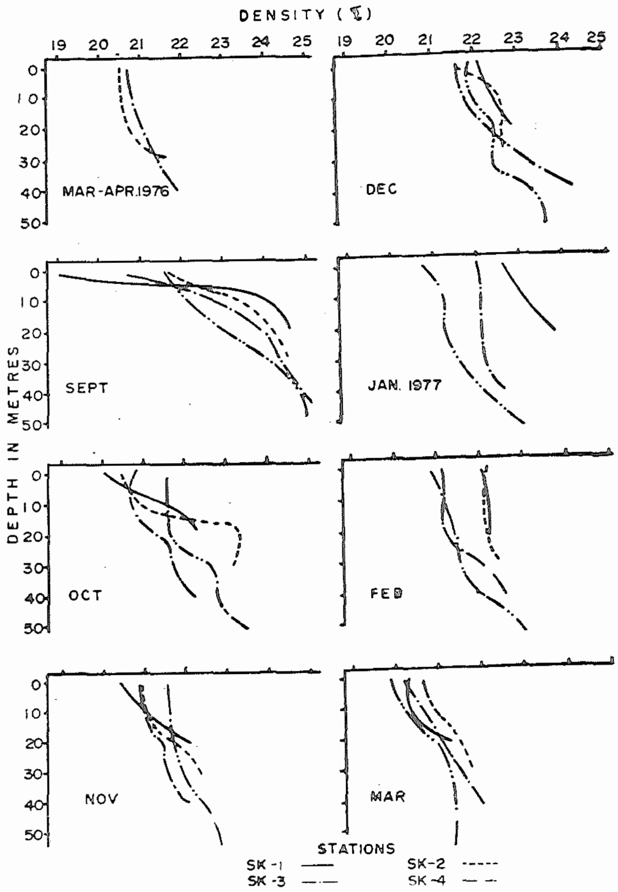

Fig. 5a. Vertical distribution of water density off Suratkal

values do show noticeable variations. It is probably implied that during September, October and November, denser waters from bottom are being transported towards the shallow regions of the continental shelf. The wide range of fluctuations in the vertical density structure of the waters in the monsoon and postmonsoon months clearly indicate conspicuous disturbances in the water body.

The vertical distribution of temperature shows three distinct phases, namely, a period of considerable variations in the vertical structure, followed by a period of thermal stability and an intermediary phase. Comparatively cooler waters existed even at shallow depths during September. September was conspicuous for temperature fluctuations from surface to bottom, may be due to cooling or entry of cold bottom waters from beyond the area of present investigation. It is possible that the cold water of the upper continental shelf is the remnant of waters upwelled under the influence of

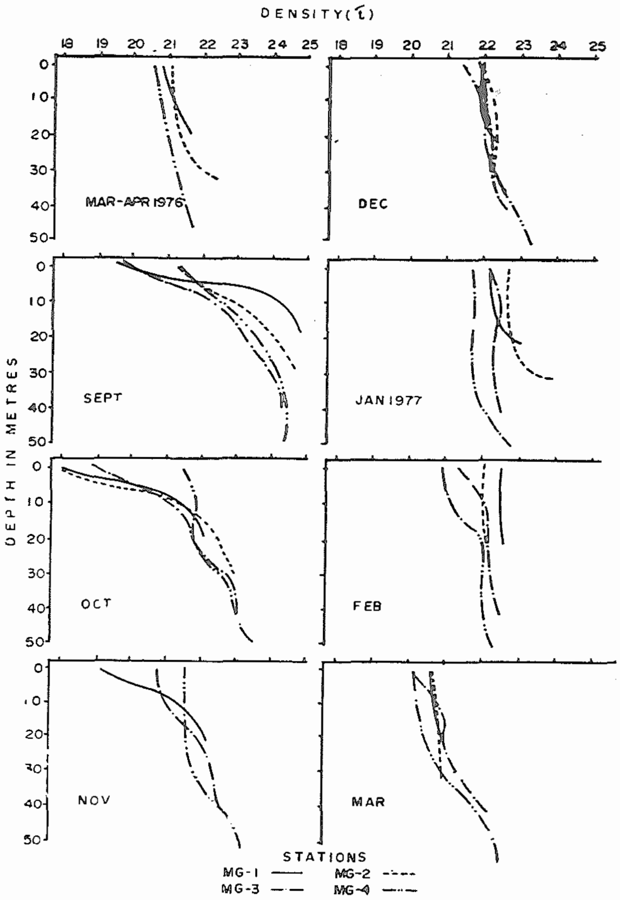

Fig. 5b. Vertical distribution of water density off Mangalore

southwest monsoon. Jayaraman & Gogate (1957) opined that under the influence of winds, the coastal waters assume the characteristics of off-shore waters owing to banking up. The fact that the surface waters get warmed up soon after monsoon, is in conformity with earlier observations (Seshappa and Jayaraman, 1956). Banse (1968) has stated that the upwelling which commences with the onset of southwest monsoon causes an uplift of the 20°C isotherm by 90–100 m. The presence of temperature gradients (3-4°C) at the top of the thermocline over intervals of less than 5 m, according to Banse (1968) suggests an active upward movement of deep water. Although comparable changes were not observed in the present study, the temperature gradient between 10 and 30 m at the deepest station during September was 5.5°C. Hence, it is logical to assume that at least at the deeper part of the upper shelf, there is considerable upward movement of water during September. It is of interest to note in this context that in the open shelf, however, a fairly deep surface layer overlies the cool bottom water during summer (Banse, 1968). The monsoon season forms a major part of the upwelling period. Ramamirtham & Jayaraman (1963) found the influence of cold waters in the Cochin area even during May. Ramasastry and Myrland (1959) felt that September is the period of upwelling along the southwest coast of India and that the subsurface water mass between 75 and 100 m in an undisturbed condition is drawn up to the surface.

The usual trend of decrease in the amount of available dissolved oxygen as depth increases was maintained in a uniform manner at almost all the stations. However, the range of fluctuations varied significantly between different months. Thus while the maximum vertical gradient was observed in September, when the surface waters had an average dissolved oxygen of 5.0 ml l^{-1} which narrowed down to 0.8 ml l^{-1} at the bottom, January, February and March showed an average surface value of 4.5 ml l^{-1} and at the bottom 3.7 ml l^{-1}. Banse (1968) stated that well-aerated waters were found up to the sea bed. This was found to be true in the present study also during March–April. Drastic decrease in oxygen of subsurface waters was observed in September, when in a few instances the waters contained absolutely no oxygen. Concentrations below 0.25 ml l^{-1} seem to be very common in the shelf area during this period. Curiously enough, Banse (1968) found total depletion of oxygen at depths ranging from 10 to 15 m off Bombay. He has remarked that oxygen depletion may be widespread below the thermocline. Extensive influx of bottom waters from areas below the compensation depth and entry of these waters to the upper shelf region, as evidenced by waters of very low oxygen even at 20 m, probably indicate that during the southwest monsoon period a distinct water mass exists in the upper shelf area of the west coast of India. It is not clear whether the presence of comparatively more oxygenated waters during October and November is an indication of withdrawal of oxygen-poor waters to deeper regions, or of high rate of oxygenation owing to enhanced primary production that invariably takes place during early postmonsoon.

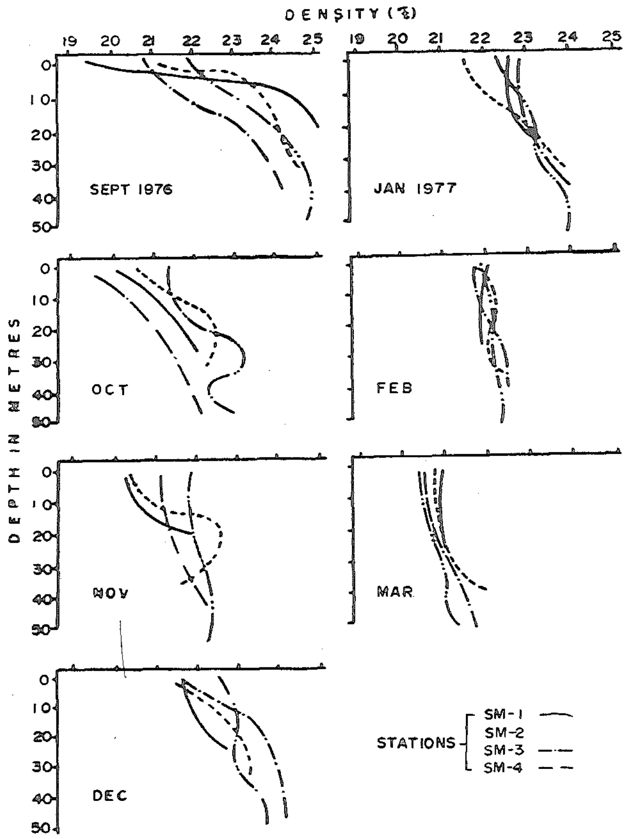

Fig. 5c. Vertical distribution of water density off Someshwar

The results clearly indicate that the change in the oxygen concentration of the water is a gradual process, and to have about 100 per cent saturation in the bottom waters the time taken can range up to four months. It has been proved recently (Anon, 1976) that during the southwest monsoon (May-October), the southward flowing current causes a lifting of the isolines of the various oceanographic parameters of coastal waters. This was pronounced during August-September when dissolved oxygen was as low as 0.5 ml l^{-1}.

The surface salinities in this area did not show noticeable difference during the monsoon months. Shah (1973) opined that the monsoonal effects by way of dilution will be felt only at the upper 5 m and that throughout the year the coastal waters will have typical marine condition below 5 m depth. Considering the amount of freshwater that is being discharged into the sea during monsoon by Netravati and Gurpur rivers, one is inclined to think that this run off will affect at least the surface salinities. But a perusal of the data clearly indicates that this was not so. A plausible explanation for this might be that the nearest station is situated around 10 km from the bar mouth. Gangadhara Rao *et al.* (1974) have observed that salinity, in general, increase towards offshore areas and with depth. However, the differences they observed were not radical. Sastry (1973) has worked out the temperature-salinity relationship at various stations in the Arabian Sea and he concluded that the salinity structure is quite complicated in the Arabian Sea, indicating mixing of water masses of varying T-S relationships. Hence, it is clear that aspects apart from the effects of monsoon should be taken into consideration when salinity structure of an area is interpreted.

The density distribution of the waters of the area clearly shows that denser waters prevail during September and to a certain extent during October and November also. Along with dense waters, in a few instances there appears to be isolated areas of less-dense waters at the surface. Such drastic changes in density between adjoining water masses is a common phenomenon during monsoon only. Interpreting the upsloping of density isolines during March-April, Varadhachari *et al.* (1974) have suggested the presence of upwelling along the coast of Mangalore-Karwar during this period. The present study has clearly indicated that the pattern of distribution of density along the coast of South Kanara is comparable with those obtained from the other parts of the west coast of India. It can be assumed that the major changes are being brought about during the southwest monsoon and the intensity and periodicity of this phenomenon might show spatial differences.

This work formed a part of the thesis submitted by one of us (Maliel) for his Master of Fisheries Science degree. He wishes to acknowledge the award of a UAS merit scholarship by the University of Agricultural Sciences, Bangalore.

References

Anon (1976) *UNDP/FAO Pelagic Fishery Project. Prog. Report.* 16, 18

Banse, K. (1959) *J. mar biol. Ass. India.* 1, 33

Banse, K. (1968) *Deep-sea Res.* **15**, 45

Banse, K. (1972) *J. mar. biol. Ass. India.* **14**, 344

Carruthers, J. N., Gogate, S. S., Naidu, J. R. & Laevastu, T. (1959) *Nature,* **183** (4668), 1084

Gangadhara Rao, L. V., Cherian, T., Varma, K. K. & Varadhachari, V. V. R. (1974) *Mahasagar,* **7**, 15

Jayaraman, R. & Gogate, S. S. (1957) *Proc. Indian Acad. Sci.* **45** B, 151

Jayaraman, R., Ramamirtham, C. P., Sundaraman, K. V. & Aravindakshan Nair, C. P. (1960) *J. mar. biol. Ass. India.* **2**, 24

Murthy, A. V. S. (1969) *Indian J. Fish.* **12**, 119

Neyman, V. G. (1961) *Okean. isled.* **4**, 62 *(in Russian)*

Noble, A. (1972) *Indian J. Fish.* **19**, 167

Patil, M. R., Ramamirtham, C. P., Udayavarma, P., Aravindakshan Nair, C. P. & Myrland, P. (1964) *J. mar. biol. Ass. India.* **4**, 151

Pradhan, L. B. & Reddy, C. V. C. (1962) *Indian J. Fish.* **9**, 100

Ramamirtham, C. P. & Jayaraman, R. (1960) *J. mar. biol. Ass. India.* **2**, 199

Ramamirtham, C. P. & Jayaraman, R. (1963) *J. mar. biol. Ass. India.* **5**, 170

Ramamurthy, S. (1963) *Indian J. Fish.* **10**, 75

Ramasastry, A. A. & Myrland, P. (1959) *Indian J. Fish.* **6**, 223

Sankaranarayanan, V. N. & Qasim, S. Z. (1968) *Bull. nat. Inst. Sci. India.* **38**, 846

Sastry, J. S. (1973) *J. mar. biol. Ass. India.* **15**, 596

Seshappa, G. & Jayaraman, R. (1956) *Proc. Indian Acad. Sci.* **43** B, 288

Shah, N. M. (1973) in *The Biology of the Indian Ocean. Ecological Studies* **3**. (Zeitzschel, B., Ed) p. 175 Springer-Verlag, Berlin

Varadhachari, V. V. R., Murthy, C. S. & Sankaranarayanan, V. N. (1794) *Indian J. Mar. Sci.* **3**, 1