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Physico-chemical characteristics of fishing grounds off Mangalore, west coast of India

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In the regions off Mukka and Hosbettu, Karnataka coast, salinity attains maximum value of 35.1×10^{-3} in May. Similarly silicate, nitrate and phosphate show high values (27, 0.12 and 1.32 μM respectively) in May. This indicates upwelling of nutrient rich bottom waters. Changes in chl *a* and nitrate, phosphate and NO_3:PO_4 ratio suggest nitrate deficiency. Multiple correlation coefficient of temperature and salinity towards oil sardine landing is highly significant ($r = 0.9917$; $P < 0.01$). This suggests that fish landing in Karnataka coast is highly influenced by physical parameters like temperature, salinity and DO and maximum landing from September to November follows the peak in chl *a* content.

Comprehensive account on nutrient chemistry and biological productivity has emerged from the studies on estuarine regions in India[1-5]. However, investigations in the coastal waters are limited. Detailed studies from confined areas are necessary to know productivity, watermass characteristics and seasonal migration of fish in the sea. The region off Mukka in coastal waters of Karnataka forms an important area with high fishing activity. Two rivers Netravati and Gurupur contribute to these coastal waters with considerable amount of nutrients and organic matter[6]. These characteristics are likely to influence the fishery potential in this region. With this in view monthly observations have been made to have a better understanding about seasonal changes in physico-chemical properties and their influence on fisheries along the coast.

Materials and Methods

Two transects were fixed perpendicular to the coast, one off Mukka (13°1'30"N; 74°41'45"E) and other off Hosbettu (12°58'N; 74°42'45"E). Along each transect 4 stations were operated (HB1 to HB4 and MK1 to MK4) perpendicular to the coast to a distance of about 40 km offshore. For comparison of results the mean values of 4 stations at each of these transects have been considered.

Seawater samples were collected every month except June-August, in 1985. During rough weather in monsoon, samples could not be collected. However, the samples collected after the first monsoon showers i.e. towards the end of May and those in September were representative of monsoon season.

Water samples from the surface, subsurface (15 m) and bottom (35 m) were collected with the help of Nansen reversing bottle. Temperature was measured by reversing thermometer and nitrate, nitrite, phosphate, silicate, salinity and dissolved oxygen (DO) were measured[7]. Chlorophyll *a, b* and *c* were measured using Spectronic 80 (Bousch & Lomb) spectrophotometer and calculated using trichromatic equation[8]. The values represent pooled average values for all stations.

Results and Discussion

Data on mackerel and sardine landing at the Mangalore port is presented in Fig. 1. The maximum landing takes place from September to November. A short peak of mackerel landing can also be seen in March, but during rest of the period the catch remains low.

Surface water temperature attained a maximum value of 31.4°C in April and minimum of 27.9°C in January 1985 (Fig. 2a). The isotherms run vertically parallel in Jaunary-February indicating homogeneous water column. During rest of the period the bottom temperature remained lower than the surface values. The maximum temperature stratification of 4.4°C between surface and bottom waters was observed in September.

Surface salinity showed a maximum value of 35.1×10^{-3} in May and a minimum of 32.1×10^{-3} in Jan-

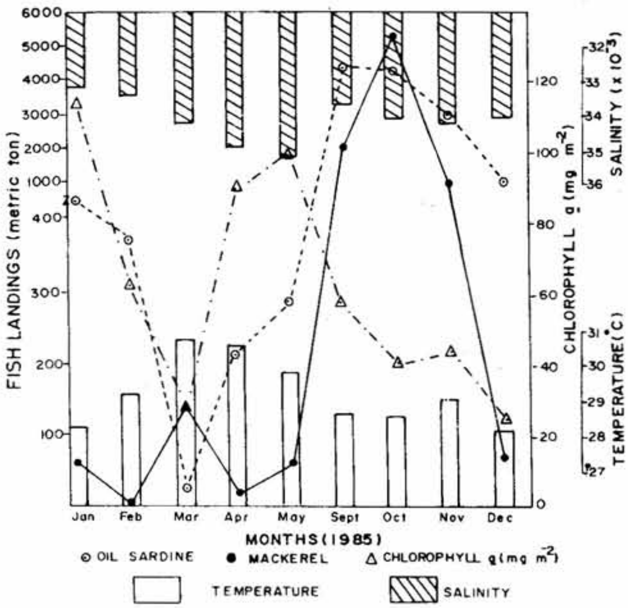

Fig. 1—Mackerel and sardine landings at Mangalore fishery jetty during 1985

uary (Fig. 2b). Vertical distribution indicates that the surface salinity values are lower than those at the bottom. Nearshore stations (16 km) showed lower salinity as compared to offshore stations. Unlike temperature and salinity, DO showed highest value in January and lowest in September, with comparatively higher values in surface waters (Fig. 2c). *p*H also remained low in September (mean bottom value 8.15). Vertical distribution of *p*H during rest of the period did not show any regular pattern between surface and bottom waters (Fig. 2d).

Nutrient distribution in surface and bottom waters along the coast up to 40 m depth is shown in Fig. 3a to f. Peak of nitrate concentration was observed in May with a maximum of 3.04 μM. Nitrate content was high till September and showed a decreasing trend in postmonsoon with a minimum value of 0.12 μM in January (Fig. 3a and b). Vertical distribution indicated that the bottom concentrations usually remained higher than those in surface waters.

Nitrite concentrations also remained high in May. The annual range varied from 0.1 to 3.04 μM. Vertical distribution showed that the concentrations generally remained higher in bottom waters than those in surface.

Phosphate concentrations ranged from 0.08 to 1.32 μM. The concentrations decreased in postmonsoon attaining low values in December-January and increased thereafter to a maximum in May (Fig. 3c and d). Sloping of isolines suggests that the phosphate values decreased towards offshore regions. Vertical distribution showed that the concentrations remained higher towards the bottom.

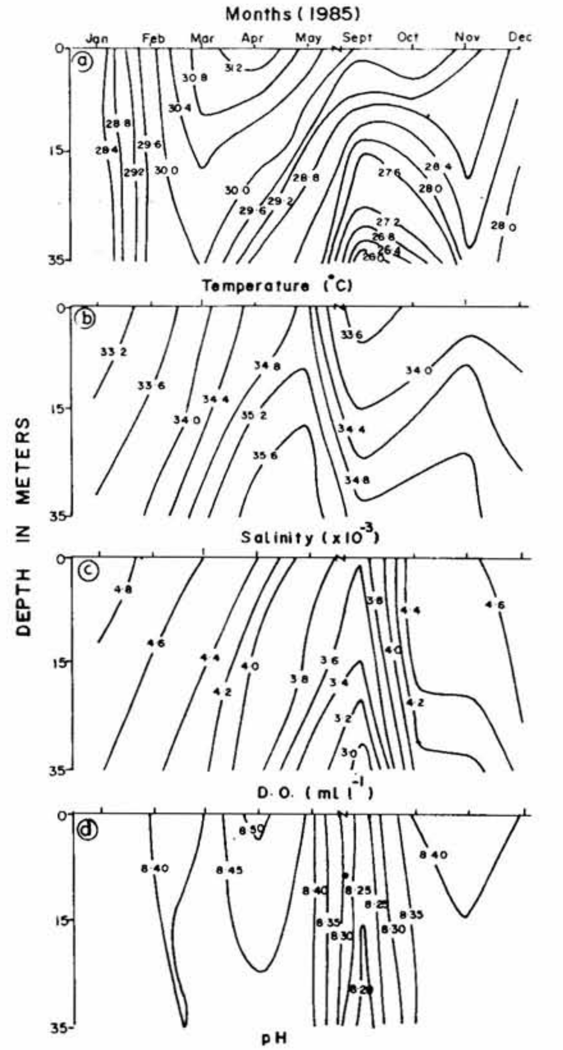

Fig. 2—Variation of temperature(a), salinity(b), DO(c) and *p*H(d) in water column during different months in 1985

Changes in silicate content showed higher values from May to October with a peak in September (Fig. 3e and f). A decreasing trend in silicate concentration was observed towards December-January. The concentrations further decreased in March. Annual range in silicate values was 0.8 to 27 μM. Vertical distribution indicated that the concentrations usually remained high in the bottom waters, except during September to October in nearshore areas.

Chl *a* of water column ranged from 2 to 130.5 mg m^{-2} (Fig. 4a). The annual variation showed 2 peaks, one in January-February and other in April-May. Lowest concentration of chl *a* was recorded in December. Chl *b* ranged from 6.5 to 59 mg m^{-2} (Fig. 4b). The concentrations attained a peak in April and remained low from September onwards, with the mini-

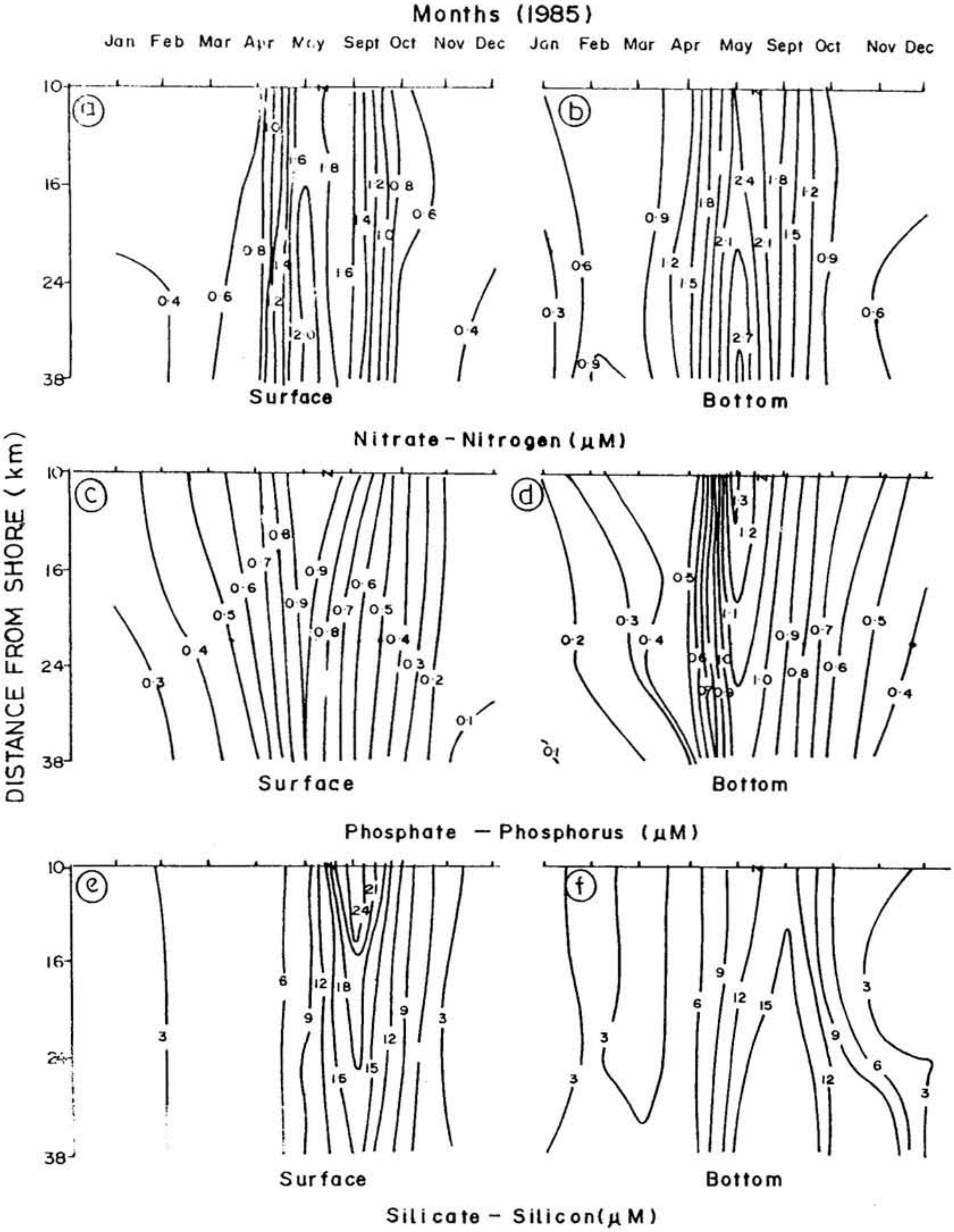

Fig. 3—Distribution of NO_3, PO_4, SiO_3 in surface and bottom waters during different months

mum value in November-December. Chl *c* ranged from 2.5 to 208.8 mg m^{-2} (Fig. 4c). The concentrations showed high values in January while during the rest of the period the distribution was patchy.

Results indicate that considerable changes in hydrographic and nutrient characteristics occur in May and September. Figs 2 and 3 show that while isolines of temperature and DO slope downwards from May to September, the isohalines rise in May. Similarly, the nutrients like nitrate, phosphate and silicate attain high concentration in May and September. Although the observations in May were made after the onset of monsoon, high salinity and *p*H values suggest that freshwater input to the coastal water was relatively low during this period. In coastal waters of Mangalore, decrease in temperature and DO and increase in salinity in May in the area within 20 m depth contour was observed[9] during 1976-1977. Seasonal changes in hydrographic parameters due to upwelling were prevalent in this region from May to September[10,11]. Sastry and D'Souza[12] showed that cyclonic circulations prevailed in these waters. They concluded that from June to September this region is subjected to direct wind mixing and indirect effects of wind induced circulation, which probably bring the cold subsurface waters to the surfacc.

Better indication of land drainage or upwelling could be derived from changes in the silicate content (Fig 3e and f). During May silicate increased from nearshore to offshore waters while the reverse was observed in September. This clearly indicated that the former could be due to upwelling and the latter due to land drainage. During monsoon Mandovi-Zuary estuarine system in Goa[2] receives large amount of silicates and nutrients from land drainage. This ultimately finds its way into coastal waters of Goa. Gurupur and Netravati rivers may similarly be responsible for the input of silicates and other nutrients in the coastal waters of Mangalore[6].

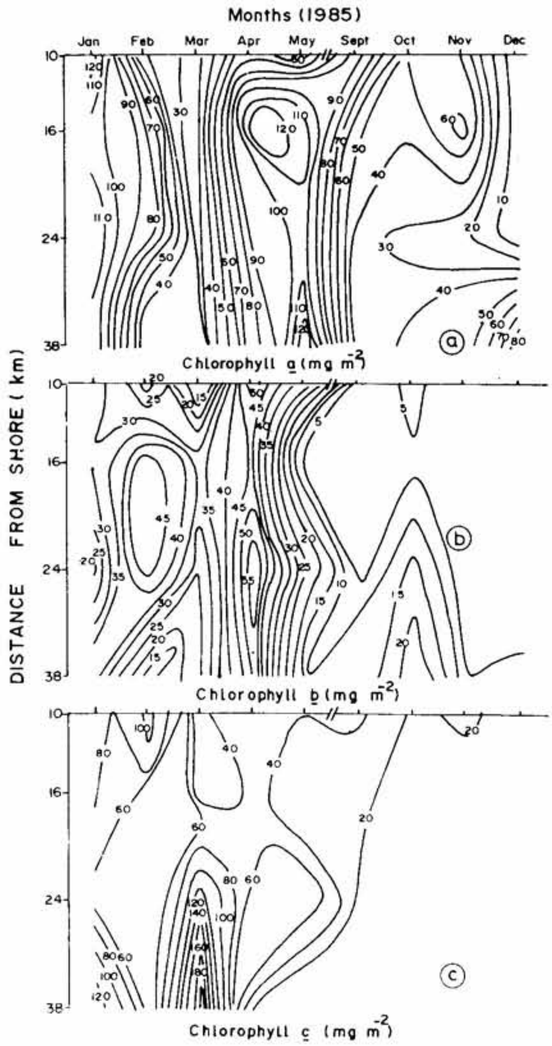

Fig. 4—Distribution of chl*a*, *b* and *c* in water column during different months

Salinity values showed good correlation with nitrate and phosphate but not with silicate (Table 1). This may be mainly due to large fluctuations in silicate values especially in May and September. Chl *a* did not show any correlation with nutrients (Table 1). However from Figs 3 and 4 it can be seen that the decrease in chl *a* content in December and March was accompanied with decrease in silica content. Similar trend was shown by chl *b* and chl *c* for December.

Like silicate, phosphate also attained low values in December with surface concentration varying between 0.08 and 0.16 μ*M* (Fig. 3b). The ks (half saturation constant) value of phosphate for *Biddulphia sinensis* and *Cerratium furca* isolated from Cochin backwaters[13] was 0.17 and 0.15 respectively. Except for December phosphate content remained higher than the ks value stated above. However, even in December phosphate was not deficient as compared to nitrate. NO_3:PO_4 ratio in these waters fluctuated between 0.5 and 4.5 throughout the period of observation. In the coastal waters of Goa NO_3:PO_4 ratio was also low (maximum value 2.1)[2]. However, the assimilation ratio, which is actually influenced by the biological utilization was much higher (11). In the present case, assimilation ratio was as low as concentration ratio. Such anomalous ratio as compared to classical Redfield's ratio[14] may represent deficient supply of nitrate. The half saturation constant for nitrate as reported for Cochin backwaters was 0.74 μ*M* for *Biddulphia sinensis* and 0.44 μ*M* for *Cerratium furca*[13]. The ks value for nitrate for 2 different sizes of phytoplankton isolated from Porto Novo waters was reported[15] to vary from 0.48 to 1.28 μ*M*. In the present study nitrate values in the surface waters remained low between 0.1 and 0.78 μ*M* except for May and September.

Table 1—Correlation coefficients (r) of different parameters

Parameter	r	n	$P<$
Salinity/SiO_3	0.1579	72	NS
Salinity/PO_4	0.4498	72	0.001
Salinity/NO_3	0.5011	72	0.001
SiO_3/NO_3	0.2600	72	0.05
NO_3/PO_4	0.8478	72	0.001
Chl *a*/SiO_3	−0.2221	24	NS
Chl *a*/PO_4	−0.0020	24	NS
Chl *a*/NO_3	−0.0752	24	NS
Chl *a*/sardine landing	0.1630	08	NS
Chl *a*/mackerel landing	0.0345	08	NS

NS = not significant, n = number of values

SiO_3:PO_4 ratio in these waters varied from 2.1 to 44.26. Telman[16] demonstrated that *Asterionella formosa* dominated in chemostat at $SiO_3:PO_4 > 100$ while *Cyclotella meneghiniana* dominated at $SiO_3:PO_4 < 10$. Some of the reports in coastal waters showed that the eutrophication by domestic wastes containing low silicates could result in the elimination of diatoms from phytoplankton communities due to silica depletion[17,18]. However the fluctuation of chl in the present study was not consistent with the changes in NO_3, PO_4 or SiO_3 (Figs 3 and 4) except at few occasions. It appears therefore that cellular nutrients determine the actual growth of phytoplankton rather than the external substrate[19,20].

Mackerel and sardine form an important fishery on the west coast of India. Multiple correlation coefficient of temperature and salinity values towards the oil sardine catch was highly significant ($r = 0.9917$; $P < 0.01$). It can be seen from the Fig. 1 that the mackerel landing as that of sardine was high when salinity and temperature were around the median range fluctuating between 32.59 and 34.89×10^{-3} and 28.4 and 29.9°C respectively, in September and November. The catches were poor when the temperature and salinity deviated much higher or lower than this particular range. DO also showed the positive correlation with sardine catch. These observation suggest that the physical parameters like temperature, salinity and DO play a vital role in abundant production of pelagic fish[9]. Mackerel and sardine are known to be herbivorous planktonic feeders[21]. However the correlation between chl *a* values and mackerel and sardine catch was insignificant (Table 1). It is worth noting that the peak of chl *a* in April and May followed the maximum landings of mackerel and sardines from September to November. This may indicate the effect of grazing by pelagic fishes.

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