Plankton of Karwar Waters with Remarks on the Hydrographic Conditions and Fishery

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The results obtained from the investigations on the abundance and seasonal fluctuations of plankton and hydrographic conditions of fishing areas of Karwar waters are presented and discussed. The displacement volume of plankton (9.2–29.6 ml/m³) showed two peaks one in November–December and other in February–March. Among the phytoplankton, the diatoms constitute the major part of the total phytoplankton with dominant species like *Fragillaria, Coscinodiscus, Thalassiothrix, Chaetoceros, Nitzschina, Rhizosolenia* and *Biddulphia* whereas among the zooplanktons, the dominant groups mainly comprised of copepods, decapod larvae, chaetognaths and medusae. The observed values of hydrographic parameter showed a bimodal peak. A correlation between plankton abundance and fishery has been attempted in this paper.

While there is relatively more information available on the hydrography of the waters off Karwar (Ramamirtham & Patil, 1965; Ramamurthy, 1965; Noble, 1968; Annigeri, 1968, 1972; Sudarshana, 1983; Naik, 1986), our knowledge of the plankton of this region is largely confined to the works of Ramamurthy (1965), Konnur (1981) and Naik (1986). The fish catches of Karwar are mostly comprised of pelagic, semi-demersal species which predate on plankton and plankton feeding fish, crustaceans etc. The amount of plankton available may not have direct and immediate effect on the fishery but it undoubtedly influences indirectly the fish abundance. The larvae, post-larvae and the juveniles of pelagic and even the demersal fishes depend upon the planktonic organisms for their nourishment (Pillai, 1968). Karwar is one of the major fishery centres in the central west coast of India. Therefore the study of the hydrobiological features is very much necessary as it might help to understand the effect of some of these parameters on the pelagic fisheries of the area. With this in view, investigations on the above aspects are carried out and the data collected on the abundance and fluctuations of plankton in relation to the observed hydrographical conditions of the fishing areas off Karwar presented and discussed in this paper.

Materials and Methods

Data presented here are based on fortnightly samples collected from fishing areas off Karwar Bay (stations 1 and 2) ever a period of twelve months from April, 1982 to March, 1983 (Fig. 1). Surface sea water samples were collected with a polythene bucket and the temperature was recorded. The plankton was collected using a conical net with a mouth ring of 35 cm diameter towed at a speed of two knots for a duration of ten min. The water samples were analysed for salinity, dissolved oxygen, suspended load and inorganic phosphate and nitrite

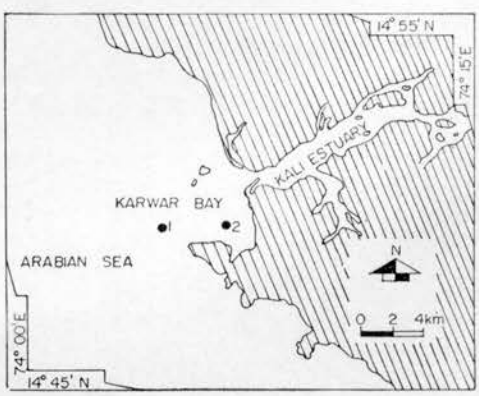

Fig. 1. Location of sampling stations

using standard methods (Strickland & Parsons, 1975). Plankton samples were standardised to a volume of 250 ml during preservation and an aliquot of 10 ml sub-sample was used for specieswise enumeration and triplicate sub-samples were analysed and its mean is represented for one metre cube of sea water. The total volume of the plankton collected was determined by the displacement volume method (Sheard, 1947). Simple correlation between plankton and environmental parameters was carried out as given by Snedecor & Cochran (1967). The rainfall data was provided by the Indian Department of Meteorological Centre, Bangalore, while Karwar fish landings (mackerel and sardine) were obtained by the State Fisheries Department, Karwar.

Results and Discussion

The observed values of surface temperature salinity, dissolved oxygen, suspended load and inorganic phosphate and nitrite content are given in Table 1. Surface temperature showed bimodal fluctuations with two maxima, one in May 1982 and the other in March 1983. The maximum temperature recorded was 31.7°C (May, 1982) and the minimum was 26.7°C (September, 1982). These values did not vary much between the two stations. Salinity showed a wide range of fluctuation from 8.23‰ (July, 1982) to 35.48‰ (April 1982). The annual average rainfall was 504.64 mm with a peak of 1197.2 mm in July, 1982. Dissolved oxygen concentration varied between 4.10 ml/l and 4.74 ml/l in November and July respectively. In both study locations, the minimum and maximum concentrations were encountered during November and July respectively. Suspended load exhibited its minimum and maximum values during December (0.9 g/l) and June (2.45 g/l) respectively. The maximum suspended load was encountered during southwest monsoon (1.69–2.45 g/l) when compared to other two pre and post-monsoon seasons. Phosphate and nitrite exhibited their low concentration in July (0.22 µg at./l PO_4P) and September (0.23 µg at./l) and highest concentration during October (0.77 µg at./l PO_4 –P) and December (0.65 µg at./l NO_2–N respectively. The annual averages of these two nutrients did not vary much among the two stations.

The displacement volume of phytoplankton (Subrahmanyan, 1959) oscillated between 1.95 (June) and 7.40 (October) ml/m³. Among the two stations, the second station encountered the highest phytoplankton production (2.1–7.6 ml/m³) during the tenure of observation. During the phase of maximum production of phytoplankton it was characterised by a striking abundance of diatoms, the predominant form being *Fragillaria oceanica*. Other diatoms which also shared their maximum towards the total phytoplankton production during this period

Table 1. *Monthly mean variations in rainfall and hydrographic parameters of Karwar waters*

Month	Rainfall*	Temderature	Salinity	Dissolved oxygen	Susp. load	Phosphate	Nitrite
	mm	°C	‰	ml/l	g/l	µg at./l	µg at./l
April 1982	—	30.0	35.48	4.52	0.27	0.40	0.33
May	189.6	31.7	32.47	4.62	0.16	0.38	0.32
June	844.7	29.3	10.14	4.43	2.45	0 57	0.30
July	1197.2	27.9	8.23	4.74	2.06	0.22	0.28
August	1056.2	29.45	9.12	4.61	1.69	0 68	0.25
September	81.7	26.7	18.20	4.36	1.85	0.61	0.23
October	70.2	29.2	26.49	4.20	0.35	0.77	0.46
November	92.9	30.0	32.05	4.10	0.26	0.72	0.45
December	—	29 1	32.64	4.33	0.09	0.48	0.65
January 1983	—	27.5	33.26	4.40	0.37	0.45	0.61
February	—	29.1	34.15	4.54	0.23	0.43	0.42
March	—	30.2	34 52	4.62	0.17	0.38	0.38

* Source: Indian Meteorological Department, Bangalore

were *Coscinodiscus, Thalassiothrix, Chaetoceros, Nitzschia, Rhizosolenia* and *Biddulphia.* There is an abundant growth of the *dinoflagellates* like *Noctiluca miliaris, Ceratium* spp., *Peridinium* spp. and *Dinophysis* spp. in September–November period.

The zooplankton production was found generally high in post-monsoon (16,724–24,321 no/m^3) and pre-monsoon seasons (18, 124-31, 624 no/m^3). During the pre-monsoon season, the maximum zooplankton production was mainly contributed by the copepods, cladoceran and decapod larvae. Copepods itself contributed more than 40% of the total zooplankton production. During the post-monsoon season, the *Acrocalanus* spp. was the dominant copepod and *Evadne tergestina* was the predominant cladoceran in the early part of this season. *Penilia avirostris* was found maximum during November. Along with these, small numbers of tintinids, larval stages of decapods, cirripedes and molluscs were also encountered. Species of *Oithona, Acartia, Paracalanus, Temora* and *Pseudodiaptomus, Sagitta* spp., appendiculatians and doliolids were also present. In the pre-monsoon season, the chiefly encountered zooplankton were copepods (species of *Acrocalanus, Oithena, Acartia* and *Paracalanus),* larval stages of copepods, molluscs and *Sagitta* spp.

Uttara Kannada district has a coastline of about 144 km. The most commercially important pelagic fisheries of Karwar are mackerel and sardine. Mackerel catch was more in April–May, 1982 (15.0–25.0 tonnes) and it gradually decreased to nil during July and August and attained peak (13.0 tonnes) in September and once again gradually fell (8.0–6.0 tonnes) during October–November (Fig. 2). Sardine catch was more (300.0–530.0 tonnes) during September–October, 1982 with a gradual fall in December, 1982 to January, 1983 (74.0–55.0 tonnes) and again attained its maximum catch (235 tonnes in February, 1983 (Fig. 2).

The fall in temperature during July–September and December. February coincibed with the southwest monsoon and winter seasons respectively and of the two, the latter did not generally reach the low levels of the former in the west coast of India (Noble, 1968). However, very heavy rain was observed preceeding the occurrence of the minimum temperature (Table 1). The salinity was very high in summer (April–May) and low during the southwest monsoon (July–August). The fall in salinity during the July–August period was likely due to the influence of rain and run off from the land and it was very low on account of Kali River discharging directly into the bay. The transition from this low to the higher values took place gradually during the post-monsoon season (Table 1). The effect of the northeast monsoon was totally absent along the Uttara Kannada coast and hence the secondary fall during December–January was possibly due to the northwesterly coastal current (Noble, 1968).

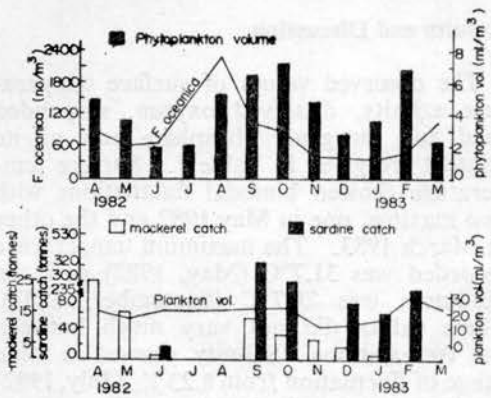

Fig. 2. Seasonal variations in planktons, mackerel and sardine catch in Karwar waters

The range in monthly mean values of oxygen in Karwar Bay ranged between 4.10 and 4.74 ml/1. Ramamurthy (1965) observed the range here between 2.75 and 5.31 ml/1. The maximum dissolved oxygen was found bimodal, the peaks occurred during December–February and June–September and decreased during September–November. The coincided with the findings of Ramamurthy (1965). Suspended load was maximum during the southwest monsoon season (1.64–2.98 g/1) and there was a gradual fall in the succeeding season (0.08–0.38 g/1). Annual average (0.74–0.91 g/1) did not vary much among the two study sites. According to Jerlov *et al.* (1978)., the amounts of suspended load vary from one to many grams per litre in open ocean to estuary and

nearshore waters during the southwest monsoon season and this may hold good for even Karwar Bay also. According to Ramamurthy (1965) the Uttara Kannada coast experiences the upwelling during southwest monsoon period, resulting heavy suspended load. Apart from this, Kali river and land drainage were also responsible for maximum suspended load in sea water.

Inorganic phosphate-phosphorus content was found maximum during the August–December (0.61–0.77 µg at./l), while the low concentration was noticed during the pre-monsoon ranging from 0.38 to 0.45 µg at./l (January-May). Nitrite-nitrogen content was very low during pre-monsoon (0.32–0.42 µg at./l) and southwest monsoon (0.23–0.30 µg at./l) respectively. These data more or less correspond to the earlier observations (Ramamurthy, 1965; Naik, 1986) made in this waters.

The plankton of Karwar waters showed seasonal changes in the species composition as well as total biomass during the period of investigation. The occurrence of two peak periods of total plankton volume (Fig. 2) during February to April and June to October is in accordance with earlier observations (Ramamurthy, 1965; Konnur, 1981; Naik, 1986). The salinity was comparatively very low during June to October but higher values were encountered during February to April. During low saline regime the nutrition budget was comparatively more with a maximum plankton biomass. As stated by Qasim *et al.* (1972), in coastal waters the lowering of salinity and temperature is associated with enrichment of water with nutrients which leads to an increase in phytoplankton production. The seasonal variability of nutrients controls the production of plankton in coastal water bodies.

A simple correlation between plankton and environmental parameters revealed relation between the two. In the present investigation, phytoplankton showed low positive correlation ($r = 0.1675$) with salinity contrary to the observation of Rajgopal (1981). Zooplankton had negative correlation ($r = 0.1440$) with salinity comparable with the results of Goswami *et al.* (1979) and Rajgopal (1981). Phosphate and nitrite were negatively correlated with zooplankton while phytoplankton showed positive correlation ($r = 0.4650$) with phosphate and negative ($r = 0.2192$) with nitrite. The most satisfactory results procured between sardine catch and plankton occurrence with significant correlation ($r = + 0.6222$) between the two. However, negative correlation ($r = -0.1834$) was observed between mackerel catch and zooplankton while positive ($r = + 0.2715$) correlation existed between phytoplankton and mackerel catch. Mackerel and sardine catch had negative correlation ($r + 0.4723$) between two. A similar trend was observed by Ramamurthy (1965). Perhaps better correlation may be expected of individual species of plankton are correlated with environmental parameter instead of planktons as a whole because of different species are known to have varying affinity with environmental parameters (Jayalakshmi *et al.*, 1986). A close association between the salinity changes in the environment and zooplankton abundance has been studied by Wellershaus (1974).

In the present investigation, the nitrite values were comparatively more in pre and post-monsoon seasons when compared to that of monsoon season. A similar trend was seen by Rajgopal (1981) and cited that, coastal waters are comparatively rich in nitrate during pre and post-monsoon seasons. The pattern of phosphorus supply and utilization in natural populations of phytoplankton is characterised by highly variable rates of uptake and release which bear little apparent relation to the physiological needs of the plankton (Jeffery, 1979).

Sudarshan (1964) has observed two peaks in the trawler catches in Bombay during May and October/November and suggested that the abundance of fish in May followed the peak plankton production during March. In the present investigation, the sardine catch was absent during April 1982 to August 1982 with exception in June (15.0 tonnes) and the catch was more (30.0 to 53.0 tonnes) during September 1982 to February 1983 with a nil catch in November 1982. Chidambaram (1950) observed a good sardine fishery when the temperature values were below 29°C. Sekharan (1962) observed good landings at Calicut when the average temperature and salinity values ranged 28.5 – 29.9°C and

33.08–35.04% respectively and when these limits were exceeded a poor fishery was resulted. In the present investigation, a good sardine catch was recorded when the temperature and salinity ranged between 26.7–30.0°C and 18.20–34.15% respectively. Subrahmanyan (1959) observed an inverse relation between the phosphate content and sardine landings. It has been observed at Karwar also that as the content of phosphate in water decreased the sardine catch increased. The mackerel fishery is not related to the integral mean phosphate content of the water but a definite relationship between the mackerel fishery and the salinity is seen. The interrelationship between upwelling and the mackerel fishery has been discussed earlier by Ramamurthy (1965) of this coast. It is discussed that upwelling brings the shoals of the mackerel to this coast but their actual incursion into the inshore waters is delayed by the lowering of salinity brought about by and drainage during the southwest monsoon season. It is also noticed that the primary cause for the mackerel leaving this coast is the warming at the beginning of the summer season.

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