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OBSERVATIONS ON THE PLANKTON OFF BOMBAY COAST WITH REMARKS ON THE HYDROGRAPHIC CONDITIONS AND FISHERY*

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THE study of fluctuations in plankton abundance in relation to hydrological features is of interest to planktonologists and fishery biologists. While there is relatively more information available on the hydrography of the waters off Bombay (Jayaraman and Gogate 1957 ; Carruthers *et al.* 1959 and Jayaraman *et al.* 1961), our knowledge of the plankton of this region is largely confined to the work of Bal and Pradhan (1945-47), Lele and Gae (1936), Gonzalves (1947) and Sudarsan (1964). The fish catches off Bombay are mostly composed of semidemersal species, predators on plankton feeding fish, crustaceans etc. The amount of plankton available may not have a direct and immediate effect on the fishery but it undoubtedly influences indirectly the fish abundance. The larvae, post-larvae and the juveniles of even the demersal fishes depend upon the planktonic organisms for their nourishment. As Bombay is one of the major fishing centres in the north-western part of India, the study of the hydro-biological features is very necessary as it might help understanding the effect of some of these parameters on the fisheries of the area. With this in view, investigations on the above aspects are being carried out at the Central Marine Fisheries Research Sub-Station, Bombay. The data collected so far on the abundance and fluctuations of plankton in relation to the observed hydrographical conditions of the fishing areas off Bombay are presented and discussed in this paper.

Surface sea water samples were collected with a polythene bucket and the temperature was measured with a centigrade thermometer. The plankton was collected using a $\frac{1}{2}$ metre diameter organdie cloth net towed at a speed of two knots for a duration of 15 minutes. The water samples were analysed for salinity, dissolved oxygen and inorganic phosphate using accepted methods. Plankton samples were standardised to a volume of 250 cc. during preservation and an aliquot of 10 cc. was used for species-wise enumeration analysis. The study was mainly on zooplankters. Smaller organisms were poorly represented in the samples, possibly due to the coarse mesh of the net used. Data presented here are based on weekly samples collected from fishing areas off Bombay over a period of 15 months from January 1966 to May 1967.

THE STANDING CROP OF PLANKTON AND THE GENERAL COMPOSITION

The displacement volume of plankton in the samples oscillated between 1 and 225 cc. with two peak periods, one in March/April and the other in October/November. Almost throughout the period of observation zooplankton was dominant in the plankton samples. The high standing crop during October/November 1966 was constituted largely by copepods, *Lucifer*, fish eggs and larvae and the diatom *Coscinodiscus* sp., while in March/April mostly by salps and siphonophores.

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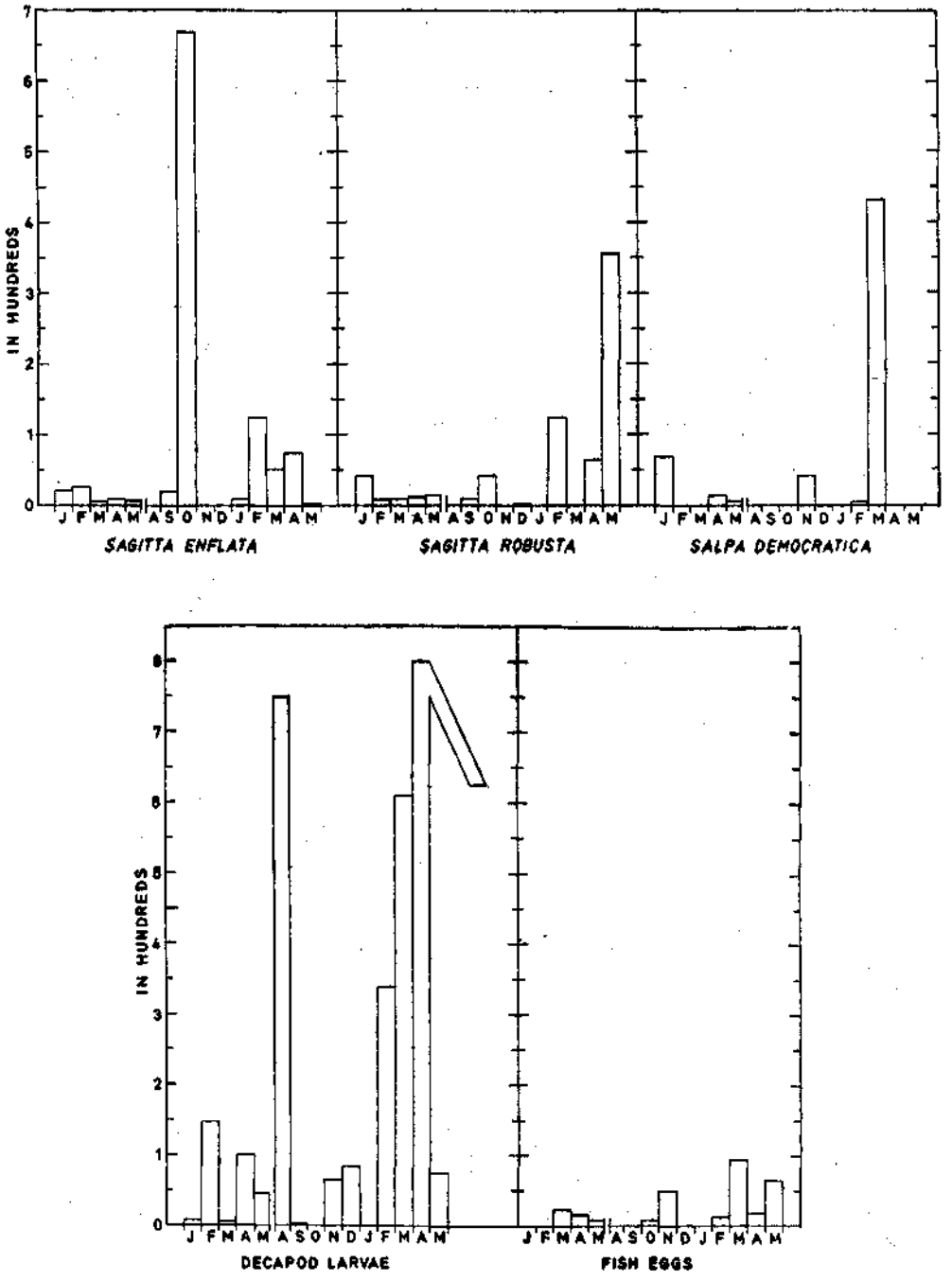

FIG. 1. Seasonal variation of *Sagitta enflata*, *S. robusta*, *Salpa democratica*, decapod larvae and fish eggs.

The observations of Bal and Pradhan (1945) also showed an appreciable increase in the zooplankton volume in the period October to December. Sudarsan (1964) observed two peaks for the total plankton volume, one in October and the other in March. In January and in May the samples consisted predominantly of phytoplankton. Gonzalves (1947) reported an abundance of phytoplankton during January/February off Bombay.

Abundance and Seasonal Variation of Zooplankters

The zooplankton consisted mainly of hydromedusae, scyphomedusae, trachymedusae, siphonophores, chaetognaths, copepods, amphipods, ostracods, decapods and their larvae, pteropods, tunicates and fish eggs and larvae. Among these, siphonophores, chaetognaths, copepods and decapod larvae were the most dominant and they occurred in the samples almost throughout the year. During March 1966 salps were present in large numbers comprising about 75% of the bulk. Polychaetes and cladocerans were very rare. A brief account of the different groups and their species composition is given below.

Coelenterata : The scyphomedusa *Pelagia noctiluca* was present in the plankton during October and March. The trachymedusa *Liriope tetraphylla* was abundant during January to March 1967. Siphonophores occurred almost round the year in the plankton, the common forms being *Bassia bassensis* and *Diphyes* sp. with their peak periods in October/November and January/February respectively. Other forms like *Lensia, Chelophyes* and *Sulculeolaria* were also observed in the samples occasionally.

Chaetognatha : The chaetognaths were most dominant and represented in the samples during most of the months (Figure 1), but in November and December 1966, when the standing crop of plankton was fairly high, these were totally absent in the plankton. The chaetognaths were represented mainly by four species, viz. *Sagitta enflata, S. robusta, S. bombayensis* and *S. tenuis. Sagitta bombayensis* was observed in plenty in some inshore samples, particularly from the harbour area. *Sagitta enflata* was fairly abundant in January, February, September and October, October being the peak period. *Sagitta robusta* was abundant during January, October, February and May, the peak period being May.

Annelida : Annelids were poorly represented in the plankton. The only record was that of some nereids during November and a few specimens of *Tomopteris* during February.

Crustacea : Class Crustacea was found to be the most dominant single group in the plankton. The following groups were represented :

Cladocerans were fairly abundant during May 1966, represented mostly by *Evadne* sp. In no other sample they occurred in noticeable numbers.

Copepods were the most dominant organisms in the plankton and they occurred throughout the year, their peak periods being October/November and March/April (Figure 2). About forty-five species of copepods were identified in the collections. Of these the following species were present almost throughout the year, viz. *Eucalanus sub-crassus, Acrocalanus gibber, A. longicornis, Centropagus orsinii, Acartia spinicauda* and *Corycaeus danae.* Certain species like *Temora stylifera* (February and March

1967) and *Macrosetella gracilis* (May and August '66 and January to April '67) were observed each in a limited period of the year. *Centropagus furcatus* was present from January to March '67, *Centropagus tenuiremis* from August to October '66

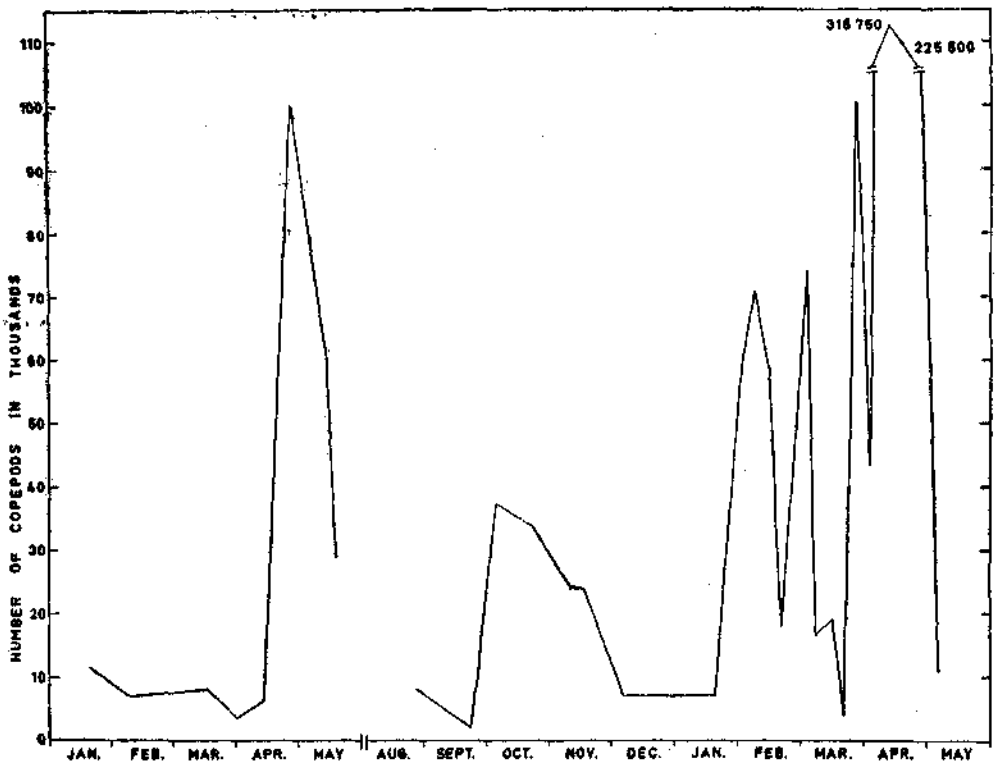

FIG. 2. Seasonal variation of copepods.

and *Labidocera pectinata* in May '66. Calanoid copepods contributed to the bulk in the samples. Copepod nauplii were abundant from January to May '67 but were rare during the same period of the preceding year.

The common amphipods were *Hyperia* sp. and *Prymno* sp., the former species being fairly abundant during the months of November, February and March. *Oxycephalus* sp. and *Simorhyncotus* sp. were observed only during May and February respectively.

Of the ostracods, *Pyrocypris* was present in the samples during the period February to April 1967. Stray specimens were also noticed during November 1966.

Decapods were largely represented by larval stages with the exception of *Lucifer typus* and *L. hansenii*. Juveniles of *Acetes indicus* also were observed in the samples occasionally. *Lucifer typus* was found to occur during February, March and October and *L. hansenii* during October to March. Decapod larvae were present in the plankton almost throughout the year with two peak periods, one in August and the other in April (Figure 3). They also occurred in fair abundance during February,

March and April. The common forms observed in the collections were larvae of *Acetes*, zoea of *Porcellana*, penaeid larvae and a number of other unidentified larval forms. In addition to decapod larvae, *Alima* larva of *Squilla* was another common member of the plankton.

Pteropoda : Pteropods represented by *Creseis acicula* showed a peak during October 1966 and were present in lesser number in January, February and March. Only a single species was represented in the plankton.

Tunicata : Salpa democratica accounted for the bulk of tunicates present in the plankton samples. Also represented but in far less numbers were *Doliolum gegenbauril.* Salps showed irregular occurrence, being present during January, April, May and November in 1966 and February and March in 1967. Swarms of salps were seen in March '67.

Appendicularia : This group was represented in the plankton by a single genus *Oikopleura,* which was abundant during May, November '66, January, February and March '67, the peak periods being May '66 and March '67.

Fish eggs and larvae : Fish eggs were observed in large numbers during March, April and May and were rare during October and November. They were almost absent during the rest of the months (Figure 3). Fish larvae were abundant in October and April and were in smaller numbers during February and March.

HYDROLOGY

The observed values of surface temperature, salinity, dissolved oxygen and inorganic phosphate content are plotted in Figure 3. Surface temperature showed a bimodal fluctuation with two maxima, one in May and the other in October. The maximum temperature recorded was 30°C and the minimum was 24.2°C (in January 1967). Surface salinity values were almost uniform during 1966 but were fluctuating during '67. The monthly averages of salinity varied from 36.22‰ in May to 33.78‰ in November. The dissolved oxygen values showed marked variations during the period of observation. High values of saturation level were observed during March and August (6.77 ml/l and 6.27 ml/l respectively). The minimum oxygen was observed during November (0·313 ml/l). Inorganic phosphate content fluctuated between 0·15 μg *at*/l to 0·42 μg *at*/*l.*

DISCUSSION

From the data given above it is evident that the plankton of Bombay waters shows seasonal changes in the species composition as well as total biomass during the period under investigation. The occurrence of the two peak periods of total plankton volume during March/April and October/November is in accordance with the earlier observations of other workers. Sudarsan (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. The high production of plankton appears to be due to presence of nutrient rich upwelled water as stated by Carruthers *et al.* (1959). The present observations of the low surface temperature, low dissolved oxygen content and high standing crop of plankton during October (Figure 3) are in agreement with their findings. Though

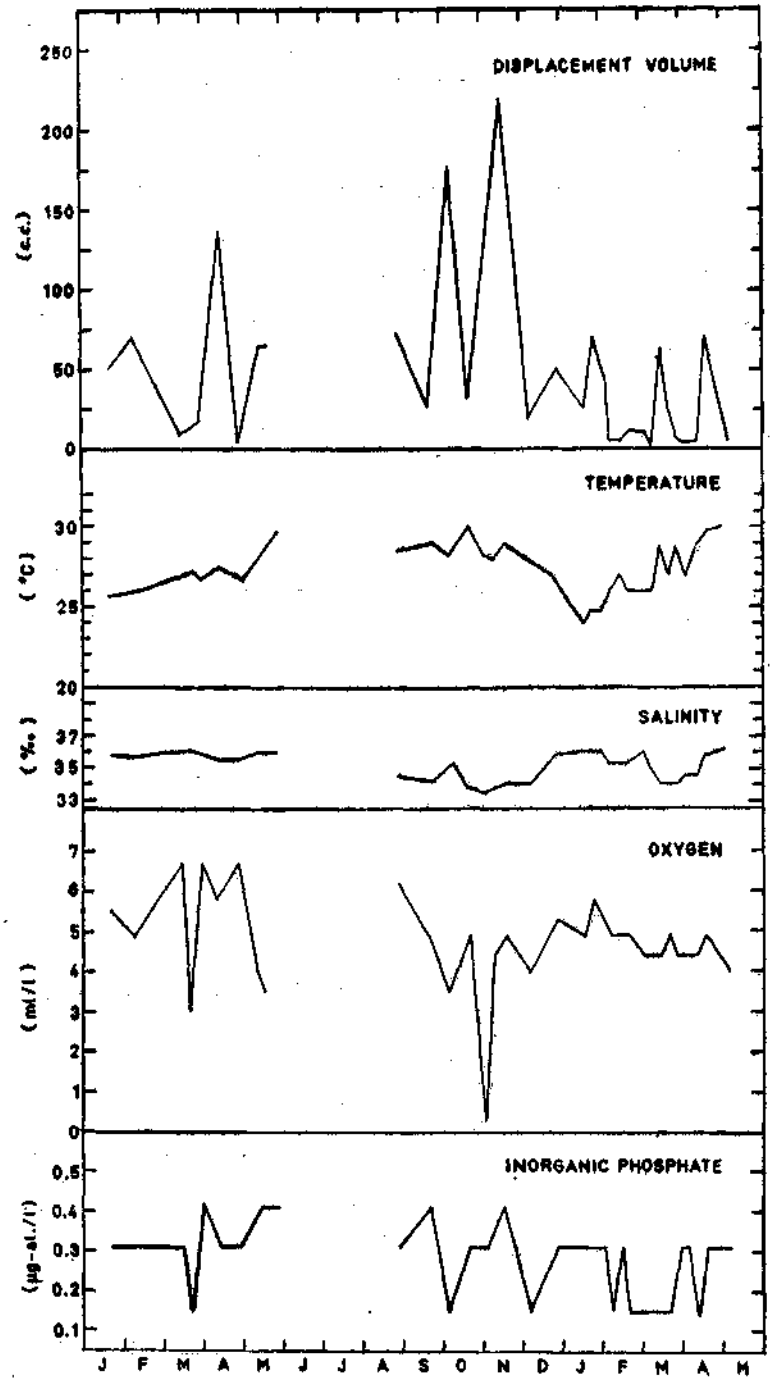

FIG. 3. Seasonal variations in the displacement volume, surface temperature, salinity, dissolved oxygen and inorganic phosphate.

zooplankters were dominating in the samples collected during October ('67), phytoplankton was also abundant, chiefly the diatom *Coscinodiscus* sp. imparting green colouration to the samples collected. Here the observation of Subrahmanyan (1959 *a*, *b*) that there is generally an increase in the population of the predators side by side with the increase of phytoplankton during the north-east monsoon season, and often the plants are eaten up and one comes across only an animal population for some time, seems to be relevant.

The observations of Bapat and Bal (1950 & '52) on food and feeding habits of the young ones of 16 species of clupeoids and of 7 other species from Bombay revealed that the majority of them were surface plankton feeders in their early part of their life and that the planktonic prawn larvae, mostly belonging to the genus *Acetes*, formed the main food of the early juveniles of a number of fish species. The author observed abundance of *Acetes* larvae during August and October. Bapat and Bal (1950) reported fairly rich occurrence of larvae and post-larvae of clupeoids in the summer and early rainy seasons. The comparatively warm water and the rich plankton production during these periods may be providing a favourable environment for the growth and survival of the young fishes. Also adult fishes like *Bregmaceros mcClellandi* which feed mainly on copepods and prawn larvae, are most abundant during the monsoon and post-monsoon periods which coincide with the abundance of decapod larvae in the plankton. It is a well known fact that *B. mcClellandi* forms a major food item for *Harpodon nehereus* which supports a major fishery in this region during the post-monsoon period. Hence it can reasonably be assumed that the abundance of plankton in the pre-monsoon period is indirectly influencing the fisheries of *Bregmaceros* and Bombay Duck in this region. However, the data collected during these investigations are not extensive enough to draw definite conclusions.

Summary

The results obtained from the investigations carried out during the period from January 1966 to May 1967 on the abundance and seasonal fluctuations of plankton and hydrographic conditions off Bombay are presented. The displacement volume of plankton showed two peaks, one in March/April and the other in October/November. Zooplankters were the dominant groups in the plankton samples, comprising mainly of copepods, decapod larvae, chaetognaths, salps, siphonophores and medusae. The abundance and seasonal variations of different groups of plankters in the samples are briefly described. The values for surface temperature, salinity, dissolved oxygen and inorganic phosphate content are given. The results obtained during these investigations are in conformity with the earlier observations. The importance of plankton abundance in relation to the fisheries of *Bregmaceros mcClellandi* and *Harpodon nehereus* is pointed out.

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