PLANKTON AND HYDROLOGICAL FACTORS AT KANDLA IN THE GULF OF KUTCH DURING 1960—1963

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ABSTRACT

The present studies relate mainly to the hydrological factors in the Gulf of Kutch at Kandla from August 1960 to December 1963. The seasonal variation in the temperature, salinity, pH, dissolved oxygen, inorganic phosphate, nitrite and silicate and their influence on plankton have been discussed. Temperature seems to be the only factor following the same pattern of variation during all the years. Dissolved phosphate and nitrite have a definite seasonal cycle among the nutrient salts. Fluctuation in salinity in the gulf appears to be erratic. Salinity and pH show a direct relationship in this area. The seasonal fluctuations of different plankters, both phytoplankton and zooplankton, have been discussed. The fluctuations in the phytoplankton count do not seem to be reflected on the total volume of plankton. It is seen that zooplankton content is mainly responsible for the variation in the plankton biomass.

INTRODUCTION

The significance of this work relates to the high potential of the fishing grounds in the Gulf of Kutch. This Gulf, marking the northern most extremity of the west coast of India, is inadequately known for its productivity potential. In a previous study (Ramamurthy and Dhawan, 1967), well-marked fluctuations in the plankton abundance at Kandla in the Gulf of Kutch were noted and, hence for the proper understanding of the environmental factors, the present study was undertaken. The paper is based on the collections of water and plankton samples made during August 1960 to December 1963 from a station in Kandla port creek. The physical features and climate of Kutch have been given by Ramamurthy and Dhawan (1967).

MATERIAL AND METHODS

The observations were made from August 1960 to December 1963 and in all 160 samples were collected. Temperature and salinity of the water were recorded from the site of plankton collection. The salinity estimations were made by Mohr's method. The pH was determined with Helliege pH comparator using cresol red as indicator. The dissolved oxygen was estimated by Winkler's method. Inorganic

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phosphate was estimated by Denigi's method as modified by Robinson and Thompson (1948 *a*). Silicate was estimated by the colorimetric method of Dunnert and Wadenbulcks as modified by Robinson and Thompson (1948 *b*). Nitrite was estimated by using Greiss-Ilosvay reagent as followed by Orr (1926). Colours were compared in Nesseler's cylinders in bright diffused light.

Horizontal plankton hauls of 15 minutes duration using a half metre organdy cloth net with 36 strands per sq. cm were made between Kandla Salt Works Jetty and cargo jetty in the central main channel of the Kandla creek. The depth in the area of collection was 12 m at low tide. The collections were made between 5 and 6.30 A.M. at flood and ebb tides alternately during each month.

Sub-samples of the aliquot of each haul was examined for a preliminary qualitative estimation immediately after its arrival in the laboratory. Later the samples were fixed in 5% seawater formalin. The volume of plankton was determined by the displacement method. It was diluted to a known concentration (250 ml) from which a sub-sample of 1 ml was examined in a plankton counting chamber for enumeration of different organisms For larger organisms such as chaetognaths, 10 ml sub-samples were taken and their numbers counted. For the study of seasonal fluctuations of the different plankters, the numbers of the zooplankton organisms were counted, whereas for phytoplankton, the following nomenclature was employed in terms of the number of diatom cells, algal filaments per ml of standardised subsample: Rare (R) — less than 100; Few (F) — 101 to 1000; Common (C) — 1001 to 10,000; Abundant (A) — over 10,000.

In order to determine whether flood and ebb currents during spring and neap tides have any marked influence on the production of plankton in the area, collections were made on the following 4 days, 26—8—1961, 2—9—1961, 12—9—1961 and 19—9—1961. Six collections of plankton and water samples were evenly timed during both rising and receding tides. The water samples thus collected were analysed for estimation of various factors like dissolved oxygen, temperature, salinity pH, inorganic phosphate, nitrite and silicate and plankton. The data on annual rainfall were procured from the meteorological department of Kandla Port [2].

It was observed that during late afternoon hours during the flood, irrespective of spring or neap tide conditions, the phytoplankton representation was higher during the new moon phase. The plankton volume at the ebb was generally higher as compared to rising tide. But the qualitative analysis of the samples revealed that it was mainly the strong currents churning the water which resulted in the floating of considerable debris from the bottom. But the collections made during rising tide showed much better representation of plankters even though their volume was much lower.

2. The author is thankful to Kandla Port authorities for making available the data on rainfall at Kandla.

Based on these observations subsequent collections were made from the central channel in Kandla creek between salt works jetty and cargo jetty, alternately during spring and neap tides irrespective of high and low waters.

Hydrological Conditions

Temperature

The surface temperature of the coastal waters in the Gulf of Kutch showed a more or less unimodal oscillation unlike the other parts of the Indian coastal waters (Prasad, 1957). In all the years the temperature showed a decline from November and reached the minimum in January. Thereafter the temperature rose steadily reaching the maximum in June-July in all the years. The maximum values recorded during 1960 to 1963 were 28.85°C, 29.60°C, 29.40°C and 29.93°C respectively and the minimum were 16.72°C, 16.50°C, 15.32°C and 15.80°C respectively. The occurrence of minimum and maximum temperature coincides with the winter and summer season respectively in the area (Fig.1).

Salinity

The salinity ranged during the period of observation from 25.40‰ to 42.98‰ (unlike during 1959 and 1960 as observed by Ramamurthy and Dhawan, 1967). The salinity has been comparatively higher during the period of observation which can be attributed to weaker monsoon during this period. Except in July-October 1961 the salinity varied from 32.63‰ to 42.83‰. During July to October 1961 there were comparatively heavy rains in this area, the monthly rainfall in these months being 314 mm, 85 mm, 51 mm and 30 mm respectively. The peak values for salinity occurred in April 1961 (41.87 ‰) June 1962 (39.25‰), and May 1963 (42.88‰) A similar variation in the occurrence of peak values of salinity has been reported by Ramamurthy and Dhawan (1967).

pH

The pH value was determined along with total alkalinity which followed the trend of changes in the salinity. The value of pH varied between 7.90 in December 1960 and 8.7 in May 1962. Fig. 1 reveals that there was not much variation in pH during the period of investigation.

Dissolved Oxygen

The dissolved oxygen content of water was lowest in June 1962 and 1963; but in 1960 the lowest was in August whereas in 1961 it was observed in July. Thereafter, it steadily increased in all the years reaching maximum in December 1960, 1961 and 1963 whereas in 1962 it was in November.

The dissolved oxygen values ranged between 3.73 ml/l in June 1963 and 6.30 ml/l in January 1961. The fresh water brought by the rivers Macchu, Banas and Saraswati through Little Rann of Kutch into the area of observation, as a matter of fact, should increase the concentration of dissolved oxygen in June. On the contrary.

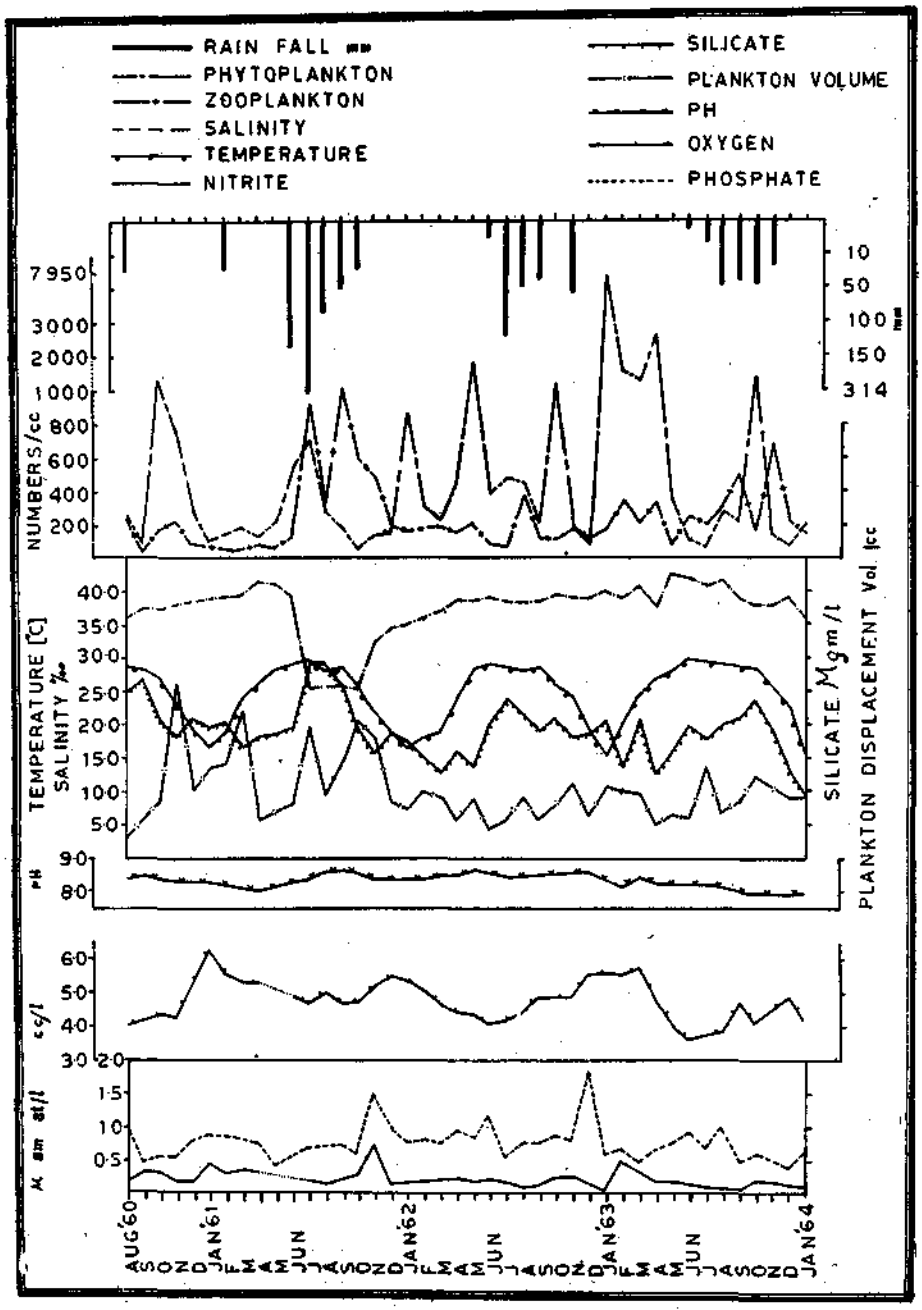

FIG. 1. Seasonal fluctuations of the hydrological factors and plankton during August 1960 to December 1963 in the Gulf of Kutch at Kandla.

the actual observation revealed that the dissolved oxygen values at this time were low which may perhaps be due to high water temperature (29.89°C and 30.29°C in June 1962, 1963 and 30.15°C in July 1961). After June in all the years the dissolved oxygen steadily increased reaching maximum in December-January during the north-east monsoon period.

Phosphate

The phosphate value varied from 0.31 μg at./l to 1.87 μg at./l (Fig.1). The minimum was noticed in October 1960, 1961, July 1962, December 1963 when fresh water with low salinity was received after heavy monsoon rains (except in December 1963), the values being 0.31, 0.64, 0.59 and 0.43 μg at./l respectively. The maximum was observed in August 1960, November 1961, December 1962 and August 1963, the values being 1.09, 1.52, 1.87 and 1.10 μg at./l respectively. In 1961 and 1962 these peaks were observed during the north-east monsoon spell which is followed by phytoplankton maxima (Fig. 1).

Nitrite

The nitrite value of the Gulf water varied from very negligible amount of 0.10 μg at./l to 0.75 μg at./l. The minimum was noticed in August 1960, 1961, 1962 and September 1963, the values being 0.17, 0.18, 0.13 and 0.10 μg at./l respectively. The maximum was always noticed during the northeast monsoon period being 0.45 μg at./l in October 1960, 0.75 μg at./l and 0.39 μg at./l in November 1961 and 1962, 0.53 μg at./l in February 1963 and 0.22 μg at./l in October 1963 (Fig. 1).

Silicate

The silicate values varied from 12.85 to 29.92 μg at./l in April 1963 and September 1961 respectively. The minimum values were noticed in April 1961, March 1962 and April 1963, being 15.65, 14.23 and 12.85 μg at./l respectively. The maximum values were recorded in September 1960, 1961, August 1962 and October 1963. Fig. 1 reveals that the maximum value of silicate content was always during the south-west monsoon, whereas the minimum was in March-April. However, it can be seen that silicate did not show any uniform pattern during these investigations which may be due to the churning of water as a result of high tidal variation in the creek.

PLANKTON

Qualitative studies

Striking differences were observed in the actual values during the three years of the present studies. The plankton crop reached the maximum in October 1961, 1962 and 1963 (Fig. 1) showing that the plankton crop was high during the north-east monsoon period (October-February) with a secondary peak during the south-west monsoon (July-September) period, the primary peak being mainly due to phytoplankton maxima which follows the maxima of nutrient salts.

TABLE 1. *Monthly variation in phytoplankton abundance during August* 1960 *to December* 1963

Month	1960	1961	1962	1963
January	—	F	F	A
February	—	C	F	C
March	—	F	F	C
April	—	F	F	C
May	—	F	C	F
June	—	F	F	F
July	—	R	F	R
August	F	F	F	F
September	F	R	F	F
October	R	C	C	C
November	F	F	F	R
December	R	F	F	R

It is clear from Table 1 that phytoplankton maximum was observed in October in all the years excepting 1960. Maximum values were also observed in February 1961 and January 1963. The phytoplankton peaks were mainly constituted by the following species of diatoms: *Coscinodiscus, Thallassiothrix, Biddulphia, Thallassionema, Nitzschia, Bellarochea, Rhizosolenia, Pleurosigma, Navicula* and *Triceratium*. They were found to be common during the north-east monsoon period, but generally the primary peak was observed during October followed by a secondary peak during January-February. Other common diatoms, like species of *Chaetoceros, Asterionella, Ditylum, Bacteriastrum, Rhabdonema, Surirella, Lauderia, Amphiprora, Synedra, Climacosphenia, Gyrosigma, Schroaderella* and *Cerataulina* were also present in fair numbers. On the whole the diatom representation in the plankton collections during the period under review were generally poor. Another notable feature was the complete absence of dinoflagellates in the collections during 1960-1961 and 1962 whereas during 1963 they occurred in negligible numbers. The presence of dinoflagellates wes observed for the first time in the plankton in May 1963. They were represented by *Ceratium furca, Ceratium massiliense* and *Ceratium fusus*. However, *Dinophysis* spp. have never been observed in the collections.

Noctiluca miliaris was found from March to July only during 1962 and 1963 whereas in 1960 and 1961 it was absent. Foraminifers occurred in small numbers during pre-monsoon and south-west monsoon period from March to September

whereas during the rest of the period either they were absent or very negligible. Radiolarians were observed in small numbers during the south-west monsoon period (June-September) in all years. Tintinnids were most common during October-April in all the years, particularly in 1962 and 1963.

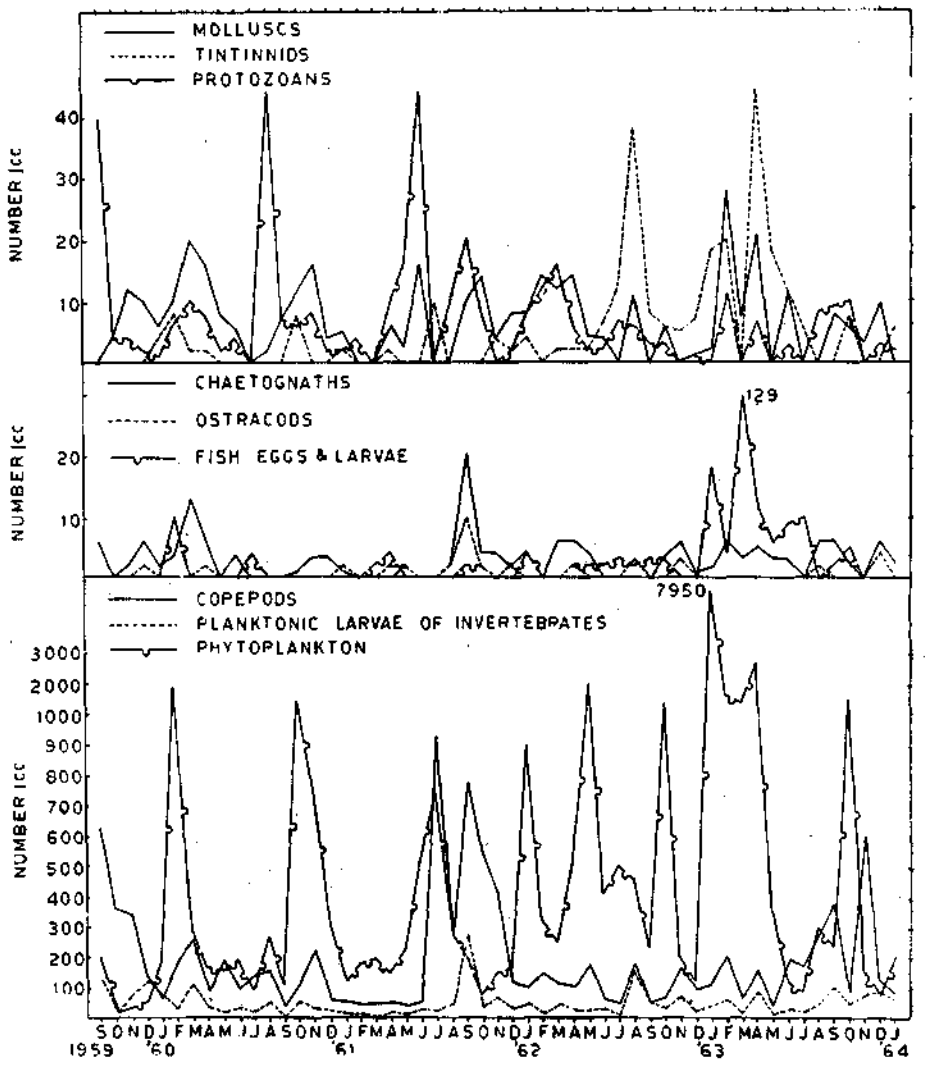

FIG. 2. Representation of different groups of plankters in the plankton at Kandla.

Coelenterate population in the collections was mainly represented by hydromedusae, siphonophores and ctenophores. These were uncommon in the gulf waters off Kandla. Hydromedusae in small numbers were noticed almost through-

out the year, but were better represented in the collection during October-April in all the years. The common species observed in the collection were of the genera *Obelia, Liriops, Octocanna, Aequorea, Phortis, Irenoposis, Gonenemus* and *Eutima.* The siphonophores, though present throughout the year, were rare. The calycophorid forms were more common. The ctenophores were observed more commonly during March-September. Among ctenophores, *Beroe* sp. was better represented than *Pleurobrachia* sp. and occasionally *Cestrum* sp. was also observed.

The most predominant chaetognaths observed were *sagitta bedoti* and *Sagitta robusta.* At times *Sagitta enflata* was observed in small numbers in the post-monsoon months of October-April. *Sagitta bedoti* was observed almost throughout the year (Fig. 2).

The common cladocerans were *Evadne tergestina* and *Penilia* sp. These appeared in considerable numbers, the former better represented than the latter, during the south-west monsoon period (July-September) in all the years. They have a definite seasonal occurrence and in the collections they outnumbered the copepods during the south-west monsoon. In the post-monsoon months the cladocerans were on the decline.

The copepods showed wide fluctuations in their occurrence in all the years. They were in abundance during March-April and then again in June-August. During 1961 and 1963 the main copepod peak was observed in July-August whereas in the other years it was in March-April. In general, the copepods showed several modes of different magnitudes in all the years except 1961 when it showed bimodal tendency. Among calanids the most common copepods were species of *Centropages, Paracalanus, Acrocalanus, Eucalanus, Pseudodiaptomus, Acartia* and *Oithona. Centropages* sp. was generally most common from August to September and then again from March to April. *Paracalanus* sp. was common in October-Novermber and then in February-March. *Acroclanus* sp., *Eucalanus* and *Pseudodiaptomus* had a definite period of occurrence during the post-monsoon months from October to November whereas in other months these were present only in small numbers. *Acartia* sp. was common in August and September in all the years. Compared to other years, in July 1961 *Acartia* bloom was unusually high. *Oithona* sp. was seen in November and May in all the years. Other copepods observed in the collections in order of their abundance were *Euterpina, Labidocera, Corycaeus* and *Oncaeus.*

The period of occurrence of the common larval forms was as follows: Decapod—March, April, July, December; Copepod—April and September; Molluscan—February-April. The less important ones were those of Polyzoa (November-May), Polychaeta (November-April), Cirripedes (April and December), Ophiuroidea (November-May). *Phoronis* (October-December) and Brachiopoda (December-March). Fish eggs and larvae occurred during July-September and December-February.

Discussion

The present study revealed wide variations in most of the hydrological factors from year to year. There were considerable variations in the time of peak occurrence of the different plankters. However, the pattern of events in the plankton cycle remained more or less the same. The temperature variation showed a unimodal pattern. The occurrence of the temperature minima and maxima coincided with the winter and summer seasons in this area.

Salinity values showed very little fluctuation except in 1961. The monthly average values exhibited an upward trend from September to May with maxima in May followed by a decline during the June to August period. The average values were always more than 34‰ except in July-September 1961. The salinity distribution in the Gulf area, more or less agreed with the general pattern along the west coast of India (Chidambaram and Menon, 1945; Bal *et al.*, 1946; George, 1953). The dissolved oxygen content remained below saturation level during the south-west monsoon. It is significant that the dissolved oxygen values were near saturation point during the post-monsoon period especially during winter months (January-February). Probably factors such as low temperature and diatom abundance augment the oxygen saturation during the post-monsoon months.

The phosphate and nitrite showed a definite seasonal cycle with a well-defined maximum during the north-east monsoon period, followed by a subsequent secondary peak during the south-west monsoon period. However, silicate showed no definite trend.

The phytoplankton concentration in the area investigated was poor as compared to the other parts of the Indian coast and particularly the south-west coast of India (George, 1953). This may be mainly due to the turbid nature of the water in the Gulf. Regular observations on light penetration with Secchi disc for a period of one year revealed that the visibility of water was never more than half metre and during south-west monsoon it was as low as 15 cm. During the course of the present study phytoplankton showed annually two maxima in a year as noticed earlier (Ramamurthy and Dhawan, 1967). However, the occurrence of the phytoplankton maxima during the latter half of the north-east monsoon appears to be a regualr feature which coincides with the prevailing low water temperature and high saline condition. It has now been confirmed that a secondary maxima also occurs regularly during the south-west monsoon period (Fig. 1). Fluctuations in the phytoplankton count do not seem to be reflected on the total volume, from which it is inferred that zooplankton content is mainly responsible for the variation in the plankton biomass.

The zooplankton was mainly comprised of copepods and planktonic larvae. The copepods showed more than one peak during March-September and these peaks more or less followed the phytoplankton maxima. The primary peak was

observed during the south-west monsoon. Bal and Pradhan (1952) observed two or three peaks of copepods during May to September in Bombay waters. The planktonic larvae showed more than one peak during a year. The maximum peak occurred in December 1959, March 1960, September 1961 and 1963 and August 1962.

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