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RESEARCH ARTICLE

Distribution and abundance of Zooplankton along Chitrapur, South-west coast of India

■ Mridula Rajesh, V. Moorthy **and** H.R.V. Reddy

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ABSTRACT : The present study was carried out over a period of 8 months from Oct. 2012 to May 2013 at 3 different depth contours *viz.*, 4m (St. 1), 8m (St. 2) and 12m (St. 3) along the coastal waters of Chitrapur, Mangaluru where Boulique Aniline Soda Factory (BASF) and Mangalore Refineries and Petro Chemical Limited (MRPL) discharge their effluents. In general, the zooplankton density was at its peak in the month of October and January and lower in the months of December and March/April. Copepodites formed the bulk of the total zooplankton and in the present investigation, they varied from 2,800 to 2,62,000 nos/m^3. These contributed to 29.86 per cent, 28.57 per cent and 20.24 per cent of the total zooplankton population in St. 1, 2 and 3, respectively. The other zooplankton groups noticed were copepodites, chaetognaths, medusae, siphonophores, ctenophores, tintinids, cladocerans, lucifer, polychaetes, Protochordates and larvae of decapods, echinoderms, bivalves followed by fish eggs and larvae.The species diversity, richness and evenness were high during premonsoon season followed by postmonsoon season at all the stations.

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Zooplankton constitutes a broad category and wide range of organisms in marine environment. Roman *et al.* (2000) have opined that zooplankton is very important to marine pelagic ecosystems, that support higher trophic levels and as the essential determinant of the potential fishery yield. Several micro zooplankton species also constitute major food stuff of the larvae of crustaceans, mollusks and fishes while some species of zooplankton are used as bioindicators of water quality and movement of water current (Resmi *et al*., 2011). Therefore knowledge on species composition, abundance and distribution of zooplankton was always considered as great significance in marine ecological and fishery management exercises. In recognition of the ecological and economic significance of marine zooplankton, emphasis has been given by several researchers engaged in the monitoring of aquatic systems to understand the various physico-chemical processes governing the biological production (Goswami and Padmavathi, 1996; D' Costa and Pai, 2013; Mridula *et al.*, 2007 and 2013; Resmi *et al.*, 2011 and Jose *et al.*, 2015). Hence, the present study was undertaken in the coastal waters of Chitrapur to understand the changes in zooplankton distribution and abundance in relation to the selected physico-chemical characteristics due to the discharge of treated effluents from BASF.

Author for correspondence :
Mridula Rajesh
Department of Fisheries Resources and Management, College of Fisheries, Mangalore (Karnataka) India
Email : mridularajesh789@yahoo.co.in

See end of the article for **Coopted authors'**

EXPERIMENTAL METHODOLOGY

In the present investigation, 3 stations were selected along Chitrapur, Mangaluru at 3 different depth contours *viz.*, 4m, 8m and 12m (Fig. A) and were designated as St1, 2 and 3, respectively. 2 industries, Boulique Aniline Soda Factory (BASF) and Mangalore Refineries and Petro Chemical Limited (MRPL) discharge their effluents in this area. The present study was carried out over a period of 8 months from Oct., 2012 to May, 2013 at monthly intervals during the cruises of the fishing vessel M.F.V. Dolphin of the College of Fisheries, Mangaluru. It was possible to conduct the study only for 8 months because the other 4 months of the year (June-Sept.) experienced heavy rainfall due to south west monsoon and during this period fishing and other activities in the sea are banned.

Standard thermometer and pH meter (WTW pH 320) were used to measure the temperature of the water and pH, respectively. Dissolved oxygen, salinity and ammonia were estimated following standard methods (APHA, 1995). Zooplankton from the water column was collected at each station using a Bongo net having mouth dimension of 60 cm dia with 250 cm long filtering cone. The mesh size of the filtering cone is 180 mm. The hauls (vertical) were taken giving 2 m safe depth from the bottom. The samples were fixed in 4 per cent formalin onboard the vessel and later preserved in 2 per cent formalin for analysis. The samples were made upto a known volume after the separation of macro zooplankton and counted. From this, 1 ml was taken and the number of different groups of micro-zooplankton were counted and represented as number/m^3. Diversity indices such as species richness (d) and evenness (J') were calculated (Shannon and Weaver, 1949 and Pielou, 1975).

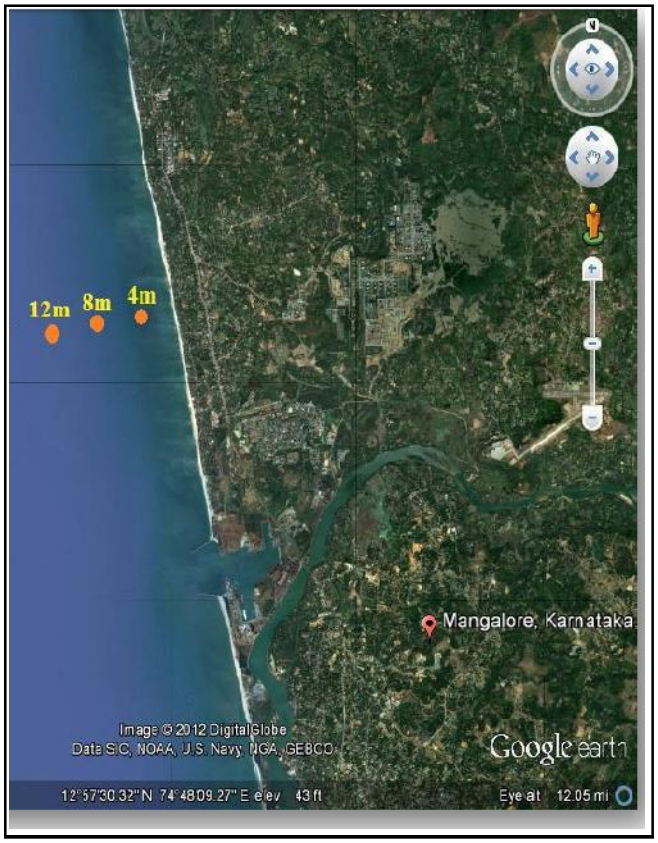

Fig. A : Map showing the location of sampling station

EXPERIMENTAL FINDINGS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under following heads :

Environmental parameters :

In the marine environment, temperature is considered as the most influencing factor as it regulates the life of aquatic organisms and environmental parameters (Vajravelu *et al.*, 2018). The surface water temperature varied from 29.43 to 32.37° C. It is evident from the data that the surface water temperature was lowest during Jan. and reached a maximum in the month of March.

Salinity of surface waters fluctuated from 29.27 to 33.13 ppt. The lower salinity recorded during October could be due to the influence of south west monsoon while higher values recorded in the month of April and May could be due to the greater evaporation during the peak summer season (Rajasegar, 2003 and Mridula *et al*., 2007).

The dissolved oxygen content of the surface waters fluctuated from 3.19 to 7.61 mg/l with an annual variation of 4.42 mg/l. Shirodkar *et al*. (2009) has recorded mean dissolved oxygen of 5.29 mg/l along Mangalore coast. It is known that the dissolved oxygen content in south west coast mainly depends on circulations, water movement and wind action. Besides the biological conditions like photosynthesis and respiratory activities of organisms are also important particularly in case of coastal waters (Mridula *et al*., 2013).

The ammonia values fluctuated between 1.7 and 12.91 µg-at/l. The higher values of ammonia coincided with the greater abundance of zooplankton. This

relationship could be attributed to the biological activity of the zooplankton especially excretion (Segar and Hariharan, 1989 and Mendon *et al*., 2002).

Distribution of zooplankton components :

The monthly variations of zooplankton density at different stations are depicted in Fig. 1. In general, the zooplankton density was maximum in the month of October and January at St. 1 whereas it was high in the month of October at St. 2 and January at St. 3. The minimum abundance of zooplankton was observed in the months of December and March/April.

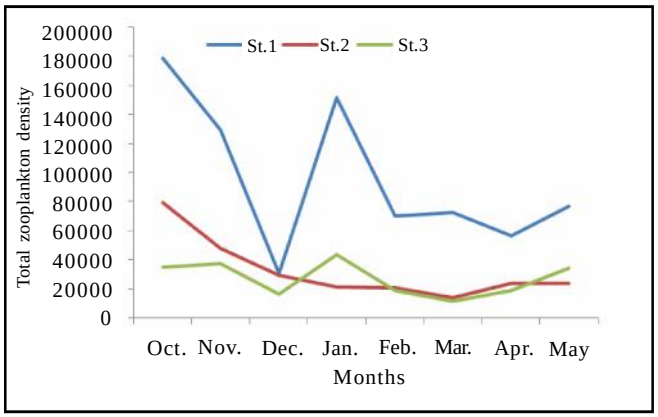

Fig. 1 : Monthly variation of zooplankton density at different stations

Copepods and copepodites :

Copepodites formed the bulk of the total zooplankton and in the present investigation they varied from 2,800 to 2,62,000 nos/m^3. These contributed to 29.86 per cent, 28.57 per cent and 20.24 per cent of the total population in St 1, 2 and 3, respectively (Table 1). It is evident from the data that intensive breeding of copepods takes place in the area throughout the season (Rai *et al*., 2006 and Resmi *et al*., 2011).

Copepods emerged as the major group making upto 50.37 per cent, 55.87 per cent and 57.12 per cent in St. 1, 2 and 3, respectively. They were also present throughout the period of study and the number varied from 5,600 to 75,000 numbers/m^3. When compared to the earlier reports, it is evident from the study that there is a drastic decline in the copepod population along the coastal waters of Mangalore (Mridula *et al*., 2007 and 2013).

Chaetognaths and chaetognath larvae :

Chaetognaths predatory habit and as an important indicator species of water mass made it a subject of intense research. In the present investigation, number of chaetognaths varied from 0 to 100 nos/m^3 making upto 0.04 per cent, 0.03 per cent and 0.04 per cent in St 1, 2 and 3, respectively. However, the numbers observed were lower than that collected along the Indian Coast (Goswami and Padmavathi, 1996; Rai *et al*., 2006; Mridula *et al*., 2007 and 2013 and Resmi *et al*., 2011). Spatially, greater abundance was found in St 1 (4m) than in St 3 (12 m) and St 2 (8m). Along Chitrapur waters, chaetognaths were present throughout the period of study with peak abundance during premonsoon season. The spatial difference could be attributed to the influence of effluent discharge from the nearby industry (Nair *et al*., 1991 and Neelam and Nair, 1993).

Chaetognath larvae varied from 0 to 8000 nos/m^3. The frequency of occurrence and abundance decreased with increased depth. Generally, chaetognath larvae reached maximum in the month of April / May in almost all the stations. The abundance of the larvae during premonsoon season revealed that higher temperature and salinity regime is more conducive for the development of chaetognaths.

Table 1 : Percentage composition of different groups of zooplankton at different stations

Groups	Stations		
	1	2	3
Tintinids	3.845	1.990	2.285
Medusae	0.467	0.198	0.517
Ctenophore	0.007	0.000	0.002
Chaetognath larvae	1.694	1.220	1.175
Chaetognath	0.054	0.032	0.040
Polychaete larvae	4.627	2.505	1.725
Polychaete	0.003	0.003	0.002
Cladocerans	0.130	0.642	2.145
Copepods	50.373	55.871	57.118
Copepodites	29.859	28.574	20.236
Copepod egg	1.303	0.385	0.560
Lucifer	0.106	0.075	0.034
Decapod larvae	0.665	2.455	5.142
Bivalve larvae	0.463	0.129	0.187
Echinoderm larvae	0.652	0.963	1.492
Oikopleura sp.	3.137	1.870	4.585
Fish eggs	2.608	3.020	2.752
Fish larvae	0.007	0.069	0.005

Decapod larvae :

The decapod larvae consisted of nauplius, protozoea,

zoea, mysis and megalopa of crabs. The spatial distribution of decapods showed higher abundance at 12 m followed by 8 m and 4 m depth contour. Similar observation was recorded by Resmi *et al*. (2011) in the coastal waters of Padubidri, Karnataka.

Medusae and ctenophores :

The number of medusae ranged from 0 to 2046 nos / m^3. The distribution of medusae indicated relatively higher numbers at St. 2 when compared to St. 1 and 3. Higher numbers were recorded during premonsoon season in St. 1 and 2 while in St. 3 it was more during postmonsoon season. Therefore, distribution of medusae could not exhibit clearcut seasonal variation along the section studied.

Ctenophores were rarely encountered. The number varied from 0 to 46/m^3. They were totally absent in St. 2 but found to be more in St. 1 when compared to St. 3.

Tintinids :

Tintinids were the single major group recorded under protozoa. The number of tintinids varied from 0 to 20,000 nos /m^3. In the present study, higher abundance of tintinids was found during the postmonsoon season in all the stations. Similar observation was recorded by Rai *et al*. (2006) along Dakshina Kannada coast. The spatial distribution showed higher abundance in 5m depth than 10m and 15m which is in agreement with Resmi *et al*. (2011).

Cladocerans and lucifer :

The study of cladocerans in the marine environment has attracted many research workers because of its high reproductive potentiality resulting in spurt at times and total absence at other times (Dellcroce and Venugopal, 1972) and also its intimate relationship with pelagic fisheries. *Penilia avirostris* and *Evadne tergestina* were the only representatives of group cladocera. The number of cladocerans varied from 0 to 1800/m^3. Spatially they were found to be more in St. 3 compared to St. 2 and 1.

Lucifer is a typical epiplanktonic decapod found distributed along both the coasts of India. Lucifers form a major component in the diet of shoal fishes and shrimps (Omari, 1977). Thus, it is assumed that this plays an important role in the food web of neretic waters. Lucifers occurred more frequently and their number ranged from 0 to 208/ m^3. Seasonally they were found to be more during the premonsoon season than the postmonsoon season.

Polychaete, polychaete larvae and echinoderm larvae :

The number of polychaetes ranged from 0 to 26 / m^3. The occurrence was found to be more in the shallower waters which is in contrast to the works of Ramesh (1989) and Rajanna (1997) along the coastal waters of Mangalore.

The number of polychaete larvae fluctuated from 0 to 3330 /m^3. Spatially the number decreased with increased depth. Along the section, abundance of larvae was observed all through the months.

Echinoderm larvae such as *Bipinnaria, Pluteus* and *Echinopluteus* were observed and their numbers varied from 0 to 4000 / m^3. The spatial distribution exhibited higher numbers in St. 1 and 3 than in St. 2.

Bivalve larvae :

The abundance of molluscan larvae in this region reflects the breeding potentiality and periods of common molluscs in this region. Bivalve larvae varied from 0 to

Table 2 : Diversity indices of zooplankton during the study period

Months	Station 1			Station 2			Station 3		
	Species diversity (H^I)	Species evenness (J^I)	Species richness (D^I)	Species diversity (H^I)	Species evenness (J^I)	Species richness (D^I)	Species diversity (H^I)	Species evenness (J^I)	Species richness (D^I)
Oct.	3.81	0.69	0.95	2.43	0.49	0.91	2.59	0.38	0.96
Nov.	3.51	0.51	0.97	4.35	0.59	0.99	5.05	0.60	0.98
Dec.	2.76	0.52	0.94	2.98	0.50	0.95	3.78	0.58	0.94
Jan.	3.2	0.44	0.97	3.03	0.43	0.8	3.01	0.44	0.96
Feb.	2.82	0.38	0.98	3.18	0.48	0.96	3.26	0.46	0.96
Mar.	3.77	0.54	0.97	4.77	0.61	0.9	4.38	0.56	0.98
Apr.	4.07	0.52	0.96	4.92	0.59	0.96	5.76	0.65	0.98
May	3.47	0.47	0.97	4.14	0.41	0.96	4.88	0.60	0.98

2000 /m^3. The spatial distribution of bivalve larvae revealed decrease in numbers with increased depth.

Protochordates :

The representatives of protochordates observed was *Oikopleura*. The number of *Oikopleura* ranged from 0 to 12,000 / m^3. Spatially the distribution of this protochordates was high in the station nearer to the coast. Hence it can be stated that protochordates proliferate well in the entrophicated water (Mridula *et al*., 2007).

Fish eggs and larvae :

The number of fish eggs ranged from 0 to 8002 / m^3 while fish larvae ranged from 0 to 167 / m^3. The abundance of fish eggs was found to be more during the postmonsoon season along all the stations while the occurrence of fish larvae was sporadic. The spatial distribution of fish eggs and larvae revealed decreased numbers with increased depth.

Diversity indices :

The results of species diversity, species richness and species evenness is given in Table 2. The species diversity, richness and evenness were high during premonsoon season followed by postmonsoon season at all the stations. The high species diversity, richness and evenness observed could be due to the stable hydrographical parameters which rendered more phytoplankton growth thereby the population density and species composition of zooplankton increased (Vajravelu *et al*., 2018). The recent studies conducted at Padubidri coast (Mridula *et al.,* 2013) and Parangipettai coastal waters (Madhav and Kondalarao, 2004).

Coopted Authors' :

V. Moorthy and H.R.V. Reddy, Department of Aquatic Environment Management, College of Fisheries, **Mangalore (Karnataka) India**

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