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Saritha Sadasivan
ICAR-Central Institute of Fisheries Education, Panch Marg, off Yari Road, Versova, Mumbai, Maharashtra, India

Udai Ram Gurjar
ICAR-Central Institute of Fisheries Education, Panch Marg, off Yari Road, Versova, Mumbai, Maharashtra, India

SP Shukla
ICAR-Central Institute of Fisheries Education, Panch Marg, off Yari Road, Versova, Mumbai, Maharashtra, India

AK Jaiswar
ICAR-Central Institute of Fisheries Education, Panch Marg, off Yari Road, Versova, Mumbai, Maharashtra, India

Latha Shenoy
ICAR-Central instItute of Fisheries Education, Panch Marg, off Yari Road, Versova, Mumbai, Maharashtra, India

Geetanjali Deshmukhe
ICAR-Central institute of Fisheries Education, Panch Marg, off Yari Road, Versova, Mumbai, Maharashtra, India

Correspondence
Geetanjali Deshmukhe
ICAR-Central institute of Fisheries Education, Panch Marg, off Yari Road, Versova, Mumbai, Maharashtra, India

Zooplankton abundance and its seasonal distribution in Patalganga estuary, Maharashtra, India

Saritha Sadasivan, Udai Ram Gurjar, SP Shukla, AK Jaiswar, Latha Shenoy and Geetanjali Deshmukhe

Abstract
Patalganga-Amba estuarine ecosystem is opening to the southern part of Mumbai harbour, Raigad district of Maharashtra. Since it is one of the most productive and diverse ecosystem, the fishermen community belonging in this area are getting full or partial advantages of estuarine functions and services. There are more than 13 number of industries along the head water of Patalganga River, hydroelectric power station, Karanja boat jetty etc. are adversely affecting and making this ecosystem vulnerable to ecosystem degradation, eutrophication and decline of species abundance. On this background we studied the zooplankton abundance and seasonal distribution in relation with hydrological parameters, which are showing spatial and temporal variations. There were 14 groups of zooplankton identified with a density ranges from 6162 and 181155 no.x 10^3 L^{-1}. Copepods and copepod nauplius were dominant followed by barnacle nauplius and foraminifera. The numerical density of zooplankton was positively correlated with phytoplankton abundance, temperature and pH and negatively correlated with salinity. Spatio-temporal variation of hydrological parameters influences the plankton distribution. H', J' and D based on zooplankton abundance ranged between 2.25, 0.874 and 1.25 respectively. The diversity indices were indicating the ecosystem was productive but observed a gradual decline while comparing with the previous studies.

Keywords: Patalganga, estuary, zooplankton, seasonal distribution, abundance

Introduction
Estuaries are one of the most productive ecosystems in nature, which is regarded as transitional waters [1, 2] having strong connectivity with both the riverine and marine environments [3, 4]. Many commercially important vertebrates and invertebrates from the marine and freshwater ecosytems depend on sheltered waters of estuaries as protected breeding, spawning and nursery ground [5, 6]. Zooplankton community in the estuarine ecosystem mediate the energy flow between phytoplankton, the primary producers and higher trophic level consumers [7]. This trophic link is important in the remineralisation and transport of nutrients [8] which is helping the conservation of modern aquatic food web [9, 10]. Presence or absence, abundance or scarcity of zooplankton population indicates aquatic pollution, as well as the zooplankton community structure, is necessary to asses the potential fishery resources of a place [11, 12].

Patalganga river arises from the steep western part of Matheran, flows westward, joins and mixes with Amba river and Karanja creek at Raigad district of Maharashtra [13]. There are more than 13 industries comprising of textiles, petrochemicals and pharmaceutical industries has been set up along the vicinity of upstream Patalganga River and act as the main source of water supply to these industries. The effluents from these industries are discharged back to this river causing substantial deterioration of water and sediment quality [14]. According to the central pollution control board, Patalganga river is one of the most polluted river among country's 38 rivers. At Patalganga estuarine area, the confluence of Patalganga River, Amba river and Karanja creek mixes well reducing the pollution effects a little extent. On this background, the present study aims to assess the abundance and seasonal distribution of zooplankton at the selected sites of Patalganga estuary.

Materials and Methods

Water samples were collected monthly basis for a period of October 2016 to December 2017 from seven stations fixed at Patalganga estuary (Fig. 1). Depth of sampling sites ranges from 1.5 to 4.5 m depending on the tidal condition prevailing at the ecosystem during sampling. Salinity, temperature and pH were assessed at the time of sampling using refractometer ATAGO S/Mill-E, mercuric thermometer and OAKTON eco tester respectively. Water samples collected in BOD bottles and transported to the laboratory for the estimation of DO and BOD following APHA [15] methods.

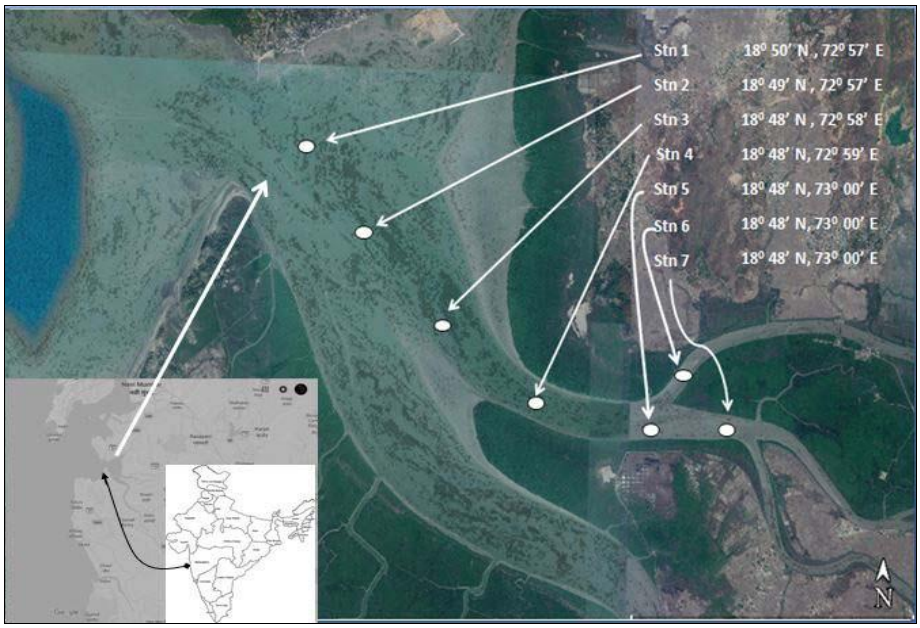

Fig 1: seven selected sampling stations in Patalganga estuary based on the salinity differences.

Zooplankton was collected by horizontal hauls of 5- 10 minutes using bolting silk net with a mouth area of 0.0855 m^2 and mesh size 0.02 mm. Collected samples were transferred to 50-100 ml plastic bottles and fixed with 5-10% formalin. HUND inverted microscope, stereoscopic microscope and Olympus FX 100 microscope were used for observing plankton and various standard keys were followed for identification. Sedgwick rafter was used for cell counting. Mathematical calculations and graph preparation done by using Microsoft Excel, 2007 and SPSS statistics 21 software and diversity indices analysed using PAST, PRIMER 6.1.15 and biodiversity pro version 2 software.

Results and discussion

Hydrological parameters analysed from Patalganga estuary showing spatial (Fig 2a) and temporal variations (Fig 2b). Monsoon rain has much influence on these hydrological parameters. The temperature was more in summer (av. 24.29 ^{0}C to 30.86 ^{0}C) and less in winter (av. 22.43 ^{0}C to 22.71 ^{0}C). Salinity was more during winter (av. 32.86 ppt to 34.71 ppt) followed by pre-monsoon and lowest was during monsoon months (av. 1 ppt to 12.14 ppt). pH was lowest during winter (av. 7.1 to 7.4) and highest was on monsoon months (av. 8.7 to 8.8). DO was less during summer (av. 3.14 mg/L to 4.11 mg/L) and highest during winter (av. 7.63 mg/L to 7.89 mg/L). BOD was showing monthly fluctuations (0.86 mg/L to 2.8 mg/L) may be because of the residence and/or flushing time prevailing at the ecosystem. All these hydrological parameters assessed were comparatively similar to the concentrations reported by Tiwari and Nair [16]. The surface water of the aquatic ecosystem is generally been influenced by the flow from an adjoining water body, flood, intensity of solar radiation, evaporation, cooling and mix up with ebb [17].

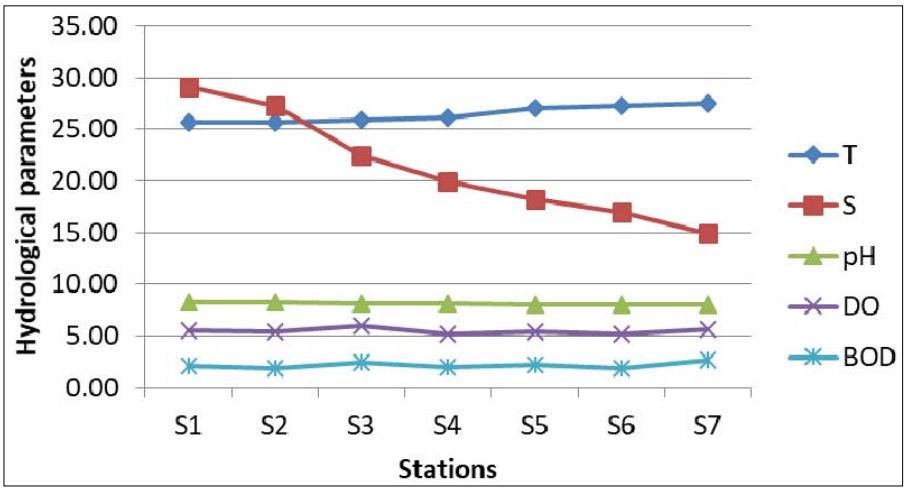

Fig. 2a) spatial variations of temperature (T), Salinity (S), pH, dissolved oxygen (DO) and biological oxygen demand (BOD).

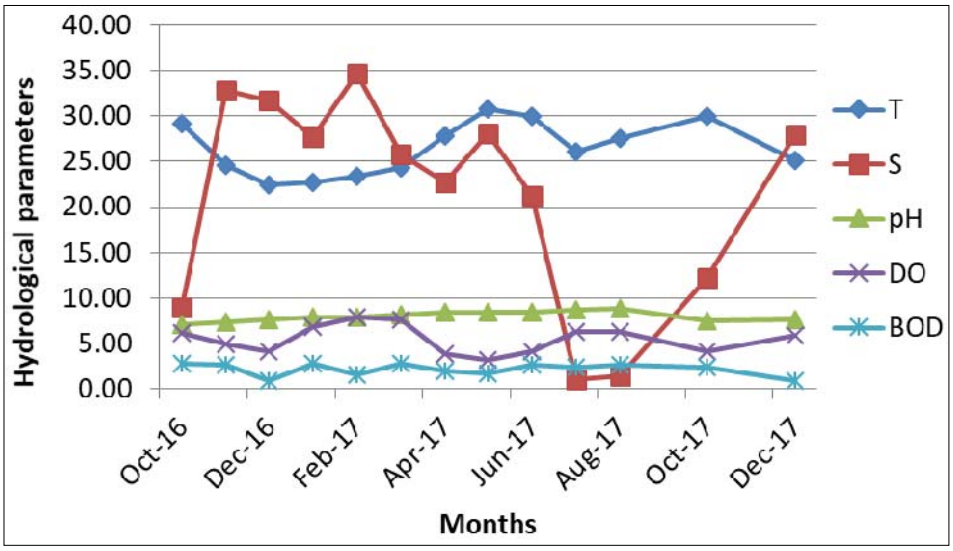

Fig. 2b) temporal variations of temperature (T), Salinity (S), pH, dissolved oxygen (DO) and biological oxygen demand (BOD).

Zooplankton was identified and clubbed as different taxonomic groups Tiwari and Nair [16] since the population density of some groups were less. Nair *et al.* [18] reported the number of zooplankton group at Vasishti estuary was 12 with a population size of 10845 no. /100 m^3 to 23308 n. /100 m^3. There were 14 groups of zooplankton recorded during the study period. Copepods and its nauplius, foraminifera, barnacle larvae, tintinnids, jelly fishes, crustaceans larvae include shrimp and crab larvae, fish eggs and larvae, *Sagita* sp., *Lucifer* sp. and larvae of insects, corals, star fishes etc. were recorded. All these groups were showing spatial and temporal (Fig. 3a and 3b) variations.

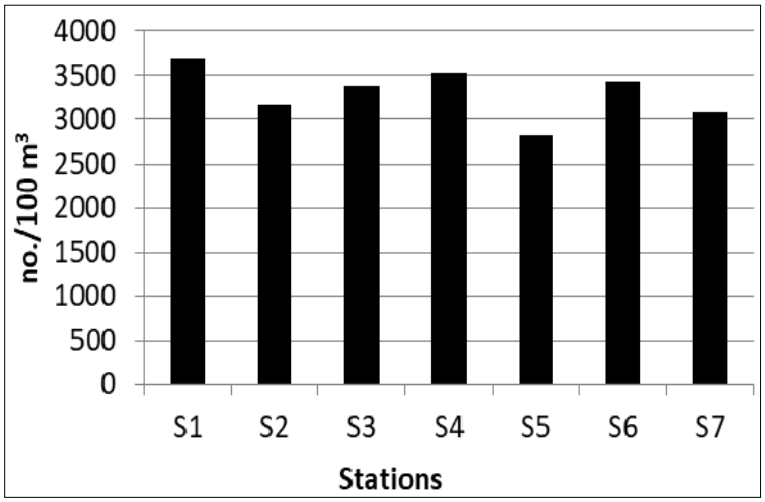

Fig 3a: Spatial distribution of zooplankton group

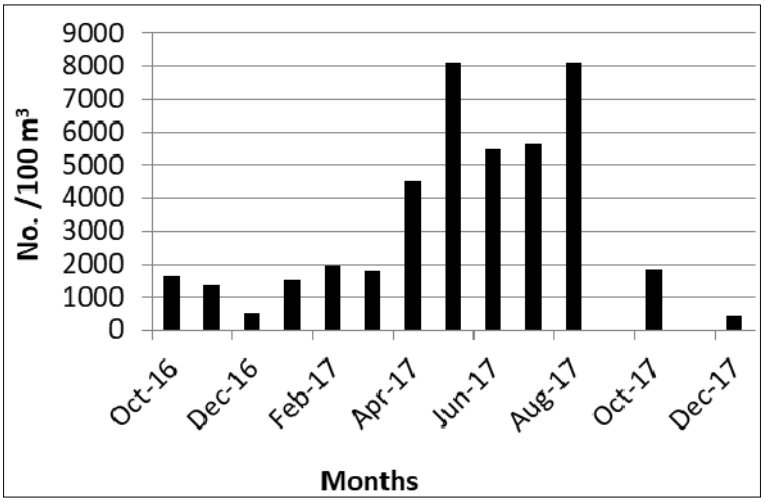

Fig 3b: Temporal distribution of zooplankton.

It was observed that copepod and copepod nauplius (48%) were more in the estuarine area (S1, S2 and S3) during the entire study period followed by barnacle nauplius (17%) and foraminifera (15%) (Fig. 4). Numerical abundance of zooplankton was more during August followed by May and its abundance was lowest during winter months especially October to March. The same observation was reported by Balakrishnan Nair *et al.* [17] at Kadinakulam backwaters.

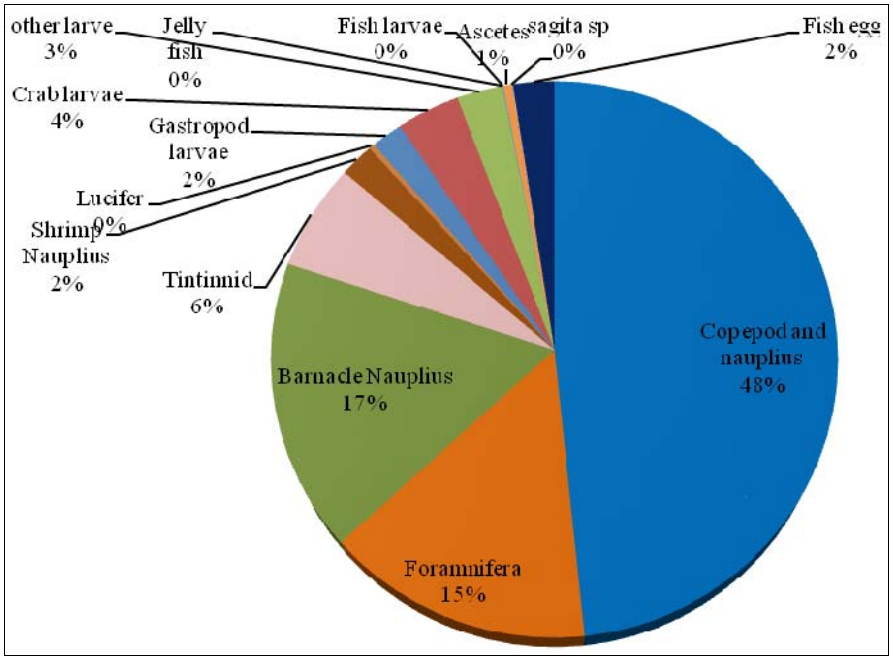

Fig 4: percentage contribution of zooplankton group

The zooplankton density of Patalganga estuary ranges from 6162 and 181155 no.100 no.x 10^3/L which is lesser than the zooplankton density reported by Tiwari and Nair [16] from Dharamtar creek adjoining Mumbai harbour. The density of zooplankton was positively correlated with phytoplankton abundance, temperature and pH and negatively correlated with salinity (Table 1).

Table 1: Correlation of zooplankton (ZP) with temperature (T), salinity (S), pH, dissolved oxygen (DO), biological oxygen demand (BOD), and phytoplankton (PP).

	T	S	pH	DO	BOD	PP	ZP
T	1						
S	-0.47839	1					
pH	0.197702	-0.31241	1				
DO	-0.56352	-0.05698	-0.03739	1			
BOD	0.244818	-0.45396	0.130805	0.251557	1		
PP	0.081225	-0.24063	0.274807	0.113478	0.274383	1	
ZP	0.599142	-0.47438	0.829381	-0.29656	0.23333	0.390248	1

Shannon-Weiner diversity index (H') based on zooplankton abundance ranged between 2.25 to 2.26, Simpsons's index (J') recorded was 0.874 and Margalef's (D) index was 1.25. If H' is more than 2 and J' is greater than 0.9 indicates the healthy diversity of the ecosystem [12]. In Dharamtar estuary H' and J' were greater than 2 and 0.8945 respectively reported by Kulkarni *et al.* [19]. Tiwari and Nair [16] reported H' ranged between 0.44 and 3.4 and D varied from 0.35 to 2.09.

Conclusion

Present study observed that the zooplankton density and abundance were lowered compared with the previous study of Tiwari and Nair [16]. This might be due to industrial, agricultural and fishing pressure to the ecosystem. Many other anthropogenic pressures like sewage effluents, plastic pollution, etc were also affecting the ecosystem functions and services. Continuous studies are required to know the spatial and temporal changes taking place at the ecosystem due to various anthropogenic pressures.

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