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Research Paper

DOMINANCE AND DIVERSITY OF ZOOPLANKTON INCOASTAL WATERS OF MUMBAI

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Abstract

Zooplankton community were studied. Zooplankton species identification, distribution, dominance index, Shannon wiener's index, and similarity of zooplankton species were carried out in coastal waters of Mumbai for one season (Post-monsoon 2007). The Identified groups were as foraminifera, ciliata, copepoda, polychaeta, gastropoda, palecypoda, chaetognatha, brachyura, ostracoda, cirripedia, eurochordata and fish eggs & larvae. Zooplankton Species composition indicate dominance of Copepoda, and Fish eggs and larvae of different invertebrates in samples collected from 16 sampling stations of 4 transects (near shore, 1km,3km,and 5km distance from shoreline) of west coast of Mumbai metropolitan city.

Key words: Zooplankton, Simpson's Dominance Index, Similarity Indice, Percent Similarity Index.

INTRODUCTION

Zooplankton samples collected from 16 sampling stations of 4 transects (near shore, 1km,3km,and 5km distance from shoreline) of west coast of Mumbai metropolitan city (Lat.$18^0$00'N - $20^0$50'N Long.$71^0$25'E - $72^0$50'E). The identification/ classification study of zooplankton was based on regional distribution range (not cosmopolitan) confined nearshore occurrence and influenced by physic-chemical processes.(ii) in the open ocean are characteristic communities in each of the different water masses [1] [2]. Earlier studies on zooplankton, number of Foraminiferan species, 47 species (3 planktonic out of the 47 benthic species are living ones) were present 4 to 13.5m water depth at Kharo creek [3]. Evidence have shown that copepod amphipods and decapoda larvae dominated in zooplankton species composition and tides influences abundance

by bringing oceanic plankton in Minicoy lagoon[4]. Zooplankton have indicated regular annual cycles, colonization and dependences on water quality of the Vishakhapatnam bay [5]. Copepod contributed maximum (58.4 to 73.9%) in dial variation of zooplankton (day to night) and found higher biomass values (av. 80ml/100m^3) at different sampling station [6]. Another study have giving account of free living copepods biodiversity, estimates of grazing and production rates of copepods, diapauses and carbon fluxes-through vertical migration, defecation and grazing by zooplankton often control phytoplankton community structure need to be studied to understand trophic chain [7]. Preliminary study have shown the existence of marine, estuarine, and freshwater copepoda (free living and parasites) 10 groups and the distant past of modern copepod date back to the cretaceous period [8]. This Study is about abundance of zooplankton in coastal water of Mumbai in October 2007 (post monsoon season).

MATERIALS AND METHODS

In this article, surface water free living Zooplankton were collected from 64 sampling stations A1-A16, B1-B16, C1-C16 and D1-D16 of transect A,B,C and D nearshore,1km, 3km, and 5km away from coast of Mumbai. Zooplankton samples were collected using hand held zooplankton nets (mesh size No.21 -80 µ pore size) from hired Fishing boat in coastal waters of Mumbai. Zooplankton samples were preserved in 5% formalin solution. The free swimming zooplankton group and genera fish eggs and larvae identification based on shape and appendages and fifth leg morphology and telson of copepoda genera using Letiz Wetzler Microscope (Germany). Instead of displacement volume, biomass of zooplankton numbers/L were carried out at all sampling transects. Density of zooplankton, were calculated using following formula [9]. Diversity of zooplankton as Shannon Wiener index and Dominance Index (Simpson's index) provided zooplankton variation in coastal waters of Mumbai.

$No./m^3 = C \times V_1 / V_2 \times V_3$

Where C = no. of organisms counted

V_1 = Volume of the concentrated sample

V_2 = Vol. of concentrated sample under microscopic observation

V_3 = Vol. of the grab samples (50 liters)

Similarity Index: Taking in to consideration of two sets of quantitative data[10] , similarity of sampling stations A1-14, B1-14, C1-14 and D1-14 quantitative data sets of four transects in nearshore, 1km, 3km, and 5km from shoreline were analyzed and compared using Simpson's (1949) dominance index (λ) and a related similarity index (C_λ):

$$\lambda_1 = \sum_{i=1}^{s} n_{1,i}\,(n_{1,i}-1)/N_1(N_1-1) \quad \text{and} \quad \lambda 2 = \sum_{i=1}^{s} n_{2,i}\,(n_{2,i}-1)/N_2(N_2-1)$$

$$C\lambda = 2\sum_{i=1}^{s} n_{1,i}\,n_{2,i}/(\lambda_1+\lambda_2)\,N_1\,N_2 \quad 0 \le C_\lambda \le 1$$

Where N_1 and N_2 are the total number of individuals in sample A and B, $n_{1,i}$ and $n_{2,i}$ are the number of individuals of species *i* in the two samples respectively, and *S* is the total number of species to be compared.

The C_π index as a revised form of the equation [11] above:

$$\sum \pi_1^2 = \sum_{i=1}^{s} (n_{1,i})^2 / N_1^2 \quad \text{and} \quad \sum \pi_2^2 = \sum_{i=1}^{s} (n_{2,i})^2 / N_2^2$$

$$C_\pi = 2\sum_{i=1}^{s} n_{1,i}\,n_{2,I} / (\Sigma\pi_1^2 + \Sigma\pi_2^2)\,N_1\,N_2 \quad 0 \le C_\pi \le 1$$

If the species in the two samples are identical, C_π becomes 1 and if the two samples donot contain any common species, it becomes 0.

The percent similarity index [12] used equation using percent composition of their component species. Within each sample species abundances are converted to percent of the total abundance of all species that is, (n1/N1) x 100. The percentage index (P) is calculated as follows:

$$\sum \pi_1^2 = P = 100 - 0.5 \sum_{i=1}^{s} (Pa_{1,i} - Pb_{2,I})$$

$$= \sum_{i=1}^{s} \min(Pa_{1,i} - Pb_{2,I})$$

where P_a,i and P_b,i are the percentage abundances of species I in samples A and B, respectively, and S is the total number of species to be compared. When the similarity is high, P approaches 100%.

RESULTS AND DISCUSSION

Results were shown the enumerated zooplankton genera belongs to foraminifera and fish eggs and larvae of invertebrates of marine origin, beside certain group of radiolaria, actinopoda and rhizopoda , Generally rotifera were absent in marine water but often enters to coastal water with fresh water influx. calanoida, cyclopoida, and harpacticoida group of copepods, polychaeta species were marine as well as freshwater. Mollascs Gastropoda, palecypoda are found in rivers and seas. Merozooplankton chaetognatha, eurochordata, larvae of many crustacean, brachyura (crabs) and cirripedia larve and fish eggs were dominated after monsoon season in marine environment. Zooplankton groups were collected from coastal waters and identified as foraminifera, ciliata, copepoda, polychaeta, gastropoda, palecypoda, chaetognatha, brachyura, ostracoda, cirripedia, eurochordata and fish eggs & larvae (Figure 1 to 8).

- Foraminifera: protozoan class exclusive marine percentage nil was occurred at sampling station 1A-16A; 1%-14.3% was observed at 4 sampling stations of 1B-16B; 1%-23% was observed at 4 sampling stations of 1C-16C; nil -2.9% was observed at 2 sampling stations of 1D-16D. Distribution was concentrated at sampling stations 3 & 11 to 14 of all transects. Fossil to recent forms were in bottom dwelling in the sediments only developmental stages appeared in surface waters.
- Ciliat: Ciliata percentage 2.1%-4.6% was occurred at 5 sampling stations of 1A-16A; 3.7%-10% was observed at 2 sampling stations of 1B-16B; nil-3% was observed at 2 sampling stations of 1C-16C; 1.2%-2.9% was observed at 2 sampling stations of 1D-16D. Distribution was concentrated at sampling stations 3 & 10 to 15 of all transects.These were free living and mostly parasites of marine animals.
- Copepoda: Copepoda percentage 12.6%-46.3% & 70%-99.2% was occurred at 3 &13 sampling stations of 1A-16A respectively; nil -64.3% & 69.7%-95.1% was observed at 6 & 9 sampling stations of 1B-16B; 30.8%-63% & 71.4-99% was observed at 3 & 13 sampling stations of 1C-16C; 25%-62.5% & 60.1%-100% was observed at 8 & overall 8 sampling stations of 1D-16D. Distribution was concentrated uniformly at sampling stations 1 to 16 of all transect except sampling stations 1C, 2C & 15,16 A,B & C where-ever fish eggs and larvae were dominated. The dominant genera of zooplankton percentage were occurred in coastal waters.
- Polychaeta: Notochaeta larvae & Nereis larvae percentage 1%-1.6% was occurred at 4 sampling stations of 1A-16A; 4.2%-10.7% was observed at 2 sampling stations of 1B-16B; nil-3.6% was observed at 1 sampling stations of 1C-16C; 1%-2.9% was observed at 3 sampling stations of 1D-16D. Distribution

was concentrated at sampling stations 12 & 13 to 15 of A,B & D transects. Meroplankton forms were partially spent life in zooplankton form other wise benthic, found in crevices of stones and muddy sediments.

- Gastropoda: Mitraria larvae percentage nil was occurred at sampling stations of 1A-16A; 0%-3.2% was observed at 1 sampling stations of 1B-16B; 0%-2.6% was observed at 1 sampling stations of 1C-16C; nil was observed at sampling stations of 1D-16D. Distribution was concentrated at sampling station 15D of all transects. Life cycle was benthic and larval stages could be detected in plankton catches.
- Palecypoda: Megalopa larvae & Mitraria larvae percentage 1%-8.2% was occurred at 2 sampling stations of 1A-16A; 0%-3.2% was observed at 1 sampling stations of 1B-16B; 1.5-2.6% was observed at 2 sampling stations of 1C-16C; 2%-50% was observed at 2 sampling stations of 1D-16D. Distribution was concentrated around sampling station 15 of all transects.Free swimming zooplankton and sessile filterfeeding forms were attached to bottom sediments
- Chaetognatha: *Sagitta enflata* percentage nil percentage was occurred at sampling stations of 1A-16A; nil was observed at sampling stations of 1B-16B; nil was observed at sampling stations of 1C-16C; 0%-1.11% was observed at 1 sampling station(7D) of 1D-16D. Exclusive marine forms were often seen in surface coastal waters.
- Brachyura: Brachyuran larvae percentage 1% was occurred at 1 sampling stations of 1A-16A; 1.35%-85% was observed at 4 sampling stations of 1B-16B; 1.5-2.64% was observed at 2 sampling stations of 1C-16C; 0.56%-2.6% was observed at 3 sampling stations of 1D-16D. Crab larval stages distribution was appeared in zooplankton catches and concentrated at sampling stations 6 to 10 of all transects.
- Ostracoda- *heterocypris* sp. nil percentage was occurred at sampling stations of 1A-16A; 1.35%-7.4% was observed at 6 sampling stations of 1B-16B; 2.38-5.1% was observed at 2 sampling stations of 1C-16C; 0.5%-12.5% was observed at 6 sampling stations of 1D-16D. Distribution was concentrated at sampling stations 5 & 10 to 15 of all transects.
- Cirripedia- *Amphibalanus Amphitrite* & proceissed larvae stages are zooplanktonic. Percentage 1.35%-17.4% was occurred at 6 sampling stations of 1A-16A; 1.4%-21.4% was observed at 10 sampling stations of 1B-16B; 1-15.4% was observed at 9 sampling stations of 1C-16C; 1%-39.6% was observed at 8 sampling stations of 1D-16D. Distribution was concentrated at sampling stations 6 to 16 of all transects. Adults balanus sp. Were seen settles over scattered rocks on rocky sea Shore
- Appendicularia- *Oikopleura dioica* percentage 2.0%-4.3% was occurred at 2 sampling stations of 1A-16A; 2.1%-5.3% was observed at 3 sampling stations of 1B-16B; 1.8-6.3% was observed at 2 sampling stations of 1C-16C; 1.2%-15.1% was observed at 4 sampling stations of 1D-16D. Distribution was marine and concentrated at sampling stations 6 to 15 of all transects.

- Fish Eggs & Zoea and Nauplius Larvae percentage 4.9%-79.2% was occurred at 15 sampling stations of 1A-16A; 1%-77.6% was observed at 13 sampling stations of 1B-16B; 1-55% was observed at 11 sampling stations of 1C-16C; 4.3%-75% was observed at 13 sampling stations of 1D-16D. Distribution was Surface zooplankton catches and concentrated at sampling stations 1 to 16 of all transects.

Diversity of zooplankton were studied among the transects A,B,C &&D of coastal waters of Mumbai. Shannon Weiner index and Simpson diversity index were used in assessment of zooplankton population. (i) SWI and DI were ranged from 0.926 (11A) to 1.981 (2A) and 0.57 (1A) to 0.99 (13A) i.e. zooplankton organisms of species were less and zooplankton species were more in coastal waters of Mumbai. SWI values >1.5 ±0.05 at were observed at nine sampling stations of transect A and Simpson's Dominance Index> 0.75±0.05 at twelve sampling stations of transect A. (ii) SWI and DI were ranged from 0.518 (8B) to 2.413 (3B) and 0.28 (8B) to 0.845 (13B). SWI values >1.5 ±0.05 at were observed at seven sampling stations of transect B and Simpson's Dominance Index> 0.75±0.05 at nine sampling stations of transect B. (iii) SWI and DI were ranged from 0.556 (8C) to 1.839 (14C) and 0.27 (8C) to 0.99 (12C). SWI values >1.5 ±0.05 at were observed at nine sampling stations of transect C and Simpson's Dominance Index> 0.75±0.05 at ten sampling stations of transect C. (iv) SWI and DI were ranged from 0.697(4D) to 1.902 (12D) and 0.663 (3D) to 0.883 (2D). SWI values >1.5 ±0.05 at were observed at six sampling stations of transect D and Simpson's Dominance Index> 0.75±0.05 at seven sampling stations of transect D.

Similarity index of zooplankton is applied to two sets of quantitative data [13] [14], which slightly different to that of Sorenson's index of similarity is applied to phytoplankton population. Quantitative analysis of zooplankton have revealed oligotrophic nature of coastal waters of Mumbai.In this study quantitative analysis of zooplankton abundances , the similarity index to use only fairly abundant and frequently occurring species *Eucalanus elongates* (Dana), *Acartia spinicauda* Giesbrecht, *Paracalanus parvus* (Claus), *Nanocalanus minor* (Claus), Fish eggs, Zoea larvae, Notochaeta larvae(Table 1). This procedure cannot avoid the loss of information inherent in minor species counts which are disregarded but likely to reflect real differences in distributional patterns. If the sample contains a small numbers of dominant species that are not shared, the similarity between two sample will be

estimated to be high .The two similarity index and Whittekar similarity percentage index (P) were analyzed comparing data set of two sampling stations of different A,B,C and D transects (Table-2). In transect A, two index and similatity percentage index (P) were ranged from 0.281 (13A & 14A) to 0.873 (11A & 12A), 0.237 (9A & 10A) to 0.501 (1A & 2A) and 40.22 (1A &2A) to 86.94 (5A & 6A). If the zooplankton species similarity is high the index tends toward 1. However as discussed earlier if there were no uniform distribution of zooplankton species, all three specified index decrease sharply in dwindling water quality.

In transect B, two index and similatity percentage index (P) were ranged from 0.034 (7B & 8B) to 0.594 (5B & 6B), 0.3 (3B & 4B) to 0.857 (12B &13B) and 10(7B &8B) to 78.93 (1B & 2B).

In transect C, the sampling stations further located away from shore, two index and similatity percentage index (P) were ranged from 0.246 (9C & 10C) to 0.666 (7C & 8C), 0.183 (7C & 8C) to 0.348 (12C & 13C) and -9.23 (7C & 8C) to 80.96 (12C & 13C).

In transect D, cleaner offshore water sampling stations were shown moderate to high indice values. Two index and similatity percentage index (P) were ranged from 0.294 (7D & 8D) to 0.45 (10D & 11D), 0.238 (7D & 9D) to 0.842 (3D & 4D) and 27.27 (3D & 4D) to 85.94 (10D & 11D).

The zooplankton reproduce in the surface layers of subtropical region have shown large number of species and a large biomass ,but there is substantial east-west variation (latitudinal barrier) that restrict spread of species [15]. study revealed copepods density (80%) along with other zooplankton groups chaetognaths, gastropod larvae, echinoderm larvae, gastropod larvae bivalve larvae, protochordates and fish eggs and larvae were spatially distributed in the area receiving industrial treated effluent in Arabian sea off chitrapur. The findings were similar to observed in the coastal waters of Mumbai during post monsoon season [16].

The similarity index is based on either presence of species in two sampling stations (common) or absence of species in two sampling stations (presence or absence of one species in two sampling stations).Therefore, Similarity index analysis is preferred over correlation co-efficient index analysis. Second advantage is quantitative estimates in the sampling errors may be reduced significantly.

Table:1: Zooplankton species observed along 4-transect in coastal waters of Mumbai

Sr.No.	Zooplankton species
	Protozoa
1	Foraminiferan *Globorotalia* sp
2	Foraminifera-*Globigerina* sp.
3	*Tintinopsis* sp.
	Calanoida Copepoda
4	*Eucalanus elongates* (Dana)
5	*Acartia spinicauda* Giesbrecht
6	*Paracalanus parvus* (Claus)
7	*Nanocalanus minor* (Claus)
8	*Acrocalanus gibber* Giesbrecht)
9	*Tortonus barbatus* (Brady)
10	*Centropages orsinii*
11	*Metacalanus aurivilli* cleve
	Cyclopoidia copepod
12	*Oithona similis*
	Harpacticoida copepod
13	*Miracia efferata* (Dana)
14	*Cornecaceous flaccus*
	Chaetognatha
15	*Sagitta enflata*
	Appendicularia
16	*Oikopleura dioica*
	Ostracoda
17	Heterocypris sp.
	Larvae and Fish eggs
18	Brachyuran Megalopa
19	Nereis larvae
20	Notochaeta larvae
21	Mitraria larvae
22	Pontelloid Nauplius
23	Crustacean-Zoea larvae
24	Crustacean - Nauplius larva
25	Cirripeds(Thoracica)-*Amphibalanus Amphitrite*
26	Cirripedian (Thoracica) processed
27	Fish eggs

Table-2: Zooplankton species showing Simpson's index and Kimoto index with whittekar percent similarity of zooplankton between sampling stations along 4-transect in coastal waters of Mumbai

Sr. No.	**Sampling stations**	**Similarity Index**		**Whittekar Similarity Percentage index (P)**
		Cλ Morisita Index	**Cπ Kimoto Index**	
	Transect A			
1	1A & 2A	0.324	0.501	40.22
2	3A & 4A	0.333	0.352	66.8
3	5A & 6A	0.424	0.402	86.94
4	7A & 8A	0.617	0.43	76.19
5	9A & 10A	0.291	0.237	79.64
6	11A & 12A	0.873	0.238	48.29
7	13A & 14A	0.281	0.316	74.55
	Transect B			
8	1B & 2B	0.579	0.835	78.93
9	3B & 4B	0.205	0.3	63.68
10	5B & 6B	0.594	0.577	72.56
11	7B & 8B	0.034	0.438	10
12	9B & 10B	0.263	0.305	78.86
13	11B & 12B	0.309	0.504	61.64
14	12B & 13B	0.512	0.857	69.25
15	14B-ND			
	Transect C			
16	1C & 2C	0.326	0.242	65
17	3C & 4C	0.321	0.31	31.77
18	5C & 6C	0.299	0.268	64.2
19	7C & 8C	0.666	0.183	9.23 (-)
20	9C & 10C	0.246	0.274	75.67
21	11C & 12C	0.272	0.304	77.08
22	12C & 13C	0.338	0.348	86.96
23	14C-ND			
	Transect D			
24	1D & 2D	0.355	0.373	45
25	3D & 4D	0.411	0.842	27.27
26	5D & 6D	0.374	0.373	74.09
27	7D & 9D	0.294	0.238	48.29
28	10D & 11D	0.45	0.401	85.94
29	12D & 13D	0.404	0.428	82.55
30	8D-ND			
31	14D-ND			

ND: samples were not collected

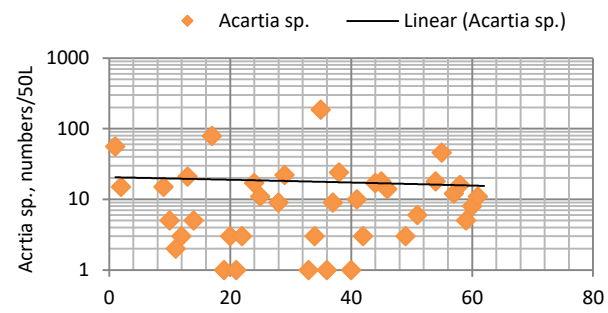

Figure-1:Density of *Acartia spinicauda* Geisbrecht in coastal waters of Mumbai

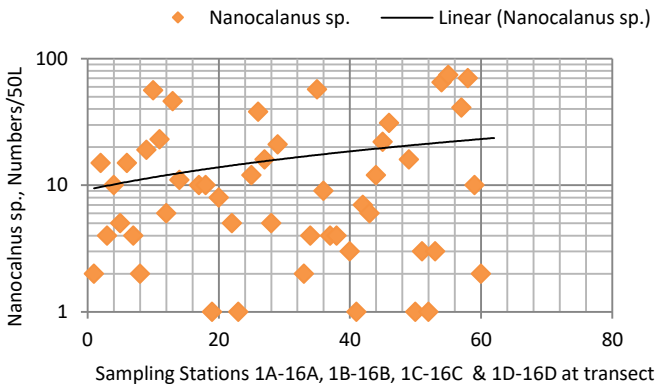

Figure-2:Density of *Nanocalanus minor* (Claus) in coastal waters of Mumbai

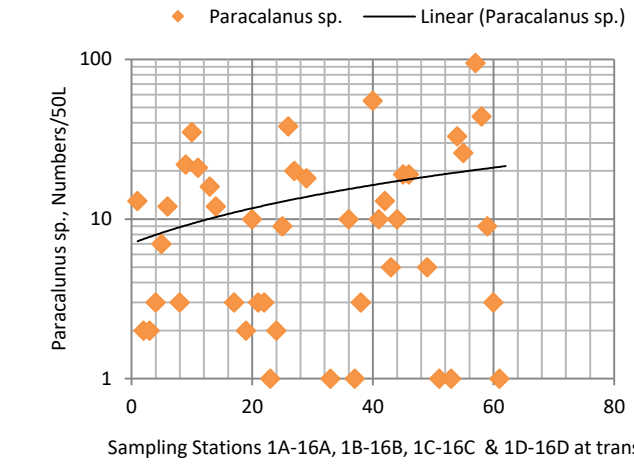

Figure-3: Density of *Paracalanus parvus* (Claus)in coastal waters of Mumbai

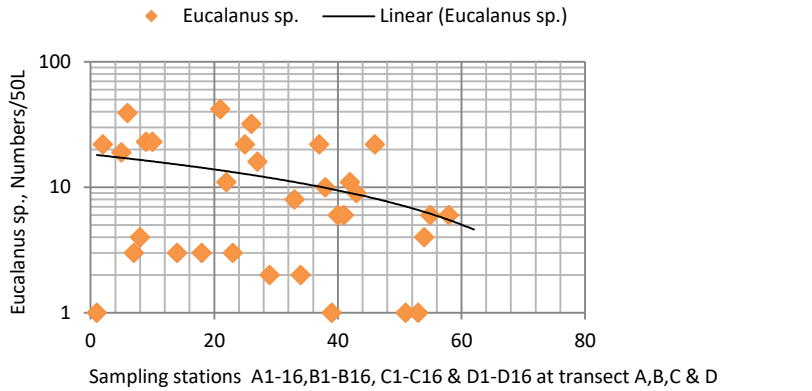

Figure-4: Density of *Eucalanus elongates* (Dana) in coastal waters of Mumbai

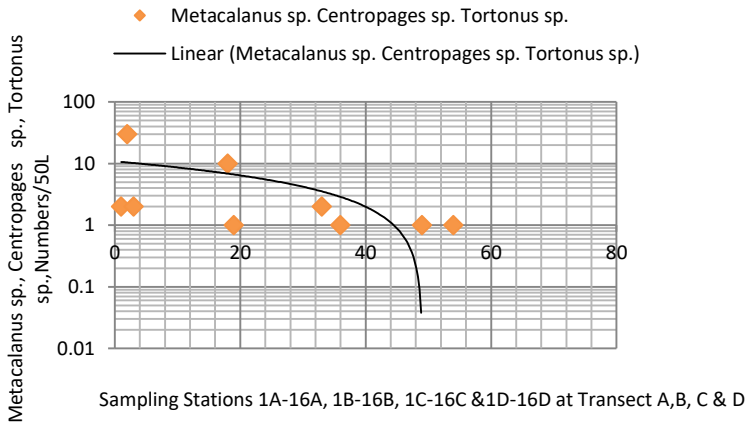

Figure-5 :Density of *Metacalanus aurivilli* cleve, *Centropages orsinii*, *Tortonus barbatus* (Brady) in coastal waters of Mumbai

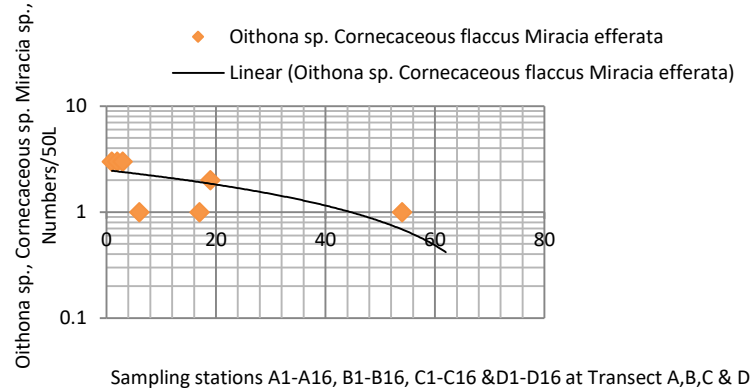

Figure-6: Density of Oithona *similis, Cornecaceous flaccus, Miracia efferata* (Dana) in coastal waters of Mumbai

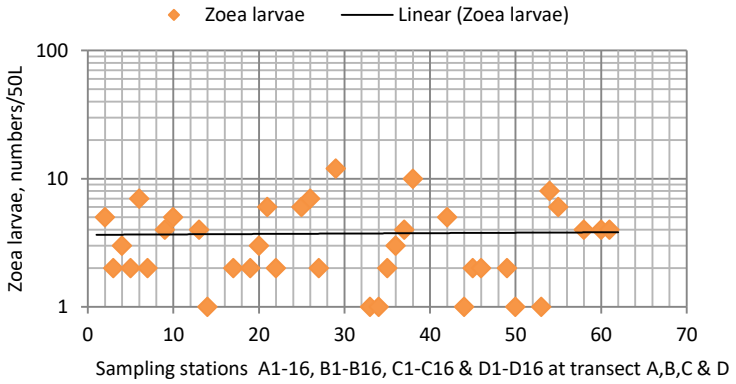

Figure-7: Density of Zoea larvae in coastal waters of Mumbai

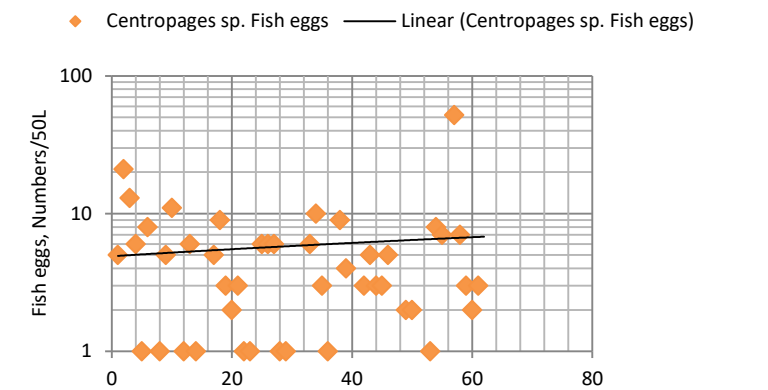

Figure-8: Density of Fish eggs in coastal waters of Mumbai

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