

ZOOPLANKTON PRODUCTION ALONG CENTRAL WEST COAST OF INDIA

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Studies were undertaken to evaluate the secondary production off Vengurla and Karwar along the central west coast of India from January to May, 1972. The two areas represent two different ecosystems — the former being a coastal area without estuarine influence and the latter has estuarine influence due to Kali river. Ecology of the area was studied and transects perpendicular to the coast were operated from shore to 40 m depth. At all stations, samples were collected for environmental parameters and zooplankton. For zooplankton, both horizontal and vertical samples were collected from different depths. The samples were analysed for biomass, faunistic composition, occurrence of dominant species under major taxa and related hydrographical parameters. At both the transects, higher biomass values were obtained between 20 to 30 m depth which are the traditional fishing grounds. Vertical samples had higher biomass values than the horizontal samples. In general, the zooplankton production was more at Vengurla than at Karwar. The mean values of biomass in relation to temperature, salinity, dissolved oxygen and nutrients in both the environments have been discussed. The qualitative and quantitative variations in zooplankton taxa, dominant species during different months at various depths along with related hydrographical parameters have also been discussed.

INTRODUCTION

The coastal zone of the west coast of India supports a rich fishery of varied intensities in different periods of the year, amounting to nearly three fourths of the total landings consisting of sardines, mackerels, pomfrets, prawns etc. It is an established fact that zooplankton forms a major food item of the pelagic fishes, particularly their larvae. Therefore, regular data on zooplankton distribution, their intensities and seasonal fluctuations in relation to environmental parameters is necessary for a correct understanding of the fishery resources. Some information is available on the hydrography and plankton in relation to pelagic fishery of the west coast of India (Ramamurthy, 1963, 1965; Noble, 1968; Pillai, 1968; Annigeri, 1968, 1972; Bhargava *et al.*, 1973). The international Indian Ocean Expedition atlas (IOEC, 1968) gives the total zooplankton biomass in the Indian Ocean. However, not much information is available on the seasonal and depthwise variations of zooplanktonic taxa and their species in relation to hydrographical parameters. Therefore, two transects, off Vengurla and Karwar, in the central west coast of India, representing two different ecosystems have been selected for such a study.

MATERIAL AND METHODS

Surface and vertical zooplankton samples were collected monthly at Vengurla and Karwar (Fig. 1) from January to May, 1972 with a HT net (Mouth

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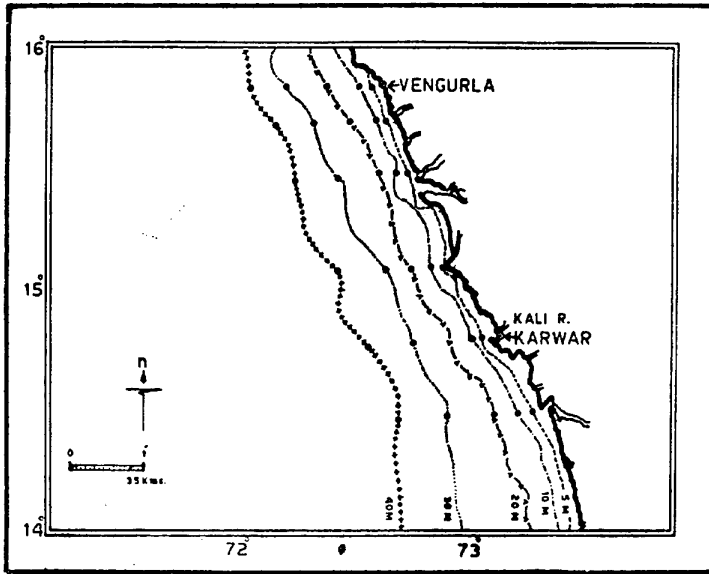


Fig. 1. Position of the stations

area, 0.25 m²; mesh width 0.3 mm). For horizontal samples, net with a flow-meter was towed for 5 min. Vertical samples were taken by lowering the net near to the bottom and hauling it up. No vertical haul was taken at 5 m depth at both transects. The samples were preserved in 5% buffered formaldehyde prepared in sea water. For the count of various taxa and their species, an aliquot of 1 to 4% was examined under the stereoscopic microscope. The number of organisms were then raised to the total volume of water filtered.

The water samples from surface and bottom were analysed for salinity, dissolved oxygen and nutrient salts as per Strickland and Parsons (1968). The water temperature was recorded immediately.

RESULTS

HYDROGRAPHY

Temperature: No appreciable difference of temperature was observed between Vengurla and Karwar. At both transects, the surface samples were warmer than the bottom samples. Surface and bottom temperatures varied from 26.0 to 29.5°C and 25.9 to 29.3°C, respectively at Vengurla and from 26.2 to 30.1°C and 26.0 to 29.3°C at Karwar. In general, low temperature was recorded during January and February and the highest values were in May. Annigeri (1972) has given a temperature range of 27.5 — 30.4°C in the Karwar Bay during 1965-66.

Salinity: The mean salinity values at surface and bottom during the period of study showed a general trend of increase from the coastline to 40 m (Table 1).

The salinity values were higher at Vengurla (northern transect) than at Karwar (southern transect). However, at both transects, the bottom waters

TABLE 1. MEAN SALINITY VALUES (‰) AT VENGURLA AND KARWAR

Transect	Sample/No. of observation	Depth (m)				
		5	10	20	30	40
Vengurla	Surface/n=4	34.35	34.19	34.40	34.67	34.93
	bottom/n=4	34.38	34.39	34.44	34.86	34.89
Karwar	Surface/n=5	33.83	34.09	34.27	34.37	34.46
	bottom/n=5	33.87	33.84	34.19	34.37	34.86

were more saline than the surface waters. The surface salinity at Vengurla and Karwar varied from 32.6 to 35.62‰ and 32.2 to 35.35‰ respectively. The lowest value of 32.2‰ was recorded at 5 m depth during February (Fig. 2). Pannikar and Jayaraman (1966) have also stated that there is a tendency of the salinity values to be high in the north on the west coast of India and to be higher in the south on its east coast.

Oxygen: Higher values of dissolved oxygen were obtained for the surface samples. The values were higher from 5 to 10 m and then decreased from 20 to 40 m at both the transects. Oxygen values ranged from 2.52 to 5.67 ml/l. The lowest value was recorded at Karwar from 40 m depth station during May and the highest from 5 m surface sample taken at Vengurla during January. In general, the values indicate occurrence of low oxygen concentration during May. Annigeri (1972) gave the surface oxygen values ranging from 4.14 to 5.77 ml/l in the Karwar Bay during the year 1965-66 and 3.63 to 4.54 ml/l during 1963-67.

Nutrients: The inorganic phosphate during the period of investigation varied from 0.23 to 2.01 $\mu\text{g-at/l}$. The highest values recorded at Vengurla and Karwar were 1.73 and 2.01 respectively. At both the transects, higher values of inorganic phosphate were observed at 5 and 10 m. The values decreased from 20 m and the lowest values were recorded at 40 m. The values were low from January to March. An upward trend was seen in April and the highest value was recorded in May (Fig. 2). The nitrate and nitrite values varied at Karwar from 0.41 to 4.21 and from 0.44 to 3.97 $\mu\text{g-at/l}$ for the surface and bottom samples respectively. The corresponding values at Vengurla varied from 0.92 to 2.51 and 0.96 to 3.99 $\mu\text{g-at/l}$ respectively. Thus, nutrient enriched waters were encountered at Karwar but the zooplankton production at the transect was comparatively less. There appears to be an inverse relationship between phytoplankton and zooplankton production at Karwar. Bhargava *et al.* (1973) have reported such relationship along Panaji-Bombay coast.

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Biomass: The zooplankton standing crop as determined by biomass was more at Vengurla than at Karwar. The pooled mean values for all the depth regions for the horizontal and vertical zooplankton samples at Vengurla were 149 and 730 ml/1000 m^3 and at Karwar, the corresponding values were 78 and 593 ml/1000 m^3 respectively. The combined vertical and horizontal biomass value of samples from 5 to 40 m at Vengurla were 113, 128, 238, 190 and 75 ml/1000

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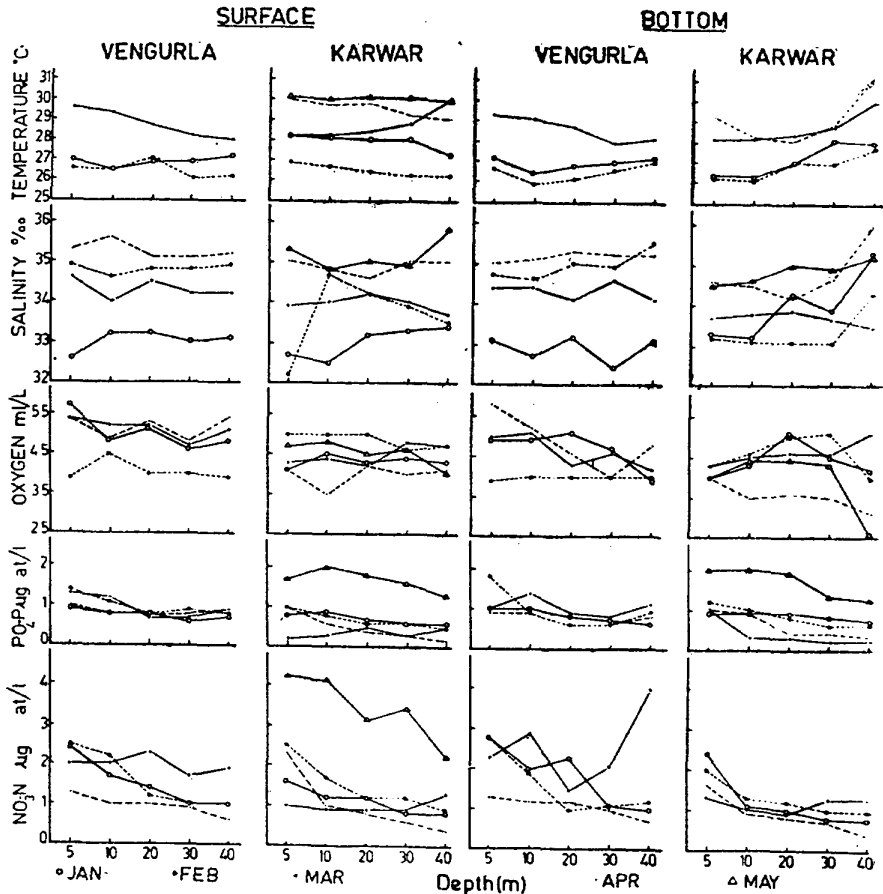


Fig. 2. Monthly values of hydrographical parameters at Vengurla and Karwar

m^3 ; at Karwar the values were 27, 76, 133, 106 and 47 $ml/1000 m^3$. At both transects, the highest values were obtained at 20 m depth (Fig. 3) In general, the values increased from 5 to 20 m and then decreased from 30 to 40 m. The monthly variation in biomass at both the transects followed almost the same pattern, being high during January and February and low during March (Fig. 4). The highest values were obtained during February at both places, being 331 $ml/1000 m^3$ at Vengurla and 164 $ml/1000 m^3$ at Karwar. There was close relationship between the biomass values of the horizontal and vertical samples indicating that in general, the zooplankton is not concentrated in the surface zone but evenly distributed from bottom to the surface layers.

Faunistic composition: The important zooplanktonic taxa observed at both the transects were hydromedusae, Siphonophora, polychaete larvae, decapod larvae, Sergestidae, Copepoda, Ostracoda, Amphipoda, Cladocera, Chaetognatha, Lamelibranchiata, Pteropoda, Copelata, salps and doliolids and fish eggs and larvae.

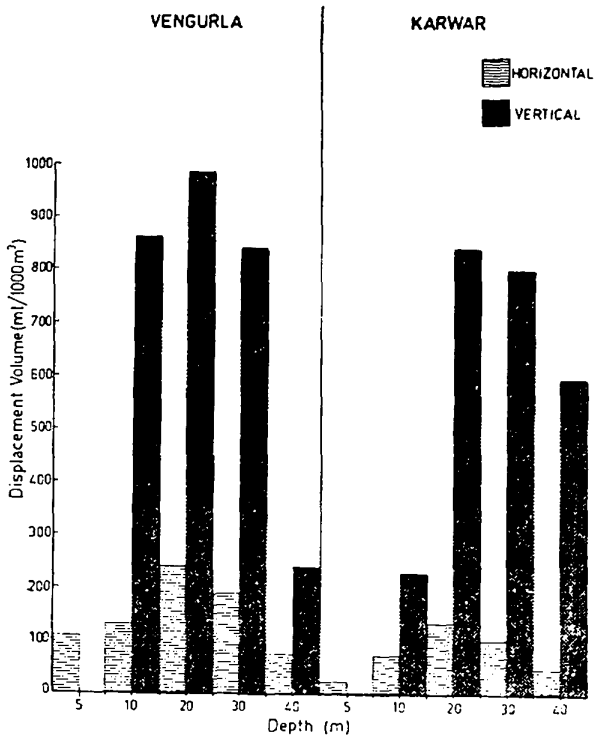


Fig. 3. Zooplankton biomass at Vengurla and Karwar

Copepoda and Cladocera were among the dominant constituents of zooplankton population at all the depths. However, no single group dominated the community during the entire period of observations. Qualitative and quantitative variations in the faunistic compositions were noticeable in the horizontal and vertical samples from both the transects and also in various depths and during different months. Sergestidae, Mysidacea, cirreped larvae and Lamellibranchiata were observed more in the samples from 5 to 10 m depth. Siphonophora, decapod larvae including the larvae of penaeid prawns, fish eggs and larvae were found from 10 to 20 m and beyond this depth, the important groups were Hydromedusae, Chaetognatha, Copelata, Amphipoda, Ostracoda, Pteropoda, salps and doliolids and large number of siphonophores, chaetognaths and pteropods.

Hydromedusae: This group was recorded more in the samples from Karwar ($82.3/m^3$), than Vengurla ($69.4/m^3$). The highest number at both the transects was observed during January. The lowest number at the former was recorded during April and at the latter, during March. The common species encountered in the samples were *Eirene ceylonensis*, *Eirene* spp. *Eucheilota menoni*, *Eutima commensalis*, *Blackfordia virginica*, *Podocoryne cornea* and *Obelia* spp. *E. ceylonensis* was the most dominant species. Only two specimens of *P. cornea* were obtained from 20 m vertical sample at Vengurla during March.

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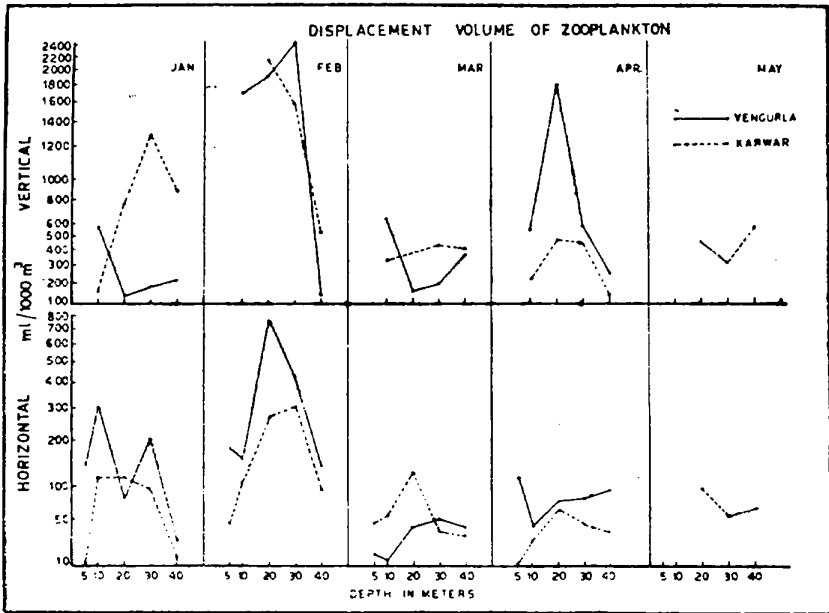


Fig. 4. Monthly biomass values at Vengurla and Karwar

Siphonophora: The highest number ($8.5/m^3$) was obtained at Vengurla during May. Species of the genera *Diphyes* and *Lensia* were present at both the transects.

Ctenophora: The ctenophores were obtained mostly from 5 to 10 m depth during April and May. *Pleurobrachia globosa* (Moser) and *Beroe* sp. were recorded.

Polychaete larvae: This group occurred sporadically in the samples. Species of the genera *Tomopteris*, *Nereis*, *Tyloscolax*, *Glycera* and *Pelagobia* were present. The polychaete larvae were more in the horizontal samples ($12.6/m^3$) than in vertical samples ($5.2/m^3$).

Decapod larvae: Brachyuran zoea were abundant in the samples from 5 to 10 m. Maximum density of $268.3/m^3$ was recorded at 5 m at Karwar during May. The other decapod larvae consisted of protozoa, mysis and postlarval stages of *Metapenaeus monoceros*, *M. dobsoni*, *M. affinis*, *Parapenaeopsis stylifera*, *Penaeus merguensis* and *P. indicus*. The maximum and minimum penaeid larvae were obtained from 20 and 40 m depth regions respectively.

Sergestidae: *Lucifer henseni* Nobili and *L. typus* M. Edw. were the two species, the former being the most common. Numerous lucifers were present in the samples taken from 10 m depth at both the transects. Few specimens of *L. typus* were recorded in the horizontal samples obtained from 20 to 40 m.

Cladocera: The cladoceran population was also represented by two species i.e. *Evadne tergestina* Claus and *Penilia arirostris* Dana. At both the transects, *E.*

tergestina appeared more in the horizontal samples while *P. avirostris* in the vertical samples (Table 2). Their total number during the period of observation was 1403.7/m³ at Vengurla and 436.2/m³ at Karwar. The cladocerans were recorded in large numbers in the samples taken from 10 to 20 m depth. The lowest number (2.1/m³) was recorded at Karwar from 5 m whereas at Vengurla, the lowest number (19.2/m³) was obtained from 40 m.

Copepoda: Copepods were among the most important group. Their highest number at Vengurla (1265.4/m³) and at Karwar (823.9/m³) were obtained during January. The copepod abundance followed almost the same pattern as that of zooplankton biomass. Their number was low at 5 m depth stations and then increased from 10 to 20 m. A decrease in number was discernible from 30 to 40 m. The total number of species were more at Vengurla than at Karwar and large number of neritic species were observed at the former transect, probably due to more saline conditions. In general, the number of species as such were more at 30 and 40 m depth stations at both the transects, showing direct relationship with slight increase in salinity.

A total of 90 species belonging to 23 families and 33 genera were observed (Table 3). Members of the genera *Nannocalanus*, *Longipedia* and *Clytemnestra* were not represented in the samples from Vengurla while at Karwar, species of the genus *Lucicutia* was not observed. However, the number of species were more at the former than at the latter. Sixteen species viz. *Eucalanus a:tenuatus*, *E. elongatus*, *Euchaeta concinna*, *E. wolfendeni*, *Lucicutia flavicornis*, *Centropages gracilis*, *Candacia pachydactyla*, *C. discaudata*, *Calanopia thompsoni*, *Labidocera bengalensis*, *Acartia negligens*, *Oithona nana*, *O. robusta*, *Corycaeus longistylis*, *Copilia vitrea*, and *Sapphirina* sp. were not recorded from the samples collected at Karwar while only 11 species viz. *Nannocalanus minor*, *Acrocalanus similis*, *Centropages alcocki*, *Labidocera minuta*, *Pontellopsis herdmani*, *Acartia centrura*, *A. plumosa*, *Tortanus gracilis*, *Longipedia scotti*, *Clytemnestra ros'rata* and *Oncea conifera*, were not recorded in Vengurla samples. It is interesting to note that the highest number of some of these common species were recorded at the same depth stations at both the transects. The depthwise distribution of these copepod species where their maximum number was recorded is shown in table 3. *Paracalanus parvus* and *Pseudodiaptomus aurivilli* have their maximum population density at 5 m depth stations both at Vengurla and Karwar. Similarly, *Eucalanus subcrassus*, *Centropages tenuiremis*, *Labidocera pectinata*, *Oithona rigida* and *Corycaeus gibbulus* at 10 m; *Eucalanus crassus*, *Paracalanus parvus*, *Pseudodiaptomus serricaudatus*, *Oithona hebes* and *Copilia quadrata* from 20 m; *Corycaeus catus* and *Sapphirina ovatolanceolata* from 30 m and *Canthocalanus pauper*, *Undinula darwini*, *Acrocalanus longicornis*, *Scolecithrix danae*, *Calanopia elliptica*, *Labidocera acuta*, *L. Kroyeri*, *Pontellina plumata*, *Pontellopsis scotti*, *Miracia efferata*, *Oithona plumifera* and *Oncea venusta* at 40 m at both the transects (Table 3).

Acrocalanus gracilis was recorded in greater number from 10 m horizontal sample at Karwar but at Vengurla this species was more at 5 m depth. Again, *Acrocalanus gibber*, *Centropages orsinii*, *Temora turbinata*, *Acartia spinicauda*, *Tortanus forcipatus*, *Euterpina acutifrons*, *Oithona brevicornis*, *Corycaeus speciosus* were observed more at 20 m at the former and at 10 m at the latter. Similarly, *Acartia erythraea* at 30 m and 20 m and *Undinula vulgaris*, *Pontellina plumata*, *Acartia danae*, *Clytemnestra scutellata* and *Sapphirina nigromaculata* from 40 m and 30 m depth stations off Karwar and Vengurla respectively. The occurrence of the common species at different depths at the two transects may probably be attributed to salinity differences. Vengurla transect being a marine

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TABLE 2. DISTRIBUTION OF CLADOCERAN SPECIES (No./m³) IN THE HORIZONTAL (H) AND

		VENGURLA									
		Depth (m)									
Months	Species	5		10		20		30		40	
		H	H	V	H	V	H	V	H	V	
January	<i>Evadne tergestina</i> Claus	0.34	6.14	1.07	3.52	2.10	5.19	0.81	0.12	0.10	
	<i>Penilia avirostris</i> Dana	1.21	23.10	109.73	15.16	18.41	6.13	7.12	0.00	0.26	
February	<i>E. tergestina</i>	0.42	3.19	4.12	21.16	9.01	17.10	2.17	1.01	0.51	
	<i>P. avirostris</i>	0.09	16.04	36.19	8.15	26.14	13.14	9.91	0.52	0.86	
March	<i>E. tergestina</i>	0.06	4.82	1.39	2.69	1.77	0.83	0.07	3.19	6.00	
	<i>P. avirostris</i>	0.00	7.13	4.61	3.11	8.15	1.16	0.98	5.27	8.13	
April	<i>E. tergestina</i>	0.00	1.91	0.11	0.26	0.04	0.00	0.61	0.00	0.00	
	<i>P. avirostirs</i>	0.03	0.66	0.07	1.11	0.60	0.00	0.03	0.00	0.00	
May	<i>E. tergestina</i>	—	—	—	—	—	—	—	—	—	
	<i>P. avirostris</i>	—	—	—	—	—	—	—	—	—	
TOTAL	—	2.15	62.99	157.89	55.76	66.22	43.55	21.70	10.11	15.86	

VERTICAL (V) HAULS AT VENGURLA AND KARWAR DURING JANUARY TO MAY 1972

KARWAR								
Depth (m)								
5	10		20		30		40	
H	H	V	H	V	H	V	H	V
89.14	132.27	52.61	141.08	39.16	8.11	30.02	9.11	1.25
17.82	61.03	92.11	26.14	48.13	19.23	37.12	2.26	0.91
31.16	51.06	33.02	64.13	16.77	10.16	6.05	1.22	0.90
9.10	17.19	37.16	10.19	22.16	18.19	3.31	0.86	1.11
0.09	3.18	1.91	2.02	2.31	0.80	0.16	0.04	0.00
0.00	1.11	0.62	1.81	1.66	0.19	0.03	0.00	0.00
4.13	6.31	1.60	9.13	2.14	1.20	0.39	0.31	0.19
1.01	2.19	3.15	4.62	5.11	0.28	0.62	0.92	0.04
—	—	—	4.32	10.68	25.79	25.19	19.19	6.23
—	—	—	7.11	12.19	10.95	56.45	16.60	8.53
152.45	274.34	222.18	270.55	160.31	94.90	159.34	50.51	19.16

TABLE 3. DISTRIBUTION OF COPEPOD SPECIES AND THEIR POPULATION DENSITY (No./m³) AT VENGURLA AND KARWAR

S. No. Species	Vengurla		Karwar		Depth at which maximum number recorded	
	Max. No.	Min. No.	Max. No.	Min. No.		
1	3	4	5	6	7	8
Family:- Calanidac						
1. <i>Nannocalanus minor</i> (Claus)	—	—	—	1.12(H)*	0.32(H)	40
2. <i>Canthocalanus pauper</i> (Giesbrecht)	1.02(H)	0.88(H)	40	3.10(H)	1.96(H)	40
3. <i>Undinula vulgaris</i> (Dana) var. <i>typica</i> Sewell.	12.52(H)	2.66(H)	30	5.91(H)	0.80(H)	40
4. <i>U. darwini</i> (Lubbock) var. <i>symmetrica</i> Sewell	13.19(H)	0.84(H)	40	4.01(H)	0.15(H)	40
Family:- Eucalanidac						
5. <i>Eucalanus subcrassus</i> Giesbrecht	16.12(H)	1.11(V)	10	9.16(H)	0.89(H)	10
6. <i>E. crassus</i> Giesbrecht	9.91(H)	0.06(H)	20	3.51(H)	0.06(V)	20
7. <i>E. monachus</i> Giesbrecht	1.60(H)	0.32(H)	40	2.11(H)	0.41(H)	30
8. <i>E. attenuatus</i> (Dana)	3.10(H)	0.19(V)	30	—	—	—
9. <i>E. elongatus</i> (Dana)	1.82(H)	0.15(H)	40	—	—	—
Family:- Pseudocalanidac						
10. <i>Calocalanus pavo</i> Dana	0.88(V)	0.04(H)	30	1.02(V)	0.17(V)	40
11. <i>Clausocalanus</i> sp.	1.02(H)	0.91(H)	40	2.51(H)	0.09(H)	30
Family:- Paracalanidac						
12. <i>Paracalanus parvus</i> (Claus)	59.16(H)	1.03(H)	5	88.12(H)	0.98(H)	5
13. <i>P. aculeatus</i> Giesbrecht	14.31(H)	1.26(H)	20	10.03(H)	0.61(H)	20
14. <i>Acrocalanus gracilis</i> Giesbrecht	164.91(H)	0.41(V)	5	296.01(H)	0.10(H)	10

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15. <i>A. gibber</i> Giesbrecht	55.16(H)	0.71(H)	10	47.19(H)	0.04(H)	20
16. <i>A. similis</i> Sewell	—	—	—	1.13(V)	0.20(V)	30
17. <i>A. monachus</i> Giesbrecht	1.93(H)	0.02(H)	30	0.88(H)	0.06(H)	20
8. <i>A. longicornis</i> Giesbrecht	1.02(H)	0.23(V)	40	0.91(H)	0.11(H)	40
Family:- <i>Euchaetidae</i>						
19. <i>Euchaeta concinna</i> Dana	0.98(V)	0.05(V)	30	—	—	—
20. <i>E. marina</i> <i>Prestrandra</i>	1.23(H)	0.02(H)	40	0.86(H)	0.07(H)	30
21. <i>E. wolfeudeni</i> A. Scott	4.91(H)	0.61(V)	40	—	—	—
Family:- <i>Scolecithricidae</i>						
22. <i>Scolecithrix danae</i> (Lubbock)	1.12(H)	0.06(H)	40	0.93(H)	0.04(H)	40
Family:- <i>Lucicutiidae</i>						
23. <i>Lucicutia flavicornis</i> (Claus)	0.56(H)	0.01(V)	30	—	—	—
Family:- <i>Centropagidae</i>						
24. <i>Centropages orsinii</i> Giesbrecht	29.11(H)	0.22(V)	10	41.01(H)	0.03(H)	20
25. <i>C. furcatus</i> (Dana)	15.91(H)	0.05(H)	20	22.17(H)	0.10(H)	20
26. <i>C. tenuicornis</i> <i>Thompson & Scott</i>	14.34(H)	0.16(H)	10	22.81(H)	0.02(H)	10
27. <i>C. atcocki</i> Sewell	—	—	—	1.39(H)	0.40(V)	20
28. <i>C. trispinosus</i> Sewell	6.14(H)	0.03(V)	20	3.61(H)	0.08(H)	20
29. <i>C. gracilis</i> (Dana)	1.02(H)	0.04(H)	20	—	—	—
30. <i>C. elongatus</i> Giesbrecht	7.31(H)	1.00(H)	40	0.92(V)	0.10(H)	40
Family:- <i>Pseudodiaptomidae</i>						
31. <i>Pseudodiaptomus aurinilli</i> Cleve	90.16(H)	0.06(H)	5	116.91(H)	0.04(V)	5
32. <i>P. serricaudatus</i> (L. Scott)	1.78(H)	0.01(H)	20	0.98(H)	0.02(H)	20
33. <i>P. mertoni</i> Fruehli	5.12(H)	0.04(H)	10	8.10(H)	0.10(V)	20
34. <i>P. ardfjuna</i> Brehm.	1.31(H)	0.26(V)	20	4.13(H)	0.04(H)	10
Family:- <i>Temoridae</i>						
35. <i>Temora turbinata</i> (Dana)	36.15(H)	0.08(H)	10	26.13(H)	0.02(V)	20
36. <i>T. discaudata</i> Giesbrecht	1.92(H)	0.01(V)	40	1.00(H)	0.06(V)	30
37. <i>T. stylifera</i> (Dana)	0.86(H)	0.02(V)	10	3.11(H)	0.04(H)	10
Family:- <i>Candaciidae</i>						
38. <i>Candacia bradyi</i> A. Scott	1.12(H)	0.42(V)	20	0.98(H)	0.02(V)	30

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39.	<i>C. pachydactyla</i> (Dana)	0.62(H)	0.01(H)	30	—	—	—	—
40.	<i>C. discaudata</i> A. Scott	0.78(H)	0.02(H)	30	—	—	—	—
Family: - Pontellidae								
41.	<i>Calanopia elliptica</i> (Dana)	1.33(H)	0.03(H)	40	0.62(V)	0.09(H)	40	—
42.	<i>C. thompsoni</i> A. Scott	0.41(H)	0.00	40	—	—	—	—
43.	<i>Labidocera pectinata</i> Thompson & Scott	49.16(H)	0.05(H)	10	71.02(H)	1.12(H)	10	—
44.	<i>L. minuta</i> Giesbrecht	—	—	—	2.00(H)	0.00	20	—
45.	<i>L. acuta</i> (Dana)	7.13(H)	0.40(H)	40	3.52(H)	0.44(V)	40	—
46.	<i>L. bengalensis</i> krishnaswamy	0.91(H)	0.02(H)	30	—	—	—	—
47.	<i>L. pavo</i> Giesbrecht	0.94(H)	0.00	30	1.17(H)	0.02(H)	40	—
48.	<i>L. kroyeri</i> (Brady)	1.10(H)	0.01(H)	40	0.36(H)	0.00	40	—
49.	<i>Pontella danae</i> Giesbrecht	6.19(H)	0.29(V)	30	4.11(H)	0.05(H)	40	—
50.	<i>P. securifer</i> Giesbrecht	0.92(V)	0.00	40	1.16(V)	0.02(V)	30	—
51.	<i>P. spinipes</i> Giesbrecht	0.63(H)	0.21(H)	30	0.04(V)	0.00	30	—
52.	<i>Pontellopsis scotti</i> Sewell	2.91(H)	0.02(H)	40	1.33(H)	1.06(H)	40	—
53.	<i>P. herdmanni</i> Thompson & Scott	—	—	—	0.98(H)	0.00	40	—
54.	<i>Pontellina plumata</i> (Dana)	3.61(H)	0.28(H)	30	0.71(H)	0.14(H)	40	—
Family: - Acartidae								
55.	<i>Acartia plumosa</i> T. Scott	—	—	—	1.00(H)	0.00	5	—
56.	<i>A. southwelli</i> Sewell	0.32(H)	0.00	10	3.91(H)	0.02(V)	5	—
57.	<i>A. centrura</i> Giesbrecht	—	—	—	12.27(H)	0.81(H)	10	—
58.	<i>A. spinicauda</i> Giesbrecht	28.21(H)	0.02(H)	10	40.03(H)	1.06(H)	20	—
59.	<i>A. erythraea</i> Giesbrecht	5.01(H)	0.08(H)	20	1.91(H)	0.00	30	—
60.	<i>A. danae</i> Giesbrecht	1.21(H)	0.04(V)	30	0.53(H)	0.00	40	—
61.	<i>A. negitigen</i> Dana	0.77(H)	0.10(V)	20	—	—	—	—
Family: Tortanidae								
62.	<i>Tortanus forcipatus</i> Giesbrecht	2.13(H)	0.09(H)	10	4.10(H)	0.02(V)	20	—
63.	<i>T. gracilis</i> (Brady)	—	—	—	1.16(H)	0.13(H)	10	—
Family: - Longipediidae								
64.	<i>Longipedia scotti</i> (Sars)	—	—	—	0.40(H)	0.00	30	—
Family: - Ectinosomidae								
65.	<i>Microsetella rosca</i> (Dana)	1.26(V)	0.01(V)	30	0.31(V)	0.00	20	—

66.	<i>M. norvegica</i> (Boeck)	0.80(H)	0.02(V)	20	0.96(H)	0.03(V)	40
Family:- Macrosetellidae							
67.	<i>Macrosetella gracilis</i> (Dana)	0.56(H)	0.02(H)	40	0.63(H)	0.01(V)	30
68.	<i>Miracra efferata</i> Dana	0.29(V)	0.00	40	0.42(V)	0.02(V)	40
Family:- Clytemnestridae							
69.	<i>Clytemnestra rostrata</i> (Brady)	—	—	—	0.38(H)	0.00	20
70.	<i>C. scutellata</i> Dana	0.79(V)	0.04(H)	30	0.30(H)	0.01(H)	40
Family:- Tachidiidae							
71.	<i>Euterpina acutifrons</i> (Dana)	10.33(H)	0.43(V)	10	6.14(H)	0.33(V)	20
Family:- Oithonidae							
72.	<i>Oithona rigida</i> Giesbrecht	26.15(H)	0.04(H)	10	12.91(H)	0.62(H)	10
73.	<i>O. brevicornis</i> Giesbrecht	17.91(H)	0.02(V)	10	13.30(H)	0.08(V)	20
74.	<i>O. hebes</i> Giesbrecht	4.78(H)	0.10(H)	20	2.91(H)	0.02(H)	20
75.	<i>O. nana</i> Giesbrecht	0.60(H)	0.00	30	—	—	—
76.	<i>O. plumifera</i> Baird	1.09(H)	0.02(H)	40	0.81(H)	0.04(H)	40
77.	<i>O. robusta</i> Giesbrecht	0.42(H)	0.02(H)	40	—	—	—
Family:- Oncaeidae							
78.	<i>Onca venusta</i> Philippi	0.71(H)	0.02(H)	40	1.36(H)	0.05(H)	40
79.	<i>O. conifera</i> Giesbrecht	—	—	—	0.11(V)	0.00	40
Family:- Corycaelidae							
80.	<i>Corycaeus speciosus</i> Dana	1.52(H)	0.80(H)	10	0.92(H)	0.04(H)	20
81.	<i>C. (Corycella) gibbulus</i> Giesbrecht	1.77(H)	0.01(H)	10	0.95(H)	0.06(H)	10
82.	<i>C. danae</i> Giesbrecht	4.06(H)	0.02(H)	20	1.55(H)	0.01(V)	20
83.	<i>C. catus</i> F. Dahl	0.38(V)	0.00	30	0.09(H)	0.00	30
84.	<i>C. longistylis</i> Dana	0.21(V)	0.00	40	—	—	—
85.	<i>Copilia vitrea</i> (Haeckel)	0.61(V)	0.00	40	—	—	—
86.	<i>C. mirabilis</i> Dana	0.29(H)	0.02(H)	30	0.41(H)	0.06(H)	30
87.	<i>C. quadrata</i> Dana	0.20(H)	0.03(H)	20	0.06(V)	0.00	20
Family:- Sapphirinidae							
88.	<i>Sapphirina ovatolanceolata</i> Dana	0.37(V)	0.00	30	0.15(V)	0.02(H)	30
89.	<i>S. nigromaculata</i> Dana	0.46(V)	0.00	30	0.09(V)	0.00	40
90.	<i>S. sp</i>	0.05(V)	0.00	40	—	—	—

*H & V in parentheses denote nature of haul (H=Horizontal, V=Vertical) — = absent.

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ecosystem with high salinity and Karwar transect with influx of water from Kail river and thereby showing estuarine conditions, the occurrence of above mentioned species at the higher depths at Karwar can be due to less saline conditions there.

Majority of species recorded during the present investigation were obtained in the horizontal samples at both the transects. However, *Euchaeta concinna*, *Pontella securifer*, *Microsetella rosea*, *Copilia vitrea* and *Sapphirina ovatolanceolata* were recorded only in the vertical hauls. *Acrocalanus gracilis* *Centropages orsinii*, *Temora turbinata*, *Labidocera pectinata*, *Acartia spinicauda*, *A. erythraea* and *Euterpina acutifrons* were recorded almost throughout the period of investigation at both the transects, while some of the species were observed only in a particular month/period. At Karwar, *Acartia centrura*, *A. plumosa*, *Oithona nana* and *Copilia quadrata* were observed in the samples collected during January only; *Centropages furcatus*, *Pseudodiaptomus ardjuna* and *P. mertonii* during February and March and *Centropages elongatus*, *Temora stylifera*, *Labidocera bengalensis*, *Candacia bradyi*, *Eucalanus attenuatus* and *Acartia negligens* during the months of April and May. Similarly, at Vengurla, *Eucalanus monachus*, *Undinula vulgaris* and *Corycaeus gibbulus* were noticed during January; *Centropages furcatus*, *Temora discaudata*, *Calanopia elliptica* and *Oncea venusta* during February and March and *Pontella spinipes* and *Candacia bradyi* during May.

Amphipoda: Several species of gammarid amphipods were present. The highest number of 5.1/m³ was observed at Karwar from horizontal sample at 30 m depth region during March.

Ostracoda: Ostracods constituted mostly by *Cypridina* sp. were present only in a few samples taken from 20 to 40 m depth area at both the transects. The highest number (2.6/m³) was obtained at Vengurla during April.

Chaetognatha: Seven species belonging to three genera viz. *Sagitta enflata* Grassi, *S. bedoti* Berneck, *S. pulchra* Doncaster, *S. neglecta* Aida, *S. robusta* Doncaster, *Krohnitta pacifica* Aida and *Pterosagitta draco* (Krohn) were recorded. *S. enflata* was the most dominant species occurring in large numbers at 10 to 20 m depth. *S. bedoti* preferred shallow waters (5 m). *S. neglecta*, *S. robusta* and *K. pacifica* were present more in the samples from 30 to 40 m depth stations. *S. pulchra* did not show any definite pattern of distribution while few specimens of *P. draco* were recorded only at Vengurla from vertical samples taken at 40 m depth during April.

Copepoda: *Oikopleura cophocera* and *Frittilaria borealis* were the common species. The maximum number of Oikopleurans recorded at Vengurla and Karwar were 3.8/m³ and 1.2/m³ respectively.

Fish eggs and larvae: The fish eggs were recorded in large number at both the transects between 10 to 20 m depth. The fish larvae belonging to the families Gobiidae, Holocentridae, Stomiidae etc. were recorded. In addition to the above mentioned groups, cyphonautes larvae, cirreped larvae, gastropod larvae, isopoda, cumecea were recorded in a small number at both the transects.

DISCUSSION

Coastal upwelling has been reported along some areas of the west coast of India and this has been proved to influence the productivity of these waters (Jayaraman and Seshappa, 1957; Banse, 1959; Carruthers *et al.*, 1959; Prasad, 1969; Sankaranarayanan and Jayaraman, 1972). The zooplankton biomass and hydrographical values also indicate that Vengurla and Karwar transects are

situated in the upwelling zone, especially the former, where the higher zooplankton production with low values of temperature and oxygen with simultaneous rise in salinity values were recorded. The zooplankton biomass values of the vertical samples at Vengurla and Karwar were 730 and 593 ml/1000 m³ respectively. Bhargava *et al.* (1973) recorded the values of zooplankton standing crop of 32 ml/m³ at Vengurla in the month of September. The IIOE atlas (IOBC, 1968) also gives high biomass values for the central west coast of India. The presence of large specimens of salps and doliolids, siphonophores, chetognaths and pteropods mainly contributed to the high biomass values of the vertical samples collected at Vengurla and Karwar. However, in the month of May, the high biomass values at Karwar resulted from a bloom of *Noctiluca miliaris*. Similar bloom of noctilucans at Karwar was also observed by Ramamurthy (1965). Several attempts have been made to study the relationship between plankton production and fish catch. Chidambaram and Menon (1945) traced relationship between plankton abundance and fish landings at Malabar and south Kanara coast. Sudarshan (1964) concluded that trawler catches at Bombay showed two peaks in a year, one following the period of plankton maximum in March and the other coinciding with the period of very high plankton crop during the post-monsoon months (October-November). Panikkar and Jayaraman (1966) have also stated that fish catch particularly pelagic, occur in areas of high plankton production. Mukundan (1967) found that the high values of plankton were accompanied by increased catch of oil sardines and mackerels.

During the period of present investigations copepods and cladocerans were the most dominant crustaceans in the zooplankton samples taken at various depths and during different months. The maximum density of cladocerans was observed at 20 m and 10 m depth stations at Vengurla and Karwar respectively (Table 2). It is well known that the Indian mackerel (*Rastrelliger kanagurta*) is a plankton feeder and earlier workers have shown direct relationship between the cladoceran peak and mackerel fisheries along the west coast of India (Menon, 1945; Bhimachar and George, 1952; George, 1953; Pradhan, 1956; Noble, 1962. Selvakumar (1970) also studied the association of cladoceran swarms and onset of mackerel fishery at Karwar during 1966 fishing season and at Goa during 1969 season and observed that in both these areas cladoceran swarms were followed by heavy catch of mackerels. The cladoceran population during the period of present studies comprised of two species, *Eradne tergestina* and *Penilia avirostris*. The previous workers also recorded the presence of these two species in the zooplankton samples collected during the mackerel fishing season. Although no fish landing data is available from Vengurla and Karwar for the evaluation of correlation between fish catch and zooplankton abundance, on the basis of zooplankton standing crop and occurrence of copepods and cladocerans as dominant plankton constituents, both the transects appear to be rich potential fishing grounds especially for the pelagic fishery.

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DISCUSSION

- GRIFFITHS : Please expand on why the vertical hauls gave consistently higher biomass results than the horizontal hauls?
- GOSWAMI : The higher biomass values in vertical samples were due to the large number of hydromedusae, siphonophores, large specimens of salps and doliolids and also due to more of pteropods, ostracods etc.
- MURTY : We expect during May to August upwelling influence at Karwar when compared to Vengurla. Will your observations on zooplankton biomass indicate a higher value as we approach Karwar from Vengurla?
- GOSWAMI : The observations were restricted for the period from January to May. Therefore, upwelling influence cannot be traced. Actually, the values were high at Vengurla than at Karwar. This is perhaps due to the changes in salinity since Vengurla is a marine environment whereas Karwar station is influenced by discharge from Kali river.