

Secondary Production & Zooplankton Abundance in the Coastal Waters from Vengurla to Malpe, West Coast of India

S C GOSWAMI

National Institute of Oceanography, Dona Paula, Goa 403004,

Received 30 April 1984; revised received 7 January 1985

Secondary production and zooplankton abundance in surface and vertical hauls at different stations along 7 transects from Vengurla to Malpe were studied. Zooplankton production varied with the depth of sampling station and type of haul taken. Secondary production values were slightly higher for the vertical (av. $26.17 \text{ mg C m}^{-2} \text{ d}^{-1}$) than for the surface samples (av. $24.5 \text{ mg C m}^{-2} \text{ d}^{-1}$). Highest ($47.83 \text{ mg C m}^{-2} \text{ d}^{-1}$) and lowest ($14.97 \text{ mg C m}^{-2} \text{ d}^{-1}$) values were obtained at 20 and 5 m depth stations. Copepods constituted the major component of zooplankton community (77.6 to 89.92%). Cladocerans, chaetognaths and decapod larvae were abundant between 20 to 30 m depths which are the traditional fishing grounds. Relationship between zooplankton abundance and pelagic fishery in the studied area is discussed.

Some information is available on the zooplankton distribution in the coastal waters of southwest (SW) coast of India^{1,2}. The region between Vengurla and Malpe, central west (CW) coast of India, has not been studied adequately^{3,4}. The present communication gives an account of zooplankton composition and abundance in the surface and vertical hauls at different stations along 7 transects between Vengurla and Malpe.

Materials and Methods

Monthly (Jan.-May 1972) surface and vertical zooplankton samples were collected at different stations along 7 transects (Fig.1). The collections were made with a HT net (mouth area 0.25 m^2 ; mesh size 0.33 mm) fitted with a calibrated flowmeter. Vertical zooplankton collections were made by lowering the net near to the bottom (5,10,20,30 and 40 m depths) and then hauling it slowly. Secondary production was estimated from the biomass values following the methods of Cushing^{5,6}. An aliquot of 1 to 10% was examined for enumeration of different organisms. Number was calculated for the whole sample (no. m^{-3}) and percentages were obtained from the average numbers of 5 month data. Surface and bottom seawater samples were taken simultaneously at each depth contour for the analyses of physical and chemical parameters⁷.

Results and Discussion

Monthly temperature, dissolved oxygen and nutrient ($\text{PO}_4\text{-P}$ and $\text{NO}_3\text{-N}$) values decreased with increasing depth of sampling. However, salinity showed a reverse pattern. Temperature and dissolved oxygen values were higher at the surface while salinity and nutrient salt values were higher at the bottom. The observed ranges in the prevailing physical and chemical conditions with mean values calculated from

the surface and bottom samples at different transects are shown in Fig.2. Spatial variations in temperature and salinity were recorded. The values were higher at the Malpe transect and at the northern transects (Vengurla and Teracol). Varadachari *et al.*⁸ reported a gradual increase of surface temperature from north to south along the CW coast of India. Highest (33°C) and the lowest (27°C) temperature values were obtained at

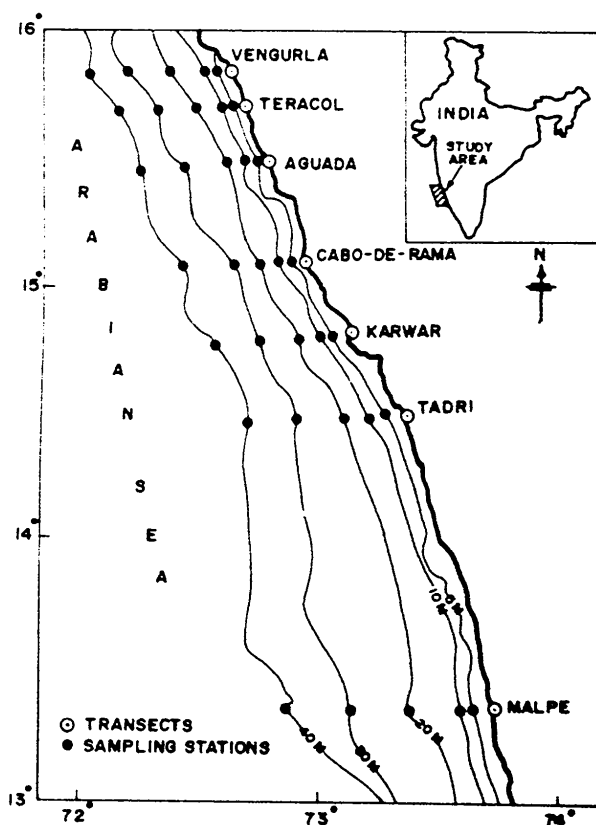


Fig. 1 — Station locations along different transects

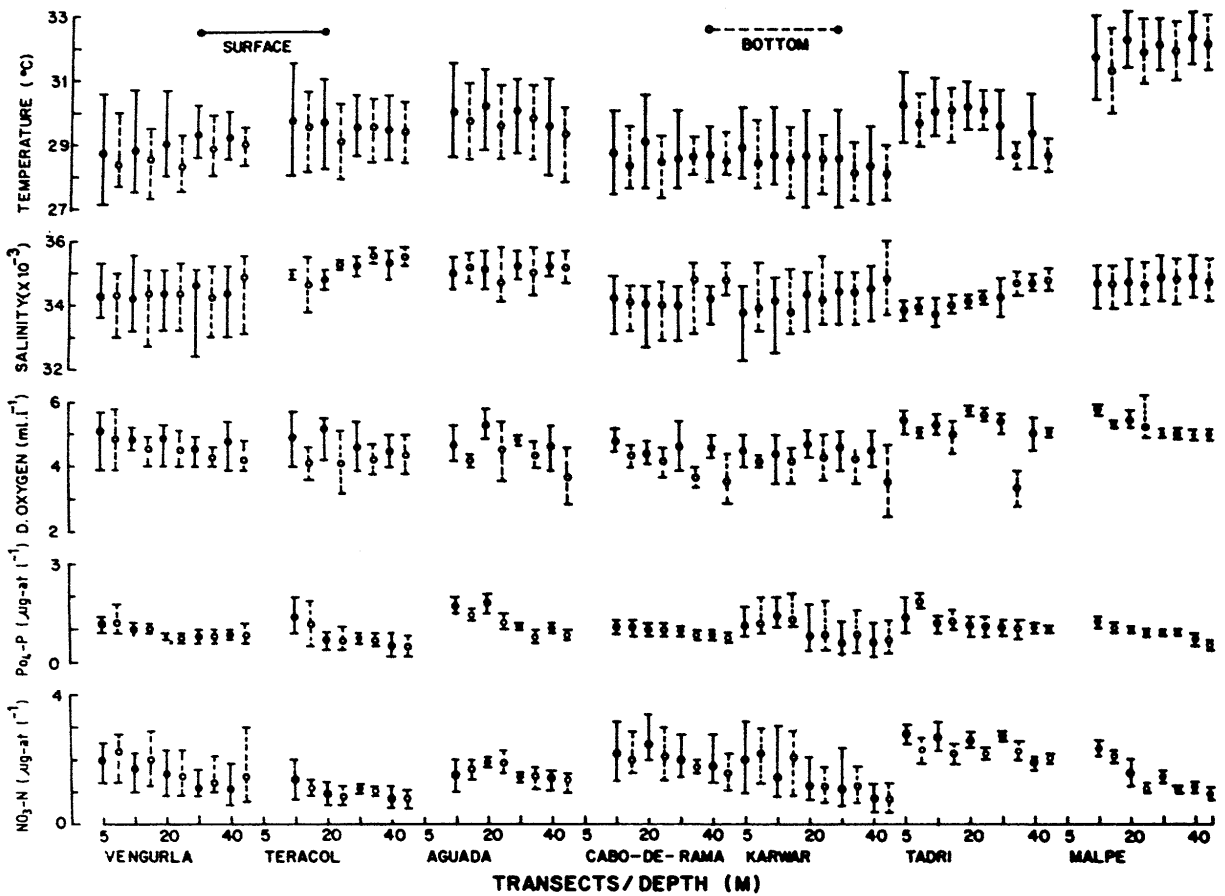


Fig. 2—Physical and chemical parameters in the study area

Malpe and Vengurla respectively in April and Jan. Rao *et al.*⁹ also recorded lower temperature of 27°C in the inshore waters of Vengurla and Karwar during Jan. and attributed this to the thorough mixing of the coastal waters by strong land and sea breezes. The salinity values increased from 5 to 40 m depth. The salinity values at all transects increased steadily from Jan. onwards with peak in May. The incursion of relatively saline subsurface waters along the inner shelf at Tadri and Malpe transects was observed from March to May. The dissolved oxygen values were higher at the surface than at the bottom except at 5 m depth where no appreciable difference was noticed. Maximum and minimum fluctuations in dissolved oxygen values were observed at Karwar and Malpe. PO₄-P and NO₃-N values were higher at the bottom. Higher values were obtained at the Vengurla, Karwar and Malpe transects during Jan. - Feb. Zooplankton biomass values were also more during this period. Fluctuation in inorganic phosphate values of surface waters were reported at Karwar¹⁰, off the North Kanara coast¹¹ and at Calicut^{12,13}.

Highest and the lowest values of secondary production were obtained at 20 and 5 m depths (Fig.3).

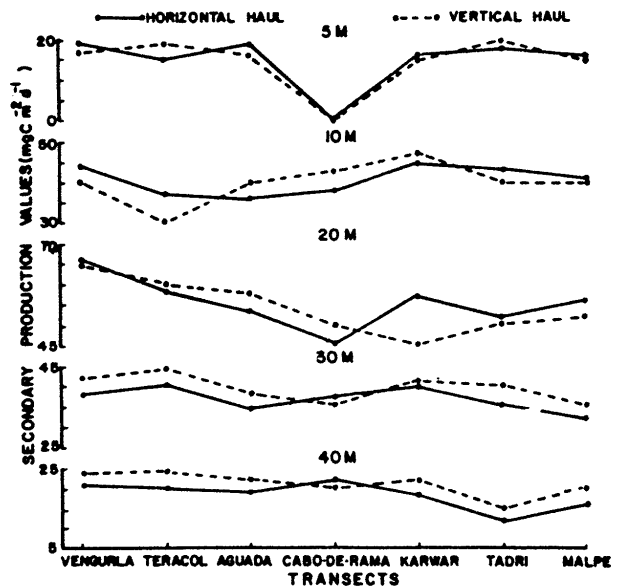


Fig. 3—Secondary production at different transects

Average secondary production along 7 transects at 5, 10, 20, 30 and 40 m depths was 9.34, 26.77, 53.64, 17.4 and 15.47 mg C m⁻²d⁻¹ respectively. A gradual increase in secondary production was observed from Jan. onwards with peak during April-May at most of the transects except at Teracol and Karwar transects where the highest secondary production was obtained in Feb. and March. The values obtained in the present study were lower compared to the values reported for inshore waters of Goa^{14,15} and for coastal waters of India from Dabhol to Tuticorin¹⁶. This may be due to the fact that zooplankton collections were made during the day time (1000-1600 hrs).

Total zooplankton counts (no. m⁻³) were greater in the surface than in the vertical samples. Highest average number recorded in the former was 4062 while in the latter it was 3005.5. The lowest number recorded in the surface and vertical samples was 1454.2 and 1320.5 respectively, obtained at 10 m depth station at the Cabo-de-Rama transect. Total number of organisms showed direct relationship with secondary production values and increased from 5 to 20 m depth and declined at the 30 and 40 m depth zones. However, the highest number (3115) was obtained at 30 m depth at the Aguada transect during May. At other transects, the highest and the lowest number was recorded during April and Feb. respectively. Of the 22 zooplankton groups observed in the samples, the percentage distribution of 14 groups is given (Table 1). The members of remaining 8 groups, viz. cirriped larvae, lamellibranchiats, isopods, cumaceans, euphausiids, ostracods, stomatopod larvae and pterods occurred sporadically and in small numbers. They have been

included under miscellaneous (Table 1). Polychaetes, mysidaceans, sergestids, decapod larvae, fish eggs and fish larvae were more abundant in the zooplankton samples collected at 5 and 10 m depths. Hydromedusae, siphonophores, amphipods, cladocerans, chaetognaths, salps and doliolids were abundant in samples taken at 20 to 40 m depths. Gelatinous organisms such as Hydromedusae, siphonophores, salps and doliolids were more abundant in the vertical samples and accounted for higher secondary production values. Amphipods and sergestids were less in the vertical samples taken at Tadri and Malpe transects. Filter feeders and omnivores were relatively abundant in the plankton samples taken during Jan.-March while carnivores were more during April-May.

Copepods dominated the zooplankton community at all transects. Highest (116.3) and lowest (782) counts (n⁻³) were obtained at Malpe and Cabo-de-Rama. Maximum (3574) and minimum (76) copepod number with annual mean of 714 was reported off Trivandrum¹⁷ and maximum copepod population density (av. 5360) was reported at Mahim¹⁸. A total of 90 copepod species belonging to 33 genera were identified. Species of the genera *Paracalanus*, *Canthocalanus*, *Clausocalanus*, *Pontellina*, *Temora*, *Macrosetella* and *Euterpina* were observed in the plankton samples collected at all transects while members of other genera showed spatial variations. Occurrence and abundance of copepod species was also dependent on the type of plankton haul taken. They were more abundant in the surface than in the vertical collections. Distribution of copepod species

Table 1—Percentage Distribution of Major Zooplankton Groups at Different Transects

[Values in parentheses indicate percentage in vertical samples]

Groups	Transects						
	Vengurla	Teracol	Aguada	Cabo-de-Rama	Karwar	Tadri	Malpe
Hydromedusae	0.51(1.48)	0.49(1.04)	0.26(1.52)	0.24(1.81)	0.20(1.54)	—(0.50)	0.04(0.62)
Siphonophora	0.63(1.93)	1.24(2.13)	0.91(1.24)	1.49(2.69)	0.80(1.85)	0.31(1.38)	0.34(0.99)
Polychaete larvae	0.55(0.48)	2.08(1.46)	2.55(1.56)	0.02(0.11)	1.63(2.24)	0.57(0.88)	0.40(0.87)
Cladocera	2.54(2.11)	1.15(1.97)	1.18(1.41)	0.45(2.40)	2.79(0.98)	1.07(1.02)	1.21(1.52)
Copepoda	83.74(81.99)	77.61(80.27)	77.60(83.59)	78.08(78.90)	83.85(87.15)	85.18(86.86)	86.49(89.92)
Mysidacea	0.34(1.94)	0.27(1.66)	0.70(3.10)	0.20(1.84)	0.47(1.54)	0.31(1.84)	0.33(1.47)
Amphipoda	2.03(1.48)	2.50(1.69)	1.41(1.26)	1.13(0.97)	0.80(0.78)	1.08(0.18)	1.06(0.17)
Sergestidae	2.53(0.68)	3.48(0.58)	4.22(1.56)	6.06(0.11)	2.01(0.09)	2.23(0.02)	2.07(0.04)
Decapod larvae	3.28(3.61)	7.58(4.89)	7.76(1.57)	8.04(6.55)	3.79(1.31)	5.49(3.95)	4.73(2.06)
Copelata	0.69(0.47)	0.67(0.40)	0.89(0.17)	0.44(—)	1.20(0.05)	1.18(0.05)	0.65(0.03)
Chaetognatha	1.66(1.94)	1.38(1.66)	1.10(1.53)	1.96(1.96)	1.02(1.30)	1.51(1.68)	1.39(1.00)
Salps & Doliolids	0.08(0.37)	0.22(0.44)	0.24(0.34)	0.22(0.79)	0.27(0.32)	0.09(0.18)	0.15(0.32)
Fish eggs	0.40(0.44)	0.45(0.69)	0.35(0.15)	0.34(0.16)	0.47(0.22)	0.45(0.41)	0.53(0.33)
Fish larvae	0.11(0.19)	0.14(0.24)	0.12(0.25)	0.19(0.51)	0.15(0.13)	0.12(0.18)	0.21(0.19)
Miscellaneous	0.88(0.89)	0.72(0.86)	0.69(1.08)	1.13(1.18)	0.53(0.48)	0.41(0.75)	0.37(0.46)

also showed some relationship with the depth of sampling (Table 2).

Cladocerans were more numerous at the surface (55.48%) than in the vertical samples (44.52%). *Evadne tergestina* Claus and *Penilia avirostris* Dana, represented the cladoceran population at all transects, the former being the dominant species (58.2%). Percentage occurrence of these species at different transects and at various depths is given in Tables 3 and 4. *Evadne* was abundant in samples taken during Jan.-Feb. while *Penilia* during March-May. *E. tergestina* was reported to occur discontinuously throughout the year in the coastal waters with peak in Nov. while *P. avirostris* showed bimodal distribution with abundance during Nov./Dec. and March/May¹⁹. Species of the genera *Sagitta* and *Pterosagitta* were common representatives of chaetognaths. Their percentage

occurrence is given (Table 5). Maximum and minimum counts were obtained at Vengurla and Tadri transects. Highest number of *S. bedoti* (80.6), *S. enflata* (38.5), *Sagitta* spp (49.3) and *Pterosagitta* spp (18.3) was obtained at 5,10,30 and 40 m depths at Vengurla, Aguada, Cabo-de-Rama and Malpe transects respectively. Chaetognath species diversity was maximum during April-May. Plaemonids, alpheids, hippolytids, porcellanids and branchyurans were common non-penaeid prawn constituents of decapod larvae in the samples (Table 6). The others included mostly anomuran larvae. Brachyurans and palaemonids were abundant in surface samples. Maximum number of brachyurans (61.3) was obtained at 10 m at Teracol. Members of the remaining groups were usually more numerous in the vertical samples and also in the collections taken at 20 to 40 m depths.

Table 2—Distribution of Common Copepod (no m⁻³) Species at Different Transects with Their Maximum Recorded Number, Depth of Sampling Stations and Type of Zooplankton Haul

[S = surface; V = vertical. Figures in parentheses denote depth of sampling station and type of haul]

Species	Transects						
	Vengurla	Teracol	Aguada	Cabo-de-Rama	Karwar	Tadri	Malpe
<i>Canthocalanus pauper</i> (Giesbrecht)	1.0 (40S)	3.2 (40S)	1.0 (40S)	9.1 (30V)	3.1 (40S)	5.5 (30S)	17.0 (30S)
<i>Nannocalanus minor</i> (Claus)	—	14.8 (30S)	14.8 (30S)	6.1 (40S)	1.1 (40S)	—	15.2 (20S)
<i>Undinula vulgaris</i> (Dana)	12.5 (30S)	114.6 (20S)	37.4 (30S)	97.3 (40S)	5.9 (40S)	72.1 (40S)	111.3 (20S)
<i>U. darwini</i> var. <i>symmetrica</i> Sewell	13.2 (40S)	34.5 (20S)	19.1 (30S)	18.2 (40S)	4.0 (40S)	—	31.4 (30S)
<i>Eucalanus subcrassus</i> (Giesbrecht)	16.1 (10S)	64.7 (10S)	11.6 (20S)	72.9 (10S)	9.1 (10S)	852.8 (10S)	61.5 (10S)
<i>E. crassus</i> (Giesbrecht)	9.9 (20S)	16.5 (10S)	6.2 (20S)	35.1 (10S)	3.5 (10S)	7.1 (10S)	9.3 (10S)
<i>E. monachus</i> (Giesbrecht)	1.6 (40S)	3.5 (40S)	1.4 (40V)	3.9 (40S)	2.1 (40S)	1.6 (40S)	1.1 (40S)
<i>E. attenuatus</i> (Dana)	3.1 (30V)	4.6 (40S)	1.3 (40V)	2.2 (40S)	—	1.4 (40S)	1.6 (30S)
<i>E. elongatus</i> (Dana)	1.8 (40S)	2.3 (40S)	7.6 (40S)	1.4 (40S)	—	5.6 (40S)	3.6 (40S)
<i>Calocalanus pavo</i> (Dana)	0.8 (30V)	1.0 (30V)	2.1 (30V)	—	1.0 (40V)	—	3.5 (30S)
<i>Clausocalanus arcuicornis</i> (Dana)	1.0 (40S)	5.1 (40S)	3.7 (40S)	10.2 (40V)	9.6 (40S)	52.2 (40S)	38.1 (40S)
<i>Paracalanus parvus</i> (Claus)	59.1 (5S)	164.7 (5S)	317.2 (5S)	212.3 (5S)	88.1 (5S)	189.1 (5S)	283.8 (5S)
<i>P. aculeatus</i> Giesbrecht	14.5 (20S)	71.6 (10S)	18.6 (20S)	81.6 (20S)	10.1 (20S)	32.1 (20S)	58.1 (20S)
<i>Acrocalanus gracilis</i> Giesbrecht	164.9 (5S)	—	56.9 (10S)	51.3 (10S)	296.0 (10S)	99.1 (10S)	69.1 (10S)
<i>A. gibber</i> Giesbrecht	55.2 (10S)	211.5 (20S)	34.1 (20S)	38.1 (20S)	47.2 (20S)	113.6 (20S)	171.9 (20S)
<i>A. similis</i> Giesbrecht	—	9.6 (20S)	3.9 (20S)	16.5 (20S)	1.1 (30V)	7.1 (20V)	19.5 (20S)
<i>A. monachus</i> Giesbrecht	1.9 (30S)	4.5 (30V)	—	8.8 (30V)	0.9 (20S)	2.1 (30V)	1.6 (30S)
<i>A. longicornis</i> (Giesbrecht)	1.0 (40V)	6.3 (40S)	1.3 (40S)	—	0.9 (40S)	1.5 (40S)	2.0 (40S)
<i>Euchaeta concinna</i> Dana	1.0 (30V)	4.9 (40S)	1.3 (40S)	5.8 (40S)	—	4.4 (40S)	3.6 (40S)
<i>E. marina</i> (Prestandrea)	1.2 (40S)	6.4 (30S)	3.5 (40S)	1.9 (40S)	0.9 (30S)	—	—
<i>E. wolfendeni</i> A. Scott	4.9 (40S)	17.2 (40S)	68.4 (40S)	17.2 (30S)	—	58.1 (40S)	29.1 (40S)
<i>Scolecithrix danae</i> (Lubbock)	1.1 (40S)	8.8 (30S)	—	4.9 (30S)	0.9 (40S)	1.6 (30S)	3.3 (30S)
<i>Lucicutia flavicornis</i> (Claus)	0.6 (30S)	1.9 (40V)	—	—	—	—	—
<i>Centropages orsinii</i> Giesbrecht	29.1 (10S)	217.2 (10S)	89.2 (10S)	112.4 (20S)	41.0 (20S)	177.5 (10S)	151.4 (10S)
<i>C. furcatus</i> (Dana)	15.9 (20S)	83.7 (10S)	111.1 (20S)	189.6 (10S)	22.2 (20S)	194.9 (20S)	166.5 (20S)

—Contd

Table 2—Distribution of Common Copepod (no m⁻³) Species at Different Transects with Their Maximum Recorded Number, Depth of Sampling Stations and Type of Zooplankton Haul —Contd

[S=surface; V=vertical. Figures in parentheses denote depth of sampling station and type of haul]

Species	Transects						
	Vengurla	Teracol	Aguada	Cabo-de-Rama	Karwar	Tadri	Malpe
<i>Centropages tenuiremis</i> Thompson & Scott	14.3 (10S)	99.9 (10V)	75.8 (10V)	81.5 (10S)	22.8 (10S)	37.2 (10S)	94.4 (5S)
<i>C. alcocki</i> Sewell	—	34.3 (5S)	41.6 (5S)	22.9 (5S)	1.4 (20S)	45.1 (5S)	81.3 (10S)
<i>C. trispinosus</i> Sewell	6.1 (20S)	68.4 (10S)	29.6 (10S)	29.4 (10S)	3.6(20S)	18.6 (10S)	21.1 (10S)
<i>C. gracilis</i> (Dana)	1.0 (20S)	0.9 (20V)	—	1.1 (20S)	—	1.3 (20V)	—
<i>C. elongatus</i> Giesbrecht	7.3 (40S)	—	—	4.9 (40S)	0.9 (40V)	2.6 (40S)	1.1 (30S)
<i>Candacia brady</i> A. Scott	1.1 (20S)	64.9 (20S)	45.4 (20S)	36.1 (30S)	1.0 (30S)	16.5 (20S)	14.4 (20S)
<i>C. pachyductyla</i> (Dana)	0.6 (30S)	1.4 (30S)	4.9 (40S)	0.4 (30S)	—	2.1 (30S)	1.6 (30S)
<i>C. discaudata</i> (A. Scott)	0.8 (30S)	4.9 (40S)	2.2 (30S)	1.9 (30S)	—	6.6(30S)	5.0 (30V)
<i>Pseudodiaptomus aurivilli</i> Cleve	90.1 (5S)	291.6 (5S)	313.9 (5S)	896.9 (10S)	116.9 (5S)	1086.1 (10S)	1419.2 (5S)
<i>P. serricaudatus</i> (T. Scott)	1.8 (20S)	168.5 (30S)	117.5 (20S)	164.9 (20S)	1.0 (20S)	71.2 (20S)	181.5 (30S)
<i>P. mertonii</i> Fruchtl	5.1 (10S)	85.1 (5S)	100.0 (10S)	—	8.1 (20S)	66.1 (10S)	55.1 (10S)
<i>P. ardjuna</i> Brehm	1.3 (20S)	17.5 (10S)	8.6 (10S)	44.1 (10S)	4.1 (10S)	23.5 (20S)	46.2 (10S)
<i>Temora turbinata</i> (Dana)	36.1 (10S)	181.6 (20S)	291.9 (20S)	177.5 (10S)	26.1 (20S)	91.6 (10V)	91.6 (20S)
<i>T. discaudata</i> Giesbrecht	1.9 (40S)	34.5 (40S)	15.6 (40S)	17.5 (40S)	1.0 (30S)	6.5 (40S)	6.2(30S)
<i>Calanopia elliptica</i> (Dana)	1.3 (40S)	6.5 (40S)	—	—	0.6 (30V)	4.2 (40S)	1.0 (40S)
<i>C. thompsoni</i> A. Scott	0.4 (40V)	—	—	—	—	—	—
<i>Labidocera pectinata</i> Thompson & Scott	49.1 (10S)	171.5 (10S)	231.6 (10S)	812.1 (10S)	71.0 (10S)	361.5 (5S)	713.1 (10S)
<i>L. minuta</i> Giesbrecht	—	3.1 (30S)	1.7 (40S)	3.3 (40S)	2.0 (20S)	6.9 (30S)	1.3 (30S)
<i>L. acuta</i> (Dana)	7.13(40S)	86.5 (30S)	55.1 (30S)	26.1 (40S)	3.5 (40S)	4.1 (40S)	1.1 (40S)
<i>L. bengalensis</i> Krishnaswamy	0.9 (30S)	27.1 (20S)	49.6 (20S)	11.1 (20S)	—	16.2 (20V)	17.1 (20S)
<i>L. pavo</i> Giesbrecht	0.9 (30S)	—	1.6 (30V)	1.4 (20V)	1.2 (40S)	4.1 (30S)	2.6 (30S)
<i>L. kroyeri</i> (Brady)	1.1 (40S)	69.7 (20S)	24.9 (30S)	16.8 (30S)	0.4 (40S)	13.3 (30S)	19.1 (30S)
<i>Pontella danae</i> Giesbrecht	6.2 (30S)	150.1 (20S)	110.6 (20S)	99.5 (20S)	4.1 (40S)	15.1 (20S)	66.1 (20S)
<i>P. securifer</i> Brady	0.9 (40V)	13.5 (10V)	16.4 (20V)	21.0 (20V)	1.2 (30V)	4.9 (20S)	3.5 (20V)
<i>P. spinipes</i> Giesbrecht	0.6 (30S)	18.2 (30S)	17.1 (30V)	29.1 (30S)	0.4 (30V)	—	—
<i>Pontellopsis scotti</i> Sewell	2.9 (40S)	34.2 (20S)	55.1 (20S)	51.9 (20S)	1.3 (40S)	15.5 (20S)	61.0 (20S)
<i>P. herdmani</i> Thompson & Scott	—	—	9.6 (30S)	1.1 (40S)	1.0 (40S)	1.9 (30S)	1.6 (30S)
<i>Pontellina plumata</i> (Dana)	3.6 (30S)	14.9 (20S)	5.1 (20S)	56.1 (30S)	0.7 (40S)	3.9 (20S)	11.1 (20S)
<i>Acartia plumosa</i> Giesbrecht	4.2 (5S)	—	—	—	1.9 (5S)	—	—
<i>A. southwelli</i> Sewell	0.3 (10S)	16.5 (5S)	71.2 (5S)	39.5 (5S)	3.9 (5S)	119.3 (5S)	61.5 (5S)
<i>A. centrura</i> Giesbrecht	—	210.2 (10S)	115.4 (10S)	271 (10S)	12.3 (10S)	59.1 (10S)	99.2 (10S)
<i>A. spinicauda</i> Giesbrecht	28.2 (10S)	77.1 (10S)	81.5 (10S)	112.5 (10S)	40.0 (20S)	198.2 (10S)	200.1 (10S)
<i>A. erythraea</i> Giesbrecht	5.0 (20S)	19.5 (10S)	39.2 (20S)	77.1 (20S)	1.9 (30S)	140.1 (20S)	88.1 (20S)
<i>A. danae</i> Giesbrecht	1.2 (30S)	29.1 (40S)	2.6 (40V)	13.1 (40S)	0.5 (40S)	13.1 (40S)	2.1 (40S)
<i>A. negligens</i> Dana	0.8 (20S)	2.9 (30S)	0.6 (30S)	6.1 (30S)	—	1.8 (30V)	1.2 (30S)
<i>Acartia</i> species	—	—	4.9 (10S)	—	—	—	—
<i>Tortanus forcipatus</i> Giesbrecht	2.1 (10S)	16.9 (20S)	21.4 (20S)	88.9 (20S)	4.1 (20S)	16.5 (20S)	3.5 (20S)
<i>T. gracilis</i> (Brady)	—	—	—	2.1 (5S)	1.2 (20S)	2.3 (5S)	10.0 (5S)
<i>Longipedia scotti</i> (Sars)	—	1.3 (20S)	10.1 (20S)	3.5 (20V)	0.4 (30S)	12.1 (20V)	10.1 (20V)

Contd

Table 2—Distribution of Common Copepod (no m⁻³) Species at Different Transects with Their Maximum Recorded Number, Depth of Sampling Stations and Type of Zooplankton Haul—Contd
 [S=surface, V=vertical. Figures in parentheses denote depth of sampling station and type of haul]

Species	Transects						
	Vengurla	Teracol	Aguada	Cabo-de-Rama	Karwar	Tadri	Malpe
<i>Microsetella rosea</i> (Dana)	1.3 (30V)	—	—	2.9 (40V)	0.3 (20V)	—	—
<i>M. norvegica</i> (Boeck)	0.8 (20S)	5.1 (30V)	1.6 (20V)	2.0 (30S)	1.0 (40S)	6.6 (30V)	1.9 (30V)
<i>Macrosetella gracilis</i> (Dana)	0.5 (40S)	3.9 (30S)	3.0 (30S)	5.1 (30S)	0.6 (30S)	1.4 (20V)	5.1 (30V)
<i>Miracia efferata</i> (Dana)	0.2 (40V)	—	—	—	—	—	—
<i>Clytemnestra rostrata</i> (Brady)	—	—	—	—	0.4 (30S)	—	—
<i>C. scutellata</i> Dana	0.8 (30V)	—	1.4 (40V)	—	0.3 (40S)	—	—
<i>Euterpina acutifrons</i> (Dana)	10.3 (10S)	116.9 (10S)	293.1 (10S)	317.4 (10S)	6.1 (20S)	115.7 (10S)	186.1 (10S)
<i>Oithona rigida</i> Giesbrecht	26.1 (10S)	193.5 (5S)	93.4 (10S)	117.4 (10S)	12.9 (10S)	71.4 (5S)	100.1 (5S)
<i>O. brevicornis</i> Giesbrecht	17.9 (10S)	14.5 (10S)	31.4 (10S)	22.1 (5S)	13.3 (20S)	3.5 (10S)	—
<i>O. hebes</i> Giesbrecht	4.8 (20S)	2.9 (20V)	3.5 (10S)	—	2.9 (20S)	—	—
<i>O. nana</i> Giesbrecht	0.6 (30S)	1.6 (20S)	9.4 (40S)	1.3 (30S)	—	9.2 (40S)	2.7 (30S)
<i>O. plumifera</i> Baird	1.1 (40S)	4.5 (40S)	3.1 (40V)	9.6 (40S)	0.8 (40S)	3.3 (40S)	1.4 (40S)
<i>O. robusta</i> Giesbrecht	0.4 (40S)	—	—	1.6 (40S)	—	—	—
<i>Oncaea venusta</i> Philippi	0.7 (40S)	4.9 (40S)	2.1 (40S)	—	1.4 (40S)	—	2.1 (40S)
<i>O. conifera</i> Giesbrecht	—	2.1 (40S)	—	—	0.1 (30V)	—	—
<i>Corycaeus speciosus</i> Dana	1.5 (10S)	2.9 (20S)	6.4 (20S)	—	0.9 (20S)	—	—
<i>C. (corcella) gibbulus</i> Giesbrecht	14.5 (10S)	14.5 (10S)	18.2 (10S)	2.9 (5S)	0.9 (10S)	18.2 (10S)	—
<i>C. danae</i> Giesbrecht	4.1 (20S)	—	2.9 (30S)	3.5 (20S)	1.5 (20S)	2.1 (20S)	5.0 (20S)
<i>C. catys</i> F. Dahl	0.4 (30S)	4.2 (20S)	1.3 (40S)	1.6 (30V)	—	—	—
<i>C. longistylis</i> Giesbrecht	0.2 (40V)	1.3 (40V)	—	—	0.4(30V)	—	—
<i>Sapphirina ovatolanceolata</i> Dana	0.3 (30V)	—	—	—	0.1 (30V)	—	—
<i>S. nigromaculata</i> Dana	0.4 (30V)	1.3 (40V)	—	—	0.09 (40V)	0.1 (40V)	—
<i>Sapphirina</i> sp.	0.05 (40V)	—	0.1 (30V)	—	—	0.3 (40V)	—
<i>Copilia vitrea</i> (Haeckel)	0.6 (40V)	0.1 (40V)	—	—	—	—	—
<i>C. mirabilis</i> Dana	0.3 (30S)	1.6 (40V)	—	1.1 (30V)	0.4 (30S)	—	—
<i>C. quadrata</i> Dana	0.2 (20S)	—	—	—	1.1 (20V)	—	—

Table 3—Percentage Occurrence of Cladoceran Species at Different Transects
 [Values in parentheses indicate percentage in bottom samples]

Station depth (m)	Transects						
	Vengurla	Teracol	Aguda	Cabo-de-Rama	Karwar	Tadri	Malpe
	<i>Evadne tergestina</i> Claus						
5	1.10(2.01)*	1.25(-)	8.31(-)	1.78(-)	20.28(18.88)	14.44(11.44)	14.16(-)
10	22.14(22.44)	14.97(27.25)	24.53(22.75)	14.93(20.52)	31.40(47.18)	20.72(19.86)	21.73(29.95)
20	38.96(43.22)	54.95(35.25)	43.09(37.94)	43.43(40.86)	35.95(26.54)	44.46(43.32)	43.31(46.39)
30	31.86(10.22)	21.90(21.73)	19.68(34.56)	30.81(21.64)	7.50(23.08)	16.92(15.95)	17.39(21.43)
40	5.93(22.11)	6.93(15.76)	4.93(4.75)	9.04(16.98)	4.86(3.19)	8.14(9.42)	3.40(2.23)
	<i>Penilia avirostris</i> Dana						
5	1.27(-)	0.94(-)	4.82(-)	2.92(-)	9.85(-)	5.28(2.57)	5.93(-)
10	46.01(65.14)	13.99(15.73)	24.72(15.37)	14.67(9.31)	28.72(40.26)	26.47(20.19)	22.90(24.88)
20	26.99(23.05)	65.04(54.43)	41.13(48.99)	48.66(42.10)	36.94(27.00)	34.33(49.86)	43.68(43.46)
30	20.04(7.80)	15.54(19.64)	22.29(26.58)	24.33(23.55)	17.21(29.52)	26.77(22.34)	20.53(24.54)
40	5.68(4.00)	4.45(10.50)	7.03(9.05)	9.42(25.04)	7.28(3.21)	7.14(5.03)	6.95(7.11)

GOSWAMI: SECONDARY PRODUCTION & ZOO PLANKTON ABUNDANCE

Table 4—Percentage Occurrence of Cladoceran Species at Different Stations in Surface and Bottom Samples

Species	Station depth (m)				
	5	10	20	30	40
	Surface				
<i>Evadne tergestina</i> Claus	13.66	24.76	41.18	15.12	5.28
<i>Penilia avirostris</i> Dana	5.01	24.05	42.92	21.16	6.86
	Bottom				
<i>E. tergestina</i> Claus	7.27	29.05	37.12	20.81	5.75
<i>P. avirostris</i> Dana	0.43	28.29	40.96	22.35	7.97

Table 5—Percentage Occurrence of Chaetognath Species at Different Transects

Species	Transects						
	Vengurla	Teracol	Aguada	Cabo-de-Rama	Karwar	Tadri	Malpe
	Surface						
<i>Sagitta bedoti</i> Beraneck	70.23	14.44	4.90	3.51	7.06	9.18	3.36
<i>S. enflata</i> Grassi	21.92	73.16	78.12	13.34	14.97	47.51	32.57
<i>Sagitta</i> sp.	7.13	12.40	16.98	83.15	76.28	40.52	60.53
<i>Pterosagitta</i> sp.	0.72	—	—	—	1.69	2.79	3.54
	Bottom						
<i>S. bedoti</i> Beraneck	18.28	9.83	14.25	5.41	11.76	20.77	6.69
<i>S. enflata</i> Grassi	44.09	36.02	46.63	12.74	45.52	38.51	34.57
<i>Sagitta</i> spp	33.55	51.63	39.12	81.85	38.11	37.95	49.45
<i>Pterosagitta</i> sp.	4.08	2.52	—	—	4.61	2.77	9.29

Table 6—Percentage Occurrence of Common Groups of Decapod Larvae at Different Transects

Groups	Transects						
	Vengurla	Teracol	Aguada	Cabo-de-Rama	Karwar	Tadri	Malpe
	Surface						
Palaemonids	17.10	37.71	29.59	36.01	35.61	21.87	26.73
Alpheids	19.28	12.89	9.87	5.91	8.58	9.31	10.66
Hippolytids	6.15	6.75	10.72	9.92	11.01	10.69	12.79
Porcellanids	9.68	10.03	8.85	15.99	16.40	12.62	15.60
Brachyurans	35.21	21.16	17.75	17.71	19.06	38.62	21.79
Others	12.58	11.46	23.22	14.46	9.34	6.89	12.43
	Bottom						
Palaemonids	7.98	15.54	8.08	12.14	4.06	19.32	6.14
Alpheids	16.99	17.42	26.52	21.85	14.97	12.60	11.73
Hippolytids	24.74	26.18	41.42	23.58	34.26	25.21	25.81
Porcellanids	6.82	14.51	—	10.29	27.66	22.97	18.95
Brachyurans	21.28	15.02	9.59	15.72	12.69	15.78	13.72
Others	22.19	11.33	14.39	16.42	6.36	4.12	23.65

Abundance of penaeid prawn larvae decreased with increase in depth of sampling. An account of the distribution of penaeid prawn larvae of commercially important species in the area studied was given earlier²⁰.

Relation to fisheries—Zooplankton forms an

important food item for fish. The success or failure of fishery particularly that of pelagic fishery is dependent on the availability of plankton²¹. Earlier studies have shown a direct correlation between plankton production and pelagic fishery in Indian waters^{22,23}. The oil-sardine *Sardinella longiceps* and the mackerel

Rastrelliger kanagurta are plankton feeders. The former is predominantly phytophagous while the latter prefers zooplankters especially copepods, cladocerans and other meroplanktonic groups. Nair and Subrahmanyam²⁴ reported that blooms of the diatom *Flagilaria oceanica* could be used as an indicator of the abundance of the oil sardine while Selvakumar²⁵ traced a relationship between the occurrence of cladoceran swarms and the onset of the mackerel fishery at Karwar and Goa. Prabhu and Dhawan²⁶ gave an assessment of the marine fishery resources of Goa during the 1971-72 fishing season and detected an increased rate of fish catch from north to south in the 20 m depth zone. During the present investigations, the zooplankton production increased at transects from north to south, maximum values being recorded at 20 m depth. Copepods and cladocerans were the major components of the crustacean population in the zooplankton samples. Swarms of *Eradne* were noticed at Karwar and Malpe transects. On the basis of zooplankton abundance and occurrence of copepods, cladocerans and meroplanktonic groups, the area studied particularly the Karwar and Malpe regions appear to be potentially rich fishing grounds for the pelagic fishery.

Acknowledgement

The author is grateful to Dr V V R Varadachari, Director, for facilities. Sincere thanks are due to Dr T S S Rao, Head, Biology Division for useful comments and to Dr R A Selvakumar for help in the collection of samples.

References

- 1 Peter K J, Iyer H K, John S & Radhakrishnan E V, in *Proceedings of the symposium on warm water zooplankton* (Spl Publ UNESCO/NIO, Goa), 1977, 80.

- 2 Menon M D & George K C, in *Proceedings of the symposium on warm water zooplankton* (Spl Publ UNESCO/NIO, Goa), 1977, 205.
- 3 Goswami S C, Selvakumar R A & Dwivedi S N, in *Proceedings of the symposium on warm water zooplankton* (Spl Publ UNESCO/NIO, Goa), 1977, 337.
- 4 Bhargava R M S, Selvakumar R A & Singbal S Y S, *Indian J Mar Sci*, **2** (1973) 103.
- 5 Cushing D H, *Adv Mar Biol*, **9** (1971) 255.
- 6 Cushing D H, in *The biology of the Indian Ocean*, edited by B Zetzschel (Springer Verlag, Berlin, Heidelberg, New York) 1973, 475.
- 7 Strickland J D H & Parsons T R, *A practical handbook of seawater analysis* (Bull Fish Res Bd Can, No 167) 1968, 11.
- 8 Varadachari V V R, Murthy C S & Sankaranarayanan V N, *Indian J Mar Sci*, **3** (1974) 1.
- 9 Rao L V G, Cherian T, Varma K K & Varadachari V V R, *Mahasagar-Bull Natn Inst Oceanogr*, **7** (1974) 15.
- 10 Annigeri G G, *Indian J Fish*, **19** (1972) 156.
- 11 Noble A, *J Mar Biol Assoc India*, **10** (1968) 197.
- 12 Subrahmanyam R, *Proc Indian Acad Sci*, **50 B** (1959) 189.
- 13 Rao S V S, *Proc Indian Acad Sci*, **45 B** (1957) 77.
- 14 Goswami S C, *Secondary production in the estuarine, inshore and adjacent waters of Goa*, Ph.D. thesis, Panjab University, 1979, 247pp.
- 15 Nair V R, *Indian J Mar Sci*, **9** (1980) 116.
- 16 Qasim S Z, Wafar M V M, Sumitra-Vijayaraghavan, Royan J P & Krishnakumari L, *Indian J Mar Sci*, **7** (1978) 84.
- 17 Haridas P, Menon P G & Madhupratap M, *Mahasagar-Bull Natn Inst Oceanogr*, **13** (1980) 239.
- 18 Gajbhiye S N, Jiyalal R & Desai B N, *Indian J Mar Sci*, **10** (1981) 346.
- 19 Della Groce N & Venugopal N, *Mar Biol*, **15** (1972) 132.
- 20 Goswami S C, Achuthankutty C T & George M J, *Mahasagar - Bull Natn Inst Oceanogr*, **10** (1977) 129.
- 21 Nair V R, *J Indian Fish Assoc*, **7** (1982) 1.
- 22 Subrahmanyam R, *Proc Indian Acad Sci*, **50 B** (1959) 115.
- 23 Prasad R R, *Proc Natn Inst Sci*, **35** (1969) 399.
- 24 Nair R V & Subrahmanyam R, *Curr Sci*, **24** (1955) 41.
- 25 Selvakumar R A, *Curr Sci*, **39** (1970) 481.
- 26 Prabhu M S & Dhawan R M, *Report on an assessment of the marine fishery resources of Goa*, Tech Rep (Nat Inst Oceanogr, Goa) 1972, 25 pp.