

Vertical distribution of mesozooplankton biomass in relation to oxygen minimum layer in the Andaman Sea during February 1999

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Abstract

Mesozooplankton biomass in the upper 1000m of the Andaman Sea was studied as part of the Marine Research-Living Resources (MR-LR) assessment programme during February 1999 providing baseline information on stratification of mesozooplankton of the area. The distribution of mesozooplankton biomass is related to the oxygen minimum layer (<0.1 ml/litre). The results show that biomass and group wise diversity were maximum in the mixed layer (average 5 ml/100m³) and sometimes in the thermocline layer (average 4.4 ml/100³). A prominent feature was that the minimum average biomass values were confined to the depth strata of 300m-Bottom of thermocline (BT) (0.9ml/100m³) where the oxygen minimum layer was more pronounced. The averages of zooplankton group percentages in the upper 1000m showed that the copepoda forms the major group (81.01 %) followed by the chaetognatha (6.7 %), ostracoda (4.8 %), siphonophora (1.9 %), and decapod larvae (1.3 %) and the corresponding average population densities were 4,620 /100m³, 1,201/100 m³, 104/100 m³, 102 /100m³, and 7 /100m³.

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Andaman Sea is one of the least explored region of the Indian Ocean in comparison with the other two major regions viz the Arabian Sea and the Bay of Bengal with regard to quantitative and qualitative distribution of zooplankton. Andaman Sea is almost a semi-enclosed basin and exchange of water with adjacent sea is restricted by sill depths of the main channel (Sengupta et al., 1981). As a part of Marine Research-Living Resources (MR-LR) assessment programme on Indian EEZ a cruise was undertaken onboard *FORV Sagar Sampada* (cruise 172) in the Andaman sea (lat 6°N to 14°N; long 91°E to 94°E) during February, 1999. The present paper describes the findings on the overall patterns of mesopelagic biomass distribution in the Andaman Sea from surface to 1000m, especially with regard to the oxygen minimum zone noticed during the month.

A Sea-Bird CTD was used to obtain the temperature, salinity and oxygen profiles. Zooplankton samples were collected from nine stations in the northern, middle and southern Andaman Sea (Fig.1) with a Multiple Closing Plankton Net (Hydro-Bios, mouth area 0.25m², mesh size 200 µm) at five depths. The depth of hauls were 1000-500m, 500-300m, 300m-bottom of thermocline (BT), BT - top of thermocline (TT) and TT-surface (mixed layer). Zooplankton biomass was estimated by displacement volume method and the samples were preserved in 4% formalin - seawater and 100% of the samples were examined for enumeration of different zooplankton groups.

The Sea Surface Temperature (SST) varied from 28.3 to 29°C with an increasing trend from north to south. The Mixed Layer Depth (MLD) ranged from 45 to 80 metres and the MLD shoaled towards the northern region. The depth of MLD in the southern Andaman Sea was 80 metres. In stations located in the middle Andaman sea basin, MLD varied from 45-68 metres. The Sea Surface Salinity (SSS) was low at the northern regions and showed a slight increase from north to south (33 - 34.2 psu). The hydrographic properties such as temperature and oxygen at some selected stations are plotted against the depth (Fig.2). The oxygen minimum zone (<0.1 ml/litre) showed more or less the same pattern of occurrence along the northern and the middle Andaman Sea. The suboxic conditions (<0.05 ml/litre) in the oxygen minimum zone were prominent along the middle Andaman Sea and towards the southern regions along the Bay of Bengal, but not to the west of great Nicobar. The thickness of the suboxic layer was ~ 457m (175 - 700m) along the northern

Andaman sea and ~ 220m (180 - 400m) along the middle Andaman sea and the suboxic water (< 0.05 ml/litre) in the oxygen minimum zone was found to be completely absent in the southern Andaman sea.

Biomass and diversity of group wise zooplankton taxa were highest in the mixed and thermocline layers. The biomass in the mixed layer ranged between 3.3 - 8 ml/100m³ (Fig. 3) and showed the highest average of 5 ml/100m³ (± 1.82). Across the thermocline layer, the values were 1.5 - 6.7 ml/100m³ with an average of 4.4 ml/100m³ (± 1.80). Below the thermocline layer-300m depth strata, a sharp decline was observed in the average biomass of 0.9 ml/100m³ (± 0.57) and the values ranged between 0.4 - 2.2 ml/100m³. A secondary subsurface higher biomass occurred in the depth strata of 300-500m and was low in 500-1000m with average values of 1.5ml/100m³ (± 0.78) and 0.75 ml/100m³ (± 0.25) respectively.

Analysis of the composition of zooplankton showed that copepods constituted the major component of zooplankton in the mixed layer, contributing 51-91% with an average of 77.4% with respect to numerical abundance (Fig. 4). The average density of copepods in the mixed layer was 11,200/100m³ ($\pm 11,150$) and the highest numerical abundance of 36000/100m³ was recorded at the station located in the middle Andaman Sea. The highest copepod density of 7,150/100 m³ was reported from the Andaman Sea from a haul made from 0-200 m depth. Carnivorous forms such as chaetognatha formed the second dominant group in the mixed layer with an average of 11.9% in the total count. A similar density distribution was observed by the Madhupratap *et al* (1981) for chaetognatha also from an undivided haul of 0-200m from the same area. Siphonophora and copelata contributed an average value of 2.4% and 1.9% and the corresponding average densities were 310/100 m³ and 390/100 m³ respectively (Tables. 3). Other groups such as decapoda (1.8%), ostracoda (1.1%), euphausiacea (0.4%), thaliacea (0.3%), and fish larvae (0.3%) also constituted in small numbers in total counts

Copepoda contributed an average of 73.4%, 80.7%, 88.2% and 85.4% in their total counts at different depths viz, TT-BT, BT-300m, 300-500m and 500-1000m and the corresponding average densities were 7,890/100 m³ ($\pm 5,450$), 1800/100 m³ ($\pm 2,230$), 1,760/100 m³ ($\pm 2,190$) and 440/100 m³ (± 200) respectively (Table.3).

The results of the zooplankton biomass values in the upper 1000m water column show that the biomass and group diversity were high in the mixed layer and at times in the thermocline layer also (Fig. 3). From the base of thermocline -300m, a sharp decrease in biomass was observed at almost all stations along the northern and middle Andaman sea where the prominent oxygen minimum zones (< 0.1 ml/litre) were observed (Figs. 2a & 2b). The numerical abundance in each taxon was not found to be very high in Andaman sea to those of Arabian Sea and Bay of Bengal (Fig. 3 & Table. 3). The average biomass values reported from the east coast of India for the upper 200 metres was 7.8 to 8.4 ml/100m³ during the southwest monsoon (Nair et al., 1977). During the late southwest monsoon period (Achuthankutty et al., 1980) and postmonsoon period (Nair et al., 1981) the biomass ranged between 2.5 to 15.4 ml/100 m³ and 8.9 to 32.2 ml/100m³ along the west coast of India. The zooplankton biomass in the Andaman Sea during late winter monsoon (Madhuratap et al., 1981) ranged from 1.8 to 14.4 ml/100 m³ in the upper 200 metres. The ranges in the biomass values obtained from *Anton brunn* cruises in March and *Pioneer* cruises in April were 1 to 13.5 ml/100 m³ and 3.8 to 12.4 ml/100 m³ respectively in the Andaman sea (Madhuratap et al., 1981).

The decrease of zooplankton biomass with depth is more or less a universal phenomenon. But in the Arabian Sea and Bay of Bengal plus Andaman Sea this is also a manifestation of the OMZ. The occurrence of suboxic waters along the northern and middle regions of the Andaman sea influence the zooplankton biomass in the oxygen minimum layer. The Bay of Bengal side of the Andaman Sea shows the absence of suboxic water (< 0.05 ml/litre) in the BT – 300m water column and comparatively high average mesozooplankton biomass (1.2 ml/100 m³). Thus the low biomass values were often found to coincide with the low oxygen levels noticed at (BT-300m) at most of the stations (Fig. 3). The critical lower limit for aerobic metabolism is about 0.13 ml/litre (Wishner et al., 1990) although for short intervals, some fish and zooplankton are known to move through narrow suboxic zones, live anaerobically or reduce metabolism for diapause (Boyd et al., 1980).

Below the OMZ, the zooplankton biomass values showed an increasing trend at the deeper layers of 500-300 (Fig. 3), but there was a considerable decrease in the diversity and density of zooplankton groups. The stratum between 500 and 1000m showed the low density among all zooplankton groups as reported earlier

from central and eastern Arabian Sea (Vinogradov and Voronina, 1962). In the present study among the zooplankton, the copepods generally dominated numerically (Fig. 4) in the upper layers followed by the carnivores such as chaetognatha, siphonophora and copelata. Another notable feature was the reduction in the number of ostracods observed in the Andaman Sea when compared to the northern Arabian Sea (Madhupratap et al, 2001). The population density of ctenophora, amphipoda, heteropoda, thaliacea, and copelata were found to decrease towards deeper (300-500 and 500-1000 m) or completely absent at most of the stations. Low levels of oxygen stretched over substantial depths resulted in the exclusion of most of the zooplankton from the respective areas in the Andaman Sea. A subsurface peak in zooplankton biomass near the base of oxygen minimum zone (500-1000m) might be due to the high fluxes of suspended food materials falling uneaten to depths from sparsely populated OMZ. To conclude it could be stated that the deep oxygen minimum zone strongly influences the vertical distribution of zooplankton in the Andaman Sea. Similar studies conducted elsewhere also suggests that diel vertical migration would be limited by low oxygen, and most zooplankton would remain in the mixed layer both day and night (Wishner et al., 1998; Saltzman and Wishner et al. 1998).

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TABLE 1. Sea Surface Temperature (SST), Sea Surface Salinity (SSS), Oxygen Minimum Zone (OMZ), Mixed Layer Depth (MLD), depth range between Top of Thermocline to Base of Thermocline (TT-BT), depth range between Base of Thermocline to 300m (BT-300) at different stations in Andaman Sea during February 1999.

Station No	Station depth (m)	Lat (°N)	Long (°E)	SST (°C)	SSS (psu)	OMZ (m) (<0.1ml/l)	MLD (m)	TT-BT (m)	BT-300 (m)
239	1923	13 00	94 05	28.3	33.5	175-700	50	60	180
240	543	12 30	93 30	28.4	33.3	180-675	60	30	210
242	2196	10 48	93 14	28.3	33.4	180-400	50	30	210
244	3028	10 48	94 47	28.4	33.1	177-415	45	80	180
245	2771	08 30	94 54	28.5	33.5	185-515	65	70	180
247	1679	06 34	94 09	28.9	33.5	-	68	52	180
248	1673	06 30	93 30	29	33.6	-	80	60	190
249	2267	06 30	93 00	28.9	33.8	-	80	70	180
250	4012	06 30	92 00	28.7	34.2	-	80	60	180

- Indicates absence of Oxygen Minimum Zone (<0.1ml/litre)

TABLE 2. Average zooplankton biomass (ml/100m³) at different depth strata from three different regions in Andaman Sea during NE monsoon 1999

Area	No. of stations	0-TT	TT-BT	BT-300m	300-500m	500-1000m
Northern Andaman sea	2	3.3	4.1	0.8	1.3	ND
Middle Andaman sea	3	6.2	3.5	0.6	1.4	ND
Southern Andaman sea	4	5	5.1	1.2	1.8	0.8

ND- No Data

TABLE 3. Average zooplankton population density (no/100m³) of dominant groups at different depth strata in Andaman sea during February 1999

Group	Depth of hauls				
	BT-				
	0-TT	TT-BT	300m	300-500m	500-1000m
Hydromedusae	9	6	2	1	1
Siphonophora	330	140	30	4	6
Polychaeta	20	40	6	2	5
Ostracoda	90	140	140	110	040
Amphipoda	10	8	9	2	-
Copepoda	11,200	7,900	1,800	1,760	440
Decapoda	210	110	30	10	2
Euphausiacea	30	20	20	30	2
Gastropoda	9	6	3	4	1
Pteropoda	30	5	4	1	-
Chaetognatha	5,590	330	100	3	10
Thaliacea	35	14	4	-	-
Copelata	390	98	30	20	-
Fish eggs	20	5	1	2	1
Fish larvae	30	14	3	4	4

- Indicates absence

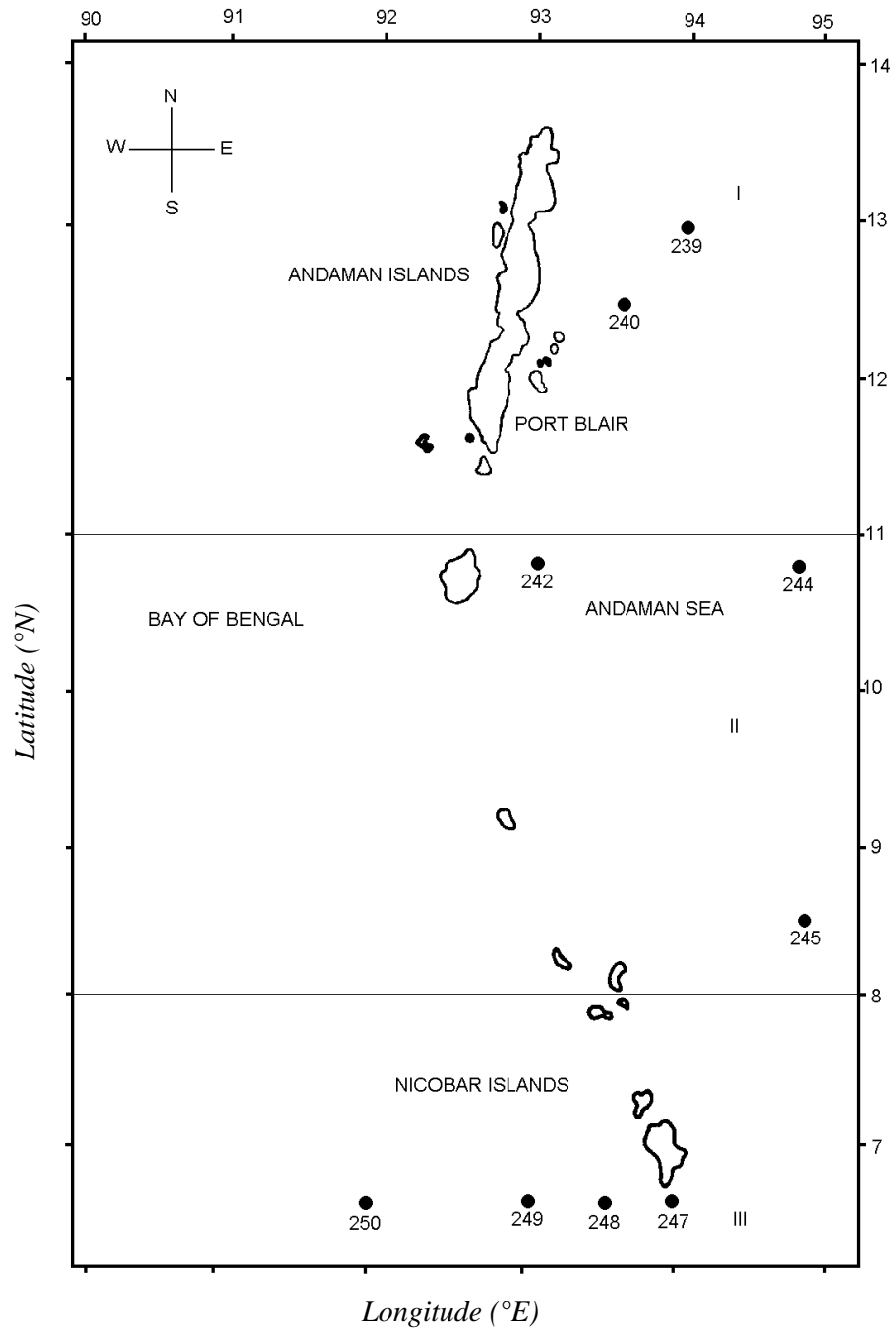


Fig. 1. Station locations, Northern Andaman Sea (I), Middle Andaman Sea (II) and Southern Andaman Sea (III)

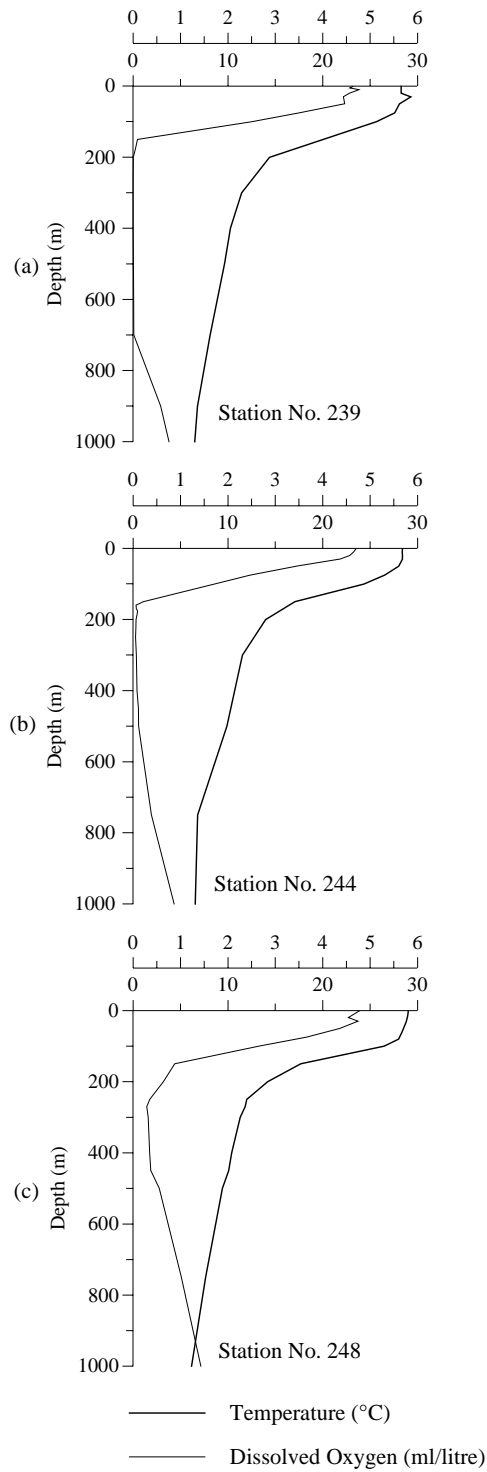


Fig. 2- Vertical profiles of Dissolved Oxygen (ml/litre) and Temperature (°C) along Northern, Middle and Southern Andaman Sea during February 1999

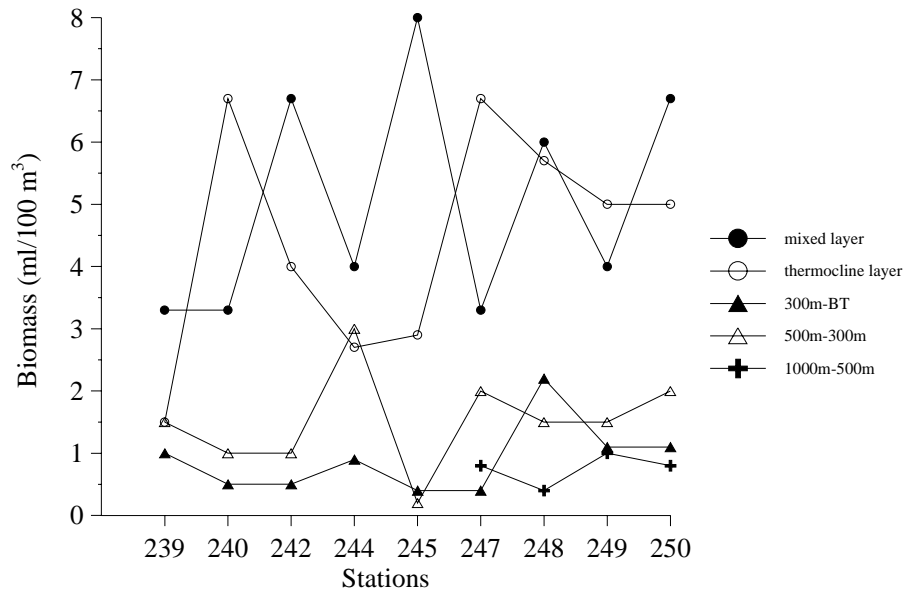


Fig. 3 - Mesozooplankton biomass (ml/100m³) at different depth strata from different stations in Andaman Sea during February 1999

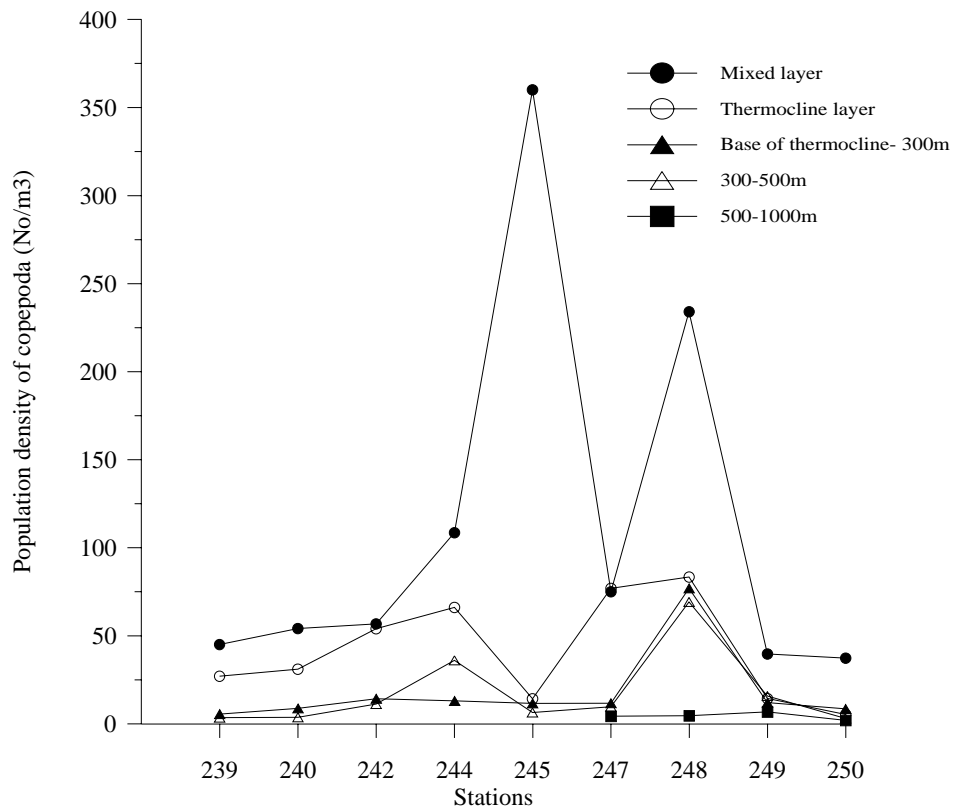


Fig. 4. Population density of copepoda ($\text{No} \times 10^2 / 100\text{m}^3$) at different depth strata from 9 stations in Andaman Sea during February 1999