Indian Journal of Marine Sciences
Vol. 10, September 1981, pp. 262-265

Thermocline & Zooplankton Distribution

M MADHUPRATAP, VIJAYALAKSHMI R NAIR*, S R SREEKUMARAN NAIR & C T ACHUTHANKUTTY
National Institute of Oceanography, Dona Paula, Goa 403 004

Received 15 *December* 1980; *revised received* 3 *April* 1981

Distribution of zooplankton above and below the thermocline layer was studied in Feb. 1979 from the Andaman Sea. Zooplankton biomass and groups like Chaetognatha, Appendicularia, Decapoda, Thaliacea and Euphausiacea showed, higher aggregation above the thermocline layer. While many of the species showed the same trend, Ostracoda and many of the less common species were usually in greater abundance below the thermocline. Thermocline acted as a barrier in vertical movements in some species. Vertical migration of zooplankton in relation to discontinuity layer is discussed.

Vertical structure of temperature in the sea has definite influence on the vertical distribution of zooplankton. Earlier studies from Indian waters have shown that many zooplankters have a tendency to accumulate above the discontinuity layer[1,2]. Whereas discontinuity layer has no apparent effect on the distribution of eurythermic species[3], thermocline has been found to act as a barrier in the vertical movements of some species of ostracods[4], siphonophores[5], chaetognaths[6] and anthozoan larvae[7]. However, the effect of discontinuity layer on the distribution of species of many groups of zooplankton has not been studied. Distribution of major groups and species of zooplankton in relation to thermocline is attempted in this study.

Materials and Methods

During the 51 and 52 cruises of *R V Gaveshani* zooplankton samples were collected in vertical hauls from 200 m to surface and from thermocline depth to surface (depth of the mixed layer usually varied between 30 and 60 m) at 20 stations located in the Andaman Sea[8] (Table 1). Sampling was done with a HT net (mesh size 500 μm) attached with a flow meter. Biomass was estimated as displacement volume and organisms were identified and counted from aliquots of the samples. Samples collected between 0600 and 1800 hrs were considered as day samples and those collected between 1800 and 0600 hrs as night samples.

Results and Discussion

Similar to earlier findings, biomass distribution in general showed higher values above the thermocline (Fig. 1). The general increase was by 60% compared to values for the 200 m column depth. Highest biomass value recorded was 23 ml/100 m^3 at st 1193 for the water column above thermocline, whereas it was only 10.5 ml/100 m^3 for the 200 m column depth (day station, collection time-0800 hrs).

Distribution of major groups showed that in general higher abundance occurred above the thermocline for Chaetognatha (average increase - 126%), Appendicularia (34%), Thaliacea (33%), Decapoda (158%) and Euphasiacea (42%) although at few stations the abundance was higher in the 200 m column (Fig. 1). For Copepoda greater aggregation above thermocline was at sts 1180, 1182 and 1192 to 1209. But on the average their total abundance was more or less even in both above thermocline and 200 m column depth. Ostracoda, on the contrary, showed a

*Present address: Regional Centre of NIO, Versova, Bombay 400061

Table 1—Date, Station No., Station Position and Time of Collection

Date	St No.	Lat. °N	Long. °E	Time of haul (hrs)
		Cruise 51, Feb. 1979		
6	1173	05°30′	90°00′	1500-1505 (D)
8	1177	07°15′	93°49′	2230-2235 (N)
9	1178	06°00′	93°41′	0700-0705 (D)
9	1180	08°42′	93°39′	1430-1435 (D)
10	1182	09°36′	93°19′	0030-0035 (N)
10	1184	10°45′	92°54′	1230-1235 (D)
		Cruise 52, Feb. 1979		
15	1186	12°30′	93°30.3′	2345-2350 (N)
16	1188	13°50′	93°30.5′	1130-1135 (D)
16	1189	14°00′	93°00′	2200-2205 (N)
17	1190	13°00′	93°00′	0645-0650 (D)
17	1191	12°00′	93°30′	1945-1950 (N)
18	1192	11°30′	93°00′	0100-0105 (N)
18	1193	11°00′	93°30′	0800-0805 (D)
19	1195	10°00′	92°45′	0300-0305 (N)
19	1196	10°00′	92°00′	0915-0920 (D)
19	1197	10°30′	92°00′	1720-1725 (D)
22	1204	11°30′	92°00′	0615-0620 (D)
23	1207	13°00′	92°00′	0045-0050 (N)
23	1209	13°30′	92°30′	1310-1315 (D)
23	1210	13°30′	92°00′	1945-1950 (N)

D = day sample; N = night sample.

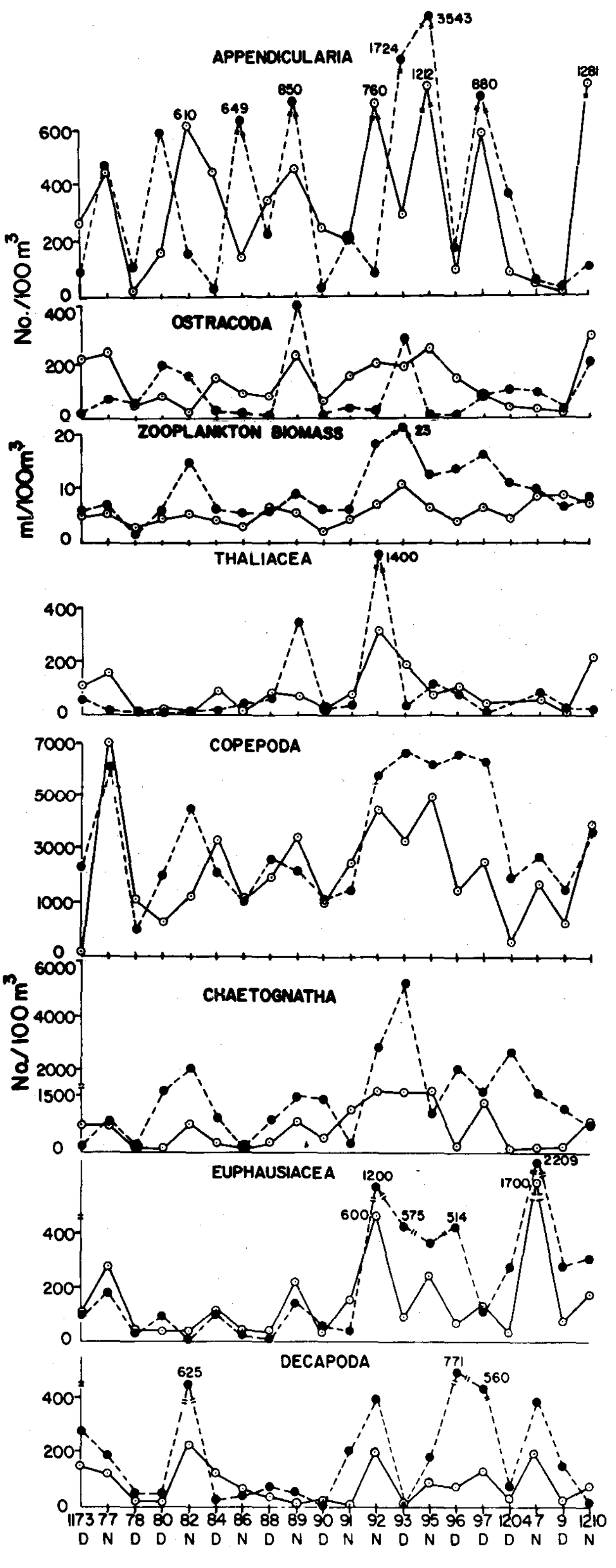

Fig. 1—Distribution of Zooplankton biomass and different major groups above the thermocline layer (●) and in 200 m water column (⊙) in the Andaman Sea [Collection taken during day (D) and night (N)]

decrease (29%) in the layer above thermocline compared to 200 m column depth (Fig. 1).

Among the common copepod species *Undinula vulgaris*, *Euchaeta marine*, *Eucalanus monachus*, *E. mucronatus*, *Corycaeus* sp. and *Oncea* sp. on the average showed higher aggregation above the thermocline although at some stations the distribution was more or less similar for thermocline and 200 m depth (Table 2). Species like *Eucalanus attenuatus*, *Pleuromamma indica* and *Aetideus* sp. were not present at some stations above the thermocline, but when present were observed (usually at night) in higher numbers above the thermocline layer. This could be attributed to the vertical migration of these species and discontinuity layer did not affect their vertical movements. Such increase of abundance in the upper 200 m column at night has been recorded for *Pleuromamma*[9]. *Candacia* sp. and *Copilia* sp. showed more or less even distribution above and below thermocline whereas species like *Scolecithrix dana*, *Rhincalanus cornutus* and *Sapphirina* sp. had greater abundance in the layer below thermocline. Some of the less common species observed in the present study like *Euchaeta concinna*, *E. wolfendeni*, *Scolecithricella nicobarica*, *Scaphocalanus* sp., *Scottocalanus* sp., *Pleuromamma xiphias*, *Gaetanus armiger* and *Euchirella amoena* were not collected above the discontinuity layer.

Among chaetognaths *Kronhitta pacifica*, *Sagitta enflata*, *S. ferox*, *S. neglecta* and *S. pacifica* were present in higher numbers above the thermocline at most of the stations (Table 2). *S. regularis* and *S. robusta* was always represented in higher number in this layer. *S. bipunctata* and *Pterosagitta draco* showed higher aggregation below the thermocline. Distribution of *Sagitta bedoti* was more or less even above and below the thermocline. *S. hexaptera* and *Kronhitta subtilis* were sporadically found in the samples and confined to the stratum below the thermocline similar to earlier findings[6].

Many of the ostracod species like *Euconchoecia aculeata*, *Halocypris brevirostris*, *Conchoecetta giesbrechti*, *Metaconchoecia rotundata*, *Orthoconchoecia striola* and *Spinoecia porrecta* were better represented in the 200-0 m hauls as observed earlier[4]. *Cypridina dentata* showed accumulation above thermocline. Distribution of *Orthoconchoecia atlantica* did not seem to be influenced by the thermocline. *O. bispinosa* and *Conchoecetta acuminata* were present only in samples from 200-0 m suggesting that thermocline acted as a barrier in their vertical movements (Table 2).

Among the decapods *Lucifer typus*, *L. hanseni*, *Leptochela aculeocaudata*, *Thalassocaris* spp and *Alpheus* spp in general showed higher aggregation

Table 2—Distribution of Species from Thermocline to Surface at Selected Stations

[Values are expressed as times higher or lower (indicated by negative sign) compared to 200 m column depth]

Species	Stations											
	1177	80	82	84	86	88	90	92	95	97	1204	10
	N	D	N	D	N	D	D	N	N	D	D	N
						Copepoda						
Undinula vulgaris	−1.1	12.1	15.6	2.9	−2.0	−1.7	5.4	1.5	−1.1	3.3	6.9	1.7
Euchaeta marina	−1.5	31.4	5.5	1.8	1.3	−3.9	−1.1	−1.1	−1.9	3.9	3.1	1.1
Eucalanus monachus	−1.3	7.9	3.3	−1.8	2.7	−1.1	2.3	4	2.2	5.3	14.6	2.9
E. mucronatus	−18.8	3.5	6.2	−1.2	1.1	22.4				1.1		
E. attenuatus	1.1			−1.3	3.2	—	—	1.7	1.2	1.6		1.5
Pleuromamma indica	6.4	—	2.7	—	—	—		11	3.2	—		1.4
Corycaeus sp.	18.8	—	1.2	1.1	1.2	15	1.9	−2.0	7.3	4.3	1.7	−1.2
Oncea sp.	—	1.1	32.8	1.1	5.1	−1.7	1.2	1.2	−1.5	6.4	8.7	1.2
Aetideus sp.	5.1	—	11.5	−13.6	1.5	—	—	7.2	16.7	—	−7	3.1
Candacia sp.	1.4	—		−3	−2.5	−1.1	—	1.1	2.9	−1.1	2.1	—
Copilia sp.	2.4	—	1.1	−1.3	−1.1	1.8	1.1		—	1.5		1.1
Scolecithrix dana	—	−5.1	−8.2	—	3.1		—			—		
Rhincalanus cornutus	—	—		−9.1				—	—			
Sapphirina sp.	—	−4.6	—	—	1.5	−1.1	—	—	—	−1.1	4.8	—
						Chaetognatha						
Krohnitta pacifica	1.3	9.8	26	2.6	1.5	—	20	—	−1.7	1.2	2.3	1.9
K. subtilis										—		—
Pterosagitta draco	—	—		−1.1		—	−1.6	—	+	2.6	—	—
Sagitta bedoti	1.2		−1.3	−1.1		−1.7		1.7	—	3.3	1.1	
S. bipunctata	—	—		−1.2	—	−1.4	−1.5	—	1.5	—	+	—
S. enflata	1.6	18.1	21.8	2.3	1.5	−2.3	3.1	2.1	1.4	3.7	41.2	4.2
S. ferox		+		+			—	1.2		5.6	4.6	
S. hexaptera								—	—			
S. neglecta	1.1	—	+	—	+	+	9	1.7	8.8	13.3		1.5
S. pacifica		10.2	—	5.3	3.3	−2	8	—	2.4	2	4.6	1.2
S. regularis								+		+	2.3	
S. robusta			1.3				4.1	+	+	2		
						Ostracoda						
Cypridina dentata			10						+		1.5	1.8
Euconchoecia aculeata	+	—	−2			—	—		—			—
Halocypris brevirostris	+		−1.3	—	—	—	—	—	—	—	+	
Conchoecetta giesbrechti			1.5	—	—	—	—	—	—			
C. acuminata				—	—	—	—	—		—		
Metaconchoecia rotundata		—	2.5	—	—	—		—	—			
Orthoconchoecia striola			—	—					—			
O. atlantica	—		2	—					—		4.6	
O. bispinosa					—	—	—	—			—	
Spinoecia porrecta	−6.5	—	—	—	+				+	−2.4		—
						Decapoda						
Lucifer hanseni	2.4		1.1	1.6		+					—	
L. typus			4.1		−1.3		—	+		3.5	4.5	+
Sergestes orientalis						—	—		−1.1	—	−1.3	
Alpheus sp.	+			—				+		+		
Thalassocaris sp.			4.1	1.3						+		

D = day, N = night, — = absent from thermocline to surface, + = present only from thermocline to surface.

above the thermocline (Table 2). On the other hand, *Sergestes orientalis* was encountered more below the discontinuity layer. Less common species like *S. crassus*, *S. cornutus*, *S. atlanticus* and *Hippolyte* sp. were collected from below thermocline depth.

The numerical abundance of other groups and species was scant to draw any conclusions on their distribution in relation to thermocline. Another aspect to be considered when comparing the zooplankton distribution with respect to discontinuity layer is vertical migration. In the present collections, variations in biomass and number of organisms occurred in both layers, and increase above thermocline was observed in collections made in day time as well as night for many species. Hence it would seem that migrations would not be seriously affected by the thermocline except in species where the discontinuity layer acts as a barrier. Also many species seem to be able to migrate to optimum light intensities within the thermocline depth during day time. Very little information is available from the Indian Ocean regarding distribution of meso and bathypelagic species. Collections from deeper waters and different strata using closing devices for nets would give a clearer picture of the vertical distribution and migration of species.

Acknowledgement

The authors thank Drs S Z Qasim and T S S Rao for facilities.

References

1 Nair V R, Peter G & Paulinose V T, *Mahasagar-Bull natn Inst Oceanogr*, **10** (1977) 45.
2 Peter G & Nair V R, *Mahasagar-Bull natn Inst. Oceanogr*, **11** (1978) 169.
3 Sakthivel M, in *The biology of the Indian Ocean* edited by B Zeitzschel (Springer-Verlag, Berlin) 1973, 383.
4 George J, Purushan K S & Madhupratap M, *Indian J mar Sci*, **4** (1975) 201.
5 Daniel R, *Proceedings of the symposium on warm water zooplankton* (Spl. Publ UNESCO/NIO) 1977, 124.
6 Nair V R, *Indian J mar Sci*, **6** (1977) 142.
7 Balachandran T, in *The biology of the Indian Ocean* edited by B Zeitzschel (Springer-Verlag, Berlin) 1973, 289.
8 Madhupratap M, Achuthankutty C T, Nair S R S & Nair V R, *Indian J mar Sci*, **10** (1981) 258.
9 Kasturirangan L R, Saraswathy M & Gopalakrishnan T C, in *The biology of the Indian Ocean*, edited by B Zeitzschel (Springer-Verlag, Berlin) 1973, 331.