Composition, Abundance and Distribution of Zooplankton in the Bay of Bengal

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Abstract

A 58 days-collaborative survey (25 October-21 December, 2007) of the BIMSTEC member countries (Bangladesh, India, Myanmar, Sri Lanka, Nepal and Thailand) was carried on in the Bay of Bengal in order to elucidate the fertility of the area as a new fishery ground. The purpose of this study was to determine the composition, abundance and distribution of zooplankton in 3 areas (area A; the northern part, area C; the eastern part and area B; the western part) of the Bay of Bengal. All samples were collected by oblique towing with Bongo net of 330 μm mesh size. The zooplankton community consisted of 205 species, 119 genera. Copepoda was the most important group both in term of species number and abundance. Widely distributed groups in this study were: copepods, protozoan zooplankton, arrow worms, larvaceans, cnidarians, ostracods and thaliaceans. The distribution pattern of major constituents of zooplankton community indicated the most productive nature of area A in comparison to other areas.

Keywords: zooplankton, Bay of Bengal, composition, abundance, distribution

Introduction

The Bay of Bengal locates in the northeastern part of the Indian Ocean. It resembles a triangle in shape and is bordered by India and Sri Lanka to the West, Bangladesh and the Indian state of West Bengal to the North and Myanmar, southern part of Thailand and the Andaman and Nicobar Islands to the East.

Zooplankton includes both planktonic or microscopic invertebrates and larval stages of some marine fishes that rely on water currents to move any great distance. Zooplankton is a broad categorization spanning a range of organism sizes that includes both small protozoans and large metazoans. Zooplankton includes holoplanktonic organisms whose complete life cycle lies within the plankton, and meroplanktonic organisms that spend part of their life cycle in the plankton before metamorphosis to either nekton or sessile, benthic existence. (wapedia, 2008) Through it consumption and processing of phytoplankton (and other food sources), zooplankton plays an important role in aquatic food webs, both as a resource for consumers on higher trophic levels and as a conduit for packaging the organic material in the biological pump (wikipedia, 2008). The importance of zooplankton as the first food for the post larval fish has been documented. Therefore, knowledges on diversity or species composition, abundance and distribution of zooplankton are of significance for fishery management. In addition, prediction of fish abundance based on only zooplankton in natural environment should be based on multiple components or food-web structure of the study area.

This study aims to present species composition, abundance of zooplankton including their distribution in the Bay of Bengal. The qualitative and quantitative data were

analyzed from 33 samples taken from 3 areas in the Bay of Bengal. This is a collaborative survey project of the BIMSTEC member countries (Bangladesh, India, Myanmar, Sri Lanka, Nepal and Thailand). The main purpose of BIMSTEC is to manage fishery resources in the Bay of Bengal.

Material and Methods

Zooplankton samples were collected from 33 stations during the cruise of fisheries research vessel M.V. SEAFDEC between 25 October to 21 December 2007 (Table 1 and Fig. 1) in the Bay of Bengal. The sampling stations were divided into 3 areas: area A (latitude 16°N-19°N, longitude 88°E-91°E) covered 15 stations (station 13-27), area B (latitude 09°N-14°N, longitude 82°E-85°E) included 7 stations (station 13-27) and area C (latitude 10°N-12°N, longitude 95°E-97°E) included 11 stations (station 1-6 and 8-12).

Zooplankton samples were collected using a Bongo net, 45 cm. in diameter and 330 µm mesh size, equipped with a flow meter and obliquely towed at a vessel speed of 2 knots. The towing depth of each haul was 150 meters. The samples were immediately preserved in 5% buffered formaldehyde sea water for further analyses.

Zooplankton samples were counted for larger representatives such as cnidarians, decapods, euphausids, arrow worms, etc. using an open counting chamber of 80 mm X 50 mm X 2 mm size. Counting was made under a binocular dissecting microscope at proper magnification. The examination at a higher magnification under the compound microscope may be used to identify questionable organisms. For dense sample, zooplanktorn fraction of <200 µm were separated from the larger ones by filtration and sub-sampled with a Widebore pipet for an aliquot of 1-5 ml for counting with a Sedgwick-Rafter counting chamber under a compound microscope at 100X magnification.

Report zooplankton as number per cubic meter:

$$\text{No. individuals/ } m^3 = \frac{C \times V_1}{V_2 \times V_3}$$

Where C = number of organisms counted,
V_1 = volume of the concentrated sample (ml),
V_2 = volume of the sample counted (ml),
V_3 = volume of the filtered volume of water (m^3)

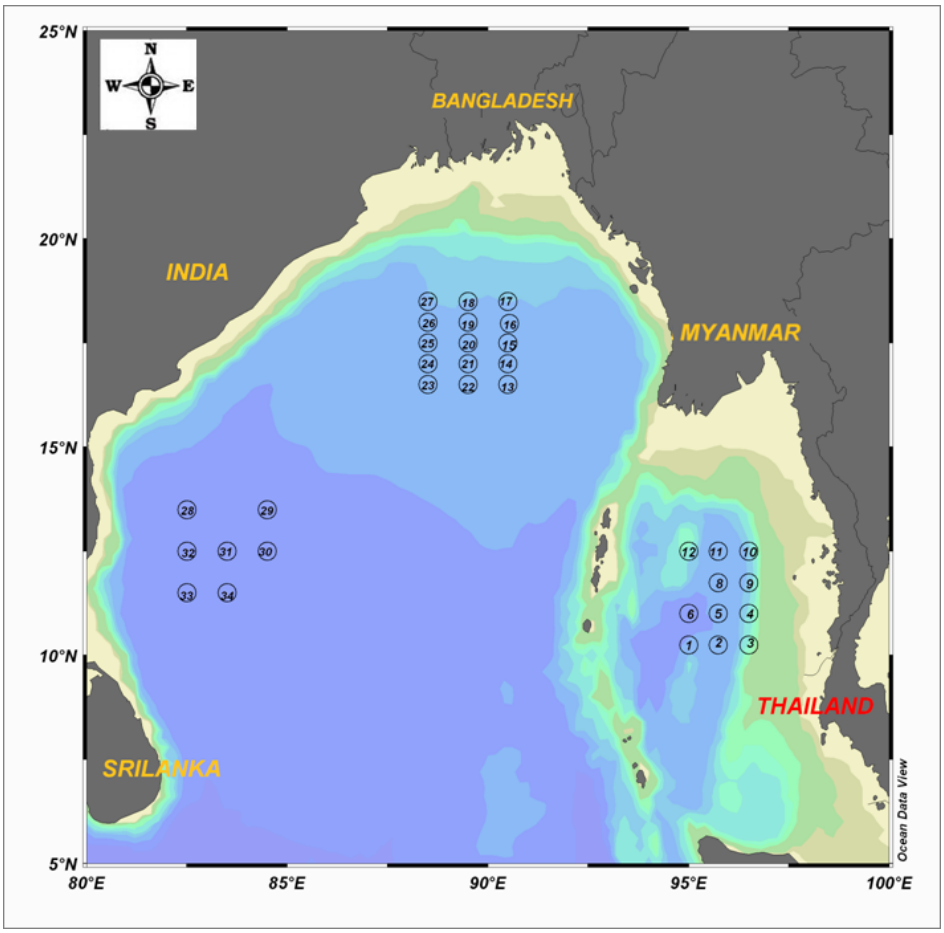

Figure 1 Sampling stations in the Bay of Bengal.

Results

Species Composition

Zooplankton communities in the Bay of Bengal consisted of 205 species, 119 genera and 44 taxa. Copepods were the most diverse group containing the highest number of species (98), followed by Cnidaria (32) and Protozoa (25). The taxa that were not identified to generic or species levels included Polychaeta, mollusk larvae, Mysidacea, decapod larvae, larval stages of Copepoda, Cyphonautes larvae, Echinodermata larva and fish larvae. There was no significant difference in the diversity and the abundance of zooplankton from three studied areas. The diversities in decreasing order were as followed: area A (150 species, 119 genera), area C (147 species, 87 genera), and area B (131 species, 81 genera).

Abundance

Copepoda were so far the most abundant taxon accounting for 45.82% of total zooplankton densities within the copepod communities, the relative abundance of calanoid copepods was 30.68% of total copepods followed by and poecilostomatoids (10.51%) and cyclopoids (6.17%) and harpacticoids (0.07%) in respective order. Major taxa of calanoids included Augaptiliidae, Acartiidae, Centropagidae, Pontellidae, Calanidae, Paracalanidae, Eucalanidae, Euchaetidae and Scolecithricidae. Copepodites were high in number at most stations. Sarcodine protozoans ranked the second in abundance after copepods and made up

for 17.52% of total zooplankton density. Other common taxa were arrow worm (8.92%) and larvaceans (6.56%) with Sagitta and Oikopleura as the regular constituents in these areas.

Total zooplankton abundance was ranging from 97-568 individuals/m^3.The highest zooplankton abundance in this study was recorded from area A with 154-568 individuals/m^3 of total abundance followed by area B (97-477 individuals/m^3 of total abundance) and area C (84-344 individuals/m^3 of total abundance). The highest abundance was observed at station 24 in area A with zooplankton density of 568 individuals/m^3, followed by 477 individuals/m^3 at station 29 in area B and 97 individuals/m^3 in station 33 of area B. Copepods, the most abundant taxon in all areas, contributed to 40.10% of total abundance in area B, 43.00% in area A, and 55.22% in area C. Sarcodine protozoans were the second most abundant taxon after copepods in area A and area B. Arrow worms occurred in all areas, and were usually found in moderate numbers ranging from 5.75% to 11.75% of total abundance. Larvaceans were rich in area A and area B with 6.55% of total abundance and 6.41% of total abundance, respectively. Ostracods were abundant only in area B with 8.80% of total abundance. Details of distribution and abundance o zooplankton were shown in table 1 and fig. 2-8.

Distribution and Abundance of Zooplankton Groups

Distribution of zooplankton groups are recorded in terms of percentage of occurrences which were divided into 4 categories: 1-25% = very rare; 26-50% = rare; 51-75% = common and 76-100% = very common/ widely distributed.

1. Sarcodine protozoans

Sarcodine protozoans consisted mainly of planktonic foraminiferans and radiolarians. A total of 24 species from 21 genera were identified. Important sarcodine protozoans species were *Centrocubus cladostylus, Hystrichaspis dorsata, Spongosphaera streptacantha, Acanthochiasma fusiforme* and *Glogigerina bulloides*. Their contributions were 82%, 64%, 55%, 48%, and 45% of occurrences, respectively. Their abundances ranged from 1 individuals/m^3 to 195 individuals/m^3. The highest abundance found at station 20 in area A.

2. Ciliates

This group was very rare in this study area with only 3% occurrence of a single species: *Tintinnopsis mortensii* with 1 individuals/m^3 at station 30 in area B.

3. Cnidarians

Cnidarians includes Hydomedusae and Siphonophores. A total of 32 species from 26 genera were identified in the study area. Cnidarian abundance ranged from 6 to17 individuals/m^3; the maximum value was found at station 19 in area A. Siphonophores were commonly distributed. *Chelophyes contorta* had highest percentage of occurrences with 94% followed by *Bassia bassensia* (85%) and *Enneagonum hyalinum* (79%), respectively**.** Most species of Hydomedusae were rarely distributed. Only two species (*Aglaura hemistoma* and *Liriope tetraphylla*) were widely distributed; with the values of 67% and 36%, respectively.

4. Polychaetes

Nine species belonging to 7 genera were collected in the study area. Polychaetes in this study included both planktonic forms and larval forms (meroplankton). All species were low in numbers and rarely found with the percentage of occurrences were not higher than 21%. Polychaete larvae were widely distributed (55%) in low number ranging from 1 to 4 individuals/m^3. The occurrence of planktonic polychaetes was rare (3-21%).

Pedinosoma curtum was widely distributed. Total abundance ranged from 1 to 4 individuals m^{-3}. The maximum densities was found at stations 22, 23, 25 and 27 in area A and stations 28 and 30 in area B.

5. Mollusks

Mollusks in this study included gastropod larvae, planktonic mollusks and bivalved larvae. Mollusks occurred in low abundances ranging from 1 to 8 individuals m^{-3}. Planktonic mollusks in class Gastropoda found in this study were in subclasses Prosobranchia and Opistobranchia. Among Prosobranchia (heteropods), Atlanta was common in this study. It was commonly distributed (55%) in small numbers (1-7 individuals/m^3). The Opistobranchia (pteropods) in order Thecosomata or shelled pteropods were less diverse, approximately 6 species were identified. The common genus was Creseis. Only *Notobranchaea* sp., the naked pteropods (Order Gymnostomata) was found at stations 25 and 27. Gastropod larvae and bivalved larvae were rarely distributed (3%) in this study.

6. Calanoid copepods

This is one of important taxa in this study. It is the most diverse groups in the area: 64 species 34 genera in 13 groups were identified. Four widely distributed (79-97%) species were *Lucicutia flavicornis, Clausocalanus arcuicornis, Scolecithricella longispinosa* and *Acrocalanus gibber*. Total abundances of calanoid copepod ranged from 18 to 271 individuals/m^3. The maximum value was found at station 24 in area A. Calanoid copepodids were very high at all stations the maximum number was observed at station 24. *Clausocalanus arcuicornis* was high in number at station 22 and 27 in area A. *Scolecithricella longispinosa* and *Paracalanus aculeatus* were also found in moderate abundance. Copepodid stages of calanoid copepods were common all stations particularly copepodites of Subeucalanus and Euchaeta. They were more abundant (148-179 individuals/m^3) and widely distributed (91-100%). However, nauplii stages of all genera were rarely distributed and low number.

7. Cyclopoid copepods

Oithona was the dominant genus in this study. It was widely distributed (100% occurrence) at all station. Their abundances varied greatly from 1 to 32 individuals/m^3. Maximum number was found at station 22 in area A.

8. Harpacticoid copepods

This groups were one of the rare groups in this study with 3-5% occurrence. Only two species (*Macrosetella gracilis* and *Miracia efferata*) were identified and observed in low numbers with 3 and 2 individuals/m^3, respectively. Harpacticoid copepods were not found in area B

9. Poecilostomatoid copepods

Thirty one species belonging to 6 genera were identified. Four widely distributed species (79-100% occurrence) were *Oncaea venusta, O. conifera, Corycaeus catus,* and *Copilia mirabilis.* Among these species *O. venusta* was the dominant species in this study. Total abundances of Poecilostomatoid copepods ranged from 7 to 110 individuals/m^3. Maximum value was found at station 1 in area C.

10. Ostracods

Ostracods were commonly distributed. Two genera: Cypridina and Euconchoecia were found in this study. Total abundances of ostracods ranged from 1 to 116 individuals/m^3.

The maximum value was found at station 29 (116 individuals/m^3) in area B. *Euconchoecia* spp. were widely distributed (97% occurrence) but completely absent station 24. *Cypridina* spp. were very rarely distributed (21% occurrence) and presented in very low to medium number (1-49 individuals/m^3).

11. Hyperiids

Ten species in 7 genera of hyperiid were identified in the study area. They were rarely distributed (3-39% occurrence) in very small numbers (1-6 individuals m^{-3}). The highest abundance found in area B with 21 individuals/m^3. *Lestrigonus macroohthalanus* was common species in the area.

12. Mysids

Mysids was one of the rare groups in this study. Its distribution was 18% occurrence with very low abundance (1-2 individuals/m^3). Mysids was completedly absent in area A.

13. Euphausids

Larval stages were commonly distributed with 70% occurrence. Low abundance values of 1-7 individuals/m^3 were observed. Maximum number was found at station 9 in area C. Adult stages found only *Stylocheiron* sp. was at stations 30 and 31 in area B with abundance values of 1 individuals/m^3

14. Stomatopod larvae

Both larval stages (erichthus and alima) were collected in the area. Alima larvae were more often observed than erichthus larvae (20% and 3% occurrence). They were always found in very low numbers (1-3 individuals/m^3)

15. Planktonic shrimps

This group included larval stages of Penaeid, Caridean and Palinuran shrimps. One genus (Lucifer) was identified in the samples. Early larval stage of Penaeid, Caridean and Palinuran shrimps were very rare (3-15% occurrence) in the samples with abundance values of 1 individuals/m^3. Abundance of Lucifer was very low both in adult forms and larval forms (protozoea and mysis); only 3-39% occurrences were recorded. Its abundance values ranged from 1 to 9 individuals/m^3; the maximum value was found at station 29 in area B.

16. Crab larvae

This group included Anomuran larvae, Porcellanid larvae and zoea stage of Brachyura (true crab). They were very rarely distributed (3-6 % occurrence) with very low abundance values (1-2 individuals/m^3) at only four stations (2,4,25 and 28).

17. Decapod larvae

This is one of the rare groups in this study. Very low abundanc was observed at station 24 in area A (2 individuals/m^3).

18. Arrow worms

A total of 10 species belonging to genera Sagitta were persent in the samples. *Sagitta* was an important genus that was widely distributed (94% occurrence) with abundance value ranged from 1 to 78 individuals/m^3. Maximum value was found at station 31 in area B. *Sagitta enflata* was the most important species occurring at most stations.

19. Bryozoans

Cyphonautes larvae, the larval stage of phylum Ectoprocta were rarely observed (9% occurrence) in this study. Very low abundances (1 individual/m^3) were recorded at three stations (11, 17 and 25). Bryozoans wwas completely absent in Area B.

20. Echinodermata larvae

This group consisted of bipinnaria larvae of class Asteroidea, auricularia larvae of class Holothuroidea, echinopluteus larvae of class Echinoidea and ophiopluteus larvae of class Ophiuroidea. They were very rare in distribution (21%, 3%, 9% and 18% occurrence), respectively. Their abundances varied from 5 to 106 individuals/m^3. Bipinnaria larvae and auricularia larvae were found only in area C. Echinopluteus larvae and Ophiopluteus larvae were found in area A and C. Echinodermata larvae was completely absent in area B.

21. Larvaceans

Only one genus: Oikopleura was found in this study. They were regularly found (18-94%) in the study area. Their abundances ranged from 1 individual/m^3 to 39 individuals/m^3. Two important species were: *O. fusiformis* and *O. longicauda*, and were widely distributed with 94% and 88% occurrences, respectively. The highest abundance found in area A (74 individuals/m^3).

22. Thaliaceans

Two groups of thaliaceans were rare and present in low number. Salps consisted three genera: Pegea, Salpa and Thalia. Only one genus of doliolids (Doliolum) was identified. *Doliolum* spp. were common in distribution (80% occurrence), but occurred in low abundance values (1-7 individuals/m^3). Maximum number of thaliaceans were found at station13 and 27 in area A. Salps were rarely distributed (15-24% occurrence) of low number ranging from 1-4 individuals/m^3

23. Fish eggs and fish larvae

The data recorded here was underestimated; accurate data will be published elsewhere under ichthyoplankton. Fish eggs and fish larvae were separarely collected by a 500 µm plankton net. Eggs and larvae of fish rarely distributed (3-9% occurrence) in low numbers ranging from 1 to 2 individuals/m^3. They were observed in three found only three samples collected from station 13, 23 and 32.

24. Cephalochordates

Amphioxides sp. was only one species collected in the study area. This groups was one of the rare groups in this study with 21% occurrence. Small number (1-4 individuals/m^3) was observed at 7 stations. The maximum value was found at station 20 in area A. Cephalochordates was absent in area C.

Table 1 Distribution of marine zooplankton and abundance (individuals/m^3) of species found at 3 Areas in the Bay of Bengal.
(The number indicated minimum and maximum density in a unit of individuals/m^3)

Taxa/Species	Abundace values		
	Area A	**Area B**	**Area C**
PHYLUM PROTOZOA (protozoans)			
Class Sarcodina			
Order Foraminiferida			
Berggrenia (Globerotalia) pumilio (Parker)	0	0	0-1
Candeina nitida d' Orbigny	0-1	0	0
Globigerina bulloides d' Orbigny	0-63	0-15	0
G. falconensis Blow	0-4	0	0-2
Globigerinella siphonifera d' Orbigny	0-2	0	0
Globigerinita minuta (Natland)	0	0	0-1
Globorotalia menardii (Parker,Jones and Brady)	0-1	0-3	0
Hastigerina digitata (Rhumbler)	0-4	0-2	0
Sphaeroidinella dehiscens (Parker and Jones)	0	0-2	0
Tenuitella parkerae (Broennimann and Resig)	0-6	0	0-2
Order Radiolarida			
Family Acanthochiasmidae			
Acanthochiasma fusiforme Haeckel	0-9	0-9	0-3
A. rubescens Haeckel	0-80	0-3	0-1
Family Acanthometridae			
Acanthometra bulbosa Haeckel	0-1	0	0
A. pellucida Müller	0-1	0	0-5
Family Dorataspidae			
Hystrichaspis dorsata Haeckel	0-10	0-6	0-3
Family Spongodiscidae			
Stylodictya sp.	0-3	0	0
Family Castanellidae			
Castanidium variabile Borgert	0-7	0	0-1
Family Actinommidae			
Carposphaera acanthosphora (Popofsky)	0-2	0	0
Centrocubus cladostylus Haeckel	8-93	0-34	0-10
Cromyomma circumtextum Haeckel	0	0	0-1
Heliosoma sp.	0-1	0	0
Spongosphaera streptacantha Haeckel	0-17	0-6	0-4
Family Phyllostauridae			
Acanthostaurus purpurascens (Haeckel)	0-1	0	0

* 0 = not found

Table 1 (Cont.)

Taxa/Species	Abundace values		
	Area A	Area B	Area C
Family Dictycanthidae			
Dictyacantha sp.	0-1	0-1	0
Class Ciliata			
Order Tintinnida			
Family Codonellidae			
Tintinnopsis mortensii Schmidt	0	0-1	0
PHYLUM CNIDARIA (cnidarians)			
Class Hydrozoa			
Order Anthomedusae			
Family Corynidae			
Euphysora bigelowi Maas	0	0	0-1
Sarsia resplendes Bigelow	0-1	0	0-1
Family Bougainvilliidae			
Bougainvillia principis (Steenstrup)	0	0	0-1
Kollikerina fasciculata Péron and Lesueur	0	0	0-1
Order Leptomedusae			
Family Phialuciidae			
Octophialucium medium Kramp	0-1	0-1	0-1
Family Eirenidae			
Eirene hexanemalis (Goette)	0-1	0	0
Eutima gracilis (Forbes and Goodsir)	0-1	0	0
Order Limnomedusae			
Family Proboscidactyla			
Proboscidactyla ornata (McCrady)	0-1	0	0
Order Trachymedusae			
Family Rhopalonematidae			
Amphogona apicata Kramp	0	0-1	0
Family Geryoniidae			
Aglaura hemistoma Péron and Lesueur	0-1	0-1	0-1
Liriope tetraphylla (Chamisso and Eysenhardt)	0-1	0-1	0-1
Order Narcomedusae			
Family Aeginidae			
Solmundella bitentaculata (Quoy and Gaimard)	0-1	0-1	0
Family Cuninidae			
Cunina octonaria McCrady	0-1	0	0-10

* 0 = not found

Table 1 (Cont.)

Taxa/Species	Abundace values		
	Area A	Area B	Area C
Order Siphonophora			
Family Agalmidae			
Agalma haeckeli Bigeloe	0-1	0-1	0-1
Family Prayidae			
Amphicaryon acaule Chun	0	0-1	0-1
A. peltifera Haeckel	0-1	0-1	0-1
Family Hippopodiidae			
Hippopodius hippopus (Forskal)	1-1	0-1	0-1
Family Diphyidae			
Sulculeolaria quadrivalvis Blainville	0-1	0-1	0-1
Diphyes bojani (Eschscholtz)	0-1	0-1	0-1
D. chamissonis (Huxley)	0-1	0	0-1
D. dispar Chamisso and Eysenhardt	0-1	0-1	0-1
Lensia campanella (Moser)	0-1	0-1	0-1
L. challengeri Totton	0-1	0-1	0-1
L. conoidea (Keferstein and Ehlers)	0-1	0-1	0-1
L. subtiloides (Len and van Riemsdijk)	0-1	0-1	0-1
Chelophyes contorta (Lens and van Riemsdijk)	0-1	1-1	0-1
Eudoxoides mitra (Huxley)	0-1	1-1	0-1
Family Abylidae			
Abyla trigona Quoy and Gaimard	0	0-1	0-1
Abylopsis eschscholtzi (Huxley)	0-1	0-1	0-1
A. tetragona (Otto)	0-1	0-1	0-1
Bassia bassensia (Quoy and Gaimard)	0-1	1-1	0-1
Enneagonum hyalinum Quoy and Gaimard	0-1	0-1	0-1
PHYLUM ANNELIDA (segment worms)			
Class Polychaeta			
Polychaete larvae	0-4	0-3	1-3
Order Phyllodocida			
Family Alciopidae			
Alciopina parasitica Clapare'de & Panceri	0	0-3	0-1
Rhynchonerella moebii (Apstein)	0	0	0-2
Family Iospilidae			
Iospilus affinis (Viguier)	0-3	0-1	0
Phalacrophorus pictus Greeff	0-1	0	0

* 0 = not found

Table 1 (Cont.)

Taxa/Species	Abundace values		
	Area A	Area B	Area C
Family Lopadorhynchidae			
Maupasia gracilis Reibisch	0-1	0	0
Pedinosoma curtum Reibisch	0-2	0-1	0-1
Family Tomopteridae			
Tomopteris dunckeri Rosa	0-1	0	0-1
T. elegans Chun	0-1	0-1	0-1
T. nationalis Apstein	0	0	0-1
PHYLUM MOLLUSCA (mollusks)			
Class Gastropoda			
Subclass Prosobranchia (heteropods)			
Order Mesogastropoda			
Family Atlantidae			
Atlanta spp.	0-7	0-5	0-1
Subclass Opistobranchia (pteropods)			
Order Thecosomata (shelled pteropods)			
Family Limacinidae			
Limacina sp.	0	0	0-1
Family Cavoliniidae			
Creseis acicula (Rang)	0-2	0	0-1
C. virgula (Rang)	0-1	0-1	0-2
Cuvierina sp.	0-1	0	0
Family Cymbuliidae			
Cymbulia sp.	0	0	0-1
Order Gymnosomata (naked pteropods)			
Family Notobranchaeidae			
Notobranchaea sp.	0-1	0-1	0
Gastropod larvae (veliger larvae)	0-1	0	0
Class Bivalvia			
Bivalve larvae (veliger larvae)	0	0-1	0
Class Cephalopoda	0-66	0-35	14-108
PHYLUM ARTHROPODA			
SUBPHYLUM CRUSTACEA (CRUSTACEAN)			
Class Maxillopoda			
Subclass Copepoda			
Copepod nauplii	0-2	0-1	0-1

* 0 = not found

Table 1 (Cont.)

Taxa/Species	Abundace values		
	Area A	Area B	Area C
Order Calanoida			
calanoid unidentified species1	0-1	0-1	0
calanoid unidentified species2	0	0-1	0
Calanoid copepodid	5-71	2-33	0-21
Superfamily Arietelloidea			
Family Augaptiliidae			
Euaugaptilus sp.	0	0-1	0-1
Haloptilis longicornis (Claus)	0-2	0-3	0-1
H. mucronatus (Claus)	0	0-1	0-1
H. spiniceps (Giesbrecht)	0-1	0	0
Haloptilus sp.1	0-1	0	0
Haloptilus sp.2	0-1	0	0-1
Haloptilis copepodid	0-1	0-1	0-1
Family Heterorhabdidae			
Heterorhabdus papilliger (Claus)	0-2	0-1	0-1
Family Lucicutiidae			
Lucicutia flavicornis (Claus)	1-9	1-4	0-4
Lucicutia copepodid	0-4	0-3	0-5
Family Metridinidae			
Pleurommama robusta (Dahl)	1-12	0-3	0-1
Superfamily Centropagoidea			
Family Acartiidae			
Acartia amboinensis Carl	0	0-1	0-5
A. danae Giesbrecht	0-1	0	0-1
A. negligens Dana	0-1	0-3	0-2
A. pacifica Steuer	0	0	0-3
Acartia copepodid	0	0-1	0-8
Family Candaciidae			
Candacia catula (Giesbrecht)	0-2	0-1	0-2
C. pachydactyla (Dana)	0	0-1	0-1
Candacia sp.1	0-1	0	0
Candacia sp.2	0-1	0	0
Candacia sp.3	0	0-1	0-1
Paracandacia truncata (Dana)	0-1	0-1	0-2
Candacia copepodid	0-1	0-3	0-5

* 0 = not found

Table 1 (Cont.)

Taxa/Species	Abundace values		
	Area A	Area B	Area C
Family Centropagidae			
Centropages calaninus (Dana)	0-2	0-1	0
C. elongatus Giesbrecht	0-1	0	0-1
C. furcatus (Dana)	0-1	0-1	0-2
C. gracilis (Dana)	0-1	0	0-1
Centropages copepodid	0-1	0	0-1
Family Pontellidae			
Calanopia aurivilli Cleve	0	0-1	0-1
C. minor A. Scott	0	0-1	0-2
Labidocera sp.	0	0-1	0
Pontellina morii Fleminger & Huslemann	0-1	0	0-2
P. plumata (Dana)	0-1	0-1	0
Labidocera copepodid	0	0-1	0
Pontella copepodid	0-1	0	0
Pontellina copepodid	0-3	0-1	0-1
Family Temoridae	3		
Temora discaudata Giesbrecht	0-6	0	0-2
Temora copepodid	0-2	0-1	0-2
Superfamily Megacalanoidea			
Family Calanidae			
Canthocalanus pauper (Giesbrecht)	0-14	0-4	0-2
Cosmocalanus darwinii (Lubbock)	0-2	0-3	0-5
Nannocalanus minor (Claus)	0-2	0-5	0-1
Undinula vulgaris (Dana)	0-1	0-1	0-2
Family Paracalanidae			
Acrocalanus gibber Giesbrecht	0-13	0-5	0-8
A. gracilis Giesbrecht	0-29	0-1	0-1
A. longicornis Giesbrecht	0-8	0-1	0-1
A. monachus Giesbrecht	0-3	0-1	0-1
Paracalanus aculeatus Giesbrecht	0-18	0-6	0-26
Family Calocalanidae			
Calocalanus pavo (Dana)	0-1	0	0-1
C. plumulosus (Claus)	0-3	0-1	0
Calocalanus copepodid	0-26	0-1	0-1

* 0 = not found

Table 1 (Cont.)

Taxa/Species	Abundace values		
	Area A	Area B	Area C
Superfamily Eucalanoidea			
Family Eucalanidae			
Pareucalanus sewelli (Fleminger)	0-1	0-2	0-3
Rhincalanus cornutus Dana	0-2	0-1	0-1
Subeucalanus crassus Giesbrecht	0	0	0-1
S. subcrassus Giesbrecht	0	0	0-1
Subeucalanus sp.	0-5	0	0
Pareucalanus copepodid	0-5	0-12	0-6
Subeucalanus copepodid	1-29	2-6	1-23
Superfamily Clausocalanoidea			
Family Aetideidae			
Aetideus sp.	0-1	0	0-1
Chiridius sp.	0-1	0-1	0
Euchirella bella Giesbrecht	0	0-11	0
Family Clausocalanidae			
Clausocalanus arcuicornis Dana	2-50	0-17	1-13
C. furcatus (Brady)	0-8	0-1	0-2
Family Euchaetidae			
Euchaeta concinna Dana	0-1	0-2	0-2
E. longicornis (Giesbrecht)	0	0-1	0
E. marina (Prestandrea)	0	0-2	0
E. wolfendeni A. Scott	0-1	0-1	0-2
E. rimana Bradford	0-1	0	0
Euchaeta copepodid	1-17	1-15	1-11
Family Phaennidae			
Phaenna spinifera Claus	0	0	0-1
Family Scolecithricidae			
Scolecithricella longispinosa Chen & Zhang	2-17	0-16	0-10
S. ctenopus (Giesbrecht)	0-1	0-2	0-1
Scolecithricella sp.1	0	0	0-1
Scolecithricella sp.2	0-4	0	0
Scolecithrix danae (Lubbock)	0-1	0-1	0-1
Scaphocalanus sp.	0-1	0	0
Order Cyclopoida			
Cyclopoid copepodid	0-1	0	0

* 0 = not found

Table 1 (Cont.)

Taxa/Species	Abundace values		
	Area A	**Area B**	**Area C**
Family Oithonidae			
Oithona spp.	1-32	3-24	1-29
Order Harpacticoida			
Family Miraciidae			
Macrosetella gracilis (Dana)	0-1	0	0-1
Miracia efferata Dana	0-1	0	0-1
Order Poecilostomatoida			
Family Corycaeidae			
Corycaeus agilis Dana	0-4	0-2	0-2
C. asiaticus F. Dahl	0-1	0	0-1
C. catus F. Dahl	0-5	0-4	1-9
C. crassiusculus Dana	0-3	0-1	0-3
C. flaccus Giesbrecht	0	0-1	0-2
C. longistylis Dana	0-1	0-1	0-4
C. speciosus Dana	0-2	0-2	0-10
Corycaeus sp.1	0-1	0-1	0-2
Corycaeus sp.2	0	0	0-1
Corycaeus sp.3	0	0	0-1
Corycaeus sp.4	0	0-2	0-1
Corycaeus sp.5	0-1	0-1	0-1
Corycaeus sp.6	0	0	0-1
Corycaeus sp.7	0-1	0	0
Farranula gibbulus Giesbrecht	0-2	0-2	0-2
Farranula sp.	0-4	0-1	0-2
Family Lubbockiidae			
Lubbockia squillimana Claus	0	0	0-1
Family Oncaeidae			
Oncaea conifera Giesbrecht	0-13	1-11	0-18
O. venusta Philippi	1-8	1-24	5-46
Family Sapphirinidae			
Copilia mirabilis Dana	0-6	0-3	0-5
C. quadrata Dana	0-2	0-1	0-2
C. vitrea (Haeckel)	0	0-1	0
Sapphirina gastrica Giesbrecht	0-1	0	0
S. metallina Dana	0	0-1	0-2
S. nigromaculata Claus	0-1	0	0-2

* 0 = not found

Table 1 (Cont.)

Taxa/Species	Abundace values		
	Area A	**Area B**	**Area C**
S. opalina Dana	0	0	0-1
S. stellata Giesbrecht	0	0-1	0-1
Sapphirina sp.1	0-1	0	0
Sapphirina sp.2	0	0	0-1
Sapphirina sp.3	0	0	0-1
Sapphirina sp.4	0-1	0	0
Sapphirina copepodid	0-2	0-2	0-1
Class Ostracoda			
Family Cypridinidae			
Cypridina spp.	0-18	0-49	0
Family Halocypridae			
Euconchoecia spp.	1-15	4-67	1-13
Class Malacostraca			
Superorder Percarida			
Order Amphipoda			
Suborder Hyperiidea			
Family Vibiliidae			
Vibilia australis Stebbing	0	0-1	0
V. propinqua Stebbing	0-1	0	0
Vibilia spp.	0	0	0-1
Family Hyperiidae			
Hyperia macrocephala (Dana)	0-1	0	0-1
Phronimopsis sp.	0	0-1	0
Lestrigonus bengalensis Giles	0-1	0	0-1
L. macrophthalanus (Vosseler)	0-3	0-6	0-2
Family Phronimidae			
Phronima colletti Bovallius	0	0-1	0
Phronimella elongata Claus	0	0-2	0
Family Oxycephalidae			
Calamorhynchus pellucidus Streets	0	0-1	0
Order Mysidacea			
Unidentified mysids	0	1-2	0-1
Order Euphausiacea			
Euphausiid larvae	0-5	0-3	0-7
Euphausiid calyptopis	0-1	0-1	0
Euphausiid Adult	0-4	0-5	0-5

* 0 = not found

Table 1 (Cont.)

Taxa/Species	Abundace values		
	Area A	Area B	Area C
Family Euphausiidae			
Stylocheiron sp.	0	0-1	0
Order Stomatopoda			
Erichthus larvae	0	0	0-1
Alima larvae	0-1	0-3	0-1
Order Decapoda			
Suborder Dendrobranchiata			
Family Penaeidea			
Penaeid larvae	0-1	0-1	0
Penaeid mysis	0	0	0-1
Family Luciferidae			
Lucifer protozoea	0-3	0-9	0-3
Lucifer mysis	0-1	0-1	0-2
Lucifer typus H.M. Edwards	0	0-1	0
Lucifer spp.	0-1	0-3	0-5
Suborder Pleocyemata			
Infraorder Caridea			
Caridean larvae	0-1	0	0
Infraorder Palinura			
Phyllosoma larvae	0-1	0-1	0
Infraorder Anomura			
Anomuran larvae	0-1	0	0
Infraorder Palinuridea			
Porcellanid larvae	0	0	0-1
Infraorder Brachyura			
Brachyuran zoea	0	0-1	0-2
Brachyuran megalopa	0	0-1	0-1
unidentified decapod larvae	0-2	0	0
PHYLUM CHAETOGNATHA (arrow worms)			
Class Sagittodidae			
Subclass Chorismogonata			
Order Aphragmophora			
Family Sagittidae			
Sagitta bedoti Beraneck	0-2	0	0-3
S. enflata Grasse	0-9	0-18	0-11
S. ferox Doncaster	0	0-1	0-2

* 0 = not found

Table 1 (Cont.)

Taxa/Species	Abundace values		
	Area A	**Area B**	**Area C**
S. hexaptera d' Orbigny	0-5	0-3	0-2
S. hispida Conant	0-1	0	0-1
S. minima Grassi	0-1	0-6	0-1
S. neglecta Aida	0-7	0-13	0-2
S. pacifica (Tokioka)	0-2	0-4	0-1
S. robusta Doncaster	0	0-1	0
Sagitta spp.	8-24	0-39	1-21
PHYLUM ECTOPROCTA (bryozoans)			
Cyphonautes larvae	0-1	0	0-1
PHYLUM ECHINODERMATA (echinoderms)			
Class Asteroidea			
Bipinnaria larvae	0	0	0-5
Class Holothuroidea			
Auricularia larvae	0	0	0-1
Class Echinoidea			
Echinopluteus larvae	0-1	0	0-1
Class Ophiuroidea			
Ophiopluteus larvae	0-1	0	0-1
PHYLUM CHORDATA (chordates)			
SUBPHYLUM UROCHORDATA			
Class Larvacea			
Family Oikopleuridae			
Oikopleura fusiformis Fol	1-39	0-12	0-6
O. longicauda Vogt	0-35	2-22	0-11
O.intermedia Lohman	0-1	0-2	0-3
Oikopleura spp.	0-2	0-3	0-7
Class Thaliacea			
Order Salpida			
Family Salpidae			
Pegea spp.	0-2	0-1	0
Salpa spp.	0-3	0-1	0-4
Thalia spp.	0-2	0-1	0-2
Order Doliolida			
Family Doliolidae			
Doliolum spp.	1-7	0-3	1-4

* 0 = not found

Table 1 (Cont.)

Taxa/Species	Abundace values		
	Area A	**Area B**	**Area C**
Class Pisces			
Fish eggs	0	0-1	0
Fish larvae	0-2	0-1	0
SUBPHYLUM CEPHALOCHORDATA			
Amphioxides sp.	0-4	0-2	0
Total of zooplankton	154-568	97-477	100-451

* 0 = not found

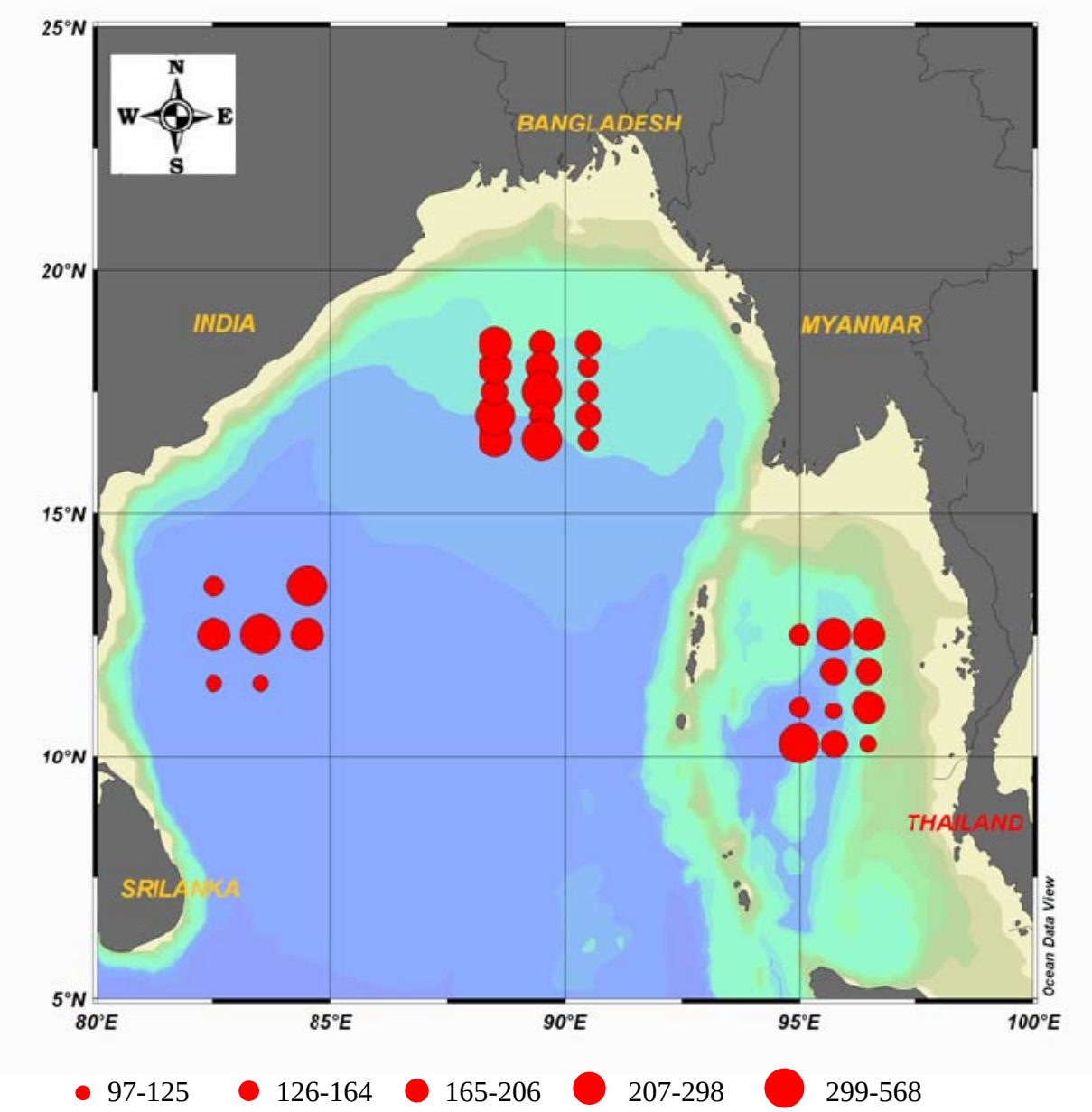

Figure 2 Distribution and abundance of total zooplankton (individuals/m^3) in the Bay of Bengal

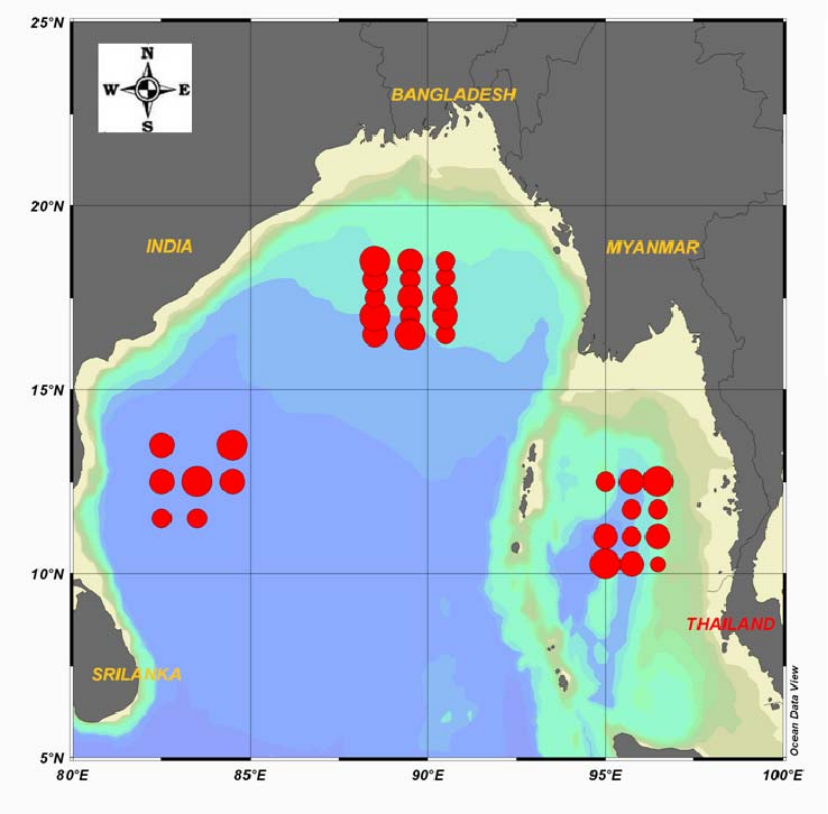

Figure 3 Distribution and abundance of calanoid copepods.

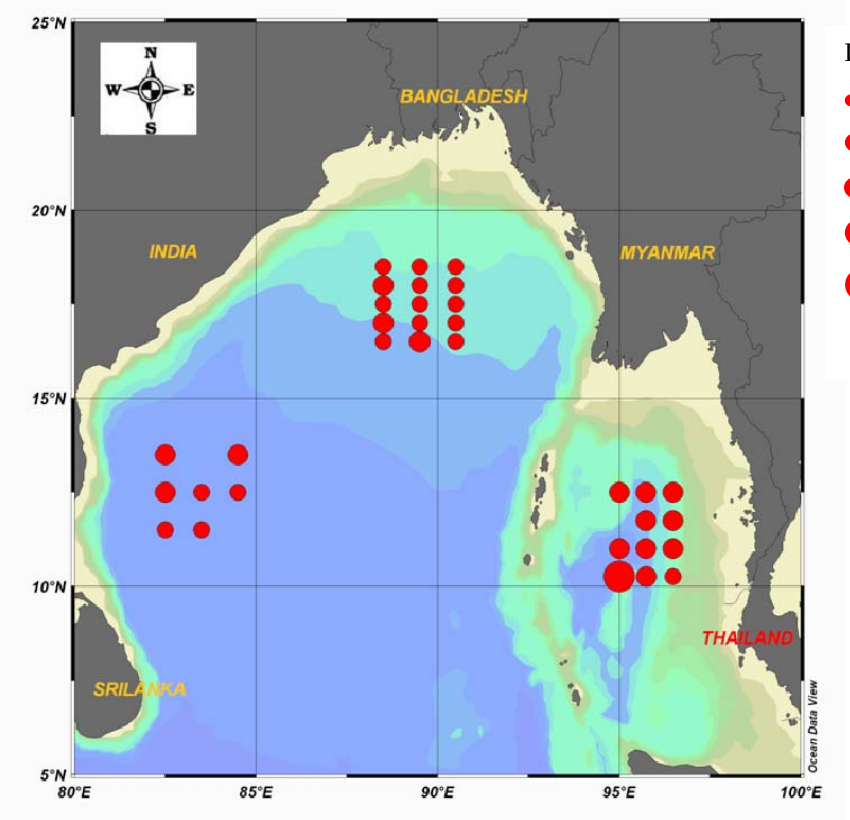

Figure 4 Distribution and abundance of poecilostomatoid copepods.

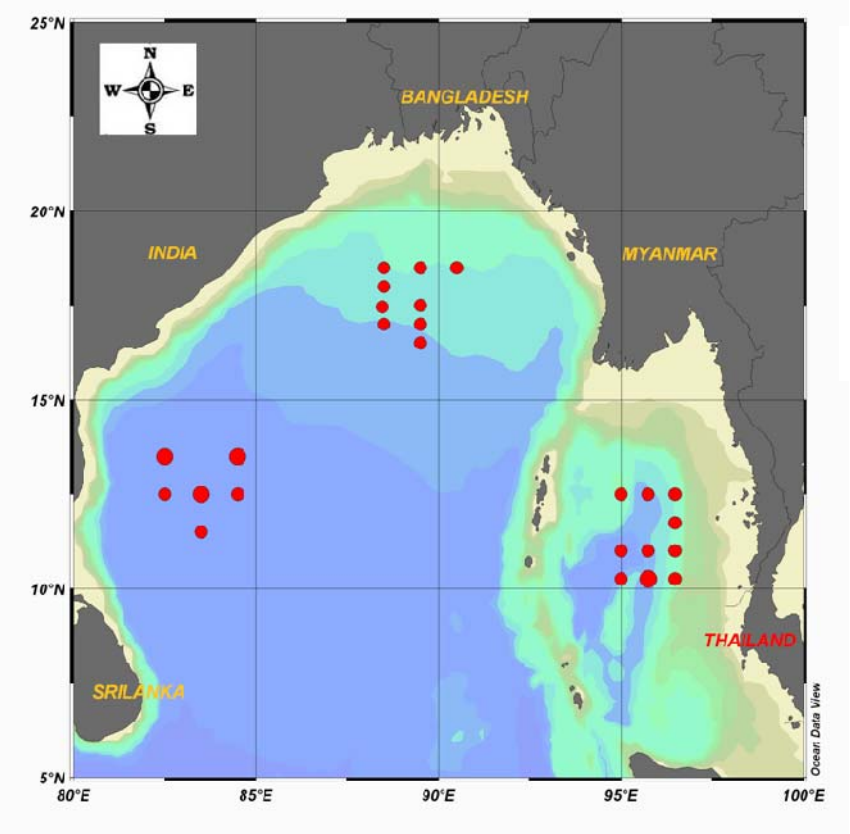

Figure 5 Distribution and abundance of planktonic shrimps.

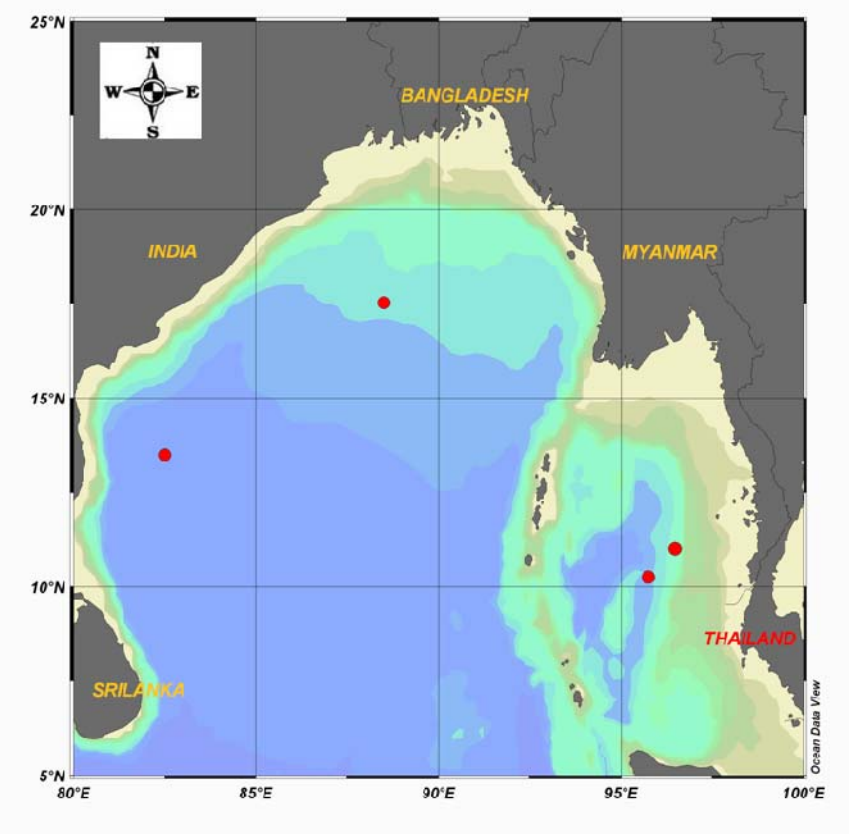

Figure 6 Distribution and abundance of crab larvae.

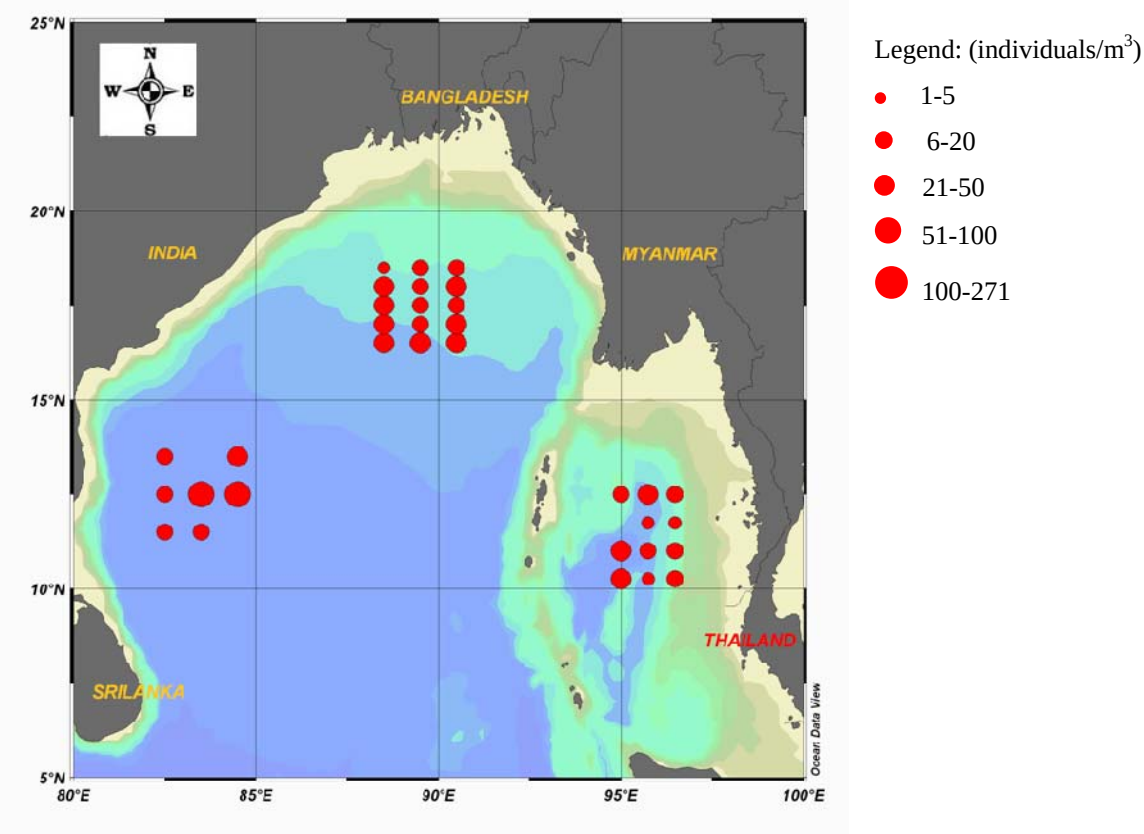

Figure 7 Distribution and abundance of arrow worms.

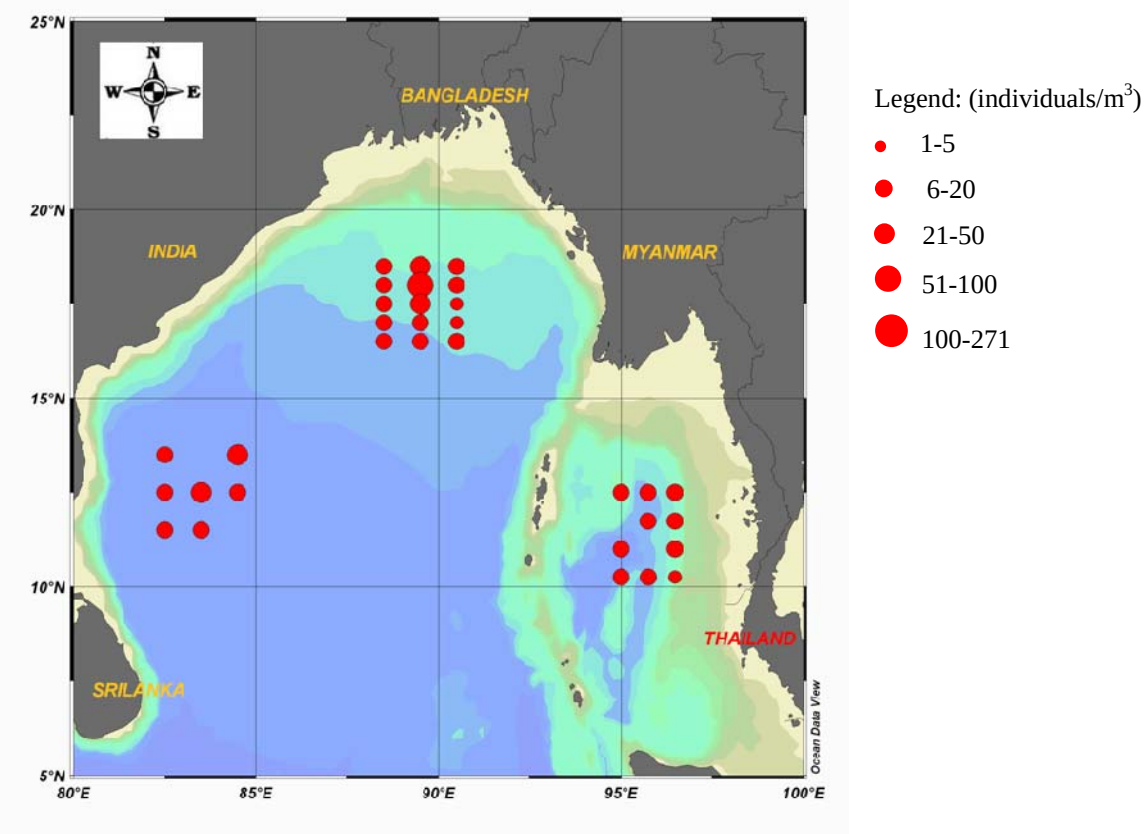

Figure 8 Distribution and abundance of larvaceans.

Discussion

Copepods are the most important group of zooplankton in the Bay of Bengal both in species number and abundance. It also formed the bulk of the zooplankton in other areas such as along the coast of Pakistan (Hag *et al*., 1973) the Red sea, the Persian Gulf and Arabian Sea (Kimor, 1973). The density of copepods was high, particularly in the northern part of the Bay during the SW monsoon, April to October, which was in consistence with the observation of Rao (1973).

Based on the ecological role of copepods reported by Sewell (1947), and Vinogradov and Vorovina (1962), out of 72 species of copepods founding this study, the most abundant copepods were epipelagic and mesopelagic species (copepod that live between surface to above 500 m depth). The bathypelagic species, on the other hand, are relatively few and largely dominanted by *Lucicutia flavicornis*, *Clausocalanus arcuicornis*, and *Scolecithricella longispinosa.* Other species that were rarely distributed included *Eugaugaptilus* sp., *Heterorhabdus papilliger*, *Pleuromamma robusta* and *Pareucalanus sewelli.*

Protozoans comprise of free-floating sarcodines (foraminiferans and radiolarians) and ciliates (tintinnids). Its abundance was next to copepods. Tintinnids are lorica-building, planktonic oligotrichid ciliates ranging in size from 20 to 200 µm. They constitute a major component of the microzooplankton in most marine environments (Beers and Stewart, 1967, Alder, 1973). They were collected in low to very low number due to the mesh size (330 µm) used for collection.

The collection includes 10 species of arrow worms. *Sagitta enflata* was the dominant species constituting 44.21% of the total arrow worm which corresponded with Nair (1977) and Nair *et al.* (2000) who described *Sagitta enflata* as being the dominant species in the Indian Ocean. Important species were *S. hexaptera, S. neglecta, S. minima* and *S. pacifica*. Among the different species of chaetognaths encountered in the present study, *Sagitta enflata* and *S. hexaptera* are cosmopolitan species of the Atlantic, Indian and Pacific Oceans (Nair *et al*., 1981), while the remaining species were characteristic of Indo-Pacific region.

Oikopleura is an important genus of larvaceans in the Bay of Bengal. According to Fenaux (1973), Oikopleura was the most abundant and frequent encountered in the Red Sea and the Persian Gulf: *Oikopleura longicauda* and *O. fusiformis* were widely distributed with high density. Both species were common during March-April period and October-November in the western part of the Bay of Bengal. Bhavanarayana and Ganapati, 1972. High abundances of larvaceans was recorded at station 19 in area A with the maximum number of 74 individuals/m^3.

Cnidarians in the Bay of Bengal comprise of thirty-two species of hydromedusae and siphonophores, but they are quite low in numerical abundance. Siphonophores were commonly distributed at all stations, but most hydomedusae were rarely distributed and very low in number. *Chelophyes contorta*, *Bassia bassensia* and *Enneagonum hyalinum* were common species of siphonophores. They were also reported elsewhere in the western part of the Bay of Bengal (Nair *et al*., 1981). *Aglaura hemistoma* and *Liriope tetraphylla* were the dominant species of hydomedusae in this study. Vannucci and Navas (1973) reported *Aglaura hemistoma* and *Liriope tetraphylla* were two predominated species in the Indian Ocean. Their abundance in the collection was affected by the geographic distribution of the sampling sites, mostly oceanic and far from land. High abundances of cnidarians were found in area A (northern part of the Bay of Bengal) as other areas (along the south west coast of India, Arabian coast, northern part of the Bay of Bengal, Thailand coast) (Rao, 1973).

Ostracods were fairly abundant in the Bay of Bengal. Only species of *Cypridina* and *Euconchoecia* were found in the area. *Cypridina dentata* and *Euconchoecia aculeate*

found in neritic as well as ocenics waters. George and Nair (1980) *Euconchoecia* spp. was dominant at most stations in the Bay of Bengal (Nair *et al*., 1981) but they always presented in low number in this study. High abundances (116 individuals/m^3) of ostracod was observed at station 29 in area B (western part of the Bay of Bengal).

Thaliaceans in the Bay of Bangal comprise of Salps (Pegea, Salpa and Thalia) and only one doliolid genus (Doliolum). *Doliolum* spp. were commonly distributed at all areas. According to Bhavanarayana and Ganapati (1972), they were common during March-April period and October-November in the western part of the Bay of Bengal. Salps were scarcely distributed in this study.

Regarding planktonic shrimps (included larval stages of Penaeid, Caridean and Palinuran shrimps and Lucifer), they were very rarely distributed with low values. Larval stages of euphausids were commonly distributed but in very low number. Only adult stages of Stylocheiron was found in area B (westhern part of the Bay of Bengal). *Stylocheiron insulare* , a coastal species, recurred in the Andaman Sea and south of Java. (Brinton and Gopolakrishnan, 1973). In the case of polycheaetes, there were both planktonic forms and larval forms (meroplankton). Larval forms were widely distributed with low number but planktonic forms occurrence were rarely distributed. Mollusks presented in the area included gastropod larvae, planktonic mollusks and bivalved larvae. Atlanta and Creseis were common in the Bay of Bengal with low number. Planktonic mollusks and bivalved larvae were sparse in this study. *Lestrigonus macroohthalanus* was the dominant species of hyperiid in the Bay of Bengal. Most hyperiids were rarely distributed in small numbers. Fairly high concentration of amphipods were noted towards the northern part of the Bay of Bengal (Nair *et al*.,1981). But the abundance of hyperiids of area B (western part of the Bay of Bengal) was higher thanthose of other areas. Echinoderm larvae, mysids, crab larvae, stomatopod larvae, decapod larva, bryozoans and cephalochordates yielded low abundance in all samples examined. Their detailed results will be published elsewhere.

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