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Macrozooplankton biomass in the deep scattering layer of the Indian EEZ

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Abstract

The surveys conducted on board FORV *Sagar Sampada* during 1998-2002 on the Deep Scattering Layer (DSL) revealed a wide spectrum of macrozooplankton in the sonic layers of the oceanic and pelagic realms from surface to 750 m depth. The macrozooplankton biomass was 6.83 and 9.21 g/1000 m^3 in the Arabian Sea and 2.14 and 2.61 g/1000 m3 in the Bay of Bengal, respectively, in the day and night hauls. Bathymetric studies showed that the plankton biomass was high at 0-50 m depth. Out of 19 groups of zooplankton from the Arabian Sea, medusae dominated the catch in day (35.6%) and night (31.4%) hauls. Out of 20 groups in the Bay of Bengal, medusae (36.8%) predominated in the day and euphausiids (32.0%) in the night. This paper shows the distribution and abundance of macrozooplankton along the various depths and seasons, including their diurnal vertical migration.

Keywords: Deep scattering layer, macrozooplankton, biomass, diurnal vertical migration

Introduction

Marine organisms aggregate at specific depths in the ocean and the scattered sound waves from these organisms can be recorded as a scattering layer on the echogram of an echosounder. This layer is referred to as the deep scattering layer (DSL) and has been observed in all the oceans (Sameoto *et al*., 1985). Hays (2003) stated that the DSL organisms, which ascend around dusk and descend around dawn, presumably reflect the predator-prey tracking. Often discrete layers are evident at different depths, each layer composed of different species or developmental stages. The DSL is a layer of living organisms, ranging from microscopic zooplankton like copepods to macroorganisms like shrimps, squids and fishes that prey from within and outside the DSL (Ingmanson and Williams, 1973).

DSL in the ocean was first recognized in 1942 and has since been found to be widespread in most of the major oceans except the Arctic and Antarctic (Dietz, 1948; Tucker, 1951). In India, Daniel *et al.* (1969) made a preliminary study of the faunal components of the DSL in the Bay of Bengal. Silas (1972) conducted acoustic surveys in the Lakshadweep Sea and recorded DSL in the oceanic areas at depths of 300–450 m and 750–950 m with characteristic vertical migrations and found that the biological components of the DSL close to the islands and reefs constitute important forage for pelagic fishes such as tuna. He also noticed that zooplankton biomass was relatively richer close to the reefs as compared to open oceans, but much less than what was obtained along the continental shelf. Majority of the zooplankton groups of DSL which form food for several crustaceans, molluscs, fish and marine mammals are known to make extensive diurnal vertical migrations in response to light and other physico-chemical characteristics of the environment (Madhupratap *et al*., 1996).

The first major attempt to study the quantitative distribution and abundance of zooplankton of the Indian Ocean was by the International Indian Ocean Expedition (IIOE) during 1960-65. Apart from the IIOE, many other intensive but localised surveys for zooplankton have been carried out. *R. V. Varuna* investigated the shelf and oceanic waters off the southwest coast of India (Ramamirtham and David

Raj, 1981). Mathew *et al*. (1990 a) conducted a detailed study of the zooplankton biomass and secondary and tertiary production of the EEZ of India. We made an attempt to study the total macrozooplankton biomass from the EEZ of India and contiguous seas during May 1998 - December 2002.

Material and methods

The macrozooplankton samples were collected from the DSL during 13 cruises of FORV *Sagar Sampada* as part of a DSL programme in the Indian EEZ covering the Arabian Sea, Bay of Bengal and Andaman Sea from May 1998 to December 2002 between 06°-21°N lat. and 66°-77°E long. (Fig.1). The gear for the collection was the Isaacs-Kidd Midwater Trawl (IKMT), designed to collect mesopelagic and bathypelagic organisms, which are larger and more active than the specimens caught by plankton net (Isaacs and Kidd, 1951). The net had an opening of 10 m^2 and a cod end with a lining of 1.5 mm square mesh with 0.25 mm twine thickness (Karuppasamy *et al*., 2006). The sample was collected in a bucket (capacity: 5 liter) attached to the cod end. The net was lowered and retrieved open, and its depth was measured by a transducer mounted at the headrope. The towing speed was 3 knots and towing time was 30 minutes. The samples were preserved in 5% buffered formalin and the volume was noted immediately after the haul. On shore, the organisms were sorted into groups, and their number and wet weight were recorded. For the wet weight of the DSL zooplankton, the samples were washed properly, put on filter paper and the weighed in an electronic balance (accuracy: 0.001 mg). The biomass was estimated as:

$$\text{Biomass (g/1000 m}^3\text{)} = \frac{\text{Weight of the group (g) x 1000}}{\text{Volume of water filtered}}$$

The sampling was done between the surface and 750 m depth and the hauling depth depended on the concentration of DSL thickness as evidenced from echograms. The biomass was estimated using the swept area method (Sparre and Venema, 1992).

Results and Discussion

In general, the waters of the northern Arabian Sea were more productive (Fig.2). The shelf area too was highly productive. High biomass of zooplankton was obtained at 17° N lat. 68° E long. (53.65 g/1000 m^3), 17° N lat. 70° E long. (24.28 g/1000 m^3), 17° N lat. 71° 50' E long. (22.90 g/1000 m^3) and 16° 29' N lat. 73° E long. (18.62 g/1000 m^3). Areas of high biomass were frequently encountered all along the shelf of the west coast. In an atlas made for the zooplankton of the EEZ of India, Supria *et al*. (1988) also have shown highly productive areas off Veraval, Bombay, Goa and Mangalore. The high zooplankton biomass in the Arabian Sea also apparently sustains a large biomass of mesopelagic myctophid fishes (Gjosaeter, 1984). In the oceanic waters of the Bay of Bengal also, the zooplankton biomass was relatively higher than in the shelf areas. Localized high biomass was noticed at 13°N lat. 84°85'E long. (9.26 g/1000 m^3), 14°N lat. 80°48'E long. (4.56 g/1000 m^3) and 10°59'N lat. 83°05'E long. (4.63 g/1000 m^3).

Fig. 1. Station locations of the DSL sampling in the Indian EEZ

Fig. 2. The distribution and biomass of macrozooplankton (g/1000 m^3) in the Indian EEZ during 1998-2002

Higher zooplankton biomass was observed in the Arabian Sea during monsoon (June-October) (10.26 g/1000 m^3) and premonsoon (Feb-May) (8.68 g/1000 m^3) during day and in premonsoon (20.35 g/1000 m^3) during night (Fig.3). Madhupratap *et al*. (1996) has observed that in February-March nutrient availability in the euphotic zone was substantial in the northern coastal and oceanic waters (north of 15°N lat.) due to winter cooling and convective mixing. This leads to increases in primary production and consequently the increase of zooplankton In the Bay of Bengal the zooplankton biomass was comparatively higher during postmonsoon (3.98 g/1000 m^3) during day and during premonsoon (3.43 g/1000 m^3) during night. In the Andaman Sea, the biomass was high in the monsoon (1.58 g/1000 m^3) during day and in the postmonsoon (1.89 g/1000m^3) during night. It is observed that the seasonal changes during day and night were more pronounced in the Arabian Sea compared to Bay of Bengal (Fig. 3).

Bathymetric studies (vertical) show that in the Arabian Sea zooplankton prefer shallow depths of 0-50m both during day (13.67 g/1000 m^3) and night (9.68 g/1000 m^3). Sharp decreases in biomass with depth were observed in many areas and the 'Arabian Sea paradox' of maintenance of high mesozooplankton biomass is now a fairly well

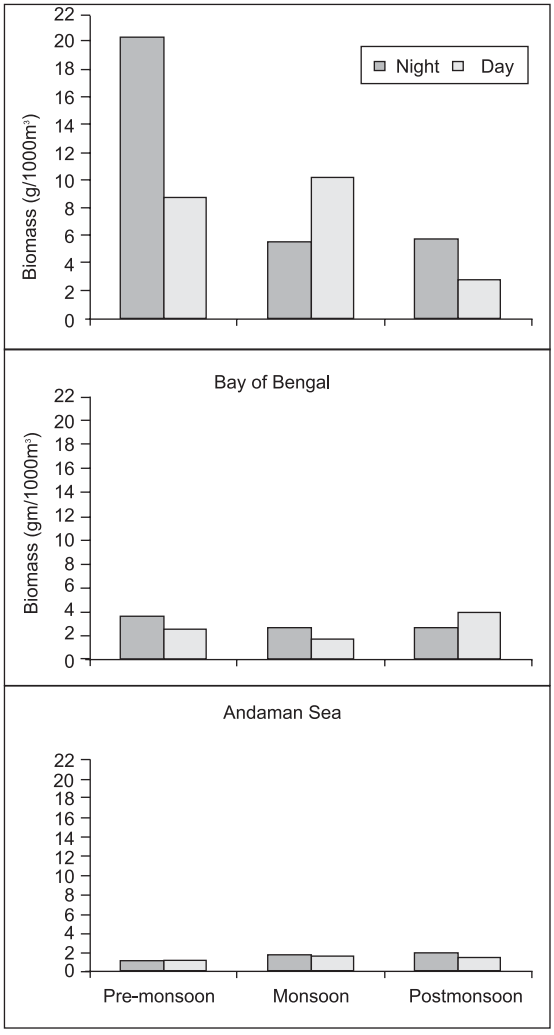

Fig. 3. Seasonal macrozooplankton biomass (g/1000 m^3) in the Indian EEZ during 1998-2002

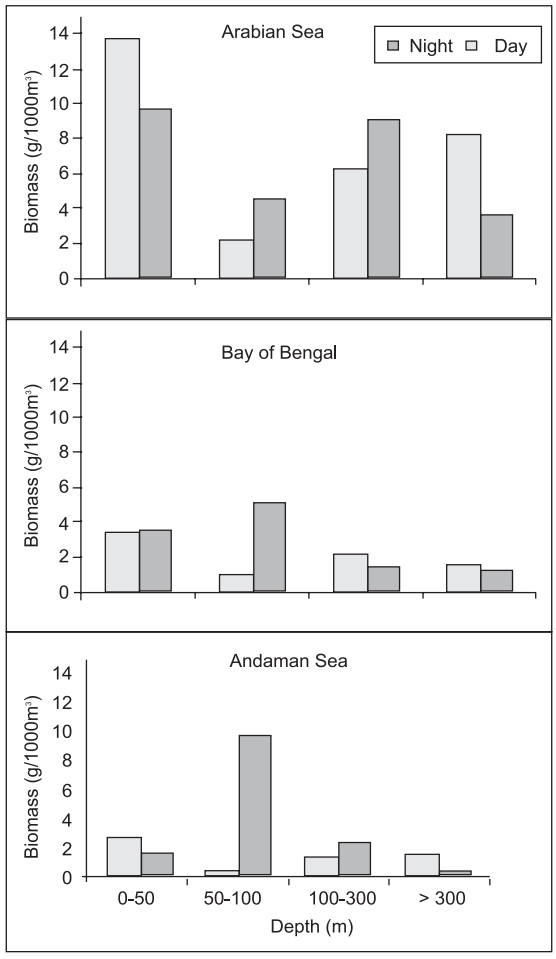

Fig. 4. Depthwise macrozooplankton biomass (g/1000 m^3) in the Indian EEZ during 1998-2002

established fact as observed in other studies, as well (Smith and Madhupratap, 2005). In the Bay of Bengal the maximum abundance 5.16 g/1000 m^3 noticed was during night at 50-100 m, and to a lesser extent 3.49 g/1000 m^3 at 0-50 m. During day, 3.40 g/1000 m^3 was observed at 0-50 m. In the Andaman Sea also high biomass was recorded during night at 50-100 m, 9.71 g/1000 m^3 and at 0-50 m 2.65 g/1000 m^3 during day (Fig. 4).

Relative abundance of macrozooplankton*:* Out of 19 groups of zooplankton caught from the Arabian Sea, medusae dominated the catch (35.6%), followed by salps (24.7%), ctenophores (10.0%), euphausiids (4.2%) and alima (3%) in the day haul (Table 1). In the night haul the dominant groups were medusae (31.4%) and salps (26.3%) followed by doliolum (15.6%), euphausiids (7%) and siphonophores (4.4%). Along the Bay of Bengal, 21 groups were recorded from the DSL. In the day catch the predominant plankton were medusae (36.8%), euphausiids (10.7%), salps (7.8%), siphonophores (6.9%) and chaetognaths (5.2%). The night haul consisted of euphausiids (32.0%), salps (19.2%), siphonophores (8.3%) and medusae (5.9%). The day hauls in the Andaman Sea yielded 1.13 g/1000 m^3 consisting of euphausiids (34.5%), salps (15.5%) and chaetognatha (9.1%). The biomass in the night haul was 1.6 g/1000 m^3 and the major fauna were euphausiids (22.5%) and salps (10.2%). Distribution of hydromedusae from the Indian Ocean was studied by Vannucci and Navas (1973). Poulsen (1969) gave a list of planktonic ostracods collected during Dana expedition and other workers on ostracods include George and Nair (1980), Smith and Madhupratap (2005) from the northern Indian Ocean and Arabian Sea respectively. The planktonic populations were found to have a high population density in the night hauls. The high density of some of the major groups of zooplankton reported in the earlier studies in the Arabian Sea *viz*. mysids, euphausiids (Mathew *et al.*, 1990 b, c), foraminiferans and cladocerans (Naomi *et al.*, 1990 a, b), chaetognaths (Srinivasan, 1990), amphipods (Revikala *et al.*, 1990), *Lucifer* and gastropods (Geetha *et al.*, 1990 a,b) are confirmed in the present study.

Table 1. Composition of macrozooplankton groups (% of total biomass) in the Indian EEZ during 1998-2002

	Arabian Sea		Bay of Bengal		Andaman Sea	
Groups	Day	Night	Day	Night	Day	Night
Amphipods	0.2	0.2	1.0	0.6	3.5	1.2
Copepods	0.1	0.3	2.6	0.9	5.1	1.9
Ostracods	0.1	0.1	2.1	0.3	%	%
Isopods	%	%	0.2	0.4	%	%
Euphausiids	4.2	7.0	10.7	32.0	23.1	34.5
Pteropods	1.0	4.4	0.6	0.7	0.2	0.1
Decapod	0.2	0.2	0.3	0.3	0.3	0.6
Alima larva	3.0	0.7	2.7	3.2	1.7	2.7
Megalopa larva	0.2	0.2	0.8	0.5	0.7	0.2
Chaetognaths	0.3	0.6	5.2	1.6	9.1	2.4
Polychaetes	0.8	%	2.2	11.1	%	%
Siphonophores	2.6	4.4	6.9	8.3	%	2.6
Medusa	35.6	31.4	36.8	5.9	3.2	2.2
Phyllosoma	0.1	%	0.2	0.2	0.4	0.1
Gastropod	0.1	0.1	1.5	0.4	2.8	0.3
Salps	24.7	26.3	7.8	19.2	18.5	15.5
Lucifer	%	%	0.1	0.3	%	0.2
Doliolum	0.3	15.6	0.8	0.3	%	%
Ctenophores	10.0	0.3	%	%	%	%
Miscellaneous*	16.4	8.2	17.8	13.9	31.8	35.2

*Includes Jelly fish parts and unidentified gelatinous items

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