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PRELIMINARY INVESTIGATION ON THE FISH BIOMASS IN THE DEEP SCATTERING LAYERS OF THE EEZ OF INDIA

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Abstract

The Fishery and Oceanography Reserach Vessel *Sagar Sampada* during her cruises 1-15 along the EEZ of India during 1985 to '86 conducted surveys of the bio-compositon of the DSL by using a 5 m Isaacs- Kidd Midwater Trawl. The survey revealed that the DSL is either single layered or some times multilayered mostly occupying depths from 200 to 540 m and 20 to 100 m. These layers were found to shift vertically from depths of 200 - 540 m during day to the surface during night, influenced by photoperiodic conditions. Out of a total of 563 stations surveyed, the IKMT gear sampled from 364 stations, which included day and night hauls. In additon to planktonic groups, under micronekton, fishes were the dominant item of the samples. The common fishes recorded in the DSL were myctophids, gonostomatids, *Bregmaceros*, eel larvae and juveniles of several other families of fishes. The estimated fish biomass varied from 0.01 to 45.5 g/ 1000 m^3 in the DSL. This paper describes the distribution and abundance of fish fauna in the DSL along various latitudes, depth, seasons and their diurnal vertical migration.

Introduction

The bio-composition of the Deep Scattering Layers of the world oceans has been well described by Marshall (1951), Tucker (1951), Barham (1957), Pearcy and Laurs (1966), Taylor (1968), Kinzer (1969), Silas (1972) etc. All the above works showed the predominance of macroplankton and micronekton in the DSL. Those studies also indicated the occurrence of a wide assemblage of young or adults of epipelagic, mesopelgaic and to a lesser extent bathypelagic fishes. For an understanding on the food relationships in the DSL and the rate of metabolism from the lower to the higher levels in the food web, it is pertinent to study the larger nekton, its extent and periodicity of migration, bathymetric and seasonal abundance and the degree to which these animals are predators or prey of other trophic levels. Johnson (1948) described the diurnal movements of DSL micro- and macro-nekton and linked them with plankton concentration. Tucker (1951) noticed a correlation between deeper, more intensive scattering and the vertical distribution of fishes and the shallower less intense scattering and the distribution of euphausiids. Pearcy and Laurs (1956) observed that day catch rates of mesopelagic fishes were larger than the night catch at depths of 150-500 m, and the reverse was the condition from the surface to 150 m. Taylor (1968) noticed that the largest night catches were usually smaller than the largest day catches and shallower. Alverson (1961) reported the unusual occurrence of bathypelagic myctophids at surface during day as 'reddish brown ball' and formed bait fishes for skipjack and yellowfin tunas.

This report gives a preliminary study on the geographical, bathymetric and seasonal distribution and abundance of DSL fishes of the Indian EEZ.

Material and Methods

The data base of this study was from the collections of FORV *Sagar Sampada* during her cruises 1-15 along the Indian EEZ during February, 1985 to May, 1986. The bio-compostion of the DSL was sampled with the help of a 5 m IKM Trawl net having a cod end mesh size of 1.5 mm at a speed of 3 knots. After ascertaining the depth of occurrence of the DSL from the echo-sounder (frequency of 38 khz and 120 khz), the net was shot to appropriate layer where there was maximum bio-concentration and horizontal hauls of 30 minutes duration were taken. Out of 563 stations covered during the cruise 1-15, the IKMT was operated from 364 stations (171 night and 193 day). Fishes occured in 83% of the total IKMT hauls with 90% and 84% of the IKMT day and night stations respectively. The surveyed area was sub divided into 4 bathymetric realms, 0-100, 100-200, 200-1000 m and above 1000 m for depthwise abundance study. The fish fauna were identified upto group level based on preserved samples. Stratified sampling along different layers

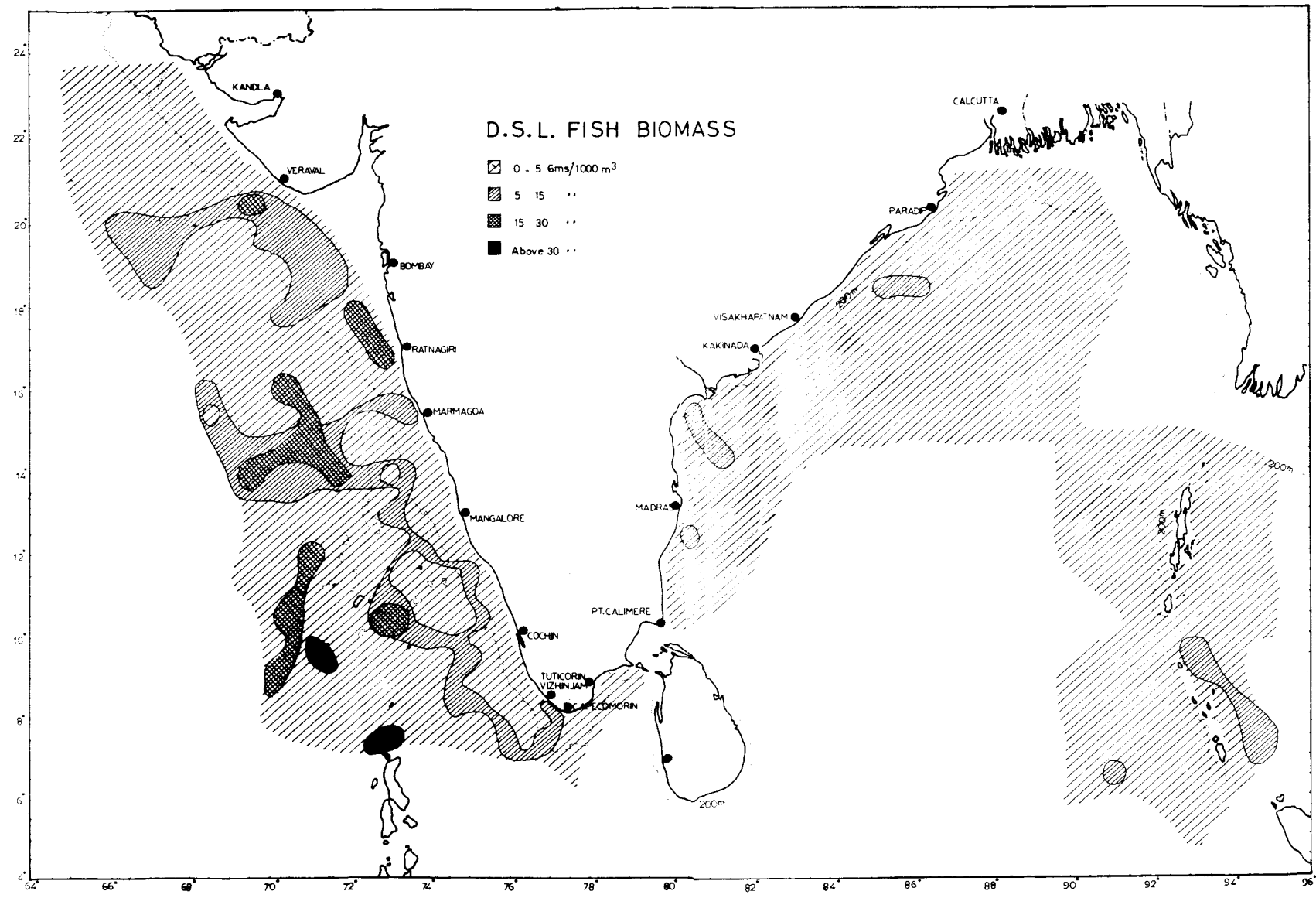

Fig. 1. Geographic distirbution and abundance (g/1000 m³) of fishes of the DSL of Indian EEZ.

of the DSL was also carried out in the area 09° 29.5'N- 10° 30'N latitude and 73° 00' E- 75° 30'E longitude in order to study the diurnal relative abundance and extent and speed of vertical ascends and descends of fishes.

Results

Geographic distribution and abundance of DSL fishes

In the total biomass (numerical) of the DSL, micro/macro nekton formed about 6% and the rest zooplankton. In the micro/macro nekton, fishes accounted for 5.4%. Fish abundance ranged from 0.01 to 45.5 g/1000 m^3 in the total DSL fish biomass. Fish was recorded in 82% of the total IKMT stations. Distribution and abundance of DSL fishes in various geographic areas of the EEZ is given in Fig. 1. The DSL of the southwest coast and Wadge Bank area showed rich concentration of fish biomass. The component groups (Table 1) of fishes occurred in the scattering layer showed that juveniles /sub-adult of several epi and mesopelagic fishes dominated the catches (39.5 % in total fish biomass). The next important item was *Vincigueria* spp. (25.7 %) of the family Gonostomatidae of meso-to bathypelagic realms with the habit of diel vertical migrations and wide distribution all along the EEZ. This genus was represented by 4 species namely *V. nimbaria, V. lucetia, V. poweriae,* and *V. attenuata.*

Table 1. *Percentage occurrence of different groups of fishes in the total fish biomass (numerical) of DSL during day and night by IKMT*

Groups Day	Night	Combined total
Juvenile/sub adult & miscellaneous fishes	40.0	35.8	39.5
Vincigueria spp.	26.0	26.8	25.7
Myctophids	14.8	18.6	17.0
Leptocephali	6.8	8.0	7.5
Stomidae	9.5	6.3	7.0
Bregmacerotidae	2.0	2.7	2.4
Other fishes	0.9	1.8	0.9

Myctophids are yet another important group commonly recorded from the DSL both during day and night with dominance in night hauls. This group accounted for about 17 % of the total fish biomass of the scattering layers with wide distribution and represented by the genera *Diaphus, Myctophum* and *Benthosema* . This group was particularly abundant along the west coast. Some other important groups ecnountered in the fish catches of the DSL were Leptocephali (7.5 %) and Stomiidae (7 %); both the groups of fishes and larvae were widely distributed all along the surveyed areas. Fishes of the family Bregmacerotidae (2.67 %) were recorded from several stations and represented by the genus *Bregmaceros.* In addition to the above groups, a wide spectrum of miscellaneous fishes from mesopelagic and bathypelagic environments were found to inhabit the DSL and showed characteristic vertical ascends and descends diurnally.

Day hauls

Day operations of IKMT revealed wide occurrence of fish biomass in the DSL of Indian EEZ. The fishes occurred in 90 % of IKMT day stations and in the bio-compositon (numerical), fish formed 6.4 %. In the total nekton population, fish accounted for 90.4 % and the rest by crabs (3.9 %) and cephalopods (5.7 %). The average number of fishes per haul was 91 in day operation. The fish biomass in the surveyed areas of the DSL varied from 0.01 to 22.5 g/1000 m^3 of water of the bioacoustic scattering layers. Geographic abundance (g/1000 m^3) of fish biomass in the DSL of day hauls is given in Fig. 2. The pockets of high density DSL fish biomass were located at lat. 15° 30'N, long. 73°30'E (1,492 nos. /haul or 22.5 g/ 1000 m^3); 09°30'N, 75° 00'E (832 nos. /haul or 12.6 g/1000 m^3), 18° 30'N, 69°30'E (751 nos. / haul or 11.3 g/ 1000 m^3), 13°00'N, 75°04'E (1267 nos. / haul or 19.3 g/ 1000 m^3) and 15°40'N, 07°24. 8'E (945 nos. / haul or 14.3 g /1000 m^3).

Night hauls

Fishes were collected from 84 % of the IKMT night stations with an average catch rate of 159 nos./ haul. In the DSL nekton compositon of night hauls, fishes accounted for 93 % and crabs and cephalopods 4.4 and 2.6 % respectively. Geographic abundance (g/1000 m ^{3}) of DSL fishes in night collections are shown in Fig. 3. DSL fishes occurred in dense concentration along the areas lat. 09°30'N, long. 74°00'E (685 nos. /haul or 9.9 g/1000 m^3); 15° 5'N 68°58'E (810 nos. /haul or 12.2 g/ 1000 m^3) ; 20°30'N, 69°30'E (1144 nos. /haul or 17.3 g/1000 m^3); 18°33'N, 85°20'E (946 nos./haul or 14.3 g/1000 m^3) and 18°27'N, 86°28'E (784 nos. / haul or 11.8 g/ 1000 m ^{3}) of the EEZ. The highest fish catch was recorded from the density pockets in Wadge Bank at lat. 07°10'N, 77°30'E (3013 nos. /haul or 45.5 g/ 1000 m^3) and 07°10'N, 76°07'E (1228 nos. / haul or 16.6 g/1000 m^3).

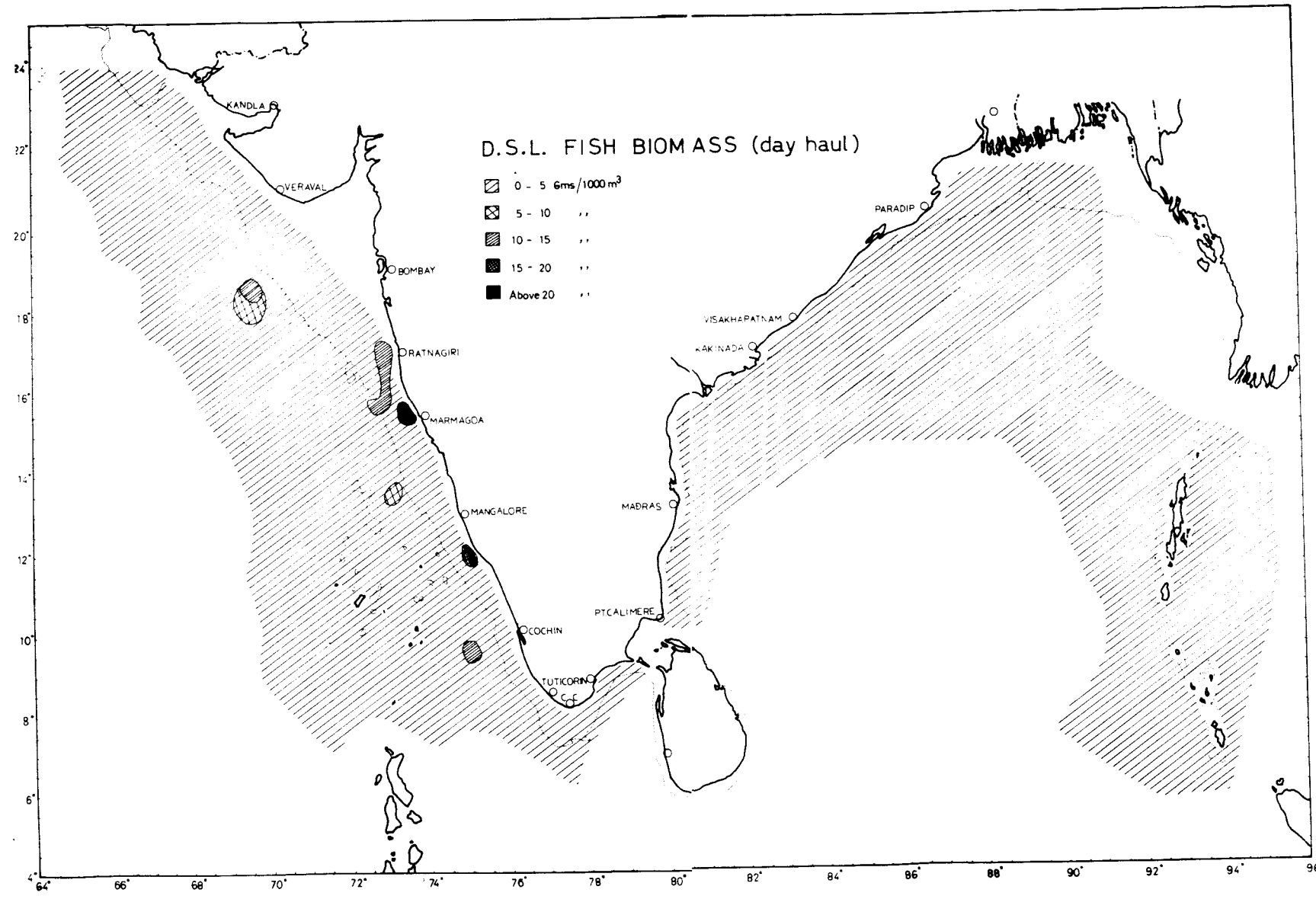

Fig. 2. Geographic distirbution and abundance (g/1000 m³) of fishes from day hauls of IKMT along the DSL of Indian EEZ.

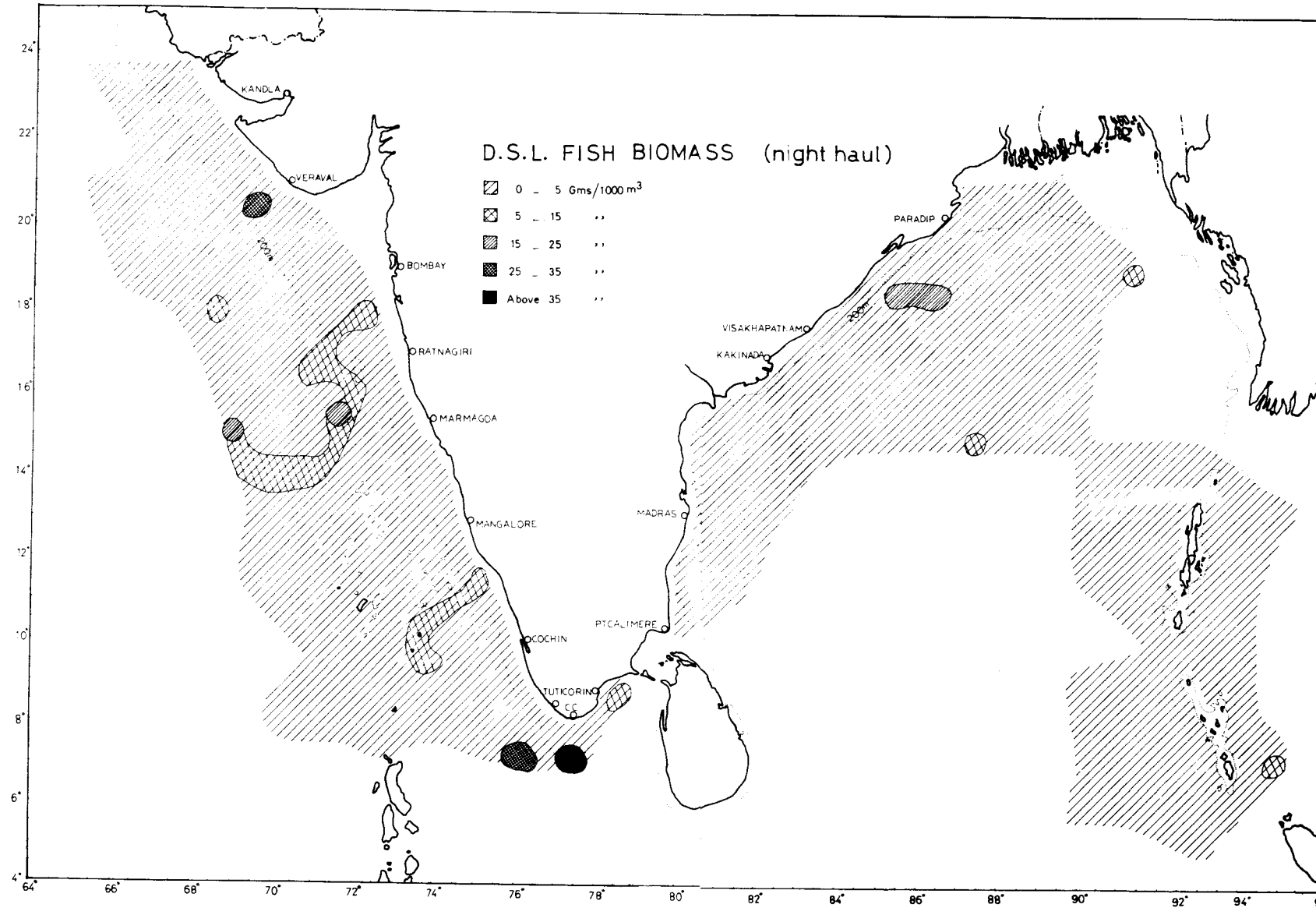

Fig. 3. Geographic distirbution and abundance (g/1000 m³) of fishes from night hauls of IKMT along the DSL of Indian EEZ.

Seasonal abundance

The seasonal trend of abundance of DSL fishes in day and night hauls (Fig. 4) showed that the night catches were invariably higher than day catches except during July, September and October. The highest catch rate was recorded in Novemebr. The available data is not sufficient to give a conclusive picture of seasonal trends of abundance because of the lack of round the year coverage along all geographical areas of the EEZ. Therefore, the data is pooled into three seasons, premonsoon, monsoon and postmonsoon (Table 2), which gave the highest vaule (194 fishes/haul in night and 125 fishes /haul in day) during postmonsoon season both in the day and night collections. This fish peak was not coincided with plankton abundance; probably this differential abundance was due to high rate of grazing by the former. The night/day catch ratio showed high value (2.6) during monsoon; whereas it was low (1.6) in postmonsoon when the fish resource was abundant in the DSL.

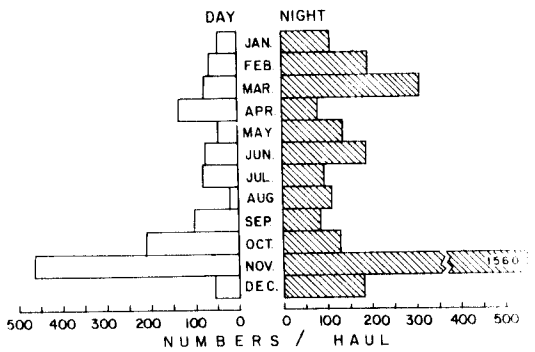

Fig. 4. Monthly average catch rates of DSL fishes in day and night IKMT hauls.

Bathymetric abundance

Depthwise analysis of fish catch from DSL showed that the resource was abundant in the slope during night hauls (340 nos./haul). In depth strata of less than 100 m the night haul yielded 181 nos./ haul (Fig. 5). The highest fish catch of 300 nos./haul

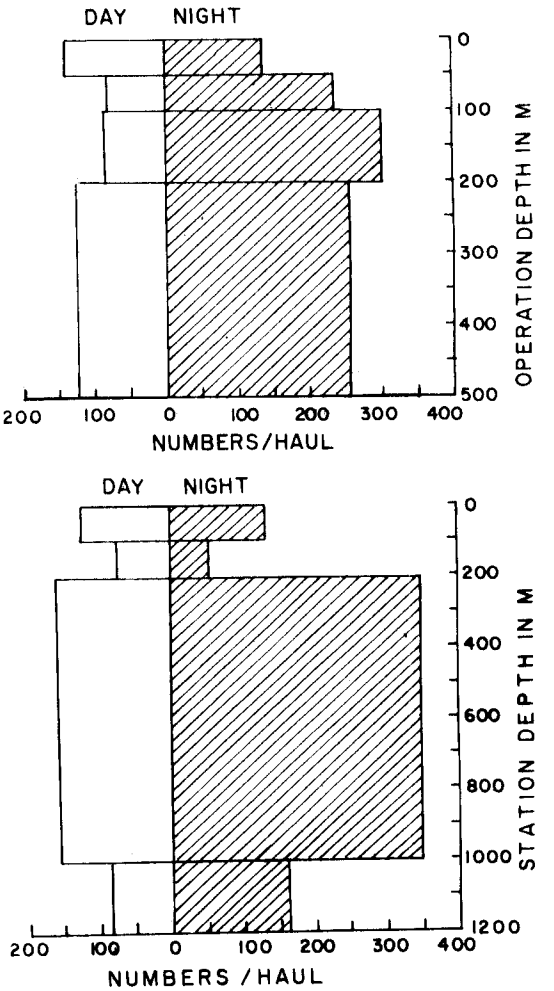

Fig. 5. Bathymetric abundance of DSL fishes.

was recorded from the depths of 100-200 m during night; whereas the catch was very low (132 nos./ haul) in the surface to 50 m. There was a clear indication that the vertical descend of fishes during night is at a slow pace. The surface (0-50 m) catches of day and night was almost of the same magnitude. In the intermediate depths (50-200 m), the night catches were far higher than the day catches. The deeper layers of the DSL (200-500 m) indicated

TABLE 2. *Seasonal catch rates of fishes and plankton in day and night DSL hauls and ratio of* N/D *fish catch rates*

Season	No. of fish/haul		Ratio N/D	No. of plankton/haul	
	Night	Day		Night	Day
Premonsoon	163	74	2.2	4174	972
Monsoon	117	45	2.6	1812	1928
Postmonsoon	194	125	11.6	2891	1445

TABLE 3. *Details of stratified sampling with IKMT in the area 09° 29.5 ' N to 10° 30' N latitude and 73° E to 75°3' E longitude during April, 1 1985*

Position		Depth of Stn.	Haul I				Haul II				Haul III			
Lat. (N)	Long. (E)		Time of oper-ation	Depth of oper-ation	Bio-mass/ haul (ml)	No.of fish/ haul	Time of oper-ation	Depth of oper-ation	Bio-mass/ haul (ml)	No.of fish/ haul	Time of oper-ation	Depth of oper-ation	Bio-mass haul (ml)	No.of fish/ haul
10 °29.6'	75°29.5'	1125	N	18	30	208	N	35	100	345	N	50	200	-
10°29.3 '	74°14.8 '	2321	N	51	70	153	D	370	150	55	D	423	251	153
10 °30'	73°00'	1730	N	27	570	24	N	115	100	46	N	390	1230	397
09°30'	73°00'	1778	D	50	260	179	D	320	25	19	D	440	240	152
08°28'	74°01'	2607	D	50	220	233	D	280	200	330	D	400	120	472
09°30'	74°07'	2525	N	75	220	348	N	310	206	137	N	320	120	167
09°30'	74°00'	2560	D	45	100	118	D	295	120	57	D	340	100	85
09°38'	74°20'	2671	N	44	60	25	N	120	60	85	N	410	-	-
09°30'	75°00'	2689	-	-	-	-	D	370	580	417	D	440	420	343

proportionately better catch rate during day. These diel differences in the catches are obvious in the mid- depths. The data indicated that the night ascend of fishes is at a slower pace than the day descend.

Stratified sampling results of IKMT

Samples collected from various layers of DSL by IKMT in the area 09°30'N to 10°30'N latitude and 73°00'E to 75°30'E longitude during day and night in April, 1985 (Table 3) showed that in the upper layer (18-75 m) of DSL the average day haul yield (177 nos. /haul) was higher than the average night catch rate (152 nos./haul). Similarly in the intermediate layer (115-370 m) the day hauls produced high catches (176 nos. /haul); whereas the night catch rate was distinctly low (89 nos. /haul). The opposite trend was apparent in the lower layer of the DSL with better average catch rate (282 nos./ haul) in night hauls than day (241 nos. / haul).

DISCUSSION

Many earlier works on the vertical migrations of epipelagic and mesopelagic fishes occurring inthe DSL described larger catches of mesopelagic fishes in near-surface waters during night than during the day (Tucker, 1951 ; Aron, 1962; King and Iverson, 1962; Pearcy and Laurs, 1966). Some of them attributed this to visual avoidance of the gear during day. But the present data invariably show highest night catches with proportionately larger catch rates during the day in the surface and deeper water. In the mid layer the ratio of night /day fish catch was high. This may be due to different speeds of ascend in night and descend in day, the former being slower than the latter. However, the study will be conclusive only through a quantitative sampling in the entire vertical range of the animals, including the depths to which they migrate during day time with the help of opening and closing IKMT nets.

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