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Distribution and Abundance of Deep Sea Fishes Along the West Coast of India

S. Venu and B. Madhusoodana Kurup
School of Industrial Fisheries, Fine Arts Avenue,
Cochin University of Science and Technology, Cochin-682 016, India

Bathymetric and spatial distribution and abundance of the deep-sea finfish resources in the EEZ off west coast of India (200-750m) are discussed based on the results of three fishing cruises carried out from FORV Sagar Sampada during 1998-2000. Results indicate the existence of potentially rich unexploited deep sea finfish resources. The area between 7° and 9° N lat was found to be more productive with catch rates ranging from 660.5 -1185.6 $kg.h^{-1}$. Comparatively low catch rates were obtained between 10° and 11° N lat and 14° and 21° N lat with catch rates ranging from 18.0 to 41.3 $kg.h^{-1}$. Areas within 9°-10° N and 11°-14° N lat contributed moderate catches with CPUE ranging from 75.79 to 229.17 $kg.h^{-1}$. Most productive depth ranges were found to be 201-300 and 301-400 m. Major species constituting the catches were *Chlorophthalmus punctatus, Chlorophthalmus bicornis, Psenopsis cyanea, Neopinnula orientalis, Hoplostethus mediterraneus, Psenes squamiceps, Nettastoma parviceps* and *Priacanthus hamrur.*

Key words: Deep sea fishes, fish distribution, EEZ, India

The existence of fairly rich fishing grounds for unexploited and under-exploited deep-sea fishery resources in the EEZ, off west coast of India has been established during the past few decades (Silas, 1969; Nair & Joseph, 1984; James & Pillai, 1990; Sivakami, 1990; Panicker *et al.* 1993; Sivakami, 1998; Khan *et al.*, 1996). In the context of increasing demand for fish and diminishing returns from the coastal fishery, exploitation of the deep sea resources could play an increasingly significant role in improving marine fishery production. Along with the deep sea shrimp and lobster resources, which are already under varying degrees of exploitation, the deep sea fishes are also gradually gaining importance in recent years. In this paper, recently acquired data on the distribution and abundance of exploitable concentrations of deep-sea finfish resources beyond 200 m depth off west coast of India are presented.

Materials and Methods

The data for the present study were collected onboard FORV Sagar Sampada (Dept. of Ocean Development, Govt. of India) during cruise nos. 174 (June-July, 1999), 183 (April, 2000) and 189 (October-November, 2000) along the west coast of India. The catch and effort data of bottom trawl operated between 7° to 21°N lat were used for this study. A total of 20 hauls were taken during cruise no. 174, 23 hauls during cruise no. 183 and 26 hauls during cruise no. 189. A 38 m High Speed Demersal Trawl II (HSDT-II) (Panicker, 1990) and 45.6 m Expo model demersal trawl (Boopendranath *et al.*, 1996) were used for operations. Total catch, catch per unit effort (CPUE) and species composition were recorded at each fishing station. Latitude-wise and depth-wise distribution and abundance of deep sea finfish resources were assessed after grouping the stations into 5 depth zones, viz., 201-300 m, 301-400 m, 401-500 m, 501-600 m and 601-750 m (Khan *et al.*, 1996). The fishes were identified using standard references (Goode & Bean, 1895; Alcock, 1899; Fischer & Bianchi, 1984; Smith & Heemstra, 1986).

Results and Discussion

During the period of observations, a total catch of 11.47 t of deep sea fishes were

Table 1. Details of catch obtained and effort expended in different latitude and depth ranges

	201-300 m			301-400 m			401-500 m			501-600 m			600-750 m			301-750 m
	Catch (t)	Effort (h)	kg.h^{-1}	Catch (t)	Effort (h)	kg.h^{-1}	Catch (t)	Effort (h)	kg.h^{-1}	Catch (t)	Effort (h)	kg.h^{-1}	Catch (t)	Effort (h)	kg.h^{-1}	kg.h^{-1}
7°–8° N lat.	1.103	1.67	660.48	–	–	–	–	–	–	–	–	–	–	–	–	660.48
8°–9° N lat.	–	–	–	6.805	4.75	1432.70	0.012	1.00	12.00	–	–	–	–	–	–	1185.57
9°–10° N lat.	0.028	1.50	18.66	0.549	6.17	88.97	0.043	0.50	85.02	–	–	–	–	–	–	75.89
10°–11° N lat.	–	–	–	0.088	4.50	19.60	0.035	3.58	9.87	0.128	2.00	63.80	0.125	0.30	690.00	35.54
11°–12° N lat.	0.966	0.83	1164.22	–	–	–	0.367	4.17	88.03	–	–	–	0.042	1.00	39.00	229.17
12°–13° N lat.	–	–	–	–	–	–	0.222	2.08	106.78	–	–	–	0.020	1.00	29.40	78.57
13°–14° N lat.	–	–	–	–	–	–	0.248	1.67	148.50	0.236	1.83	128.79	–	–	–	138.29
14°–15° N lat.	0.123	4.92	24.98	–	–	–	–	–	–	–	–	–	–	–	–	25.00
15°–16° N lat.	–	–	–	0.018	2.75	6.43	0.151	1.17	129.41	–	–	–	0.007	1.00	6.50	35.77
16°–17° N lat.	–	–	–	0.018	1.00	18.00	–	–	–	–	–	–	–	–	–	18.00
20°–21° N lat.	0.136	2.67	50.79	0.002	0.67	2.69	–	–	–	–	–	–	–	–	–	41.32
Total catch (t)	2.356			7.480			1.078			0.363			0.194			11.471
Total effort (h)		11.59			19.840			14.17			3.83			3.50		52.93
kg.h^{-1}			203.28			377.02			76.08			94.78			55.43	216.72

Table 2. Depth-wise and latitude-wise distribution of catch ($kg.h^{-1}$) of deep sea fishes in the EEZ off west cost of India

Laptitude	Species	CPUE ($kg.h^{-1}$)				
		201-300m	301-400m	401-500m	501-600m	601-750m
7°-8°N lat.	*Chlorophthalmus maculatus*	5.99	–	–	–	–
	Chlorophthalmus punctatus	5.99	–	–	–	–
	Cubiceps pauciradiatus	5.99	–	–	–	–
	Neoepinmula orientalis	2.99	–	–	–	–
	Paratriacanthodes herrei	8.98	–	–	–	–
	Psenopsis cyanea	11.98	–	–	–	–
	Saurida undosquamis	17.96	–	–	–	–
	Trichiurus sp. (juveniles)	600.60	–	–	–	–
8°-9°N lat.	*Chlorophthalmus bicornis*	–	241.47	–	–	–
	Chlorophthalmus punctatus	–	1114.74	12.00	–	–
	Cubiceps natalensis	–	6.74	–	–	–
	Cubiceps pauciradiatus	–	4.63	–	–	–
	Hoplostethus mednerraneus	–	1.89	–	–	–
	Neopinnula orientalis	–	2.13	–	–	–
	Nettastoma parviceps	–	1.73	–	–	–
	Porogadus miles	–	25.26	–	–	–
	Psenopsis cyanea	–	32.21			
	Trichiurus auriga	–	3.79			
9°-10°N lat.	*Chlorophthalmus bicornis*	–	0.69	–	–	–
	Chlorophthalmus punctatus	4.82	16.72	–	–	–
	Cubiceps natalensis	–	19.34	–	–	–
	Cubiceps pauciradiatus	–	1.51	–	–	–
	Neoepinmula orientalis	4.26	2.12	–	–	–
	Nettastoma parviceps	–	9.28	2.42	–	–
	Polymixia nobilis	0.82	–	–	–	–
	Porogadus miles	–	0.08	9.80	–	–
	Psenopsis cyanea	7.96	35.22	–	–	–
	Rexea promethoides	0.80	0.19	–	–	–
	Synagrops japonicus	–	0.52	–	–	–
	Trichiurus sp.	–	0.50	–	–	–
	Zenopsis conchifer	–	2.79	–	–	–
	Chimaera	–	–	66.40	–	–
	Myctophids	–	–	6.40	–	–
10°-11°N lat.	*Alepocephalus* sp.	–	–	–	–	12.42
	Centrophorus granulose	–	–	–	4.10	51.00
	Chimaera	–	–	–	–	105.60
	Chlorophthalmus bicornis	–	0.61	1.88	–	–
	Chlorophthalmus punctatus	–	3.82	–	–	–
	Cubiceps natalensis	–	3.33	–	–	–
	Cubiceps pauciradiatus	–	0.27	–	–	–
	Halelurus hispidis	–	–	–	1.55	–
	Hoplostethus mediterraneus	–	1.78	1.68	0.56	5.66
	Malacocephalus laevis	–	–	–	35.70	9.60
	Nettastoma parviceps	–	1.83	4.92	8.70	25.64
	Physiculus sp.	–	–	–	3.63	40.90
	Polymixia nobilis	–	0.71	–	–	–
	Porogadus miles	–	1.33	0.28	9.56	–
	Psenopsis cyanea	–	4.67	–	–	–
	Synagrops japonicus	–	0.53	–	–	–

	Myctophids	–	–	1.12	–	–
	Rays	–	–	–	–	140.40
	Sharks	–	–	0.56	10.62	–
	Skatcs	–	0.71	–	–	–
11°-12°N lat.	*Chlorophthalmus bicornis*	240.96	–	–	–	–
	Chlorophthalmus punctatus	765.06	–	–	–	–
	Cubiceps natalensis	31.93	–	7.19	–	–
	Holplostethus mediterraneus	–	–	5.88	–	–
	Neoepinnula orientalis	19.28	–	–	–	–
	Nettastoma parviceps	–	–	10.22	–	16.00
	Ostichthys sp.	3.37	–	–	–	–
	Polymixia nobilis	42.17	–	–	–	–
	Porogadus miles	–	–	12.71	–	18.00
	Psenopsis cyanea	34.94	–	–	–	–
	Rexea prometlioides	26.51	–	–	–	–
	Chimaera	–	–	1.68	–	–
	Eel juveniles	–	–	24.94	–	–
	Myctophids	–	–	5.04	–	8.00
	Sharks	–	–	20.38	–	–
12°-13°N lat.	*Holplostethus mediterraneus*	–	–	4.05	–	–
	Nettastoma parviceps	–	–	37.93	–	4.20
	Physiculus sp.	–	–	6.24	–	3.70
	Porogadus miles	–	–	12.96	–	–
	Chimaera	–	–	–	–	9.00
	Myctophids	–	–	14.88	–	–
	Sharks	–	–	30.72	–	1.65
	Skates	–	–	–	–	5.30
13°-14°N lat.	*Nettastoma parviceps*	–	–	23.95	–	–
	Physiculus sp.	–	–	1.80	3.28	–
	Porogadus miles	–	–	8.98	1.64	–
	Psenopsis cyanea	–	–	–	0.37	–
	Eel juveniles	–	–	–	78.69	–
	Chimaera	–	–	2.99	3.28	–
	Rays	–	–	–	3.28	–
	Sharks	–	–	110.78	38.25	–
14°-15°N lat.	*Bembrops caudimacula*	0.20	–	–	–	–
	Cubiceps natalensis	0.61	–	–	–	–
	Neoepinnula orientalis	0.33	–	–	–	–
	Psenopsis cyanea	17.17	–	–	–	–
	Physiculus sp.	0.47	–	–	–	–
	Priacanthus hamrur	5.69	–	–	–	–
	Sharks	0.51	–	–	–	–
15°-16°N lat	*Nettastoma parviceps*	–	–	105.88	–	0.50
	Physiculus sp.	–	–	–	–	1.00
	Porogadus trichiurus	–	–	23.53	–	–
	Priacamthus hamrur	–	6.43	–	–	–
	Chimeara	–	–	–	–	5.00
16°-17°N lat.	*Priacanthus hamrur*	–	18.00	–	–	–
20°-21°N lat.	*Cubiceps natalensis*	–	0.30	–	–	–
	Neoepinnula orientalis	0.11	0.45	–	–	–
	Priacanthus hamrur	48.43	1.94	–	–	–
	Sphyraena sp.	2.25	–	–	–	–

landed by expending a total of 52.93 h of fishing effort, resulting in an average CPUE of 216.74 kg.h^{-1} (Table 1). The area between 7° and 9° N lat was found to be more productive with catch rates ranging from 660.48 to 1185.62 kg.h^{-1}. Comparatively low catch rates were obtained between 10° and 11° N lat and 14° and 21° N lat, the catch rates ranging from 18.00 to 41.32 kg.h^{-1}. Areas within 9°-10° N and 11°-14° N lat contributed moderate catches with CPUE ranging from 75.79 to 229.17 kg.h^{-1}.

The results of the present study revealed that highest average catch rate of 377 kg.h^{-1} was obtained from 301-400 m depth zone, followed by 201-300 m depth zone (203.26 kg.h^{-1}). The area between 11° and 12° N lat was found to be most productive in the 301-400 m depth zone with a catch rate of 1164.22 kg.h^{-1}, followed by the area 7°-8° N lat (660.479 kg.h^{-1}). The highest catch rate of 1432.70 kg.h^{-1} was obtained in the area 8°-9° N lat in the depth zone of 301-400 m. Depth zone 601-750 m yielded the lowest catch rate of 55.45 kg.h^{-1}.

During the present study, a total of 23 species could be identified upto the species level from the landings (Table 2). *Chlorophthalmus* spp. was found to be the dominant species in the landings. In the area 7°-12° N lat, *Chlorophthalmus punctatus* and *C. bicornis* formed the dominant species. Panicker *et al.* (1993) reported *Centrolophus* sp. and *Chlorophthalmus* spp. as the dominant species in the depth zone 200-500 m, between 7° to 17° N lat, off west coast of India. According to Sivaprakasam (1986), *Chlorophthalmus agassizi* was abundant in the deeper waters (200-600 m) in the Indian EEZ. Sivakami (1990) observed a promising potential for deep sea fishes like *Psenopsis* spp., *Chlorophthalmus* spp., *Priacanthus* spp., *Cubiceps* spp., *Neoepinnula* spp., and *Trichiurus auriga* in the southwest zone in the depth range 151-398 m. Dominance of any single species was not discernible in the region between 12° and 21° N lat. (Table 2). Prasad & Nair (1973) have shown high abundance of deep-sea fishes such as *Chlorophthalmus agassizi, Neoepinnula orientalis, Psenopsis cyanea,* and *Cubiceps natalensis,* in the upper continental slope (180-450 m depth) in the Indian EEZ.

In the 7°-8° N lat (201-300 m depth zone), juveniles of *Trichiurus* sp. dominated the catch (600.6 kg.h^{-1}), followed by *Saurida undosquamis* (17.96 kg.h^{-1}) and *Psenopsis cyanea* (11.98 kg.h^{-1}). Along with these, there were representations of *Chlorophthalmus punctatus, C. maculatus, Cubiceps pauciradiatus, Paratriacanthodes herrei* and *Neoepinnula orientalis.*

Chlorophthalmus punctatus and *C. bicornis* were the major species in 8°-9° N lat with a catch rate of 1114.74 kg.h^{-1} and 241.47 kg.h^{-1}, respectively, followed by *Psenopsis cyanea* (32.21 kg.h^{-1}) and *Porogadus miles* (25.26 kg.h^{-1}). Other species represented in this area were *Cubiceps natalensis, C. pauciradiatus, Neoepinnula orientalis, Hoplostethus mediterraneus* and *Nettastoma parviceps.*

Altogether 15 groups of finfishes were recorded in 9°-10° N lat, in the three depth zones sampled, viz., 201-300, 301-400 and 401-500 m. Chimaeras appeared as the most important group (66.40 kg.h^{-1}) in the 401-500 m depth zone, followed by *Porogadus miles,* myctophids and *Nettastoma parviceps. Psenopsis cyanea* (35.22 kg.h^{-1}) *Cubiceps natalensis* (19.34 kg.h^{-1}) and *Chlorophthalmus punctatus* (16.72 kg.h^{-1}) were dominant in the 301-400 m depth zone. *Psenopsis cyanea* formed a major part of the catch in the 201-300 m depth zone also, though catch rates were comparatively low (7.96 kg.h^{-1}). Other species represented in this area were *Chlorophthalmus bicornis, Cubiceps pauciradiatus, Neoepinnula orientalis, Polymixia nobilis, Rexea promethoides, Synagrops japonicus, Trichiurus* sp. and *Zenopsis conchifer.*

A total of 20 groups of finfishes could be registered in the 10°-11° N lat. *Nettastoma parviceps* and *Hoplostethus mediterraneus* were

present in all depth zones from 301 to 750 m. Rays were the dominant group in this latitude with a CPUE of 140.40 kg.h^{-1} (601-750 m) followed by Chimaera (105.60 kg.h^{-1}; 601-750 m depth zone), *Physiculus* sp. (40.90 kg.h^{-1}; 601-750 m depth zone), and *Malacocephalus laevis* (35.70 kg.h^{-1}; 501-600 m depth zone). A high average catch rate was found in the depth zone 601-750 m with a CPUE of 250.82 kg.h^{-1}. Chimaeras and rays dominated in this depth zone.

Chlorophthalmus punctatus appeared as the most dominant species among the finfishes landed, with a catch rate of 765.06 kg.h^{-1} (201-300 m depth zone) in the 11°- 12° N lat, followed by *Chlorophthalmus bicornis* (240.96kg.h^{-1}), *Polymixia nobilis* (42.17 kg.h^{-1}), *Psenopsis cyanea* (34.94 kg.h^{-1}), *Cubiceps natalensis* (31.93 kg.h^{-1}), *Rexea peomethoides* (26.51 kg.h^{-1}) and other species. Sharks and eel juveniles were found in appreciable quantities in the 401-500 m depth zone.

In 12°-13° N lat, *Nettastoma parviceps* followed by sharks dominated in the 401-500 m depth zone with catch rates of 37.93 kg.h^{-1} and 30.72 kg.h^{-1}, respectively. *Porogadus miles* and Myctophids were also obtained with moderate catch rates. Chimaeras (9 kg.h^{-1}) dominated the catches in the 601-750 m depth zone, followed by skates (5.30 kg.h^{-1}) *Nettastoma parviceps* (4.20 kg.h^{-1}), *Physiculus* sp. (3.70 kg.h^{-1}) and Myctophids (1.65 kg.h^{-1}).

Sharks formed the major catch in 13°-14° N lat, with a catch rate of 110.78 kg.h^{-1} followed by *Nettastoma parviceps* (23.95 kg.h^{-1}) in the 401-500 m depth zone, while eel juveniles dominated (78.69 kg.h^{-1}), in the 501-600 m depth zone, followed by sharks (38.25 kg.h^{-1}). *Porogadus miles*, Chimaeras, *Physiculus* sp., rays and *Psenopsis cyanea* were also represented in the catches. In 14°-15°N lat, *Psenopsis cyanea* appeared as the major species in the catches with a catch rate of 17.17 kg.h^{-1}. *Priacanthus hamrur, Cubiceps natalensis, Physiculus* sp., sharks, *Neopinnula orientalis* and *Bembrops caudimacula* were also observed in the catches. *Nettastoma parviceps* formed the most abundant species in the 15°-16° N lat, with a catch rate of 105.88 kg.h^{-1} in the 401-500 m depth zone, followed by *Porogadus miles* (23.53 kg.h^{-1}). Other species represented in this area were *Physiculus* sp., *Priacanthus hamrur* and Chimaera. In the 16°-17° N lat *Priacanthus hamrur* was caught at a catch rate of 18.00 kg.h^{-1}. In the area between 20° and 21° N lat, *Priacanthus hamrur* (48.43 kg.h^{-1}) dominated the catch in the depth range from 201 to 400 m. Other species represented in the area were *Cubiceps natalensis, Neoepinnula orientalis, Priacanthus hamrur* and *Sphyraena* sp.

Results of the present study have shown that there is significant variation in the spatial and bathymetrical distribution of deep sea fishes inhabiting the area between 7° and 21° N lat. The area between 7° and 9°N lat was observed to be the most productive area for the deep sea fishes. The species diversity was found to be greater in the area between 9° and 12° N lat. The most productive depth zone was found to be 301-400 m, followed by 201-300 m. The predominant species such as *Chlorophthalmus punctatus, C. bicornis* and *Psenopsis cyanea*, could form a potential resource for commercial level exploitation in future. The sharks and rays also showed appreciable occurrence in certain areas.

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