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FISHERY RESOURCES OF THE INDIAN EXCLUSIVE ECONOMIC ZONE WITH SPECIAL REFERENCE TO UPPER EAST COAST*

D. SUDARSAN and V.S. SOMVANSHI

INTRODUCTION

A growing and enlightened awareness of fishery resources, their assessment and exploitation, among industry and Governmental agencies in India has come about subsequent to the declaration of 200 nm Exclusive Economic Zone (EEZ). The 2.02 million sq km EEZ has been estimated to have an annual fish potential far in excess of the present annual marine fish landings, around 1.7 million tonnes, underscoring the scope for augmenting marine fish production.

Resources surveys have been the precursors of development of commercial trawl fishery in general and shrimp trawl fishery in particular. Fishery Survey of India has been the vanguard in locating many a new resource and fishing ground and has been geared up to shoulder the increased responsibilities especially since the declaration of EEZ in 1976. Fishery Survey of India, in the recent past, has adopted diversified techniques to explore the fishery resources at the bottom, surface and midwater levels of the water column using the techniques of purse seining, pelagic/midwater trawling and long lining, besides bottom trawling deploying large modern trawlers with electronic, navigational and fish search and location equipment.

Results of demersal fishery resources survey by bottom trawling in coastal and offshore areas around mainland India as well as Andaman islands, within 70 m depth have been published earlier (Sudarsan, 1978; Joseph, 1980). The present paper deals with the recent knowledge gained through the progressive survey of demersal, midwater/pelagic and oceanic resources. The upper east coast by virtue of its having a fairly wide continental shelf area (76360 sq km) forming 63% of the total shelf area on east coast and 18.4% in entire Indian continental shelf area, is expected to play a vital role in increasing marine fish production as well as marine food products

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export from India. The primary productivity investigations conducted in the Bay of Bengal by NIO have also shown that the productivity in the Bay is not less than that in Arabin sea (Bhattathiri, et al., 1980) though the total biomass of production is of a lesser magnitude on account of the narrow continental shelf. The wider continental shelf along upper east coast should naturally contribute substantially to marine fish production.

MATERIAL AND METHODS

In all, nine large vessels (32.5 - 40.5 m OAL & 750-2030 BHP) were deployed for resources survey. **Matsya Varshini** and **Matsya Darshini** were used for purse seining and bottom/pelagic trawling. Combination trawlers **Matsya Nireekshani, Matsya Shikari, Matsya Jeevan, Matsya Shakti** and **Matsya Vishwa** were used for either demersal or pelagic trawling.

Matsya Sugundhi and **Matsya Harini** undertook cruises for oceanic resources by long lining. Fishing gear used in exploratory surveys were 34 m fish trawl, 44 m star model trawl, 45.5 m expo model trawl, 27 m fish trawl, 45 m shrimp trawl with 60-80 mm cod end mesh for demersal resources, 416.5 m x 94 m (18.4 mm mesh) purse seine and 21.6 x 21.6 m (444 mesh x 540 mm) midwater trawl for pelagic/columnar resources and long line gear of 150 baskets, each basket having five branch lines bearing No.6 tuna hooks for oceanic resources. The data collected during 1980-1986 have been analysed in respect of each of the fishing techniques/methods and as far as possible for each area betwen two consecutive latitudes in Arabian Sea, Bay of Bengal and Oceanic waters. The results are expressed in catch per hour of demersal fish (kg), catch per successful purse seine set (kg), catch per successful midwater tow (kg), and hooking rate of tuna and other oceanic fish varieties caught (as percentage of number of hooks operated).

RESULTS

Results of these surveys are presented fishing technique/method-wise, hereunder.

Purse seining

Exploratory purse seining and subsequent commercial fishing by

this method had significant impact on production of oil sardine and mackerel along Karnataka - Kerala coast. These developments during the late seventies and eighties coupled with introduction of exploratory technique of encircling fish shoals of higher magnitude using large purse seines by large vessels in deeper waters (upto 200 m depth contour) on east as well as west coast have opened new avenues in pelagic fishing thereby revealing several types of pelagic resources that could be tapped. Besides the conventional resources of oil sardine and mackerel, the species caught in purse seine catches were frigate mackerel **(Auxis thazard)**, little tuna **(Euthynnus affinis)**, **Caranx** spp., rainbow runner **(Elagatis bipinnulatus)**, Scads **(Decapterus** spp.), other species of tunas, lesser sardines, horse mackerel, **Chorinemus** sp., cuttle fish, elasmobranchs etc. On west coast the catches south of Cochin had mackerel and carangids as the most important groups. Little tuna was found to dominate the catches from Lat. 12°, 13°, 19° and 21°N. Oil sardine was the maximum catch (26 tonnes/set) along south Maharashtra coast and horse mackerel (5 tonnes/set) on Gujarat coast. The industrial fishery survey along north west coast by a chartered vessel, **M.T.Murena**, during 1977 had also revealed rich resources of horse mackerel along Gujarat coast (Anon.,1979). The purse seine survey conducted by **Matsya Darshini** in Bay of Bengal was limited to upper east coast. The areas south of Kakinada (south of Lat.17°) gave higher catches of clupeids. Tunas especially young yellow fin were caught in purse seine almost in all the latitudes. The other groups forming sizable quantities in the catches were Decapterids, pomfrets, horse mackerel, carangids, silver belly, seer fish, dolphin fish and moon fish. Table - I gives the number of purse seine sets made, successful sets and catch details thereof. The catch per successful set in the exploration on east coast varied from 40 to 1293 kg with an average of 871 kg. On west coast the catch per set varied from 114 to 25370 kg with the average for all the areas explored being 2215 kg. Some of the sets gave 10-35 tonnes of shoaling fish catches. These results show availability of varied types of pelagic resources. The quantity of fish caught does not reflect the true picture of abundance of resources as the purse seine operations were conducted while the crew were undergoing training from foreign experts.

Pelagic trawling

The technique of netting the transitory fish species moving from the surface layer and sea bottom due to diurnal migration, in search of food etc by pelagic/midwater trawling is a comparatively recent method in India. This technique, though tentatively attempted in the past from small craft, was introduced from larger vessels only during 1980-81 on a regular basis, but on a modest scale. The total effort was rather limited. The catches were mainly constituted by elasmobranchs (sharks and rays), ribbon fish, nemipterids, clupeids and horse mackerel. Table - II gives details of midwater trawling and catches by four larger survey vessels on east and west coasts. An average catch rate of 785 kg per successful tow was registered off the east coast, the latitude-wise range being 233 (Lat. 19°N) to 2194 kg (Lat. 14°N). On the west coast, the catch per tow was in the range of 23-923 kg, the average being 711 kg in respect of the identical trawlers **Matsya Vishwa** and **Matsya Shakti** surveying south-west coast and 230 kg by **Matsya Varshini** for north-west coast. Similar to the results of purse seine operations, midwater trawling reveals availability of resources rather than their abundance.

Long lining

Oceanic resources of tunas and allied species were being exploited from Indian ocean and seas around India by Japan, Korea and Taiwan until the declaration of EEZ by India. While the EEZ of 2.02 million sq km was brought under our national jurisdiction, the technique and skill required for exploiting these resources was inadequate. A few attempts made during the seventies to acquire the technique did not prove successful as the vessels available were not only of less speed but also smaller in size and could not venture into the high seas. With the acquisition of larger vessels and expertise from Japan, a major break-through in exploration of tuna resources was achieved. The results of survey conducted by the vessels **Matsya Sugundhi** and **Matsya Harini** are presented in Fig.1. It could be seen that the aggregate hooking rate from many of the areas was only 1-2%. The areas along Lat.1°N (Equatorial zone), 11°, 12° and 13°N (in Bay of Bengal) and 10° (Andaman sea) yielded higher hooking rate of 2-5%. The hooking rate in respect of

yellow fin tuna is presented in Fig. 2. Hooking rates comparable to or even better than most commercial operations were obtained from the Arabian sea in the areas off the west coast, Lat. 12° and 13°N with hooking rate of 5-10% and Lat. 14°N and 15°N with hooking rate of 10-20%. Some sets in these areas yielded hooking rate of over 40%. Among the four regions explored, the highest hooking rate registered was from the Arabian sea (6.22%), followed by Bay of Bengal (2.26%). However, the hooking rates in Andaman sea and equatorial region, where the effort expended was comparatively less, were 1.51 and 1.69% respectively. The lower hooking rate in the Andaman sea and equatorial region cannot be taken as a reflection of the abundance since only a limited effort was made in these areas and that too in a very short duration of 2-4 months. Similarly, the catch composition (by number) for the regions explored indicates dominance of yellow fin tuna, **Thunnus albacares**, from Arabian sea (70%) and equatorial zone (58%) whereas in Andaman sea and off the east coast sharks formed 43% and 44% respectively. Percentage composition of big eye tuna, **T. obesus** and skipjack tuna, **Katsuwonus pelamis**, was found to be higher in the catches from the equatorial belt (8 and 3% respectively). Bill fishes contributed to the catches from all the regions (0.4-20%). The consistency in abundance of yellow fin tuna from October to March indicates that this period is the fishing season for this species in the Arabaian sea.

Demersal trawling

The demersal fish resources within 70 m depth contour along Indian coast and Andaman islands have been explored and assessed by 20 identical trawlers of 17.5 m OAL during 1971-80. With the acquisition of larger trawlers, the survey could be extended upto 300-500 m depth in different sections of east and west coasts. The results of these surveys are presented in Fig. 3 (a, b & c). The catch rate (kg/hr) along each latitude pertains to the vessels as per the programme allocations during the specific period (Table IV).

Name of vessel	Area surveyed
Arabian sea	
Matsya Nireekshani	Lat. 20°N - 23°N
Matsya Nireekshani	Lat. 6°N - 11°N
Matsya Varshini	Lat. 16°N - 19°N
Matsya Shakti & Matsya Vishwa	Lat. 12°N - 15°N
Bay of Bengal	
Matsya Jeevan	Lat. 10°N - 12°N
Matsya Darshini	Lat. 13°N - 15°N
Matsya Shikari	Lat. 16°N - 20°N

Table IV: Area surveyed by different fishing vessels

The gear operated by these vessels were not of the same specifications. As such the relative abundance of resources could not be compared in respect of different vessels. It would easily be comparable in the areas where the same vessels or identical vessels were operated for the survey using identical fishing gear. However, until the studies for stock assessment in respect of all the programmes are completed the catch rate should serve only as an indication of abundance and availability of demersal fish resources.

Fig. 3 shows that the areas between Lat. 22°N and 24°N on Gujarat coast and north of 15°N parallel along Andhra Pradesh coast are abundant in demersal fish resources (400 kg/hr). Excepting the area between Lat.18°N and 19°N (west coast) the catch rates recorded from most of the areas were in the range of 100-200 kg/hr. On east coast, the spatial distribution of demersal fishes was found to vary among latitudes and all five ranges in catch rates 50-100, 100-200, 200-300, 300-400, and 400 and above (kg/hr) were recorded. In general, the depth range 100-150 m yielded better catch

rates. Sciaenids (35%), ribbon fish (14%), nemipterids (19%) and elasmobranchs (7%) formed the bulk of the catches along north west coast whereas nemipterids (17%), **Centrolophus niger** (16%), cat fish (12%), **Priacanthus** spp. (11%), **Ariomma indica** (6%),lizard fish (6%) were found to dominate the demersal trawl catches along south west coast. Perches had the maximum share in the catches from Wadge Bank (37%) and Gulf of Mannar (20%). Other groups contributing to the bulk of the catches were nemipterids (24%) in Wadge Bank and barracuda (22%) in Gulf of Mannar. **Centrolophus niger, Priacanthus** spp. and **Ariomma indica** together formed 14% of the catches from lower east coast, followed by perches (12%), silver bellies (8%) and carangids (6%). The catches from upper east coast were supported mainly by sciaenids (14%), **Decapterus** spp. (14%), clupeids (9%), mackerels (6%), cat fish and carangids (5% each), and pomfret and perches (4% each). Deeper waters beyond 200 m depth gave the non-conventional species of fish **(Centrolophus niger, Priacanthus** spp.) and deep sea prawns belonging to the genera **Aristeus, Heterocarpus. Solenocera** and **Perapandalus**, and deep sea lobster **Puerulus sewelli.**

Fishery resources along upper east coast

Exploratory fishing in upper east coast by 17.5 m vessels revealed potentially rich fish and prawn resources during the seventies. Bottom trawling by larger vessels along with diversified fishing adopting purse seining and midwater trawling during the years 1980-86 have also lead to location of new fishing grounds beyond traditional fishing areas.

Purse seine operations for pelagic resources have indicated several exploitable shoaling species. Fig. 4 shows that tunas (skipjack **Katsuwonus pelamis** and yellow fin tuna **Thunnus albacares**),horse mackerel, frigate mackerel, sharks, pomfrets, cat fish, carangids, silver bellies, seer fish, dolphin fish could be pursed by tracking down their schools/aggregations. The catch per set varied from 40 (20-87 area) to 7755 kg (14-80 area). The maximum catch obtained was 7755 kg of skipjack tuna in a set made in the area 14-80 at 235 m depth. The average catch recorded for the explored areas is 871 kg/set. As stated earlier, the results are more of a qualitative nature.

Pelagic/midwater species/groups were also explored by midwater trawling. The areas surveyed and the dominant fish species caught therein are shown in Fig. 5. The bulk of the catches were of ribbon fish which was caught to the extend of 4208 kg in a single haul. The other groups encountered in the catches were elasmobranchs, clupeids, mackerels, anchovies, carangids, cat fish, pomfret, seer fish, etc. The catch rate of 785 kg/tow indicates the merits of midwater trawling. The catches obtained by both the techniques (i.e. purse seining and midwater trawling) from the areas south of Narsapur (between Lat. 14°N & 16°N) and off Chilka lake (between Lat. 19°N & 20°N) were dominated by clupeids whereas the areas south of Visakhapatnam and Kakinada yielded higher catches of sharks.

Demersal fishery resources survey data from larger vessels operating along upper east coast are studied. To facilitate analysis, the survey area is divided into three sectors, namely I (Lat. 13°N to 16°N), II (Lat. 16°N to 20°N) and III (Lat. 20°N to 21°N). The catch rate obtained in each of the squares (1° Lat. x 1° Long.) is grouped into six yield ranges (Fig. 6). The areas south of Kakinada explored by the vessel **Matsya Darshini** have recorded higher catch rates of 200 and 400 kg/hr. The northern areas surveyed by **Matsya Shikari** and **Matsya Darshini** between 18°N and 21°N mainly registered uniform catch rate 101-200 kg/hr. The areas off Visakhapatnam produced comparatively poor catch rates(<50 and 50-100 kg/hr). Fig. 7 shows the catch rate obtained from three depth zones. Comparatively higher catch rate was recorded from 50-100 m depth zone of Sectors I and II, whereas the catch rate was found to decrease from shallow to deeper waters in Sector III. The surveys indicate potentially rich resources of clupeids, pomfrets. 'Ghol', decapterids, mackerels, nemipterids, cat fish, and silver bellies in the areas within and around 100 m depth along upper east coast. Clupeids belonging to the genera **Ilisha, Thryssa, Sardinella** and **Hilsa** formed a significant component of the catches especially from the areas off Kakinada, off Chilka lake and the Sand heads. Some of these species gave maximum catch rate from deeper waters (51-100 m). The average catch rate 109 kg/hr was recorded from the area 17-83. Pomfret rich grounds have been located (140 kg/hr at 51-100 m depth) off Narasapur and Machilipatnam (Lat. 15°N, 16°N). About 5 tonnes of pomfrets were netted in a single haul of 3 hours

duration from 71-73 m depth. Potentially rich grounds of mackerels (**Rastrelliger kanagurta, R. brachysoma** and **R. faughni**) have been locateed significantly in the course of demersal trawl survey along Andhra Pradesh, Orissa and West Bengal coast, their abundance was more pronounced around 101-150 m depth zone. The sand heads appear to be an area of abundance for mackerels, where catches as much as 5-10 tonnes were commonly caught in 2-3 hours of trawling. The Indian drift fish, **Ariomma indica** and Bulls eye, **Priacanthus** spp. though caught seasonally from areas within 100 m depth, the 100-300 m depth belt appears to be their regular habitat. Along Andhra Pradesh coast priacanthids were caught at the maximum rate of 1225 kg/hr and their abundance traced to waters around 150 m depth. The Indian drift fish registered an aggregate catch rate of 10 kg/hr, the highest yield being 400 kg/hr.

Discussion and general considerations

Marine fish production in India had reached a level of 1.2 million tonnes in the year 1973 and thereafter registered slow growth for quite some period. It appeared to have reached a plateau during 1981-1983 (1.4 to 1.5 m tonnes). However, from 1984 onwards the catches are around 1.7 m tonnes. In 1976, Government of India declared EEZ of 200 nm encompassing 2.02 million sq km sea area around the country. This event followed by increased mechanisation, import of trawlers and exploratory surveys undertaken in different sections of Indian coast led to the increase in marine fish production thereafter to reach 1.7 million tonnes in 1984. Exploratory Surveys have been one of the catalytic agents for development of fisheries. Soon after establishing demersal trawling as an effective fishing technique, the 17.5 m vessels and larger trawler **Matsya Vigyani** from Paradeep and Calcutta bases of Fishery Survey of India (then EFP), located rich prawn grounds along Orissa-West Bengal coast (Sudarsan & Joseph, 1979). Since then the Sandheads and adjoining areas have been the main commercially viable prawn fishing grounds. The areas within 70 m depth along the Indian coast and Andaman Islands were assessed for demersal fishery resources by 20 identical trawlers (17.5 m OAL & 200 BHP) during 1971-80. The demersal fishery resources around mainland India were estimated to have an annual potential yield of 16,79,000 tonnes (Joseph, 1980), and those around Andaman islands as 44,576 tonnes (Sudarsan, 1978). While these surveys were in progress, the need for diversified fishing

techniques was keenly felt in the context of increasing fish production in India and particulary for exploiting varied types of resources of the upper east coast. With the acquisition of larger vessels the demersal trawl survey was extended to deeper water areas upto 300-500 m depth. While assessment of demersal fishery resources from deep sea areas in different sections of Indian coast are in progress, such study in respect of Wadge Bank shows the potential yield as 19,000 tonnes (Joseph et al; 1987). Purse seining and midwater trawling could be adopted to exploit the surface shoaling and transitory fish species. The tuna long line surveys have established commercially viable resources of yellow fin tuna (4.33% hooking rate) along south west coast (Arabian sea) besides the promising hooking rate registered in Bay of Bengal, Andaman sea and equatorial region.

George et al., (1977) and Sudarsan and Joseph (1978) have opined that upper east coast's share (in marine fish production of our country) could be substantially increased through developmental efforts/surveys. The surveys conducted along upper east coast, in recent years, have shown that purse seining and midwater trawling could be effectively employed for harvesting the surface shoaling and transitory fish species/groups. Skipjack tuna **(Katsuwonus pelamis)** and yellow fin tuna **(Thunnus albacares)**, horse mackerel, frigate mackerel, elasmobranchs, pomfrets, ribbon fish, carangics, mackerels, silver bellies, anchovies, decapterids and dolphin fish can be the target species/groups that could be caught in midwater trawls and purse seines. Though the tuna long lining technique is yet to be tried on an adequate scale in Bay of Bengal, the consistent occurrence of tunas (skipjack and yellow fin tuna) and dolphin fish in purse seine and midwater trawl catches lend support to the belief that tuna and tuna-like fishes are abundant in this region. It is interesting to add that yellow fin tuna are caught seasonally (October - December/January) by the crew of shrimp trawlers using hand lines from the area north of 17°N latitude. Hence, the oceanic resources of tuna and allied species should form one of the major resources off upper east coast. This view could be further strengthened by the fact that east coast and the Andaman and Nicobar archipelago have about 60% of the EEZ of India (1.16 million sq km).

Recent demersal fishery resources surveys extended to cover deeper water areas upto 300/500 m depth have elucidated three types of resources on upper east coast.

(i) Conventional resources that could yield more from traditionally fished areas/grounds;

(ii) Conventional resources that could be exploited from extended grounds in deeper waters beyond the traditional ground and

(iii) Non-conventional resources available in deeper waters.

Clupeids, 'Ghol', Pomfrets, decapterids, mackerels, cat fish, silver bellies, nemipterids, elasmobranchs formed the first and second categories of resorurces whereas Indian drift fish - **Ariomma indica**, Bulls eye- **Priacanthus** spp., Black ruff - **Centrolophus niger**, deep sea prawns and oceanic squids could be grouped under non-conventional resources. Earlier exploratory fishing off Andhra Pradesh, Orissa and West Bengal coasts have also shown abundance of nemipterids and cat fishes in this region (Krishnamoorthi, 1973; Sekharan, 1973). Though the declining trend in demersal fish catch rate in certain pockets along Indian coast has been reported (Sivaprakasam and Somvanshi, 1986), the exploration in deeper water areas in all the sectors gave promising results thereby indicating scope for increasing marine fish production. Several small, but trawlable grounds rich in deep sea fish resources have been located beyond 200 m depth which dispels the belief that the grounds are not trawlable in deeper waters along the east coast (Somvanshi and Joseph, 1986). Sudarsan and Joseph (1978) have estimated the potential yield from east coast and Bay of Bengal as 1.869 million tonnes (about 42% of the 4.5 million tonnes expected from Indian EEZ). The trend in marine fish production and share of upper east coast in all India marine fish landings during 1956-1985 (Table V) reveals that there has been perceptible increase in contribution from upper east coast over the years (7% in 1960 and 13% in 1984-85). Similar trend in the export of marine food products from upper east coast has been set (0.4% in 1970 and 23% in 1984-85) mainly due to the presence of grounds rich in prawns along upper east coast. Sudarsan and Joseph (loc.cit.) have aptly

stated that "if the past was with the west coast, western states and Arabian sea, the future perhaps lies more in the east coast, eastern states and Bay of Bengal". It has been concluded, based on primary productivity studies (Radhakrishna et al., 1978; Bhattathiri et al., 1980), that there is not much of a difference in the point to point productivity in Bay of Bengal (East coast) and Arabian Sea (West coast). Therefore, the difference in fish landings vis-a-vis fish production would be due to the extent of continental shelf in each of the zones on east and west coasts. The foregoing account, on the resources picture emerging from the results of progressive surveys conducted along the upper east coast, reveals that there are varied types of resources available in considerable abundance in our EEZ and we require diversified fishing techniques for their exploitation.

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Table I: Details of Purse seining

Coast/vessel/ Latitude (°N)	No.of sets made	No.of successful sets	Catch (kg)	Catch per successful set (kg)
EAST COAST				
Matsya Darshini				
13	1	1	120	120
14	25	7	9052	1293
15	21	4	238	60
16	27	12	10660	888
17	17	5	4573	915
19	24	13	12770	982
20	9	1	40	40
Sub-total	124	43	37453	871
WEST COAST				
Matsya Varshini				
7	3	2	11025	5513
8	28	22	53715	2442
9	46	25	47788	1912
10	8	5	9054	1811
11	7	-	-	-
12	12	1	1025	1025
13	9	4	5209	1302
14	3	-	-	-
15	4	-	-	-
16	3	1	25370	25370
18	3	-	-	-
19	7	5	6321	1264
20	6	5	568	114
21	18	12	21525	1794
22	5	-	-	-
Sub-total	162	82	181600	2215

Table II: Details of Pelagic Trawling

Coast /vessel/ Latitude(°N)	No.of tows made	No.of successful tows	Catch (kg)	Catch per successful tow (kg)
EAST COAST				
Matsya Darshini				
14	3	3	6582	2194
15	11	6	2990	498
16	42	29	27341	943
17	12	5	3717	743
19	20	11	2563	233
Sub-total	91	55	43193	785
WEST COAST				
Matsya Vishwa & Matsya Shakti				
10	11	-	-	-
11	39	4	94	23
12	45	16	14762	923
13	34	1	82	82
Sub-total	129	21	14938	711
Matsya Varshini				
18	2	-	-	-
20	6	4	241	60
21	7	3	1313	438
22	6	5	1210	242
Sub-total	21	12	2764	230

Table III: Region wise catch, hooking rate (%) and catch composition (% by number) by tuna long lining

Region	No.of hooks operated	Total No. of fish caught	Yellow fin tuna	Big eye tuna	Skip-jack	Sharks	Bill fishes	Others
Bay of Bengal (East coast) Lat. 10°N-15°N	97845	2216	627	-	38	970	440	141
	Hooking rate (%)	2.26	0.64	-	0.03	0.99	0.44	0.14
	Catch composition(%)		28.29	-	1.71	43.77	19.85	6.36
Arabian sea (West coast) Lat. 6°N-15°N	166115	10334	7206	40	1160	2332	515	81
	Hooking rate (%)	6.22	4.33	0.02	0.09	1.40	0.31	0.04
	Catch composition(%)		69.73	0.38	1.54	22.57	4.98	0.78
Andaman sea (Lat.5°N-14°N)	30750	465	151	7	6	202	50	49
	Hookikng rate (%)	1.51	0.49	0.02	0.01	0.65	0.16	0.15
	Catch composition(%)		32.47	1.51	1.29	43.44	10.75	10.54
Equatorial zone Lat. 0°-5°N	25900	438	252	33	13	86	36	18
	Hooking rate (%)	1.69	0.97	0.13	0.05	0.33	0.14	0.07
	Catch composition(%)		57.53	7.53	2.97	19.63	8.22	4.11

Table V: All India Marine Fish Landings and Share of Upper East Coast

Year	All India Marine fish landings (tonnes)	UPPER EAST COAST	
		Fish landings (Tonnes)	Percent in all India fish landings
1956	7,18,779	68,733	9.56
1960	8,79,681	62,586	7.11
1970	10,85,687	1,03,862	9.11
1980	12,49,837	1,83,007	14.64
1984-85	16,15,752	2,16,867	13.18

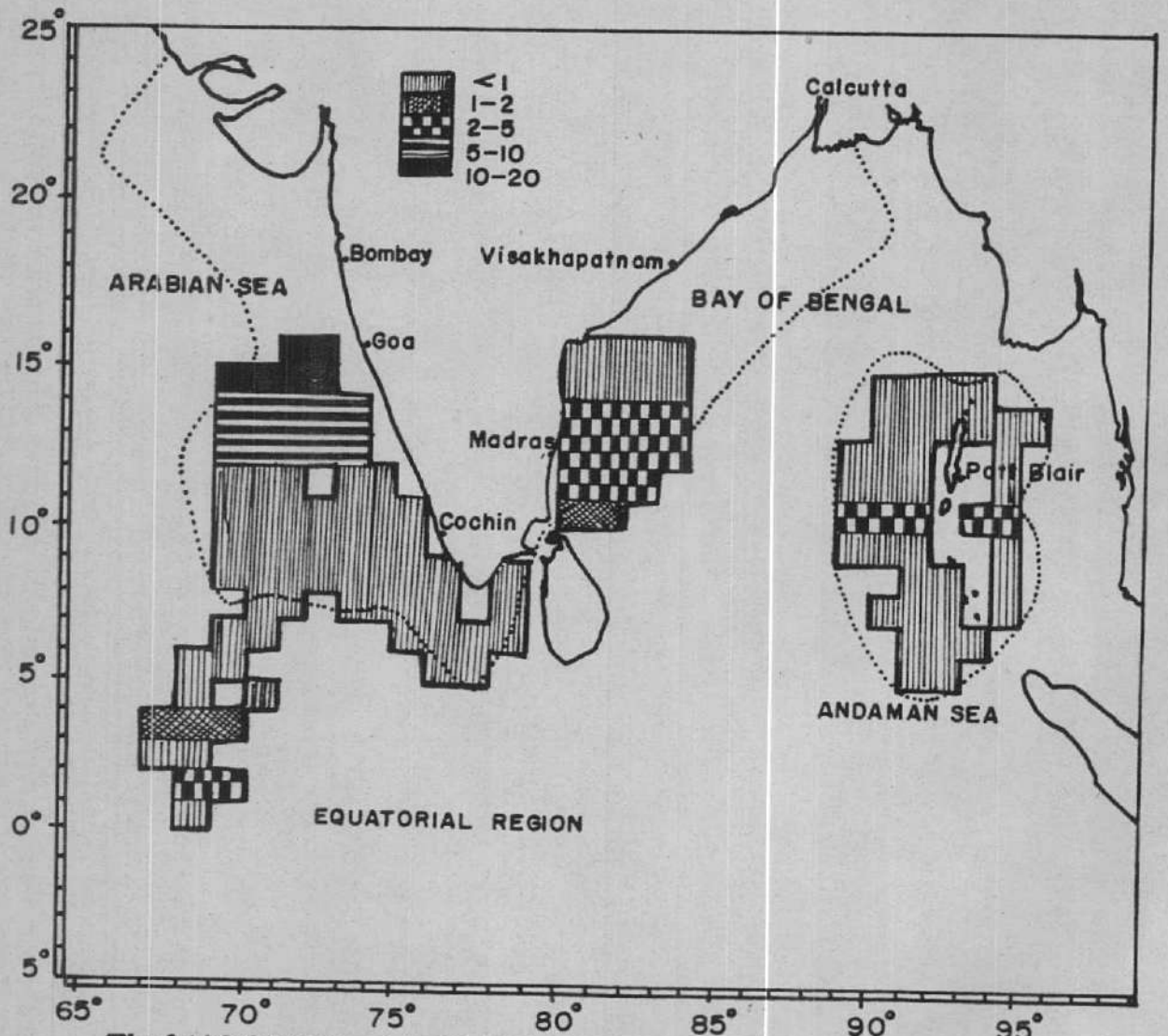

Fig.1 HOOKING RATE (%) BY TUNA LONG LINING

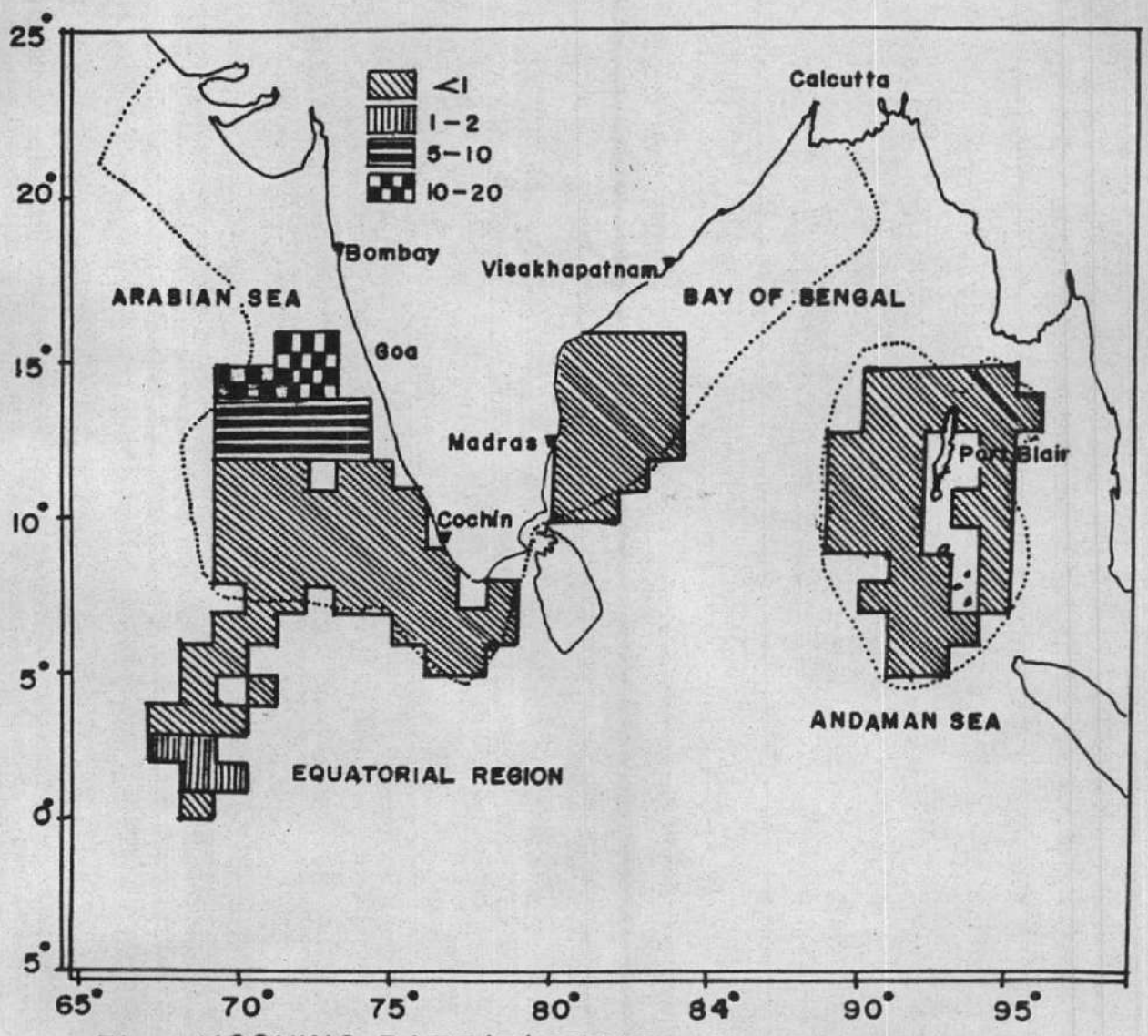

Fig.2 HOOKING RATE(%) OF YELLOW FIN TUNA

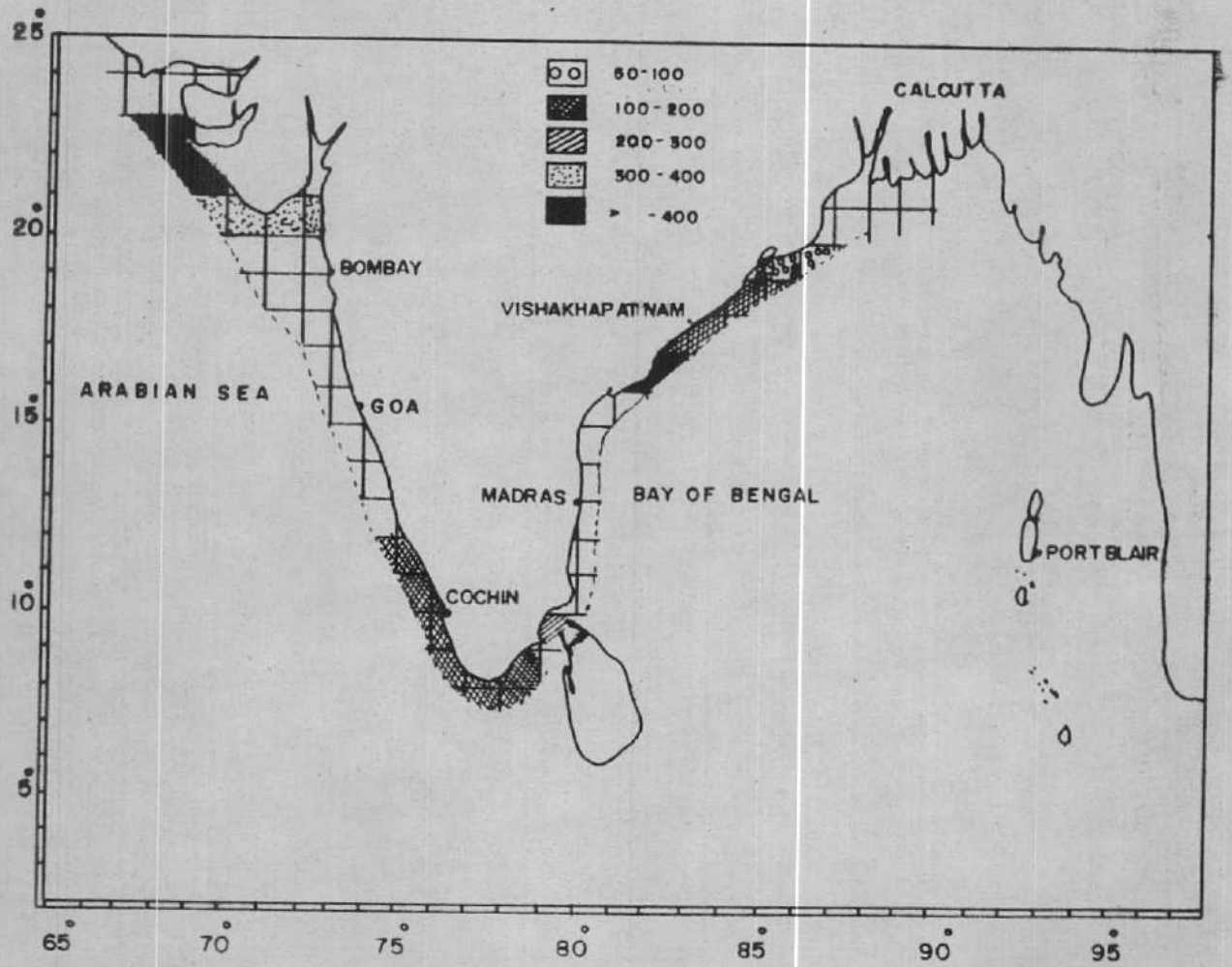

Fig. 3a DEMERSAL FISH CATCH RATE (kg/hr) BY MATSYA SHIKARI & NIREEKSHANI

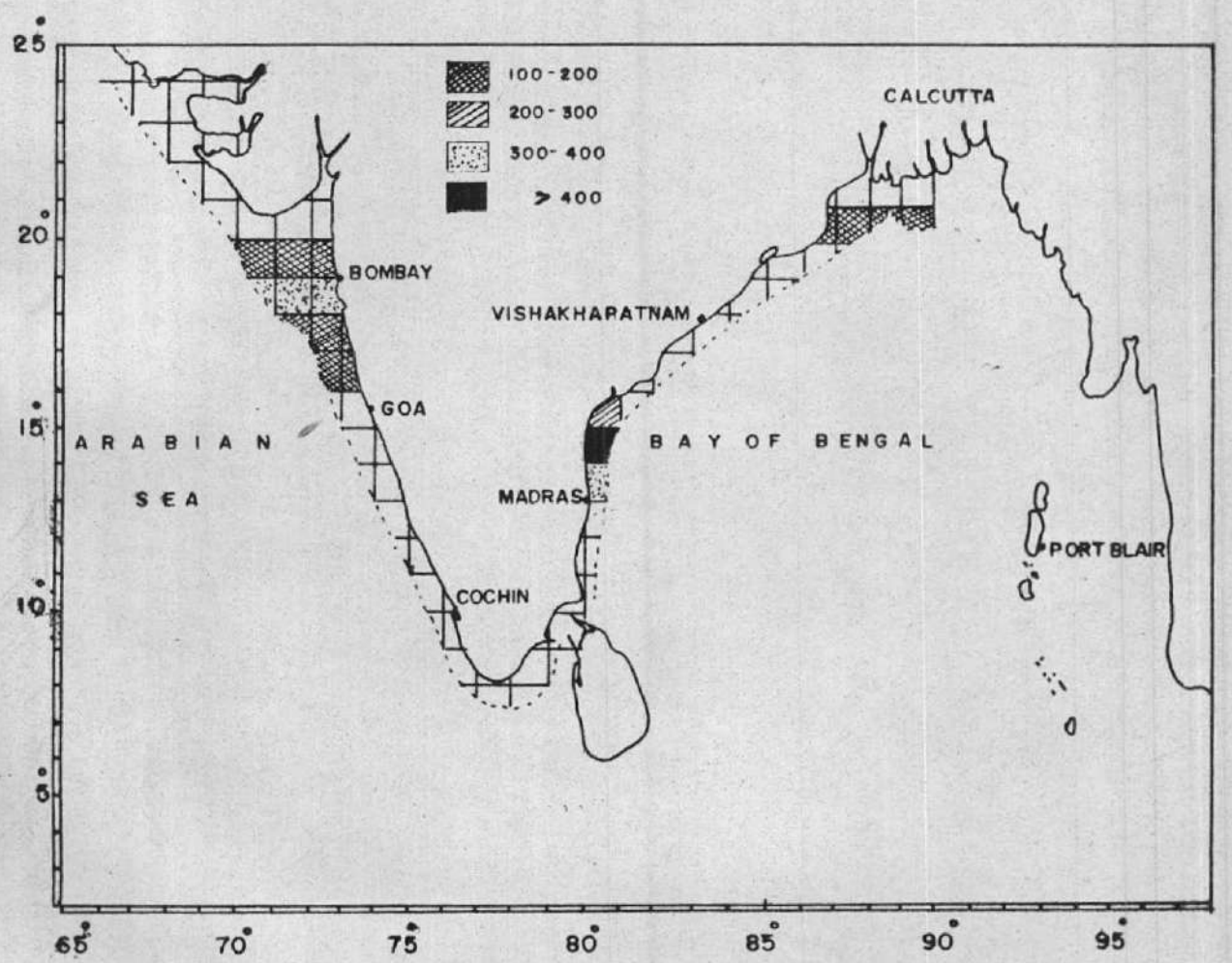

Fig 3b DEMERSAL FISH CATCH RATE (kg/hr) BY MATSYA VARSHINI & DARSHINI

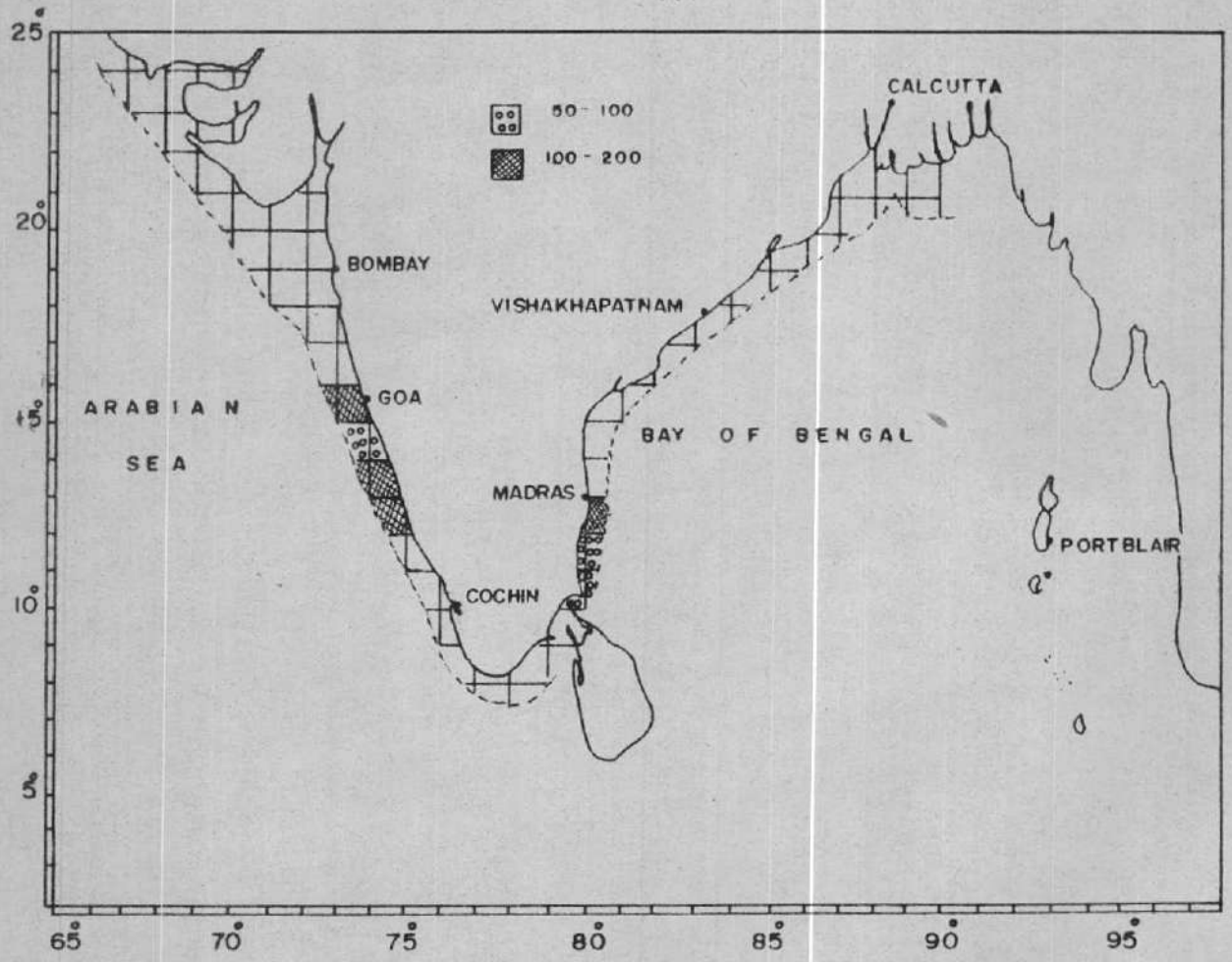

Fig. 3c DEMERSAL FISH CATCH RATE (kg/hr) BY MATSYA JEEVAN, VISHWA & SHAKTI

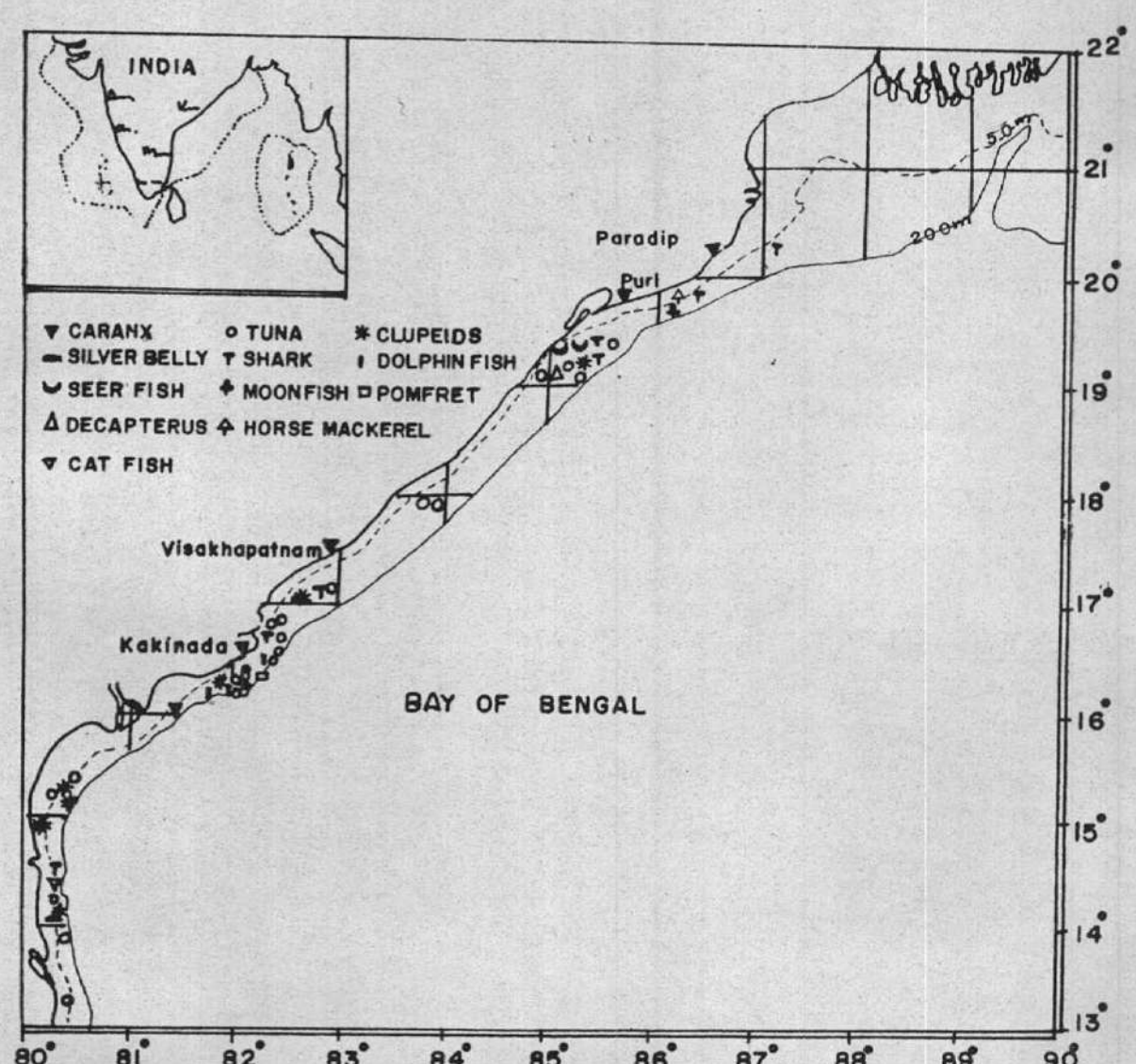

Fig. 4 DOMINANT FISH GROUPS CAUGHT IN PURSE SEINE SETS MADE ALONG UPPER EAST COAST

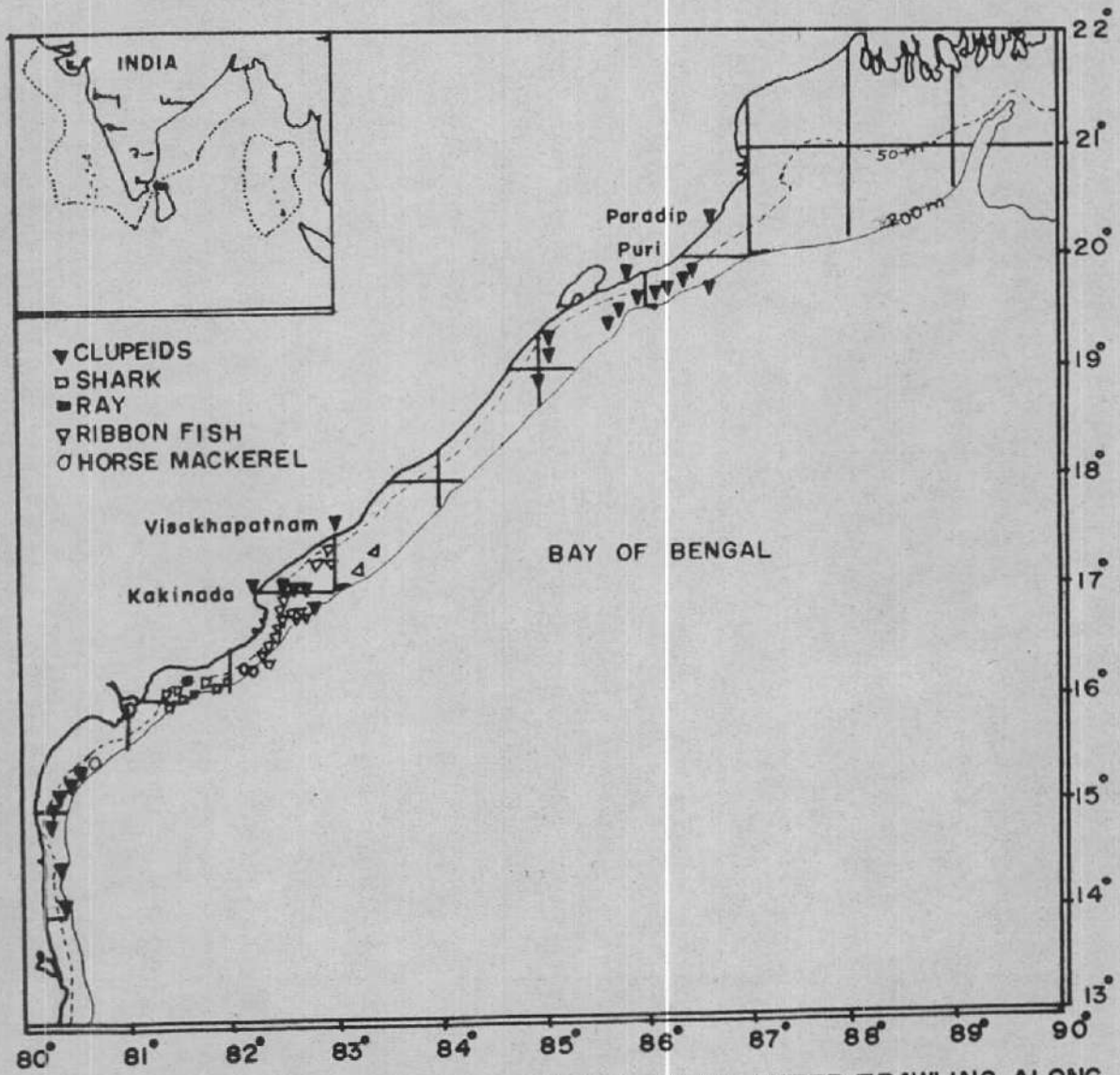

Fig.5 DOMINANT FISH GROUPS CAUGHT IN MID-WATER TRAWLING ALONG UPPER EAST COAST

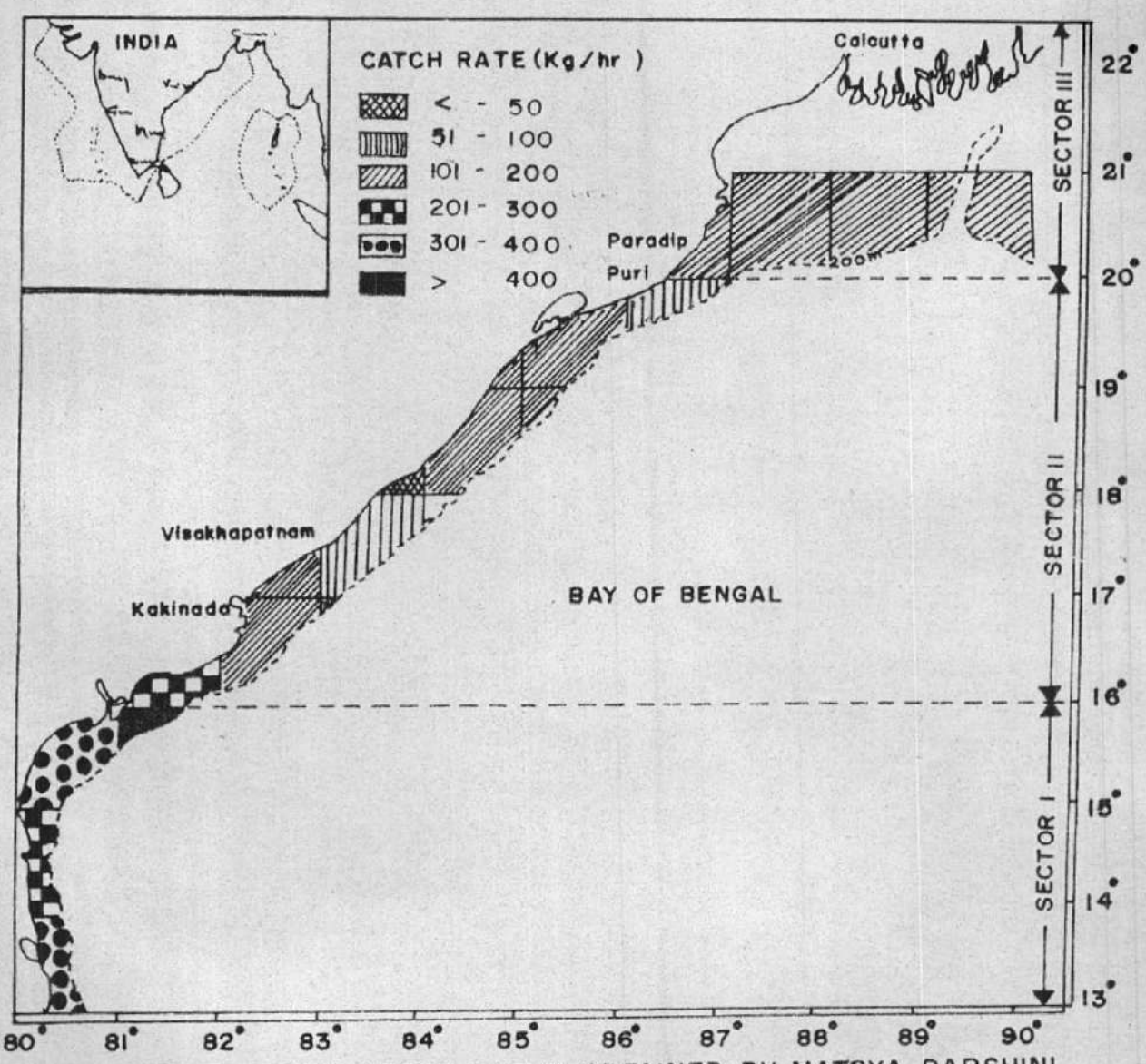

Fig. 6 DEMERSAL FISH CATCH RATES OBTAINED BY MATSYA DARSHINI (Sector I & III) AND MATSYA SHIKARI (Sector II)

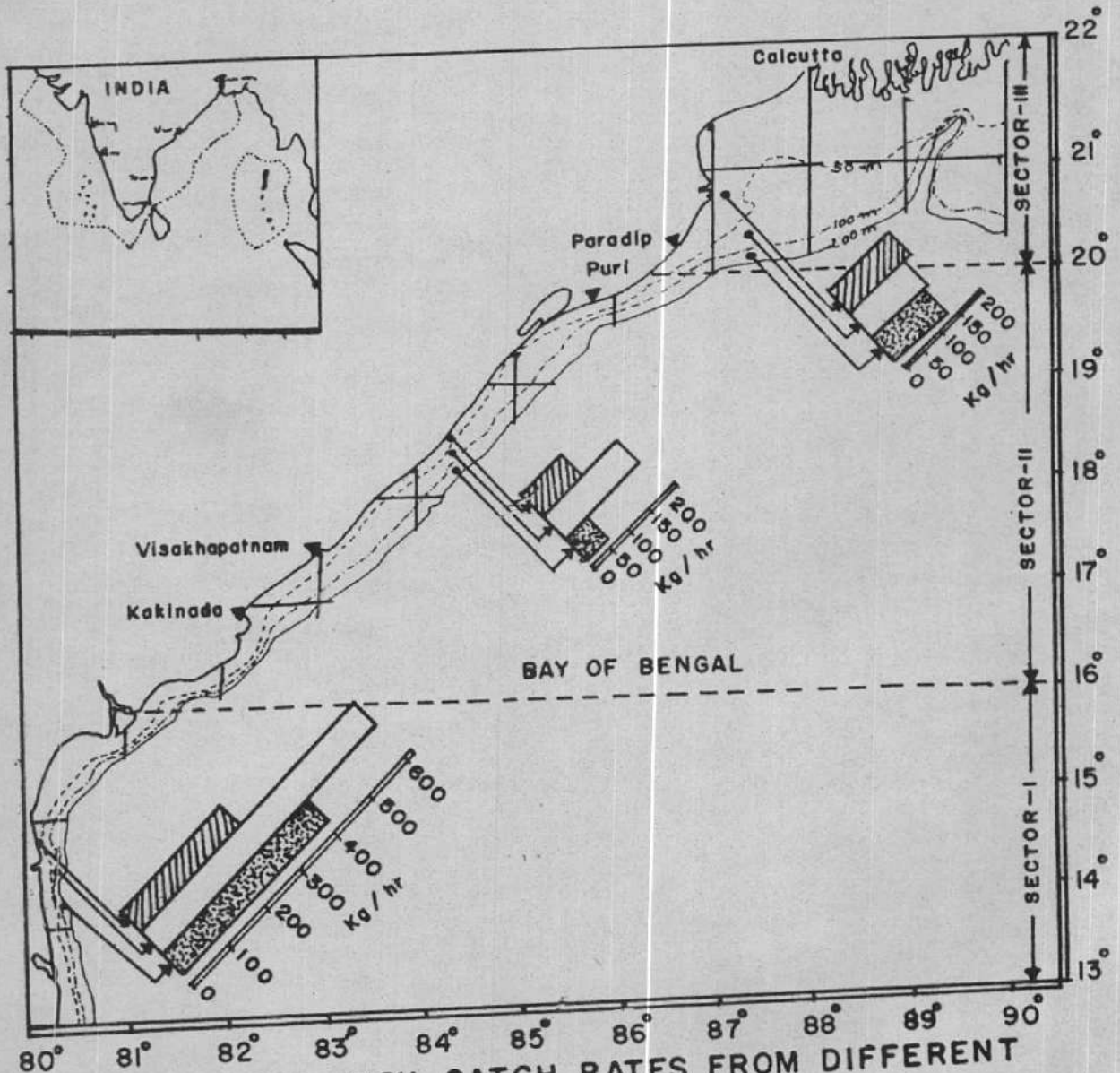

Fig.7 DEMERSAL FISH CATCH RATES FROM DIFFERENT DEPTH ZONES

OFFSHORE, DEEP SEA AND OCEANIC FISHERY RESOURCES OFF KERALA COAST

P. SULOCHANAN and M.E. JOHN

INTRODUCTION

Among the maritime states in India, Kerala occupies the foremost position in marine fish production contributing about 23 percent of the total fish production in the country (1981-84). The 560 km coast line of the state with about 220 fish landing centres encompasses 304 fishing villages having a fishermen population of about 7.8 lakhs. There are about 35,000 traditional fishing craft and 2,500 mechanised fishing boats operating in the coastal waters of Kerala. For the harvest and the post harvest systems the state has comparatively well developed infrastructural facilities. The industry, besides providing considerable employment to the coastal folk, caters to the nutritional needs of the masses and earns sizable amount of foreign exchange , Of the total 85,843 tonnes marine products valued at Rupees 461 crores exported from India during 1986-87, the shipments from Kerala accounted for about 36 percent in quantity and value (MPEDA, 1987).

In the fifties of the century, the pioneering effort of Fishery Survey of India, (formerly Offshore Fishing Station/Exploratory Fisheries Project) introduced bottom trawling in the region. The rapid mechanisation of the fishing craft in the succeeding decades resulted in the phenomenal growth of marine fish production in the State. The contribution from the traditional sector also increased steadily. Exploitation of pelagic stocks by purse seining accelerated the developmental process enhancing the total marine landing in the early seventies to over 4 lakh tonnes per annum. The significant role of Fishery Survey of India in such developments by introducing appropriate technology and undertaking resource appraisal surveys needs no special emphasis. Several productive grounds for shrimps and fish were located and the information on the nature and magnitude of exploitable stocks were disseminated to the industry from time to time.

In the seventies FSI acquired a fleet of 17.5 m vessels and conducted a comprehensive survey of the demersal fishery resources of the Indian coast upto about 70 m depth. Based on the catch data collected by these vessels Joseph (1980) assessed the maximum sustainable yield of demersal stocks from south west coast within the 70 m depth as 3,76,800 tonnes.

TRENDS IN FISH PRODUCTION IN KERALA

Fig.1 depicts the fluctuating trend in aggregate marine fish production in the state as well as the landing levels of demersal and pelagic components. The increasing trend of marine fish production of the state reached its peak in the year 1973 with 4.98 lakh tonnes. Thereafter the catches declined considerably recording the lowest production of 2.74 lakh tonnes in 1980. This declining trend in landings is conspicuous in the case of shrimps as well (Anon 1984). However from 1982 production figures indicated a positive trend reaching 4.2 lakh tonnes in 1984, which can be considered as a manifestation of cyclic ups and downs due to the biotic and other environmental factors.

An examination of the catch components during 1980-84 indicates that the harvest from pelagic realm accounts for 66.5 percent of total marine production. Oil sardine, with an average annual landing of 1.23 lakhs tonnes contributed 54.9 percent followed by anchovies (11.3%), lesser sardines (9.2%), mackerel (7.1%), carangids (4.6%), ribbon fish (3.1%), coastal tunas (3.0%) etc. The demersal resources with average landing of 1.13 tonnes was composed of penaeid prawns (28.8%), cat fish (11.1%), perches (8.9%), flat fish (7.2%), sciaenids (4.6%), silver belly (5.2%), lizard fish (4.5%), cephalopods (3.0%) etc. The production pattern of major pelagic and demersal components during 1971 to 1984 are furnished in Fig. 2 and 3.

The figures of stagnating fish production reveals that exploitation of most of the coastal fishery stocks are close to the MSY level and do not offer scope to increase the production. The size of coastal

fleet at the level of maximum economic yield has surpassed years back resulting in considerable decline of the input-output ratio. This has seriously affected the socio-economic structure of the industry. The state has promulgated regulations delimiting the fishing zones for different classes of crafts. Encroachment often leads to disputes between the artisanal and mechanised groups. The Kalavar Commission which recently examined the matter in detail recommended drastic reduction in the number of mechanised trawlers to a mere 1145.

DEEP SEA AND OCEANIC RESOURCES SURVEYS

The shrimp oriented industry restricted the operational zone within the narrow coastal belt of 50 m depth leaving the resources in outer shelf and continental slope virtually unexploited. Obviously, expanding the area of operation beyond the present realm of 40-50 m depth is the only means to augment the fish production. Absence of adequate information on the structure and compsition of the exploitable stocks beyond the 50 m contour has been cited as a major constraint for the industry to venture for the highly capital intensive proposition of deep sea and oceanic fishing.

Since 1979, with the acquisition of larger survey vessels, FSI has been able to collect consideraable amount of data on the fishery resources of the hitherto un-explored grounds in different sections of Indian EEZ. The three vessels listed below were based at Cochin Base of FSI for different durations.

Vessel	OAL (m)	GRT	BHP	Country built	Type of survey	Duration of survey
Matsya Nireekshani	40.5	329.26	2030	Holland	Bottom trawling	Oct'81-Sept'83 April'85-todate
Matsya Sugundhi	31.5	245.8	650	Japan	Tuna long lining	Dec'80 to-date
Matsya Varshini	36.5	268.8	1160	Denmark	Purse sening	June'83 to-date

DEMERSAL RESOURCES

Kerala coast

A preliminary investigation of deep sea demersal resources along the coast north of Cochin Lat. 10°-14° was undertaken by Matsya Nireekshani druing April to September 1983. The survey in south Kerala coast between Lat. 8°N to 10°N, started in April 1985, is nearing completion. It has provided information on the resources of the deeper zones of the continental shelf and slope upto 500 m depth of the region. George et al. (1977) estimated the biomass of demersal components from 50-200m depth zone of south west coast at about 68,000 tonnes. Considering that 65 percent (1980-84 average) of demersal catches of south west coast is landed in Kerala, the standing stock along the state's coastal belt of 50-200 m can be taken to be about 44,000 tonnes. Based on the survey data till 1984, Joseph (1985) estimated the standing stock as 193,000 tonnes from the 40-70 m depth zone and 60,000 tonnes from the 70-200 m depth region. The resources in peripheral shelf and continental slope between 75 to 450 m was projected by Silas (1969) as 59,000 tonnes. Oommen (1985) estimated the standing stock of deep sea demersal stock in 180-460 m between Lat. 7° and 13° N as 26,000 tonnes.

The synoptic picture of the resource information collected in the present survey upto January 1987, converted to stock density per unit area in respect of different latitudes and depth zones applying the swept area method is given below (Lat. 8° means the area between Lat.8° and 9°, and Lat. 9° means the area between Lat.9° and 10° and so on).

Latitude	Depth zone(m)/standing stock(t) per sq.km			
	40-50	50-100	100-200	200-500
8°	3.89	3.48	2.41	4.95
9°	1.95	5.91	3.89	3.18
10°	2.88	4.79	0.23	0.60
11°	6.35	6.09	1.30	0.69

The inner shelf area (40-50 m) in Lat. 11° and 8° supported higher stock densities of 6.35 tonnes and 3.89 tonnes per sq km. The 50-100m depth belt all along the coast was comparatively more productive. The standing stock in different latitudes ranged from 3.48 to 6.09 tonnes per sq km. Latitude 9° indicated high stock density in 100-200 m. In the continental slope of 200-500 m depth range Lat. 8° was more productive with 4.95 tonnes stock per sq km followed by Lat. 9° (3.18 tonnes per sq km). Joseph et al (1976) have estimated the stock density in 20-70 m along Kerala coast as 3.66 tonnes per sq km. Silas (1969) has projected the standing stock in 70-180 m as 1.66 tonnes per sq km. The average density in the continental shelf upto 180 m has been assessed by Silas (1969) as 3.16 tonnes per sq km, whereas Jones and Banerji (1973) placed the estimate at 4.2 tonnes per sq km. From the current survey it is significant to note that, in contrast to the earlier findings, the standing stock per unit area in the outer shelf and slope of Lat. 8° and 9° are comparable or even higher than that of the inner shelf.

Resource Components

The 3420 hours of survey effort yielded aggregate catch of 440 tonnes. The resource structure exhibited wide variation within the shelf area and in the continental slope as furnished below.

Depth zone	40-200 m	Depth zone	200-500 m
Groups	%	Groups	%
Nemipterids	35.0	Black ruff	31.3
Cat fish	12.3	Green eye	26.1
Priacanthids	9.8	Other deep sea fishes	24.2
Perches	9.2	Deep sea prawns	8.1
Cephalopods	7.5	Deep sea lobster	7.8
Elasmobranchs	6.0	Deep sea crabs	2.5
Decapterids	4.5		
Lizard fish	4.0		
Other fishes	11.7		

Nemipterids

Forming 35% of catch within 200 m, nemipterids emerged as the most potential resource in the outer shelf area. Silas (1969) has reported that nemipterids predominated demersal catches from 75-100 m depth along south west coast. The present survey indicated that during the monsoon season dense distribution of nemipterids is within 100-200 m depth zone whereas with the onset of south west monsoon the stock moves to shallow area of 50-100 m depth. Remarkably high catchesranging from 454-3714 kg/haul were recorded in September 1986 from 50-60 m depth between Quilon and Alleppey.

Cat fish

Cat fish forming an important demersal component from the inner coastal belt was found to have extended distribution upto 80 m depth. About 22% of catch from 50-100 m zone was constituted by cat fish.

Priacanthids

Trawl survey in the deeper waters of Kerala revealed the occurrence of large concentrations of priacanthids, popularly known as 'big eye'. Joseph (1986) has reported this fish in considerable abundance all along the Indian coast. In the 100-200 m depth belt of Kerala coast it contributed 30% of the total catch. The highest catch rate of 306 kg per hour was obtained from the same depth range of Lat. 8°N during December followed by 171 kg/hr in Lat. 9° in November. During May to October it emerged as one of the major resources from 50-100 m depth range contributing upto 34.7% of the total catch.

Perches

Larger perches consisting mainly of serranids, lutjanids and lethrinids formed 9.17% of catch from the continental shelf. Menon and Joseph (1969) have indicated possibilities of hand line fishing for serranids along Kerala coast in 60-90 m depth zone. Silas (1969) indicated considerable scope for exploitation of perches from about 60-100 m depth. Recent surveys show highest concentration of perches in the southern areas to

Lat. 8°N yielding catch per hour of 62 to 96 kg during October - December and 60 to 78 kg during March - May in the 40-50 m depth zone. The 50-100 m zone gave the highest catch rate of 40 kg per hour from Lat. 8° and 19 kg per hour from Lat. 9° during October.

Cephalopods

Squids and cuttle fish account for 7.5% of demersal catch from the shelf area of Kerala coast. Being the principal target group, cephalopods are taken in sizable quantity by the foreign trawlers operating in Indian waters under joint venture programmes. Sulochanan and John (1982) have indentified two productive grounds of cuttle fish off Quilon and Calicut-Ponnani area based on the survey reports of 17.5 m vessels. The current survey by **Matsya Nireekshani** revealed that 50-100 m stratum is the most productive ground for cephalopods where 11.3% of catch was formed of this group. The dominant seasonal changes in the distribution of cephalopods as revealed during the survey is furnished below (considering an yield above 20 kg/hr).

Month	Latitude	Depth (m)	Catch/hr(kg)
February	9°	50-100	33.2
March	10°	< 50	20.1
May	10°	50-100	28.8
September	8°	50-100	29.2
	9°	50-100	67.3
October	8°	< 50	46.3
		50-100	33.9
	9°	50-100	57.3
	10°	50-100	142.9

A bimodal pattern with the highest peak during post monsoon and second peak of lesser magnitude in the pre-monsoon is evident. During October upto 200 kg cephalopods were obtained in many hauls in 60-80 m depth. A record haul of 1.5 tonnes of cuttle fish in a single haul was made from Lat. 10°N off Ponnani.

Other demersal species

Elasmobranchs, decapterids and lizard fish constituted 4 to 6% of catch from the shelf area. Important among the species/groups contributing in lesser proportion are mackerel (2.1%), **Caranx** spp. (1.8%), ribbon fish (1.7%), barracuda (1.3%), leiognathids (0.6%), pomfret (0.5%), sciaenids (0.4%), Elacate **nigra** (0.2%), **Ariomma indica** (0.1%) etc.

Deep sea demersal stocks

The fish stocks in the peripheral shelf area and continental slope consist of few un-conventional species viz. **Centrolophus niger** ('black ruff'), **Chlorophthalmus sp.** ('green eye'), **Cubiceps** sp., **Epinnula** sp., **Emmelichthys** sp., etc. besides deep sea prawns and lobsters.

Deep sea prawns

Based on survey by the vessels of Integrated Fisheries Project during the late sixties, observations on distribution of deep sea prawns was first reported by Joseph (1970). Mohammed and Suseelan (1973) have estimated a potential yield of 5300 tonnes while Oommen (1980,85) has estimated a standing stock of 5200 tonnes from the continental slope between 7°N to 13°N. On comparing the relative yield structure from different sections of Indian coast Joseph and John (1986) observed that the continental slope of Kerala coast is the most productive zone for this crustacean group. The present review indicated average catch rate of 14.72 kg per hour with highest abundance in Quilon Bank falling in Lat. 8°N. The seasonal abundance pattern indicated October - January as the most productive season with peak catch rates of 43.6 kg per hour in Lat. 8° and 38.3 kg in Lat. 9° during January. The speceis contributing to the stock are **Heterocarpus woodmasoni, H.gibbosus, Aristeus semidentatus, Parapandalus spinipes, Plesionika martia** and **Solenocera hextii.**

Deep sea lobster

The deep sea lobster stock is formed of a single species, **Puerulus sewelli.** Oommen (1985) had indicated maximum density of the species

in 180-275 m depth range and estimated the standing stock as 12,940 tonnes between Lat. 7°N and 13°N. The recent survey of FSI vessels yielded 7.8 percent lobster from the continental slope of Kerala coast. A single haul of 550 kg lobster was recorded in Quilon Bank during August'86. Though Oommen (1985) has reported the most productive season for the species along south west coast as February to June, the present survey revealed a protracted season of abundance from August to February.

WADGE BANK

Wadge Bank lying close to the southern tip of Indian peninsula, is situated between Lat. 07°00' to 08°20'N and Long. 76° 40' to 78°00'E. This bank of high fishery potential which is in proximity to the deep sea fisheries harbour at Vizhinjam assumes considerable significance in the development of marine fisheries in Kerala. Though the demersal resources of the Bank was heavily exploited by the vessels of Sri Lanka and Taiwan, the declaration of EEZ in 1976 precluded operation of alien fleets from this fertile Bank. The charter policy of Government of India while permitting fishing in Indian waters have categorically banned the operation of these vessels in Wadge Bsank, thus reserving the bounty for our exclusive exploitation.

Fishery Survey of India undertook an exhaustive survey of the demersal resources of the Bank during 1981-83 deploying the vessel **Matsya Nireekshani.** The periodic reports on the survey and the fishery charts (FSI, 1984) give detailed information on the structure, composition and seasonal abundance of the fishery stock. Joseph et al. (1987) assessed the mean density of fish population in the Bank as 3.37 tonnes per sq km.

Resource components and their distribution

The demersal stock of Wadge Bank is composed of a large number of species. The resources could be segregated into eight groups and the

percentage composition is given below.

Groups	Percentage	Groups	Percentage
Perches	36.7	Lizard fish	4.1
Nemipterids	23.8	Cat fish	2.8
Rays	10.1	Upeneoids	2.4
Cephalopods	6.6	Others	7.8
Carangids	5.7		

Perches, a highly esteemed group of table fish are the most prominent in the Wadge Bank accounting for 36.7 percent of catch and yielding an average rate of 51.3 kg per hour. Nemipterids formed the second major group contributing 23.8 percent followed by rays (10.1%), cephalopods (6.6%) and carangids (5.7%). The bulk of cephalopod catch was consisted of large size cuttle fish **Sepia pharoanis.** Lizard fish, cat fish, red mullets (Upeneoids) and Indian drift fish (**Psenes indicus**) formed 1 to 4 percent of catch. Among crustaceans the swarming crab **Charybdis** sp. was in considerable abundance. The species contributing less than 1% are ballistids, decapterids, mackerel, pomfret, barracuda, **Priacanthus** sp., **Rachycentron canadus, Seriola nigrofaciata, Elegatis bipinnulatus,** etc. Prominent differences in the resource composition in regions within the Bank is depicted in Fig.4.

The average catch rate recorded in the survey was 139.9 kg per hour, the break up details of which are furnished below.

Groups	Catch/hr (kg)	Groups	Catch/hr (kg)
Perches	51.3	Lizard fish	5.7
Nemipterids	33.3	Cat fish	3.9
Rays	14.2	Upeneoids	3.4
Cephalopods	9.2	Others	10.9
Carangids	8.0		

The distribution pattern of the demersal stock in general as well as of the major fishery components are well documented in the fishery charts (FSI, 1984).

The unique phenomenon of the fishery which is contributed by a resident and migrant population (Sivalingam and Medcof, 1957) explains the prominent seasonal variation in yield structure. High productivity was observed in the south west monsoon season with maximum catch rate of 444 kg/hr in June.

Standing stock

The mean density of fish population in the Bank has been estimated as 3.37 tonnes per sq km and the total biomass within 20 to 180 m as 38,330 tonnes (Joseph et al.,1987). The relative fish density per unit area and estimate of standing stock are given below.

Depth strata (m)	Density per sq km (tonnes)	Standing stock (tonnes)
20-45	3.13	8550
45-75	2.12	7820
75-130	3.15	11220
130-180	5.08	10760

The stock densities of commercially important varieties are mostly confined in the inshore waters upto 75 m depth. Though the area is only 53% of the total bank, 85% of the perch and cephalopod stock was obtained from this area. In deeper areas the fishery was supported by higher density of nemipterids.

COASTAL PELAGIC RESOURCES

Oil sardine and mackerel form the main-stay of coastal pelagic fishery of the state. Present landing of these species are 1.23 lakh and 9.16 lakh tonnes respectively against the estimated stock of 4 and 3 lakh tonnes repectively (PFP,1976). Based on the landings of last several years

about 70% of the stock of oil sardine (2.8 lakh tonnes) and 60% of the mackerel stock (1.8 lakh tonnes) can be apportioned to the Kerala coast. However the trend in landing of these pelagic species leave little scope for further expansion of the fishery within the coastal belt. The recent pelagic survey by purse seining conducted by the vessel **Matsya Varshini** in 40-200 m depth revealed availability of the conventional stocks and other resources extending upto 60 m depth beyond the present zone of exploitation. Though mackerel and oil sardine constituted the major components forming 33% and 17% of catch respectively it was significant to note that their period of availability in deeper waters differed considerably from that of the inshore region. Mackerels were mainly obtained during June to November and sardine during September - November. Among coastal tunas, schools of little tuna were more often encountered and frigate tuna and bullet tuna in lesser concentrations. **Alepes djedaba, A. melanoptera** and **Decapterus** spp. were among the carangids recorded. Purse seine operated off Cape Comorin during February 1985, caught 7 tonnes of "rainbow runner" **(Elegatis bipinnulatus)** and 3 tonnes **Caranx** sp along with an assortment of other species such as **Elacate nigra, Scomberomorus** sp., **Euthynnus affinis, Caranx** sp. (Sivaprakasam and Nagarajan, 1986).

The survey revealed that the pelagic shoals in general were available mainly within 60 m depth and the results do not indicate considerable resources in deeper waters.

OCEANIC RESOURCES

The potential yield of high sea tunas from Indian Ocean has been estimated by several authors in the range of 100-150 thousand tonnes (Gulland, 1971; Suda 1974; IOFC, 1977). Tuna fleets of Japan, Republic of Korea and Taiwan were known to exploit these resources from the fifties. But there is no organised tuna fishery in India, except the pole and line fishing for Skipjack in Lakshadweep.

Fishery Survey of India had commenced investigation on the larger pelagic resources of Indian seas since early sixties. **M.V. Pratap** conducted preliminary investigations during 1961-63 based on which Eapen (1964) had suggested positive developmental prospects of tuna fishing in Indian waters. Recognising the urgent need of developing tuna fishery from the country a systematic survey in Indian EEZ by long lining was taken up by FSI from 1980 deploying the vessel **Matsya Sugundhi.** From the available data Varghese et al. (1984), Sulochanan et al. (1986) and Sivaprakasam and Patil (1986) have reported revival of the tuna stock in the Arabian sea. The results obtained during October 1983 to January 1987 give a precise understanding of the stock structure and relative abundance pattern of tunas and allied species in the south west region of the EEZ. About 1.95 lakh hooks were operated during this period between Lat. 5°N to 16°N and Long. 69° to 79°E.

Resource composition and Hooking rate

The survey yielded an aggregate catch of 11505 fishes weighing about 355 tonnes. Yellowfin tuna **(Thunnus albacares)** was the predominant species forming 68.5% of catch by number and 71.4% by weight. Further discussion on the resources is based on numerical indices done. Big eye tuna and skipjack were the other scombroids forming 1.5% of total catch. Bill fishes consisting of sail fish, marlins and sword fish accounted for 5.6% and pelagic sharks 23.1%.

The average hooking rate obtained in the survey was 5.9 fishes (182 kg) per 100 hooks. The individual hooking indices of different species recorded alongwith average weight are furnished below.

Species/group	Hooking rate (%)	Average weight (kg)
Yellow fin tuna	3.95	32.2
Big eye tuna	0.04	41.9
Skipjack	0.11	4.3
Bill fishes	0.29	40.5
Sharks	1.30	31.8
Others	0.21	5.2

On examining the catch rate for every 1° square it was found that the maximum rate of 28.1 percent hooking was from the area 14-69 followed by 23.6 percent in 15-72 and 19 percent in 14-72. The highrate of productivity and protracted period of sustainability in the area 14-72 was established by repeated sets of operation of 19,300 hooks. Sampling in the other two squares being limited, further investigation is required to confirm the magnitude of their sustainability. The hooking rates, aggregate as well as in respect of yellow fin tuna for every 1° square of the survey are furnished in Fig. 5. The areas in Lat. 12°N to 15°N, 50-150 miles off Mangalore - Goa coast is the richest grounds from where average hooking rate of 10.8 percent was recorded. The hooking rate of 4.07 percent yellow fin tuna in the survey area in general and the indices in the range of 10 to 28 percent from the squares 12-69, 13-71, 14-69, 14-72 and 15-72 are incomparably higher than the hooking rates of 0.6 to 1.4 percent recorded by the fleets of Japan, Korea and Taiwan from Indian Ocean during the last decade. While analysing the tuna long line catches close to India, Maldives and Srilanka Sivasubramaniam (1981) reported hooking rates of 0.07 to 1.5 percent in the oceanic areas north of equator upto Lat. 10° between Long. 70°E and 80°E. Druzhinin (1973) reported catch rate of 16.7 kg tuna per 100 hooks in the western Arabian sea in Lat. 10°N-15°N which roughly works out to 0.5% hooking by number. The comparisons substantiate the exceptionally high productivity of tuna in the south west oceanic areas of the EEZ.

The seasonal abundance showed that high catch rates prevailed from the fag end of south west monsoon commencing from September-October and lasting upto April - May. The hooking rates of tuna obtained in the most productive sets from these areas are given below.

Month	Area	Tuna hooking rate(%)	Month	Area	Tuna hooking rate(%)
October'85	14-72	23.8	October'86	13-72	20.1
January'86	12-73	27.4	November'86	13-71	39.4
"	14-72	38.2	"	14-69	27.8
February'86	14-71	37.8	December'86	15-72	40.5
April'86	14-72	27.3	January'87	14-72	20.1
September'86	12-73	20.2			

The hooking rates are probably the highest recorded in the realm of Indian Ocean. The high degree of sustainability of the stock was confirmed by repeated survey and monitoring over several months and in successive seasons. The survey thus indicated remarkably high possibilities of exploitation of tuna from the Indian waters.

CONCLUSION

The possibilities of augmenting fish production from the shallow waters of Kerala is rather limited. Diversification of effort to exploit the conventional resources may effect only marginal increase. The idea of reduction of fishing pressure in the inner shelf for conservation of the stocks is gaining ground. In these circumstances, exploitation of the resources of outer continental shelf and slope offers ample scope for increasing the production.

The recent surveys by FSI have revealed availability of potential demersal stocks in deep seas. South west coast forms one of the best productive tuna grounds in the world. The strategy for increasing fish production in the state is probably an integrated approach of exploiting the newly found resources, developing economically viable utilisation techniques and promoting overseas trade. As an initial step towards this goal FSI has been able to generate appropriate approximations on the size and structure of potential fishery stocks in the offshore, deep sea and oceanic areas off Kerala coast and adjoining seas.

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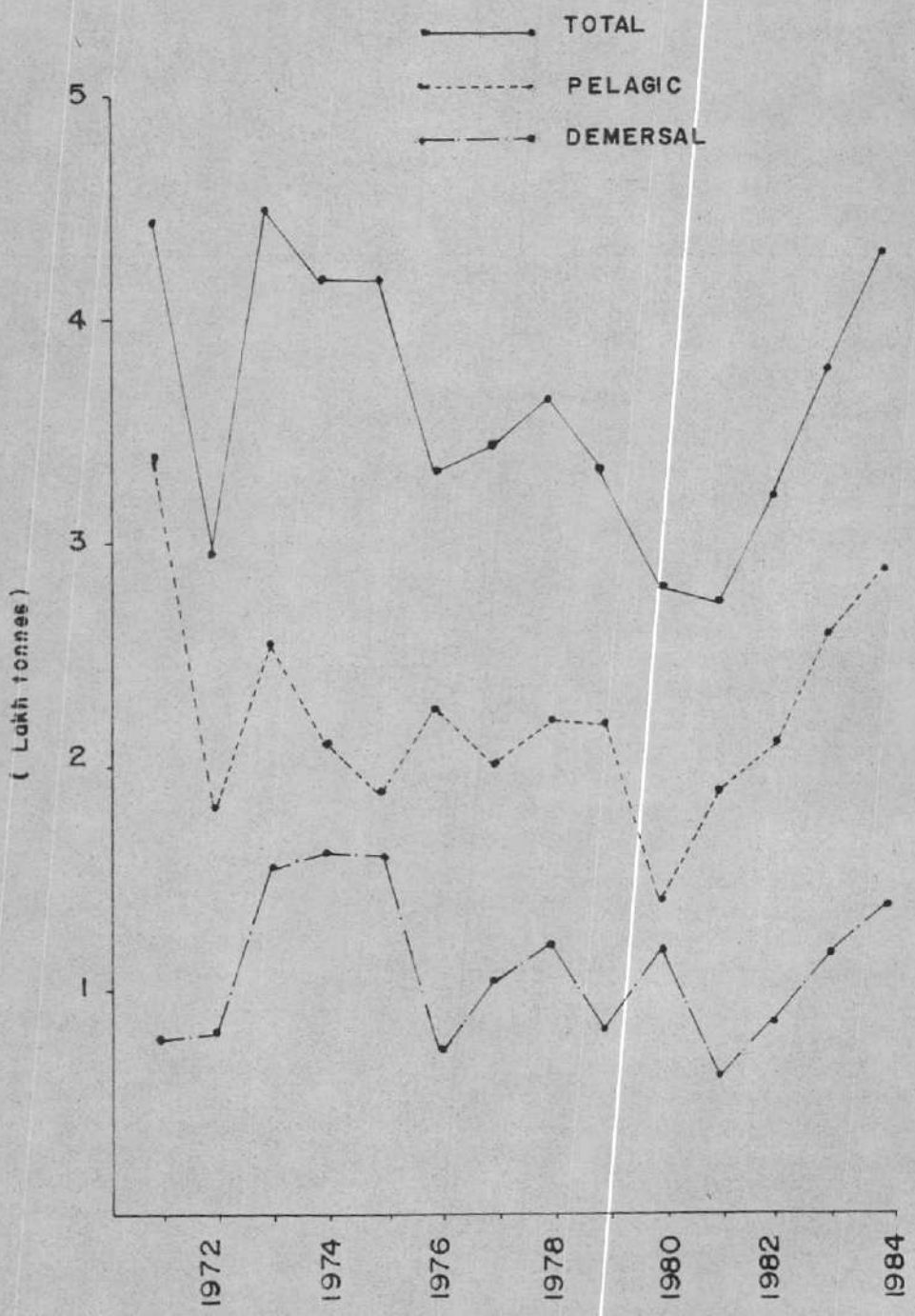


Fig.1 TREND IN MARINE FISH PRODUCTION IN KERALA ; PELAGIC, DEMERSAL AND TOTAL (1971-1984)

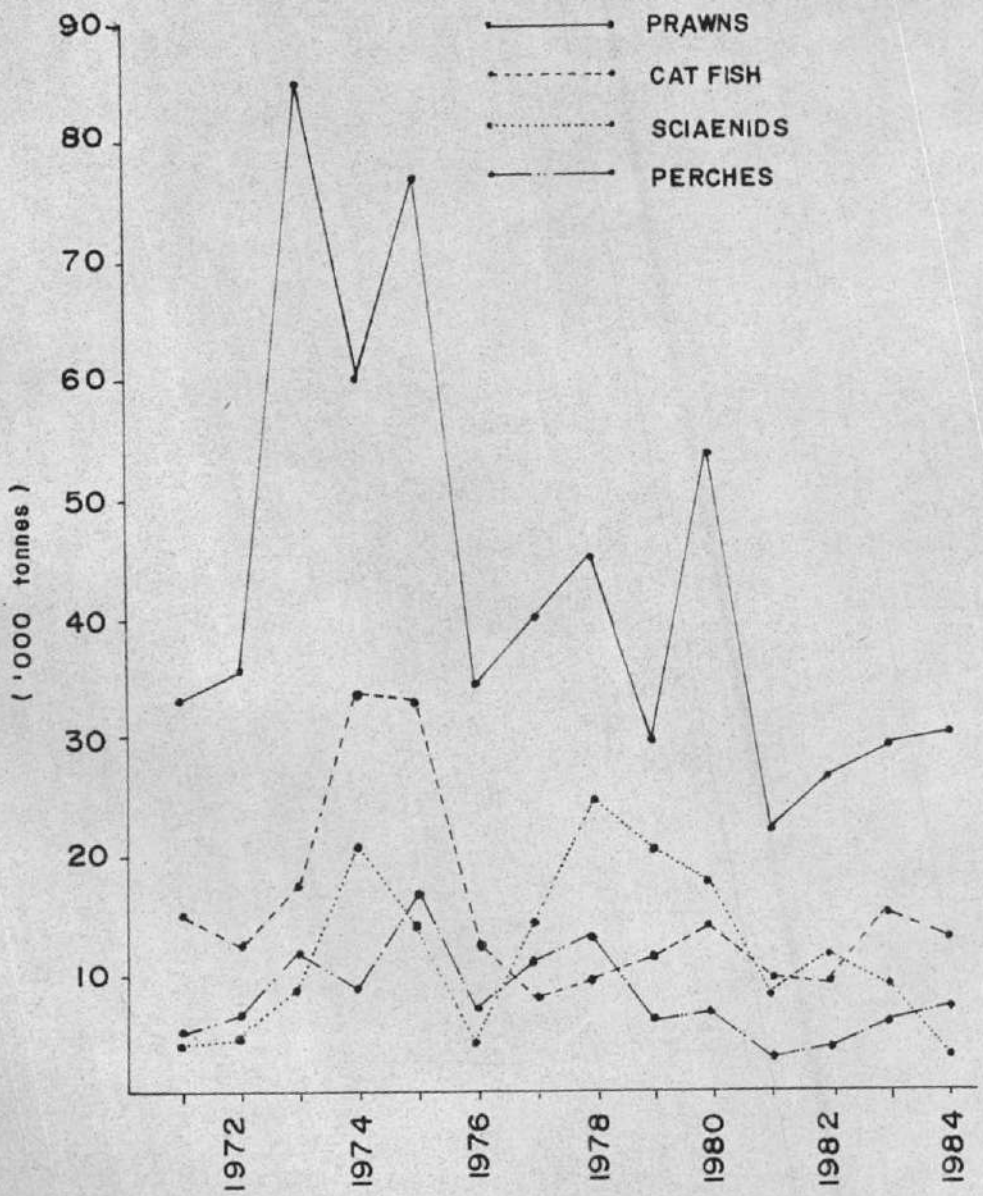


Fig 2 LANDING OF MAJOR DEMERSAL SPECIES IN KERALA (1971 TO 1984)

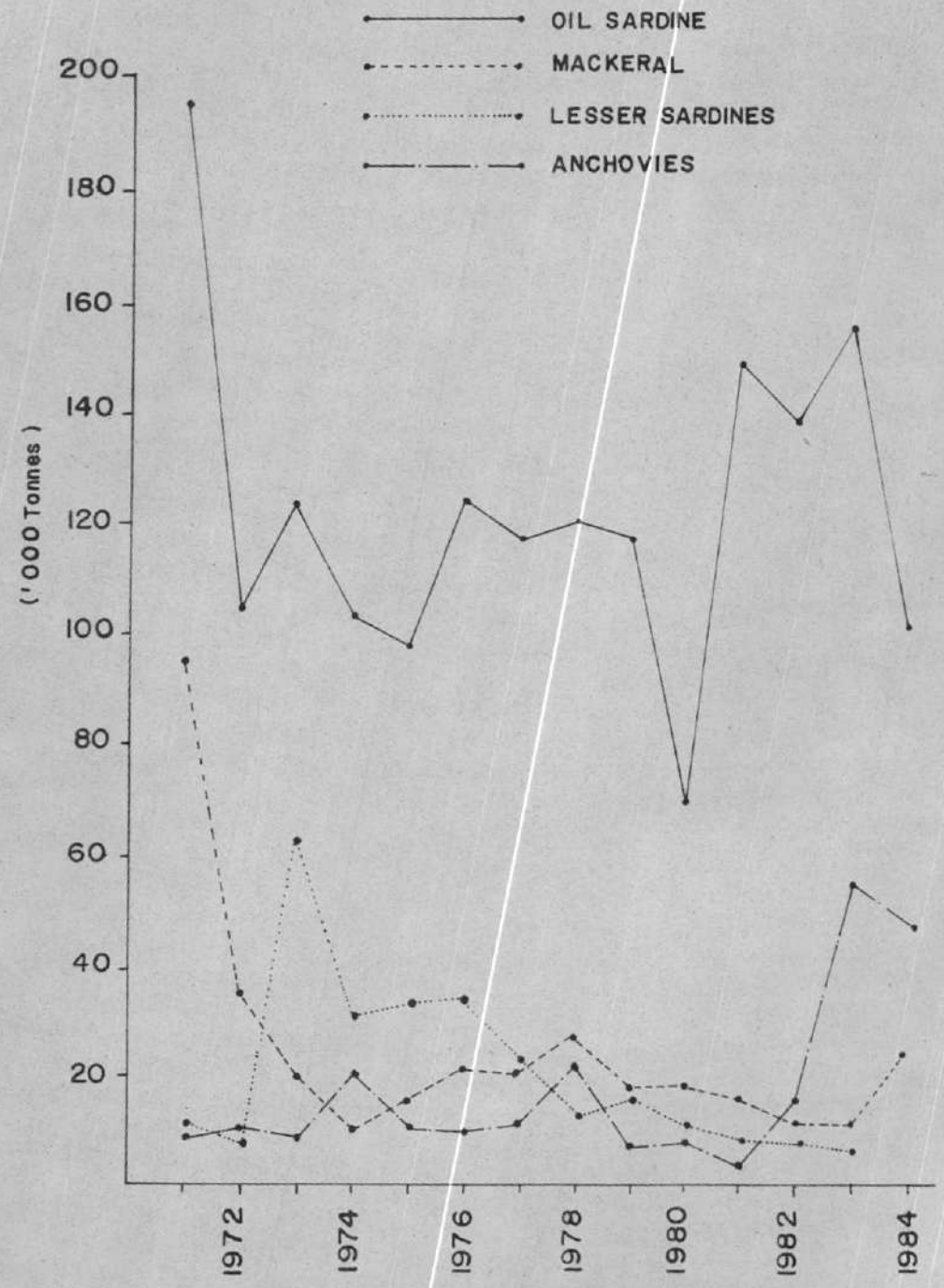
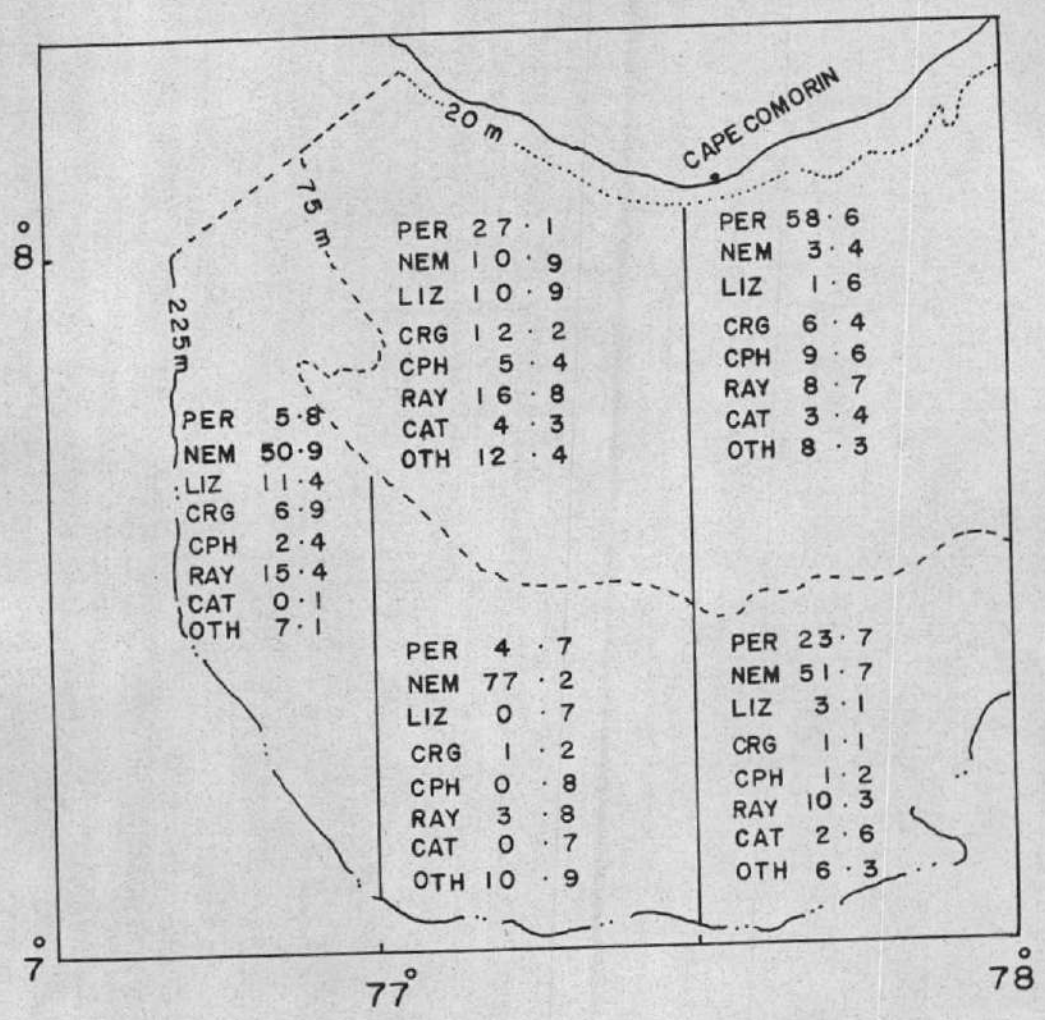


Fig. 3 LANDING OF MAJOR PELAGIC SPECIES IN KERALA (1971 TO 1984)



(PER = PERCHES , NEM = NEMIPTERIDS , LIZ = LIZARD FISH,
CRG = CARANGIDS , CPH = CEPHALOPODS RAY = RAYS ,
CAT = CAT FISH , OTH = OTHER FISHES)

Fig. 4 REGION-WISE PERCENTAGE COMPOSITION OF DEMERSAL RESOURCES IN WADGE BANK

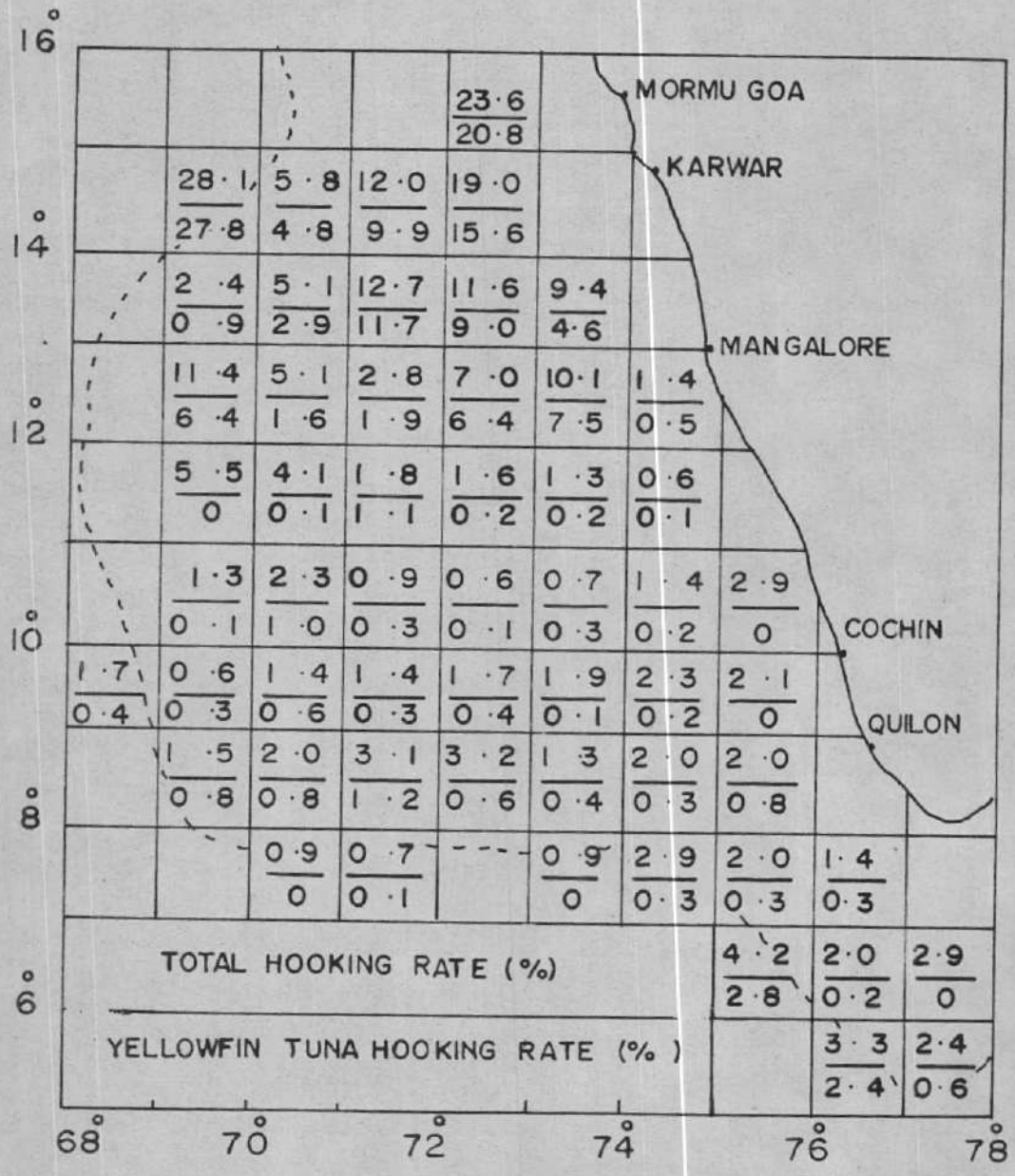


Fig. 5 TOTAL HOOKING RATE AND HOOKING RATE OF YELLOWFIN TUNA OBTAINED BY MATSYA SUGUNDHI (OCTOBER '83 - JANUARY '87)

INDIAN EEZ - AVAILABILITY OF RESOURCES AND MANPOWER REQUIREMENTS FOR THE DEVELOPMENT OF DEEPSEA FISHING INDUSTRY*

D. SUDARSAN and T.E. SIVAPRAKASAM

INTRODUCTION

The extension of the legal regime of the oceans upto 200 nautical miles marks an important milestone in the socio-economic development of coastal nations. A new area of souvereignty is created for the exclusive use of living resources. Fishing is an important economic activity which provides protein rich food for the masses, income and employment for large number of people and export earning. It has therefore become necessary to review the contributions that the fishery resources of our EEZ can make to the nutritional and economic goals and to develop and manage these resources (FAO, 1986).

The country's fish production has made a quantum jump from 7.51 lakh tonnes in 1950-51 to 28.8 lakh tonnes in 1985-86. The average annual marine fish production during 1980-84 is around 15.5 lakh tonnes. The growth rate has been 3.5% and the production could reach 17.16 lakh tonnes in 1985-86. The exports however showed tremendous growth from 15700 t valued at Rs. 3.92 crores in 1961-62 to 86200 t valued at Rs. 384.29 crorers in 1984-85. As per indication of latest exports the value of exports have exceeded Rs. 450 crores - about 4% of the total exports earning of the country. The per capita availability of fish however continues to be 3.5 - 4 kg which is about 1/3 of the nutritional requirements. The demand for fish has been estimated at 10-13 lakh t for the domestic market and 23 lakh t for industrial and export market against the current

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production 15.5 lakh t. With the increasing population (100 crores by 2000AD), the demand has been estimated at 36 lakh t and the supply should be increased to that level. This demands a growth rate of 16% per annum.

It is therefore, high time that we look at the resource potential, the present level of exploitation and the additional potential that is available for further exploitation and devise ways and means of increasing fish production through introduction of more mechanised and deepsea fishing vessels. Introduction of more vessels calls for, besides capital requirements, more trained manpower for operation and fishing, especially certificated personnel for manning the deepsea fishing vessels. The availability of resources for the development of deepsea fishing industry and the manpower requirements form the theme of this paper.

AREAS AVAILABLE FOR EXPLOITATION

Seven thousand five hundred and seventeen km of coast line can be literally the runway for the sake of fishing ventures. West coast has a coastline of 3100 km and the east coast 2600 km. The areas of continental shelf which forms the habitat of most of the fish resources including bottom fish, midwater/columnar fish and pelagic fish and that of the new ocean regime, EEZ including the continental shelf are furnished regionwise and coastwise in Table I. It is noteworthy that two thirds of our shelf area are on the west coast and half of our shelf area is on the northwest coast because of the wide shelf which is the richest in fish resources. The shelf on the east coast is narrow except along the upper east coast. But nearly 60% of our EEZ is on the eastern side particularly around the Andaman & Nicobar Islands.

The shelf area forms about a fifth of the EEZ and the area beyond 200 m forms four-fifths of the EEZ. This is noteworthy as we could see in (Table V) that 89% of the potential yield is available within 20% of the EEZ within 200 m depth. 11% of the potential yield is spread over 80% of EEZ beyond 200 m which however includes the valuable tuna resources. About 30% of EEZ is around the Andaman & Nicobar Islands. Among the remaining areas of EEZ two-thirds are along the west coast and rest along east coast.

It will be also seen that the inshore area upto 50 m forms 40% of the continental shelf and supports 63% of the fish potential. Over 99% of the fish production at present comes from this area.

FISHERY RESOURCES: EXPLORATIONS AND ASSESSMENT OF POTENTIAL

Avaialability of fish resources based on an assessment of the total biomass, current fish production and net available potential yield is a basic requirement for planning fishery development programmes. There are other requirements also such as finance, expertise, manpower etc. and based on the priorities of a nation, production targets are fixed, priority sectors are established and development programmes are drawn up. We are considering here the availability of resources and the manpower requirement for the development of deepsea fishing industry.

The Fishery Survey of India (formerly Deepsea/Offshore Fishing Station and later Exploratory Fisheries Project) has made pioneering efforts in the area of experimental and exploratory fishing. The FSI is the oldest organisation under the Government of India and at present the largest organisation too. Established in 1946, the FSI has been conducting experimental/demonstration fishing and organised exploratory fishing for various kinds of resources viz., the demersal, midwater/pelagic and oceanic resources. Other Government of India organisations, Integrated Fisheries Project, CIFNET, CMFRI have also made significant contributions in the exploration and assessment of the resources. The CMFRI and State Fisheries Departments are collecting statistics on the current fish production. There are a number of studies to assess the marine fishery potential, the current yield and additional harvestable yield (National Commission of Agriculture, 1976, Silas, 1977, Georgee et al.1977, Joseph 1985, 1987). The studies by George et al. (op cit) has been widely accepted and their estimates have been refined by Joseph (1986, 1987). These estimates are generally based on the exploratory surveys by FSI, IFP, PFP and also the trend of production. These are presented in Table II. The potential yield and current yield have been presented on a region-wise basis. It has been generally accepted that the current fish production almost entirely comes from 0-50 m belt and the areas beyond 50 m are practically unexploited. George et al.(op cit) estimated a total

annual potential yield of 4.5 million tonnes. With the increasing fishing effort by way of additional traditional craft, motorisation, additional mechanised boats and deep sea trawlers, the situation has considerably changed. Joseph (1985) therefore estimated an annual potential yield of 3.14 million tonnes. The current annual yield based on the average fish production for the period 1980-84 is around 1.56 million tonnes. Therefore a net harvestable yield of 1.62 - 2.9 million tonnes of fish are available for further exploitation. It will also be seen from Joseph (1985) that in the southwest coast and lower east coast the current production has already reached the sustainable yield level. Much of the additional yield has to come from the northwest coast, the upper east coast and the oceanic areas around Lakshadweep, and Andaman and Nicobar islands.

A more objective and policy-oriented analysis is presented in Table III. The resources have been grouped under Crustaceans (exportable) and Fishes under 3 categories viz., high quality (exportable), medium quality (high value) and low quality (low value). The current production, the estimates of potential by George et al.(1977) and Joseph (1987) and the addditional harvestable yield based on Joseph (1987) are presented. Joseph (1987) has made further revised estimates in the area between 0-200 m and 200-500 m mostly based on exploratory surveys by FSI. It will be seen from the Table that over the continental shelf about 2 million t of demersal and pelagic resources are available for further exploitation and about a lakh t over the continental slope. This does not take into account the tuna resources of which about2.5 lakh t could be expected. Among the first category, about 18000 t of prawns and about 1.6 lakh t of cephalopods could be exploited largely from the coastal belt upto 50 m through introduction of additional mechanised boats and deepsea trawlers. The second category of exportable fishes to the extent of 7 lakh t could be exploited by introduction of deepsea trawlers for perches/carangids, tuna long liners for tuna and mechanised boats of medium size for trawling as well as gill netting. The third category of medium quality fish to the tune of 4.35 lakhs t could be exploited by additional mechanised boats, beach-landing craft etc. The last category of fishes to the extent of 7.26 lakh t could be exploited by the traditional non-motorised and motorised boats. Motorisation and beach-landing crafts are likely to result in additional production and benefit will directly accrue to the poor

fishermen. The deepsea trawlers could also exploit the deepsea prawns, lobsters and fishes profitably in certain localized grounds like the Pedro Bank off Pt. Calimere and the Quilon Bank.

The current marine fish production has marginally increased during the recent years. The data in respect of 1984-85 are presented in Table-IV. It will be seen from the Table that the demersal and pelagic components have almost become equal from a pre-dominant position of the pelagic component earlier. Oil sardine continues to be the largest single resource (10.2%) followed by penaeid prawns (8%), Bombay duck (7.7%), anchovies (7.5%), sciaenids (6.7%), other clupeids (5.3%), other sardines (4.2%) etc. Statewise Kerala continues to be the major producer (23.4%) followed by Maharashtra (19.2%), Gujarat (17.8%), Tamilnadu (14.4%), Andhra Pradesh (8.2%) etc.

The availability of areas, fish potential etc. in respect of inshore and offshore areas of the continental shelf and the shelf area and area beyond in respect of the Exclusive Economic Zone are presented in Table V. The current number of traditional, mechanised and deepsea vessels and additional vessels that can be sustained by additional resources available are also presented in this table. It will be seen that in the continental shelf about 40% of the area falls within 0-50 m and almost 100% of the current fish production are believed to come from this belt. About 2/3 of the total potential are also available in this coastal belt. It will be seen that most of the additional yield have to come from offshore and deepsea areas between 50-200 m. Considering the EEZ the continental shelf forms only a fifth of the 2.20 million sq km and about four - fifths fall under oceanic areas beyond 200 m. But resource-wise about 89% of the potential is available on the continental shelf which forms 22% of the EEZ and 11% of the potential is spread over 78% of the EEZ. Based on the earlier analysis, the additional vessels that could be introduced for the exploitation of the additional resources available are also presented. It will be seen that about 3000 mechanised boats can be introduced in the coastal belt upto 50 m and another 5000 in the offshore areas, essentially for the exploitation of pelagic resources by gill netting. About 1000 deepsea vessels can be introduced for the exploitation of demersal and pelagic resources in the offshore and deepsea areas beyond 50 m and about 500 vessels including tuna long liners, purse seiners and pole and liners can be introduced in the oceanic areas for the exploitation of tuna resources and other oceanic resources like Bill fishes and Sharks.

MANPOWER REQUIREMENTS FOR DEEPSEA VESSELS

The deepsea fishing vessels require highly skilled and experienced fishermen for different kinds of fishing. Certificated officers are also required under the Merchant Shipping Act 1958. Some projections of manpower requirements have been made by Chidambaram (1985 a & b) and strategies for building up trained manpower discussed by Swaminath (1983, 1985). The statutory requirements fall under three major categories viz., the deckside officers - Skippers, Mates and Bosuns; engineside officers - Engineer and Engine Driver and Radio Telephone/Wireless Operators. Extracts of the statutory requirements under the Merchant Shipping Act 1958 are presented in Annexure-I. The requirement of officers, their certificate of competency, the minimum requirement for round the clock operation and the total number of certificated officers by the end of 7th, 8th and 9th Plans based on the projected introduction of oceangoing fishing vessels are presented in Table VII. It will be seen that the requirement of certificated officers are very high. Considering the slow nature of the training process tremendous efforts will have to be put into build up certificated manpower as projected. The training process has to be hastened taking into account the emerging manpower requirements through appropriate strategies and strengthening of the training Institutions.

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Table I: Areas available for exploitation in the Indian EEZ

(Lakh km2)

Region	Continental shelf			Exclusive Economic Zone			
	0-50 m	50-200 m	Total	0-200m	200 m to EEZ Edge	Total	
North west coast	0.93	1.31	2.24 (49.7)	2.24			
South west coast	0.21	0.59	0.80 (17.7)	0.80			
Total west coast	1.14	1.90	3.04 (67.4)	3.04	5.56	8.6	(42.6)
Upper east coast	0.44	0.24	0.68 (15.1)	0.68			
Lower east coast	0.23	0.21	0.44 (9.7)	0.44			
Total east coast	0.67	0.45	1.12 (24.8)	1.12	4.48	5.6	(27.7)
Andaman & Nicobar Islands	-	0.35	0.35 (7.8)	0.35	5.65	6.0	(29.7)
Grand Total	1.81	2.70	4.51 (100)	4.51(22.3)	15.7 (77.7)	20.2 (100)	

(Figures in parenthesis indicate percentage)

Table II: Estimated potential yield (P.Y.) and current yield (C.Y.) of marine fishery resources in India

(Figures in '000 tonnes)

Region	P.Y.estimate by George et al.(1977)						P.Y.estimate by Joseph (1985)						C.Y.(average for 1980-84)		
	0-50 m			0-200 m			0-70 m			0-200 m			0-200 m		
	Pelagic	Demersal	Total	Pelagic	Demersal	Total	Pelagic	Demersal	Total	Pelagic	Demersal	Total	Pelagic	Demersal	Total
North west coast	190	350	540	325	555	880	255	698	953	319	928	1247	241	360	601
South west coast	430	270	700	760	660	1420	447	377	824	506	438	944	335	140	475
Lower east coast	225	25	480	300	380	680	117	229	346	122	243	365	139	122	261
Upper east coast	180	360	540	195	545	740	90	372	462	97	416	513	104	108	212
Sub total	1025	1235	2260	1580	2140	3720	909	1676	2585	1044	2025	3069	819	730	1549
Lakshadweep	-	-	-	55	35	90	-	-	-	-	-	-	3	1	4
A & N Islands	-	-	-	130	30	160	-	-	-	51	22	73	2	1	3
Sub total	-	-	-	185	65	250	-	-	-	51	22	73	5	2	7
Total	1025	1235	2260	1765	2205	3970	909	1676	2585	1095	2047	3142	824	732	1556
Oceanic resources >200 m	-	-	-	-	-	500									
GRAND TOTAL	1025	1235	2260	1765	2205	4470									

Table III: Potential yield, present yield and additional yield of marine fisheries resources of Indian EEZ

('000 tonnes)

Major Groups	Current production (average 1980-84)	Estimated potential yield						Additional harvestable yield based on Joseph, 1987)	
		George et al.(1977)				Joseph (1987)			
		0-50 m	50-200m	Andaman & Lak-	200m-EEZ	Below 200 m	200-500 m	Below 200 m	200-500m
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
CRUSTACEANS AND MOLLUSCS (EXPORTABLE)									
Penaeid prawns	107	155	25	-	-	118	-	11	-
Non-penaeid prawns	96	90	15	-	-	96	-	-	-
Other crustaceans	20	30	10	-	-	38	13	18	13
Deepsea prawns	-	-	-	-	-	-	9	-	9
Cephalopods	13	50	125	5	-	177	-	164	-
Sub total	236	325	175	5	-	429	22	193	22
FISHES									
High quality (Exportable)									
Pomfrets	49	70	15	-	-	103	-	54	-
Seer fish	29	10	-	5	-	50	-	21	-
Perches	30	55	185	10	-	160	-	130	-
Carangids	33	105	160	-	-	210	-	177	-
Mackerel	46	100	-	5	-	145	-	99	-
Tuna	22	20	70	150	500	235	-	213	-
Sub total	209	360	430	170	500	903	-	694	-

Contd.....

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Medium quality (high value)									
Nemipterids	63	-	-	-	-	186	-	123	-
Cat fish	60	145	165	-	-	170	-	110	-
Elasmobranchs	51	95	70	20	-	137	-	86	-
Oil sardine	190	195	-	-	-	244	-	54	-
Other clupeids	35	145	5	15	-	97	-	62	-
Sub total	399	580	240	35	-	834	-	435	-
Low quality (low value)									
Sciaenids	117	170	40	-	-	198	-	81	-
Leiognathids	48	90	10	-	-	56	-	8	-
Ribbon fish	63	125	145	-	-	258	-	195	-
Bombay duck	100	100	-	-	-	1100	-	-	-
Anchovies	80	70	170	-	-	124	-	44	-
Deepsea fishes	-	440	-	-	-	209	61	209	61
Others	296	-	250	40	-	485	-	189	-
Sub total	704	995	615	40	-	1430	61	726	61
TOTAL	1548	2260	1460	250	500	3596	83	2048	83

Table IV: Current marine fish production (1984-85)

Categories	Landing (tonnes)	%
Demersal		
Elasmobranchs	55005	3.4
Cat fish	52290	3.2
Nemipterids	38316	2.4
Perches	33878	2.1
Croakers	108672	6.7
Silver bellies	52157	3.2
Pomfrets	46579	2.9
Penaeid prawns	130540	8.0
Non-penaeid prawns	73964	4.6
Other crustaceans	59354	3.7
Cephalopods	24096	1.5
Others	126663	7.9
Sub total	801514	49.6
Pelagic		
Oil sardines	165537	10.2
Other sardines	68314	4.2
Anchovies	120373	7.5
Other clupeids	86019	5.3
Bombay duck	124947	7.7
Ribbon fish	52318	3.2
Carangids	57390	3.6
Mackerel	40515	2.5
Seer fish	33996	2.2
Tunnies	20466	1.3
Others	44363	2.7
Sub total	814238	50.4
TOTAL	1615752	100.0

Source: CMFRI (1986)

Table V: Availability of resources and current yield vis-a-vis availability of areas in the Indian EEZ

Criteria	Continental shelf			Exclusive Economic Zone			
	0-50 m	50-200 m	Total	0-200 m	200 m to edge of EEZ		Total in EEZ
Area (lakh km2)	1.8 (40)	2.7 (60)	4.5	4.5 (22.4)	15.7 (77.6)		20.2
Fishery resource potential (lakh tonnes)	25.1 (63.2)	14.6 (36.8)	39.7	39.7 (88.8)	5.0 (11.2)		44.7
Current yield (lakh tonnes)	15.6	-	15.6	15.6	-		15.6
Additional harvestable yield (lakh tonnes)	9.5	14.6	24.1	24.1	5.0		29.1
Fishing vessels							
Traditional (in thousands)	142.4	-	142.4	142.4	-		142.4
Mechanised boats (in thousands)	22.0	-	22.0	22.0	-		22.0
Deepsea vessels (in thousands)	-	0.1	0.1	0.1	0.002		0.102
Additional vessels sustainable							
Mechanised (in thousands)	3.0	5.0	8.0	8.0	-		8.0
Deepsea vessels (in thousands)	-	1.0	1.0	1.0	0.5		1.5

Figures in parenthesis indicate percentage

Table VI: Projected requirements of certificated officers for deepsea fishing vessels

Categories of certificated officers	Certificate of competency	Minimum requirement for round the clock operation	Requirement of certificated officers at the end of 7th, 8th and 9th PLANS		
			1990 (350 vessels)	1995 (1000 vessels)	2000 (1500 vessels)
Skipper	Skipper of Fishing Vessel	1	350	1000	1500
Mate	Skipper of Fishing Vessel	2	700	2000	3000
Bosun Certified	Fishing Second Hand	3	1050	3000	4500
Chief Engineer Gr. I	Engineer Fishing Vessel (Motor)	1	350	1000	1500
Chief Engineer Gr.II	Engine Driver Fishing Vessel (Motor)	2	700	2000	3000
Radio Telephone/ Wireless Operator	Certificate of proficiency (Maritime Mobile Station General)	1	350	1000	1500

ANNEXURE I

Extracts from Merchant Shipping Act, 1958

Section 76(4)

Every fishing vessel when going to sea from any port or place in India shall be provided -

(a) If the vessel exceeds twenty five tons gross but does not exceed fifty tons gross, with a certificated Skipper;

(b) If the vessel exceeds fifty tons gross, wih a certificated Skipper and a certificated second hand;

(c) If the vessel is of fifty nominal horse-power or more, with atleast one engineer duly certificated, being an engineer of a fishing vessel, who shall be designated as the chief engineer;

(d) If the vessel is of less than fifty nominal horse-power, with atleast one engineer duly certificated, being an engineer of a fishing vessel, who shall be designated as the chief engineer or with atleast one engine driver of a fishing vessel duly certificated.

Explanation:- For the purposes of clause (c), persons holding certificates of competency as first class or second class engineers shall be deemed to be duly certificated and for the purposes of clause (d), persons holding certificates of competency as engine drivers of sea-going ships shall be deemed to be duly certificated.

Section 291(1)

Every Indian passenger ship and every Indian cargo ship of three hundred tons gross tonnage or more, shall, in accordance with the rules made under section 296, be provided with a radio installation and shall maintain a radio telegraph service or a radio telephone service of the prescribed nature and shall be provided with such certificated operators as may be prescribed.