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An appraisal of the marine fishery resources of the Indian Exclusive Economic Zone

Govt. of India
FISHERY SURVEY OF INDIA
Bombay

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October 1988

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I. INTRODUCTION

1. Background

India is a maritime nation with rich endowment of living and non-living resources. The country has a long coastline of over 7500 km, a shelf area of nearly 5 lakh sq km and an Exclusive Economic Zone (EEZ) of over 2 million sq km extending in Arabian Sea, Bay of Bengal and Indian Ocean. The marine fish production has been registering a growth rate of 3.5% for a number of years and the present fish production is about 1.8 million tonnes. The marine products exports have also been steady, retaining number one position in the export of shrimps until recently. The present marine products export is 97179 tonnes valued at Rs. 531 crores (1987-88). This amounts to about 13.21% increase over the previous year's exports by volume and 15.31% by value.

While the progress has been satisfactory on both these fronts, the present fish production forms only about one-third of our wealth of marine resource. The annual potential yield of marine fishery resources of Indian EEZ estimated from primary productivity studies, exploratory surveys, rate of fish production and its extrapolation etc, ranges from 2.3 to 8.5 million tonnes. Among these the estimate by George et al. (1977) of 4.5 million tonnes has been widely accepted. A recent study by Joseph (1987) indicates an additional harvestable yield of 2.6 million tonnes per annum over the current yield. With the acquisition of more intensive and reliable information in future it might become necessary to revise these figures. Increased data base from the east coast may also lead to different estimates. Evidently, there is ample scope for further exploitation of the marine fishery resources of Indian EEZ. The present fishing fleet includng traditional craft, motorised boats, mechanised boats, offshore shrimp boats and the so called deepsea fishing vessels reportedly fish upto 70 m depth or at best a little beyond because of their accent on shrimps and other considerations. The deepsea fish resources comprising demersals, and small and large pelagics are practically unexploited.

One of the reasons for non-exploitation of the deepsea resources has atleast till recently been lack of deepsea fishing vessels which are highly capital intensive. Dearth of funds, lack of expertise for commercial level operations in certain techniques of fishing, inadequate information on the deepsea resources etc are also cited as some of the reasons for not exploiting the deepsea resources. The Government of India have therefore been formulating and introducing schemes for the exploitation of deepsea fish resources through chartering of foreign fishing vessels, joint ventures, import of vessels, indigenous construction of vessels and other measures. In line with the world-wide concept of Exclusive Economic Zones (EEZ) India also extended its sovereignty over seas around the country upto a limit of 200 nautical miles in 1976. The chartered foreign vessels introduced subsequently were reported fishing in shallow waters leading to conflicts between the traditional/mechanised boats and chartered vessels and depletion of fish stocks. Legislation to regulate fishing by foreign fishing vessels was enacted during 1981 and Rules were notified under this Act in 1982. Indian companies were issued licences to charter foreign fishing vessels to fish in the EEZ. This also led to several conflicts and violations of law though the total fish production increased marginally. Several restrictions by way of depth and distance of area of operation by foreign fishing vessels were also imposed. However, adverse effects on the inshore stocks and the conflicts continued.

The Government of India, therefore, desired to critically review the operation of foreign chartered fishing vessels, after a reappraisal of the marine fishery resources by depth and distance from the main land. An indepth study of the marine fishery resources of the Indian EEZ by a Special Group of Scientists of Fishery Survey of India was therefore ordered. The present report is the result of such a study by this group of Scientists and is an appraisal of the marine fishery resources of the Indian EEZ including an assessment of the resources beyond the present area of exploitation based on the surveys conducted by large survey vessels of FSI for nearly a decade.

2. Continental Shelf, Continental Slope and Exclusive Economic Zone

It is well known that all living resources including fish, crustaceans, molluscs etc. are of dynamic and self-renewing nature. These are the ultimate result of primary production by photosynthesis by phytoplankton through a chain or matrix of trophic relationships at several levels viz. primary, secondary, tertiary and so on. The fishery resources, finfish prawn, lobster, crab, squid, cuttle fish and other groups can be broadly classified into the bottom living or demersal resources, midwater or columnar resources and surface living or pelagic resources. The pelagic resources especially the small pelagics consisting sardines, anchovies, mackerels, carangids etc. form a major portion of the fish resources. The larger pelagics, coastal as well as oceanic tunas, bill fishes and sharks also form an important resource. The extension of maritime economic zone upto 200 nautical miles has brought large stocks of the larger pelagics within our sovereignty and it is our responsibility to ensure their exploitation. The U.N. Law of the Sea provides guidelines for the sharing of underexploited and unexploited resources by other states.

The continental shelf and slope essentially support the demersal resources and small pelagics, and the oceanic waters upto a limit of 200 miles and beyond support large pelagics including tunas. The rich endowment of fishery resources is mainly due to the high level of productivity and the vastness of our EEZ. Expanse of the continental shelf and slope are presented on a regionwise basis below.

(Area in sq.km)

Region/Latitude	Depth zone (m)				
	0-50	51-100	101-200	201-300	Total
North west coast(15°-23°N)	99200	97665	16445	6145	219455
South west coast(8°-14°N)	28305	30260	10245	10115*	78925
Wadge Bank & Gulf of Mannar	11660	5135	5840	2860	25495
Lower east coast(10°-14°N)	27090	6680	4805	2185	40760
Upper east coast(15°-21°N)	39330	17355	14480	2755	73920
Total	205585	157095	51815	24060	438555**

* Upto 500 m depth

** The continental shelf area around Lakshadweep and Andaman & Nicobar groups of islands not included.

It will be seen from the Table that the continental shelf area reckoned at 200 m is about 4,14,495 sq km and the continental slope between 200-300 m is about 24,060 sq km. The latter figure includes area between 300-500 m also in the case of south west coast off Quilon where a distinct bank well known for its deepsea prawns and deepsea lobster resources exist. The Andaman and Nicobar islands which have a narrow shelf of about 35000 sq km are not included in the above Table.

The area covered by the EEZ and continental shelf of India is presented below:

Coast	Area in (sq km)	
	0-200m	EEZ upto 200 miles
West coast	2,82,120	8,59,992 (including Lakshadweep)
East coast	1,32,375	5,61,388
Andaman & Nicobar islands	35,000	5,96,554
Total	4,49,495	20,17,934

It will be seen from the above that the EEZ section along west coast forms about 42.6%, on the east coast 27.8% and around Andaman & Nicobar islands about 29.6% of the Indian EEZ.

3. Fishing Laws

Early fishery laws in India were typically revenue oriented. The Indian Fisheries Act, 1897, the Andaman & Nicobar Fishing Regulations, 1938 etc., were aimed at collecting revenue from shell fisheries, pearl fisheries etc. Until recently there were no laws regulating fishing by foreign fishing vessels except the Foreigners Act, the Indian Penal Code etc. The Territorial Waters, the Contiguous Zone, the Continental Shelf, the EEZ and other Maritime Zones Act (1976), besides extending sovereign rights of the country to explore, exploit and manage living and non-living resources of the seas around the country upto the EEZ limits, also marks the beginning of the fisheries legislation aimed at exploration, exploitation,

conservation and management of our resources. The Maritime Zones of India (Regulation of Fishing by Foreign Fishing Vessels) Act, 1981 was the first law to regulate fishing by foreign fishing vessels in Indian EEZ, although chartering of foreign fishing vessels was permitted as early as 1976. The Act also aims at preventing poaching of fishery resources of our country by foreign fishing vessels. Under the Act, the detailed Rules viz. Maritime Zones of India (Regulation of fishing by Foreign Fishing Vessels) Rules 1982 were framed, which forbid fishing by foreign vessels for shrimp and other finfish resources in the coastal areas, where there were already conflicts among different sectors of our own fishing industry for which all maritime states have either enacted or are in the process of enacting legislation. Some of them have so far only issued executive instructions delimiting different zones for fishing by different sectors. The convertional area of operation by our own fishing fleet, traditional boats, mechanised boats and offshore shrimping vessels were made out of bounds for foreign fishing vessels.

Subsequently the rules under the Act (Regulation of Fishing by Foreign Fishing Vessels) were modified incorporating the following restrictions.

The chartered vessels shall fish:

(A) Beyond 24 nautical miles from the shore on west coast as a general rule

(a) **Off Maharashtra - Gujarat Coast**

No fishing by foreign vessels shall be allowed between the coast line and line joining the following points;

22°54'N - 67°33'E, 21°33'N - 68°56'E

19°02'N - 72°E, 18°33'N - 72°E, 18°N - 72° 31'E

(b) **Off Kerala - Tamil Nadu coast**

No fishing by foreign vessels shall be allowed in the areas defined by the following points:

7°45'N - 77°E, 7°45'N - 78°E

7°30'N - 78°E, 7°30'N - 77°E

(B) Beyond 12 nautical miles from the shore on the east coast as a general rule subject to the following restrictions viz.

a) Fishing may be done beyond 24 nautical miles between the Nizampatnam (Andhra Pradesh) and the Paradeep Port (Orissa)

b) No fishing shall be allowed between the area covered by the coast line and the line joining the following points in the north of Chilka (Orissa) and upto Bangladesh boundary:

19°22'N - 85°30'E, 20°N - 86°E
20°42'N - 88°E, 21°8'N - 89°7'E
21°16'N - 89°14'E

These operational restrictions are still in force. Fishing by chartered vessels in our waters has resulted only in marginal increase in marine fish production. Further, other objectives of the charter policy on development of deepsea fishing could not be fully achieved, as the chartered vessels have been reported to be fishing around the restricted depth contours and areas. In this context, identification of appropriate resources and distant fishing grounds would not only help in earmarking areas for chartered fishing vessels but also go a long way to increase marine fish production and foreign exchange earnings. A judicious mix of chartering, joint venture, import and indigenous construction of vessels and resource oriented development programmes is what is necessary for the optimum utilization of the resources of our EEZ.

4. Fishery resources of the presently exploited areas

It is widely accepted that the present fishing fleet comprising the traditional, non-motorised and motorised boats, mechanised boats and offshore shrimp trawlers were fishing within 50 m depth until recently and presently fishing upto 70 m depth. Barring one or two tuna vessels, there are practically no deepsea fishing vessels capable of fishing upto our legal regime of 200 nautical miles from the coastline. High sea fishing beyond the EEZ is practically unheard of, though much smaller nations like Japan, Korea, Taiwan etc. are traditionally known to be fishing in the high seas the world over.

As stated elsewhere in the report, several estimates have been made of the fishery resource potential or annual maximum sustainable yield from the Indian EEZ based on primary productivity studies, exploratory surveys, and other parameters. However, the most direct among them are those based on exploratory surveys in the case of demersal resources and acoustic surveys coupled with test fishing in the case of small pelagics. We have estimates by Jones and Banerjee (1973), Mitra (1973), Silas (1969), George et al. (1977), Joseph (1987) etc. Excepting the last mentioned all the others were results of desk research only. These estimates range from 2.3 to 8.5 million tonnes for the EEZ upto 200 nautical miles from the coast. Joseph (1980) made estimates of demersal resources upto 40 fathoms or 73 m based on demersal resources surveys. Sudarsan (1978) assessed the demersal resources of Andaman and Nicobar Islands on the basis of exploratory surveys. George et al. (loc. cit) made estimates for the area between 0-50m, 50-200m and upto the EEZ of both demersal and pelagic resources. Recently Joseph (1987) made a study of both demersal and pelagic resources for the areas between 0-200m and 200-500m depth. Most of these estimates have already served as data base for development planning and investment decisions. It should however be pointed out that many of these estimates are rather outdated and the basis of some are not explicitly stated. The importance of these estimates can not however, be under-estimated.

The estimates of fish production by the Central Marine Fisheries Research Institute are based on a nation-wide multi strata random sampling of fish landings. As already stated, the currently exploited area generally extends upto 50m depth. The fishery resources potential, both demersal and pelagic, and the current production of these resources from these areas are summarised below, while the resource potential beyond the presently exploited areas based on the surveys conducted by the Fishery Survey of India from 50m depth and beyond upto the EEZ limits follows later.

(in '000 tonnes)

Region	*Current production(0-50m)			Potential yield **		
	Demersal	Pelagic	Total	0-50m (including current production)	50-200m (No Production at present)	>200m within EEZ (No production at present)
North west coast	375.4	265.4	640.8	540.0	340.0	
South west coast	169.7	333.6	503.3	700.0	720.0	
Lower east coast	136.4	111.0	247.4	480.0	200.0	
Upper east coast	132.1	85.9	218.0	540.0	200.0	500
Andaman &Nicobar islands	2.4	4.2	6.6	160.0***		
Total	816.0	800.1	1616.1	2420.0	1460.0	500

* 1984-85,Source: CMFRI ** George *et al.* (1977) *** 0-200m

The estimates of demersal and pelagic resources from 0-200 and 200-500m depth by Joseph (1987) are summarised below.

(in '000 tonnes)

Region	* Current production(0-50m)			Potential yield **	
	Demersal	Pelagic	Total	0-200m (including current production)	200-500m (no production at present)
North west coast	375.4	265.4	640.8	1598.0	22.0
South west coast	169.7	333.6	503.3	915.0	28.0
Lower east coast	136.4	111.0	247.4	411.0	14.0
Upper east coast	132.1	85.9	218.0	512.0	19.0
Andaman & Nicobar islands	2.4	4.2	6.6	160.0	
Total	816.0	800.1	1616.1	3596.0	83.0

* 1984-85,Source: CMFRI ** Joseph, 1987

The foregoing account gives a sufficiently clear picture of the fishery resources of the Indian EEZ as studied so far. However the

basis of some of these estimates has not been fully elaborated. Availability of resources by distance, has not been worked out. In the following pages an attempt is made to present a picture of the latest position of the fishery resources of Indian EEZ beyond the presently exploited areas both in qualitative and quantitative terms backed by exploratory fishing surveys conducted by the larger vessels of FSI for nearly 8 years. The information is presented on the following lines:

(a) Demersal fishery resources of the mainland (Andaman has very little shelf area and as such not considered in this study) in the continental shelf from 0-200m depth and continental slope from 200-300m depth (200-500m in the case of south west coast where there is a distinct bank well known for deepsea prawns, deepsea lobster etc.) on a region-wise basis.

(b) The pelagic resources position over the continental shelf area especially along north west coast, south west coast and upper east coast is based on midwater trawling and purse seining surveys. It should be admitted here that the surveys for the small pelagics was limited on account of non-availability of suitable survey vessels. Further, the echo-integrator for estimating the biomass of pelagic stocks was not available on board any of these vessels. Therefore no attempt has been made to estimate the annual potential yield of the small pelagics, but the results of purse-seining and midwater trawling operations are indicative of the columnar and pelagic resources.

(c) The large pelagics comprising tunas, bill fishes and sharks normally occur beyond the continental shelf. Reconnaissance surveys were initially conducted in the south west coast, lower east coast, Andaman & Nicobar sea and some parts of the equatorial waters. However, the survey could be completed only in the case of south west coast for which we have a wealth of information. As a matter of fact, this information has formed the basis of a reportedly large number of applications for charter, joint venture and import of tuna longline vessels.

(d) An attempt is made in this report to estimate the potential yield of demersals and large pelagics and project an appropriate fleet strength for optimum utilisation of the various resources of the Indian EEZ beyond the present area of exploitation which will go a long way in planning for chartering, joint ventures and acquisition of deepsea fishing vessels.

II. DEMERSAL FISHERY RESOURCES

1. Methodology and approach

1.1 Demersal fishery resources in the seas around India upto 300m depth as surveyed by FSI is assessed in this chapter. Only in the case of a section of south west coast (Lat. 8°N-10°N) deeper water areas upto 500m have been considered.

1.2 It is considered that the demersal stocks within 50m depth around mainland India are exploited almost to the extent of MSY level and the same may not require any further developmental effort excepting for a few stocks like squids, cuttle fish, perches etc., in certain of the shelf pockets, and thus the areas beyond 50 m depth are relevant for further developmental efforts.

1.3 Data collected by 7 large survey vessels of FSI since 1979, during different periods by each vessel, till March'87 are analysed for this study.

1.4 The survey area, period of survey and fishing gear used in respect of each of the vessels are given in Table 1.

1.5 The Indian coast and shelf is divided, for the purpose of this study, into six regions namely, north-west coast (Lat. 15°N to 23°N), south-west coast (Lat. 8°N to 14°N), upper east coast (Lat. 15°N to 21°N), lower east coast (Lat. 10°N to 14°N), Wadge Bank and Gulf of Mannar.

1.6 Methodology followed is the "Swept area" method with 40% of the head rope of trawl as effective horizontal trawl opening and the catchability coefficient of 0.4 for 34 m fish trawl and 0.5 for other trawls used in the surveys.

For studying the distribution of the stocks along each latitude on east and west coasts by depth and distance, stock density is computed for each survey stratum. Having regard to the higher density of stock

Table 1. Area, vessels, fishing gear and period of survey

Region/Area	Name of vessel	Depth range (m)/ Gear employed		Period of survey
		50-200	200-300/500	
West coast				
Lat. 20°-22°	Matsya Nireekshani	34 m fish trawl	-	January'79 to August'81
Lat. 18°-19°	Matsya Varshini	45.5 m Expo model trawl	-	March'80 to December'83
Lat. 14°-17°	Matsya Shakti & Matsya Vishwa	27m fish trawl	47 m shrimp trawl	April'83 to March'87
Lat. 11°-13°	Matsya Shakti & Matsya Vishwa	27 m fish trawl	47 m shrimp trawl	April'83 to March'87
Lat. 8°-10°	Matsya Nireekshani	34 m fish trawl	45 m shrimp trawl	May'83 to September'83 & April'85 to March'87
Wadge Bank	Matsya Nireekshani	34 m fish trawl	34 m fish trawl	October'81 to to April'83
Gulf of Mannar	Matsya Nireekshani	34 m fish trawl	34 m fish trawl	October'83 to March'85
East coast				
Lat. 10°-14°	Matsya Jeevan	27 m fish trawl	47 m shrimp trawl	July'82 to March'87
Lat. 15°-19°	Matsya Shikari	34 m fish trawl	34 m fish trawl	April'79 to March'87
Lat. 20°-21°	Matsya Darshini	44 m Star model trawl	44 m Star model trawl	March'80 to March'87

and large extent of shelf area within 100m depth contour, the resources data are analysed at 20m depth interval upto 100m depth and thereafter the depth ranges followed are 100-150m,150-200m and 200-300m or 200-500m. The data base has a limitation, in that some of the areas, namely, along north-west coast (Lat. 17° to 23°) and along upper east coast (Lat. 20°) the resources data are not available for 150-200m and 200-300m depth zones as surveys could not be conducted in these areas/depth zones for want of infrastructure facilities. In these cases, data recorded in the respective depth zones of adjacent latitudes is considered for computing density of the stocks. The density by distance is analysed at 10 nautical miles intervals covering the areas upto 300/500m depth by superimposing the distance zones over the density data by depth.

Stock size by depth is calculated for 50-100m, 100-200m and 200-300/500m depth zones in each region i.e. north-west coast, south-west coast, lower east coast, upper east coast, Wadge Bank and Gulf of Mannar. Since the areas beyond 50m depth are mostly unexploited, the maximum sustainable yield is calculated using the expression Y max = 0.5M Bv (Gulland 1971), where 'M' is the natural mortality and 'Bv' the biomass of the virgin stock. Natural mortality rate is considered as 1 for all the demersal species contributing to the catches.

Seasonal variations vis-a-vis movement of each resource is studied in relation to depth in different sections of the continental shelf and slope areas surveyed.

2. Demersal fish stock assessment

2.1 Absolute abundance of demersal fish by depth

Depth-wise abundance of demersal resources studied as density per sq km for each latitude on east and west coasts, and Wadge Bank and Gulf of Mannar is presented in Table 2 as well as in Figs. 1 to 5.

Table 2. Density of demersal resources (tonnes/sq km) in different depth zones

Latitude (°N)	Depth range (m)/Density (tonnes/sq km)						
	20-40	40-60	60-80	80-100	100-150	150-200	200-300/500
West coast							
8	0.7	4.1	3.6	0.4	4.7	4.4	4.0
9	1.6	3.4	7.5	9.6	12.2	12.9	2.3
10	0.7	4.7	3.6	2.5	1.3	1.6	0.5
11	3.0	4.5	2.3	3.3	4.9	2.2	5.4
12	2.1	3.7	2.3	2.2	4.1	6.2	4.0
13	2.8	3.4	2.4	1.1	6.0	0.6	1.0
14	2.5	4.8	1.9	2.3	4.1	0.6	0.9
15	2.8	4.3	3.1	3.1	9.2	-	0.2
16	4.0	2.7	2.5	4.5	3.7	-	0.2
17	1.6	3.6	2.9	2.0	1.4	-	-
18	10.3	5.3	7.4	0.7	1.2	-	-
19	4.1	4.6	3.0	0.8	0.7	-	-
20	2.9	9.8	13.3	12.2	5.9	-	-
21	6.1	8.5	11.9	8.3	20.0	64.9	-
22	14.9	12.3	10.2	8.2	11.2	-	-
23	7.5	12.6	9.2	13.9	-	-	-
Wadge Bank							
8	5.6	5.8	2.5	-	-	-	-
7	4.8	3.8	2.2	1.3	7.6	2.8	0.7
Gulf of Mannar							
7	3.0	5.1	19.3	2.9	-	-	9.0
8	5.8	3.3	1.5	0.6	5.3	4.5	0.8
9	3.5	9.5	-	2.2	-	-	0.5
East coast							
10	2.2	1.4	1.7	5.8	2.0	2.2	2.2
11	1.5	1.6	1.7	3.4	-	10.7	1.7
12	1.1	1.2	2.8	8.7	2.0	6.0	1.7
13	0.7	1.7	1.4	7.0	0.9	11.0	4.4
14	8.5	6.1	14.9	1.2	18.8	5.0	0.3
15	0.3	4.7	10.1	16.6	14.3	0.3	0.3
16	2.3	7.4	10.8	12.4	2.7	2.1	0.9
17	-	3.1	4.9	9.5	3.8	0.6	0.5
18	3.9	4.7	3.6	5.1	1.5	0.3	0.01
19	4.2	7.6	7.9	5.3	3.0	2.7	0.2
20	3.3	3.0	3.2	7.6	3.4	-	-

West coast

(a) Quantitative assessment

The stock density was found to be higher in 40-60m and 60-80m depth belts in all latitudes (Figs. 1 & 2). An increasing trend in the abundance was noticed with increase in depth along latitudes 9°N, 12°N & 21°N. In general, the depth belt 80-100m had lesser density as compared to 60-80 m and 100-150m depth belts. The highest average density for north-west coast was in 100-150m depth zone (7.5 tonnes/sq km). Most productive depth belt along south-west coast for demersal fish was 150-200m (5.2 tonnes/sq km)

(b) Qualitative assessment

The percentage composition of demersal resources from west coast in different depth zones, namely, 20-40m, 40-60m, 60-80m, 80-100m, 100-150m, 150-200m, 200-300m/500m obtained by each vessel in their area of survey is given in Tables 3 to 6. Nemipterids formed the highest percentage (21-25%) along 8°N to 13°N and registered significant percentage in the catches from 40-60m to 150-200m depth belts. Cat fish was found to dominate the catches from Lat.14°-17°N and elasmobranchs from Lat. 18°-25°N. The former gave higher percentage composition in depth zone 20-60m, whereas the latter group was in significant proportion in depth zone 20-80m. The other major contributors to the catches from this area are Black ruff **(Centrolophus niger)**, Green eye **(Chlorophthalmus** sp), Bulls eyes **(Priacanthus** spp), lizard fish, cat fishes, Indian drift fish **(Ariomma indica)**, ribbon fishes, mackerels, **Caranx** spp and crabs. In the areas between Lat. 14°N and 17°N cat fish topped with 21.1% followed by Bulls eye (20.9%) and nemipterids (17.3%). Ghol **(Protonebea diacanthus)** formed 3.6% of catch in Lat. 18°-23°N and the other sciaenids comprising of Koth **(Otolithoides brunneus)** and smaller sciaenids made up 6.8%. The

Table 3. Percentage composition of demersal fish resources from Lat. 8°N to 10°N along west coast

Species/Groups	Depth ranges (m)						
	20-40	40-60	60-80	80-100	100-150	150-200	200-500
Elasmobranchs	18.9	7.3	3.2	1.9	0.2	0.4	0.6
Cat fishes	7.5	19.9	3.1	1.2	0.1	-	-
Clupeids	0.1	-	-	-	-	-	-
Lizard fish	0.2	3.5	5.9	0.7	0.7	1.9	0.2
Perches	4.0	10.3	3.5	1.3	0.5	0.1	0.5
Nemipterids	0.5	25.6	47.3	44.6	40.7	38.4	0.1
Upenoids	-	0.1	-	0.6	-	-	-
Ghol	0.1	0.1	-	-	-	-	-
Other sciaenids	1.8	0.4	-	-	-	-	-
Ribbon fishes	2.3	2.4	0.2	0.3	-	1.5	0.3
Caranx spp.	11.7	2.4	0.7	0.2	0.4	0.9	-
Decapterus spp.	3.8	7.0	7.9	1.4	2.2	0.2	-
Horse mackerel	0.4	0.2	-	-	-	-	-
Leiognathids	0.8	0.5	-	-	0.1	-	-
Pomfrets	2.2	0.4	0.1	-	-	-	-
Mackerels	10.4	3.1	1.1	0.7	-	0.7	-
Seer fishes	1.0	0.1	-	-	-	-	-
Balistids	1.3	0.3	0.1	-	-	-	--
Barracuda	11.1	0.9	0.4	-	-	-	-
Ariomma indica	0.3	0.1	0.3	-	0.4	2.2	-
Priacanthids	2.1	5.5	8.7	37.9	26.1	5.4	0.4
Centrolophus niger	-	-	-	-	1.8	1.6	37.6
Chlorophthalmus spp.	-	-	-	-	8.4	5.0	25.8
Squids & cuttle fishes	8.3	6.1	10.3	8.7	0.5	0.5	-
Crabs	4.4	0.1	4.3	-	12.6	39.9	2.3
Deepsea prawns	-	-	-	-	0.1	0.2	9.1
Deepsea lobster	-	-	-	-	-	0.1	8.1
Others	6.8	3.7	2.9	0.5	5.2	1.0	15.0

Table 4. Percentage composition of demersal fish resources from Lat. 11°N to 13°N along west coast

Species/Groups	Depth ranges (m)							
	20-40	40-60	60-80	80-100	100-150	150-200	200-300	300-500
Elasmobranchs	5.2	4.3	3.1	2.3	1.3	0.6	0.7	16.6
Cat fishes	14.1	26.6	11.0	3.5	0.9	-	-	-
Clupeids	2.3	0.2	-	-	0.1	-	-	-
Lizard fish	2.4	3.4	12.0	7.6	13.3	7.8	3.3	6.2
Perches	0.4	1.7	0.9	1.8	1.0	0.2	-	-
Nemipterids	6.1	13.4	23.9	52.8	48.2	19.7	-	-
Upenoids	0.1	1.0	0.2	0.1	-	-	-	-
Sciaenids	2.2	0.1	-	0.4	-	-	-	-
Ribbon fishes	4.2	2.2	-	-	0.2	-	0.1	-
Caranx spp.	20.0	7.6	3.6	0.7	0.3	1.3	0.8	-
Decapterus spp.	8.6	13.4	17.9	3.5	2.0	2.6	-	-
Horse mackerel	0.3	0.7	0.1	0.1	0.1	-	-	-
Leiognathids	2.9	2.7	0.4	-	-	-	-	-
Pomfrets	0.8	0.3	-	-	0.2	-	-	-
Mackerels	1.5	3.3	2.0	0.8	-	-	-	-
Seer fishes	0.8	0.2	-	0.1	-	-	-	-
Barracuda	1.8	1.7	0.5	0.7	1.5	-	-	-
Ariomma indica	0.2	0.1	0.4	0.7	2.4	24.1	15.1	9.8
Priacanthids	8.9	10.4	9.8	5.5	11.5	19.6	2.5	-
Centrolophus niger	-	0.2	1.7	0.2	0.5	16.6	68.1	17.4
Squids & cuttle fishes	9.7	3.1	9.5	16.2	4.4	0.3	0.1	-
Crabs	-	-	-	1.7	10.8	3.0	0.1	-
Deepsea prawns	-	-	-	-	0.5	1.0	7.4	7.6
Deepsea lobster	-	-	-	-		0.1	1.1	5.2
Others	7.5	3.4	3.0	1.3	0.8	3.1	0.7	17.2

Table 5. Percentage composition of demersal fish resources from Lat.14°N to 17°N along west coast

Species/Groups	Depth ranges (m)							
	20-40	40-60	60-80	80-100	100-150	150-200	200-300	300-500
Elasmobranchs	3.2	3.1	4.7	2.9	0.5	0.7	0.2	-
Eels	0.6	0.2	0.2	-	-	-	0.1	-
Cat fishes	45.6	32.5	24.5	11.2	1.5	-	-	-
Clupeids	0.9	0.6	0.7	-	-	-	-	-
Lizard fish	0.3	0.8	1.4	1.8	3.8	6.6	-	-
Perches	0.9	1.6	3.4	28.2	4.4	-	-	-
Nemipterids	2.1	4.7	6.4	16.0	45.3	6.0	0.3	-
Upenoids	-	0.4	0.1	-	-	-	-	-
Ghol	0.4	0.3	0.2	-	-	-	-	-
Koth	-	0.04	-	0.1	-	-	-	-
Other sciaenids	4.1	1.0	3.5	-	-	-	-	-
Ribbon fishes	21.8	25.3	21.6	6.4	1.5	-	-	-
Caranx spp.	2.5	2.6	3.7	2.7	0.4	0.3	-	-
Decapterus spp.	-	1.8	1.7	6.9	0.8	-	-	-
Horse mackerel	2.2	1.4	0.4	0.1	-	-	-	-
Leiognathids	1.7	1.8	0.3	-	-	-	-	-
Pomfrets	1.7	1.7	2.2	0.1	-	-	-	-
Mackerels	0.2	0.6	0.1	0.3	0.02	-	-	-
Seer fishes	0.3	0.5	0.7	-	-	-	-	-
Balistids		-	-	-	-	-	-	-
Barracuda	1.2	0.5	0.7	0.5	0.6	0.1	-	-
Ariomma indica	-	0.1	0.1	0.1	0.3	-	2.3	-
Priacanthids	1.4	12.0	18.3	18.8	36.4	78.4	88.2	1.6
Centrolophus niger	-	-	-	0.1	0.5	6.3	2.4	53.1
Squids & cuttle fishes	3.4	3.0	2.3	2.8	1.3	0.4	-	8.8
Crabs	0.2	0.2	0.1	0.2	0.6	-	0.2	-
Deepsea prawns	-	-	-	-	-	1.2	5.6	14.4
Deepsea lobster	-	-	-	-	-	-	-	-
Others	4.8	3.8	2.7	0.6	2.0	-	0.7	22.1

Table 6. Percentage composition of demersal fish resources from Lat. 18°N to 23°N along west coast

Species/Groups	Depth ranges (m)					
	20-40	40-60	60-80	80-100	100-150	150-200
Elasmobranchs	16.6	18.3	11.6	9.4	5.4	0.6
Eels	0.4	0.4	0.4	0.1	-	-
Cat fishes	2.5	4.3	3.2	2.0	0.3	-
Clupeids	0.5	1.4	0.6	3.5	0.1	-
Lizard fish	0.6	0.3	0.5	0.1	0.7	-
Perches	4.3	7.6	8.9	8.5	2.4	-
Nemipterids	0.5	5.4	13.2	5.5	18.2	0.4
Upenoids	-	-	0.5	-	-	-
Ghol	7.3	4.3	2.2	1.8	0.5	-
Koth	0.1	0.5	0.1	-	-	-
Other sciaenids	6.2	10.0	3.0	1.3	0.7	-
Ribbon fishes	6.3	2.0	3.1	3.0	0.7	-
Caranx spp.	0.9	0.6	0.6	0.3	0.3	-
Decapterus spp.	-	0.1	-	-	0.1	-
Horse mackerel	0.1	0.2	2.4	7.4	55.4	98.9
Leiognathids	-	0.4	0.5	0.2	-	-
Pomfrets	2.8	1.8	8.4	6.1	0.1	-
Mackerels	0.2	0.4	0.7	1.0	0.2	-
Seer fishes	0.2	0.2	0.2	-	0.1	-
Barracuda	-	0.1	0.4	0.3	0.6	-
Priacanthids	-	-	0.1	-	-	-
Squids & cuttle fishes	1.5	4.9	4.9	6.4	2.7	0.1
Others	49.0	36.8	34.5	43.1	11.5	-

ranking of the species in different areas surveyed along west coast is furnished below.

Species/Groups	Latitude			
	8°-10°N	11°-13°N	14°-17°N	18°-23°N
Nemipterids	I(24.7)	I(20.9)	III(17.3)	II(7.7)
Centrolophus niger	II(10.6)	II(17.2)	XII(0.2)	-
Chlorophthalmus spp	III(8.4)	-	-	-
Crabs	IV(7.4)	XI(2.9)	-	-
Cat fishes	V(7.1)	III(8.6)	I(2.1)	IX(3.4)
Priacanthids	VI(6.8)	IV(8.2)	II(20.9)	-
Perches	VII(4.2)	XV(0.8)	V(4.6)	III(7.2)
Squids & cuttle fish	VIII(4.0)	VIII(4.1)	VI(2.4)	VI(4.5)
Elasmobranchs	IX(3.5)	IX(3.6)	VI(2.4)	I(15.0)
Decapterus spp	IX(3.5)	VI(6.7)	VIII(1.8)	-
Deepsea prawns	X(2.5)	XII(2.2)	XIII(0.1)	-
Deepsea lobster	XI(2.1)	XIV(0.6)	-	-
Lizard fish	XI(2.1)	V(7.5)	VIII(1.8)	-
Mackerels	XII(1.5)	XIII(1.1)	-	-
Caranx spp	XIII(1.3)	X(3.4)	VII(1.2)	XIII(0.6)
Ribbon fishes	XIV(1.3)	X(3.4)	VII(1.2)	XIII(0.6)
Ariomma indica	XV(0.4)	VII(5.1)	XII(0.2)	-
Leiognathids	-	XV(0.8)	X(0.9)	-
Pomfrets	-	-	IX(1.1)	VIII(3.5)
Horse mackerel	-	-	XI(0.8)	V(6.2)
Other sciaenids	-	-	-	IV(6.8)
Ghol	-	-	-	VII(3.6)
Clupeids		-	-	XIII(1.1)
Chorinemus spp	-	-	-	XII(1.0)

Note: i) I - XV, is ranking of the species/groups in descending order of percentage

ii) Figure in parentheses are percentages.

East coast

(a) Quantitative assessment

Demersal fish abundance was observed to increase from shallow to deeper water depth belts reaching the peak values in 80-100m depth zone (8.8 tonnes/sq km) and declining thereafter to 2.3 tonnes/sq km in 200-300m depth belt (Figs. 3 & 4). Highest density (18.9 tonnes/sq km) was registered from 100-150m depth zone in Lat. 14°N, exceptionally.

(b) Qualitative assessment

Depth-wise percentage composition of demersal species is furnished for each sector on east coast viz.. Lat.10-14°, 15-19° and 20°N, in Tables 7 to 9. **Caranx** spp dominating the catches from 10°-14°N and 15°-19°N, were widely distributed with higher percentage in areas upto 150 m depth. Mackerels having the highest aggregate percentage (39.7) in Lat. 20°N, were observed to improve its contribution to the catches through shallow (20-40m, 0.1%) to deeper water zones (100-150m, 66.4%). Thus the increasing density and the proportion of mackerels should give higher catch and catch rates in deeper water zones. The ranking of the different species/group according to its share in the demersal catches in each sector on east coast is presented hereunder.

Species/Groups	Latitudes (East coast)		
	10°-14°N	15°-19°N	20°N
(1)	(2)	(3)	(4)
Caranx spp	I(20.3)	I(16.7)	X(2.4)
Priacanthids	II(14.7)	X (2.8)	IX(3.1)
Perches	III(8.5)	VI(5.1)	VII(3.5)
Centrolophus niger	IV(8.0)	XV(0.9)	-
Leiognathids	V(7.2)	XII(2.4)	IV(5.6)
Ariomma indica	VI(5.7)	IX(3.2)	II(6.7)
Elasmobranchs	VII(5.3)	V(5.4)	VII(4.0)
Mackerels	VII(4.5)	III(13.0)	I(39.7)

contd.....

(1)	(2)	(3)	(4)
Nemipterids	IX(3.5)	VIII(3.9)	XVII(0.5)
Other deepsea fish	X(3.5)	-	-
Clupeids	XI(3.3)	IV(5.7)	V(5.0)
Cat fishes	XII(2.4)	II(15.2)	X(2.4)
Squids & cuttle fishes	XIII(1.4)	XVI(0.5)	-
Gerrids	XIV(1.3)	-	-
Other sciaenids	XV(1.2)	VII(4.3)	XII(1.7)
Barracuda	XVI(1.1)	XII(2.4)	-
Deepsea prawns	XVII(1.1)	XVII(0.5)	-
Pomfret	-	XI(2.7)	XI(2.8)
Ghol	-	XIII(1.9)	-
Ribbon fishes	-	XIV(1.4)	III(6.1)
Decapterus spp	-	-	VI(1.5)
Eel	-	-	XII(1.5)
Anchoviella spp	-	-	XIV(1.2)
Upenoids	-	-	XV(1.0)
Horse mackerel	-	-	XVI(0.9)

Note: i) I-XV, is ranking of the species/groups in descending order of percentage.

ii) Figuresin parentheses are percentages.

Wadge Bank and Gulf of Mannar

(a) Quantitative assessment

The density of the stock is depicted in Fig.5. The abundance index (density) pattern in Wadge Bank is characterised as shown in Fig.5, by its increasing trend towards shallow waters(0.4 tonnes/sq km) in 200-300m depth zone to (5.2 tonnes/sq km) in 20-40m depth zone. Nevertheless, the areas in 100-150m depth zone have recorded exceptionally high density (7.3 tonnes/sq km) and poor density in 80-100m depth zone (1.3 tonnes/ sq km). On the other hand, in Gulf of Mannar the trend remaining same

Table 7. Percentage composition of demersal fish resources from Lat. 10°N to 14°N along east coast

Species/Groups	Depth ranges (m)						
	20-40	40-60	60-80	80-100	100-150	150-200	200-300
Elasmobranchs	5.9	13.3	2.7	1.9	1.1	0.2	0.5
Eels	-	0.1	0.1	-	-	-	-
Cat fishes	5.7	4.3	1.8	0.5	3.5	-	-
Clupeids	7.6	2.1	12.5	2.0	1.0	-	-
Lizard fish	1.7	0.9	2.7	0.1	0.8	0.6	-
Perches	10.2	19.8	7.9	1.3	5.2	-	-
Nemipterids	3.0	1.7	5.3	13.3	9.4	1.7	-
Upenoids	2.1	1.0	2.0	-	-	-	-
Sciaenids	2.6	1.9	0.2	0.8	2.9	-	0.1
Ribbon fishes	2.8	0.1	1.4	0.1	1.8	-	-
Caranx spp.	17.1	11.8	9.3	4.8	3.2	-	-
Decapterus spp.	1.0	6.7	11.0	17.7	26.9	5.6	-
Horse mackerel	3.1	0.9	1.1	45.6	9.4	-	-
Leiognathids	18.1	14.1	6.3	1.3	2.7	-	-
Pomfrets	0.3	0.2	-	-	-	-	-
Mackerels	8.5	8.9	7.6	0.3	-	-	-
Seer fishes	2.3	0.8	0.1	-	-	-	--
Balistids	-	0.1	-	-	-	-	-
Barracuda	1.3	1.8	2.6	0.6	-	0.2	-
Ariomma indica	-	0.1	12.5	8.3	15.0	1.8	9.9
Priacanthids	-	0.4	4.8	-	7.6	75.2	4.0
Centrolophus niger	-	-	-	-	-	5.8	55.7
Chlorophthalmus sp.	-	-	-	-	-	-	0.3
Squids & cuttle fishes	1.7	1.8	3.2	0.4	1.0	-	-
Crabs	-	-	-	-	3.6	1.8	-
Deepsea prawns	-	-	-	-	0.1	2.3	3.9
Deepsea lobster	-	-	-	-	-	-	0.2
Others	5.0	7.2	4.9	1.0	4.8	4.8	25.4

Table 8. Percentage composition of demersal fish resources from Lat. 15°N to 19°N along east coast

Species/Groups	Depth ranges (m)						
	20-40	40-60	60-80	80-100	100-150	150-200	200-300
Elasmobranchs	9.5	6.3	5.0	5.2	2.0	2.1	9.7
Eels	-	0.4	0.2	0.1	-	-	0.1
Cat fishes	16.3	16.2	16.3	14.3	8.3	-	-
Clupeids	0.1	1.5	7.7	15.4	0.4	-	-
Lizard fish	0.1	0.3	-	-	-	-	-
Perches	6.3	5.7	5.1	4.7	2.8	-	-
Nemipterids	0.8	3.0	1.7	5.5	18.5	1.1	-
Upenoids	-	0.9	1.1	0.4	-	-	-
Ghol	-	0.7	4.0	1.3	-	-	-
Koth	-	0.4	0.6	0.1	-	-	-
Other sciaenids	-	1.8	7.1	4.9	5.3	0.5	-
Ribbon fishes	-	0.8	2.4	1.6	-	-	-
Caranx spp.	4.6	4.4	3.5	1.4	0.4	0.1	-
Decapterus spp.	-	2.3	12.2	14.1	9.3	4.1	0.1
Horse mackerel	5.7	8.0	3.3	3.4	5.6	-	-
Leiognathids	37.6	2.6	1.3	4.9	-	-	-
Pomfrets	1.6	2.6	3.3	2.6	0.1	-	-
Mackerels	4.8	21.4	7.3	5.1	11.5	0.3	-
Seer fishes	2.1	0.7	0.2	-	-	-	-
Balistids	-	-	-	-	-	-	-
Barracuda	0.2	1.1	5.2	0.9	1.2	0.3	-
Ariomma indica	-	2.4	3.8	3.8	1.6	0.2	-
Priacanthids	-	1.4	1.1	1.0	15.2	84.8	11.7
Centrolophus niger	-	-	-	1.4	3.4	0.1	57.3
Chlorophthalmus sp.	-	-	-	-	-	-	-
Squids & cuttle fishes	-	0.9	0.3	0.1	0.2	-	0.5
Crabs	-	0.4	0.7	0.5	-	2.3	1.7
Deepsea prawns	-	-	-	-	0.1	0.2	3.2
Deepsea lobster	-	-	-	-	-	-	-
Others	10.3	13.8	6.6	7.3	14.1	3.9	15.7

Table 9. Percentage compostion of demersal fish resources from Lat. 20°N along east coast

Species/Groups	Depth ranges (m)				
	20-40	40-60	60-80	80-100	100-150
Elasmobranchs	7.5	8.5	3.8	1.4	1.0
Eels	7.6	3.1	0.6	0.3	-
Cat fishes	6.0	3.7	3.6	1.9	0.1
Clupeids	9.0	11.2	10.0	0.4	0.7
Lizard fish	0.4	0.4	0.5	0.1	0.1
Perches	7.3	5.8	4.8	0.2	1.5
Nemipterids	0.5	0.1	1.4	0.2	0.5
Upenoids	1.4	1.1	2.0	0.3	0.5
Ghol	0.7	0.3	0.1	1.2	0.2
Koth	1.2	3.2	0.1	0.1	0.1
Other sciaenids	3.6	2.7	2.6	0.1	0.7
Ribbon fishes	15.5	15.8	2.8	1.2	1.1
Caranx spp.	3.7	8.0	2.1	1.5	0.8
Decapterus spp.	-	0.1	3.9	4.3	9.3
Horse mackerel	1.4	2.0	1.5	-	-
Leicgnathids	10.8	13.4	7.2	0.5	-
Pomfrets	4.1	7.3	3.5	0.1	-
Mackerels	0.1	1.7	35.9	66.4	66.4
Seer fishes	0.9	0.8	0.3	-	-
Balistids	0.1	-	-	-	--
Ariomma indica	0.3	3.8	2.1	17.7	8.0
Priacanthids	-	0.1	0.4	1.0	8.7
Squids & cuttle fishes	-	-	-	0.1	-
Others	17.9	6.9	10.8	1.0	0.3

as in the Wadge Bank, the depth belt 60-80m gave the higher abundance (6.1 tonnes/sq km). However the fishing effort expended in this depth zone was comparatively less.

(b) Qualitative assessment

Perches are the highest contributors to demersal catches from Wadge Bank (30.4%) as well as Gulf of Mannar (17.7%). They generally formed a sizable proportion in the catches from areas upto 100 m depth (Tables 10 & 11). Nemipterids formed the second highest group in the catches in Wadge Bank (22.4%). However they dominated (74.5%) in the 100-150m depth zone. Similarly crabs were abundant in deeper water areas of Gulf of Mannar and Wadge Bank registering high percentage in 200-300m (60.4%) and 150-200m depth zones (30.3%) respectively. Barracudas dominated the catches from 100-150m (31.9%) and 150-200m (21.8%) depth zones. The other resources that require special mention are the cephalopods (Wadge Bank - 5.4% and Gulf of Mannar - 1.6%), and deepsea lobster (Gulf of Mannar 0.3% and Wadge Bank 0.01%). The region-wise percentage composition of important species is given below.

Species/groups	Wadge Bank	Gulf of Mannar
(1)	(2)	(3)
Perches	I(30.4)	I(17.5)
Nemipterids	II(22.4)	VII(3.0)
Elasmobranchs	III(10.0)	IV(10.6)
Caranx spp	IV(9.7)	V(9.3)
Squids & cuttle fishes	V(5.4)	X(1.6)
Balistids	VI(4.4)	-
Lizard fish	VII(4.3)	-
Cat fishes	VIII(4.0)	VIII(2.7)
Upenoids	IX(1.9)	-
Crabs	X(1.6)	II(16.2)
Ariomma indica	XI(1.1)	XII(1.4)
Priacanthids	XII(0.7)	XIII(1.3)
Deepsea prawns	XIII(0.01)	XVI(0.2)

(1)	(2)	(3)
Deepsea lobster	XIV(0.1)	XV(0.3)
Barracuda	-	III(12.5)
Leiognathids	-	VI(6.4)
Pomfrets	-	IX(2.1)
Drepane sp	-	IX(2.1)
Clupeids	-	XI(1.5)
Ribbon fishes	-	XIV(1.2)

Note: i) I - XIV is ranking of species/groups in descending order of percentage

ii) Figures in parentheses are percentages.

Demersal fish stock abundance by distance

West coast

On west coast the continental shelf area extends upto 150 nautical miles and the distance zones that cover 300 m depth contour are maximum along north-west coast. Density for each distance zone of 10 nautical miles from shore is computed for the areas along every latitude (Figs.6 & 7). The demersal fish abundance was found to improve from shore (4.2 tonnes/sq km) to 80-90 nm zone (9.8 tonnes/sq km) and thereafter it decreased to 1.3 tonnes/sq km in the 140-150 nm along the north-west coast. The areas from 30-110 nautical miles surveyed in northern latitudes were observed to be more abundant in demersal fish (8.2 tonnes/sq km). Along south-west coast the density steadily improves from shore (0-10nm being 3.0 tonnes/sq km) to the distance zone (70-80 nm being 5.0 tonnes/sq km).

East coast

The continental shelf being rather narrow the maximum distance surveyed (upto 300 m depth contour) is about 80 nm from the shore along

Table 10. Percentage composition of demersal fish resources from Wadge Bank

Speceis/Groups	Depth ranges (m)							
	20-40	40-60	60-80	80-100	100-150	150-200	200-300	300-500
Elasmobranchs	16.1	9.8	19.4	25.9	3.2	9.1	12.9	15.4
Cat fishes	1.3	5.8	4.2	1.9	0.6	0.4	-	-
Lizard fish	0.1	4.9	4.9	2.0	3.0	7.9	4.9	1.1
Perches	34.3	40.9	33.3	36.2	2.5	8.7	33.5	21.6
Nemipterids	3.2	7.1	10.2	17.3	74.5	26.4	15.3	18.7
Upenoids	1.5	2.3	4.0	1.8	0.2	0.2	2.3	8.8
Ribbon fishes	-	-	-	-	-	-	4.2	-
Caranx spp.	16.8	8.2	7.0	2.1	2.6	0.3	1.3	-
Decapterus spp.	3.1	1.9	1.1	2.3	3.6	4.7	-	8.8
Horse mackerel	-	0.2	0.2	1.3	0.1	0.1	0.4	-
Leiognathids	0.2	-	-	-	-	-	-	-
Pomfrets	0.2	-	-	-	-	-	-	-
Mackerels	0.4	0.7	0.7	0.6	0.1	0.1	0.5	-
Seer fishes	0.5	0.1	-	-	-	-	-	-
Balistids	12.5	5.8	4.4	-	-	-	-	-
Ariomma indica	-	-	-	0.7	4.8	1.2	0.5	0.9
Priacanthids	-	0.5	0.1	0.1	0.8	3.5	14.5	5.7
Centrolophus niger	-	-	-	-	-	0.1	-	-
Squids & cuttle fishes	4.0	7.4	6.1	4.4	0.9	0.3	1.0	0.4
Crabs	-	-	0.1	0.4	2.6	30.3	2.6	1.1
Deepsea prawns	-	-	-	-	-	-	0.9	-
Deepsea lobster	-	-	-	-	-	1.2	0.3	0.2
Others	5.8	4.4	4.3	3.0	0.5	5.5	4.9	17.3

Table 11. Percentage composition of demersal fish resources from Gulf of Mannar

Species/Groups	Depth ranges (m)							
	20-40	40-60	60-80	80-100	100-150	150-200	200-300	300-500
Elasmobranchs	17.5	12.6	7.5	10.8	9.3	3.4	1.6	7.7
Eels	-	-	-	4.1	-	-	-	-
Cat fishes	0.9	6.4	-	-	0.4	-	-	-
Clupeids	1.8	3.2	-	0.2	0.5	-	-	-
Lizard fish	1.1	0.3	-	-	0.8	0.5	-	-
Perches	25.7	33.1	56.9	56.0	0.3	0.4	1.9	-
Nemipterids	1.8	1.0	-	1.0	7.1	3.7	1.7	-
Upenoids	0.2	0.6	-	-	0.6	0.7	-	-
Sciaenids	0.3	1.4	-	-	-	-	-	-
Ribbon fishes	-	0.1	-	0.8	0.8	5.5	2.0	3.7
Caranx spp.	20.3	4.3	4.4	4.9	2.7	2.2	0.8	-
Decapterus spp.	4.9	0.8	-	-	2.2	3.0	-	-
Horse mackerel	-	-	-	-	0.2	-	-	-
Leiognathids	5.7	13.2	-	-	1.0	1.3	-	-
Pomfrets	0.5	5.3	-	-	-	-	-	-
Mackerels	0.6	1.7	-	-	0.2	-	-	-
Seer fishes	1.1	1.6	-	-	0.1	-	-	-
Balistids	0.3	2.3	-	-	-	-	-	-
Barracuda	2.6	2.5	-	0.2	31.9	21.8	1.0	0.1
Ariomma indica	-	-	-	3.3	3.9	3.2	0.9	-
Priacanthids	-	-	-	-	2.1	3.9	5.6	-
Centrolophus niger	-	-	-	-	-	-	0.1	30.8
Squids & cuttle fishes	0.6	0.7	-	4.1	4.0	1.4	-	-
Crabs	-	-	-	3.3	28.4	45.4	60.4	28.5
Deepsea prawns	-	-	-	-	0.1	0.6	2.9	1.5
Deepsea lobster	-	-	-	-	-	0.1	9.0	6.5
Others	14.1	8.9	31.2	11.3	3.4	2.9	12.1	21.2

upper east coast and 30-40 nm on lower east coast. On upper east coast, the demersal fish abundance decreased with increasing distance from the shore (6.5 tonnes/sq km in 0-10 nm zone to 4.4 tonnes/sq km in 70-80 nm zone). However, the density pattern along lower east coast was different, in that the abundance increased steadily from the shore upto 30 nautical miles (2.0 tonnes/sq km in 0-10 nm to 2.8 tonnes/sq km in 20-30 nm) and declined thereafter to 2.6 tonnes/sq km in 30-40 nm zone (Figs. 8 & 9).

Wadge Bank and Gulf of Mannar

Demersal fish stocks on Wadge Bank did not show any clear pattern of density distribution based on depth, perhaps due to the curvature of the mainland. The density was maximum 6.9 tonnes/sq km in 50-60 nm zone and minimum 0.7 tonnes/sq km in 60-70 nm zone (Fig. 10). On the other hand, in Gulf of Mannar, the abundance index was found to decrease from the shore to distant water zone surveyed (5.8 tonnes/sq km in 0-10 nm zone to 2.1 tonnes/sq km in 40-50 nm zone).

3. Seasonal variation

Seasonal variation vis-a-vis movement of demersal stock in relation to depth in different regions of west coast, east coast, Wadge Bank and Gulf of Mannar is worked out and presented as density per sq km in Fig.11 (a,b & c).

On north-west coast two peaks in the density of the stock were noticed first during January to May/June and second during October/November to December. Higher density figures from 0-60m and 100-200m depth zones along Lat. 14°N - 17°N were registered during November to May and October to March respectively. Along Lat. 8°N - 10°N low density of stock prevailed in 20-60m and 60-100m depth zones during January to April. The higher density during the same period is traced in 100-200m depth zone indicating the movement of the stock to deeper waters.

Lower east coast shows higher density of stock during September to December (7.5 - 28 tonnes/sq km). Along Lat. 15°N - 19°N, the mid-shelf area between 20 and 100m depth consistently registered higher stock density (upto 14 tonnes/sq km) with varying densities in shallow as well deeper waters in different months. In Sandheads highest density upto 12.3 tonnes sq km was recorded in 100-200m depth during June-July followed by 11.5 tonnes per sq km in September from 60-100m depth suggesting shoreward movement of the stock.

Wadge Bank recorded peak density of the stock during monsoon months, June to September, in 20-60m, June to July in 60-100m, and May to July and October to November in 100-200m depth belt. This feature of good fishery during monsoon months is highlighted by Joseph et al., (1987) in their study on Wadge Bank demersal stock. Gulf of Mannar exhibited higher density of the stock in 20-60m during June to September and in 100-200m from October to April.

4. Potential yield estimates

Potential yield per unit area

An analysis of the resources data was carried out to get yield of demersal fish per unit area from 50-100, 100-200, 200-300/500 m depth zones of east and west coasts, Wadge Bank and Gulf of Mannar. The results are furnished below.

Region / Depth zone(m)	Yield/sq km (tonnes)		
	50-100	100-200	200-300/500
West coast	2.47	3.85	1.35
East coast	2.32	1.50	0.69
Wadge Bank	1.61	2.95	0.34
Gulf of Mannar	1.85	2.48	0.20

Among the three depth zones studied along the east and west coasts it is seen that on the east coast the yield per unit area decreases

with increasing depth(2.32 tonnes in 50-100m depth zone to 0.69 tonnes in 200-300m depth zone) where as on the west coast the abundance of demersal fish per unit area which is maximum (3.85 tonnes) in the 100-200m depth belt, declines both towards the shallower (2.47 tonnes in 50-100m) and deeper (1.35 tonnes in 200-300/500 m depth) zones. The yield pattern in different depth zones of Wadge Bank and Gulf of Mannar is similar to that of west coast. It may be mentioned here that the higher unit area yield value from the deeper water zone of 100-200m is mainly due to the abundance of fish species namely, **Nemipterus** spp., **Priacanthus** spp., **Centrolophus niger** and **Ariomma indica** in general and in addition barracuda in Gulf of Mannar.

Region-wise potential yield

Assessment of demersal fish stocks, for knowing their potential yield, has been made in respect of east and west coasts, Wadge Bank and Gulf of Mannar separately following the three depth zones, 50-100, 100-200m and 200-300/500m. As mentioned elsewhere, the areas along south-west coast (Lat. 8°N to 14°N) have been surveyed upto 500m depth. The results of the assessment are as follows.

Region	Yield in tonnes			Total
Depth zone(m)	50-100	100-200	200-300	
West coast	315206	102630	22024	439860
East coast	55923	28909	3385	88217
Wadge Bank	6820	12098	687	19605
Gulf of Mannar	1698	4345	166	6209

It may be seen that from the estimated 5.5 lakh tonnes of exploitable yield, the maximum, 4.4 lakh tonnes, is expected from west coast followed by 0.9 lakh tonnes from the east coast, 0.20 lakh tonnes from Wadge Bank and 0.06 lakh tonnes from Gulf of Mannar. Thus, the area between 50-300/500m depth zone which remains practically unexploited

would yield about 5.5 lakh tonnes of demersal fish. These estimates do not include yield for the stocks around the island groups viz. Andaman and Nicobar and Lakshadweep. A study on the demersal fish resources around Andaman group of islands by Sudarsan (1978) shows a biomass of 0.45 lakh tonnes of exploitable resources.

Specieswise potential yield

The qualitative and quantitative structure of exploitable yield of 5.5 lakh tonnes of demersal fish stock from different regions of the Indian coast are given in Table 12. The same table also gives the ranking of different species/groups in descending order of their contribution to demersal stock. It is seen that nemipterids with their total yield of about 1.01 lakh tonnes, form a principal resource particularly in west coast (0.88 lakh tonnes), Wadge Bank (0.09 lakh tonnes) and upper east coast (0.03 lakh tonnes). The second highest yield group, cat fishes (0.53 lakh tonnes) promises annual catch of 0.45 lakh tonnes from west coast, followed by 0.08 lakh tonnes along upper east coast. The species/groups expected to yield appreciable quantities from north west coast and upper east coast are sciaenids (18 and 3 thousand tonnes respectively), pomfrets (7 and 14 thousand tonnes respectively) and clupeids (3.1 and 1 thousand tonnes respectively). Leiognathids promise better yield on east coast (2.2 thousand tonnes) and in Gulf of Mannar (0.1 thousand tonnes), whereas comparatively large yield of lizard fish is expected from west coast (12.3 thousand tonnes). Of the 29 thousand tonnes of total yield of perches, the maximum harvest, 26 thousand tonnes has to come from the west coast, Wadge Bank and Gulf of Mannar. North-west coast, Gulf of Mannar and upper east coast are expected to contribute for 8 thousand tonnes of pomfrets from 50-100m depth belt. About 27 thousand tonnes of mackerel comprising 23 thousand tonnes from east coast and 4 thousand tonnes from west coast) could be harvested annually by demersal trawling from the Indian waters. Of the 17.3 thousand tonnes of cephalopods comprising squids and cuttle fishes as much as 17 thousand tonnes to be caught from west coast annually. Deeper water crustaceans, crabs, prawns and lobsters amount to the harvestable yield of about 7 thousand tonnes togeher from south west coast, Wadge Bank, Gulf of Mannar and east coast.

Table 12. Potential yield of important species/groups from different regions

Species	West coast		Wadge Bank	Gulf of Mannar	East coast		Total
	Lat. 14°-22°N	Lat. 8°-13°N			Lat. 10°-14°N	Lat. 15°-20°N	
Nemipterids	67.9	20.1	9.2	0.3	0.3	2.9	100.7
Cat fishes	38.0	6.6	0.6	-	0.2	7.5	52.9
Horse mackerel	41.3	-	-	-	0.6	2.1	44.0
Elasmobranchs	35.4	1.8	1.5	0.6	0.2	3.0	42.5
Priacanthids	18.1	11.0	0.3	0.1	2.0	4.0	35.5
Perches	20.6	1.5	2.5	0.9	0.6	2.9	29.0
Mackerels	4.1	1.1	-	-	0.4	22.6	28.2
Ribbon fishes	24.2	0.4	-	0.1	-	1.2	25.9
Squids & cuttle fishes	12.7	3.6	0.5	0.1	0.1	0.3	17.3
Decapterus spp	1.5	5.4	0.6	0.1	1.0	6.2	14.8
Other sciaenids	12.2	-	-	-	-	2.6	14.8
Lizard fish	8.0	4.3	1.1	-	0.1	0.1	13.6
Caranx spp	6.0	1.8	1.1	0.2	0.5	2.0	11.6
Pomfrets	6.6	-	-	-	-	1.4	8.0
Centrolophus niger	-	6.4	-	-	0.8	0.7	7.9
Ghol	5.6	-	-	1.2	-	0.9	7.1
Crabs	-	4.0	0.8	1.7	0.1	0.3	6.9
Ariomma indica	-	1.2	0.5	0.2	0.7	4.0	6.6
Clupeids	3.1	-	-	-	-	1.0	4.1
Barracuda	0.8	-	-	1.2	-	1.2	3.2
Leiognathids	-	-	-	0.1	0.4	1.8	2.3
Deepsea prawns	-	1.1	-	-	0.1	0.1	1.3
Deepsea lobster	-	0.7	0.02	0.02	-	-	0.7

Comparability of yield estimates

A comparative study of the estimates arrived at in the present study and estimates by various authors along with the current yield from the demersal fish stocks in the seas around India is furnished in Table 13. The Wadge Bank and Gulf of Mannar were not included by earlier authors in west coast and east coast respectively in their estimates. The total estimate arrived at in the present study is not comparable with the figure of 1948 thousand tonnes estimated by Joseph (1987) as the latter figure is inclusive of potential yield from 0-50m depth zone also. The estimates of Jones and Banerji (1973) appear to be on the lower side. The current yield in the case of east coast has already surpassed their estimated yield by several thousand tonnes. Difference of about 192 tonnes between the yield of demersal fish estimated by George et al. (op.cit.) and the present estimate for 50-200m depth zone, is mainly due to their assumption of common average densities in different regions irrespective of depth. The estimate, 5.5 lakh tonnes annual harvestable yield of demersal fish computed in the present report is based on the density figures recorded by exploratory surveys in different depth zones of each of the six regions and hence this along with the information furnished in the preceeding pages on the qualitative and quantitative assessment by depth and distance should serve as basis for policy decisions.

Table 13. Current yield and potential yield - present study and earlier estimates

('000 tonnes)

Region	Current yield	Potential yield							
		Present study				Jones & Banerjee (1973)	George et al., (1977)	Joseph (1987)	
		50-100m	100-200m	200-300/500	Total	0-200m	50-200m	0-200m	200-500
West coast	545.1	315.2	102.6	22.0	439.9	577	502.5	1364.5	50.0
East coast	270.9	55.9	28.9	3.4	88.2	143	280.0	500.5	33.0
Wadge Bank	-	6.8	12.1	0.7	19.6	-	-	-	-
Gulf of Mannar	-	1.7	4.4	0.2	6.3	-	-	-	-
Total	816.0	379.6	148.0	26.3	553.9	720	782.5	1865.0	83.0

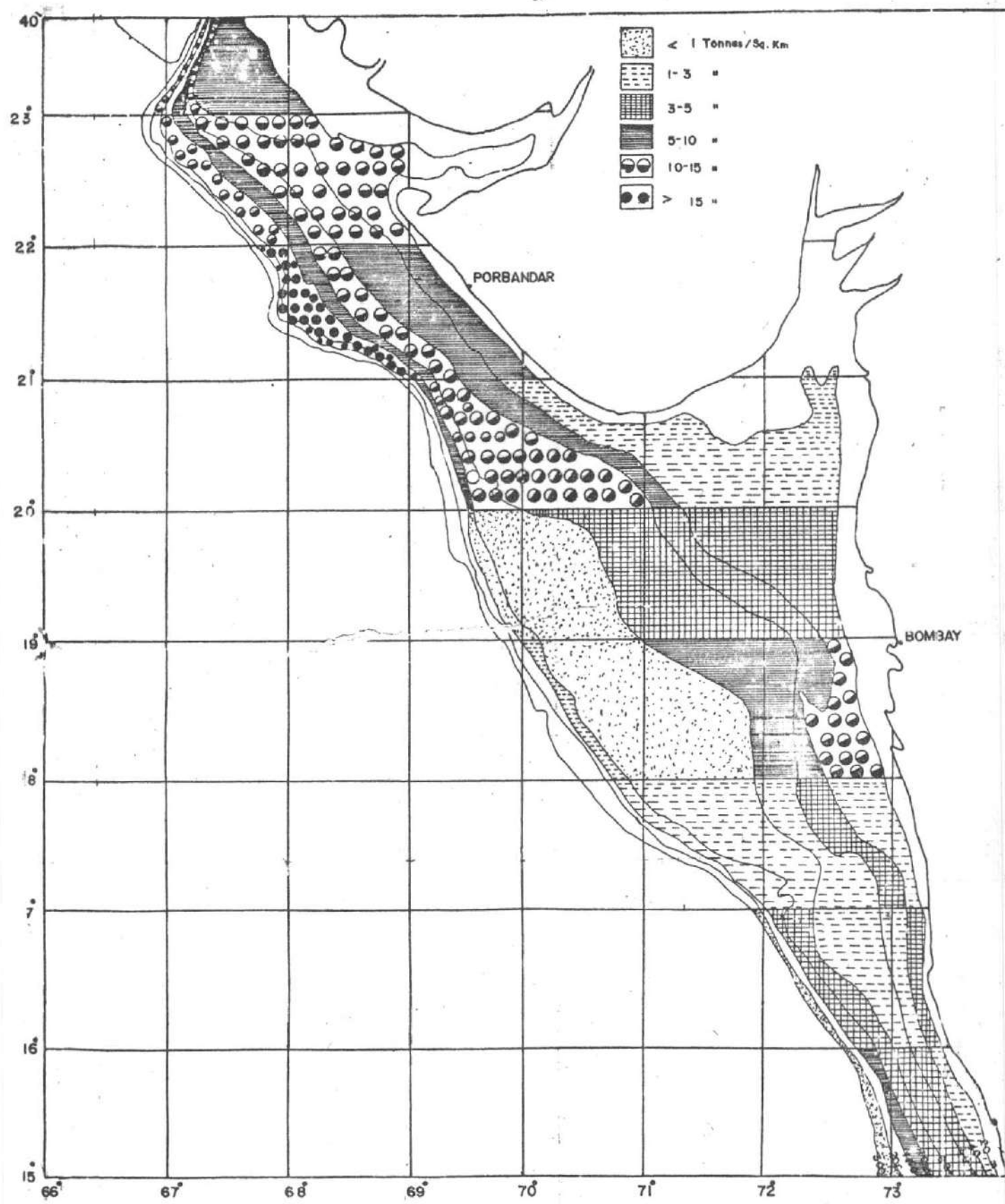

FIG. 1 MEAN DENSITY (TONNES/SQ KM) OF DEMERSAL FISH RESOURCES FROM DIFFERENT DEPTH ZONES ALONG NORTH-WEST COAST.

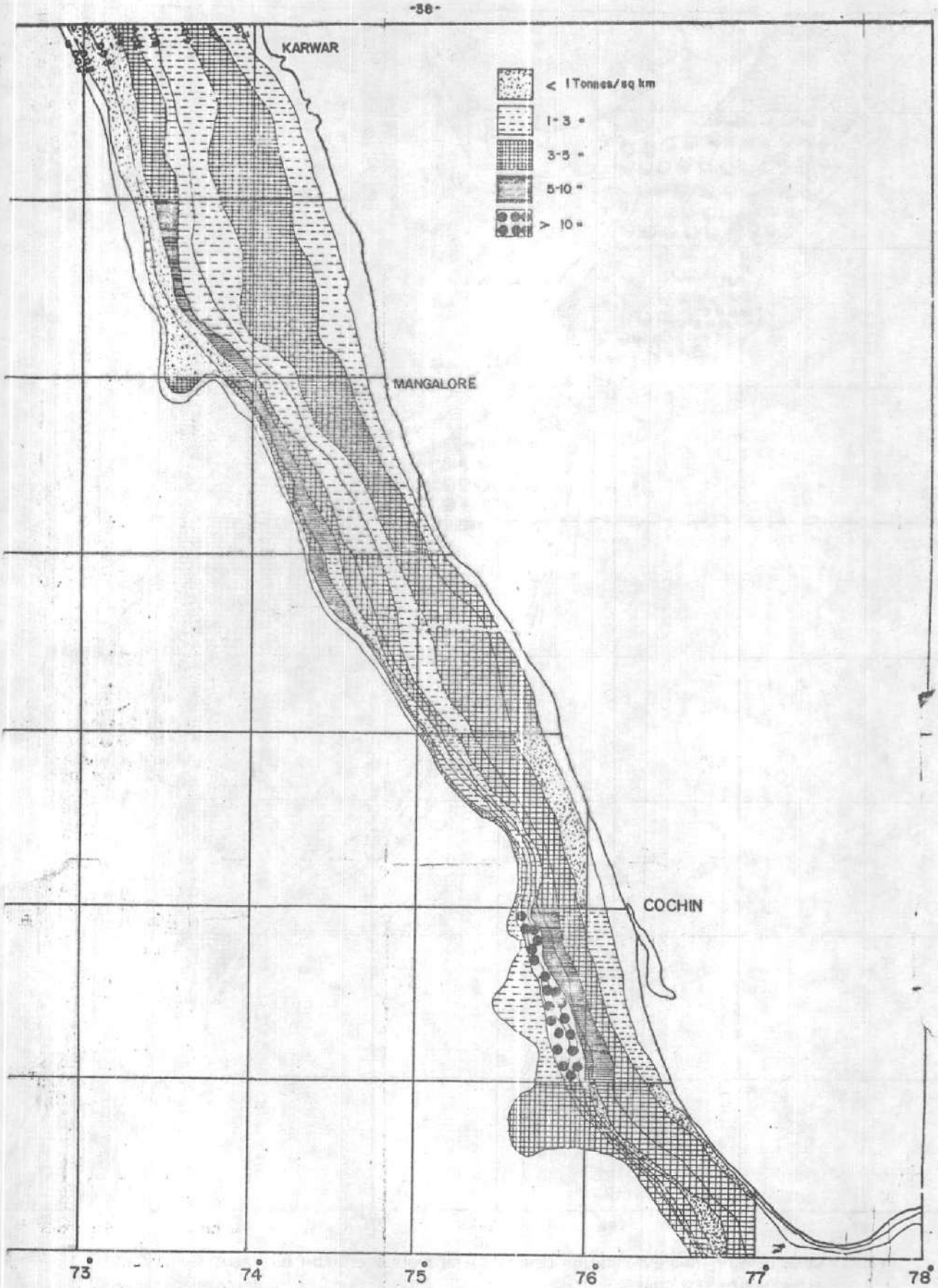

FIG. 2 MEAN DENSITY (TONNES/SQ KM) OF DEMERSAL FISH RESOURCES FROM DIFFERENT DEPTH ZONES ALONG SOUTH-WEST COAST.

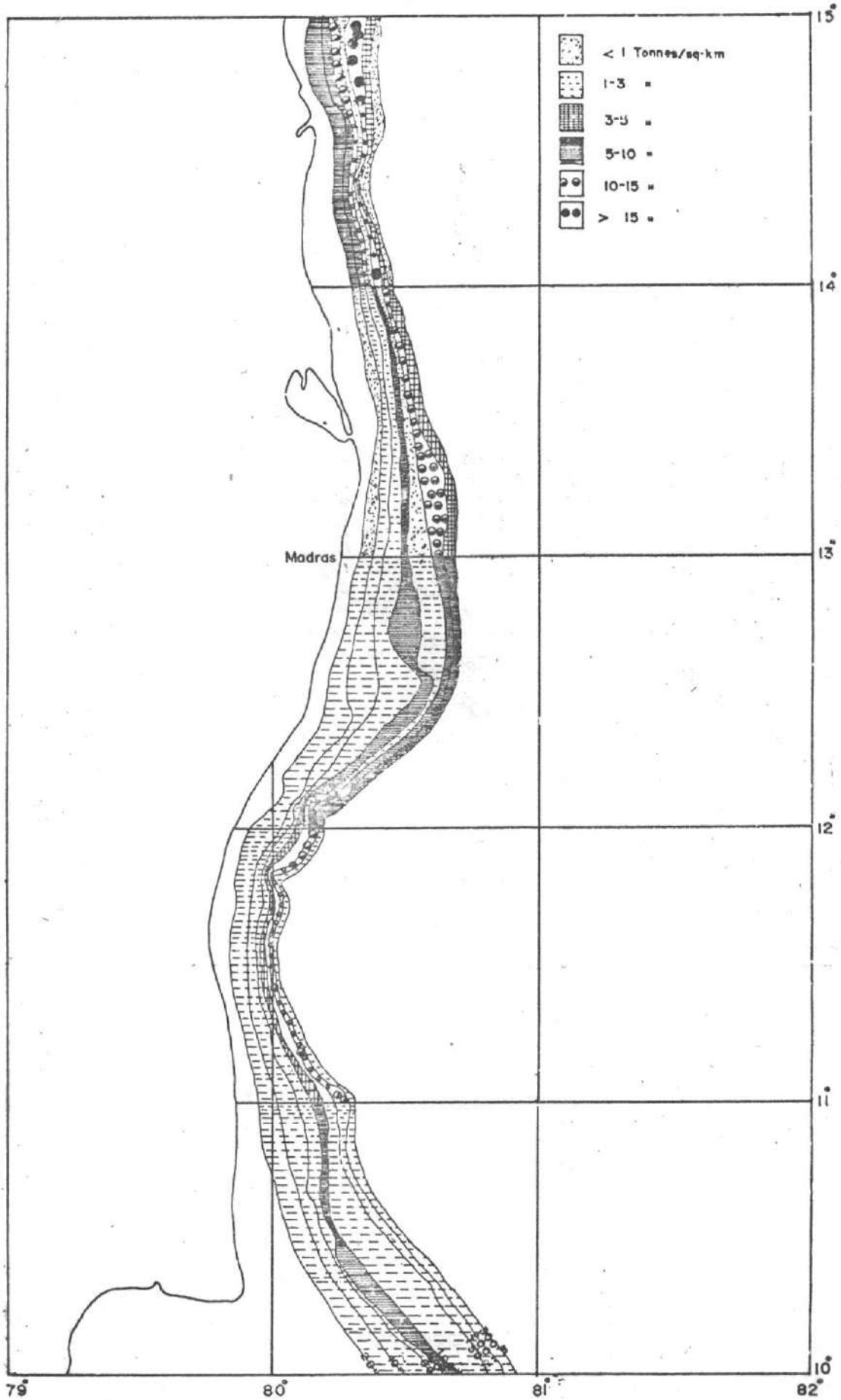

FIG. 3 MEAN DENSITY (TONNES/SQ KM) OF DEMERSAL FISH RESOURCES FROM DIFFERENT DEPTH ZONES ALONG LOWER EAST COAST.

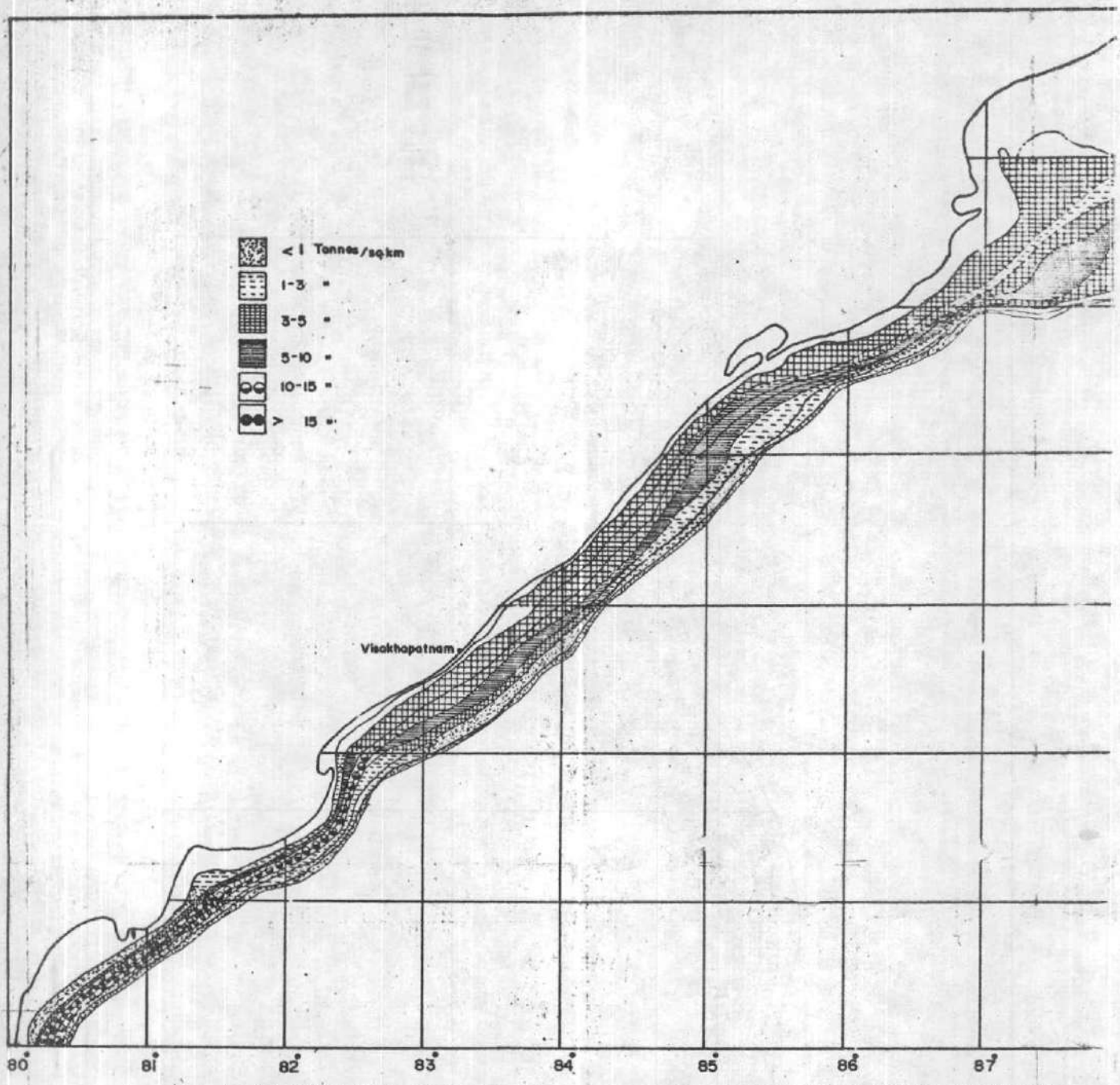

FIG. 4 MEAN DENSITY (TONNES/SQ KM) OF DEMERSAL FISH RESOURCES FROM DIFFERENT DEPTH ZONES ALONG UPPER EAST COAST.

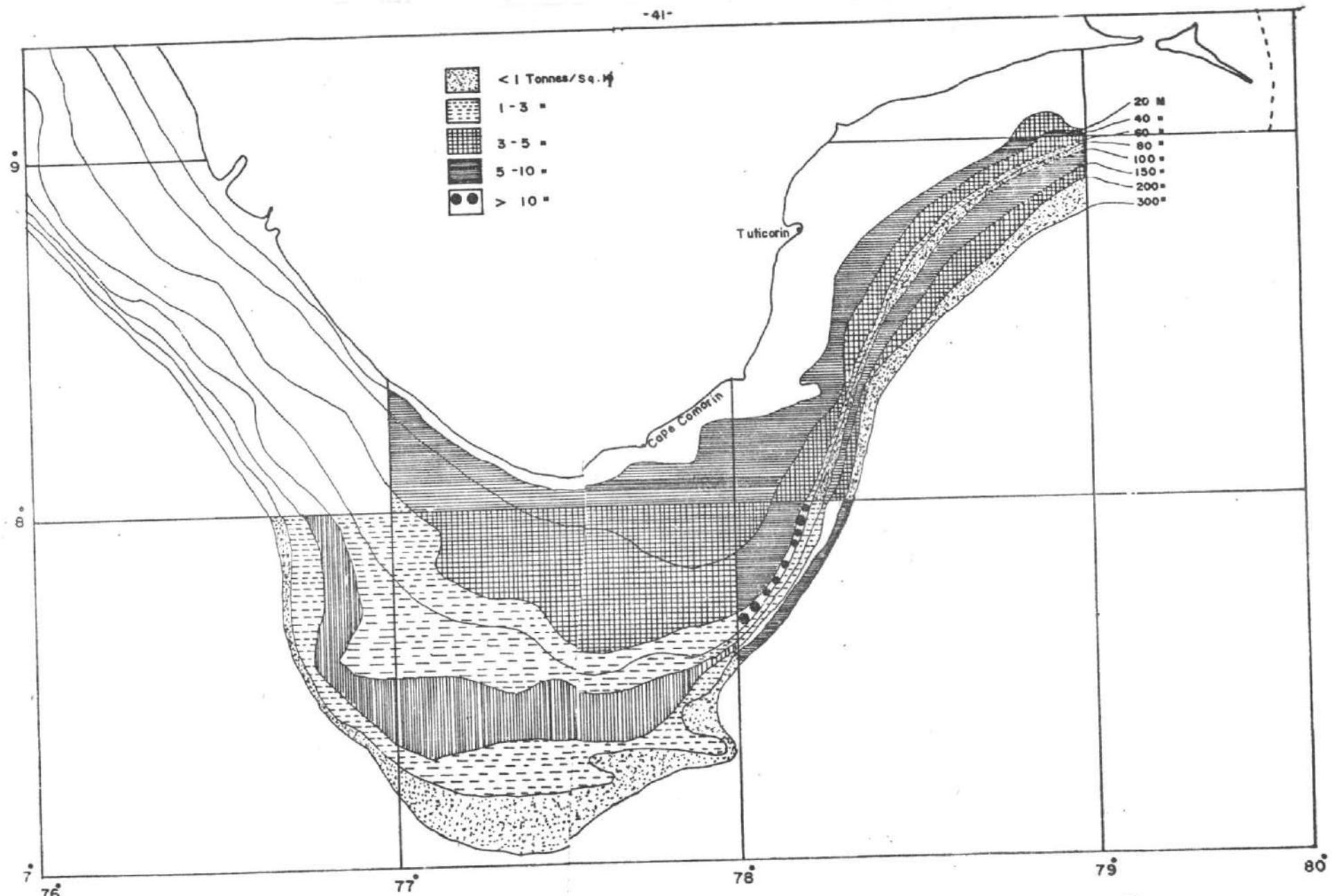

FIG. 5 MEAN DENSITY (TONNS/SQ KM) OF DEMERSAL FISH RESOURCES FROM DIFFERENT DEPTH ZONES ALONG WADGE BANK AND GULF OF MANNAR.

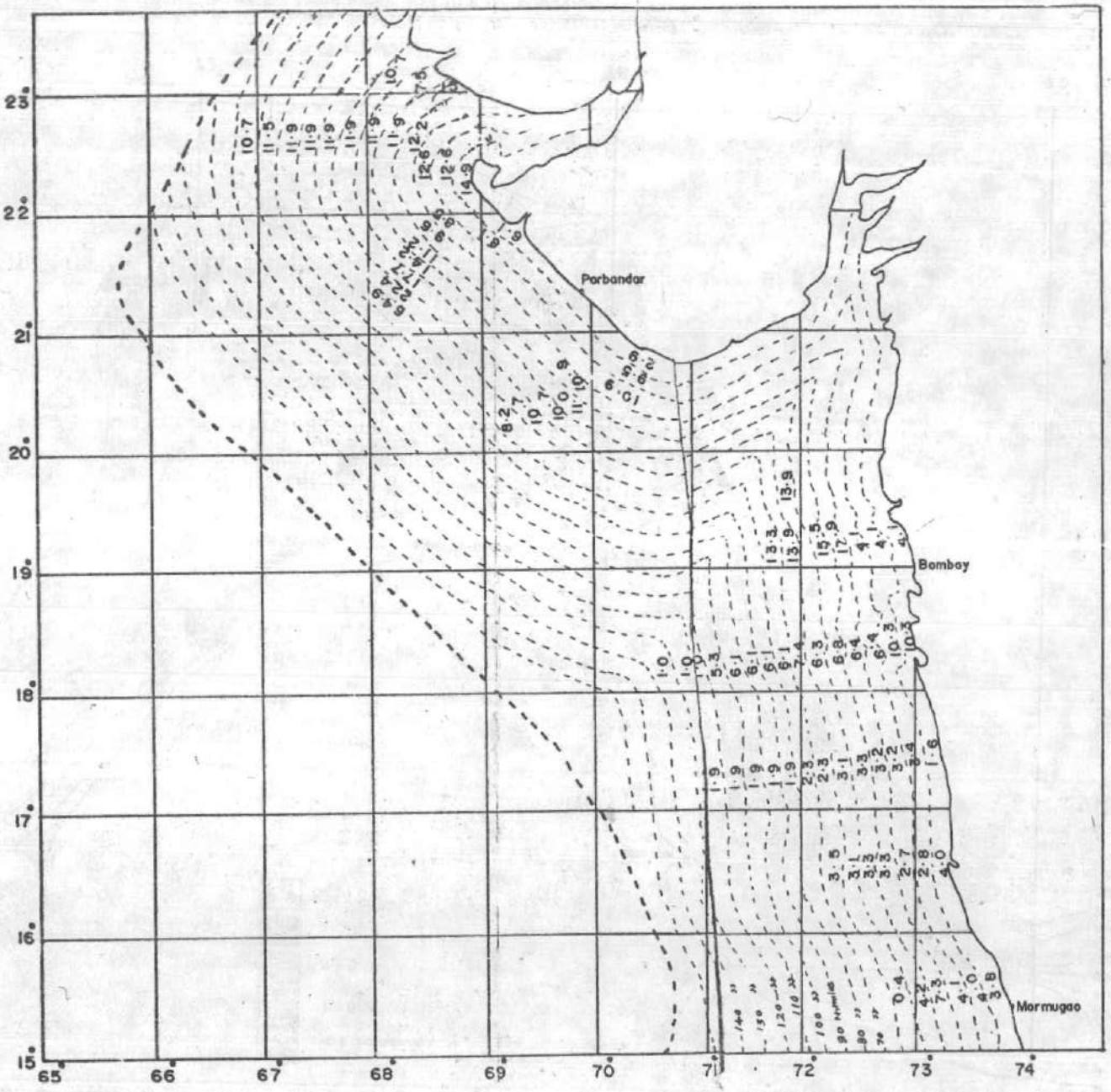

FIG. 5 MEAN DENSITY (TONNES/SQ KM) OF DEMERSAL FISH RESOURCE FROM DIFFERENT DISTANCE ZONES ALONG NORTH-WEST COAST.

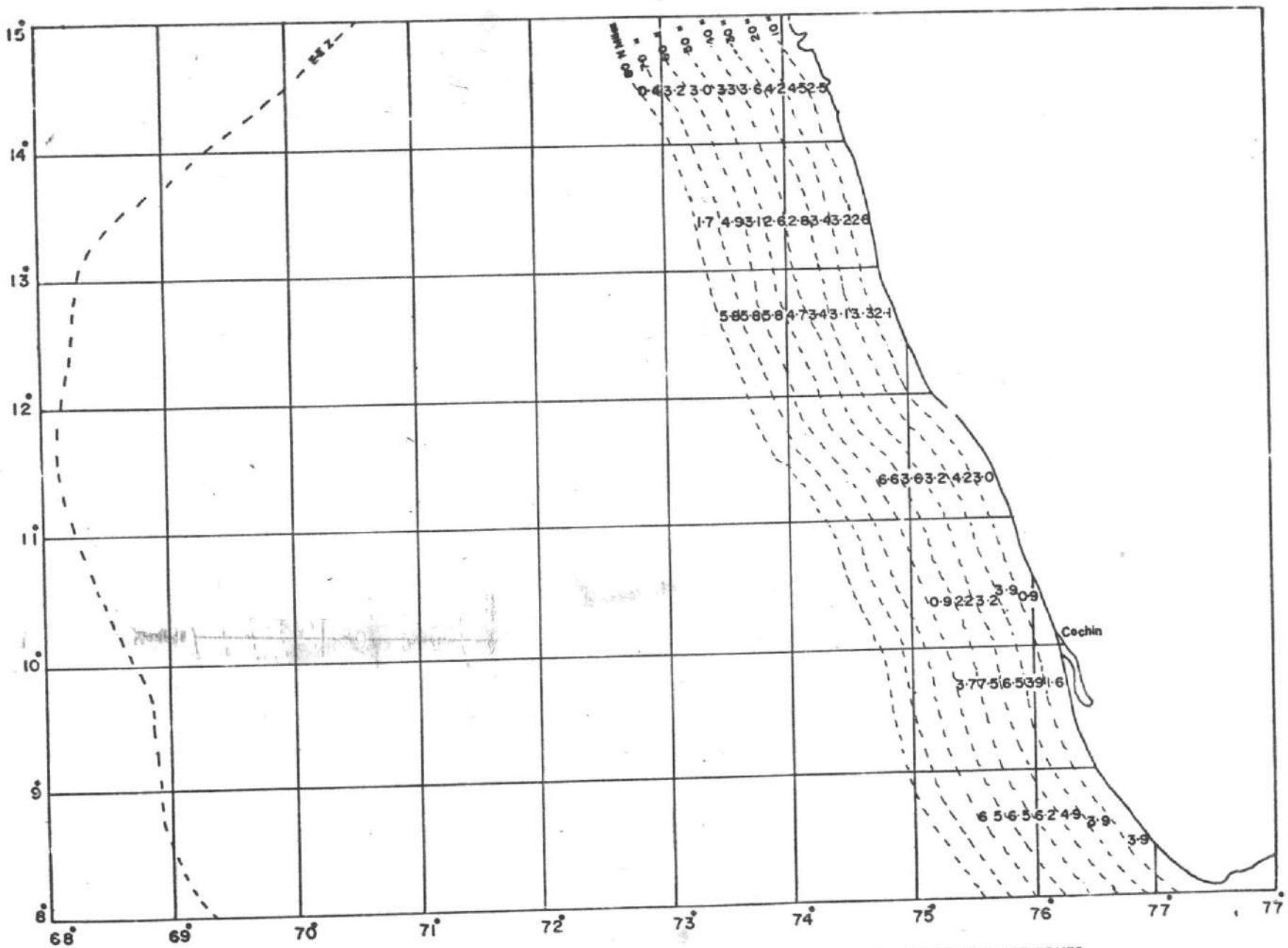

FIG. 7 MEAN DENSITY (TONNES/SQ KM) OF DEMERSAL FISH RESOURCES FROM DIFFERENT DISTANCE ZONES ... ALONG SOUTH-WEST COAST.

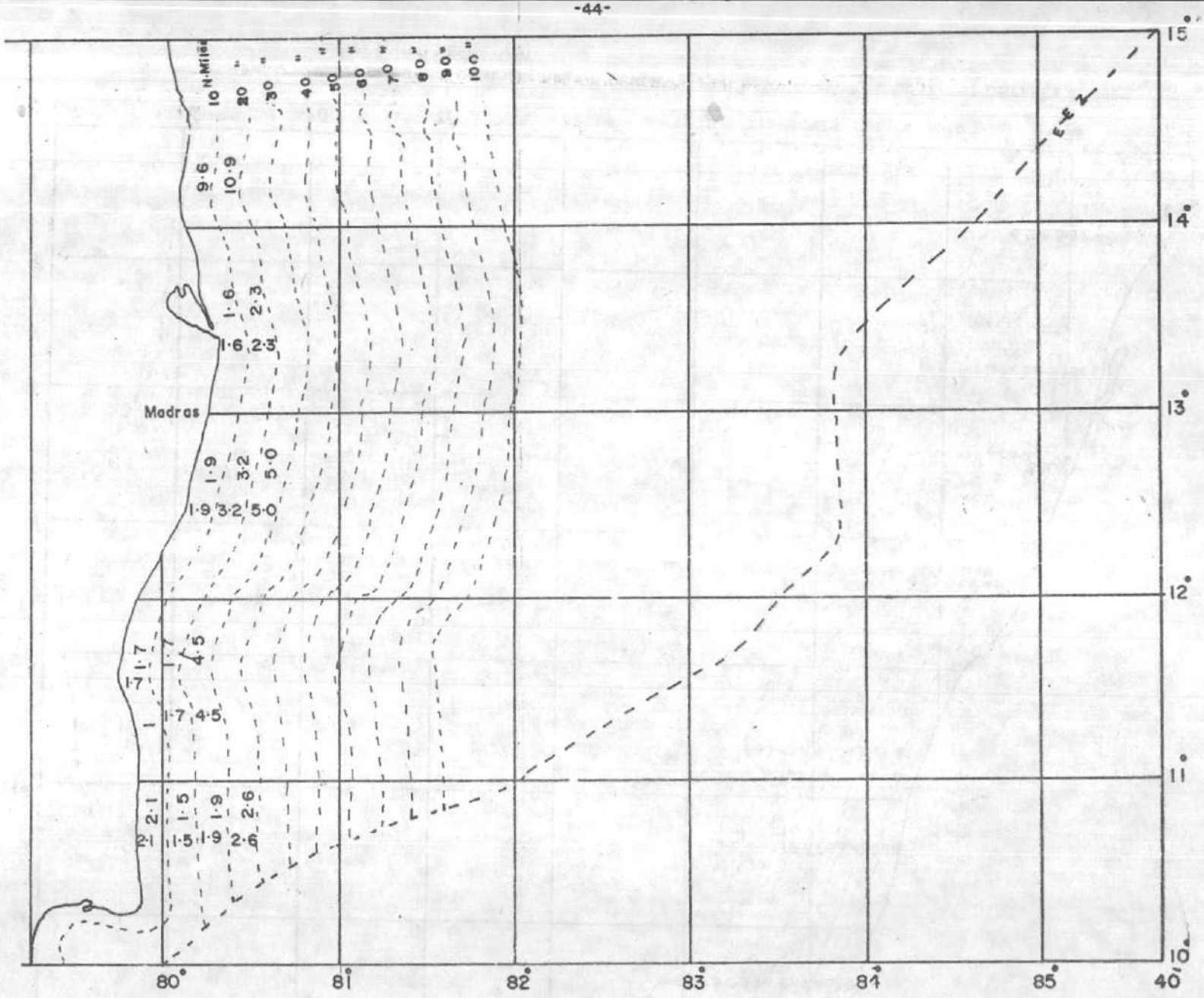

FIG. 8 MEAN DENSITY (TONNES/SQ KM) OF DEMERSAL FISH RESOURCES FROM DIFFERENT DISTANCE ZONES ALONG LOWER EAST COAST.

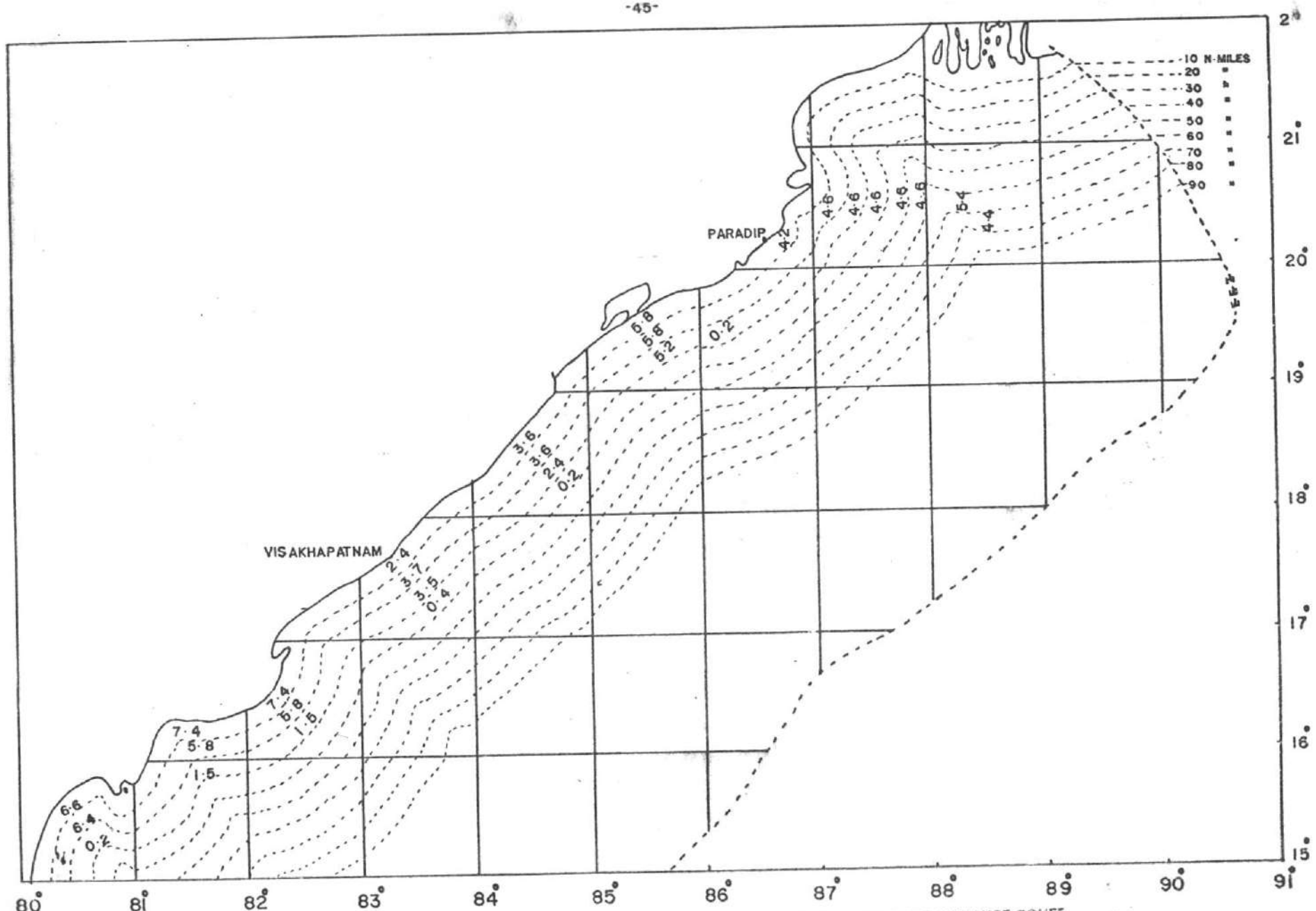

FIG. 9 MEAN DENSITY (TONNES/SQ KM) OF DEMERSAL FISH RESOURCES FROM DIFFERENT DISTANCE ZONES ALONG UPPER EAST COAST.

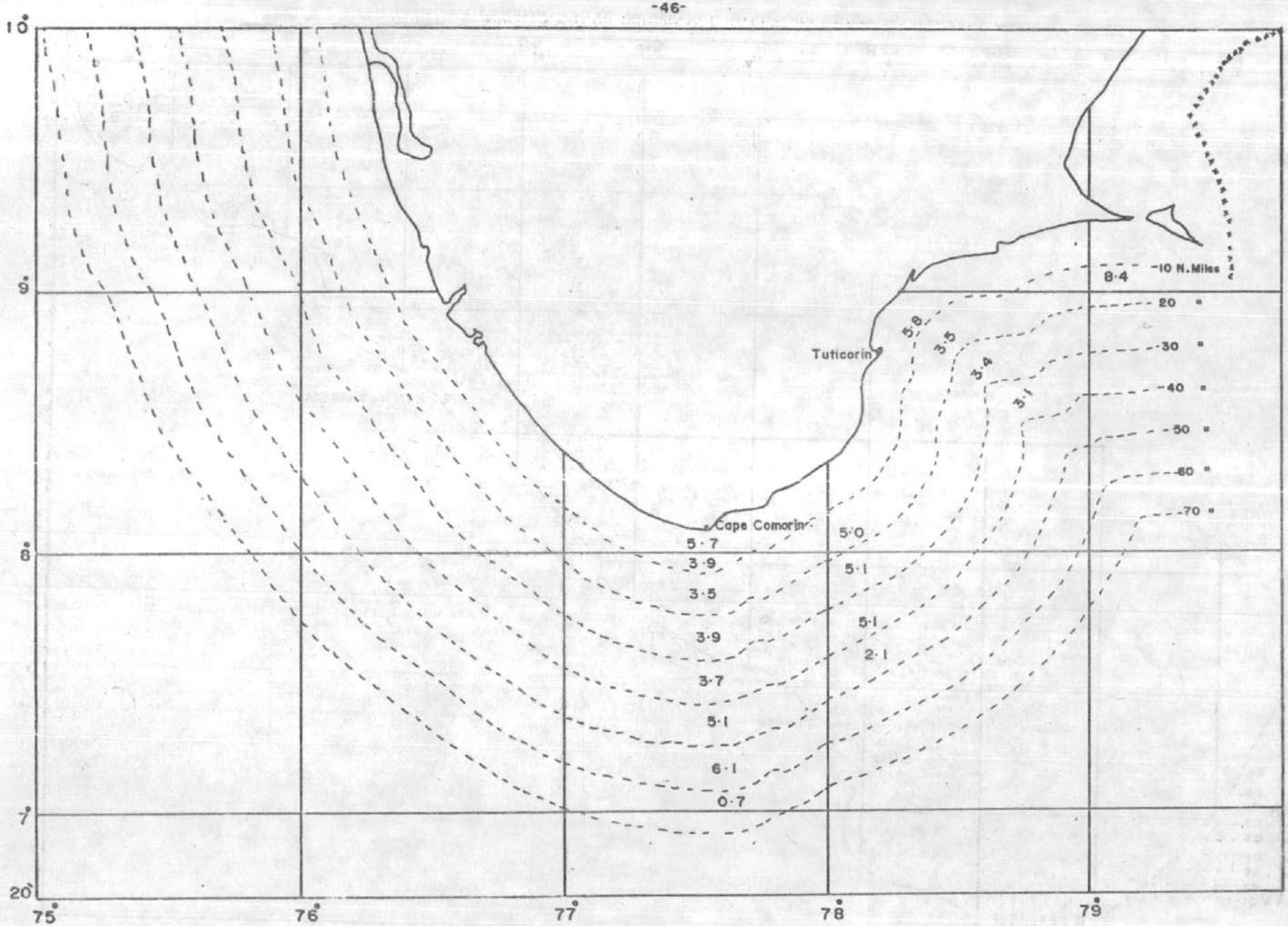

FIG. 10 MEAN DENSITY (TONNES/SQ KM) OF DEMERSAL FISH RESOURCES FROM DIFFERENT DISTANCE ZONES ALONG WADGE BANK AND GULF OF MANNAR.

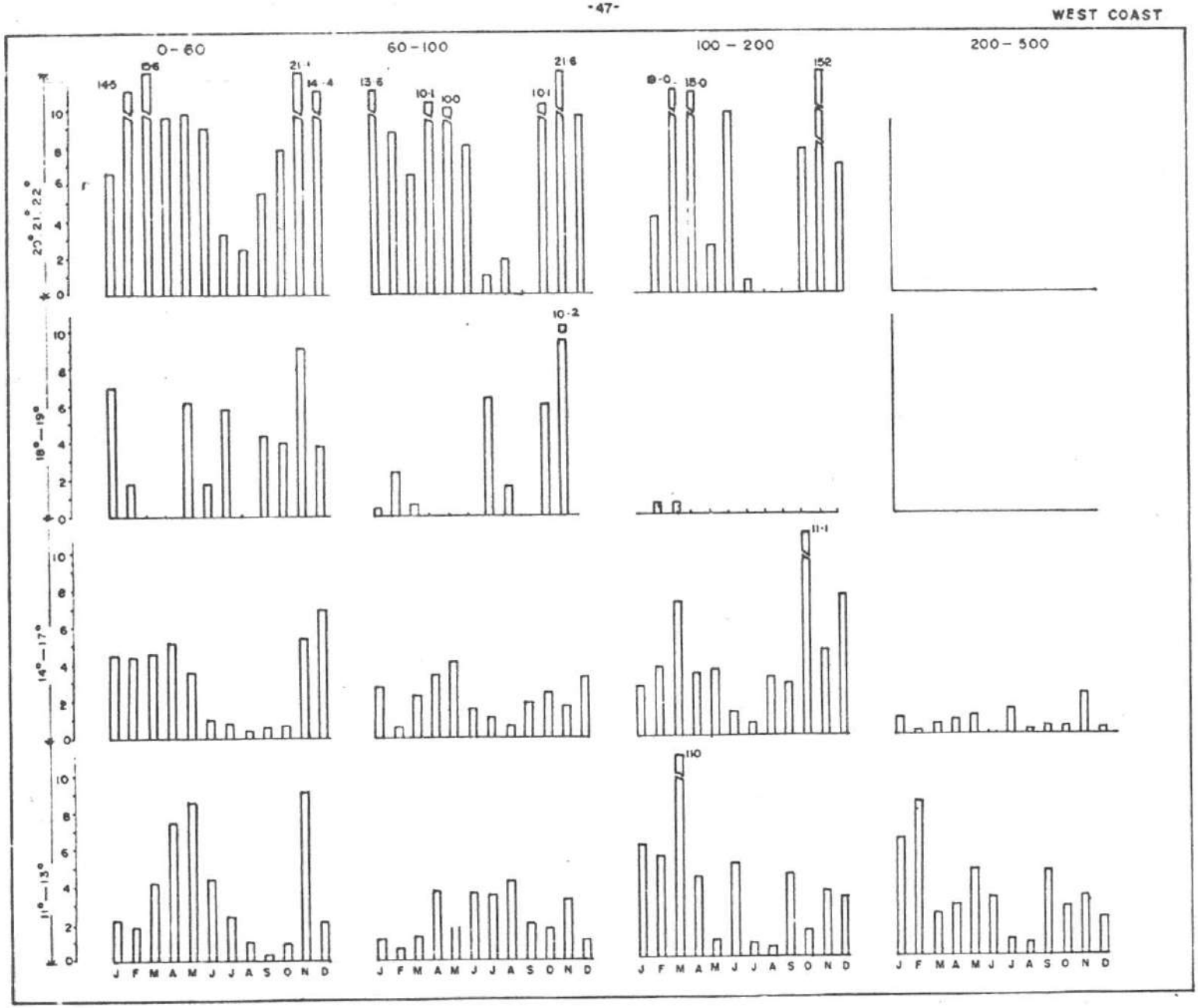

FIG. 11 (a) SEASONAL VARIATION OF DEMERSAL FISH STOCK BY REGION AND DEPTH ALONG WEST COAST

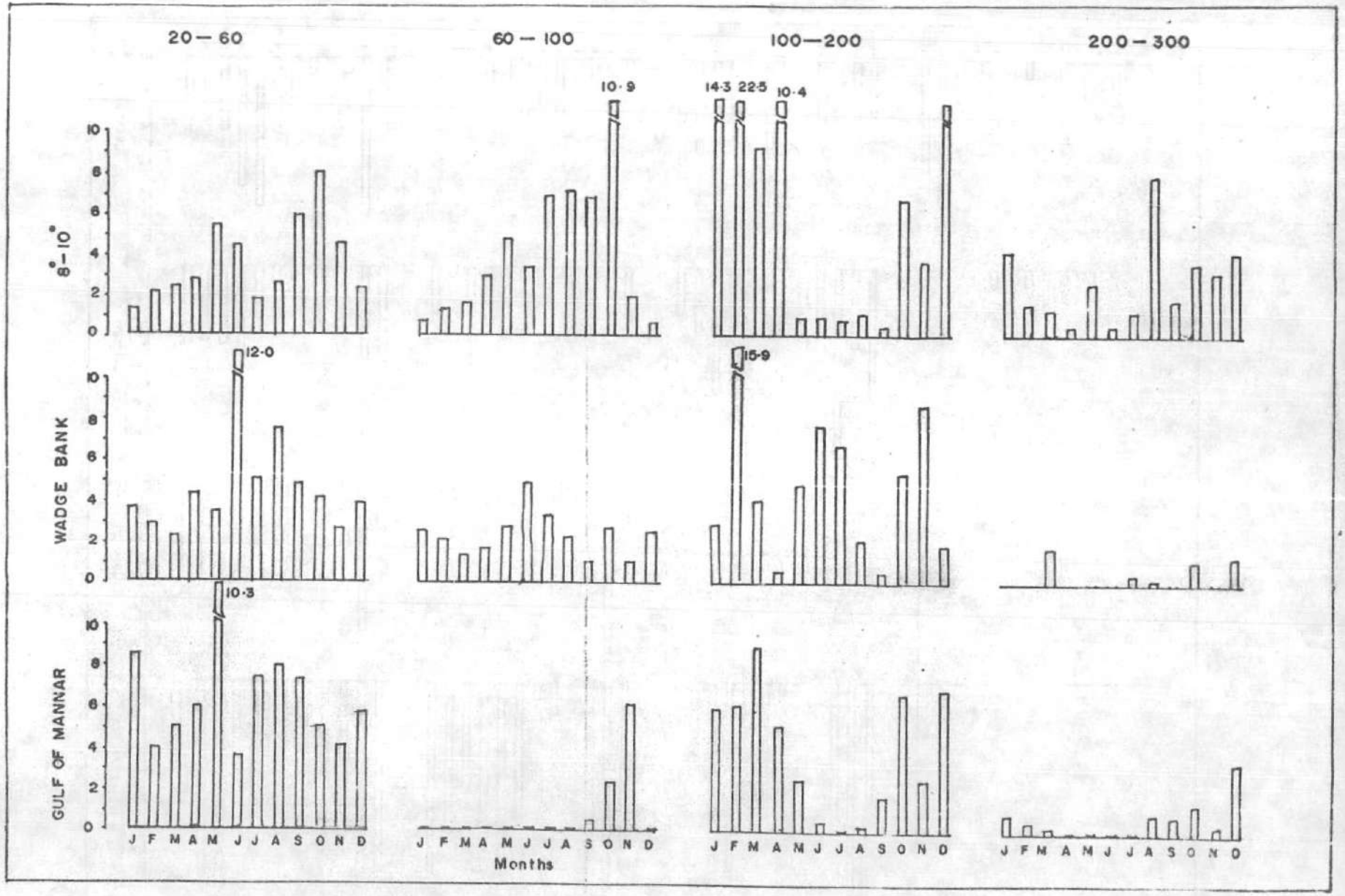

FIG. 11 (b) SEASONAL VARIATION OF DEMERSAL FISH STOCK BY REGION AND DEPTH ALONG WEST COAST (LAT. 8°-10°N), WADGE BANK AND GULF OF MANNAR

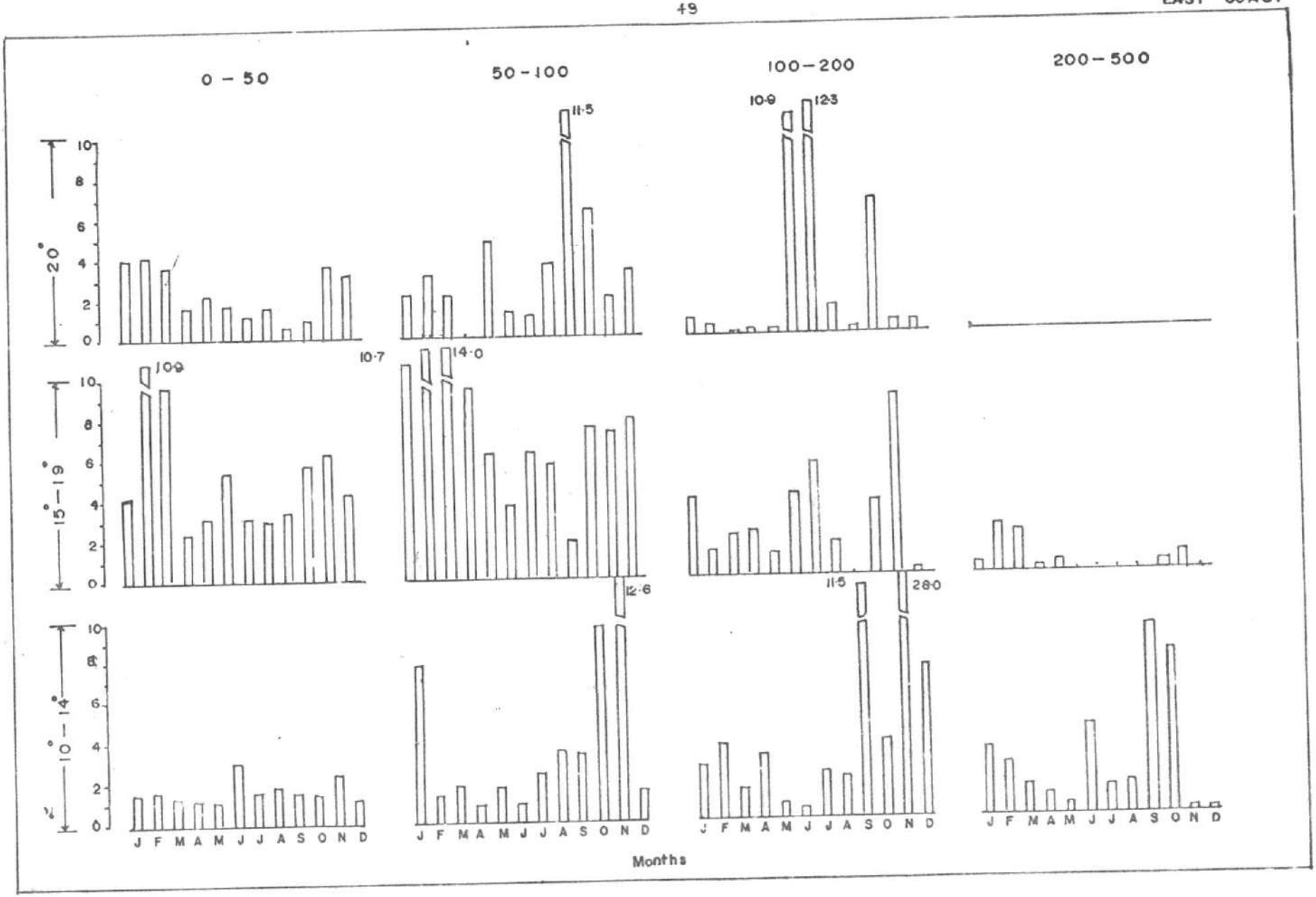

FIG. 11 (c) SEASONAL VARIATION OF DEMERSAL FISH STOCK BY REGION AND DEPTH ALONG EAST COAST

III. PELAGIC FISHERY RESOURCES

1. Present status

The pelagic resources contributed on an average 48% (74,1871 tonnes) to the total marine fish landings in the country during 1979-84 of which the west coast accounted about 70%. This group formed about 38% and 63% of the total pelagic fish landings of west coast along north west coast and south west coast respectively. Along south east coast and upper east coast pelagic groups together contributed to 46% to the total pelagic fish landings. The percentage composition of pelagic groups landed in the country (except island waters) as well as in different regions are shown in Fig. 12.

2. Pelagic resources abundance

2.1 At present the exploitation of pelagic resources just as in the case of demersal resources is mostly confined to a narrow coastal belt upto 50m depth and the landings are mainly by indigenous craft and gear. The resources beyond this region are virtually unexploited. Exploratory surveys carriedout by FSI and other agencies in the recent past, have revealed potential pelagic resources outside the conventional zone. Details of these resources are given in the ensuing paragraphs.

2.2 The vessels **M.T. Murena, Matsya Nireekshani** and **Matsya Varshini** carried out pelagic trawl survey along north-west coast and recorded potential pelagic resources in the outershelf region. **M.T. Murena** conducted three pelagic trawl survey cruises during 1977 employing 64/112 x 59/92 side flat pelagic rope trawl and 59/88 x 53/66 - side flat pelagic trawl. During 1979-80 **Matsya Nireekshani** and **Matsya Varshini** used pelagic trawl of size 69.4m x 64.4 m x 78m and 12 x 12 fm respectively. The details of pelagic trawl surveys conducted by the above vessels are presented in Table 14 to 19.

The most significant observation of the above surveys are good concentration of horse mackerel off Porbandar and Dwaraka and ribbon fish resources off Goa, Bombay and Veraval. Horse mackerel was found abundant in the depth range 91-125 m (474 kg/hr) and 126-360 m (188 kg/hr) whereas ribbon fish was abundant in the depth 55-90 m (148 kg/hr).

Table 14. Latitude-wise effort and catch rate obtained by M.T. Murena by pelagic trawling off north west coast

Latitude (°N)	Fishing effort (hrs)	Catch rate (kg/hr)
15	49.24	103.21
16	62.23	62.19
17	72.98	51.70
18	104.33	188.88
19	211.18	444.66
20	179.94	388.45
21	117.71	83.22
22	256.83	885.93
23	10.71	255.65
Total/Average	1065.15	409.63

Table 15. Latitude-wise effort and catch rate obtained by Matsya Nireeekshani by pelagic trawling off north west coast

Latitude (°N)	Fishing effort (hrs)	Catch rate (kg/hr)
19	6.37	18.84
20	27.08	115.32
21	63.01	908.54
22	51.13	206.77
Total/Average	147.59	481.48

Table 16. Latitude-wise effort and catch rate obtained by Matsya Varshini by pelagic trawling off north west coast

Latitude (°N)	Fishing effort (hrs)	Catch rate (kg/hr)
20	8.50	8.24
21	5.00	5.80
22	16.00	75.70
Total/Average	29.50	44.41

Table 17. Catch composition and catch rate obtained by M.T. Murena by pelagic trawling off north west coast

Species	Percentage	Catch rate (kg/hr)
Elasmobranchs	8.19	33.5
Cat fishes	3.42	14.0
Clupeids	0.06	0.2
Chorinemus spp	0.48	2.0
Perches	1.43	5.9
Nemipterids	0.06	0.2
Ghol	1.70	7.0
Koth	0.01	0.0
Other sciaenids	0.88	3.6
Ribbon fishes	27.88	114.2
Caranx spp	1.09	4.5
Elacate nigra	0.08	0.3
Horse mackerel	38.90	159.4
Pomfrets	6.59	27.0
Seer fishes	0.98	4.0
Tuna	0.25	1.0
Barracuda	0.12	0.5
Lactarius lactarius	0.23	0.9
Polynemus spp	0.27	1.1
Bombay duck	0.03	0.1
Squids	0.02	0.1
Shrimp	0.14	0.6
Others	4.04	16.6
Total/Average	100.00	409.6

Table 18. Catch composition and catch rate obtained by Matsya Nireekshani by pelagic trawling off north west coast

Species	Percentage	Catch rate (kg/hr)
Elasmobranchs	10.01	48.2
Eels	0.35	1.7
Cat fishes	0.21	1.0
Clupeids	2.33	11.2
Chirocentrus spp	0.19	0.9
Perches	0.91	4.4
Ghol	0.06	0.3
Other sciaenids	0.06	0.3
Ribbon fishes	4.28	20.6
Caranx spp	0.19	0.9
Horse mackerel	70.68	340.6
Pomfrets	8.62	41.5
Mackerel	0.23	1.1
Seer fishes	0.37	1.8
Others	1.50	7.2
Total/Average	100.00	481.48

Table 19. Catch composition and catch rate obtained by Matsya Varshini by pelagic trawling off north west coast

Species	Percentage	Catch rate (kg/hr)
Elasmobranchs	46.87	20.8
Ghol	1.83	0.8
Ribbon fishes	34.43	15.3
Horse mackerel	3.13	1.4
Pomfrets	3.13	1.4
Seer fishes	3.13	1.3
Polynemus spp	1.83	0.8
Others	5.65	2.5
Total/Average	100.00	44.4

The purse-seine survey conducted by **Matsya Varshini** along north west coast indicated that the important shoaling fishes are little tuna **(Euthynnus affinis)**, horse mackerel **(Megalaspis cordyla)** etc. The vessel employed a purse-seine net of size 221.5 fm x 50 fm. The purse-seine survey results are given below.

Area	No.of sets operated	Total catch (kg)	Species composition (%)					
			Tunnies	Sardine	Horse mackerel	Carangids	Mackerel	Others
22-68	3	-	-	-	-	-	-	-
21-68	1	-	-	-	-	-	-	-
21-69	9	17190	98	-	-	-	-	-
20-69	2	128	72	-	28	-	-	-
20-70	4	440	3	-	51	-	-	46
19-72	7	6321	98	-	-	-	-	2
18-71	2	-	-	-	-	-	-	-
16-72	2	-	-	-	-	-	-	-
16-73	1	25370	-	100	-	-	-	-
15-72	1	-	-	-	-	-	-	-
15-73	4	-	-	-	-	-	-	-

2.3 The report on the survey conducted by the erstwhile Pelagic Fisheries Project during 1972-77 along south west coast indicated majority of the pelagic resources in the shelf, i.e. in waters within 30 nautical miles from the shore. The purse-seine survey carried out by **Matsya Varshini** during 1984-86 also confirms the above findings and distribution of the conventional pelagic resources such as oil sardine, Indian mackerel were found mostly within 60 m depth contour and no significant shoals have been recorded beyond this depth. Adequate data were not available inrespect of the pelagic shoals of tunas. The details of purse seine survey carried out by **Matsya**

Varshini are given below:

\reas	No.of sets oper-ated	Total catch (kg)	Species compositiong (%)				
			Tun-nies	Sar-dine	Caran-gids	Mack-erel	Others
14-73	3	-	-	-	-	-	-
13-73	2	-	-	-	-	-	-
13-74	18	30209	99	-	1	-	-
12-74	14	1025	59	-	-	-	41
11-75	6	-	-	-	-	-	-
11-74	1	-	-	-	-	-	-
10-75	7	6405	2	39	49	-	10
9-75	8	4868	-	13	-	87	-
9-76	9	26385	9	-	37	53	11
8-76	9	35876	4	43	-	46	7
8-77	1	745	-	-	-	100	-

The important observations of the above survey are occurrence of large number of shoals of little tuna (**Euthynnus affinis**) off Malpe along Karnataka coast, mackerel off south Kerala coast and carangids especially rainbow runner (**Elagatis bipinnulata**) off Cape Comorin. Shoals of Indian mackerel were observed during south west monsoon in greater magnitude. Carangids especially decapterids formed a sizable portion of the demersal trawl catches in the deeper waters of south west coast.

2.4 The pelagic resources survey conducted along east coast, although inconclusive does indicate the availability of tunnies, pomfrets etc. Results of pelagic trawling and purse-seining by **Matsya Darshini** during 1979-83 along Andhra - Orissa coast are given in Tables 20 and 21. The vessel operated a 12 x 12 fm midwater trawl and a 221.5 fm x 50 fm purse seine net. The details of purse seine are furnished below.

Area	No.of sets oper-ated	Total catch (kg)	Species composition (%)					
			Tun-nies	Horse mack-erel	Sar-dines	Pomf-ret	Anch ovies	Others
12-81	1	-	-	-	-	-	-	-
13-80	1	120	-	-	-	-	-	100
14-80	25	8,467	78	-	7	-	-	5
15-80	15	175	3	-	35	-	-	62
15-81	6	-	-	-	-	-	-	-
16-81	7	5,139	5	-	20	-	58	17
16-82	19	7,400	29	-	12	47	-	12
16-84	1	-	-	-	-	-	-	-
17-82	6	2,010	-	-	-	-	-	100
17-83	11	2,062	100	-	-	-	-	-
19-82	1	984	13	-	-	-	-	87
19-84	2	450	52	-	22	-	-	26
19-85	11	4,790	9	-	46	-	-	45
19-86	10	6,330	-	79	-	-	-	21
20-87	9	40	-	-	-	-	-	100

However, one of the significant observations of the demersal trawl survey carried out by FSI vessels in the above region is that truely pelagic shoaling species, the Indian mackerel surprisingly forms a major component of the demersal trawl catches. Potentially rich resources of Indian mackerel have been located all along the east coast in the depth range 50-150m mainly off Andhra Pradesh, Orissa and West Bengal coasts. Besides horse mackerel, decapterids, lesser sardines etc. were also found in sizable quantities in deeper waters.

2.5 Estimate of potential of pelagic fish resources is not attempted, here. However, the potential of pelagic resources from Indian waters has

Table 20. Latitude-wise effort and catch rate obtained by Matsya Darshini by pelagic trawling off east coast

Latitude(°N)	Fishing effort(hrs)	Catch rate (kg/hr)
13	3.25	149
14	45.75	442
15	32.00	200
16	131.00	209
17	67.00	54
18	4.00	3
19	35.25	73
Total	319.00	190

Table 21. Catch composition and catch rate obtained by Matsya Darshini by pelagic trawling off east coast

Species	Percentage	Catch rate (kg/hr)
Elasmobranchs	5.0	13.31
Eels	0.6	1.60
Cat fishes	1.8	4.80
Clupeids	36.9	98.25
Anchovies	0.8	2.13
Perches	3.0	7.99
Sciaenids	0.7	1.86
Pomfrets	2.6	6.92
Ribbon fishes	7.2	19.17
Mackerel	5.2	13.85
Seer fishes	1.1	2.93
Others	35.1	93.46
Total/Average	100.0	266.25

been estimated by various authors between 0.6 to 2.1 million tonnes as detailed below:

('000 tonnes)

Region	Jones & Banerji (1973)	George *et al.* (1977)	Joseph (1987)
North east coast	-	395	496
South west coast	1020	840	549
South east coast	672	310	197
North east coast	-	240	292
Andamans	8	140	139
Lakshadweep	2	55	63

George *et al.* (1977) estimated the potential of pelagic resources from Indian EEZ at 2.1 million tonnes. Pelagic resources potential from the waters around mainland between 50-200m is placed at 0.7 million tonnes. Joseph (1987) has assessed a total potential of pelagic resources at 1.7 million tonnes, of which 1.5 million tonnes is anticipated from the seas around mainland (0-200m) with an additional harvestable yield of about 0.8 million tonnes. Jones and Banerji (1973) have estimated the potential yield of pelagic resources as 0.6 million tonnes. The standing stock of oil sardine, mackerel and white baits, along south west coast as projected by UNDP/FAO Pelagic Fisheries Project, is 4,3 and 2 lakhs tonnes respectively. The "shallow water mix" comprising scads, silver bellies and **Ambasis** spp is estimated to have 0.6 lakh tonnes of standing stock in south west coast (PFP,1976).

From the available information, it could be concluded that among the pelagic groups, carangids, Indian mackerel etc., are the important resources which have great development potential especially in the deeper waters. Along the north west coast there are good indications for development of commercial fishery based on horse mackerel and ribbon fishes whereas along south west coast the commercially important groups in the deeper waters are **Decapterus** spp, little tuna, **Caranx** spp, etc. Along east coast mackerel is the promising resources especially off Andhra Pradesh, Orissa and West Bengal.

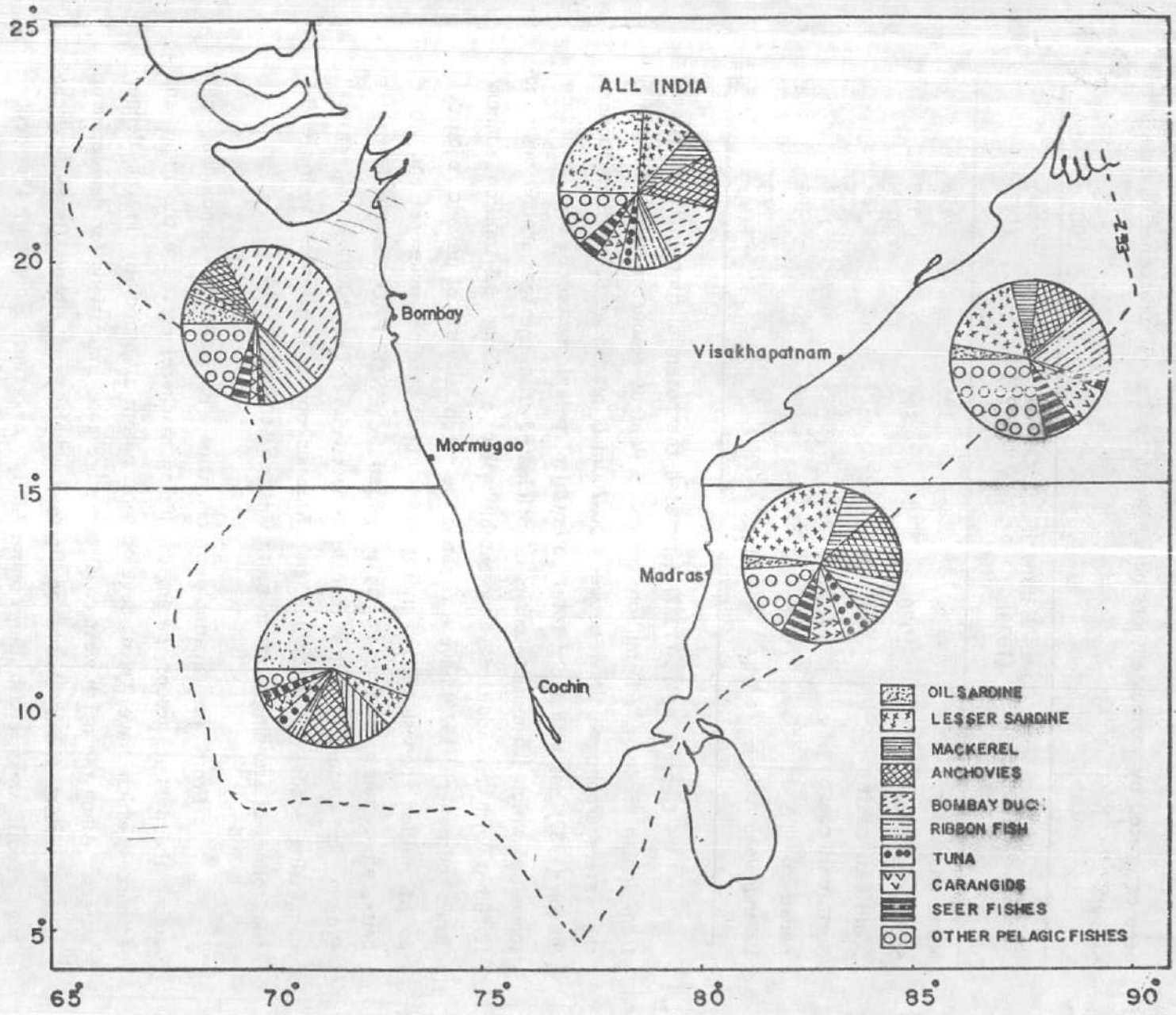

FIG. 12 PERCENTAGE COMPOSITION OF PELAGIC FISH LANDINGS DURING 1979-84.

IV. TUNAS AND ALLIED OCEANIC RESOURCES

1. Present status

Tuna fisheries in Indian Ocean accounts for about 10-12% of the world production of tunas and tuna like fishes. But it is one of the least exploited resources of Indian seas. The average annual production of these scombroids from Indian waters is about 24,000 tonnes, mainly the coastal tunas.

The major tunas have a continuous and widespread distribution in the Indian Ocean. Absence of precise information on the separation of these stocks according to the geographical areas render assessment of stock size within the EEZ rather difficult. However, a review of the potential yield estimates of tunas in the Indian Ocean as given below, will be indicative of the magnitude of these stocks within our EEZ.

Gulland (1971)	100-150,000 tonnes
IPFC/IOFC (1973)	115-137,000 tonnes
Suda (1974)	123-131,000 tonnes
IOFC (1977)	125,000 tonnes
Silas & Pillai (1982)	510-785,000 tonnes*

George *et al.* have assessed the potential exploitable yield of tunas and tuna like fishes upto 200 m as follows.

North west coast	...	10,000 tonnes
South west coast	...	60,000 tonnes
Lower east coast	...	10,000 tonnes
Upper east coast	...	10,000 tonnes
Lakshadweep islands	...	50,000 tonnes
Andaman & Nicobar islands	...	100,000 tonnes
Total		240,000 tonnes

*Including 325-600 tonnes of skipjack and other small tunas.

Dwivedi and Devaraj (1983) projected an assessment of standing stock of larger tunas in Indian seas as 6,000 tonnes and the MSY as 3,000 tonnes. This was based on the proportion of 220,000 tonnes tuna biomass in the Indian Ocean that is likely to be distributed within the EEZ of India which forms 2.8% of the total Indian Ocean areas. But in view of the habitat preference of the group in favour of the warmer waters the proportion is likely to be much higher. Besides, such a simplistic assumption is not desirable. Based on the spatial distribtuion pattern of yellowfin tuna, exhibiting wide fluctuations in different regions of Indian Ocean and also in different parts of EEZ, this simple arithmetic of apportioning is probably not reflective of the real stock size in the Indian EEZ.

Exploratory surveys of tuna resources in Indian waters is insufficient to attempt even approximations on the size of tuna stocks in the entire EEZ. However, from the investigations by the tuna long liner **Matsya Sugundhi** from October, 1983 to March 1987 and that of **Matsya Harini** from July 1986 to March 1987, a fairly clear picture on the spatial distribution of the species exploitable by long lining has emerged.

2. Resource composition

The resources could be categorised into three major groups viz. scombroids, billfishes and pelagic sharks. Among the scombroids yellowfin tuna made up about 97% and big eye tuna and skipjack formed the rest. Billfishes consisted of striped marlin, blue marlin, black marlin, sail fish and swordfish. Pelagic sharks included wide variety of sharks such as mako shark, thresher shark, tiger shark, hammer-head shark etc. The average weight per piece of the species obtained are given below:

Species	Average weight(kg)	Species	Average weight(kg)
Yellowfin tuna	30-35	Black marlin	70-80
Big eye tuna	40-45	Sail fish	20-30
Skipjack tuna	4-6	Swordfish	20-30
Striped marlin	35-40	Sharks	25-30
Blue marlin	35-40		

The resources composition showed marked variation in different sections of EEZ as given below.

Species	West coast		East coast	Andaman & Nicobar sea
	5°-10°N	10°-16°N		
Yellowfin tuna	20.7	75.2	31.9	35.8
Big eye tuna	3.2	0.1	-	-
Skipjack	2.8	1.0	1.1	-
Marlin	8.8	1.0	1.1	
Sail fish	7.4	2.0	6.6	10.4
Swordfish	1.2	0.3	0.2	
Sharks	54.0	19.5	53.0	43.8
Others	1.9	0.9	6.1	10.0

West coast in Lat. 10° to 16°N yielded the highest percentage of yellowfin tuna.

The average number of fish obtained per 100 hooks was 4.95. The rate of hooking in general was found to be the highest in Arabian Sea (6.57%), followed by eastern shelf (3.08%) and the area around the Andamans (1.51%). The hooking rates of the various groups recorded in the different regions are given below. The results obtained from the eastern shelf and Andaman waters is only indicative. The exploratory effort in these two areas is far less than in the Arabian Sea.

Species/Groups	West coast		East coast	Andaman & Nicobar sea
	5°N-10°N	10°N-16°N		
Tunas	0.56	7.32	1.02	0.54
Billfishes	0.32	0.31	0.43	0.16
Sharks	1.02	1.87	1.44	0.66
Others	0.04	0.09	0.19	0.15

The relative abundance index in terms of hooking rate was examined for each 1° square for all fishes together (Fig.13) and separately for each species/group (Figs. 14 to 16). Excellent hooking rates in the

range of 11 to 28% was obtained from 8 squares between Lat. 13° and 16°N, largely contributed by yellowfin tuna.

Yellowfin tuna is the most important resource in longline catches with average hooking rate of 7.22% in west coast north of Lat. 10°N, 0.39% in 5°N to 10°N, 0.98% in east coast and 0.53% in Andaman & Nicobar waters. As this species essentially forms the mainstay of any longline fishery to be established in Indian waters, MSY estimates of the species in Indian Ocean is reviewed here.

IOFC (1969)	...	30-35,000 tonnes
IPFC/IOFC (1973)	...	30-35,000 tonnes
Suda (1974)	...	35,000 tonnes
Wetherall et al. (1979)	...	43-45,000 tonnes
Suzuki (1979)	...	39,000 tonnes
FAO (1980)	...	40-60,000 tonnes

It has been suggested that in view of the withdrawal of longline fishery by the non-Indian ocean countries, the potential for exploitation of yellowfin tuna may perhaps be higher than the estimates made in earlier decades (Sivasubramaniam, 1985).

The most encouraging factor to be considered is that the hooking rate in Indian seas is significantly higher than that for the Indian Ocean as a whole. The hooking rates of yellowfin tuna recorded in 1970's by the Japanese, Korean and Taiwanese fleets were 0.23%, 0.62% and 0.17% respectively. Sivasubramaniam (1985) while analysing the tuna longline catches from the seas bordering India, Maldives and Sri Lanka reported yellowfin tuna hooking rate as 0.7% between Lat. 0°N-5°N in Long. 70°E-75°E, 0.19% between Lat. 0°N-5°N in Long.75°E-80°E and 1.5% between Lat. 5°N-10°N in Long. 75°E-80°E. The present study indicates much higher hooking rate as may be seen from Fig.13. Further, the recent investigations reveal that the catch rate in Indian seas is considerably higher than the average of

1.15% hooking from equatorial region. 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. But the average catch rate of tuna from the same latitude within Indian EEZ is 7.2%. Based on earlier investigations, the National Commission on Agriculture (1976) indicated the share of tuna in longline catches at 15% whereas the recent observations show that the tuna component as 70.7%. All these suggest that with the reduction in fishing pressure consequent to withdrawal of alien fleets from Indian seas, the tuna stocks have considerably revived and its availability in Indian seas is far higher than the average for the entire Indian Ocean. Indian EEZ thus offers immense possibilities of supporting a viable longline fishery.

3. Distribution of resources by distance

Availability of major species/groups occurring in longline catches is examined at distance intervals of 50 n miles from the coast line. The number of 1° square yielding hooking rates of different ranges in each of these 50 n mile belts is given in Tables 22 to 25. Along west coast availability of yellowfin tuna was found to be higher in 50-100 n miles from coast line of either the main land or the Lakshadweep islands. There are however few squares with high yield rates in 150-200 n miles zone in Lat. 12°N-15°N. In east coast a clear trend of relative abundance could not be inferred except that the grounds within 50 n miles yielded comparatively iow hooking rates. This finding need not however be taken as conclusive as the efficiency of the longliner used was far lesser and the total effort far smaller when compared to the west coast. In Andaman Sea, areas adjoining the island within 100 n miles indicated better results and the catch rates were found to decline with increasing distance. It is however, not prudent to draw any conclusions as the effort so far has only been token.

The percentage of area within each distance interval of the EEZ is approximately as below:

50 n mile	... 36%	100-150 n miles	... 21%
50-100 n miles	... 24%	150-200 n miles	... 19%

Table 22. Number of 1° Lat. x 1° Long. squares (3600 sq. nautical miles) yielding different ranges of hooking rate of yellowfin tuna in 50 nautical miles distance zones (south of Lat. 16°N)

WEST COAST

Distance zone (nm)	Hooking rate (%)				
	0.1-1	1-2	2-5	>5	Total
<50	9	-	2	1	12
50-100	11	-	3	4	18
100-150	7	-	2	1	10
150-200	5	-	1	1	7
Total	32	-	8	7	47

EAST COAST

Distance zone (nm)	Hooking rate (%)				
	0.1-1	1-2	2-5	>5	Total
<50	4	1	-	-	5
50-100	1	4	-	-	5
100-150	3	2	-	-	5
150-200	-	3	-	-	3
Total	8	10	-	-	18

ANDAMAN & NICOBAR WATERS

Distance zone (nm)	Hooking rate (%)				
	0.1-1	1-2	2-5	>5	Total
<50	4	2	-	-	6
50-100	10	1	1	-	12
100-150	8	1	-	-	9
150-200	7	-	-	-	7
Total	29	4	1	-	34

Table 23. Number of 1° Lat. x 1° Long. squares (3600 sq. nautical miles) yielding different ranges of hooking rates of bill fishes in 50 nautical miles distance zones (south of Lat. 16°N)

WEST COAST

Distance zone (nm)	Hooking rate (%)				
	<0.2	0.2-0.3	0.4-0.5	>0.5	Total
<50	4	5	4	1	14
50-100	2	8	7	2	19
100-150	1	4	3	1	9
150-200	1	3	-	-	4
Total	8	20	14	4	46

EAST COAST

Distance zone (nm)	Hooking rate (%)				
	<0.2	0.2-0.3	0.4-0.5	>0.5	Total
<50	-	2	2	1	5
50-100	2	1	2	1	6
100-150	1	3	-	1	5
150-200	-	3	-	-	3
Total	3	9	4	3	19

ANDAMAN & NICOBAR WATERS

Distance zone (nm)	Hooking rate (%)				
	<0.2	0.2-0.3	0.4-0.5	>0.5	Total
<50	2	2	-	1	5
50-100	4	4	3	-	11
100-150	3	2	-	-	5
150-200	1	1	1	-	3
Total	10	9	4	1	24

Table 24. Number of 1° Lat. x 1° Long. squares (3600 sq. nautical miles) yielding different ranges of hooking rate of sharks in 50 nautical miles distance zones (south of Lat. 16°N)

WEST COAST

Distance zone (nm)	Hooking rate (%)				
	< 0.5	0.5-1	1-2	> 2	Total
< 50	4	7	1	4	16
50-100	-	7	7	5	19
100-150	-	3	3	6	12
150-200	4	1	2	1	8
Total	8	18	13	16	55

EAST COAST

Distance zone (nm)	Hooking rate (%)				
	< 0.5	0.5-1	1-2	>2	Total
< 50	1	2	2	1	6
50-100	-	5	1	1	7
100-150	1	-	2	1	4
150-200	1	-	2	-	3
Total	3	7	7	3	20

ANDAMAN & NICOBAR WATERS

Distance zone (nm)	Hooking rate (%0				
	<0.5	0.5-1	1-2	> 2	Total
< 50	2	3	1	-	6
50-100	5	9	3	-	17
100-150	7	1	3	-	11
150-200	3	1	1	-	5
Total	17	14	8	-	39

Table 25. Number of 1° Lat. x 1° Long. squares (3600 sq.nautical miles) yielding different ranges of aggregate hooking rate in 50 nautical miles distance zones (south of Lat. 16°N)

WEST COAST

Distance zone (nm)	Hooking rate (%)					
	< 1	1-3	3-5	5-10	>10	Total
< 50	3	9	3	2	-	17
50-100	2	7	1	4	3	17
100-150	-	9	3	3	2	17
150-200	1	3	1	-	1	6
Total	6	28	8	9	6	57

EAST COAST

Distance zone (nm)	Hooking rate (%)					
	< 1	1-3	3-5	5-10	>10	Total
< 50	1	5	-	-	-	6
50-100	-	4	2	-	-	6
100-150	-	4	1	-	-	5
150-200	-	2	1	-	-	3
Total	1	15	4	-	-	20

ANDAMAN & NICOBAR WATERS

Distance zone (nm)	Hooking rate (%)					
	< 1	1-3	3-5	5-10	>10	Total
< 50	1	3	1	-	-	5
50-100	5	12	1	-	-	18
100-150	3	7	-	-	-	10
150-200	4	2	-	-	-	6
Total	13	24	2	-	-	39

High yielding zone: The area upto EEZ boundary between Lat. 12°N - 15°N along the south-west coast is identified as a high yielding zone for yellowfin tuna. The high catch rates prevail from September to May.

4. Assessment of oceanic resources in south-west coast

The MSY estimated for larger tunas in Indian waters by Dwivedi and Devaraj (1983) as 3000 tonnes appears to be an underestimates as discussed earlier. The exploratory survey by FSI conducted in south-west coast covering the Indian EEZ from Lat. 5°N-16°N, shows quite a high abundance index. An attempt has therefore been made to compute the potential of tuna stock in Indian EEZ along south-west coast assuming that the current production of tunas in the adjacent EEZ of Maldives is at the MSY level and using actual hooking rate recorded by **Matsya Sugundhi** during 1983-87.

Considering the extent of EEZ area along south-west coast, 6.29 lakh sq km, and the hooking rate obtained by **Matsya Sugundhi**, the potential yield of larger oceanic pelagics are worked out as under:

Tunas	17,100 tonnes
Billfishes	1,400 tonnes
Pelagic sharks	6,300 tonnes
Others	300 tonnes
Total	25,100 tonnes

It could be seen that a total of 25,100 tonnes of oceanic fish including 17,100 tonnes yellowfin tuna can be obtained annually off the south-west region of Indian EEZ by longlining. Estimates for lower east coast and Andaman & Nicobar waters are not attempted as the exploratory surveys carried out in these areas are only of token nature in terms of effort and duration of survey.

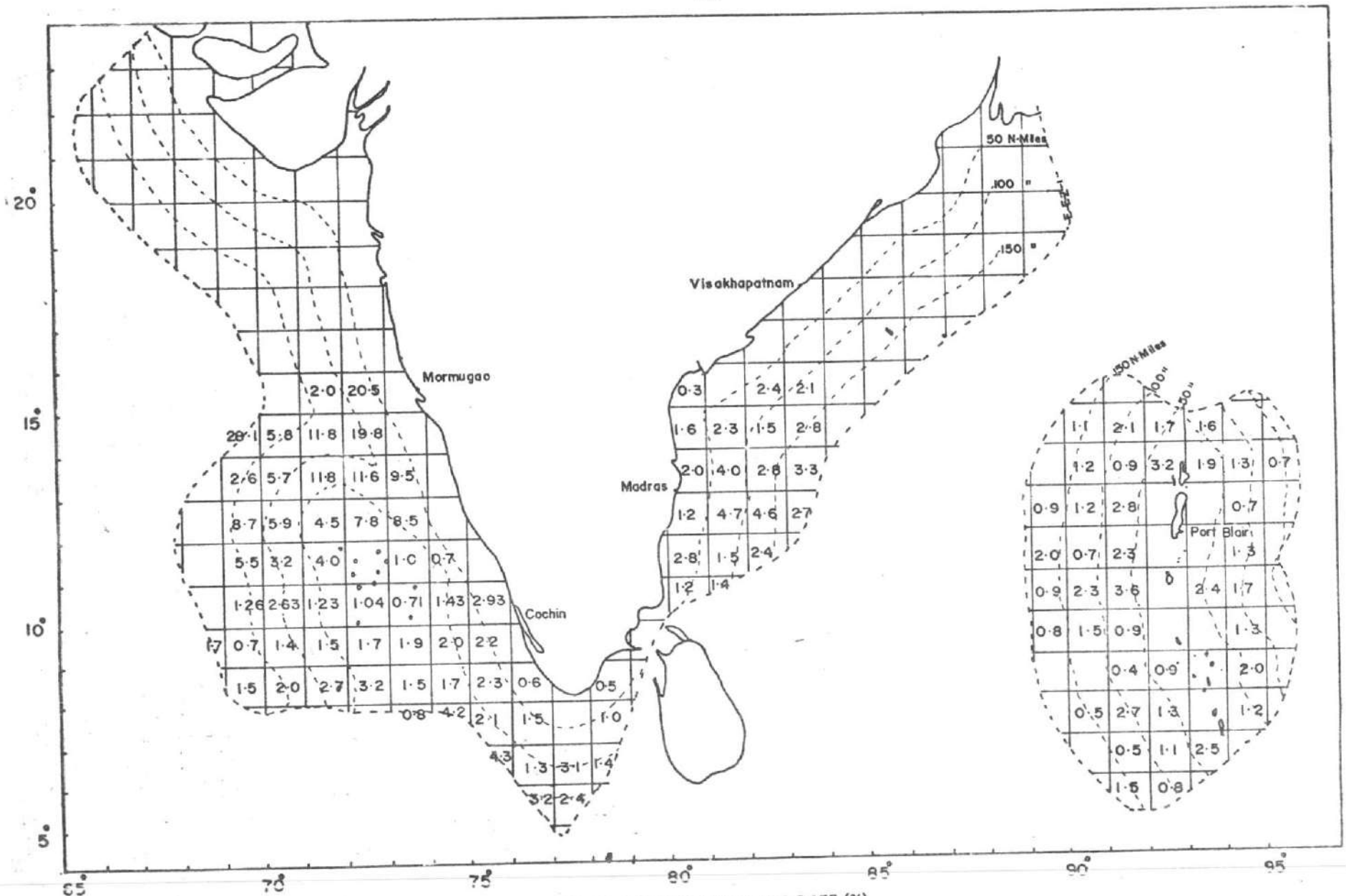

FIG. 13 "ALL FISH" HOOKING RATE (%)

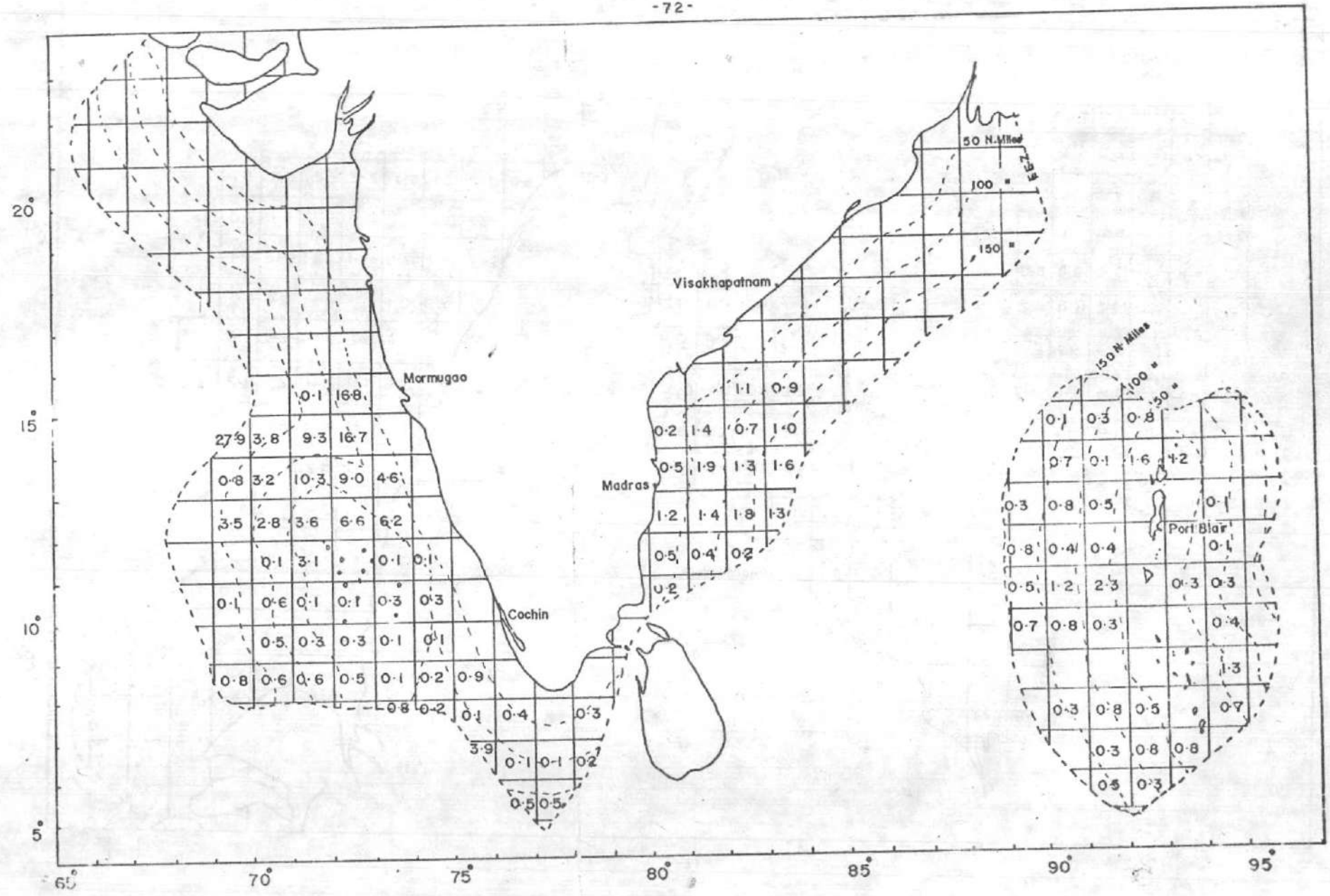

FIG. 14 YELLOWFIN TUNA HOOKING RATE (%)

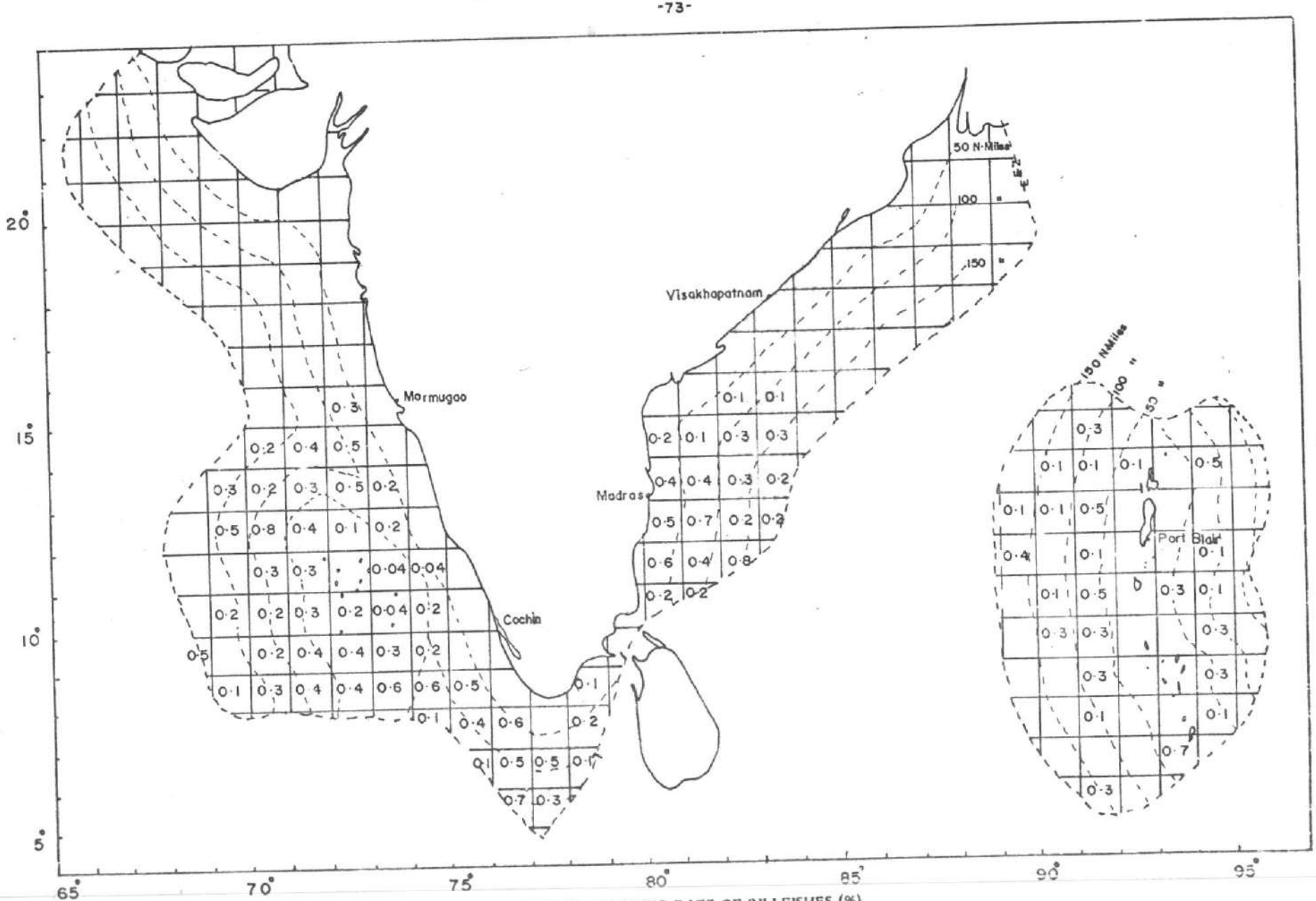

FIG. 15 HOOKING RATE OF BILLFISHES (%)

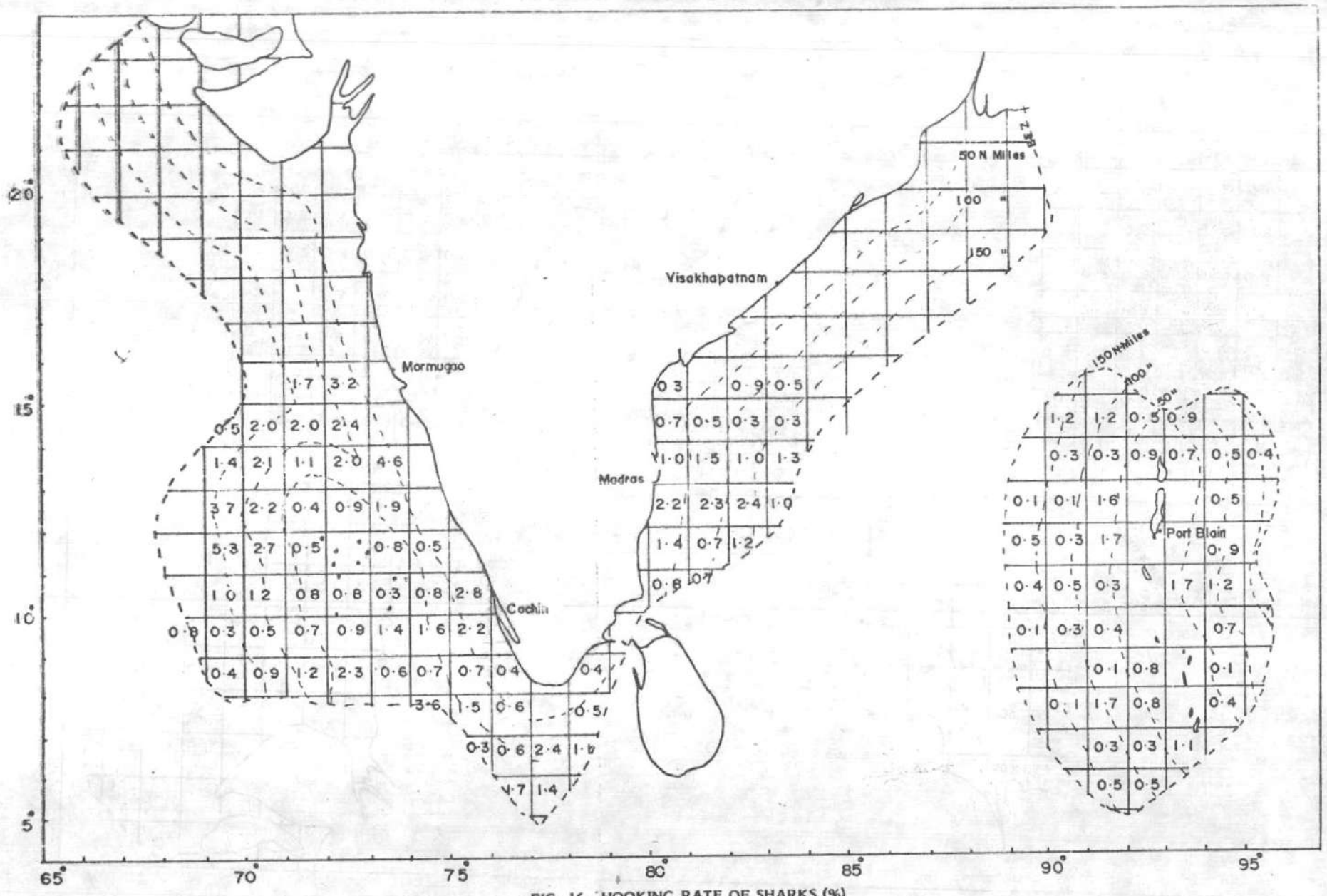

FIG. 16 HOOKING RATE OF SHARKS (%)

V. RESOURCES VERSUS INVESTMENT IN VESSELS

1. The MSY estimates of demersal stock from 50-300m depth in different regions and oceanic resources of south-west coast between Lat. 5°N-16°N have been computed and presented elsewhere in this report. The demersal fish stock of west coast and east coast are estimated at 444 thousand tonnes and 88 thousand tonnes respectively, whereas Wadge Bank and Gulf of Mannar together are assessed to yield about 26 thousand tonnes. The oceanic resources of south-west coast are estimated at 25 thousand tonnes of which the MSY of yellowfin tuna is about 17 thousand tonnes.

2. The demersal stock beyond 50m depth is virtually unexploited except marginal exploitation by few chartered vessels, whose operations are mostly within 100 m depth. The oceanic resources such as tuna and tuna like fishes are practically unexploited. There is vast scope for developing fishery based on demersal resources beyond 50 m depth as well as the oceanic stocks. Therefore, an attempt has been made in this report to work out the number of vessels required to exploit the resources upto the level of MSY.

3. Most of the deepsea trawlers available at present in India are outriger trawlers in the 23-25 m range deployed mainly for the exploitation of shrimp. The chartered vessels being operated in Indian waters are of 32 to 42 m OAL and 250 to 300 GRT. Joseph (1985) suggested introduction of trawlers of about 20 m length with 100 GRT for exploiting the demersal resources. Taking into consideration of the available infrastructure facilities especially deepsea fishing harbours, further he had recommended vessels of 30 m OAL with 200 GRT. However, in view of the successful operation of chartered fishing vessels and the 23-24m shrimp trawlers in deepsea fishing in Indian waters in recent times, it would be ideal to introduce 25-35m stern trawlers with 30 days endurance and 25 days actual fishing with 15 hours of trawling/day. The above vessels are capable of covering the whole west coast or east coast from a suitable base. The vessel requirements for the optimum exploitation of demersal fish stock have been computed on this basis.

It is assumed that the average catch per hour along west coast will be about 300 kg per hr and along east coast, Wadge Bank and Gulf of Mannar 250 kg per hr. Correspondingly, it is computed that a trawler would land about 1125 tonnes per annum if operated along west coast and about 940 tonnes per annum if operated in the other regions. Hence the number of vessels required to exploit the demersal resources beyond 50 m depth at the level of MSY is 390 along west coast, 94 along east coast and 27 in Wadge Bank and Gulf of Mannar.

The survey carried out by the FSI vessels revealed potential grounds for yellowfin tuna off the south-west coast especially between Lat. 10°N-16°N within the EEZ. MSY of the oceanic resources is computed at 25,000 tonnes in the south-west coast alone. It is assumed that a 30-35 m vessel will land about 1200 tonnes per annum. The number of vessels required to exploit the resources at the level of MSY is worked out as 20. No survey for tunas has been done along north-west coast of India and the upper east coast. Only preliminary surveys have been done along lower east coast and Andaman & Nicobar Islands. These areas traditionally known for tuna resources could possibly support another 75-80 vessels.

VI. SUMMARY

1. The current yield of fishery resources of the seas around India is about 1.8 million tonnes against wide ranging estimates of a potential of 2.3-8.5 million tonnes, which offers great scope to increase the marine fish production.

2. The continental shelf and slope upto 300m depth is computed as 4,38,545 sq km (excluding Lakshadweep and Andaman & Nicobar islands). The Indian EEZ covers approximately 2.02 million sq km.

3. The operation of chartered vessels has been one of the reasons for the marginal increase in growth rate of marine fish landings from deepsea fishing in recent years. However, much needs to be done in identifying the potential resources and fishing grounds so as to develop deepsea fishing and to increase the marine fish landings.

4. The present study on the marine fishery resources is based on the exploratory survey data collected by FSI vessels and attempts to assess the quantum of resources from the presently unexploited grounds outside 50m depth upto 300m in the case of demersal resources and upto EEZ boundary in respect of oceanic resources.

5. Assessment of demersal resources both qualitatively and quantitatively are dealt in detail.

6. Along the west coast the stock density was found to be high in the 40-80m depth belt in general, but a progressive increase in abundance with increase in depth was noticed in latitudes 9°N to 12°N and 21°N. In certain pockets very high mean densities were obtained from north-west and south-west coasts in the 100-150m and 150-200m depth ranges respectively. Nemipterids were abundant along south-west coast (21-25%) whereas cat fishes were predominant along Konkan - south Maharashtra coast. Deepsea prawns and black ruff were abundant between latitudes 8°-13°N.

7. A progressive increase in abundance of resources with increase in depth upto 100m depth and declining thereafter was observed along the east coast. However, exceptionally high density of 18.9 tonnes/ sq km was observed in 100-150m depth zone of latitude 14°N. Caranx spp with a wide area of abundance upto 150m depth were the dominant group between latitude 10°N to 19°N whereas mackerel was predominant in the Sandheads (Lat. 20°N). Maximum catches of mackerel (66.4% of demersal catch) were obtained from 100-150m depth in this region.

8. In Wadge Bank, highest stock density 7.3 tonnes per sq km, of demersal resources was observe between 100 and 150m depth, mainly formed of threadfin breams and scads. In Gulf of Mannar the 60-80m depth zone is very productive, the principal resource components being perches, elasmobranchs, Caranx spp and barracuda. Perches, forming 30.4% of demersal fish biomass in Wadge Bank and 17.7% in Gulf of Mannar, are the most important resources in this region. A well defined perch ground has been located south east off Cape Comorin, extending from longitude 77°20'E to 78°E in 35-65m depth. Towards north east, this ground extends to the Gulf of Mannar.

9. Along the north-west coast an increase in the density with increase in distance was noticed upto 90 nautical miles and thereafter a decline whereas along south-west coast maximum density was recorded between 50-60 nautical miles. Contrary to this, along the upper east coast the demersal fish abundance decreased with increasing distance from shore. The effort expended in deeper and distant water zones of upper east coast was comparatively less and adequate sampling in these areas may provide a more dependable picture. In the Wadge Bank maximum density was recorded in the 50-60 nautical miles zone whereas in the Gulf of Mannar shallow water region (0-10 miles) was observed to be more productive.

10. Along the east coast the density decreases with increasing depth beyond 20 miles whereas in other regions maximum abundance of demersal resources was recorded in 100-200m depth zones.

11. The estimated potential of demersal resources from 50 to 300m depth is about 5.54 lakh tonnes of which the highest potential of 4.4 lakh tonnes is assessed from west coast and about 0.9 lakh tonnes from east coast. The estimated potential of Wadge Bank and Gulf of Mannar is 0.2 lakh and 0.06 lakh tonnes respectively.

12. The important demersal stocks which constitute the resource are nemipterids (1.01 lakh tonnes), cat fishes (0.5 lakh tonnes), horse mackerel (0.4 lakh tonnes), priacanthids (0.4 lakh tonnes), perches (0.3 lakh tonnes), mackerels (0.3 lakh tonnes) etc.

13. The current yield of pelagic fishery resources is about 742 thousand tonnes of which about 70% is accounted for by the west coast.

14. Potential pelagic resources such as horse mackerel and ribbon fishes were located along north-west coast especially in deeper waters. Survey by purse seining in the inner shelf areas revealed that the principal shoaling fishes in the above region are horse mackerel, little tuna, sardine etc.

15. The distribution of pelagic shoals along south-west coast was mainly observed to be upto 60m depth contour and important shoaling fishes are little tuna and carangids besides conventional resources such as mackerel and sardines. The UNDP/FAO Pelagic Fisheries Project have estimated standing stock of oil sardine, mackerel and white baits as 4,3 and 2 lakhs tonnes respectively. The "shallow water mix" comprising scads, silver bellies and Ambassis spp is estimated to have 0.6 lakh tonnes of standing stock along south-west coast.

16. The pelagic shoaling fishes are, as per the limited surveys, considerably less and more dispersed along east coast in general. However, the important resources are horse mackerel, mackerels, lesser sardines and little tuna.

17. The potential of pelagic fishery resources from Indian coast is estimated between 0.6 to 2.1 million tonnes by different authors.

18. The average annual landings of tunas and tuna like fishes from Indian waters is about 24,000 tonnes, but these are mostly small coastal tunas caught incidentally while fishing for other target species. However, the estimated potential of tuna from the Indian Ocean varies from 100 to 150 thousand tonnes.

19. The exploratory longline survey carried out by FSI vessels revealed the potential tuna grounds off south-west coast as well as off Tamil Nadu coast.

20. Yellowfin tuna contributes to the major portion of the longline catches and formed about 75% of the catch from the Lat. 10°-16°N along south-west coast, whereas its contribution off Tamil Nadu and the Andaman sea was 32% and 36% respectively.

21. The average hooking rate is highest in Arabian Sea (6.57%) followed by east coast (3.08%) and Andaman & Nicobar seas (1.51%). The exploratory surveys in the latter two regions were very limited.

22. Tuna was found abundant between Lat. 10°N and 16°N off south-west coast with a hooking rate of 7.3%, yellowfin tuna alone accounting for 7.22% from the above region.

23. In general along west coast the availability of yellowfin tuna was found to be higher in 50-100 nautical miles from the coast line. However, the 150-200 nautical miles zone between Lat. 12°N and 15°N was also found to be productive whereas along east coast no clear pattern could be observed. This may be due to the very limited survey effort.

24. The potential of oceanic tunas, bill fishes and sharks off south-west coast between Lat. 5°N and 16°N is estimated at about 25,000 tonnes of which the potential of yellowfin tuna is about 17,000 tonnes.

25. Purse seine surveys have indicated the occurrence of skipjack tuna shoals in different regions of Indian EEZ. But the information is inadequate to attempt even a first approximation on the magnitude of the stock harvestable from Indian waters. However, estimates of potential yield of skipjack in Indian Ocean based on other parameters are in the range of 2.25 to 4 lakh tonnes. Except the pole and line fishing in Lakshadweep there is no effort in the country aimed at exploiting skipjack.

26. The vessels requirement to exploit the demersal fish stock from 50-300m depth at MSY level is worked out as 390 vessels along west coast, 94 vessels along east coast and 27 vessels in the Wadge Bank and Gulf of Mannar. The vessels are 25-30m OAL with 200-300 GRT and are expected to operate 300 days in a year with 250 days actual fishing and land about 1115 tonnes per annum along west coast and 940 tonnes per annum along east coast, Wadge Bank and Gulf of Mannar.

27. The number of vessels requirement to exploit the oceanic resources along south west coast is about 20 based on the assumption that a 35 m longliner will land about 1200 tonnes catch per annum. The remaining areas of the Indian EEZ may require about 80 vessels to exploit the oceanic resources.

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