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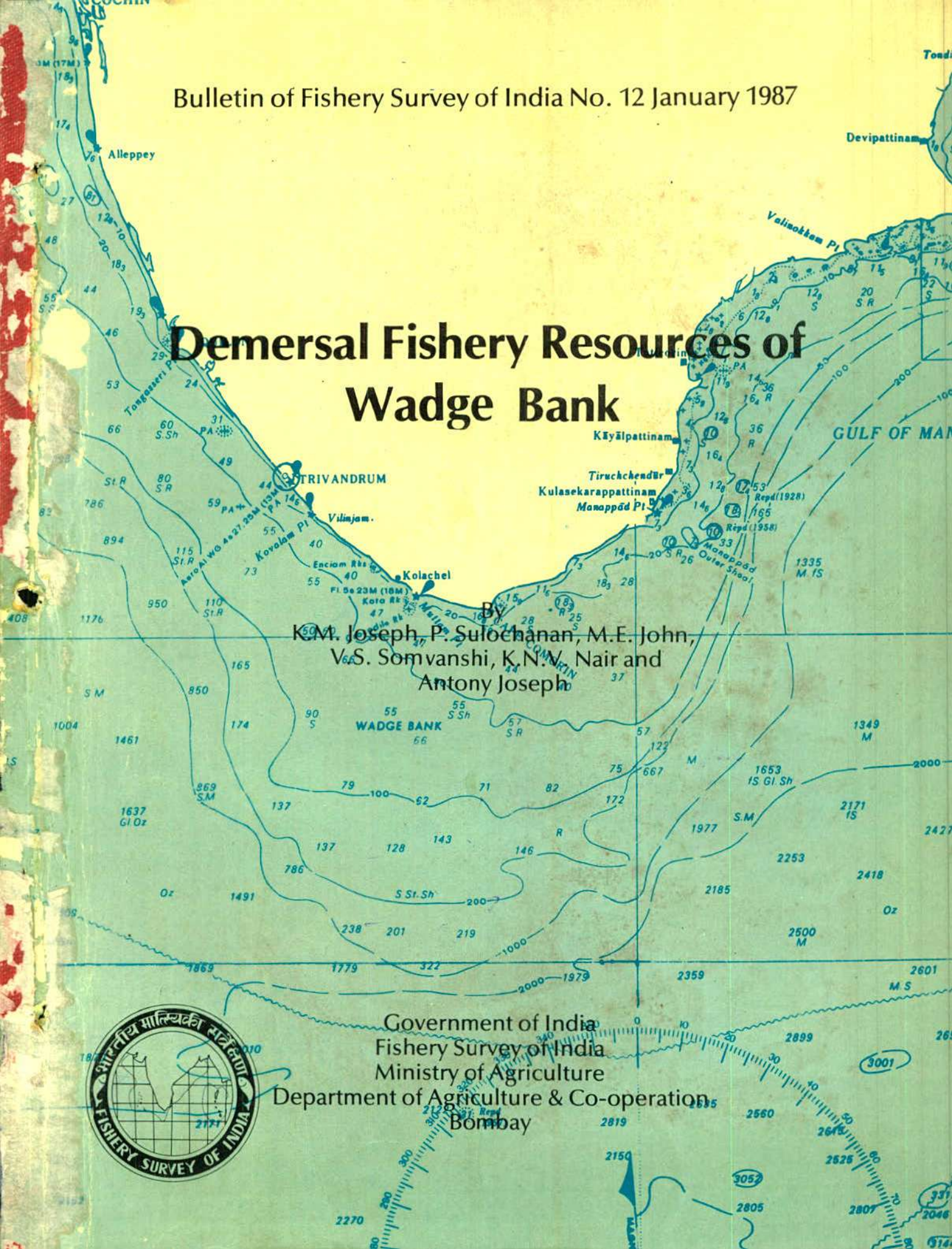

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Bombay

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INTRODUCTION

In close proximity to the southern apex of Indian peninsula, where the three seas surrounding the sub-continent converge lies the Wadge Bank which was first described by Hornell in the year 1916. From the earlier decades of the century few stray attempts have been made to survey the demersal fishery resources of this part of the continental shelf. The first in the series was a single cruise of the trawler 'Violet' in 1907 by Capt.Cribb (Hornell,1916). During 1921-23 Government of Ceylon organised two cruises from the vessel 'Lilla' (Malpas, 1926) in the premonsoon season. The third survey was conducted by Madras Govt. in 1927-29 with the trawler 'Lady Goschen' which carried out 76 trawl hauls in Wadge Bank as part of a general survey of southern Indian coasts (Gravely, 1929; Sundera Raj, 1930; Sundera Raj & Devanesan, 1942). In 1948-49, MFV Sagar Kumary of the West Coast Fisheries (Travancore) Ltd. conducted a few short cruises during which she operated 52 trawl hauls in the Bank (John,1959). The research vessel 'Varuna' of Integrated Fisheries Project during her cruise in 1969 made 11 try net stations in the upper continental slope bordering the Wadge Bank (Silas,1969). Subsequently the vessels of Integrated Fisheries Project and Fishery Survey of India made occasional attempts to survey the Wadge Bank during early seventies but published account of the results are available only in the case of the latter (Joseph et al, 1976; Joseph, 1980).

But for these sporadic attempts of limited efforts and rather unsystematic sampling, the Bank remained largely unexploited. Consequent to the declaration of Indian Exclusive Economic Zone in 1976, a comprehensive assessment of the resources potential of the area has been keenly felt. During 1981-83 Fishery Survey of India undertook a systematic survey to study the distribution, composition and magnitude of the demersal fishery resources available in the Bank. The immediate reason was a request from the Government of Kerala to provide requisite data base for development of its Vizhinjam Fishing Harbour Project. An attempt has already been made to present a quantitative and qualitative picture of the demersal fishery of the region by depth, distance and time through fishery charts (FSI, 1984). A few progress reports (EFP,1982 a & b, 1983) have also been published. In order to meet the needs of fishery planners, Govt. financing agencies, fishing industry etc. further in this regard, an attempt has been made in this paper to discuss the various aspects of the demersal fishery resources in detail and to study the MSY.

2. VESSEL AND GEAR

2.1. Matsya Nireekshani, a combination trawler was deployed for the survey. Built in Holland in 1978, this is the largest vessel among the fishery survey fleet in India. The major specifications of the vessel are given below:

Length overall (m)	40.55
Breadth (m)	8.00
Mean draught (m)	4.00
Gross registered tonnage	329.26
Net Registered tonnage	128.72
Main engine	B & W Alpha - 2030 BHP at 800 rpm
Auxiliary engines (2)	Caterpillar - 250 BHP/120 BHP
Power generators (2)	INDAR - 205 KVA/100 KVA
Fuel storage	180 m3
Fresh water storage	34 m3
Disalination plant	7 tonnes in 24 hrs.at full rating of main engine
Flake ice plant	6 tonnes per day
Plate freezers (2)	10 tons capacity per day
Frozen storage hold (-25°C)	75 m3
Cold storage (0°C)	235 m3
Trawl winch	Electrical motor driven - 350HP-pull 8 tons at 75 m/min.
Net winch	Electrical motor driven-60HP-pull 3 tons at 75 m/min.
Speed	13 knots
Endurance	22 days
Crew	20

The vessel is fitted with several modern fish detecting equipment and navigational aids enabling precise observation and accurate recording of data. Important among the electronic gadgets are:

1. Echosounder (2 Nos)	Simrad EQ 38, Simrad EQ50
2. Echo magnifier	Simrad MC
3. Sonar	Simrad SQ 4
4. Net recorder	Simrad F1

5. Satellite navigator	Magnovox
6. Omega receiver	Koden Model OR-166
7. Marine radar	Decca RM 916-C
8. Gyro-compass	Microtechnica MB-12

2.2 The Gear used in the survey was 34 m two seam bottom trawls in combination with polyvalent otter doors weighing 1350 kg each. The nets were made of either imported polyamide twines or indigenous high density polyethylene twines and the mesh size ranged from 80 mm in the cod-end to 400 mm in the forepart (Fig.1). The cod-end was protected with chafing gear and the ground rope rigged up with bobbin assembly made of metalic rollers and rubber discs. To ensure optimum vertical opening of the trawl a kite was attached to the head rope, besides floats.

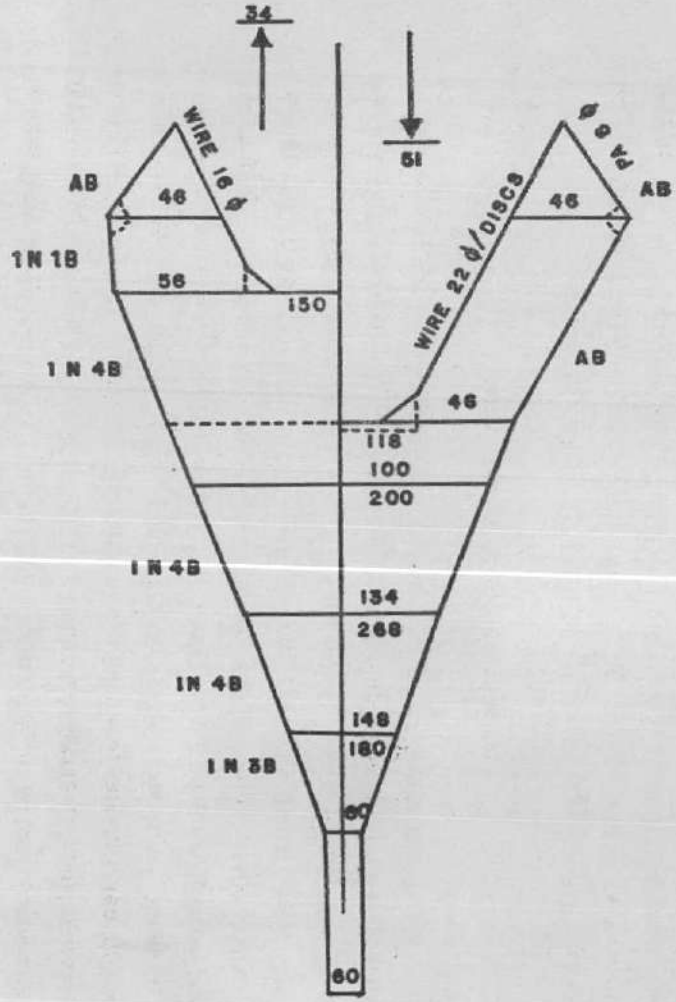
3. METHODOLOGY OF SURVEY

The methodology of survey was a combination of acoustic search with fish finders and sampling by actual trawling on the basis of a preliminary examination of the bottom topography. The cruise tracks were designed in such a way that trawl coverages are achieved at 5 fm (10 m) depth intervals in every successive cruise. Trawl stations were identified roughly at 5 n.miles apart and obligatory hauls were taken to ensure even distribution of sampling. Though trawling time was fixed as 2.5 hours quite often the trawls were to be hauled up earlier due to obstructions on the sea bed. One or more Fishery Scientists took part, invariably, in every cruises to ensure proper implementation of the scheduled survey programme and collection of resources data besides, observations on bottom topography, hydrographic and oceanographic parameters, length frequency etc. The data are codified and entered in standard formats.

4. SURVEY AREA

The area under study lies between lat. 07°00'N to 08°20'N and long 76°30'E to 78°00'E (Fig.2). Bounded by 10 fm (18 m) and 125 fm (223m) depth contours the area admeasures about 3600 sq.n.miles.

LENGTH IN mm	TOTAL LENGTH IN m
400	8
400	8
400	10
400	8
200	10
100	10
80	8
80	



NUMBER ※	TWINE NR
20	210 / 240
15	/ 240
43	/ 240
$37\frac{1}{2}$	
$13\frac{1}{2}$	/ 240
50	/ 132
100	/ 126
100	/ 108

Fig. 1 DESIGN OF 34 m FISH TRAWL

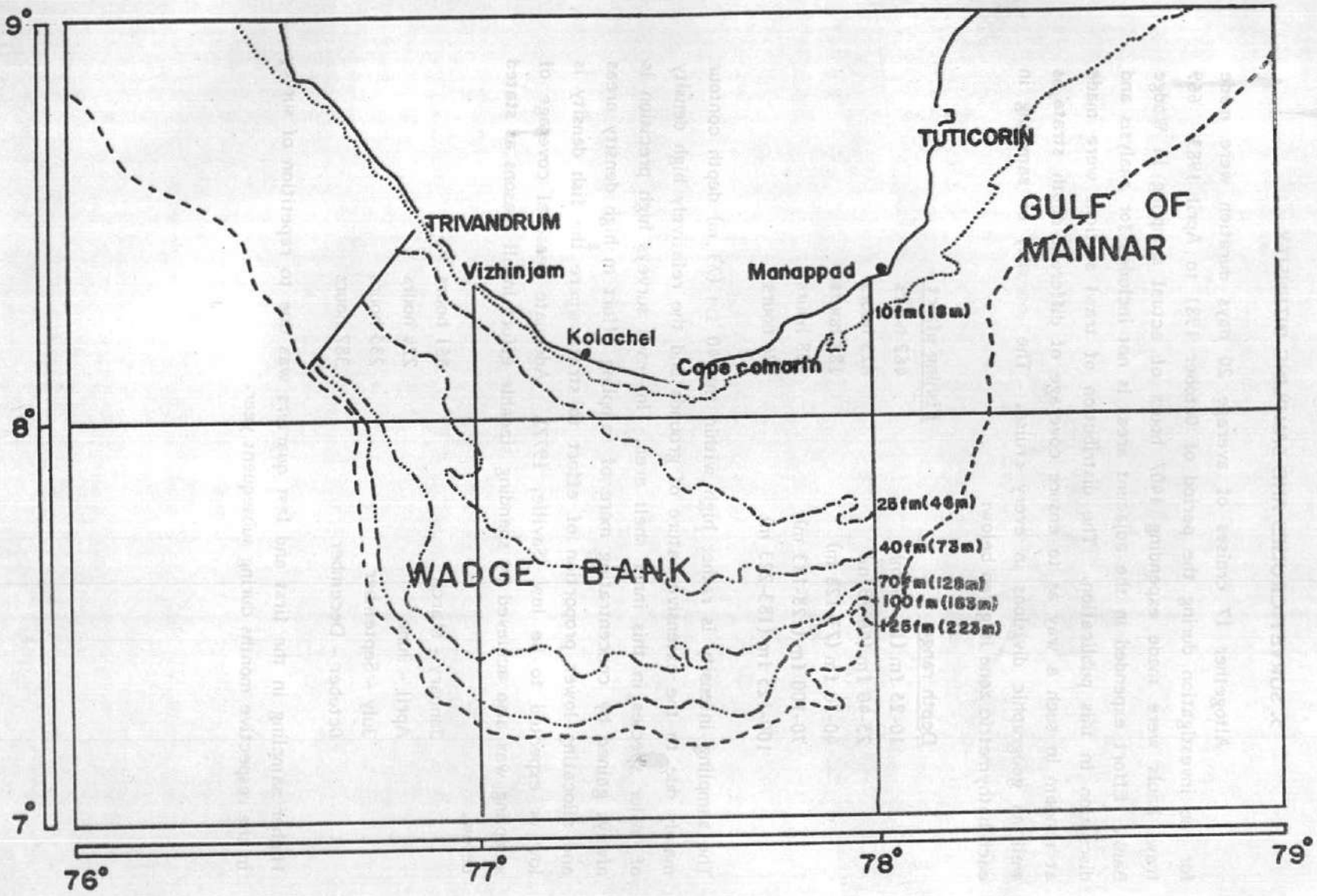


Fig. 2 LOCATION OF WADGE BANK

5. SURVEY CRUISES AND SAMPLING INTENSITY

Altogether 17 cruises of average 20 days duration were made for the investigation during the period of October 1981 to April 1983. 669 trawl hauls were made expending 1407 hours of actual sampling in Wadge Bank. Effort expended in the adjacent areas is not included for analysis and discussion in this publication. The distribution of trawl stations were made at random in such a way as to ensure coverage of different depth strata as well as geographic divisions in every cruise. The intensity of sampling in each bathymetric zone is given below:

Depth range	Fishing effort
10-25 fm (18-46 m)	462 hours
25-40 fm (46-73 m)	623 hours
40-70 fm (73-128 m)	188 hours
70-100 fm (128-183 m)	108 hours
100-125 fm (183-223 m)	26 hours

The sampling intensity is rather high within the 40 fm (73 m) depth contour mainly due to the extensive nature of grounds and the relatively high density of major species in this inner shelf area. In trawl surveys high precision is always gained by concentrating more of sampling effort in high density areas and allocating lower proportion of effort to strata where the fish density is low or expected to be low (Saville, 1977). Adequate seasonal coverage of sampling was also achieved by spending sizeable effort in all seasons as stated below.

January - March	561 hours
April - June	224 hours
July - September	235 hours
October - December	387 hours

Higher sampling in the first and last quarters was due to repetition of survey in the respective months during subsequent year.

6. BOTTOM TOPOGRAPHY AND HYDROGRAPHY

Inadequate information on the nature of bottom was a serious hurdle for un-interrupted survey in the initial cruises. Rocky outcrops, clusters of rocks, hard stones and corals are abundant in Wadge Bank. Vigilant observation of echograms and continuous monitoring of bottom structure has resulted in accumulation of large volume of data on bottom topography. A brief description of the nature and composition of the fishing ground is considered inevitable to enable true appreciation of the resource distribution. The bottom is formed of sand, mud, rock, corals, hard stones and shell fragments in varying combinations. In certain areas there is heavy growth of sponges, alcyonarians, gorgonids and black corals whereas in other parts such growths are scarce. Based on the composition of substratum the nature of the sea bed is generalised and presented here.

i) Rough, hard and uneven ground with projecting rocks and dense growth of seaweeds exist in the northeast corner of area 7-76 in 70-100 m (39-56 fm) depth belt. Extending northwards by about 5 n.miles from lat. 8°N there is another patch of untrawlable ground again within the 100 m (56 fm) contour line. Towards the eastern extremity of Wadge Bank there are few discrete patches dangerous to trawling in 40-50 m (22-28 fm) and 70-100 m (39-56 fm) depth strata. Distributed along the 50 m (28 fm) contour line few rocky outcrops have been observed south east of Kolachel extending to the eastern grounds of 77° longitude. Besides, isolated rocky pinnacles dangerous to trawling have been spotted in different parts of Wadge Bank. Though not to be totally excluded from trawling utmost vigilance should be exercised while trawling in such grounds.

ii) Hard ground, even or uneven with sand and dense or scattered overgrowth of sea-fans is the nature of Wadge Bank grounds in general upto 90 m (50 fm). The western grounds extending upto Vizhinjam are comparatively more hard, occasionally associated with coral growth and less proportion of sand. Each haul in this region brought up masses of gorgonids, alcyonarians, sponges and echinoderms of many shapes and hues. The maximum quantity of such bottom fauna was observed in the north-eastern part of Wadge Bank.

iii) Sand or sand and mud with hardly any sub-marine growth is the nature of seabed beyond 90 m (50 fm) depth. The grounds west of long.77°30' extending upto the overfall is principally composed of sand with less mud content whereas the eastern areas are predominantly muddy and sandy with occasional hard bottom areas.

The major climatic feature in Wadge Bank is the occurrence in conjunction with the south-west and north-east monsoon of rather strong winds causing moderate to high swells from June to December.

The tides are of semi-diurnal nature, the level of tidal difference being 0.2 to 1.2 m. There are no major river systems opening to the sea near Wadge Bank.

Due to its unique geographic position, the current pattern in Wadge Bank is a bit complex as is characteristic of any cape. During south-west monsoon the current flows southwards with relatively high velocity. Upwelling, characteristic of south-west coast, is less pronounced in Wadge Bank. In north-east monsoon the current system reverses thereby transporting the low salinity water from equatorial region northwards. Though this forms the normal pattern, unpredictable fluctuations of varying degrees have been noticed very often. General hydrological features of Wadge Bank as obtained from published records indicate that the monthly mean of salinity ranges between 33.2‰ to 36.16‰, surface water temperature 26.02°C to 29.58°C and dissolved oxygen 4 ml/l to 5.15 ml/l (Rao, 1973). However, very low salinity values have been recorded in December - January and low temperature and oxygen content in January - February (Anon, 1974).

7. RESOURCE

Wadge Bank provides an excellent example of a tropical multi-species population with unusually large number of species dwelling in a ratherr limited area. The complexity of substratum, high rate of plankton production, abundance of huge number of animals of lower taxa, uniqueness of the geographical position causing mixing up of different water masses etc. might be the factors fostering the species multiplicity which support the demersal fishery resource in the Bank.

7.1. Major groups

For an easy understanding of the resource structure and its distribution the catch is classified into 9 groups, viz. perches, nemipterids, rays, cephalopods, carangids, lizard fish, cat fish, upeneoids and other varieties and the composition is depicted in Fig.3.

7.1.1. Perches

Apart from taxonomic consideration, commercial importance of the species is also taken into account while grouping fishes under this category, thus excluding the less important species of the family percidae. Principally supported by serranids, lutjanids and lethrinids, the group perches is the most predominant among the Wadge Bank stock (36.7%). The serranids (groupers) included several species such as **Epinephelus diacanthus, E.areolatus, E.malabaricus, E.maculatus** and **E.tauvina.** Among lutjanids (snappers) the commonly occurring species were **Lutjanus argentimaculatus, L.malabaricus, L.lineolatus, L.lutjanus** and **L.rivulatus. Lethrinids** (Sea breams) were mainly represented by two species namely **Lethrinus ramak** and **L.nebulosus. Plectorhinchus pictus, Gaterin** sp., **Scolopsis vosmeri, S.bimaculatus** and **S.phaeops** are the other species classified under this group.

7.1.2. Nemipterids

Threadfin breams locally known as 'kilimeen' or 'rani fish' formed the second major component (23.8%), contributed by **Nemipterus japonicus** and **N.mesoprion** in their order of abundance. The species **N.tolu** was also recorded in trace quantities.

7.1.3. Rays

Rays, comprising various species such as **Aetobatus narinari** (eagle ray), **Dasyatis** sp. (sting ray) and **Mobula diabolus** (devil ray) contributed to the extent of 10.1% to the total catch from the Bank.

7.1.4. Cephalopods

Among cuttle fishes **Sepia pharaonis** was the dominant species contributing over 80 per cent of the cephalopod catch. Other species obtained were **Sepia aculeata** and **Sepiella inermis** in stray quantities. Among squids

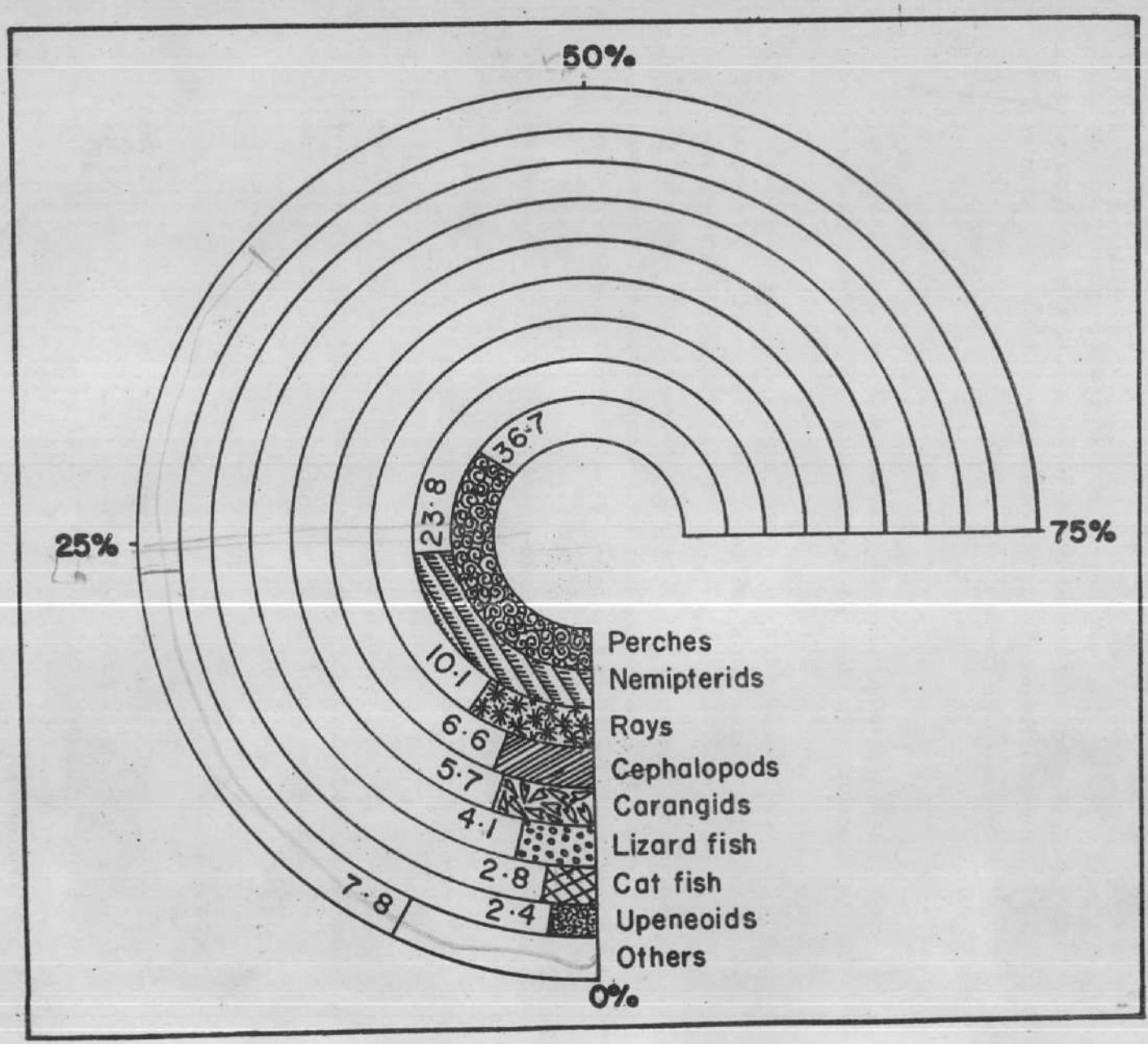


Fig. 3 PERCENTAGE COMPOSITION OF IMPORTANT GROUPS

Loligo duvauceli was the only important species though Sepioteuthis arctipinnis was also obtained occasionally. Cephalopods formed 6.6% of catch from the area.

7.1.5. Carangids

The group was represented by a large number of species such as Caranx carangus, C. malabaricus, C.oblongus, C.sexfasciatus, C.kalla, Alepes djeddaba etc. Carangids accounted to 5.7% of the catch.

7.1.6. Lizard fish

Lizard fish consisted Saurida tumbil as the important component followed by Synodus indicus and stray specimens of blunt nose lizard fish Trachinocephalus myops. They together formed 4.1% of the catch.

7.1.7. Cat fish

Trachysurus dussumieri and T.thalassinus were the two main species of cat fish obtained during the survey amounting to 2.8% of the catch.

7.1.8. Upeneoids

The 'goat fishes' or 'red mullets' as popularly called, were mainly represented by Upeneus indicus, U.vittatus, U.sulphureus and Parupeneus fraterculus which formed 2.4% of the catch.

7.1.9. Other species

The varieties each contributing less than 2% of the catch are pooled under this category and the composition of this assortment is given below:

Indian drift fish (Psenes indicus)	1.39%
Sharks	
Scoliodon sorrakowa, S.palasorra, Carcharhinus melanoptera, C.dussumieri, Sphyrna zygaena	0.74%

Skates	**Rhinobatus annandalei, Rhynchobatus Djiddensis, Rhina ancylostoma**	0.67%
Balistids	**Odonus niger, Balistes maculatus**	0.64%
Round Scads	**Decapterus dayi, D.russelli**	0.61%
Mackerel	**Rastrelliger kanagurta**	0.59%
Barracuda	**Sphyraena jello, S.picuda, S.obtusata**	0.29%
File fish (flute fish)	**Fistularia sp.**	0.25%
Horse mackerel	**Megalaspis cordyla**	0.25%
Bulls eye	**Priacanthus hamrur, P.tayenus**	0.17%
Flat fish	**Psettodes erumei**	0.11%
King fish/Sergeant fish	**Rachycentron canadus**	0.10%

Besides several other species were reported in trace quantities forming less than 0.1% of catch such as **Seriola nigrofasciata, Elagatis bipinnulatus, Parastromateus niger, Acanthocybium solandri, Scomberomorus guttatus, Mene maculata, Leiognathus splendens, Callyodon oktodon** (parrot fish), **Chorinemus sp., Gerres sp., Ephippus orbis, Platycephalus sp., Terapon sp., Trachinotus sp., Cynoglossus sp., Emmelichthys sp., Centrolophus sp., Cubiceps sp., Chlorophthalmus sp.** etc. The deepsea lobster **Puerulus sewelli** formed 0.95% of the catch and other crustaceans in trace numbers were the spiny lobster **Pannulirus sp.,** Zebra prawn, **Penaeus canaliculatus** and deepsea prawns **Aristeus sp.,** and **Heterocarpus sp.**

The swarming crab **Charybdis sp.** was in abundance and the other discarded crustacean was **Squilla.**

Though juveniles of ribbon fish measuring 15-20 cm were observed in considerable quantity from the outer shelf areas, no adult specimen was reported in the catch. Similar is the case with distribution of the ray **Urogymnus asperrimus** the young ones of which were hauled in plenty from the deeper strata of 76° longitude.

7.2. Areawise resource composition and relative density

The bottom nature and catch composition exhibited high degree of regional heterogenity. The Bank is therefore divided into western, north west, south west, north east and south east regions, the boundaries of which are defined by longitudes and depth contours, for the purpose of data assimilation and analysis. The resource composition worked out separately in respect of each region is given in Table I and illustrated in Fig.4.

Species/group	Percentage composition				
	Western region	Northwest region	Southwest region	Northeast region	Southeast region
Perches	5.8	27.1	4.7	58.6	23.7
Nemipterids	50.9	10.9	77.2	3.4	51.7
Rays	15.4	16.8	3.8	8.7	10.3
Cephalopods	2.4	5.4	0.8	9.6	1.2
Carangids	6.9	12.2	2.7	6.4	1.1
Lizard fish	11.4	10.9	1.2	1.6	3.1
Cat fish	0.1	4.3	0.7	3.4	2.6
Upeneoids	1.9	3.5	0.9	2.6	3.5
Other varieties	5.2	8.9	8.0	5.7	2.8

Table I: Regionwise species composition

Highest percentage of perches (58.6%) was from the northeast region followed by the adjacent northwest region (27.1%) the outer boundary of these sectors being demarcated by the (40 fm) 73 m contour line. The southwest and western regions contributed minimum share of perches to the total stock. Nemipterids also showed marked difference in its percentage contribution in different regions. They were abundant in southwest region (77.2%) followed by the southeast (51.2%) and western regions (50.9%). The norhern grounds specially the region east of Cape Comorin yielded very low percentage of this group. The variability in percentage contribution was again conspicuous in the case of rays, cephalopods, carangids, lizard fish etc. as could be seen from the Table 1 and Fig.4.

Considering catch per unit effort as the relative index of population density the resource structure was examined in toto as well as with reference to the five regions. The aggregate catch per unit effort recorded was 139.9 kg/hr and for the different regions it varied from 92.6 kg/hr in the western

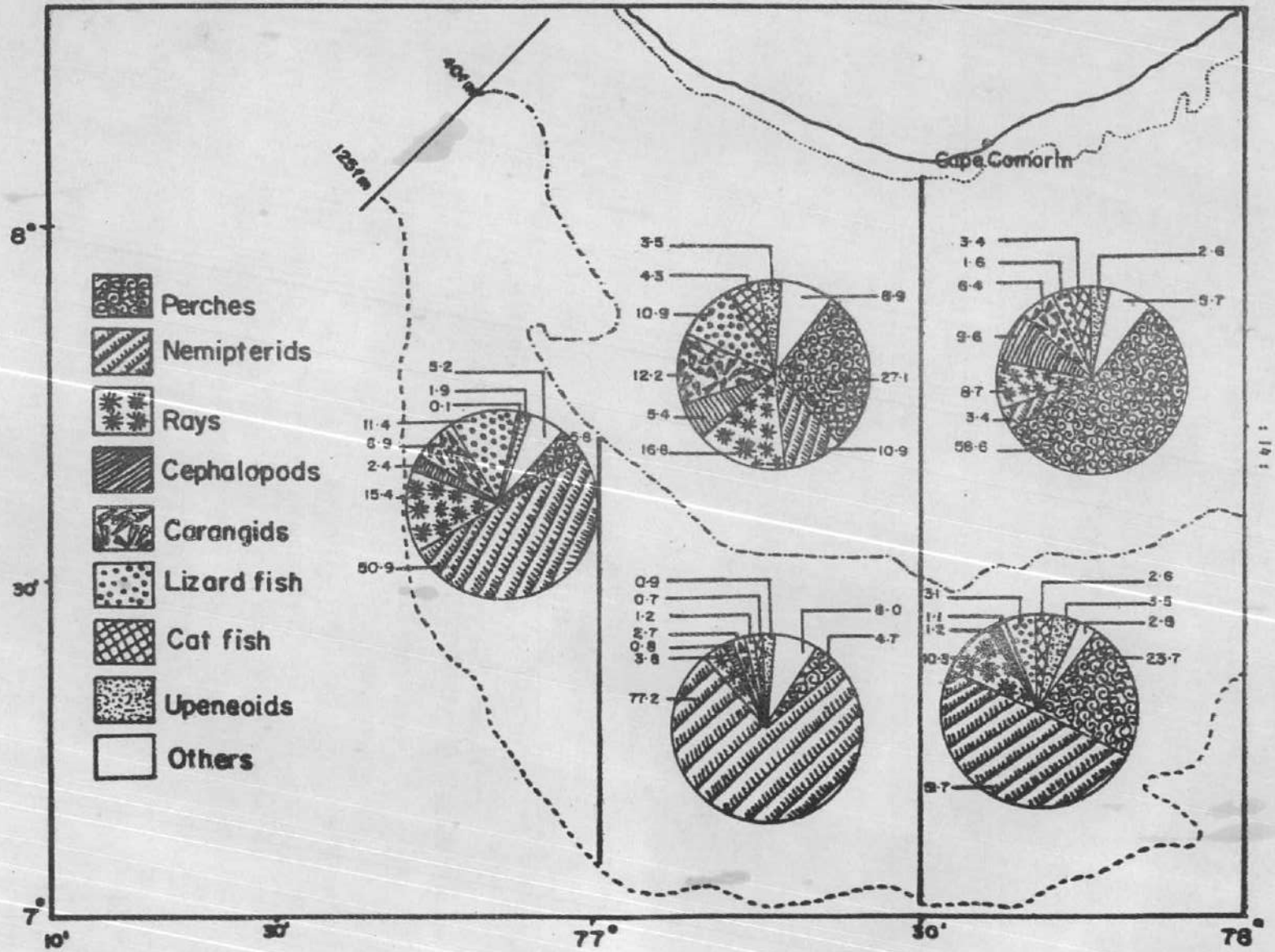


Fig. 4 REGION WISE SPECIES COMPOSITION

region to 302 kg/hr in the southwest region. Barring nemipterids which formed the bulk of the catch from peripheral regions. Perches recorded highest yield rate from all areas except the western regions. The most encouraging return of 80.7 kg/hr was from the area southeast of Cape Comorin. The species-wise density separately for all major groups in different regions is furnished in Table 2 and Fig.5.

Species/groups	Catch per hour(kg)				
	Western region	Northwest region	Southwest region	Northeast region	Southeast region
Perches	5.4	29.8	14.2	80.7	31.3
Nemipterids	47.2	12.0	253.5	4.6	68.3
Rays	14.3	18.5	11.5	12.0	13.7
Cephalopods	2.2	6.0	2.3	13.2	1.6
Lizard fish	10.5	11.9	3.7	2.1	4.1
Carangids	6.4	13.4	8.2	8.2	1.5
Cat fish	0.1	4.7	2.1	4.6	3.4
Upeneoids	1.8	3.4	2.7	3.6	4.6
Others	4.9	9.7	25.2	7.0	3.6

Table 2: Regionwise density of different species/group

7.3. Depthwise stock distribution

The depthwise catch per unit effort obtained in respect of the major groups and of the total fish biomass worked out with respect of each major area have been projected in the fishery charts published by the organisation (FSI,1984). The information as such has therefore not been furnished here and the discussion is limited to the population density in the different depth strata. The depth-wise catch per hour for all fish together recorded in the survey ranged from 67.4 kg to 251.2 kg in the different zones as presented in Table 3 and Fig.6.

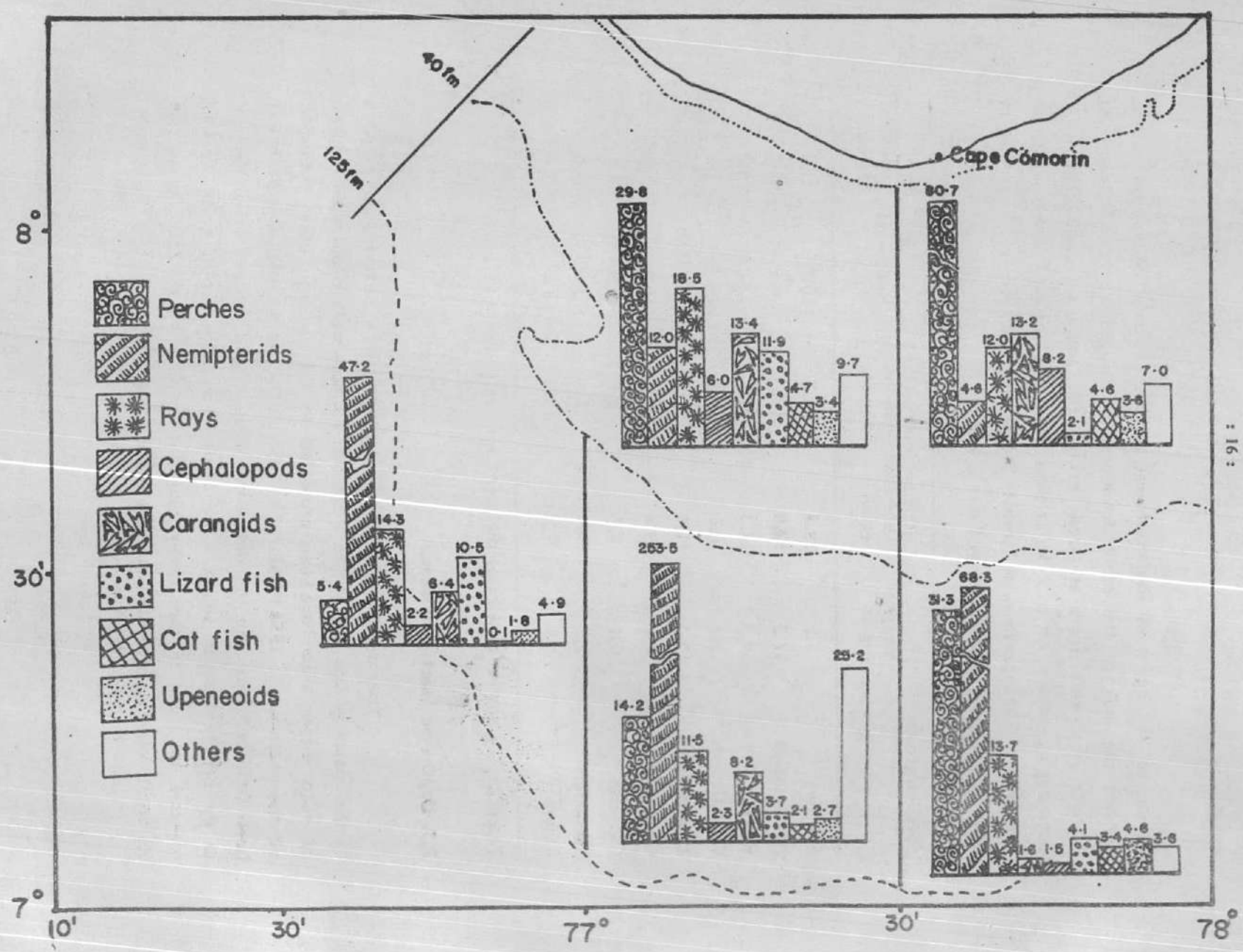


Fig. 5 REGION WISE DENSITY (KG/HR) OF DIFFERENT SPECIES/GROUPS

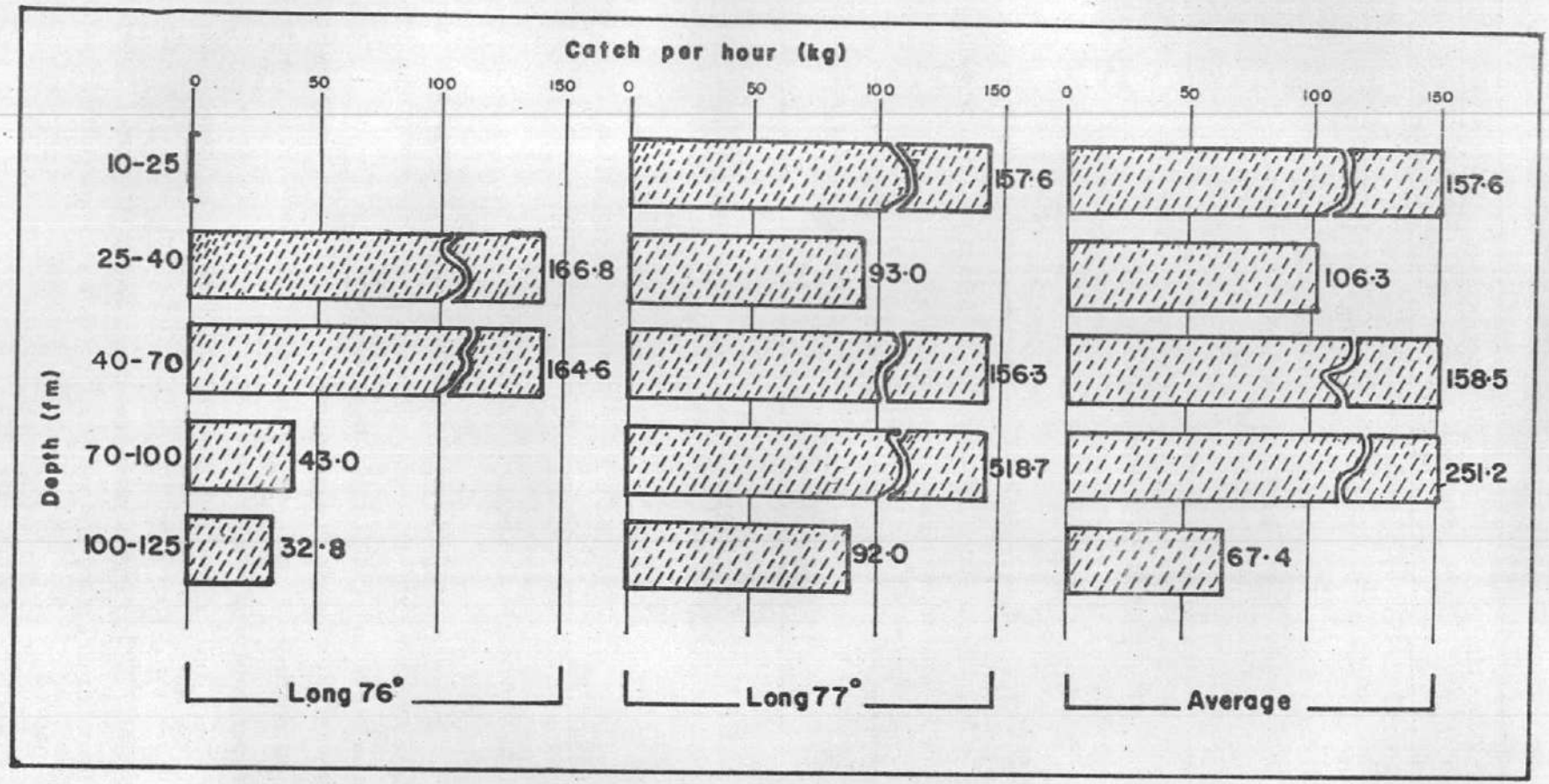


Fig. 6 YIELD PATTERN OF ALL FISH IN RELATION TO DEPTH

Depth strata (fm)	Catch per hour(kg)		
	Long 76°	Long 77°	Average
10-25	-	157.6	157.6
25-40	166.8	93.0	106.3
40-70	164.6	156.3	158.5
70-100	43.00	518.7	251.2
100-125	32.8	92.0	67.4

Table 3: Yield in relation to depth (all fish)

7.3.1. Perches

The highest catch rate of perches was obtained from the 18-46 m (10-25 fm) depth belt in long. 77°, the relative density being higher south of 8° latitude line (Table 4 and Fig.7).

Depth range(fm)	Catch per hour(kg)		
	Long 76°	Long. 77°	Average
10-25	-	94.6	94.26
25-40	20.4	42.6	38.6
40-70	9.9	20.7	17.8
70-100	2.5	3.4	2.9
100-125	-	77.6	45.4

Table 4: Yield pattern of perches in relation to depth

A well marked perch ground could be established southeast of Cape Comorin extending from longitude 77° 20'E to 78°00' E and between latitude 7°40'N and 8°00'N in depth range 36-64 m (20-35 fm). The general pattern of distribution indicated higher relative density towards eastern half of longitude 77° declining westwards. Similarly with increasing depths catch per unit effort decreased steadily in all the areas with an exception where very high catch rate was recorded from the hauls taken in the month of March above the 183 m (100 fm) depth line in the eastern side of longitude 77°. Perches were generally abundant in areas where there is growth of sea fans and hard sea bottom with intermittant patches of sand and mud .

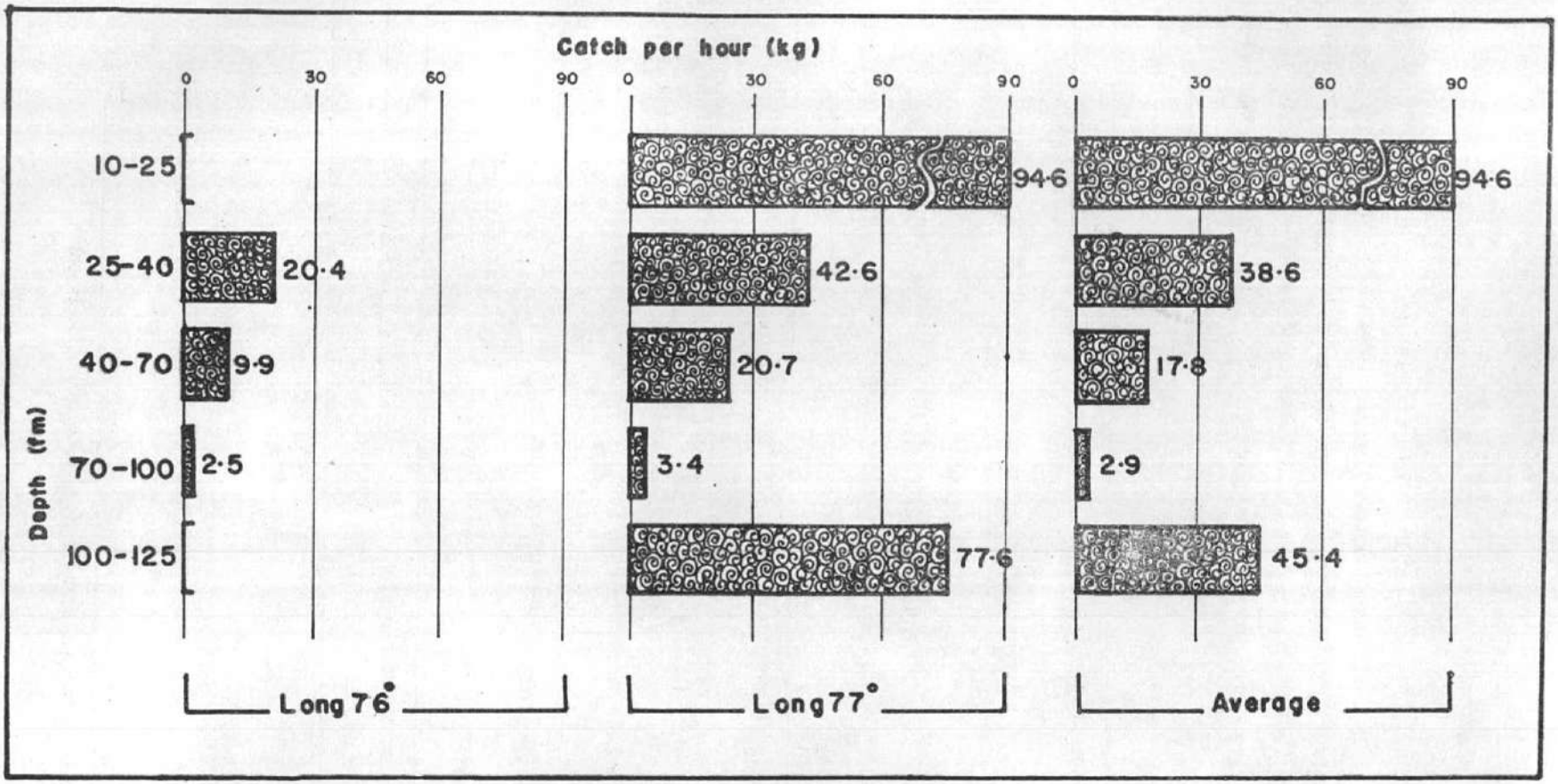


Fig. 7 YIELD PATTERN OF PERCHES IN RELATION TO DEPTH

7.3.2. Nemipterids

The threadfin breams exhibited a clear trend of higher density with increasing depths upto the 128-183 m (70-100 fm) zone beyond which the catch was very meagre (Table 5 & Fig. 8). Maxmimum yield as high as 850 kg per hour was obtained between 128-168 m (70-90 fm) in the western grounds of longitude 77°. Here the sea bed was either muddy or sandy and devoid of any obstructions for trawling.

Depth strata (fm)	Catch per hour (kg)		
	Long 76°	Long 77°	Average
10-25	-	2.0	2.0
25-40	20.4	9.2	11.2
40-70	94.9	101.5	99.7
70-100	15.4	427.2	199.1
100-125	1.4	6.6	4.4

Table 5: Yield pattern of nemipterids in relation to depth

Nemipterus mesoprion dominated the catch from the deeper strata whereas distribution of **N.japonicus** was more pronounced in the inner shelf areas. The species **N.tolu** was mainly recorded from the western grounds. In general, nemipterids unlike perches were found to be in even grounds devoid of rock.

7.3.3 Rays

Depth strata (fm)	Catch per hour(kg)		
	Long 76°	Long.77°	Average
10-25	-	15.0	15.0
25-40	25.9	11.4	14.0
40-70	20.1	11.4	13.7
70-100	11.9	19.1	15.1
100-125	-	-	-

Table 6: Yield pattern of rays in relation to depth.

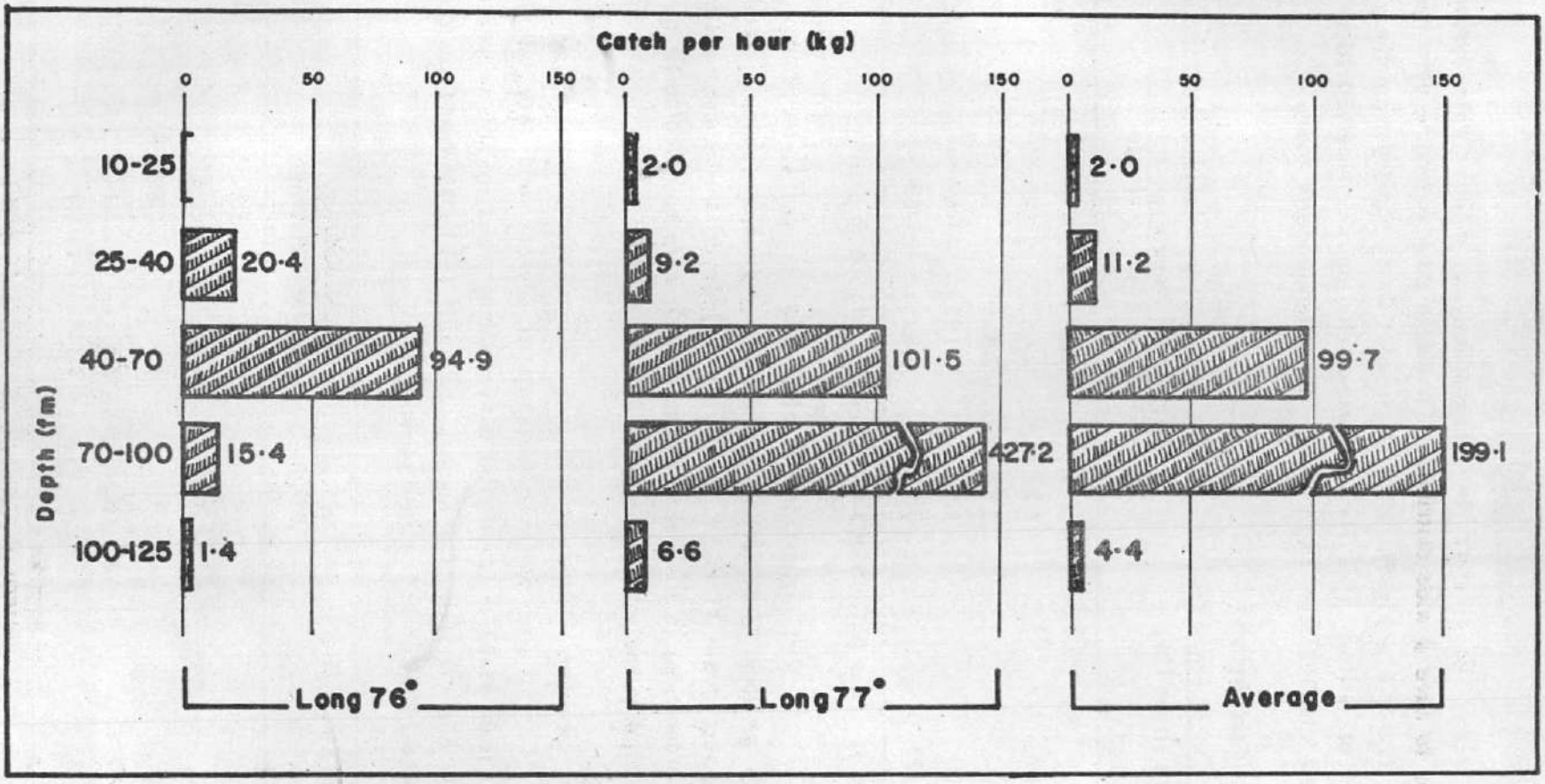


Fig. 8 YIELD PATTERN OF NEMIPTERIDS IN RELATION TO DEPTH

Rays which is predominantly a shallow water group was found to have a wide distribution in Wadge Bank extending upto the shelf edge (Table 6 & Fig. 9). High catch rates were reported from the grounds north of latitude 8°. The average catch rate was observed to be more or less similar (13.7 - 15.1 kg/hr) in the different depth zones.

7.3.4. Cephalopods

Depth strata (fm)	Catch per hour(kg)		
	Long 76°	Long 77°	Average
10-25	-	17.5	17.5
25-40	9.8	4.6	5.5
40-70	3.8	2.8	3.1
70-100	1.1	0.1	0.7
100-125	0.9	0.8	0.9

Table 7: Yield pattern of Cephalopods in relation to depth

With highest density of 17.5 kg per hour in the shallow water strata of long. 77°, cephalopods showed a gradual declining trend with increasing depth (Table 7 & Fig.10). However this characteristic was less pronounced in the case of squids which were observed to be of lesser proportion in the total cephalopod catch.

7.3.5. Carangids

Carangids were obtained at higher yield rate (10 kg per hour) from 46-73 m (25-40 fm) with reducing trend towards deeper waters (Table 8 & Fig. 11). The highest catch rate (30 kg per hour) was recorded from 46-73 m (25-40 fm) zone of long. 76°E.

Depth strata (fm)	Catch per hour(kg)		
	Long. 76°	Long 77°	Average
10-25	-	8.2	8.2
25-40	30.2	5.5	10.0
40-70	9.1	5.7	6.6
70-100	0.1	2.5	1.1
100-125	-	1.8	1.1

Table 8: Yield pattern of carangids in relation to depth

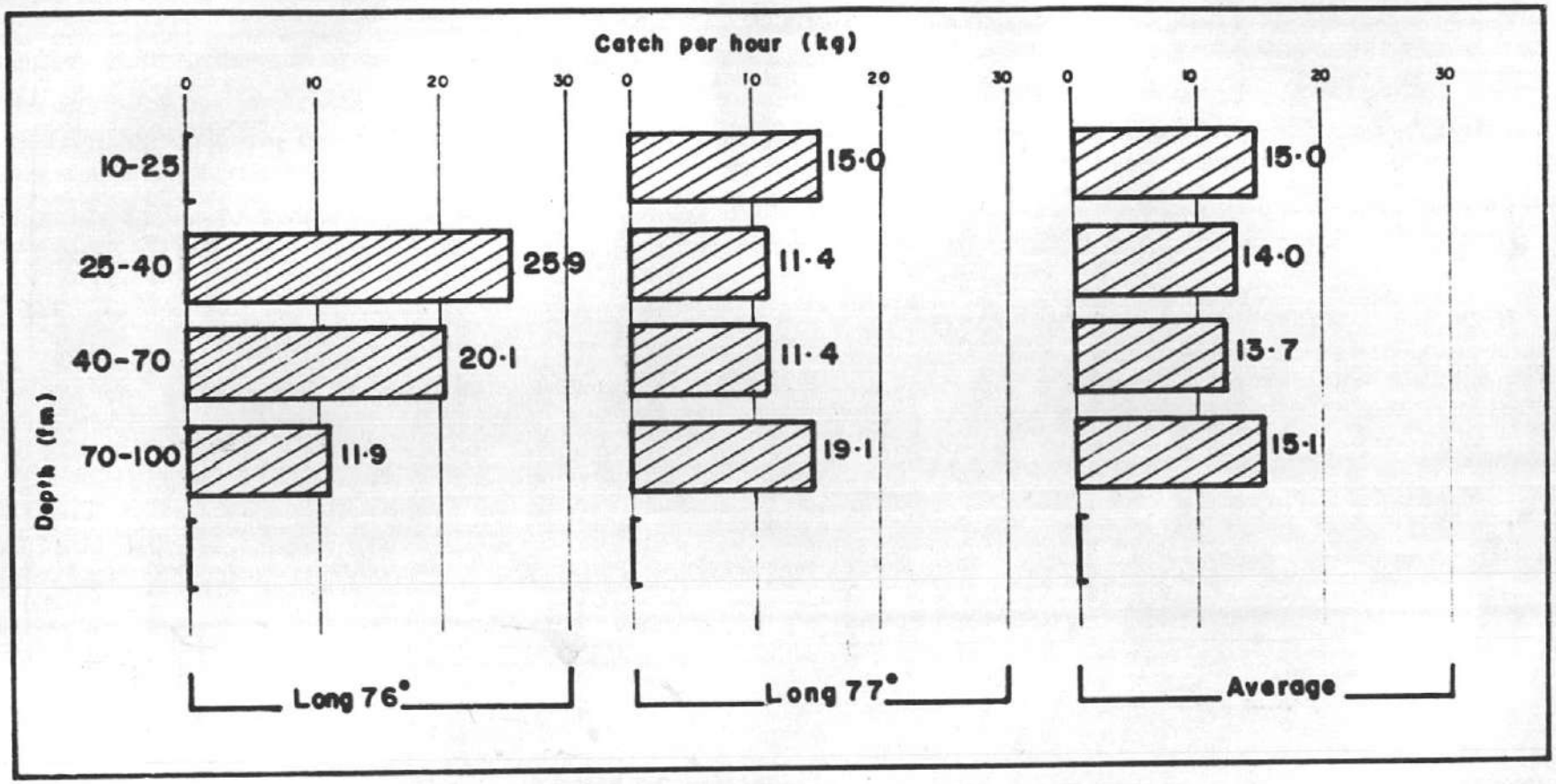


Fig. 9 YIELD PATTERN OF RAYS IN RELATION TO DEPTH

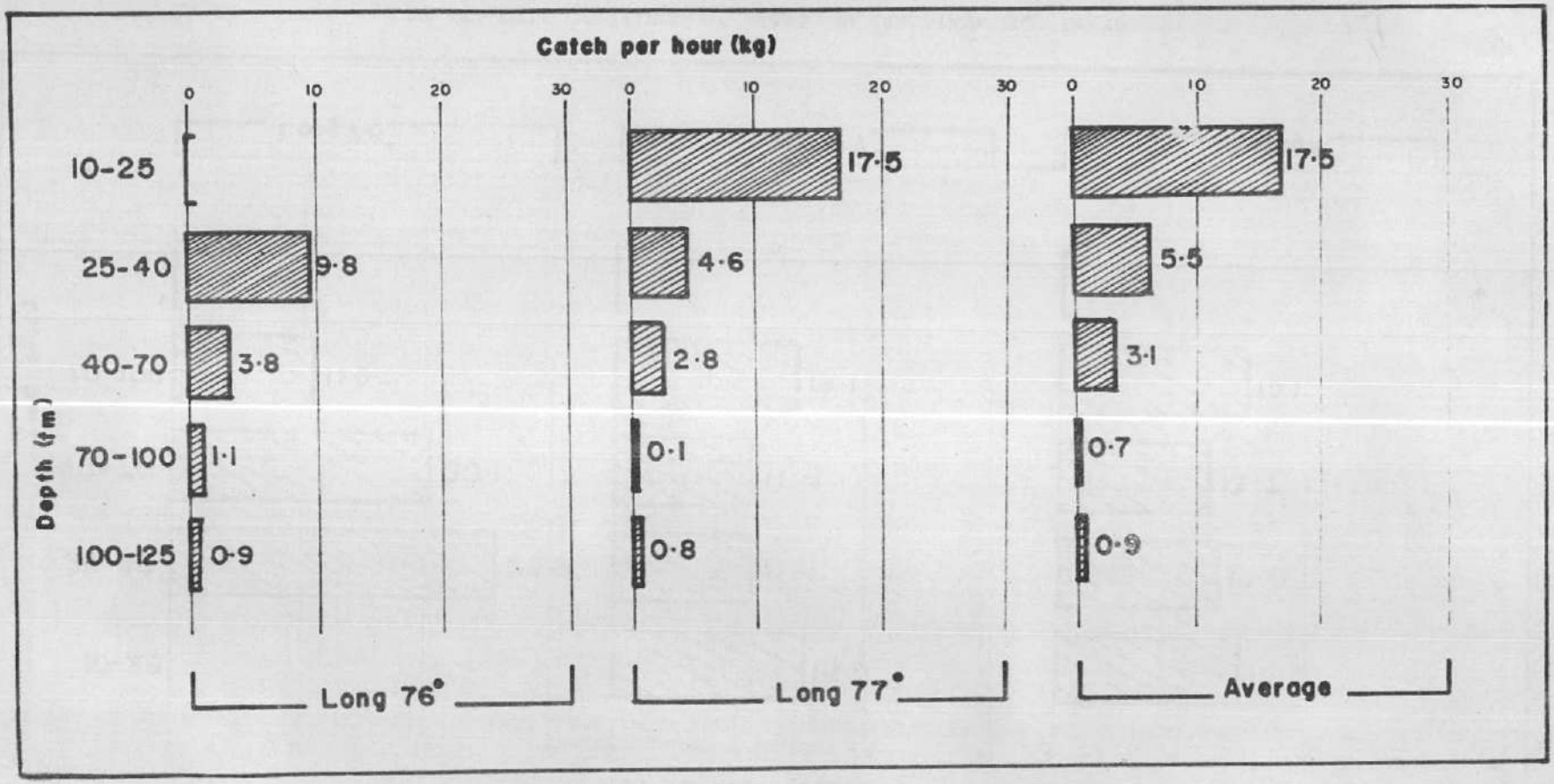


FIG. 10 YIELD PATTERN OF CEPHALOPODS IN RELATION TO DEPTH

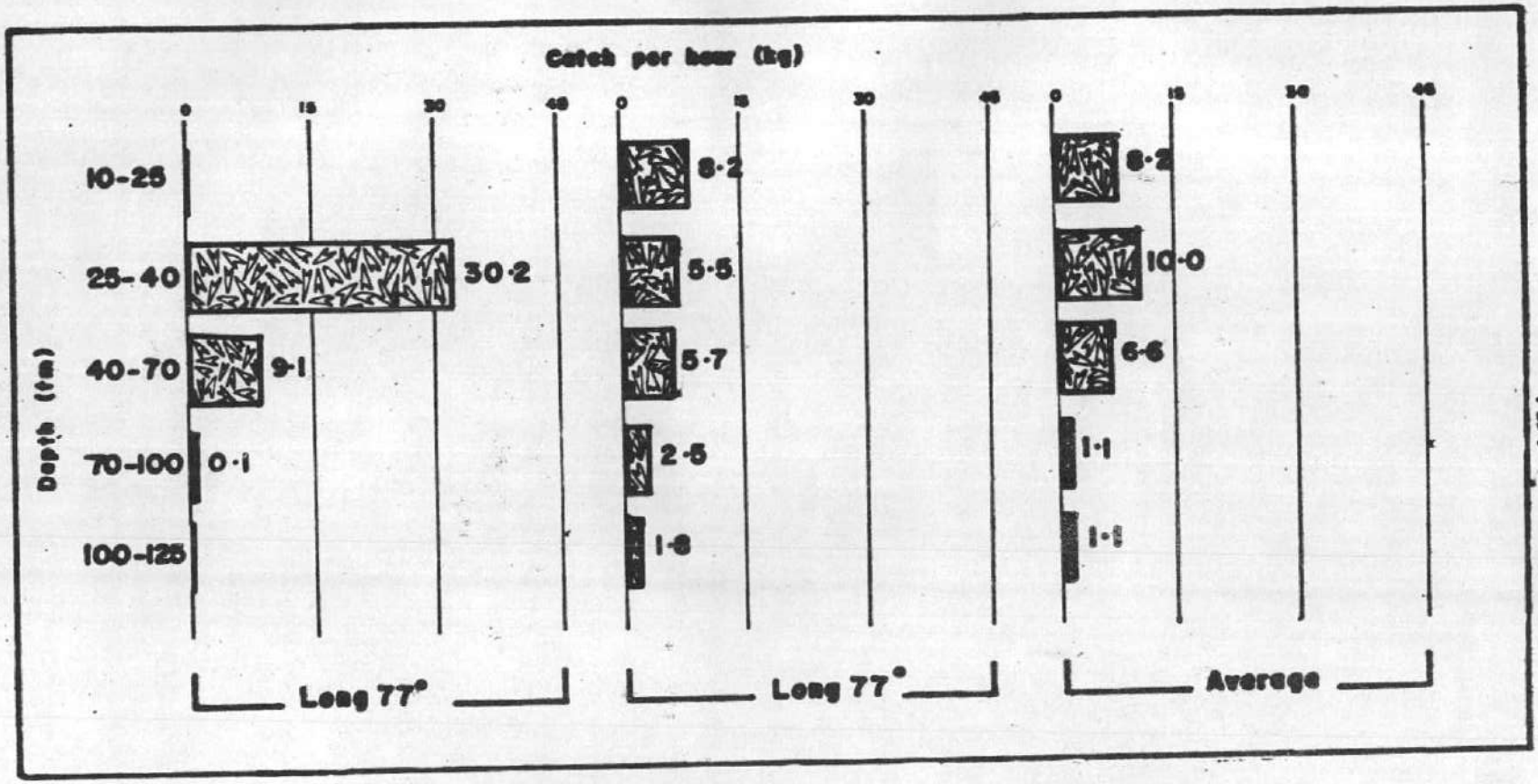


Fig. 11 YIELD PATTERN OF CARANGIDS IN RELATION TO DEPTH

7.3.6. Lizard fish

Distribution pattern of lizard fish (Table 9 & Fig.12) was almost similar to that of carangids with higher density in the different depth zones of longitude 76°E. Its occurrence in 182-223 m (100-125 fm) depth belt of long. 76° E is noteworthy (20.2 kg per hour).

Depth strata (fm)	Catch per hour(kg)		
	Long.76°	Long.77°	Average
10-25	-	0.2	0.2
25-40	33.3	4.6	9.8
40-70	16.4	4.4	7.6
70-100	3.9	2.2	3.1
100-125	20.2	-	8.4

Table 9: Yield pattern of lizard fish in relation to depth

7.3.7. Cat fish

The findings as recorded in Table 10 & Fig. 13 reveal that cat fish move towards south mainly through 46-73 m (25-40 fm) depth range of long. 76°E (yield 10.6 kg per hour) and are distributed in all the strata of long. 77° E excepting 143-223 m (100-125 fm).

Depth strata (fm)	Catch per hour(kg)		
	Long 76°	Long.77°	Average
10-25	-	5.3	5.3
25-40	10.6	2.7	4.1
40-70	-	2.9	2.1
70-100	0.1	1.6	0.8
100-125	-	-	-

Table 10: Yield pattern of cat fish in relation to depth

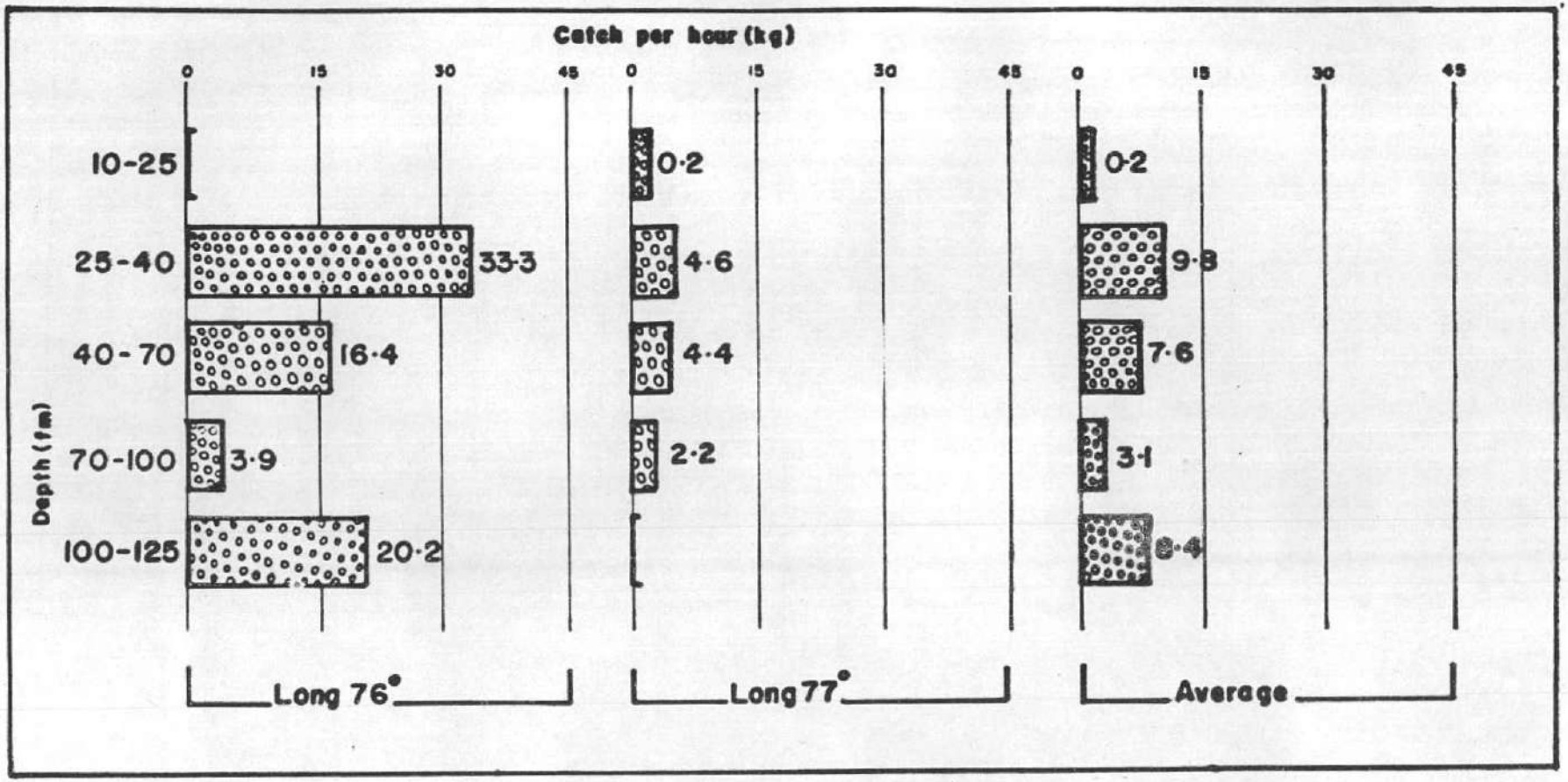


Fig. 12 YIELD PATTERN OF LIZARD FISH IN RELATION TO DEPTH

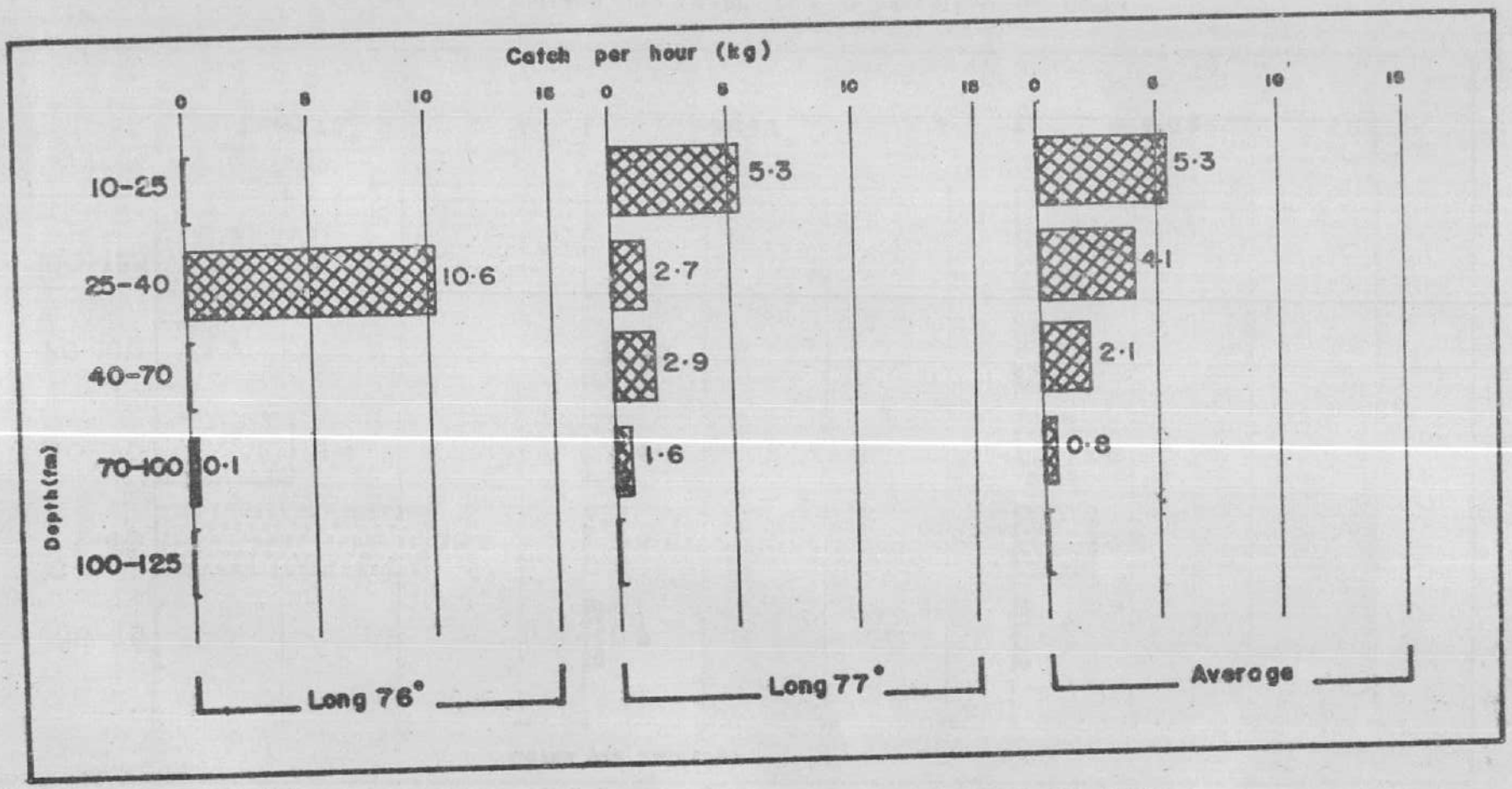


Fig. 13 YIELD PATTERN OF CAT FISH IN RELATION TO DEPTH

7.3.8. Upeneoids

Upeneoids yield was observed to be better in shallow waters with descending catch rates towards the deeper areas (Table 11 & Fig.14).

Depth strata (fm)	Catch per hour (kg)		
	Long 76°	Long 77°	Average
10-25	-	4.10	4.20
25-40	5.5	3.10	3.5
40-70	2.3	2.9	2.7
70-100	1.7	0.9	1.3
100-125	-	3.6	2.1

Table 11: Yield pattern of Upeneoids in relation to depth

7.3.9. Other varieties

The yield pattern of other varieties are presented in Table 12 & Fig. 15.

Depth stata (fm)	Catch per hour(kg)		
	Long 76°	Long.77°	Average
10-25	-	10.4	10.4
25-40	10.6	9.5	9.7
40-70	8.1	3.8	5.0
70-100	6.4	61.7	31.1
100-125	10.3	1.7	5.3

Table 12: Yield pattern of other varieties in relation to depth

Among the various miscellaneous species classified under other varieties, the Indian drift fish **Psenes indicus** was more dominant in 77° longitude. A catch rate upto 60 kg per hour was recorded from 128-183 m (70-100 fm) depth belt of the area 7-77. Sharks, barracuda and **Seriola sp.** recorded higher relative densities from the inshore stratum of 77° longitude whereas horse mackerel, skates and scads were found to have preference to the 46-73 m (25-40 fm) depth zone of the same longitude. The highest catch rate reported in case of mackerel was

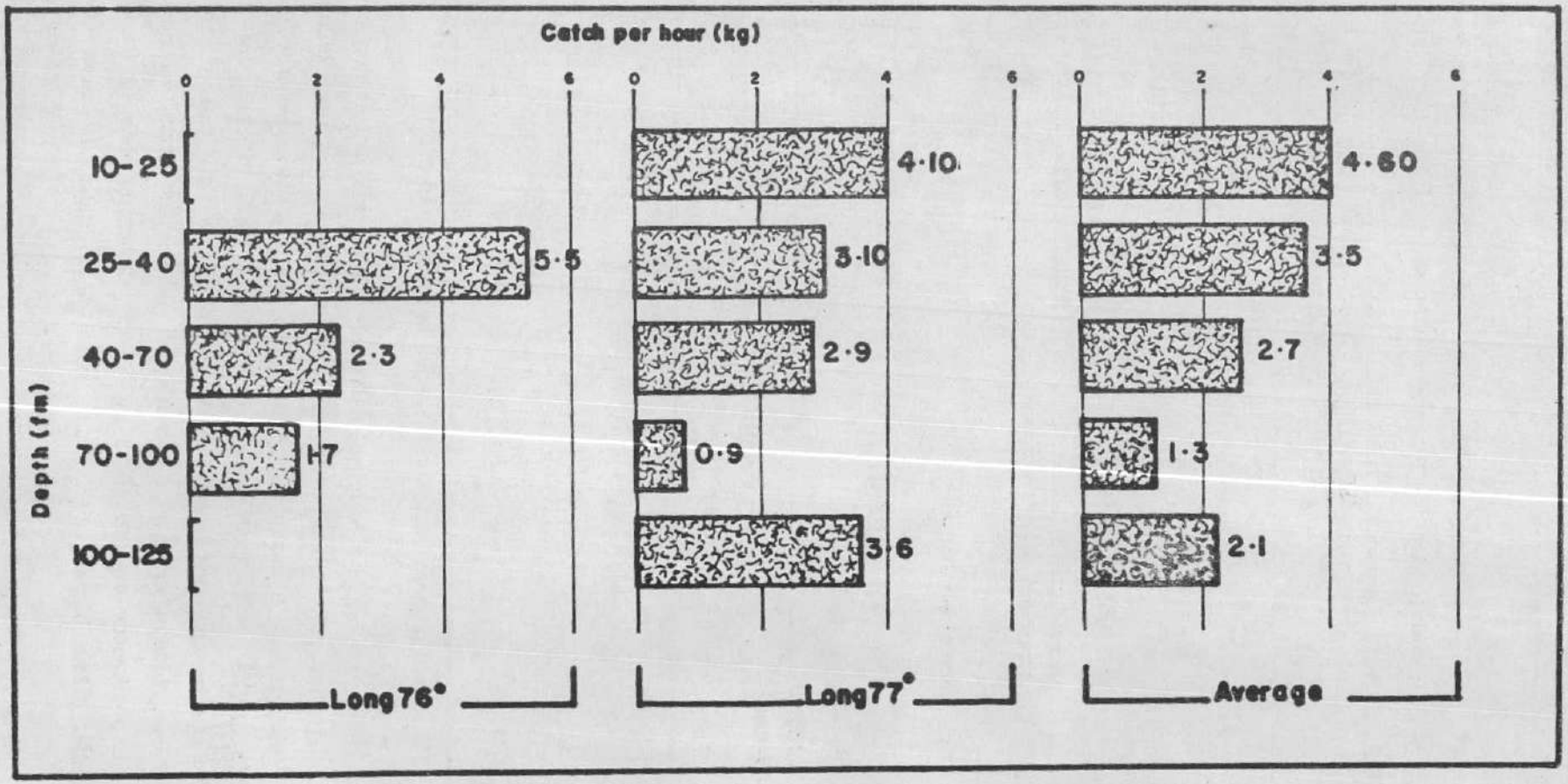


Fig. 14 YIELD PATTERN OF UPENEOIDS IN RELATION TO DEPTH

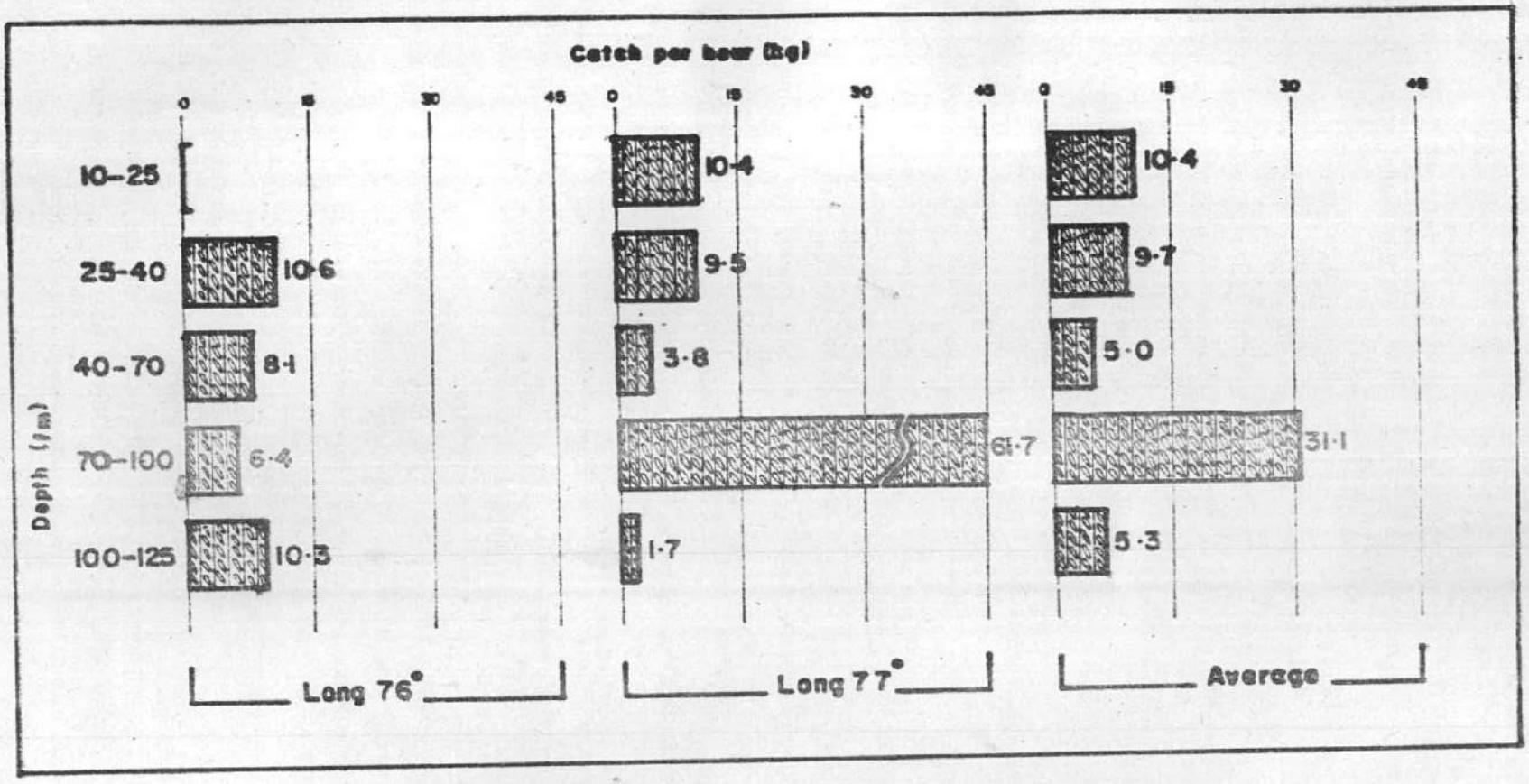


Fig. 15 YIELD PATTERN OF OTHER FISHES IN RELATION TO DEPTH

1.34 kg per hour from the area 8-76 in 46-73 m (25-40 fm) depth belt and the same area extending upto 128 m (70 fm) was found to be the preferred habitat of king fish **Rachycentron canadus.**

The deep sea lobster was found to occur toward the western periphery of Wadge Bank in 150-183 m (80-100 fm) depth extending northwards beyond the 8° latitude. Though the resources from this ground have been reported earlier (Silas, 1969: Oommen and Philip, 1974) the catch per unit effort of 8.8 kg per hour recorded from the area 7-76 with the trawl of very large meshes is significant.

7.4. Seasonal variation

Conspicuous seasonal variation in yield pattern was observed in case of almost all species. It has been reported earlier (Shivalingam and Medcof, 1957; Shivalingam 1969) that the Wadge Bank stock is composed of two groups; the resident stock which is present in the fishing ground throughout the year and the migrant stock that appears on the bank during southwest monsoon period. Shivalingam (1957) has further observed that the migrant stock is composed of carangids, lutjanids and sharks. The findings in the present survey are in conformity with these observations as far as carangid and lutjanid groups are concerned. The average catch per hour of carangids obtained during June - August was 10.1 kg whereas the yield index for the rest of year was only 2.9 kg per hour. The length frequency observations of larger carangids and lutjanids are also supporting this concept. Sharks did not indicate any positive relationship with southwest monsoon as evidenced by the relatively meagre catch reported during this period. Apart from the distribution pattern of these migrant species, higher catch rate for all species together (reaching upto 444 kg per hour in June) was reported during the monsoon period.

The percentage of each species/group in total catch worked out on a monthly basis has been projected in fishery charts referred earlier and hence not repeated in this report. However the relevant resource information as observed for the four different quarters of the year in the various geographic and bathymetric divisions are discussed here.

The relative density as indicated by catch per hour of all fish and separately for the dominant groups of the different sub-divisions is depicted in Fig.16-24.

7.4.1. Perches

Perches recorded high catch rate during the third quarter with maximum yield in August. The north east region within 46 m (25fm) of area 7-77 recorded 153.4 kg/hr during this season. An exceptionally high catch rate (167.7 kg/hr) was recorded in March 1983 from the south-east region in 183-223 m (100-125 fm) depth.

7.4.2. Nemipterids

Nemipterids during the first quarter indicated very high density in narrow longitudinal strip between 77°00' & 77°30' in the 128-183 m (70-100 fm) stratum (Fig.18). A northeast movement of the stock was observed during second quarter and the stock almost concentrated in 73-128 m (40-70 fm) stratum during third quarter. The distribution in the last quarter was again similar to that in first quarter in all the regions except in 73-128m (40-70 fm) depth zone of the southwest region where the yield was observed to be higher.

7.4.3. Rays

During January - March, rays registered higher density in the 128-183 m (70-100 fm) depth belt which was found to extend upto the 73 m (40 fm) line in the next quarter. The third quarter indicated restricted distribution of the group to the inshore waters and started spreading to deeper strata in the succeeding months. The distribution pattern is depicted in Fig.19.

7.4.4. Cephalopods

The first quarter recorded negligible catch of squid and cuttle fish but the yield rate improved by middle of second quarter. The higher catch rate of 22 kg per hour in the second quarter was recorded in the 46-73 m (25-40 fm) stratum west of latitude 07°30' N (Fig.20). Significant catch rate was obtained from the same stratum in the succeeding

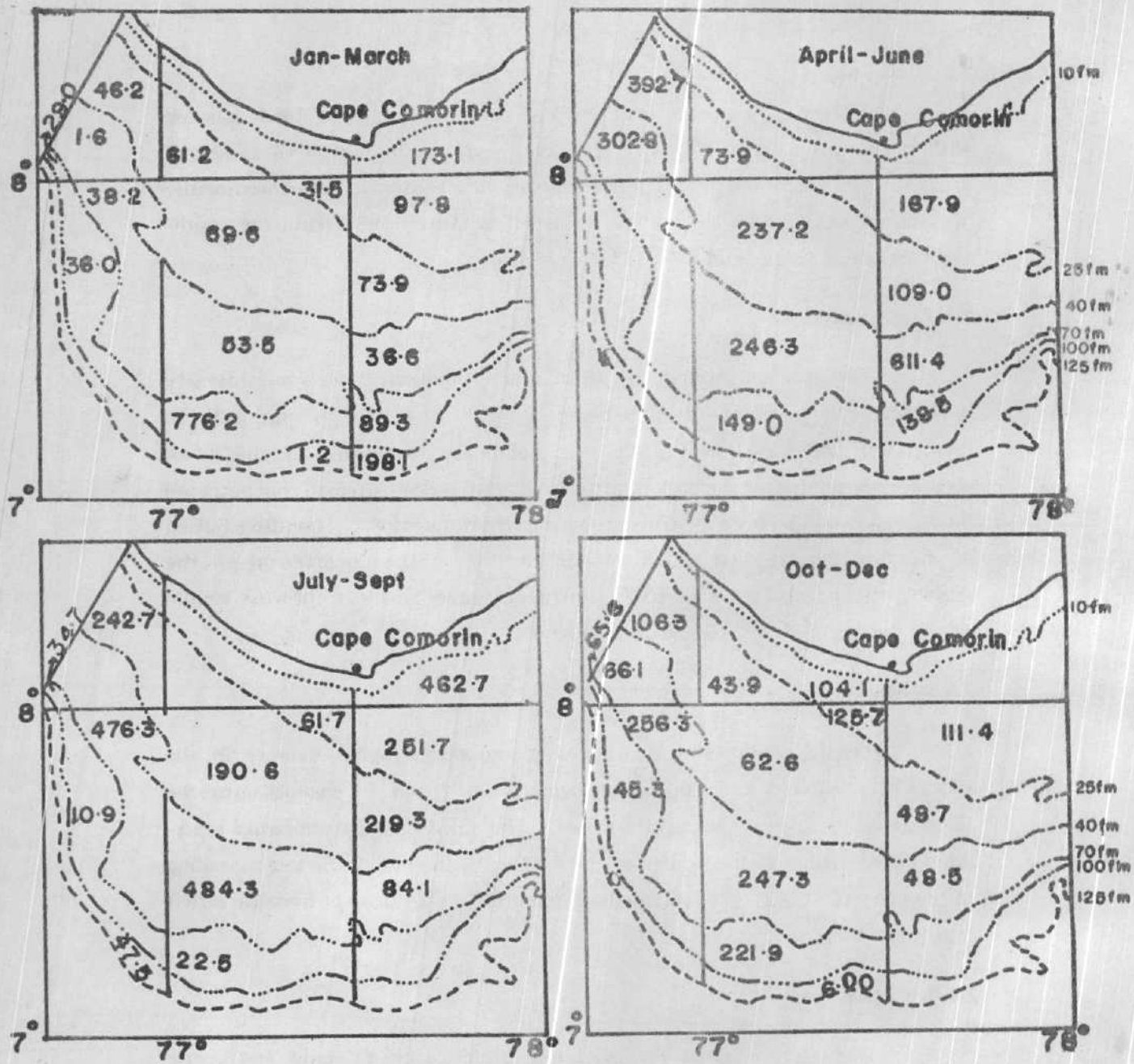


Fig. 16 SEASONAL CHANGES IN YIELD PATTERN OF ALL FISH (KG/HR)

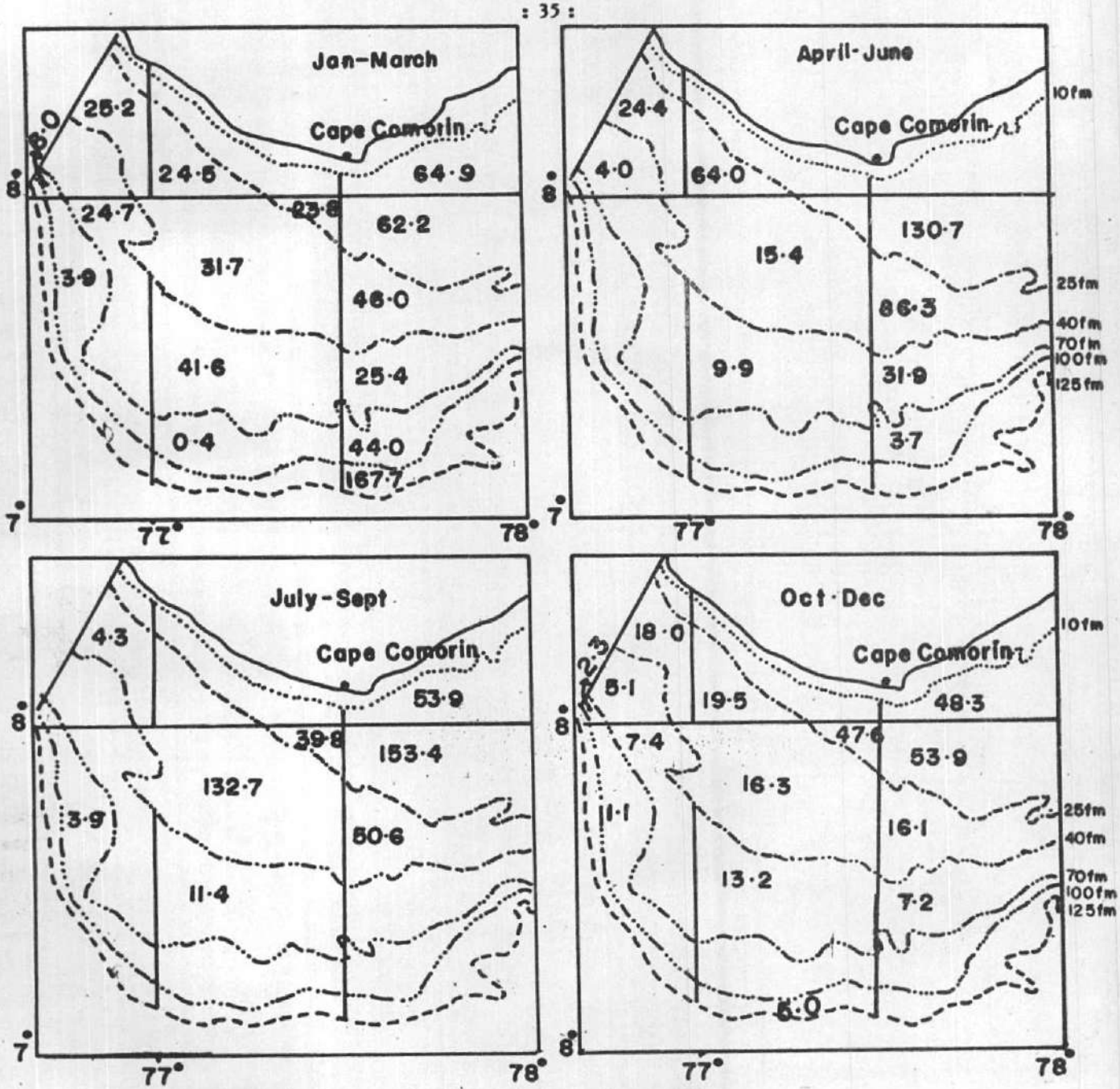


Fig. 17 SEASONAL CHANGES IN YIELD PATTERN OF PERCHES (KG/HR)

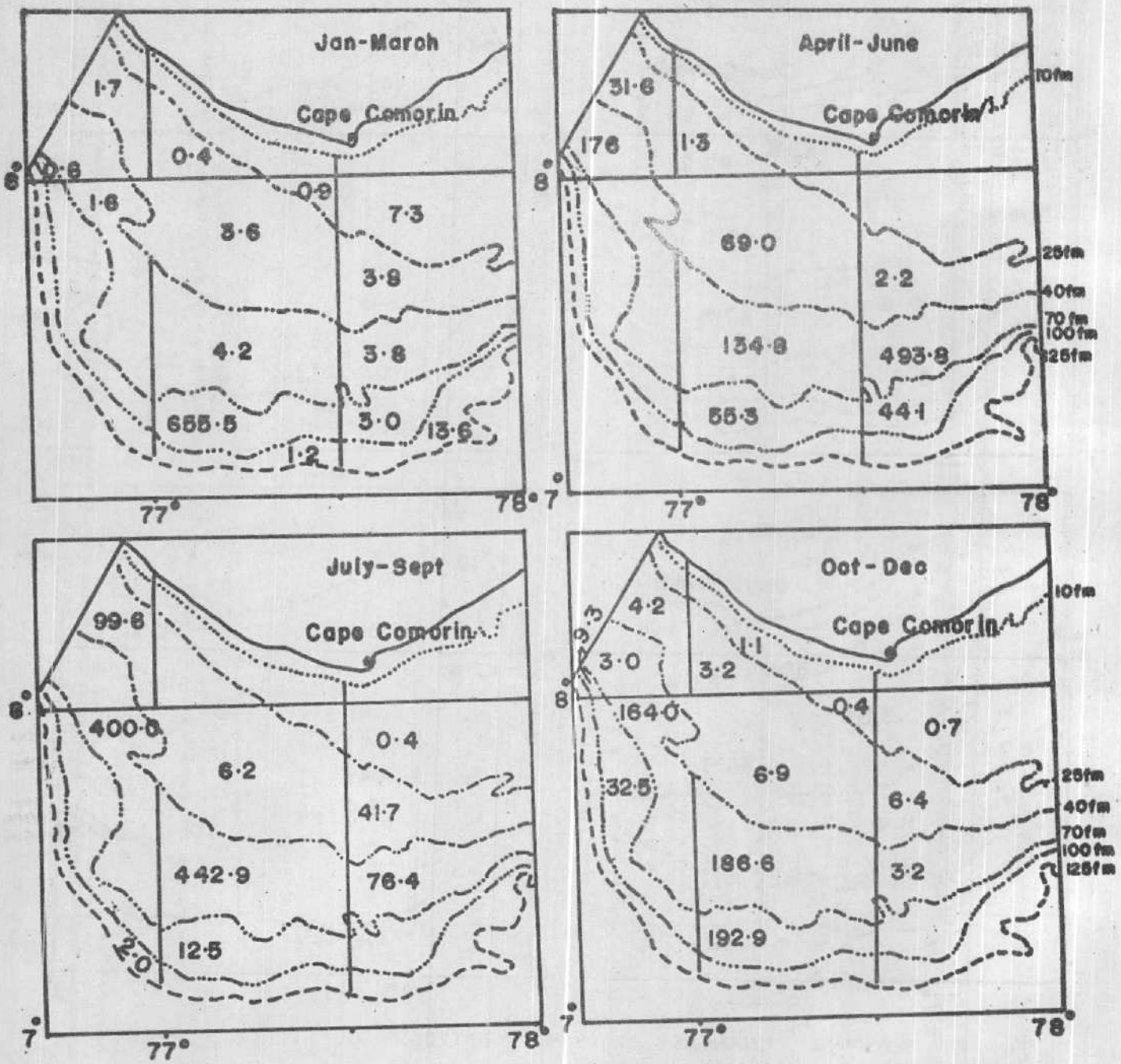


Fig. 18 SEASONAL CHANGES IN YIELD PATTERN OF NEMIPTERIDS (KG/HR)

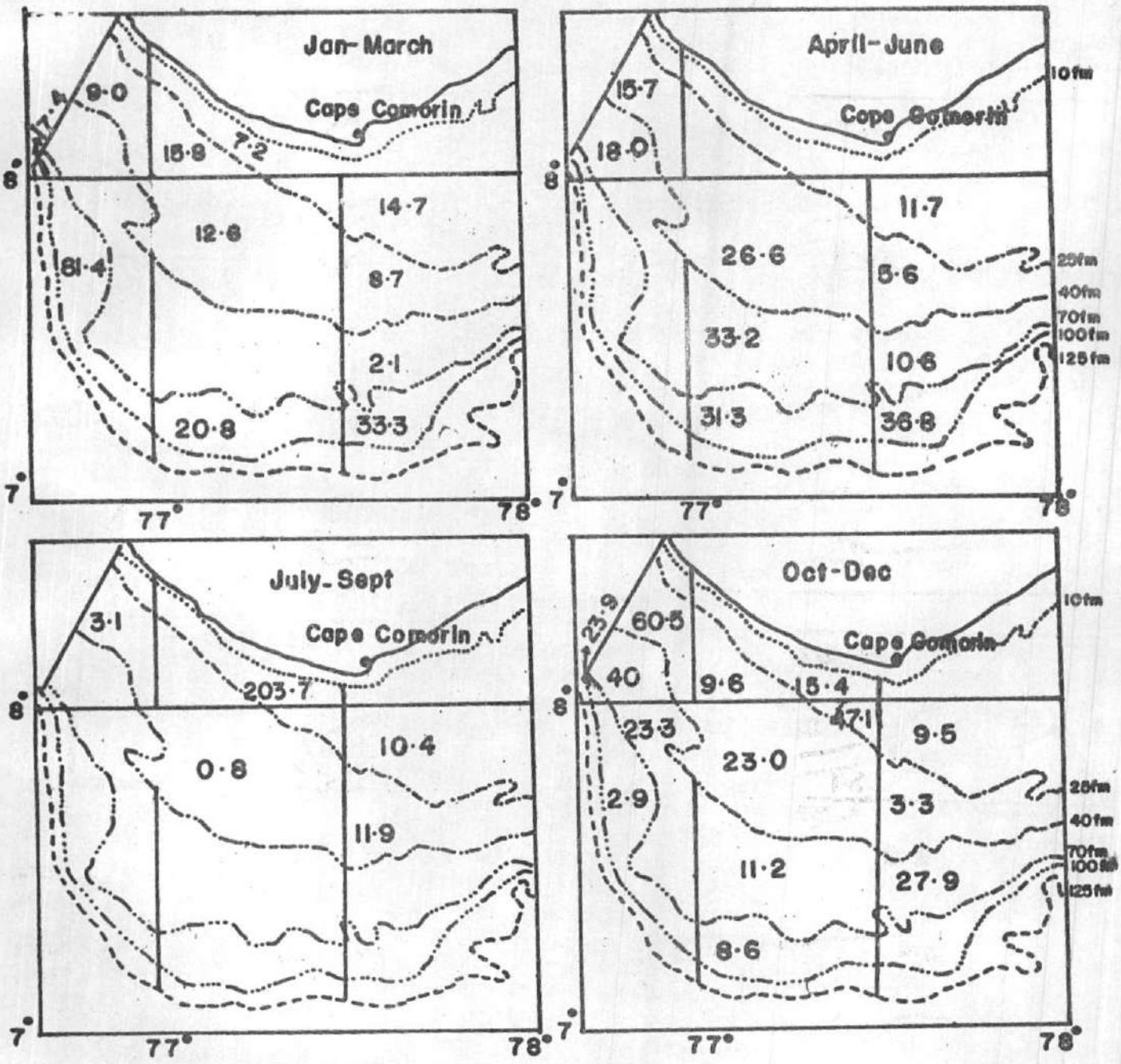


Fig. 19 SEASONAL CHANGES IN YIELD PATTERN OF RAYS (KG/HR)

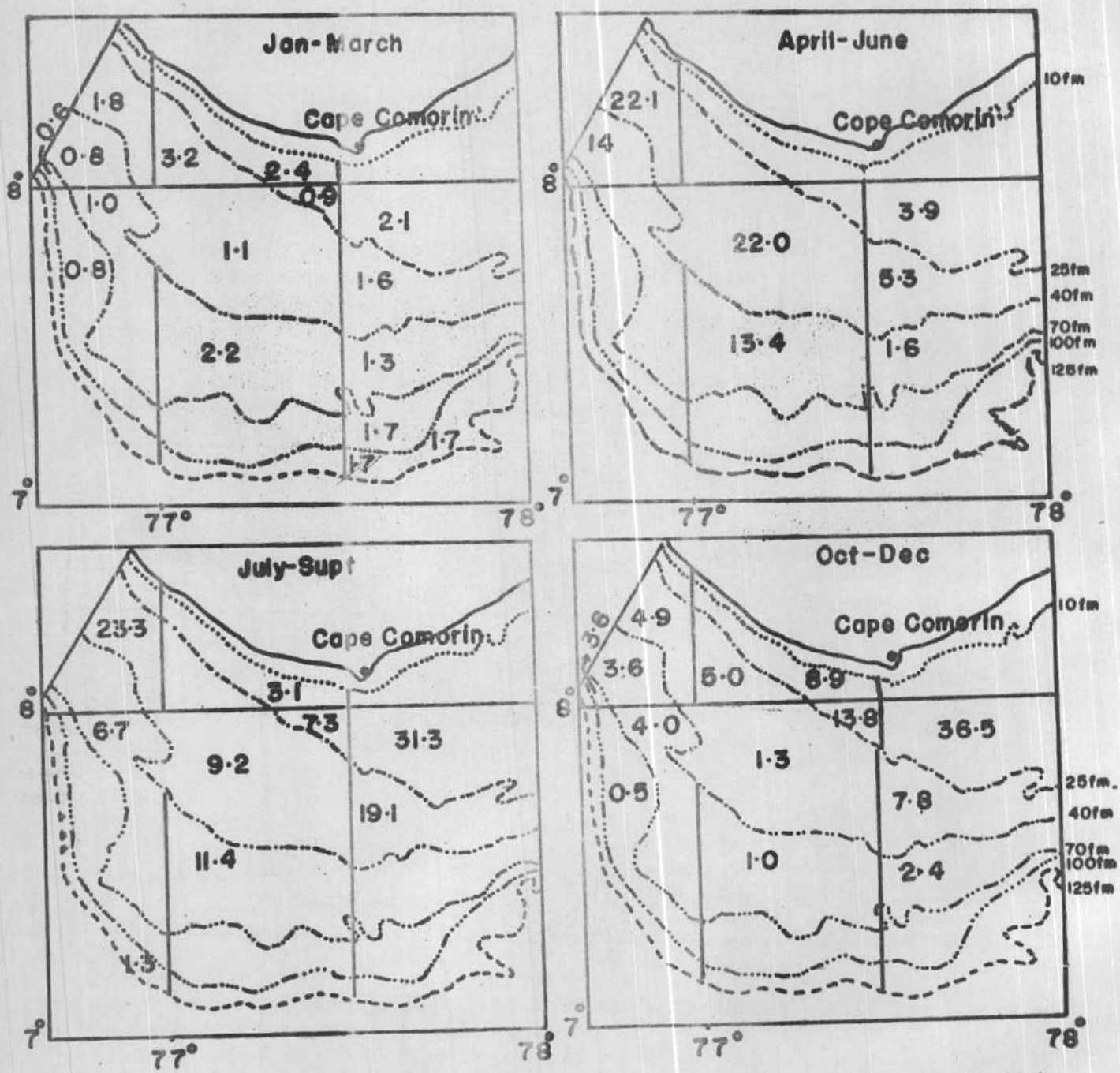


Fig. 20 SEASONAL CHANGES IN YIELD PATTERN OF CEPHALOPODS (KG/HR)

quarter but still higher concentration was reported from adjacent northern region below 46 m (25 fm) east of Cape Comorin. During the last quarter this same ground in the north east part of area 7-77 registered highest catch rate of 36.5 kg per hour whereas distribution in other areas was rather scattered.

7.4.5. Lizard fish

The contribution of lizard fish to the trawl catch in Wadge Bank was almost nil during the first quarter. During June - July an average catch of 70 kg per hour was recorded. The 46-73 m (25-40 fm) zone of the major area 8-76 was found to be the most productive ground in the second and third quarters. The fourth quarter yielded appreciable catch only from the 73-120 m (40-70 fm) strata of area 7-76 (Fig.21).

7.4.6. Cat fish

During the first quarter cat fish was obtained only in January and the distribution was found to be almost confined to the area 8-77. The second quarter yielded higher catch rate from the 46-73 m (25-40fm) stratum of 8-76 and 73-183 m (40-100 fm) stratum of 7-77. During the third quarter significant quantity of the species was recorded from the area 7-77 within the 73 m (40 fm) depth line. The catch rate recorded in the last quarter was almost negligible as indicated in the Fig.22.

7.4.7. Upeneoids

This group was represented in the catch in considerable quantity during the second quarter from 46-128 m (25-70 fm) depth belt (Fig.23). In general the individuals of this group appear to move to deeper waters 128 m (70 fm) during first two quarters of the year and the catches at higher rate (upto 26 kg/hr) were obtained during second quarter.

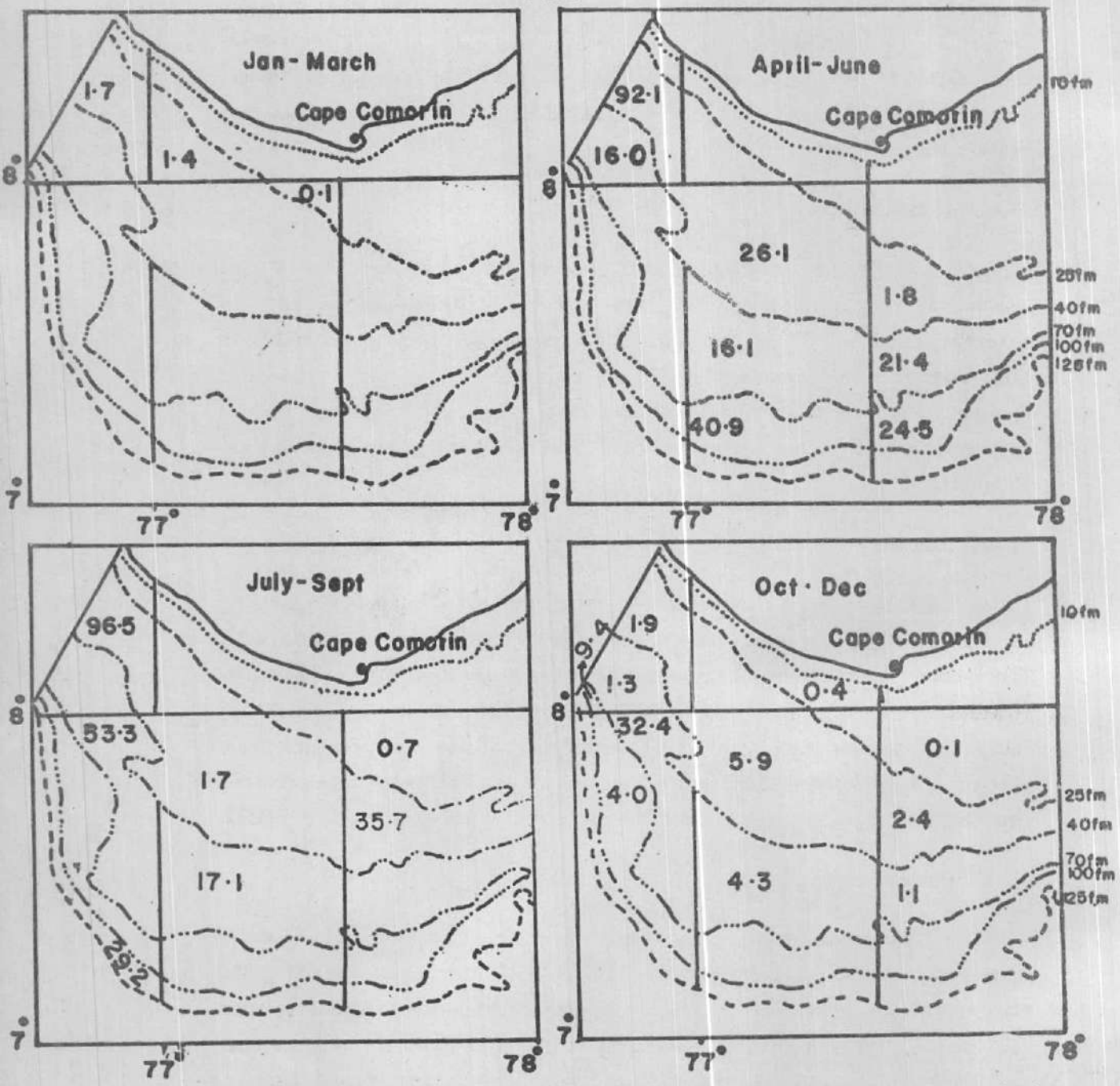


Fig. 21 SEASONAL CHANGES IN YIELD PATTERN OF LIZARD FISH (KG/HR)

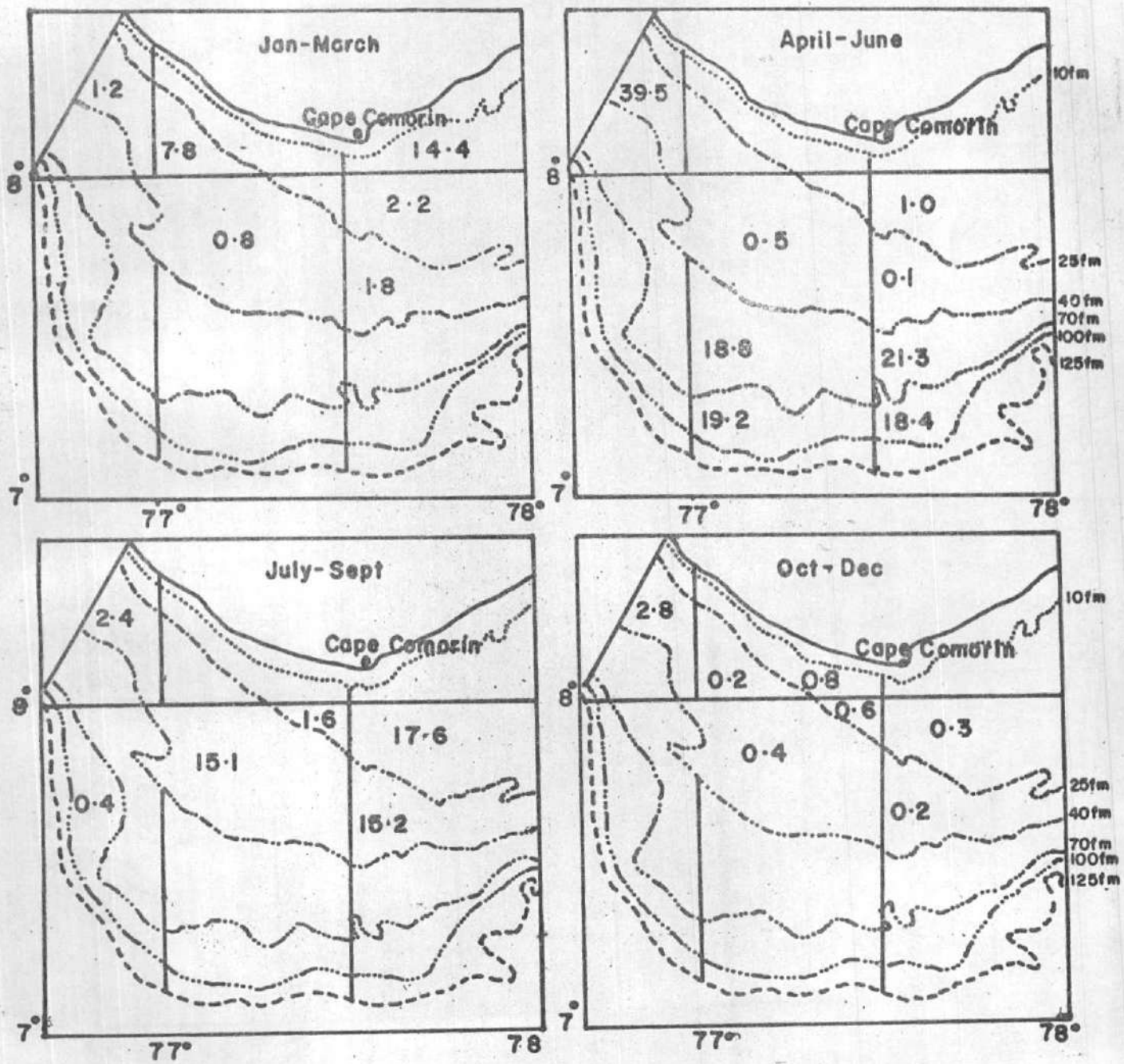


Fig. 22 SEASONAL CHANGES IN YIELD PATTERN OF CAT FISH (KG/HR)

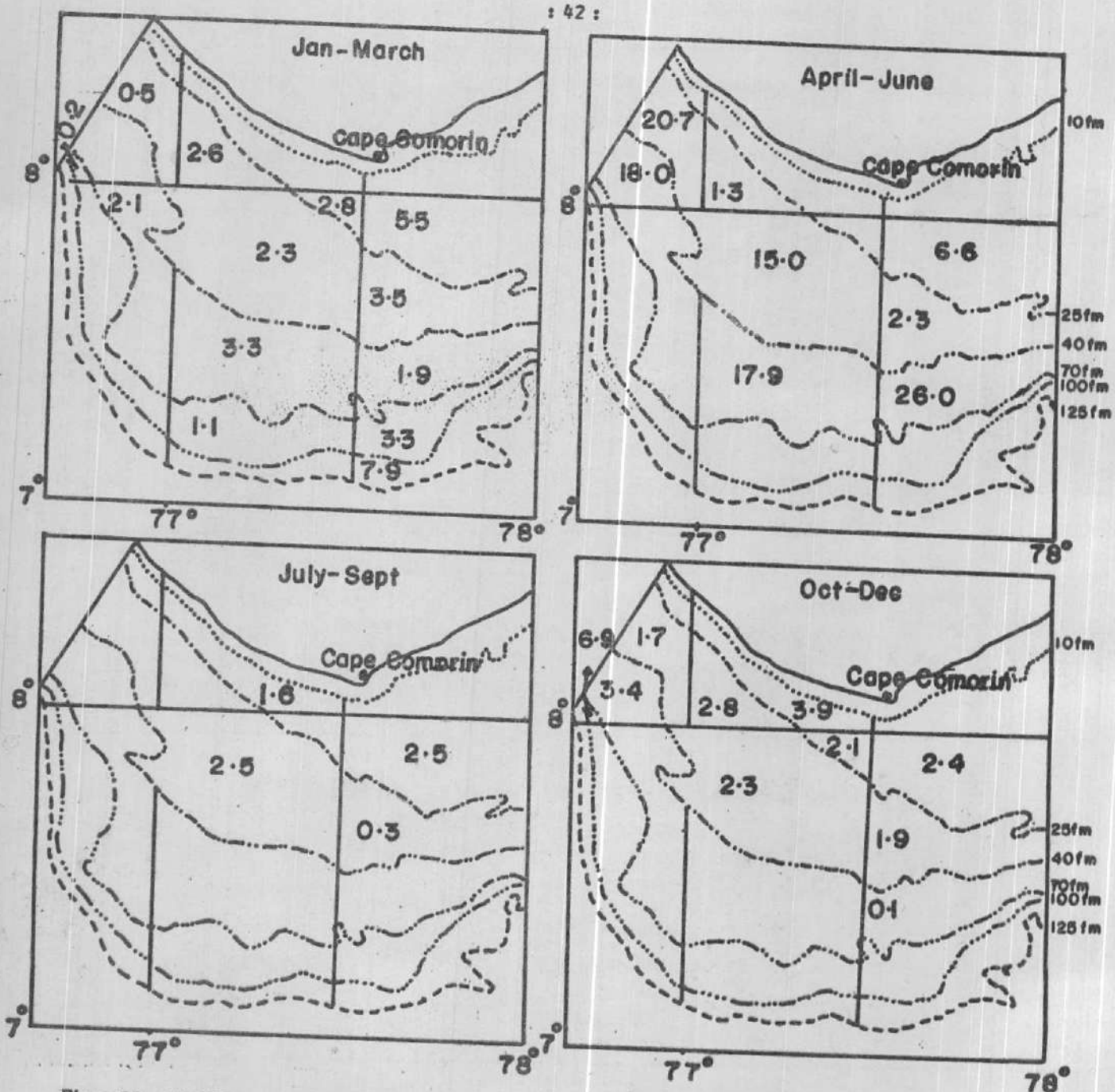


Fig. 23 SEASONAL CHANGES IN YIELD PATTERN OF UPENEOIDS (KG/HR)

7.4.8. Carangids

Maximum catch rate of 89 kg per hour and 30 kg per hour of carangids was obtained during June and August respectively. The distribution pattern indicated higher density in the grounds west of 7°30'N in the second quarter. A shift in the concentration to the shallower strata was noticed in the third quarter and the distribution pattern was highly scattered in the last quarter (Fig.24).

7.5. General observations

Thus, some of the species/group exhibit local migratory trends during different seasons, other groups being residents. Contributed by the resident and the migratory species, the bank appears to support a fishery of considerable magnitude. Similarly, primary production in the Wadge Bank has been reported to show wide seasonal fluctuations, the plankton density of the first quarter of year being minimum (Anon, (1974). But during May - December very high plankton crop has been reported (Rao, 1973). Yet another study on primary productivity has shown high value within 40 m (21 fm) (2.09 g c/m2/day) recording a peak at 90 m (48 fm) depth (4.55 g c/m2/day) during September in Wadge Bank. Moreover a constant replenishment of nutrients between surface and sub-surface level has also been observed in the Bank (Nair et al 1973).

8. STANDING STOCK AND POTENTIAL YIELD

The technique used for estimating the standing stock is the conventional 'swept area method' which is based on the assumption that catch per unit effort is a function of stock density in the area surveyed and changes in the catch per unit effort are directly proportional to the variations in density (Ricker, 1940; Gulland, 1964).

The method further assumes even and random distribution of fish in the area and constant catchability coefficient. The fish density per unit area is calculated from the relationship:

$$B = \frac{c/f}{a.x1}$$

Where c/f is the mean catch per unit effort obtained from a given stratum, 'a' the area swept by the net during one unit of effort and 'x1' the escapement factor or selective action of the gear. In South

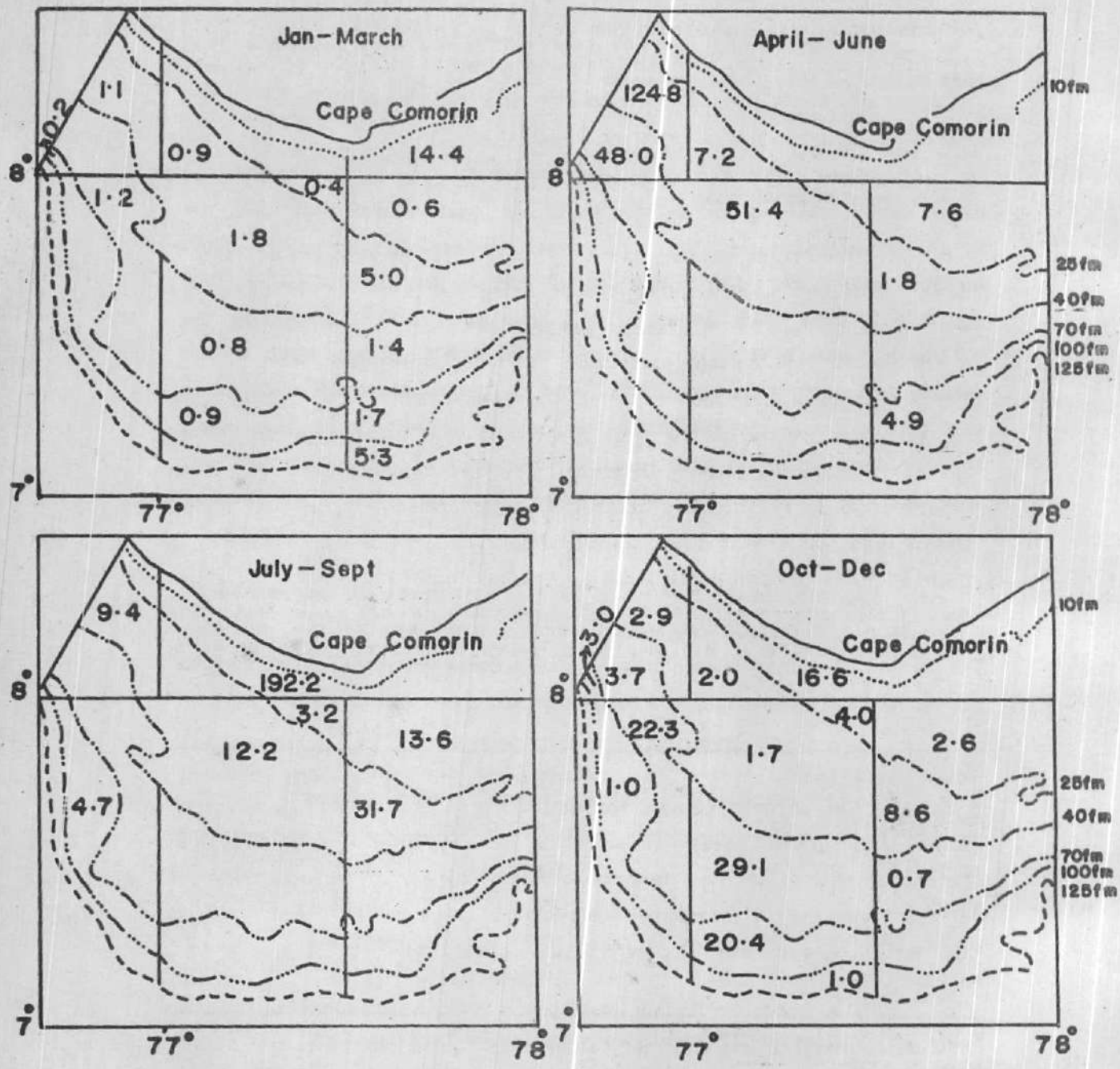


Fig. 24 SEASONAL CHANGES IN YIELD PATTERN OF CARANGIDS (KG/HR)

East Asian waters, a value of x1 = 0.5 is commonly used (Isarankura,1971; Saeger et al, 1976) and there is evidence that this value might in fact be very realistic (Pauly, 1983).

The area swept by the gear during one unit of effort has been computed from the expression:

a = t.v.h. x2

Where 't' is the time spent in trawling, 'v' is the velocity of vessel while trawling, 'h' is the length of trawl's head rope and 'x2' is a fraction expressing the wing spread or working gap of the gear. In South East Asian waters value for 'x2' ranging between 0.4 (SCSP,1978) and 0.66 (Mendis 1965; Shinoda, 1973) have been used. Considering the parameter value adopted by different authors and giving regard to the various test reports Joseph (1980) found it reasonable to have the value as 0.4 to estimate the fish population density of Indian continental shelf and the same value is taken here. The product of the density per unit area and the total area of the stratum gives the estimate of standing stock.

The assessment arrived at here is in respect of the four depth strata upto 183 m (100 fm) which forms a total area of 3540 sq.miles. The extent of area available in each depth zone, the relative fish density per sq.mile and estimate of standing stock are given in Table 13.

Depth strata (fm)	Area (sq.mile)	Density per sq.mile (tonnes)	Standing stock ('000 tonnes)
10-25	800	10.69	8.55
25-40	1080	7.24	7.82
40-70	1040	10.77	11.22
70-100	620	17.36	10.76

Table 13: Strata-wise fish population density and standing stock

The mean density of fish population in the Bank is 11.51 tonnes per sq.mile and total fish biomass in the 3540 sq.mile area works out to 38,330 tonnes. As the target species in any commercial venture to exploit the Bank fishery will be perches, cephalopods, caranx etc. a group-wise account of the standing stock in the different depth strata appears appropriate and furnished in Table 14.

Group	10-25 fm	25-40 fm	40-70 fm	70-100 fm	Total
1. Perches	5148	2836	1259	122	9365
2. Nemipterids	109	823	7054	8397	16383
3. Rays	816	1029	965	637	3447
4. Cephalopods	952	404	219	30	1605
5. Carangids	446	735	467	46	1694
6. Lizard fish	11	720	538	131	1400
7. Upeneoids	218	257	191	55	721
8. Other varieties	566	713	354	1312	2945

Table 14: Strata-wise standing stock estimates of major groups (in tonnes)

It is significant to note that the stock densities of commercially important varieties are mostly confined in the inshore waters upto 73 m depth (40 fm). 85 percent of the perch and cephalopod stock and 70 percent of the caranx stock are from these strata despite the extend area being only 53 percent. Higher density of nemipterids alone support a higher stock value in the deeper strata.

Assessment of maximum sustainable yield in tropical trawl fisheries exploiting a larger number of species simultaneously had always been a complex problem.. In case of Wadge Bank the situation is further complicated by the presence of two distinct populations, the resident and the migrant. Though not being exploited by Indian trawlers many chartered Taiwanese vessels have been found to operate in Wadge Bank and the estimated biomass therefore cannot be treated as virgin. Effort and catch statistics of these foreign vessels are not available to enable application of any refined models of assessment. However, considering 50 percent of the total biomass as the maximum sustainable yield it has been estimated that the Bank can support an annual yield of 19,165 tonnes of which 6,365 tonnes are high quality varieties like perches, carangids and cephalopods.

9. STRATEGY OF WADGE BANK DEMERSAL FISHERY DEVELOPMENT

Having arrived at the standing stock and MSY estimates which form the main criteria in policy decisions and mangement strategies, it was felt that guide lines for development of the Bank fishery are given as part of conclusion of this report. In addition to the availability of prime quality fishes like groupers, snappers, lethrinids, caranx and cuttle fish totally contributing over 50 percent of the landings from the area, the standing stock to the tune of 38 thousand tonnes and annual potential yield of 19 thousand tonnes indicate scope for development of demersal fishery of the region which is presently being exploited at a very low scale.

Considering weather conditions and fishing grounds in India, (Joseph 1982) suggested trawlers of about 20 m overall length and 100 GRT for exploiting the demersal resources. However he added that from the present day availability of infrastructure facilities mainly of deep sea fishing harbours and also location of fishing grounds, vessels of 30 m length and 200 GRT could be recommended. Having regard to the type and size discussed above, total number of such vessels required for development of the fishery on Wadge Bank is computed. It is assumed that in commercial operation without much prejudice, the catch rates would increase by 100% whereas the vessels to be deployed will have 20 days endurance and achieve 275 days out at sea and 250 days actual fishing with 18 hours trawling per day. The catch rate 140 kg/hr recorded during the exploratory fishing coupled with the conditions assumed, a trawler would land about 1260 tonnes of fish per annum. In order to exploit the resources upto the level of maximum sustainable yield 15 trawlers are required for Wadge Bank.

	Area: 10-100 fm
Maximum sustainable yield	19165 t
Catch per hour(Survey)	140 kg
Anticipated catch per hour (commercial)	280 kg
Fishing effort: Days out	275
Fishing days	250
Fishing hours per day	18 hrs
Annual landing (Single vessel)	1260 t
No.of vessels	15

Earlier workers have indicated that the Wadge Bank could support upto 10 trawlers (Hickling, 1951; Blegvad, 1951). John (1951) and Mendis (1965) have recommended deployment of less than 7 vessels on Wadge Bank. It may be mentioned here that earlier surveys and commercial fishing which formed basis of these speculations were limited to areas mainly within 73 m (40 fm) depth. In order to have a critical examination of this, the data collected through present exploratory fishing programme within 73 m (40 fm) depth contour was analysed seperately for arriving at potential yield of demersal fish stock.

Area: 10-40 fm	
Maximum sustainable yield	8185 t
Catch per hour (survey)	130 kg
Anticipated catch per hour (commercial)	260 kg
Fishing effort: Days out	275
Fishing days	250
Fishing hours per day	18
Annual landing (single vessel)	1170 t
No.of vessels	7

The standing stock of 16370 tonnes could give an annual yield of 8185 tonnes which would be harvested by about 7 trawlers of the above mentioned specifications. Each of these vessels will catch upto 1170 tonnes of fish annually at the rate of 260 kg per hour. The yield from the areas coming under 73 m (40 fm) depth is chiefly due to top quality and highly priced snappers, groupers, lethrinids, cuttle fish etc. which could be the main attraction in development of the fishery. The resource, beyond 73 (40 fm) depth may support 8 more vessels. However as revealed during the present study the catches from the depth strata beyond 73 m (40 fm) contour are mainly supported by nemipterids. The number of trawlers exploiting the resources in deeper waters, should be increased in a phased scheme which would give time for examining economic viability and finding/ developing market for low priced fish varieties.

The demersal fish resources of Wadge Bank had been exploited from time to time untill late seventies especially by Srilanka, Taiwan and Thailand. Summing up the views expressed by Mendis (1965), Sivalingam (1966) and others, Shamura (1971) concluded that the demersal resources on the Bank has potential yield of 7800 tonnes. While transmitting general information of resources around peninsular curve based on earstwhile Pelagic Fishery Project's work, George et al, (1977) stated that Wadge Bank ground fish stock is of the order of 73,000 tonnes and as per Cushing's (1971) approximation on tertiary production at the rate 6.5 tonnes per km the potential yield estimated is 87,750 tonnes. All these estimates were based either on indirect studies or limited survey or commercial fishing in certain highly productive pockets in the Bank. Moreover areas beyond 40 fm depth were systematically surveyed for the first time during the current studies. The estimations by earlier authors were arrived at considering the stock as enjoying homogenous distribution in the entire Bank and also by adopting varying assumptions. Mendis' (1965) estimation is arrived at by applying the wing spread of gear while trawling as 66% and without giving allowance to the catchability co-efficient of the gear. When modified with the normal assumptions employed in swept area method and using the values applied in this report the estimate is however close to the present assessment.

Comparing the relative fishery potential of known grounds such as Cochin, Calicut and Bassas, Wadge Bank was found to be as productive as the above grounds but less productive than the Bombay waters. These quantitative assessments when coupled with the quality of resources from the respective grounds the Wadge Bank stock becomes obviously superior. Compared with few of the best trawl grounds in the temperate zone areas, Shivalingam and Medcof (1957) has found that the potential in Wadge Bank is higher than the Eastern Australia, Great Australian Bight and Eastern Adriatic but rated low compared to north west Atlantic. Cushing (1971) observed that the stock densities found on Wadge Bank are probably as good or better than average north sea catches.

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