Bulletin 24

CONTRIBUTIONS ON DEEPSEA FISHERY RESOURCES IN INDIAN EEZ - I

Govt. of India
FISHERY SURVEY OF INDIA
Bombay

September 1992

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Bulletins are issued by Fishery Survey of India with the objective of presenting results of comprehensive studies on marine fisheries resources

Abbreviation: *Bull. Fish. Surv. India*

Published by: D.Sudarsan, Director General, Fishery Survey of India
Botawala Chambers, Sir P.M. Road, Bombay 400 001
Secretarial assistance: Meena A.Chawla and Radha P. Balchandani
Cover design: R. Selvaraj, Drawings: R.V. John

Price: Rs. 26/-

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OBSERVATIONS ON THE DISTRIBUTION AND BIOLOGY OF INDIAN DRIFT FISH, *ARIOMMA INDICA* (DAY) ALONG THE NORTH EAST COAST OF INDIA

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INTRODUCTION

Ariomma indica (Day, 1870), a neritic deep water fish of the family Ariommidae, occurs all along the Indian coast. It is mainly caught by the trawlers engaged in shrimp fishing. Exploratory trawl surveys conducted by the Fishery Survey of India indicated presence of this species along the continental shelf in 50-150m depth range along the east and west coasts with high density between 50-100m depth (Joseph and John, 1986; Joseph, 1986; Sudarsan **et al.**, 1988). Among the different regions the upper east coast showed the highest density (Sudarsan **et al.**,1990).

Very limited studies are available on this species from the Indian coasts. Silas and Prasad (1966), based on the collections of **R.V. Varuna, Kalava** and some medium vessels belonging to the Integrated Fisheries Project, Kochi have given an account of the distribution and some aspects of biology of this species. Luther **et al.** (1988) have given some general information of this species and its fishery based on the landings during 1981-86 at Visakhapatnam. They estimated an average annual landing of 123 tonnes of **A. indica** by the shrimp fishing vessels at Visakhapatnam. Though this species is very common in the offshore waters, landing data on all India basis is not available.

The present paper is a study on the distribution and abundance of **A. indica** along the north-east coast of India where it is found abundantly. Some preliminary observations are made on the biology of the species. The data collected in the survey cruises on board the vessels of the Fishery Survey of India is used for this purpose.

DATA SOURCE AND METHODS

The data collected during the period 1988-90 are used in this study. During this period two survey vessels namely **Matsya Shikari** (39.8m OAL) and **Matsya Darshini** (36.5m OAL) conducted regular trawl surveys along the north-east coast of India. The area under study comprises the Andhra Pradesh, Orissa and West Bengal coasts lying between latitude 16°00'N and 21°00'N, in the depth range 30-300 m. For the purpose of this study the whole area is divided into four depth zones viz., below 50m, 50m to 100m, 100m to 200m and above 200m. The trawl stations were selected randomly. The hauls were of 1.5 hours duration with a trawling speed of 3.5 knots. The vessels operated 34m fish trawl and 44m shrimp trawl with codend mesh of 40 mm and 30 mm respectively. Distribution and abundance in respect of space and time were studied on the basis of catch per unit effort. Besides, observations were made on the length composition, length-weight relationship, maturity etc.

BIOLOGICAL STUDIES

General features of A. indica

The body of **A. indica** is moderately deep and compressed, with short and slender caudal peduncle. Two low fleshy lateral keels are found on each side of the caudal peduncle. The snout is blunt and rounded with large eyes surrounded by thick adipose tissue. Scales are large, cycloid, thin and easily detachable. The colour is silvery with a blueish tinge on the back. The dark pigmentation along the inner lining of the operculum gives the portion of the head of dusky appearance. A few darker and variable blotches are seen on the sides. The species normally occurs in schools over muddy bottom in moderately deep water on the continental shelf within 150 m depth. It is found distributed in the continental shelf and upper slope along the coasts of East Africa, India and Gulf of Suez. In quality, the species is comparable to other table varieties of fishes.

Length-weight relationship

The length-weight relationship is estimated based on 451 observations (173 females and 278 males). Samples stored on board the vessels in frozen condition were used after thawing. Total length from the tip of the snout to the dorsal caudal tip was measured, correct to one mm. The weight of individual fish was taken with an accuracy of 0.5 gm.

The length varied from 115 mm to 210 mm in female and 130 mm to 205 mm in male.

Length-weight relationship is expressed by the formula $W = aL^b$ where W is the weight of the fish, 'L' is the total length and 'a' and 'b' are the intercept and slope respectively. The equations obtained are as follows.

Male	$W = -4.88\ L^{3.0007}$
Female	$W = -4.88\ L^{3.0013}$
Combined	$W = -4.79\ L^{3.00}$

Logarithmic transformation gives a straight line relationship of the form:

$$\text{Log } W = \text{Log } a + b \text{ Log } L$$

The logarithmic values of observed lengths and corresponding weights were plotted (Fig.1) and the straight line fitted well which clearly showed the linear relationship between the two variables.

The corresponding logarithmic equations worked out for both the sexes and combined are given below:

Male	: Log W = 0.6884 + 3.0007 Log L
Female	: Log W = 0.6884 + 3.0013 Log L
Combined	: Log W = 0.6803 + 3.00 Log L

It may be seen from the values that males and females do not differ in the length-weight relationship.

Length frequency distribution and growth

A total of 2812 fishes were measured. The length measurements were pooled into monthly samples and grouped into length classes of 5mm interval. The percentage frequency of each length group was calculated to study the occurrence of dominant length group in the population. The modes in each length frequency sample were identified by separating the sample into the component distributions following the Bhattacharya (1967) method by using the length based Fish Stock Assessment (LFSA) program (Sparre, 1987). It may be seen that in most of the months,

a single mode is observed between 140 and 160 mm (Fig. 2) while in April two distinctly separated modes are seen; the first component being in the length range of 70-109 mm (model class at 85-89 mm) and a second component in the length range of 120-200mm (model class at 165-169mm). The length range of samples of each month and the mean value of component distributions therein are plotted against time in Fig. 2 and given separately for males and females in Fig. 3. The progression of modes could be traced for some of the months. It was observed that there is a mode at 156 mm in January which could be traced to 161 mm in February and further traced to 169 mm in April. Thus a growth of 13 mm is obtained in 3 months from January to April at a rate of 4.7 mm per month. There is another mode at 85 mm in April which can be traced to 118 mm in June and further traced to 151 mm in December indicating a monthly growth rate of 15.5 mm between 85-118 mm and 5.5 mm between 118-151mm. However, the growth parameters can be arrived at after making further studies over a period of few years.

Sex ratio

The frequency of occurrence of females and males in each month was calculated which indicated that in most of the months females outnumbered the males (Table 1). But during the months of December and July, the males dominated with the percentage occurrence of 86.2% and 69.9% respectively. It was observed that among the larger size groups females were more dominant than males. The pooled data for the entire period showed a male-female ratio of 48.6 : 51.4.

Maturity stages

To study the gonad activity, the general appearance of ovary, its relative length to the abdominal cavity and development of ova have been taken into consideration. The maturity stages are determined following the maturity key prepared by the International Council of Exploration of Seas (ICES). Sexes could not be differentiated in specimen below 110mm. Luther **et al.** (1988) have observed the size at first maturity as 160 mm. Smaller specimen with stage I was not observed during the period of study.

The month-wise percentage of different stages of maturity is given in Table 2. Stage II was predominant during the month of June and stage III in July. Specimens with ovaries in stage VI and VII were observed towards the later part of the year. Thus there is a gradual shifting of the stages.

Table 1. Monthwise sex ratio and mean length

Month	Sample size	Sex ratio (%)		Mean length (cm)	
		Male	Female	Male	Female
February'90	60	50.0	50.0	16.9	17.9
March	132	42.5	57.6	14.9	15.6
April	56	42.9	57.1	15.9	16.8
May	100	30.0	70.0	16.4	17.2
June	56	44.6	55.4	12.0	11.9
July	73	69.9	30.1	16.8	17.4
August	179	40.8	59.2	16.0	16.8
September	54	27.8	72.2	16.7	17.7
October	-	-	-	-	-
November	65	44.6	55.4	16.7	16.9
December	116	86.2	13.8	15.3	18.6

Table 2. Monthwise distribution of maturity stages

Month	% of maturity stages					
	II	III	IV	V	VI	VII/Spent
February'90	-	10.7	60.7	28.6	-	-
March	1.6	44.4	43.9	10.1	-	-
April	-	7.3	45.5	45.4	1.8	-
May	2.0	40.8	40.8	12.2	-	4.1
June	57.1	42.9	-	-	-	-
July	-	58.0	42.0	-	-	-
August	0.9	43.9	15.9	6.5	11.2	21.5
September	-	11.3	45.3	43.4	-	-
October	-	-	-	-	-	-
November	-	-	25.0	34.4	29.7	10.9
December	32.4	31.5	24.1	2.8	0.9	8.3
January'91	-	17.1	62.9	20.0	-	-

Fecundity

Total length and weight of the individual fish were measured and the gonads were then dissected out for fecundity studies. The ovaries of 12 fish ranging from size 160 to 184 mm were examined and weighed after removing the moisture. The weight of the ovary ranged from 2.7 to 4.5 gm. As the ova from the anterior, middle and posterior portions did not show marked difference in diameter, a piece of ovary from one of the lobes was separated and weighed. The entire ova in this sub-sample were counted and raised to the whole ovary. The number of ova in each ovary varied from 47,800 to 86,500 and the mean number was 66,680.

DISTRIBUTION

Distribution by area and depth

The latitude 20°N (off Paradip) registered the highest catch rate of 13.9 kg/hr followed by latitude 16°N (off Narasapur) with 10.1 kg/hr. The lowest catch rate of 3.5 kg/hr was recorded from latitude 17°N (off Visakhapatnam). The average catch rates recorded from the different latitudes and depth zones during the years 1988 to 1990 are given in Table 3.

Table 3. Latitude-wise and depth-wise catch rate (kg/hr) of A.indica obtained in bottom trawl survey by Matsya Shikari and Matsya Darshini during 1988 to 1990

Lat.	Depth zone (m)		
	30-50	50-100	100-200
16°N	24.6	12.3	2.1
17°N	3.0	4.3	3.1
18°N	4.4	22.6	-
19°N	0.4	13.0	0.5
20°N	1.0	51.3	-

A. indica was seen to occur only upto 140m depth. While comparing the results obtained from different depth zones, it is seen that 50-100m depth zone yielded better catch rates in all latitudes except latitude 16°N where 30-50m depth zone registered a higher catch rate. The average catch rates recorded from the three bathymetric zones 30-50m, 50-100m and 100-200m for the whole area are 4.8 kg/hr., 14.2 kg/hr and 1.3 kg/hr respectively. The highest catch rate of 51.3 kg/hr was recorded

in 50-100m depth zone of latitude 20°N. The areas in 50-60m depth showed the highest catch rates beyond which a declining trend was noticed as the depth increases. About 1300 kg. was caught in a haul of 1.5 hrs. duration off Narasapur.

A. indica constituted 7.4% of the total catch from the 50-100m depth zone of the survey area during the period 1988-'90 whereas the 30-50m and 100-200m depth zones yielded 3.2% and 2.9% respectively.

Seasonal distribution

Catch of **A. indica** was recorded in almost all the months and the catch rate varied with the seasons (Fig. 4). The highest catch rate was recorded during the month of February (16.4 kg/hr) followed by March (14.6 kg/hr). During the period of July - November the catch rates were either negligible or very low.

DENSITY, BIOMASS AND POTENTIAL YIELD

Density, biomass and potential yield were estimated based on the catch per unit effort. The swept area method is adopted for estimating the density. The catchability coefficient was taken as 0.5 in the case of 44 m shrimp trawl and 0.4 in the case of 34 m fish trawl considering the mesh sizes of the gear (Sivaprakasam 1986, John and Sudarsan 1988). The density and biomass of the stock in different latitudes and depth strata are shown in the table 4. Higher density is observed from the 50-100m depth zone. The latitude 20°N (off Paradip) showed the maximum density of 1457 kg/sq.km. The total biomass of **A. indica** for the entire area is worked out to 14,865 tonnes.

Table 4. Latitude-wise and depth-wise density and biomass of A. indica along the north-east coast

Latitude	Depth zone (m)					
	30-50		50-100		100-200	
	Density (kg/sq.km)	Biomass (t)	Density (kg/sq.km)	Biomass (t)	Density (kg/sq.km)	Biomass (t)
16°N	431.6	224.4	215.8	148.9	36.8	37.9
17°N	52.6	80.7	75.4	331.8	54.4	68.3
18°N	125.0	101.3	642.2	2003.0	-	-
19°N	11.4	21.8	369.3	729.4	14.2	23.9
20°N	28.4	119.8	1457.4	10974.2	-	-

As stated elsewhere **A. indica** is caught by the trawlers engaged in shrimp fishing and major portion of the catch is thrown out. Luther **et al.** (op.cit) reported that 123 tonnes of **A. indica** is annually landed at Visakhapatnam by the shrimp trawlers. They have estimated that this species forms about 2% of the trawl catches. The catch landed by these trawlers may represent only small portion of the actual yield as the fish is being thrown out particularly during the early part of the voyages The shrimp trawlers generally operate upto 70-80m depth. Hence, it can be said that this stock is being exploited now. In the present study **A. indica** formed 5.4% of the total catch for the whole area. Considering the concentration in the 50-100m depth zone and in the northern areas 3% of the total annual landing of the demersal varieties from the Andhra, Orissa and West Bengal coast is presumed as the contribution of **A. indica.** MSY is calculated on considering the yield thus derived and using the equation MSY = 0.5 (Y + MB) where Y is the current yield, M the natural mortality rate and B the biomass (Cadima, 1977). Natural mortality rate is taken as one (Sudarsan **et al.** 1990). Thus the MSY of **A. indica** is estimated as 10,118 tonnes from the area under study.

ACKNOWLEDGEMENT

The authors are thankful to the Director General, FSI, Bombay for his constant encouragement and interest in the present study. Thanks are due to Shri T.E.Sivaprakasam, Dr.V.S. Somvanshi, Shri M.E.John and Antony Joseph, FSI, Bombay for their guidance and offering valuable suggestions. We are also thankful to the scientific staff of the Visakhapatnam Zonal Base for their assistance in collecting the samples.

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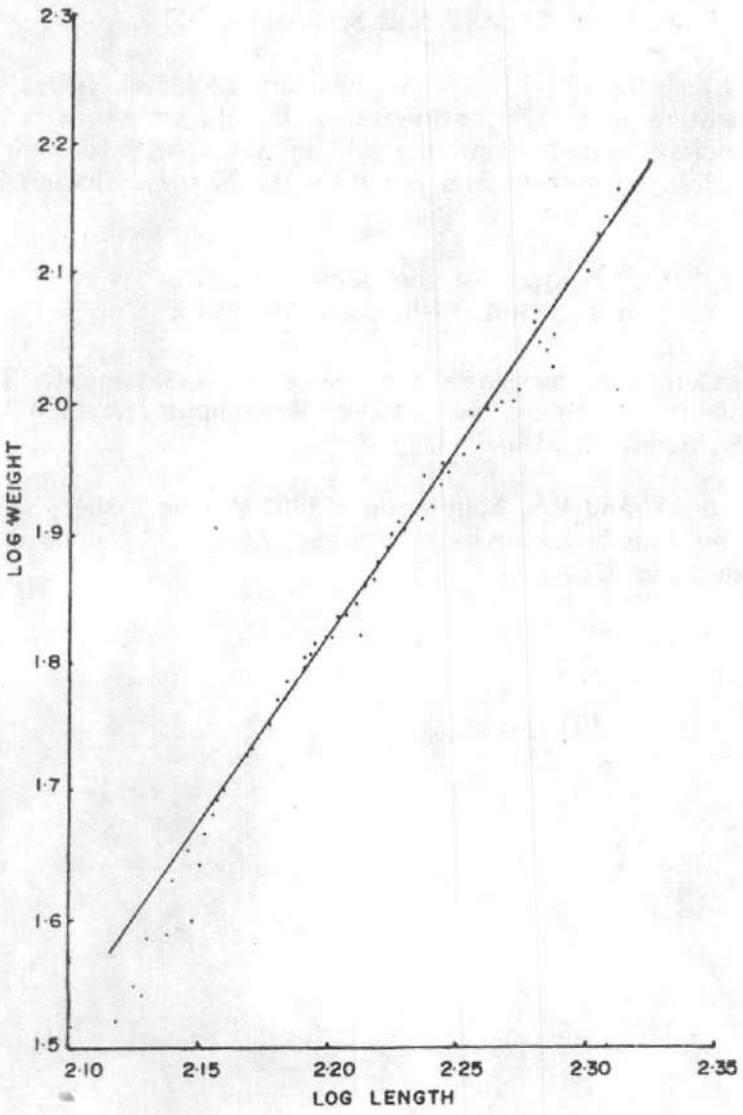

Fig.1 Length-weight relationship of A. indica

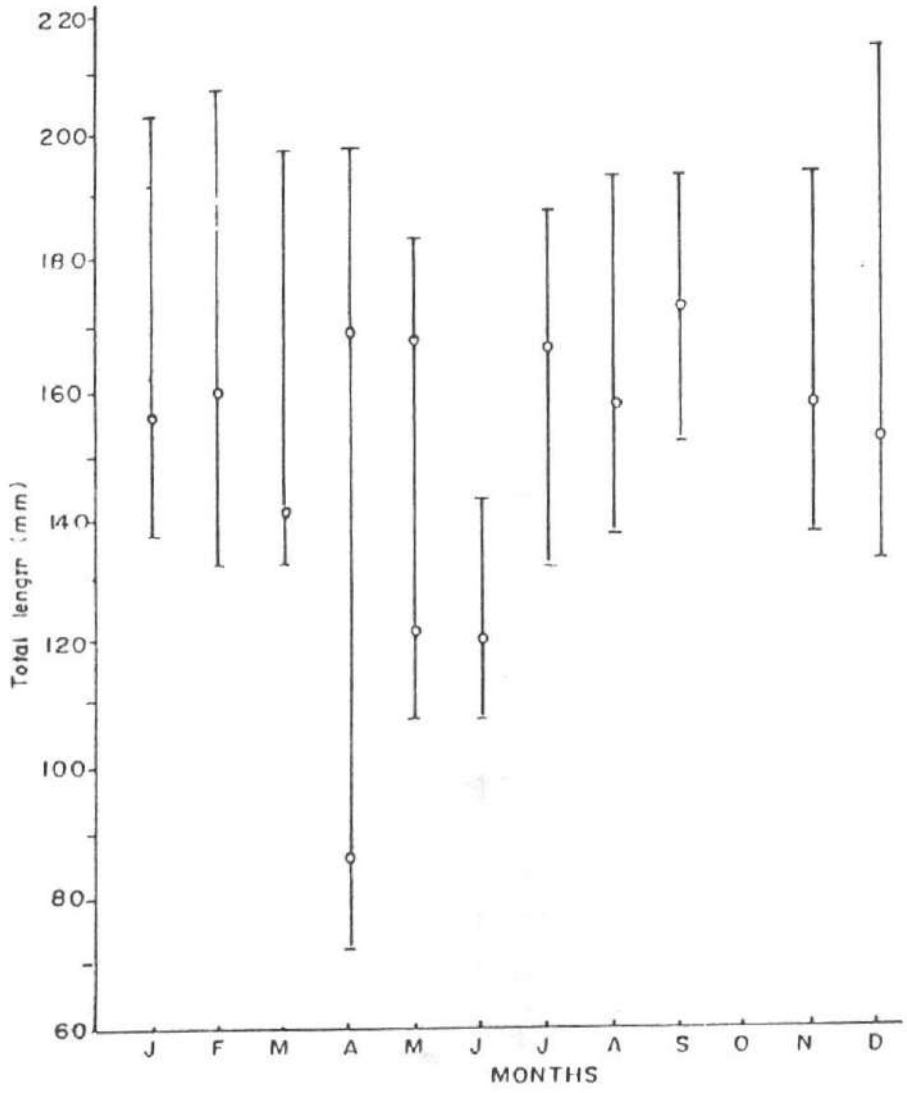

Fig.2 Monthwise length range and modes observed

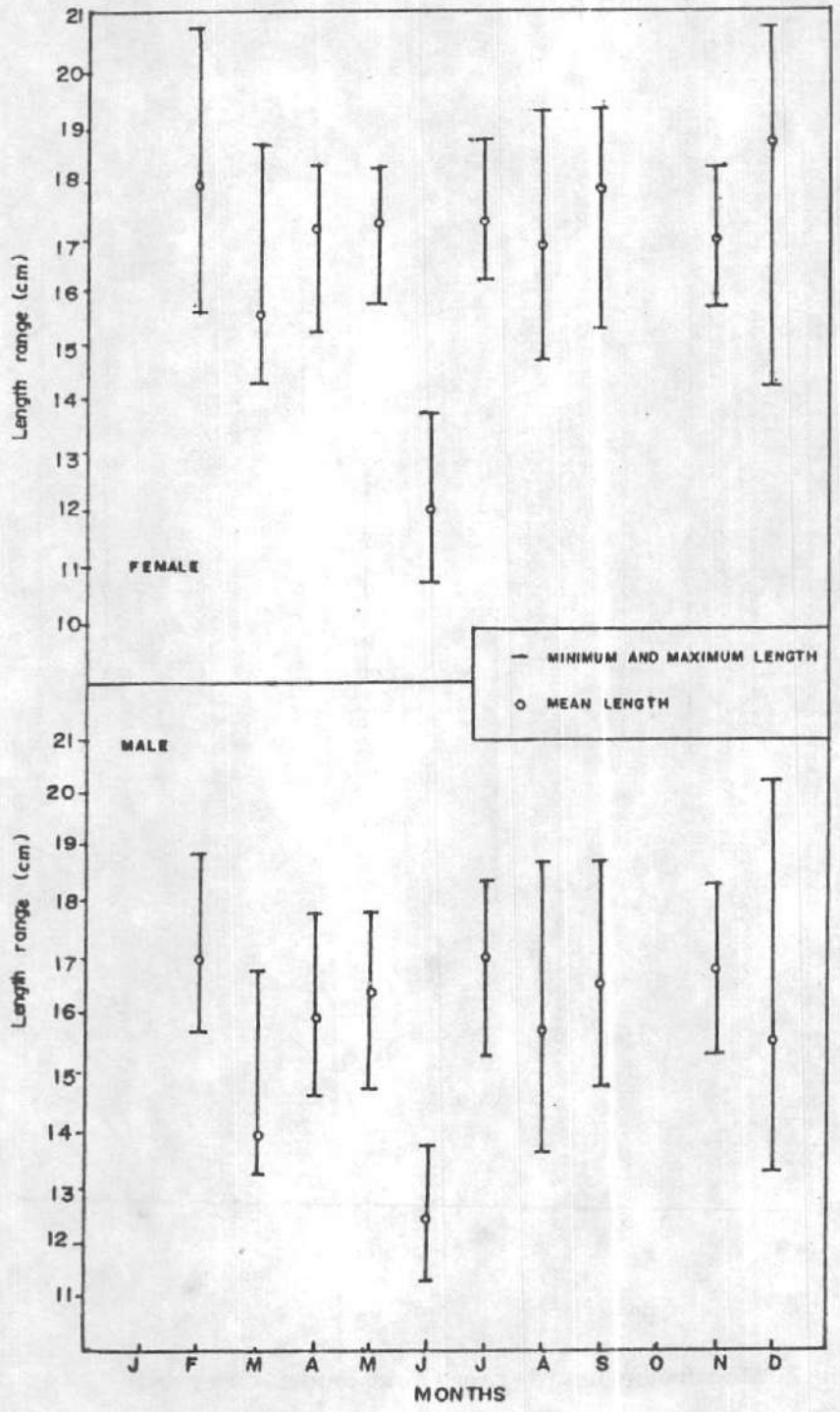

Fig.3 Sexwise length range and mean length

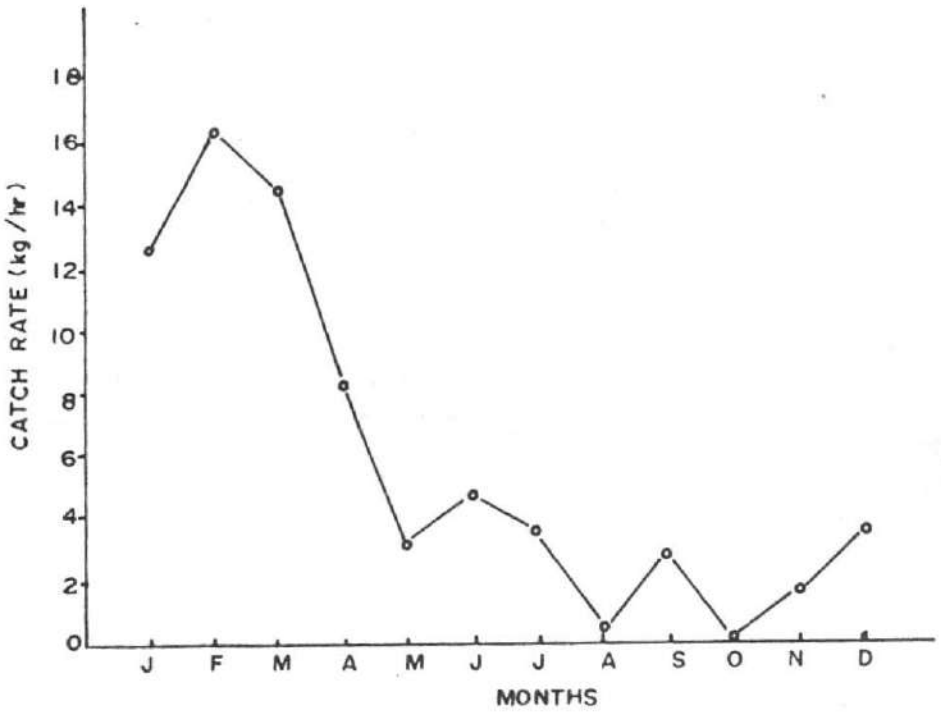

Fig.4 Monthwise catch rate of A. indica obtained in surveys by Matsya Shikari and Matsya Darshini along north-east coast

OBSERVATIONS ON DEMERSAL RESOURCES SURVEY BETWEEN LAT. 7°N AND 11°N ALONG SOUTH-WEST COAST, WADGE BANK AND GULF OF MANNAR DURING 1988-90

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INTRODUCTION

Demersal fishery resources of south-west coast (Lat. 8°N-11°N), Wadge Bank and Gulf of Mannar have been assessed based on a number of surveys by survey vessels of Fishery Survey of India since 1979 (Sudarsan **et al.**, 1988, 1990). The resources structure of Wadge Bank (Lat. 07°00'N to 08°20'N and Long. 76°30'E to 78°00'E) had been described by Joseph **et al.** (1987). Sivaprakasam (1986) presented a study of the demersal resources of the Wadge Bank and Gulf of Mannar. Demersal resources survey between Lat. 7°N and 11°N along south-west coast, Wadge Bank and Gulf of Mannar was continued with accent on coverage of unsurveyed and inadequately surveyed grounds during the period 1988-90. The aim of the present work is to pin-point changes in abundance and sizes of the common resources of the area based on the trawl survey conducted by **M.V. Matsya Nireekshani** during April, 1988 to March, 1990.

VESSEL AND GEAR

Matsya Nireekshani the combination trawler was deployed for survey. The major specifications of the vessel are given below.

Length overall (m)	40.55
Breadth (m)	8.00
Mean draft (m)	4.00
Gross registered tonnage	329.26
Net registered tonnage	128.72
Main Engine	B&W Alpha - 2030 B.H.P. at 800 rpm
Fuel storage	180 cu.m
Fresh water storage	34 cu.m
Frozen storage hold (-25°C)	75 cu.m
Trawl winch	Electrical motor driven - 350 HP pull 8 tons at 75 m/min.
Net winch	Electrical motor driven - 60 HP pull 3 tons at 75 m/min.

Speed	13 knots
Endurance	22 days
Crew	20

The vessel is fitted with several modern fish detecting equipments. The navigational aids include satellite navigator and gyrocompass.

Two types of fishing gear were used by the vessel for sampling the resources.

a) 34m fish trawl (Fig.1) was put to use for sampling in the depth strata 30-200m.

b) 45m shrimp trawl (Fig.2) was used for sampling the resources of depth range 100-500m.

The 34m fish trawl was made of high density polythylene twines. Its 400 mm fore-part meshes decreased through 200 mm, 100 mm and 80 mm to 30 mm nylon mesh at the cod end. The 45m shrimp trawl was made of polyethylene twines and the mesh size ranged from 100 mm in the fore-part to 30 mm at cod end. Floatation consisted of 11 inch floats for both the trawls. Polyvalent otter doors weighing 1350 kg each were used for both the trawls.

METHODOLOGY

Stratified random sampling aimed at reducing variance and achieving higher precision of estimates was followed in the survey. Duration of haul was 90 minutes.

SURVEY AREA

The stratum area (Fig.3) of demersal trawl survey by latitudes and depth contours is given below.

(area in sq.km)

Lat. (°N)	Depth range (m)			
	30-50	50-100	100-200	200-500
10 °(West coast)	1730	2555	715	415
9° (West coast)	1685	2350	850	2135
8° (Gulf of Mannar)	500	600	1540	825
7° (Wadge Bank)	2430	3930	4090	2510
8° (West coast)	1700	3870	870	2650

SURVEY CRUISES AND SAMPLING DETAILS

Altogether 22 cruises of average 20 days duration were made during the period April, 1988 to March, 1990. The vessel fished at depths between 30 and 500 m of the aforesaid areas, expending 3079.76 hours of actual sampling effort. Adequate coverage was achieved in all seasons.

CATCH PER UNIT EFFORT OF DEMERSAL RESOURCES IN DIFFERENT DEPTHS

The catch per unit effort of various species of fish in different depths of south-west coast, Wadge Bank and Gulf of Mannar is given in Table I. The percentage composition is depicted in Table 2. The catch rates obtained by 34m fish trawl and 45m shrimp trawl are shown separately. The catch rate for all fish was 150.50 kg/hr within 50m depth. Perches (34.50 kg/hr), Balistids (30.83 kg/hr) and Nemipterids (30.53 kg/hr) were the dominant species in this depth belt. A combined catch rate of 218.68 kg/hr was obtained in depth range 50-100m. Nemipterids (75.70 kg/hr), Cat fish (21.29 kg/hr), Lizard fish (19.14 kg/hr), Perches (19.04 kg/hr), Decapterids (17.81 kg/hr) and Balistids (16.24 kg/hr) were the major components of the catch. The highest catch rate for all fish in 100-200m by fish trawl was 299.65 kg/hr. Nemipterids (97.62 kg/hr), Barracuda (74.65 kg/hr), Crab (66.78 kg/hr) and Lizard fish (18.58 kg/hr) were the major groups in this depth belt. The total catch/hour of all fish was 434.42 kg/hr in depth 100-200m by shrimp trawl. Nemipterids (180.37 kg/hr) and Crab (178.70 kg/hr) were the principal components of catch. Average catch/hour of 12.98 kg of deep sea prawns and 8.72 kg of deep sea lobster was obtained in depths 200-500m by shrimp trawl.

The catch rates of all fish recorded in different depth belts of the three major regions are shown in Fig.4.

Fig. 5-9 show the depth-wise dominance of major resources obtained in the three major regions.

AREA-WISE PERCENTAGE COMPOSITION AND CATCH PER UNIT EFFORT OF DEMERSAL RESOURCES

Percentage composition and catch per unit effort of demersal resources - area-wise - are presented in Tables 3 and 4. Nemipterids dominated the finfish resources in Lat. 10°, 9°, 8° and 7°N of south-west coast and Wadge Bank forming 45.84%, 39.06%, 27.08% and 31.47% respectively.

The catch rates were of the order 44.74 kg/hr, 109.01 kg/hr, 50.15 kg/hr and 105.54 kg/hr. The catch composition in Gulf of Mannar (Lat. 8°N) is characterised by Crabs (26.79%), Balistids (19.12%) and Perches (15.67%) with a catch rate of 32.94 kg/hr, 23.50 kg/hr and 19.27 kg/hr respectively. Lizard fish (9.75%: 9.52 kg/hr) and Cuttle fish (6.54%: 6.38 kg/hr) were the other prominent resources in Lat. 10°N. Cat fish with a catch rate of 24.57 kg/hr formed 8.80% of catches in Lat. 9°N. Crabs (23.35%)formed a major component of deep sea crustacean resources in Lat. 9°N. Contribution of deep sea prawns (1.04%: 2.91 kg/hr) and deep sea lobster (0.84%: 2.36 kg/hr) was also noteworthy in this area. The demersal varieties in Lat. 8°N are perches (10.37%: 19.21 kg/hr), Decapterids (7.94%: 14.70 kg/hr), Lizard fish (7.51%:13.90 kg/hr) and Cuttle fish (3.38%: 6.26 kg/hr). The relatively wider expanse of Wadge Bank (Lat. 7°N) provided a variety of demersal species. Besides Nemipterids, Perches (11.98%: 40.21 kg/hr), Balistids (13.04%: 43.74 kg/hr), Lizard fish (5.53%: 18.56 kg/hr), Barracuda (3.30%: 11.08 kg/hr) and Cuttle fish (1.15%: 3.88 kg/hr) were the dominant varieties of the area. Deep sea prawns (0.38%: 1.30 kg/hr) and Deep sea lobster (0.08%: 0.27 kg/hr) were the commercially important crustaceans obtained in this area. In the Gulf of Mannar commercially important resources were Perches (15.67%: 19.27 kg/hr) and Barracuda (4.29%: 5.28 kg/hr).

SEASONAL VARIATIONS

Month-wise analysis of data of demersal species from waters of south-west coast (Lat. 8°, 9° & 10°N), Wadge Bank (7°N) and Gulf of Mannar (8°N) was done to know the seasonal variation in their abundance. The relative density as observed by catch/hour in various geographic and bathymetric divisions are discussed. The seasonal variation in abundance of ground fish as observed for the four different quarters of the year are presented in Fig. 10.

SOUTH-WEST COAST (LAT. 8°, 9° & 10°N)

Nemipterids

The post-monsoon quarters of October-December and January-March yielded the highest catch rates for the species. 100-200m depth strata of Lat. 9° produced the best annual catch rate of 261.4 kg/hr with a peak production of 1022.2 kg/hr during the month of November. Distribution of the species in shallower depths of the area was observed during the months of July and August. **Nemipterus japonicus** was the principal species that supported the fishery. **Nemipterus bleekeri, Parascolopsis aspinosa** and **Parascolopsis criomma** are the other species which contributed to the fishery to a lesser extent.

Perches

Fourth quarter yielded high catch rate for perches. Depth strata below 50m of Lat. 8°N provided an annual catch rate of 73.33 kg/hr for the species. Relatively good yield was recorded in depths 50-100m of Lat.8° during IInd and IIIrd quarters of the year. Contribution of perch in water of higher latitudes was observed to be less. Lethrinidae, Lutjanidae and Pomadasyidae were the principal contributors of perch fishery.

Decapterids

Fourth quarter yielded best catch rate for Decapterids. A catch rate of 40.65 kg/hr was recorded below 50m depth of Lat. 10°N. Third quarter also pvovided good catch rate for the species. A general decline in the catch rate was observed in the Ist quarter of the year. **Decapterus russelli** and **D. macrosoma** were the dominant species.

Elasmobranchs

Although not much seasonal variations in catch rate were discernible in respect of elasmobranchs, the Ist quarter provided high catch rate. Concentration of elasmobranchs were observed in shallower waters upto 100m depth. Rays and coastal sharks contributed to the fishery.

Cuttle fish

Third and fourth quarters (July to December) yielded best catch rates for cuttle fish. Depth range 50-100m of Lat. 10°N provided the best catch rate for cuttle fish with a peak of 136.05 kg/hr during the month of August. **Sepia pharaonis** was the principal species.

Squids

Fourth quarter registered high catch rate for squids. Best concentration of the resource was observed below 50m depth of Lat. 8°N. Relatively good concentration was recorded during October in depth zone 50-100m. **Loligo duvaucelii** and **Doryteuthis sibogae** supported the fishery.

Lizard fish

July-September yielded high catch rate. Best concentration of the resource was observed in 50-100m depth of Lat. 10° and 8°N during

August. Catch rates were higher during Ist quarter in depth zone 100-200m of Lat. 8°N. **Saurida tumbil** was the principal species that supported the fishery.

Deepsea prawns and lobster

The 200-500m depth strata have prawns and lobster in some commercial quantities. The season October - December yielded high catch rates for prawns with a catch of 23 kg/hr. The highest catch rate of 52.38 kg/hr was recorded during December in Lat. 9°N. Catch rate of deepsea prawns during the Ist quarter was also encouraging. **Heterocarpus woodmasoni, H. gibbosus, Parapandalus spinipes, Penaeopsis rectacuta** and **Solenocera hextii** were the major contributors of deepsea prawn fishery.

Lobster recorded high catch rate during July-September. The yield during Ist quarter was also encouraging. A high catch rate of 23.8 kg/hr was obtained during March in depth zone 200-350m of Lat.9°N. Lobster fishery is constituted exclusively by **Puerulus sewelli.**

Crabs

Crabs dominated crustacean catches by shrimp trawl in depth zone 100-200m. High catch rate of 638.3 kg/hr was recorded during 4th quarter. A catch rate as high as 1822.2 kg/hr was obtained in Lat. 9°N during November. **Charybdis cruciata** was the dominant species of crab catches.

WADGE BANK (LAT. 7°N)

Perches

High catch rate (130.4 kg/hr) was obtained during July to September within 50m depth. Appreciable concentration of perch was observed during 4th quarter also at depth upto 100m. A significant catch rate of 182.5 kg/hr was recorded during November in 45m depth.

Nemipterids

Dense concentration of the resource was observed during Ist quarter in 100-200m depth belt (1173 kg/hr). A shift in concentration of the resource to 50-100m depth was observed during July-September. A catch rate as high as 1666.6 kg/hr was recorded during March by shrimp trawl.

Barracuda

Barracuda registered high concentration during October to December in depth 30-50m. Persisting catch rate was obtained during 3rd quarter also. A high catch rate (123.3 kg/hr) during September was noteworthy. **Sphyraena obtusata** and **S. picuda** largely contributed to the fishery.

Cuttle fish

3rd and 4th quarters provided commercial concentration of cuttle fish. Depths 30-100m yielded better catch rate. A significant catch rate (21.22 kg/hr) was recorded in below 50m depth during October.

Squids

July and September yielded high catch rate for squids. Distribution of the resource was observed within 60m depth.

Elasmobranchs

Low quantities of elasmobranchs were recorded in almost all seasons with marginal increase during 4th quarter.

Lizard fish

October to December provided high catch rate for lizard fish. Appreciable concentration (233.3 kg/hr) was observed in 100-200m depth during December.

Decapterids

Third quarter registered high catch rate (21.5 kg/hr) in 50-100m depth. Availability of the species among ground fish resource was negligible during Ist and 2nd quarters.

Carangids

Best catch rate (19.9 kg/hr) was obtained during July to September within 50m depth. High concentration of resource (46.25 kg/hr) was recorded during September.

Upeneoids

3rd quarter provided high catch rate for the species with concentration in depth 50-100m. High catch rate (75 kg/hr) was recorded during September in 60m depth.

Odonus niger

Ist and 4th quarters were observed to be most productive seasons for the species. A catch rate (404.1 kg/hr) was recorded in below 50m depth during January.

Deepsea prawns and lobsters

October to December registered high catch rate (24.8 kg/hr) for deepsea prawns and deepsea lobster (9.0 kg/hr). A catch rate of 37.5 kg/hr was recorded for deepsea prawns in depth 200-500m during November. Lobster recorded a high catch rate (13.4 kg/hr) during October in 350m depth.

GULF OF MANNAR (LAT. 8°N)

Perches

July to September registered high catch rate for perches. Depth 50-100m yielded high catch rate (141.0 kg/hr) during the quarter. A catch rate of 239.1 kg/hr was recorded during July.

Elasmobranchs

April to June was the productive season for elasmobranchs. Concentration of the resource was more in shallower depths. High catch rate (90.7 kg/hr) was registered during May.

Barracuda

Second quarter provided high catch rate (346.3 kg/hr) in depth 100-200m. Relatively lesser concentration of resource was noticed during 3rd and 4th quarters as well.

Cuttle fish and squids

Squids during 3rd quarter and Cuttle fish during 4th quarter yielded high catch rates in 40-60m depths. Cuttle fish registered a high catch rate of 45.92 kg/hr during November.

Odonus niger

High concentration of this species (210.0 kg/hr) was obtained during October-December in depths 30-50m. Catch rate (300 kg/hr) was high during November.

Crabs

Ist quarter registered high catch rate (498.4 kg/hr) in depths 100-200m. Shrimp trawl yielded a high catch rate (1031.2 kg/hr) during March.

Deepsea prawns and lobsters

Deepsea prawns registered a high catch rate (19 kg/hr) during 4th quarter. Significantly high catch rate (46 kg/hr) was recorded during December. Second quarter provided high catch rate (33.6 kg/hr) for lobster.

OTHER OBSERVATIONS

Sampling of demersal resources of depth zone 100-200m of south-west coast (Lat. 8°, 9° & 10°N) by shrimp trawl have revealed that catches of finfish and non-commercial crustaceans viz. crabs account for more than 88% of the catch. Crab constituted 47.6% of total catch in this depth zone. Nemipterids (34.4%) and crocodile fish (5.7%) were the dominant finfish resources of this area. The crab population offers scope for harvesting on large scale and a pragmatic approach at this stage would be to look into various possible economic uses offered by this resource. Some possibilities would be to use the crabs as food for fish in fish farms. It is hoped that eventually, through the application of appropriate technology a diverse range of fishery products can be made available from crabs.

BIOMASS AND MAXIMUM SUSTAINABLE YIELD

As stated elsewhere 34m fish trawl and 45m shrimp trawl were operated during survey. The survey area was stratified into 4 depth zones viz; less than 50m depth, 50-100m, 100-200m and 200-500m. The 'swept area method' which is based on the assumption that catch per unit effort is an index of density was adopted for estimating the standing stock. The catch/hour data were converted to catch/square km. by dividing the former by the area swept by the trawl in one hour. The swept area was estimated following the expression $a = t.v.h.x_2$ where 't' is the time spent, 'v' is the speed of the vessel, 'h' is the head rope length and 'x_2' is the fraction of the head rope which is equal to the width of the path swept by the trawl.

As accepted in earlier studies, the 'x 2' value was taken as 0.4. The average trawling speed of the vessel was 3.5 knots. Indices of stock density (mean catch per sq.km) were worked out separately for different latitude/depth strata and estimated standing stock are given in table below.

Area	Depth strata (m)	Area (km^2)	Density (tonnes/km^2)	Standing stock ('000 tonnes)
Lat. 10° (West coast)	30-50	1730	2.84	4.91
	50-100	2555	1.98	5.05
	100-200	715	2.03	1.45
	200-500	415	0.90	0.37
Lat. 9° (West coast)	30-50	1685	2.31	3.89
	50-100	2350	6.32	14.85
	100-200	850	12.02	10.21
	200-500	2135	3.55	7.57
Lat. 8° (West coast)	30-50	1700	3.04	5.16
	50-100	3870	4.68	18.11
	100-200	870	3.54	3.07
	200-500	2650	3.20	8.48
Lat. 7° (Wadge Bank)	30-50	2430	4.77	11.59
	50-100	3930	5.04	19.80
	100-200	4090	8.03	32.84
	200-500	2510	9.97	24.97
Lat. 8° (Gulf of Mannar)	30-50	500	3.41	1.78
	50-100	600	2.94	1.76
	100-200	1540	5.67	8.73
	200-500	825	4.98	4.10

Shrimp trawl catch data was used for estimating the resources of 100-500m depth taking into account of its tendancy to take more species including crustaceans.

The biomass estimated for the three regions viz; South-west coast (Lat. 10°, 9° and 8°N), Wadge Bank (Lat. 7°N) and Gulf of Mannar (Lat.8°N) for four different depth strata are given below.

	Depth strata (m)	Area (km^2)	Density (tonnes/ sq.km)	Standing stock ('000 tonnes)
Region I				
	30-50	5115	2.46	12.58
South-West	50-100	8775	4.60	40.36
Coast	100-200	2435	6.00	14.61
(Lat. 10°, 9°	200-500	5200	3.01	15.65
& 8°N)				
Sub total		21525		83.20
Region II				
	30-50	2430	4.77	11.59
Wadge Bank	50-10	3930	5.04	19.80
(Lat. 7°N)	100-200	4090	8.03	32.84
	200-500	2510	9.95	24.97
Sub total		12960		89.20
Region III	30-50	500	3.41	1.70
Gulf of Mannar	50-100	600	2.94	1.76
(Lat. 8°N)	100-200	1540	5.67	8.73
	200-500	825	4.98	4.10
Sub total		3465		16.29

The total ground fish biomass of South-west coast (region I) works out to 83,200 tonnes. In the Wadge Bank (region II) the biomass was estimated as 89,200 tonnes and in Gulf of Mannar area (region III), it was estimated as 16,290 tonnes. Considering 50 percent of the total biomass as maximum sustainable yield, it has been estimated that the MSY figures for the three regions viz; South-west coast (10°, 9° and 8°N), Wadge Bank (7°N) and Gulf of Mannar (Lat. 8°N) to be in the order of 41,600 tonnes, 44,600 tonnes and 8,145 tonnes respectively.

ACKNOWLEDGEMENT

The authors are thankful to the Director General, Fishery Survey of India, Bombay for his constant encouragement and interest in the present study and for critically going through the manuscript and offering valuable suggestions. Sincere thanks are due to project Co-ordinator, project

leader and project associates who participated in the cruises and collected the valuable data for preparing this paper. The co-operation extended by the Skipper and crew of **Matsya Nireekshani** is duly acknowledged.

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Table 1. Catch per unit effort (kg/hr) of different species in various depth zones

	Depth zone (m)	Below 50	50-100	100-200	100-200	200-500
	Gear *	F.T.	F.T.	F.T.	S.T.	S . T .
Species/group						
Total catch rate (kg/hr)		150.50	218.68	299.65	434.42	274.62
1.	Elasmobranchs	7.71	3.52	0.88	0.92	2.57
2.	Carangids	3.28	2.22	0.09	-	-
3.	Mackerel	1.49	1.63	-	-	-
4.	Decapterids	10.58	17.81	0.42	4.76	-
5.	Nemipterids	30.53	75.70	97.62	180.37	-
6.	Barracuda	10.30	0.39	74.65	5.43	-
7.	Cuttle fish	5.48	8.41	5.09	2.41	0.05
8.	Squid	3.11	1.89	0.21	0.02	-
9.	**Psenes indicus**	0.19	0.54	11.72	4.71	-
10.	Upeneoids	0.57	9.89	-	0.46	-
11.	Lizard fish	4.54	19.14	18.58	27.36	3.27
12.	Cat fish	1.01	21.29	0.03	-	-
13.	Flat fish	0.01	0.14	0.03	0.33	-
14.	Sciaenids	0.24	1.04	0.24	0.01	-
15.	Seer fish	0.23	0.06	-	-	-
16.	Pomfret	0.33	0.08	-	-	-
17.	Perches	34.50	19.04	1.50	2.86	0.03
18.	**Odonus niger**	30.83	16.24	0.03	-	-
19.	Crab	0.16	13.28	66.78	178.70	58.70
20.	Crocodile fish	-	1.14	3.73	6.56	-
21.	Octopus	-	0.05	0.03	-	0.03
22.	**Fistularia** spp.	0.03	0.55	-	-	-
23.	**Acanthurus** spp.	0.80	1.62	-	-	-
24.	Miscellaneous fish	3.23	2.10	6.07	5.26	32.47
25.	**Priacanthus** spp.	0.38	0.68	6.86	6.77	-
26.	Prawns	0.50	0.09	-	-	12.98
27.	Ribbon fish	0.33	-	-	-	38.51
28.	Deepsea lobsters	-	-	-	-	8.72
29.	**Centrolophus** sp.	-	-	0.41	1.90	68.10
30.	**Chlorophthalmus** sp.	-	-	4.56	5.40	49.13

* FT = 34m fish trawl, ST = 45m shrimp trawl

Table 2. Depth-wise percentage composition of species obtained by Matsya Nireekshani during 1988-90

	Depth zone(m)	Below 50	50-100	100-200	100-200	200-500
	Gear *	F.T.	F.T.	F.T.	S.T.	S.T.
Species/group						
1.	Elasmobranchs	5.12	1.61	0.29	0.21	0.93
2.	Carangids	2.17	1.01	0.03	-	-
3.	Mackerel	0.99	0.74	-	-	-
4.	Decapterids	7.03	8.14	0.14	1.09	-
5.	Nemipterids	20.29	34.62	32.57	41.52	-
6.	Barracuda	6.84	0.17	24.91	1.25	-
7.	Cuttle fish	3.64	3.84	1.70	0.55	0.02
8.	Squid	2.07	0.86	0.07	0.005	-
9.	**Psenes indicus**	0.13	0.24	3.91	1.08	-
10.	Upeneoids	0.38	4.52	-	0.10	-
11.	Lizard fish	3.01	8.75	6.20	6.29	1.19
12.	Cat fish	0.67	9.73	0.01	-	-
13.	Flat fish	0.01	0.06	0.01	0.07	-
14.	Sciaenids	0.16	0.47	0.08	0.002	-
15.	Seer fish	0.15	0.02	-	-	-
16.	Pomfret	0.22	0.03	-	-	-
17.	Perches	22.92	8.70	0.50	0.65	0.01
18.	**Odonus niger**	20.48	7.43	0.01	-	-
19.	Crab	0.10	6.07	22.28	41.13	21.37
20.	Crocodile fish	-	0.52	-	1.51	-
21.	Octopus	-	0.02	0.01	-	0.01
22.	**Fistularia** spp.	0.02	0.25	-	-	-
23.	**Acanthurus** spp.	0.53	0.74	-	-	-
24.	Miscellaneous fishes	2.14	0.96	2.02	1.21	11.82
25.	**Priacanthus** spp.	0.25	0.31	2.29	1.56	-
26.	Ribbon fish	0.22	-	-	-	14.02
27.	Prawns	0.33	0.04	-	-	4.72
28.	Deepsea lobster	-	-	-	-	3.17
29.	**Centrolophus** sp.	-	-	0.13	0.43	24.80
30.	**Chlorophthalmus** sp.	-	-	1.52	1.24	17.89

* FT = 34m fish trawl, ST = 45m shrimp trawl

Table 3. Area-wise percentage composition of species obtained by Matsya Nireekshani during 1988-90

	Species/group	Area*				
		Lat.10°N	Lat. 9°N	Lat.8°N (W.C)	Lat.7°N (W.B)	Lat.8°N (G.M)
1.	Elasmobranchs	2.97	0.66	2.26	1.66	4.32
2.	Carangids	0.74	0.44	0.81	0.84	1.27
3.	Mackerel	0.60	0.22	0.73	0.49	0.17
4.	Decapterids	1.38	3.77	7.94	2.24	0.44
5.	Nemipterids	45.84	39.06	27.08	31.47	1.42
6.	Barracuda	0.15	0.88	0.34	3.30	4.29
7.	Cuttle fish	6.54	2.01	3.38	1.15	2.54
8.	Squid	0.59	0.66	1.15	0.54	0.54
9.	**Psenes indicus**	0.06	1.50	1.58	0.35	0.22
10.	Upeneoids	2.65	0.06	4.05	1.39	0.26
11.	Lizard fish	9.75	5.13	7.51	5.53	0.55
12.	Cat fish	4.09	8.80	0.36	0.11	0.04
13.	Flat fish	0.05	0.06	0.01	0.03	-
14.	Sciaenids	0.30	0.02	0.19	0.38	-
15.	Seer fish	0.16	0.06	0.01	-	0.09
16.	Pomfret	0.01	0.11	0.005	-	0.22
17.	Perch	0.27	0.51	10.37	11.98	15.67
18.	**Odonus niger**	-	0.006	2.47	13.04	19.12
19.	Crab	5.29	23.35	11.98	9.97	26.79
20.	Crocodile fish	-	1.52	0.07	0.37	0.11
21.	Octopus	-	0.006	0.05	-	-
22.	**Fistularia** spp.	0.25	0.01	0.04	0.15	-
23.	**Acanthurus** spp.	-	-	1.02	0.37	0.10
24.	Miscellaneous fishes	1.22	2.53	5.16	0.35	7.87
25.	**Priacanthus** spp.	0.76	1.04	0.66	1.05	2.49
26.	Deep sea prawns	0.65	1.04	0.97	0.38	0.81
27.	Deep sea lobster	0.14	0.84	0.51	0.08	0.62
28.	**Centrolophus** sp.	2.71	3.18	4.41	3.28	6.04
29.	**Chlorophthalmus** sp.	0.34	2.31	4.75	3.03	1.38
30.	Ribbon fish	-	0.10	0.03	6.10	2.48

* W.C. = West coast, W.B. = Wadge Bank, G.M. = Gulf of Mannar

Table 4. Area-wise catch rates obtained by Matsya Nireekshani during 1988-90

Species/group	Area				
	Lat.10°N	Lat.9°N	Lat.8°N (W.C)	Lat.7°N (W.B)	Lat.8°N (G.M)
Total catch rate (kg/hr)	97.59	279.03	185.21	335.39	122.93
1. Elasmobranchs	2.90	1.84	4.20	5.58	5.31
2. Carangids	0.72	1.25	1.50	2.85	1.56
3. Mackerel	0.59	0.63	1.35	1.66	0.20
4. Decapterids	1.35	10.52	14.70	7.53	0.54
5. Nemipterids	44.74	109.01	50.15	105.54	1.74
6. Barracuda	0.15	2.45	0.64	11.08	5.28
7. Cuttle fish	6.38	5.62	6.26	3.88	3.12
8. Squid	0.58	1.84	2.13	1.82	0.67
9. **Psenes indics**	0.06	4.21	2.92	1.20	0.27
10. Upeneoids	2.59	0.18	7.50	4.66	0.32
11. Lizard fish	9.52	14.31	13.90	18.56	0.68
12. Cat fish	3.99	24.57	0.66	0.39	0.05
13. Flat fish	0.05	0.18	0.01	0.11	--
14. Sciaenids	0.30	0.07	0.35	1.29	-
15. Seer fish	0.16	0.17	0.02	-	0.11
16. Pomfret	0.01	0.31	0.009	-	0.28
17. Perches	0.26	1.43	19.21	40.21	19.27
18. **Odonus niger**	-	0.18	4.57	43.74	23.50
19. Crab	5.17	65.15	22.19	33.45	32.94
20. Crocodile fish	-	4.25	0.13	1.24	0.14
21. Octopus	-	0.01	0.09	-	-
22. **Fistularia** spp.	0.25	0.05	0.08	0.51	-
23. **Acanthurus** spp.	-	-	1.89	1.27	0.13
24. Miscellaneous fishes	1.19	7.07	9.56	1.19	9.67
25. **Priacanthus** spp.	0.74	2.92	1.23	3.53	3.07
26. Deepsea prawns	0.64	2.91	1.81	1.30	1.00
27. Deepsea lobster	0.13	2.36	0.94	0.27	0.76
28. **Centrolophus** sp.	2.64	8.89	8.17	11.00	7.43
29. **Chlorophthalmus** sp.	0.33	6.44	8.81	10.19	1.70
30. Ribbon fish	-	0.28	0.05	20.47	3.06

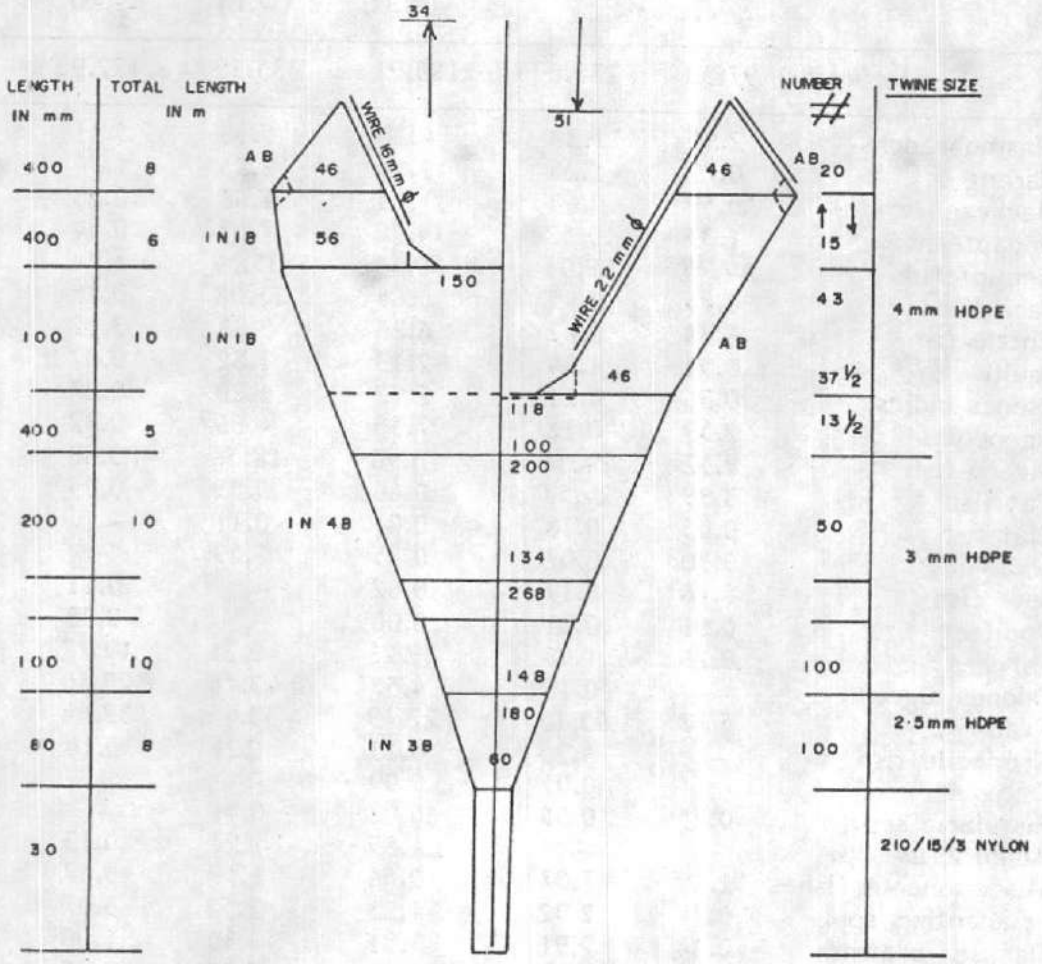

Fig.1 Design of 34m fish trawl

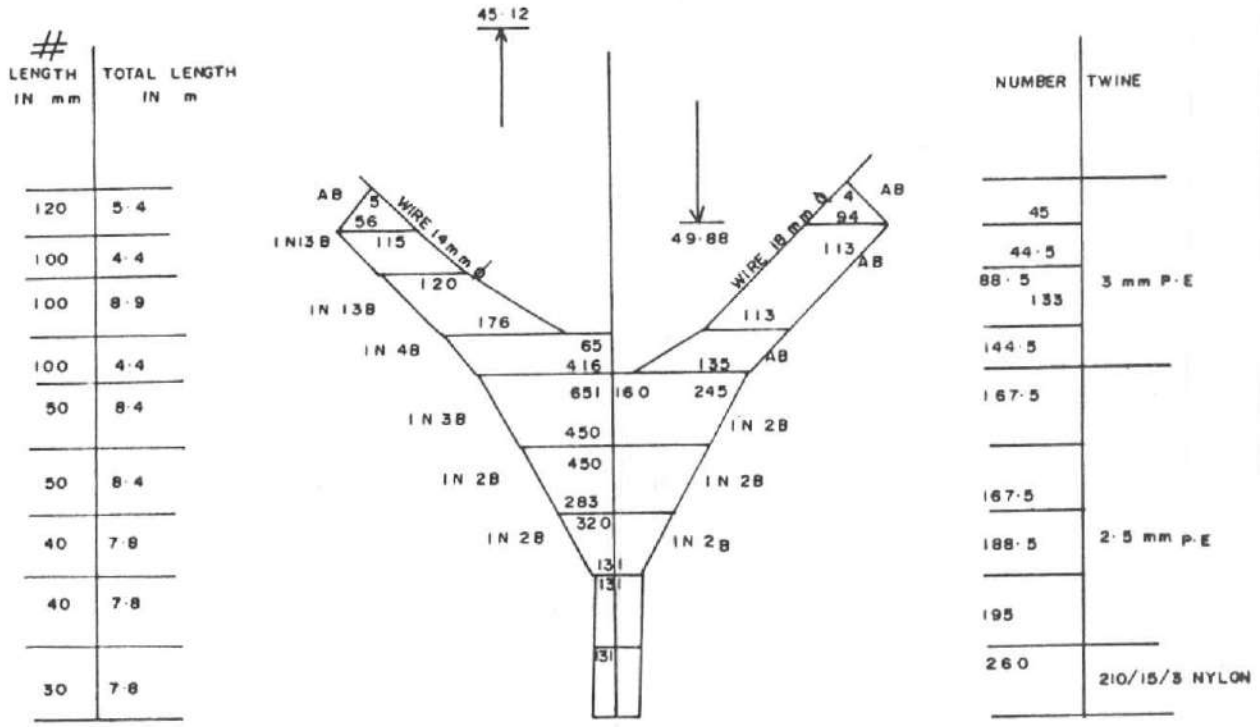

Fig.2 Design of 45m shrimp trawl

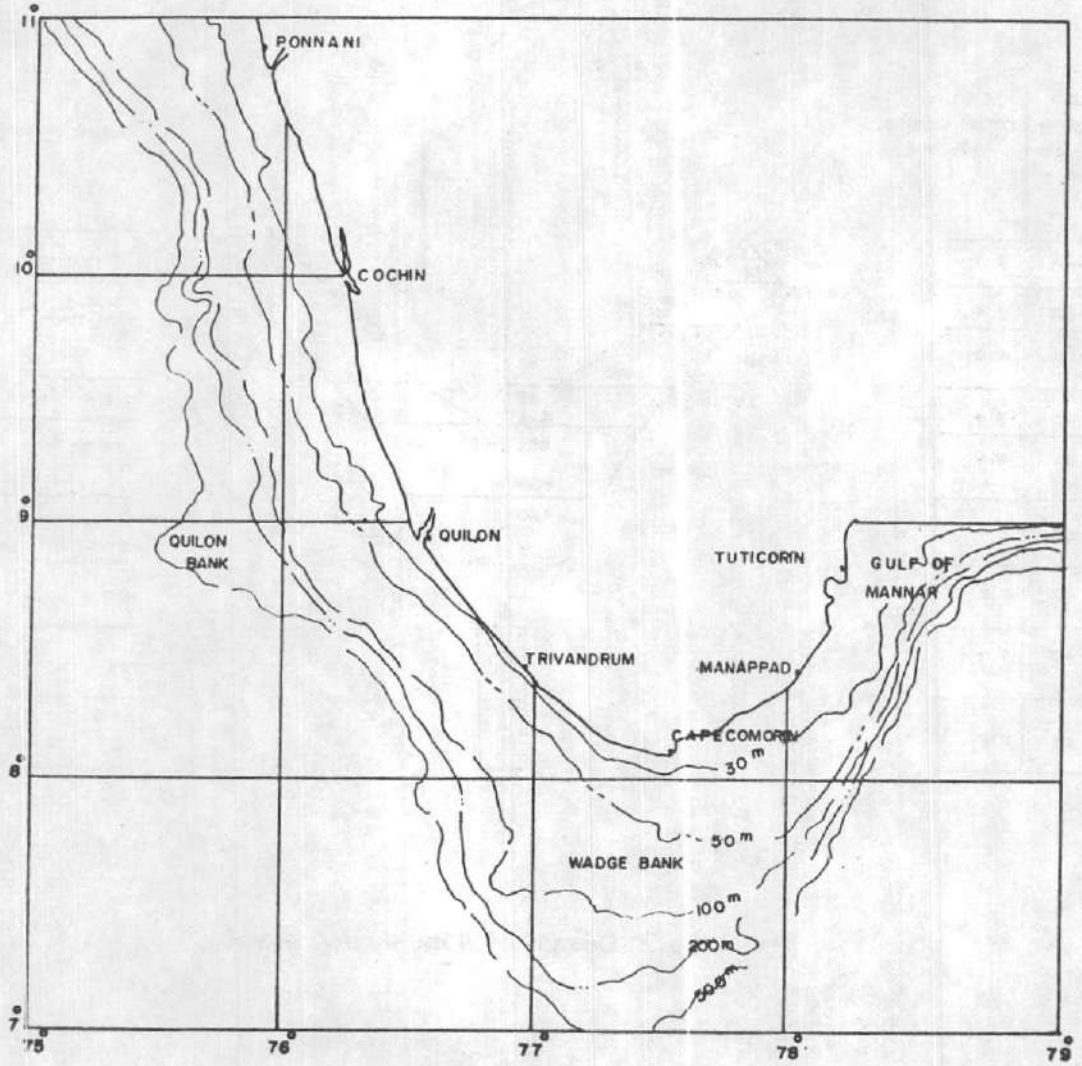

Fig. 3 Survey area

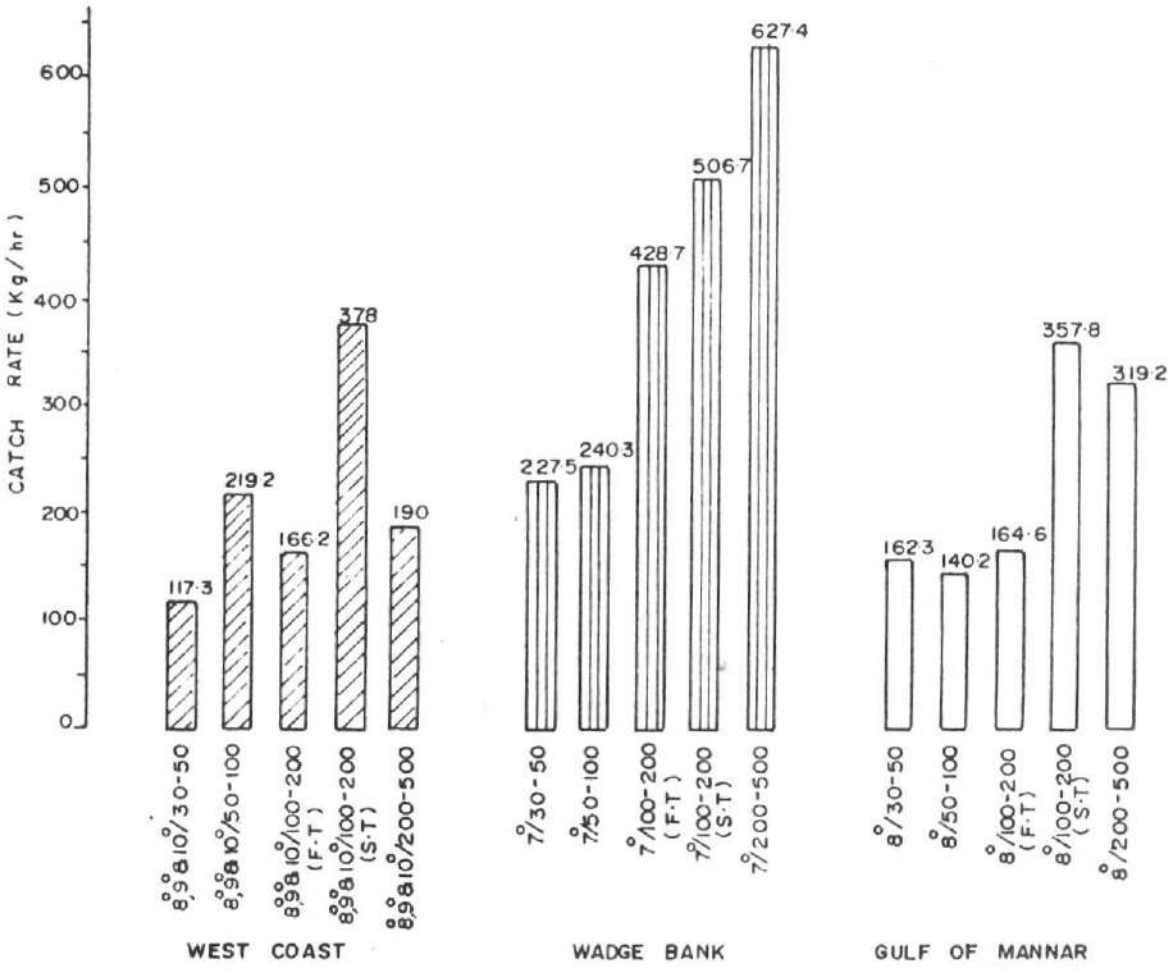

Fig.4 The catch rate of all fish recorded in different depth belts of 3 major regions

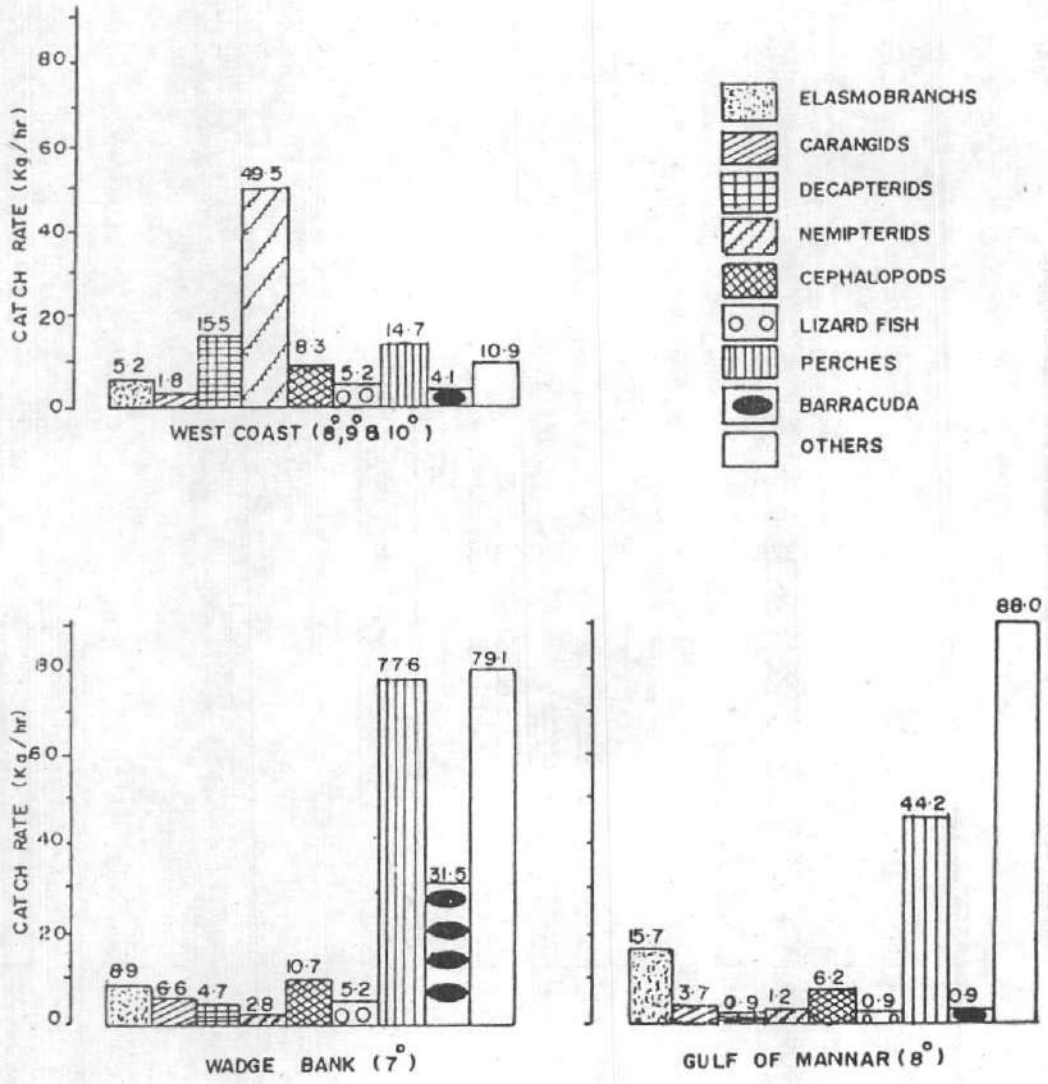

Fig.5 Region-wise dominance of major resources within 50m depth

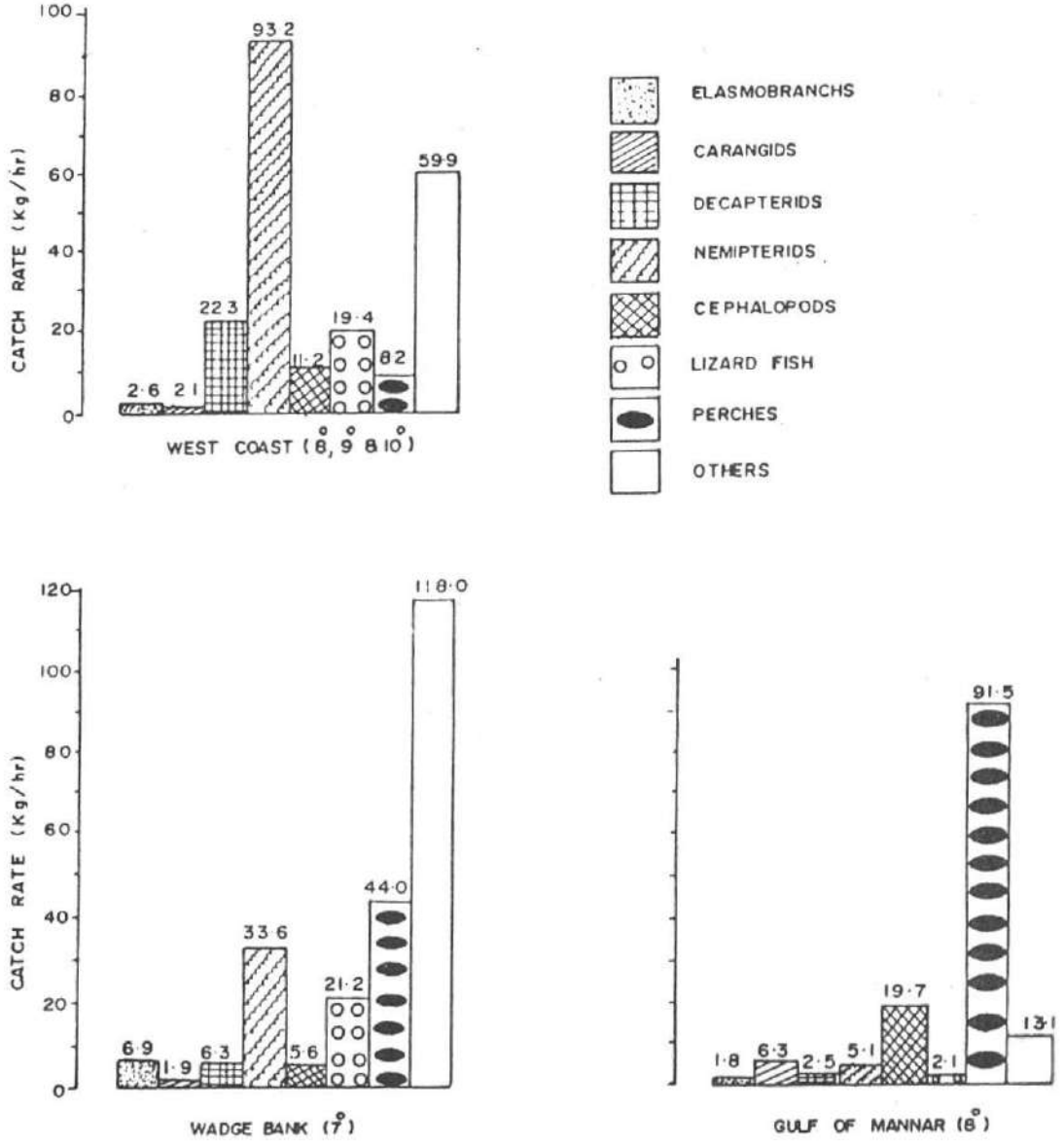

Fig.6 Region-wise dominance of major resources in 50-100m depth

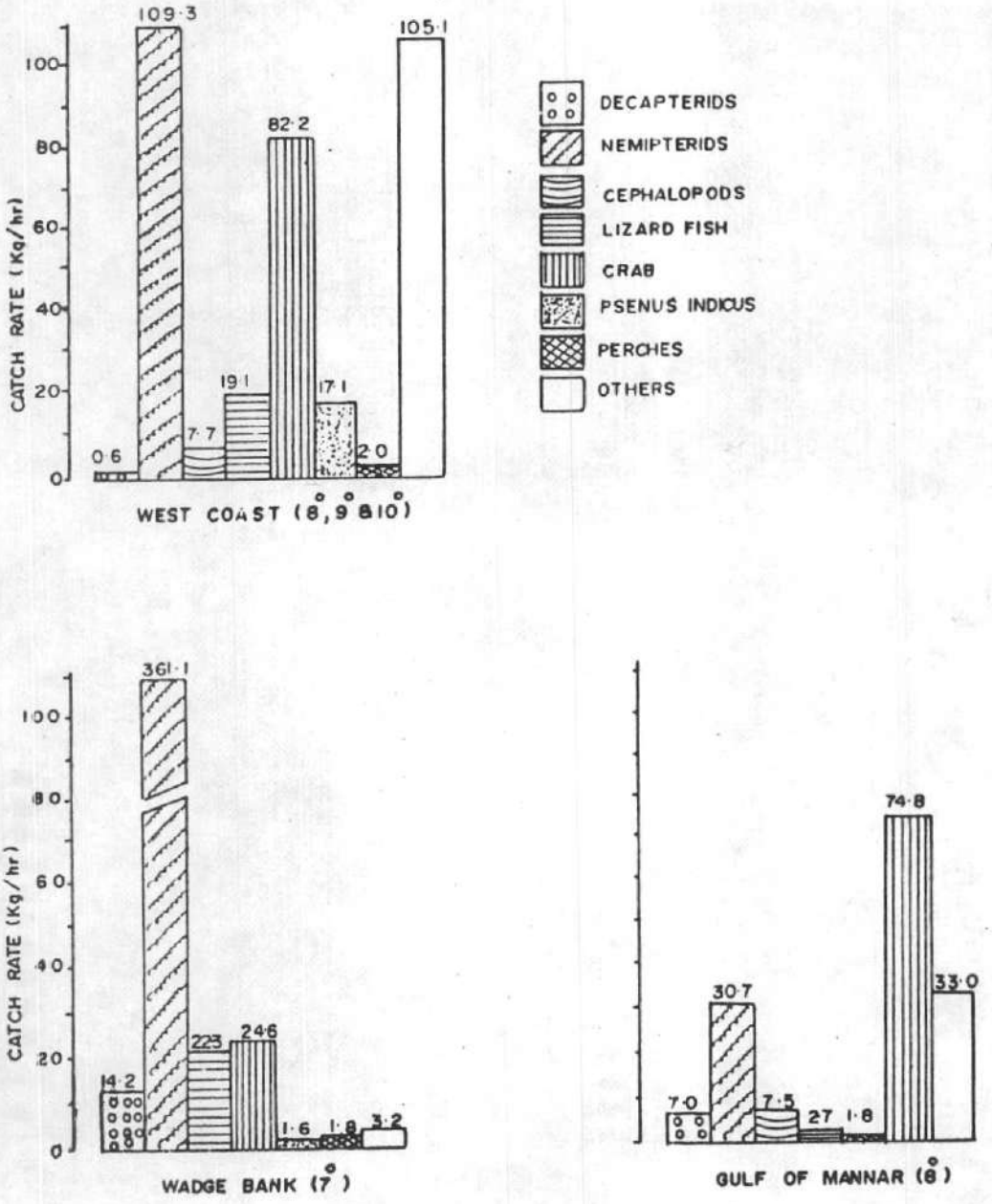

Fig.7. Region-wise dominance of major resources in 100-200m depth by fish trawl

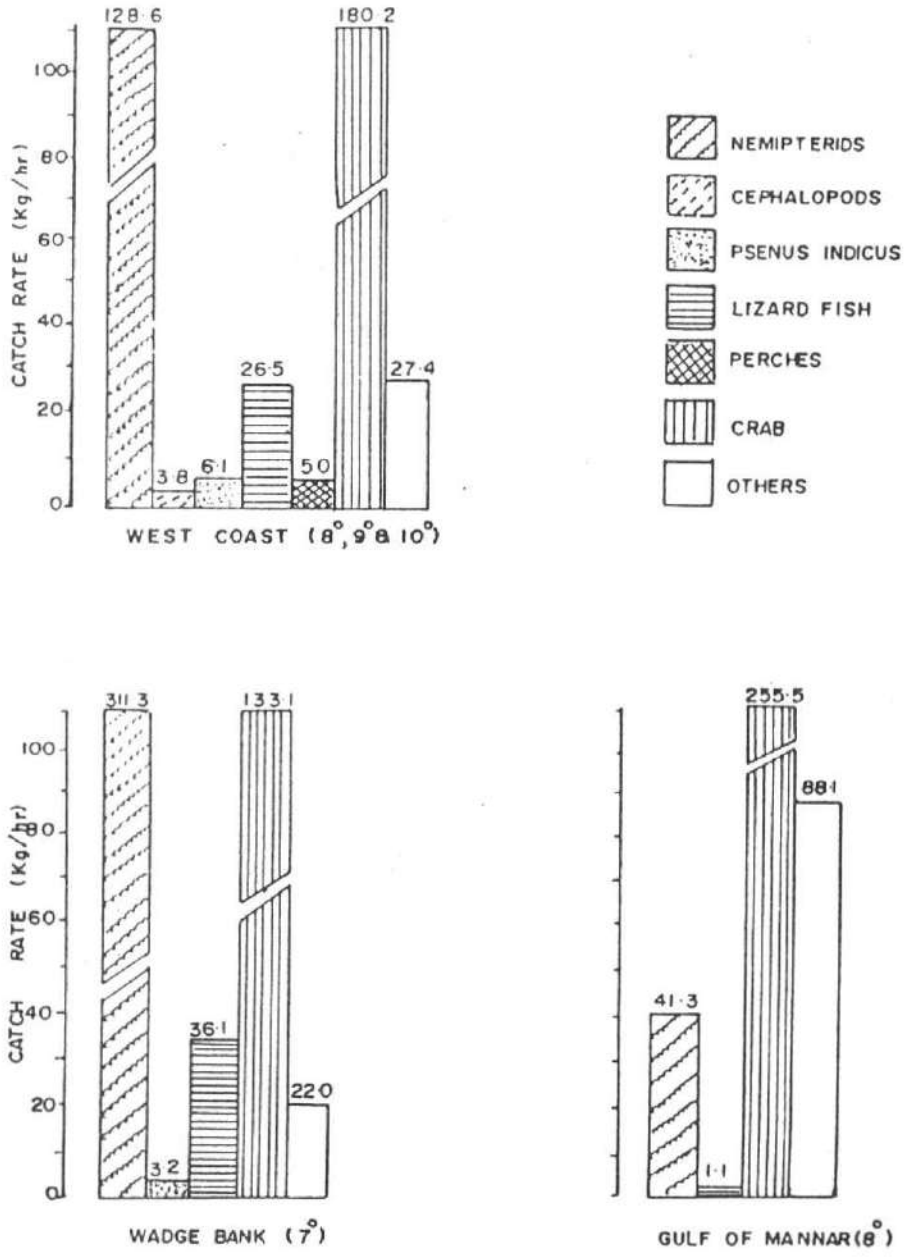

Fig.8 Region-wise dominance of major resources in 100-200m depth by shrimp trawl

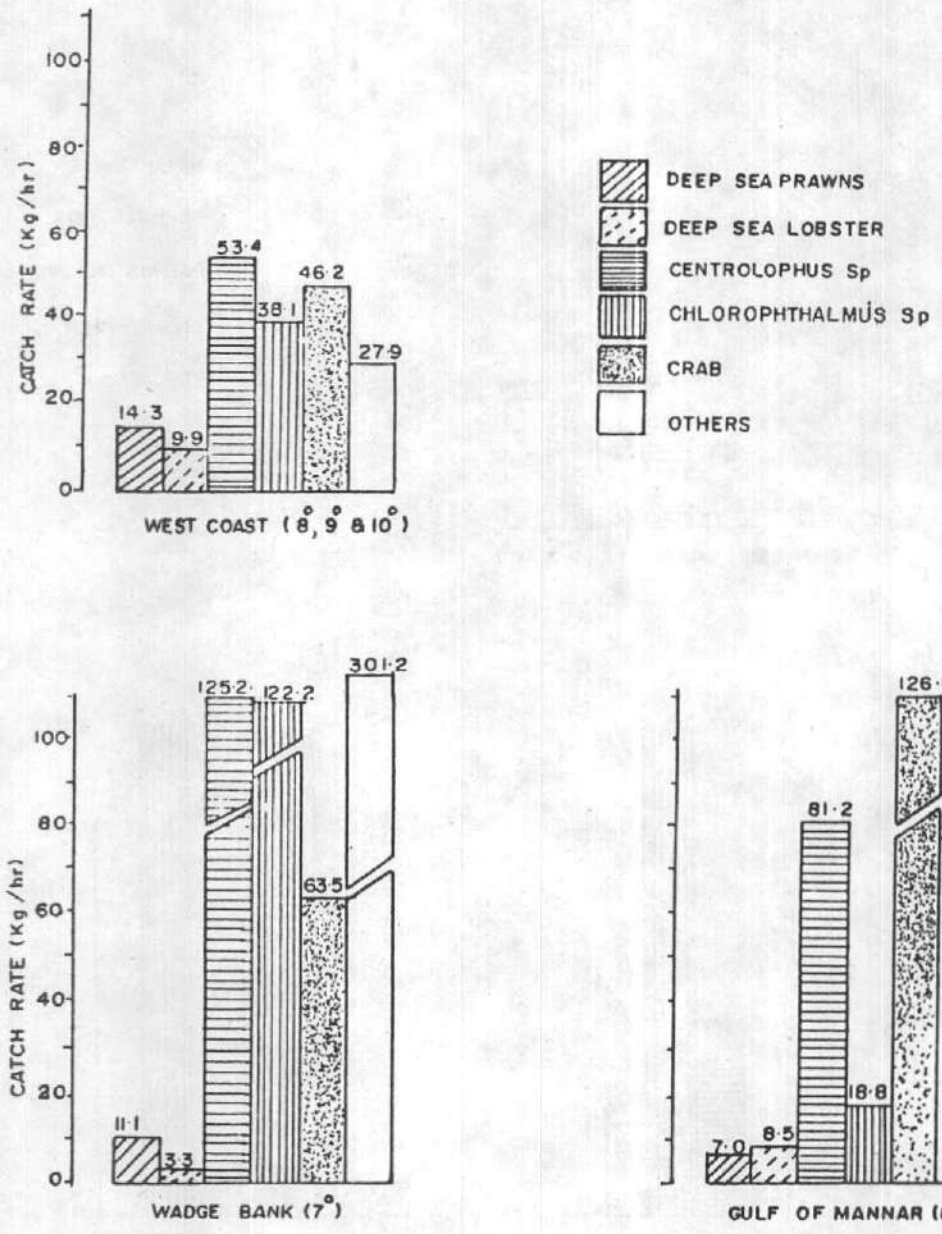

Fig.9. Region-wise dominance of major resources in 200-500m depth

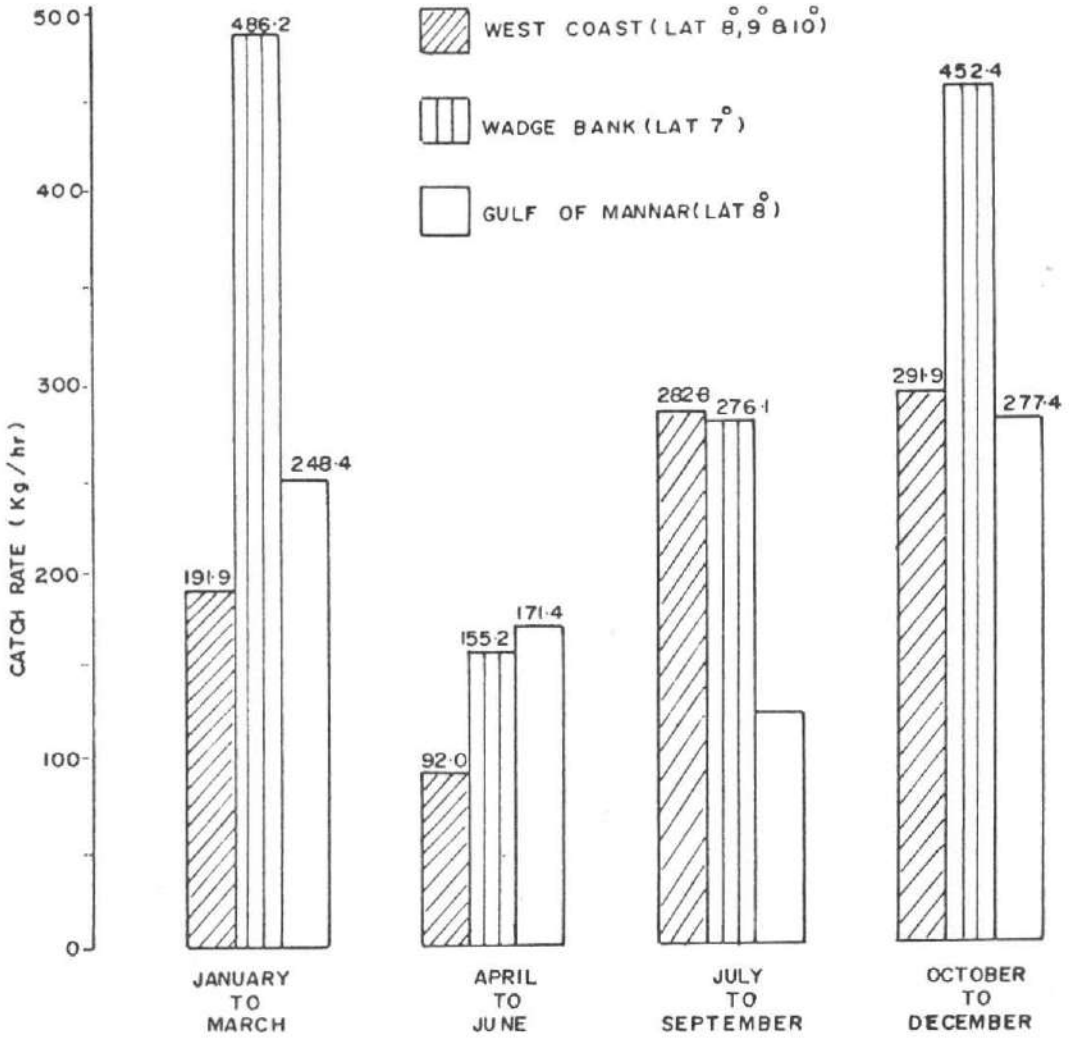

Fig. 10 The seasonal variation in abundance of ground fish for the different quarters

A STUDY ON THE FOOD AND FEEDING HABITS OF YELLOWFIN TUNA *(THUNNUS ALBACARES)* CAUGHT IN ANDAMAN WATERS OF INDIAN EEZ BY TUNA LONGLINING

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INTRODUCTION

Tuna longlining has emerged as the main fishing method to exploit the larger tunas in Indian waters. Yellowfin tuna **(Thunnus albacares)** is the most important species among the larger tunas and is widely distributed in the Indian EEZ. However, there has not been any detailed study on the food and feeding habits of yellowfin tuna taken by longlining from the Indian seas. Silas **et al.** (1985) have briefly described the food of yellowfin tuna. An attempt is made in this paper to study the food and feeding habits of yellowfin tuna caught in Andaman waters of Indian EEZ.

MATERIALS AND METHODS

The study is based on analysis of gut contents of yellowfin tuna caught during the oceanic fishery resources survey by tuna longlining in Andaman waters of Indian EEZ by the vessel **Yellowfin** (OAL 36 m) from September 1989 to August'90. A total of 188 samples were taken for the gut analysis. Sex was determined visually after cutting open the belly. The stomach contents were removed and kept in separate polythene bags, labelled and preserved in freezer. The stomach contents were analysed by gravimetric method in the shore laboratory on completion of each cruise. The state of stomach contents was categorised into three, namely prey, semi-digested and digested food and weighed to nearest gram. For qualitative observations the stomach contents were broadly classified into four groups viz., deepsea fishes, other teleosts, cephalopods and crustaceans. Sex-wise difference in feeding was obtained by summarising data on the stomach contents of male and female seperately. The feeding rate per hour was determined by the formula used by Olson (1982) but excluded the semi-digested and digested food.

RESULTS AND DISCUSSION

Prey organisms

The prey organisms consumed by yellowfin tuna consisted of deepsea fishes (**Centrolophus** sp., **Priacanthus** spp. etc.), other teleosts (flying fish, carangids, ribbon fish, pipe fish etc.), cephalopods (squids and cuttle fish) and crustaceans (crabs, squilla and deepsea prawns).

28 stomachs were found empty of which 25 were male and 3 were female.

Weight of stomach contents

The average weight of contents per stomach of yellowfin tuna (both sexes) was 106 gm consisting of 93.4% prey, 3.8% semi-digested food and 2.8% in digested condition. The monthly average weight of the stomach content ranged from 59 gm in May to 180 gm in April (Table 1). The average stomach content of 106 gm is considerably lower than that of 419 gm reported in case of yellowfin tuna caught around Payaos by handline in Moro Gulf (Barut, 1988). The average stomach content of yellowfin tuna caught in troll lines and longlines off south-west of Taiwan was 94 gm per stomach (Chi and Yang, 1971) whereas Hayashi and Mori (1967) reported 80 cc(volumetric method) per stomach of yellowfin tuna caught in Central Pacific by longlining. The varying values may be attributed to the mode of capture and preservation of stomach contents (Yesaki, 1983).

Sex-wise weight of stomach contents

The average weight of contents per stomach of male yellowfin tuna was 112 gm, comprised of 93.7% prey, 4.5% semi-digested and 1.8% digested food. The monthly average weight of stomach content ranged from 69 gm in July to 170 gm in September (Table 2).

The average weight of contents per stomach of female yellowfin tuna was 91 gm, comprised of 92.3% prey, 2.2% semi-digested and 5.5% digested food. The monthly average weight of stomach content ranged from 17 gm in May to 180 gm in April (Table 3).

Weight of content per stomach of male (112 gm) and female (91 gm) yellowfin tuna showed no significant difference. Stomach contents of male and female yellowfin tuna caught around Payaos by handline in Moro Gulf was 427 gm and 405 gm respectively with no significant diffe-

rence in food consumption rates of male and female (Barut, 1988). Earlier studies by Yesaki (1983) and Chi and Yang (1971) also showed no significant difference in feeding rate of male and female yellowfin tuna.

Consumption of prey orgnisms

The food items found in the stomach of yellowfin tuna is categorised into four groups viz. deepsea fishes, other teleosts, cephalopods and crustaceans. The month-wise average weight of prey organisms consumed by yellowfin tuna is given in Table 4.

The monthly consumption of prey organisms shows that there is a low intake of food during first half of the year (January - June) than the second half. The reason for the high intake of food during certain months may be attributed to the tendency of yellowfin tuna to take more food during spawning period (Yamanaka, 1987). Presence of crustaceans in the stomach content was found more during the months from September to November whereas cephalopods were found to be more in July. As yellowfin tunas are voracious eaters and generally non-selective, eating any living organisms available in the open ocean (Ronquillo, 1951), the reason for occurrence of particular food organism in more quantity in stomach content may be attributed to the availability of such organisms more frequently in particular season.

Estimation of food consumption

Average weight of prey organisms consumed per day and per year by yellowfin tuna was estimated as per the formula used by Olson (1982). To get the feeding rate (r) per hour, the observed weight of stomach content (W) was divided by area (A) under evacuation curve (average proportion of food remaining in the stomach over the evacuation period).

$$\text{i.e.} \qquad r = \frac{W}{A}$$

The value 4.69 determined by Olson (op.ct.) from the feeding experiments conducted with mackerel **(Scomber japonicus)** is used in this study as the parameter A to calculate the feeding rate though this value could be an underestimation as mackerels are digested slower than most other species (Yesaki, 1983). Consumption per day was calculated by multiplying r by 24 assuming that yellowfin tunas eat throughout the day though some authors have considered that the species feeds only during day light hours (Reintjes and King, 1983). Estimated average weight of food organisms consumed per day and per year by one yellowfin tuna (and also sex-wise) is given in Table 5.

The average estimated total consumption per day and per year was 507 gm and 185 kg respectively. This estimation is comparatively lower than the daily consumption of 642 gm for 12 hours per yellowfin tuna caught by purse-seine in the Eastern Pacific (Olson, 1982) and 2145 gm per day per yellowfin tuna caught around Payaos by handlines in Moro Gulf (Barut, 1988).

The food consumption of male yellowfin tuna was estimated as 537 gm per day and 196 kg per year while that of female was 430 gm and 157 kg respectively. The estimated total weight and the percentage composition of prey organisms consumed by yellowfin tuna is shown in Fig.1.

SUMMARY

1. The average total weight of stomach contents per yellowfin tuna was 106 gm which is comprised of 93.4% prey, 3.8% semi-digested and 2.8% digested food.

2. The average total weight of stomach contents per male yellowfin tuna was 112 gm which is comprised of 93.7% prey, 4.5% semi-digested and 1.8% digested food while that of female was 91 gm which is comprised of 92.3% prey, 2.2% semi-digested and 5.5% digested food.

3. Prey organisms consumed per day and per year by one yellowfin tuna was estimated as 507 gm and 185 kg respectively which is composed of deepsea fishes 13.5%, other teleost fishes 25.4% , cephalopods 30.8% and crustaceans 30.3%.

4. Prey organisms consumed per day and per year by one male yellowfin tuna was estimated as 537 gm and 196 kg respectively while that of female was 430 gm and 157 kg.

ACKNOWLEDGEMENT

The authors are thankful to Dr.V.S.Somvanshi and Shri M.E.John, Sr. Fisheries Scientist, Fishery Survey of India, Bombay for providing the required data collected during the voyages participated by them.

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Table 1. Monthly average weight of stomach contents of yellowfin tuna

Month	No.of stomachs examined	Average weight (gm) of stomach contents			
		Prey	Semi-digested	Digested	Total
September'89	14	165	-	3	168
October	3	163	-	-	163
November	30	135	-	2	137
December	44	108	-	-	108
January'90	19	70	-	16	86
February	22	74	12	-	86
March	34	73	16	-	89
April	1	180	-	-	180
May	13	53	-	6	59
June	3	108	-	5	113
July	5	77	-	8	85
Total	188	99 (93.4%)	4 (3.8%)	3 (2.8%)	106

Table 2. Monthly average weight of stomach contents of male yellowfin tuna

Month	No.of stomachs examined	Average weight (gm) of stomach contents per fish			
		Prey	Semi-digested	Digested	Total
Sept.'89	13	167	-	3	170
October	2	155	-	-	155
November	24	132	-	1	133
December	27	134	-	-	134
January'90	11	65	-	7	72
February	17	70	14	-	84
March	25	78	19	-	97
April	-	-	-	-	-
May	10	64	-	8	72
June	3	108	-	5	113
July	4	59	-	10	69
Total	136	105 (93.7%)	5 (4.5%)	2 (1.8%)	112

Table 3. Monthly average weight of stomach contents of female yellowfin tuna

Month	No.of stomachs examined	Average weight (gm) of stomach contents per fish			
		Prey	Semi-digested	Digested	Total
September'89	1	140	-	-	140
October	1	180	-	-	180
November	6	149	-	7	156
December	17	68	-	-	68
January'90	8	79	-	27	106
February	5	90	6	-	96
March	9	57	10	-	67
April	1	180	-	-	180
May	3	17	-	-	17
June	-	-	-	-	-
July	1	150	-	-	150
Total	52	84 (92.3%)	2 (2.2%)	5 (5.5%)	91

Table 4. Monthwise average weight of prey organisms (in gms) consumed per yellowfin tuna

SEX	FOOD ITEMS	SEP.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR	MAY	JUNE	JULY	AUG.
	DEEPSEA FISHES												
MALE		2	40	37	-	16	18	9	-	3	-	-	-
FEMALE		-	20	17	3	23	10	8	-		-	6	-
COMBINED		2.00	33.33	33.23	0.07	18.42	15.91	8.53	-	1.92	-	5.00	-
	OTHER TELEOSTS												
MALE		17	65	18	69	-	4	4	-	11	2	1	-
FEMALE		80	80	3	39	1	16	9	10	10	-	-	-
COMBINED		21.43	70.00	15.00	57.59	0.05	6.36	5.29	10.00	10.76	1.67	0.20	-
	CEPHALOPODS												
MALE		17	3	13	59	24	21	5	-	7	15	51	-
FEMALE		60	-	18	25	38	16	11	10	7	-	50	-
COMBINED		19.86	1.66	14.20	45.72	29.84	20.28	6.47	10.00	6.92	15.00	50.00	-
	CRUSTACEANS												
MALE		131	48	51	6	1	15	18	-	6	-	-	-
FEMALE		-	80	78	1	2	22	13	-	-	-	-	-
COMBINED		121.43	58.33	56.46	3.82	0.42	16.82	16.18	-	4.62	-	-	-

Table 5. Estimated average weight of food organisms consumed per day and per year by one yellowfin tuna

Food item	Male yellowfin tuna		Female yellowfin tuna		Combined	
	per day (gm)	per year (kg)	per day (gm)	per year (kg)	per day (gm)	per year (kg)
Deepsea fishes	77	28	52	19	70	25
Other teleosts	128	47	131	48	129	47
Cephalopods	159	58	145	53	155	57
Crustaceans	173	63	102	37	153	56
TOTAL	537	196	430	157	507	185

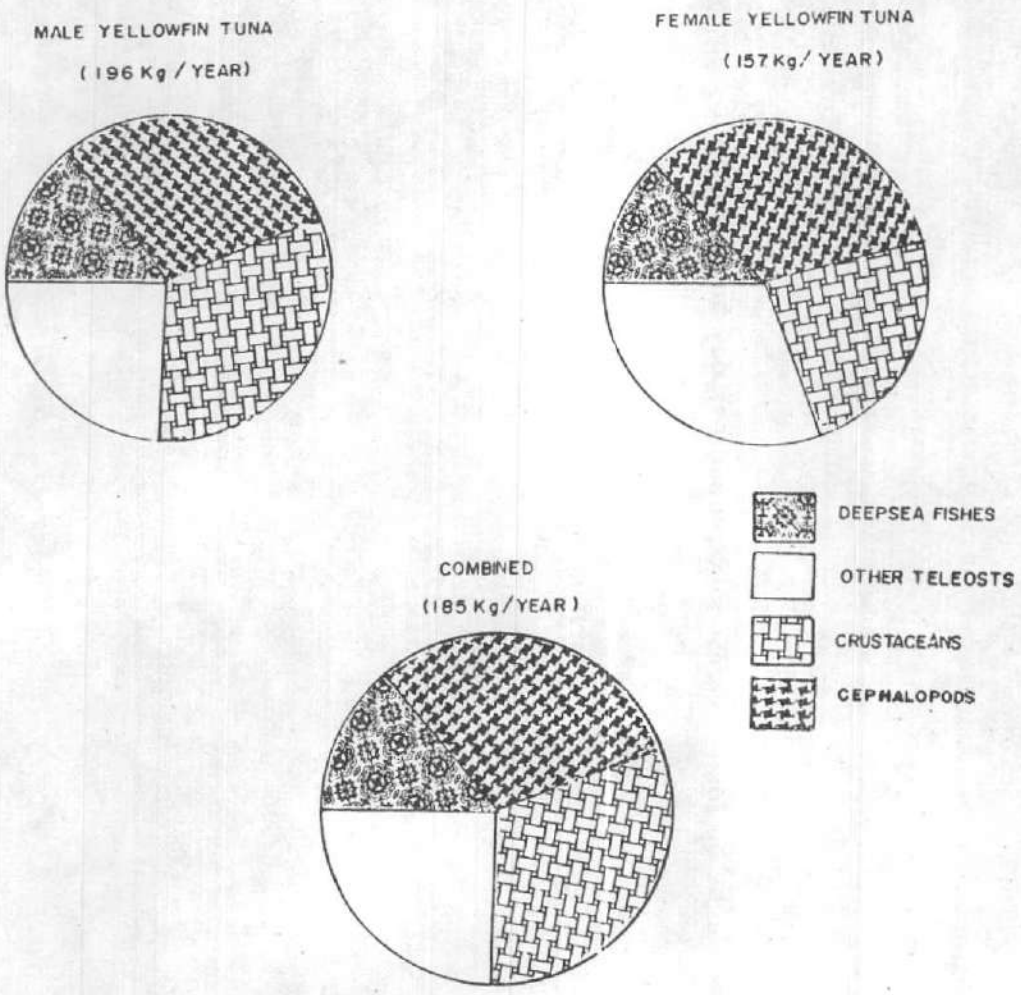

Fig.1 Estimated total weight and percentage composition of prey organisms consumed per year per yellowfin tuna

STUDIES ON MESH SELECTIVITY OF 27.5M BOTTOM TRAWL OPERATED BY M.V. MATSYA JEEVAN

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INTRODUCTION

There has been a steady increase in exploitation of demersal fishes in Indian seas, particularly in the coastal waters. This is due to increased fishing effort for exploitation of resources. However, unrestricted use of fishing gear often results in landing of large quantities of small fishes including juveniles ultimately leading to overfishing of the stocks. This calls for management measures for ensuring optimum utilisation of resources. Controlling fishing effort and regulating the size at which fish are first exploited are among the methods of managing fish stocks. Regulating mesh size of fishing gear is a common measure adopted in temperate waters dealing with less number of species. In order to formulate management measures it is necessary to know the mesh selectivity. This paper deals with the results of a study on trawl mesh selectivity by covered codend method as described by Pope **et al.** (1975) and Jones (1976).

VESSEL AND GEAR

The study was carried out during July - August 1988 on board **Matsya Jeevan** (OAL 36.5M) engaged in fishery resources survey by bottom trawling along Tamil Nadu and Andhra Pradesh coast. The gear employed for the study was 27.5m bottom fish trawl having a codend mesh size of 40 mm. Duration of each haul was 30 minutes.

MATERIALS AND METHODS

For the mesh selectivity study, the codend was covered by a loosely fitted cover of 20 mm mesh size in order to catch those fish escaping through the meshes of the codend of 40mm mesh size (Fig.1). Species of fishes caught both in codend and codend cover were measured in full. The eight species occurred in two or more observations were taken for selectivity

studies. The species thus studied are **Nemipterus japonicus, Saurida tumbil, Decapterus russelli, Secutor insidator, Gerres setifer, Upeneus vittatus, U. sulphureus** and **Sphyraena obtusata.** Fork length was measured for **Nemipterus japonicus** and total length for the rest of the species.

CODEND MESH SELECTIVITY

Percentage retention

The percentage retained in the codend at each length group is estimated from the total number in respective length groups caught both in codend and cover. Species-wise and length-wise number of fishes caught in codend, cover and percentage retained in codend are given in Tables 1 to 8.

Selection ogive

Selection ogive (curve) is obtained for each species by plotting the percentage retention in the codend for each length against the length of fish. From this curve, percentage retained at particular length is determined. Codend selectivity is expressed in terms of 50% retention length (Beverton and Holt, 1957; Jones, 1976) at which half the fish entering the codend escape through the meshes while the other half are retained. Selection range represents the length range of fish between 25% and 75% retention on the selection curve. Though Aoyama (1961) used the length range between 50% and 84.13% retention value, the selection range between 25% and 75% retention length used by Jones (1976) is generally accepted. Species-wise selection curve, 50% retention length and selection range between 25% and 75% are shown in Fig. 2 to 9.

Selection factor

Selection factor is determined by the formula as adopted by Jones (1976). Selection Factor (S.F.) is expressed as the ratio of the 50% retention length (lc) to the mesh size (M.S.), both measured in the same units.

$$\text{i.e.} \quad S.F. = \frac{lc}{M.S.}$$

Selection factor, 50% retention length and selection range for all the 8 species were worked out.

RESULTS AND DISCUSSION

Species-wise results obtained for 8 species are given below:

Name of the species	50% retention length (cm)	Selection factor	Selection range (cm)
Nemipterus japonicus	11.2	2.80	9.5 - 12.8
Saurida tumbil	15.3	3.83	13.3 - 17.3
Decapterus russelli	14.2	3.55	13.0 - 15.4
Secutor insidator	8.7	2.18	7.5 - 9.6
Gerres setifer	11	2.75	9.9 - 12.0
Upeneus vittatus	11.6	2.90	9.7 - 13.4
Upeneus sulphureus	10.8	2.70	9.6 - 12.1
Sphyraena obtusata	19	4.75	17.9 - 20.0

The selection factor of 2.80 for **Nemipterus japonicus** is lower than the earlier study (3.3) by Jones (1976). This may be due to the measurement of fork length of **Nemipterus japonicus** for present study. Further biological studies may help to correlate the 50% selection length with length at first maturity. This will help in designing gears with suitable mesh size for different species.

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Table 1. Length frequencies of Nemipterus japonicus from covered codend experiments

Length* (cm)	No. of fishes caught			% retained
	In codend	In cover	Total	
6	0	6	6	0
7	1	17	18	5.55
8	11	90	101	10.89
9	50	138	188	26.59
10	150	233	383	39.16
11	165	163	328	50.30
12	107	67	174	61.49
13	101	19	120	84.16
14	99	8	107	92.52
15	69	0	69	100
16	40	0	40	100
17	34	0	34	100
18	27	0	27	100
19	9	0	9	100
20	21	0	21	100
21	6	0	6	100

No. of observations - 7 * Fork length

Table 2. Length frequencies of Saurida tumbil from covered codend experiments

Length (cm)	No. of fishes caught			% retained
	In codend	In cover	Total	
11	0	9	9	0
12	38	82	120	31.66
13	57	111	168	33.93
14	67	142	209	32.06
15	69	91	160	43.12
16	73	59	132	55.30
17	81	28	109	74.31
18	65	12	77	84.42
19	46	6	52	88.46
20	45	6	51	88.24
21	34	0	34	100
22	1	0	1	100
23	1	0	1	100
24	2	0	2	100

No. of observations - 16

Table 3. Length frequencies of Decapterus russelli from covered codend experiments

Length (cm)	No. of fishes caught			% retained
	In codend	In cover	Total	
9	0	1	1	0
10	0	0	0	0
11	0	2	2	0
12	12	72	84	14.28
13	130	281	411	31.63
14	114	162	276	41.30
15	110	73	183	60.10
16	140	27	167	83.83
17	143	2	145	98.62
18	24	1	25	96.00
19	2	0	2	100

No. of observations - 6

Table 4. Length frequencies of Secutor insidator from covered codend experiments

Length (cm)	No. of fishes caught			% retained
	In codend	In cover	Total	
5	2	35	37	5.40
6	18	149	167	10.77
7	15	35	50	30.00
8	40	67	107	37.38
9	37	37	74	50.00
10	23	4	27	85.18
11	1	0	1	100

No. of observations - 2

Table 5. Length frequencies of Gerres setifer from covered codend experiments

Length (cm)	No. of fishes caught			% retained
	In codend	In cover	Total	
8	1	11	12	8.33
9	5	37	42	11.90
10	20	33	53	37.73
11	34	35	69	49.27
12	8	3	11	72.72
13	4	0	4	100

No. of observations - 2

Table 6. Length frequencies of Upeneus vittatus from covered codend experiments

Length (cm)	No. of fishes caught			% retained
	In codend	In cover	Total	
8	1	16	17	5.88
9	9	34	43	20.93
10	41	82	123	33.33
11	120	124	244	49.18
12	75	32	107	70.09
13	135	41	176	76.70
14	189	37	226	83.62
15	304	23	327	92.96
16	129	21	150	86.00
17	72	7	79	91.13
18	22	3	25	88.00
19	2	0	2	100
20	1	0	1	100

No. of observations - 6

Table 7. Length frequencies of Upeneus sulphureus from covered codend experiments

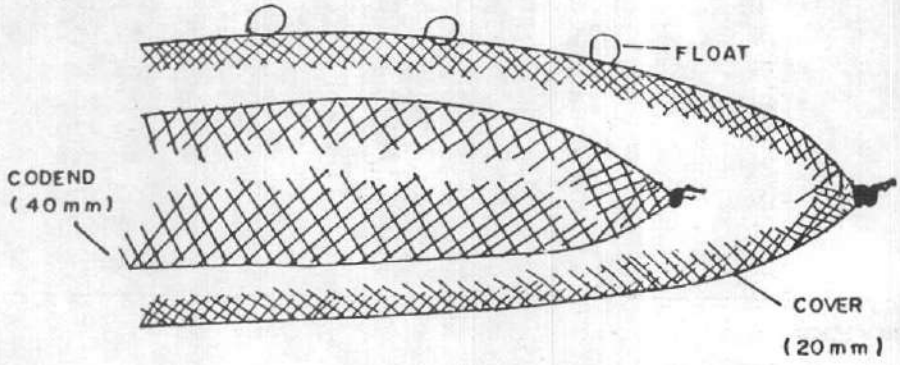
Length (cm)	No. of fishes caught			% retained
	In codend	In cover	Total	
9	1	10	11	9.09
10	8	11	19	42.10
11	73	33	106	68.86
12	64	19	83	77.10
13	77	6	83	92.77
14	28	1	29	96.55
15	8	6	14	57.14
16	1	-	1	100
17	2	-	2	100

No. of observations - 3

Table 8. Length frequencies of Sphyraena obtusata from covered codend experiments

Length (cm)	No. of fishes caught			% retained
	In codend	In cover	Total	
18	3	8	11	27.27
19	8	8	16	50.00
20	25	8	33	75.75
21	13	1	14	92.85
22	10	0	10	100
23	18	0	18	100
24	12	0	12	100
25	5	0	5	100
26	6	0	6	100
27	1	0	1	100

No. of observations - 2



Codend

Mesh size	:	40mm
Circumference	:	125 mesh x 2
Length	:	200 mesh

Cover

Mesh size	:	20mm
Circumference	:	290 mesh x 2
Length	:	470 mesh

Fig. 1 Codend and cover used for the selectivity study

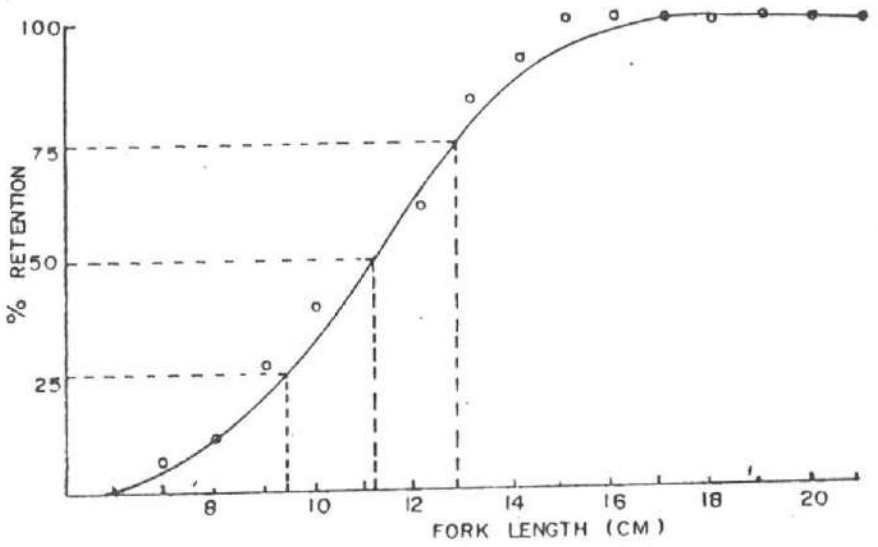


Fig.2 Selection ogive for Nemipterus japonicus

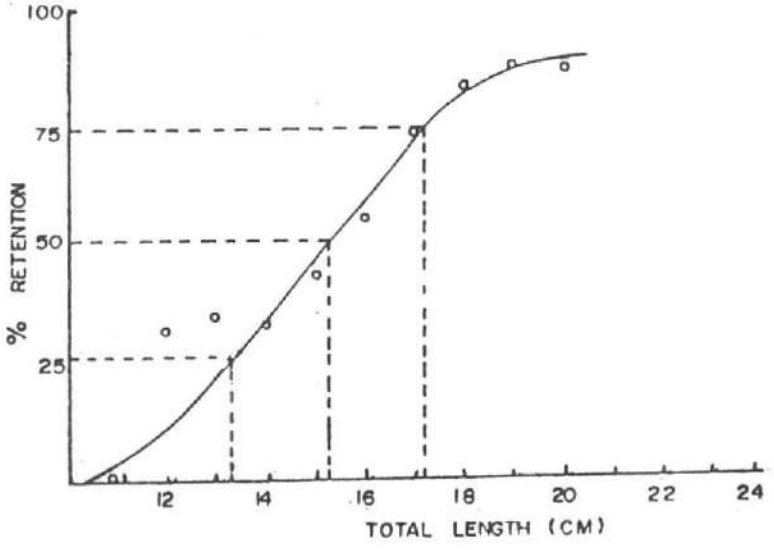


Fig.3 Selection ogive for Saurida tumbil

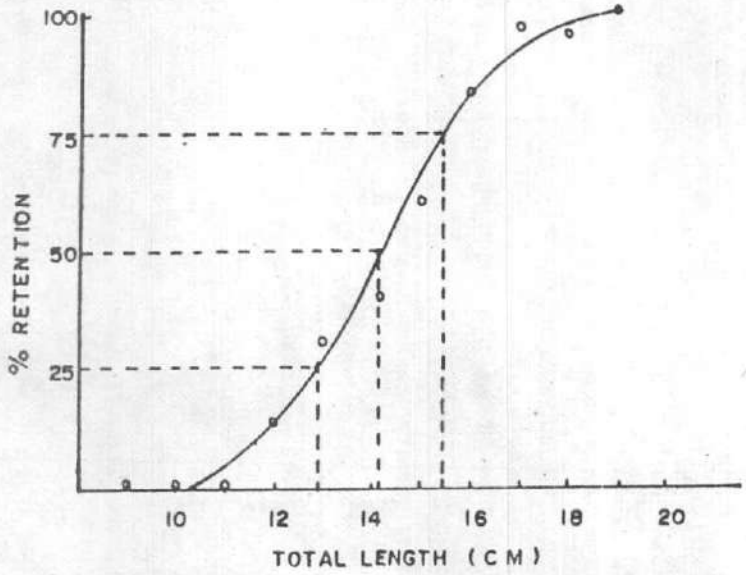


Fig.4 Selection ogive for Decapterus russelli

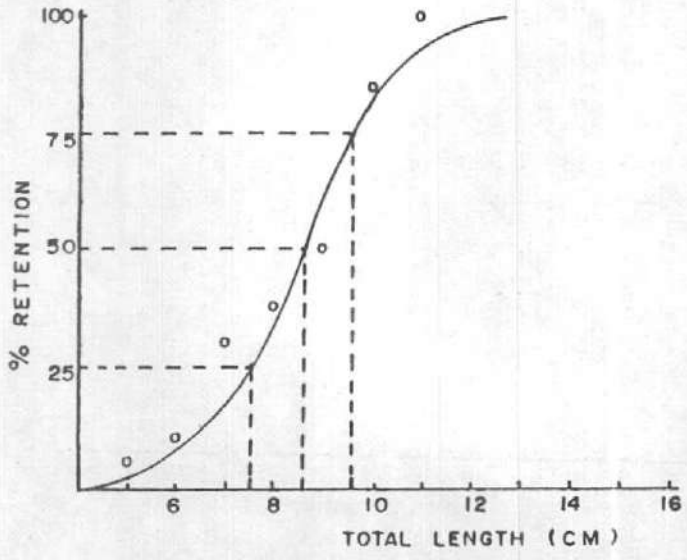


Fig.5 Selection ogive for Secutor insidator

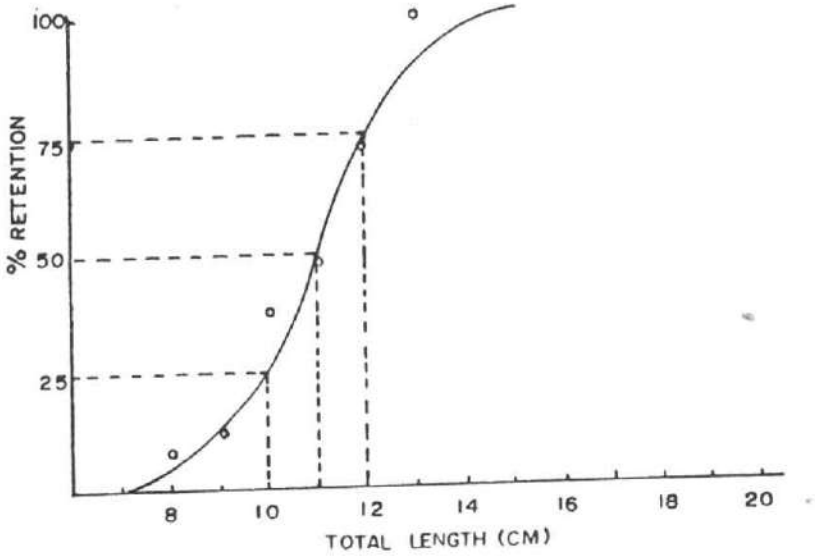


Fig.6 Selection ogive for Gerres setifer

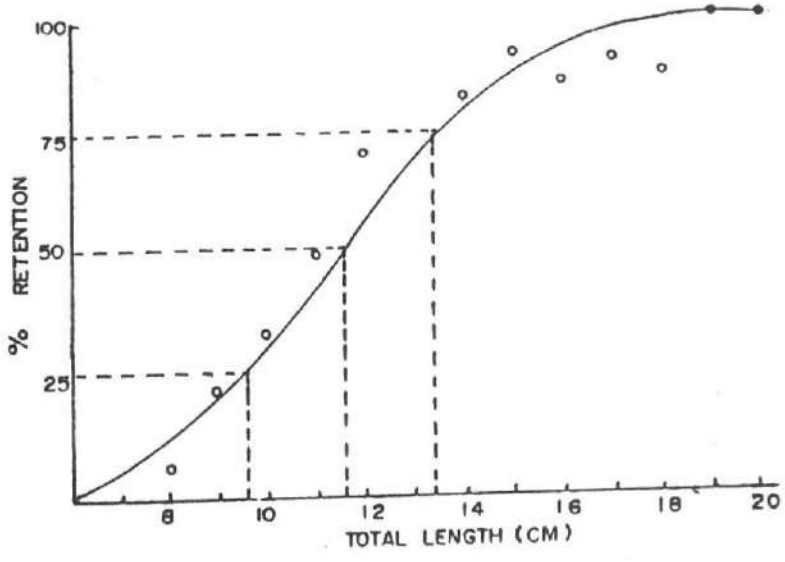


Fig.7. Selection ogive for Upeneus vittatus

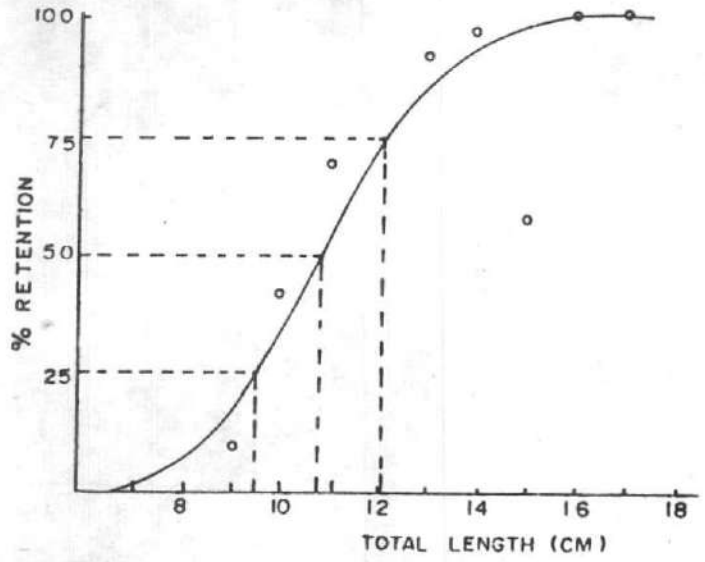


Fig.8 Selection ogive for Upeneus sulphureus

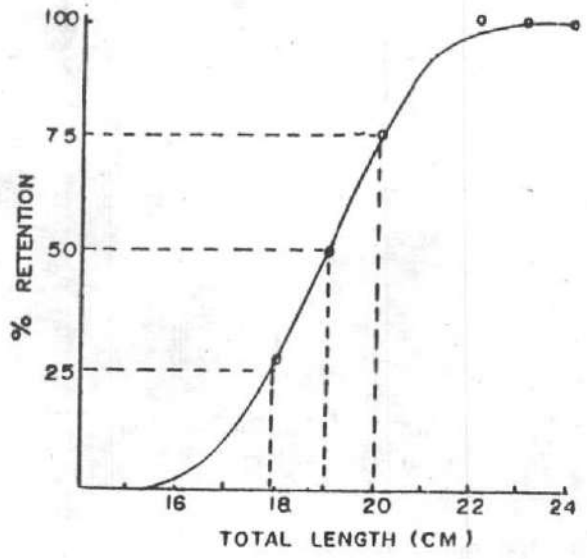


Fig.9 Selection ogive for Sphyraena obtusata

TUNA RESOURCES, COSTS AND EARNINGS FROM TUNA LONGLINERS

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Fishery Survey of India, Madras Base

INTRODUCTION

Fish catches from tropical, central and western Pacific in recent years have been completely dominated by the highly migratory tunas and billfishes. The contribution of Indian Ocean to the world tuna production of 2.8 million tonnes (1984) is 12.4%. Exploration and exploitation of the fishery resources in our waters over the past three decades have shown that the tuna resources consist of yellowfin tuna (**Thunnus albacares**), bigeye tuna (**T. obesus**), long tail tuna (**T. tonggol**), skipjack tuna (**Katsuwonus pelamis**), eastern little tuna (**Auxis rochei**), dog tooth tuna (**Gymnosarda unicolor**) and oriental bonito (**Sarda orientalis**). The tuna fishery in India was confined to shallow inshore waters contributed mainly by the last five species till the foreign chartered vessels were permitted to exploit tuna in our EEZ recently. In Lakshadweep Islands skipjack tuna and a small fraction of juvenile yellowfin tuna, which enter the surface waters, are caught by pole and lines and troll lines.

Though the proximity of our country to the resources facilitates profitable exploitation of the fishery, the growth of development is rather unsatisfactory even after the enactment of the laws of the seas (1976) and subsequent withdrawal of the foreign fleet from our EEZ.

POTENTIAL YIELD OF TUNA AND ALLIED RESOURCES

Availability of tuna and allied resources is not a constraint for the development of tuna fishery in India. According to Joseph (1972), Silas **et al.** (1979, 1982) Haruta (1983) and Sivasubramaniam (1985) tuna

and tuna-like fishes hold the greatest scope for the development of fishery in India. The estimates of potential yield of tuna and allied resources in the Indian Ocean as assessed by various authors are as follows:-

Potential yield estimates of tunas in the Indian Ocean ('000 tonnes)		Potential yield estimates of yellowfin tuna in Indian Ocean ('000 tonnes)	
Gulland (1971)	100-150	IOFC (1969)	30-35
IPFC/IOFC (1973)	115-137	IPFC/IOFC (1973)	30-35
Suda (1974)	123-131	Suda (1974)	35
IOFC (1977)	125	Wetheral **et al.** (1979)	43-45
Silas & Pillai (1982)	510-785	Suzuki (1979)	39
		FAO (1980)	40-60

In the Indian Exclusive Economic Zone the potential yield of larger tunas amenable to longline fishery in the south-west region was estimated as 25.1 thousand tonnes (Sudarsan **et al.,** 1988) and the aggregate oceanic tuna fishery potential in the EEZ as 246 thousand tonnes (Sudarsan **et al.,** 1990).

It is evident from the assessments of various authors that availability of tuna and tuna-like resources is not at all a constraint for entering into the commercial venture. However the fishing industry is yet to enter in a big way to the field of exploitation of tuna, tuna-like fishes and sharks. This is perhaps due to the fact that the economic feasibility of such ventures have not been worked out taking into consideration of the capital cost, cost benefit ratio, discounted cash flow technique and percentage of return. The present paper attempts to analyse these economic aspects as followed by Dwivedi (1980) and Rao and Anrose (1983) based on tuna resources of our EEZ.

DATA SOURCE AND METHODOLOGY

The log books and inspection reports of 14 chartered vessels, namely HIAO CHUN, KAO FONG-6, LIEN CHING YU-112, KIN SIN, CHIN LUNG YUN, YU CHAN, HAI FA, TAI CHIN, HSIN HUNG, TAI HSING-11,

KAO FONG-11, YUNG HAI, HUNGLI-212, HSIN YUAN-202 form the basis of this study. All the vessels were tuna longliners operating 2,500 to 3,000 hooks/day/vessel with 5 to 7 hooks/basket. The operational details are furnished in Table 1.

The data thus collected were pooled and aggregate hooking rate (%) are presented in 1° Lat. x 1° Long. on monthly basis (Fig. 1). For better understanding of the resource availability and the seasonal variations rate of hooking and catch composition by number and weight grouped under four geographic regions viz. north-west coast, south-west coast, east coast and Andaman & Nicobar Islands are presented in Fig. 2 and Table 2. From the total catches of 14 vessels, the average was worked out for a 36 m tuna longliner operating 2,000 hooks/day. The estimated average catch for the vessel per voyage of 30 days was 28.78 tonnes consisting of yellowfin 19.934 tonnes (69.26%), big-eye 0.245 tonnes (0.85%), skipjack 0.030 tonnes (0.11%), billfishes 1.871 tonnes (6.5%), sharks 6.648 tonnes (23.1%) and other fishes 0.051 tonnes (0.18%). Accordingly catch for 8 voyages has been projected. The whole catch is meant for export to Japan and the export value to be realised is US Dollars 1289834.2 as per rates given in INFOFISH, December 1990 (Table 3). The tuna longliner would require a capital investment of Rs. 2.65 crores. The specification and other particulars of vessel and gear are given in Annexure 1 and Fig. 3 and 4. SCICI's loan interest rate of 7.5% is taken for calculating the interest rate for the capital cost. The item-wise costs and earnings analysis is given below.

COSTS AND EARNINGS OF 36M TUNA LONGLINER

I. Capital investment

i)	Cost of vessel and engine	...	Rs.	2,50,00,000
ii)	Cost of longline gear with accessories	...		15,00,000
				2,65,00,000

II.A.Fixed costs (FC)

i)	Marine insurance for one year @ 1.5%	...	Rs.	3,75,000
ii)	Depreciation on the capital investment @ 10%			26,50,000
iii)	Interest on capital @ 7.5% per annum			19,87,500
iv)	Port dues, registration, transport to cold storage and harbour for export etc.	...		50,000
				50,62,500

B. Variable costs (VC)

i)	H.S.D. oil: 30,600 litres per voyage (main engine) @ Rs. 5.42 (85 litres/hour) for 30 days and Aux. engine 10,800 litres/voyage at the rate of 15 litres/hour for 30 days =(2,24,388 x 8 voyages)			... Rs.	17,95,104
ii)	Lub oil 360 litres for 30 days @ Rs. 24.11 =(8680 x 8 voyages)			...	69,440
iii)	Refrigerent/annum (stock)			...	35,000
iv)	Compressor oil, hydraulic oil, grease and other lubricants per annum			...	17,750
v)	Gear and accessories (Snood wire, sekiyama, hooks etc) per annum			...	50,000
vi)	Spare parts of main engine, auxillary engine, compressor etc. and electronic spares			...	2,00,000
vii)	Annual drydocking			...	3,00,000
viii)	Berth hire charges and fresh water per annum			...	25,000
ix)	Bait fish for 8 cruises (2.5 tons/cruise) - (Mackerel, Nemipterids, Decapterids, Squid etc.) @ Rs. 15/- per kg. 2,500 x 15 x 8			...	3,00,000
x)	Other sundry expenses			...	40,000
xi)	**Floating staff salary**				
	a) Skipper	(1)	@ Rs. 4000/- p.m.	4000	23400 x 12 =2,80,800
	b) Engineer	(1)	@ Rs. 3000/- p.m.	3000	
	c) Mate	(1)	@ Rs. 2500/- p.m.	2500	
	d) Engine Driver	(1)	@ Rs. 2000/- p.m.	2000	
	e) Cooks	(2)	@ Rs. 750/- p.m.	1500	
	f) Oil man	(2)	@ Rs. 850/- p.m.	1700	
	g) Deckhand	(8)	@ Rs. 1000/- p.m.	8000	
	h) Topass	(1)	@ Rs. 700/- p.m.	700	
			Total		31,13,094

B/F... Rs. 31,13,09 4

xii) **Messing allowance for 320 days**

1) Officers @ Rs. 30/day 4 x 30 x 320	... Rs. 38,400		
2) Crew @ Rs.25/day 13 x 25 x 320.	... 1,04,000	Rs.	1,42,400

xiii) **Sea allowance for 240 fishing days**

1) For Skipper & Chief Engineer @ Rs.120/day 2 x 120 x 240	Rs. 57,600/-		
2) For Mate @ Rs. 70/day 1 x 70 x 240	Rs. 16,800		
3) For Engine Driver @ Rs.30/day 1 x 30 x 240	" 7,200		
4) For other crew @ Rs. 20/day 13 x 20 x 240	" 62,400	Rs.	1,44,000

xiv) Ocean freight charges for export of 230 tons of tuna catches in 9 1/2 feet freight container of 15 tons capacity from Madras to Japan. @ USD 4650 = Rs. 86,025/container

1) Rate for 16 container = 16 x 86,025 -	Rs.13,76,400		
2) Bunker charges @ USD 120/Rs.2220 - Rs. 2,220 x 16 =	Rs. 35,520	Rs.	14,11,920
xv) Shore expenses		Rs.	1,00,000
		Rs.	49,11,414
FC + VC		Rs.	99,73,914

C. Estimated catch and value

Average catch per voyage = 28.78 tons

1) Yellowfin tuna	(kg)	19,934 x @ USD 6.43	1,28,175.62
ii) Big eye tuna	(kg)	245 x @ USD 9.8	2,401.00
iii) Skipjack	(kg)	31 x @ USD 0.98	30.38
iv) Bill fishes	(kg)	1871 x @ USD 5.68	10,627.28
v) Shark	(kg)	6648 x @ USD 3.00	19,944.00
vi) Others	(kg)	51 x @ USD 1.00	51.00
			1,61,229.28

	Total revenue for a cruise of 30 days	USD....		1,61,229.28
	Total revenue for 8 cruises	USD ...		12,89,834.2
	In Indian rupees @ Rs. 18.50/US Dollar		Rs.	2,38,61,932.00
D	Total income for 8 cruises (one year)	=	Rs.	2,38,61,932.00
E	Total annual cost for one year	=	Rs.	99,73,914.00
F	Revenue D-E	=	Rs.	1,38,88,018.00
G	Incentive to crew @ 40%	=	Rs.	55,55,207.20
H	Less - Provision for income tax at 50% of revenue after deducting incentive to crew	=	Rs.	41,66,405.50
I	Net Profit	=	Rs.	41,66,405.50
	Add depreciation	=	Rs.	26,50,000.00
				68,16,405.50

1. Cost benefit ratio for 1 year ... 0.683

2. Percentage return on capital employed for 1 year

$$\frac{\text{(Net income x 100)}}{\text{Total cost}}$$ 68.3

3. Gross profit for one year (income - variable cost) 1,89,50,518/-

4. Gross profit ratio for one year - $\frac{\text{Gross profit}}{\text{Net sales}}$ 0.794

5. Net profit ratio - $\frac{\text{Net profit}}{\text{Net sales}}$ 0.285

6. Pay out period - $\frac{\text{Total investment outlays}}{\text{Gross return per gross profit}}$ 1.39 yrs.

7. Discount present value = PV = $R1 \frac{1}{(1+r)}$

(Discount rate is 10%)

1st year	=	1,72,27,744
2nd year	=	1,56,61,586
Total value for 2 years, $R1 \frac{1}{(1+r)} + R2 \frac{1}{(1+r)}$		3,28,89,330

In fact the investment decisions, acceptance or rejection of the projects is based on net present value. The Net Present Value may

be defined as the difference between the present value and the cost of investment.

PV is	...		3,28,89,330
C	...		2,65,00,000
N P V = P V - C	...	+	63,89,330

DISCUSSIONS

The cost and earning analysis showed the cost benefit ratio of 0.683, Gross profit ratio for one year is 0.794 and the net profit ratio is 0.285. The project payout period worked out to be 1.39 years. The discount present value worked out by using the formula $PV = R1 \frac{1}{(1+r)}$ where the discount rate is 10%. Hence for the two years by using the formula = $R1 \frac{1}{1+r} + R2 \frac{1}{1+r}$ for obtaining PV = 3,28,89,330. In the investment decisions, acceptance or rejection of the project is based on the Net Present Value. The Net Present Value (NPV) is defined as the difference between the present value and the cost of investment. The Net Present Value (NPV) is highly positive (+ 6389330). It proves that the project is economically viable and worth taking. Therefore the fishing industries can readily go in for investment for harvesting the tuna and allied resources in our EEZ.

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Table 1. Operational details of 14 chartered tuna longline vessels

Sl. No.	Name of the vessel / O.A.L.(m)	Voyage period From	To	No. of hooks	Days out at sea	Days fished & sets operated	Total catch (tonnes)	Hooking rate(%)	Fish concentration & hooking rate for the voyage									
									Y.F. Tuna		Bigeye tuna		Skipjack		Bill fishes		Sharks	
									Weight (tonnes)	H.R. %	Weight (tonnes)	H.R. %	Weight (tonnes)	H.R. %	Weight (tonnes)	H.R. %	Weight (tonnes)	H.R. %
1.	HIAO CHUN(56.61)	1.9.89	2.2.90	292350	127	91	183.71	1.99	152.51	1.37	0.11	0.02	-	-	8.5	0.10	22.65	0.52
2.	KAO PONG-6 (54.85)	8.9.89	21.2.90	360000	167	120	118.80	1.14	74.50	0.67	-	-	-	-	20.56	0.13	23.74	0.33
3.	LIEN CHING YU-112 (49.88)	19.9.89	19.2.90	332800	145	109	126.43	1.16	86.82	0.76	0.42	0.004	-	-	13.61	0.09	25.58	0.31
4.	KIN SIN (42.9)*	20.10.89	21.3.90	321000	119	107	102.37	1.19	52.50	0.47	0.26	0.002	0.78	0.03	19.02	0.17	26.24	0.46
5.	CHIN LUNG YUN (57.91)	7.1.90	6.2.90	105400	42	34	30.91	1.09	14.35	0.44	1.35	0.04	-	-	3.67	0.08	11.54	0.56
6.	YU CHAN (47.80)	20.1.90	11.8.90	308000	205	154	193.77	1.84	105.04	0.76	15.45	0.13	0.33	0.07	28.63	0.31	44.32	0.58
7.	HAI FA (56.30)	17.3.90	30.8.90	34500	161	115	157.48	1.29	112.78	0.88	-	-	0.51	0.01	6.94	0.17	26.24	0.46
8.	TAI CHIN (56.30)	26.4.90	16.8.90	309000	106	102	221.88	1.57	143.39	1.06	-	-	0.28	0.02	12.96	0.07	65.25	0.42
9.	HSIN HUNG 101(47.80)	30.4.90	18.8.90	264000	120	87	168.66	2.02	122.46	1.34	0.04	-	0.37	0.02	9.63	0.11	36.16	0.55
10.	TAI HSING-11(56.30)	4.5.90	18.8.90	249200	105	98	150.30	1.85	112.10	1.34	-	-	-	-	1.65	0.02	36.55	0.49
11.	KAO FONG-11(54.85)	11.5.90	6.9.90	257600	124	92	190.03	2.11	144.74	1.42	-	-	-	-	7.90	0.11	37.39	0.58
12.	YUNG HAI (44.0)	30.5.90	6.9.90	184800	95	66	179.70	2.72	125.54	1.99	-	-	-	-	1.5	0.02	52.66	0.71
13.	HUNG LI 212(56.50)	10.7.90	31.8.90	162000	54	54	177.28	3.31	136.20	2.28	-	-	-	-	-	-	41.08	1.03
14.	HSIN YUAN-202(55.95)	20.7.90	29.8.90	104000	40	40	67.71	1.62	50.00	1.16	-	-	-	-	-	-	17.71	0.46

* Other fishes 3.57 tonnes (H.R.0.05%)

Table 2. Percentage composition of catch by weight and hooking rate (kg/1000 hooks) in the four regions of Indian EEZ obtained by the 14 chartered tuna longliners

Region	ANDAMAN & NICOBAR SEA		EAST COAST 9°N - 17°N		SOUTH-WEST COAST 6°N - 15°N		NORTH- WEST COAST 16°N - 22°N	
Species	% by wt	Wt/1000 hooks	% by wt	wt/1000 hooks	% by wt	wt/1000 hooks	% by wt	wt/1000hooks
YFT	61.39	312.00	54.38	273.00	31.19	152.90	73.91	464.00
BET	1.17	5.90	0.48	2.40	18.97	93.10	0.01	0.29
SKJ	0.07	0.35	0.16	0.80	0.33	1.60	0.09	0.60
MAR	3.88	19.70	6.30	32.00	5.15	25.30	2.36	15.00
SAI	2.82	14.30	2.99	15.00	15.84	77.60	1.49	9.30
SWD	5.56	28.00	5.84	29.00	2.74	13.50	0.08	0.50
SHR	25.11	127.40	29.32	147.00	25.78	126.50	21.92	137.70
OTH	-	-	0.53	2.61	-	-	0.14	0.87

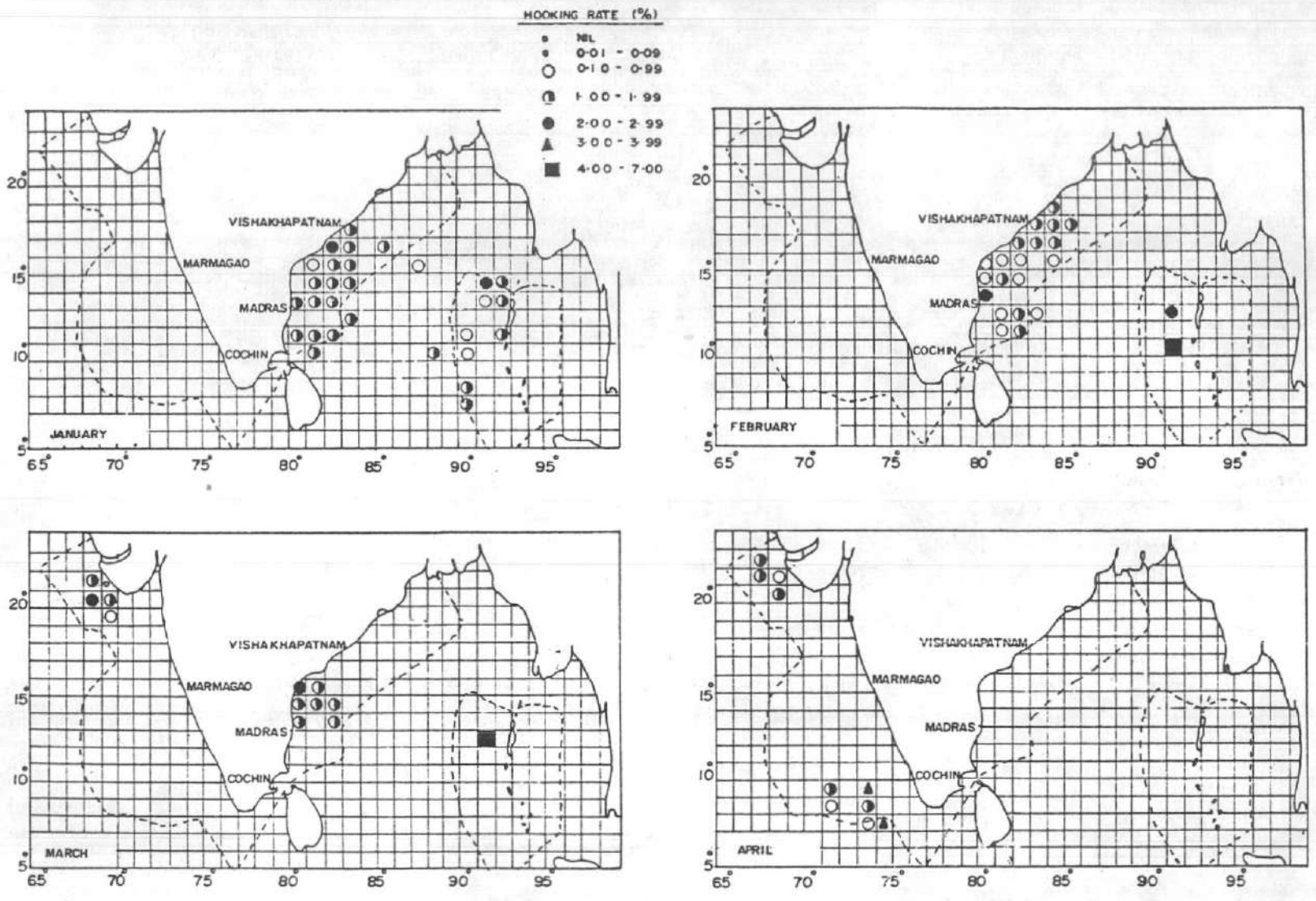
Note: YFT - Yellow fin tuna, BET - Big eye tuna, SKJ - Skip jack tuna, MAR - Marlin, SAI - Sail fish, SWD - Sword fish, SHR - Shark, OTH - Other fishes.

Table 3. Rates of different species in Japan/Singapore market

Fish species	Product form & Grading	Indicative Price In JPY/Kg Range	Indicative Price USD/Mt in Range (1 USD=132.15 JPY)	Average unit price in JPY/Kg	USD/Mt	USD/Kg	Rs/Kg (1 USD= Rs.18.50)	Price reference and Market area
1. Yellowfin Tuna	Frozen (G & G) Large	200-1500	1513-11,350	850	6431.5	6.43	118.96	Auction Tsukiji Market - Japan
2. Big eye Tuna	- do -	1300-6500	9837-49,186	3900	9,837*	9.8	181.30	- do -
3. Skipjack	Frozen-round	130	984	130	984	0.984	18.20	Shinizu Market, Japan
4. Bill fishes	Frozen	-	-	-	-	-	105.1**	Tokyo Central Market (Anon-1986)
i) Marlin Striped	"	1602	6149	812.6	6149	6.15	113.78	
Blue	"	601						
Other	"	235						
ii)Sword fish	Frozen	688	5206	688	5206	5.21	96.39	Tisuki Market & Shinizu Market,Japan
5. Shark	Fillet	-	2250 ***	-				
	Fin	-	25000 3000	-	3000	3.0	55.5	Singapore Market
	Skin	-	1650	-				
6. Others	Frozen	-	-	-	-	1.0	18.50	

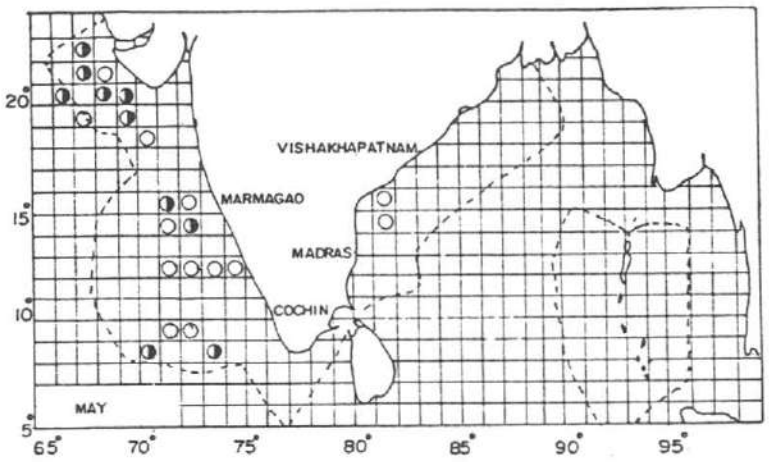
Source - INFOFISH Trade News 15 December 1990. No. 23/90

Note: * Lowest rate
** Average rate
*** Approximate rate



contd.

Fig. 1 Monthwise average hooking rate (in number) recorded by 14 chartered vessels in Indian EEZ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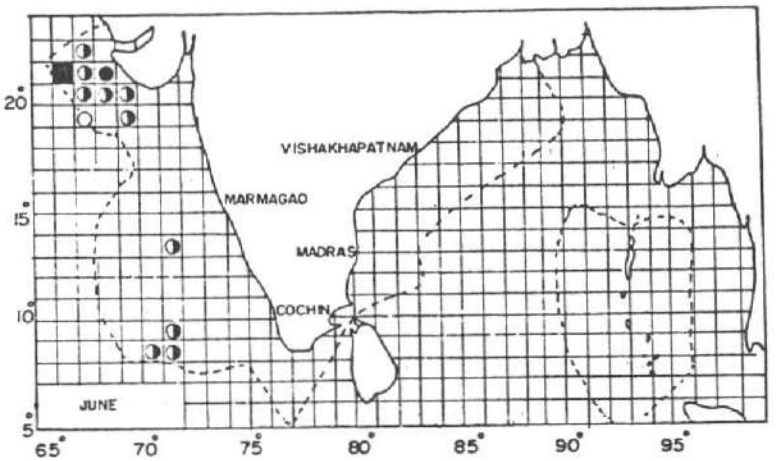
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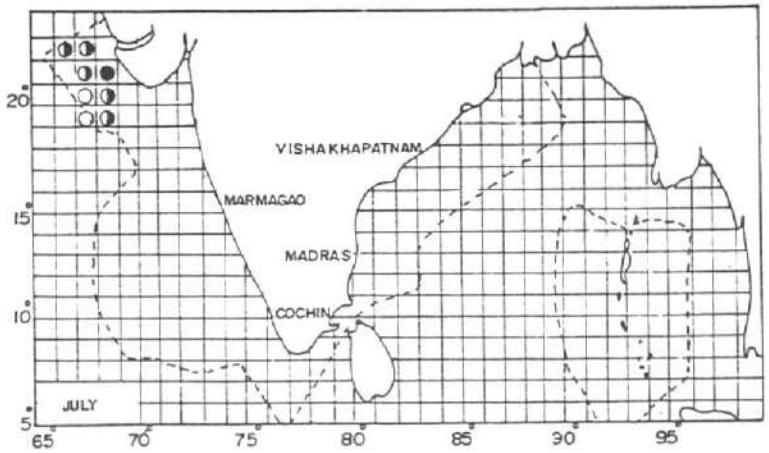
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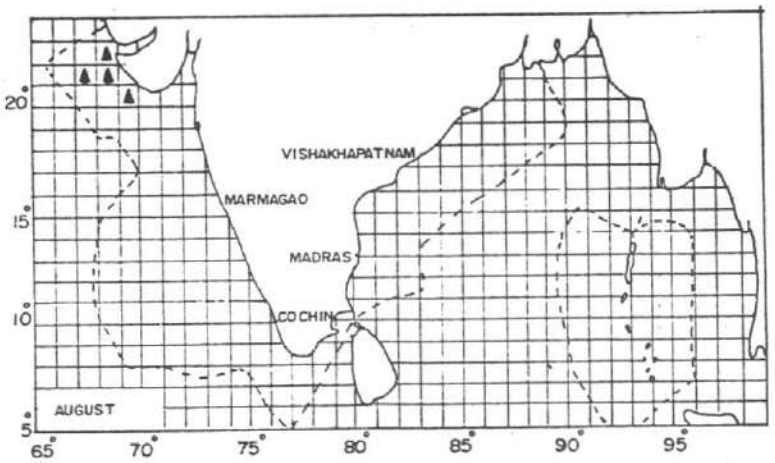
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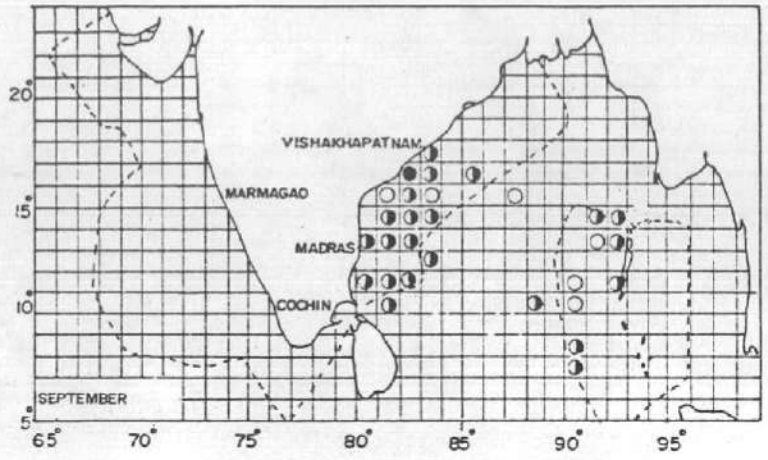
contd.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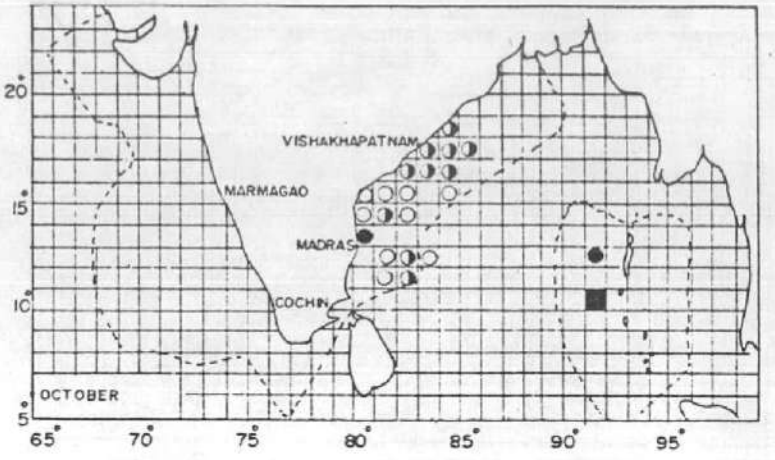
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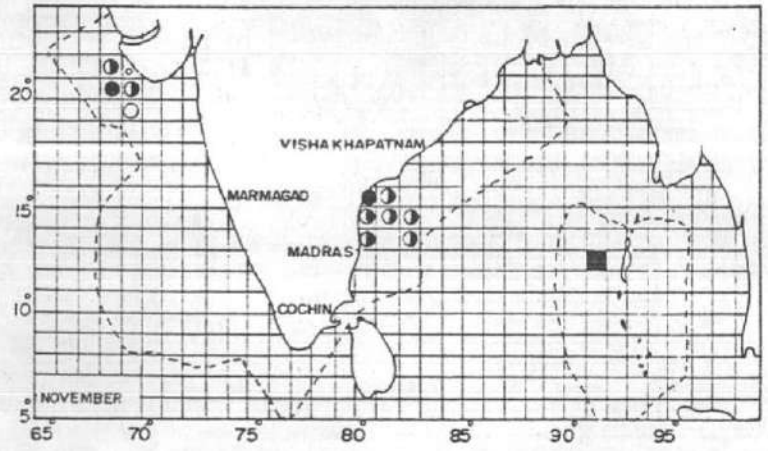
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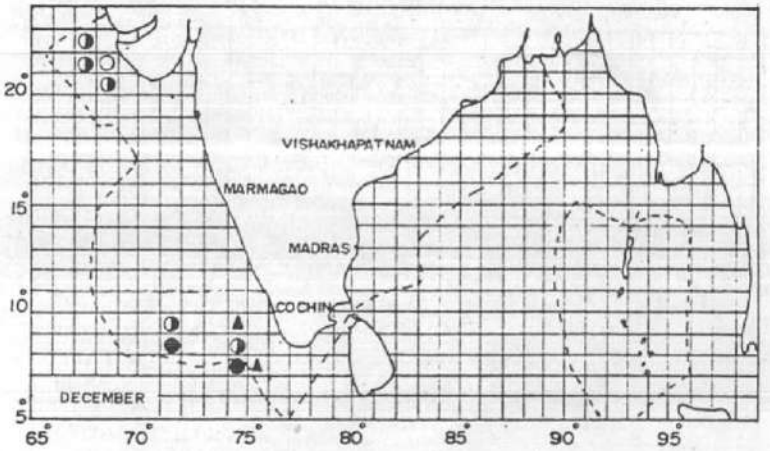
VISHAKHAPATNAM
MARMAGAO
MADRAS
COCHIN
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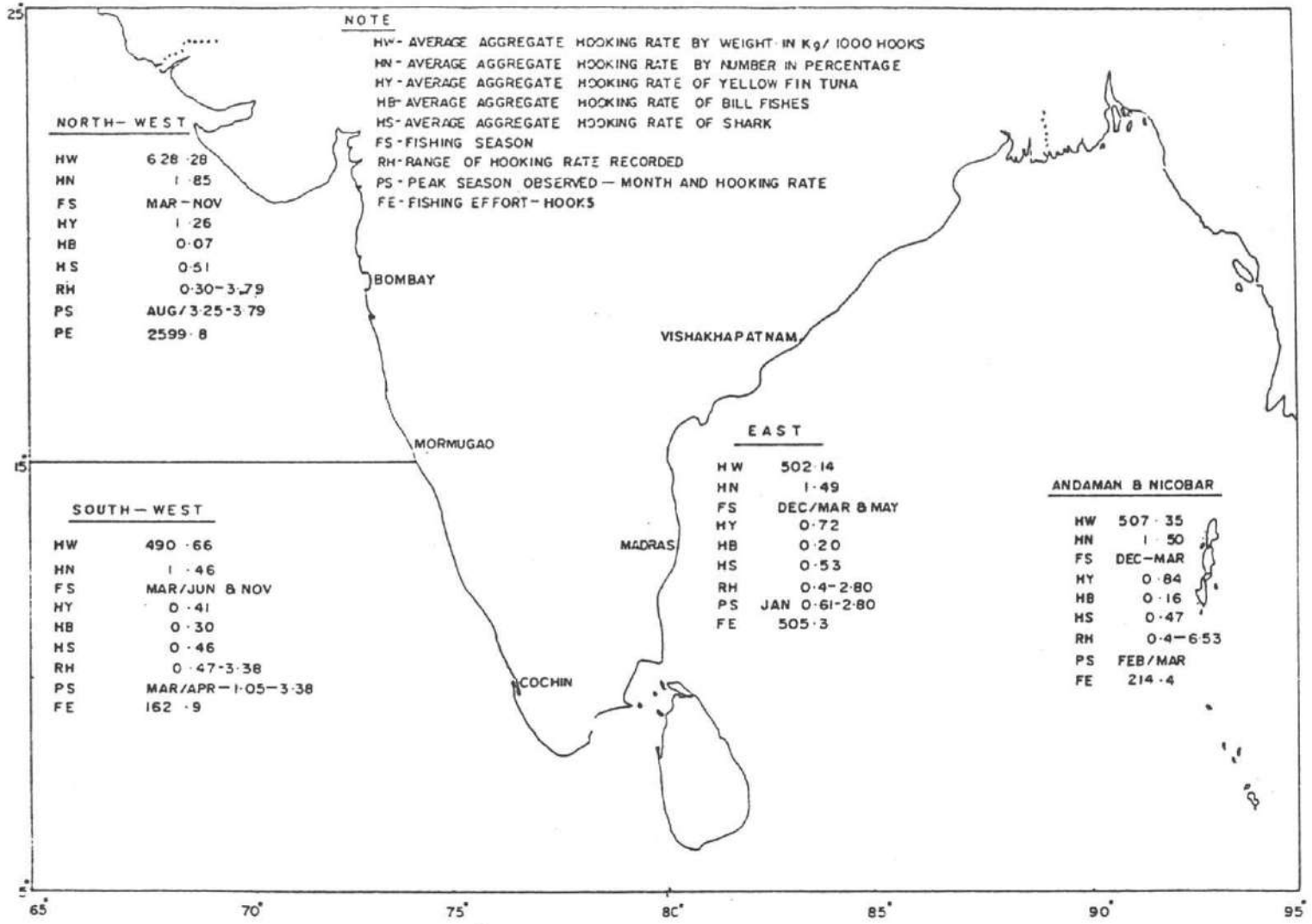


Fig. 2 Results of longline operation of 14 chartered vessels

CAPACITY & TONNAGE

LENGTH OVER ALL	ABT	36.00m
LENGTH BETWEEN PERPENDICULARS	ABT	31.00m
BREADTH MOULDED	ABT	7.40m
DEPTH MOULDED	ABT	3.20m
DESIGNED LOAD DRAFT	ABT	2.00m

CAPACITY

FISH HOLD	(BALE)	ABT 110.0m^3
FREEZING ROOM	(GRAIN)	ABT 55.0m^3
PREPARTION ROOM	(BALE)	ABT 28.0m^3
FUEL OIL TANKS	(100%)	ABT 120.0m^3
FRESH WATER TANKS	(100%)	ABT 50-60 m^3

GROSS TONNAGE (INTERNATIONAL REGULATION 1968) ABT 200 GT

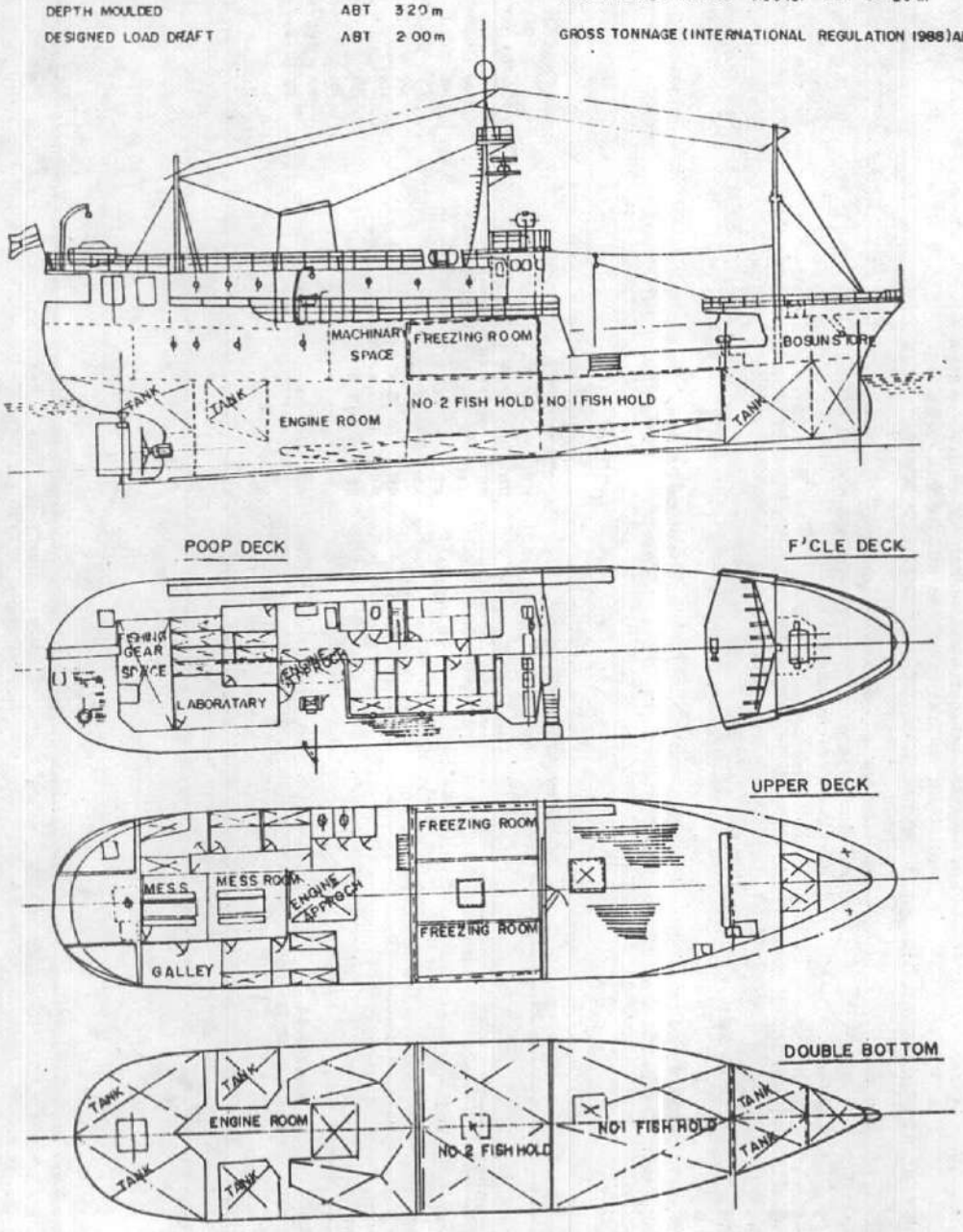
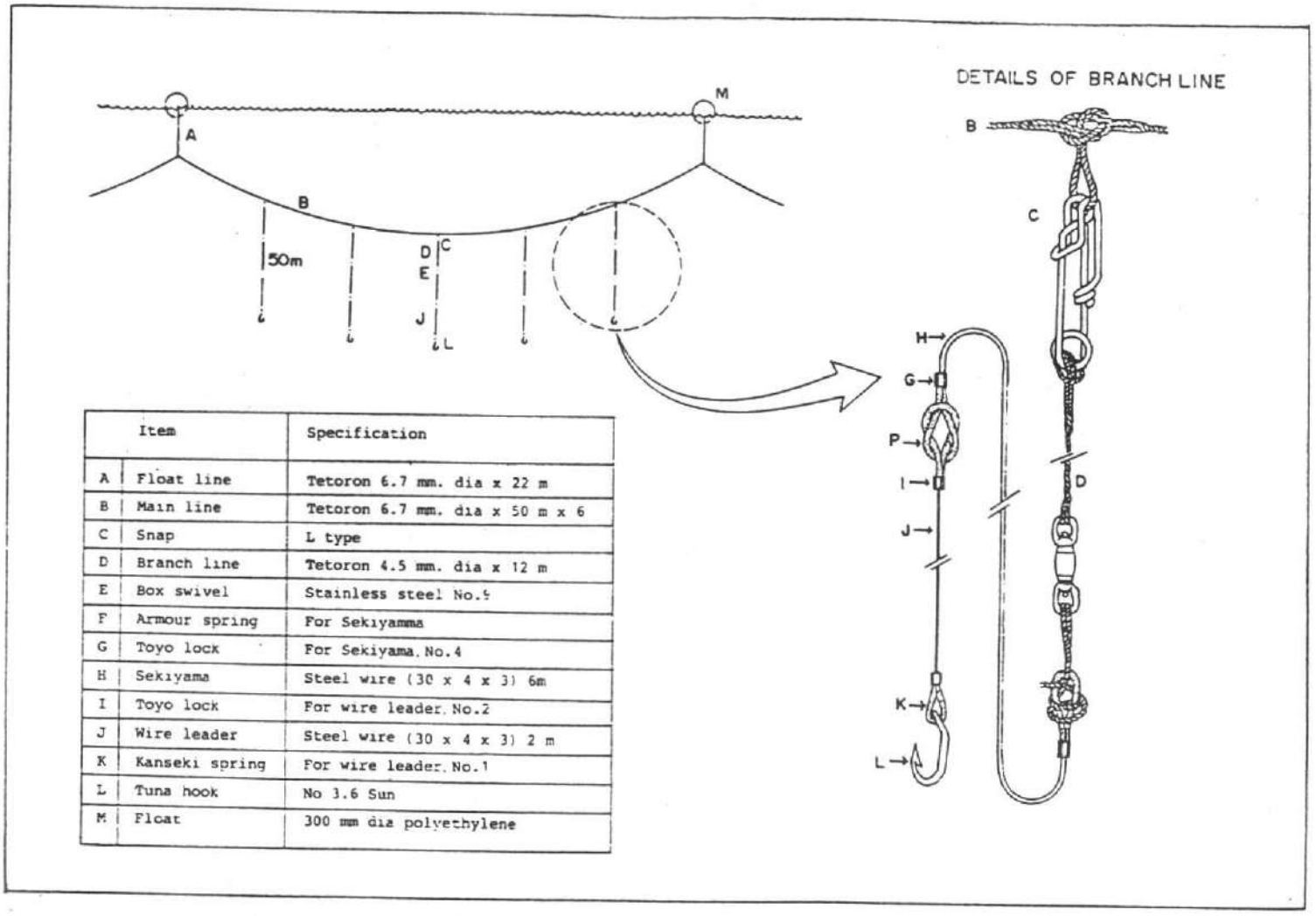


Fig. 3 Tuna long liner



	Item	Specification
A	Float line	Tetoron 6.7 mm. dia x 22 m
B	Main line	Tetoron 6.7 mm. dia x 50 m x 6
C	Snap	L type
D	Branch line	Tetoron 4.5 mm. dia x 12 m
E	Box swivel	Stainless steel No.4
F	Armour spring	For Sekiyamma
G	Toyo lock	For Sekiyama. No.4
H	Sekiyama	Steel wire (30 x 4 x 3) 6m
I	Toyo lock	For wire leader. No.2
J	Wire leader	Steel wire (30 x 4 x 3) 2 m
K	Kanseki spring	For wire leader. No.1
L	Tuna hook	No 3.6 Sun
M	Float	300 mm dia polyethylene

Fig. 4 Longline gear

ANNEXURE - I

VESSEL PARTICULARS

a) **Principal dimensions**

L.O.A.	36.00 M.
L.B.P.	31.00 M.
Breadth moulded	7.40 M.
Depth moulded	3.20 M.
Engine power	800 PS
Cruising speed	10-11 knots
Endurance	7,000 Nautical Miles
Gross Tonnage	310
Net Tonnage	93
Fish hold capacity	110 M^3 at -50°C
Freezing space	4 tonnes at -55°C
Fuel oil tank	120 M^3
Fresh water tank	60 M^3

b) **Fishing Machinery**

i) Line hauler ii) Line storage and line storage boxes
iii) Line throwing machine iv) Branch line reel
v) Belt conveyors vi) Guide roller, Guide fittings and guide pipe
vii) Hoist

c) **Navigational and fish finding equipment**

i) Gyro compass with Auto Pilot System ii) Radar
iii) Direction finder iv) SSB Radio Telephone v) VHF
vi) Satellite Navigator vii) Magnetic Compass
viii) Fish finder ix) Weather fascimile receiver etc.

d) **Tuna longline gear** specifications are shown in Fig. 4