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TUNA FISHERIES OF THE EXCLUSIVE ECONOMIC ZONE OF INDIA: Biology and Stock Assessment

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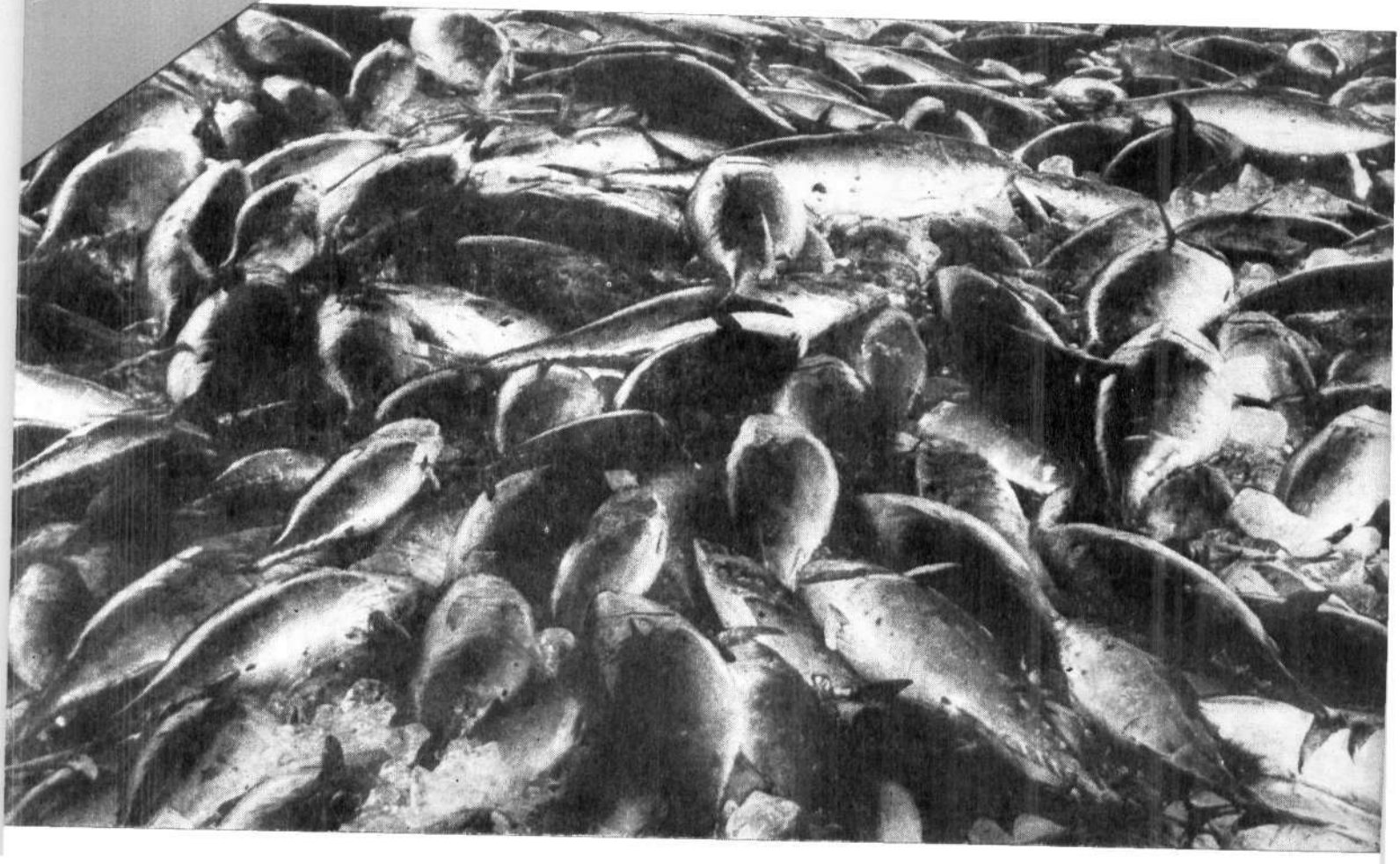

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
(Indian Council of Agricultural Research)
P.B. No. 2704, Cochin 682 031, India

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OBSERVATIONS ON THE FISHERY AND CERTAIN ASPECTS OF THE BIOLOGY OF YELLOWFIN TUNA, *THUNNUS ALBACARES* (BONNATERRE) TAKEN BY LONGLINE GEAR IN THE EEZ OF INDIA

E. G. SILAS, P. P. PILLAI, A. A. JAYAPRAKASH AND M. A. PILLAI
Central Marine Fisheries Research Institute, Cochin, 682 031

The two oceanic species of tunas that are exploited by India at present are the skipjack and yellowfin (mainly young ones) tunas. The distribution of yellowfin tuna in the area extends from the oceanic waters to the marginal range of neritic provinces, and the exploitation of this species is chiefly along the fringe of its distribution. In the case of the yellow fin tuna, the juvenile and immature fishes enter the surface fishery in the insular ranges and the adults are mainly confined to the sub-surface waters in the oceanic area where they contribute to the tuna longline fishery.

The present communication is based partly on the information available in the publications and partly on the results of observations on the fishery and biology of yellowfin tuna carried out by the authors on the long line catches from the oceanic waters of India. Some aspects of the biology of this species, estimated based on the data collected from the fishery by surface gears are also included in the text in order to facilitate comparison of biological parameters.

FISHERY

Recently, BOBP (1985) presented an estimation of the landings of yellowfiin tuna by the longline fishery by the Japanese, Taiwanese and Korean longliners from the waters close to India, Maldives and Sri Lanka for the years 1977-'82. Recent trend of the catch rate of this species is presented in Table 1.

TABLE 1. *Yellowfin tuna catches and their mean size, by the longline fishery from the area 0°-10°N ; 70°-80°E*

Area and particulars			1979	1980	1981	1982
0°-5°S	Hooks	(Nos)	971,916	176,500	464,800	290,800
70°-75°E	Catch	(Nos)	6,249	695	2,813	1,188
	HR	(%)	0.64	0.39	0.61	0.41
0°-5°N	Hooks	(Nos)	306,452	11,500	..	76,000
70°-75°E	Catch	(Nos)	3,007	33	..	52
	HR	(%)	0.48	0.29	..	0.07
0°-5°N	Hooks	(Nos)	1,232,134	423,971	136,700	499,500
75°-80°E	Catch	(Nos)	7,083	1,742	386	946
	HR	(%)	0.57	0.42	0.28	0.19
5°-10°N	Hooks	(Nos)	584,511	..	12,000	..
75°-80°E	Catch	(Nos)	8,821	..	..	..
	HR	(%)	1.50	..	..	..
Total Hooks		(Nos)	3,095,013	611,971	615,500	866,300
Total catch		(Nos)	25,160	2,470	3,199	2,186
HR		(%)	0.81	0.40	0.53	0.25
Mean size	(kg)		31.12	31.00	31.00	33.60

It is evident from the production rate presented in Table 1, that peak production of yellowfin tuna in commercial fishery was in 1979 (783 tonnes) which declined in the later years (1980=77 tonnes ; 1981= 99 tonnes ; 1982=73.4 tonnes).

The pioneering attempt by India to conduct exploratory longline fishery in the oceanic waters off the south-west coast of India (5°N-12°N) was during the period 1964-65. Fourteen fishing operations were conducted during the months of April, May, June, November and December in 1964 and in January in 1965. The fishery survey vessels '*M. T. Pratap*', '*Kalyani IV*' and *Kalyani V* which belonged to the erstwhile Deep Sea Fishing Organisation of the Government of India (present Fishery Survey of India) were employed for carrying out experimental tuna longline operations. The results of the operations including the effort expended, catch and hook-rate are presented in Table 6. Maximum percentage composition of yellowfin tuna in the area 5°N-12°N was recorded in the month of April (10.1) although high hook-rate was observed in December (2.45%) (Kawaguchi 1967).

M. V. '*Prashikshani*', the training vessel of the Central Institute of Fisheries Nautical and Engineering Training (CIFNET) commenced operation for training in longline fishery from January, 1981, mainly in the oceanic waters in the depth range of 2000-2500 m off Lakshadweep Islands. A brief account of the effort expended, total catch of tunas and by-catch taken during the operation of the vessel in the Lakshadweep Sea has been presented earlier (Pillai 1981). The areas of operation of M.V. '*Prashikshani*' and catch composition are presented in Figs. 5 and 6 (paper 3) and the total effort expended and catch of tunas, marlins pelagic sharks and other fishes during 1981 and 1982 are given in Table 6 (paper 3). In 1981, the effort expended (number of hooks) was high during the months March, April and May (500 hooks). Whereas in 1982, maximum effort was put in during January, July and October (200 hooks). The hook-rate of tunas in 1981 (698 Nos) was 1.43 per cent which was declined in 1982 (185 Nos) to 1.27 per cent. Yellowfin tuna constituted ninety per cent of the catch of tunas in both the years.

"*Matsya Sugundhi*", the survey vessels of the Fishery Survey of India conducted exploratory tuna longline operations under the 'Wadge Bank Programme' from 1981. The areas and results of surveys of this vessel during October to December, 1981 ; 1982 and 1983-84 are presented in Figs. 7-9 and Tables 7 & 8 (paper 3).

In 1983, operation of this vessel was in the waters close to the inshore region. Joseph (1984) briefly summarised the surveys conducted by '*Matsya* Sugundhi' during October, 1983 to March, 1984 in the Arabian Sea and Bay of Bengal. Five voyages were conducted by this vessel of 20-40 days duration, of which four were in the Arabian Sea between 8°N and 9°N and 68°E and 72°E. In the Bay of Bengal, the survey of 40 days period covered the area between 8° and 16°N. The catch from the equatorial area consisted of 85 per cent tunas (bigeye, yellowfin and skipjack) and from the east coast 53 per cent (yellowfin and skipjack tunas). Hook-rate upto 2.5 per cent was realised in the case of yellowfin tuna from the equatorial waters.

Varghese *et al.* (1984) presented in detail the total effort expended, catch and hook-rate of tunas and other fishes in the exploratory longline fishery surveys by '*Matsya Sugundhi*', during the same period from the south-west coast of India, equatorial waters and from the east coast. The aggregate percentage composition of yellowfin tuna in the total catch from the west coast was 2.03, from the east coast 43.82 and from the equatorial waters 73.62, and the respective hook-rates from the above three areas were 0.05 per cent, 0.96 per cent and 1.14 per cent.

Region-wise hook-rate of yellowfin tuna during the survey were as follows :

Area		Hook-rate (%)
8°-9°N.	74°-75°E	0.1
" " "	75°-76°E	0.1
" " "	76°-77°E	0.6
7°-8°N.	75°-76°E	0.3
5°-6°N.	68°-69°E	1.1
" " "	69°-70°E	0.6
4°-5°N.	67°-68°E	0.3
" " "	68°-69°E	0.6
" " "	69°-70°E	1.0
3°-4°N.	67°-68°E	0.0
" " "	68°-69°E	0.9
" " "	69°-70°E	0.4
2°-3°N.	67°-68°E	1.7
" " "	68°-69°E	1.5
1°-2°N.	68°-69°E	1.3
" " "	69°-70°E	2.5
0°-1°N.	68°-69°E	0.9

Sivasubramaniam (1985) observed that the longline catches of yellowfin tuna from the inshore waters of Sri Lanka were high during the north-east monsoon period. According to him, in the oceanic waters of

Sri Lanka the catch rates were high during the first quarter and first half of the second year. Catch rates rapidly declined during the second quarter in the area close to the equator. Peak catches were observed in the exploratory longline fishery survey from the oceanic waters of the south-west coast of India in November-December period. Maximum catch of young yellowfin tuna by the pole and line fishery at Minicoy was also recorded during the north-east monsoon period.

MORPHOMETRY

In the present study, data on the morphometric characters collected from 29 specimens of yellowfin tuna, ranging in length from 87.0 and 160.0 cm taken by the longline fishery from the oceanic waters of India in 1984 have been analysed and the summary results presented in Table 2. The regression of different morphometric characters on the fork length, and the correlation matrix of the characters of *T. albacares* are presented in Tables 3 and 4.

LENGTH COMPOSITION

Very little information is available on the length composition of yellowfin tuna from the oceanic waters around India. Silas *et al.* (1979) stated that the size range of this species caught along the south-west coast of India is 63-78 cm. In the Minicoy Island they were present in the live-bait pole and-line fishery in the size range 28-66 cm. Sivasubramaniam (1985) observed

TABLE 2. *Summary of morphometric data of* T. albacares (in cm) (N 29)

Characters	Maximum	Minimum	Mean	Standard deviation
Total length ..	160.0	87.0	106.067	22.35
Fork length ..	143.0	77.5	96.087	18.938
Standard length ..	133.0	73.0	89.203	17.390
Snout to eye ..	13.3	8.0	9.479	1.570
Eye diameter ..	4.2	3.1	3.595	0.877
Snout to D1 ..	38.0	24.0	28.431	4.374
Snout to pectoral ..	38.8	22.2	27.305	4.384
Height of pectoral ..	31.7	21.2	24.790	3.152
Base of pectoral ..	9.9	4.0	6.495	1.264
Height of D1 ..	18.1	9.0	11.528	2.374
Snout to D2 ..	73.5	43.0	50.954	8.710
Height of D2 ..	29.0	11.0	15.464	5.950
Base of D2 ..	12.0	5.6	7.867	1.516
Snout to anal ..	81.3	47.7	57.367	9.626
Height of anal ..	40.3	10.7	16.918	8.107
Caudal fork ..	50.0	26.0	32.446	7.717
Snout to pelvic ..	43.0	25.3	30.582	4,882
Length of pelvic ..	15.2	8.8	10.692	1.886
Girth ..	37.2	20.0	24.508	4.676

TABLE 3. *Regression of different morphometric characters on the fork length of* T. albacares (N. 29)

Characters	*a*-value	*b*-value
Total length ..	24.276	0.858
Standard length ..	7.987	0.852
Snout to Eye ..	2.344	0.075
Eye diameter ..	2.558	0.011
Snout to D1 ..	8.329	0.211
Snout to Pectoral ..	7.756	0.208
Height of Pectoral ..	10.761	0.147
Base of Pectoral ..	0.872	0.059
Height of D1 ..	0.396	0.115
Snout to D2 ..	10.679	0.422
Height of D2 ..	—12.600	0.302
Base of D2 ..	1.457	0.067
Snout to Anal ..	12.760	0.468
Height of Anal ..	—19.982	0.387
Caudal fork ..	—2.760	0.369
Snout to Pelvic ..	6.033	0.252
Length of Pelvic ..	2.179	0.089
Girth ..	3.240	0.223

TABLE 4. *Correlation matrix of various morphometric characters of* T. albacares

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
1.	Total length ..																		
2.	Fork length ..	+																	
3.	Standard length ..	+	+																
4.	Snout to eye ..	+	+	+															
5.	Eye diameter ..	0	0	0	0														
6.	Snout to D1 ..	+	+	+	+	0													
7.	Snout to pectoral ..	+	+	+	+	0	+												
8.	Height of pectoral ..	+	+	+	+	0	+	+											
9.	Base of pectoral ..	+	+	+	+	0	+	+	+										
10.	Height of D1 ..	+	+	+	+	0	+	+	+	+									
11.	Snout to D2 ..	+	+	+	+	0	+	+	+	+	+								
12.	Height of D2 ..	+	+	+	+	0	+	+	a	a	a	+							
13.	Base of D2 ..	+	+	+	+	0	+	+	a	+	a	+	a						
14.	Snout to anal ..	+	+	+	+	0	+	+	+	+	+	+	+	+					
15.	Height of anal ..	+	+	+	+	0	+	+	+	+	+	+	+	a	+				
16.	Caudal fork ..	+	+	+	+	0	+	+	+	+	+	+	+	+	+	+			
17.	Snout to pelvic ..	+	+	+	+	0	+	+	+	+	+	+	+	+	+	+	+		
18.	Length of pelvic ..	+	+	+	+	0	+	+	+	+	+	+	+	+	+	+	+	+	
19.	Girth ..	+	+	+	+	0	+	+	+	+	+	+	+	+	+	+	+	+	+

(Ranges of Correlation coefficients : 0=0.200-0.300 : 'a' = 0.800-0.899 : '+' = 0.900-0.999)

that the yellowfin tuna caught by pole-and-line fishery around Sri Lanka ranged from 20 to 145 cm (?) and from the Maldive area 20.5 to 56.5 cm. Joseph (1985) reported on the yellowfin tuna taken by the drift gillnet fishery around Sri Lanka in the size range 28-94 cm.

In the longline catches from the oceanic waters around India, the size of yellowfin tuna was observed to range from 50-170 cm (Fig. 1) indicating that the longline caught tunas are larger when compared to those taken by surface gears. Two distinct modes are discernible at 80 cm and at 120 cm fork length respectively.

The length-weight relationship collected from 210 specimens of yellowfin tuna taken by longline gear from the oceanic waters around India during the period 1982-1984 indicates that the relationship can be expressed by the regression :

$$W = 0.0001036\ L^{2.66410884}$$

However, in the live-bait pole-and-line fishery at Minicoy, Madan Mohan and Kunhikoya (MS) observed the length-weight relationship of yellowfin tuna (young ones) as follows :

Males : Log W = —10.751095 + 2.961902 LogL
Females : Log W = —11.137845 + 3.010763 LogL
Pooled : Log W = —11.036032 + 3.001012 LogL

Food of yellowfin tuna

Observations on the food of yellowfin tuna (males and females) taken by the longline fishery from the oceanic waters in November 1984 indicate that the pelagic crab (*Charybdis edwardsii*) was met with frequently in the food items of this species. The percentage composition of different food items (by volume) of the yellowfin tuna observed was as follows :

Items	Percentage composition
Teleosts	
Barracuda ..	2.60
Decapterus spp. ..	2.30
Priacanthus spp. ..	1.30
Puffer fish ..	0.40
Small tunas ..	14.10
Teleosts parts ..	18.70
Others ..	0.04
Crustaceans	
Crabs (*Charybdis edwardsii*)	58.50
Cephalopods	
Squids ..	2.10

Details regarding the size, stage of maturity, condition of the stomach and the food items of yellowfin tunas examined, and the number and volume of the food items are presented in Table 5.

The UNDP/FAO Pelagic Fishery Project (IND/593) reporting on their survey results for 1972/73 (*Progress Report No 6 :* Survey results 1972/73, IND 69/593, 141 pp. 1974) indicate the abundant occurrence of *Spratelloides japonicus* (*Anchoviella japonicus*) on the Angria Bank at 16° 30′ - 16° 40′ N "in August when they occurred in spawning aggregations". The size range was 25 to 80 mm and all fish are said to have "fully developed gonads and appeared to be spawning in this area at this time". Besides this species, the project survey found another excellent tuna bait fish, *Caesio* sp. on the San Pedro Bank further south. This is also indicative of the greater abundance of tunas along this belt. The recent results of the Fishery Survey of India (FSI) and the Central Institute of Fisheries Nautical and Engineering Training (CIFNET) longliner's catch of yellowfin tuna in good quantities along the Angria Bank and San Pedro Bank are highly significant. Heavy concentration of puffer fishes, another forage species for the yellowfin tuna has also been noticed during the October, Jan February period in this area. In Fig. 2 the distribution and abundance of yellowfin tuna seen from longline catches of the FSI and CIFNET Fishery Vessels is indicated to show the areas of very high hook rates around the San Pedro Bank.

No attempt has hitherto been made to investigate the age and growth parameters of yellowfin tuna taken by the longline fishery from the oceanic waters of India. However, based on the data collected from the *live-bait pole-and-line fishery* at Minicoy and Sri Lanka the following estimates are available :

Source	L_∞	Z	M	E
Present study ..	145	3.168	0.49	0.85
Sivasubramaniam (1985) ..	174	2.680	0.70	0.74

As opined by Silas and Pillai (1982), the development of surface fishery in the Indian Ocean may potentially increase the total production of yellowfin tuna from this area although it may reduce the abundance of this species in the longline catches. This trend needs close monitoring.

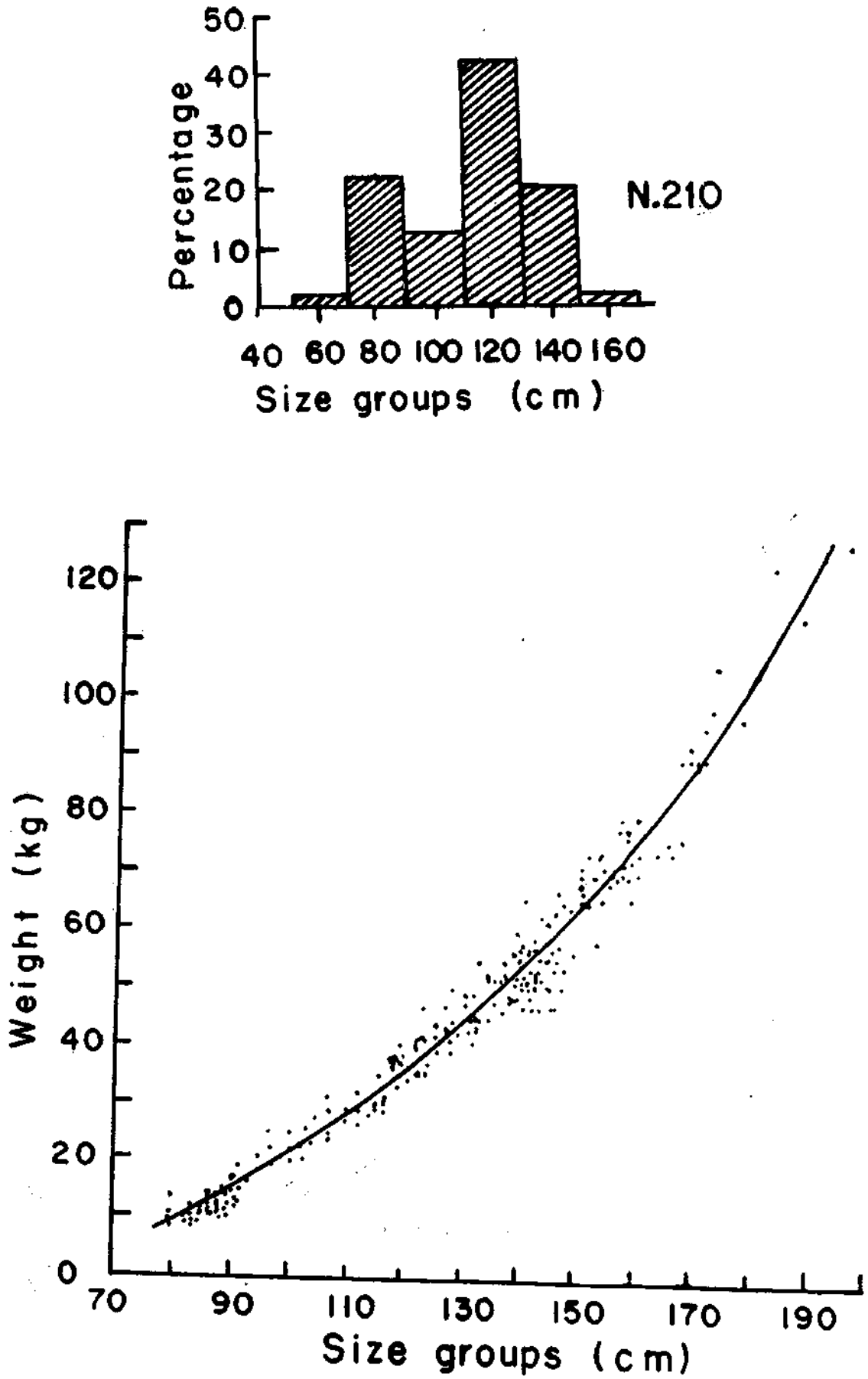

Fig. 1. Length frequency distribution (percentage) (upper) and length-weight relationship of *T. albacares* (lower) taken by longline fishery from the oceanic waters of the Indian Seas.

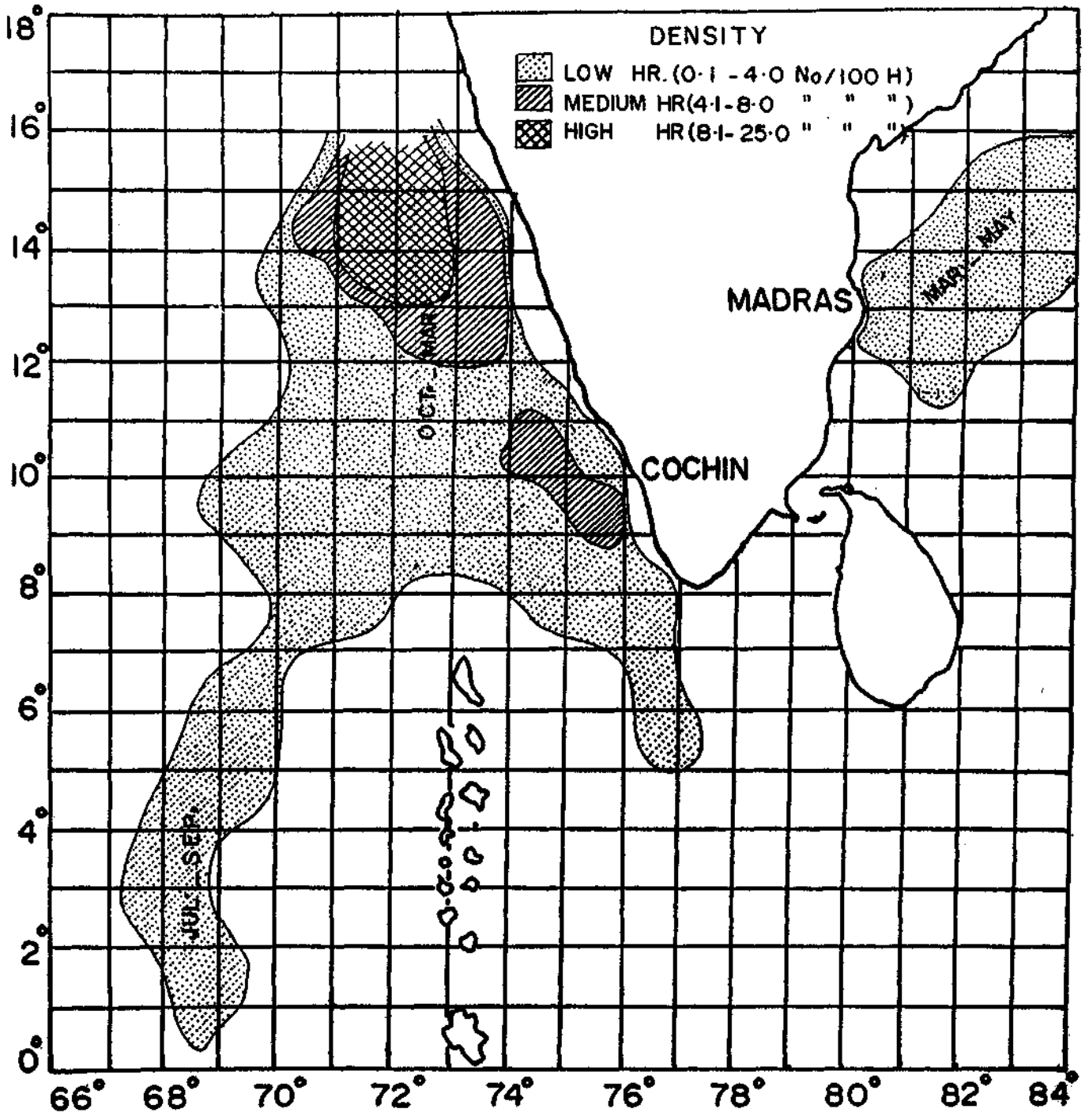

Fig. 2. Distribution and abundance of yellowfin tuna (*Thunnus albacares*) taken by longline fishery by CIFNET and FSI during the period 1981-85 (Courtesy : K. V. N. Rao and P. P. Pillai).

TABLE 5. *Food items of* T. albacares *in the tuna longline fishery* (November 1984)

Fork length (cm) (1)	Sex and stages of maturity (2)	Fullness of stomach (3)	Food items (4)	No. (5)	Volume (ml) (6)
			MALES		
78	M III	1/8	Teleost remains	..	50.00
78	M II	TR	Squids	3	8.00
82	M II	TR	Squids	1	3.00
82	M III	EM	..	..	..
86	M III	EM	..	..	..
78	M IV	EM	..	..	..
79	M IV	TR	Teleost parts	..	2.00
82	M IV	EM	..	..	..
83	M IV	1/8	Crabs	3	45.00
83	M IV	EM	..	..	..
84	M IV	TR	*Decapterus* sp. (digested)	1	30.00
86	M IV	EM	..	..	..
86	M IV	TR	Teleost parts	..	3.00
88	M IV	TR	Semidigested crabs and squids (parts)	..	5.00
89	M IV	TR	Teleost parts	..	15.00
89	M IV	TR	Teleost parts	..	12.00
89	M IV	TR	Squids	3	10.00
91	M IV	1/8	Semidigested teleosts	..	55.00
91	M IV	TR	Teleost parts and squids	..	4.00
94	M IV	EM	..	..	..
115	M IV	1/4	Crabs	11	200.00
115	M IV	TR	Crabs and teleost parts	..	..
117	M IV	EM	..	..	..
91	M V	EM	..	..	..
93	M V	1/4	Semidigested tuna	1	100.00
133	M V	1/2	Semidigested tuna	1	500.00
136	M V	TR	Crab	1	25.00
137	M V	EM	..	..	17.00
139	M V	EM	..	..	..
140	M V	1/4	Barracuda (Semidigested)	2	200.00
140	M V	1/8	Semidigested fish	..	15.000
140	M V	1/8	Crabs	5	80.00
141	M V	1/4	Crabs	21	300.00
141	M V	3/4	Crabs	46	750.00
141	M V	3/4	Crabs	41	600.00
			Squids and teleost parts	..	11.00
141	M Spent	1/2	Crabs	22	400.00
142	M V	1/8	Crabs	5	180.00
147	M V	1/2	Crabs	16	320.00
			Squids and teleost parts	..	12.00
149	M Spent	1/8	Crabs	7	100.00

(1)	(2)	(3)	(4)	(5)	(6)
			FEMALES		
68	F III	1/4	Squids	3	50.00
79	F III	EM	..	..	..
82	F IV	EM	..	..	..
84	F IV	1/8	Pufferfish	1	28.00
84	F IV	TR	Squids	4	18.00
85	F IV	EM	..	..	..
85	F III	EM	..	..	..
86	F IV	TR	Squids and teleost parts	..	4.00
86	F IV	EM	..	..	..
86	F IV	TR	Squids and teleost parts	..	4.00
86	F IV	TR	Teleost parts	..	3.00
87	F III	TR	Small squids	3	10.00
87	F IV	EM	..	..	..
87	F IV	TR	Semidigested crabs	..	10.00
87	F IV	EM	..	..	..
88	F IV	TR	Teleost parts	..	20.00
88	F III	TR	Teleost parts	..	3.00
89	F IV	TR	Teleost parts	..	25.00
89	F IV	TR	Teleost parts	..	2.00
89	F IV	TR	Semidigested squids	..	5.00
89	F IV	EM	..	..	..
90	F IV	EM	..	..	..
91	F IV	1/8	*Decapterus* sp. (semidigested)	1	95.00
107	F Spent	EM	..	..	..
112	F Spent	1/2	Semidigested teleosts	3	400.00
117	F Spent	1/2	Semidigested small tuna	1	300.00
118	F Spent	1/2	Crabs	11	
			Squids and small tunas		408.00
123	F IV	Crabs		4+2	70.00
		1/8	Squids and teleost parts		10.00
128	F IV	1/2	Semidigested teleost	1	350.00
132	F IV	Full	Squids	2	900.00
			Priacanthus sp.	1	100.00

(EM—empty., TR—trace)

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