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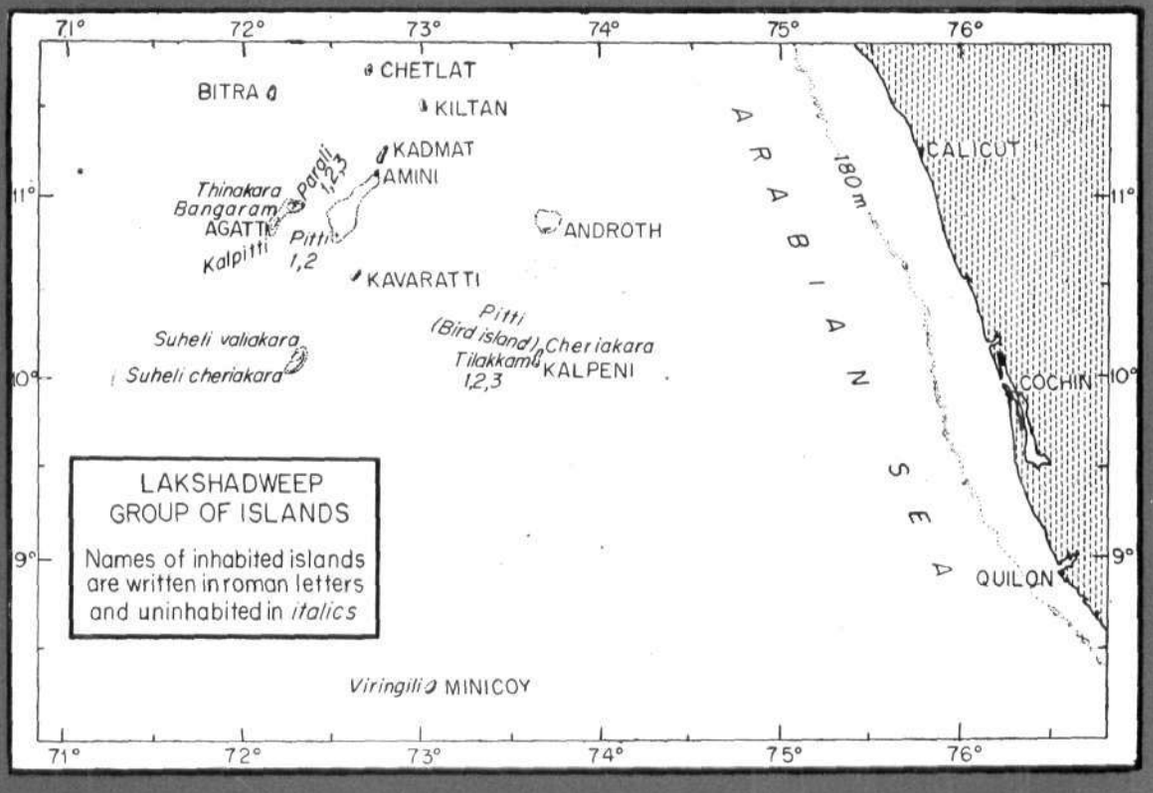

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EXPLOITED AND POTENTIAL RESOURCES OF TUNAS OF LAKSHADWEEP

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Introduction

Oceanic species of tunas such as skipjack *(Katsuwonus pelamis)* and yellowfin tuna *(Thunnus albacares)* constitute the major tuna resources taken from the Lakshadweep waters from September–October to May every year. They are being exploited from these islands by pole and line fishery with live-baits (Silas and Pillai, 1982). At Minicoy, an organised fishery for tunas is in vogue for a number of years, and from 1960 onwards pole and line fishing has been adopted in the other islands of Amini group with the introduction of mechanised boats. In seventies, the traditional tuna fishing boat ('odums') were replaced by mechanised boats fitted with live-bait tanks. Thus tuna fishing which plays a major role in the economy of the Lakshadweep became popular.

The total tuna catch in the Lakshadweep Is. and the all India total tuna landings during the period 1970–'84 is presented in Fig. 1. It is evident that the total catch has increased considerably from 571 tonnes in 1970 to 4,101 tonnes in 1984. Island-wise tuna catch data and the number of mechanised boats (25' and 30')

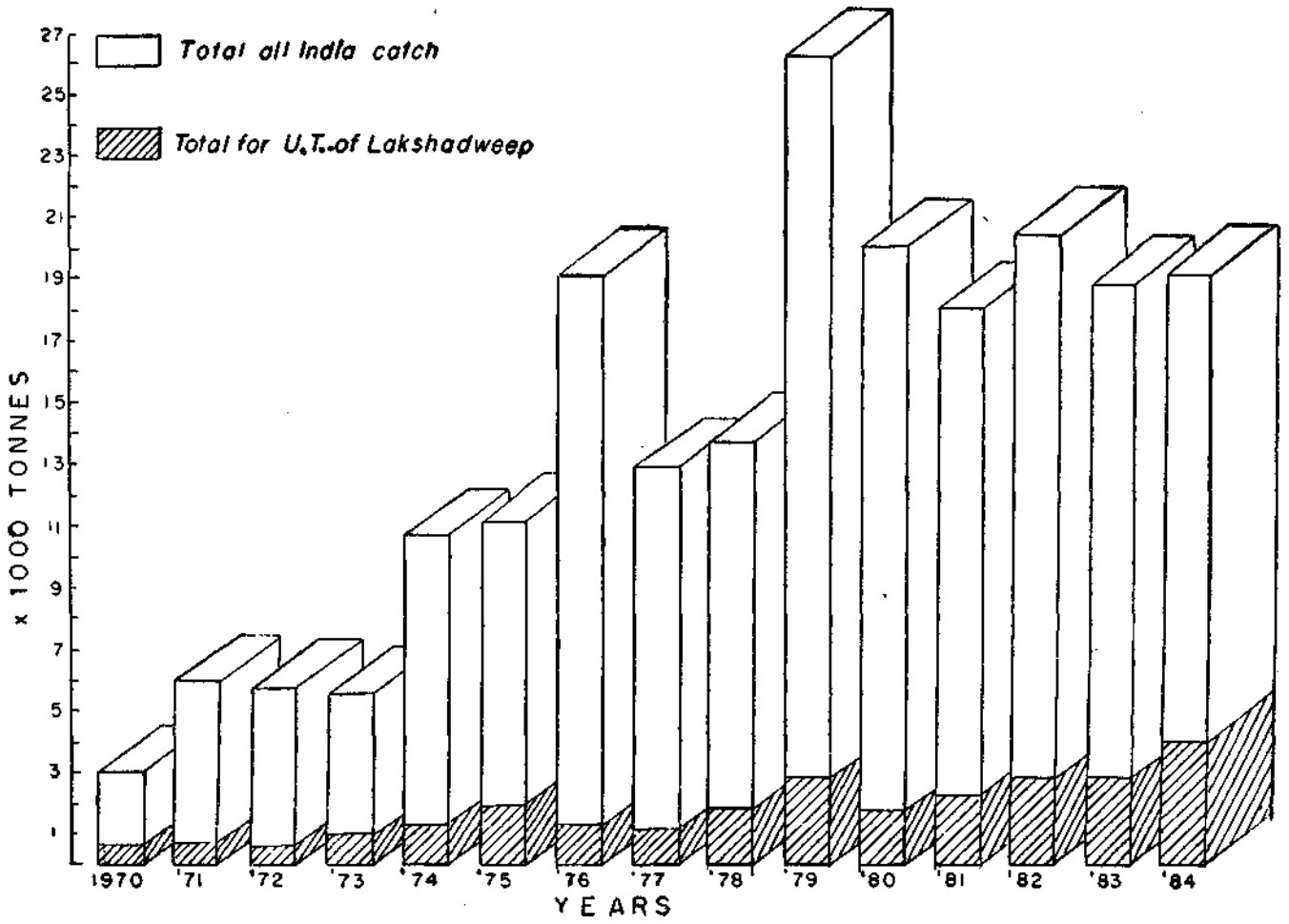

Fig. 1. Total tuna catch in the Lakshadweep and the total all India tuna landings for the years 1970-'84.

available during the period 1978–'83, are presented in Table 1. Increase in the number of mechanised boats in the tuna fishery is evident from 1978 and concomitantly catch has also increased to a considerable extend.

Detailed information on the catch, effort, species composition, biology and population dynamics of tunas are available from the Minicoy Island and hence the information presented here are based on the data collected by CMFRI from this area.

The pole and line fishery for tunas at Minicoy Island has earlier been reported by Hornell (1910), Ellis (1924), Mathew and Ramachandran (1956), Jones (1958, 1960a, 1960b, 1964a, 1964b), Jones and Kumaran (1959), Thomas (1954), Varghese (1971), Puthran & Pillai (1972), Ben-Yami (1980), Silas and Pillai (1982) and Madan Mohan *et al.* (1985). There has been a changing pattern in the pole and line fishery in this island through these years. The traditional tuna boat of Minicoy (*'Mas-odi'*) is now replaced by small mechanised boats equipped with live-bait tanks which has resulted in the improvement of the catches. This increase in catch has not created any problem for disposal due to the demand for the traditionally cured fish *'Mas min'* and also due to tuna canning factory at Minicoy.

Craft and gear

The details of pole and line boat, pole and line gear, the bait fish net and bait fish basket are described by Silas and Pillai (1982).

Operation

Fishermen start from their base by 0600 hrs for live-bait fishing in the lagoon. The number of crew range from 10 to 15. The area of the lagoon from where live-baits have to be fished and the mesh size of the bait-fish

Table 1. *Island-wise and year-wise production (in tonnes) of tuna in Lakshadweep*

Year	Name of the Island											Annual total tuna landing (mt)
	Agatti	Amini	Androth	Bitra	Chetlat	Kadmat	Kalpeni	Kava-ratti	Kiltan	Minicoy	Suheli	
1978	899	64	173	92	36	49	21	211	19	311	—	1875
1979	1314	72	303	118	116	100	62	207	86	415	—	2793
1980	490	46	179	104	33	43	27	150	54	643	—	1759
1981	820	81	196	126	38	37	41	395	24	485	—	2236
1982	550	77	243	345	148	38	63	150	102	427	823	2966
1983	731	53	283	166	96	36	59	164	55	273	1121	3037
Annual Average	801	66	230	159	78	50	45	213	57	426	972	3097
No. of Mechanised fishing boats (25' and 30')												
1978	29	14	16	6	9	12	7	16	9	27	—	145
1979	31	17	21	8	12	14	11	21	12	29	—	177
1980	35	18	24	9	13	14	12	25	13	30	—	194
1981	35	18	24	9	13	14	12	25	13	31	—	223
1982	40	22	29	10	15	14	13	30	16	31	—	223
1983	49	29	33	10	17	16	14	37	22	36	—	263

net to be operated depend on the species of live bait available at that time. Normally by about 0900 hrs sufficient quantity of live bait will be collected. Then they go out of the lagoon scouting for tuna shoals. Once a shoal is sighted it is approached, chummed and fished. If the live-bait fishing, scouting and chumming are quick, they return to the shore by noon with good catch. Then they unload the catch and again go for bait fishing for a second trip. On the other hand, if the fishing is not successful scouting for tuna shoals may continue till dusk and they return to the shore. The remaining live-bait fish will be stored in the bait baskets floated in the lagoon.

Production

The catch of tunas, standard effort and catch per standard effort during 1976–'85 are given in Table 2.

The catch per standard effort was high during the period 1970–'80, and during the subsequent years it fluctuated between 242 to 334 kg. From Table 2 it is evident that the effort has also increased from 1,060 to 2,422, but the C/SE has not indicated any increasing trend.

Table 2. *Catch, SE and catch per standard effort of tunas at Minicoy* 1976 *to* 1984–'85

Year	Catch (tonnes)	SE	C/SE (kg)
1976	312	1603	194
1977	355	1060	335
1978	539	1317	409
1979	509	1145	445
1980	687	1338	514
1981	327	1176	278
1981–'82	321	1241	258
1982–'83	371	1112	334
1983–'84	343	1370	250
1984–'85	569	2422	•235

Biology

Species composition of tuna

Data on pole and line catches indicate that skipjack tuna, *Katsuwonus pelamis* contributed bulk of the tuna catches, while in the troll line catches, always yellowfin tuna, *Thunnus albacares* dominated. During 1980–'81 season *K. pelamis* contributed 78.4% of total tuna catch

followed by 21.31% of yellowfin tuna and stray catches of *Auxis rochei* and *Euthynus affinis* (0.25%). During 1982-'83 season skipjack tuna formed 91.4% followed by yellowfin tuna (8.54%) and *A. rochei* and *E. affinis* (0.06%). In 1983-'84 season skipjack dominated the catch by contributing 84.9% followed by yellowfin tuna (15.0%) and *E. affinis* and *A. rochei* (0.1%). During 1984-'85 season the most abundant tuna was skipjack (93.7%) followed by yellowfin tuna (6.2%), *A. rochei* and *E. affinis* (0.1%).

Size composition of tunas

Studies on the size composition showed that during 1981-'82 season, fork length of the skipjack tuna ranged from 270-669 mm with size group 470 mm to 530 mm dominating in the pole and line catch. For yellowfin tuna the length of fish ranged from 300 - 1,380 mm while the size group 460 - 540 mm dominated the catch. During 1982-'83 season the length of *K. pelamis* ranged from 280 - 680 mm while the size group 460 - 570 mm dominated in the catches. For *T. albacares* the length ranged from 250 - 1,120 mm and the size group 400 - 550 mm were predominant in the catches. During 1983-'84 season the length of *K. pelamis* ranged from 242 - 680 mm while the size group 460-580 mm dominated. For *T. albacares* the length ranged from 230 - 1,150 mm while the size group 500-600 mm dominated. During 1984-'85 season the skipjack tuna were taken over a wide range of size from 300-720 mm and the dominant group was at 530-630 mm. For yellowfin tuna the size ranged from 310-1,009 mm and bulk of the catches consisted of fish in the length range of 560-600 mm.

Length-weight relationship of K. pelamis *and* T. albacares

440 specimens of skipjack and 134 specimens of yellowfin tunas were collected from Minicoy fish landing centre and data obtained were analysed. Regression equations for both the species were calculated for males and females separately. Testing for significance difference between regression equations of both the sexes were performed for both species. In both species regression lines for males and females were found coincidental. Therefore data for males and females were pooled together for both species and common regression equations were derived.

For skipjack tuna

$$\text{Log } W = -5.80855 + 3.39301 \text{ Log } L$$

For yellowfin tuna

$$\text{Log } W = -11.036032 + 3.001012 \text{ Log } L$$

Age and growth studies of K. pelamis *and* T. albacares

For skipjack tuna, based on the monthly length-frequency analysis and monthly progression of modes, lengths of 1, 2 and 3 years old skipjack were estimated as 360 mm, 564 mm and 682 mm respectively. By applying Von Bertalanffy's Growth Equation for the one year old skipjack the size observed was 367 mm, for two years old 573 mm, for three years old 690 mm and for four years old 777 mm. The monthly growth rates for four years were as 30.58 mm, 17.16 mm, 9.75 mm and 7.25 mm respectively.

Based on monthly length-frequency analysis the progression of modes length of one and two years old yellowfin were estimated as 500 mm and 780 mm. By applying Von Bertalanffy's Growth Equation, length upto seven years was 506, 769, 952, 1,088, 1,187, 1,259 and 1,311 mm respectively with monthly growth rate for seven years as 42.16 mm, 21.91 mm, 15.25 mm, 11.33 mm, 8.25 mm, 6.00 mm and 4.53 mm respectively.

Spawning biology

One of the important technical approaches to investigate the resource characteristics of oceanic skipjack tuna, *Katsuwonus pelamis* which forms 70 to 90% of the tuna catches of Minicoy, was to study the phases of its life history. The main aspects covered were maturity, sex ratio, spawning season and frequency of spawning and fecundity.

Maturity: For this study data collected during the calendar year 1981 and 1982 were analysed. Data revealed that fishes of all seven stages of maturity were available in the catches at Minicoy. Development of ova to maturity was traced for all the seven stages. The frequency distribution of ova diameter measurements from ripe and spawning ovaries of skipjack revealed that this species spawned more than once in a year at Minicoy.

Sex ratio: Ratio of males to females was found as 1:1.18 for the year 1981 and 1:0.98 for the year 1982. For both the years together, females dominated over males but not very significantly. Monthly variations in sex ratio was observed during both the years.

Spawning: Data on the maturity of skipjack over two successive years were analysed which revealed that fishes of various maturity stages were present in any month of the year. When female fishes were divided into three major categories i.e. immature, maturing and

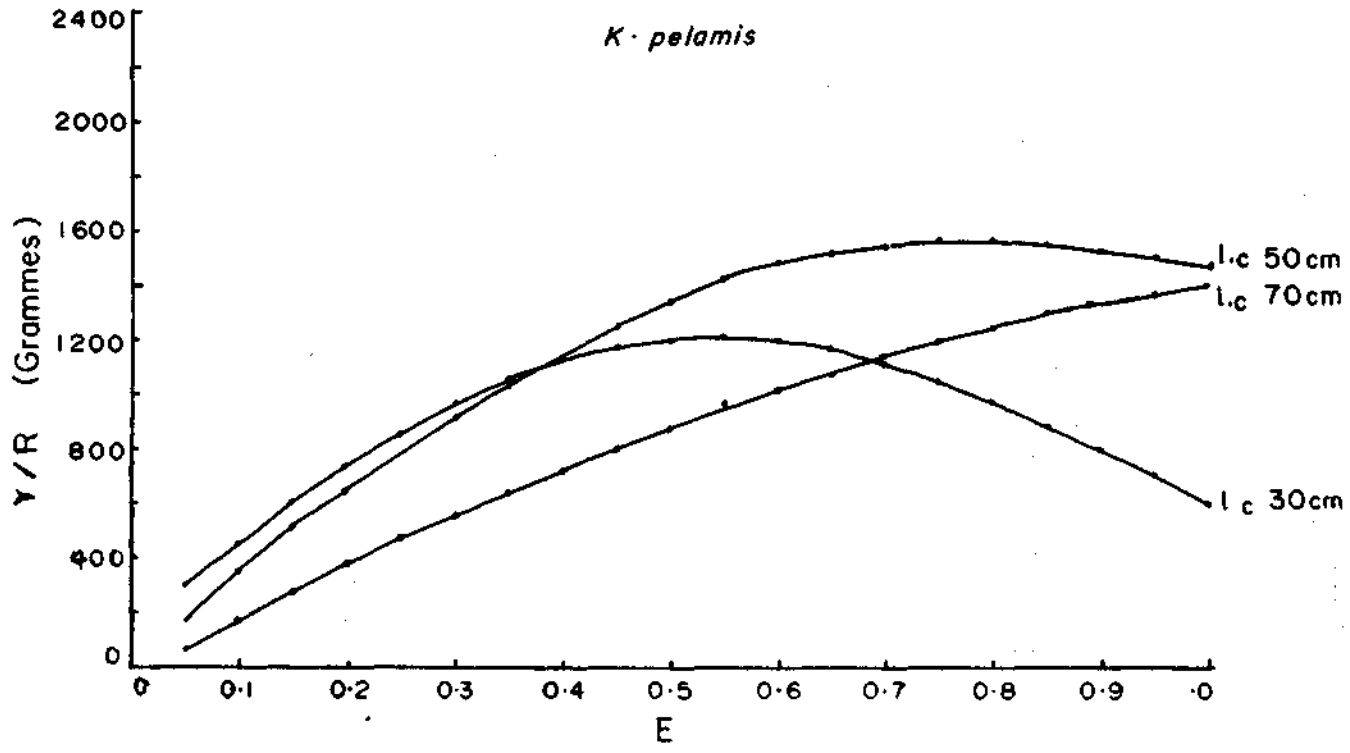

Fig. 2. Yield per recruit of *Katsuwonus pelamis*

as mature, it was seen that mature fish occurred almost throughout the pole and line fishing period. During 1981 peak occurrence of mature fish was from January to May but in 1982 mature fish dominated during all the months except October.

Therefore the occurrence of mature females throughout the pole and line fishing season and the presence of young fishes of about 30 cm during this period, clearly indicates that the skipjack tuna spawns throughout the year in the Minicoy waters.

Fecundity: A total of 23 mature ovaries were examined. Number of mature ova in an ovary ranged from 170,555 to 682,899 when length of the fish ranged from 465 mm to 660 mm. Each fish can produce about one lakh mature ova per kilogram of its body weight. Fecundity of the fish increased with the length and weight of the fish.

Population dynamics of tunas

The values of the different parameters of Von Bertalanffy's Growth Equation for skipjack and yellowfin tunas calculated for age and growth estimations based on the data collected during 1981 and 1982 were used to estimate mortality rates, yield per recruit and present rate of exploitation of both species. For skipjack tuna yield per recruit and present rate of exploitation were calculated as below.

Yield per recruit

Katsuwonus pelamis

The values of different parameters were as below:

W	= 16,372 g	M	= 0.75
lc	= 54 cm	M/K	= 1.54
lr	= 30 cm	$e^{M\,(tr-to)}$	= 1.861

For skipjack tuna, calculating Z (Annual mortality rate) as 2.555 and other parameters as given above, the present exploitation ratio calculated was 0.71 based on the equation

$$F/Z = \frac{Z - M}{Z} = \frac{2.555 - 0.75}{2.555}$$

This indicates that the present level of exploitation of skipjack tuna at Minicoy Island is not affecting this species' stock and the capture of this species in the area has not reached the maximum sustainable yield.

E	Y/R	Ep
0.05	179.1	
0.10	349.4	
0.15	510.6	**0.71**
0.20	662.1	
0.25	803.8	
0.30	934.9	
0.35	1055.3	
0.40	1164.4	
0.45	1261.8	
0.50	1347.1	
0.55	1419.9	
0.60	1480.0	
0.65	1526.9	
0.70	1560.6	
0.75	1581.0	
0.80	1588.2	
0.85	1582.6	
0.90	1565.0	
0.95	1536.0	
1.00	1498.5	

Y/R=Yield per recruit, Ep=Present exploitation rate.

E	Y/R	Ep
0.05	485.9	
0.10	927.2	
0.15	1323.0	
0.20	1671.9	**0.86**
0.25	1972.7	
0.30	2224.0	
0.35	2425.9	
0.40	2577.3	
0.45	2678.2	
0.50	2728.7	
0.55	2729.7	
0.60	2683.2	
0.65	2590.7	
0.70	2456.6	
0.75	2285.9	
0.80	2085.0	
0.85	1863.3	
0.90	1631.3	
0.95	1401.7	
1.00	1188.9	

Y/R=Yield per recruit, Ep=Present exploitation rate.

Yield per recruit

Thunnus albacares

The values of different parameters were as below:

W_∞	= 49,478 g	M	= 0.49
lc	= 45 cm	M/K	= 1.54
lr	= 30 cm	$e^{M\ (tr\ -\ to)}$	= 1.426

Adults of yellowfin tuna are highly migratory and deep dwelling and hence only young ones of about one year age are caught at Minicoy by the pole and line fishing. By calculating Z (Annual mortality rate) as 3.488 and other parameters as above the present exploitation ratio for yellowfin tuna was estimated as 0.86. Expanding the fishing operations to areas beyond the present zone of exploitation would widen the scope for realising higher yields.

Observations on the tuna shoals associated with flotsam in the offshore waters off Minicoy

Types of flotsam objects observed: On most of the occasions flotsam objects were wooden material drifting with sea currents towards Minicoy. Other objects found floating along with tuna shoals were nylon nets, rubber pieces, nylon ropes and plastic pieces.

Most of the flotsam had some attached algal material and very rarely a few ascidians. Though very few small fishes were found around flotsams, they disappeared from the sight when tuna fishing commenced around flotsam.

Live-bait fishes used: Chromis spp. were the main species used as live-bait followed by *Spratelloides delicatulus.* These were used to chum tunas from floating objects to tuna fishing boats. Out of the 75 fishing boats observed during these studies the quantity of live-bait used by only 28 boats could be recorded which was 57.5 kg.

Always more than one fishing boat approach a floating object. The first boat use livet-bait to chum tuna and on most of the occasions it is not necessary for other boats to throw bait since tuna shoals would be already feeding on live-bait thrown by the first boat.

Tuna catches: Totally 26 number of flotsams were observed from September, 1982 to May, 1983. 75 tuna fishing boats approached these shoals and caught 40,886 kg of fishes around them. The maximum catch was recorded from six floatsams during October when 14 fishing boats could catch 13,371.6 kg of fishes.

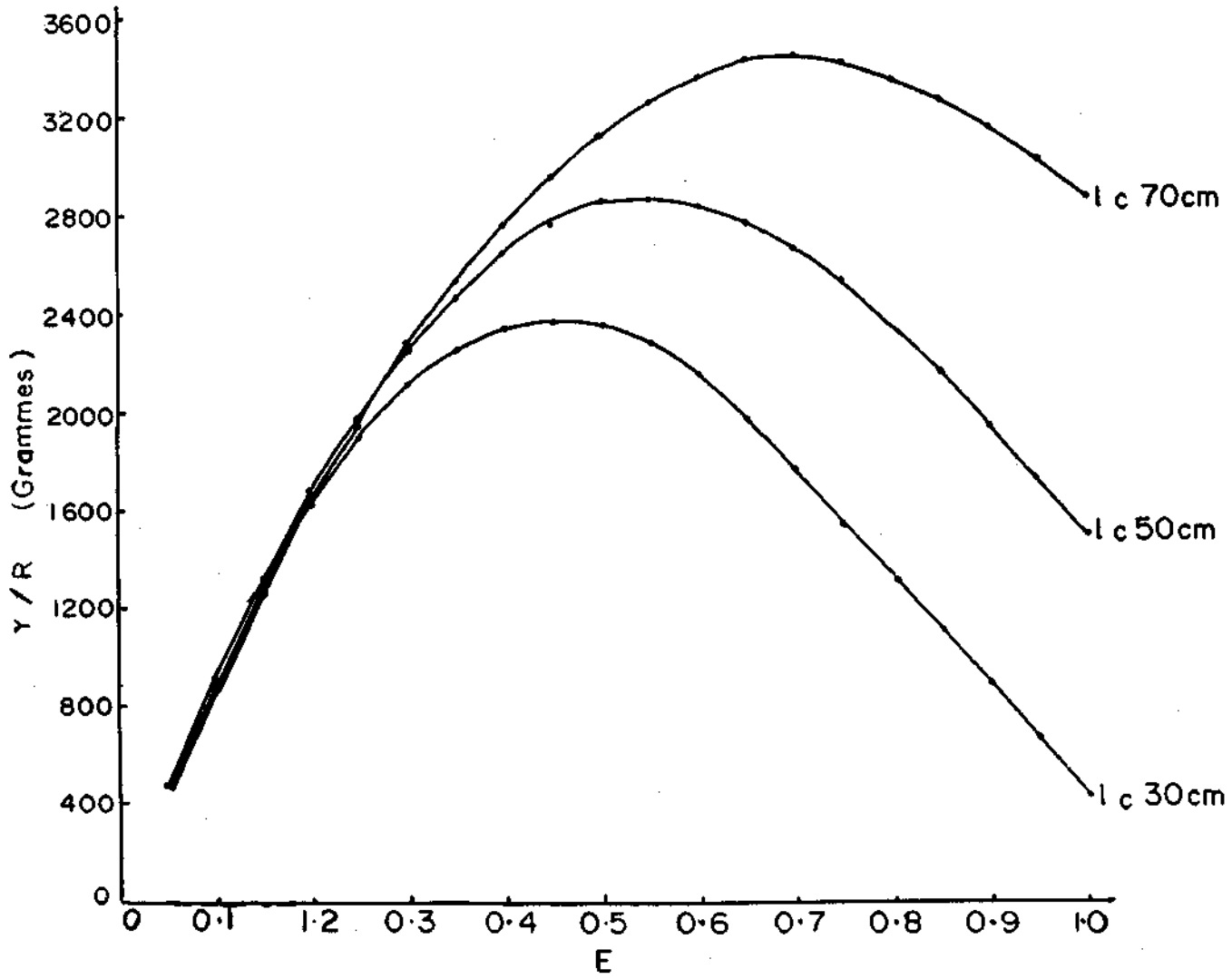

Fig. 3. Yield per recruit of *Thunnus albacares*

Species composition: Specisewise, the yellowfin tuna *(Thunnus albacares)* dominated the catches and accounted for 18,875.5 kg (46.17%) of the total catches. It was followed by skipjack *(Katsuwonus pelamis)* 11,106.3 kg (27.16%), sharks 7,558 kg (18.48%), *Elagatis bipinnulatus* 2677.8 kg and others.

Catch per unit effort: Average catch per unit of effort for the season as a whole from floatsam associated catches was 908.58 kg. The maximum catch per unit effort was recorded during October, being 1,593.05 kg and was followed by December (1,150.5 kg), September (1,040.33 kg), April (780.44 kg), May (722.83 kg), November (624.70 kg) and the lowest of 507.67 kg during January.

It is interesting to note here that average CPUE from floatsam catches was about three times higher than average CPUE for pole and line catches during 1982–'83 tuna fishing season. The reason is the availability of fishes in good concentrations around these floating objects.

Catch per floatsam object: The maximum catch of 3,451.5 kg per float was recorded during December followed by September (3,121 kg), October (2,228.6 kg), April (1,592.10 kg), May (1,445.67 kg), November (890.91 kg) and January (761.50 kg). The average catch per floatsam object for the season as a whole was 1,572.54 kg.

During 1984–'85 season tuna fishing associated with flotsam was noted to be five times, and wooden pieces mostly constituted the flotsam. It was observed that both *K. pelamis* and *T. albacares* along with *Coryphaena* sp.

Fig. 4. Pole and line fishing for tunas around Minicoy.

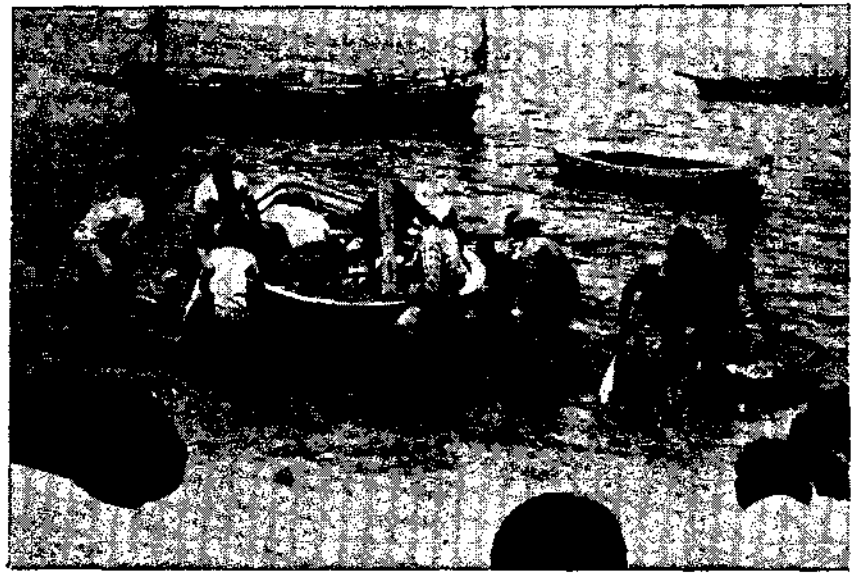

Fig. 5. Tuna landings.

Fig. 6. A catch of skipjack being taken ashore.

Fig. 7. Regular biological studies are needed for proper management of fishery.

Fig. 8. Tunas being gutted at the landing centre.

Fig. 9. Tunas are taken for processing in the factory

Fig. 10. Tuna processing in progress.

Fig. 11. Canning tunas at a factory.

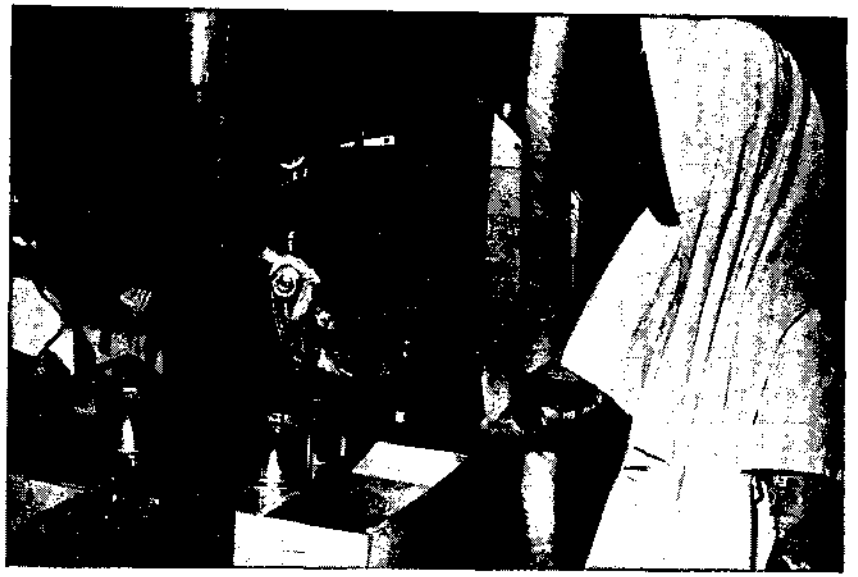

Fig. 12. Mechanical brine filling unit in operation.

Fig. 13. Tuna being dried in the open air.

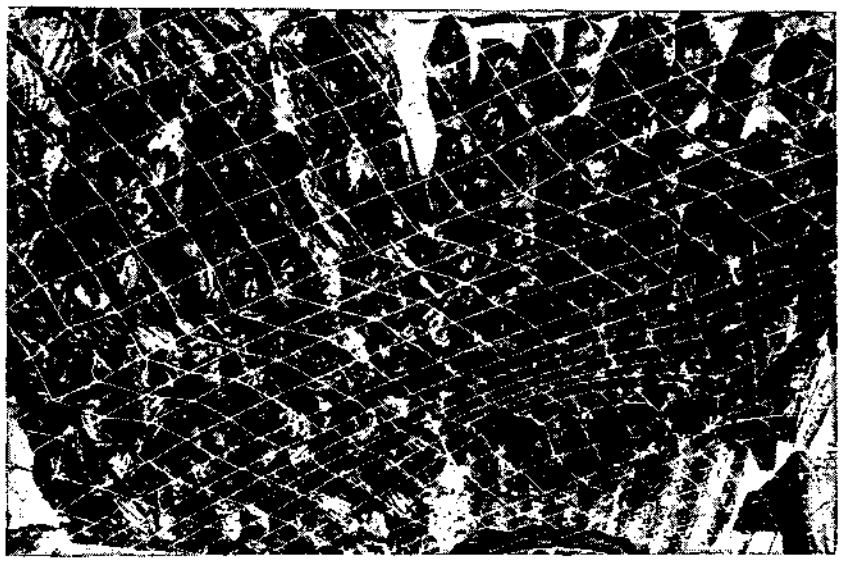

Fig. 14. *'Masmin'* – the cured and dried product of tuna.

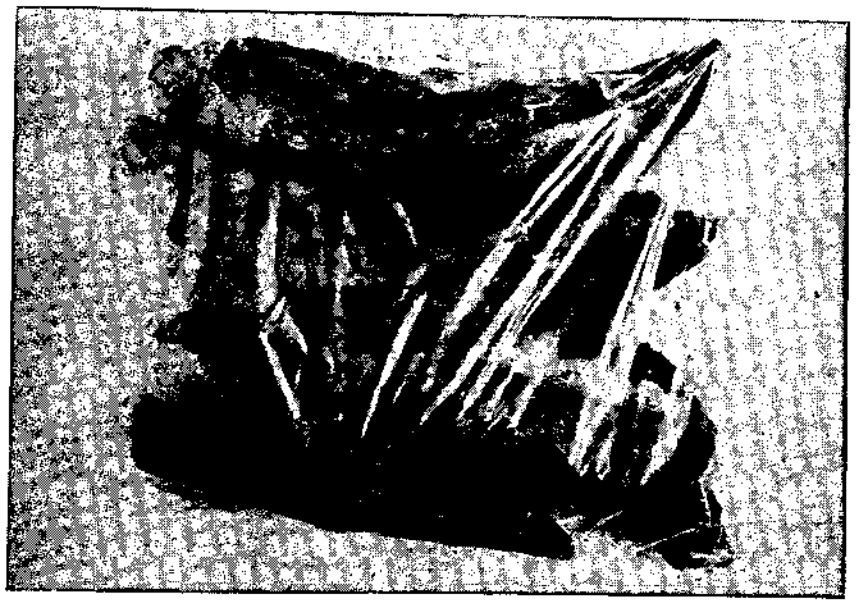

Fig. 15. *'Masmin'* – ready for marketing.

and *Elagatis bipinnulatus* were taken. The catch per boat of fishing associated with the flotsam ranged from 256.7 kg to 1,159.9 kg and averaged to 580.2 kg. An interesting aspect noted in this type of fishing was that skipjack tuna associated with floatsam ranged from 320–570 mm and yellowfin tuna 310–560 mm.

Strategies for future development

George *et al.* (1977) estimated a projected exploitation potential of 50,000 tonnes of tuna from Lakshadweep. Silas and Pillai (1985) proposed that by 2000 AD the total production of skipjack and young yellowfin tuna should achieve a commercial production target of 150,000 tonnes.

The introduction of larger pole and line boats recommended by Silas and Pillai (1982) is particularly significant to the Lakshadweep islands. The fishermen are not able to go in search of tuna shoals outside the vicinity of the islands. For undertaking prolonged fishing trips and improvements in operational techniques, navigational aids and catch storage facilities will be of great advantage and would increase tuna production. In this connection it is worth mentioning that a Radio Beacon Station (320 KHZ) and a Radar transponder Beacon (RACON) (9300 to 9500 MHZ) are working at Minicoy light house. These navigational aids can be made use of by the fishermen with the help of simple Radio Direction Finder/rader equipments.

The scarcity of live-baits is no doubt a limiting factor for the expansion of the fishery. Research inventory on live-bait fishes including the assessment of the availability and abundance of live-bait resources in space and time, along with large scale culture of suitable live-bait fishes for supplying to the fishermen deserve special attention. In this context the proper management and conservation of the coral reef habitat which sustains the bait fishes are of prime importance.

The above aspects along with adequate improvements in post-harvest technology and marketing can go a long way in the development of pole and line tuna fishery at Minicoy Island.