Current Knowledge of the Distribution, Behaviour and Abundance of Tunas with Suggestions for the Development of Tuna Fishery in the Indian EEZ

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Abstract

The paper outlines the status of the tuna fishery in the Indian EEZ and the annual and seasonal fluctuations in the catches in the maritime states. A brief account of the catch, effort, CPUE, species and size composition and distribution pattern of tunas caught by multiple gears at selected centres like Mangalore, Calicut, Cochin Vizhinjam, Tuticorin and Minicoy along with some aspects of behaviour of tunas is given.

The results of the recent tuna long line fishery operations by vessels of Fishery Survey of India (FSI) and Central Institute of Fisheries Nautical and Engineering Training (CIFNET) have been discussed. The available information on environmental features of the tuna fishing grounds has been reviewed to highlight the gaps in our knowledge. The paper also highlights the effect of fishing on the stocks of *Euthynnus affinis, Auxis thazard* and *Katsuwonus pelamis* along with the estimates of standing and average annual stocks. Suggestions for the development of tuna fishing in the Indian EEZ have been indicated.

Introduction

The tunas, though forming a mere 3 per cent of the total fish production of the world, constitute one of the major resources. Important tuna fisheries exist in the tropical and temperate waters. The world tuna catch during 1984 amounted to 2099,000 tonnes. Over 70 nations exploit the resource. The major share is by some of the developed and developing countries such as Japan (39%), U.S.A. (13%), Spain (6%), Philippines and Indonesia (5% each). During the ten years since the declaration of EEZ, some of the developing countries could expand their tuna fishery considerably.

In India tuna fishery is still an artisanal activity using non-mechanised and small mechanised units. The operational activity is limited to the 50 m depth zone. There is no organised fishery for tunas from the mainland. The important gears of the traditional sector such as the drift gillnets, purse seines and hooks and lines are meant to exploit a variety of large pelagics, and tunas form only part of the catch. Organised fishery for tunas exist only at Lakshadweep where the pole and line units mainly exploit the skipjack and yellowfin tunas. Deep sea fishing has not acquired momentum yet, though there exists vast scope for exploiting the oceanic tunas from the EEZ. Foreign fleets have been conducting longlining for tunas from the Indian Ocean. Longlining carried out by two government owned has indicated good fishing grounds for tunas in our EEZ. Tunas are highly migratory and widely distributed and have distinct behaviour patterns. They are found to congregate in places where special ecological and environmental conditions prevail. To predict the temporal and spatial variations in their abundance it is essential to have information on the ecology of tunas as well as the influence of various oceanographic parameters. The present paper discusses all these aspects in the light of recent data.

Area of fishery, craft and gear

Presently the tuna fishing activity is confined to the 50 m depth zone all along the coast line of the mainland of India. The pole and line and trolling operations are conducted in the vicinity of the islands. Longlining carried out by two vessels of the Govt. of India is mainly for survey of the tuna resources and to train the personnel. Both mechanised and non-mechanised crafts are engaged in exploitation of tunas in the main land (Table 1). The important gears such as the drift gillnets, purse seines and hooks and lines have a mixed target to catch large and small pelagics like the tunas, seerfishes, pomfrets, mackerel, barracudas, elasmobranchs etc. the number of non-mechanised units like dug-out canoes, plank-built boats and catamarans have increased from 65,000 in 1951 to 135,000 in 1983. During 1984 there were 20,000 mechanised boats. The mechanisation of the fishing craft has enabled the fishermen greater flexibility and efficiency in fishing operations. The domestic demands and aim for profit have turned the fishermen to go for high unit value species rather than to larger catches of uneconomical varieties. The pole and line (272 boats) and trolling operations employing mechanised and nonmechanised crafts are carried out in the Lakshadweep. In the oceanic waters large scale exploitation of tunas is yet to be started. The two longliners (M.V. *Prashikshani*, 34.0 m OAL. 750 BHP of CIFNET; and MFV. *Matsyasugundhi* 31.5 m OAL of FSI) are carrying out survey as well as training of personnel for longlining.

Production of tunas

The average all India tuna catch for the 20 year period from 1965 to 84 was 11,560 tonnes. During 1970 to 85 the average catch amounted to 16,375 tonnes. The catch increased from 1970 onwards and declined in 1977 and 1978. But in 1979 it leaped to 26,000 t and further reached 31,000 t in 1985 and 34,000 t in 1986 (Fig. 1). The north east region contributes only marginally while the south west and south east regions mainly contribute to the bulk of the catch. Recently the production in the north west region has increased and surpassed that of the south east region (Fig. 2).

The trend in production of tunas and billfishes from the east and west coast of India and Union Territory of Lakshadweep and Andaman Nicobar islands during 1970-86 is given in Fig. 3. The average annual contribution during 1983-86 from the west coast was 68.4%, east coast 13.8%, Lakshadweep 15.3% and Andaman and Nicobar islands 1.6% to the total tuna catch. Kerala contributed 34% followed by Gujarat (12.6%) and Karnataka (12%). Along the east coast, Tamil Nadu contributed to 8.4%. Statewise production of tunas and billfishes (Av. 1983-86) and percentage contribution are given in Fig. 4. The contribution by the mechanised and non-mechanised sector to the production of tunas is given in Table 2. On the east coast 69.4% of the catch of tunas was contributed by non-mechanised sector whereas on the west coast the major share (55%) came from the mechanised sector.

There are nearly 585 purse seiners (11.5-13.5 m OAL, 110 HP) operating in Kerala (60), Karnataka (405), Goa (80) and Maharashtra (40). Tunas are caught occasionally in the purse seines and the landings are given in Table 3.

The pole and line fishing in Lakshadweep waters using live-baits is the only organised fishery for tuna. The production of tuna in Lakshadweep varied from 500 tonnes in 1968 to 4313 tonnes in 1984 (Fig. 5). Tunas constitute about 83% of the total catch and 53% of the tuna production came from Agatti, Bangaram, Perumul Par and Suheli Par (James & Pillai, 1987). The estimated annual production was 17.8 tonnes. Silas *et al.* (1986) and James and Pillai (1987) summarised the results of the studies carried out by CMFRI at Minicoy. The total catch of tunas and effort expended during 1981-82 to 1985-86 are given in Table 4.

The status of the tuna fishery in Agatti island has been described by Varghese and Shanmugham (1987). Agatti, Bitra, Suheli Par, Perumal Par, Valiyapani, Cheriyapani, Kadmat and Kalpeni are important centres of pole and line fishing activity. Agatti was found to be the richest. There has been marked increase in the total catch mainly due to increased effort, though certain years showed declining trends. The catch increased from 179 t in 1971 to 718 T IN 1975 and declined to 392 t in 1977. The catch leaped to 1313 t in 1979. A record catch of 2054 t was made in 1984. The effort (no. of boat days) increased from 816 in 1978 to 4486 in 1984. The CPUE ranged from 209 to 384 kg during 1971-74. The proficiency of the fishermen and increased effort during succeeding periods yielded high CPUE varying from 600-1091 kg.

Species composition

More than 50% of the total tuna catch in India is constituted by the little tunny. The frigate and bullet tunas accounted for 8 to 25%. The longtail tuna formed 17.4% during 1985. The details are given in Table 5. The catch composition of tunas in Minicoy has been reported by James and Pillai (1987 b). The species composition of pole and line catch at Agatti Group of island (Varghese & Shanmugham, 1987) for the years 1977-78 and 1978-79 were *K. pelamis* 72-81%, *T. albacares* 11%, *E. affinis* 3-14% & *A. thazard* 3-4.5%. The Central Marine Fisheries Research Institute has an ongoing project on tunas. The catch, effort CPUE, species, size composition and other biological parameters are constantly monitored from centres like Minicoy, Goa, Mangalore, Calicut, Cochin, Vizhinjam, Tuticorin, Madras and Waltair.

A total catch of 6275 tonnes of tunas was landed at these centres during 1985-86 compared to 1936 t in 1984-85 (Annual reports CMFRI, 1985-86). There was increase in production at all centres except Waltair. The principal gears that contributed to the landings were drift gillnet (39.3%). Purse seine (39.2%) and hooks and line (21.5%) at the mainland centres and pole and line (95.3%) at Minicoy. Tunas constituted 98.4% and billfishes the rest. The tunas comprised mainly *E. affinis* (49.7%), *A. thazard* (24.8%), *A rochei* (17.7%) and *K. tonggol* (21.1%). At Minicoy skipjack and yellowfin tunas constituted 83% and 17% respectively. The peak abundance of skipjack was during November-January and March-April and for little tunny during May-Aug and Oct-Dec on the west coast and during June-August off east coast centres. The size range of the species forming the fishery at the respective centres are given in Fig. 6.

Seasonal pattern of tuna fishery

The quarterwise landings (Av. 1983-85) are given in Fig. 7. In Kerala, the 2nd and 3rd quarters are more productive. The fourth quarter is more productive in Karnataka and Maharashtra. Along the east coast production is high in the 1st and 4th quarters in Andhra Pradesh. In Tamil Nadu, 2nd and 3rd quarters are more productive. In Lakshadweep the highest production is during the 1st quarter. The catch gradually increases from 1st to 4th quarters in Andaman Nicobar islands.

Longline fishery

Though the high seas of the Indian EEZ hold great potential for oceanic tunas like yellowfin and skipjack, the deep sea fishing ventures have not developed as an industry. Some early attempts made in India relate to 1964-65 period. During 1980 two vessels were acquired by the Government of India and since then were carrying out longlining for tunas. The results of these two vessels M.V. *Prashikshani* and M.F.V. *Matsyasugundhi* have been summarised by Silas and Pillai (1985, 1986), Varghese *et al.* (1984), Joseph (1986), Sulochanan *et al* (1986), Joseph and John (1986), Sivaprakasam and Patil 1986), Swaminath *et al.* 1986, Swaminath and Nair (1987) James and Pillai (1987 b). Varghese *et al.* (1984) presented the resul (1983-84) of tuna longlining along the southwest coast of India (7° and 12°N), equatorial waters (0° and 6°N) and from the east coast (upto 18°N). The aggregate catch composition of yellowfin tunas was 21.5%, skipjack 2.01%, bigeye 1.7%, billfishes 9.4%, pelagic sharks 64.2% and other fishes 1.2%. Tunas constituted 85% in equatorial region, 53% from the east coast and 0.03% from west coast. The catch rates respectively were 47.6%, 38.2%, 35.8% and 62.3% from west coast, Bay of Bengal, Andaman sea and equatorial region (Joseph & John, 1986). The richest tuna ground has been located off Mangalore-Karwar with hook rate 12.9% (14° – 72°), 11.3% (13° – 73°) and 8.2% (14° – 71°). The catch rates of tunas increased during 1985-86 (Sivaprakasam & Patil, 1986). The hook rate varied from 0.26 – 0.39% during May to September and 6.4% – 24.9% from October to January and 10.9 – 17.3% during February and March. Swaminath *et al.* (1986) and Swaminath and Nair (1987) presented the results of the tuna longline operations of M.V. *Prashikshani*. During 1981-82, the operations conducted were mainly aimed at getting proficient in the technique. During 1983-86 the vessel operated (6°S – 23°N and 67°E – 97°E) in the Indian EEZ and equator region. Out of 382 sets 306 sets yielded 9100 fishes comprising yellowfin tuna (73%) Bigeye (0.8%), Skipjack (2.1%) Marlin (2.5%), Sailfish (2.5%) Swordfish (0.4%) and Sharks (17.4%). Results obtained, from Karnataka-Konkan coast, equatorial waters, areas off Madras and Andaman sea, are encouraging. The highest hook rate of 43.7% was from 14° – 72°. The intensive fishing during October 1985 to May 1986 putting in 40,422 hooks yielded 147 tonnes out of which tunas formed 128 t. The average monthly hooking rate varied from 5.4% to 28.4%. With an average hooking rate of 13.4% the yellowfin tunas formed 87.8% of the catch.

Environmental features in relation to tuna fishery

Tunas and billfishes, being active swimmers, are highly migratory and have distinct behaviour patterns. Shoals tend to congregate in places where special ecological and environmental features prevail. Though the effect of environmental properties on the distribution and abundance of tunas has been studied for the past four to five decades in other areas (including Indian Ocean) and several factual observations available, not much work to correlate the available information to the commercial fishery at microlevel has been carried out in India. Silas and Pillai (1982) reviewed the available information on tuna environment. Temperature and pelagic food supply have a direct major effect and in special situations dissolved oxygen and illumination influence their distribution. Food supply, ocean currents, convergence and divergence, fronts, upwelling, thermocline, eddies, topography, temperature gradients in the thermocline, levels of oxygen, position of the islands, banks and land masses also affect the migration and distribution of tunas (See Table 6). Sharp (1979) discussed on the 'areas of potentially successful exploitation of tunas in the Indian Ocean (including Indian EEZ) based on sea surface isotherms and oxygen. The thermocline and thermocline ridges are areas where tunas aggregate for forage organisms. The bimonthly variation of the depth of the mixed (top of the thermocline) layer in the Indian Ocean have been given by Wyrtki (1971). The thermocline is observed at a depth of 75-150 m in the oceanic waters of the west coast of India. But during the peak of the SW monsoon period, the depth of the mixed layer will be very shallow. Marcille (1985) indicated an apparent migratory pattern of yellowfin tuna northwards during October to March and southwards during April to September in the Arabian sea based on the analysis of data collected from longline fishery. The northward shift in the seasonal pattern of abundance of these species has been indicated by Joseph and John, (1986) and Sivaprakasam and Patil, (1985). The pattern of major current systems, boundaries and oceanic fronts in the Indian Ocean also are available (Krey and Bebenard, 1976; Uda and Nakamura, 1973). Ramamirtham (1981) indicated the large cyclonic gyre north of Maldives and anticyclonic one in south. Along the coasts of India and around Minicoy the phenomenon of upwelling has been studied. The relation between the upwelling is a complicated feature and the linkage may be connected with other factors like method of fishing, ecological conditions and other environmental parameters. Oceanic island area, sea mounts and continental slope are also good tuna fishing grounds. Formation of eddies and consequent time lagged production of forage organisms will attract tuna. The presence of forage organisms in the fishing ground and the biting response of tuna during the pole and line fishing and the prevalent environmental parameters are to be studied (James *et al.* 1987 b). The unusual concentration of yellowfin tuna off Karnataka-Konkan coast could be due to plentiful availability of squids in the area. Tuna fishery might be a fore-runner to a cephalopod fishery (Swaminath *et al.* 1987).

Though not much salinity variations occur in the oceanic realm, low salinity affects the tunas in the coastal waters. Optimum transparency for tunas is 25-35 m depth and sight feeding will be difficult beyond this range. Hence purse seining and gillnetting will be sucessful in turbid waters unlike the pole and line fishing in which visual response to live baits will be effective in transparent waters. James *et al.* (1987) while reviewing the four decades of research carried out in Marine Biology and Oceanography by CMFRI suggested the need for integrating the environmental research with resources for better understanding of the dynamics of the latter. Silas (1986) and James and Pillai (1987 b) opined that telemetric tagging and tracking of tunas by satellite is a new area which needs further study. Tagging of tunas also are to be undertaken. The Western Indian Ocean is now characterised by hectic purse seining. The fish from other areas will be migrating to the thinned' out area. Time may come to formulate management policies at the national level.

Stock assessment

Assesment of stocks of commercial speices of tunas on an all India basis is of utmost importance for the judicious exploitation of the resources. Results of such studies (Silas *et al.* 1986) are available. In the case of *E. affinis* the average annual stock was estimated to be 2.17 lakh tonnes, standing stock being about 32,000 tonnes. The average annual stock of *A. thazard* was found to be 7745 tonnes with standing stock about 925 tonnes. The present landing of *E. affinis* and *A. thazard* from the coastal fishery is 18,218 tonnes and 8485 tonnes. Further, the studies indicated that any increase in the fishing effort from the present level may not yield much higher catches from the present fishing grounds unless expansion of the fishery takes place to new grounds. The present rate of exploitation of *K. pelamis* is well below that of MSY level indicating further scope of realising higher yields by increasing the rate of exploitation. In the case of *T. albacares* (young ones) the present rate of exploitation is beyond the MSY level. At the present rate of exploitation increasing $l\alpha$ upto 90 cm may yield higher catches. Recent studies (James *et al.* 1987 a) indicated the effect of fishing on the stocks of little tunny, frigate and skipjack tuna, highlighting the estimates of standing and average stocks (see Table 7). In the case of *E. affinis* except at Mangalore and Vizhinjam there is likely to be increase in yields with increase in fishing effort. Studies on *A. thazard* revealed that there may not be significant increase in yield at Cochin with increase in effort. But at Tuticorin increased effort may result in higher yields. At Minicoy there is scope for getting increased catches of *K. pelamis* with increased effort.

Discussion

The estimated potential of tunas in the EEZ is 500,000 – 800,000 tonnes of which 250,000 tonnes could be exploited. Immediate attention should be paid for the development of tuna fishery in the small-scale sector as well as the oceanic sector. Augmenting production of coastal species of tuna through diversification in the small scale fishing with greater use of drift gillnets and other suitable gears has been discussed by Silas and Pillai (1986). Each boat could harvest 25-30 tonnes annualy of which tunas may constitute nearly 6 tonnes (20%). Major improvement in the gillnet unit by better storage facilities and mechanisation of hauling the gear would allow more time for fishing and also increase the operational range. Seasonal conversion of shrimp trawlers (9.6 – 13.0 m OAL) would also enhance operational range of the drift gillnet fishery. The catch of longtail and other tunas could be increased with extension of the fishing upto the outer continental shelf (Yesaki, 1987). At Vizhinjam hooks and lines operated from mechanised units have been giving good results compared to the non-mechanised units. Large shoals of coastal tunas have been often located off Porbunder and along the south west coast. Attention should be diverted to exploit them by purse seining.

The present trend of tuna fisheries in Lakshadweep has been reviewed by Silas *et al.* (1986 a), James and Pillai (1987 b), James *et al.* 1987 b, (1987 c) and Varghese and Shanmugham (1987). The constraints appear to be the lack of boats, expertise and labour needed for such fishing. Silas and Pillai (1986 b) and James and Pillai (1987) opined that a new generation of pole and line boats (OAL 15-20 m) with navigational and fish storage facility for 4-5 days of fishing would produce 60-100 tonnes per boat per season. Each boat may require 0.5 to 0.8 t of bait fishes per season. A target of 10,000 tonnes by 2000 A.D. could be achieved by introduction of 100 such units. Already shortage of preferred live-bait fishes has been felt. Recent survey by CMFRI has indicated good potential for other live-bait fishes. Culture of these species should be attempted to meet the demands.

It will be worthwhile to initiate purse seining in this area (Silas and Pillai, 1986 b and James *et al.* 1987 b). Organised fishery by purse seining can harvest large quantities of this resource. Historical review of the development and recent trend of the industrial tuna purse seining in the tropical Indian ocean were summarised by Marcille (1985), Hallier (1985), Cort (1985) Watanabe (1985) and Michard and Hallier (1986). Marcille (1985) indicated that successful purse seine season in Lakshadweep was November-May and in the Andaman sea March-May. Employment of 10-12 purse seiners with an annual production capacity of 6000 tonnes and 20 purse seiners each of 4000 tonnes poduction capacity would lead to the production of about 150,000 tonnes of tunas from the oceanic waters around India (Silas and Pillai 1986 b).

Silas and Pillai (1982, 1983 and 1986 a) discussed in detail the different aspects of longline fishery, operational methods, constraints and management problems in the EEZ of India. Augmentation of production of tunas from the large scale commercial sector could be achieved by the proper deployment and management of oceanic purse seiners and improvements and expansion of longline fishery. Silas and Pillai (1986 b) suggested that successful surface fishery for tunas can be achieved by large scale purse seine operations through joint venture/ownership agreements. About 150 long liners each with capacity to produce around 450 tonnes of tunas annually are required to achieve the production target of 60,000 – 75,000 tonnes by 2000 A.D.

There is urgent need to improve the post harvest technology, product deployment and marketing both domestic and export. Unless we make rapid inroads into the foreign markets with diversified products the programme of deep sea ventures will be a failure since the value of both frozen and fresh tuna in domestic as well as foreign markets is low.

The available infrastructure is inadequate to meet the requirements of even the present fishing industry. Though several fishing harbours have been commissioned during the past most of them do not have proper berthing facilities. Facilities for handling, transportation, frozen storage, product development, quality control for export are areas which require priority attention.

The environmental changes and the damages caused to the various ecosystems will have far reaching consequences. The feeding and breeding grounds of fish can undergo changes. Conventional fishing grounds identified and charted during periods of early exploitation can undergo changes due to increase in fishing pressure as well as environmental damage. In many areas in the world, tuna investigations have always been supported by large scale oceanographic studies. There is urgent need to integrate the environmental features with the tuna fishery at the microlevel. This will enable to predict the fishery, the concentration and time of occurrence of fishery which can save a lot of manpower and energy. Future developmental programmes of research should constantly monitor the catch, effort, size, maturity of tunas from the small scale and oceanic sector. A total 'Systems approach' has to be followed to understand the complex multispecies multigear fishery. It is also necessary to understand various interactions, both technological and biological to arrive at meaningful management strategies without disturbing the resource balance.

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Table 1. Characteristics of small scale tuna fishing crafts and gears

Type	CAL(m)	Material	Power (HP)	Mesh size (cm)	Depth (m)	Length (m)	No.of crew	Species of tunas
Drift/gillnetters	7.6–9.1	Wood	24–45	4.5–14.0	5–8	800–1200	3–4	Kawakawa, frigate, long tail, yellowfin, Bullet tunas.
Purse seiners	13.0–14.0	Wood	105–120	1.4	40–60	400–600	18–25	Kawakawa, frigate & bullet tunas.
Pole and line boats	7.9–9.1	Wood	10–40	–	–	Pole 3–4	10–15	Skipjack, yellowfin, kawakawa.
Troll line boats	3.0–8.8	Wood	Sail	–	–	Pole 3–4	4–10	Yellowfin, Sailfish, Skipjack.
Dug out canoes	8.3–9.7	Wood	OBM (Partly)					
Plank built boats	5–6	Wood	OBM (Partly)					
Catamarans	7–9	Wood	OBM (Partly)					

Table 2. Statewise landings of tunas and total fish catch in the mechanised and non-mechanised sector average for 1982-83 to 1984-85.

(Unit = tonnes)

States	Mechanised sector		Non-mechanised sector	
	Tuna	Total fish	Tuna	Total fish
West Bengal	10	15,038	1	14,009
Orissa	—	24,477	136	20,213
Andhra Pradesh	6	37,772	913	1,03,417
Tamil Nadu	1,039	1,21,577	1,522	1,26,950
Pondicherry	83	4,814	4	9,525
East Coast	1,138	2,03,678	2,576	2,74,114
Each Sector %	30.6	42.6	69.4	57.4
Kerala	2,479	1,92,134	3,643	1,77,523
Karnataka	1,068	1,05,017	653	15,055
Goa	62	33,601	–	4,392
Maharashtra	1,670	2,63,692	1,198	18,528
Gujarat	1,486	1,83,675	36	54,481
West Coast	6,765	7,78,119	5,530	2,69,979
Each sector %	55.0	74.0	45.0	26.0

Table 3. Purse-seine landings of Tuna from Goa, Karnataka and Kerala.

Year	Goa		Karnataka		Kerala	
	Effort (units)	Catch	Effort (units)	Catch	Effort (units)	Catch
1982–83	5,937	–	66,457	928	9,558	43
1983–84	4,704	–	56,249	862	14,226	1
1984–85	7,548	–	76,424	529	16,226	13
1985–86	11,926	209	42,575	2,486	2,945	607

Table 4. Total catch and effort expended for capture of Tunas during 1981–82 to 1985–86.

Year	Effort (Units)	Catch (t)	C/SE (Kg)	Catch/unit baits (Kg)	Skipjack tuna (%)	Yellowfin tuna (%)
1981–82	1241	321	258	115	85.4	14.9
1982–83	1112	381	343	134	81.2	10.6
1983–84	1370	345	252	107	79.6	12.1
1984–85	2422	569	235	133	94.2	5.7
1985–86	2575	623	242	139	85.9	14.0
1986–87	2359	722	253	112	91.0	8.6

(After James and Pillai, 1987 b)

Table 5. Details of the species-wise percentage composition of catch of Tunas during 1983–86.

Species/Group	Percentage composition			
	1983	1984	1985	*1986
E. affinis	52.9	54.7	31.8	53.3
Auxis spp.	14.2	8.1	9.7	24.9
K. tonggol	0.1	1.0	17.4	0.5
K. pelamis	15.8	16.6	12.1	9.3
Other tunas	11.9	13.7	6.0	7.6
Bill fishes	5.1	5.9	3.0	4.4
	*Source CMFRI (Unpublished)			

Table 6. Temperature range for distribution, preferred temperature

	1/Temp. range for distribution (°C)	2/Preferred Temp. (°C)	3/Habitat relative. size
Yellowfin tuna	18–31 (20–28)	23–22	Pelagic, large
Bigeye tuna	11–28 (18–22)	11–15	Deep pelagic, large
Skipjack tuna	17–28 (19–23)	15–29	Pelagic, medium
Bonito	12–25 (15–22)	Temporate/Tropical	Coastal to pelagic, medium
Little tunny	17–28 (18–23)	Tropical	Coastal to pelagic, medium
Frigate tuna	–	Tropical	Coastal to pelagic, medium
Longtail tuna	–	25–32	Pelagic, large

Figures in parenthesis indicate temperature range. 1/Source:Laevastu and Rosa (1963) 2,3/Source: Sharp and Pirage (1978).

Table 7. Data on the Standing stock and average annual stock of *E. affinis*.

Centre	*E. affinis* Fishing mortality DGN(M)	DGN(N)	PS	HL(M)	HL(NM)	Z	Standing stock	Av. annual stock
Mangalore	0.3256	–	0.9260	–	–	1.713	498	1042
Calicut	0.707	–	–	–	–	1.269	52	92
Cochin	0.724	–	0.12	–	–	1.406	539	1004
Vizhinjam	0.3486	0.1863	–	0.1243	0.1675		546	1011
Tuticorin	1.2582	–	–	–	–	1.82	136	295
(Cochin) *A. thazard*	4.048	–	–	–	–	4.8008	62	300
K. pelamis (Minicoy)		Pole and line				1.89	455	1013

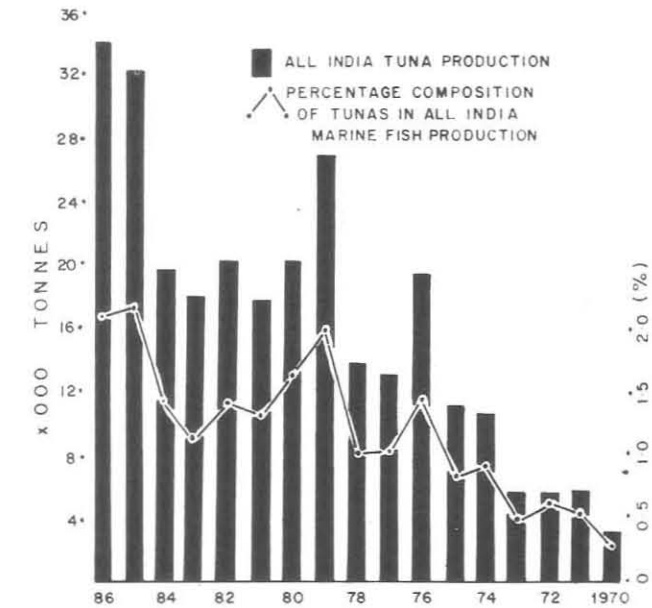

Fig. 1. All India production of tunas and the percentage contribution to the total marine fish landings during 1970 – 86.

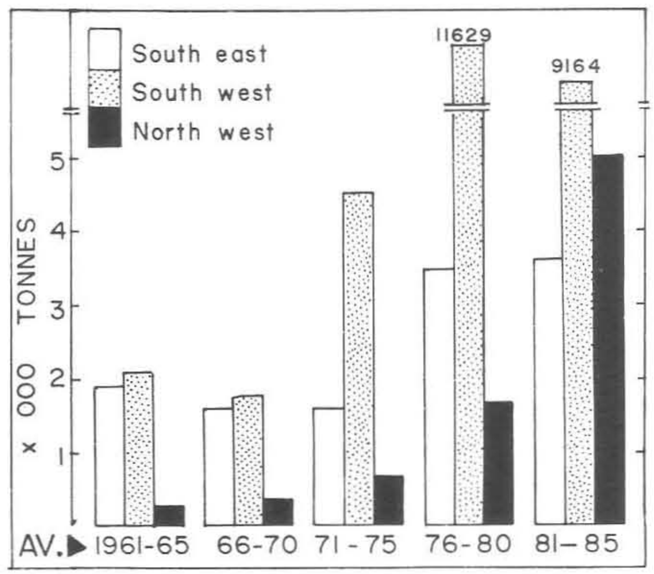

Fig. 2. Production of tunas (average) in the south east, south west and north west regions of the mainland of India.

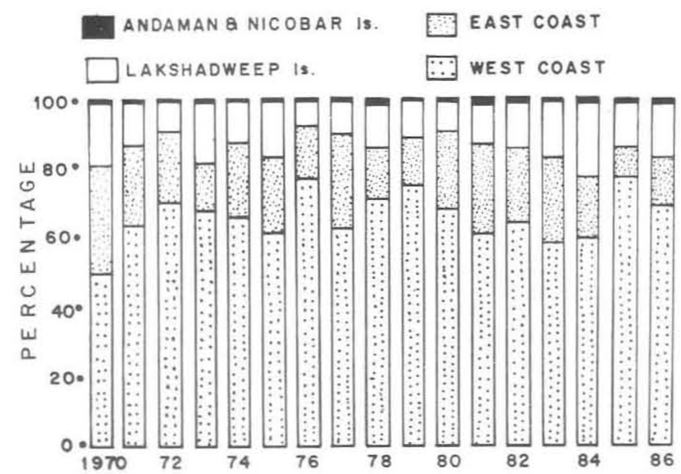

Fig. 3. Percentage composition of tunas landed along the east and west coast, Andaman & Nicobar Islands and Lakshadweep.

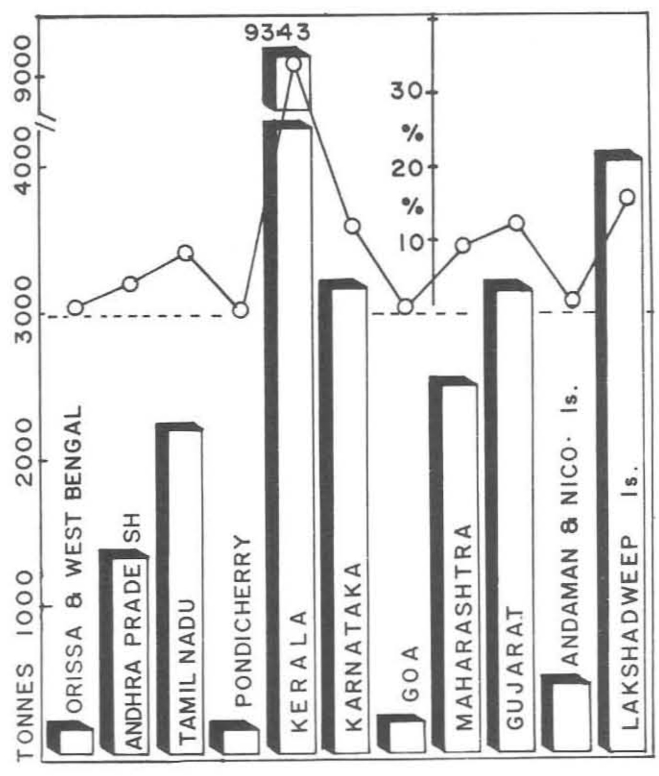

Fig. 4. State-wise and island-wise average annual production of tunas in India during 1983-86 and the respective percentage contribution.

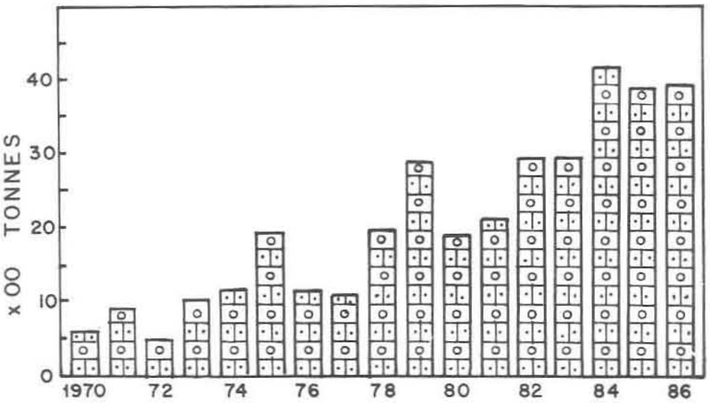

Fig. 5. Production of tunas in the Lakshadweep Islands (1970-'86).

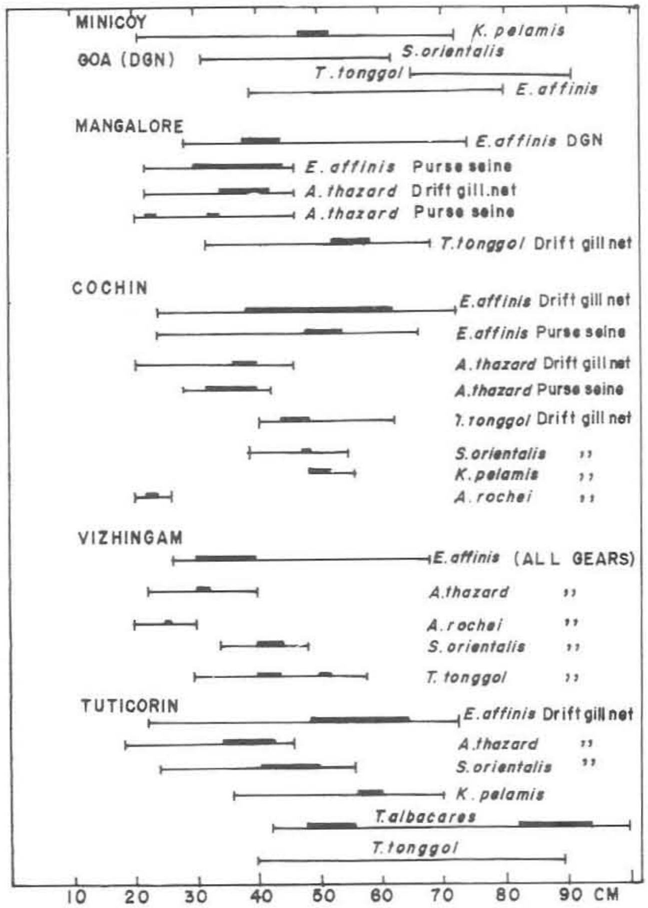

Fig. 6. Size range and modes of different species of tunas at various centres during 1985-'86.

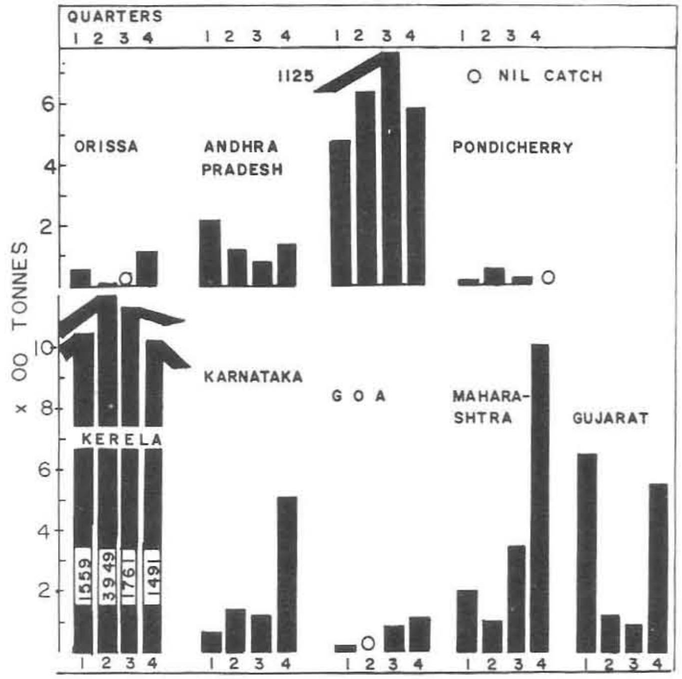

Fig. 7. Quarterly pattern of tuna landings in different maritime states of India (Average 1983-85)

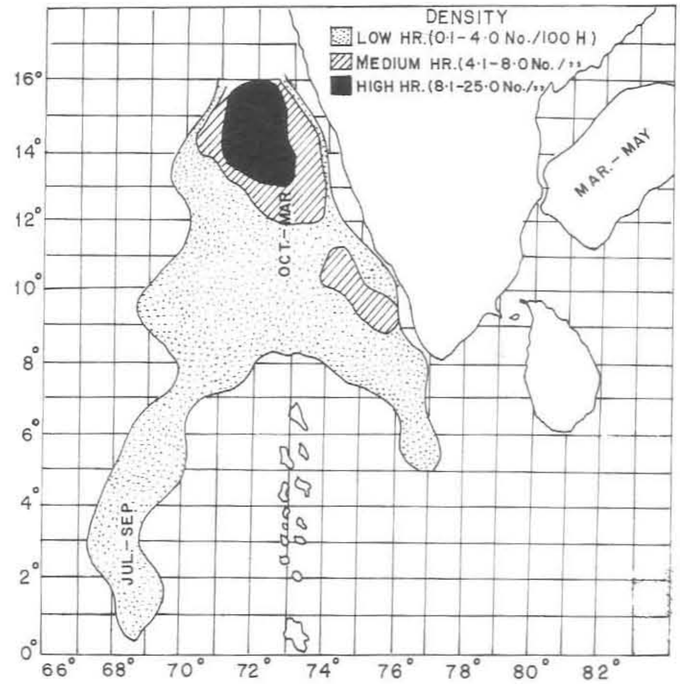

Fig. 8. Distribution and abundance of yellowfin tuna (*Thunnus albacares*) taken by longlinr fishery by CIFNET and FSI during 1981-85. (Courtesy: K.V.N. Rao and P.P. Pillai)