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Status of the World Tuna Fishery with Special Reference on the Strategies for the Development and Management of Tuna Fishery in Indian Waters

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Abstract

Tuna production in the world continued to increase from an average annual catch of 1.745 million t during 1970-'74 to a peak of 5.975 million t in 1999. The Pacific Ocean produced 68.9% followed by the Indian Ocean 17.3% and the Atlantic Ocean 13.8%. Skipjack was the most dominant species constituting 35.3% followed by yellowfin 25.9%, big-eye 6.3%, albacore 5%, other tunas 25.3% and longtail, kawakawa, southern and northern bluefins each less than 1%. Except skipjack, and albacore in the Atlantic, northern bluefin in the western Atlantic, kawakawa, longtail and other small tunas in the eastern Indian Ocean, all other species are fully exploited and some of them are at the verge of depletion. Tuna production from India continued to increase from a mere 3445 t in 1969 to a peak of 46,466 t in 1997. The species composition was *E. affinis* 52.3%, *Auxis* spp. 21.2%, *K. pelamis* 2.0%, *T. tonggol* 8.6% and other tunas 15.9%. The west coast landed 85.2% and the east coast 14.8%. The south-west coast contributed 55.4%, north-west coast 29.8%, South-east coast 14.4% and North-east coast a mere 0.4%. The motorised sector landed 50.4% followed by the mechanised sector 37.8% and non-mechanised sector 11.8%. In the mechanised sector, the gillnet landed 59.4% followed by purse seine 23.1%, ring seine 10.4% and trawl 7.1%. Other than the coastal tuna fishery, there is no organised fishery for oceanic tunas in India. Deployment of longline and purse seine fishing fleet for the exploitation of oceanic surface and sub-surface tunas in the Indian Ocean is discussed and detailed suggestions for the development and management of the oceanic tuna fishery are given.

Key words: Tuna fishery, management, Indian waters

Introduction

A critical review of the present status of exploitation of tuna resources in the world indicates that most of the commercially important species are fully exploited and some are even facing depletion. Only a very few species are either under or moderately exploited and that too in a few limited regions of the three major Oceans. Consequently, the world tuna fishing industry of the developed countries has to undergo a transformation including the reduction and re-deployment of major fishing fleets to areas of under and moderate exploitation (FAO, 1995). Many developing countries have expanded their fishing activities with an aim to intensify the exploitation of the tuna resource of their EEZ (Silas, 1985; James and Pillai, 1991). The present status of tuna fishery in the Indian Ocean reveals that except for the longline tuna fishery by Japan, Taiwan and the Republic of Korea, and purse seine fishery for tuna by Seychelles there is no organised high seas tuna fisheries in the Indian Ocean. In view of their wide distribution, highly migratory habit and complex nature of occurrence in relation to different environmental factors, the exploitation of tunas require a very efficient and highly mobile fishing fleet with different fishing techniques. This kind of complex nature is itself a major factor to contend with the tuna fishery among the developing coastal and island states. Further, a regional co-operation among the member states of the Indian ocean becomes essential for the development and efficient management of the tuna fishery without generating conflicts/developing protective interests and exclusive attitude (Silas and Pillai, 1982).

Tuna production from Indian Ocean varied around 0.707 to 0.917 million t during 1990-'95 and India's contribution was 45,000 t which is 5.9% of the total tuna production from Indian Ocean. In the present account, a review of the trend in the tuna production in the world with special reference to the Indian Ocean during the recent years is analysed. Present status of exploitation of tuna resource in India is discussed with emphasis on the need for the development of the oceanic tuna fisheries in the EEZ and contiguous seas around the Indian Ocean.

Data Base

The data on the country-wise and species-wise tuna production from Pacific, Atlantic and Indian Oceans for the period from 1973-95 were obtained from the FAO Fisheries Circular (1997) and for the period from 1996 to 1998 were down loaded from the FAO website. The gear-wise catch and species composition of the tuna resource from Indian waters were obtained from the Fishery Resource Assessment Division and Annual Report of the CMFRI.

Global Tuna Production

The tuna and billfishes production in the world continued to increase from an average annual catch of 1.745 million t during 1970-'74 to a peak of 5.975 million t in 1999. The contribution towards total tuna production by the three major Oceans during 1991-'95 was the Pacific Ocean 64.9% followed by the Indian Ocean 20.8% and the Atlantic Ocean 14.3%. The production from the Pacific Ocean increased from an annual average catch of 1.180 million t during 1973-'75 to 2.595 million t during 1991-'95. From the Indian Ocean it increased from 0.217 million t to 0.832 million t and from the Atlantic Ocean from 0.408 million t to 0.571 million t during 1973-'75 and 1990-'95 respectively (Table 1). The global tuna production during 1950-98 by different gears given in Fig. 1A indicates that the purse seine catches increased gradually from 1960 to 1980 and then there was a sharp increase during 1981-92 with a stabilisation during 1993-98 exhibiting minor fluctuations. Production by long line attained an optimum from 1962 onwards with minor fluctuations and that of pole and line also exhibited a similar stabilised production from 1972 onwards. The species composition of tuna catches by different gears indicates that skipjack *Kutsuwonus pelamis* was the dominant species followed by yellowfin *Thunnus albacares* in the catches of purse seine (Fig. 1B) and pole and line (Fig. 1D) and the catches of other species were limited. In the long line catches the dominant species was bigeye *T. obesus* followed by yellowfin, albacore *T. alalunga*, swordfish, marlin and bluefins *T. thynnus* and *T. maccoyii* (Fig. 1C). Nominal and spatial catches of tuna and billfishes catches by different gears like long line, purse seine, pole and line and other gears from Pacific Ocean (Fig. 2), Atlantic Ocean (Fig. 3) and Indian Ocean (Fig. 4) indicates that there has been a progressive increase in production by all the gears in all the three oceans except by pole and line in Pacific Ocean and other gears in Atlantic Ocean.

Table 1. Tuna production from the Pacific, Indian and Atlantic Oceans during 1973-'95

Species	Average tuna production in tonnes					Percent
	1093-75	1976-80	1981-85	1986-90	1991-95	
Pacific Ocean	1180406	1471666	1685807	2270912	2595166	64.9
Indian Ocean	218291	202357	329724	614811	831946	20.8
Atlantic Ocean	408168	422544	525207	512049	570971	14.3
Total	1806865	2096567	2540738	3397772	3998083	100.0

As many as 134 countries have been recorded to produce tuna in the world and among them only 18 countries contribute more than 1.0% toward the total catch. The top twelve tuna producing countries during 1985-'95 are Japan (20.3%), Philippines (9.7%), Indonesia (8.7%), USA (7.8%), China Taiwan (6.6%), Spain (6.3%), Korean Republic (5.2%), France (4.3%), Mexico (3.9%), Thailand (3.4%), Venezuela (2.8%) and Maldives (2.0%).

More than 12 species belonging to six genera support the tuna fishery in the world. Percentage

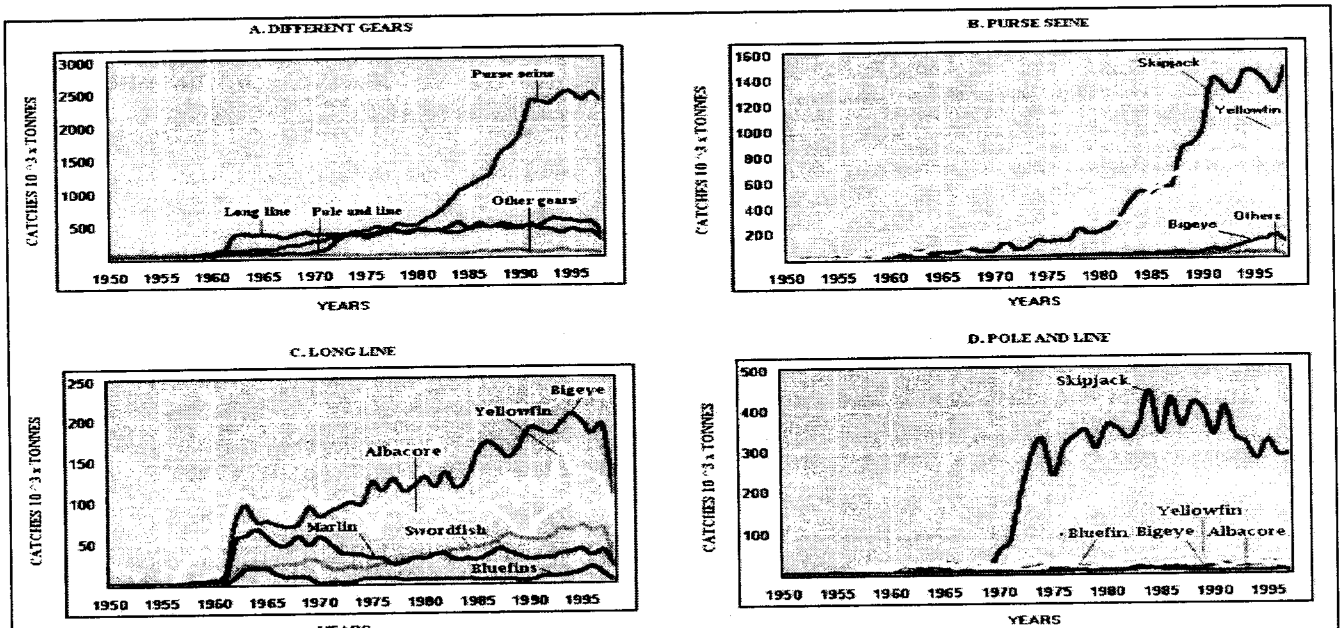

Fig 1. Global tuna catches by different gears (A) and species composition of tuna catches by purse seine (B), long line (C) and pole and line (D) during the years from 1950 to 1998.

composition of different species indicates that the catch was dominated by skipjack *Katsuwonus pelamis* (38.0%), followed by yellowfin *Thunnus albacares* (27.5%), big-eye *T. obesus* (7.5%), albacore *T. alalunga* (4.8%), frigate and bullet tuna *Auxis thazard* and *A. rochei* (5.2%), kawakawa *Euthynnus affinis* (4.4%), long tail *Thunnus tonggol* (2.8%), northern bluefin *T. thynnus* (1.0%), Eastern Pacific bonito *Sarda chilliensis* (0.9%) and other species such as tuna like fishes, southern bluefin *T. maccoyii*, Atlantic bonito *S. sarda*, Atlantic black skipjack *E. alletteratus*, blackfin tuna *T. atlanticus*, Oriental bonito *S. orientalis*, plain bonito *Orcynopsis unicolor*, black skipjack *E. lineatus* etc., constituted all together 7.9%. The production of skipjack continued to increase from an average annual catch of 0.559 million t during 1973-'75 to attain a peak of 1.518 million t during 1991-'95. Similar trend in the production of yellowfin was observed, as the catch increased from 0.454 million t in 1973-'75 to attain a peak of 1.101 million t during 1991-'95. More or less similar trend is observed in the production of different species with marginal variation in the magnitude of production. However, when most of the species registered either an increasing or a stabilised trend in production, *T. alalunga* and *T. maccoyii* alone showed a declining trend. The production of these two species continued to decline in subsequent five year periods from 1973-'75 with a marginal revival during 1986- '90 by *T. alalunga* and during 1981-'84 by *T. maccoyii*. During 1991-'95 in addition to these two species *S. sarda*, *E. alletteratus*, *T. atlanticus*, *S. orientalis*; *O. unicolor*, *E. lineatus* and Tunnini also registered a decline (Table 2).

Table 2. Species composition of tuna landings in the world during 1973-'95

Species	Average tuna production in tonnes					Percent
	1093-75	1976-80	1981-85	1986-90	1991-95	
K. pelamis	559277	710652	879494	90720	17675	37.96
T. albacares	453761	532911	627644	924583	1100901	27.54
T. obesus	166466	199706	217729	252262	298083	7.46
Tuna like fishes	138554	178208	184674	210103	259949	6.50
Auxis spp.	48427	89705	126337	179182	208252	5.21
T. alalunga	228234	205657	185159	227413	192830	4.82
E. affinis	81108	63732	97361	146546	175070	4.38
T. tonggol	1046	269	60848	121835	113363	2.84
T. thynnus	35057	36845	41615	33227	40106	1.00
S. chilliensis	31519	14790	23059	33730	36801	0.92
S. sarda	16734	20473	34794	29602	26297	0.66
T. maccoyii	42813	35434	41147	22074	13079	0.33
E. alletteratus	3527	7095	17262	21195	11592	0.29
T. atlanticus	134	137	1788	2646	2584	0.06
S. orientalis	0	0	19	752	643	0.02
O. unicolor	118	601	450	719	410	0.01
E. lineatus	74	323	967	872	283	0.01
Thunnini	14	31	390	311	164	0.00
Total	1806865	2096567	2540738	3397772	3998083	100.00

Ocean-wise Production

Pacific Ocean

Skipjack landings continued to increase from 0.448 million t during1973-'75 to attain a peak production of 1.097 million t during 1991-'95 and it constituted 42.3% of the total tuna production during 1991-'95. Yellowfin constituted 26.3% of the total tuna production. Big-eye and albacore landings exhibited a declining trend in general and these two species constituted 5.4 and 4.3%, respectively. The northern bluefin continued to decline from 1981-'84 onwards and it is currently exposed to over fishing. The southern bluefin declined from 1976-'79 onwards with a marginal revival during 1991-'95. The big-eye, albacore, long tail, northern bluefin, black skipjack and small tunas registered a decline during 1991-'95 (Table 3).

In all forty-eight countries have been recorded to exploit tuna from the Pacific Ocean during 1985-'95 and among them the foremost 10 countries are Japan 27.1%, Indonesia 12.2%, Philippines 12.2%, USA 10.2%, China Taiwan 8.2%, Korean Republic 6.9%, Mexico 5.3%, Thailand 4.9%, Venezuela 2.1% and Ecuador 2.1% .

Indian Ocean

Many species constituted the tuna fishery in the Indian Ocean. Among them yellowfin constituted 32.5%, followed by skipjack 30.5%, big-eye and kawakawa each 7.4%, long tail 5.6%, frigate and bullet tuna 3.9%, *T. alalunga* 2.2%, *T. maccoyii* 0.8%, *S. orientalis* 0.1% and tuna like fishes 9.6% of the total tuna catch during 1991-'95 (Table 4). Western Indian Ocean contributed 77.6% and Eastern Indian Ocean 22.4% to the total tuna production from the Indian Ocean. The species composition of the tuna landings from the Eastern Indian Ocean was different from that of Western Indian Ocean, since the tuna like fishes were the dominant group forming 23.4% followed by the yellowfin 18.6%, kawakawa 18.2%, skipjack 12.4%, long tail 10.2%, big-eye 8.1%, *T. alalunga* 3.9%, southern bluefin 3.0% and the frigate and bullet tuna 2.2%. Whereas, in the Western Indian Ocean, yellowfin was the dominant species constituting 36.5% followed by skipjack 35.8%, big-eye 7.2%, tuna like fishes 5.5%, frigate and bullet tuna 4.4%, long tail and little tunny 4.3% each, *T. atlanticus* 1.6%, southern bluefin 0.2% and *S. orientalis* 0.1% during 1991-95.

Table 3. Species composition of tuna landings from the Pacific Ocean during 1973-'95

Species	Average tuna production in tonnes					Percent
	1093-75	1976-80	1981-85	1986-90	1991-95	
K. pelamis	448194	582622	665980	864655	1097192	42.28
T. albacares	289203	359983	412523	618194	682795	26.31
Tuna like fishes	64215	112878	136219	135613	171579	6.61
T. obesus	92995	128180	110511	141555	139024	5.36
T. alalunga	133417	120361	103687	131433	111175	4.28
Auxis spp.	32806	76048	99188	140010	165733	6.39
E. affinis	60246	49786	72157	107924	113399	4.37
T. tonggol	44	24	38212	84756	66372	2.56
S. chilliensis	31519	14790	23059	33730	36801	1.42
T. thynnus	16726	18667	17645	9704	7199	0.28
T. maccoyii	10967	7995	5650	2399	3595	0.14
E. lineatus	74	323	967	872	283	0.01
Thunnini	0	10	10	68	20	0.00
Total	1180406	1471666	1685807	2270912	2595166	100.00

Table 4. Species composition of tuna landings from the Indian Ocean during 1973-'95

Species	Average tuna production in tonnes					Percent
	1093-75	1976-80	1981-85	1986-90	1991-95	
T. albcares	39308	43004	68527	162325	270289	32.5
K. pelamis	24538	32309	80515	200424	253896	30.5
Tuna like fishes	53819	43259	42529	59986	79464	9.6
T. obesus	26439	34878	38689	48492	61687	7.4
E. affinis	20863	13947	25204	38622	61671	7.4
T. tonggol	1002	245	22635	37079	46990	5.6
Auxis spp.	5333	2301	6577	22991	32657	3.9
T. atlanticus	0	0	1877	27155	18005	2.2
T. maccoyii	26645	19897	30109	16984	6642	0.8
S. orientalis	0	0	19	752	643	0.1
T. thynnus	0	0	0	1	0	0
T. alalunga	20344	12517	13280	0	0	0
Total	218291	202357	329962	614811	831946	100.0

Table 5. Species composition of tuna landings from the Atlantic Ocean during 1973-'95

Species	Average tuna production in tonnes					Percent
	1093-75	1976-80	1981-85	1986-90	1991-95	
T. albacares	125251	129924	146594	144065	147817	25.90
K. pelamis	86545	95721	132999	125640	166587	29.19
T. alalunga	74472	72779	66315	68826	63649	11.15
T. obesus	47032	36647	68409	62216	97373	17.06
S. sarda	16734	20473	34794	29602	26297	4.61
T. thynnus	18331	18178	23970	23521	32907	5.77
Auxis spp.	10288	11356	21173	16181	9862	1.73
Tuna like fishes	20520	22071	5726	14504	8906	1.56
E. alletteratus	3527	7095	17262	21195	11592	2.03
T. maccoyii	5200	7542	5348	2691	2842	0.50
T. atlanticus	134	137	1788	2646	2584	0.45
O. unicolor	118	601	450	719	410	0.07
Scombridae	14	21	380	243	144	0.30
Total	408168	422544	525207	512049	570971	100.00

The countries which exploit tuna resource effectively from the Western Indian Ocean are Spain 17.0%, France 14.4%, Maldives 12.5%, China Taiwan 8.8%, India 7.0%, Sri Lanka 6.3%, Iran 5.7%, Japan 5.2%, Pakistan 4.2% and Oman 4.1%. From the Eastern Indian Ocean, Indonesia 36.2%, Thailand 17.8%, India 12.1%, China Taiwan 7.6%, Japan 7.1%, Malaysia 2.7%, Australia 2.6 % and other nations have been recorded to exploit the tuna resource.

Atlantic Ocean

Skipjack and yellowfin are equally dominant, constituting 29.2 and 25.9%, respectively, followed by big-eye 17.1%, albacore 11.2%, northern bluefin 5.8%, *S. sarda* 4.6%, *E. alletteratus* 2.0%, tuna like fishes 1.6%, southern bluefin 0.5%, *T. atlanticus* 0.5% and *O. unicolor* 0.1% (Table 5). Though eighty-five countries have been recorded to exploit tuna resource from the Atlantic Ocean, Spain (24.2%), France (13.2%), Japan (9.5%), Ghana (8.9%), China Taiwan (6.7%), Venezuela (5.6%), Brazil (5.2%), Portugal (3.1%), Turkey (2.9%), Italy (1.8%) and USA (1.6%) exploit more intensively than the other countries. Present status of global exploitation of different economically important species of tuna during 1995 is summarised in Table 6.

Tuna Production in India

All India production

Tuna production in India increased rapidly from a mere 3445 t in 1969 to the peak of 54001 t in 2000. The kawakawa is the dominant species constituting 54.7%, followed by Auxis spp. 18.7%, K. pelamis 1.9%, T. tonggol 9.1% and other tunas 15.6% (Table 7). The geographical region-wise tuna production indicates that the West Coast produced the bulk of the catch (85.2%) and the East Coast only 14.8%. Along the west coast, the south-west coast produced 55.4% and the northwest coast 29.8% and along the east coast, the South-

Table 6. Status of global exploitation of different species of tuna in the three major Oceans during 1995

Ocean	Species	Countries	Fishery status
Pacific	Albacore (*T. alalunga*)	China Taiwan, Japan, USA, Fiji	North: O, R South: F
	Bigeye (*T. obesus*)	Japan, Korea Rep	M- F
	N–Bluefin (*T. thynnus*)	Japan, USA	Y/R overfishing
	Skipjack (*K. pelamis*)	Japan, USA, Philippines, Indonesia	M
	Yellowfin (*T. albacares*)	Mexico, Japan, Indonesia, Korea Rep.	East: F Centre&West:M
Indian	Albacore (*T. alalunga*)	China Taiwan	? F
	Bigeye (*T. obesus*)	China Taiwan, Japan, Korea Rep.	? F
	S. bluefin (*T. maccoyii*)	Japan, Australia	D
	Skipjack (*K. pelamis*)	Spain, Maldives, France, Japan	U-M
	Yellowfin (*T. albacares*)	France, Spain, Pakistan, China Taiwan	? F
Atlantic	Albacore (*T. alalunga*)	Spain, China Taiwan, France	North: ?U-M South: ? F-O
	Bigeye (*T. obesus*)	Japan, Spain, France, Portugal,	? F-O
	N. bluefin (*T. thynnus*)	France, Italy, Spain, Japan	West: ? D East: ? F-O
	Skipjack (*K. pelamis*)	Spain, France, Ghana, Brazil	? M
	Yellowfin (*T. albacares*)	Spain, France, China Taiwan, Venezuela	F

Table 7. Species-wise tuna landings (in t) in India during 1985-2000

Species	1985	1986-90 Average	1991-95 Average	1996-2000 Average	1985-2000 Average	Percent
E. affinis	16582	21163	19431	19996	19293	54.7
Auxis spp.	3076	6662	7220	9342	6575	18.7
K. pelamis	85	318	212	2075	673	1.9
T. tonggol	1086	728	4318	6674	3202	9.1
Others	6434	3477	4212	7833	5489	15.6
Total	27263	32348	35393	45919	35232	100.0

Table 8. Annual average landings (in t) of different component species of tunas from the four geographical regions of India during 1990-'97

Species	North-east	South-east	South-west	North-west	Total	Per cent
E. affinis	151(0.7)	4082 (19.2)	13222(62.1)	3827 (18.0)	21282	54.9
Auxis spp.	4 (0.05)	561 (7.1)	6567(83.1)	770 (9.75)	7902	20.4
K. pelamis	0 (0.0)	184 (81.3)	29 (12.6)	14 (6.1)	227	0.6
T. tonggol	0 (0.0)	302 (6.4)	576 (12.2)	3857 (81.4)	4735	12.2
Others	25 (0.55)	445 (9.62)	1081 (23.33)	3082 (66.50)	4633	11.9
Total	180 (0.4)	5574 (14.4)	21475 (55.4)	11548 (29.8)	38777	100.0

*Figures within the parentheses indicate the percentage contribution by the respective geographical regions

Table 9. Tuna production (in t) by non-mechanised, mortorised and mechanised sectors in India during 1985-'96.

Fishery Sector	1985	1986-90 Average	1991-95 Average	1996	1985-96 Average	Percent
Motorised	5208	14530	21944	29043	17681	50.4
Mechanised	17650	13275	10143	8450	12380	37.8
Non-mechanised	440	454	3306	3427	3920	11.8
Total	27263	32348	35393	40920	33981	100.0

east coast produced 14.4% and the North-east coast produced a mere 0.4%. As already mentioned above, the order of dominance of different species remained to be the same with little variation (Table 8).

Production by different sectors

The motorised sector produced more than half (50.4%) of the total tuna production in India, followed by the mechanised sector (37.8%) and then the non-mechanised sector (11.8%). The mechanised sector registered a continued decline in the catch and the non-mechanised sector registered a marginal increase during 1986-'90 and then declined during the latter years. Whereas the production by the motorised sector continued to increase steadily from 5,208 t in 1985 to 29,043 t in 1996 (Table 9).

The species composition of the landings by these three sectors indicate that there is no difference in the order of dominance of the species and only the quantum of the catch of different species varied. The order of dominance the different species were *E. affinis*, other tunas, *Auxis* spp., *T. tonggol* and *K. pelamis*. *E. affinis* and *Auxis* spp. alone constituted 92.4% in the non-mechanised sector catch, 78.9% in the mortorised sector catch and 72.2% in the mechanised sector catch.

Gear-wise species composition

Chiefly the drift gillnet with mesh size 60 to 160 mm, hooks & lines, purse seine, long line and pole and line are employed for the exploitation of tuna along the Indian coasts. The tuna production by different types of fishing fleet under the mechanised sector indicate that during 1985-'96 the gillnet landed 59.4%, followed by the purse seines 23.1%, ring seine 10.4% and the trawl 7.1%. The tuna landings by purse seine stabilised around 3551 and 3593 t during 1986-'90 and 1991-'95 respectively and then declined drastically to 519 t in 1996. The ring seine introduced in the late 1980's reflects a decline in the catch from 2793 t during 1986-'90 to 1662 t during 1991-'95, and further to a mere 18 t in 1996. The landings by gillnet also reflect a similar declining trend in the production as that of ring seine with a marginal revival in 1996. Tuna production by trawl initially declined from 1082 t in 1985 to an average annual catch of 451 t during 1986-'90 and then revived during 1991-'96 (Table 10).

The species composition of purse seine landings given in Fig. 13 indicates that the first three dominant species were *E. affinis* 63.2%, *Auxis* spp. 24.5% and *T. tonggol* 10.5%. Only two species, *E. affinis* (67.8%) and *Auxis* spp. (30.2%) were dominant in the ring seine catch. The dominance of species was also slightly different in gillnet landings, as the second dominant group was other tunas (26.6%) next to *E. affinis* (58.5%) followed by *T. tonggol* (7.3%) and *Auxis* spp. (6.9%). The species composition of trawl was similar to that of gillnet with little difference.

Table 10. Tuna production (in t) by different gears operated by the mechanised sector in India during 1985-'96

Gears	1985	1986-90 Average	1991-95 Average	1996	1985-96 Average	Percent
Gillnet	13228	6300	3968	6637	7349	59.4
Purse seine	3340	3551	3593	519	2865	23.1
Ring seine	0	2973	1662	18	1292	10.4
Trawl	1082	451	920	1276	874	7.1
Total	17650	13275	10143	8450	12380	100.0

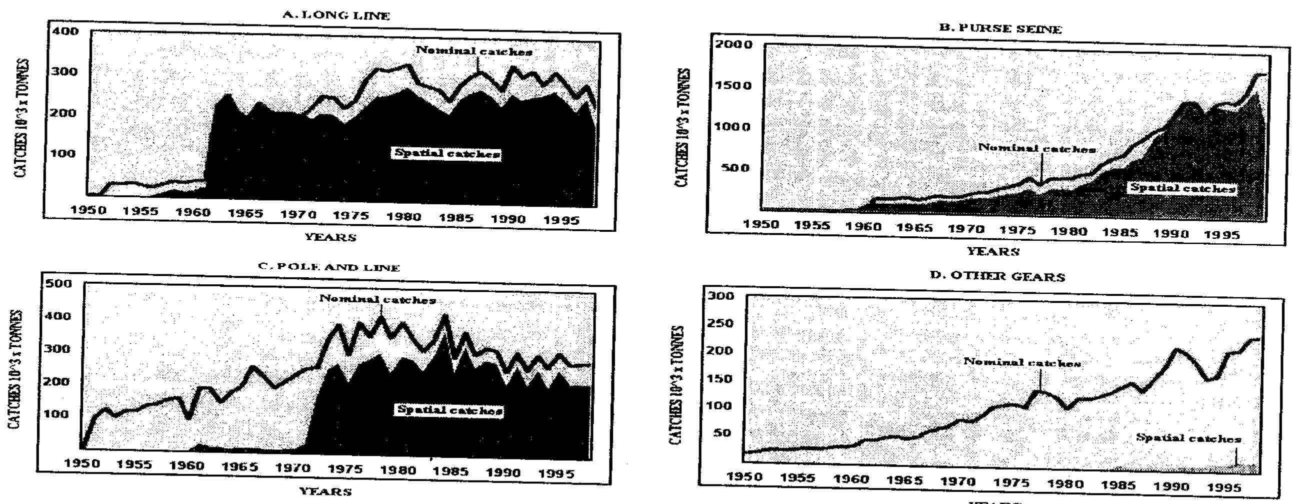

Fig 2. Tuna and billfishes catches from Pacific Ocean by long line (A), purse seine (B), pole and line (C) and other gears (D) during 1950 -1998. Nominal catches refer to all catches reported including those for which 5° x 5° data are not available. Spatial catches refer to only catches for which 5° x 5° data are available.

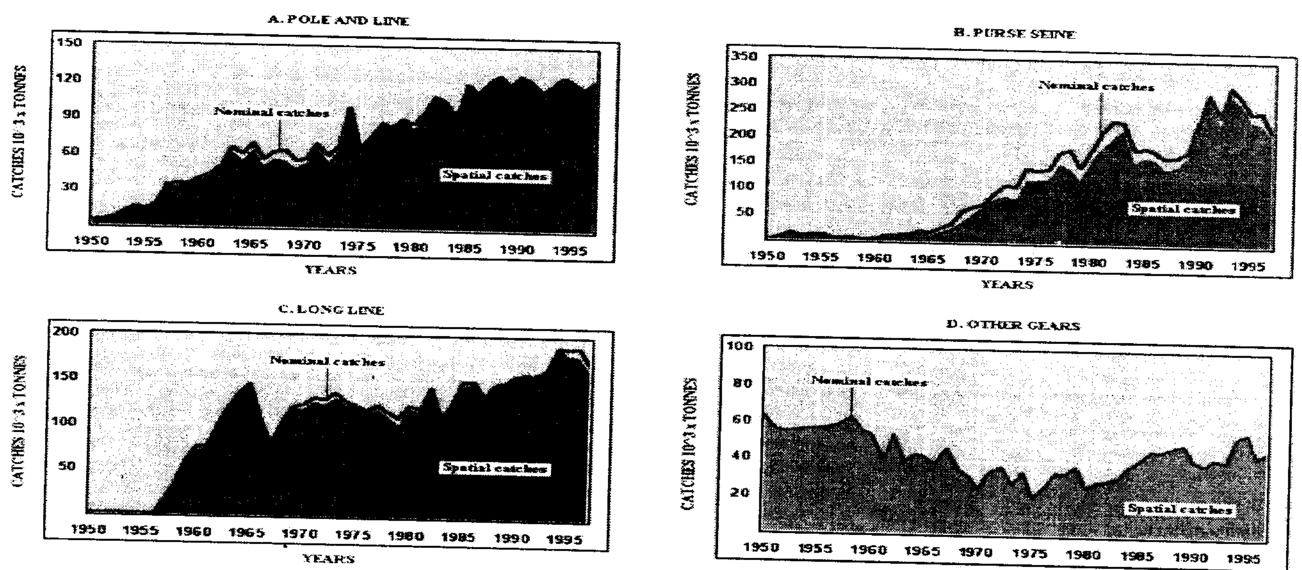

Fig 3. Tuna and billfishes catches from Atlantic Ocean by different gears indicated during the years from 1950 to 1998. Nominal catches refers to all catches reported including those for which 5° x 5° data are not available and spatial catches refers to only catches for which 5° x 5° data are available.

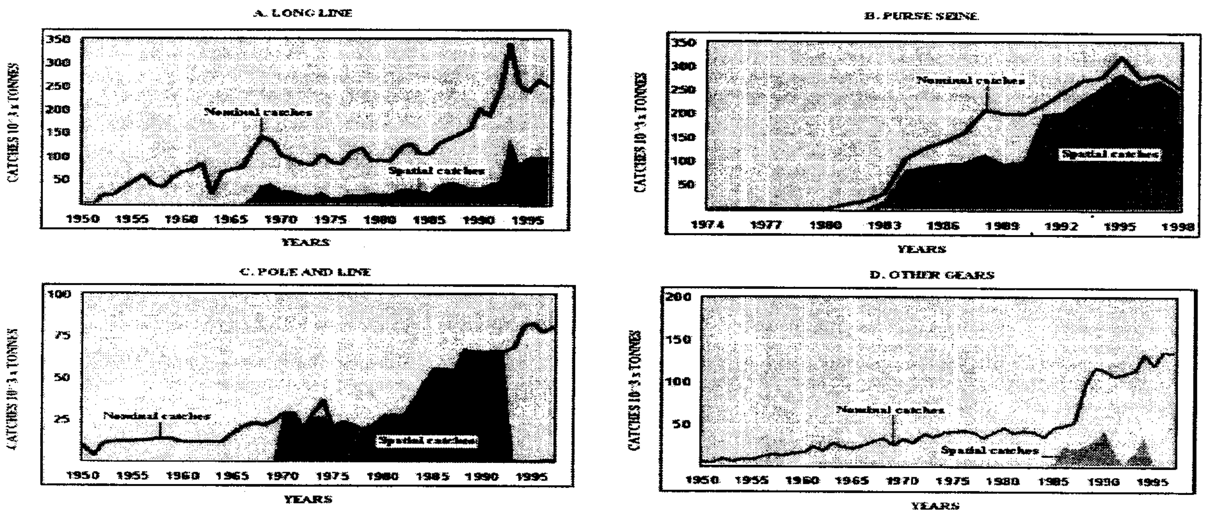

Fig 4. Tuna and billfishes catches from Indian Ocean by long line (A), purse seine (B), pole and line (C) and other gears (D) during 1950 - 1998. Nominal catches refers to all catches reported including those for which 5° x 5° data are not available. Spatial catches refers to only catches for which 5° x 5° data are available.

Discussion

Though many species support the global tuna fishery, only seven species *T. albacares, T. obesus, T. alalunga, T. thynnus, T. maccoyii, Auxis* spp. and *K. pelamis* are universal in occurrence. Among the other species, *E. affinis* and *T. tonggol* are confined to Indo-Pacific Oceans, *T. atlanticus* to Indo-Atlantic, *S. orientalis* to Indian, *S. chilliensis* and *E. lineatus* to Pacific and *S. sarda, E. alletteratus* and *O. unicolor* to Atlantic Oceans. Among the universal seven species, albacore *T. alalunga* is fully exploited in the southern Pacific, southern Atlantic and Indian Oceans, over-exploited with a sign of recovery at present in the northern Pacific, and either under-exploited or moderately exploited in the northern Atlantic Ocean. The big-eye, *T. obesus* is fully exploited in the Atlantic and Indian Ocean and either moderately or fully exploited in the Pacific Ocean. The northern bluefin, *T. thynnus* is suffering from Y/R over fishing in the Pacific Ocean. It is facing depletion in the western Atlantic Ocean and either fully or over- exploited in the eastern Atlantic Ocean. The southern bluefin, *T. maccoyii* is facing almost depletion in the Indian Ocean. The yellowfin, *T. albacares* is fully exploited in all the three Oceans except in the central and western Pacific Ocean where it is moderately exploited. The skipjack is the only species moderately exploited in the Pacific, Atlantic Oceans and either moderately or under-exploited in the Indian Ocean. The frigate and bullet tunas are not commercially important owing to their small size. All the five important species of the genus *Thunnus* are fully exploited and are almost depleted in many areas, except albacore in the northern Atlantic, where it is either under or moderately exploited, the big-eye in the Pacific, where it is moderately fished and the yellowfin in the central and western Pacific, where it is moderately exploited.

Current world tuna longline vessels equipped with deep freezer facilities are over 1,400 including 703 Japanese vessels, 334 Taiwanese vessels, 206 Korean vessels and 200 re-flagging vessels. Among the leading tuna producing countries, around 1,000 tuna fishing vessels were in operation in Japan during 1995, producing over 4 billion dollars worth catch and employing 20,000 fishermen, making tuna industry the largest sector among Japanese fisheries sectors. Japanese tuna industry is facing difficulty in finding new crew on one hand and with restrictions in international fishing grounds on the other. As a result the number of tuna longlining vessels decreased by 36% and skipjack pole and line boats by 70%. However, tuna purse seiners have increased by 8% in number. Overall Japanese tuna production declined by 12% despite great efforts by fishermen to maintain their production level despite appreciation of yen against US dollar. The plateaunic growth of tuna production in Indonesia is attributed to the Indonesian fishing methods. Gillnetting, trolling, pole and line, purse seining and small wooden boats are still significant as the gear and crafts for catching tuna. Among the 2,828 deep sea fishing boats in 1994, about 73.4% were below 100GT and only 161 were above 300 GT. Long liners were 992, fish carriers 135, purse seiners 260 and pole and line boat 94. In 1995, the number of boats declined to 2,308 of which 967 were foreign flag vessels. In Thailand also the tuna industry is showing signs of decline after more than a decade of steady and at times very fast growth. The Philippines tuna industry also indicates signs of slowing growth. The industry is actually aggressively expanding by joining the ranks of distant water fleet operators due to the high demand by the canning industry, as the domestic tuna production is lower than actual need.

There is scope for further increase in the production of yellowfin, skipjack and small tunas from the Indian Ocean, as the landings of these species continued to increase with minor fluctuations. Whereas, southern bluefin landing started to decline from the early 1980's onwards and that of longtail, kawakawa, big-eye and albacore from the latter 1980's onwards. Albacore, big-eye and yellowfin are fully exploited in the Indian Ocean and southern bluefin is at the verge of depletion. Only skipjack is either under or moderately exploited.

Exploratory surveys and experimental fishing for tuna by purse seine was commenced in 1981 in the Indian Ocean. French and Spanish entered Indian Ocean by shifting part of their purse seine fleet from Atlantic during 1984 and the number of the units owned by all the countries varied from 32 to 38 during 1984-'86. The French owned purse seine fleet based at Seychelles mostly operated in the equatorial western Indian Ocean in the area 42°-72°E and 12°S-5°N. The sudden increase in the production was mainly due to skipjack and yellowfin and the fleet owned by the distant water nations contributed almost 55% of the total tuna production from the Indian Ocean. Detailed review on the development and subsequent changes in the trend of the industrial purse seine fishery for tuna in the tropical Indian Ocean have been summarised by Marcille (1985), Hallier (1985), Watanabe (1985) and Michard and Hallier (1986). As reported by James and Pillai (1991) the tuna production by the developed countries like USA, France, Spain, Taiwan, Republic of Korea declined from 74% as early in 1979 to 69% in 1984. Whereas, the production by the developing countries like Indonesia, Philippines, Mexico, Venezuela, Solomon Is, Maldives, Equador, Ghana, Brazil, Panama, Sri Lanka, Australia and others increased from 445,000 t in 1979 to 656,000 t in 1984, registering 45% increase and constituted 81% of total tuna catch.

Silas and Pillai (1985, 1986), Varghese *et al.* (1984), Joseph (1986), Sivaprakasam and Patil (1986), James and Pillai (1987,1991) have dealt in details with tuna longline operations by FSI vessels in the Arabian sea, Bay of Bengal and equatorial Indian Ocean areas during 1980's. The catch rate of tuna was recorded to be 35.76% in Andaman Sea, 38.1% in Bay of Bengal, 47.59% in Arabian Sea and 62.3% in the equatorial Indian Ocean. A high hook rate of 1.48-2.74% was reported in the Arabian Sea during September-December period compared to 1.13-1.18% in the Bay of Bengal during January-April period and 1.2-2.19% in the equatorial ndian Ocean area during October-November period (Joseph and John, 1986). Swaminath *et al.* (1986) have reported a high percentage composition of tuna i.e., yellowfin 73.0%, skipjack 2.1% and big-eye 0.8% in the catch from the longline surveys of tuna resources in northern Indian Ocean (6°-15°N, and 67°-97°E). The hooking rate by tuna remained as high as 2.21 and 2.29% by the longliner Vaishnavi I and II, respectively of M/s Fishing Falcons Ltd., during March and September, 1993 (Sivaprakasam, 1995). Pillai *et al.* (1993) reported that yellowfin is landed by drift gillnet, hooks & lines and troll tines within 50 m depth during the tuna fishery season. Small scale pole and line fishery (live-bait) and troll line (surface) fishery in the Lakshadweep exploits young yellowfin tunas, which forms 16% of total tuna landing from islands. Oceanic survey/training longline vessels of Govt. of India (during 1983-'90) and the foreign longline vessels operating in the EEZ under chartered agreement (during 1985-'90) have landed an average catch of 92.8 t and 2539 t, respectively.

Tuna production from India has steadily increased during the last 3 decades and there is scope for further increase as indicated by the available resource potential in the Indian EEZ and the contiguous seas around India. South-west monsoon and post-monsoon period are the productive seasons for tuna along the south-west coast of India and post-south-west monsoon period is the productive season along the north-west coast. Along the Lakshadweep islands, December-April is the peak period of production. Fisheries potential of the EEZ of India is estimated to be 3.9 million t and out of this 2.21 million t is assessed to be from the 50 m depth and the balance 1.69 million t is estimated from beyond 50 m depth (Anon, 1991). Marine fish production by India in 1997 was 2.7 million t, in which 2.21 million t have been landed from the area within 50 m depth and the balance 0.49 million t have been landed from the area beyond 50 m depth. There is scope for further increase in production to the tune of 1.2 million t from the area beyond 50 m depth only as the near shore water is fully exploited at present. As per Devaraj et al. (1997) small tunas (*Auxis* spp., *Euthynnus* spp., *Thunnus tonggol, Sarda* spp.,) have been assessed to be the potentially transboundary pelagic stocks in western Indian Ocean, Malacca strait, Gulf of Thailand, South China sea, Celebes sea (Sulawesi sea) and being exploited by coastal states along the eastern Indian Ocean and east China sea. The resource potential of different species/groups of tuna in the Indian Ocean are estimated to be, yellowfin 100-150,000 t, big-eye 30-60,000 t, skipjack 200-400,000 t, small tunas and seerfishes 200-300,000 t, billfishes 10,000 t and in the Indian EEZ yellowfin 109,000 t, big-eye 300 t, skipjack 100,000 t, billfishes 3,800 t *and* the total including other fishes 246,000 t (FAO, 1987; Sudarsan *et al.*, 1990). The total resource potential of tuna and tuna like fishes in the Indian Ocean works out to 920,000 t and tuna production alone attained 769,000 t in the Indian Ocean as early as 1992 and now it may be still higher. Tuna and billfishes are estimated to constitute 213,100 t, nearly 87% of the total estimated potential for the Indian EEZ. As per the above estimates as much as 26.7% of the total tuna resource potential of Indian Ocean is available within the Indian EEZ.

All these observations and other published reports indicate that a considerable magnitude of tuna resource is available for exploitation and all the tuna fishing industry should be performing well, but it appears that all the Indian tuna companies are experiencing much hardship to make profit. Some of the researchers who maintained that deep-sea fishing is uneconomical, have reported that tuna fishing in Indian EEZ will be profitable (Gokhale, 1988). However, the tuna fishing in the EEZ and adjacent seas has not taken off so far. Many fishery workers, administrators and managers have expressed that it is very essential and imminent for India to exploit the oceanic tuna resource in the Indian Ocean considering the availability of the untapped resource potential and expertise prevalent in the fishing industry in India (Sivaprakasam, 1995; Mitra, 1999). Not only India, many other countries in the Indian Ocean are also in the same position as that of India facing similar problems in venturing into the deepsea oceanic fishing for tuna in the Indian Ocean. The Round Table Conference on Tuna Fishing in Indian EEZ organised by the MPEDA and the Association of Indian Fishery Industries (AIFI) in June, 1999 has come forward with eight useful recommendations to be implemented by various Government and Non-Government Organisations for strengthening the tuna fishing in the Indian EEZ and the surrounding seas in the Indian Ocean. As an initial step the existing idle trawlers on the North-east coast of India have to be equipped with the tuna monofilament long lining so as to undertake tuna long line operations.

It will be more relevant to summarise the salient observations/recommendations made by the earlier workers for the development and management of the tuna fishing in Indian Ocean hereunder (Sivaprakasam, 1995; Mitra, 1999).

Finance appears to be main crux of the industry. A system of financing the marine fishing sector has to be introduced, may be direct financing by the Government to the private sector for the acquisition of vessels, fortified with intensive supervision and guidance like that of the Australian pattern. Financing should be efficient and quick, devoid of delay, which often kills the sprit and the very objective of the fishing industry.

Survey reports show that the hooking rate was as high as 45% during 1985-87 with an average of 6% in the Indian Ocean owing to the virgin status of the tuna resource at that time. Now the hooking rate has come down due to increased exploitation of the resource by charted tuna longliners and purse seine fleet owned by the distant water nations. Now many huge longliners are not faring well because of high capital investment and heavy interest charges, which results in poor profitability coupled with the reduced abundance and extra fuel expenditure in search of the tuna shoals. It would be advisable to go in for more number of smaller vessels operating with a single mother ship as prevalent in Indonesian waters.

The violent variation in the tuna catches may be attributed to the global distribution, highly extensive migratory habit and varying behaviour due to ambient environmental parameters. One has to track them down in the sea with required sophisticated gadgets and catch them. The experience and expertise of Japanese and Taiwanese in tuna longlining and of the Americans, Spanish and French in tuna purse seining may be availed. Installation of remote sensing equipments on board will help in identifying thermal fronts, sea mounts etc., where tunas congregate.

Operational overhead charges may be kept minimal by deploying optimum number of shore staff for the required number of vessels. Sharing of the shore establishment by more than one company with minimal number of vessels may be explored by mutual co-operation/amalgamation.

Post-harvest processing and preservation of tuna on board is very important as the batter quality ensured higher price in the Sashimi market. 'Chilled tuna' commands better price than the frozen tuna in Japan. Collaboration with developed countries in this area is inevitable in this area till we are conversant with such post-harvest processing practices.

The sub-surface deep water dwelling species like the yellowfin, big-eye, albacore, southern bluefin are exploited heavily by the longliners. The surface dwelling skipjack resource is considered to be either under or moderately exploited and there is a good scope for the exploitation of this species by deploying purse seining in a big way.

The oceanic habitats of the Andaman-Nicobar and the Lakshadweep islands offer an excellent environment for the deployment of the 'Fish Aggregating Devices' (FAD) which serve as the rafts or 'payos' for the exploitation of tunas which congregate around these FAD. This will improve the economy of the fishermen tremendously as in Philippines.

Potential yield from the Indian EEZ is estimated to be 3.94 million t and the present production is estimated to be 2.7 million t, in which, 2.2 million t is realised from the inshore water within 50 m depth, which is equivalent to the estimated potential yield from this area. Only 0.5 million t is produced from the oceanic waters beyond 50 m depth area, whereas the production can be increase by 1.24 million t more to attain the potential yield of 3.9 million t. The major resources, which can contribute for the increase in production, are mainly the straddling resource like tuna and billfishes. At present only the coastal tunas like *E. affinis* and *A. thazard* are being exploited by the mechanised and motorised sectors in India within 100 m depth area owing to the lack of proper oceanic fishing fleet, trained man power, expertise in pole and line, long line and purse seine operations, appropriate post-harvest handling and shore-based infrastructures. The existing mechanised sector is suffering from excess effort expenditure prompting an urgent need for a reduction in the number of mechanised units. Therefore, as an experimental measure, conversion of a part of the steel trawlers presently idling on the North-eEast Coast may be attempted for tuna longlining similar to that of Indonesian tuna fishing along the Indian waters also. In order to overcome the financial constraint for the conversion, the Government may provide subsidy to the fleet owners along with a soft loan. If such conversions are proved to be successful, more number of such medium sized mechanised vessels may be introduced for tuna longlining with appropriate financing facilities to meet the capital investment.

It is very essential to monitor the tuna fishery closely to avoid over exploitation and over capitalisation so as to avoid the collapse of the fishery due to socio-economic problems. Such collapse of the fisheries has been observed not only in many parts of the world, but in our own country also i.e., the shrimp fishery of upper East Coast. Therefore, the tuna fishery and its resource characteristics of not only the Indian EEZ but the entire Indian Ocean needs monitoring and this will be possible only by mutual co-operation of the member countries of the Indian Ocean and other distant water nations which exploit tuna in the Indian Ocean. As proposed by Silas and Pillai (1982) the establishment of the 'ICCIOT' (International Commission for the Conservation and Management of Indian Ocean Tunas) may be imminent to design and implement a coherent policy for the Indian Ocean tuna fishery.

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