Work Plan Implementation
(General Papers)

IPTP/90/GEN/18

REPORT OF THE EXPERT CONSULTATION ON STOCK ASSESSMENT OF TUNA IN THE INDIAN OCEAN

Bangkok, 2 - 6 July, 1990

September 1990

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INDO-PACIFIC TUNA DEVELOPMENT AND MANAGEMENT PROGRAMME (IPTP)
Colombo, Sri Lanka

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REPORT OF THE EXPERT CONSULTATION
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1. OPENING OF THE MEETING

The Expert Consultation on the Stock Assessment of Tuna in the Indian Ocean was held at the FAO Regional Office for Asia and the Pacific (RAPA), Bangkok, Thailand, from 2 to 6 July 1990. On behalf of FAO, Mr H. Tsuchiya, Officer-in-Charge, RAPA, welcomed the participants and opened the meeting.

Mr T. Sakurai, Programme Leader of the Indo-Pacific Tuna Development and Management Programme (IPTP), expressed first of all his sincere thanks to participants for their attendance and then explained the history and objectives of the Expert Consultation. He emphasized that it was a scientific meeting and participation was as an expert and not as a government representative. He therefore, requested frank discussions in order to conclude the meeting successfully.

All participants introduced themselves by their names and official titles from their respective governments and organizations. A list of participants is attached as Appendix 1.

2. ADOPTION OF AGENDA AND ARRANGEMENTS FOR THE MEETING

The Provisional Annotated Agenda and Timetable prepared by the Secretariat was presented and adopted without amendments. The adopted agenda and timetable is attached as Appendix 2.

A number of papers giving background information were presented by participants and the Secretariat. List of documents presented is attached as Appendix 3.

The chairman of the meeting and chairmen and rapporteurs for the discussions of each agenda item were appointed as follows.

1. Chairman of the meeting

   Dr A. Fonteneau

2. Chairmen and rapporteurs of the discussion groups

   Agenda item 3 - Review of national fisheries and research programmes.

   Chairman - Dr. A. Fonteneau

   Agenda item 4 - Report of the Indo-Pacific Tuna Development and Management Programme.

   Chairman - Dr. A. Fonteneau
   Rapporteur - Mr. M. Yesaki

Agenda item 5 - Review of the scientific papers on biological study and stock status

5.1 Yellowfin and skipjack tuna

Chairman - Dr. G. Sakagawa
Rapporteurs - Dr. Z. Suzuki for yellowfin tuna
Dr. F. Marsac for skipjack tuna

5.2 Bigeye, albacore and southern bluefin tuna

Chairman - Dr. D. Sudarsan
Rapporteurs - Dr. J.P. Hallier for bigeye tuna
Dr. H. Liu for albacore
Mr. P. Neave for southern bluefin tuna

5.3 Small tuna, seerfish and billfish

Chairman - Mr. P. Ward
Rapporteurs - Ms. Chee Phaik Ean for small tunas
Dr. P. P. Pillai for seerfish
Dr. P. Dayaratne for billfish

Agenda item 6 - Interaction and tagging experiments

Chairman - Dr. P.S.B.R. James
Rapporteur - Mr. T. Lawson

Agenda item 7 - Drift gillnet fishery

Chairman - Dr. P. Cayre
Rapporteur - Dr. J. Majkowski

Agenda item 8 - Review of status of IPTP database

Chairman - Ms. G. Lablache Carrara
Rapporteur - Mr. M. Yesaki

In memory of John Gulland

The recent death of John Gulland was received with sadness by participants of the Consultation. John Gulland was a friend, teacher and colleague of many of the participants. His contribution to fishery science in general and tuna assessment in particular has been monumental and will be missed. The Consultation dedicated a moment of silence to honour the memory of John Gulland.

3. REVIEW OF NATIONAL FISHERIES AND RESEARCH PROGRAMMES

An expert from each country presented a country status report describing the present status of tuna fisheries, research and data collection activities.

Summary of the country status reports presented are given in Appendix 4.

4. REPORT OF THE INDO-PACIFIC TUNA DEVELOPMENT AND MANAGEMENT PROGRAMME

Mr T. Sakurai, Programme Leader of IPTP, presented Document TWS/90/5) on the Report of the Activities of the Indo-Pacific Tuna Development and Management Programme (IPTP), which outlined the history and objectives of IPTP projects. The Programme's activities for the 1988-1989 period were summarized under the following topics.

(1) Tuna database building

Statistics are collected from 36 countries in the Indian Ocean and Southeast Asian regions. This information is compiled and published in four statistical bulletins and disseminated to countries in these regions. IPTP also makes available information to interested parties on request.

(2) Review on the status of tuna stocks and their exploitation

IPTP convened an Expert Consultation on Stock Assessment of Tuna in the Indian Ocean, 2 Southeast Asian Tuna Conferences, and Workshops on Small Tunas in the Gulf of Thailand and on Tunas and Seerfishes in the north Arabian Sea, during the past 2 years to assess the status of tuna stocks.

(3) Assistance Programmes on data collection and research activities

The Programme provided assistance for sampling programmes and tagging experiments to various countries in the two regions. Assistance was also provided for an age and growth study of juvenile kawakawa and seerfish and to stock assessment of western Pacific yellowfin tuna and small tunas in the South China Sea.

(4) Training courses

The Programme conducted training courses for participants from the region on stock assessment, tagging and database management with computers. Scientists were also sent on study tours and training courses on specific subjects.

(5) Publications

The Programme continued publishing documents in its various publication series.

The Expert Consultation was informed of the future prospects of the IPTP projects, as follows:

(1) The project "Tuna Development and Management in the Indian Ocean and Southeast Asian Regions (INT/89/048 : Phase III)", (UNDP project) will extend up to the end of 1991 as a result of the Diplomatic Conference held in Rome, 3-7 April 1989 and on the recommendation of a Tripartite Review Meeting of the IPTP held in Rome on 7 April 1989. This project is funded on a cost-sharing basis with participating countries and EEC.

(2) The project "Investigation on Indian Ocean and Western Pacific Small Tuna Resources (GCP/RAS/099/JPN)" (Japanese trust fund project) is scheduled to terminate at the end of 1990.

The IPTP activities performed over the past eight years were appreciated by the participants and in recognition of the importance of the continuation of its activities, the Expert Consultation recommended that;

(1) a new body to deal with Indian Ocean tuna to replace IPTP should *inter alia* undertake to:

i) improve and standardize systems for the collection of accurate catch, effort, size and other biological information on tuna and tuna-like species;

ii) encourage and support working level cooperation and collaboration between fishery researchers on regional activities;

iii) organize regular and *ad hoc* regional and sub-regional meetings to consider items such as:

- the implementation of regional research programme,
- stock assessment,
- the recommendations of fisheries management and development programmes.

(2) the present Japanese Trust Fund Project be continued until such time that a new body to deal with Indian Ocean tuna is established.

(3) a new project be established for Southeast Asian countries i.e., the Philippines, Indonesia, Thailand and Malaysia, with similar functions to those outlined in (1) above after IPTP terminates its activities in this area.

5. REVIEW OF SCIENTIFIC PAPERS ON BIOLOGICAL STUDY AND STOCK STATUS

5.1 YELLOWFIN AND SKIPJACK TUNAS

5.1.1 OVERVIEW OF FISHERIES

1. Purse seine fisheries

The industrial purse seine fishery is restricted to the western part of the Indian Ocean (FAO area 51). The exploitation on an industrial basis started in 1979 with a purse seiner operated by a Mauritius-Japan joint venture. French purse seiners started exploratory fishing in 1980 and continued until 1983. These successful surveys were followed in 1984 by a movement of the whole French fleet and part of the Spanish fleet, from the Atlantic to the Indian Ocean. By the end of 1984, 49 activive vessels were fishing in the western Indian Ocean. In 1986, the number of vessels decreased to 38 but started to increase again in the following years to reach a maximum of 52 seiners by the end of 1989. In 1989, the countries having large purse seiners in the western Indian Ocean were Cayman Islands, France, Japan, Mauritius, Panama, Spain and USSR. (YFT Fig. 1 and YFT Table 1).

Total catches by purse seiners increased steadily to 230,000 t in 1988, then decreased slightly to 220,000 t in 1989. The catches are mainly composed of yellowfin and skipjack, more or less in the same proportion (45 to 55 percent) on a yearly basis. However, the species breakdown is very closely related to the fishing strategy that prevails, and the seasonal or inter-annual variation of log associated or free schools fishing activity has an effect upon the predominant species found in the catch. Fishing on logs results in lower proportions of yellowfin (24 percent on 1984-89 figures for the French fleet), a higher proportion of skipjack (71 percent) and a significant proportion of bigeye (5 percent). Japanese and Mauritian vessels, whose fishing strategy is based on deployment of artificial drifting rafts, catch higher proportions of bigeye than the other fleets. With respect to Mauritian vessels, the bigeye portion of the catch increased over the last three years, to reach more than 15 percent in 1989, which is very different from the French and Spanish fleets. This might be related to the Mauritian vessels using a deeper purse seine. While French and Spanish nets range from 180 to 230 m in depth, the Japanese and Mauritian vessels are geared with deeper nets (250 to 300 m). This allows more intensive exploitation in the deeper layers where bigeye are concentrated. On free schools, yellowfin is the major species caught, comprising more than 70 percent of the catch while skipjack represents around 25 percent. This species composition is reversed in log schools i.e., the catch is dominated by skipjack.

The size composition of skipjack in the catch does not vary much between log and free schools. On the other hand, the size frequency distribution varies considerably for yellowfin tuna and is quite different between the two types of schools; In log schools more than 75 percent of the number of yellowfin belong to the 40-70 cm size group or 27 percent of the total yellowfin weight: In free schools, 38 percent by number, belong to the 120-150 cm size group or 68 percent by weight (YFT Fig. 4).

2. Pole and line fishery

Live bait pole-and-line fishing contributes more than 95 percent of the catches for the Maldives Islands. In Sri Lanka, this gear is used in the southern coastal areas only, and the catch is small. In India, pole-and-line live bait fishing is strictly limited to the Lakshadweep area. The target species is skipjack with catches of around 5,000 t per annum. This fishery is the best organized tuna fisheries in India.

Two exploratory fishing experiments with large pole-and-line fishing vessels were conducted in Mozambique from 1983 to 1984 and in the Seychelles in 1979 and 1982. No following development of a major industry resulted from these experiments. In Madagascar (north-west coast), pole-and-line fishing was undertaken on an industrial basis by a Madagascar-Japan joint-venture using Japanese vessels from 1973 to 1975. This venture which was mostly conducted in the northern Mozambique Channel and around Aldabra Island was interrupted before completion because of problems not related to tuna resources.

For the current review only the traditional Maldives pole-and-line fishery was considered. The target species is skipjack, with catches exceeding 58,000 t in 1988 (90 percent of the catch). Yellowfin remains stable at a lower level (6,400 t in 1988).

The size composition of skipjack (SKJ Fig. 3) taken by the Maldivian fishery consists of two groups (modes at 45 cm and 66 cm FL).

3. Longline fishery

Tuna catches of longline fishery in the Indian Ocean almost exclusively have been made by three distant-water fishing countries, Korea, Taiwan (Province of China) and Japan. Longline catches other than from these three countries are small. India has entered the longline fishery in 1986 with Indian longliners as well as with foreign fishing vessels chartered by Indian companies.

The Japanese fleet with the longest history, started operations in the Indian Ocean from 1952 followed by the Taiwanese from 1963 and then by the Korean fleet from 1966.

The Japanese fleet shifted the target species from yellowfin, albacore and bigeye tunas in the tropical areas to southern bluefin and bigeye tunas in the higher latitudes during the 1970's. The Taiwanese fleet had been targeting on albacore but recently changing the target species to yellowfin and bigeye tunas, while still keeping a dominant albacore catch among the three longlining countries. The Korean fleet has been operating in the tropical waters since the beginning of its fishery targeting on yellowfin and bigeye tunas.

Deep longlining was introduced first by the Japanese longliners in the late 1970's and became dominant by the turn of the 1980's in the tropical waters. This method has higher fishing efficiency for bigeye tuna compared with regular longlining. The Korean and Taiwanese fleets also use the deep longlining primarily in the tropical waters.

4. Gillnet fisheries

Taiwanese large-scale drift gillnets began fishing in the Indian Ocean from 1983. They target albacore but land bigeye, yellowfin and bluefin tuna as by-catches. Billfishes, skipjack and sharks are also caught.

5. Artisanal fisheries

In the Indian Ocean, coastal states fish for tuna using artisanal or traditional gear. Those include gillnets, troll lines, longlines and handlines. The increasing use of fish aggregating devices in fishing for skipjack, yellowfin and marlin in Mauritius was reported. In the Maldives, pole-and-line fishery with live bait and troll lines are operated. Skipjack is the dominant tuna species caught. Yellowfin, frigate tuna and kawakawa are also landed in much lesser quantities. In Sri Lanka, 90 percent of the tuna caught in the offshore area are by gillnets. Presently a combination of fishing gears including gillnet, longline, handline and troll line is being used. The majority of tuna caught is skipjack and yellowfin. Indian fishermen using drift nets, purse seines and hooks and lines operate within 50 miles along the coast and land small tunas with some skipjack and yellowfin. In the state of Lakshadweep pole-and-line fishing and troll lines catch skipjack and yellowfin. Off the northeastern coast of Oman, catches of yellowfin tuna are made with handlines.

The artisanal gillnet fleets operating in the region are usually characterised by small fishing boats - generally averaging 10 m in length (with the exception of the longer Pakistani boats) - using nets less than 1.5 km in length. Both mechanised and non-mechanised boats are used. Fishing trips usually last about 1-6 days. However, the Pakistani vessels fish for a longer duration.

5.1.2 STOCK EVALUATION, YELLOWFIN TUNA (YFT)

1. Distribution

The yellowfin tuna, *Thunnus albacares*, population of the Indian Ocean is distributed in the tropical region principally north of 30°S latitude. The stock structure is unknown, although it is often assumed that the population consist of a single stock. Currently, only the western part of the range, i.e., the area centered off the Seychelles, supports an intense surface fishery (YFT Fig. 1). Longline fishery covers almost the entire Indian Ocean and has been operating intensively on the high seas from the early 1950s. In the rest of the range, fishing has largely been with artisanal or small-scale gears.

The surface fishery in the western Indian Ocean is dominated by purse seiners registered in France, Japan, Mauritius, Spain and U.S.S.R. (YFT Table 1.), that target yellowfin tuna in an area bound by about 10°N to 10°S and west of 70°E during roughly January to April and in some years to as late July (YFT Fig. 2). This fishery also takes skipjack tuna and often as the dominant species. During the rest of the year, fishing shifts south to the Mozambique Channel from April to May and off Somalia from August to November. The current annual catch (1989) for this fishery is about 110,000 t of yellowfin tuna (YFT Table 2).

The longline fishery operates throughout the tropical region of the Indian Ocean by vessels registered in Japan, Korea and Taiwan (Province of China) in search of yellowfin tuna and other large-sized tunas. The yellowfin tuna catch for this fishery has recently increased to a level comparable to that of the 1970s, after experiencing a low period in the intervening years. The yellowfin tuna catch by longline in 1988 was 35,000 t.

Artisanal or small-scale fisheries are locally concentrated and target on pelagic species, with yellowfin tuna being one of several species often caught. Significant amounts are taken by the fisheries of Oman, Indonesia, Maldives, Pakistan and Sri Lanka. The total yellowfin tuna catch from these fisheries was about 36,000 t in 1988.

Since 1981, the total catch of yellowfin tuna from the Indian Ocean has increased markedly from 47,000 t in 1982 to 183,000 t in 1988 (YFT Fig. 3). Most of this increase is largely due to the development and expansion of the industrial fishery in the western region, i.e., purse seine fishery. However, substantial increase in catch by the artisanal fishery also occurred during this period.

The sizes of yellowfin tuna caught by the different fisheries are shown in YFT Fig. 4 and indicate that there is an overlap in sizes caught by the fisheries. A wide range of sizes (30 - 160 cm FL) is taken by purse seiners. Longliners take principally larger sizes (80 - 180 cm FL), and pole-and-line vessels take primarily small sizes (25 - 80 cm FL).

2. Movement

Movements of yellowfin tuna were reported in two documents which dealt with tagging experiments (Document TWS/90/10 and 61). Preliminary results of tagging in the Maldives during the period January to March 1990, resulted in one yellowfin tuna (53 cm FL at tagging), recovered from off Sri Lanka after 196 days at liberty. This fish measured 61.5 cm at the time of recovery.

A tagging programme in the Mozambique Channel area was conducted by the Association Thoniere (Indian Ocean Commission). Two yellowfin tuna were recovered from 419 tagged yellowfin tuna. These returns were from fish tagged in Comoros Islands waters at a size of 67 cm and 73 cm FL and recovered in the vicinity of the Seychelles after 160 and 252 days at liberty. The observed growth rate of these fish was 23 and 29 cm/yr, which is comparable to growth rates observed in the Atlantic and Indian Oceans for fish in the same size range.

3. Behaviour

Information on the behaviour of yellowfin tuna was inferred from data on purse seine sets (Documents TWS/90/45, 46 and 66). The data include school type, species involved and size composition of tunas in the school that were captured by purse seiners.

Data from observers on purse seiners indicate that yellowfin are rarely associated with dolphins in the purse seine fishery of the western Indian Ocean. Also, the fishery is heavily dependent on log-associated schools, which accounts presently for roughly 50 percent of the total purse seine sets.

Species and size composition differ significantly according to school type. In free schools, or unassociated schools, yellowfin dominate the catch, whereas in log-associated schools skipjack is the dominant species. In log-associated schools, smaller yellowfin tends to be more available than in free schools (YFT Fig. 4). These observations are similar to those reported for purse seine fisheries in the Atlantic and Pacific Oceans.

Observations on a unique fishery that uses dolphins to locate yellowfin tuna were presented. The fishery uses handline and troll line gears off the west coast of Sri Lanka (Document TWS/90/18). Spinners, Stenella longirostrus, and spotted, S. attenuate, dolphins are involved. The dolphins are used to locate the school of yellowfin and fishing is carried out in front of the dolphin school when the fishermen observe yellowfin tuna associated with the dolphin school. The sizes of yellowfin caught by this fishery is mainly large fish over 100 cm FL.

4. Morphometrics

Information on length-weight relationships of yellowfin caught by purse seiners was presented (Document TWS/90/48). Some differences by sex in this relationship were obtained but the differences were not large.

Document TWS/90/26 reported on results of morphometric analysis for yellowfin from several areas off the Indonesian coast in the Indian and Pacific Oceans. The results indicate no significant difference in morphometric characters of yellowfin tuna from the different areas, suggesting that a single population of yellowfin tuna occurs in Indonesian waters.

5. Reproductive biology

A study on reproductive biology (Document TWS/90/68) was presented which covered sex ration, spawning season, size at 50 percent maturity and fecundity. As a sex ratio, large yellowfin tuna greater than 150 cm FL tend to be virtually all males. Because there appears to be no excess of females in the size range just under 150 cm, i.e., 120 - 130 cm range, differential growth does not appear to be a principal factor causing this phenomenon in the Indian Ocean stock. This is a different result from that observed for the Atlantic, where there is an excess of female yellowfin tuna at sizes just before the size with predominance of males. Main spawning season in the tropical western Indian Ocean is from November to March and the size at first maturity (50 percent of samples) is about 110-115 cm FL.

6. Stock status

Various cpue (catch per unit of effort) index series for yellowfin tuna of the Indian Ocean were made available to the Consultation. They are for all Western Indian Ocean purse seiners except USSR and Mauritian purse seines (Document TWS/90/50), Japanese longline (Document TWS/90/59), Korean longline (Document TWS/90/52) and Indian longline fisheries (YFT Table 2). French purse seine cpue show a declining trend from 1978 to 1985 but the cpue increased markedly in 1988 followed by a decrease in 1989. Document 50 analyzed the Western Indian Ocean purse seine cpue in relation to both environmental factors and the size composition of the catch and hypothesized that the high cpue in 1988 was due to higher catchability related to a shallower thermocline in conjuction with a strong year class. Because of this effect of the environment on the French purse seine cpue, it was felt that the application of the cpue for estimating parameters of the production model might not be meaningful. In fact, the catch and estimated effort relationship from using this cpue measurement resulted in a poor fit with the production model (Document TWS/90/51). The fit might be improved if the increase of fishing efficiency due to technological improvement of the fishing gear, as well as to other factors such as the increased use of artificial rafts, improved fishermen's knowledge, etc., of the purse seine fishery, and environmental factors are taken into account in the analysis.

Neither the cpue of Japanese nor Korean longlines, which operate over a large part of the distributional range of the yellowfin tuna, show a particular consistent trend for the years 1983 to 1987, during which period the purse seine catch increased substantially. These results support the conclusion of the third Expert Consultation that the stock was not adversely affecteed by the build-up of the purse seine fishery and can withstand the current level of exploitation. On the other hand, the Japanese longline cpue calculated for areas where the purse seiners are mainly operating, showed a sharp drop in 1989 (YFT Fig. 5). A similar decline in cpue for 1989 is also observed for the Indian longline fishery (YFT Table 3). Although no definitive conclusion can be drawn from this observation due to the preliminary nature of the Japanese 1989 statistics and the observation is for only one year, this decline might be a sign of local interaction between the purse seine and longline fisheries. On the other hand, the decline may be due to the effects of environmental factors causing differential catchability from one year to the next as in the purse seine fishery.

There is concern about the increasing catch of juvenile yellowfin taken by purse seiners in association with logs. Preventing the catch of juvenile yellowfin tuna will affect the catch of skipjack because skipjack is the dominant species in log sets. To assess the impact of this catch on potential future yields and on the catch of the longline fishery which takes primarily larger fish, yield-per-recruit analysis is needed and the impact assessment must take into account the catch of skipjack, which is currently believed to be underexploited.

In summary, the yellowfin stock appears to be able to support the current level of exploitation. However, monitoring of all fisheries need to be continued and intensified. Further expansion in the western region must proceed with caution because of the uncertainties of the current assessment. On the other hand, further expansion in the eastern region where exploitation is not currently as intense as in the western region, seems possible with less caution.

7. Recommendation

(1) Statistics

i Size frequency data from all fishing countries need to be submitted to IPTP on a timely basis for use in size or age-specific assessment analyses, ii Species composition sampling must be undertaken for all fisheries that take substantial amounts of small, or juvenile yellowfin and bigeye tunas, and the data made available when submitting statistics on total catches.

(2) Research

i Growth of yellowfin needs to be determined with use of a combination of tagging, hard parts analysis and modal progression techniques.

ii Cohort and yield-per-recruit analysis need to be undertaken especially to assess the effects of increased catches of juveniles by the purse seine fishery on future yields.

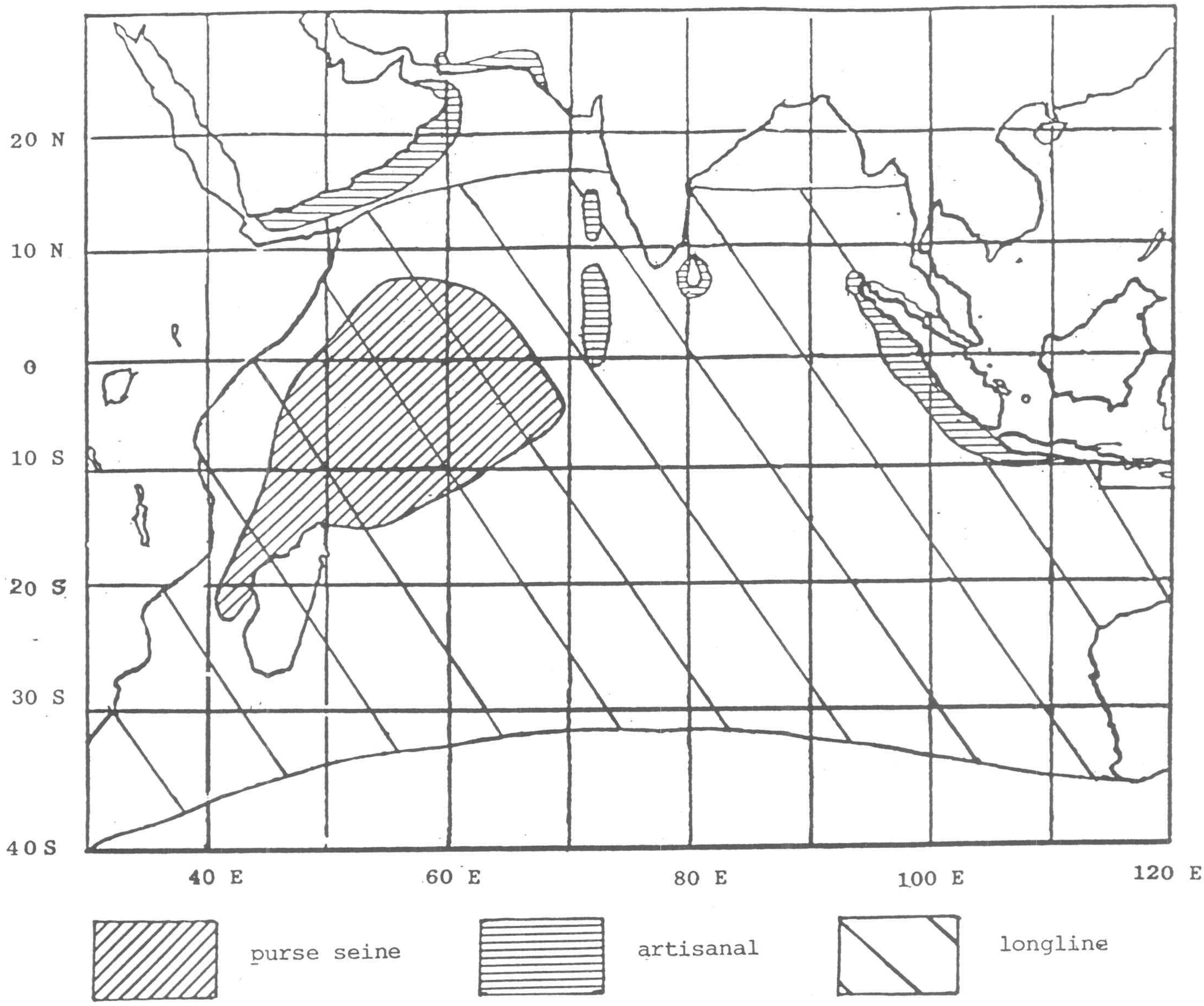
iii Standardization of fishing effort, taking into account the effects of increased fishing efficiency of purse seiners and the shift to more log sets need to be initiated.

iv Studies on the role of environmental conditions on fishing efficiency and year class strength, etc., need to be continued.

v The IPTP tagging programme needs to be expanded to include a more intensive effort in the western Indian Ocean.

(3) Management

No management measures are recommended for the yellowfin tuna population of the Indian Ocean.



YFT Fig. 1. **Location of major artisanal and industrial fisheries for yellowfin tuna.**

YEAR	FRANCE	SPAIN	PANAMA	JAPAN	MAURITIUS	USSR	UNITED KINGDOM	IVORY COAST	CAYMAN ISLANDS	INDIA	TOTAL
1984	19(27)	6(14)	1 (1)		1 (1)		(1)	4 (5)			31 (49)
1985	22(27)	11(15)	1 (1)		1 (1)		1 (1)	2 (5)			38 (49)
1986	20(22)	11(12)	1 (1)		1 (1)		1 (1)				34 (38)
1987	18(20)	12(14)	1 (1)	(1)	2 (2)	1 (4)					34 (41)
1988	20(20)	15(19)	1 (1)	1(1)	3 (3)	3 (4)				(1)	43 (48)
1989	19(20)	21(23)	1 (1)	1(3)	3 (3)	3 (4)			1		49 (53)

( ) denotes maximum numbers

YFT Table 1. Number of purse seiners active in the western Indian Ocean tropical tuna fishery (TWS/90/45).

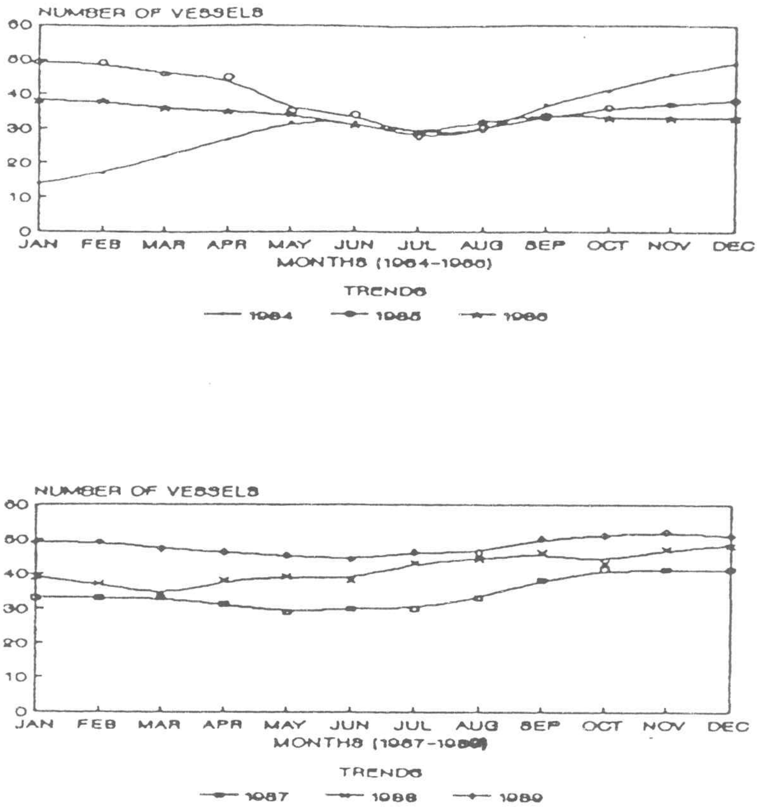
SBT **TABLE 2: Catch of Yellowfin tuna (YFT) by fishery, gear and country**

SPECIES: YFT	GEAR	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
SURFACE FISHERIES:													
MALDIVES	BB	3214	3692	3647	4740	3770	5984	6893	5797	5200	6531	6378	5831
MOZAMBIQUE		0	0	0	0	0	15	11	15	0	0	0	na
SPAIN		0	0	0	363	55	0	0	0	0	0	0	0
SRI LANKA		0	0	0	0	418	452	258	27	2	0	0	na
TOTAL	BB	3214	3692	3647	5103	4243	6451	7162	5839	5202	6531	6378	na
CHINA (TAIWAN)	GILL	0	0	0	0	0	0	0	21	73	80	12	na
INDONESIA		0	0	0	0	0	0	0	0	21	21	22	na
PAKISTAN		0	0	0	0	0	0	0	0	2093	1330	2480	na
SRI LANKA		0	0	0	0	6680	7237	5151	6145	6559	0	0	na
TOTAL	GILL	0	0	0	0	6680	7237	5131	6166	8746	1431	2514	na
FRANCE	PS	0	0	0	260	1224	10773	33611	37965	35122	37118	54149	38411
INDONESIA		0	0	0	0	17	0	27	29	144	149	156	na
IVORY COAST		0	0	0	0	0	0	5107	3046	562	0	0	na
JAPAN		239	0	136	0	0	193	0	109	160	236	602	956
MAURITIUS		0	0	0	0	.0	1057	1234	914	661	1694	1136	na
PANAMA		0	0	0	0	0	0	2441	3236	3432	3831	3597	na
SPAIN		0	0	0	0	0	0	13796	15411	17532	20361	43159	33852
UNITED KINGDOM		0	0	0	0	0	0	155	1177	1050	0	0	na
USSR		0	0	0	0	0	0	0	484	2614	3138	3800	2968
TOTAL	PS	239	0	136	260	1241	12023	56371	62371	61277	66527	106599	na
DEEP SEA FISHERIES:													
CHINA (TAIWAN)	LL	3179	2775	2850	3071	3531	4179	4353	5145	9125	10909	14386	na
INDONESIA		0	0	0	0	515	0	585	441	120	0	0	na
IRAN		0	341	322	0	0	0	0	0	0	0	0	na
JAPAN		4024	2023	3304	4699	6355	7039	7467	9263	10955	7552	8854	na
KENYA		0	0	67	171	204	322	0	0	0	0	0	na
KOREA		25165	17788	12537	11777	18654	15337	9895	12017	14891	12575	13428	na
MAURITIUS		0	0	0	0	0	0	0	0	190	70	98	na
MOZAMBIQUE		0	0	0	0	0	0	177	0	0	0	0	na
SEYCHELLES		0	0	0	0	0	43	198	140	0	0	0	na
SRI LANKA		0	0	0	0	834	905	644	222	636	0	0	na
USSR		0	0	0	0	0	0	0	0	0	0	77	na
TOTAL	LL	32368	22927	19080	19718	30093	27825	23319	27228	35917	31106	36843	na
UNCLASSIFIED:													
AUSTRALIA	UNCL	15	28	34	0	8	18	41	43	42	40	12	na
COMOROS		100	100	100	110	110	120	130	140	140	140	150	na
INDONESIA		2811	3236	3348	3350	3208	5888	3635	4073	2985	3100	3255	na
JAPAN		0	0	0	2	0	0	0	0	0	0	0	na
MALDIVES		370	597	582	544	234	257	230	269	121	139	157	251
MAURITIUS		15	5	1	1	0	0	50	0	0	0	0	na
MOZAMBIQUE		0	0	0	0	0	0	0	0	15	15	15	na
OMAN		0	0	0	0	0	0	0	0	0	5843	15485	na
SEYCHELLES		100	128	357	949	518	114	0	7	10	8	3	na
SOUTH AFRICA		0	0	0	0	0	166	0	84	0	6	4	na
SRI LANKA		5369	6166	6906	7662	418	452	386	322	780	7147	7426	na
TANZANIA		0	0	0	0	0	0	0	0	600	0	0	na
YEMEN DEM.		0	0	0	0	80	80	12	511	510	510	510	na
TOTAL	UNCL	8780	10260	11328	12618	4576	7095	4484	5449	5203	16948	27017	na
TOTAL	SPECIES	44601	36879	34191	37699	46833	60631	96467	107053	116345	122543	179351	na

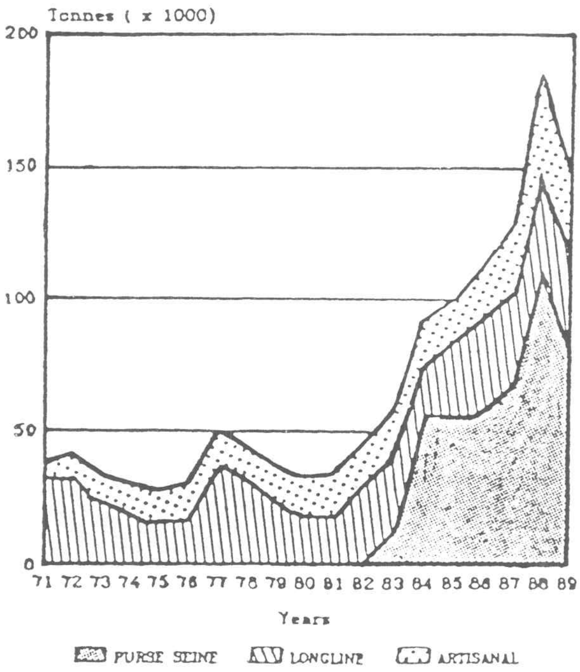
Note: 1) statistics are compiled from I.P.T.P. statistics report N° 10 and from the following amendments:

CHINA (TAIWAN): Tuna research center. Taiwan university
FRANCE: Revised by HALLIER, 1990
INDIA: Review of tuna fisheries in India (P. JAMES, 1990)
JAPAN: 1989 PS landings estimated from Seychelles landings
MAURITIUS: Status of the tuna fisheries in Mauritius (A. VENKATASAMI)
USSR: Present situation in the soviet tuna fishing (ROMANOV, 1990)

2) na: data not available



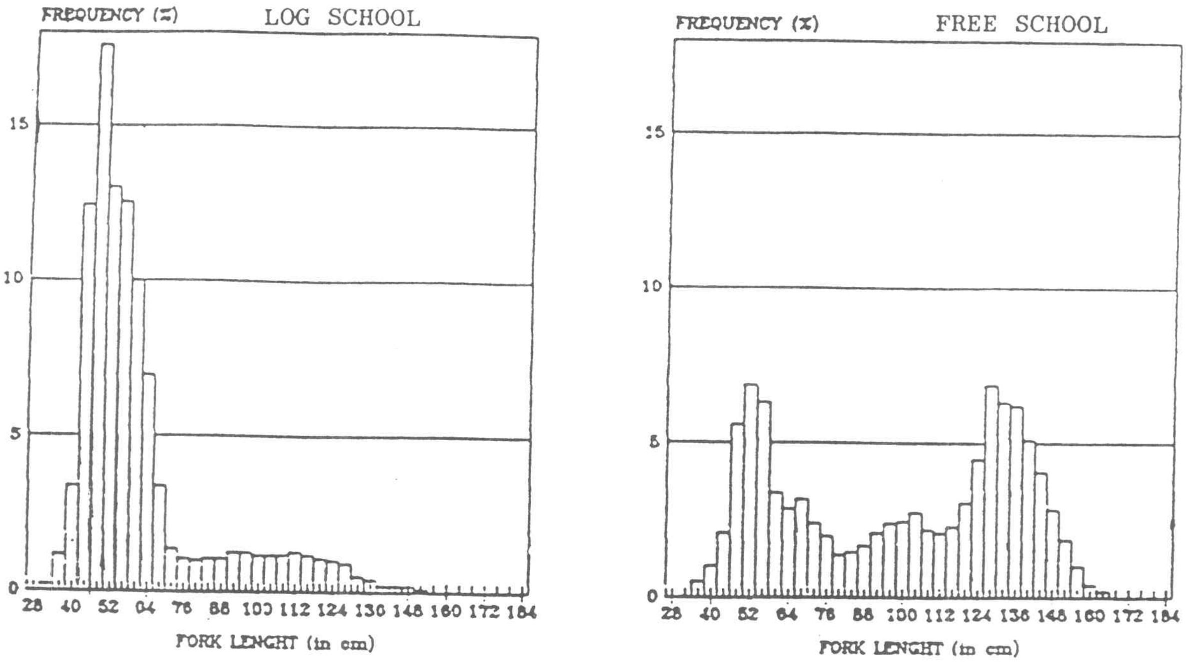
YFT Fig. 2 Seasonal purse seining activity in the Western Indian Ocean (1984 - 1986 and 1987 - 1989)



YFT Fig. 3. Yellowfin catch by gear in the Indian Ocean (1971-89)

YFT Fig. 4 Length composition of YFT taken by purse seine, longline and baitboat fisheries

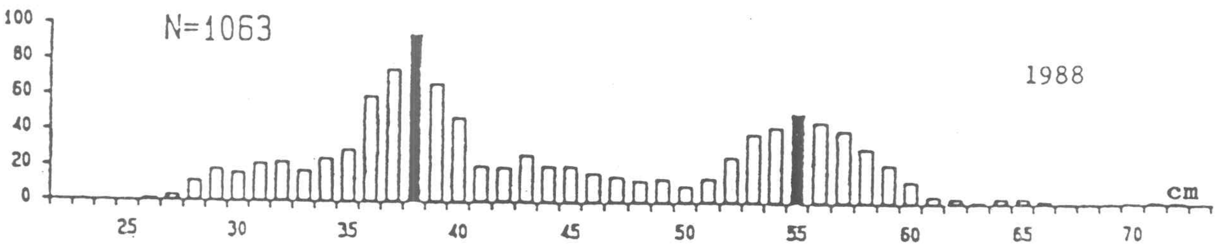
French PS (1984-89)

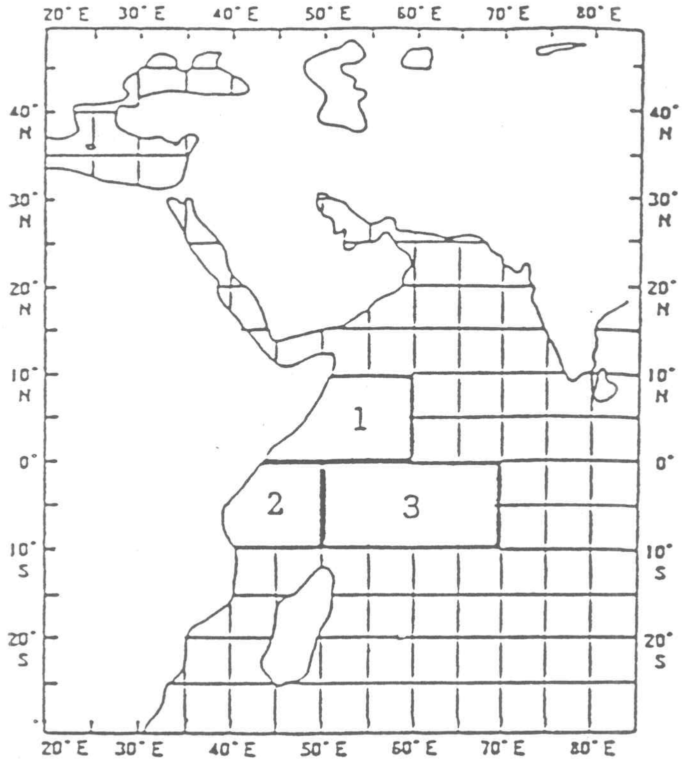


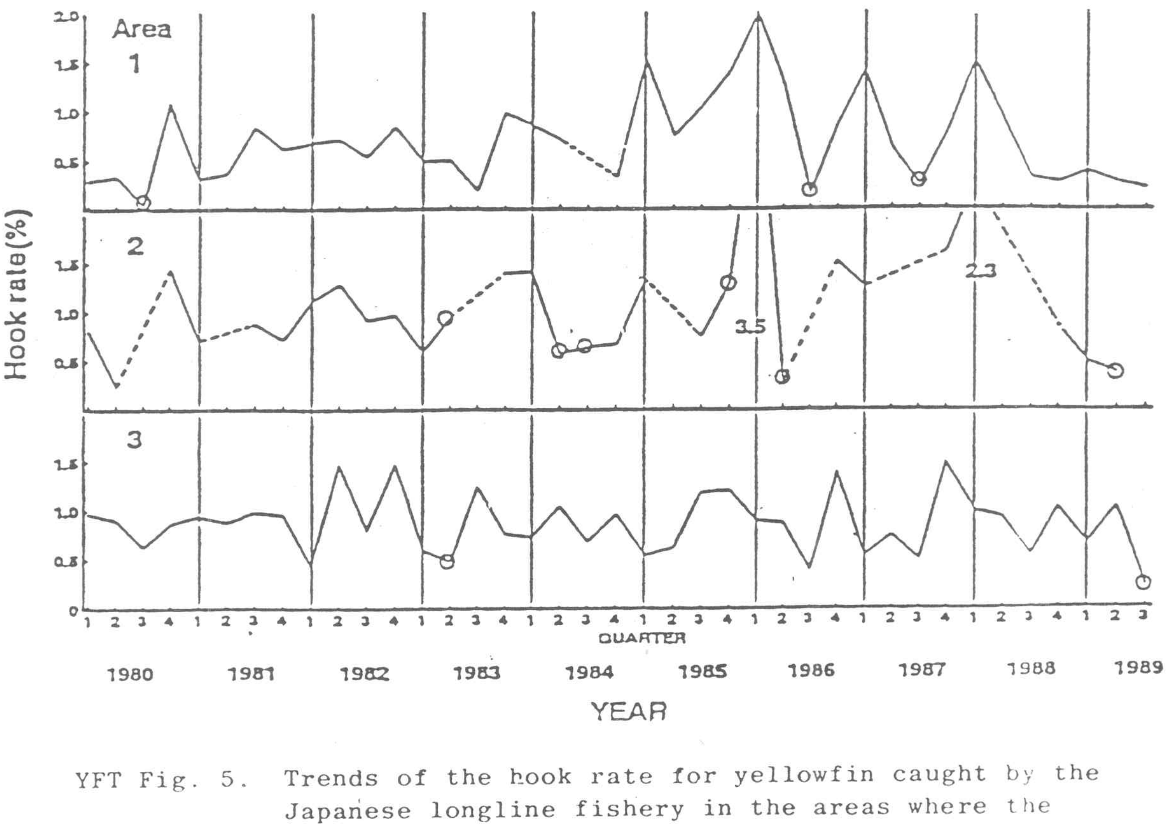
(Hallier, 1990)

(Korean LL) Park (1990)

(Maldivian BB) (Rochepeau and Hafiz 1990)







YFT Fig. 5. Trends of the hook rate for yellowfin caught by the Japanese longline fishery in the areas where the purse seine operations are significant.

TWS/90/59.. The 1989 data are preliminary. Dotted lines and open circles denote the data are missing between the ends and observations less than 20000 hooks, respectively.

YFT Table 3. Cpue series for various fisheries on yellowfin tuna

FISHERY	YEAR															
	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89
1					6.00	5.50	5.50	5.00	5.00	4.50	3.18	2.79	2.88	4.09	5.44	3.69
2	0.52	0.65	0.52	0.77	0.50	0.59	0.42	0.42	0.43	0.49	0.45	0.48	0.58	0.50	0.58	
3							3.98	5.97	7.89	6.29	5.62	6.83	8.68	7.92		
4												0.55	0.76	0.54	0.85	0.59

1. Western Indian Ocean purse seine (ton/10h searching) standardized and effective effort.
2. Japanese longline (No.fish/100 hooks) effective effort
3. Korean longline (No.fish/1000 hooks) nominal effort
4. Indian longline (ton/day at sea)

5.1.3. STOCK EVALUATION, SKIPJACK TUNA (SKJ)

1. Distribution

Skipjack tuna, Katsuwonus pelamis, occurs in the tropical regions of the Indian Ocean, generally north of 30-35°S latitude. Within this range, skipjack is mainly available to surface gears such as pole-and-line, purse seine, gillnets, trolling lines and other miscelleneous coastal gears. The geographical distribution of both artisanal and industrial fisheries is given in SKJ Fig. 1.

The total catch of skipjack increased substantially during 1984 to 1989 owing to the development of the industrial purse seine fishery in the western Indian Ocean. Countries such as France, Mauritius, Panama, Spain, USSR and more recently Japan and Cayman Islands, participated in the fisheries and contributed to this increase. Latest figures (SKJ Table 1) show that the purse seine catch of skipjack tuna exceeded 116,000 t in 1988 and represented 59 percent of the total skipjack catch from the Indian Ocean (206,000 t).

The artisanal fisheries for skipjack tuna are well developed in the Maldives where the pole-and-line gear is used and the catch amounted to 58,000 t in 1988 and 1989. In the Lakshadweep Islands of India, pole-and-line technique is also used to produce about 5,000 t/year. In Indonesia, Pakistan and Sri Lanka, gillnets are deployed for skipjack and the catch is about 14,000 t for Indonesia, 1,300 t for Pakistan and 13,000 t for Sri Lanka (1988 and 1989). Other small-scale fisheries (including gillnet in some countries) had an aggregate catch of around 24,000 t in 1987.

The sizes of skipjack tuna caught by the fisheries are principally greater than 35cm FL. One size mode (50cm) is present in the catch of the large purse seiners (SKJ Fig. 2), whereas two size modes (46 cm and 68 cm) are present in the pole-and-line catch of the Maldivian fleet (SKJ Fig.3).

2. Movement

New information on movement of skipjack was presented in two documents (Document TWS/90/10 and 61). Document TWS/90/10 presented preliminary results of movement of skipjack tuna tagged in the Maldives. A tagging programme undertaken by IPTP and the Marine Research Section of Maldives is ongoing. Recoveries have been made to date from 2,601 tagged skipjack. The most interesting result is the eastward movement of skipjack tuna from the Maldives to India and Sri Lanka. The maximum number of days at liberty was 127 days for fish recovered to date.

Document TWS/90/61 presented results of movements of skipjack tuna tagged in the southwest Indian Ocean areas. The tagging programme conducted by the Regional Tuna Project of the Indian Ocean Commission in 1988 and 1989 was not very successful. The overall recovery rate for the three species tagged (419 yellowfin, 359 skipjack, 175 bigeye) was low (1.4 percent). Despite the poor recovery results, the study is of special interest because of the long distance travelled by the recovered fish (900 to 1,170 km), and the long duration at liberty (140-400 days). The results suggests that the Comoros Island area is a gathering place for fish that are in transit; whereas in the Reunion Island area, skipjack remained in the area during the summer for a long period. The growth rate of the fish recovered ranged from 8 to 11 cm/year, which is similar to results obtained in studies in the equatorial Atlantic Ocean.

3. Behaviour

Behavioural studies reviewed by the participants included principally observations from purse seine sets on floating objects. Skipjack is increasingly being caught around floating objects (Documents TWS/90/45, 46, 60, 66). This fishing method takes advantage of the high density of fish that gathers around floating objects for foraging, protection, etc. Skipjack appears to concentrate largely in the upper stratum and therefore is the most vulnerable of the tropical tunas (skipjack, yellowfin, bigeye) to surface gears such as the purse seine: 75 percent of the total catch of skipjack in the period 1984-1989 was caught with floating objects. The sizes of skipjack caught with floating objects is not significantly different from sizes of fish caught in free schools (SKJ Fig. 2).

An analysis of successful sets made consecutively on the same log (Document TWS/90/66) demonstrated local depletion of skipjack over a few days. It also showed that migration and attraction of fish to a log over a short period can be insufficient to balance the level of removals by a large purse seiner.

The major areas of log fishing by large purse seiners are the northern Mozambique Channel during April to May and the Somalian basin from August to October.

4. Morphometrics

New information on length-weight relationships was presented in Document TWS/90/48. The study was based on 2,155 skipjack tuna measured at sea onboard purse seiners. The new relationships are of great value for accurately converting length sampling data into weight distributions and for extrapolated sampling information to the total catch by fishing area. This is an important step in construction of size composition of the catch by time-space stratum for performing stock assessments.

5. Reproduction biology

A document containing new information on the reproductive biology of skipjack was reviewed (Document TWS/90/25). With a small sample of 7 female skipjack caught in Indonesian waters, fecundity and distribution of ova diameter were studied. Fecundity was estimated to range from 540,000 t to 1,283,000 egs and spawning to be in batches over a period of time; hence the reproductive capacity is probably larger than indicated by the above estimates of fecundity.

6. Stock status

No document on the assessment of skipjack resources was available for review; consequently, the participants examined trends in cpue and had to rely on the less than adequate cpue series from the purse seine fishery of the western Indian Ocean (SKJ Table 2). The data show an increasing trend with levelling off at a high level in 1988 and 1989. This trend occured during a period when the Maldivian pole-and-line fishery and the western Indian Ocean purse seine fishery experienced increased catches, which are currently at historically high levels. This would suggest that the skipjack stock is healthy.

However, this conclusion which is unlike that reported for other skipjack tuna stocks in other oceans, should not be used as a reason for reducing the level of research on this species. Research must continue because of the expanding fisheries for tunas in the Indian Ocean region and because the existing fleets are relying more on skipjack for landings. Research should focus particularly on the following questions:

(1) Is the population made up of several stocks or a single stock?
(2) Can nominal fishing effort from artisanal or small scale fisheries, which target on skipjack tuna, be corrected for use in standardized cpue?
(3) Is catch per set of the purse seine fishery a better estimate of skipjack tuna abundance because of the wide use of floating objects (logs) by purse seiners?
(4) What is the effect of the environment on catchability of skipjack and can environmental measurements be used to adjust nominal fishing effort or to forecast fishing success?

7. Recommendations

(1) Statistics

The collection and processing of environmental data need to be continued and expanded. Analysis of the data with indices of skipjack abundance should be undertaken with consideration to investigating the effects of various environmental scenerios on catchability and corresponding catch rates.

(2) Research

i Analysis of the increasing fishing power in the Maldivian pole-and-line fishery should be undertaken to adjust the cpue. The fishing power has changed during recent years due to mechanization of mas dhonis and new equipment on board.

ii Current tagging experiments as those conducted in the Maldives and in the southwest Indian Ocean must be continued to provide information on growth rates and diffusion of the fish from the area, as well as general information on the biology of the stock.

iii Tagging on an ocean-wide scale, and particularly within the industrial purse seine fishery, should be implemented. This will complement information from the tagging programmes noted above and provide information on mixing and exploitation rates, and valuable information on the possible interaction between the industrial purse seine fishery and other fisheries.

iv Available data from the purse seine fishery need to be analyzed for use as an index of skipjack tuna abundance.

(3) Management

No management recommendations are offered for the skipjack tuna population of the Indian Ocean.

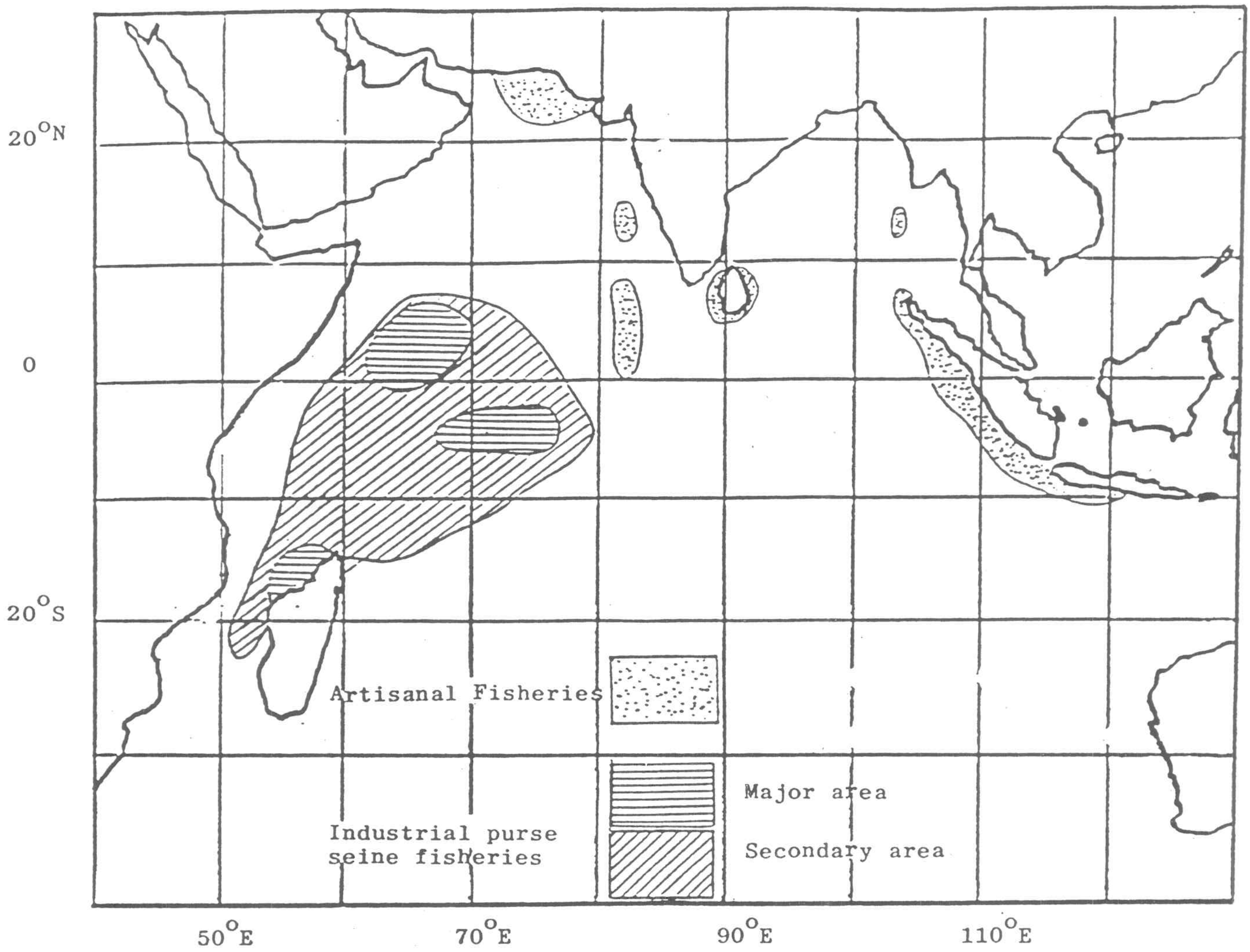
SKJ **TABLE 1: Catch of Skipjack tuna (SKJ) by fishery, gear and country**

SPECIES: SKJ	GEAR	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
SURFACE FISHERIES:													
AUSTRALIA	BB	0	0	0	0	0	0	0	0	0	0	10	na
INDIA		0	0	0	0	0	0	0	2621	3750	5094	4568	na
JAPAN		0	0	0	7	0	0	0	0	0	0	0	na
MALDIVES		13549	17798	23074	20198	15694	19491	31714	42170	45268	41872	58108	57808
MOZAMBIQUE		0	0	0	0	0	60	154	80	0	0	0	na
SPAIN		0	0	0	179	14	0	0	0	0	0	0	0
SRI LANKA		0	0	0	0	1987	2095	1510	1757	517	0	0	na
TOTAL	BB	13549	17798	23074	20384	17695	21646	33378	46628	49535	46966	62686	na
CHINA (TAIWAN)	GILL	0	0	0	0	0	0	0	22	76	101	241	na
INDIA		0	0	0	0	0	0	0	31	0	0	0	na
INDONESIA		0	0	0	0	0	0	0	858	862	1361	1170	1300
PAKISTAN		0	0	0	0	0	733	694	0	105	325	1337	na
SRI LANKA		0	0	0	0	10600	11178	8714	10070	13187	0	0	na
TOTAL	GILL	0	0	0	0	10600	11911	9408	10981	14230	1787	2748	na
FRANCE	PS	0	0	0	210	771	10075	29953	36831	46754	48765	45169	43082
INDONESIA		0	0	0	0	284	0	356	388	1633	1658	1740	2850
IVORY COAST		0	0	0	0	0	0	5112	3197	175	0	0	na
JAPAN		908	0	478	0	0	592	0	547	562	823	3926	3371
MAURITIUS		0	41	990	1726	2414	1396	2500	2118	1850	4766	4757	5592
PANAMA		0	0	0	0	0	0	1462	2990	4606	4210	5111	na
SPAIN		0	0	0	0	0	0	8079	22854	24877	35399	52863	77632
UNITED KINGDOM		0	0	0	0	0	0	20	1589	1155	0	0	na
USSR		0	0	0	0	0	0	0	806	1878	4507	2563	2564
TOTAL	PS	908	41	1468	1936	3469	12063	47482	71320	83490	100128	116129	na
DEEP-SEA FISHERIES:													
CHINA (TAIWAN)	LL	6	13	9	21	13	8	24	40	5	3	10	na
JAPAN		11	3	6	13	5	3	2	9	5	1	5	na
KENYA		0	0	0	3	1	2	0	0	0	0	0	na
KOREA		253	65	43	48	57	8	0	0	0	0	12	na
MAURITIUS		0	0	0	0	0	0	0	0	0	0	2	na
TOTAL	LL	270	81	58	85	76	21	26	49	10	4	29	na
UNCLASSIFIED:													
AUSTRALIA	UNCL	49	58	37	0	0	0	0	550	550	600	0	na
COMOROS		300	300	300	320	330	340	350	360	360	360	380	na
INDIA		0	0	0	1803	2399	1801	3488	624	313	456	238	na
INDONESIA		4093	6524	7573	6579	11548	12458	10091	9214	9034	9160	9618	10208
JAPAN		0	0	0	10	0	0	0	0	0	0	0	na
KENYA		0	0	0	68	96	31	45	63	70	81	78	na
MALDIVES		275	338	487	419	187	210	335	432	177	240	438	337
MAURITIUS		14	10	4	5	3	0	350	0	0	0	0	na
MOZAMBIQUE		0	0	0	0	0	0	0	0	80	80	80	na
PAKISTAN		0	449	134	446	5156	0	0	0	0	0	0	na
SEYCHELLES		10	10	0	0	0	0	0	0	0	0	0	na
SOUTH AFRICA		0	0	0	0	0	13	0	4	0	0	0	na
SRI LANKA		10994	8309	12700	13758	663	699	1395	291	33	12896	13398	na
YEMEN DEM.		0	0	0	0	400	400	12	7	10	10	10	na
TOTAL	UNCL	15735	15998	21235	23408	20782	15952	16066	11545	10627	23883	24240	na
TOTAL	**SPECIES**	**30462**	**33918**	**45835**	**45813**	**52622**	**61593**	**106360**	**140253**	**157892**	**172768**	**205832**	**na**

Note: 1) statistics are compiled from I.P.T.P. statistics report N° 10 and from the following amendments:

CHINA (TAIWAN):	Tuna research center. Taiwan university
FRANCE:	Revised by HALLIER, 1990
INDIA:	Review of tuna fisheries in India (P. JAMES, 1990)
JAPAN:	1989 PS landings estimated from Seychelles landings
MAURITIUS:	Status of the tuna fisheries in Mauritius (A. VENKATASAMI)
USSR:	Present situation in the soviet tuna fishing (ROMANOV, 1990)

2) na: data not available



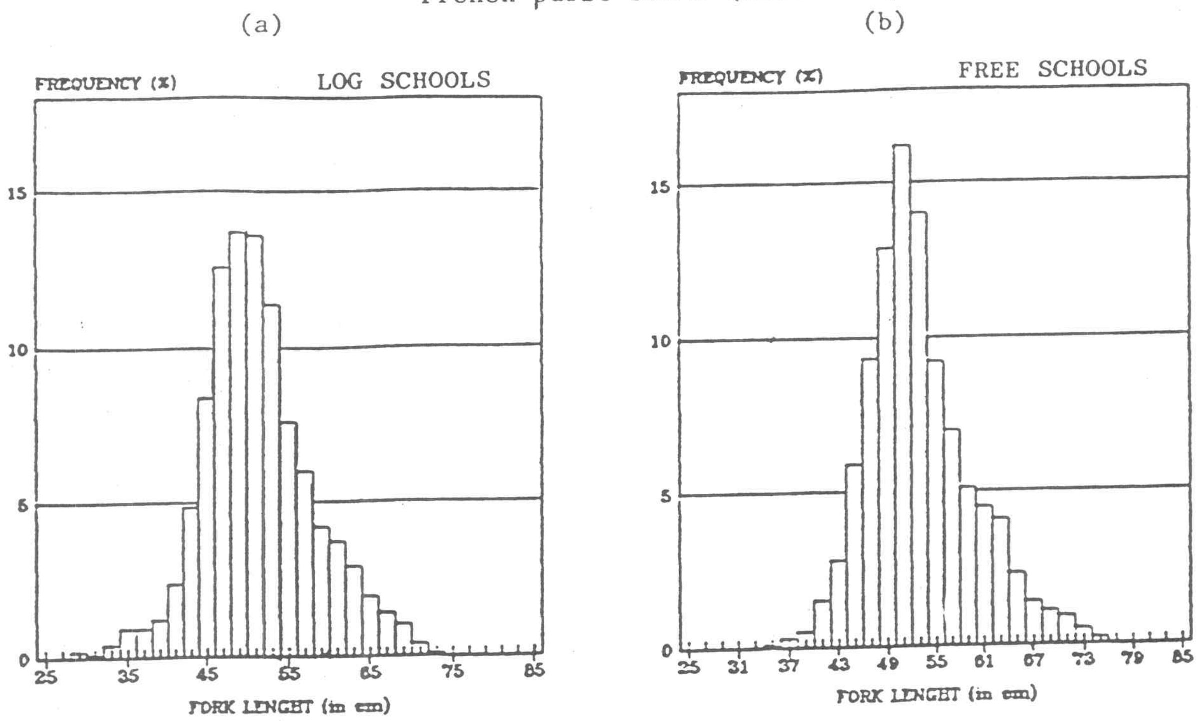
SKJ Fig. 1. Skipjack tuna fishing grounds exploited by artisanal and industrial fisheries.

YEAR	CATCH	FISH. DAYS	CATCH/FISHING DAY
1984	45,320	8,178	5.5
1985	68,219	10,048	6.8
1986	82,002	9,422	8.7
1987	100,451	9,108	11.0
1988	114,870	10,300	11.2
1989	138,213	12,158	11.4

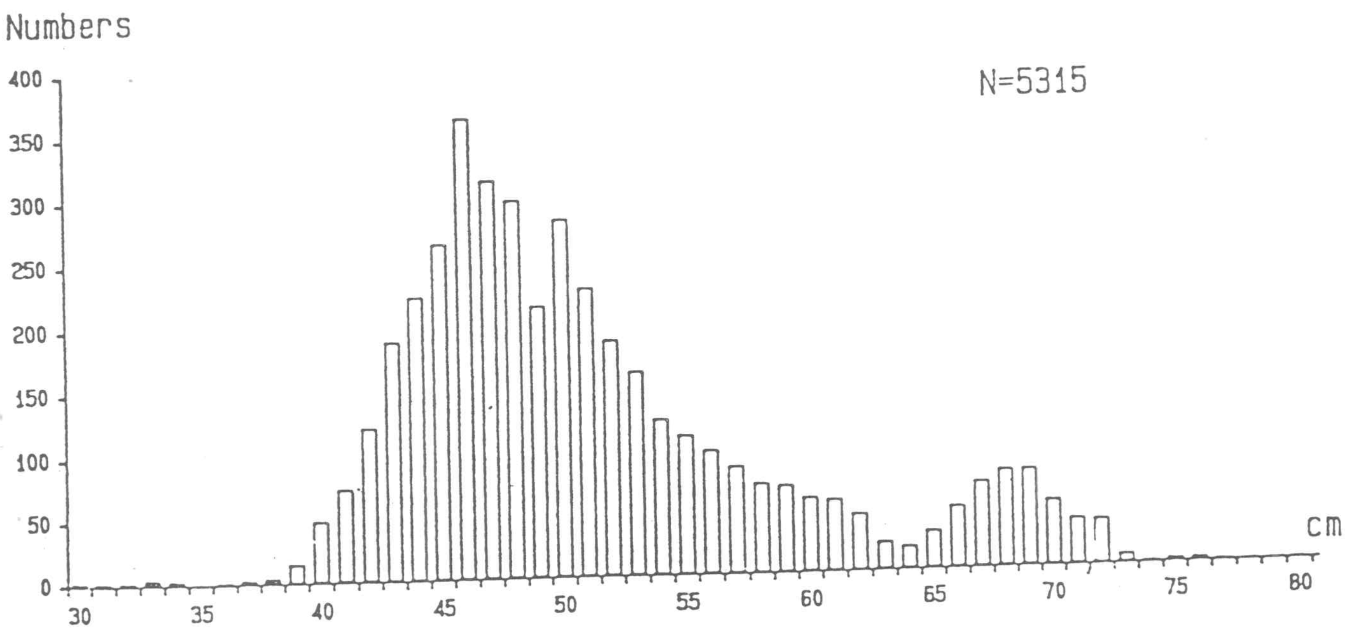
SKJ Table 2. Catch, effort and cpue on skipjack by industrial purse seiners in the Indian Ocean, from 1984 - 1989

Fleets considered: France, Cote d'Ivoire, Japan, Mauritius, Panama, United Kingdom, USSR, Spain.

French purse seine (1984 - 89)



SKJ Fig. 2. Size frequency distribution of skipjack caught on log schools (a) and on free schools (b) (TWS/90/66).



SKJ Fig.3 Length frequency distribution of Skipjack tunas landed at Male market (Maldives) in 1988.

5.2 BIGEYE, ALBACORE AND SOUTHERN BLUEFIN TUNA

5.2.1 BIGEYE TUNA (BET)

1. Description

Bigeye tuna, Thunnus obesus, occur throughout the Indian Ocean between 20°N and 50°S but the main fishing grounds are located between 10°N and 20°S (BET Fig. 1).

Before 1983, longliners from Japan, Korea and Taiwan were vitually the exclusive bigeye producers in the Indian Ocean, catching principally adults or large fish. Beginning in 1984 with the movement of part of the eastern Atlantic purse seine fleet to the western Indian Ocean, purse seiners began catching small and medium bigeye. The purse seine catch has since increased. Currently, bigeye is being caught by both the longline and surface fisheries.

2. Catch trends

Bigeye tuna catches by gear and country are listed in BET Table 1. Total bigeye catches from 1974 to 1988 have fluctuated markedly: low catches being recorded in 1974 with 21,200 t and in 1979 with 31,000 t; high catches were made in 1978 of 47,000 t and in 1988 of 52,000 t. This 1988 catch is the highest recorded since the beginning of the fishery in 1952. This fluctuation is also evident in the catches of individual countries such as Japan and Korea (BET Table 1) and probably reflect changes in market and economic forces rather than the availability or abundance of bigeye tuna. Japan was the dominant fishing nation until 1973. In 1973, Korea became the dominant nation. Taiwan began fishing in the Indian Ocean in 1963 and has gradually increased its production of bigeye. Each of these three countries has evolved different fishing strategies but their share of the total bigeye catch was about the same in 1988, between 12,000 t and 16,000 t.

Despite an increasing share of the total catch taken by purse seines since 1983/84, longline remains by far the main bigeye fishing gear accounting for more than 80 percent of the 1988 catch. Purse seine catches were 9,400 t and gillnet catches 400 t. The gillnet gear is a new gear used for industrial-type tuna fishing in the Indian Ocean and first appeared in 1983 in the Indian Ocean.

Bigeye is not a targeted species for purse seiners as well as gillnetters. The catch of purse seiners, nevertheless, has increased from 86 t in 1982 to 9,400 t in 1988. In 1988, the bigeye catch represented about 4 percent of the total purse seine catch.

Eighty percent of the purse seine catch of bigeye tuna of the French-Spanish fleet comes from fishing log-associated schools, containing smaller bigeye than in free-swimming schools (BET Fig. 2). Nevertheless, most purse seine caught bigeye are generally between 40 and 85 cm FL (average weight approximately 5 to 8 kg.) and less than sizes caught by longliners (BET Fig. 3) i.e., mainly fish between 80 and 165 cm FL (approximately 50 kg.). Because of the smaller sizes of fish taken by the purse seine fishery, purse seiners take about twice the number of bigeye tuna than longliners. Recent practices of purse seiners to fishing mainly on log-associated schools will only increase the amount of small bigeye being caught.

Significant Japanese purse seining operations in the Indian Ocean began in 1989 with three vessels. These vessels are fishing exclusively on fish agregating devices and with deep nets. Up to 10 to 15 percent of their catch consist of bigeye, estimated from catch sampling in the Seychelles. Two Mauritian purse seiners are also using this fishing procedure and catching a similar proportion of bigeye.

Small bigeye tuna can be mis-identified as yellowfin unless special identification procedures are used. Recently, such procedures have been instituted, so perhaps part of the recent increase of bigeye catches by purse seine is due to the procedures rather than a real increase in catch of bigeye tuna.

Artisanal fisheries also catch small sizes of tunas and report high catches of yellowfin (nearly 36,000 t in 1988). There is a good chance that some of these catches are actually bigeye tuna mis-identified as yellowfin tuna. A recent survey conducted in Sri Lanka found 0.3 percent bigeye among the normally reported yellowfin catch. Data from tagging operation near the Comoros Islands show a surprisingly high percentage (18 percent) of bigeye among the tagged fish, whereas no bigeye catch is reported in statistics for the artisanal fishery operating in the Comoros Islands area. There is a need, therefore, for proper identification procedure to be used in all fisheries that take small sizes of tunas so that an accurate estimate of the bigeye catch as well as information on the sizes of fish caught can be obtained.

3. Effort trends

Longline effective fishing effort on bigeye tuna has fluctuated widely over time (BET Fig. 4). The first peak in the time series was in 1967 when fishing was mainly by Japan. Effort then increased steadily into the 1970s with addition of fishing by Korea and later by Taiwan vessels. With the introduction of deep longline technique in the mid 1970s to early 1980s, fishing for bigeye tuna increased substantially and may have contributed to increased variability in the estimated effective effort. Most recently, part of the Japanese fishing effort in the Indian Ocean, which was targetting mainly for southern bluefin tuna, has been re-directed to bigeye tuna as a consequence of quota regulations on southern bluefin tuna.

The Taiwan fleet, which traditionally targets albacore, recently increased fishing on bigeye by utilizing the deep longline fishing technique and changing its fishing areas. The Korean fleet is also known to be using the deep longlining technique for bigeye tuna. Data to standardize the longline effort for regular and deep longlining were provided by Taiwan and are available for the Japanese fleet. However, a complete set is not available for all fleets. A partial analysis was therefore performed which show a marked increase in longline effective fishing effort on bigeye since 1981 from 234 million hooks in 1981 to 520 million hooks in 1988 (BET Fig. 4). Further work on standardizing longline fishing effort was recommended in light of new data provided by Korea and Taiwanese scientists.

No work has been done on estimating purse seine effective effort on bigeye tuna. However, the task is being evaluated, particularly because bigeye is an incidental catch for the purse seine fishery.

4. Trends in catch-per-unit of effort

A series of detailed longline hook rates (cpue) for bigeye tuna were reviewed (BET Fig. 5). Data from all fleets show a declining trend since the beginning of their operations, except for a shift to a higher level in 1977-78. This shift appears to be related to the introduction of the deep longline technique but the exact cause including the possible effects of environmental changes, is still under investigation.

Part of the difficulty in interpreting the trend in cpue is that the effective fishing effort has so far been estimated from partial or incomplete data. For example, only recently Taiwanese scientists were able to separate logbook data into regular and deep longline effort; Japanese scientists have completed this task for their data. Korean scientists have not yet addressed this task although they provided new data on catch and effort for their 1986 and 1987 season.

5. Stock structure

No new information on bigeye stock structure was submitted to the meeting, the participants, therefore, reiterated the determination of past Consultations: there is no conclusive information on stock structure of the Indian Ocean population of bigeye. The bigeye distribution appears continuous throughout the entire Indian Ocean; therefore, it appears that the bigeye tuna population of the Indian Ocean represents a single stock.

6. Population parameters

As no new information on population parameters was presented to this meeting. The participants noted that length-weight relationships and growth estimates for Pacific bigeye tuna are still being used for stock analysis of Indian Ocean bigeye tuna, pending results for the Indian Ocean stock.

7. Production model

A document dealing with production model analysis of bigeye tuna was submitted to the meeting. The results (BET Fig. 6) were similar to those presented at the 1988 Consultation. The range of MSY is from 40,000 t to 56,100 t. However, these results should be considered with caution in view of reservations mentioned above in sections 3. (Effort trends) and, 4. (Trends in catch-per-unit of effort). In fact, the 1988 point in BET Fig. 6 appears somewhat aberrant, i.e., at the extreme right. This is probably a result of the way effective fishing effort was calculated and the fact that several developments in the bigeye fishery have changed the fishing pattern of fisheries for this species, i.e.,

- increasing catch of small bigeye by the purse seine fishery and
- increased use of deep longline by longliners

8. Yield-per-recruit analysis

No new result of yield-per-recruit analysis was submitted to the meeting. This lack of analytical results was viewed with concern because this model offers the best way for quantitatively evaluating the changes of yield due to changes in fishing patterns, such as the increased catches by purse seines and shift of longliners to deep longlining.

9. Stock status

The information on stock assessment presented at this meeting did not provide the participants with a clear basis to evaluate the state of the Indian Ocean bigeye stock. For instance, it is not clear why the 1988 point of the production model (BET Fig. 6) is an aberration and not in conformity with the general trend observed in the previous years. Perhaps, the use of the Japanese fleet data as a means of standardizing fishing effort for the model is inappropriate. For a clearer picture to emerge, the participants felt that a comprehensive analysis of the catch, size, and effort data from all countries need to be integrated in a comprehensive analysis of the stock status.

Recognizing this lack of new information, the participants relied on information on past consultations and general experience with bigeye fisheries to note that the stock seems to be currently in a healthy condition. However, the recent large increase in effective effort suggests that further increases in longline effort may not result in appreciable increase in catch, especially since cpue has a downward trend. Given this condition, close monitoring of this stock is necessary.

10. Recommendations

(1) Statistics

i The collection of longline logbook data has improved; however, there is a need for the fishing effort to be reported separately for regular and deep longlining operations, e.g., from Korea and Japan. Also, there is a need for more timely submission of statistics by all major longlining countries, especially since this fourth Consultation had only complete data for up to 1987 for all fleets and for up to 1988 for some fleets.

ii Bigeye size data must be collected from all fisheries (purse seine, longline and gillnet).

iii Special procedures need to be instituted for accurate identification of small bigeye tuna in catches. A procedure has been implemented for the purse seine fishery using a scientific species sampling scheme. A similar scheme is needed for the artisanal fisheries in which the possible occurrence of bigeye may be significant. Scientists are encouraged to develop and implement sampling schemes for species compositions especially in Sri Lanka and the Maldives.

(2) Research

i A valid growth curve for Indian Ocean bigeye tuna need to be developed. Such a curve will be essential for conducting age-structured analysis.

ii Scientists that are monitoring the three major longline fisheries (Japan, Korea, Taiwan) need to pool their longline data and study ways to standardize their fishing effort into a single meaningful effective effort for use in indices of abundance.

iii Other methods besides production model analysis should be used to assess the condition of the stock. In particular, the historical data on catches and sizes of fish should be used in yield-per-recruit models to evaluate the possible changes of yield-per-recruit due to the increased catches of small bigeye by purse seiners.

iv Environmental factors as well as changes in fishing strategies should be investigated as explanations for the anomolous increase in the bigeye cpue for longliners since 1977-78.

(3) Management

No management recommendation is offered at this time.

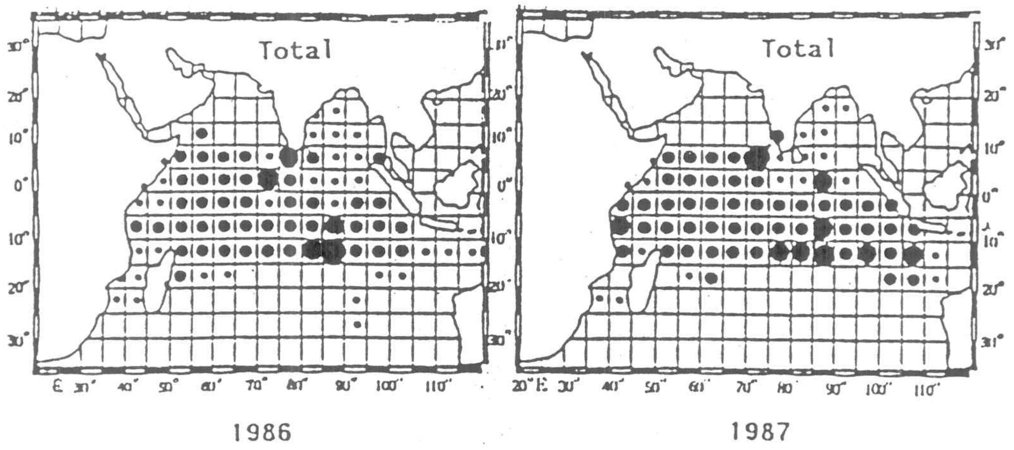
BET **TABLE 1: Catch of Bigeye tuna (BET) by fishery, gear and country**

SPECIES: BET	GEAR	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
SURFACE FISHERIES:													
MOZAMBIQUE	BB	0	0	0	0	0	1	0	0	0	0	0	na
CHINA (TAIWAN)	GILL	0	0	0	0	0	0	0	16	275	1	172	na
FRANCE	PS	0	0	0	0	0	0	1126	1937	4018	3322	2852	3568
IVORY COAST		0	0	0	0	0	0	23	128	0	0	0	0
JAPAN		5	0	1	0	0	59	0	175	142	90	505	na
MAURITIUS		0	0	12	0	86	284	241	747	340	601	681	1305
PANAMA		0	0	0	0	0	0	0	22	0	0	258	na
SPAIN		0	0	0	0	0	0	809	161	550	1925	2846	3537
UNITED KINGDOM		0	0	0	0	0	0	0	70	0	0	0	na
USSR		0	0	0	0	0	0	0	0	51	13	279	103
TOTAL	PS	5	0	13	0	86	343	2199	3240	5101	5951	7421	na
DEEP SEA FISHERIES:													
CHINA (TAIWAN)	LL	4170	5613	6538	4964	8272	8474	8163	9060	9499	9167	13326	na
JAPAN		10349	4183	5903	8395	11687	18425	13516	16502	16204	14744	12149	na
KENYA		0	0	159	148	150	237	0	0	0	0	0	na
KOREA		32855	21231	18690	18871	18949	16651	11481	12438	11397	13862	16509	na
MAURITIUS		0	0	0	0	0	0	0	0	179	46	78	na
MOZAMBIQUE		0	0	0	0	0	9	0	0	0	0	0	na
SEYCHELLES		0	0	0	0	37	171	74	0	0	0	0	na
TOTAL	LL	47374	31027	31290	32378	39095	43967	33234	38000	37279	37819	42062	na
TOTAL	SPECIES	47379	31027	31303	32378	39181	44311	35433	41256	42655	43771	49655	na

Note: 1) statistics are compiled from I.P.T.P. statistics report N° 10 and from the following amendments:

CHINA (TAIWAN): Tuna research center. Taiwan university
FRANCE: Revised by HALLIER, 1990
INDIA: Review of tuna fisheries in India (P. JAMES, 1990)
MAURITIUS: Status of the tuna fisheries in Mauritius (A. VENKATASAMI)
USSR: Present situation in the soviet tuna fishing (ROMANOV, 1990)

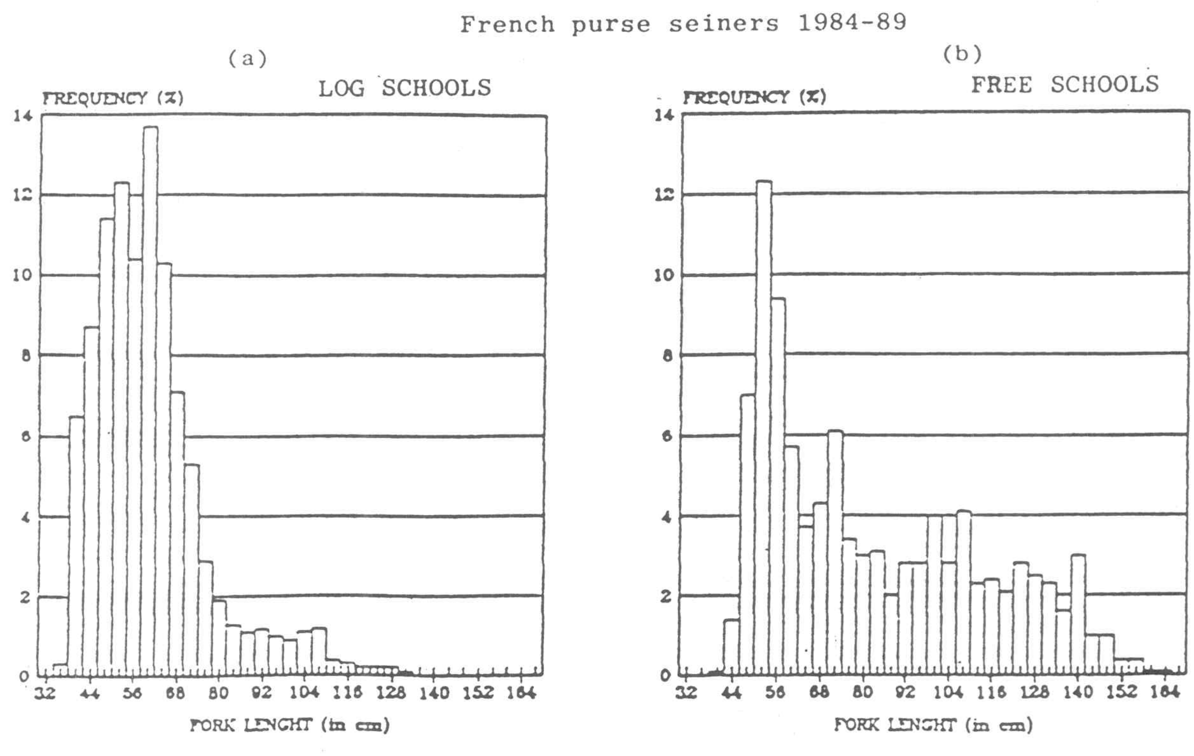
2) na: data not available



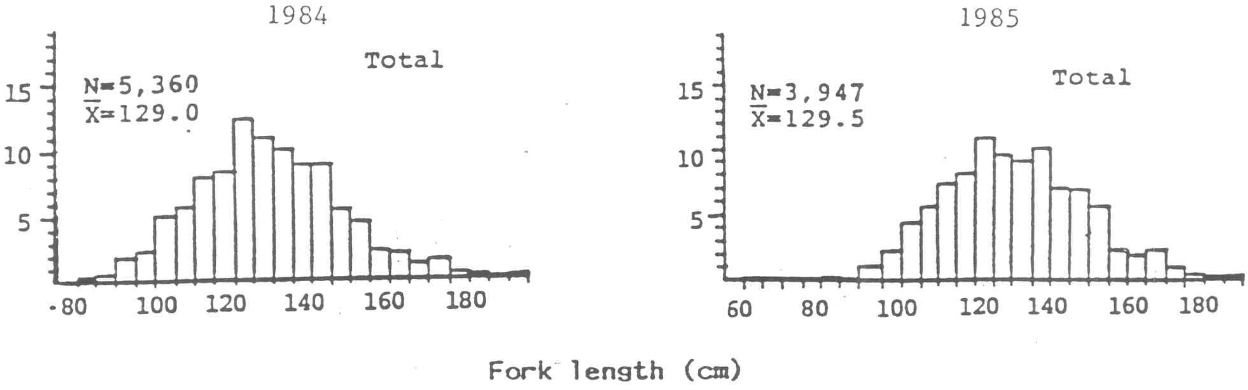
BET Fig.1 CPUE distribution for bigeye tuna taken by Korean longliners in the Indian Ocean, 1986-1987. (TWS/90/52)

cpue (No. of fish/100 hooks)

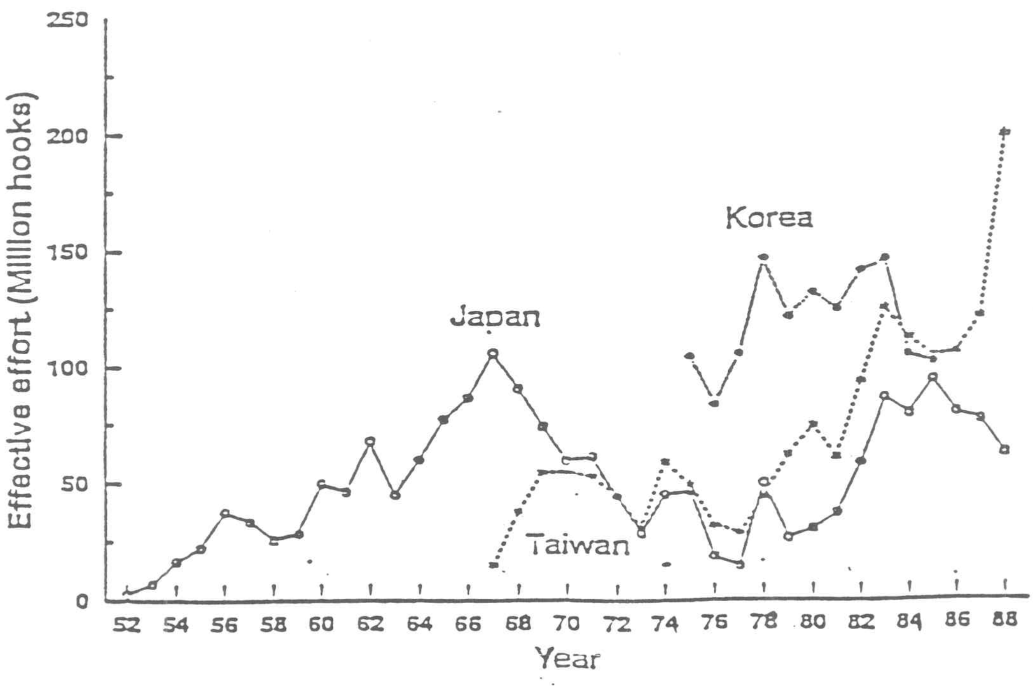
•<0.4 ●0.5 - 1.0 ●1.1 - 1.5 ●>1.6



BET Fig.2 Size frequency distribution of bigeye tuna caught with French purse seiner on log schools (a) and free schools (b), 1984-89. (TWS/90/66)

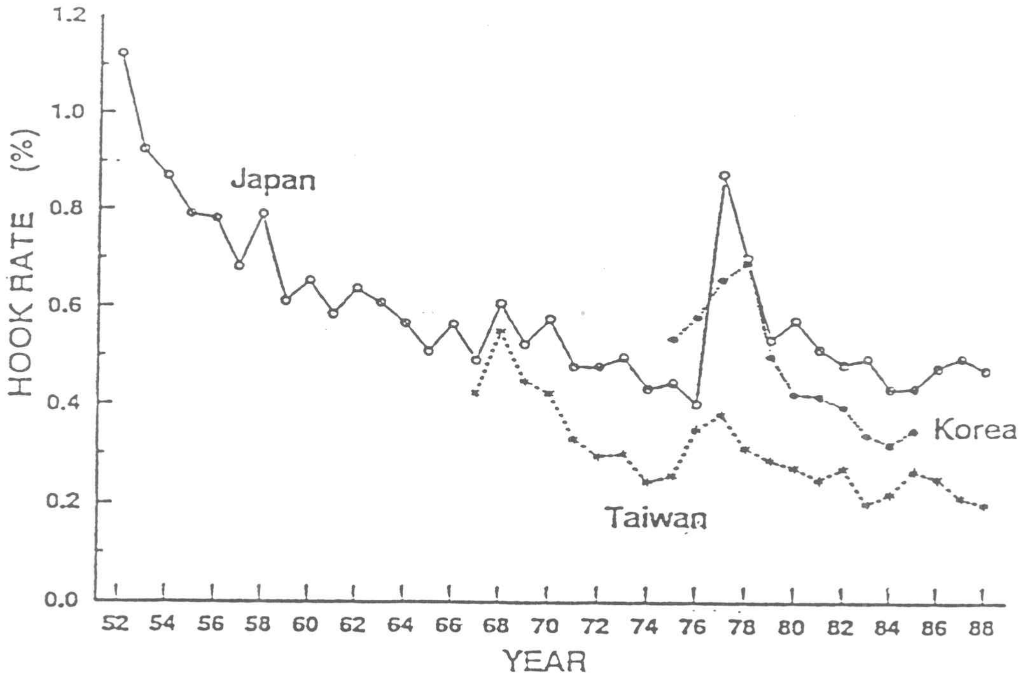


BET Fig. 3 Bigeye size frequency distributions for Korean longliners in the Indian Ocean, 1984 and 1985 (TWS/90/52)



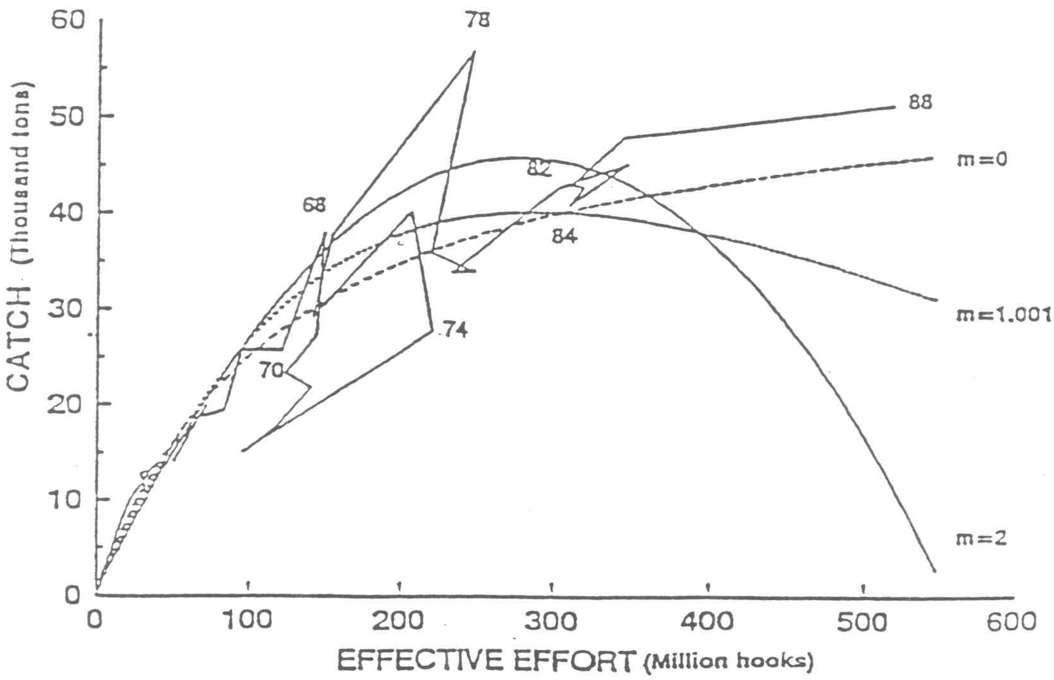
BET Fig.4 Trends of effective fishing effort to bigeye tuna by major longline countries in the Indian Ocean.

Data up to 1985 from Miyabe (1988). (TWS/90/59)



BET Fig.5 Trends of hook rate for the Indian bigeye stock by major longline countries (TWS/90/59).

(TWS/90/59)



BET Fig. 6. Catch and effort relationship and equilibrium curves fitted for the Indian bigeye stock (TWS/90/59).

5.2.2 ALBACORE (ALB)

1. Description of Fisheries

Albacore, Thunnus alalunga, occurs throughout the Indian Ocean between about 15°N and 45°S, and is more abundant between 10°S and 40°S. Commercial exploitation on a large-scale in the Indian Ocean was begun by Japanese longliners in 1952; since then, Korean and Taiwanese longliners have joined the fishery in 1957 and 1963 respectively. Recently, Taiwan began large-scale pelagic drift gillnetting (1983). The drift gillnet catch has become a significant amount of the total albacore catch from the Indian Ocean since 1985.

In 1988, Japanese longline fishing effort was principally distributed north of 15°S, and off south and southwest Australia, and southeast Africa (TWS/90/58). Korean longline effort was distributed north of 15°S and concentrated in waters off eastern Africa (TWS/90/52). Taiwanese fishing effort, including longliners (ALB. Fig. 1) and gillnetters, were widely distributed in the Indian Ocean but concentrated between 20°S to 40°S in the southern Indian Ocean (ALB. Fig. 2.) (TWS/90/54).

2. Catch trends

Annual catches of Indian Ocean albacore are shown in ALB Fig. 3 and tabulated in ALB Table. 1. Total catch increased steadily from 67 t in 1952 to 18,000 t in 1964, and fluctuated thereafter between 10,000 t and 22,000 t except in 1974 when the catch reached a very high level of 27,250 t.

Japanese longliners produced most of the catches before 1968. Since then, Taiwanese longliners have dominated the fishery as the Japanese and Korean fleets targetted on other species, such as southern bluefin tuna and bigeye tuna. Currently, the Korean fleet targets bigeye tuna and yellowfin tuna (beginning from about 1974). The Taiwanese fleet continues to target albacore although there appears to be an emerging shift to targeting on tropical species. The catch of Taiwanese gillnetters has been estimated to be over 10,000 t since 1987.

In 1988, approximately 22,000 t of albacore were produced from the Indian Ocean, a 12 percent decrease from previous years. About 51 percent or 11,368 t of this total was caught by longliners; 48 percent or 10,699 t by Taiwanese gillnetters; and about 1 percent or 203 t by purse seiners. The Taiwanese longline fleet took 88 percent of the total longline catch of albacore.

3. Effort trends

Effective fishing effort for albacore was estimated with the Honma method using data for only regular longlining operations of the Taiwan fleet. The nominal number of hooks spent by deep longlining was then adjusted by the rate of fishing efficiency of regular longlining. The results are estimates of effective fishing effort for the Taiwan fleet. The effective fishing effort (ALB Fig. 4) has fluctuated between 50 million to 200 million hooks since 1963. The variation appears to be greater for recent years. The level in 1988 was 110 million effective hooks.

The effort of Taiwanese gillnetters declined slightly from about 8,810 fishing days in 1987 to about 8,534 fishing days in 1988. The number of gillnet vessels, however, appears to have increased from 123 vessels in the 1986-87 season to 130 vessels in the 1987-88 season.

4. Trend in catch-per-unit effort

Catch of albacore per unit of effective effort (cpue) was quite high at the beginning of the longline fishery followed by a decline until 1984. Since then the cpue has fluctuated, e.g., between 1 and 1.5 t/10,000 effective hooks during the 1980s, but appear to have stabilized at a low level (ALB Fig. 4).

5. Stock structure

No new information was submitted on the stock structure of Indian Ocean albacore. However, based on previous studies on albacore larval distribution, spawning, which occurs between 10^{o}S and 25^{o}S, and distribution of small-sized fish (20 cm to 90 cm FL), the stock is assumed to be continuous across the Indian Ocean but distinct from the albacore stock in the Pacific Ocean. However, observations of longline cpue in the South Atlantic and Indian Ocean indicate that there may be seasonal inter-mingling of albacore between the two oceans.

6. Population parameters

New information on growth from scale-readings was presented (Document TWS/90/53). The growth curve described had Von Bertalanffy parameters L_{oo} = 128.13 cm, K = 0.162 $year^{-1}$ and to = 0.897 year. This information was considered to be preliminary and required validation of the ages.

7. Production model

An updated production model analysis was presented with data for the period 1962 to 1988 and including catch and effort of Taiwanese gillnetters from 1983 to 1988 (Document TWS/90/55). Compared to the picture presented in the previous Expert Consultation meeting, the analysis was a significant contribution and highlighted new uncertainties in the analysis.

The updated production analysis reduced the scatter of longline catches observed in 1986. However, the increasing significance of the drift gillnet catch has introduced a new level of complexity to the analysis, requiring further development of techniques for standardizing driftnet effort against longline effort. Consequently, the Consultation felt that the MSY of 19,000 to 25,000 t reported in document TWS/90/55 should be interpreted with caution, although they are similar to those of past studies. Because of uncertainities in the estimated catch and effective effort, the participants felt that the results were preliminary and further analytical work was required.

8. Yield-per-recruit analysis

A yield-per-recruit analysis was performed this year by using assumptions and 1979-1988 length frequency data of Taiwanese longliners (TWS/90/56). The Von Bertalanffy growth equation with L_{oo} = 163.71 cm, K = 0.1019 $year^{-1}$ was used. The mean surface temperature (18^{o}C) in 1987 and 1988 and growth estimates were used in Pauly's equation to estimate the instantaneous natural mortalitry rate (M) of 0.206 year^{-1}. Yearly instantaneous total mortality rates (Zs) were estimated from catch curves, and fishing mortality rates (Fs) were obtained by substracting M from Zs. A Beverton and Holt yield-per-recruit (Y/R) model was used and results indicate that the Indian Ocean albacore was exploited in the past at an optimum level.

The results of this year's Y/R analysis are considered to be approximations that require refining because of limitations with the data and yield-per-recruit model used. A more appropriate analytical model would be a multi-gear yield-per-recruit model and use of a full set of information from the gillnet and longline fisheries.

9. Stock status

The trend in the different adjusted cpue's (ALB Fig. 5 for the stock shows a similar periodicity from 1971. The cpue's have declined and appear to be stabilizing at a low level. The influence of the recent shift in the fishery to large catches by drift gillnets is not yet evident in these longline indices. If the gillnet fishery catches primarily small sizes of fish that are different from that of the longline fishery, then the yield-per-recruit has been reduced and we may see reductions in the cpue of the longline fishery in 1989 and beyond. On the other hand, if the gillnet fishery catches similar sizes of fish as the longline fishery, then the yield-per-recruit has not changed and the stock is in good condition.

10. Recommendation

The participants noted a significant improvement in both statistics and research on the albacore stock, especially due to the activities of scientists monitoring the major fisheries and recommended that the effort be continued. The participants also outlined the following as primary recommendations.

(1) Statistics

i Longline countries should submit on a timely basis complete catch and effort statistics on their tuna fisheries by 5 degree squares, month, species and possibly, by regular and deep longline operations.

ii Size data from the gillnet fishery should be submitted on a timely basis to IPTP.

iii Statistical area for reporting and for integrating data from several sources should be established.

(2) Research

i The stock structure of albacore should be reviewed using all available biological information, and particularly, to determine the exchange between Atlantic and Indian Ocean stocks;

ii Effort standardization methods should be developed for combining longline and gillnet effort if possible;

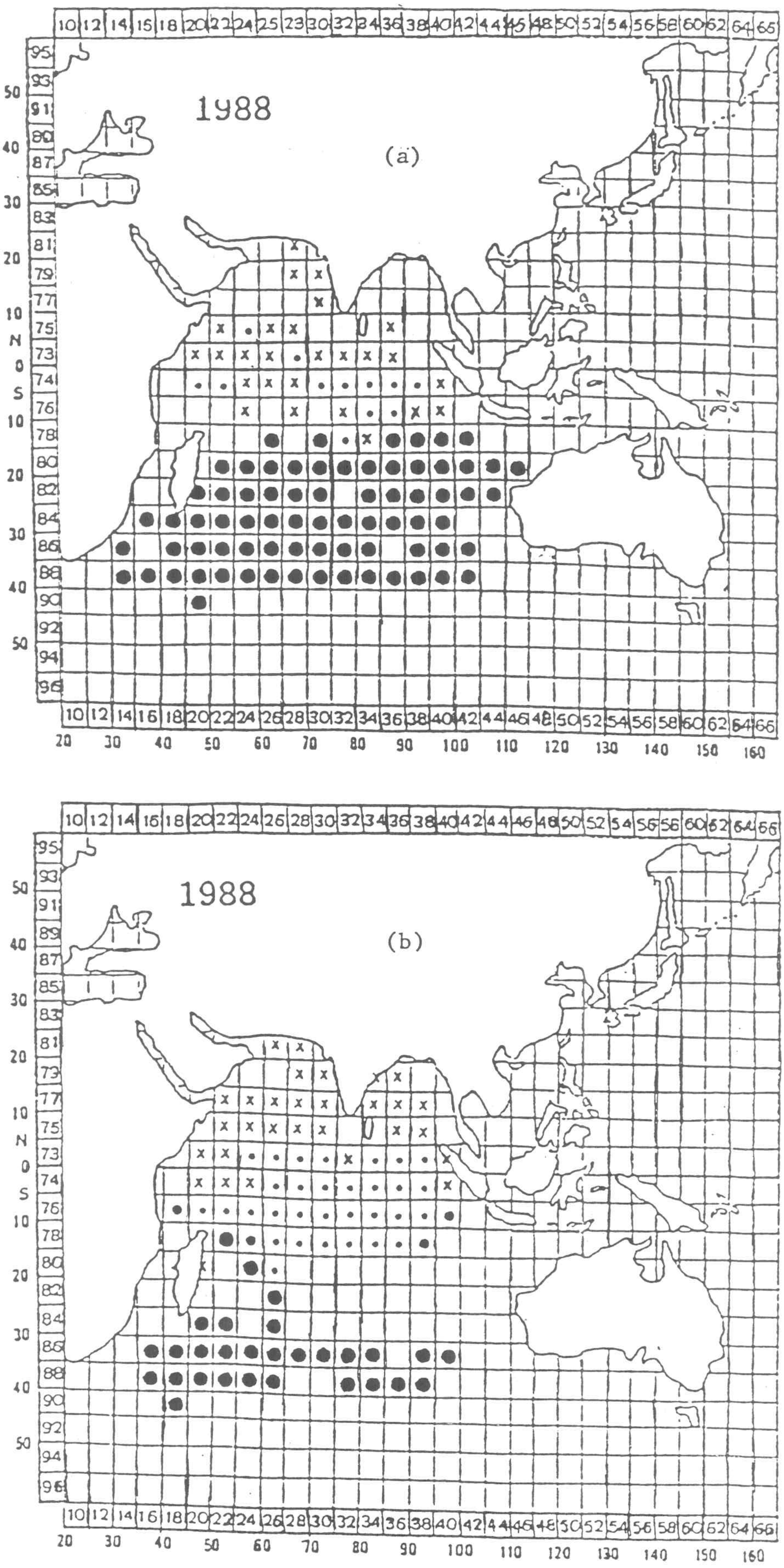
iii Age-structured models, such as cohort analysis, should be used in determining the state of the stock. Change of yield-per-recruit due to the development of the gillnet fishery should also be investigated.

iv Growth, reproductive biology, distribution and movement of albacore should be investigated in light of the new findings and approaches developed for Pacific albacore.

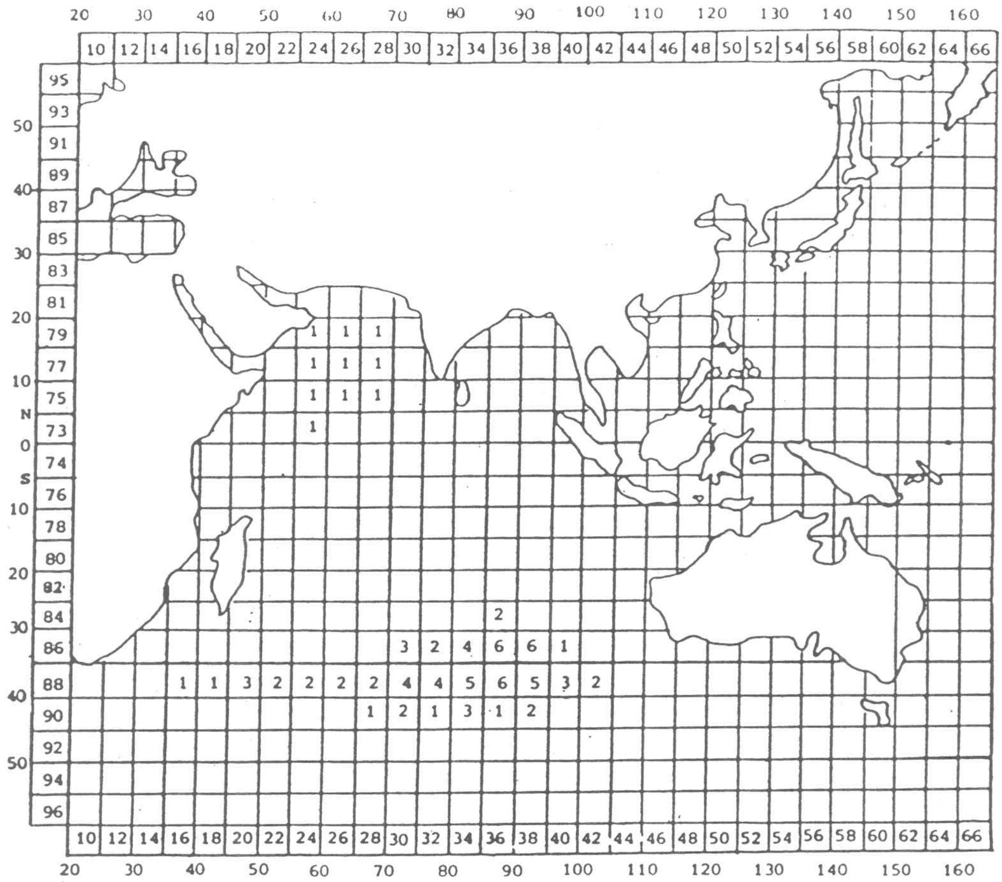
v Scientists from the major albacore fishing countries should continue to cooperate with the IPTP and participate in future IPTP working groups.

(3) Management

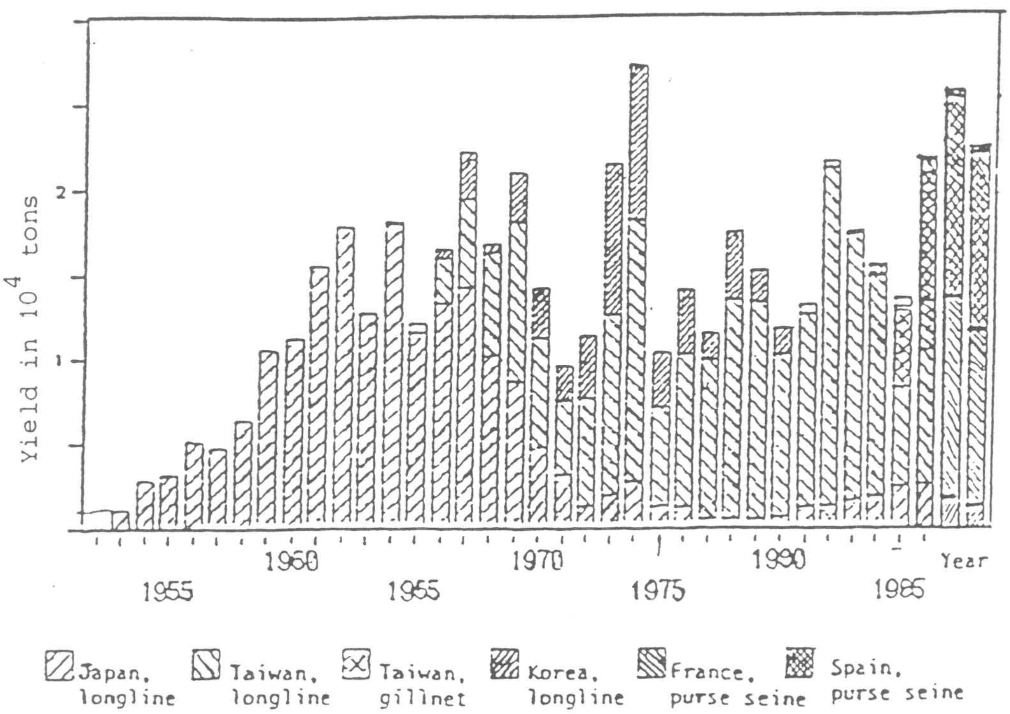
No management recommendations are offered at this time.



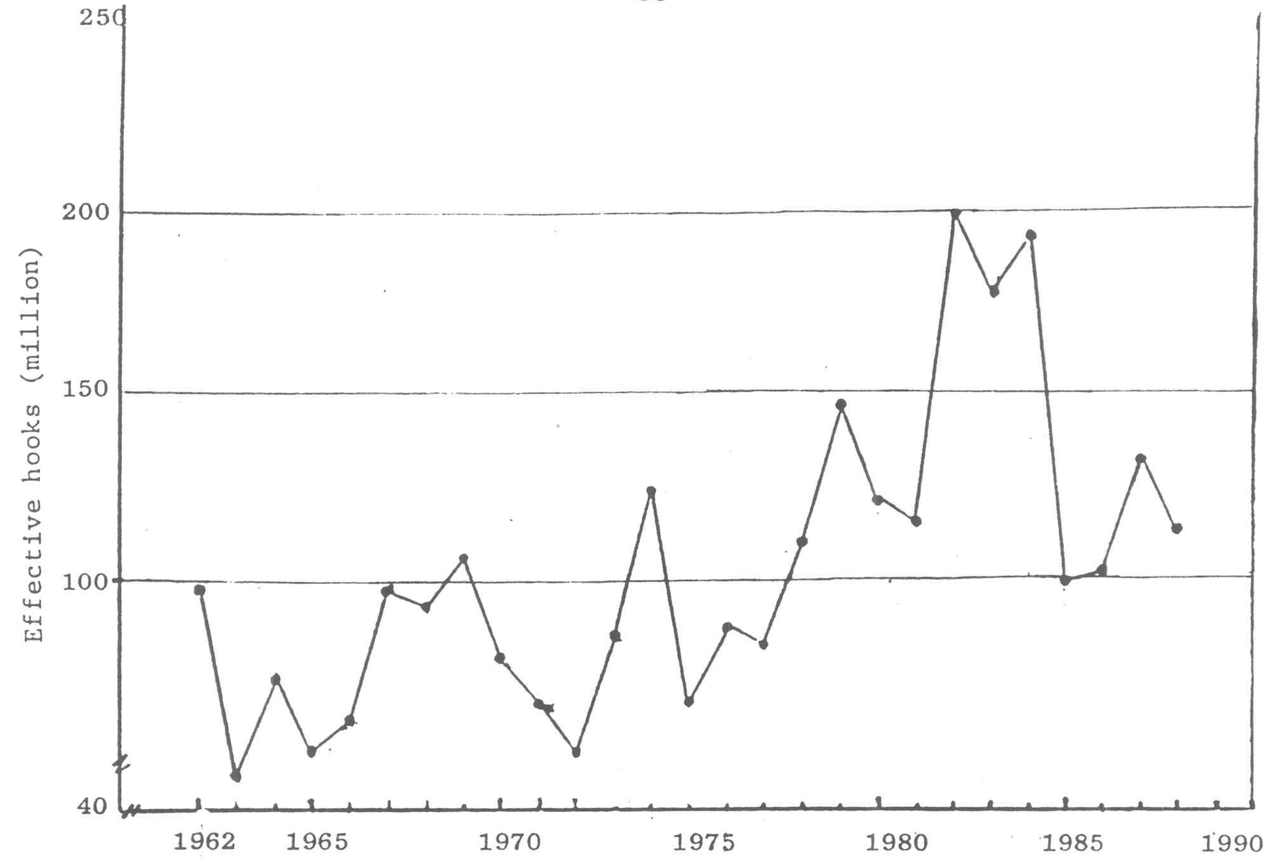
ALB Fig.1 Distribution of Taiwanese catch per unit effort of albacore by (a) regular and (b) deep longline fisheries.



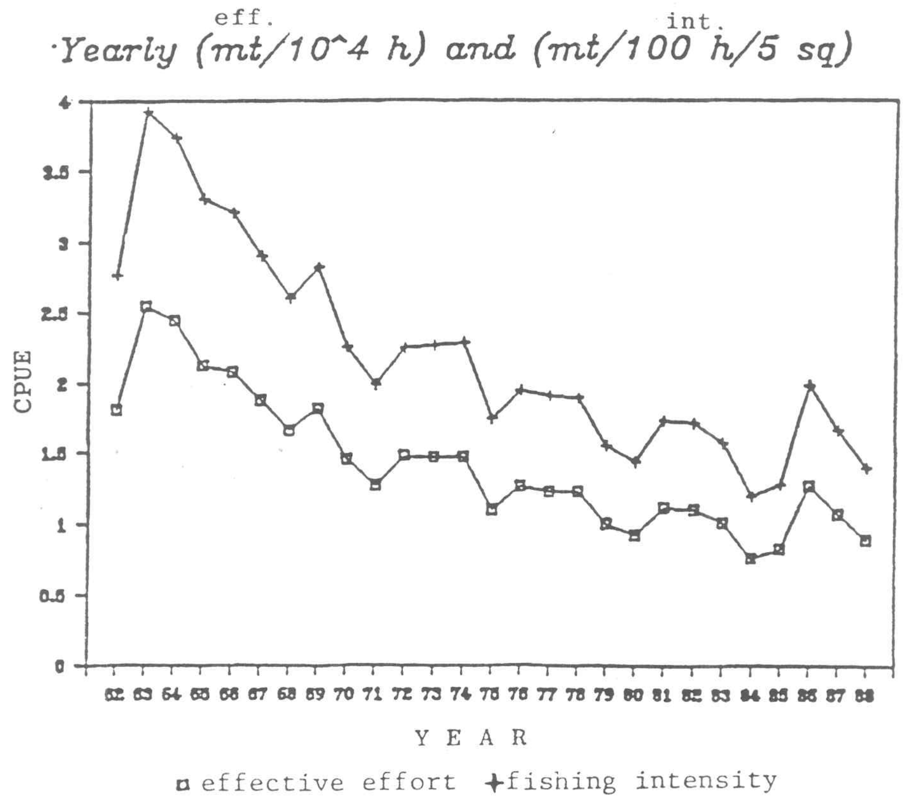
ALB Fig. 2. The accumulated numbers of month of 1987-1988 fishing season which Taiwanese large-scale pelagic drift gillnet fishery had operated in the 5°x5° square grid cell using to understand the fishery activities.



ALB Fig. 3. Trends of annual catches by country and gear for Indian Ocean albacore, 1952-1988



ALB Fig. 4. Effective fishing effort of Indian Ocean albacore by longline fisheries, 1962 - 1988



ALB Fig. 5. Adjusted CPUE trend of Indian Ocean albacore by longline fisheries, 1962-1988.

ALB **TABLE 1: Catch of Albacore (ALB) by fishery, gear and country**

SPECIES: ALB	GEAR	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
SURFACE FISHERIES:													
CHINA (TAIWAN) *	GILL	0	0	0	0	0	0	14	2362	8257	11356	10699	na
FRANCE	PS	0	0	0	0	0	0	222	424	143	174	182	na
IVORY COAST		0	0	0	0	0	0	0	48	0	0	0	na
SPAIN		0	0	0	0	0	0	217	59	227	13	0	na
USSR		0	0	0	0	0	0	0	0	0	0	21	na
TOTAL	PS	0	0	0	0	0	0	439	531	370	187	203	na
DEEP SEA FISHERIES:													
CHINA (TAIWAN) *	LL	11644	13629	9974	11206	19936	15422	12665	5596	10030	11790	10045	na
JAPAN		418	396	577	1174	1184	1592	1588	2328	2121	1641	1171	na
KENYA		0	0	2	14	48	76	0	0	0	0	0	na
KOREA		3606	1484	1231	654	352	221	254	324	201	221	115	na
MAURITIUS		0	0	0	0	0	0	0	0	0	41	37	na
MOZAMBIQUE		0	0	0	0	0	0	9	0	0	0	0	na
TOTAL	LL	15668	15509	11784	13048	21520	17311	14516	8248	12352	13693	11368	na
TOTAL	SPECIES	15668	15509	11784	13048	21520	17311	14969	11141	20979	25236	22270	na

Note: 1) statistics are compiled from I.P.T.P. statistics report N° 10 and from the following amendments:

CHINA (TAIWAN): Tuna research center. Taiwan university
FRANCE: Revised by HALLIER, 1990
INDIA: Review of tuna fisheries in India (P. JAMES, 1990)
MAURITIUS: Status of the tuna fisheries in Mauritius (A. VENKATASAMI)
USSR: Present situation in the soviet tuna fishing (ROMANOV, 1990)

2) na: data not available

5.2.3 SOUTHERN BLUEFIN TUNA (SBF)

1. Description

Southern bluefin tuna, Thunnus maccoyii, is found only in the southern hemisphere, and is fished in the Indian, Pacific and Atlantic Oceans, generally between the 30°S and 50°S latitudes (SBF Fig.1 and 2). The species is known to spawn in the Indian Ocean, south of Indonesia (10°S) at approximately 8 years of age. It is believed they live to about 20 years of age.

Australia and Japan have the largest southern bluefin tuna fisheries, with New Zealand having a small handline fishery. Juvenile southern bluefin tuna (2 to 5 years) form surface schools off southern Australia and are exploited by Australian baitboat and purse seine fisheries. Catches for Australian fishermen peaked at 21,500 t in the 1982/83 fishing season. Southern bluefin tuna are the prime target species of the Japanese longline fleet. The fleet tends to exploit the fish (4 years and older) on the high seas. Japanese catches peaked at 77,000 t in 1961. New Zealand has a relatively small fishery of a few hundred tonnes annually. The total Indian Ocean catch has varied between 19,000 and 37,000 t during the last decade (SBF Table 1).

2. State of stock

Scientists from Australia, Japan and New Zealand have monitored and assessed the southern bluefin tuna stock status on a regular basis. At the eighth meeting of the Trilateral Scientific Group held in Japan in September, 1989, the scientists reaffirmed their concerns at the poor current state of the stock. Data has been collected from the fisheries since the 1960s making southern bluefin tuna fisheries a well documented case. In analyzing the status of the stock, scientists examined all existing data sets includig comprehensive catch and effort statistics from both the surface and longline fisheries, length frequency information, the results of tag release and recapture studies and the results of analyses of age structured models. Analysis of the data indicates that the parental biomass is between 8 percent and 25 percent of its earlier exploitation level.

3. Current regulations

Strict quota controls have been implemented on the catch of the Australian, Japanese and New Zealand fleets in response to the major scientific concerns over the status of the stock. Global catch limits for 1989/90 season have been set at 11,750 t: 6,065 t for Japan, 5,265 t for Australia and 420 t for New Zealand. This represents a significant reduction from approximately 38,650 t when global quotas were introduced in 1985.

The southern bluefin tuna catch from other nations are largely unknown. Information from IPTP data summaries shows that Taiwan, Indonesia and Korea have taken southern bluefin tuna in the past. In 1987, Taiwanese gillnetters took 175 t of juvenile southern bluefin tuna. Korean longliners currently do not operate in the principal area of southen bluefin tuna occurrence. Indonesia currently catches a few tons annually. The need to identify and quantify the impacts of southern bluefin tuna by countries not currently included in the global quota arrangements was given a high priority in the future research needs identified by the Trilateral Scientific Group and further emphasized at the Expert Consultation.

4. Recommendations

(1) Statistics

IPTP should continue to collect catch information on southern bluefin tuna from participating countries. The provision of length frequency data and other biological information to the Trilateral Scientific Group is encouraged.

(2) Research

The Trilateral Scientific Group should continue to cooperate in research on southern bluefin and make their findings available to the Expert Consultation.

(3) Management

The Expert Consultation supports the management measures for southern bluefin tuna recommended by the Trilateral Scientific Group, comprising scientists from Australia, Japan and New Zealand.

SBF **TABLE 1: Catch of Southern Bluefin tuna (SBF) by fishery, gear and country**

SPECIES: SBF	GEAR	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
SURFACE FISHERIES:													
AUSTRALIA	BB	0	0	0	0	0	0	0	0	1082	1210	1078	415
CHINA (TAIWAN)	GILL	0	0	0	0	0	0	0	1	4	175	5	na
DEEP SEA FISHERIES:													
AUSTRALIA	LL	0	0	0	0	0	0	0	0	0	0	0	16
CHINA (TAIWAN)		50	57	42	23	42	21	97	3	4	58	74	na
INDONESIA		4	10	8	3	2	3	1	4	na	3	3	na
JAPAN		10059	10293	14488	12861	10788	17297	15551	13794	9153	8397	8256	na
KOREA		94	0	0	0	6	0	1	0	0	0	0	na
TOTAL	LL	10207	10360	14538	12887	10838	17321	15650	13801	9157	8458	8333	na
UNCLASSISFIED:													
AUSTRALIA	UNCL	6916	6587	9677	13182	18305	19424	14515	14196	11408	9593	9500	4638
TOTAL	SPECIES	17123	16947	24215	26069	29143	36745	30165	27998	21651	19436	18916	na
WORLD CATCHES OF THE STOCK													
	LL	av	27789	33412	28081	20854	24758	23421	20405	15791	14034	10803	na
	SURFACE	av	10783	11325	17042	21806	17827	13504	12683	12613	10880	10684	na
	TOTAL	av	38572	44757	45123	42660	42585	36925	33088	28404	24914	21487	na

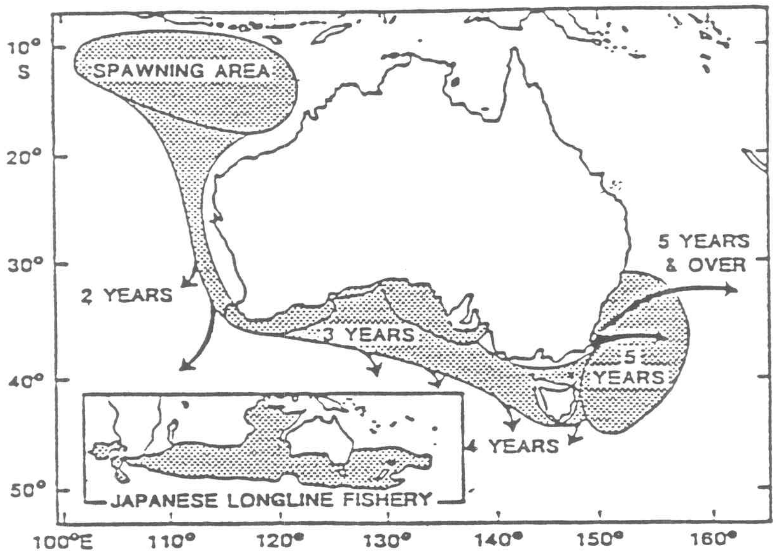
Note: 1) statistics are compiled from I.P.T.P. statistics report N° 10 and from the following amendments:

CHINA (TAIWAN): Tuna research center. Taiwan university.
INDONESIA: State entreprise of Perikanan Samodra Besar.

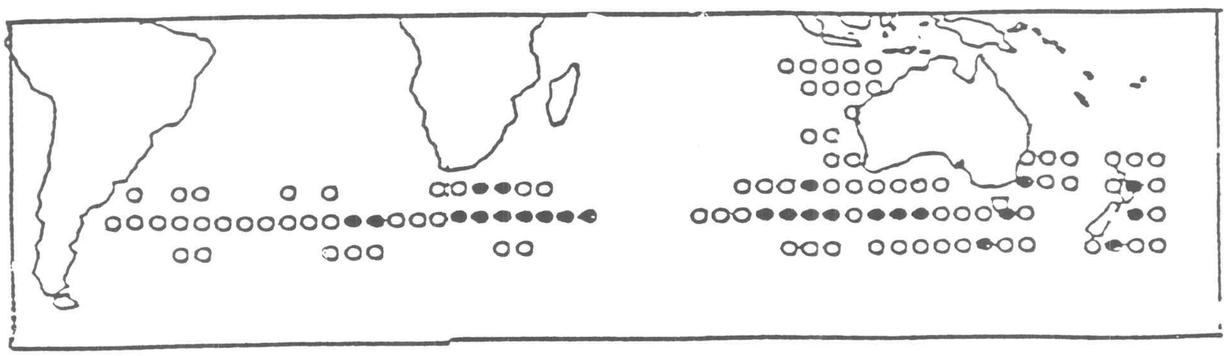
2) Source for "world" section: Report on the Eight meeting of Australian, Japanese and New Zealand Scientists on So
Bluefin Tuna.

3) na: data not available.

SBF Figure 1. Spawning area and principal migration routes off Australia



SBF Fig.2 Distribution (circles) of Japanese longline catches of southern bluefin tuna



5.3 SMALL TUNAS, SEERFISH AND BILLFISH

5.3.1 Description of Fisheries

Small tuna, seerfish and billfish present unique and contrasting problems to research in the Indian Ocean and Indo-Pacific region. Small tunas and seerfish tend to be neretic, distributed over the continental shelves of coastal nations; research and management may thus be more effectively conducted by individual nations rather than on an ocean-wide basis. In contrast, many of the billfish species are oceanic and known to be highly mobile, occasionally undertaking trans-oceanic migrations. Billfish require management and research on a large multi-lateral basis. Furthermore, the fisheries for small tunas and seerfish are comprised of small-scale commercial and artisanal operations which present major problems for the collection of fisheries statistics. Billfish are mainly a by-catch of distant-water industrial fisheries and tend to be overshadowed by the commercial importance of the target species such as yellowfin tuna and bigeye tuna. Several of the fisheries, such as those for longtail tuna and kawakawa, are unique to the Indo-Pacific region. Unlike well-studied species, such as skipjack tuna, there is no good foundation of biological knowledge which can be relied on when assessing the status of these species.

Regardless of the inherent problems presented by the small tunas, seerfish and billfish to research, it must be emphasized that the group is of tremendous importance in the Indian Ocean. Small tunas and seerfishes are an important food supply to many of the coastal nations. Catches have expanded rapidly during the previous decade. Small tunas, billfish and seerfish comprised more than one-third of the total catch reported by the IPTP in 1988.

Coastal states of the region fish for small tunas using a variety of fishing gears throughout the year. Gears include gill net, troll line, pole-and-line, longline and handline. Purse-seines are used in Malaysia and Thailand. The countries with the highest catches of small tunas in 1988 were India, Indonesia, Iran, Malaysia, Maldives, Oman, Pakistan, Sri Lanka, Thailand and the United Arab Emirates (UAE) (TUN Table 1).

There are 16 locations throughout the Indian Ocean where sampling programmes have been instituted to monitor small-scale fisheries for catches of small tunas, seerfishes and billfishes. These include nine locations on the Indian sub-continent, three locations in eastern Indonesia and two locations in the North Arabian Sea. Information on catch, effort, species composition and size composition for landings of small-scale fisheries is generally limited and especially poor for the north Arabian Sea where present landings of narrow-barred Spanish mackerel and longtail tuna are quite substantial.

In addition, seven landing sites on the west coast of Thailand are monitored twice a month by staff of the Andaman Sea Fisheries Development Center, Department of Fisheries.

5.3.2 SMALL TUNAS (TUN)

1. Fishing areas

Longtail tuna, Thunnus tonggol, is distributed throughout the Indo-Pacific region, from the northeast coast of Somalia, eastward to Japan in the north, to the east coast of Australia in the south. Longtail tuna is neretic and is not reported from oceanic islands. It is generally only abundant off large land masses that have broad continental shelves. The principal fishing area for longtail tuna is the North Arabian Sea off Oman, UAE, Islamic Republic of Iran and Pakistan, which accounted for 91 percent of the 1988 catches (TUN Table 2). Another fishing area for this species is the Andaman Sea off the coasts of Thailand and Malaysia.

Kawakawa, Euthynnus affinis, is more widely distributed than longtail tuna. Kawakawa is distributed from the east coast of Africa throughout the Indo-Pacific region. Kawakawa occurs off oceanic islands and is generally abundant in coastal areas over continental shelves. The principal fishing area for this species is adjacent to the Indian sub-continent (India and Sri Lanka) where 48 percent of the 1988 landings were reported. Other fishing grounds for kawakawa include the North Arabian and Andaman Sea areas.

Frigate tuna Auxis thazard, and bullet tuna, A. rochei, are circumtropical in distribution. They are commonly found from over the continental shelf out into contiguous waters. The Andaman Sea and the Indian sub-continent are the principal fishing grounds.

2. Fishing gear

The most important fishing gear for small tunas in the India Ocean is the gillnet. Generally, the gillnet fisheries target narrow-barred spanish mackerel with significant catches of longtail and kawakawa in many areas. Narrow-barred Spanish mackerel, longtail and kawakawa are taken by gillnet in the North Arabian Sea, Iran, Oman, UAE and Pakistan. In India and Sri Lanka, the principal neretic large pelagic species captured by gillnets are the narrow-barred Spanish mackerel, kawakawa and frigate tuna. Off the west coasts of Thailand and Malaysia, the large mesh gillnet fishery targets primarily on the narrow-barred Spanish mackerel with a small by-catch of small tunas.

Small tunas, mainly kawakawa (TUN Fig. 1), frigate tuna (TUN Fig. 2) and bullet tuna, are captured incidentally by purse-seines targeting for small pelagic species (Indian and Indo-Pacific mackerels and scads) off the west coasts of India, Thailand and Malaysia. There is a small-scale purse-seine fishery off the north coast of Sumatra and a Danish seine fishery off southeastern Java that targets frigate tuna, bullet tuna and skipjack tuna. There is also a small-scale purse-seine fishery developing off the south coast of Sri Lanka for frigate tuna and bullet tuna.

Small tunas (and seerfishes) are also taken in many areas of the Indo-Pacific region by artisanal fishermen, using hook and line.

3. Processing and marketing

Longtail tuna, kawakawa and Auxis species are usually marketed fresh in the North Arabian countries, canned in Iran and Thailand and salt-dried in Pakistan. Longtail tuna is the most esteemed of the small tunas. The only international trade in small tunas is the export of salt-dried fish from Pakistan to Sri Lanka and canned tuna from Thailand to north America and Europe.

4. Fisheries trends and current situation

TUN Table 1 shows the catches of small tunas, seerfishes and billfishes in the Indian Ocean from 1976 to 1988. Reported landings of small tunas in the Indian Ocean increased from 63,000 t in 1976 to 145,000 t in 1988. During this period, landings of longtail tuna, frigate tuna and kawakawa increased by factors of 14, 6 and 2, respectively. Unidentified tuna landings fluctuated between 37,000 t and 63,000 t.

In the earlier years, catches of tuna which include mixed tuna species (TUN), dominated the catch. In later years, however, an increasing proportion of kawakawa, longtail tuna and frigate tuna were recorded in the catches. This was probably a result of better identification and separation of the species of small tunas.

In Indonesia all small tunas continue to be reported as TUN. On the Baluchistan coast of Pakistan, all tunas continue to be reported as TUN.

In the years prior to 1986, more kawakawa than longtail tuna were caught in the Indian Ocean. However, since 1987, more longtail were caught than kawakawa and longtail is now the most important small tuna species caught in terms of quantity landed.

5. Size composition, age and growth

Longtail tuna caught by gillnets off the coasts of Iran range from 40 to 95 cm FL with a large majority of the fish between 60 to 85 cm (TUN Fig. 1). The average size of longtail is 77 cm. Small longtail of 30 to 40 cm are caught off the UAE and the Batinah coast of Oman.

In Thailand, longtail tuna enters the fishery at 11.0 cm FL. The sizes of fish caught, range from 11.0 to 51.0 cm with 2 modes. In Somalia longtail tuna ranged from 57 to 98 cm with one mode at 69 cm.

In Sri Lanka, the commercially exploited kawakawa are between 28 to 61 cm FL. The length frequency of the kawakawa caught in the Maldives show four length modes at 32, 36, 40 and 44 cm respectively (TUN Fig. 3). In Thailand, kawakawa recruit into the fishery at 8.5 cm. The size of fish caught range from 8.5 to 58.0 cm and the length frequency is unimodal. The annual length frequencies of kawakawa taken by fisheries of various countries show mostly 3 modes with the exception of fish from the Seychelles.

The commercially exploited frigate tuna in Sri Lanka range from 22 to 42 cm FL. In the Maldives, two modes at 31 cm and 36 cm were observed in the length frequency distribution. However, more intentive sampling is required to confirm these results. In Thailand, frigate tuna recruit into the fishery at 9.0 cm. The sizes of fish caught ranged from 9.0 to 44.0 cm. Generally, it was observed that the sizes of small tunas caught by the light luring Thai purse seines were smaller than those caught by the regular purse seine.

6. Age and growth of kawakawa

Two documents were presented on the age and growth of kawakawa. One study (Document TWS/90/8) was based on daily increment on otoliths and the other (Document TWS/90/16) analyzed modal lengths in frequency distributions, grouped by yearly intervals. The study based on otolith increment counts relies on a validation study, using tetracycline injection, carried out previously. The study suggested more rapid growth than reported by other workers, with kawakawa attaining lengths of 45, 60 and 64 cm in the 1st, 2nd and 3rd year of life, respectively.

In the other study, modal lengths frequency distributions, grouped by 1 year intervals, were defined by the Bhattacharya routine of the LFSA software package. Ages of modal lengths less than 49cm obtained from this analysis were determined with the Von Bertalanffy growth curve obtained in the study reported in Document TWS/90/8. Growth curves derived for kawakawa from Malaysia, Maldives, Pakistan, Sri Lanka and Thailand were very similar, but slightly different from the growth of kawakawa from the Seychelles. Kawakawa in the Seychelles attain a larger size after age one than kawakawa from the other regions. Results for male and female kawakawa from the Seychelles showed different growth rates, with males attaining a larger size than female after age one.

7. Reproductive biology of longtail tuna

Results of a study of longtail tuna in Iranian waters indicate no modal progression in the monthly length frequency distributions. No significant differences in the sex ratio of male and female were found throughout the study period. The spawning season for longtail tuna in Iranian waters appears to extend from August through October. Spawning may occur more than once a year but further investigations are required on spawning frequency.

5.3.3 SEERFISHES

Seerfish landings in the Indian Ocean steadily increased from 43,000 t in 1976 to 104,000 t in 1988 (TUN Table 1). Most of the seerfish catch was reported by India, Indonesia, Malaysia, Oman Pakistan, Sri Lanka, and UAE (TUN Table 2).

Two species, the narrow-barred Spanish mackerel, *Scomberomorus commerson* and the Indo-Pacific king mackerel, *S. guttatus*, contribute the bulk of the landings. Wahoo, *Acanthocybium solandri*, contribute only a minor proportion of the total seerfish catch. The two mackerels occur in the continental shelf waters while wahoo is oceanic. The principal fishing grounds for narrow-barred Spanish mackerel are the North Arabian Sea, the waters adjacent to the Indian sub-continent, Kenya and western Indonesia. The waters off the Indian sub-continent and western Indonesia are also major fishing grounds for king mackerel. In 1988 narrow-barred Spanish mackerel contributed about 54 percent, of the total seerfish landings in the Indian Ocean while king mackerel contributed about 14 percent. Most of the catches are taken by artisanal drift gillnet, hook and line and troll lines.

The narrow-barred Spanish mackerel is considered a premium eating fish throughout the region. It is generally marketed fresh. There is also a limited international market for narrow-barred Spanish mackerel. This species is exported from Oman, Pakistan and United Arab Emirates to the other Arabian Peninsular countries.

Preliminary results of a biological study of narrow-barred Spanish mackerel in Kenya were presented (Document TWS/90/43). L_{oo} was reported as 240 cm FL.

The yields of seerfishes were reported for several areas of the Indian Ocean. Yields were estimated to be between 0.09 and 0.86 t/km2. It was also observed that narrow-barred Spanish mackerel is presently heavily exploited in Oman, Pakistan and along the southwest and northeast coasts of India (Document TWS/90/9).

5.3.4 BILLFISHES

During the past decade the billfish production in the Indian Ocean has increased by 50 percent from around 10,000 t in 1979 to 15,000 t in 1988. There are no major fisheries specifically targeting billfishes but there is a significant by-catch longline and gillnet fisheries. Billfishes are also taken by recreational fishermen in several countries. Six species contribute to the catch (TUN Table 1); swordfish, blue marlin, striped marlin, sailfish and black marlin.

The catches of billfish are reported from the longline fisheries of India, Japan, Korea, Taiwan; gillnet fisheries in Pakistan and Sri Lanka; and unidentified gears in Oman and Tanzania. Striped marlin, swordfish and blue marlin are important species in the Taiwanese and the Japanese longline fisheries and the Sri Lankan gillnet fisheries. Several billfish species are also important in Omani and Tanzanian coastal fisheries. Recreational fishing for billfish is popular in Mauritius and Australia.

Yield-per-unit area analyses indicated that the yield of billfish for coastal states where the catches are high ranged from 2.76 to 7.33 kg per square km. The relatively low yield of billfishes in the Indian Ocean may result from incomplete reporting of statistics and the inefficiency of the longline gear in catching billfishes.

No new research results on billfishes were made available to the Consultation. However, the Consultation was informed that some work is being initiated in Mauritus and Australia where there are active recreational fisheries for billfishes.

5.3.5 <u>Recommendations</u>

(1) Statistics

i Investigate alternative methods for collecting data from those fisheries where progress has been unsatisfactory.

The Consultation highlighted longstanding problems with the data for artisanal operations, especially for catches of billfishes. Most of the nations have failed to comply with requests for data on their fisheries.

Scientific surveys of principal artisanal fishing areas and interviews with fisheries officers might be considered as a way to collect the data.

ii Improve the level of detail for fisheries statistics

Several nations group catch data into the general categories, notably "TUN", rather than identifying the catch by species - longtail, kawakawa, etc. Aggregation hampers identification of resources, and precludes assessment of exploitation levels. All nations should report their catches by species.

(2) Research

i Initiate programmes to consolidate the understanding of the biology of kawakawa, longtail tuna and narrow-barred Spanish mackerel.

Substantial progress had been achieved in ageing kawakawa on the basis of daily rings on otoliths and analysis of length frequency modes. The Consultation emphasized the importance of validating age estimates, with methods such as tag-recapture data and rearing experiments.

ii Assess the potential for swordfish fishery

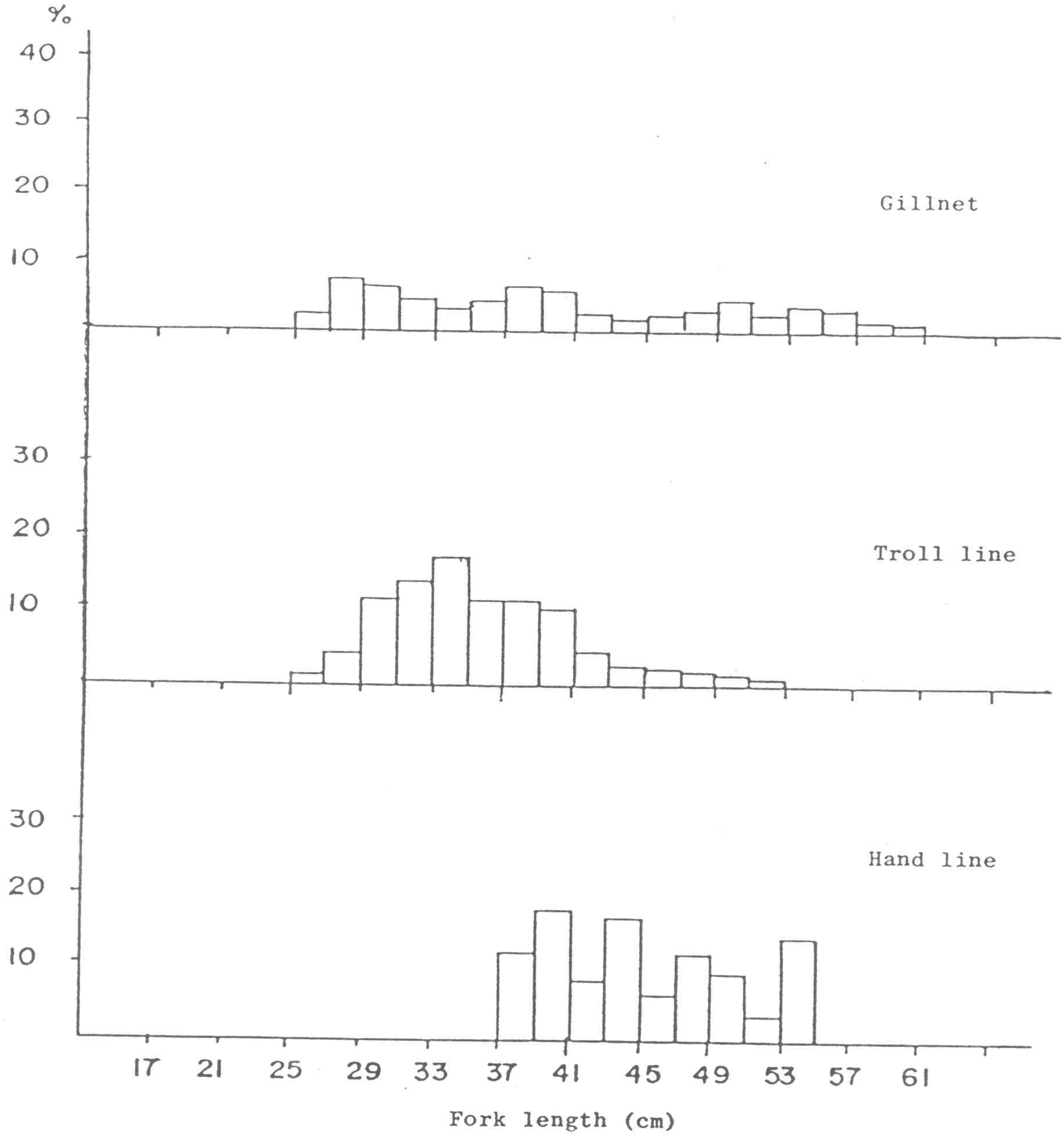
A significant swordfish fisheries do not exist in the Indian Ocean, unlike in the Atlantic and Pacific Oceans. High longline catch rates of swordfish have been reported from several areas of the Indian Ocean and the region might be able to support a large, commercial fishery for swordfish. The potential need to be investigated.

iii Support tagging

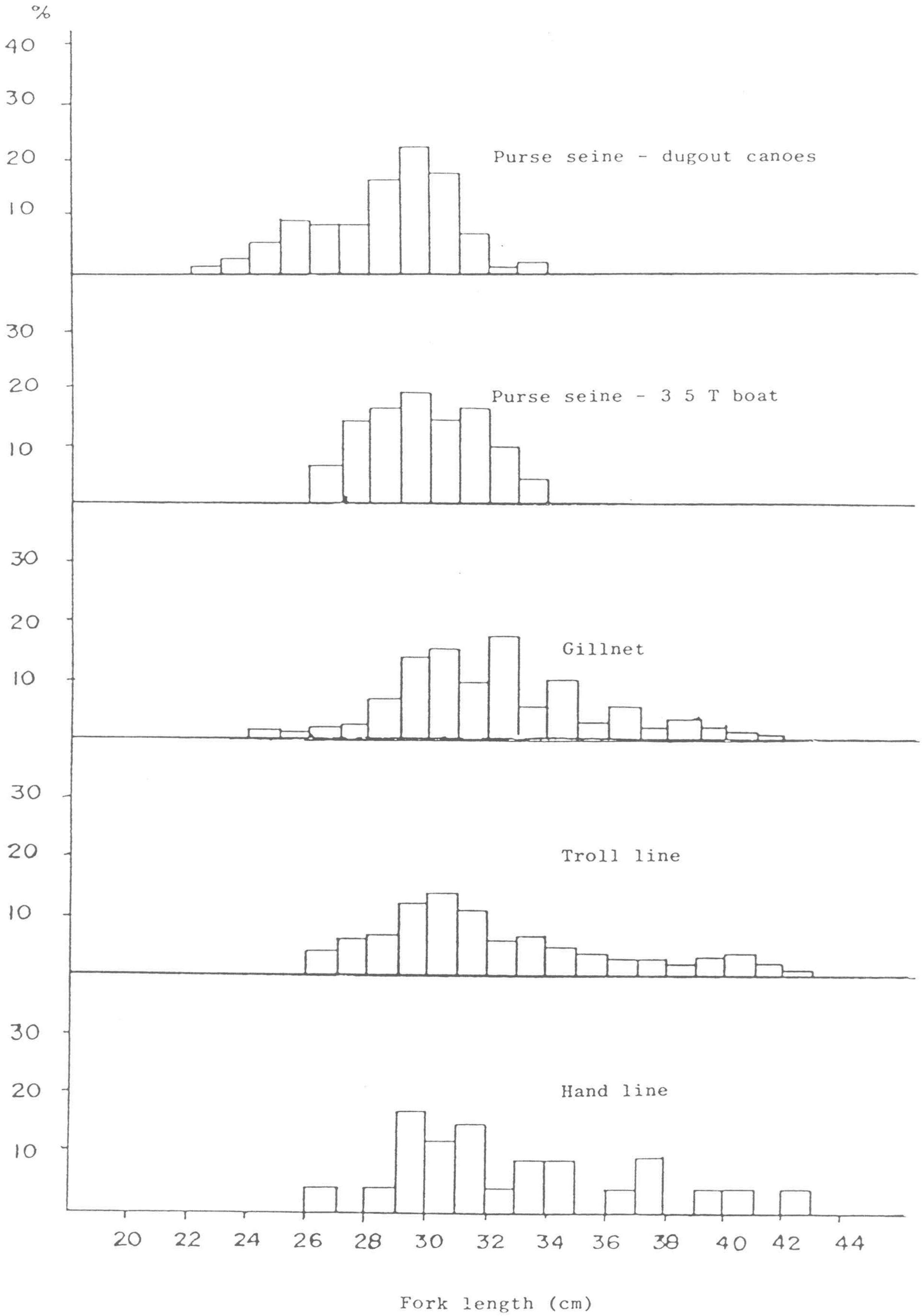
The IPTP should assist in planning and executing a tagging programme for small tuna in cooperation with coastal nations. Such a program would be valuable in advancing the knowledge on the biology of small tuna, e.g., migration, growth, etc.

(3) Management

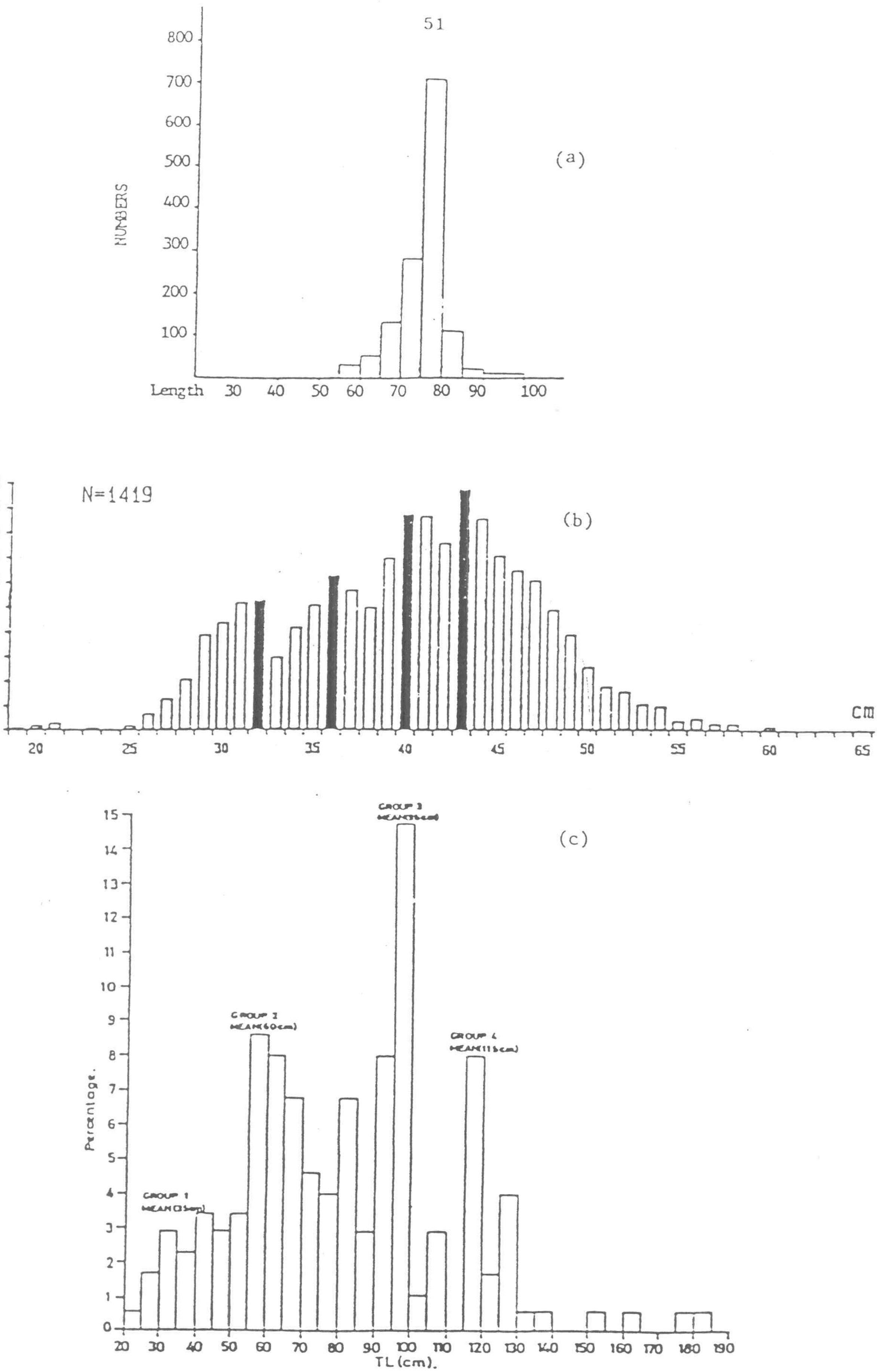
No management recommendations are offered at this time.



TUN Fig. 1. Length frequency distribution of kawakawa caught by different gear.



TUN Fig. 2. Length frequency distribution of frigate tuna caught by different gear.



Tun Fig. 3 Length frequency distributions of (a) longtail captured by gillnet in Iran, (b) kawakawa captured by pole and line in the Maldives and (c) narrow-barred Spanish mackerel captured by hook and line in Kenya.

TUN Table 1. Catches of small tunas, seerfishes and billfishes from 1972-1988

SPECIES	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
LOT	666	869	2126	2421	3046	3305	1936	4589	3215	5710	15337	15957	16329	28962	21570	38783	45655
KAW	14204	12264	15832	16756	16529	15019	9660	14480	8282	23223	25507	21322	29080	25978	28369	30656	37687
FRZ	3186	6626	6006	4057	2708	3086	1661	1701	1595	2908	4967	5675	9337	6501	12635	16574	21034
TUN	20770	48007	38065	31205	40290	42082	41622	43989	60329	37011	47761	45489	36014	63161	53897	48054	42080
TOTAL	38826	67766	62029	54439	62573	63492	54879	64759	73421	68852	93572	88443	90760	124602	116471	134067	146456
COM	13300	11200	12850	11557	14364	17003	17914	20481	16018	34978	43333	47371	43303	57947	58102	53740	55914
GUT	600	600	759	498	315	100	157	245	182	13661	15570	15685	14479	19351	13837	14584	14522
STS	0	0	0	0	0	0	0	0	0	279	165	230	225	76	2175	73	73
WAH	0	0	0	0	0	0	0	0	0	0	1	61	713	59	6	3	3
KGX	23217	19323	25570	23801	28531	27419	25778	36173	39069	9702	14665	10593	7101	19810	22812	38776	33705
TOTAL	37117	31123	39179	35856	43210	44522	43849	56899	55269	58620	73734	73940	65821	97243	96932	107176	104217
BLZ	1792	939	1374	2286	1550	1429	2605	2534	2440	1971	2071	2691	2717	2825	3653	3315	2260
BLM	124	71	53	30	13	92	68	87	180	546	468	752	1027	1012	1602	1551	1249
MLS	1430	966	1932	1161	833	1755	2803	2468	3025	3121	1559	1891	2148	4150	2933	2118	2296
SFA	500	200	245	438	384	148	219	248	312	172	163	149	126	1220	1229	1626	1544
SWO	836	769	726	983	774	923	1631	1424	1197	1395	1597	1952	1807	2943	2704	2729	2266
BIL	896	800	2406	852	1240	1453	2214	3400	2663	3214	5054	2768	3330	5181	5000	3943	5212
TOTAL	5578	3745	6736	5750	4794	5800	9540	10161	9817	10419	10912	10203	11155	17331	17121	15282	14827

1/ LOT = Longtail
KAW = Kawakawa
FRZ = Frigate and Bullet tuna
TUN = Tunas NEI
COM = Narrow-barred Spanish mackerel
GUT = Indo-Pacific king mackerel
STS = Streaked seerfish
WAH = Wahoo
KGX = Seerfishes NEI
BLZ = Indo-Pacific blue marlin
BLM = Black marlin
MLS = Striped marlin
SFA = Indo-Pacific sailfish
SWO = Swordfish
BIL = Billfishes NEI

TUN Table 2. Catches of small tunas, seerfishes and billfishes by country in the Indian Ocean during 1988

(metric tons)

COUNTRIES	LOT	KAW	FRZ	TUN	COM	GUT	STS	WAH	KGX	BLZ	BLM	MLS	SFA	SWO	BIL	TOTAL
								S P E C I E S								
Australia	40	0	0	0	310	0	0	0	0	0	0	0	0	0	0	350
Bahrain	0	0	0	0	189	0	0	0	0	0	0	0	0	0	0	189
Bangladesh	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0	16
China (Taiwan)	0	0	0	0	0	0	0	0	0	110	34	1283	2	591	0	2020
Comoros	0	1360	0	150	0	0	0	0	440	0	0	0	0	0	0	1950
Djibouti	0	0	0	32	0	0	0	0	26	0	0	0	0	0	0	58
Egypt	0	0	0	80	0	0	0	0	0	0	0	0	0	0	0	80
India	1299	15292	5962	3007	18368	12729	73	0	0	0	0	0	0	0	802	57532
Indonesia	0	0	0	23831	4743	1096	0	0	0	0	0	0	0	0	0	29670
Iran	16907	2165	348	0	1000	667	0	0	0	0	0	0	0	0	0	21087
Israel	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	100
Japan	0	0	0	0	0	0	0	0	0	807	223	309	54	1095	0	2488
Kenya	0	0	0	0	52	0	0	0	0	0	0	0	0	0	0	52
Korea Rep.	0	0	0	1259	0	0	0	0	0	16	6	82	0	78	2467	3908
Kuwait	0	0	0	0	23	30	0	0	0	0	0	0	0	0	0	53
Malaysia	1740	2197	1097	1	0	0	0	0	4933	0	0	0	0	0	8	9976
Maldives	0	1257	1629	84	0	0	0	0	0	0	0	0	0	0	0	2970
Mauritius	0	0	0	690	0	0	0	0	0	0	0	0	0	0	0	690
Mozambique	0	0	0	280	0	0	0	0	380	0	0	0	0	0	0	660
Oman	15669	3420	0	1123	27834	0	0	0	0	0	0	0	0	0	1551	49597
Pakistan	3010	2937	27	10445	0	0	0	0	10497	0	0	471	650	0	0	28037
Qatar	0	0	0	0	143	0	0	0	0	0	0	0	0	0	0	143
Reunion	0	0	0	264	0	0	0	0	0	0	0	0	0	0	0	264
Saudi Arabia	0	0	0	267	0	0	0	0	3047	0	0	0	0	0	0	3314
Seychelles	0	153	0	0	0	0	0	3	0	0	0	0	4	0	0	160
South Africa	0	0	0	0	89	0	0	0	0	0	0	0	0	0	0	89
Sri Lanka	0	1580	1588	5	0	0	0	0	3842	1327	986	151	834	492	0	10805
Tanzania	0	0	0	532	0	0	0	0	1489	0	0	0	0	0	384	2405
Thailand	2556	3524	9632	0	0	0	0	0	1911	0	0	0	0	0	0	17623
UAE	3930	2260	620	0	0	0	0	0	7140	0	0	0	0	0	0	13950
USSR	0	0	11	14	0	0	0	0	0	0	0	0	0	0	0	25
Yemen Arab Rep.	414	272	0	0	2273	0	0	0	0	0	0	0	0	0	0	2959
Yemen P.D.R	90	1270	20	0	890	0	0	0	0	0	0	0	0	10	0	2280
TOTAL	45655	37687	21034	42080	55914	14522	73	3	33705	2260	1249	2296	1544	2266	5212	265500

Sources - IPTP, 1990

6. INTERACTION AND TAGGING EXPERIMENTS

6.1 Tagging experiments

As a starting point to consideration of this agenda item, the Chairman reviewed two tagging experiments that have recently been conducted in the region (Documents TWS/90/5, 10 and 61).

A tuna tagging programme in the Maldives was initially proposed following discussions during the Ninth Session of the IOFC Committee for the Management of Indian Ocean Tuna, held in Colombo, December 1986. At a preparatory meeting held in Colombo in June 1989, it was decided to commence tagging in the Maldives in January 1990. The principal objective of the tagging programme is to determine the movement of skipjack and yellowfin in the area bounded by the Maldives, Sri Lanka and India.

Three trips of about two weeks duration have been carried out, in January, March and May 1990, utilising local pole-and-line vessels (mus dhoanis) and employing staff from the Maldive Marine Research Section and local crew, with assistance from IPTP. Vinyl dart tags were used. The local fishermen were compensated with US$ 3.00 for each fish tagged. Tag rewards included T-shirts and hooks. Data were collected on size and school type.

A total of 3,733 tuna (2,601 skipjack and 1,130 yellowfin) were tagged and released so far. As of April 1990, a total of 187 tags have been recovered (178 skipjack and 9 yellowfin), several of which were recovered in the waters off the southern tip of India and to the south and southwest of Sri Lanka.

Three more trips are to be conducted and it is hoped that the total number of fish tagged will reach 10,000. A small-scale tagging programme, in which 1,200 fish will be tagged to the south of Sri Lanka, will be conducted later in the year.

Five tagging cruises during September 1987 to September 1989, aboard a medium-sized purse seiner adapted for pole and line operations, took place as part of the Regional Tuna Project of the Indian Ocean Commission. The results were hampered by several factors, notably the inadequacy of the tagging vessel and the inexperience of the crew. Only 955 fish were tagged (419 yellowfin, 359 skipjack, 175 bigeye and 2 dolphin fish), mostly off the northwest coast of Madagascar and around the Comoros Islands. Some 114 fish (103 yellowfin, 9 skipjack and 2 dolphins) were tagged near fish aggregating devices around Reunion.

As of June 1990, 13 fish have been recovered, giving a preliminary recovery rate of 1.4 percent. Among the 13 recaptures, 7 were observed after more than three months at large. Four fish were recovered more than 500 nautical miles from the point of release; these recaptures support the hypothesis that tropical tunas exploited by industrial and artisanal fisheries in the Southwest Indian Ocean come from the same stocks.

Several tagging experiments in other ocean areas were also discussed (Documents TWS/90/5 and 27).

A tagging programme off the east coast of Peninsular Malaysia was initiated in June 1990 with a target of 3,500 tagged fish. This programme was conducted with two traditional trollers based in Kuala Terengganu. In addition, a support vessel accompanied the trollers to provide lodging for the tagging teams. Each team consisted of three persons during the initial cruises. The gear used was monofilament line with two artificial lures. The number of lines used varied from three to four depending on the number of fishermen.

Three cruises have been conducted, during which 1,462 fish (80 percent kawakawa and 20 percent longtail tunas) were tagged. The size range of fish tagged during the first cruises was 16-46 cm for kawakawa and 17-39 cm for longtail tuna. The troll line thus seems to be an effective gear for tagging small tunas and may potentially be an alternative gear for tagging juvenile skipjack and yellowfin, 15-25 cm, aggregated under payaos in the Philippines, and for tagging longtail tuna and kawakawa off both coasts of Thailand and in the gulf between Iran and the Arabian Peninsular.

A large-scale tagging project financed by the European Community is currently being conducted in the Western Pacific by the South Pacific Commission (SPC) in order to study the structure and population dynamics of skipjack and yellowfin stocks. A Japanese style pole-and-line vessel has been chartered since December 1989. During the first five months of vessel charter, 22,087 tunas (10,612 yellowfin, 10,824 skipjack, 612 bigeye and 39 others) have been tagged in the Solomon Islands - Papua New Guinea area. SPC has also conducted additional tagging projects in Solomon Islands since July 1989, during which 5,798 tuna (5,328 skipjack, 411 yellowfin and one bigeye) have been tagged.

Recoveries from the SPC tagging projects, as of May 1990, total 978 giving an early return rate of 3.5 percent. In particular, the return rate of releases in Solomon Islands, where tagging occurred early on and where there is an active fishery, has approached 13 percent. A further 15 months of tagging is scheduled, including visits by the tagging vessel to the Philippines and Indonesia.

Discussion of these and other tagging experiments focused on the following points.

- The determination of the objectives of the tagging experiments is essential. The usual objectives include fish movements and growth, but also mortality, abundance, fisheries interactions and yield-per-recruit.

- Once the objectives have been determined, then the appropriate experimental design or tagging strategies can be elucidated.

- The size of fish to be tagged will depend on the objective of experiment.

- The rate of recovery will depend on a number of factors, including the level of fishing effort, the rate of non-reporting of tags and the rate of tag shedding. Under certain objectives of the tagging experiment, even a low rate of recovery may result in useful information.

- Due consideration should be given to the type of vessel used. Successful tagging in the Maldives and Malaysia with artisanal vessels have demonstrated that large industrial vessels are not a prerequisite.

6.2 Interactions among fisheries

The Expert Consultation on Interactions of Pacific Ocean Tuna Fisheries, will be organized and funded by FAO and hosted in early 1991 in Noumea, New Caledonia, by the South Pacific Commission and ORSTOM (Document TWS/90/65). The objectives of the Consultation are:

- to collate the background information on the status of Pacific Ocean tuna stocks, the distribution of these resources, and the available data on tuna movements;

- to review the present knowledge on interaction problems between various types of fisheries, between gear types, and between fisheries operating close to each other; and

- to identify future research needs to improve the understanding and assessment of these resources.

The Consultation will be organized within the framework of working groups covering the following species and species groups: southern bluefin tuna, northern bluefin tuna, bigeye, Eastern Pacific yellowfin, Western Pacific yellowfin, skipjack, North Pacific albacore, South Pacific albacore and small tunas. An additional working group will address the subject of methods of fisheries interactions.

The preparatory and follow-up work to the Consultation on Interaction will be carried out within the framework of a network of scientists using electronic mail between microcomputers. The present Consultation recommended that scientists of the Indian Ocean region should join the network and participate in the Consultation on Interactions.

A paper addressing possible interactions between the industrial purse seine and the Maldivian bait boat skipjack fisheries in the Indian Ocean (Document TWS/90/67) was presented. The analysis was based on the size distribution of skipjack caught in the two fisheries and utilized a simulation model to investigate the effect of rates of mixing between the stocks. The preliminary conclusion was that there was little or no effect on the Maldivian fishery from increased catches in the purse seine fishery. It was shown that this could be due to a low mixing rate, low exploitation rates, or a combination of the two. It was suggested that only an intensive tagging project in both the purse seine fishery and the bait boat fishery would improve knowledge on exploitation rates and mixing rates.

Two papers were discussed that briefly addressed the issue of interactions between the industrial purse seine and longline fisheries for yellowfin in the Western Indian Ocean (Documents TWS/90/45 and 59). Both papers noted that the trends in catch rates for the two fisheries did not suggest that important interactions were occurring.

While much of the previous discussion concerned interaction problems on an ocean-wide scale for skipjack and yellowfin, namely, interactions between geographic areas (Maldives vs Sri Lanka, Maldives vs industrial purse seiners in the Western Indian Ocean, artisanal fisheries in the Southwest Indian Ocean vs purse seiners, of interactions between gear types [purse seiners vs longliners]), a number of documents were presented which discussed interactions problems on a local scale, namely, interactions between fleets of different gear types which share stocks of small tunas (Documents TWS/90/15, 17, 24, 31 and 32). Local interaction problems or potential problems were thought to exist in Malaysia (commercial purse seine vs artisanal gillnet on the west coast, troll vs gillnet vs purse seine on the east coast), Thailand (regular purse seine vs light-luring purse seine in the Andaman Sea and the Gulf of Thailand) and Sri Lanka (multi-gear artisanal fisheries).

Based on the above review, the following major issues emerge on interactions between fisheries (Int. Fig. 1).

(1) Surface fisheries operating in different areas on similar sized fish (skipjack and small tunas).

(2) Surface and longline fisheries operating on juveniles and adults in areas wide apart (southern bluefin, bigeye and albacore tunas).

(3) Surface fishery for free schools of large individuals and log associated schools of small fishes on one hand, and long line fishery catching adults on the other (yellowfin tunas).

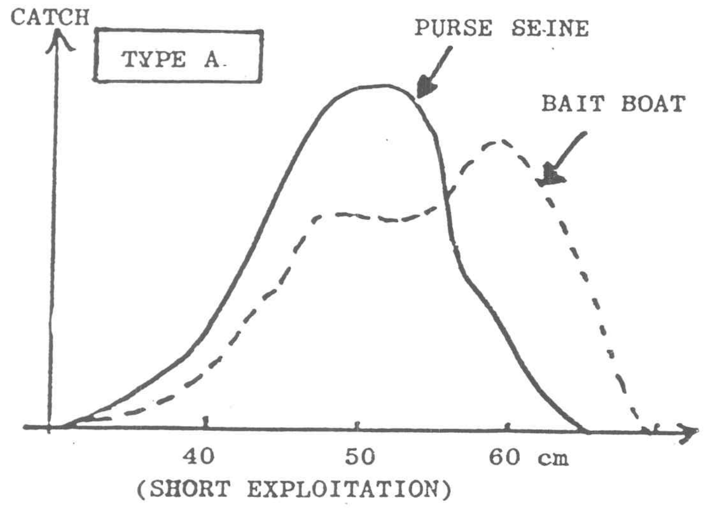
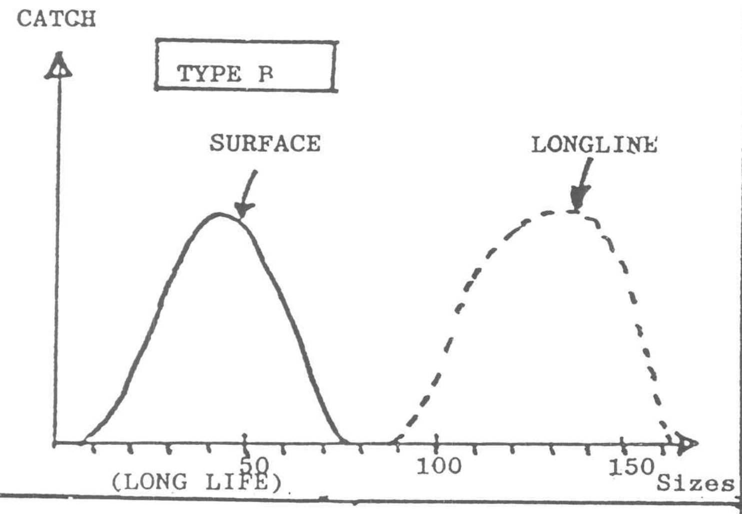
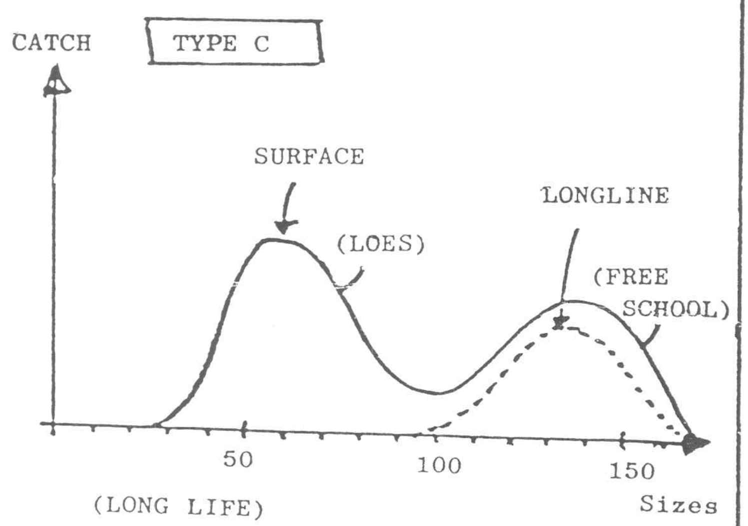
(4) Research needs proposed are tagging, catch/cpue/yield-per-recruit analysis and must be developed differently, depending on the type of interactions.

In-depth studies on interactions between fisheries in the Indian Ocean area are at present lacking. Therefore, there is need for developing such research.

Multigear and multispecies problems reflecting issues of interactions in some countries of the area are considered local issues and could probably be analyzed at a national level.

It is essential to take into consideration the environmental parameters, recruitment, stock status and catchability while dealing with problems of interactions in fisheries.

Int. Fig.1 Types of fisheries interaction in the Indian Ocean, a theoretical model

TYPE OF INTERACTION	SPECIES
	- SKIPJACK - SMALL TUNAS
	- BIGEYE - ALBACORE - SOUTHERN BLUEFIN
	- YELLOWFIN

7. DRIFT GILLNET FISHERY

The Secretariat recalled that at its Ninth Session (Mahe, Seychelles, October 1989), the Indian Ocean Fishery Commission (IOFC), discussed the issue of drift gillnet fishing and felt that the real effect of drift gillnets should be assessed on the basis of a thorough scientific investigation. It is requested that the matter be considered at the Eleventh Session of its Committee on the Management of Indian Ocean Tuna.

On 21 December 1989, the Generaly Assembly of the United Nations adopted a Resolution (44/225) on Large-Scale Pelagic Driftnet Fishing and its Impact on the Living Marine Resources of the World's Oceans and Seas. Paragraph 4(a) of the Resolution recommending moratoria on all large-scale pelagic driftnet fishing on the high seas by 30 June 1992 was brought to the attention of the Consultation as being of particular relevance. It was noted that such a measure will not be imposed in a region or, if implemented, can be lifted, should effective conservation and management measures be taken based upon statistically sound analysis to be jointly made by concerned parties of the international community with an interest in the fishery resources of the region, to prevent unacceptable impact of such fishing practices on that region and to ensure the conservation of the living marine resources of that region.

As a follow-up to the UN Resolution and to the recommendation formulated by the FAO Conference at its Twenty-fifth Session (Rome, November 1989), the Director-General of FAO convened an Expert Consultation (Rome, April 1990), the Report of which was submitted to the present Consultation.

The Secretariat explained that in August 1990, FAO will submit to the Secretariat-General of the UN, a report on large-scale pelagic driftnet fishing and its impact on the living marine resources.

At the request of the Secretariat, the experts provided significant information on the status of drift gillnet fisheries in their countries. The only distant water drift gillnet fishing fleet operating on the high seas in the Indian Ocean is Taiwanese, but there are many artisanal or semi-artisanal fleets operating in the region from Bangladesh, India, Indonesia, the Islamic Republic of Iran, Malaysia, Oman, Pakistan, Sri Lanka, Thailand and Yemen. The 1988 catches of tuna and tuna-like species of most of these countries are presented in DN Table 1.

It was noted (Document TWS/90/54) that Taiwanese large-scale pelagic drift gillnet fishing was initiated in the Indian Ocean in November 1983. The specification of the nets used is summarized in DN Table 2.

The number of boats, landings and catch estimates of the Taiwanese fleets are given in DN Table 3 while the species composition of catch by this fleet appears in DN Table 4. No information is available on the incidental capture of marine mammals.

Indications were also given on the spatial and temporal variations of the fishery. The main catches occurred in the region between 30^o and 45^{o}S, where small albacores of an average of 9 kgs were caught.

In Sri Lanka, the drift gillnet method has been used for many decades, but it has become very popular since the mid-sixties (see Document TWS/90/19). There are two size classes of vessels operating in the fishery (2,000 and 70 boats of weight classes of 3.5 to 4 and 11 tons, respectively). Many of these boats are multi-gear. The drift gillnet used are made of small units called net pieces joined together to form a net of 3 to 4.5 km in total length. It seems that there is a tendency to increase the number of net pieces used in a single operation. Although a range of mesh size from 90 mm to 180 mm (stretched mesh) is used, 140 mm and 152 mm meshes are the most commonly used.

At present, 90 percent of the offshore catch of Sri Lanka is taken by drift gillnets. The fishery targets are skipjack and yellowfin. These species together with small tuna represent 70 percent of the drift gillnet catch. Also billfish, sharks, marine mammals, sea turtles and other fish species are caught. These non-target species are equally important in economic terms as they are consumed locally and some species even fetch prices higher than tuna. The total production of large pelagics by drift gillnet and other combination gear have remained around 30,000 t during the past few years. The association of marine mammals in fisheries is not new in Sri Lanka. Fishermen have traditionally used dolphins, especially oceanic species to locate schools of tuna and other fishes.

However, after the introduction of synthetic netting, the cetacean mortality in the driftnet fishery increased significantly. According to recent statistics approximately 13,000 marine mammals (mainly spinner dolphins) were caught in 1988. It was noted that the fishing industry provides full-time employment to around 100,000 persons.

Sri Lanka is presently cooperating with FAO in the preparation of a Technical Cooperation Project to evaluate better the impact of artisanal drift gillnetting on marine mammals and other living resources. In view of its potential interest for other countries of the region, the Consultation recommended that this project should receive a high priority and be executed as soon as possible.

In India, traditional drift gillnet are generally of the length 50 to 70 m, and seldom over 1.5 km. These nets are mult-meshed and are operated mostly within the 50 m depth zone off the western and eastern coasts. Drift gillnets are among the mainstays of the artisanal as well as small mechanized sectors in the country. The catches from this gear comprise small tunas, seerfishes, sharks, mackerel, sardines, pomfrets and a variety of pelagic species. Thus this gear can be regarded as multispecies. A majority of over 150,000 indigenous crafts, as well as a few thousand (it may be around 6000 to 8000) small mechanized boats, also employ this gear. Dolphins are also occasionally caught by the drift gillnets. They are invariably the incidental component of the catch.

In the Islamic Republic of Iran, the drift gillnet tuna fishery is considered as the major activity of the artisanal sector. Drift gillnets used for the catch of tuna range from 0.5 km on smaller vessels to 7 to 8 km on larger vessels. There are about 2500 multipurpose artisanal boats engaged in the tuna fishery. These vessels are mostly wooden and range from 5 to 100 GT. The smaller boats are usually fibre glass and range from 12 to 27 ft. The drift gillnets have a mesh size between 140 to 160 mm. Drift gillnets with 130 and 110 mm mesh size are also used for catching seerfishes. Polyamid nets have widely been used but multifilament nylon nets have also been introduced recently. The drift gillnets made of polyamid are usually longer than nylon nets. Artisanal fishermen in some parts of the country use drift gillnets in the rather deep waters of the Gulf of Oman to catch bigger tunas such as yellowfin and skipjack.

In Indonesia, an artisanal fleet of small vessels (3 to 6 GRT and 40 HP) manned by a crew of four, is using drift gillnets of 1.2 to 1.8 km to catch skipjack (70 to 80 percent of the total drift gillnet catch) in the Indian Ocean. It takes also a certain proportion of marlins, sharks, swordfishes, redfishes and kawakawa.

In Pakistan, drift gillnets averaging 2.5 km in length and vessels of approximately 50 GRT are used to catch skipjack, yellowfin and billfishes. These vessels operate from Pakistan to the coasts of Oman and Somalia and make trips of up to two months in duration.

The distinction between small and large-scale drift gillnet fishing was discussed at length. However, in view of the socio-economic importance of drift gillnet fishing and of the diversity (including sizes) of the gear used, it was considered that the definition of large drift gillnets being envisaged in other regions of the world (such as the South Pacific) might not be directly applicable in the Indian Ocean region. On the other hand, it was recognized that a large number of small drift gillnets may have the same impact on target and non-target species as the small number of large drift gillnets.

The Consultation recognized that its own mandate did not cover socio-economic aspects, however, bearing in mind the importance of artisanal drift gillnet fisheries as a source of food, employment and income, and it was recommended that any regulation of the gear should be preceded by a study of its socio-economic implication.

With regard to high seas drift gillnetting operations, it was noted that since the mid eighties a rather large distant water fleet started operating in the Indian Ocean. Concern was expressed about the possible impact of high seas pelagic drift gillnet fishing on the stocks of Southern bluefin tuna and albacore.

Taking into account the need to gather more information on the impacts of drift gillnets on tuna and tuna-like species, the Consultation recommended intiating or improving the collection of data on catches, their species and size composition, and fishing effort. With regard to by-catch, especially marine mammals, the Consultation encouraged the implementation of observer programmes, similar to those already being carried out in the Pacific Ocean. In general more research on the impact of drift gillnet fishing should be undertaken by all the countries concerned.

DN Table 1. Catch (tons) of tunas, seerfishes and billfishes by drift gillnet fisheries in the Indian Ocean, 1988

	YFT	BET	ALB	LOT	SBF	KAW	SKJ	FRZ	TUN	KGX	BLZ	MLS	SWO	BIL
BANGLADESH	0	0	0	0	0	0	0	0	16	0	0	0	0	0
CHINA (TAIWAN)	12	172	10669	0	5	0	241	0	0	0	2	26	7	14
INDIA	0	0	0	1200	0	13461	0	4456	1818	0	0	0	0	0
INDONESIA	22	0	0	0	0	0	1170	0	1788	0	0	0	0	0
IRAN	0	0	0	16907	0	2165	0	348	0	0	0	0	0	0
MALAYSIA	0	0	0	935	0	291	0	615	0	3762	0	0	0	0
PAKISTAN	0	0	0	3010	0	2937	1337	27	1123	10497	0	471	0	0
SRI LANKA	6300	0	0	0	0	1400	13398	635	5	2200	650	38	79	946
THAILAND	0	0	0	0	0	0	0	0	0	522	0	0	0	0
TOTAL	6334	172	10669	22052	5	20254	16146	6081	4750	16981	652	535	86	960

DN Table 2 Specifications of the Taiwanese large-scale pelagic drift gillnet deployed in the Indian Ocean tuna fishery

Items	Dimensions
Mesh sizes of net	20 - 22 cm
Vertical numbers of mesh of a single net	100 - 120
Vertical depth of a single net	20 - 24 m
Total numbers of net for a deployment	700 - 900
Length of rope between two buoyancy marks	20 m
Distance of a deployment	20 - 25 nm
or	37 - 47 km

DN Table 3. Number of boats, landings and catch estimates of Taiwanese large-scale pelagic drift gillnets in the Indian Ocean by fishing season.

Fishing season	No. of boats	Landings (MT)	Catch estimates *3 (MT)
1983 - 1984	1	24	-
1984 - 1985	36	3,941	-
1985 - 1986	74	13,777	-
1986 - 1987	123	18,281	17,395
1987 - 1988	130	18,486	11,627*1
1988 - 1989*2	139		19,523

*1 : in provisional data, estimates are going to be updated.
*2 : in provisional data, for reference only.
*3 : from logbooks.

DN Table 4. Species compositions of catch by Taiwanese large-scale pelagic drift gillnet fishery in the Indian Ocean from 1986-1987 and 1987-1988 fishing seasons (in %)

Fishing season	Item	Species Compositions								
		ALB	BET	YFT	SBF	SWO	MLS	SKJ	Sharks	OTH
1986 / 1987	number	72.61	1.49	0.30	0.31	0.22	0.65	0.59	23.76	0.07
	weight	59.93	1.91	0.53	0.81	0.79	5.27	0.55	29.57	0.65
1987 / 1988	number	95.12	0.58	0.12	0.04	0.46	0.06	0.33	0.52	2.77
	weight	91.76	1.48	0.10	0.05	1.80	0.32	0.12	2.07	2.30

Code		English Name
ALB	=	Albacore
BET	=	Bigeye tuna
YFT	=	Yellowfin tuna
SBF	=	Southern bluefin tuna
SWO	=	Swordfish
MLS	=	Striped marlin
SKJ	=	Skipjack tuna

8. REVIEW OF STATUS OF IPTP DATABASE

Mr Sakurai briefly reviewed the species and area covered by IPTP and outlined the present status and problem areas for the six types of data required for the IPTP database:

In the discussion, it was proposed that the 16 species listed in a document presented at the Conference for the Adoption of a Draft Agreement for the Establishment of the Indian Ocean Tuna Commission be retained as <u>Auxis</u> species are oceanic tunas and for the scientific reason that the neritic tunas should be monitored on a global basis. It was further proposed that the FAO fishing area boundary off South Africa be retained as changing this boundary would cause greater problems in other species. However, it was suggested that IPTP should collect statistics for the area between 20^{o} and 30^{o}E not covered by IPTP and ICCAT.

The present status and problem areas for the six types of data are:

(1) Annual catch statistics by species and area

IPTP collects annually these statistics from 36 countries and compiles them in IPTP Data Summary.

IPTP has not received the catch statistics for foreign flag vessels based in Indonesia and Reunion (France) that were operating in the Indian Ocean. However, it is expected that these countries will provide the catch statistics in the future as effort has already been taken to collect these data.

(2) Annual craft statistics by gears and types of boats

IPTP has collected these statistics from 23 countries and compiled in IPTP Data Summary.

In many cases, countries report the numbers of registered instead of operating vessels.

(3) Catch and effort statistics by time and area strata for industrial fisheries

The present status of the statistics collected by IPTP is shown in Table 1. The participants noticed that the IPTP statistics database had been improved in the past two years.

Countries that have not provided these statistics for industrial fisheries include India, Indonesia and USSR.

(4) Catch and effort statistics for artisanal fisheries

Table 2 shows the status of the statistics in the IPTP database. Regarding the problems of sampling programmes for artisanal fisheries, it was suggested that collection of effort statistics be de-emphasized in favour of better species and size composition data. However, several other interventions supported the continued collection of effort statistics which may be useful as supportive evidence.

(5) Size frequency data by time and area strata for industrial fisheries

The present status of the data in the IPTP database are listed in Table 3.

Five countries with industrial fisheries in the Indian Ocean are providing the required data. However, this information is submitted in different formats which greatly hampers comparative analysis.

(6) Size frequency data for artisanal fisheries

Table 4 gives the information available in the IPTP database.

Recommendations.

The following recommendations were retained from the previous Expert Consultation.

- to improve reporting on separate species in catch statistics;

- to cross check catch statistics with landings for industrial longline fisheries to improve its accuracy;

- introduce log book system for the industrial purse seine and longline fisheries of Indonesia, Philippines and India;

- IPTP continue to assist coastal countries to maintain and improve sampling programmes;

- to establish a sampling programme in Mauritius and Indonesia to monitor the longline fisheries based in these countries;

- to compile catch, effort and size composition information into a standard format in the IPTP database.

- IPTP should, as in the case of ICCAT, in lieu of official flag figures, report statistics corrected for inconsistencies between reporting countries its in data summaries.

Additional recommendations were:

- IPTP complete a comprehensive comparison of national statistics and sampling programme information by country and present a report of its findings at the next Expert Consultation.

- IPTP evaluate national and sampling programme statistics and retain the information deemed more reliable in its database.

Table 1 Catch/effort statistics by time and area strata for industrial fisheries

Country	Type of gear in Operation (No. of boats in operation for 1988)	Status of IPTP database
China (Taiwan)	LL (187)	1969 - 1988
	GILL (139)	1986 - 1988
France	PS (20)	1982 - 1989
India	LL (?)	NA
Indonesia	LL (56)	NA
Japan	LL (220)	1952 - 1988
	PS (3)	NA
Korea	LL (112)	1968 - 1987
Mauritius	LL (3)	NA
	PS (2)	NA
Panama	PS (1)	NA
Spain	PS (19)	1984 - 1989
USSR	LL (2)	NA
	PS (5)	NA

Table 2 Status of IPTP database of catch and effort statistics for artisanal fisheries

A) Raised data

Country	Year	Gear	Catch	Effort	Time	Area
1) Maldives	1970 / 1988	BB TROL HAND	NO.FISH	NO.DAYS	MONTH	ATOLL

Note: National statistics collected in complete enumeration method

Country	Year	Gear	Catch	Effort	Time	Area
2) Thailand	1972 / 1986	GILL PS	MT	NO.DAYS	MONTH	LOCAL SUB-AREA

Note: National statistics collected in sampling method

B) Unraised data

Country	Year	Gear	Catch	Effort	Time	Area
1) Philippines	1979 / 1989	HAN RIN TROL	KG KG KG	NO.DAYS (NO. L.D.)	MONTH	SITE
2) Indonesia	1979 / 1989	BB GILL PS SEN TROL	NO.FISH KG KG KG KG	NO.DAYS (NO.TRIP)	MONTH	SITE

B) Unraised data (cont'd)

Country	Year	Gear	Catch	Effort	Time	Area
3) Sri Lanka	1985 / 1989	GILL	KG	NO.DAYS	MONTH	SITE
4) Pakistan	1987 / 1989	GILL	KG	NO.DAYS	MONTH	SITE
5) Thailand	1987 / 1989	GILL PS	KG KG	NO.DAYS	MONTH	SITE
6) Malaysia	1987 / 1989	TROL PS	KG KG	NO.DAYS	MONTH	SITE

Table 3. Status of IPTP database of size information for industrial fisheries

Country	Year	Gear	Species	Monthly/ Quarterly	Area	Raised Unraised
China (Taiwan)	1985	LL	ALB, YFT, BET, BFT, SKJ, SWO, MLS, BLZ, BLM, SAF	M	$5^{o}x5^{o}$	U
	1986	LL	- do -	M	$5^{o}x5^{o}$	U
	1987	LL	- do -	M	$5^{o}x5^{o}$	U
	1988	LL	- do -	M	$5^{o}x5^{o}$	U
Japan	1982 / 1988	LL	YFT	Q	$10^{o}x20^{o}$	U
France	1984	PS	SKJ	Q	$5^{o}x5^{o}$	R
			YFT			R
	1985	PS	SKJ	Q	$5^{o}x5^{o}$	R
			YFT			R
			BET			U
	1986	PS	SKJ	Q	$5^{o}x5^{o}$	R
			YFT			R
			BET			U
Spain	1984 / 1989	PS	SKJ YFT BET	M	NA	R
Korea	1983 / 1985	LL	YFT BET	Y	IPTP sub-area	U

Table 4 Status of IPTP database of size frequency data for artisanal fishery

Country	Year	Gear	Catch	Effort	Area
1) Maldives	1983 / 1989	BB TROL HAND	SKJ YFT FRI KAW	MONTH	SITE
2) Philippines	1970 / 1989	HAND RIN TROL	BET YFT FRI KAW SKJ BLT	MONTH	SITE
3) Indonesia	1981 / 1989	TROL BB GILL PS	SKJ YFT KAW FRI	MONTH	SITE
4) Sri Lanka	1982 / 1989	GILL	SKJ YFT	MONTH	SITE
5) Malaysia	1987 / 1989	TROL PS	LOT KAW FRI	MONTH	SITE
6) Thailand	1987 / 1989	GILL PS	LOT KAW FRI	MONTH	SITE

All above data are unraised.

9. REVIEW OF PROGRESS IN RESEARCH

(1) Overview

This fourth Expert Consultatioin on the Stock Assessment of Tuna in the Indian Ocean reviewed a significant number of contributed documents, a substantial increase from previous meetings. This increase in number of documents is a sign that interest in research on tuna resources of the Indian Ocean is growing as tuna fisheries expand and potential fisheries conflicts multiply. The participants, however, noted that there was a paucity of documents involving analytical studies for stock assessment, despite a significant increase in data collected by IPTP and national laboratories, and an increase in basic biological studies by national scientists. The partricipants discussed the reasons for this paucity of analytical studies including: (1) the pool of trained scientists capable of performing analytical studies has not grown to keep up with the increased work load; (2) new information on the fisheries and environment has shown that the traditional, simple assessment approaches need to be applied with caution or new approaches need to be developed, and (3) with the increased volume of fishery statistics being collected, processing of the data for analytical studies is more involved and time consuming.

The participants agreed that new approaches need to be considered if the Consultation is to make progress in handling the increased data and in making maximum use of the data in analytical studies on the status of the stocks of the Indian Ocean. Several approaches were discussed including establishing research priorities with respect to either research subject or species stock; changing the working arrangements of the Consultation, such as organizing workshops during intersessional periods for analytical studies as well as for planning research initiatives; and specifying a common format for countries to report all fishery statistics to IPTP and for IPTP to follow in assembling data on an ocean-wide basis for use in quantitative analyses.

The participants noted that considerable fisheries statistics are now in hand particularly for bigeye, yellowfin and albacore and they should be analyzed as soon as possible for information on the current condition of the stock. The Consultation recommended that a workshop to examine all data on yellowfin tuna for assessment purposes be convened by IPTP in the second half of 1991. Furthermore, for the preparation of this workshop, the IPTP Secretariat would request that all nations fishing for yellowfin tuna submit their up-to-date statistics, that a database of the statistics be prepared before the workshop and the workshop be held in Colombo in order that the IPTP computer be utilized by the participants. It was emphasized that full cooperation of experts from national governments and institutions was essential for a proper assessment of these stocks.

(2) Stock structure

There is little that is known about the stock structures of most Indian Ocean tunas. For convenience, a single stock hypothesis is routinely assumed for many of the large tunas. This assumption can have a major effect on the interpretation of stock assessment information and on management advise; consequently, stock structure is an important research topic that requires emphazising. The participants felt that the best way to answer the stock structure question at this time is with a well-designed tagging programme. They also noted that recent results by the I-ATTC with morphometric analysis are encouraging and that the method should be considered for Indian Ocean tunas.

(3) Movement/migration

Movement and migration information is becoming more important in quantitative analysis because of questions concerning fisheries interactions. However, there has not been the necessary level of research support for obtaining migration information.

For example, the IPTP has an on-going tagging programme in the Maldives for movement information. The Indian Ocean Commission executed a tagging programme in the Southwest Indian Ocean in 1988-1989 funded by the EEC which was unsuccessful due to the unsuitable fishing vessel used for this programme.

The participants felt that adequately funded and well-executed tagging programmes are the best way to study movement and migration of tunas. The recommended programmes for the Indian Ocean are of three types, depending on the fisheries and species to be studied: (1) tagging in small areas to study movements primarily of small tunas and other species involved in artisanal fisheries; (2) tagging on a large, ocean-wide scale of yellowfin, skipjack and bigeye tuna for studying fisheries interactions; and (3) tagging with dart tags and acoustic tags of tunas around floating objects to study short-distant movements and behaviour of tunas relative to the environment. The participants recommended that IPTP develop a plan for a type (2) study for possible funding by the European Community, by fishermen who would benefit from the results and from other funding sources.

(4) Biology

There has been some progress in determining the age and growth and other biological parameters for tunas since the last meeting, but estimates of biological parameters are still largely unavailable for most Indian Ocean tuna species. The participants recommended that research be expanded particularly for biological studies that will provide information for assessment techniques such as cohort analysis. The group also noted that tagging can be used to study growth as well as other research questions.

10. ADOPTION OF THE REPORT

The report of the Expert Consultation on Stock Assessment of Tuna in the Indian Ocean, was adopted on 6 July 1990.

Appendix 1

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Appendix 2

AGENDA AND TIME TABLE

Agenda Item	MONDAY, 2 JULY 1990 Morning, 09:00 hours
1	Opening of meeting
2	Adoption of the agenda and arrangements for the meeting
3	Review of national fisheries and research programme
	Afternoon, 14:00 hours
3	Review of national fisheries and research programme (continued)
	TUESDAY, 3 JULY 1990 Morning, 09:00 hours
4	Report of the Indo-Pacific Tuna Development and Management Programme (IPTP)
5	Review of scientific papers on biological study and stock status
	5.1 Yellowfin and skipjack tunas
	Afternoon, 14:00 hours
	5.1 Yellowfin and skipjack tunas (continued)
	WEDNESDAY, 4 JULY, 1990 Morning, 09:00 hours
5	Review of scientific papers on biological and stock status (continued)
	5.2 Bigeye, albacore and southern bluefin tunas

Agenda Item	WEDNESDAY, 4 JULY, 1990 Afternoon, 14:00 hours
5	Review of scientific papers on biological and stock status (continued)
	5.3 Small tunas, seerfish and billfish
	THURSDAY, 5 JULY 1990 Morning, 09:00 hours
6.	Interaction and tagging experiments
7.	Drift gillnet fishery
8.	Review of status of IPTP database
9.	Any other matters
	FRIDAY, 6 JULY, 1990 Morning - F R E E
	Afternoon, 14:00 hours
10.	Adoption of the report

LIST OF DOCUMENTS

TWS/90/1	Provisional annotated agenda and timetable.
TWS/90/2	Provisional list of documents.
TWS/90/3	Provisional list of participants.
TWS/90/4	IPTP Data Summary No. 10 - Indian Ocean and Southeast Asian Tuna Fisheries Data Summary for 1988 (IPTP).
TWS/90/5	Report of the activities of the Indo-Pacific Tuna Development and Management Programme (IPTP).
TWS/90/6	Status of the IPTP database and its problems involved (T. Sakurai).
TWS/90/7	Report of the Expert Consultation on Stock Assessment of Tunas in the Indian Ocean, held in Mauritius, 22-27 June, 1988 (IPTP).
TWS/90/8	Age and growth of kawakawa (*Euthynnus affinis*) based on modal length (M. Yesaki).
TWS/90/9	Yields per unit area of small tunas, seerfishes and billfishes in the Indian Ocean (M. Yesaki).
TWS/90/10	Preliminary results of a tuna tagging programme in the Maldives (S. Rochepeau)
TWS/90/11	Analysis of the Maldivian tuna fisheries data 1970 to 1988 (S. Rochepeau and A. Hafiz).
TWS/90/12*	The Maldivian tuna fishery - an update (A. Hafiz).
TWS/90/13**	Strategies for the development of tuna fisheries in the Maldives.
TWS/90/14	Tuna fisheries in Sri Lanka - an update (P. Dayaratne and J. de Silva)
TWS/90/15	Recent trends in fisheries for small tunas in Sri Lanka (P. Dayaratne and J. de Silva)
TWS/90/16	Age and growth estimates of juvenile kawakawa (*Euthynnus affinis*) by using daily growth increments in otolith (P. Dayaratne)
TWS/90/17	Observations on the recently developed offshore fisheries for skipjack and yellowfin tunas in Sri Lanka. (J. de Silva and P. Dayaratne)

TWS/90/18 The study of the handline fishery on the west coast of Sri Lanka with special reference to the use of dolphin for locating yellowfin tuna (Thunnus albacares) (de silva and B. Boniface).

TWS/90/19 Drift gillnet fishery in Sri Lanka (P. Dayaratne).

TWS/90/20 Review of tuna fisheries in India (P.S.B.R.James).

TWS/90/21 Tuna fisheries in Lakshadweep islands (P.P. Pillai).

TWS/90/22 Live baitfish resources in Lakshadweep (P.P.Pillai).

TWS/90/23 Tuna longline fisheries in India (D. Sudarsan, M.E. John, A.K. Bhargava and SM.M. Patil).

TWS/90/24 Review of the status of tuna stocks in Malaysia (R. Hassan).

TWS/90/25 Preliminary study on the fecundity of skipjack tuna from the waters adjacent to Pelabuhan Ratu (J. Uktolseja and R. Purwasasmita).

TWS/90/26 Morphometric and body weight comparisons of yellowfin tuna (J. Uktolseja).

TWS/90/27 Activities of the SPC tuna and billfish assessment programme (SPC).

TWS/90/28 Present situation in the Soviet tuna fishing in the Indian Ocean, the systems of the fishing statistics collection and of the tuna investigations (YugNIRO)

TWS/90/29 Activities of tuna in the western Pacific, 1965 - 1988, and the status of skipjack and yellowfin stocks (SPC)

TWS/90/30 Some observation on the size composition and gonad development of longtail tuna (thunnus tonggol) in Iranian waters (A. Nikouyan and A. Firozy).

TWS/90/31 The tuna fishery of the west coast of Peninsular Malaysia (E. Chee).

TWS/90/32 Present status of small tuna fisheries and resources on the west coast of Thailand Andaman Sea (V. Boonragsa).

TWS/90/33** Exploratory tuna fishing (D. Pooreyanond).

TWS/90/34** Stock identification of longtail tuna through gill rackers counts (Pakistan).

TWS/90/35* Production trends in tuna fishery of Pakistan.

TWS/90/36** Drift gillnet fishery in Pakistan.

TWS/90/37 Status of tuna and seerfishes fisheries in Iran (A. Nikouyan).

TWS/90/38** Tuna fisheries in Oman (A. Barwani)

TWS/90/39**	Case study of tuna fisheries in Egypt (Azer).
TWS/90/40	The status of tuna in Somalia (O. Dubad).
TWS/90/41**	Review of national fisheries in Somalia (Y. A. Nur)
TWS/90/42	The status of artisanal tuna fishery in Kenya (R.M.Nzioka)
TWS/90/43	Population characteristics of kingfish (Scombormorus commerson) in inshore waters of Kenya (R.M. Nzioka)
TWS/90/44**	Industrial tuna fishery in Madagascar (Andriamiarantsoa)
TWS/90/45	Tuna fishing trends in the western Indian Ocean (G. Lablache)
TWS/90/46	The Seychelles Observer Programme (1986 - 1989) (X. De Montaudouin and Lablache).
TWS/90/47	Tuna Research activities of the Seychelles Fishing Authority (G. Lablache)
TWS/90/48	Length-weight relationships for yellow (Thunnus albacares) and skipjack (Katsuwonus pelamis) from the western Indian Ocean (X. de Montaudouin, J.P. Hallier and S. Hassan)
TWS/90/49	Purse seine set durations and their effects on the searching effort of western India Ocean purse seine fishery (X. de Montaudouin and J. P. Hallier)
TWS/90/50	The recent drop in the yellowfin catches by the western Indian Ocean purse seine fishery : overfishing or oceanographic changes ? (F. Marsac and J.P Hallier)
TWS/90/51	Statistics of Spanish tropical tuna fleet in the Indian Ocean, 1984 - 1989 (P. Pallares)
TWS/90/52	Status report of the the Korean tuna longline fishery in the Indian Ocean (Y. C. Park)
TWS/90/53	Age and growth of Indian Ocean albacore, Thunnus alalunga by scales (Chao-Shen Huang, Chi-Lun Wu, Chin-Lau Kuo and Wei-Cheng Su)
TWS/90/54	Taiwanese longline and gillnet fisheries in the Indian Ocean (Chien-Chung Hsu and Hsi-Chiang Liu).
TWS/90/55	A briefly updated assessment of the Indian Ocean albacore stock by production model (Chien-Chung Hsu and Hsi-Chiang Liu)
TWS/90/56	Yield per recruit analysis of the Indian Ocean albacore stock (Ying-Chou Lee, Chien-Chung Hsu, Shui-Kai Chang and Hsi-Chiang Liu)
TWS/90/57	Standardized catch per unit effort of albacore in the Indian Ocean caught by longline fisheries (Chien-Chung Hsu and Hsi-Chiang Liu)

TWS/90/58 Status report of Japanese tuna fisheries in the Indian Ocean (Z. Suzuki)

TWS/90/59 Stock analysis of bigeye and yellowfin tunas based on longline fishery data (Y. Miyabe and Z. Suzuki)

TWS/90/60 Catches and landings of tuna in Mauritius from 1987 to 1989 and description of the 1989 Mauritian purse seine fishery (description and size composition of the catches) (P. Cayre, D. Norungee and C. Begue)

TWS/90/61 Results of the tagging operations conducted within the regional tuna project (Indian Ocean Commission) in 1988 and 1989) (P. Cayre and B. Ramcharrun)

TWS/90/62** Japanese tuna drift gillnet fishery in Pacific Ocean (Y. Watanabe).

TWS/90/63 Report of the eight meeting of Australian, Japan and New Zealand scientists on southern bluefin tuna held in Shimizu, Japan, 4-10 September 1989

TWS/90/64 Report of the Expert Consultation on Large-Scale Pelagic Driftnet Fishing held in Rome, 2-6 April 1990

TWS/90/65 Report of the Expert Consultation on Interaction of Pacific Ocean Tuna Fisheries Preliminary meeting, held in Noumea, New Caledonia, 30 October - 3 November 1989

TWS/90/66 Tuna fishing on log associated schools in the Western Indian Ocean : an aggregation behaviour (J. P. Hallier)

TWS/90/67 Possible interactions between the purse and baitboat skipjack fisheries in the Indian Ocean (A. Fonteneau and J.P. Hallier)

TWS/90/68 Sexual maturity spawning and fecundity of the yellowfin tuna of the western Indian Ocean (S. Hassani and B. Stequert)

TWS/90/69 Country statement - Australia

TWS/90/70 Status of the tuna fisheries in Mauritius (A. Venkatasamy)

TWS/90/71 Statistics of Spanish tropical tuna fleet in the Indian Ocean 1984 - 1989 (P. Pallares)

TWS/90/72 Incidence of juvenile bigeye tuna (Thunnus obesus) among the tuna catches in south-west coast of Sri Lanka (R. Maldeniya, P. Dayaratne and B. Boniface)

TWS/90/73 The Spanish fisheries method for the study and analysis of the tropical tunas in the Indian Ocean (P. Aranda).

* Was not presented at the Expert Consultation but was received by the Secretariat after the conclusion of the Consultation.

** Not issued

Appendix 4

COUNTRY STATUS REPORTS

1. Australia
2. France
3. India
4. Indonesia
5. Iran
6. Japan
7. Kenya
8. Korea
9. Malaysia
10. Maldives
11. Mauritius
12. Oman
13. Pakistan
14. Seychelles
15. Spain
16. Sri Lanka
17. Taiwan (Province of China)
18. Thailand

Note: These country status reports were prepared by participants representing each country except for Oman and Pakistan which were prepared by the Secretariat.

1. AUSTRALIA

(1) Fisheries

The southern bluefin tuna is currently the fishery of greatest economic importance to Australia in the region. The majority of the Australian catch of southern bluefin tuna is taken by the surface fishery (mainly pole and live bait in conjunction with purse seine, but also pole and dead bait). Relatively small catches are also taken by longline.

The geographic extent of the surface fishery has diminished in recent years. Scientific evidence of a significant depletion of the parental biomass resulted in limits being placed on catch levels of southern bluefin tuna. Catch quotas have been reduced from 21,000 t in 1983/84 to 5265 t in 1989/90; catches have fallen from almost 16,000 t in 1983/84 to about 6000 t in 1988/89.

Other tuna fisheries and billfish and seerfish fisheries tend to be concentrated on the eastern seaboard, the area of highest population. However, commercial trolling fisheries for mackerels, such as grey mackerel and broad barred Spanish mackerel, are developing off western Australia and northern Australia. Waters off western Australia hold potential for development of a domestic longline fishery for bigeye and yellowfin tuna. Nevertheless, at the time of writing, few commercial tuna fishing activities for species other than southern bluefin tuna, had been reported from the area. A small recreational fishery for marlins, such as blue marlin, has been established off western Australia.

(2) Statistics

All fishing vessels operating in the southern bluefin tuna fishery have been required to complete daily logbooks since the late seventies when a logbook programme was re-established. Logbook information is verified against landing data. The southern bluefin tuna catch is routinely sampled as part of a size-monitoring program.

Monthly catch returns are routinely provided by commercial fishermen landing mackerel. Catch and effort data are not at present collected from recreational fishermen.

(3) Research

Southern bluefin tuna research programs currently underway include a project investigating aerial surveys as a means of obtaining alternative indexes of abundance and assessing escapement from the surface fishery, and a study of the micro-chemical composition of otoliths as an indicator of a fish's environment. Stock assessments, based on the extensive data base of catch and effort data, size/age composition data and other biological information, are regularly conducted.

2. FRANCE

(1) Overview of the fishery

France is one of the fishing nations using industrial purse seiners in the Indian Ocean. The whole fleet is based in Seychelles and operates in a wide area covering the western basin of the Ocean.

The catches are trans-shipped on board reefers in Seychelles (port of Victoria) for 10 months of the year, and in Antsiranana (Madagascar) in April and May. During these two months the vessels are fishing in the Mozambique Channel. The fleet is composed of 20 purse seiners with carrying capacity ranging from 500 to 900 tons. The number of active vessels decreased from 1984 (27 vessels) to 1987 (20 vessels) and has remained stable until now. The area covered by the fleet has not varied significantly over the years. Maximum extension in latitude is from 23°S to 9°N, and 4°E to 75°E in longtitude.

(2) Statistics

The figures for the years 1988 and 1989 are summarized in tables 1 and 2. The catches decreased from 102,371 t in 1988 to 85,067 t in 1989 (17 percent decrease). A similar trend was observed for the fishing effort but the decrease (3 percent) did not show the same magnitude as the catch. The average number of fishing days per vessel was 283 days in 1988 and 272 days in 1987.

In 1988, yellowfin tuna was the predominant species (53 percent of the total catch) and the catch of this species (54,149 t) was the highest ever recorded in the fishery. The proportion of yellowfin in 1989 (45 percent) was similar to the one obtained in 1987. With respect to skipjack, no great difference in the catches was observed between 1988 and 1989. Bigeye remain a marginal species (3 to 4 percent of the catch) and albacore catches are not significant.

The CPUE by species highlight the high catchability for yellowfin in 1988. The CPUE for skipjack has remained stable.

TABLE 1 Catches by species and fishing effort

	Catches (metric tons)					Effort	
Year	YFT	SKJ	BET	ALB	TOTAL	DS	FD
1988	541149	45169	2852	201	102371	5653	5225
1989	38411	43082	3568	6	85067	5442	5060

DS: days at sea
FD: fishing days

TABLE 2 Catch per unit effort by species

	YFT	SKJ	BET	ALB
1988	10.4	8.6	0.5	-
1989	7.6	8.5	0.7	-

(3) Research

The French research is conducted by ORSTOM which is based in Seychelles, Mauritius and more recently, in Reunion Island.

In Seychelles, ORSTOM has been working since 1980 under a cooperation agreement between France and Seychelles. ORSTOM research is integrated within the activities of the Seychelles Fishing Authority. It consists of collection, sampling, management and processing of French purse seine data, also in biological studies (reproduction, growth) by ad hoc sampling carried out on board vessels and at the cannery. The staff is composed of two scientists, one computer engineer and one technical officer.

ORSTOM has a bilateral agreement with the Mauritius Government. Research activities are carried out under the Regional Tuna Project of the Indian Ocean Commission (Association Thoniere). They cover biological studies (physiology of reproduction), migration and behavioural analysis on large and small scale, by classical tagging operations (in 1988 and 1989) and sonic tagging operations around Comoros Islands. The staff is composed of two scientists.

In Reunion, ORSTOM also operates under the Regional Tuna Project. Research is focused on the environment of tuna fisheries, on both biological and physical sides. Tropic relationships between tuna and forages are studied as well as the effect of ocean climatological variability upon tuna abundance and catchability. For this latter purpose, a NOAA satellite tracking station was installed in Reunion in 1989 and images are now analyzed in real time. In situ surface (SST, wind) and subsurface data (thermal profiles) are gathered through meteorological network (GTS) for assimilation with statellite data, and allow a continuous survey of the hydrological conditions in the western Indian Ocean. The staff is composed of three scientists, one computer engineer and one technical officer.

3. INDIA

The recent status of tuna fisheries in India is dealt with in Documents TWS/90/20, 21, 22 and 23.

(1) Fishery

Major tuna fishery sectors in India are the small-scale sector (mechanized and non-mechanized), on the mainland, the small-scale sector in Lakshadweep and the industrial sector where a few Indian-owned longliners and chartered longline fleets are employed. Fishing gears of the small-scale sectors in which tunas are caught include the dirft gillnets (M + NM), purse seines (M), hooks and lines (M + NM), ring nets (M), pole and lines (M), and troll lines (M + NM). Organized tuna fishery is in vogue in Lakshadweep (pole and line and troll line fisheries). Mechanization of the small-scale units and introduction of new gears such as multi-meshed ring nets are the recent developments.

(2) Statistics

The all-India tuna catch reached 35,600 t in 1986, and after a decline in 1987 (31,060 t), the total production of tunas was estimated to be 31,170 t in 1988. The average annual contribution to the tuna fishery by the west coast of Indian was 66 percent of total tunas.

Lakshadweep contributed 19 percent and the east coast of India 15 percent. Average species composition of tunas landed during the 1986-88 period indicate that kawakawa contributed 49 percent, followed by frigate tuna (19 percent), skipjack and young yellowfin tunas (16 percent), billfishes (4 percent) and other tunas including longtail tunas (11 percent).

In Lakshadweep, 134 pole-and-line boats and 98 troll line boats are engaged in the tuna fishery which produced about 6,810 t of tunas in 1989 with an average CPUE of 260 kg. Skipjack constituted about 85 percent and young yellowfin tuna 12 percent of the total catch.

Chartered longliners operating in the Indian EEZ produced about 4,200 t of tunas and billfishes during 1989-90. Yellowfin constituted about 71 percent of the total catch. Average CPUE has been estimated as 1.07 no/100 hooks. In addition Indian-owned longliners landed an estimated 500 to 600 t.

Trend in catch rate (CPUE) observed at different centres monitored in the small-scale tuna fishery indicate that in the drift gillnet fishery it varied from 15.5 to 103.8 kg., in purse seine fishery 6.6 to 125.1 kg. in hooks and line fishery 5.3 to 30.4 kg., in pole and line fishery 297.5 to 411.0 kg., and in troll and line fishery 26.3 to 36.3 kg.

(3) <u>Research and future prospects</u>

Current research on tuna fisheries include gear-oriented investigations in the small-scale sector, investigations on tuna-environment relationship, stock assessment of tunas, studies on production potential of tunas and live-baits in the insular regions, and investigations employment artificial reef structures. In the industrial tuna fisheries length frequency data and basic biological information on food and feeding and maturity studies are underway.

The Government of India is taking several steps to tap fully the tuna resources. Besides the charter scheme, acquisition of purse seiners and longliners through import/indegenous constructions and joint ventures are being encouraged for achieving substantial expansion in the near future.

4. INDONESIA

The total tuna landings in Indonesia ranged from 206,757 t to 265,739 t between 1983 to 1987 with an average of 231,755 t or an annual growth rate of 6.5 percent. About 16 percent (41,942 t) of the total tuna landing comes from the east Indonesian waters, the Indian Ocean side. The production of tuna in 1987 accounted for 13.2 percent of the country's total marine fish landing or 9.9 percent of the total fisheries productions.

The total export of fish amounted to some 88,364 t valued at US$ 257 million in 1983, reached US$ 832.72 million in 1989. Tuna exports increased from 22,530 t (22.5 percent of fishery export) worth US$ 19.25 million to 56,677 mt (24.5 percent of fishery product) worth US$ 102.66 million in 1989. Compared to the year 1988, the export of tuna increased 15.06 percent by volume and 39.46 percent by value, respectively. The number of tuna canning companies was 20 in 1989, compared to 10 in the 1970's. The productions of these canneries reached 20,593 t worth US$ 39,332 million in 1989 from 8,504 t valued US$ 20,706 million in 1988.

In the Indian Ocean side, the main gears used for catching small tunas are purse seine in Banda Aceh (north coast of Sumatra) and Prigi (south coast of east Java, troll lines in Padang along the west coast of Sumatra and Benoa (Bali), gillnets in Prigi and Pelabuhan Ratu (south coast of west Java), and seine net in Pelabuhan Ratu.

In east Indonesian waters, pole and lining is the most important fishing method for catching skipjack and yellowfin tuna and handlining for large tunas (mostly yellowfin). The deep-sea FAD combined with fisheries nucleus scheme has been implemented in the pole and line and handline fisheries since 1983. These methods of fishing are well developed in the Province of Irian Jaya (Sorong), Molucca (Ambon, Ternate, Labuha), north Celebes (Bitung, Gorontalo), southeast Celebes (Kendari, Kolaka) south Celebes (Majene, Mamuju), and Maumere in Nastenggara).

The numbers of longliners (30-300GT) increased from 22 in 1985 to 167 in 1989 because of the high demand for fresh tuna (Sashimi) in Japan. Their fishing bases are in Jakarta and Benoa (Bali) and the main fishing grounds in the Indian Ocean are the waters adjacent to Engganao Island, Bali and Nusa Tenggara.

In 1988 there were about 1200 foreign vessesl (licensed) to operate in the Indonesian EEZ, but it decreased to about 542 in 1989, on the other hand, Indonesian vessels have increased from 621 to 903.

Skipjack tuna is the dominant species caught (95 percent) in east Indonesian waters, and 60 - 70 percent in the Indian Ocean in the surface fishing. The species composition of the longline catch over the period 1978 - 1988 was yellowfin (70.7 percent), bigeye 19.5 percent, albacore 9.6 percent and bluefin 0.2 percent.

5. IRAN (ISMALIC REPUBLIC OF)

(1) Tuna and seerfish fisheries.

Tuna fishery in the Islamic Republic of Iran is considered as the major activity of the artisanal sector. Species contributing to the catch, include: longtail, kawakawa and frigate tuna. The catch of yellowfin tuna and skipjack have also been reported from the Gulf of Oman which are landed mainly in Chabahar area. Seerfishes captured in the Islamic Republic of Iran consist of two commercially important species of Scomberomorus namely, S. commerson and S. guttatus. The total annual production of tuna in the Islamic Republic of Iran increased from 13,500 t in 1985 to nearly 19,500 t in 1988. Longtail tuna contributed more than 85 percent of the total tuna catch in the Islamic Republic of Iran. The remaining 12 and 3 percent of the production consist of kawakawa and frigate tuna respectively. The total catch of seerfishes in the Islamic Republic of Iran accounted for about 1,700 t in 1988. Among the seerfishes, S. commerson dominate the catch and consists about 60 percent of the total seerfish catch. S. guttatus is the second most common species contributing 40 percent of the catch. The available data indicate that the total catch of tuna and seerfishes from the Iranian waters increased from 14,700 t in 1985 to about 21,000 t in 1988. This represented about 15 to 16 percent of the total artisanal catches in Iran.

There are about 2,596 multipurpose artisanal boats which range from 5 to 100 GT engaged in tuna fishery. Gill nets used for the catch of tuna are 120 mm deep with mesh size between 140 to 160 mm. Gill nets with 130 and 110 mm mesh size are used for the catch of seerfishes. Tuna are captured throughout the year with variable peak season from place to place. The peak landing for longtail tuna is from May through September and for kawakawa is from November through February.

Although there are no accurate catch information for two species of yellowfin and skipjack, it seems that good quantity of both species can be obtained by introducing an alternative fishing method. In this regard, the National Fisheries Organization of the Islamic Republic of Iran (SHILAT), is now investigating the possibility of introducing purse seine for tuna fishing aiming at the larger species such as yellowfin in deeper area of the Gulf of Oman.

The reliability of the available national statistics on tuna species and total landing is not sufficient as the considerable quantity of the total catch are distributed to the private sector by the fishermen before the catch data can be recorded. To overcome this problem a proper data collection system is being prepared and will be initiated in the near future.

6. JAPAN

(1) Tuna fisheries in the Indian Ocean

There are two types of Japanese fishery in the Indian Ocean, i.e., longline and purse seining. The Japanese longline fishery has a long history, beginining in 1952 in the Eastern Equatorial Indian Ocean. This fishery has been a major component of the Japanese tuna fisheries in the Indian Ocean up to the present time. The purse seine fishery by Japanse boats in contrast, started very recently in 1989, with three boats in the Western Indian Ocean with the catch much smaller than that of the longline.

(2) Longline fishery

After commencing operations in 1952, the Japanese longline fishery expanded its fishing ground rapidly and covered almost the entire tropical areas in the early 1960s. Since that period, the longline boats shifted their operations significantly towards the temperate areas because of the change in economy, from securing export oriented canning materials such as yellowfin, albacore and bigeye tunas caught in the tropical waters to higher priced domestic sashimi materials such as southern bluefin and bigeye tunas in the higher latitudes.

For the five years from 1984 to 1988, the total catch by the Japanese longline fishery ranged from 47 to 33,000 t, major species caught were bigeye, southern bluefin and yellowfin tunas. The fishing effort in terms of number of fishing boats operating is on the decline. This is mainly due to a reduction in the fishing operations in tropical waters. The southern bluefin catch has been decreasing due to the overfishing by the participating countries to exploit this stock. In order to manage this stock better, three major fishing countries for southern bluefin tuna, i.e., Australia, Japan, and New Zealand regularly hold meetings and from 1985 national catch quota regulation have been implemented by the three countries. The quota has been lowered in recent years and the decline in southern bluefin catch reflects in part the intensified regulation.

In late 1989, three commercial purse seine boats (approximately 500 tons of carrying capacity) participated in the operations in the Western tropical Indian Ocean. They use the FAD mentioned previously and are experiencing fairly good catches.

7. KENYA

The marine fishery in Kenya is mainly artisanal, accounting for over 90 percent of the total annual catch of which, the large pelagic account for 17 percent. The large pelagic fish comprise of tuna, marlin, sailfish, wahoo, seerfish, barracuda and skipjack.

Prior to 1984 there was a commercial tuna fishing industry in cooperation with Korea but this has since collapsed. Artisanal fishermen have constantly been landing tunas, mainly yellowfin tuna, skipjack, kawakawa and frigate mackerel. The yellowfin is the most important in terms of catch.

In 1988, artisanal fishermen landed 22.3 t of yellowfin tuna, 3 t of skipjack and 6.6 t of kawakawa. It should be noted that although the skipjack is not landed in large quantities it is available all round the year in small schools along the entire Kenyan coast. Most of the yellowfin tuna landed are between 5 to 10 kg except in the Pamba Channel near the Tanzanian border where fish up to 20 kg are caught as close as 5 km offshore.

Research activities on biology of all pelagic fish species have been launched for the next five years. Target species are yellowfin, skipkack, seerfishes and caragids. Meanwhile, research will be concentrated on the artisanal fishery sector until such time as a new oceanographic and fishery research vessel has been acquired.

8. KOREA

(1) Fishing activities

The number of Korean longliners operating in the Indian Ocean showed a peak of 185 in 1975, then decreased to 62 in 1985. However, it was increased to 112 in 1988 from 66 in 1986. The total Korean longline catches of tuna and tuna-like fishes amounted to 34,469 t in 1988, a 11.5 percent increase compared to the 1987 catch (30,094 t). The catch composition by major species is as follows:

Bigeye 16,509 t (48 percent of the total catch)
Yellowfin 13,428 t (39 percent of the total catch)

(2) Research activities

Catch and effort data, and size frequency data for the Indian tuna and tuna-like species have been collected continuously from the Korean fishing vessels. The NFRDA has been in charge of collecting and processing the tuna fishery data.

An intensive effort was made to improve the coverage rate and accuracy of data for a better assessment of Indian tuna and tuna-like species resources. As a result, the catch coverage was 91 percent in 1987.

An Annual Bulletin of Korean Longline Catch and Effort Statistics and Fishing Grounds for 1986 to 1987, has been published. Size frequency data of bigeye and yellowfin tunas by IPTP sub-area for 1983 to 1985 were submitted to IPTP.

Korea presented the working document (TWS/90/52) to this meeting, which is to review fishing vessels, fluctuation of catch and catch-per-unit effort, fishing ground and length composition of bigeye and yellowfin tunas for the Korean tuna longline fishery.

9. MALAYSIA

The tuna fishery in Malaysia is developing from a traditional fishery to a more commercial scale fishery. The major gears that are being used for catching tuna are troll line, drift nets and the purse seine. Troll lines operating from Kuala Terengganu on the east coast of Peninsular Malaysia land the bulk of the tuna in Malaysia. Gillnets do not only target for tuna but catch seerfishes (mainly Spanish mackerels) as well while purse seines also catch tuna as a by-catch. Certain purse seines do target for tuna.

Overall increase in the landings of tuna has been observed since 1970. The total tuna landings increased from 6,000 tons in 1970 to reach a peak of 29,000 tons in 1987. However, small fluctuations in landings were observed between 1970 and 1987. From 1988 a decline in landings has been observed.

59 percent of the total tuna landings in Malaysia were landed on the east coast of Peninsular Malaysia, followed by 19 percent each, recorded from the west coast of Peninsular Malaysia and Sabah in 1988. Sarawak accounted for 3 percent of the total tuna landings in 1988.

The major tuna species caught off the east coast of Peninsular Malaysia is the longtail (Thunnus tonggol), with a lower percentage of kawakawa (Euthynnus affinis) and the frigate tuna (Auxis thazard). On the west coast of Peninsular Malaysia, Kawakawa and frigate tuna are the main species caught. With the expansion of tuna fishing into the more oceanic water off the states of Sarawak and Sabah, it is expected that more skipjack and yellowfin tuna will be landed.

A tuna sampling programme was started in 1987 in collaboration with IPTP. Sampling is presently still being done at Kuala Terengganu and Chendering, Terengganu. Besides collecting information on catch and effort, size frequencies of tuna by species are being monitored. In 1990 a programme for tagging Thunnus tonggol and Euthynnus affinis was started with aid from IPTP. As of June 1990, a total of 1,462 fish had been tagged and released. Also the use of payaos in tuna fishing is still going on.

10. MALDIVES

The Maldives landings have increased sharply in recent years; 71,500 t have been landed in 1988 and 1989, of which 59,500 t are skipjack followed by 6,000 MT of yellowfin, frigate and kawakawa accounted for 3,000 MT each.

The number of active fishermen was around 22,000 in 1988, down from the early eighties but we observe a fresh resurgence in fishing activities due to government policy as well as better earnings.

The number of fishing vessels operating also declined to 1,100 in 1988. The mechanization of pole-and-line boats which started in 1974 is now completed. Motorization of traditional vadhu dhonis has more recently commenced, although the number is still declining (500 in 1988).

The effort in terms of fishery days is stabilized at 240,000 days a year. Catches have doubled since 1978 from 200 kg/day to 400/kg/day. They have even tripled for skipjack from 100 to 300 kg/day. Catch rates of yellowfin have dropped to 30 kg/day.

Data collection is under the responsibility of the Ministry of Fisheries and, research activities are undertaken by the Marine Research Station.

Included in these activities are several separate IPTP programmes. Tagging experiments started in January 1990 and should be carried on throughout the year. Sampling activities were also initiated at four locations in order to collect length frequencies and give support to serve research activities. The ratio between bigeye tuna and yellowfin tuna in yellowfin tuna catches is also being investigated.

11. MAURITIUS

Mauritius has served as a base for tuna trans-shipment since 1965. During 1988 and 1989, 7179 t and 8040 t of tuna were unloaded in Port Louis Harbour for trans-shipment by Taiwanese, Japanese and Mauritian longliners. Catches of longliners are dominated by albacore which comprise more than 80 percent of the fish.

A purse-seine fishery has developed since 1979 with the launching of one vessel in that year and in 1987 with a second vessel. Total catch in 1989 was 8,341 t comprising of skipjack, yellowfin and bigeye tunas.

An artisanal fishery for pelagic fishes is actively developing with the deployment of fifteen fish aggregating devices around the island. Total catch (including trolling for billfishes by recreational fishermen) is estimated to be around 650 t per year.

Statistics for tuna trans-shipment are collected from agents of longliners calling at the harbour whilst a regular sampling system for the purse seiners has been established since 1989. Statistics on the artisanal fishery are collected as part of a general fishery data collection system and also independent estimates made by interviewing fishermen and fishmongers directly on an ad-hoc basis.

Research on tuna is mainly carried out under the Regional Tuna Project (members being Madagascar, Comoros and Reunion with Seychelles as observer) since its commencement in 1987. In this project Mauritius has been allocated the responsibility for studies with a view for stock assessment purposes. Activities include collection of biological information, tagging and collection and processing of tuna statistics for the region. Assistance for research is being provided by two tuna scientists from ORSTOM, and one computer specialist under French Voluntary Assistance Programme.

12. OMAN(*)

The 1988 landings of tunas, seerfishes and billfishes totalled 65,000 t, a 25 percent increase over the previous year. The largest increase was in yellowfin, which jumped from 5,800 t to 15,500 t. Narrow-barred Spanish mackerel landings totalled 28,000 t, the highest ever.

Most of the fishing vessels in Oman are FRP hulls of 8 to 10 m length, powered with outboard motors. The principal fishing gears are gillnets and hooks and lines.

A fishing statistics collection system was initiated in 1984 and since 1987 has reported landings by species, but not by gears. The Marine Science and Fisheries Center started a research programme for large pelagic species in late 1987. Length measurements are taken during the first 10 days of each month at Muttrah fish market of narrow-barred Spanish mackerel, longtail, kawakawa and oriental bonito.

13. PAKISTAN(*)

Tuna, seerfish and billfish landings were 32,000 t in 1988, a 36 percent increase since the previous year. Tuna accounted for 63 percent, seerfish for 33 percent and billfish for 4 percent of this total. The principal tuna species were longtail, kawakawa and yellowfin, whereas the dominant seerfish was the narrow-barred Spanish mackerel.

Fishing vessels in Pakistan are constructed of wood and are about 50 GT. The principal fishing gear is the gillnet, which average 2.5 km in length. These vessels generally do not carry ice so the catch is butchered and salted at sea. Trip durations may be up to 60 days. The fishing grounds extend from Pakistan to the coasts of Oman and Somalia.

A sampling programme was initiated at Karachi fishing harbour in September 1987. This is the only significant landing site along the entire coast of Sind province. Good information is now being collected on catch, effort and species composition. Good size composition data is still not being collected as most of the catch is landed in salt-dried form. There is no sampling programme for the Balukistan coast so there is no information of species composition.

14. SEYCHELLES

(1) Fisheries

Small quantities of tuna (kawakawa and yellowfin) are taken by artisanal fishing boats and sports fishermen totalling 200 to 300 t annually.

An important industrial purse seine fishery has been in operation since 1983, around the Seychelles area. The fleet is mostly of French and Spanish nationality and operate under license agreements. Catches in this fishery increased from 20,000 t in 1983 to 228,000 t in 1988, levelling off to 224,000 t in 1989. The number of vessels active during 1989 reached an all time high of 52 at the end of 1989, with an average of 48 vessels present throughout the year.

Additionally, some 100 longliners are licensed for 1 to 3 months' duration. The licensed fleets are entirely comprised of long-ranging longliners from the Republic of Korea and Japan (since 1987) whereas Taiwanese vessels occasionally call into Port Victoria.

(2) Statistics

All fishing vessels (longliners and purse seiners) licensed to fish in Seychelles waters are required to submit catch and effort records for each fishing trip. A complete coverage of the purse seine fleet is obtained and since most trans-shipment is made in Seychelles, the catch data is cross-checked with trans-shipment receipts. Detailed and more refined catch and effort data is available for the French fleet through the joint programme with ORSTOM, as well as additional data collected at sea by observers.

Data collection for longliners is more problematic as these vessels operate throughout the Indian Ocean and are usually licensed for short periods. Logbook returns for these vessels are only partial though they have improved over recent years, with a coverage of 50 percent of the licenced days achieved todate.

A computerized database is operational and details of catch, effort, trans-shipment statistics, etc., are published in the "SFA Tuna Bulletin", on a quarterly basis.

(3) Research

Major biological programmes are being undertaken in Seychelles, mostly in collaboration with ORSTOM. These activities are as follows:

a) Tuna statistics (see (2)

b) Biological sampling to obtain a more precise breakdown of species composition and catch at length data. This operation which is undertaken at trans-shipment was started in 1984 on French seiners and has now been introduced on Japanese purse seiners. A study on yellowfin reproduction was started in 1987, based on data collected at the local cannery.

c) Observer programmes based on foreign purse seiners (started since 1985) provide biological data in addition to that generated from logbooks. Typical information collected concerns vessel activity, duration of fishing sets, abundance of schools, biometric data, fishing patterns and environmental parameters.

(d) Fish Agregating Devices programme which involved the anchoring maintenance and monitoring of FADs for the artisanal fishery.

(e) Joint research with "Association Thoniere" (Regional Tuna Project). Though Seychelles is not a member of this project, certain programmes are being conducted with their collaboration such as environmental data collection, tagging of drifting logs and yellowfin reproduction study.

15. SPAIN

The Spanish fishery in the Indian Ocean is a purse seine fishery started in 1984. From one year to the next, the vessels move between the Indian and Atlantic Oceans, so the size of the permanent fleet may suffer fluctuations from year to year. However, the number of purse seiners present in the area has increased during the last two years up to 23 boats in 1989.

In the same way catches have continuously increased especially since 1988 (99,113 t against 57,698 in 1987). Taking into account the high value of the catch rate in that year - 27 percent higher than the mean value of previous years - we can suppose that this heavy increase is due to some increase in effort but also by other factors acting on the fishing efficiency of the fleet.

Catch and effort data are collected by log books which contain detailed information from fishing set by set. A biological sampling programme has been carried out in the port of Victoria (principal port of landing of the Spanish fleet) to obtain size distribution of the catches.

The collection of statistics is controlled by a fishery biologist who was moved to the area at the beginning of 1990. Data is compiled in Spain by the tuna experts at the Spanish Institute of Oceanography. Research is conducted to analyse the fishing strategy of the fleet in the area (mainly directed to log-school) as a starting point in order to obtain accurate values of fishing statistics as an effective fishing effort, size frequency distribution and species composition of the catches.

16. SRI LANKA

The present production of 30,000 t of tunas in Sri Lanka comes from a fleet of 2000, 3.5 - 4 ton class of boats and 70, 11 ton boats. Drift gillnet is the primary gear while longline, handline and troll line are used in combination with gill nets.

A recent development is the multiday fishing operation carried out by the 3.5 to 4 ton class of boats. This development was after the success of the multiday fishing operations carried out by other 11 ton boats. As a result the fishing area has shifted from the coastal waters to offshore/deepsea areas and the fishermen stay at sea for six to seven days. Tuna catch rates have not changed during the past few years but the use of combination gear has shown a slight improvement in the catch rates. Shark catch rates have increased considerably. Skipjack tuna is the dominant species among tunas followed by yellowfin tuna. Small tuna production has declined probably due to the shifting of the fishing area to offshore waters. A recent development is the purse seiner fishery for small tunas in the south.

Research on tuna is carried out by the research staff of the Marine Division of the National Aquatic Resources Agency (NARA). Some biological studies on yellowfin tuna, skipjack tuna and small tunas have been completed. Age and growth studies of small tunas by daily growth increment in otolith are continuing.

Since 1986, NARA together with IPTP established a sampling programme on the west coast of Sri Lanka to collect the catch/effort and size frequency of the important tuna and related species. The work on the tuna tagging programme in the central Indian Ocean has already been initiated and the Sri Lankan scientists will assist in the collection of recoveries and also tagging of tuna in Sri Lanka on a small scale.

17. TAIWAN (PROVINCE OF CHINA)

Two types of tuna fishery were pursued in the Indian Ocean in 1988. These were longline and large-scale pelagic drift gillnet fisheries. The former has been the traditional one since 1963, and a regular and deep line setting has been distinct for targeting different species since 1965. The number of Taiwanese longliners has declined from 199 boats in 1983 to 127 boats in 1985, and increased again to 187 boats in 1988. Total 1988 yearly catch by longliners was estimated at about 44,000 t. The fishing effort has been continuously increasing since 1967 to a maximum of about 86 x 10^{0} nominal hooks in 1983, and abruptly declined in 1985 to about 65 x 10^{0} nominal hooks, and then increased to about 107 x 10^{0} nominal hooks in 1988. Therefore, the nominal CPUE of overall longline fishery is 41.12 kg/100 hooks. Regular longline fishery targets on albacore, and deep longling fishery on bigeye and yellowfin tunas, and almost fished northernly 10°S rather than the whole Indian Ocean.

The latter gillnet fishery was initiated in 1983-1984 fishing season in Indian Ocean. The numbers of fishing vessels increased every season to 139 boats in 1988-1989 fishing season in comparison to 130 boats in 1987-1988 season. Total catch of 1987-1988 was estimated about 12,000 t, of which albacore constituted 95 percent in weight of the catch magnitude. The main fishing ground of this fishery is between 25°S to 45°S of the Indian Ocean.

The catch and effort statistics of both Taiwanese longline and gillnet fisheries were based on the logbook system and estimated in the basis of 5 degree square cells by month and by species. Almost all the research efforts were on the biological and stock evaluation studies of albacore. Currently a survey cruise has been proposed for the growth, distribution studies of Indian Ocean albacore. Also assessing models analyses are pursued in the laboratory of the Institute of Oceanography, National Taiwan University and Taiwan Fisheries Research Institute.

18. THAILAND

Present status of small tuna fisheries and resources on the west coast of Thailand, Andaman Sea.

The production of small tuna, kawakawa, frigate tuna and longtail tuna showed an increasing trend from 1983 to 1987 and declined in 1988 but it was still higher than in 1986. The main fishing gear used for catching small tunas off this coast is the purse seine, which contributed a catch of small tunas approximately 97 percent of total landings.

Seasonal variation in catch and CPUE of kawakawa and frigate tuna were recorded to peak high during the Northeast monsoon between November to May. The lower rates for the Southwest monsoon period were generally due to adverse meterological conditions at sea; but, longtail tuna was not clear to define the season in both catch and CPUE, probably due to longtail tuna distributed more abundantly out of the intensive purse seine fishing ground.

The status of tuna stock entering the fishing ground in this area, taking into account the fishing effort, especially purse seiners which aim to catch the pelagic species, and not specific directly on tunas and also not specific in areas where only tunas are abundant, it is believed that tuna stocks are unlikely to be affected by the present fishing efforts in this area.

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