Indian Ocean Tuna Commission
Commission des Thons de l'Océan Indien

Report of the Sixth Session of the IOTC Working Party on Tropical Tunas

Victoria, Seychelles, 13-20 July, 2004

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1. Opening of the Meeting and Adoption of the Agenda

The Sixth Meeting of the Working Party on Tropical Tunas (WPTT) was opened on 13 July 2004 in Victoria, Seychelles, by the Chairperson, Dr. Pilar Pallarés, from the Instituto Español de Oceanografia, Spain, who welcomed the participants (Appendix I).

The Agenda for the Meeting was adopted as presented in Appendix II.

In accordance with the instructions of the Commission, the WPTT objectives for the meeting were to review and analyse issues relevant to the fisheries and status of bigeye tuna, and consideration to the exceptional catches of yellowfin tuna in 2003.

The list of documents presented to the meeting is given in Appendix III.

2. Review of Statistical Data for the Tropical Tuna Species

2.1. Nominal Catch (NC) data

The nominal catch data series for the tropical tunas; yellowfin (YFT), bigeye (BET) and skipjack (SKJ) are considered to be almost complete since 1950. Bigeye tuna is mainly caught by longlines and purse seines; yellowfin tuna by purse seines, longlines and gillnets; and skipjack tuna by purse seines, gillnets and pole and lines. Large increases in the catches of these three species have been reported since the mid-1980's.

The IOTC Secretariat conducted several reviews of the NC database during 2003. In particular, the work to disaggregate catch statistics that aggregated by species and/or gear led to changes in the estimates of catches of skipjack tuna and, to a lesser extent, yellowfin tuna and bigeye tuna. Details about this work can be found in IOTC-2004-WPTT-06.

Although the quality of the information on the three tropical tunas is generally considered to be good, the completeness and accuracy of the records are compromised by:

- **Catch data not being available**: several countries were not collecting fishery statistics, especially in years prior to the early 1970's, and others have not reported their statistics to IOTC. While in most cases, the catches of tropical tunas in those countries were probably minor, the catches of some important longline fleets are unknown, for example, the foreign fresh tuna longliners operating from Maldives.
- **Poor resolution of catch data**: catches of tunas and tuna-like species are sometimes reported in an aggregated form[1]. The Secretariat estimates the species and gear composition of these aggregates using a range of information but the accuracy of such estimates is probably low.

There is considerable uncertainty associated with the catch estimates for the following fisheries:

- **Yemen gillnet and handline fisheries**: The information collected during several missions to Yemen by FAO staff indicates that gillnet catches in Yemen may be around 45,000 t per year, with large catches of yellowfin tuna taken in recent years. This figure is five times higher than that recorded in the FAO database, which, unfortunately, is the only information available to the Secretariat.
- **Sri Lankan gillnet (and longline) fishery**: The catch series for yellowfin and skipjack tunas in Sri Lanka were re-estimated for the period 1950-2002. Marked differences between the re-estimated catches and those produced in Sri Lanka are of concern. However, the new catch series are considered to be more accurate.
- **Fresh tuna longliners based in Indonesia**: The data collected since June 2002 has allowed the estimation of the catches by longline vessels based in Benoa for 2003. The new catch estimates differ from those obtained by using the previous catch estimation procedure (CSIRO-RIMF sampling). Therefore, the catch series is expected to change once that new catches are estimated for 2003 (all previous estimates were based on the catches obtained through CSIRO-RIMF sampling in Benoa).
- **Other fresh tuna longline fleets**: Although the catches of fresh tuna longline vessels based in various ports of the Indian Ocean were re-estimated from data coming from past or recent sampling schemes, the precision of the estimates is still considered to be poor, especially for those fleets operating from ports not covered by the schemes, and where past catches have been estimated using recent catch levels.

[1] This is the case notably when data are not reported to the Secretariat and have to be taken from the FAO nominal catch database.

- **Deep-freeze longline fleets**: The Secretariat re-estimated catches for the period 1992-2002 using new information collected during 2003. These catch estimates remain uncertain due to the many assumptions made in estimating total catches and the species breakdown. The number of vessels operating under flags of non-reporting countries has decreased markedly since 2001. The reason for this decrease is not fully known and revisions to the catch estimates may be undertaken when more information become available.
- **Former Soviet Union purse seiners**: The catch statistics of the nine to 11 former Soviet Union purse seiners operating under the flags of Panama and Belize in recent years are not available for the period 1995-1997. Total catches and effort for the period 1998-2002 were reported in 2003, but the new data did not include catch by species and type of school (consequently, these will have to be estimated by the Secretariat).

2.2. Catch-and-Effort (CE) data

Catch-and-effort records are available for the main fleets fishing for tropical tunas in the Indian Ocean, namely baitboat (SKJ and YFT), purse seine (SKJ, YFT and BET) and longline (BET and YFT). Some gillnet fisheries produce substantial catches of tropical tunas, but the contribution of other gears to the total catches is small.

- **Baitboat**: Catch-and-effort statistics from the Maldives are available by species, month and atoll for 1970-1993. Only catch and effort by species, year and atoll are available since 1993.
- **Longline:** Catch-and-effort statistics are available since 1952 for Japan, 1967 for Taiwan,China[2] and 1975 for Korea. Catch and effort data for other fleets is scarce or inaccurate (e.g. there are some non-reporting fleets such as Philippines).

The catch and effort statistics provided by Japan and Taiwan,China are generally considered to be accurate. Figure 1 shows a comparison of total annual catches by species taken by Japanese and Taiwanese longliners during recent years. This figure shows the variability of the fishing patterns and targeted species developed by each fleet, and the differences in the species composition of the tuna catches taken in the same areas by Japan and Taiwanese longliners.

Korean catch and effort statistics are considered to be highly inaccurate. Many inconsistencies have been found in the data, when comparing the catches in this database with those reported as nominal catches.

Total longline catches by species and area are provided in Figures 2 and 3.

- **Purse seine:** Catch-and-effort statistics are complete for European-owned purse seiners and those monitored by European scientists, and from Seychelles. Statistics are also available for other fleets including the former Soviet Union purse seine fleet (1998-2002; under Belize and Panama flags), Mauritius and Japan. As is the case for the NC data, the CE data for the purse-seine fleet formerly under the Soviet Union flag are not considered to be accurate, especially the species composition and type of school fished information. Partial catch and effort data are available for the Iran purse seine fleet. Recent trends in the spatial distribution on the purse-seine catches are shown in Figures 4 and 5.
- **Gillnet**: Few data are available for gillnet fisheries. This is of concern because gillnets have been used both in coastal waters and on the high seas in recent years.

[2] Taiwan, China refers to Taiwan province of China.

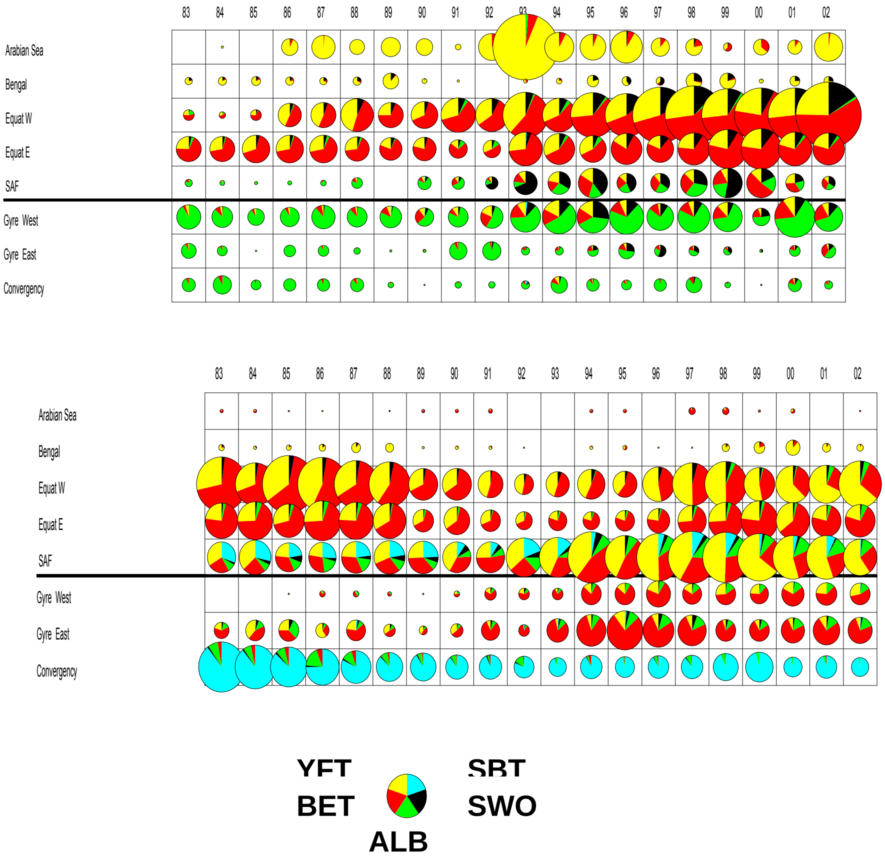


Figure 1. Annual total catches (t) of tunas and swordfish: yellowfin (YFT), bigeye (BET), skipjack (SKJ), southern bluefin (SBT), albacore (ALB), and swordfish (SWO) by Japanese and Taiwanese longline vessels operating in the Indian Ocean over the period 1983 to 2002.

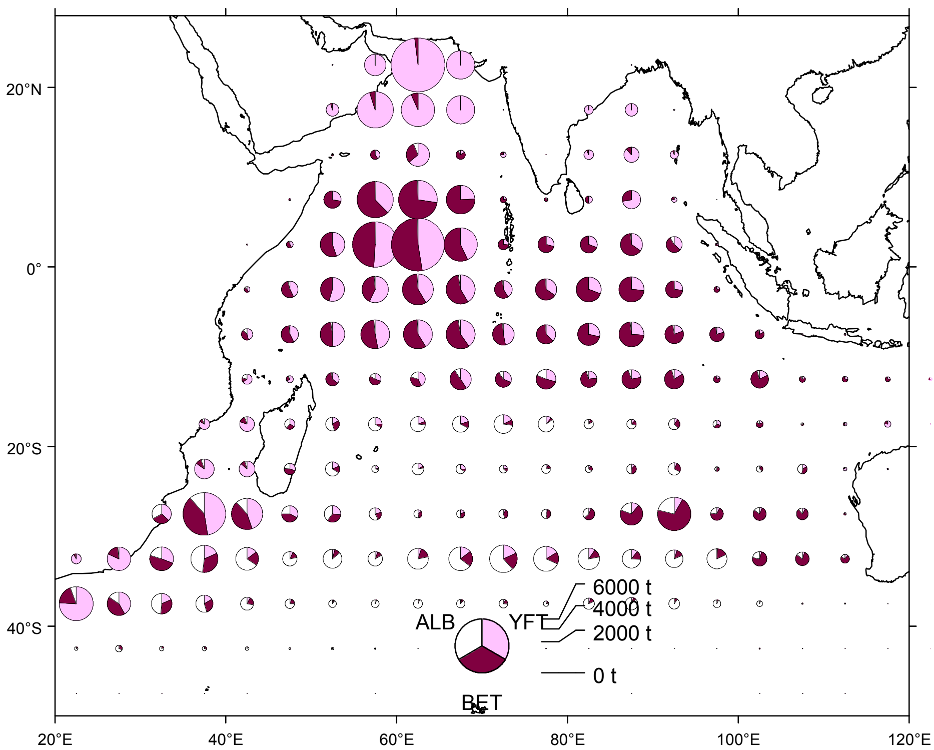


Figure 2. Mean of annual total catches (t) of tropical tunas: yellowfin (YFT), bigeye (BET) and albacore (ALB) by Japanese and Taiwanese long line vessels operating in the Indian Ocean over the period 1990 to 1999.

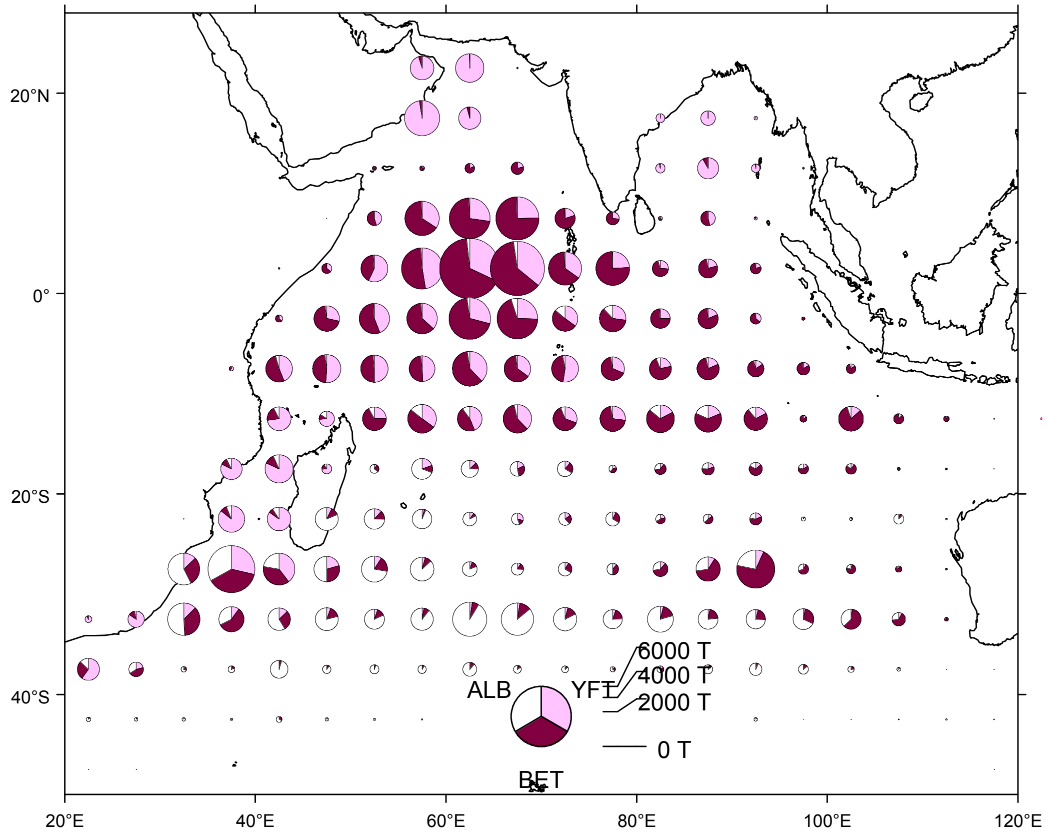


Figure 3. Mean of annual total catches (t) of tropical tunas: yellowfin (YFT), bigeye (BET) and albacore (ALB) by Japanese and Taiwanese long line vessels operating in the Indian Ocean over the period 2000 to 2002.

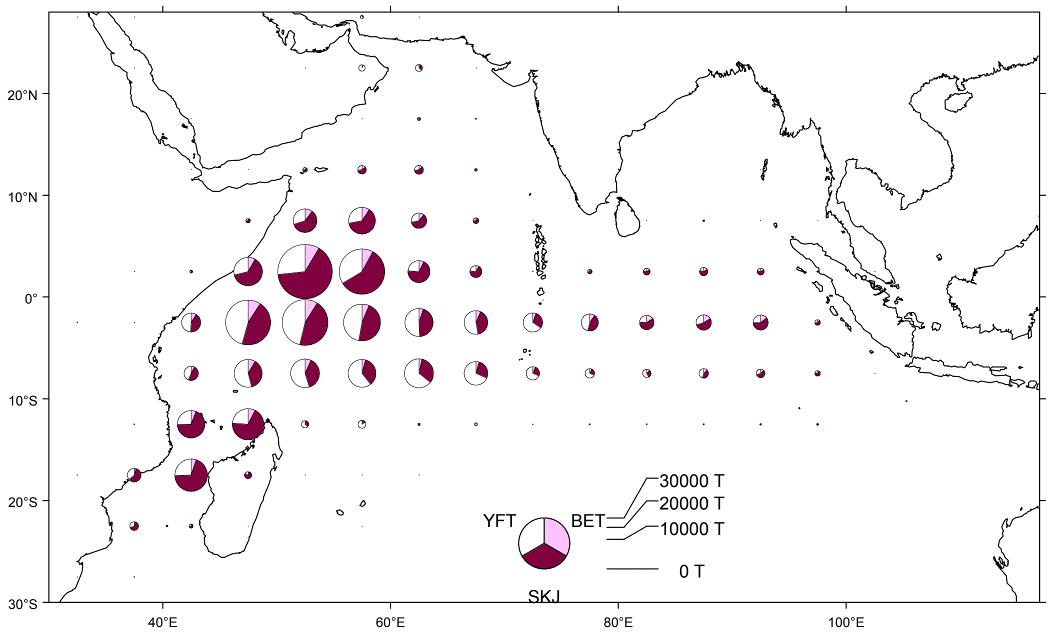


Figure 4. Mean of annual total catches (t) of tropical tunas: yellowfin (YFT), bigeye (BET) and skipjack (SKJ) by purse seine vessels operating in the Indian Ocean over the period 1990 to 1999.

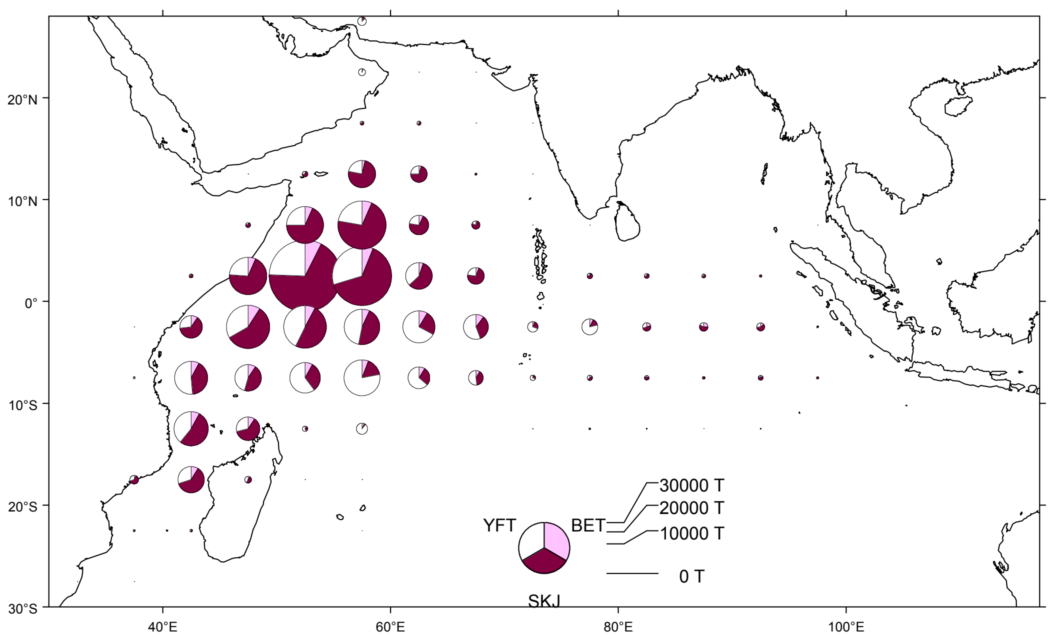


Figure 5. Mean of annual total catches (t) of tropical tunas: yellowfin (YFT), bigeye (BET) and skipjack (SKJ) by purse seine vessels operating in the Indian Ocean over the period 2000 to 2002.

2.3. Size-Frequency (SF) data

- **Purse seine**: The quality of the purse seine data is considered to be good for fleets under European monitoring. Little or no data is available for Iranian, Japanese and former Soviet Union purse seiners. The size frequency statistics for Mauritian purse seiners since 1986 is complete.
- **Baitboat**: The completeness and quality of the sampling on baitboat fisheries (Maldives) is considered to be good up to 1998. No data are available from 1999.
- **Longline:** Only Japan has been reporting size-frequency data since the beginning of the fishery. In recent years, the numbers of fish being measured have been very low in relation to the total catch; furthermore, they have been decreasing year by year. The size-frequency statistics available from the two other main longline fleets are either very incomplete (Taiwan,China for which only four years of data are available) or inaccurate (Korea). This limits the use of these data. The collection of size data from port sampling fresh tuna longline fleets operating in Thailand and Indonesia continued in 2003 and 2004.
- **Gillnet**: Although size data are available for some important gillnet fisheries (including Iran, Sri Lanka and Oman[3]) sample sizes are very low.
- **Other gears**: Few size data are available for other gears.

2.4. Estimation of catch for non-reporting fleets

The catch estimates for several non reporting fleets were updated in 2003:

- **Sri Lanka and Oman:** The catches of Sri Lanka and Oman domestic fisheries (mainly gillnet) were re-estimated in 2003 for the periods 1950-2002 and 1950-1984, respectively. The revised Sri Lanka catch estimates for yellowfin and skipjack tunas up to the mid 1970's are higher than those previously reported, while the revised estimates since the mid-1970's are lower.
- **Other non-reporting fleets (NEI):** The high number of non-reporting fleets operating in the Indian Ocean in recent years has led to large increases in the number of catches that need to be estimated. This reduces confidence in the catch estimates for yellowfin tuna and bigeye tuna and, to a lesser extent, skipjack tuna.

[3] Size frequency data of yellowfin tuna was collected during 2003 in Oman

- **Purse seine:** The catches of former Soviet Union purse seiners were re-estimated for the period 1997-2002 using new information. Total catches available were assigned to species and type of school according to the species composition and type of school of European Community purse seiners. The new catch estimates (averaging around 30,000 t per year) are very similar to those estimated previously by the Secretariat.
- **Fresh tuna longline**: Catches by fresh tuna longliners were estimated for each port where the different fleets were based. Most of the fresh tuna longline catch appears to be taken by Taiwanese vessels.
- **Indonesia**: The catches by Indonesian vessels during 2002 were estimated on the basis of previous reviews. Information collected through the multilateral catch monitoring programme in Indonesia will assist catch by species to be re-estimated.
- **Thailand**: The catches of fresh tuna longliners from Taiwan,China and Indonesia in Phuket were estimated using data collected through the AFRDEC (Andaman Sea Fisheries Research and Development Centre)-OFCF (Overseas Fishery Cooperation Foundation of Japan)-IOTC Sampling Programme.
- **Malaysia and Singapore**: The catches by fresh tuna longliners based in Malaysia and Singapore since 1992 were estimated using data from the IPTP Sampling Programme, new estimates from the Fisheries Research Institute of Penang, and vessel activity information for Singapore (Jurong).
- **Sri Lanka**: The catches by fresh tuna longliners that unload to processing plants in Sri Lanka were estimated on the basis of previous data collected by NARA (National Aquatic Resources Research and Development Agency) in Colombo and estimates from Phuket and Penang sampling.
- **Maldives:** The catches by fresh tuna longliners were not estimated due to lack of reliable information on their numbers and activity.
- **Deep-freeze longline**: The catches by large longliners from several non-reporting countries were estimated using IOTC vessel records and the catch data from Taiwanese longliners, based on the assumption that most of the vessels operate in a way similar to the longliners from Taiwan,China. The collection of new information on the non-reporting fleets during the last year, in particular the number and characteristics of longliners operating, led to improved estimates of catches. The number of vessel operating since 1999 has decreased and this has led to a marked decrease in catch levels. The reason for this decrease in the number of vessels (and catches) operating in the Indian Ocean is not fully explained. Nevertheless, this decrease is somewhat proportional to an increase in the number of vessels recorded operating under flags of reporting countries, such as Philippines and the Seychelles.

2.5. Documents relating to statistics

Document IOTC-2004-WPTT-01 provided an update on the status of the IOTC tropical tuna databases and is elaborated in Section 2 above. The IOTC Secretariat conducted several reviews of the databases during 2003. In particular, the work to disaggregate catch statistics aggregated by species and/or gear led to changes in the estimates of catches of skipjack tuna and, to a lesser extent, yellowfin tuna and bigeye tuna. Details about this work can be found in IOTC-2004-WPTT-06.

Document IOTC-2004-WPTT-08 provided a summary of the activities of French, Spanish, Italian, Seychelles and EU related NEI purse seine fleets (representing some 90% of the total purse seine activity in the Indian Ocean) fishing since 1981. This included effort, catch by species and fishing type (log and free swimming schools), catch per unit of effort, sampling, mean weights and size distribution for the main species. Nominal effort slightly decreased in 2003, while the total number of sets remained stable, the number of free school sets increased while the number of log sets decreased. The total catch exceeded 406,000 t in 2003 and was the highest catch since the beginning of the purse seine fishery.

Document IOTC-2004-WPTT-11 outlined the European Union's Data Collection and Management Programme for the period 2002 – 2006. One of the actions to be performed within this programme is the deployment of observers on tuna purse-seiners in the Indian and Atlantic Oceans to obtain information about tuna discards and species associated with tuna fishing. The document presents some of the preliminary results obtained in four campaigns by the Spanish observers, with 110 days at sea and 73 sets. Commercial catch and discards are also presented.

Document IOTC-2004-WPTT-12 described the format of the logbooks that will be distributed to the support boats for the Spanish purse seine fleet fishing in the Indian Ocean (The Scientific Committee of the IOTC has recommended the development of mechanisms to facilitate information about supply boats).

Document IOTC-2004-WPTT-07 provided a summary of the French purse-seine activities in the Indian Ocean since 1981, including, effort, catch by species and fishing type (log and free swimming schools), catch per unit of effort, sampling, mean weights and size distribution for the main species. While the total number of sets in 2003 remained stable, there was an increase of the number of free school sets and a decrease in the number of log sets. Following 2002, 2003 was again an exceptionally good year, with a total catch of 108,150 t – and the highest catch rates observed since the beginning of the French fishery.

Document IOTC-2004-WPTT-13 provided summary statistics of the Spanish purse seine fleet fishing in the Indian Ocean from 1984 to 2003. Data included catch and effort statistics as well as some fishery indicators by species and fishing mode. Information about the sampling scheme and the coverage of sampling, together with maps and diagrams representing the fishing pattern of this fleet by time and area strata was also included.

Document IOTC-2004-WPTT-21 provided summary statistics of purse seiners and longliners licensed to operate inside the Seychelles EEZ. It contains statistics on catch, effort and fishing grounds for 2003 and compares these to previous years.

2.6. General discussion on statistics

The WPTT noted the progress achieved in the preparation of 'disaggregated' catch statistics for use by scientists participating to IOTC Working parties.

A general discussion took place on the data collection system in Taiwan,China and the process used to raise the logbook data to estimate total catch. A brief presentation was given about the Taiwanese tuna statistics system in response to observations about discrepancies between nominal catch (NC) by species and catch estimates from catch and effort data (CE) in the Taiwanese data (Refer to Appendix IV). Logbooks from the Taiwanese tuna longline fleet have been collected since late 1960s, but the coverage has not been sufficient to justify their use to estimate NC. Therefore, two major data sources have been developed: one is the trading information (commercial data from four sources) that is used to estimate NC ; the other is the logbooks, which are used to estimate CE.

The Taiwanese logbook data (LB) are reviewed and verified using several procedures, then raised to NC for creating the CE. To retain the information on species composition and CPUE by species (between LB's and the CE), a common raising factor is applied to the catches of all the species and the effort from the LB. The common factor is obtained by dividing the catch of the major species from LB by that from NC (the major species covered are albacore, yellowfin and bigeye tunas, and more recently swordfish). Since a common factor is applied to catches of all the species and the effort, it is inevitable that discrepancies will exist between CE and NC, otherwise ‘different effort’ will come into being in the CE for different species and the catch composition will change in CE against LB. The magnitude of the discrepancy in the years before deep longline fishery developed is thought to be small, but it has probably increased by year since the 1990's. This implies that the discrepancy might have been affected by the different logbook coverage from different fleets.

Taiwanese scientists have developed a preliminary plan to improve their data quality, including improving the data system structure and data processing schedule, and to increase data sources for cross-checking and verification e.g. data from VMS, observers programme and, in the future, port sampling.

The WPTT was appreciative of the presentation and welcomed the intention by Taiwanese scientists to improve the data quality.

The WPTT noted that a Taiwan,China port sampling programme will be initiated in the near future. It is intended to carry out port sampling in several major harbours. The WPTT supported and encouraged the initiative. It was also noted that the port sampling programme may, in the future, replace the current ship-based size frequency sampling scheme.

The WPTT noted that size frequency statistics for bigeye caught by Taiwanese longliners have not been available since 1989. And that the coverage of size sampling by the Japanese longline fleet is very small in relation to the amount of bigeye they are catching. The WPTT strongly reiterated its concerns that size frequency information from a major part of the fishery is not available for scientific purposes.

The WPTT agreed that logbook data collected from former Soviet Union purse seiners provides a very valuable source of information on the activities of the fleet, and encouraged IOTC Secretariat to validate this information.

Given the paucity of information on tuna catches, in particular catches of yellowfin tuna, from Yemen, the WPTT strongly supports any initiatives from the IOTC to send a mission to Yemen to obtain any available data on

Yemen tuna fisheries, and develop a closer working relationship with Yemenite authorities to ensure the flow of data in the future.

2.7. Data related issues for tropical tunas

The following data related issues were highlighted by the WPTT:

- **Poor knowledge** of the catches, effort and size-frequency from fresh tuna longline vessels, especially from Taiwan,China and several non-reporting fleets.
- **Poor knowledge** of catch, effort and size-frequency from non-reporting fleets of deep-freezing tuna longliners, especially since the mid-1980's.
- Lack of accurate catch, effort and size-frequency data for the Indonesian longline fishery before 2002.
- Poor knowledge of the species composition and lack of size-frequency data for former Soviet Union purse seine boats flying flags of convenience in recent years.
- **Scarcity of data**, especially size frequency data, for the Maldives handline and pole and line fisheries since 1998.
- **Uncertainty** of the catch, effort and size frequency data from domestic gillnet boats operating in Yemen, Sri Lanka and Pakistan.

Improvements have taken place in a number of areas. These include:

- **A better level of reporting**: New NC, CE and SF datasets have been obtained from South Africa, Malaysia, Australia and Seychelles longline fisheries.
- **Revision of the IOTC databases**: Several revisions of the IOTC databases have been conducted during the last year. This has led to revised NC data for some countries.
- **An improved Vessel Record**: More information has been obtained on the number and type of vessels operating under the flags of non-reporting parties. This information comes mostly from the various licensing schemes in the Indian Ocean and has become an important element in the estimation of the catches of non reporting fleets.
- **Improved estimation of catches of non-reporting fleets**: The collection of historical and current information on the landings of small fresh tuna longliners in ports in the Indian Ocean has improved the accuracy of earlier estimates. The more complete Vessel Record also permitted the estimation by flag of the catches of deep-freezing longliners. The catches of former Soviet Union purse seiners for 1998-2002 are considered to be more accurate.
- **IOTC/OFCF sampling programmes**: The collection of information on the activities of fresh tuna longliners landing in Phuket and Indonesia has continued during 2003. This has led to more complete and accurate estimates of catches by these fleets. Other valuable data collected under these programmes includes length frequencies (which will allow length-length, length-weight and weight-length relationships to be updated). Yellowfin tuna size frequency data was collected from Oman in 2003.
- **IOTC/OFCF Regional Workshop on Data Collection and Processing Systems**: New catch estimates for tuna and tuna-like species for several countries were produced during 2003 following the IOTC/OFCF Regional Workshop on Data Collection and Statistical Systems (Seychelles, March 2004). The data collection and processing systems of 10 countries in the Indian Ocean region were reviewed during the Workshop and this greatly improved the Secretariat's understanding on how fisheries statistics are generated.
- **Sri Lanka and Oman NC**: The catches of Sri Lankan and Omani domestic fisheries were updated during 2003 with the whole catch series added for Sri Lanka and 1950-1984 catches estimated for Oman.

The current status of the data for each of the tropical tuna species can be summarised as follows:

YELLOWFIN AND BIGEYE TUNA

- **Nominal Catch (NC) data**: Relatively well known for most purse-seine fisheries and the main longline fleets (Japan, Korea and Taiwan,China). Catches of non-reporting longline and purse seine fleets are still uncertain, although they are considered to be more accurate than the estimates reported in the past. The estimates of non-reporting are 25% for bigeye, 15% for yellowfin for the NEI fleets.

Artisanal catches of bigeye tuna are negligible. By contrast, the levels of yellowfin tuna catches by artisanal gears (mainly gillnets) remain uncertain, but are believed to have increased markedly in recent years.

- **Catch and Effort (CE) data**: Well known in the purse-seine fisheries and the main longline operations (Japan, Korea and Taiwan,China). Nevertheless, the Korean data are considered to be inaccurate. No catch-and-effort statistics are available for non-reporting longline, purse seine and most gillnet fisheries.
- **Size-Frequency (SF) data**: Sampling coverage from Japan and Korea has been is low in recent years. The only data available on non-reporting fleets come from Phuket, Penang, Sri Lanka and Indonesia. No SF data are available from Taiwanese vessels since 1989. Little information is available on important artisanal catches from Oman, Pakistan, Yemen and Comoros.

SKIPJACK TUNA

- **NC and CE data:** Relatively well known for most purse-seine fisheries. Data are available for the important artisanal fishery in Maldives. The artisanal components which are important for this species are not well known. In several coastal countries (e.g. Indonesia) the catches are not reported by gear.

The estimate of non-reporting of skipjack is 3% for the NEI fleets.

- **SF data:** Available for reporting purse seine fleets (1984-2002), Maldivian baitboats (1983-1998) and some gillnet fisheries and years (Pakistan, Iran, Indonesia and Sri Lanka), although sample sizes are low in some cases.

3. Review new information on the biology and stock structure of tropical tunas, their fisheries and related environmental data

3.1. Bigeye tuna

Information documents IOTC-2004-WPTT-INF02 and IOTC-2004-WPTT-INF03 related to the second international symposium on world-wide bigeye stocks organized by ICCAT in March 2004. Document IOTC-2004-WPTT-INF02 reviewed the age-specific levels and variability in natural mortality in tuna populations. A review of the literature indicated that a ‘U’ shaped curve that reflects the changes in natural mortality with size and age should be used in stock assessments. Natural mortality is relatively high for larvae and juveniles, lower for fish prior to their first spawning, and then increases during spawning and for older fishes due to old age. The biological factors contributing to the variability in natural mortality of tunas are discussed. Profiles and levels of natural mortality currently used for bigeye tuna by various tuna Commissions are compared. Results of VPA and yield per recruit analyses are greatly influenced by the natural mortality vector. It was noted that a better understanding of natural mortality is required, and tagging experiments may provide valuable insight into the magnitude and shape of the natural mortality curve. In the absence of this information, it was considered important that stock assessments include investigations of the sensitivities of alternative natural mortality curves.

Information document IOTC-2004-WPTT-INF03 provided a comparison of bigeye stocks and fisheries in the Atlantic, Indian and Pacific Oceans. Starting in the 1980's, there was a rapid and quite synchronous increase in bigeye catches. Since the late 1990's, catches have been relatively stable or slowly declining. Bigeye catches are principally made up from fishing for small, low value bigeye using purse seiners (mainly under FADs), and larger, more valuable bigeye targeted by longliners for the sashimi market. Biological characteristics of bigeye tuna such as growth, sex ratio at size and natural mortality estimated in the various oceans are discussed. Bigeye tuna fisheries in the various oceans are compared, and the historical changes in these fisheries are analysed. Bigeye stock status and the recent changes in the stock assessment approaches used in the three oceans by the different tuna commissions are examined. It was concluded that despite a general increase in bigeye tuna research in recent years, there continues to be considerable limitations and uncertainties in the stock assessments.

Two documents related to the age, growth and reproduction of bigeye tuna. Information document IOTC-2004-WPTT-INF04 provided information on the age and growth of bigeye tuna in the eastern and western Australian Fishing Zone. The maximum age estimated from otoliths was 15 years for females and 12 years for males. A recent tag return from a bigeye tuna at liberty for 12 years (after being tagged as a 2 year old) provided support for the maximum age estimates. Growth rates varied between areas, and bigeye in the western Pacific Ocean grew faster than bigeye in the eastern Indian Ocean. The timing of opaque zone formation could not be precisely identified consequently birth dates may vary substantially leading to biases in the estimates of age. While these biases do not influence comparisons of growth between areas or sexes, they will affect the estimates of growth parameters used in stock assessments. It was noted that annual age estimation of bigeye tuna using otoliths is not straightforward. Use of daily age estimates and tagging information has been necessary to provide evidence for annual increments in bigeye tuna in the Indian Ocean, western Pacific Ocean and eastern Atlantic Ocean.

Document IOTC-2004-WPTT-05 provided information on the reproductive biology of bigeye tuna in the eastern Indian Ocean. Samples were collected from surface longliners at Phuket fishing port, Thailand from January 2000 to August 2003. The spawning season for the bigeye tuna sampled occurred from December to January and June. The size at first maturity for females and males was 88.08 and 86.85 cm FL respectively. Sex ratios varied between monthly samples and by length class, which indicated small sized bigeye tuna (85.00-115.00 cm FL) comprised more females, while large sized bigeye tuna (125.00-155.00 cm FL) comprised more males (Figure 6) A gonadosomatic index as a function of size is provided in Figure 7.

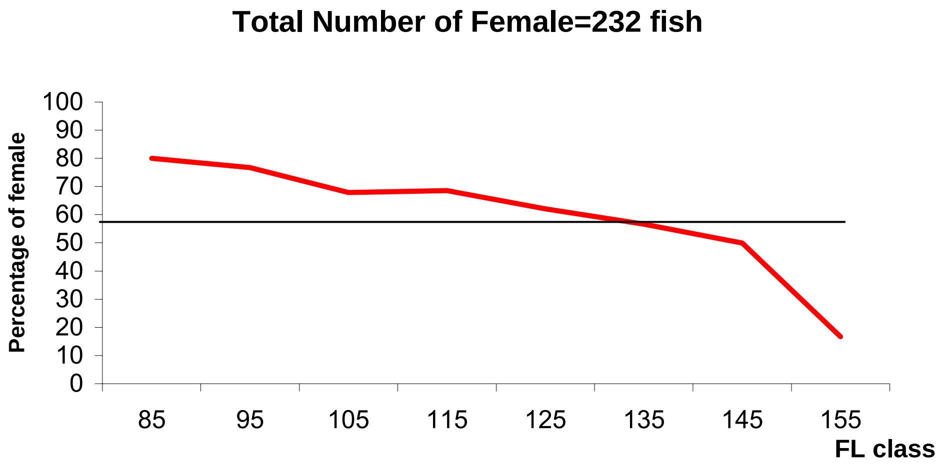


Figure 6. Bigeye tuna: sex ratio by size observed in the equatorial Indian Ocean.

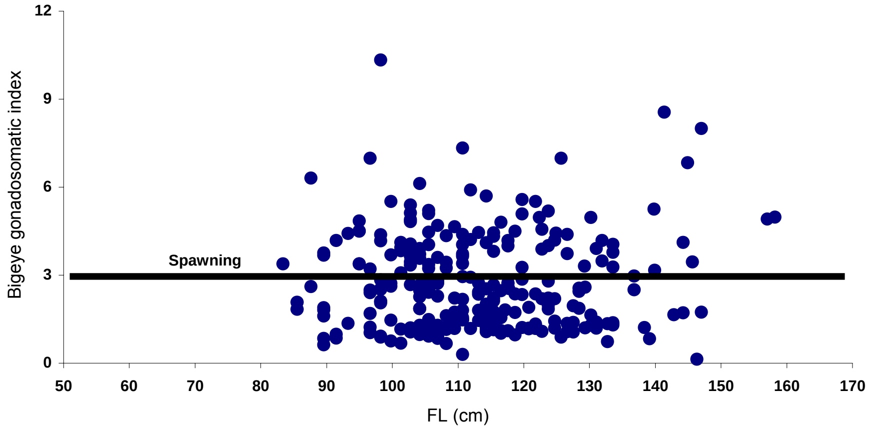


Figure 7. Bigeye tuna: gonadosomatic index by size for bigeye observed in the equatorial Indian Ocean.

Document IOTC-2004-WPTT-INF05 described the development of an operational model for bigeye in the Atlantic Ocean to investigate the sensitivities of assessment results to the uncertainties in the model inputs. The operational model is part of a simulation framework that will also allow the performance of management strategies to be evaluated. Possible hypotheses to be tested in the near future include: is the management procedure robust to the uncertainty posed by the difficulty of separating species of juvenile tuna ? are the management procedures designed to protect juvenile tuna robust to the level of uncertainty present in M ? can current management procedures cope with a shift in selectivity towards small tunas ?

3.2. Skipjack tuna

Document IOTC-2004-WPTT-03 provided information on the daily increments obtained from the otoliths of 25 skipjack tunas (42.8-66.2 cm FL) caught in the eastern Indian Ocean during February and March 2004. Three different increment patterns were observed in the otoliths, which was consistent with skipjack tuna from the Pacific Ocean. Skipjack tunas in the eastern Indian Ocean were estimated to attain about 45 cm FL in 1 year and 50-55 cm FL in 1.5 years. The growth rates estimated for skipjack tunas in the eastern Indian Ocean were similar to the direct estimates of growth from the Western and Central Pacific Ocean.

3.3. Yellowfin tuna

Document IOTC-2004-WPTT-24 described the growth of the yellowfin tuna occurring in the Indian EEZ. The von Bertalanffy growth parameters derived from length frequency data collected during longline surveys were estimated separately for two regions. Parameter estimates were Linf=197.96 cm TL and K=0.201/year for Arabian Sea and Linf=190.28 cm TL and K=0.206/year for Bay of Bengal. The study indicated that there was no significant difference in the growth rates of yellowfin tuna in both regions. The results also suggest that yellowfin tuna may have a slower growth rate in Indian waters compared to other areas.

Document IOTC-2004-WPTT-25 provided tuna catches and average weights for yellowfin tuna from the oceanic sector of the Indian EEZ commercial operations. Thirty charter longline vessels landed 2844 tonnes in 1994-95 and 28 longline vessels operating under lease during 1998-2000 landed 3556 tonnes. Four joint venture vessels reported 340 tonnes between 1998-2002 and three vessels operating under Indian owned licenses landed 197.3 tonnes during 2002-2003. The catch comprised yellowfin tuna, skipjack tuna and bigeye tuna, with yellowfin tuna contributing more than 50% of the total tuna catch in the Indian EEZ. As a result of the observed smaller average size of yellowfin tuna landed in Arabian Sea, the authors recommended that it would be useful to gain a better understanding of the dynamics of the tuna species and the impacts of commercial operations.

3.4. Predation on tunas

Document IOTC-2004-WPTT-22 summarised the results of the predation survey conducted by the Japanese commercial tuna longline fisheries between September 2000 and December 2002. It was noted that there are difficulties in raising the numbers of reported operations (i.e. those operations that include at least one damaged fish) to the total number of operations as reported by logbooks. Appropriate raising factors are unknown. The lack of appropriate raising factors will make it difficult to estimate total tuna mortality by longliners (as opposed to total landings); this is a statistic that is useful for stock assessment purposes. Additional data will be required to investigate this issue.

Reports from the local longline fishery in the Seychelles suggest that false killer whales prey on tuna baits. The Japanese longline fishery has also reported this.

Document IOTC-2004-WPTT-26 presented observations on the predation of yellowfin tuna during a longline survey carried out in the Indian EEZ from 1997-2003. Results indicate that predation on yellowfin tuna is common in Indian waters. The average annual percentage of predation on yellowfin tuna was estimated as 9% and sharks were identified as the common predator. Predation was found to be higher in the Arabian Sea than in the Bay of Bengal.

3.5. Other

Document IOTC-2004-WPTT-23 described a framework for fisheries science and management in the R statistical language. The two main objectives for this work are to develop a flexible, generic framework for conducting basic fisheries biology numerical tasks; and to provide the tools for stochastic evaluation of management strategies. The framework uses the open-source and free R statistical language. A brief overview of the work to date is presented in the document.

3.6. Review of new information on the status of yellowfin and bigeye tunas

BIGEYE TUNA

Fishery characteristics

The following information characterising the Indian Ocean bigeye fisheries is based on document IOTC-2004-INF03 and discussions and figures generated at the meeting.

Total catch of bigeye by longliners in the Indian Ocean has increased steadily since the 1950's, with catches exceeding 100,000 in the period 1996-2000 (Figure 8). In 2002 catches were 99,500 t. Japan, Korea and Taiwan,China are the major fleets fishing for bigeye (Figure 9). While most bigeye catches have been taken in the equatorial areas, in recent years there has been an increase in catches in the temperate areas (Figure 9), between 30°S and 10°N (Figures 10, 11, 12).

Total catch of bigeye by purse seiners in the Indian Ocean in 2002 was 29,100 t (Figure 8). Forty to sixty boats have operated in the fishery since 1984. Carrying capacity in recent years has been just over 50,000 t (Figure 13). There has been a steady increase in the number of positive sets on FADs over time; while the catch per set has typically ranged between 2-4 t per set (Figure 14). The percentage of log sets has been around 50-60% in recent years, while the percentage of bigeye captured on log sets, compared to other tuna species is typically between 60-90% (Figure 15). Recent trends in the spatial distribution on the purse-seine catches of bigeye are shown in Figures 16 and 17.

The overall size distributions for the purse seine and longline catches (1992-2002) are provided in Figure 18. Size and weight distributions of bigeye from taken by purse seine vessels on free schools and FADs are given in Figure 19.

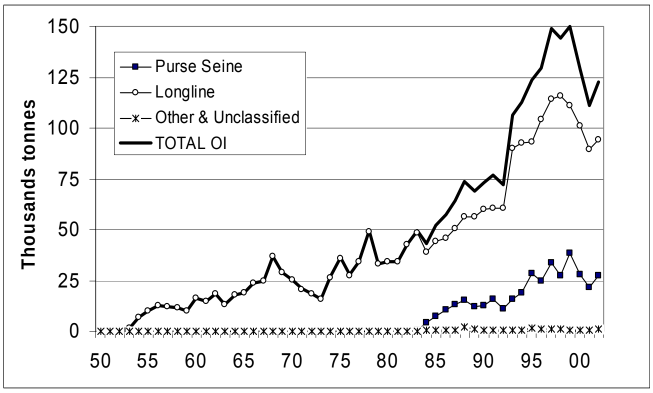


Figure 8. Bigeye tuna: annual catches (t x 1000) by gear type.

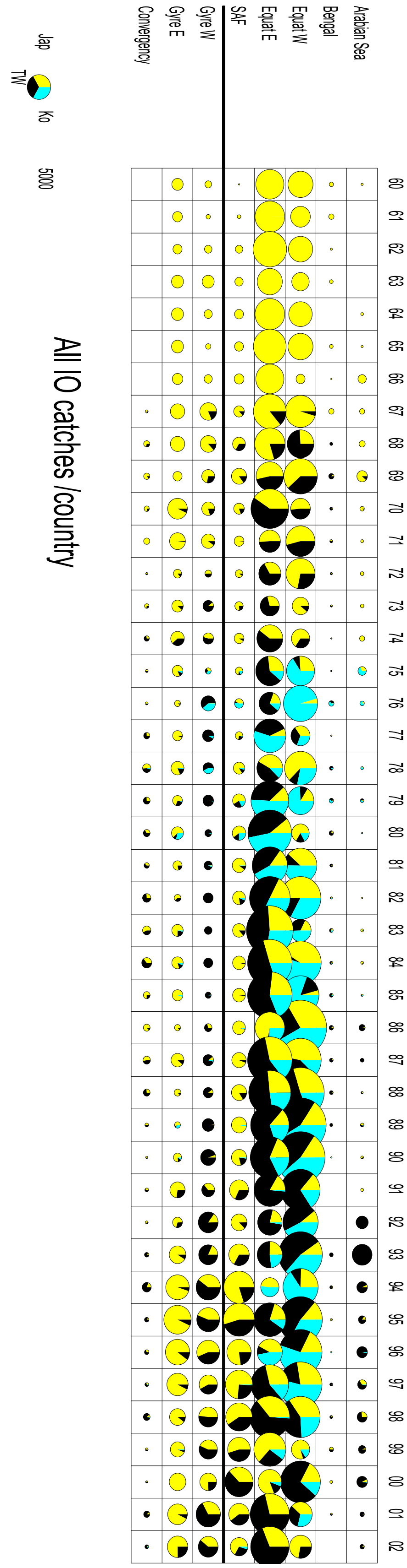


Figure 9. Annual catches of bigeye tuna by longline vessels belong to the major fleets (Japan, Taiwan,China, Korea) operating in the Indian Ocean.

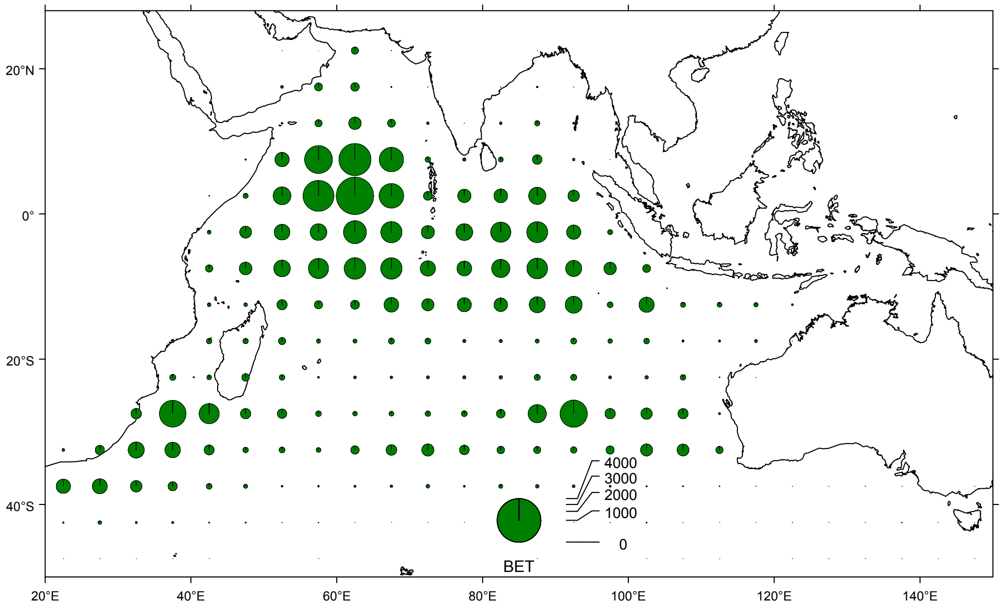


Figure 10. Mean of annual total catches (t) of bigeye tuna by Japanese and Taiwanese longline vessels operating in the Indian Ocean over the period 1990 to 1999.

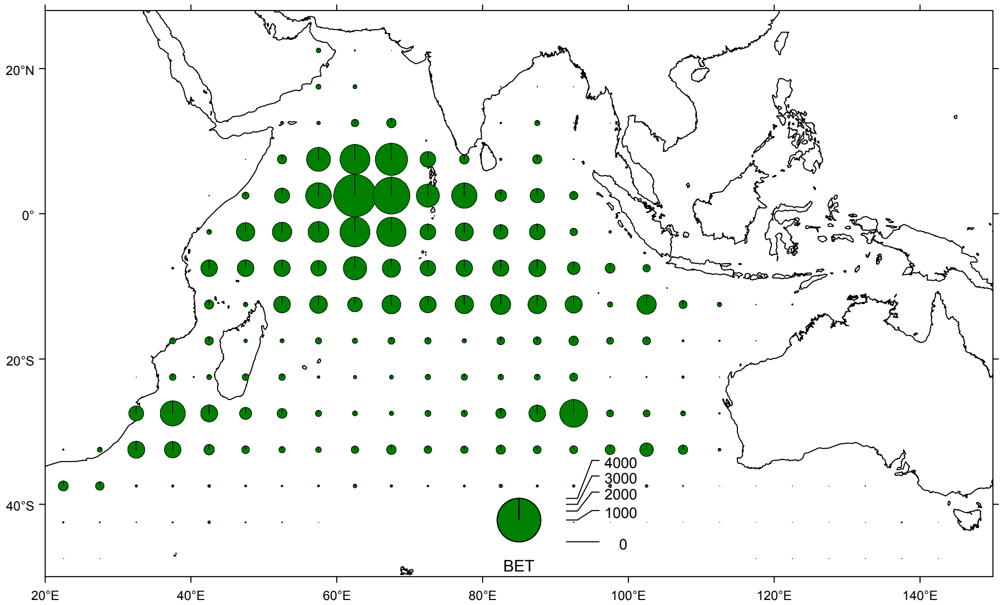


Figure 11. Mean of annual total catches (t) of bigeye tuna by Japanese and Taiwanese longline vessels operating in the Indian Ocean over the period 2000 to 2002.

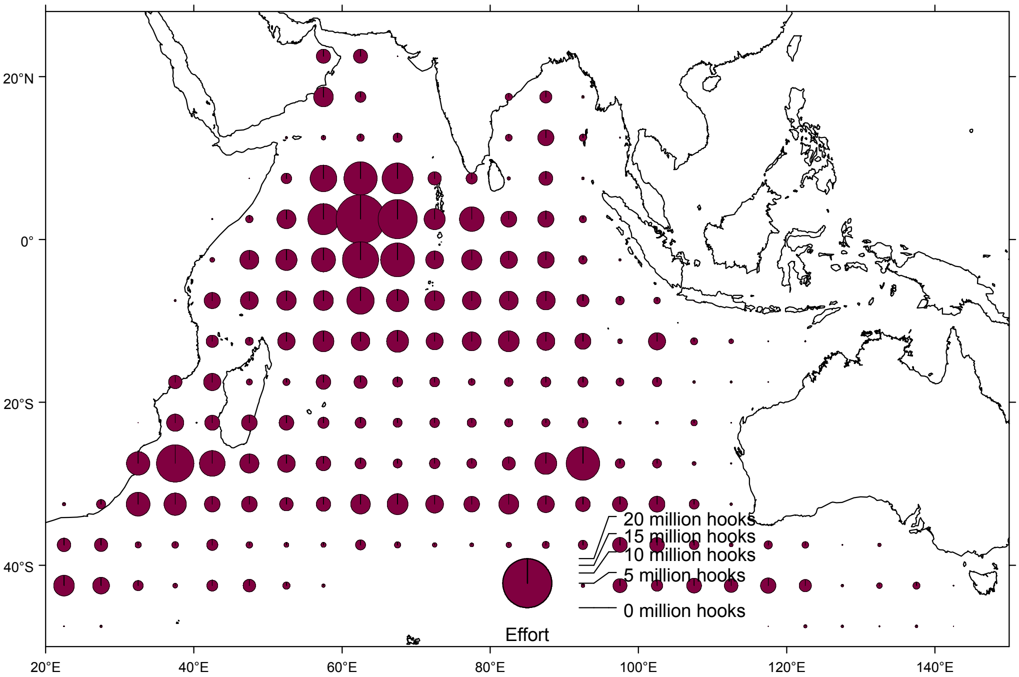


Figure 12. Mean of annual total effort (millions of hooks) of Japanese and Taiwanese longline vessels operating in the Indian Ocean over the period 2000 to 2002.

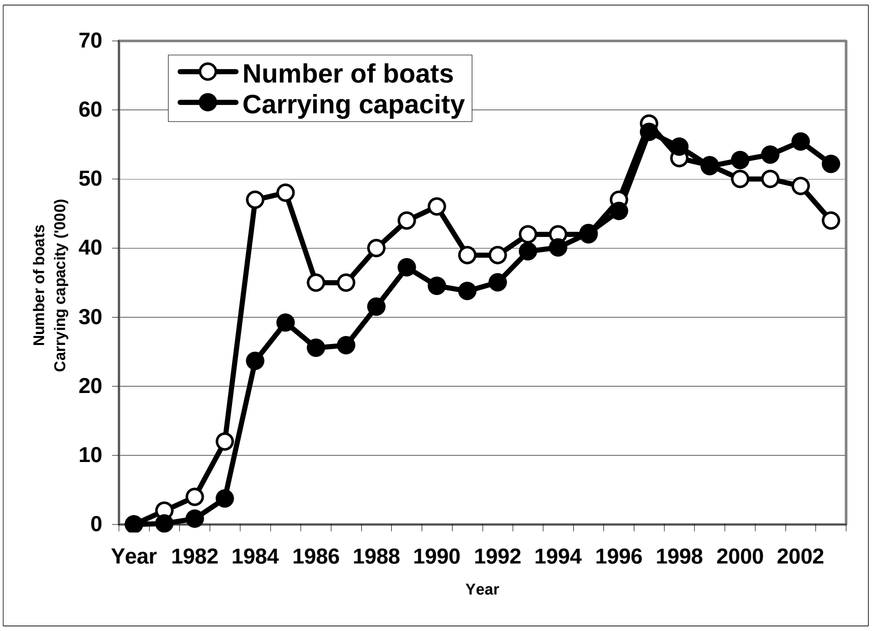


Figure 13. Carrying capacity and number of boats in main purse seine fleets fishing in the Indian Ocean

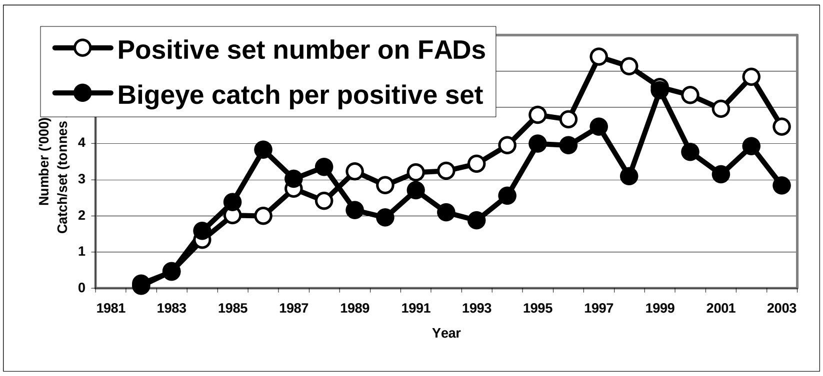


Figure 14. Fishing results for main purse seine fleets fishing in the Indian Ocean

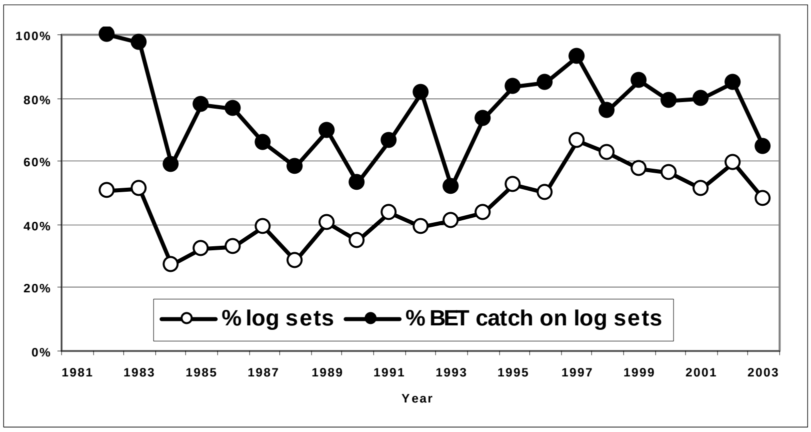


Figure 15. Fishing results for log sets by main purse seine fleets fishing in the Indian Ocean

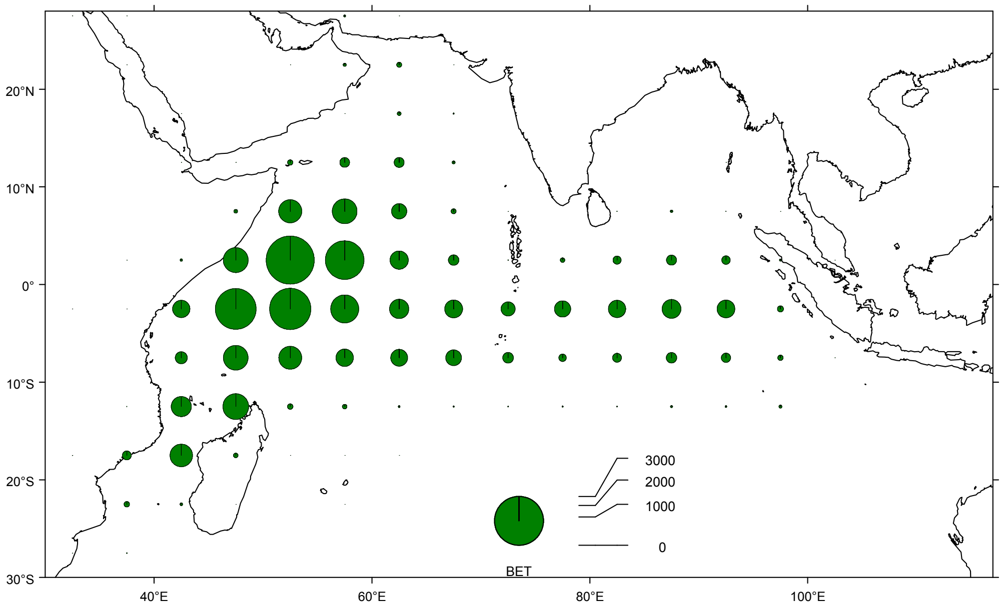


Figure 16. Mean of annual total catches (t) of bigeye tuna by purse seine vessels operating in the Indian Ocean over the period 1990 to 1999.

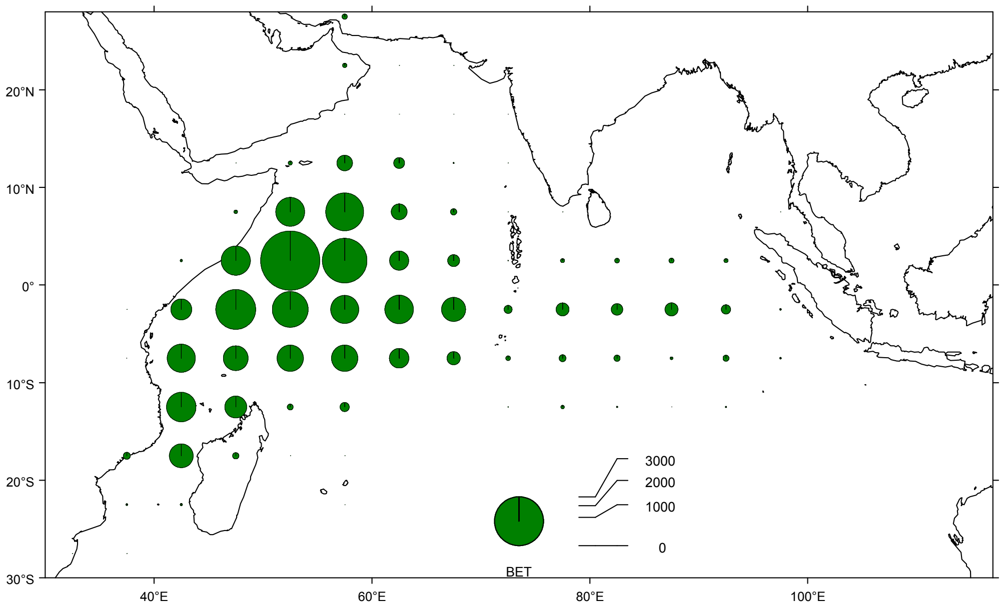


Figure 17. Mean of annual total catches of bigeye tuna by purse seine vessels operating in the Indian Ocean over the period 2000 to 2002.

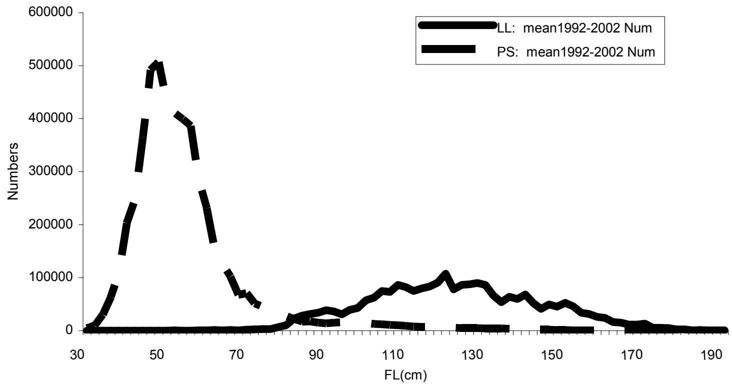


Figure 18. Mean numbers of BET caught by purse seine (PS) and longline (LL) vessels during the period 1992-2002 (based on the 2004 catch at size table).

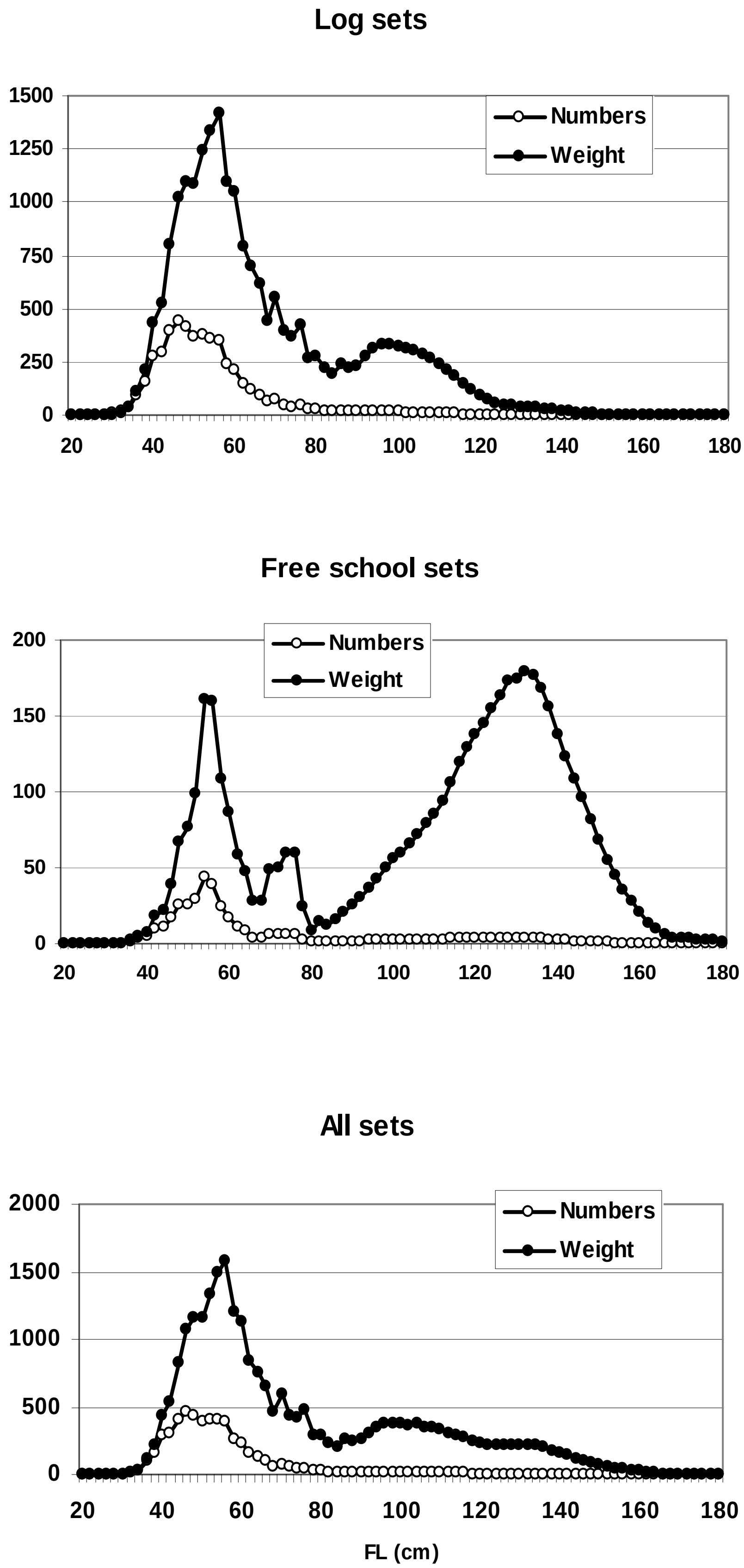


Figure 19. Size of bigeye caught by purse seine vessels on free and FAD schools during recent years.

CPUE indices of relative abundance

Documents were presented detailing two indices of abundance. Document IOTC-2004-WPTT-18 described a standardised CPUE index for the Japanese longline fleet from 1960 to 2002 using a GLM to account for the influences of area, season, gear configuration(defined as number of hooks between two floats), as well sea surface temperature (SST) and mixed layer depth (MLD). Three separate indices were included, covering the whole Indian Ocean, the tropical area and the temperate area. Only the whole Indian Ocean and tropical indices (Figure 20) were used in the 2004 stock assessment for bigeye. WPTT scientists undertook an analysis to examining whether an index derived from a highly specified area of the tropical Indian Ocean (excluding areas where bigeye is not targeted) would be more informative than the current tropical index. Results indicated that the indices were similar and the WPTT agreed not to replace the existing indices at this stage.

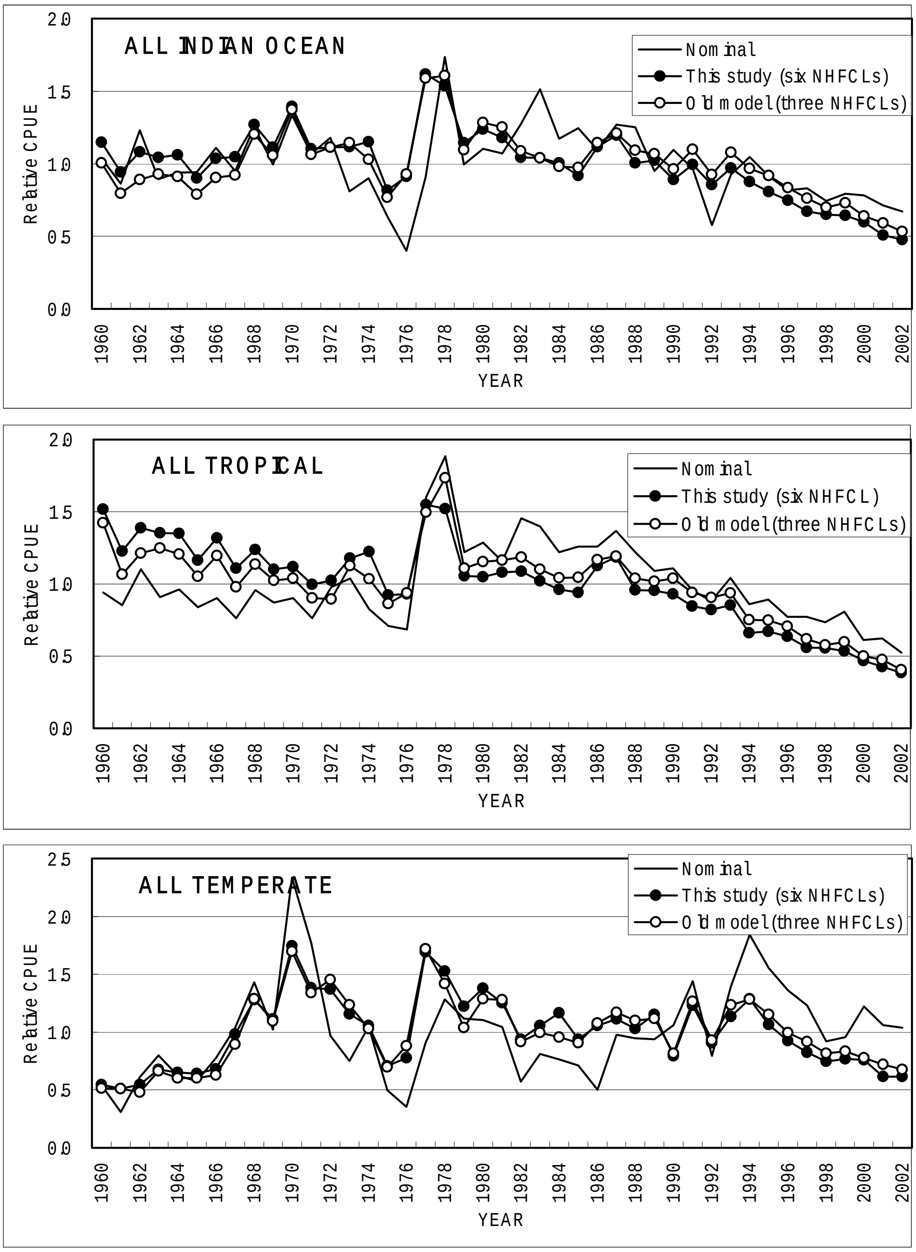


Figure 20 Relative CPUEs for ALL Indian Ocean, Tropical and South areas derived from new model with six categories of NHFCL (solid circles) and old model with three categories of NHFCL (open circles) with Nominal CPUE.

A standardised Taiwanese longline CPUE index for bigeye was also derived using the same model as that used to derive the Japanese longline index (IOTC-2004-WPTT-20). The WPTT acknowledged the valuable collaborative effort of the Japanese and Taiwanese scientists working on this topic as the Taiwanese data covers an increasingly significant fleet. The target effect was estimated based on catch composition approach in the GLM model for 1968-1995, instead of using NHF (Number of Hooks between Floats) due to insufficient information. For the period of 1995-2002, targeting effect was estimated based on actual NHF information. Figure 21 shows that the standardized CPUE trend of the Taiwanese longline fleet was similar to that of the Japanese fleet in the temperate area (being slightly lower than the Japanese index during the middle 1980's). In the tropical area the Taiwanese index showed a declining trend from 1968 to 1991 (similar to the Japanese index). However, CPUE increased significantly after 1991 and then gradually declined until 2000 to the level of the early 1980s. In the same period, the Japanese series declined continuously to 2002.

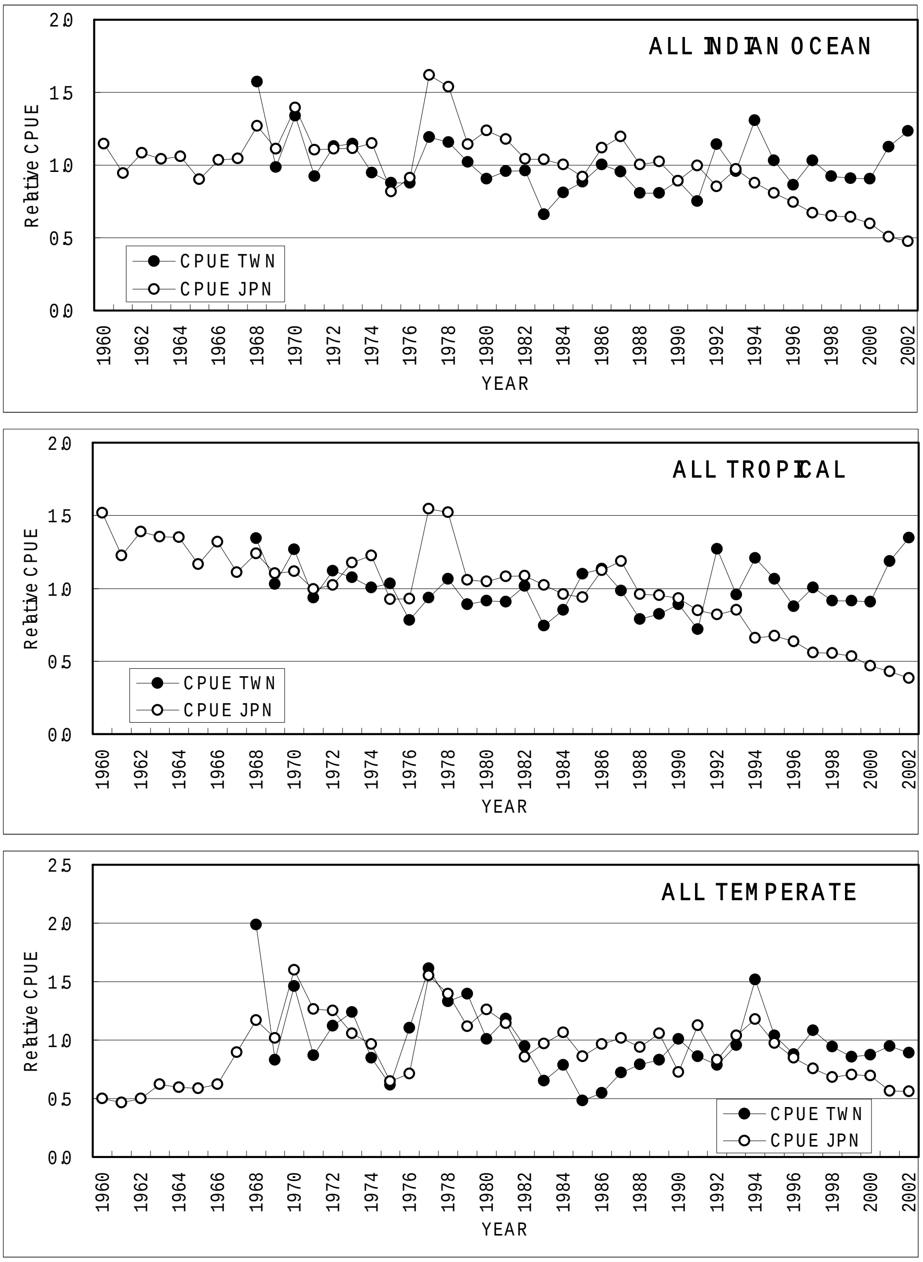


Figure 21. Standardized CPUE (1968-2002) derived from CASE C2 with standardized Japanese longline CPUE expressed in relative scale as average for 1968-2002 is 1.0.

Other investigations into the Taiwanese longline data (related to the development of a CPUE index) included addressing the unavailability and/or low coverage of information on the number of hooks-per-basket information (Document IOTC-2004-WPT-10) and the separation of the Taiwanese regular and deepwater data by using catch ratios (Document IOTC-2004-WPTT-INF01)

A small working party was formed to provide advice to the WPTT on how to progress the development of a standardised CPUE for the Taiwanese longliners given the problems associated with the treatment of classifications and targeting issues. The report from this group is provided in Appendix V. The working party outlined two approaches (a trip based approach and a species based approach) that could be effective to derive a robust LL CPUE and overcome the absence of historical information of the numbers of hooks per basket. Japanese and other scientists will undertake this work using the Japanese LL data from 1970-85 in the tropical and/or the whole Indian Ocean, before attempting an analysis of the Taiwanese data. It is anticipated that the results of this work will be reported to the WPTT in 2005.

A combined index using both the Japanese and Taiwanese CPUE data (for both the whole ocean and the tropical area only) was calculated by WPTT scientists during the meeting for use in some of the assessment models. A mean of the normalised series, weighted by the relative catch, was used. The opposite trends observed in recent years in both longline indices was problematic when the were combined. The high values in CPUE observed in the last two years of the Taiwanese series were considered to be unusual, thus a combined index was derived including and excluding these data. Results from the use of this index in the stock assessment are given below.

The use of length-based indices as an alternative to catch and effort based indices was explored in document IOTC-2004-WPTT-15. This study described the standardisation of length-based indices, and investigation of spatial and seasonal effects. Results for bigeye and yellowfin in the longline and purse seine fisheries in the Indian Ocean showed that the standardised length-based indices were similar to the nominal indices. This may suggest that, for the current datasets, there is not a strong need to standardise. Standardisation, however, does have other advantages, as it enables standard errors to be estimated, and provides insight into spatial and seasonal effects.

The nominal CPUE calculated from the catches of small fish (possibly ages 0 and 1) in the major purse-seine fishery does not provide evidence of any clear trend in the recruitment in recent years (Figure 22).

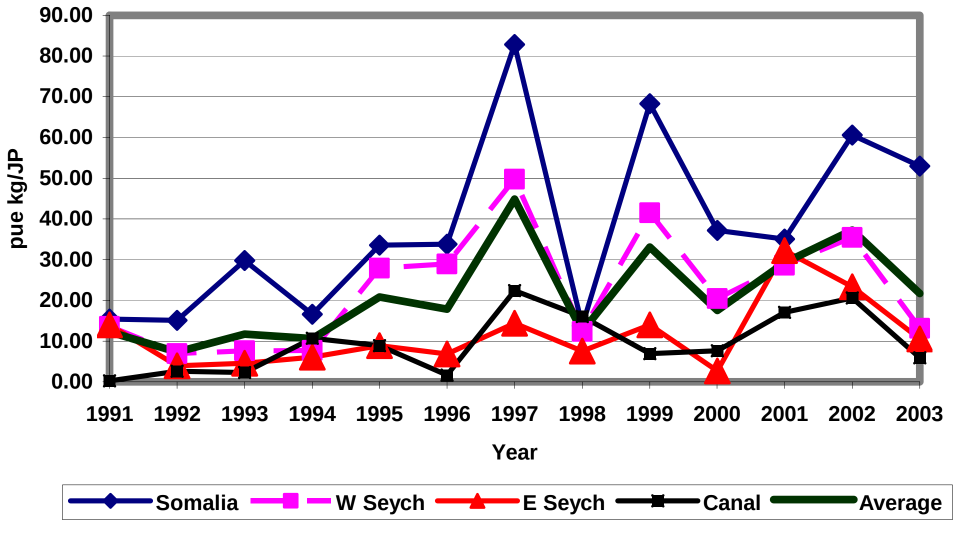


Figure 22. Annual catch rates of juvenile bigeye tuna by purse seine vessels operating in the Seychelles area of the Indian Ocean.

Bigeye Stock Assessment

The model

The age-structure production model (ASPM) used in the previous bigeye assessment was updated for the 2004 assessment (IOTC-2004-WPTT-09 and IOTC-2004-WPTT-09 addendum). New information available since the last assessment was used to update the input values for weight-at-age (based on a different growth curve and length-weight relationships) and new selectivity-at-age. A summary of the input data for the ASPM runs is given in Table 1.

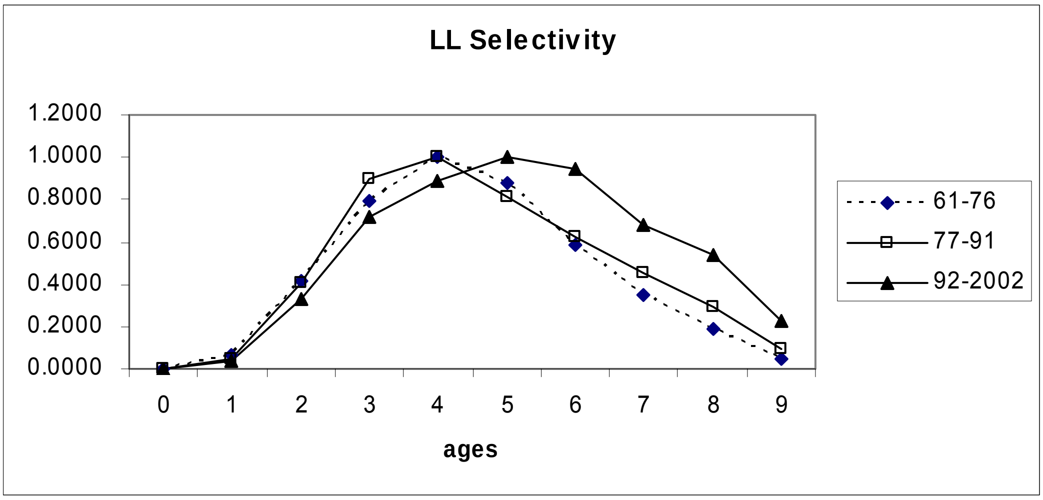
Inputs

Selectivities were obtained using a Forward VPA approach instead of the separable VPA used in the previous assessment (Figure 23). This avoided the need to make assumptions about inputs such as age of reference, overall fishing mortality value, selectivity of plus group related to the age of reference.

Preliminary model outputs indicated a weak stock-recruitment relationship, therefore a constant recruitment was assumed. Using this, recruitment survivals were calculated using the cohorts analysis proposed by Pope (as a simple VPA approach).

Fishing mortalities at age were calculated from the abundance at age matrix. From this, values of partial F at age for PS and LL were calculated. Partial Fs by age were then averaged by period (1960-76, 1977-91 and 1992-2002 for LL and 1981-1990 and 1991-2002 for PS). Selectivities by gear and period were obtained from these mean F vectors.

Recruitment was assumed to be 50,000,000 of fish per year. Selectivities were not sensitive to the absolute recruitment value. The natural mortality vector was that used for the Atlantic bigeye (0.8 for ages 0 and 1; 0.4 for older). The model was applied to the catch-at-age matrix obtained using the Stequert (2003) growth curve (Figure 24).



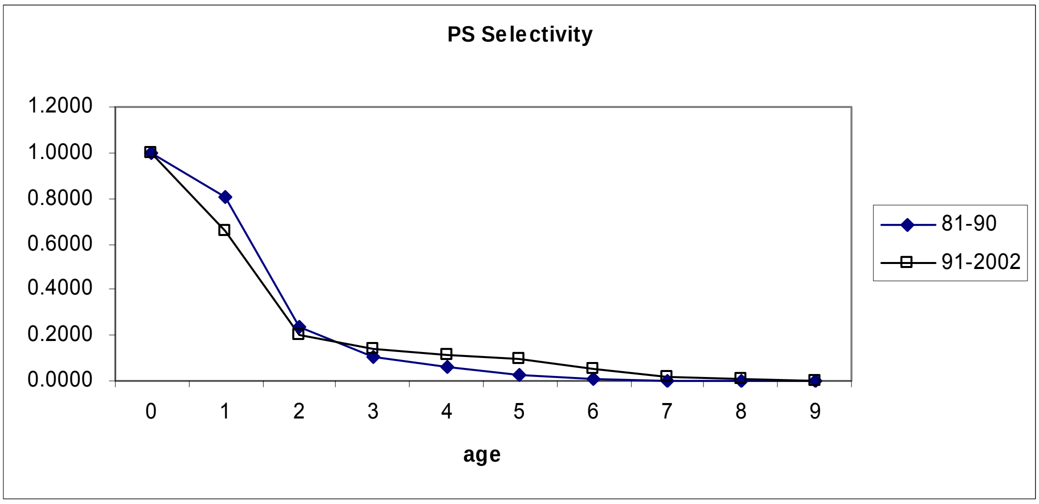


Figure 23. Age selectivities for the longline (LL) and purse seine (PS) fisheries, respectively derived from the ASPM analysis (see also Table 1)

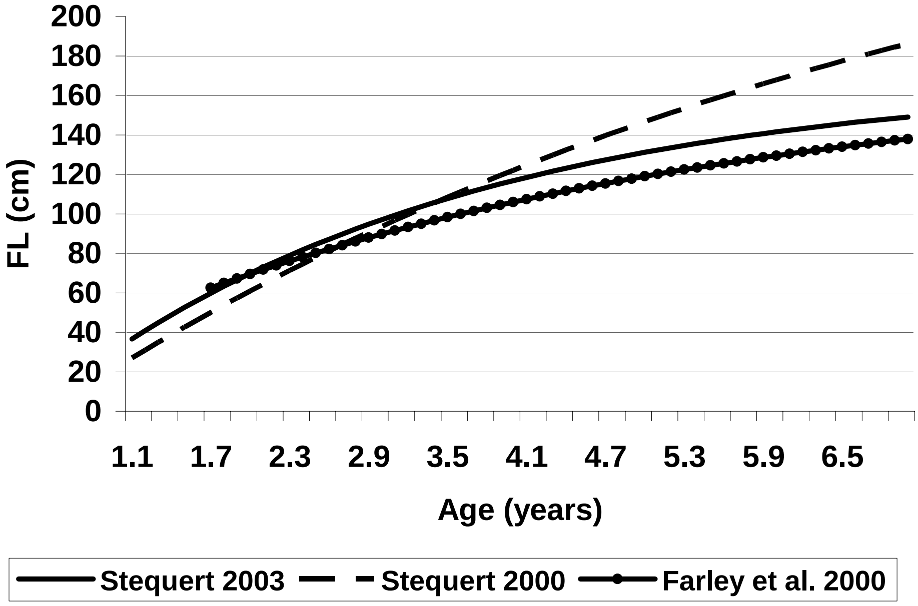


Figure 24. Comparison of three bigeye growth curves

<u>Results</u>

Six runs of the ASPM software were conducted using various assumptions as listed in Table 1. The estimating procedure reached convergence in four of the six runs. Of those, Run 1 was chosen as the base case because it showed the best fit to the data (in terms of R-squared) and it used the same CPUE index as the previous assessment. The WPTT considered that results from the runs using the Taiwanese longline index were unreliable at this stage because the index needs more work on the way it incorporates targeting, and in some cases, the results were unrealistic.

To explore the uncertainty affecting the results, a distribution of key parameters was obtained using a bootstrap procedure.

For the base case, the ratio of Fcurrent compared with F(MSY) (the fishing mortality level that would keep the stock at MSY) is estimated to be 1.0, indicating that current fishing mortality level is estimated at the MSY level although there is a large uncertainty surrounding this value as indicated by the confidence interval and Figure 35.

By contrast, the ratio of SSB(current) compared with SSB(MSY) (the spawning stock level that would keep the stock at MSY) is estimated to be greater than 1.0 indicating that the current spawning stock is estimated to be still above the level at MSY.

Table 1. 2004 bigeye stock assessment input data and results.

INPUT DATA						
Catch	Long line and purse seine					
Length Weight	Based on data from IOTC Sampling Schemes					
Growth	$L_{t(cm)} = 169(1-e^{-0.32[t-(-0.336)]})$ (Stequert, 2003 - compared with previous curves in Figure 24)					
Natural mortality	Age 0-1 M=0.8; Age 2+ M= 0.4 (based on the current assumptions in ICCAT bigeye assessments)					
Maturity at age	0-2 year = 0; age 3 = 0.5; age 3+ = 1 (based on ICCAT information)					
Selectivity	Longline: 1961-76, 1977-91, 1992-2002 (Figure 23) Purse seine: 1981-90, 1991-2002 (Figure 23) Developed using Forward VPA approach					
Stock recruitment relationship	Beverton-Holt SRR assumed					
Fishing period	1960-2002					
Area	Whole of Indian Ocean Tropical waters					
CPUE data (graphed in Figures 20,21)	**LL Japan** 1960-2002	LL Japan 1960-2002 / Taiwan,China (1968-2000)	LL Japan 1960-2002 / Taiwan,China (1968-2002)	LL Japan 1960-2002	LL Japan 1960-2002 / Taiwan, china (1968-2000)	LL Japan 1960-2002 / Taiwan,China (1968-2002)
RESULTS						
Model convergence	**C**	C	C	NC	C	NC
Ln(likelihood)	**-109.03**	-139.90	-124.3		-133.81	
R-Squared	**0.921**	0.708	0.62		0.711	
Steepness	**0.99**	0.99	0.99		0.99	
Virgin biomass (1960) (million t)	**0.77**	0.98			0.85	
Spawning Biomass SSB						
SSB 2003 (million t)	**0.21**	0.38	0.70		0.27	
SSB(MSY) (million t)	**0.16**	0.20	0.27		0.18	
B ratio (for SSB)	**1.31**	1.90	2.59		1.50	
Fishing mortality						
F(MSY)	**0.527**	0.467	0.500		0.484	
F(2002)	**0.527**	0.333	0.185		0.441	
F ratio (95% C.I.)	**1.00** **(0.48-1.38)**	0.71	0.37		0.91	
MSY (t) (95% C.I.)	**96,270** **(59,003-120,880)**	113,980	158,208		100,543	

The model indicated that between 1960 and 1988 SSB was generally around 700,000 t. Since the late 1980's SSB has decreased steadily to about 200,000 t as of 2002

Overall, the results suggest that the population is likely to be above the MSY level, but it has been declining since the late 1980s (Figure 25). The fishing mortality is estimated to be currently at the MSY level (Table 1), but recent catches have exceeded the MSY and, therefore, are probably not sustainable.

The recruitment parameters estimated by the model, although poorly estimated, suggest a very weak dependency of the recruitments on the spawning biomass level. There is a slight increasing trend in the estimated recruitments for the period considered (Figure 26), although it was noted that this might be due to a trend in catchability not accounted for in the model formulation.

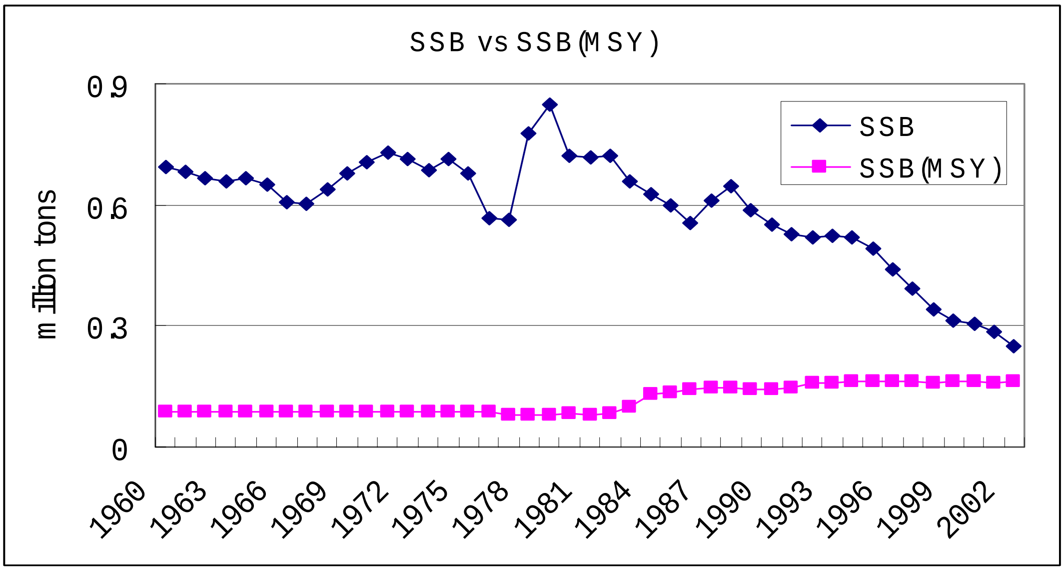


Figure 25. 2004 bigeye stock assessment: spawning biomass trajectories

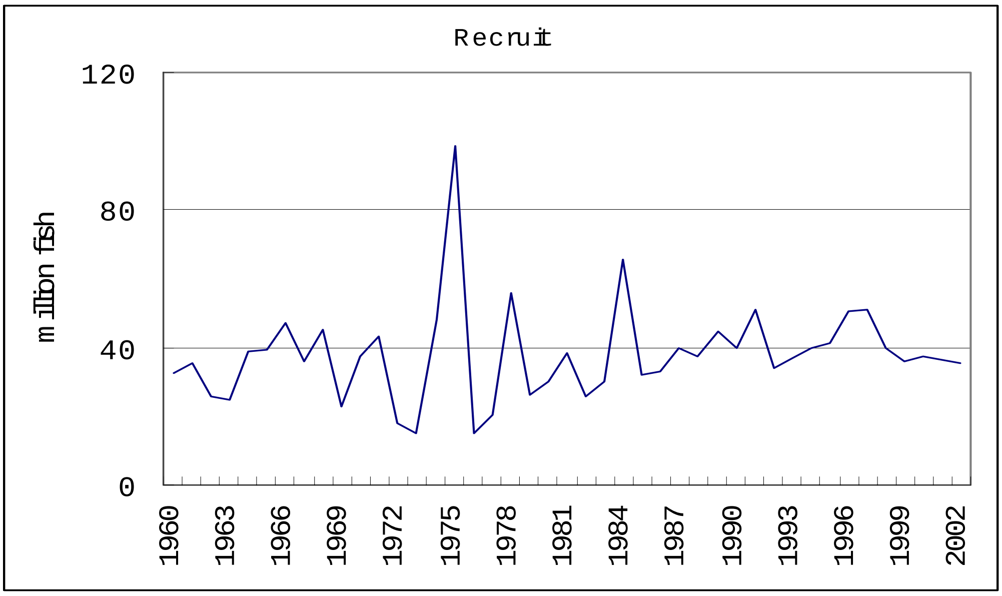


Figure 26. 2004 bigeye stock assessment: recruitment estimates

Current uncertainties in the assessment

A number of uncertainties in the 2004 assessment were identified by the WPTT, including:

Uncertainty about how well the model structure used in the assessment approximates the true dynamics of the population, and about the quality of the estimation of some of the model key parameters.

The lack of adequate size information for the catches of longline fisheries, especially in recent years, which influences the estimation of the catch-at-size and catch-at-age data required to estimate selectivities for the ASPM.

Uncertainty about the conversion form catch-at-size to catch-at-age due to small sample sizes.

Uncertainty about the natural mortality at various life stages, including uncertainty about the functional form of its dependency with age.

Uncertainty about changes in catchability of the different fisheries involved, especially in the longline fishery.

There are still uncertainties concerning the available indices of abundance, particularly as they provide contradictory information about recent trends in the population.

Other assessments

Document IOTC-2004-WPTT-14 described the outcomes from two alternative stock assessment models for Indian Ocean bigeye tuna. The first was an implementation of Deriso's (1998) delay-difference model that explains the effect of fishing into the stock in terms of biomass changes, but predicts the current biomass from the previous biomass and the parameters for survival, growth and recruitment. Both Japanese and combined JAP-TWN abundance indices were applied to it. The stock was assumed to be at equilibrium equal to the virgin biomass in 1950. The model fitted the data reasonably well, although MSY-related quantities were poorly estimated due to the lack of definition of the stock-recruitment parameters.

The second model was an age-structured production model implemented in AD Model Builder. The model utilised a single CPUE series, selectivities by age and year combined for all gears in the fishery, together with the usual biological parameters, to estimate a biomass trajectory starting at the assumed virgin biomass prior to fishing. The model was able to converge and provide useful results when applied to different CPUE series. However, in common with all other models applied, MSY-related quantities were poorly estimated.

Runs conducted using this second model and the ASPM model (under the same specifications) produced similar results. The possible use of alternative stock-recruitment relationships was tested with the model but could not be analysed in detail in the time available. The authors expressed their intention of improving and extending the present implementation given their possibilities.

A length based cohort analysis (Jones method on pseudo-cohorts) using mean catches at size data to estimate the fishing mortality patterns and the stock biomass was undertaken during the meeting (no paper was presented). In this approach, given an estimate of natural mortality, a terminal fishing mortality and the growth curve (Stequert parameters adopted by the WPTT last year), the Jones approximated equation are used to calculate the fishing mortality by size for five periods of five years. The fishing patterns clearly reflect the evolution of the fisheries and in particular first the emergence of the purse fisheries, catching the young fishes and second the dramatic increase of the overall fishing mortality level (Figure 27).

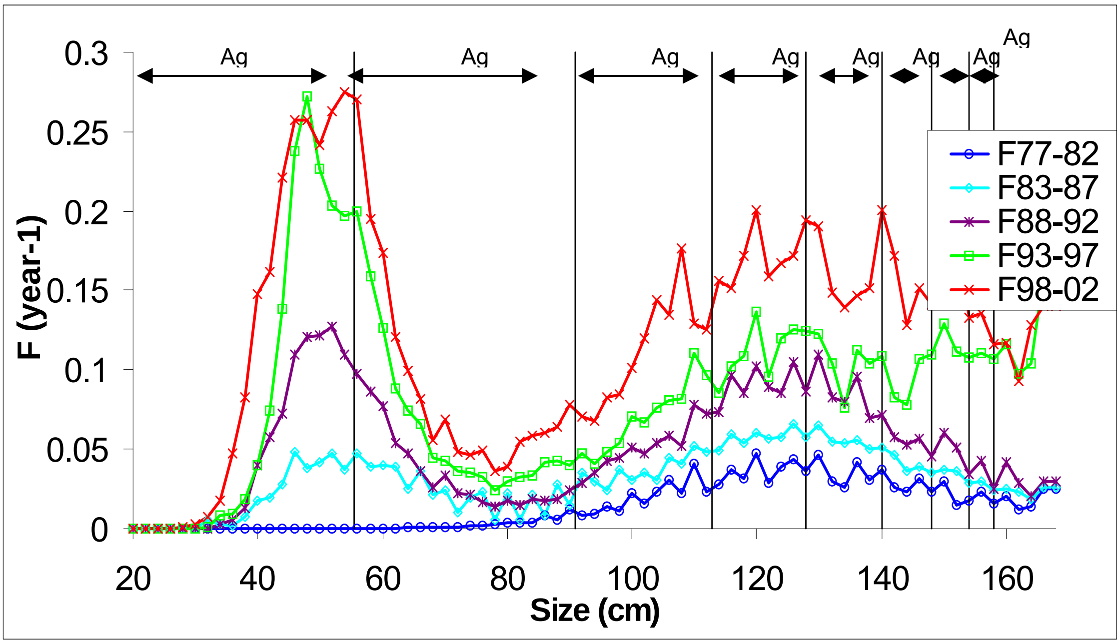


Figure 27. Results of a length based cohort analysis (Jones method on pseudo-cohorts) using mean catches at size data to estimate the fishing mortality patterns and the stock biomass.

Document IOTC-2004-WPTT-16 described a very preliminary attempt to apply MULTIFAN CL to Indian Ocean bigeye tuna. A simple, single region MULTIFAN CL model was fitted to available data. Some of the settings which defined the main assumptions about the model are discussed. Results for runs were most sensitive to the relative weighting of size frequency data and assumptions about catchability associated with the standardised CPUE series; and to a lesser extent the length of the time series and assumptions about natural mortality. Although the preliminary results were promising, the author indicated that further work was required to address a range of areas including the definition of fisheries, length of the data series, input values for biological parameters, priors and penalties. The WPTT recommended that a small group be formed to assist the authors in preparing the specifications of future assessments with this software.

Likely future trends under alternative exploitation scenarios

Forward projections were conducted for the period 2003-2013 on the basis of the results of the ASPM assessment and using the procedure described in the document IOTC-WPTT-04-19, assuming the following three scenarios:

A constant catch scenario, where the catches are maintained at 2002 levels throughout the projected period.

A constant fishing mortality scenario, in which the fishing mortality is assumed to remain constant at the levels estimated for 2002.

An increasing fishing mortality scenario, in which fishing mortality is assumed to continue to increase at a rate of 6 % per year during the projected period.

These scenarios are the same used in the previous assessment.

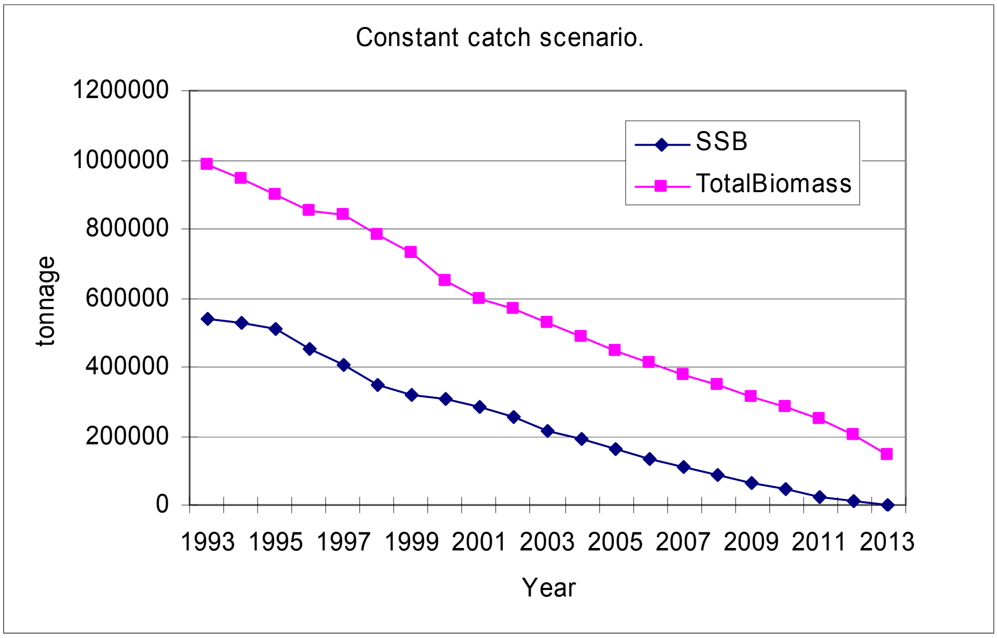


Figure 28. Forward projections. Trends of SSB and TB in current Catch (2002) level using Japanese(1960-2002) CPUE in the whole Indian Ocean.

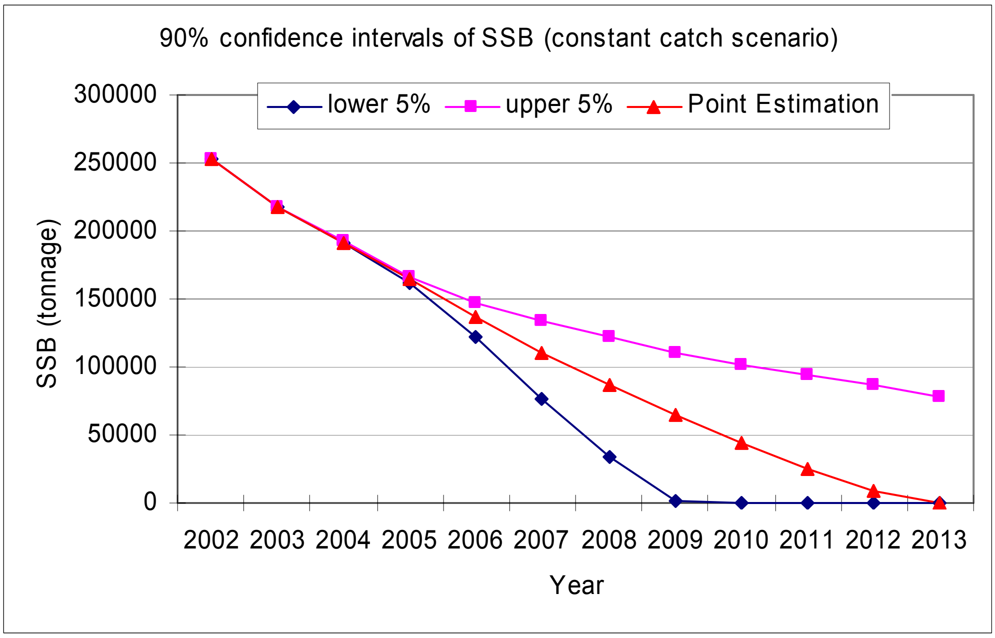


Figure 29. Forward projections. 90% confidence intervals of SSB in the current Catch (2002) level using Japanese CPUE (1960-2002) in the whole Indian Ocean.

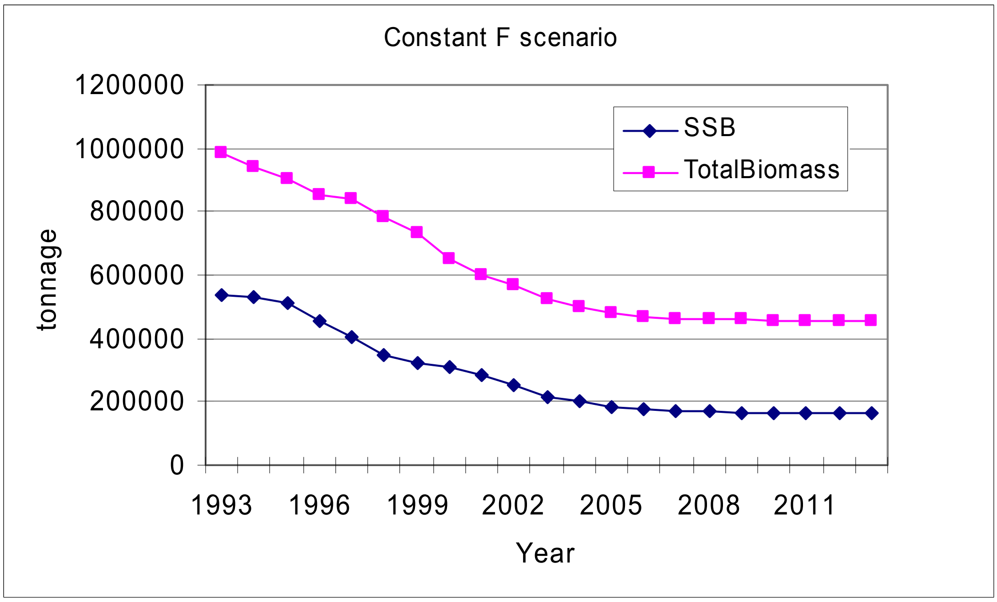


Figure 30. Forward projections. Trends of SSB and TB in current F (2002) level using Japanese(1960-2002) CPUE in the whole Indian Ocean.

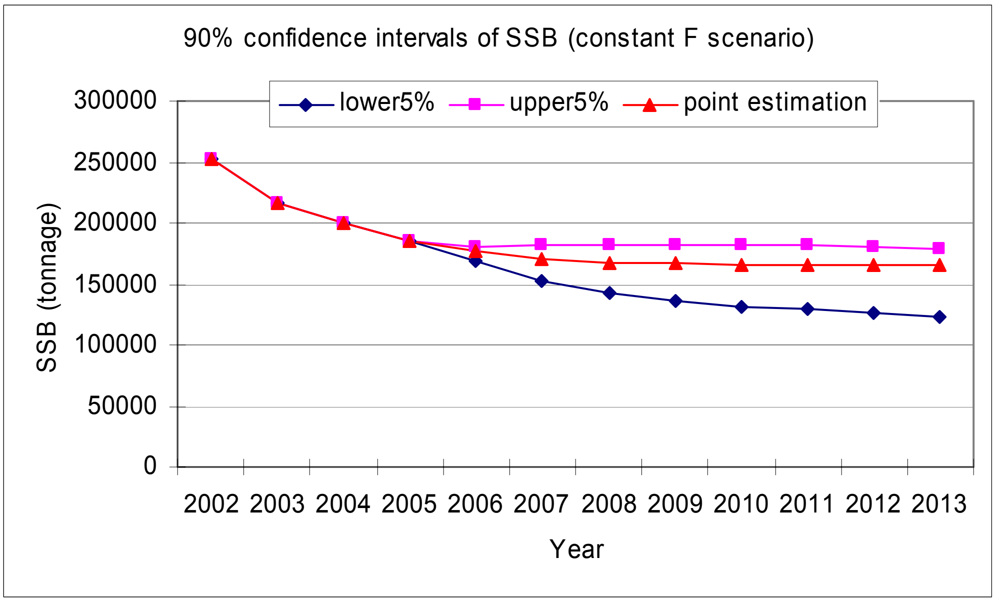


Figure 31. Forward projections. 90% confidence intervals of SSB in the current F (2002) level using Japanese CPUE (1960-2002) in the whole Indian Ocean.

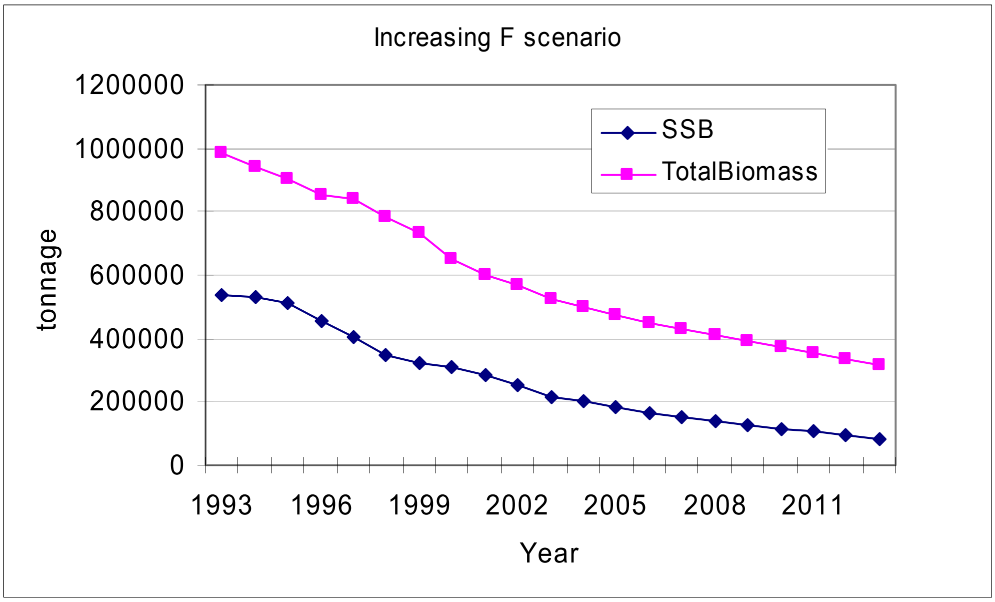


Figure 32. Forward projections . Trends of SSB and TB in increase F (6% per year) using Japanese(1960-2002) CPUE in the whole Indian Ocean..

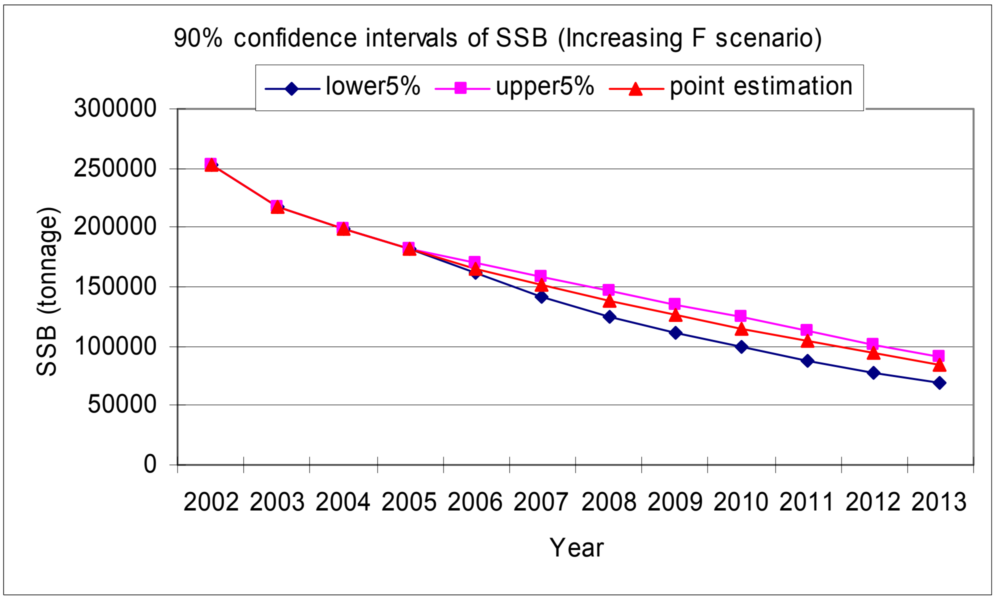


Figure 33. Forward projections . 90% confidence intervals of SSB in the increase F (6% per year) using Japanese CPUE (1960-2002) in the whole Indian Ocean.

The constant-catch scenario predicts the continued steady decline of both the spawning stock biomass and the exploited biomass (Figures 28, 29). This indicates that current catch levels are probably not sustainable.

Projections under the constant F scenario indicate that both the spawning stock biomass and the total biomass would reach equilibrium at the MSY level by around 2008 (Figures 30, 31). This is a direct consequence of the assumed fishing mortality for the projected period that has been estimated by the model to be exactly the fishing mortality level that would produce MSY.

Projections assuming F increases at an annual rate of 6 % per year are similar to those achieved under the constant-catch scenario i.e. a continued steady decline of both the spawning stock biomass and the total biomass (Figures 32, 33). Of particular concern is the predicted reduction of the spawning stock biomass by the year 2013 to below 20 % of the virgin state, a value that is often considered as a limit reference point.

Given that the current assessment suggests that recruitment is almost independent of spawning stock biomass, the results of the projections reflect mostly yield-per-recruit effects, which could also be evaluated using a multi-gear yield-per-recruit analysis such as the one depicted in Figure 34. This figure illustrates the changes in long-term yield-per-recruit that arise from changes in the fishing mortalities (relative to the current fishing mortality). This calculation was done on the basis of the results and assumptions on input values from the ASPM assessment.

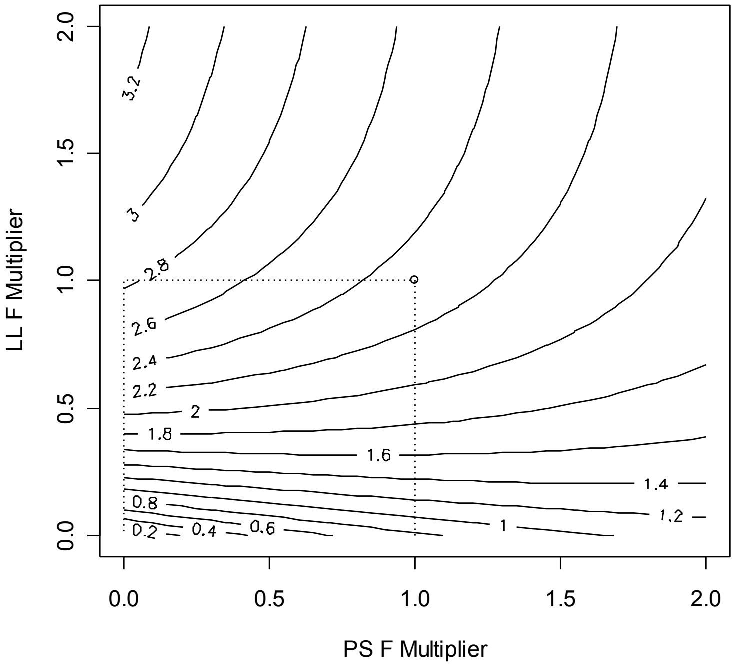


Figure 34. Multi-gear yield-per-recruit calculations, in kg/recruit, with the growth, natural mortality and fishing mortality assumptions from the base case in the ASPM assessment.

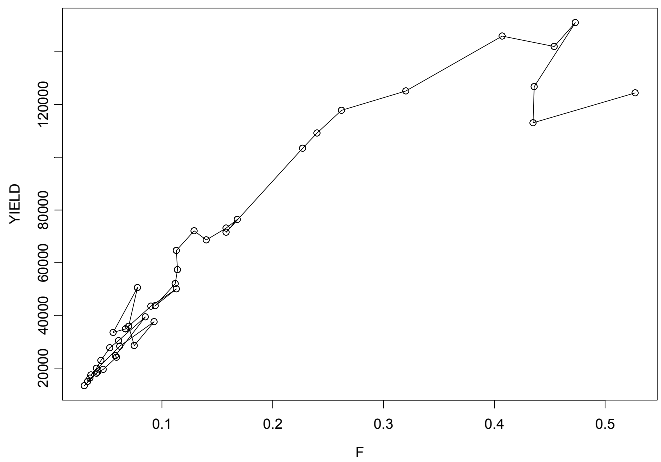


Figure 35. Annual yield (t) as a function of overall fishing mortality as estimated by the 2004 stock assessment.

The WPTT stressed that the caveats and uncertainties expressed about the 2004 assessment apply even more strongly to the results of the projections. The projections indicate what trends in the fishery are possible if the resource was well approximated by the model. Because the resource is not well approximated by the model, the predictions regarding actual catch levels and their rates of change over time should be viewed with considerable caution. For example, the assessment predicts that recruitment is almost constant since, according to the assessment, there is no data on the level of recruitment at reduced spawning biomass levels. If recruitment is actually reduced as a consequence of a decline in spawning biomass in the future, reductions in population levels and on catches will be more pronounced than in the current projections.

Other status indicators

As in past meetings, the WPTT also discussed the evolution of other potential indicators of stock status.

Trends in total catch: After reaching a peak in 1999, catches have been below 140,000 t for the past three years. Reductions in the catch have been recorded in both the longline and purse-seine fisheries (Figure 36).

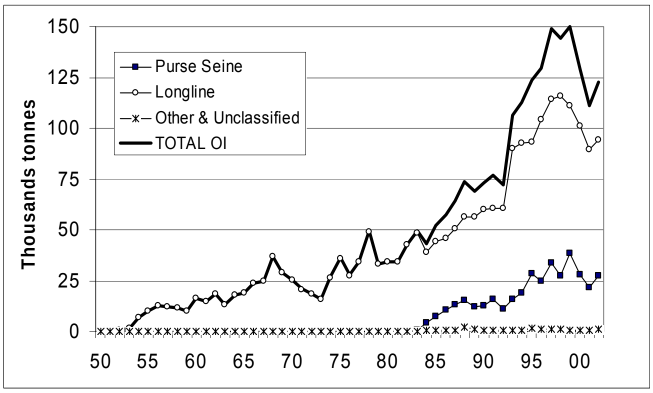


Figure 36. Annual total catches of bigeye tuna by gear type.

Trends in mean weight: Trends in average weight in the catch have shown little change in recent years for both the longline and the purse-seine fisheries (Figure 37).

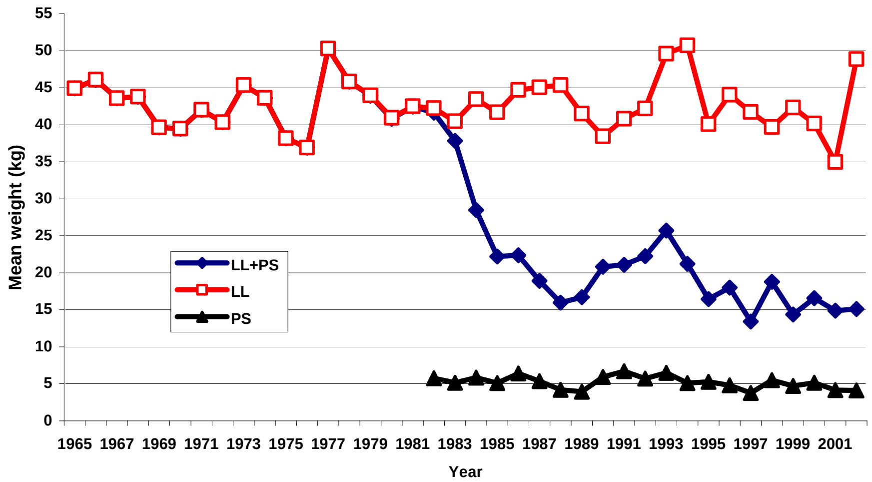


Figure 37. Mean weight of bigeye measured from purse seine (PS) and longline (LL) catches over time.

Trends in catch-per-successful-set: The catch of bigeye per successful set in the major purse-seine fisheries has shown little change in recent years after reaching a peak in 1999 (Figure 38)

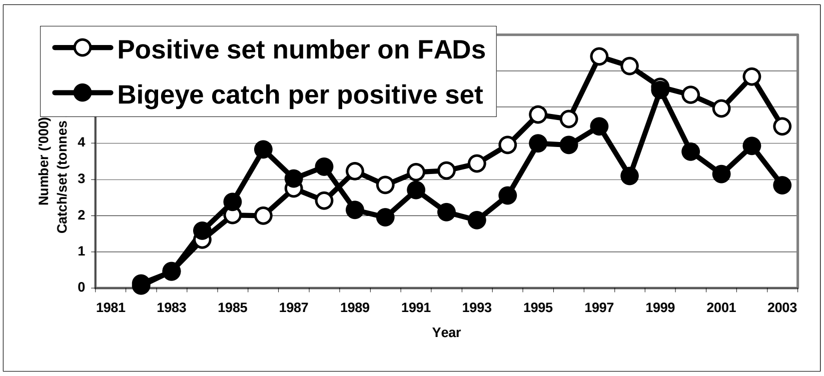


Figure 38. Fishing results for main purse seine fleets fishing in the Indian Ocean

Technical advice for bigeye tuna

The WPTT had already noted with concern the rapid increase of catches of bigeye tuna at its meeting in 1999. Since then, catches have decreased for two of the past three years. Nevertheless, taking into account the results of the current assessment, which represents the best effort to date to analyse the available data in a formal context, it is likely that current catches are still above MSY and it is possible that the fishing effort has exceeded the effort that would produce MSY.

Bearing in mind those considerations, the WPTT recommended that a reduction in catches of bigeye tuna from all gears to the MSY level should be effected as soon as possible, and that fishing effort should be reduced or, at least, it should not increase further.

The WPTT briefly discussed some of the actions that could achieve these goals. Possible means of reducing fishing mortality on juvenile bigeye tuna from the purse-seine fishery on floating objects were discussed by the WPTT in 2003, when it was noted that this measure could also impact catches of skipjack as bigeye tuna is not the main target of the fishery on floating objects.

The WPTT recognized that, given the uncertainty in the relationship between nominal effort and fishing mortality for purse seiners, it will be very difficult to achieve a reduction in catches by attempting to reduce purse-seine effort. An obvious alternative is to control catches of bigeye tuna directly (e.g. by setting catch quotas), but this also poses practical problems, given the difficulty in distinguishing between juvenile yellowfin and bigeye tunas.

In principle, a reduction in longline catches of bigeye tuna could be achieved by reducing the numbers of longline vessels operating in the Indian Ocean. However, the WPTT noted that a number of longline fleets operating in the Indian Ocean were targeting temperate tuna or billfish, and therefore taking at most only a very small bycatch of bigeye tuna. Even for the longline fleets targeting tropical tunas, bigeye tuna almost always represent a minority of the catch. Thus a blanket management measure such as this could reduce the longline catches of other species.

YELLOWFIN TUNA

Status Indicators

Trends in total catch: Although compilation of the 2003 fishery data is not yet complete, it is clear that yellowfin catches in the Indian Ocean were extraordinarily high during 2003. It is expected that 2003 will be a record year (in excess of 500,000 t) once the catches from all fleets are reported. This exceeds the previous peak of 386,000 t in 1993, and is a marked change from the declining trend in catches from 1992 to 2002 (Figure 39).

Trends in catch per unit effort: Japanese longline CPUE has been variable but without obvious trend over the last 20 years (IOTC-2004-WPTT-17), with the exception that CPUE in the tropical west Indian Ocean area increased to its highest recorded level in 2003 (Figure 40). Purse seine catch rates (especially those in the south Seychelles area) in 2003 are the highest recorded (Figures 41, 42).

Trends in mean weight: Mean weight of yellowfin taken by purse seiners has declined since 1993, but shows an increase in 2003 (Figure 43).

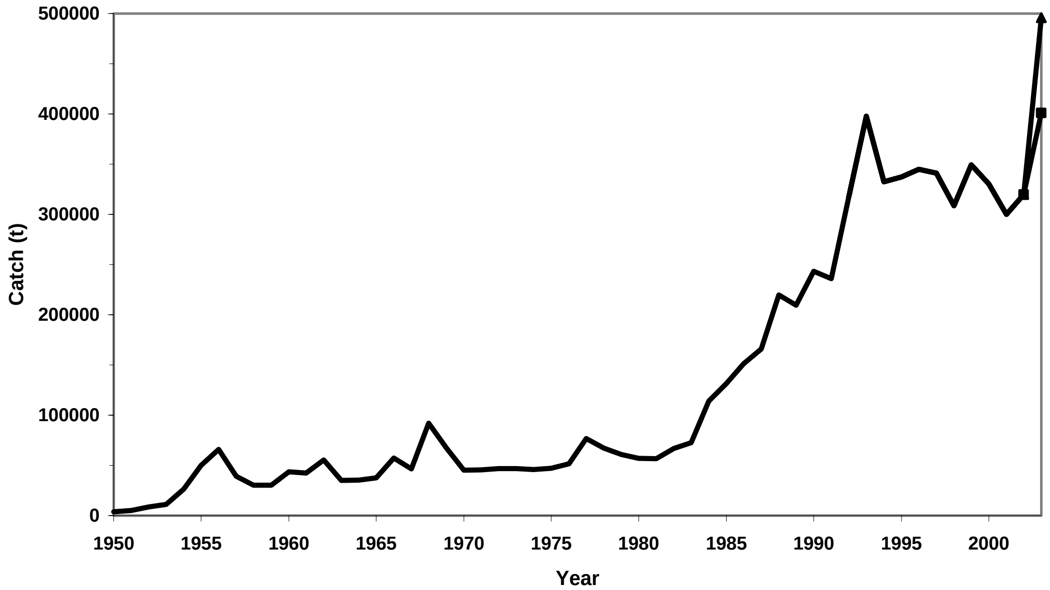


Figure 39. Total yellowfin catch over time

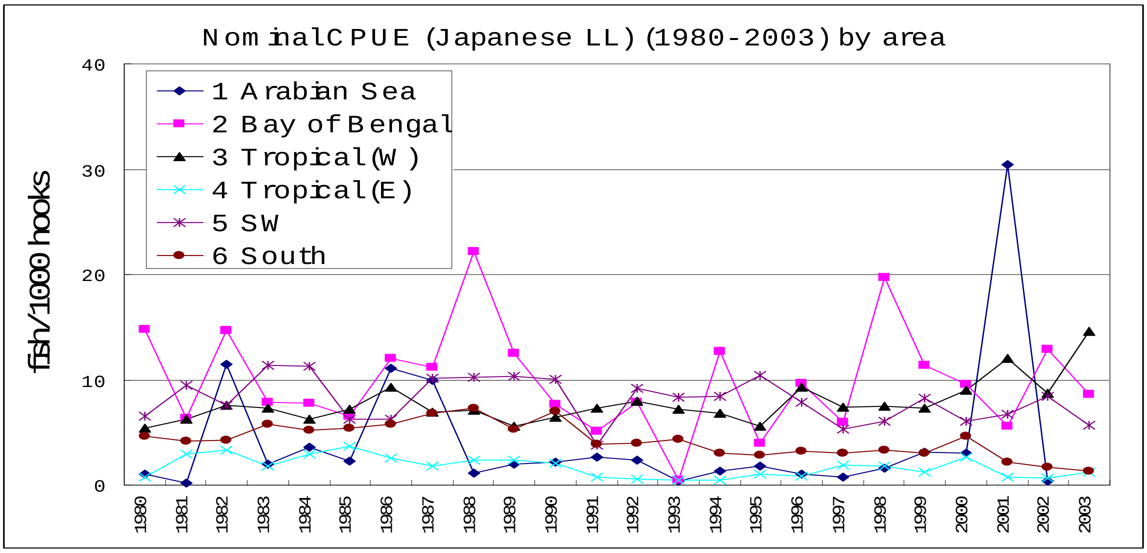


Figure 40. High catch rates of yellowfin tuna in 2003. Annual Japanese longline catch rates showing increased catch rates in Tropical west in 2003.

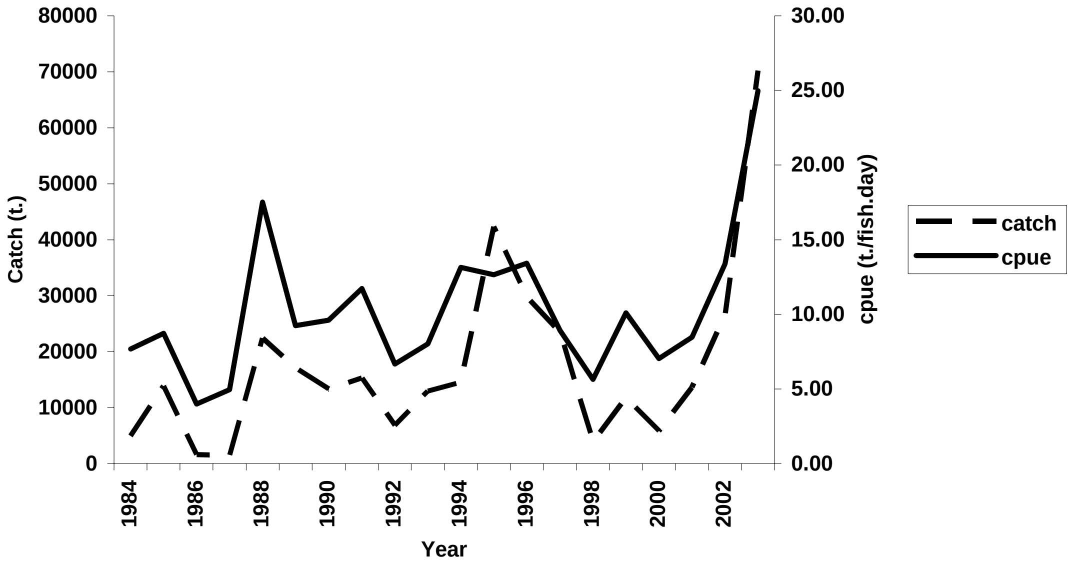


Figure 41. Yellowfin catches by purse seine in the south Seychelles area

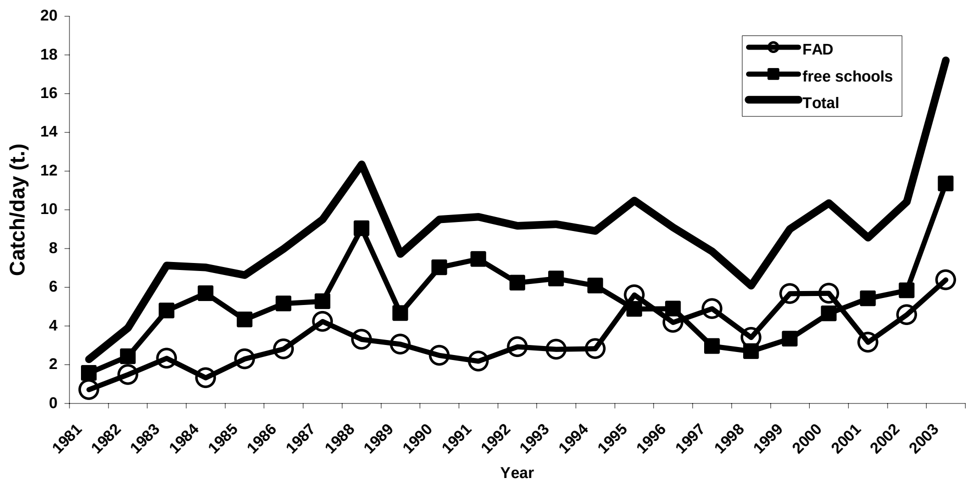


Figure 42. Annual yellowfin catch rates by the FAD and free school purse seine fisheries and purse seine fisheries overall.

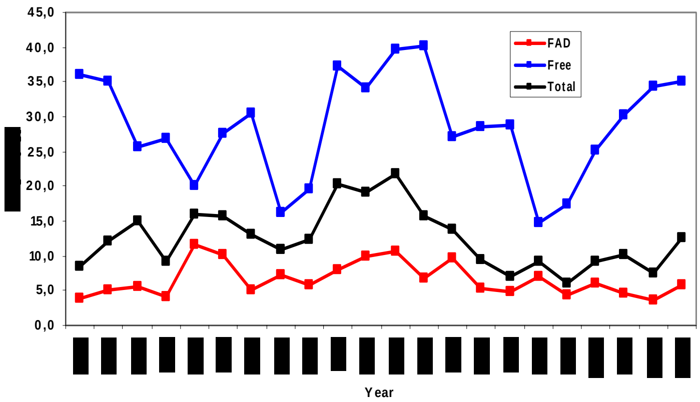


Figure 43. Mean weight (kg) of yellowfin catch rates by the FAD and free school purse seine fisheries and purse seine fisheries overall.

Analysis of the exceptional catches of yellowfin tuna in 2003

Although compilation of the 2003 fishery data is not yet complete, it is clear that yellowfin catches in the Indian Ocean were extraordinarily high during 2003. It is expected that 2003 will be a record year once the catches from all fleets are reported to the IOTC Secretariat.

The 2003 event has been analysed in document IOTC-2004-WPTT-02, using the complete fishery data available from the major fleets of purse seiners. This document provided a preliminary estimate of the 2003 yellowfin catch by purse seiners at over 200,000 t, and discussed the causes and consequences of such a very high catch. It appears that while the 2003 fishing effort and fishing zones were similar to those in previous years, extraordinary high catches of yellowfin catches were taken in a particular area south and SW of Seychelles. A range of information was examined in an attempt to better understand this event.

IOTC-2004-WPTT-17 reported a preliminary analysis of the Japanese longline catch, effort and CPUE data. It appears that unusually high yellowfin catches were also experienced by longliners in the tropical western Indian Ocean area (north of 15°S to 10°N) (Figure 40). An analysis of the fishery in 2003 revealed local anomalies in effort, catch and CPUE (relative to the mean levels observed in the fishery for the period 1998-2002), and these are consistent with the hypothesis of a concentration of yellowfin tuna. This area of concentration coincides with the area of high catches identified for the purse-seine fishery.

The WPTT discussed the possible hypotheses explaining the observed high catches, noting that it is possible that a combination of factors were responsible for this event. There are two main categories of factors:

An increase in catchability due to a concentration of the resource, and an increase in the fishing efficiency:

It is possible that due to some unexplained environmental conditions, large yellowfin tuna aggregated over a relatively small area, so that it became easier to catch them in large quantities. For the purse seine fishery, catches may have been amplified due to the use of new sonar technology that enables vessels to find schools that were previously not detected on the surface (see below). The presence of large concentrations of the crustacean *Natosquilla investigatoris*, reported to have occurred in large quantities in various locations of the Indian Ocean was also cited as possible reason for the unusual concentrations of yellowfin tuna, as they were observed feeding voraciously on the *Natosquilla* concentrations. On the other hand, it was also noted that this surface concentrations of prey would not necessarily increase the availability of fish for the longline fishery.

By the end of 2002, most purse seine vessels had new sonar equipment installed. Apparently these devices enable skippers to locate schools at distances up to 5 km, night and day. This means that schools are more vulnerable to fishing, and catches could be expected to increase. However, there is no indication of similar increases in efficiency in the Atlantic Ocean, where vessels were also fitted with the same equipment. More information is needed to understand this factor.

Increase in the biomass of the population:

According to this hypothesis, large recruitments to the population in 1998-1999 (fish around 120 -140 cm FL) would be responsible for the large increase in yellowfin catches. In 1998-1999 an oceanographic event occurred in the Indian Ocean, creating environmental conditions that in other oceans have been associated with good recruitment. The high catches 120-140 cm FL yellowfin tuna by both the purse-seine and longline fleets supports this hypothesis, as do informal reports of exceptionally high catches by the commercial and artisanal fisheries from Yemen, Oman and Maldives. If these reports are confirmed, they indicate that the event took place over much larger area than data from the purse-seine and longline fisheries suggest.

The WPTT noted there is no evidence from existing data of unusually large numbers of small fish being caught in the surface fisheries prior to 2003. However, the ability to detect this from size-frequency sampling during 1998-2000 may have been reduced due to the low level of sampling from areas traditionally associated with small yellowfin tuna.

The WPTT concluded that the information available at this time does not allow a firm conclusion to be reached about the factors contributing to the exceptional catches of yellowfin tuna in 2003. The WPTT recommended that the Secretariat to continue its efforts to better understand the event by and obtaining data from all fisheries, in particular the artisanal fisheries, and encouraged national scientists to continue analyses of their fisheries and environmental data and report results in future meetings.

Considering the implications of event, the WPTT expressed its desire to better understand the situation and recommended that the following work be undertaken:

Enhancement of the catch, effort and size frequency databases for yellowfin, especially for the major artisanal fisheries such as Yemen.

Monitoring of yellowfin catches by size taken by purse seiners and longliners in 2004.

Development of a database containing environmental information (sea surface temperature, thermocline depth, phytoplankton, prey species etc) for the western Indian Ocean. This information should be analysed, in combination with results from stock assessment models, in an attempt to better understand the reasons for the large yellowfin catches in 2003.

Investigation of the effects that the new long range sonar have on the efficiency of the European Union purse seiners (for both FAD and free school sets).

A critical examination of yellowfin year class strength estimates.

Investigation of changes in the geographical of adult yellowfin distribution (using data from longline, purse seine and artisanal fleets fishing in the western Indian Ocean) with a view to identifying areas of concentration (as these may increase catchability).

A critical review of all the hypotheses that could explain the very high 2003 catches of yellowfin.

Technical advice on yellowfin tuna

The WPTT did not conduct a formal assessment of yellowfin tuna during this meeting. However, it discussed possible explanations for the exceptional catches recorded in 2003.

The WPTT noted that there could be serious consequences if the hypothesis that there was only an increased catchability during 2003 is correct. In this case, the very large catches would represent a much higher fishing mortality and, certainly, would not be sustainable. Furthermore, they would lead to a rapid decline of the existing adult biomass of yellowfin tuna and a serious over-exploitation of the stock, according to the status of yellowfin tuna as assessed in 2002. If such is the case, urgent management actions might be needed to reduce fishing mortality.

4. Research Recommendations and Priorities

4.1. General

The WPTT noted recent work to better interpret longline CPUEs for tunas and tuna-like species, and in particular, better understand the factors that influence them. However, there is still considerable work to be done in this area and scientists are encouraged to continue their work.

The WPTT also noted the general lack of CPUEs indices for all surface fisheries (e.g. purse seine, baitboat, gillnet), and urges researchers to develop these indices, and thereby improve understanding of the changes that occur in the juvenile components of the stocks.

To improve understanding of both the impact of tuna fishing on the ecosystem functioning and the consequences that climate changes may have on ecosystem structure and hence on tuna stocks, WPTT recommended that ecosystem modelling including detailed tuna population dynamics be attempted for the Indian Ocean. Research on the influence of top predators on ecosystem functioning including field work, retrospective data analysis and modelling is also encouraged. Researchers interested in this area of work should be aware of (and if possible, collaborate with) the international project GLOBEC-CLIOTOP (refer to Section 7).

Scientists are encouraged to continue to collect information on predation, to incorporate the effects of the predation into stock assessments, and to develop research on possible mitigation measures.

Considering the extraordinary large catches of yellowfin in 2003, the WPTT expressed its desire to better understand the situation, and encouraged researchers to enhance the catch, effort and size databases for this species, specially for the major artisanal fisheries e.g. Yemen.

As many stock assessment new models often take days to be tuned and run, the WPTT stressed the importance of getting all data in advance of the annual WPTT meeting so scientists can prepare their assessments in good time. The WPTT proposed that all the complete set of 2003 data be made available to the Secretariat by the end of February 2005.

4.2. Statistics

All parties with significant gillnet fisheries catching tropical tunas are requested to make every possible effort to collect detailed catch, effort and size frequency statistics on their fisheries and to improve the flow of information to the IOTC Secretariat.

The WPTT recommended that the IOTC Secretariat continue its efforts to retrieve historical records on logbooks as well as individual weights of tuna and tuna-like species from landings of fresh tuna longliners to Indian Ocean ports.

All parties with longline vessels fishing for tropical tunas in the Indian Ocean are requested to make every possible effort to improve their logbook and size sampling coverage.

The WPTT noted that good progress has been made through the IOTC-OFCF Project to describe the data collection and processing systems for tropical tuna species in a range of countries. The WPTT strongly recommended that the IOTC-OFCF Project be continued, given the success of the Project to date.

The WPTT encourages all countries reporting statistics to the IOTC, to provide summary descriptions of how the catches and/or effort and/or size frequency were generated for each fishery, as well as a description of the data collection and processing systems for tropical tuna species implemented in their country.

The WPTT noted with satisfaction that some countries have started to collect information on discards, and reiterated their request to other parties having fisheries likely to have tropical tunas discarded, to improve the collection and reporting of discard statistics to the IOTC.

The WPTT stressed the importance of obtaining statistics from the former Soviet Union purse seiners, and encouraged all parties to contribute in any way to obtain these.

The WPTT acknowledged the research contribution from Taiwanese scientists and especially welcomed the plan to improve the data quality of their fisheries data, as they are an essential component of the data needed for the assessment of tuna resources in the Indian Ocean.

The WPTT recommended that a the Secretariat conduct a mission to Yemen, possibly under the auspices of the IOTC-OFCF project, to improve the knowledge on its fisheries.

4.3. Stock Assessment

While some progress has been achieved, all scientists are encouraged to continue research on the standardization of longline CPUE, including studies to differentiate regular and deep longline sets, estimate the changes in fishing efficiency, improve the knowledge on targeting practices by skippers, and examine the effects of environmental factors.

The WPTT also noted the necessity to get more information on historical and recent changes in fishing practices and gear technology for all fisheries, including the use of FADs and electronic equipment. This will enable researchers to better evaluate the relationship between CPUEs and abundance.

Scientists are encouraged to continue research to develop reliable indices of abundance for tuna associated with fish aggregating devices.

The WPTT noted the programmes being set up by EU and Australian scientists to develop operational models and simulation models, and encouraged their application to Indian Ocean tropical tunas.

The WPTT noted recent and ongoing work to estimate biological parameters such as growth and sex ratio, and encourages researchers to continue work in this area.

The WPTT encourages researchers to include ecosystem information into stock status evaluations.

The WPTT encourages researchers to examine the spatial distributions of tropical tunas in the Indian Ocean in order to better define tropical tuna habitats.

As new stock assessment models (such as MULTIFAN CL) are highly dependant on a large range of input parameters and flags (how the model is structure, which parameters are estimated and how penalties are dealt with). The WPTT recommend that a small group of scientists be convened to assist in the preparation and definition of the inputs and flags to be used in such stock assessments models.

4.4. Tagging

The WPTT noted the good progress of the IOTTP, as well that as of the various pilot and small scale tagging operations promoted and planned by the IOTC in various countries. And encouraged researchers to continue there work on this topic as tagging results will be essential to run an improved and more reliable stock assessment of BET, YFT and SKJ stocks in the Indian Ocean.

The WPTT recalled its previous recommendation that it will be essential to run the tagging operations in both sides of the Indian Ocean simultaneously and at equivalent levels; and noted the need for a large scale tagging programme in the eastern Indian Ocean.

The WPTT also supports the various technical recommendations by the WPT that promote the efficient planning and implementation of tagging operations, as well as of recovery of tags and data analysis. The WPTT also reiterated the need to obtain the active cooperation of all the countries involved in the Indian Ocean tuna fisheries.

4.5. Bigeye Tuna

The WPTT recommended that researchers to continue to progress the development of a standardised CPUE for the Taiwanese longliners using the two approaches determined by the small working party and outlined in Appendix V.

4.6. Yellowfin Tuna

Taking note of the problems which arose during the last yellowfin working group regarding the models used/agreed, and in order to improve the efficiency of the next assessment, the WPTT encourages scientists to agree on the methods and inputs to be used and prepare this work before the venue of the working group.

Taking note of the extraordinary catches of yellowfin observed in 2003, the WPTT expressed its concern on the consequences it may have for the stock and consequently recommends that the following actions be implemented:

Carefully follow the yellowfin catches by size taken by purse seiners and as far as possible by longliners in 2004.

Update the biological information on yellowfin growth, spawning and sex ratio at size in the eastern and western Indian Ocean.

Build a database with environmental information (sea surface temperature, thermocline depth, phytoplankton, Natosquilla, others?) in the western Indian Ocean and analyse this data base (including results from models) in order to understand the origin of the large yellowfin catches in 2003.

Understand and evaluate the potential effects on the European Union purse seiners efficiency (for FAD and free schools) of the new long range sonar.

Estimate the potential recent changes in year class strength of yellowfin.

Evaluate the changes in the 2003/2004 overall geographical distribution (from longline, purse seine and artisanal fleets data) of adult yellowfin stock and identify concentration areas in the western Indian Ocean, as this concentration may tend to increase catchability.

Analyse and synthesize all the hypothesis that could explain the very high 2003 catches of yellowfin.

Run a full stock assessment that will evaluate the yellowfin stock status in 2003, including a retrospective analysis.

Further research on methods leading to the standardization of longline (regular and deep longline differentiation, targeting, changes in fishing efficiency) and purse seine (FAD vs. free schools, changes in fishing efficiency) CPUEs needs also to be done in the case of yellowfin.

4.7. Skipjack Tuna

An important potential problem in the skipjack fisheries is the interaction between industrial and artisanal fisheries, in particular between the western Indian Ocean purse-seine fishery and the Indian and Maldivian baitboat fishery. Countries with artisanal fisheries for skipjack tuna should make a special effort to submit data on these fisheries to the IOTC in order to improve understanding of the interactions. However, the WPTT recognizes that only a tagging programme would provide the necessary data to better estimate the level of the interactions.

5. other business

5.1. Background on a new international research programme to investigate climate impacts on oceanic top predators

The WPTT was briefed on a new international research programme, CLIOTOP (CLimate Impacts on Oceanic TOp Predators), which is being developed as part of the IGBP (International Geosphere Biosphere Programme) core project GLOBEC (GLOBal ECosystem dynamics http://www.globec.org).

CLIOTOP aims to develop a collaborative international research effort to a better understand open ocean pelagic ecosystems dynamics in which top predators including tunas are living. The main goal of the project is to improve our understanding of oceanic top predators within their ecosystems and ultimately to develop a reliable predictive capability of their dynamics.

CLIOTOP focuses on retrospective and modelling worldwide comparative studies (between areas, regions, oceans and species) of ecosystem dynamics submitted to both fishing pressure and climate variability and change. It is based on the idea that the variety of climatic and oceanographic conditions in the three oceans provides a unique opportunity for large scale comparative analyses of open ocean ecosystem functioning.

CLIOTOP is organized around the following five working groups that cover the key processes and scales:

- Early life history of top predators
- Physiology, behaviour and distribution
- Trophic pathways in open ocean pelagic ecosystems
- Synthesis and modelling
- Socio-economic aspects and management strategies

Each working group will focus on a set of key questions relevant to the programme's objectives, and work strategically to address those questions. Each working group will organise workshops and meetings focusing on their specific area. More general science meetings and symposia will bring together all the working groups and all interested scientists will be welcome to attend these meetings.

5.2. Study of marine *birds* as indicators of pelagic ecosystems health

The WPTT was briefed about a new research project recently prepared by an international team of bird scientists. The project, focusing on the Western Equatorial Indian Ocean area, will investigate marine birds (shearwater and tern) as indicators of pelagic ecosystems health. One of the goals of the programme will be to evaluate if and how the recent declines of tuna biomass in the ecosystem (due to increasing catches by fisheries), have affected the structure of sea bird populations.

Acknowledging the potential for seabirds to be indicators of ecosystem functioning, the WPTT agreed that the results would be of interest to IOTC scientists and expressed its support for the programme.

5.3. Invitation to host *the* seventh meeting of WPTT in Thailand

The WPTT unanimously accepted the invitation from the Thailand authorities to host the next meeting and agreed that, pending confirmation by the Scientific Committee, the next meeting will take place in Phuket, Thailand, in June 2005.

6. Adoption of the report

The Report of the Sixth Session of the Working Party on Tropical Tunas was adopted on July 20th 2004.

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APPENDIX II. AGENDA OF THE MEETING

1. Review the statistical data for the tropical tuna species and the situation in reporting countries on data acquisition, for reporting to the WPDCS.
2. Review new information on the biology and stock structure of tropical tunas, their fisheries and related environmental data.
3. Review of new information on the status of bigeye tuna.
   3.1. Stock status indicators.
   3.2. Undertake stock assessment for bigeye tuna.
4. Develop technical advice on management options, their implications and related matters with priority given to the situation of bigeye tuna.
5. Review of new information on the status of yellowfin and skipjack tunas.
   5.1. Analysis of the exceptional catches of yellowfin tuna in 2003.
6. Consider the question of the optimum fishing capacity of the fishing fleet.
7. Identify research priorities, and specify data and information requirements, necessary for the Working Party to fulfil its responsibilities.
8. Any other business
9. Adoption of the Report

APPENDIX III. LIST OF DOCUMENTS PRESENTED TO THE MEETING

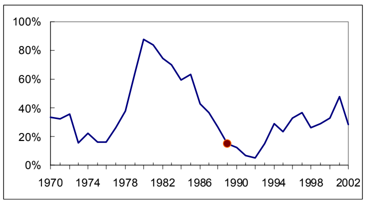
DOCUMENTS	TITLES
IOTC-2004-WPTT-01	Status of IOTC databases for Tropical Tunas. *IOTC Secretariat*
IOTC-2004-WPTT-02	The Indian Ocean yellowfin stock and fisheries in 2003: overview and discussion of the present situation. *Fonteneau Alain, Javier Ariz, John Peter Hallier, Vincent Lucas and Pilar Pallares*
IOTC-2004-WPTT-03	Daily age of skipjack tuna, *Katsuwonus pelamis* (Linnaeus), in the eastern Indian Ocean. *Sadaaki Kayama[1], Toshiyuki Tanabe[2], Miki Ogura[2], Hiroaki Okamoto[2], and Yoshiro Watanabe[1]*
IOTC-2004-WPTT-04	Survey on some biological aspects of yellowfin *(thunnus albacares)* and skipjack *(Katsuwonus pelamis)* tunas in the Oman Sea (sistan-O-Baluchistan Province). *Dr Farhad Kaymaram and Mr Seyed Abbas Hosseini*
IOTC-2004-WPTT-05	Reproductive Biology of Bigeye Tuna in the Eastern Indian Ocean. *Praulai Nootmorn*
IOTC-2004-WPTT-06	Disaggregation of catches recorded under aggregates of gear and species in the IOTC nominal catches database. *IOTC Secretariat*
IOTC-2004-WPTT-07	French purse-seine tuna fisheries statistics in the Indian Ocean, 1981-2003. *R. Pianet[1], Viveca Nordstrom[2] and Patrice Dewals[3]*
IOTC-2004-WPTT-08	Purse Seine Statistics. *R. Pianet*
IOTC-2004-WPTT-09	Updated stock assessment of bigeye tuna *(tunnus obesus)* resource in the Indian Ocean by the age structured production model (ASPM) analyse to 2002. *Tom NISHIDA, and Hiroshi SHONO*
IOTC-2004-WPTT-10	Reviews and prospects on approaches reflecting actual dynamics of Taiwanese longline fisheries in CPUE standardizations when number of hook per basket information not available. *Tom NISHIDA[1] Ying-Chou LEE[2] Chien-Chung HSU [3] and Shui-Kai CHANG [4]*
IOTC-2004-WPTT-11	Observers trips carry out by the instituto Espanol de Oceanografia during in the Indian Ocean in 2003. *J. Ariz, A. Delgado de Molina, P. Pallarés y J.C. Santana*
IOTC-2004-WPTT-12	Logbooks system to collect information on the supply vessels associated to the purse seine fleet. *A. Delgado de Molina, J. Ariz y P. Pallarés*
IOTC-2004-WPTT-13	Statistics of the purse seine Spanish fleet in the Indian Ocean (1984-2002). *Alicia Delgado de Molina, Pilar Pallarés, Juan José Areso y Javier Ariz*
IOTC-2004-WPTT-14	Alternative stock assessments for Indian Ocean Bigeye tuna using delay-difference and age-structured models. *Iago Mosqueira, Pilar Pallarés y Alicia Delgado de Molina.*
IOTC-2004-WPTT-15	Standardisation of size-based indicators for bigeye and yellowfin tuna in the Indian Ocean. *Marinelle Basson & Natalie Dowling*
IOTC-2004-WPTT-16	A very preliminary attempt to apply Multifan CL to Indian Ocean bigeye tuna. *Marinelle Basson*
IOTC-2004-WPTT-17	Preliminary investigation of the high catch (2003) of yellowfin tuna (Thunnus albacares) in the tropical western Indian Ocean based on the Japanese longline data. *Tom NISHIDA, and Yukiko SHIBA*
IOTC-2004-WPTT-18	Standardized Japanee longline CPUE for bigeye tuna in the Indian Ocean up to 2002 with consideration on gear categorization. *Hiroaki OKAMOTO, Naozumi MIYABE and and Hiroshi SHONO*
IOTC-2004-WPTT-19	Future projections for bigeye tuna in the Indian Ocean. *Hiroshi SHONO, Tsutomu NISHIDA and Hiroaki OKAMOTO*
IOTC-2004-WPTT-20	Standardized Taiwanese longline CPUE for bigeye tuna in the Indian Ocean up to 2002 applying targeting index in the model. *Hiroaki OKAMOTO[1], Shui-Kai CHANG[2],Yu-Min YEH[3] and Chien-Chung HSU[4]*
IOTC-2004-WPTT-21	Trend in the activities of Industrial fishing vessels licensed to operate inside the Seychelles EEZ (1995 - 2003). *Vincent Lucas SFA*
IOTC-2004-WPTT-22	Report of the predation survey by the Japanese commercial tuna longline fisheries (September, 2000 – December, 2002). *Tom Nishida[1] and Yukiko Shiba[2]*
IOTC-2004-WPTT-23	FLR: A framework for fisheries science and management in the R statistical language. *Mosqueira, I.[1], Kell, LT[2]*

IOTC-2004-WPTT-24	Comparison of growth parameters of yellowfin tuna caught from Arabian Sea and Bay of Bengal. *V.S Somvanshi, S. Varghese, A.k. Bhargava and Sijo P. Varghese*
IOTC-2004-WPTT-25	Tuna catches from commercial operations and average weight of YFT in Exploration. *S. Varghese, V.S Somvanshi, P.C. Rao and A.S. Kadam*
IOTC-2004-WPTT-26	Predation on yellowfin tuna in the longline catches from Indian waters. *V.S Somvanshi, and S. Varghese*
IOTC-2004-WPTT-INF01	Separation of the Taiwanese regular and deep tuna longliners in the Indian Ocean using bigeye tuna catch ratiosm. *Ying-Chou Lee*[1*], *Tom Nishida*[2] *and Masahiko Mohri*[3]
IOTC-2004-WPTT-INF02	Tuna natural mortality as a function of their age: the bigeye tuna case. *Alain Fonteneau*[1] *and Pilar Pallares*[2]
IOTC-2004-WPTT-INF03	A comparison of Bigeye stocks and fisheries in the Atlantic, Indian and Pacific Oceans. *Alain Fonteneau, J. Ariz, A. Delgado, P. Pallares and R. Pianet*
IOTC-2004-WPTT-INF04	Age and growth of bigeye tuna (Thunnus obesus) in the eastern and western AFZ. *Jessica H. Farley, Naomi P. Clear, Bruno Leroy, Tim L.O. Davis, Geoff McPherson*
IOTC-2004-WPTT-INF05	The development of an operational model and simulation procedure for testing uncertainties in the Atlantic bigeye (thunnus obesus) stock assessment. *Pilar Pallarés, Mariá Soto, D. J. Die, D. Gaertner, I. Mosqueira and L. Kell*

APPENDIX IV. THE DATA COLLECTION SYSTEM USED BY THE TAIWANESE LONGLINE FLEET, AND THE PROCESS USED TO RAISE THE LOGBOOK DATA TO ESTIMATE TOTAL CATCH.

Dr Chang gave the following presentation on the Taiwanese tuna statistics system in response to observations about discrepancies between nominal catch (NC) by species and catch estimates from catch and effort data (CE) in the Taiwanese data (refer also the General Discussion on Statistics section).

Coverage of logbooks



1. Logbooks from the Taiwanese tuna longline fleet have been collected since late 1960s, but the coverage has not been sufficient to justify their use to estimate NC.

Two different data systems

- Commercial data – for estimation of Nominal Catch (NC)
  - traders' sales record,
  - verification of fishing vessels' sales settlement,
  - certified weight reports of New Japan Surveyors and Sworn Measures Association, NJSSMA
  - verification records by Taiwan Tuna Boatowners and Exporters Association.
- Logbook data – for estimation of Catch and Effort data (CE)

2. Therefore, two major data sources have been developed: one is the trading information (commercial data from four sources) that is used to estimate NC ; the other is the logbooks, which are used to estimate CE.

Raising of logbook data

- Coverage of logbook is not enough for estimation of NC directly
- Raise logbook data to obtain CE data
  - Species composition
  - CPUE by species
- Calculate common raising factor (constant)
  - Based on the major species
    - ALB, BET, YFT in the past
    - ALB, BET, YFT, SWO currently

3. The Taiwanese logbook data (LB) are reviewed and verified using several procedures, then raised to NC for creating the CE. To retain the information on species composition and CPUE by species (between LB's and the CE), a common raising factor is applied to the catches of all the species and the effort from the LB. The common factor is obtained by dividing the catch of the major species from LB by that from NC (the major species covered are albacore, yellowfin and bigeye tunas, and more recently swordfish).

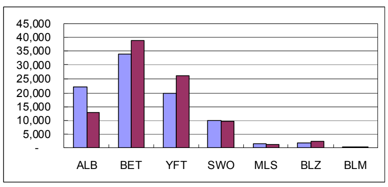
Raising of logbook data

1. $Cov_i = LB_i / NC_i$,   i: the major species
2. Cov = average of Cov_i
3. $CE_k = LB_k / Cov$ k: all the species

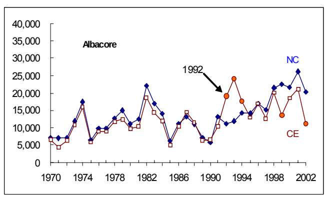
	ALB	BET	YFT	SWO	MLS	BLZ	BLM	Hooks
LB	2,000	6,000	4,000	1,500	200	400	50	45,000
NC	22,000	34,000	20,000	10,000	1,500	1,800	200	
LB/NC	9%	18%	20%	15%				
COV	15%							
CE	12,958	38,874	25,916	9,718	1,296	2,592	324	291,555
NC-CE	9042	-4874	-5916	282	204	-792	-124	

Specie composition and CPUE by species in CE will be the same as the LB

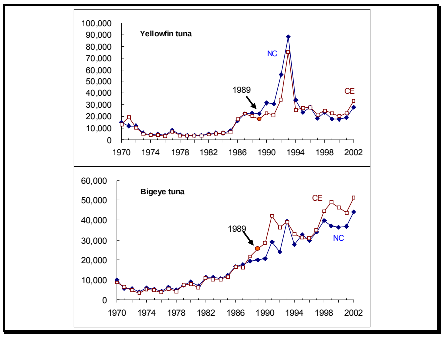
4. Since a common factor is applied to catches of all the species and the effort, it is inevitable that discrepancies will exist between CE and NC, otherwise 'different effort' will come into being in the CE for different species and the catch composition will change in CE against LB.



5. The magnitude of the discrepancy in the years before deep longline fishery developed is thought to be small.



6. But it has probably increased by year since the 1990's. This implies that the discrepancy might have been affected by the different logbook coverage from different fleets



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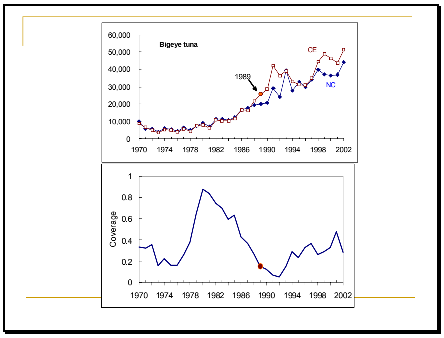

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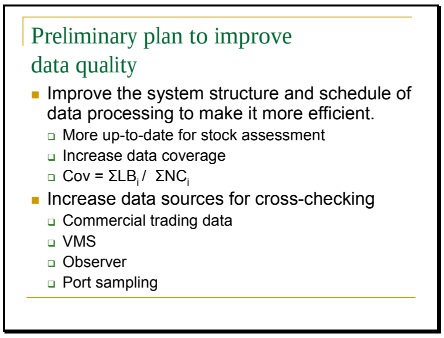

9. There is a preliminary plan to improve their data quality, including improving the data system structure and data processing schedule, and to increase data sources for cross-checking and verification e.g. data from VMS, observers programme and, in the future, port sampling.

APPENDIX V. REVIEWS AND PROSPECTS ON THE TREATMENTS OF CLASSIFICATIONS AND TARGETING FOR THE TAIWANESE LONGLINERS IN CPUE STANDARDIZATIONS - A REPORT OF THE SMALL GROUP MEETING

Report of the small group meeting

(9-11 AM, July 17, 2004 at the IOTC meeting room. Participants

Anganuzzi, Nishida, Okamoto, Shono, Chang, Mosqueira and Fujiwara

Based on detail and extensive discussions, we consider that following two approaches may be effective to reflect real LL fisheries in CPUE standardization when we don't have number of hook between basket information. Japanese and other scientists interesting in these approaches will attempt for BET using the Japanese LL data from 1970-85 in the tropical and/or the whole Indian Ocean. The Japanese LL data will be used as they have a longer period and wider fishing grounds as test (learning) data sets in Taiwan,China. Then results can be evaluated by comparing with those with real information (learning data sets). Results plan to be reported in the next WPTT in 2005.

It was recognized that for SWO, the approach developed in the last WPB is effective and useful as the results were very similar to those of the learning data sets (data with the number of hook per basket).

Trip based approach

LL trip (longer term) instead of short (e.g., set-by-set) term based analyses is proposed to investigate the target practices. This approach likely more reflects real targeting practices as the data are aggregated into one trip which usually uses consistent (common) gear configurations. Based on this approach, we can learn the relationship between gear configuration and targeting practices. Hence, once we learn their characteristics we can classify for example, Regular, Deep or Super Deep LL, which is likely more robust than the catch rate approach by Lee et al (2004) which include heterogeneous gear configurations creating biases (misclassification). Then, Using the hook per basket known data (leaning data set), we can evaluate accuracy (performance) of this approach.

Species composition approach

We need to reflect real changes of LL fisheries in the GLM or other related methods in CPUE standardization. As the species compositions are considered to reflect real changes of LL fisheries, CPUE standardization incorporating species compositions might be potentially effective and useful method. For example, if we want to standardize BET and if we have 4 major species in catch (BET, ALB, YFT and SWO), we will have the following GLM model:

$$\ln(\text{CPUE BET}) = (\text{mean}) + Y + M + A$$
$$+ (\text{ENV or q related factors}) + (ALB' + YFT' + SWO') + \text{errors}$$

where, ALB', YFT' and SWO' are the 10 categories of species compositions (as example). Then, if we have 22%(BET), 39%(YFT), 3%(SWO) and 36%(ALB), YFT'=3, SWO'=0 and ALB'=3. BET species composition is not included because (a) to avoid the potential statistical problem to use same variable in both independent and dependent variables and (b) BET' information is reflected by other species compositions in the GLM as BET'= 1 – (YFT'+ALB'+SWO'). This is a sort of the combined approach of current two types (separation and targeting based) approaches.