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Indian Ocean Tuna Commission
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Report of the Fifth Session of the IOTC Working Party on Tropical Tunas

Victoria, Seychelles, 3-12 June, 2003

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1. OPENING OF THE MEETING AND ADOPTION OF THE AGENDA

The Fifth Meeting of the Working Party on Tropical Tunas (WPTT) was opened on 3 June 2003 in Victoria, Seychelles, by the Chairman, Dr. Geoffrey Kirkwood, from Imperial College, London, who welcomed the participants (Appendix III). The Chairman indicated that as he had been recently appointed as Chairman of the Scientific Committee, he felt it inappropriate that he also serve as Chairman of WPTT. Accordingly, he requested that WPTT elect a new chair for the Working Party. The WPTT thanked Dr Kirkwood for his leadership in the past four years and unanimously elected Dr Pilar Pallares to chair the Meeting, deferring the question of electing a new Chair for the next biennium until the end of the meeting.

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

The WPTT, aware of the request from the Commission to provide technical advice in relations to **Resolution 02/09: On the conservation of bigeye and yellowfin tuna in the Indian Ocean**, gave priority to the analyses required to provide such advice. After this, priority was given to a consideration of the status of skipjack tuna.

The documents available for discussion are listed in Appendix III.

2. REVIEW OF STATISTICAL DATA FOR THE TROPICAL TUNA SPECIES

2.1 Nominal Catch (NC) data

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

The Secretariat conducted several reviews of the NC database during 2002. These revisions led to slight changes in the estimates of catches (not lower or higher than 10% of previous estimates) of the three tropical tuna species, especially since the mid-eighties.

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

Unreported catches: several countries were not collecting fishery statistics, especially in years prior to the early seventies, and others have not reported their statistics to IOTC. In most cases, the catches of tropical tunas in those countries were probably minor. Nevertheless, the catches of some important longline fleets are unknown, as it is the case with the foreign longliners operating from Maldives.

Underestimated catches: catches of tunas and tuna-like species are sometimes reported aggregated[1]. When possible, the Secretariat estimates the species and gear composition of these aggregates. In addition, catches in several Indian Ocean coastal countries are probably underestimated as sampled landings are not raised to total catch.

Uncertainty in the catches may occur in the following cases:

- **Fresh tuna longline fleets**: Although the catches of fresh tuna longline ships based in different ports of the Indian Ocean were re-estimated from data coming from past or recent sampling schemes operated, the accuracy of the estimates is still far from complete, especially in the case of fleets operating from ports not covered by these schemes or past catches estimated on the basis of recent estimates, very far in time.

- **Deep-freezing longline fleets**: The catches are thought not too accurate due to the many assumptions made in estimating the total catches and species breakdown. A dramatic decrease in the number of vessels operating under flags of non-reporting countries was recorded in 2001. The reason for this decrease is not fully known and changes in the catch estimates are expected as more information become available.

- **Ex-Soviet purse seiners**: The catches of nine to eleven ex-Soviet purse seiners, operating under the flags of Panama and Belize in recent years, have not been submitted to the IOTC since 1995. The catches estimated since that year and, in particular, the species allocation, are likely to be less accurate than those of previous years.

[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.

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 very small.

Baitboat: Catch-and-effort statistics from the Maldives have been reported by species, month and atoll since 1970.

Longline: Catch-and-effort statistics are available since 1952 for Japan, since 1967 for Taiwan,China[2] and since 1975 for Korea. Catch and effort data for other fleets is scarce or inaccurate (e.g. non-reporting fleets, Philippines, etc.).

The statistics provided by Japan and Taiwan,China are in general considered accurate. Nevertheless, the inconsistencies found during the validation of data records for some years, involving the Taiwan,China data for the period 1990-92, are still unsolved. The Japanese catch-and-effort data series (1950-2001) was replaced by new estimates that took into account the whole of the IOTC Area, on the contrary of previous estimates only accounting for the FAO areas 51 and 57. Only slight changes in the catches of tropical tunas were noted.

Korean CE statistics are thought to be highly inaccurate. Many inconsistencies were found in the data, when comparing the catches in this database with those reported as nominal catches, for instance.

Purse seine: Catch-and-effort statistics are complete for European-owned purse seiners and those monitored by European scientists, as well as those from Seychelles. Statistics are also available for other countries including Mauritius, Japan and Iran. As is the case for the NC data, the CE data for the purse-seine fleet formerly under the Russian flag are inaccurate and, at this time, are only available to IOTC for short periods of the operation of this fleet.

2.3 Size-Frequency (SF) data

Purse seine: The quality of the data is thought to be good for fleets under European monitoring, apart from the species and size composition for 1997-2000, which are likely to be less accurate due to problems in the sampling on those vessels. No or scarce data is available for Iranian, Japanese and ex-Soviet purse seiners. The size frequency statistics of Mauritian purse seiners is complete since 1986.

Baitboat: The completeness and quality of the sampling on baitboat fisheries (Maldives) is thought good until 1998. No data are available since 1999.

Longline: For longline fisheries, however, only Japan has been reporting size-frequency data since the beginning of the fishery. In recent years, the number of specimens measured is very low in relation to the total catch and has 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 are available) or inaccurate (Korea), which invalidates their use. The recovery of size data from port sampling regarding fresh tuna longline fleets operating in Phuket, Penang, Sri Lanka and, recently Indonesia, continued in 2002 and 2003, with many records input to the SF database.

The availability of size frequency statistics for gears other than pole and line, purse seine and longline is very low. Nevertheless, it is worth mention the recovery of Indonesian, Sri Lankan and Omani length frequency statistics referring to gillnet and other fisheries in these countries.

2.4 Estimation of catches of non-reporting fleets

The estimates of catches of non reporting fleets were updated in 2002 thanks to new information available during the last year:

- **Indonesia:** The changes in the estimates originated in:
    - Re-estimation of **longline** catches by Indonesian vessels: The new catches estimated represent only slight increases in the catches of tropical tunas, with new catches estimated for 2000 and 2001. The number of ships and catches estimated for recent years, averaging 70,000 tons, situate Indonesia among the most important fishing fleets in the Indian Ocean, second only to the Taiwanese fleet.
    - Re-estimation of **artisanal** catches: The catches of artisanal fleets in Indonesia were estimated since 1975, according to new data reported by Indonesia to the FAO. The new reports considered the new

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

FAO boundaries, now fully consistent with the IOTC eastern boundary. The catches of tropical tunas, especially skipjack tuna, increased considerably in relation to previous estimates. Recent catches of tropical tunas under artisanal gears amount to around 60,000 tons.

- **Other non-reporting fleets** (NEI): The increase in the number of non-reporting fleets in recent times has led to dramatic increases in the catches that had to be estimated, reducing in this way the quality of the data of yellowfin tuna, bigeye tuna and, less significantly, skipjack tuna.
- **Purse seine:** The catches of ex-Soviet purse seiners were estimated since 1995 on the basis of the number of purse seiners operating, previous catches reported and data coming from other purse seine fleets (European Community). Recent catches estimated are around 30,000 tons.
- **Fresh tuna longline**: The catches of fresh tuna longliners were estimated according to the port where the different fleets were based. Most of the catches estimated are from Taiwanese longliners according to the information available.
  - **Indonesia**: The catches of foreign fresh tuna longliners based in Indonesian ports were estimated on the basis of catches of domestic vessels. The catches estimated refer to the period 1986-99 with highest catches estimated in the early nineties (around 30,000 tons). No foreign fresh tuna longliners have been operating in Indonesia since 1999.
  - **Thailand**: The catches of fresh tuna longliners from Taiwan,China and Indonesia in Phuket were estimated according to the data collected through the AFRDEC (Andaman Sea Fisheries Research and Development Centre)-OFCF (Overseas Fisheries Cooperation Foundation of Japan)-IOTC Sampling Program. Recent catches are around 3,000 tons.
  - **Malaysia**: The catches of fresh tuna longliners based in Malaysia were estimated on the basis of previous data recorded (IPTP Sampling Program) and new estimates from FRI (Fisheries Research Institute of Penang). The 1989-2000 estimates ranged from 10,000 to 35,000 tons with a dramatic drop in the catches unloaded in Penang noted in 2001 (around 2,000 tons).
  - **Sri Lanka**: The catches of fresh tuna longliners unloading 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. Catches ranging from 300 to 3,500 tons were estimated for the period 1990-2001.
  - **Maldives:** The catches of fresh tuna longliners were not estimated due to lack of reliable information on their numbers and activity.
  - **Other Fleets:** The catches of fresh tuna longliners operating in Seychelles and South Africa were submitted during 2002 and replace previous estimates.
- **Deep-freezing longline**: The catches of large longliners from several non-reporting countries were estimated according to the number of vessels estimated from the IOTC vessel record and the catches of Taiwanese longliners, on the assumption that most of the vessels operated as the longliners from Taiwan,China. The collection of new information regarding these non-reporting fleets during the last year, especially concerning the number of longliners operating, led to better estimates of catches. A decrease in the number of vessel recorded operated during 2001 led to a dramatic decrease in the catches estimated, from 50,000 tons in 2000 to 25,000 tons in 2001. 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 General Discussion on Statistics

The WPTT noted the progress achieved regarding data collection, data processing and dissemination at the Secretariat. To a question on the progress of the Catch Monitoring Program in Indonesia the Secretariat informed that, since its implementation, an important amount of data have been collected for both industrial and artisanal fisheries. The sampling of fresh tuna longline catches started in June 2002, with more than 2,000 sampling conducted and coverage levels ranging from 20% to 30% of the total catches landed in Cilacap, Jakarta and Benoa. The Secretariat further informed that it will be providing estimates of catches of Southern bluefin tuna in Indonesia to the CCSBT in the future, as agreed in a technical meeting held by the CCSBT in April 2002. The WPTT agreed that the information collected under the Indonesian Multilateral Cooperation Project[3] is providing very valuable information on the activities of longline fleets for which no or scarce information was available before and encouraged all parties to continue with the activities in the future. In this context, the WPTT requested the IOTC Secretariat to continue efforts to retrieve historical records on the individual weights of tuna and tuna-like species from landings of fresh tuna longliners to Indian Ocean ports.

The WPTT showed concern regarding the lack or scarcity of size frequency statistics from several large scale longline fleets. The WPTT recommended that all parties with longline vessels fishing for tropical tunas in the Indian Ocean should make every possible effort to improve the size sampling coverage.

The WPTT recommended that both raw and raised size frequency data be provided to the Secretariat by all countries reporting size data. The WPTT further recommended that all countries reporting statistics to the IOTC provide summaries describing 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 used in the country. The Secretariat informed the WPTT on a project just initiated under the umbrella of the OFCF-IOTC cooperation to improve the knowledge about data collection and processing systems in several Indian Ocean coastal countries. The main objective of this Project will be to draft Country Reports including basic information about the fisheries for tunas in these countries as well as a description of the data collection and processing systems in place and details about its implementation. The information gathered will be reviewed in a Regional Workshop that will be held in Seychelles early in 2004. The WPTT welcomed this initiative from the OFCF and looked forward to see the result during its next meeting.

The WPTT noted that size frequency statistics of skipjack tuna caught under Japanese longlines were available from several publications but no data were available for this species at the Secretariat. The WPTT recommended that Japan make every possible effort to report these data to the Secretariat.

The WPTT showed concern the lack of detailed statistics for many gillnet fisheries for which dramatic increases in the catches have been noted in recent times. The WPTT strongly recommended that all parties having gillnet fisheries catching important amounts of tropical tunas make every possible effort to collect more detailed statistics on these fisheries.

The WPTT noted that the scarcity of statistics regarding the discards of tropical tunas by some industrial fleets operating in the Indian Ocean have been preventing to raise estimates on the amount of tropical tunas lost to discarding. The WPTT recommended that all parties having industrial fisheries likely to have tropical tunas discarded improve the collection and reporting of statistics to the IOTC.

2.6 Documents relating to Statistics

Document **WPTT-03-03** makes a comparison of size data taken independently on the EU purse seiners by the field technicians based in Antsiranana (Madagascar) and in Victoria (Seychelles) during the period 1992- 2002. The size data taken in the Mozambique Channel during the 2nd quarter were used to do this comparison. This comparison shows that sizes of bigeye and yellowfin taken independently in both ports were very similar or identical until June 1998 and since June 2001. The conclusion is that the Victoria sampling was biased only from mid-1998 to the end of 2001.

The EU scientists informed the WPTT that the statistics relating to European and associated purse seiners will be recalculated according to the results of these analysis and new CE and SF statistics reported to the Secretariat soon.

Document **WPTT-03-13** presents summary statistics of the purse seine Spanish fleet fishing in the Indian Ocean from 1984 to 2002. Data include catch and effort statistics as well as some fishery index 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 is also included.

To a question on the availability of effort data of supply vessels associated to purse seiners the WPTT was informed that no data have been collected so far on these vessels. It was also noted that most of these vessels operate under flags of countries other than the EU so preventing the possibility of being monitored through observers. The WPTT noted that several EU purse seiners operate with supplies of non-EU countries and recommended that every possible

[3] This Project involves cooperation from the following institutions: Directorate General of Capture Fisheries of Indonesia (DGCF), Research Institute For Marine Fisheries of Indonesia (RIMF), Commonwealth Scientific and Industrial Research Organization (CSIRO), Australian Center for International Agricultural Research (ACIAR), Indian Ocean Tuna Commission (IOTC) and Overseas Fisheries Cooperation Foundation of Japan (OFCF)

effort be made to collect information on the activity of these vessels, as it is the case with purse seiners of non-EU countries. The WPTT was informed that the collection of information on the activities of non EU supplies associated to European vessels was, nevertheless, expected through observers on board EU purse seiners.

Document **WPTT-03-18** summarizes the activities of French purse seiners in the Indian Ocean since 1981: effort, catch by species and fishing type (log and free-swimming schools), catch per unit of effort, sampling and mean weights for the main species.

Document **WPTT-03-14** presents a summary of the statistics of French, Spanish, Italian, Seychelles and EU related (NEI) purse seine fleets fishing in the Indian Ocean since 1981: effort, catch by species and fishing type (log and free swimming schools). Catch per unit of effort, sampling and mean weights for the main species.

The WPTT noted the dramatic changes in average weight of yellowfin tuna caught on free-schools throughout the series. The EU scientists informed that either large or small specimens are caught on free schools with no or very scarce catches of specimens of intermediate size. It was noted that the availability or unavailability of free-schools of large yellowfin tunas in some years of the series was likely to be the reason of these fluctuations in the average size, as well as area-related effects.

2.7 Data related issues for tropical tunas

A number of problem areas were identified in the data situation for tropical tunas:

- 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 the catches, effort and size-frequency from non-reporting fleets of deep-freezing tuna longliners, especially since the mid-eighties.
- Lack of accurate catch, effort and size-frequency data for the Indonesian longline fishery in recent years.
- Poor knowledge of the catches and lack of effort and size-frequency data for ex-Soviet purse seine boats flying flags of convenience in recent years.

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 several countries as for South Africa and Seychelles longline fisheries.
- **Revision of the IOTC databases**: Several revisions have been conducted during the last year on the IOTC databases. This has led to new datasets being input, especially regarding CE and SF statistics (Indonesia, Sri lanka) and to new series of NC data for some countries.
- **An improved Vessel Record**: More information has been obtained on the number and type of vessels operating under flags of non-reporting parties. This information comes mostly from 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.
- **Recovery of historical activity and size data from processing plants**: The collection of historical information from operators in different ports of the Indian Ocean has continued since last year. Some 250,000 individual fish weight records by species have been retrieved to date for 1998 to 2002.
- **IOTC/OFCF sampling programmes**: The collection of information on the activities of fresh tuna longliners landing in Phuket, Penang and Sri Lanka has continued during 2002. This has led to more complete and accurate estimates of catches of these fleets. Other valuable data collected in the scope of these programmes refer to length frequencies which will allow length-length, length-weight and weight-length relationships to be established.
- **Plan of Action in Indonesia**: A large scale operation involving several local and foreign institutions was initiated in April 2002 in Indonesia. The primary objective of this multi-lateral cooperation is building the necessary capabilities in the country, so as to allow Indonesia to generate good quality statistics in the near

future. Sampling of landings of fresh tuna longliners operating in this country started in June 2002 , with more than 2,000 sampling conducted (160,000 monitored) between June 2002 and March 2003, with coverage levels ranging from 20% to 30% of the catches unloaded by longliners in Indonesia.

- **Japan NC and CE:** New estimates of catches of Japanese longline vessels for 1950-1969 were conducted during 2002 on the basis of new information reported by Japan. New CE data was also submitted for 1950-2001 to replace previous estimates that did not consider the IOTC boundaries but the FAO ones.
- **Indonesia NC**: The NC for 1975-2001 was replaced by new estimates that took into account the IOTC Eastern boundary.
- **Taiwan,China NC**: The catches of Taiwanese longliners were updated during 2002 with new catches added for the period 1954-1965 and 1966-1978 catches updated.

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

Yellowfin and Bigeye Tuna

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 believed more accurate than past catches estimated.

Artisanal catches are negligible as regards bigeye tuna. On the contrary, catches of yellowfin tuna under artisanal gears, mainly gillnets, have dramatically increased in recent years being still uncertain in most cases.

CE data: Well known in the purse-seine fisheries and the main longline operations (Japan, Korea and Taiwan,China). Nevertheless, the Korean data are thought inaccurate. No catch-and-effort statistics are available for non-reporting longline, purse seine and most gillnet fisheries.

SF data: Data for the period 1997-2000 from the EU PS sampling is considered less accurate. Sampling coverage from Japan and Korea is low in recent years. The only data available regarding non-reporting fleets are from sampling in Phuket, Penang, Sri Lanka and Indonesia. No SF data are available from Taiwanese vessels since 1989. Little information is available on important artisanal catches (e.g. 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. Artisanal components (not well known) are important for this species. In several coastal countries the catches are not reported by gear (Indonesia).

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).

3. Review of New Information on the Biology of Skipjack Tuna

Document WPTT-03-22 presented size information of skipjack in the Indian EEZ. These data were from longline sets conducted by the Fishery Survey of India (FSI). Annual summaries for the years 1994-2002 from Arabian Sea (15°-24°N; 69°-74°E) and the Andaman & Nicobar Islands (4°-15°N; 89°-96°E) that includes the annual mean length and size range were presented. Information about the sample size the distribution was not available. The absolute size range of the skipjack from Arabian Sea was 44-84 cm FL with range of the annual means about 64-74 cm. Skipjack sizes from the Andaman & Nicobar were smaller. Their absolute size range was 45-70cm with annual means in the range 54-63cm FL. It was noted that size data be reported as size distributions indicating size of the samples.

Three documents presented information about growth. Document WPTT-03-17 presented an outline of a growth study on skipjack tuna in the **Western Pacific Ocean** including validation of daily increment deposition rates in sagital otoliths. Increment deposition rates were validated for sub-adults using an oxy-tetracycline injection experiment. The fish subjected to experiment were caught on handline and were held in floating cages. A von–Bertalanffy model was fitted to the 453 data points that gave L_∞ = 93.6, K = 0.43 per year. It was noted that L_∞ was too high probably due to mis-identification of the "daily" increments in the "young-adult" region on the otoliths. In the discussion it was also noted that difficulty in resolving increment counts in large size classes was reported in a different study conducted in the Western Central Pacific Ocean.

The document WPT-03-23 reported estimates of growth from the tagging experiment conducted in the Maldives during 1993-1995. Using the standard von – Bertalanffy model and fitting increment length against time-at-liberty L_∞ was estimated at 64.3 cm and K at 0.54 per year. The paper noted that lack of data for the small and particularly the very large size classes makes the estimates of L_∞ uncertain.

The document WPTT-03-02 presented a comparison of the skipjack growth from the Atlantic, Eastern Pacific and the Western Pacific Oceans along with the estimates reported in WPT-03-23. While the comparison is only preliminary, the results indicated that skipjack growth is probably very similar in the Indian and Atlantic Oceans, but significantly different in the EPO and WPO. It was noted that due to skipjack's opportunistic feeding behavior its growth could show high variability within regions of Oceans as have been observed in the Atlantic, eastern and western Pacific Oceans. Such observations raises concerns in extrapolating the estimates made from the Maldives tagging data to the entire Indian Ocean stock since those estimates may not be valid in other areas.

Document WPTT-03-02 provided a comparative overview of the skipjack fisheries and stocks worldwide including information on natural mortality rate. The natural mortality rates of skipjack tuna have been estimated from tagging data for the Indian, Atlantic and Pacific Oceans. In general the estimates of natural mortality rate were very high. The size dependent natural mortality rate estimates show higher rates in juveniles and adults that result a "U" shaped curve – a phenomenon commonly observed in many animals. The absolute levels of natural mortality rate estimated by various tuna management bodies are still very uncertain and highly dependent on the method used. In the Western and Eastern Pacific estimates have been obtained from statistical models; MULTIFAN-CL and ASCALA respectively whereas in the ICCAT they are only guesstimated values. Using the more traditional method of Pauly (1980), which uses mean environmental temperatures and growth curve it can be shown that skipjack natural mortality would be in the range between 1.2 and 1.5 per year.

Document WPTT-03-Info 3 provided an atlas summary of the maturity stages of skipjack tuna in the Indian Ocean. The data for this atlas was from the Japanese training longliners and from experimental tuna purse seine fishery dating from 1965 – 2000. These data are held in the databases of the National Research Institute of Far Seas Fisheries (NRIFSF) and cruise reports of JAMARC. Using the female gonad weights and their size a gonad index (GI) was computed as $GI = W \times 10^4 / L^3$ where L is the fork length of the fish in cm and W is the gonad weight in grams.

The results, aggregated at 5° x 5° areas, were presented on maps summarized as annual and monthly average compositions. During the southwest monsoon (May to July) most individuals were immature. At the end of the southwest monsoon season (August and September) female skipjack tuna gradually become mature. During the northeast monsoon season (November – February) ripe and mature individuals are distributed widely in the equatorial waters of the Indian Ocean. It was noted that more detailed information regarding the quality of the data, sample sizes and their geographic coverage should be presented in future studies and in a more complete atlas.

4. REVIEW OF NEW INFORMATION ON THE STATUS OF SKIPJACK TUNA

Indian Ocean skipjack tuna catches have been increasing steadily (Figure 1 and Table xx). In the recent years the total catches amounts to about 400,000 t. Between 50 to 60% of the catch comes from the purse seine fishery in the Western Central Indian Ocean centered primarily in the Somali Basin and in the Mozambique Channel (Figure 2). The coastal nations, particularly the Maldives, take a substantial component of the Indian Ocean skipjack catch which in 2002 amounts in excess of 100,000 t. Currently the coastal country's catch represents about 35% of the total Indian Ocean catch.

Three documents dealing with the information relevant for stock assessment were presented and discussed by the WPTT.

CPUE Trends

Document WPTT-03-22 presented catch rates of skipjack tuna in the Indian EEZ. These were based on the catches taken from the **longline** surveys conducted by the Fishery Survey of India (FSI) during 1994 – 2002. The abundance indices were based on hooking rate per 100 hooks and weight of the fish caught per 1000 hooks. Annual data were aggregated into two broad areas; Arabian Sea (15°-24°N; 69°-74°E) and the Andaman and Nicobar Islands (4°-15°N; 89°-96°E). The average number of skipjack recorded per year was 64 for the Arabian Sea and 13 for the Andaman and Nicobar Island areas giving hooking rates less than one fish per 100 hooks. It was noted that the samples sizes were too small to give meaningful estimates of catch rates of skipjack in the area. In general longline catches skipjack are very few in the Indian Ocean and therefore catch rates observed from longline cannot be used as a measure of skipjack abundance.

An overview of the CPUE trends in the Maldivian livebait pole-and-line tuna fishery was presented in the document WPTT-03-23. The fishing effort is recorded as number of fishing days. The fishing fleet (masdhonis) used to be a sailing one but was mechanized starting from 1974. By about 1985 the entire fleet was mechanized. Since then enormous changes in fishing fleet has occurred. The average size of a fishing vessel is now 50 – 60 feet compared with about 30-40 feet about 10 years ago. Currently larger more efficient vessels dominate the fishery and the smaller and more inefficient vessels are being eliminated. To take into account of this change in the unit fishing effort, i.e. one day, the effort series was adjusted in attempt at standardizing the effort. The adjustments were:

- Reducing the fishing effort of the sailing vessels from 1970 – 1977 by half. This was based on the observation of the catch from sailing and mechanized vessels during 1974 – 1977.
- Reducing the fishing effort of the sailing vessels linearly starting from 0.5 in 1978 to 0 in 1985 thereby eliminating the sailing vessel effort from 1986 onwards.
- Increasing the mechanized vessel fishing effort linearly by 1% per year starting from 1986 onwards.

The adjusted skipjack CPUE (kg /day) was relatively stable at about 250 – 300 kg/day from 1985 – 1997 (Figure 3). Since then the standardized CPUE has shown a sharp increase to over 450 kg /day in 2002. This increase is due in part at least to the significant increase in number of large masdhonis in the fleet (which can land several tonnes per day). It was noted in the discussion that 1% increase per year in the recent years might not be sufficient to reflect the enormous changes that have occurred in the past few years. There is a recognized need to quantify these changes in fishing power of the masdhonis fleet in order to obtain a better standardization of pole-and-line fishing effort in recent years. Maldivian skipjack CPUE trends have been shown to be related to large-scale oceanographic variations. For example, during El Nino years skipjack catch rates are depressed while in La Nina years they are elevated.

Standardizing Purse Seine Effort

A variety of devices are equipped on purse seine vessels to help increase the effectiveness of the fishing effort and therefore of catch. These devices include power blocks, purse winch, bird radar, sonar, tele-sounder, GPS, weather displays, etc. In addition the vessel (its tonnage and speed) and the fishing net characteristics (its length, depth and mesh-size) also contribute success of the catch. The document WPTT-03-19 reports an attempt at standardizing Japanese purse seine catch per unit effort (CPUE) in the Indian Ocean taking into consideration of such devices using the approach of GLM. Logbook data from 9 vessels that reported full information about fishing devices were used in the analysis. The reporting period covers from 1989-2001, the period when Japanese commercial purse seine vessels were most active in the Indian Ocean. Two measures of CPUE were used: CPUE1 was the catch per fishing day that included both operation and searching days and CPUE2 was catch per a fishing operation. An ANOVA showed significant differences between the vessels in both the CPUEs. Younger (i.e., modern) vessels with new and more powerful devices did not always have a better ability. Taking the vessel effect into account the standardized CPUE1 showed and increasing trend that was different from the nominal CPUE1. Trend of the normalized standardized CPUE2 was higher in early 1990s but was lower in the late 1990s. It was noted in the discussion that the Japanese purse seine vessel shifted their operations from east Somali Basin to the western Indonesian area during 1994-1995 causing inconsistency in the observed CPUE trends. This may result in lowering of their CPUE2 in the latter part of the 1990s.

Other general information

Document WPTT-03-02 presented a comparative review of the skipjack fisheries and stocks for Indian, Atlantic and Pacific Oceans. Only the information relevant to stock assessment is mentioned here.

Results from various tagging programs indicate that skipjack tuna tend to show only limited scale movements. Most of the skipjack recoveries worldwide have been less than 1500 nautical miles. In the Maldivian tagging programs 98% of the recoveries were made from the local fisheries and the great majority was recovered within first few months of release. Transoceanic migrations have been seldom observed for skipjack tuna. The conclusion drawn is that skipjack populations are probably quite “viscous”, resulting isolated and somewhat sedentary fractions with low mixing between various components of an oceanic stock. Such a notion, albeit controversial, was suggested by Hilborn and Sibert (1988) based on their analysis tagging data from the western Pacific Ocean suggesting that skipjack management may be effective at the levels of the larger EEZs as seen in many of the Pacific island states. A reanalysis of the same data and estimates of lifetime displacements, however, showed skipjack would diffuse well beyond normal range of the EEZs (Sibert and Hampton, 2002). Such information for the Indian Ocean skipjack will only be available once that tagging experiment has been completed.

The document noted that variability of skipjack catches is very different in the three oceans. The variability in skipjack catches is low in the Indian and Western Pacific Ocean, the most productive areas for skipjack. Although during the El Nino years of 1983 and 1998 have shown large variability in catch, the inter-annual variability in skipjack catches have been about 14% for the Indian Ocean. The catches of skipjack in all the oceans are dependent on the CPUE of the tuna species: when yellowfin catch rates are high there is less incentive to target skipjack, and opposite when yellowfin are rare. A general consensus among the scientist is that the relationship between catch rates with stock biomass is complex. The belief is that the catch rates are driven by changes in catchability mediated through multiple and combined factors. Such factors may include:

- A universal trend to increase fishing power of the vessels (use of FADs, bird radars, etc.)
- The availability of the skipjack to the fishery related to environmental variability.
- The economic factors such as variability in world market for tuna.

These uncontrolled factors constitute a serious limitation on ability for modeling the skipjack resource.

The document also noted the present levels of exploitation of skipjack stocks in various oceans. In the Eastern Pacific and the Western Pacific Ocean it is believed that stocks are still in good shape. These results are obtained from integrated statistical models: MULTIFAN-CL in the WPO by SPC and ASCALA in the EPO by the IATTC. The maximum potential catch in these areas is still questionable and highly uncertain, especially in the EPO. In the Atlantic where a two-stock hypothesis is used the situation is less clear. In the most recent assessment by the ICCAT it was concluded that stocks were somewhat overfished in some areas of the Eastern Atlantic. It was noted that these conclusions were related to a rapid decline of average weights of skipjack in some areas resulting low CPUE. Also skipjack catches have been declining there recently as a direct consequence of a moratorium of use of FADs. The final conclusion is that it was unclear if the stocks were locally fully exploited or overfished.

A more general consensus concerning skipjack is that they are difficult to severely overfish because of their biological characteristics; widespread and sporadic spawning, high fecundity, fast growing, short-lived resulting high population turnover rates. A recent computer simulation comparing the population dynamics and risks of overfishing of skipjack and bluefin tuna stocks showed that skipjack stocks are much less vulnerable to increased fishing mortality showing great resistance to recruitment overfishing. This is attributable to skipjack’s short “exploited life” and rapid population turnover.

4.1 Stock Status Indicators

The WPTT did not develop a formal stock assessment for skipjack tuna. However, a length-based cohort analysis was carried during the meeting to analyze skipjack catches and length frequencies. In the approach, given an

Figure 1: *Indian Ocean skipjack tuna catches, 1970—2001 separated by Eastern (crosses) and Western (triangle) Indian Ocean. Filled circles represent the total catch. Note: 2002 catches are estimated based on purse seine and Maldives catches.*

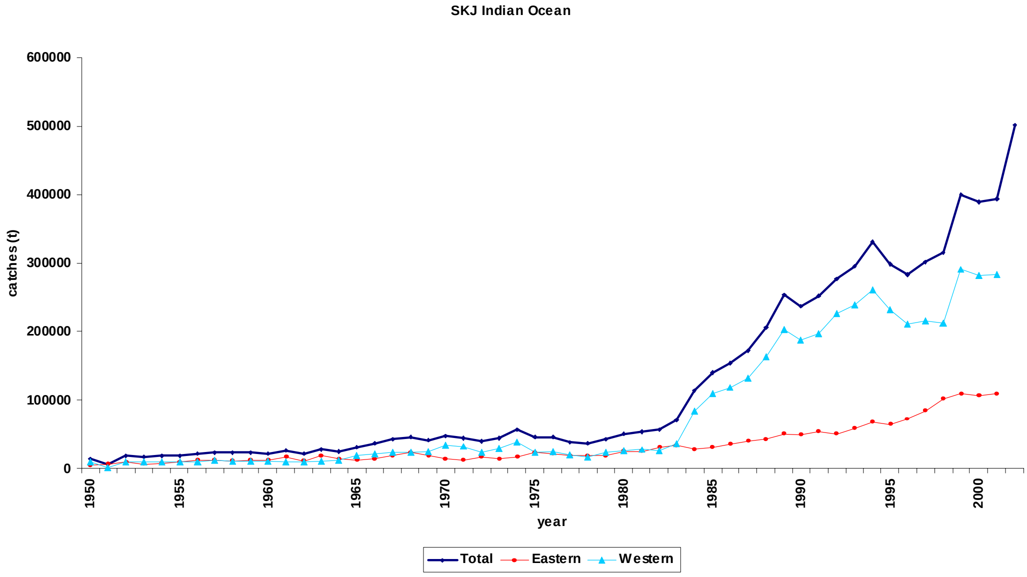
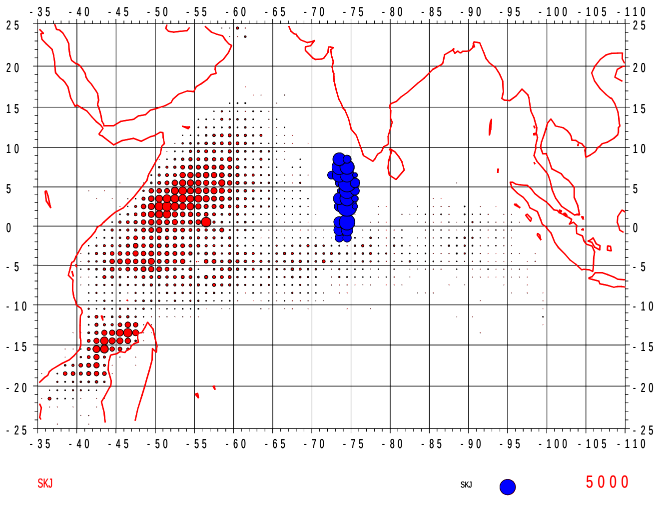


Figure 2: *Average spatial distribution of Indian Ocean skipjack catches for 1995—2001 for purse-seine and baitboat.*



estimate of natural mortality and terminal fishing mortality and the growth curve, the Jones approximated equations were used to calculate the abundance and the fishing mortality by size from the catches (Figure 4) and their size frequencies (Figure 5). Ten pseudo-cohorts corresponding to 5 year mean catches by size from 1950-2001 are reconstructed. The terminal fishing mortality is calculated for pseudo-cohort so that the estimated variance of the recruitment (numbers of skipjack of size 20 cm) is minimized. The recent period is characterized by a dramatic increase of catches of smaller size fish due to the development of the purse seine FAD fishery and the largest mode reflects the artisanal (essentially Maldives's pole-and-line) fishery.

The fishing pattern is shown in Figure 6. They reflect the evolution of the fishery and in particular the increased mortality on both purse seine and the artisanal components. In particular they represent increase of purse seine fishery in the eighties and of the FAD fishery in the nineties.

Figure 3. *Time series of Maldives CPUE and the nominal and adjusted effort (WPTT-03-23).*

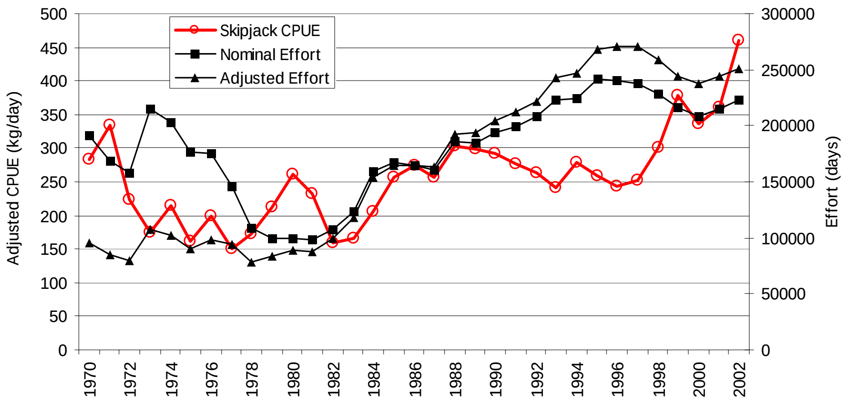
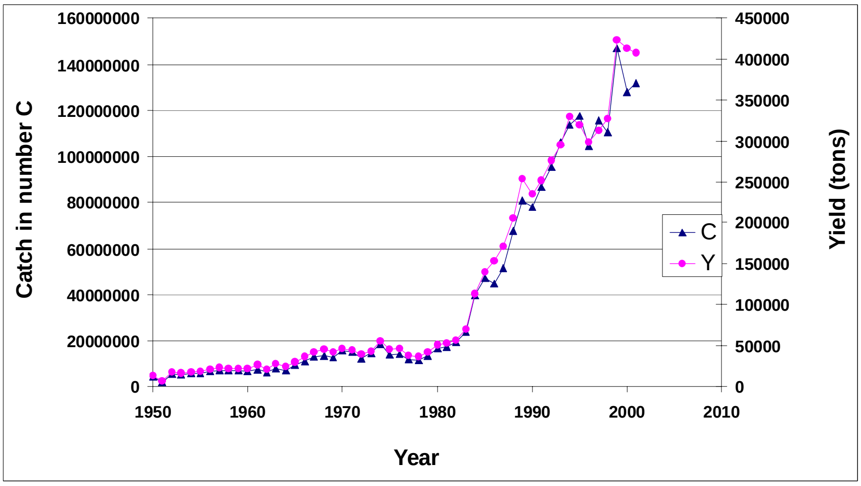


Figure 4.*Total skipjack catches in number and yield in weight from 1950.*



1. **Trends in catches**: The trend in catches indicate a large and continuous increase in the catches of skipjack tuna since the mid-1980's, particularly due to an expansion of the FAD-associated fishery in the western Indian Ocean. There is no sign that the rate of increase is diminishing in recent years.
2. **Nominal CPUE Trends:** Figure 7 shows the nominal CPUE trends of the purse seine fishery for three major areas: Somalia area, Western Seychelles area and Mozambique Channel. In the Somalia and Western Seychelles area catches have been increasing recently and so as the nominal CPUE trends. In each of these areas, with the exception of west Seychelles in 2002 the nominal CPUE has been relatively stable since the late 1980's. Since this is a period during which is believed that effective purse-seine effort has increased substantially it is likely that the true abundance in these areas has decreased. In itself, this is not unexpected given the large increase in catches over that period. However, as these areas may be source of skipjack recruitment to the Maldives artisanal fishery, there is the potential for an interaction to be occurring between these fisheries.
3. **Average weight and catch by fisheries:** The Working Party noted that the average weights of the skipjack taken from various areas have been more or less the same since 1991 (Figure 8). Figure 9 shows catches at size expressed as weight from three major gears; purse seine, baitboat and gillnet. The purse seine and the baitboat fisheries take the greatest catch around 40-50 cm while catches taken from gillnet fisheries ranges from 70-80 cm.
4. **Number of squares fished:** The trend in the number of one-degree squares visited and with catches of skipjack tuna by the main purse-seine fleets suggests that, after the late 1990's, the spatial distribution of the main purse-seine has remained at the same average level. In 1998, a particularly strong El Niño episode resulted in a much wider spatial distribution of the catches.

Figure 5: *Size frequencies of the yield (top panels) and catch by numbers (bottom panels) for the three time periods: 1950-1960 (green), 1981-1990 (red) and 1991-2001 (blue). Left panels are actual numbers and right panels are in proportions. Note the two modes (40-50 and 55-65 cm) that appear in the yield frequencies but which are less visible in the number frequencies.*

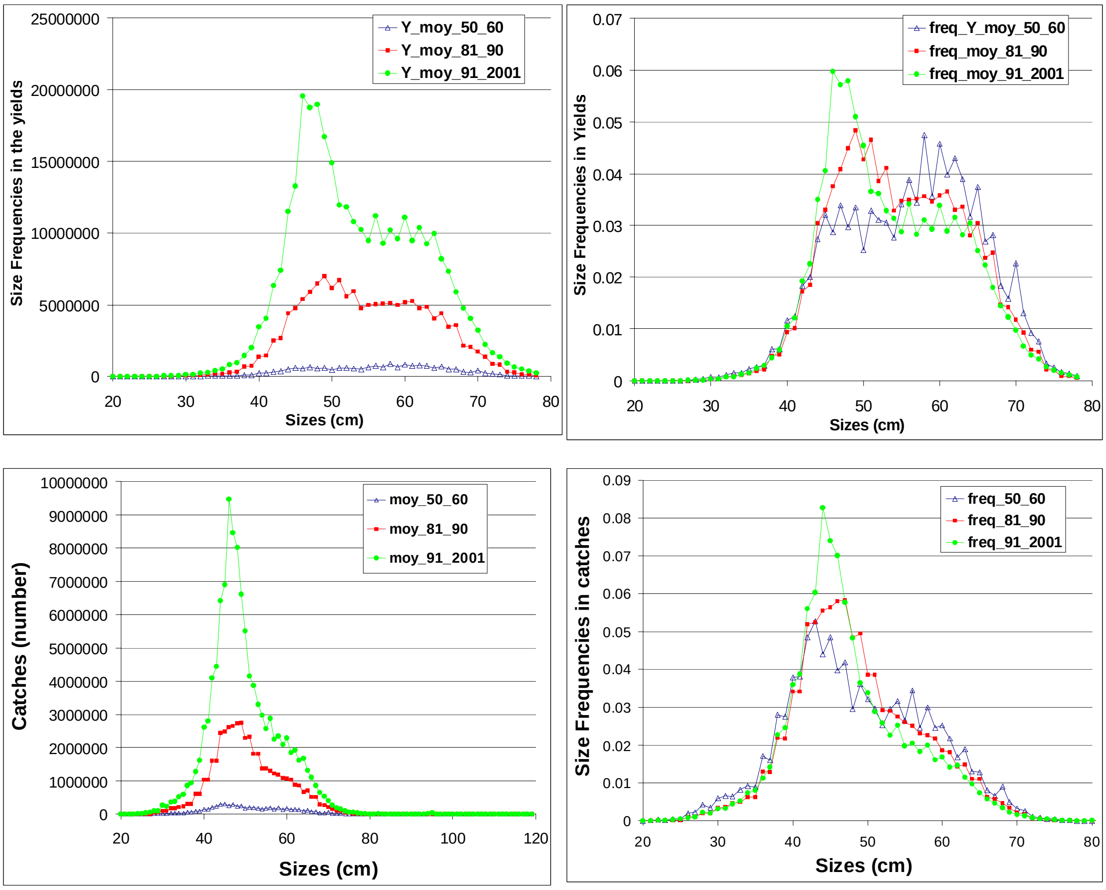


Figure 6: *Estimated fishing mortality by size for the four five-year mean periods : (1950-1955, 1981-1985 ; 1996-2001)*

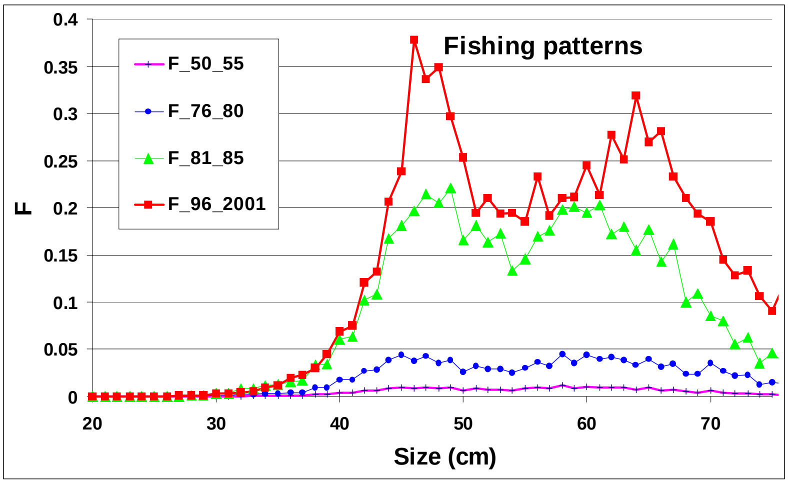
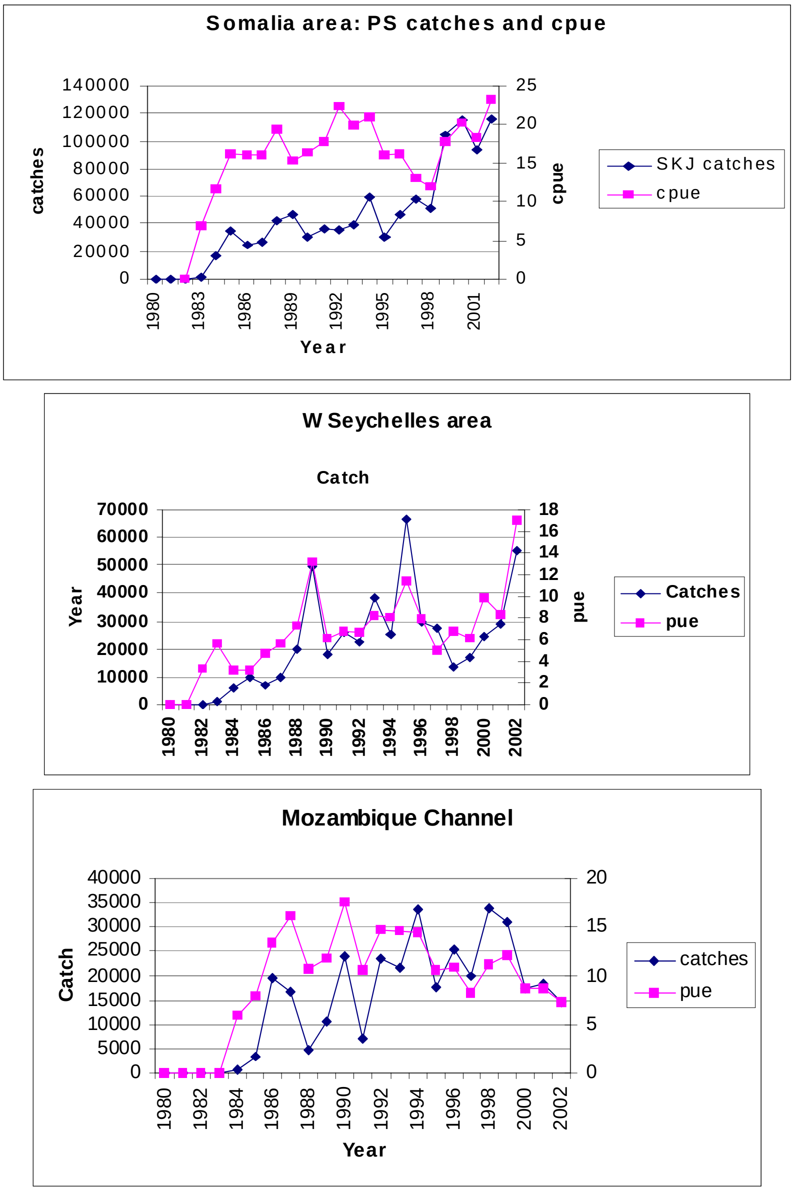


Figure 7. *Nominal CPUEs for three important purse seine fishing ground areas: Somali Basin (top panel); Mozambique Channel (middle panel) and Western Seychelles (bottom panel).*



4.2 Technical Advice on the Status of Skipjack Tuna

The WPTT was not able to conduct a full stock assessment. However, the life history characteristics of skipjack tuna, the information presented in the documents reviewed, and the information in the stock status indicators prepared during the meeting suggests that there is no need for immediate concern about the status of skipjack tuna.

***Figure 8**: Time series of average weight of the purse seine caught skipjack by major areas. (1991 - 2002)*

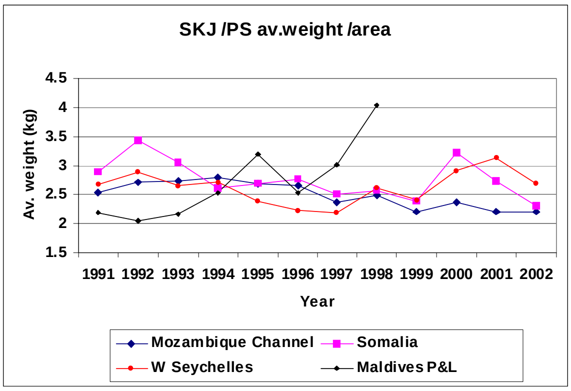


***Figure 9**: Average catches at size given in weight (extrapolated to the catches of each gear) for the period 1992-2001 taken by purse seine, by drift net and pole and line vessels (predominantly from Maldives).*

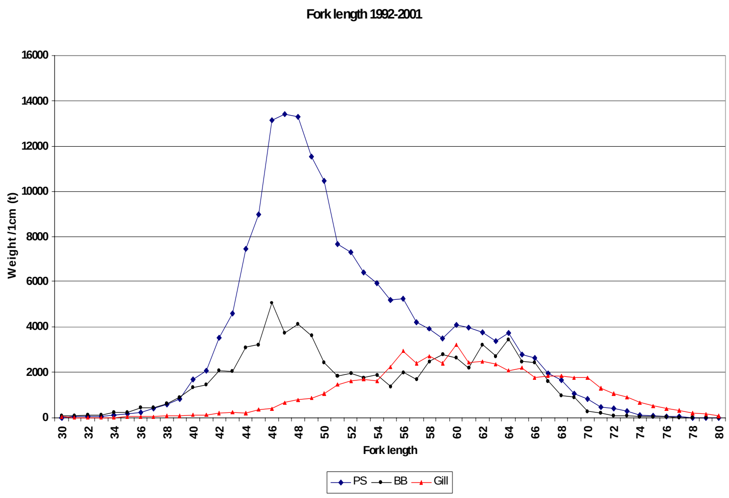
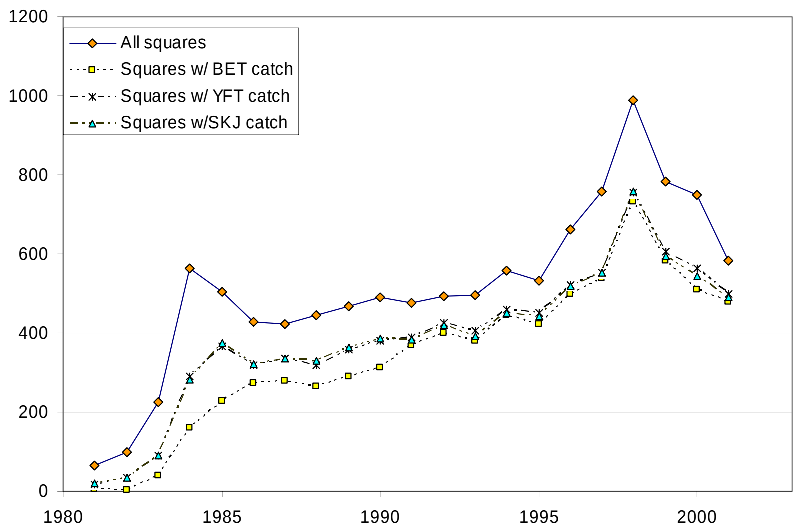


***Figure 10**. Number of one-degree squares visited and with catch of tunas, for the main purse-seine fleets.*



5. NEW INFORMATION ON THE BIOLOGY AND STOCK STRUCTURE OF BIGEYE AND YELLOWFIN TUNAS

5.1 BIGEYE TUNA (*Thunnus obesus*)

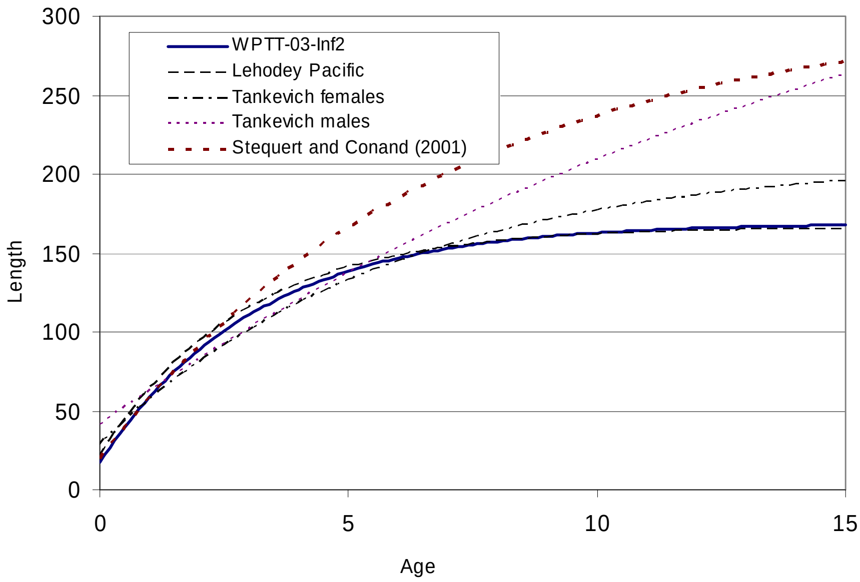
New Biological Information

New information on growth of bigeye tuna in the western Indian Ocean was presented in WPTT-03-Inf2. Using scanning electron microscopy it proved possible to resolve daily microincrements in otoliths, including those in large fish (> 120 cm FL) that had been unresolved under optical microscopy. The following von Bertalanfy growth parameters were estimated:

L_∞ = 169 cm; K = 0.000879 per day (0.32 per year) ; t_0 = -123 days

Members of the WPTT expressed increased confidence in this study and the revised growth parameters. (Figure 11)

Figure 11: *Comparison of previously assumed growth curves with the results listed in WPTT-03-Inf2*



New Fisheries Information

The Indian Ocean purse seine fishery now catches a larger percentage of tuna under FADs (c 70%) than any other tuna fishery (WPTT-03-4). While this fishery essentially targets skipjack, significant quantities of bigeye tuna (20-25,000 t per year in recent years) and yellowfin tuna are taken as well. Bigeye tunas taken under FADs are mostly small juveniles (modal length 50-60 cm) but some intermediate length bigeye are also taken (mostly less than 120 cm). In contrast, bigeye taken in free schools are mostly large (110-150 cm). Average weights of bigeye taken under FADs have decreased slightly over the period 1984-2001. The most important FAD fishing area is off Somalia (in August to November) where some 50% of the total western Indian Ocean purse seine tuna catch has been made over the past 4 years.

Documents WPTT-03-13, WPTT-03-18 and WPTT-03-14 summarized fishery statistics for the Spanish, French and combined purse seine fleets respectively. All noted the trend towards larger and more efficient vessels. Some purse seiners (Spanish and flag of convenience) operate with supply vessels, which can assist with deployment and checking of FADs. It is believed that this can increase catches, but such increases are impossible to quantify at present.

As part of a wider evaluation of the effects of purse seine fishing on bigeye stocks (WPTT-03-12) it was demonstrated that that the percentage of bigeye tuna in purse seine catches on FADs decreases during the course of the day, being lowest around midday. It was also noted that most FAD fishing by purse seiners in the Indian Ocean is carried out during the second half of the year.

The Maldivian pole and line fishery catches small quantities of juvenile bigeye tuna, which are not distinguished in the national statistics from yellowfin tuna. WPTT-03-23 provided rough estimates of bigeye tuna catches, 1970-2002. Annual catches in recent years have been of the order of 500-1200 t. While these are not large in terms of weight landed, the catch numbers may be quite high because of the small size of the fish taken. The WPTT encouraged further catch sampling.

5.2 YELLOWFIN TUNA (*Thunnus albacares*)

New Biological Information

Yellowfin catch and size data from fisheries surveys conducted by two research longliners in Indian waters were summarized in WPTT-03-21 and WPTT-03-22. In the Arabian Sea, the yellowfin were relatively small (mostly 80-140 cm, mean 103 cm), and highest catch rates were observed in the pre-monsoon season (January to April). In contrast, in Andaman and Nicobar waters, yellowfin were larger (mostly 110-150 cm, mean 127 cm). In addition there was less seasonal variation in catches, but with highest catch rates in the monsoon season (May to August). The following von Bertalanffy growth parameters (for all length frequency samples combined) were estimated:

$L_\infty = 193$ cm; $K = 0.20$ per year

It was noted that growth rates might be different in the two areas studied, and while it was recognized that samples (which represented the total research survey catch) had to be pooled to obtain reasonable sample sizes, it would be useful to present regional data separately in future studies.

New Fisheries Information

The yellowfin tuna caught by the Maldivian pole and line fishery have traditionally been almost entirely small juveniles. Over the past 12-15 years a fishery for large yellowfin has developed, as the result of the development of domestic and export markets (WPTT-03-23). Large yellowfin are taken mainly by livebait handline and modified pole and line, and now account for nearly 30% of the total yellowfin catch by weight. Also in the Maldives, total yellowfin catches and catch rates have increased substantially since 1990.

Documents WPTT-03-13, WPTT-03-18 and WPTT-03-14 summarized fishery statistics for the Spanish, French and combined purse seine fleets respectively. All noted the trend towards larger and more efficient vessels. Some purse seiners (Spanish and flag of convenience) operate with supply vessels, which can assist with deployment and checking of FADs. It is believed that this can increase catches, but such increases are impossible to quantify at present. In addition, the use of improved echosounders, which facilitate the following and capture of fast moving schools has also contributed to increased catch rates. More generally, there has been a distinct increase in fishing power in recent years.

In the Indian Ocean purse seine fishery, yellowfin tuna is caught in roughly equal quantities under FADs and from free schools (WPTT-03-4). This is in contrast to skipjack and bigeye, both of which are caught in very much larger quantities under FADs than from free schools. Yellowfin caught under FADs show a distinctly bimodal size frequency distribution, with on average about half of the catch being of small fish (40-70 cm) and half being large fish (90-140 cm). The average weight of yellowfin caught under FADs has declined over the past decade. The most important FAD fishing areas and seasons are off Somalia (August to November), northwest of Seychelles (much of the year apart from December and January) and in the Mozambique Channel (March to May). Yellowfin caught from free schools are almost entirely large fish (100-160cm); these fish are mostly spawners and are larger than the large yellowfin caught under FADs. The most important fishing areas and seasons for yellowfin from free schools are off northwest Seychelles (February-March and June-July) and off southeast Seychelles (December to February).

5.3 Predation Survey

A progress report on the survey of predation on tuna catches by Japanese commercial longliners was presented in WPTT-03-10. Between Sept 2000 and Sept 2001, reports from 1311 longline operations by 111 vessels were received. Only operations in which at least one fish was damaged by predators are reported. Among such operations the following results were found:

- Highest rates of damage were noted around the Seychelles, and off south and east Africa.
- Three species (yellowfin, bigeye and albacore tunas) accounted for 85% of all damaged fish
- 66% of fish were damaged by sharks and 30% by killer or false killer whales (sharks and whales being distinguished by tooth marks).

It was reported by fishers that killer whales or false killer whales did not damage tail-caught tunas. It was therefore proposed to investigate the possibility of hanging dummy tunas by their tails on longlines as a mitigation measure.

It was noted that there are difficulties in raising the numbers of reported operations (ie 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), which would be of value for stock assessment purposes. Additional data will be required to address this issue. It was also recognized that low reporting rates may contribute to apparent interannual shifts in seasonal centers of predation.

It was noted that since 66% of damage was caused by sharks, an analysis of shark catches by tuna longliners should shed light on the issue of shark predation. It was reported that there is a time series of Japanese longline shark catches, including some by species.

Shark species composition in local longline catches in the Maldives was noted in WPTT-03-23. This report also noted the interactions between oceanic sharks and tunas and the potential importance of an ecosystem approach to tuna management.

Information document WPTT-03-Inf1 announced plans to develop a collaborative database for predation information of longline caught tuna and billfishes. It also noted the desirability of postponing the proposed predation workshop from 2004 to late 2005 or early 2006 (allowing time for data collected in 2004 to be analysed).

Seychelles noted its continued interest in collaborating in this programme. It also noted that it was collected predation information from its local longline fishery, but that reporting rates were low. India also expressed interest in collaborating in this programme.

5.4 By-Catch

No new information on by-catch was presented. However, a European Union observer programme on purse seiners in the Indian Ocean is due to start in 2003 on both Spanish (WPTT-03-16) and French vessels. It is hoped to have observer coverage of 10% of trips by 2005. The programme will concentrate particularly on fishing on floating objects (which is believed to have significant by-catch and discards).

It was noted that rare catches of very large numbers of sharks (which are made by purse seiners in other oceans) would probably be missed by an observer programme with limited coverage. The importance of adequate observer coverage was therefore stressed. It was also noted that there was some concern about by-catch of turtles in Indian Ocean tuna fisheries (WPTT-03-Inf4).

6. REVIEW OF NEW INFORMATION ON THE STATUS OF YELLOWFIN AND BIGEYE TUNAS

6.1 BIGEYE TUNA (*Thunnus obesus*)

Preliminary results from application of delay-difference models to stock assessment of Indian Ocean bigeye tuna were presented in WPTT-03-15. It was noted that robust results had not yet been obtained. Two as yet unresolved problems were the unrealistic assumption of knife-edge selection, and the difficulty of incorporating the dramatic increase in catches of young fish (following increased fishing on FADS in the early 1990s) into the model.

Japanese longline data are potentially of great value for investigating changes in abundance of Indian Ocean bigeye, because of their long temporal and wide spatial coverage. However, there are difficulties in using the data because of changes in operating methods and efficiency over the past decades. WPTT-03-11 described a standardization procedure for Japanese longline CPUE for bigeye tuna in the Indian Ocean, applying GLM to data for 1960-2001. Sea surface temperature (SST) and MLD (mixed layer depth) were included in the model. Applying these environmental factors appeared to give a better fit than using SST and southern oscillation index (SOI) as had been done previously. In the tropical Indian Ocean, the main longline fishing area for bigeye, CPUE has declined continuously since 1987. The decline from 1987 to 1993 was within the range of previous fluctuations, but since 1993 bigeye CPUE has declined to the lowest level in the history of Japanese longlining in the Indian Ocean.

The average weights of bigeye taken by purse seiners under FADs have decreased slightly during recent years (WPTT-03-4). This is largely due to the decrease in proportion of large fish in the catch. In contrast, the average weights of bigeye taken in free schools have increased in recent years. This is believed to be largely an artefact of limited sampling (on relatively small catches). For purse seine catches as a whole, mean weight appears stable.

Other Status Indicators

1. **Trends in total catch**: Total Indian Ocean catch of bigeye tuna peaked during 1997-99 at 144-150,000 t per year. Catches fell to 129,000 t in 2000 and 111,000 t in 2001. This decline is most pronounced in purse seine catches, but is also seen in longline catches. (Figure 12)
2. **Trends in catch per unit effort:** As mentioned above, Japanese longline CPUE has decreased steadily over the past 15 years. It is now at its lowest level ever. For the western Indian Ocean purse seine fishery, nominal CPUE (catch per successful set on FADs) has varied quite considerably, but without clear trend, since 1995. Since the fishing power of the fleet is believed to have increased in that time, it is assumed that standardized CPUE may have decreased (Figure 13)
3. **Trends in mean weight**: As mentioned above, mean weight of bigeye taken by purse seine under FADs has declined slightly in recent years. This appears to be due to a change in the proportion of large and small fish in the catch. For purse seine catches as a whole, and for longline catches, the average weight of bigeye has been roughly stable over the past 20 years. (Figure 14)

Technical Advice on the Status of Bigeye Tuna

The new information presented relating to stock status of Indian Ocean bigeye tuna is in agreement with advice given by the WPTT in its last report, suggesting high levels of exploitation. Further details are given in the Executive Summary.

***Figure 12.** Yearly catches (in thousands of metric tons) of bigeye tuna by gear for the period 1950-2001.*

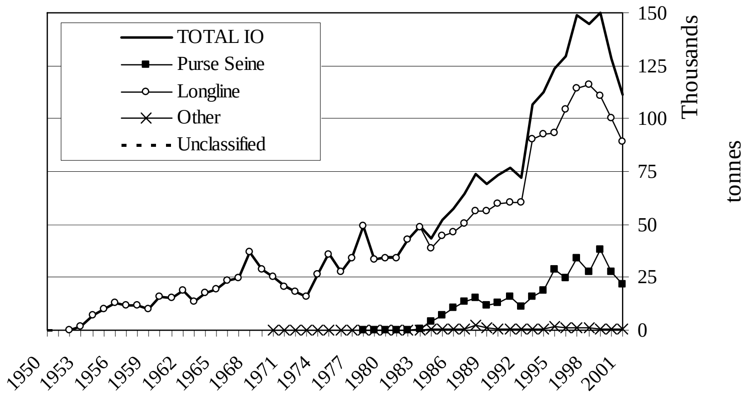


***Figure 13.** Nominal and standardized bigeye tuna CPUE of the Japanese tuna longline fisheries based on GLM analysis (1960-2001) (WPTT-03-11)*

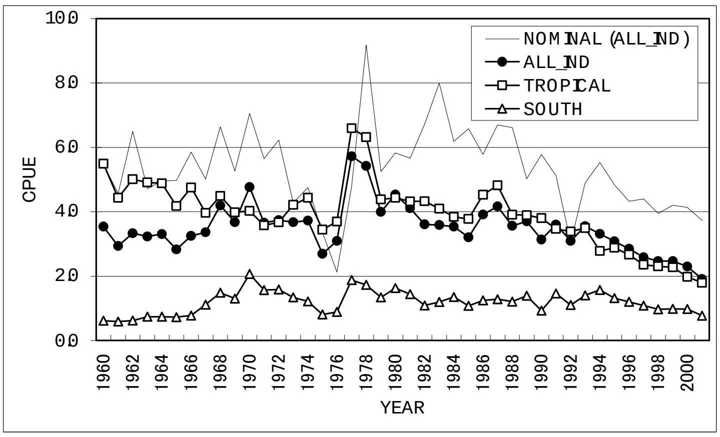
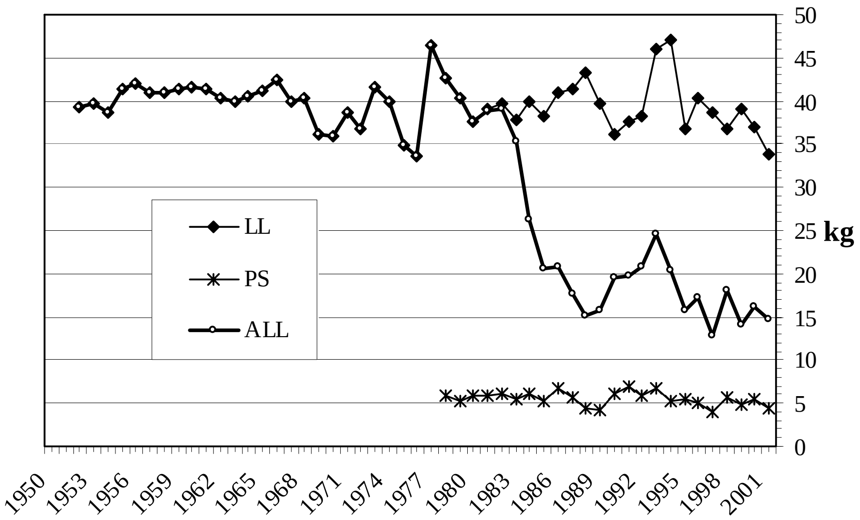


***Figure 14**. Bigeye tuna average weight in the catch, by gear (from the size-frequency data) and for the whole fishery (estimated from the total catch-at-size).*



6.2 YELLOWFIN TUNA (*Thunnus albacares*)

Japanese longliners have been operating in the Indian Ocean since 1952. Particularly since 1974 there has been a trend towards increasing fishing depth by increasing the numbers of hooks between floats. The results of a comparison of two methods to standardize yellowfin tuna CPUE of Japanese tuna longline fishery (General Linear Model, GLM, and combined GLM/Habitat-Based Model, HBM/GLM) were presented in WPTT-03-05. Most attempts at standardization of Indian Ocean CPUE time series have been based on GLM. However, the HBM approach takes into account actual depths of habitat and gear, so it may provide a more realistic and reliable means of CPUE standardization. As a first step, a minimum of information (depth distribution of longline gear and vertical distribution of yellowfin tuna) was used to carry out a HBM/GLM analysis. This proved more effective than a simple GLM approach on the basis of the proportion of variance explained by the model and other similar criteria. It is therefore planned to carry out further development of HBM/GLM standardization of longline CPUE (for example using oceanographic data such as shear current, temperature at depth, and oxygen). Preliminary results of this approach are presented in Figure 16. The trend of HBM/GLM standardized CPUE is rather similar to that obtained previously: a fairly rapid decline in CPUE during the first 10-15 years of the fishery has been followed by a long period of rather stable CPUE.

The average weights of yellowfin tuna taken by purse seiners under FADs have decreased slightly during recent years (WPTT-03-4). This is largely due to the decrease in proportion of large fish in the catch. In contrast, the average weights of yellowfin taken in free schools have increased in recent years. For purse seine catches as a whole, mean weight has decreased. Total catch has been maintained at roughly constant levels in recent years, but only by catching greater numbers of yellowfin.

Other Status Indicators

1. **Trends in total catch**: Total Indian Ocean catch of yellowfin tuna peaked at about 386,000 t in 1993. This peak was largely the result of exceptionally high catches by Taiwanese longliners in the northern Arabian Sea during that year. Even ignoring this exceptional peak, total yellowfin catch has declined slowly and erratically in recent years. In 2001 total catch declined to 281,000 t, the lowest level since 1991 (Figure 15)
2. **Trends in catch per unit effort**: As mentioned above, Japanese longline CPUE has been roughly stable (varying slightly without obvious trend) over the last 20 years. For the western Indian Ocean purse seine fishery, nominal CPUE (for all catches) has been roughly stable for the last 12 years. However, fishing power of the fleet is believed to have increased during that time, so it is assumed that standardized CPUE should have decreased (Figure 16). As it was noted in previous WPTT reports, the large decrease in the early years in the Japanese LL CPUE is not considered to reflect an actual decrease in yellowfin abundance.
3. **Trends in mean weight**: Mean weight of yellowfin taken by purse seiners has declined since 1993. This is due to a change in the proportion of large and small fish in the catch. Whether this change is a simple reflection of a change in fishing practice (more fishing on FADs) or is also of biological significance is not clear. For longline catches, the average weight of yellowfin has been declining slowly since 1977. (Figure 17)

Technical Advice on the Status of Yellowfin tuna

The new information presented relating to stock status of Indian Ocean yellowfin tuna is in agreement with advice given by the WPTT in its last report, suggesting high levels of exploitation. Further details are given in the Executive Summary.

Figure 15. *Yearly catches (in thousands of metric tons) of yellowfin tuna by gear for the period 1950-2001.*

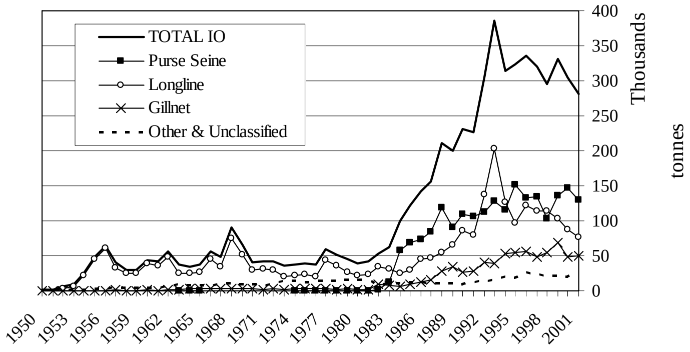


Figure 16. *Standardized yellowfin tuna CPUE of the Japanese tuna longline fisheries based on the GLM and the HBM (Habitat-Based-Model)/GLM combined analyses (1958-2001) (WPTT-03-05).*

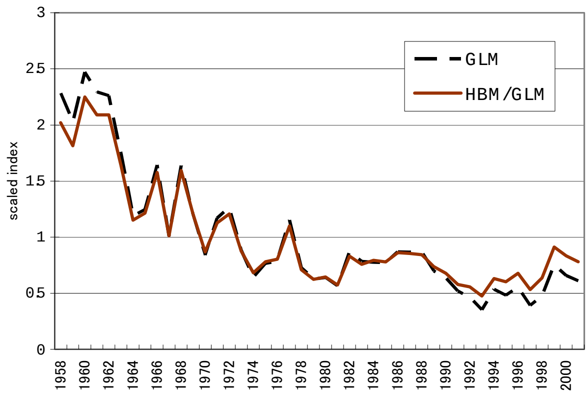
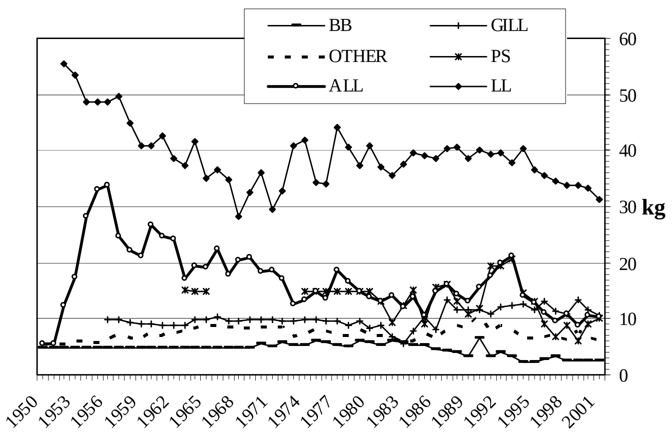


Figure 17. *Yellowfin average weight in the catch by gear (from size-frequency data) and for the whole fishery (estimated from the total catch at size).*



7. TECHNICAL ADVICE ON RESOLUTION 02/09: ON THE CONSERVATION OF BIGEYE AND YELLOWFIN TUNA IN THE INDIAN OCEAN

At its 7th Session, the Commission adopted Resolution 02/08, the main operative paragraphs of which include "*The IOTC … resolves to seek technical advice from the Scientific Committee for the next session of the Commission on:*

> - *Potential management measures designed to reduce the fishing mortality on juvenile bigeye and yellowfin tuna. The measures to be investigated should include, but not be restricted to, time and/or area closures on purse seine fishing on floating objects, and other forms of effort reduction or alternative fishing strategies.*
> - *Other potential management measures aimed at maintaining or reducing the effective fishing effort and catches of yellowfin and bigeye tunas by all gears.*
> - *The likely effect of these measures on the future productivity of the stocks of bigeye and yellowfin tunas and their consequences on catches of skipjack tuna.*

On the basis of the updated scientific advice, the Commission will seek to adopt appropriate measures to address the recommendations of the Scientific Committee at the 2003 Session of the Commission".

7.1 Background and new or updated information

The WPTT considered new and updated information with regard to this issue.

Document WPTT/03/04 presents an overview of the FAD fishery in the Indian Ocean since the early eighties. Comparisons are made between FAD and free school fisheries. The difference between size distributions from catches on free schools and catches on FADs, particularly for bigeye, is shown. Maps identify the area with highest catches from FADs in recent years as the region off Somalia. Fishing on FADs in this area occurs in all months, but catches peak between July and November. This reconfirms the findings on appropriate areas and times of the Working Party meeting in 2000. The document also lists potential management measures for FAD fishing; these are further addressed below. During discussion, it was noted that the spatial and temporal distribution of peak catches on FADs has been reasonably consistent in the recent past.

Document WPTT/03/12 evaluates the effect of different purse seine fishing effort reduction scenarios. This document also provides an analysis of data on catches on FADs by time of day, which suggest that particularly high catches are obtained at sunrise, and they contain a high proportion of bigeye. The data do not, however, allow distinction between a first or subsequent set on the same FAD.

Information on FAD fishing activity, based on observations on one Spanish vessel, was presented in WPTT/03/24. The number of retrieved, recycled and newly deployed FADs was monitored, as well as the number of visits to FADs and random encounters with "natural" FADs. The type of equipment associated with FADs had an effect on the number of visits and the catches obtained under the FADs. It was also noted that although GPS-equipped FADs may appear to be inefficient because many visits were made with relatively low catch, this may be misleading because it is very easy to visit a GPS-equipped FAD. FADs with echosounders were also sometimes visited without sets being made because the echosounder only provides information about fish right underneath the FAD, and not about fish in a wider area around the FAD.

The WPTT agreed that it is essential to obtain more information on the characteristics of the FAD-associated fishery, in particular, the overall number of FADs in operation in the Indian Ocean, noting that this could vary greatly within a year. In order to correctly estimate the effects of the FAD other information will also be necessary, such as the effective 'lifespan' of FADs.

7.2 Management measures to reduce the fishing mortality of juvenile bigeye and yellowfin tunas

As requested by the Commission, the WPTT evaluated a number of potential management measures that could lead to a reduction in the fishing mortality on juvenile bigeye and yellowfin tunas. These are listed in Tables IV.1 and IV.2 in Appendix IV, which summarise the management measures, their likely effects and advantages and disadvantages. A more detailed discussion of each of the measures considered can be found in the following sections.

Various analyses were conducted in order to assess the effects of the measures considered. These are described in detail under the relevant sections. In several cases, the WPTT could not conduct a quantitative assessment of the effects of a particular measure due to the absence of data pertinent to that measure. In some cases, the likely response of the fishing fleets to the measures is difficult to quantify. In these cases, estimates of the effects of management measures given in Table IV.1 are maximum achievable numbers since they essentially assume perfect implementation of the measure, or in the case of a time-area closure, that purse seiners that normally fish in the moratorium area do not fish elsewhere during the moratorium period. In other cases, such as the reduction in the number of purse-seine vessels, the effect of the measure can be more accurately predicted, as it is unlikely to be compensated for by a change in fishing strategy.

Short-term vs long-term effects. A distinction needs to be made between the immediate losses that would come from the application of a management measure (short-term effects) in terms of lost catches of the three species of tuna, and the beneficial effects that are to be expected from improved productivity of the stocks (long-term effects). The procedures used to estimate short-term effects differ in detail among the management measures considered, so they are described under the pertinent sections. However, in general short-term calculations were based on recent catch rates by species and sizes and, therefore, these applied to all three tropical tuna species. In contrast, the long-term calculations could only be conducted for bigeye tuna, as this is the only species for which estimates of fishing mortality at age are available. To estimate long-term effects on total catch of bigeye tuna, where it was possible to estimate the potential reduction in fishing mortality, the WPTT used two approaches: **stock projections** and **per-recruit analyses**. As these approaches were used in the evaluation of several of the options, they are reviewed next.

> **Long-term effects using stock projections.** The WPTT conducted stock projections only for bigeye tuna, as there are no reliable estimates of the required parameters for the other tropical tuna species. The WPTT updated the projections done in 2001 with new information, including a revised and updated catch series, a new growth curve, and the standardized longline CPUE for the most recent years. The projections cover a period of ten years, during which both annual catches and sizes of the spawning stock of bigeye can be estimated. To explore the effect of the uncertainty on the natural mortality by age, the projections were done based on three different assumed patterns:
>
> The WPTT reiterates the uncertainties and caveats noted in its reports of 2001 and 2002 with respect to the bigeye assessment (on which the stock projections are based), including uncertainty about the natural mortality at age and about the increase in efficiency of the different fisheries involved, lack of adequate size-frequency data for longline fisheries, especially in recent years and unresolved questions about how well the longline-based standardized CPUEs reflect abundance.
>
> As previously, the WPTT stressed the fact that the caveats and uncertainties expressed about the assessment apply even more strongly to the results of the projections. These calculations are meant to be interpreted as an example of what are possible trends in the fishery if the current status of the resource is well approximated by the results of the assessment. As such, the predictions regarding actual catch levels and their changes over time should be taken with considerable caution.
>
> **Long-term effects using per-recruit analyses.** As in the case of the projections, this approach was only applied to bigeye tuna, since fishing mortality at age is not available for the other tropical tuna species. The analyses allow quantification of the likely long-term effects on the yield per recruit and spawning stock per recruit. Given that estimates of the fishing mortality at age of bigeye tuna come from the assessment, the same uncertainties and caveats apply to the per-recruit analyses.

Long-term effects of reductions in fishing mortality of bigeye tuna. The management options considered were designed to result in a reduction in fishing mortality. In order to evaluate the likely long-term effects (ten years of those management options, first the extent to which they would reduce fishing mortality has to be estimated. Then, this reduction is applied to estimates of current fishing mortality which are then used as inputs for both projections and per-recruit analyses.

Both the projections of the total yield of bigeye tuna and the yield-per-recruit analyses provide very similar results for the long-term effects. Considering that the current assessment suggests that there is only a very weak relationship between the size of the spawning stock biomass and the recruitment, both analyses are essentially the same. Therefore, only the results of the projections were used for assessing long-term effects.

The main feature shared by these analyses is that, according to the current assessment of the bigeye tuna, the likely long-term benefits in total catch of any level of reduction in the purse-seine fishing mortality are at best moderate. This is illustrated by estimating the improvement in yields arising from a hypothetical measure that would result in a 100% reduction in fishing mortality of juvenile bigeye tuna (fish younger than two-years old). Such a measure would result in an improvement of about 13-24% (depending on the assumed patterns of juvenile natural mortality and according to the results of the current assessment).

The projections also indicate that the effects will be different for the purse-seine and the longline fisheries. The purse-seine fishery would suffer losses of catches. There would be, however, long-term increases in the catches of longline fishery, as more fish become available to the latter. The Table 1 illustrates the long-term effects on bigeye catches of a reduction in purse seine fishing mortality compared to current levels of fishing mortality. Estimates are based on the current assessment and a juvenile natural mortality value of 0.8. Estimates are very similar for the two alternative assumptions about juvenile natural mortality.

Table 1. *Long-term effects of reduction in PS fishing mortality on total catch of bigeye tuna.*

Reduction in PS fishing mortality	Change in PS catch	Change in LL catch	Change in Total catch
5%	-3.8%	+1.9%	+0.6%
10%	-7.7%	+3.8%	+1.2%
15%	-11.8%	+5.8%	+1.8%
20%	-15.9%	+7.8%	+2.4

The WPTT also investigated the possible long-term effects of reductions in fishing mortality of both the purse seiner and longliner fleets, and compared results to the case where there is no reduction in the LL fishing mortality. The table below shows that a reduction in PS fishing mortality, combined with a reduction in LL fishing mortality generally leads to a reduction in overall (total) yield. An increase in total yield is only obtained for a relatively large reduction in PS fishing mortality and a small (or no) reduction in the LL fishing mortality.

Table 2. *Long-term effects of changes in both PS and LL fishing mortality on total catch of bigeye tuna.*

	10% reduction in PS fishing mortality	20% reduction in PS fishing mortality
0% reduction in LL fishing mortality	PS: -8% LL: +4% Total: +1%	PS: -16% LL +8% Total: +2%
10% reduction in LL fishing mortality	PS: -6% LL: +1% Total: -1%	PS: -14% LL: +5% Total: +0.4%
20% reduction in LL fishing mortality	PS: -3% LL: -3% Total: -3%	PS: -11% LL: +0.5% Total: -2.1%

The situation is different concerning the spawning stock biomass. A decrease in the catches of any of the gears leads to an increase in the long-term spawning stock biomass. Although the current assessment indicates that spawning stock biomass is above the MSY level, there is considerable uncertainty about the estimation of the level of stock size that would produce the MSY.

Table 3. *Changes in spawning stock biomass (SSB) for reductions in PS and LL fishing mortality*

	10% reduction in PS fishing mortality	20% reduction in PS fishing mortality
0% reduction in LL fishing mortality	+4%	+8%
10% reduction in LL fishing mortality	+15%	+20%
20% reduction in LL fishing mortality	+27%	+33%

- **Time-area closure to purse seine fishing**

If a closure to all purse seine fishing were to be implemented in an area for a specified time period, then this could be enforced through a VMS system, without placement of inspectors, on all vessels that have a VMS system installed. Such a closure would, however, impose a restriction on fishing free schools, which is not necessary to achieve a reduction in fishing mortality on juvenile bigeye tuna. An alternative option would be to apply the closure only to fishing on floating objects, with no restrictions being placed on fishing on free schools. In principle, this would allow fishermen to fish on free-swimming schools in the closed area, as such schools do not contain small fish. However, existing data on purse-seine fishing in the proposed moratorium area and period indicate that only a very small proportion of the catches have been taken from free-swimming schools. Further, enforcement of this measure would require the presence of inspectors on board all vessels. In the calculations that follow, the WPTT considered only the first option, that is, a closure to all purse-seine fishing.

Options for a time-area closure of the purse-seine fishery have been already considered and its short-term effects assessed by the WPTT in 2000, following a request from the Commission. During the current meeting, an analysis of the most recent data concerning the spatial and temporal distribution of the purse-seine bigeye catches did not reveal any major changes in the patterns identified in the 2000 meeting (Figure 18). Therefore, the WPTT retained the options presented at that time, and updated the calculations concerning the effects in juvenile mortality and short-term effects on catches of tunas. The areas and times considered are (see Figure 19):

- An area extending from 60°E to the African coast and from the equator to 5°N, closed from September to October (two months)
- A larger area extending from 60°E to the African coast and from the equator to 10°N, closed from August to November (four months)
- An area extending 55°E to the African coast and from the equator to 5°N, closed from January to December (twelve months)

Short-term consequences of the different options for the moratorium were assessed in terms of the following species and size categories, based on historical size-frequency distributions for yellowfin and bigeye tunas taken on drifting objects:

- Yellowfin tuna (below and above 5 kg)
- Bigeye tuna (below and above 10 kg),
- Skipjack (all sizes)

The results of the calculations concerning the options presented (listed in Table 4) are similar to those obtained previously. The WPTT was unable to predict the catches resulting from fishing outside the moratorium area, so the results presented are based in the extreme assumption that the loss of the catch in the moratorium area will not be offset by catches in other areas (i.e. all vessels that previously had fished on drifting objects in the defined region stop fishing for the period of the moratorium). The WPTT emphasised that in practice there would be, almost certainly, less loss of catch and a lower reduction in juvenile fishing mortality than that suggested by the current calculations, but it was unable to estimate their extent.

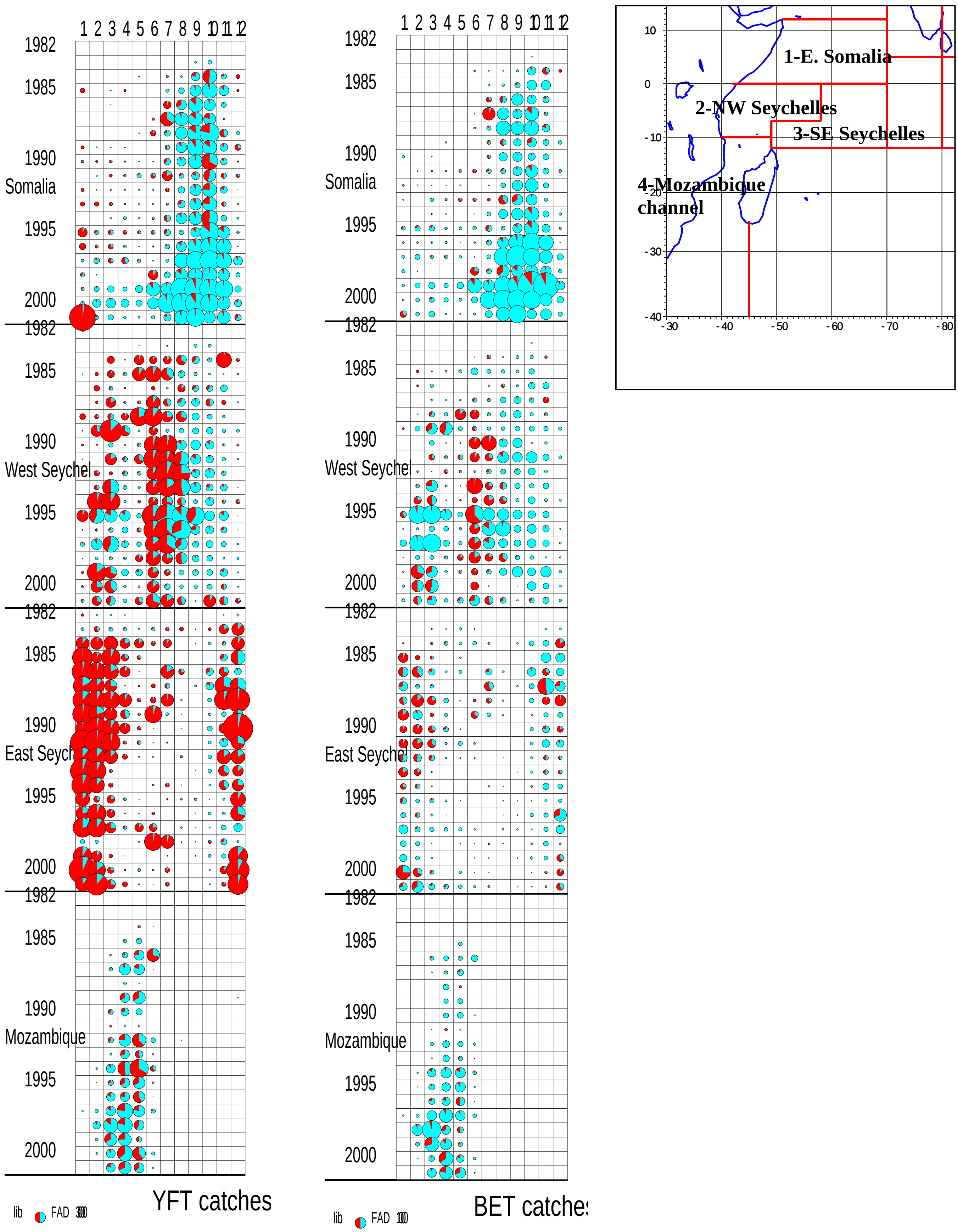
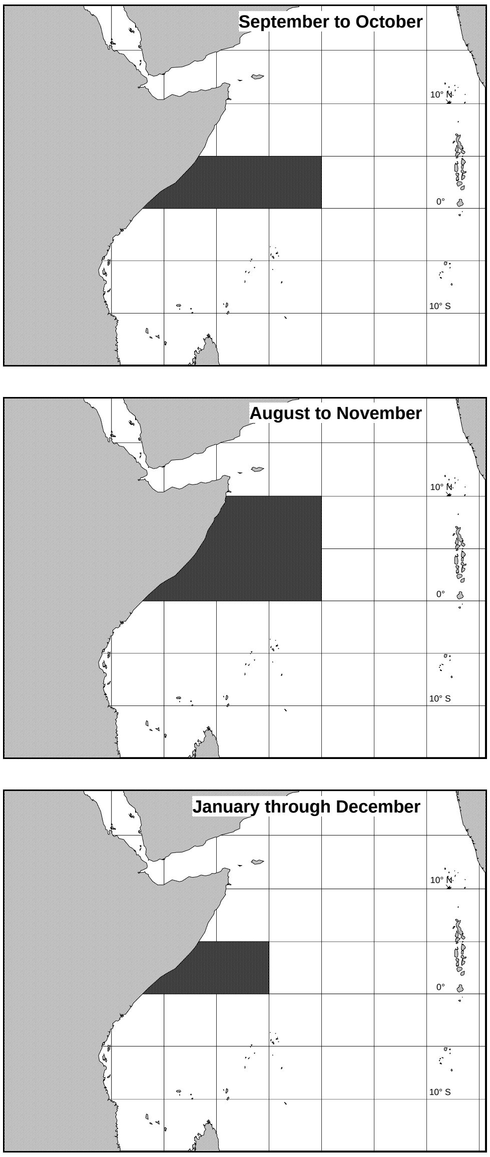


Figure 9. *Monthly catches of yellowfin (left) and of bigeye (right) taken by area under FADs (grey) and on free schools (dark) by Indian Ocean purse seiners (from WPTT-03-04)*

Figure 19. Areas and periods considered in the assessment of options for a time-area closure.



- **Reduction in overall purse seine effort**

A reduction in overall purse seine effort could be implemented in different ways, for example, a reduction in the number of vessels, or an increase in the number of days in port. With regard to an increase in the number of days in port, the idea is that after a purse seiner has unloaded following a fishing trip, the vessel would be forced to remain in port for an additional specified number of days. The WPTT considered two options for a measure requiring increased number of days in port: a) the measure is applied only in the second semester (July to December) when most catches are taken on FADs, and b) the measure is applied over the whole year (see Table 5). The WPTT noted that the latter option would apply to vessels even during those periods when the fishing is primarily on free-swimming schools.

Table 4. *Potential benefits (in percent reduction of juvenile mortality) for three options for the moratorium. Large tunas: bigeye > 10 kg + yellowfin > 5 kg.*

Area	*Months*	*Benefits (reduction of juvenile mortality)*		*Maximum costs (loss of catches in t)*	
		Bigeye	*Yellowfin*	*Large tunas*	*Skipjack*
0°- 5°N; Coast – 60° E	Sep through Oct	12%	15%	5,900	19,500
0°- 10°N; Coast – 60° E	Aug through Nov	31%	38%	14,800	49,400
0°- 5°N; Coast – 55° E	Jan through Dec	20%	26%	10,400	31,600

The approach used to evaluate the likely effects of a reduction in overall purse seine effort is presented in WPTT/03/12. The approach uses the average catch rates by species across vessels to infer the likely losses of catches for assumed reductions in purse seine effort. Information on individual size in the catch is used to separately infer the effects on catches of juvenile (< 10kg) bigeye and (< 10kg) yellowfin and on total catches (all sizes) of bigeye and yellowfin. Catch rates vary between vessels and this was taken into account in the calculations in order to estimate a range of likely effects. This approach allows quantification of likely effects on catches in the short term for yellowfin, bigeye and skipjack.

- **Limitations on the number of FADs and/or their electronic equipment**

Limiting the total number of FADs deployed would directly address the problem of reducing fishing mortality on juvenile bigeye and yellowfin tunas. However, monitoring the number of drifting objects deployed by purse seiners or supply vessels would imply having inspectors on board permanently. Furthermore, at this stage there is no information about the current number of drifting objects deployed or about the relation between the number of drifting objects and the resulting catches.

- **Ban on supply vessels**

There was no new information on this possible management measure, but a comparison of the catches of Spanish and French purse seiners on drifting objects was presented to the WPTT in 2000 (see Report of the WPTT-2000). This emphasized the difference in bigeye tuna catch rates of the Spanish and French purse seiners since 1994, the year when a supply vessel first operated in the fishery. It was suggested that the higher catch rates obtained by the Spanish fleet were associated with the use of supply vessels. Catch rates during the years before 1994 were similar for the Spanish and French boats, as both fleets were operating in a similar manner.

The WPTT noted that the current information is too limited to properly quantify the effect of the supply vessels.

Table 5. *Reduction in annual catch for two level of reduction in the number of purse-seiners, estimated from the average annual catch rates. UL represents an upper limit based on the average plus one standard error; LL represents the lower limit calculated as the average minus one standard error.*

		Effort	*Total catch*	*YFT > 10kg*	*SKJ*	*BET > 10kg*	*YFT < 10kg*	*BET < 10kg*	*Number of sets*
Current catch in tons		15,406	354,487	143,677	180,807	30,003	45,946	21,609	11,150
					Percent changes				
5% reduction in number of vessels (3)	UL	6%	8%	8%	9%	9%	9%	9%	8%
	mean	5%	5%	5%	5%	5%	5%	5%	5%
	LL	4%	2%	2%	2%	2%	2%	2%	3%
10% reduction in number of vessels (6)	UL	13%	17%	17%	17%	17%	18%	18%	16%
	mean	10%	10%	10%	10%	10%	10%	10%	10%
	LL	7%	5%	5%	4%	4%	4%	4%	5%

- **Limits on skipjack catches by purse seiners**

Early in 2001, a voluntary restriction on the landings of skipjack tuna was agreed among tuna boat owners as a response to the oversupply of skipjack tuna in the worldwide market. As a consequence, there was a reduction in the number of FAD-associated sets. Such a reduction probably led to a decrease in the catches of juvenile bigeye and yellowfin tuna. However, the WPTT noted that such a measure would be difficult to implement in the form of a management measure, and would probably lead to increased discards of skipjack tunas.

- **Size Limit**

As was demonstrated by ICCAT's experience with similar regulations, the Working Party believed that it is not possible to implement this management measure effectively. The WPTT considers that, if a size limit on bigeye and yellowfin could be implemented in such a way that all fish below size are returned to sea alive, then the effect would be 100% reduction in fishing mortality on juvenile bigeye and yellowfin. In practice, this is impossible in the purse seine fishery.

Other considerations

One additional measure, namely preventing setting at sunrise, was considered because catches on FADs appear to be highest at sunrise, and also contain high proportions of bigeye (WPTT/03/12), based on data collected by observers. Implementing and enforcing such a measure is considered to be highly impractical.

The WPTT noted that the intended benefits of any of the measures considered would be fully attained only to the extent that fleets comply with the measures. The WPTT realizes that IUU fleets might not comply with the measures. However, it was noted that the estimated catches of tropical tunas by vessels that would probably comply represent a substantial proportion of the total catch of tropical tunas.

7.3 Reducing the effective fishing effort and catches of yellowfin and bigeye tunas by all gears

In 2001, the WPTT noted with concern that catches of bigeye tuna had been increasing up to 1999, the last year with data available for analyses. Taking this into account, the WPTT concluded that it was likely that current catches were well above MSY and recommended that a reduction in catches of bigeye tuna from all gears be effected as soon as possible.

Since then, catches of bigeye tuna have decreased and current catches are closer to estimated MSY levels. However, the WPTT noted that there is uncertainty about the level of the spawning stock biomass corresponding to MSY as a result of the caveats that applied to the 2001 assessment.

An evaluation of the likely long-term effects of a reduction of fishing effort or catch in both purse-seine or longline fishery was presented in Table 3 and discussed in section 6.2.

As noted above, reductions in purse-seine fishing effort or controls on the catch of yellowfin or bigeye tuna would result in important losses of skipjack tuna, the main target species of this fishery. Similarly, effort or catch controls on longline fisheries could negatively affect those fleets that, while targeting other species, still catch bigeye tuna in small quantities as an incidental catch.

8. TECHNICAL ADVICE ON OPTIMAL FISHING CAPACITY

The Working Party agreed that for the reasons given in its report in 2001, it was unable to provide substantive advice on the optimal fishing capacity for tropical tunas.

However, the WPTT noted that there is convergence in terms of the assessments and technical advice for bigeye and yellowfin tuna. In particular, the advice that there should be a reduction in catches of bigeye tuna by all gears and, at least, no further increase in catches of yellowfin tuna, implies that there should be no further increases in effective effort directed at two of the three main tropical tuna species. Furthermore, the advice regarding the need to reduce catches of juvenile bigeye and yellowfin tuna on floating objects is also consistent. It is noted that measures to achieve this reduction are also likely to affect catches of skipjack tunas.

9. RESEARCH RECOMMENDATIONS AND PRIORITIES

General

1. The WPTT strongly reiterates its previous major recommendation in support for a large scale tagging programme targeting yellowfin, bigeye and skipjack in the entire Indian Ocean. There are no doubts that such tagging programme will be the key stone for most tropical tuna researches done during the incoming years in the Indian Ocean. Undoubtedly, such programme will provide multiple and valuable information concerning tuna growth rates, stock structure and mixing, natural mortality at age, fishing mortality and stock sizes at age, behavior of tunas associated to FADs, etc. that will provide major improvements to the reliability of all future tuna stock assessment in the Indian Ocean.
   The WPTT was very pleased to take note of the major progresses recently obtained concerning this IOTC tagging programme, primarily because of the large funding pledged in 2003 by the EU (>15M$ over a 5 years period, starting in 2004), and because of the Japanese proposal to initiate soon a pilot tagging of tunas in the Eastern Indian Ocean.
   The WPTT firmly reiterates its recommendation that the IOTC tagging programme should necessarily be conducted simultaneously, in a well coordinated way, in the Eastern and Western Indian Ocean. This simultaneous tagging will be necessary in order to reach the main goals of the IOTC programme, for instance concerning growth, movement patterns and stock sizes estimates. Then, the working party is strongly recommending giving more strength and better international involvement to the Eastern Indian Ocean tagging soon initiated by Japan.

2. Scientists are encouraged to undertake – in relation with other Commissions – further research on interpretation of longline CPUEs for tunas and tuna-like species, and in particular on the possible causes of the substantial important decreasing trend in the early years of the fishery and the apparent stability on recent years. Possible approaches include incorporation of behavioral models and/or vertical stock stratification into the operational models.

3. Developments in fishing practices and gear technology – and more specifically regarding the use of FADs – need to be fully documented, and the European scientists are encouraged to continue retrieving information on these subjects, with an emphasis on historical data in the Somalia area. Further research needs also to be done on differentiating regular and deep longlines and other aspects of targeting.

4. Where possible, ecosystem components should be incorporated into stock status evaluations. As a starting point, information on the condition factors was considered a possible indicator of the status of the ecosystem. Information on condition factors should be obtained for the purse seine as well as for the longline fisheries.

5. To improve our understanding of both the impact of tuna fishing on the ecosystem functioning and he consequences that climate changes may have on ecosystem structure and hence on tuna stocks, it is

recommended that ecosystem modeling including detailed tuna population dynamics be attempted in the Indian Ocean.

6. Scientists are encouraged to further research on the spatial distribution of tropical tuna in the Indian Ocean in order to redefine areas more in accordance with the tropical tuna habitats.
7. Scientists are encouraged to continue collection of information on predation and to incorporate the effects of the predation into stock assessments and develop research on possible mitigation measures.

Statistics

8. The IOTC Secretariat is requested to continue efforts to retrieve historical records on the individual weights of tuna and tuna-like species from landings of fresh tuna longliners to Indian Ocean ports.
9. All parties with longline vessels fishing for tropical tunas in the Indian Ocean are requested to make every possible effort to improve the size sampling coverage.
10. All countries reporting statistics to the IOTC are encouraged, if have not done that, 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 the country.
11. The Japanese scientists are encouraged to make every possible effort to retrieve all information available on size frequency data of skipjack tuna caught under longlines and report it to the IOTC Secretariat.
12. All parties having gillnet fisheries catching important amounts of tropical tunas are requested to make every possible effort to collect detailed catch and effort and size frequency statistics on these fisheries and to improve reporting on existent statistics to the IOTC Secretariat.
13. All parties having industrial fisheries likely to have tropical tunas discarded are requested to improve the collection and reporting of discard statistics to the IOTC.
14. The WPTT strongly recommend that the IOTC-OFCF Project be continued, given the success of the Project to date.

Stock Assessment

15. Even though some progress has been achieved, all scientists are encouraged to further research on methods leading to the standardization of longline CPUE, including studies to differentiate regular and deep longlines, estimate the changes in fishing efficiency, improve the knowledge on targeting practices by skippers as well as to include environmental data in the calculation of indices of abundance.
16. Scientists are encouraged to continue research on the dynamics of tunas associated with fish aggregating devices in the Indian Ocean in order to better understand their behavior and to try to identify and develop reliable indices of abundance for tuna associated with fish aggregating devices.
17. The WPTT took note of the programs being set up by EU and Australian scientists in order to develop an operational model and appropriate simulation models for testing methods of analysis, and encourage their application to Indian Ocean tropical tunas.
18. Noting that many of the biological parameters and stock structure definition presently available and used by the working party are quite old and often uncertain, scientists are encouraged to develop studies in order to update these parameters.

Bigeye Tuna

No specific recommendation (or included in Stock assessment).

Yellowfin Tuna

No specific recommendation (or included in Stock assessment).

Skipjack Tuna

19. An important potential problem in the skipjack fisheries is interaction between industrial and artisanal fisheries, and more particularly between the western Indian Ocean purse-seine fishery and the 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 be able to improve these analyses. However, the WPTT recognizes that only a tagging programme would provide the necessary data to better estimate the level of the interactions.

9.1 Recommendations on organization of future work

The WPTT stressed the importance to have at its disposal, in addition to the evaluations, a set of traditional simple indicators for the main fisheries such as: catch trends, nominal efforts and raw CPUE, trends in sizes and average weight of the catches; size of the exploited fishing area; etc. These indicators should be prepared in advance according to the data available to the Secretariat and made available at the beginning of the working groups meetings.

The WPTT examined possible priorities to consider at its next meeting. The WPTT decided that it will give priority to either yellowfin or bigeye tuna, unless there are instructions on the contrary from the Scientific Committee or the Commission. The choice will largely depend on the availability of new fishery and biological data, more reliable CPUE indices for longline and purse-seine fisheries, and size-frequency data from non-reporting fleets. Consequently, the WPTT decided not to make any specific recommendation to the Scientific Committee, who will then have the opportunity to decide on the priority for the next WPTT meeting on the basis of the information available at its next Session.

Taking note of the programs being set up by EU and Australian scientists, the WPTT consider that a meeting of the Working Party on Methods in 2004 will be convenient in order to define and coordinate the work on development of operational models and appropriate simulation models for testing methods of analysis. This meeting will probably need two days, and it has not necessarily to be linked to the WPTT meeting.

10. ANY OTHER BUSINESS

10.1 Election of a new Chairperson for the period 2003-2005

The Working Party on Tropical Tunas unanimously agreed to elect Dr Pilar Pallares to chair the WPTT for the next biennium.

11. ADOPTION OF THE REPORT AND ARRANGEMENT FOR NEXT MEETING

The report of the WPTT was adopted on June 12th, 2003. It was agreed that next meeting of the Working Party on Tropical Tunas should be held in June of 2004. The details of dates and place and venue are to be arranged by the Secretariat.

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APPENDIX II. AGENDA OF THE MEETING

1. *Opening of the Meeting*
2. *Review the statistical data for the tropical tuna species and the situation in reporting countries on data acquisition, for reporting to the WPDCS.*
3. *Review new information on the biology of skipjack tuna.*
4. *Review of new information on the status of skipjack tuna.*
5. *Review of new information on the biology of yellowfin and bigeye tunas.*
6. *Review of new information on the status of yellowfin and bigeye tunas.*
7. *Develop technical advice on Resolution 02/09: "On the conservation of bigeye and yellowfin tuna in the Indian Ocean"*
8. *Consider the question of the optimum fishing capacity of the fishing fleet.*
9. *Identify research priorities, and specify data and information requirements, necessary for the Working Party to fulfil its responsibilities.*
10. *Any other business*
11. *Adoption of the Report*

APPENDIX III. LIST OF DOCUMENTS PRESENTED TO THE MEETING

DOCUMENTS	TITLES
WPTT-03-01	Status of IOTC databases for Tropical Tunas. *IOTC Secretariat*
WPTT-03-02	A comparative overview of skipjack fisheries and stocks worldwide*. A. Fonteneau*
WPTT-03-03	Note upon the sampling problems of the purse seine fishery during the year 1998. *A. Fonteneau*
WPTT-03-04	Prospects for the management of FAD fisheries in the Indian Ocean. *A. Fonteneau*
WPTT-03-05	Comparative study on Japanese tuna longline CPUE standardization of yellowfin tuna (*Thunnus albacares*) in the Indian Ocean using two approaches: General Linear Model (GLM) and Habitat-Based Model (HBM). *T. Nishida, K. Bigelow, M. Mohri and F. Marsac*
WPTT-03-06	Japanese skipjack fishery and research activities in the Indian Ocean. *Ogura et al*
WPTT-03-10	Report on the predation survey by the Japanese commercial tuna longline fisheries (September, 2000 - September, 2002). *T. Nishida and Y. Shiba*
WPTT-03-11	Standardized Japanese longline CPUE for bigeye tuna in the Indian Ocean up to 2001. *H. Okamoto and N. Miyabe*
WPTT-03-12	Evaluation of the effect on the bigeye stock of different purse seine fishing effort reduction scenarios. P. *Pallares, H. Arrizabalaga, A. Delgado de Molina, A. Fonteneau, I. Artetxe and V. Lucas*
WPTT-03-13	Statistics of the purse seine Spanish fleet in the Indian Ocean (1984-2002). *A. Delgado de Molina, P. Pallares, J. J. Areso and J. Ariz*
WPTT-03-14	Statistics of the main purse seine fleets fishing in the Indian Ocean (1981-2002). *P. Pallares, A. Delgado de Molina, R. Pianet, J. Ariz, V. Nordstrom, P. Dewals and V. Lucas*
WPTT-03-15	Use of delay-difference models to assess the Indian Bigeye stock. *P. Pallares, V. Restrepo, A. Delgado de Molina and J. Ariz*
WPTT-03-16	European Union observer programme on purse seiners in the Indian Ocean. *A. Delgado de Molina, J. Ariz, P. Pallares, H. Arrizabalda, L Artetxe and J. C. Santana*
WPTT-03-17	An outline of the growth study on skipjack tuna (*Katsuwonus pelamis*) in the Western Pacific. *T. Tanabe, S. Kayama and M. Ogura*
WPTT-03-18	French purse-seine tuna fisheries statistics in the Indian Ocean, 1981-2002. *R. Pianet, V. Nordstrom and P. Dewals*
WPTT-03-19	Some consideration on the fishing ability of individual Japanese purse seine vessels and standardized CPUE on their fishery data. *M. Ogura and T. Matsumoto*
WPTT-03-20	Provisional plan on tuna tagging experiments in the eastern Indian Ocean by Japan. *National Research Institute of Far Seas Fisheries (NRIFSF)*
WPTT-03-21	Growth parameters estimated for Yellowfin Tuna occurring in the Indian EEZ. *V.S. Somvanshi, A.K. Bhargava, D.K. Gulati, S. Varghese and Sijo P. Varghese*
WPTT-03-22	Trends In The Abundance Indices Of Yellowfin And Skipjack Tunas In The Indian EEZ. *V.S. Somvanshi, S. Varghese and P. Sivaraj*
WPTT-03-23	The Maldivian Tuna Fishery. *S. Adam, Ch. Anderson, and A. Hafiz*
WPTT-03-24	Preliminary data on FAD deployment, recovery and associated catch by Spanish purse-seiners in the Western Indian Ocean. *I. Artetxe and I. Mosqueira*

APPENDIX IV. SUMMARY EVALUATION OF VARIOUS MANAGEMENT MEASURES TO REDUCE FISHING MORTALITY ON JUVENILE BIGEYE AND YELLOWFIN TUNA

***Table IV.1**. Summary evaluation of potential effects of the management measures considered (see text for details).*

Management measure	Comment	Likely effect on juvenile bigeye mortality	Likely effect on juvenile yellowfin mortality	Likely effect on bigeye catches	Likely effect on yellowfin catches	Likely effect on skipjack catches
Time-area closure to purse seine fishing	A spatial-temporal closure has been applied in the Atlantic, and considered by the IOTC in 2000	12-31% reduction depending on scenario	15-38% reduction depending on scenario	Short term: 6000-15000t loss of large BE+YF to PS Long term: 2 - 6% increase in total yield	short term: 6000-15000t loss of large BE+YF to PS long term: not available	20,000- 50,000t reduction
Reduction in overall purse seine effort	Reducing the number of vessels	10% reduction in no. of vessels: 4-18% reduction	10% reduction in no. of vessels: 4-18% reduction	Short term: 10% reduction in no. of vessels: 4-17% reduction Long term: <2.2% increase in overall yield	short term: 10% reduction in no.of vessels: 5-17% reduction in catch long term: not available	10% reduction in no.of vessels: 4-17% reduction in catch
	Increasing days in port when unloading	2-4 days: 5-11% reduction (2nd semester only) 2-4 days: 7-15% reduction (whole year)	2nd semester only, 2-4 days:5-10% reduction whole year, 2-4 days: 7-15% reduction	Short term: 2-4 days:5-11% catch reduction (2nd semester only) 2-4 days: 7-15% catch reduction (whole year) Long term: <3% increase in overall yield	Short term: 2-4 days:4-9% catch reduction (2nd semester only) 2-4 days: 7-15% catch reduction (whole year) Long term: not available	2nd semester only 2-4 days:5-11% reduction in catch whole year 2-4 days: 7-15% reduction in catch
Limitations on the number of FADs and/or their electronic equipment	Should potentially reduce the fishing mortality due to FADs	Reduction; not enough information to quantify	Reduction; not enough information to quantify	Uncertain, but even total ban is unlikely to increase yield by more than 13-24% depending on scenario	Reduction; not enough information to quantify	Reduction, with amount depending on extent of the limitation
Ban of supply vessels	Supply vessels are important only for some PS vessels (9 supply vessels operating)	Reduction; not enough information to quantify	Reduction; not enough information to quantify	Uncertain	Uncertain	Reduction; not enough information to quantify
Limits on skipjack catches by trip for purse seiners	Recommended in 2001 by various tuna boat owner associations in order to improve the SKJ market prices	Reduction; not enough information to quantify	Reduction; not enough information to quantify	Uncertain	Uncertain	Reduction depending on extent of limitation
Size Limit	Such measures have commonly been adopted by various fisheries agencies; used for tunas by ICCAT	Uncertain, depending on success of implementation	Uncertain, depending on success of implementation	Uncertain, depending on success of implementation	Uncertain, depending on success of implementation	Uncertain, depending on success of implementation

Table IV.2. *Summary evaluation of advantages and disadvantages of the management measures considered.*

Management measure	Advantages	Disadvantages
Time-area closure to purse seine fishing	• Improve the long-term yield per recruit. (It was noted that, in case of stocks that are heavily exploited a reduction in the catch of juveniles would lead to an increase in yield per recruit and spawning stock size. In the case of yellowfin tuna, the benefits would flow to the purse seine, driftnet and longline fisheries. For bigeye tuna the only beneficiary would be the longline fishery). • Possible decrease in the total discards from the fishery.	• Loss of catch of skipjack to purse seine fleet • Likely difficulties with compliance; lack of compliance would reduce the benefits of the measure • Likely redirection of effort to other areas within the Indian Ocean
Reduction in overall purse seine effort	<u>Reduction in number of vessels:</u> • Could reduce the catches of bigeye and yellowfin taken in association with FADs • Reduced effort cannot be redirected to another area/time within the Indian Ocean	<u>Reduction in number of vessels:</u> • May be difficult to implement • Given the differences in efficiency between vessels, different implementations (choice of vessels to exclude from the fleet) would lead to different levels of effectiveness of this measure
	<u>Increase in the number of days in port:</u> • Could reduce the catches of bigeye and yellowfin taken in association with FADs	<u>Increase in number of days in port:</u> • May be difficult to implement, particularly in case of transhipping at sea
Limitations on the number of FADs and/or their electronic equipment	• Addresses problem directly • Reduction in the number of FAD-associated sets	• Monitoring the number of drifting objects deployed by purse seiners would imply having inspectors on board permanently, including on supply vessels. • At this stage there is no information about the relation between the number of drifting objects deployed and the resulting catches.
Ban of supply vessels	Could lead to a reduction in the number of FAD-associated sets.	• Difficult to quantify at this stage • Only some vessels use supply vessels • May be difficult to implement
Limit on skipjack catches by trip for purse seiners	Could lead to a reduction in the number of FAD-associated sets.	• Difficult to implement • Decrease in catch of skipjack • Possible increase in discards
Size limit	Currently none - cannot be implemented	It is not possible to implement this measure effectively given current technology.