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

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

Seychelles, 24-28 July, 2006

TABLE OF CONTENTS

1. OPENING OF THE MEETING AND ADOPTION OF THE AGENDA

1. The Eighth Meeting of the Working Party on Tropical Tunas (WPTT) was opened on 24 July 2006 in Seychelles, by Mr Alejandro Anganuzzi, Secretary IOTC.

2. In the absence of the elected Chairperson, Dr. Iago Mosqueira chaired the meeting in a caretaker role. Dr. Mosqueira welcomed the participants (Appendix I) and the Agenda for the meeting was adopted as presented in Appendix II.

3. The objectives for the meeting were to undertake a major review the stock status of bigeye and update the stock indicators for yellowfin and skipjack.

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

2. REVIEW OF STATISTICAL DATA FOR THE TROPICAL TUNA SPECIES

5. The following information on the statistical data for the tropical tuna species has been summarised from IOTC-2006-WPTT-03.

2.1. Nominal Catch (NC) data

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

7. The Secretariat conducted several reviews of the NC database during 2005. A disaggregation exercise in which aggregated data were assigned to species led to increases in the estimates of catches of skipjack tuna (15%) and to a lesser extent yellowfin tuna (4%) and bigeye tuna (<0.5%).

8. Although the quality of the information on the three tropical tunas is generally considered to be good, the representativeness of the data is compromised by:

- **Some catch data not being available:** several countries were not collecting fishery statistics, especially in years prior to the early 1970's, and others have not reported their statistics to IOTC. In most cases, the catches of tropical tunas in those countries were probably minor.
- **Poor resolution of catch data:** catches of tunas and tuna-like species are sometimes reported in an aggregated[1] form. The Secretariat estimates the species and gear composition of these aggregates using a range of information but the accuracy of the estimates is probably low.
- **Considerable uncertainty associated with the catch estimates from the following fisheries:**
  - Yemen artisanal fisheries: The catch series for this fishery was reviewed in 2005 and the database was updated with the new estimates; however, the new figures are highly uncertain due to the paucity of information available on catch and effort in this country.
  - Sri Lankan gillnet (and longline) fishery: The catches series for yellowfin and skipjack tunas in Sri Lanka were re-estimated for the period 1950-2004. Marked differences between the re-estimated catches and those produced in Sri Lanka are of concern. The IOTC-OFCF Project signed an agreement with the National Aquatic Resources and Development Agency of Sri Lanka in 2004 to allow for an extension of the sampling activities in this country. The first results from this program suggest that the catches of tropical tunas, mainly skipjack tuna and yellowfin tuna, recorded in the IOTC database for the last decade are higher than those that actually occurred.
  - Fresh tuna longliners based in Indonesia: The data collected since June 2002 has allowed catches of longline vessels based in Benoa to be estimated for the period 2003-2005. The new catch estimates differ from those obtained by using the previous catch estimation procedure, therefore the catch series is expected to change once more data become are available. The catch series before 2002 is highly uncertain.

[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.

- o Other fresh tuna longline fleets: Although the catches of fresh tuna longline vessels based in various ports of the Indian Ocean were re-estimated from data coming from past or recent sampling schemes, the catch estimates are uncertain, especially for those fleets operating from ports not covered by these schemes, and where past catches have been estimated using recent catch information.
- o Deep-freezing longline fleets: The Secretariat re-estimated catches for the period 1992-2004 using new information collected during 2005. These estimates remain uncertain due to the many assumptions made in estimating the total catches and species breakdown. The number of vessels operating under flags of non-reporting countries has decreased markedly since 2001. The reason for this decrease is not fully known and revisions to the catch estimates may be undertaken when more information become available.
- o Former-Soviet Union purse seiners: The catches of 6 to 11 former Soviet Union purse seiners, operating under unknown flags in recent years, are not available for 1995-1997 and 2003-August 2005. Total catches and effort for 1998-2002 were reported in 2003 for this fleet but the new data did not include catch by species and type of school (consequently these will have to be estimated by the Secretariat). Since September 2005, six former Soviet Union purse seiners have been operating under the flag of Thailand.

2.2. Catch-and-Effort (CE) data

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

- **Pole and line:** Catch-and-effort statistics from the Maldives are available by species, month and atoll for 1970-1993. Only catches and effort by species, year and atoll are available for 1993-2001. Baitboat Catch-and-Effort data are not available since 2002.
- **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 considered to be inaccurate.
  - o The catch and effort statistics provided by Japan and Taiwan,China are generally considered to be accurate. Nevertheless, some inconsistencies are apparent when comparing nominal catches and catch and effort data for Taiwan,China and Japan. These indicate that either nominal catches or catches in the CE are not accurate or that size data are incomplete.
  - o Korean CE statistics are considered to be highly inaccurate. Many inconsistencies have been found in the data, e.g. when comparing the catches in this database with those reported as nominal catches.
- **Purse seine:** Catch-and-effort statistics are complete for European-owned purse seiners and those monitored by scientists from Europe and Seychelles. Statistics are also available for other fleets including the former Soviet purse seine fleet (1998-2002; under Belize and Panama flags), Mauritius and Japan. As is the case for the NC data, the CE data for the purse-seine fleet formerly under the Soviet Union flag are not considered to be accurate, especially the species composition and type of school fished information. Partial catch and effort data are available for the Iran purse seine fleet.
- **Gillnet:** Few CE data are available for gillnet fisheries. This is of concern because gillnets have been used in both coastal waters and on the high seas in recent years.

2.3. Size-Frequency (SF) data

- **Purse seine**: The quality of the SF data is considered to be good for fleets under European monitoring. Little or no data are available for Iranian, Japanese and the former Soviet Union purse seiners. The size frequency statistics of Mauritian purse seiners since 1986 is complete.
- **Baitboat**: The completeness and quality of the sampling on baitboat fisheries (Maldives) is considered to be good up to 1998. No data are available for 1999-2002 and 2004-05.
- **Longline**: Only Japan has been reporting size-frequency since the beginning of the fishery. In recent years, the numbers of fish being measured is very low in relation to the total catch; furthermore they have been decreasing year by year (Figure 20-23). Coverage rates in some areas are very low. The size-frequency

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

statistics available from Korea are inaccurate, which limits their use. The recovery of size data from port sampling of fresh tuna longline fleets operating in Thailand and Indonesia continued in 2005 and 2006. Coverage rates for the Indonesia are around 40% (number of fish). Catch-at-size tables were estimated for fresh tuna longline vessels operating in Indonesia during 2003-04 and other ports for 1998-2004.

  - In 2005, Taiwan,China provided size data for yellowfin tuna and bigeye tuna by year, quarter and 10 degrees latitude by 20 degrees longitude areas for 1980-2004.

- **Gillnet**: Although size data are available for some important gillnet fisheries (including Iran, Sri Lanka and Oman[3]) sample sizes are very low.
- **Other gears:** Few size data are available for other gears.

2.4. Estimation of catch for non-reporting fleets

10. The estimates of catches of non reporting fleets were updated in 2005. The high number of non-reporting fleets operating in the Indian Ocean since the mid-1980s has led to large increases in the numbers of catches that need to be estimated. This reduces confidence in the catch estimates for yellowfin tuna and bigeye tuna, and to a lesser extent, skipjack tuna.

- **Purse seine:** Catches for former Soviet Union purse seiners were re-estimated for 1995-August 2005. The new catch estimates (averaging around 30,000 t per year) are very similar to those estimated previously by the Secretariat.
- **Deep-freezing longline:** The catches by large longliners from several non-reporting countries were estimated using IOTC vessel records and the catch data from Taiwanese or Spanish longliners, based on the assumption that most of the vessels operate in a way similar to the longliners from Taiwan,China or Spain. The collection of new information on the non-reporting fleets during the last year, in particular the number and characteristics of longliners operating, led to improved estimates of catches.
- **Fresh tuna longline:** Fresh tuna longline vessels, mainly from Taiwan,China and Indonesia, have been operating in the Indian Ocean since the early 1970’s. In 2006 Taiwan,China provided total catches for its longline tuna fleet operating in the Indian Ocean for the period 2000 to 2005. The catches provided are higher than those estimated by the IOTC Secretariat for most years. The new catches provided for 2001-05 were used to replace those in the IOTC database. This was done on the assumption that vessels from Taiwan,China have been operating in ports from non-reporting countries and their catches have not been accounted for in previous estimates.

2.5. Documents relating to statistics

11. Document IOTC-2006-WPTT-10 described the development of an historical database of Soviet tuna longline tuna research in the Indian and Atlantic Oceans (first results of the YugNIRO-NMFS data rescue project). YugNIRO (formerly AzCherNIRO, till 1988), Kerch, Ukraine started tuna research in the Indian Ocean in early 1960’s and continued until the early 1990’s. For research purposes, medium-sized fishing trawlers were converted for pelagic longlining. The data inventory covers about 130 pelagic longline cruises from 1961 to 1989 that targeted tunas (generally *Thunnus*), billfishes (*Makaira*, *Tetrapturus*, *Xiphias gladius*), pelagic sharks (*Carcharhinus*, *Isurus*, *Alopias*, *Prionace glauca*, *Galeocerdo cuvier*). Other pelagic species were recorded as bycatch. More than 5200 longline sets with about 2.5 millions nominal hooks were shot. For every research cruise the following data were colleted on set by set basis: number of hooks, hooks distribution by depth, total catch, and catch by species. Almost all the fish caught were measured, weighed, and analyzed. Estimated catch depth of every fish was recorded. Environmental data and MBT station data is also available. Due to lack of computer equipment and limited funding throughout years of data sampling these valuable data were stored on paper logbooks. Despite careful treatment by YugNIRO personnel, there was a danger of losing these unique data due to natural deterioration, accidents etc. In late 2002 under support of NMFS and NFWF a data rescue project was initiated to enter the data into a computer database and make it available for joint YugNIRO/SWFSC analyses and for IOTC and ICCAT. Data are being digitised and stored in a relational database. This project is at the final stage. These data represent unique dataset for Indian Ocean which could be used as an independent long-term biological and fisheries dataset. Descriptions of the data and database, database structure, data digitizing, analyses, and potential access to the data are presented in this paper.

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

12. Document IOTC-2006-WPTT-11 gave a general description of YugNIRO database on Soviet tuna purse seine fisheries in the Indian Ocean. The principal source of the information was daily radio reports on operations and on catch composition. Vessel types, temporal schedule of activities, total catch and data quality, and database structure are described. The report covers the period 1985 to 1995, 11,092 records for 18 vessels of three type/size classes. Several vessels fished consistently throughout the 11 years. Total catch over this period was 72,211 t. This paper is a supplement for a fine-scale (1-degree/month) catch statistics and activities dataset, presented to IOTC Secretariat.

13. The WPTT commended IRD (France), Southern Scientific Research Institute of Marine Fisheries & Oceanography (YugNIRO) Ukraine, and the Southwest Fisheries Science Center (USA) for their work in securing the highly valuable historical Soviet tuna longline tuna research data.

14. Document IOTC-2006-WPTT-30 reported on the various validation methods applied to the logbook data for all vessels licensed to fish in the Seychelles EEZ, all Seychelles registered vessels and the statistics for the Seychelles registered vessels for the years 2000 to 2005. All the historical data were transferred into FINSS and routine data entry in FINSS started in June 2005. The data was checked for missing positions, positions on land, missing hooks and wrong species. The logbook positions were crosschecked with VMS data revealing 88% of data were correct. Weight of fish and catches were verified or corrected. Analysis of the corrected data shows an improvement in logbook coverage and an increasing trend in catch and effort of the Seychelles flagged vessels. Bigeye tuna remain the dominant species of the total catch from 2000 to 2004 and was replaced by yellowfin tuna in 2005. Further analysis will be conducted to investigate the species composition and yearly economic yield of vessels.

15. Document IOTC-2006-WPTT-31 presented preliminary catch estimates of tuna and tuna-like species from NARA / IOTC / OFCF sampling program in Sri Lanka. The offshore fishery in Sri Lanka has targeted tuna and billfish since early 1960’s. In 2004, the Indian Ocean Tuna Commission (IOTC) and the Overseas Fishery Cooperation Foundation of Japan (OFCF) agreed to supply technical and financial support to improve the large pelagic data collection programme in Sri Lanka. A new sampling scheme was implemented in late December 2004. The project will end in December 2006. The objective of this collaborative project involving NARA, IOTC and OFCF is to strengthen data collection and processing systems on Sri Lankan billfish and tuna fisheries and increase the amount and quality of size frequency data for these species. This paper describes the current sampling regime and the problems encountered during its implementation. It also highlights the complexity of this fishery. Discrepancies were observed when crosschecking the data collected in the program with data from other sources. Some adjustments were made to improve the accuracy of the data. The first interim results indicate that the national production statistics for tuna and billfish have been overestimated in the past. A standardization of the data collection and a stronger collaboration between the different institutions could contribute to improve the fishery statistical system in Sri Lanka.

16. The WPTT acknowledged the valuable work being undertaken by NARA in conjunction with the IOTC-OFCF Project. In particular, the WPTT noted that the project has highlighted some possible major discrepancies in the Sri Lankan catch statistics that need to be further examined. The WPTT was highly supportive of the work currently being undertaken in Sri Lanka to continue.

2.6. General discussion on statistics

17. The WPTT noted again that the low sample size and coverage per area regarding the size frequency data available from longliners of Japan during the last decade is of concern. It was noted that the Japanese size data was used to estimate the size frequency on most non-reporting longline fleets. The WPTT stressed the need to increase the amount of size data collected on longline vessels agreeing that the use of existing data greatly compromises the quality of any Catch-at-Size estimates derived from it.

2.7. Data related issues for tropical tunas

18. The following data related issues were highlighted by the WPTT:

- Poor knowledge of the catches, effort and size-frequency from fresh tuna longline vessels, especially from Taiwan,China, before 1998.
- Poor knowledge of the catches, effort and size-frequency from non-reporting fleets of deep-freezing tuna longliners, especially since the mid-1980’s.
- Lack of accurate catches, effort and size-frequency data for the Indonesian longline fishery before 2002.

- Poor knowledge of historical species composition and size-frequency data for the former Soviet Union purse seine boats.
- Scarcity of data, especially size frequency data, for the Maldives hand line, troll line, gillnet and pole and line fisheries since 1998.
- Uncertainty about the catches, mainly gillnet, hand line and troll line, by domestic boats operating in Yemen and Sri Lanka.

19. 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 for Sri Lanka domestic fisheries and Taiwan,China longline fisheries. Taiwan,China provided more detailed size data for its longline fleet for 1980-2004.
- **Revision of the IOTC databases:** Several revisions have been conducted during the last year on the IOTC databases. This has led to revised NC data for some countries.
- **An improved Vessel Record:** More information has been obtained on the number and type of vessels operating under 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. The catches of the former Soviet Union purse seiners for 1998-2002 are considered to be more accurate.
- **Estimation of catch-at-size for Indonesia, Taiwan,China and China fresh tuna longliners:** The collection of size data in Thailand, Sri Lanka and Indonesia underpins the estimates of catch-at-size for fresh tuna longliners for 1998-2004 (longliners based in ports other than Indonesia) and 2002-04 (longliners based in Indonesia). CAS tables for these fleets in 2005 are being estimated.
- **IOTC/OFCF sampling programmes:** The collection of information on the activities of fresh tuna longliners landing in Phuket and Indonesia has continued during 2005. This has led to more complete and accurate estimates of the catches by these fleets. Other valuable data collected under these programmes include length frequencies (which will allow length-length, length-weight and weight-length relationships to be updated). Size data were also obtained for Sri Lanka (skipjack tuna and yellowfin tuna) artisanal fisheries since 2005.
- **Yemen NC:** The catches of Yemen domestic fisheries were updated during 2004. New catch estimates are markedly higher than previous estimates, especially since the early 1990's.

SUMMARY OF THE STATE OF THE DATA AVAILABLE FOR TROPICAL TUNAS

YELLOWFIN AND BIGEYE TUNA

Nominal Catch 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 the estimates reported in the past.

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

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

Size Frequency data: Sampling coverage from Japan and Korea has been low in recent years. Size data is not available at the five degrees square resolution. The only data available for non-reporting fleets come from sampling in Phuket, Penang, Sri Lanka and Indonesia. Little information is available on important artisanal catches (e.g. Pakistan, Yemen, Sri Lanka and Comoros).

SKIPJACK TUNA

Nominal Catch and Catch and Effort data: Relatively well known for most purse-seine fisheries. Data are available for the important artisanal fishery in Maldives although only up to 2001. Artisanal components (not well known) are important for this species. In several coastal countries (e.g. Indonesia) the catches are not reported by gear or are uncertain (Sri Lanka)

Size Frequency data: Available for reporting purse seine fleets (1984-2005), Maldivian baitboats (1983-1998 and 2003) and some gillnet fisheries and years (Pakistan, Iran, Indonesia and Sri Lanka), although sample sizes are low in some cases.

3. NEW INFORMATION ON THE FISHERIES, BIOLOGY, ECOLOGY AND OCEANOLOGY RELATING TO TROPICAL TUNAS

3.1. Fisheries

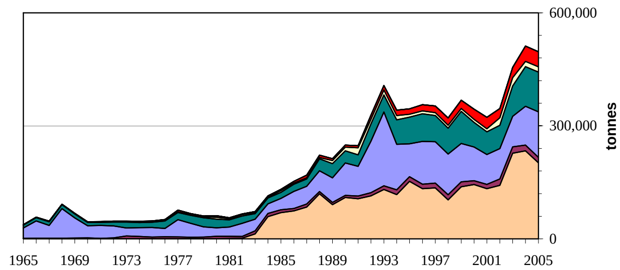


Figure 1: *Catches of yellowfin tuna (YFT) per gear type and year in the IOTC Area from 1965 to 2005*

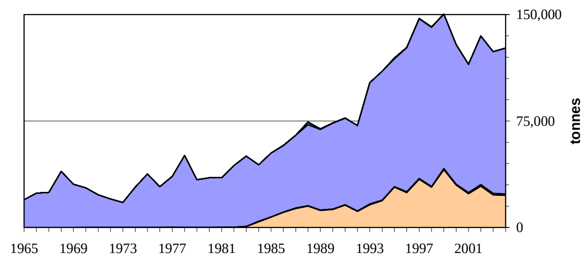
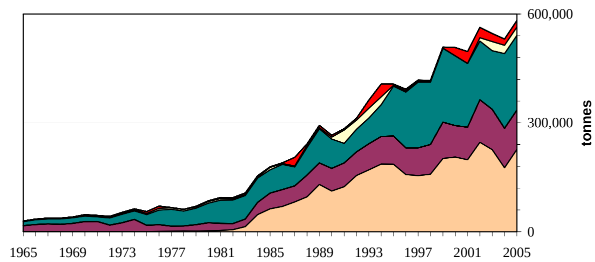


Figure 2: *Catches of bigeye tuna (BET) per gear type and year in the IOTC Area from 1965 to 2005*

Legend:

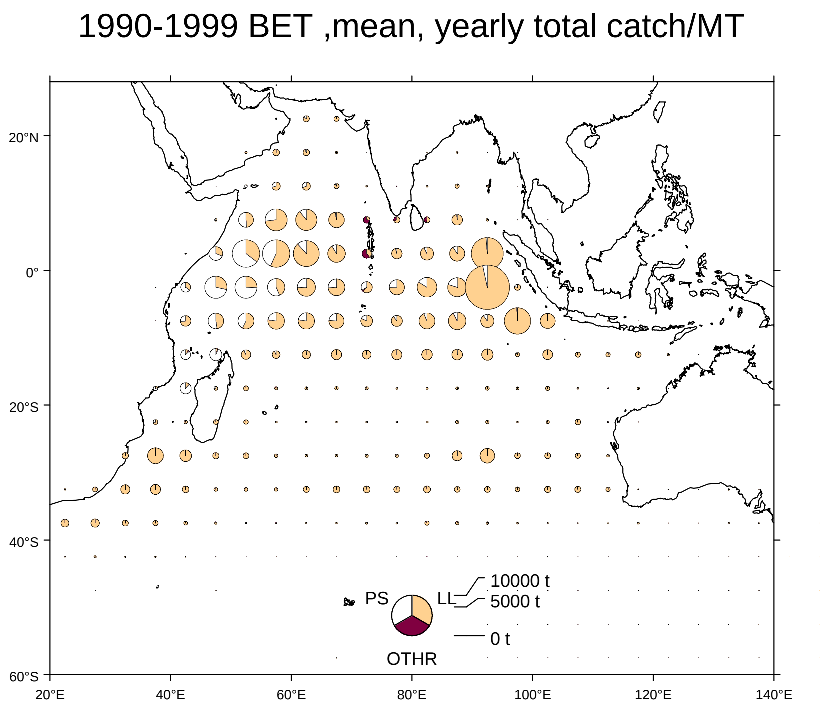


Note that the catches series estimated for 1950-2005 include catches assigned to each species after allocation of species aggregates to individual species by the Secretariat.

Figure 3: *Catches of skipjack tuna (SKJ) per gear type and year in the IOTC Area from 1965 to 2005*

BIGEYE TUNA

20. Most bigeye tuna are taken by longliners followed by purse seiners. Bigeye catches have increased markedly over the history of the fishery and peaked at around 150,000 t in 1998 (Figure 2). Recent catches have been around 130,000 t. The distribution of catches over the periods 1990-1999 and 2000-2005 has changed little (Figure 4).



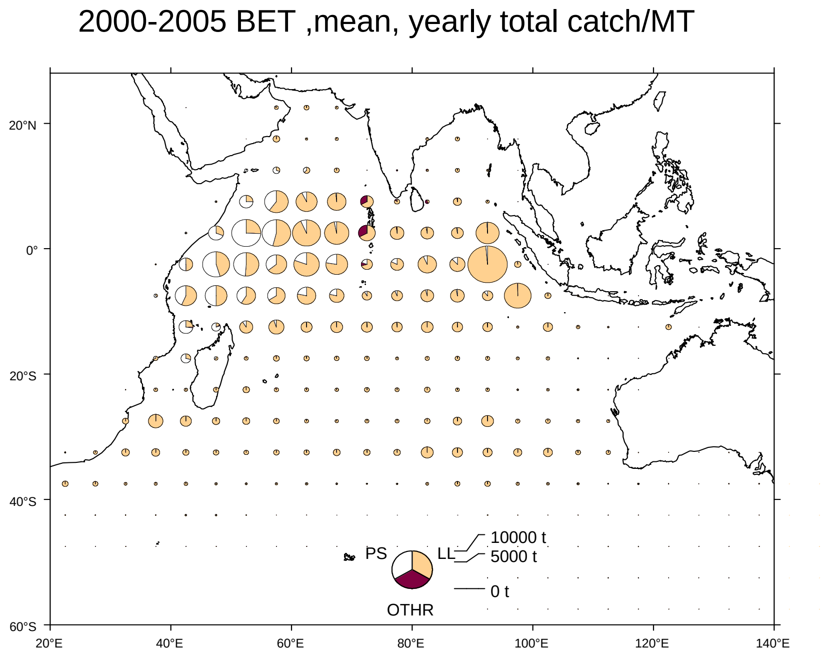


Figure 4. Location and size of bigeye tuna catches in the Indian Ocean by gear type. LL = longline, PS = purse seine.

YELLOWFIN TUNA

21. Most yellowfin tuna are taken by purse seiners followed by longliners and gillnets. Yellowfin catches have increased markedly over time and peaked at around 525,000 t in 2004 (Figure 1). Recent catches have been around 500,000 t. While the distribution of catches over the periods 1990-1999 and 2000-2005 have changed little (Figure 5), extraordinarily high catches of yellowfin were taken in 2003 and 2004 (Figure 6).

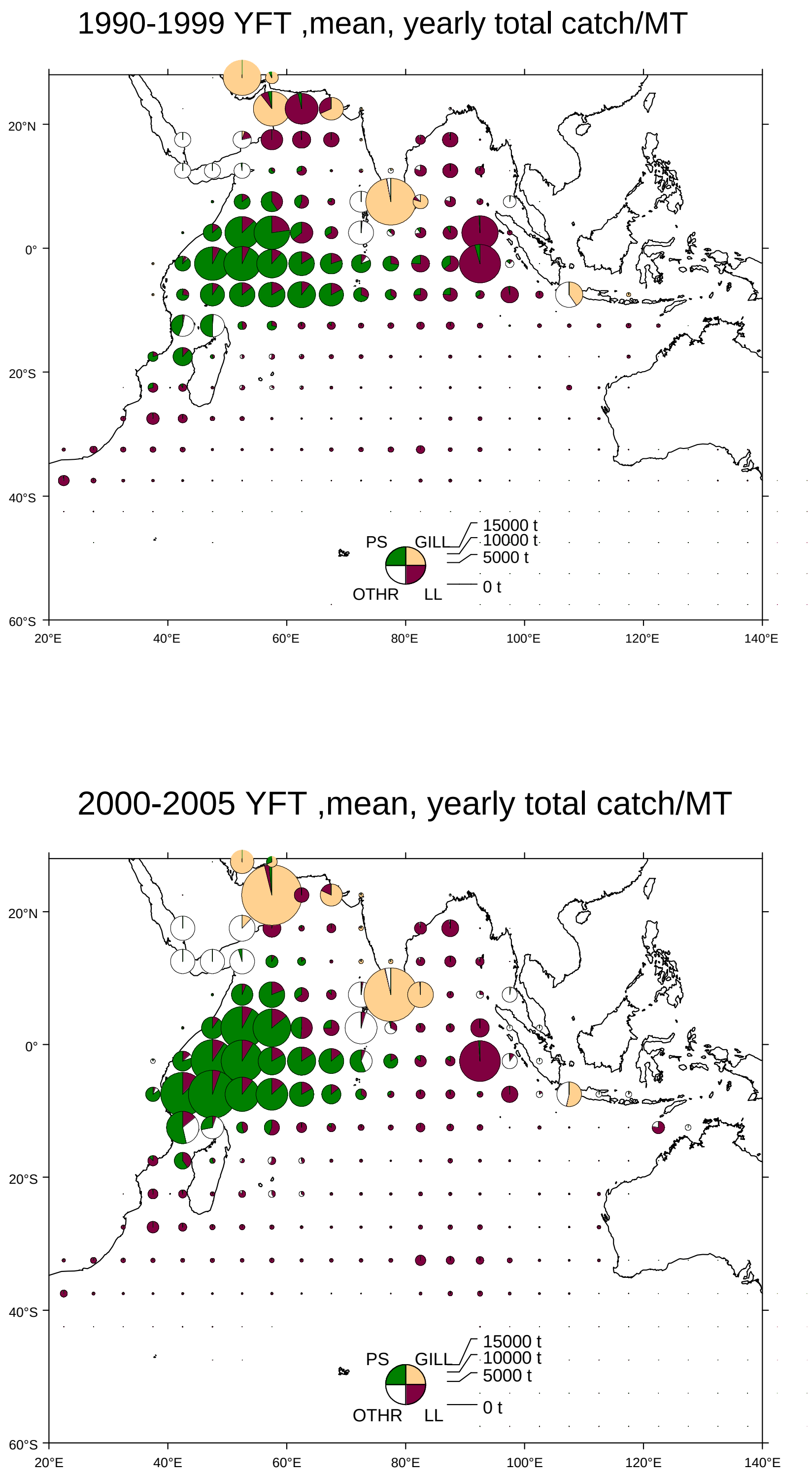


Figure 5. Location and size of yellowfin tuna catches in the Indian Ocean by gear type. GILL = gillnet, LL = longline, PS = purse seine.

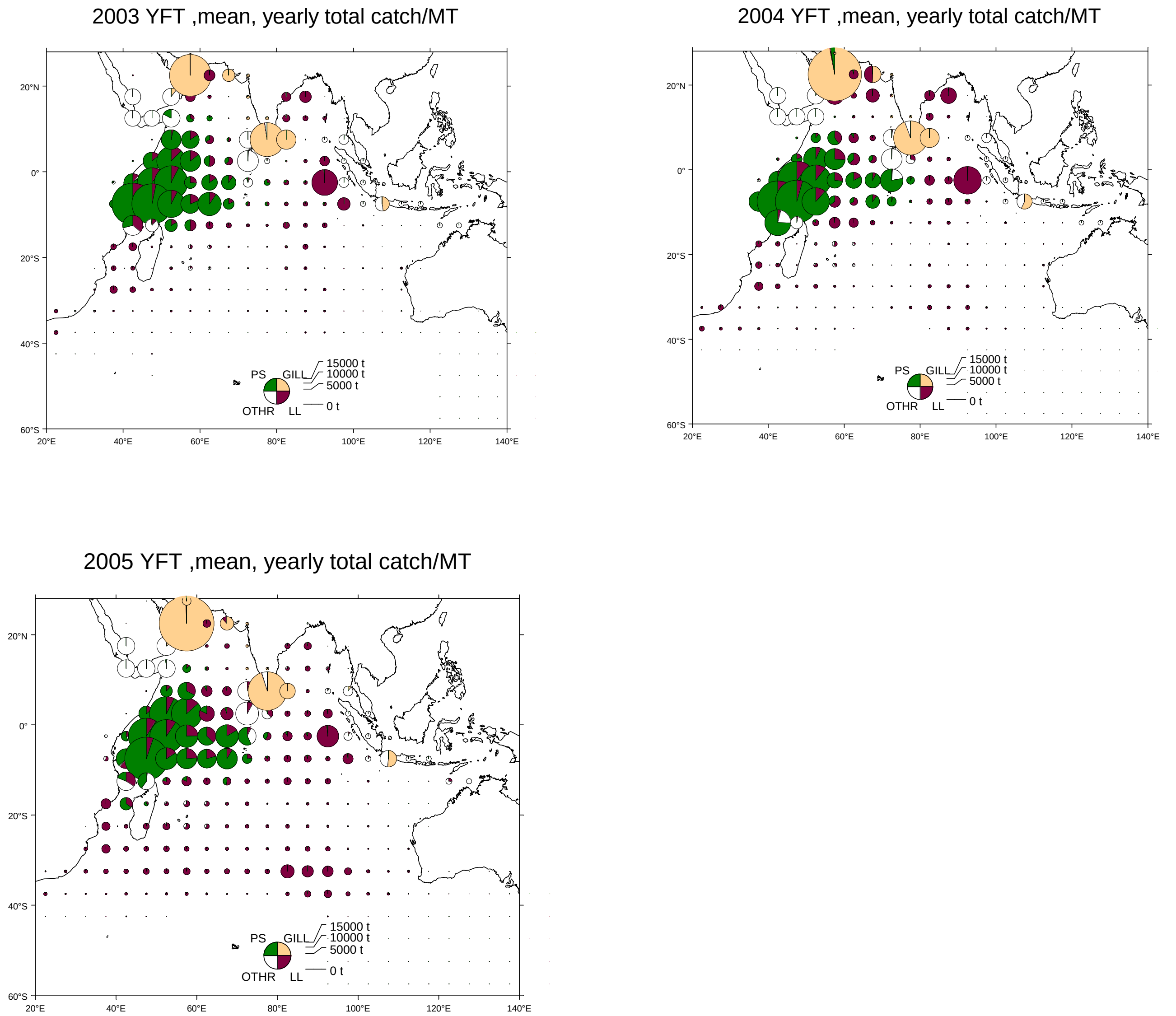


Figure 6 Location and size of yellowfin tuna catches in the Indian Ocean by gear type for 2003, 2004 and 2005 when extraordinarily large catches were taken. GILL = gillnet, LL = longline, PS = purse seine.

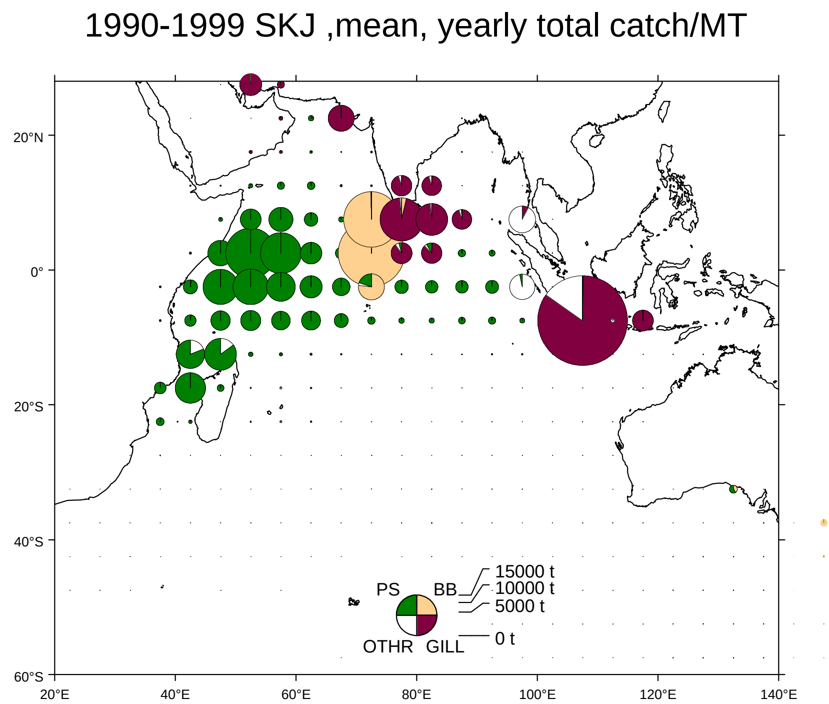
EXTRAORDINARY HIGH YELLOWFIN CATCHES CONTINUE IN 2005

22. The WPTT briefly discussed the extraordinary high catches of yellowfin that were a feature of the tropical tuna fisheries in the Indian Ocean from 2003 to 2005. This occurred around the western central areas of the Indian Ocean (Figure 6). Preliminary estimates indicate purse seine catches of yellowfin in 2005 are slightly lower than in 2003 and 2004, but they were still well above previous levels.

23. In IOTC-2005-SC-R, the Scientific Committee hypothesised that the high catches could be explained as an increase in catchability, an increase in biomass, or a combination of both. The two explanations have different implications about the status of the stock. In IOTC-2006-S10-R, the Commission requested that an attempt to discriminate between the two hypotheses be undertaken when the 2005 fisheries data becomes available. The WPTT examined this matter and agreed that given the available data, and the last yellowfin stock assessment (in 2005), it appears the high catches were due to an increased recruitment, together with an increased availability as fish concentrated in a much reduced area than normal. The WPTT anticipates that the catches of yellowfin will return to pre-2003 levels, but notes that the full impact of the event on the yellowfin stock can only be assessed once full catch data for 2005 and 2006 are available, and ideally after a new stock assessment for yellowfin tuna is carried out.

SKIPJACK TUNA

24. Most skipjack tuna are taken by purse seiners followed by gillnets and pole and line vessels. Skipjack catches have increased over the history of the fishery and currently are around 600,000 t (Figure 3). The distribution of catches over the periods 1990-1999 and 2000-2005 has changed little (Figure 7).



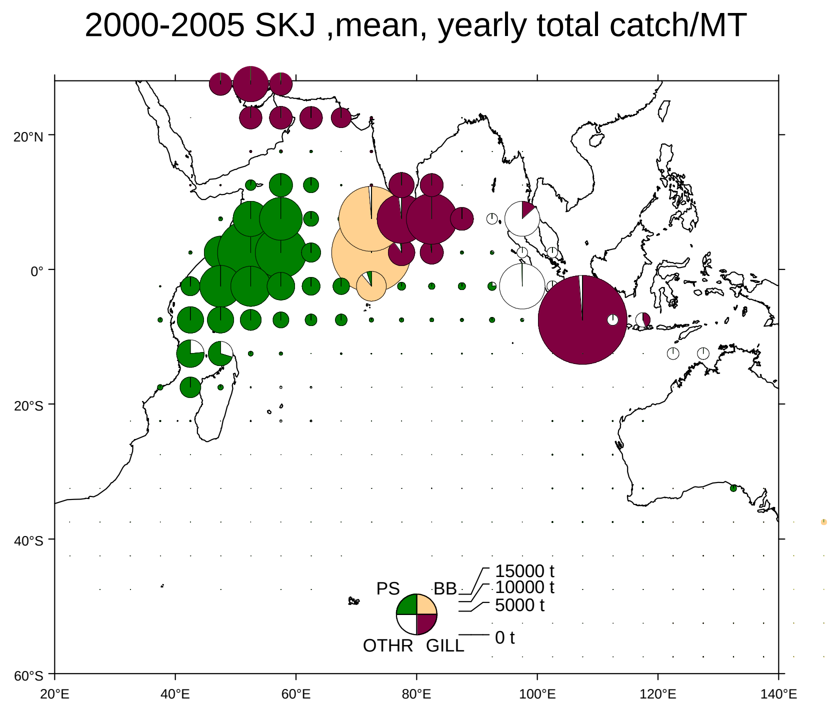


Figure 7. Location and size of skipjack tuna catches in the Indian Ocean by gear type. BB = bait boat or pole and line, GILL = gillnet, LL = longline, PS = purse seine.

25. Document IOTC-2006-WPTT-27 presented a summary of the main French purse-seine activities in the Indian Ocean since 1981, including effort, catch by species and fishing type (log and free swimming schools), catch per unit of effort, sampling and mean weights for the main species. The number of free-school sets in 2005 (2759) was higher than the average of the last five years (2152), the number of log sets remained stable (1683 cf 1650 being the average for the last 5 years). Following 2003 and 2004, 2005 was again a good year with a total catch of 107,140 t.

26. Document IOTC-2006-WPTT-04 presented summary statistics of the Spanish purse seine fleet fishing in the Indian Ocean from 1984 to 2005. Data included catch and effort statistics as well as some fishery indices 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 are also included.

27. Document IOTC-2006-WPTT-28 presented a summary of the main (French, Spanish, Italian, Seychelles and EU related NEI) purse-seine fleets in the Indian Ocean (1981-2005). The number of free-school sets in 2005 (7358 sets) was higher than the average of the last five years (5665 sets), the number of log sets remained relatively stable (5923 cf 5335 being the average for the last 5 years). Total catches in 2005 (386,635 t) were slightly above the average for the past 5 years (365,092 t). 307,216 tuna were measured in 2005.

28. The WPTT noted that between 2003 and 2005 the nominal fishing effort by the main PS fleets has been increasing significantly (+15%) as has the average carrying capacity of this fleet (Figure 8). This increased effort has not produced an increase of BET catches, but the WPTT concluded that such trend is potentially dangerous for the long term sustainable exploitation of the BET stock in case of a potential future increase of its FAD associated catches.

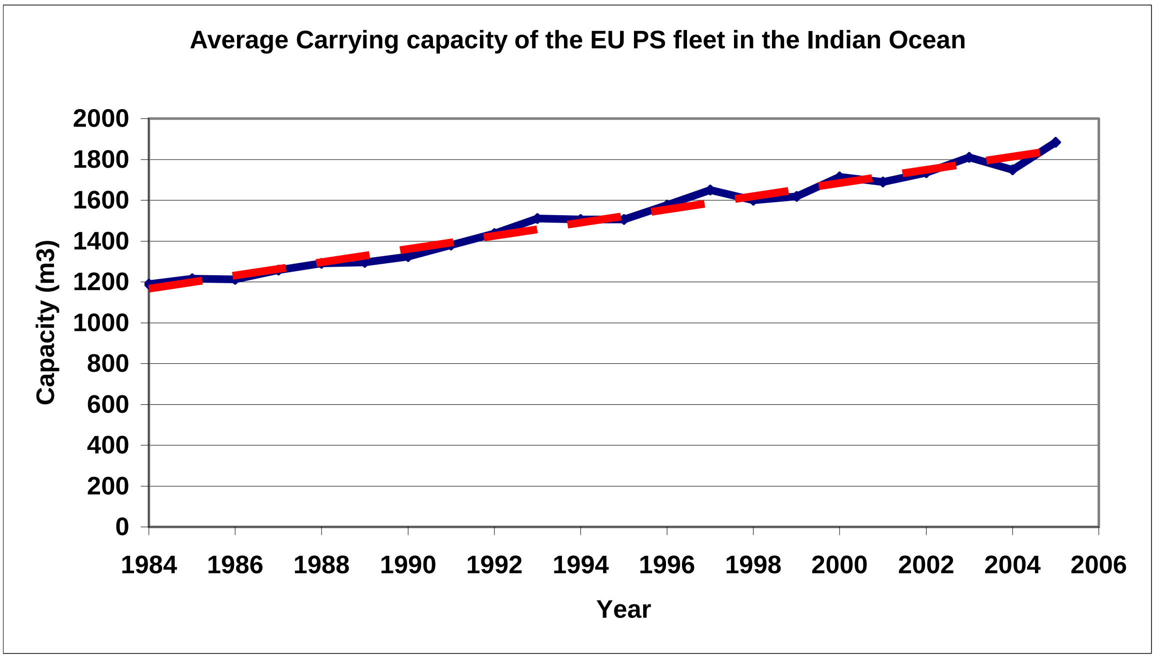


Figure 8. Average(dashed line) carrying capacity (hold size) of the European Union purse seine fleet in the Indian Ocean (source: A Fonteneau).

3.2. Biology

29. Document IOTC-2006-WPTT-05 presented the sex ratio information for bigeye tuna (BET) and yellowfin tuna (YFT) obtained by observers in experimental Spanish longline fisheries using a range of hook types and bait. Two surface longliners carried out their work from mid December 2004 to mid December 2005 in international waters between 25º S and 35º S and 30º E and 50º E. The sex of 1339 BET comprised 621 males (46%) and 718 females (54%); and for 582 YFT, 307 males (53%) and 275 females (47%). In the case of BET, there was a predominance of females across the whole year; while YFT, females were found predominantly only in the third quarter of the year. BET ranged from 25 to 208 cm furcal length (FL); however, 95% were between 80 and 139 cm FL. YFT ranged from 58 and 181 cm FL, with 92% of the samples between 125 and 164 cm FL.

30. Document IOTC-2006-WPTT-09 aims to demonstrate the great potential of routine sampling at canneries to collect data on biological parameters of tuna species and to track changes (by space and time) in the diets of top pelagic predators. The present dataset which covers the period 1984-2006 and has been obtained from observers at sea and at the cannery in Seychelles. These data have been used to update some of the biometric relationships for

yellowfin tuna in the IOTC Area, including (i) the relationship between first dorsal length to fork length: $FL = 2.0759\ FDL^{1.1513}$; (ii) size to weight $W = 1.8860E\text{-}05\ FL^{3.0195}$. The length at first maturity has been re-estimated at 104 cm (for females) from a large dataset obtained from the WIO purse seine fishery. The data also indicate that the estimate of the size at which males become dominant in the population has decreased from 154 cm to 144 cm. Gut contents analyses clearly show spatial differences in the prey of top pelagic predators over the area covered by the purse seine fishery.

3.3. Observer programmes

31. Document IOTC-2006-WPTT-29 described fishing experiments and data collected in the CAPPES (CAPturabilité des grands PElagiques exploités à la palangre dérivante dans la Zone Economique Exclusive des Seychelles) research project. The local pelagic longline fishery targeting swordfish started in the Seychelles in 1995 and has since become well established. A sharp decline in fishing activities was recorded from 2001 onwards. This decline was due to various constraints that were identified by stakeholders during a workshop held in February 2004. CAPPES was implemented to seek solutions for the various problems. The short-term objective of the programme was to diversify this fishery and improve targeting and efficiency of the fishing gear. Between December 2004 and April 2006, 10 experimental longline trips were conducted. A total of about 70 sets corresponding to a fishing effort of 35,000 hooks were made. Data on gear configuration, capture and environment parameters collected during the project have been compiled in a database and awaiting verification after which reports and publications will be produced.

32. Document IOTC-2006-WPTT-06 described result of a pilot study into acoustic selectivity in tropical tunas. This work is part of the Experimental Purse-seine Campaign in the Indian Ocean being conducted by the General Secretariat of Maritime Fisheries in Spain, the Albacora company, and the Spanish Oceanographic Institute (IEO). The Programme aims to determine the size and species of tuna schools prior to fishing, with a view to establishing guidelines and criteria that will enable more selective fishing regarding the size and species caught. The objectives of the pilot study were: 1. Identification of different species and sizes of tuna using acoustic methods and 2. understanding the behaviour of tuna and associated species which aggregate around floating objects. The work was conducted on a Spanish tuna purse-seiner and a support vessel. The project demonstrated the utility of commercial vessels to provide logistic support for fishery research (noting that most vessels are equipped with the required acoustic detection equipment). Sonar echo traces were classified according to two types of structure: large compact schools (mostly skipjack) and small schools where the distance from the nearest neighbouring school was closer than the average school size. Preliminary analyses indicate that yellowfin schools appear to have a different structure to skipjack schools. However, the analysis of school characteristics is insufficiently discriminatory for a final conclusion about the specific recognition of types of tuna school structures, unless it can be matched with an analysis of TS provided by the echo sounder. This is work for the future. Finally, the possibility of creating an “expert system” seems possible, which would lead to improved selectivity within the tuna fishery, based on echo sounder and sonar data. Preliminary analyses also indicate that the echo sounder TS histogram may be able to differentiate between skipjack and yellowfin specimens, noting that the sizes of both species studied so far were very different.

33. Document IOTC-2006-WPTT-16 presented an update on FADIO (Fish Aggregating Devices as Instrumented Observatories of pelagic ecosystems), a European Union funded project to develop new observation and assessment tools and collect data on the behaviour of pelagic fish around drifting FADs. Associative behaviour is a major component of the life of pelagic fish. Tropical tuna and other species are often found in association with floating objects, other animals, and topographic features such as seamounts. Because they occur in large schools, fishermen target such structures and objects to increase their catches. More than 50% of the world tuna catches are made from schools associated with floating objects. There is a clear need for new technologies to study these associations and to propose innovative methods of management. The project: FADIO1 conducted five extensive field surveys of the Western Indian Ocean in conjunction with the large-scale purse seine fishery operating on drifting FADs. Two categories of instruments are being developed in collaboration with manufacturers: (1) autonomous buoys equipped with omni scan sonar and cameras to observe aggregations, acoustic receivers to detect individuals carrying electronic tags and satellite uplinks for both, (2) new electronic tags with ecological sensors. Various field experiments are being conducted to assist in the development of these prototypes. Different instruments and methods are being used to record the behaviour of associated species concurrently resident around FADs, including: fishing and acoustic tagging, passive and active acoustic surveys, and underwater visual census. Observations (often made from a combination of methods) are used to gain insights in the dynamics of FAD aggregations. These instruments can be used in the future to build the foundation for future observatories of pelagic

ecosystems (using FADs as scientific platforms for observation and data collection), to understand the effects of FADs on tuna and other associated species, even in remote areas, and to find methods to reduce by-catch around FADs.

34. The WPTT noted with concern that a proposal for the continuation of the FADIO work (FADIO2) had not received funding and consequently a valuable opportunity for FADIO to overlap and complement the RTTP-IO would not occur. The WPTT greatly regretted this lost opportunity and moreover the break in the continuity of the project as some of the techniques developed by FADIO showed the potential to underpin to the development of a fishery independent index of abundance for tropical tunas.

35. Document IOTC-2006-WPTT-07 presented data obtained from purse-seine observers from a project carried out by the Instituto Español de Oceanografía under the national database plan between 2003 and 2006. Data on vessel activity obtained by observers on board purse-seiners operating in the Indian Ocean between 2003 and 2006 is presented. Observation days totalled 601 from 17 campaigns. Catches and discards per species and type of association are described. 477 sets were performed, resulting in catches of 17184 t of tuna, of which 490 t were discarded (corresponding to 2.9% of the total catch, with 0.5% in sets over free schools and 1.9% of sets over objects). These data are compared to data obtained from the fishery in the same period. Bycatch data including a presence index per type of association, size distribution and turtle catch data are also presented.

36. Document IOTC-2006-WPTT-12 described a comparison of catch rates derived using observer data collected onboard fresh longlining vessels which operated in the tropical high seas of the Indian Ocean (0º47´N～10º16´N, 61º40´E～70º40´) from 15 September to 12 December 2005. This paper provided a comparison of the catch rates (individuals/1000hooks) and the average gilled and gutted weight of bigeye and yellowfin tuna achieved using ring hooks and circle hooks at different drifting speed. Drifting speed of the longline ranged from 0.00 to 0.76m/second and was allocated into the following drifting speed categories: low speed (0.00-0.20 m/s), medium speed (0.21-0.40 m/s) and high speed (0.41-0.76 m/s). Catch rates of bigeye caught on ring hooks were relatively stable and were affected only slightly by drifting speed; while yellowfin catch rates varied with the drifting speed, with the highest catch rates occurring at the medium drifting speed. The catch rates of both bigeye and yellowfin tuna caught on circle hooks decreased as drifting speed increased. Catch rates of bigeye and yellowfin tunas were not significantly different in each category (hook and drifting speed) examined.

37. Document IOTC-2006-WPTT-33 described the results of an examination of hook depth profiles from Chinese fresh tuna longlines based on TDR data . Data were recorded by TDRs which were attached to the branch line of Chinese tuna longliners operating in the tropical high seas of the Indian Ocean from 15 September to 12 December 2005. TDR recorded fishing depths of hooks are compared with the depths calculated by catenary algorithms. Nine types of catenary depth estimations (25 hooks per basket) were calculated for different line setting speeds and boat speeds. Results showed that line setting speed affects the fishing depth of the hooks more than boat speed and current speed. TDR data also indicated that fishing depth of a hook during soaking is not stable and the vertical fluctuations of a hook depth vary according to the position of the branch line. The vertical fluctuation is greater when the branch line the hook is connected to is closer the middle position of the basket line and reaches the maximum at the middle position of the basket line. TDR depth of hooks is shallower than catenary depth.

38. Document IOTC-2006-WPTT-25 was an expression of interest by researchers to conduct a scientific observer programme on longliners operating around Seychelles waters. The paper described the present major uncertainties in the relationship between the hooks between floats parameters and the species targeted by longliners and recommended that an ad hoc observer programme should be urgently developed on board of Japanese and Taiwanese longliners in the Western Equatorial Indian Ocean. Such a programme would measure on a scientific basis all the parameters in the line configuration and line handling that are conditioning hook depth. It should also measure the real depths reached by the various hooks. It is anticipated that such programme could provide highly significant results that would be essential to do the yellowfin and bigeye stock assessments, even with observations from only a small number of sets.

3.4. Environment

39. Document IOTC-2006-WPTT-08 provided an overview of an analysis to derive indices of environmental variability in the Indian Ocean for 1970-2005. The environmental variability of the Indian Ocean is described by a time series of climate and oceanographic variables for the period 1970-2005 in two areas located West and East of the ocean basin. Six environmental datasets were processed: 1. pseudo wind stress 2. Sea Surface Temperatures, (3) vertical temperature profiles (4) Sea Surface Chlorophyll (5) sea surface height anomalies (6) sea level pressure

anomalies. The paper discusses long term trends, interannual climate variability, and the impact on the distribution of the purse seine catch.

40. Document IOTC-2006-WPTT-13 examined the influence of environmental factors on longlining for yellowfin tuna in the Indian Ocean. A survey on the yellowfin tuna fishing ground was carried out from two Chinese longliners in the tropical high seas of the Indian Ocean from 15 September to 12 December 2005. Stepwise regression methods were used to analyse the catch rate of yellowfin tuna at different depths, temperatures, salinities, chlorophyll-a and dissolved oxygen. The results indicate that the environmental preferences of yellowfin tuna are as follows: 100.0-179.9 m, 14-17.9°C, 35.3-35.6‰, 0.040-0.099µg/l and 1.00-2.99mg/l, respectively. Catch rates of yellowfin were highest in he following DTSCO ranges: 120-139.9 m, 16.0-16.9°C, 35.40-35.49‰, 0.090-0.099µg/l and 2.00-2.49mg/l, respectively.

41. Document IOTC-2006-WPTT-14 examined the influence of environmental factors on longlining for bigeye tuna in the Indian Ocean. A survey on the bigeye tuna fishing ground was carried out from two Chinese longliners in the tropical high seas of the Indian Ocean from 15 September to 12 December 2005. Stepwise regression methods were used to analyse the catch rate of bigeye tuna at different range of depth, temperature, salinities, chlorophyll-a and dissolved oxygen. The results indicate that the environmental preferences of bigeye tuna are as follows: 160.0-219.9 m, 13-15.9°C, 35.2-35.5‰, 0.030-0.059µg/l and 1.00-2.49mg/l, respectively. Catch rates of bigeye were highest in the following DTSCO ranges: 160-179.9 m, 14.0-14.9°C, 35.40-35.49‰, 0.040-0.049µg/l and 2.00-2.49mg/l, respectively.

42. Document IOTC-2006-WPTT-23 reported on the predation survey by Japanese commercial tuna longline fisheries from September 2000 to December 2005. Total number of fish attacked during 2000-2005 was 10,534 with YFT (49%), BET (26%) and ALB (13%), SWO (4%) and SBT (2%). 2,078 individual predators were reported in 2000-2005. Of these, 58% were sharks, 40% false killer or killer whales and others for 2%. According to the Japanese fishers, the majority of the toothed whales attacking the LL caught tuna in the tropical and sub-tropical waters were probably false killer whales. On average, each fishing operation was attacked by one predator species.

43. Document IOTC-2006-WPTT-24 described the results of a meso-scale analysis of data from a purse seine fleet fishing in the western Indian Ocean in February 2005 on a large concentration of tuna. This event took place during a short period of 12 days in a small area of about 3500 nautical miles^2, located west of the Seychelles EEZ and produced a record catch of 22.000 t. Sets were made mainly on free schools (and contributed to 93% of the total catch) and 78% of the catch was composed of large yellowfin tuna (average weight of 38 kg). Catch rates were very high with the average CPUE being 68 t per day and the average catch per set being 91 t. This fishing event took place in an area where there was a high concentration of chlorophyll (observed by satellite) at least 9 days before the fishing event. It was proposed that tunas were attracted to the area by a large biomass of prey species associated with the chlorophyll.

4. STOCK ASSESSMENT FOR BIGEYE TUNA

4.1. Abundance indices

44. Document IOTC-2006-WPTT-32 discussed the utility of Japanese longline gear configurations as a targeting index in the standardization of longline CPUE. NHF (number of hooks between floats) has usually been used as a targeting index in the standardisation of longline CPUE for tunas and billfishes. The relationship between the NHF, gear depth and targeting is briefly discussed. NHF is not an indicator of absolute depth of gear because NHF is not necessarily related to depth, therefore, it is not appropriate to expect "hooks per basket (HPB) to be a good proxy indicator of the maximum fishing depth in a drifting longline fishery. An important and essential assumption for using NHF as targeting index would be that the gear depth relationship to NHF is consistent across year-area strata or quarter-area strata. In the early 1990s, NHF increased abruptly by about 5 or 6, and 4 in the tropical and temperate areas, respectively. This rapid increase of NHF seems to be derived mainly from introduction of nylon material to longline gear rather than any target shifting (this would indicate that gear material information may be required in the models used for standardisation).

45. Document IOTC-2006-WPTT-20 presented the standardised Japanese longline CPUE for bigeye tuna (1960 to 2004) derived using GLM (CPUE-LogNormal error structured model) in which Sea Surface Temperature was included in the model as an oceanographic factor and NHF (Number of Hooks between Float) which was divided into six classes and main-line materials was applied in the model as fishing gear information. In the early 1990's, a rapid shift of the longline gear configuration to a greater NHF occurred. This appears to have occurred at the same time as Nylon material began to be used in longline gears. In order to remove the effect of this gear shift,

information of main line materials was used in the standardisation model. In the tropical Indian Ocean (the main longline fishing ground for bigeye), the CPUE index generally declined from 1960 until 2002 (except for markedly higher indices in 1977 and 1978). Indices in 2003 and 2004 were higher than the historical low in 2002 (Figure 9). In temperate areas of the Indian Ocean, CPUE has fluctuated over time with little trend.

46. Document IOTC-2006-WPTT-17 described the general linear mixed model analysis of bigeye tuna catch per unit effort (number caught per 1,000 hooks) by Taiwan,China longline fleets in the Indian Ocean for the period 1968-2004. The index was generated from numbers of bigeye tuna caught and reported in the logbooks submitted by commercial fishermen since 1982, and aggregated data from 1968 to 1981. A step-wise regression procedure was used to select the set of systematic factors and interactions that significantly explained the observed variability; and a deviance analysis was used to select the most appropriate factors in the standardization for the observed data. Variables used in standardisation are year, area, season, target (bigeye, albacore and yellowfin) and their interactions. In addition, observers' data were used to verify logbooks' records and where necessary adjust the catch data for the years from 1990 onwards. The index from the Taiwanese fleet shows a variable by generally decreasing trend, similar to that of the Japanese fleet (Figure 9)

47. The WPTT recalled that in previous years there were major differences in the regression models and the trends of the respective Japanese and Taiwanese CPUE indices but it was not still not clear why there was such agreement in the latest results. The WPTT concluded that the relationship between the CPUE indices from the Japanese and Taiwanese longline fisheries is poorly understood and that more work is needed to investigate this. For example, the changes in the trend for the last few years on the Taiwanese index appeared to be influenced to a great extent by the standardisation procedure. In the meantime, the WPTT decided that the Japanese LL index was to be used in the 2006 bigeye stock assessment.

4.2. Catch at size and catch at age

48. Catch at size and catch at age data were generated by the Secretariat (IOTC-2006-WPTT-19). Given that a catch-at-size matrix is an integral part of both length and age based assessment methods, the WPTT expressed their ongoing concerns about the low levels of size sampling being collected in the Indian Ocean. Notwithstanding these concerns the WPTT was encouraged by the potential of the information being obtained from the RTTP-IO in the belief that this programme is going to be important alternative source of size data in the very near future.

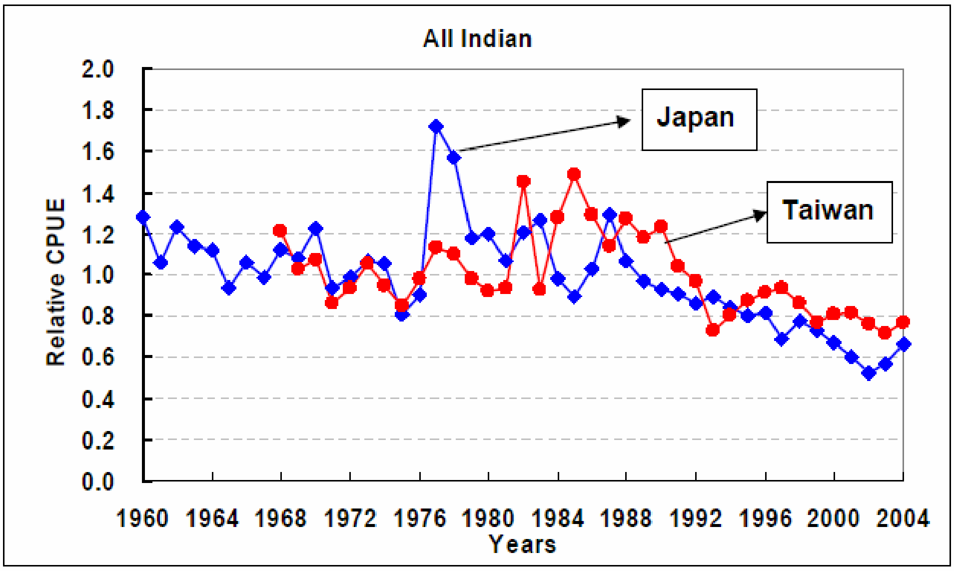


Figure 9. Standardised CPUE indices for the Japanese and Taiwanese longline fleets in the Indian Ocean (source : IOTC-2006-WPTT-17)

4.3. Models

49. Five stock assessment models were applied to the Indian Ocean bigeye tuna stock. In this meeting, the results obtained from the models were inspected and discussed. To assist the WPTT compare the assessment outputs and results, an agreed list of input parameters was used (Table 1). Extra runs were carried out during the meeting to explore various sensitivity scenarios. Projections were also carried out.

Table 1. Common inputs used in the 2006 bigeye tuna assessment models.

INPUT DATA	
Catch	Longline and purse seine
Length Weight	*For fork length < 80 cm: W* = (2.74 x 10-5)*l*2.908 ; *For 80cm <=fork length: W* = (3.661x10-5)*l*2.90182 IOTC-2006-WPTT-22
Growth	$L_{t(cm)} = 169(1\text{-}e^{-0.32[t-(-0.336)]})$ IOTC-2006-WPTT-22
Natural mortality	Age 0-1 M=0.8; Age 2+ M= 0.4 (based on the current assumptions in ICCAT bigeye assessments)
Maturity at age	0-2 year = 0; age 3 = 0.5; age 3+ = 1 (based on ICCAT information)
Selectivity	Longline: 1961-76, 1977-91, 1992-2002 Purse seine: 1981-90, 1991-2002 Developed using Forward VPA approach
Stock recruitment relationship	Beverton-Holt stock recruitment relationship assumed
Fishing period	1960-2004
Area	Tropical waters

50. Alternative natural mortality vectors were also explored during the meeting (Table 2). The current vector was considered not to fully reflect the available knowledge on the biology of the species. A higher value for M at age 0 was applied, and a lower one for ages 1 and 2, reflecting the pre-spawning increase in survival with size.

Table 2. Alternative (M1 and M2) natural mortality by age vectors examined in the bigeye tuna assessment models.

Age	**0**	**1**	**2**	**3**	**4**	**5**	**6+**
M1	1.0	0.6	0.3	0.4	0.4	0.4	0.4
M2	1.0	0.6	0.3	0.4	0.4	0.4	0.6

51. The WPTT discussed the topic of exploitation of bigeye by the purse seine fishery starting on 9 month old fish not 0-8 month old fish, and that certain calculations used in the stock assessment models did not explicitly consider this. If this were to be of significance, it would have implications for the overall assessment of the stock and for the estimated interaction between the purse seine and longline fisheries. The WPTT agreed that the issue should be explored previous to the next assessment.

ASPM

52. An implementation of an Age Structured Production Model (ASPM; Restrepo, 1997) that had been used in previous assessments was presented (IOTC-2006-WPTT-22). The model used the input values common to all models: catch, M vector, growth curve. It also applied a set of selectivity curves by fleet obtained from a Separable Population Analysis (SPA). Initial runs were conducted using either or both the Japanese or Taiwanese LL CPUEs. By contrast with previous assessments and after a modification in the source code of ASPMS, the steepness parameter for the stock-recruitment relationship was not estimated but assigned a value of 0.7.

53. Initial results of the ASPM indicated the stock is being overexploited, with current catches 20% above MSY. Current fishing mortality was around the level expected at MSY, while SSB was still slightly over that at MSY.

54. The ASPM was re-run using a higher value of steepness, 0.8, as this was the value used in the other models. The resulting estimate of MSY was 10% higher and subsequently the outlook for the stock more optimistic. ASPM presented a stock near its maximum level of exploitation or slightly overexploited, especially when considering the ratios of fishing mortality and catch.

55. Bootstraps were also carried out to assess the range of the uncertainty in the estimated values. Variability in the bootstraps was introduced through re-sampling of the residuals of the abundance index. The CV observed in the estimates was consistent with that estimated for the abundance index (around 15%).

STOCK SYNTHESIS 2

56. An assessment using Stock Synthesis 2 (Methot, 2005) was presented in document IOTC-2006-WPTT-18. SS2 is a length-based integrated modelling approach introduced for the first time to the WPTT. To assist in its interpretation, the SS2 model was run using the similar conditions / assumptions used in the ASPM and CASAL analyses. The advantages of this type of length-based integrated model (similar to MULTIFAN-CL, A-SCALA, CASAL etc.) over the 'traditional' stock assessment models such as ASPM, ASPIC or Tuned VPA etc are:

- a reduction in the aging error resulting from the catch-at-size to catch-at-age conversion
- being able to introduce the prior information (regarding the uncertain parameters)
- flexibility with respect to parameterisation (e.g. for selectivity, catchability, spawning-recruitment relationship and biological parameters - growth, M, maturity etc).

57. The year trends of SSB, total biomass and recruitment obtained from the SS2 model were similar to those obtained by the ASPMS model while the absolute levels were lower. Results, such the high ratio between MSY and SSB at MSY (over 72%) and the SSB estimated in 2004 being almost equal to that estimated at MSY were less intuitive and because of this the WPTT suggested that the SS2 modelling approach for bigeye be further explored.

CASAL

58. Document IOTC-2006-WPTT-15 presented an assessment using CASAL (C++ algorithmic stock assessment laboratory)[4]. This assessment method is commonly applied in CCAMLR for the evaluation of toothfish stocks. CASAL is a statistical catch-at-age, or catch-at-length, model that is able to accept multiple sources of information.

59. The base case used the Japanese standardised CPUE as index of abundance, catch-at-age as estimated by the Secretariat and the biological vectors used in the previous assessment. Two fleets were considered: longline and purse seine and selectivity by age was estimated for both fleets.

60. Results showed a good fit to the index of abundance and to the age frequencies by year for both fleets. The main difference observed with other methods relates to the interpretation of the high values observed in the Japanese CPUE in 1977-78. The model was not allowed to explain those changes in terms of increased recruitments. This resulted in higher estimates of virgin SSB and a more optimistic outlook given current catches.

61. Sensitivity runs were carried out using the Taiwanese CPUE, using two alternative values for natural mortality on the younger ages (1.2 and 0.6 for age 0), and for two alternative values to the steepness parameter of the Beverton-Holt stock-recruitment relationship (0.7 and 0.9). Those runs showed that the model results were little affected by the changes in the biological parameters, but that the use of the Taiwanese CPUE resulted in much higher estimates of SSB and MSY.

62. The incorporation of catches obtained by the artisanal fleets was also explored. This increased the complexity of the model, as the time series of artisanal catches had to be divided in 3 sections to fit separate selectivity curves. Estimated values did not differ from those obtained from the previous runs, and the group agreed that the catches of bigeye by the artisanal fleets were too small to warrant the extra effort needed to accommodate them.

ASPIC

63. A run of the ASPIC software5, implementing the Fox form of the surplus production model, was carried out during the meeting (no document presented). The model used the Japanese CPUE series. Results showed the stock to be below MSY levels in catch, biomass and fishing mortality.

[4] http://www.niwascience.co.nz/ncfa/tools/casal

[5] http://shrimp.ccfhrb.noaa.gov/~mprager/ASPIC.html

SPBAYES – BAYESIAN PELLA-TOMLISON

64. A Bayesian Pella-Tomlison model, on which the shape parameter is not estimated, as implemented in the FLR library6 was applied to the bigeye data during the meeting (IOTC-2006-WPTT-34). Given the difficulty of estimating both r and K parameters using one-way-trip indices of abundance, a strong prior pdf for r was estimated using biological data.

65. The model fitted well to the CPUE data, especially to the downward trend started in the early 1990s. Similar to the other models, biomass depletion levels were estimated to be around the 50% level. The confidence intervals obtained through Bayesian analysis give an indication of the uncertainties associated with estimating absolute levels, even when using simple models such as this one.

4.4. Results

66. Table 3 summarises the results obtained by the different models using a common set of inputs (Table 1), a value of 0.8 for the steepness of the stock-recruitment relationship, a new natural mortality vector (M1, Table 2), and the Japanese CPUE series for the whole Indian Ocean.

67. The WPTT acknowledged the considerable amount of work undertaken by scientists to assess the status of bigeye from a wide range of modelling perspectives. Examining the results, it was noted that the values of some indicators were fairly consistent across the models, in particular, the estimate of MSY which ranged from 111,195 to 137,427 t.

68. Despite the broad agreement of the models in estimating MSY, they produced quite different estimates of absolute levels of virgin and current biomass, and thus in the ratios of current levels of F and SSB to MSY (Table 3). For example, the two models with similar structures (SS2 and CASAL) provided quite different estimates of virgin, current and at-MSY spawning stock biomasses. This was probably due to how the variations in CPUE were interpreted by each model. While SS2 (and ASPMS) estimate recruitment deviations, and thus assigns changes in CPUE, like those observed in the late 1970's, to increases in recruitment, CASAL attempts to model the signal in the CPUE, and cannot interpret the history of catches in this fishery without a higher virgin biomass. It is also worth noting how the two models gave different perspectives with respect to how well the stock is able to sustain exploitation. For example, by observing at the ratios between the estimates of MSY and of SSB at MSY. CASAL's results appear to be more in accordance with those of ASPMS and the surplus production models, indicating that MSY for this stock should not be higher than 0.3 of SSB.

69. The WPTT agreed that the results of the ASPM would be used in the Bigeye Executive Summary in 2006.

70. Given the range of the estimates of MSY from the five models (111,195 to 137,427 t) and that the reported catches for 2004 amounted to 126,518 t, it appears that the stock is being exploited at around its maximum level. Results from the ASPIC analysis plotting the annual catches as a function of fishing mortality illustrate the MSY and its uncertainty (Figure 10).

71. Biomass trajectories indicate that the spawning stock biomass is currently just above the MSY level, but it has been declining since the late 1970's (Figure 11). Similarly, the current fishing mortality is estimated be to just above the MSY level, but fishing mortality has been increasing steadily since the 1980's (Figure 12).

[6] http://flr-project.org/

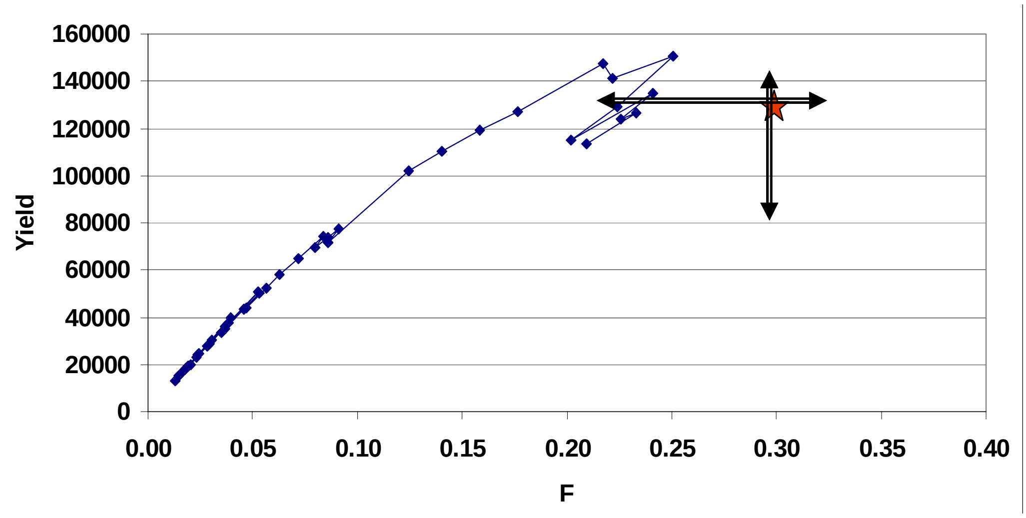


Figure 10: Plot of annual bigeye tuna catches as a function of mean fishing mortality derived from the ASPIC model. The star represents MSY and the arrowed lines represent the associated uncertainty (source A. Fonteneau).

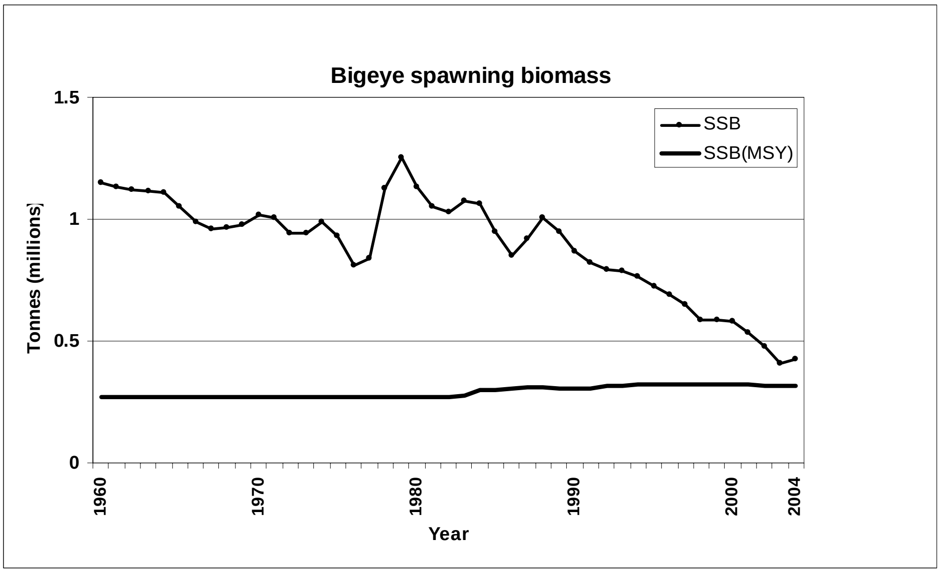


Figure 11: 2006 bigeye stock assessment (ASPM): spawning stock trajectories relating estimates of annual spawning stock size and the estimated maximum sustainable yield of the spawning stock biomass.

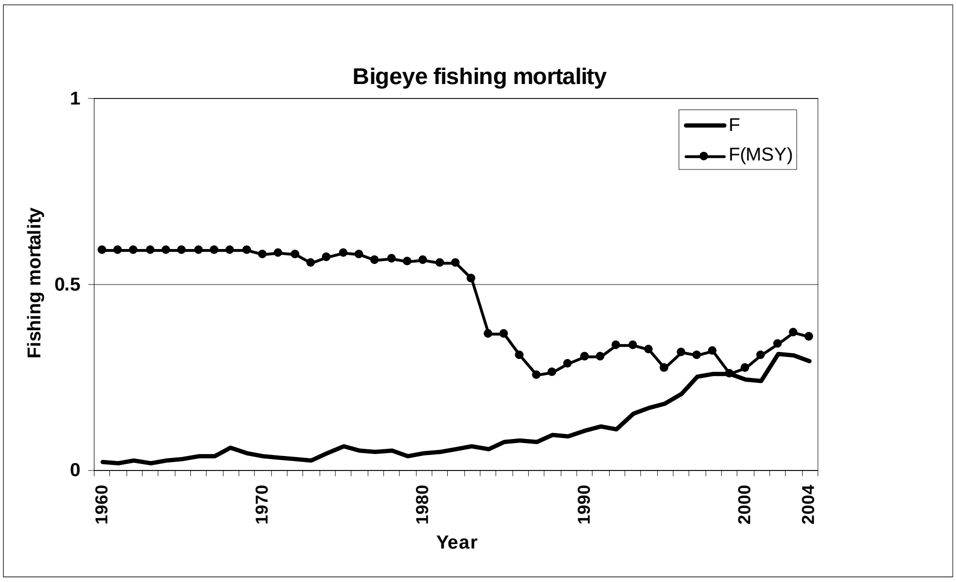


Figure 12: 2006 bigeye stock assessment (ASPM): fishing mortality trajectories relating estimates of annual fishing mortality and the estimated maximum sustainable level of fishing mortality.

Table 3: Summary of results obtained by the different assessment methods. Total biomass refers to the whole stock biomass in ASPM and to exploitable biomass on the surplus production models. Note, there were some differences in the input parameters used in the different models. 90 % CI given for ASPM results.

	ASPM	SS2	CASAL	ASPIC	spBayes
B_0	1,380,000 t[7]				680,477 t[8]
B_{2004}	720,000 t				370,000 t
B_{MSY}				393,800 t	340,239 t
Ratio B_{2004} / B_0	0.52 (0.43-0.61)				0.54
Ratio B_{2004} / B_{MSY}				1.38	1.12
SSB_0	1,150,000 t	848,360 t	1,750,000 t		
SSB_{2004}	430,000 t	187,819 t	774,141 t		
SSB_{MSY}	350,000 t	189,880 t	445,548 t		
Ratio SSB_{2004} / SSB_{MSY}	1.34 (1.04-1.64)	0.99	1.74		
Ratio SSB_{2004} / SSB_0	0.39 (0.31-0.47)		0.44		
MSY	111,195 t (94,738-127,652)	128,970 t	137,427 t	127,200 t	125,313 t
C_{2004}	126,518 t				
F_{2004}	0.29	0.20	0.16		
F_{MSY}	0.30	0.28	0.37	0.32	
Ratio F_{2004} / F_{MSY}	0.81 (0.54-1.08)	0.71	0.48	0.65	
HR_{2004}			0.15		0.34
HR_{MSY}			0.31		0.37
Ratio HR_{2004} / HR_{MSY}			0.48		0.89

PROJECTIONS

72. Ten year projections were carried out using CASAL, ASPM and SS2 for the following agreed scenarios:

- constant catch at 2004 levels
- with a 10% reduction in 2004 catch levels
- constant F at 2004 levels, at 2000-02 levels and at 1998-01 levels

73. Predictions by the models for the constant catch scenario (2004 levels) range from a gradual future reduction in the SSB by the ASPM and SS2 to a stabilisation of SSB at around current levels predicted by the CASAL model (Figure 13). At a constant catch equivalent to 10 % below the 2004 catch level, the declines illustrated by ASPM and SS2 were less severe while CASAL predicts a slight increase in SSB.

74. Three different fishing mortality at age scenarios were selected as they reflected different patterns of exploitation for juvenile and adult bigeye. In the period 1998-2000, the fishing pressure on juveniles was higher than it was during the period 2000-2002. The 2004 scenario reflects a fishery in which there was relatively lower pressure on juveniles compared to the other time periods. Scenarios based on F levels were presented, and the results from all models indicate that the three levels considered (2004, 2000-02 and 1998-2001) would not have a strong effect in the trajectories of future SSB, as the differences are relatively minor given the current level of uncertainty. The ASPM model outputs are used to illustrate these results (Figure 14).

7 Total biomass

8 Exploitable biomass

YIELD PER RECRUIT ANALYSIS

75. The effects of the three scenarios of fishing mortality were also considered in terms of yield per recruit (based on the inputs and results of the ASPM model). A multi-fleet YPR analysis was carried out during the meeting (no document) that indicated that an exploitation pattern such as the one observed in 2004 would have a positive impact on the yield per recruit obtained, when compared to the 2000-02 and 1998-01 fishing mortalities by fleet (Figure 15, based on the results of the statistical catch-at-age).

76. A slightly higher yield per recruit resulted from a pattern of exploitation in which there was lower pressure on juveniles. Yield per recruit increased from 1.98 kg for the 1998-2001 pattern of exploitation, to 2.06 kg for 2000-02 pattern, up to 2.22 kg if the 2004 pattern of exploitation were to be retained.

NOTES ABOUT EXPLOITATION PATTERNS

77. It was noted that the exploitation patterns observed in 2003 and 2004 could be considered anomalous, and heavily influenced by the high abundances of yellowfin tuna, which concentrated the activity of the surface fleets. The decrease in the fishing pressure on bigeye currently observed is likely to be temporal, as the fleets appear to have come back in the second half of 2005 to their previous pattern of activity.

78. Two other factors were also mentioned that could influence the short term evolution of the fishery. Rising fuel costs appear to be having an effect on the operating procedures of the surface fleets. Distances travelled at night, and consequently the number of FADs visited, are being reduced to save on fuel costs. The effect of this change could be however reduced by the increasing use of supply vessels, tasked with visiting FADs and informing purse seiners of the abundance of fish around them.

79. The second factor is the limitation on the activity of all fishing fleets on the coast and EEZ of Somalia, due to the increase in the activity of pirates in the area. Some purse seine fleets have receive indications from their governments not to venture into those waters. An important fishery on FADs has traditionally taken place in this area on the last quarter of the year, with significant catches of juvenile bigeye.

80. Another factor to consider when analysing the possible futures trends in SSB is the trend in effective fishing power observed in the fleets involved in this fishery. Figure 8, for example, shows the evolution in the carrying capacity of the purse seine fleet.

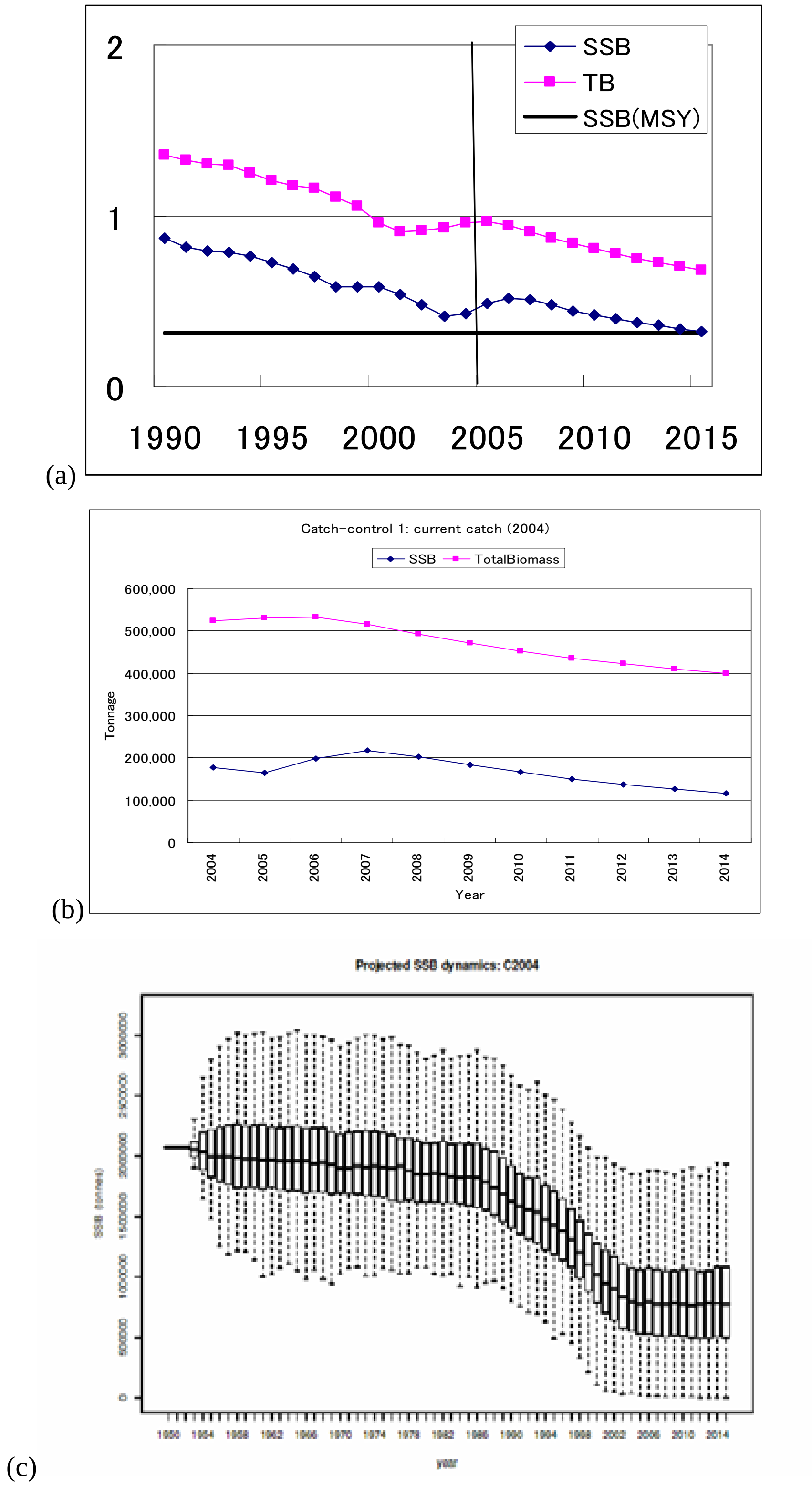
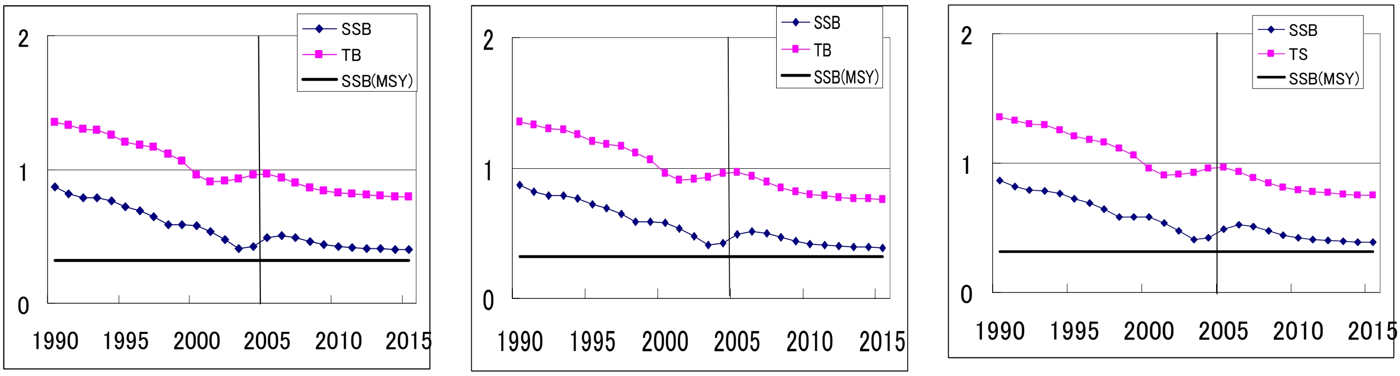
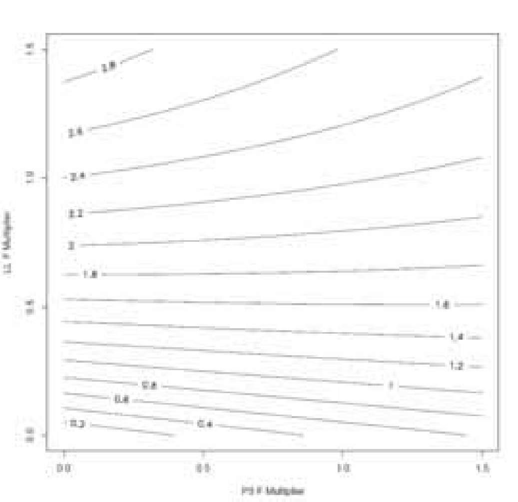


Figure 13: Forward projections from (a) the ASPM model (b) the SS2 model and (c) the CASAL model illustrating trends in total biomass and spawning biomass for bigeye tuna in the Indian Ocean if catches were maintained at the 2004 level.

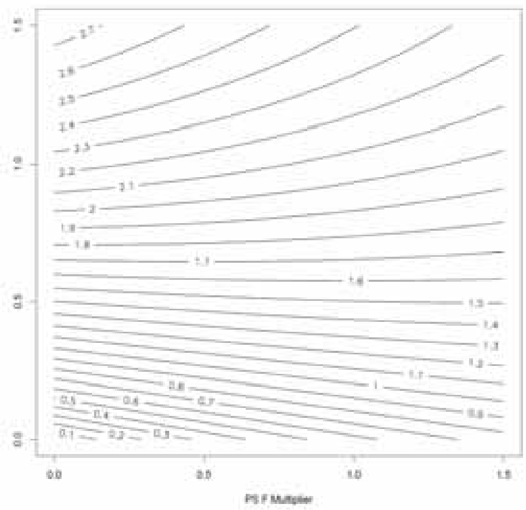


(a) F (2004) = 0.293 (b) F (2000-2002) = 0.265 (c) F (1998-2001) = 0.251

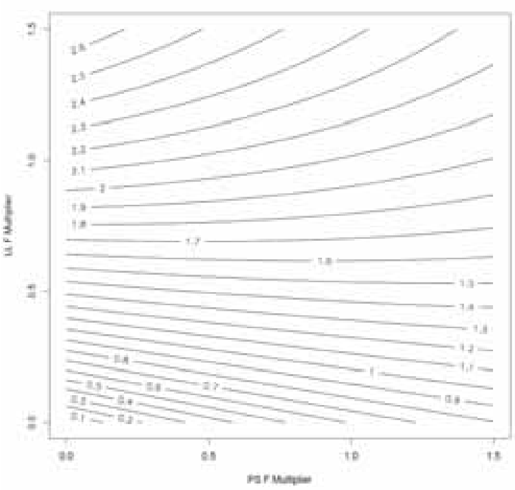
Figure 14: Forward projections from the ASPM model illustrating trends in total biomass and spawning biomass for bigeye tuna in the Indian Ocean at various levels of fishing mortality (a) F in 2004 (b) F between 2000-02 (c) F between 1998 and 2001.



(a) 2004



(b) 2000-02



(c) 1998-2001

Figure 15: Yield per recruit calculations, in kg/recruit, for different fishing mortality at age scenarios reflecting three different patterns of exploitation on juvenile and adult bigeye. The growth, natural mortality assumptions are from the base case in the ASPM.

4.5. Technical advice on bigeye tuna

81. A comprehensive assessment was attempted for bigeye tuna in 2006 by the WPTT and the following management advice was delivered to the Scientific Committee:

> MANAGEMENT ADVICE
>
> The results of the various stock assessments conducted in 2006 were broadly similar and, in general, were more optimistic than previous ones. These ASPM results indicate that the 2005 catch is close to the MSY. Furthermore, spawning stock biomass seems to be above the level that would produce MSY, and the fishing mortality in 2004 seems to below the MSY level. Current (2004) catches of juveniles bigeye by the surface fleets are also less detrimental in terms of yield-per-recruit that previous patterns.
>
> However, the current outlook could revert to a more pessimistic one, if the exploitation pattern is to return to the pre-2003 levels, as expected. Changes in the fishery occurred in 2003 and 2004, but these were due to the exceptional catches of yellowfin, which seem to be the result of anomalous conditions. In 2005, the fishery is already showing a return to the previous pattern of exploitation, which is likely to increase the catches of bigeye tuna associated with floating objects.
>
> If the level in catch in numbers of juvenile bigeye tuna by purse seiners fishing on floating objects returns to pre-2003 levels, this is likely to be detrimental to the stock, as fish of these sizes are below the optimum size for maximum yield-per-recruit.
>
> The WPTT also noted that juvenile bigeye tuna are caught in the FAD purse-seine fishery that targets primarily skipjack tuna. Some measures to reduce the catches of bigeye tuna in this fishery could be expected to result in a decrease in the catches of skipjack tuna.
>
> In view of the most current assessment, the WPTT recommended that catches and fishing effort should not increase further.

5. RESEARCH RECOMMENDATIONS AND PRIORITIES

82. Scientists are strongly encouraged to extend the collection of biological samples and data for all tuna species, especially yellowfin and bigeye. For example, sampling programmes at the canneries could prove an essential source of biological data on maturity, growth and other parameters.

83. The differences between both longline indices of abundance, and the relative impact of the various factors introduced in the standardization procedure should be further explored. The dependency of all assessment methods to these indices as sources of information on stock trends makes the work on this area essential for the successful assessment of the resource.

84. Scientists are encouraged to continue their work on the use of integrated statistical assessment models. Their ability to make use of other sources of information, such as that obtained from tagging, makes them the more valuable given the current uncertainties observed in the indices of abundance and the development of the Indian Ocean Tagging Programme currently underway.

85. - Further exploration of a number of ecosystem end environmental indicators of possible relevance to Indian Ocean fisheries is to be pursued. The recent events regarding yellowfin catches have demonstrated how limited our understanding of Indian Ocean oceanography and its impact on fisheries still is, and how useful in terms of management such knowledge could be.

86. - Exploration of the likely impact of uncertain events such as the recent yellowfin catches could be greatly aided by the development of Management Strategy Evaluation systems and/or Operating Models of the tropical tuna fishery. Work along this line is to be encouraged and scientists should report on their developments.

6. OTHER BUSINESS

UPDATE ON TUNA TAGGING ACTIVITIES IN THE INDIAN OCEAN

87. Document IOTC-2005-WPTT-21 provided an update in the Regional Tuna Tagging project in the Indian Ocean. The RTTP-IO started its tagging operation in May 2005 and will pursue them until September 2007. After 15 months, 72,176 tuna have been tagged and released in the South-West Indian Ocean (Seychelles, Mozambique Channel, Tanzania & Kenya) including 24,855 yellowfin (34%), 11,242 bigeye (16%) and 35,798 skipjack (50%). It is anticipated that the minimal target of 80,000 tagged tunas assigned to the project will be exceeded. There has been a good coverage of species and sizes and the information obtained is expected to contribute to improved stock assessment of the three tuna species in the future. A publicity and tag recovery scheme is in place to manage the return of the tagged tuna caught by the fisheries. Most of the 2,600 recoveries to-date have come from the purse seine fishery. The majority of the tuna recovered had been at liberty for between one month and one year. This demonstrates a good dispersion and mixing of the tagged tuna among the rest of the population (a basic necessity for tagging for stock assessment purpose). The overall recovery rate is now 4% noting that adjustment to this rate will be made using information from tag shedding and tag reporting rates (which will be determined by double-tagging of 20% of the tagged fish and a tag seeding operation on board purse seiners). So far the South-Western Indian Ocean has been well surveyed and other regions of the Western Indian Ocean will be covered in the future.

88. A verbal update was provided on the small scale and pilot tagging projects involving IOTC. Tag Seeding. IOTC started a tag seeding experiment in April 2004 on the purse-seine fleet based in Seychelles. To-date 899 tags have been released. 69 tags (7,7%) were placed onboard French purse-seiners and the remaining 92% on the Spanish purse-seine fleet. The minimum recovery rate for tags is expected to be around 55 to 60%. To-date 475 tags have been recovered. As 75% of the catch is leaving Seychelles on reefers, reporting rate estimates need to be adjusted accordingly. However, information on the fish flow is difficult to gather as the industry is not always keen to providing this information and as the skippers of the reefers do not know in general when they are leaving Victoria, what will be their final destination will be. Tag seeding will continue during the project and approaches will be made to increase the involvement of the French fleet. Tag seeding will also soon be trialled on reefers but special tags will have to be used as the fish are deep frozen.

Small-scale tagging programme. Western Indian Ocean. Due to lack of funding, the last Small-scale programme took place in Lakshadweep (India). This project started in March 2005 and finished in March 2006. During three tagging periods (March/April 2005, November 2005 and March 2006), 4958 tunas (164 YFT and 4794 SKJ) were tagged and released around three islands of the Lakshadweep. To-date, 213 tags have been recovered around the Lakshadweep islands and 10 outside (Maldives and from the purse-seine fleet). Eastern Indian Ocean In February 2006, a workshop involving IOTC, NRIFSF (Japan), CSIRO (Australia), RCCF (Indonesia) and the FSI (India) was held in Indonesia to plan the projects in the EIO. A pilot study to tag 5000 tunas (preferably Yellowfin and Bigeye) off the coast of Sumatra in the Mentawai Strait is scheduled to start in October and run for six weeks. The project will involve a pole-and-line vessel from Sulawesi and a patrol vessel from Directorate General of Marine and Fisheries Resources Surveillance.

UPCOMING MEETING AND WORKSHOPS RELEVANT TO THE WPTT

89. Document IOTC-2006-WPTT-INF04 outlined plans for a workshop on the predation in tuna longline fisheries to discuss results and implications of the five year predation survey on tuna longline fisheries undertaken by Japanese scientists. A two day workshop is planned to coincide the 9th session of the WPTT in 2007.

90. The WPTT was informed about the First Symposium on Integrating Satellite Data into Ecosystem-based Management of Marine Living Resources to be held in Shanghai, China from 5-8 December 2006; and the International Symposium on Tuna and Pelagic Fish Stock Assessment and Management to be held in Shanghai, China from 12-15 March 2007.

ELECTION OF WPTT CHAIR

91. Dr. Iago Mosqueira was elected as the new chair of the WPTT for the next biennium.

7. ADOPTION OF THE REPORT

92. The Report of the Eighth Session of the Working Party on Tropical Tunas was adopted by correspondence.

APPENDIX I. LIST OF PARTICIPANTS

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APPENDIX II. AGENDA OF THE MEETING

1. **REVIEW OF THE DATA**

   Review of the statistical data available for the tropical tuna species

2. **NEW INFORMATION ON BIOLOGY AND STOCK STRUCTURE OF TROPICAL TUNAS**

   Biology, Observer programs, Statistics, Environment

3. **REVIEW OF NEW INFORMATION ON THE STATUS OF BIGEYE**

   Input into stock assessments:

   - Catch and effort
     - LL, PS and other gears
     - How to treat lack of data from artisanal fleets and other problems
   - Catch at size
   - Growth curves and age-length key
   - Catch at age
   - CPUE
     - Raw CPUE indices
     - Standardised CPUE indices (LL and other major gears)
     - factors influencing CPUE — such as change of targeting practices, environment and technology

   Stock assessments

   Discussion of stock status indicators, including among others

   - Trends in total catch and catch per unit effort
   - Trends in mean weight
   - Trends in catch-per-successful-set

   Discussion of stock assessment sensitivities and projection scenarios

4. **DEVELOP TECHNICAL ADVICE ON THE STATUS OF THE STOCK OF BIGEYE TUNA**
5. **REVIEW OF NEW INFORMATION ON THE STATUS OF YELLOWFIN AND SKIPJACK**

   Review of catch trends (Secretariat), CPUE, mean weight etc (as provided by Members)

   Analysis of the 2003-04 catches of YFT

   Discussion of stock status indicators

6. **RESEARCH RECOMMENDATIONS AND PRIORITIES**
7. **OTHER BUSINESS**

   Regional Tuna Tagging Programme – Indian Ocean

   Workshop on Predation in Tuna Longline Fisheries

   FADIO

   Any other business

   Election of chairperson

APPENDIX III. LIST OF DOCUMENTS PRESENTED TO THE MEETING

DOCUMENTS	TITLES
IOTC-2006-WPTT-01	Draft agenda of the Working on Tropical Tunas
IOTC-2006-WPTT-02	WPTT List of documents
IOTC-2006-WPTT-03	Status of the IOTC databases for tropical tunas. *IOTC Secretariat*
IOTC-2006-WPTT-04	Statistics of the purse seine Spanish fleet in the Indian Ocean (1984-2006). *A. Delgado de Molina, Juan J. Areso and J. Ariz*
IOTC-2006-WPTT-05	Bigeye tuna and yellowfin tuna sex-ratio analysis from observer data obtained during the experimental cruise on Spanish longliners in the Southwestern Indian Ocean in 2005. *J. Ariz, A. Delgado de Molina , Mª L. Ramos and J. Santana*
IOTC-2006-WPTT-06	Acoustic Selectivity in Tropical Tuna (Experimental Purse-seine Campaign in the Indian Ocean). *J. Miquel, A. Delgado de Molina, J. Ariz, R. Delgado de Molina1, S. Déniz, N. Díaz, M. Iglesias, J. Santana and P. Brehmer*
IOTC-2006-WPTT-07	Data obtained from purse-seine observers carry out by the Instituto Español de Oceanografía (IEO) from the National Database Plan (PNDB) between 2003 and 2006. *R. Sarralde, A. Delgado de Molina, J. Ariz and J. Santana*
IOTC-2006-WPTT-08	Indices of environmental variability in the Indian Ocean 1970-2005 and effects on tuna fisheries. *F. Marsac*
IOTC-2006-WPTT-09	A routine collection of biological and trophic descriptors at the tuna canning factory in Seychelles. *Potier M, F. Marsac, C. Peignon, V. Lucas, A. Fonteneau and F. Menard*
IOTC-2006-WPTT-10	Historical database on Soviet tuna longline tuna research in the Indian and Atlantic oceans (first results of YugNIRO-NMFS data rescue project). *E. Romanov, G. Sakagawa, F. Marsac, and N.'y. Romanova*
IOTC-2006-WPTT-11	Catch and effort data on Soviet tuna purse seine fisheries in the Indian Ocean based on daily radio reports database; fine-scale 1-degree/month dataset on Soviet purse-seine tuna fisheries in the Indian Ocean for 1985-1994. *E. Romanov and N'y. Romanova*
IOTC-2006-WPTT-12	Catch rate comparison between the circle hooks and the ring hooks in the tropical high seas of the Indian Ocean based on the observer data. *X. Liu-xiong, S. Li-ming, J. Wen-xin and W. Jia-qiao*
IOTC-2006-WPTT-13	Environment factors of yellowfin tuna (*Thunnus albacares*) in the tropical high seas longlining of the India Ocean. *S. Li-ming, Z. Yu, X. Liu-xiong, J. Wen-xin and W. Jia-qiao*
IOTC-2006-WPTT-14	Environment factors of bigeye tuna (*Thunnus obesus*) longlining in the tropical high seas of the India Ocean. *S. Li-ming, Z. Ji, Z. Yingqi, J. Wen-xin and W. Jia-qiao*
IOTC-2006-WPTT-15, add1, add2	Assessment of the Indian Ocean bigeye tuna stock using CASAL. *R.M. Hillary, I. Mosqueira.*
IOTC-2006-WPTT-16	FADIO (Fish Aggregating Devices as Instrumented Observatories of pelagic ecosystems): a European Union funded project on development of new observational instruments and the behavior of fish around drifting FADs. *L. Dagorn*
IOTC-2006-WPTT-17	Japanese longline CPUE for bigeye tuna in the Indian Ocean up to 2004 standardized by GLM applying gear material information in the model. *H. Okamoto*
IOTC-2006-WPTT-18, add1	Preliminary stock assessment for bigeye tuna in the Indian Ocean using Stock Synthesis II (SS2). *H. Shono.*
IOTC-2006-WPTT-19	Estimation of Catch-At-Size, Catch-At-Age and Catches per time-area strata for tropical tuna species - *IOTC Secretariat*
IOTC-2006-WPTT-20	Standardized catch per unit effort of bigeye tuna (*Thunnus obesus*) caught by Taiwanese longline fleets in the Indian Ocean by general linear mixed model. *C-C. Hsu*
IOTC-2006-WPTT-21	An up-to-date on the implementation of the RTTP. *J-P. Hallier*
IOTC-2006-WPTT-22, add1, add2, add3, add4	Updated stock assessment of bigeye tuna (*Thunnus obesus*) resource in the Indian Ocean by the age structured production model (ASPM) analyses (1960-2004). *T. Nishida and H. Shono*
IOTC-2006-WPTT-23	Report of the predation* survey by the Japanese commercial tuna longline fisheries *T. Nishida and Y. Shiba*
IOTC-2006-WPTT-24	Meso-scale exploitation of a major tuna concentration in the Indian Ocean. *A. Fonteneau, A. Delgado, V. Lucas and H. Demarcq*
IOTC-2006-WPTT-25	Note on the interest to conduct a scientific observer programme on longliners operating around Seychelles waters. *V. Lucas, P. Bach and A Fonteneau*

IOTC-2006-WPTT-26	Analysis of data obtained from observer programmes conducted in 2005 and 2006 in the Indian ocean on board French purse seiners. *A. Viera. and R. Pianet.*
IOTC-2006-WPTT-27	French purse-seine tuna fisheries statistics in the Indian Ocean, 1981-2005. *R. Pianet, V. Nordstrom and A. Hervé.*
IOTC-2006-WPTT-28	Statistics of the main purse seine fleets fishing in the Indian Ocean (1981-2005). *R. Pianet, A. Delgado de Molina, J. Doriso, V. Nordstrom and A. Hervé.*
IOTC-2006-WPTT-29	Fishing experiments and data collected in the frame of the cappes research project. *V. Lucas, P. Bach, C. Gamblin*
IOTC-2006-WPTT-30	Report on the validation of Seychelles Industrial longline data. *J. Dorizo, A. Fonteneau and V. Lucas*
IOTC-2006-WPTT-31	Preliminary catch estimates of tuna and tuna-like species from NARA / IOTC / OFCF sampling program in Sri Lanka. *D.C.T. Dissanayake, C. Amarasiri, E.K.V. Samaraweera, U. Adikari, F. Poisson*
IOTC-2006-WPTT-32	Short note on the Japanese longline gear confiuration as a targeting index. *H. Okamoto.*
IOTC-2006-WPTT-33	Profile of Hook depth of Chinese Fresh tuna longline in the tropical Indian Ocean based on TDR data. *X. Liuxiong, Z. Guoping and S. Liming*
IOTC-2006-WPTT-34	Bayesian Pella-Tomlinson model for Indian Ocean bigeye tuna. *R.M. Hillary, I. Mosqueira.*
IOTC-2006-WPTT-INF01	Climatic oscillations and tuna catch rates in the Indian Ocean: a wavelet approach to time series analysis. Fisheries Oceanography. – *F. Ménard., F. Marsac, E. Bellier, B. Cazelles* (in press). Abstract only.
IOTC-2006-WPTT-INF02	Folly and fantasy in the analysis of spatial catch rate data. *T. Nishida*
IOTC-2006-WPTT-INF03	Feeding habits of the longnose lancetfish (*Alepisaurus ferox* Lowe, 1833) in the western Indian Ocean. – *E. V. Romanov and V. Zamorov.* Abstract only.
IOTC-2006-WPTT-INF04	Workshop on Predation in tuna longline fisheries. *T. Nishida*
IOTC-2006-WPTT-INF05	Species identification of swimming crabs fed by yellowfin tuna (YFT) during its high catch periods (2003-2004) in the western Indian Ocean. *T Nishida, S. Fujiwawa and S. Adam*
IOTC-2006-WPTT-INF06	IOTC Technical Report 02/01: Converting weight data into length data. *IOTC Secretariat*
IOTC-2006-WPTT-INF07	IOTC Technical Report 06/02: Converting length data into age. *IOTC Secretariat*