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

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

Mombasa, Kenya

15-23 October, 2009

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1. OPENING OF THE MEETING AND ADOPTION OF THE AGENDA

1. During the opening ceremony to the Eleventh Session of the Working Party Tropical Tunas (WPTT) held in Mombasa, Kenya from 15 to 23 October 2009, the Deputy Director-General of Department Fisheries in Kenya, Mrs. Martha Mukira, welcomed the participants to Mombasa and wished them to have a productive meeting.

2. The meeting was chaired by Dr. Iago Mosqueira and the agenda for the Meeting was adopted as presented in Appendix I.

3. The list of participants is provided in Appendix II and a list of the documents presented to the meeting is given in Appendix III.

2. THE STATUS OF THE IOTC FISHERIES STATISTICS RELATING TO TROPICAL TUNA SPECIES

4. The Secretariat presented a detailed description of the status of the IOTC databases for tropical tunas (IOTC-2009-WPTT-13). The following information is a summary for each of the three tropical species.

2.1. Bigeye tuna (BET)

Retained catches are well known for the major fleets (Figure 1); but are less certain for non-reporting industrial purse seiners and longliners (NEI) and for other industrial fisheries (longliners of India and Philippines and purse seiners of Iran and Thailand). Catches are also uncertain for some artisanal fisheries including the pole-and-line fishery in the Maldives and the gillnet/longline fishery in Sri Lanka, and Iran, due to problems in species identification for any of these fisheries (*eg.* Iran gillnet fisheries yearly catches of yellowfin and skipjack: 100,000t).

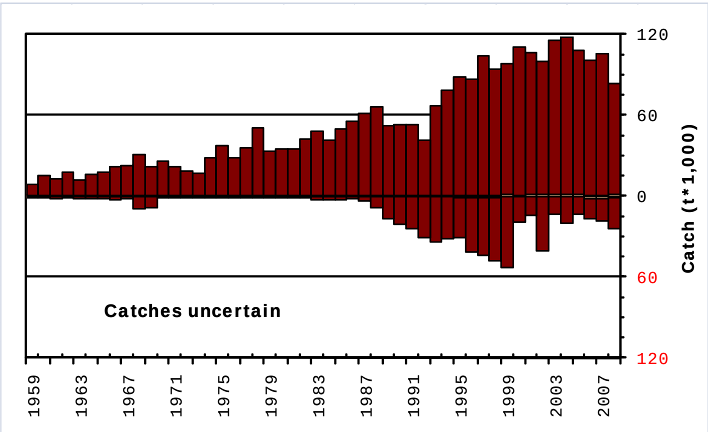


Figure 1. Uncertainty of annual catch estimates for bigeye tuna. The amount of the catch below the zero-line has been categorised as uncertain according to the criteria given in the text. Light bars represent data for artisanal fleets and dark bars represent data for industrial fleets. Data as of September 2009

Discard levels are believed to be low although they are unknown for most industrial fisheries. Discard levels were estimated for the purse-seine fishery for the period 2003-2008.

Changes to the catch series: There have not been significant changes to the catches of bigeye tuna since the WPTT in 2008 (Figure 2). The changes in recent years are mostly due to revisions to the catches of the major longline fleets.

CPUE Series: Catch and effort data are generally available from the major industrial fisheries. However, these data are not available from some fisheries or they are considered to be of poor quality, especially throughout the 1990s for the following reasons:

- non-reporting by industrial purse seiners and longliners (NEI)

- uncertain data from significant fleets of industrial purse seiners from Iran and longliners from India, Indonesia, Malaysia, Oman, Philippines, and Taiwan,China (fresh tuna).

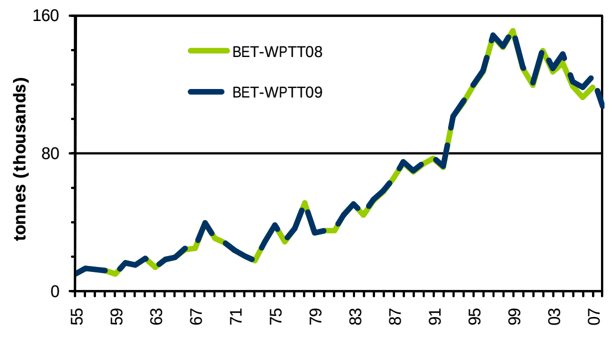


Figure 2. Bigeye tuna: Catches used by the WPTT in 2008 versus those estimated for the WPTT09 (1955-2008)

Trends in average weight can be assessed for several industrial fisheries although they are incomplete or of poor quality for most fisheries before the mid-1980s and for some fleets in recent years (*e.g.* Japan longline) (Figure 3).

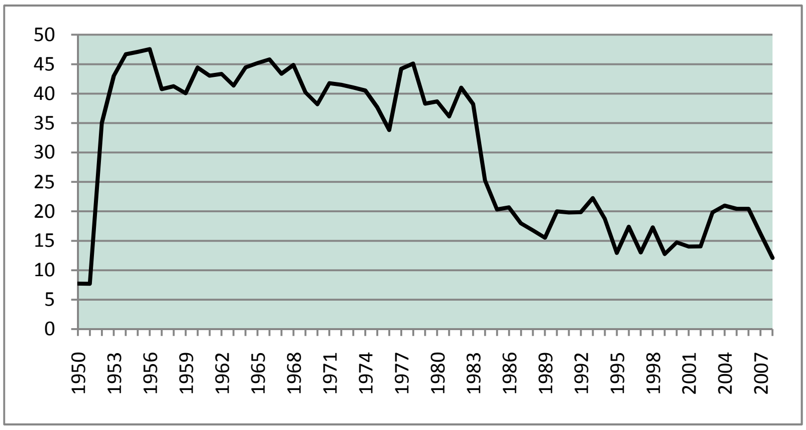


Figure 3. BET average weight all fleet combined from 1950 to 2008

Catch-at-Size(Age) table: This is available but the estimates are more uncertain (Figure 4) for some years and some fisheries due to:

- the paucity of size data available from industrial longliners before the mid-60s, from the early-1970s up to the mid-1980s and in 2008
- the paucity of catch by area data available for some industrial fleets (NEI, India, Indonesia, Iran)

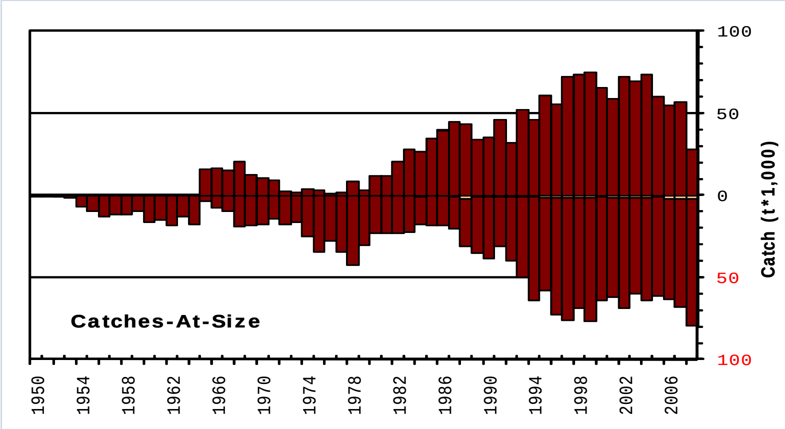


Figure 4. Uncertainty of catch at size data for bigeye tuna. The amount below the zero-line indicates the amount of catch for which the estimated catch at size has been categorised as uncertain according to the criteria given in the text. Light bars represent data for artisanal fleets and dark bars represent data for industrial fleets. Data as of September 2009

2.2. Skipjack tuna (SKJ)

Retained catches are generally well known for the industrial fisheries but are less certain for many artisanal fisheries (Figure 5), notably because:

- catches are not being reported by species
- there is uncertainty about the catches from some significant fleets including the Sri Lankan gillnet/longline fishery and the industrial purse seiners from Iran.

Discard levels are believed to be low although they are unknown for most industrial fisheries,. Discard were estimated for the purse seine fishery for the period 2003-2008.

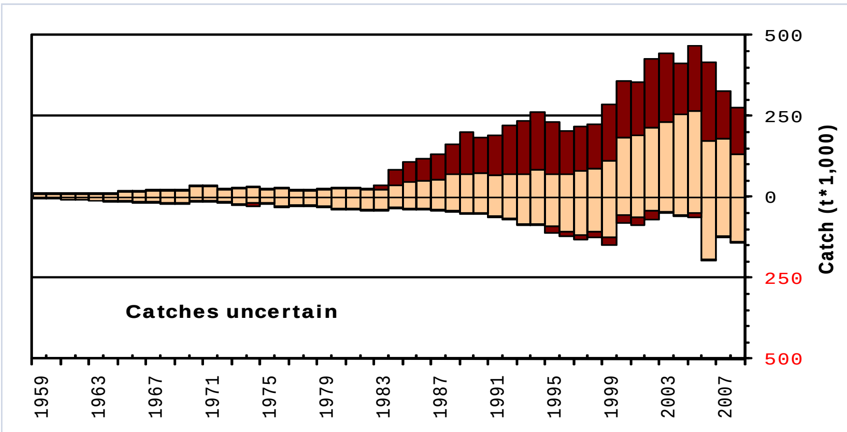


Figure 5. Uncertainty of annual catch estimates for skipjack tuna. The amount of the catch below the zero-line has been categorised as uncertain according to the criteria given in the text. Light bars represent data for artisanal fleets and dark bars represent data for industrial fleets. Data as of September 2009

Changes to the catch series: There have been no major changes to the catches of skipjack tuna since the WPTT in 2008 (Figure 6).

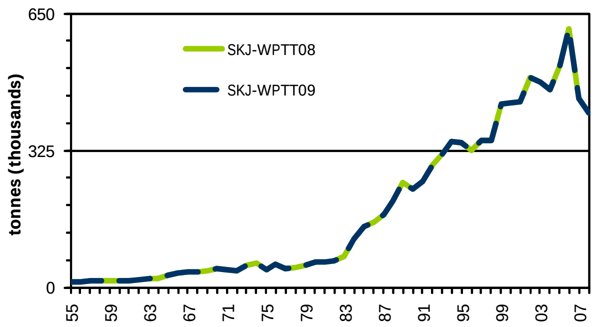


Figure 6. Skipjack tuna: Catches used by the WPTT in 2008 versus those estimated for the WPTT09 (1955-2008)

CPUE Series: Catch and effort data are available from various industrial and artisanal fisheries. However, these data are not available from the important artisanal fisheries or they are considered to be of poor quality for the following reasons:

- almost no data are available for the artisanal fisheries of Indonesia
- the poor quality effort data for the significant gillnet/longline fishery of Sri Lanka
- no data are available for the significant pole-and-line fishery of Maldives in recent years.

Trends in average weight cannot be assessed before the mid-1980s and are incomplete for most artisanal fisheries thereinafter, namely hand lines, troll lines, many gillnet fisheries (Indonesia) and the pole-and-line fishery of Maldives in recent years (Figure 66).

Catch-at-Size table: CAS are available but the estimates are uncertain for some years and fisheries due to (Figure 7):

- the lack of size data before the mid-1980s
- the paucity of size data available for some artisanal fisheries, notably most hand lines and troll lines, many gillnet fisheries (Indonesia) and the pole-and-line fishery of Maldives in recent years

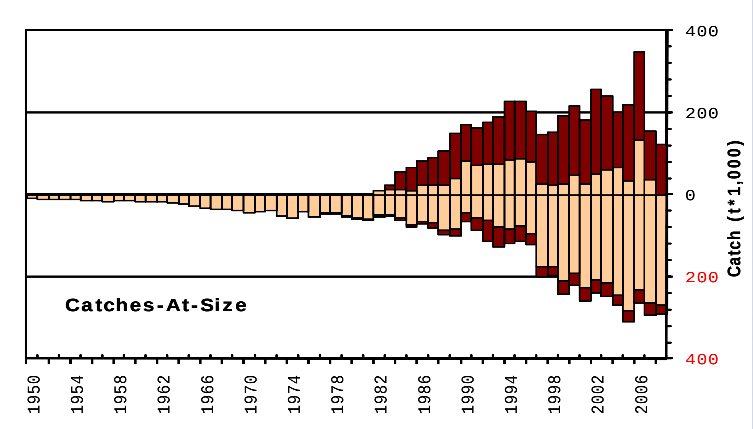


Figure 7. Uncertainty of catch at size data for skipjack tuna. The amount below the zero-line indicates the amount of catch for which the estimated catch at size has been categorised as uncertain according to the criteria given in the text. Light bars represent data for artisanal fleets and dark bars represent data for industrial fleets. Data as of September 2009

2.3. Yellowfin tuna (YFT)

Retained catches are generally well known (Figure 8); however, catches are less certain for:

- many artisanal fisheries, notably those from Indonesia, Sri Lanka, Yemen and Comoros
- non-reporting industrial purse seiners and longliners (NEI), longliners of India and purse seiners of Iran.

Discard levels are believed to be low although they are unknown for most industrial fisheries,. Discard were estimated for the purse seine fishery for the period 2003-2008.

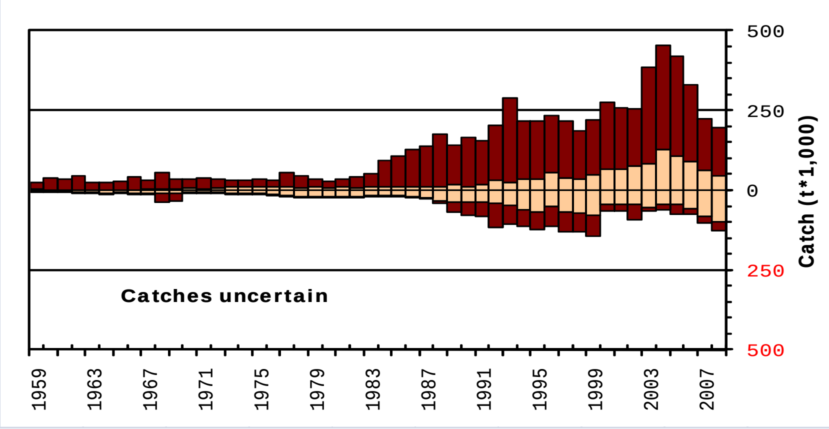


Figure 8. Uncertainty of annual catch estimates for yellowfin tuna. The amount of the catch below the zero-line has been categorised as uncertain according to the criteria given in the text. Light bars represent data for artisanal fleets and dark bars represent data for industrial fleets. Data as of September 2009

Changes to the catch series: There have not been significant changes to the catches of yellowfin tuna since the WPTT in 2008 (Figure 9).

CPUE Series: Catch and effort data are available from the major industrial and artisanal fisheries. However, these data are not available for some important artisanal fisheries or they are considered to be of poor quality for the following reasons:

- poor quality effort data for the gillnet/longline fishery of Sri Lanka
- no data available from the gillnet fisheries of Iran and Pakistan
- no data are available for the artisanal fisheries of Indonesia, Yemen and Comoros
- no data are available for the pole and line fishery of Maldives in recent years.

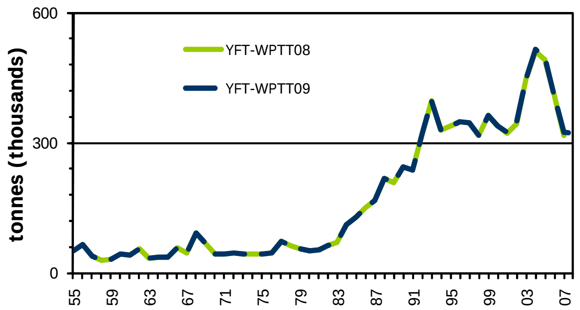


Figure 9. Yellowfin tuna: Catches used by the WPTT in 2008 versus those estimated for the WPTT09 (1955-2008)

Trends in average weight can be assessed for several industrial fisheries but they are very incomplete or of poor quality for some artisanal gears, namely hand lines, troll lines, many gillnet fisheries (Yemen, Oman, Indonesia) and the pole and line fishery of Maldives in recent years (Figure 10).

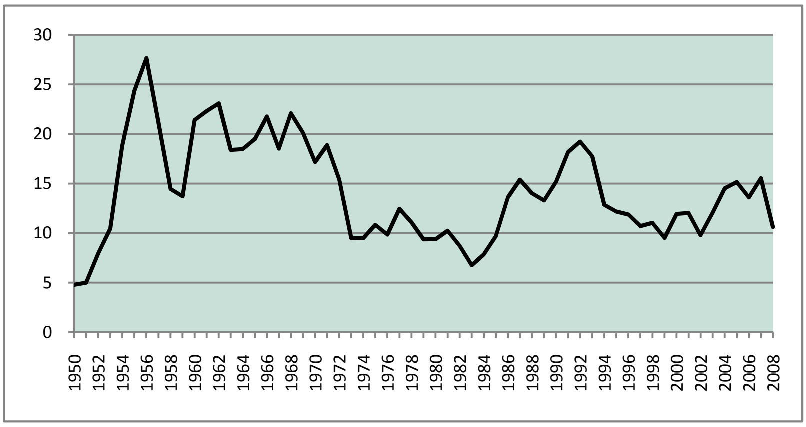


Figure 10. YFT average weight all fleets combined from 1950 to 2008.

Catch-at-Size(Age) table: This is available although the estimates are more uncertain (Figure 11) in some years and some fisheries due to:

- size data not being available for most artisanal fisheries, notably Yemen and Indonesia (lines and gillnets), Comoros (lines) and Maldives (pole and lines) in recent years
- the paucity of size data available from industrial longliners from the late-1960s up to the mid-1980s
- the paucity of catch by area data available for some industrial fleets (NEI, Iran, India, Indonesia, Malaysia).

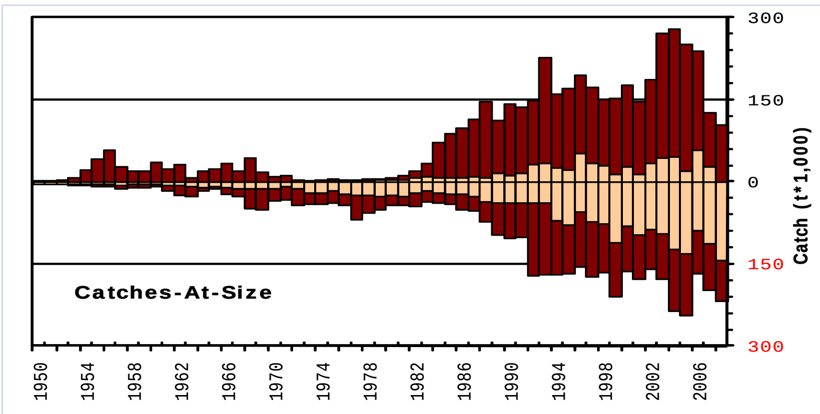


Figure 11. Uncertainty of catch at size data for yellowfin tuna. The amount below the zero-line indicates the amount of catch for which the estimated catch at size has been categorised as uncertain according to the criteria given in the text. Light bars represent data for artisanal fleets and dark bars represent data for industrial fleets. Data as of September 2009

2.4. Recommendations to improve the data available to IOTC

5. The WPTT express its satisfaction regarding the preparation of the data and the document provided by the Secretariat. The problems are well identified and the general quality of the data is decreasing in addition to the development of ghost fleets. The WPTT also noted that the use of complex stock assessment model requires reliable size frequency and catch and effort data, and made the recommendations summarized in Table 1.

Table 1. List of recommendations to improve data available

Improve the certainty of catch and effort data from artisanal fisheries, by:
• Yemen, Comoros and Madagascar implementing fisheries statistical collection and reporting systems. • Sri Lanka to increase sampling coverage to 2005-06 levels in order to improve estimates of catches for its fisheries, especially species and gear breakdown. • Indonesia, Iran, Maldives, Pakistan, and Sri Lanka providing catch-and-effort data as per IOTC standards for their artisanal fisheries, notably gillnet, pole-and-line and hand line. • Maldives modifying its data collection system to allow for the catches of bigeye tuna to be estimated, especially for its pole-and-line and hand line fisheries.

• Fisheries data collection agencies in India and Sri Lanka collaborating to produce the best possible set of catch statistics for their fisheries, revising their historical data series basing on the results of this analysis. • Countries to increase sampling coverage to obtain acceptable levels of precision (CV to be initially set at less than 20%) in their catch-and-effort statistics and to report this information to the Secretariat, routinely.
Improve the certainty of catch-and-effort data from industrial fisheries by: • Countries having industrial fisheries for tropical tunas to use the standard IOTC logbooks to collect catch and effort data by species, in particular: – Longliners from India, Indonesia, Malaysia, Philippines, and Oman, including those vessels based outside their flag states. – Fresh-tuna longliners from Taiwan,China – Industrial purse seiners from Iran • The above logbooks should include tools to assist fishers and data collectors to correctly identify tropical tunas, especially juvenile tunas. • Countries ensuring that logbook coverage is appropriate to produce acceptable levels of precision (CV to be initially set at less than 20%) in their catch-and-effort statistics and to report this information to the Secretariat, routinely. • Countries with observer programmes to analyse the data collected to estimate discards of tropical tuna species and the precision of these estimates, and to report this information to the Secretariat, routinely.
Increase the amount of size data available to the Secretariat by: • Comoros, India, Indonesia, Pakistan, and Yemen collecting and providing size data for tropical tunas taken by artisanal fisheries, especially gillnet, handline and troll fisheries. • Maldives providing size frequency data by atoll and gear • Thailand and Iran collecting and providing size data for their industrial purse seine fleets • Taiwan,China collecting and providing size data from their fresh tuna longliners. • India, Indonesia, Malaysia, Philippines and Oman collecting and providing size data for their longline vessels, including those based outside their flag states
Reduce uncertainty in the following biological parameters important for the assessment of stock status of tropical tuna species by: • Conversion relationships: Countries catching significant amounts of tropical tunas collecting, preferably through observer programmes, and providing the basic data that would be used to establish length-weight keys, non-standard measurements-fork length keys, processed weight-live weight keys for these species.

6. All tuna stock assessments are now based on detailed catch and effort and catch at sizes data. As a consequence it is of increasing importance to have these detailed data for a maximum of the fisheries It was noted by the WPTT that the large industrial fleets, historically dominant in the Indian Ocean stock assessment, form noiw a smaller percentage of the total catch, while new industrial fleets have developed and some artisanal fleets have started a process on improvement that has not been followed by the submission of sufficient data to the Secretariat. This is the case, for example, for some fisheries in India (longline), Indonesia (longline), Taiwan,China (fresh-tuna longline) and Iran (purse seine and gillnet). The WPTT recommended that complete and good quality data should be reported to the Secretariat as per IOTC requirements for all the fisheries. Nevertheless, these data difficulties do not prevent the WPTT to make stock assessment and provide the Commission with technical advice.

2.5. Progress achieved on the data related recommendations outstanding from past WPTT meetings

7. A list of recommendations has been made at the last Session of the WPTT to improve the data available to IOTC (Table 2), and these recommendations were reviewed during this Session. Some of these recommendations were made over and above the existing obligations and technical specifications related to the reporting of data.

Table 2. 2008 Recommendations and progress to improve the data available to IOTC

To improve the quality of catch and effort data available for artisanal fisheries: • Yemen, Comoros and Madagascar implement fisheries statistical collection and reporting systems. *The IOTC-OFCF Project attended in 2009 a meeting convened by the Southwest Indian Ocean Fisheries Commission (SWIOFC) to assess progress concerning data collection and processing systems in **Yemen**, **Comoros**, **Madagascar** and other countries in the region.* *The situation in these three countries remains of concern.* *The Secretariat planned visits to **Yemen** and **Madagascar** in 2009. However the missions had to be cancelled following bans on UN staff missions to Yemen and Madagascar, implemented by the UN Security Agency.* *The IOTC-OFCF Project will send a mission to **Comoros** in December 2009, to assess the current situation regarding data collection and processing systems in this country.*

The IOTC Secretariat and the SWIOFC agreed to strengthen cooperation in the planning and implementation of future activities.

- Sri Lanka strengthen its data collection systems with an emphasis on providing data by species and gear.

The IOTC Secretariat is not aware of changes in ***Sri Lanka*** *concerning the above recommendation.*

However, after a mission of the OFCF to Sri lanka in September 2009, the Secretariat was informed of ***Sri Lanka****'s plans to extend data collection to its northern provinces and to implement logbooks on 800 of its off-shore fleets, including gillnet/longline combination vessels and handline vessels.*

- Maldives, Iran and Pakistan provide catch and effort data for their artisanal fisheries, notably gillnets, pole and lines and handlines.

Iran *and* ***Pakistan*** *have not reported any catch-and-effort data for their gillnet fisheries to the Secretariat.*

Maldives *has not provided complete sets of catch-and-effort data to the IOTC in recent years.*

- Countries having emerging hand line fisheries, notably Maldives, Sri Lanka and Indonesia, make the necessary arrangements to collect and provide statistics for those fisheries.
- Countries having fisheries likely to catch significant amounts of bigeye tuna, notably Maldives, Indonesia and Sri Lanka make the necessary arrangements to ensure that the catches estimated for this species are sufficiently precise.

The changes in the data collection and processing systems of ***Maldives*** *and* ***Sri Lanka*** *indicated in the previous sections may lead to improvements in the quality of data reports from these countries, including gear and species breakdown.*

Although ***Indonesia*** *has been reporting more detailed catches by species and gear in recent years, the quality of the datasets reported remains uncertain*

- Fisheries data collection agencies in each country, notably those in India and Sri Lanka, collaborate to produce one consistent set of catch statistics.

The Secretariat is not aware of any arrangements made by ***India*** *or* ***Sri Lanka*** *concerning the above issues*

- Countries increasing sampling coverage to obtain acceptable levels of precision in their catch and effort statistics.

The Secretariat does not receive information about the levels of precision of IOTC statistics when they are reported by countries.

To improve the quality of catch and effort data available for industrial fisheries:

- Indonesia and Malaysia collect catch and effort information for their fresh tuna and/or deep-freezing longline fleets, including those not based in Indonesia

Indonesia *will initiate implementation of a new logbook system for its fleets in January 2010, to cover all Indonesian vessels, including those not based in Indonesia.*

Malaysia *reported in 2009 incomplete catch-and-effort data for its longline fisheries during 2008, not including information on the area fished. No catch-and-effort data was reported for those Malay longliners that are not based in Malaysia.*

- Taiwan,China collect and provide catch and effort data for their fresh tuna longline fleets.

Taiwan,China *has not provided catch-and-effort data for its fresh-tuna longline fleet in the Indian Ocean, in spite of an increase in the number of fresh-tuna longliners that have operated in the area in recent years.*

- India collect and provide catch and effort data for its longline fleet.

India *has not provided catch-and-effort data for its commercial longline fleet.*

- Iran report catch and effort data for its industrial purse seine fleet.

Iran *has reported total effort (in number of fishing days) by vessel in 2008. However, the Secretariat has not received catch-and-effort data as per IOTC standards.*

- Countries having industrial fleets ensure that log book coverage is appropriate to produce acceptable levels of precision in their catch and effort statistics.

The next meeting of the WPDCS will consider which levels of precision are appropriate for catch-and-effort data relating to IOTC and dependent species.

- Countries having industrial fleets implement or increase coverage of existing Vessel Monitoring Systems in order to be able to validate data collected through logbooks.

The Compliance Section of the Secretariat sent a questionnaire in 2009 to assess implementation of VMS by IOTC CPC's, including questions about levels of coverage and use of information collected through VMS.

- Countries having industrial fleets increase observer coverage to produce acceptable levels of precision in their estimates of bycatch and discard levels.

The next meeting of the WPDCS will consider which levels of precision are appropriate for observer data relating to IOTC and dependent species

- Countries having industrial fleets provide estimates of discard levels of tropical tuna species.

__Australia__ (longline), the __EC__ (purse seine), and __South Africa__ (longline) have reported information on recent levels of discards of tropical tunas and other species for its fisheries. The Secretariat has not received information from other countries concerning discard levels of tropical tunas.

- Countries having industrial fleets provide information on the activities of vessels presumed to be from non-reporting fleets.

Several reports from IOTC CPC's or other countries in the region about the activities of vessels whose catches had not been reported to the IOTC were received. The Secretariat estimated catches for these and other vessels whose activities were not monitored by the flag countries. All these catches are presented under the NEI category.

- **To increase the amount of size data available to the Secretariat:**
- Pakistan, Comoros, Indonesia and Yemen collect and provide size data for tropical tunas taken by artisanal fisheries, especially gillnet, handline and troll fisheries.

The Secretariat is not aware of __Comoros__, __Indonesia__, __Yemen__, or __Pakistan__ having implemented sampling schemes for the collection of size data from their artisanal fisheries.

- India provide its size data available for tropical tunas.

__India__ has reiterated that it will not provide length frequency data for its artisanal fisheries, indicating that these data is not for release. In addition, India has not reported length frequency data for its commercial longline vessels.

- Maldives provide size frequency data by gear

__Maldives__ has provided length frequency data for its fisheries but not by gear. With the development of the handline fisheries targeting large yellowfin, the size data provided by the Maldives cannot be used.

- Thailand and Iran collect and provide size data for their industrial purse seine fleets

__Thailand__ and __Iran__ have implemented port sampling schemes for the collection of length frequency data from their industrial purse seine fisheries. However, considering the type of vessels involved and onboard fish storage practices, it is thought that the size data collected through port sampling has limited use. To date, __Thailand__ and Iran have not provided length frequency data for its purse seine fisheries

- Taiwan,China collect and provide size data from their fresh tuna longliners.

The Secretariat has not received length frequency data from __Taiwan,China__ concerning its fresh-tuna longline fleets.

- Indonesia and Malaysia collect and provide size data for their longline vessels based in other countries.

The Secretariat is not aware of __Indonesia__ or __Malaysia__ having implemented sampling schemes for the collection of size data on longline vessels under its flag based in other countries.

- China, Oman, Philippines, Seychelles and South Korea provide size data from their longline fleets.

__Seychelles__ provided during 2009 length frequency data for its industrial longline fishery, for the years 2007 and 2008. __South Korea__ and __China__ provided during 2009 length frequency distributions for tropical tunas caught by longliners operating under their flag. Length frequency data are collected through scientific observers. However, the data collected has limited use as observer coverage levels are thought to be too low.

The Secretariat is not aware of __Oman__ or __Philippines__ having implemented sampling schemes for the collection of size data from its longline vessels based in other countries.

- Japan increase size sampling coverage of its longline fleet.

__Japan__ informed the Secretariat in 2009 about its plans to increase observer coverage in longliners operating in the Indian Ocean. __Japan__ indicated that it expected an increase in the amount of size data collected from its fisheries in the nearly future.

- Countries catching significant amounts of tropical tunas review their existing sampling schemes to ascertain that the data collected are representative of their fisheries.

The next meeting of the WPDCS will consider which levels of precision are appropriate for length frequency data relating to IOTC and dependent species.

To reduce uncertainty in biological parameters important for the assessment of tropical tuna species:

- Conversion relationships: Countries catching significant amounts of tropical tunas providing the basic data that would be used to establish length-weight keys, non-standard measurements-fork length keys, processed weight-live weight keys for these species.

The IOTC Secretariat revised in 2009 length-weight and length from the tip of the snout to the base of the first dorsal fin-fork length equations for the yellowfin tuna, based on new information presented to the WPTT in 2007[1] by the __EC__.

The Secretariat has not information to convert the following measurements into the standard measurements selected for tropical *tunas:*

- *Length from the base of the first dorsal fin to the fork of the tail – fork length, for yellowfin tuna and skipjack tuna.*
- *Curved fork length measurements (e.g. with a tape measure) – straight fork length measurements (e.g. with a caliper), for the three species.*

- Countries collecting biological information on tropical tunas caught in their fisheries, preferably through observer programmes, and providing this information (including the raw data where possible) to the Secretariat.

*In recent years, the **Republic of Korea** and the **EC** provided samples containing length-weight, processed weight-round weight and fork length-sex for tropical tuna species. The Secretariat has not received biological data from other countries in recent years.*

8. The WPTT recognize the effort made by the IOTC-OFCF program to improve data collection and statistics in some countries and express its recognition to the OFCF for funding this project. The WPTT recommended that the Secretariat maintains its support to developing countries in the IOTC region regarding data collection and processing, through the IOTC-OFCF Project or other initiatives.

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

3.1. Bigeye Tuna

3.1.1 LATEST STATISTICS ON THE BIGEYE TUNA FISHERIES FROM THE IOTC DATABASES (IOTC-2009-WPTT-13)

9. Industrial longline and purse seine are the main fisheries catching bigeye in the Indian Ocean (figure 10). Total annual catches averaged 121,700 t over the period 2004 to 2008. The 2007 catch was 124,500 t and the provisional 2008 catch stands at 107,000 t (Figure 12). The location of the fishery has changed little since 1990, bigeye tuna is fished throughout the Indian Ocean, with the majority of the catch being taken in western equatorial waters (Figure 13). However, during the last two years, the fishery has been moving far off the coast of Somalia due to active piracy in the area.

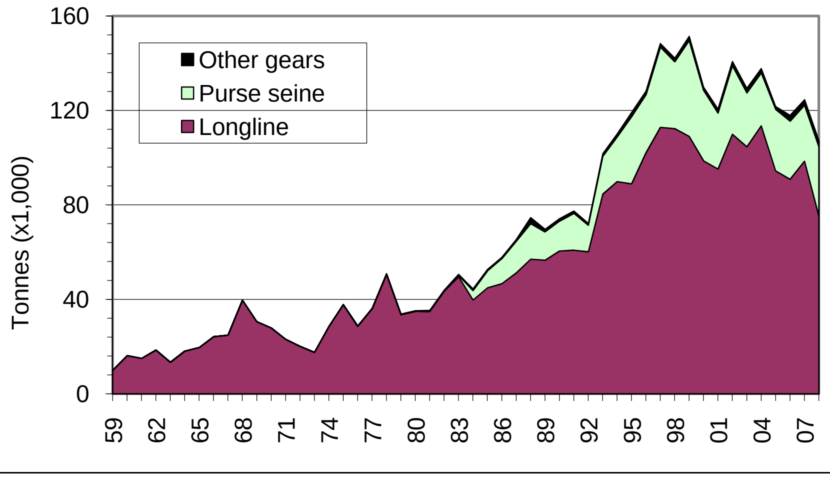
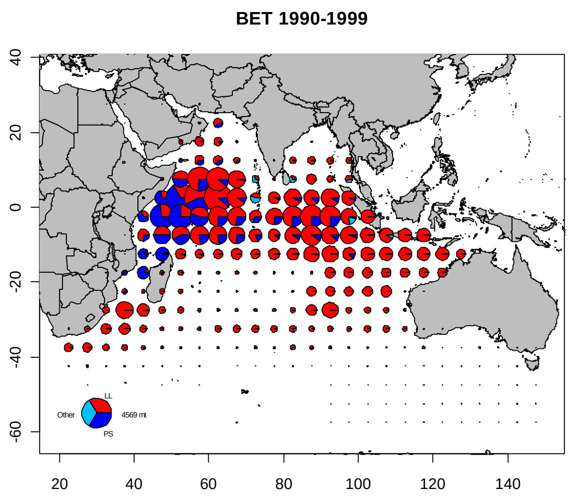


Figure 12. Annual catches of bigeye tuna by gear from 1959 to 2008



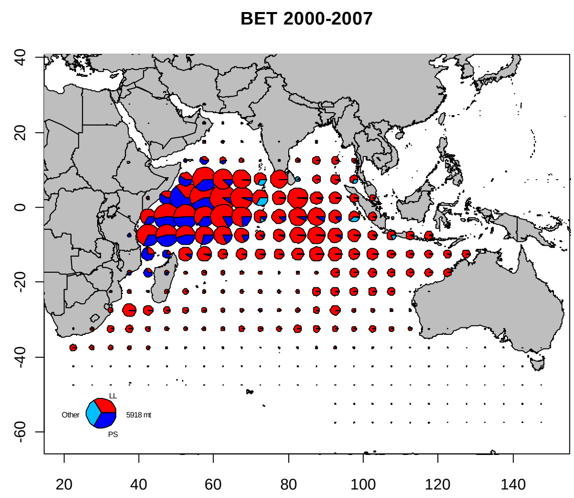
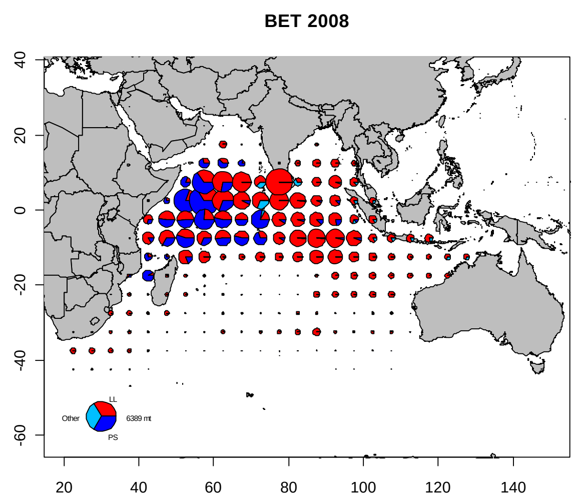


Figure 13. Mean of annual total catches of bigeye tuna by gear operating in the Indian Ocean over the period 1990-1999, 2000-2007 and 2008.



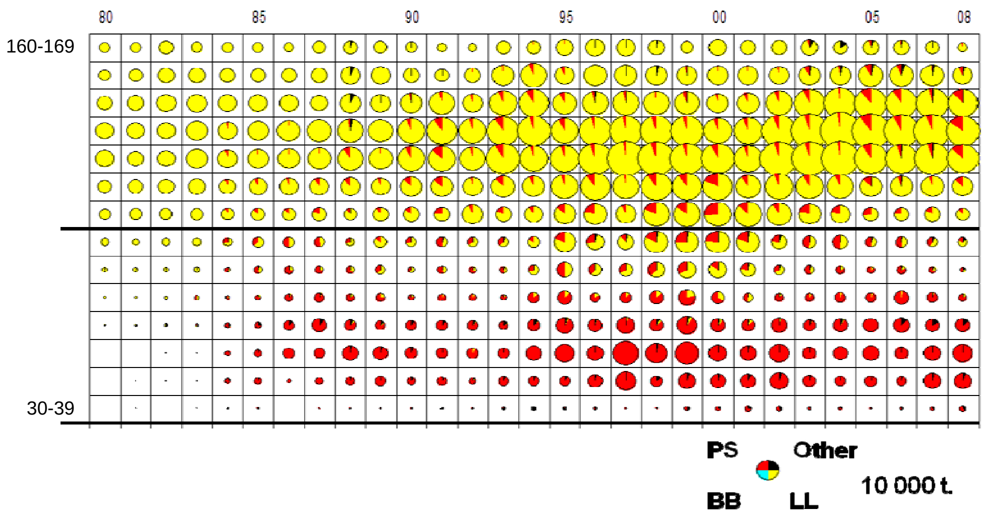


Figure 14. Bigeye catch at size by gear, by 10 cm size classes from 1980 to 2008

3.1.2 STATUS OF BIGEYE TUNA PURSE SEINE STATISTICS (IOTC-2009-WPTT-03, 22, 23)

10. Over 75% of purse seine bigeye catches are taken in log-schools along with skipjack and yellowfin tuna. Catches increased since the beginning of the fishery, peaked at over 30,000 t from 1997 to 1999 and then stabilized at around 20,000 t (Figure 15). During the last years, an increase of the catches is observed peaking in 2008 at 26,445 t.

11. The mean weight of bigeye tuna in the purse-seine fishery reflects mainly the log school catches, and remains very stable around 6kg (Figure 16). By contrast, free schools sets exhibit large variations, remaining high (over 30 kg) these last years. It was noted that this could be due to sampling procedures, and/or from highly variable proportions of small and large bigeye in the catch, and so results should be interpreted with some caution.

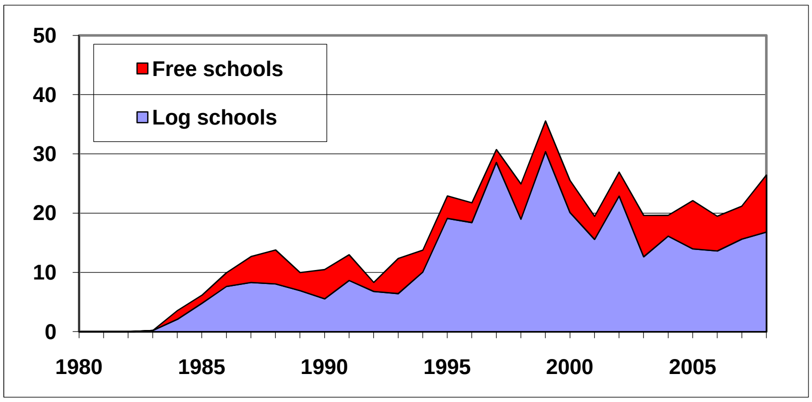


Figure 15. Bigeye catches (tonnes x 1000) from the purse seine fishery on log and free schools

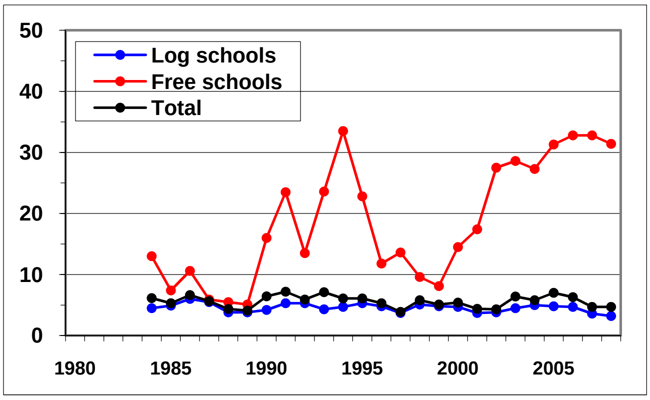


Figure 16. Mean weight of bigeye tuna attributed to purse seine fishing on free schools and logs.

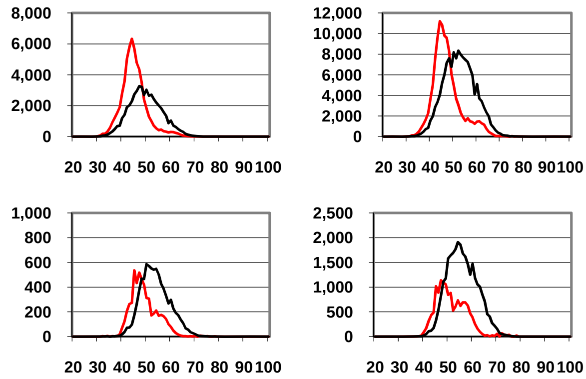


Figure 17. BET size distributions attributed to purse seine fishing on free schools (bottom) and logs (up) (2003-2007 in black, 2008 in red ; left in number right in weight).

12. The WP was informed (document WPTT-2009-Inf01) that a data processing bias has been recently found in the species composition of EU purse seiners. This bias tends to overestimate the catches of large bigeye, especially on free schools but also on FAD sets. The WP was also informed that the geographical bias previously noticed, concerning the major latitudinal heterogeneity in the bigeye species composition in the Somalia area, has not yet been corrected in the historical catches of EU and Seychelles purse seiners. These data processing biases faced for the EU and Seychellois purse seiners, should be corrected as soon as possible, including for past statistical series of these fleets.

3.1.3 MAIN TAGGING RESULTS FOR BIGEYE TUNA (IOTC-2009-WPTT-24)

13. The WPTT recognized that the RTTP-IO was the first tuna tagging project releasing such a large number of bigeye tuna (34568). Almost all the release were done off the coast of Tanzania and 5320 fish (15.4%) have been recovered so far, 95% of them by the European purse seine fishery. Recoveries are well spread in the Indian Ocean (Figure 18) and seem to indicate a good mixing of the tagged population with the wild population, and to confirm the one stock hypothesis in the Indian Ocean.

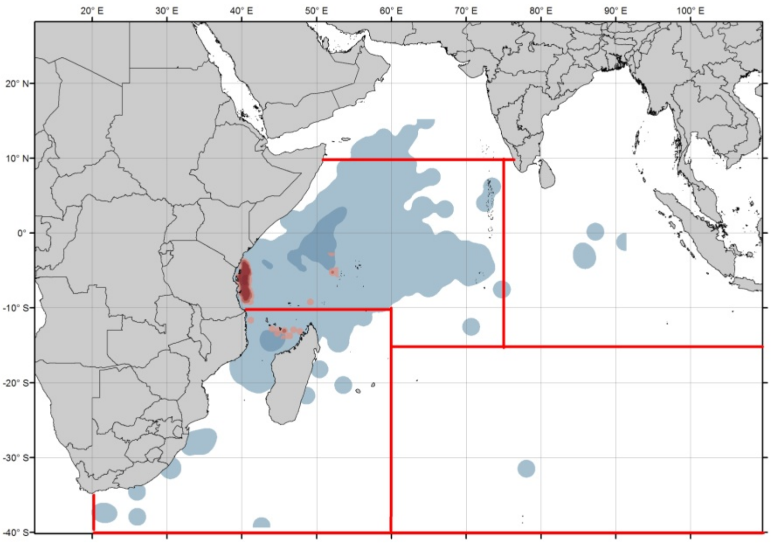


Figure 18. Density map of Releases (red) and Recoveries (blue) of bigeye tuna during the RTTP-IO.

14. The amount of data generated through this project have been used in various ways by the scientist of the WPTT and brought a considerable amount of new information on this species in the Indian Ocean.

Growth

15. Various studies undertaken for the 10th Session of the WPTT demonstrated that growth is following a multi stanza pattern. However, the lack of recoveries of large fish did not allow the various models used to estimate a reliable Linf. This lack is mainly due to the lack of reporting by the longline fisheries of the Indian Ocean.

Movements

16. Tag and recovery data are showing large oceanic movements of bigeye tuna in the Indian Ocean with an average time-at-liberty of 220 (Figure 19) days and average distance between release and recapture being of 656 nm (Figure 20). Furthermore, fish have been recovered in all major bigeye fishing grounds by the purse seine fishery, however, the lack of reporting by longliners (2.9% of bigeye recapture) is detrimental to the general estimation of movement (*eg*. There is no recapture east of 80deg east).

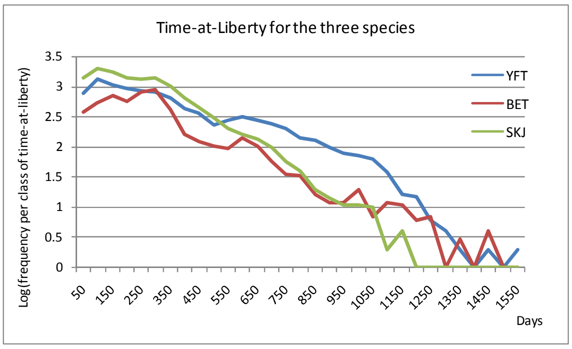


Figure 19. Distribution of the frequency of the time-at-liberty for the three species.

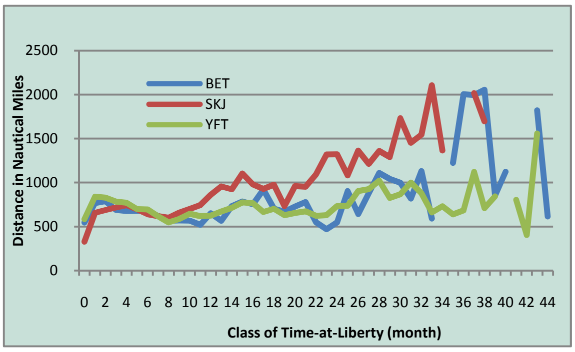


Figure 20. Distance vs. time-at-liberty for the three species.

Natural Mortality

17. This tagging experiment also allowed estimation of natural mortality at age. A study was undertaken in 2008 but would need to be updated with the new data available.

3.2. Yellowfin tuna

3.2.1 LATEST STATISTICS ON THE YELLOWFIN TUNA FISHERIES FROM THE IOTC DATABASES (IOTC-2009-WPTT-13)

18. Yellowfin tuna is mainly caught by purse seine, longline and gillnet fisheries but also by handline and pole and line fleets. Total annual catches averaged 413,100 t over the period 2004 to 2008. Total catches peaked at 448,700 t in 2003, 515,600 t in 2004 and 495,900 t in 2005 before decreasing to 406,600 t in 2006. Catches in 2008 were 322,500 t and it appears that the catches have returned to pre 2003 levels (Figure 21). The location of the fishery has changed little since 1990, yellowfin tuna is fished throughout the Indian Ocean, with the majority of the catches being taken in western equatorial waters. The location and relative magnitude of the extraordinary high catches made in 2003 to 2005 is also shown (Figure 22). During the last two years, it has been observed that the purse seine fleet moved far off the coast of Somalia due to the active piracy in the region.

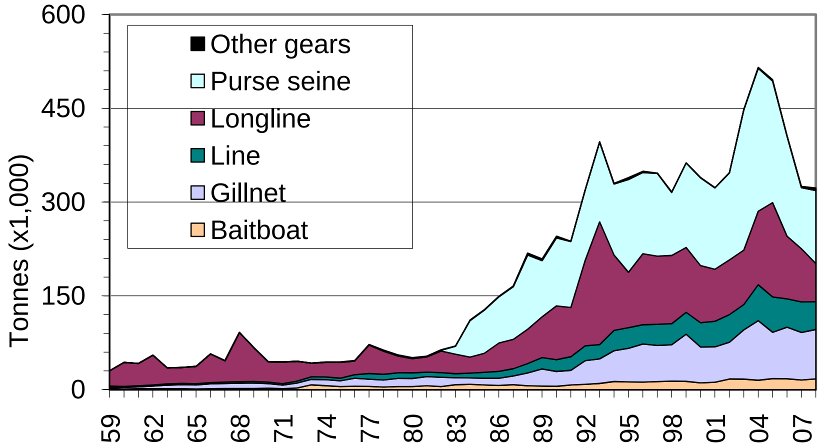
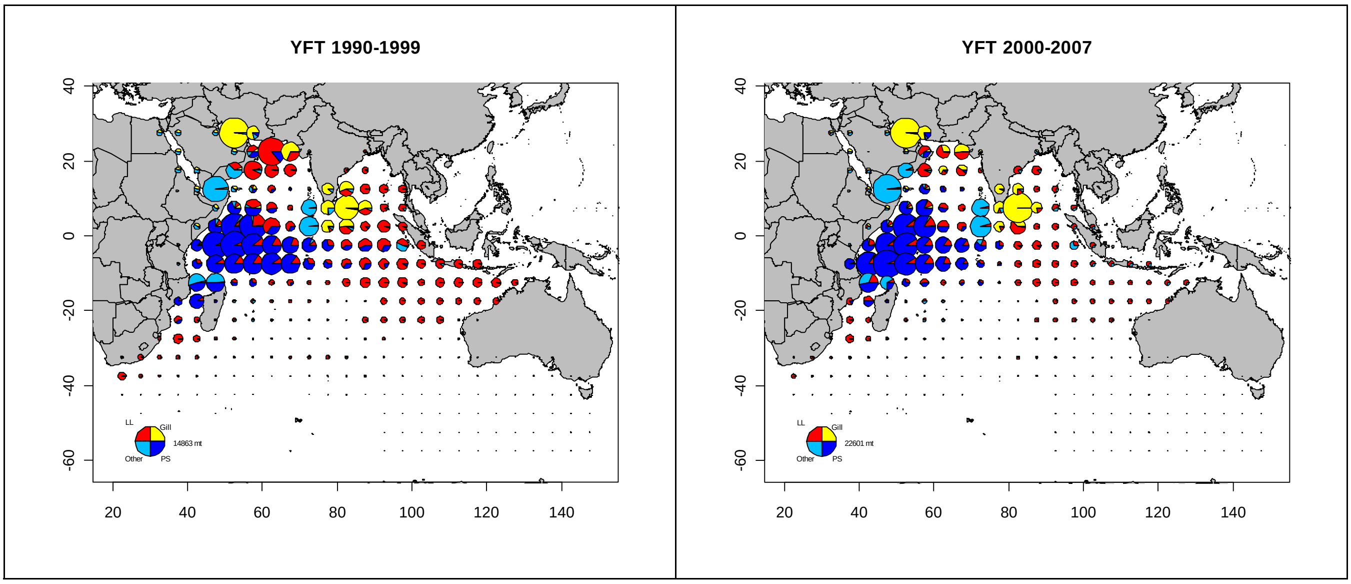


Figure 21. annual catches of yellowfin tuna by gear from 1959 to 2008.



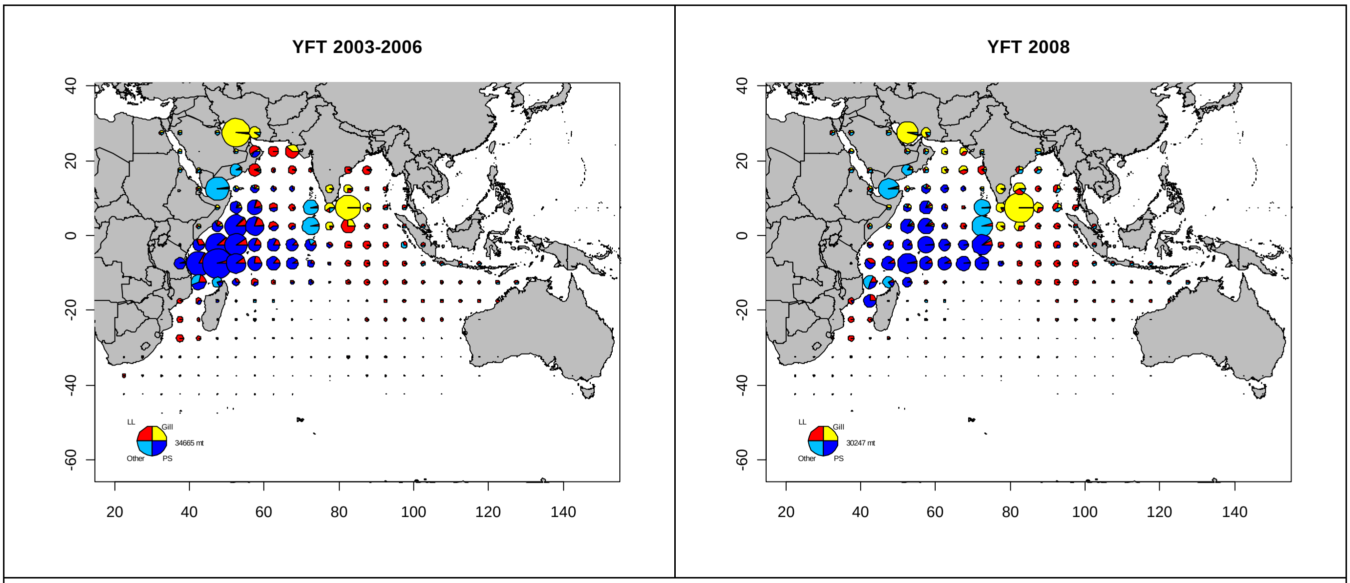


Figure 22. Mean of annual total catches of yellowfin tuna by gear operating in the Indian Ocean over the period 1990-1999, 2000-2007, 2003-2006 and 2008. (*note that catches of some artisanal fisheries,* eg. *Gillnet, where allocated according to the landing place rather than the actual area fished, as time-area catches from these fisheries are not available)*

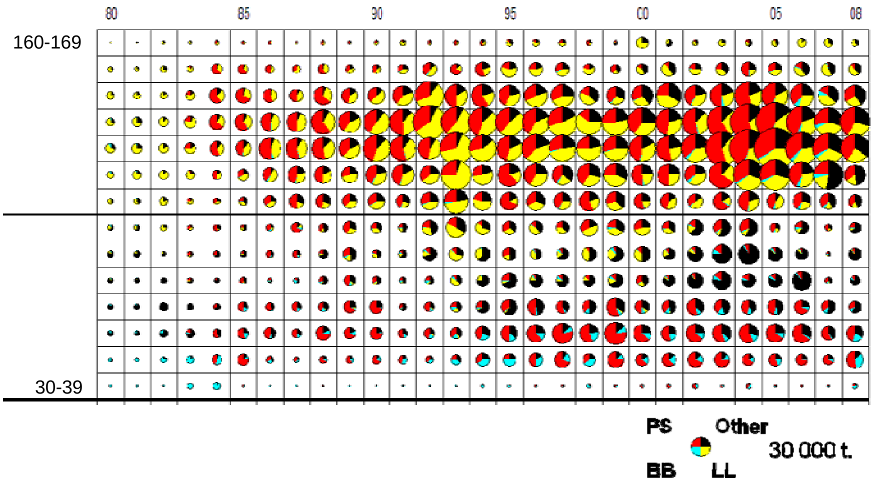


Figure 23. Yellowfin catch at size by gear, by 10 cm size classes from 1980 to 2008

3.2.2 Status of yellowfin tuna purse seine statistics (IOTC-2009-WPTT-03, 22, 23)

19. Over 40% of purse seine yellowfin catches are taken in log-schools along with skipjack and bigeye tuna. Catches increased since the beginning of the fishery, peaked over 200,000 t in 2004 decreasing sharply thereafter to 110,000 t in 2008 (Figure 24).

20. Catch per unit effort (expressed as tons per searching days) follows the catch variations on free schools, while remaining stable for log schools (around 3.2 t/search day up to 1994, around 5.5 t/sd over the period 1995 to 2006, before falling back to the previous low levels in 2008 of 3.7 t /sd (Figure 25). Catch per positive set remained stable at 7 t on logs and 24 t on free schools, except for the high values for 2002-2005.

21. Mean weight (for all yellowfin tuna caught by purse seiners) fluctuated between 10-20 kg until 1996, and since then has been between 6-15 kg. Mean weight has remained stable for log caught yellowfin (4-10 kg), with relatively lower levels (4-6 kg) since 1996. Mean weight fluctuates more widely for free school yellowfin (15-32 kg), but it has been relatively stable at high levels since 2002 (35-40 kg) (Figure 26). The observed size distributions in 2008 are similar to those over the period 2003-2007 (Figure 27).

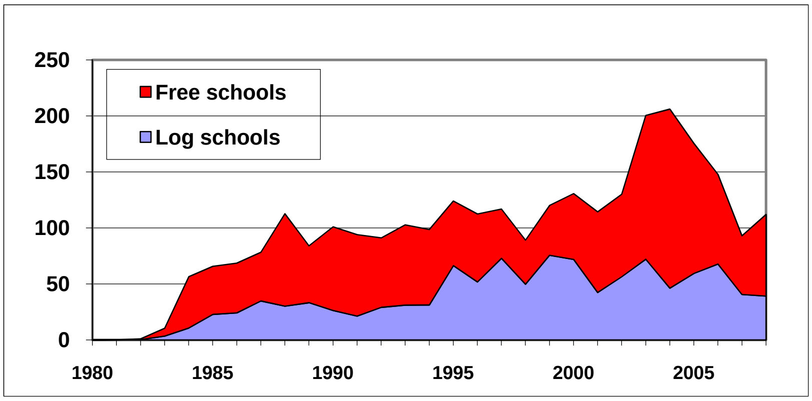


Figure 24. Catches (tonnes x 1000) of yellowfin attributed to purse seine fishing on free schools and logs

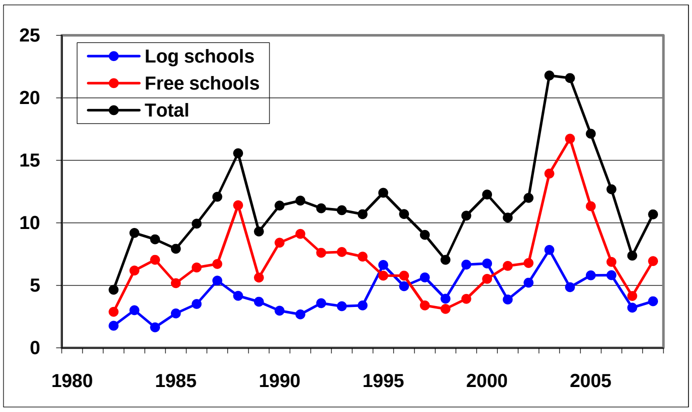


Figure 25. Catch rates (tonnes per searching day) of yellowfin tuna attributed to purse seine fishing on free schools and logs

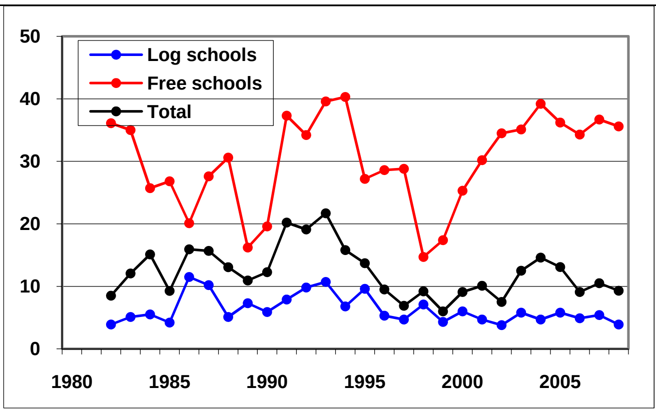


Figure 26. Mean weight (kg) of yellowfin tuna attributed to purse seine fishing on free schools and logs

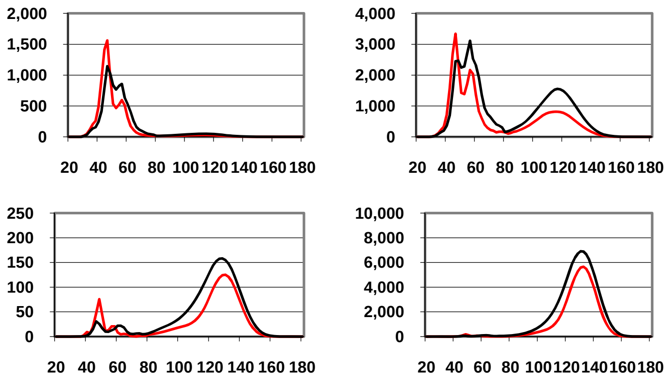


Figure 27. YFT size distributions attributed to purse seine fishing on free schools (bottom) and logs (up) (2003-2007 in black, 2008 in red ; left in number right in weight).

3.2.3 Handline Large Yellowfin Tuna Fishery of the Maldives (IOTC-2009-WPTT-15)

22. The handline fishery for large yellowfin tuna in the Maldives was presented in document IOTC-2009-WPTT-15. Yellowfin tuna is the second most important species caught in the Maldivian tuna fishery. Total catches are currently around 23,000 t annually representing roughly 15% of the reported national tuna catch. Although a substantial amount of this catch continues to be of juveniles from pole-and-line fishery (< 60 cm FL) a significant amount of large yellowfin tuna (>100 cm FL) are caught from handline and longline fisheries. The handline catch is exclusively for export and fetched 30 million US$ in 2008, representing more than 28% total marine exports from the Maldives.

23. In the past there was no targeted fishery for large yellowfin because there was no local demand. The restructuring of the fishery sector and access to overseas fresh fish markets of Far East and Europe made it possible to developing the handline fishery. Information about the fishery has been lacking. The Marine Research

Centre employed a field-officer to collect detailed information about the fishery and undertake size sampling. The work has been going on since September 2007. Additional data for this report was obtained from the Ministry of Fisheries and Agriculture. The handline fishery is regulated whereby the vessels require a fishing license renewable on annual basis. Fishing is conducted from standard pole-and-line vessels mostly using handlines.

24. A variety of livebait are used to catch large yellowfin and most popular has been the trigger fish, Odonus niger, recently. Fishing trips last 3-15 days (average 8 days) on which more than 2 t are of large yellowfin are caught. The catch is gutted and gilled and stored on ice-boxes. More than 95% of the catch is sold to the exporters. Rejects are sold at the Malé Fish Market. Based on average catch per trip and the number of trips vessels make in a given month it is estimated the present catch of large yellowfin would be about 10,500 t per year. This is about 60% more than the reported catch by the fishermen. Data shows that catches have stagnated or are declining. This is also supported by declining catch rates.

25. The WPTT acknowledged the considerable work that has been undertaken in recent years to develop and improve the data collection of yellowfin. With respect to future work in this area, the WPTT recommended that size data collection for yellowfin in Maldives continue and, if possible, it would be separate by fleet (pole-line vs. handline).

3.2.4 MAIN TAGGING RESULTS FOR YELLOWFIN TUNA (IOTC-2009-WPTT-24)

26. The RTTP-IO tagged and released 54685 yellowfin mainly off the coast of Tanzania but also in the Arabian sea, around Seychelles and in the Mozambique channel. So far 9499 fish (17,4%) have been recovered and reported, 93% of them by the purse seine fleet. Recoveries are well spread in the Indian Ocean (Figure 28) and seem to indicate a good mixing of the tagged population with the wild population, and to confirm the one stock hypothesis in the Indian Ocean.

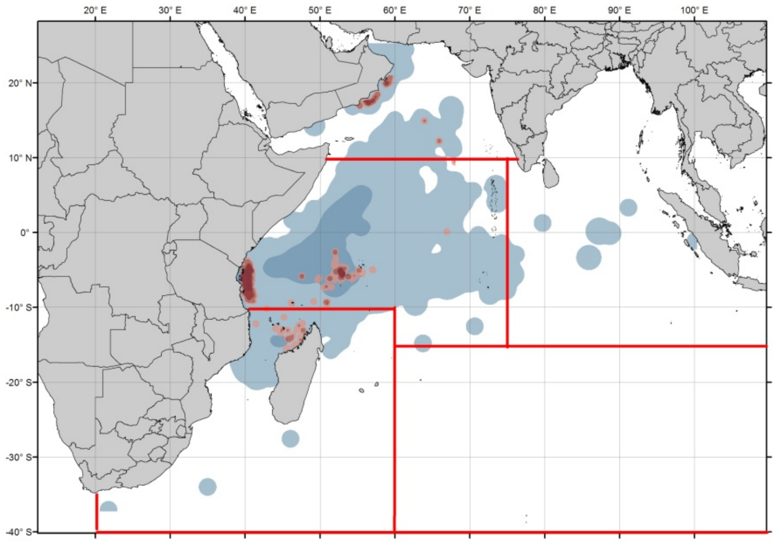


Figure 28. Density map of Releases (red) and Recoveries (blue) of yellowfin during the RTTP-IO.

27. The amount of data generated through this project have been used in various ways by the scientist of the WPTT and brought a considerable amount of new information on this species in the Indian Ocean.

Growth

28. Various studies undertaken for the 10th Session of the WPTT demonstrated that growth is not following a Von Bertalanffy curve but a multi-stanza pattern. However, the lack of recoveries of large fish did not allow the various models used to estimate a reliable L_{inf}, and new analysis should be undertaken using the tagging data, taking into account that now all recoveries are large fish.

Movements

29. Recoveries of tagged yellowfin also demonstrate the high and rapid migration patterns of the yellowfin in the Indian Ocean with an average distance between tagging and recapture of 710nm (Figure 20). Large number of fish tagged off the coast of Tanzania were recovered far east of Seychelles and one of them along the coast of Sumatra. This seems to confirm the hypothesis of a single stock for the Indian Ocean.

30. The mixing of the tagged population of yellowfin with the wild population seems to be confirmed with the high average time at liberty (306 days), the large distance covered by the fish and the spread of the recoveries (Figure 19). As for bigeye, but not at the same extend because purse seiners are reporting large yellowfin, the lack of reporting by the longliners (0.9% of yellowfin recaptures) is hampering the general movement picture (*eg.* there is no recapture east of 80deg east).

Natural Mortality

31. This tagging experiment also allowed estimation of natural mortality at age. A study was undertaken in 2008 but would need to be updated with the new data available.

3.3. Skipjack Tuna

3.3.1 Latest statistics on the skipkjack tuna fisheries from the IOTC databases (IOTC-2009-WPTT-13)

32. Skipjack tuna is mainly caught by purse seine, gillnet and baitboat —using pole and line. Total annual catches averaged 494,100 t over the period 2004 to 2008. The 2006 catch peaked to 612,900 t while the provisional catch estimate for 2008 stands at 413,600 t (Figure 29). The location of the fishery has changed little since 1990 (Figure 22), skipjack tuna is fished throughout the equatorial waters of the Indian Ocean with the majority of the catch being taken in western areas (Figure 30). However, during the last two year, the purse seine fleet moved far off the coast of Somalia due to active piracy in the region.

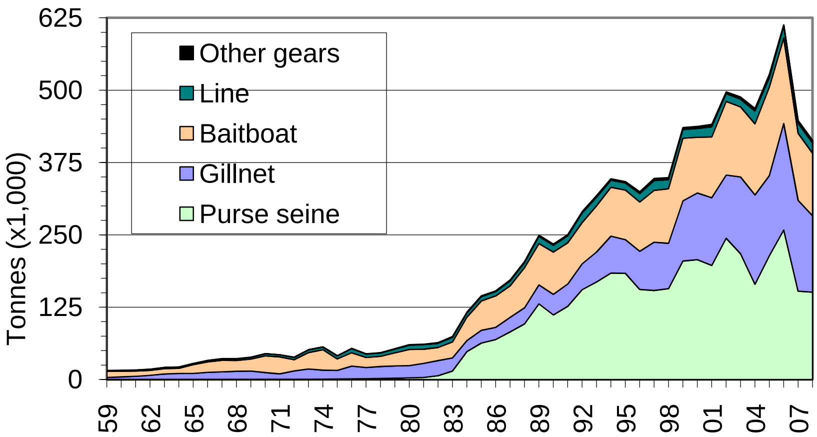


Figure 29. Annual catches of skipjack tuna by gear from 1959 to 2008.

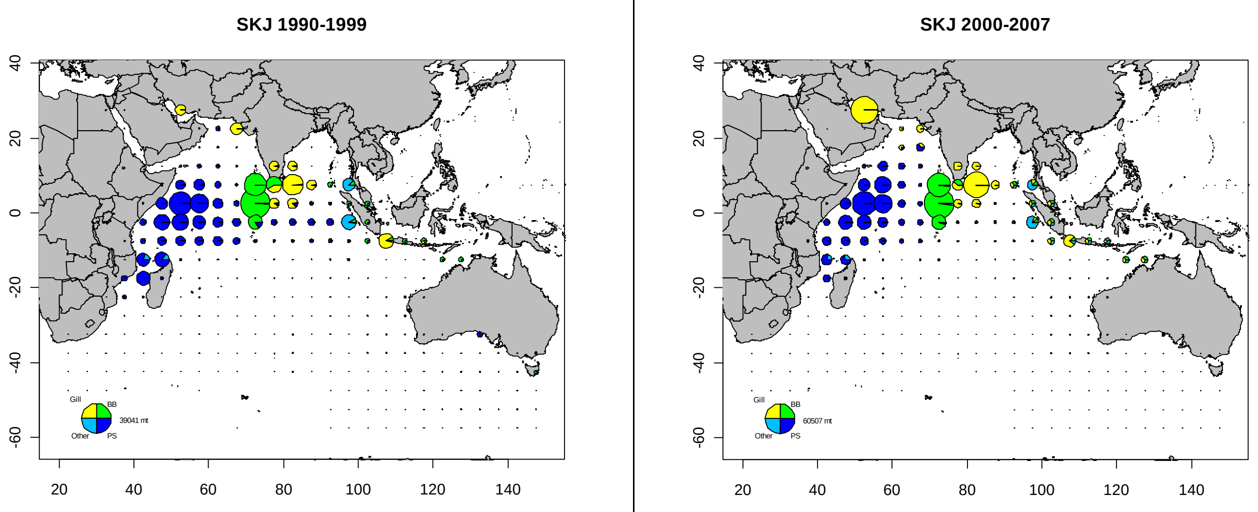
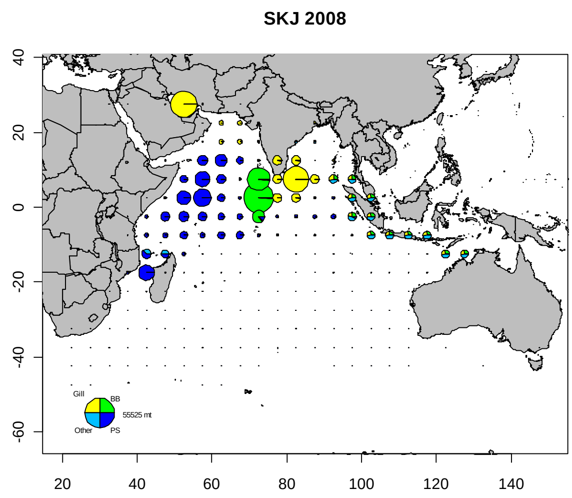


Figure 30. Mean of annual total catches of skipajck tuna by gear operating in the Indian Ocean over the period 1990-1999, 2000-2007 and 2008. (*note that catches of some artisanal fisheries,* eg. *Gillnet, where allocated according to the landing place rather than the actual area fished, as time-area catches from these fisheries are not available)*



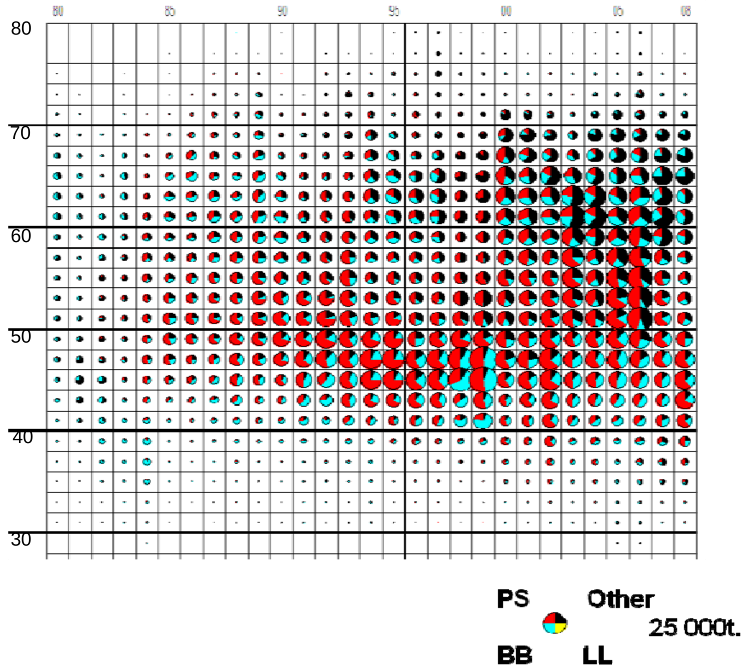


Figure 31. Skipjack catch at size by gear, by 10 cm size classes from 1980 to 2008

3.3.2 *Status of Skipjack Tuna Purse seine Statistics (IOTC-2008-WPTT-05, 06, 07)*

33. Over 80% of the purse seine skipjack catches from EC fleets from log schools. Catches in 2008 (134,133 t) were low relative to those in 2005 and 2006 catch (188,000 to 221,000 t), and the last two years are the lowest since 1998 (Figure 32).

34. While annual catch rates (expressed as tonnes per searching day) on free schools of skipjack tuna have been relatively stable over time, catch rates on log schools increased steadily up to 2002, fluctuated over the period 2003 to 2006 then) and dropped markedly in 2007 and 2008 (Figure 33). The higher catch rates in 2003-2006 coincided with the presence of favourable environmental conditions for tunas in the surface layer.

35. The mean weight of the skipjack in the catches reflects mainly the catches from log school (Figure 34). The mean weight from log school tuna has varied between 2.1 and 3.0 kg since the 1990's and show a large decrease since the last 2 years. By contrast with yellowfin and bigeye, there is little difference between the sizes of skipjack tunas caught on logs and free schools (Figure 35).

36. The WP noted the declining trend in the lengths of skipjack tuna caught by purse seiners in 2007 and 2008 noting that this may be the consequence of a shift in fishing grounds due to piracy or other causes as the same trends are observed in Maldives. The WP recommended more research in this area.

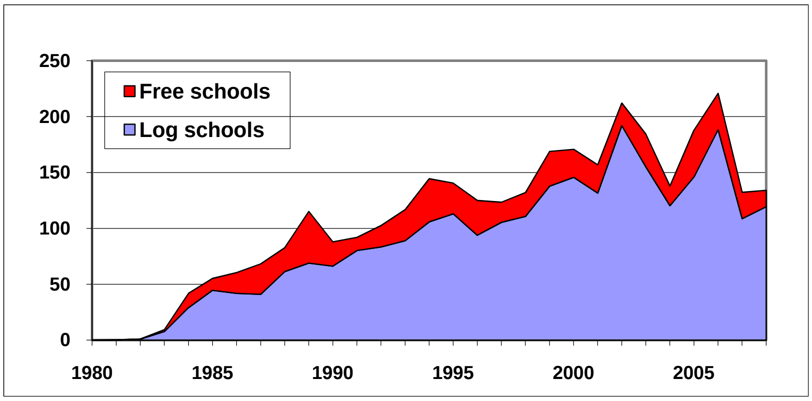


Figure 32. Catches (tonnes x 1000)of skipjack tuna attributed to purse seine fishing on free schools and logs

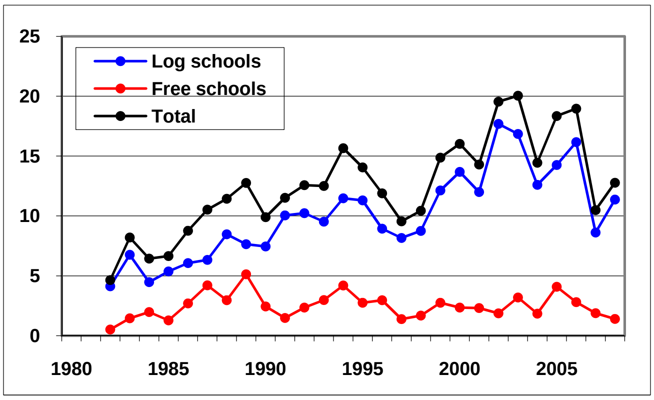


Figure 33. Catch rates for skipjack (tonnes per search day) attributed to purse seine fishing on free schools and logs

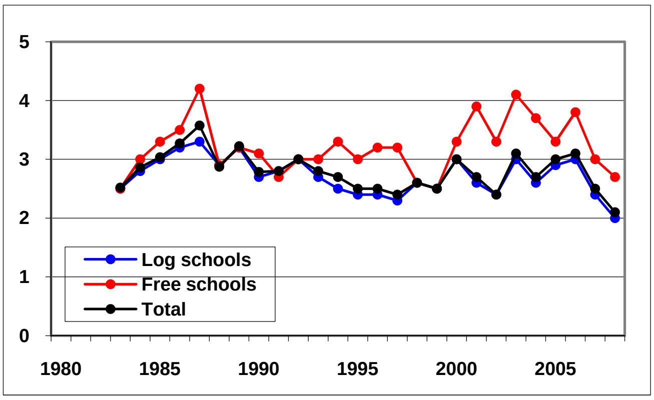


Figure 34. Mean weight (kg) of skipjack tuna attributed to purse seine fishing on free schools and logs.

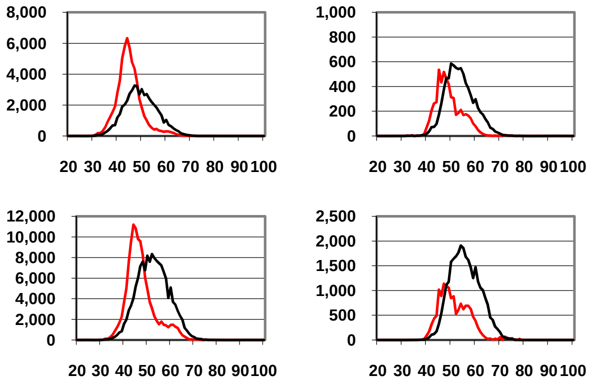


Figure 35. SKJ size distributions attributed to purse seine fishing on free schools (bottom) and logs (up) (2003-2007 in black, 2008 in red ; left in number right in weight).

3.3.3 MAIN TAGGING RESULTS FOR SKIPJACK TUNA (IOTC-2009-WPTT-24)

37. The RTTP-IO tagged and released 78324 skipjack mainly off the coast of Tanzania, around Seychelles and in the Mozambique channel. So far 12568 fish (16%) have been recovered and reported, 96% of them by the purse seine fleet. Recoveries are well spread in the Indian Ocean (Figure 36) and seems to indicate a good mixing of the tagged population with the wild population, and to confirm the one stock hypothesis in the Indian Ocean.

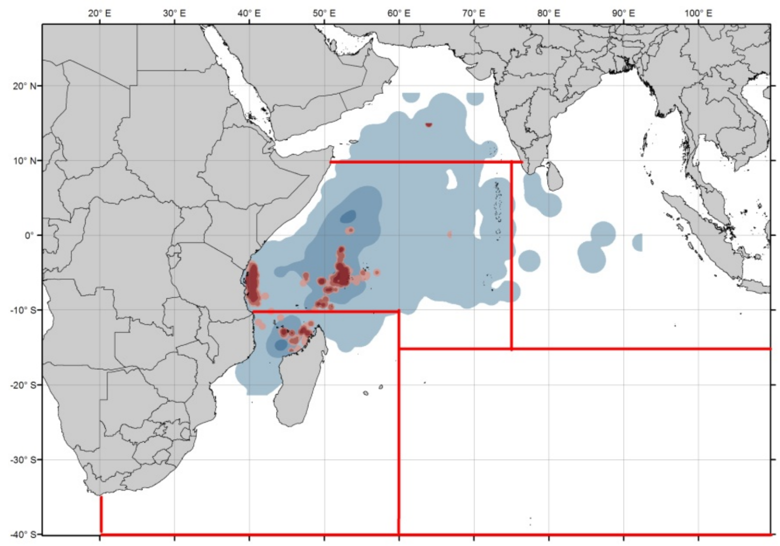


Figure 36. Density map of Releases (red) and Recoveries (blue) of skipjack during the RTTP-IO.

38. The amount of data generated through this project have been used in various ways by the scientist of the WPTT and brought a considerable amount of new information on this species in the Indian Ocean.

Growth

39. Various studies undertaken for the 10th Session of the WPTT demonstrated that growth is following a Von Bertalanffy curve.

Movements

40. Recoveries of tagged skipjack also demonstrate the high and rapid migration patterns of the skipjack in the Indian Ocean with an average distance between tagging and recapture of 696nm (Figure 20). Large numbers of fish tagged of the coast of Tanzania were recovered far east of Seychelles. This seems to confirm the hypothesis of a single stock for the Indian Ocean.

41. The mixing of the tagged population of skipjack with the wild population seems to be confirmed with the high average time at liberty (220 days), the large distance covered by the fish and the spread of the recoveries (Figure 19).

Natural Mortality

42. This tagging experiment also allowed estimation of natural mortality at age. A study was undertaken in 2008 but would need to be updated with the new data available.

3.4. Papers presented

3.4.1 FISHERIES

Preliminary analysis of fishing activities of Purse Seiners fishing in the Western Indian Ocean over the period January to June 2009) was presented (IOTC-2009-WPTT-28).

43. The goal of this paper is to analyze the catches and CPUE of the Purse seine fleet active in the western Indian Ocean during the first 6 months of 2009 and to compare these results with the same parameters observed during the same period of previous years. The paper also analyses the fishing zones during the first six months of 2009, given the increasing pressure by Somalian piracy.

44. The analyses show that one major anomaly observed in the 2009 fishery is the significant shift eastward of exploited zones. Activities on the coast of Africa and in the area NW of the Seychelles were significantly reduced in 2009. The latter is considered as an area where large yellowfin are caught in great quantities each year during the 1st quarter (spawning strata). Fishing effort and yellowfin catches were very low in this stratum in 2009. Another important point worth noting is the significant increase in set made on FAD's associated school, which subsequently lead to a significant increase in the catches of small (< 10kg) bigeye and yellowfin tuna often in association with these floating objects.

45. The WP noted that, due to acts of piracy, effort levels in 2009 had decreased significantly in the core fishing area of industrial purse seiners, in particular in waters off-Somalia and beyond. The WP agreed that more research is required on the consequences that such shifts in fishing area may have on the stocks of tropical tunas.

Comparative study of the distribution of natural versus artificial drifting Fish Aggregating Devices (FADs) in the Western Indian Ocean (IOTC-2009-WPTT-19).

46. Natural floating objects such as logs or branches have always been a component of the habitat of tropical tunas. However, the introduction of artificial floating objects (fish aggregating devices – FADs) modifies this habitat. In order to quantitatively and qualitatively assess how much those FADs modify the offshore pelagic habitat, we compared the spatial distribution of natural and artificial floating objects. We used data from Spanish and French observers onboard tuna purse seiners in the Western Indian Ocean from December 2006 to December 2008 (for a total of 52 fishing trips). Natural and artificial floating objects were compared using different analyses: Global Index of Collocation (GIC), numbers of FADs per area and quarter, K Ripley function. Although natural objects mainly occupy waters south of 7°S (Mozambique Channel) and FADs waters north of 7°S, all types of FADs are found everywhere. Results from the GIC analyses mainly show an overlap between the two types of FADs, indicating that in the Western Indian Ocean, FADs do not contribute to generate new major areas of floating objects that were free of natural objects before. The K Ripley analysis shows that both natural and artificial FADs exhibit an aggregated distribution. The major change due to the introduction of FADs concerns the number of FADs. Except in the Mozambique Channel and Chagos, the number of FADs is multiplied by 2 at least everywhere, and can reach up to 20 and 40 (Somalia area). These results are discussed in relation to the Ecological Trap hypothesis.

47. The WP noted that the numbers of FAD recorded by observers, in combination with additional information from the fisheries and the ecosystem could be ultimately used to estimate indices of abundance for tropical tunas, provided that observer coverage is sufficient. The WP recommended that more research be devoted in this area.

48. The WP further noted that, to date, the IOTC has not received information concerning the numbers of FADs set by industrial purse seiners operating in the Indian Ocean, stressing the need for countries having purse seine fisheries to collect and report these data as soon as possible.

Analysis of purse seine set times for FAD and free school associations in the Atlantic and Indian Ocean (IOTC-2009-WPTT-09).

49. This paper analyses a sub set of recent observer data taken on French and Spanish purse seiners fishing in the Atlantic and Indian oceans. Its goal is to analyze and to compare the set times relative to sunrise of FAD and free schools sets in each ocean. This analysis indicates that set times are equivalent for French and Spanish fleets, and equivalent in both oceans. A wide majority of FAD sets have been observed in the morning (80 %), & frequently before sunrise or during the hour after sunrise (44% of sets), but some FADs sets are also done at any time of the day by both fleets. On the opposite free schools sets have been observed in + or - equal proportion at any time of the day between sunrise and sunset showing a small decline in the afternoon. The paper also makes recommendation do develop in depth statistical studies of a wider sample of these observer data.

50. The WP noted that the results of the current analysis appear different from those obtained in previous studies, in particular in the case of FAD sets. The WP noted that, while previous studies showed that FAD sets occurred almost exclusively in the early morning the present study shows that a higher proportion of FAD sets occurred at other times during the day. The WP recommended that the reasons for this difference be investigated.

On the use of the De Finetti ternary diagrams to show the species composition of free and FAD-associated tuna schools in the Atlantic and Indian oceans (IOTC-2009-WPTT-08).

51. This paper shows the difficulty to visually to illustrate the variability of the species composition of sampled sets landed by purse seiners in the Indian and Atlantic Oceans. While large numbers of sets have been sampled during the last 30 years, it is still quite difficult to visualize the heterogeneity of their species compositions. This paper proposes to use the ternary plots proposed by De Finetti to solve this problem. These ternary plots have been drawn as examples on the Free and FAD schools sets sampled in the Indian and Atlantic oceans during the 2002-2008 period. These ternary plots have been drawn as examples using 3 different plotting methods, but other alternate improved methods could also be envisaged following the discussion of this working document.

52. The WP agreed that the diagrams presented were useful to represent the species composition of industrial purse seiners. The WP noted that using the same type of diagrams to represent length frequency trends over time may be useful. The WP agreed that they would also be useful to represent length frequency samples collected from observers, as the samples collected in port do not always relate to individual sets.

3.4.2 ECOSYSTEM

53. The WP was updated on climate and oceanographic conditions in the Indian Ocean based on recent data (IOTC-2009-WPTT-14). An El Nino event is slightly growing in the Pacific Ocean, but the latest expert diagnostics forecast a moderate event. There is some concern whether the Indian Ocean will be or not impacted by this event. In the Indian Ocean, the major interannual anomalies are linked to the dipole events, whose positive phase mimics the warm El Nino anomalies in the Pacific. During positive dipole, above-normal sea surface temperature (SST) and deeper than normal mixed layer (MLD) occur in the West Indian Ocean. A suite of various climatic and oceanographic factors that are known to be related to the development of dipole/ENSO events in the Indian Ocean were examined: atmospheric indices, zonal wind stress in the East Indian Ocean, anomalies of SST, MLD, depth of 20°C isotherm and sea surface chlorophyll (SCHL). No major sustained anomalies were detected in the trend of those factors; overall, they depict a return to almost normal conditions in 2008 and 2009 after the ENSO-related anomaly of 2007 (which was well documented in a document of the 2008 WPTT). The relationship with the PS CPUE was studied in the equatorial area where large yellowfin congregate in free schools, notably during the reproductive season (December to February). Yellowfin CPUEs on free schools in Dec-Feb, that were very low in 2007, increased by more than 50% in 2008 compared to 2007. We observed similar and almost synchronous oscillating patterns for PS CPUE and SCHL during the period 1997-2008, suggesting that the SCHL anomalies can be used as a good proxy for further statistical analyses to standardizing PS CPUE

54. The WP noted that the trends in some of the indices presented showed an apparent good correlation with trends in catches of tropical tunas. In particular, trends in the concentration of chlorophyll and the depth of the termocline seem to be correlated with trends in catches of yellowfin tuna. The WP noted the preliminary results of this study agreeing that further research was required, in particular research on the spatial structure of the anomalies and interaction with other indicators.

3.4.3 GROWTH

Update of the study of growth of yellowfin and bigeye tuna (*Thunnus albacares and T. obesus*) from the Indian Ocean by otolith microincrement analysis (IOTC-2009-WPTT-31)

55. The WP received an update of the study of growth of yellowfin tuna (*Thunnus albacares*) and bigeye tuna (*T.obesus*) from the Indian Ocean by otolith microincrement analysis. Since 2008 more otoliths have been read, particularly for YFT of fork length between 30 and 49 cm, 72 and 100 cm and more than 115 cm. Regarding, BET there is still a lack of fish below 40cm and over 95cm. The new data on YFT confirm what was already suggested last year and the relationship between fish length and total otolith length shows that at around 60cm, the slope relationship becomes less acute, possibly indicating a two stanza growth model. Regarding BET, the size range is too limited to see a difference before and after 60cm. Reading show a good fit of daily increment validation for both YFT and BET for less than 500 days at liberty, and a small bias is always towards underestimation of the number of daily increments. For YFT, the otolith readings are consistent with a multi-stanza growth model. For BET, a correction factor for increments still have to be calculated, and today the lack of fish smaller than 40cm and larger than 95cm do not allow the study to conclude on a two stanza growth model. More readings are still to be done and this data should be included in future growth study.

56. The WP noted that the results of this study were in agreement with recent estimates of growth of yellowfin tuna and bigeye tuna, carried out using tagging data. It was agreed that the present results seem to are consistent with growth for growth of yellowfin tuna and bigeye tuna specimens following a two or three-stanza pattern.

57. The WP noted that the specimens used for the present study were collected from the industrial purse seine fisheries that operate in the western Indian Ocean area. In light of this, the WP recommended that more samples be collected from other areas and fisheries, in particular from longliners operating in the eastern Indian Ocean region. In addition, as a means to validate otolith readings, the WP recommended to compare the number of days estimated from otolith readings with the number of days-at-liberty obtained for tagged specimens with known date-at-release and date-at-recovery.

Estimate of the non-linear growth rate of yellowfin tuna (*Thunnus albacares*) in the Atlantic and in the Indian Ocean from tagging data (IOTC-2009-WPTT-17).

58. The Estimation of the non-linear growth rate of yellowfin tuna (*Thunnus albacares*) in the Atlantic and in the Indian Ocean from tagging data was presented in document IOTC-2009-WPTT-17. In the lack of a satisfactory formulation for the two-stanza growth curve of yellowfin, estimates of growth rate by size class can be used as an alternative input for integrated models. From tagging data collected in the Atlantic and in the Indian Ocean, it was shown however that for growth rate that does not follow a classical linear decreasing trend over size, simple estimates of length increments by size are biased due to an averaging effect of the time spent at liberty.

59. The length at recapture was simulated to illustrate the magnitude of the bias which can be expected depending on the duration of the time at liberty. The results suggest that for large time at liberty growth rates by size are smoothed in such a way that the Von Bertalanffy model could erroneously be considered as a good alternative. With the aim of removing this bias a generalized additive model (GAM) was used to calculate an instantaneous growth rate by size (i.e., fixing time at liberty at 1 day at sea). The predicted growth rates by size are lower than the apparent growth rates but are similar in magnitude and in shape with observed growth rates for moderate times at liberty (< 90 days at sea). In the light of these findings, it was suggested that hard part reading analyses, which in general reject the two-stanza growth assumption, could have been affected by the same type of bias.

3.4.4 TAGGING

The contribution of the Regional Tuna Tagging Project – Indian Ocean to IOTC stock assessment (IOTC-2009-WPTT-24).

60. The coordinator of the RTTP-IO presented an update about the activities and main results of the RTTP-IO. From May 2005 to August 2007, the Regional Tuna Tagging Project-Indian Ocean (RTTP-IO) released 168,150 YFT, BET and SKJ. So far 27,400 recoveries have been reported or 16.3% (Figure 37). Recoveries per species, month, type of tag, gear, size, tagger, country are explored. For double-tagged tuna 6.8% has lost one tag when recovered. PS recoveries are accounting for 95% of the recoveries with ¼ found at sea and ¾ found ashore. Once date(s) and position(s) are estimated, 80% of PS recoveries have possible recovery dates 7 days apart or less resulting in a good quality level. Time-at-liberty and travelled distance, whatever the species, demonstrate a rapid and extended mixing of the tagged tuna among the rest of the population within 1 or 2 months (Figure 38): a necessity rarely meet by the other tagging projects. SKJ present the highest proportion of long distance recoveries before YFT and BET but all species reached the Eastern Indian Ocean. Movements are important: (1) differences between species are minor; (2) they are not size dependant; (3) they support the hypothesis of a single stock at the level of the Indian Ocean for the three species. The value of the extremely large number of bigeye tagged by the project is undermined by the very low reporting rate of the longline fishery.

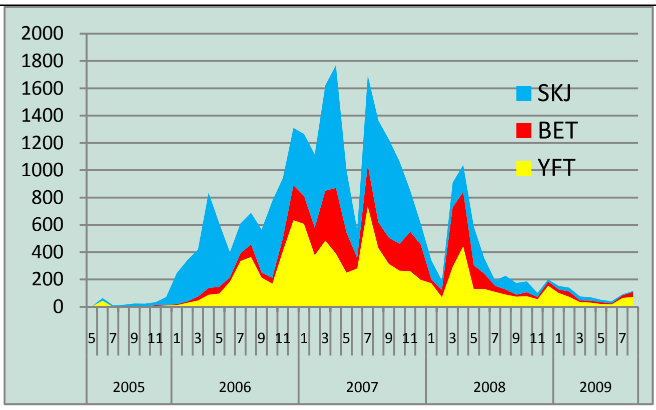


Figure 37. Number of recoveries per species and per months (Data as from August 2009, n=27,390)

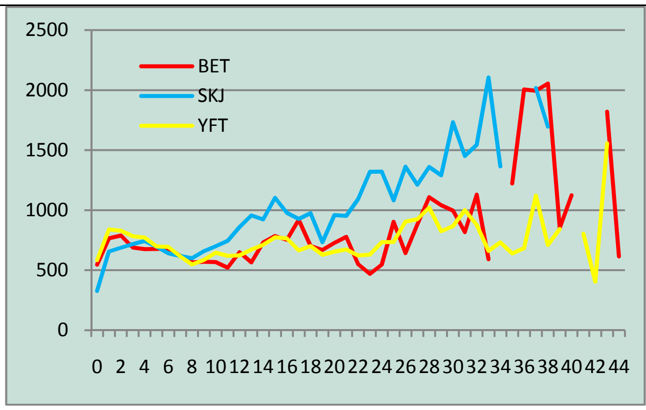


Figure 38. Average distance between tagging and recovery position versus time at liberty

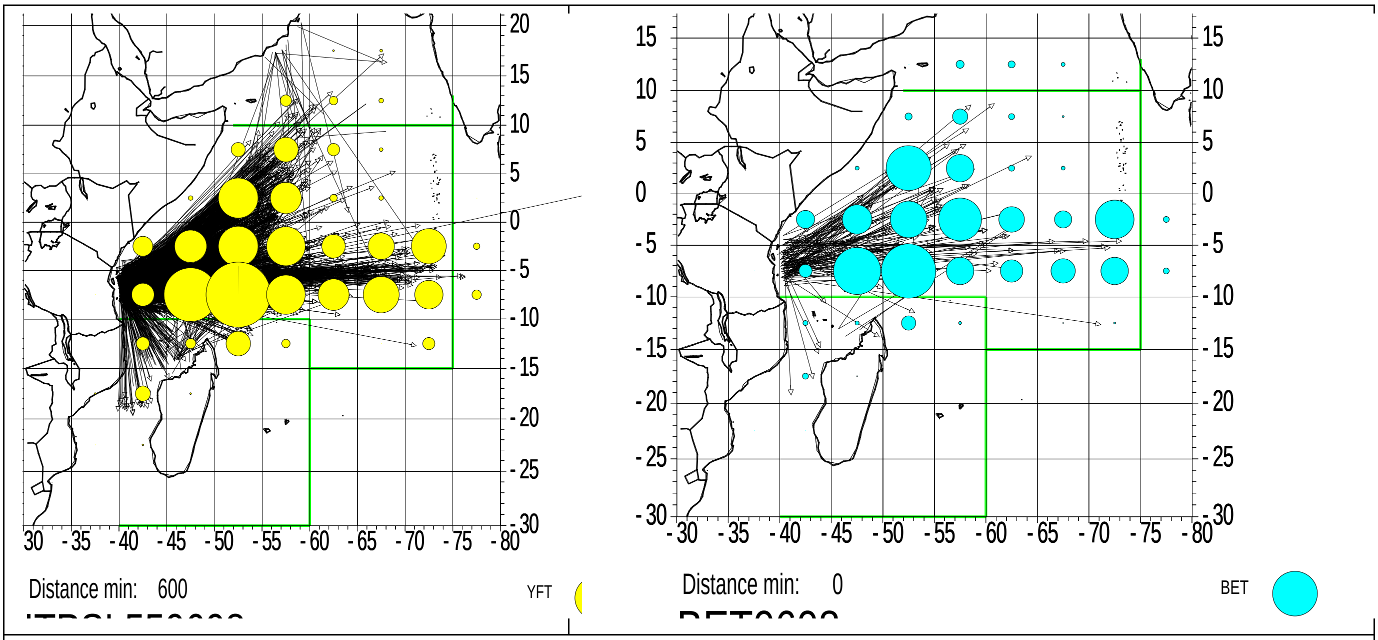


Figure 39. Average catches of large YFT and BET caught at sizes > 1 m during the 2006-2008 period, and recoveries of large YFT/BET by purse seiners: recoveries of adult YFT/BET have been observed in all strata showing significant catches of large YFT/BET.

61. RTTP-IO targets were fulfilled and even surpassed and the data generated are going to contribute greatly to the stock assessment tasks of IOTC for many years to come.

62. The WP noted that the RTTP-IO had been successful in most areas, congratulating the RTTP-IO team for their dedication to the Project and for achieving results beyond expectation. The WP noted that the amount and quality of the data collected by the Programme contributes to more precise assessments of tropical tuna species, noting that the quality of the assessments is expected to further improve as the data from the Programme is fully utilized.

63. The WP identified two areas that will require further research in the future:

- Incremental loss of tags over time: taking into account the small number of recoveries that are still expected in the future, the WP considers that tag shedding rates are not likely to increase significantly above those presented in document IOTC-2009-WPTT-34. However the WP recommends when more data will become available that an update of tag shedding rates should be done.

- Embedment of tags under the skin as fish grows older: The WP was informed that recent recoveries of large tunas that had been tagged in juvenile stage showed tags for which only a little portion remained visible, the remainder of the tag embedded under the skin. The WP noted that this fact may make it harder to identify fish tagged, especially tagged with small tags (18%), and may reduce the reporting rates as times-at-liberty increase. However, during the tag seeding experiment, some shortened tags (tag cut in half) have been deployed to try to account for this effect. The WP recommended that tag seeding experiments to be continued with shortened tags deployed on large fish.

64. The WP noted that reporting rates remained very low for some fisheries, in particular longline and drifnets. The WP stressed the need for countries having fisheries that are likely to catch fish with tags to enhance reporting. In addition, the WP stressed the need for the tag seeding experiments to continue for as long as significant amounts of tags are recovered from the fisheries. The WP noted that as from January 2010, the recovery activities will be taken care of by the Secretariat as the RTTP-IO is ending on the 31st December 2009.

Small Scale Tuna Tagging Program 2007 (IOTC-2009-WPTT-16)

65. The WP received an update on activities concerning the Small Scale Tuna Tagging Program in the Maldives. The Indian Ocean Tuna Tagging Programme (IOTTP) provided the opportunity of undertaking a third tuna tagging programme in Maldives. The last phase of the project started in July 2007 and ended in April 2009. A total of 16,445 tagged fish (3887 yellowfin tuna, 11803 skipjack tuna, 463 bigeye tuna and 292 unknown) were released. About 78 percent of the fish were tagged and released near anchored FADs. More tagged fish were released in the north and south of Maldives than in the central due to poor fishing in the central parts of the

country. Fish tagged in the south of the Maldives were larger than those released in the other parts. Fifteen pop-up satellite archival tags – 2 in the north and 13 in the south –were deployed on large yellowfin.

66. In October 2009, 2069 tags were recovered, *ie.* 12.58% of the releases. Majority of the recoveries were done in Maldives around the same FADs where tagging was carried out. However, some fish have also been recovered by purse seiners operating in the east and west of Maldives and others by gillnetters from Sri Lanka. Tagging in Maldives is crucial to study the tuna migration in the Indian Ocean due to its strategic location and high proportion of tuna catch in the Indian Ocean. A permanent tagging platform in the Maldives maybe important for continuous feeding of information for IOTC stock assessment works.

67. The WP congratulated all staff involved in the small-scale tagging programme in the Maldives for the very effective work and outstanding results achieved by the programme.

68. The WP noted that some of the fish released in the Maldives had been recovered by industrial purse seiners, noting that, in addition, fish tagged in Tanzania by the RTTP-IO had been recovered by the fisheries in Maldives. The WP agreed that this information will be helpful for the estimation of levels of interaction between fisheries, in particular industrial purse seiners and the pole-and-line fishery in the Maldives. It was further noted that a significant proportion of the skipjack tuna specimens tagged around Fish Aggregating Devices had been recovered at the same location, with average time-at-liberty around 20 days. The WP agreed that this tends to indicate a certain level of fidelity of skipjack tuna specimens to a particular FAD, recommending that this matter be further investigated.

69. The WP noted that the small-scale tagging programmes so far implemented in the Indian Ocean had proven extremely useful, recommending that new small-scale tagging activities be initiated, provided that additional funds can be secured for this activities to be carried out.

SImulatioN of TAGs (SINTAG) revisited: An updated model to estimate the number and size of tunas tagged by the RTTP-IO that are still alive in 2009 (IOTC-2009-WPTT-07)

70. An update of the SINTAG model to estimate the number and the size of the tunas tagged by the RTTP-IO that are still alive in 2009 was presented to the WPTT. During the 2008 meeting of the IOTC WPTDA it was suggested that a simple model should be devised to estimate the number and size of tuna tagged by the large scale Regional Tuna Tagging Programme in the Indian Ocean (RTTP-IO) for a projected period of time after the completion of tagging. This suggestion was made, as the RTTP-IO had reported a 16% return rate of the 168.000 tuna tagged between 2005 and 2007. Approximately 95% of these returns have been reported from the purse seine fishery. This has led to speculation that the tagged tuna have not yet reached sizes at which they could be caught by longliners (bigeye and yellowfin) or by the baitboat fishery (skipjack). A simple exponential decay and growth model developed in 2008 indicated that this was probably not the case, and tagged individuals should have been available to these fisheries at that stage. The model presented in 2008 has been updated to include tag reporting and shedding rates and the latest recapture data has been included to clarify those findings. It would still appear that tagged tuna have not been fully reported by the longline and baitboat fisheries. Thus, an effort should be made to increase the level of tag reporting in those fleets as theoretically there may still be large numbers of tagged tuna at liberty and, therefore, still good prospects for their recovery in the future.

71. In light of the results presented, the WP noted that significant numbers of tropical tunas with tags are likely to be available to pole-and-line (skipjack tuna), longline (yellowfin tuna and bigeye tuna) and purse seine fisheries (yellowfin tuna and skipjack tuna). It was pointed out that, in spite of this, reporting rates remained low for longline and pole-and-line. The WP stressed the need for countries having important longline and pole-and-line fisheries to promote recoveries of tags from their vessels.

4. STOCK ASSESSMENT FOR YELLOWFIN TUNA

4.1. Introduction

72. The yellowfin tuna stock assessment work in the Indian Ocean is an extremely difficult task because of the conflicting trends in the basic data, total yearly catches and abundance indices used based on the longline CPUE: the observed trends in YFT catches and CPUEs are not consistent with production-model dynamics, or really with any known theory of fishing. For any fished stock, to give larger and larger yields with no significant decline in

abundance, cannot be explained, unless there is some major underlying and uncaptured factor affecting the CPUE series and limiting its value as index of abundance for the stock.

73. There is now a wide consensus that the initial decline in the early longline CPUEs during the 1953 -1970 period was due to a decline of stock catchability (Polacheck 2006[1]) and not to a major decline in stock density and biomass due to an early stock overfishing, as it was concluded by Myers and Worm in 2003[2]. However, the moderate decline of recent CPUEs, that has been observed since 1980 during the period of large increases of total catches (especially of small YFT) remains difficult to evaluate. It was noted that the standardization of the CPUEs available for the Japanese and Taiwanese longline fleets, used for the yellowfin assessments, did not take into consideration the likely increases in fishing efficiency that these fleets may have undergone over time. The WP noted that the more important changes in fishing power have been realized for a fleet, the more optimistic the trends in abundance would appear to be, unless those changes are taken into account in the standardization of the CPUEs.

4.2. Catch at size

74. The need to know the sex of the large yellowfin tagged when they are recovered by fisheries was presented in document IOTC-2009-WPTT-21. It has been often assumed based on the dominance of males at large sizes in the landing of purse seiners and longliners that natural mortality of spawning females was much higher than for males. This hypothesis has not been demonstrated by scientific observation despite being important for modern stock assessment models and the dynamics of these simulated stocks. The recent IOTC tagging programme should allow the recovery of significant numbers of large tunas, especially yellowfin that are well reported by most purse seiners. If the sex and growth rates of all these large tagged yellowfin can be identified, it should be easy to estimate if the observed differential sex ratio at size is due to a higher natural mortality of spawning females, or to their lower growth rate and lower L_{∞}. This scientific result would be obtained for the first time and it would probably be of key importance for all future yellowfin stock assessment world-wide.

75. Given the differences in sex-ratio of larger length-classes, the WP recommends to get the sex of largest yellowfin recaptured, especially for the purse-seine fleet. This would allow the analysis of this skewed sex-ratio.

76. As an extension of this recommendation, the group acknowledged the importance of collecting as much biological information (sex-ratio, maturity, weight, etc.) as possible, both in observers programs as well as in port and cannery sampling.

4.3. CPUE indices and standardised CPUE indices

77. The WPTT worked intersessionally to derive a five region spatial stratification for the CPUE analyses in 2009 (Figure 40). The current demarcation of areas is similar to that used in previous years, with modifications based on the results obtained from the tagging, environment, catches and species composition of the longliner catches and the most expeditious use of these data in the MFCL assessment. The size of the area defined are very different (Table 3).

Table 3. Approximative size of the areas used for the assessment.

Area	1	2	3	4	5
Size in km^2	1 000 000	2 100 000	2 200 000	5 800 000	2 500 000

1 Tom Polacheck_2006 ; Tuna longline catch rates in the Indian Ocean: Did industrial fishing result in a 90% rapid decline in the abundance of large predatory species? Marine Policy 30 (2006) 470–482

2 Myers, R., and Worm, B. 2003, 'Rapid worldwide depletion of predatory fish communities' , Nature, vol. 423, pp. 280-283.

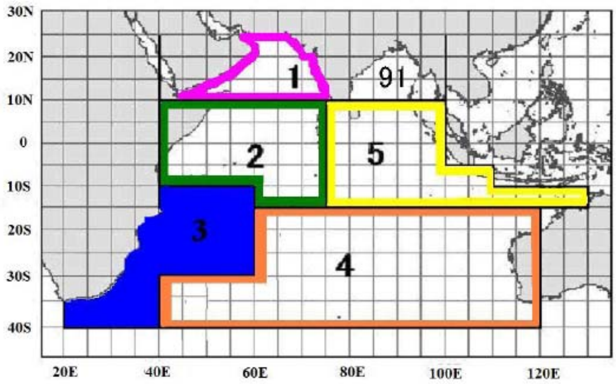


Figure 40. Areas used for CPUE analyses of yellowfin tuna in 2009

78. Document IOTC-2009-WPTT-06 presented the standardization of the Japanese longline CPUE. Japanese longline CPUE for yellowfin tuna was standardized up to 2008 by GLM (CPUE-LogNormal error structured model) in which SST (Sea Surface Temperature) was included in the model as an oceanographic factor. Number of hooks between float (NHF) and material of main line and branch line were applied to the model in order to explain the change in catchability which variation in fishing gear configuration brought to the fishery. Quarterly and annual CPUEs in the main fishing ground and whole Indian Ocean were standardized to provide an abundance index for the yellowfin assessment used in the IOTC WPTT in 2009. In the main fishing ground, CPUE continuously decreased from around 28.7 (real scale) in 1960 to 10.5 in 1972, and was kept at approximately the same level until 1988. Thereafter, it declined to about 4.5 in 1994 and has remained at this low level with fluctuations between 3.3 and 4.6 until 2006. After that, the CPUE in 2007 was much lower (3.0) and that in 2008 was estimated to be extremely low (2.0), although the data of 2008 is still preliminary. The trend of standardized CPUE for whole Indian Ocean was similar to that of the main fishing area.

79. The standardized CPUE smooths out some of the variability observed in the nominal series (Figure 41) particularly between 2002 and 2007. This is most noticeable for the 2 major fishing regions (areas 2 and 3). The cause of this difference between the nominal and standardised CPUE series needs to be explored further in order to assess what factor/s are responsible for this discrepancy. This is driven by the concern that if all variability in the data is removed, it may remove abundance effects in addition to the catchability effects. It was also recommended that further investigations into the effect of fishing power (gear change and skipper experience) be carried out as these were only superficially included in the model.

80. Standardized series of CPUE for the Taiwanese (TWN) LL fleet were presented in document IOTC-2009-WPTT-29. For CPUE standardization of Yellowfin Tuna Caught by Taiwanese Longline Fishery in the Indian Ocean, the researchers followed the procedure adopted in the previous study (Chang *et al.* 2008) as a base case; but with recent data updates and with new area definitions. In this study, other alternatives of target proxy were also used in the GLM as a sensitivity case to standardize YFT CPUE based on the information of Taiwanese observer data from 2002 to 2007. Relative standardized CPUE series obtained from two cases looked very similar. The CPUE series shows a relatively stable trend; slightly decreasing from 2004 to 2008. In this case, very preliminary analysis of observer data was carried out. However, this may be worth further investigations on the observer data in the future to consider the technological effects issue in CPUE standardizations.

81. The WPTT noted that the trend of the Taiwanese CPUE series was very different to that of the Japanese series (Figure 42 and Figure 43). It was recognised that the two series begin at different times and thus comparisons of the trends over the same time period is more appropriate, however even over the same temporal scale the differences remain large, the only similarity between trends being the recent trend of decline since 2005. It was noted that both the nominal and standardised Taiwanese CPUEs were showing the same hump between 2002 and 2007 as the Japanese nominal CPUE series, which is no described in the standardized Japanese CPUE. The WPTT recommended to further investigate the factors driving the standardization CPUE series.

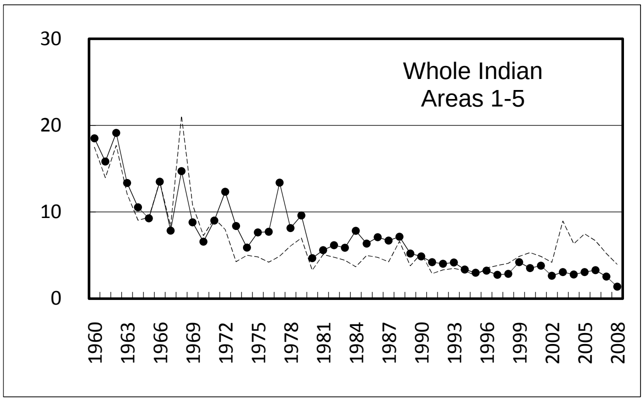


Figure 41. Nominal and Standardised CPUE for the Japanese longline fishery catching yellowfin tuna (solid line represents GLM standardised CPUE, while the dotted line represents nominal CPUE)

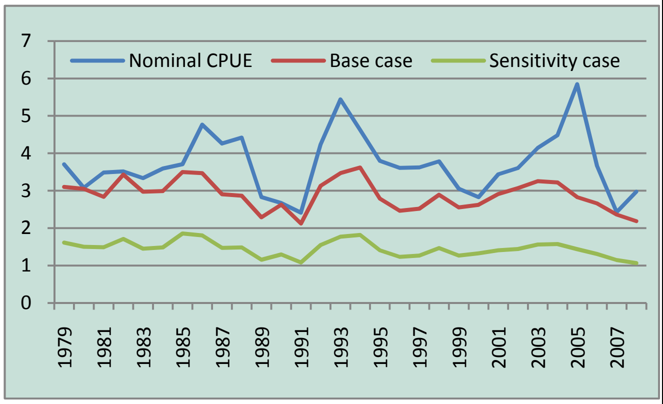


Figure 42. Standardised CPUE for the Taiwanese longline fishery catching yellowfin tuna.

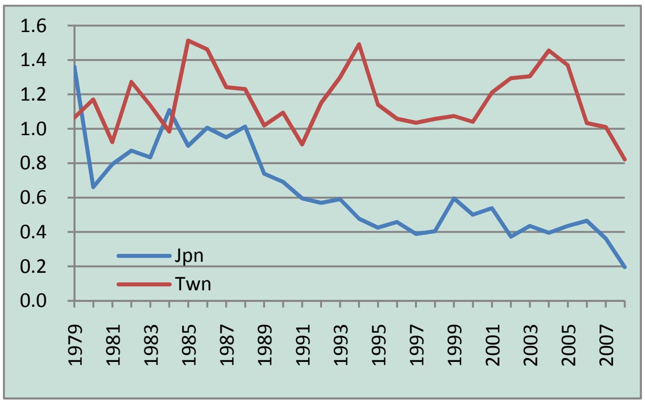


Figure 43. Comparison of the relative standardized yellowfin CPUEs for Japan and Taiwan,China for the period 1979-2008.

82. An attempt at investigating catch rates of yellowfin by the purse seine fleet was documented in an Ad Hoc presentation (Ad Hoc03). Purse seine-based CPUE indices on large yellowfin (>30kg) were proposed to complement the longline CPUE indices. GLMs were produced from purse seine logbook data at the 2008 WPTT assessments and no new GLMs were computed during this session. Rather, refined nominal CPUEs were proposed. Large yellowfin catches made on the free schools distributed in the equatorial region (0°-10°S / 40°E-80°E) were selected. CPUEs were computed by searching time (*i.e* the fishing time minus time spent setting) across three cases: a base case and 2 additional cases considering increase in fishing effort of respectively 2% and 3% on an annual basis, in order to explore scenarios of increasing fishing efficiency. The method used to produce the refined indices consists of a three-step averaging procedure: firstly averaging the set by set CPUEs by 1° square and month, secondly averaging the 1°square-month CPUEs over the fished squares only, in order to obtain a monthly value for the whole region, then averaging the monthly values over the fishing season (December to February) or over the whole year. The result show fluctuating values with no trend, with particularly low values in 1990, 1995, 1998 and 2007 and high values in 2003-2004. Applying the 2 and 3% increase in fishing effort tends to reduce the magnitude of the 2003-2005 hump but no particular declining trend is shown over the period studied (1984-2008) The current series of refined CPUEs is very close to that described in 2008 using GLMs. The group acknowledged that no significant improvement in the GLM is likely to occur without incorporating technological factors (implementation of various radars and sonars, deeper nets, satellite technology) that contributed to improve detection and capture of schools. Therefore it recommends that effort should be devoted to collecting this information from the fishing companies.

83. The overall trend of PS indices is flat, so do the Japanese and Taiwanese LL CPUE indices over the period 1993-2002. Only the last 3 years where all are showing major decline. The method used for Purse seine refinement is however very preliminary and the fishery is seasonal so the two series are not easily comparable. A similarity was noted for the years 2002 to 2007 where the purse seine CPUE series also displayed the hump observed for the Japanese nominal LL and Taiwanese standardised CPUE series. It was suggested that the very stable CPUE exhibited by the PS fishery could be a result of the fishery operating during spawning season and thus may show hyper-stability due to the schools congregating during this time. This congregation could continue

to occur until a population low threshold is reached. The preliminary nature of this study was made clear as was the need for further analysis.

84. The WP was presented in document IOTC-2009-WPTT-33 with the results of surveys undertaken by the Fishery Survey of India in order to compare catch rates of conventional longline with tuna hooks versus monofilament longline with circle hooks. Those surveys took place in the Arabian Sea and in the Bay of Bengal, and showed higher CPUEs for yellowfin tuna and lower CPUEs for sharks with monofilament longline than with conventional longline.

85. The WP noted that the present study estimated a potential yield for the yellowfin tuna within the EEZ of India that represents approximately 1/3 of the MSY currently estimated for the yellowfin Indian Ocean stock. Questions were raised on the apparent use of these results, from which estimates of potential yield over an area of the Indian Ocean have been made. Concerns were expressed that these estimates do not take into account the changing spatial distribution of tuna, and could lead to unrealistic expectations of catch rates and profitability. Using these calculations as a basis for fleet development is likely to lead to overfishing and not achieve the desired results in yield and catch rates.

4.4. Stock assessments

4.4.1. MULTIFAN-CL, (MFCL)

86. A size-based, age- and spatially-structured population model (Multifan-CL, MFCL) initially carried out in 2008 was updated and applied to the Indian Ocean yellowfin tuna stock, as presented in document IOTC-2009-WPTT-10. This method is routinely used to conduct the stock assessment of tuna stocks of the western and central Pacific Ocean, including yellowfin tuna. Multifan-CL has the functionality to integrate tagging data. For this reason, the IOTC Working Party on Tagging Data Analysis held in June–July 2008 recommended conducting an assessment of the Indian Ocean yellowfin tuna stock using MFCL software (IOTC-2008-WPTDA-R). A number of fisheries were defined by aggregating all LL catches by area, separating PS catches between log and free school catches, and assigning the various artisanal fleets to separate fisheries by area. These were updated and revised from the 2008 assessment based on recommendations but the WPTT. The standardised CPUE series from the longline fisheries in each region was essentially used as the index of relative stock size. Additionally, additional tag and recovery data were available and included.

87. A five-region spatial stratification (Figure 34) with quarterly time steps for the 1960-2008 period were adopted for this model. The time period was later curtailed to cover only the 1972-2008 period. This was carried out in reaction to difficulties in the assumption regarding LL catchability which resulted in significant changes to the biomass trajectories for the early years of the model. In the past it was assumed that the selectivities for the LL fisheries were dome-shaped, however after much discussion, the group decided a logistic selectivity for these fisheries was more appropriate. In addition, biomass estimation for 2008 was considered to be poorly estimated and thus for reference point estimation, biomass calculated for 2007 was used as a proxy of current biomass.

88. The steepness of the stock-recruitment relationship was fixed and analysis were conducted with a range of plausible values (0.6-0.8) as recommended by the WPTT in 2008.

89. Initial model runs attempted to estimate growth internally within MFCL informed by the length frequency data. The resulting growth estimates were considerably higher than growth estimated externally using tag growth increment data. These external growth estimates were also consistent with the results of otolith ageing. On that basis, it was decided to fix growth in the model at the values derived from the external analysis. .Growth was fixed to approximate the growth curve based on tagging and recovery data and on the observed growth rate between tagging and recovery as a function of fish sizes. (Figure 44).

a b

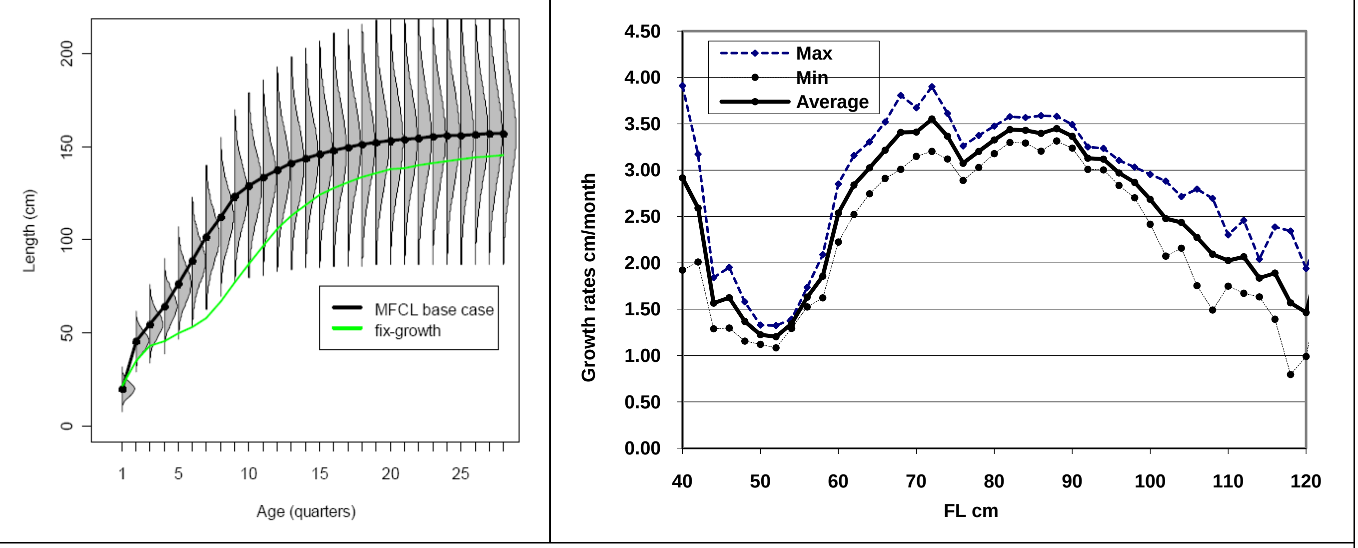


Figure 44a. Growth of yellowfin used in the assessment model in green. The growth estimated by the model is also presented, the black line represents the estimated mean length (FL, cm) at age and the grey area represents the estimated distribution of length at age. **b.** Apparent growth rate of yellowfin estimated from tagging data

90. Movement among the five areas was estimated by the model, although very limited information exists in either the catch or tagging datasets, as both releases and recaptures have so far concentrated in area 2 resulting in Movement rates being highest between region 2 and adjacent regions. The case has improved somewhat with additional returns from 2008, however, the WP considers that movements rates are underestimated due to the lack of reporting of recaptured fish by longline fisheries.

91. Estimated movement coefficients for some region boundaries are close to zero (especially for region 4), while overall, most estimated movement rates are low. These results were likely to be due to limited data for the estimation of the movement parameters. Alternative model scenarios were used to explore the possible influence of movement parameters on overall results. It was suggested to increase all movement parameters in the model, effectively creating a single-region aggregated model.

92. Natural mortality was initially assumed to be fixed at the values suggested by the 2008 WPTT (Figure 45). The group considered these values may not be fully appropriate especially in light of the change in assumption regarding selectivity of the LL fisheries in the Indian Ocean. The final model estimated the overall average level of natural mortality, while maintaining the age specific functional form. Complete mixing of tagged fish assumed that tagged yellowfin mix fairly quickly with the untagged population at the region level and that this mixing process is complete by the end of the second quarter after release. The release phase of the tagging programme was essentially restricted to region 2.

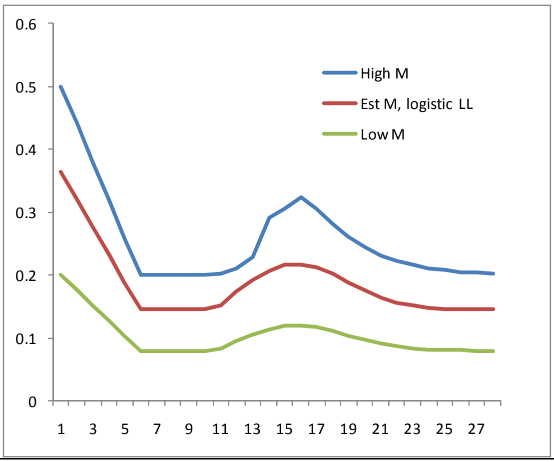


Figure 45. YFT age-specific natural mortality. High M is the M value assumed in the WCPO. Low M is that previously assumed in the IOTC, and Est M, Logistic LL is the M calculated by MFCL using a logistic selectivity for the LL fisheries Age class units are

quarter years.

93. For almost all fisheries, there is good fit to the length frequency data revealed from a comparison of the observed and predicted length data aggregated over time (Figure 46). For most fisheries, the size composition of individual length samples is consistent with the temporal trend in the size composition of the fishery-specific exploitable component of the population. A number of fisheries have considerable variability in the size frequency data (for example, PS FS 2, 3, & 5, TR 5 and LL 3) which may be partly due to sampling error. Further, the model does not reflect the strong decline in the length of fish sampled from the gillnet fishery in region 1 (GI 1); such a trend was not evident in the length data collected from the other fisheries in the same region, most notably the longline fishery (LL 1). Similarly, tag returns for most quarters are well explained.

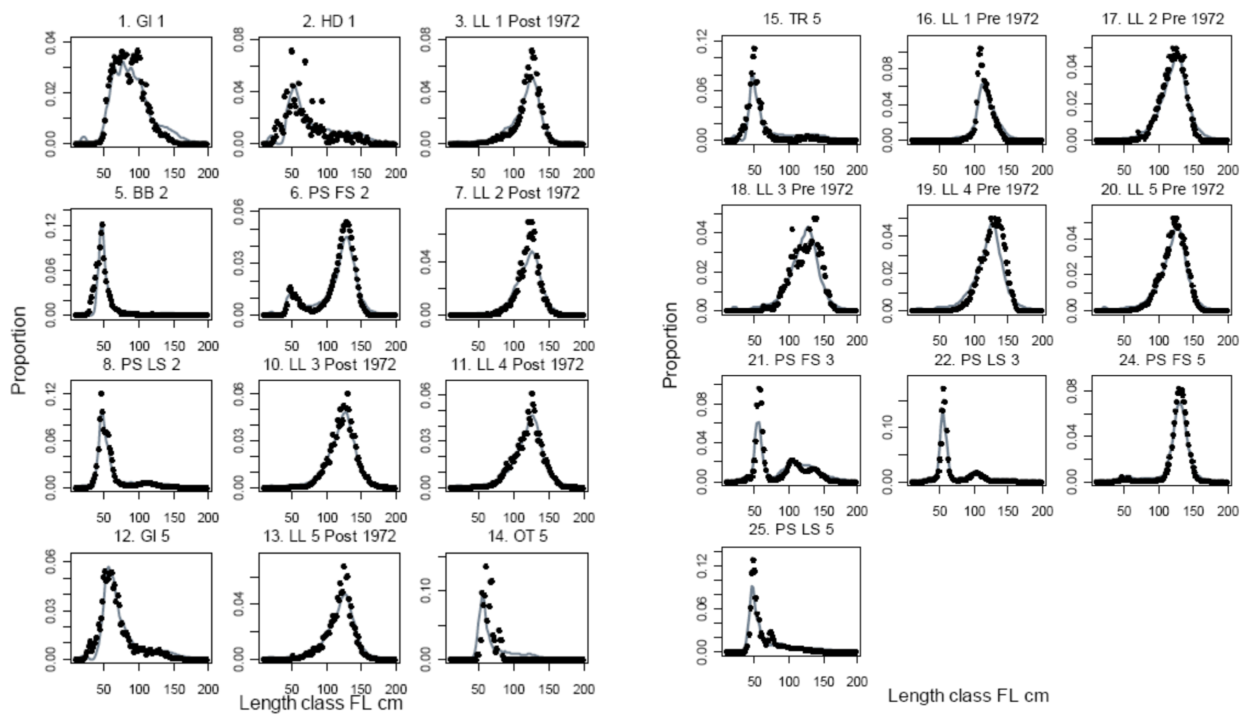


Figure 46. Observed (points) and predicted (line) YFT length frequencies (in cm) for each fishery aggregated over time.

94. The initial model accounted for the early (pre 1972) decline in longline CPUE by estimating a strong decline in catchability in most regions (Figure 47). These years were however subsequently dropped from the model. For the principal longline fisheries (1972 onwards), catchability was assumed to be constant over time, with the exception of seasonal variation. This resulted in early recruitments being comparable to the equilibrium level and removed some of the strong temporal trend in recruitment and biomass.

95. Extra runs were carried out that incorporated a number of suggestions made by the group, some of them mentioned above. As many of the attempts to tease out the primary driving forces of the estimated biomass were unsuccessful in significantly changing the biomass trajectories, the results of these various sensitivity runs would appear to indicate that interactions between recent time series of catch and LL CPUE trends (historic and recent and in all areas) are the strongest factors driving the biomass trends. These factors are generally still poorly understood.

96. Given the information content of the datasets used, it appears that the model is currently unable to provide a satisfactory explanation of movements across regions. As a consequence the levels and trends of recruitment, biomass and fishing mortality per area might be questionable. This is not surprising, given the difficulties generally encountered in estimating movement, and the limited spatial spread of tagging releases and recaptures currently available. Concerns were expressed about the impact this factor could have on the overall estimates obtained, and the WPTT agreed further work is necessary to improve this aspect of this assessment. The still limited availability of tag recoveries from fleets operating outside of the main area for tag releases further limits its use for estimating movement. The authors also noted that the estimates of reporting rates from field experiments available only covered part of the purse seine fleet and none of the other fleets returning or likely to return tags.

97. Tag reporting rates for the purse-seine fisheries (combined within a region for the estimation of tag recoveries) were fixed in the analysis. For all other fisheries, no information was available regarding tag reporting rates and fishery-specific reporting rates were estimated with virtually no constraint. For those fisheries with tag recoveries, the estimated reporting rates were generally low (less than 20%), with the exception of the artisanal fishery in region 1 (OT 1) and the troll fisheries in regions 2 and 3 (TR 2 & 3).

98. The base-case assessment assumes a constant catchability of yellowfin by the longline fisheries, as indexed by the Japanese and Taiwanese standardized CPUE indices. However, the CPUE standardization is unlikely to account for a range of variables that may have increased (or decreased) the efficiency of the longline fleet with respect to yellowfin tuna. A sensitivity analysis (LL q incr) indicates that the stock assessment conclusions are sensitive to the assumptions regarding longline catchability. More detailed information regarding gear technology and fishing strategy is necessary to investigate changes in longline catchability over the model period.

99. Overall, the WPTT strongly recommended that the development of the MFCL model on Indian Ocean tunas continue. The WPTT noted that this work should include further analyses to determine the most representative spatial structure for the fisheries and explore various mixing rate scenarios. This was necessary due to the potentially unrealistic estimates of biomass and recruitment for each region (Figure 48). For example, in some years, area 3 was estimated to have higher biomass than area 2 despite the latter being the core of the YFT fishery. This was partially explored by significantly increasing the movement between regions in the model, but it was suggested that a single region model may be informative.

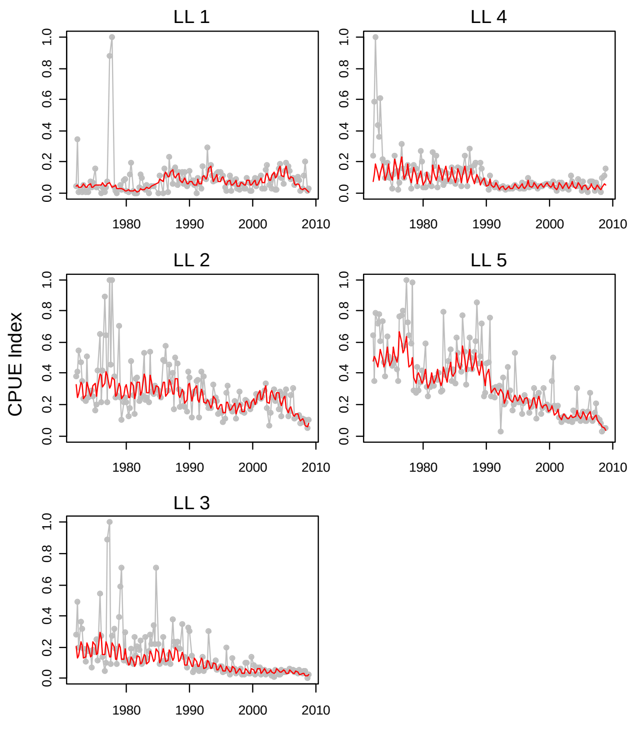


Figure 47. A comparison of longline exploitable YFT biomass by quarter and region (red line) and the quarterly standardised CPUE indices (grey line and points) for the fisheries. For comparison, both series are scaled to the average of the series

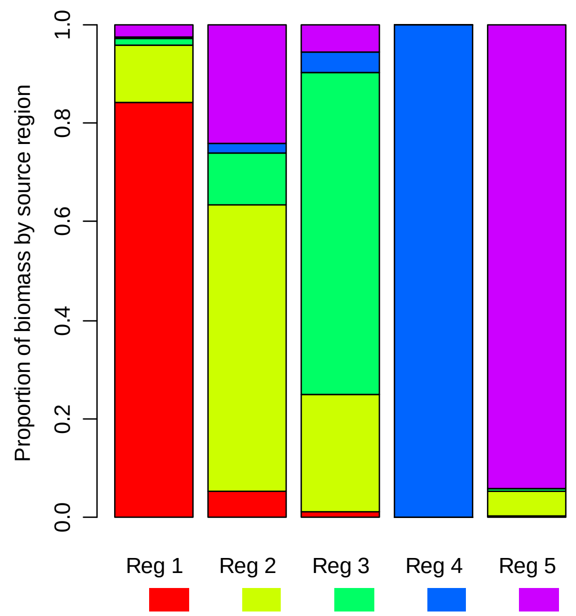


Figure 48. Proportional distribution of total YFT biomass (by weight) in each region (Reg 1–5) apportioned by the source region of the fish. The colour of the home region is presented below the corresponding label on the x-axis. The biomass distributions are calculated based on the long-term average distribution of recruitment among regions, estimated movement parameters, and natural mortality. Fishing mortality is not taken into account.

100. Results obtained appear to indicate that estimated recent levels of fishing mortality are at an historical high level and the stock has experienced a period of overfishing during 2003-2006 (*i.e.* Fcurrent > FMSY) for all values of steepness. Current catches are likely to be higher than the estimated MSY, which ranges from 250,000 to 300,000 t, depending on the shape of the stock-recruitment relationship. Biomass based reference points also vary with the assumed level of steepness. For the lowest value of steepness (0.60), spawning biomass in 2007 is estimated to be below the MSY level (SB/SBMSY <1); *i.e.* the stock is in an overfished state. For higher values of steepness, recent (2007) biomass is above the MSY level (SBcurrent > SBMSY) and the stock is not in an

overfished state. The model estimates that recent recruitment has been lower than average (Figure 49) and on this basis total and spawning biomass could be expected to decline further over the next few years (Figure 50).

101. The trend in the status of the yellowfin tuna stock relative to $F_t/\tilde{F}_{MSY}$, $B_t/\tilde{B}_{MSY}$ and $SB_t/\tilde{SB}_{MSY}$ reference points over the period 1960 to 2007 is illustrated in Figure 51.

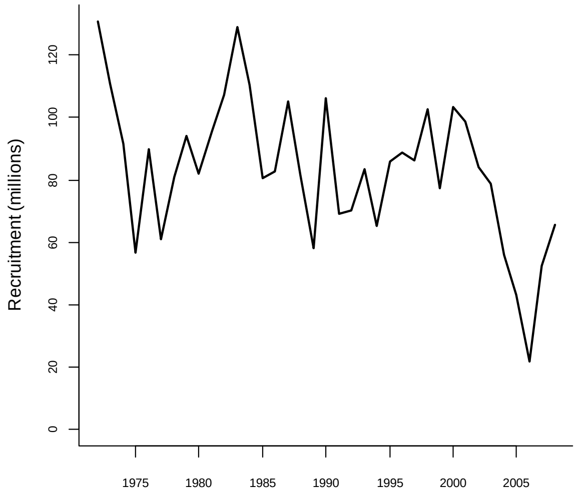


Figure 49. Estimated annual recruitment (millions of fish) for the whole Indian Ocean.

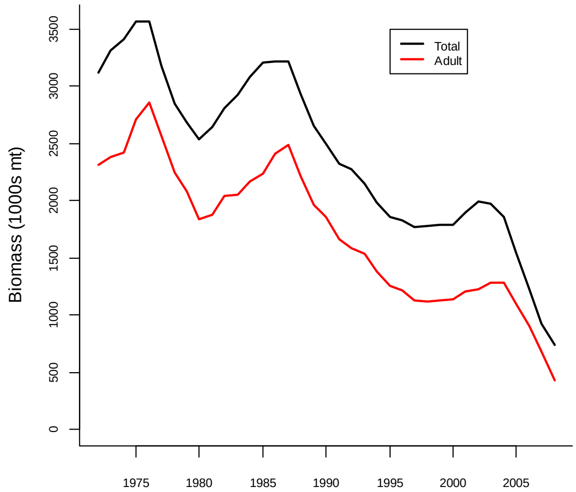


Figure 50. Temporal trend in total and adult biomass (1000s mt) for the whole Indian Ocean.

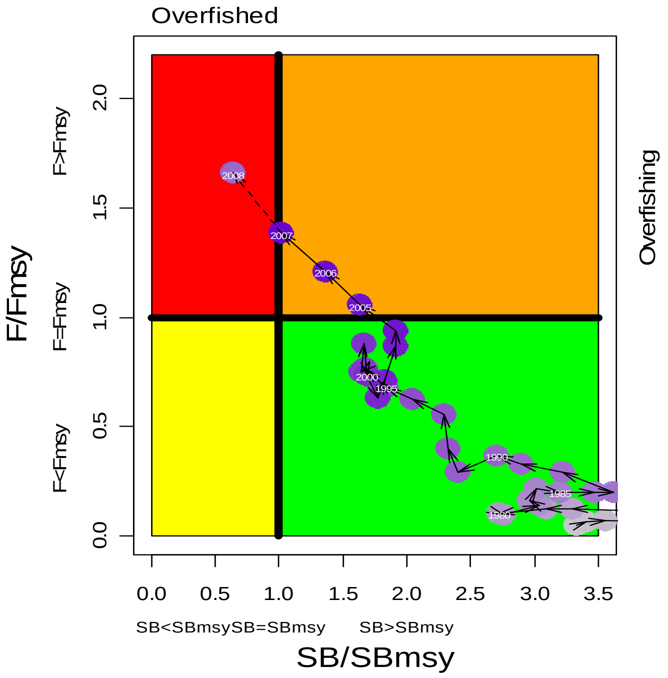
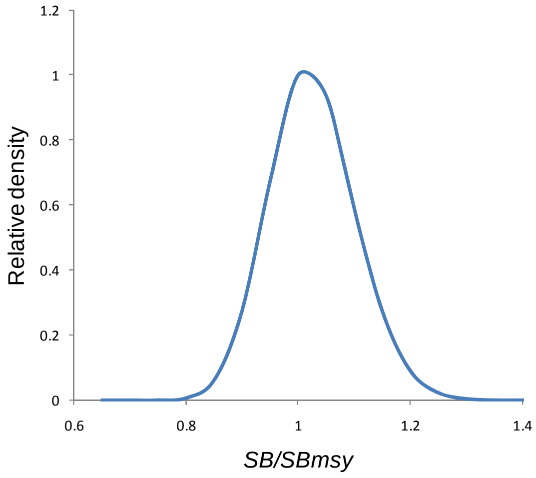


Figure 51. Temporal trend in annual stock status, relative to SBMSY (x-axis) and FMSY (y-axis) reference points (steepness 0.7). The colour of the points is graduated from mauve (1960) to dark purple (2007). The 2008 estimate appears as dashed as it is provisional



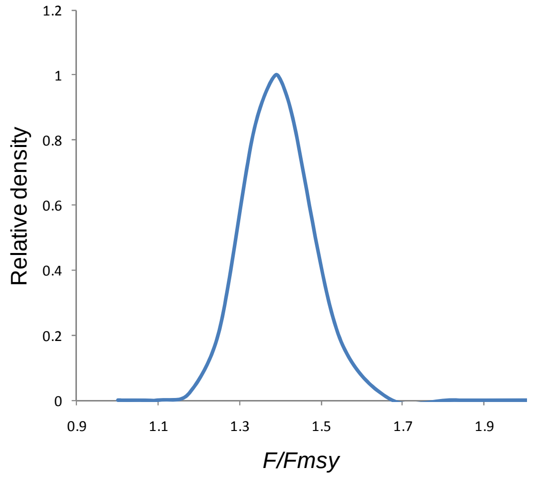


Figure 52. Likelihood profiles of SB/SB_{msy} and F/F_{msy} for the 2007 estimates.

4.4.2 Comment on the MFCL and other assessment models

102. The MFCL model enabled scientists to use the tagging data and other information in an Indian Ocean tuna stock assessment and the WPTT endorsed its use in the future. The WPTT recommend to use other models with alternative structures that do not require particular inputs such as tagging or size frequency data, provide valuable alternative views of an assessment situation and in some circumstances can better evaluate the information content of the omitted data sets. Moreover, the WPTT agreed that is always a useful exercise to examine the results from a range of models in order to assess the conflicts and consistencies of the different data used in the models and the structural hypothesis used by each of them. To this end, the WPTT suggested that a range of stock assessments approaches continues to be conducted in the future. Conversely, the development of simple methods centred on the use of the tagging data set as main source of information was mentioned as an interesting alternative for comparison of information content among datasets.

4.5. Technical advice for Yellowfin tuna

103. The WPTT estimated the status of the yellowfin stock in 2009 by using an integrated stock assessment using data sources, including tagging data, to estimate historical trends, current status, and reference points for the stock. A number of indicators were also inspected.

104. An important source of information for assessment purposes is the index of abundance derived from the Japanese longline CPUE series. Problems have been identified with these series that impact their use as an indicator of the abundance of yellowfin over time. The WPTT acknowledges its view on the status of the stock is still affected by the difficulty of understanding the changes in the fishery to explain the patterns observed in the index of abundance.

105. Problems have been identified in the catch data from some fisheries, on sizes in the catches of various fleets, another important source of information for assessment. The unavailability of these data directly impacts the quality of the advice provided.

106. The availability of tagging data, together with the efforts made by the Secretariat at improving the available statistics, enables the WPPT to conduct analyses on which to base management recommendations for this stock.

107. Given the partial availability of data, and the uncertainties in the estimation of recruitment and biomass for 2008, the advice provided by the WPTT refers to the status of the stock in 2007, although reference to 2008 catches and estimates of biomass are also made.

108. The WPTT notes that model estimates of potential short term yield are expected to be lower than MSY, as they are based on a projection of the recruitment patterns estimated over the last few years, lower than the long term average.

4.5.1 Management advice

Current status

109. Estimates of total and spawning stock (adult) biomass show a recent decrease, probably accelerated by the high catches of 2003-2006. It appears that overfishing has been occurring over those years, and the effect on the standing stock is still noticeable as biomass appears to be decreasing despite catches returning to pre-2003 levels.

110. The estimates of MSY obtained are between 250,000 t and 300,000 t for different stock-recruitment relationships. The 2008 catch of 322,000 t is above the current estimates of MSY while annual catches over the period 2003-2006 (averaging 464,000 t) were substantially higher than this range of MSY estimates.

111. The most recent estimate of biomass (2007) is probably already at the MSY-related reference value, while fishing mortality levels are estimated to be above those linked to MSY catches. Preliminary estimates for 2008 show the stock may be below the SSB at MSY value and the fishing pressure might be even higher than in 2007.

112. Various indicators of catch rates for different fleets and areas appear to confirm this downward trend in abundance. Catches in 2008 for longliners operating in the Arabian Sea, for example, are at a historic low.

113. Two hypotheses have been put forward in the past to explain the very high catches in the 2003-2006 period: (i) an increase in catchability by surface and longline fleets due to a high level of concentration across a reduced area and depth range, and (ii) increased recruitment over the 1999-2001 period. Recent analyses of environmental and oceanographic conditions appear to be consistent with the first hypothesis, which would mean that the catches probably resulted in stock depletion. Environmental anomalies also appear to be a factor linked to the lower catches in 2007.

Outlook

114. Catches in 2008 (322,000 t) were slightly lower than the average catch taken in the 1998-2002 period (336,000 t) i.e. preceding the 2003 to 2006 period when extraordinarily high catches of yellowfin were taken. While there is uncertainty about future catches, recent events in 2008 and 2009 where some vessels have left the fishery, together with fleets avoiding the historically important fishing grounds in the waters adjacent to Somalia for security reasons, may reduce catches in the short-term to below the pre-2003 levels. The WP noted that a return to a normal fishing scenario may result in increased effort levels, leading to catches above MSY levels.

115. Fishing mortality has very likely exceeded the MSY-related levels in recent years, therefore some reduction in catch or fishing effort would be required to return exploitation rates to those related to MSY levels. The WPTT considers that the stock of yellowfin has recently become overexploited. Management measures should be considered that allow an appropriate control of fishing pressure to be implemented.

Recommendations

116. Current estimates of MSY are in the range of 250,000 and 300,000 t, lower than the average catches sustained over the 1992-2002 period of around 343,000 t. The high catches of the 2003-2006 period appear to have accelerated the decline of biomass in the stock, which might be currently unable to sustain the 1992-2002 level of catches.

117. The WPTT recommends that catches and fishing mortality levels for yellowfin tuna do not exceed the MSY levels estimated by the current assessment.

118. The WPTT recommends that monitoring is strengthened over the coming year to more closely follow the stock situation.

5. STOCK ASSESSMENT FOR BIGEYE TUNA

5.1. CPUEs

119. Working paper IOTC-2009-WPTT-05 was presented, describing the Japanese longline CPUE standardization for bigeye tuna (*Thunnus obesus*) for 7 sub-regions of the Indian Ocean (Figure 53). The 5*5 degree monthly CPUE series from 1960 to 2008 was standardized using GLM. The method of standardization was the same as that used for the bigeye assessment in 2006. In the tropical Indian Ocean, CPUE continuously decreased from around 9.0 (real scale) in 1960 to 3.2 in 2002 when it has increased to about 4.4, about the same level as that in the late 1990s. Standardized CPUE in the south area which did not show a clear trend during the period between 1984 and 2000 (CPUE was 3.5 on average), decreased to 2.3 in 2003 and increased to 3.0 in 2004

after, which it decreased to 1.7 in 2005 and remained at this low level thereafter. As a result, CPUE for the whole Indian Ocean, which had decreased until 2002, increased a little in 2003 and 2004 after when it remained around the level of 3.3. Nominal and standardized CPUE are shown in Figure 54.

120. The WP discussed possible explanations for the large increase in CPUE observed between 1976 and 1977 in the tropical areas 1 to 5. This was considered to be more likely a catchability effect, due to the introduction of deep longline by the Japanese fleet in 1977 (change from 5 to 11 HBF), than an abundance increase. A similar shift was reported in the Japanese longliners operating in the Atlantic but was not observed in the Taiwanese fleet in the Indian Ocean (the Taiwanese fleet experienced a CPUE peak in 1979). The WP suggested that oceanographic data at a 2x2 degree resolution could be used in the future to explore physical mechanisms affecting CPUE prior to 1980 (the first year that the satellite SST fields are available). It was suggested that any model that uses the CPUE series prior to 1977 should explore the implications of a substantial catchability shift around this date.

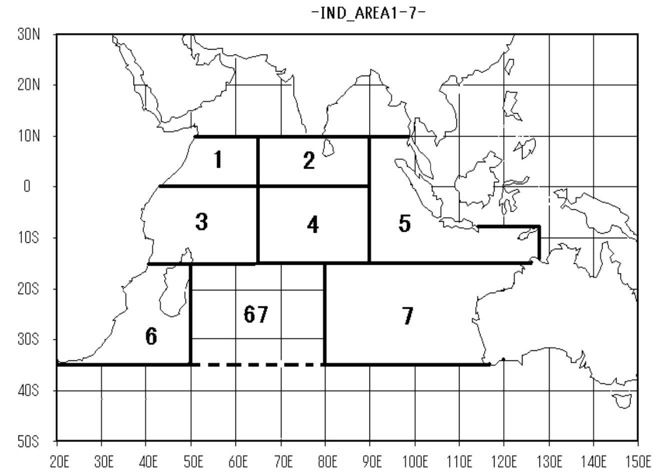
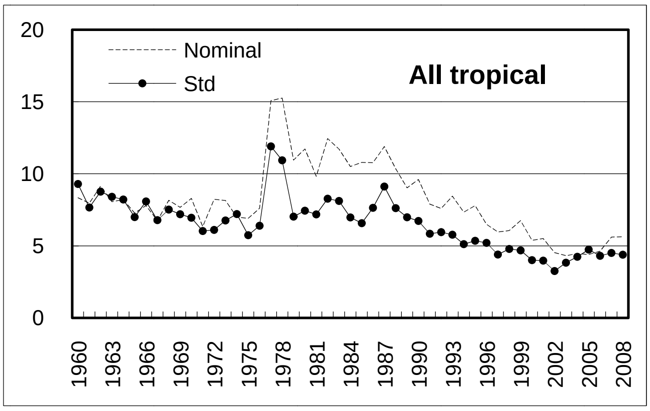
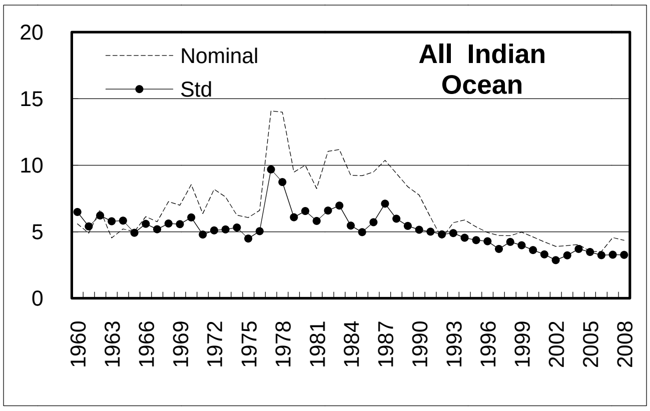


Figure 53. Spatial Structure used for the Japanase longline catch rate standardization





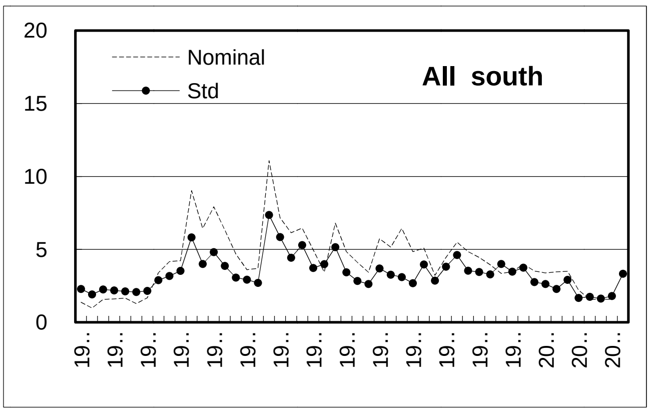


Figure 54. Nominal and 5*5 degree standardized Japanese longline CPUE series in the tropical, southern and whole Indian Ocean

121. IOTC-2009-WPTT-18 was presented, describing the CPUE standardization for bigeye tuna based on the fine scale catch and effort data of the Japanese tuna longline fisheries. The standardized abundance index was estimated based on the fine scale catch and effort data with environmental factors. The time series for 29 years (1980-2008) corresponds with the available duration of the fine scale environmental data, which are a combination of moon phase, Indian Ocean Index, temperature, salinity, thermocline depth, shear current and its amplitudes assigned to monthly 1*1 degree monthly strata. The strongest explanatory factors related to temperature, salinity and thermocline depth, which explained 30.3 % of variance in the final model. The next and fourth dominant factors were the shear current associated factors (22.5 %) and main effects (19.5%; year, area and quarter), respectively. The large explanatory power of the environmental factors demonstrates the effectiveness of the fine scale CPUE with environmental factors. The time series is illustrated in Figure 55.

122. The WP noted that there were a large number of factors included in the GLM standardization, which increases the risk of adopting spurious explanatory factors. It was suggested that additional analyses should be undertaken to determine if the explanatory mechanisms are plausible, and to ensure that the standardization is only removing the effects of catchability variability, and not the abundance trends. The WP noted that the CPUE trend was very similar between the 5*5 and 1*1 series, during the period of overlap.

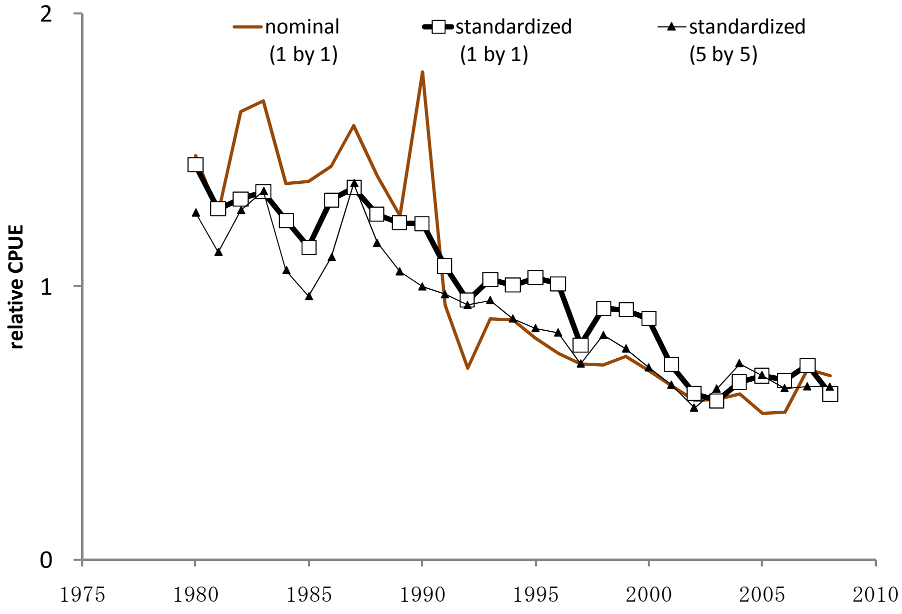


Figure 55. Comparison of 1*1 nominal, 1*1 standardized and 5*5 standardized Japanese longline CPUE series of the whole Indian Ocean

123. Working paper IOTC-2009-WPTT-30 was presented, describing the catch rate standardization of the Taiwanese longline bigeye tuna CPUE series. The authors used catch composition as a targeting proxy in the GLM to standardize BET CPUE from 1979 to 2008 as a base case. As sensitivity cases, the researchers also used NHBF data as an alternative targeting proxy and environmental data for the period between 1995 and 2008, using the using the methods of Wang and Nishida (2006), as applied to the Indian Ocean swordfish fishery. Relative standardized CPUE series obtained from base and sensitivity cases look very similar during the overlap period of 1995 to 2008. The CPUE series are relatively stable except for an obvious peak in 2003. The base case series is shown in Figure 58.

124. The WP noted that it could be problematic to use other species catch as a proxy for targeting, because the estimated targeting effect would be confounded with abundance trends in the other species. Similarly, if species composition proportions are used, this introduces the target species to both sides of the GLM equation. The series developed using NHBF targeting data were recommended to avoid these issues.

125. An analysis was undertaken to explore the discrepancy between the nominal Taiwanese and Japanese longline CPUE series. The series were compared, along with the ratios of bigeye catch to total catch (denoted by %TW_CATCH, and %JP_CATCH) by fishery and by region based on Task II data. The %TW_CATCH in Region1 was increasing from 1986, 50% in 1991, 25-35% during 1992 and 2007, and up to 45% in 2008 (preliminary data). In contrast, %JP_CATCH in Region1 was decreasing from 40% in 1986, drop to 5% in 1999. From 1986, %TW_CATCH in Region3 started to increase dramatically to 40% in 2005. For %JP_CATCH in

Region3, from 1986 to 2003, it remained below 10%. Meanwhile, in Region6, %TW_CATCH was relatively low around 5%, except in 1995 and 2000. In Region7, %TW_CATCH is also relatively low around 5%, except in 1974. In summary, Region1 and Region3 are the main fishing grounds for Taiwanese longline fishery, with %TW_CATCH in these two regions reaching 80% after 2001. During 1991 and 2003, Region2, Region6, and Region 7 are the main fishing grounds for the Japanese longline fishery, with %JP_CATCH around 60%. Therefore, the different characteristics shown in the two longline fleets might explain the discrepancy between the nominal CPUE series (Figure 56). A preliminary analysis of Taiwanese longline fishery observer data showed that further research on the technological changes over time might be informative. Also the WP noted that the fishing grounds and species composition of the longline catches of Japan and Taiwan,China were very different and could also explain some of those discrepancies (Figure 57).

126. The WP noted that the analysis described a number of interesting operational differences in the two fleets, including differing trends over time. However, it remains uncertain which mechanisms are affecting catchability. Further analyses along these lines were encouraged for the Japanese and Taiwanese longline fleets.

127. The working party recognized that the longline CPUE series are very important in stock assessment. Further analysis on catchability and investigation into the conflicting trends between the Japanese and Taiwanese CPUE series was encouraged.

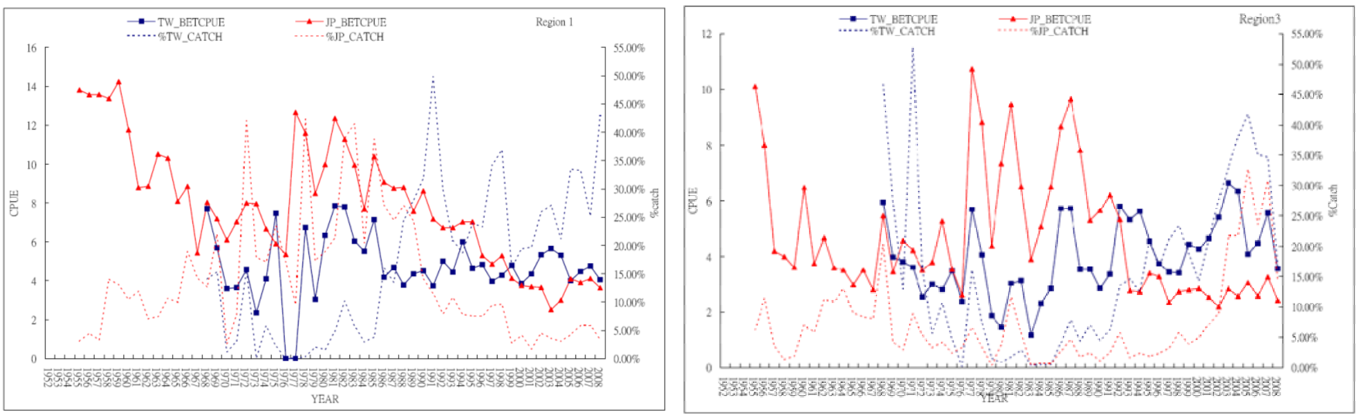


Figure 56. Taiwanese (in red) and Japanese CPUE and catch in area 1 and 3

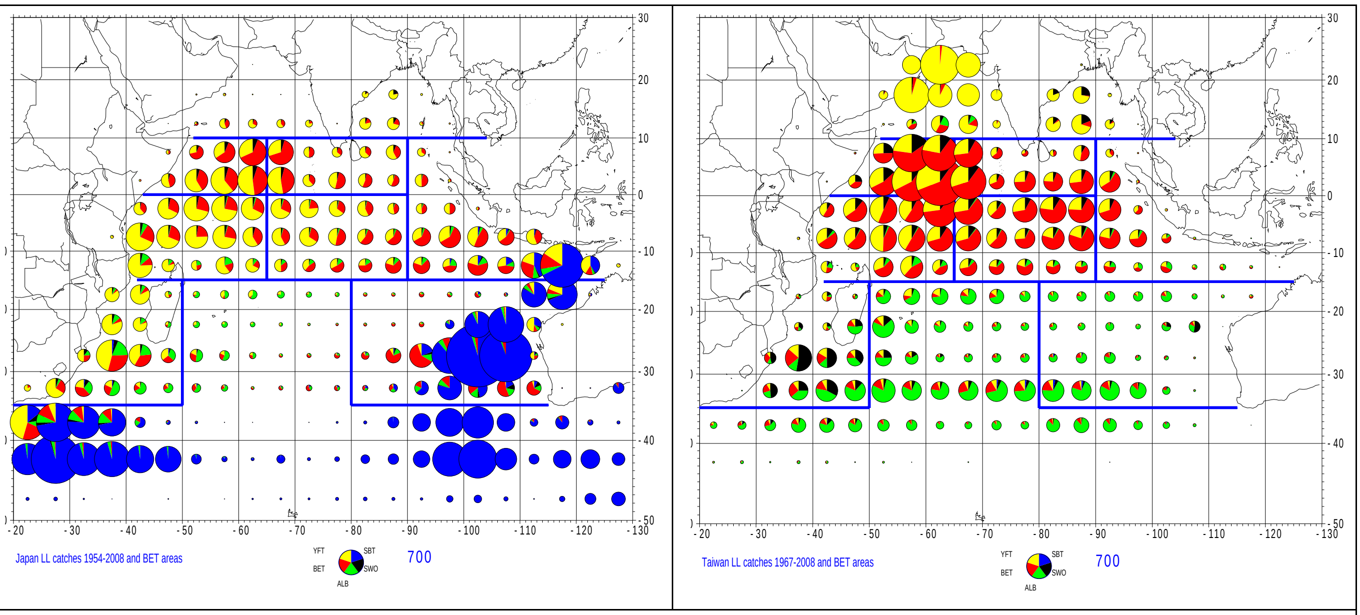


Figure 57. Japanese (a) and Taiwanese (b) longline catches of tuna in the Indian Ocean between 1955 and 2008**.**

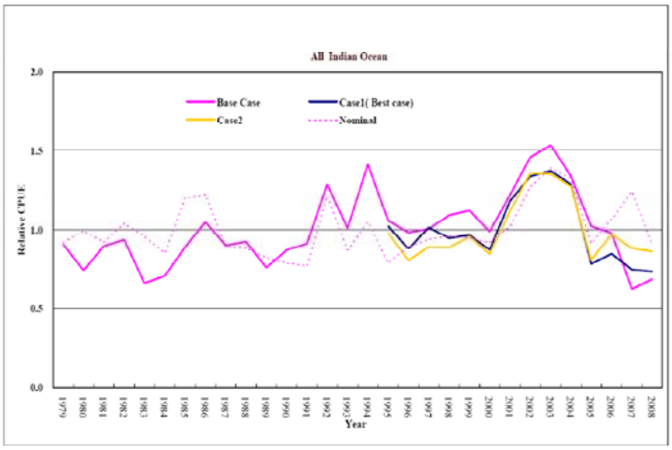


Figure 58. Comparison of nominal and 1*1 standardized Taiwanese longline CPUE series for the whole Indian Ocean

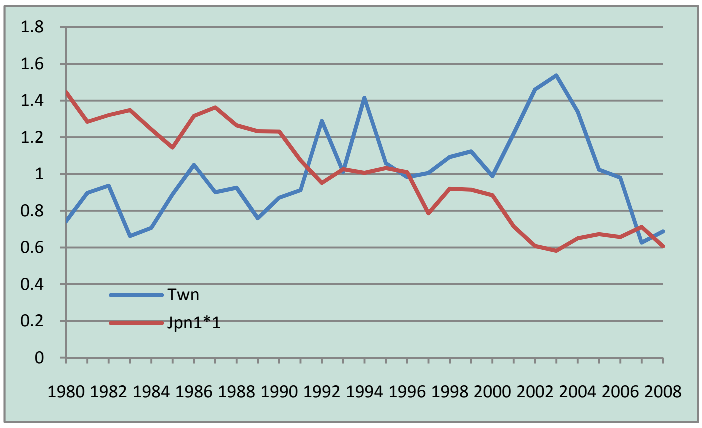


Figure 59. Comparison of BET 1*1 degree Standardized CPUE for Taiwan,China and Japan for the period 1980-2008.

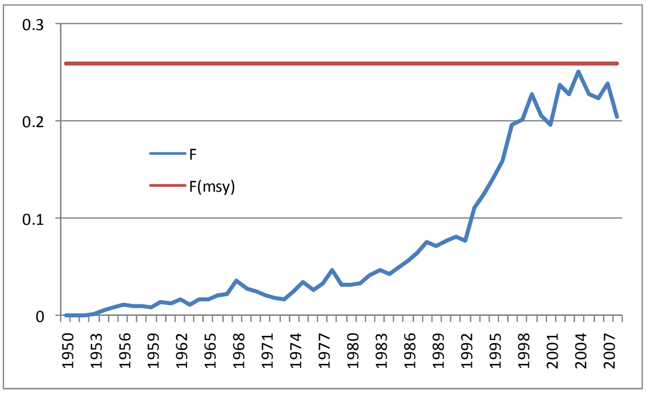
5.2. Stock assessments

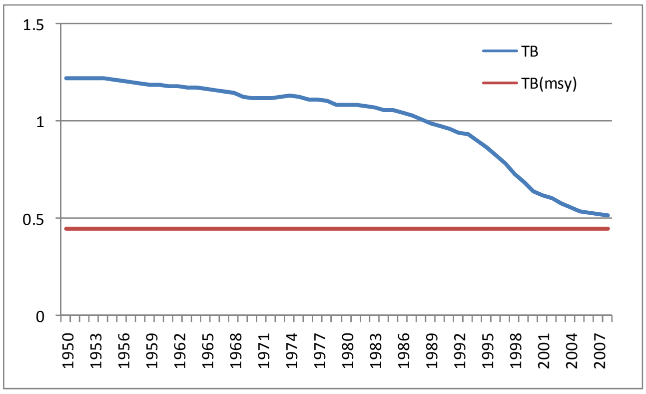
5.2.1 Surplus Productions Models (PRODFIT, PROCEAN and ASPIC)

128. Working paper IOTC-2009-WPTT-04 was presented, describing the application of a range of surplus production models (PRODFIT, PROCEAN and ASPIC) for the assessment of the Indian Ocean bigeye tuna population. Data included the coarse (5x5 degree) and fine scale (1x1 degree) GLM standardized Japanese longline CPUE for 1960-2008 and 1980-2008, respectively. The results of the models were consistent in terms of diagnostics and suggested that the bigeye tuna stock is close to a situation of MSY, with a biomass in 2008 comprised between 1.17-1.3 times the biomass at the maximum sustainable yield (MSY) and a fishing mortality in 2008 equal to 65-79% of the fishing mortality at MSY (FMSY) for the base case runs. A sensitivity analysis performed to account for uncertainty in some input parameters and based on the 1980-2008 standardised CPUE time series showed that the results were quite robust to the parameter changes with F2008/FMSY and B2008/BMSY comprised between 0.7-0.84 and 1-1.28, respectively. The use of random walks on catchability showed a sharp shift upward in the abundance index time series in 1977-78 that could suggest a problem in the standardisation process linked to the implementation of deep longline in the late 1970s. Summary results are shown in Figure 60, Figure 61, Figure 62 and Figure 63 and Table 4.

129. The WP was generally encouraged by the consistency in the results from these models. However, it was noted that the strong shift in selectivity associated with the development of the purse seine fishery cannot be explicitly described in a non-age-aggregated model.

130. The ASPIC biomass dynamic model provided quite different results depending on whether the 1*1 CPUE series was used or the 5*5 CPUE series. The WP felt that this was probably due primarily to the length of the time series (and the inclusion of the strange CPUE behaviour in the 1970s), rather than the standardization methodology or the spatial resolution. All biomass dynamics model struggle to fit the changes experienced in the middle of the Japanese longline CPUEs in series.





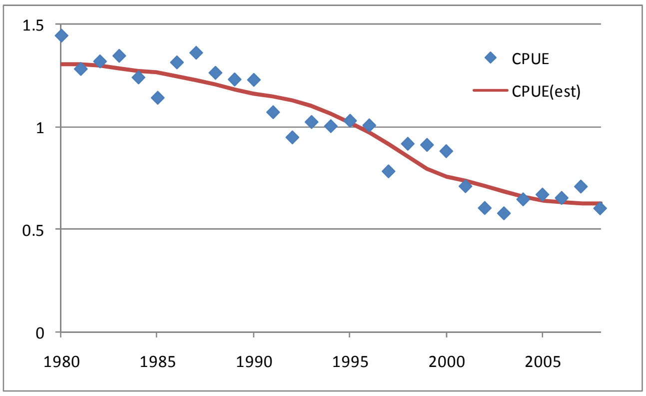


Figure 60. Summary of ASPIC assessments results.

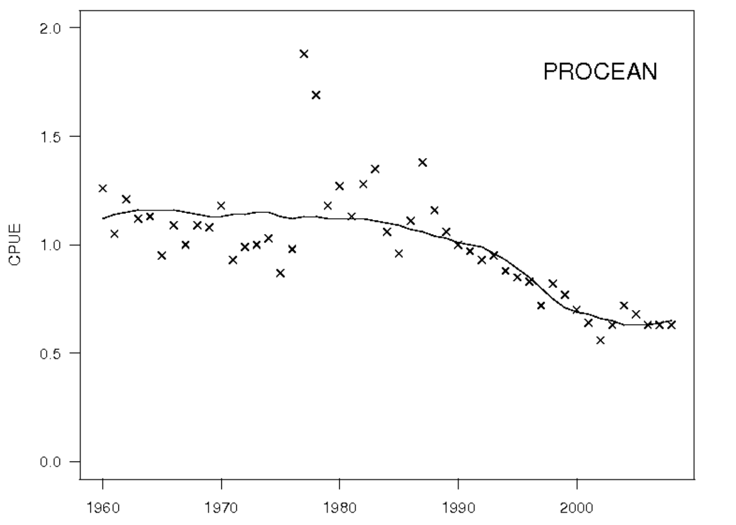


Figure 61. CPUE observed (crosses) and predicted (solid line) in the base case runs of PROCEAN

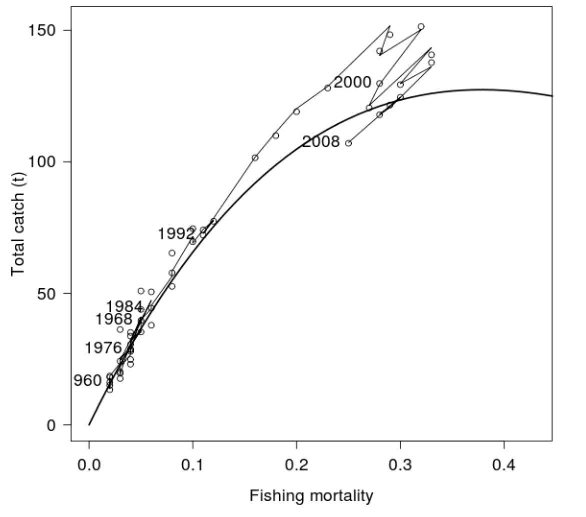


Figure 62. Total catch observed (circles) and equilibrium production curve (thick solid line) estimated in the base case run for PROCEAN

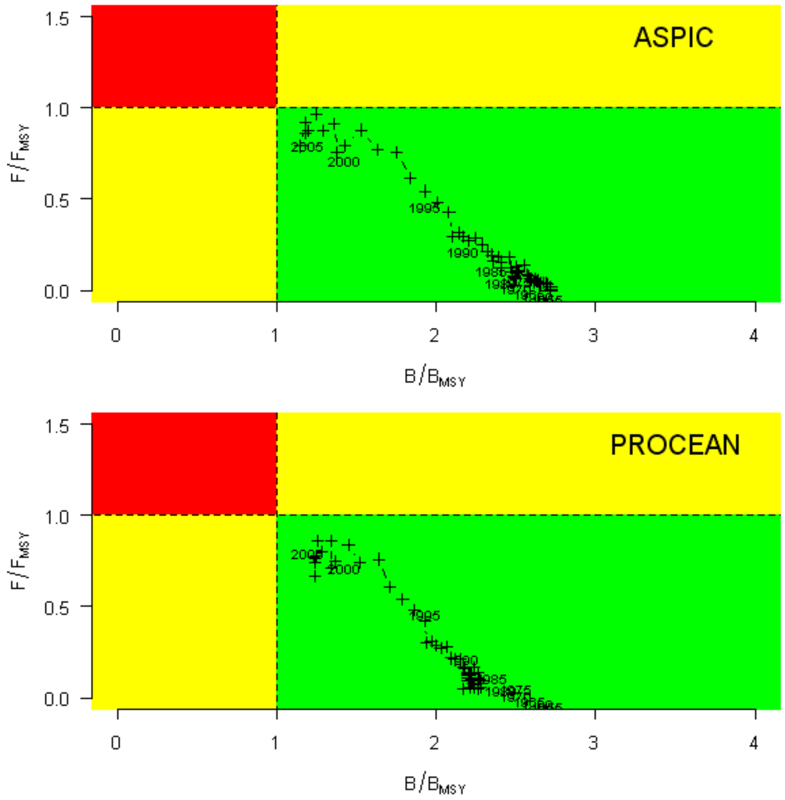


Figure 63. ASPIC and PROCEAN Kobe plots.

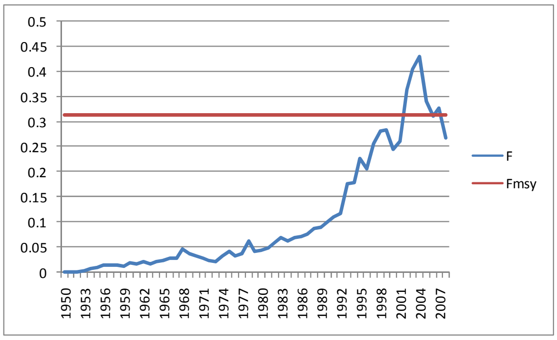
5.2.2 ASPM

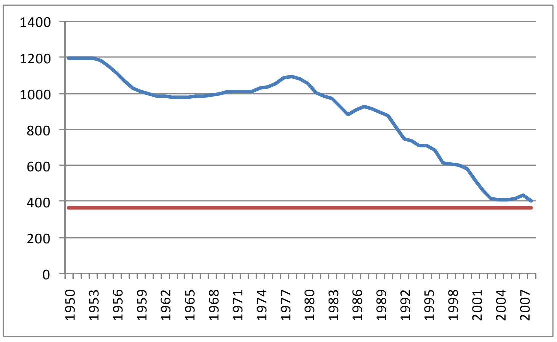
131. Working paper IOTC-2009-WPTT-25 was presented, describing the implementation of ASPM in AD Model Builder, and the application to the Indian Ocean bigeye tuna assessment. ASPM FORTRAN code from Victor Restrepo (ICCAT, 1997) has been used in the tropical tuna (YFT and BET) stock assessments (SA) in the IOTC as one of stock assessment approaches in the WPTT in past. However, this FORTAN based ASPM has several limitations: i) it is very slow, especially for bootstrap variance estimates (it takes more than 10 hours if number of the re-sampling is large), ii) it can handle only a maximum of four fleets, and iii) stock recruitment steepness cannot be fixed (and often estimates unrealistic values of 0.999). To improve these problems, ASPM software using AD Model Builder has been developed and will be released next year.

132. The ADMB based ASPM software was used to conduct the IO BET stock assessment. In the base case run, the selectivity [S] was estimated within the model.

133. The WP requested further clarification on model assumptions and some additional model fits. The 2008 growth curve that was used to create the catch-at-age matrix appeared to be fully consistent with the new tagging results. Exploration of a flat-top longline selectivity function resulted in a more pessimistic assessment, and seemed to be more realistic than the original dome-shaped selectivity. The WP noted that assessments are often sensitive to the interactions between selectivity and natural mortality, and expressed concern about the validity of arbitrarily fixing both sets of assumptions. The summary results from the flat-top model are shown in Figure 64 and Table 4.

134. The WP recognized that ASPM could be a useful model of intermediate complexity. Unlike the age-aggregated production models, it has some capacity to describe the important selectivity shift associated with the development of the purse seine fishery. The WP requested additional implementation details and model diagnostics in future applications.





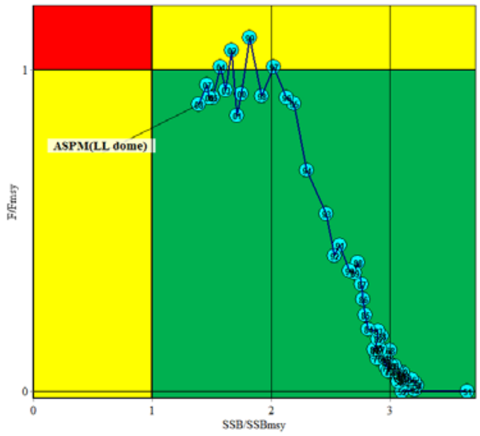


Figure 64. Summary of ASPM assessment results

5.2.3 Stock Synthesis III

135. Working paper IOTC-2009-WPTT-20 was presented, describing an initial stock assessment for bigeye tuna in the Indian Ocean using Stock Synthesis III (SS3), an age-structured, catch-at-length model as a feasibility study. The biomass and recruitment time series, and the stock status reference points obtained from the SS3 model are similar to those of the previous assessment conducted in 2006 using SS2 (Stock Synthesis II) and the absolute biomass levels were a little lower compared with the ASPM and/or ASPIC results. MSY, SSBmsy and Fmsy in the base case model (and sensitivity case corresponding to an alternative CPUE series) were estimated at 190,561 MT (242,197 MT), 461,477 MT (571,298 MT) and 0.290 (0.291), respectively. More optimistic results were obtained when the Taiwanese LL CPUE were included in addition to the Japanese LL CPUE. The choice of CPUE series and the starting year of computation had a large effect on the results.

136. The WP thanked the authors for their work, noting that they were now using the latest available version of this software. The WP also noted a number of concerns about the initial application of this model. The high MSY estimates conflicted with the other models, and were inconsistent with expectations, given the current catches and declining CPUE trends. The declining CPUE trend seemed to be explained by declining recruitment, rather than fishing mortality. The estimated value of SSBMSY/SSB0 was judged to be too low at 25%, and it was thought that this might be a consequence of unrealistic interactions between the dome shaped selectivity and natural mortality assumptions.

137. Additional runs were proposed testing a flat-topped selectivity assumption and an alternative growth curve. These models were more plausible, with the flat-topped selectivity in line with the age-aggregated models. Key results from these models are summarized in Figure 65 and Table 4. The WP encouraged further development of the SS3 bigeye assessment, and recognized that it would be particularly valuable once the tagging data was incorporated.

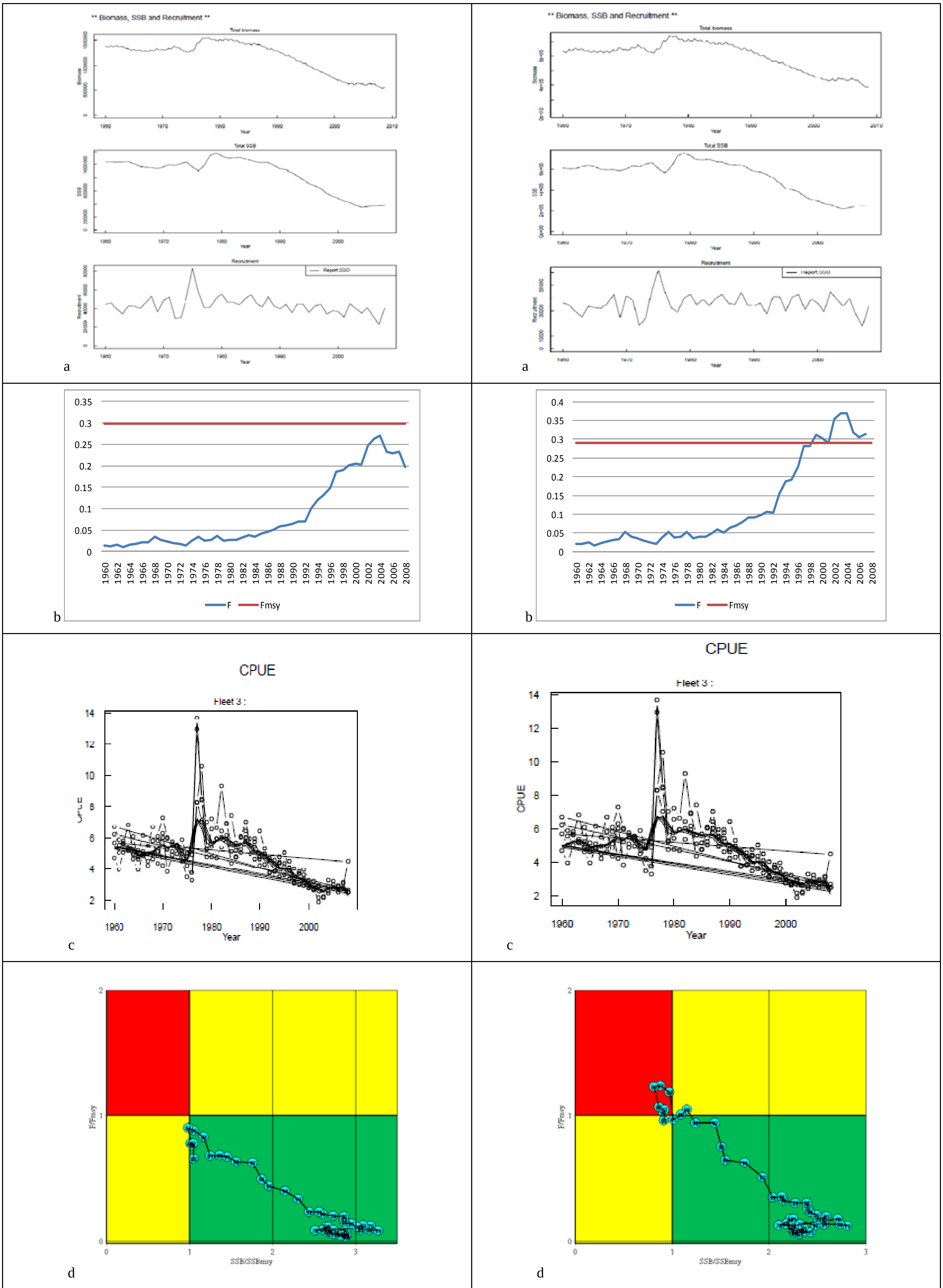


Figure 65. Summary of SS3 assessment results. Left panels represent the dome-shaped selectivity reference case and the right panels represent the flat-topped selectivity sensitivity case (**a.**Biomass, SSB and recruitment, **b.**Exploitation rates, **c.**CPUEs, **d.**Kobe plots).

138. Table 4 illustrates that most of the assessments provide similar reference point estimates, although the WP later based its advice on what it considers as most credible values. The WP noted that the bigeye stock appears to be approaching full exploitation, and recommended a focused effort on the bigeye assessment in the near future, including the tagging data.

139. The various stock assessment models provided a range of estimates for MSY and MSY-related reference values. Given the dynamics of the index of abundance obtained from the Japanese LL CPUE series, and the known limitations of models based on equilibrium assumptions to appropriately model those changes in CPUE, the WPTT considered that the estimates provided by PRODFIT were to be considered not reliable enough and would not be used when providing management advice for the stock. Similarly, the WP was cautious about the estimates of MSY provided by PROCEAN as the catchability estimates appear to interact with the trends in CPUE. The WPTT considered that further work should be carried out to understand the interaction between the CPUE, catchability and equilibrium assumptions in this type of model.

140. The WP recognized the general value of using multiple models in an assessment, including a range from simple production models to highly disaggregated integrative models. Identifying differences and exploring the cause of the differences in model inferences is expected to result in a more robust assessment. Some combination of simple and complex models was encouraged for future years.

Table 4. Summary of BET assessment results from a range of models

MODEL	MSY (1000 t)	B/BMSY	F/FMSY	SSB/SSBMSY
PRODFIT base case	132	1.30	0.65	
PROCEAN base case	127	1.24	0.67	
ASPIC JPN 1x1 CPUE (80%bootstrap)	116 (87 – 123)	1.17 (1.05 – 1.31)	0.92 (0.79 - 1.11)	
ASPM flat-top sel (80%bootstrap)	99 (71-128)		0.89 (0.56-1.22)	1.17 (0.74 – 1.62) (SSB)
SS3 *flat-top sel* (90%CI)	*113* *(110 - 117)*		*0.99*	*0.91* (SSB)

141. A demonstration of the Japanese software for producing Kobe plots was presented (IOTC-2009-WPTT-26). The Kobe diagram is one of the key tools for managers and scientists, allowing visualization of the biomass and fishing mortality time series trajectories and current stock status. In order to produce this plot easily, quickly and effectively, the menu driven software is under development. Using the software, two types of plots can be made: (i) Point estimates with any confidence interval, or ii) point estimates for multiple trajectories. Future projection can be included. Joint uncertainty in B and F can also be shown. This software will be completed in 2010.

5.3. Research recommendation:

142. Since several years, the high catches of juvenile BET tuna in the purse seine FAD fishery have been noted. The WPTT recommended that the effect of this mortality on the stock status should be re-investigated.

5.4. Technical advice on Bigeye Tuna

143. In 2009 the WPTT analysed the status of the bigeye tuna stock using a range of stock assessments, from biomass dynamics to age and length-structured integrated statistical models, with a range of assumptions and data

requirements. The quality of the estimates of bigeye growth has been much improved, by the RTTP–IO tagging data.

144. The recoveries available so far from the RTTP-IO project indicate that bigeye tuna in the Indian Ocean consists of a single stock.

145. The Japanese longline CPUE-based index of abundance is the main dataset informing the models used on the trends and status of the stock. The attempts at using statistical methods to explain the changes in targeting and efficiency in this dataset have not provided a full explanation of the actual dynamics of this fleet.; this significantly limits the use of the whole series as sole indicator of stock abundance. Several features in the series, which cannot be attributed to changes in stock abundance, remain unexplained. However, fine-scale longline CPUE-based indices, limited to a shorter period (1980-2008) provided better information on the trends in abundance.

5.4.1 MANAGEMENT ADVICE

Current status

146. The results of the stock assessments conducted in 2009 were broadly similar to previous work. Current (2008) exploitation levels for this stock (107,000 t) are within the range of estimated MSY levels (100,000 - 115,000 t), catches in the past (1997-1999) have significantly exceeded MSY.

147. Estimated values of fishing mortality and SSB for 2008 are also close to MSY-related values, indicating a fully exploited stock.

Outlook

148. Recent changes in the areas fished by purse seiners do not appear to have had an effect on mortality for juvenile bigeye, despite the decrease in effort in the Somali basin where fishing on FADs usually caught the majority of juvenile bigeye.

149. The indices of abundance from two longline fleets available for this stock present divergent trends over the last few years, the differences observed in targeting are not fully explained.

Recommendations

150. The WPTT recommends that catches of BET should not exceed MSY levels and that effort should be maintained at or below that of 2006.

6. SKIPJACK TUNA

6.1. Introduction

151. An Ad Hoc analysis of the purse seine skipjack CPUE from FAD/log-associated schools was presented (AdHoc7). The analysis was of EU, Seychelles and other flags purse seine logbooks for the period July to November for the entire time series 1984-2008. In the absence of a GLM analysis, refined CPUE indices were produced from the method already described for yellowfin. CPUEs were computed from two types of efforts, by positive set and by searching time. A base case and two cases of 2% and 3% increase in fishing efficiency were applied on searching time to explore the effect on the CPUE trend. There was no a priori for selecting these rates of increase in fishing effort, but they were considered plausible given the observed increase in efficiency over the years especially in the purse seine FAD fishery (use of supply vessels, use of buoys on FADs, more efficient sonars to locate the core of the school). The indices were averaged at three nested spatial scales in the north equatorial region to investigate the account for the expanding size of the fishery in the recent years: a core zone (0°-5°N / 50°E-55°E) where catch are the highest for the region, an intermediate zone (0°-10°N / 50°E-60°E) and a large zone (0°-15°N / 45°E-75°E) encompassing the present distribution of the associated catches north of the equator. With respect to the catch per positive sets, trends are similar over the three areas with an overall decline of 26 to 29% between 1984 and 2008. When considering the base case, catch per searching time fluctuate without trend. For all areas, a range of 32-38% overall decline in CPUE was observed for 2% increase in fishing effort and ca. 58% decline for 3% increase in fishing efficiency over the entire time series. Mean weights of skipjack caught on logs were also shown to be declining and this trend was consistent for all major areas of the skipjack

purse seining fleet (Figure 66). This is also visible in catch-at-size (Figure 31) showing a decrease of the size of the skipjack caught during the last two years. A decrease in mean weight of skipjack was also seen which was estimated to be 28-31% relative to the start of the time period (from 3.3 to 2.4 kg). The rate of decline in mean weight was particularly high at all latitudes during the last 2 years of the series (2007 and 2008). The yearly size distribution of the PS data also showed a sharp declining large skipjack in the last two years. However, it was noted that the current small size of skipjack are above the size at first maturity.

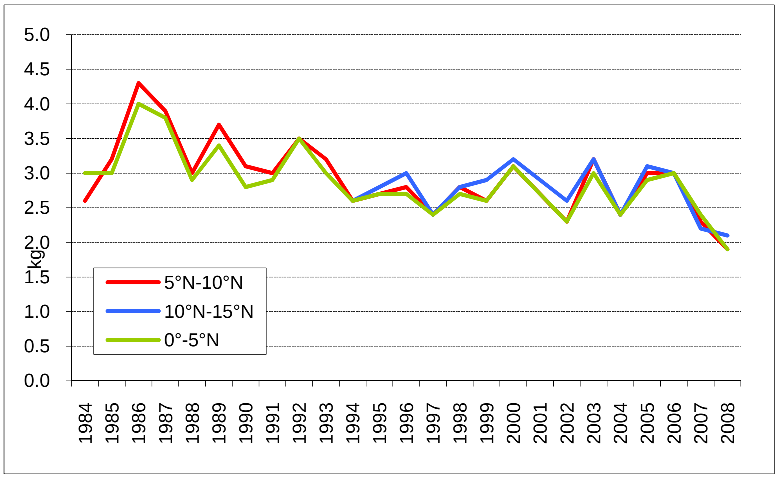


Figure 66. **Mean weight of skipjack caught by purse seiners on logs according to latitude**

152. The WP recommended that priority is given to undertaking a formal assessment of skipjack in 2010.

6.2. Technical advice on Skipjack Tuna

Current status

153. The high productivity and life history characteristics of skipjack tuna suggest this species is resilient and not easily prone to overfishing. However, the analysis of some indicators of stock status for recent years suggests that the situation of the stock should be closely monitored in 2010.

Outlook

154. No new analysis has been carried out this year that allows the WPTT to predict the future evolution of this stock.

Recommendations

155. Given the limited nature of the work carried out on the skipjack in 2009, no new advice is provided for the stock.

7. EFFECT OF PIRACY ON INDIAN OCEAN TROPICAL TUNA FISHERIES

156. The group was presented with a number of initial analysis of the effects on the tropical tuna fishery of the acts of piracy that have taken place in recent times around, but not exclusive to, the coast of Somalia. A number of vessel, including fishing vessels fishing for tuna, have suffered attacks and kidnappings, and the situation has led to a displacement of the activity of some fleets. The purse seine fleet commonly operating from Mahé, Seychelles, even decided to move their operations away from their usual base port for a period of time last year.

157. A preliminary investigation into the effect of changing spatial fleet dynamics on yellowfin in the Indian Ocean through a spatial model of catch redistribution was presented in document IOTC-2009-WPTT-32. The possible effects that the displacement by the purse seine fleet of catches of between areas with different length distributions of yellow tuna was analysed. The changes brought do not seem significant, but the issue of effort re-distribution remains to be examined in detail.

158. The WPTT welcomed this effort, and considered very useful the development of this type of tools that could help the SC evaluating the effect of certain developments in the spatial dynamics of the fishery and on the status of the stock.

159. A presentation to the WPTT attempted to summarise the changes in the fishing activities of EU purse seiners over the last few years and explore how much of that pattern could be related to the threat of piracy. Since 2008, the fishing fleets fishing off the coasts of Somalia have been subject to about 13 attacks, with 4 successful hijackings. To ensure security for their crew members, European fishing companies have defined a ~500-600 nm eastern limit off the Somali coasts in September 2008 where their purse seiners should not operate. Since July 2009, 4 military personnel boarded each purse seiner flying the French flag, allowing for an extension of the fishing area back to the ~300 nm eastern limit off the Somali coasts. The military presence onboard purse-seiner halted the observer programmes.

160. The spatial reallocation of fishing effort of vessels occurring within the vicinity of the zone where attacks have taken place was assessed visually through maps of catch for recent years (Figure 67). The potential displacement of Japanese and Taiwanese longliners was difficult to assess due to the coarse level of the geographic position of catch data available, *i.e.* on a 5*5-degree basis. For the European purse seiners, a clear avoidance of the extended Somali area (500nm off the coast) was shown from both catch and VMS data (Figure 68). This area represented during the period 2000-2005 an average of 25%, 45%, and 38% of the European purse seiner catch of yellowfin, skipjack, and bigeye, respectively. Since September 2008, 10 purse seiners have left the Indian Ocean because of low catch rates and non-access to the fishing grounds off Somalia.

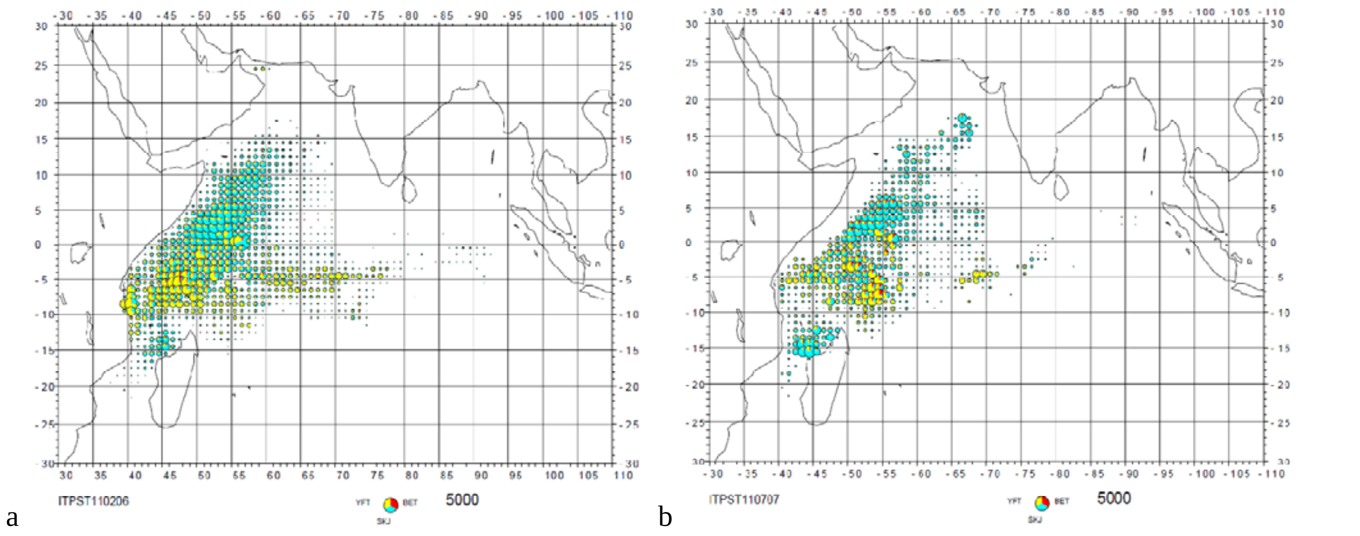


Figure 67. Catches of tropical tunas by European purse-seiners in a)2002-2006 and b)2007.

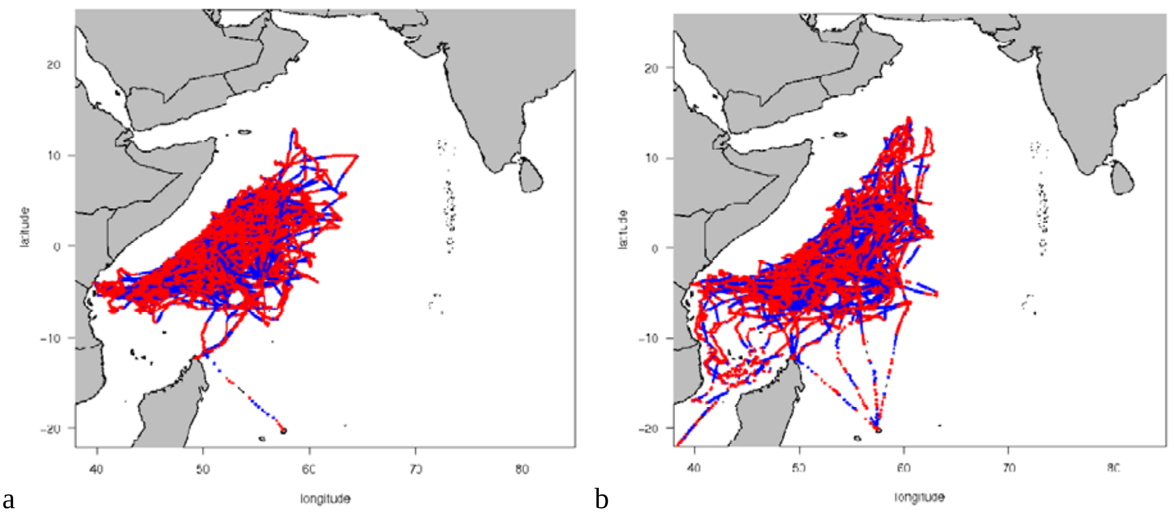


Figure 68. VMS tracks (red day, blue night) of French purse seiners from July to September in a) 2007 and b) 2008 (*source E. Walker, IRD*).

161. The change in the activity of the purse seiners due to piracy led them to unload in port where less sampling could be conducted. This has had an impact in the level of sampling of catches from that fleet for that period, which could have a negative impact in the quality of the catch at size by specie estimates used in stock assessments.

162. The WPTT welcomed these initial analyses and reiterated its support for the fleets operating under threat. Further exploration of the data, and specially the effect of other recent changes in the fishery on the patterns observed needs to be analysed in detail. The high catches of yellowfin tuna during 2003-2006 and the extension of piracy in the Indian Ocean, led to a shift in fishing grounds away from those typically used for the Skipjack FAD-based fishery. This limits the use of the years between 2003-2006 for comparisons on the effect of piracy.

163. The WPTT recommended that a number of scientists, co-ordinated by the chair, will work on extending these analyses and present them to the next meeting of the Scientific Committee so that they can then be made available to the Commission.

8. OTHER BUSINESS

164. The WP noted that the RTTP-IO was coming to an end as a separate project, although recovery of tags will continue and will be handed by the IOTC Secretariat. The staff of the RTTP-IO project were also coming to the end of their contracts. The WP once again recognized the immense contribution that the RTTP-IO project has made to our knowledge of the tropical tuna stocks and fisheries in the Indian Ocean and wished the members of the RTTP-IO team good luck in future endeavours.

165. IPTP documents are now scanned and available upon request to the Secretariat.

166. The WPTT express its satisfaction for the preparation of the data and work undertaken prior to the meeting by the Secretariat and Dr. Adam Langley. The WPTT recommends that Dr. Langley still be involve in the assessment of tropical tuna stocks with the IOTC.

9. SUMMARY OF WPTT RECOMMENDATIONS IN 2009

DATA

1. That the actions in Table 1 (Page 8) be taken to improve the standing of the data on tropical tuna species currently available at the Secretariat (Paragraph 5).
2. The WPTT recommends that complete and good quality data, as per IOTC requirements, is reported to IOTC Secretariat in due time, as these data are essential to the provision of scientific advice on stock status (Paragraph 6).
3. The WPTT recommends that the IOTC-OFCF program to improve data collection and statistics should continue and be extended (Paragraph 8).
4. The WPTT recommends that size data collection for yellowfin in Maldives continue and, if possible, data is collected separate for both fleets operating in that fishery (Paragraph 25).
5. The WPTT recommends that data is collected and analysed to prepare abundance indicators for purse seiners based on numbers and catches around FADs (Paragraph 47).
6. The WPTT recommends that data is collected on technological change in the purse seine fleet in order to improve the use of its CPUE series as an index of abundance of the stocks (Paragraph 82).

DATA ANALYSIS

7. The WPTT recommends that the differences between data reported in a recent document (IOTC-2009-WPTT-09) and previous literature regarding catches and setting times on FADs should be investigated (Paragraph 50).
8. The WPTT recommends that electronic tagging data is analysed in order to better understand the dynamics of residency of tuna around FADs ((Paragraph 68).
9. The WPTT recommends that further work on the various factors linked to fishing efficiency, such as gear change, use of technology and skipper experience, is carried out for the longline CPUE-based indices of abundance (Paragraph 79).

10. The WPTT recommends that a more detailed analysis is carried out and presented on the relative influence of the various factors introduced in the standardization process of the longline CPUE series on the estimated trends (Paragraph 81).
11. The WPTT recommends the continuing development and improvement of the MFCL model implementation for yellowfin tuna and the future involvement of the external consultant responsible for its application to Indian Ocean yellowfin (Paragraph 99).
12. The WPTT recommends that an important effort is made to assemble the necessary scientific knowledge that will enable a more detailed and precise evaluation of the status of the skipajck tuna resource in the Indian Ocean. Particular effort should be made in developing a range of indices of abundance, in application of indicators and estimators of exploitation rates based on tagging data, and in assembling a range of data sources, indicators and models that would allow the WPTT to provide well-backed advice on skipjack in 2010 (Paragraph 152).

RESEARCH

13. The WPTT recommends that national scientists conduct further research into the apparent declining trend in skipjack tuna length in purse seine catches to understand the reasons behind it (Paragraph 36).
14. The WPTT recommends that further research in carried out on the growth of yellowfin and bigeye tuna by means of otolith analysis. Samples should be obtained from the longline fisheries and from different areas of the Indian Ocean. Furthermore, and as a means to validate otolith readings, the WPTT recommends to compare the number of days estimated from otolith readings with the number of days-at-liberty obtained for tagged specimens with known date-at-release and date-at-recovery. The WPTT also recommends that sex and other biological information should be obtained from recaptured tagged fish of large size (Paragraph 57).
15. The WPTT recommends that new small-scale tagging programmes should be initiated, in particular in Maldives, and that additional funds should be secured for these activities to be carried out (Paragraph 69).
16. The WPTT recommends that the relative importance and future effects of the current levels of catches on juvenile bigeye tuna around FADs be re-investigated (Paragraph 142).

PIRACY

17. The WPTT recommends more analysis to be developed regarding the effect of piracy on the spatial dynamics of the purse seine and longline fleets and their respective catch and present them to the next meeting of the Scientific Committee so that they can then be made available to the Commission (Paragraph 163).

10. ADOPTION OF THE REPORT

167. The WPTT express its thanks the Fisheries Department and to the government of Kenya for hosting the meeting, providing support to the Secretariat and for their warm welcome to Mombasa.

168. The Report was adopted in the main on Friday 23 October 2009 and finalised by correspondence on 10 November 2009.

APPENDIX I

DRAFT AGENDA FOR THE 11TH SESSION OF THE WORKING PARTY ON TROPICAL TUNAS, 15-23 OCTOBER 2009

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

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

Update: Regional Tuna Tagging Programme – Indian Ocean

3. REVIEW OF NEW INFORMATION ON THE STATUS OF YELLOWFIN

Data for input into stock assessments:

- Catch and effort
- Catch at size
- Growth curves and age-length key
- Catch at age
- CPUE indices and standardised CPUE indices
- Tagging data
- Stock assessments
- Selection of Stock Status indicators

4. REVIEW OF STOCK STATUS INDICATORS FOR SKIPJACK Review of data:

- Catch and effort
- Catch at size
- CPUE
- Tagging data
- Selection of Stock Status indicators

5. REVIEW OF NEW INFORMATION ON THE STATUS OF BIGEYE

Data for input into stock assessments:

- Catch and effort
- Catch at size
- Growth curves and age-length key
- Catch at age
- CPUE indices and standardised CPUE indices
- Tagging data
- Stock assessments

- Selection of Stock Status indicators

6. DEVELOP TECHNICAL ADVICE ON THE STATUS OF THE STOCKS

- Yellowfin tuna
- Skipjack tuna
- Bigeye tuna

7. RECOMMENDATIONS AND PRIORITIES

- Recommendations on alternative data collection and sampling
- Research recommendations

8. EFFECT OF PIRACY ON TROPICAL TUNA CATCHES

9. OTHER BUSINESS

APPENDIX II

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APPENDIX III

Document	Title	Availability
IOTC-2009-WPTT-01	Draft agenda of the Working Party on Tropical Tunas	✓
IOTC-2009- WPTT-02	WPTT List of documents	✓
IOTC-2009-WPTT-03	Statistics of the purse seine Spanish fleet in the Indian Ocean (1984-2008). *A. Delgado de Molina, JJ. Areso , M. Soto and J. Ariz*	✓
IOTC-2009-WPTT-04	Application of Global Generalized Models to BET stocks". *E. Chassot, T. Nishida and A. Fonteneau*	
IOTC-2009-WPTT-05	Japanese longline CPUE for bigeye tuna in the Indian Ocean up to 2008 standardized by GLM. *H. Okamoto, K. Satoh and H. Shono*	✓
IOTC-2009-WPTT-06	Standardization of annual and quarterly CPUE for yellowfin tuna caught by Japanese longline fishery in the Indian Ocean up to 2008 using general linear model. *H. Okamoto, K. Satoh and H. Shono*	✓
IOTC-2009-WPTT-07	SImulatioN of TAGs (SINTAG) revisited: An updated model to estimate the number and size of tunas tagged by the RTTP-IO that are still alive in 2009. *P. A. de Bruyn, H. Murua and A. Fonteneau*	✓
IOTC-2009-WPTT-08	Use of the De Finetti ternary diagrams to show the species composition of free and FAD-associated tuna schools in the Atlantic and Indian oceans. *A. Fonteneau, E. Chassot, S. Ortega-García, A. Delgado de Molina and N. Bez*	✓
IOTC-2009-WPTT-09	Analysis of purse seine set times for FAD and free school associations in the Atlantic and Indian ocean. *A. Fonteneau, J. Ariz, A. Damiano and A. Delgado de Molina*	✓
IOTC-2009-WPTT-10	Stock assessment of yellowfin tuna in the Indian Ocean using MULTIFAN-CL. *A. Langley, M. Herrera, JP. Hallier and J. Million*	✓
IOTC-2009-WPTT-11	Preparation of data input files for the assessments of Indian Ocean yellowfin tuna stock using Multifan-CL. *M.Herrera, IOTC Secretariat*	✓
IOTC-2009-WPTT-12	Estimation of Catch-at-Size, Catch-at-Age and Total Catch per Area. *M.Herrera, IOTC Secretariat*	✓
IOTC-2009-WPTT-13	Status of IOTC databases for TROPICAL TUNAS. *M.Herrera, L. Pierre, IOTC Secretariat*	✓
IOTC-2009-WPTT-14 (pres)	Update 2009 on climate and oceanographic conditions in the Indian Ocean. *F. Marsac*	✓
IOTC-2009-WPTT-15	Development of Large Yellowfin Tuna Fishery in Maldives. *M. Shiham Adam, A. Riyaz Jauharee and R. Charles Anderson*	✓
IOTC-2009-WPTT-16	Preliminary Analysis of Small Scale Tuna Tagging Programme – Maldives 2007. *A. Riyaz Jauharee, M. Shiham Adam and C. Anderson*	
IOTC-2009-WPTT-17	Estimate of the non-linear growth rate of yellowfin tuna (*Thunnus albacares*) in the Atlantic and in the Indian Ocean from tagging data. *D. Gaertner, E. Chassot, A. Fonteneau, J.P. Hallier and F. Marsac*	✓
IOTC-2009-WPTT-18	BET fine scale STD CPUE. *K. Satoh, T. Nishida, H. Okamoto and H. Shono.*	✓
IOTC-2009-WPTT-19	Comparative study of the distribution of natural versus artificial drifting Fish Aggregating Devices (FADs) in the Western Indian Ocean *T. Fauvel, N. Bez, E. Walker, A. Delgado, H. Murua, P .Chavance, L. Dagorn*	✓
IOTC-2009-WPTT-20	Updated stock assessment for bigeye tuna in the Indian Ocean up to 2008 using Stock Synthesis III (SS3). *H. Shono, K. Satoh, H. Okamoto and T. Nishida*	✓
IOTC-2009-WPTT-21	On the need to know the sex of the large yellowfin tagged when they are recovered by fisheries. *A. Fonteneau and P. Dewals*	✓
IOTC-2009-WPTT-22	Statistics of the main purse seine fleets fishing in the Indian Ocean (1981-2008). *R. Pianet, A. Delgado de Molina, J. Doriso, P. Dewals, V. Norström and J. Ariz.*	✓
IOTC-2009-WPTT-23	French purse-seine tuna fisheries statistics in the Indian Ocean, 1981-2008. *R. Pianet, V. Nordstrom and P. Dewals.*	✓
IOTC-2009-WPTT-24	The contribution of the Regional Tuna Tagging Project – Indian Ocean to IOTC. *JP. Hallier and J. Million*	✓
IOTC-2009-WPTT-25	*Development of the ADMB based ASPM software (final stage): Rademeyer and Nishida*	✓
IOTC-2009-WPTT-26(pres)	Development of the Stock Trajectory (Kobe plot) software (initial stage): *Nishida, Matsuo and Itoh*	✓
IOTC-2009-WPTT-27 (pres)	BET SA by the ADMB based ASPM : *Nishida and Rademeyer*	✓
IOTC-2009-WPTT-28	Preliminary analysis of fishing activities of Purse Seiners fishing in the Western Indian Ocean over the period January to June 2009. *J. Dorizo,V. Lucas, C. Assan, and A. Fonteneau*	✓
IOTC-2009-WPTT-29	CPUE Standardizations for Yellowfin Tuna Caught by Taiwanese Longline Fishery in the Indian Ocean Using Generalized Liner Model and Generalized Linear Mixed Model. *Y.M Yeh and S.T. Chang*	✓
IOTC-2009-WPTT-30	Standardized Taiwanese CPUE for bigeye tuna in the Indian Ocean. *S.T. Chang and Y.M. Yeh*	✓
IOTC-2009-WPTT-31 (pres)	Update of the study of growth of yellowfin and bigeye tuna (*Thunnus albacares* and *T. obesus*) from the Indian Ocean by otolith microincrement analysis. *E. Morize, C.A. Davies, E. Dabas, J.M. Muraron*	✓
IOTC-2009-WPTT-32	Preliminary investigation into the effect of changing spatial fleet dynamics on yellown in the Indian Ocean. *C.T.T. Edwards*	✓
IOTC-2009-WPTT-33 (pres)	Changes in Fishing Gear- Impact on Tropical Tuna Landing. *B.C. Varghese*	✓
IOTC-2009-WPTT-34	An Updated Analysis of Tag-Shedding by Tropical Tunas in the Indian Ocean. *D. Gaertner, J.P. Hallier*	✓
IOTC-2009-WPTT-Inf01	Note upon difficulties, uncertainties and potential bias in the multispecies sampling and data processing of large tunas (yellowfin, bigeye and albacore) sampled in free schools by the Indian Ocean and Atlantic purse seiners. *A. Fonteneau, A. Hervé, R. Pianet, A. Delgado de Molina and V. Nordstrom*	✓
IOTC-2009-WPTT-Inf02	Environmental preferences of bigeye tuna, *Thunnus obesus*, in the Indian Ocean: an application to a longline fishery. *L. Song, J. Zhou, Y. Zhou, T. Nishida, W. Jiang and J. Wang.*	✓
IOTC-2009-WPTT-Inf03	Considerations of stock structure of yellowfin tuna (*Thunnus albacares*) in the Indian Ocean based on fishery data. *T. Nishida*	✓

Document	Title	Availability
IOTC-2009-WPTT-Inf04	Comparison between GLM and Spatial GLM : *Pereira, Leandro, Petrere and Nishida*	✓
IOTC-2009-WPTT-Inf05a	Pelagic protected areas: the missing dimension in ocean conservation. *E.T. Game, H.S. Grantham, A.J. Hobday, R.L. Pressey, A.T. Lombard, L.E. Beckley, K. Gjerde, R. Bustamante, H.P. Possingham and A.J. Richardson*	✓
IOTC-2009-WPTT-Inf05b	Pelagic MPAs: The devil is in the details. *D.M. Kaplan, E. Chassot, A. Gruss and A. Fonteneau*	✓
IOTC-2009-WPTT-Inf05c	Response to Kaplan *et al.:* Pelagic MPAs; the devil you know. *E.T. Game, H.S. Grantham, A.J. Hobday, R.L. Pressey, A.T. Lombard, L.E. Beckley, K. Gjerde, R. Bustamante, H.P. Possingham and A.J. Richardson*	✓
IOTC-2009-WPTT-Inf06ab	Review on tuna tagging experiments in the eastern-central Indian Ocean for 30 years (1980-2009) and its future prospect. *T. Nishida*	✓
IOTC-2009-WPTT-Inf07	An Example of the use of Management Strategy Evaluation for North Atlantic Albacore, using Multifan-CL and FLR. *L. T. Kell, P. De Bruyn, M. Soto Ruiz and H. Arrizabalaga*	✓
IOTC-2009-WPTT-Inf08	Evaluation of Management Advice for North Atlantic Albacore; Linking MULTIFAN-CL and FLR. *L.T. Kell, P. De Bruyn, M. Soto Ruiz and H. Arrizabalaga*	✓