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

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

Victoria, Seychelles, 18-25 October, 2010

IOTC-2010-WPTT-R[E]

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1. OPENING OF THE MEETING AND ADOPTION OF THE AGENDA

1. The twelfth Session of the Working Party Tropical Tunas (WPTT) was opened in Victoria, Seychelles on the 18th October 2010. The Chair, Dr. Iago Mosqueira, welcomed the participants and the Chair of the Scientific Committee, Dr. Francis Marsac, introduced the results of and the questions raised during the last Session of the Commission that was held in Busan, Korea, in March 2010.

2. 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-2010-WPTT-03). The following information is a summary for each of the three tropical species.

2.1. Bigeye tuna (BET)

Retained catches are thought to be 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 largely unknown for some artisanal fisheries including the pole-and-line fishery in the Maldives, the gillnet fisheries of Iran and Pakistan, the gillnet/longline fishery in Sri Lanka and the artisanal fisheries in Indonesia, Comoros and Madagascar.

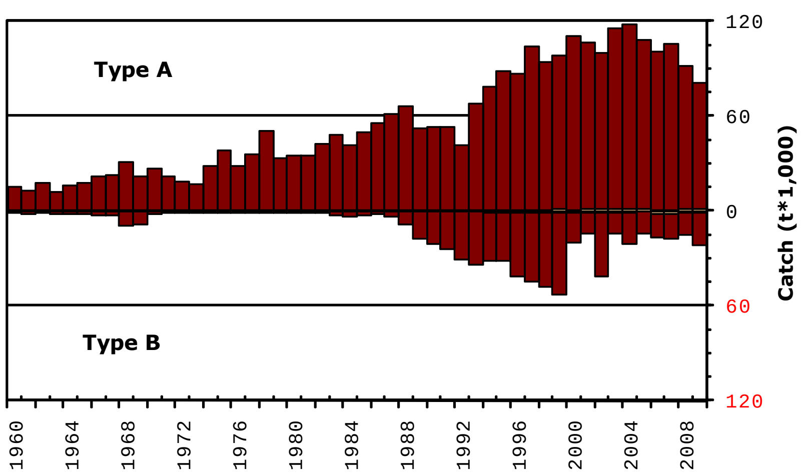


Figure 1. Uncertainty of annual catch estimates for bigeye tuna (Data as of September 2010)

Catches below the zero-line (Type B) refer to fleets that do not report catch data to the IOTC (estimated by the IOTC Secretariat), do not report catch data by gear and/or species (broken by gear and species by the IOTC Secretariat) or any of the other reasons provided in the document. Catches over the zero-line (Type A) refer to fleets for which no major inconsistencies have been found to exist. Light bars represent data for artisanal fleets and dark bars represent data for industrial fleets.

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 2009 (Figure 2).

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 and in recent years, 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 up to 2006)
- No data available for the gillnet fisheries of Iran and Pakistan and the gillnet/longline fishery of Sri Lanka, especially in recent years.

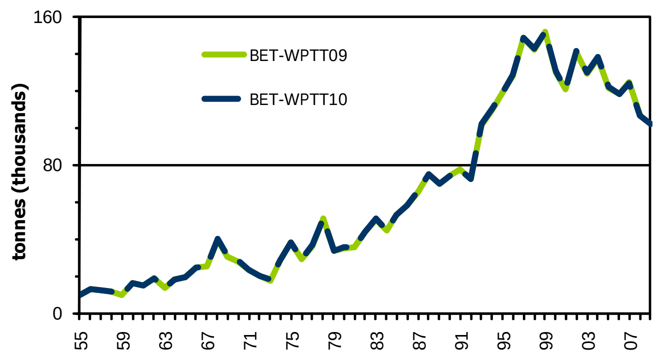


Figure 2. Bigeye tuna: Catches used by the WPTT in 2009 versus those estimated for the WPTT in 2010 (1955-2009)

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).

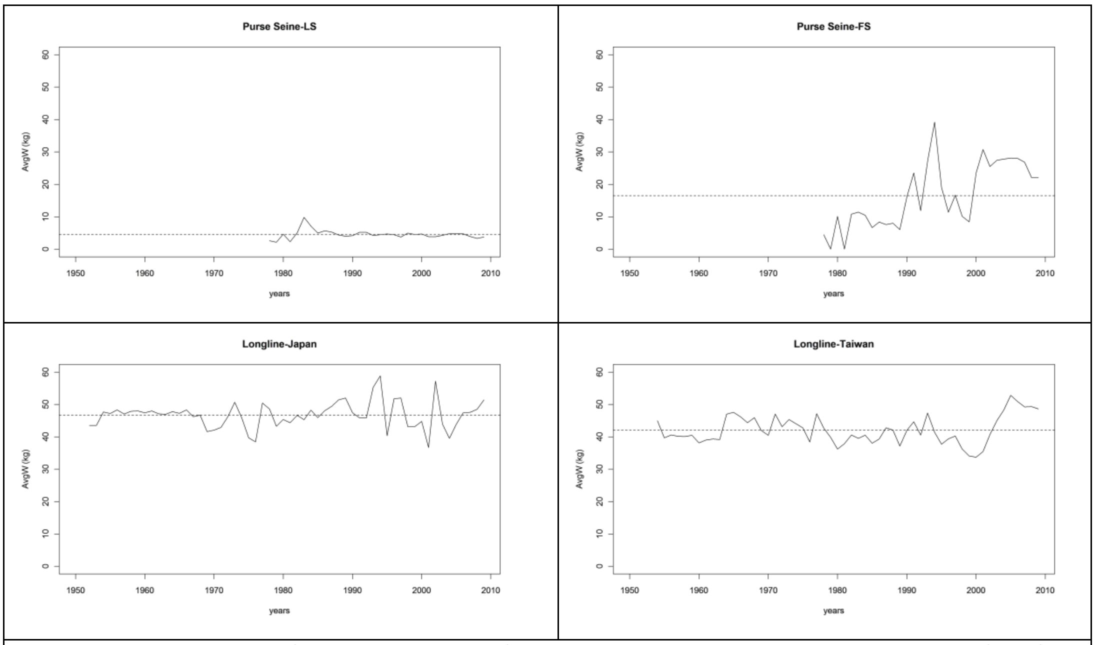


Figure 3. BET average weight for purse-seine (log and free school), longline (Japan and Taiwan) and artisanal fleets from 1950 to 2009

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 recent years (Japan)
- the paucity of catch by area data available for some industrial fleets (NEI, India, Indonesia, Iran, Sri Lanka)

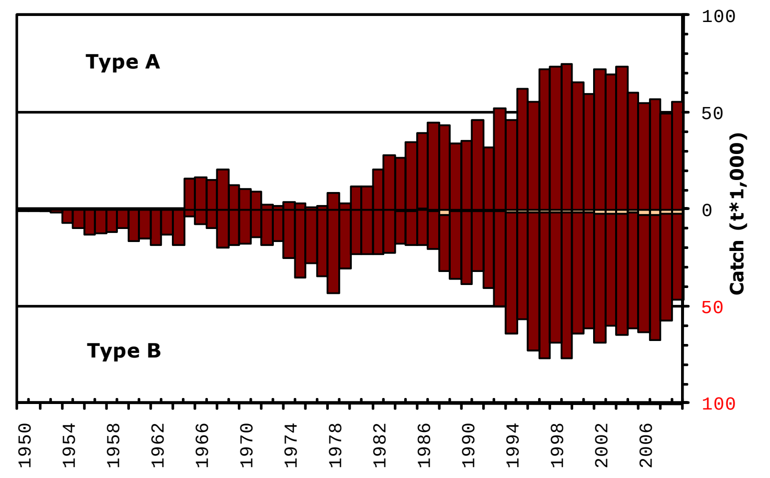


Figure 4. Uncertainty of catch-at-size data for bigeye tuna (Data as of September 2010)

Catches below the zero-line (Type B) refer to fleets that do not report length data to the IOTC, do not report length data by gear, species, month, fishing area or any of the other reasons given in the document. Catches over the zero-line (Type A) refer to fleets for which no major inconsistencies have been found to exist. Light bars represent data for artisanal fleets and dark bars represent data for industrial fleets.

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 and coastal fisheries, the coastal fisheries of Comoros and Madagascar 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.

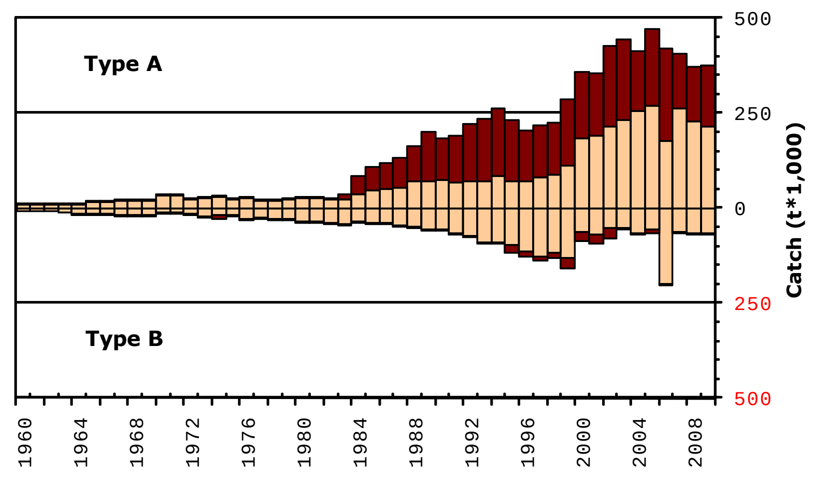


Figure 5. Uncertainty of annual catch estimates for skipjack tuna (Data as of September 2010)

Catches below the zero-line (Type B) refer to fleets that do not report catch data to the IOTC (estimated by the IOTC Secretariat), do not report catch data by gear and/or species (broken by gear and species by the IOTC Secretariat) or any of the other reasons provided in the document. Catches over the zero-line (Type A) refer to fleets for which no major inconsistencies have been found to exist. Light bars represent data for artisanal fleets and dark bars represent data for industrial fleets.

Changes to the catch series: There have been no major changes to the catches of skipjack tuna since the WPTT in 2009 (Figure 6).

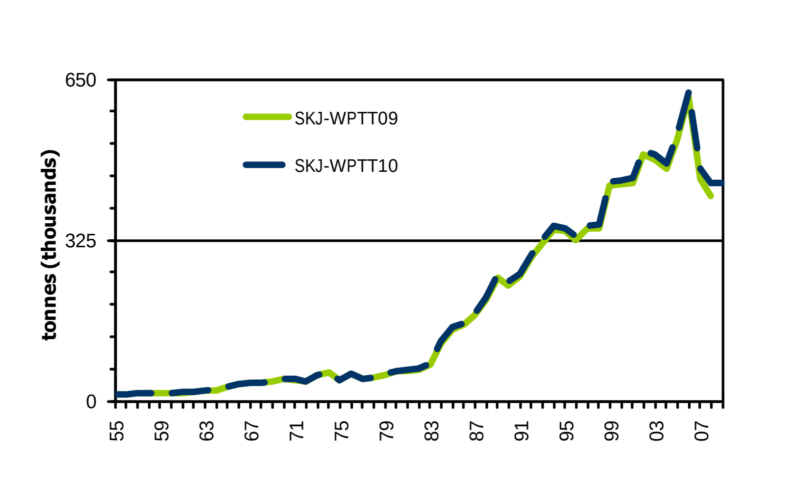


Figure 6. Skipjack tuna: Catches used by the WPTT in 2009 versus those estimated for the WPTT in 2010 (1955-2009)

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

- no data are available for the gillnet fisheries of Iran and Pakistan
- the poor quality effort data for the significant gillnet/longline fishery of Sri Lanka
- no data are available from important coastal fisheries using hand and/or troll lines, in particular Indonesia, Madagascar and Comoros

Trends in average weight cannot be assessed before the mid-1980s and are incomplete for most artisanal fisheries thereinafter, namely hand lines, troll lines and many gillnet fisheries (Indonesia) (Figure 7).

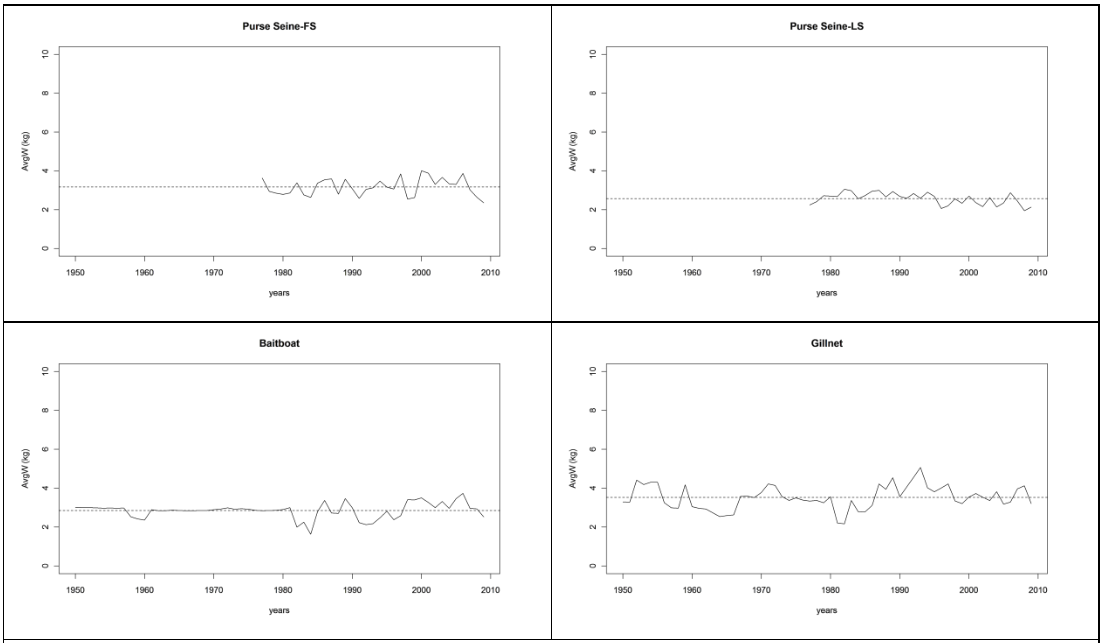


Figure 7. SKJ average weight for purse-seine (log and free school), baitboat and gillnet fleets from 1950 to 2009

Catch-at-Size table: CAS are available but the estimates are uncertain for some years and fisheries due to (Figure 8):

- 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 (Madagascar, Comoros) and many gillnet fisheries (Indonesia, Sri Lanka)

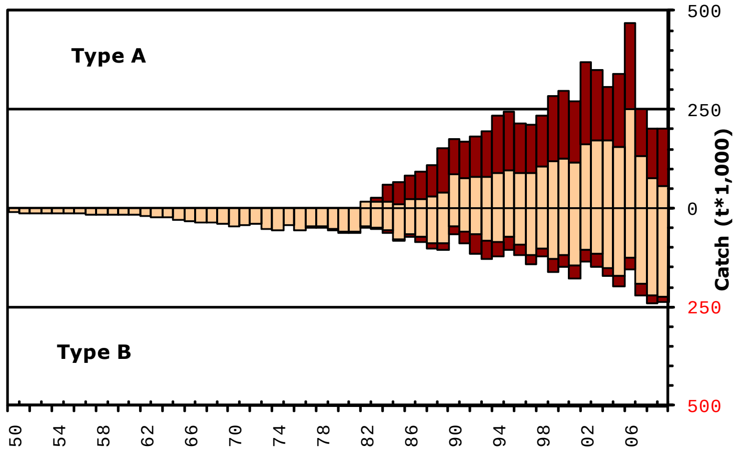


Figure 8. Uncertainty of catch-at-size data for skipjack tuna (Data as of September 2010)

Catches below the zero-line (Type B) refer to fleets that do not report length data to the IOTC, do not report length data by gear, species, month, fishing area or any of the other reasons given in the document. Catches over the zero-line (Type A) refer to fleets for which no major inconsistencies have been found to exist. Light bars represent data for artisanal fleets and dark bars represent data for industrial fleets.

2.3. Yellowfin tuna (YFT)

Retained catches are generally well known (Figure 9); however, catches are less certain for:

- many coastal fisheries, notably those from Indonesia, Sri Lanka, Yemen, Madagascar and Comoros
- the gillnet fisheries of Iran and Pakistan and the gillnet/longline fishery of Sri Lanka
- non-reporting industrial purse seiners and longliners (NEI), and longliners of India .

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.

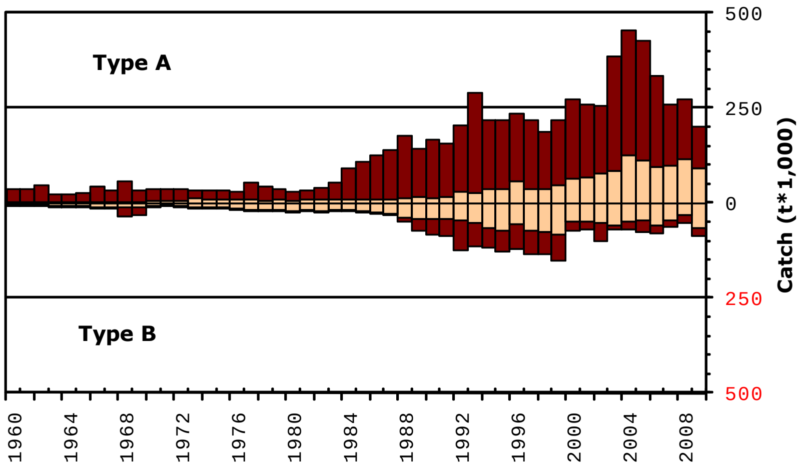


Figure 9. Uncertainty of annual catch estimates for yellowfin tuna (Data as of September 2010)

Catches below the zero-line (Type B) refer to fleets that do not report catch data to the IOTC (estimated by the IOTC Secretariat), do not report catch data by gear and/or species (broken by gear and species by the IOTC Secretariat) or any of the other reasons provided in the document. Catches over the zero-line (Type A) refer to fleets for which no major inconsistencies have been found to exist. Light bars represent data for artisanal fleets and dark bars represent data for industrial fleets.

Changes to the catch series: There have not been significant changes to the catches of yellowfin tuna since the WPTT in 2009 (Figure 10).

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:

- no data are available for the gillnet fisheries of Iran and Pakistan
- the poor quality effort data for the significant gillnet/longline fishery of Sri Lanka
- no data are available from important coastal fisheries using hand and/or troll lines, in particular Yemen, Indonesia, Madagascar and Comoros.

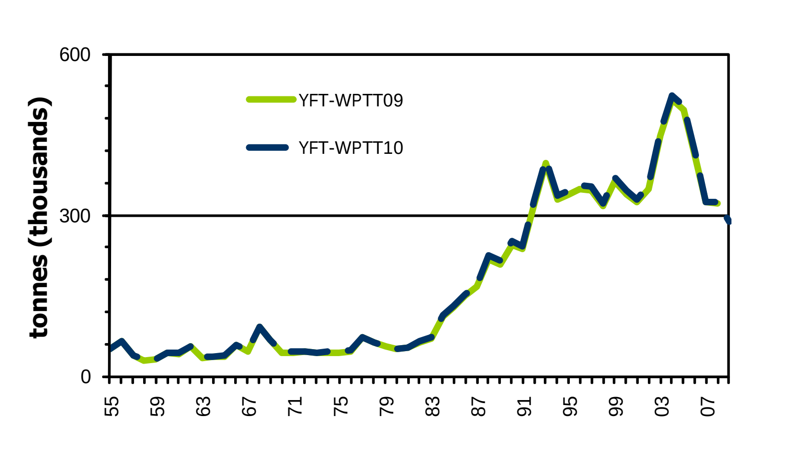
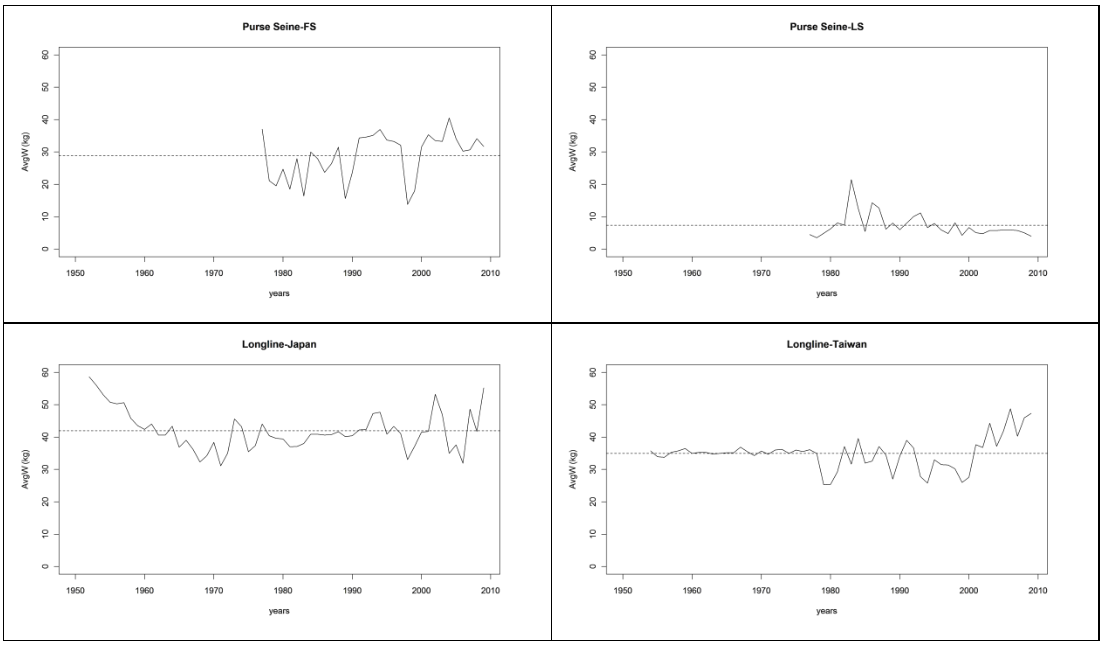


Figure 10. Yellowfin tuna: Catches used by the WPTT in 2009 versus those estimated for the WPTT09 (1955-2009)

Trends in average weight can be assessed for several industrial fisheries but they are very incomplete or of poor quality for some fisheries, namely hand lines (Yemen, Comoros, Madagascar), troll lines (Indonesia) and many gillnet fisheries (Figure 11).



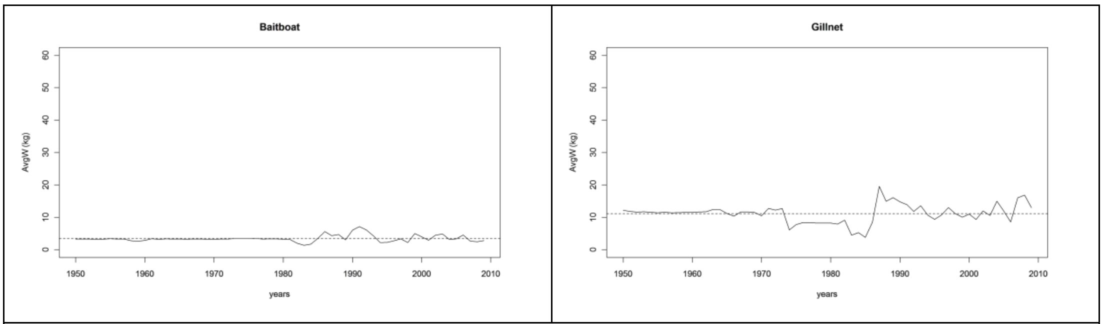


Figure 11. YFT average weight for purse-seine (log and free school), longlines (Japan and Taiwan), baitboat and gillnet fleets from 1950 to 2009.

Catch-at-Size table: This is available (Figure 12) although the estimates are more uncertain in some years and some fisheries due to:

- size data not being available from important fisheries, notably Yemen, Pakistan, Sri Lanka and Indonesia (lines and gillnets) and Comoros and Madagascar (lines)
- 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).

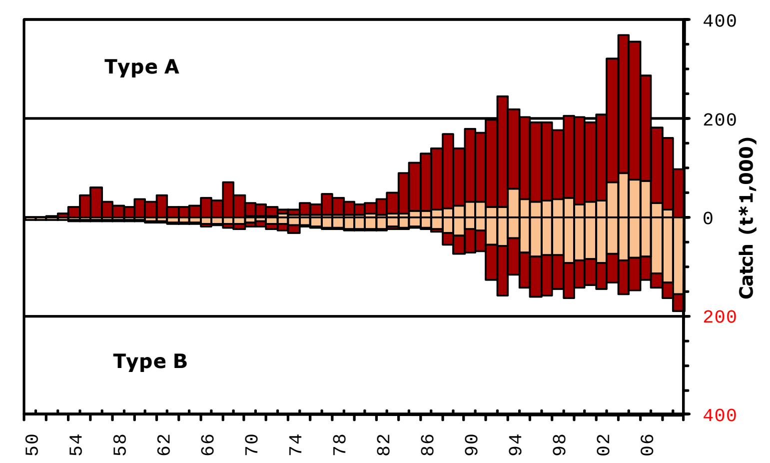


Figure 12. Uncertainty of catch-at-size data for yellowfin tuna (Data as of September 2010)

Catches below the zero-line (Type B) refer to fleets that do not report length data to the IOTC, do not report length data by gear, species, month, fishing area or any of the other reasons given in the document. Catches over the zero-line (Type A) refer to fleets for which no major inconsistencies have been found to exist. Light bars represent data for artisanal fleets and dark bars represent data for industrial fleets.

2.4. Main data issues identified by the WPTT

5. The WPTT express its satisfaction regarding the preparation of the data and the document provided by the Secretariat. The WPTT identified (Table 1) a number of issues outstanding in relation with the statistics available for tropical tuna species.

Table 1. List of issues identified by the WPTT concerning the data on tropical tunas

Catch-and-Effort data from Coastal Fisheries:

- Drifting gillnet fisheries of Iran and Pakistan: To date, Iran and Pakistan have not reported catches of bigeye tuna for their gillnet fisheries. Although both countries have reported catches of yellowfin tuna and skipjack tuna, they have not reported catch-and-effort data as per the IOTC standards, in particular for those vessels that operate outside their EEZ.
- Gillnet/longline fishery of Sri Lanka: Although Sri Lanka has reported catches of bigeye tuna for its gillnet/longline fishery, the catches are considered to be too low. This is probably due to the mislabelling of catches of bigeye tuna as yellowfin tuna. In addition, Sri Lanka has not reported catch-and-effort data as per the IOTC standards, including separate catch-and-effort data for longline and gillnet and catch-and-effort data for those vessels that operate outside its EEZ.
- Pole-and-line fishery of Maldives: Maldives has not reported catch-and-effort data by gear type and geographic area since

2002[1]. • Coastal fisheries of Comoros, Indonesia, Madagascar, Sri Lanka (other than gillnet/longline) and Yemen: The catches of tropical tunas for these fisheries have been estimated by the Secretariat in recent years. The quality of the estimates is thought to be very poor due to the paucity of the information available about the fisheries operating in these countries.
Catch-and-Effort data from Surface and Longline Fisheries: • Longline fishery of India: India has reported very incomplete catches and catch-and-effort data for its commercial longline fishery. • Longline fisheries of Indonesia and Malaysia: Indonesia and Malaysia have not reported catches for longliners under their flag that are not based in their ports. In addition Indonesia has not reported catch-and-effort data for its longline fishery to date. • Industrial tuna purse seine fishery of Iran: Iran has reported very low catches for its industrial tuna purse seine fishery in recent years. This includes low catches of yellowfin tuna and very low or no catches at all of other tropical tunas. The catch rates (around 2000 t by vessel by year) and average number of fishing days operated by vessel (around 80 days by vessel by year) are much lower than those recorded for all other industrial purse seine fleets. • Industrial tuna purse seine fishery of Thailand: the proportion of bigeye and yellowfin in the Thai purse seine fishery is very different from the species composition on the other purse seine fisheries operating in the same area, and this could be a consequence of the sampling system. • Longline fishery of Philippines: Philippines has reported very low catches of tropical tunas for its longline fishery, in particular catches of bigeye tuna. The amounts of frozen bigeye tuna products exported from Philippines vessels to other countries (IOTC Bigeye tuna Statistical Document Programme) have been consistently higher than the amounts reported by Philippines as total catch for this species. • Discard levels for all fisheries: The total amount of tropical tunas discarded at sea remains unknown for most fisheries and time periods. The EU presented estimations of bycatch and discard levels on its purse-seine fleets, however, due to the anti-piracy activities on board the fleet, no observer could be deployed in 2009 in order to refine those estimates.
Size data from All Fisheries: • Gillnet fisheries of Iran and Pakistan: Pakistan has not reported size frequency data for its gillnet fishery to date. Iran has not reported size frequency data by month and geographic area. • Gillnet/longline fishery of Sri Lanka: Although Sri Lanka has reported length frequency data for tropical tunas in recent years, sampling coverage is thought to be too low and lengths are not available by gear type or fishing area. • Longline fisheries of India, Malaysia, Oman and Philippines: To date, these countries have not reported size frequency data for their longline fisheries. • Longline fishery of Indonesia: Indonesia has reported size frequency data for its fresh-tuna longline fishery in recent years. However, the samples cannot be fully broken by month and fishing area (5x5 grid) and they refer exclusively to longliners based in Indonesia. • Fresh-tuna longline fishery of Taiwan,China: To date, Taiwan,China has not provided size frequency data for its fresh-tuna longline fishery. • Longline fishery of Japan: Japan has not reported samples for its commercial fishery since 2000 and the number of samples reported from training vessels has dropped dramatically since that time. • Coastal fisheries of Comoros, India, Indonesia and Yemen: To date, these countries have not reported size frequency data for their coastal fisheries. • Pole-and-line fishery of Maldives[2]: Maldives has not provided size data by month, geographic area and gear type since 1998. The size data available is highly aggregated and not by IOTC standards. • Industrial purse seine fisheries of Thailand and Iran: To date, Thailand and Iran have not provided individual lengths of tropical tunas by month and 5 degrees square grid for their industrial purse seine fisheries.
Biological data for all tropical tuna species: • Surface and longline fisheries, in particular Taiwan,China, Indonesia, Japan, EU and China: The Secretariat had to use length-age keys, length-weight keys, and processed weight-live weight keys for tropical tuna species from other oceans due to the general paucity of biological data available from the Indian Ocean.

6. The WPTT noted that some of the issues identified in Table 1 have been outstanding for several years urging the countries concerned to consider addressing such issues as soon as possible. In this regard, the WPTT requested the countries concerned to report to the next meeting of the WPTT about the actions undertaken and progress achieved in addressing these issues. In addition, the WPTT requested the IOTC Secretariat to follow-up on these issues, assisting the countries concerned where required.

7. Table 2 presents an attempt to show the main fleets for which the WPTT have identified data issues. Fleets are sorted according to the importance of the catches of tropical tunas (over the total catches for each species), the type of fisheries involved and the areas in which the statistical systems existing for each fleet would need strengthening for data to be produced as per the IOTC minimum data requirements.

[1] It is important to note that Maldives has used the available catch-and-effort data to derive CPUE indices for its pole-and-line fishery, and have worked on the development of preliminary assessments of skipjack tuna in cooperation with the IOTC Secretariat, presented at the WPTT in 2010.

[2] It is important to note that Maldives is currently revising its size frequency statistics database and will be providing this dataset soon.

Table 2. Main fleets for which the WPTT has identified issues with the data available at the IOTC. Fleets are sorted according to the importance of the catches of tropical tunas estimated and the number of problem areas identified in the statistical systems with fleets having the highest catches and number of problems identified at the top of the table.

Countries in bold are those that have requested assistance from the IOTC to address the issues identified - through the IOTC-OFCF Project or by other means -, including countries that have signed agreements with the IOTC for the implementation of activities in the short term and *countries in which consultations between the IOTC and the institutions concerned are ongoing and may lead to implementation of other activities in the future*.

Fleet	Gear	Type fishery	% catch over total			Need to Improve					Remarks
						Data Collection			DB Sys.	Data Proc.	
			YFT	BET	SKJ	NC	CE	SF			
Sri Lanka	**G/L**	AI	6	<1	9						
Iran	***Gillnet***	AI	6	0	13						
Indonesia	***All artisanal***	A	1	1	9						Catch highly uncertain
Sri Lanka	**All artisanal**	A	4	0	6						Catch highly uncertain
Indonesia	***Longline***	I	3	8	<1						Catch likely to be underestimated
Maldives	Pole-and-line	AI	4	1	20						
Yemen	Handline	A	5	0	<1						Catch highly uncertain
India	Longline	I	1	5	<1						Catch likely to be underestimated
Madagascar	Lines	A	2	<1	2						Catch highly uncertain
Japan	Longline	I	4	12	<1						
Comoros	**Lines**	A	2	<1	1						Catch highly uncertain
Pakistan	Gillnet	AI	1	0	1						Catch likely to be underestimated
Thailand	Purse seine	I	<1	2	2						
Taiwan,China	Longline(Fresh)	I	3	4	<1						
Philippines	Longline	I	<1	1	<1						Logbook coverage likely to be poor
Malaysia	Longline	I	<1	1	<1						Catch likely to be underestimated
Iran	***Purse seine***	I	1	<1	<1						Catch likely to be underestimated
Oman	Longline	I	1	0	0						

Key to table 2:

Fleet and gear: Flag country and type of fishing gear used, including:

- Gillnet refers to fleets that use gillnets of different sizes, including drifting gillnets
- G/L refers to a fleet that uses a combination of gillnet and longlines
- Handline refers to fleets of small vessels using handlines
- Lines refers to fleets of small vessels using handlines and/or trolling
- Longline refers to fleets of freezing longliners (longline) or fresh-tuna longliners (Longline(Fresh))
- Pole-and-line refers to fleets of baitboats of different sizes using pole-and-lines
- Purse seine refers to fleets of industrial tuna purse seiners
- All artisanal refers to fleets that operate different types of artisanal gears, including handlines, trolling, gillnet and other minor gears

Type fishery, including:

- Artisanal fisheries (A) defined as those fisheries made up of fishing crafts having length overall under 24 meters and that operate within the EEZ of the country concerned
- Industrial fisheries (I) defined as all fisheries other than those defined above
- Mixed fisheries (AI) defined as those made up by a combination of artisanal and industrial crafts

% catch over total: Proportion (percentage) that the catches of tropical tunas, by species (Yellowfin tuna (YFT), bigeye tuna (BET) and skipjack tuna (SKJ)), made out of the total estimated catches for each species in recent years (2007-09).

Need to improve: Components of the statistical systems in each country that are thought to need strengthening, including:

- Data Collection: Data collection is thought to be insufficient (red) compromising the ability to produce nominal catch (NC) and/or catch-and-effort (CE) and/or size frequency (SF) as per the IOTC Standards
- DB Sys.: The database systems existing, if any, are believed to be inappropriate (red; orange if unknown) and would compromise the ability of the country concerned to verify the data collected or produce estimates within the deadline of submission agreed by the IOTC.
- Data Proc.: The routines existing for the estimation of catches, if any, are thought to be inappropriate (red) and are likely to compromise the ability of the country concerned to produce reliable estimates of catches, effort or catch-at-size and/or report these data within the deadline agreed by the IOTC.

8. As all tuna stock assessments are now based on detailed catch and length samples, it is essential that access to detailed fisheries data is given to WPTT scientists. For several years, the WPTT noted that the proportion of the catch by large industrial fleets, historically dominant in the Indian Ocean stock assessment, is decreasing in

favour of new industrial and artisanal fleets for which the data submitted to the Secretariat are not of enough quality. This is the case for some developing longline fisheries, *e.g.* in India and Indonesia, some drifting gillnets fisheries, *e.g.* in Pakistan and Iran, and some purse-seine fisheries, *e.g.* in Iran.

9. The WPTT recommended that complete and good quality data should be reported to the Secretariat as per IOTC requirements for all the fisheries, and that this issue is brought to the attention of the Scientific Committee with a view of reporting to the Compliance Committee. Nevertheless, the deficiencies and limitations presented here should 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

10. The WPTT revised implementation of the recommendations to improve the data available at the IOTC issuing from the last Session of the WPTT (**Error! Reference source not found.**).

Table 2. Recommendations and progress to improve the data available to IOTC (WPTT 2009)

Improve the certainty of catch and effort data from artisanal fisheries, by:

- Yemen, Comoros and Madagascar implementing fisheries statistical collection and reporting systems.

The IOTC-OFCF Project and the IOTC Secretariat have agreed to provide support to ***Comoros*** *in two areas:*

- Census of artisanal fisheries
- Data collection, processing and reporting

The Secretariat estimated a complete series of catches of tropical tunas for the artisanal fisheries of ***Madagascar*** *in 2009, using information from the FAO database and other sources. In addition, the Secretariat estimated recent catches for the fisheries of* ***Yemen*** *and* ***Comoros****.*

Notwithstanding the above, the situation in these countries remains of concern.

- 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.

Following a request from the Department of Fisheries and Aquatic Resources (DFAR) of ***Sri Lanka*** *the IOTC-OFCF Project send a mission to Sri Lanka in September 2010 to assess the status of fisheries data collection and processing in Sri Lanka, with a view to improve the quality of the information available at the IOTC concerning coastal and high seas fisheries in Sri Lanka. The IOTC-OFCF Project presented a report at the end of the mission, including the areas in which support could be provided in the future:*

- Strengthening of sampling effort for coastal and off-shore fisheries
- Design and implementation of a centralized database system
- Capacity building activities in relation with the implementation of a logbook system for the fisheries of Sri Lanka

The DFAR of Sri Lanka is currently considering the type of activities that could be undertaken with the support of the IOTC-OFCF Project and will send a proposal to be considered by the Project soon.

- 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.

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

Sri Lanka *and* ***Maldives*** *have reported incomplete datasets, not by IOTC standards. It is important to note, however, that the IOTC Secretariat and Maldives worked together in the standardization of the CPUE for the pole-and-line fishery in the Maldives. Maldives indicated that the CE dataset is currently being revised and will be submitted soon.*

- 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.

The Department of Fisheries and Aquatic Resources of ***Maldives*** *implemented a new logbook system in 2009. The catches of bigeye tuna, yellowfin tuna and skipjack tuna are to be recorded separately for all 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.

The WPTT is not aware of any arrangements made by ***India*** *or* ***Sri Lanka*** *concerning the above issue.*

- 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.

To date, the Secretariat has not received information about the levels of precision of IOTC statistics when they are reported by countries.

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

***India** provided in 2010 a very incomplete catch-and-effort dataset for its commercial longline fleet, not by IOTC standards.*

***Indonesia** will initiate implementation of a new logbook system for its fleets in December 2011, to cover all Indonesian vessels, including those not based in Indonesia.*

***Malaysia** reported in 2010 incomplete catch-and-effort data for its longline fisheries during 2009, not including information on the area fished. No catch-and-effort data was reported for those Malay longliners that are not based in Malaysia.*

*To date, **Philippines** has not implemented a logbook system on its longline vessels, the catch-and-effort data reported to the Secretariat being highly aggregated and incomplete.*

***Oman** reported in 2010 incomplete catch-and-effort data for its longline fisheries during 2009, not including information on the area fished.*

*The IOTC Secretariat downloaded for the first time catch-and-effort data for the fresh-tuna longline fishery of **Taiwan,China**, for the years 2006-09.*

*The Islamic Republic of **Iran** reported in 2010 the total number of days fished and catches for its industrial purse seine fleet. However, to date Iran has not reported catch-and-effort data as per IOTC standards for this fishery.*

- 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.

The IOTC Secretariat modified in 2010 the forms for the reporting of data to the IOTC including changes in the catch-and-effort forms to allow for countries to report levels of coverage and other information when reporting catch-and-effort data. Although some countries have provided this information, levels of reporting for are still low.

- 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.

***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.*

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.

***Comoros** will be implementing sampling on its artisanal fisheries with the support of the IOTC-OFCF Project soon.*

*The Secretariat is not aware of **Indonesia**, **Yemen**, or **Pakistan** having implemented sampling schemes for the collection of size data from their artisanal fisheries.*

*To date, **India** has not provided and length frequency data for its artisanal fisheries.*

- Maldives providing size frequency data by atoll and gear.

***Maldives** provided preliminary size frequency statistics to be used by the WPTT indicating that the SF dataset is currently being revised and will be submitted soon.*

- Thailand and Iran collecting and providing 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 by IOTC standards.*

- Taiwan,China collecting and providing size data from their fresh tuna longliners.

*The Secretariat has not received length frequency data from **Taiwan,China** concerning its fresh-tuna longline fleets.*

- India, Indonesia, Malaysia, Philippines and Oman collecting and providing size data for their longline vessels, including those based outside their flag states

*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.*

*The Secretariat is not aware of **India**, **Oman** or **Philippines** having implemented sampling schemes for the collection of size data from its longline vessels based in other countries.*

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.

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.

11. The WPTT recognized 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-2010-WPTT-03)

12. Bigeye tuna is mainly caught by industrial purse seine and longline fisheries and appears only occasionally in the catches of other fisheries. However, in recent years the amounts of bigeye tuna caught by gillnet fisheries are likely to be considerably higher due to the major changes experienced in some of these fleets, notably changes in boat size, fishing techniques and fishing grounds (Figure 13). Total annual catches have increased steadily since the start of the fishery, reaching the 100,000 t level in 1993 and peaking at 151,700 t in 1999.They averaged 114,600 t over the period 2005 to 2009. The 2008 catch was 106,700t and the provisional 2009 catch stands at 102,200t.

13. By contrast with yellowfin and skipjack tunas, for which the major catches take place in the western Indian Ocean, bigeye tuna is also exploited in the eastern Indian Ocean (Figure 14). In recent years (Figure 15) the catches of bigeye tuna in the western Indian Ocean have dropped considerably, especially in areas off Somalia, Kenya and Tanzania and in particular in 2008 and, especially, 2009. The drop in catches is the consequence of a drop in fishing effort in the area of both purse seine and longline fisheries, due to the effect of piracy in the western Indian Ocean region, while catches are increasing in the eastern Indian Ocean probably due to the shift of some longline fleet in the areas because of the piracy activities along the Somalia area.

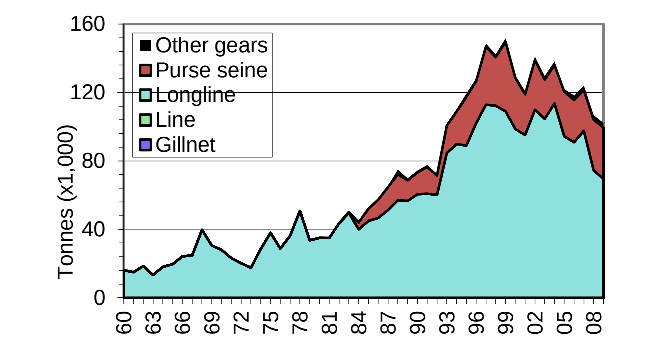


Figure 13. Annual catches of bigeye tuna by gear from 1960 to 2009

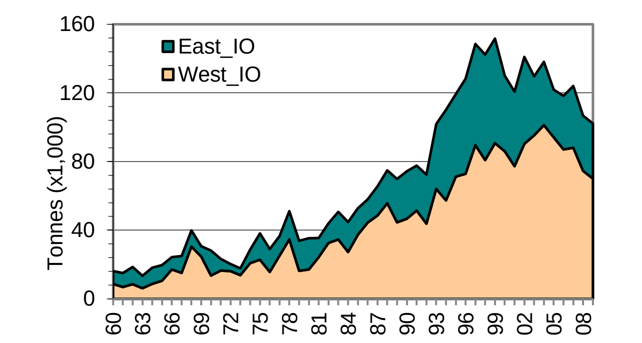


Figure 14. Catches of bigeye tuna in the Eastern and Western Indian Ocean from 1960 to 2009.

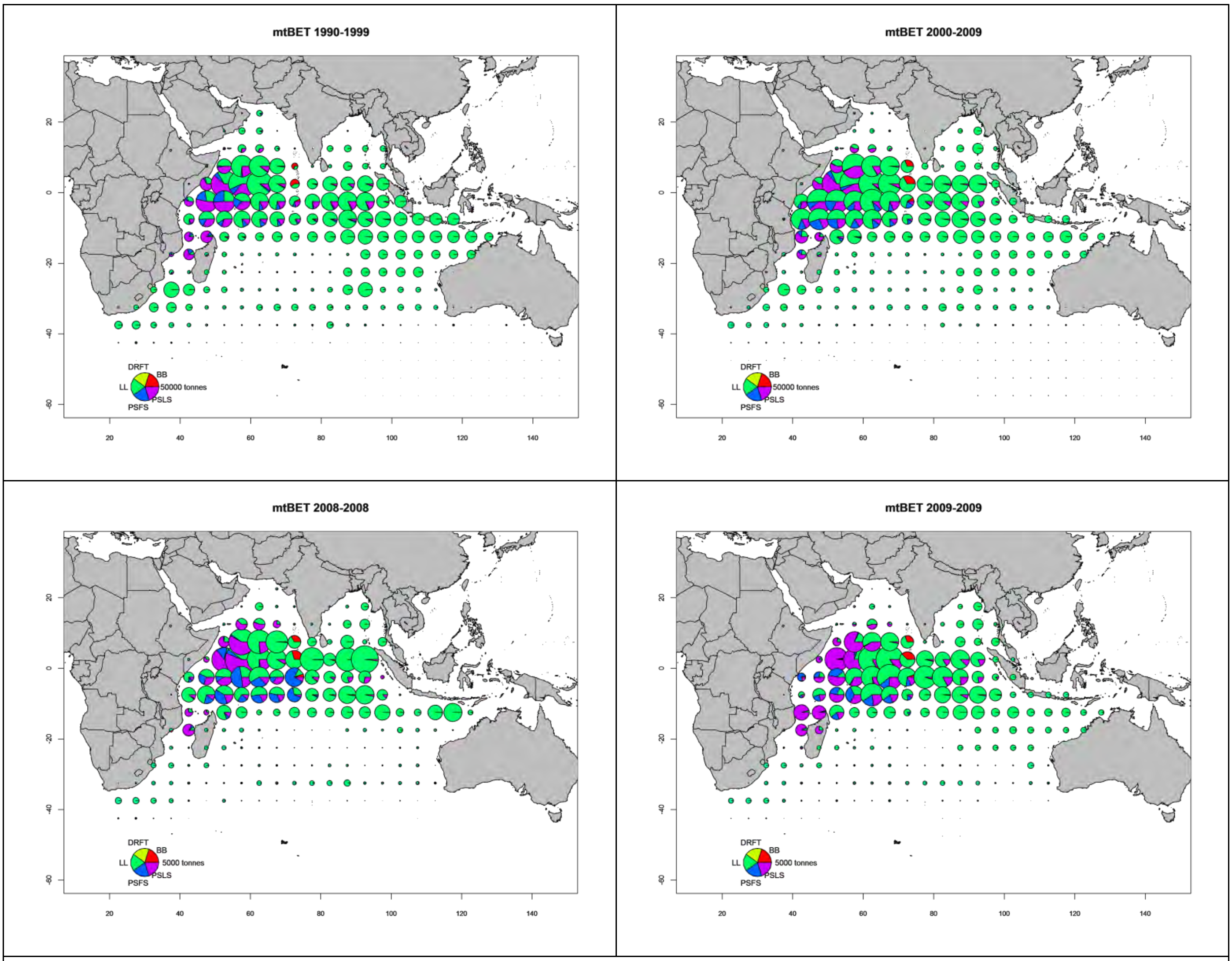


Figure 15. Total catches of bigeye tuna by gear in the Indian Ocean over the period 1990-1999 and 2000-2009, and for the years 2008 and 2009. (*excludes gillnet fisheries of Indonesia, Iran and Pakistan, gillnet/longline fishery of Sri Lanka and other coastal fisheries)*

14. The time series of average weight in the catch of bigeye tuna for all fleets and gears is shown in Figure 16. The sudden change in average weight observed corresponds to the introduction of fishing on FADs by purse seiners, which greatly increased the catch in numbers of small bigeye (Figure 17).

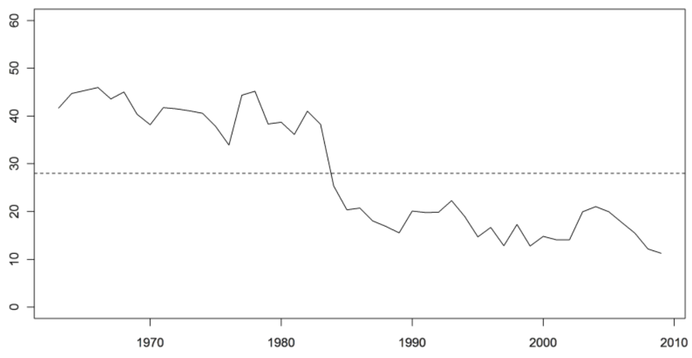


Figure 16. Temporal trend of average weight of bigeye (kg) for all fleets combined from 1963 to 2009.

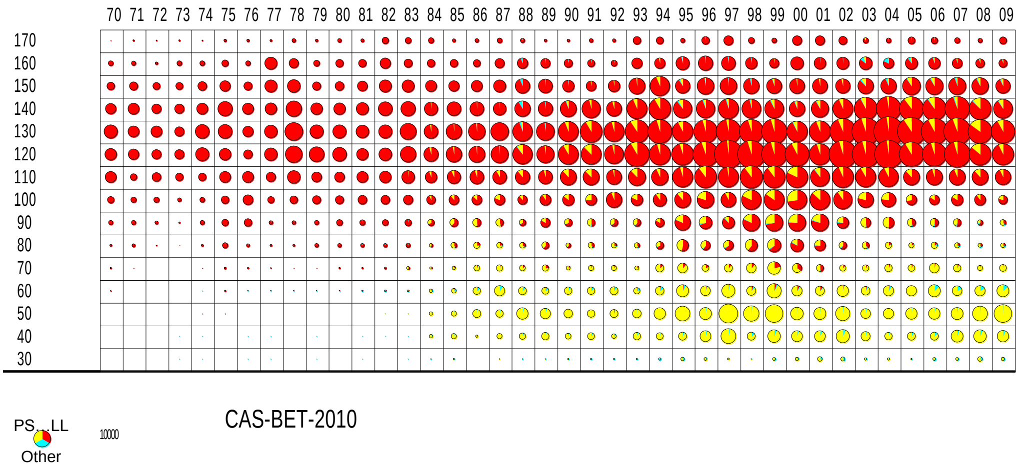


Figure 17. Bigeye catch at size by gear, by 10 cm size classes from 1970 to 2009.

3.1.2 Status of Bigeye Tuna Purse Seine Statistics (IOTC-2010-WPTT-12, 13, 14, 19)

15. One of the main evolution of the purse seine fishery these last years is the impact of piracy which led to a decrease of the nominal effort, *i.e.* number of boats, total carrying capacity, number of fishing and searching days, total number of set (Figure 18) as well as changes in the fishing behaviour due to the new security rules (boats working in pair with military on board, restriction of the fishing area, *etc*).

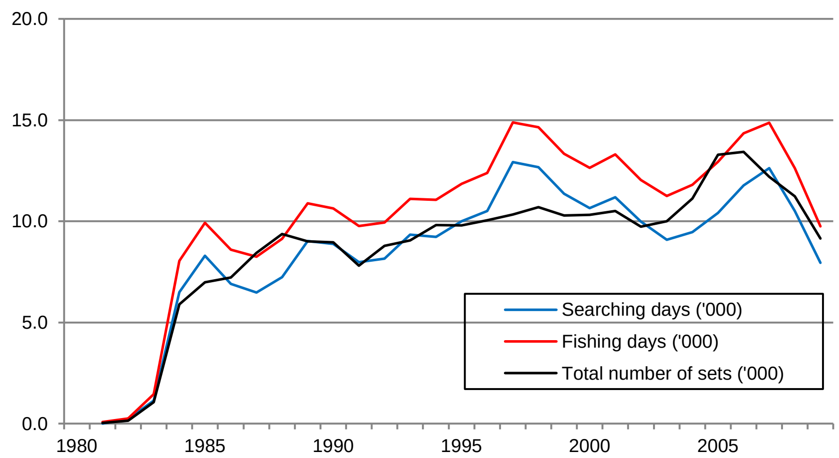


Figure 18. Nominal effort of the European purse-seine fleet from 19080 to 2009.

16. Around 75% of purse seine bigeye catches are taken in log-schools along with skipjack and yellowfin tuna, 80% of them being less than 5kg. Catches increased since the beginning of the fishery, peaked at over 30,000 t from 1997 to 1999 and then stabilized at around 22,000 t (Figure 19). During the last years, an increase of the catches is observed peaking in 2008 and 2009 at 26,500 t. However, bigeye catches remains relatively low, representing some 8% of the total catch since 1991 (9% on logs and 5% on free schools).

17. In 2009, the proportion of log schools (around 50% of the sets since 1991) increased over 70%, representing 80% of the total bigeye catches.

18. The mean weight of bigeye tuna in the purse-seine fishery reflects mainly the log school catches, and remains very stable around 6kg (Figure 21). By contrast, free schools sets exhibit large variations, remaining high (over 30 kg) between 2002 and 2008, and dropping to 17kg in 2009. 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.

19. Size distribution (Figure 22) in 2009 were compared with those observed in the previous periods 2004-2008 and 2006-2008 (the latter being choose to correct the impact of the large free schools yellowfin catches in 2003-2005). Log schools shows a large number of small bigeye (less than 65 cm) in the catches (as well in number than in weight), much higher than during the previous periods. Small bigeye free schools catches were also important and higher than previously in numbers, the larger one (over 100 cm) remaining in the same range; in weight, the pattern is close to the average situations, with a somewhat larger catch of small bigeye.

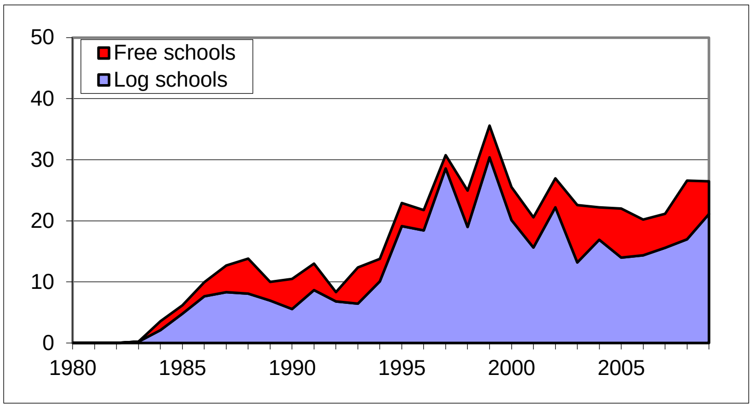


Figure 19. Bigeye catches (tonnes x 1000) from the purse seine fishery on log and free schools from 1980 to 2009.

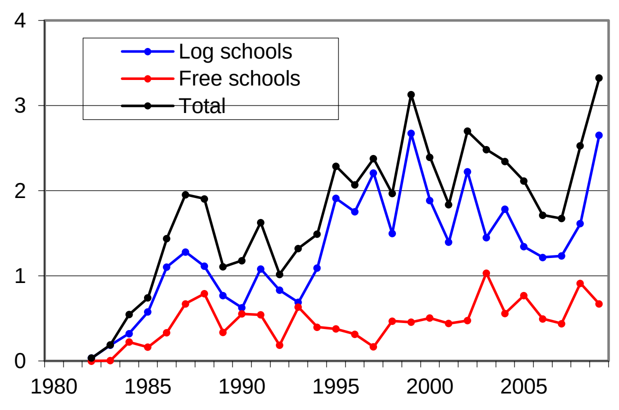


Figure 20. Catch rates (tonnes per searching day) of bigeye tuna attributed to purse seine fishing on free schools and logs

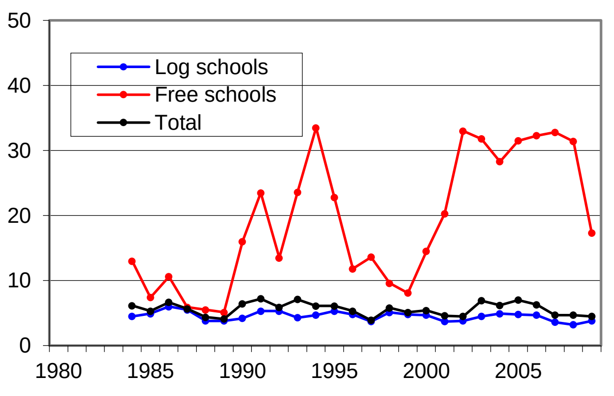


Figure 21. Mean weight of bigeye tuna attributed to purse seine fishing on free schools and logs.

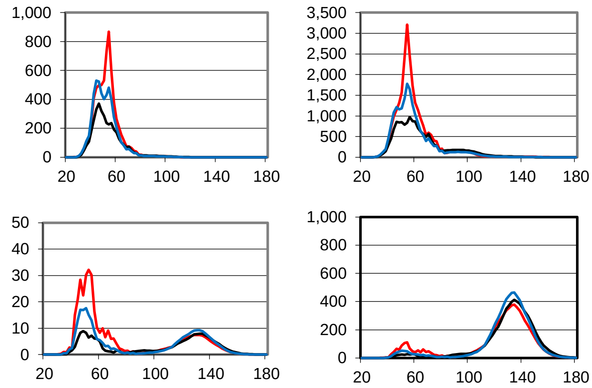


Figure 22. BET size distributions attributed to purse seine fishing on free schools (bottom) and logs (up) (2004-2008 in black, 2006-2008 in blue and 2009 in red ; left in number (*1000), right in tons).

3.1.3 Main tagging results for Bigeye Tuna (IOTC-2010-WPTT-03)

20. The WPTT reiterated its recognition of the Regional Tuna Tagging Project – Indian Ocean (RTTP-IO) for its successes in terms of releases and recoveries. This project was the first tuna tagging project releasing such a large number of bigeye tuna (34,565), most of them being released off the coast of Tanzania. So far 5461 fish (15.8%) have been recovered and reported, most of them by the European and Seychelles purse seine fleets. Recoveries are well spread in the Indian Ocean (Figure 23) 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. Moreover, in 2010 a bigeye was recovered in the ICCAT area, off the coast of Namibia.

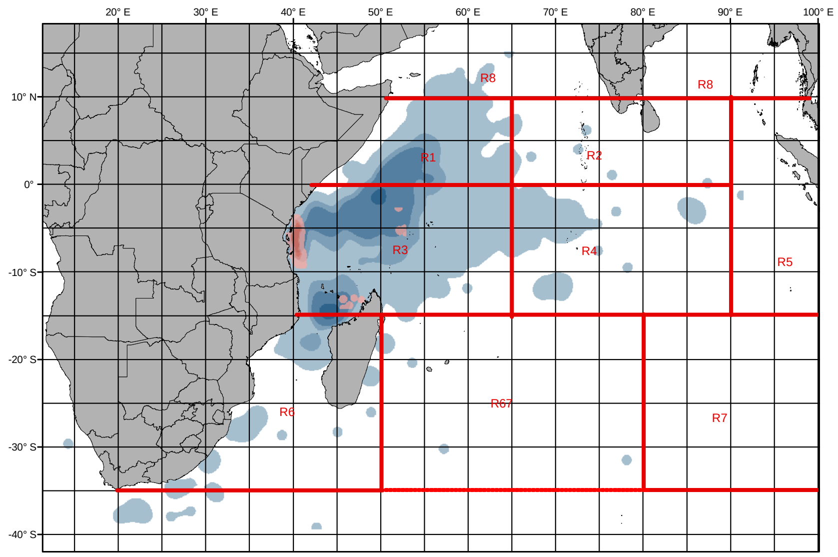


Figure 23. Density map of Releases (red) and Recoveries (blue) of bigeye tuna during the RTTP-IO in the different assessment areas.

21. During the meeting, an exploratory stock assessment of bigeye tuna was presented that use SS3, an integrated model that included for the first time for this stock the tagging data. The amount of data generated during the tagging programme is being used in multiple ways by scientists and is bringing to the table a considerable amount of new information on this species in the Indian Ocean. The WPTT encouraged further analysis to be conducted on the tagging data.

Growth

22. Various studies undertaken for the 10th Session of the WPTT demonstrated that growth is following a multi stanza pattern. Since that study, more recapture of large fish have been reported, and the analysis should be updated in order for the various models to estimate a reliable L_{inf}. However, the WPTT recognized that a lot of

information is being missed due to the lack of reporting by the longline fisheries of the Indian Ocean which could provide valuable returns of large tagged fish.

Natural Mortality

23. This tagging experiment also allowed preliminary estimations 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-2010-WPTT-03)

24. 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 372,200 t over the period 2005 to 2009. Total catches peaked at 456,000 t in 2003, 523,600 t in 2004 and 503,700 t in 2005 before decreasing to 414,400 t in 2006. Catches in 2009 were 288,100 t which is the lowest catch since 1991(Figure 24). 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 (Figure 25). The location and relative magnitude of the extraordinary high catches made in 2003 to 2005 is also shown (Figure 26).

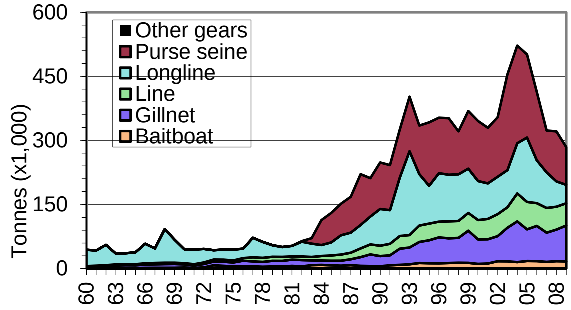


Figure 24. Annual catches of yellowfin tuna by gear from 1960 to 2009.

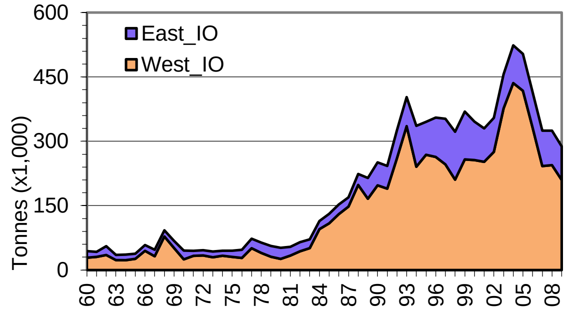
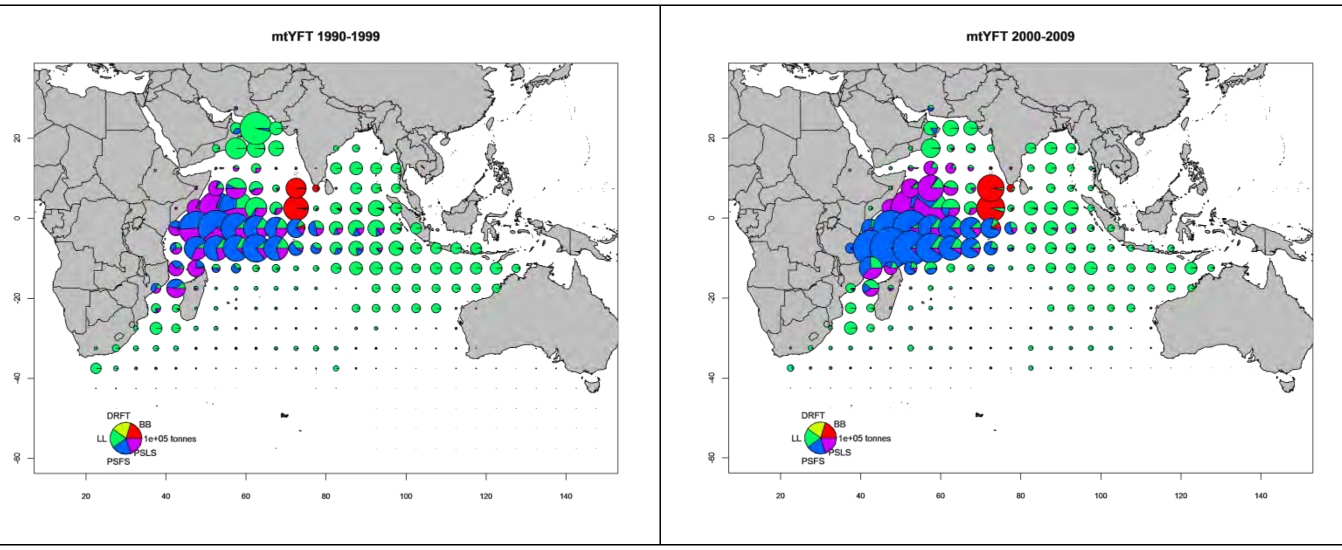


Figure 25. Catches of yellowfin tuna in the Eastern and Western Indian Ocean from 1960 to 2009.



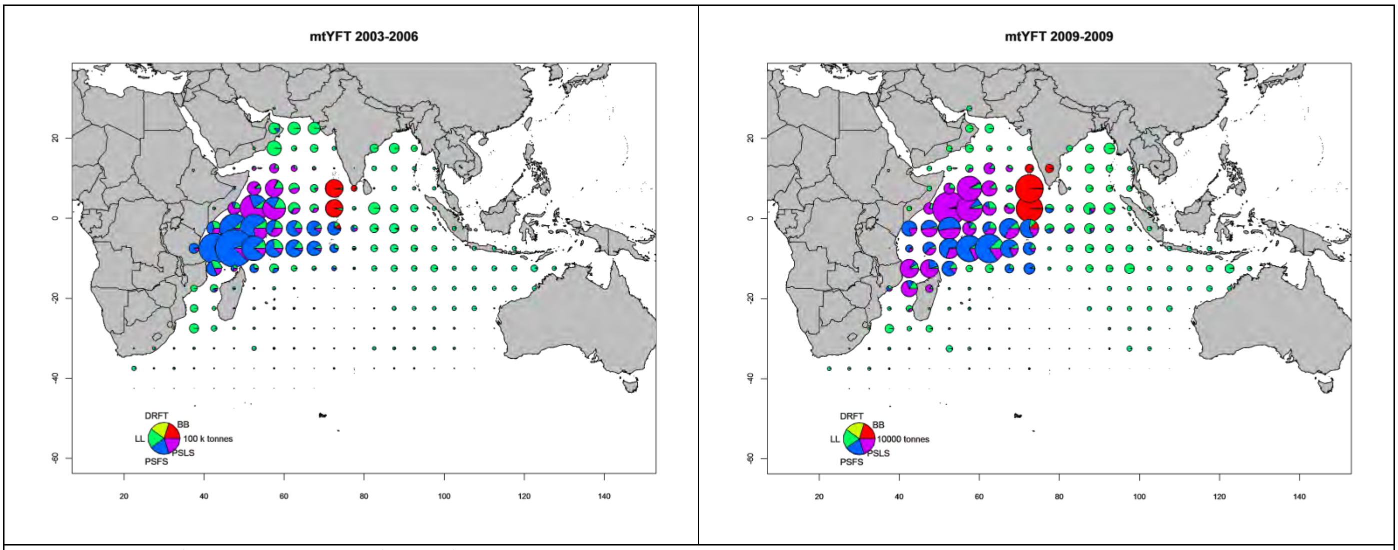


Figure 26. Total of annual total catches of yellowfin tuna by gear operating in the Indian Ocean over the period 1990-1999, 2000-2009, 2003-2006 and 2009. (*excludes gillnet fisheries of Indonesia, Iran and Pakistan, gillnet/longline fishery of Sri Lanka and other coastal fisheries).*

25. The time series of average weight in the catch of yellowfin tuna for all fleets and gears is shown in Figure 27. No large changes in this indicator are observed, despite the increase in the numbers of small yellowfin caught by purse seiners with the introduction of fishing on FADs (Figure 28). This is due to the corresponding large catches of adult yellowfin by all fleets, including purse seiners

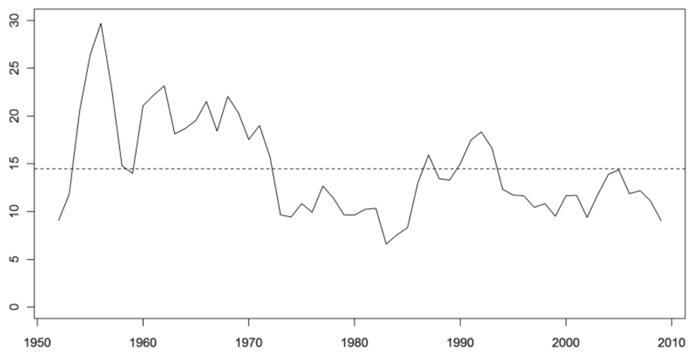


Figure 27. Temporal trends of average weight of yellowfin (kg) for all fleets combined from 1952 to 2009.

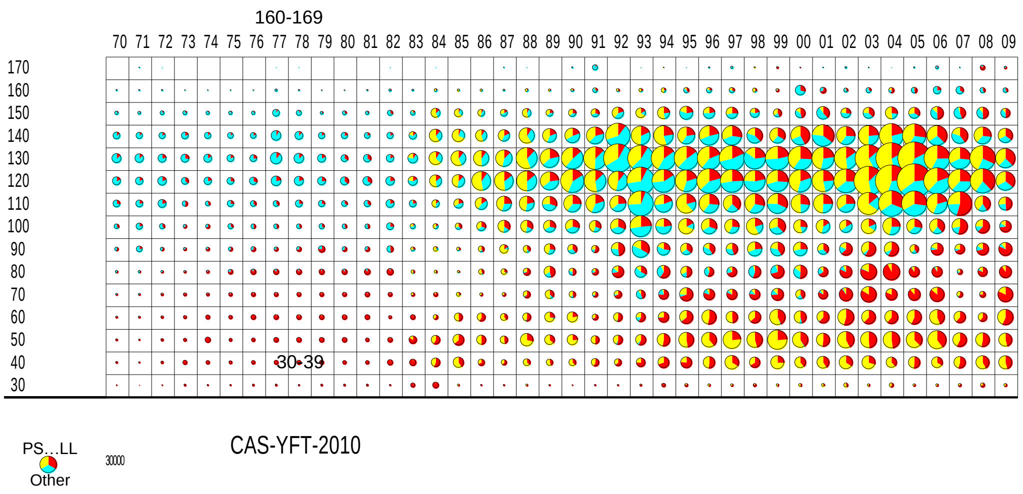


Figure 28. Yellowfin catch at size by gear, by 10 cm size classes from 1970 to 2009

3.2.2 Status of yellowfin Tuna Purse seine Statistics (IOTC-2010-WPTT-12, 13, 14, 19)

26. One of the driving forces behind recent changes in the purse seine fishery has been the impact of piracy, which has led to a decrease of the nominal effort (number of boats, total carrying capacity, number of fishing and searching days, total number of sets, Figure 29) as well as changes in the fishing behaviour due to the new security measures in place (boats working in pairs with military personnel on board, restriction on fishing areas, *etc)*.

27. 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 (with very high catches during the period 2003-2006), and then decreased sharply thereafter to 85,000 t in 2009 (Figure 29).

28. For 2009, the fishery operated mainly on log schools (75% of the total sets, the higher value observed, the average since the beginning of the fishery being around 50%). The catch on logs was low but in the range of the catches made since 1995, while catches on free schools were the lowest observed since 1984, the first year with a well established fishery.

29. Catch per unit effort (expressed as tons per searching days) follows the catch variations on free schools, with very high values during 2003-2005 (14t/search day compared to an average of 7.2t/search day since 1991), while remaining more or less stable for log schools (around 3.2t/search day up to 1994, around 5.5t/search day over the period 1995 to 2006, falling back to the previous low levels in 2008 of 3.7t/search day before increasing again in 2009 over 6t/search day (Figure 30). Catch per positive set remained stable at 7t on logs and 243t on free schools, except for the high values for 2002-2005.

30. 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 31).

31. Size distribution (Figure 32) in 2009 were compared with those observed in the previous periods 2004-2008 and 2006-2008 (the latter being choose to correct the impact of the large free schools yellowfin catches in 2003-2005). Log schools catches shows a large number of small yellowfin (less than 80 cm), including a second mode shifted towards the larger sizes compared with the previous reference periods, as well in number than in weight. Free school catches exhibits also a very large number of small yellowfin (three times that of the previous period) with two modes, the second one being also largely shifted towards the larger fishes; on the contrary, the amount of large fishes (over 100 cm) is lower than that of these reference periods, with somewhat bigger fishes.

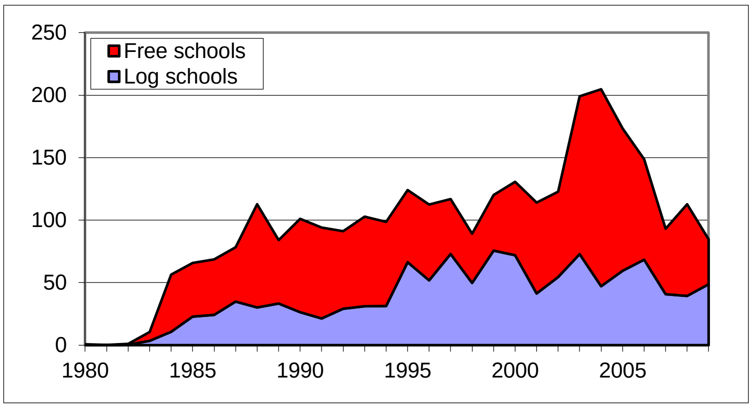


Figure 29. Catches (tonnes x 1000) of yellowfin attributed to purse seine fishing on free schools and logs

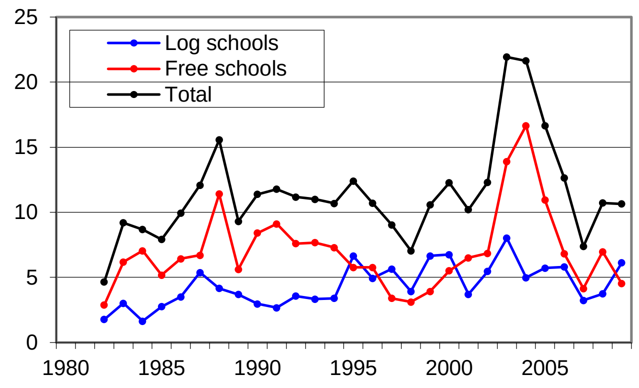


Figure 30. Catch rates (tonnes per searching day) of yellowfin tuna attributed to purse seine fishing on free schools and logs

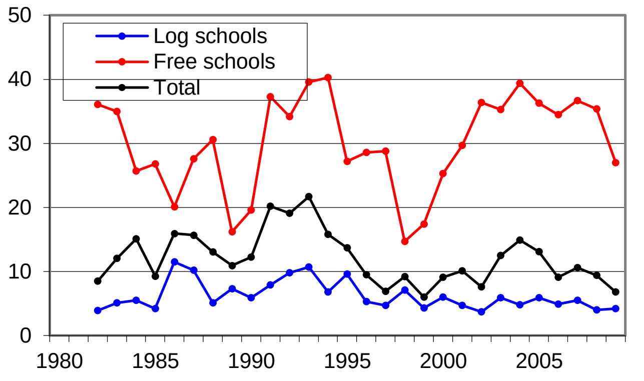


Figure 31. Mean weight (kg) of yellowfin tuna attributed to purse seine fishing on free schools and logs

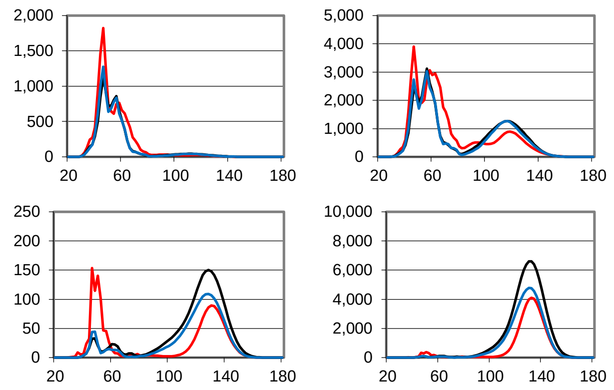


Figure 32. YFT size distributions attributed to purse seine fishing on free schools (bottom) and logs (up) (2004-2008 in black, 2006-2008 in blue and 2009 in red ; left in number (*1000), right in tons).

32. The fishing activities of the French purse seine fishery during January-June 2010, as inferred from log-book data, *i.e.* before processing the data for correcting species composition was presented to the WPTT (IOTC-2010-WPTT-14). The number of purse seiners decreased from 17 in 2009 to 11 in 2010, due to the sale of 2 vessels, the departure of 5 vessels to the Atlantic Ocean, and the arrival of a new vessel. Consequently, the carrying capacity decreased from an average value of more than 9,300 GRT during 2007-2009 to about 5,600 GRT in 2010. During the first semester of 2010, the number of sets made on free swimming and log-associated schools was 535 and 881, respectively, for a total effort of about 1,500 days-at-sea. Only 255 positive sets on free swimming schools were made during January-June 2010 with a spatial extent of the fishing grounds restricted to an area west of 55°E (Figure 33). Catches on free swimming schools recorded in log-books over the first semester decreased from about 20,000 t in 2005-2006 to about 6,400 in 2010 while skipjack catches on log-associated schools remained at 2005-2009 average levels (~14,000 t) despite the decrease in fishing effort. Compared to 2009, catch rates for yellowfin decreased on free swimming schools (4.5 t.d^{-1}) but increased on log-associated schools (4.65

t.d^{-1}). By contrast, catch rates of skipjack on log-associated schools remained stable in 2010 at more than 16.8 t.set-1. The reallocation of several French and Spanish vessels in the Atlantic Ocean in 2010 is increasing fishing pressure on Atlantic tuna stocks and raised concerns for the ICCAT during the last Standing Committee on Research and Statistics.

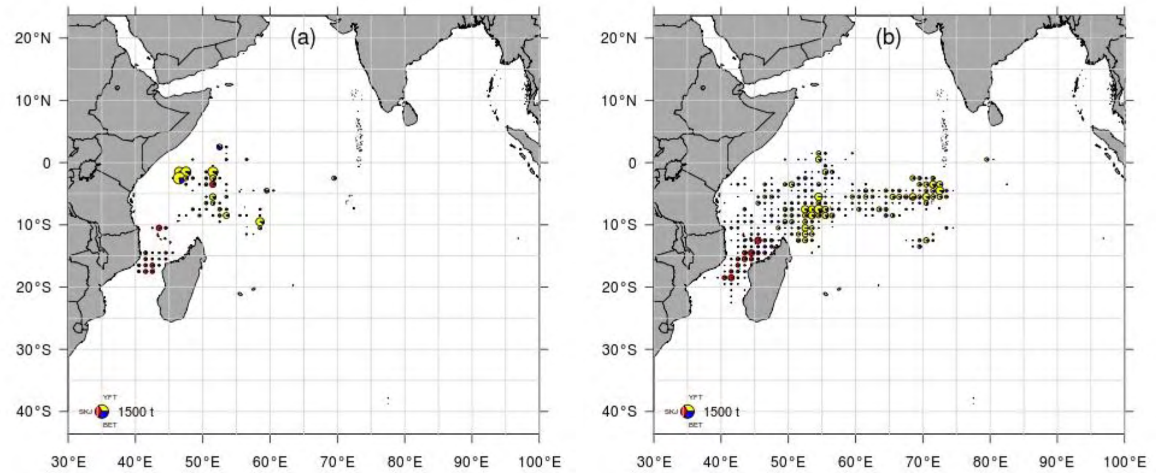


Figure 33. Spatial distribution of French PS catch on free swimming schools during a) Jan-Jun 2010 and b) 2007-2009

3.2.3 Main tagging results for Yellowfin Tuna (IOTC-2010-WPTT-03)

33. The RTTP-IO tagged and released 54 687 yellowfin mainly off the coast of Tanzania but also in the Arabian Sea, around Seychelles and in the Mozambique Channel. So far 9,739 fish (17,8%) have been recovered and reported, 93% of them by the European and Seychelles purse seine fleets. Recoveries are well spread in the Indian Ocean (Figure 34) 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.

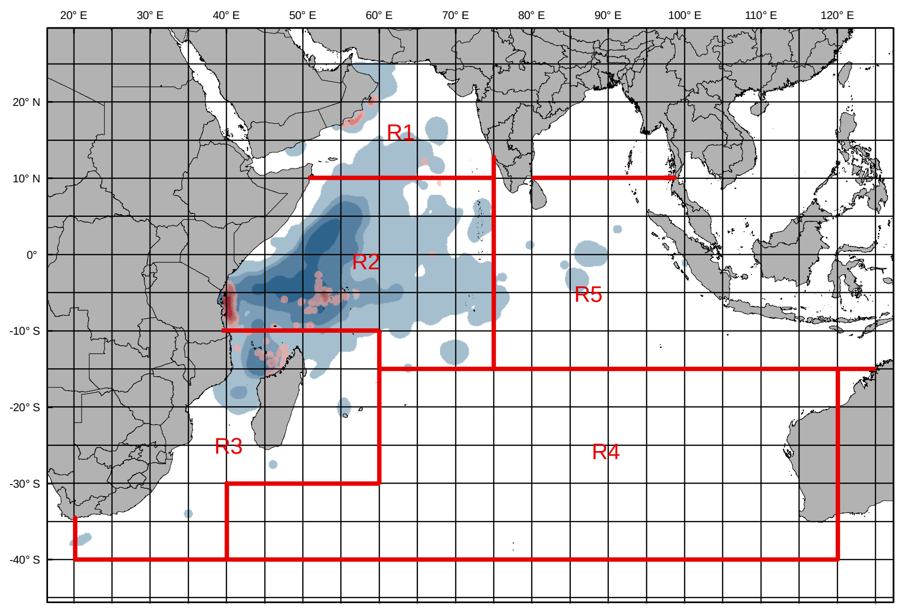


Figure 34. Density map of Releases (red) and Recoveries (blue) of yellowfin during the RTTP-IO in the different assessment areas.

34. For the third consecutive year, the tagging data generated by the RTTP-IO were incorporated into integrated stock assessments models. The amount of data generated through this project is being applied used in multiple

ways by scientists and is bringing a considerable amount of new information on this species in the Indian Ocean. The WPTT encouraged further analysis to be conducted on the tagging data.

Growth

35. 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 but the lack of recoveries of large fish did not allow the various models used to reliably estimate the asymptotic length L_{inf}, at that time. New analyses have been conducted and preliminary results were presented during this session of the WPTT, which recommended that they are pursued further, as they include new recoveries of large fish..

Natural Mortality

36. 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 skipjack tuna fisheries from the IOTC databases (IOTC-2010-WPTT-03)

37. Skipjack tuna is mainly caught by purse seine, gillnet and baitboat —using pole and line. Total annual catches averaged 505,200 t over the period 2005 to 2009. The 2006 catch peaked to 622,600 t while the provisional catch estimate for 2009 stands at 440,600 t (Figure 35). The location of the fishery has changed little since 1990, skipjack tuna is fished throughout the equatorial waters of the Indian Ocean with the majority of the catch being taken in western areas (Figure 36). However, during the last two years, the purse seine fleet moved far off the coast of Somalia due to active piracy in the region (Figure 37).

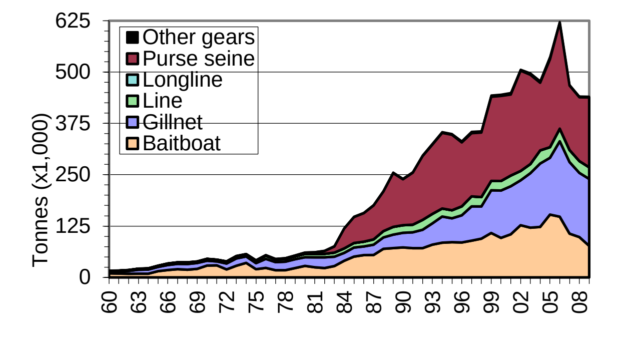


Figure 35. Annual catches of skipjack tuna by gear from 1960 to 2009.

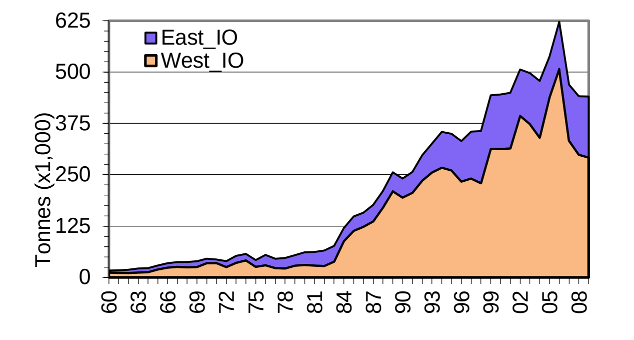


Figure 36. Catches of skipjack tuna in the Eastern and Western Indian Ocean from 1960 to 2009.

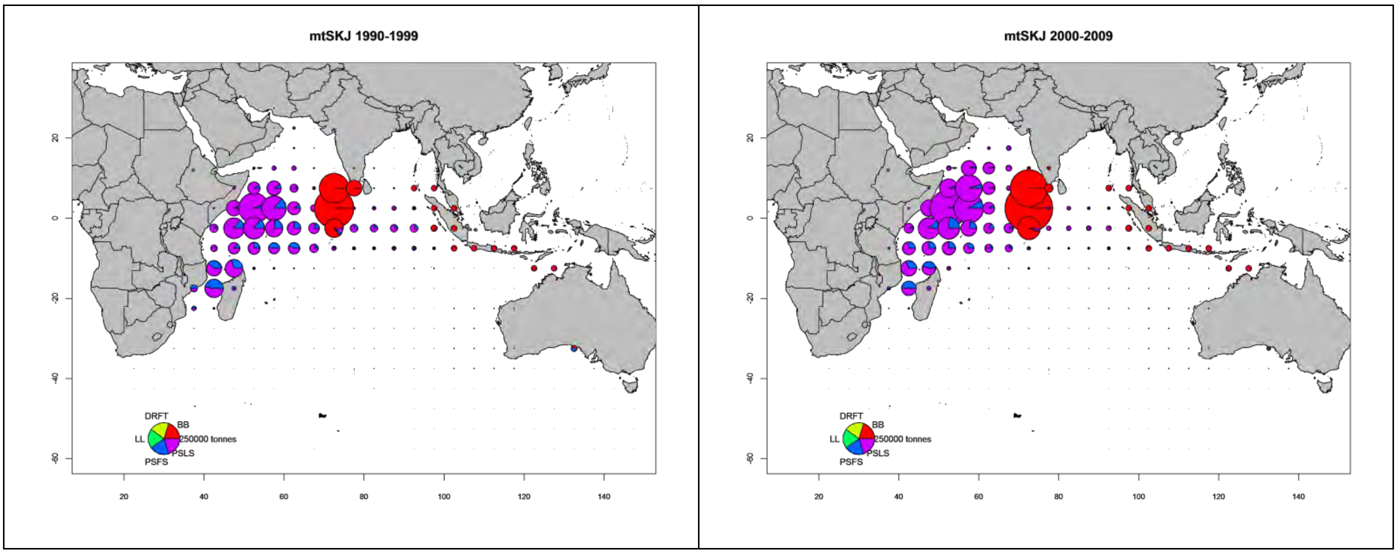
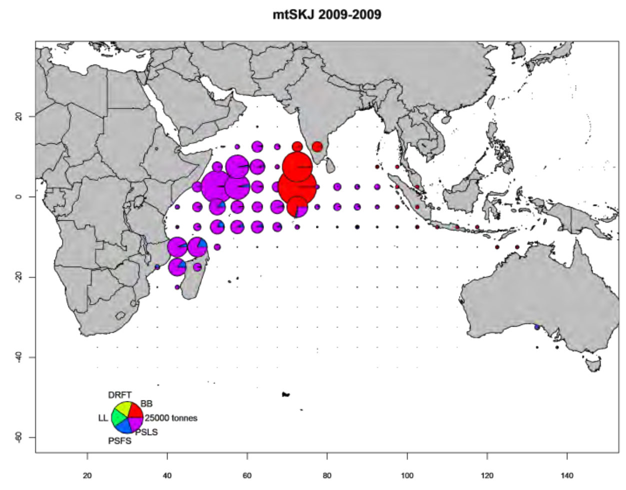


Figure 37. Total of annual total catches of skipjack tuna by gear operating in the Indian Ocean over the period 1990-1999, 2000-2009 and 2009. (*excludes gillnet fisheries of Indonesia, Iran and Pakistan, gillnet/longline fishery of Sri Lanka and other coastal fisheries)*



38. The time series of average weight in the catch of skipjack tuna for all fleets and gears is shown in Figure 38. The stable trend observed indicates that no major changes in overall selectivity have occurred, and is an indication of a constant yield-per-recruit

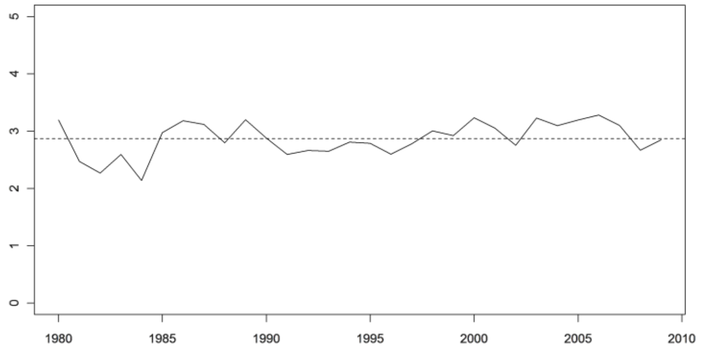


Figure 38. Temporal trend of average weight of skipjack (kg) for all fleets combined from 1980 to 2009.

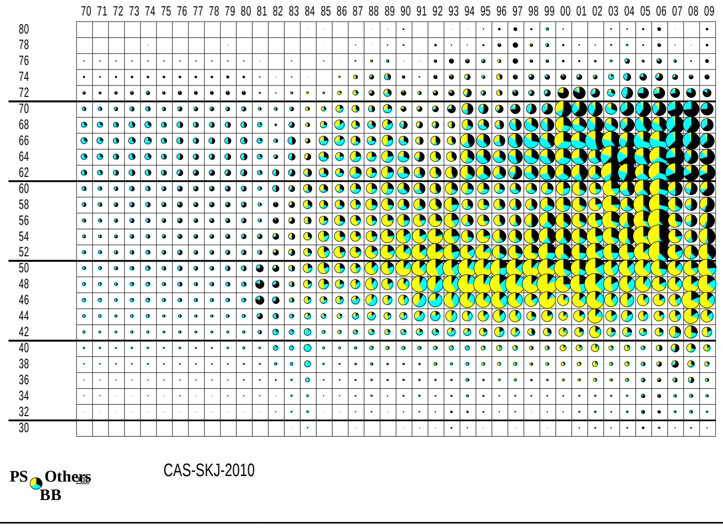


Figure 39. Skipjack catch at size by gear, by 10 cm size classes from 1970 to 2009

3.3.2 Status of skipjack tuna purse seine statistics (IOTC-2010-WPTT-12, 13, 14, 19)

39. One of the main evolution of the purse seine fishery these last years is the impact of piracy which led to a decrease of the nominal effort (number of boats, total carrying capacity, number of fishing and searching days,

total number of sets, Figure 24a, yellowfin section) as well as changes in the fishing behaviour due to new security rules (boats working in pair with military on board, restriction of the fishing area, …).

40. Total skipjack catches increased regularly since the beginning of the fishery to each a maximum of 220,000 tons in 2006, and then stabilized around 140,000 t (Figure 34), over 80% of the being made on log schools.

41. Catches in 2009 (146,800 t), logs school sets contributing to 94% of the total catch, were low relative to those in 2005 and 2006 catch (188,000 to 221,000 t), and the last three years are the lowest since 1998 (Figure 40).

42. Catch per unit effort (expressed as tons per searching days - sd) on free schools of skipjack tuna is relatively low and remained stable over time, around 2.5t/sd since 1991 (Figure 41). On the contrary, catch rates on log schools increased steadily up to 2002, fluctuated over the period 2003 to 2006 and then dropped markedly in 2007 and 2008. Catch by positive set remains in the historical range (19t/set since 1991); this is also the case for log schools (21.9t/set compared to an average of 25.0t/set since 1991), while free schools catch by set remains low (6.0t/set compared to an average of 8.7t/set since 1991).

43. The mean weight of the skipjack in the total catches reflects mainly the catches from log school as they represent over 80% of the total catch. (Figure 42). The mean weight from log school tuna has varied between 2.1 and 3.0 kg since the 1990's (average 2.6 kg), decreased largely in 2007 and 2008 (2kg) before increasing to 2.4kg in 2009, which remains less than the average since 1991. For free schools, the mean weight fluctuated between 3 and 4 kg (3.2 average) until 2007, and then dropped markedly to 2.4 kg in 2009, the lowest value ever observed.

44. Size distributions (Figure 43) in 2009 are compared with those observed in the previous periods 2004-2008 and 2006-2008 (the latter being chosen to correct the impact of the large free schools yellowfin catches in 2003-2005). Log schools catches in 2009 are higher than those of the reference periods, both in numbers and weight, with a very similar pattern. On the contrary, if the free school catches amount is equivalent to the reference ones in numbers, the distribution is shifted towards smaller sizes, resulting in a lower catch.

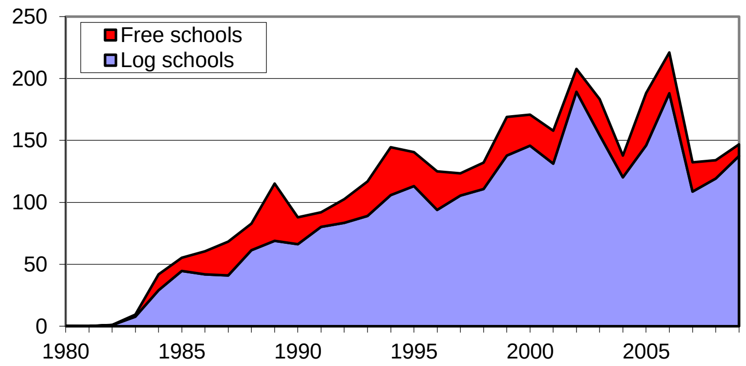


Figure 40. Catches (tonnes x 1000)of skipjack tuna attributed to purse seine fishing on free schools and logs

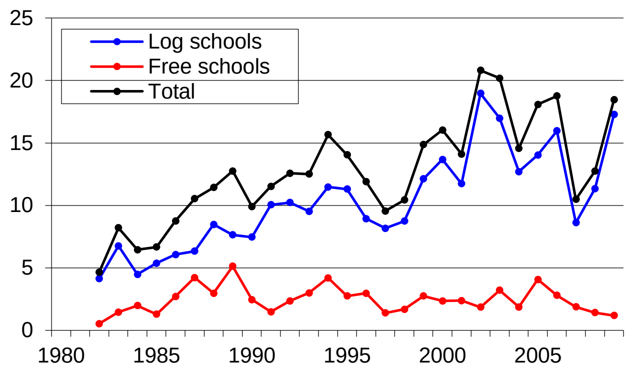


Figure 41. Catch rates for skipjack (tonnes per search day) attributed to purse seine fishing on free schools and logs

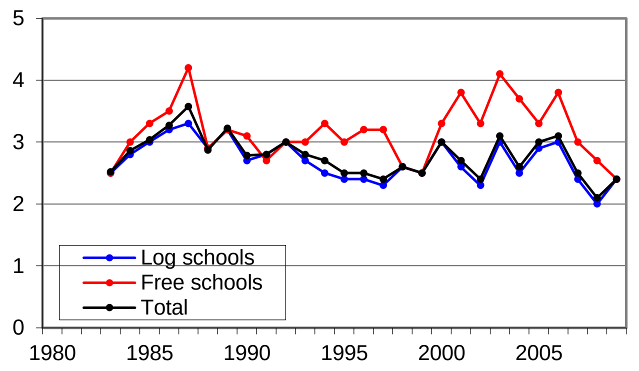


Figure 42. Mean weight (kg) of skipjack tuna attributed to purse seine fishing on free schools and logs.

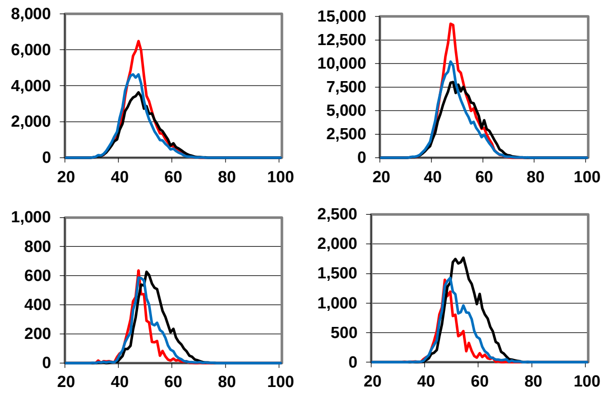


Figure 43. SKJ size distributions attributed to purse seine fishing on free schools (bottom) and logs (up) (2004-2008 in black, 2006-2008 in blue and 2009 in red ; left in number (*1000), right in tons).

3.3.3 *Main tagging results for Skipjack Tuna (IOTC-2010-WPTT-03)*

45. The RTTP-IO tagged and released 78,326 skipjack mainly off the coast of Tanzania, around Seychelles and in the Mozambique channel. So far 12,631 fish (16.1%) have been recovered and reported, 96% of them by the European and Seychelles purse seine fleets. Recoveries are well spread in the Indian Ocean (Figure 44) 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.

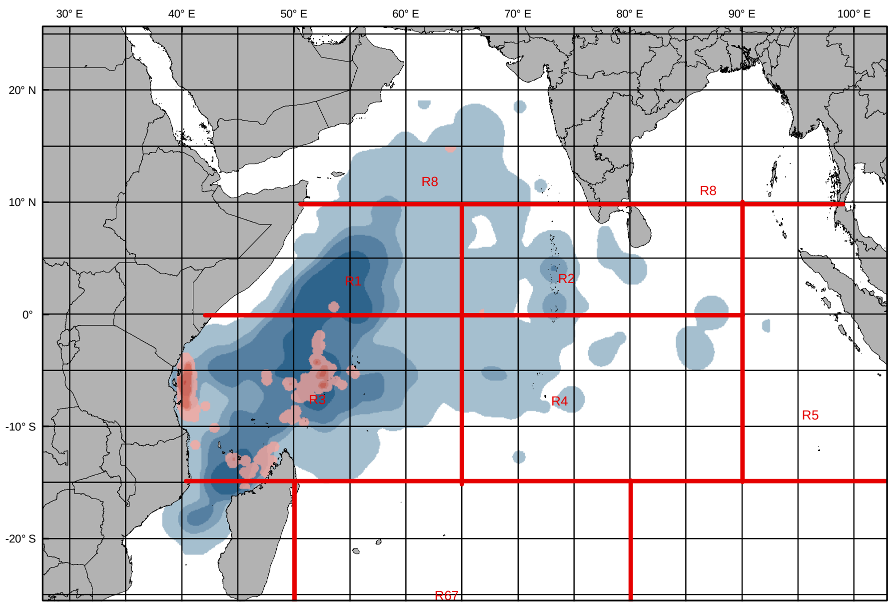


Figure 44. Density map of Releases (red) and Recoveries (blue) of skipjack during the RTTP-IO in the different assessments areas.

46. The amount of data generated through this project is being applied in multiple ways by scientists and is bringing a considerable amount of new information on this species in the Indian Ocean. The WPTT encouraged further analysis to be conducted on the tagging data

Growth

47. Various studies undertaken for the 10th Session of the WPTT demonstrated that growth is following a Von Bertalanffy curve, however these analyses should be refined as since then, numerous new recaptures have been reported.

Natural Mortality

48. 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

Declining catches of skipjack in the Indian Ocean – Observations from the Maldives (IOTC-2010-WPTT-09)

49. Skipjack are known to have high population turnover rates, year round spawning, short life span, high mortality and fast growth. Because of these reasons skipjack stocks are believed to be resilient and not easily prone to overfishing. Skipjack is one the most important tuna species in the Indian Ocean, targeted by the purse-seine fleets in the WIO, by pole-and-line fisheries in the Maldives and Lakshadweep (India), and by gillnet fisheries in Sri Lanka and Oman. Prior to 1980 skipjack were mainly caught by the Maldivian pole-and-line fishery, and since then, caches increased rapidly following the introduction of industrial purse-seine fishery and subsequent developments of coastal fisheries of Maldives, Sri Lanka and Oman.

50. Reported catches in the Maldivian pole-and-line fishery reached a peak of 138,000 tons in 2006 and dropped of more than 50% to around 66,000 tons in 2009, which raised great concerns for the fishing communities of the outer atolls and the country’s revenue from skipjack exports. This drop could be explained by the decrease of fishing effort from the Maldivian pole-and-line fishery, due to high fuel prices and decreasing availability of livebait, by a declining abundance of skipjack in the core fishery areas due to over-exploitation of the stock, to changes in some environmental factors linked to skipjack abundance and distribution, or by a combination of the three.

51. In the Maldives two distinct size classes of skipjack are observed throughout its long history of the pole-and-line fishing; small skipjack of between 40-50 cm and 60+ cm size class. In the recent years, abundance of the large skipjack in the Maldivian fishery has declined. This is supported by the sampling data and by opinion survey conducted with fishermen in 2009.

52. The group noted that catches of large skipjack may actually be different due to the static conversion factors (mean weight) being used in the Maldives. Maldives has a total enumeration system where fishermen record number of fish caught which are then converted to weights by use of conversion factors. Also the use of only fishermen reported catch may cloud the overall picture of the catches in the Maldives.

Oversea Thai Tuna Fishery of Thailand during 2008-2009 (IOTC-2010-WPTT-10)

53. In 2008 and 2009, oversea Thai tuna fishery operated in the Indian Ocean was composed of 2 tuna longliners and 4 tuna purse seiners. Data from their logbooks displayed important information of catch, fishing operation and effort.

54. Tuna longliners were conducted in the western Indian Ocean. The total catch in 2008 was 265.57 tons with 412 days of fishing effort and CPUE was 16.71 number/1,000 hooks. In 2009, the annual catch was 295.33 tons obtained from 477 days of fishing effort. The CPUE was 14.67 number/1,000 hooks. The main composition of catch in 2008 was yellowfin tuna contrary to that in 2009 which bigeye tuna was mostly caught.

55. The main fishing ground of tuna purse seiners was the western Indian Ocean. Skipjack tuna occupied the highest percentage of catch composition. An annual catch in 2008 was 9,608 tons taken from 388 hauls and CPUE was 24.76 tons/hauls. In 2009, the fishing effort was 436 hauls resulted in 11,084 tons of total catch and 25.42 tons/haul of CPUE.

56. The WPTT noted that the proportion of bigeye and yellowfin in the catch from the Thai purse seiners is very different from the proportion of bigeye and yellowfin in the European and Seychelles purse seine fleets which are operating in the same area. In fact, there is far more bigeye in the Thai catch. The WPTT recommended to investigate this issue, as this could come from a problem in the sampling..

From VMS data to tuna distribution maps and indices of abundance (IOTC-WPTT-2010-21).

57. Vessel Monitoring Systems (VMS) data are used to analyse the different fishing activities of the French fleet of purse seiners at a small scale (*i.e.* stop, track and cruise), generally embedded into the definition of a nominal

fishing effort. A state-space model (run in a Bayesian framework) was applied to speeds and turning angles from Vessel Monitoring Systems (VMS) data to identify the different "states" of the fishing behaviour of a purse seiner over a fishing trip. The activities "fishing", "tracking", and "cruising" were estimated on the vessels trajectories and aggregated at the fleet level. Summary statistics of the various components of the fishing effort were calculated and highlighted the variability in time and space of the fishing effort from French tuna purse-seiners in the Indian Ocean. Distribution maps of the presence of tuna were derived and aggregated by stratum to build VMS-based indices of abundance. A comparison with traditional CPUE is performed for the study period (2006-2008)

58. The WPTT noted the information provided by the paper but also questioned *i*) the utilisation of a more complex method if the usual catch rate 5 by 5 º is given comparable results and *ii*) the gain in information by dividing searching time in "tracking" and "cruising". The authors noted that this information would allow to a more comprehensive estimation of effective effort and would be valuable to estimate some abundance indexes for tropical tunas.

The study of population dynamic parameters of Yellowfin tuna in the Oman Sea (IOTC-WPTT-2010-39)

59. More than 20000 t of yellowfin tuna are caught annually in the southern waters of Iran. Sampling was carried out to estimate biological and life history parameters of management interest.

60. Data form different landing sites from 2005 to 2007 was pooled. Based on the length of more than 9300 specimens, ranging from 37 to172 cm, a growth curve was fitted where asymptotic length (L_{inf}) was estimated at 183 cm, with a corresponding growth parameter of 0.45 per year. The mortality rates were estimated as Z = 1.54 (F=1.06 and M= 0.48). The occurrence of empty stomachs was high (68 %) in the specimens sampled. Teleost fishes were the most dominant prey species observed in the study (42 %). Occurrence of *Portunus pelagicus* was found to be the second in importance (28%). *Sthenoteuthis oualaniensis* (22%), Natosquila (5%) and Octopus (3%) were also identified. The study on sex ratio indicated that male ratio to female was 1:1. The monthly gonadosomatic indices indicated higher values in April to June. The general trend suggested that the spawning period probably goes from April to June-July. The length at first maturity was estimated to be around 77 cm.

61. The WPTT acknowledged the important information provided in relation to Iran's yellowfin fisheries as well as yellowfin biology and ecology in that area. The WPTT further noted that, to date, the IOTC has not received information concerning the fishery information from Iran and, thus, the WPTT recommended that effort are carried out to collect and report to IOTC the necessary information on Iran's fishery statistics.

Status of the Comorian tuna fishery (IOTC-2010-WPTT-37)

62. The tuna fishing sector is very important in Comoros, with tuna landings representing 80% of the total estimated catch by Comorian fishermen. Annual catches of tuna, mainly yellowfin and skipjack, are estimated to be around 12000 tonnes per year. There is no statistical system in place in Comoros at the moment and the IOTC-OFCF project will start in January 2011 a sampling programme and a framework survey in order to better estimated the total catch of tuna and tune-like in the country. This project will last for a year, and the Comorian government will carry on the data collection activities once the project is finished.

63. The WPTT acknowledged the importance of the tuna fishery for the Comoros islands, however, it noted that it is necessary to implement a statistical system in Comoros. It recognized that the one year project that is currently being developed by IOTC-OFCF is crucial in order to collect and report to IOTC, reliable catch statistics for the archipelago. It also noted that Comoros should take over the sampling at the end of this project and report the relevant data to IOTC.

Note on yellowfin and bigeye catches collected during fishing and research cruises on board pelagic longliners of the La Réunion fleet in 2008 and 2009 (IOTC-2010-WPTT-11)

64. The pelagic longline fleet based in La Réunion started modification of its fishing strategy in 2005. Largest longliners of the fleet (LOA ranged between 20 m and 25 m) moved towards the west of La Réunion to exploit waters of the Madagascar EEZ. Such modification of the fishing strategy was driven both by the reduction of the swordfish CPUE in the EEZ of La Reunion and the difficulties to obtain satisfying sale prices for swordfish at the EU market. Then, currently the local longline fishery is split into two parts, one part composed by mini-longliners (mainly less than 17 m LOA) fishing inside EEZ of La Reunion, mostly off west side of the Island. The second

part of the fleet composed of largest longliners and several mid-sized vessel fishing in the eastern and south eastern parts of the Madagascar EEZ. Though fishing strategy did not exhibit drastic modifications in terms of gear, bait, fishing time, fishing depth, the change of fishing grounds led to variation in the species composition of catches. Common target species caught using current fishing strategy (swordfish) was gradually displaced by tuna, mostly yellowfin and bigeye. In this note we present and discuss data collected *i)* by observers placed on board fishing vessels in the frame of the EU project "Data Collection Framework" and *ii)* during scientific surveys carried out in the frame of several research projects: SWIOFP (South West Indian Ocean Fisheries Project), IOSSS (Indian Ocean Swordfish Stock Structure) and MADE (Mitigation of Adverse Ecological Impact of the open ocean fisheries).

Report on the unloading of purse-seiners in the Antsiranana harbour over the last nine years (2000-2009) (IOTC-2010-WPTT-35)

65. The document reported on the unloadings of the European purse-seine fleet in Antsiranana port. During the last nine years more than 30000t were unloaded in Madagascar corresponding to 1400 days of activity. In 2009, the number of unloadings reached a maximum with a total of 48 unloadings taking place in Antsiranana.

66. The WPTT noted that the purse-seine fleet is still unloading significant amount of fish in Antsiranana port, however, it noted that data on artisanal catches are still missing from the database hosted at the Secretatiat. It encouraged that a statistical system is developed and implemented in order to report on those catches, which are being estimated by the Secretariat at the moment.

Kenyan sports fishing Tuna CPUE (IOTC-2010-WPTT-42)

67. Catch per unit effort (CPUE) can be used as an indicator of fish abundance especially when a long time catch and effort data is available. This is mostly so for a fishery that does not change quickly with time thus maintaining a similar catchability for the target species. This report presents the CPUE for tuna species caught by the sports fishers in Malindi sport fishing club. The catch data is for 18 years from 1987 to 2006 whereby over 22,000 trips were recorded. The years 1988 and 1999 are not included as the data was missing. The CPUE for yellowfin tuna (*Thunnus albacares*) remained stable with occasional rise and fall. The situation was different for the skipjack tuna (*Katsuwonus pelamis*) which increased remarkably up to 1998 and has from then been on a decline. The Neritic tuna (Kawakawa (*Euthynnus affinis*), Kingfish (*Scomberomorous commerson*) and frigate tuna (*Auxis thazard*) however showed an increase in CPUE over the same duration. The use of sport fishing catches as an indicator of stocks status should be encouraged.

68. The WPTT welcomed this new source of information on this fishery. Comments were made on the interest of this work to continue. The views gathered on stock abundance changes in time and space by this stable fisheries, despite their low contribution to total catches, are of great interest to tuna researchers

3.4.2 ECOSYSTEM

Application of the APECOSM-E model to the skipjack tuna (*Katsuwonus pelamis*) fisheries of the Indian Ocean (IOTC-2010-WPTT-17)

69. APECOSM-E (Apex-Predator-Ecosystem-Model – Estimation) is a deterministic model that represents the 3D dynamic distribution of tropical tuna under the joint effect of environmental conditions and exploitation by fisheries. It is a simplified version of the top predator component of the APECOSM framework, based on a single partial differential equation. The model is structured in 3D space and fish weight (or size) and considers size dependent reproduction, growth, predation, natural mortality and fishing mortality. The representation of growth, reproduction and ageing mortality follows the Dynamic energy budget (DEB) theory, while horizontal movements and vertical distribution are driven by habitat gradients, physical currents and diffusion. Processes are time, space and size-dependent and linked to the environment through mechanistic bioenergetic or behavioural parameterizations.

70. This paper presents the application of the APECOSM-e model to the skipjack tuna fishery in the Indian Ocean. The model is run on a daily time step and on a 1° by 1° grid with 20 vertical layers and fitted to available fishing data using a maximum likelihood approach. Our results highlight the influence of environmental conditions on the horizontal and vertical distribution of skipjack tuna. Furthermore, they allow visualizing the

spatial and temporal variability of growth and recruitment, and emphasize the resilience of the skipjack population to increasing exploitation rate under present fleet spatial distribution, vertical and size selectivity.

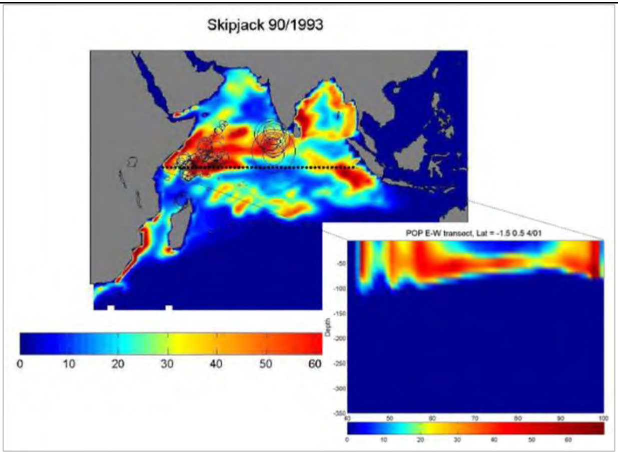


Figure 45. Example of output from the APECOSM model. Computed exploitable skipjack biomass distribution versus catch (circles) in winter 1993: (left) horizontal view representing the vertically integrated biomass and (right) vertical view on the West-East transect (dotted line)

71. It was noted that the gillnet fishery, for which little information is available, was not included in the APECOSM model application. Some questions were raised about the uncertainties of the inputs used in the model that are estimated from the coupled physical-biogeochemical ocean model (NEMO/PISCES). Sensitivity analyses to account for the range of input uncertainties might be useful for estimating the impact on the results. Due to its current spatial resolution (1°x1°), the model was not able to represent mesoscale and sub-mesoscale oceanographic features such as observed in the Mozambique Channel and around the Maldives and hence the magnitude of SKJ catches in these areas. Future model runs should be made on a 0.5°x0.5° grid to better capture finer scale physical features but ultimately depend on the availability of the fields of temperature, currents, and forage derived from the NEMO/PISCES model. It was recalled that the SEAPODYM and APECOSM models are based on overall similar features and mainly differ in the representation of tuna physiological processes based on the Dynamic Energy Budget (DEB) theory and the description of habitat layers in the ocean.

72. The WPTT noted that the operational character of end-to-end ecosystem models such as APECOSM for management advice remains poor at the moment but that they can provide a complementary view of current stock assessment models by linking the biological parameters to the environment. They might also provide useful insights into the analysis of technical interactions between fishing fleets.

Environmental preferences of yellowfin tuna (*Thunnus albacares*) in the northeast Indian Ocean: an application of remote sensing data to longline catches (IOTC-2010-WPTT-43)

73. Ocean environmental parameters such as sea surface temperature, chlorophyll_*a* and sea surface height derived from remote sensing satellites were analysed with Yellowfin tuna dataset. The dataset were obtained from Sri Lankan longliners fished from 2006-2008 in the northeast part of the Indian Ocean. The results have shown that the relationship between Yellowfin tuna catch rates and oceanographic parameters are significant. These relationships can be used to predict fishable aggregations of Yellowfin tuna using near real-time satellite derived oceanographic parameters. High frequencies of Yellowfin tuna catches were obtained in the areas where sea surface temperature varied primarily between 28-30°C. The corresponding sea surface heights ranged from 205-215 cm and the chlorophyll_*a* concentration ranged from 0.1-0.4 $mg.m^{-3}$. The relationships between catch rates and the three environmental parameters have been proved by the results obtained from the empirical cumulative distribution function (ECDF). The degrees of the differences between the ECDF and catch-weighted cumulative distributions of the three variables are statistically significant ($P<0.01$). The strongest association showed between catch rates and chlorophyll_*a* while sea surface heights showed lowest. The results obtained from a Generalized Additive Model (GAM) shown the space-time factor is well above the ocean environmental factors. However, the oceanographic factors were also in significant levels ($P<0.05$). Therefore, the migratory pathway is an essential factor in predicting Yellowfin tuna habitats in the northeast Indian Ocean

74. The WP noted the work done to relate the catch rates of Sri Lanka LL catch rates and environmental parameters. However, the WPTT also discussed specifically the appropriateness of using some time lag between

chlorophyll_*a* concentration and catch rates which will account for the production processes through the food chain as observed in other studies.

75. It was also raised some questions about the length of the fish caught by this Sri Lanka longline and the depth that longline are operating since in other longliners fleet operating deeper other environmental parameters seems to drive the relationship between catch rates. However, the authors noted that this longline fishery operations are carried out in depths more superficial in comparison to other longline fleets.

76. The group also noted the difficulty to identify bigeye from yellowfin based on logbook data. However, the author noted that research was carried to identify species composition. As the catch statistics provided by Sri Lanka do not contain estimates of bigeye catches, the WPTT recommended that the species composition obtained in this study is provided to IOTC Secretariat in order to improve Sri Lanka catch statistics in IOTC.

Update 2010 on the climate and ocean conditions in the Indian Ocean (IOTC-2010-WPTT-20)

77. An update of the climate and oceanographic conditions was presented, including observations up to September 2010. The long term and basin scale trend of the sea surface temperature (SST) has been steadily increasing since the mid of the 20th century at a rate of 0.12°C/decade. The variability pattern of the SST displays a dipole-like spatial structure, with opposite signals developing in the westernmost and easternmost parts of the equatorial basin. As depicted in the first component analysis of the SST anomalies for 1980-2010, the greatest warm anomalies occurred in the Western basin in 1983, 1987-88, 1998 and 2007, in relation with El Niño and positive Indian Ocean dipole events. The most recent data of the Southern Oscillation Index suggest that a Niña event is developing in the Pacific Ocean, which may affect the Indian Ocean by increasing SST and convection in the East, and decreasing SST in the West. However, no clear signal of decreasing SST in the West has been noticed so far. On the long term, it is shown that zonal wind stress anomalies in the Equatorial Central Indian Ocean (ECIO) precede by 2 months the changes in SST in the West, with anomalous easterlies (westerlies) leading to positive (negative) SST anomalies. The zonal wind stress situation in September 2010 is about normal in the ECIO. An analysis of the changes in the mixed layer depth (1980-2010) and sea surface Chlorophyll (1997-2010) was also performed in relation with the purse seine CPUEs on free schools, therefore concerning yellowfin making the bulk of catches on free schools. The study area is the West Indian Ocean, with a focus where spawning aggregations take place (50°E-70°E / 0-10°S). A deeper mixed layer is associated with El Niño and IO positive dipole events, with area-averaged anomalies of about +15 meters, reaching locally a magnitude of +60 meters. For the most recent years, shallow thermocline episodes occurred in 2001-2006 (the longest continuous record of such anomaly since 1980) and in 2008-2010. The satellite-derived Chlorophyll-a series depicts significantly below than normal concentration in the WIO during El Niño and IO positive dipole events. By contrast, 2002-2006 is characterized by strong above-normal concentration. After a Chl-a depleted situation in 2007, Chl-a exhibited positive anomalies in 2008 with much higher productivity recorded in 2009 compared to 2008. An abrupt decline of Chl-a concentration was observed in 2010. The PS CPUEs of yellowfin caught on free schools followed closely the thermocline and Chl-a changes (on a monthly basis, integrated on the whole study area) with higher CPUEs associated with shallow thermocline and positive Chl-a anomalies. In the peculiar case of the 2003-2005 record catches, those can likely be explained by an increased catchability effect due to shallow thermocline and favourable feeding conditions boosted by enhanced primary productivity. In addition, biological effects, such as a higher growth rate, lower natural mortality better condition factor, may be considered in such a context of high biological productivity. The huge decline of free schools PS CPUE in 2007 was probably induced by an environmental anomaly (without excluding an additional effect from a reduced biomass). There is a concern that the above-normal primary productivity and shallow thermocline in 2008 and 2009 may have induced a high catchability rate (at least from the PS) on the yellowfin stock, leading to a substantially high fishing mortality on an already depleted biomass.

78. The WPTT recommended that more work is carried out on catchability and selectivity of longliners and purse-seiners integrating the environmental factors described in this study. It was also noted that these data should be analysed at different scale in order to identify “hot spots”.

3.4.3 GROWTH

Preliminary first results obtained from the recovery of tagged sexed YFT: sex ratio and growth (IOTC-WPTT-2010-27)

79. Document 2010-WPTT-27 made a first study of the recovered yellowfin tunas upon which the sex has been identified by scientists. This sample is still limited, only 33 large yellowfin recovered up to date (17 females and

16 males) but it has already provided significant results. The first result, based on the 50/50 recovery rates of the 2 sexes, is that the natural mortality of adult females appears to be similar to the natural mortality of males. The second result is that there is an apparent differential growth between males and females yellowfin, females showing a significantly lower L infinity (about 10 cm lower). The paper concludes that this sampling of recovered sexed yellowfin tunas should be immediately reinforced, for instance sampling all the large tunas landed in Victoria harbour by Spanish and Seychelles fleets; for which there is not data yet.

80. The WPTT acknowledged the importance and implications on the assessment of yellowfin tuna of the results discussed in this paper and, thus, the WPTT recommended that effort are directed to measure the sex and length for any large tagged recovered fish.

Estimating the growth of yellowfin tuna (*Thunnus albacares*) combining otolith and tagging data within a Bayesian framework (IOTC-2010-WPTT-15).

81. A Bayesian version of the von Bertalanffy-log K model was developed to estimate the growth of yellowfin tuna from 4,009 tag-recapture and 207 otolith data collected through the RTTP-IO which were available until September 2010. In a first step, an operating simulation model was built to assess the sensitivity of the model results to the amount and level of uncertainty in the input data, and to the choice of prior distributions. Simulations mainly showed that the estimation was sensitive to the quantity of information provided on the large individuals and that strong correlations occurred between parameters in the estimation process. In addition, some simulations showed that the asymptotic length parameter (L_{inf}) was underestimated when information on age was noisy. Overall results emphasized the importance of expertise and prior knowledge when fitting the model to the RTTP-IO dataset. In a second step, three estimation models with increasing complexity were fitted to the: *i)* otolith data assuming age was known without error, *ii)* tag-recapture and otolith data by fixing L_{inf} at 160 cm and beta at 8, and *iii)* otolith data considering age was an unobserved latent variable. Model *iii)* was based on the multiple readings of daily rings deposits and described the observation errors occurring at the nucleus, oxytetracycline mark, and extremity of the otolith. Results of model *i)* were consistent with the 2-stanza growth curve used in the current yellowfin stock assessment (SA) but sensitive to the prior on L_{inf} for lengths > 110 cm. Combining otolith and tag-recapture data improved the precision and accuracy in the parameter estimation, the ages being correctly estimated as shown by simulations. In this case, the growth curve was consistent with the SA growth for ages < 3 years but the median length was higher after (Figure 46).

82. The WPTT noted that the results of this study were in agreement with the 2-stanza growth model used in the current stock Multifan-CL model used in the yellowfin assessment.

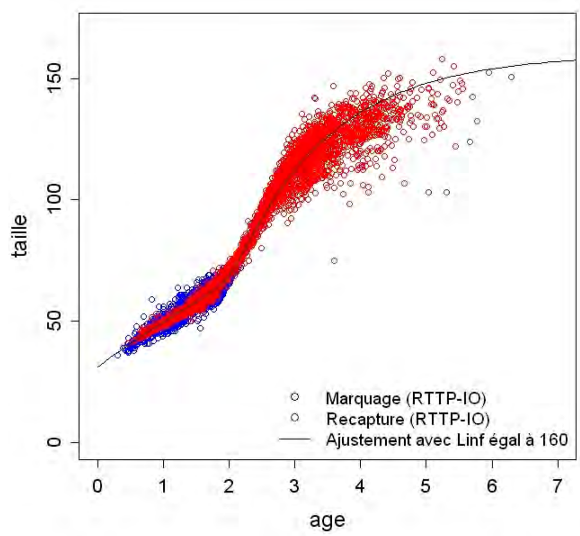


Figure 46. Fit of the von-Bertalanffy log-K model to the RTTP-IO otolith and tag-recepture data for yellowfin. The final median values estimates for the 6 parameters of the model were: k1=0.1544, k2 = 0.6914, alpha=3.433, beta=8, Linf=160, t0= -1.407.

3.4.4 Biology and Behaviour

Spawning activity and batch fecundity of skipjack, *Katsuwonus pelamis*, in the Western Indian Ocean (IOTC-2010-WPTT-07).

83. Document IOTC-2010-WPTT-07 focused on the reproductive biology of the skipjack, Katsuwonus pelamis, of the Western Indian Ocean. The reproductive strategy of the skipjack is defined, by histological analysis of the ovaries and oocyte size frequency distribution. Moreover, the reproductive capacity of individuals was assessed by estimating the size at first maturity and the fecundity parameters, such as the batch fecundity and relative batch fecundity. A total of 1269 skipjack tuna, ranging from 32 to 68 cm in fork length, were sampled from commercial catches on-board of a purse-seiner in three different areas of the Western Indian Ocean: SE and NW Seychelles, Somalia and the Mozambique Channel in three different periods (from January 2009 to May 2010). The histological analysis was carried out in 501 skipjack females. The skipjack was defined as indeterminate fish with an asynchronous ovarian development organization and asynchronous spawning. The size at first maturity was estimated in 37.8 cm. The batch fecundity ranged from 100,828 to 627,325 oocytes, and the mean relative batch fecundity was estimated at around 150 oocytes/g. From the results it seems that batch fecundity and relative batch fecundity were related to the condition of fish. From the monthly variation of the proportion of different stages (determined by histological analysis) and GSI data, it is concluded that the spawning is observed all year around in the three sampling areas, with increasing periods of the activity that could be related to monsoon events: North monsoon (November to March) and South monsoon (June to August).

84. Although still preliminary, the WPTT welcomed the new and interesting information provided through the analysis on the maturity and fecundity of skipjack. The length at maturity (L50) estimated in this analysis, 38 cm, was lower than previous estimates of around 41-42 cm (Stéquert and Ramacharrun 1996). The difference probably stemmed from the method of classifying individuals as mature, *i.e.* when oocytes in cortical alveoli stage appeared in the ovary. The WPTT noted that only about 10% of the total skipjack catch in the Indian Ocean is composed of fishes smaller than L50, which could concur to the robustness of skipjack to exploitation.

Differences in large-scale movement between free swimming and fish aggregating device (FAD) caught tuna (IOTC-2010-WPTT-06)

85. The Indian Ocean Tuna Commission tag recapture database was used in the IOTC-2010-WPTT-06 to determine whether there are differences in movement characteristics between tuna caught in free schools and those caught under FADs that might be indicative of an impact of FADs on large-scale tuna movement. We found that there were some differences in displacement rates between individuals caught at FADs and those caught in free swimming schools, as well as differences in movement angles. We suggest, however, that this is not necessarily an indication of a FAD effect on tuna movement, but might be an artefact of the non-uniform distribution of FAD fishing effort. We furthermore show that movement characteristics did not differ between fish tagged during periods of high and those tagged during periods of low FAD density and suggest that this might indicate the absence of an ecological trap effect. We conclude that school type at recapture might not be representative of a tuna’s movement history and therefore not suitable for detecting an ecological trap effect of FADs. Hence we propose the use of a more sophisticated statistical model of the tag-recapture data to address the question of whether FADs have the potential to alter large-scale tuna movements.

86. The WPTT acknowledged the importance of this type studies to better understand the ecology and behaviour of tropical tunas and the effects of fishery on them (*e.g.* ecological trap), but also noted some improvements that can be done as for example restricting the study to a limited time period of tag-recapture to study the direction of fishes since, using all tag-recapture data, can confound the conclusions.

Comparing condition indices of skipjack tuna (*Katsuwonus pelamis*) associated with natural floating objects and those from free-swimming schools in the Mozambique Channel (IOTC-2010-WPTT-24).

87. The objective of IOTC-2010-WPTT-23 is to compare condition indices of skipjack tuna (*Katsuwonus pelamis*) (plumpness, bioelectrical impedance) caught in schools associated to natural floating objects with fish caught in free-swimming schools. All samples were collected in the Mozambique Channel within 3 weeks (April 2010) assuming that all skipjack tuna were experiencing the same environmental conditions. The Mozambique Channel was chosen as it is a major fishing area that has not been hardly modified by the introduction of FADs (artificial floating objects), then representing the natural habitat of tuna before the use of FADs. All samples come from 6 free-swimming schools and 21 log-associated schools. For both indices, skipjack tuna around logs

revealed lower conditions than in free-swimming schools. We propose two possible interpretations of our results that can help better understand the reason why tuna aggregate under floating object. Differences could come from different feeding success (foraging strategies) between fish around logs and those in free-swimming schools. Considering that in average, tuna stay associated to floating objects for a few days only, it would mean *i)* that condition indices rapidly change (within a week) and *ii)* that the reason for which skipjack tuna has developed this associative behaviour is not linked to feeding behaviour but to other major component of their behaviour, such as schooling (see the meeting point hypothesis). The other interpretation is that the observed difference is not the consequence of the association but the cause why tuna aggregate under logs. Skipjack tuna would associate to floating objects after some bad feeding success in free-swimming schools. Associating to floating objects could be a behavioural strategy for fish in free-swimming schools that are in low conditions to save energy, form larger schools that could be more efficient when foraging, *etc*. Our results are not in favour of the ecological trap hypothesis as they tend to represent the conditions of tuna before the introduction of FADs and it is difficult to assume that animals could have developed a behaviour that would lead to lower fitness. However, before concluding, further analyses are needed to better understand what the absolute values of condition indices represent and to measure the differences of condition indices in areas that are highly modified by FADs.

88. The group discussed the scale at which the “ecological trap” hypothesis should be analysed, the thousands of FADs seeded each year in the Indian Ocean by the purse seine fisheries potentially impacting the biological components of tunas (*e.g.* growth, natural mortality at age and movement patterns) at the scale of the population. Some issues were raised about the ability to discriminate free swimming from FAD-associated schools in the Mozambique Channel. Similarly, the speed at which individual fishes might switch from free swimming to FAD-associated school might affect the assignation of a given fishing mode to a fish sampled.

89. Questions were raised about the limits of the spatio-temporal sampling design restricted to the month of April 2010. The Mozambique Channel was however considered to be the only area where such sampling could be carried out and Somali piracy prevented the boarding of scientists aboard purse seiners in most parts of the ocean. The difference in the size range of the tunas sampled between individuals sampled on free-swimming and FAD-associated schools was also noted by the WPTT but similar results were obtained when considering similar size ranges.

Behaviour of tuna associated with drifting fish aggregating devices (FADs) in the Mozambique Channel (IOTC-2010-WPTT-25)

90. The behaviour of yellowfin (*Thunnus albacares*), skipjack (*Katsuwonus pelamis*) and bigeye tuna (*Thunnus obesus*) was studied around two Drifting Fish Aggregating Devices (DFAD34 and DFAD31) through the tagging of individuals with long-lived, coded sonic transmitters and attached automated sonic receivers to DFADs in the Mozambique Channel, Western Indian Ocean. Two different methods were used to estimate residency times of tunas associated with DFADs; the Continuous Residence Time (CRT) and fine-scale residence time (FCRT). The median CRTs of yellowfin, skipjack and bigeye tuna were 9.98, 4.47 and 3.89 days respectively with no interspecific differences observed. However, for all species combined the median CRTs at DFAD34 were significantly higher than those at DFAD31, indicating that the tunas were more resident at DFAD34. In contrast, the median FCRT of yellowfin, skipjack and bigeye tuna were 0.59, 0.12 and 0.10 days respectively. There was a significant difference between the FCRT of yellowfin and skipjack tuna whilst, there was no differences in FCRTs between bigeye and yellowfin and skipjack tuna. Moreover, the FCRT of yellowfin tuna was significantly higher than the sum of its absence time (AT), whilst that of skipjack was not significant. This indicates that yellowfin tuna were more associated to DFAD than the two other species. The arrival and departure events were significantly higher during night time compared to daytime for all three species of tuna. For both DFAD combined, the median number of excursions per day of skipjack tuna (2.13) was significantly higher than that of yellowfin tuna (1.08). However, the median total time of excursions of skipjack (2.30) and yellowfin tuna (1.80) was not significantly different. This shows that skipjack tuna made more excursions of more than one hour away from the DFAD than yellowfin tuna but spent almost the same amount of time away from the DFAD as yellowfin tunas. All three species of tuna exhibited diel patterns in their vertical distribution, with deeper median depths encountered during the day than during the night. The median depth of bigeye tuna was significantly deeper than that of yellowfin and skipjack tuna during daytime and night time. In addition, that of skipjack tuna was significantly deeper than that of yellowfin tuna. More studies of this nature on DFADs are needed to establish if there are any temporal and spatial effects on the behaviour of tunas.

91. Results on residency time and depth-distribution were found to be very novel and interesting although the current small sample size might restrict inference to the population. The peak of arrival under the FAD at sunrise was found to well match with the time purse seiners started fishing as shown in document IOTC-2009-WPTT-09.

92. The WPTT noted that this type of studies are very useful to investigate the hypothesis of the ecological trap, which was proposed in the context of a network of FADs, where one fish leave one FAD and is "trapped" by another one, affecting the movement pattern and condition of the fishes. The WPTT also noted that it would be very important to compare the metabolic rates, *e.g.* how long a fish can survive going from a FAD to another without feeding, and the parameter that the BIA is measuring. Research is currently on going in order to relate BIA estimation with the kinetics of condition under the same project. The group also noted that the information provided by 2 archival tags released and recaptured in the Mozambique Channel, with a 1 month of liberty, showed that these two bigeye spent 2-3 days at a FAD with only 10 % of the time of close association with it. It also showed that the time between 2 FADs was around 20 days which are similar results compare to the study of Schaeffer and Fuller (2010).

Reproductive biology of yellowfin tuna (*Thunnus albacares*) in the Western and Central Indian Ocean (IOTC-WPTT-2010-48)

93. The reproductive biology of the yellowfin, *Thunnus albacares*, of the Western Indian Ocean was presented in document IOTC-WPTT-2010-48. A total of 1561 yellowfin were sampled from commercial catches on-board a purse-seiner in three different areas of the Western Indian Ocean and at the Seychelles cannery (from January 2009 to May 2010) and gonads collected in the Seychelles cannery. The description of different oocytes developmental stages as well as oocyte size frequency distribution seems to indicate that yellowfin has an indeterminate fecundity type. In the present work, the size at first maturity was estimated at 77,8 cm, the female-ratio was found to be 1:0.9, mean batch fecundity and the mean relative batch fecundity was estimated to be of 2.5 million oocytes and 61.9 oocytes per gram of body weight, respectively. Moreover, the area between 0º North and 10 º South were identified as the most active spawning ground and January, February and June have been the months when most developed ovaries were found with corresponding highest levels of GSI values (over 1.5 GSI value).

94. This value is significantly smaller than the length determined in previous studies by Stequer and Marsac (1989[3]), Bashmaker *et al.* (1991[4]) and Zhu *et al.* (2008[5]). The differences on the estimates of above studies can rely in the fact that different oocyte stages were used to define a mature female. In the present work, ovaries with the most advanced oocytes in the cortical alveoli stage were considered mature (Murua and Motos 2000[6]; Lowerre-Barbieri *et al.*, 2009[7]; Brown-Peterson *et al.*, in press[8]). This was because, the cortical alveoli stage, which is dependent of gonadotropin for their formation (Wallace and Selman 1981[9], Luckenbach *et al.* 2008[10]; Lubzens *et al.* 2010[11]), is the precursor of vitellogenesis indicating the onset of oocyte development and, hence, gonad maturation in short time (Murua and Motos, 2000). However, when the same criteria for maturity staging of previous work is used (*i.e.* ovaries with vitellogenic oocytes as most advance stage were considered as mature), similar value of length at first maturity is estimated.

3 Stéquert B. and Marsac, F.. 1989. *Tropical tuna – surface fisheries in the Indian cean*. FAO Fisheries technical paper no. 282 Rome, Italy. 238 pp.

4 Bashmaker, V.F., Zamorov, V.V. and Romanov, E.V., 1991: Notes on reproductive biology of Yellowfin tuna in the western Indian Ocean. IPTP. Coll. Vol. Work. Doc. TWS/91/32.

5 Zhu, G., Xu, L., Zhou, Y., and Song, L., 2008. Reproductive biology of yellowfin tuna *T. albacares* in the west-central Indian Ocean. *Journal of Ocean University of China* (English Edition) 7: 327-332

6 Murua, H. and Motos, L. ,2000. Reproductive biology of roughhead grenadier. *Sarsia* 85, 393-402

7 Lowerre-Barbieri, S.K., Henderson, N., Llopiz, J., Walters, S., Bickford, J.,and Muller, R., 2009. Defining a spawning population (spotted seatrout *Cynoscion nebulosus*) over temporal, spatial, and demographic scales. *Mar Ecol Prog Ser* 394:231-245

8 Brown- Peterson, N., Wyanski, D., Saborido-Rey, F., Macewicz, B., Lowerre-Barbieri S. In press. A standarized terminology for describing reproductive development in fishes. *Coastal and Marine Fisheries*. In press

9 Wallace, R.A., and Selman, K., 1981. Cellular and dynamic aspects of oocyte growth in teleostes. *Am. Zool*. 21,325-343.

10 Luckenbach, J.A., D.B. Iliev, F.W. Goetz, and Swanson, P. 2008. Identification of differentially expressed ovarian genes during primary and early secondary oocyte growth in coho salmon, *Oncorhynchus kisutch*. *Reproductive Biology and Endocrinology* 6:2

11 Lubzens, E, G. Young, J. Bobe and J.Cerda. 2010. Oogenesis in teleosts: how fish eggs are formed. *General and Comparative Endocrinology* 165:367-389.

95. The WPTT acknowledged the importance of biological information to be considered in the assessment models. With respect to future work in this area, the WPTT recommended that the gonad collection and calculation of the gonadosomatic index for yellowfin continue.

Some aspects of the biology of bigeye tuna (*Thunnus obesus*, Lowe 1839) in Andaman and Nicobar waters (IOTC-2010-WPTT-41)

96. Among the three species of oceanic tunas recorded in the Andaman and Nicobar waters, *i.e.* yellowfin, bigeye and skipjack tuna, the level of exploitation of bigeye is less than the other two species. Bigeye tunas are recorded mostly in the southern part of Andaman waters. Measurements and analysis were realised during a survey in the Andaman and Nicobar waters in order to derive some biological aspects and morphometric characters of bigeye, *i.e.* length frequency, length weight relationship, sex ratio, maturity and food and feeding habits. The males measured were in the FL range of 104-173 cm while the females measured were in the FL range of 122-172cm, with a sex ratio male to female of 1:0.7. Maturity stages varied from immature to mature. The food and feeding studies indicated dominance of oceanic squids and teleosts in the diet.

97. The WPTT acknowledged that biology of the bigeye tuna in the area of Andaman and Nicobar waters is unknown and noted that fisheries data for the region is very scarce. It recommended that detailed fisheries data and statistics are reported to the Secretariat for the region.

3.4.5 TAGGING

Updated analysis for 2006/07 and new analysis for 2008 of the RTTP-IO tagging data for Skipjack (IOTC-2010-WPTT-26, 31)

98. The documents detailed the analyses of tagging and catch data from the Indian Ocean skipjack fishery, using an age-structured model described in document IOTC-2009-WPTT-16, and implemented in IOTC-2009-WPTT-15. The model was used to estimate abundance and exploitation rates for 2006, 2007 and 2008. Compared to the previous analysis in 2008, a more complete data set was used. In addition, different assumptions regarding the data aggregation were explored, with results suggesting that estimates of exploitation rate are robust to these assumptions. It was concluded that all the tag data recorded at sea, at unloading by stevedores, or during processing, could be used, with a global reporting rate estimated from all the tag seeding data. Estimates of the number of tags surviving until the end of 2007 were used to initialize the model for 2008, allowing estimation of harvest rates for this year. Comparison of results across years indicates that exploitation rates are increasing, and for ages 3 and 4 are over 20% in 2007 and 2008.

99. The WPTT encouraged further analysis of the RTTP-IO data to provide information on the exploitation rates of SKJ. It was noted that the model did not fit well the tag data which might indicate some conflicting information.

Fishing mortality based reference point estimates for Skipjack (IOTC-2010-WPTT-49)

100. The analysis presented in the document estimates the fishing mortality for each year and age, based on the harvest rate estimates estimated from the results presented in the documents IOTC-2010-WPTT-26 and IOTC-2010-WPTT-31. It then compares these estimates to the reference points $F_{0.1}$ and F_{MAX}. These provide an upper and lower bound for F_{MSY}. Results indicate that the fishing mortality for ages 3 to 5 is increasing over years and exceeds the values of F_{MAX} in 2008, suggesting that overfishing may be occurring on these age groups.

101. Some questions were raised about the decrease in selectivity estimated after age 2. Migrations of the large skipjack outside the fishing grounds (*e.g.* in the vicinity of La Réunion island) might explain the decrease in selectivity. The group noted that F estimates were computed based on natural mortality rates assumed constant at 0.2, which is the value used at ICCAT. The WPTT recommended the use of Brownie and Petersen models to derive more consistent natural mortality rates based on the latest RTTP-IO data.

102. After a request from the WPTT, the analyses presented in document IOTC-2010-WPTT-26 and 49 were re-run with new values of M: 0.2 for all ages, as it was used in previous analysis in 2008. The new results showed that fishing mortality has increased between 2006 and 2008 for ages 3 to 5, and is currently much higher than that associated with the MSY (Table 3). This suggests that overfishing is taking place on these age groups. For ages 2 to 5, exploitation is less severe, but is still increasing, creating cause for concern (Table 4).

Table 3. Estimates of fishing mortality and comparison of the mean across ages 2 to 5 to F-based reference points

		Year			
		2006	*cv*	2007	*cv*
Age	2	0.22	(0.08)	0.13	(0.099)
(Quarters)	3	0.23	(0.026)	0.34	(0.035)
	4	0.16	(0.05)	0.48	(0.062)
	5	0.06	(0.149)	0.08	(0.238)
$\bar{F}$		0.17	(0.032)	0.26	(0.038)
$\bar{F}$ / $\bar{F}^{MAX}$		0.26	(0.032)	0.41	(0.038)
$\bar{F}$ / $\bar{F}^{0.1}$		0.47	(0.032)	0.73	(0.038)

Table 4. Estimates of fishing mortality and comparison of the mean across ages 3 to 5 to F-based reference points

		Year					
		2006	*cv*	2007	*cv*	2008	*cv*
Age	3	0.23	(0.026)	0.34	(0.035)	0.38	(0.059)
(Quarters)	4	0.16	(0.05)	0.48	(0.062)	0.81	(0.064)
	5	0.06	(0.149)	0.08	(0.238)	0.1	(0.174)
$\bar{F}$		0.15	(0.03)	0.3	(0.042)	0.43	(0.046)
$\bar{F}$ / $\bar{F}^{MAX}$		0.4	(0.03)	0.8	(0.042)	1.14	(0.046)
$\bar{F}$ / $\bar{F}^{0.1}$		0.72	(0.03)	1.43	(0.042)	2.04	(0.046)

103. Alternative natural mortality estimates were taken from the assessment for skipjack in the Western and Central Pacific Ocean (Langley, personal communication). Specifically, M = 0.68, 0.60, 0.55, 0.44, 0.35, 0.32, 0.29, and 0.25 for ages 0 to 7. Results of this run are shown in Table 5 and Table 6. The revised M values are higher than those originally assumed. This results in higher estimated exploitation rates, presumably because tags are being lost faster from the population.

Table 5. Revised M values: Estimates of fishing mortality and comparison of the mean across ages 2 to 5 to F-based reference points

		Year			
		2006	*cv*	2007	*cv*
Age	2	0.18	(0.077)	0.11	(0.1)
(Quarters)	3	0.25	(0.025)	0.3	(0.033)
	4	0.18	(0.051)	0.48	(0.061)
	5	0.06	(0.145)	0.08	(0.236)
$\bar{F}$		0.17	(0.029)	0.24	(0.039)
$\bar{F}$ / $\bar{F}^{MAX}$		0.37	(0.029)	0.53	(0.039)
$\bar{F}$ / $\bar{F}^{0.1}$		0.59	(0.029)	0.86	(0.039)

Table 6. Revised M values: Estimates of fishing mortality and comparison of the mean across ages 3 to 5 to F-based reference points

		Year					
		2006	*cv*	2007	*cv*	2008	*cv*
Age	3	0.23	(0.024)	0.29	(0.033)	0.72	(0.064)
(Quarters)	4	0.17	(0.051)	0.46	(0.06)	1.54	(0.054)
	5	0.06	(0.145)	0.08	(0.236)	0.15	(0.178)
$\bar{F}$		0.16	(0.03)	0.28	(0.043)	0.80	(0.04)
$\bar{F}$ / $\bar{F}^{MAX}$		0.58	(0.03)	1.03	(0.043)	3.01	(0.04)
$\bar{F}$ / $\bar{F}^{0.1}$		0.93	(0.03)	1.65	(0.043)	4.80	(0.04)

104. The WPTT noted the interest of this type of analysis, especially for a stock for which no stock assessment is available. However, at this stage the WPTT felt that the results from this analysis are too preliminary to be used for management advice. For example, the results appear to be difficult to interpret given the expected patterns of exploitation at age, and thus, should be taken with great care.

105. The WPTT recommended that further exploration of this analysis is conducted, especially on the reasons for the estimates of F at age obtained. Explorations of alternative estimators using the same data should also be attempted in order to understand how much of results observed are driven by the data and how much is dependent on the assumptions of the model being violated. The WPTT also encouraged the development of a multiyear Brownie-Petersen estimator to directly estimate M for next year meeting.

4. STOCK ASSESSMENT FOR YELLOWFIN TUNA

4.1. Introduction

106. Assessing the status of the stock of yellowfin tuna in the Indian Ocean is presentlycomplicated by the conflicting trends in the data: total yearly catches, length frequency data and abundance indices based on the longline CPUE. The observed trends in yellowfin catches and CPUEs are not mutually consistent. For any fished stock, to sustain increasing yields with no significant decline in abundance, cannot easily be explained.

107. 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[12]) and not to a major decline in stock density and biomass due to an early stock overfishing, as defended by some author (Myers and Worm, 2003[13]). 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. Present GLM CPUEs may correspond to a real trend in stock densities (the present hypothesis), but it may well underestimate the declining trend in stock biomass due to “cryptic” technological factors (not incorporated in the present GLM) that may have increased the fishing power of longliners.

108. A number of integrated stock assessment methods have the functionality to integrate tagging data in their estimation procedure. For this reason, the IOTC Working Party on Tagging Data Analysis held in June-July 2008 recommended conducting stock assessments on Indian Ocean yellowfin using those models (IOTC-2008-WPTDA-R).

109. Those models were initially run based on a spatially disaggregated structure. The 5 areas used in the YFT stock assessment corresponds quite well to rather homogeneous eco-biological areas, wider but similar to the areas proposed by Alan Longhurst in 1998:

- Area 1 corresponds to the Arabian Sea, an area with very low oxygen rates at all subsurface levels,
- The equatorial monsoon area has been divided in its western and eastern components at 75°East (areas 2 and 5),
- Area 3 corresponds to the East Africa coastal region of Longhurst,
- Area 4 corresponds to the south subtropical gyre of Longhurst.

4.2. CPUE indices and standardized CPUE indices

110. As with the 2009 WPTT meeting, a five region spatial stratification for the CPUE analyses in 2010 (Figure 40 and table 3) was maintained. The current demarcation of areas is similar to that used in previous years, with modifications based on the results obtained from the tagging project and the most expeditious use of these data in the MFCL assessment.

12 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

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

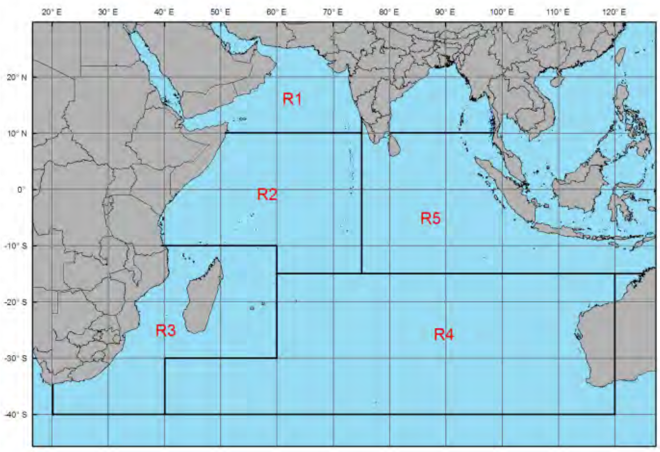


Figure 47. Areas used for CPUE analyses of yellowfin tuna in 2009

Table 7. Estimated size of the areas used for the assessment.

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

111. Catches of yellowfin in the 5 areas is very heterogeneous (Figure 48) and has changed since the beginning of the fishery, and especially in the 80s when the purse-seine fleet started to fish in the Indian Ocean. Overall, more than 80% of the yellowfin are being caught in area 2 and are 3, and for 2009, 88% were caught in these two areas.

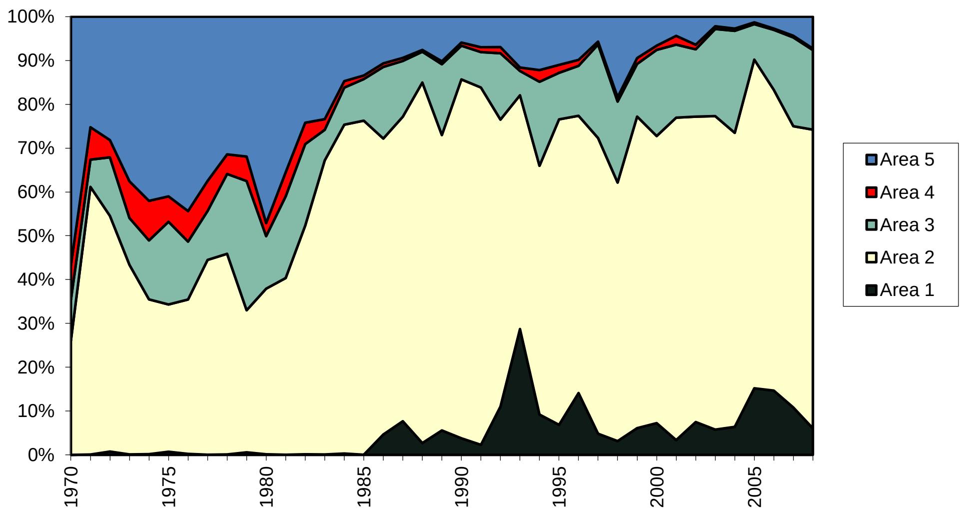


Figure 48. Catches of yellowfin in the 5 areas used for the assessment from 1970 to 2009

112. The standardisation of the Japanese longline CPUE for yellowfin tuna up to 2009, using a GLM was presented in document IOTC-2010-WPTT-30. Japanese longline CPUE for yellowfin tuna was standardized up to 2009 by GLM (CPUE-LogNormal error structured model). Number of hooks between float (NHF) and material of main line and branch line were applied in the model to standardize the change of the catchability which has been derived by fishing gear configuration. SST (Sea Surface Temperature) which was included in the model in the previous analysis as oceanographic factor was not applied this time because high catch rate at the low temperature in Area3 cause unnatural trend of CPUE. Quarterly and annual CPUEs in the main fishing ground and whole Indian Ocean were standardized to provide abundance index for yellowfin assessment using standard models, such as ASPIC, in the IOTC WPTT in 2010. Additionally, quarterly CPUE in each area in each of five areas in the whole Indian Ocean was also standardized for the assessment using Multifan-CL and SS3.

113. Trends of annual CPUEs for main fishing ground in the Indian Ocean (Area 2, 3 and 5) and whole Indian Ocean standardized from 1960 through 2009 using L5, L1 and set by set data are shown in figure 38 in real scale overlaying nominal CPUE and in relative scale. Basically, CPUE trends derived from different data sets were similar. In the main fishing ground, CPUE continuously decreased from around 15 (real scale) in early 1960s to

around 5.0 in 1974, and was kept in same level until 1992 with jump to 10.0 in 1977. Thereafter, it declined to about 3.0 in 1994 and has been kept in the low level with fluctuation between 2.3 and 3.2 until 2006. After that, the CPUE declined to about 1.2 in 2008 and 2009 although the data of 2009 is still preliminary. The trend of standardized CPUE for whole Indian Ocean was similar to that of main fishing ground, and also shows remarkable decrease in the last three years.

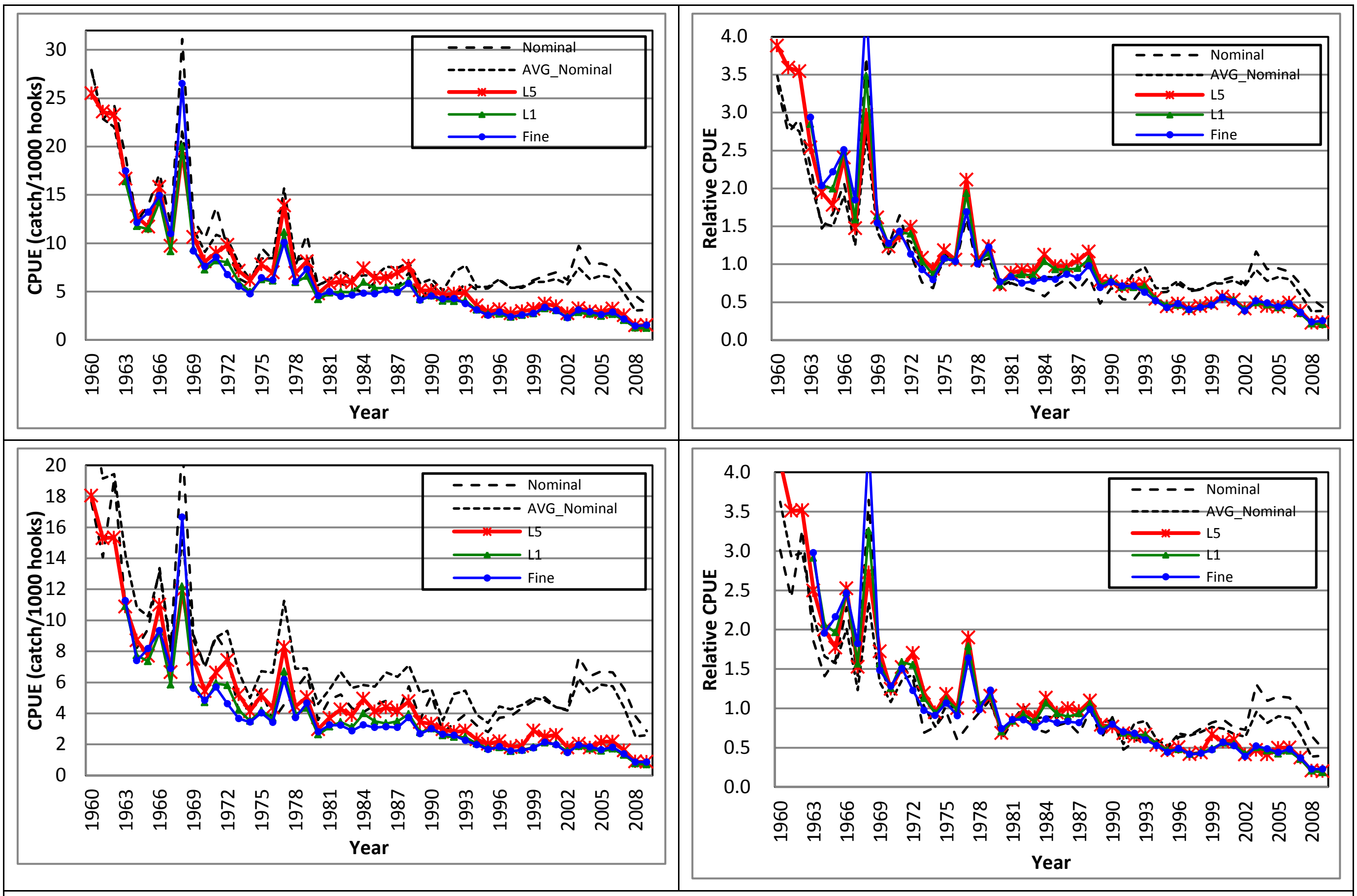


Figure 49. Annual based Japoanese LL CPUE in number standardized using L5, L1 and fine (set by set) data sets from 1960 to 2009 for main fishing ground (top) and whole (bottom) Indian Ocean expressed in relative (left figure) and real (right figure) scale overlaid with nominal CPUE.

114. As with the previous year, there was concern regarding the standardised CPUE series. This was largely related to two parts of the series *i)* the departure of the standardised CPUE series from the nominal series in the early 1990s. and *ii)* the decline in CPUE in recent years. A possible explanation for the former issue is that the gear used by the Japanese Longline fishery changed significantly during this time, however, the full data regarding this change was not available for the early years of this change. This has resulted in a scenario, where the GLM, even including interactions with a gear factor, has not been properly able to account for this change in regime. The latter problem is of greater concern as although a proposal that this decrease has been due to the effects of piracy attempted to explain this trend, the downward trend started before the onset of piracy and that the decrease is affecting the CPUEs in all the areas. It was proposed that a finer spatial scale is needed to account for changes in the density gradient within this area as there is diversity in fishing activity. Alternatively a core area where fishery has always occurred with similar fleets could be identified and investigated as this would allow the identification of changes in trends.

115. There was also concern as to whether this CPUE series is accounting for improvements in gear technology. It was suggested that a small constant increase in catchability, possibly based on work conducted in the western Pacific Ocean, could be included in the stock assessment models to account for the changes in fishing efficiency over time. It was acknowledged that this may already be taken into account in the GLM, and that catchability does not always show a clear consistent trend, however, the risk of assuming that gear efficiency is constant over time was also considered important.

116. An initial attempt to standardise the yellowfin tuna CPUE for the Korean longline fleet was presented in IOTC-2010-WPTT-33. The results suggested that standardized Korean CPUE were similar to those of Japan and

Taiwan. This suggested that the improved catch and effort database could be used to develop standardized CPUE for other species.

117. The WPTT strongly urged that the corrected databases used to produce this standardized CPUE series are made available to the IOTC Secretariat.

118. Standardized series of CPUE for the Taiwanese longline fleet were presented in document IOTC-2010-WPTT-40. For CPUE standardization of yellowfin tuna caught by the Taiwanese longline fishery in the Indian Ocean, the procedure adopted in the previous study (Yeh *et al.* 2009) was followed. In this study, environmental data were also used to in the GLM to standardize yellowfin CPUE based on the fine scale catch and effort data from 1995 to 2009. Relative standardized CPUE series obtained shows a relatively stable trend; slightly decreasing from 2005 to 2009 (Figure 50).

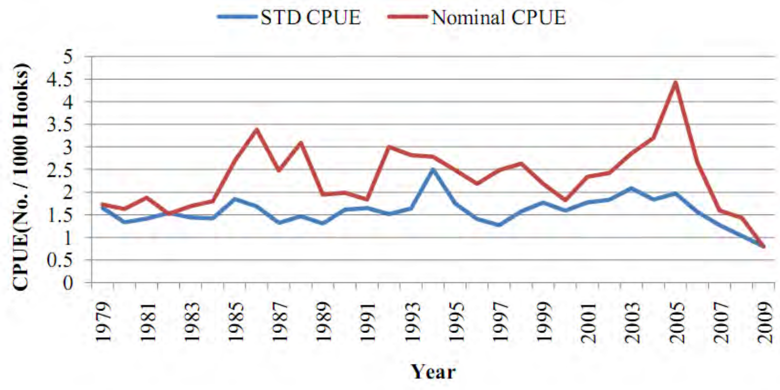


Figure 50. Nominal and Standardized annual CPUE series for yellowfin tuna from 1979 to 2009 for the Taiwanese LL fishery.

119. The WPTT noted once again, that the trend in CPUE for the Taiwanese LL fishery differed from that of the Japanese LL series. It was noted that a large decrease in effort has been recorded since the early 2000s sue to a decrease in effort. It was suggested that this may impact on the spatial coverage of this fleet. This is important, as this series is the primary series used by MFCL in region 1 and thus will impact on the model. It was thus requested that a plot showing the change in effort over time per region should be produced for this fishery.

120. For many years there have been problems with discrepancies in the trends of standardized CPUE between Japanese and Taiwanese tuna longline fisheries (LL) in the Indian Ocean (IO). This was investigated in document IOTC-2010-WPTT-32. Two major likely reasons proposed include: (a) both CPUE have been compared in the large geographical areas (such as whole or tropical IO) and (b) there are no numbers of hooks between floats (NHF) information (*i.e.*, effective targeting correction factors) in Taiwanese CPUE before 1994. To mitigate these problems, the authors attempted the following methods in this document: (a) to search common fishing grounds between Japan and Taiwan,China and (b) to use the Taiwanese CPUE after 1995 where NHF data are available.

121. It was noted that the large decline in Japanese CPUE in the early 1990s is not observed when only the core fishing area was included, which is different from other the standardised CPUE series. The differences can plausibly be explained by the fact that in this current study, area weighting was not considered and gear classification differed as well. It was also pointed out that gear classified as “deep” did not necessarily fish at a greater depth in each case, but had the potential to do so.

122. Comparisons of standardised Asian longline CPUE series were presented in document IOTC-2010-WPTT-44. There are different types of standardized CPUE every year to be used for stock assessments and also to see rough trends of abundance indices. But these standardized CPUE are made under different methods and factors, *i.e.* methods are different types of statistical analyses (GLM, GAM, *etc.*) and factors are grid (5x5, 1x1 *etc.*), sub-areas, analysing years, correction factors of targeting (number of hooks between floats or species compositions), environmental information (temperature, thermo-cline depths, shear currents, moon phase *etc.*). Thus it is difficult to compare and evaluate the best standardized CPUE (most representing abundance indices) under such circumstances. For this year we have new Korean standardized CPUE which makes the situation more difficult. The quick and empirical approach to evaluate standardized CPUE is to compare the trends of standardized CPUE. Although it is not the rigid scientific methods, standardized CPUE show similar trends are likely more reliable. Using this empirical approach with r^2, standardized CPUE are examined and evaluated. In

additional we assume that fine scale data (1x1 and set by set) produce more reliable indices. But we compared all results including standardized CPUE based on 5x5 grid.

123. Data collected from a longline fishery in the Indian Ocean were used to evaluate the performance of "deterministic habitat based standardization (detHBS)" method for the CPUE standardization (IOTC-2010-WPTT-50). The habitat preference indices of the yellowfin tuna (*Thunnus albacares*) were estimated for different classes of depth, temperature, chlorophyll-a, and dissolved oxygen classes. The detHBS was applied to standardizing the yellowfin tuna CPUE based on the habitat preference indices of the yellowfin tuna. The nominal CPUE and normalized nominal CPUE were compared with the standardized CPUE and normalized standardized CPUE, respectively, using the paired two-sample t-test. The results showed that (1) nominal CPUE was greatly different from standardized CPUEs; (2) there were no differences between normalized nominal CPUE and normalized standardized CPUEs estimated based on the data of depth, temperature, and DO classes;(3) there was difference between normalized nominal CPUE and normalized standardized CPUE estimated based on the data of chlorophyll-a data. This study suggests that detHBS improves the precision of CPUE standardization effectively. The depth data were most important for detHBS in estimating CPUE of yellowfin tuna.

124. It was noted that this method depends on the deployment of large numbers of Temperature Depth Recorders (TDR) on longline gear, which is costly. The model also did not include bait selectivity which may have further impacts on the predictive power of the model. Lastly, it was suggested that the small temporal time-scale of this experiment may result in some factors being incompletely described in the model, particularly factors which may be strongly influenced by seasonality, such as temperature and depth.

125. The indicators of fishing effort targeting yellowfin (and bigeye) exerted by Japanese and Taiwanese longline fisheries was presented in document IOTC-2010-WPTT- 28. This working paper estimate the fishing effort of Japanese and of China Taipei longliners that have been targeting yellowfin or bigeye in the Indian Ocean at the basic level of the 5° and month strata. The changes in the monthly and yearly sizes of targeted fishing zones are also estimated as well as the CPUEs in these targeted strata. This paper shows major differences and changes in the targeted efforts exerted by the 2 fleets. It is concluded that such basic fishery indicators may be of indirect use in the stock assessment of bigeye and yellowfin.

126. IOTC-2010-WPTT-51 described an integrated habitat index for yellowfin tuna using longline data. A survey on tuna fishery has been carried out aboard of the longliners Huayuanyu No. 18 and Huayuanyu No. 19 in the Indian Ocean in 2005. Based on the survey data collected by Huayuanyu 18, the vertical profile data of temperature, salinity, chlorophyll-a concentration, dissolved oxygen concentration and the catch rate data of yellowfin tuna (Thunnus albacares) were applied to develop the “Integrated Habitat Index (IHI)” models by the quantile regression method. The data collected by Huayuanyu No.19 were also applied to validate these models. The results showed that the optimal inhabiting depth of yellowfin tuna was from 80 to 160 m in the survey area; the IHI in the area of 3°30'N~8°30'N, 62°E ~64°E was the highest; the IHI in the area of 3°N~6°N, 64°E~70°E area was relative higher; the main environmental variables which affected the distribution of yellowfin tuna in specific depth stratum were different; the weighted average of temperature and dissolved oxygen concentration effected to the spatial distribution of yellowfin tuna significantly. The quantile regression method could be used to study the pelagic species spatial distribution.

4.3. Stock assessments

4.4.1. ASPIC

127. Runs of a surplus production model, ASPIC, using the Fox function, were presented in document IOTC-2010-WPTT-34. The analyses were conducted using two standardized Japanese LL CPUE series for the tropical area (scenario 1) and the whole Indian Ocean (scenario 3). The results obtained appear to indicate an overfished stock that has been suffering from overfishing over a period of time (Table 8). The estimates of MSY obtained are in the range of those estimated by the WPTT in the past.

Table 8. Summary of the ASPIC results for two alternative scenarios

Scenarios	MSY	$F_{current}/F_{MSY}$	$TB_{current}/TB_{MSY}$
1 – Tropical area	324 000 t	1.87	0.49
3 – Whole Indian Ocean	287 000 t	1.47	0.69

128. The estimated trends in the status of the yellowfin tuna stock relative to F_t/F_{MSY}, B_t/B_{MSY} reference points are illustrated in Figure 51 and Figure 52.

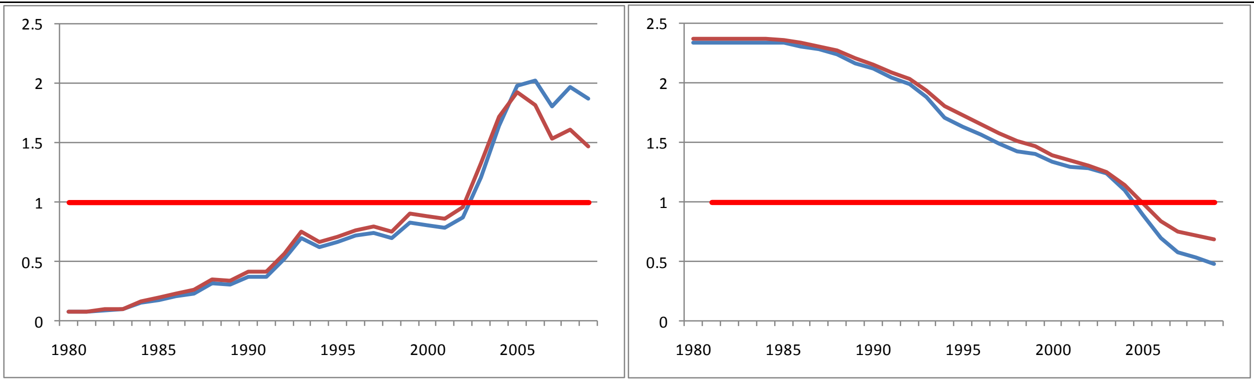


Figure 51. F/F_{MSY} (left) and B/B_{MSY} (right) for scenario 1 in blue and scenario 3 (in red).

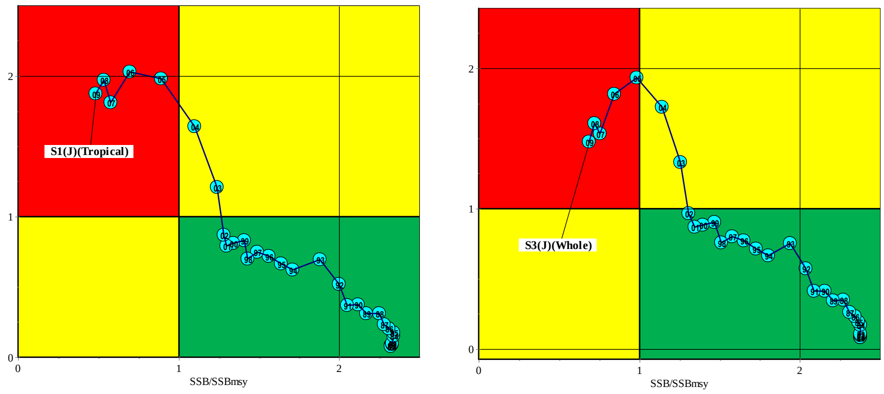


Figure 52. Kobe plots for scenario 1 (left) and scenario 3 (right).

129. The WPTT acknowledged that biomass dynamics models provide a basic exploration of the information contained in the index of abundance, although the structure of the model cannot accommodate the changes in fishery dynamics related to size that have been observed in this fishery. The use of a single source of information on stock abundances, in this case a CPUE series (Figure 53)for which doubts exist over its relationship to the status of the stock, limits the use of the results generated by ASPIC for management purposes

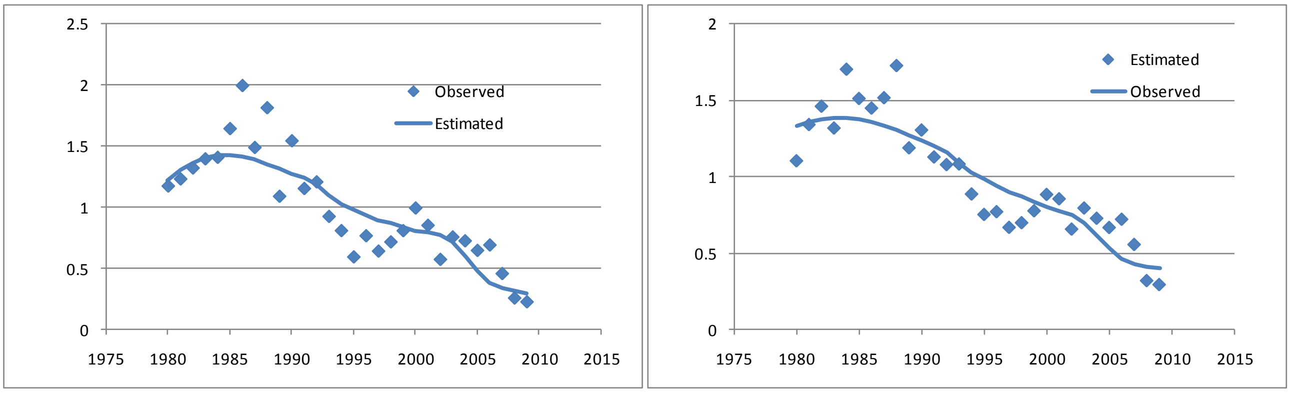


Figure 53. Fits to the CPUE for the scenario 1 - tropical area (left) and scenario 3 – whole Indian Ocean (right).

130. A Kobe 2 table of probabilities of stock status under various catch regimes was generated from the ASPIC results (Table 9). The uncertainty in the projection comes only from that calculated for the index of abundance, by bootstraping of the CPUE residuals. Given the pattern of residuals observed, and the limitations in the dynamics included in this model, the results of these projections should be considered exploratory.

Table 9. Kobe 2 Strategy matrix for Setting Management Measures based on ASPIC (Green: Pr<0.01 low risk, Yellow: 0.01≤Pr<0.4 moderate risk, Red: Pr≥0.4 high risk).

Stock status Reference Point	Projection Time frame	Alternative Catch Projections			
		C(2009) -30% (201,682t)	C(2009) -20% (230,494t)	C(2009) (288,117t)	C(2009) +20% (345,740t)
Pr(B_t<B_{MSY})	In 3 years	0.29	0.37	0.54	0.76
	In 10 years	<0.01	0.03	0.95	1
Pr(F_t>F_{MSY})	In 3 years	<0.01	0.07	1	1
	In 10 years	<0.01	<0.01	1	1

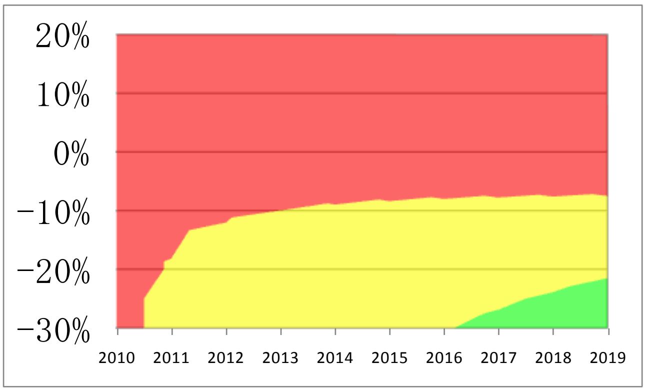


Figure 54. Graphic representation of the Kobe II strategy matrix, Total biomass (B) based on ASPIC scenario 3. The Y-axis represents the level of catch, 0% being the current situation (2009). Green: P(B_t<B_{MSY})<0.01 low risk, Yellow: 0.01≤P B_t<B_{MSY})<0.4 moderate risk, Red: P(B_t<B_{MSY})≥0.4 high risk

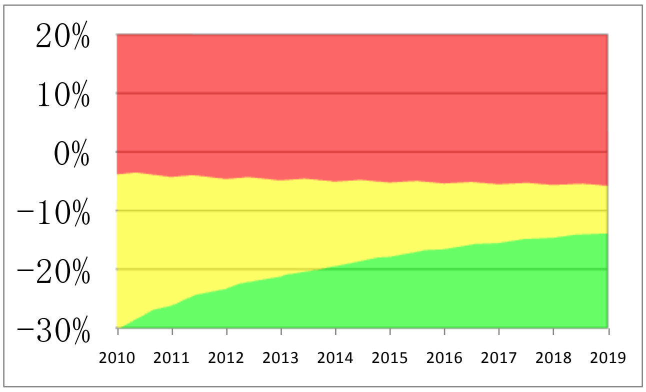
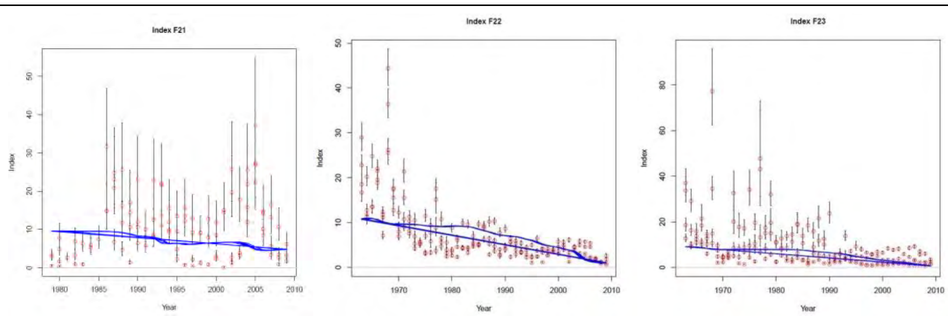


Figure 55. Graphic representation of the Kobe II strategy matrix, Fishing mortality (F) based on ASPIC scenario 3. The Y-axis represents the level of catch, 0% being the current situation (2009). Green: P(F_t>F_{MSY})<0.01 low risk, Yellow: 0.01≤P(F_t>F_{MSY})<0.4 moderate risk, Red: P(F_t<F_{MSY})≥0.4 high risk

4.4.1. SS3

131. Document IOTC-2010-WPTT-45 described a stock assessment exercise for yellowfin tuna in the Indian Ocean using Stock Synthesis III (SS3) (Methot, 2005; Methot, 2010), a kind of length-based integrated model, including tagging data, and using multiple areas and fisheries. Estimated MSY-related values (MSY around 300,000 t, B_{MSY} around 1,200,000t, *etc*.) obtained from SS3 were on the range estimated in the past by the WPTT.

132. The utility of the SS3 model was recognised and acknowledged by the WPTT. However, at this stage it was felt that the results from this model are too preliminary to be used for management advice. For example, concerns were raised on the degree of fit to tagging and CPUE data (Figure 56 and Figure 57) while the trends in SSB by area appear to contradict the known differences in productivity across the Indian Ocean. With highly complex integrated models, a large amount of work is required to parameterise them properly in order to better capture stock dynamics. It was suggested that further work was required in this regard to improve the model outputs.



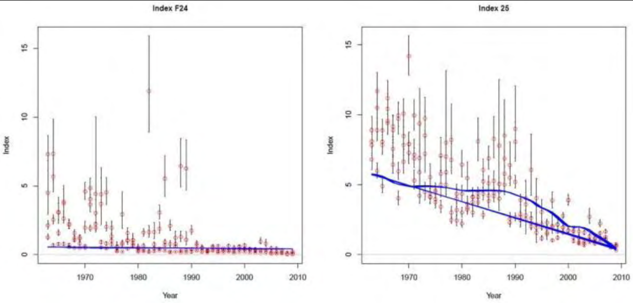


Figure 56. Fits to CPUE for each area of the assessment

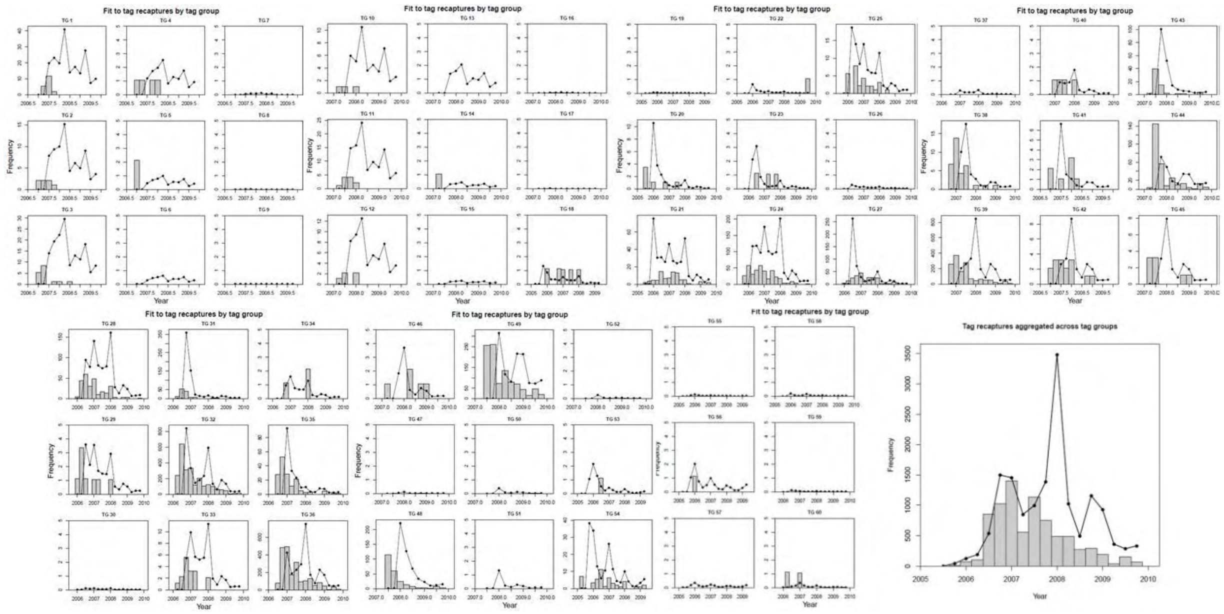


Figure 57. Fits to the tagging data for each tag group and aggregated

4.4.1. Multifan-CL, (MFCL)

Introduction

133. A size-based, age- and spatially-structured population model (Multifan-CL, MFCL) initially carried out in 2008 and again in 2009 was updated and applied to the Indian Ocean yellowfin tuna stock, as presented in document IOTC-2010-WPTT-23. This method is routinely used to conduct the stock assessment of tuna stocks of the western and central Pacific Ocean, including yellowfin tuna. The model described in that document was however revised several times during the meeting in response to comments and suggestions from the WPTT.

Fisheries structure

134. A five-region spatial stratification (Figure 47) with quarterly time steps for the 1972-2009 period wase adopted for this model. Due to concerns regarding the seemingly unrealistic movement dynamics displayed by this model, an additional spatially aggregated model run was also conducted. In 2009 it was assumed that the selectivities for the LL fisheries were logistic in nature. This was, however, revisited in 2010 and it was decided that a logistic selectivity for LL may not be appropriate and that there may indeed be decreasing selectivity with age. This assumption was therefore included in subsequent model runs. By suggestion of the WPTT it was also decided to split the PS fleet into 3 separate time periods (prior to 2003, 2004 -2006 and post 2006) and to estimate separate selectivities for these three periods. This was done, as the catch-at-size data for the period between 2003 and 2006 showed an extremely large number of large yellowfin tuna were being taken during this time.

135. 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.

136. The indices of abundance by area as used in the MFCL assessment are presented in Figure 58. The Japanese longline standardized CPUE series for regions 2 to 4 were used for those areas, that include the main tropical distribution of the stock. For area 1, given the very limited activity of the Japanese longliners, the 2009

standardized CPUE series for the Taiwanese longline was used. The divergences in trends observed are likely to impact severely the ability of the assessment model to fully explain the stock dynamics

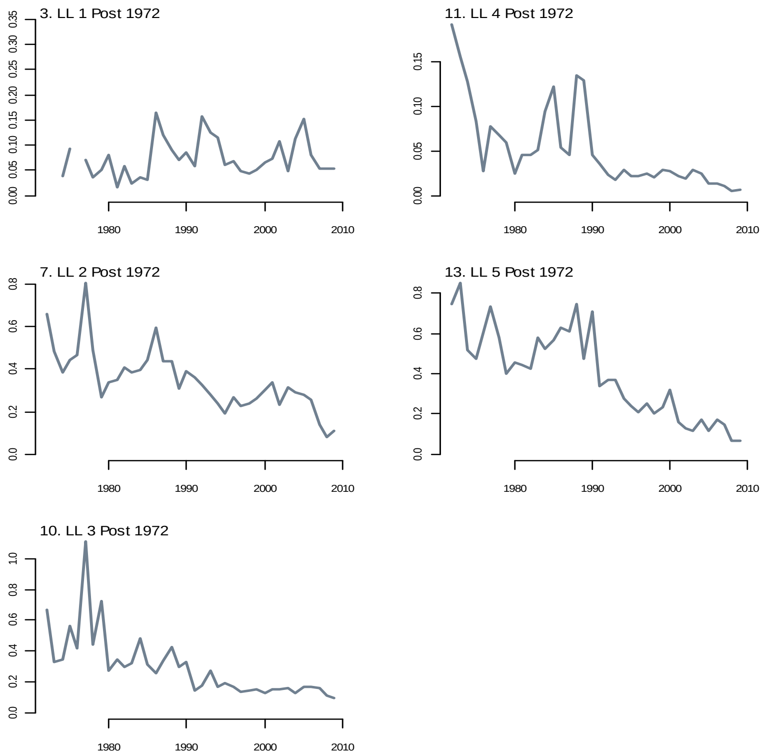


Figure 58. CPUEs for each of the 5 areas used in MultiFan-CL

137. The longline fisheries were grouped for the purpose of initial catchability, and timeseries variation was assumed not to occur in this group. As noted earlier, this assumption is similar to assuming that the CPUE for these fisheries indexes the exploitable abundance both among areas and over time. For the non longline fisheries, catchability was allowed to vary slowly over time (akin to a random walk) using a structural time-series approach. Random walk steps were taken every one or two years, and the deviations were constrained by prior distributions of mean zero and variance specified for the different fisheries according to our prior belief regarding the extent to which catchability may have changed.

Steepness

138. The steepness of the stock-recruitment relationship was conducted with a range of fixed values of steepness (0.6-0.8) as recommended by the WPTT in 2008 and 2009, although an additional value of 0.9 was included at the request of the WPTT.

Growth

139. For the current assessment, growth parameters were fixed at values that replicated the growth curve derived by Fonteneau (2008) (Figure 59).

Length frequency data

140. For the initial model runs, the size data were considered to be moderately informative and were given an according weighting in the likelihood function; individual length frequency distributions were assigned an effective sample size of 0.05 times the actual sample size, with a maximum effective sample size of 50. In subsequent model runs, varies weights were applied to the SF data ranging from effective samples sizes between 50 and 10.

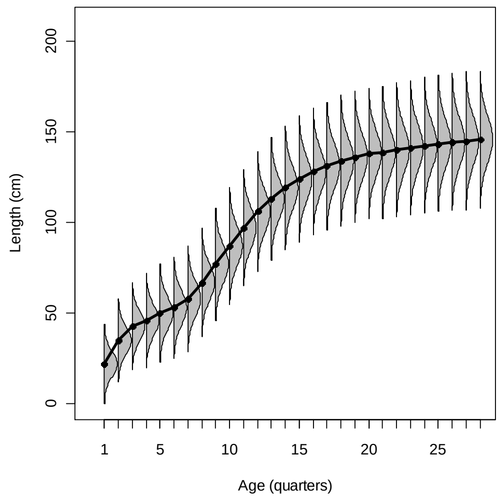


Figure 59. Growth of yellowfin used in the assessment model in green. The growth estimated by the model is also presented, the black line represents the estimated mean length (FL, cm) at age and the grey area represents the estimated distribution of length at age. **b.** Apparent growth rate of yellowfin estimated from tagging data

Movement

141. 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 and 2009.

142. 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. To this end, a single spatially aggregated model was devised.

Natural mortality

143. Natural mortality was initially assumed to be fixed at the values suggested by the 2009 WPTT (Figure 60). For the model runs conducted during the 2010 WPTT meeting, the “low Mortality” rate was assumed in each case. The low mortality option was selected as it was more consistent with the M-at-age estimates derived from model trials that estimated M-at-age, at least for the age range where tagging data were available to inform the model (1-12 quarters).

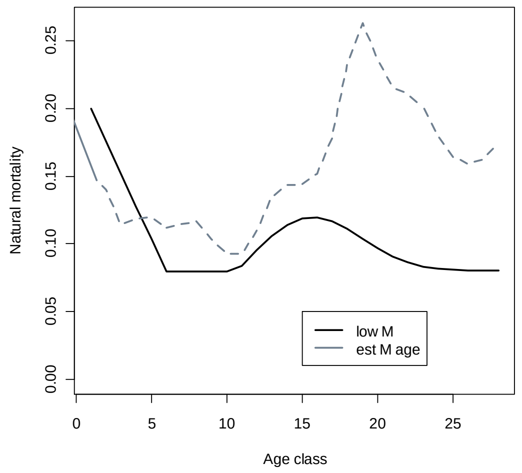


Figure 60. YFT age-specific natural mortality, low M adopted for the main stock assessment models and the results of a model option that estimated age specific natural mortality.

Results

144. The changes in the selectivity assumptions in this current assessment resulted in substantial changes in the model outputs from the previous year. The presentation of a single region model, using the CPUE series of the tropical area (region 2 and 5), too provided the WPTT with a very different outlook on the potential dynamics of the stock.

145. Extra runs were carried out that incorporated a number of suggestions made by the group, some of them mentioned above. The final model variations included:

- Two model variations – a single region and a five region model
- Four values of steepness – 0.6, 07, 0.8 and 0.9

146. The effect of splitting the PS time series and the low weighting of the length frequency data (maximum size of 10) had significant effects on the estimated selectivity (Figure 61). The periods pre-2003 and post 2006 were generally more similar than the period from 2004 – 2006.

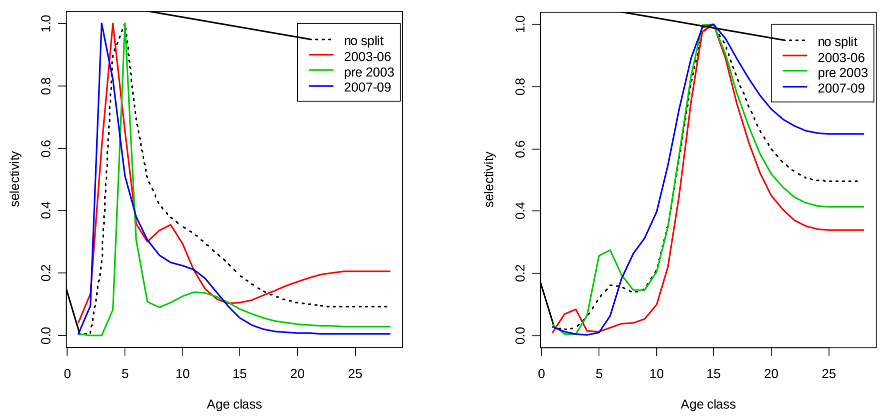


Figure 61. Estimated selectivity for the PS fleet on log (left) and free (right) schools.

147. 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). The fits to the CPUE series by area (Figure 62) show the ability of the model to explain the trends observed in the indices of abundance.

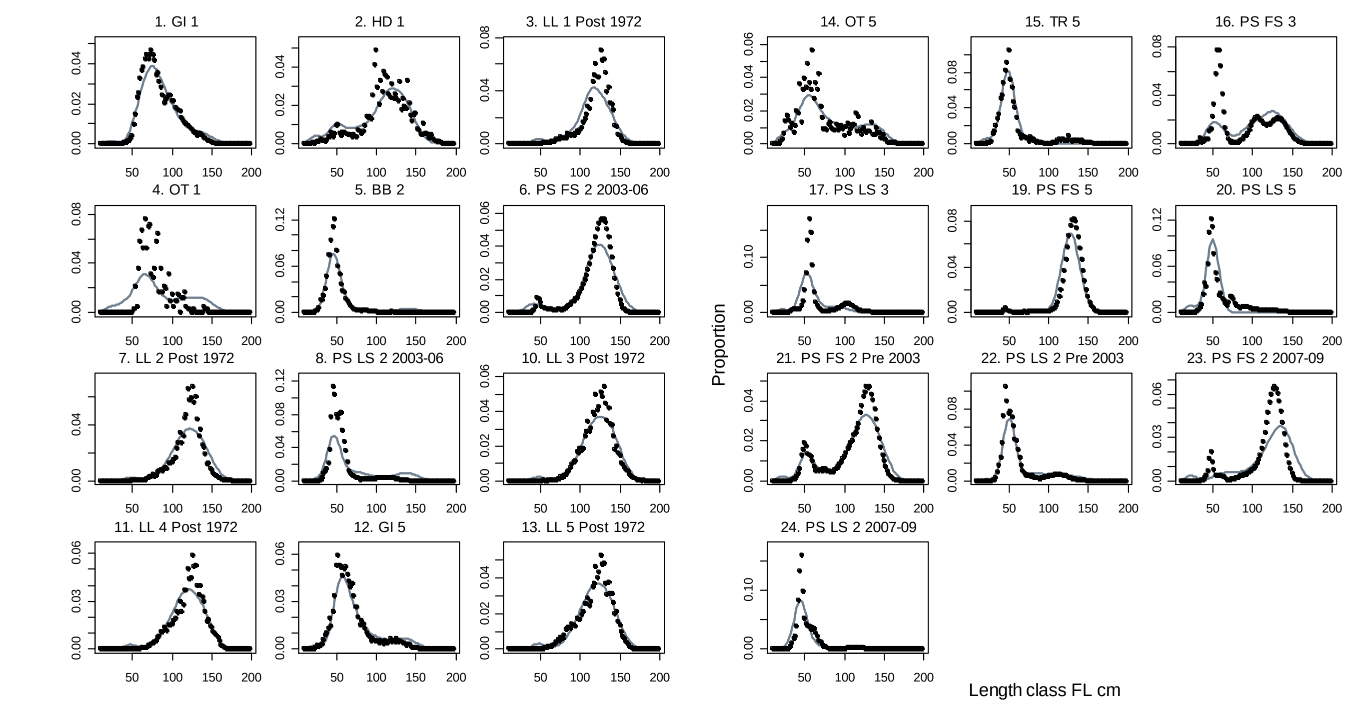


Figure 62. Observed (points) and predicted (line) YFT length frequencies (in cm) for each fishery aggregated over time.

Stock status

148. Results obtained appear to indicate that recent levels of fishing mortality are at a high level and the stock may currently be experiencing a period of overfishing, depending on the level of steepness assumed in the model. The model assuming a single region is more pessimistic than the model that incorporates 5 regions (Table 4). Current catches are likely to be higher than the estimated MSY, which ranges from 205,000 to 350,000 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), current spawning biomass is estimated to be below the MSY level (SB/SB_{MSY} <1); *i.e.* the stock is in an overfished state for the five region model, while for the single region model SSB is below SSB_{MSY} for all levels of steepness. For higher values of steepness (0.7 – 0.9), recent biomass is above the MSY level ($B_{current} > B_{MSY}$) and the stock is not in an overfished state. For the single region model, the current Biomass is below B_{MSY} for all levels of steepness. The model estimates that recent recruitment has been lower than average (Figure 50).

Table 10. Biological references points for the 2 different model variations and four assumed levels of steepness.

Model	Steepness	F_{2009}/F_{MSY}	MSY	B_{2009}/B_{MSY}	SB_{2009}/SB_{MSY}
5 regions	0.6	**1.385**	258 800	**0.91**	**0.93**
	0.7	**1.149**	292 840	**0.99**	1.02
	0.8	0.994	320 360	1.07	1.11
	0.9	0.853	347 680	1.17	1.25
One region	0.6	**2.366**	205 960	**0.63**	**0.63**
	0.7	**1.931**	232 680	**0.69**	**0.69**
	0.8	**1.696**	250 040	**0.74**	**0.76**
	0.9	**1.455**	269 480	**0.82**	**0.86**

149. 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, resulting in unrealistic estimates of the recruitment in each region (Figure 64). The WP considers that movement rates are underestimated due to the lack of reporting of recaptured fish by longline and artisanal fisheries. The differences observed between the CPUE series, together with the limited amount of tagging data, for areas 1 and 2, make the estimation of movement rates across them very complicated. The WPTT recognized that the information available does not allow the model to provide with estimates of movement rates and distribution of the biomass (Figure 64) that are coherent with the known biology of the stock. Therefore, the WP conducted a run of MFCL on a single area assumption, including CPUE series for the tropical area and tagging data for the former area 2 only.

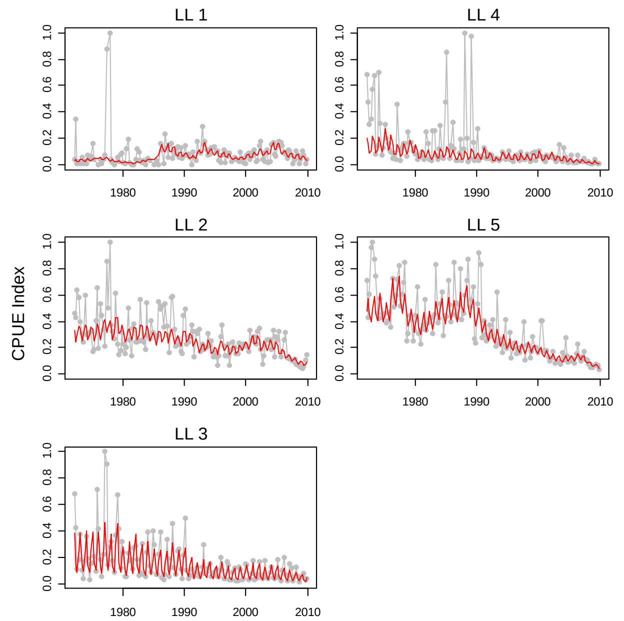


Figure 63. A comparison of longline exploitable YFT biomass by quarter and region (red line) and the quarterly standardised CPUE indices (grey line and points) for the fisheries. For comparison, both series are scaled to the average of the series

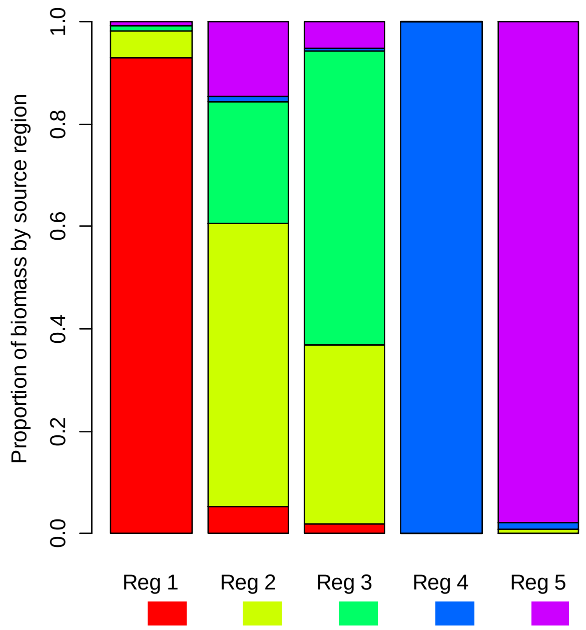


Figure 64. Proportional distribution of total YFT biomass (by weight) in each region (Reg 1–5) apportioned by the source region of the fish. The colour of the home region is presented below the corresponding label on the x-axis. The biomass distributions are calculated based on the long-term average distribution of recruitment among regions, estimated movement parameters, and natural mortality. Fishing mortality is not taken into account.

150. The model estimates a global decreasing total biomass trend in each area (Figure 66) which accelerated between 2003-2006.

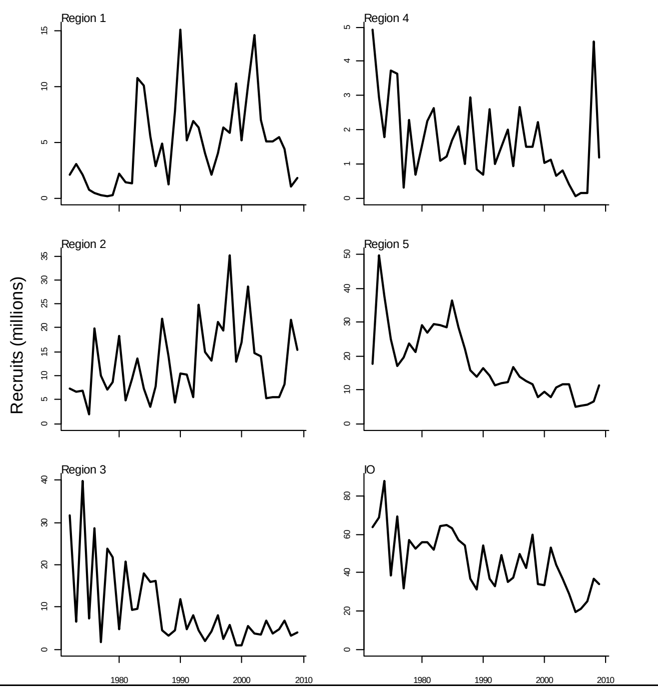


Figure 65. Estimated annual recruitment (millions of fish) for each area and for the whole Indian Ocean.

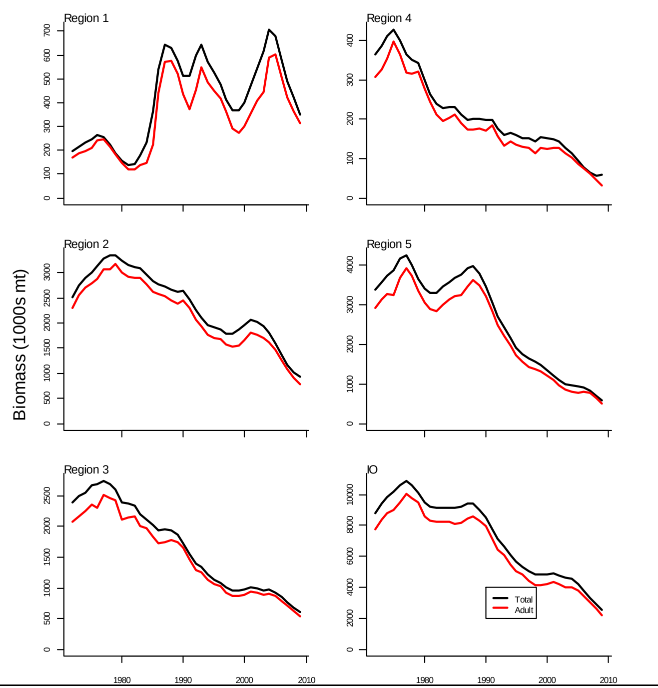


Figure 66. Temporal trend in total and adult biomass (1000s mt) for each area and in the whole Indian Ocean.

151. Recent fishing mortality rates, for the period used in the computation of references points (2005-2008), were highest in regions 2 and 3, particularly for the younger age classes (1 to 6), and the older age classes in region 1 (Figure 67). In region 3, the exceptionally high fishing mortality rate for the youngest age classes is attributable to the troll fishery that is estimated to exclusively catch these age classes.

152. The trend in the status of the yellowfin tuna stock relative to F_t/F_{MSY}, B_t/B_{MSY} and SB_t/SB_{MSY} reference points over the period 1960 to 2009 is illustrated in Figure 69a. Although a complete quantification of the uncertainty around the estimates obtained by this model is not available, the WPTT commented on the likely sources of uncertainty and their likely impact in the strength of the results. Uncertainty in the stock-recruitment relationship (Figure 68) was recognized as an important element, and its effect was investigated by model runs in which the values of steepness were fixed at 0.6, 0.7, 0.8 and 0.9 respectively. As observed in Figure 69b, the current status of the stock is affected by the choice of steepness value

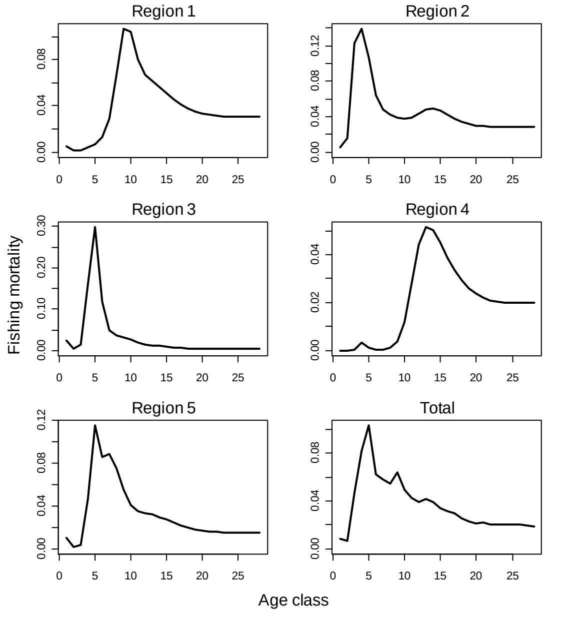


Figure 67. Recent fishing mortalities per area and for the whole Indian Ocean (average 2005-2008). *Note that the scale of the Y-axis differs from one region to another.*

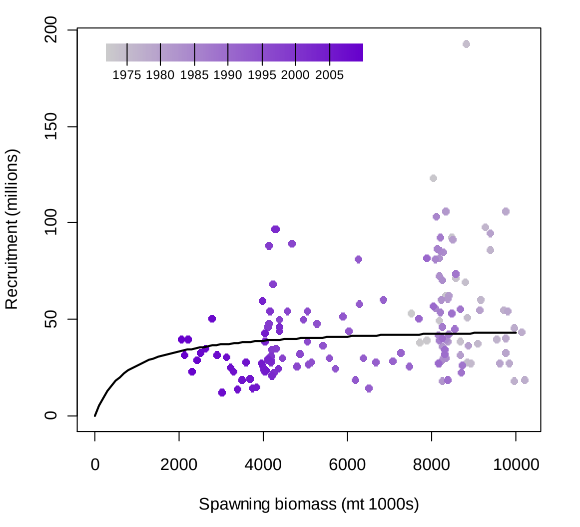
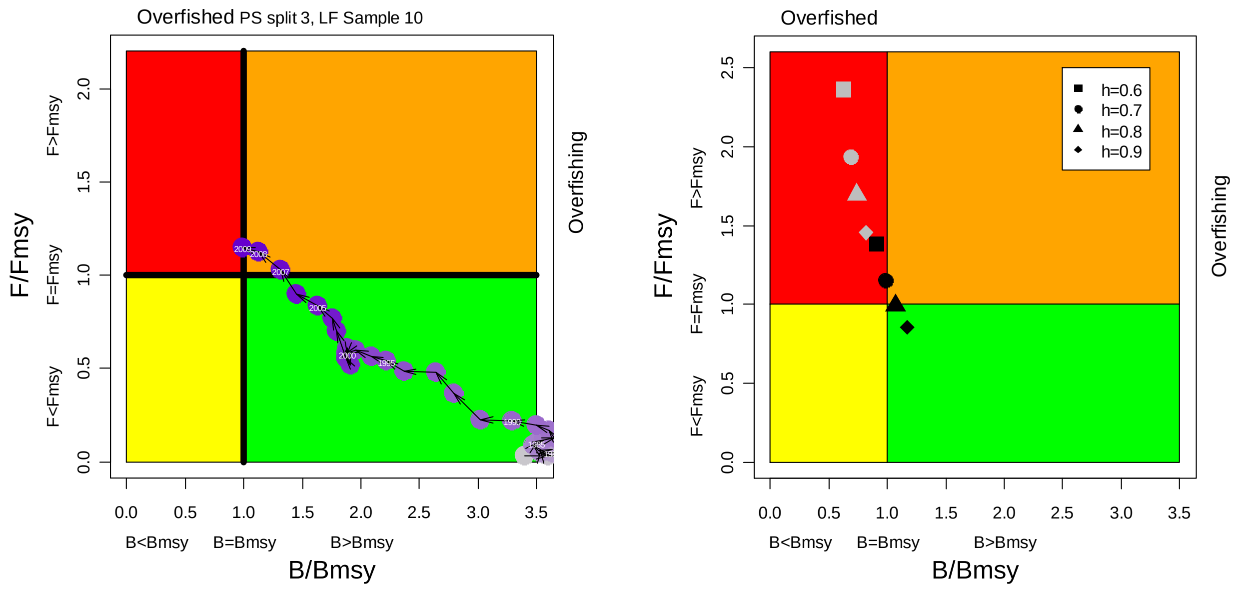


Figure 68. Relationship between equilibrium recruitment and equilibrium spawning biomass (steepness=0.7).



a **b**

Figure 69. Temporal trend in annual stock status, relative to SB_{MSY} (x-axis) and F_{MSY} (y-axis) reference points for ***a)***the final 5 area run(steepness 0.7), and ***b)***2009 situation for a range of run for a single area model (in grey) and the 5 area model (in black) at four different steepness. The colour of the points is graduated from mauve (1960) to dark purple (2009).

153. The assessment using MFCF is still a work in progress, and would need to be pursued and refined at the next Session of the WPTT. In the meantime, the WPTT recommended to explore the possibility of developing a Kobe II Strategy Matrix for MFCL which could be presented at the next Session of the Scientific Committee.

154. The MFCL and SS3 integrated models enabled scientists to use the fisheries and tagging data, as well as other information for and the WPTT recommended their use in the future. The WPTT noted that 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.

155. 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. The group acknowledged that in the current WPTT session several different models were presented, which allowed the contrasting of model results and the simulation of different dynamics and hypothesis. To this end, the WPTT suggested that a range of stock assessments approaches continues to be conducted, integrated or not, in the future.

4.4. Technical advice for Yellowfin tuna

156. The WPTT estimated the status of the yellowfin stock in 2010 by using a number of stock assessment models, from biomass dynamics to age and length-structured integrated statistical models, and stock status indicators.

157. The main source of information on abundance trends for stock assessment purposes is the index of abundance derived from the Japanese longline CPUE series. Concerns have been raised on the ability of this standardized CPUE series to represent the yellowfin stock abundance in the Indian Ocean. This index has shown steep declining trends in the Western tropical area, where most of the catches occur, over the last five years. The WPTT acknowledges the difficulty of fully understanding and quantifying changes in the fishery that would help interpreting the patterns observed in the index of abundance.

158. Problems have also been identified in the catch data from some fisheries, and especially on the length frequencies in the catches of various fleets, a very important source of information for assessment. Length frequency data is almost unavailable for some fleets, while in other cases sample sizes are too low to reliable document changes in abundance and selectivity by age. Moreover, in general, catch data from artisanal fisheries is considered as poor. Consequently, a low weight was assigned to this dataset in the estimation procedure.

159. The available tagging data has provided WPTT with relevant information on various biological parameters, such as natural mortality and growth. Further use of these data should better support the analyses conducted by the WPTT.

160. All of the above, together with the efforts made by the Secretariat at improving the available statistics, has enabled the WPPT to conduct analyses on which to base management recommendations for this stock.

MANAGEMENT ADVICE

Current status

161. Estimates of total and spawning stock biomass show a marked decrease over the last decade, accelerated in recent years by the high catches of 2003-2006. It appears that the stock is currently overfished or approaching an overfished state, and overfishing has been occurring over recent years. The effect on the standing stock of the high catches of the 2003-2006 period is still noticeable as biomass appears to be decreasing despite catches returning to pre-2003 levels.

162. The estimates of MSY estimated are between 250,000 t and 350,000 t in different stock assessment models and for different stock-recruitment relationships and spatial model structures. The mean catch over the 2007-2009 period of 310,000 t is in the middle of that range while annual catches over the period 2003-2006 (averaging 464,000 t) were substantially higher than any of the MSY estimates.

163. The main mechanism that appears to be behind the very high catches in the 2003-2006 period is an increase in catchability by surface and longline fleets due to a high level of concentration across a reduced area and depth range. This was likely linked to the oceanographic conditions at the time generating high concentrations of suitable prey items that yellowfin exploited. A possible increase in recruitment in previous years, and thus in abundance, cannot be completely ruled out, but no signal of it is apparent in either data or model results. This means that those catches probably resulted in considerable stock depletion.

164. Various indicators of catch rates for different fleets and areas appear to confirm this downward trend in abundance. Recruitment is estimated to have been low over the course of the last five years.

Outlook

165. Catches in 2009 (288,000 t) were on the lower range of MSY values. Improvements in the status of the stock, even with those lower catches, are dependent of future recruitments returning to the higher levels observed in the past.

166. The reduction in catches observed has been influenced by the reduction in effort and the decline of efficiency for most industrial fleets, consequence of the security situation in the Somali area. An improvement in this situation could rapidly reverse these changes in fleet activity and lead to an increase in effort that the stock might not be able to sustain in its current state, as catches would then be likely to exceed MSY levels.

167. Fishing mortality is likely to have exceeded the MSY-related levels in recent years, therefore some reduction in catch or fishing effort could be required to return exploitation rates to those related to MSY levels.

168. Recent catches are around the lower end of MSY levels, but could be unsustainable in the longer term if the current level in estimated recruitment is maintained.

Recommendations

169. The WPTT considers that the stock of yellowfin has recently become overexploited or is very close to be so. Management measures should be considered that allow an appropriate control of fishing pressure to be implemented.

170. At this moment, the effect of time-area closures cannot be directly translated into management quantities of direct effect on the status of the stock, such as catches or fishing mortality, so their possible effect on the future evolution of the stock cannot be evaluated.

171. The WPTT recommends that catches of yellowfin tuna in the Indian Ocean should not increase beyond 300,000 t in order to bring the stock to biomass levels that could sustain catches at the MSY level in the long term. If recruitment continues to be lower than average, catches below MSY would be needed to maintain stock levels.

172. The WPTT recommends that the situation of this stock is closely monitored.

5. STOCK ASSESSMENT FOR BIGEYE TUNA

6.1. CPUEs

173. Japanese longline CPUE for bigeye tuna from 1960 to 2009 was standardized by GLM (CPUE-LogNormal error structured model). Method of standardization was as same as that used for bigeye assessment in 2009. SST (Sea Surface Temperature) was included in the model as oceanographic factor. NHF (Number of Hooks between Float) and material of main and branch lines were applied to standardize the change in catchability of longline gear.

174. In the tropical Indian Ocean, CPUE continuously decreased from around 9.3 (real scale) in 1960 to 3.2 in 2002 when it has increased to 4.2 - 4.7 in 2004 through 2008, about the same level as that in the late 1990's. However it has decreased again to about 3.4 in 2009 although the statistics in 2009 is still preliminary. Standardized CPUE in the south area which didn't show clear trend during the period between 1984 and 2000 (CPUE was 3.5 on average), decreased to 2.5 in 2003. It increased to 3.2 in 2004 after when it decreased to 1.3. and 1.5 in 2008 and 2009. As a result, CPUE in all Indian Ocean, which had been kept in the same level around 5 to 7 decreased to 3.0 in 2002, increased a little in 2003 and 2004 after when it decreased to about 3.0 in 2008 (2.5 in 2009 but preliminary).

175. It was also presented that historical pattern of targeting and gear configuration has been considerably different between Taiwan,China and Japan longline fleets.

176. There was some discussion about differences between the Japanese and Taiwanese patterns of CPUE, and of differences in the model between the final model for bigeye CPUE standardization and the final model for yellowfin CPUE.

177. To better understand the performance of "deterministic habitat based standardization (detHBS)" and to improve the estimating accuracy of standardized CPUE, a survey on tuna longline fishery has been carried out aboard the longliner "Shenliancheng 719". Based on the survey data, and the archival tagging data, we estimated the habitat preferences of bigeye tuna (*Thunnus obesus*), respectively. The detHBS was applied to standardize the CPUE of bigeye tuna. The differences between nominal CPUE and standardized CPUEs estimated by different group data, and normalized nominal CPUE and normalized standardized CPUEs were compared by Monte Carlo permutation test, respectively. Bayesian Information Criterion (BIC) was applied to ascertain which group data is the best one for the detHBS. This study suggests that (1) the nominal CPUE was greatly different from the standardized CPUEs estimated by different group data; (2) there were no deference between normalized nominal CPUE and normalized standardized CPUEs estimated by different group data, respectively; (3) the BIC value of V group data (hook's distribution in the specific depth classes was estimated based on predicted depth; the habitat preference of depth was estimated from the CPUE based on predicted depth) was the lowest one (BIC=-2.57) and was the optimum data group to standardize the CPUEs; (4) "detHBS" improved the precision of CPUE standardization effectively.

178. The group noted that depth specific data will be needed to apply the model more widely, however this data is not necessarily available for all areas.

179. The group was presented with a paper on potential indicators of fishing effort for Japanese and Taiwanese longliner (IOTC-2010-WPTT-28). This working paper estimate the fishing effort of Japanese and of Taiwan,China longliners that have been targeting yellowfin or bigeye in the Indian Ocean at the basic level of the 5° and month strata. The changes in the monthly and yearly sizes of targeted fishing zones are also estimated as well as the CPUEs in these targeted strata. This paper shows major differences and changes in the targeted efforts exerted by the 2 fleets. It is concluded that such basic fishery indicators may be of indirect use in the stock assessment of bigeye and yellowfin.

180. The WPTT suggested to get data on prices per species.

6.1. Stock assessments

181. Paper IOTC-2010-WPTT-04 was presented, describing a Stock Synthesis (SS3) stock assessment for bigeye (1952-2009). New elements to the 2010 assessment included the integration of the RTTP-IO tagging data,

and a systematic exploration of the interactions among several key model assumptions. Core assumptions in all models included:

- Spatially-aggregated, age-structured, sex-aggregated population, iterated on a quarterly time-step 1952-2009
- Four fishing fleets:
  i. LL - combined longline (primarily Japan and Taiwan)
  ii. PSFS - unassociated Purse Seine (PS) sets in the western equatorial region
  iii. PSLS - FAD/log associated PS sets in the western equatorial region
  iv. Other - includes PS outside the core area plus all other non-longline fleets.
- Catch in mass was assumed to be known without error for all fleets.
- Standardized Japanese LL CPUE for the whole Indian Ocean (IOTC-2009-WPTT-29) was adopted as a highly informative (CV 5%) relative abundance index.
- Mean length-at-age (constant over time) was adopted from Eveson and Million 2009 (IOTC-2008-WPTT-09). Due to constraints in the SS3 growth curve flexibility, it was not possible to describe the length of the first two year-classes very well. To reduce the influence of this problem, size classes smaller than 50cm were pooled into one bin.
- Maturity was adopted from IOTC-2009-WPTT-20 (constant over time with 50% mature at ~age 2).
- Age-based selectivity was estimated for each fleet independently, with independent parameters for each age (or group of consecutive ages) to admit the possibility of logistic, dome-shaped or polymodal functions. Temporal variability in selectivity was included in some models.
- Beverton-Holt stock-recruitment dynamics, with fixed steepness and spawning biomass proportional to the total mass of mature fish.
- The RTTP-IO data have been included, with recaptures up to the end of 2009, including point estimates for the reporting rates derived from the tag seeding programme. Deterministic assignment of tag release lengths to ages was based on the Eveson and Million curve. Only recoveries from the PSLS fleet were included in the analysis.
- Objective function terms included the likelihoods for the fit to the standardized CPUE from the Japanese LL fleet (1960-2008), Catch-at-Length from all fleets, tag recoveries from the PSLS fleet, and priors on all estimated parameters. Estimated parameters included: virgin recruitment, CPUE catchability, selectivity by fleet, and recruitment deviates. In some cases, M, temporal variability in selectivity and tag recovery negative binomial overdispersion parameters were estimated.
- Additional important assumptions are listed in the model grid definitions below.

182. Initial modelling efforts revealed some problems fitting the data (tag recovery and non-longline size composition data) and the stock status was sensitive to some poorly quantified assumptions. A systematic exploration of the interactions among 8 different sets of assumptions was undertaken. In the first grid, (144 models) interactions among length-at-age variance, selectivity, size composition sample size assumptions, and the influence of the tag data were examined, primarily to improve the fit to the tags and PS size composition data:

- 2 Length-at-age variance options (CV low, high)
- 8 Tag recovery options related to the incomplete mixing period and the negative binomial overdispersion parameter (tau). Note that tau = 70 is consistent with recent WCPFC BET assessments (in which the input MULTIFAN-CL tau parameter is internally transformed by the addition of 50):
  – nt: tags not used
  – t002: tau = 2, 4 quarters of incomplete mixing
  – t020: tau = 20, 4 quarters of incomplete mixing
  – t070: tau = 70, 4 quarters of incomplete mixing
  – t200: tau = 200, 4 quarters of incomplete mixing
  – tODE: tau estimated (~140-150 in cases examined), 4 quarters of incomplete mixing
  – M2t20: tau = 20, 2 quarters of incomplete mixing
  – M2t70: tau = 70, 2 quarters of incomplete mixing

- 3 PSLS selectivity assumptions (stationary, annual deviates for tagging years 2005-8, or annual deviates 1985-2008)
- 3 Catch-at-Length likelihood weights (approximate input sample size) (LL 200, PSLS 200), (LL 200, PSLS 20), (LL 20, PSLS 20); in all cases PSFS and Other fisheries sample size is 20.
- 1 recruitment deviate option, SD(log(devs)) = 0.6 (annual recruitment deviates were estimated from 1985-2008)
- 1 CPUE series option (no catchability trend), sd(log(devs)) = 0.05
- 1 stock-recruitment steepness option (h = 0.75)
- 1 natural mortality vector M(age 2y+) = 0.4

183. None of the models resulted in a substantial improvement to the PS size composition data or tag recovery distribution. The most plausible and influential options from above were retained in the stock status grid of 288 models that was intended to quantify the effects and interactions among a number of other fundamental life history assumptions that are known to be important and difficult to estimate:

- 1 Length-at-age option (CV high)
- 4 Tag recovery options (x = incomplete mixing period in quarters, tau = negative binomial overdispersion parameter): x, tau = (tags not used), (4, 20), (4, 70), (2, 70). The tau=70 options were adopted to be consistent with the recent WCPFC BET assessment.
- 1 PSLS selectivity assumptions (stationary)
- 2 recruitment deviate option (SD(log(devs)) = 0.6, 0). The latter was intended to test whether year class strength was being strongly influenced by stationary selectivity assumptions.
- 2 CPUE options (no catchability trend, catchability trend of 0.47%/y)
- 3 steepness option (h = 0.55, 0.75, 0.95)
- 3 M vectors: M(age 2y+) = 0.32, 0.4, 0.48
- 2 Catch-at-Length input sample size assumptions (LL 200, PSLS 200) (LL 20, PSLS 20). PSFS and Other fleets 20.

184. The maximum posterior Density (MPD) estimates from these models indicate a broad range of uncertainty, including many plausible scenarios in which the B_{MSY} and F_{MSY} reference points were exceeded. The more pessimistic interpretations were generally associated with the CPUE catchability trend, low stock-recruit steepness, low M, and tags fully mixed after 2 quarters. The likelihood of some of these assumptions cannot be evaluated within the context of the model (*e.g.* catchability trends and tag mixing periods). Some parameters might be estimated in principle (*e.g.* M, steepness), however experience with other stocks and simulations suggests that these estimates are frequently very poor (in this specific case, the M estimates were not believable as the youngest ages tended to have the lowest values). Fits to the CPUE series (Figure 70), and size composition data (Figure 71) are shown for two models with MSY estimates near the extremes of the observed range. Tag recovery fits are shown for the pessimistic model in Figure 72. The fits to the data are very similar, typical of the other models in the grid, and qualitatively illustrate that the data seem to be almost equally consistent with very different stock status interpretations. The stock recruitment relationships are compared in Figure 73, biomass and fishing mortality time series are shown in Figure 74.

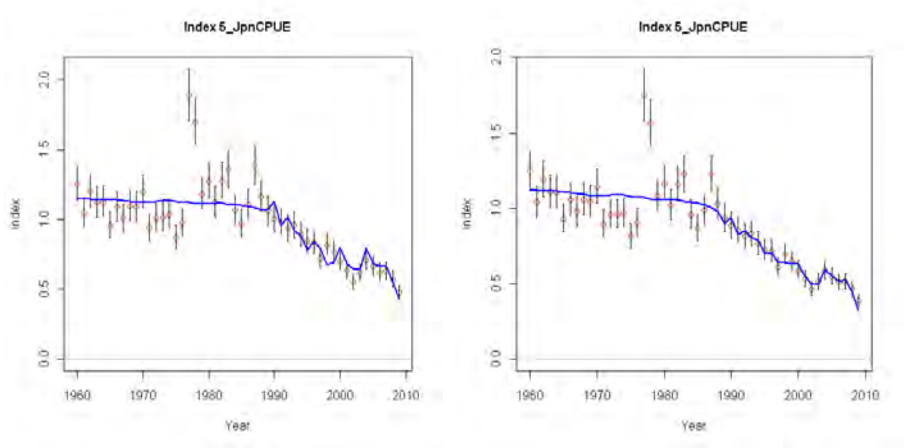


Figure 70. Predicted (line) and observed (points) fit to the LL CPUE series for the most optimistic (left) and pessimistic (right) models from the stock status grid.

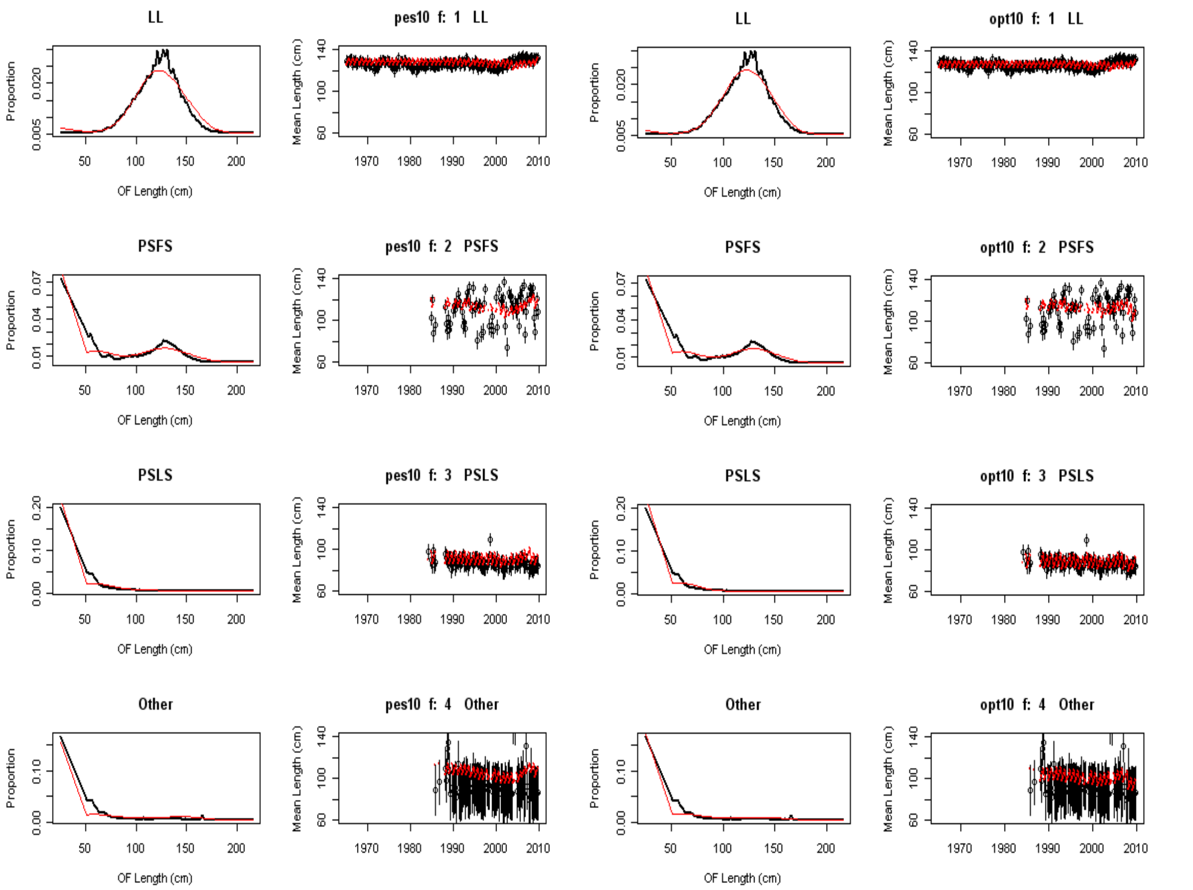


Figure 71. Predicted (red) and observed (black) fit to the size composition data for the most optimistic (left 2 columns) and pessimistic (right 2 columns) models from the stock status grid. Columns 1 and 3 represent the distributions aggregated overtime, columns 2 and 4 represent the time series of mean size.

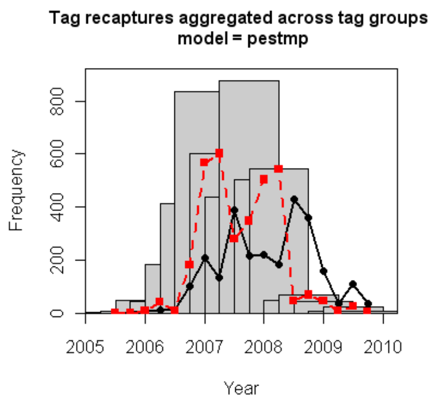


Figure 72. Predicted (red) and observed (black) tag recoveries from the most pessimistic model from the stock status grid. Columns indicate tag recoveries within the period of incomplete mixing and are not informative in the model

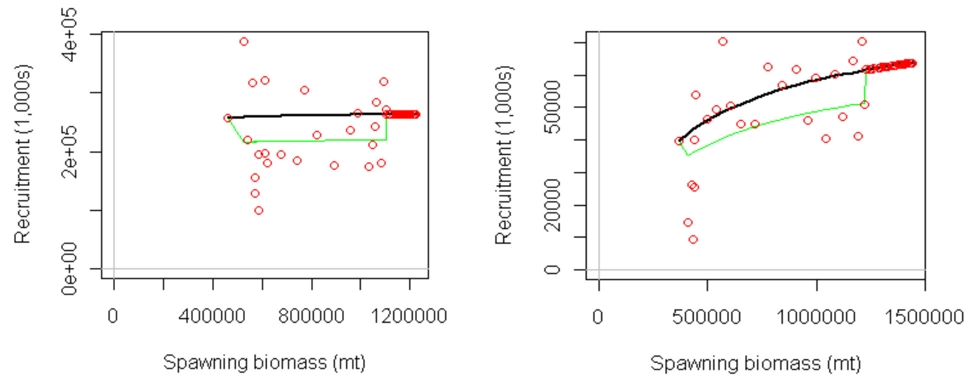


Figure 73. Estimated stock-recruitment relationships for the most optimistic (left) and pessimistic (right) models from the stock status grid

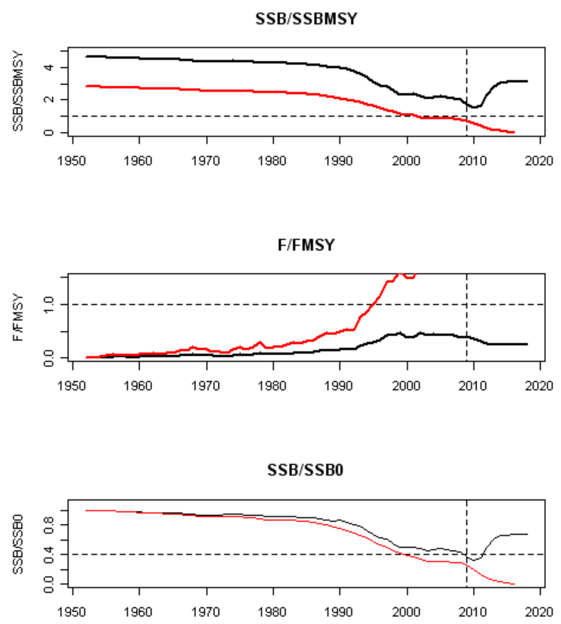


Figure 74. Biomass and fishing mortality time series from the most optimistic (black) and pessimistic (right) models from the stock status grid

185. Table 11 indicates the subjective, but transparent, scheme that was used to weight the results of the 288 model grid (*i.e.* Bayesian posteriors equal to the priors), to provide a synthesis of stock status results. WPTT participants were encouraged to provide additional insight to revise the weightings, but no specific changes were proposed. The weighted median of the biomass and fishing mortality time series are shown in Figure 75, along with the most extreme of the Maximum Posterior Density (MPD) estimates. Key reference points are summarized in Table 12, and a Kobe plot is included in Figure 76.

Table 11. Weighting scheme for integrating the assumptions from the 288 model stock status grid

Assumption	Option Weighting			
Tags (p=mixing period, τ=overdispersion)	no tags 0.5	p=4, τ =20 0.167	p=4, τ=70 0.167	p=2, τ=70 0.167
Recruitment sd(log(dev))	σ=0 0.5	σ=0.6 0.5		
Catchability	no trend 0.8	q increasing 0.2		
SR Steepness	h=0.55 0.1	h=0.75 0.7	h=0.95 0.2	

Natural Mortality (a=2+)	M=0.32 0.33	M=0.40 0.33	M=0.48 0.33	
Catch-at-Length input N (LL, PSLS)	N=200, 200 0.5	N=20, 20 0.5		

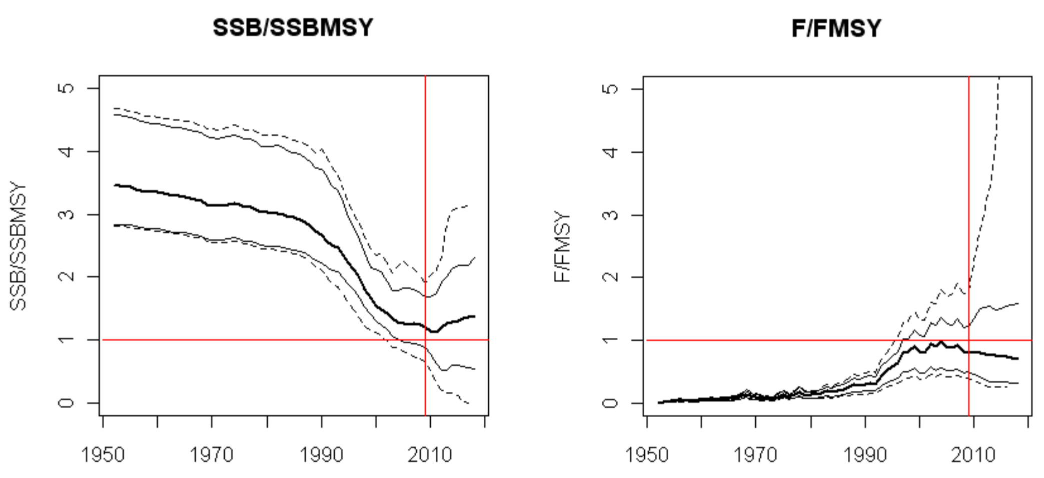


Figure 75. Time series of MSY reference point estimates from the stock status grid, including 10 years of catch projections at 2009 levels. Thick black lines represent the median MPD value from the weighted aggregate of 288 models. Thin black lines represent the 5th and 95th percentiles, and broken lines indicate the full MPD range

Table 12. Stock status summary table. Percentiles are drawn from a cumulative frequency distribution of MPD values with models weighted as in Table 5

	Median	5th and 95th percentiles	MPD range
SSB_{2009}/SSB_{MSY}	1.20	0.88 – 1.68	0.67 - 1.91
F_{2009}/F_{MSY}	0.79	0.50 – 1.22	0.40 - 1.79
MSY (*1000 t)	114	95 – 183	81 - 214
SSB_{2009}/SSB_0	0.34	0.26 – 0.40	0.22 – 0.42
SSB_{2009} (*1000 t)	381	236 - 762	184 - 1150

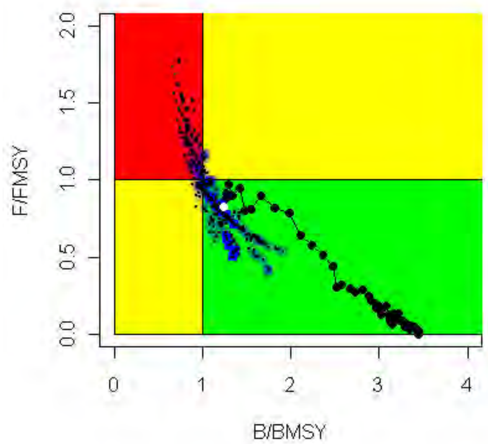


Figure 76. Kobe plot for the 288 model stock status grid. Black circles represent the time series of annual median values from the weighted stock status grid (white circle is 2009). Blue squares indicate the MPD estimates for 2009 corresponding to each individual grid C model, with colour density proportional to the weighting (each model is also indicated by a small black point, as the squares from highly downweighted models are not otherwise visible).

186. A Kobe-2 Strategy Matrix (management options decision table) is presented in Table 13. Table entries summarize projections from the 288 model stock status grid (weighted as in Table 11), based on the following projection assumptions:

- 10 years with deterministic recruitment (from the stock recruitment relationship)
- Constant catch with proportions among fleets distributed as in 2009.
- 5 catch levels at Catch(2009) -40%, -20%, +0%, +20%, +40%

Table 13. Kobe 2 Strategy matrix derived from the weighted stock status grid

Stock status Reference Point	Projection Time frame	Weighted proportion of scenarios that violate the Reference Point				
		C(2009) -40%	C(2009) -20%	C(2009)	C(2009) +20%	C(2009) +40%
$P(B_t<B_{MSY})$	In 3 years	0.19	0.24	0.28	0.40	0.50
	In 10 years	0.19	0.24	0.30	0.55	0.73
$P(F_t>F_{MSY})$	In 3 years	<0.01	0.06	0.22	0.50	0.68
	In 10 years	<0.01	0.06	0.24	0.58	0.73

187. There is a large degree of uncertainty in the stock status derived from this analysis, and this is not surprising given the uninformative 'one way trip' nature of the fishery to date, general uncertainty of life history parameters. Priority items for future analyses include data improvements (species composition estimates from some of the artisanal fleets, additional analyses on the CPUE series, partitioning of European and non-European fleets in the PSLS fishery to improve the representation of tag recaptures), and model modifications to improve the resolution of growth and selectivity processes for ages less than 2 years.

188. The group had some technical discussions about the parameterization of the SS3 model that was used for this assessment, and in particular on the size-based *vs.* age-based selectivity, and the effort creep assumption that was based on the Pacific scenario, *ie.* linear 0.47%/year.

189. Regarding the weighting schemes among the 288 models, it was suggested that a likelihood-based weighting scheme could be used, however, the WPTT noted that the terms are not comparable for models with different assumptions, such as different weightings of sample sizes.

190. The group recommended that the efforts put in the development of this assessment using SS3 and including the tag data are continued, and refined at the next Session of the WPTT.

6.1. Technical advice on Bigeye Tuna

191. The WPTT 2010 advice on the status of BET is derived from data-based indicators and models using an integrated statistical assessment method. Several hundred model formulations were explored to ensure that various plausible sources of uncertainty were explored and represented in the final result.

192. The RTTP-IO tagging data was included in the model, and was influential in informing current stock status estimates. However, conflicts were found between the tagging data and some other data sources, in particular the purse seine size composition data. It is not clear at this point how the different information sources should be weighted in the analysis. The model assumed a single, well-mixed stock, which is consistent with the results of the RTTP-IO to date. It is possible that mixing rates are slow enough to justify the use of some spatial disaggregation, but this cannot be adequately quantified at this time, due to the low rate of returned tags outside of the core purse seine fisheries.

193. The standardized Japanese longline CPUE index, together with the catch data, represents the most important input in the stock assessment on the abundance of the stock. There have clearly been large temporal changes in the gear configurations and spatial distributions of effort in this fishery, and it remains unclear how well the standardization can account for these effects.

194. In general, the data did not seem to be sufficiently informative to justify the selection of any individual model, and the results were combined on the basis of a model weighting scheme that was proposed to, and agreed by, the WPTT.

MANAGEMENT ADVICE

Current status

195. The central tendencies of the stock status results from the WPTT 2010 were similar to those presented in 2009, while the uncertainty was recognized to be greater. The weighted results suggest that the stock is probably not overfished, and overfishing is probably not occurring (relative to MSY reference points). However, the stock is probably near full exploitation, and the possibility of overfishing cannot be ruled out on the basis of the estimated uncertainty, and the continuing observed decline in CPUE.

Outlook

196. The recent declines in longline effort, particularly from the Taiwanese longline fleet, are thought to be causing the recent declines in catches, and this is relieving some of the pressure on this stock. Changes in purse seine effort in the west Somali basin are expected to be less important than those on the longline fleet for this stock.

Recommendations

197. Under the light of this the WPTT recommends that bigeye catches are kept at or lower than the 2009 level.

6. SKIPJACK TUNA

6.1. CPUEs

198. Paper IOTC-2010-WPTT-05 was presented, describing an initial attempt to estimate a relative abundance index from the Maldivian skipjack tuna pole-and-line (PL) fishery catch and effort data. This fleet has operated for hundreds of years, and has evolved rapidly over the last couple decades from an artisanal fleet into a substantial industrial operation. There are detailed records about many elements of the fishery which may be useful for quantifying changes in efficiency over time, however not all of these records are currently available in electronic format. Vessel-specific data were only available from a small number of observations (8% of the total PL catch) in the period 2004-2007 (*i.e.* monthly catches by atoll, with effort measured in boat-days). To estimate historical efficiency, a fleet composition model was employed in which the vessel registry provides the year of entry of different vessels into the fleet, and each vessel was assumed to remain active for a fixed number of years. The vessel effects estimated from 2004-2007 were then applied to the historical fleet composition to estimate effective effort from the nominal effort data series from 1970-2007. The nominal CPUE (and GLM standardized series that excluded vessel effects) shows a strong increasing trend that parallels the fleet trend toward larger boats over the past two decades. The CPUE series that were standardized using historical estimates of fleet composition were either stable or decreasing over time. The most pessimistic model suggested that the standardized catch rates may have declined by about 60% between 1980 and 2000. No consistent decline was observed over the last 10 years (in which catches have been the highest on record) for any of the time series (but note that there is a drop between 2006 and 2007, and that years 2008-9 were not included in the analysis). There are a number of problems with the analysis, including:

- There are few observations from the smallest vessels in the 2004-2007 period (with limited contrast in some important factors), and the historical time series is very sensitive to the efficiency estimates for these vessels. There are additional important changes in vessel characteristics that cannot be examined from these data (*e.g.* the transition to mechanized operations)
- It is possible to estimate some of the core features of the historical fleet characteristics from the vessel registry, but producing relative abundance indices requires several speculative assumptions. *e.g.* i) vessel type (the registry does not distinguish between PL and other types of fishing vessels), ii) the registry only indicates the year that the vessel enters the fishery, not the year of exit from the fishery or the number of days spent fishing in any specific year, and iii) the registry is incomplete (at least prior to the 1980s).
- Information collected by atoll does not necessarily provide a good indication of the spatial distribution of effort in recent years.

199. It is expected that considerably more data can be recovered to improve the analysis for next year. Additional vessel-specific data is accessible, including: alternative measures of effort (number of fishermen,

number of poles), additional vessel characteristics (hull-type, horsepower), and the detailed time series should be extended to include 2004-2010. This may be informative even without the historical extrapolation. However, efforts should be made to recover the historical data as well. Assuming that catch rates can be standardized to account for vessel efficiency, there remain difficult questions of interpreting how these catch rates relate to abundance in the local fishery, and the broader Indian Ocean.

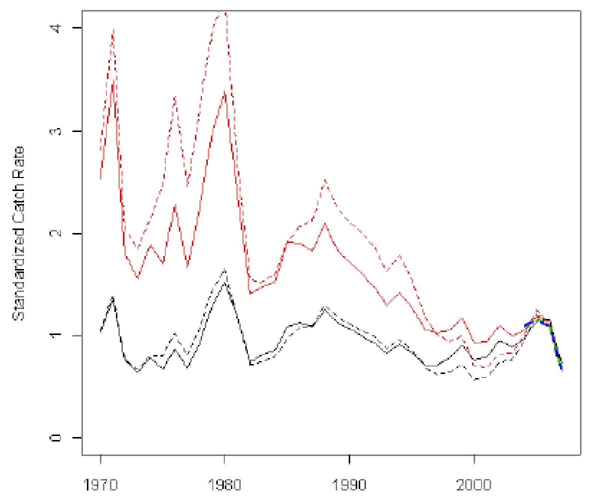


Figure 77. Comparison of the final relative abundance indices estimated by combining the fleet composition model with GLM-based vessel efficiency models.

Length-efficiency relationship derived from model A (which includes additional terms for month and atoll) in black, and from model B in red.
Solid lines indicate a vessel lifespan of 15 years, broken lines a vessel lifespan of 5 years.
The standardized CPUE series from models A (green) and B (blue) 2004-7 are also shown (largely overlapping with the other series).
Each series is scaled to have a mean of 1 over the last 4 years.

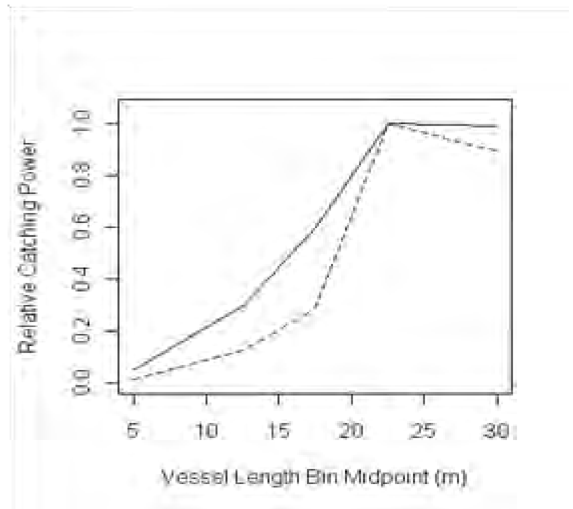


Figure 78: Effect of vessel length on efficiency as estimated by two simple GLM models using data from 2004-7.

Model A (solid line) includes Year, Month, Atoll and vessel length effects.

Model B (broken line) includes only Year and vessel length effects.

200. Some issues were raised by the group about the number of vessels derived from the vessel registry as the separation between handline and pole-and-line vessels were not made. The WPTT noted that the 10-fold increase in the SKJ catches from about 50,000 t in the 1950s should have resulted in a strong decline in the catch rates of the fishery well before 2005. The WG recognized that there were strong similarities between the Maldivian pole-and-line and the European purse-seine fisheries in the difficulties associated with estimating fishing effort, *i.e.* the definition of a unit of fishing effort for tuna schools associated with FADs and the monitoring of changes in fishing technology and power over time. Although vessel size might be a good proxy of variables such as engine power, it does not allow represent modifications of electronic equipment used to improve the detection of schools. In the western Pacific Ocean, information collected about the introduction of electronic components (*e.g.* sonar, *etc.*) available from the logbooks of the Japanese pole and line fishery revealed significant positive effects of such technology for locating tuna schools. It was also noted that the importance of FADs steadily increased in the last two decades and that they play a major role in increasing the catchability of tunas. The use of a FAD-deployment database available in the Maldives was encouraged in future approaches to improve the time series of CPUE by including the number of FADs in the catch rates standardization process.

201. Aside from the difficulties of practically capturing the technological developments in the fishery It was noted that availability of livebait will always be an issues when one considers estimating the CPUE indices from baitboat data. Unless very fine scale data, such as vessel track plots to that may be used to partition the times for baiting, searching and fishing are available, reliable estimation of CPUE indices will be an issues.

202. The CPUE series of skipjack for the European purse-seine fleet is presented in Figure 41. The nominal CPUE has remained fairly stable, despite the long history of intense fishing on this stock. Although attempts have been made at standardizing this CPUE series to account for changes in efficiency, no reliable index of abundance is currently available.

203. Acknowledging the usefulness of standardizing CPUE for skipjack, the WPTT recommended that the work is pursued and that progress are presented at the next Session.

6.2. Stock Assessment

204. The plan to develop an integrated stock assessment for skipjack this year could not be undertaken due to the limitations of the CPUE series currently available as indices of abundance for the stock which could be used in a stock assessment.

205. It was noted that skipjack assessment are difficult to conduct in all RFMOs, however the group recommended that a stock assessment is conducted next year, and that a range of models as well as of fisheries indicators should be used to give a comprehensive picture of the current stock status.

6.3. Technical advice on Skipjack Tuna

Current status

206. Skipjack tuna are widely regarded to be resilient to over-exploitation due to their life-history characteristics (*i.e.* rapid growth, early maturation and high reproductive potential). However, this does not exclude completely the possibility for skipjack to become overfished. Recent trends in certain fisheries suggest that the situation of the stock should be closely monitored and, thus, WPTT recommends that new attempts are made to assess the status of the stock during the next Session of the WPTT in 2011.

Outlook

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

Recommendations

208. Given the limited nature of the work carried out on the skipjack in 2010, no new advice is provided for the stock.

7. Analysis of Tagging Data

209. The WPTT devoted some time to reflect on the experience of using for various purposes the large amount of tagging data collected mostly by the RTTP-IO. From its incorporation in stock assessment models to detailed analysis of the information on movement, mortality and growth, a range of analyses have been influentially informed by the tagging dataset of IOTC. The WPTT recognized the essential contribution to our knowledge of the Indian Ocean stocks made by the RTTP-IO.

210. A number of issues were raised that could be further explored by analysing in greater detail the information contained in the dataset, so a number of ideas for future work were presented and discussed.

- Improved calculations of the mixing period to be used in stock assessment models stratified by area: The length of time taken for tagged fish to become available to fisheries in the release area and neighbouring ones is an important parameter for movement rates estimates based on tagging results.
- Further exploration of the information on natural mortality that can be extracted from tagging data.
- Analysis of possible changes in selectivity away from the information contained in length-frequency data.
- Simulations of the likely effect on stock assessment estimates of imbalances across fleets on reporting rates.
- Developments in integrated stock assessment methods (SS3 and MFCL).
- Use of fine-scale analysis based on diffusion dynamics models to explore movements at spatial levels with resolution enough to be of use for evaluation of movements associated with time-area closures.
- Incorporation of tagging data in the estimation step of environmental models that attempt to predict movements and spatial distribution of tuna.
- Investigation of temporal changes in selectivity for certain fleets.
- Continue and develop the sex identification of recaptured tagged yellowfin and bigeye

211. The low rate of recovery from the longline fleets, able to capture larger fish, was noted as limiting the use of the tagging data to inform on some of growth parameters for yellowfin and bigeye. The asymptotic length of fish, L_{inf}, can only be reliable estimated if a sufficient number of fish are tagged and recovered that have grown to very large sizes. The WPTT encouraged scientists involved with those fleets to step up their efforts to aid at the recovery of tagged fish caught by those gears.

212. The WPTT was informed of a number of ongoing or future research initiatives that will be covering some of the points above. A planned symposium on tagging data, scheduled initially for 2012, should encourage further work in this area and the WPTT expressed its interest in the outcome of that meeting.

213. The IOTC Secretariat informed the WPTT of the ongoing work towards the integration of the datasets obtained by the various small-scale tagging programmes into the database currently hosting the RTTP-IO data, with the intention of providing researchers with a single source of data, following common standards of quality and reporting, on all tagging conducted on tunas in the IOTC area. The WPTT welcomed the initiative and congratulated the Secretariat for its work in that direction.

214. The chair of the WPTT and the Secretariat would work together in compiling recent information on precise activities taking place along these lines, and would follow up their developments to encourage researchers to present relevant work in this area to future meetings of WPTT.

215. The WPTT was informed of the on going preparations for an international symposium on tagging in tuna fisheries, to be organized with the support of IOTC probably in 2012. An steering committee is being setup, and the main objective is to provide for a forum for the exchange of experiences, findings and ideas on the development of tagging programmes, and the use of information thus gathered for stock assessment and management purposes. IOTC researchers are encouraged to plan for work to be carried out with a view of being presented at this symposium

8. ANALYSIS OF TIME-AREA CLOSURES (IOTC RESOLUTION 10/01)

216. The IOTC Resolution 10/01 instructed the Scientific Committee to provide at its 2011 Session an analysis of the effects of the time-area closure on international waters on the Northwest Indian Ocean (Figure 79), initially set to be in place for one month: November for purse seiners and January for longliners. It also instructed the Scientific Committee to proposed modifications to that closure if deemed necessary. The WPTT discussed possible ways for that analysis to be conducted over the coming year. It was noted that the process of adoption of this management measure included a number of proposals of the temporal extension of the closure, but that no detailed analysis of available data was used to inform it.

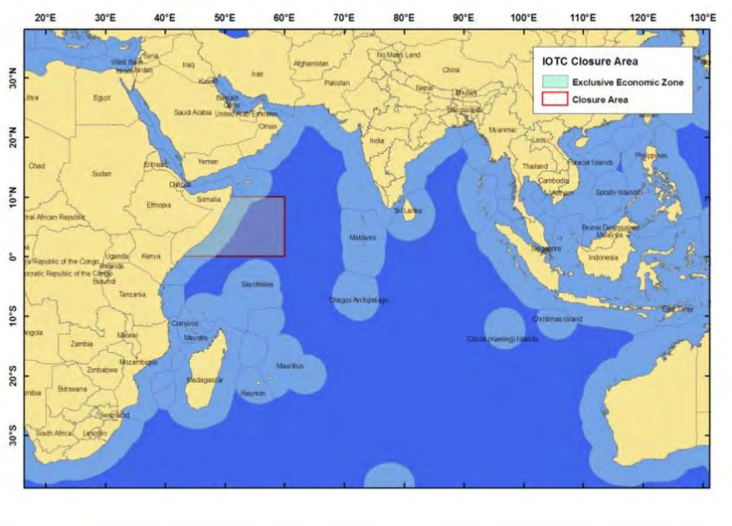


Figure 79: IOTC closure area (Resolution 10/01)

217. The WPTT was reminded of the analyses carried out in the past on the likely effect of time-area closures for the various fleets and stocks involved. Two possibilities for conducting such analyses were considered in previous exercises: reallocation of fishing effort to other areas, or a simple calculation of 'potential loss', *i.e.* the maximum loss in catches that would be obtained in the unlikely event of fleets not moving to other areas during

the closure. Document IOTC-2003-WPTT-R contains the tables of such an analysis of 'potential loss' conducted for a range of spatial and temporal scenarios, all of them larger than the current one, in 2003.

218. A simple calculation of 'potential loss', obtained from an inspection of the average catches obtained in that area and periods (2009) by the two main fleets, is as follows:

- Longline, January: 640 t f yellowfin and 640 t of bigeye tuna.
- Purse seine, November: 5,300 t of yellowfin, 1,100 t of bigeye tuna, and 8,300 t of skipjack.

219. The WPTT noted that these figures amount to a 1.5% reduction in catches for those stocks, a quantity likely to have no impact on the population trends. For comparison, the recent closure to all fishing activities of the waters around the Chagos Archipelago affects an area from which an average of 8% of the total purse seine catch and 3% of the total yellowfin catch was obtained in the past. The match in time of the establishment of both closures will severely impact the ability of the WPTT scientists to analyse, as requested by the Commission, the effect of the time-area closure on the stocks.

220. The recent experience in the Pacific Ocean with similar closures was brought to the attention of WPTT. The short duration of the closure imposed, on an area with large concentrations of FADs, can have a detrimental effect, as the concentrations of fish under those FADs become larger during the closure, and can be easily be caught once the fishery opens again

221. The WPTT tasked its Chair with the preparation, in collaboration with the Secretariat, of a document presenting an analysis based on maximum potential loss of catches, as estimated from the catch statistics of IOTC, together with a brief review of similar experiences on other tuna RFMOs, most notable ICCAT and WCPFC. This should be presented at the 2010 meeting of the Scientific Committee. The WPTT Chair will also then request guidance from the Scientific Committee on any extra analyses that it would like WPTT to conduct at its next meeting, for example on alternative times for such a closure.

9. MANAGEMENT STRATEGY EVALUATION FOR INDIAN OCEAN TROPICAL TUNA

222. The 2010 Commission meeting of IOTC supported the suggested development of Management Strategy Evaluation (MSE) tools as a means of assessing the likely impacts of management options for tuna stocks, and help the commission in managing those stocks for a range of objectives. The chairperson of the Scientific Committee requested the WPTT to initiate an exploration of MSE tools and gather among the views of its members on the issue.

223. A presentation by the Secretariat introduced the basic ideas and methodology behind MSE (IOTC-2010-WPTT-55). The traditional approach involves an iterative cycle: *i)* an assessment step, in which some sort of quantitative fishery model(s) is employed to estimate the effect of the fishing fleet on the fish population, *ii)* management advice is formulated based on these perceptions of stock status and fishing mortality using a more or less ad hoc decision to (attempt to) modify the activity of the fishery, and *iii)* repeat. MSE involves a somewhat different approach to reach the same objectives. In essence, the MSE approach aims to evaluate the expected performance of decision rules that will be translated into future management actions. The decision rules (and data requirements) are agreed in advance, but are designed to interpret incoming data in a way that provides sensible management actions to a broad range of possible responses by the fish population. The decision rules are tested and compared on the basis of simulations, using operating models that represent the major uncertainties in the fishery.

224. MSE is often promoted on the basis of the following advantages:

- MSE development normally increases the level of engagement between scientists, managers and industry. Explicit quantification of management trade-offs are illustrated, which allows objectives to be prioritized in a much more effective way than can typically be achieved if they are discussed independently.
- MSE emphasizes the development of decision rules that are robust (*i.e.* likely to perform reasonably well under a broad range of situations and avoid catastrophe in the most pessimistic scenarios) rather than optimal decision rules (which can be designed to work very well provided that there is little uncertainty about the underlying dynamics). In this sense, MSE directly incorporates the principles of the precautionary approach.

- Decision rules are designed to operate effectively for several years. This adds certainty to the decision process that can help industry with strategic investment plans.
- The MSE framework is useful for identifying the value of information, and helping to design data collection and research requirements (*e.g.* is it better to age 10000 fish every year or hold a tagging programme once every 10 years?).

225. However, MSE is not an all-purpose panacea. It will not remove the need for quality data, and it will not remove the difficult decisions that need to be made when fishing effort has to be reduced. There is initially an increased demand for scientific resources and stakeholder meetings to cooperatively develop the MSE (typically a 2-3 year time period), but there should be a longer term advantage of freeing up resources from the usual stock assessment process, allowing them to be focused on more strategic research.

226. Document IOTC-2010-WPTT-16 presented the structure and implementation of an example MSE simulation framework for Indian Ocean yellowfin tuna. The document covers in detail a possible approach for an initial setup of an MSE framework for this stock, where a complex assessment model is assumed to provide an accurate representation of the biological component of the system, while uncertainties in key parameters are introduced through simulation. The example presented has been developed using a freely available library in the R statistical computing language that is being made available with the objective of facilitating the work of scientists on simulation and MSE in fisheries (http://flr-project.org).

227. The WPTT welcomed the presentation of this work, and encouraged its authors to pursue it further. The use of a stock assessment method as the basis of the biological operating model, although an useful first step, was considered to be not the ideal procedure, as detailed incorporation of other sources of information and uncertainty can be limited by the model structure. Developing a complete Operating Model of biology and fishery, while a more complex task, can reap great benefits in terms of understanding the role of different elements in the dynamics of the system, and the quality and quantity of information available.

228. An example MSE simulation for Indian Ocean bigeye tuna was presented in document IOTC-2010-WPTT-52. In this case a model population was generated based on the results on an integrated stock assessment model and projected forward in time under a range of constant catch scenarios, and a simple harvest rule based on biological reference points. The results were considered very preliminary but showed the dangers of constant catch management, especially in fisheries already at a fully exploited situation.

229. The WPTT thanked the authors for their contribution and noted that further work should be carried out. The lack of the 'full-feedback' system, where the status of the stock is reassess at certain moments in time as part of the simulation procedure, impedes the testing of harvest rules based on dynamic reference points. Also, a wider exploration of the most relevant uncertainties, and of their relative importance, would greatly improve the ability of such a model to inform on the probabilities of success and failure of various management options.

230. The WPTT considered that MSE and similar procedures are of great interest for IOTC and encouraged researchers to work on this issue over the coming year.

10. EFFECT OF PIRACY ON INDIAN OCEAN TROPICAL TUNA FISHERIES

231. No document was presented on this issue, however plots of spatial changes in the activity of various fleets were inspected. The various developments in the fishery related to the security situation in the waters around Somalia were clearly apparent in maps of the spatial distribution of effort for the main fleets operating in the area (Figure 80 and Figure 81). Effort was redistributed away from the coasts of Somalia as the number of piracy events increased, and lead to a large decrease in activity, especially by purse seiners, in the second quarter of 2009. The establishment of security measures on board the vessels has brought a return to a nearly-normal distribution of effort, although a number of boats that had left the Indian Ocean have not returned. The number of European and European-associated purse seine vessels has gone down from 51 in 2007 to 43 in 2009.

232. The WPTT was informed that the French purse seine fleet has been operating over the last year in pairs of boats that sail together all the time. When one boat starts a fishing operation, the other remains inactive in the vicinity, as to be of assistance in an attack is carried out while the net is set. Also, fishing trips are now generally shorter than usual, so effective effort has decreased as the number of days spent sailing to and from port has increased. All of this is expected to impact greatly the catch rates and possibly the total catch obtained by this fleet. The WPTT recommended that French scientists investigate further these changes in activity, possibly by means of VMS data. The WPTT noted that there were also some significant effects on the Spanish and Seychelles purse-seine fleet affecting their fishing strategy, and that this should be investigated as well.

233. The WPTT was also informed that a number of Taiwanese longline vessels have the intention to leave the Indian Ocean, however this could lead to an overcapacity situation for Taiwan,China in the other oceans. A suggestion was made that the effect of limitations on vessel operations due to piracy on the standardized indices of abundance from longline fleets be investigated.

234. An on-going analysis on the effects of the piracy activities on catch rates of purse seine fleets was mentioned to the WPTT. The authors were encouraged to present their findings at the next meeting of the Scientific Committee.

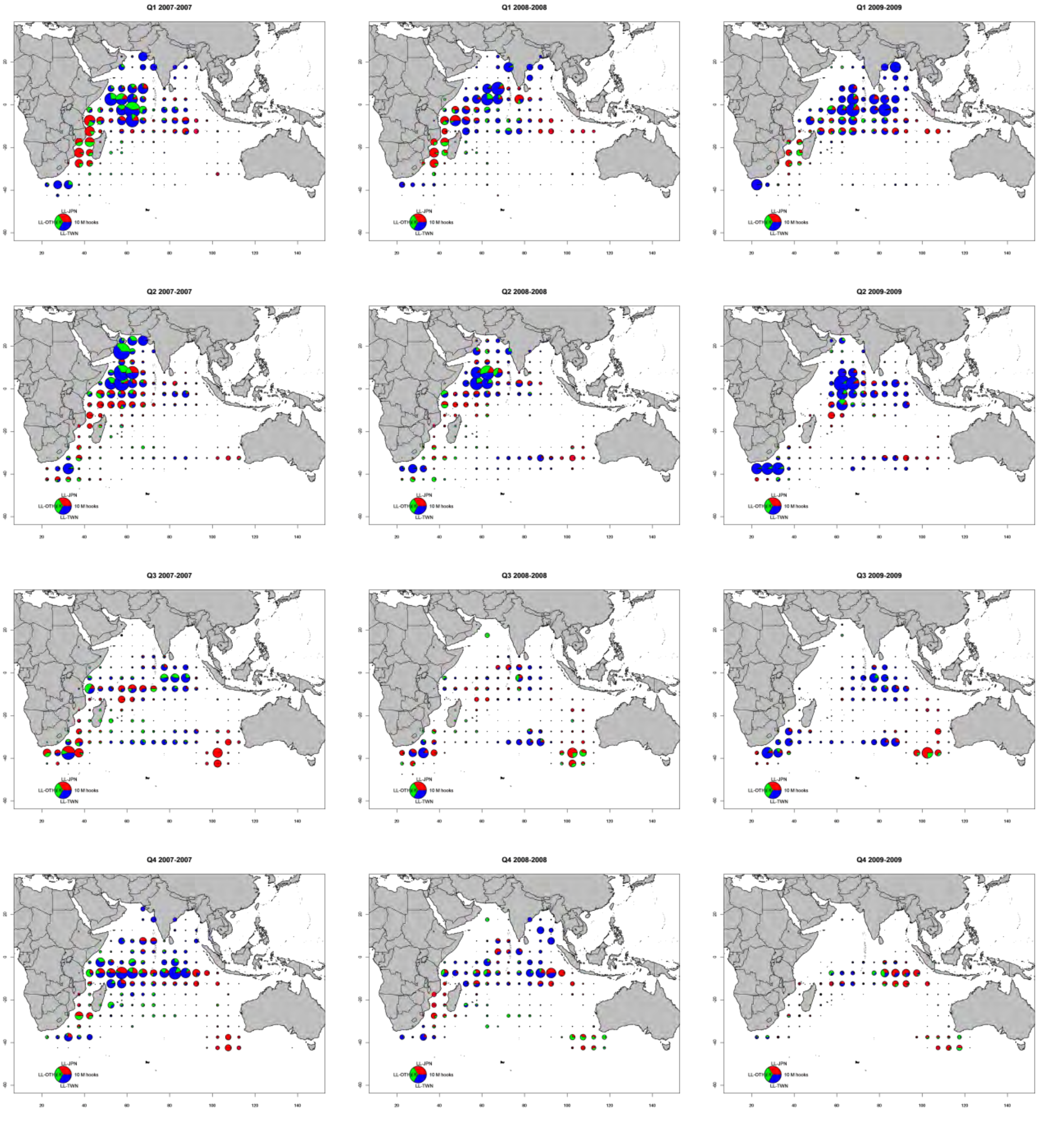
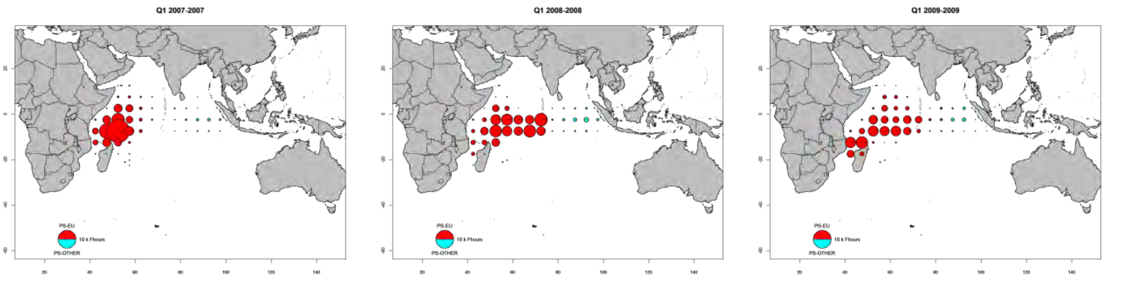


Figure 80: Longline effort per quarter from 2007 to 2009.



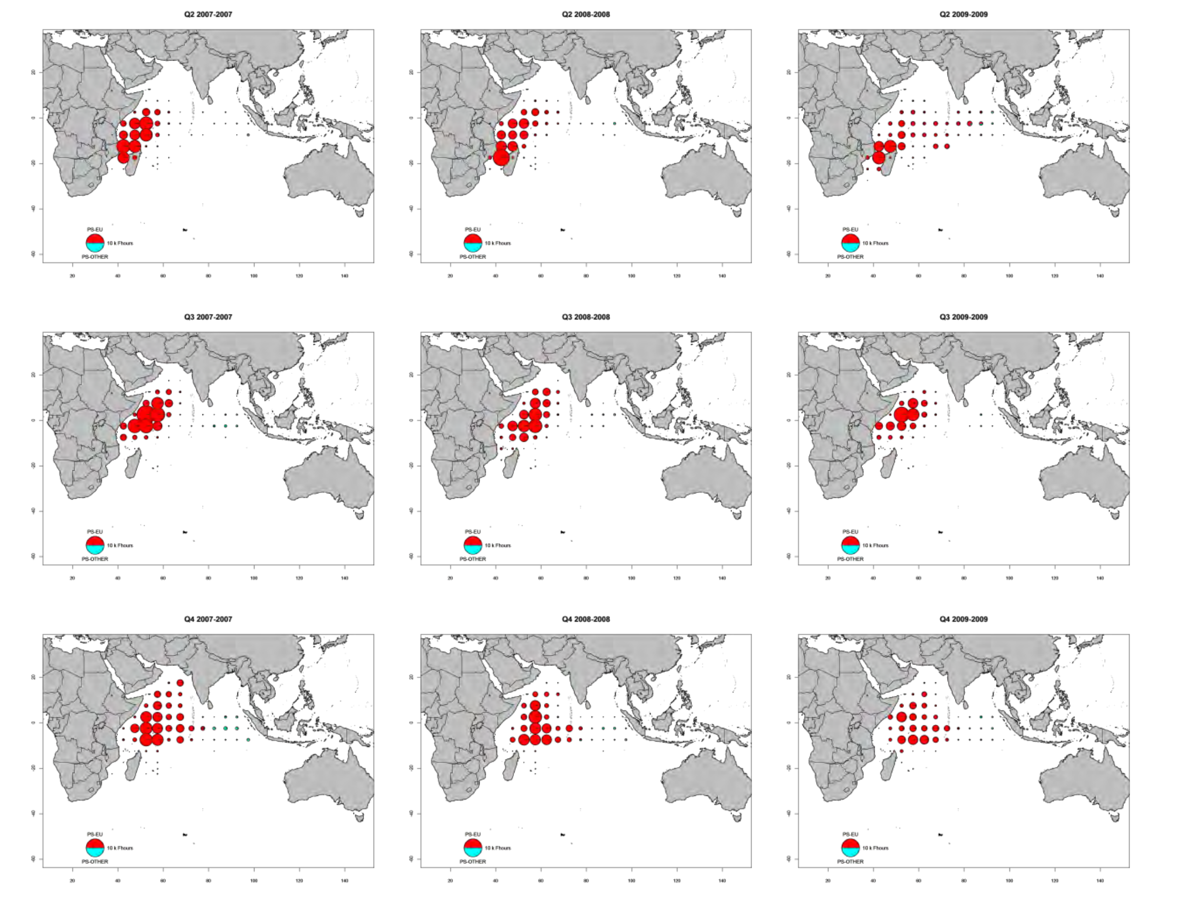


Figure 81: Purse seine effort per quarter from 2007 to 2009.

11. ISSUES ON FISHING CAPACITY FOR TROPICAL TUNA

235. Assessments of fishing capacity and, in particular, of overcapacity are increasingly part of national management activities. India has made concerted efforts to assess fishing capacity in marine fisheries, quantitatively and qualitatively, in order to avoid overcapacity and excess capacity. However, this positive sign is often complicated by the multispecies and multifleet nature of the fisheries. India periodically estimates potential yield of fishery resources, which includes neritic and oceanic tunas in the Indian EEZ. Census on fishing craft and gear in the commercial fisheries, carried out for the mainland by CMFRI and for the islands by FSI in 2005 and 2010, provided data on the number of fishing boats and gear, fishermen population engaged in marine fisheries and other important data for assessing fishing capacity. Trying to define fisheries becomes more complex when different fleets target different species in overlapping as well as different areas. For example, inshore artisanal boats with sail power target and catch yellowfin tuna that extend into deeper waters, where they are taken by an offshore longline fleet. Hence, the input-based target capacity requires not only an estimate of total vessel numbers, but also vessel types, numbers and gear type. Considering the multifleet, multispecies nature of fisheries in India, estimating fishing capacity is a challenge, but not impossible. Analysis of data available with FSI and CMFRI and collection of relevant primary data are prerequisites to estimate the fishing capacity.

236. The WPTT acknowledged the information provided in the document about the input capacity and output capacity of the Indian fleet measured as the number and power of vessels and the catch for each fleet, respectively.

237. The WPTT noted that the improvements carried out in the fishery statistics data recollection; however, there were some questions raised by the fact that the data was collected by two different institutes, FSI and CMFRI, and the effect that the different methodology for data collection and analysis of both institution can have in the final results. However, the cross-checking of the estimates and a consultation process between the two institutes provide accurate information.

238. The WPTT also commented about the definition of capacity used in the study as well as the estimation of sustainable input/output capacity of India EEZ presented by the paper as the activity of various fleets in the Indian region (*i.e.* outside Indian EEZ) can affect the dynamics of highly migratory species.

239. The WPTT also noted that the number of vessels larger than 24 meters LOA in the Secretariat database were larger than the number presented in the document. Moreover, the catch estimated in the paper were double than the one estimated and recorded by Secretariat for India (13000 tonnes in comparison to the 29000 tonnes presented in the document). The WPTT recommended authors to check with their authority about the accuracy of the data, both number of boats and catch, and to report to the Secretariat the correct figures of number of boats and catch.

12. OTHER BUSINESS

12.1 Presentation of the Tuna Atlas of the Indian Ocean

240. A recent publication containing an atlas of the tuna fisheries in the Indian Ocean was presented to the group. The volume contains a large number of maps and graphs showing the trends, changes and dynamics of the tuna stocks and fleets in the IOTC area since the start of the fishery. Those interested in obtaining a copy of this publication should contact the Publications office of IRD, France at http://www.ird.fr/editions/index.php.

12.2 Meeting Participation Fund

241. The WPTT acknowledged with satisfaction the participation of several scientists from the IOTC developing Members, *i.e.* China, Comoros, Iran, India, Kenya, Indonesia, Madagascar, Sri-Lanka, Thailand and Cooperating non-Contracting Parties, *i.e.* Maldives. It was noted that this was made possible by the Meeting Participation Fund decided by the Commission at its 14th Session in 2010 (Resolution 10/05). The WPTT firmly welcomed this initiative as this has significantly increased the number of countries present at WPTT meetings. The WPTT encouraged the Scientific Committee to inquiry the Commission on possible avenues to maintain this fund.

12.3 Participation of invited experts and consultants

242. The WPTT extended a warm thanks to Dr Ian Taylor for his contribution as an invited expert.

243. The participation of Dr Adam Langley, as a consultant with expertise on integrated stock assessment models, was also welcomed, and the WPTT recommended that his engagement be renewed for the coming year. The WPTT considered that as the application of complex integrated models is further extended, the need for highly specialized expertise on those models should be fulfilled by encouraging scientists with such expertise from other areas to participate in the WPTT meetings.

244. A question was raised on the selection procedure for consultants and invited experts. The chair and the Secretariat explained the informal procedure that is routinely followed in the cases of invited experts. The chair of the Working Party in consultation with the chair of the Scientific Committee and members of various delegations, as appropriate, considers potential candidates that would bring relevant expertise to the work of the Working Party. This consultation process often involved the Secretariat as needed to confirm the availability of funds. In the case of the appointment of the consultant, the WPTT had recommended the appointment at last year's WPTT, as listed in the report of that meeting. The Secretary noted that, as the Working Party is constituted by individuals, not delegations of Member countries, it would be inappropriate to vote on the participation of consultants.

245. The discussion extended into the role of the Secretariat stock assessment expert, as some participants expressed their reservations on the need for consultants to take part in the WPTT meetings, and on the existence of the stock assessment expert position. The Secretariat explained in detail what the procedure had been for the appointment of the stock assessment expert, and how its appointment had been requested for many years by the Scientific Committee. The participants were reminded that the guidelines about the duties of the stock assessment expert were discussed at the Scientific Committee in 2008. The Chair agreed to bring the issue to the attention of the Scientific Committee as it involves questions of procedure beyond the WPTT mandate.

12.4 Location of the 2011 meeting of the WPTT

246. The WPTT has been invited to celebrate its next meeting in 2011 in the Maldives. The invitation was warmly welcomed and will be communicated to the Scientific Committee.

12.5 Administrative limitations to recruitment for IOTC staff

247. The Secretariat updated the WPTT on the process for the recruitment of a new Deputy Executive Secretary, which is being delayed greatly by administrative issues with the FAO central office. The current situation, where recruitment of technical personnel has become an extremely long and time-consuming process, is considered to impact severely the ability of the IOTC Secretariat to attract potential candidates and adapt its workforce to changes in its activities and priorities. The WPTT agreed to communicate this information to the Scientific Committee with a view of informing the next Commission meeting on the impact of these problems on the IOTC scientific activity.

12.6 Contribution by the Secretariat stock assessment expert

248. The WPTT recognized the contribution of the recently appointed Stock Assessment Expert. Questions were raised about the need for the Secretariat to increase its level of expertise in this area, maybe through a possible appointment of a member of staff to work under the supervision of the stock assessment expert. It was also noted that the data collection and preparation work depends on a very limited number of staff. The Secretariat indicated that new additions to its technical staff would obviously improve its capacity to provide support to the IOTC activities, but that no immediate plans are in place for any new technical position.

12.7 IOTC website

249. The Secretariat was inquired on the progress of work to develop a new website for IOTC that would better serve the needs of the IOTC community. The WPTT was informed of the state of negotiations with a local supplier that will develop the framework on which current and new content will be incorporated. A more detailed presentation on the expected structure and aspect of the new website will be made to the Scientific Committee meeting.

12.8 Tagging symposium

250. Funds have been identified to organized a final tagging symposium, funded by the EU DG-Mare and the IOTC for a total budget of 250 000 euros, of which 135 000 euros should be dedicated to fund expertise and analysis of the tagging data gather during the Indian Ocean Tuna Tagging Programme, and the remaining to the organization of the meeting and invitation of regional participants. This tagging symposium should take place in 2012 and could be organized in Mauritius, as the Indian Ocean Commission implemented the project.

251. The WPTT acknowledged the desirability of such a symposium taken place in the near future. A Steering Committee should be appointed soon in order to take care of the organization and formalize the appointment of the technical personnel that should lead on the analyses of the tagging data.

12.9 Election of chairperson

252. Dr. Hilario Murúa, of AZTI Tecnalia, Spain, was unanimously elected as chair of the Working Party on Tropical Tuna for the next biennium.

13. SUMMARY OF WPTT RECOMMENDATIONS IN 2010

DATA

1. The WPTT noted that some of the issues identified in Table 1 have been outstanding for several years urging the countries concerned to consider addressing such issues as soon as possible. In this regard, the WPTT requested the countries concerned to report to the next meeting of the WPTT about the actions undertaken and progress achieved in addressing these issues. In addition, the WPTT requested the IOTC Secretariat to follow-up on these issues, assisting the countries concerned where required (paragraph 6).
2. The WPTT recommended that complete and good quality data should be reported to the Secretariat as per IOTC requirements for all the fisheries, and that this issue is brought to the attention of the Scientific Committee with a view of reporting to the Compliance Committee (paragraph 9).
3. 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 (paragraph 11).
4. The WPTT acknowledged the important information provided in relation to Iran's yellowfin fisheries as well as yellowfin biology and ecology in that area. The WPTT further noted that, to date, the IOTC has not received information concerning the fishery information from Iran and, thus, the WPTT recommended that effort are carried out to collect and report to IOTC the necessary information on Iran's fishery statistics (paragraph 63)
5. The WPTT noted that the purse-seine fleet is still unloading significant amount of fish in Antsiranana port, however, it noted that data on artisanal catches are still missing from the database hosted at the Secretariat. It encouraged that a statistical system is developed and implemented in order to report on those catches, which are being estimated by the Secretariat at the moment (paragraph 66).
6. As the catch statistics provided by Sri Lanka to Sri Lanka do not contain estimates of bigeye catches, the WPTT recommended that the species composition obtained in this study is provided to IOTC Secretariat in order to improve Sri Lanka catch statistics in IOTC (paragraph 76).
7. The WPTT acknowledged that biology of the fish in the area is unknown and noted that fisheries data for the region is very scarce. It recommended that detailed fisheries data and statistics are reported to the Secretariat for the region (paragraph 97).

DATA ANALYSIS

8. The amount of data generated during the tagging programme is being used in multiple ways by scientists and is bringing to the table a considerable amount of new information on this species in the Indian Ocean. The WPTT encouraged further analysis to be conducted on the tagging data (paragraph 21, 34, 46).
9. Various studies undertaken for the 10th Session of the WPTT demonstrated that growth is following a multi stanza pattern. Since that study, more recapture of large fish have been reported, and the analysis should be updated in order for the various models to estimate a reliable L_{inf}. However, the WPTT recognized that a lot of information is being missed due to the lack of reporting by the longline fisheries of the Indian Ocean which could provide valuable returns of large tagged fish (paragraph 22).
10. 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, but the lack of recoveries of large fish did not allow the various models used to reliable estimate the asymptotic length, L_{inf}, at that time. New analyses have been conducted and preliminary results were presented during this session of the WPTT, which recommended that they are pursued further, as they include new recoveries of large fish (paragraph 35).
11. Various studies undertaken for the 10th Session of the WPTT demonstrated that growth is following a Von Bertalanffy curve, however these analysis should be refined as since then,

numerous new recaptures have been reported (paragraph 47).

12. The WPTT noted that the proportion of bigeye and yellowfin in the catch from the Thai purse seiners is very different from the proportion of bigeye and yellowfin in the European and Seychelles purse seine fleets which are operating in the same area. In fact, there is far more bigeye in the Thai catch. The WPTT recommended to investigate this issue, as this could come from a problem in the sampling (paragraph 56).
13. The WPTT recommended that more work is carried out on catchability and selectivity of longliners and purse-seiners integrating the environmental factors described in this study. It was also noted that these data should be analysed at different scale in order to identify "hot spots" (paragraph 78).
14. The WPTT recommended the use of Brownie and Petersen models to derive more consistent natural mortality rates based on the latest RTTP-IO data (paragraph 101).
15. The WPTT recommended that further exploration of this analysis is conducted, especially on the reasons for the estimates of F at age obtained. Explorations of alternative estimators using the same data should also be attempted in order to understand how much of results observed are driven by the data and how much is dependent on the assumptions of the model being violated. The WPTT also encouraged the development of a multiyear Brownie-Petersen estimator to directly estimate M for next year meeting (paragraph 105).
16. The assessment using MFCF is still a work in progress, and would need to be pursued and refined at the next Session of the WPTT. In the meantime, the WPTT recommended to explore the possibility of developing a Kobe II Strategy Matrix for MFCL which could be presented at the next Session of the Scientific Committee (paragraph 153).
17. The MFCL and SS3 integrated models enabled scientists to use the fisheries and tagging data, as well as other information for and the WPTT recommended their use in the future (paragraph 154).
18. The group acknowledged that in the current WPTT session several different models were presented, which allowed the contrasting of model results and the simulation of different dynamics and hypothesis. To this end, the WPTT suggested that a range of stock assessments approaches continues to be conducted, integrated or not, in the future (paragraph 155).
19. The group recommended that the efforts put in the development of this [bigeye] assessment using SS3 and including the tag data are continued, and refined at the next Session of the WPTT (paragraph 190).
20. The use of a FAD-deployment database available in the Maldives was encouraged in future approaches to improve the time series of CPUE by including the number of FADs in the catch rates standardization process (paragraph 200). Acknowledging the usefulness of standardizing CPUE for skipjack, the WPTT recommended that the work is pursued and that progress are presented at the next Session (paragraph 203).
21. It was noted that skipjack assessment are difficult to conduct in all RFMOs, however the group recommended that a stock assessment is conducted next year, and that a range of models as well as of fisheries indicators should be used to give a comprehensive picture of the current stock status (paragraph 205).
22. The WPTT considered that MSE and similar procedures are of great interest for IOTC and encouraged researchers to work on this issue over the coming year (paragraph 230).
23. The participation of Dr Adam Langley, as a consultant with expertise on integrated stock assessment models, was also welcomed, and the WPTT recommended that his engagement be renewed for the coming year (paragraph 243).

RESEARCH

24. The WPTT acknowledged the importance and implications on the assessment of yellowfin tuna of the results [sex ratio by length] discussed in this paper and, thus, the WPTT recommended that effort are directed to measure the sex and length for any large tagged

recovered fish (paragraph 80).

25. The WPTT acknowledged the importance of biological information to be considered in the assessment models. With respect to future work in this area, the WPTT recommended that the gonad collection and calculation of the gonadosomatic index for yellowfin continue (paragraph 95).
26. The low rate of recovery from the longline fleets, able to capture larger fish, was noted as limiting the use of the tagging data to inform on some of growth parameters for yellowfin and bigeye. The asymptotic length of fish, L_{inf}, can only be reliable estimated if a sufficient number of fish are tagged and recovered that have grown to very large sizes. The WPTT encouraged scientists involved with those fleets to step up their efforts to aid at the recovery of tagged fish caught by those gears (paragraph 211).

MANAGEMENT

27. The WPTT recommends that catches of yellowfin tuna in the Indian Ocean should not increase beyond 300,000 t in order to bring the stock to biomass levels that could sustain catches at the MSY level in the long term. If recruitment continues to be lower than average, catches below MSY would be needed to maintain stock levels (paragraph 171).
28. Under the light of this the WPTT recommends that bigeye catches are kept at or lower than the 2009 level (paragraph 197).

PIRACY

29. The WPTT recommended that French scientists investigate further these changes in activity, possibly by means of VMS data. The WPTT noted that there were also some significant effects on the Spanish and Seychelles purse-seine fleet affecting their fishing strategy, and that this should be investigated as well (paragraph 232).
30. An on-going analysis on the effects of the piracy activities on catch rates of purse seine fleets was mentioned to the WPTT. The authors were encouraged to present their findings at the next meeting of the Scientific Committee (paragraph 234).

MEETING PARTICIPATION FUND

31. The WPTT acknowledged with satisfaction the participation of several scientists from the IOTC developing Members, *i.e.* China, Comoros, Iran, India, Kenya, Indonesia, Madagascar, Sri-Lanka, Thailand and Cooperating non-Contracting Parties, *i.e.* Maldives. It was noted that this was made possible by the Meeting Participation Fund decided by the Commission at its 14th Session in 2010 (Resolution 10/05). The WPTT firmly welcomed this initiative as this has significantly increased the number of countries present at WPTT meetings. The WPTT encouraged the Scientific Committee to inquiry the Commission on possible avenues to maintain this fund (paragraph 241).

14. ADOPTION OF THE REPORT

253. The WPTT express its thanks to the Secretariat and to the government of Seychelles for hosting the meeting.

254. The Report was adopted in the main on Monday 25 October 2010 and finalized by correspondence on 10 November 2010.

APPENDIX I
AGENDA OF THE 12TH SESSION OF THE WORKING PARTY ON TROPICAL TUNAS

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.

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

Stock assessments

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. DEVELOPMENT OF THE TECHNICAL ADVICE ON THE STATUS OF THE STOCKS

7. ANALYSIS OF TAGGING DATA

8. ANALYSIS OF THE TIME-AREA CLOSURES (Resolution 10/01)

9. MANAGEMENT STRATEGY EVALUATION FOR INDIAN OCEAN TROPICAL TUNA

10. EFFECT OF PIRACY ON TROPICAL TUNA CATCHES

11. ISSUES ON FISHING CAPACITY FOR TROPICAL TUNA

12. RECOMMENDATIONS AND PRIORITIES

Recommendations on alternative data collection and sampling

Research recommendations

13. OTHER BUSINESS

Election of a new Chairperson

APPENDIX II
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APPENDIX III
LIST OF DOCUMENTS

Document	Title	Availability
IOTC-2010-WPTT-01	Draft agenda of the Working Party on Tropical Tunas	✓
IOTC-2010- WPTT-02	WPTT List of documents	✓
IOTC-2010- WPTT-03	Status of IOTC Database for tropical tunas. *Herrera, M. and Pierre, L.*	✓
IOTC-2010- WPTT-04	Exploration of Indian Ocean Bigeye Tuna Stock Assessment Sensitivities 1952-2008. *Kolody, D. Herrera, M. and Million, J.*	✓
IOTC-2010- WPTT-05	Skipjack catch rate standardization for the Maldivian pole and line fishery. *Kolody, D., Adam, M.S. and Anderson, C.*	✓
IOTC-2010- WPTT-06	Differences in large scale movement between free swimming and fish aggregating device (FAD) caught tuna. *Stehfest, K.M. and Dagorn, L.*	✓
IOTC-2010- WPTT-07	Preparation of data input files for the assessments of Indian Ocean yellowfin tuna stock using Multifan-CL. *Herrera, M. and Million, J.*	✓
IOTC-2010- WPTT-08	Preparation of data input files for the stock assessments of Indian Ocean tropical tuna species. *Herrera, M. and Pierre, L.*	✓
IOTC-2010- WPTT-09	Declining Catches of Skipjack in the Indian Ocean – Observations from the Maldives. *Adam, M.S.*	✓
IOTC-2010- WPTT-10	Tuna Fisheries of Thailand during 2008-2009. *Bunluedaj, C.*	✓
IOTC-2010- WPTT-11	Catch of yellowfin and bigeye by the longline fishing fleet based in La Reunion island. *Bach, P.*	✓
IOTC-2010- WPTT-12	French purse seine tuna fisheries statistics in the Indian Ocean 2001-2009. *Floch, Dewals, P., Chassot, E., Chavance, P., Pianet, R.*	✓
IOTC-2010- WPTT-13	Statistics of the main purse seine fleets fishing in the Indian Ocean, 1981-2009. *Pianet, R., Delgado de Molina, A., Dewals, P., Lucas, V., Floch, Chassot; E., Ariz, J.*	✓
IOTC-2010- WPTT-14 (pres)	Statistics of the French purse seine tuna fishing fleet in the first semester of 2010. *Floch, Dewals, P., Chassot, E., Pianet, R.*	✓
IOTC-2010- WPTT-15 (pres)	Estimating the growth of yellowfin (*Thunnus albacares*) combining otolith and tagging data in a Bayesian framework. *Massiot-Granier, Rivot, Morize, E., Hallier, J.P., Million, J., Chassot, E.*	✓
IOTC-2010- WPTT-16	The framework and utility of an MSE evaluation for yellowfin tuna (Thunnus albacares) in the Indian Ocean region. *De Bruyn, P., Kell, L., Soto Ruiz, M., Mosqueira, I. and Murua, H.*	✓
IOTC-2010- WPTT-17	Application of the APECOSM-E model to the skipjack tuna (*Katsuwonus pelamis*) fisheries of the Indian Ocean. *Dueri, S. and Maury, O.*	✓
~~IOTC-2010- WPTT-18~~	*- No document -*	~~---~~
IOTC-2010- WPTT-19	Statistics of the purse seine Spanish fleet in the Indian Ocean (1984-2009). *Delgado de Molina, A., Areso, J.J. and Ariz, J.*	✓
IOTC-2010- WPTT-20	Update 2010 on the climate and ocean conditions in the Indian Ocean. *Marsac, F.*	✓
IOTC-2010- WPTT-21	From VMS data to tuna distribution maps and indices of abundance. *Bez, O., Walker, Gaspar, Gaertner, D., Rivoirard.*	✓
IOTC-2010- WPTT-22	Analysis of activity data obtained from supply vessels' logbooks implemented by the Spanish fleet in the Indian Ocean. *Ramos, L., Delgado de Molina, A. and Ariz, J.*	✓
IOTC-2010- WPTT-23	YFT assessment MFCL 2010. *Langley, A.*	✓
IOTC-2010- WPTT-24	Comparing condition factors of skipjack tuna associated with natural floating objects and those from free swimming schools in the Mozambique Channel. *Robert, M., Dagorn, L. and Deneubourg, J.L.*	✓
IOTC-2010- WPTT-25	Behaviour of Tuna associated with Drifting FADs in the Mozambique Channel. *Govinden, R., Dagorn, L., Soria, M. and Filmalter, J.D.*	✓
IOTC-2010- WPTT-26	Updated analysis of 2006/07 RTTP-IO tagging data for Skipjack. *Edwards, C.T.T. de Bruyn, P.A., Million, J., Hillary, R.M.*	✓
IOTC-2010- WPTT-27	Preliminary first results obtained from the recovery of tagged sexed YFT: sex ratio and growth. *Fonteneau, A. and Hallier, J.P.*	✓
IOTC-2010- WPTT-28	Potential indicators of fishing efforts targeting yellowfin and bigeye tuna exerted by Japanese and Taiwanese longliners in the Indian Ocean. *Fonteneau, A.*	✓
IOTC-2010- WPTT-29	Japanese longline CPUE for bigeye tuna in the Indian Ocean up to 2009 standardized by GLM. *Okamoto, H. and Shono, H.*	✓
IOTC-2010- WPTT-30	Japanese longline CPUE for yellowfin tuna in the Indian Ocean up to 2009 standardized by general linear model. *Okamoto, H. and Shono, H.*	✓
IOTC-2010- WPTT-31	Analysis of 2008 RTTP-IO tagging data for Skipjack. *Edwards, C.T.T. de Bruyn, P.A., Million, J., Hillary, R.M.*	✓

Document	Title	Availability
IOTC-2010- WPTT-32	Searching comparable standardized YFT CPUE between Japanese and Taiwanese tuna longline fisheries in the common fishing grounds in the Indian Ocean. *Nishida, T. and Chang, L.*	✓
IOTC-2010- WPTT-33	Yellowfin tuna CPUE standardization of the Korean tuna longline fisheries in the Indian Ocean (1980-2009). *Hwang, S. and Nishida, T.*	✓
IOTC-2010- WPTT-34 (pres)	Stock assessments of YFT in the Indian Ocean by ASPIC. *Nishida, T.*	✓
IOTC-2010- WPTT-35	Report on the unloading of PS in the port of Antsiranana over the 9 last years 2002-2010. *Rahombanjanahary, D.*	✓
IOTC-2010- WPTT-36	Standardizing the tuna longline CPUE of *Thunnus obesus*: An application of “deterministic habitat based standardization” to the data in Marshall Islands Waters*”. Yuwei, L., Liming S, and,Yingqi, Z.*	✓
IOTC-2010- WPTT-37	Status of the tuna fisheries in Comoros. *Abdouchakour, M.*	✓
IOTC-2010- WPTT-38	Tropical Tunas Catch Trends in Indonesia. *Zarochman, K.*	✓
IOTC-2010- WPTT-39	The study of population dynamic parameters of Yellowfin tuna in the Oman Sea. *Kaymaram, F.*	✓
IOTC-2010- WPTT-40	CPUE standardizations for yellowfin tuna caught by Taiwanese longline fishery in the Indian Ocean using generalized linear model. *Yeh, Y.M., Chang, S.T.*	✓
IOTC-2010- WPTT-41	Some aspects on the biology of bigeye Tuna (*Thunnus obesus*, Lowe 1839) in Andaman and Nicobar waters. *Anrose, A.*	✓
IOTC-2010- WPTT-42	CPUE of tuna from the Kenya's sport fishery. *Ndegwa, S.*	✓
IOTC-2010- WPTT-43	Environmental preferences of Yellowfin tuna (Thunnus albacores) in the northeast Indian Ocean: an application of remote sensing data to longline catches. *Rajapaksha, J.K.*	✓
IOTC-2010- WPTT-44	Comparisons of STD YFT CPUE of tuna longline fisheries among Japan, Korea and Taiwan. *Nishida, T.*	✓
IOTC-2010- WPTT-45	Stock assessment for yellowfin tuna in the Indian Ocean from 1963 to 2009 by Stock Synthesis III (SS3) including tagging data. *Shono, H., Yeh, Y.M., Okamoto, H., Taylor, I., Herrera, M. and Million, J.*	✓
IOTC-2010- WPTT-46	Effects of environmental factors on catch rates of FAD-associated yellowfin (*Thunnus albacares*) and skipjack (*Katsuwonus pelamis*) tunas in the western Indian Ocean. *Fraile, I., Murua, H., Goñi, N. and Caballero, A.*	✓
IOTC-2010- WPTT-47	Spawning activity and batch fecundity of skipjack, *Katsuwonus pelamis*, in the Western Indian Ocean. *Grande, M., Murua, H. and Zudaire, I.*	✓
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