# Report of the Fourteenth Session of the IOTC Working Party on Tropical Tunas

Mauritius, 24–29 October 2012

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# ACRONYMS

| | |
|---|---|
| aFAD | anchored Fish aggregation device |
| ASPM | Age-Structured Production Model |
| B | Biomass (total) |
| BET | Bigeye tuna |
| $B_{MSY}$ | Biomass which produces MSY |
| CE | Catch and effort |
| CI | Confidence Interval |
| CMM | Conservation and Management Measure (of the IOTC; Resolutions and Recommendations) |
| CPCs | Contracting parties and cooperating non-contracting parties |
| CPUE | Catch per unit of effort |
| CTD | Conductivity, Temperature, and Depth sensors (a multi-sensor profiling instrument) |
| current | Current period/time, i.e. $F_{current}$ means fishing mortality for the current assessment year. |
| EU | European Union |
| EEZ | Exclusive Economic Zone |
| ENSO | El Niño–Southern Oscillation |
| F | Fishing mortality; $F_{2011}$ is the fishing mortality estimated in the year 2011 |
| FAD | Fish aggregation device |
| $F_{MSY}$ | Fishing mortality at MSY |
| GLM | Generalised liner model |
| HBF | Hooks between floats |
| IO | Indian Ocean |
| IOI | Indian Oscillation Index |
| IOTC | Indian Ocean Tuna Commission |
| K2SM | Kobe II Strategy Matrix |
| LL | Longline |
| M | Natural Mortality |
| MSY | Maximum sustainable yield |
| n.a. | Not applicable |
| PS | Purse-seine |
| q | Catchability |
| ROP | Regional Observer Programme |
| SC | Scientific Committee of the IOTC |
| SB | Spawning biomass (sometimes expressed as SSB) |
| $SB_{MSY}$ | Spawning stock biomass which produces MSY |
| SKJ | Skipjack tuna |
| SS3 | Stock Synthesis III |
| Taiwan,China | Taiwan, Province of China |
| VB | Von Bertalanffy (growth) |
| WPTT | Working Party on Tropical Tunas of the IOTC |
| XBT | Expendable BathyThermograph probes |
| YFT | Yellowfin tuna |

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## EXECUTIVE SUMMARY

The Fourteenth Session of the Indian Ocean Tuna Commission's (IOTC) Working Party on Tropical Tunas (WPTT) was held in Mauritius, from 24 to 29 October 2012. A total of 47 participants attended the Session, including one invited expert, Dr. Andrew Cooper, from Simon Fraser University, Canada. The following are a subset of the complete recommendations from the WPTT14 to the Scientific Committee, which are provided at Appendix IV.

### New information on fisheries and associated environmental data relating to tropical tunas

WPTT14.02 (para.68) The WPTT **RECOMMENDED** that Japan and Taiwan,China review catch, effort and size frequency datasets in order to assess reasons for discrepancies identified by the IOTC Secretariat and to report results at the next meeting of the WPTT, including a comparison of length frequency data samples collected from commercial and research and training vessels.

### Bigeye tuna

WPTT14.03 (para.73) The WPTT **NOTED** the main tropical tuna data issues that are considered to negatively affect the quality of the statistics available at the IOTC Secretariat, by type of dataset and fishery, which are provided in Appendix VI, and **RECOMMENDED** that the CPCs listed in the Appendix, make efforts to remedy the data issues identified and to report back to the WPTT at its next meeting.

WPTT14.05 (para.97) The WPTT **RECOMMENDED** that the SC note the draft resource stock status summary for bigeye tuna (*Thunnus obesus*) – Appendix VII.

### Skipjack tuna

WPTT14.07 (para.116) The WPTT **RECOMMENDED** further investigation of the existing data to produce an improved standardised CPUE series for the FAD-associated school skipjack tuna fishery in the Indian Ocean, and for information on these matters to be presented to the next meeting of the WPTT.

WPTT14.09 (para.142) The WPTT **RECOMMENDED** that the SC note the draft resource stock status summary for skipjack tuna (*Katsuwonus pelamis*) – Appendix VIII.

### Yellowfin tuna

WPTT14.11 (para.182) **NOTING** that data from Taiwanese vessels flagged to India was not used in the analysis, the WPTT **RECOMMENDED** that national scientists from Taiwan,China work with the IOTC Secretariat to gain a better estimate of catch in the Bay of Bengal.

WPTT14.14 (para.233) The WPTT **RECOMMENDED** that the SC note the draft resource stock status summary for yellowfin tuna (*Thunnus albacares*) – Appendix IX.

### Analysis of the Time-Area Closures (including Resolution 12/13)

WPTT14.15 (para.246) **NOTING** that the objective of Resolution 12/13 is to decrease the overall pressure on the main targeted stocks in the Indian Ocean, in particular yellowfin tuna and bigeye tuna, and also to evaluate the impact of the current time/area closure and any alternative scenarios on tropical tuna population, the WPTT reiterated its previous **RECOMMENDATION** that the SC request that the Commission specify the level of reduction or the long term management objectives to be achieved with the current or alternative time area closures, as these are not contained within Resolution 12/13.

### Effect of Piracy on Tropical Tuna Catches

WPTT14.16 (para.251) The WPTT **RECOMMENDED** that given the potential impacts of piracy on fisheries in other areas of the Indian Ocean through the relocation of longliners to other fishing grounds, specific analysis should be carried out and presented at the next WPTT meeting by CPCs most affected by these activities, including Japan, Rep. of Korea and Taiwan,China. For example, longline fishing effort has been redistributed to traditional albacore fishing grounds in recent years, thereby further increasing fishing pressure on the albacore stock (see IOTC–2012–WPTmT–R).

### Research Recommendations and Priorities

WPTT14.17 (para.256) **NOTING** that nominal juvenile purse seine CPUE, once standardised, can be used as an indicator of the recruitment index in the stock assessment models, the WPTT **RECOMMENDED** that the standardised CPUE index for juvenile yellowfin tuna and bigeye tuna caught by the EU

purse seiner fleets, be estimated and submitted to the WPTT before the next round of stock assessments of tropical tunas.

WPTT14.18 (para.257) The WPTT **RECOMMENDED** that standardisation of purse seine CPUE be made where possible using the operational data on the fishery.

**Review of the draft, and adoption of the Report of the Fourteenth Session of the WPTT**

WPTT14.22 (para.271) The WPTT **RECOMMENDED** that the SC consider the consolidated set of recommendations arising from WPTT14, provided at Appendix IV.

A summary of the stock status for tropical tuna species under the IOTC mandate is provided in Table 1.

**Table 1.** Status summary for species of tropical tuna under the IOTC mandate.

| Stock | Indicators | Prev[1] | 2010 | 2011 | 2012 | Advice to Commission |
|---|---|---|---|---|---|---|
| Bigeye tuna<br>*Thunnus obesus* | Catch 2011: 87,420 t<br>Average catch 2007–2011: 101,639 t<br>SS3[3] ASPM[4]<br>MSY (1000 t): 114 (95–183) 103 (87–119)<br>$F_{curr}/F_{MSY}$:[2] 0.79 (0.50–1.22) 0.67 (0.48–0.86)<br>$SB_{curr}/SB_{MSY}$:[2] 1.20 (0.88–1.68) 1.00 (0.77–1.24)<br>$SB_{curr}/SB_0$:[2] 0.34 (0.26–0.40) 0.39 | 🟩 2008 | 🟩 | 🟩 | 🟩 | At this time, annual catches of bigeye tuna should not exceed 102,000 t. If the recent declines in effort continue, and catch remains substantially below the estimated MSY, then immediate management measures are not required. However, continued monitoring and improvement in data collection, reporting and analysis is required to reduce the uncertainty in assessments. <Click here for full stock status summary> |
| Skipjack tuna<br>*Katsuwonus pelamis* | Catch 2011: 398,240 t<br>Average catch 2007–2011: 435,527 t<br>MSY (1000 t): 478 (359–598)<br>$F_{2011}/F_{MSY}$: 0.80 (0.68–0.92)<br>$SB_{2011}/SB_{MSY}$: 1.20 (1.01–1.40)<br>$SB_{2011}/SB_0$: 0.45 (0.25–0.65) | ⬜ | ⬜ | 🟩 | 🟩 | At this time, annual catches of skipjack tuna should not exceed 478,000 t. If the recent declines in effort continue, and catch remains substantially below the estimated MSY, then immediate management measures are not required. However, recent trends in some fisheries, such as Maldivian pole-and-line, as well as the decrease of catches of large skipjack tuna, suggest that the situation of the stock should be closely monitored. <Click here for full stock status summary> |
| Yellowfin tuna<br>*Thunnus albacares* | Catch 2011: 302,939 t<br>Average catch 2007–2011: 302,064 t<br>MSY (1000 t): 344 (290–453)<br>$F_{2010}/F_{MSY}$: 0.69 (0.59–0.90)<br>$SB_{2010}/SB_{MSY}$: 1.24 (0.91–1.40)<br>$SB_{2010}/SB_0$: 0.38 (0.28–0.38) | 🟥 2008 | 🟨 | 🟩 | 🟩 | At this time, annual catches of yellowfin tuna should not exceed 300,000 t, in order to ensure that stock biomass levels could sustain catches at the MSY level in the long term. Recent recruitment is estimated to be considerably lower than the whole time series average. If recruitment continues to be lower than average, catches below MSY would be needed to maintain stock levels. <Click here for full stock status summary> |

[1] This indicates the last year taken into account for assessments carried out before 2010

[2] Current period ($_{curr}$) = 2009 for SS3 and 2010 for ASPM.

[3] Central point estimate is adopted from the 2010 SS3 model, percentiles are drawn from a cumulative frequency distribution of MPD values with models weighted as in Table 12 of 2010 WPTT report (IOTC–2010–WPTT12–R); the range represents the 5th and 95th percentiles.

[4] Median point estimate is adopted from the 2011 ASPM model using steepness value of 0.5 which is the most conservative scenario (values of 0.6, 0.7 and 0.8, which are more optimistic, are considered to be as plausible as these values but are not presented for simplification); the range represents the 90 percentile Confidence Interval.

| **Colour key** | Stock overfished($SB_{year}/SB_{MSY} < 1$) | Stock not overfished ($SB_{year}/SB_{MSY} \geq 1$) |
|---|---|---|
| Stock subject to overfishing($F_{year}/F_{MSY} > 1$) | 🟥 | 🟧 |
| Stock not subject to overfishing ($F_{year}/F_{MSY} \leq 1$) | 🟨 | 🟩 |
| Not assessed/Uncertain | ⬜ | |

# 1. OPENING OF THE MEETING

1. The Fourteenth Session of the Indian Ocean Tuna Commission's (IOTC) Working Party on Tropical Tunas (WPTT) was held in Mauritius, from 24 to 29 October 2012. A total of 47 participants attended the Session. The list of participants is provided at Appendix I. The meeting was opened by the Chair, Dr. Hilario Murua, who welcomed participants to Mauritius.

# 2. ADOPTION OF THE AGENDA AND ARRANGEMENTS FOR THE SESSION

2. The WPTT **ADOPTED** the Agenda provided at Appendix II. The documents presented to the WPTT14 are listed in Appendix III.

# 3. OUTCOMES OF THE FOURTEENTH SESSION OF THE SCIENTIFIC COMMITTEE

3. The WPTT **NOTED** paper IOTC–2012–WPTT14–03 which outlined the main outcomes of the Fourteenth Session of the Scientific Committee (SC14), specifically related to the work of the WPTT.

4. The WPTT **NOTED** the recommendations of the SC14 on data and research related to tropical tunas and **AGREED** to consider how best to progress these issues at the present meeting.

# 4. OUTCOMES OF SESSIONS OF THE COMMISSION

## *4.1 Outcomes of the Sixteenth Session of the Commission*

5. The WPTT **NOTED** paper IOTC–2012–WPTT14–04 which outlined the main outcomes of the Sixteenth Session of the Commission, specifically related to the work of the WPTT.

6. The WPTT **NOTED** the 15 Conservation and Management Measures (CMMs) adopted at the Sixteenth Session of the Commission (consisting of 13 Resolutions and 2 Recommendations), and in particular the following three Resolutions which have a direct impact on the work of the WPTT: Resolution 12/01 *on the implementation of the precautionary approach*; Resolution 12/03 *on catch and effort recordings by fishing vessels in the IOTC area of competence*; Resolution 12/08 *On a Fish Aggregating Devices (FADs) Management Plan*; Resolution 12/11 *On the implementation of a limitation of fishing capacity of Contracting Parties and Cooperating non-Contracting Parties* and Resolution 12/13 *For the Conservation and Management of Tropical Tunas Stocks in the IOTC Area of Competence*.

7. The WPTT **NOTED** the Commission's recognition that the Kobe II strategy matrix is a useful and necessary tool for management, and requested that such a matrix shall be provided for all stock assessments by the species Working Parties, and for these to be included in the report of the SC in 2012 and all future reports.

8. The WPTT **NOTED** that participants of the Kobe III meeting made the following recommendation regarding the K2SM:

> "*Emphasizing the potential of the Kobe II Strategy Matrix (K2SM) to communicate efficiently among all stakeholders and to assist in the decision-making process according to different levels of risk, but also recognizing that substantial uncertainties still remain in the assessments, Kobe III participants recommended that the Scientific Committees and Bodies of the tRFMOs develop research activities to better quantify the uncertainty and understand how this uncertainty is reflected in the risk assessment inherent in the K2SM.*"

9. The WPTT **NOTED** the outcomes of the Sixteenth Session of the Commission, and **AGREED** to consider how best to provide the SC with the information it needs, in order to satisfy the Commission's requests, throughout the course of the meeting.

## *4.2 Review of Conservation and Management Measures relating to tropical tunas*

10. The WPTT **NOTED** paper IOTC–2012–WPTT14–05 which aimed to encourage the WPTT to review the existing Conservation and Management Measures (CMMs) relating to tropical tunas, and as necessary to

1) provide recommendations to the SC on whether modifications may be required; and 2) recommend whether other CMMs may be required.

11. The WPTT **AGREED** that it would consider proposing modifications for improvement to the existing CMMs following discussions held throughout the current WPTT meeting.

## 5. PROGRESS ON THE RECOMMENDATIONS OF WPTT13

12. The WPTT **NOTED** paper IOTC–2012–WPTT14–06 which provided an update on the progress made in implementing the recommendations from previous WPTT meetings, and also provided alternative recommendations for the consideration and potential endorsement by participants.

13. The WPTT **AGREED** to a set of revised recommendations, that are provided throughout this report and in the consolidated list of recommendations (Appendix IV), for the consideration of the SC.

14. The WPTT **NOTED** the outcomes of the Fourth Session of the IOTC Working Party on Methods (WPM04), presented by the WPM Chair, Dr. Iago Mosqueira, in particular the following:

    - *The WPM **NOTED** with concern that the interim limit reference points (LRP) contained in IOTC Recommendation 12/14 may not be precautionary (see IOTC Resolution 12/01), or consistent with the FAO Code of Conduct for Responsible Fisheries. The fishing mortality rate which generates MSY should be regarded as a minimum standard for LRP. Thus, the WPM **AGREED** to analyse the robustness of TRPs and LRPs as outlined in the workplan.* (para. 22 of the WPM04 report)
    - *The WPM **AGREED** that management objectives should explicitly state the goals for the fishery, and that some of these objectives are likely to conflict with one another (e.g. maximising total allowable catch (TAC) versus minimising the risk of low population levels). Where possible, the Commission should be made aware of any conflicting management objectives which they agree upon so that Commissioners set priorities among objectives throughout the MSE process.* (para. 24 of the WPM04 report)
    - *The WPM **RECOMMENDED** that the SC consider the draft workplan for the development of the IOTC MSE process, provided at Appendix IV of the WPM04 report.* (para. 43 of the WPM04 report)

15. The WPTT **NOTED** that the WPM has established a web-based platform to help development of models and inter-sessional work to be carried out by IOTC scientists across various national institutions. The platform allows for all material developed (e.g. source code, documents, analyses) to be centrally stored and accessible to any interested party, who would be free to download, modify and experiment with the information. The WPM development webpage can be found at http://iotcwpm.github.com.

## 6. NEW INFORMATION ON FISHERIES AND ASSOCIATED ENVIRONMENTAL DATA RELATING TO TROPICAL TUNAS

### *Satellite derived oceanographic parameters*

16. The WPTT **NOTED** paper IOTC–2012–WPTT14–08 Rev_1 which provided an outline of how to predict thermal structure of the ocean using satellite data to locate hooking depths of tuna longlines in the north east Indian Ocean, including the following abstract provided by the authors:

    > "*Ocean environmental parameters such as sea surface temperature, chlorophyll and sea surface height derived from remote sensing satellites were analyzed with yellowfin (T. albacores) catches. Fishery data from Sri Lankan long-liners in the northeast part of the Indian Ocean were used. The results have shown that the relationship between yellowfin catch rates and oceanographic parameters are significant. These relationships have been used to predict fishable aggregations of yellowfin tuna using near-real time satellite derived oceanographic parameters. Predicted fishing grounds were validated and shown encouraging results. However, the spatial variability of fishable aggregations is influenced by the thermal structure of the ocean influencing the swimming depths of yellowfin tuna. The accuracy of the tuna forecast can be enhanced by providing hooking depths by predicting vertical temperature profiles in space and time. Hence a predictive model for the vertical temperature of the ocean is developed incorporating temperature vertical profiles from Argo profiling floats, sea surface heights and sea surface temperature obtained from earth observing satellites.* – see paper for full abstract."

17. The WPTT **NOTED** that the Argo profiles may smooth the real vertical temperature structure of the water column as they drift in the water mass during their descent and ascent. The model should be assessed based on other data collected by instruments, such as Expendable BathyThermograph (XBT) probes or Conductivity, Temperature, and Depth (CTD) sensors, providing temperature profiles at a given location and often depicting finer structures.

18. The WPTT **NOTED** that the depth of the 20°C isotherm is often used to delineate the depth of thermocline. However, this is not directly applicable in the Sri Lankan LL fishery which uses a shallow gear configuration not reaching 20°C which is generally found much deeper.

***Environmental data***

19. The WPTT **NOTED** paper IOTC–2012–WPTT14–09 which provided an outline of climate and oceanographic conditions in the Indian Ocean over the period 2002–2012, including the following abstract provided by the author:

    "*In this paper, we examine the trends of climate and oceanographic conditions from various perspectives. First, the trend of climate indicators and their impact on sea surface temperature (SST) and mixed layer depth (MLD) during the past 40 years are presented. Unlike the Southern Oscillation Index (SOI), the Indian Oscillation Index (IOI) has been shifting towards more frequent negative anomalies since the early 2000s. Whether this trend is related to an increased rate of warming observed in the Indian Ocean since the early 1980s needs further investigation. Negative IOI anomalies (below -1) are associated with a deeper thermocline in the West Indian Ocean and the full development of the MLD anomaly is reached 2 months after the IOI signal. Secondly, we investigate the variability patterns during the period 2002-2012 by a principal component analysis on SST, MLD and Sea Surface Chlorophyll (SSC) anomalies. The 3 variables are highly structured in space and the most developed anomalies over the study period are associated with the 2006-2007 Niño and the 2010-2011 Niña.* – see paper for full abstract."

20. The WPTT **NOTED** the development of a La Niña event / negative dipole mode in the Indian Ocean in mid-2010, extending through to the first quarter of 2011. The situation in 2012 is a neutral El Niño–Southern Oscillation (ENSO).

21. The WPTT **NOTED** the general pattern of two synchronised temporal phases in sea surface temperature (SST) and sea surface chlorophyll (SSC), with a cool and chlorophyll-enhanced phase from 2002 to 2005 and a warm and chlorophyll-depleted phase from 2007 onwards, with 2006 being a transition year.

22. The WPTT **NOTED** that the overall depletion of SSC (range of 20 to 38%) in four areas (Somali basin, Mozambique Channel, Maldives, and west Equatorial area) may indicate less energy available for intermediate and upper trophic levels and could be a major cause driving the decrease of purse seine free-school CPUEs from 2002–06 to 2007–11, including those of the Maldives pole-and-line catches. However the relationship between variation in chlorophyll levels, or other effects of the Indian Oscillation Index (IOI), and stock numbers needs to be further investigated.

23. The WPTT **REQUESTED** that further case studies are needed to improve understanding of the link between the IOI, primary productivity and trends in nominal catch and CPUE. One potential study would be to use standardised CPUE indices, age-specific CPUEs and to explore time lags between environmental signals and population responses. In the case of Japan, IOI data is already used to inform standardisation of CPUE, however quantifying the relationship is difficult and there is often a lag of several months between changes in IOI and CPUE.

***Maldives tuna fisheries and anchored FADs***

24. The WPTT **NOTED** paper IOTC–2012–WPTT14–10 which provided an outline of the evolving Maldivian tuna fishery and its increasing dependence on the anchored FADs, including the following abstract provided by the authors:

    "*In the past 15 years Maldivian pole-and-line tuna fishery has undergone many changes. The obvious change being the fishery changing from a few species fishery (SKJ and YFT) to a multi species fishery targeting pelagic (tuna) to reef fish. The gear used has also changed from a single gear (pole-and-line) to a multi gear (pole-and-line, drift handline, bottom handline and trolling). The decrease in tuna catches in the recent years and the increase in demand for fish both in the local and international markets has prompted this change in the fishery. The decrease in tuna catch has also increased the fishing pressure at the anchored FADs. The study is based on information obtained during the 68 observation trips made by MRC staff onboard tuna fishing vessels. The study showed that more than half of the tuna catch in the Maldives are caught around anchored FADs. In addition, today nearly half the tuna fishing fleet use multiple gears and targets not only YFT and SKJ (using pole-and-line) but a number of species like large YFT, kawakawa, frigate tuna, billfish and several species of reef fish by handline and trolling.*"

25. **NOTING** the improved data collection systems being implemented by the Maldives, which includes in particular the identification of bigeye tuna in catches, the WPTT **ENCOURAGED** Maldives to continue the development of its program.

26. Noting that the Maldivian skipjack tuna catch is not separated by association type, i.e. aFAD and free schools, and therefore the proportion of skipjack tuna caught under the aFADs around the Maldives is unknown, the WPTT **RECOMMENDED** that the Maldivian data collection system is further improved in order to account for the association of the reported catch, as this could improve the standardisation of the pole-and-line CPUE.

27. The WPTT **NOTED** that the results of the survey tend to indicate that the contribution of pole-and-line and handline catches around aFADs have increased in recent years, including higher catches of bigeye tuna. In this regard, the WPTT was informed that the Maldives will be reviewing estimates of catches by gear and species in its waters and will report a new catch series to the IOTC Secretariat before the next WPTT meeting.

28. **NOTING** that bigeye tuna in the Maldives have previously been recorded as yellowfin tuna by samplers and in logbooks, the WPTT **URGED** the Maldives to make every possible effort to collect catch and length frequency samples by species, as well as to assess the likely bias introduced in the length frequency distributions available for yellowfin tuna, derived from length samples where specimens of both yellowfin tuna and bigeye tuna had previously been recorded as yellowfin tuna.

### *Optimum soak time of longline gear*

29. The WPTT **NOTED** paper IOTC–2012–WPTT14–11 Rev_2 which provided the results of a study examining optimum soak time of tuna longline gear in the Indian Ocean, including the following abstract provided by the authors:

> "*Based on the data collected in the tuna longline survey from September 2005 to December 2005 in the Indian Ocean, the calculation models of soak time for every branch line were built by two methods of hook retrieval in this study. The soak time of hook is divided into one hour interval for the quantity of hooks and the individuals of bigeye tuna (Thunnus obesus) and yellowfin tuna (Thunnus albacores), respectively. The respective catch rates (CPUEs) of bigeye tuna and yellowfin tuna in each hour interval were calculated. The results showed that (1) both CPUE of bigeye tuna and yellowfin tuna presented increasing at first and then decreasing trend along the increase of soak time; (2) the quadratic curves can be used to fit the relationships between soak time and the CPUEs of bigeye tuna, and yellowfin tuna; (3) the CPUEs of bigeye tuna and yellowfin tuna has been the highest when soak time were from 11.5 to 12.5h and from 10.5h to 11.5h, respectively. –* see paper for full abstract."

30. The WPTT **NOTED** that all sets were made during the daytime, in order to target tuna. Also, the potential effect of current shear (in the vertical plane) on the shape of the longline gear was not considered in this study.

### *I.R. Iran fisheries*

31. The WPTT **NOTED** paper IOTC–2012–WPTT14–12 Rev_1 which provided an overview of the catches of tuna and tuna-like species by Iranian fleets in Indian Ocean from 2001 to 2011, including the following abstract provided by the authors:

> "*Tuna catches covers 6 percent of the world total catch, but in Iran more than 40 percent of the country catch belongs to tuna and tuna-like species. So tuna catch in Iran has attach-importance. Because 6500 out of 12000 fishing vessel with 60000 fishers are engaged in fishing activities and as the capture fishery in Iran is handled mainly small scale, so there are variety of socio-economic and management issues. Actions carried out concerning improvements of 13th working party approvals for tropical tuna in Iran:*
>
> - *Design and duplicate of 400 logbooks for semi-industrial fishing vessels.*
> - *Training on how to fill out Logbookand other IOTC requirements to Captain and Crew of fishing vessels.*
> - *Picking up observers from fishing vessels crew and train them*
> - *Amendment and completing of AMAR software to meet IOTC & FAO demanded outputs with a suitable reporting*
> - *A guideline was Translated in Persian and disseminated among port samplers and fishers to identify bigeye tuna and yellowfin tuna.*"

32. The WPTT **NOTED** that since 2007 the area of operation of gillnet vessels and purse seiners from the I.R. Iran seems to have been reduced due to piracy activities in the western Indian Ocean.

33. The WPTT **NOTED** that Iran has provided preliminary catch, effort, and size data for 2011, by type of vessel, gear, year, month and Province. The WPTT thanked Iran for providing the statistics for 2011, noting that although the new reported data represents an improvement with respect to those from the past, the catch and effort and size data reported were not entirely as per IOTC requirements. The WPTT **ENCOURAGED** Iran to complete this information and report data as per IOTC reporting requirements (Resolution 10/02) for all previous years.

34. **NOTING** the low catches reported for industrial purse seiners flagged to Iran, in particular in recent years, and the lack of bigeye tuna in the catches of both purse seine and gillnet vessels.

35. The WPTT **URGED** the I.R. Iran to continue improving reporting from their purse seine fleet, and to report progress to the WPTT at its next meeting.

***Madagascar fisheries – data collection***

36. The WPTT **NOTED** paper IOTC–2012–WPTT14–13 which provided an outline of the data collection protocol for the national longliners at the CSP Madagascar, including the following abstract provided by the authors:

> "*Observer program exist and is operational at the CSP of Madagascar. Data bases on national longliners vessels are created at the CSP to record data. Data are provided by observers as trip reports. A pre-established canvas is filled out by each observer during his staying on board. Information permitting of the resource monitoring are collected by observers. Thus, information on catches and efforts are the most concerned and they are recorded in data base. Cover rate is around 30% of national fleets.*"

37. The WPTT **NOTED** the difficulties faced by Madagascar in ensuring adequate monitoring and sampling of its artisanal fleet and encouraged other Members of the IOTC to provide assistance and/or guidance where feasible.

***Madagascar fisheries – distribution and species composition***

38. The WPTT **NOTED** paper IOTC–2012–WPTT14–14 which provided an outline of the spatial distribution and species composition of Madagascar longline catches from 2007 to 2011, including the following abstract provided by the authors:

> "*Some national fleets are interested in longline fishing for some time. Trip reports are provided by observers of CSP during the period from 2007 to 2011, covering around 30% of fleets has been used on this analysis of the national longline catch, including the spatial distribution and species composition of the catch. Mapped from geographic coordinates, the longline fishery is currently focused in the center east of the Malagasy EEZ. However, in 2008 and 2009, the longline fishery has been present in western Madagascar EEZ. Family of Scombridae, mostly composed of Albacore yellow fin Tuna and big eye tuna, dominates the national longline catches. Along the observation period, the catch rate of tropical tunas (albacore, yellow fin Tuna and Big Eye Tuna) varies between 25 to 51% of the total catch. Albacore Tuna predominate (36%), followed by the Yellow fin tuna (32%) and last comes the Bigeye tuna (28%).*"

39. The WPTT **NOTED** that while a number of longliners flagged to Madagascar have operated in the Indian Ocean in recent years, no data has been reported to the IOTC Secretariat. The WPTT **REQUESTED** Madagascar to report this information as soon as possible, and ensure that data collected in future years is also provided to the IOTC Secretariat, noting that it is already a mandatory reporting requirement (Resolution 10/02).

***Mauritius fisheries – tropical tuna catches***

40. The WPTT **NOTED** paper IOTC–2012–WPTT14–15 Rev_1 which provided an outline of the catch of tropical tuna from licensed foreign and local vessels landed in Mauritius from 2008 to 2011, including the following abstract provided by the authors:

> "*Data on the catch of tropical tunas landed in Mauritius were obtained and compiled from logbooks submitted by licensed foreign and local longliners and purse seiners. Annual trends have shown a considerable increase in the catch of yellowfin (Thunnus albacares), skipjack (Katsuwonus pelamis) and bigeye tunas (Thunnus obesus) by purse seiners in the past four years with a total of 21 956 tonnes in 2011 compared to 3 116 tons in 2008. This is mainly attributed to a higher number of licensed purse seiners calling at the port with 10 licences issued to purse seiners in 2008 as compared to 33 issued in 2011. There were no sharp changes in the annual trends of bigeye tuna with catch levels varying between 2%-6%. The proportion of skipjack and yellowfin tuna in the total catch of purse seiners has changed over the years (2008-2011) such that in 2008, the most significant catches comprised skipjack tuna representing 73 % of the total catch followed by yellowfin tuna (25%) while in 2011, the catch levels of skipjack (49%) and yellowfin tuna (46%) were nearly the same.* – see paper for full abstract."

41. **NOTING** that the catches of some of the foreign vessels landing catch in Mauritius are not being reported from the flag countries, in particular tuna longliners flagged to Indonesia, the WPTT **REMINDED** Indonesia that it is a mandatory IOTC requirement that it monitors its fleet and reports catch and effort data to the IOTC Secretariat.

42. **NOTING** that Mauritius has plans to add four industrial tuna purse seiners to its fleet operating within the IOTC area of competence, the WPTT **ENCOURAGED** Mauritius to make the necessary arrangements to collect and report data on the activities of these vessels, as per IOTC requirements.

***Thailand fisheries***

43. The WPTT **NOTED** paper IOTC–2012–WPTT14–16 Rev_1 which provided an outline of tropical tuna catches from foreign fleets unloading in Phuket, Thailand during 1995–2011, including the following abstract provided by the authors:

> "*Two types of foreign tuna fleets have unloaded in Phuket, Thailand since 1995 to present, namely surface tuna longliner and tuna purse seiner. Surface tuna longline caught the mainly as yellowfin tuna, bigeye tuna, miscellaneous species and billfish, which the proportion were 63, 21, 7 and 5% of total landing during 1995 to 2011. The main fishing ground was in the north-east Indian Ocean. In 2011, the total landing of yellowfin tuna, miscellaneous species, bigeye tuna and bill fish were 3,810, 1,135, 507 and 66 mts. Taking in to account of the percentage of main target species, yellowfin tuna fluctuated during 1995 to 2002 with the peak of 80.8% of total landing in 1998, while the percentage of bigeye tuna fluctuated opposite with yellowfin tuna during 1995 to 2002 with the peak of 49.7% of total landing in 2002, after then, it continued downward trend to 11.8% of total landing in 2007, increased to 22.9% in 2008 and decreased lowest to 4% in 2010.* – see paper for full abstract."

44. The WPTT **THANKED** Mauritius and Thailand for the provision of data on the activities of foreign vessels based in their ports, and **ENCOURAGED** them to continue providing these valuable datasets in the future.

***Japanese fisheries***

45. The WPTT **NOTED** paper IOTC–2012–WPTT14–17 Rev_1 which provided a review of Japanese fisheries and tropical tuna catch in the Indian Ocean, including the following abstract provided by the authors:

> "*Introduction on the fishing efforts, tropical tuna catch, CPUE and body size was summarized for Japanese longline and purse seine fisheries operating in the Indian Ocean including recent trends. Japanese longline vessels have been targeting bigeye and yellowfin tunas along with albacore and southern bluefin tuna. The fishing effort for longline fishery fluctuated and has been sharply decreasing in recent years probably due to effect of piracy. Both bigeye and yellowfin tuna catch peaked in 1968, sharply decreased in 1970s especially as for yellowfin tuna, fluctuated after that, and is decreasing in recent years. In the early period, the effort was deployed mainly in the tropical area, and then expanded to the south. Fishing effort in the northwestern part (around Somalia) sharply decreased after 2009 due to pirates activities. Both bigeye and yellowfin tunas are main component of the catch especially during late 1980s and 1990s. High CPUE for bigeye and yellowfin tuna was observed mainly in the eastern and western Indian Ocean, respectively.* – see paper for full abstract."

46. The WPTT **NOTED** that the data presented, in terms of the numbers of yellowfin tuna and bigeye tuna measured on longliners flagged to Japan, include only fish length measurements, not weights, and that measurements taken by scientific observers were not included. The WPTT **REQUESTED** that Japan present all available information to the next WPTT meeting (i.e. including the data collected by scientific observers).

47. The WPTT **NOTED** that size frequency samples collected on longliners from Japan come from different fishing platforms, including samples collected on training vessels and samples collected from the commercial fishery, by fishers and scientific observers. In the western Pacific Ocean area, the use of length samples collected on training vessels and commercial vessels may introduce a bias, as the length distributions derived from samples collected on training vessels proved to be different from those derived from commercial vessels. For this reason, the WPTT **REMINDED** Japan of the need to provide separate series of size frequency samples, by type of sampler and sampling platform, and assess which dataset(s) are representative of Japan's longline fishery.

***Seychelles fisheries***

48. The WPTT **NOTED** paper IOTC–2012–WPTT14–18 Rev_1 which provided a preliminary analysis of Seychelles fishing activities by purse seiners fishing in the western Indian Ocean over the period January to June 2012, including the following abstract provided by the authors:

> "*The goal of this paper is to analyze the catches and CPUE of the Purse seine fleet active in the western Indian Ocean during the first 6 months of 2012 and to compare these results with the same parameters observed during the same period of previous years. The paper also analyses the fishing zones exploited during the first six months of 2012, in comparison with the same period of the previous year. It is anticipated that the findings from the most recent fishery data, be incorporate in the discussion of the Stock Assessment results. The analyses show that the fleet is progressively returning to their traditional fishing grounds, after moving eastwards of exploited zones in 2009. Slight increases in catches were recorded in the Seychelles Zones, particularly in the SE of the Seychelles. The NW of the Seychelles is considered as an area where large yellowfin tuna are caught in great quantities each year during the 1st quarter (spawning strata).* – see paper for full abstract."

49. The WPTT **NOTED** that while catch rates of industrial purse seiners on free-schools of yellowfin tuna had been higher during the first semester of 2012, the catch rates in FAD fisheries are lower than in previous years.

***EU,Spain purse seine fishery***

50. The WPTT **NOTED** paper IOTC–2012–WPTT14–19 which provided statistics of the EU,Spain purse seine fleet in the Indian Ocean from 1990 to 2011, including the following abstract provided by the authors:

> "*This document presents summary statistics of the purse seiner Spanish fleet fishing in the Indian Ocean from 1990 to 2011. Data include catch and effort statistics as well as some fishery index by species and fishing mode. Information about the sampling scheme and the coverage of sampling, together with maps and diagrams representing the fishing pattern of this fleet by time and area strata is also included.*"

***EU,France purse seine fishery***

51. The WPTT **NOTED** paper IOTC–2012–WPTT14–20 Rev_1 which provided statistics of the EU,France purse seine fishing fleet targeting tropical tunas in the Indian Ocean from 1981 to 2011, including the following abstract provided by the authors:

> "*In 2011, the French purse seine fishing fleet of the Indian Ocean was composed of 8 large size vessels that represented a total carrying capacity of about 8,000 t. Catches reached a total of 43,000 t and were composed of 50%, 42%, and 8% of yellowfin, skipjack, and bigeye, respectively. After a period of increase during 2006-2008, the fishing effort of the fleet has been decreasing to reach a minimum of 1,800 searching days in 2011. The decrease in effort was associated with a contraction of the fleet fishing grounds in the recent years and mainly characterized by a strong decrease in the number of sets made on free-swimming schools; a total of 1,800 fishing sets being made in 2011 compared to about 4,200 y−1 in the mid-2000s. Hence, the percentage of sets made on FAD-associated schools steadily increased since 2004 to reach more than 65% in 2010-2011, FAD-fishing resulting in 75% of the total catch of the French purse seine fishing fleet in 2011.* – see paper for full abstract."

***France(OT) purse seine fishery***

52. The WPTT **NOTED** paper IOTC–2012–WPTT14–21 Rev_1 which provided statistics of the purse seine fleet of the French overseas territories targeting tropical tunas in the Indian Ocean from 2001 to 2011, including the following abstract provided by the authors:

> "*In 2011, the purse seine fleet of France's Overseas Territories operating in the Indian Ocean was composed of 5 large size purse seiners that represented a total carrying capacity of more than 5,000 t. Catches reached a total of 26,000 t and were composed of 50%, 42%, and 8% of yellowfin, skipjack, and bigeye, respectively. With the progressive arrival of new purse seiners, the fishing effort of the fleet has steadily increased since 2006 to reach more than 1,000 searching days in 2011. The increase in effort was associated with an expansion of the fleet fishing grounds in the recent years. Fishing sets increased from about 100 in 2006 to more than 1,100 in 2011, with 60% of the sets made on FAD-associated schools and 40% on free-swimming schools. In relation with the high success of sets on FAD-associated schools, the proportion of catch from FAD-fishing increased from 60% in 2007 to more than 70% in 2010-2011. Species-specific catch rates (in t per searching day) do not reveal any clear trend over the short period 2007-2011 but suggest an increase in catch rates of small yellowfin on FAD-associated schools.*"

***European Union purse seine fishery***

53. The WPTT **NOTED** paper IOTC–2012–WPTT14–22 Rev_1 which provided statistics of the European purse seine fishing fleet and associated flags targeting tropical tunas in the Indian Ocean from 1981 to 2011, including the following abstract provided by the authors:

> "*In 2011, the European and associated flags purse seine fishing fleet of the Indian Ocean was composed of 34 vessels of individual carrying capacity > 800 t, which all represented a total carrying capacity of about 45,000 t. The total cumulated nominal effort was of more than 9,500 and 7,700 fishing and searching days, respectively. The total number of fishing sets was less than 10,000 with more than 70% realised on FAD-associated schools. Total fishery catches were of about 260,000 t and composed of 42%, 49%, and 8% of yellowfin, skipjack, and bigeye, respectively. Albacore and neritic tunas represented less than 0.5% of the purse seine catch. Sets on FAD-associated schools have a high level of success (i.e. 94% vs. 55% for free-swimming schools (FSC) in 2011), and resulted in 80% of the total catch. Catch rates expressed in tonnes per searching day were high in 2010-2011 for FAD-associated schools (i.e. > 15 t d−1 for skipjack and close to 10 t d−1) while rates for FSC appeared rather low (i.e. 4.5 t d−1 for yellowfin) and stable during 2009-2011.* – see paper for full abstract."

54. The WPTT **NOTED** the sharp decline in the proportion of free-school sets in 2010 and 2011 which may have been due to a number of factors, including a decline in the volume of free-schools of yellowfin tuna in the available area, or a possible declining trend in primary productivity, and different fleet behaviours during recent years.

55. The WPTT **NOTED** that there has been a large increase in the individual size and capacity of the EU purse seine fleet operating in the Indian Ocean over the last 30 years.

56. The WPTT **NOTED** that there has been a strong decrease in the mean weight of skipjack tuna caught from free-swimming schools in recent years.

57. The WPTT **NOTED** that logbook data of the EU purse seine fleet has confirmed the change in the fleet strategy identified at the previous WPTT meeting, with a major reduction in catch on the free swimming schools to FAD-associated schools, with 82% of the total catch being taken in association with FADs in 2010–11 in comparison to 65% over the period 2004–09.

### *Growth estimates for tropical tuna*

58. The WPTT **NOTED** paper IOTC–2012–WPTT14–23 Rev_1 which provided updated growth estimates for skipjack tuna, yellowfin tuna and bigeye tuna in the Indian Ocean using the most recent tag-recapture and otolith data, including the following abstract provided by the authors:

> "*Results from fitting multi-stanza parametric growth models to the most recent mark-recapture data from yellowfin (Thunnus albacares), bigeye (T. obesus) and skipjack (Katsuwonus pelamis) tuna in the Indian Ocean are presented. The models were fit using a maximum likelihood method that models the joint density of release and recapture lengths as a function of age by treating age at tagging as a random variable. The method allows for individual variability in growth by modelling the asymptotic length parameter as a random effect. This method was first applied to the Indian Ocean tagging data from all three species in 2008 (Eveson & Million 2008a,b), and updated for skipjack in 2011 (Eveson 2011). Otolith readings data were also integrated into the models for yellowfin and bigeye since a preliminary investigation of the otolith readings from tag-recaptured fish that were injected with oxytetracycline (OTC) at the time of tagging suggests that daily rings are formed in the otoliths of these species; this does not appear to be the case for skipjack.* – see paper for full abstract."

59. The WPTT **NOTED** that more data regarding growth of all three tropical tuna species are available since these growth models were last fitted (2008 for bigeye tuna and yellowfin tuna; 2011 for skipjack tuna). The updated results continue to support two-stanza (VB log k) growth for bigeye tuna and yellowfin tuna, with similar parameter estimates as before. However, for skipjack tuna the updated data (particularly the new information on small fish) suggest that a two-stanza (VB log k) growth model rather than a VB model, is appropriate for skipjack tuna as well, and that initial growth is very fast (up to ~age 1).

60. The WPTT **NOTED** that the otolith data for yellowfin tuna at the youngest ages are not consistent with the tag-recapture data, and the variability in length-at-age for these otoliths is very small compared to that for the older otolith samples. The otoliths for these young fish were sampled from a different location (i.e. in Indonesia during the Western Sumatra Tuna Tagging Project) than the other otoliths, which were collected opportunistically throughout the Indian Ocean. Due to these issues with the otolith data, the WPTT **NOTED** that the models for yellowfin tuna that weight the otolith data highly in order to fit these data better may not be appropriate.

61. The WPTT **NOTED** that otolith data for bigeye tuna are highly variable and only cover a relatively small length range, so they do not provide a lot of information on growth; however, the data available appear consistent with the tagging data for bigeye tuna.

62. The WPTT **NOTED** that the mean asymptotic length (Linf) may have been too small (145 cm) for yellowfin tuna. The result obtain may have been an artefact of the small number of fish sampled over the estimated values of Linf (1% to 4% for Linf 150 cm to 140 cm). The WPTT further **NOTED** that the results to be presented at the Indian Ocean Tuna Tagging Symposium, using the Powell method, suggest that the estimated Linf of yellowfin tuna could be between 150 and 160 cm.

### *Hierarchical Bayesian integrated model*

63. The WPTT **NOTED** paper IOTC–2012–WPTT14–24 Rev_1 which provided a *hierarchical Bayesian integrated model incorporated direct ageing, mark-recapture and length-frequency data for yellowfin (Thunnus albacares) and bigeye (Thunnus obesus) of the Indian Ocean*, including the following abstract provided by the authors:

> "*Despite several studies conducted in the 3 oceans, the shape and parameterization of yellowfin and bigeye growth curves are still open to debate. In this study, we present an integrated growth model that combines mark-recapture and direct ageing data from saggital otoliths collected through the Indian*

> *Ocean Tuna Tagging Program (RTTP-IO) and the West Sumatra Tuna Tagging Project (WSTTP) as well as length-frequency data sampled from the European purse seine fishery over the last decade. Developed in a Bayesian framework, the model accounts for uncertainty in age estimates and includes ancillary information derived from expert judgment on otolith reading as well as from data on sex and observed maximum size of fish individuals. Our results confirm the existence of 2 stanzas for the growth of yellowfin and bigeye during exploitation phase.*"

64. The WPTT **NOTED** the results presented were generally consistent with other growth studies for yellowfin tuna in the Indian Ocean.

***Comparison of CPUE calculation methods for longline gear***

65. The WPTT **NOTED** paper IOTC–2012–WPTT14–42 Rev_2 which provided a comparison of two CPUE calculation method of longline fishing, including the following abstract provided by the authors:

> "*The soak time of fishing gear influences the fishing efficiency, the catch rates (CPUE) and fishing mortality of target species in longline fishing. Based on the data collected in the tuna longline survey from September 2005 to December 2005 in Indian Ocean, the soak time calculation models of every branch line in each operation were built by both modes of hook retrieval. The fishing effort was calculated by soak time (10000 hours) and by the conventional number of hooks (1000 hooks). The respective CPUE of bigeye tuna (Thunnus obesus) for the entire water column and each water layer of each survey site were calculated, and the t-test was applied to test the significant differences between two CPUE calculation methods. The results showed that (1) Except to no. 1 and no. 25 hook, the total soak time of the different hook no. fluctuated in a small range at every operations (about 10h); (2) The soak time model can be used to estimate the soak time of each hook accurately. It is suggested that the soak time of fishing gear can be used for CPUE standardisation.* – see paper for full abstract"

66. The WPTT **NOTED** that information on the times of setting and hauling of longlines is not available for a long time series from some CPCs, and that this limits the implementation of the approach proposed on longline fleets.

***Other information***

67. The WPTT **NOTED** the other information papers provided to the meeting, as detailed in IOTC–2012–WPTT14–02 and thanked the contributors for the information.

68. The WPTT **RECOMMENDED** that Japan and Taiwan,China review catch, effort and size frequency datasets in order to assess reasons for discrepancies identified by the IOTC Secretariat and to report results at the next meeting of the WPTT, including a comparison of length frequency data samples collected from commercial and research and training vessels.

69. **NOTING** that to date, no catch or effort information has been received from the Yemen since 2009, the WPTT **REQUESTED** that Yemen collect and report statistics on their coastal fisheries and provide the information to the IOTC Secretariat.

# 7. BIGEYE TUNA – REVIEW OF NEW INFORMATION ON STOCK STATUS

## *7.1 Review of the statistical data available for bigeye tuna*

70. The WPTT **NOTED** paper IOTC–2012–WPTT14–07 Rev_1 which summarised the standing of a range of data and statistics received by the IOTC Secretariat for bigeye tuna, in accordance with IOTC Resolution 10/02 *Mandatory statistical requirements for IOTC Members and Cooperating non-Contracting Parties (CPC's)*, for the period 1950–2011. Statistics for 2012 were not covered in the paper as preliminary catches for the previous year are usually reported later during the following year (June–October). The paper also provided a range of fishery indicators, including catch and effort trends, for fisheries catching bigeye tuna in the IOTC area of competence. It covers data on nominal catches, catch-and-effort, and size-frequency. A summary of the supporting information for the WPTT is provided in Appendix V.

71. The WPTT **NOTED** the importance of presenting the information of catch at size when reviewing the fishery statistics of each species. Fig. 1 shows the plot of catch at size for bigeye tuna by gear from 1970 to 2011, and for the sake of clarity of the plots, the WPTT **REQUESTED** that alternative ways of presenting this information be developed.

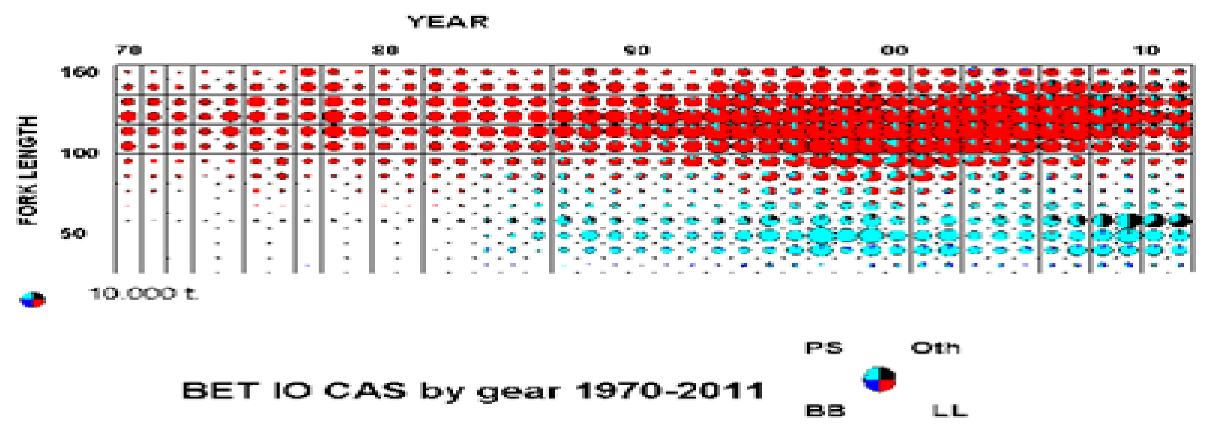

**Fig. 1.** Bigeye tuna: Catch at size by gear from 1970 to 2011.

72. The WPTT **NOTED** that 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) (Fig. 2). Repeated in Appendix V.

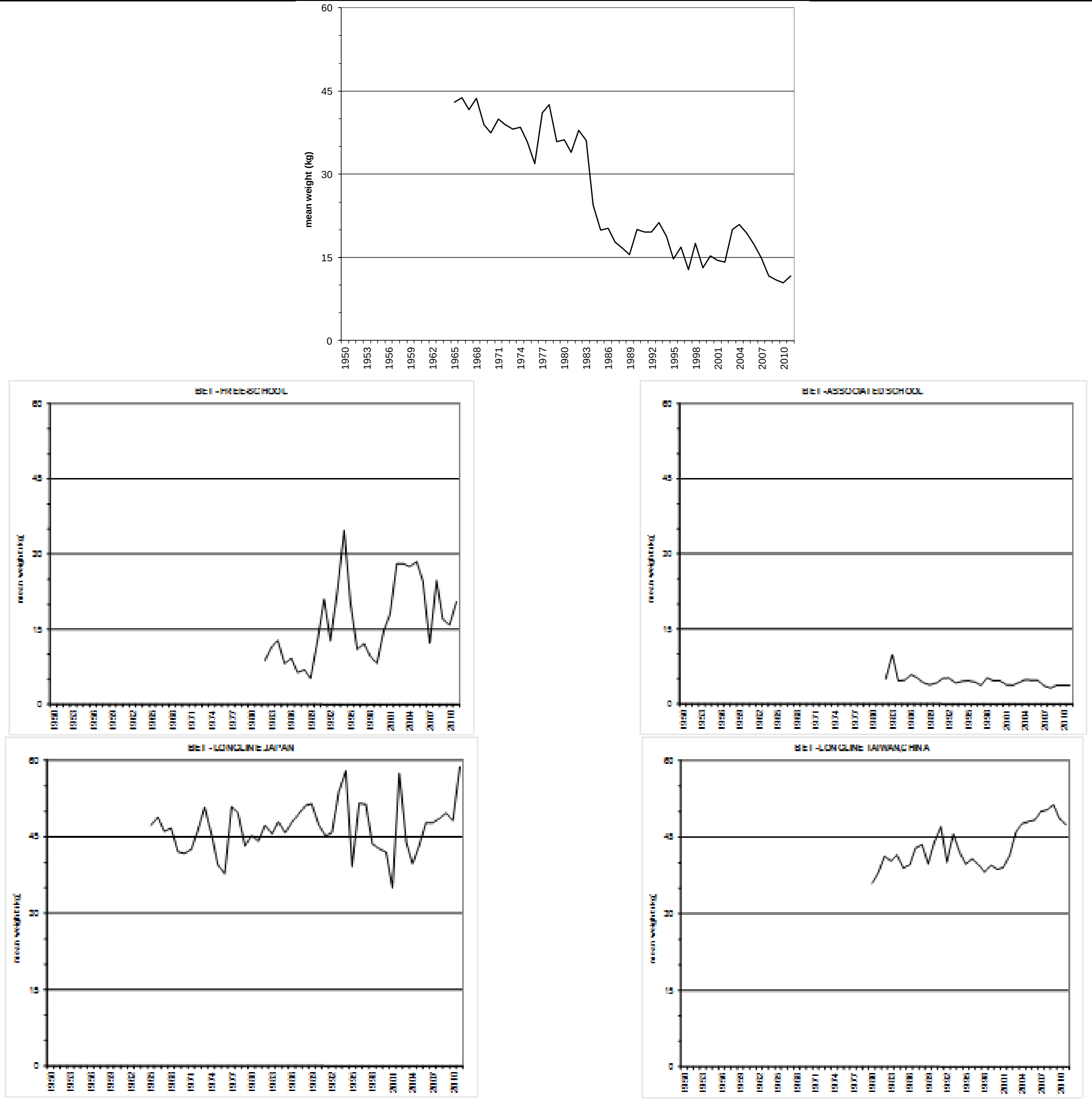

**Fig. 2.** Bigeye tuna: Changes in average weight (kg) of bigeye tuna from 1950 to 2010 – all fisheries combined (top) and by main fleet (Data as of September 2012).

73. The WPTT **NOTED** the main tropical tuna data issues that are considered to negatively affect the quality of the statistics available at the IOTC Secretariat, by type of dataset and fishery, which are provided in Appendix VI, and **RECOMMENDED** that the CPCs listed in the Appendix, make efforts to remedy the data issues identified and to report back to the WPTT at its next meeting.

74. The WPTT **NOTED** issues on the accuracy of total catch estimates related to the capture of juvenile bigeye tuna. In the case of I.R. Iran and the Maldives coastal fisheries, juveniles often account for a substantial proportion of the total catch but are either not reported or assigned to an 'Other' species category. The WPTT **REQUESTS** CPCs catching large numbers of juvenile bigeye tuna improve the enumeration and classification of this species to improve the quality of total catch estimates.

75. The WPTT **NOTED** that tagged bigeye tuna recovered by the longline fleets show that adult fish are undertaking frequent large scale north-south movements, often reaching latitudes as far south as 40°S and sometimes to the Atlantic Ocean. These apparent movement patterns are more pronounced for bigeye tuna than the ones observed for yellowfin tuna (see paper IOTC–2012–WPTT14–INF12).

### *7.2 Review new information on the biology, ecology, stock structure, their fisheries and associated environmental data for bigeye tuna*

76. No items were discussed under this item in 2012, although these issues were covered in the general revision of information of agenda item 6.

### *7.3 Data for input into stock assessments*

***Republic of Korea – Catch-per-unit-of-effort (CPUE)***

77. The WPTT **NOTED** paper IOTC–2012–WPTT14–25 Rev_1 which provided a CPUE standardisation for bigeye tuna caught by Korean tuna longline fisheries in the Indian Ocean from 1978 to 2011, including the following abstract provided by the authors:

> "*CPUE (catch per unit effort) standardization for bigeye tuna of Korean longline fisheries in the Indian Ocean was conducted by GLM using fisheries data (1978-2011), i.e., catch (number of fishes), effort (number of hooks) and number of hooks between floats (HBF) by year, month and 5°× 5° (Lat. and Long.) area. The standardized CPUE was about 10 in 1978, but since then it had showed the declining trend until the early of 2000s except one jump in 1996, and showed a steady trend with a level of 2-3 in recent years.*"

78. The WPTT **NOTED** the similar trend between the CPUE series from the Rep. of Korea and Japan longline fleets and **ENCOURAGED** further investigation and use of CPUE data from the Rep. of Korea in the future.

79. The WPTT **NOTED** that area definition for CPUE standardisation would be separated based on the biology and fisheries for bigeye tuna, which is likely to more accurately reflect actual catch.

***Japan – Catch-per-unit-of-effort (CPUE)***

80. The WPTT **NOTED** paper IOTC–2012–WPTT14–26 Rev_1 which provided an updated Japanese longline CPUE for bigeye tuna in the Indian Ocean standardized by GLM, including the following abstract provided by the authors:

> "*Standardized Japanese longline CPUE for bigeye tuna was updated from 1960 up to 2011 by using GLM (CPUE log normal error structured model). Method of standardization was as same as that used for bigeye assessment in 2011. NHF (number of hooks between float) and material of main line were applied to standardize the change in catchability of longline gear. The standardized CPUEs of three regions were almost identical with the indices of the last assessment (2011). In the tropical Indian Ocean, CPUE slightly decreased from around 9.5 (real scale) in 1960 to 6.5 in 1976. It suddenly jumped up to around 12 in 1977 and 1978 and then it was declined and stable to around 1990 with some fluctuation, after that it had continuously decreased to 3.2 in 2002. It was 4.8 in 2011, which is larger than those of the last decade (3.2 – 4.7). The standardized CPUE in the south region also increased (8.3) in 1977 and then showed slightly decreasing trend.* – see paper for full abstract."

81. The WPTT **NOTED** that the standardised CPUE of the previous assessment in 2011 and in this study were almost identical in the tropical, the south region and the whole Indian Ocean areas. Standardised CPUE series in 2010 were higher than in 2011 in the three regions, however the number of hooks deployed by the Japanese longline fleet in 2011 was very small, approximately 5% and 60% of the levels in 2007 in the tropical and south regions, respectively, considered to be a result of piracy off the Somalia coastline. The low and unusual distribution of effort should be considered with caution when interpreting of the results of the CPUE standardisation in 2011.

82. The WPTT **NOTED** that Japanese scientists presented a thorough analysis of the 1970–1980 period during which the use of deep longlines targeting bigeye tuna became the standard in the Japanese fleet. However, all

standardised Japanese CPUEs still show a sharp increase during this period, and it appears unlikely that this increase, could correspond to a simultaneous, rapid increase of the biomass of the population.

83. The WPTT **NOTED** that the standardised and nominal CPUE series showed large differences, which was also observed in the 2011 analysis. Historical changes in species composition and gear-setting for the Japanese longline fleet since 1960 was summarised in an attempt to determine reasons for the differences. A stepwise illustration of the factors influencing the divergent trends was undertaken by comparing the year-effect between the final selected model and the modified model, which excluded each explanatory variable from the final selected model. A large part of the divergence was explained by the introduction of the number of hooks between floats (NHBF) and the material of mainline as explanatory variables.

84. The WPTT **NOTED** that plots of the standardised residuals against the predicted values are appropriate for diagnosis to see if there are any biases in model fitting and heterogeneities in error variance.

***Taiwan,China – Catch-per-unit-of-effort (CPUE)***

85. The WPTT **NOTED** paper IOTC–2012–WPTT14–27 Rev_1 which provided a CPUE standardisations for bigeye tuna caught by Taiwanese [Taiwan,China] longline fishery in the Indian Ocean using generalized linear model, including the following abstract provided by the authors:

> "*Quarterly and annual Taiwanese longline CPUEs for bigeye tuna in the tropical and whole Indian Ocean were standardized up to 2011 by GLM. Sensitivity analysis showed various proxies for targeting had no significant impact on the stability of CPUE series. The trend of standardized CPUE for whole Indian Ocean was similar to that of the tropical Indian Ocean. Standardized CPUE series showed a relatively stable trend over the period from 1979 to 2011. However, it is noted that the CPUE series for the whole Indian Ocean showed a decline trend after 2004 to 2009, and then started to increase in recent two years.*"

86. The WPTT **NOTED** that the CPUE series for the Taiwan,China longline fleet conflicts with the declining trends of the Japanese and Rep. of Korea series, except for the most recent years. It was **AGREED** that the recent decline in the Taiwan,China CPUE series and the divergence between nominal and standardised series was thought to be due to changes in targeting and in the spatial distribution of effort, likely related to piracy activities in the northwest Indian Ocean.

87. The WPTT **NOTED** the discrepancy between the CPUE trend using the catch composition of target species as a proxy for targeting and the CPUE trend using hooks per basket for swordfish species in previous work by Taiwanese authors, was not observed for the bigeye tuna CPUE trends.

88. The WPTT **NOTED** that the standardised CPUE series for bigeye tuna caught by the Taiwan,China longline fleet in the temperate region of the Indian Ocean may provide important information regarding stock status for bigeye tuna. The bigeye tuna catch by the Taiwan,China longline fishery is relatively high compared with other fisheries. It was suggested that the standardised CPUE series for the Taiwan,China bigeye tuna longline fishery in the temperate region of the Indian Ocean should be considered in future analysis of bigeye tuna.

***Bigeye tuna CPUE discussion summary***

89. The WPTT **NOTED** that the CPUE series presented at the meeting, listed below and shown in Fig. 3, would be updated for the bigeye tuna assessment in 2013, noting that the Japanese series from the tropical areas and the Indian Ocean as a whole, showed very similar trends
    - Japan data (1960–2011): Series 2 from document IOTC–2012–WPTT14–26. Whole Indian Ocean (Fig. 3).
    - Taiwan,China data (1979–2011): Series from document IOTC–2012–WPTT14–27 (Fig. 3).
    - Rep. of Korea data (1978–2011): Series from document IOTC–2012–WPTT14–25 (Fig. 3).
    - Japan data (1960–2011): Series 1 from document IOTC–2012–WPTT14–26. Tropical area of Indian Ocean (Fig. 3).

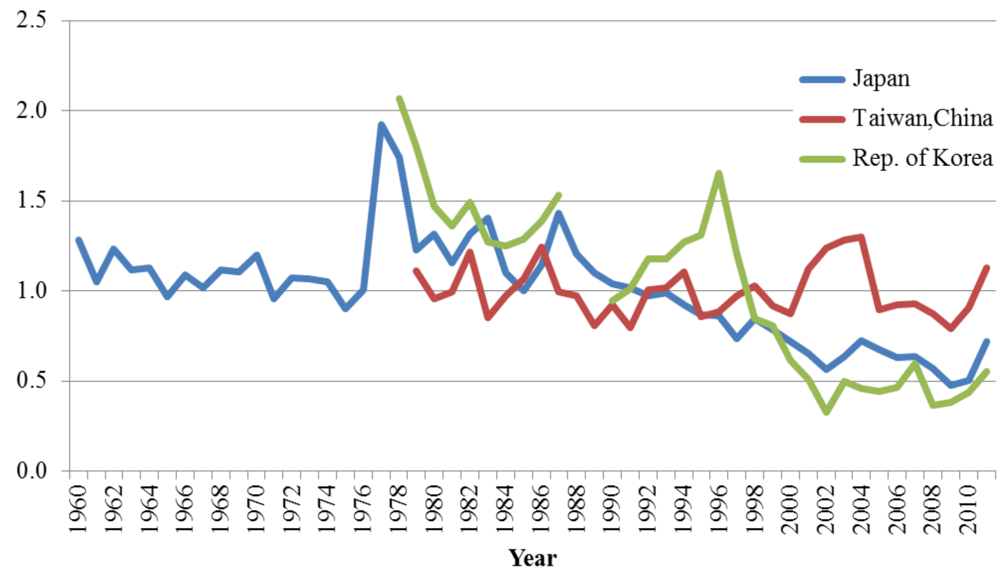

**Fig. 3.** Comparison of the three standardised CPUE series for Indian Ocean bigeye tuna. Series have been rescaled relative to their respective means from 1960–2011.

Note: levels of recent catches caught by each of the fleets during recent years are widely different. i.e. during the last 10 years an average bigeye tuna catch of 37,200 t by Taiwan,China; 11,100 t by Japan and 1,260 t by the Rep. of Korea.

### *7.4 Stock assessment updates*

90. The WPTT **NOTED** paper IOTC–2012–WPTT14–INF05 which discussed an outline for the stock assessment of bigeye tuna scheduled to be undertaken immediately following the WPTT14 meeting. The proposed structure of the stock assessment model would adopt a regional structure that was consistent with the spatial configuration of the key data sets, principally fishery catch data, tag release/recovery data and longline CPUE indices. An initial review of these data and previous assessments suggested the development of a model based on three regions encompassing the entire Indian Ocean: two equatorial regions (west and east) and a southern region.

91. The WPTT **AGREED** that the stock assessment would incorporate longline CPUE indices from the main fishing fleets. Standardised CPUE indices are available from the Japan, Rep. of Korea and Taiwan,China longline fleets. However, some of the CPUE indices reveal contradictory trends in relative abundance. It is intended to utilise the Japanese longline CPUE indices as the primary index and Japanese scientists have agreed to revise the CPUE indices in alignment with the proposed spatial structure (3 regions).

92. The WPTT **AGREED** that the assessment would incorporate a range of key sensitivity analyses identified during previous assessments and issues that emerge during the course of the analysis. The model sensitivities are likely to include the duration of the tag mixing period, natural mortality, model period, regional structure and stock-recruitment parameters.

93. The WPTT **NOTED** the intention to undertake the assessment intersessionally using an external stock assessment consultant. The consultant has undertaken to regularly consult with key parties during the development of the assessment model(s). A draft report detailing the results of the assessment will be provided to the IOTC Secretariat early in 2013 and the results will be presented at the next meeting of the WPTT.

#### *Parameters for future analyses: Bigeye tuna CPUE standardisation and stock assessments*

94. The WPTT **AGREED** that in order to obtain comparable CPUE standardisations, the analyses shall be conducted with similar parameters and resolutions in 2013, for presentation at the CPUE workshop agreed to by the SC. Table 2 provides a set of parameters, discussed during previous WPTT meetings that shall give guidelines, if available, for the standardisation of CPUE in 2013 to be used as indices of abundance for the stock assessments.

**Table 2.** Tentative set of parameters for the standardisation of CPUE series in 2013.

| CPUE standardisation parameters | Value for 2013 CPUE standardisation |
|---|---|
| Area | 3 regions<br>two equatorial regions (west and east) and a southern region |
| CE Resolution | Operational data |
| GLM Factors | Year, Quarter, Area, HBF, vessel, environmental + interactions |
| Model | negative binomial, zero-inflated or delta-lognormal models |

95. It was noted that the current time frames for data exchange do not allow enough time to conduct thorough stock assessment analyses, and this could have a detrimental effect on the quality of advice provided by the WPTT. Thus, the WPTT **RECOMMENDED** that data exchanges should be made as early as possible, but no later than 45 days prior to a working party meeting, so that CPUE analysis can be provided to the IOTC Secretariat no later than 30 days before a working party meeting.

### *7.5 Selection of Stock Status indicators*

96. No stock assessment was carried out in 2012. The most up to date CPUE trends do not give a pessimistic view of the stock which would require a more thorough stock assessment in 2012. Thus, the WPTT **AGREED** that management advice for bigeye tuna should be based on the 2010 SS3 stock assessment and various steepness scenarios of the current 2011 ASPM stock assessment results. For last year's SS3 assessment, 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 in 2010.

### *7.6 Development of technical advice on the status of bigeye tuna*

97. The WPTT **RECOMMENDED** that the SC note the draft resource stock status summary for bigeye tuna (*Thunnus obesus*) – Appendix VII.

98. The WPTT **REQUESTS** that the IOTC Secretariat update the draft stock status summary for bigeye tuna with the latest 2011 catch data, and for these to be provided to the SC as part of the draft Executive Summaries, for its consideration.

## 8. SKIPJACK TUNA– REVIEW OF NEW INFORMATION ON STOCK STATUS

### *8.1 Review of the statistical data available for skipjack tuna*

99. The WPTT **NOTED** paper IOTC–2012–WPTT14–07 Rev_1 which summarised the standing of a range of data and statistics received by the IOTC Secretariat for skipjack tuna, in accordance with IOTC Resolution 10/02 *Mandatory statistical requirements for IOTC Members and Cooperating non-Contracting Parties (CPC's)*, for the period 1950–2011. Statistics for 2012 were not covered in the paper as preliminary catches for the previous year are usually reported later during the following year (June–October). The paper also provided a range of fishery indicators, including catch and effort trends, for fisheries catching skipjack tuna in the IOTC area of competence. It covers data on nominal catches, catch-and-effort, and size-frequency. A summary of the supporting information for the WPTT is provided in Appendix V.

100. The WPTT **NOTED** that while the average weight of skipjack tuna across all fisheries have been stable over the last 20 years (at around 3 kg), it has been fluctuating according to the different gear type. Average catch weights from purse seine vessels have fallen by around 20% since 2007 with similar decrease in pole-and-line fishery of the Maldives, including noticeable decline in the proportion of large skipjack tuna; which have been offset by gillnet fleets that report increases in average weight from the mid-1990s, and also account for an increasing proportion of the total catch across all gears over the same period.

101. The WPTT **NOTED** the importance of presenting the information of catch at size when reviewing the fishery statistics of each species. Fig. 4 shows the plot of catch at size for skipjack tuna by gear from 1980 to 2011, and for the sake of clarity of the plots, the WPTT **REQUESTED** that alternative ways of presenting this information be developed.

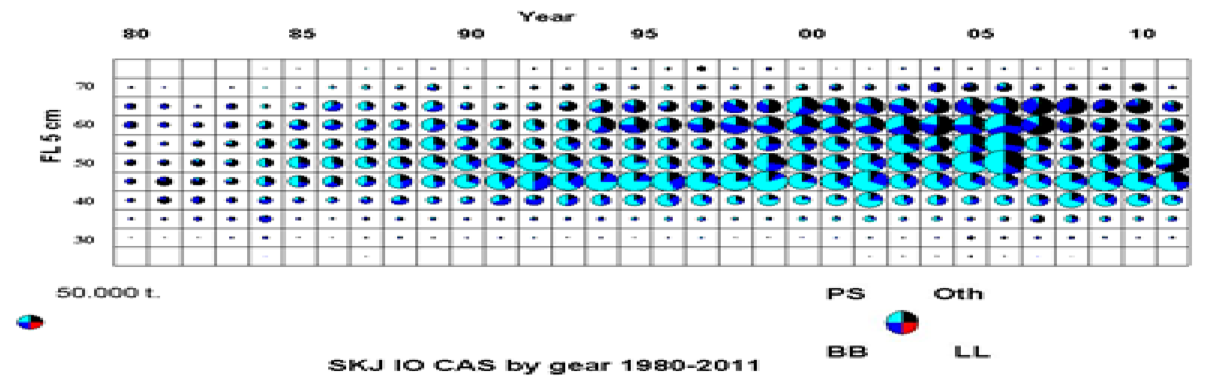

**Fig. 4.** Skipjack tuna: Catch at size by gear from 1970 to 2011.

102. The WPTT **NOTED** that 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) (Fig. 5). Repeated in Appendix V.

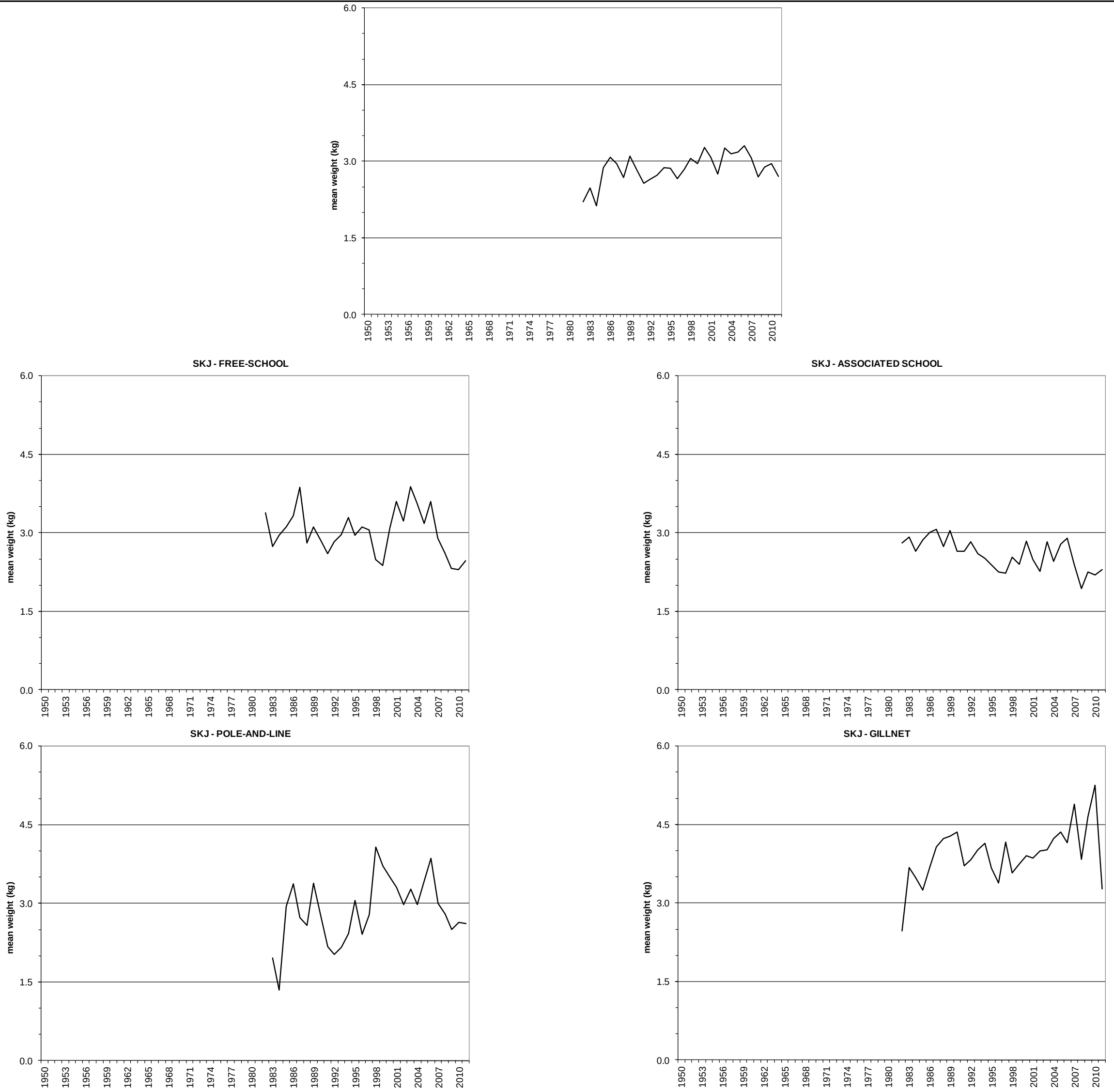

**Fig. 5.** Skipjack tuna: Changes in average weight (kg) of skipjack tuna from 1950 to 2011 – all fisheries combined (top) and by main fleet (Data as of September 2012).

### *8.2 Review new information on the biology, ecology, stock structure, their fisheries and associated environmental data for skipjack tuna*

103. No items were discussed under this item in 2012, although these issues were covered in the general revision of information of agenda item 6. As a summary, the WPTT **NOTED** that several papers were presented dealing with skipjack tuna growth and movements based on tagging studies. Those studies will be complemented with the work presented in the coming Indian Ocean tuna tagging symposium; which may improve our basic

biological knowledge of skipjack tuna to be used in future assessments. Biological knowledge acquired from tagging data is unique for this species worldwide, showing for example that the Indian Ocean skipjack tuna population is highly mobile and also showing a 2-stanza growth pattern.

## *8.3 Data for input into stock assessments*

### *Maldives – Catch-per-unit-of-effort (CPUE): challenges and opportunities*

104. The WPTT **NOTED** paper IOTC–2012–WPTT14–28 Rev_1which provided an outline of the challenges and opportunities for standardisation of Maldivian skipjack CPUE, including the following abstract provided by the authors:

> "*Standardized CPUE from commercial fishery data is the most important input for stock assessment work of The Indian Ocean Tuna Commission (IOTC). Lack of standardized CPUE for skipjack tuna has hampered progress on stock assessment of skipjack tuna. The most important and longest time series of skipjack tuna catch and effort data is from the Maldives' pole-and-line fishery. Its direct use is not helpful due to pervasive increase of fishing power and efficiency of the fishing effort over time. In the Maldives this is happening at varying degrees and in several aspects of fishing operation. The size of the vessels has been increasing from mid 1970s. From around 2000, FRP-hulled vessels replaced the traditional wooden-hulled vessel allowing further and rapid increase in size and engine horsepower. Other areas of increasing fishing efficiency are use of the anchored fish aggregating devices, changes in livebait catching and holding techniques, increased use of fish finding equipment and opportunities for disposing large volumes of catch.* – see paper for full abstract."

105. The WPTT **NOTED** the importance of having a standardised CPUE series for the Maldives pole-and-line fishery for input to the stock assessment, as this fishery has the longest time series of catch and effort data for skipjack tuna in the Indian Ocean. A standardised series from 2004–2009 was produced in 2011, however further work is required to improve the standardisation of this series before the next stock assessment.

106. The WPTT **NOTED** the improved data sets available for standardising the pole-and-line CPUE series, and **ENCOURAGED** further improvements be made in future. In this regard, the WPTT **NOTED** that a web-enabled database is being developed and should be completed in 2013 by the Maldives.

107. The WPTT **NOTED** that the data currently available for CPUE standardisation include: improved vessel logbook data; new live bait fishery logbook data; and anchored FAD (aFAD) data that are potentially informative about "hyperstability" conditions that may be caused by fishing on aFADs.

108. The WPTT **RECALLED** the following caveats with respect to the use of the skipjack tuna CPUE time series in the context of last years' (2011) stock assessment:
    - There are a number of data irregularities that do not seem to be consistent with the general perception of the fishery operations and may be a consequence of systematic reporting errors (e.g. large proportion of positive effort, zero skipjack tuna observations).
    - There are operational factors that are suspected of being important, but for which there are no data (e.g. declining bait availability, technological innovation).
    - The analysis lacks contrast, as the relatively short time period covered corresponds only to recent peak catches. Furthermore, anchored FAD fishing is thought to predominate during this period (which can be expected to cause hyper-stability in CPUE indices).
    - Even if these CPUE series are reliable indicators of abundance for the Maldives region, there are additional concerns about using them as the primary input for a regional stock assessment, because the Maldives represents a very small part of the Indian Ocean skipjack tuna range, and abundance may not be representative of the whole population.

109. The WPTT **NOTED** the large drop in the catches of skipjack tuna observed in some fisheries, primarily the Maldivian pole-and-line fishery, and **AGREED** on the need for further work to assess the reasons of the observed decline, as it was considered that the Maldivian skipjack tuna fishery had not been affected by piracy. In this regard, the WPTT **ENCOURAGED** the Maldivian scientists to carry out this work and present results to the next meeting of the WPTT.

### *European Union and related purse seiner activities*

110. The WPTT **NOTED** that, while the total number of purse seine sets on associated schools has been more or less constant in recent years, the number of sets on free-schools has decreased markedly since 2007. The WPTT also **NOTED** that since the onset of piracy in the tropical western Indian Ocean purse seiners have not operated in the same way, with more time devoted to fishing on FADs than free-schools.

***Skipjack tuna CPUE discussion summary***

111. **NOTING** that the standardised Maldivian CPUE series (2004–09) has declined from the peak of 2006, but shows no clear trend over the past few years, the WPTT **AGREED** that it is difficult to evaluate the Maldivian CPUE series as the time period is so short.

112. The WPTT **RECOMMENDED** further investigation of the existing data irregularities, and expansion of the logbook programme to improve CPUE analyses for skipjack tuna in the Indian Ocean, and for information on these matters to be presented to the next meeting of the WPTT.

113. The WPTT **NOTED** that while improvements are being made in data collection for standardising the recent and future Maldive pole-and-line CPUE series, it is unlikely that the historical series can be corrected.

114. The WPTT **NOTED** that of the CPUE series available for assessment purposes, listed below, the standardised pole-and-line series from 2004 to 2010 was used in the stock assessment model for 2012. The other two series were explored (shown in Fig. 6).
    - Maldives nominal pole and line: 1970–2003 from document IOTC–2012–WPTT14–29 Rev_1.
    - Maldives standardised pole-and-line: (2004–2009): Series1 (PL – preferred) from document IOTC–2011–WPTT13–29 and 31 and IOTC–2012–WPTT14–29 Rev_1.
    - EU,France purse seine free school data (1991–2010): Series from document IOTC–2011–WPTT13–20 and IOTC–2012–WPTT14–29 Rev_1. This series was not used in the assessment because it was not standardised and likely subject to problems as noted in the sections above.

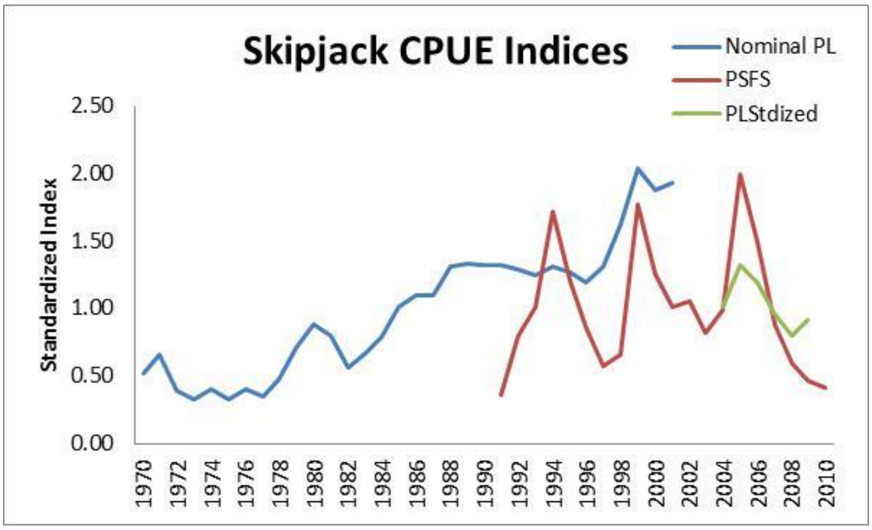

**Fig. 6.** Skipjack tuna: CPUE Indices based on different fisheries, and methods examined.

115. The WPTT **NOTED** that the EU purse seine free-school CPUE is not a good indicator of the skipjack tuna population abundance as this fishery is seasonal and mainly located in the Mozambique Channel. As such, it would not be as representative as the Maldivian pole-and-line CPUE series of the overall population abundance. Thus, the WPTT **AGREED** that a the FAD-associated school purse seine fishery should be used in future assessments which may better represent the abundance index trends of the population.

116. The WPTT **RECOMMENDED** further investigation of the existing data to produce an improved standardised CPUE series for the FAD-associated school skipjack tuna fishery in the Indian Ocean, and for information on these matters to be presented to the next meeting of the WPTT.

## *8.4 Stock assessments*

### Stock Synthesis (SS3)

117. The WPTT **NOTED** paper IOTC–2012–WPTT14–29 Rev_1 which provided an integrated stock assessment (SS3) of Indian Ocean skipjack tuna using data from 1950 to 2011, including the following summary provided by the authors:

> "*A stock assessment of the Indian Ocean skipjack tuna (Katsuwonas pelamis, SKJ) population 1950-2011 is presented. The analysis extends the assessment developed by Kolody et. al. 2011 to incorporate spatial structure in the assessment by assuming fleets fishing in different areas, i.e. the pole-and-line fleet of Maldives has an available Biomass, and the other three fisheries have another Biomass (for simplicity the other fleet was aggregated in Area 1 as no tags were used for recoveries in this fleet). Results of this*

*assessment are compared with the spatially aggregated model (Kolody et. al. 2011) and results are discussed. Key reference points and Kobe plots examining the stock trajectory over time are presented for the one and two area models.* – see paper for full abstract."

118. The WPTT **NOTED** that a key feature of the updated assessment is the comparison of a single area versus two-area model. Using a single or two-area model provides different inferences about stock status. The two area model requires estimates of movement between the two areas, for which there is little information in the data sets available, so the two area results should be considered preliminary until further work is done.

119. The WPTT **NOTED** that a two area (east/west) model was worth exploring, but questioned whether including the Maldives in the east was a reasonable approach (this was required to have enough tag recaptures in both areas to get estimates of movement). It was also considered useful to explore the Maldives fishery separately for illustrative purposes.

120. The WPTT **AGREED** that an alternative two area model be considered with the west and Maldives being the two areas (and omitting the eastern Indian Ocean); i.e. assuming no mixing of skipjack tuna in the east with the west (including the Maldives).

121. The WPTT **NOTED** that the model estimates are highly sensitive to assumptions about parameters estimated, prior choices and likelihood weightings. Sensitivity of the results to the key assumptions about natural mortality, steepness and selectivity for the different fisheries were explored. The affect of giving different weights to the CPUE data versus the length composition data (with more weight being given to the CPUE data in order to achieve better fits to these data) was also examined.

122. The WPTT **NOTED** that 12 different runs were examined that increased in complexity in terms of the numbers of parameters estimated (or in terms of the likelihood weights in the fitting procedure). The runs examined the following; i) assumed fixed natural mortality estimates, ii) estimated natural mortality rates, iii) used estimates of the Brownie estimator of natural mortality from 2011, iv) assumed a beta prior on virgin recruitment or a normal prior on virgin recruitment with different bounds, v) assumed time varying selectivity, vi) different steepness values with M fixed, or vii) steepness values with M estimated, viii) different spatial assumptions with fixed M, ix) different spatial assumptions with M estimated, x) different spatial assumptions with different selectivities estimated for the PL fleet, xi) very low weights on the length composition, and high weights on CPUE in a one area assessment, xii) intermediate weights on the length composition, and high weights on the CPUE estimates in the one area assessment.

123. The WPTT **NOTED** the CPUE abundance indices used in the assessment could not be representative of the overall abundance of the stock. However, the WPTT **ACKNOWLEDGED** the effort carried out during the assessment as they were the only standardised CPUE series available.

124. The WPTT **AGREED** that large uncertainties exist in the data inputs (the CPUE indices especially) and model assumptions, but that the biomass trajectories tend to show similar patterns (despite different absolute levels) and, in general, the results suggest the stock is not currently being overfished.

125. The WPTT **NOTED** that $F_{MSY}$ is difficult to estimate in SS3 (sensitive to many assumptions) so caution must be used in making inferences using this reference point.

126. The WPTT **NOTED** that the assessment had a strong reliance on the tagging data, so it is important to keep in mind issues with tagging data (e.g. small numbers of releases and recaptures in the east). Some investigations were undertaken to compare the SS3 results with a simple Petersen mark-recapture analysis assuming no mixing between the east and west areas, and the results showed similarities in SS3 results with the tag analysis in 2007, and 2008, but diverged in 2006 and 2009. A possible explanation for this divergence is the tag reporting rate in the Maldives fisheries, and the tag recovery rate in the purse seine fisheries.

127. **NOTING** that the assessment using the VB growth curve from last year's assessment, the WPTT **AGREED** that the assessment should be re-run with the most recent two-stanza growth curve for skipjack presented in IOTC–2012–WPTT14–23 Rev_1. This work was undertaken during the meetings, and led to higher absolute biomass estimates, higher optimal yield targets, but did not greatly affect the relative reference points.

128. The WPTT **NOTED** that the SS3 results estimate large variability in recruitment and biomass of the stock. The variability is considered to be unlikely, as the purse seine CPUE of juvenile fish being recruited in the fishery is fairly stable during the period examined.

129. The WPTT **AGREED** that a sensitivity run be conducted using a new purse seine FAD-associated school CPUE series corrected for an assumed annual increase of effort creep of 3%. This work was conducted at the meeting and the results showed a more stable recruitment and population trajectory and a much lower biomass, through relative reference points in recent years were comparative with other runs.

130. The WPTT **NOTED** that it may be possible to estimate a CPUE time series for the eastern Indian Ocean from a Japanese research vessel that has been operating in that area since the early 1970's; these data could provide very useful information for the assessment model, if they can be standardised appropriately, and should be presented at the next WPTT meeting.

131. The WPTT **NOTED** Table 3 which provides an overview of the key features of the stock assessment model used in 2012.

**Table 3.** Summary of final model features as applied to the Indian Ocean skipjack tuna resource in 2012.

| **Model feature** | **SS3** |
|---|---|
| Software availability | NMFS toolbox |
| Population spatial structure / areas | 2 |
| Number CPUE Series | 2 |
| Uses Catch-at-length | Yes |
| Uses tagging data | Yes |
| Age-structured | Yes |
| Sex-structured | No |
| Number of Fleets | 4 |
| Stochastic Recruitment | Yes |

132. The WPTT **NOTED** the key assessment results for the stock synthesis model (SS3) as shown below that averages the 2nd, 4th, 11th and 12th runs (paragraph 122 above) for the one area assessment (Tables 4 and 5 based on the 2011 assessment; Fig. 7).

**Table 4.** Key management quantities from the SS3 assessment, for the aggregate Indian Ocean.

| **Management Quantity** | **Aggregate Indian Ocean** |
|---|---|
| 2011 catch estimate | 398,240 t |
| Mean catch from 2007–2011 | 435,527 t |
| MSY (95% CI) | 478,190 t (358,900–597,500 t) |
| Data period used in assessment | 1950–2011 |
| $F_{2011}/F_{MSY}$ (95% CI) | 0.8 (0.68–0.92) |
| $B_{2011}/B_{MSY}$ | – |
| $SB_{2011}/SB_{MSY}$ (95% CI) | 1.2 (1.01–1.43) |
| $B_{2011}/B_0$ | – |
| $SB_{2011}/SB_0$ (95% CI) | 0.45 (0.25–0.65) |
| $B_{2011}/B_{1950,\ F=0}$ | – |
| $SB_{2011}/SB_{1950,\ F=0}$ | 0.45 (0.25–0.65) |

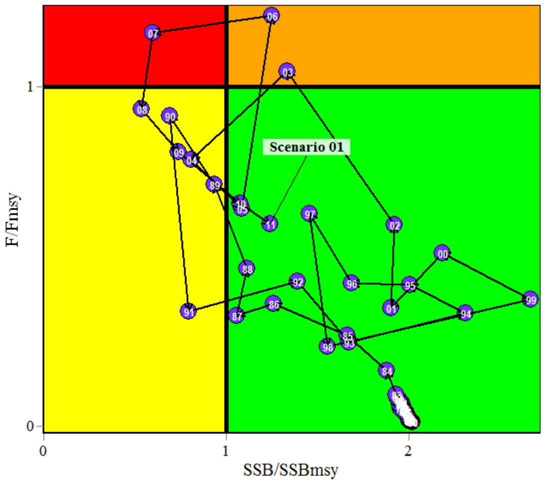

**Fig. 7.** Skipjack tuna: SS3 Indian Ocean assessment Kobe plot (mean values of the weighted models used in the analysis in 2012). Circles indicate the trajectory of the point estimates for the SB ratio and $F/F_{MSY}$ ratio for each year 1950–2011.

133. The WPTT **NOTED** that projections for this stock over a 10 year period may not be appropriate bearing in mind the large uncertainties in the outputs from the stock assessment model.

134. The WPTT **NOTED** that the update stock assessment carried out in 2012 were similar to the results gathered in 2011 which give consistency to the general perception of the stock status. Thus, it was considered not necessary to update the K2SM and, as an illustrative purpose, the 2011 K2SM is presented below in Table 5.

**Table 5.** Skipjack tuna: 2011 SS3 Aggregated Indian Ocean assessment Kobe II Strategy Matrix. Probability (percentage) of weighted distribution of models violating the MSY-based reference points for five constant catch projections (2009 catch level, ± 20% and ± 40%) projected for 3 and 10 years. Note: from the 2011 stock assessment using catch estimates at that time.

| **Reference point and projection timeframe** | **Alternative catch projections (relative to 2009) and weighted probability (%) scenarios that violate reference point** | | | | |
|---|---|---|---|---|---|
| | **60%**<br>(274,000 t) | **80%**<br>(365,000 t) | **100%**<br>(456,000 t) | **120%**<br>(547,000 t) | **140%**<br>(638,000 t) |
| $SB_{2013} < SB_{MSY}$ | <1 | 5 | 5 | 10 | 18 |
| $C_{2013} > MSY$ (proxy for $F_{2013}/F_{MSY}$) | <1 | <1 | 31 | 45 | 72 |
| $SB_{2020} < SB_{MSY}$ | <1 | 5 | 19 | 31 | 56 |
| $C_{2020} > MSY$ (proxy for $F_{2020}/F_{MSY}$) | <1 | <1 | 31 | 45 | 72 |

***Parameters for future analyses: Skipjack tuna CPUE standardisation and stock assessments***

135. The WPTT **AGREED** that in order to obtain comparable CPUE standardisations, the analyses shall be conducted with similar parameters and resolutions in 2013, for presentation at the CPUE workshop agreed to by the SC. Table 6 provides a set of parameters, discussed during the WPTT that shall give guidelines, if available, for the standardisation of CPUE in 2013 to be used as indices of abundance for the stock assessments.

**Table 6.** Skipjack tuna: A set of parameters for the standardisation of CPUE series in 2013.

| **CPUE standardisation parameters** | **Value for 2013 CPUE standardisation** |
|---|---|
| Area | *To be defined (possible eastern and western Indian Ocean.*<br>Explore core area(s) |
| CE Resolution | Operational data |
| GLM Factors | Year, Quarter, Area, HBF, vessel, environmental + interactions |
| Model | negative binomial, zero-inflated or delta-lognormal models |

136. Noting that the areas used in the various CPUE standardisations undertaken in 2012 varied, the WPTT **AGREED** that there is a need to define core area(s) for each gear (pole-and-line and purse seine) for the CPUE standardisation of skipjack tuna and **RECOMMENDED** that scientists from CPCs with pole-and-line, and purse seine fisheries for skipjack tuna, work together to explore their data and defined such core areas for each gear, well in advance of the next WPTT meeting in 2013.

137. The WPTT **NOTED** that the model parameters contained in Table 7 could be considered appropriate for applicable for future skipjack tuna stock assessments preliminary base case analysis, with appropriate sensitivity runs.

**Table 7.** Skipjack tuna: Model parameters for use in future base case stock assessment runs.

| **Biological parameters** | **Value for assessments** |
|---|---|
| Sex ratio | 1:1 |
| Age (longevity) | 8+ years |
| Natural mortality | M=0.8 (/year) constant over ages (or estimated within the model to be 1.48 age 0-1,1.13 age 1-2, 1.13 age 2-3, 0.83 for 3-4 and older) |
| Growth formula | VB log K 2-stanza growth (IOTC–2012–WPTT–23 Rev_1) |
| Weight-length allometry | $W=aL^b$ with $a= 5.32*10^{-6}$ and $b=3.4958$ common to sex |
| Maturity | Length-specific (50% mature at length 38 cms, fully mature at 44 cms) |
| Fecundity | Proportional to the spawning biomass |
| Stock-recruitment | B&H, h=0.8 (plus sensitivity e.g. 0.7 and 0.9), sigma_R=0.6 |
| **Other parameters** | |
| Fisheries | 4 (Maldives PL, Purse Seine FS, Purse Seine LS, Other) |
| Abundance indices | PSFS/PSLS combined, Maldives PL |
| Selectivity | Fishery specific. Cubic splines |

### *8.5 Selection of Stock Status indicators*

138. The WPTT **NOTED** that despite the difficulties facing the assessment of skipjack tuna in the Indian Ocean, the comparison of various fishery indicators with their historical levels may provide a basis to infer the status of the stock in the absence of traditional reference points. However, the interpretation of the fishery indicator trends should take into account several caveats and incorporate expert knowledge.

139. The WPTT **NOTED** that in general the indicators obtained for skipjack tuna in this study are partially conflicting and highly variable. The average size indicators from the purse seine fleets have dropped for both free and associated schools in recent years. In the long term, however, there does not appear to be an overall major change in mean weight. For the pole-and-line fishery, the average weight indices have also been decreasing over the last three years. However, the gillnet fishery showed an increasing trend during recent years.

140. The WPTT **NOTED** that the catch rates on associated schools are increasing for both the EU,Spain and EU,France fleets. The WPTT **AGREED** that it was difficult to interpret these results, however, it seems that the increase in catch rate is associated with a decrease in effort which could be interpreted as a positive signal. It is possible that the high catch rates for associated schools may be caused by hyperstability (i.e. the aggregating effect of the FADs is masking decreasing population numbers), which is not relevant for free schools of tuna.

141. The WPTT **AGREED** that the advice on the status of skipjack tuna in 2012 would be derived from models using an integrated statistical assessment method. Model formulations were explored to ensure that various plausible sources of uncertainty were explored and represented in the final result. In general, the data did not seem to be sufficiently informative to justify the selection of any individual model, and the results of different model runs were presented.

### *8.6 Development of technical advice on the status of skipjack tuna*

142. The WPTT **RECOMMENDED** that the SC note the draft resource stock status summary for skipjack tuna (*Katsuwonus pelamis*) – Appendix VIII.

143. The WPTT **REQUESTS** that the IOTC Secretariat update the draft stock status summary for skipjack tuna with the latest 2011 catch data, and for these to be provided to the SC as part of the draft Executive Summaries, for its consideration.

## 9. YELLOWFIN TUNA – REVIEW OF NEW INFORMATION ON STOCK STATUS

### *9.1 Review of the statistical data available for yellowfin tuna*

144. The WPTT **NOTED** paper IOTC–2012–WPTT14–07 Rev_1 which summarised the standing of a range of data and statistics received by the IOTC Secretariat for yellowfin tuna, in accordance with IOTC Resolution 10/02 *Mandatory statistical requirements for IOTC Members and Cooperating non-Contracting Parties (CPC's)*, for the period 1950–2011. Statistics for 2012 were not covered in the paper as preliminary catches for the previous year are usually reported later during the following year (June–October). The paper also provided a range of fishery indicators, including catch and effort trends, for fisheries catching yellowfin tuna in the IOTC area of

competence. It covers data on nominal catches, catch-and-effort, and size-frequency. A summary of the supporting information for the WPTT is provided in Appendix V.

145. The WPTT **NOTED** reports from Taiwan,China that longline vessels from its fleet appears to be moving back towards the central Indian Ocean in 2011, as a direct result of increased CPUE being recorded in these areas. The WPTT **AGREED** that this movement back into the area vacated due to piracy activities should be closely monitored and reported at the SC and the next WPTT meeting.

146. The WPTT **NOTED** that the proportion of catch sampled for size has declined over the last five years (from over 60% in 2006 to around 35% in 2010), which has implications on the quality of size data from 2007 onwards. Appendix VI summarises the main data quality issues in the collection of size data, and identifies low sampling rates by Japan and Taiwan,China as one of the main contributing factors to the recent decline in the quality of size data.

147. The WPTT **NOTED** a number of IOTC–OFCF capacity building activities aimed at improving the quality of size data estimates have already been agreed, including: strengthening the sampling activities in Sri Lanka (from December 2012), and a workshop on the evaluation of length frequency samples collected by the longline fisheries of Japan and Taiwan,China, postponed until later in 2013, or via correspondence.

148. The WPTT **NOTED** the importance of presenting the information of catch at size when reviewing the fishery statistics of each species. Fig. 8 shows the plot of catch at size for yellowfin tuna by gear from 1970 to 2011, and for the sake of clarity of the plots, the WPTT **REQUESTED** that alternative ways of presenting this information be developed.

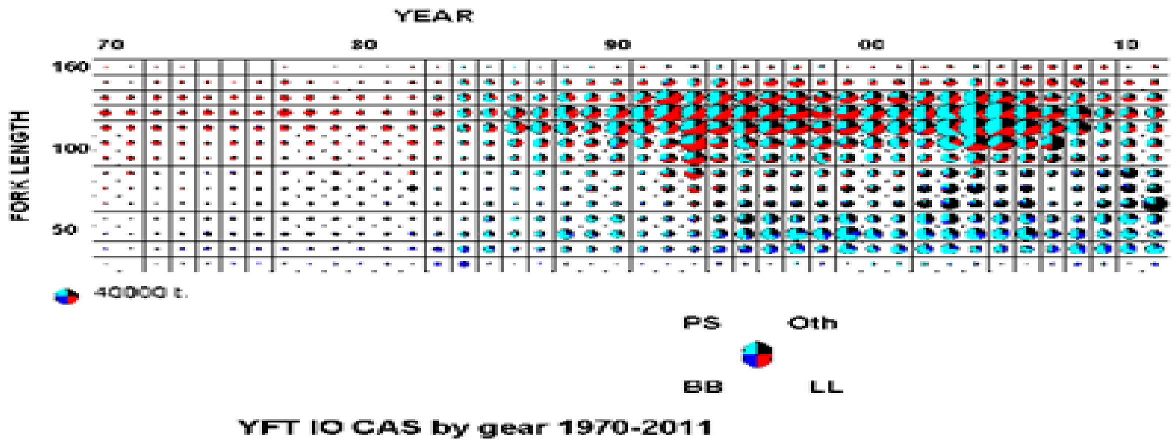

**Fig. 8.** Yellowfin tuna: Catch at size by gear from 1970 to 2011.

149. The WPTT **NOTED** that 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 (Fig. 9). Repeated in Appendix V.

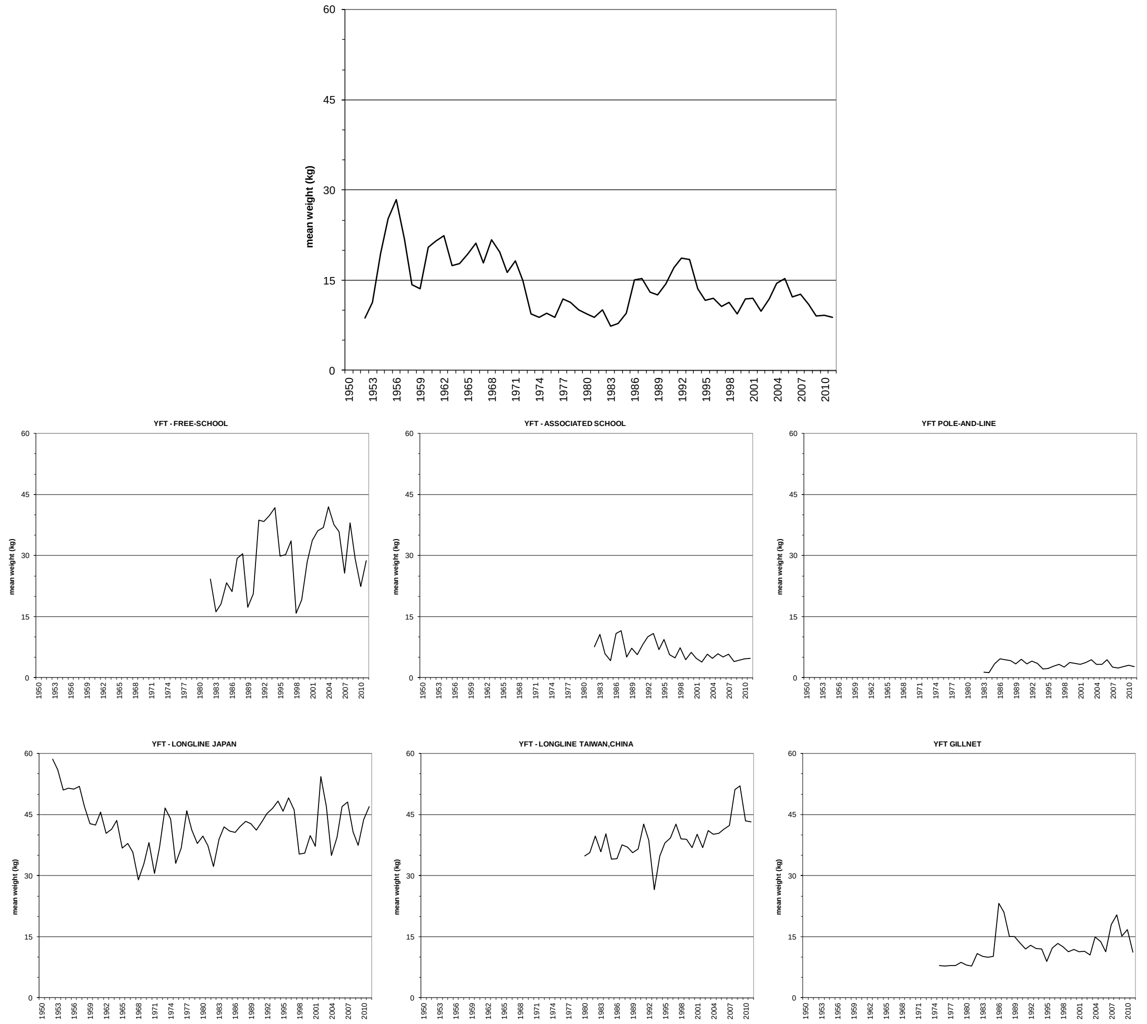

**Fig. 9.** Yellowfin tuna: Changes in average weight (kg) of yellowfin tuna from 1950 to 2011 – all fisheries combined (top) and by main fleet (Data as of September 2012).

### *9.2 Review new information on the biology, ecology, stock structure, their fisheries and associated environmental data for yellowfin tuna*

#### *Growth and population parameters in Andaman and Nicobar waters*

150. The WPTT **NOTED** paper IOTC–2012–WPTT14–30 Rev_1 which provided an outline of a study of the growth and population parameters of yellowfin tuna (*Thunnus albacares*) in the Andaman and Nicobar waters based on length frequency data, including the following abstract provided by the authors:

> "*The exploitation level of tuna is meagre to the total marine fish landings in India. The Exclusive Economic Zone(EEZ) of India around A&N islands is 30% of the Indian EEZ. Three species of oceanic tunas are commonly recorded in the Andaman and Nicobar waters. The tuna landings is only 4.2 % of the total marine fish landings in the Island groups. The growth pattern of yellowfin tuna appears to be complex in the Indian Ocean. Very limited studies are available on the growth and population parameters of yellowfin tuna in the Andaman and Nicobar waters. Hence an attempt has been made to study the growth and population parameters of yellowfin tuna in the Andaman and Nicobar waters based on the data collected by the departmental vessel M.F.V Blue Marlin in the Indian EEZ around Andaman and Nicobar during the period 2002-11.* – see paper for full abstract."

151. The WPTT **EXPRESSED** its concern about the estimate of "Potential catch" used by the authors. The assumption behind the analysis appears to be that the catch of tropical tuna species in the Andaman and Nicobar Islands' EEZ could be expanded by a factor that does not seem to be in agreement with the current status of the stock.

152. WPTT **NOTED** that the paper should examine uncertainty in the estimates over time so as to compare whether the current estimates of the growth curve estimates are statistically different from the other estimates reported in the paper.

### *Tag mixing period*

153. The WPTT **NOTED** paper IOTC–2012–WPTT14–31 which provided a method of determining an appropriate tag mixing period for the Indian Ocean yellowfin tuna stock assessment, including the following abstract provided by the authors:

> "*The inclusion of tag release/recovery data in a stock assessment model is potentially informative regarding stock size (recent biomass) and exploitation rates. However, a crucial assumption is that the tag releases are homogeneously mixed with the entire population. A spatial analysis of tag recovery rates from the yellowfin tuna catch from the purse-seine FAD fishery revealed the incomplete mixing of tagged fish in this component of the population. Conversely, the diagnostics for the free-school tag recoveries indicate a higher degree of mixing with the fished population. The paper provides recommendations for the treatment of the tagging data within the stock assessment. The paper also proposes a potential mechanism for the dispersal of tagged fish within the western Indian Ocean.*"

154. The WPTT **NOTED** that while tagged tuna rapidly move large distances from their release point, there could be mixing limitations that could have impacts on the stock assessment. These mixing limitations may come from systematic or non-systematic non-mixing, and that for the latter case, the apparent non-mixing would be more likely related to the schooling behaviour of the fish.

155. **NOTING** that based on an example presented for bigeye tuna which indicated that this work could be affected by the inclusion in the analysis the 1 ° by 1° squares with low catches, because to recapture a fish tagged a minimum catch in a given area should be occurred. Thus, the WPTT **AGREED** that this work should be revised by removing from the analysis the 1 degree squares with very low catches (e.g. less than the average level of catch needed to recapture one tagged fish during the studied period).

156. The WPTT **NOTED** that various works in relation to tag mixing will be presented during the coming Indian Ocean Tuna Tagging Symposium and, thus, the WPTT **AGREED** to revisit the tagging mixing issue during the next stock assessment, which seems crucial in the stock assessment, in the light of new information presented in the Symposium.

157. The WPTT **NOTED** that the randomness of the distribution of zero recoveries (no tags recovered in 1° square fished) should be examined in detail as zero events should be randomly distributed in a given area.

158. The WPTT **AGREED** that for the 2012 yellowfin tuna stock assessment, a mixing period of four quarters is used as in previous years, and that a sensitivity run with a mixing period of 1 and 2 quarters is carried out.

159. The WPTT **AGREED** that there appears to be no tagger bias in the tagging data, and that tag shedding rates appear to be low.

### *Tag reporting rate and tag shedding*

160. The WPTT **NOTED** that the estimation of tag reporting rates for the purse seine fishery and tag shedding rates presented in 2008 have been updated.

161. The WPTT **NOTED** a summary presentation on the analysis of tag reporting rates for fisheries other than purse seine fisheries, which were to be presented to the tagging symposium. The WPTT **NOTED** that new tag reporting rates have been estimated for all other fisheries using their fleet specific recoveries of tags, fleet specific catch-at-size, and the purse seine reporting rates that are estimated by tag seeding. Reporting rates of tags estimated for the main longline fleets (Japan, Taiwan,China and China) were very low at about 5%, while reporting rates of most artisanal fisheries were estimated to be much lower than 5%. However, it seems that the estimation of the reporting rate for the pole-and-line fishery (23%), mainly active in the Maldives, is underestimated due to the spatial heterogeneity of the fished area, and based on empirical estimates by Maldivian scientists and would probably be closer to around 80%.

## *9.3 Data for input into stock assessments*

### *Brownie-Petersen method for estimating mortality rates*

162. The WPTT **NOTED** paper IOTC–2012–WPTT14–32 Rev_1 which provided an application of the Brownie-Petersen method for estimating mortality rates and abundance to Indian Ocean yellowfin tuna tag-recapture and catch data, including the following abstract provided by the authors:

> "*The Brownie-Petersen method for estimating mortality rates and abundance was applied to yellowfin tuna (Thunnus albacores) tag-recapture data and catch data from the Indian Ocean in years 2005 to 2007. The results presented are for a model with a half-yearly time-step and a single fishery (i.e., tag returns and catches were aggregated across fisheries within each time period). Several alternative scenarios were considered and the results could vary significantly between them, particularly when*

> *different growth curves were used to age the data. However, overall, the results suggest: natural mortality between ages 0 and 1 years is high but then declines rapidly; fishing mortality rates vary significantly between years and ages, but were highest for age classes 1, 1.5 and 2 years; and abundance has declined over time. When interpreting the results, it is important to note that a large number of uncertainties exist in the data and the model assumptions, as discussed in the paper. The results presented can only be considered preliminary until some of these issues have been resolved and further sensitivity runs have been conducted*."

163. The WPTT **NOTED** that the estimates of natural mortality (M) from the analysis assumes that mixing across all areas is close to zero for ages 1.5 and older. Although some participants expressed that even though natural mortality for tunas larger than 70 cm might be low since they have few predators, a natural mortality close to zero was considered to be unreaslistic. Estimates of M from the analysis using only data from assessment area 2 and assuming no mixing with other areas (models run during the meeting) were much higher for ages 1.5 and older, but it was agreed that further investigation of mixing and other key model uncertainties, such as the most appropriate growth curve to use for ageing the data, was required before recommending a "best" M vector.

164. **NOTING** that large uncertainties were identified in the data and model assumptions presented, the WPTT **AGREED** that aspects of the analysis which could be improved include:
    - overdispersion in the tag-recapture likelihood (i.e. using Dirichlet-multinomial) to draw better information on uncertainty in the parameter estimation and also to provide a reasonable balance between two likelihood contributions from tag and catch data;
    - to add random effects to fishing mortality would reduce high variability observed in the current analysis;
    - to further investigate the choice of a half-year time-step over a quarterly time-step; and
    - to consider if the area 2 definition from the MULTIFAN-CL assessment could be modified to better represent the purse seine fishery (for example, expanded south to 15 degrees south in the Mozambique channel to include the purse seine catches in area 3).

***Purse seine CPUEs***

165. The WPTT **NOTED** paper IOTC–2012–WPTT14–33 which provided an outline of decomposing purse seine CPUEs to estimate an abundance index for yellowfin free-swimming schools in the Indian Ocean during 1981–2011, including the following abstract provided by the authors:

> "*The current stock assessment of yellowfin tuna in the Indian Ocean does not include any abundance index derived from purse seine fishing. The overall objective of the analysis was to assess whether temporal changes in yellowfin population abundance in the Indian Ocean could be related to changes in the number or/and the size of tuna schools. Three indices of catch per unit effort (CPUE) were considered for the European purse seine fleet fishing on free-swimming schools during 1981-2011 so as to decompose tuna abundance and vessel fishing power. First, the number of sets per searching day was considered to model the number of schools and the ability to detect tuna schools. Second, the proportion of successful sets was used to model the ability to succeed in the set. Third, the yellowfin catch per positive set was used as a proxy of the size of the schools and the ability to maximise the catch from the school.* – see paper for full abstract."

166. The WPTT **NOTED** that the decomposition of CPUE into multiple components assumes independence of interactions, and should work on conditionality of interactions (i.e. have a nested model to be used in an analysis).

167. **NOTING** that the relative number of sets per searching day on free-swimming and log/FAD schools has been changing over time, especially in the last years where the fleet behaviour was more focused on FADs, and **RECOGNISING** that this can affect the results of the analysis, the WPTT **AGREED** that the analysis should account for the number of sets in log/FADs in addition to the number of free should sets, which may account for the observed decreased in the number of free schools.

168. **NOTING** the likely changes in fleet behaviour with regard to targeting free– and FAD–schools, the WPTT **AGREED** that the analysis should be restricted to after 1990 when the FAD fishery was developed.

169. The WPTT **AGREED** that the size of tuna schools was not correlated with the ability of fishers to circle the school (catchability) by the purse seine fleets and thus could be ignored as a factor in the analysis.

***Rep. of Korea – Catch-per-unit-of-effort (CPUE)***

170. The WPTT **NOTED** paper IOTC–2012–WPTT14–34 Rev_1 which provided a CPUE standardisation for yellowfin tuna caught by Korean tuna longline fisheries in the Indian Ocean from 1978 to 2011, including the following abstract provided by the authors:

> "*CPUE (catch per unit effort) standardization for yellowfin tuna of Korean longline fisheries in the Indian Ocean was conducted by GLM using fisheries data (1978-2011), i.e., catch (number of fishes), effort (number of hooks) and number of hooks between floats (HBF) by year, month and 5°× 5° (Lat. and Long.) area. The standardized CPUE showed the level of 3-4 from 1978 to 1987 except in 1980, but dropped to 2.3 in 1990. After then it had the declining trend with a fluctuation till 2002 when had the lowest value. And it showed somewhat of increasing in 2004 through 2007, but decreased again to 0.7 in 2008 and showed a low level in recent years.*"

171. The WPTT **AGREED** that analysis using 1° x 1°area effects and examining the interaction between Year and Quarter should be investigated and presented at the next WPTT meeting.

172. The WPTT **NOTED** that the catch by the Rep. of Korea longline fleet has been relatively small in comparison to the main fleets and therefore it might not provide a reliable indicator for determining the stock status of yellowfin tuna.

173. The WPTT **AGREED** that although useful, given the preliminary condition of the analysis, the Rep. of Korea standardised CPUE series should not be used in the stock assessment at this time.

***Japanese – Catch-per-unit-of-effort (CPUE)***

174. The WPTT **NOTED** paper IOTC–2012–WPTT14–35 Rev_1 which provided the Japanese longline CPUE for yellowfin tuna in the Indian Ocean up to 2011 standardised by general linear model, including the following abstract provided by the authors:

> "*Japanese longline CPUE (quarterly and annual) for yellowfin tuna in the main fishing ground and whole Indian Ocean, as well as CPUE in each area in each of five areas for SS3 and Multifan-CL, was standardized up to 2011 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 catch rate which has been derived by fishing gear configuration. In order to avoid the bias of CPUE trend which may be caused by critical decrease of effort in the northwestern Indian Ocean, scenarios without Area 2 was also applied. Basically, two series of standardized CPUEs including and excluding Area2 showed a similar trend. In the main fishing ground, CPUE continuously decreased from around 15 (a nominal scale) in early 1960s to around 5.0 in 1974, and was kept in same level until 1990 with jump to 12.0 in 1977. –* see paper for full abstract."

175. The WPTT **NOTED** that, as with previous years, the standardised and nominal CPUE series demonstrated a degree of divergence not commonly observed when conducting CPUE standardisations, and that the decline in fishing effort in recent years, including in 2011, may be driving the anomalous results observed.

176. The WPTT **NOTED** that the change in gear appears to have had the effect of increasing the ratio of yellowfin tuna in the Japanese longline catch when compared to bigeye tuna. The WPTT also **NOTED** that other factors associated with targeting shifts could be explored in more detail (e.g. NHFCL might not always be the best indicator of hook depth or targeting). Understanding the interactions among NHFCL, fine-scale oceanographic condition, and gear shape under the water might bring further improvement of the CPUE standardization and, thus, the WPTT **RECOMMENDED** further examination of those issues in the future.

177. The WPTT **NOTED** the decrease in effort by the Japanese fleet since 2009; in 2011 the majority of the yellowfin tuna catches by the Japanese longline fleet (64% of their total 2011 catches) being caught in a single 5º square of Region 3 (south west of Madagascar) and a major decline in the total yellowfin tuna catches by Japanese longliners during recent years, decreasing to 3,990 t in 2011, the lowest catches of yellowfin tuna since 1989. As a consequence, these issues may have greatly affected the representativeness of the Japanese CPUE abundance index for yellowfin tuna in recent years.

178. The WPTT **NOTED** the temporal change in spatial density of the longline fishing effort. The lack of fine-scale spatial resolution in the data by MULTIFAN-CL defined fishing region has made it difficult to quantify the spatial effect on the CPUE series. Reduction of fishing in regions 2 and 5 during recent years cannot be fully investigated unless finer-resolution spatial information is included in CPUE standardisation.

179. The WPTT **AGREED** that the analysis had been improved from the previous year by incorporating the 5° by 5° block effects, and **REQUESTED** the following for further improvement in 2013:
    - examination of the residuals against the fitted log-CPUEs

- examination of whether there is a spatial correlation among the residuals in adjacent blocks and if there is a correlation, then move to GAM models for non-linearity, which includes a spatial smoothness structure
- use mixed-effect models to account for variation of catch efficiencies among vessels
- analyse the data using covariates such as SST and those relevant to fishing power

***Taiwan,China– Catch-per-unit-of-effort (CPUE)***

180. The WPTT **NOTED** paper IOTC–2012–WPTT14–36 Rev_1 which provided a CPUE standardisation for yellowfin tuna caught by the Taiwanese [Taiwan,China] longline fishery in the Indian Ocean using generalized linear model, including the following abstract provided by the authors:

> "*Quarterly and annual Taiwanese longline CPUEs for yellowfin tuna in the Area 1(Arabian Sea), tropical and whole Indian Ocean were standardized up to 2011 by GLM. Sensitivity analysis showed various proxies for targeting had no significant impact on the stability of CPUE series. The trend of standardized CPUE for whole Indian Ocean was similar to that of the tropical Indian Ocean. Standardized CPUE series showed a relatively stable trend from 1979 to 2004. After that, the CPUE continuously decreased to the historical low level in 2009, and then started to increase in recent two years. In Area 1 fishing ground, standardized CPUE trend showed a wide range but intermittent signal due to insufficient fishing records in several years. Especially, there was no fishing operation in Area 1 in 2011.*"

181. The WPTT **NOTED** that the nominal and standardised CPUE series were similar, and showed a flat trend until 2004 and a recent increase after a rapid decline during 2005–09 for the whole Indian Ocean.

182. **NOTING** that data from Taiwanese vessels flagged to India was not used in the analysis, the WPTT **RECOMMENDED** that national scientists from Taiwan,China work with the IOTC Secretariat to gain a better estimate of catch in the Bay of Bengal.

183. The WPTT **NOTED** that targeting in this paper was handled by using the catch composition of the target species as a proxy for targeting, as opposed to the use of hooks per basket in the Japanese longline CPUE series. It was suggested that the effect of these two different proxies should be investigated. In response to the question about the mixed-effect model, the authors replied that such models did not show better fitting and therefore they did not used them this year.

***Sensitivity of the MFCL assessment model***

184. The WPTT **NOTED** paper IOTC–2012–WPTT14–37 which provided an investigation of the sensitivity of the Indian Ocean MFCL yellowfin tuna stock assessment to key model assumptions, including the following abstract provided by the authors:

> "*A range of model runs were undertaken to investigate the sensitivity of the 2011 YFT IO MFCL assessment model to key structural assumptions (Langley et al 2011). The analysis was, in part directed by a review of the assessment conducted on behalf of the Secretariat. For comparative purposes, most of the model sensitivities were conducted using a base model with longline selectivity parameterised using a logistic function (full selection of the older age classes). Most of the model options were examined using the same MFCL code used to undertake the 2011 stock assessment.*"

185. The WPTT **NOTED** the effect of spatial structure, natural mortality, steepness, growth and selectivity on the MFCL model. The effect on the assessment of different parameter values illustrates how sensitive the model is to certain key structural assumptions; which reflects the effect of changing those parameters on key reference points. The effect of spatial model structure, the selectivity shapes assumed, the mortality pattern and other various assumptions in relation to how the tagging data is treated, have a large influence on the assessment, which may require further investigation.

186. The WPTT **NOTED** the effect of the new MFCL software and the resultant differences in model outcomes. Some participants expressed concern on whether the improved version of the MFCL software should be used, as the model outcomes were different from the previous version.

187. The WPTT **AGREED** that natural mortality (M) calculated in paper IOTC–2012–WPTT14–32 Rev_1should be used in the stock assessments in 2012, **NOTING** that MFCL also estimates M in a similar manner.

188. The WPTT **NOTED** that when using Lorezen curves to estimate age-specific natural mortality, the model assumes an exponential decrease in M over time based on the assumed maximum age of the species. However, the curve can then be scaled to coincide with the assumed functional form of the mortality curve based on external analysis data (e.g. tagging data) or biology knowledge of the species.

### *CPUE discussion summary*

189. The WPTT **NOTED** that the standardised CPUE trend estimated by the Taiwan,China longline fleet is in contrast to the consistent negative trend displayed by the Japanese series. The difference in the series between Taiwan,China and Japan/Rep. of Korea standardised CPUEs was questioned as it would seem intuitive that the trend should have decreased when catches increased significantly at the advent of the purse seine fishery.

190. The WPTT **NOTED** that residuals vs. fitted plots should be included to test for homogeneous variance. This is considered a more important assumption than that of normality and should always be explored.

191. The WPTT **AGREED** that the inclusion of latitude and longitude in models should be considered to allow for spatial correlation and local hot-spots. However, these should be included non-linearly; perhaps through a Generalized Additive Model (GAM). Alternatively, researchers could include a spatial covariance structure if they do not want to model the spatial dynamics explicitly. GLMs assume that all residuals are independent; however, that assumption is often violated with spatial data. Residuals from nearby grid cells tend to be more similar with each other than residuals from cells that are far apart.

192. The WPTT **NOTED** that the use of hooks between floats as a proxy for targeting should be further explored. Currently, most papers break HBF into fixed, discrete categories, but they do not test the sensitivity of their results to changes in these categories (e.g., 2-3, 4-5, 6-8 vs. 2-4, 5-6, 7-8). Another way to investigate this would be to treat HBF as a non-linear continuous term, possibly in a GAM.

193. The WPTT **NOTED** that in general, researchers will be better off not aggregating their data and instead tracking CPUE by individual vessel which will allow for the inclusion of vessel effects, temporal correlation, and possibly even accounting for similar performance of vessels owned by the same company.

194. The WPTT **NOTED** that all the models currently assume that there have been zero changes in efficiency. The one thing we do know is that efficiency has increased over time, and ignoring that will bias the result. The uncertainty lies in how much has efficiency changed. It is highly recommended that researchers include variables that might account for such changes in efficiency. This could be done using fleet-level variables (e.g. the approximate percentage of the fleet that has adopted each type of technological improvement) or maybe even at the vessel level if such information is available. If neither of these options are available, then researchers should at least allow for a fixed percentage change in efficiency over certain periods of time based on expert opinion. The specific dates and values will depend on expert knowledge and are just listed here as example, not as a recommended value or timeline.

195. The WPTT **AGREED** that the main source of information on abundance trends for stock assessment purposes is the index of abundance derived from the Japan and Taiwan,China longline CPUE series. Concerns have been raised on the ability of this standardised CPUE series to represent the yellowfin tuna stock abundance in the Indian Ocean. These indices have shown steep declining trends in the Western tropical area, where most of the catches occur, over the last five years. Moreover, the decrease and almost disappearance of effort of the Taiwan,China and Japan longline vessels in the north-western part of the Indian Ocean during recent years due to the piracy, raise a concern about the utility and representativeness of these indices for stock assessment during recent years. There is substantial difficulty in fully understanding and quantifying changes in the fishery that would help interpreting the patterns observed in the index of abundance.

196. The WPTT **NOTED** that for the longline fisheries (LL fisheries in regions 1–5; Fig. 10, CPUE indices were derived using generalised linear models (GLM) from the Japanese longline fleet (LL regions 2–5) and for the Taiwanese longline fleet (LL region 1) to be used in the stock assessment. Standardised longline CPUE indices for the Taiwanese fleet were available for 1979–2008. The GLM analysis used to standardise the Japanese longline CPUE indices was refined for the 2011 and 2012 assessments to include a spatial (latitude*longitude) variable. The resulting CPUE indices were generally comparable to the indices derived from the previous model and were adopted as the principal CPUE indices for the 2012 assessment (Fig. 11. There is considerable uncertainty associated with the Japanese CPUE indices for region 2 in the most recent year (2010) and no CPUE indices are available for region 1 for 2009–10.

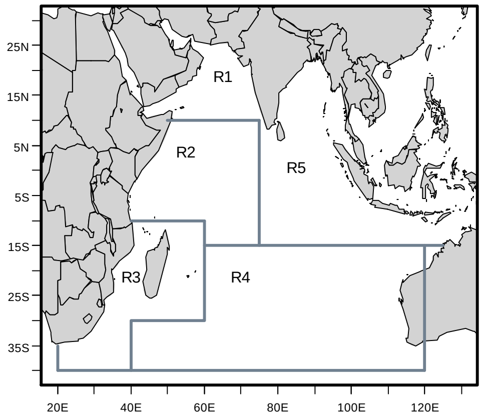

**Fig. 10**. Spatial stratification of the Indian Ocean for the MFCL assessment model.

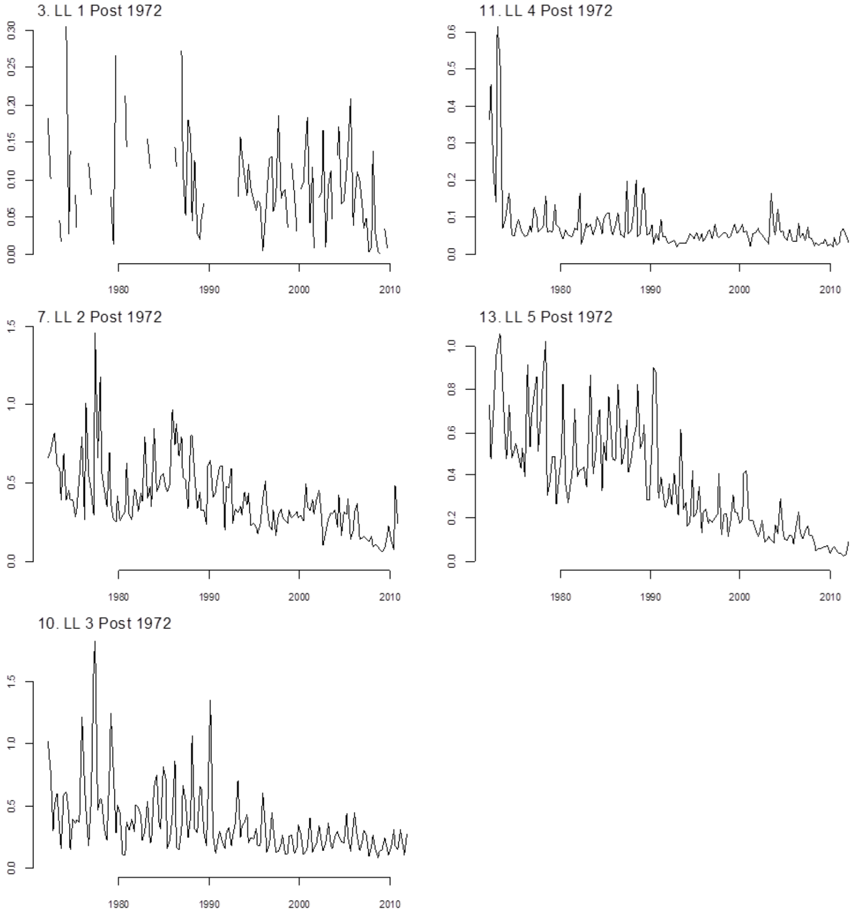

**Fig. 10.** Yellowfin tuna: Quarterly GLM standardised catch-per-unit-effort (CPUE) for the principal longline fisheries (LL 1 to 5) scaled by the respective region scalars.

## *9.4 Stock assessments*

197. The WPTT **NOTED** that a range of quantitative modelling methods were applied to the yellowfin tuna assessment in 2012, ranging from the non-spatial, age-structured production model (ASPM) to the age and spatially-structured MULTIFAN-CL and SS3 analysis. The different assessments were presented to the WPTT in documents IOTC–2012–WPTT14–38, 39 and 40 Rev_2. Each model is summarised in the sections below.

### Summary of stock assessment models in 2012: yellowfin tuna

198. The WPTT **NOTED** Table 8 which provides an overview of the key features of each of the three stock assessments presented in 2012 and Table 9, which provides a summary of the assessment results.

**Table 8.** Yellowfin tuna: Summary of final stock assessment model features as applied to the Indian Ocean yellowfin tuna resource in 2012.

| **Model feature** | **MFCL (Doc #38)** | **SS3 (Doc# 39)** | **ASPM (Doc #40 Rev_1)** |
|---|---|---|---|
| Software availability | MULTIFAN-CL | NMFS toolbox | Rademeyer & Nishida |
| Population spatial structure / areas | 5 | 5 | 1 |
| Number CPUE Series | 1 (TWN: 1972–2010); 2–5 (JPN: 1972–2011) | 1 (TWN,CHN 1972–2010); 2 (JPN: 1972–2011) | 1 (JPN 1950–2011) |
| Uses Catch-at-length/age | Yes | Yes | Yes (transformed to catch-at-age) |
| Age-structured | Yes | Yes | Yes |
| Sex-structured | No | No | No |
| Number of Fleets | 25 | 21 | 9 |
| Stochastic Recruitment | Yes | Yes | Yes |

**Table 9.** Yellowfin tuna: Summary of final model features for 2012 for the Indian Ocean yellowfin tuna resource.

| Management quantity | MFCL[1] | SS3 | ASPM |
|---|---|---|---|
| Most recent catch estimate (2011) | 302,939 t | | |
| Mean catch over last 5 years (2007–2011) | 302,064 t | | |
| *h* (steepness) | 0.8 (0.7 and 0.9 for sensitivity) | 0.7 (0.6 and 0.8 for sensitivity) | 0.9 (0.7 and 0.8 for sensitivity) |
| MSY<br>(80% CI)<br>MFCL: range of the points estimates from the different runs | 344,000 t (290,000–453,000 t) | 423,796 t | 320,403<br>(283,403-358,262) |
| Data period (catch) | 1972–2011 | 1950–2011 | 1950–2011 |
| CPUE series | JPN LL (Region 2-5) and TWN LL (Region 1) | JPN LL (Region 2-5) and TWN LL (Region 1) | JPN LL (Region 2-4) |
| CPUE period | JPN (1963-2011)<br>TWN (1978-2009) | JPN (1963-2011)<br>TWN (1978-2009) | 1963–2011 |
| $F_{2011}/F_{MSY}$<br>(80% CI)<br>MFCL: range of the points estimates from the different runs | [1]0.69 (0.59–0.90) | 0.72 | 0.61<br>(0.31–0.91) |
| $B_{2011}/B_{MSY}$<br>(80% CI)<br>MFCL: range of the points estimates from the different runs | [1]1.28 (0.97–1.38) | 0.84 | n.a. |
| $SB_{2011}/SB_{MSY}$<br>(80% CI)<br>MFCL: range of the points estimates from the different runs | [1]1.24 (0.91–1.40) | 0.84 | 1.35<br>(0.96–1.74) |
| $B_{2011}/B_{1950}$<br>(80% CI) | n.a | 0.29 | n.a. |
| $SB_{2011}/SB_{1950}$<br>(80% CI)<br>MFCL: range of the points estimates from the different runs | [1]0.38 (0.28–0.38) | n.a. | 0.36<br>(n.a.) |
| $SB_{2011}/SB_{current, F=0}$ | n.a. | n.a. | n.a. |

[1] MFCL results are for 2010, not 2011 as the WPTT considered the 2011 results too preliminary and uncertain without the recent longline CPUE indices being included.

**MULTIFAN-CL (MFCL)**

199. The WPTT **NOTED** paper IOTC–2012–WPTT14–38 which provided a stock assessment of yellowfin tuna in the Indian Ocean using MULTIFAN-CL (MFCL), including the following abstract provided by the authors:

> "*This paper presents the stock assessment of yellowfin tuna (Thunnus albacares) in the Indian Ocean (IO) using the MULTIFAN-CL software (Fournier et al. 1998; Hampton and Fournier 2001; Kleiber et al. 2003; http://www.multifan-cl.org) which implements a size-based, age- and spatially-structured population model. Parameters of the model are estimated by maximizing an objective function consisting both of likelihood (data) and prior information components. MULTIFAN-CL is routinely used to conduct the stock assessment of tuna stocks of the western and central Pacific Ocean, including yellowfin tuna. For the Indian Ocean, stock assessments of yellowfin tuna conducted before 2008 had used more traditional methods such as VPA and production models (Nishida & Shono 2005 & 2007). MULTIFAN-CL has the functionality to integrate data from tag release/recovery programmes and, thereby, utilise the information collected from the large-scale tagging programme conducted in the Indian Ocean in recent years. For this reason, the IOTC Working Party on Tagging Data Analysis held in June–July 2008 recommended conducting an assessment of the IO yellowfin tuna stock using MULTIFAN-CL software (IOTC 2008a). – see paper for full abstract.*"

200. The WPTT **NOTED** the following with respect to the modelling and estimation approach presented at the meeting:
    - The main features of the model in the 2012 assessment included a fixed growth curve (with variance) with an inflection, an age-specific natural mortality rate profile (M), the modelling of 25 fisheries including the separation of two purse seine fisheries into three time blocks, using logistic and cubic spline functions to estimate longline selectivities, separation of the analysis into five regions of the Indian Ocean as well as the three steepness parameters for the stock recruitment relationship (h=0.7, 0.8 and 0.9).
    - In addition to another year of data, the 2012 assessment included several changes to the previous assessment: the longline CPUE indices were modified (Japanese updated with latest year which included information about latitude and longitude in the standardisation process for Regions 2–5 was supplied except for Region 2 in 2011; no update was available for the Taiwan,China index for Region 1; All of the analyses were conducted using a new version of MFCL provided by the Secretariat of the Pacific Community.

201. The WPTT **NOTED** the problems 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 stock assessments. Length frequency data is almost unavailable for some fleets, while in other cases sample sizes are too low to reliably document changes in abundance and selectivity by age. Moreover, in general, catch data from some coastal fisheries is considered as poor.

202. The WPTT **REVIEWED** the results of the MFCL model in detail to improve the understanding of the estimated population dynamics and address specific properties of the model that were inconsistent with the general understanding of the yellowfin tuna stock and fisheries. The main issues identified are as follows:
    - The model estimates a strong temporal decline in recruitment and in biomass within the eastern equatorial region (Region 5). This declining trend in recruitment is driven by the decline in the Japanese longline CPUE indices over the model period. There are limited data to reliably estimate recruitment in the region as the size data included in the model are considered uninformative. Consequently, the resulting recruitment and biomass trends may be unreliable. A participant noted that during this period the Taiwan,China longline fleet, a fleet more active than the Japanese longline fleet in this area, showed a stable nominal CPUE trend and high stable catches.
    - The model estimates limited movement between the two equatorial regions. This is consistent with the low number of tag recoveries from the eastern equatorial region, an area from where recovery rates are difficult to estimate but probably low. Nonetheless, the low movement rate is consistent with the oceanographic conditions that prevailed during the main tag recovery period (see papers IOTC–2012–WPTT14–9 and 31). The model assumes a constant movement pattern throughout the model period and estimated movement pattern may not persist under different oceanographic conditions.
    - Similarly, movement rates between the western equatorial region and the Arabian Sea (Region 1) were estimated to be very low. Although various recoveries crossing the border limit of 10°N line in both directions may suggest a higher mixing rate, the observation is consistent with the tag release/recovery observations (few tag releases from Region 2 were recovered in Region 1 and vice

versa). However, reporting rates of most fisheries operating in Region 1 are estimated to be low and this may underestimate the low mixing rate observed by the model.

- The model estimated that fishing mortality rates within the western equatorial region did not increase during 2002–2006 period to the extent that would be anticipated given the large increase in catch from the purse seine fishery during that period (on average 470,000 t: well above all estimated MSY values). The large increase of catch, previously described due mainly to a catchability increased, will suggest an expected corresponding increase in fishing mortality well above the level of $F_{MSY}$. The explanation for this is that the longline standardised CPUE remained relatively constant during the period of high purse seine catch and in the subsequent years. To fit to the longline CPUE indices during this period the model increases the level of recruitment in the period that precedes the high purse seine catches which may be considered unreliable. This recruitment pattern was evident in all model options. However, further examination of the size frequency data is warranted to confirm that this recruitment trend is consistent with the other fisheries data. The status of the yellowfin tuna stock assessed by the model during the period of very high catches (2003–2006), estimated to be in the middle of the green area of the Kobe plot, was questioned by some participants.

203. The WPTT **AGREED** that the available tagging data has provided the 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.

204. The WPTT **AGREED** on a final base model option for the 2012 assessment. The model incorporated the 5–region spatial structure, full selectivity of the older age classes by the longline fishery and estimated (average) natural mortality within the MFCL model, and a period of 4 quarter for tag mixing. For sensitivity analysis, a tag mixing period of 2 quarters was also analysed. In both cases three values of steepness (0.7, 0.8 and 0.9) were considered plausible. The estimated level of natural mortality was considerably higher than the level of natural mortality assumed in previous assessments. However, the estimated level of natural mortality was generally consistent with an external analysis of the tag release/recovery data (IOTC–2012–WPTT14–32), especially for younger ages, and with levels of natural mortality assumed for the assessment of yellowfin tuna by other RFMOs.

205. The WPTT **NOTED** that biomass was estimated to have declined to about the $B_{MSY}$ level, while fishing mortality rates had remained well below the $F_{MSY}$ level. The base model estimated recent (1997–2011) recruitment levels that were considerably lower (approximately 25%) than the long term level of recruitment. This resulted in an apparent inconsistency between the annual trend in MSY based fishing mortality and biomass reference points and the observed catch trajectory. Biomass was estimated to have declined to about the $B_{MSY}$ level, while fishing mortality rates had remained well below the $F_{MSY}$ level. This pattern was evident for the range of steepness values considered for the stock-recruitment relationship. The recruitment trend may be an artefact of the model as there are limited data to reliably estimate the time series of recruitment and, hence, the model has considerable freedom to estimate recruitments to account for the observed decline in the longline CPUE abundance trend. The resulting estimates of MSY (380,000–450,000 t) are considerably higher than levels of catch sustained from the fishery and are considered to be overly optimistic. Similarly, the corresponding estimates of stock status are considered to be highly uncertain or unreliable.

206. The WPTT **AGREED** that it was more appropriate to formulate stock status advice based on the more recent period of recruitment on the basis that the level of recruitment from the early period is highly uncertain and that, at least in the short-term, recruitment would be more likely to be in line with recent levels. Estimating the stock status based on the recent (average 1997–2011) recruitment level resulted in lower MSY values, levels of fishing mortality that were comparable to the base model, and a more optimistic level of biomass relative to $B_{MSY}$.

207. The WPTT **NOTED** that the potential yield from the stock from different harvesting patterns was investigated by comparing alternative age specific patterns of fishing mortality that corresponded to the estimated selectivity of the main fisheries. A shift in the strategy to exclusively harvest the stock by longline or free-school purse seine would result in a substantial increase (50%) in the overall yield from the fishery relative to current yields. Conversely, a harvest pattern consistent with the purse seine FAD based fishery would result in a large (42%) reduction in overall yields. A shift to a gillnet based harvest pattern had a neutral effect relative to current yield. This analysis simply illustrates the relative yield per recruit of the individual fisheries, however, the results are theoretical and do not consider the complex nature of the operation of this multi-gear/multi-species fishery or the practicalities of substantially changing the harvest pattern.

208. The WPTT **NOTED** Table 10 which provides an overview of the key features of the MFCL stock assessment model used in 2012.

**Table 10.** Summary of final model features as applied to the Indian Ocean yellowfin tuna resource in 2012

| Model feature | MFCL |
|---|---|
| Software availability | MULTIFAN-CL |
| Population spatial structure / areas | 5 |
| Number CPUE Series | 5 (4 JPN and 1 TWN,CHN) |
| Uses Catch-at-length | Yes |
| Tagging data | Yes |
| Age-structured | Yes |
| Sex-structured | No |
| Number of Fleets | 25 |
| Stochastic Recruitment | Yes |

209. The WPTT **NOTED** the key assessment results for the MFCL stock assessment as shown below (Table 11; Fig. 12).

**Table 11.** Key management quantities from the MFCL assessment, for the agreed scenarios of yellowfin tuna in the Indian Ocean. The range values represent the point estimates of different scenarios analysis (6 scenarios showing long term and short term recruitment with three values of steepness as well as the sensitivity analysis with 2 quarter for tag mixing, long- and short term recruitment and 0.8 value of steepness). The range is described by the range values between those scenarios.

| Management Quantity | Indian Ocean |
|---|---|
| 2011 catch estimate | 302,939 t |
| Mean catch from 2007–2011 | 302,064 t |
| MSY | 344,000 t (290,000–453,000 t) |
| Data period used in assessment | 1972–2011 |
| $F_{2010}/F_{MSY}$ | 0.69 (0.59–0.90) |
| $B_{2010}/B_{MSY}$ | 1.28 (0.97–0.1.38) |
| $SB_{2010}/SB_{MSY}$ | 1.24 (0.91–1.40) |
| $B_{2010}/B_0$ | n.a. |
| $SB_{2010}/SB_0$ | 0.38 (0.28–0.38) |
| $B_{2010}/B_{0,\ F=0}$ | n.a. |
| $SB_{2010}/SB_{0,\ F=0}$ | n.a. |

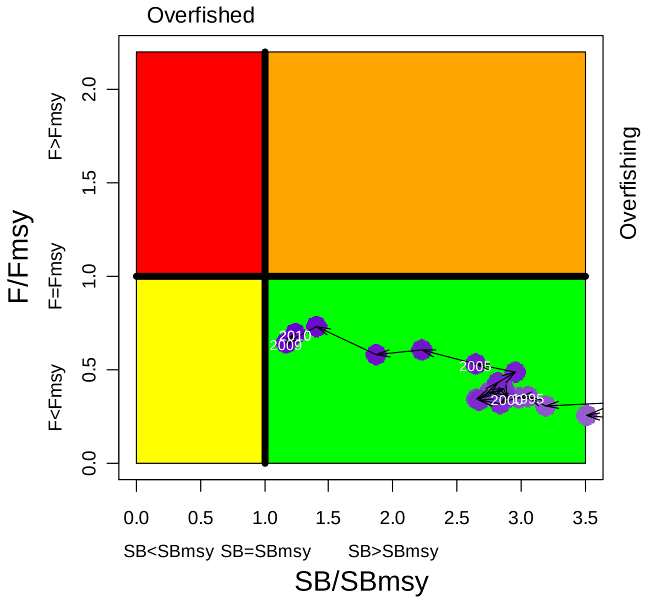

**Fig. 12.** Yellowfin tuna: MULTIFAN-CL Indian Ocean yellowfin tuna stock assessment Kobe plot. Blue circles indicate the trajectory of the point estimates for the B ratio and F ratio for each year 1972–2010 for the scenario of short-term recruitment, 4 quarters tag mixing with steepness value as indication equal to 0.8.

210. The WPTT **NOTED** that the range of MSY estimates are between 290,000 t and 435,000 t based upon the range of Multifan-CL model options considered. However the upper range of the MSY estimates are based on long terms level of recruitment and when the lower short term recruitment value is considered the range are between 290,000 and 453,000 tonnes. The mean catch over the 2008–2010 period of 300,000 t is in the low range of the MSY estimated based on short-term recruitment while annual catches over the period 2003–2006 (averaging 477,000 t) were substantially higher than any of the MSY estimates.

211. The WPTT **NOTED** that in 2011, a range of deterministic projections of stock status were undertaken to formulate the probability of breaching key MSY based reference points (K2SM). During the current assessment, preliminary projections were undertaken, however, the ability of the WPTT to carry out the projections with MFCL for yellowfin tuna was limited bearing in mind the large uncertainties in the outputs from the stock assessment model. Moreover, these projections highlighted a number of deficiencies in the approach, primarily related to the assumptions regarding future fishery-specific catches. Recent high catches from number of the fisheries that primarily catch small yellowfin, including a number of the domestic fisheries for which catch estimates are considered to be highly uncertain. The sharp increase in the catch from these fisheries has shifted the overall harvest pattern towards smaller fish, reducing yield per recruit. These recent catch estimates do not unduly impact on the main assessment; however, they are highly influential in the stock projections, resulting in a significant shift in the overall age-specific fishing mortality, declining yields and more pessimistic stock status throughout the projection period. The WPTT was concerned that the assumptions about future catch, based on potentially unreliable recent catch estimates, may not be valid and could result in unreliable estimates of future stock status. On that basis, the K2SM was not updated with the results of the 2012 assessment (see IOTC–2011–WPTT13–R).

212. The WPTT **THANKED** Mr. Adam Langley (consultant) for his contributions and expertise on integrated stock assessment models, and **RECOMMENDED** that his engagement be renewed for the coming year.

### Stock Synthesis III (SS3)

213. The WPTT **NOTED** paper IOTC–2012–WPTT14–39 which provided a preliminary stock assessment of yellowfin tuna in the Indian Ocean using SS3, including the following abstract provided by the authors:

> "*Stock assessment for the Indian Ocean yellowfin tuna was attempted using Stock Synthesis III (SS3) based on available data up to 2011 on catch, abundance indices (standardized CPUE series), length frequencies and tagging data. In the result of reference case (all CPUE CV=0.2, Fixed f size selectivity for fishery 3, 7, 10, 11, 19 and 21), the maximum sustainable yield (MSY) was estimated at 423,796 ton, and the current stock indicators, F2011/FMSY and B2011/BMSY, were estimated 0.922 and 0.857, respectively. The robustness/sensitivity of results under the reference case was further investigated based on several extended runs. The resultant outcomes revealed that it is sensitive to use tagging data for SS3 in the Indian Ocean yellowfin tuna stock assessment.*"

214. The WPTT **NOTED** the following with respect to the modelling approach presented at the meeting:
    - The main features of the model in the 2012 assessment included a fixed Von Bertalanffy (VB) growth, an age-specific natural mortality rate profile (M) used in 2011 MFCL assessment, the modelling of 21 fisheries, mainly using a double-normal curve to estimate longline selectivities, separation of the analysis into five regions of the Indian Ocean and the specification of three steepness parameters for the stock recruitment relationship (h=0.6, 0.7 and 0.8).
    - In addition to another year of data, the 2012 assessment included several changes to the previous assessment: the longline CPUE indices were modified (Japanese updated with latest year which included information about latitude and longitude in the standardisation process for Regions 2–5 was supplied and the Taiwan,China index was revised for region 1).

215. The WPTT **NOTED** that there were subtle differences in the SS3 and MFCL assessment. The assessment recruitment trends should be displayed to see if recruitment is driving this difference. The numbers of fisheries were different as well, and the overall differences in the assessment were **NOTED**. Area 1 and 4 were showing the same biomass trend dynamics as Area 2 and 5, which seemed spurious.

216. The WPTT **NOTED** that sample sizes should be used in all fisheries including the Purse Seine Fisheries.

217. **NOTING** that the use of a VB growth curve was considered inadequate for yellowfin tuna, as paper IOTC–2012–WPTT–23 Rev_1 supports the 2-stanza growth for yellowfin tuna, the WPTT **AGREED** that a 2-stanza growth curve is included in future stock assessments.

218. The WPTT **NOTED** Table 12 which provides an overview of the key features of the SS3 stock assessment model used in 2012.

**Table 12.** Yellowfin tuna: Summary of final SS3 model features as applied to the Indian Ocean yellowfin tuna resource in 2012.

| **Model feature** | **SS3** |
|---|---|
| Software availability | Stock Synthesis III (ver. 3.23b) |
| Population spatial structure / areas | 5 |
| Number CPUE Series | 5 (4 JPN and 1 TWN,CHN) |
| Uses Catch-at-length | Yes |
| Tagging data | Yes |
| Age-structured | Yes |
| Sex-structured | No |
| Number of Fleets | 21 |
| Stochastic Recruitment | Yes |

219. The WPTT **NOTED** the key assessment results for the SS3 stock assessment as shown below (Table 13; Fig. 13).

**Table 13.** Key management quantities from the SS3 assessment, for the agreed scenarios of yellowfin tuna in the Indian Ocean.

| **Management Quantity** | **Indian Ocean** |
|---|---|
| 2011 catch estimate | 302,939 t |
| Mean catch from 2007–2011 | 302,064 t |
| MSY | 423,796 t |
| Data period used in assessment | 1950–2011 |
| $F_{2011}/F_{MSY}$ | 0.72 |
| $B_{2011}/B_{MSY}$ | 0.84 |
| $SB_{2011}/SB_{MSY}$ | 0.84 |
| $B_{2011}/B_0$ | 0.29 |
| $SB_{2011}/SB_0$ | 0.29 |
| $B_{2011}/B_{0,\ F=0}$ | n.a. |
| $SB_{2011}/SB_{0,\ F=0}$ | n.a. |

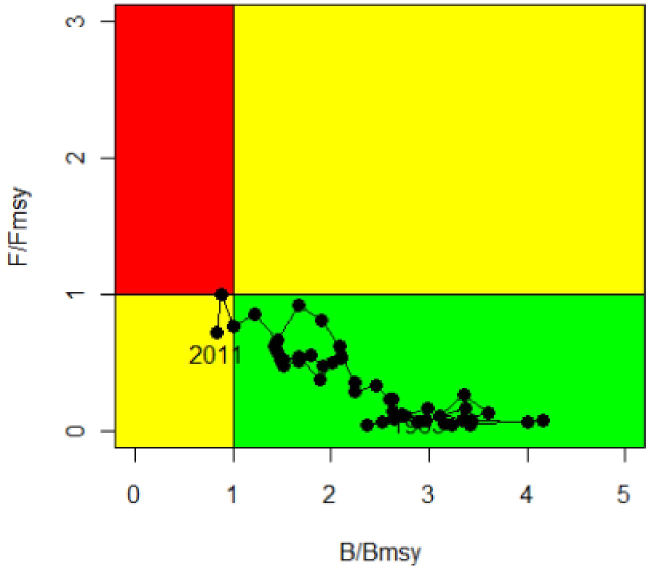

**Fig. 13.** Yellowfin tuna: Indian Ocean yellowfin tuna SS3 stock assessment Kobe plot. Black circles indicate the trajectory of the point estimates for the B ratio and F ratio for each year 1950–2011.

220. The WPTT **AGREED** that further analysis using a two-stanza growth curve and new estimates of reporting and shedding rates should be carried out. However, due to limited time, the model was unable to reach any reasonable results, and therefore no further updates were provided during the meeting for considering implications to the management advice for yellowfin tuna.

221. The WPTT **NOTED** that the stock assessment carried out using SS3 was preliminary and that the results were unrealistic. However, the WPTT **ACKNOWLEDGED** the effort done in the preliminary assessment of SS3 and **ENCOURAGED** the authors to continue further with the assessment and to expand their analysis to investigate various the sensitivity of the model structure to inputs parameters.

### Age-Structured Production Model (ASPM)

222. The WPTT **NOTED** paper IOTC–2012–WPTT14–39 which provided a stock and risk assessments on yellowfin tuna (*Thunnus albacares*) in the Indian Ocean based on AD Model Builder implemented Age-Structured Production Model (ASPM), including the following abstract provided by the authors:

> "*We applied AD Model Builder implemented Age-Structured Production Model (ASPM) to assess the status of the yellow tuna stock in the Indian Ocean using 62 years of data (1950-2011). Results of the final ASPM indicate that the fishing effort (2011) is below the MSY level (F/Fmsy=0.61), while the spawning stock biomass (SSB) is above the MSY level (SSB/SSBmsy=1.35). The current catch (2011) is 303,000 tons which is below the MSY (320,000 tons). From these results, it is suggested that the catch level should not exceed the MSY level (320, 000 ton).*"

223. The WPTT **NOTED** that main differences in the assumption of the ASPM analysis from the integrated ones such as MFCL and SS3 are 1) it has no spatial structure (i.e. the whole Indian Ocean as single region) and therefore it used the standardised CPUE for the whole Indian Ocean; 2) no use of tagging data; 3) less number of classifications in the definition of fisheries; and 4) a smaller extent of recruitment deviation (CV=0.2) was assumed.

224. The WPTT further **NOTED** the following points with respect to the ASPM analysis:
    - A total of 7 age classes were assumed (0, 1, ..., 6+)
    - The values of natural mortality M was similar to the ones used in the MFCL, but lower than the SS3 assessment
    - The steepness values h=0.7, 0.8 and 0.9 were tried to used but convergence was reached for only h=0.9
    - The CV for recruitment deviation was assumed to be 0.2 which seems to be small
    - The results given by the ASPM seems to be optimistic in terms of the F-ratio and B-ratio.

225. The WPTT **NOTED** that the authors tried to select a better standardised CPUE from some possible area-combinations by considering the possible negative relationship between increasing catch series and decreasing standardised CPUE series. The authors decision was to delete information on CPUE from Region 2. However, there was a concern for that treatment because Region 2 is a main distribution area for the yellowfin tuna and therefore, the CPUE trends in other areas may not capture the actual trend in the stock biomass.

226. The WPTT **NOTED** the uncertainty in the catch-at-age (CAA) matrix used in the ASPM. The uncertainty in the CAA potentially comes from two sources: the estimation uncertainty in growth curve (and its sex difference) and representativeness of size-at-length. Both processes are very complex, the former having a large variability of growth between individuals and being related to different growth for male and females and the latter is closely related to the issue of the effective sample size in methods using the length frequencies. Therefore, the methods using the length frequencies and CAA essentially share a same issue, which is crucial for not only stock assessment but also for the better interpretation of risk analysis. Further research in this regard was suggested before the next assessment.

227. The WPTT **NOTED** Table 14 which provides an overview of the key features of the ASPM stock assessment model used in 2012.

**Table 14.** Yellowfin tuna: Summary of final ASPM model features as applied to the Indian Ocean yellowfin tuna resource in 2012.

| Model feature | ASPM |
|---|---|
| Software availability | Rademeyer & Nishida |
| Population spatial structure / areas | 1 |
| Number CPUE Series | 1 (JPN: 1963–2011) |
| Uses Catch-at-length | Yes (transformed to CAA) |
| Tagging data | No |
| Age-structured | Yes |

| | |
|---|---|
| Sex-structured | No |
| Number of Fleets | 9 |
| Stochastic Recruitment | Yes |

228. The WPTT **NOTED** the key assessment results for the ASPM stock assessment as shown below (Table 15; Fig. 14).

**Table 15.** Key management quantities from the ASPM assessment, for the agreed scenarios of yellowfin tuna in the Indian Ocean. The range represents the 90 percentile Confidence Interval.

| **Management Quantity** | **Indian Ocean** |
|---|---|
| 2011 catch estimate | 302,939 t |
| Mean catch from 2007–2011 | 302,064 t |
| MSY (90% CI) | 320,403 t<br>(283,403–358,262 t) |
| Data period used in assessment | 1950–2011 |
| $F_{2011}/F_{MSY}$ (90% CI) | 0.61<br>(0.31–0.91) |
| $B_{2011}/B_{MSY}$ | n.a. |
| $SB_{2011}/SB_{MSY}$ (90% CI) | 1.35<br>(0.96–1.74) |
| $B_{2011}/B_0$ | n.a. |
| $SB_{2011}/SB_0$ | 0.36<br>(n.a.) |
| $B_{2011}/B_{0,\ F=0}$ | n.a. |
| $SB_{2011}/SB_{0,\ F=0}$ | n.a. |

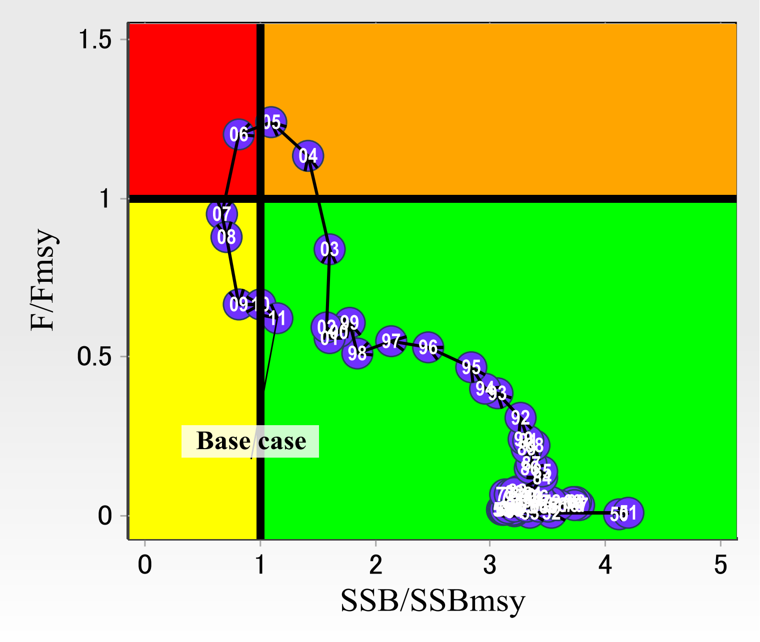

**Fig. 14.** Yellowfin tuna: Indian Ocean yellowfin tuna ASPM stock assessment Kobe plot. Blue circles indicate the trajectory of the point estimates for the B ratio and F ratio for each year 1950–2011.

229. The WPTT **NOTED** that the range of MSY estimates are between 283,000 t and 358,000 t with a median value of 320,000 t. The mean catch over the 2007–2011 period of 302,000 t is in the low range of the MSY estimated while annual catches over the period 2003–2006 (averaging 477,000 t) were substantially higher than any of the MSY estimates.

***Parameters for future analyses: Yellowfin tuna CPUE standardisation and stock assessments***

230. The WPTT **AGREED** that in order to obtain comparable CPUE standardisations, the analyses shall be conducted with similar parameters and resolutions in 2013, for presentation at the CPUE workshop agreed to by the SC. Table 16 provides a set of parameters, discussed during the WPTT that shall give guidelines, if available, for the standardisation of CPUE in 2013 to be used as indices of abundance for the stock assessments.

**Table 16.** Yellowfin tuna: A set of parameters for the standardisation of CPUE series in 2013.

| CPUE standardisation parameters | Value for 2013 CPUE standardisation |
|---|---|
| Area | *To be defined.*<br>Explore core area(s) |
| CE Resolution | Operational data |
| GLM Factors | Year, Quarter, Area, HBF, vessel, environmental + interactions |
| Model | negative binomial, zero-inflated or delta-lognormal models |

231. Noting that the areas used in the various CPUE standardisations undertaken in 2012 were very different from one analysis to another, the WPTT **AGREED** that there is a need to define core area(s) for the CPUE standardisation of yellowfin tuna and **RECOMMENDED** that scientists from CPCs with longline and purse seine fisheries for yellowfin tuna, work together to explore their data and defined such core areas, well in advance of the next WPTT meeting in 2013.

### *9.5 Selection of Stock Status indicators*

232. The WPTT **AGREED** that management advice for yellowfin tuna should be based on the 2012 MFCL stock assessment based upon the base case analysis with short term recruitment with alternative steepness of the stock-recruitment relationship of 0.7, 0.8 and 0.9 and the ASPM based case using steepness of 0.9. A major limitation of the ASPM model is that it is not spatially structured and thus does not allow the internal incorporation of tagging data, although it does externally by using the improved catch-at-age table and natural mortality estimates based on tagging data.

### *9.6 Development of technical advice on the status of yellowfin tuna*

233. The WPTT **RECOMMENDED** that the SC note the draft resource stock status summary for yellowfin tuna (*Thunnus albacares*) – Appendix IX.

234. The WPTT **REQUESTS** that the IOTC Secretariat update the draft stock status summary for yellowfin tuna with the latest 2011 catch data, and for these to be provided to the SC as part of the draft Executive Summaries, for its consideration.

## 10. ANALYSIS OF TAGGING DATA

### *Tuna mortality rates inferred from tagging data*

235. The WPTT **NOTED** paper IOTC–2012–WPTT14–41 which provided preliminary assessments of tuna mortality rates from a Bayesian Brownie-Petersen model, including the following abstract provided by the authors:

> "*The natural mortality-at-age of three populations of Indian Ocean tunas (yellowfin, bigeye and skipjack) can be assessed through the use of a Brownie-Petersen model estimated from tagging and recapture experiments, commercial catch data and tag recovery estimates. The present paper focuses on eliciting a Bayesian version of this model from the RTTP-IO database, accounting for the differences of fishing pressure exerted by the main fleets. The rationale for choosing a Bayesian framework is that it offers a major treatment of uncertainties. The main sources of error in the data are highlighted and included in the model, while the are updated using new growth curves for each species. These preliminary assessments provide new natural mortality curves that seem to be mostly decreasing over time, although they remain embued with non-negligible uncertainty.*"

### *General discussion on tagging data*

236. The WPTT **NOTED** that between 2002 and 2009, a total of 201,425 tunas were tagged and released in the framework of the Indian Ocean Tuna Tagging Programme (IOTTP). The main phase of the project, the EU-funded Regional Tuna Tagging Project – Indian Ocean (RTTP-IO) tagged and released 84% of the tunas while the remaining where tagged and released during pilot and small-scale operation taking place in both the western and eastern Indian Ocean, i.e. Maldives, Lakshadweep and Andaman islands (India), Mayotte, Indonesia, South Africa and by JAMARC, NRIFSF and SEAFDEC.

237. The WPTT **NOTED** that more than 32,000 (16%) tagged tunas have been recovered and reported to the IOTC Secretariat, however, there are large discrepancies between recovery rates of the different projects. While the number of tagged fish being recaptured is now very low, recovery activities are being maintained in the Seychelles by the IOTC Secretariat with the cooperation of the Institut de Recherche pour le Développement (IRD) and the Oficina Española de Pesca (OEP). This sustained scientific effort is of great importance as the

expected long term recoveries of yellowfin tuna and bigeye tuna will be of major interest, for instance allowing to better estimate the growth of tuna, and their maximum length ($L_{inf}$) and their natural mortality by sex.

238. The WPTT **NOTED** that in 2011 and 2012, the data from the different small-scale projects as well as from historical projects in Maldives have been imported into the main database developed for the RTTP-IO. This is now allowing the IOTC to provide complete datasets, including all the releases and recaptures from the IOTTP and historical projects, to researchers and scientists, in particular for their integration into the integrated stock assessments for the three species.

239. The WPTT **NOTED** that the sex of most large tagged yellowfin tuna and bigeye tuna recovered in Seychelles on the European purse seine fleet have been identified since July 2009. This program offers a unique potential to evaluate if adult yellowfin tuna and bigeye tuna male and female show a differential growth. The results already obtained tend to confirm the existence of such sex differential growth. Worldwide, this is the first time that tagged yellowfin tuna and bigeye tuna have been sexed by scientists. The WPTT **AGREED** that this sampling programme should be maintained as long as these tunas are recovered, in order to ideally sex 100% of the future recoveries.

240. The WPTT **NOTED** the high tag reporting rates (average of 16%) observed for the three species (bigeye tuna, skipjack tuna, yellowfin tuna). When these tag return rates are extrapolated to the number of potential recoveries (combination of tag recoveries, tag shedding estimates and non-reporting estimates), the estimated recovery rates are close to 40% for all three species, which may imply a higher exploitation rate than currently assumed. Similarly, the results may imply lower levels of natural mortality for the three species than previously assumed. These results will be analysed during the Indian Ocean tuna tagging symposium and the WPTT **AGREED** that the information be further analysed prior to the next WPTT meeting.

241. The WPTT **AGREED** that more analyses on the tagging data should be undertaken in 2013, and should include analysis of mixing rates/period and tag induced mortality (in particular for the small-scale projects). These analyses should be done in advance of the next Session of the WPTT in order to be included in future analyses and stock assessments.

## 11. ANALYSIS OF THE TIME-AREA CLOSURES (INCLUDING RESOLUTION 12/13)

242. The WPTT **NOTED** IOTC Resolution 12/13 *for the conservation and management of tropical tunas stocks in the IOTC area of competence*, which instructed the Scientific Committee to provide at its 2012 Session the following:
    a) *an evaluation of the closure area* [see Fig. 15], *specifying in its advice if a modification is necessary, its basic scientific rationale with an assessment of the impact of such a closure on the tropical tuna stocks, notably yellowfin and bigeye tuna.*
    b) *an evaluation of the closure time periods, specifying in its advice if a modification is necessary, its basic scientific rationale with an assessment of the impact of such a closure on the tropical tuna stocks, notably yellowfin and bigeye tuna.*
    c) *an evaluation of the impact on yellowfin and bigeye tuna stocks by catching juveniles and spawners taken by all fisheries. The Scientific Committee shall also recommend measures to mitigate the impacts on juvenile and spawners.*

243. The WPTT **NOTED** the work carried out by the Chair and others between the previous WPTT meeting and SC in December 2011, which included the presentation of a paper to the SC (see IOTC–2011–SC14–39). The paper presented to the SC in 2011 provided an evaluation of the IOTC time-area closure by estimating what the maximum potential loss of catches would be under different scenarios of time-area closure, as estimated from the catch statistics of the IOTC. The estimation was based on the historical IOTC database as no information was available for the specific closed periods of 2011 (February for longline, November for purse seine) when the measure took effect. The longline effort had already been entirely redistributed to other areas and the purse seine data for November were not yet available when the paper was prepared, nor at the date of the SC.

244. The WPTT **NOTED** that the results obtained from the study were similar to the analysis carried out for the SC in 2010, which emphasized that catch reduction expected from the current time-area closure were negligible.

245. The WPTT **NOTED** the advice provided by the SC to the Commission that the current closure defined in Resolution 12/13 is likely to be ineffective, as fishing effort will be redirected to other fishing grounds in the Indian Ocean. The positive impacts of the moratorium within the closed area would likely be offset by effort reallocation.

246. **NOTING** that the objective of Resolution 12/13 is to decrease the overall pressure on the main targeted stocks in the Indian Ocean, in particular yellowfin tuna and bigeye tuna, and also to evaluate the impact of the current

time/area closure and any alternative scenarios on tropical tuna population, the WPTT reiterated its previous **RECOMMENDATION** that the SC request that the Commission specify the level of reduction or the long term management objectives to be achieved with the current or alternative time area closures, as these are not contained within Resolution 12/13.

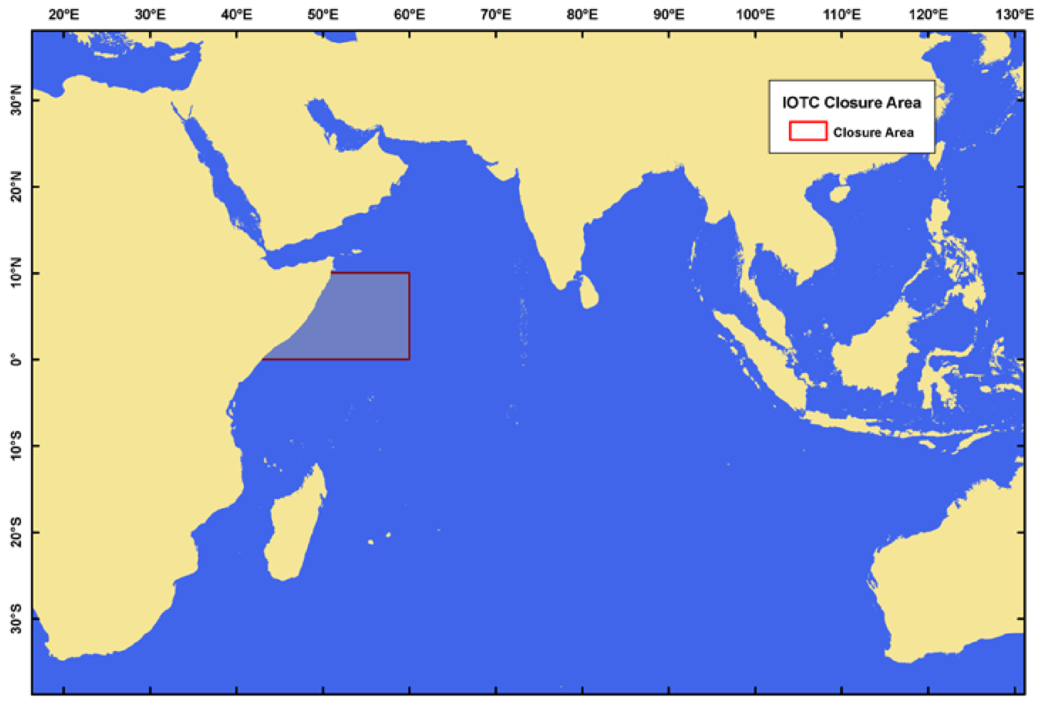

**Fig. 15.** IOTC closure area as detailed in Resolution 12/13.

## 12. EFFECT OF PIRACY ON TROPICAL TUNA CATCHES

247. The WPTT **NOTED** that, although no specific analysis of the impacts of piracy on fisheries in the Indian Ocean were presented at this meeting, many papers presented demonstrated clear impacts of piracy on fishing operations in the western Indian Ocean, including papers IOTC–2012–WPTT14–07 and 17 which indicated that there has been a substantial displacement of effort eastward (Fig. 16).

248. The WPTT **NOTED** that the number of active vessels in the IOTC area of competence have declined substantially since 2008 (Fig. 17), and **AGREED** that this was likely due to the impact of piracy activities in the western Indian Ocean.

249. The WPTT **NOTED** that the impacts appear to have been greatest on the longline fleets with effort having declined to negligible levels in recent years by most fleets (Figs. 16 and 17). Fishing effort of the purse seine fleet has also shifted east by at least 100 miles compared to the historic distribution of effort and piracy was reported to also be playing a role in determining the behaviour of small-scale fishing vessels which have declined in the region.

250. The WPTT **NOTED** that there has also been a substantial reduction in total effort due to piracy, evident from the decline in total effort from all major fleets (Fig. 11). In the first half of 2011, 11 vessels from Taiwan,China, moved to the Atlantic Ocean and 2 to the Pacific Ocean. However, in the second half of 2011, 5 vessels returned from the Atlantic Ocean, and 1 vessel returned from the Pacific Ocean. In 2012, the trend has been reversed, with a total of 15 vessels being transferred from the Atlantic Ocean back to the Indian Ocean. Similarly, 6 vessels from Taiwan,China have been transferred from the Pacific Ocean back to the Indian Ocean in 2012. Japan reported a reduction of ~140 vessels since 2006, with 85 remaining in 2011 (preliminary), which corresponds to a decrease of total catch of about 80% (for bigeye tuna and yellowfin tuna combined). In recent years, the proportion of fishing effort of the Japanese longline fleet sharply decreased in the north-western Indian Ocean (off the Somalia coastline; Fig 18), while fishing effort increased in the area south of 25°S, especially off western Australia. The Rep. of Korea reported that one longline vessel was hijacked in 2006 and this had resulted in a large reduction (50%) of the number of Rep. of Korean active vessels, from 26 in 2006 to 7 in 2011; while the remaining vessels moved to the Southern Indian Ocean. The number of EU and associated purse seiners has also decreased from 51 in 2006 to 34 in 2011 (a 33% of reduction).

251. The WPTT **RECOMMENDED** that given the potential impacts of piracy on fisheries in other areas of the Indian Ocean through the relocation of longliners to other fishing grounds, specific analysis should be carried out and presented at the next WPTT meeting by CPCs most affected by these activities, including Japan, Rep. of Korea and Taiwan,China. For example, longline fishing effort has been redistributed to traditional albacore fishing grounds in recent years, thereby further increasing fishing pressure on the albacore stock (see IOTC–2012–WPTmT–R).

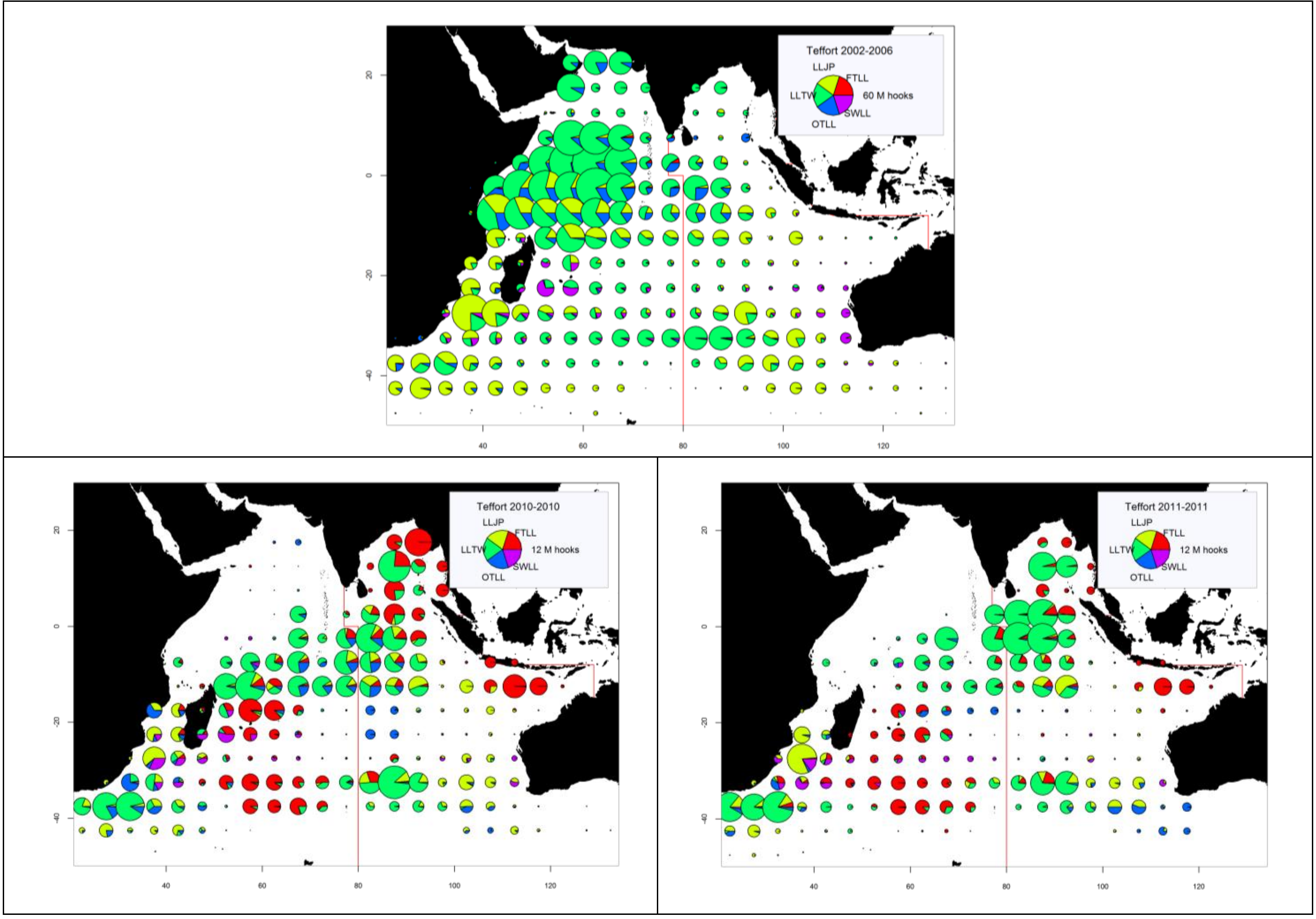

**Fig. 16.** The geographical distribution of fishing effort (millions of hooks) as reported for the longline fleets of Japan (LLJP), Taiwan,China (LLTW), fresh-tuna longline (FTLL), other longline (OTLL), and longline directed at swordfish (SWLL), in the IOTC area of competence, 2002–06, and 2010–11. The red line represents the boundary between western and eastern Indian Ocean regions. LLJP (light green): deep-freezing longliners from Japan; LLTW (dark green): deep-freezing longliners from Taiwan,China; SWLL (turquoise): swordfish longliners (Australia, EU, Mauritius, Seychelles and other fleets); FTLL (red): fresh-tuna longliners (China, Taiwan,China and other fleets; OTLL (blue): Longliners from other fleets (includes Belize, China, Philippines, Seychelles, South Africa, South Korea and various other fleets).

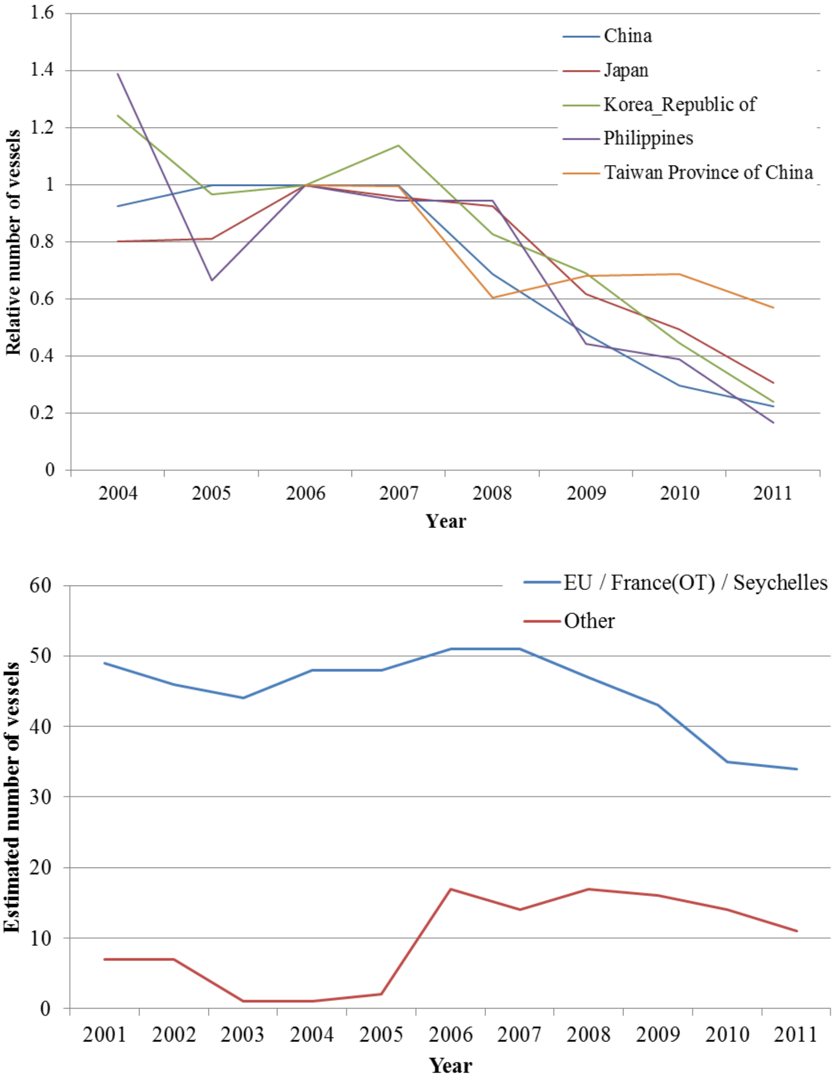

**Fig. 17.** The change in the relative number of some active longline fleets since 2004 (upper – numbers have been scaled to the number of active vessels in 2006) and estimated numbers of active purse seine vessels from 2001 to 2011 (lower) in the Indian Ocean.

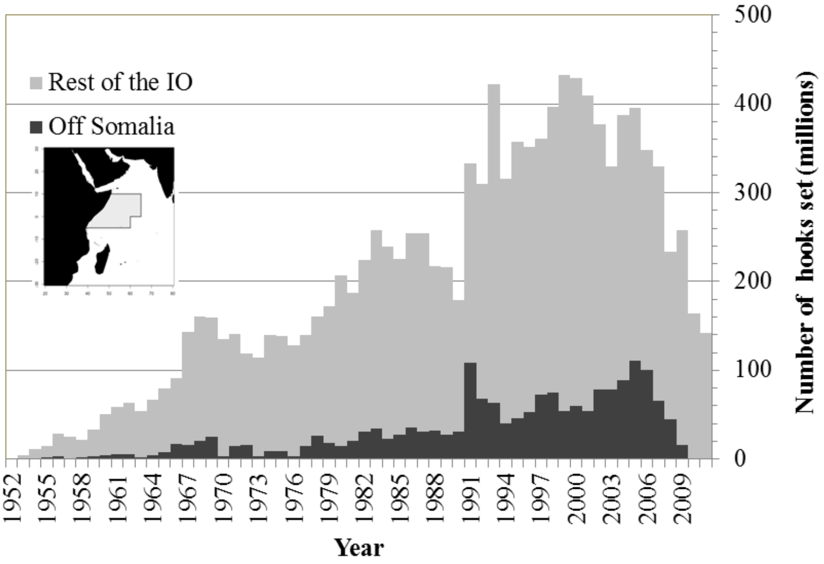

**Fig. 18.** The total number of hooks set (in millions), by year and geographical area: off the Somalia coastline (area shown in the insert) and for the rest of the Indian Ocean (IO), from 1952 to 2011.

# 13. RESEARCH RECOMMENDATIONS AND PRIORITIES

## *13.1 Revision of the WPTT work plan*

### *Size data improvements*

252. WPTT **NOTED** that the evaluation of length frequency samples collected by the longline fisheries of Japan and Taiwan,China, has been postponed until later in 2013, or will occur via correspondence only.

253. The WPTT **NOTED** the indication from Japan that over the last two years, problems had been identified by the WPTT in the Japanese size data for tropical tunas. However, the planned size data meeting, to be held in Taiwan,China in January 2013 had been cancelled. The intention of the meeting was for Japan, Taiwan,China and the IOTC Secretariat to work towards resolving the size data issues for these two fleets.

254. The WPTT **NOTED** the efforts by Japan and Taiwan,China, and **URGED** all parties to resolve the problems as soon as possible, and before the next WPTT meeting.

### *CPUE standardisation*

255. Noting the importance of the various CPUE indices for stock assessment of the tuna tropical species, the WPTT **AGREED** that there was an urgent need to investigate the CPUE issues as detailed in the sections above for bigeye tuna, skipjack tuna and yellowfin tuna, and for these to be a high priority research activity for the tropical tuna resources in the Indian Ocean in 2013.

256. **NOTING** that nominal juvenile purse seine CPUE, once standardised, can be used as an indicator of the recruitment index in the stock assessment models, the WPTT **RECOMMENDED** that the standardised CPUE index for juvenile yellowfin tuna and bigeye tuna caught by the EU purse seiner fleets, be estimated and submitted to the WPTT before the next round of stock assessments of tropical tunas.

257. The WPTT **RECOMMENDED** that standardisation of purse seine CPUE be made where possible using the operational data on the fishery.

258. The WPTT **REQUESTS** that the following matters be taken into account when undertaking CPUE standardisation analysis for bigeye tuna as well as yellowfin tuna in 2013, noting that this is a modified list produced at the previous WPTT meeting in 2011:

- The WPTT **AGREED** that changes in species targeting is the most important issue to address in CPUE standardisations, and that the following points should be taken into consideration:
    i. While hooks between floats (HBF) provides some indication of setting depth, it is generally considered not to be a sufficient indicator of species targeting. HBF is just one aspect of the setting technique, which can vary by species, area, set-time, and other factors.
    ii. Highly aggregated (e.g. 5x5 degrees) data can make it difficult to observe the factors driving CPUE in a fishery, in particular the targeting effects. Operational data provides additional information that may allow effort to be classified according to fishing strategy (e.g. using cluster analyses or regression trees to estimate species targeting as a function of spatial areas, bait type, catch species composition, set-time, vessel-identity, skipper, etc.). Operational data also permits vessel effects to be included in analyses.
    iii. The inclusion of other species as factors in a Generalized Linear Model (GLM) standardization may be misleading, because the abundance of all species changes over time. Including these factors may also fail to resolve problems due to changes in targeting, particularly when modeling aggregated data. However, comparing models with and without the other species factors can be useful to identify whether there is likely to be a targeting problem.

- The WPTT **AGREED** that appropriate spatial structure needs to be considered carefully as fish density (and targeting practices) can be highly variable on a fine spatial scale, and it can be misleading to assume that large areas are homogenous when there are large shifts in the spatial distribution of effort. The following points should also be taken into consideration:
    i. Addition of finer scale (e.g. 1x1 degrees or latitude/longitude) fixed spatial effects in the model can help to account for heterogeneity within sub-regions.
    ii. Efforts should be made to identify spatial units that are relatively homogeneous in terms of the population and fishery to the extent possible (e.g. uniform catch size composition and targeting practices).
    iii. There may be advantages in conducting separate analyses for different sub-regions. The error distribution may differ by sub-region (e.g. proportion of zero sets), and there may be very different interactions among explanatory variables.
    iv. If the selectivity differs among regions (e.g. due to spatial variability in the age composition of the population), it may not be appropriate to pool sub-regional indices into a regional index.

   v. The possibility of defining a representative 'space-time' window: if this leads to the identification of a fishery with homogeneous targeting practices, it is probably worthwhile. However, it may not be possible to identify an appropriate window, or the window may be so small that it is not representative of the larger population (or has a high variance).

- The WPTT **NOTED** that the appropriate inclusion of environmental variables in CPUE standardisation is an ongoing research topic. The WPTT **AGREED** that often these variables do not have as much explanatory power as, or may be confounded with, fixed spatial effects. This may indicate that model-derived environmental fields are not accurate enough at this time, or there may need to be careful consideration of the mechanisms of interaction to include the variable in the most informative way.

***Stock assessment***

259. Noting the difficulty of carrying out stock assessments for three tropical tuna species in a single year, the WPTT **RECOMMENDED** a revised assessment schedule on a two- or three-year cycle for the three tropical tuna species as outlined in Table 17. Following the uncertainty remaining in the bigeye tuna assessment carried out for the previous WPTT meetings in 2010 and 2011, the WPTT **AGREED** that bigeye tuna would be the priority species for stock assessments in 2013. Only stock status indictors (i.e standardised CPUE series) should be updated for skipjack tuna and yellowfin tuna.

**Table 17.** Schedule of stock assessments for bigeye tuna, skipjack tuna and yellowfin tuna by the WPTT.

| Species | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|
| **Bigeye tuna** | Full assessment | Indicators | Indicators | Full assessment | Indicators |
| **Skipjack tuna** | Indicators | Full assessment | Indicators | Indicators | Full assessment |
| **Yellowfin tuna** | Indicators | Indicators | Full assessment | Indicators | Indicators |

Note: the assessment schedule may be changed dependant on the annual review of fishery indicators, or SC and Commission requests.

# 14. OTHER BUSINESS

260. The WPTT **NOTED** with thanks to all authors, that for the first time every working paper submitted to the WPTT14 was provided prior to the commencement of the Session, with most being submitted 15 days in advance of the meeting. The advanced submission of working papers enables all participants sufficient time to thoroughly review meeting papers and therefore be able to comment and contribute to discussions during the Session.

261. The WPTT **URGED** all authors to continue ensure that they comply with the recommendation from the SC that all working party papers need to be submitted to the IOTC Secretariat no later than 15 days prior to the relevant meeting.

## *14.1 Review of the 'Guidelines for the Presentation of Stock Assessment Models'*

262. The WPTT **NOTED** that the SC had revised the "*Guidelines for the Presentation of Stock Assessment Models*" at his 13th Session in 2010, which are applicable to all IOTC Working Party meetings (provided in paper IOTC–2012–WPTT14–INF01). The guidelines attempt to ensure greater transparency and facilitate peer-review of models employed in the provision of advice on the status of the stocks to the SC. However, the SC and the Commission have since agreed to several additional elements to be provided, such as the Kobe management strategy matrix, Kobe plots and interim reference points.

263. The WPTT **RECOMMENDED** that the IOTC Secretariat work with interested scientists to develop a draft revised set of "*Guidelines for the Presentation of Stock Assessment Models*" for the consideration of the SC in December 2012.

## *14.2 Development of priorities for an Invited Expert at the next WPTT meeting*

264. The WPTT **NOTED** with thanks, the outstanding contributions of the invited expert for the meeting, Dr. Andrew Cooper, from Simon Fraser University, Canada, and **ENCOURAGED** him to maintain links with IOTC scientists to aid in the improvement of stock assessment approaches for IOTC stocks.

265. The WPTT **RECOMMENDED** the following core areas of expertise and priority areas for contribution that need to be enhanced for the next meeting of the WPTT in 2013, by an Invited Expert:
    - CPUE analysis and standardisation
    - Tuna tagging data analysis
    - Tuna stock assessment models

Where possible the Invited Expert should attend both the CPUE workshop and the Working Party in 2013, noting that Invited Experts are unpaid.

### 14.3 Date and place of the Fifteenth Session of the WPTT

266. The WPTT participants were unanimous in thanking Mauritius for hosting the Fourteenth Session of the WPTT and commended Mauritius on the warm welcome, the excellent facilities and assistance provided to the IOTC Secretariat in the organisation and running of the Session.

267. Following a discussion on who would host the Fifteenth Session of the WPTT, the WPTT **AGREED** that the next meeting be held in Spain, at the AZTI Tecnalia, preferably in late-September to mid-October 2013. The exact dates and meeting location will be confirmed and communicated by the IOTC Secretariat to the SC for its consideration at its next session to be held in December 2012, noting that the length of the meeting should be 5 to 6 days.

### 14.4 Election of a Chairperson of the WPTT for the next biennium

268. The WPTT **NOTED** that the first term of the current Chair, Dr. Hilario Murua is due to expire at the closing of the current WPTT meeting and as such, participants either need to re-elected Dr. Murua for a second and final term, or a new Chair needs to be elected.

269. The WPTT **CONSIDERED** candidates for the position of Chair of the WPTT for the next biennium. Dr. Hilario Murua was nominated for a second term and unanimously re-elected as Chair of the WPTT for the next *biennium*.

270. The WPTT **REQUESTS** that the SC note that Dr. Hilario Murua (EU) was re-elected as Chair of the WPTT for the next *biennium*.

### 14.5 Review of the draft, and adoption of the Report of the Fourteenth Session of the WPTT

271. The WPTT **RECOMMENDED** that the SC consider the consolidated set of recommendations arising from WPTT14, provided at Appendix IV.

272. The report of the Fourteenth Session of the Working Party on Tropical Tunas (IOTC–2012–WPTT14–R) was **ADOPTED** on the 13 November 2012.

# APPENDIX I
# LIST OF PARTICIPANTS

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# APPENDIX II
# AGENDA FOR THE THIRTEENTH WORKING PARTY ON TROPICAL TUNAS

**Date:** 24–29 October 2012
**Location:** Grand Baie International Conference Centre (GBICC)
Royal Road, Grand Baie, Mauritius
**Time:** 09:00 – 17:00 daily
**Chair**: Dr. Hilario Murua; **Vice-Chair**: Dr. Shiham Adam

1. **OPENING OF THE MEETING** (Chair)

2. **ADOPTION OF THE AGENDA AND ARRANGEMENTS FOR THE SESSION** (Chair)

3. **OUTCOMES OF THE FOURTEENTH SESSION OF THE SCIENTIFIC COMMITTEE** (Secretariat)

4. **OUTCOMES OF SESSIONS OF THE COMMISSION** (Secretariat)
    - 4.1 Outcomes of the Sixteenth Session of the Commission (Secretariat)
    - 4.2 Review of Conservation and Management Measures relating to tropical tunas (Secretariat)

5. **PROGRESS ON THE RECOMMENDATIONS OF WPTT13** (Chair and Secretariat)

6. **NEW INFORMATION ON FISHERIES AND ASSOCIATED ENVIRONMENTAL DATA RELATING TO TROPICAL TUNAS**
    - 6.1 Review new information on fisheries and associated environmental data (CPC papers)

7. **BIGEYE TUNA – REVIEW OF NEW INFORMATION ON STOCK STATUS**
    - 7.1 Review of the statistical data available for bigeye tuna (Secretariat)
    - 7.2 Review new information on the biology, ecology, stock structure, their fisheries and associated environmental data for bigeye tuna (CPC papers)
    - 7.3 Data for input into stock assessments:
        - o Catch and effort
        - o Catch at size
        - o Growth curves and age-length key
        - o Catch at age
        - o CPUE indices and standardised CPUE indices
        - o Tagging data
    - 7.4 Stock assessment updates
    - 7.5 Selection of Stock Status indicators
    - 7.6 Development of technical advice on the status of bigeye tuna

8. **SKIPJACK TUNA – REVIEW OF NEW INFORMATION ON STOCK STATUS**
    - 8.1 Review of the statistical data available for skipjack tuna (Secretariat)
    - 8.2 Review new information on the biology, ecology, stock structure, their fisheries and associated environmental data for skipjack tuna (CPC papers)
    - 8.3 Data for input into stock assessments:
        - o Catch and effort
        - o Catch at size
        - o Growth curves and age-length key
        - o Catch at age
        - o CPUE indices and standardised CPUE indices
        - o Tagging data
    - 8.4 Stock assessments
    - 8.5 Selection of Stock Status indicators
    - 8.6 Development of technical advice on the status of skipjack tuna

## 9. YELLOWFIN TUNA – REVIEW OF NEW INFORMATION ON STOCK STATUS

9.1 Review of the statistical data available for yellowfin tuna (Secretariat)

9.2 Review new information on the biology, ecology, stock structure, their fisheries and associated environmental data for yellowfin tuna (CPC papers)

9.3 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

9.4 Stock assessments

9.5 Selection of Stock Status indicators

9.6 Development of technical advice on the status of yellowfin tuna

## 10. ANALYSIS OF TAGGING DATA

## 11. ANALYSIS OF THE TIME-AREA CLOSURES (including Resolution 12/13)

## 12. EFFECT OF PIRACY ON TROPICAL TUNA CATCHES

## 13. RESEARCH RECOMMENDATIONS AND PRIORITIES

13.1 Revision of the WPTT work plan

## 14. OTHER BUSINESS

14.1 Review of the ‘*Guidelines for the Presentation of Stock Assessment Models*’

14.2 Development of priorities for an Invited Expert at the next WPTT meeting

14.3 Date and place of the Fifteenth Session of the WPTT

14.4 Election of a Chairperson of the WPTT for the next biennium

14.5 Review of the draft, and adoption of the Report of the Fourteenth Session of the WPTT

# APPENDIX III
# LIST OF DOCUMENTS

| Document | Title | Availability |
|---|---|---|
| IOTC–2012–WPTT14–01a | Draft agenda of the Fourteenth Working Party on Tropical Tunas | ✓(25 July 2012) |
| IOTC–2012–WPTT14–01b | Draft annotated agenda of the Fourteenth Working Party on Tropical Tunas | ✓(1 October 2012) |
| IOTC–2012–WPTT14–02 | Draft list of documents for the Fourteenth Working Party on Tropical Tunas | ✓(28 September 2012) |
| IOTC–2012–WPTT14–03 | Outcomes of the Fourteenth Session of the Scientific Committee (Secretariat) | ✓(2 October 2012) |
| IOTC–2012–WPTT14–04 | Outcomes of the Sixteenth Session of the Commission (Secretariat) | ✓(2 October 2012) |
| IOTC–2012–WPTT14–05 | Review of Conservation and Management Measures relating to tropical tunas (Secretariat) | ✓(2 October 2012) |
| IOTC–2012–WPTT14–06 | Progress made on the recommendations of WPTT13 (Secretariat and Chair) | ✓(9 October 2012) |
| IOTC–2012–WPTT14–07 Rev_2 | Review of the statistical data and fishery trends for tropical tunas (Secretariat) | ✓(9 October 2012)<br>✓(16 October 2012)<br>✓(23 October 2012) |
| **Multi-species** | | |
| IOTC–2012–WPTT14–08 Rev_2 | Predicting thermal structure of the ocean using satellite data to locate hooking depths of tuna longlines in the north east Indian Ocean (J. Rajapaksha) | ✓(9 October 2012)<br>✓(17 October 2012)<br>✓(27 October 2012) |
| IOTC–2012–WPTT14–09 | Outline of climate and oceanographic conditions in the Indian Ocean over the period 2002–2012 (F. Marsac) | ✓(18 October 2012) |
| IOTC–2012–WPTT14–10 | The evolving Maldivian tuna fishery and its increasing dependence on the anchored FADs (R. Jauharee and M.S. Adam) | ✓(13 October 2012) |
| IOTC–2012–WPTT14–11 Rev_2 | Optimum soak time of tuna longline gear in the Indian Ocean (W. Chen, L. Song, J. Li, W. Xu and D. Li) | ✓(9 October 2012)<br>✓(21 October 2012)<br>✓(24 October 2012) |
| IOTC–2012–WPTT14–12 Rev_1 | Tuna and tuna-like fishes catch in Iran with the emphasis on tropical tuna in Indian Ocean during 2001 to 2011 (M. Akhondi) | ✓(9 October 2012)<br>✓(24 October 2012) |
| IOTC–2012–WPTT14–13 | Data collection protocol of the national longliners at CSP Madagascar (R. Fanazava) | ✓(15 October 2012) |
| IOTC–2012–WPTT14–14 | Spatial distribution and species composition of national longliners catches (R. Fanazava) | ✓(9 October 2012) |
| IOTC–2012–WPTT14–15 Rev_1 | Catch of tropical tuna from licensed foreign and local vessels landed in Mauritius from 2008 to 2011 (T. Sooklall, S.P. Beehary and Z. Dhurmeea) | ✓(9 October 2012)<br>✓(26 October 2012) |
| IOTC–2012–WPTT14–16 Rev_1 | Tropical tunas from foreign tuna fleets unloading in Phuket, Thailand during 1995–2011 (P. Nootmorn, S. Rodpradit, T. Chaiyen and S. Panjarat) | ✓(9 October 2012)<br>✓(24 October 2012) |
| IOTC–2012–WPTT14–17 Rev_1 | Review of Japanese fisheries and tropical tuna catch in the Indian Ocean (T. Matsumoto and K. Satoh) | ✓(9 October 2012)<br>✓(17 October 2012) |
| IOTC–2012–WPTT14–18 Rev_1 | Preliminary analysis of fishing activities of purse seiners fishing in the western Indian Ocean over the period January to June 2012 (C. Assan and V. Lucas) | ✓(12 October 2012)<br>✓(19 October 2012) |
| IOTC–2012–WPTT14–19 | Statistics of the purse seine Spanish fleet in the Indian Ocean (1990–2011) (A. Delgado de Molina, J. Ariz and J. José Areso) | ✓(1 October 2012) |
| IOTC–2012–WPTT14–20 Rev_1 | Statistics of the French purse seine fishing fleet targeting tropical tunas in the Indian Ocean (1981–2011) (E. Chassot, L. Floch, P. Dewals, I. Terrier and P. Chavance) | ✓(5 October 2012)<br>✓(9 October 2012) |
| IOTC–2012–WPTT14–21 Rev_1 | Statistics of the purse seine fleet of the French overseas territories targeting tropical tunas in the Indian Ocean (2001–2011) (E. Chassot, L. Floch, P. Dewals, I. Terrier and P. Chavance) | ✓(5 October 2012)<br>✓(9 October 2012) |
| IOTC–2012–WPTT14–22 Rev_1 | Statistics of the European purse seine fishing fleet and associated flags targeting tropical tunas in the Indian Ocean (1981–2011) (L. Floch, A. Delgado de Molina, C. Assan, P. Dewals, J.J. Areso and E. Chassot) | ✓(9 October 2012)<br>✓(23 October 2012) |

| Document | Title | Availability |
|---|---|---|
| IOTC–2012–WPTT14–23 Rev_1 | Updated growth estimates for skipjack, yellowfin and bigeye tuna in the Indian Ocean using the most recent tag-recapture and otolith data (P. Eveson, J. Million, F. Sardenne and G. Le Croizier) | ✓(9 October 2012)<br>✓(24 October 2012) |
| IOTC–2012–WPTT14–24 Rev_1 | A hierarchical Bayesian integrated model incorporated direct ageing, mark-recapture and length-frequency data for yellowfin (*Thunnus albacares*) and bigeye (*Thunnus obesus*) of the Indian Ocean (E. Dortel, F. Sardenne, G. Le Croizier, J. Million, J.P. Hallier, E. Morize, J.M. Munaron, N. Bousquet and E. Chassot) | ✓(10 October 2012)<br>✓(24 October 2012) |
| **Bigeye tuna** | | |
| IOTC–2012–WPTT14–25 Rev_1 | CPUE standardization for bigeye tuna caught by Korean tuna longline fisheries in the Indian Ocean (1978–2011) (S.I. Lee, Z.G. Kim, M.K Lee, D.W. Lee and T. Nishida) | ✓(9 October 2012)<br>✓(15 October 2012) |
| IOTC–2012–WPTT14–26 Rev_1 | Updated Japanese longline CPUE for bigeye tuna in the Indian Ocean standardized by GLM (K. Satoh and H. Okamoto) | ✓(9 October 2012)<br>✓(17 October 2012) |
| IOTC–2012–WPTT14–27 Rev_2 | CPUE standardizations for bigeye tuna caught by Taiwanese [Taiwan,China] longline fishery in the Indian Ocean using generalized linear model (Y.-M. Yeh and S.-T. Chang) | ✓(9 October 2012)<br>✓(24 October 2012)<br>✓(30 October 2012) |
| **Skipjack tuna** | | |
| IOTC–2012–WPTT14–28 Rev_1 | Challenges and opportunities for standardization of Maldivian skipjack CPUE (S. Adam) | ✓(8 October 2012)<br>✓(22 October 2012) |
| IOTC–2012–WPTT14–29 Rev_1 | Indian Ocean skipjack tuna stock assessment (1950–2011) (Stock Synthesis) (R. Sharma, M. Herrera and J. Million) | ✓(9 October 2012)<br>✓(17 October 2012) |
| **Yellowfin tuna** | | |
| IOTC–2012–WPTT14–30 Rev_1 | Study of the growth and population parameters of yellowfin tuna (*Thunnus albacares*) in the Andaman and Nicobar waters based on the length frequency data (A.B. Kar, L. Ramalingam, K. Govindaraj and G.V.A. Prasad) | ✓(8 October 2012)<br>✓(21 October 2012) |
| IOTC–2012–WPTT14–31 | Determining an appropriate tag mixing period for the Indian Ocean yellowfin tuna stock assessment (A. Langley and J. Million) | ✓(16 October 2012) |
| IOTC–2012–WPTT14–32 Rev_1 | Application of the Brownie-Petersen method for estimating mortality rates and abundance to Indian Ocean yellowfin tuna tag-recapture and catch data (P. Eveson, J. Million and M. Herrara) | ✓(18 October 2012)<br>✓(24 October 2012) |
| IOTC–2012–WPTT14–33 Rev_1 | Decomposing purse seine CPUEs to estimate an abundance index for yellowfin free-swimming schools in the Indian Ocean during 1981–2011 (E. Chassot, L. Dubroca, A. Delgado de Molina, C. Assan, M. Soto, L. Floch and A. Fonteneau) | ✓(19 October 2012)<br>✓(28 October 2012) |
| IOTC–2012–WPTT14–34 Rev_1 | CPUE standardization for yellowfin tuna caught by Korean tuna longline fisheries in the Indian Ocean (1978–2011) (S.I. Lee, Z.G. Kim, M.K Lee, D.W. Lee and T. Nishida) | ✓(9 October 2012)<br>✓(15 October 2012) |
| IOTC–2012–WPTT14–35 Rev_1 | Japanese longline CPUE for yellowfin tuna in the Indian Ocean up to 2011 standardized by general linear model (T. Matsumoto, H. Okamoto and T. Kitakado) | ✓(9 October 2012)<br>✓(17 October 2012) |
| IOTC–2012–WPTT14–36 Rev_2 | CPUE standardizations for yellowfin tuna caught by Taiwanese [Taiwan,China] longline fishery in the Indian Ocean using generalized linear model (Y.-M. Yeh and S.-T. Chang) | ✓(9 October 2012)<br>✓(24 October 2012)<br>✓(30 October 2012) |
| IOTC–2012–WPTT14–37 | An investigation of the sensitivity of the Indian Ocean MFCL yellowfin tuna stock assessment to key model assumptions (A. Langley) | ✓(1 October 2012) |
| IOTC–2012–WPTT14–38 | Stock assessment of yellowfin tuna in the Indian Ocean using MULTIFAN-CL (A. Langley, M. Herrera and J. Million) | ✓(4 October 2012) |
| IOTC–2012–WPTT14–39 Rev_1 | Preliminary stock assessment of yellowfin tuna in the Indian Ocean using SS3 (H. Ijima, K. Sato, T. Matsumoto, T. Nishida and T. Kitakado) | ✓(12 October 2012)<br>✓(28 October 2012) |
| IOTC–2012–WPTT14–40 Rev_2 | Stock and risk assessments on yellowfin tuna (*Thunnus albacares*) in the Indian Ocean based on AD Model Builder implemented Age-Structured Production Model (ASPM) and Kobe I + II software (T. Nishida, R. Rademeyer, H. Ijima, K. Sato, T. Matsumoto, T. Kitakado and A. Fonteneau) | ✓(17 October 2012)<br>✓(23 October 2012)<br>✓(28 October 2012) |
| **Other topics** | | |
| IOTC–2012–WPTT14–41 | Preliminary assessments of tuna mortality rates from a Bayesian Brownie-Petersen model (N. Bousquet, E. Dortel, E. Chassot, J. Million, P. Eveson and J.-P. Hallier) | ✓(15 October 2012) |

| Document | Title | Availability |
|---|---|---|
| IOTC–2012–WPTT14–42 Rev_2 | A comparison of two CPUE calculation methods for longline fishing (L. Song, J. Li, W. Xu, D. Li and W. Chen) | ✓(17 October 2012)<br>✓(19 October 2012)<br>✓(28 October 2012) |
| **Information papers** | | |
| IOTC–2012–WPTT14–INF01 | IOTC SC – Guidelines for the Presentation of Stock Assessment Models | ✓(1 October 2012) |
| IOTC–2012–WPTT14–INF02 | Statistics of the French purse seine fleet targeting tropical tunas in the Indian Ocean during the first semester 2012 (L. Floch, P. Dewals and E. Chassot) | Withdrawn |
| IOTC–2012–WPTT14–INF03 | Preliminary analysis of the dynamics of French fish aggregating devices in the Atlantic and Indian Oceans based on buoys positions (A. Maufroy, E. Chassot and D.M. Kaplan) | Withdrawn |
| IOTC–2012–WPTT14–INF04 | Notes on Presence of 'Other Marine Fish' in Maldives Pole-and-line catch (M.S. Adam and H. Sinan) | ✓(22 October 2012) |
| IOTC–2012–WPTT14–INF05 | Indian Ocean bigeye tuna stock assessment 2013 (A. Langley) | ✓(15 October 2012) |
| IOTC–2012–WPTT14–INF06 | Review and evaluation of recruitment and the stock-recruitment relationship for the assessment and management of yellowfin tuna in the eastern Pacific Ocean (M.N. Maunder and A. Aires-da-Silva) | ✓(16 October 2012) |
| IOTC–2012–WPTT14–INF07 | An exploration of alternative methods to deal with time-varying selectivity in the stock assessment of yellowfin tuna in the eastern Pacific Ocean (A. Aires-da-Silva and M. Maunder) | ✓(16 October 2012) |
| IOTC–2012–WPTT14–INF08 | A review and evaluation of natural mortality for the assessment and management of yellowfin tuna in the eastern Pacific Ocean (M.N. Maunder and A. Aires-da-Silva) | ✓(16 October 2012) |
| IOTC–2012–WPTT14–INF09 | Managing fishing capacity in tuna regional fisheries management organisations (RFMOs): Development and state of the art (M. Aranda, H. Murua and P. de Bruyn) | ✓(22 October 2012) |
| IOTC–2012–WPTT14–INF10 | The Precautionary approach to fisheries management: How this is taken into account by Tuna regional fisheries management organisations (RFMOs) (P. de Bruyn, H. Murua and M. Aranda) | ✓(22 October 2012) |
| IOTC–2012–WPTT14–INF11 Rev_1 | Tuna Fishery in the Indian Ocean by Thai longliners during 2007–2011 (C. Chookong and W. Chumchuen) | ✓(24 October 2012)<br>✓(28 October 2012) |
| IOTC–2012–WPTT14–INF12 | On the period of YFT full mixing? (Anon.) | ✓(25October 2012) |

# APPENDIX IV

# CONSOLIDATED RECOMMENDATIONS OF THE FOURTEENTH SESSION OF THE WORKING PARTY ON TROPICAL TUNAS

***Note: Appendix references refer to the Report of the Fourteenth Session of the Working Party on Tropical Tunas (IOTC–2012–WPTT14–R)***

## *New information on fisheries and associated environmental data relating to tropical tunas*

### Maldives tuna fisheries and anchored FADs

WPTT14.01 (para.26) Noting that the Maldivian skipjack tuna catch is not separated by association type, i.e. aFAD and free schools, and therefore the proportion of skipjack tuna caught under the aFADs around the Maldives is unknown, the WPTT **RECOMMENDED** that the Maldivian data collection system is further improved in order to account for the association of the reported catch, as this could improve the standardisation of the pole-and-line CPUE.

### Other information (Japan and Taiwan,China)

WPTT14.02 (para.68) The WPTT **RECOMMENDED** that Japan and Taiwan,China review catch, effort and size frequency datasets in order to assess reasons for discrepancies identified by the IOTC Secretariat and to report results at the next meeting of the WPTT, including a comparison of length frequency data samples collected from commercial and research and training vessels.

### Review of the statistical data available for bigeye tuna

WPTT14.03 (para.73) The WPTT **NOTED** the main tropical tuna data issues that are considered to negatively affect the quality of the statistics available at the IOTC Secretariat, by type of dataset and fishery, which are provided in Appendix VI, and **RECOMMENDED** that the CPCs listed in the Appendix, make efforts to remedy the data issues identified and to report back to the WPTT at its next meeting.

## *Bigeye tuna*

### Parameters for future analyses: Bigeye tuna CPUE standardisation and stock assessments

WPTT14.04 (para.95) It was noted that the current time frames for data exchange do not allow enough time to conduct thorough stock assessment analyses, and this could have a detrimental effect on the quality of advice provided by the WPTT. Thus, the WPTT **RECOMMENDED** that data exchanges should be made as early as possible, but no later than 45 days prior to a working party meeting, so that CPUE analysis can be provided to the IOTC Secretariat no later than 30 days before a working party meeting.

### Development of technical advice on the status of bigeye tuna

WPTT14.05 (para.97) The WPTT **RECOMMENDED** that the SC note the draft resource stock status summary for bigeye tuna (*Thunnus obesus*) – Appendix VII.

## *Skipjack tuna*

### Skipjack tuna CPUE discussion summary

WPTT14.06 (para.112) The WPTT **RECOMMENDED** further investigation of the existing data irregularities, and expansion of the logbook programme to improve CPUE analyses for skipjack tuna in the Indian Ocean, and for information on these matters to be presented to the next meeting of the WPTT.

WPTT14.07 (para.116) The WPTT **RECOMMENDED** further investigation of the existing data to produce an improved standardised CPUE series for the FAD-associated school skipjack tuna fishery in the Indian Ocean, and for information on these matters to be presented to the next meeting of the WPTT.

### Parameters for future analyses: Skipjack tuna CPUE standardisation and stock assessments

WPTT14.08 (para.136) Noting that the areas used in the various CPUE standardisations undertaken in 2012 varied, the WPTT **AGREED** that there is a need to define core area(s) for each gear (pole-and-line and purse seine) for the CPUE standardisation of skipjack tuna and **RECOMMENDED** that scientists from CPCs with pole-and-line, and purse seine fisheries for skipjack tuna, work together to explore their data and defined such core areas for each gear, well in advance of the next WPTT meeting in 2013.

### Development of technical advice on the status of skipjack tuna

WPTT14.09 (para.142) The WPTT **RECOMMENDED** that the SC note the draft resource stock status summary for skipjack tuna (*Katsuwonus pelamis*) – Appendix VIII.

## *Yellowfin tuna*

### Japanese – Catch-per-unit-of-effort (CPUE)

WPTT14.10 (para.176) The WPTT **NOTED** that the change in gear appears to have had the effect of increasing the ratio of yellowfin tuna in the Japanese longline catch when compared to bigeye tuna. The WPTT also **NOTED** that other factors associated with targeting shifts could be explored in more detail (e.g. NHFCL might not always be the best indicator of hook depth or targeting). Understanding the interactions among NHFCL, fine-scale oceanographic condition, and gear shape under the water might bring further improvement of the CPUE standardization and, thus, the WPTT **RECOMMENDED** further examination of those issues in the future.

### Taiwan,China – Catch-per-unit-of-effort (CPUE)

WPTT14.11 (para.182) **NOTING** that data from Taiwanese vessels flagged to India was not used in the analysis, the WPTT **RECOMMENDED** that national scientists from Taiwan,China work with the IOTC Secretariat to gain a better estimate of catch in the Bay of Bengal.

### MULTIFAN-CL (MFCL)

WPTT14.12 (para.212) The WPTT **THANKED** Mr. Adam Langley (consultant) for his contributions and expertise on integrated stock assessment models, and **RECOMMENDED** that his engagement be renewed for the coming year.

### Parameters for future analyses: Yellowfin tuna CPUE standardisation and stock assessments

WPTT14.13 (para.231) Noting that the areas used in the various CPUE standardisations undertaken in 2012 were very different from one analysis to another, the WPTT **AGREED** that there is a need to define core area(s) for the CPUE standardisation of yellowfin tuna and **RECOMMENDED** that scientists from CPCs with longline and purse seine fisheries for yellowfin tuna, work together to explore their data and defined such core areas, well in advance of the next WPTT meeting in 2013.

### Development of technical advice on the status of yellowfin tuna

WPTT14.14 (para.233) The WPTT **RECOMMENDED** that the SC note the draft resource stock status summary for yellowfin tuna (*Thunnus albacares*) – Appendix IX.

## *Analysis of the Time-Area Closures (including Resolution 12/13)*

WPTT14.15 (para.246) **NOTING** that the objective of Resolution 12/13 is to decrease the overall pressure on the main targeted stocks in the Indian Ocean, in particular yellowfin tuna and bigeye tuna, and also to evaluate the impact of the current time/area closure and any alternative scenarios on tropical tuna population, the WPTT reiterated its previous **RECOMMENDATION** that the SC request that the Commission specify the level of reduction or the long term management objectives to be achieved with the current or alternative time area closures, as these are not contained within Resolution 12/13.

## *Effect of Piracy on Tropical Tuna Catches*

WPTT14.16 (para.251) The WPTT **RECOMMENDED** that given the potential impacts of piracy on fisheries in other areas of the Indian Ocean through the relocation of longliners to other fishing grounds, specific analysis should be carried out and presented at the next WPTT meeting by CPCs most affected by these activities, including Japan, Rep. of Korea and Taiwan,China. For example, longline fishing effort has been redistributed to traditional albacore fishing grounds in recent years, thereby further increasing fishing pressure on the albacore stock (see IOTC–2012–WPTmT–R).

### *Research Recommendations and Priorities*

#### CPUE standardisation

WPTT14.17 (para.256) **NOTING** that nominal juvenile purse seine CPUE, once standardised, can be used as an indicator of the recruitment index in the stock assessment models, the WPTT **RECOMMENDED** that the standardised CPUE index for juvenile yellowfin tuna and bigeye tuna caught by the EU purse seiner fleets, be estimated and submitted to the WPTT before the next round of stock assessments of tropical tunas.

WPTT14.18 (para.257) The WPTT **RECOMMENDED** that standardisation of purse seine CPUE be made where possible using the operational data on the fishery.

#### Stock assessment

WPTT14.19 (para.259) Noting the difficulty of carrying out stock assessments for three tropical tuna species in a single year, the WPTT **RECOMMENDED** a revised assessment schedule on a two- or three-year cycle for the three tropical tuna species as outlined in Table 17. Following the uncertainty remaining in the bigeye tuna assessment carried out for the previous WPTT meetings in 2010 and 2011, the WPTT **AGREED** that bigeye tuna would be the priority species for stock assessments in 2013. Only stock status indictors (i.e standardised CPUE series) should be updated for skipjack tuna and yellowfin tuna.

### *Other Business*

#### Review of the 'Guidelines for the Presentation of Stock Assessment Models'

WPTT14.20 (para.263) The WPTT **RECOMMENDED** that the IOTC Secretariat work with interested scientists to develop a draft revised set of "*Guidelines for the Presentation of Stock Assessment Models*" for the consideration of the SC in December 2012.

#### Development of priorities for an Invited Expert at the next WPTT meeting

WPTT14.21 (para.265) The WPTT **RECOMMENDED** the following core areas of expertise and priority areas for contribution that need to be enhanced for the next meeting of the WPTT in 2013, by an Invited Expert:

- CPUE analysis and standardisation
- Tuna tagging data analysis
- Tuna stock assessment models

Where possible the Invited Expert should attend both the CPUE workshop and the Working Party in 2013, noting that Invited Experts are unpaid.

#### Review of the draft, and adoption of the Report of the Fourteenth Session of the WPTT

WPTT14.22 (para.271) The WPTT **RECOMMENDED** that the SC consider the consolidated set of recommendations arising from WPTT14, provided at Appendix IV.

# APPENDIX V
# STATISTICS FOR TROPICAL TUNAS

*Extract from IOTC–2012–WPTT14–07*

## Effort trends

The recent total effort from longline vessels flagged to Japan, Taiwan,China and other CPCs by five degree square grid (Fig. 1), and total effort from purse seine vessels flagged to the European Union (operating under flags of EU countries), French territories and Seychelles, and others, by five degree square grid and main fleets (Fig. 2).

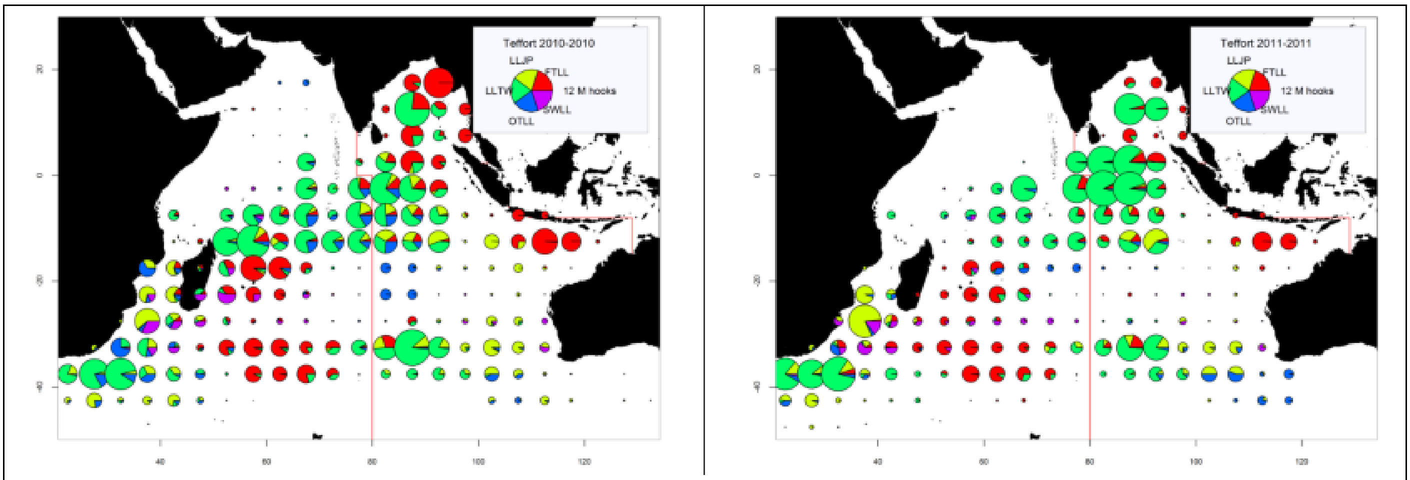

**Fig. 1** Number of hooks set (millions) from longline vessels by five degree square grid and main fleets, for the years 2010 and 2011 (Data as of September 2012).

LLJP (light green): deep-freezing longliners from Japan
LLTW (dark green): deep-freezing longliners from Taiwan,China
SWLL (turquoise): swordfish longliners (Australia, EU, Mauritius, Seychelles and other fleets)
FTLL (red) : fresh-tuna longliners (China, Taiwan,China and other fleets)
OTLL (blue): Longliners from other fleets (includes Belize, China, Philippines, Seychelles, South Africa, South Korea and various other
fleets)

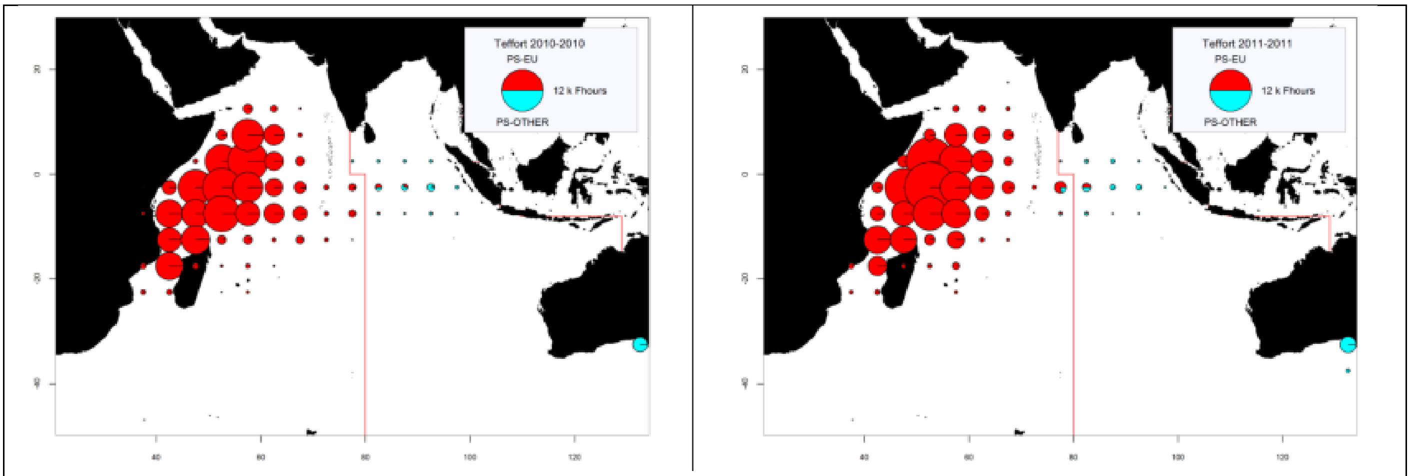

**Fig. 2.** Number of hours of fishing (Fhours) in thousands (k), from purse seine vessels by 5 degree square grid and main fleets, for the years 2010 and 2011 (Data as of September 2012).

PS-EU (red): Industrial purse seiners monitored by the EU and Seychelles (operating under flags of EU countries, Seychelles and other flags)
PS-OTHER (green): Industrial purse seiners from other fleets (includes Japan, Mauritius and purse seiners of Soviet origin) (excludes effort data for purse seiners of Iran and Thailand)

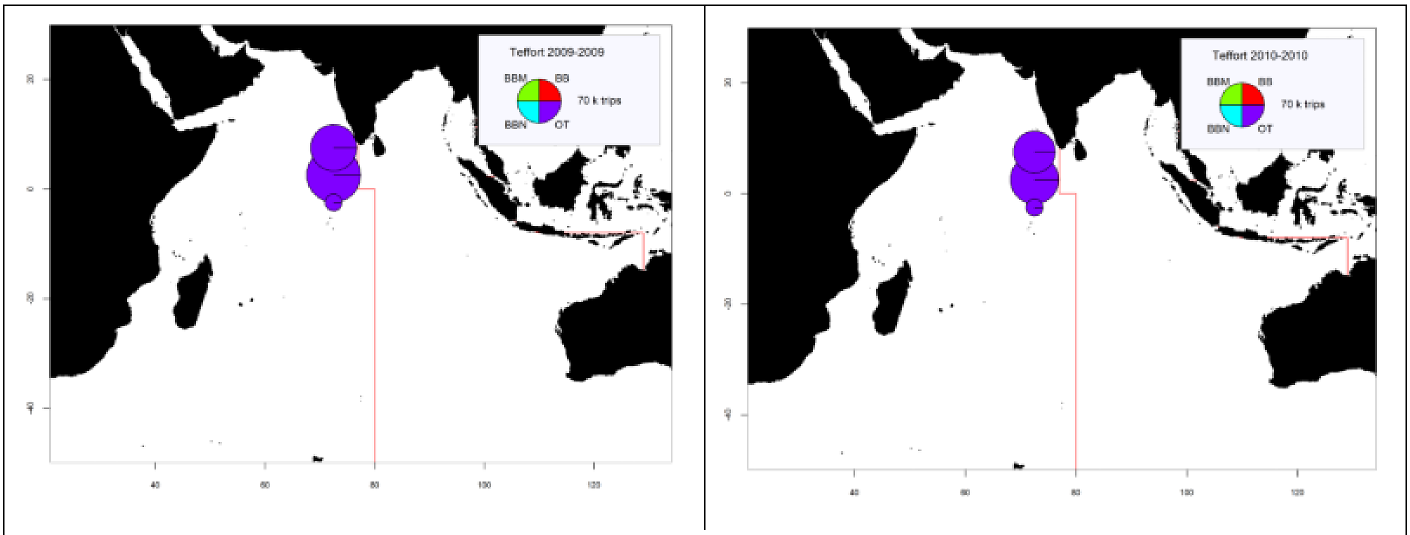

**Fig. 3.** Number of trips (equivalent to fishing days) in thousands (k), from pole-and-line vessels by 5 degree square grid and main fleets, for the years 2009 and 2010 (Data as of September 2012).

BBM (green): Pole-and-line (mechanized baitboats)
BBN (blue): Pole-and-line (non-mechanized baitboats)
BB (red): Pole-and-line (all baitboats, especially mechanized)
OT (purple): Pole-and-line and other gears unidentified

## Bigeye tuna (*Thunnus obesus*)

### *Bigeye tuna – Fisheries and catch trends*

Bigeye tuna is mainly caught by industrial longline (59% in 2011) and purse seine (26% in 2011) fisheries, with the remaining 15% of the catch is taken by other fisheries (Table 1; Fig. 1). However, in recent years the catches of bigeye tuna by gillnet fisheries are likely to be higher, due to the major changes experienced in some of these fleets, notably changes in boat size, fishing techniques and fishing grounds, with vessels using deeper gillnets on the high seas, in areas where catches of bigeye tuna are high.

Total annual catches have increased steadily since the start of the fishery, reaching the 100,000 t level in 1993 and peaking at 150,000 t in 1999 (Fig. 1). Catches dropped since then to values between 120,000–140,000 t (2000–07), further dropping in recent years, to values under 90,000 t in recent years (2010–11). The SC believes that the recent drop in catches could be related, at least in part, with the expansion of piracy in the northwest Indian Ocean, which has led to a marked drop in the levels of longline effort in the core fishing area of these species.

**Table 1.** Bigeye tuna: Best scientific estimates of the catches of bigeye tuna (*Thunnus obesus*) by gear and main fleets [or type of fishery] by decade (1950–2009) and year (2002–2011), in tonnes. Data as of September 2012. Catches by decade represent the average annual catch, noting that some gears were not used for all years (refer to Fig. 1).

| Fishery | By decade (average) | | | | | | By year (last ten years) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1950s | 1960s | 1970s | 1980s | 1990s | 2000s | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
| LL | 6,488 | 21,970 | 30,462 | 45,940 | 88,106 | 93,721 | 109,895 | 104,613 | 113,940 | 94,094 | 90,668 | 93,493 | 69,947 | 66,761 | 46,371 | 51,587 |
| FS | 0 | 0 | 0 | 2,067 | 4,808 | 6,042 | 4,099 | 7,172 | 3,658 | 8,501 | 6,406 | 5,670 | 9,648 | 5,317 | 3,827 | 6,172 |
| LS | 0 | 0 | 0 | 4,234 | 18,224 | 20,147 | 24,944 | 15,662 | 18,749 | 17,568 | 18,249 | 18,066 | 19,831 | 24,773 | 18,440 | 16,636 |
| OT | 146 | 262 | 567 | 1,449 | 2,086 | 4,560 | 2,236 | 2,306 | 2,257 | 2,618 | 5,467 | 5,912 | 8,620 | 11,868 | 12,228 | 13,024 |
| **Total** | 6,634 | 22,231 | 31,030 | 53,690 | 113,225 | 124,470 | 141,174 | 129,753 | 138,604 | 122,782 | 120,791 | 123,141 | 108,047 | 108,719 | 80,866 | 87,420 |

Longline (**LL**); Purse seine free-school (**FS**); Purse seine associated school (**LS**); Other gears nei (**OT**).

Bigeye tuna have been caught by industrial longline fleets since the early 1950's, but before 1970 they only represented an incidental catch (Fig. 2). After 1970, the introduction of fishing practices that improved catchability of the bigeye tuna resource, combined with the emergence of a sashimi market, resulted in bigeye tuna becomes a primary target species for the main industrial longline fleets. Total catch of bigeye tuna by longliners in the Indian Ocean increased steadily from the 1970's attaining values over 90,000 t between 1996 and 2007, and dropping markedly thereafter (Fig. 1). Bigeye tuna catches in recent years have been low representing less than half the catches of bigeye tuna recorded before the onset of piracy in the Indian Ocean. Since the late 1980's Taiwan,China has been the major longline fleet fishing for bigeye tuna in the Indian Ocean, taking as much as 40% of the total longline catch in the Indian Ocean (Fig. 2). However, the catches of longliners from Taiwan,China have decreased in recent years, with current catches of bigeye tuna (≈20,000 t) three times lower than those in 2003. Large bigeye tuna (averaging just above 40 kg) are primarily caught by longlines, in particular deep longlines.

Since the late 1970's, bigeye tuna has been caught by purse seine vessels fishing on tunas aggregated on floating objects and, to a lesser extent, associated to free swimming schools (Fig. 1) of yellowfin tuna or skipjack tuna. The highest catch of bigeye tuna by purse seiners in the Indian Ocean was recorded in 1999 (≈40,000 t). Catches since 2000 have been between 20,000 and 30,000 t. Purse seiners under flags of EU countries and Seychelles take the majority of purse seine caught bigeye tuna in the Indian Ocean (Fig. 2). Purse seiners mainly take small juvenile bigeye (averaging around 5 kg) whereas longliners catch much larger and heavier fish; and while purse seiners take lower tonnages of bigeye tuna compared to longliners, they take larger numbers of individual fish. Even though the activities of purse seiners have been affected by piracy in the Indian Ocean, the impacts have not been as marked as for longline fleets. The main reason for this is the presence of security personnel onboard purse seine vessels of the EU and Seychelles, which has made it possible for purse seiners under these flags to continue operating in the northwest Indian Ocean (Fig. 3).

By contrast with yellowfin tuna and skipjack tuna, for which the major catches are taken in the western Indian Ocean, bigeye tuna is also exploited in the eastern Indian Ocean (Fig. 3). The relative increase in catches in the eastern Indian Ocean in the late 1990's was mostly due to increased activity of small longliners fishing tuna to be marketed fresh. This fleet started its operation in the mid 1970's (Fig. 2, Indonesia). However, the catches of bigeye tuna in the eastern Indian Ocean have shown a decreasing trend in recent years, as some of the vessels moved south to target albacore.

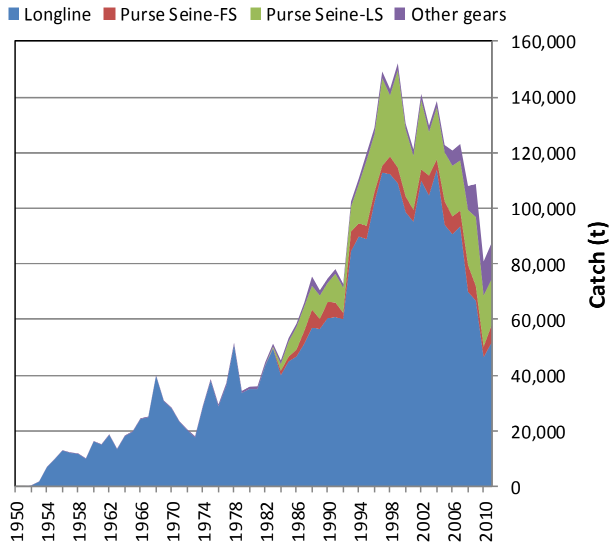

**Fig. 1.** Bigeye tuna: Annual catches of bigeye tuna by gear (1950–2011). Data as of September 2012.

**Fig. 2.** Bigeye tuna: Annual catches of bigeye tuna by fleet (1950–2011). Data as of September 2012.

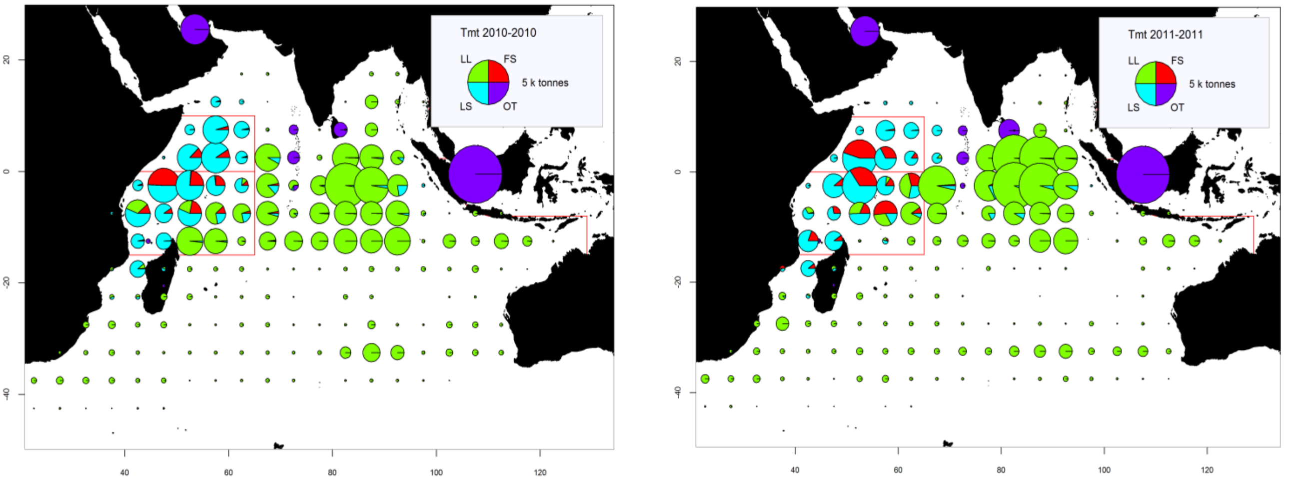

**Fig. 3.** Bigeye tuna: Time-area catches (total combined in tonnes) of bigeye tuna estimated for 2010 (left) and 2011 (right) by gear. Longline (**LL**), Purse seine free-schools (**FS**), Purse seine associated-schools (**LS**), and other fleets (**OT**), including pole-and-line, drifting gillnets, and various coastal fisheries. Data as of September 2012. The catches of fleets for which the flag countries do not report detailed time and area data to the IOTC are recorded within the area of the countries concerned, in particular driftnets from Iran, gillnet and longline fishery of Sri Lanka, and coastal fisheries of Indonesia.

### *Bigeye tuna – uncertainty of catches*

**Retained catches:** Thought to be well known for the major fleets (Fig. 4) but are less certain for non-reporting industrial purse seiners and longliners (NEI) and for other industrial fisheries (longliners of India and Philippines). Catches are also uncertain for some artisanal fisheries including the pole-and-line fishery in the Maldives, the gillnet fisheries of Iran and Pakistan, the gillnet and longline combination fishery in Sri Lanka and the artisanal fisheries in Indonesia, Comoros and Madagascar.

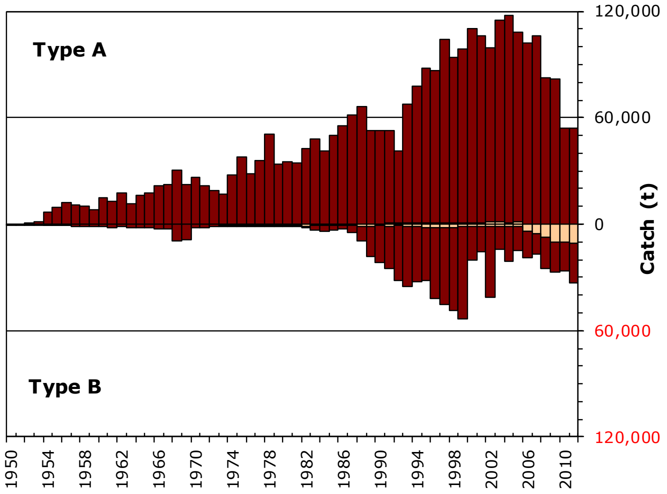

**Fig. 4.** Bigeye tuna: Uncertainty of annual catch estimates for bigeye tuna (Data as of September 2012). Catches below the zero-line (**Type B**) refer to fleets that do not report catch data to the IOTC (estimated by the IOTC Secretariat), do not report catch data by gear and/or species (broken by 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:** Believed to be low although they are unknown for most industrial fisheries, excluding industrial purse seiners flagged in EU countries for the period 2003–07.

**Changes to the catch series:** There have not been significant changes to the catches of bigeye tuna since the WPTT in 2011.

**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)
- no data are available for the fresh-tuna longline fishery of Indonesia, over the entire time series, and data for the fresh-tuna longline fishery of Taiwan,China are only available since 2006
- uncertain data from significant fleets of industrial purse seiners from Iran and longliners from India, Indonesia, Malaysia, Oman, and Philippines.
- No data available for the driftnet fisheries of Iran and Pakistan and the gillnet/longline fishery of Sri Lanka, especially in recent years.

***Bigeye tuna: Fish size or age trends (e.g. by length, weight, sex and/or maturity)***

**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) (Fig. 5).

**Catch-at-Size table**: This is available but the estimates are more uncertain 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 and Taiwan,China)
- the paucity of catch by area data available for some industrial fleets (NEI, India, Indonesia, Iran, Sri Lanka).

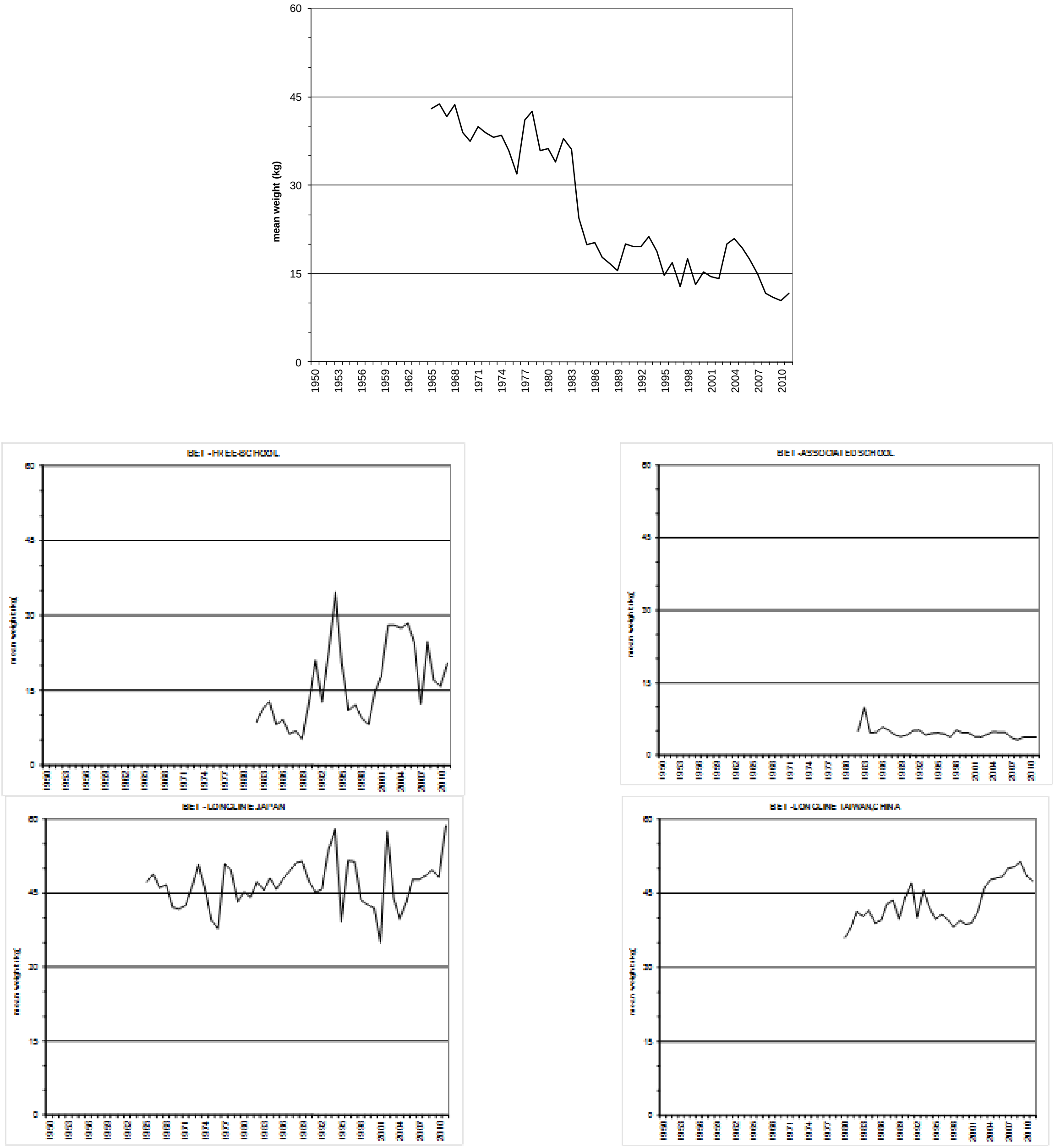

**Fig. 5.** Bigeye tuna: Changes in average weight (kg) of bigeye tuna from 1950 to 2010 – all fisheries combined (top) and by main fleet (Data as of September 2012).

### *Bigeye tuna – tagging data*

A total of 35,997 bigeye tuna (17.9%) were tagged during the Indian Ocean Tuna Tagging Programme (IOTTP). Most of them (96.0%) were tagged during the main Regional Tuna Tagging Project-Indian Ocean (RTTP-IO) and released off the coast of Tanzania in the western Indian Ocean, between May 2005 and September 2007 (Fig. 6). The remaining were tagged during small-scale projects, and by other institutions with the support of the IOTC Secretariat, in the Maldives, Indian, and in the south west and the eastern Indian Ocean. To date, 5,740, (15.9%), have been recovered and reported to the IOTC Secretariat. These tags were mainly reported from the purse seine fleets operating in the Indian Ocean (91.5%), while 4.9% were recovered from longline vessels.

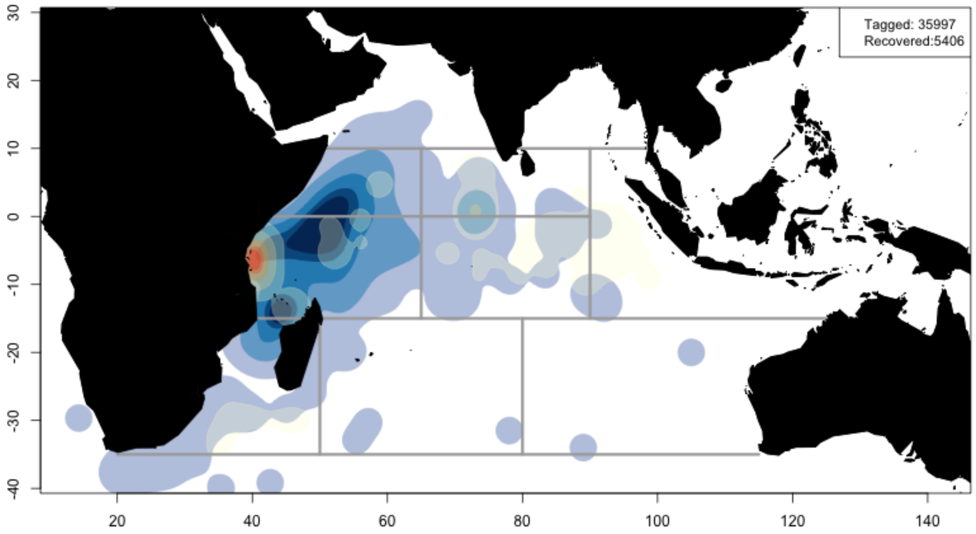

**Fig. 6.** Bigeye tuna: Densities of releases (in red) and recoveries (in blue). Data as of September 2012.

## Skipjack tuna (*Katsuwonus pelamis*)

### *Skipjack tuna: Fisheries and catch trends*

Catches of skipjack increased slowly from the 1950s, reaching around 50,000 t during the mid-1970s, mainly due to the activities of fleets using pole-and-lines and gillnets (Table 2; Fig. 7). The catches increased rapidly with the arrival of the purse seiners in the early 1980s, and skipjack became one of the most important commercial tuna species in the Indian Ocean. Annual catches peaked at over 600,000 t in 2006 (Fig. 7). Though preliminary, the catch levels estimated for 2011, at around 400,000 t, represent the lowest catches recorded since 1998.

The increase in skipjack tuna catches by purse seiners (Table 2; Fig. 8) is due to the development of a fishery in association with Fish Aggregating Devices (FADs). In recent years, 85% of the skipjack tuna caught by purse seine vessels is taken from around FADs (Table 2; Fig. 7). Catches by purse seiners increased steadily since 1984 with the highest catches recorded in 2002 and 2006 (>240,000 t). The catches dropped in the years 2003 and 2004, probably as a consequence of high purse seine catch rates on free schools of yellowfin tuna during those years. In 2007 purse seine catches declined by around 100,000 t, from those taken in 2006. The constant increase in catches and catch rates of purse seiners until 2006 are believed to be associated with increases in fishing power and in the number of FADs (and the technology associated with them) used in the fishery. The sharp decline in purse seine catches since 2007coincided with a similar decline in the catches by Maldivian baitboats.

**Table 2.** Skipjack tuna: Best scientific estimates of the catches of skipjack tuna (*Katsuwonus pelamis*) by gear and main fleets [or type of fishery] by decade (1950–2009) and year (2002–2011), in tonnes. Data as of September 2012. Catches by decade represent the average annual catch, noting that some gears were not used for all years (refer to Fig. 7).

| Fishery | By decade (average) | | | | | | By year (last ten years) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1950s | 1960s | 1970s | 1980s | 1990s | 2000s | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
| BB | 9,497 | 13,368 | 22,797 | 40,538 | 77,729 | 111,118 | 124,300 | 116,672 | 114,567 | 140,346 | 147,391 | 106,509 | 98,819 | 77,555 | 69,032 | 69,032 |
| FS | | | | 1,626 | 1,602 | 897 | 22,801 | 30,992 | 18,565 | 43,123 | 34,954 | 24,198 | 16,277 | 10,458 | 8,853 | 8,906 |
| LS | | | | 3,776 | 8,147 | 13,385 | 215,781 | 180,556 | 137,882 | 168,012 | 211,940 | 120,925 | 128,596 | 148,717 | 144,139 | 123,012 |
| OT | 6,596 | 16,809 | 30,752 | 52,490 | 101,765 | 185,519 | 137,693 | 172,988 | 204,444 | 195,670 | 223,817 | 211,689 | 205,587 | 208,144 | 199,899 | 197,291 |
| **Total** | **16,093** | **30,177** | **53,549** | **98,430** | **189,244** | **310,918** | **500,575** | **501,209** | **475,457** | **547,151** | **618,102** | **463,321** | **449,278** | **444,874** | **421,923** | **398,240** |

Pole-and-Line (**BB**); Purse seine free-school (**FS**); Purse seine associated school (**LS**); Other gears nei (**OT**).

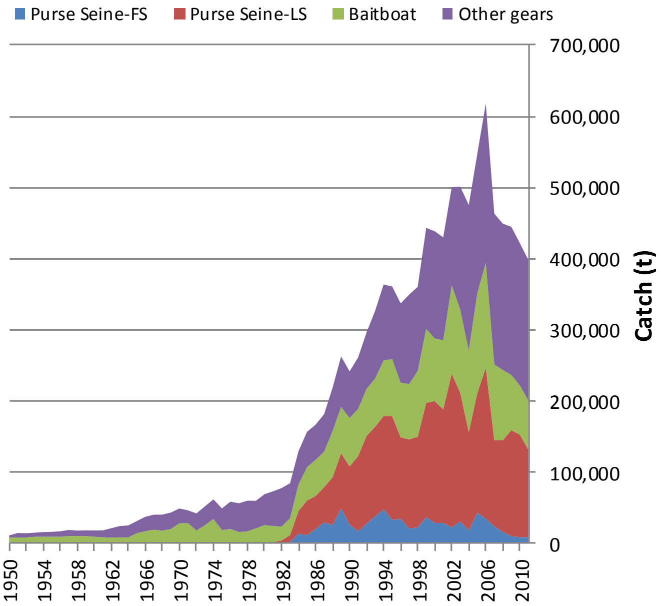

**Fig. 7.** Skipjack tuna: Annual catches of skipjack tuna by gear (1950–2011). Data as of September 2012.

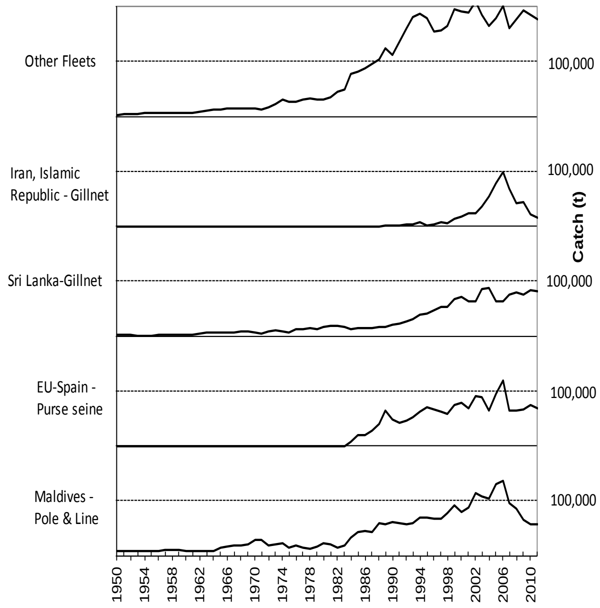

**Fig. 8.** Skipjack tuna: Catches of skipjack tuna by fleet by year (1950–2011). Data as of September 2012.

The Maldivian fishery (Fig. 8) has effectively increased its fishing effort with the mechanisation of its pole-and-line fleet since 1974, including an increase in boat size and power and the use of anchored FADs since 1981. Skipjack tuna represents some 75% of its total catch, and catch rates regularly increased between 1980 and 2006, the year in which the maximum catch was recorded for this fishery (≈135,000 t). The catches of skipjack tuna have declined since, with catches in recent years estimated to be at around 55,000 t, representing less than half the catches taken in 2006.

Several fisheries using gillnets have reported large catches of skipjack tuna in the Indian Ocean (Fig. 7), including the gillnet/longline fishery of Sri Lanka, driftnet fisheries of Iran and Pakistan, and gillnet fisheries of India and Indonesia. In recent years gillnet catches have represented as much as 20 to 30 % of the total catches of skipjack tuna in the Indian Ocean. Although it is known that vessels from Iran and Sri Lanka (Fig. 8) have been using gillnets on the high seas in recent years, reaching as far as the Mozambique Channel, the activities of these fleets are poorly understood, as no time-area catch-and-effort series have been made available for those fleets to date.

The majority of the catches of skipjack tuna originate from the western Indian Ocean (Fig. 9). Since 2007 the catches of skipjack tuna in the western Indian Ocean have dropped considerably, especially in areas off Somalia, Kenya, Tanzania and around the Maldives. The drop in catches are considered by the SC to be partially explained by the drop in catch rates and fishing effort by some fisheries due to the effects of piracy in the western Indian Ocean region, including all industrial purse seiners and fleets using driftnets from Iran

(Fig. 8) and Pakistan; and the drop in the catches of skipjack tuna by Maldives baitboats (Fig. 8) following the introduction of handlines to target large specimens of yellowfin tuna.

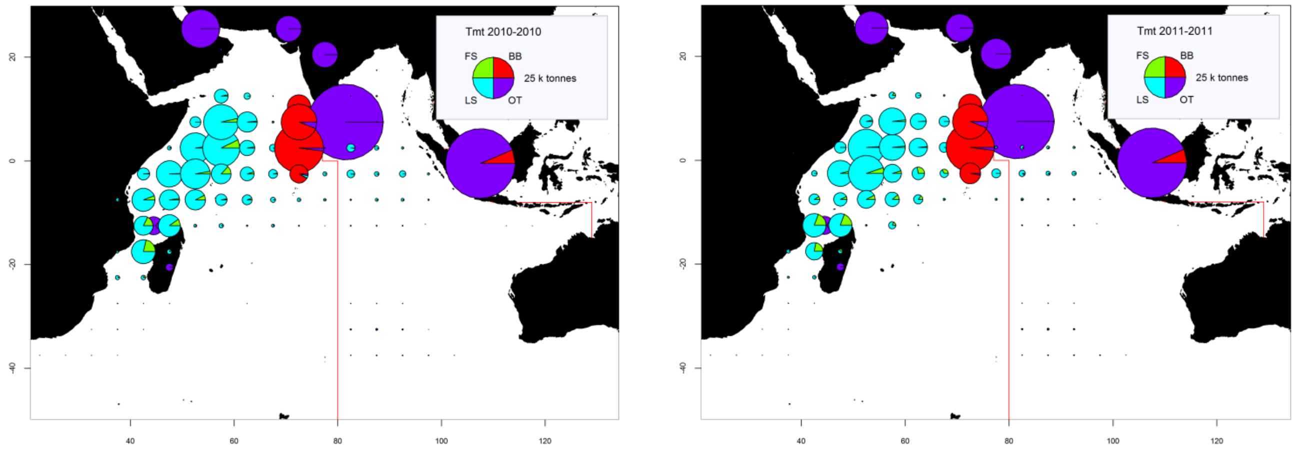

**Fig. 9.** Skipjack tuna: Time-area catches (total combined in tonnes) of skipjack tuna estimated for 2010 (left) ad 2011 (right) by gear.

Purse seine free-schools (**FS**), Purse seine associated-schools (**LS**), pole-and-line (BB), and other fleets (**OT**), including longline, drifting gillnets, and various coastal fisheries. Data as of September 2012. The catches of fleets for which the flag countries do not report detailed time and area data to the IOTC are recorded within the area of the countries concerned, in particular driftnets from Iran and Pakistan, gillnet and longline fishery of Sri Lanka, and coastal fisheries of Comoros, Indonesia and India.

### *Skipjack tuna – uncertainty of catches*

**Retained catches:** Generally well known for the industrial fisheries but are less certain for many artisanal fisheries (Fig. 10), notably because:

- catches are not being reported by species
- there is uncertainty about the catches from some significant fleets including the coastal fisheries of Sri Lanka, Comoros and Madagascar.

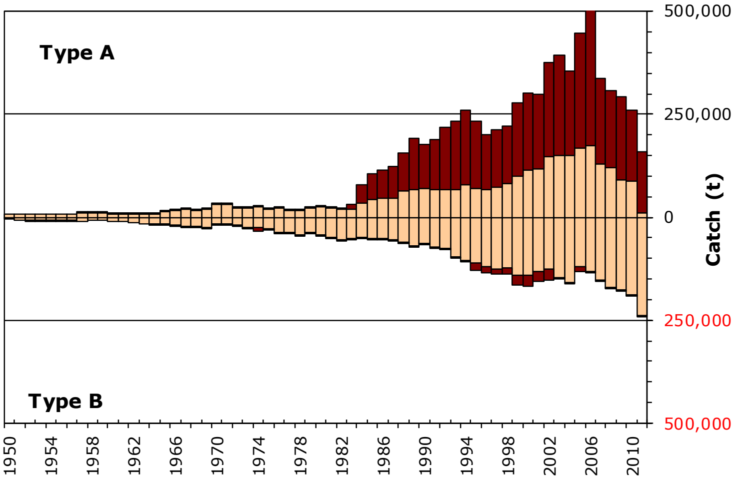

**Fig. 10.** Skipjack tuna: Uncertainty of annual catch estimates for skipjack tuna (Data as of September 2012). Catches below the zero-line (**Type B**) refer to fleets that do not report catch data to the IOTC (estimated by the IOTC Secretariat), do not report catch data by gear and/or species (broken 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:** Believed to be low although they are unknown for most industrial fisheries, excluding industrial purse seiners flagged in EU countries for the period 2003–07.

**Changes to the catch series:** There have been no major changes to the catches of skipjack tuna, as a whole, since the WPTT in 2011. However, the IOTC Secretariat used new information compiled during 2011-12 to rebuild the catch series for the coastal fisheries operated in some countries, in particular Madagascar, Sri Lanka, and India. In general, the new catches of skipjack tuna estimated by the IOTC Secretariat are lower than those used in the past by the WPTT.

**CPUE Series**: Catch and effort data are available from various industrial and artisanal fisheries. However, these data are not available from some 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 gillnet/longline fishery of Sri Lanka
- no data are available from important coastal fisheries using hand and/or troll lines, in particular Indonesia, India, Madagascar and Comoros.

***Skipjack tuna: Fish size or age trends (e.g. by length, weight, sex and/or maturity)***

**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) (Fig. 11).

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

- 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).

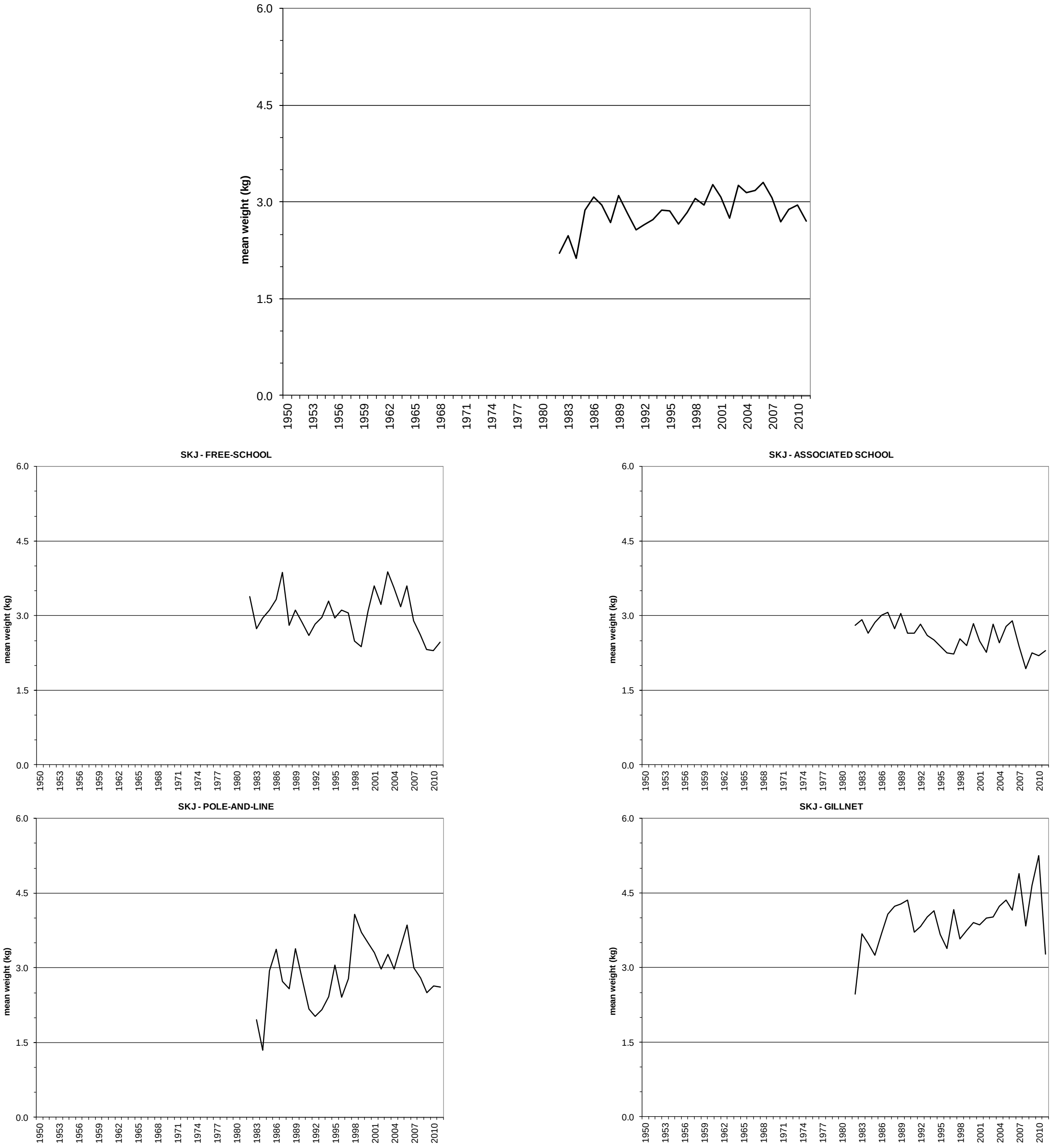

**Fig. 11.** Skipjack tuna: Changes in average weight (kg) of skipjack tuna from 1950 to 2011 – all fisheries combined (top) and by main fleet (Data as of September 2012).

### *Skipjack tuna – Tagging data*

A total of 101,212 skipjack (representing 50.2% of the total number of fish tagged) were tagged during the Indian Ocean Tuna Tagging Programme (IOTTP). Most of them, 77.4%, were released during the main Regional Tuna Tagging Project-Indian Ocean (RTTP-IO) and were released around Seychelles, in the Mozambique Channel and off the coast of Tanzania, between May 2005 and September 2007 (Fig. 12). The remaining were tagged during small-scale tagging projects, and by other institutions with the support of IOTC, around the Maldives, India, and in the south west and the eastern Indian Ocean. To date, 15,729 (15.5%), have been recovered and reported to the IOTC Secretariat. Around 78% of the recoveries were from the purse seine fleets operating from the Seychelles, and around 20% by the pole-and-line vessels mainly operating from the Maldives. The addition of the data from the past projects in the Maldives (in 1990s) added 14,506 tagged skipjack tuna to the databases, or which 1,960 were recovered mainly in the Maldives.

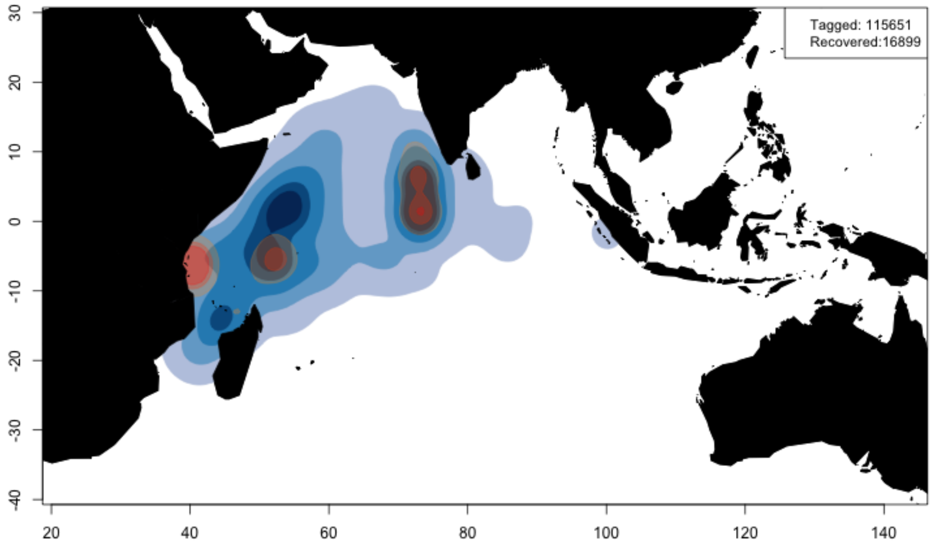

**Fig. 12**. Skipjack tuna: Densities of releases (in red) and recoveries (in blue). Data as of September 2012.

## Yellowfin tuna *(Thunnus albacares)*

### *Yellowfin tuna – Fisheries and catch trends*

Catches by gear, area, country and year from 1950 to 2011 are shown in Figs. 13, 14 and 15. Contrary to the situation in other oceans, the artisanal fishery component in the Indian Ocean is substantial, taking 20–30% of the total catch. Catches of yellowfin tuna remained more or less stable between the mid-1950s and the early-1980s, ranging between 30,000 and 70,000 t, owing to the activities of longliners and, to a lesser extent, gillnetters. The catches increased rapidly with the arrival of the purse seiners in the early 1980s and increased activity of longliners and other fleets, reaching over 400,000 t in 1993 (Table 3; Fig. 13). Catches of yellowfin tuna between 1994 and 2002 remained stable, between 330,000 and 350,000 t. Yellowfin tuna catches during 2003, 2004, 2005 and 2006 were much higher than in previous years with the highest catches ever recorded in 2004 (over 520,000 t) and average annual catch for the period at around 470,000 t. Yellowfin tuna catches dropped markedly after 2006, with the lowest catches recorded in 2009. Catch levels in 2011 are estimated to be at around 300,000 t, although they represent preliminary figures.

**Table 3.** Yellowfin tuna: Best scientific estimates of the catches of yellowfin tuna (*Thunnus albacares*) by gear and main fleets [or type of fishery] by decade (1950–2009) and year (2002–2011), in tonnes. Data as of September 2012. Catches by decade represent the average annual catch, noting that some gears were not used for all years (refer to Fig. 21).

| Fishery | By decade (average) | | | | | | By year (last ten years) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1950s | 1960s | 1970s | 1980s | 1990s | 2000s | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
| FS | | | 18 | 32590 | 64942 | 89761 | 77,058 | 137,492 | 168,799 | 124,024 | 85,021 | 53,529 | 74,990 | 36,263 | 32,022 | 36,591 |
| LS | | | 17 | 18090 | 56304 | 61909 | 61,934 | 86,585 | 59,597 | 69,873 | 74,454 | 43,843 | 41,453 | 51,565 | 73,387 | 76,460 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LL | 21990 | 41257 | 29513 | 33889 | 66689 | 57032 | 53,125 | 55,727 | 86,597 | 117,324 | 70,388 | 51,240 | 25,973 | 20,014 | 18,139 | 19,027 |
| LF | | | 615 | 4286 | 47570 | 32955 | 34,425 | 31,290 | 31,303 | 34,083 | 30,741 | 30,642 | 29,675 | 22,776 | 24,390 | 26,152 |
| BB | 1795 | 1490 | 4693 | 6830 | 11005 | 15675 | 17,291 | 17,150 | 15,686 | 16,235 | 17,302 | 15,569 | 17,975 | 16,719 | 12,755 | 12,755 |
| GI | 2376 | 6838 | 11395 | 18560 | 54805 | 74081 | 57,363 | 82,354 | 101,902 | 85,053 | 88,414 | 68,543 | 73,437 | 70,918 | 91,722 | 85,754 |
| HD | 681 | 1170 | 2660 | 6823 | 18854 | 31346 | 33,857 | 31,379 | 39,337 | 36,824 | 30,126 | 30,438 | 30,036 | 24,914 | 20,600 | 20,612 |
| TR | 630 | 1066 | 3185 | 5489 | 10366 | 17929 | 13,828 | 13,272 | 19,824 | 14,545 | 17,299 | 22,238 | 28,225 | 24,271 | 24,545 | 24,909 |
| OT | 118 | 130 | 497 | 686 | 851 | 1165 | 670 | 1,170 | 1,581 | 1,286 | 1,546 | 1,228 | 1,564 | 1,036 | 747 | 679 |
| **Total** | **27,589** | **51,951** | **52,593** | **127,242** | **331,386** | **381,854** | **349,551** | **456,419** | **524,626** | **499,247** | **415,291** | **317,270** | **323,328** | **268,476** | **298,307** | **302,939** |

Purse seine free-school (**FS**); Purse seine associated school (**LS**); Deep-freezing longline (**LL**); Fresh-tuna longline (**LF**); Pole-and-Line (**BB**); Gillnet (**GI**); Hand line (**HD**); Trolling (**TR**); Other gears nei (**OT**).

Although some Japanese purse seiners have fished in the Indian Ocean since 1977, the purse seine (Figs. 13 and 14) fishery developed rapidly with the arrival of European vessels between 1982 and 1984. Since then, there has been an increasing number of yellowfin tuna caught, with a larger proportion of the catches made of adult fish, as opposed to bigeye tuna catches, of which the majority refers to juvenile fish. Purse seine vessels typically take fish ranging from 40 to 140 cm fork length (FL) and smaller fish are more common in the catches taken north of the equator. Catches of yellowfin tuna increased rapidly to around 130,000 t in 1993, and subsequently they fluctuated around that level, until 2003–05 when they were substantially higher (over or close to 200,000 t). The amount of effort exerted by the EU purse seine vessels (fishing for yellowfin tuna and other tunas) varies seasonally and from year to year.

The purse seine fishery is characterised by the use of two different fishing modes (Table 3; Fig. 13). The fishery on floating objects (FADs), which catches large numbers of small yellowfin tuna in association with skipjack tuna and juvenile bigeye tuna, and a fishery on free swimming schools, which catches larger yellowfin tuna on multi-specific or mono-specific sets. Between 1995 and 2003, the FAD component of the purse seine fishery represented 48–66% of the sets undertaken (60–80% of the positive sets) and accounted for 36–63% of the yellowfin tuna catch by weight (59–76% of the total catch). The proportion of yellowfin tuna caught (in weight) on free-schools during 2003–06 (64%) was much higher than in previous or following years (at around 50%).

The longline fishery (Table 3; Figs. 13 and 14) started in the early 1950’s and expanded rapidly over throughout the Indian Ocean. Longline gear mainly catches large fish, from 80 to 160 cm FL, although smaller fish in the size range 60 – 100 cm (FL) have been taken by longliners from Taiwan,China since 1989 in the Arabian Sea. The longline fishery targets several tuna species in different parts of the Indian Ocean, with yellowfin tuna and bigeye tuna being the main target species in tropical waters. The longline fishery can be subdivided into a deep-freezing longline component (large scale deep-freezing longliners operating on the high seas from Japan, Korea and Taiwan,China) and a fresh-tuna longline component (small to medium scale fresh tuna longliners from Indonesia and Taiwan,China). The total longline catch of yellowfin tuna reached a maximum in 1993 (≈200,000 t). Catches between 1994 and 2004 fluctuated between 85,000 t and 120,000 t. The second highest catches of yellowfin tuna by longliners were recorded in 2005 (≈150,000 t). As was the case for the purse seine fleets, since 2005 longline catches have declined with current catches estimated to be at around 45,000 t, representing a three-fold decrease from the catches taken in 2005. The SC believes that the recent drop in longline catches could be related, at least in part, with the expansion of piracy in the northwest Indian Ocean, which has led to a marked drop in the levels of longline effort in one of the core fishing areas of the species (Fig. 16).

Catches by other gears, namely pole-and-line, gillnet, troll, hand line and other minor gears, have increased steadily since the 1980s (Table 3; Figs. 13 and 14). In recent years the total artisanal yellowfin tuna catch has been around 140,000–160,000 t, with the catch by gillnets (the dominant artisanal gear) at around 80,000 t. During the year 2004 the catches by artisanal gears attained its maximum over the time series, peaking at 180,000 t.

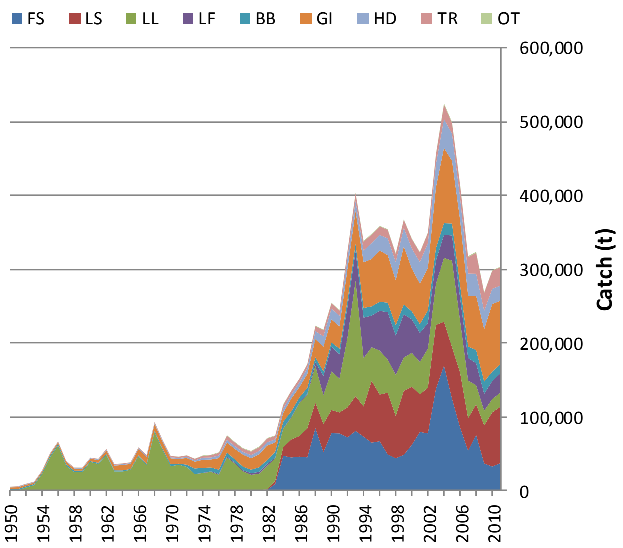

**Fig. 13.** Yellowfin tuna: Catches of yellowfin tuna by gear by year estimated for the WPTT (1950–2011). Data as of September 2012. Purse seine free-school (**FS**); Purse seine associated school (**LS**); Deep-freezing longline (**LL**); Fresh-tuna longline (**LF**); Pole-and-Line (**BB**); Gillnet (**GI**); Hand line (**HD**); Trolling (**TR**); Other gears nei (**OT**)

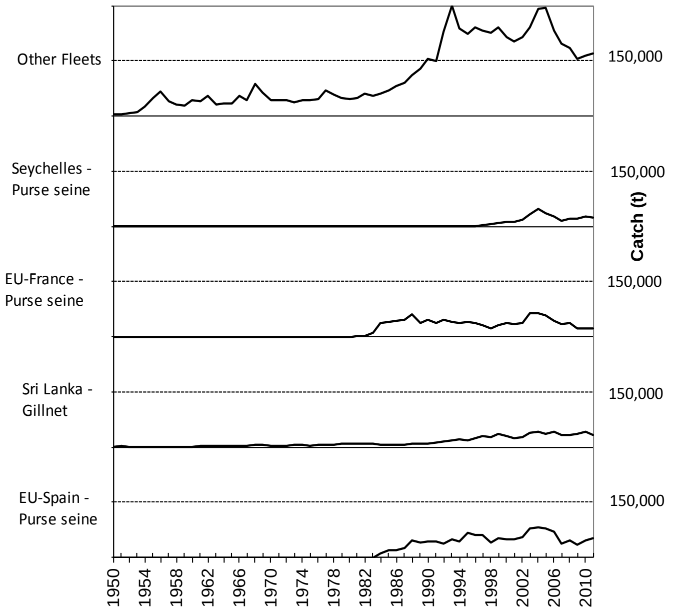

**Fig. 14.** Yellowfin tuna: Catches of yellowfin tuna by fleet by year estimated for the WPTT (1950–2011). Data as of September 2012.

Yellowfin tuna catches in the Indian Ocean during 2003, 2004, 2005 and 2006 were much higher than in previous years (Fig. 13), while bigeye tuna catches remained at their average levels. Purse seiners currently take the bulk of the yellowfin tuna catch, mostly from the western Indian Ocean (Table 4) around Seychelles and off Somalia (R2) and Mozambique Channel (R3); Fig. 16). In 2003 and 2004, total catches by purse seine vessels in this area were around 225,000 t — about 50% more than the previous largest purse seine catch, which was recorded in 1995. Similarly, artisanal yellowfin tuna catches have been near their highest levels and longliners have reported higher than normal catches in the tropical western Indian Ocean during this period.

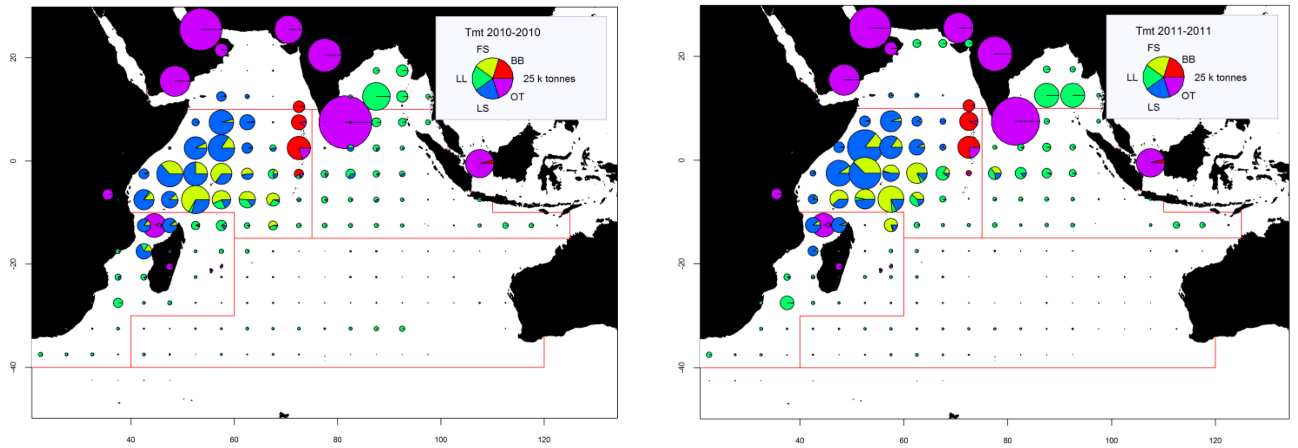

**Fig. 15.** Time-area catches (total combined in tonnes) of yellowfin tuna estimated for 2010 (left) and 2011 (right) by gear. Longline (**LL**), Purse seine free-schools (**FS**), Purse seine associated-schools (**LS**), pole-and-line (**BB**), and other fleets (**OT**), including drifting gillnets, and various coastal fisheries. Data as of September 2012. The catches of fleets for which the flag countries do not report detailed time and area data to the IOTC are recorded within the area of the countries concerned, in particular driftnets from Iran and Pakistan, gillnet and longline fishery of Sri Lanka, and coastal fisheries of Yemen, Oman, Comoros, Indonesia and India.

**Table 4.** Yellowfin tuna: Best scientific estimates of the catches of yellowfin tuna (*Thunnus albacares*) by area by decade (1950–2009) and year (2002–2011), in tonnes. Data as of September 2012. Catches by decade represent the average annual catch. The areas are presented in Fig. 2(a).

| Fishery | By decade (average) | | | | | | By year (last ten years) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1950s | 1960s | 1970s | 1980s | 1990s | 2000s | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
| R1 | 1,912 | 4,502 | 7,506 | 18,021 | 79,714 | 90,252 | 81,265 | 90,744 | 134,533 | 136,556 | 106,021 | 80,660 | 75,150 | 60,035 | 68,998 | 71,660 |
| R2 | 11,869 | 23,064 | 21,137 | 73,042 | 135,201 | 175,180 | 154,305 | 254,089 | 261,289 | 240,184 | 189,622 | 122,182 | 132,649 | 100,288 | 110,034 | 116,774 |
| R3 | 643 | 7,299 | 4,169 | 7,470 | 24,425 | 27,828 | 28,634 | 25,251 | 29,579 | 28,471 | 28,019 | 28,909 | 27,011 | 25,864 | 25,407 | 25,817 |
| R4 | 997 | 1,919 | 1,639 | 1,321 | 3,555 | 3,503 | 4,618 | 4,255 | 5,878 | 4,780 | 3,218 | 1,349 | 1,449 | 1,501 | 1,866 | 1,707 |
| R5 | 12,169 | 15,168 | 18,142 | 27,389 | 88,491 | 85,092 | 80,728 | 82,082 | 93,348 | 89,252 | 88,409 | 84,166 | 87,076 | 80,792 | 92,002 | 86,977 |
| **Total** | **27,590** | **51,953** | **52,592** | **127,243** | **331,386** | **381,855** | **349,550** | **456,420** | **524,627** | **499,242** | **415,289** | **317,267** | **323,336** | **268,479** | **298,307** | **302,935** |

**Areas**: Arabian Sea (**R1**); Off Somalia (**R2**); Mozambique Channel (**R3**); South Indian Ocean (**R4**); East Indian Ocean (**R5**). See Fig. 22 for areas. Totals from Table 3 and 4 may differ, due to rounding.

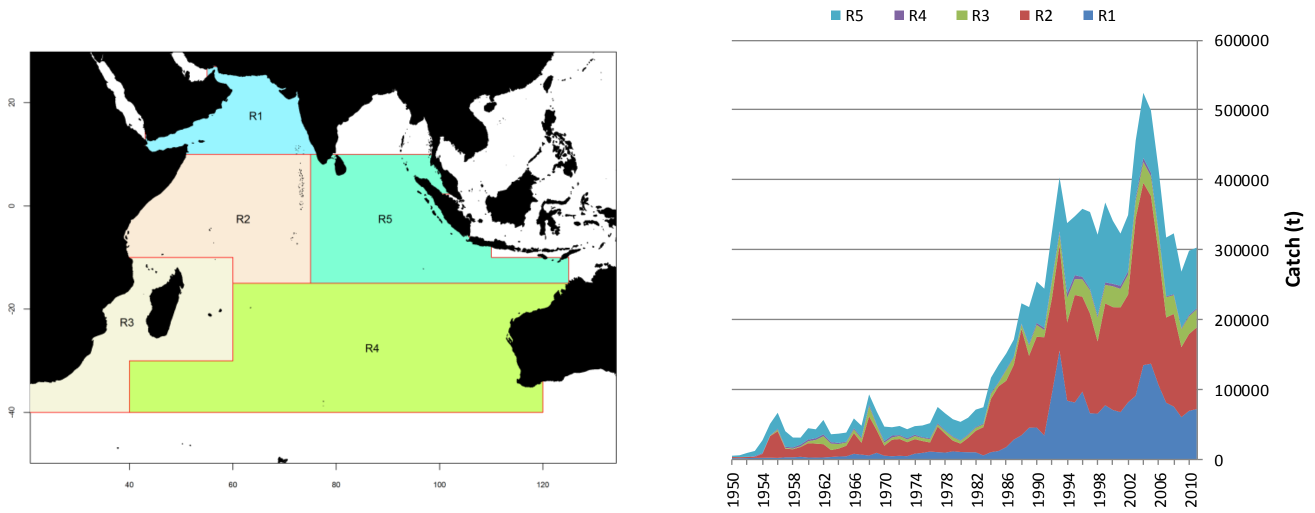

**Fig. 16.** Yellowfin tuna: Catches of yellowfin tuna by area (left) by year (right) estimated for the WPTT (1950–2011). Data as of September 2012. Catches outside the areas presented in the Map were assigned to the closest neighbouring area. Arabian Sea (**R1**); Off Somalia (**R2**); Mozambique Channel (**R3**); South Indian Ocean (**R4**); East Indian Ocean (**R5**)

In recent years the catches of yellowfin tuna in the western Indian Ocean have dropped considerably, especially in areas off Somalia, Kenya and Tanzania and in particular between 2007 and 2011 (Fig. 16). The drop in catches is the consequence of a drop in fishing effort due to the effect of piracy in the western Indian Ocean region. Even though the activities of purse seiners have been affected by piracy in the Indian Ocean, the effects have not been as marked as with longliners, for which current levels of effort are close to nil in the area impacted by piracy. The main reason for this is the presence of security personnel onboard purse seine vessels of the EU and Seychelles, which has made it possible for purse seiners under these flags to continue operating in the northwest Indian Ocean.

### *Yellowfin tuna – uncertainty of catches*

**Retained catches:** Generally well known (Fig. 17); however, catches are less certain for:

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

**Discard levels:** Believed to be low although they are unknown for most industrial fisheries, excluding industrial purse seiners flagged in EU countries for the period 2003–07.

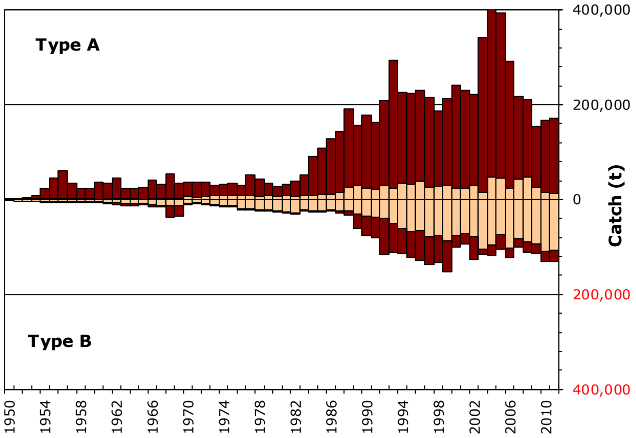

**Fig. 17.** Yellowfin tuna: Uncertainty of annual catch estimates for yellowfin tuna (Data as of September 2012). Catches below the zero-line (**Type B**) refer to fleets that do not report catch data to the IOTC (estimated by the IOTC Secretariat), do not report catch data by gear and/or species (broken 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 total catches of yellowfin tuna since the WPTT in 2011.

However, the IOTC Secretariat used new information compiled during 2011–12 to rebuild the catch series for the coastal fisheries operated in some countries, in particular Madagascar, Sri Lanka, and India. In general, the new catches of yellowfin tuna estimated by the IOTC Secretariat are lower than those used in the past by the WPTT.

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

- no data are available for the fresh-tuna longline fishery of Indonesia, over the entire time series, and data for the fresh-tuna longline fishery of Taiwan,China are only available since 2006
- 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.

***Yellowfin tuna – Fish size or age trends (e.g. by length, weight, sex and/or maturity)***

**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 (Fig. 18).

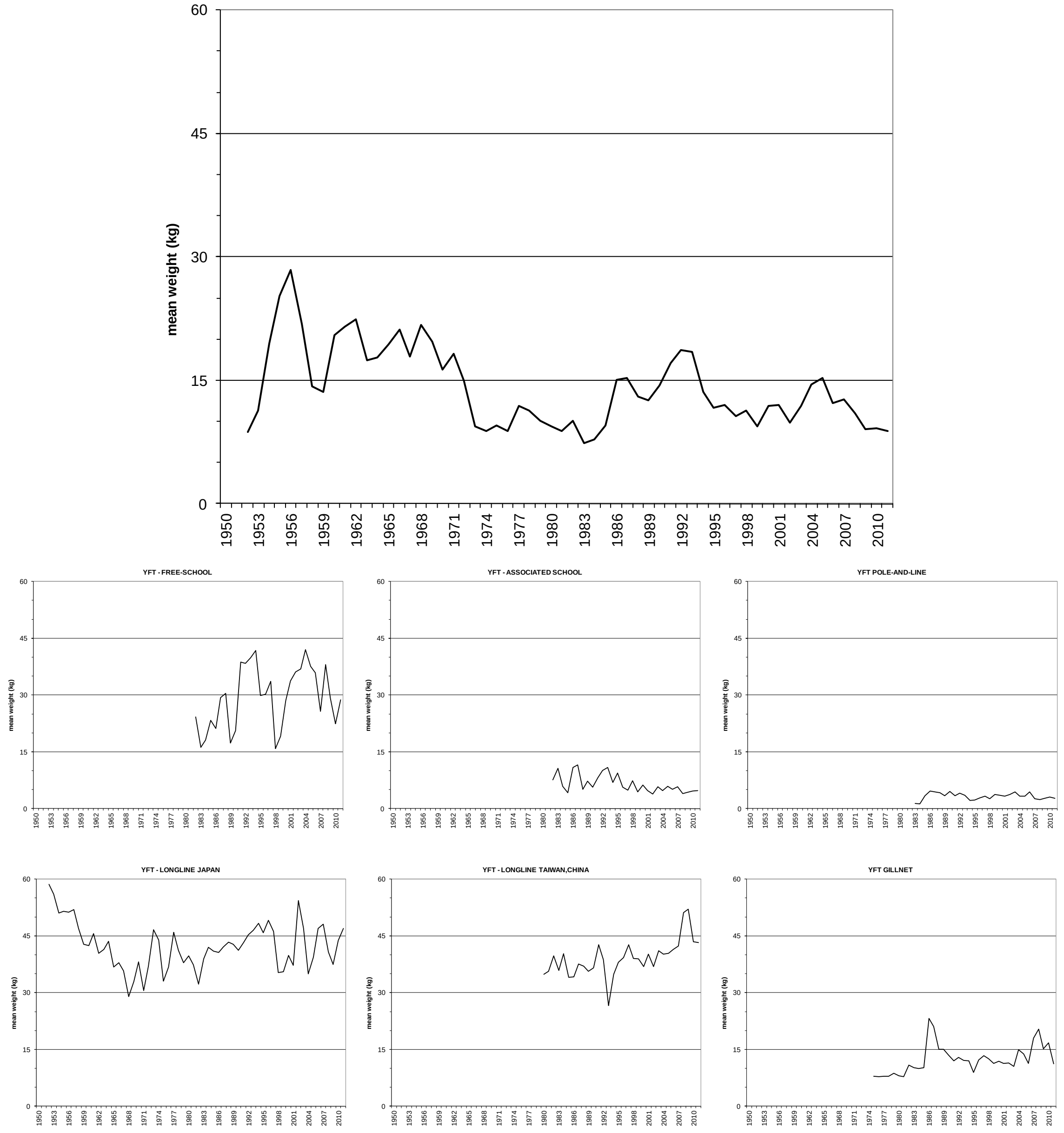

**Fig. 18.** Yellowfin tuna: Changes in average weight (kg) of yellowfin tuna from 1950 to 2011 – all fisheries combined (top) and by main fleet (Data as of September 2012).

**Catch-at-Size table**: This is available 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, and in recent years (Japan and Taiwan,China)
- the paucity of catch by area data available for some industrial fleets (NEI, Iran, India, Indonesia, Malaysia).

***Yellowfin tuna – tagging data***

A total of 63,328 yellowfin tuna (representing 31.4% of the total number of specimens tagged) were tagged during the Indian Ocean Tuna Tagging Programme (IOTTP). Most of them (86.4%) were released during the main Regional Tuna Tagging Project-Indian Ocean (RTTP-IO) and were released around Seychelles, in the Mozambique Channel, along the coast of Oman and off the coast of Tanzania, between May 2005 and September 2007 (Fig. 19). The remaining were tagged during small-scale tagging projects, and by other institutions with the support of IOTC Secretariat, in Maldives, India, and in the south west and the eastern Indian Ocean. To date, 10,662 (16.8%), have been recovered and reported to the IOTC Secretariat. More than 87% of these recoveries we made by the purse seine fleets operating in the Indian Ocean, while around 8.5% were made by pole-and-line and less than 1% by longline vessels. The addition of the data from the past projects in the Maldives (in 1990s) added 3,211 tagged skipjack to the databases, or which 151 were recovered, mainly from the Maldives.

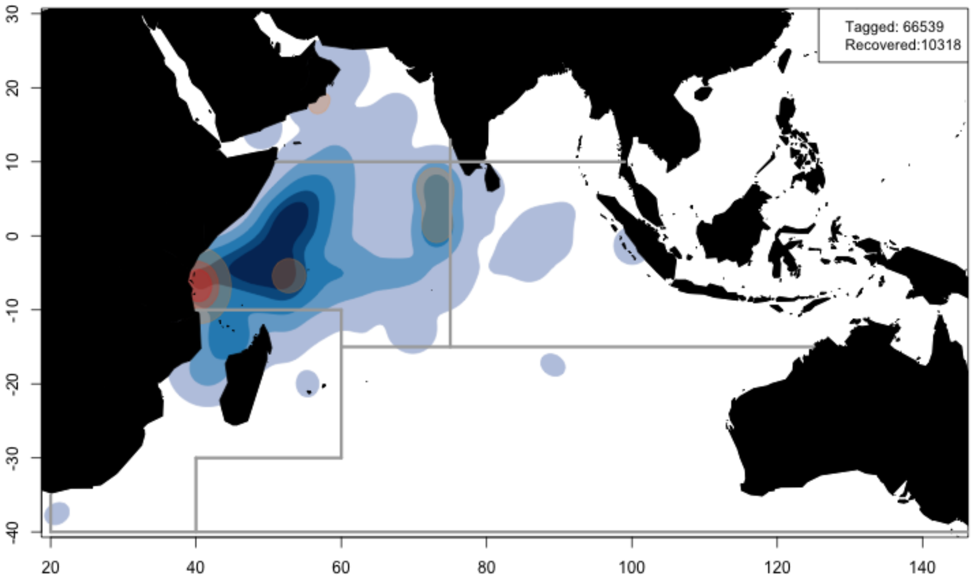

**Fig. 19**. Yellowfin tuna: Densities of releases (in red) and recoveries (in blue). The red line represents the stock assessment areas. Data as of September 2012.

# APPENDIX VI
# MAIN ISSUES IDENTIFIED RELATING TO THE STATISTICS OF TROPICAL TUNAS

*Extract from IOTC–2012–WPTT14–07*

The following list is provided by the Secretariat for the consideration of the WPTT. The list covers the main issues which the Secretariat considers affect the quality of the statistics available at the IOTC, by type of dataset and type of fishery.

## 1. 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 (average catches at around 75,000 t during 2007–11) they have not reported catch-and-effort data as per the IOTC standards, in particular for those vessels that operate outside their EEZ. The IOTC Secretariat estimated caches of bigeye tuna for Iran, assuming various levels of activity of vessels using driftnets on the high seas, depending on the year, and catch ratios bigeye tuna:yellowfin tuna recorded for industrial purse seiners on free-swimming tuna schools in the northwest Indian Ocean. Catches of bigeye tuna were estimated for the period 2005–11, with average catches estimated at around 1,500 t per year.
- **Gillnet/longline** fishery of **Sri Lanka**: Although Sri Lanka has reported catches of bigeye tuna for its gillnet/longline fishery (average catches at around 560 t during 2007–11), 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**: Although the pole-and-line fishery of Maldives do catch bigeye tuna, both yellowfin tuna and bigeye tuna are reported aggregated, as yellowfin tuna. The IOTC Secretariat used samples collected in the Maldives to estimate the amount of bigeye tuna that is reported as yellowfin tuna, per year, with average catches estimated at around 900 t per year. Maldives has not reported catch-and-effort data by gear type and geographic area for 2002–03[1].
- **Coastal** fisheries of **Comoros[2]**, **Indonesia, Madagascar, Sri Lanka** (other than gillnet/longline) and **Yemen**: The catches of tropical tunas for these fisheries have been estimated by the IOTC Secretariat in recent years (total average catches of tropical tunas for the period 2007-11 amount to 150,000 t per year, especially skipjack tuna). 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.

## 2. 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, with average catches amounting to around 5,000 t per year.
- **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**: To date, Iran has not reported catch-and-effort data as per IOTC standards for its purse seine fleet.
- **Longline** fishery of **Philippines:** The 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

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[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 undertaken preliminary assessments of skipjack tuna in cooperation with the IOTC Secretariat, presented at the WPTT in 2011. In addition, in October 2012 Maldives provided catch-and-effort data for its pole-and-line fishery for the period 2004-11.

[2] The “Direction national des resources haléutiques” of the Comoros conducted a fisheries census in 2011, with the assistance of the IOTC-OFCF Project. In addition, the IOTC Secretariat provided support for the implementation of a sampling system. These activities will make it possible for Comoros to estimate catches of tropical tunas and other species for 2011 and following years.

exported from the 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. Discards of tropical tunas are thought to be significant during some periods on industrial purse seine fisheries using fish aggregating devices (FADs).

### 3. Size data from All Fisheries:

- **Longline** fisheries of **Japan** and **Taiwan,China:** During the WPTT meeting in 2010, the IOTC Secretariat identified several issues concerning the size frequency statistics available for Japan and Taiwan,China, which remain unresolved. In addition, the number of specimens sampled for length onboard longliners flagged in Japan in recent years remains low.
- **Gillnet** fisheries of **Iran** and **Pakistan:** To date, Pakistan has not reported size frequency data for its gillnet fishery. Even though Iran has reported size frequency data for its gillnet fishery, data are not reported by month or geographic area; in addition, the proportion of fish sampled over the total numbers of fish caught has been decreasing in recent years, for all species.
- **Longline** fisheries of **India, Oman** and the **Philippines:** To date, these countries have not reported size frequency data for their longline fisheries.
- **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 **Indonesia** and **Malaysia**: Indonesia and Malaysia have 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 ports in those countries.
- **Coastal** fisheries of **Comoros**[3], **India, Indonesia** and **Yemen**: To date, these countries have not reported size frequency data for their coastal fisheries.

### 4. Biological data for all tropical tuna species:

Surface and longline fisheries, in particular **Taiwan,China**, **Indonesia**, **Japan**, and **China**: The IOTC database does not contain enough data to allow for the estimation of statistically robust length-weight or non-standard size to standard length keys for tropical tuna species due to the general paucity of biological data available from the Indian Ocean.

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[3] *Ibid.* 7

# APPENDIX VII
## DRAFT RESOURCE STOCK STATUS SUMMARY – BIGEYE TUNA

## DRAFT: STATUS OF THE INDIAN OCEAN BIGEYE TUNA (*THUNNUS OBESUS*) RESOURCE

**TABLE 1**. Status of bigeye tuna (*Thunnus obesus* ) in the Indian Ocean.

| **Area**[1] | **Indicators** | | | **2012 stock status determination** |
|---|---|---|---|---|
| Indian Ocean | Catch in 2011:<br>Average catch 2007–2011: | 87,420 t<br>101,639 t | | 🟩 |
| | | SS3[3] | ASPM[4] | |
| | MSY (1000 t): | 114 (95–183 t) | 103 t (87–119 t) | |
| | $F_{curr}/F_{MSY}$: | 0.79 (0.50–1.22) | 0.67 (0.48–0.86) | |
| | $SB_{curr}/SB_{MSY}$ : | 1.20 (0.88–1.68) | 1.00 (0.77–1.24) | |
| | $SB_{curr}/SB_0$: | 0.34 (0.26–0.40) | 0.39 | |

[1] Boundaries for the Indian Ocean stock assessment are defined as the IOTC area of competence.

[2] The stock status refers to the most recent years' data used in the assessment.

[3] Central point estimate is adopted from the 2010 SS3 model, percentiles are drawn from a cumulative frequency distribution of MPD values with models weighted as in Table 12 of 2010 WPTT report (IOTC–2010–WPTT12–R); the range represents the 5th and 95th percentiles.

[4] Median point estimate is adopted from the 2011 ASPM model using steepness value of 0.5 (values of 0.6, 0.7 and 0.8 are considered to be as pausible as these values but are not presented for simplification); the range represents the 90 percentile Confidence Interval.

Current period (curr) = 2009 for SS3 and 2010 for ASPM.

| **Colour key** | Stock overfished($SB_{year}/SB_{MSY}$< 1) | Stock not overfished ($SB_{year}/SB_{MSY}$≥ 1) |
|---|---|---|
| Stock subject to overfishing($F_{year}/F_{MSY}$> 1) | 🟥 | 🟧 |
| Stock not subject to overfishing ($F_{year}/F_{MSY}$≤ 1) | 🟨 | 🟩 |

### INDIAN OCEAN STOCK – MANAGEMENT ADVICE

***Stock status.*** No new stock assessment was carried out in 2012. Revised stock status indicators (e.g. standardised CPUE series) do not show any substantial differences from those carried out in 2011 that would warrant a change in the overall stock status advice. Both of the stock assessments carried out in 2010 and 2011 indicate that the stock is above a biomass level that would produce MSY in the long term and that current fishing mortality is below the MSY-based reference level (i.e. $SB_{current}/SB_{MSY}$ > 1 and $F_{current}/F_{MSY}$ < 1) (Table 1 and Fig. 1). Current spawning stock biomass was estimated to be 34–40 % (Table 1) of the unfished levels. The central tendencies of the stock status results from the WPTT 2011 when using different values of steepness were similar to the central tendencies presented in 2010. Catches in 2011 (87,420 t) remain lower than the estimated MSY values from the 2010 and 2011 stock assessments (Table 1). The average catch over the previous five years (2007–2011; 101,639 t) also remains below the estimated MSY. On the weight of stock status evidence available, the bigeye tuna stock is therefore not overfished, and is not subject to overfishing.

***Outlook.*** The recent declines in longline effort, particularly from the Japanese, Taiwan,China and Republic of Korea longline fleets, as well as purse seine effort have lowered the pressure on the Indian Ocean bigeye tuna stock, indicating that current fishing mortality would not reduce the population to an overfished state in the near future.

The Kobe strategy matrix (Combined SS3 and ASPM) illustrates the levels of risk associated with varying catch levels over time and could be used to inform future management actions (Table 2). Based on the ASPM projections from the 2011 assessment, with steepness 0.5 value for illustration, there is relatively a low risk of exceeding MSY-based reference points by 2020 both when considering current catches of 87,420 t (approximately 11% risk of $SB<SB_{MSY}$) or even if catches increase to around 100,000 t (<41% risk that $B_{2020}<B_{MSY}$ and $F_{2020}>F_{MSY}$).

Moreover, the SS3 projections from the 2010 assessment show that there is a low risk of exceeding MSY-based reference points by 2019 if catches are maintained at the lower range of MSY levels or at the catch level of 102,000 t (< 30% risk that $B_{2019}<B_{MSY}$ and < 25% risk that $F_{2019}$>FMSY) (Table 1). The following key points should be noted:

- The Maximum Sustainable Yield estimate for the Indian Ocean ranges between 102,000 and 114,000 t (range expressed as the median value for 2010 SS3 and steepness value of 0.5 for 2011 ASPM for illustrative purposes (see Table 1 for further description)). Annual catches of bigeye tuna should not exceed the lower range of this estimate which corresponds to the 2009 catches and last year's management advice.
- If the recent declines in effort continue, and catch remains substantially below the estimated MSY of 102,000–114 000 t, then immediate management measures are not required. However, continued monitoring and improvement in data collection, reporting and analysis is required to reduce the uncertainty in assessments.
- provisional reference points: Noting that the Commission in 2012 agreed to Recommendation 12/14 *on interim target and limit reference points*, the following should be noted:
    - **Fishing mortality**: Current fishing mortality is considered to be below the provisional target reference point of $F_{MSY}$, and therefore below the provisional limit reference point of $1.4*F_{MSY}$ (Fig. 1).
    - **Biomass**: Current spawning biomass is considered to be above the target reference point of $SB_{MSY}$, and therefore above the limit reference point of $0.4*SB_{MSY}$ (Fig. 1).

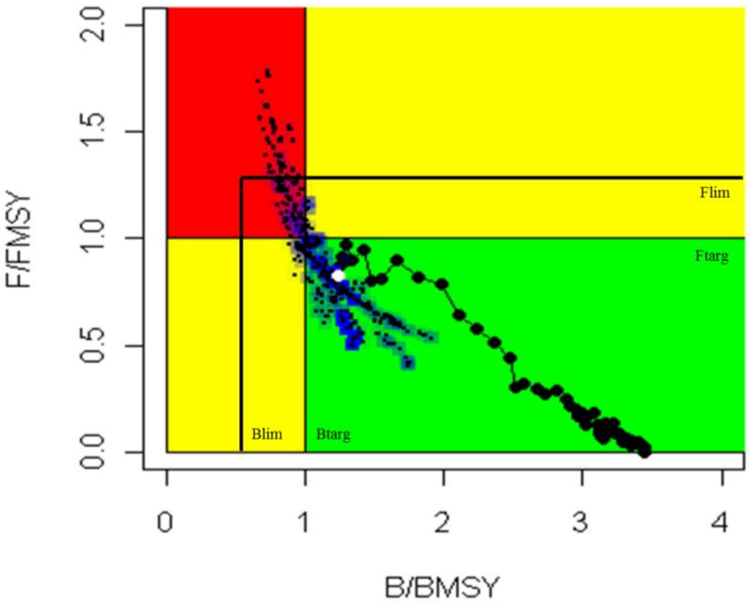

**Fig. 1.** Bigeye tuna: SS3 Aggregated Indian Ocean assessment Kobe plot. Black circles represent the time series of annual median values from the weighted stock status grid (white circle is 2009). Blue squares indicate the MPD estimates for 2009 corresponding to each individual grid C model, with colour density proportional to the weighting (each model is also indicated by a small black point, as the squares from highly down-weighted models are not otherwise visible).

**TABLE 2.** Bigeye tuna: Combined 2010 SS3 and 2011 ASPM Aggregated Indian Ocean assessment Kobe II Strategy Matrix. Probability (percentage) of violating the MSY-based reference points for five constant catch projections (2009 and 2010 catch levels, ± 20% and ± 40%) projected for 3 and 10 years. K2SM adopted from the 2011 ASPM model using steepness value of 0.5 (values of 0.6, 0.7 and 0.8 are considered to be as pausible as these values but are not presented for simplification). Note that the catch levels for 2009 and 2010 have since been revised, but are not reflected in the projections.

| **Reference point and projection timeframe** | **Alternative catch projections (relative to 2009) and probability (%) of violating reference point** | | | | |
|---|---|---|---|---|---|
| | | | **2010 SS3** | | |
| | **60%**<br>(61,200 t) | **80%**<br>(81,600 t) | **100%**<br>(102,000 t) | **120%**<br>(122,400 t) | **140%**<br>(142,800 t) |
| $SB_{2012} < SB_{MSY}$ | 19 | 24 | 28 | 40 | 50 |
| $F_{2012} > F_{MSY}$ | <1 | <6 | 22 | 50 | 68 |
| | | | | | |
| $SB_{2019} < SB_{MSY}$ | 19 | 24 | 30 | 55 | 73 |
| $F_{2019} > F_{MSY}$ | <1 | <6 | 24 | 58 | 73 |

| **Reference point and projection timeframe** | **Alternative catch projections (relative to 2010) and probability (%) of violating reference point** | | | | |
|---|---|---|---|---|---|
| | **2011 ASPM** | | | | |
| | **60%** (42,900t) | **80%** (57,200t) | **100%** (71,500t) | **120%** (85,800t) | **140%** (100,100t) |
| $SB_{2013} < SB_{MSY}$ | 4 | 8 | 15 | 24 | 35 |
| $F_{2013} > F_{MSY}$ | <1 | <1 | 1 | 8 | 33 |
| | | | | | |
| $SB_{2020} < SB_{MSY}$ | <1 | <1 | 1 | 11 | 41 |
| $F_{2020} > F_{MSY}$ | <1 | <1 | <1 | 5 | 38 |

# APPENDIX VIII
# DRAFT RESOURCE STOCK STATUS SUMMARY – SKIPJACK TUNA

## DRAFT: STATUS OF THE INDIAN OCEAN SKIPJACK TUNA (*KATSUWONUS PELAMIS*) RESOURCE

**TABLE 1.** Status of skipjack tuna (*Katsuwonus pelamis*) in the Indian Ocean.

| **Area**[1] | **Indicators** | | **2012 stock status determination** |
|---|---|---|---|
| Indian Ocean | Catch 2011:<br>Average catch 2007–2011: | 398,240 t<br>435,527 t | 🟩 |
| | MSY (1000 t):<br>$F_{2011}/F_{MSY}$:<br>$SB_{2011}/SB_{MSY}$:<br>$SB_{2011}/SB_0$: | 478 t (359–598 t)<br>0.80 (0.68–0.92)<br>1.20 (1.01–1.40)<br>0.45 (0.25–0.65) | |

[1] Boundaries for the Indian Ocean stock assessment are defined as the IOTC area of competence.

| **Colour key** | Stock overfished($SB_{year}/SB_{MSY} < 1$) | Stock not overfished ($SB_{year}/SB_{MSY} \geq 1$) |
|---|---|---|
| Stock subject to overfishing($C_{year}$/MSY> 1) | 🟥 | 🟧 |
| Stock not subject to overfishing ($C_{year}$/MSY≤ 1) | 🟨 | 🟩 |

### INDIAN OCEAN STOCK – MANAGEMENT ADVICE

***Stock status.*** The results suggest that the stock is not overfished ($B > B_{MSY}$) and that overfishing is not occurring ($C < MSY$ and $F < F_{MSY}$) (Table 1 and Fig. 1). Spawning stock biomass was estimated to have declined by approximately 45 % in 2011 from unfished levels (Table 1).

***Outlook.*** The recent declines in catches are thought to be caused by a recent decrease in purse seine effort as well as due to a decline in CPUE of large skipjack tuna in the surface fisheries. There remains considerable uncertainty in the assessment, and the range of runs analysed illustrate a range of stock status to be between 0.73–4.31 of $SB_{2011}/SB_{MSY}$ based on all runs examined. The WPTT does not fully understand the recent declines of pole-and-line catch and CPUE, which may be due to the combined effects of the fishery and environmental factors affecting recruitment or catchability. Catches in 2010 (428,000 t) and 2011 (398,240 t) as well as the average level of catches of 2007–2011 (435,527 t) are below MSY targets though may have exceeded them in 2005 and 2006.

The Kobe strategy matrix illustrates the levels of risk associated with varying catch levels over time and could be used to inform management actions. Based on the SS3 assessment conducted in 2011, there is a low risk of exceeding MSY-based reference points by 2020 if catches are maintained at the current levels (< 20 % risk that $B_{2019} < B_{MSY}$ and 30 % risk that $C_{2019} > MSY$ as proxy of $F > F_{MSY}$) and even if catches are maintained below the 2005–2010 average (500,000 t) based on the analysis done in 2011 (the 2012 reference point indicates that 500,000 t levels maybe too high for the Indian Ocean skipjack tunastock). The following key points should be noted:

- The mean estimates of the Maximum Sustainable Yield for the skipjack tuna Indian Ocean stock is 478,190 t (Table 1) and considering the average catch level from 2007–2011 was 435,527 t, the stock appears to be in no immediate threat of breaching target and limit reference points.
- If the recent declines in effort continue, and catch remains substantially below the estimated MSY, then urgent management measures are not required. However, recent trends in some fisheries, such as Maldivian pole-and-line, suggest that the situation of the stock should be closely monitored.
- The Kobe strategy matrix (Table 2: from the 2011 assessment) illustrates the levels of risk associated with varying catch levels over time and could be used to inform management actions.
- provisional reference points: Noting that the Commission in 2012 agreed to Recommendation 12/14 *on interim target and limit reference points*, the following should be noted:
    - **Fishing mortality**: Current fishing mortality is considered to be below the provisional target reference point of $F_{MSY}$, and therefore below the provisional limit reference point of $1.4*F_{MSY}$ (Fig. 1).
    - **Biomass**: Current spawning biomass is considered to be above the target reference point of $SB_{MSY}$, and therefore above the limit reference point of $0.4*SB_{MSY}$ (Fig. 1).

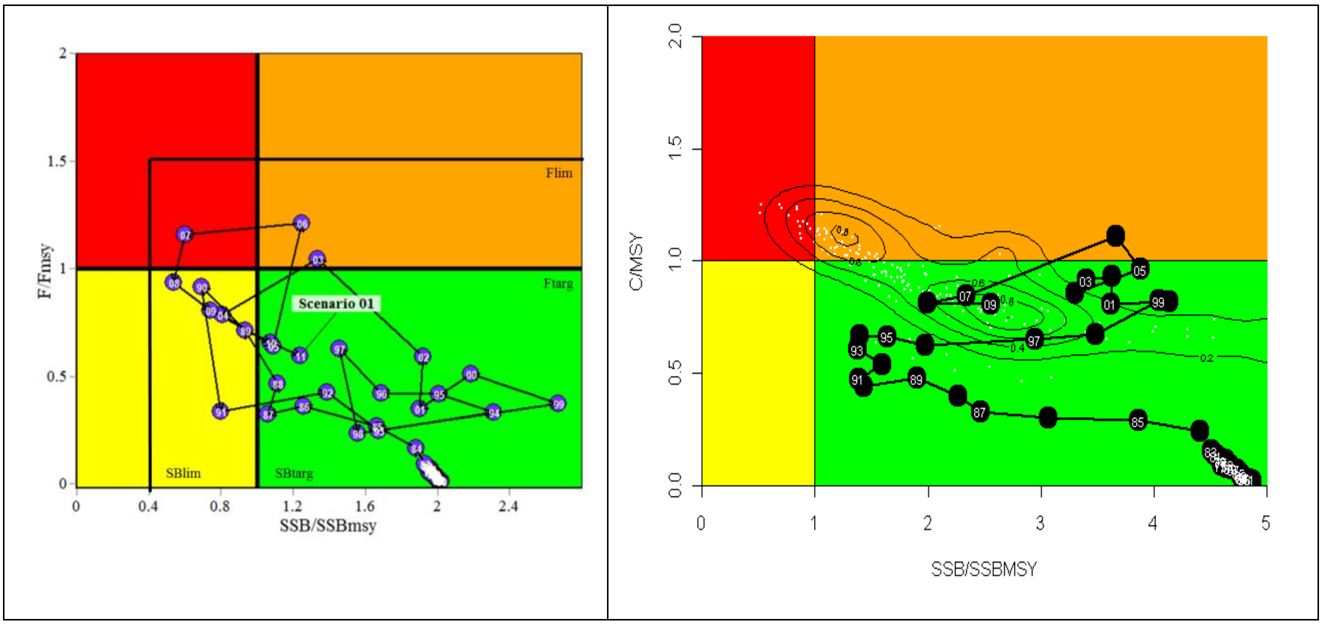

**Fig. 1.** Skipjack tuna: 2012 SS3 Indian Ocean assessment Kobe plot (left; mean values of the weighted models used in the analysis in 2012). Circles indicate the trajectory of the point estimates for the SB ratio and F/FMSY ratio for each year 1950–2011. 2011 SS3 Aggregated Indian Ocean assessment Kobe plot (right). Black circles indicate the trajectory of the weighted median of point estimates for the SB ratio and C/MSY ratio for each year 1950–2009. Probability distribution contours are provided only as a rough visual guide of the uncertainty (e.g. the multiple modes are an artifact of the coarse grid of assumption options). Due to numerical problems in the $F_{MSY}$ calculations for this population, the proxy reference point C/MSY is reported instead of $F/F_{MSY}$, which should be interpreted with caution for the reasons given under Table 1 above.

**TABLE 2.** Skipjack tuna: 2011 SS3 Aggregated Indian Ocean assessment Kobe II Strategy Matrix. Weighted probability (percentage) of violating the MSY-based reference points for five constant catch projections (2009 catch level, ± 20% and ± 40%) projected for 3 and 10 years. Note: from the 2011 stock assessment using catch estimates at that time.

| **Reference point and projection timeframe** | **Alternative catch projections (relative to 2009) and weighted probability (%) scenarios that violate reference point** | | | | |
|---|---|---|---|---|---|
| | **60%**<br>(274,000 t) | **80%**<br>(365,000 t) | **100%**<br>(456,000 t) | **120%**<br>(547,000 t) | **140%**<br>(638,000 t) |
| $SB_{2013} < SB_{MSY}$ | <1 | 5 | 5 | 10 | 18 |
| $C_{2013} > MSY$ (proxy for $F_{2009}/F_{MSY}$) | <1 | <1 | 31 | 45 | 72 |
| $SB_{2020} < SB_{MSY}$ | <1 | 5 | 19 | 31 | 56 |
| $C_{2020} > MSY$ (proxy for $F_{2009}/F_{MSY}$) | <1 | <1 | 31 | 45 | 72 |

# APPENDIX IX
# DRAFT RESOURCE STOCK STATUS SUMMARY – YELLOWFIN TUNA

## DRAFT: STATUS OF THE INDIAN OCEAN YELLOWFIN TUNA (*THUNNUS ALBACARES*) RESOURCE

**TABLE 1.** Status of yellowfin tuna (*Thunnus albacares*) in the Indian Ocean.

| Area[1] | Indicators | | 2012 stock status determination |
|---|---|---|---|
| Indian Ocean | Catch 2011: | 302,939 t | 🟩 |
| | Average catch 2007–2011: | 302,064 t | |
| | MSY (1000 t): | 344 t (290–453 t) | |
| | $F_{2010}/F_{MSY}$: | 0.69 (0.59–0.90) | |
| | $SB_{2010}/SB_{MSY}$: | 1.24 (0.91–1.40) | |
| | $SB_{2010}/SB_0$ : | 0.38 (0.28–0.38) | |

[1] Boundaries for the Indian Ocean stock assessment are defined as the IOTC area of competence.

| **Colour key** | Stock overfished($SB_{year}/SB_{MSY} < 1$) | Stock not overfished ($SB_{year}/SB_{MSY} \geq 1$) |
|---|---|---|
| Stock subject to overfishing($F_{year}/F_{MSY} > 1$) | 🟥 | 🟧 |
| Stock not subject to overfishing ($F_{year}/F_{MSY} \leq 1$) | 🟨 | 🟩 |

### INDIAN OCEAN STOCK – MANAGEMENT ADVICE

***Stock status.*** The stock assessment model results for 2012 do not differ substantively from the previous (2011) assessment; however, the final overall estimates of stock status differ somewhat due to the refinement in the selection of the range of model options due to increased understanding of key biological parameters (primarily natural mortality). The stock assessment model used in 2012 suggests that the stock is currently not overfished ($SB_{2010} > SB_{MSY}$) and overfishing is not occurring ($F_{2010} < F_{MSY}$) (Table 1 and Fig. 1). Spawning stock biomass in 2010 was estimated to be 38% (31–38%) (from Table 1) of the unfished levels. However, estimates of total and spawning stock biomass show a marked decrease from 2004 to 2009, corresponding to the very high catches of 2003–2006. Recent reductions in effort and, hence, catches resulted in a slight improvement in stock status in 2010.

***Outlook.*** Estimates of stock status using 2011 data are not considered reliable. The potential yields from the fishery have also declined over the last five years as an increased proportion of the catch is comprised of smaller fish, primarily from the purse seine FAD fishery. 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 tuna 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.

In an attempt to provide management advice independent of the MSY construct, the recent levels of absolute fishing mortality estimated from region 2 were compared to the natural mortality level. It is considered that the tagging data provides a reasonable estimate to fishing mortality for the main tag recovery period (2007–09). The estimates of fishing mortality for the main age classes harvested by the purse-seine fishery are considerably lower than the corresponding levels of natural mortality and on that basis, recent fishing mortality levels are not considered to be excessive.

The decrease in longline and purse seiner effort in recent years has substantially lowered the pressure on the Indian Ocean stock as a whole, indicating that current fishing mortality has not exceeded the MSY-related levels in recent years. If the security situation in the western Indian Ocean were to improve, a rapid reversal in fleet activity in this region may lead to an increase in effort which the stock might not be able to sustain, as catches would then be likely to exceed MSY levels. Catches in 2010 (299,000 t) are within the lower range of MSY values The current assessment indicates that catches of about the 2010 level are sustainable, at least in the short term. However, the stock is unlikely to support substantively higher yields based on the estimated levels of recruitment from over the last 15 years.

In 2011, the WPTT undertook projections of yellowfin tuna stock status under a range of management scenarios for the first time, following the recommendation of both the Kobe process and the Commission, to harmonise technical advice to managers across RFMOs by producing Kobe II management strategy matrices. The purpose of the table is to quantify the future outcomes from a range of management options (Table 2). The table describes the presently estimated probability of the population being outside biological reference points at some point in the future, where "outside" was assigned the default definitions of $F>F_{MSY}$ or $SB<SB_{MSY}$. The timeframes represent 3 and 10 year projections (from the last data in the model), which corresponds to predictions for 2013 and 2020. The management options represent three different levels of constant catch projection: catches 20% less than 2010, equal to 2010 and 20% greater than 2010.

The projections were carried out using 12 different scenarios based on similar scenarios used in the assessment for the combination of those different MFCL runs: LL selectivity flat top vs. dome shape; steepness values of 0.7, 0.8 and 0.9; and computing the recruitment as an average of the whole time series vs. 15 recent years (12 scenarios). The probabilities in the matrices were computed as the percentage of the 12 scenarios being $SB>SB_{MSY}$ and $F<F_{MSY}$ in each year. In that sense, there are not producing the uncertainty related to any specific scenario but the uncertainty associated to different scenarios.

There was considerable discussion on the ability of the WPTT to carry out the projections with MFCL for yellowfin tuna. For example, it was not clear how the projection redistributed the recruitment among regions as recent distribution of recruitment differs from historic; which was assumed in the projections. The WPTT agreed that the true uncertainty is unknown and that the current characterization is not complete; however, the WPTT feels that the projections may provide a relative ranking of different scenarios outcomes. The WPTT recognised at this time that the matrices do not represent the full range of uncertainty from the assessments. Therefore, the inclusion of the K2SM at this time is primarily intended to familiarise the Commission with the format and method of presenting management advice. The following key points should be noted:

- The Maximum Sustainable Yield estimate for the whole Indian Ocean is 344,000 t with a range between 290,000–453,000 t (Table 1), and annual catches of yellowfin tuna should not exceed the lower range of MSY (300,000 t) in order to ensure that stock biomass levels could sustain catches at the MSY level in the long term.
- Recent recruitment is estimated to be considerably lower than the whole time series average. If recruitment continues to be lower than average, catches below MSY would be needed to maintain stock levels.
- provisional reference points: Noting that the Commission in 2012 agreed to Recommendation 12/14 *on interim target and limit reference points*, the following should be noted:
    - **Fishing mortality**: Current fishing mortality is considered to be below the provisional target reference point of $F_{MSY}$, and therefore below the provisional limit reference point of $1.4*F_{MSY}$ (Fig. 1).
    - **Biomass**: Current spawning biomass is considered to be above the target reference point of $SB_{MSY}$, and therefore above the limit reference point of $0.4*SB_{MSY}$ (Fig. 1).

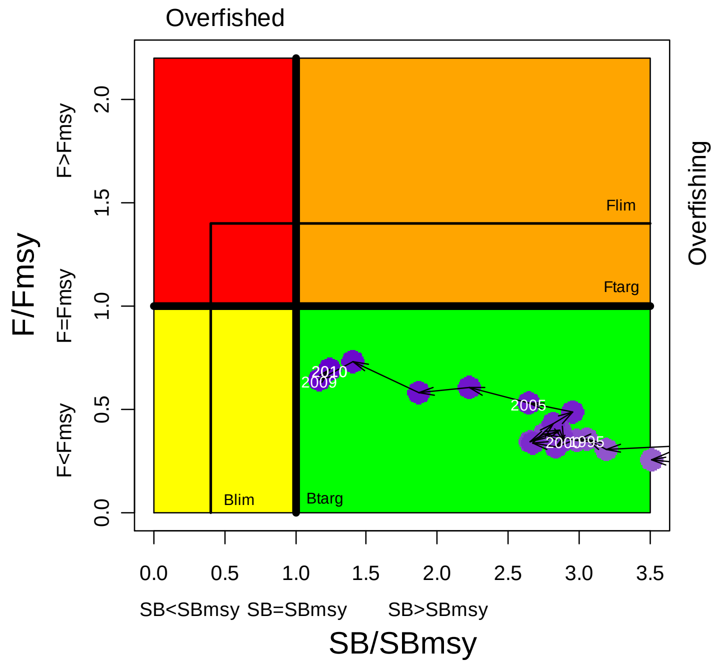

**Fig. 1.** Yellowfin tuna: MULTIFAN-CL Indian Ocean yellowfin tuna stock assessment Kobe plot. Blue circles indicate the trajectory of the point estimates for the SB ratio and F ratio for each year 1972–2010 for a steepness value of 0.8.

**TABLE 2.** Yellowfin tuna: 2011 MULTIFAN-CL Indian Ocean yellowfin tuna stock assessment Kobe II Strategy Matrix. Percentage probability of violating the MSY-based reference points for five constant catch projections (2010 catch level, ± 20% and ± 40%) projected for 3 and 10 years. In the projection, however, 12 scenarios were investigated: the six scenarios investigated above as well as the same scenarios but with a lower mean recruitment assumed for the projected period. Note: from the 2011 stock assessment using catch estimates at that time.

| **Reference point and projection timeframe** | **Alternative catch projections (relative to 2010) and probability (%) of violating reference point** | | | | |
|---|---|---|---|---|---|
| | **60%** (165,600 t) | **80%** (220,800 t) | **100%** (276,000 t) | **120%** (331,200 t) | **140%** (386,400 t) |
| $SB_{2013} < SB_{MSY}$ | <1 | <1 | <1 | <1 | <1 |
| $F_{2013} > F_{MSY}$ | <1 | <1 | 58.3 | 83.3 | 100 |
| $SB_{2020} < SB_{MSY}$ | <1 | <1 | 8.3 | 41.7 | 91.7 |
| $F_{2020} > F_{MSY}$ | <1 | 41.7 | 83.3 | 100 | 100 |