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

Lankanfinolhu, North Malé Atoll, Republic of Maldives, 16–23 October 2011

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EXECUTIVE SUMMARY

The Thirteenth Session of the Indian Ocean Tuna Commission's (IOTC) WPTT was held in Lankanfinolhu, North Malé Atoll, Republic of Maldives, from 16 to 23 October 2011. A total of 49 participants attended the Session including two invited experts, Dr. Joseph Powers (LSU–USA) and Ms. Paige Eveson (CSIRO–Australia).

The following are a subset of the complete recommendations from the WPTT13 to the Scientific Committee, which are provided at Appendix IV.

Skipjack tuna: INDIAN OCEAN STOCK – MANAGEMENT ADVICE

The WPTT **RECOMMENDED** the following management advice for skipjack tuna in the Indian Ocean, for the consideration of the Scientific Committee (para. 164).

> ***Stock status.*** The weighted results suggest that the stock is not overfished ($B>B_{MSY}$) and that overfishing is not occurring ($C<MSY$ used as a proxy for $F<F_{MSY}$). Spawning stock biomass was estimated to have declined by approximately 47 % in 2009 from unfished levels (Table 3).

The WPTT **RECOMMENDED** that the Scientific Committee consider the following (para. 165):

- The median estimates of the Maximum Sustainable Yield for the skipjack tuna Indian Ocean stock is 564,000 t (Table 3) and considering the average catch level from 2005–2009 was 492,000 t, catches of skipjack tuna should not exceed the average of 2005–2009.
- 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 4) illustrates the levels of risk associated with varying catch levels over time and could be used to inform management actions.

Yellowfin tuna: INDIAN OCEAN STOCK – MANAGEMENT ADVICE

The WPTT **RECOMMENDED** the following management advice for yellowfin tuna in the Indian Ocean, for the consideration of the Scientific Committee (para. 201).

> ***Stock status.*** The stock assessment model used in 2011 suggests that the stock is currently not overfished ($B_{2009}>B_{MSY}$) and overfishing is not occurring ($F_{2009}<F_{MSY}$) (Table 6 and Fig. 26). Spawning stock biomass in 2009 was estimated to be 35% (31–38%) (from Table 6) of the unfished levels. However, estimates of total and spawning stock biomass show a marked decrease over the last decade, accelerated in recent years by the high catches of 2003–2006. Recent reductions in effort and, hence, catches has halted the decline.
>
> 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.

The WPTT **RECOMMENDED** that the Scientific Committee consider the following (para. 202):

- The Maximum Sustainable Yield estimate for the whole Indian Ocean is 357,000 t with a range between 290,000–435,000 t (Table 6), 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.

Bigeye tuna: INDIAN OCEAN STOCK – MANAGEMENT ADVICE

The WPTT **RECOMMENDED** the following management advice for bigeye tuna in the Indian Ocean, for the consideration of the Scientific Committee (para. 223).

> ***Stock status.*** Both assessments suggest 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 $F_{current}/F_{MSY} < 1$). Current spawning stock biomass was estimated to be 34–40 % (Table 11) 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.

The WPTT **RECOMMENDED** that the Scientific Committee consider the following (para. 224):

- 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 11 for further description)). Annual catches of bigeye tuna should not exceed the lower range of this estimated which corresponds to the 2009 catches and last year management advice.
- If the recent declines in effort continue, and catch remains substantially below the estimated MSY of 100,000–114 000 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.

The WPTT **RECOMMENDED** that a dedicated workshop on CPUE standardization, including issues of interest for other IOTC species should be carried out before the next round of stock assessments in 2012, and that where possible it should include a range of invited experts, including those working on CPUE standardisation in other ocean/RFMOs, in conjunction with scientists from Japan, Republic of Korea and Taiwan,China, and supported by the IOTC Secretariat (para. 272).

The WPTT **RECOMMENDED** that the Scientific Committee note the new Vice-Chair, Dr. M. Shiham Adam (Maldives) of the WPTT for the next *biennium* (para. 294).

1. Opening of the Meeting

1. The Thirteenth Session of the Indian Ocean Tuna Commission's (IOTC) WPTT was held in Lankanfinolhu, North Malé Atoll, Paradise Island Resort and Spa, Republic of Maldives, from 16 to 23 October 2011. A total of 49 participants attended the Session. The list of participants is provided at Appendix I.

2. The meeting was opened on 16 October, 2011 by the Chair, Dr. Hilario Murua, who subsequently welcomed participants to the Republic of Maldives, as did Dr. Shiham Adam, on behalf of the Minister of Fisheries and Agriculture. Participants were informed that a Vice-Chair for the next biennium would need to be elected prior to the close of the meeting.

2. Adoption of the Agenda

3. The WPTT **ADOPTED** the Agenda provided at Appendix II, noting that the planned Working Party on Methods would be amalgamated into the WPTT13 meeting under agenda item 15. The documents presented to the WPTT are listed in Appendix III.

3. Outcomes of the Thirteenth Session of the Scientific Committee

4. The WPTT **NOTED** paper IOTC–2011–WPTT13–03 which outlined the main outcomes of the Thirteenth Session of the Scientific Committee, specifically related to the work of the WPTT.

5. The WPTT **NOTED** the Scientific Committee's request that for all future Working Party meetings, complete stock assessment documents, describing the analysis, its assumption and its results, as well as associated model diagnostics and input/output files are provided and archived so as to facilitate transparency in the process of stock assessment for IOTC species.

6. The WPTT **NOTED** the Scientific Committee's request that choice of particular assumptions, e.g. steepness of the stock recruitment relationship, are fully justified and described in the report of the relevant Working Party.

7. The WPTT **NOTED** that the Scientific Committee had revised the stock assessment guidelines previously agreed to at his 10th Session in 2007, which are applicable to all IOTC Working Party meetings (provided in paper IOTC–2011–WPTT13–INF01).

8. The WPTT **NOTED** that the Scientific Committee reminded scientists conducting stock assessment that these guidelines provide a minimum set of outputs required for Working Party participants to be able to properly analyse the results presented. As such, scientists and Working Party participants should ensure that these guidelines are followed to the extent possible, and Working Party chairs should make every possible effort to make sure this is done so.

9. The WPTT **NOTED** the recommendations of the Thirteenth Session of the Scientific Committee on data and research related to tropical tunas and agreed to consider how best to progress these issues at the present meeting.

10. Noting that each year the Scientific Committee and the Commission make a number of requests to the various working parties, without clearly identifying the task to be undertaken, its priority against other tasks previously or simultaneously assigned to the working parties, and without assigning a budget to fund the request made, the WPTT **RECOMMENDED** that these matters be addressed by the Scientific Committee at its next session.

4. Outcomes of the Fifteenth Session of the Commission

11. The WPTT **NOTED** paper IOTC–2011–WPTT13–04 which outlined the main outcomes of the Fifteenth Session of the Commission, specifically related to the work of the WPTT.

12. The WPTT **NOTED** the Commission's request that, due to the decreasing effort of the Japanese longline fleet during the last few years, alternative CPUE series for other fleets are used by the Scientific Committee and its Working Parties in stock assessments.

13. The WPTT **NOTED** the Commission's request that a Kobe II strategy matrix be provided for all stock assessments by the species Working Parties, in particular for yellowfin tuna, and for these to be included in the species Executive Summaries which will be provided in the report of the Scientific Committee in 2011 and all future reports.

14. The WPTT **NOTED** the Commission's request that the Scientific Committee assess the effect of piracy on fishing fleet operations and subsequent catch and effort trends.

15. The WPTT **NOTED** the Commission's request that the Scientific Committee in its 2011 Session evaluate the data provision needs for longline, purse seine, gillnet and pole-and-line gear types, notably regarding information relating to the vessel characteristics and the definition of the pole-and-line 'fishing event'. The evaluation is requested in order to ensure that consistent and uniform information is collected for all gears to assist the IOTC to fulfil its management mandate. The Scientific Committee should make appropriate recommendations to the 2012 Commission meeting.

16. The WPTT **NOTED** the Commission's request that the Scientific Committee should evaluate the time-area closure established in Resolution 10/01 *for the conservation and management of tropical tuna stocks in the IOTC area of competence*, in terms of its impacts on the stocks of tuna and tuna-like species.

17. The WPTT **NOTED** the Commission's request that: *the Scientific Committee provide advice to the Commission that adds to the information currently available or already requested of the Scientific Committee regarding the take of juvenile yellowfin tuna, bigeye tuna and other species, and on alternative management measures, including an assessment of the impact of current purse seine activities, including the size/fishing capacity (and gear types i.e. mesh size etc.) of vessels, and the potential implications that may arise for tuna and tuna-like species. Such advice should include options for capping purse seine effort and use in conjunction with drifting FADs in the Indian Ocean*.

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

5. Progress on the Recommendations of WPTT12

19. The WPTT **NOTED** paper IOTC–2011–WPTT03–05 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.

20. 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 Scientific Committee.

6. Review of the Data Available For Tropical Tuna Species

21. The WPTT **NOTED** paper IOTC–2011–WPTT03–06 which summarised the standing of a range of data received by the secretariat for tropical tunas, in accordance with IOTC Resolution 10/02 *Mandatory statistical requirements for IOTC Members and Cooperating non-Contracting Parties (CPC's)*. Statistics for 2010 represent preliminary catch information.

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

Fishery trends

23. The WPTT **NOTED** paper IOTC–2011–WPTT13–08 which provided a range of fishery indicators to assist the WPTT in developing its advice to the Scientific Committee, including catch and effort trends for fisheries catching tropical tuna species as well as average weight by fisheries for tropical tunas in the IOTC Area of Competence.

24. The WPTT **NOTED** 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).

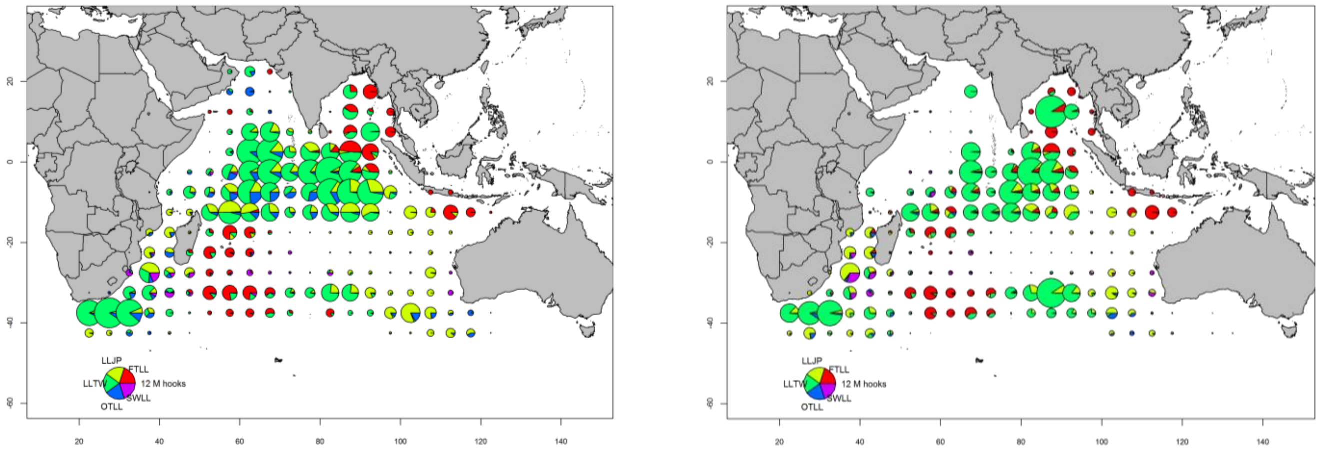

Fig. 1a–b Number of hooks set (millions) from longline vessels by five degree square grid and main fleets, for the years 2009 and 2010 (Data as of September 2011).

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, Rep. of Korea and various other fleets)

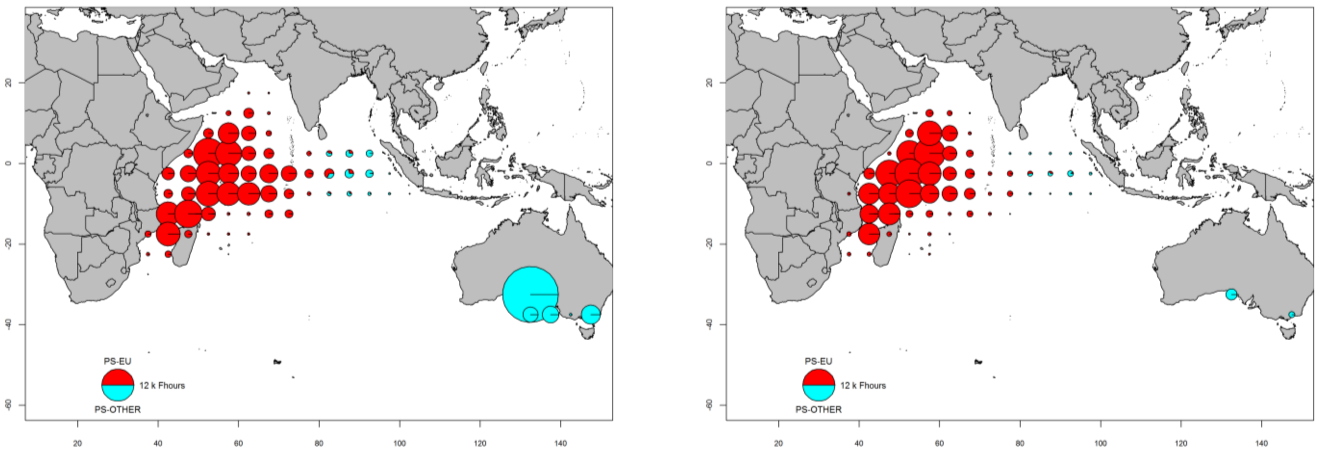

Fig. 2a–b. Number of hours of fishing (Fhours) in thousands (k), from purse seine vessels by 5 degree square grid and main fleets, for the years 2009 and 2010 (Data as of September 2011).

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

Bigeye tuna – catch trends

25. The WPTT **NOTED** that bigeye tuna are mainly caught by industrial purse seine and longline fisheries and appears only occasionally in the catches of other fisheries (Fig. 3). However, in recent years the amounts of bigeye tuna caught by gillnet fisheries are likely to be considerably higher than what is reported, due to the major changes experienced in some of these fleets, notably changes in boat size, fishing techniques and fishing grounds.

26. The WPTT **NOTED** that total annual bigeye tuna 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. 3). Total annual catches averaged 131,000 t over the period 2001–2005 and 105,000 t over the period 2006–2010. In 2010, preliminary catches of bigeye tuna have been estimated to be at around 70,000 t, representing a large decrease in catches with respect to those estimated for 2009 and previous years (Figs. 3, 4).

27. The WPTT **AGREED** that the recent drop in catches of bigeye tuna could be related to the expansion of piracy in the western tropical Indian Ocean, which has led to a marked drop in the levels of longline effort in the core fishing area of the species (Figs. 5a, b).

28. The WPTT **NOTED** that bigeye tuna has been caught by industrial longline fleets since the early 1950's, but before the mid-1970's they only represented an incidental component of the total catch. With the introduction of fishing practices that improved the access to the bigeye tuna resource and the emergence of a sashimi market in the mid-1970's, bigeye tuna became an important target species for the main industrial longline fleets (Figs. 3, 4). The catches estimated for 2010 are at around 46,000 t, representing less than half the longline catches of bigeye tuna recorded before the onset of piracy in the Indian Ocean.

29. The WPTT **NOTED** that the total catch of bigeye tuna by purse seiners in the Indian Ocean reached 40,700 t in 1999, but the average annual catch for the period 2006–2010 was 26,000 t (25,000 t for 2001–2005) (Fig. 3). Purse seiners mainly take small juvenile bigeye tuna (averaging around 5–6 kg) whereas longliners catch much larger and heavier fish; and therefore while purse seiners take much lower tonnages of bigeye tuna compared to longliners, they take larger numbers of individual fish.

30. The WPTT **NOTED** that although the activities of purse seiners have been affected by piracy in the Indian Ocean, the effects have not been as marked as with longliners. The main reason for this is the presence of security personnel onboard purse seine vessels since the mid-2009, which has made it possible for purse seiners to operate in the northwest Indian Ocean without a reduction in fishing effort (Fig. 5). However, in the IOTC area an approximate 30% reduction of the number of purse seiner has been observed since 2006.

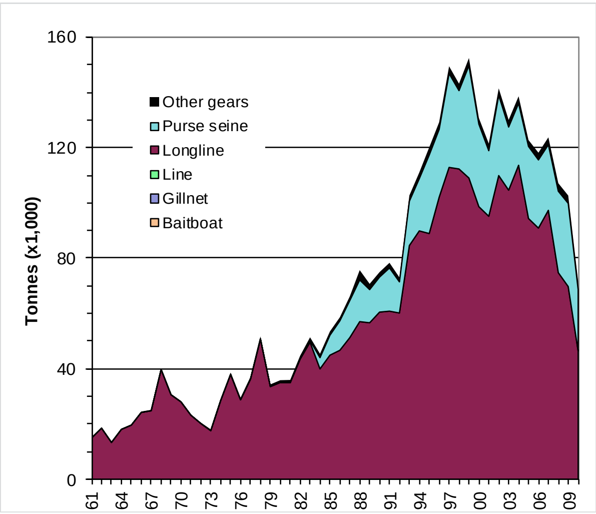

Fig. 3. Annual catches of bigeye tuna by gear recorded in the IOTC Database (1961–2010) (Data as of September 2011).

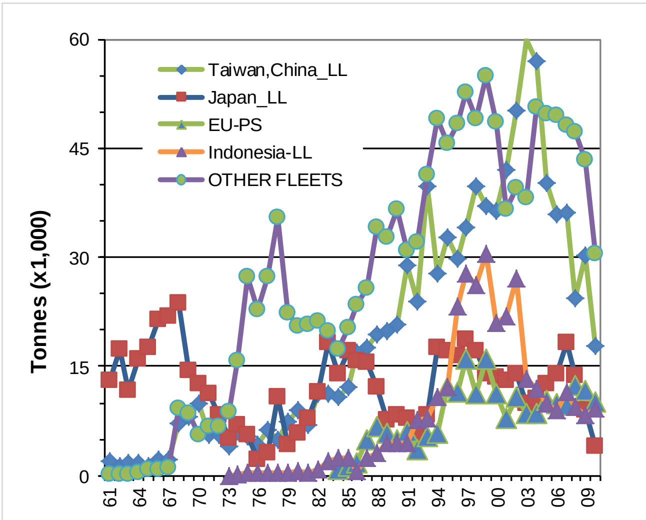

Fig. 4. Annual catches of bigeye tuna by fleet recorded in the IOTC Database (1961–2010) (Data as of September 2011).

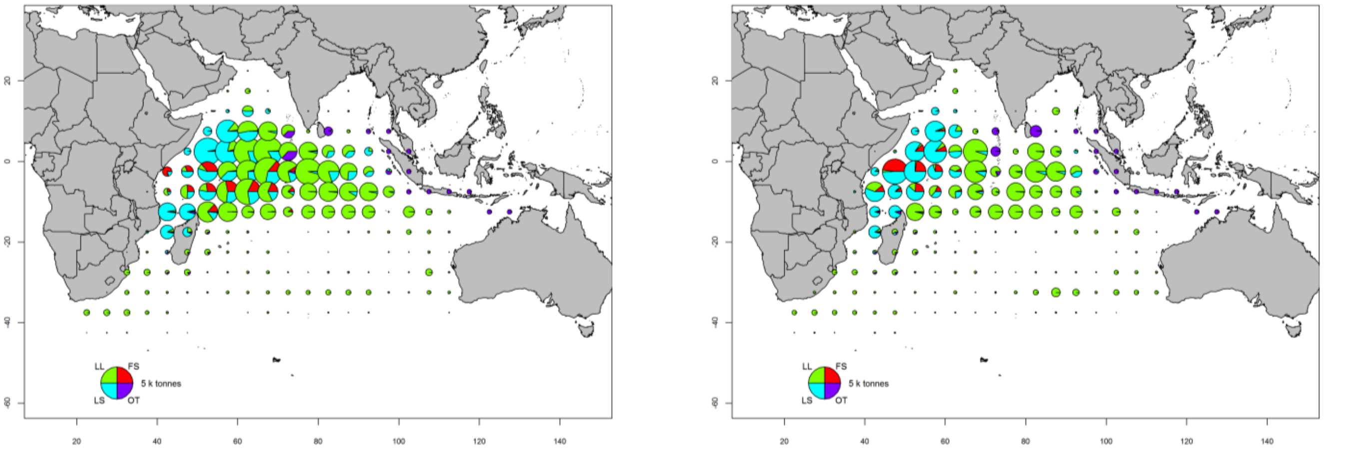

Fig. 5a–b. Time-area catches (total combined in tonnes) of bigeye tuna estimated for 2009 and 2010 by type of gear: Longline (LL), Purse seine free-schools (FS), Purse seine associated-schools (LS), and other fleets (OT), including pole-and-line, drifting gillnets, and various coastal fisheries (Data as of September 2011).

Bigeye tuna – uncertainty of catches

31. The WPTT **NOTED** that retained catches are thought to be well known for the major fleets (Fig. 6); but are uncertain for the fleets listed below, noting that catches for these fleets are considered to represent a small proportion of total catches:
    - Non-reporting industrial purse seiners and longliners (NEI) and for other industrial fisheries (longliners of India and Philippines).
    - Some artisanal fisheries including the pole-and-line fishery in the Maldives.
    - The gillnet fisheries of Iran and Pakistan.
    - The gillnet/longline fishery in Sri Lanka.
    - The artisanal fisheries in Indonesia, Comoros and Madagascar.

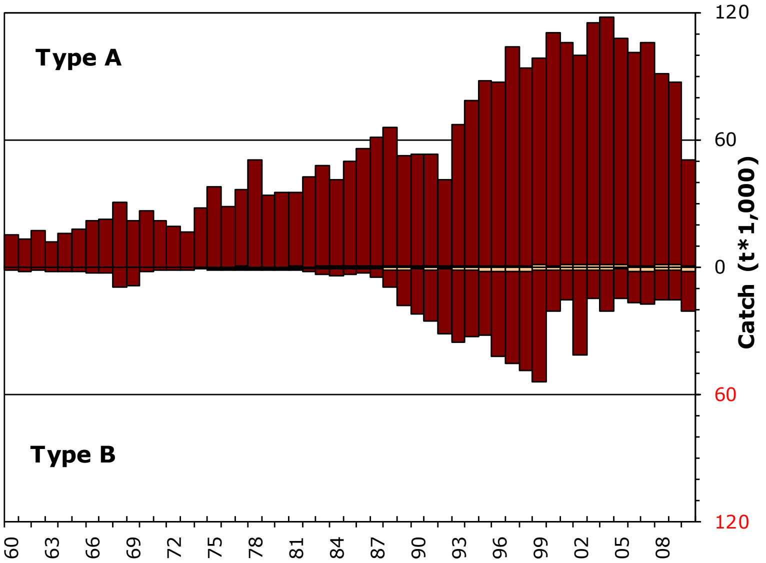

Fig. 6. Uncertainty of annual catch estimates for bigeye tuna (Data as of September 2011).

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.

32. The WPTT further **NOTED** that:
    - The catch series for bigeye tuna has not been significantly revised since the WPTT12 in 2010.
    - Levels of discards are believed to be low although they are unknown for most industrial fisheries, excluding industrial purse seiners flagged in EU countries for the period 2003–2007.

- Catch-and-effort series 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 very little data available for the fresh-tuna longline fishery of Taiwan,China.
    - uncertain data from significant fleets of industrial purse seiners from Iran and longliners from India, Indonesia, Malaysia, Oman, Philippines, and Taiwan,China (fresh tuna up to 2006).
    - no data available for the highseas gillnet fisheries of Iran and Pakistan and the gillnet/longline fishery of Sri Lanka, especially in recent years.
- Trends in average weight (Fig. 7) 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) (see paper IOTC–2011–WPTT13–08).

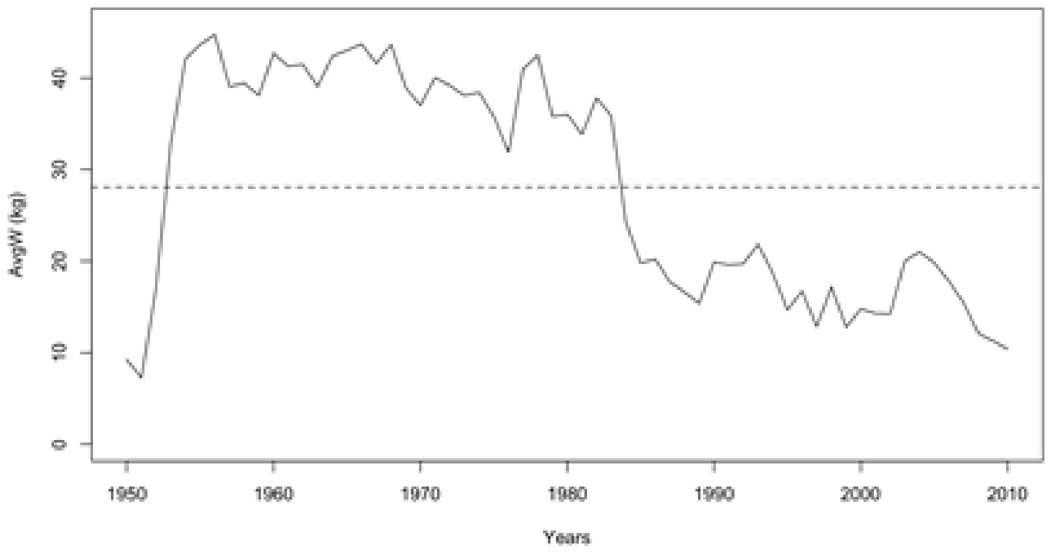

Fig. 7. Changes in average weight (kg) of bigeye tuna from 1950 to 2010 – all fisheries combined (Data as of September 2011).

- Catch-at-Size and Age tables are available but the estimates are highly uncertain for some periods and fisheries including:
    - the paucity of size data available from industrial longliners before the mid-60s, from the early-1970s up to the mid-1980s and in recent years (Japan).
    - the paucity of catch by area data available for some industrial fleets (NEI, India, Indonesia, Iran, Sri Lanka).

Bigeye tuna – tagging data

33. The WPTT **NOTED** that a total of 35,971 bigeye tuna were tagged during the Indian Ocean Tuna Tagging Programme (IOTTP) which represented a 17.8% of the total number of fish tagged. Most of the bigeye tuna tagged (96.1%) were tagged during the main EU-funded Regional Tuna Tagging Project-Indian Ocean (RTTP-IO) and were primarily released off the coast of Tanzania (Fig. 8) between May 2005 and September 2007. The remaining were tagged during small-scale projects around the Maldives, India and the southwest and eastern Indian Ocean by institutions with the support of IOTC. To date 5,563 (15.7%) of tagged fish have been recovered and reported to the IOTC Secretariat.

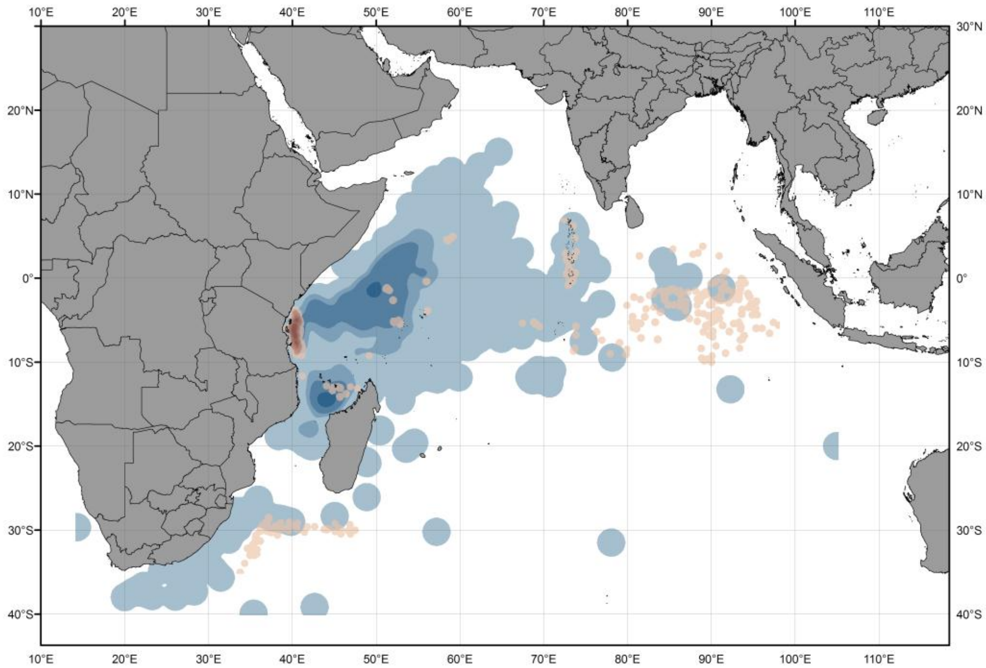

Fig. 8. Densities of releases (in red) and recoveries (in blue) of bigeye tuna. Data as of September 2011.

Yellowfin tuna – catch trends

34. The WPTT **NOTED** that contrary to the situation in other oceans, the artisanal fishery component of yellowfin tuna catches in the Indian Ocean is substantial, taking approximately 20–25% of the total catch landed. 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 (Fig. 9).

35. The WPTT **NOTED** that catches of yellowfin tuna increased rapidly with the arrival of the purse seine fleets in the early 1980s (Figs. 9 and 10), along with increased activity by longline vessels, with more than 400,000 t landed in 1993. Purse seiners typically take fish ranging from 40–140 cm fork length and smaller fish are more common in the catches taken north of the equator.

36. The WPTT **NOTED** that the purse seine fishery is characterized by the use of two different fishing modes: a fishery on drifting objects (FADs), which catches large numbers of small yellowfin 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 took 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 2003–2006 (64%) was much higher than in previous (49% for 1999–2002) or following years (55% for 2007–2009).

37. The WPTT **NOTED** that the longline fishery primarily catches large fish, from 80–160 cm fork length, although smaller fish in the size range 60–100 cm have been taken and reported 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, Rep. of Korea and Taiwan,China) and a fresh-tuna longline component (small to medium scale fresh tuna longliners from Indonesia and Taiwan,China). As was the case with purse seine fisheries, since 2005 longline catches have decreased substantially with current catches estimated to be at around 41,000 t, representing a more than three-fold decrease over the catches in 2005 (Fig. 9).

38. The WPTT **NOTED** that total yellowfin tuna catches dropped markedly from the peak catches taken in 2006, with the lowest catches recorded since the early 1990's reported in 2009, at around 275,000 t. Preliminary catch levels in 2010 are estimated to be around 299,000 t.

39. The WPTT **AGREED** that the recent drop in catches of yellowfin tuna could be related, at least in part, to the expansion of piracy in the western tropical Indian Ocean, which has led to a marked drop in the

levels of longline effort in the core fishing area of the species (Figs. 11a, b) as well as to the decline in the number of purse seiners in the Indian Ocean (~30% reduction).

40. The WPTT **NOTED** that catches by other gears, i.e. pole-and-line, gillnet, troll, hand line and other minor gears, have increased steadily since the 1980s (Fig. 9). In recent years the total artisanal yellowfin tuna catch has been between 140,000–160,000 t, with the catch by gillnets (the dominant artisanal gear) at around 80,000 t.

41. The WPTT **NOTED** that most yellowfin tuna are caught in the Indian Ocean, north of 12°S, and in the north of the Mozambique Channel (Figs. 11a, b). 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 2008 and 2010. The drop in catches is the consequence of a generalised drop in fishing effort due to the effect of piracy in the western Indian Ocean region.

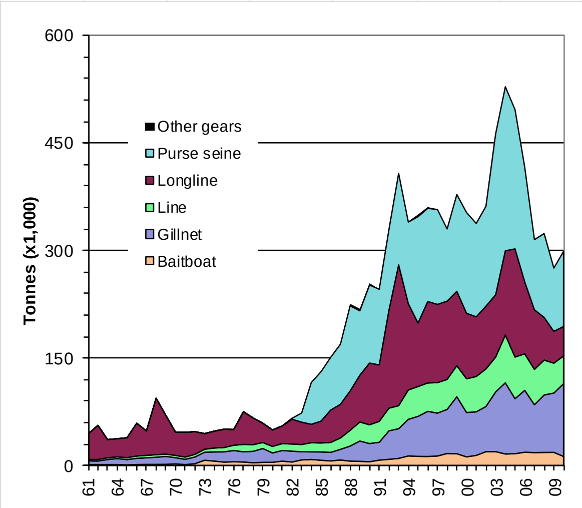

Fig. 9. Annual catches of yellowfin tuna by gear recorded in the IOTC Database (1961–2010) (Data as of September 2011).

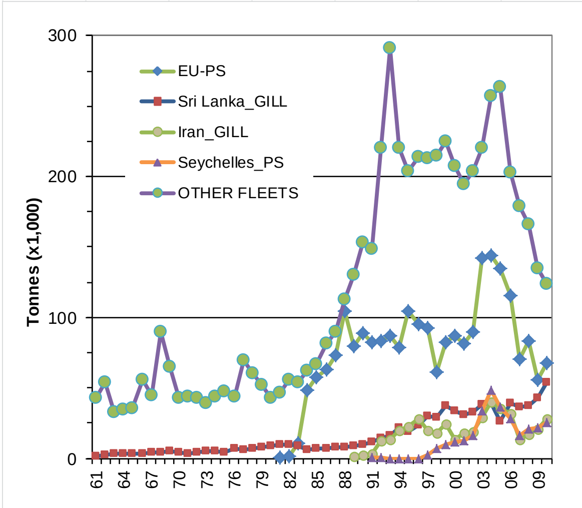

Fig. 10. Annual catches of yellowfin tuna by fleet recorded in the IOTC Database (1961–2010) (Data as of September 2011).

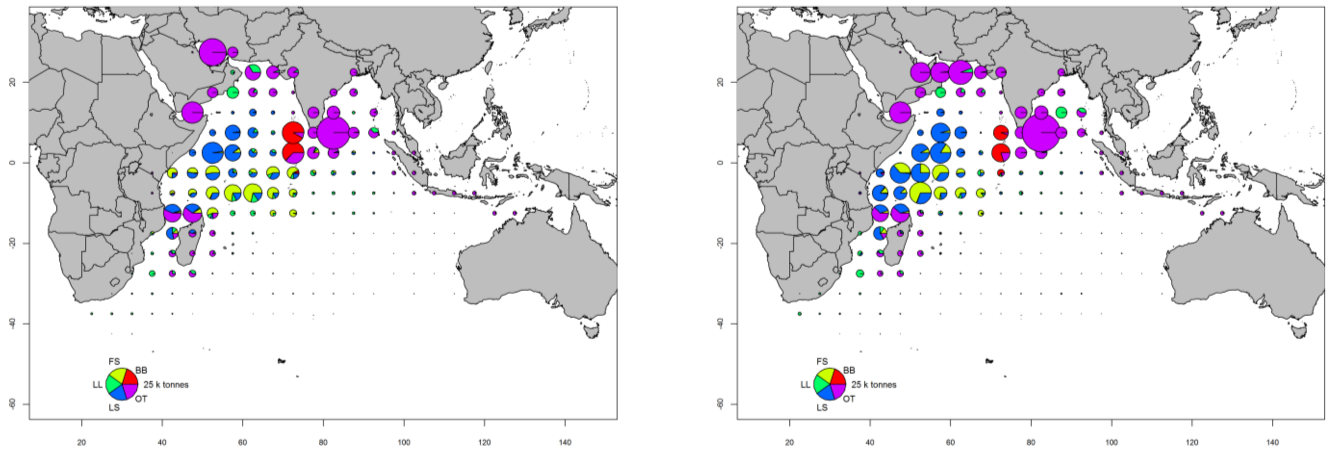

Fig. 11a–b. Time-area catches (total combined in tonnes) of yellowfin tuna estimated for 2009 and 2010 by type of gear: Longline (LL), Purse seine free-schools (FS), Purse seine associated-schools (LS), pole-and-line (BB), and other fleets (OT), including drifting gillnets, and various coastal fisheries (Data as of September 2011).

Yellowfin tuna – uncertainty of catches

42. The WPTT **NOTED** that retained catches are generally well known for the major fleets (Fig. 12); but 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 commercial longliners from India.

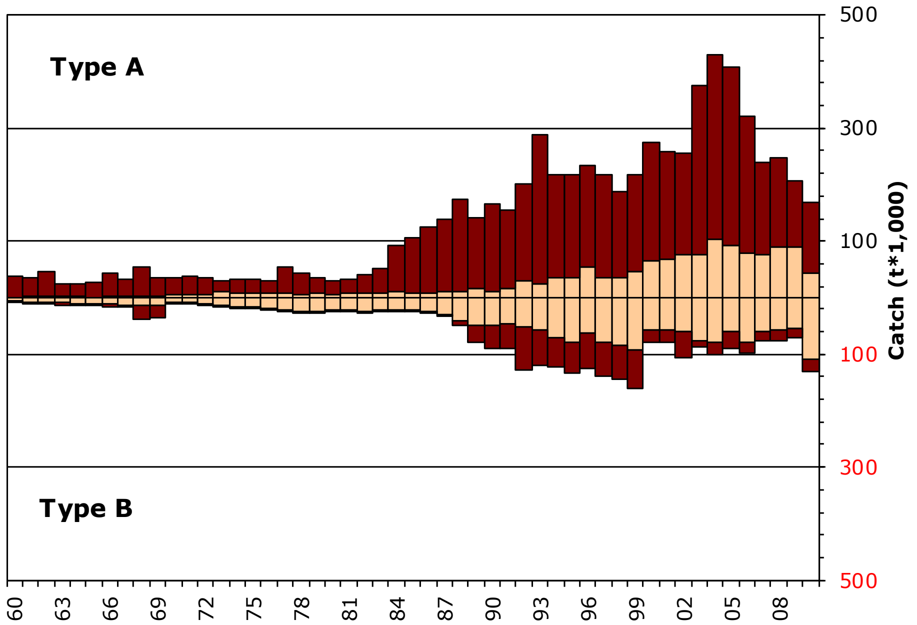

Fig. 12. Uncertainty of annual catch estimates for yellowfin tuna (Data as of September 2011).

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.

43. The WPTT further **NOTED** that:
   - the catch series for yellowfin tuna has not been significantly revised since the WPTT12 in 2010, although there has been some revision to the time series of catch from the fisheries of India leading to changes in catches by gear.
   - levels of discards are believed to be low although they are unknown for most industrial fisheries, excluding industrial purse seiners flagged in EU countries for the period 2003–2007.
   - catch-and-effort series are available from the major industrial and artisanal fisheries. However, these data are not available for some important artisanal fisheries or they are considered to be of poor quality for the following reasons:
     - no data are available for the fresh-tuna longline fishery of Indonesia, over the entire time series, and very little data available for the fresh-tuna longline fishery of Taiwan,China.
     - no data are available for the gillnet fisheries of Pakistan.
     - although Iran has provided catch and effort data, it is not reported as per the IOTC standards.
     - 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.
   - trends in average weight (Fig. 13) 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 (see paper IOTC–2011–WPTT13–08).

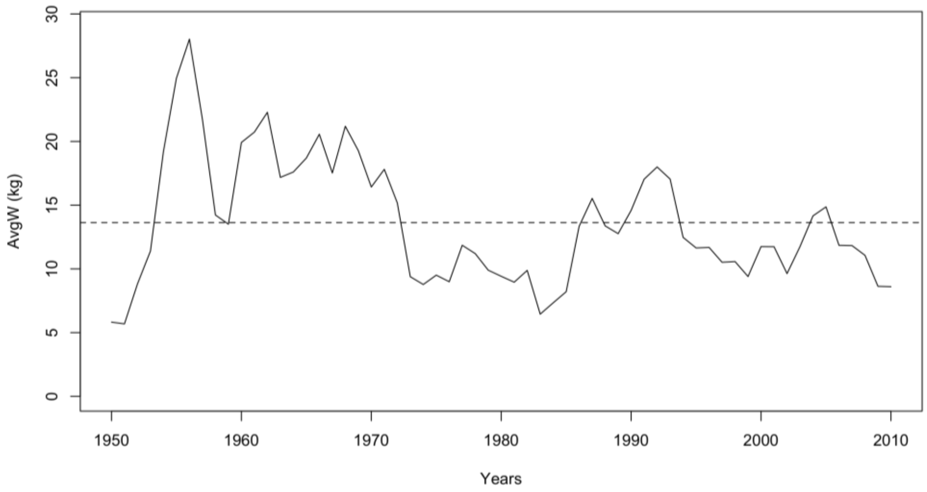

Fig. 13. Changes in average weight (kg) of yellowfin tuna from 1950 to 2010 – all fisheries combined (Data as of September 2011).

- catch-at-Size and Age tables are 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.
  - the paucity of catch by area data available for some industrial fleets (NEI, Iran, India, Indonesia, Malaysia).

Yellowfin tuna – tagging data

44. The WPTT **NOTED** that a total of 63,310 yellowfin tuna were tagged during the Indian Ocean Tuna Tagging Programme (IOTTP) which represented 31.4% of the total number of fish tagged. Most of the yellowfin tuna tagged (86.4%) were tagged during the main Regional Tuna Tagging Project-Indian Ocean (RTTP-IO) and were primarily released off the coasts of the Seychelles, in the Mozambique Channel, along the coast of Oman and off the coast of Tanzania (Fig. 14) between May 2005 and September 2007. The remaining were tagged during small-scale projects around the Maldives, India and the southwest and eastern Indian Ocean by institutions with the support of IOTC. To date 10,560 (16.7%) tagged fish have been recovered and reported to the IOTC Secretariat.

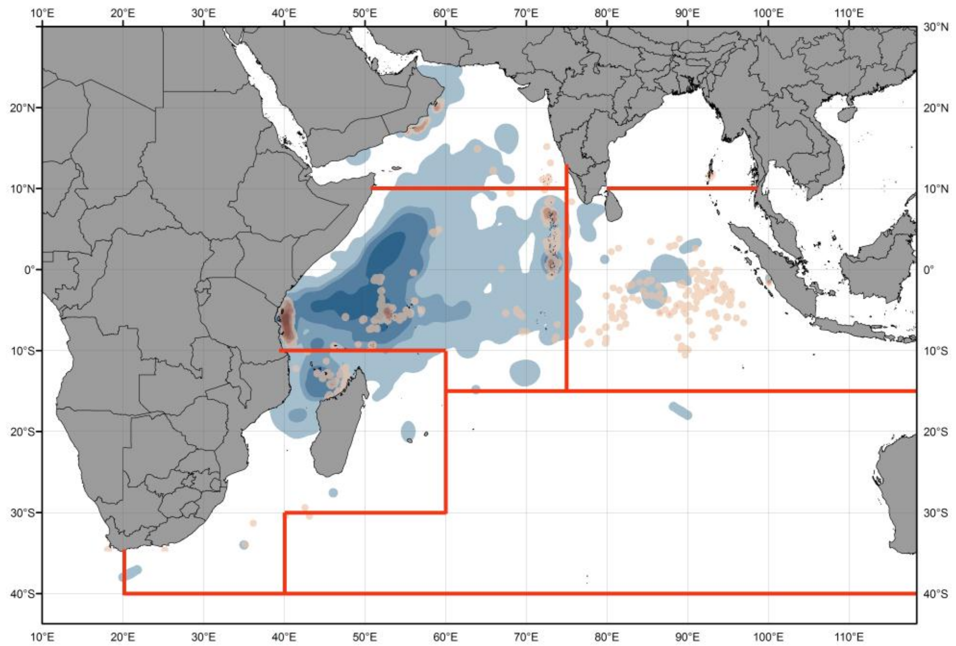

Fig. 14. Densities of releases (in red) and recoveries (in blue) of yellowfin tuna. Data as of September 2011.

Skipjack tuna – catch trends

45. The WPTT **NOTED** that catches of skipjack tuna increased slowly from the 1950s, reaching around 50,000 t during the mid-1970s, mainly due to the activities of pole-and-lines and gillnets (Figs. 15 and 16). The catches increased rapidly with the arrival of purse seiners in the early 1980s, and skipjack tuna became one of the most important tuna species in the Indian Ocean.

46. The WPTT **NOTED** that the increase in purse seine caught skipjack tuna post 1984 (Figs. 15 and 16) was due to the development of a fishery in association with Fish Aggregating Devices (FADs). Since the 1990's, 85% of the skipjack tuna caught by purse seine vessels was taken in association with FADs. Following the peak catches taken in 2002 (240,000 t) and 2006 (247,000 t), catches dropped markedly, probably as a consequence of exceptional purse seine catch rates on free schools of yellowfin tuna. In 2007 purse seine catches dropped by around 100,000 t (145,000 t), with similar catches recorded in 2008 and have remained low (150,000–160,000 t).

47. The WPTT **NOTED** that 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 used in the fishery. The sharp decline in purse seine catches shown since 2007 (resulting partially from an approximate 30% decline of effort) coincided with a similar decline in the catches of Maldivian pole-and-line vessels (Fig. 16). The Maldivian fishery effectively increased its fishing effort with the mechanisation of its pole-and-line fishery from 1974, including an increase in boat size and power and the use of anchored FADs since 1981. The decrease in catches of both fisheries may also be the result of a sharp decrease in the mean skipjack tuna weight during this period, from 3 kg in 2006 to 2.3 kg in 2010. It should be noted that during the period 2006–2010, the gillnet fishery was catching over 100,000 tons of large skipjack tuna (~4.3 kg).

48. The WPTT **NOTED** that several fisheries using gillnets have reported large catches of skipjack tuna in the Indian Ocean (Fig. 16), 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 20–30% of the total catches of skipjack tuna in the Indian Ocean. Although it is known that vessels from Iran and Sri Lanka 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.

49. The WPTT **NOTED** that the majority of the catches of skipjack tuna originate from the western Indian Ocean (Fig. 17). 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. Although the drop in catches could be partially explained by a drop in catch rates and fishing effort by the purse seine fishery, due to the effects of piracy in the western Indian Ocean region, drops in the catches of other fisheries, in particular for the Maldives, are not fully understood.

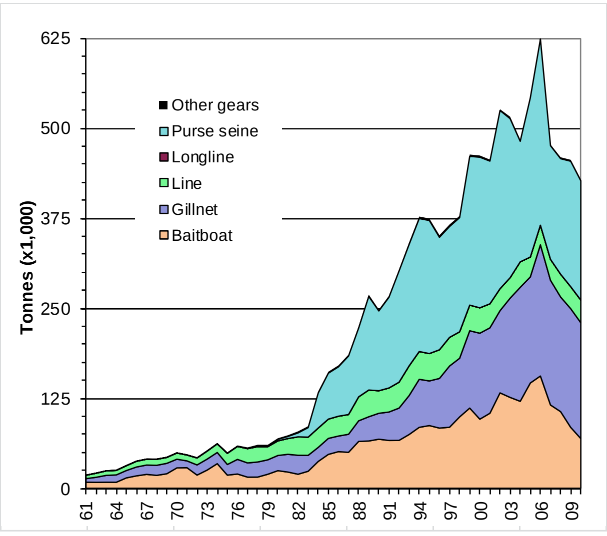

Fig. 15. Annual catches of skipjack tuna by gear recorded in the IOTC Database (1961–2010) (Data as of September 2011).

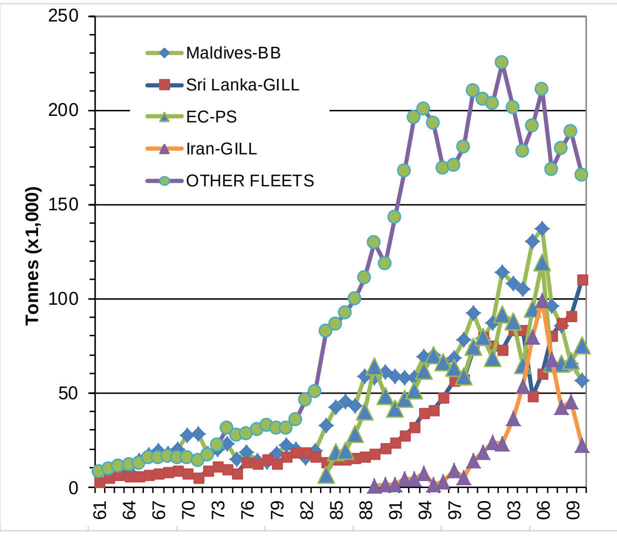

Fig. 16. Annual catches of skipjack tuna by fleet recorded in the IOTC Database (1961–2010) (Data as of September 2011).

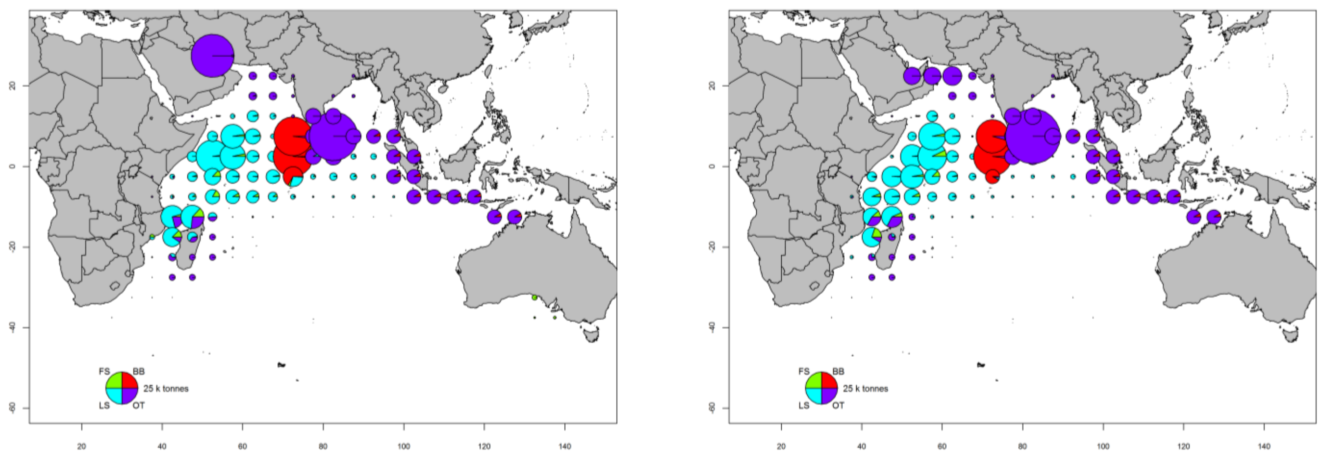

Fig. 17a–b. Time-area catches (total combined in tonnes) of skipjack tuna estimated for 2009 and 2010 by type of gear: Purse seine free-schools (FS), Purse seine associated-schools (LS), pole-and-line (BB), and other fleets (OT), including longline, drifting gillnets, and various coastal fisheries (Data as of September 2011).

Skipjack tuna – uncertainty of catches

50. The WPTT **NOTED** that retained catches are generally well known for the industrial fisheries but are less certain for many artisanal fisheries (Fig. 18), notably because:
- Catches are not being reported by species.
- There is uncertainty about the catches from some important fleets including the Sri Lankan coastal fisheries, and the coastal fisheries of Comoros and Madagascar.
- Approximately 10–12 % of the reported catches from some coastal fisheries are uncertain.

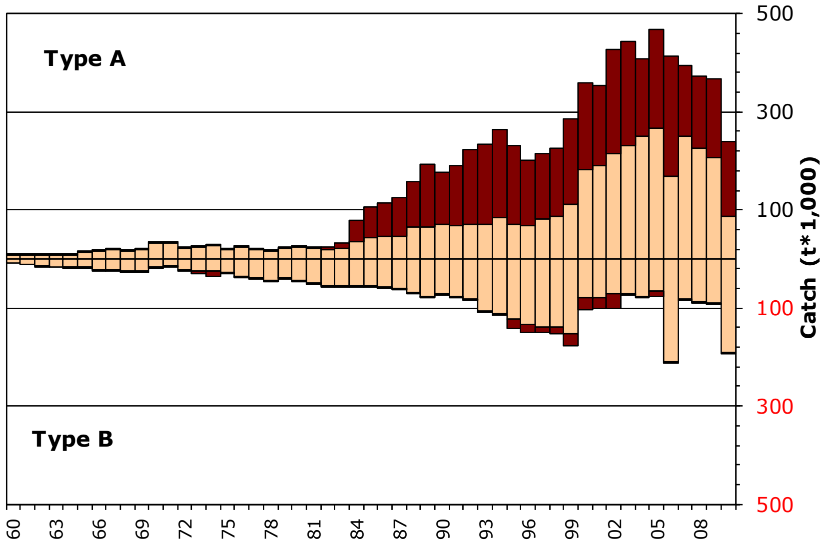

Fig. 18. Uncertainty of annual catch estimates for skipjack tuna (Data as of September 2011).

*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.*

51. The WPTT further **NOTED** that:
- the catch series for skipjack tuna has not been substantially revised since the WPTT12 in 2010.
- levels of discards are believed to be low although they are unknown for most industrial fisheries, excluding industrial purse seiners flagged in EU countries for the period 2003–2007.
- catch-and-effort series 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 fishery of Pakistan.
  - although Iran has provided catch and effort data, it is not reported as per the IOTC standards.

   - the poor quality effort data for the significant gillnet/longline fishery of Sri Lanka.
   - no data are available from important coastal fisheries using hand and/or troll lines, in particular Indonesia, Madagascar and Comoros.
- trends in average weight (Fig. 19) cannot be accurately assessed before the mid-1980s and are incomplete for most artisanal fisheries post-1980, namely hand lines, troll lines and many gillnet fisheries (Indonesia) (see paper IOTC–2011–WPTT13–08).

Fig. 19. Changes in average weight (kg) of skipjack tuna from 1950 to 2010 – all fisheries combined (Data as of September 2011).

- catch-at-Size and Age tables 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).

Skipjack tuna – tagging data

52. The WPTT **NOTED** that a total of 100,620 skipjack tuna were tagged during the Indian Ocean Tuna Tagging Programme (IOTTP) which represented 49.8% of the total number of fish tagged. Most of the skipjack tuna tagged (77.8%) were tagged during the main Regional Tuna Tagging Project-Indian Ocean (RTTP-IO) and were primarily released off the coasts of the Seychelles and Tanzania and in the Mozambique Channel (Fig. 20) between May 2005 and September 2007. The remaining were tagged during small-scale projects around the Maldives, India and the southwest and eastern Indian Ocean by institutions with the support of IOTC. To date, 15,270 (15.2%) of the tagged fish have been recovered and reported to the IOTC Secretariat.

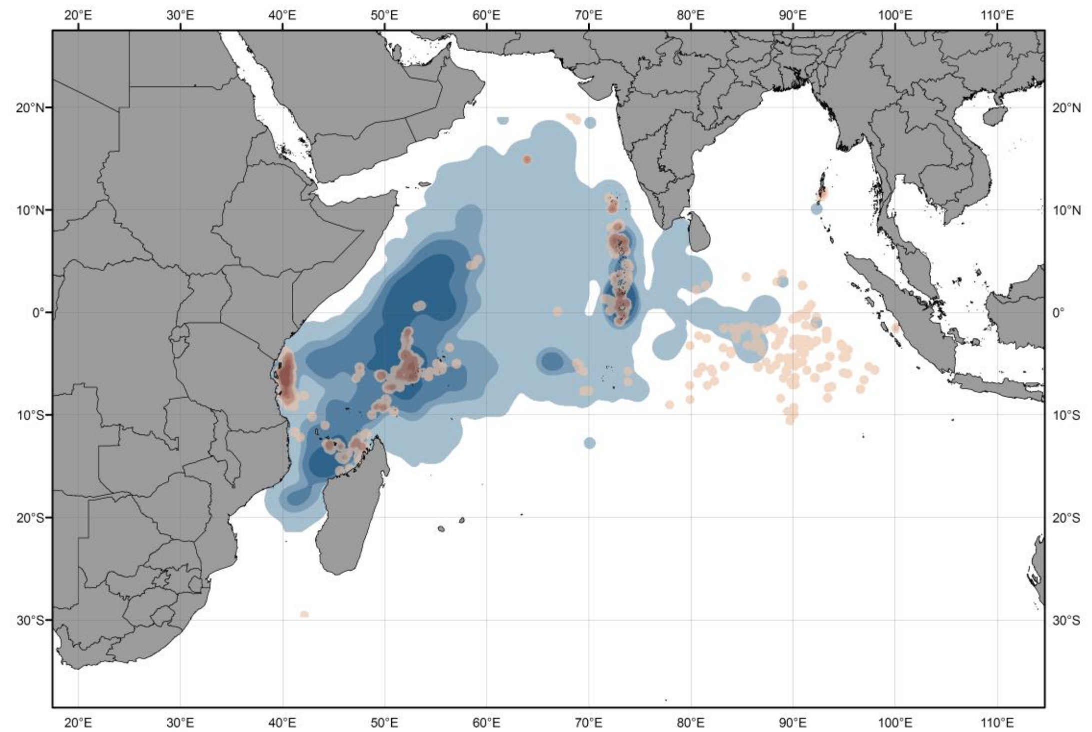

Fig. 20. Densities of releases (in red) and recoveries (in blue) of skipjack tuna. Data as of September 2011.

Data collection and reporting summary

53. The WPTT **NOTED** the IOTC Secretariat's recent activities in Iran, which aimed at finalising agreement for the implementation of systems to strengthen data management and to implement pilot sampling activities to assess the quality of the statistics being collected from gillnet fisheries.

54. Noting that an IOTC mission to Pakistan was scheduled but had to be postponed due to the situation in the country, the WPTT **RECOMMENDED** that the IOTC Secretariat travel to Pakistan once the situation improves, in order to assess the status of data collection and reporting systems in this country and to report back to the WPTT at its 2012 session.

55. The WPTT **RECOMMENDED** that as a matter of priority, Pakistan provide catch-and-effort data and size data for tropical tunas, in particular from their gillnet fisheries, noting that this is already a mandatory reporting requirement.

56. The WPTT welcomed the efforts of Sri Lanka to improve data collection and management for its fisheries and **RECOMMENDED** that the IOTC-OFCF project and Sri Lanka continue their cooperation towards improving the collection and reporting of fisheries statistics and to report back to the WPTT at its 2012 Session.

57. The WPTT **RECOMMENDED** that Maldives report catch and effort data as per the IOTC standards for 2010 and that for earlier statistics (2002 to 2009), and that they are reported by atoll, month, gear and species, as it was done in the past.

58. The WPTT **NOTED** the plans from the IOTC-OFCF Project to hold a Catch Estimation Workshop in Indonesia in March 2012, in order to assess data collection and reporting systems for Indonesia's coastal and longline fisheries. The WPTT thanked the IOTC-OFCF Project for this initiative and **RECOMMENDED** that the outcomes of the Workshop be reported to the next Session of the WPTT.

59. The WPTT urged Madagascar and Yemen to collect and report statistics on their coastal fisheries and **RECOMMENDED** that these countries request assistance from the IOTC Secretariat where required.

60. The WPTT **RECOMMENDED** that as a matter of priority, the IOTC Secretariat liaise with India, Oman, Indonesia, Philippines and Malaysia to implement the minimum requirements of IOTC Resolution 08/04 *concerning the recording of catch by longline vessels in the IOTC area*, in order to improve the quality of the data reported from their longline fleets, by species, and to report back to the WPTT at its next meeting.

61. The WPTT **RECOMMENDED** that the IOTC Secretariat continue working with the Iranian authorities towards improving reporting from their purse seine fleet, and to report progress to the WPTT at its next meeting.

62. The WPTT **RECOMMENDED** that Philippines investigate the reasons for the differences between bigeye tuna export data and reported catch data from their longline fishery, and to report findings to the next WPTT meeting.

63. The WPTT **RECOMMENDED** that Iran and Pakistan report size data for tropical tuna species, as per the IOTC requirements, for their gillnet fleets, noting that this is already a mandatory reporting requirement, and that the Secretariat assist Iran and Pakistan to facilitate reporting of this information where required.

64. The WPTT **RECOMMENDED** that India, Malaysia, Oman and Philippines make every possible effort to collect and report size data for tropical tuna species for their longline fleets, noting that this is already a mandatory reporting requirement.

65. The WPTT **RECOMMENDED** that Indonesia report size data for tropical tuna species for its longline vessels as soon as possible as per IOTC standards, noting that this is already a mandatory reporting requirement.

66. The WPTT **RECOMMENDED** that Japan increase sampling coverage to attain at least the minimum required by the IOTC Resolution 10/02 *on mandatory statistical requirements* (1 fish by metric ton of catch by type of gear and species), and for the IOTC Secretariat to assess levels of reporting for Japan upon receiving size data for 2010 and to report back to the WPTT at its next meeting

67. The WPTT **RECOMMENDED** that biological data is gathered and reported to the IOTC Secretariat in order to develop specific length-age, length-weight and processed weight-live keys for the Indian Ocean tropical tuna species, in particular by the main longline fisheries (Taiwan,China, Indonesia, Japan, EU and China).

68. Noting the importance of biological information to be considered in the stock assessment models, the WPTT **RECOMMENDED** that gonad collection and calculation of the gonadosomatic index for yellowfin tuna be carried out prior to the next WPTT meeting.

69. Noting the difficulties that the IOTC Secretariat has experienced in completing the review of datasets for tropical tunas, including the implementation of a scoring system and further use of those scores to derive alternative series of catches for tropical tuna species, the WPTT **RECOMMENDED** that the Secretariat makes every possible effort to finalize this work before the next meeting of the WPTT in 2012.

70. Noting the preliminary results of a study conducted by the IOTC Secretariat comparing average weights, as derived from the length frequency, and time area catches in number and weight available for the longline fleets of Japan and Taiwan,China, the WPTT **RECOMMENDED** that the IOTC Secretariat complete this study and present results to the next meeting of the WPDCS.

71. 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.

72. The WPTT **RECOMMENDED** that all CPCs catching small yellowfin tuna should undertake scientific sampling of their yellowfin tuna catches in order to identify potential bigeye tuna catches (in particular for those CPCs identified in previous paragraphs) and to report findings at the next WPTT meeting.

7. NEW INFORMATION ON BIOLOGY, ECOLOGY, FISHERIES AND ENVIRONMENTAL DATA RELATING TO TROPICAL TUNAS

7.1 Review new information on the biology, stock structure, their fisheries and associated environmental data

Environmental data

73. The WPTT **NOTED** paper IOTC–2011–WPTT13–11 which provided an outline of climate and oceanographic conditions in the Indian Ocean up until August 2011, including the following abstract provided by the author:

    "*Various datasets (SST, wind stress, mixed layer depth, chlorophyll) are used to depict past trends and present situation (up to August 2011) of several ocean-climate indicators in the Indian Ocean. The long term and basin scale trend of the sea surface temperature (SST) has been steadily increasing since 1955 at a rate of 0.10°C/decade and the SST in the Western Indian Ocean (WIO) increased at an even higher rate (0.13°C/decade). Accordingly, the occurrence of 2°area-month strata with SST>26°C (a threshold for tuna larvae survival) has increased by more than 2% since the period 1960-1965. The anomalous events recorded in the past two years were an El Nino (warm event in Central Pacific and WIO) in 2010 and La Nina (cold event in CentPac and WIO) in 2011. However, the anomalous response in the WIO exhibits a greater magnitude during El Nino (+ 0.6°C) than during La Nina (-0.15°C) events. Regional analyses are also conducted. A working hypothesis, which would need further investigation, is a detrimental effect of the current depressed biological productivity at the base of the food chain on tuna concentration and biological processes (slower growth, increased natural mortality). This should be considered when assessing the reasons for the substantial decline in PS CPUE on free schools in the WIO in 2010 and 2011 and the dramatic decline of SJK catch rates observed in Maldives since 2006 (-55%).*"

74. The WPTT **NOTED** the first analysis which covered the northern slope of the Seychelles-Chagos thermocline ridge (SCTR, 0°–10°S) which corresponds to the core of yellowfin tuna spawning grounds, from December to March. There, deeper thermocline is associated with El Niño and Positive Dipole events, and the signal is fully developed at the turn of the year (depth anomaly of +40 m and +20 m for respectively Jan 1998 and Jan 2007). From 2008 onwards, shallow thermocline prevailed in the SCTR during December–January and no anomalous deepening of the thermocline was observed during the 2010 warm event.

75. The WPTT **NOTED** the second analysis which covered the whole WIO, and where the surface chlorophyll concentration (SCC) has oscillated from lows (during the 1997–1998 El Niño) to highs (2003–2005) then back to lows from 2007 onwards. The negative SCC anomalies in 2010 and 2011 have been estimated at 25–30% below the average, as depicted in Jan-Feb and Aug-Sept (the two peaks of the seasonal cycle). SCC anomalies in Aug-Sept seem to be related to a weaker Somali upwelling as a prominent southward wind stress anomaly (i.e. not favouring the upwelling activity) has been recorded since 2008 in the West Somali Basin. A declining trend in SCC is evidenced from 2009 to 2011 in the WIO.

76. The WPTT **NOTED** the third analysis where the Maldives archipelago and Central Indian Ocean areas were considered. In Maldives, the analysis points out persistent low SCC anomaly since 2006, which represents a 15% below-normal SCC in 2011. By contrast, an anomalously lasting event of enhanced SCC was detected in the Central Indian Ocean (5°S–15°S/75°E–90°E) from October 2010 onwards, and still visible in the last available month of the series (August 2011). Combined plots of SST, 20°C isotherm depth anomaly and SCC suggest that the high productivity was initially triggered by a very shallow thermocline leading to a cooling of the mixed layer, then becoming visible in the SST and SCC 2 months later. Potential effect on forage enhancement for top predators might be considered. Conversely, the substantial decline of SSC in the WIO might limit the carrying capacity of the pelagic ecosystem.

77. The WPTT **NOTED** that more work is required to better understand the relative effects of the environment on catchability and on abundance. Catchability changes forced by the environment occur in the short term, whilst time lags must be considered for the abundance. It was recognised that ecosystem models would help to resolve those confounding effects.

78. The WPTT **AGREED** that environmental factors such as dissolved oxygen and oxyclines be explored in the 2012 CPUE standardisation work.

Mozambique catch data

79. The WPTT **NOTED** paper IOTC–2011–WPTT13–12 which provided some results for tropical tuna based on catch data in Mozambique, including the following abstract provided by the authors:

“*Mozambique does not have a national fishing fleet targeting tuna and tuna like species. and tropical tuna (Thunnus albacares, Thunnus obesus and Katswonus pelamis) are caught by foreign fleets of longliners and purse-seiners. During several months of 2010, four longliners from China were licensed to fish along the Mozambican coasts and observers were deployed on board allowing collection of their logbooks.”*

80. Noting the difficulties Mozambique has experienced in receiving the logbooks of fishing vessels licensed to fish in its EEZ, the WPTT **RECOMMENDED** that the CPCs concerned send the logbook data to Mozambique, noting that this is already a mandatory requirement under IOTC Resolution 08/04 *concerning the recording of catch by longline fishing vessels in the IOTC area* and Resolution 10/03 *concerning the recording of catch by fishing vessels in the IOTC area*.

81. Noting that to date, Mozambique has not reported data for its coastal fisheries to the IOTC Secretariat the WPTT **RECOMMENDED** that data are collected and reported as soon as possible.

Comoros artisanal fisheries

82. The WPTT **NOTED** paper IOTC–2011–WPTT13–13 which provided a census of artisanal fishing vessels in Union of the Comoros, including the following abstract provided by the authors:

“*A frame survey was financed by the IOTC-OFCF project in order to undertake a census of the fishing vessels of the artisanal Comorian fleet. The Comorian fishing fleets are essentially artisanal, locally made and work less than 30 nautical miles from the shore in general. The fishing vessels are small, with dimensions included under category 1.1 (0.1–5.9m) and under category 1.2 (6.0–11.9m) defined by FAO. A total of 5,323 boats were recorded in 2011 against 3,946 units in 1994. Today, 32% of the Comorian fisheries fleet is motorized against 14 % in 1994. Regarding fishing gear, 26% of fishing operations are done using trolling line, 24 % by using short line and 51% of all operations target tuna species.”*

83. The WPTT welcomed the implementation of a frame survey and of a new sampling programme in the Comoros and strongly **RECOMMENDED** that Comoros maintain this activity after the end of the programme to be able to report annual data as per IOTC requirements.

Pakistan fisheries

84. The WPTT **NOTED** paper IOTC–2011–WPTT13–14 which outlined the fishing gear and methods used to harvest tuna and tuna-like species in the EEZ of Pakistan, including the following abstract provided by the authors:

“*Although a variety of fishing gears and methods are used to harvest fisheries resources in Pakistan, drifting gillnet is the only gear used to catch tuna and tuna like species by local wooden fishing boats. Longlines, purse-seine and pole-and-line are not used by local vessels to target tuna in marine waters of Pakistan. This paper describes the technical parameters and specification of a typical large gillnetter, its fishing gear and methods. After undertaking a number of interviews, assessments, observations etc., it appears that the preservation methods on board the fishing vessels has changed from dry-salted to fresh (iced). This resulted in a reduction of the number of fishing days as well as decrease in length of the gillnets used to land better quality catch.”*

85. The WPTT **NOTED** that prior to the adoption of IOTC Resolution 09/05 *to prohibit the use of large-scale driftnets on the high seas in the IOTC area*, gillnet vessels flagged to Pakistan used gillnets up to 9 kilometers in length, and this despite the United Nations General Assembly Resolution 46/125 adopted in 1992. The WPTT further **NOTED** that, at present, the maximum length of gillnets reportedly used by Pakistan vessels are 2.5 km, stressing the need for Pakistan to strengthen monitoring of vessels under its flag.

86. The WPTT **NOTED** that Pakistan has not yet implemented a vessel monitoring system (VMS) programme for its gillnet vessels of and over 15 m as required under IOTC Resolution 06/03 *on establishing a vessel monitoring programme*, although it intends on doing so before the end of 2011.

87. The WPTT **NOTED** paper IOTC–2011–WPTT13–15 which outlined the catches and landing of tuna and tuna-like species by Pakistan fleets, including the following abstract provided by the authors:

> "*Fisheries resources play an important role in the economic development of Pakistan. It contributes about 0.8% to the overall Gross Domestic Product (GDP), 3.7% to the Agricultural GDP and less than 0.1% percent to the national employment. Contribution of tuna landings in total marine fish production ranged from 10% to 12%. A study has been conducted to record tuna catches and to collect information on size-frequency of five different species. The study shows that catches of oceanic tuna species, particularly yellowfin and skipjack tunas, are declining, while there seems to be no threat for other species as the catch rates are normal. However, the length-frequencies clearly shows a decrease in the size of all species.*"

Madagascar fisheries

88. The WPTT **NOTED** paper IOTC–2011–WPTT13–16 which provided a partial analysis of the catches of tropical tuna fishing industry in the Malagasy EEZ, including the following abstract provided by the authors:

> "*Partial analysis of the data contained in the databases of Fisheries Surveillance Centre has been made for the period 2005 to 2010. The changes in some parameters of the fishery industry of tropical tunas have been followed. The daily yield of each type of vessels (longliner and purse seiner) was calculated from information received by the declarations of input/output of each vessel. The composition of the catch logbooks as well as the average weight of the three tropical tuna species are studies. Stability, despite a small decrease, was observed on the average weight of fish caught and the daily yield of longliners over the years. However, a change in the composition of the catch is palpable especially for the three tropical tuna species (bigeye, yellowfin and skipjack).*"

89. 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.

90. 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 **URGED** Madagascar to collect and report this information as soon as possible.

Malaysian fisheries

91. The WPTT **NOTED** paper IOTC–2011–WPTT13–17 which provided catch, species composition and biology of tuna caught in the Indian Ocean by the Malaysian tuna longliners, including the following abstract provided by the authors:

> "*Penang port has long been recognized as a potential port for transshipment of tuna caught by longliners in the Indian Ocean. After facing a period of continuous declining in tuna landings from vessel operating in the Indian Ocean, Malaysia stand to develop his own fleet for tuna fishing in open seas particularly in the Indian Ocean. From 15 longline vessels in 2003, the number of registered vessels increased to 59 in 2010 while landings in Penang of tropical tuna increased from 770 tons to 1138 tons during the same period. Vessels landings at Penang port are seasonal, with peaks from October to February the following year and most of the vessels are believe to be operating in the eastern Indian Ocean. From 2000 to 2002, three training and research trips were carried out using training vessel from DoF and two chartered commercial tuna longline vessels. Catch and biology parameters of yellowfin and bigeye tuna were obtained from these trips. During the trip of the 2 commercial longline vessels, a total of 533 yellowfin tuna (231 males + 302 female) and 423 bigeye tuna (194 males + 229 females) were sampled over the period July to October. Both vessels operated in areas between Longitude 77oE – 85oE and Latitude 5°N – 5°S. Their average CPUE were at 6.7± 1.8 and 4.7 ± 2.7 respectively. Average size of yellowfin and bigeye caught were 119cm and 125cm respectively. More than 60% of yellowfin and 40% of bigeye were sexually matured during the period of study.*"

92. Noting that to date, vessels flagged to Malaysia are not using logbooks to record their activities, as required by IOTC Resolution 08/04, which includes minimum requirements for collecting and reporting operational data, the WPTT **RECOMMENDED** that Malaysia implement the requirements under Resolution 08/04 as a matter of priority.

93. The WPTT **NOTED** that the total catches reported for longliners flagged to Malaysia only represent the catch landed in Malaysia and do not include the catches of vessels based outside Malaysia, stressing the need for Malaysia to improve monitoring of vessels under its flag.

Indian fisheries

94. The WPTT **NOTED** paper IOTC–2011–WPTT13–18 which provided an overview of the interannual and geographic variations in the abundance indices of yellowfin tuna, billfishes and sharks in the Indian EEZ, including the following abstract provided by the authors:

> "*Spatio-temporal abundance indices of large pelagic predators were studied using data from longline survey conducted in the Eastern Arabian Sea, Western Bay of Bengal and the Andaman and Nicobar waters. During the study period (1984-2008), the entire Indian EEZ was surveyed with a total fishing effort of 1,711,087 hooks. The trends in the abundance indices revealed drastic reduction in the abundance indices of sharks, yellowfin tuna and billfishes. The study calls for immediate adoption of management measures for maintaining healthy stocks of these resources in the Indian Ocean with the cooperation of other nations engaged in the fishery of large pelagic in the Indian Ocean. The study emphasises the importance of continuous monitoring of the stock status of these resources by fishery independent surveys.*"

95. The WPTT **NOTED** the declining trend in the abundance of large pelagic predators within the Indian EEZ, particularly since the mid-1990's, and encouraged India to continue monitoring the abundance of ecosystem dynamics and to provide further updates at the next WPTT meeting.

96. Noting that India has a large data set collected on the research longline vessels operated by the Fishery Survey of India during the last 30 years, the WPTT **RECOMMENDED** that Indian scientists participate in the CPUE standardization workshop in order to assess the value of using this information.

EU,Spain purse seine fishery

97. The WPTT **NOTED** paper IOTC–2011–WPTT13–19 which outlines the statistics of the Spanish purse seine fleet in the Indian Ocean (1990–2010), 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 2010. Data include catch and effort statistics as well as some fishery indices by species and fishing mode. Information about the sampling scheme and the coverage of sampling, together with maps and diagrams representing the fishing pattern of this fleet by time and area strata is also included.*"

EU,France purse seine fishery

98. The WPTT **NOTED** paper IOTC–2011–WPTT13–20 which outlines the statistics of the French purse seine fleet targeting tropical tunas in the Indian Ocean (1991–2010), including the following abstract provided by the authors:

> "*The French purse-seine fleet of the Indian Ocean was composed of 13 large size purse seiners in 2010 that represented a total carrying capacity of more than 12,000 GRT. After a period of increase during 2006-2008, the fishing effort of the fleet has been decreasing to reach a minimum of 2,500 searching days in 2010. 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 less than 2,700 fishing sets being made in 2010 compared to more than 4,500 in the mid-2000s. Hence, the percentage of sets made on log-associated schools steadily increased since 2004 to reach 68% in 2010, corresponding to 70% of the total catch in the recent years. No clear trend is apparent in the time series of species-specific catch rates expressed in tonne per searching day for each fishing mode of the fishery. The mean weight in the catch of the 3 tropical tunas has shown a decrease between 15% and 50% in 2009-2010 for both log-associated and free swimming schools.*"

99. 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 drop in the volume of free-schools of yellowfin tuna in the area; a possible declining trend in primary productivity; the implementation of the BIOT MPA; recent changes in the market value of skipjack tuna with prices higher than average and closer to those of yellowfin tuna; and that the EU,France purse seiners are were operating in pairs as a way to mitigate the effects of piracy.

100. The WPTT **NOTED** the preliminary information concerning the activities of EU,France purse seiners during 2011 and encouraged the authors to provide further updates prior to the next meeting of the WPTT.

Main purse seine fisheries

101. The WPTT **NOTED** paper IOTC–2011–WPTT13–24 which outlines the statistics of the main purse seine fleets fishing in the Indian Ocean (1981–2010), including the following abstract provided by the authors:

> "*This document presents a summary of the statistics of French, Spanish, Italian, Seychelles and EU related NEI purse seine fleets fishing in the Indian Ocean since 1981: effort, catch by species and fishing type (log and free swimming schools), catch per unit of effort, sampling and average weights for the main species. Since 2002, data from the European fleet (France and Spain) are collected within the framework of the EU "Data Collection Regulation" (DCR, Reg. 1543/2000 and 1639/2001), followed in 2008 by the "Community framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy" (DCF, Reg 199/2008 and 665/2008). Data from other fleets are collected by SFA (Seychelles Fishing Authority). Data processing (species composition and size distribution) is done collectively for the whole fishery."*

102. The WPTT **NOTED** that logbook data of the EU,France purse seine fleet for the first semester of 2011 confirmed the change in the fleet strategy with a major reduction in catch on the free swimming schools from 65% in the period 2006–2008 to 40% in the period 2009–2011.

Ageing of tuna using otoliths

103. The WPTT **NOTED** paper IOTC–2011–WPTT13–22 which outlines a Bayesian observation error model for otolith reading using yellowfin tuna from the Indian Ocean as a case study, including the following abstract provided by the authors:

> "*Growth curves are an essential input into the stock assessment of fish species. For yellowfin tuna, despite several studies conducted in the 3 oceans, based on tag-recapture experiments, length–frequency analyses data and direct ageing from calcified structures, the shape of the growth curve and its parameterization are still open to debate. In this study, a growth curve is derived using age estimates from the micro increments of sagittal otoliths from 179 yellowfin (19 and 135.4 cm FL). Otolith reading involve some subjective interpretation of the reader and entails different sources of uncertainty. Thus, an ageing error model that accounts for these uncertainties was developed., This model was then coupled with a Bayesian growth model that accounts for uncertainties in age estimation, individual variability in growth and measurement errors and integrates experts knowledge. A VB log K growth curve that allows a smooth transition between two different growth rate parameters was used. Results give a two-stanza growth pattern with a slow growth rate (2.381 cm.month-1) up to around 67.5 cm FL, followed by a more rapid growth until 97 cm FL then a gradual decrease (4.24 cm.month-1). Such results are consistent with both those found in previous studies and with the biology of yellowfin. As a result, a new age-length key to update the conversion of catch-at-size into catch-at-age for future stock assessments of yellowfin is proposed."*

104. The WPTT **NOTED** that the authors intend to complete the work, including the tag-recapture data of the IOTTP, and to make their results available at least one month prior the next session of the WPTT in order for a new growth curve to be considered in the stock assessment.

Kenyan and Tanzanian fisheries

105. The WPTT **NOTED** paper IOTC–2011–WPTT13–23 which provided an update on the Kenyan and Tanzanian EEZs longline CPUE for yellowfin tuna and bigeye tuna, including the following abstract provided by the authors:

> "*The fishing activity by the longliners within the Kenyan and Tanzanian EEZs reached a peak between 2005 and 2007 after which there has been a sharp decline which is probably associated with the piracy affecting the area. This report looks at the spatial distribution of the catches reported by 35longliners licensed in Kenya during 2007. After 1,443 fishing days, a total of 37,488 fish weighing 1,001 tons were caught. Both Yellowfin tuna and Bigeye tuna composed 71.4% of the total catch in weight with a maximum of 86% recorded during the month of February. The month of June had the highest number of fishing days (207) while February had the lowest (44). The average nominal CPUE for Yellowfin tuna was 3.2 fish per 1000 hooks. The highest CPUE was recorded in March at 10.1 but later declined to between 1.2 and 0.5 during the months of July to November. Bigeye tuna on the other hand had an average nominal CPUE of 3.2 fish per 1000 hooks. The highest CPUE was recorded during the month of February at 5.9*

and later declined to between 2.3 and 2.0 during the months of June to October. The report also shows the spatial distribution of the reported catches within the Kenyan and Tanzanian EEZs."

106. The WPTT **NOTED** that due to the effects of piracy, no longline effort had occurred in the Kenyan or Tanzanian EEZ's in 2010.

Reproductive biology of skipjack tuna

107. The WPTT **NOTED** paper IOTC–2011–WPTT13–25 which outlines a macroscopic study on the reproductive biology of skipjack tuna in the Western Indian Ocean, including the following abstract provided by the authors:

"*A macroscopic study on some aspects of the reproductive biology of skipjack tuna (Katsuwonus pelamis) was carried out at Albion Fisheries Research Centre in Mauritius. The study aimed at determining seasonal sexual variations, length at first maturity, sex ratio, spawning seasons and reproductive indices. Gonadal samples were collected from 758 fish. The different maturity stages of gonads assessed by gross visual examination indicated that whatever the month, there is always a majority of fish with gonads in terminal stage of maturation. The study showed that the reproduction of the species occurred throughout the year, with some periods of more intense sexual activity."*

108. The WPTT **AGREED** that the identification of maturity stages for tunas usually requires validation through histological analysis, as some of the stages are difficult to distinguish by direct observation, and recalled that a paper covering these matters had been presented to the WPTT meeting in 2010, encouraging the authors to refer to it to validate the results presented in the current study.

Thailand fisheries

109. The WPTT **NOTED** paper IOTC–2011–WPTT13–49 which outlines the activities of the Thai tuna fisheries in the Indian Ocean during 2007–2010, including the following abstract provided by the authors:

"*There are two types of gear within the Thai tuna fishery, tuna longline and tuna purse-seine, which were operating in the Indian Ocean from 2007 to 2010. Data collected from their logbooks shows information on their catch, fishing operation and effort. During 2007–2010, 1,904 days fishing operation were recorded. The Thai tuna longline fleet was composed of 3 vessels in 2007 and 2 vessels from 2008 to 2010. Their main fishing ground was located in the southern part of the Indian Ocean (around the east and south coast of Madagascar). The total annual catch was the highest in 2010 with 607.69 tonnes followed by 461.64, 295.23 and 265.53 tonnes respectively in 2007, 2009 and 2008 respectively. The CPUEs was the highest in 2010 (13.62 fishes/1,000 hooks) followed by years 2007, 2008 and 2009 (10.20, 5.88 and 5.16 fishes/1,000 hooks, respectively). During 2007–2009, the main species caught was yellowfin tuna was caught (32.80 % of the total catch) followed by bigeye tuna, albacore, swordfish, other fishes and sharks. In 2010, albacore was the main species caught (63.5%). The Thai tuna purse seine fishery, composed of four purse seiners, conducted 952 fishing operations in the Indian Ocean during 2007–2010. The fishing grounds were mainly located in the western Indian Ocean. This purse seine fishery was operating throughout the year in both the eastern and western Indian Ocean with maximum catch from February - May and September - October. The total catch was 28,688.50 tonnes. Skipjack tuna is the main species caught by purse-seine (64.94%) followed by bigeye tuna (18.83%), yellowfin tuna (13.78%) and kawakawa (2.44%). The average size of the caught skipjack, yellowfin and bigeye tuna were 50.34cm±9.87, 63.32cm±23.09 and 63.24cm±16.94 cm."*

110. Noting that both the total catches and species composition presented for purse seine vessels flagged to Thailand were substantially different from those reported for other purse seine fleets operating in the Indian Ocean, and that the difference may originate from Thai and EU purse seiners operating in different areas, the WPTT **RECOMMENED** that the EU and Thailand further investigate the reasons for this difference and to report findings to the next WPTT meeting.

Republic of Korea longline fishery

111. The WPTT **NOTED** paper IOTC–2011–WPTT13–51 which provided a review of yellowfin tuna catch by Korean longline fleet in the Indian Ocean, including the following abstract provided by the authors:

"*Longline is the only type of gears used by Korean tuna fisheries in the Indian Ocean. Catch statistics have been available since the mid-1960s and catch and effort since the 1970s. At the beginning, the main target species were yellowfin, bigeye and albacore tuna, and then southern* *bluefin tuna from 1991. Fishing grounds were in the tropical area between 20°N and 20°S at the beginning and later extended southward down to 45°S. The total catch of tuna and tuna-like species by Korean longline fleet in the Indian Ocean steeply increased and peaked at 71,100 mt in 1978 and then largely decreased with fluctuation thereafter. The catch trend closely coincided with the changes in the number of active vessels throughout the period, with a peak at 185 in 1975 and a gradual decrease to 13 in 2010. The yellowfin tuna catch considerably increased and peaked at 33,237 mt in 1977 but sharply decreased with fluctuation to 708 tons in 2010. The nominal CPUE of yellowfin tuna peaked at 19 fishes/1000hooks in 1977 but were 33% of its peak from 1978 to 1992, 13% from 1993 to 2002 but increased to 37% from 2003 to 2007 and then decreased to 13.4% in recent years. In terms of spatial-decadal distribution, when the catch was higher in the 1970s, the effort was located in the tropical Indian Ocean, extending to 40°S in the western Indian Ocean, with higher catch and CPUEs. During the last decade, the effort moved southward in both western and eastern Indian Ocean which resulted in lower catch and CPUE in the tropical zone. The length frequency data of yellowfin tuna, compiled from Korean scientific observations, is available for 2003-2010. In general, length frequency distribution ranged from 97 to 187 cm in fork length with a main mode around 120-140 cm and a secondary mode around 150-170 in both the western and eastern Indian Ocean."*

112. The WPTT **NOTED** paper IOTC–2011–WPTT13–59 which provided a review of bigeye tuna catch by Korean longline fleet in the Indian Ocean, including the following abstract provided by the authors:

"*Longline is the only type of gear used by Korean tuna fisheries in the Indian Ocean. Bigeye tuna catch quickly increased at the beginning of the fishery to peak at 34,309 mt in 1978 and later decrease with fluctuations to a few hundreds tons in recent years. The nominal CPUEs of bigeye tuna peaked at 17 fishes/1000hooks in 1977 but were 37% of its peak from 1979 to 1997 and then gradually declined below 10% in recent years. In terms of spatial-decadal distribution, when the catch was higher in the 1970s, the effort was mainly located in the tropical Indian Ocean, extending to 40°S in the western Indian Ocean where bigeye tuna catches and CPUE were higher. During the last decade, the effort moved southward in both western and eastern Indian Ocean, which result in lower catch CPUE in the tropical area. The length frequency data of bigeye tuna, compiled from Korean scientific observations, is available for 2003-2010. The range of fish size ranged from 80 to 200 cm during 2003-2009, with no meaningful difference in their distribution by year and area."*

113. Noting that the nominal catch (NC) and the catch-and-effort (CE) data provided at the WPTT13 meeting was found to conflict with the historical data for the longline fleet previously provided by the Rep. of Korea to the IOTC Secretariat, and that the differences were due to the ongoing internal data review by the Rep. of Korea, the WPTT **RECOMMENDED** that the Rep. of Korea liaise with the Secretariat to provide a fully justified revised catch history which will replace the data currently held by the Secretariat before the end of 2011.

China integrated habitat index analysis

114. The WPTT **NOTED** paper IOTC–2011–WPTT13–54 which outlines a comparison of calculation methods of an integrated habitat index for yellowfin tuna in the Indian Ocean, including the following abstract provided by the authors:

"*Based on the survey of the Chinese longline vessel Huayuan yu no.18 in the Indian Ocean in 2005, we used the data, such as the weighted and arithmetic average value of temperature, salinity, chlorophyll-a concentration, dissolved oxygen concentration, other environmental variables, the interactions among them, the nominal CPUE and the standardized CPUE calculated by the deterministic habitat based standardization, to build four "integrated habitat index" models of yellowfin tuna (<u>Thunnus</u> <u>albacares</u>) by the quantile regression method. We applied the F test and T test to analyse them. The results showed that, the main distribution area of yellowfin tuna was 3°N-6°30'N, 62°E-67°E.The temperature and dissolved oxygen concentration have significant effect on the spatial distribution of yellowfin tuna, and whether salinity also effect the spatial distribution of yellowfin tuna needs further study. The study suggested that temperature and dissolved oxygen should be taken into account for the study of the integrated habitat index and predict CPUE. If the time series is shorter, such as less than one year, a nominal CPUE and the arithmetic average value of environmental variables could be used to study the integrated habitat index of yellowfin tuna with the quantile regression method. If the time series is longer, it would be better to use the nominal CPUE and weighted average environment variables in the quantile regression model to study the integrated habitat* *index of yellowfin tuna. However there is probably large changes in the operational parameters of the fishing gears and in the environment factors, and this needs further study."*

115. The WPTT **NOTED** the results of the study which showed that temperature and dissolved oxygen were the most important variables in explaining the spatial distribution of yellowfin tuna in the study area, however, the influence of salinity on the spatial distribution of yellowfin tuna requires further study.

Seychelles purse seine fishery

116. The WPTT **NOTED** paper IOTC–2011–WPTT13–55 provided a preliminary analysis of fishing activities of Purse Seiners fishing in the Western Indian Ocean over the period January to June 2011, including the following abstract provided by the authors:

"*The goal of this paper is to analyse the catches and CPUE of the Purse seine fleet active in the western Indian Ocean during the first 6 months of 2011 and to compare these results with the same parameters observed during the same period of previous years. The paper also analyses the fishing zones during the first six months of 2011. There is no doubt that piracy has had significant impact on the fishing pattern of the WIO purse seine fishery (particularly in 2009 and 2010). However it seems that the fleet is finding ways for mitigation and is slowly returning to their traditional fishing zones particularly the E. Somalia area. It should be noted that reduction in fishing zones may have resulted in the increase in effort on FADs particularly in 2009 and 2010. The level of productivity on FAD's observed for 2009 and 2010 were quite good, and although a slight decrease has been reported for the first semester of 2011 compared to the same period of the previous 2 years, productivity on FAD's is still relatively high compared to the pre 2008 period. The CPUE on large yellowfin tuna and large bigeye tuna (>30 Kg) had been experiencing a declining trend since 2004 and 2008 respectively. This continued for the first semester 2011. The cause for this decline is difficult to establish given the various possible factor or factors s that could be responsible. It is worth noting the decline in catches of juvenile bigeye tuna (<10kg) reported for the first semester of the past 2 years. However catch level for the first semester 2011 is still higher than for 2008, which may be a point for concern."*

I.R. Iran fisheries

117. The WPTT **NOTED** paper IOTC–2011–WPTT13–58 which provided an overview of the tuna fishing trends in Iran with emphasis on tropical tunas, including the following abstract provided by the authors:

"*This document presents a summary of the fisheries statistics collected in Iran: total catch, number of active vessels by category, fishing gear and fishing effort. Moreover, the tuna catch trends in Iran, with emphasis on tropical tuna species, and the fishing method by species are discussed. Information about the fisheries statistical data collection system (length frequency, catch, effort, number of vessels) data collection and the data processing methods used in Iran, , are also provided. In 2010, the total fish production in Iran was 660,000 tons, which can be distributed as 56% coming from southern waters, 6% from northern waters and 38% through inland water. The total marine catch in 2010 was 412,000 tons, out of which about 168,000 tons were tuna and tuna like species. In 2006, 207,000 tons of tuna and tuna like species were caught and this decrease of catch is mainly due to piracy in the IOTC region. Regarding skipjack, the catch decreased from 103,000 tons in 2006 to 22,000 tons in 2010. As a result, the vessels changed fishing grounds and are now operating in coastal areas. The fishing effort in coastal areas increased in recent years, and the catches of longtail tuna increased from 25,000 tons in 2006 to 64,000t in 2010."*

118. The WPTT **NOTED** that Iran has provided preliminary catch, effort, and size data for 2010, by type of vessel, gear, year, month and Province. The WPTT thanked Iran for providing the statistics for 2010, 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 fully as per IOTC requirements. The WPTT **ENCOURAGED** Iran to complete this information and report data as per IOTC requirements (Resolution 10/02) for all previous years.

119. The WPTT **NOTED** 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.

120. 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 in the western Indian Ocean.

121. The WPTT **RECOMMENDED** that the I.R. Iran strengthen its port sampling so that bigeye tuna can be properly identified and its catches estimated routinely by field samplers.

Maldives tuna length sampling

122. The WPTT **NOTED** paper IOTC–2011–WPTT13–56 which provided an overview of the tuna length sampling activities being undertaken in the Maldives, including the following abstract provided by the authors:

> "*The pole-and-line tuna fishery is the most important fisheries in the Maldives. Although tourism earns the most foreign revenue, the fishery remains the principal livelihood activity in many of the outer islands. Pole-and-line caught tuna size sampling program was one of the first activities of the Marine Research Section (MRS) and later Marine Research Centre (MRC) and is still active today. Data collection that began at the Malé Market in 1984 was later developed to an island-based field officer scheme. As the quality of their work deteriorated, leading to the failure of this approach, the island-based samplers were replaced by active skipper samplers around the early 1990s. This data collection system is the one still in place today but has its limitations. An alternative approach that is being considered would be to base the samplers at the shore-based collection facilities complemented by active fishermen samplers in few major fishing islands.*"

123. Noting that to date no bigeye tuna have been reported as being caught by the Maldives pole-and-line fleet, despite independent verification of substantial numbers of bigeye tuna being caught by these vessels, the WPTT **RECOMMENDED** that the Maldives rapidly improve species identification in logbooks and in their sampling programme.

Maldives yellowfin tuna fishery

124. The WPTT **NOTED** paper IOTC–2011–WPTT13–60 which provided an overview of the yellowfin tuna fishery in the Maldives, including the following abstract provided by the authors:

> "*Yellowfin tuna is the second most important species of tuna caught by the Maldivian fishermen. Total catches were around 25,000 t in 2007 but since then recorded catches declined to 13,000t in 2010, representing about 17% of the tuna catch in the country. Since skipjack used to be the preferred tuna there was no fishery targeting large yellowfin tuna in the past. However, yellowfin are now targeted by both the pole-and-line and a handline fishery. The access to overseas fresh fish markets led to the development of the handline fishery only targeting large yellowfin (>80cm). The Marine Research Centre (MRC) employs field-officers to collect detailed information about the fishery as well as size frequencies. Sampling data for 10 years (2001 to 2010) were analysed for this study (166,956 yellowfin were measured). Additional data for this study was obtained from the Ministry of Fisheries and Agriculture. The national fisheries statistics data used in this study (2006 to 2010) showed that the yellowfin catch reached a peak of 24,414 t in 2007 and since then started to decline, reaching 13,137 t in 2010. Though the catch declined the size of yellowfin caught by both pole-and-line and handline fishery did not decrease as much as claimed by many local fishermen. Most of the yellowfin catch reported was caught in the north of the Maldives. Today, the fishermen are using larger vessels with better facilities, including ice ,and they often operate all over the country. With no spatial location of the catch, it has proven difficult to assign the position of the catch. To fully understand the yellowfin fishery, it is necessary to developed and implement a more comprehensive sampling and data collection system that could minimize such errors.*"

125. The WPTT commended the authors for the efforts devoted to reviewing the time-series of catch and length data for the fisheries in the Maldives and the results presented to the meeting. In this regard, the WPTT **RECOMMENDED** that the revised dataset be reported to the IOTC Secretariat by the end of 2011, so that the IOTC databases can be updated to include the latest estimates produced by the Maldives.

126. Noting that an ad-hoc procedure had been used to separate length frequency samples of yellowfin tuna not recorded by gear, in particular those combining specimens of yellowfin tuna caught by pole-and-line and handline gears during the same trip, the WPTT **RECOMMENDED** that the Maldives validate the procedure using samples collected for each individual gear, in port or, where not possible, through observers onboard baitboats, and to report progress to the next WPTT meeting.

Maldives skipjack tuna fishery

127. The WPTT **NOTED** paper IOTC–2011–WPTT13–INF11 which provided an overview of the skipjack tuna fishery of the Maldives, including the following abstract provided by the authors:

“*The Maldives skipjack tuna fishery is one of the most important in the Indian Ocean. Skipjack landings in the Maldives amounts to roughly 20% of the reported total Indian Ocean skipjack catch. Catches in the Maldives reached a peak in 2006 amounting to 138,000t, but have been declining since then. Reported catches were only 59,000t in 2010, over 55% lower than the catches in 2006. Nominal catch rates dropped from around 800 kg/trip in 2006 to less than 400 kg/trip in 2010. The rapid decline in skipjack catches are of concern to the Maldives. Possible reasons for this decline include, among other things, unfavourable environmental condition affecting vulnerability to surface pole-and-line gear. It may also be due to socio-economic factors related high cost of fishing during periods of poor catch, but also due to overall reduction in abundance of stock due to increased fishing pressure in the western Indian Ocean where the main industrial purse seine fleet operates. Time series of size samples show the considerable changes in bimodal size distribution of the skipjack but also a noticeable reduction in the proportion of the large skipjack otherwise well represented in the Maldivian skipjack catches. The presentation provides a general review of the status of the fishery, including structural changes in the fleet and its operational aspects occurred in the recent years. Information on the developments taking place to improve the data collection and compilation are also presented*.”

128. Noting that the Maldivian skipjack tuna catch is not separated for FAD and free schools, and therefore the proportion of skipjack tuna caught under the FADs anchored around the Maldives is unknown, the WPTT **RECOMMENDED** that the Maldivian data collection system is improved in order to account for the association of the reported catch, as this could improve the standardization of the pole-and-line CPUE.

Other new information

129. The WPTT **NOTED** the other information papers provided to the meeting, as detailed in IOTC–2011–WPTT13–02.

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

8.1 Data for input into stock assessments (stock status indicators for skipjack tuna)

Japan – Research vessel Catch-per-unit-of-effort (CPUE)

130. The WPTT **NOTED** paper IOTC–2011–WPTT13–26 which provided an analysis of the decadal trend in catch per unit effort for skipjack by research purse-seiner "Nippon-maru" in the eastern Indian Ocean, including the following abstract provided by the authors:

“*Purse Seine catch data for Eastern Indian Ocean were collected from 1993 to 2010. The nominal CPUE (M.T./set) increased sharply in 2005 after staying relatively low for the first half of the period. Proportion of smaller Skipjack (<2.5kg) increased from 2002*.”

131. The WPTT **NOTED** that high skipjack CPUE from 2005 to 2007 in the Eastern Indian Ocean as well as the large increase in the proportion of small skipjack tuna in catches from 2005 were similar to the trends observed in the western Indian Ocean.

European Union and related purse seiner activities

132. The WPTT **NOTED** paper IOTC–2011–WPTT13–27 which provided a note on the 1983–2010 skipjack tuna activities of European Union purse seiners in the Indian, including the following abstract provided by the authors:

“*This paper reviews and discuss a wide range of SKJ indicators, primarily obtained from the EU purse seine fleet. These indicators are based in 3 categories: (1) indicators from the public domain IOTC data (catch & effort & sizes of PS), (2) indicators based form the original log books of EU PS and (3) other factors that are playing a role in conditioning the efficiency and targeting of EU PS on skipjack and then their CPUEs. This wide range of indicator allows to conclude that most present GLM CPUEs would have major difficulties to integrate the multiple parameters that have been conditioning the PS fishing efficiency on SKJ and then the CPUE biomass relationship. One of the major conclusion is that Somalian piracy did produced during the last 5 years major changes in fishing zones, and in their fishing patterns of PS, outside the* *visible decline of their fishing effort and declining SKJ catches. However it also appears that the recent declines of average weight observed in most SKJ fisheries is probably due to the increasing exploitation rate suffered by the SKJ stock. Furthermore, the high value of SKJ observed since 2008, probably increased the fishing pressure on SKJ. This complex combination of SKJ indicators should be kept in mind if complex models are developed to model the SKJ stock status in an integrated way*."

133. 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.

134. The WPTT **NOTED** that the absolute price of skipjack tuna in the world tuna market, as well as its relative value compared to yellowfin tuna prices, has been greatly increased during recent years (80% increase of average landing values between the 2000–2006 and 2007–2011 periods). It was considered by the WPTT that the high value had contributed to an increase in the fishing pressure and targeting on skipjack tuna during recent years.

135. 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.

136. The WPTT **NOTED** that the same number of FADs fished by quarter had been reported for French purse seiners in 2009, agreeing that the information provided is unreliable as the number of FADs used in each season is likely to be different. In this regard, the WPTT was informed that detailed data on FAD releases have been recorded on French purse seiners since 2011 which will allow reporting of this information as per the IOTC standards in the future.

137. Noting that catch rates by free and associated school sets for purse seine have showed analogous absolute levels on yearly fluctuations over the time-series, the WPTT **RECOMMENDED** that EU scientists explore the reasons for this, and to report findings at the next session of the WPTT.

Preliminary stock status indicators

138. The WPTT **NOTED** paper IOTC–2011–WPTT13–28 which provided indicators of stock status for skipjack tuna in the Indian Ocean, including the following abstract provided by the authors:

"*Fully quantitative stock assessments for skipjack tuna are difficult to conduct and as such alternative methods of investigating current stock status are required. Fishery Stock status indicators have been constructed from total catch, average weight and catch rates from the purse seine fisheries of France and Spain as well as Maldivian pole-and-line (when possible) have been investigated to infer stock status. In order to investigate current status in relation to historic levels, upper and lower limit reference levels have been advocated including both 5th and 95th percentiles as well as a standard deviation multiplier that incorporates 90% of the data series. These rough indicators can be difficult to interpret and are sometimes potentially contradictory. The indicators in this study provide some evidence that the skipjack population may be experiencing increasing pressure, although further analysis is required. These indicators provide a potential tool for applying empirical harvest control rules for fisheries management.*"

139. 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.

140. 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.

141. The WPTT **NOTED** that the catch rate indicators vary between free and associated schools. Those for free schools for both the EU,Spain and EU,France fleets appear to show a decline in catch rate of this fishery. However, it should be taken into account that the free school catch of purse seiners is relatively small in comparison to FAD-associated fishing (less than 10 %) and is a seasonal fishery located mainly in the Mozambique Channel during the first quarter of the year.

142. 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.

143. Noting that the short Maldivian CPUE series has declined from the peak of 2006, but shows no clear trend over the past three years, the WPTT **AGREED** that it is difficult to evaluate the Maldivian CPUE series as the time period is short. As the Maldivian CPUE is estimated quarterly, the fluctuations in this series are likely due to seasonality in the fishery. The overall trend appears to be negative, but again, the short time period allows for no long term trends to be identified.

144. The WPTT **NOTED** that should the indicator approach be adopted at some point in the future, a link between the indicator and management action would first need to be agreed upon. Due to the short life span of skipjack, management might be appropriate on a yearly scale or less, which would be facilitated by an indicator-based approach incorporating an empirical harvest control rule.

Brownie-Petersen Method

145. The WPTT **NOTED** paper IOTC–2011–WPTT13–30 which provided a preliminary application of the Brownie-Petersen method to skipjack tag-recapture, including the following abstract provided by the authors:

> *"Results from applying the Brownie-Petersen method for estimating mortality rates and abundance to skipjack tag-recapture data and catch data from years 2005 to 2009 (using data corresponding to cohorts 2001 to 2005) are presented. The analysis used an annual time-step and a single fishery (i.e., tag returns and catches were aggregated within each year across fisheries). Several alternative scenarios were considered; however, overall, the results suggest natural mortality rate at ages 1 to 4+ is U-shaped (highest at ages 1 and 4+ and lower at ages 2 and 3). Fishing mortality rates vary significantly between years and ages, but were higher in 2006 and 2007 than in 2008 and 2009. When interpreting the results, it is important to note that a large number of uncertainties exist in the data and the model assumptions. The results presented can only be considered preliminary until some of these issues are resolved and/or further sensitivity runs are conducted.*"

146. The WPTT **AGREED** that the results presented provided a useful first step in estimating mortality rates and abundance from the skipjack tag-recapture data. The estimates of natural mortality may prove particularly useful given the lack of alternative methods for estimating this parameter. Nevertheless, a large number of uncertainties exist in the data inputs and assumptions of the model, and the results must be considered preliminary. For example, a fully reliable growth curve for skipjack has yet to be established so as the age estimates are fairly uncertain. Also, an annual time-step is arguably too coarse given the rapid population dynamics of skipjack, and the fact that different components of the fishery operate at different times and can have highly variable exploitation rates by quarter.

147. The WPTT **AGREED** that a number of sensitivity analyses should be conducted before drawing conclusions from the Brownie-Petersen results. For example, further model runs that would be informative include:
    - use quarterly time step.
    - check sensitivity to which cohorts and release/recapture ages are included in the analysis.
    - estimate fishery-specific Fs.
    - test sensitivity to larger range of growth models.
    - include overdispersion in the tag return data.
    - Investigate inclusion of small-scale tagging program releases.

Maldives – Catch-per-unit-of-effort (CPUE)

148. The WPTT **NOTED** paper IOTC–2011–WPTT13–29 which provided a Maldivian pole and line fishery catch rate standardization 2004–2010, including the following abstract provided by the authors:

> "*A qualitative description and GLM-based standardization of the Maldivian skipjack (Katsuwona pelamis, SKJ) pole and line fishery catch rate data was presented for the period 2004-2010. Observations consist of monthly records of catch (numbers) and effort (fishing days) by month, atoll and vessel. The registry of new vessels provides a record of fishing vessel characteristics. Conventional linear models were used to estimate log(CPUE) from independent variables Year, Quarter, Atoll, and Length of vessel. There are some important irregularities in the data, most notably, a very large number of positive effort, zero SKJ catch records, that do not seem to be consistent with the general perception of how the fishery operates, and with an increasing trend over time. This is thought to represent systematic misreporting of effort or gear type that may bias the CPUE series. Different attempts were made to account for the zero catch observations: i) using subsets of the data corresponding to larger vessels (which report fewer zeros), ii) using subsets of the data in which SKJ catch is a very high proportion of the total catch (to reduce the influence of non-SKJ targeting trips), and iii) attempting to directly estimate the quarterly probability of not targeting SKJ, on the basis of the relationship between the proportion of zero SKJ observations and the number of days spent fishing. All of the models estimated standardized time series that were very similar to each other and the nominal CPUE. Two series were recommended for use in stock assessment. Further investigation of the fishery operations and data reporting is encouraged to understand the irregularities.*"

149. The WPTT **NOTED** the following caveats with respect to the use of the skipjack tuna CPUE time series in the context of the 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.
    - Genetic analyses have suggested that there might be (at least) two skipjack tuna subpopulations in the Indian Ocean, the relative abundance of the two could differ, and the Maldives fishery would presumably not index both of them accurately.

CPUE discussion summary

150. 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.

151. The WPTT **NOTED** that of the CPUE series available for assessment purposes, listed below, the PL – preferred series was used in the stock assessment model for 2011. The other two series were explored (shown in Fig. 21).
    - Maldives data (2004–2010): Series1 (PL – preferred) from document IOTC–2011–WPTT13–29 and 31.
    - Maldives data (2004–2010): Series 2 (PL – sensitivity) from document IOTC–2011–WPTT13–29 and 31. This series was not used in the assessment because initial results were very similar to the preferred series.

- EU,France purse seine free school data (1991–2010): Series from document IOTC–2011–WPTT13–20. This series was not used in the assessment because it was not standardized and likely subject to problems as noted in paras. 133 and 141.

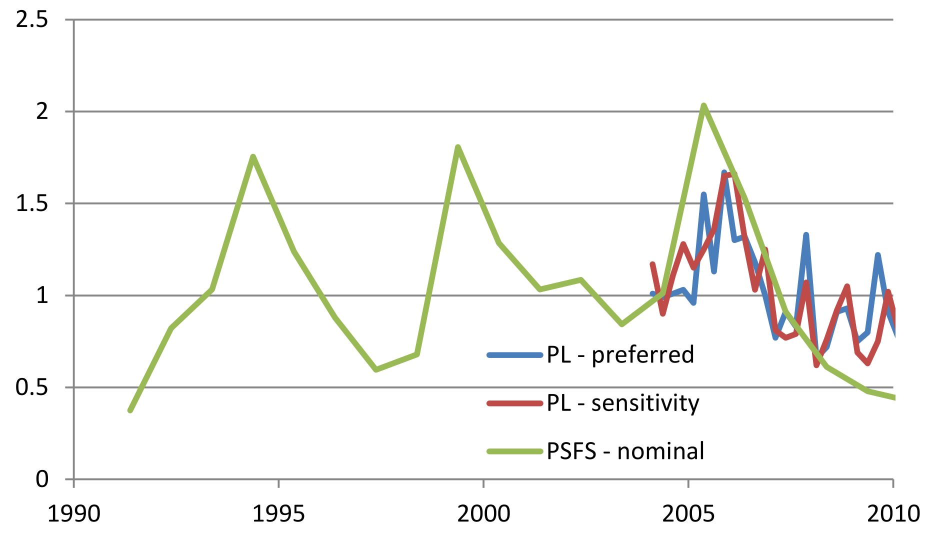

Fig. 21. Comparison of the two standardised Maldivian pole-and-line CPUE series for Indian Ocean skipjack tuna with the nominal EU,France purse seine free school CPUE series. Series have been rescaled relative to their respective means from 2004–2010.

8.2 Stock assessments

Stock Synthesis (SS3)

152. The WPTT **NOTED** paper IOTC–2011–WPTT13–31 which provided an integrated stock assessment (SS3) of Indian Ocean skipjack tuna using data from 1950–2009, including the following summary provided by the authors:

“*A stock assessment of the Indian Ocean skipjack tuna (Katsuwonas pelamis, SKJ) population 1950-2009 was undertaken using Stock Synthesis software. The model was age-structured, iterated on a quarterly time-step, spatially aggregated, with four fishing fleets and Beverton-Holt recruitment dynamics. Model parameters (virgin recruitment, selectivity by fleet, recruitment deviations, and M in some cases) were estimated by fitting predictions and observations of Maldivian PL CPUE (2004 – 2010), length frequency data for all fleets, and tag recoveries (for the PS fleets, and in some cases, the Maldivian PL fleet). The uncertainties and interactions among a range of assumptions was examined (including a range of fixed values for parameters that are known to be difficult to estimate). The stock status estimates represented a synthesis from 180 models (balanced factorial design of 5 assumptions, including i) 3 M options (estimated internally, fixed at point estimates from the preliminary Brownie analysis (IOTC–2011–WPTT13–30), or fixed at ICCAT values), ii) 5 stock recruit steepness options (h = 0.55–0.95), iii) 2 tagging program release/recovery options (RTTP or combined RTTP and small-scale), iv) 2 growth curve options and v) 3 tag recovery overdispersion options. In most cases, the models estimated a highly productive stock, with moderate depletion. All models suggested that the younger spawners are weakly selected by the fisheries and represent a spawning biomass reserve, such that it may be difficult to seriously overfish the stock. This also resulted in numerical problems with the software that prevented FMSY from being reported reliably, and as a consequence C/MSY is reported as a proxy for F/FMSY. In consultation with the WPTT, a weighting scheme was devised with which to combine the results of the 180 models into a distribution which roughly reflects the core uncertainties in the assessment. Notably, steepness was limited to the range 0.75–0.95, and the M estimates derived from the RTTP tagging program were rejected, due to unrealistically low estimates for M(a=0-1). Deterministic constant catch projections (catches at 60%, 80%, 100%, 120% and 140% of 2009 levels and 2009 allocations by fleet) are summarized in a Kobe-2 Strategy Matrix. The analysis was repeated for the western Indian Ocean, under the assumption that it may represent a reasonably discrete population, and results were found to be consistently more optimistic than the aggregate model. A number of recommendations for future assessments are discussed.*”

153. The WPTT **NOTED** that the models estimate a steep biomass decline between 1980 and 1990 followed by a steep biomass increase. At this stage, there are no CPUE series during this period to inform the model. The catch increased in this period due to the onset of purse seine fishing and industrialization of

the Maldivian pole and line fishery and thus, trends in recruitment are required to explain the biomass patterns. The biomass/recruitment trends were supported only by the length frequency data, and it is not likely that these data are sufficiently informative to estimate this trend. Furthermore, the trend is not evident in the nominal CPUE series from either the pole and line or purse seine fisheries.

154. The WPTT **NOTED** that 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 following reasons:
   - it may incorrectly suggest $F>F_{MSY}$ when there is a large biomass (early development of the fishery or large recruitment event)
   - it may incorrectly suggest that $F<F_{MSY}$ when the stock is highly depleted
   - due to a flat yield curve, C could be near MSY even if $F << F_{MSY}$.

155. 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. However, it was agreed that projections could assist in providing management advice and responses to management actions.

156. The WPTT **NOTED** that although CPUE from the EU,France fleet targeting free school was only reliable for yellowfin tuna and bigeye tuna after 1991, due to species misidentification, for skipjack tuna this series could be extended back to 1983, as misidentification would not have occurred between this species and the others. It was noted, however, that this nominal series would not take into account changes in fishing/gear efficiency and so could still be unsuitable as an index of abundance for the earlier years. This restrictions also apply to the post–1991 series. However, it should be taken into account that the free school catch of purse seiners is relatively small in comparison to FAD-associated fishing (less than 10%) and the fishery is seasonal, located mainly in the Mozambique Channel during the first quarter of the year.

157. The WPTT **NOTED** that most of the natural mortality assumptions included in the assessment were lower than those assumed in other oceans (Fig. 22). The values estimated within the model only using the WPTT tagging data were unrealistically low for ages 0–1. The values estimated within the model appeared plausible when the small-scale tagging data was included with the RTTP data. The values adopted from the independent Brownie analysis using only RTTP data showed a similar pattern of M(age) to the SS3 RTTP+small-scale estimates, but were substantially lower. It was noted that there were some differences in the way that the SS3 model and Brownie analysis estimated M, but it was not obvious why either of the approaches would be biased.

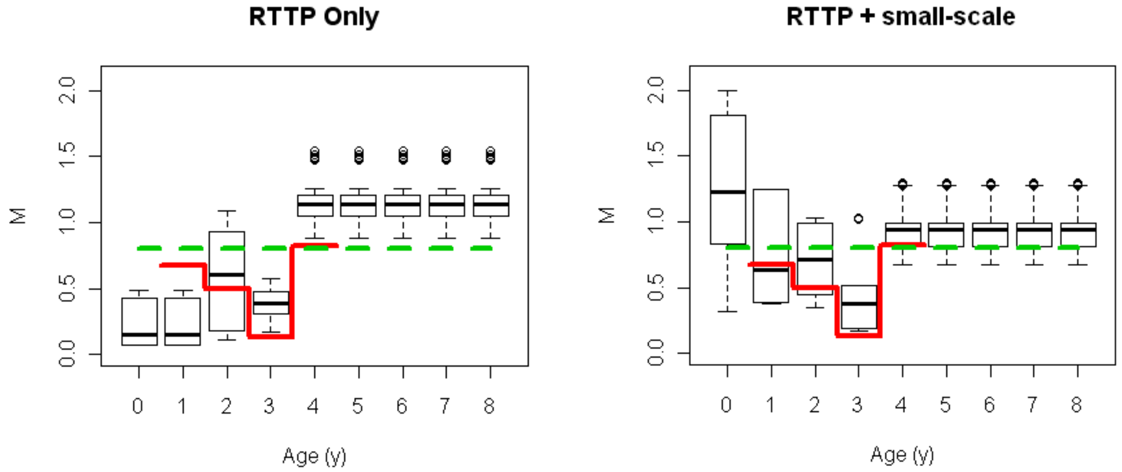

Fig. 22. Comparison of SKJ M assumptions in the assessment. Boxplots indicate the distribution of M estimated within the assessment model (the two panels represent exclusion or inclusion of the small-scale tag releases), red line indicates one of the preliminary Brownie estimates, and the green line indicates the ICCAT assumption.

158. The WPTT **AGREED** that the originally proposed model weighting scheme would be revised for the stock status advice, with the lowest steepness (h=0.65) and the natural mortality vector estimated within the model (for the RTTP data) receiving zero weight in the final weighting scheme of the combined model grid (Table 1).

Table 1. Model weighting for the skipjack tuna stock assessment.

Model inputs	Option Weighting			
Tag Data	RTTP = 0.75	RTSS = 0.25		
Tag Recovery Overdispersion	od02 = 0.2	od20 = 0.6	od70 = 0.2	
Growth	L70 = 0.5	L83 = 0.5		
Stock-Recruit Steepness	H0.65 = 0	H0.75 = 0.3	H0.85 = 0.4	H0.95 = 0.3
Natural Mortality	MeA1 = 0 MeAs = 0.33	MB = 0.33	MAt = 0.33	

RTTP: excludes small-scale tag releases, RTSS= includes small-scale tag releases; L70: VB with L_{inf} = 70 cm; L83: VB with L_{inf} = 83 cm; h: different values of Beverton-Holt steepness; MeA1= M estimated in SS3 excluding small-scale releases; MeAs M estimated in SS3 including small-scale releases; MB = M fixed at preliminary Brownie estimates; and MAt = Atlantic skipjack tuna mortality pattern.

159. The WPTT **NOTED** Table 2 which provides an overview of the key features of the stock assessment model used in 2011.

Table 2. Summary of final model features as applied to the Indian Ocean skipjack tuna resource in 2011.

Model feature	SS3
Software availability	NMFS toolbox
Population spatial structure / areas	1
Number CPUE Series	1
Uses Catch-at-length	Yes
Uses tagging data	Yes
Age-structured	Yes
Sex-structured	No
Number of Fleets	4
Stochastic Recruitment	Yes

160. The WPTT **NOTED** the key assessment results for the stock synthesis model (SS3) as shown below (Table 3 and 4; Fig. 23).

Table 3. Key management quantities from the SS3 assessment, for the aggregate Indian Ocean. Estimates represent 50th (5th–95th) percentiles from the weighted distribution of MPD results. 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 in para. 154.

Management Quantity	Aggregate Indian Ocean
2009 catch estimate (1000 t)	456
Mean catch from 2005–2009 (1000 t)	492
MSY (1000 t) (90% CI)	564 (395–843)
Data period used in assessment	1950–2009
$C_{2009}/_{MSY}$ (90% CI) (proxy for F_{2009}/F_{MSY})	0.81 (0.54–1.16)
B_{2009}/B_{MSY}	–
SB_{2009}/SB_{MSY} (90% CI)	2.56 (1.09–5.83)
B_{2009}/B_0	–
SB_{2009}/SB_0 (90% CI)	0.53 (0.29–0.70)
$B_{2009}/B_{1950, F=0}$	–
$SB_{2009}/SB_{1950, F=0}$	0.53 (0.29–0.70)

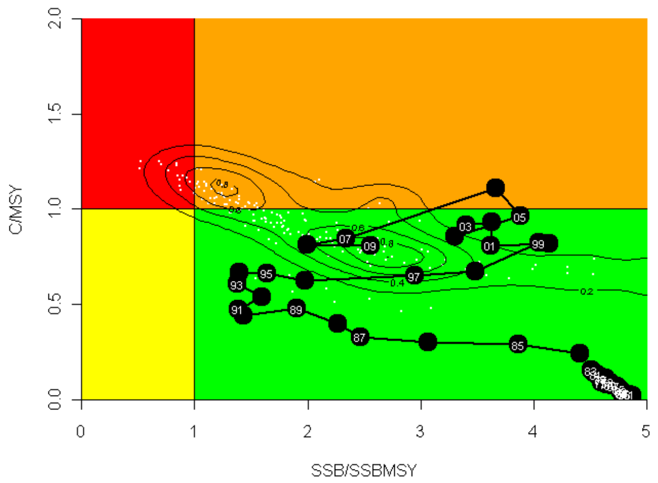

Fig. 23. SS3 Aggregated Indian Ocean assessment Kobe plot. Black circles indicate the trajectory of the weighted median of point estimates for the SB ratio and C/MSY ratio for each year 1950–2009. Probability distribution contours are provided only as a rough visual guide of the uncertainty (e.g. the 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 in para. 154.

Table 4. 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.

Reference point and projection timeframe	Alternative catch projections (relative to 2009) and weighted probability (%) scenarios that violate reference point				
	60% (274,000 t)	**80%** (365,000 t)	**100%** (456,000 t)	**120%** (547,000 t)	**140%** (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

161. The WPTT **NOTED** that the probability contours calculated for the 2009 stock status on the Kobe plot (Fig. 23) appeared to be bimodal. This bimodal distribution is due to the fact that the results are achieved using a coarse grid of different model assumptions. Although refining the contours might reduce this issue, it cannot be removed completely.

162. The WPTT **AGREED** that there was a need to further develop the pole-and-line (prior to 2004) and purse seine CPUE series (complete time-series), and to further investigate the use of and diagnostics for the tagging data.

8.3 Selection of Stock Status indicators

163. The WPTT **AGREED** that the advice on the status of skipjack tuna in 2011 would be derived from data-based indicators and models using an integrated statistical assessment method. Several hundred model formulations were explored to ensure that various plausible sources of uncertainty were explored and represented in the final result. In general, the data did not seem to be sufficiently informative to justify the selection of any individual model, and the results were combined on the basis of a model weighting scheme that was agreed by the WPTT.

Skipjack tuna

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

164. The WPTT **RECOMMENDED** the following management advice for skipjack tuna in the Indian Ocean, for the consideration of the Scientific Committee.

Stock status. The weighted results suggest that the stock is not overfished ($B>B_{MSY}$) and that overfishing is not occurring (C<MSY, used as a proxy for $F<F_{MSY}$). Spawning stock biomass was estimated to have declined by approximately 47 % in 2009 from unfished levels (Table 3).

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. However, 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 2009 (455,000 t) and 2010 (428,000 t) as well as the average level of catches of 2005–2010 (500,000 t) were lower than median value of MSY.

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, 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).

165. The WPTT **RECOMMENDED** that the Scientific Committee consider the following:
- The median estimates of the Maximum Sustainable Yield for the skipjack tuna Indian Ocean stock is 564,000 t (Table 3) and considering the average catch level from 2005–2009 was 492,000 t, catches of skipjack tuna should not exceed the average of 2005–2009.
- 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 4) illustrates the levels of risk associated with varying catch levels over time and could be used to inform management actions.

9. Review of New Information on the Status of Yellowfin Tuna

9.1 Data for input into stock assessments (stock status indicators for yellowfin tuna)

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

166. The WPTT **NOTED** paper IOTC–2011–WPTT13–34 which provided a Japanese longline CPUE for yellowfin tuna in the Indian Ocean up to 2010 standardized by general linear, including the following abstract provided by the authors:

"*Quarterly and annual Japanese longline CPUEs for yellowfin tuna in the main fishing ground and whole Indian Ocean were standardized up to 2010 to provide abundance index for yellowfin assessment using standard models in the IOTC WPTT in 2011. In order to avoid the bias of CPUE trend which may be caused by critical decrease of effort in the northwestern Indian Ocean, scenario in which area 2 was not included was also applied and the results were compared. Quarterly CPUE in each of five areas was also standardized for the assessment using integrated models. In the main fishing ground, CPUE continuously decreased until 1974 after when it was kept in same level until 1990. After that, the CPUE declined to historical low level in 2008 through 2010. As this declining trend in the resent year was detected in both model including and excluding Area 2 the resent declining trend would be reflecting actual change in abundance rather than effect of shift of fishing ground and/or decreased effort caused by increased piracy activity. The trend of standardized CPUE for whole Indian Ocean was similar to that of main fishing ground. Trends of CPUEs of each area were relatively similar, i.e. large decline to middle 1970s, relatively stable trend until around 1991 and steadily declining trend thereafter. Applying LT5LN5 factor in the model showed relatively large effect on the CPUE trend for area 3 and 4 in which the declining trend until around 1990 was steeper in the model without LT5LN5. It is concerned that applying LT5LN5 in the model may cause bias in the resulted CPUE trend, because time period covered by each LT5LN5 would be different depending on the fishing distribution of each year or each period although the stock status should be different in each period*."

167. The WPTT **NOTED** that, as with previous years, the standardized CPUE and nominal CPUE series showed a degree of divergence not commonly observed when conducting standardizations. It was further **NOTED** that in 2010, a stepwise illustration of the factors influencing this divergence was undertaken (IOTC–2010–WPTT12–30). In addition to the main effects (Year, Quarter, Area), a large

part of the divergence was explained by the introduction of the number of hooks between floats (NHFCL) as an explanatory variable.

168. 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** to further examine those issues in the future.

169. 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 standardization.

Yellowfin tuna integrated habitat index analysis

170. The WPTT **NOTED** paper IOTC–2011–WPTT13–32 which provided a comparison of methods for the prediction of an Integrated Habitat Index for yellowfin tuna in the Indian Ocean – general linear model and quantile regression model considerations, including the following abstract provided by the authors:

> "*There are many methods to study the tuna spatial distribution, and it is important to know the habitat of the fish species for better conservation and management of marine ecosystems. Based on the survey data collected by the longline vessel Huayuanyu No. 18, the vertical profile data of temperature, salinity, chlorophyll-a concentration, dissolved oxygen concentration and the catch rate data of yellowfin tuna (Thunnus albacares) were used to develop the "Integrated Habitat Index (IHI)" models with the quantile regression method and general linear model (GLM). We used the statistical Wilcoxon test and residual analysis to test the results from the two kinds of models. The results showed that, the quantile regression method could be better than the general linear method to study the pelagic species spatial distribution. Yellowfin tuna main swimming depth was ranging from 80 to 200 m in the survey area. The main environmental variables which influence the distribution of yellowfin tuna in specific depth stratum were different and the weighted average of temperature and dissolved oxygen concentration affected significantly the spatial distribution of yellowfin tuna.*"

171. The WPTT **NOTED** that the focus area for the study is generally considered to be relatively homogeneous in terms of environmental variability and urged the authors to consider expanding their work to include snapshots in other areas of the Indian Ocean.

Length-based selectivity and growth

172. The WPTT **NOTED** paper IOTC–2011–WPTT13–33 which provided an analysis on whether length-based selectivity can explain the two stage growth curve observed in Indian Ocean yellowfin tuna and bigeye tuna, including the following abstract provided by the authors:

> "*Indian Ocean yellowfin (YFT) and bigeye (BET) tuna populations appear to follow a 2 stage growth curve. Relative to a classic von Bertalanffy function, YFT growth appears to be slower than expected to length ~60cm, and faster than expected for lengths ~60-100 cm. The paper describes a simple simulation to examine how size-based selectivity (where selectivity refers to the combined effect of the gear and the spatial distribution of the fish) might bias the estimated length-at-age relationship. Two selectivity functions were assumed, resembling the modes of the purse seine log and free school catch-at-length distribution (the fisheries from which the most tag recoveries are reported), and used to sample a hypothetical YFT population with classic von Bertalanffy growth. The age-length relationship derived from the simulated samples closely resembled the preferred 2 stage growth curve. This suggests that size selectivity could be responsible for at least some of the irregular shape of the estimated growth curves. Since the purpose of the growth curve is the (indirect) inference of age from length in an assessment model, the two stage curve would still be the most appropriate curve to use for the purse seine fisheries, even if it is not representative of the broader population. However, using this growth curve to infer ages for fisheries with different selectivity might cause problems, and comparing growth curves derived from different fisheries could introduce a false perception of growth*

variability by area or over time. The relevance of size selectivity could easily be tested by comparing growth curves derived from different fisheries that operate in the same area."

173. The WPTT **NOTED** that even if all of the data and analyses are perfect, we should not be surprised if an integrated assessment model (e.g. MFCL) estimates a different growth curve than an analysis based on tag recoveries, if the tag recoveries are not representative of the population. Similarly, evidence for differential growth by area or over time might be misleading if it is based on samples/tag recoveries from different fleets.

174. The WPTT **NOTED** however, that the growth pattern estimated was based on the direct estimation of the growth rate of thousands of individual fish tagged and recaptured, which in turn can be considered a robust estimation of the growth pattern.

175. The WPTT **AGREED** on the need to:
    - Estimate alternative growth curves from different sources.
    - Examine the sensitivity to the alternative growth curves, and represent this uncertainty in the assessment.
    - If necessary/feasible, use different length-at-age functions for different regions/fisheries.

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

176. The WPTT **NOTED** paper IOTC–2011–WPTT13–35 which provided updated CPUE standardization for yellowfin tuna caught by the Taiwanese longline fishery in the Indian Ocean using generalized liner model, including the following abstract provided by the authors:
    "*For the CPUE standardization of yellowfin tuna caught by the Taiwanese longline fishery in the Indian Ocean, the procedure adopted in the previous study (Yeh et al. 2010) was used with recent data updates and some adjustments. The adjustments involved the principle of data extraction and the classification of target proxy factor used in the GLM. Relative standardized CPUE series obtained show a relatively stable trend; but decreasing from 2004 to 2010.*"

177. The WPTT **NOTED** that the nominal and standardized CPUE series were similar, and showed a flat trend, which is in contrast to the negative trend displayed by the Japanese series. The stability of the series 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.

178. 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.

179. The WPTT **AGREED** that the main source of information on abundance trends for stock assessment purposes is the index of abundance derived from the Japanese and Taiwan,China longline CPUE series. Concerns have been raised on the ability of this standardized 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 Japanese 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. The WPTT acknowledges the difficulty of fully understanding and quantifying changes in the fishery that would help interpreting the patterns observed in the index of abundance.

CPUE discussion summary

180. The WPTT **NOTED** that for the longline fisheries (LL fisheries in regions 1–5; Fig. 24), CPUE indices were derived using generalized 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 assessment 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 2011 assessment (Fig. 25). 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.

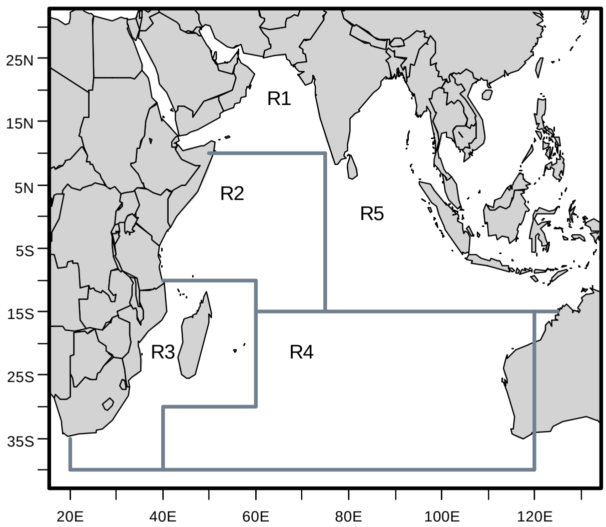

Fig. 24. Spatial stratification of the Indian Ocean for the MFCL assessment model.

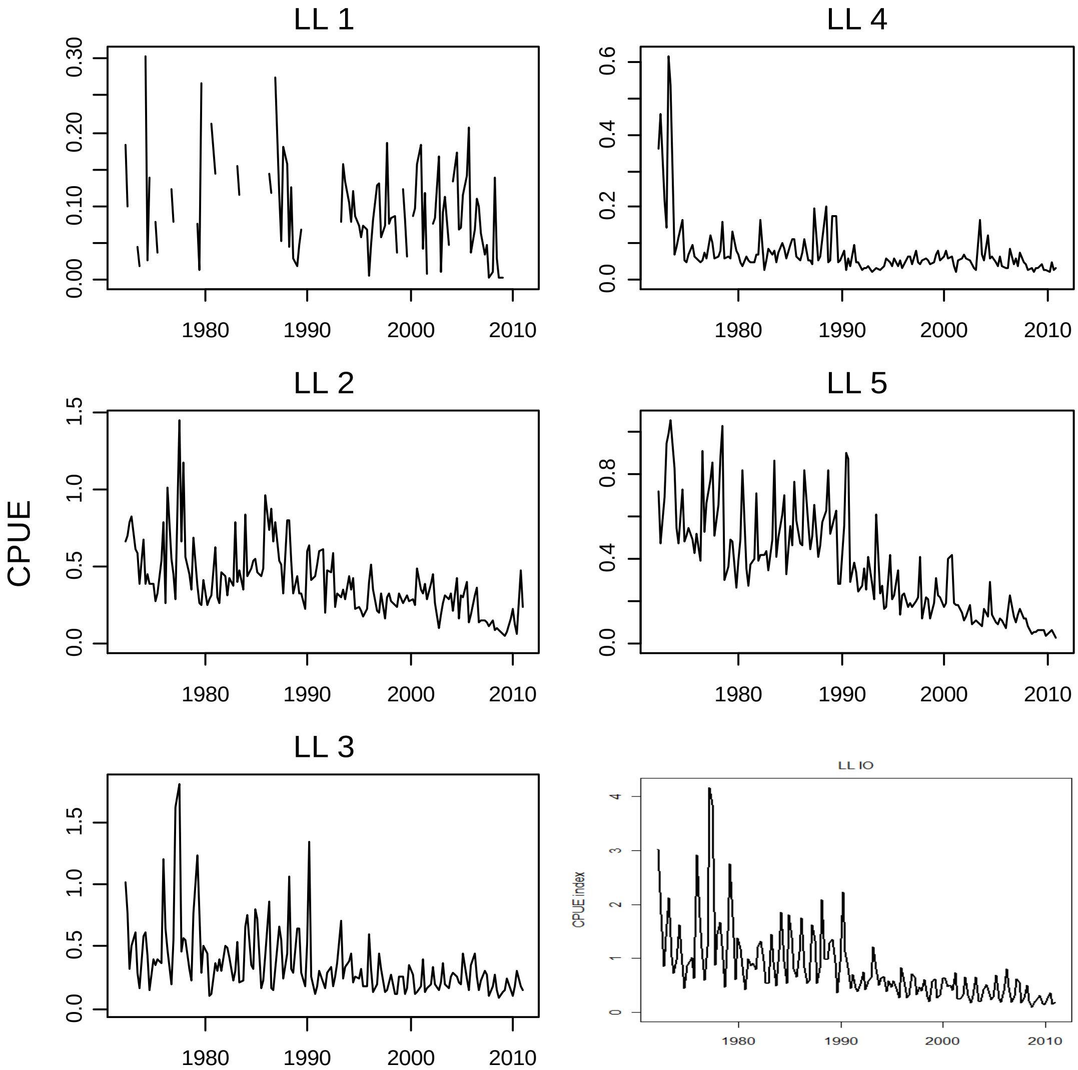

Fig. 25. Annualised GLM standardised catch-per-unit-effort (CPUE) for the principal longline fisheries (longline region 1: Taiwan,China and longline regions 2–5: Japan) and the whole Indian Ocean (IO), scaled by the respective region scalars.

Stock assessments

MULTIFAN-CL (MFCL)

181. The WPTT **NOTED** paper IOTC–2011–WPTT13–36 which provided a stock assessment of yellowfin tuna in the Indian Ocean using MULTIFAN-CL, including the following abstract provided by the authors:

“*The stock assessment of yellowfin tuna was implemented in MULTIFAN-CL (MFCL). The assessment models essentially replicated the options that were adopted by the 12th WPTT meeting. The model incorporates catch data from 25 fisheries that are defined by gear type and region, fishery specific length frequency data, CPUE indices derived from the Japanese and Taiwanese longline fisheries and tag release and recovery data from the RTTP. Yellowfin tuna growth is fixed in accordance with Fonteneau (2008) and age-specific natural mortality was fixed with a low average level. For the base model, a spatially aggregated model structure was adopted using a five region spatial structure. An alternative spatially disaggregated model was also considered. The length frequency data are assigned a low weight in model due to uncertainty regarding the representativeness of these data for most fisheries. Selectivity for the principal longline fisheries was parameterised using a cubic spline function, resulting in low selectivity for the older age classes. The estimated regional biomass trajectories are consistent with the corresponding LL CPUE indices which exhibit a strong decline for most regions. There are corresponding temporal trends in recruitment in some regions, with strong declines in recruitment in region 3 and 5. Overall, the model diagnostics indicate a good fit to the time series of tag recoveries by the principal purse-seine fishery. A range of sensitivity analyses were conducted to investigate the influence of the spatial structural assumptions, the selectivity parameterisation of the principal longline fisheries and the duration of the mixing period prior to tag recovery. For the computation of MSY based reference points, a range of steepness values were assumed for the stock-recruit relationship.*”

182. The WPTT **NOTED** the following with respect to the modelling approach presented at the meeting:
    - The main features of the model in the 2010 assessment included a fixed growth curve (with variance) with an inflection, an age-specific natural mortality rate profile (M), the modelling of 24 fisheries including the separation of two purse seine fisheries into three time blocks, using a cubic spline method to estimate longline selectivities in the place of a logistic curve, the down-weighting of length frequency data in the fitting, separation of the analysis into five regions of the Indian Ocean and the specification of four steepness parameters for the stock recruitment relationship (h=0.6, 0.7, 0.8 and 0.9).
    - In addition to another year of data, the 2011 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); major historical catch revisions for fisheries in Region 5, splitting the longline fleet in Region 5 into distant water and fresh tuna logline fleets leaving 25 total fleets in the model; and the range of steepness evaluated was expanded to h=0.55-0.95.

183. The WPTT **NOTED** that while the biomass trends were very similar between the 2010 and 2011 assessments, the estimates of stock productivity and thus, the status, differed. There were several reasons for this: there was poor convergence in the 2010 assessment, thus the fits were suboptimal and alternative solutions were near optimal. Refitting the 2010 assessment is now more optimistic. Also, fitting the 2010 model to 2011 data was more optimistic. Thus, revisiting of key parameters and the inclusion of the latest year of data in the 2011 assessment appeared to be important. These issues are difficult to explore in the MFCL framework. The WPTT reviewed several alternative model structures and parameter formulations for the model that were presented in the assessment. These included: the new longline model structure for Region 5; alternative Japanese CPUE indices; a single region model where all 5 Regions were collapsed into one; a Region 2 model estimated separately from other Regions; the 5 values of steepness and alternative tag mixing periods (1–4 quarters). Additionally, an attempt was made to estimate age-specific M’s. In regards to the latter, this parameter was not well estimated and the WPTT adopted the low M profile as the most appropriate way to proceed.

184. 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.

185. 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.

186. The WPTT **NOTED** that in the previous assessment purse seine selectivity in the period 2003-2007 was separated into three blocks of time surrounding 2005 to accommodate the unusually large catches in the middle of that time period. This was continued in the current assessment. However, the WPTT questioned whether this was the most appropriate way to do this. An alternative was suggested in which the time blocks of PS fleet were removed and the same selectivity was applied throughout the period. This was explored in new model runs. Results were not demonstrably different.

187. The WPTT **AGREED** to revisit the issue of longline selectivity. It was suggested that this selectivity might still be best described by a logistic (flat-topped) model instead of a cubic spline approach, whereby the resulting selectivity was dome-shaped. This option reinvigorated a long standing debate that has yet to be resolved. A run whereby logistic selectivities were imposed was evaluated.

188. The WPTT **NOTED** that generally, the runs with alternative parameter and model structures did not suggest large differences in the approach and resulted in qualitatively predictable outcomes. The WPTT felt that the alternative outcomes were an expression of uncertainties in the model, data and assessment. Therefore, the WPTT focused on following basic alternatives for characterizing the uncertainty: logistic versus cubic spline longline selectivity; using the low M profile; alternative steepness of the stock-recruitment relationship of 0.7, 0.8 and 0.9, and estimation of MSY based reference points using the average recruitment for the whole time series. It was determined that with current knowledge outcomes using these alternatives are equally likely and a combined evaluated was generated based upon this.

189. The final range of model options adopted by the WPTT included the 2 alternative parametrization of longline selectivity (cubic spline and logisitic) and three steepness options (0.7, 0.8 and 0.9). For the cubic spline model option, there is a strong temporal trend in recruitment and recent recruitments (average of the last 15 years) is estimated to be lower (80%) than the long term recruitment level. On that basis, it was agreed to also derived alternative MSY estimates based on the recent levels of recruitment for comparative purposes.

190. The WPTT **NOTED** Table 5 which provides an overview of the key features of the MFCL stock assessment model used in 2011.

Table 5. Summary of final model features as applied to the Indian Ocean yellowfin tuna resource in 2011.

Model feature	MFCL
Software availability	Multifan-CL
Population spatial structure / areas	5
Number CPUE Series	2
Uses Catch-at-length	Yes
Tagging data	Yes
Age-structured	Yes
Sex-structured	No
Number of Fleets	25
Stochastic Recruitment	No

191. The WPTT **NOTED** the key assessment results for the MFCL stock assessment as shown below (Tables 6 and 7; Fig. 26).

Table 6. Key management quantities from the MFCL assessment, for the agreed scenarios of yellowfin tuna in the Indian Ocean. Values represent an equal weighting mean of the scenarios investigated. The range is described by the range values between those scenarios.

Management Quantity	Indian Ocean
2010 catch estimate (1000 t)	299.1
Mean catch from 2006–2010 (1000 t)	326.7
MSY (1000 t)	357 (290–435)
Data period used in assessment	1972–2010
F_{2009}/F_{MSY}	0.84 (0.63–1.10)
B_{2009}/B_{MSY}	1.46 (1.35–1.59)
SB_{2009}/SB_{MSY}	1.61 (1.47–1.78)
B_{2009}/B_0	0.49
SB_{2009}/SB_0	0.35 (0.31–0.38)
$B_{2009}/B_{0,\ F=0}$	0.58
$SB_{2009}/SB_{0,\ F=0}$	–

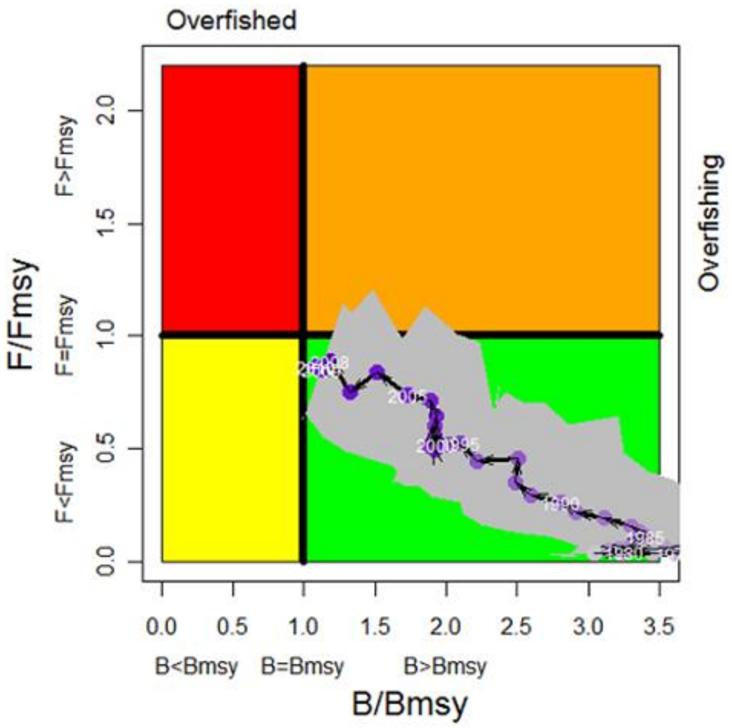

Fig. 26. MULTIFAN-CL Indian Ocean yellowfin tuna stock assessment Kobe plot. Blue circles indicate the trajectory of the point estimates for the B ratio and F ratio for each year 1972–2009. The equal weighted mean trajectory of the scenarios investigated in the assessment. The range is given by the different scenarios investigated.

192. 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. For model options using longline dome-shaped selectivity, recent recruitment is considerably lower than the long term level and MSY estimates for those options based only on recent recruitment levels all approximate 300,000 tons. The mean catch over the 2008–2010 period of 300,000 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.

193. The WPTT **AGREED** to undertake deterministic projections of stock status according to the Kobe management strategy matrix such that the probabilities of exceeding F_{MSY} and of depletion below B_{MSY} were computed for 2013 and 2020 based upon alternative model structure scenarios (6 explained before + 6 using average recruitment of recent 15 years) and based on 2009 catch distribution. There was considerable discussion on the ability of the WPTT to do this. On one hand it is clear that the true

uncertainty is unknown and that the current characterization may not be complete. On the other hand the projections may provide a relative ranking of outcomes that might be useful to the Commission.

Table 7. 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.

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)
$B_{2013} < B_{MSY}$	<1	<1	<1	<1	<1
$F_{2013} > F_{MSY}$	<1	<1	58.3	83.3	100
$B_{2020} < B_{MSY}$	<1	<1	8.3	41.7	91.7
$F_{2020} > F_{MSY}$	<1	41.7	83.3	100	100

194. 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. It was **AGREED** that projections could assist in providing management advice and responses to management actions, while they are estimated to be realistic.

195. The results of the stock projections are presented in Table 6. Over the next three years, it is estimated that there is a very low probability (<1%) of the biomass declining below the B_{MSY} level, although the 10 year projection indicates there is a medium (41.7%) and high probability (91.7%) of the stock declining below B_{MSY} for scenarios with increased, 20% and 40%, levels of catch, respectively (above the 2009 level). The probability of fishing mortality rates exceeding the F_{MSY} are higher than the corresponding probability of the biomass levels being below B_{MSY} both for short and long-term projections. This is due to the model assumptions regarding the regional distribution of future recruitments and the resultant changes in the age-specific pattern of fishing mortality. The validity of the assumptions regarding future recruitment need to be further evaluated

A comparison of MFCL and SS3

196. The WPTT **NOTED** paper IOTC–2011–WPTT13–50 which provided a comparison of the 2010 Indian Ocean yellowfin tuna assessment using MFCL and SS3, including the following abstract provided by the authors:

“*Recent Indian Ocean yellowfin tuna stock assessments have been implemented in MFCL. During the 12th WPTT meeting there was an attempt to implement a parallel assessment using Stock Synthesis (SS). SS has also been the software platform used to undertake IO stock assessments for skipjack tuna and bigeye tuna. The 2010 yellowfin tuna stock assessment was used as the basis for a comparison of the performance of SS and MFCL software platforms. The 2010 MFCL data sets were translated into SS input data sets and the SS model was configured with comparable structural assumptions to the MFCL model, including a five region spatial structure, quarterly time step, movement dynamics, key biological parameters, fishery selectivities and similar weighting to the various data sets. The SS model yielded similar estimates of the key parameters and similar magnitude and trends in recruitment and total biomass, although some differences are apparent in the regional distribution of biomass. One key limitation of SS in the application to the yellowfin tuna assessment was the lack in the flexibility to parameterise growth patterns that deviate from standard growth models. However, SS has a number of features, not available in MFCL, that may have application in tuna assessments, in particular the ability to address regional differences in growth (via growth morphs) and temporal variation in key parameters (e.g. selectivity). Further, the formulation of the SS catch equation removes the need to estimate the large number of nuisance parameters (effort deviates) estimated in MFCL, thereby, greatly reducing the number of parameters estimated. As a result, it is feasible to estimate the statistical uncertainty of the SS model using MCMC procedures.*”

197. The WPTT **AGREED** that in 2012, both an SS3 and MULTIFAN-CL as well as other stock assessment methods should be developed and presented to the WPTT, noting the limitations of SS3 in using a complex growth curve (2-stanza growth).

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

199. The WPTT **RECOMMENDED** that the IOTC stock assessment scientist and consultant work in collaboration with Japanese scientists and other interested participants to produce an SS3 assessment for yellowfin tuna in 2012 for presentation to the WPTT.

9.2 Selection of Stock Status indicators

200. The WPTT **AGREED** that management advice for yellowfin tuna should be based on the 2011 MFCL stock assessment based upon the 6 scenarios investigated (logistic versus cubic spline longline selectivity; alternative steepness of the stock-recruitment relationship of 0.7, 0.8 and 0.9, and estimation of MSY based reference points using the average recruitment for the whole time series).

Yellowfin tuna

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

201. The WPTT **RECOMMENDED** the following management advice for yellowfin tuna in the Indian Ocean, for the consideration of the Scientific Committee.

Stock status. The stock assessment model used in 2011 suggests that the stock is currently not overfished (B_{2009}>B_{MSY}) and overfishing is not occurring (F_{2009}<F_{MSY}) (Table 6 and Fig. 26). Spawning stock biomass in 2009 was estimated to be 35% (31–38%) (from Table 6) of the unfished levels. However, estimates of total and spawning stock biomass show a marked decrease over the last decade, accelerated in recent years by the high catches of 2003–2006. Recent reductions in effort and, hence, catches has halted the decline.

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.

Outlook. 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 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 7). 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 B<B_{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 $B>B_{MSY}$ 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.

202. The WPTT **RECOMMENDED** that the Scientific Committee consider the following:
- The Maximum Sustainable Yield estimate for the whole Indian Ocean is 357,000 t with a range between 290,000–435,000 t (Table 6), 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.

10. Review of New Information on the Status of Bigeye Tuna

10.1 Data for input into stock assessments (stock status indicators for bigeye tuna)

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

203. The WPTT **NOTED** paper IOTC–2011–WPTT13–38 which provided a standardization of bigeye tuna CPUE of Korean tuna longline fisheries in the Indian Ocean, including the following abstract provided by the authors:

> "*CPUE standardization for bigeye tuna of the Korean longline fisheries in the Indian Ocean was conducted by GLM using fisheries data (1977–2009), i.e., catch (number), effort (number of hooks) and number of hooks between floats (NHF) by year, month and 5°× 5° (Lat. and Long.) area. Explanatory variables for the GLM analysis are year, quarter, area and NHF. Standardized (STD) CPUE showed the declining trend in general except one jump in 1996. STD CPUE between Korea and Japan are similar, while STD CPUE of Taiwan shows the flat trend, which is different from those of Korea and Japan. This difference is likely caused by the fact that Taiwan used species ratios as for the targeting correction factor, while Korea and Japan, number of hooks between float.*"

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

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

205. The WPTT **NOTED** paper IOTC–2011–WPTT13–39 which provided an updated CPUE standardization for bigeye tuna caught by the Taiwanese longline fishery in the Indian Ocean using generalized liner model, including the following abstract provided by the authors:

> "*For CPUE standardization of bigeye tuna caught by the Taiwanese longline fishery in the Indian Ocean, the procedure adopted in the previous study (Yeh et al. 2010) was used with recent data updates and some adjustments. The adjustments involved the principle of data extraction and the classification of target proxy factor used in the GLM. Preliminary data for 2010 was excluded in the study, since some parameters could not be estimated in the GLM with the temporal factor being months. Relative standardized CPUE series obtained show a relatively stable trend; but continually decreasing from 2003 to 2009.*"

206. 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 standardized series was thought to be due to changes in targeting and the spatial distribution of effort, likely related to piracy activity in the northwest Indian Ocean.

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

207. The WPTT **NOTED** paper IOTC–2011–WPTT13–52 which provided an updated Japanese longline CPUE for bigeye tuna in the Indian Ocean standardized by GLM for the period from 1960 to 2010, including the following abstract provided by the authors:

"*Standardized Japanese longline CPUE for bigeye tuna was updated from 1960 up to 2010 by using GLM (CPUE-LogNormal error structured model). Method of standardization was the same as the one used for the bigeye assessment in 2010. NHF (Number of Hooks between Float) and material of main and branch lines were applied to standardize the change in catchability of longline gear. In the tropical Indian Ocean, CPUE continuously decreased from around 9.3 (real scale) in 1960 to 3.2 in 2002 when it has increased to 4.2 - 4.7 in 2004 through 2008, about the same level as that in the late 1990's. However it has decreased again to about 3.3 in 2009 and 3.1 in 2010. Standardized CPUE in the south area which did not show clear trend during the period between 1984 and 2000 (CPUE was 3.5 on average), decreased to 2.5 in 2003. It increased to 3.2 in 2004 after when it decreased to 1.3 in 2008 and increased to 1.7 in 2010. As a result, CPUE in all Indian Ocean, which had been kept in the same level around 5 to 7 until 1993 decreased to 3.0 in 2002, increased a little in 2003 and 2004 after when it decreased to about 3.0 in 2008 and 2.5 in 2009 and 2010.*"

Length-based yield per recruit analysis

208. The WPTT **NOTED** paper IOTC–2011–WPTT13–40 which provided an analysis of the performance of different length information on stock assessment of bigeye tuna from the Indian Ocean by length-based yield per recruit analysis, including the following abstract provided by the authors:

"*Catch-at-size of longline fishery was estimated from both on board measurements and Taiwan logbook data in 2006 and 2007, and this sort of monthly catch-at-size was combined with those of purse seine fishery for the corresponding time period into a complete catch-at-size matrix. The finalized catch-at-size matrix is a representative of the bigeye tuna stock in the Indian Ocean, and was used to evaluate the fishing pressures of the stock and to estimate biological reference points. First, the von Bertalanffy growth curve was estimated from the catch-at-size matrix. Second, the estimated von Bertalanffy growth parameters were used to estimate total mortality coefficients by length converted catch curve. Third, the biological reference points were then estimated using yield per recruit and spawning stock biomass per recruit models analysis. And finally, a multi-gear yield per recruit was applied to estimate the biological reference points by gears. The current stock status was evaluated by the estimated biological reference points. Results of multi-gear yield per recruit model analysis indicated that the purse seine fishery competed with longline fishery by harvesting different sizes, and results of spawning stock biomass per recruit model analysis tend to be reduced with increases in fishing mortality rates of both longline and purse seine fisheries, indicating that the spawning biomass percentages will be reduced more greatly when harvested by two or more fisheries simultaneously.*"

Age structured projection model development

209. The WPTT **NOTED** paper IOTC–2011–WPTT13–48 which provided an overview of the development of an age structured projection model for bigeye tuna in the Indian Ocean, including the following abstract provided by the authors:

"*A simple age structured projection model for bigeye tuna (Thunnus obesus) in the Indian Ocean for the years 2008 to 2037 was developed using the formal fishery program Age Structured Projection Model (AGEPRO). Two constant harvest control variables, FMSY and MSY derived from recent stock assessment, were examined under different steepness assumptions for the B-H model. A constant FMSY rule would result in the recovery of the stock to MSY level in a few years under an assumptions of steepness being 0.9 or 0.8, while would cause the stock to go down from 2008 to 2037 under an assumption of steepness being 0.7. A constant MSY (89,000t) rule can increase the stock steadily from 2008 to 2037; however, the model was projected only by including uncertainty associated with recruitment.*"

210. The WPTT **NOTED** that this was a preliminary study and that further work is needed before the results would be considered informative enough to be used in the development of management advice. As

such, the WPTT request the authors to further refine the analysis and present an update at the next WPTT meeting.

Virtual Population Analysis (VPA)

211. The WPTT **NOTED** paper IOTC–2011–WPTT13–41 which provided a preliminary assessment of bigeye tuna in the Indian Ocean based on a tuned Virtual Population Analysis analysis, including the following abstract provided by the authors:

“*A preliminary assessment of bigeye tuna in the Indian Ocean (1950-2008) was conducted using a Virtual Population Analysis (VPA/ADAPT), based on a single stock assumption. Two age-structure scenarios about plus age class, i.e., age-structure covering age class 0-9+ (Base-case) and age-structure covering age classes 0-18+ (Alternative-case), were examined. Two abundance indices (the index for the tropical area and the index for the whole Indian Ocean) from the Japanese longline fishery (1960-2008) with equal weighting were used for parameter estimation. Both the Base-case model and Alternative-case model did not fit well to the abundance indices time series. The model overestimated CPUEs for the period 1988-2008, while underestimated CPUEs for the period 1960-1985. The assumption about age-structure of the VPA model may have large impacts on stock parameter estimates. Retrospective errors were obvious, both for the estimates of spawning biomass and fishing mortality.*”

212. The WPTT **AGREED** that the model used did not fit the data well and suggested that the model be updated with the latest CPUE series and growth curve, and for this to be presented to the next WPTT meeting.

CPUE discussion summary

213. The WPTT **RECOMMENDED** that the following matters be taken into account when undertaking CPUE standardisation analysis for bigeye tuna as well as yellowfin tuna in 2012:

- 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 standardization 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.

214. The WPTT **NOTED** that of the CPUE series available for assessment purposes, listed below, only the Japanese series from the tropical areas of the Indian Ocean was used in the stock assessment model for 2011 (shown in Fig. 28).
- Taiwan,China data (1980–2010): Series from document IOTC–2011–WPTT13–39 (Fig. 27).
- Japan data (1960–2010): Series 2 from document IOTC–2011–WPTT13–52. Whole Indian Ocean (Figs. 27 and 28).
- Rep. of Korean data (1977–2009): Series from document IOTC–2011–WPTT13–38 (Fig. 27).
- Japan data (1960–2010): Series1 from document IOTC–2011–WPTT13–52. Tropical area of Indian Ocean (Fig. 28).

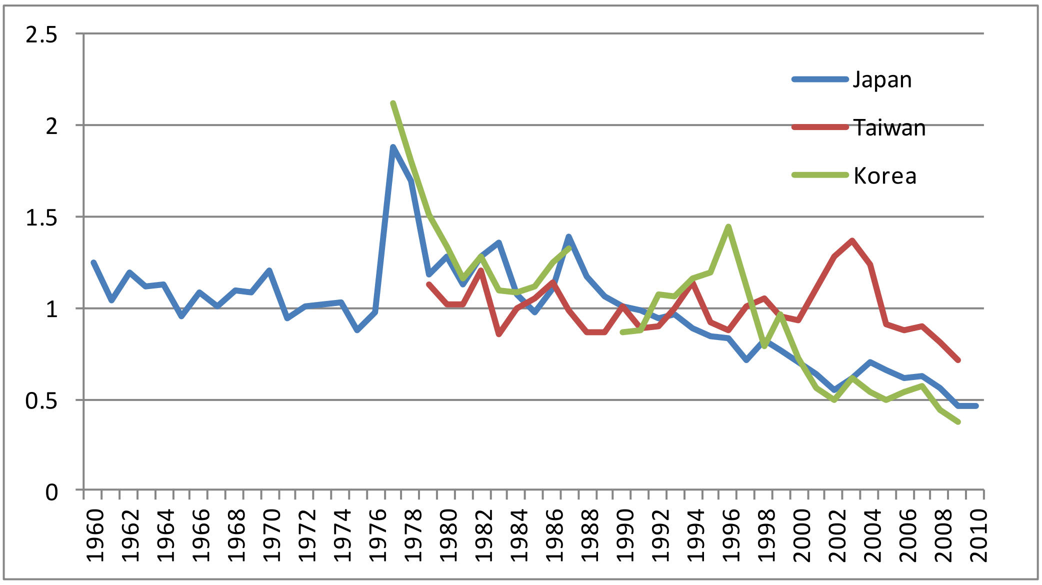

Fig. 27. Comparison of the three standardised CPUE series for Indian Ocean bigeye tuna. Series have been rescaled relative to their respective means from 1960–2010.

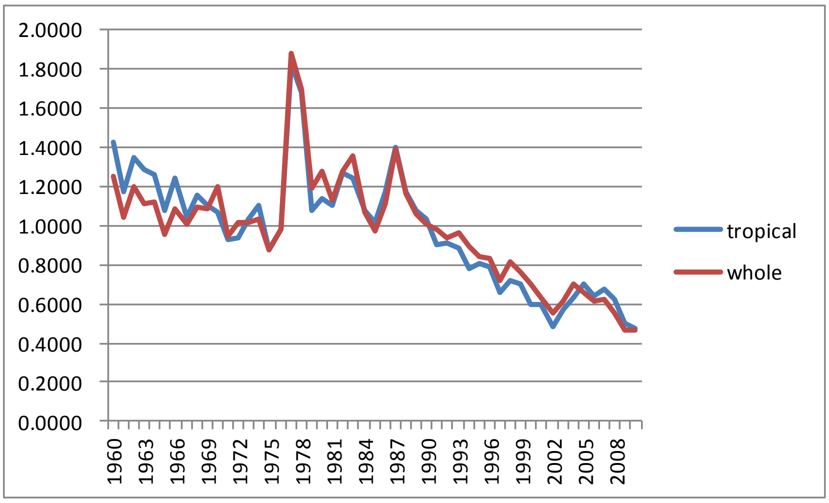

Fig. 28. Comparison of two Japanese standardised CPUE series for Indian Ocean bigeye tuna, one for the whole Indian Ocean and one for the tropical area only. Series have been rescaled relative to their respective means from 1960–2010.

215. The WPTT **NOTED** the large increase in both the nominal and standardized bigeye tuna CPUEs for longline fleets in the Indian Ocean (as well as in the Atlantic) (Figs. 27 and 28). The increase in CPUEs may be due (1) to a large increase in the adult stock biomass, or (2) more probably to the introduction of deep longline in 1977. The fishery data does not allow to estimate a fully realistic trend of adult BET biomass during the seventies.

10.2 Stock assessments

Age-Structured Production Model (ASPM)

216. The WPTT **NOTED** paper IOTC–2011–WPTT13–42, and subsequent revisions, which provided a stock assessment of bigeye tuna in the Indian Ocean by AD Model Builder implemented Age-Structured Production Model (ASPM), including the following abstract provided by the authors:

> "*We applied an Age-Structured Production Model (ASPM) to assess the status of the bigeye tuna stock (Thunnus obesus) in the Indian Ocean using 61 years of data (1950-2010). In addition, risk assessments, based on the ASPM results, were conducted to evaluate the probabilities of the Spawning Stock Biomass (SSB) falling below MSY level and Fishing mortality (F) exceeding this level in next 10 years (2011-2020) under five constant catch scenarios. The AD Model Builder (Otter Research) code for this ASPM is based on the (previously used) Fortran-implemented ASPM software (Restrepo, 1997). The ADMB implemented ASPM software is detailed in the users' manual in another document submitted to this meeting (IOTC-2011-WPTT13-46). The assessment results suggested that the SSB (2010) is near the MSY level (1.00), while F (2010) is way down from the MSY level (0.67). Risk assessments suggest that catch can be increased by 20% (86,000 tons) from the 2010 catch (71,000 ton) with the low risk (< 20%) to exceed the MSY levels (SSB and F).*"

217. The WPTT **NOTED** the following with respect to the modelling approach presented at the meeting:
    - The steepness value (h=0.5) was selected on the basis of the likelihood and was near the lower boundary of what would be considered plausible for bigeye tuna. Selection of steepness on the basis of the likelihood was not considered reliable because i) steepness is difficult to estimate in general, and ii) substantial autocorrelation in the recruitment deviates was ignored in the likelihood term.
    - Cohort-slicing to estimate ages from lengths introduces substantial errors, for long-living species such as bigeye tuna, except for the youngest ages.
    - Uncertainty in natural mortality was not considered.

218. The WPTT **AGREED** that it was essential to include uncertainty in the steepness parameter as a minimum requirement for the provision of management advice.

219. The WPTT **NOTED** that the general population trends and MSY parameters estimated by the ASPM model appeared to be plausibly consistent with the general perception of the fishery and the data. However, these results are considered to be uncertain because of i) uncertainty in the catch rate standardization, and ii) uncertainty in recent catches.

220. The WPTT **NOTED** Table 8 which provides an overview of the key features of the ASPM stock assessment model used in 2011.

Table 8. Summary of final model features as applied to the Indian Ocean bigeye tuna resource in 2011.

Model feature	**ASPM**
Software availability	ADMB_ASPM (v1.0)
Population spatial structure / areas	1
Number CPUE Series	1
Uses Catch-at-length	No
Tagging data	No
Age-structured	Yes
Sex-structured	No
Number of Fleets	3
Stochastic Recruitment	Yes

221. The WPTT **NOTED** the key assessment results for the Age-Structured Production Model (ASPM) as shown below (Tables 9 and 10; Figs. 29, 30 and 31).

Table 9. Key management quantities from the ASPM bigeye tuna stock assessment for the aggregate Indian Ocean. 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 pausible as these values but are not presented for simplification); the range represents the 90 percentile Confidence Interval.

Management Quantity	Aggregate Indian Ocean
2010 catch estimate (1000 t)	71.5
Mean catch from 2006–2010 (1000 t)	104.7
MSY (1000 t) (90% CI)	102.9 (86.6–119.3)
Data period used in assessment	1950–2010
F_{2010}/F_{MSY} (90% CI)	0.67 (0.48–0.86)
B_{2010}/B_{MSY} (90% CI)	–
SB_{2010}/SB_{MSY} (90% CI)	1.00 (0.77–1.24)
B_{2010}/B_{1950} (90% CI)	0.43 (n.a.)
SB_{2010}/SB_{1950}	0.39
$B_{2010}/B_{1950,\ F=0}$	–
$SB_{2010}/SB_{1980,\ F=0}$	–

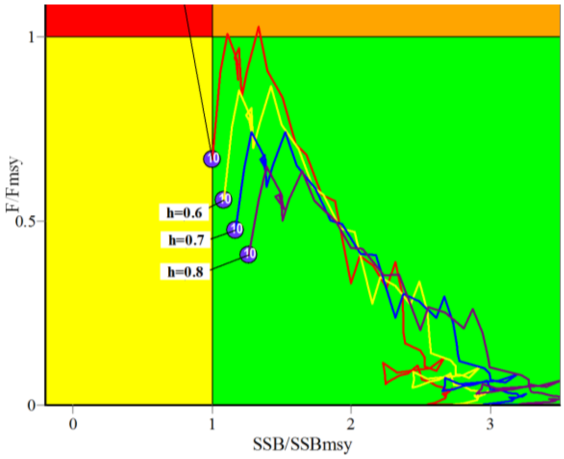

Fig. 29. Bigeye tuna: ASPM Aggregated Indian Ocean assessment Kobe plot. Red, yellow, blue and purple lines indicate the trajectory of the point estimates for the SB ratio and F ratio for each year 1950–2010 for values of steepness 0.5, 0.6, 0.7, and 0.8, respectively.

Table 10. Bigeye tuna: ASPM Aggregated Indian Ocean assessment Kobe II Strategy Matrix. Probability (percentage) of violating the MSY-based reference points for five constant catch projections (2010 catch level, ± 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 plausible as these values but are not presented for simplification).

Reference point and projection timeframe	Alternative catch projections (relative to 2010) and probability (%) of violating reference point				
	60% (42,900 t)	**80%** (57,200 t)	**100%** (71,500 t)	**120%** (85,800 t)	**140%** (100,100 t)
$SB_{2013} < SB_{MSY}$	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

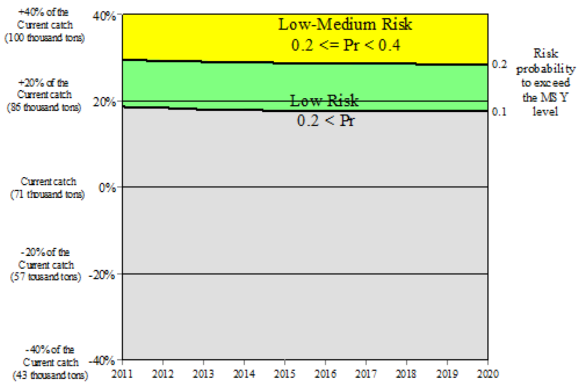

Fig. 30. The diagram for the Kobe II risk assessment matrix showing risk probabilities of F ratios to exceed their MSY levels in 2011–2020.

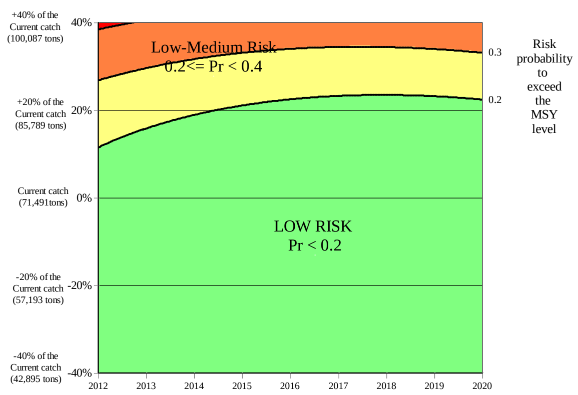

Fig. 31. The diagram for the Kobe II risk assessment matrix showing risk probabilities of BET SSB ratios to exceed their MSY levels in 2011–2020.

10.3 Selection of Stock Status indicators

222. 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 (Tables 11 and 12). 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.

Table 11. Key management quantities from the 2010 SS3 and 2011 ASPM assessments for bigeye tuna in the Indian Ocean.

Management Quantity	**2010 SS3**	**2011 ASPM**
2009 (SS3) and 2010 (ASPM) catch estimate (1000 t)	102	71.5
Mean catch from 2006–2010 (1000 t)	104.7	104.7
MSY (1000 t)	114 (95–183)	102.9 (86.6–119.3) [2]
Data period used in assessment	1952–2009	1950–2010
F_{curr}/F_{MSY} [3]	0.79 [1] Range[1]: 0.50 – 1.22	0.67 (0.48–0.86) [2]
B_{curr}/B_{MSY} [3]	–	–
SB_{curr}/SB_{MSY} [3]	1.20 [1] Range[1]: 0.88 – 1.68	1.00 (0.77–1.24) [2]
B_{curr}/B_0 [3]	–	0.43 (n.a.)
SB_{curr}/SB_0 [3]	0.34[1] Range[1]: 0.26 – 0.40	0.39[2]
$B_{curr}/B_{0,\ F=0}$ [3]	–	–
$SB_{curr}/SB_{0,\ F=0}$ [3]	–	–

[1] 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.

[2] 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.

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

Table 12. 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 plausible as these values but are not presented for simplification).

Reference point and projection timeframe	**Alternative catch projections (relative to 2009) and probability (%) of violating reference point**				
	2010 SS3				
	60% (61,200 t)	**80%** (81,600 t)	**100%** (102,000 t)	**120%** (122,400 t)	**140%** (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

Bigeye tuna

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

223. The WPTT **RECOMMENDED** the following management advice for bigeye tuna in the Indian Ocean, for the consideration of the Scientific Committee.

Stock status. Both assessments suggest 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 $F_{current}/F_{MSY} < 1$). Current spawning stock biomass was estimated to be 34–40 % (Table 11) 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.

Outlook. The recent declines in longline effort, particularly from the Japanese, Taiwan,China and Republic of Korea longline fleets, as well as purse seiner 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.

Catches in 2010 (72,000 t) were lower than MSY values and catches in 2009 (102,000 t) were at the lower range of MSY estimates. The mean catch over the 2008–2010 period was 94,000 t which is lower than estimated MSY.

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 management actions (Table 12). Based on the ASPM projections this year (2011) 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 72,000 t (maximum of 15% risk of $B<B_{MSY}$) or 2009 catches of 100,000 t (<40% risk that $B_{2020}<B_{MSY}$ and $F_{2020}>F_{MSY}$). Moreover, the SS3 projections from last year (2010) 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 from 2009 (< 30% risk that $B_{2019}<B_{MSY}$ and < 25% risk that $F_{2019}>FMSY$) (Table 11).

224. The WPTT **RECOMMENDED** that the Scientific Committee consider the following:
- 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 11 for further description)). Annual catches of bigeye tuna should not exceed the lower range of this estimated which corresponds to the 2009 catches and last year management advice.
- If the recent declines in effort continue, and catch remains substantially below the estimated MSY of 100,000–114 000 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.

11. Development of Technical Advice on the Status of the Stocks

Update of species Executive Summaries

225. The WPTT **NOTED** paper IOTC–2011–WPTT13–09 which aimed to encourage the WPTT to develop clear and concise draft Executive Summaries for tropical tunas for the consideration of the Scientific Committee.

226. The WPTT **NOTED** that Recommendation 30 from the IOTC performance review panel states: "New guidelines for the presentation of more user friendly scientific reports in terms of stock assessments should be developed. …".).

227. The WPTT **NOTED** that the IOTC currently uses the reference points of SB_{MSY} (or B_{MSY}) and F_{MSY} in providing its advice on stock status to the Commission and typically represents the advice as a ratio of current spawning biomass (SB_{curr}), total biomass (B_{curr}) or fishing rates/mortality to SB_{MSY}, B_{MSY} and F_{MSY} respectively; species with current spawning biomass estimates $<SB_{MSY}$ or $<B_{MSY}$ are considered overfished, and fishing mortality $>F_{MSY}$ is considered overfishing. There are currently no agreed harvest strategies, explicit target of limit reference points or decision rules that are followed when reference points are being approached or have been reached. Stocks of tuna and tuna-like species under the IOTC mandate are currently classified independently in each of the two categories described above (overfished and overfishing). Within these two categories there is a positive and a negative, as well as an uncertain status.

228. The WPTT **NOTED** that, at the Fifteenth Session of the Indian Ocean Tuna Commission, the Commission made the following request of the Scientific Committee, and by default, the Working Parties:

> "*The Commission noted the provision by the Scientific Committee of the Kobe II matrix for bigeye tuna and swordfish, and recognized that it is a useful and necessary tool for management. The Commission requests that such matrices be provided for all stock assessments by the species Working Parties, in particular for yellowfin tuna, and for these to be included in the report of the Scientific Committee in 2011 and all future reports*." (IOTC–2011–S15–R, para. 37).

229. The WPTT **ENDORSED** the new Executive Summary format (IOTC–2011–WPTT13–09) to be used in developing the draft tropical tuna resource Executive Summaries for the Scientific Committee's consideration.

230. The WPTT **RECOMMENDED** that the Scientific Committee:
- **NOTE** the current definition of overfishing used by the IOTC, where fishing mortality is in excess of F_{MSY} ($F_{curr}/F_{MSY} > 1$) is considered overfishing;
- **NOTE** that fishing mortality in excess of F_{MSY} is not always defined as overfishing (within tRFMOs) if the stock is well above the B_{MSY} level, although no specific threshold has been defined;
- **CONSIDER** the current definition of overfishing ($F_{curr}/F_{MSY} >1$), and determine that if in situations where the biomass of a given stock is well above B_{MSY}, but $F_{curr}/F_{MSY} >1$, under what circumstances should a stock be classified as subject to overfishing;
- **NOTE** the draft resource stock status summary for:
    - i. Bigeye tuna (*Thunnus obesus*) – Appendix VI
    - ii. Yellowfin tuna (*Thunnus albacares*) – Appendix VII
    - iii. Skipjack tuna (*Katsuwonus pelamis*) – Appendix VIII

231. The WPTT **RECOMMENDED** that the IOTC Secretariat update the draft stock status summaries for tropical tunas with the latest 2010 catch data, and for these to be provided to the Scientific Committee as part of the draft Executive Summaries, for its consideration.

Review of current Conservation and Management Measures for tropical tuna species

232. The WPTT **NOTED** paper IOTC–2011–WPTT13–10 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 Scientific Committee on whether modifications may be required; and 2) recommend whether other CMMs may be required, and **AGREED** that it did not have the resources at the current meeting to review the science-based components of the CMMs.

KOBE plot software

233. The WPTT **NOTED** paper IOTC–2011–WPTT13–45 which provided an introduction to the Kobe Plot I and II software (ver. 1) and encouraged interested participants to collaborate with the authors to further refine the software.

ADMB_ASPM user's guide

234. The WPTT **NOTED** IOTC–2011–WPTT13–46 which provided an overview of the AD Model Builder Implemented Age-Structured Production Model (ADMB_ASPM) software Users' Guide (ver. 1.0) and encouraged interested participants to collaborate with the authors to further refine the software.

Comparison of stock assessment practices in other RFMO's

235. The WPTT **NOTED** paper IOTC–2011–WPTT13–47 which provided a comparison of stock assessment practices in tuna-RFMOs, including the following abstract provided by the authors:

    "*Tuna and tuna-like species are important socio-economic resources as well as a significant source of protein for the society. They include approximately forty species occurring in the Indian, Pacific and Atlantic oceans, with a current global production of almost 6 million tonnes. The most commercially important tuna species are albacore (Thunnus alalunga, ALB), bigeye (Thunnus obesus, BET), Atlantic bluefin (Thunnus thynnus, BFT), Pacific bluefin (Thunnus orientalis, PBF), skipjack (Katsuwonus pelamis, SKJ), southern bluefin (Thunnus maccoyii, SBF) and yellowfin (Thunnus albacares, YFT). These species perform long migrations and their spatial distribution includes the temperate and tropical regions of all oceans. The total catch of the most important commercially tuna species increased continuously from 1950 to 2007, with the highest level, around 4.5 million tonnes, observed in 2005. In 2007, their catch was above four million tonnes, which represents around 75 percent of the total catch of all tuna and tuna-like species.*"

236. The WPTT **NOTED** that, to date, the tRFMOs have tended to work independently concerning the assessment of stocks under their responsibility, in spite of the fact that many species occur in multiple oceans, and are likely to share similar life history traits.

237. The WPTT **AGREED** on the need for increased cooperation among tRFMOs towards harmonization, where appropriate, of the biological information that is used for species managed by two or more RFMOs.

238. The WPTT **RECALLED** that recommendations issued by participants at the first Kobe Meeting, which called for collaborative work to be carried out under the Kobe process. The ISSF has initiated work towards this goal and urged IOTC scientists to contribute to this, or any related, initiatives where feasible.

239. The WPTT **NOTED** with concern, the lack of basic data on biological parameters in the tRFMO databases, including those used to derive live weights or standard lengths from non-standard measurements, stressing the need for WPTT scientists to forward all available information to the IOTC Secretariat, who would then make this information available via the IOTC website.

12. ANALYSIS OF TAGGING DATA

240. The WPTT **NOTED** that between 2002 and 2009, a total of 200,877 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, SEAFDEC and IEO in the high seas.

241. The WPTT **NOTED** that more than 31,000 (15.7%) 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}).

242. The WPTT **NOTED** that in 2011, the large Maldivian release and recovery database has been verified and validated and all the data from the small-scale projects 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, to researchers and scientists and in particular for their integration into the integrated stock assessments for the three species. However, before being able to obtain the maximum information from the newly added small-scale projects, in depth analysis of the data gathered during these projects is required and should be done prior to the next session of the WPTT, in preparation for the Tagging Symposium to be held in late 2012.

243. The WPTT **NOTED** the progress achieved by the IOTC Secretariat regarding the validation and integration of the small-scale tagging data into the main IOTTP database and **COMMENDED** the IOTC Secretariat for its work since 2002 in relation to the tagging activities.

244. 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 **RECOMMENDED** that this sampling programme should be maintained as long as these tunas are recovered, in order to ideally sex 100% of the future recoveries.

245. The WPTT **AGREED** to a revised set of criteria to be used in the production of datasets for growth studies, as provided in Appendix IX. The revised criteria will remove uncertain and likely erroneous data from the existing tag dataset and is to be used in the estimation of growth curves for future stock assessments.

246. The WPTT **RECOMMENDED** that more analyses on the tagging data should be undertaken in 2011 and 2012, and should include the estimation of mixing rates 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.

247. The WPTT **NOTED** that a tagging symposium, funded by the European Union, the IOTC and the IRD, will be held in Mauritius in late 2012, and that the IOTC has secured funds to undertake analysis of the tagging data (e.g. re-estimation of the reporting rates, independent analyses of the exploitation rates and natural mortalities, in depth analysis of the Maldivian tagging project and interaction between the surface fisheries of the Indian Ocean, estimation of growth curves for the 3 species and integration of the tagging data into the stock assessment).

248. The WPTT **RECOMMENDED** that analysis of the tagging data carried out in preparation for the Tagging Symposium and presented at the next WPTT meeting.

13. Analysis of the Time-Area Closures (incl. Resolution 10/01)

249. The WPTT **NOTED** IOTC Resolution 10/01 which instructed the Scientific Committee to provide at its 2011 Session an analysis of the effects of the time-area closure on international waters on the Northwest Indian Ocean (Fig. 32), initially set to be in place for one month: November for purse seiners and February for longliners. It also requested the Scientific Committee to investigate alternative time areas if deemed necessary.

250. The WPTT **RECALLED** the analyses carried out in the past on the likely effect of time-area closures for the various fleets and stocks involved. Two possibilities for conducting such analyses were

considered in previous exercises: reallocation of fishing effort to other areas, or a simple calculation of 'potential loss', i.e. the maximum loss in catches that would be obtained in the unlikely event of fleets not moving to other areas during the closure. Document IOTC–2000–SO5–R and IOTC–2003–WPTT05–R contains the tables of such an analysis of 'potential loss' conducted for a range of spatial and temporal scenarios in 2000 and 2003.

251. The WPTT **RECALLED** the analysis carried out for the 2010 SC which emphasized that catch reduction expected from the time-area closure were negligible and that recent event in the Somali area has affected in a major extend the population than the closure. In particular, as described in the next section, longliners do not operate anymore off the Somali coast and in the northwest India Ocean, despite purse seiner catch in the area are relatively small during the month of November (5.7 % of total yearly yellowfin tuna catch, 4.5 % for bigeye tuna, and 6.1 for skipjack tuna in 2010), the total purse seine vessels has been reduced in 30 % since 2006.

252. Noting that the request contained in Resolution 10/01 does not specify the expected objective to be achieved with the current or alternative time area closures, and that the WPTT was not clear about the intended objectives of the time-area closure taking into account recent reduction of effort (see next section) as well as recent likely recovery of the yellowfin tuna population, the WPTT **RECOMMENDED** that the Commission specify clear objectives as to what are the management objectives to be achieved with this and/or alternative measures. This will, in turn, guide and facilitate the analysis of the WPTT in 2012 and future years.

253. The WPTT **AGREED** to undertake preliminary analysis before the Scientific Committee meeting in December 2011. The WPTT tasked a small group with the preparation, with the guidance of the Chair of the WPTT, and in collaboration with the Secretariat, of a document presenting an analysis based on maximum potential loss of catches, as estimated from the catch statistics of IOTC. The WPTT Chair will also then request guidance from the Scientific Committee on any extra analyses that it would like WPTT to conduct at its next meeting, for example on alternative times/areas for such a closure.

254. Noting the lack of papers examining time-area closures in the Indian Ocean for WPTT13 as well as the slow progress to address Commission request, the WPTT **RECOMMENDED** that SC chair begins a consultative process with the Commission in order to get clear guidance from the Commission about the management objectives intended with the current or any alternative closure. This will allow the SC to address the Commission request more thoroughly. At the same time, the SC needs to include the issue of the time area closure as a priority in the research activity for 2011/2012 depending on Commission feedback.

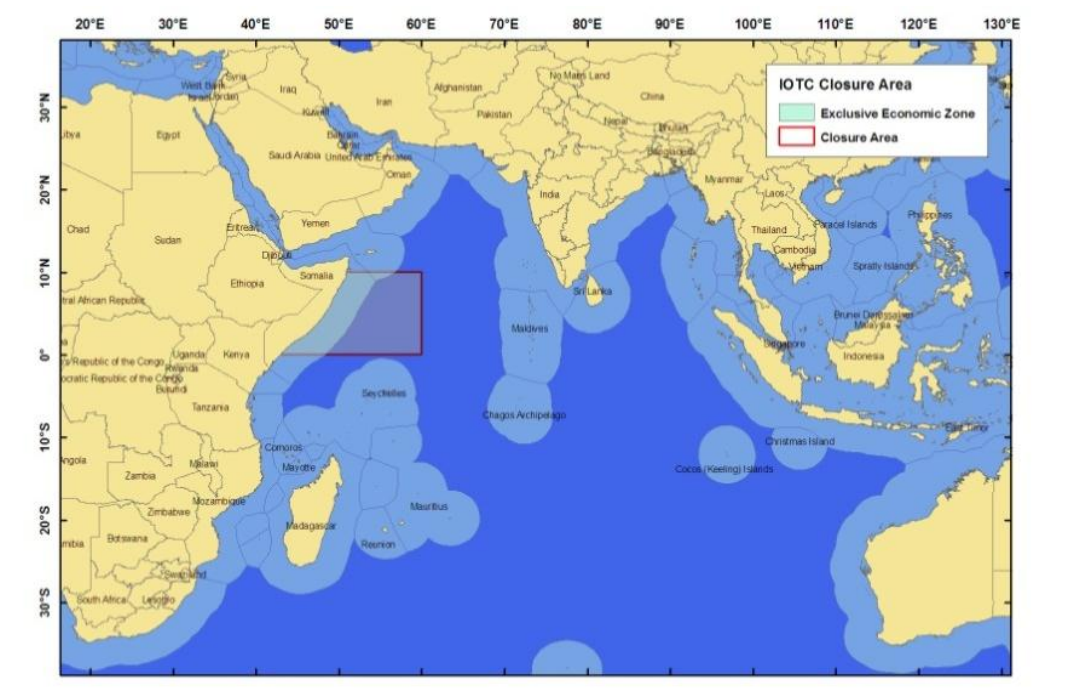

Fig. 32. IOTC closure area as detailed in Resolution 10/01.

14. Effect of Piracy on Tropical Tuna Catches

255. The WPTT **NOTED** paper IOTC–2011–WPTT13–44 which provided a preliminary analyses of the effect of Piracy on the catch and fishing patterns of Japanese longline fishery in the Indian Ocean, including the following abstract provided by the authors:

> *"Historic Japanese longline catch and effort were reviewed with respect to the increased piracy off Somalia. As the activity of piracy increased and spread since 2007, Japanese longliners have retreated from West Indian Ocean, especially from the north. In 2008, the effort off Somalia decreased and that of north of equator and west of 60oE disappeared in 2009, and most of effort disappeared from North of 10oN and West of 80oE in 2010. The number of strata fished in the NW area has declined since 2007/2008, corresponding with the decline in effort. For both bigeye and yellowfin tuna, CPUE calculated from 1991-2005 using strata which were active from 2006 to 2010 showed a similar trend to the CPUE calculated using all data over the same period. However, the CPUE from the data extracted by strata in 2010 for the NW region showed a different trend to the CPUE based on all data or CPUE calculated from extracted strata in other years. Although most differences between relative CPUEs based on all data and those based on extracted data were <0.2, there were large fluctuations in the NW in 2010 ranging from -0.8 to 0.5 for bigeye and -0.6 to 0.9 for yellowfin. These results indicate that the decline in effort and shift in fishing location due to piracy and/or a decline in yellowfin CPUE have not critically affected yellowfin and bigeye CPUE in the Indian Ocean with the exception of the NW region in 2010. This data from the NW Indian Ocean in 2010 does not appear to be representative of the real CPUE trend due to the low and unusual distribution of effort, so should be treated carefully during CPUE standardisation".*

256. The WPTT **AGREED** that the high resolution displayed in Figure 3 in paper IOTC–2011–WPTT13–44 would be good to see in future papers, rather than 5º by 5º data.

257. The WPTT **NOTED** that many papers presented to at the current meeting demonstrated clear impacts of piracy on fishing operations in the western Indian Ocean. In particular, 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. 33, 34 and 35). 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.

258. 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. Of Taiwanese vessels, 10 have moved to the Atlantic. These originally targeted bigeye tuna, however according to information from observers, some of the remaining vessels have now moved south to target albacore. Japan reported a reduction of ~90 vessels since 2006, with 85 remaining in 2010 (preliminary), which corresponds to a decrease of total catch of about 75–80%. 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 13 in 2010; 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 35 in 2010 (a 30% of reduction).

259. The WPTT **NOTED** that some effort removed from the Somali area due to piracy has been redistributed. Redistribution of effort occurred fairly evenly across the Indian Ocean, rather than relocation to a specific area.

260. 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, Republic of Korea and Taiwan,China.

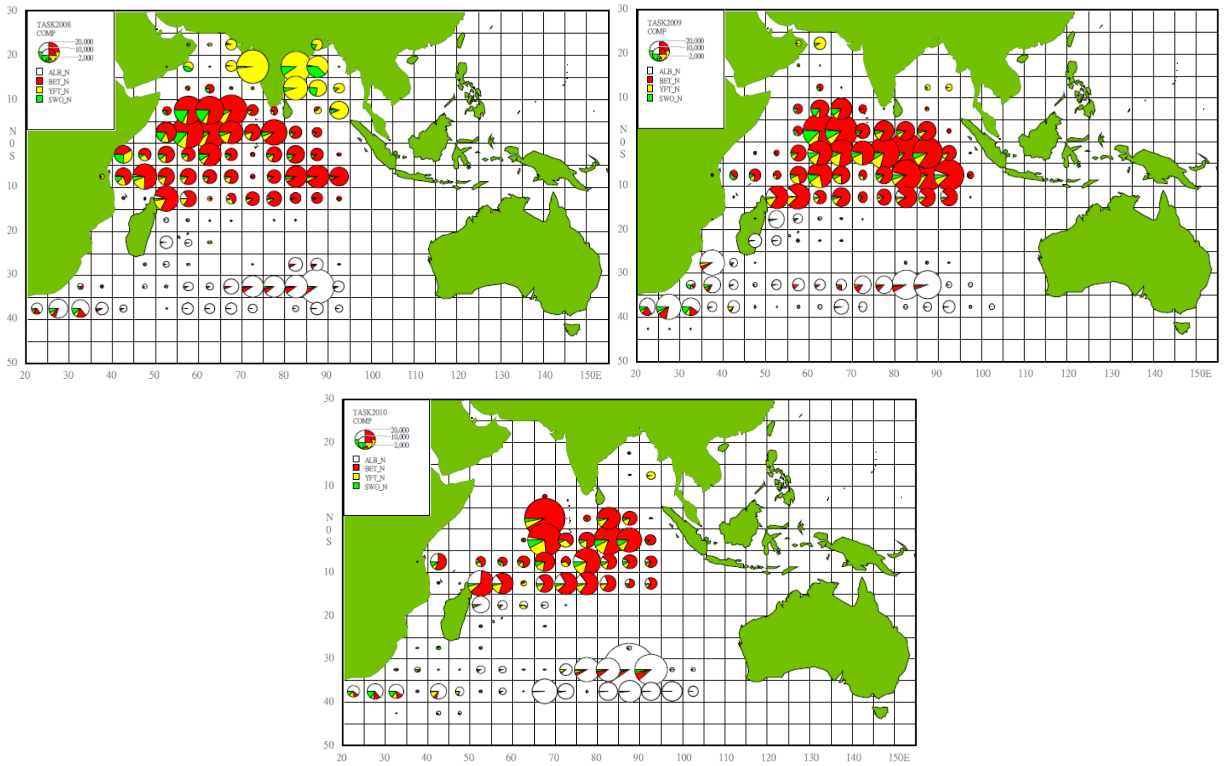

Fig. 33. Distribution of the Taiwanese LL catches in the Indian Ocean by year from 2008 (top left panel) to 2010 (bottom panel).

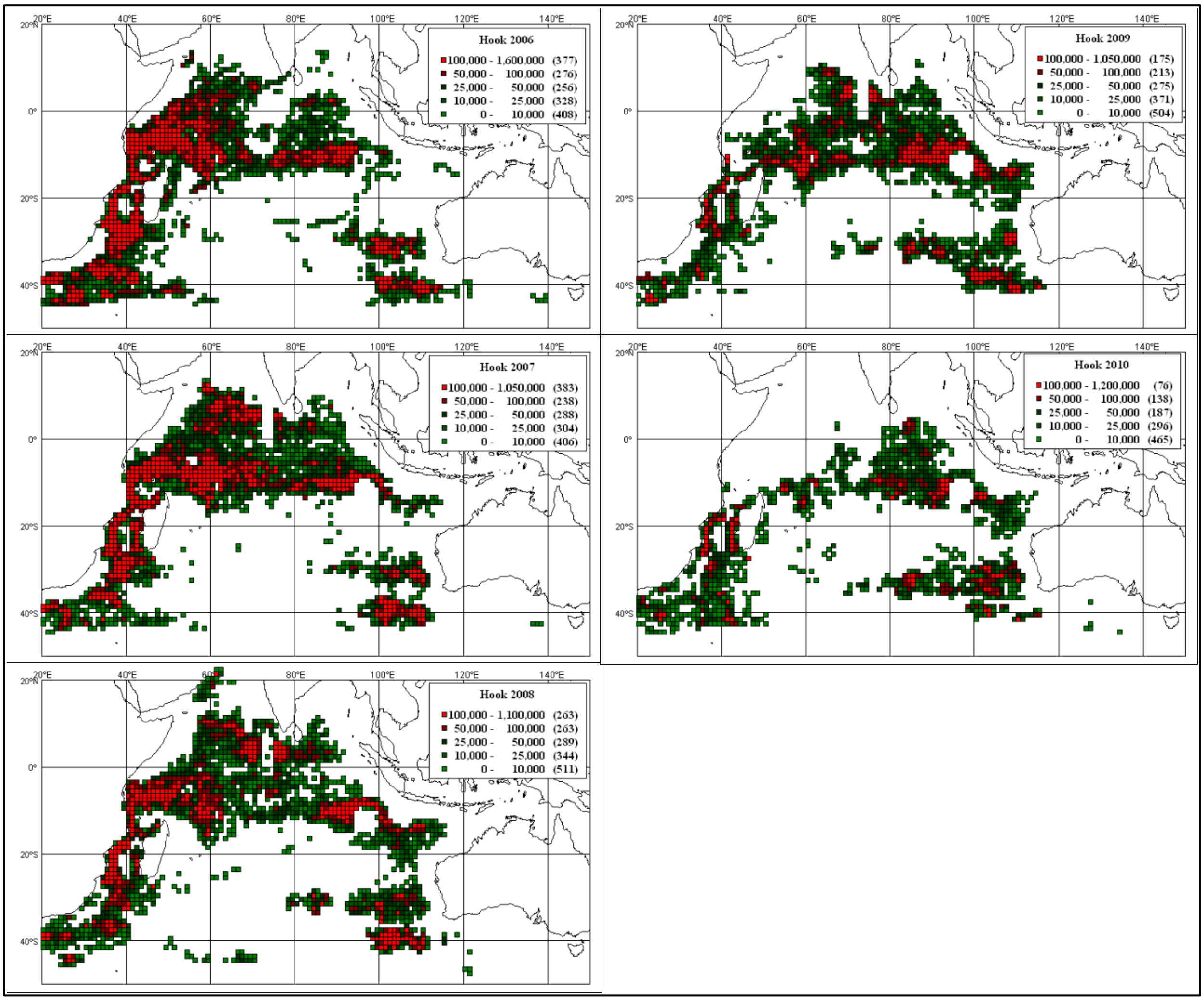

Fig. 34. Distribution of the Japanese LL effort in the Indian Ocean by year from 2006 (top left panel) to 2010 (bottom right panel).

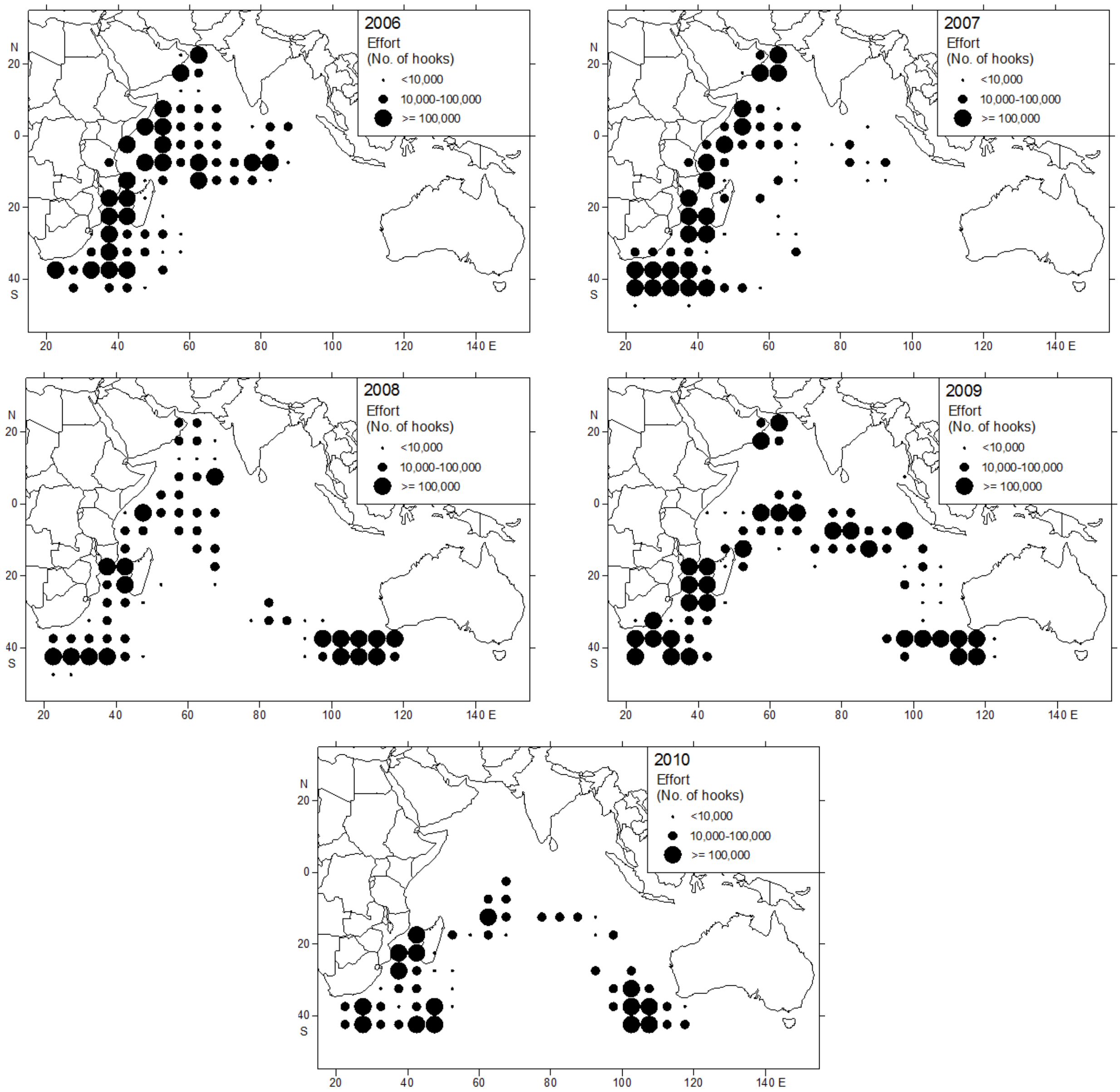

Fig. 35. Distribution of the Korean longline effort (number of hooks) in the Indian Ocean from 2006 to 2010.

15. METHODS

15.1 Reference points and harvest control rules for IOTC stocks

261. The WPTT **NOTED** paper IOTC–2011–WPTT13–61 which provided a preliminary evaluation of a harvest control rule for Indian Ocean yellowfin tuna using limits and target reference points, including the following abstract provided by the authors:

"Management strategy evaluation has been proposed as an appropriate method to incorporate additional sources of uncertainty into the assessment process than is traditionally done. This addressing of additional uncertainty is more consistent with the precautionary approach to fisheries management. A simple harvest control rule incorporating using both an target F and Biomass trigger was tested for the Indian Ocean yellowfin tuna population using an MSE framework. The operating model was based on a past Multifan-CL assessment model. The outputs of the MSE process indicated that measurement error, in this case uncertainty in CPUE series, had a greater effect than changes in parameters such as steepness. In addition, the Btrigger had a greater effect on average annual variation (AAV) than on the actual estimated values with a lower value of Btrigger resulting in lower variability. Also, in reality catches, harvest (and hence fishing effort) and stock trends show great variability and do not follow the smooth trends implied by the median projections. Future HCR development should take this into account, possibly restricting inter-annual variability in TACs and fishing effort. Although this

work is considered preliminary and much additional effort is needed, the benefit of the MSE process is clear."

262. The WPTT **NOTED** the preliminary nature of this work and encouraged the authors to further develop the evaluation in conjunction with the WPM.

15.2 Management Strategy Evaluation (MSE)

263. The WPTT **NOTED** paper IOTC–2011–WPTT13–53 which provided an introduction to the Management Strategy Evaluation and welcomed the presentation of this work.

264. The WPTT **NOTED** that an MSE process would include setting limits and targets: precautionary approach; setting objectives: risks; agreeing to performance measures: biological and/or economic; and working in collaboration with scientists, managers and industry.

265. The WPTT **AGREED** that developing a complete Operating Model of biology and fishery, could reap great benefits in terms of understanding the role of different elements in the dynamics of the system, and the quality and quantity of information available.

266. The WPTT **NOTED** that MSE is often promoted on the basis of the following advantages:
    - MSE development normally increases the level of engagement between scientists, managers and industry. Explicit quantification of management trade-offs is illustrated, which allows objectives to be prioritized in a much more effective way than can typically be achieved if they are discussed independently.
    - MSE emphasizes the development of decision rules that are robust (i.e. likely to perform reasonably well under a broad range of situations and avoid catastrophe in the most pessimistic scenarios) rather than optimal decision rules (which can be designed to work very well provided that there is little uncertainty about the underlying dynamics). In this sense, MSE directly incorporates the principles of the precautionary approach.
    - Decision rules are designed to operate effectively for several years. This adds certainty to the decision process that can help industry with strategic investment plans.
    - The MSE framework is useful for identifying the value of information, and helping to design data collection and research requirements.

267. Noting that the development of an MSE process will require management objectives to be developed, the WPTT **RECOMMENDED** that the Commission provide clear guidance in this regard, noting that the adoption of the Precautionary Approach, as defined in the Fish Stocks Agreement, may be the first step.

268. The WPTT **ENDORSED** the roadmap presented for the implementation of MSE in the Indian Ocean in IOTC–2011–WPTT13–53 and **RECOMMENDED** to the Scientific Committee the organization of a joint meeting between managers, stakeholder and scientist during 2012 to begin discussions about the implementation of MSE in IOTC.

269. The WPTT **NOTED** paper IOTC–2011–WPTT13–INF16 which provided an evaluation of three harvest control rules for bigeye tuna fisheries in the Indian Ocean, including the following abstract provided by the authors:

    "A simple Management Strategy Evaluation (MSE) demonstration for the Indian Ocean BET fishery is described, comparing three harvest control rules (HCRs): i) constant fishing mortality, ii) constant catch, and iii) constant escapement. The operating model was conditioned to the 2010 stock assessment. The population dynamics and fishery parameters were adopted from the point estimates from three model specifications selected to encompass a range of uncertainty in productivity, current stock status and biological parameters. Performance was compared on the basis of three management objectives i) the probability of maintaining spawning stock biomass above the level that can sustain Maximum Sustainable Yield (MSY) on average, ii) average catch, and iii) interannual variability in catches. The feedback-based HCRs were able to differentially exploit the productivity variability, reducing spawning biomass risk and increasing catch relative to the constant catch HCR. The results are presented as a work in progress to illustrate the MSE process, and the type of management advice that could be provided largely as an extension of the Kobe 2 Strategy Matrix."

270. The WPTT **NOTED** the preliminary nature of this work and encouraged the authors to further develop the evaluation in conjunction with the WPM.

15.3 Advances in CPUE standardisation

271. The WPTT **NOTED** paper IOTC–2011–WPTT13–62 which proposed a workshop on Indian Ocean longline CPUE standardization methods, including the following abstract provided by the authors:

"Commercial Catch Per Unit Effort (CPUE) is a critical input to all of the model-based stock assessments conducted by the IOTC. CPUE needs to be standardized to account for changes in catchability over time, so that it can be interpreted as a relative abundance index, and used to make inferences about the impact of the fishery on the population. The working parties have noted concerns about all of the standardized CPUE series and the timeframe for exchange (e.g. see Working Party Report extracts in attachment 1). A dedicated CPUE workshop has been proposed to help improve the CPUE analyses."

272. The WPTT **RECOMMENDED** that a dedicated workshop on CPUE standardization, including issues of interest for other IOTC species should be carried out before the next round of stock assessments in 2012, and that where possible it should include a range of invited experts, including those working on CPUE standardisation in other ocean/RFMOs, in conjunction with scientists from Japan, Republic of Korea and Taiwan,China, and supported by the IOTC Secretariat.

273. The WPTT also **ENCOURAGED** data to be used in stock assessments, including CPUE standardisations, be made available not less than three months before each meeting by CPCs and where possible, data summaries no later than two months prior to each meeting, from the IOTC Secretariat; and **RECOMMENDED** that data to be used in stock assessments, including CPUE standardisations by CPCs be made available not less than 30 days before each meeting.

15.4 Presentation of stock assessment results from multiple models

274. The WPTT **NOTED** paper IOTC–2011–WPTT13–63 which discussed the presentation of IOTC stock status advice from multiple models to the broader fisheries community.

275. The WPTT **NOTED** that stock assessment models tend to conflict to some degree and that to date, the Working Parties often spend large amounts of time at each meeting trying to develop careful language to reach a written consensus on the stock status.

276. The WPTT **AGREED** that of the options presented in the paper, model averaging in some form was the optimal way to represent uncertainty, noting that some form of model weighting may be necessary.

277. The WPTT **NOTED** that the various issues highlighted in the paper had been referred to the next meeting of the Working Party on Methods.

16. RESEARCH RECOMMENDATIONS AND PRIORITIES

16.1 Development a draft work plan for the WPTT

278. The WPTT discussed various research priorities and **AGREED** to the following workplan and priorities for 2012:

CPUE standardisation

279. 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 outlined in sections 8–10, 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 2012.

280. The WPTT **NOTED** that there are various levels of needs for each fleet. For example, while for pole-and-line and purse seine fleets, the data and methodological approach are considered key issues to be resolved before any attempt of CPUE standardization; longline CPUE standardization constraints (differences between fleets, spatial structure, materials, etc.) can be resolved and reviewed in a dedicated workshop with the presence of other tRFMO CPUE experts.

281. The WPTT **NOTED** the para. 272 above, outlining the need for a longline CPUE standardization workshop where operational data, under IOTC confidentiality rules, will be jointly analysed.

282. The WPTT **RECOMMENDED** that the Secretariat and Maldivian scientists continue the joint effort to standardize the Maldivian pole-and-line CPUE in preparation for assessment in 2012.

283. The WPTT **RECOMMENDED** that standardization of purse seine CPUE be made where possible using the operational data on the fishery, and that participants working on CPUE for the main fleets, attend the CPUE standardization workshop being organized by ISSF in Honolulu, Hawaii in 2012.

Stock assessment

284. Noting the difficulty of carrying out stock assessments for three tropical tuna species in a single year, the WPTT **RECOMMENDED** to a revised assessment schedule on a two- or three-year cycle for the three tropical tuna species as outlined in Table 13. Following the uncertainty remaining in the yellowfin tuna assessment the WPTT **AGREED** that priories for stock assessments in 2012 would be yellowfin tuna (Multifan-CL and SS3, and possibly others) with an update of fishery indicators for the other two species.

Table 13. New schedule proposed for tropical tuna species stock assessment to be recommended to the SC:

Species/Assessment year	2012	2013	2014	2015	2016	2017
Yellowfin tuna	Full	Update	Update	Full	Update	Update
Skipjack tuna	Update	Full	Update	Update	Full	Update
Bigeye tuna	Update	Update	Full	Update	Update	Full

Note: the schedule may be change depending on the situation of the stock from various sources such as fishery indicators, Commission requests, etc.

Additional topics for research

285. The WPTT **RECOMMENDED** that the Scientific Committee add the following core topic areas as priorities for research over the coming year in order of priority:
- An update of the Brownie-Peterson method for the 3 tropical tuna species (possible issue for the 2012 IO Tuna Tagging Symposium).
- An update YFT growth curve (work in progress to be presented to 2012 Tuna Tagging Symposium).

286. The WPTT **NOTED** that several analysis using tagging data will be carried out by external consultants for the Indian Ocean Tuna Tagging Symposium in 2012 and that this may affect the workplan of the WPTT (see para. 248). Therefore, the WPTT **URGED** the Steering Committee of the Tagging Symposium to present the core topics to be included in those analysis during next Scientific Committee meeting.

17. Other Business

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

287. The WPTT **NOTED** with thanks, the outstanding contributions of the invited experts for the meeting, Dr. Joseph Powers (LSU) and Ms. Paige Eveson (CSIRO–Australia) and encouraged them both to maintain links with IOTC scientists to aid in the improvement of stock assessment approaches for IOTC stocks.

288. 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 2012, by an Invited Expert:
- Priority areas for contribution: (1) CPUE analysis and standardisation, and (2) Updating the Brownie-Peterson analysis on skipkjack tuna, bigeye tuna and yellowfin tuna.

17.2 Date and place of the Fourteenth Session of the Working Party on Tropical Tunas

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

290. Following a discussion on who would host the Fourteenth Session of the WPTT, the WPTT **RECOMMENDED** that the next meeting of the WPTT be held immediately prior to the Tuna Tagging Symposium, preferably in October 2012, aware that the Scientific Committee is held in early December each year. The exact dates and meeting location will be confirmed and communicated by the IOTC Secretariat to the Scientific Committee for its consideration at its next session to be held in December 2011.

291. The WPTT **AGREED** that the length of the WPTT meeting could be shortened by at least one day.

292. The WPTT **NOTED** the increased attendance by scientists from developing CPCs in 2010 and 2011 was partly due to the IOTC Meeting Participation Fund, adopted by the Commission in 2010 (Resolution 10/05 on the establishment of a Meeting Participation Fund for developing IOTC Members and non-Contracting Cooperating Parties), and **RECOMMENDED** that this fund be maintained.

17.3 Election of a Vice-Chairperson of the Working Party on Tropical Tunas for the Next Biennium

293. The WPTT **CONSIDERED** candidates for the position of Vice-Chair of the WPTT for the next biennium. Dr. M. Shiham Adam (Maldives) was nominated and elected as Vice-Chair of the WPTT for the next *biennium* unanimously.

294. The WPTT **RECOMMENDED** that the Scientific Committee note the new Vice-Chair, Dr. M. Shiham Adam (Maldives) of the WPTT for the next *biennium*.

17.4 Review of the draft, and adoption of the Report of the Thirteenth Session of the Working Party on Tropical Tunas

295. The WPTT **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPTT13, provided at Appendix IV.

296. The report of the Thirteenth Session of the Working Party on Tropical Tunas (IOTC–2011–WPTT13–R) was **ADOPTED** on the 23 October 2011.

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

Date: 16–23 October 2011
Location: Paradise Island Resort, Lankanfinolhu,
North Malé Atoll, Maldives
Time: 09:00 – 17:00 daily

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

2. **ADOPTION OF THE AGENDA** (Chair)

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

4. **OUTCOMES OF THE FIFTEENTH SESSION OF THE COMMISSION** (Secretariat)

5. **PROGRESS ON THE RECOMMENDATIONS OF WPTT12** (Secretariat)

6. **REVIEW OF DATA AVAILABLE FOR TROPICAL TUNA SPECIES**
   7.1. Review of the statistical data available for tropical tuna species (Secretariat)
   7.2. Data from other sources (papers from CPCs)
   7.3. Develop recommendations to the Scientific Committee

7. **NEW INFORMATION ON BIOLOGY, ECOLOGY, FISHERIES, ENVIRONMENTAL DATA AND STOCK STRUCTURE RELATING TO TROPICAL TUNAS**
   8.1. Review new information on the biology, stock structure, their fisheries and associated environmental data (CPC papers)

8. **REVIEW OF NEW INFORMATION ON THE STATUS OF SKIPJACK TUNA**
   8.1 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

   8.2 Stock assessments
   8.3 Selection of Stock Status indicators

9. **REVIEW OF NEW INFORMATION ON THE STATUS OF YELLOWFIN TUNA**
   9.1 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

   9.2 Stock assessments
   9.3 Selection of Stock Status indicators

10. REVIEW OF NEW INFORMATION ON THE STATUS OF BIGEYE TUNA

- 10.1 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
- 10.2 Stock assessment updates
- 10.3 Selection of Stock Status indicators

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

12. ANALYSIS OF TAGGING DATA

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

14. EFFECT OF PIRACY ON TROPICAL TUNA CATCHES

15. METHODS

- 15.1 Reference points and harvest control rules for IOTC stocks
- 15.2 Management Strategy Evaluation (MSE)
- 15.3 Advances in CPUE standardisation
- 15.4 Presentation of stock assessment results from multiple models

16. RESEARCH RECOMMENDATIONS AND PRIORITIES

- 16.1 Develop a draft work plan
- 16.2 Develop recommendations to the Scientific Committee

17. OTHER BUSINESS

- 17.1 Development of priorities for an Invited Expert at the next Working Party on Tropical Tuna meeting
- 17.2 Date and place of the Fourteenth Session of the Working Party on Tropical Tunas
- 17.3 Election of a Vice-Chairperson of the Working Party on Tropical Tunas for the next biennium
- 17.4 Review of the draft, and adoption of the Report of the Thirteenth Session of the Working Party on Tropical Tunas

APPENDIX III
LIST OF DOCUMENTS

Document	Title	Availability
IOTC–2011–WPTT13–01a	Agenda of the Thirteenth Working Party on Tropical Tunas	✓(20 July)
IOTC–2011–WPTT13–01b	Annotated agenda of the Thirteenth Working Party on Tropical Tunas	✓(15 September)
IOTC–2011–WPTT13–02	List of documents	✓(15 September)
IOTC–2011–WPTT13–03	Outcomes of the Thirteenth Session of the Scientific Committee (Secretariat)	✓(21 July)
IOTC–2011–WPTT13–04	Outcomes of the Fifteenth Session of the Commission (Secretariat)	✓(21 July)
IOTC–2011–WPTT13–05	Progress made on the recommendations of WPTT12 (Secretariat and Chair)	✓(28 September)
IOTC–2011–WPTT13–06	Review of the statistical data available for the tropical tuna species (M. Herrera, L. Pierre and J. Million — Secretariat)	✓(30 September)
IOTC–2011–WPTT13–07a	Preparation of catch-at-size and catch-at-age files for the stock assessments of tropical tunas (M. Herrera and L. Pierre — Secretariat)	✓(30 September)
IOTC–2011–WPTT13–07b	Preparation of data input files for the assessments of Indian Ocean yellowfin tuna stock (M. Herrera and J. Million — Secretariat)	✓(30 September)
IOTC–2011–WPTT13–08	Review of fishery trends for tropical tunas species (M. Herrera and J. Million — Secretariat)	✓(3 October)
IOTC–2011–WPTT13–09	Template for the 'Executive Summary' of tropical tuna species (Secretariat and Chair)	✓(9 August)
IOTC–2011–WPTT13–10	Review of current Conservation and Management Measures for tropical tuna species (Secretariat and Chair)	✓(8 September)
IOTC–2011–WPTT13–11 Rev_1	Outline of climate and oceanographic conditions in the Indian Ocean: an update to August 2011 (F. Marsac)	✓(13 October) ✓(18 October)
IOTC–2011–WPTT13–12	Some results for tropical tuna based on catch data in Mozambique (B. Palha de Sousa)	✓(4 October)
IOTC–2011–WPTT13–13	Census of artisanal fishing vessels in Union of the Comoros (I.M. Toihir)	✓(6 October)
IOTC–2011–WPTT13–14	Fishing gear and methods used to harvest tuna and tuna-like species in the EEZ of Pakistan (S. Hussain)	✓(16 October)
IOTC–2011–WPTT13–15 Rev_1	Catches and landing of tuna and tuna-like species – Pakistan (Basit and H. Badar)	✓(16 October) ✓(17 October)
IOTC–2011–WPTT13–16	Partial analysis of tropical tuna catches by industrial fishing in the Malahasy EEZ (R. Fanazava)	✓(3 October)
IOTC–2011–WPTT13–17	Catch, species composition and biology of tuna caught in the Indian Ocean by the Malaysian tuna longliners (S. Basir)	✓(30 September)
IOTC–2011–WPTT13–18	Interannual and geographic variations in the abundance indices of yellowfin tuna, billfishes and sharks in the Indian EEZ (S.P. Varghese, A. Tiburtius, K. Vijayakumaran, Premchand and D.K. Gulati)	✓(10 October)
IOTC–2011–WPTT13–19	Statistics of the purse seine Spanish fleet in the Indian Ocean (1990–2010) (J. Ariz, A.D. de Molina and J.J. Areso)	✓(22 September)
IOTC–2011–WPTT13–20 Rev_1	Statistics of the French purse seine fleet targeting tropical tunas in the Indian Ocean (1991–2010) (E. Chassot, L. Floch, P. Dewals, R. Pianet and P. Chavance)	✓(6 October) ✓(18 October)
IOTC–2011–WPTT13–21	Changes in fishing power of the French purse seiners of the Indian Ocean: Back to the basics (E. Chassot, A. Fonteneau, D. Gaertner and A. Laurec)	Withdrawn
IOTC–2011–WPTT13–22 Rev_1	A Bayesian observation error model for otolith reading: The case study of yellowfin tuna (*Thunnus albacares*) in the Indian Ocean (E. Dortel, F. Massiot-Granier, E. Chassot, E. Morize, J. Million and E. Rivot)	✓(16 October) ✓(19 October)
IOTC–2011–WPTT13–23	Kenyan and Tanzanian EEZs longline CPUE for Yellowfin and Bigeye tuna in 2007 (S. Ndegwa)	✓(7 October)

Document	Title	Availability
IOTC–2011–WPTT13–24 Rev_1	Statistics of the main purse seine fleets fishing in the Indian Ocean (1981–2010) (R. Pianet, A. Delgado de Molina, P. Dewals, V. Lucas, L. Floch, E. Chassot and J. Ariz)	✓(8 October) ✓(19 October)
IOTC–2011–WPTT13–25 Rev_1	Macroscopic study on some aspects of the reproductive biology of skipjack tuna (*Katsuwonus pelamis*) in the Western Indian Ocean (D. Norungee and D. Kawol)	✓(10 October) ✓(17 October)
IOTC–2011–WPTT13–26	Decadal trend in catch per unit effort for skipjack by research purse-seiner "Nippon-maru" in the eastern Indian Ocean (T. Oshima and I. Fusejima)	✓(7 October)
IOTC–2011–WPTT13–27 Rev_1	Note on the 1983–2010 skipjack activities of EU purse seiners in the Indian Ocean. (A. Fonteneau, J. Ariz, E. Chassot, V. Lucas, A. Delgado de Molina, H. Murua and D. Gaertner)	✓(10 October) ✓(18 October)
IOTC–2011–WPTT13–28	Indicators of stock status for skipjack tuna in the Indian Ocean (P. de Bruyn and H. Murua)	✓(6 October)
IOTC–2011–WPTT13–29	Maldivian skipjack pole and line fishery catch rate standardization 2004–2010 (D. Kolody and S. Adam)	✓(29 September)
IOTC–2011–WPTT13–30 Rev_1	Preliminary application of the Brownie-Petersen method to skipjack tag-recapture data (P. Eveson)	✓(6 October) ✓(12 October)
IOTC–2011–WPTT13–31	Integrated stock assessment (SS3) of Indian Ocean skipjack tuna 1950–2009 (D. Kolody, J. Million, and M. Herrera)	✓(15 October)
IOTC–2011–WPTT13–32	A comparison of methods for prediction of Integrated Habitat Index of *Thunnus albacares* in the Indian Ocean – general linear model and quantile regression model considerations (L. Song, Y. Wu and T. Nishida)	✓(1 October)
IOTC–2011–WPTT13–33	Can length-based selectivity explain the two stage growth curve observed in Indian Ocean YFT and BET? (D. Kolody)	✓(30 September)
IOTC–2011–WPTT13–34 Rev_1	Japanese longline CPUE for yellowfin tuna in the Indian Ocean up to 2010 standardized by general linear model (H. Okamoto)	✓(30 September) ✓(16 October)
IOTC–2011–WPTT13–35	Updated CPUE standardizations for Yellowfin tuna caught by Taiwanese longline fishery in the Indian Ocean using generalized liner model (Y.-M. Yeh and S.-T. Chang)	✓(8 October)
IOTC–2011–WPTT13–36 Rev_1	Stock assessment of yellowfin tuna in the Indian Ocean using MULTIFAN-CL (A. Langley, M. Herrera and J. Million)	✓(4 October) ✓(27 October)
IOTC–2011–WPTT13–37	Stock assessment by Stock Synthesis III (SS3) for yellowfin tuna in the Indian Ocean (T. Kitakado, K. Satoh, H. Ijima and H. Okamoto)	Withdrawn
IOTC–2011–WPTT13–38	Standardization of bigeye tuna CPUE of Korean tuna longline fisheries in the Indian Ocean (S. Lee, Z. Kim and T. Nishida)	✓(13 October)
IOTC–2011–WPTT13–39	Updated CPUE standardizations for bigeye tuna caught by Taiwanese longline fishery in the Indian Ocean using generalized liner model (Y.-M. Yeh and S.-T. Chang)	✓(12 October)
IOTC–2011–WPTT13–40	Performance of different length information on stock assessment of bigeye tuna from the Indian Ocean by length-based yield per recruit analysis (Y.-J. Lin, Y.-M. Yeh, C.-Y. Chen and C.-C. Hsu)	✓(13 October)
IOTC–2011–WPTT13–41 Rev_1	Stock assessment of bigeye tuna (*Thunnus obesus*) in the Indian Ocean based on a tuned VPA analysis (J. Zhu, X. Dai and L. Xu)	✓(30 September) ✓(20 October)
IOTC–2011–WPTT13–42 Rev_3	Stock and risk assessments on bigeye tuna (*Thunnus obesus*) in the Indian Ocean by AD Model Builder implemented Age-Structured Production Model (ASPM) (T. Nishida and R. Rademeyer)	✓(8 October) ✓(10 October) ✓(18 October) ✓(20 October)
IOTC–2011–WPTT13–43	A preliminary investigation into the effects of the British Indian Ocean Territory and IOTC MPAs on yellowfin tuna (*Thunnus albacares*) (S. Martin, C. Edwards, L. Nelson and C. Mees)	Withdrawn
IOTC–2011–WPTT13–44	Preliminary analyses of the effect of the Piracy activity in the northwestern Indian Ocean on the CPUE trend of bigeye and yellowfin (H. Okamoto)	✓(30 September)
IOTC–2011–WPTT13–45	Kobe Plot I and II software (ver. 1) (T. Nishida, Y. Matsuo and K. Itoh)	✓(4 October)

Document	Title	Availability
IOTC–2011–WPTT13–46 Rev_1	AD Model Builder Implemented Age-Structured Production Model (ASPM) Users' Guide (ver. 1.0) (R. Rademeyer and T. Nishida)	✓(9 October) ✓(13 October)
IOTC–2011–WPTT13–47	A comparison of stock assessment practices in tuna-RFMOs (H. Murua, P. de Bruyn and D. Kolody)	✓(15 October)
IOTC–2011–WPTT13–48 Rev_1	Developing an age structured projection model for bigeye tuna (*Thunnus obesus*) in the Indian Ocean (J. Zhu and X. Dai)	✓(30 September) ✓(20 October)
IOTC–2011–WPTT13–49	Thai Tuna Fisheries in the Indian Ocean during 2007–2010 (P. Saikliang, W. Premkit and P. Chaidee)	✓(7 October)
IOTC–2011–WPTT13–50	MFCL vs SS3: A comparison of the 2010 Indian Ocean yellowfin tuna assessment (A. Langley)	✓(21 September)
IOTC–2011–WPTT13–51	Review of yellowfin tuna catch by Korean longline fleet in the Indian Ocean (Z.G. Kim, S.I. Lee, D.Y. Moon and D.W. Lee)	✓(13 October)
IOTC–2011–WPTT13–52	Updated Japanese longline CPUE for bigeye tuna in the Indian Ocean standardized by GLM for the period from 1960 to 2010 (H. Okamoto)	✓(30 September)
IOTC–2011–WPTT13–53	An introduction to the evaluation of management procedures through simulation (I. Mosqueira)	✓(18 October)
IOTC–2011–WPTT13–54	A comparison of calculation methods of an integrated habitat index for yellowfin tuna in the Indian Ocean (Y. Wu and L. Song)	✓(1 October)
IOTC–2011–WPTT13–55	Preliminary analysis of fishing activities of Purse Seiners fishing in the Western Indian Ocean over the period January to June 2011 (C. Assan)	✓(16 October)
IOTC–2011–WPTT13–56	Tuna length sampling activities in the Maldives (M. Ahusan, M.S. Adam and A.R. Jauhary)	✓(7 October)
IOTC–2011–WPTT13–57	An analysis of the effects of the use of Fish Aggregating Devices on yellowfin tuna *Thunnus albacores* in the Indian Ocean (S. Martin, C. Edwards and C. Mees)	Withdrawn
IOTC–2011–WPTT13–58	Tuna fishing trends in Iran with emphasis on Tropical Tunas (M. Akhondi)	✓(16 October)
IOTC–2011–WPTT13–59	Review of bigeye tuna catch by Korean longline fleet in the Indian Ocean (Z.G. Kim, S.I. Lee, D.Y. Moon and D.W. Lee)	✓(13 October)
IOTC–2011–WPTT13–60	Yellowfin tuna fishery of the Maldives – is the size of tuna decreasing? (A.R. Jauharee, M.S. Adam and M. Ahusan)	✓(13 October)
IOTC–2011–WPTT13–61 Rev_1	An evaluation of a harvest control rule for Indian Ocean yellowfin tuna using limits and target reference points (P. de Bruyn, L. Kell, I. Mosqueira and H. Murua)	✓(18 October)
IOTC–2011–WPTT13–62	Proposed workshop on Indian Ocean longline CPUE standardization methods (Secretariat)	✓(1 October)
IOTC–2011–WPTT13–63	Presenting IOTC stock status advice from multiple models to the broader fisheries community (Secretariat)	✓(1 October)
INFORMATION PAPERS		
IOTC–2011–WPTT13–INF01	IOTC SC – Guidelines for the Presentation of Stock Assessment Models	✓(5 August)
IOTC–2011–WPTT13–INF02	Genetic analysis reveals two stocks of skipjack tuna (*Katsuwonus pelamis*) in the northwestern Indian Ocean (S.T. Dammannagoda, D.A. Hurwood and P.B. Mather)	✓(15 September)
IOTC–2011–WPTT13–INF03	Evidence for fine geographical scale heterogeneity in gene frequencies in yellowfin tuna (*Thunnus albacares*) from the north Indian Ocean around Sri Lanka (S.T. Dammannagoda, D.A. Hurwood and P.B. Mather)	✓(15 September)
IOTC–2011–WPTT13–INF04	Yellowfin tuna fishery by traditional fishermen at isakhapatnam, Andhra Pradesh (P. Rohit, G. Syda Rao and K. Rammohan)	✓(15 September)
IOTC–2011–WPTT13–INF05	Validation of the Global Ocean Data Assimilation System (GODAS) data in the NOAA National Centre for Environmental System (NCEP) by theory, comparative studies, applications and sea truth (T. Nishida, T. Kitakado, H. Matsuura and S.-P. Wang)	✓(24 September)
IOTC–2011–WPTT13–INF06	Identification of candidate limit reference points for the key target species in the WCPFC (A. Preece, R. Hillary and C. Davies)	✓(23 August)

Document	Title	Availability
IOTC–2011–WPTT13–INF07	Evaluation of stock status of bigeye, skipjack, and yellowfin tunas against potential limit reference points (S. Harley and N. Davies)	✓(23 August)
IOTC–2011–WPTT13–INF08	Evaluation of the KOBE plot and strategy matrix and their application to tuna in the EPO (M.N. Maunder and A. Aires-da-Silva)	✓(16 October)
IOTC–2011–WPTT13–INF09	Purse-seine length frequencies corrected for selectivity bias in grab samples collected by observers (T. Lawson)	✓(15 September)
IOTC–2011–WPTT13–INF10	Report on Project 60: Collection and evaluation of purse-seine species composition data	✓(15 September)
IOTC–2011–WPTT13–INF11	Skipjack tuna fishery of the Maldives – an update (M.S. Adam and A.R. Jauharee)	✓(17 October)
IOTC–2011–WPTT13–INF12	Influence of the marine environment variability on the yellowfin tuna (*Thunnus albacares*) catch rate by the Taiwanese longline fishery in the Arabian sea, with special reference to the high catch in 2004 (K.-W. Lan, T. Nishida, M.-A. Lee, H.-J. Lu, H.-W., Huang, S.-K. Chang and Y.-C. Lan)	✓(17 October)
IOTC–2011–WPTT13–INF13 Rev_1	Standardized catch rates for skipjack (*Katsumonus pelamis*) for the European purse seine fleet of the Indian Ocean, 1990-2010	✓(18 October) ✓(20 October)
IOTC–2011–WPTT13–INF14	An update of the Indian Ocean skipjack growth curve parameters with tagging data. Some new evidences on area-specific growth rates (D. Gaertner, J.-P. Hallier, E. Dortel, E. Chassot and A. Fonteneau)	✓(18 October)
IOTC–2011–WPTT13–INF15	Scientific observations on the live bait skipjack pole and line fishery in the Maldives Islands in 1604 (P. de Laval)	✓(20 October)
IOTC–2011–WPTT13–INF16	Evaluation of three harvest control rules for bigeye tuna (*Thunnus obesus*) fisheries in the Indian Ocean (Y. Tong, D. Kolody, C. Xinjun and C. Yong)	✓(20 October)
IOTC–2011–WPTT13–INF17	Tips and tricks in designing management procedures (R.A. Rademeyer, E.E. Plaganyi and D.S. Butterworth)	✓(20 October)

APPENDIX IV
CONSOLIDATED RECOMMENDATIONS OF THE THIRTEENTH SESSION OF THE WORKING PARTY ON TROPICAL TUNAS

Note: Appendix references refer to the Report of the Thirteenth Session of the Working Party on Tropical Tunas (IOTC–2011–WPTT13–R)

Outcomes of the Thirteenth Session of the Scientific Committee

WPTT13.01 (para.10) Noting that each year the Scientific Committee and the Commission make a number of requests to the various working parties, without clearly identifying the task to be undertaken, its priority against other tasks previously or simultaneously assigned to the working parties, and without assigning a budget to fund the request made, the WPTT **RECOMMENDED** that these matters be addressed by the Scientific Committee at its next session.

Review of the data available for tropical tuna species

WPTT13.02 (para.22) The WPTT **NOTED** the main tropical tuna data issues that are considered to negatively affect the quality of the statistics available at the IOTC, by type of dataset and fishery, which are provided in Appendix V, and **RECOMMENDED** that the CPCs listed in Appendix V make efforts to remedy the data issues identified and to report back to the WPTT at its next meeting.

WPTT13.03 (para.54) Noting that an IOTC mission to Pakistan was scheduled but had to be postponed due to the situation in the country, the WPTT **RECOMMENDED** that the IOTC Secretariat travel to Pakistan once the situation improves, in order to assess the status of data collection and reporting systems in this country and to report back to the WPTT at its 2012 session.

WPTT13.04 (para.55) The WPTT **RECOMMENDED** that as a matter of priority, Pakistan provide catch-and-effort data and size data for tropical tunas, in particular from their gillnet fisheries, noting that this is already a mandatory reporting requirement.

WPTT13.05 (para.56) The WPTT welcomed the efforts of Sri Lanka to improve data collection and management for its fisheries and **RECOMMENDED** that the IOTC-OFCF project and Sri Lanka continue their cooperation towards improving the collection and reporting of fisheries statistics and to report back to the WPTT at its 2012 Session.

WPTT13.06 (para.57) The WPTT **RECOMMENDED** that Maldives report catch and effort data as per the IOTC standards for 2010 and that for earlier statistics (2002 to 2009), and that they are reported by atoll, month, gear and species, as it was done in the past.

WPTT13.07 (para.58) The WPTT **NOTED** the plans from the IOTC-OFCF Project to hold a Catch Estimation Workshop in Indonesia in March 2012, in order to assess data collection and reporting systems for Indonesia’s coastal and longline fisheries. The WPTT thanked the IOTC-OFCF Project for this initiative and **RECOMMENDED** that the outcomes of the Workshop be reported to the next Session of the WPTT.

WPTT13.08 (para.59) The WPTT urged Madagascar and Yemen to collect and report statistics on their coastal fisheries and **RECOMMENDED** that these countries request assistance from the IOTC Secretariat where required.

WPTT13.09 (para.60) The WPTT **RECOMMENDED** that as a matter of priority, the IOTC Secretariat liaise with India, Oman, Indonesia, Philippines and Malaysia to implement the minimum requirements of IOTC Resolution 08/04 *concerning the recording of catch by longline vessels in the IOTC area*, in order to improve the quality of the data reported from their longline fleets, by species, and to report back to the WPTT at its next meeting.

WPTT13.10 (para.61) The WPTT **RECOMMENDED** that the IOTC Secretariat continue working with the Iranian authorities towards improving reporting from their purse seine fleet, and to report progress to the WPTT at its next meeting.

WPTT13.11 (para.62) The WPTT **RECOMMENDED** that Philippines investigate the reasons for the differences between bigeye tuna export data and reported catch data from their longline fishery, and to report findings to the next WPTT meeting.

WPTT13.12 (para.63) The WPTT **RECOMMENDED** that Iran and Pakistan report size data for tropical tuna species, as per the IOTC requirements, for their gillnet fleets, noting that this is already a mandatory reporting requirement, and that the Secretariat assist Iran and Pakistan to facilitate reporting of this information where required.

WPTT13.13 (para.64) The WPTT **RECOMMENDED** that India, Malaysia, Oman and Philippines make every possible effort to collect and report size data for tropical tuna species for their longline fleets, noting that this is already a mandatory reporting requirement.

WPTT13.14 (para.65) The WPTT **RECOMMENDED** that Indonesia report size data for tropical tuna species for its longline vessels as soon as possible as per IOTC standards, noting that this is already a mandatory reporting requirement.

WPTT13.15 (para.66) The WPTT **RECOMMENDED** that Japan increase sampling coverage to attain at least the minimum required by the IOTC Resolution 10/02 *on mandatory statistical requirements* (1 fish by metric ton of catch by type of gear and species), and for the IOTC Secretariat to assess levels of reporting for Japan upon receiving size data for 2010 and to report back to the WPTT at its next meeting

WPTT13.16 (para.67) The WPTT **RECOMMENDED** that biological data is gathered and reported to the IOTC Secretariat in order to develop specific length-age, length-weight and processed weight-live keys for the Indian Ocean tropical tuna species, in particular by the main longline fisheries (Taiwan,China, Indonesia, Japan, EU and China).

WPTT13.17 (para.68) Noting the importance of biological information to be considered in the stock assessment models, the WPTT **RECOMMENDED** that gonad collection and calculation of the gonadosomatic index for yellowfin tuna be carried out prior to the next WPTT meeting.

WPTT13.18 (para.69) Noting the difficulties that the IOTC Secretariat has experienced in completing the review of datasets for tropical tunas, including the implementation of a scoring system and further use of those scores to derive alternative series of catches for tropical tuna species, the WPTT **RECOMMENDED** that the Secretariat makes every possible effort to finalize this work before the next meeting of the WPTT in 2012.

WPTT13.19 (para.70) Noting the preliminary results of a study conducted by the IOTC Secretariat comparing average weights, as derived from the length frequency, and time area catches in number and weight available for the longline fleets of Japan and Taiwan,China, the WPTT **RECOMMENDED** that the IOTC Secretariat complete this study and present results to the next meeting of the WPDCS.

WPTT13.20 (para.71) 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.

WPTT13.21 (para.72) The WPTT **RECOMMENDED** that all CPCs catching small yellowfin tuna should undertake scientific sampling of their yellowfin tuna catches in order to identify potential bigeye tuna catches (in particular for those CPCs identified in previous paragraphs) and to report findings at the next WPTT meeting.

New information on biology, ecology, fisheries and environmental data relating to tropical tunas

Mozambique catch data

WPTT13.22 (para.80) Noting the difficulties Mozambique has experienced in receiving the logbooks of fishing vessels licensed to fish in its EEZ, the WPTT **RECOMMENDED** that the CPCs concerned send the logbook data to Mozambique, noting that this is already a mandatory requirement under IOTC Resolution 08/04 *concerning the recording of catch by longline fishing vessels in the IOTC area* and Resolution 10/03 *concerning the recording of catch by fishing vessels in the IOTC area*.

WPTT13.23 (para.81) Noting that to date, Mozambique has not reported data for its coastal fisheries to the IOTC Secretariat the WPTT **RECOMMENDED** that data are collected and reported as soon as possible.

Comoros artisanal fisheries

WPTT13.24 (para.83) The WPTT welcomed the implementation of a frame survey and of a new sampling programme in the Comoros and strongly **RECOMMENDED** that Comoros maintain this activity after the end of the programme to be able to report annual data as per IOTC requirements.

Malaysian fisheries

WPTT13.25 (para.92) Noting that to date, vessels flagged to Malaysia are not using logbooks to record their activities, as required by IOTC Resolution 08/04, which includes minimum requirements for collecting and reporting operational data, the WPTT **RECOMMENDED** that Malaysia implement the requirements under Resolution 08/04 as a matter of priority.

Indian fisheries

WPTT13.26 (para.96) Noting that India has a large data set collected on the research longline vessels operated by the Fishery Survey of India during the last 30 years, the WPTT **RECOMMENDED** that Indian scientists participate in the CPUE standardization workshop in order to assess the value of using this information.

Thailand fisheries

WPTT13.27 (para.110) Noting that both the total catches and species composition presented for purse seine vessels flagged to Thailand were substantially different from those reported for other purse seine fleets operating in the Indian Ocean, and that the difference may originate from Thai and EU purse seiners operating in different areas, the WPTT **RECOMMENED** that the EU and Thailand further investigate the reasons for this difference and to report findings to the next WPTT meeting.

Republic of Korea longline fishery

WPTT13.28 (para.113) Noting that the nominal catch (NC) and the catch-and-effort (CE) data provided at the WPTT13 meeting was found to conflict with the historical data for the longline fleet previously provided by the Rep. of Korea to the IOTC Secretariat, and that the differences were due to the ongoing internal data review by the Rep. of Korea, the WPTT **RECOMMENDED** that the Rep. of Korea liaise with the Secretariat to provide a fully justified revised catch history which will replace the data currently held by the Secretariat before the end of 2011.

I.R. Iran fisheries

WPTT13.29 (para.121). The WPTT **RECOMMENDED** that the I.R. Iran strengthen its port sampling so that bigeye tuna can be properly identified and its catches estimated routinely by field samplers.

Maldives tuna length sampling

WPTT13.30 (para.123) Noting that to date no bigeye tuna have been reported as being caught by the Maldives pole-and-line fleet, despite independent verification of substantial numbers of bigeye tuna being caught by these vessels, the WPTT **RECOMMENDED** that the Maldives rapidly improve species identification in logbooks and in their sampling programme.

Maldives yellowfin tuna fishery

WPTT13.31 (para.125) The WPTT commended the authors for the efforts devoted to reviewing the time-series of catch and length data for the fisheries in the Maldives and the results presented to the meeting. In this regard, the WPTT **RECOMMENDED** that the revised dataset be reported to the IOTC Secretariat by the end of 2011, so that the IOTC databases can be updated to include the latest estimates produced by the Maldives.

WPTT13.32 (para.126) Noting that an ad-hoc procedure had been used to separate length frequency samples of yellowfin tuna not recorded by gear, in particular those combining specimens of yellowfin tuna caught by pole-and-line and handline gears during the same trip, the WPTT **RECOMMENDED** that the Maldives validate the procedure using samples collected for each individual gear, in port or, where not possible, through observers onboard baitboats, and to report progress to the next WPTT meeting.

Maldives skipjack tuna fishery

WPTT13.33 (para.128) Noting that the Maldivian skipjack tuna catch is not separated for FAD and free schools, and therefore the proportion of skipjack tuna caught under the FADs anchored around the Maldives is unknown, the WPTT **RECOMMENDED** that the Maldivian data collection system is improved in order to account for the association of the reported catch, as this could improve the standardization of the pole-and-line CPUE.

Review of new information on the status of skipjack tuna

WPTT13.34 (para.137) Noting that catch rates by free and associated school sets for purse seine have showed analogous absolute levels on yearly fluctuations over the time-series, the WPTT **RECOMMENDED** that EU scientists explore the reasons for this, and to report findings at the next session of the WPTT.

WPTT13.35 (para.150) 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.

WPTT13.36 (para.164) The WPTT **RECOMMENDED** the following management advice for skipjack tuna in the Indian Ocean, for the consideration of the Scientific Committee.

Stock status. The weighted results suggest that the stock is not overfished ($B>B_{MSY}$) and that overfishing is not occurring ($C<MSY$, used as a proxy for $F<F_{MSY}$). Spawning stock biomass was estimated to have declined by approximately 47 % in 2009 from unfished levels (Table 3).

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. However, 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 2009 (455,000 t) and 2010 (428,000 t) as well as the average level of catches of 2005–2010 (500,000 t) were lower than median value of MSY.

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, 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).

WPTT13.37 (para.165) The WPTT **RECOMMENDED** that the Scientific Committee consider the following:

- The median estimates of the Maximum Sustainable Yield for the skipjack tuna Indian Ocean stock is 564,000 t (Table 3) and considering the average catch level from 2005–2009 was 492,000 t, catches of skipjack tuna should not exceed the average of 2005–2009.
- 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 4) illustrates the levels of risk associated with varying catch levels over time and could be used to inform management actions.

Review of new information on the status of yellowfin tuna

WPTT13.38 (para.168) 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** to further examine those issues in the future.

WPTT13.39 (para.198) The WPTT thanked Dr. Adam Langley (consultant) for his contributions and expertise on integrated stock assessment models, and **RECOMMENDED** that his engagement be renewed for the coming year.

WPTT13.40 (para.199) The WPTT **RECOMMENDED** that the IOTC stock assessment scientist and consultant work in collaboration with Japanese scientists and other interested participants to produce an SS3 assessment for yellowfin tuna in 2012 for presentation to the WPTT.

WPTT13.41 (para.201) The WPTT **RECOMMENDED** the following management advice for yellowfin tuna in the Indian Ocean, for the consideration of the Scientific Committee.

Stock status. The stock assessment model used in 2011 suggests that the stock is currently not overfished (B_{2009}>B_{MSY}) and overfishing is not occurring (F_{2009}<F_{MSY}) (Table 6 and Fig. 26). Spawning stock biomass in 2009 was estimated to be 35% (31–38%) (from Table 6) of the unfished levels. However, estimates of total and spawning stock biomass show a marked decrease over the last decade, accelerated in recent years by the high catches of 2003–2006. Recent reductions in effort and, hence, catches has halted the decline.

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.

Outlook. 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 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 7). 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 B<B_{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 B>B_{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.

WPTT13.42 (para.202) The WPTT **RECOMMENDED** that the Scientific Committee consider the following:

- The Maximum Sustainable Yield estimate for the whole Indian Ocean is 357,000 t with a range between 290,000–435,000 t (Table 6), 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.

Review of new information on the status of bigeye tuna

WPTT13.43 (para.213) The WPTT **RECOMMENDED** that the following matters be taken into account when undertaking CPUE standardisation analysis for bigeye tuna as well as yellowfin tuna in 2012:

- 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:
  - vi. 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.
  - vii. 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).
  - viii. 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.
  - ix. 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.
  - x. 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 standardization 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.

WPTT13.44 (para.223) The WPTT **RECOMMENDED** the following management advice for bigeye tuna in the Indian Ocean, for the consideration of the Scientific Committee.

Stock status. Both assessments suggest 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 $F_{current}/F_{MSY} < 1$). Current spawning stock biomass was estimated to be 34–40 % (Table 11) 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.

Outlook. The recent declines in longline effort, particularly from the Japanese, Taiwan,China and Republic of Korea longline fleets, as well as purse seiner 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.

Catches in 2010 (72,000 t) were lower than MSY values and catches in 2009 (102,000 t) were at the lower range of MSY estimates. The mean catch over the 2008-2010 period was 94,000 t which is lower than estimated MSY.

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 management actions (Table 12). Based on the ASPM projections this year (2011) 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 72,000 t (maximum of 15% risk of $B<B_{MSY}$) or 2009 catches of 100,000 t (<40% risk that $B_{2020}<B_{MSY}$ and $F_{2020}>F_{MSY}$). Moreover, the SS3 projections from last year (2010) 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 from 2009 (< 30% risk that $B_{2019}<B_{MSY}$ and < 25% risk that $F_{2019}>FMSY$) (Table 11).

WPTT13.45 (para.224) The WPTT **RECOMMENDED** that the Scientific Committee consider the following:

- 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 11 for further description)). Annual catches of bigeye tuna should not exceed the lower range of this estimated which corresponds to the 2009 catches and last year management advice.
- If the recent declines in effort continue, and catch remains substantially below the estimated MSY of 100,000–114 000 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.

Development of technical advice on the status of the stocks

Update of species Executive Summaries

WPTT13.46 (para.230) The WPTT **RECOMMENDED** that the Scientific Committee:

- **NOTE** the current definition of overfishing used by the IOTC, where fishing mortality is in excess of F_{MSY} ($F_{curr}/F_{MSY} > 1$) is considered overfishing;
- **NOTE** that fishing mortality in excess of F_{MSY} is not always defined as overfishing (within tRFMOs) if the stock is well above the B_{MSY} level, although no specific threshold has been defined;

- **CONSIDER** the current definition of overfishing (F_{curr}/F_{MSY} >1), and determine that if in situations where the biomass of a given stock is well above B_{MSY}, but F_{curr}/F_{MSY} >1, under what circumstances should a stock be classified as subject to overfishing;
- **NOTE** the draft resource stock status summary for:
  - iv. Bigeye tuna (*Thunnus obesus*) – Appendix VI
  - v. Yellowfin tuna (*Thunnus albacares*) – Appendix VII
  - vi. Skipjack tuna (*Katsuwonus pelamis*) – Appendix VIII

WPTT13.47 (para.231) The WPTT **RECOMMENDED** that the IOTC Secretariat update the draft stock status summaries for tropical tunas with the latest 2010 catch data, and for these to be provided to the Scientific Committee as part of the draft Executive Summaries, for its consideration.

Analysis of Tagging Data

WPTT13.48 (para.244) 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 **RECOMMENDED** that this sampling programme should be maintained as long as these tunas are recovered, in order to ideally sex 100% of the future recoveries.

WPTT13.49 (para.246) The WPTT **RECOMMENDED** that more analyses on the tagging data should be undertaken in 2011 and 2012, and should include the estimation of mixing rates 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.

WPTT13.50 (para.248) The WPTT **RECOMMENDED** that analysis of the tagging data carried out in preparation for the Tagging Symposium and presented at the next WPTT meeting.

Analysis of the Time-Area Closures (incl. Resolution 10/01)

WPTT13.51 (para.252) Noting that the request contained in Resolution 10/01 does not specify the expected objective to be achieved with the current or alternative time area closures, and that the WPTT was not clear about the intended objectives of the time-area closure taking into account recent reduction of effort (see next section) as well as recent likely recovery of the yellowfin tuna population, the WPTT **RECOMMENDED** that the Commission specify clear objectives as to what are the management objectives to be achieved with this and/or alternative measures. This will, in turn, guide and facilitate the analysis of the WPTT in 2012 and future years.

WPTT13.52 (para.254) Noting the lack of papers examining time-area closures in the Indian Ocean for WPTT13 as well as the slow progress to address Commission request, the WPTT **RECOMMENDED** that SC chair begins a consultative process with the Commission in order to get clear guidance from the Commission about the management objectives intended with the current or any alternative closure. This will allow the SC to address the Commission request more thoroughly. At the same time, the SC needs to include the issue of the time area closure as a priority in the research activity for 2011/2012 depending on Commission feedback.

Effect of Piracy on Tropical Tuna Catches

WPTT13.53 (para.260) 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, Republic of Korea and Taiwan,China.

Methods

WPTT13.54 (para.267) Noting that the development of an MSE process will require management objectives to be developed, the WPTT **RECOMMENDED** that the Commission provide clear guidance in this regard, noting that the adoption of the Precautionary Approach, as defined in the Fish Stocks Agreement, may be the first step.

WPTT13.55 (para.268) The WPTT **ENDORSED** the roadmap presented for the implementation of MSE in the Indian Ocean in IOTC–2011–WPTT13–53 and **RECOMMENDED** to the Scientific Committee the organization of a joint meeting between managers, stakeholder and scientist during 2012 to begin discussions about the implementation of MSE in IOTC.

WPTT13.56 (para.272) The WPTT **RECOMMENDED** that a dedicated workshop on CPUE standardization, including issues of interest for other IOTC species should be carried out before the next round of stock assessments in 2012, and that where possible it should include a range of invited experts, including those working on CPUE standardisation in other ocean/RFMOs, in conjunction with scientists from Japan, Republic of Korea and Taiwan,China, and supported by the IOTC Secretariat.

WPTT13.57 (para.273) The WPTT also **ENCOURAGED** data to be used in stock assessments, including CPUE standardisations, be made available not less than three months before each meeting by CPCs and where possible, data summaries no later than two months prior to each meeting, from the IOTC Secretariat; and **RECOMMENDED** that data to be used in stock assessments, including CPUE standardisations by CPCs be made available not less than 30 days before each meeting.

Research Recommendations and Priorities

WPTT13.58 (para.282) The WPTT **RECOMMENDED** that the Secretariat and Maldivian scientists continue the joint effort to standardize the Maldivian pole-and-line CPUE in preparation for assessment in 2012.

WPTT13.59 (para.283) The WPTT **RECOMMENDED** that standardization of purse seine CPUE be made where possible using the operational data on the fishery, and that participants working on CPUE for the main fleets, attend the CPUE standardization workshop being organized by ISSF in Honolulu, Hawaii in 2012.

WPTT13.60 (para.284) Noting the difficulty of carrying out stock assessments for three tropical tuna species in a single year, the WPTT **RECOMMENDED** to a revised assessment schedule on a two- or three-year cycle for the three tropical tuna species as outlined in Table 13. Following the uncertainty remaining in the yellowfin tuna assessment the WPTT **AGREED** that priories for stock assessments in 2012 would be yellowfin tuna (Multifan-CL and SS3, and possibly others) with an update of fishery indicators for the other two species.

Table 13. New schedule proposed for tropical tuna species stock assessment to be recommended to the SC:

Species/Assessment year	2012	2013	2014	2015	2016	2017
Yellowfin tuna	Full	Update	Update	Full	Update	Update
Skipjack tuna	Update	Full	Update	Update	Full	Update
Bigeye tuna	Update	Update	Full	Update	Update	Full

Note: the schedule may be change depending on the situation of the stock from various sources such as fishery indicators, Commission requests, etc.

WPTT13.61 (para.285) The WPTT **RECOMMENDED** that the Scientific Committee add the following core topic areas as priorities for research over the coming year in order of priority:

- An update of the Brownie-Peterson method for the 3 tropical tuna species (possible issue for the 2012 IO Tuna Tagging Symposium).
- An update YFT growth curve (work in progress to be presented to 2012 Tuna Tagging Symposium).

Other Business

WPTT13.62 (para.288) 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 2012, by an Invited Expert:

- Priority areas for contribution: (1) CPUE analysis and standardisation, and (2) Updating the Brownie-Peterson analysis on skipkjack tuna, bigeye tuna and yellowfin tuna.

WPTT13.63 (para.290) Following a discussion on who would host the Fourteenth Session of the WPTT, the WPTT **RECOMMENDED** that the next meeting of the WPTT be held immediately prior to the Tuna Tagging Symposium, preferably in October 2012, aware that the Scientific Committee is held in early December each year. The exact dates and meeting location will be confirmed and communicated by the IOTC Secretariat to the Scientific Committee for its consideration at its next session to be held in December 2011.

WPTT13.64 (para.292) The WPTT **NOTED** the increased attendance by scientists from developing CPCs in 2010 and 2011 was partly due to the IOTC Meeting Participation Fund, adopted by the Commission in 2010 (Resolution 10/05 on the establishment of a Meeting Participation Fund for developing IOTC Members and non-Contracting Cooperating Parties), and **RECOMMENDED** that this fund be maintained.

WPTT13.65 (para.294) The WPTT **RECOMMENDED** that the Scientific Committee note the new Vice-Chair, Dr. M. Shiham Adam (Maldives) of the WPTT for the next *biennium*.

WPTT13.66 (para.295) The WPTT **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPTT13, provided at Appendix IV.

APPENDIX V
MAIN ISSUES IDENTIFIED RELATING TO THE STATISTICS OF TROPICAL TUNAS

Extract from IOTC–2011–WPTT13–06

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, they have not reported catch-and-effort data as per the IOTC standards, in particular for those vessels that operate outside their EEZ.
- **Gillnet/longline** fishery of **Sri Lanka**: Although Sri Lanka has reported catches of bigeye tuna for its gillnet/longline fishery, the catches are considered to be too low. This is probably due to the mislabelling of catches of bigeye tuna as yellowfin tuna. In addition, Sri Lanka has not reported catch-and-effort data as per the IOTC standards, including separate catch-and-effort data for longline and gillnet and catch-and-effort data for those vessels that operate outside its EEZ.
- **Pole-and-line** fishery of **Maldives**: Maldives has not reported catch-and-effort data by gear type and geographic area since 2002[1].
- **Coastal** fisheries of **Comoros**[2], **Indonesia, Madagascar, Sri Lanka** (other than gillnet/longline) and **Yemen**: The catches of tropical tunas for these fisheries have been estimated by the Secretariat in recent years. The quality of the estimates is thought to be very poor due to the paucity of the information available about the fisheries operating in these countries.

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 longline fishery.
- **Longline** fisheries of **Indonesia** and **Malaysia**: Indonesia and Malaysia have not reported catches for longliners under their flag that are not based in their ports. In addition Indonesia has not reported catch-and-effort data for its longline fishery to date.
- **Industrial tuna purse seine** fishery of **Iran**: To date, Iran has not reported catch-and-effort data as per IOTC standards for its purse seine fleet.
- **Longline** fishery of **Philippines:** Philippines has reported very low catches of tropical tunas for its longline fishery, in particular catches of bigeye tuna. The amounts of frozen bigeye tuna products exported from Philippines vessels to other countries (IOTC Bigeye tuna Statistical Document Programme) have been consistently higher than the amounts reported by Philippines as total catch for this species.
- **Discard levels for all fisheries**: The total amount of tropical tunas discarded at sea remains unknown for most fisheries and time periods.

[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

[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.

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, Malaysia, Oman** and **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** fishery of **Indonesia**: Indonesia has reported size frequency data for its fresh-tuna longline fishery in recent years. However, the samples cannot be fully broken by month and fishing area (5x5 grid) and they refer exclusively to longliners based in Indonesia.
- **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 Secretariat had to use length-age keys, length-weight keys, and processed weight-live weight keys for tropical tuna species from other oceans due to the general paucity of biological data available from the Indian Ocean.

[3] *Ibid.* 7

APPENDIX VI
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 – 2011 assessment**			**2011 stock status determination 2009**[2]
		SS3[3]	ASPM[4]	
Indian Ocean	Catch (1000 t):	102.0 t	71.5 t	(green)
	Average catch last 5 years:	104.7 t	104.7 t	
	MSY (1000 t):	114 (95–183 t)	102.9 t (86.6–119.3 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 for 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 5[th] and 95[th] 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 ($SB_{year}/SB_{MSY}\geq$ 1)
Stock subject to overfishing(F_{year}/F_{MSY}> 1)	(red)	(orange)
Stock not subject to overfishing ($F_{year}/F_{MSY}\leq$ 1)	(yellow)	(green)

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

The WPTT **RECOMMENDED** the following management advice for bigeye tuna in the Indian Ocean, for the consideration of the Scientific Committee.

Stock status. Both assessments suggest 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.

Outlook. The recent declines in longline effort, particularly from the Japanese, Taiwan,China and Republic of Korea longline fleets, as well as purse seiner 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.

Catches in 2010 (72,000 t) were lower than MSY values and catches in 2009 (102,000 t) were at the lower range of MSY estimates. The mean catch over the 2008-2010 period was 94,000 t which is lower than estimated MSY.

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 management actions (Table 2). Based on the ASPM projections this year (2011) 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 72,000 t (maximum of 15% risk of $B<B_{MSY}$) or 2009 catches of 100,000 t (<40% risk that $B_{2020}<B_{MSY}$ and $F_{2020}>F_{MSY}$). Moreover, the SS3 projections from last year (2010) 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 from 2009 (< 30% risk that $B_{2019}<B_{MSY}$ and < 25% risk that F_{2019}>FMSY) (Table 1).

The WPTT **RECOMMENDED** that the Scientific Committee consider the following:

- 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 estimated which corresponds to the 2009 catches and last year management advice.
- If the recent declines in effort continue, and catch remains substantially below the estimated MSY of 100,000–114 000 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.

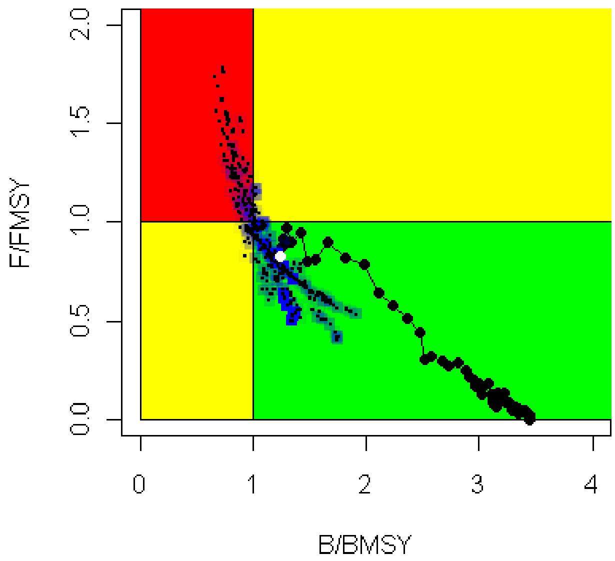

Fig. 1. SS3 Aggregated Indian Ocean assessment Kobe plot. Black circles represent the time series of annual median values from the weighted stock status grid (white circle is 2009). Blue squares indicate the MPD estimates for 2009 corresponding to each individual grid C model, with colour density proportional to the weighting (each model is also indicated by a small black point, as the squares from highly downweighted 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).

Reference point and projection timeframe	**Alternative catch projections (relative to 2009) and probability (%) of violating reference point**				
	2010 SS3				
	60% (61,200 t)	**80%** (81,600 t)	**100%** (102,000 t)	**120%** (122,400 t)	**140%** (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 VII
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 – 2011 assessment**		**2011 stock status determination**
			2009[2]
Indian Ocean	Catch 2009:	456,000 t	
	Average catch 2005-2009:	492,000 t	
	MSY (1 model):	594,000 t (395,000–843,000 t)	
	C_{2009}/MSY (1 model)[3]:	0.81 (0.54–1.16)	
	SB_{2009}/SB_{MSY} (1 model):	2.56 (1.09–5.83)	
	SB_{2009}/SB_0 (1 model):	0.53 (0.29–0.70)	

[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 for the assessment.
[3]Due to numerical problems in the F_{MSY} calculations for this population, the proxy reference point C/MSY is reported instead of F/FMSY, which should be interpreted with caution for the following reasons: it may incorrectly suggest $F>F_{MSY}$ when there is a large biomass (early development of the fishery or large recruitment event); it may incorrectly suggest that $F<F_{MSY}$ when the stock is highly depleted; due to a flat yield curve, C could be near MSY even if $F << F_{MSY}$.

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

The WPTT **RECOMMENDED** the following management advice for skipjack tuna in the Indian Ocean, for the consideration of the Scientific Committee.

Stock status. The weighted results suggest that the stock is not overfished ($B>B_{MSY}$) and that overfishing is not occurring (C<MSY, used as a proxy for $F<F_{MSY}$) (Table 1 and Fig. 1). Spawning stock biomass was estimated to have declined by approximately 47 % in 2009 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. However, 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 2009 (455,000 t) and 2010 (428,000 t) as well as the average level of catches of 2005–2010 (500,000 t) were lower than median value of MSY.

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, 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).

The WPTT **RECOMMENDED** that the Scientific Committee consider the following:

- The median estimates of the Maximum Sustainable Yield for the skipjack tuna Indian Ocean stock is 564,000 t (Table 1) and considering the average catch level from 2005–2009 was 492,000 t, catches of skipjack tuna should not exceed the average of 2005–2009.
- 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) illustrates the levels of risk associated with varying catch levels over time and could be used to inform management actions.

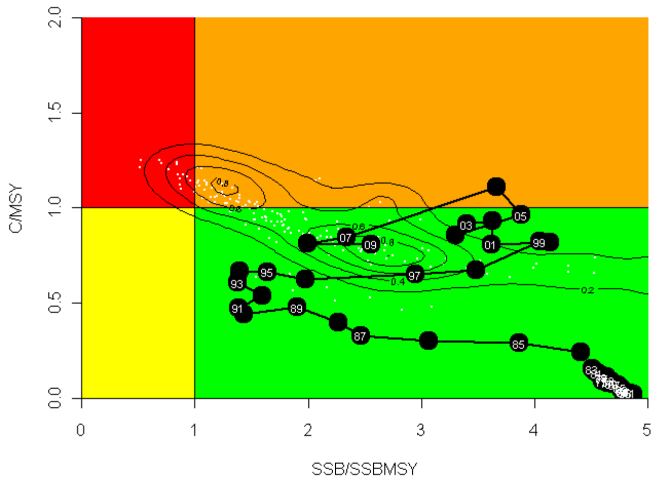

Fig. 1. SS3 Aggregated Indian Ocean assessment Kobe plot. Black circles indicate the trajectory of the weighted median of point estimates for the SB ratio and C/MSY ratio for each year 1950–2009. Probability distribution contours are provided only as a rough visual guide of the uncertainty (e.g. the 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. 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.

Reference point and projection timeframe	**Alternative catch projections (relative to 2009) and weighted probability (%) scenarios that violate reference point**				
	60% (274,000 t)	**80%** (365,000 t)	**100%** (456,000 t)	**120%** (547,000 t)	**140%** (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 VIII
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 – 2011 assessment		2011 stock status determination 2009[2]
Indian Ocean	Catch 2010 (1000 t):	299.1	
	Average catch 2006–2010 (1000 t):	326.7	
	MSY:	357 (290–435)	
	F_{2009}/F_{MSY}:	0.84 (0.63–1.10)	
	SB_{2009}/SB_{MSY}:	1.61 (1.47–1.78)	
	SB_{2009}/SB_0:	0.35 (0.31–0.38)	

[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 for the assessment.

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

The WPTT **RECOMMENDED** the following management advice for yellowfin tuna in the Indian Ocean, for the consideration of the Scientific Committee.

Stock status. The stock assessment model used in 2011 suggests that the stock is currently not overfished (B_{2009}>B_{MSY}) and overfishing is not occurring (F_{2009}<F_{MSY}) (Table 1 and Fig. 1). Spawning stock biomass in 2009 was estimated to be 35% (31–38%) (from Table 1) of the unfished levels. However, estimates of total and spawning stock biomass show a marked decrease over the last decade, accelerated in recent years by the high catches of 2003–2006. Recent reductions in effort and, hence, catches has halted the decline.

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.

Outlook. 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 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 B<B_{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 $B>B_{MSY}$ 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 WPTT **RECOMMENDED** that the Scientific Committee consider the following:

- The Maximum Sustainable Yield estimate for the whole Indian Ocean is 357,000 t with a range between 290,000–435,000 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.

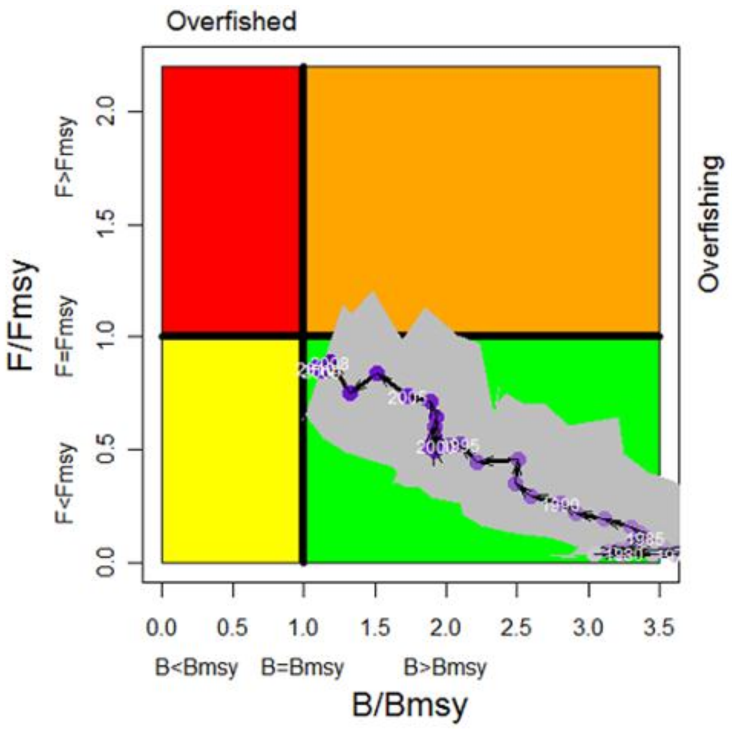

Fig. 1. MULTIFAN-CL Indian Ocean yellowfin tuna stock assessment Kobe plot. Blue circles indicate the trajectory of the point estimates for the B ratio and F ratio for each year 1972–2009. The equal weighted mean trajectory of the scenarios investigated in the assessment. The range is given by the different scenarios investigated.

TABLE 2. 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.

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)
$B_{2013} < B_{MSY}$	<1	<1	<1	<1	<1
$F_{2013} > F_{MSY}$	<1	<1	58.3	83.3	100
$B_{2020} < B_{MSY}$	<1	<1	8.3	41.7	91.7
$F_{2020} > F_{MSY}$	<1	41.7	83.3	100	100

APPENDIX IX
CRITERIA USED TO GROOM THE TAG DATASET TO PRODUCE A REVISED DATASET FOR GROWTH ANALYSES

During the meeting, a sub-group of participants revised the set of data grooming criteria agreed upon at the WPTDA01 in 2008. This set of criteria is developed to remove uncertain and likely erroneous data from the existing tag dataset for growth.

It was decided to **remove** records when:

- species at tagging had a reliability code of 2 (uncertain);
- length at tagging were not of the best quality (records are retained only when code is *1* for FL reliability at tagging;
- length at recovery were not of the best quality (records are retained only when the length reliability code at recovery is *good*);
- there was a discrepancy in species recorded between tagging and recovery, including when this has been corrected at a later stage;
- recovery length code is CL, SL, or UNK;
- recovery measurement tool is eye, string or unknown;
- recovery has a time at liberty ≤ 30 days;
- recovery from purse seiners found in port for which the dates of the possible different sets are more than 10% of the time-at-liberty;
- recovery made in canneries after the fish was cooked.
- On the 1st April 2007, the RTTP-IO deployed recovery teams onboard the purse seine fleet calling in port Victoria. Tags reported before this date should be taken into account in the analysis with caution as there is some uncertainty on the dates and position of recovery.