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

Report of the Sixth Session of the IOTC Working Party on Billfish

Seychelles 7 – 11 July 2008

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1. 1. OPENING OF THE MEETING AND ADOPTION OF THE AGENDA

1. The Sixth Meeting of the Working Party on Billfish (WPB) was opened on 7 July 2008 in Victoria, Seychelles. The first activity for the Working Party was to elect a new Chairperson for the next biennium. Mr. Jan Robinson (Seychelles) was elected chairperson; he subsequently welcomed the participants (Appendix I) and the Agenda for the meeting was adopted as presented in Appendix II.

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

2. REVIEW OF STATISTICAL DATA FOR BILLFISH

2.1. Catch trends - nominal catch (NC) data

Swordfish

3. Swordfish is caught mainly using drifting longlines (95%) and gillnets (5%) (Figure 1). Swordfish was mainly a bycatch of industrial longline fisheries before the early 1990's. Catches increased gradually from 1950 to 1990 as the catches of targeted species (such as tropical and temperate tunas) increased. Catches increased markedly after 1990 to a peak of around 35,000 tonnes in 1998. The current catch of swordfish is around 30,000 t. The increase in catch is attributed to a change in target species from tunas to swordfish by part of the Taiwanese fleet, the development of longline fisheries in Australia, Reunion Island, Seychelles and Mauritius targeting swordfish, and the arrival of longline fleets from the Atlantic Ocean (Portugal, Spain and other fleets operating under various flags) also targeting swordfish (Figure 2).

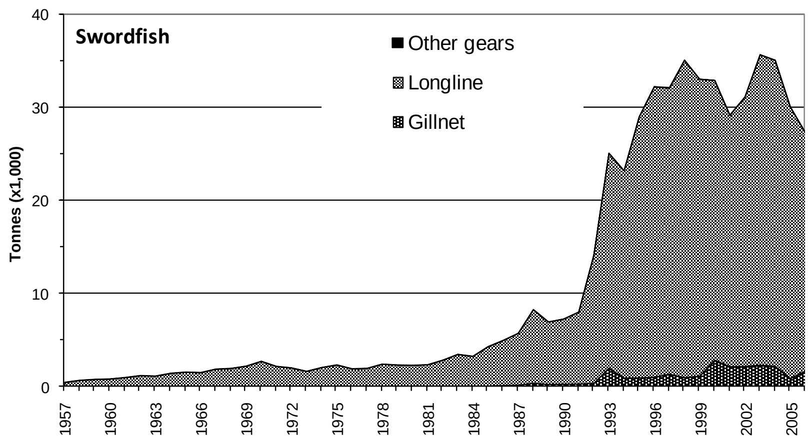


Figure 1: *Catches of swordfish in the Indian Ocean by gear type. From document IOTC-2008-WPB-08*

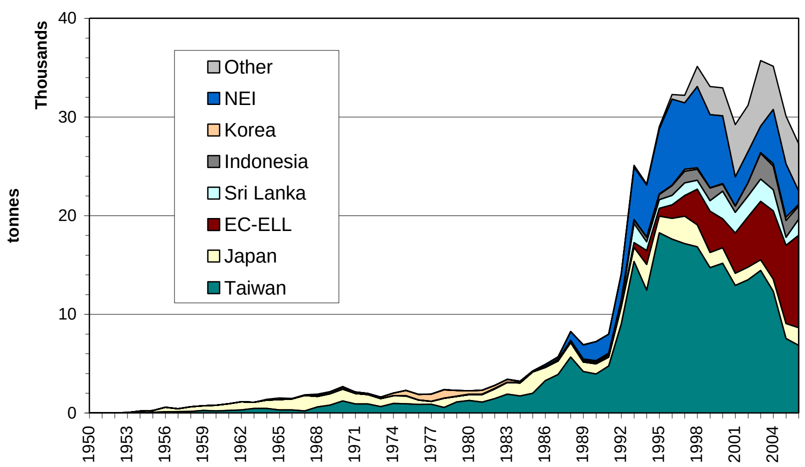
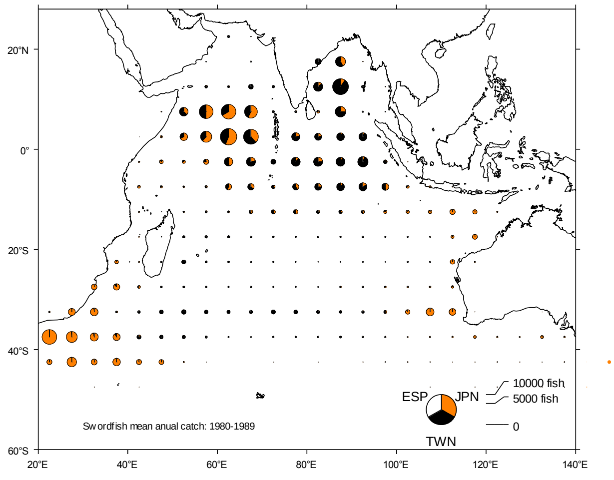


Figure 2: *Catches of Swordfish by fleet recorded in the IOTC Database (1950-2006). From document IOTC-2008-WPB-08*



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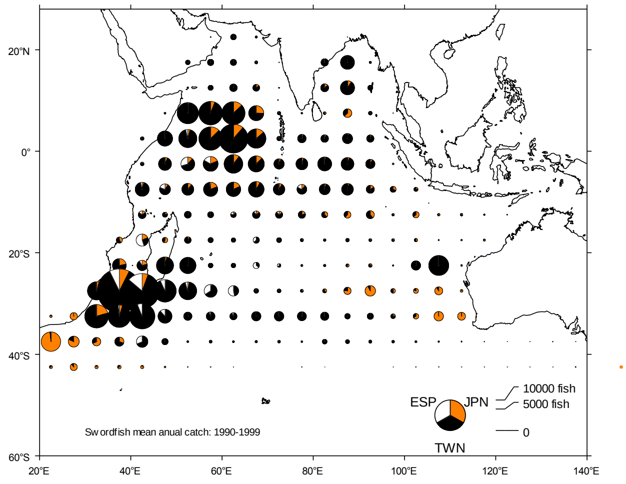
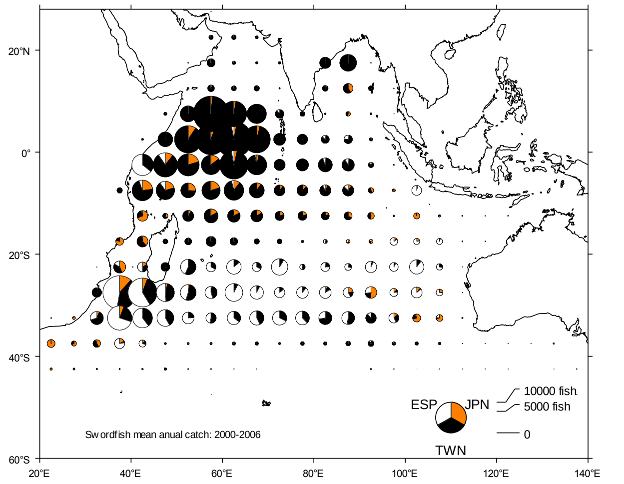


(b)

Figure 3: *Mean annual catches of swordfish (number) by longline vessels operating in the Indian Ocean over the periods (a) 1980 to 1989, (b) 1990 to 1999 and (c) 2000 to 2006. From document IOTC-2008-WPB-14*



(c)

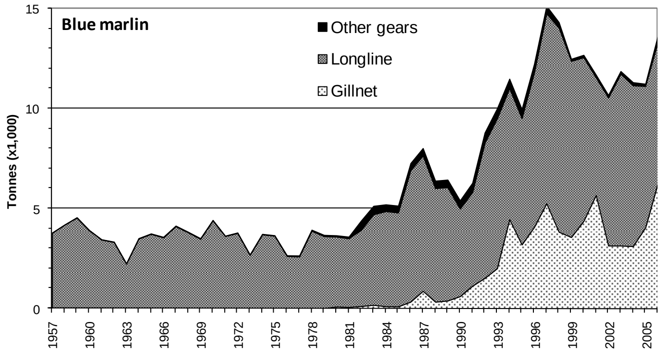
Marlins

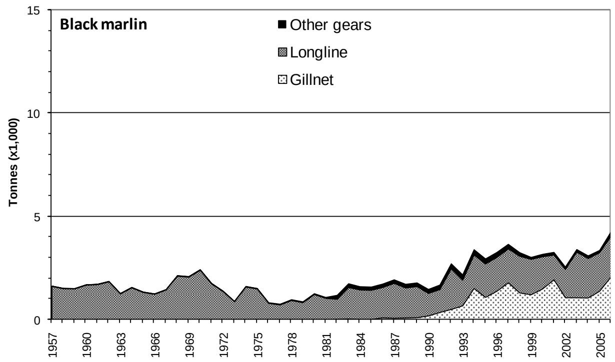
4. Blue, black and striped marlins are caught mainly using drifting longlines (70%) and gillnets (20%) and some troll and hand lines. These species are considered as bycatch for industrial and artisanal fisheries, but they are targeted by sport fisheries. Minimum catch estimates for the three marlin species have been derived from very small amounts of information and are therefore highly uncertain. The total catch of all marlin species varies from year to year. It reached a maximum of around 24,000 t in 1997 while current catches are around 18,000 t to 21,000 t.

5. Catches of blue marlin are greater than those of black and striped marlin combined. The minimum average annual catch estimated for blue marlin for the period 2002 to 2006 is around 11,700 t (Figure 4). In recent years, the fleets of Taiwan,China (longline), Indonesia (longline), Sri Lanka (gillnet) and India (gillnet) are attributed with the highest catches of this species. The distribution of blue marlin catches has changed since the 1980's, with catches in the western Indian Ocean increasing and an increase in the catch by the Taiwanese fleets (Figure 5).

6. The minimum average annual catch of black marlin estimated for the period 2002 to 2006 is around 3,300 t (Figure 4), with the fleets of Taiwan,China (longline), Sri Lanka (gillnet) and India (gillnets) being attributed with the highest catches. The distribution of black marlin catches has changed since the 1980's with most of the catch now taken in the western areas of the Indian Ocean. Since the 1990's most of the catch has been taken by the Taiwanese fleets (Figure 6).

7. The minimum average annual catch estimated for striped marlin for the period 2002 to 2006 is around 3,100 t (Figure 4). In recent years, the fleets of Taiwan,China (longline) and to a lesser extent Indonesia (longline) are attributed with the highest catches of this species. The distribution of striped marlin catches has changed since the 1980's with most of the catch now taken in the western areas of the Indian Ocean. As with the other marlin species, since the 1990's most of the catch has been taken by the Taiwanese fleets (Figure 7).





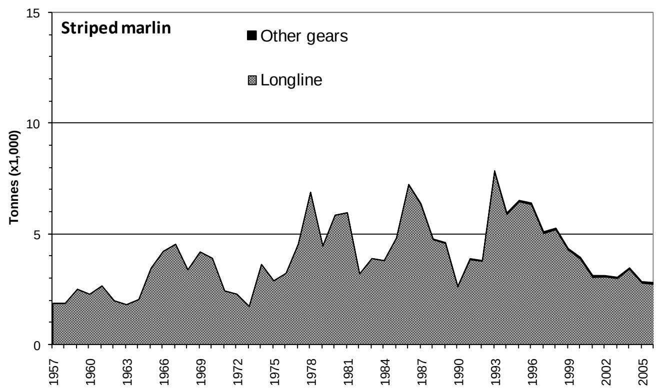
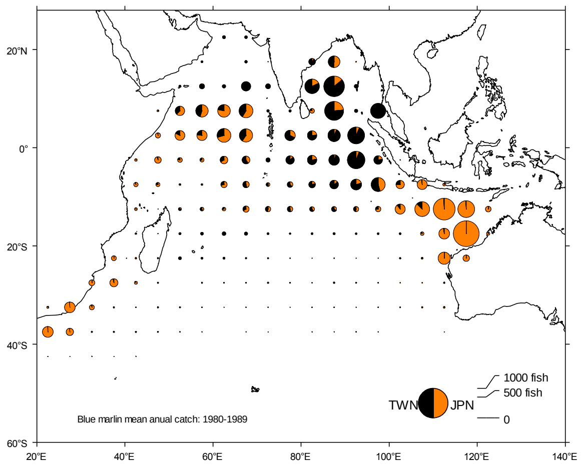


Figure 4: *Estimated catches of marlins by gear recorded in the IOTC Database (1967-2006). From document IOTC-2008-WPB-08.*



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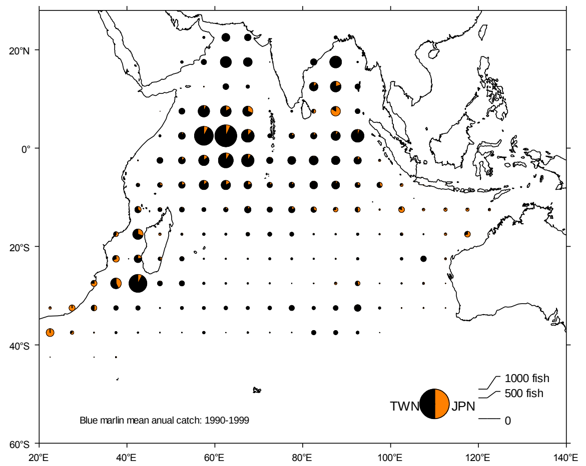
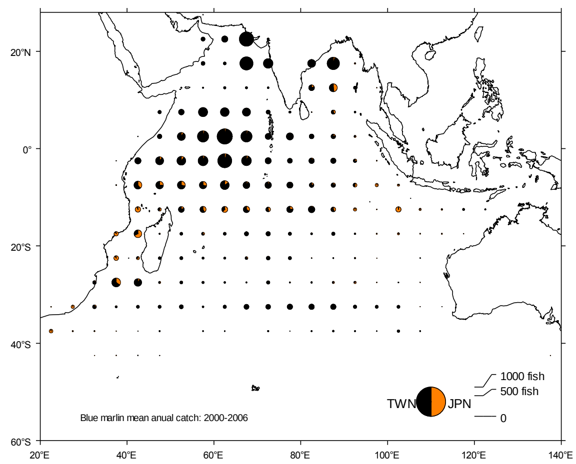


(b)

Figure 5: *Mean annual total catches of blue marlin (number) by longline vessels operating in the Indian Ocean over the periods (a) 1980 to 1989, (b) 1990 to 1999 and (c) 2000 to 2006. From document IOTC-2008-WPB-14.*



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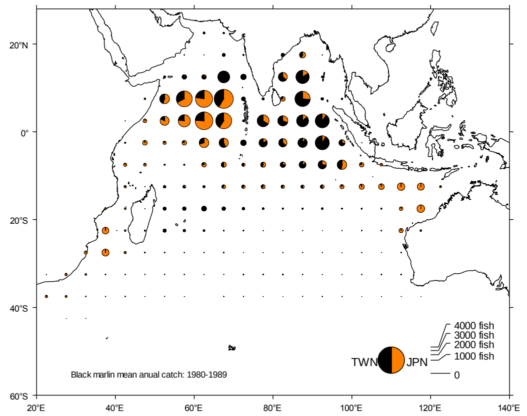

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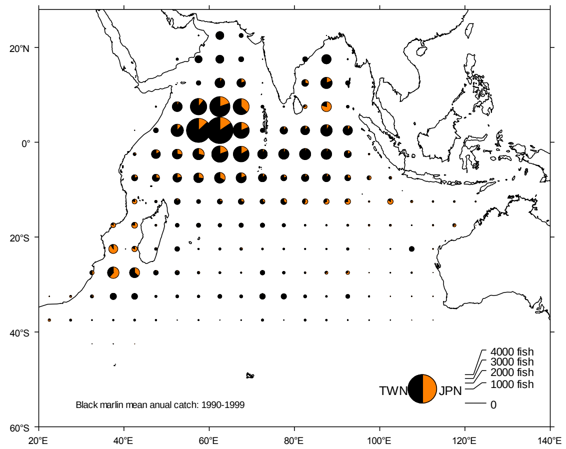
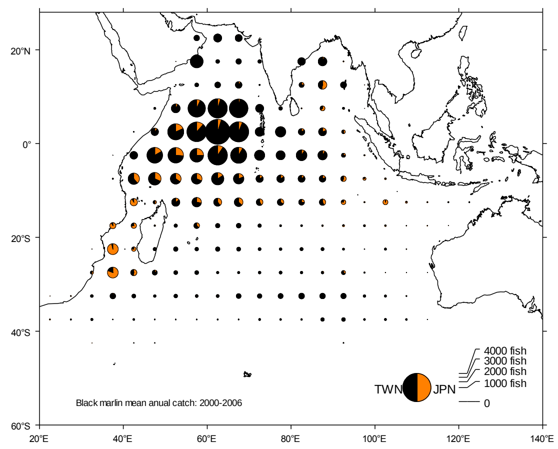


(b)

Figure 6: *Mean annual catches of black marlin (number) by longline vessels operating in the Indian Ocean over the periods (a) 1980 to 1989, (b) 1990 to 1999 and (c) 2000 to 2006. From document IOTC-2008-WPB-14.*



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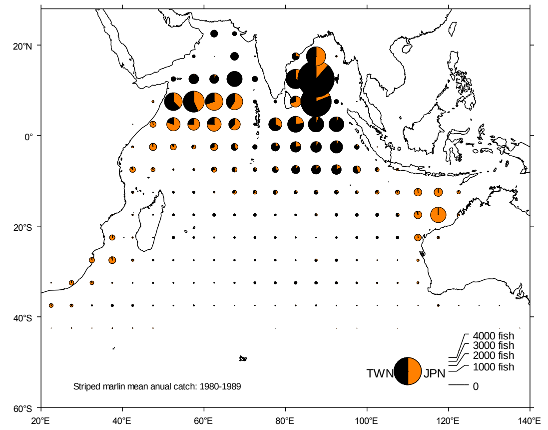

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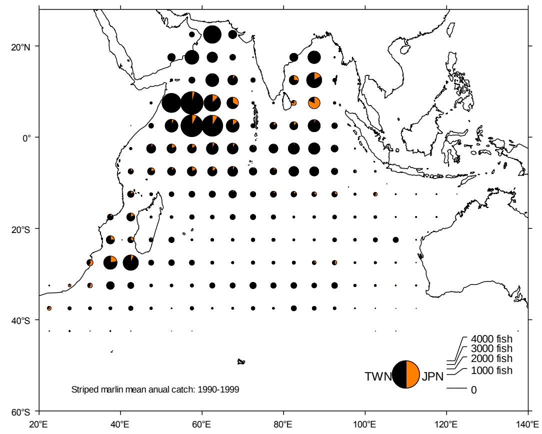

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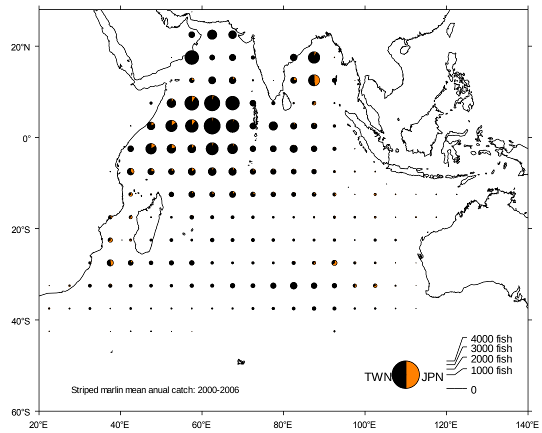
***Figure 7:** Mean annual catches of striped marlin (number) by longline vessels operating in the Indian Ocean over the periods (a) 1980 to 1989, (b) 1990 to 1999 and (c) 2000 to 2006. From document IOTC-2008-WPB-14.*



(c)

Indo-Pacific Sailfish

8. Sailfish is caught mainly by gillnets (80%) and to a lesser extent troll and hand lines (10%), longlines (7%) and other gears (Figure 8). The catches of sailfish have greatly increased since the mid-1980's in response to the development of the gillnet / longline fishery in Sri Lanka. Minimum catch estimates have been derived from very small amounts of information and are therefore highly uncertain. The minimum average annual catch estimated for the period 2002 to 2006 is around 24,000 t. In recent years, the countries attributed with the highest catches of Indo-Pacific sailfish are situated in the Arabian Sea and are Iran, Sri Lanka, India and Pakistan. Smaller catches are reported for line fishers in Comores and Mauritius and by Indonesia longliners (Figure 8).

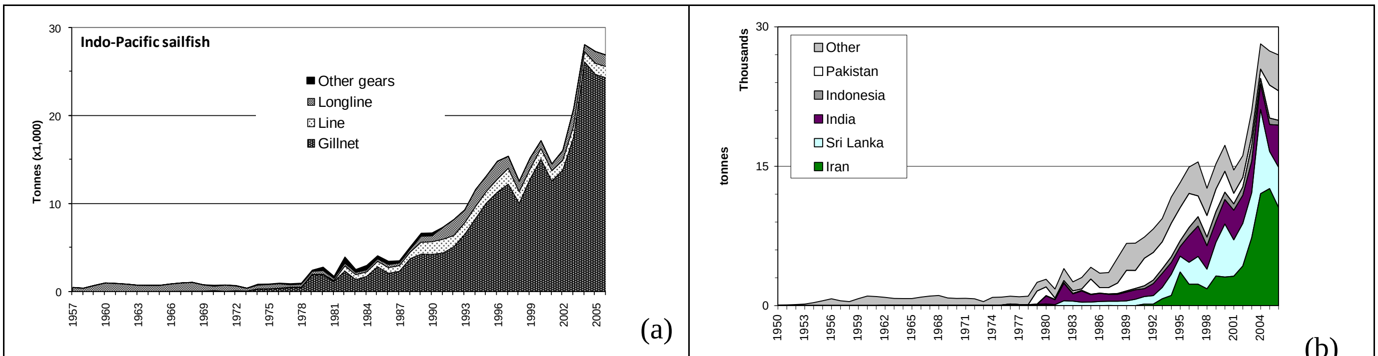


***Figure 8:** Estimated catches of sailfish by (a) gear and (b) fleet recorded in the IOTC Database (1967-2006). From document IOTC-2008-WPB-08.*

2.2. *The current status of the data for billfish*

Swordfish

Retained catches of the major fleets are considered to be accurate; however, uncertainties in the overall catch arise (Figure 9) due to:

- non-reporting industrial longliners (NEI): The numbers of non-reporting longliners targeting swordfish appear to have increased in recent years as there has been an increase in reports of foreign vessels operating in the Indian Ocean from third parties.
- conflicting catch reports: The catches for South Korean longliners reported as nominal catches and catches and effort are conflicting, with higher catches recorded in the CE table.

Discard levels are believed to be low although they are unknown for most industrial fisheries.

CPUE Series: Catch and effort data are available from the major industrial longline fleets. Nevertheless, catch and effort are not available from some fisheries or they are considered poor quality, especially throughout the 1990s (e.g. Indonesia, fresh-tuna longliners from Taiwan,China, and non-reporting longliners (NEI)). The catch and effort that are available from artisanal fisheries are believed to be inaccurate (poor quality effort data for the gillnet/longline fishery of Sri Lanka).

Trends in average weight can be assessed for several industrial fisheries although they are incomplete or poor quality for most fisheries before the early-80s and in recent years (low size of samples and time-area coverage for longliners from Japan).

Catch-at-Size(Age) table: CAS are available but the estimates less certain (Figure 9) for some years and fisheries due to:

- a lack of size data before the early-1980s and from artisanal fisheries (Sri Lanka)
- a paucity of size data available from industrial longliners since the early-1990s (Japan, Seychelles, Philippines, India, China)
- a paucity of catches per area available for some industrial fleets (NEI)
- a paucity of the biological data available, notably sex-ratio at size and sex-length-age keys

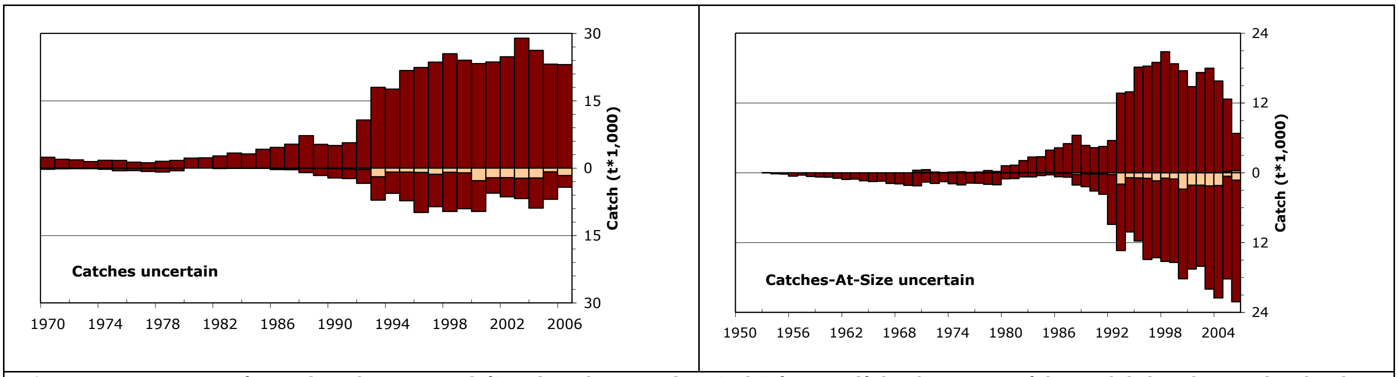


***Figure 9**: Uncertainty of annual catch estimates (left) and catch at size data (right) for swordfish. The amount of the catch below the zero-line has been categorised as uncertain according to the criteria given in document IOTC-2008-WPB-08. Data as of June-July 2008. Light bars represent data for artisanal fleets and dark bars represent data for industrial fleets. From document IOTC-2008-WPB-08.*

Blue marlin

Retained catches are poorly known for many fisheries (Figure 10) due to:

- catches per species not being available for many artisanal (gillnet/longline fishery of Sri Lanka and artisanal fisheries of India, Iran and Pakistan) and some industrial (longliners of Indonesia and Philippines) fisheries
- uncertain catches for non-reporting industrial longliners (India, NEI)
- catches being incomplete for many industrial fisheries for which the blue marlin is seldom the target species. No catches are available for industrial purse seiners although they are known to occur
- conflicting catch reports: The catches for South Korean longliners reported as nominal catches and catches and effort are conflicting, with higher catches recorded in the CE table

- a lack of catch data for major sport fisheries (e.g. Mauritius, South Africa, Australia, Kenya and the United Arab Emirates.

Discard levels are unknown for most industrial fisheries, mainly longliners.

CPUE Series: Catch and effort data are available from some industrial longline fisheries although the catch data is possibly incomplete (the catches of species other than the target are not always recorded in the logbooks). No catch and effort are available from sport fisheries, besides the sport fisheries of Kenya, or other artisanal (gillnet/longlines of Sri Lanka) or industrial fisheries (NEI longliners and all purse seiners).

Trends in average weight can only be assessed for the longline fishery of Japan since 1970 and Taiwan,China since 1980. The number of specimens measured in recent years is, however, very low.

Catch-at-Size(Age) table: The Secretariat has not built CAS or CAA tables for blue marlin. The paucity of size data available for this species made it very difficult any attempt to estimate CAS.

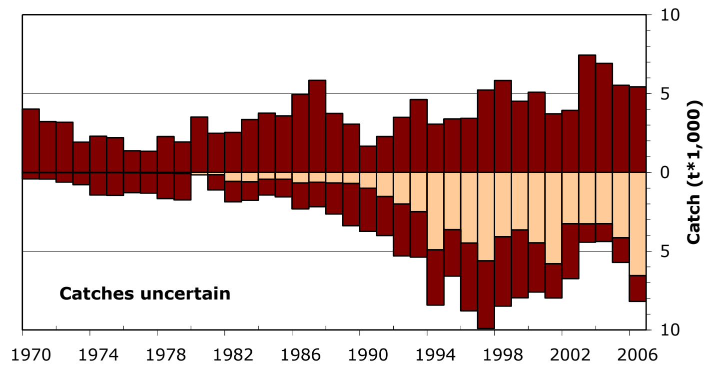


Figure 10: *Uncertainty of annual catch estimates for blue marlin. The amount of the catch below the zero-line has been categorised as uncertain according to the criteria given in the text in IOTC-2008-WPB-08. Light bars represent data for artisanal fleets and dark bars represent data for industrial fleets. Data as of June 2008. From document IOTC-2008-WPB-08.*

Black marlin

Retained catches are poorly known for many fisheries (Figure 11) due to:

- catches per species not being available for many artisanal (gillnet/longline fishery of Sri Lanka and artisanal fisheries of India, Iran and Pakistan) and some industrial (longliners of Indonesia and Philippines) fisheries
- uncertain catches for non-reporting industrial longliners (India, NEI)
- catches being incomplete for most industrial fisheries for which the black marlin is seldom the target species. No catches are available for industrial purse seiners although they are known to occur
- conflicting catch reports: The catches for South Korean longliners reported as nominal catches and catches and effort are conflicting, with higher catches recorded in the CE table
- a lack of catch data for major sport fisheries.

Discard levels are unknown for most industrial fisheries, mainly longliners.

CPUE Series: Catch and effort data are available from some industrial longline fisheries although the catch data may be incomplete (the catches of species other than the target are not always recorded in the logbooks). No catch and effort are available from sport fisheries, besides the sport fisheries of Kenya, or other artisanal (gillnet/longlines of Sri Lanka) or industrial fisheries (NEI longliners and all purse seiners).

Trends in average weight can only be assessed for the longline fishery of Japan since 1970 and Taiwan,China since 1980. The amount of specimens measured in recent years is, however, very low.

Catch-at-Size (Age) table: The Secretariat has not built CAS or CAA tables for black marlin. The paucity of size data available for this species would make it very difficult any attempt to estimate CAS.

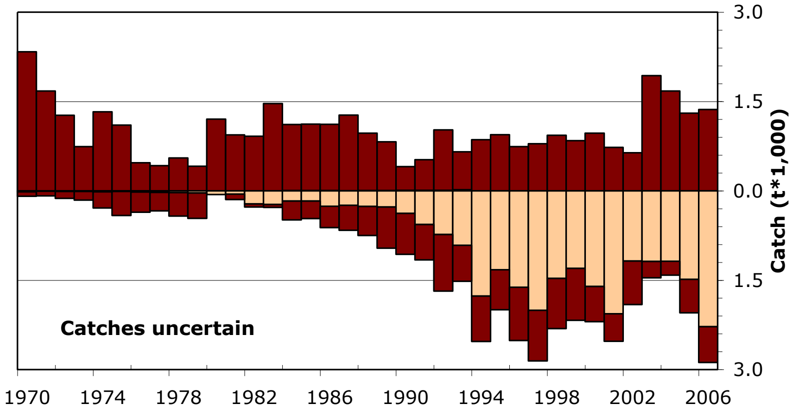


Figure 11: *Uncertainty of annual catch estimates for black marlin. The amount of the catch below the zero-line has been categorised as uncertain according to the criteria given in the text in document IOTC-2008-WPB-08. Light bars represent data for artisanal fleets and dark bars represent data for industrial fleets. Data as of June 2008. From document IOTC-2008-WPB-08*

Striped marlin

Retained catches are reasonably well known; however, overall catches are uncertain (Figure 12) because:

- catches per species are not available for some industrial fisheries (longliners of Indonesia and Philippines).
- uncertain catches for non-reporting industrial longliners (India, NEI)
- catches are believed to be incomplete for many industrial fisheries as striped marlin is seldom a target.
- conflicting catch reports: The catches for South Korean longliners reported as nominal catches and catches and effort are conflicting, with higher catches recorded in the CE table
- a lack of catch data from major sport fisheries.

Discard levels are believed to be low although they are unknown for most industrial fisheries, mainly longliners.

CPUE Series: Catch and effort data are available from some industrial longline fisheries although the catch data may be incomplete (the catches of species other than the target are not always recorded in the logbooks). No catch and effort are available from sport fisheries, except for Kenya, or industrial fisheries (NEI longliners).

Trends in average weight can only be assessed for the longline fishery of Japan since 1970 and Taiwan,China since 1980. The amount of specimens measured in recent years is, however, very low.

Catch-at-Size (Age) table: The Secretariat has not built CAS or CAA tables for striped marlin. The paucity of size data available for this species would make it very difficult any attempt to estimate CAS.

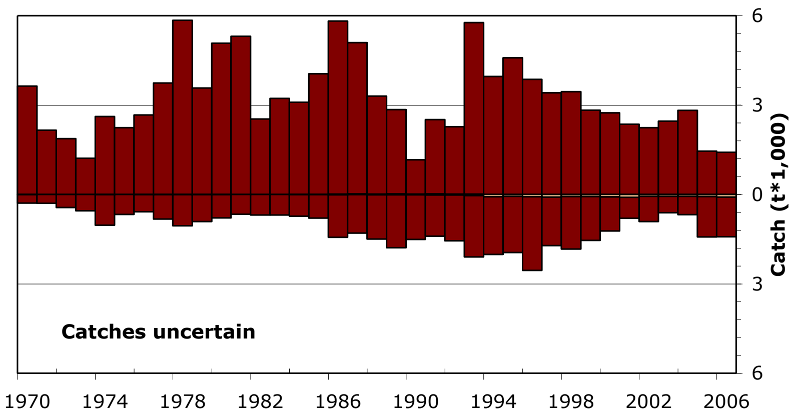


Figure 12: *Uncertainty of annual catch estimates for striped marlin. The amount of the catch below the zero-line has been categorised as uncertain according to the criteria given in the text of document IOTC-2008-WPB-08. Light bars represent data for artisanal fleets and dark bars represent data for industrial fleets. Data as of June 2008. From document IOTC-2008-WPB-08*

Indo-Pacific Sailfish

Retained catches are poorly known for most fisheries (Figure 13) due to:

- catches per species not being available for many artisanal fisheries (mainly India and Indonesia)
- catches being very incomplete for most industrial fisheries for which this species is a by-catch. No catches are available for industrial purse seiners although they are known to occur
- catches being incomplete for many artisanal fisheries (gillnets of Pakistan, pole and lines of Maldives) due to under-reporting.
- a lack of catch data for sport fisheries.

Discard levels are unknown for most industrial fisheries, mainly longliners (for which they are presumed to be moderate-high).

CPUE Series: Catch and effort data are available from some industrial longline fisheries but they are believed to be of poor quality (catches of sailfish are incomplete). No catch and effort are available from sport fisheries besides the sport fisheries of Kenya. The catch and effort that are available from artisanal fisheries are believed inaccurate (no data from Iran and Pakistan and poor quality effort data for the gillnet/longline fishery of Sri Lanka).

Trends in average weight can only be assessed for the longline fishery of Japan since 1970 and the gillnet/longline fishery of Sri Lanka since the late 80s. The amount of specimens measured is, however, very low. Furthermore, the specimens discarded might be not accounted for in industrial fisheries, where they are presumed to be of lower size (possible bias of existing samples).

Catch-at-Size(Age) table: The Secretariat has not built CAS or CAA tables for IP sailfish. The paucity of size data available for this species would make it very difficult any attempt to estimate CAS.

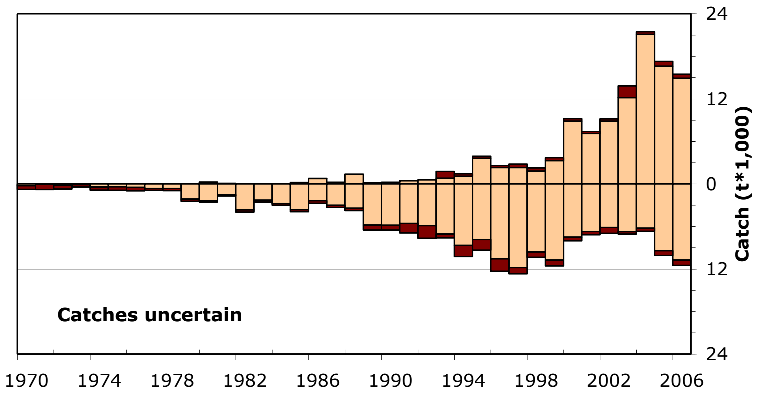


Figure 13: *Uncertainty of annual catch estimates for Indo-Pacific sailfish. The amount of the catch below the zero-line has been categorised as uncertain according to the criteria given in the text in document IOTC-2008-WPB-08. Light bars represent data for artisanal fleets and dark bars represent data for industrial fleets. Data as of June 2008. From document IOTC-2008-WPB-08*

3. INFORMATION ON BIOLOGY, ECOLOGY, OCEANOGRAPHY AND FISHERIES RELATING TO BILLFISH

The French longline fishery

9. Document IOTC-2008-WPB-04 described the current status of the French longline fishery focusing on the La Reunion swordfish fishery. The first longliner started in 1991 and currently there are 45 vessels of an average length of just under 15 metres operating in the fishery (Figure 14).

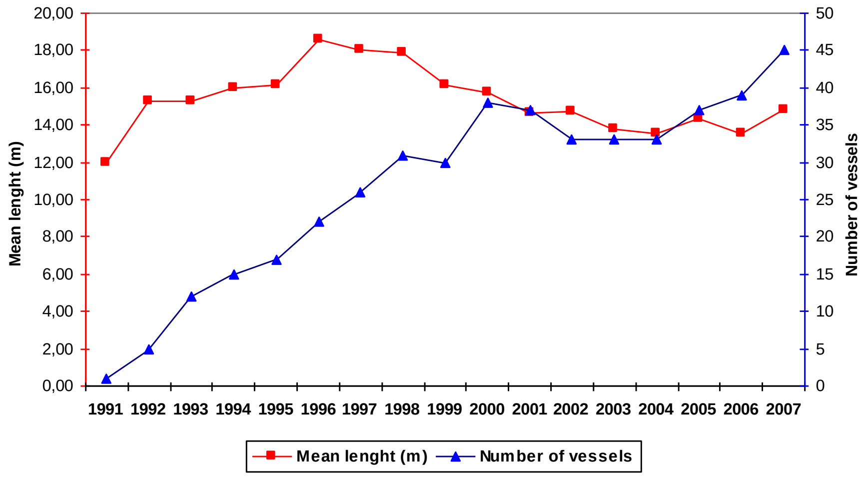
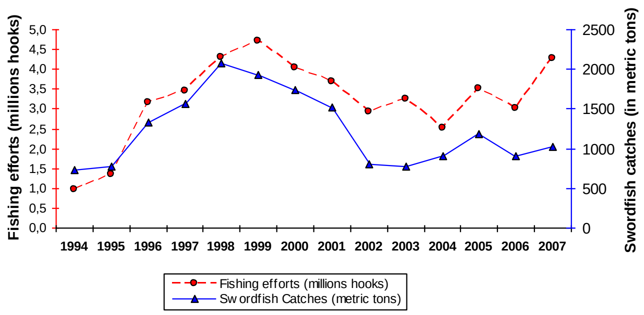


Figure 14: *Number of French longliners and their mean size over the period 1991 to 2007. From document IOTC-2008-WPB-04.*

10. The fleet mainly targets swordfish but also retains other species like tuna, dolphin fish, other billfishes, sharks and wahoos. In 2000, the catch comprised around 50% swordfish while in recent years this has dropped to around 30%. According to fishermen, this decrease is the consequence of the fleet targeting tuna.

11. Effort steadily increased from 1994 to 1998 (reaching more than 4 million hooks) and then decreased to 3 million hooks in 2006. After a peak of catches in 1998 (2000 t), annual swordfish catches have recently stabilized at around 1000 t (Figure 15). However, the CPUE for this species has been declining since 1994 (Figure 15).



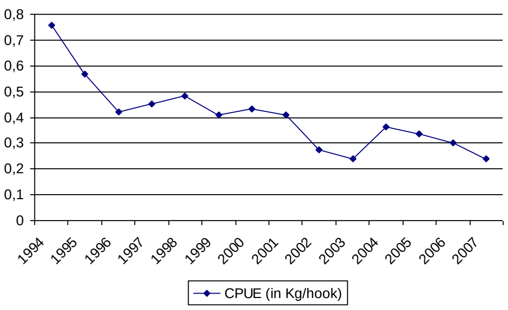


Figure 15: *Catch and effort (a) and CPUE (b) of swordfish caught by La Réunion longline fishery from 1994 to 2007. From document IOTC-2008-WPB-04.*

12. Since 1994, IFREMER has sampled the size of swordfish caught by French longliners fleet operating in the Indian Ocean. In 2007, 1423 swordfishes were measured (Lower Jaw Fork length – LJFL). In 2007, the average LJFL of swordfish was 159.9 cm (Figure 16).

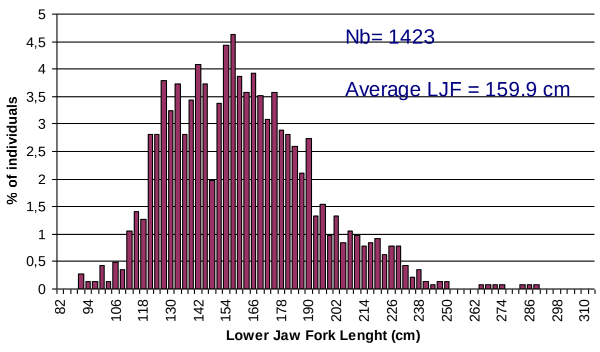


Figure 16: *Distribution of size (LJF length) of swordfish caught by La Reunion's longliners in 2007. From document IOTC-2008-WPB-04.*

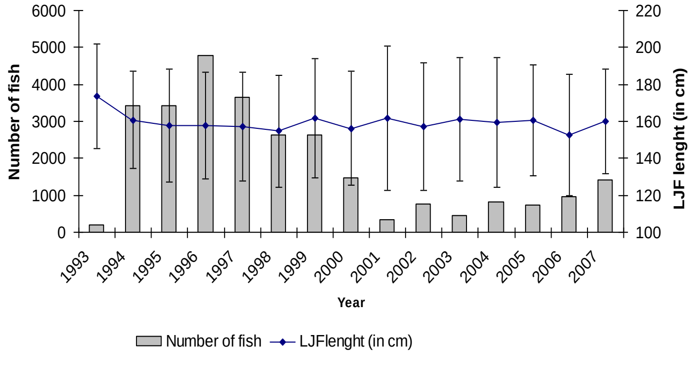


Figure 17: *Evolution of the distribution of the mean size of swordfish caught by La Reunion's longliners from 1993 to 2007 From document IOTC-2008-WPB-04.*

13. Based on size data collected since 1994, there has been littler change in the average size (LJFL) of swordfish caught by the French longliners operating in the south West Indian Ocean (Figure 17).

14. The other billfish species caught by the French longline fishery are sailfish – *Istiophorus platypterus*, shortbill spearfish – *Tetrapturus angustirostris*, blue marlin – *Makaira mazara*, black marlin – *M. indica* and striped marlin – *T. audax*. In 2007, this fleet caught 106.5 t of marlins (3.2% of the total catches), 27.7 t of sailfish (0.8%) and 9.6 t of spearfish (0.3%) (Figure 18).

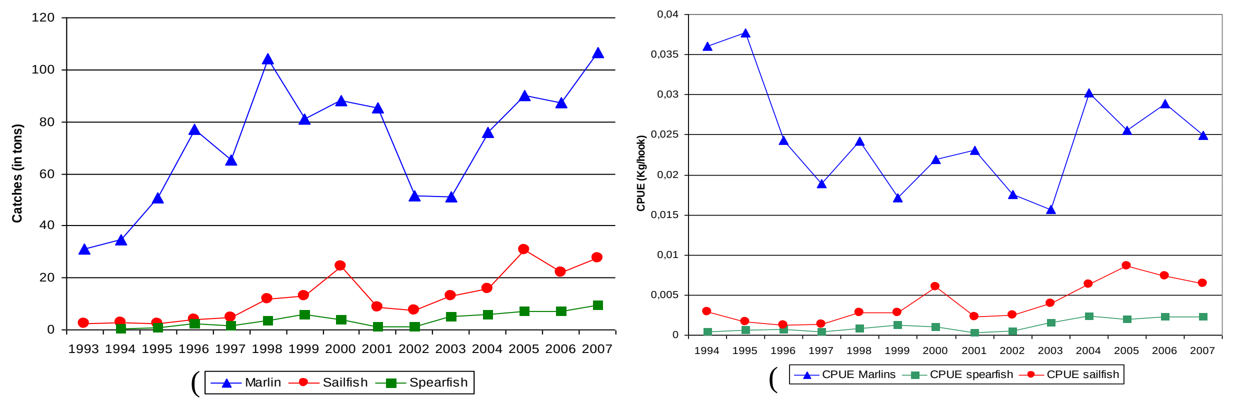


Figure 18: *Evolution of the catches (left) and CPUE (right) for other billfishes (marlins, sailfishes and shortbill spearfishes) caught by La Reunion's longliners from 1993 to 2007. From document IOTC-2008-WPB-04.*

The La Reunion coastal fishery

15. The La Reunion coastal fleet currently comprises 203 boats most of which use hand-line and troll-line gears. Two coastal fleets fish for large pelagic fishes: one targeting only large pelagic fishes (29 boats in 2007) and another targeting benthic fishes and large pelagic fishes (168 boats in 2007). Estimates of effort on the large pelagic fishes, however, are difficult to obtain because, despite data reporting being obligatory since 2006, the levels of reporting have been variable and landings are uncertain. Work is being undertaken to improve this situation with interview sampling being done in the different harbours of the island.

Swordfish structure in the south west Indian Ocean

16. Document IOTC-2008-WPB-16 described the population structure swordfish (*Xiphias gladius*) in the southwest Indian Ocean obtained from DNA analyses. Eleven microsatellite loci and the mitochondrial control region (517 bp) were examined in fish from four proximal localities of the southwest Indian Ocean. The aim of this study was to test for congruency of structure detected by these two genetic markers, with the intention of conducting a study at the scale of the whole ocean. Analyses of multilocus microsatellite genotypes and mitochondrial control region sequences both revealed considerable homogeneity between samples. Genetic diversity detected at the regional scale was not significantly higher than that detected at the local scale. Results suggest that swordfish in the southwest Indian Ocean function as a unique panmictic population. However some discrete genetic differences appeared, possibly indicating the influence of a second genetic pool in the northern part of the Indian Ocean.

17. The WPB acknowledged the valuable contribution this work would make to better understanding the stock structure and movements of swordfish and resoundingly endorsed the proposal and encouraged all IOTC members to participate or contribute to the project as much as possible. To this end the WP requested that the Secretariat inform IOTC member scientists about the initiative and encourage them to participate.

Seychelles semi-industrial longline fishery

18. Document IOTC-2008-WPB-16 described the evolution of the Seychelles semi-industrial longline fishery (a monofilament longline fishery (targeting mainly swordfish and tuna) operated solely by Seychellois fishers). The local pelagic longline fishery targeting swordfish started in the Seychelles in 1995. After increasing from 1 to 12 vessels in 2002, only 4 vessels were actively targeting swordfish in 2007. A monitoring program was set up by SFA in 1995 to closely monitor the semi industrial fishery and data are collected from logbooks filled by skippers and landing data from fish processors. In 2007, 4 vessels conducted a total of 40 longline fishing trips (for tuna and swordfish) with an average duration of 10 days per trip (compared to 6 vessels in 2006).

19. Following the decrease in fishing effort during the 2003-2004 periods, linked to the market constraints of swordfish, an increase in fishing effort was observed in 2005 and has since then remained more or less constant (Figure 19).

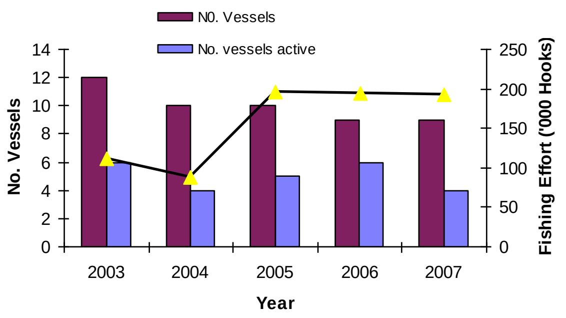


Figure 19: Number of vessels active and fishing effort of semi Industrial fishery, 2003- 2007. From document IOTC-2008-WPB-16

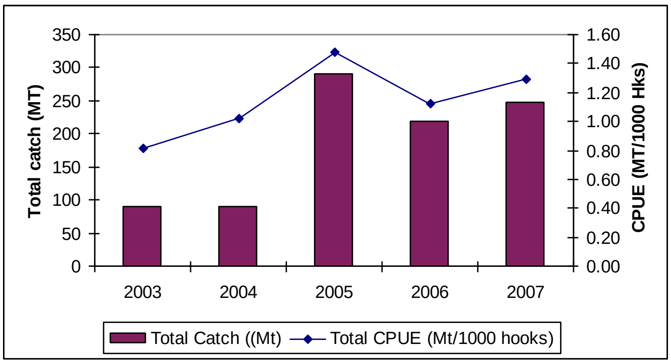


Figure 20: Catch and catch rate of semi Industrial fishery targetting swordfish or tuna, 2003- 2007. From document IOTC-2008-WPB-16

20. The lowest recorded catch in the semi industrial fishery was in 2004 when a total catch of 90 t was recorded (Figure 20). The total catch then increased in 2005 reaching 290 t and has since then remained more or less constant. The CPUE increased from 0.81 t/1000 hooks in 2003 to a record of 1.48 t/1000 hooks in 2005, then drop to 1.13 t/ 1000 hooks in 2006. In 2007 the CPUE stands at 1.29 t/1000 hooks.

21. Swordfish dominated the catches making up 61.2% of the total catch followed by yellowfin (17.6%) and bigeye tuna (17.2%) – Figure 21. Since 2005 the proportion of tuna in the semi industrial fishery has been on the increase from 36% of the total catch in 2005 to 44% in 2006. In 2007, for the first time since the beginning of the fishery, tuna (125 t) dominate the catch accounting for 51% of the total catch whilst swordfish (111t) accounted for 45% of the total catch. This is may be due to increased targeting of tuna by the fleet. By-catches constituted of sharks (2%), sailfish (1%), marlin and other species <1%.

22. The mean (Pectoral Anal Length (PAL) of swordfish over 5 recent most years was 51.4 cm (Figure 22).

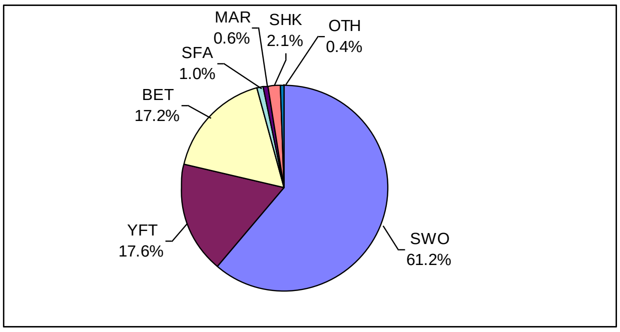


Figure 21: Average Species composition of semi Industrial fishery for the 2003- 2007 period. From document IOTC-2008-WPB-16

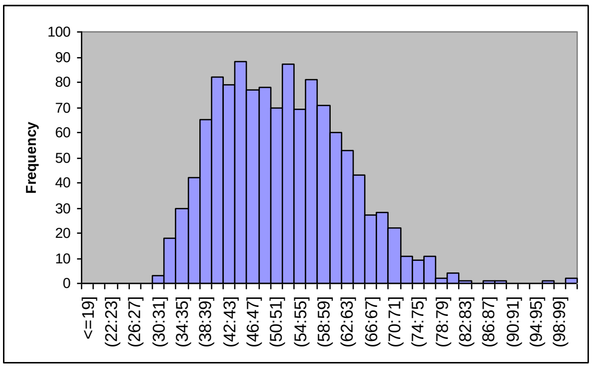


Figure 22: Swordfish size frequency distributions (PAL in cm) from fish landed by Seychelles' longliners in Victoria for the period 2003 - 2007 (n=1216). From document IOTC-2008-WPB-16

23. Over the period 2003 to 2005, the swordfish CPUE (Figure 23) shows an increasing trend reaching a peak of 0.86 t/1000 hooks in 2005 before decreasing to 0.58 t/1000 hooks in 2007. For yellowfin and bigeye tuna a sharp increase in both species CPUE was reported during 2005 reaching 0.25 t/1000 hooks and 0.28 t/1000 hooks respectively. The yellowfin CPUE has increased further in 2007 to 0.29 t/1000 hooks whilst the bigeye CPUE has remained constant. The CPUE for by-catches (marlins, sailfish and other species) has remained less than 0.1 t/1000hookss over the past 5 years.

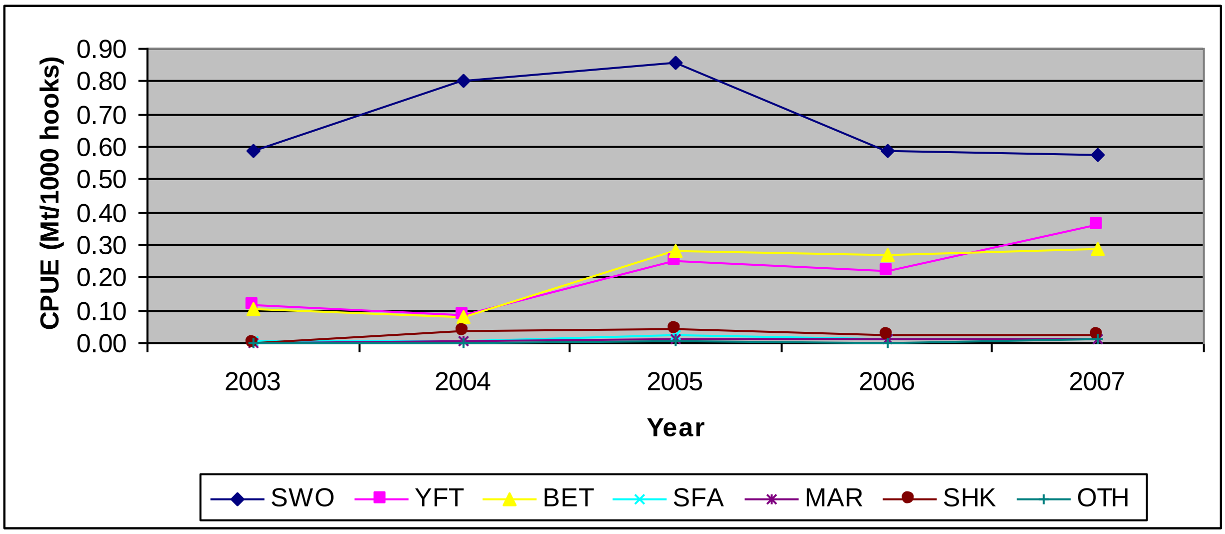


Figure 23: *Catch rate (t/1000 hooks) by species of semi Industrial fishery, 2003- 2007. From document IOTC-2008-WPB-16*

Spanish longline fishery

24. The WPB noted document IOTC-2008-WPB-05 which summarised the activity of the Spanish surface longline fleet targeting swordfish in the Indian Ocean for the period 2003-2006. A total number of 19, 24, 23 and 28 Spanish surface longline vessels carried out commercial fishing activities in the Indian Ocean in the years 2003 to 2006, respectively. In 2005 – 10 vessels and in 2006 – 11 vessels were also involved in experimental surveys, mostly in northern and southwestern areas of the Indian Ocean. Plots of landings by number of fish and by kg of round weight and nominal effort in thousands of hooks set by the fleet are presented (in 5x5 degree format). The numbers of swordfish landed in the period 2003-2006 amounted to 73,921, 86,773, 102,233 and 108,403, respectively. The total round weight in tonnes was 4,290 t, 4,713 t, 5,079 t and 5,155 t and the individuals sampled for size were 34,669, 31,871, 19,443 and 32,888. This represents an average sampling rate of about 32.0% of the fish caught over this period. Nominal CPUEs are given in number and round weight. These data refer to the catch of the Spanish fleet using the "American" longline gear (only one vessel used the traditional Spanish longline in 2006). The overall nominal CPUE in number of fish was about 17 individuals for the years 2003 and 2004, 19 for the year 2005 and 17 for 2006. The overall nominal CPUE in weight for these years was 966, 920, 964 and 787 kg round weight, respectively (Figure 24).

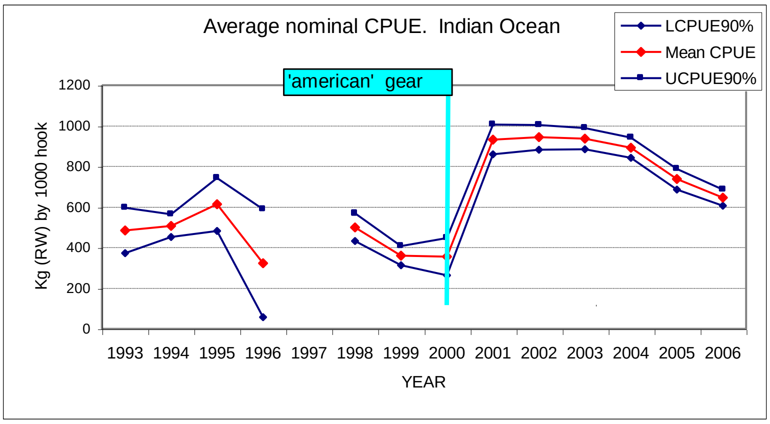


Figure 24: *Mean nominal CPUE (kg of swordfish round weight per thousand hooks) of the Spanish surface longline fleet obtained in the Indian ocean as a whole during the 1993-2006 period (data not available for year 1997). From document IOTC-2008-WPB-05*

25. The WP noted the potential of the data being obtained by the Spanish fleets; but expressed its disappointment that much of the data are not available to the Commission in particular catch and effort for all IOTC species by 5° resolution in accordance with IOTC obligations. The WP requested that the Scientific Committee Chair contact

the Spanish authorities an request greater access to this information; in particular, data for all billfish, if possible, disaggregated by sex

4. Update of stock indicators

4.1. Swordfish

CPUE Indices

The Spanish longline fishery

26. The WPB noted document IOTC-2008-WPB-06. This document described preliminary standardized catch rates obtained using General Linear Modeling (GLM) procedures from sets carried out by the Spanish surface longline fleet targeting swordfish in the Indian Ocean over two independent periods, 1993-2000 and 2001-2007. The factors used for modeling were year, area, semester/quarter, gear and ratio between swordfish and blue shark catches. The models explained 24% and 51% of the CPUE variability for the first and the second period, respectively. As in the case of the Atlantic and Pacific swordfish, an important part of the CPUE variability was attributed to the ratio between the two most prevalent species in the catch. Other significant, although less important factors, were also identified. The different sensitivity trials have shown similar trends over time. The conclusions on the standardized CPUE suggest a 'learning' and erratic trend over the first period of activity of the Spanish fleet and a decreasing trend during the second period (Figure 25).

27. The WP noted potential importance of the CPUE derived from the data of the Spanish fleet and encouraged the authors to further examine the effects of the targetting ratio parameter and the changes in fishing practices. It has been noted in the IATTC and WCPFC that use of the swordfish to blue shark ratio potentially masks abundance trends because swordfish abundance occurs on both sides of the GLM equation. It might also be informative to disaggregate the Spanish CPUE analyses, along the lines of that undertaken for the Japanese and Taiwanese analyses

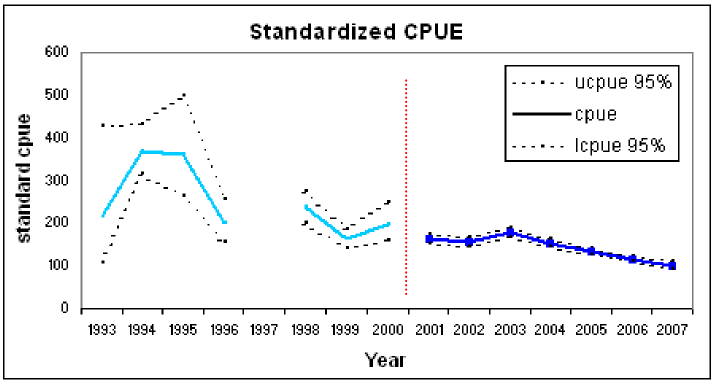


Figure 25: *Annual change in the standardized catch rates in weight and 95% confidence intervals obtained for the independent periods 1993-2000 and 2001-2007 (note fishing gear changed in 2001). IOTC-2008-WPB-06*

The Japanese longline fishery

28. Document IOTC-2008-WPB-03 described the standardisation of swordfish CPUE from the Japanese tuna longline fisheries in the Indian Ocean for 2 periods (1980-2006 and 1992-2006), using Generalized liner models (GLM). In this analysis the 9 sub-areas used previously by the WPB were condensed into 4 new areas (Figure 26) in order to reduce non convergence problems in the GLM analyses caused by missing values. The time periods chosen reflect periods when (i) there were marked shifts in gear deployment, in particular relating to fishing depth and the number of hooks between floats (Figure 27) and (ii) when environmental factors were considered to be important (IOTC-2008-WPB-INF04). Three models (Table 1) were examined with factors such as salinity, thermocline depth, and amplitude of shear current being significant in certain cases. These models differed in their use of year interaction terms. The standardised indices generated by each case were similar and the results from case 1 only are presented further. The standardised CPUE index for all areas combined showed a gradual decrease after the late 1980's with some fluctuations (Figure 28). A decrease in CPUE was common among all areas, but the time or amplitude of decrease was different among areas (Figure 29). In general, annual trends of

CPUE in the two western Indian Ocean areas showed similar trends i.e. a relatively high level of CPUE before 1993 with some fluctuations then a rapid decrease after 1993. In the eastern areas, a relatively stable trend was observed compared to western parts, while a relatively rapid decrease of CPUE from 0.4 to 0.1 was observed during 1982 to1990 in southeast area.

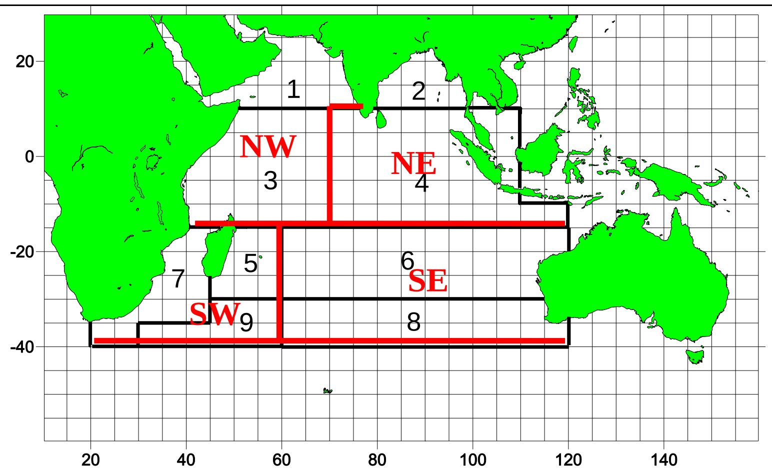


Figure 26: *Areas used in the standardisation of swordfish CPUE from the Japanese and Taiwanese tuna longline fisheries in the Indian Ocean. From document IOTC-2008-WPB-03.*

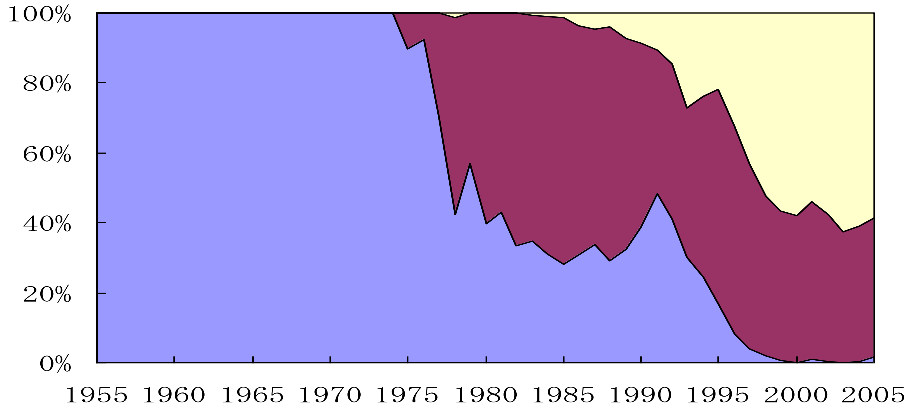


Figure 27: *Changes in the gear deployed by the Japanese longline fleet over time. Blue (left) reflects shallow and regular longline fishing using <= 9 hooks between floats. Red (middle) reflects deep fishing using 10 to 14 hooks between floats and the yellow (right) indicated ultra deep fishing using ≥15 hooks between floats. From document IOTC-2008-WPB-INF04*

Table 1*. Model cases used in the Standardisation of Japanese longline CPUE.*

Case	Year interaction in the model
1	only one year interaction (year* new area) was used
2	Many year interaction terms were used.
3	YR*Q was excluded from Case 2

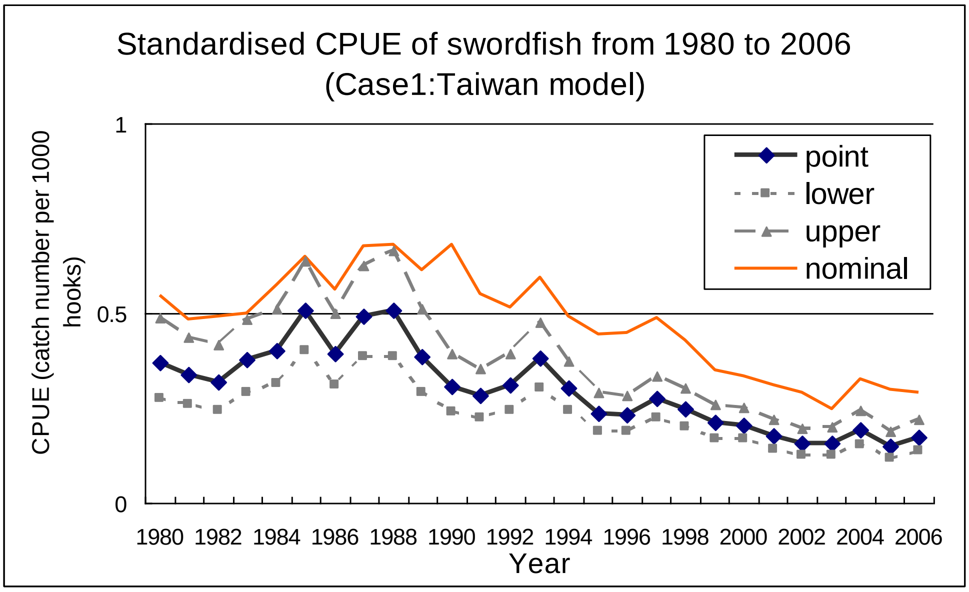


Figure 28: Standardised CPUE index for the Japanese longline fleet 1980 to 2006. IOTC-2008-WPB-03

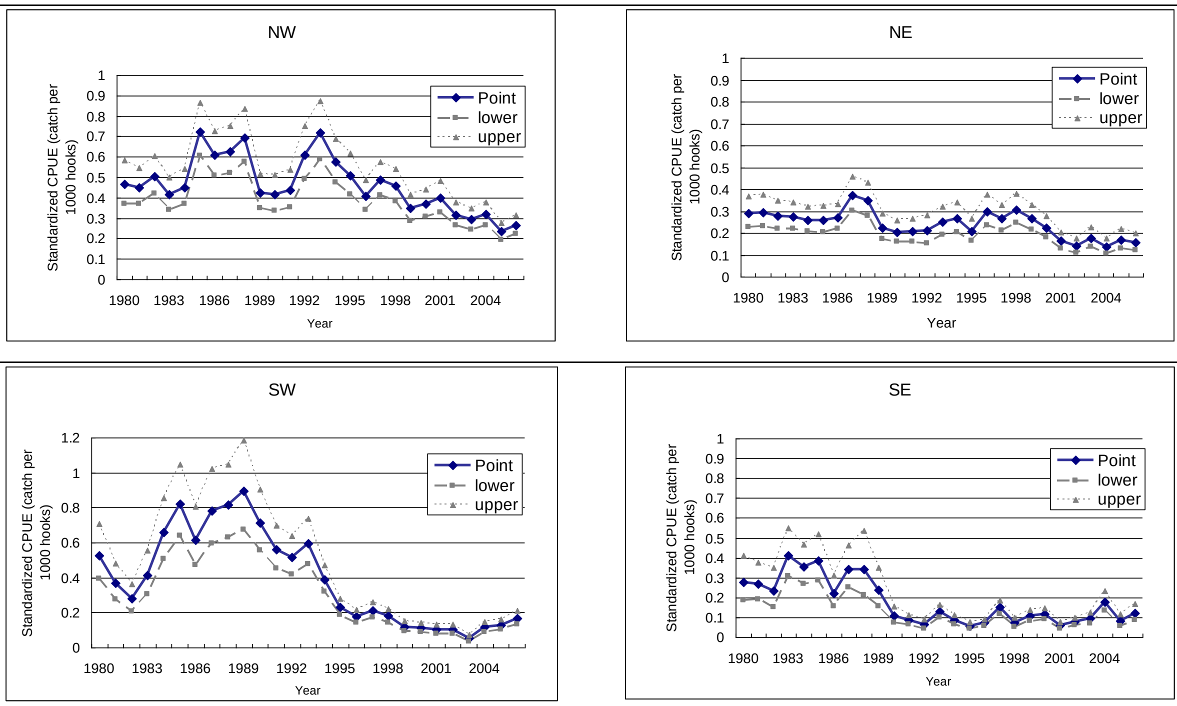


Figure 29: Standardised CPUE trends (using case 1) for swordfish by the Japanese longline fishery in four areas of the Indian Ocean derived using Model 1. NW = north west, SW = south west, NE = north east, SE = south east. From IOTC-2008-WPB-03

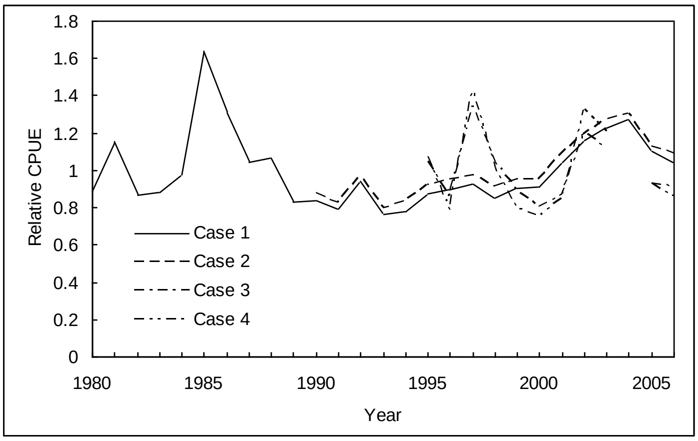
The Taiwanese longline fishery

29. Document IOTC-2008-WPB-10 described the standardisation of swordfish CPUE from the Taiwanese tuna longline fisheries in the Indian Ocean over the periods 1980 to 2006 and 1995 to 2006 and for the revised areas shown in Figure 26 using generalized linear model (GLM). In this study, four model cases were examined (Table 2) using daily shot-by-shot catch and effort data aggregated to 5x5 deg squares and environmental information. The information of number of hooks between floats (NHBF) was only available from 1995 and the percentage of data with NHBF was about 62% of the total data.

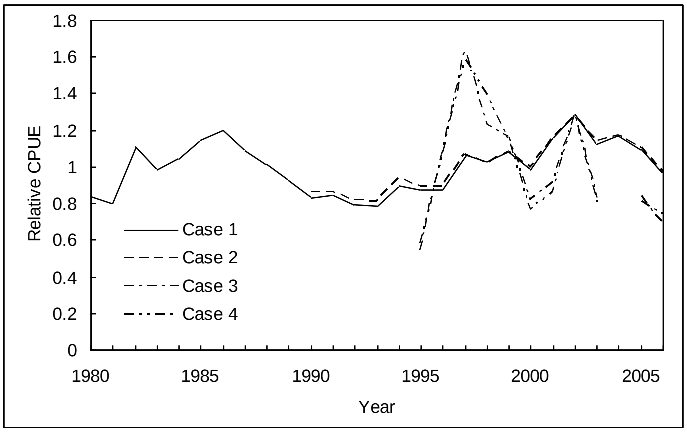
30. The standardisations had a marked influence on the CPUE trends as demonstrated by the marked differences in the variability of the nominal CPUEs compared to that of the standardised indices. The standardised CPUE indices in each of the areas were, overall, less variable and showed little trend (Figure 30). Similarly, the overall, standardised swordfish CPUE (for all areas combined) showed a relatively flat trend over time (Figure 31).

***Table 2:** Models used in the standardisation of swordfish CPUE from the Taiwanese longline fisheries in the Indian Ocean. From document IOTC-2008-WPB-10.*

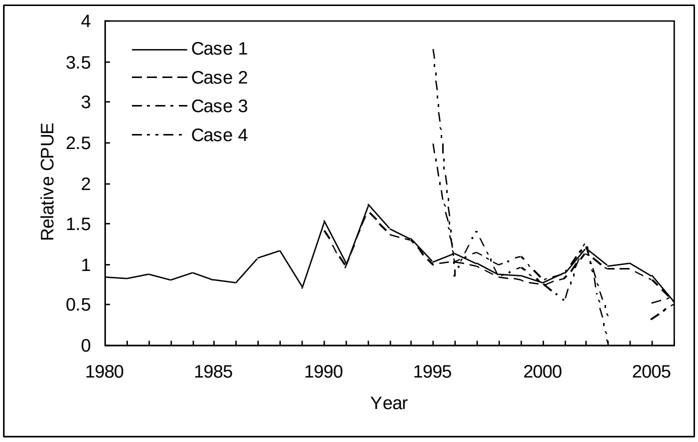
Case 1	Data = 1980-2006; catch composition is used as a target effect.
Case 2	Data = 1990-2006; catch composition is used as a target effect.
Case 3	Data = 1995-2006 ; number of hooks between floats is used as target effect.
Case 4	Data = 1995-2006 ; number of hooks between floats is used as target effect. Additional environmental data, including sheer currents, amplitude of the shear current, temperature gradient, salinity gradient, temperature and salinity at 75, 95, 105 and 135 m depth corresponding to average gear depths, were included in the model.



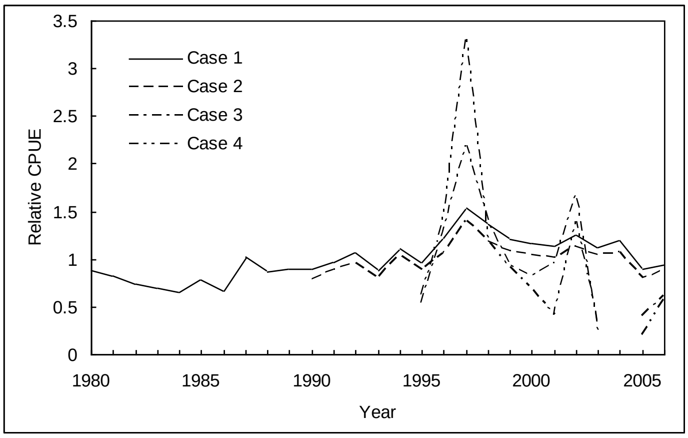
(a) North west Indian Ocean



(b) North east Indian Ocean



(c) South west Indian Ocean



(d) South east Indian Ocean

***Figure 30:** Standardised CPUE trends for swordfish by the Taiwanese longline fishery in four areas of the Indian Ocean derived using four model cases. Nominal CPUE is also shown. From document IOTC-2008-WPB-10.*

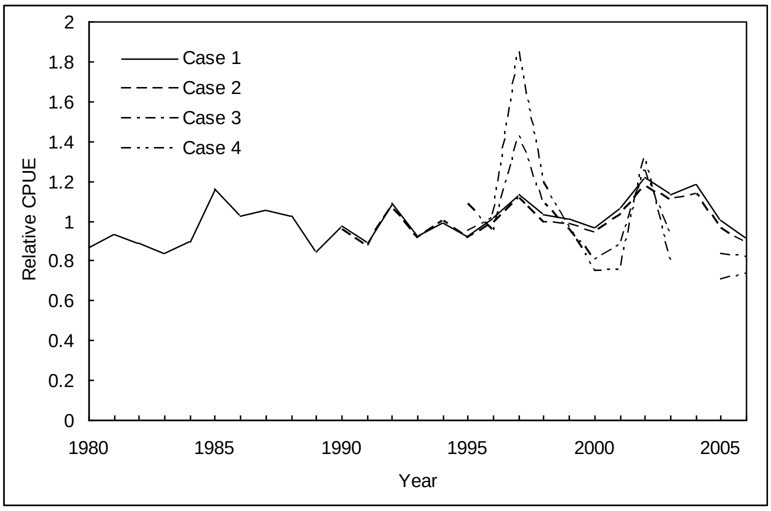


Figure 31: *Standardised CPUE trends for swordfish by the Taiwanese longline fishery in the entire Indian Ocean derived using four model cases. Nominal CPUE is also shown. From document IOTC-2008-WPB-10.*

31. The WP thanked the Japanese and Taiwanese scientists for their collaborative efforts in the CPUE analyses. The WP noted the following issues relating to the current CPUE analyses:

- Both analyses used 5x5 catch data and strongly recommended that future analyses include finescale,1x1 deg data, noting that this is critical when integrating environmental information (which is now available at a fine scale)
- Work should continue to identify the most informative predictive variables in the CPUE standardisations
- Japanese and Taiwanese CPUE trends are most similar when the targeting factors included numbers of hooks per float only.
- There remains uncertainty in understanding the degree to which environmental factors may be influencing catchability and abundance

Average Weight trend

32. The annual average weights of swordfish reported by the Japanese and Taiwanese longline fleets respectively have been variable and without trend over time (Figure 32). The annual average weight for swordfish reported by the Taiwanese fleet, until recent years has been lower than that of the Japanese fleet. The WP noted the numbers of swordfish being measured by the major fleets catching swordfish (Figure 32) and reiterated its concern about the lack of size data being reported for swordfish (as shown in Figure 9) and noted that detecting any trend in average size is likely to be influenced by low sample sizes, discard practices and area fished.

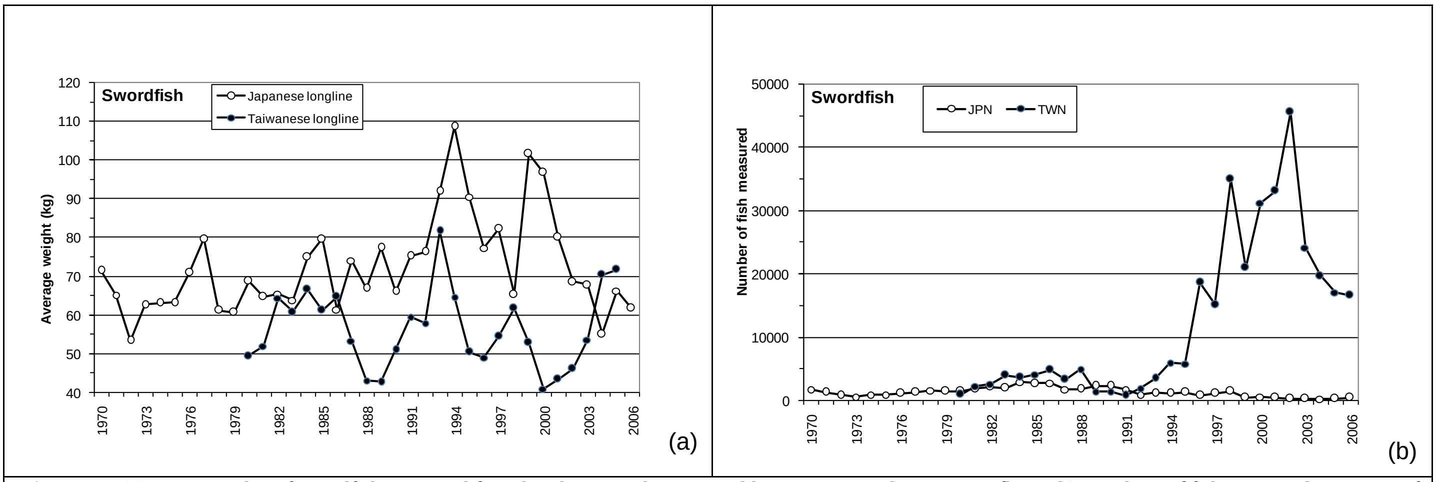


Figure 32: *(a) mean weights of swordfish estimated from longline samples reported by Japanese and Taiwanese fleets (b) numbers of fish measured. Data as of July 2008. From document IOTC-2008-WPB-14*

Length distribution from catch samples

33. There has been no change in the length composition of the swordfish catch over time (Figure 33); in particular, there has been no reduction in the numbers of large swordfish in the catch. Most fish measured are between 135-195 cm long.

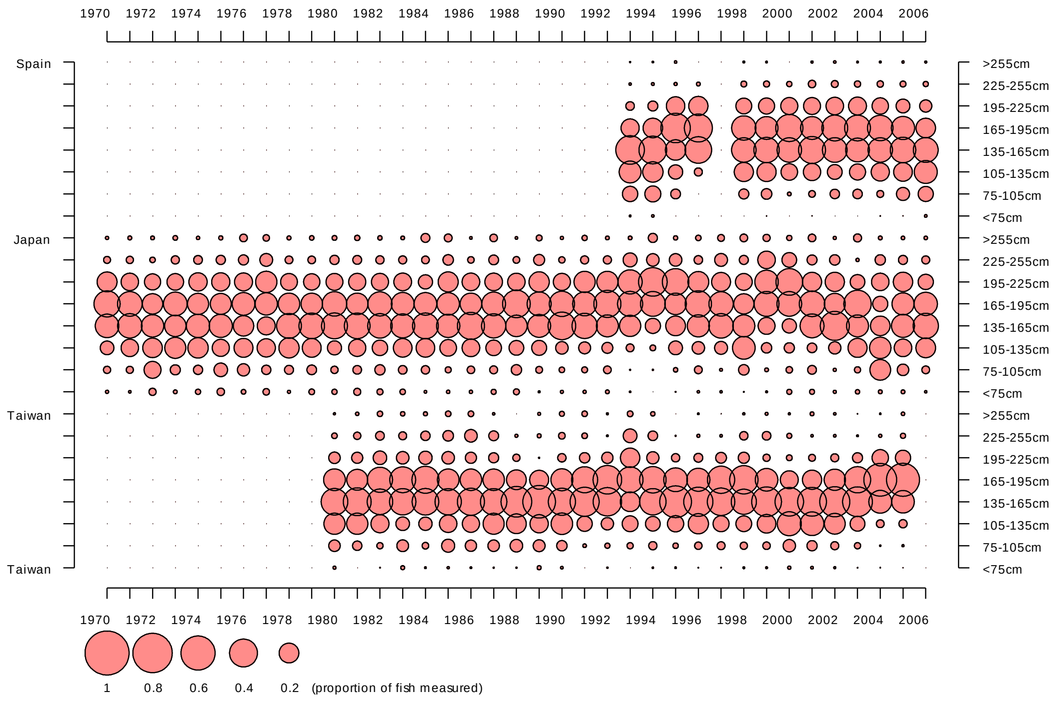
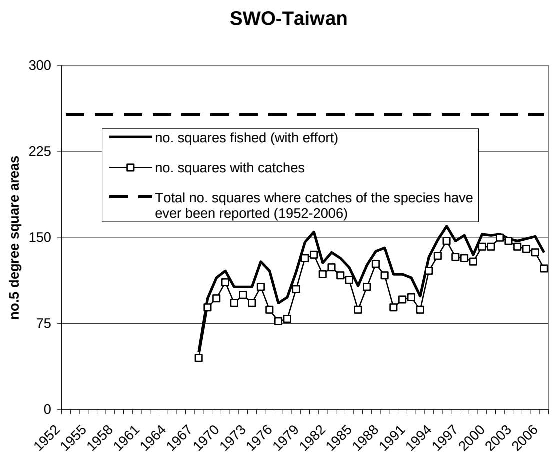
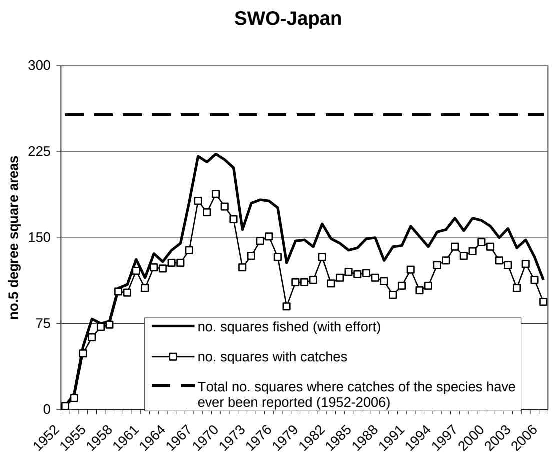


Figure 33: *Length composition of swordfish measured from catches over time. From document IOTC-2008-WPB-14*

Area fished

34. The WP noted that the expanding and contracting nature of the swordfish fishery over time might have important implications for the interpretation of CPUE as an index of relative abundance. An examination of the numbers of 5deg squares fished (Figure 34) shows that the Japanese and Taiwanese fishing grounds are of a similar size. In the case of Japan the change in area fished over time arise from an initial exploratory period and changing numbers of vessels. In the case of Taiwan,China changes in the area fished may be influenced by the levels of logbook coverage over time. The gap between the two lines may reflect targeting practices. When the lines are close this may suggest that swordfish is the target species. This is most apparent for the Spanish fleet where the number of areas fished and having catches of swordfish are identical because swordfish is the target of this fleet.





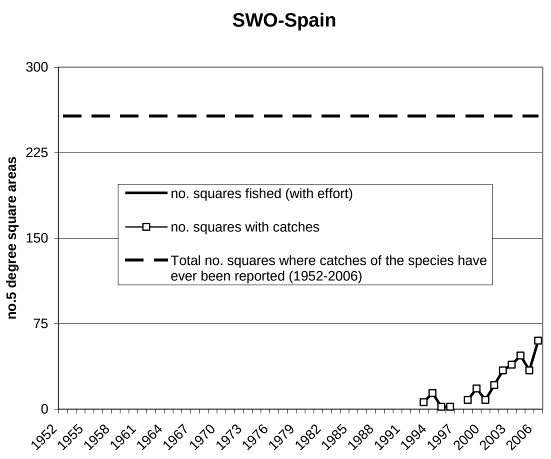


Figure 34: *The numbers of 5deg squares fished by the major longline fleets catching swordfish in the Indian Ocean.*

4.2. Marlins and Sailfish

35. Marlins and sailfishes are highly migratory species taken in relatively minor quantities in the Indian Ocean compared to tunas and swordfish. They are not typically targeted by commercial fisheries, but they are targeted by many sports fisheries. Marlins and sailfish are large predators that play an important role in pelagic ecosystems as they may influence the abundance, distribution and behaviour of a wide range of pelagic species.

36. Given the paucity of data and the intermittent nature of the fisheries exploiting marlins and sailfish, many of the quantitative stock assessment approaches used by scientists for tunas and swordfish cannot be used on these species and a range of more qualitative stock status indicators invariably become the only available means to follow the status of these populations.

37. The WPB was introduced to a range of possible stock status indicators for the marlins and sailfish derived from data from the current major industrial fishing fleets (IOTC-2008-WPB-PRES02). These included examinations of:

i. Nominal longline CPUEs: for instance derived from Japanese (1952-2005) and Taiwanese (1967-2005) data, but preferably in selected core equatorial waters and areas within the known range of the species being examined (Figure 35)

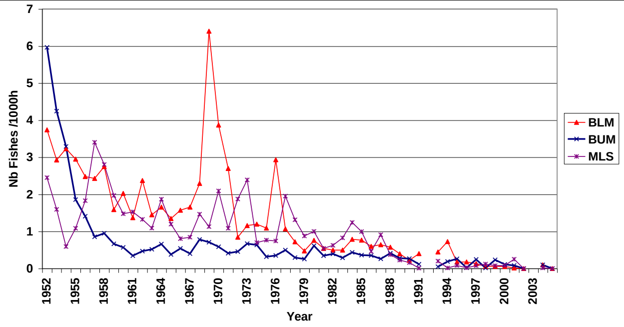
ii. Annual percentage of fishing effort by area: for example percentage of fishing effort that took place in the areas that produced dominant billfish catches in given each 5° by month strata (for the whole Indian Ocean and selected areas) (Figure 36)

iii. Annual average of the three highest monthly CPUEs or catches / fleet by 5°-month strata, estimated for each billfish species (Figure 37)

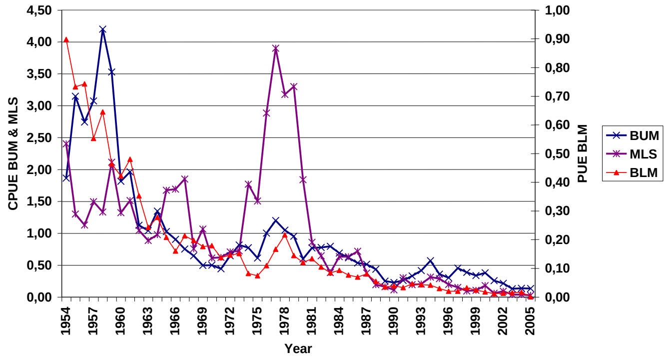
iv. Maps of total catches by species over selected periods(with pies showing the average catches /flag, for major fleets) – Figure 38.

v. Maps of annual CPUEs by 5° squares over selected periods. For example the 1952-2005 period for Japanese and Taiwanese fleets, or for the combined longline fleets – Figure 39.

38. Figure 35 shows the trends of nominal CPUE for marlins for two of the major historical fishing zones in the Indian Ocean. A continual decline in this indicator over time could signal that the stock is being depleted. Around the Seychelles, CPUE's show a variable but decreasing trend for each species since the start of industrial fisheries in 1952. A similar trend is exhibited for marlins in north west Australia (another of the major historical fishing zones), noting that the CPUE of striped marlin is considerably lower than those of the other species.

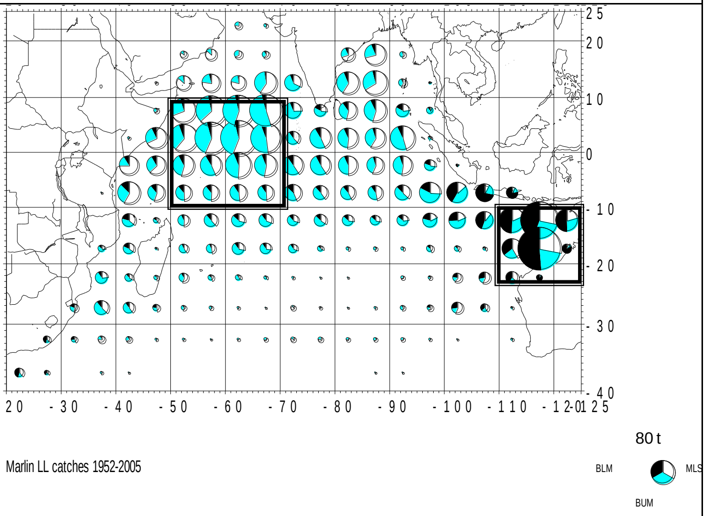


(a)



(b)

Figure 35: *(a) nominal yearly CPUE (in numbers of fishes / 1000 hooks) of Japanese longliners in the North West Australia area (10-25°S,110-125°E) for blue marlin (BUM), striped marlin (MLS) and black marlin (BLM) (b) nominal yearly CPUE (in numbers of fishes / 1000 hooks) of Japanese longliners in the area around Seychelles Islands (10°N-10°S,50-70°E) (c) average annual catches (tonnes) of marlins taken by longliners during the 1952-2005 periods, the two areas used to calculate CPUE indicators are marked by squares. From document IOTC-2008-WPB-PRES02*



(c)

39. Figure 36 illustrates an indicator for each marlin species based on the annual total of 5° squares in which at least one tonne of catch was taken. For all species, the index increased from 1952 to 1967, then declined to 1976-77. Since the late 1970's the index has been variable without trend. The black marlin index is typically lower than those of the other marlins, while the trends of blue marlin and striped marlin indices are similar. A continual decline in this indicator over time could be signalling that the stock is being depleted.

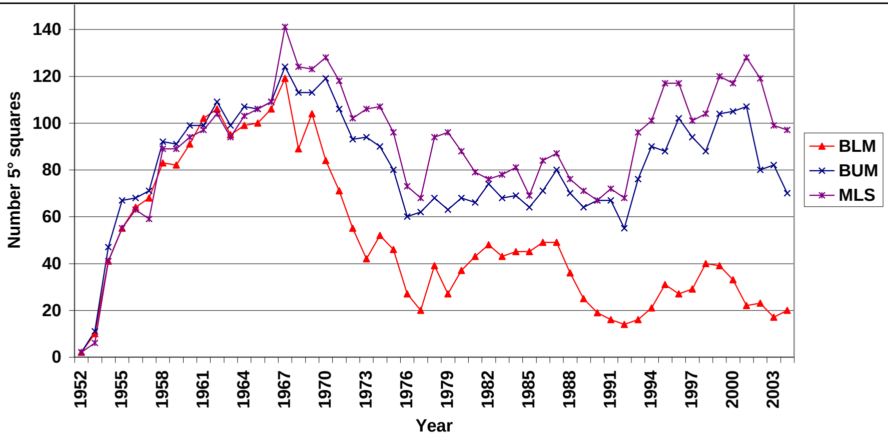
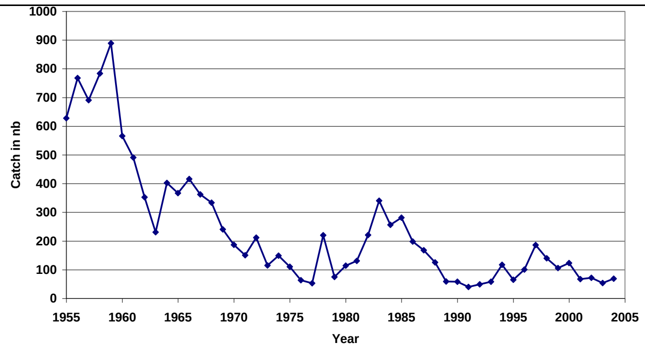


Figure 36: Number of 5° squares with a minimal catch of 1 t of black (BLM) , blue (BUM) and striped marlin (MLS) in the Indian Ocean. From document IOTC-2008-WPB-PRES02

40. Figure 37 illustrates the trends of the annual mean of the three highest monthly catches of each marlin species by Japanese longliners taken by 5° squares by month across the entire Indian Ocean. A continual decline in this indicator over time could be signalling that the stock is being depleted. Each marlin species is showing a variable but declining trend in this indicator since the start of the industrial fishery.



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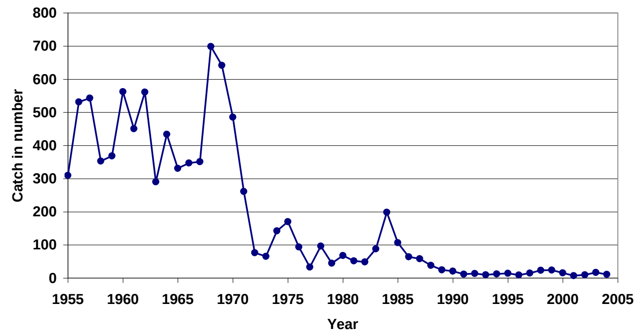
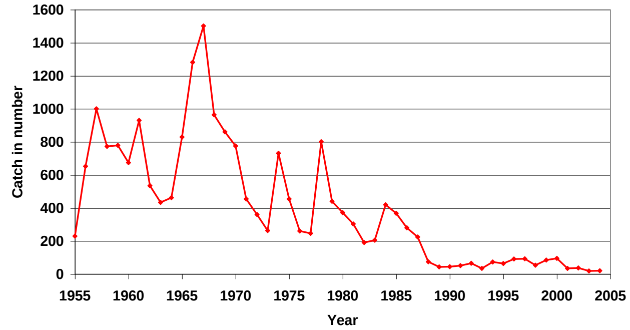


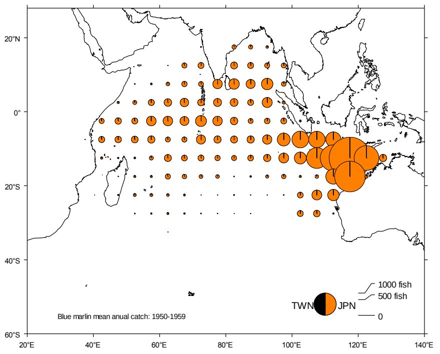
(b)

Figure 37: Annual mean of the 3 highest monthly catches of blue marlin (a) black marlin (b) and striped marlin (c)by Japanese longliners taken by 5° squares (in numbers of fishes). From document IOTC-2008-WPB-PRES02

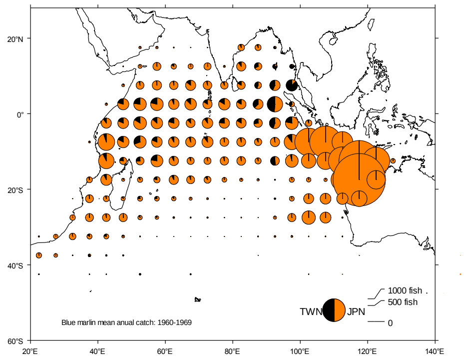


(c)

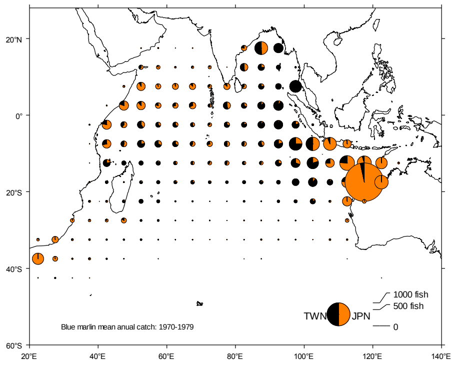
41. Figure 38 illustrates the spatial changes in mean annual catches of blue marlin over time by the major longline fleets (blue marlin is used as an example of the indicator in this instance). If the fishing is consistent from year to year, a reduction in the catches over time (as reflected by a decrease in pie sizes over time) may indicate overfishing. This, however, needs to be interpreted carefully as changes in catch levels may occur as a result of a change in fishing grounds, as is the case in the Japanese fleet from the 1990's.



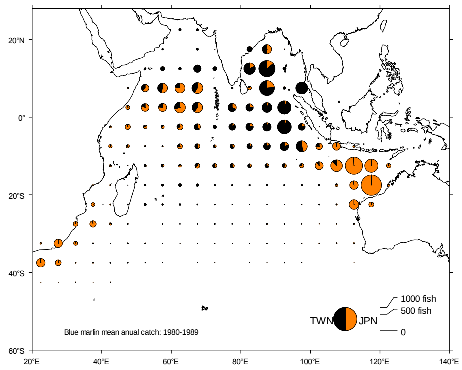
1950-1959



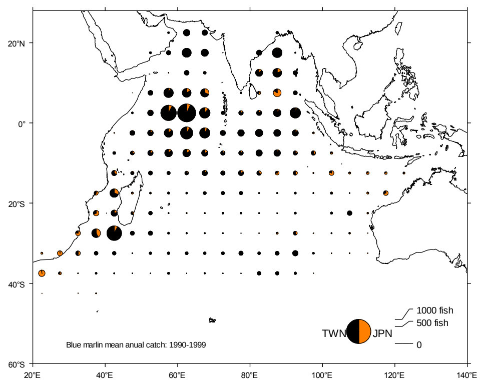
1960-1969



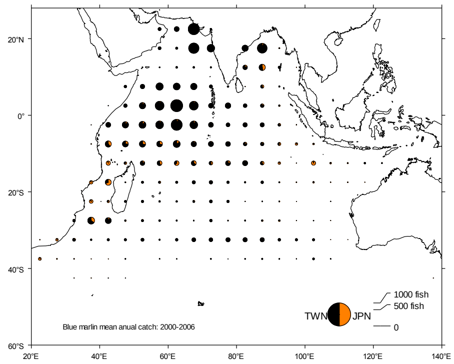
1970-1979



1980-1989



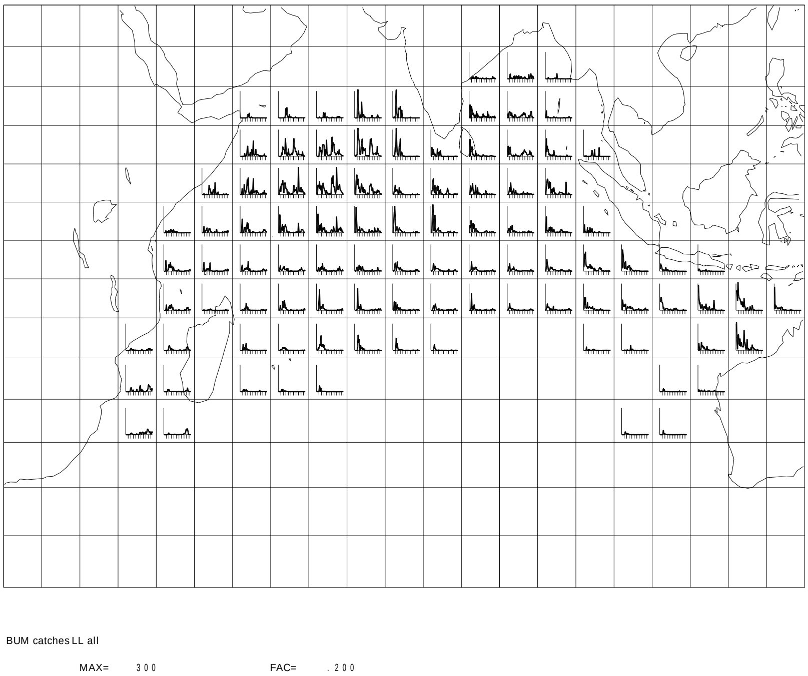
1990-1999



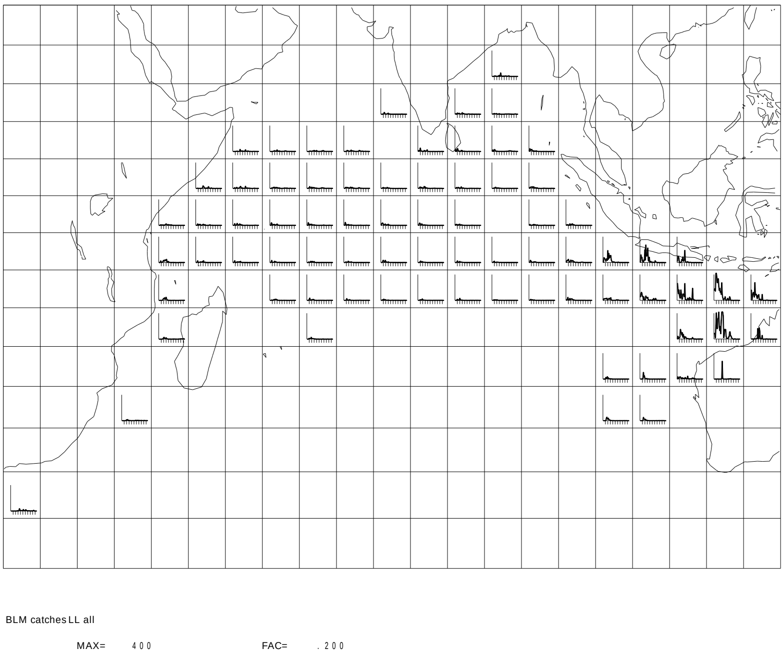
2000-2006

Figure 38: *Mean of annual total catches of blue marlin (number) by longline vessels operating in the Indian Ocean by decade over the periods 1952 to 2006. Figures produced by the Secretariat*

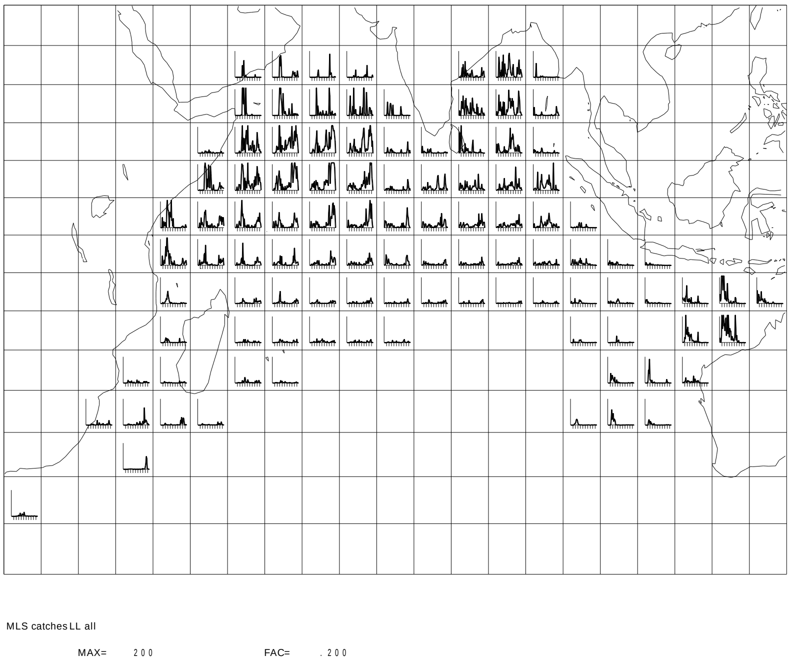
42. Figure 39 provides an overview of marlin catches reported by longliners in the Indian Ocean since the beginning of industrial fishing. This indicator is informative about the trends of catches over time in each 5deg area of the Indian Ocean. Blue marlin and striped marlin are commonly taken in equatorial waters and north of the equator whereas black marlin is most common in the eastern Indian Ocean. Catches of striped marlin appear to have decreased in eastern Indian Ocean areas while they have increased in some western areas.



Blue marlin catches in weight (maximum y axis= 100 t – note the y axis is the first bar in each histogram).



Black marlin catches in weight (maximum y axis= 400 t – note the y axis is the first bar in each histogram).



Striped marlin catches in weight (maximum y axis= 200 t – note the y axis is the first bar in each histogram)

Figure 39: *Map showing the levels of annual marlin catches reported by longliners in the indian Ocean during the 1955-2005 period. Squares are empty when average yearly catches during the period are <1 t.*

43. The WP noted that the analyses presented above were preliminary and there was considerable uncertainty about the degree to which the derived parameters represent abundance. Furthermore, while the marked declines in the marlin catches and CPUEs may correspond to major declines in biomass, they may also be due to other factors, for instance: changes in the fishing gear over time resulting in changes to catchability; changes in targeting practices, changes in fishing grounds by the fleets overtime (including the implications of exploratory fishing), changes in discarding practices whereby low value species such as marlins are not retained and reported (the value of marlins is variable but lower than many other pelagic species; striped marlin tends to be the most valuable and can reach prices around those of bigeye tuna); changes in management practices e.g. in Australia, the numbers of Japanese longliners has been limited under access agreements since the 1980's and all blue and black marlin taken alive at the time of longline retrieval are voluntarily released by Japanese crew. Furthermore, the common mis-identification of marlins is currently an overarching concern relating to available data.

44. With respect to the marlins in particular, the WP also noted that while marlins appear to concentrate for feeding and reproduction, they tend not to school. Furthermore, individual marlins can reach very large sizes, over 500 kg and sometimes as much as 1000 kg, and at these sizes, may not be attracted to small sized baits offered by longlines or sportsfishers. These characteristics of individual behaviour and food size preference may reduce their catchability to many fishing gears and as such larger marlins may be less vulnerable to fisheries than smaller marlins.

45. Notwithstanding this uncertainty in the indicators presented above, the WP acknowledged that if the above preliminary indicators did in some way represent abundance, then the abundance of marlins (and especially striped marlin and black marlin) may have been showing major declines overtime and this should be of serious concern for the IOTC.

46. In response to this possibility, the WP strongly recommended that further work be undertaken to further explore these parameters and others as stock status indicators. In particular, the WP agreed that analysis of marlin 'hot spots' (where marlins used to be caught in great numbers) and the analysis of the numbers of 5° squares fished with marlin catches showed potential, and recommended that such an analysis be undertaken before the next WP meeting. Hot spots showing apparent major declines in CPUE and in local catches of marlins should be a priority because these areas could be of major importance for the conservation of those species.

47. The WP also recommended that other catch and catch rate data, e.g. from sport and artisanal fisheries, be analysed. Trends and levels of these fisheries should be compared to those obtained from the longline fisheries data.

48. The WP was informed that a preliminary examination of the recently acquired Kenyan sportsfishery records, currently being processed and entered in to the IOTC databases, indicated some 26,000 records pertaining to sailfish. The WP noted that this dataset was likely to be one of the most informative datasets on this species available to the Commission.

49. The WP was also informed about a generous offer from African Billfish Foundation to provide a 20 years dataset including the tag / release information on marlins to the IOTC Secretariat. The WP expressed its sincere thanks to the ABF and requested that the Secretariat follow up on this offer to secure the dataset in the IOTC databases as soon as possible.

50. The WP encouraged members to analyse these new sport fishing datasets and present the results at the next WPB session.

5. STOCK ASSESSMENTS OF BILLFISH

5.1. Review of methods used for swordfish in the Pacific

51. Document IOTC-2008-WPB-PRES01 provided the WP with an update on current approaches being used for the assessment of west Pacific Ocean swordfish. In the last couple years, a range of model-based assessments have been pursued to provide advice on different management-related questions. At the simplest level, estimators of depletion and renewal have been applied to the inshore Australian fishery, in an attempt to quantify harvest rates that can be sustained without causing further decline in inshore CPUE. Spatially-structured surplus production models were explored in an attempt to link local Australian dynamics with the greater SW Pacific population. More complex assessment models (Multifan-CL and CASAL) are being used to integrate all of the fisheries and biological data in a manner that can represent many of the relevant processes, describing age-, sex-, and area-specific details of the sub-populations and their links through migration. These models will be used to formulate advice related to policies for meeting local and regional management objectives. However, it is recognized that the stock assessment methods might not deliver information at the level of precision that will be required to satisfy competing fisheries management objectives, and as such, the pursuit of management strategies that are robust to the major uncertainties is encouraged.

52. A stock assessment for swordfish was attempted by the WPB in 2008. Given the paucity of information currently available no assessment was attempted for marlin and sailfish species.

5.2. 2008 stock assessment for Swordfish

Models

53. A quantitative stock assessment was attempted for swordfish in 2008 by the WPB using a range of methods. Document IOTC-2008-WPB-12 described assessment results from Fox models (using a Stock-Production Model Incorporating Covariates (ASPIC software)). This model was subsequently re-run using revised data inputs recommended by the WPB. An alternate assessment using a Spatially-Disaggregated Pella Tomlinson surplus production model was also carried out during the meeting with some final runs being reported after the meeting concluded (IOTC-2008-WPB-09 and 09-add1). In addition an age-structured assessment model was conducted (Document IOTC-2008-WPB-PRES03).

ASPIC

54. A Stock-Production Model Incorporating Covariates (ASPIC) fits several forms of surplus-production models to catch (mass) and relative abundance data, including the Schaefer logistic model, the Fox exponential-yield model, and the Pella-Tomlinson generalised model. ASPIC uses bootstrapping to provide estimates of parameter uncertainty.

55. The ASPIC model as described in document IOTC-2008-WPB-12 originally fitted a Schaefer model and CPUE derived from three gear types (Japanese longline, Taiwanese longline and gillnet) with a catch time series for the period 1980 to 2006. After examination of the results, the Working Party recommended that the model be re-run using the Fox model, examining a range of combinations of two CPUEs (Japanese and Taiwanese longline fleets only (1980-2006 and 1992-2006) and three catch series (1952 to 2006; 1980-2006 and 1992-2006) for a total of nine models.

ASPIC Results

56. After discussion, a subset of the models i.e. A4, B4 and C1 (Table 3) was selected for further examination on the basis of the following criteria: where Bmsy ≤ 2; B2006/B1980 > 1. and F2006 ≥ 0.5 (IOTC-2008-WPB-12-add1).

57. Model C1 was rejected by the WP because it considered the catch time series to be too short i.e. it did not capture the fishery impact on the stock prior to 1990. Model A4 was rejected because the estimates of increasing population size in the early part of the fishery were inconsistent with those expected from an unfished population.

58. The ASPIC model B4 results were optimistic in terms of the current stock status of swordfish. Based on the point estimates and confidence limits, the assessment indicated that there is not likely to be overfishing of the swordfish stock occurring in Indian Ocean (Current/ FMSY < 1 – Table 3 and Figure 40) and the stock currently appears not to be in an overfished state (Current/ BMSY > 1 – Table 3 and Figure 40). However these optimistic results may have been produced to some degree by the sharp drops in catches in 2004 and 2005. Considering this, and because average catch levels in the last 12 years (31,900 t over the period 1995-2006) have been above the MSY (31,500 t: 80% confidence limits 24,500 t - 34,400 t) (Table 3), the current stock status of swordfish is likely around the MSY level and will improve if annual catches less than the MSY level continue in the future.

Table 3: *2008 swordfish stock assessment. Results of the ASPIC stock assessment in which nine scenarios were examined . Scenario B4 was adopted by the WPB . From document IOTC-2008-WPB-12-add1.*

no	Period	CPUE		Catch 2006	MSY	K	Biomass			Biomass ratio		F (***)		F ratio	RMS
		J	T3	in 1,000 tonnes			Virgin	2006	MSY (*)	2006 /1980 (**)	2006 /MSY	2006	MSY	2006 /MSY	
A1	(A)	J1	ON		32	135	60	60	50	1.00	1.23	0.46	0.64	0.72	0.17
A2	1952		OFF		30	167	127	68	61	0.54	1.13	0.40	0.49	0.82	0.17
A3	-	J3	ON		33	178	102	88	66	0.86	1.36	0.31	0.50	0.63	0.19
A4	2006		OFF		31	204	157	96	75	0.61	1.29	0.29	0.41	0.69	0.20
B1	(B)	J1	ON	27	32	126	108	55	46	0.50	1.22	0.50	0.68	0.73	0.17
B2	1980		OFF		30	148	124	59	54	0.48	1.11	0.46	0.56	0.83	0.16
B3	-	J3	ON		33	172	181	86	63	0.48	1.38	0.32	0.52	0.61	0.19
B4	2006		OFF		31	201	205	95	74	0.46	1.31	0.29	0.43	0.67	0.20
C1	(C)1992-2006	J1	ON		31	262	242	131	96	0.54	1.37	0.21	0.32	0.85	0.15

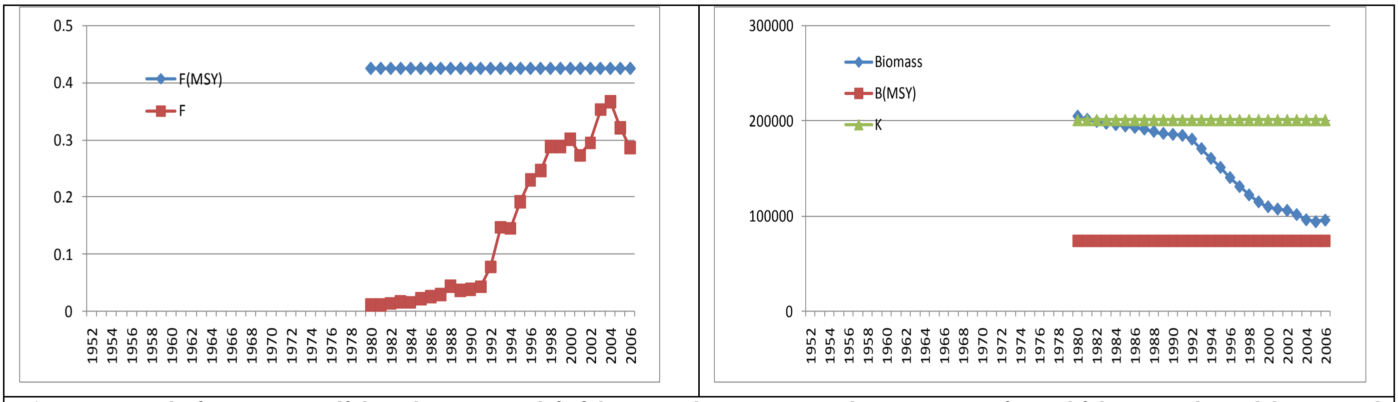


Figure 40: *Results from 2008 swordfish stock assessment (left) fishing mortality trajectories relating estimates of annual fishing mortality and the estimated maximum sustainable level of fishing mortality and (right) comparison of annual biomass estimates, estimated maximum sustainable level of biomass and annual estimates of the biomass equivalent to the carrying capacity of the population. From document IOTC-2008-WPB-12-add1*

Spatially-Disaggregated Pella-Tomlinson surplus production model

59. A spatially disaggregated Pella-Tomlinson (SDPT) surplus production model was applied to the Indian Ocean swordfish fishery as an exploratory tool to gain insight into the stock status, productivity and spatial dynamics of the population (IOTC-2008-WPB-09 and 09-add1). The models explored were similar to those employed in 2006, except that the model was divided into 4 spatial units (Figure 41), corresponding to the spatial disaggregation used to conduct the Japanese and Taiwanese CPUE standardizations. A range of model specifications were applied, to examine the following questions:

- Are the catch and CPUE abundance indices more consistent with 4 independent sub-populations (zero/low mixing rates), or one rapidly mixing population?
- Do the two additional years of data, and updated CPUE analyses since the 2006 assessment provide any additional insight into the global stock productivity?
- What are the stock status inferences and how uncertain are these inferences?

60. Six models were examined encompassing alternative assumptions relating to the following:

- mixing rates: no mixing versus high mixing (effectively a homogenous population)
- different surplus production functions: given the difficulty in reliably estimating the Pella-Tomlinson shape parameters from catch and effort data, equilibrium yield curves were derived from high and low productivity populations that are expected to bound the production dynamics of Indian Ocean swordfish.
- • Between 1 and 6 free parameters were estimated depending on the model, including Carrying capacity (K) for each area (or constant among areas), migration rate and the productivity parameter (MSY/BMSY) (the latter in one case only)

61. Other key assumptions included:

- Catch (numbers) from the entire Indian Ocean 1952-2006 is assumed to be known without error. Values reported in mass assume a constant relationship of 60kg per fish. Catch data from the aggregate Indian Ocean NEI fleet was split evenly among the 4 areas, while the other fleets should be apportioned to area correctly.
- GLM Standardised CPUE from the Japanese fleet (Case 1 in document IOTC-2008-WPB-03) is assumed to be proportional to abundance from 1980-2006 in each of the 4 sub-areas (with lognormal observation error SD = 0.2). A potential discontinuity in Japanese fishing methods around 1990 (related to set depths) was identified in 2006 and it remains questionable whether CPUE standardization is capturing this effect.
- Stock production dynamics (combined growth + recruitment – natural mortality) are deterministic, iterated on an annual time step, starting from an unfished state (and equilibrated before the first time step to account for movement dynamics).
- Movement was assumed to be a random diffusive process, with equal proportions of fish moving to each of the three other areas every time-step (as implemented, modest to high mixing essentially eliminates the importance of area-specific K).

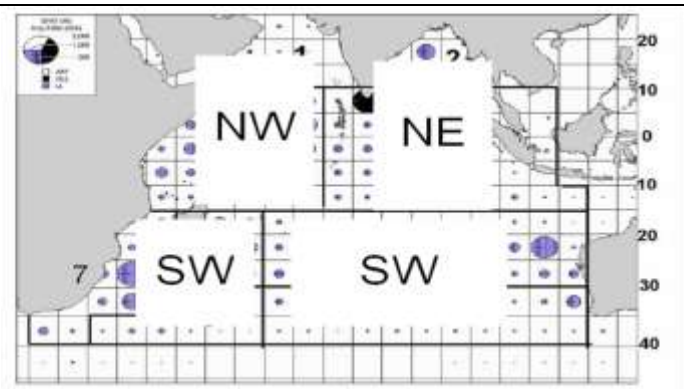


Figure 41: *2008 swordfish stock assessment. Areas used in the surplus production models. From document IOTC-2008-WPB-09.*

Table 3: *2008 swordfish stock assessment using surplus production modelling approches. Major characteristics of the models' examined. From document IOTC-2008-WPB-09-add1*

Model	Production Curve	Migration Rate (m)	Cmax	K by area	Estimated parameters
1	High	fixed-0.20	0.08	constant	Cmax, K
2	High	est.-0.33	0.12	constant	Cmax, m, K
3	High	est.-0.02	0.14	variable	Cmax, m, K1, K2, K3, K4
4	Low	fixed-0.20	0.06	constant	Cmax, K
5	Low	est.-0.33	0.09	constant	Cmax, m, K
6	Low	est-0.02	0.10	variable	Cmax, m, K1, K2, K3, K4

SDPT Results

62. The models all demonstrated a reasonable capacity to fit the disaggregated fisheries catch and CPUE data. Figure 42 illustrates the population dynamics and agreement between predictions and observations by area for model 3. Plots for both the high productivity models (1-3) and low productivity models (4-6) were qualitatively very similar so not all plots are shown.

63. All the areas have similar catch and CPUE histories and this made it difficult to resolve whether there is one effectively well mixed population of swordfish or four independent, or semi independent, populations. However, the best fitting models (models 3 and 6 according to the Log-likelihood statistics) suggest that a small amount of mixing is occurring (~2% per year). These models also suggest that the south-west area may be experiencing relatively high localised depletion. For example, Bcurrent in the SW area is estimated to be ~0.2B0, this is lower than the other regions where Bcurrent ranges from ~0.44 to 0.57B0 (Table 5).

64. While models 3 and 6 provided better fits to the data the results from these models are preliminary and should be viewed cautiously as some of the fundamental assumptions and data choices underpinning them have not been fully explored; as well the models produced some counter-intuitive results due to the interactions among the productivity and migration dynamics (refer to IOTC-2008-WPB-09-add1).

65. At this stage, the models are not expected to estimate MSY-related properties very well because, inter alia, of the difficulties estimating stock recruitment curves and natural mortality. This problem is a feature of a species, such as the Indian Ocean swordfish, which exhibit a one-way-trip history (consistently increasing catches and decreasing relative abundance indices).

66. The WPB noted the range of recommendations from the author (see IOTC-2008-WPB-09-add1) for improving a future assessment using the above approach.

67. Overall, differences in the shape parameters of the two models (High vs: Low Production Curve) had a relatively minor effect on the fit to the data and stock status results, relative to the other model assumptions explored. Estimation of K by area had the largest effect on the model fit and stock status parameters.

68. Table 4 contains a range of stock status summary statistics, and the likelihood values for the six models. The point estimates from the different models are consistent in terms of the size of the estimated biomass in 2006 compared to that in 1952 where B2006/B1952 ranged from 0.39 to 0.44. The estimates of current biomass relative to Bmsy were also consistently optimistic with B2006/BMSY ranging from 1.13 to 1.27 suggesting that the population in 2006 was not in an overfished state. The results relating to estimates of fishing mortality are divergent with point estimates of F2006/FMSY ranging from 0.87 to 2.72 with 5 of the 6 models suggesting that overfishing is occurring in the fishery (F2006/FMSY $\geq$ 1). The estimates of MSY also vary, with a range from 14,000 t to 40,000 t.

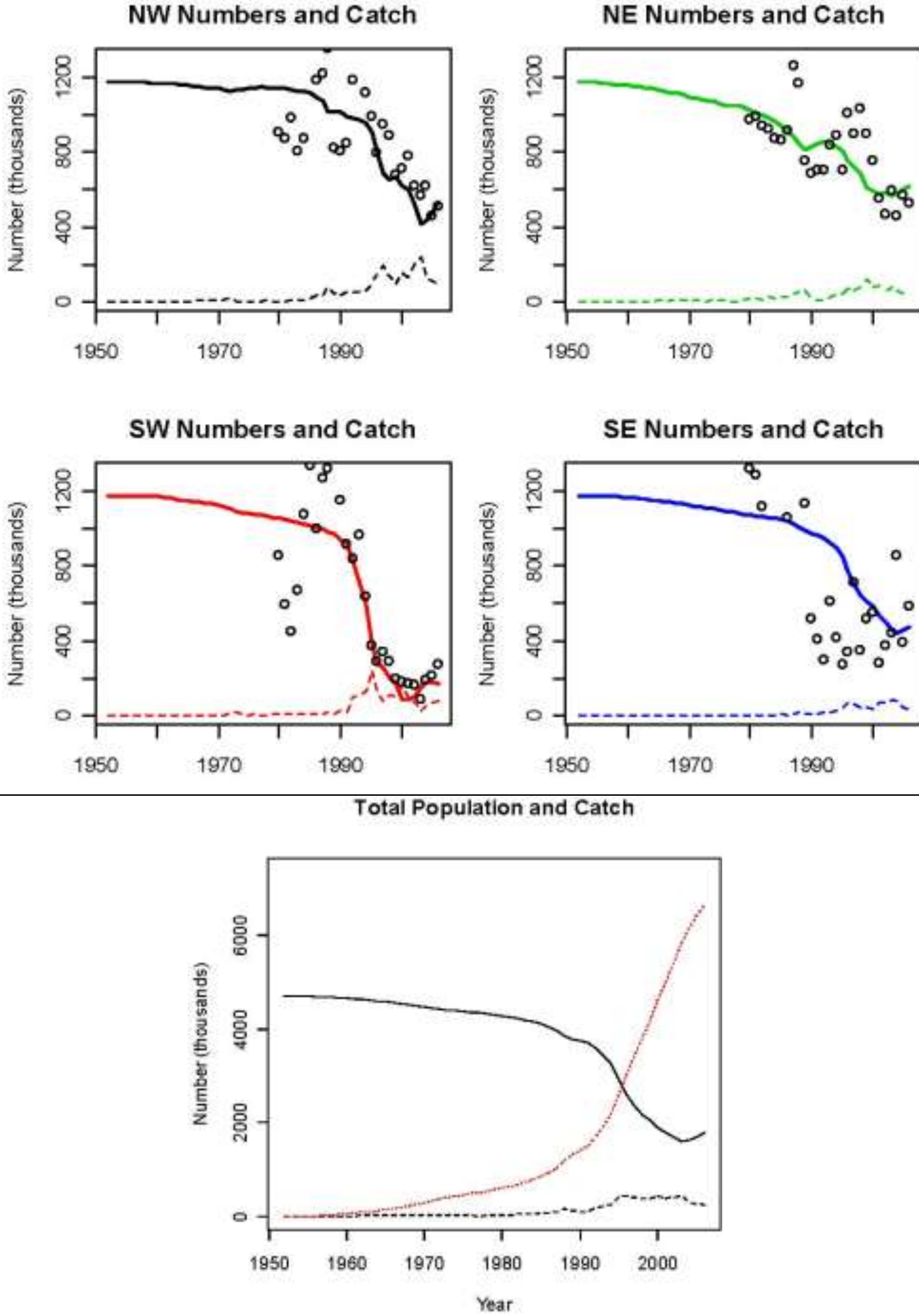


Figure 42: *Model 3 – Predicted population size (in numbers, solid lines), observed Japanese CPUE (circles, scaled by catchability), and catches (broken lines), by area (top 4 panels) and for the whole of the Indian Ocean (bottom panel). The bottom panel also includes the total aggregate catch over time (dotted line). From document IOTC-2008-WPB-09-add1*

Table 4: *2008 swordfish stock assessment using surplus production modelling approachs. Stock status reference points, and the final value of the minimized objective function for the model. From document IOTC-2008-WPB-09-add1*

Model	Production Curve	(-) Log-Likelihood	B2006 / B1952	B2006 / BMSY	F2006 / FMSY	MSY (1000 t)
1	High	251.42	0.40	1.21	2.08	18
2	High	244.15	0.43	1.27	1.79	20
3	High	152.45	0.44	1.14	0.87	40
4	Low	257.50	0.39	1.18	2.72	14
5	Low	251.96	0.41	1.25	2.12	17
6	Low	153.68	0.43	1.13	1.10	32

Table 5: *2008 swordfish stock assessment using surplus production modelling approachs. Depletion estimates for the 6 models by area. From document IOTC-2008-WPB-09-add1*

Model	B2006/B1952 NW	B2006/B1952 SW	B2006/B1952 NE	B2006/B1952 SE	B2006/B1952 combined
1	0.39	0.41	0.41	0.41	0.40
2	0.46	0.42	0.42	0.41	0.43
3	0.53	0.21	0.57	0.44	0.44
4	0.37	0.39	0.39	0.39	0.39
5	0.44	0.41	0.40	0.39	0.41
6	0.49	0.19	0.55	0.49	0.43

Age structured model

69. An age-structured assessment model aggregating sexes was conducted for evaluating the population status of the swordfish in the Indian Ocean (Document IOTC-2008-WPB-PRES03). Given the paucity of information on age and sex of Indian Ocean swordfish, the analyses were conducted with parameter estimates derived for swordfish from other oceans. The WP also noted that the selectivities for fleets and areas would need further clarification and dome shaped selectivities should be explored in the future. Overall, the results of this analysis were considered to be preliminary at this stage. Based on the results of the base-case analysis, the fleet-aggregated exploitation rate in 2006 was higher than that at which MSY is achieved and the spawning stock biomass in 2006 was about 40% of its initial level and about 2 times of that at which MSY is achieved. The result of the sensitivity analyses indicated that the estimations of the assessment model are sensitive to the values of natural mortality. Nevertheless, the least optimistic results only occurred when natural mortality and variation of recruitment were assumed to be a relatively low value (the spawning stock biomass in 2006 was remaining about 30% of its initial level but still much higher than that at which MSY is achieved). After presentation of the initial results the WP recommended that the model be re-run to examine the effects of differential weights placed on the catch at length and CPUE likelihoods. The results differed only substantially when the catch at size likelihoods were down-weighted by a factor of 1/100. In this case the Japanese CPUE trend were fitted better by the model; however the Japanese LF data was poorly fitted and the fits to the other fisheries data was not strongly influenced.

70. The WP recognised that the model approach represented a positive advance in the assessment of swordfish in the IO particularly in its attempt to use all of the biological research and data in a single integrated framework. The WP encouraged work to continue to develop the model and identify the sources of conflict in the data and model assumptions.

Uncertainties in the assessment results

71. While the stock assessments represent a further advance in the assessment of Indian Ocean swordfish considerable uncertainties remain, including:

- Uncertainty in how the CPUE index reflects relative abundance. In particular, there is a need to better understand the effects of changing gear configuration and setting practices over time and space.
- The production models used in the assessment have limited flexibility to represent many potentially important aspects of fisheries dynamics, including recruitment variability and transient age structure effects. The simple models cannot directly include additional data relating to size frequencies, sex composition or spatial dynamics.

- Unknown stock structure migration patterns and mixing rates.
- For the age structured model, the use of some life history and production parameters derived from Pacific Ocean swordfish in the Indian Ocean assessment might not be appropriate.
- The fishery has a monotonically declining CPUE and this lack of contrast makes it difficult for models to reliably distinguish between a relatively large and unproductive stock or a relatively small and productive stock. Hence the interpretation of MSY-related reference points should be treated with caution.

Summary of the assessment results

72. Results from three stock assessment approaches used on Indian Ocean swordfish were presented to the WPB in 2008. Excluding the results of the age-structured assessment, which were considered to be too preliminary at this stage, uncertainties of varying severity remain for each of the assessments conducted.

73. All models examined using the ASPM and SDPT approaches indicated that the stock was not in an overfished state (B2006/Bmsy >1) and the estimates of current biomass to virgin biomass levels were around 42% (46% for ASPM and 39 to 44% for SDPT). Despite the broad agreement on these biomass indicators, the assessments gave quite different results on fishing mortality with the SPDT indicating in 5 out of six models that overfishing was occurring; while the ASPM was more optimistic, with all models indicating that overfishing was not occurring. The WPB agreed that the results of the ASPM would be used in its advice on swordfish in 2008. However, it was recognised that the issue of possible localised depletion occurring in the SW region remains a concern, and this is not reflected in the spatially-aggregated assessment.

6. TECHNICAL ADVICE ON BILLFISH

6.1. Swordfish

74. The WPB considered a range of information in formulating its technical advice in 2008.

75. The overall standardized CPUE of swordfish for the Japanese fleet for all areas of the Indian Ocean shows a general continuous decline over the period 1980 to 2006; however, the last five years have been relatively stable. By contrast the standardized CPUE of swordfish for the Taiwanese fleet are variable but show no consistent trend.

76. The apparent fidelity of swordfish to particular areas is a matter for concern as this can lead to localised depletion. The CPUE of the Japanese fleet in the south west IO has the strongest decline of the four areas examined in 2008; furthermore, the La Reunion CPUE series shows a declining trend in this area over the last 10 years. In previous years, localised depletion was inferred on the basis of decreasing CPUEs following fine scale analyses of the catch effort data[1]. Therefore the WPB cannot discount the possibility that localised depletion is still occurring in some areas. Localised depletion has occurred in other parts of the world where swordfish have been heavily targeted.

77. The annual average sizes of swordfish in the respective Indian Ocean fisheries are variable but show no trend. It was considered encouraging that there are not yet clear signals of declines in the size-based indices, but these indices should be carefully monitored. It was noted that since females mature at a relatively large size, a reduction in the biomass of large animals could potentially have a strong effect on the spawning biomass.

78. The results of the 2008 ASPIC stock assessment were more optimistic than those from 2006. Based on the point estimates and confidence limits, on balance the assessment model results indicate that overfishing of the swordfish stock in Indian Ocean is not occurring (Fcurrent/ FMSY < 1) and the stock appears not to be in an overfished state (Bcurrent/ BMSY > 1). Recent catch levels (averaging 31,900 t per year over the five year period 2002-2006) have been around the current estimate of MSY (31,500 t, 80% confidence limits 24,500 t - 34,400 t).

79. Notwithstanding this outlook, given the existing uncertainties relating to the current assessment, the WPB considered that any increase in the catch of, or fishing effort on, swordfish should not be allowed. Furthermore, management measures focussed on controlling and/or reducing effort, especially in the south-west Indian Ocean are recommended.

[1] Refer to the 2004 report of the WPB (IOTC-2004-WPB-R)

6.2. Marlins and sailfish

80. The Secretariat provided draft Executive Summaries for the marlins and Indo-Pacific sailfish under the IOTC mandate for the consideration of the WPB (IOTC-2008-WPB-07). These summaries were based on information compiled by the Secretariat.

81. The Executive Summaries for blue marlin, black marlin, stripped marlin and Indo-Pacific sailfish (Appendix IV) were endorsed by the WPB which also recommended that they be put forward to the Scientific Committee for adoption. The WPB encouraged scientists to further contribute to the contents of these documents.

7. RESEARCH RECOMMENDATIONS AND PRIORITIES

7.1. Priorities

Response to the request from the Commission in relation to apparent localised Swordfish depletions

82. Following the presentation of the 2004 report of the Scientific Committee (IOTC-2004-SC-R) to the Commission at S9, the Commission noted (para 21) the technical recommendations made by the SC regarding the status of the swordfish resource and agreed that the issue of local depletion was serious and requested the SC to undertake area-specific analyses, with particular emphasis for the southwest Indian Ocean, for the Commission's future consideration.

83. The WP includes in its advice in 2008 its concerns about the possibility of localised depletion occurring in the south west IO area. To better understand the situation in the SW IO, the WP recommended that the La Reunion CPUE be standardised, and that that changes in standardised CPUE trends be interpreted alongside size data. In addition, the WP began to develop new tools (e.g. a spatially disaggregated production model) to examine further this issue. In 2008 the results were preliminary but further development of the model should be a priority for the future. The WP noted that tagging of swordfish would provide direct estimates of movement and mixing rates of swordfish and would help to determine the degree to which localized depletion might be occurring. Conventional and electronic tagging programmes were encouraged.

7.2. Recommendations to improve the data available to IOTC

1. Improve the catch and effort data from artisanal fisheries, by:

- Members having artisanal fisheries for swordfish and marlins, notably Sri Lanka, to improving their collection and reporting of species and gear information.
- Members having artisanal fisheries for sailfish, notably Iran , Oman India and Pakistan, to providing catch and effort data for those fisheries
- Members increasing sampling coverage to obtain acceptable levels of precision in their catch and effort statistics.

2. Improve the recovery of existing catch and effort data from sport fisheries, by:

- The Secretariat to identify the major sports fishing bodies in the Indian Ocean and approach them regarding access to any available data sets.
- The Secretariat to make a special request to members in this year's SC meeting reminder to integrate analyses of sport fisheries data in their National Reports.

3. Improve the catch and effort data from industrial fisheries by:

- Members having industrial fisheries for swordfish, marlins and sailfish to improving their collection and reporting of species information. This should include tools to assist fishers and data collectors to correctly identify billfish species
- The Republic of Korea improving the consistency of its catch and effort statistics.
- Indonesia and Taiwan,China collecting and reporting catch and effort data for their fresh tuna longliner fleets.

- The EC-Spain LL to provide catches of marlins and sailfish by time and area strata.
- The UK long line fleet to provide catch and effort for all species.
- Members reporting on IOTC species taken as bycatch.
- Members ensuring that log book coverage is appropriate to produce acceptable levels of precision in their catch and effort statistics.
- Members with observer programmes to analyse the data collected to estimate retained catches and discards and the precision of these estimates.

4. Increase the amount of size data available to the Secretariat by:

- The EC and India collecting and reporting size data for their longline fleets, notably for marlins and sailfish.
- Taiwan,China collecting and providing size data from their fresh tuna longliners.
- Japan increasing size sampling coverage from its longline fleet.
- Members having sport fisheries collecting and reporting size data to the Secretariat.
- Members collecting and reporting size data for artisanal fisheries for billfish, in particular gillnet fisheries of Iran, India and Pakistan.
- Members reviewing their existing sampling schemes to ascertain that the data collected are representative of their fisheries and provide the results to the Secretariat.

5. Reduce uncertainty in the following biological parameters important for the assessment of stock status of IOTC species by:

- Conversion relationships: Members submitting to the Secretariat the basic data that would be used to establish length-age keys, length-weight keys, processed weight-live weight keys for billfish species.
- Obtaining sex ratio information by size and area.
- Analysis of the apparent stability in the catch size data and whether the existing data are representative of the fishery.

7.3. Research recommendations

1) Swordfish stock structure and migratory range — using genetics techniques: The WPB encourages IOTC members to participate or contribute to the planned IOSSS project as much as possible, in particular in the collection of samples for analysis by the project. Samples from northern areas of the Indian Ocean are of particular importance.

2) Swordfish stock structure and movement rates — using tagging techniques: Including:

- Scientific tagging, primarily with electronic tags
- Encouraging longline fishermen and observers to tag small swordfish and where possible mark fish with OTC.
- Use the existing momentum for tag recovery process under the RTTP-IO
- Collaborate with the (pop up) tagging initiatives of SWIOFP and MADE.

3) Swordfish growth: The WPB recommended researchers to undertake growth studies and report on these regularly to the WPB. This should include opportunistic tagging and OTC work (i.e. for age validation studies – see growth below), comparisons of methods and results from previous studies (e.g. the study by IFREMER in La Reunion in 1999-2001).

4) Size data analyses: Conversion of lengths to ages using different assumptions on sex ratios at size/age for the Taiwanese, Japan and EC fleets size data.

5) Stock status indicators: Further research is recommended concerning the definition and estimation of stock indicators that reflect the status of stocks of billfish species.

The WP requested the Secretariat to coordinate the exploration of indicators from available data and report these to the next meeting of the WPB. This work should include the types of analyses given in Section 3.

6) **CPUE Standardization**:

- Examine the relationship between the number of hooks per basket and hook depth
- Improving the definition of variables that could be used as a proxy for targeting. In addition to hooks per basket considerations, this should include examining the effects of set-times, moon-phase, light-sticks, bait-types and species composition.
- Examine methods to better account for the influence of zero catches in CPUE analyses
- Consideration of alternative ways of combining area-specific indices into a global index using different weighting schemes. Consider alternative methods of estimating fish densities in areas across the species range that have not been fished consistently over time.
- Continue the work on integration of environmental factors – validation for factors such as sheer currents. Catch rate data should be examined at a fine scale, particularly in relation to oceanographic variability that is available at a fine scale.
- Use of same space and time scales

Given the importance of these recommended actions to the swordfish assessment, the WPB encourages a collaborative approach to the work be taken.

Efforts should be made to provide additional CPUE series from other fisheries (e.g. La Réunion, Seychelles) for the next WPB.

7) **Stock assessment:** Further development of stock assessment models for swordfish in particular, production models, spatial models – including models that examine localised depletion, age structured models and habitat-based models.

8) **Research on Istiophorids:** The WPB recommended that the following research on istiophorids be undertaken.

- In collaboration with sports fishing bodies, the collection of biometric and morphometric data.
- Increased tagging of billfish in the Indian Ocean should be encouraged on an opportunistic basis.
- Popup satellite tagging experiments should be conducted on an opportunistic basis on blue, black and striped marlins to provide information on biology, including long-term vertical behaviour, movement and mixing rates. Collaboration with relevant SWIOFP initiatives should be explored

8. OTHER BUSINESS

84. None.

9. ADOPTION OF THE REPORT

85. The Report was adopted in the main on Friday 11 July 2008 and finalised by correspondence on 28 September 2008. Thanks were conveyed to Seychelles Fishing Authority for the use of the SFA Training Room.

APPENDIX I
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APPENDIX II

AGENDA OF THE MEETING

1. OPENING OF THE MEETING

2. ADOPTION OF THE AGENDA

3. REVIEW OF THE DATA

- Review of the statistical data available for the billfish species (Secretariat)

4. INFORMATION ON BIOLOGY, ECOLOGY AND FISHERIES OCEANOGRAPHY RELATING TO BILLFISH

- Review new information on the biology, stock structure of billfish, their fisheries and associated environmental data
  Papers as provided by Members

5. REVIEW OF NEW INFORMATION ON THE STATUS OF BILLFISH

- Stock status indicators for marlins, sailfish and swordfish.
  - C*atch and effort*
  - *CPUE*
  - *Changes in fishing area*
  - *Trends in size distributions of the catch*
- Stock assessments
  - Assessment methods
  - Any new assessments on billfish species
- Selection of Stock Status indicators and Likely future trends under alternative exploitation scenarios

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6. DEVELOP TECHNICAL ADVICE ON THE STATUS OF THE STOCKS

- Marlins – new Executive Summary
- Sailfish – new Executive Summary
- Swordfish – update the Executive Summary

7. RESEARCH RECOMMENDATIONS AND PRIORITIES

8. **OTHER BUSINESS**

APPENDIX III

LIST OF DOCUMENTS

Document	Title
IOTC-2008-WPB-01	Draft agenda of the Working Party on Billfish
IOTC-2008-WPB-02	WPB List of documents
IOTC-2008-WPB-03	Standardization of swordfish CPUE of the Japanese tuna longline fisheries in the Indian Ocean. (1980- 2006 and 1992-2006) *Yasuko Semba, Tom Nishida and Sheng-Pin Wang*
IOTC-2008-WPB-04	Current status of French longline fishery in the Indian Ocean focus on billfish data - *Jérôme Bourjea, and Hugues Evano*.
IOTC-2008-WPB-05	Activity of the Spanish surface longline fleet targeting swordfish (*Xiphias gladius*) in the Indian Ocean for the period 2003-2006. *B. García-cortés, a. Ramos-cartelle, J. Mejuto*
IOTC-2008-WPB-06	Standardized catch rates in biomass for the swordfish (Xiphias gladius) caught by the Spanish longline fleet in the Indian Ocean for the period 1993-2007. *J. Mejuto, B. García-Cortés, A. Ramos-Cartelle*
IOTC-2008-WPB-07	DRAFT Executive summaries for black marlin, blue marlin, striped marlin and Indo-Pacific sailfish. *Secretariat*
IOTC-2008-WPB-08	Status of IOTC databases for billfish. *IOTC Secretariat*
IOTC-2008-WPB-09	A Flexible Spatially-Disaggregated Production Model for Exploratory Assessment of Indian Ocean swordfish. *Dale Kolody*
IOTC-2008-WPB-09-add1	A Flexible Spatially-Disaggregated Production Model for Exploratory Assessment of Indian Ocean Swordfish - updated. *Dale Kolody*
IOTC-2008-WPB-10	CPUE standardization of swordfish (*Xiphias gladius*) caught by Taiwanese longline fishery in the Indian Ocean. *Sheng-Ping Wang, Yasuko Semba, and Tom Nishida*
IOTC-2008-WPB-11	New environmental information (NCEP) applied for standardized swordfish CPUE of tuna longline fisheries (Japan and Taiwan) in the IOTC WPB6. *Tom Nishida, Hiroshi Matsuura and Francis Marsac*
IOTC-2008-WPB-12	Preliminary stock assessment of swordfish (Xiphias gladius) in the Indian Ocean by A Stock-Production Model Incorporating Covariates (ASPIC). *Tom Nishida and Yasuko Semba*
IOTC-2008-WPB-12-add1	Addendum to Preliminary stock assessment of swordfish (*Xiphias gladius*) in the Indian Ocean by A Stock-Production Model Incorporating Covariates (ASPIC). *Tom Nishida and Yasuko Semba*
IOTC-2008-WPB-13	Notes on the standardized swordfish CPUE of tuna longline fisheries (Japan and Taiwan) in WPB6 (1980-2006 and 1992-2006) Tom Nishida
IOTC-2008-WPB-14	Fisheries Indicators for billfish. IOTC Secretariat
IOTC-2008-WPB-15	Congruency between microsatellite and mitochondrial DNA analyses of swordfish (Xiphias gladius) population structure in the southwest Indian Ocean: importance in a way of stock assessment. *Delphine Muths & Jerome Bourjea*
IOTC-2008-WPB-16	Status Of Seychelles Semi Industrial Longline Fishery. *Juliette Dorizo, Cindy Assan, Nanet Bristol*
IOTC-2008-WPB-PRES1	Stock assessment of swordfish in the Pacific Ocean. *D. Kolody*
IOTC-2008-WPB-PRES2	Stock status indicators for billfish – a compliation of presentations: *Alain Fonteneau*
IOTC-2008-WPB-PRES3	Age structured stock assessment for swordfish. *Sheng Ping Wang*
IOTC-2008-WPB-INF01	Methods for standardizing CPUE and how to select among them. *Hinton and Maunder*
IOTC-2008-WPB-INF02	Preliminary results of standardization of swordfish CPUE of Taiwanese and Japanese tuna longline fisheries in the Indian Ocean (1980- 2006 and 1990-2006) (*)- Preliminary report for the IOTC WPB6. *Semba, Nishida, Wang*
IOTC-2008-WPB-INF03	Forage fauna in the diet of three large pelagic fishes (lancetfish, swordfish and yellowfin tuna) in the western equatorial Indian Ocean. *Michel Potier, Francis Marsac, Yves Cherel , Vincent Lucas, Richard Sabati´, Olivier Maury, Fr´ed´eric M´enard*
IOTC-2008-WPB-INF04	Notes on the standardized swordfish CPUE of tuna longline fisheries (Japan and Taiwan) in WPB6 (1980-2006 and 1992-2006). *Tom Nishida*

APPENDIX IV

DRAFT EXECUTIVE SUMMARIES FOR MARLINS AND INDO-PACIFIC SAILFISH

DRAFT Executive summary of the status of black marlin

(as revised by the IOTC Working Party on Billfish, July 2008)

BIOLOGY

Black marlin (*Makaira indica*) is mainly found in the tropical and subtropical waters of the Pacific and the Indian Oceans. Individuals have been reported in the Atlantic Ocean but there is no information to indicate the presence of a breeding stock in this area. Black marlin is mainly found in oceanic surface waters above the thermocline and typically near land masses, islands, coral reefs etc; however, they may range to depths of 1000 m.

Little is known on the biology of the black marlin in the Indian Ocean. In other oceans, black marlin can grow up to 4.5 m long and weigh 750kg. Young fish grow very quickly in length then put on weight later in life. In eastern Australian waters black marlin grows from 13 mm long at 13 days old to 1800 mm and around 30 kg after 13 months. Males are in general smaller than females.

Sexual maturity is attained at around 100kg for the females and 50 to 80 kg for males, no spawning grounds have been identified but in Australia spawning individuals apparently prefer water temperatures around 27-28°C. Females may produce up to 40 million eggs.

FISHERIES

Black marlin is caught mainly by longliners and gillnetters in the Indian Ocean. Minimum catch estimates have been derived from very small amounts of information and are therefore highly uncertain. Difficulties in the identification of marlins also contribute to the uncertainties of the information available to the Secretariat.

The minimum average annual catch estimated for the period 2002 to 2006 is around 3,300 t. In recent years, the fleets of Taiwan,China (longline), Sri Lanka (gillnet) and India (gillnets) are attributed with the highest catches of black marlin.

AVAILABILITY OF INFORMATION FOR STOCK ASSESSMENT

There is no reliable information on the catches of black marlin and no information on the stock structure or growth and mortality of black marlin in the Indian Ocean. Furthermore, there is little information from which fishery indicators can be derived. For example:

1. **Trends in catches**: catch estimates for black marlin are highly uncertain. Available catch data varies from year to year and mis-identification of marlins is probably common.
2. **Nominal CPUE Trends:** data is available from several fleets (mainly longline) and time periods but this species is not targeted therefore interpretation of catch rates may be problematic as they are likely to be affected by changes in the fisheries targeting other species.
3. **Average weight of fish in the catch:** the average weight of fish is derived from various weight and length information. The reliability of average weight estimates is reduced when relatively few fish out of the total catch are measured.
4. **Sex ratio:** such data are not available to the Secretariat
5. **Lengths of fish being caught –** fish size is derived from various length and weight information. The reliability of the size data is reduced when relatively few fish out of the total catch are measured.
6. **Number of squares fished:** such data are not available to the Secretariat.

No quantitative stock assessment on black marlin in the Indian Ocean is known to exist and no such assessment has been undertaken by the IOTC Working Party on Billfish.

MANAGEMENT ADVICE

No quantitative stock assessment is currently available for black marlin in the Indian Ocean, and due to a paucity of data there a no stock indicators that are considered to be reliable, therefore the stock status is uncertain.

DRAFT Executive summary of the status of the blue marlin

(as revised by the IOTC Working Party on Billfish, July 2008)

BIOLOGY

Blue marlin[2] (*Makaira nigricans*) is found throughout the tropical and subtropical regions of the Pacific, Indian and Atlantic Oceans. Blue marlin is a solitary species and prefers the warm offshore surface waters (>24°C); it is scarce in waters less than 100m or close to land.

A highly migratory species, the blue marlin is known to make regular seasonal migrations, (in the Atlantic Ocean) moving toward the equator in winter and away again in summer. In the Pacific Ocean one tagged blue marlin is reported to have travelled 3000nm in 90 days.

Blue marlin may live up to 28 years. Females are typically grow larger than males, some attaining over 4 m and exceeding 900 kg. Males grow more slowly than females and generally do not exceed 3 m or 200 kg.

Sexual maturity is attained at between 2 and 4 years of age. A large female can produce in excess of 10 million eggs. Blue marlin is a serial spawner and in some environments females may spawn all year round.

FISHERIES

Blue marlin is caught mainly by longliners and gillneters in the Indian Ocean. Minimum catch estimates have been derived from very small amounts of information and are therefore highly uncertain. Difficulties in the identification of marlins also contribute to the uncertainties of the information available to the Secretariat.

The minimum average annual catch estimated for the period 2002 to 2006 is around 11,700 t. In recent years, the fleets of Taiwan,China (longline), Indonesia (longline), Sri Lanka (gillnet) and India (gillnet) are attributed with the highest catches of blue marlin.

AVAILABILITY OF INFORMATION FOR STOCK ASSESSMENT

There is no reliable information on the catches of blue marlin and no information on the stock structure or growth and mortality of blue marlin in the Indian Ocean. Furthermore, there is little information from which fishery indicators can be derived. For example:

1. **Trends in catches**: catch estimates for blue marlin are highly uncertain. Available catch data varied from year to year and mis-identification of marlins is probably common.
2. **Nominal CPUE Trends:** data is available from several fleets (mainly longline) and time periods but this species is not targeted therefore interpretation of catch rates may be problematic as they are likely to be affected by changes in the fisheries targeting other species.
3. **Average weight of fish in the catch:** the average weight of fish is derived from various weight and length information. The reliability of average weight estimates is reduced when relatively few fish out of the total catch are measured.
4. **Sex ratio:** such data are not available to the Secretariat
5. **Lengths of fish being caught –** fish size is derived from various length and weight information. The reliability of the size data is reduced when relatively few fish out of the total catch are measured.
6. **Number of squares fished:** such data are not available to the Secretariat.

No quantitative stock assessment on blue marlin in the Indian Ocean is known to exist and no such assessment has been undertaken by the IOTC Working Party on Billfish.

MANAGEMENT ADVICE

No quantitative stock assessment is currently available for blue marlin in the Indian Ocean, and due to a paucity of data there a no stock indicators that are considered to be reliable, therefore the stock status is uncertain.

[2] Some scientists consider that blue marlin comprises two different species, *M. mazara* and *M. nigricans* based on differences in the lateral line. More commonly, however, these two species are lumped together as a single species.

DRAFT Executive summary of the status of the striped marlin

(as revised by the IOTC Working Party on Billfish, July 2008)

BIOLOGY

The striped marlin (*Tetrapturus audax*) occurs in both the Pacific and Indian Oceans. Its distribution is different from other marlins in that it prefers more temperate or cooler waters and tends to be less migratory. Striped marlin is rarely found in the Atlantic Ocean. In the Indian Ocean seasonal concentrations of striped marlin occur in four main regions: off the east African coast (0º-10ºS), the south and western Arabian Sea, the Bay of Bengal, and north-western Australian waters.

Striped marlins may live up to 10 years and are relatively fast growing. The larger individuals may exceed 3 m long and 240 kg. Striped marlin is the smallest of the marlin species; but unlike the other marlin species, striped marlin males and females grow to a similar size.

Sexual maturity is attained at between 2 and 3 years of age and a large female can produce in excess of 20 million eggs. Unlike the other marlins which are serial spawners, striped marlin appear to spawn once per season

Striped marlin belong to the genus *Tetrapturus* whereas black and blue marlins belong to the genus *Makaira*. Stripped marlins can be distinguished from the blue and black marlins by a range of morphological and genetic characteristics; however, the distinction between the striped marlin and the white marlin (*T. albidus*) is apparently less clear and is the subject ongoing debate among scientists.

The stock structure of striped marlin in the Indian Oceans is uncertain.

FISHERIES

Striped marlin is caught mainly by longliners in the Indian Ocean. Minimum catch estimates have been derived from very small amounts of information and are therefore highly uncertain. Difficulties in the identification of marlins also contribute to the uncertainties of the information available to the Secretariat.

The minimum average annual catch estimated for the period 2002 to 2006 is around 3,100 t. In recent years, the fleets of Taiwan,China (longline) and to a lesser extent Indonesia (longline) are attributed with the highest catches of striped marlin.

AVAILABILITY OF INFORMATION FOR STOCK ASSESSMENT

There is no reliable information on the catches of striped marlin and no information on the stock structure or growth and mortality of striped marlin in the Indian Ocean. Furthermore, there is little information from which fishery indicators can be derived. For example:

1. **Trends in catches**: catch estimates for striped marlin are highly uncertain. Available catch data varied from year to year and mis-identification of marlins is probably common.
2. **Nominal CPUE Trends:** data is available from several fleets (mainly longline) and time periods but this species is not targeted therefore interpretation of catch rates may be problematic as they are likely to be affected by changes in the fisheries targeting other species.
3. **Average weight of fish in the catch:** the average weight of fish is derived from various weight and length information. The reliability of average weight estimates is reduced when relatively few fish out of the total catch are measured.
4. **Sex ratio:** such data are not available to the Secretariat
5. **Lengths of fish being caught –** fish size is derived from various length and weight information. The reliability of the size data is reduced when relatively few fish out of the total catch are measured.
6. **Number of squares fished:** such data are not available to the Secretariat.

No quantitative stock assessment on striped marlin in the Indian Ocean is known to exist and no such assessment has been undertaken by the IOTC Working Party on Billfish.

MANAGEMENT ADVICE

No quantitative stock assessment is currently available for striped marlin in the Indian Ocean, and due to a paucity of data there a no stock indicators that are considered to be reliable, therefore the stock status is uncertain.

DRAFT Executive summary of the status of the Indo-Pacific sailfish

(as revised by the IOTC Working Party on Billfish, July 2008)

BIOLOGY

Indo-Pacific sailfish[3] (*Istiophorus platypterus*) is found throughout the tropical and subtropical regions of the Pacific and the Indian Oceans. It is mainly found in surface waters above the thermocline, close to coasts and islands. Indo–Pacific sailfish is a highly migratory species and renowned for its speed and (by recreational fishers) for its jumping behaviour — one individual has been reported swimming at speeds in excess of 110 km/h over short periods.

In the Indian Ocean, some sailfish make regular seasonal migrations to Arabian Gulf waters, aggregating around October to April each year before moving northwest into Iranian waters. It is not known, however, where the population goes over the period from July to September.

The Indo-Pacific sailfish is one of the smallest-sized billfish species, but is relatively fast growing. Individuals may grow to over 3 m and up to 100kg, and live to around 7 years.

The stock structure of Indo-Pacific sailfish in the Indian Oceans is uncertain.

FISHERIES

Indo-Pacific sailfish is caught mainly by gillnets and to a much lesser extent by troll and handlines, and longlines. This species is also a reknown catch for sport fisheries, e.g off Kenya.

Minimum catch estimates have been derived from very small amounts of information and are therefore highly uncertain. Unlike the other billfish, sailfish are probably more reliably identified because of the large and distinctive first dorsal fin that runs most of the length of the body.

The minimum average annual catch estimated for the period 2002 to 2006 is around 24,000 t. In recent years, the countries attributed with the highest catches of Indo-Pacific sailfish are situated in the Arabian Sea and are Iran, Sri Lanka, India and Pakistan. Smaller catches are reported for line fishers in Comores and Mauritius and by Indonesia longliners.

AVAILABILITY OF INFORMATION FOR STOCK ASSESSMENT

There is no information on the stock structure of Indo-Pacific sailfish in the Indian Ocean, and no information on age and growth information in the Indian Ocean. Possible fishery indicators:

1. **Trends in catches**: catch estimates for Indo-Pacific sailfish are highly uncertain and there is little information available for the years prior to 1970. However, catches appear to have been rapidly increasing since the mid 1980's.
2. **Nominal CPUE Trends:** few data are available, furthermore this species is not generally targeted therefore interpretation of catch rates may be problematic as they are likely to be affected by changes in the fisheries targeting other species .
3. **Average weight in the catch by fisheries:** few data are available to the Secretariat.
4. **Sex ratio:** such data are not available to the Secretariat
5. **Number of squares fished:** such data are not available to the Secretariat.

No quantitative stock assessment on Indo-Pacific sailfish in the Indian Ocean is known to exist and no such assessment has been undertaken by the IOTC Working Party on Billfish.

MANAGEMENT ADVICE

No quantitative stock assessment is currently available for Indo-Pacific sailfish in the Indian Ocean, and due to a paucity of data there a no stock indicators that are considered to be reliable, therefore the stock status is uncertain.

[3] There is some debate on whether there is a single worldwide sailfish species, *I. Platypterus*; or two species, being an Indo–Pacific sailfish (*I. platypterus*) and an Atlantic species *I. albicans*.