DRAFT: EXECUTIVE SUMMARY: SWORDFISH

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

Status of the Indian Ocean swordfish (SWO: *Xiphias gladius*) resource

TABLE 1. Swordfish: Status of swordfish (*Xiphias gladius*) in the Indian Ocean

Area[1]	Indicators		2013 stock status determination
Indian Ocean	Catch 2012: Average catch 2008–2012:	26,184 t 24,545 t	
	MSY (4 models): F_{2009}/F_{MSY} (4 models): SB_{2009}/SB_{MSY} (4 models): SB_{2009}/SB_0 (4 models):	29,900–34,200 t 0.50–0.63 1.07–1.59 0.30–0.53	

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

Colour key	Stock overfished ($SB_{year}/SB_{MSY} < 1$)	Stock not overfished ($SB_{year}/SB_{MSY} \geq 1$)
Stock subject to overfishing ($F_{year}/F_{MSY} > 1$)		
Stock not subject to overfishing ($F_{year}/F_{MSY} \leq 1$)		

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

Stock status. All models suggest that the stock is above, but close to a biomass level that would produce MSY and current catches are below the MSY level. MSY-based reference points were not exceeded for the Indian Ocean population as a whole ($F_{2009}/F_{MSY} < 1$; $SB_{2009}/SB_{MSY} > 1$). Spawning stock biomass in 2009 was estimated to be 30–53% (from Table 1; Fig. 1) of the unfished levels. The most recent catch estimate of 26,184 t in 2012 indicate that the stock status is unlikely to have changed. Thus, the stock remains not overfished and not subject to overfishing. However, recent revisions to the catch history for swordfish make it timely for a new stock assessment to be undertaken in 2014.

Outlook. The decrease in longline catch and effort in recent years has lowered the pressure on the Indian Ocean stock as a whole, indicating that current fishing mortality would not reduce the population to an overfished state. There is a low risk of exceeding MSY-based reference points by 2019 if catches reduce further or are maintained at current levels until 2019 (<11% risk that $B_{2019} < B_{MSY}$, and <9% risk that $F_{2019} > F_{MSY}$) (Table 2). The following key points should be noted:

- the Maximum Sustainable Yield estimate for the whole Indian Ocean is 29,900–34,200 t (range of best point estimates from Table 2) and annual catches of swordfish should not exceed this estimate.
- if the recent declines in effort continue, and catch remains substantially below the estimated MSY of 30,000–34,000 t, then management measures are not required which would pre-empt current resolutions and planned management strategy evaluation. However, continued monitoring and improvement in data collection, reporting and analysis is required to reduce the uncertainty in assessments.
- the Kobe strategy matrix illustrates the levels of risk associated with varying catch levels over time and could be used to inform management actions.
- advice specific to the southwest region is provided below, as requested by the Commission.
- provisional reference points: Noting that the Commission in 2012 agreed to Recommendation 12/14 *on interim target and limit reference points*, the following should be noted:
    a. **Fishing mortality**: Current fishing mortality is considered to be below the provisional target reference point of F_{MSY}, but below the provisional limit reference point of $1.4*F_{MSY}$ (Fig. 1).
    b. **Biomass**: Current spawning biomass is considered to be above the target reference point of SB_{MSY}, and therefore above the limit reference point of $0.4*SB_{MSY}$ (Fig. 1).

TABLE 2. Swordfish: Aggregated Indian Ocean assessment - Kobe 2 Strategy Matrix, indicating a range of probabilities across four assessment approaches. Probability (percentage) of violating the MSY-based reference points for five constant catch projections (2009 catch level, ± 20% and ± 40%) projected for 3 and 10 years.

Reference point and projection timeframe	**Alternative catch projections (relative to 2009) and probability (%) of violating reference point**				
	60% (12,502 t)	**80%** (16,670 t)	**100%** (20,837 t)	**120%** (25,004 t)	**140%** (29,172 t)
$B_{2012} < B_{MSY}$	0–4	0–8	0–11	2–12	4–16
$F_{2012} > F_{MSY}$	0–1	0–2	0–9	0–16	6–27
$B_{2019} < B_{MSY}$	0–4	0–8	0–11	0–13	6–26
$F_{2019} > F_{MSY}$	0–1	0–2	0–9	0–23	7–31

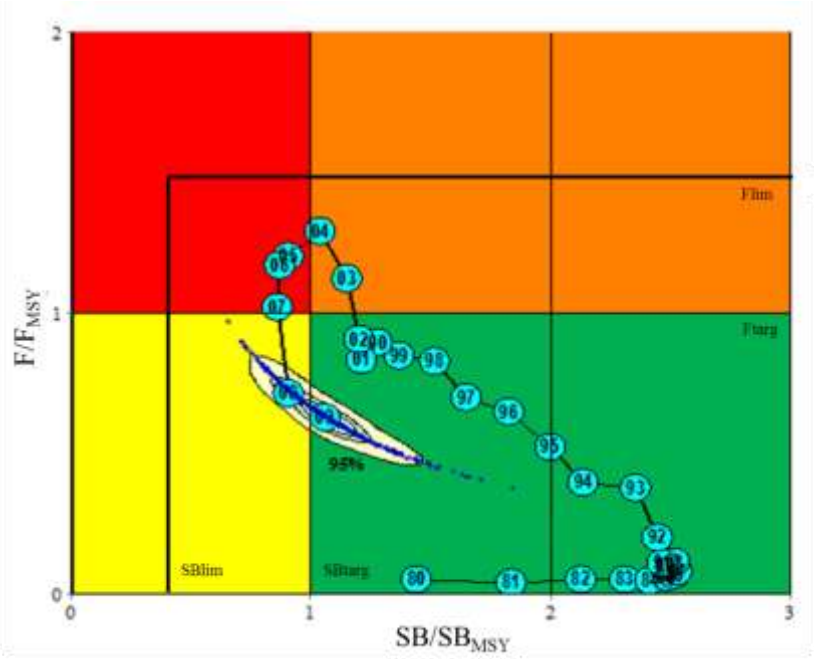

Fig. 1. Swordfish: ASPIC Aggregated Indian Ocean assessment Kobe plot (95% Confidence surfaces shown around 2009 estimate). Blue circles indicate the trajectory of the point estimates for the SB ratio and F ratio for each year 1950–2010. Target (Ftarg and SBtarg) and limit (Flim and SBlim) reference points are shown.

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Status of the southwest Indian Ocean swordfish (SWO: *Xiphias gladius*) resource

TABLE 3. Swordfish: Status of swordfish (*Xiphias gladius*) in the southwest Indian Ocean

Area[1]	**Indicators**		**2013 stock status determination**
Southwest Indian Ocean	Catch 2012: Average catch 2008–2012:	6,662 t 6,808 t	
	MSY (3 models): F_{2009}/F_{MSY} (3 models): SB_{2009}/SB_{MSY} (3 models): SB_{2009}/SB_0 (3 models):	7,100 t–9,400 t 0.64–1.19 0.73–1.44 0.16–0.58	

[1]Boundaries for southwest Indian Ocean stock assessment are defined in IOTC–2011–WPB09–R.

Colour key	Stock overfished ($SB_{year}/SB_{MSY}< 1$)	Stock not overfished ($SB_{year}/SB_{MSY}\geq 1$)
Stock subject to overfishing ($F_{year}/F_{MSY}> 1$)		
Stock not subject to overfishing ($F_{year}/F_{MSY}\leq 1$)		

SOUTHWEST INDIAN OCEAN – MANAGEMENT ADVICE

Stock status. Most of the evidence provided to the WPB indicated that the resource in the southwest Indian Ocean is not a separate genetic stock. However this region has been subject to localised depletion over the past decade and biomass remains below the level that would produce MSY (B_{MSY}). Recent declines in catch and effort have brought fishing mortality rates to levels below F_{MSY} (Table 3). The catches of swordfish in the southwest Indian Ocean increased in 2010 to 8,099 t, which equals 121.3% of the recommended maximum catch of 6,678 t agreed to by the SC in 2011. If catches are maintained at 2010 levels, the probabilities of violating target reference points in 2013 are less than 34% for F_{MSY} and less than 32% for B_{MSY} (Table 4). Despite the fact that the total estimated catch in 2011 was 6,663 t, and 6,662 t in 2012, lower that the recommended level set by the SC in 2011 (6,678 t), the resource remains **not subject to overfishing** but **overfished**, as no further estimate of biomass is available.

Outlook. The decrease in catch and effort over the last few years in the southwest region has reduced pressure on this resource. However, in 2010 catches exceeded the maximum recommended by the WPB09 and SC14 in 2011 (6,678 t), with 8,099 t caught in this region in 2010. The WPB09 estimated that there is a low risk of exceeding MSY-based reference points by 2019 if catches reduce further or are maintained at 2009 levels (<25% risk that $B_{2019} < B_{MSY}$, and <8% risk that F2019 > F_{MSY}). There is a risk of reversing the rebuilding trend if there is any increase in catch in this region (Table 4). The following key points should be noted:

- the Maximum Sustainable Yield estimate for the southwest Indian Ocean is 7,100–9,400 t (range of best point estimates from Table 3).
- catches in the southwest Indian Ocean should be maintained at levels at or below those observed in 2009 (6,678t), until there is clear evidence of recovery and biomass exceeds B_{MSY}.
- total estimated catch in 2011 was 6,663 t, and 6,662 t in 2012, lower that the recommended level set by the SC in 2011 (6,678 t).
- the Kobe strategy matrix illustrates the levels of risk associated with varying catch levels over time and could be used to inform management actions.
- provisional reference points: Noting that the Commission in 2012 agreed to Recommendation 12/14 *on interim target and limit reference points*, the following should be noted:
    a. **Fishing mortality**: Current fishing mortality is considered to be below the provisional target reference point of F_{MSY}, and thus, below the provisional limit reference point of $1.4*F_{MSY}$.
    b. **Biomass**: Current spawning biomass is considered to be below the target reference point of SB_{MSY}, and therefore, below the limit reference point of $0.4*SB_{MSY}$ (Fig. 1).

TABLE 4. Swordfish: Southwest Indian Ocean assessment - Kobe 2 Strategy Matrix, indicating a range of probabilities across three assessment approaches. Probability (percentage) of violating the MSY-based reference points for five constant catch projections (2009 catch level, ± 20% and ± 40%) projected for 3 and 10 years

Reference point and projection timeframe	**Alternative catch projections (relative to 2009) and probability (%) of violating reference point**				
	60% (3,960 t)	**80%** (5,280 t)	**100%** (6,600 t)	**120%** (7,920 t)	**140%** (9,240 t)
$B_{2012} < B_{MSY}$	0–15	0–20	0–25	0–30	12–32
$F_{2012} > F_{MSY}$	0–1	0–5	0–8	0–18	13–34
$B_{2019} < B_{MSY}$	0–15	0–20	0–25	0–32	18–34
$F_{2019} > F_{MSY}$	0–1	0–5	0–8	0–18	19–42

SUPPORTING INFORMATION

(Information collated from reports of the Working Party on Billfish and other sources as cited)

CONSERVATION AND MANAGEMENT MEASURES

Swordfish in the Indian Ocean is currently subject to a single direct Conservation and Management Measure adopted by the Commission: Resolution 12/11 *On The implementation of a limitation of fishing capacity of Contracting Parties and Cooperating Non-Contracting Parties.* This Resolution applies a freezing of fishing capacity for fleets targeting swordfish in the Indian Ocean to levels applied in 2007. The Resolution limits vessels access to those that were active (*effective presence*) or under construction during 2007, and were over 24 metres overall length, or under 24 meters if they fished outside the EEZs. At the same time the measure permits CPCs to vary the number of vessels targeting swordfish, as long as any variation is consistent with the national fleet development plan submitted to the IOTC, and does not increase effective fishing effort. This Resolution is effective for 2012 and 2013. Swordfish is also subject to the following non species-specific Conservation and Management Measures adopted by the Commission:

- Resolution 13/03 on the recording of catch and effort by fishing vessels in the IOTC area of competence
- Resolution 13/07 concerning a record of licensed foreign vessels fishing for IOTC species in the IOTC area of competence and access agreement information
- Resolution 12/11 *on the implementation of a limitation of fishing capacity of Contracting Parties and Cooperating Non-Contracting Parties*
- Resolution 11/04 *on a regional observer scheme*
- Resolution 10/02 *mandatory statistical requirements for IOTC Members and Cooperating non-Contracting Parties (CPC's)*
- Resolution 10/08 *concerning a record of active vessels fishing for tunas and swordfish in the IOTC area*

FISHERIES INDICATORS

Swordfish: General

Swordfish (*Xiphias gladius*) is a large oceanic apex predator that inhabits all the world's oceans (Fig. 2). Throughout the Indian Ocean, swordfish are primarily taken by longline fisheries, and commercial harvest was first recorded by the Japanese in the early 1950's as a bycatch/byproduct of their tuna longline fisheries. Swordfish life history characteristics, including a relatively late maturity, long life and sexual dimorphism, make the species vulnerable to over exploitation. Table 5 outlines some of the key life history traits of swordfish specific to the Indian Ocean.

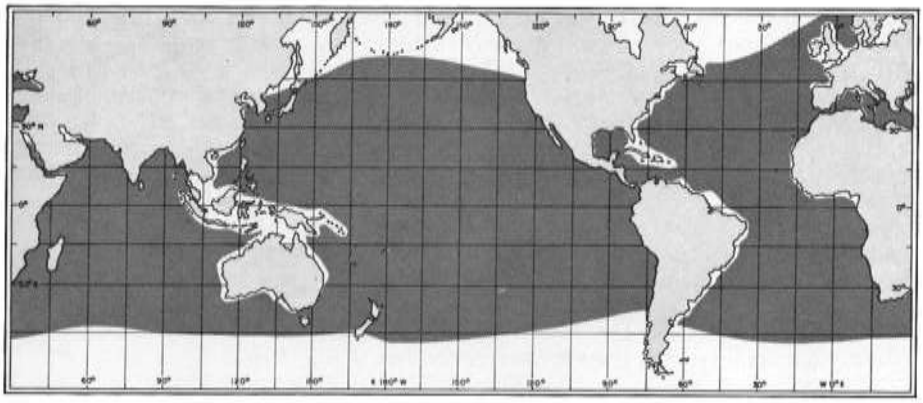

Fig. 2. Swordfish: The worldwide distribution of swordfish (Source: Nakamura 1984)

TABLE 5. Swordfish: Biology of Indian Ocean swordfish (*Xiphias gladius*)

Parameter	Description
Range and stock structure	Entire Indian Ocean down to 50˚S. Juvenile swordfish are commonly found in tropical and subtropical waters and migrate to higher latitudes as they mature. Large, solitary adult swordfish are most abundant at 15–35˚S. Males are more common in tropical and subtropical waters. By contrast with tunas, swordfish is not a gregarious species, although densities increase in areas of oceanic fronts and seamounts. Extensive diel vertical migrations, from surface waters during the night to depths of 1000 m during the day, in association with movements of the deep scattering layer and cephalopods, their preferred prey. A recent genetic study did not reveal any structure within the Indian Ocean with the markers used, however the hypothesis of a population structuring at the regional level cannot be discarded and needs to be investigated using different markers or approaches. Results obtained from the markers used may simply be a matter of the resolving power of the markers used, which may simply have been insufficient for detecting population subdivision. Spatial heterogeneity in stock indicators (catch–per–unit–effort trends) indicates the potential for localised depletion of swordfish in the Indian Ocean.
Longevity	30+ years
Maturity (50%)	**Age**: females 6–7 years; males 1–3 years **Size**: females ~170 cm LJFL; males ~120 cm LJFL
Spawning season	Highly fecund batch spawner. May spawn as frequently as once every three days over a period of several months in spring. Known spawning ground and season are: tropical waters of Southern hemisphere from October to April, including in the vicinity of Reunion Island.
Size (length and weight)	Maximum: 455 cm lower-jaw FL; 550+ kg total weight in the Indian Ocean. Sexual dimorphism in size, growth rates and size and age at maturity - females reach larger sizes, grow faster and mature later than males. Most swordfish larger than 200 kg are female. Recruitment into the fishery: varies by fishing method; ~50 cm LJFL for longline fisheries. By one year of age, a swordfish may reach 90 cm lower-jaw FL (~15 kg). The average size of swordfish taken in Indian Ocean longline fisheries is between 40 kg and 80 kg (depending on latitude). L-W relationships for the Indian Ocean are: females TW=0.00002409*LJFL^2.86630, males TW=0.00006289*LJFL**2.66196, both sexes mixed TW=0.00001443*LJFL^2.96267. TW in kg, LJFL in cm

Sources: Froese & Pauly 2009, Muths et al. 2009, Poisson & Fauvel 2009, Bach et al. 2011, Romanov, Romanova, 2012

Swordfish: Catch trends

Around 90% of swordfish are caught mainly using drifting longlines, on longline fisheries directed to tunas (Table 6, LL) or swordfish (Table 6, ELL), while the remaining the catches are taken by other fisheries, in particular drifting gillnets. Between 1950 and 1980, catches of swordfish in the Indian Ocean slowly increased in tandem with the level of coastal state and distant water fishing nation longline effort targeting tunas (Fig. 3). Swordfish were mainly a bycatch of industrial longline fisheries before the early 1990's with catches slightly increasing from 1950 to 1990 proportionally to the increase in the catches of target species (tropical and temperate tunas).

The catches of swordfish markedly increased after 1990, from around 9,000 t in 1991 to a peak of 38,000 t in 1998 and 41,000 t in 2004. The change in target species from tunas to swordfish by part of the fleet of Taiwan,China along with the development of longline fisheries in Australia, Reunion island, Seychelles and Mauritius and the arrival of longline fleets from the Atlantic Ocean (Portugal, Spain, the UK and other fleets operating under various flags), all targeting swordfish, are the main reasons for this significant increase.

Since 2004, annual catches have declined steadily (Fig. 3), largely due to the continued decline in the number of active Taiwan,China longliners in the Indian Ocean. Annual catches since 2004 have been dominated by the Taiwan,China and EU fleets (Spain, UK, France and Portugal), with the fishery extending eastward due to the effects of piracy actions (Fig. 2). Catches of swordfish of up to 6,000 t have been recorded in recent years for a fleet of deep-freezing and fresh tuna longliners operating under flags of non-reporting countries (NEI). The catches have been low since 2006, at just over 1,000 t (Fig. 4).

Swordfish is mostly exploited in the western Indian Ocean (Fig. 5), in waters off Somalia, and in the southwest Indian Ocean. Other important fisheries operate in waters off Sri Lanka, Western Australia and Indonesia. In recent years (Fig. 3) the catches of swordfish in the western tropical Indian Ocean have dropped considerably (Table 7), especially in areas off Somalia, Kenya and Tanzania, from around 25,000 t in 2005 to 15,000 t in 2008, and falling to the lowest levels of around 9,000 t in 2011. The drop in catches is the consequence of a drop in fishing effort in the area by longline fisheries, due to either piracy or decreased fish abundance, or a combination of both.

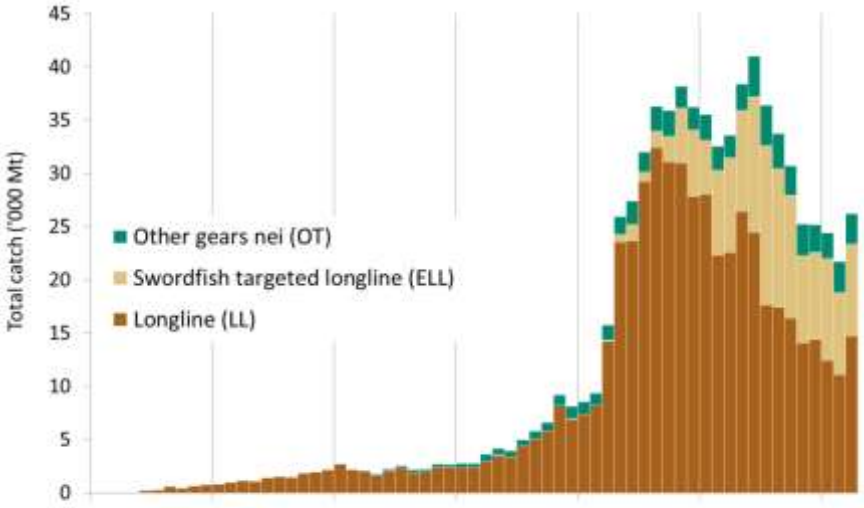

Fig. 3 Swordfish: Catches of swordfish by gear and year recorded in the IOTC Database (1950–2012) (Data as of October 2013).

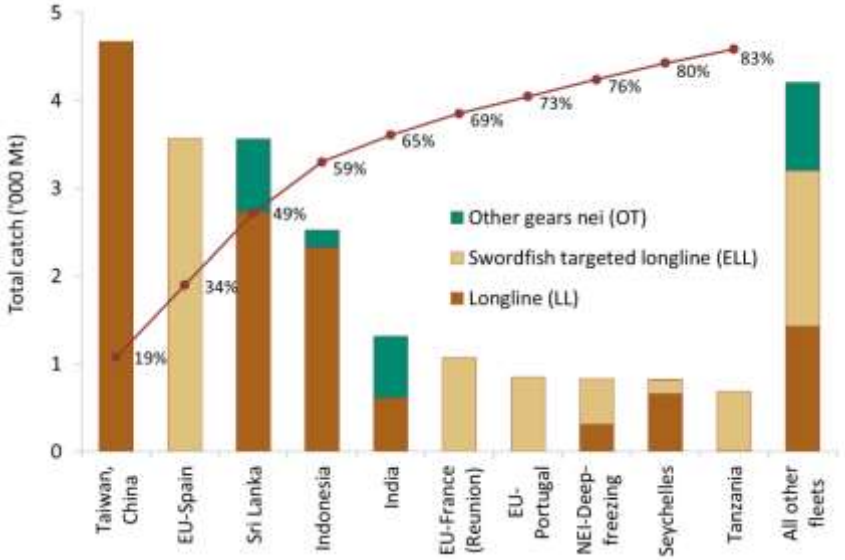

Fig. 4. **Swordfish**: average catches in the Indian Ocean over the period 2009–12, by country. Countries are ordered from left to right, according to the importance of catches of swordfish reported. The red line indicates the (cumulative) proportion of catches of swordfish for the countries concerned, over the total combined catches of this species reported from all countries and fisheries (Data as of October 2013).

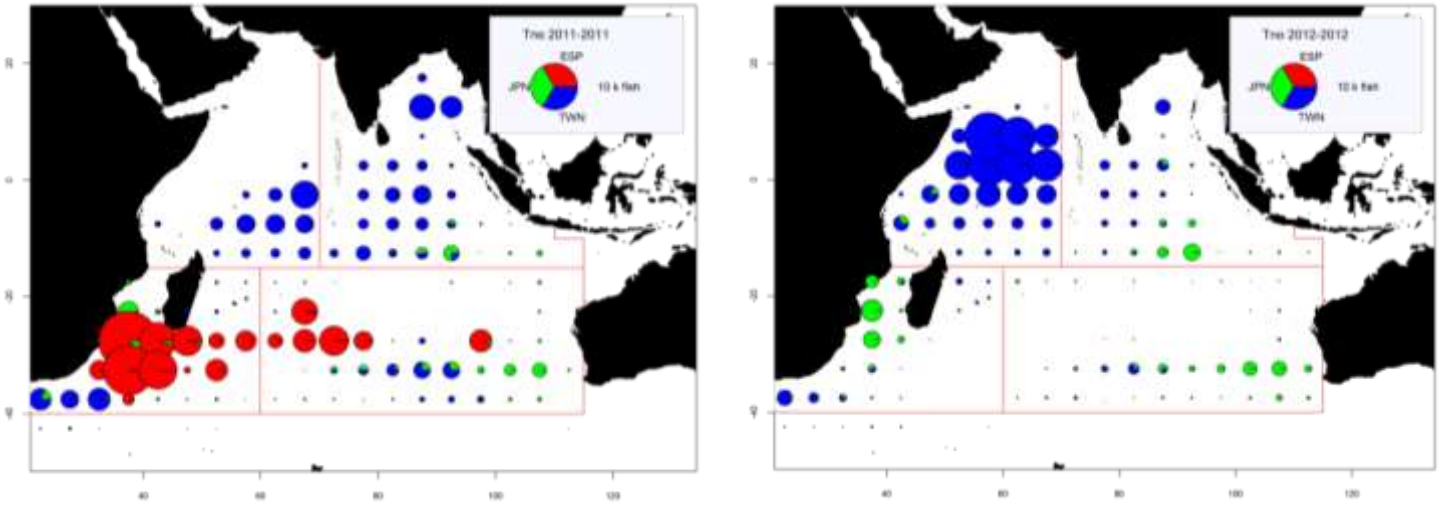

Fig. 5a–b. Swordfish: Time-area catches (total combined in tonnes) of swordfish as reported for the longline fleets of Japan (JPN), Taiwan,China (TWN), and EU-Spain (ESP), the latter directed at swordfish, for 2011 and 2012 (excluding EU-Spain). Red lines represent the boundaries of the areas used for the assessments of swordfish.

TABLE 6. **Swordfish**: Best scientific estimates of the catches of swordfish by type of fishery for the period 1950–2012 (in metric tons). Data as of October 2013.

Fishery	By decade (average)						By year (last ten years)									
	1950s	1960s	1970s	1980s	1990s	2000s	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
ELL	0	0	0	9	1,847	10,417	10,700	13,415	15,625	13,630	12,011	8,581	8,262	9,708	7,742	8,604
LL	282	1,425	2,141	4,524	22,934	19,977	25,224	23,819	16,977	16,843	15,949	13,699	14,336	12,292	11,113	14,771
OT	37	39	180	655	1,774	2,841	2,483	3,769	3,793	3,253	2,758	2,970	2,577	2,433	2,828	2,809
Total	**320**	**1,464**	**2,320**	**5,188**	**26,556**	**33,235**	**38,407**	**41,003**	**36,395**	**33,726**	**30,718**	**25,250**	**25,175**	**24,433**	**21,683**	**26,184**

Fisheries: Swordfish longline (**ELL**); Longline (**LL);** Other gears (**OT**)

TABLE 7. **Swordfish**: Best scientific estimates of the catches of swordfish by fishing area for the period 1950–2012 (in metric tons). Data as of October 2013.

Area	By decade (average)						By year (last ten years)									
	1950s	1960s	1970s	1980s	1990s	2000s	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
NW	100	545	776	1,887	8,303	10,587	15,737	13,635	13,133	11,529	8,869	6,566	4,785	2,843	2,672	7,961
SW	14	256	406	607	8,624	7,643	4,129	6,295	9,753	8,940	7,366	6,186	6,429	8,099	6,663	6,662
NE	168	451	755	2,206	6,799	9,274	9,871	11,470	7,748	9,272	9,250	8,956	10,809	10,037	9,589	8,770
SE	37	204	308	347	2,741	5,713	8,648	9,570	5,747	3,980	5,219	3,539	3,147	3,444	2,754	2,790
OT	0	8	75	142	89	19	22	33	15	5	14	5	5	11	7	3
Total	**319**	**1,464**	**2,320**	**5,188**	**26,556**	**33,236**	**38,407**	**41,003**	**36,396**	**33,726**	**30,718**	**25,252**	**25,175**	**24,434**	**21,685**	**26,186**

Areas: Northwest Indian Ocean (**NW**); Southwest Indian Ocean (**SW**); Northeast Indian Ocean (**NE**); Southeast Indian Ocean (**SE**); Southern Indian Ocean (**OT**)
Note: differences in the total catches in table 6 and 7 are due to rounding errors.

Uncertainty of time–area catches

Retained catches are fairly well known (Fig. 6); however catches are uncertain for:

- **Drifting gillnet fishery of Pakistan**: For the first time Iran has reported catches of swordfish for its gillnet fishery. Although Pakistan has reported catches of swordfish they are considered to be too low for a driftnet fishery (catches of swordfish in recent years represent around 2% or less of the total catches of swordfish in the Indian Ocean).
- **Longline fishery of Indonesia**: The catches of swordfish for the fresh tuna longline fishery of Indonesia may have been underestimated in recent years due to insufficient sampling coverage. Although the new catches estimated by the Secretariat are thought to be more accurate, swordfish catches remain uncertain, especially in recent years (where they represent between 5% to 10% of the total catches of swordfish in the Indian Ocean).
- **Longline fishery of India**: India has reported very incomplete catches and catch-and-effort data for its longline fishery. Although the new catches estimated by the Secretariat are thought to be more accurate,

catches of swordfish remain uncertain (catches of swordfish in recent years represent around 5% or less of the total catches of swordfish in the Indian Ocean).

- **Longline fleets from non-reporting countries (NEI)**: The Secretariat had to estimate catches of swordfish for a fleet of longliners targeting tunas or swordfish and operating under flags of various non-reporting countries. The catches estimated since 2006 are, however, low (representing around 4% of the total catches of swordfish in the Indian Ocean).
- **Discards** are believed to be low although they are unknown for most industrial fisheries, mainly longliners. Discards of swordfish may also occur in the driftnet fishery of Iran, as this species has no commercial value in this country.
- **Changes to the catch series**: There have been changes to the catches of swordfish since the WPB meeting in 2012. Most changes that have been made to the data series since the last WPB are relatively small increases to the nominal catch as a result of reallocation of catch reported as other billfish species or as aggregated species groups reported by Sri Lanka, I.R. Iran, and Pakistan to a lesser extent. These changes, however, did not lead to very significant changes in the total catch estimates.

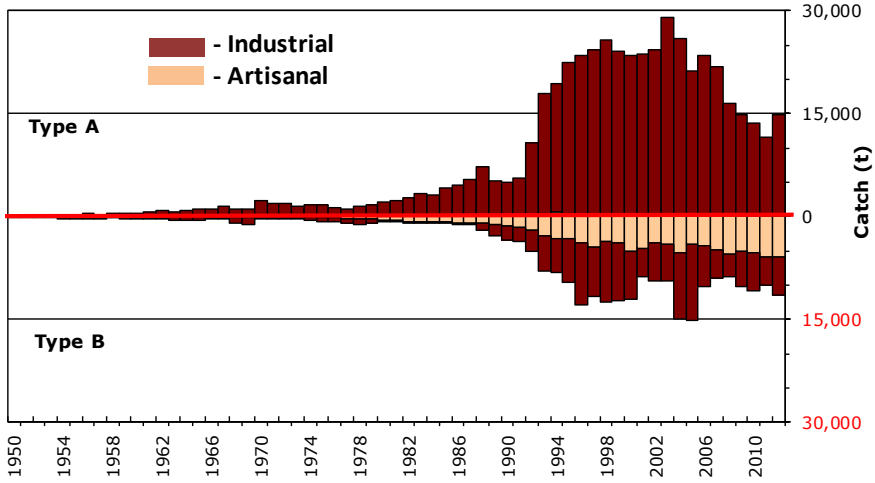

Fig. 6. Swordfish: Uncertainty of annual catch estimates for swordfish (Data as of October 2013).

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

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

In general, the amount of catch for which size data for the species are available before 2005 is still very low and the number of specimens measured per stratum has been decreasing in recent years.

- **Average fish 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 sampling coverage and time-area coverage of longliners from Japan). The average weights of swordfish are variable but show no clear trend. It is considered encouraging that there are no clear signals of declines in the size-based indices, but these indices should be carefully monitored, as females mature at a relatively large size, therefore, a reduction in the biomass of large animals could potentially have a strong effect on the spawning biomass.
- **Catch-at-Size(Age)** data are available but the estimates are thought to have been compromised for some years and fisheries due to:
  - the uncertainty in the length frequency data recorded for longliners of Japan and Taiwan,China, for which average weights of swordfish derived from length frequency data and catch-and-effort data are very different.
  - the uncertainty in the catches of swordfish for the drifting gillnet fisheries of Iran and the fresh-tuna longline fishery of Indonesia.
  - the total lack of size data before the early-70s and poor coverage before the early-80s and for most artisanal fisheries (Pakistan, India, Indonesia).
  - the paucity of size data available from industrial longliners since the early-1990s (Japan, Philippines, India and China).
  - the lack of time-area catches for some industrial fleets (Indonesia, India, NEI).
  - the paucity of biological data available, notably sex-ratio and sex-length-age keys.

Swordfish: Effort trends

Total effort from longline vessels flagged to Japan, Taiwan,China and EU,Spain by five degree square grid in 2011 and 2012 are provided in Fig. 7, and total effort from purse seine vessels flagged to the EU and Seychelles (operating under flags of EU countries, Seychelles and other flags), and others, by five degree square grid and main fleets, for the years 2011 and 2012 are provided in Fig. 8.

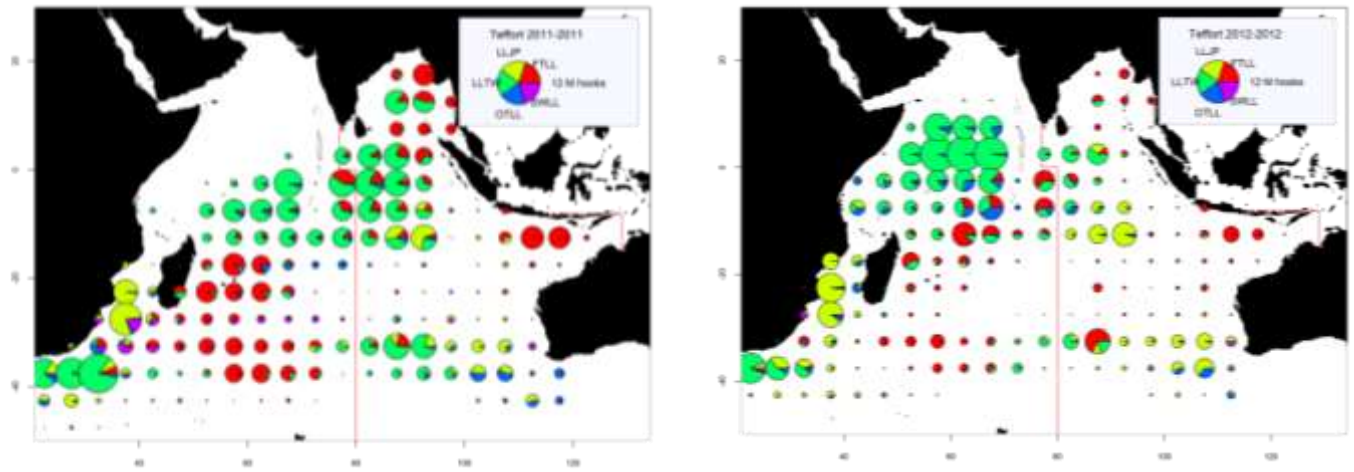

Fig. 7. Number of hooks set (millions) from longline vessels by five degree square grid and main fleets, for the years 2011 (left) and 2012 (right) (Data as of October 2013)
LLJP (light green): deep-freezing longliners from Japan
LLTW (dark green): deep-freezing longliners from Taiwan,China
SWLL (turquoise): swordfish longliners (Australia, EU, Mauritius, Seychelles and other fleets)
FTLL (red) : fresh-tuna longliners (China, Taiwan,China and other fleets)
OTLL (blue): Longliners from other fleets (includes Belize, China, Philippines, Seychelles, South Africa, Rep. of Korea and various other fleets)

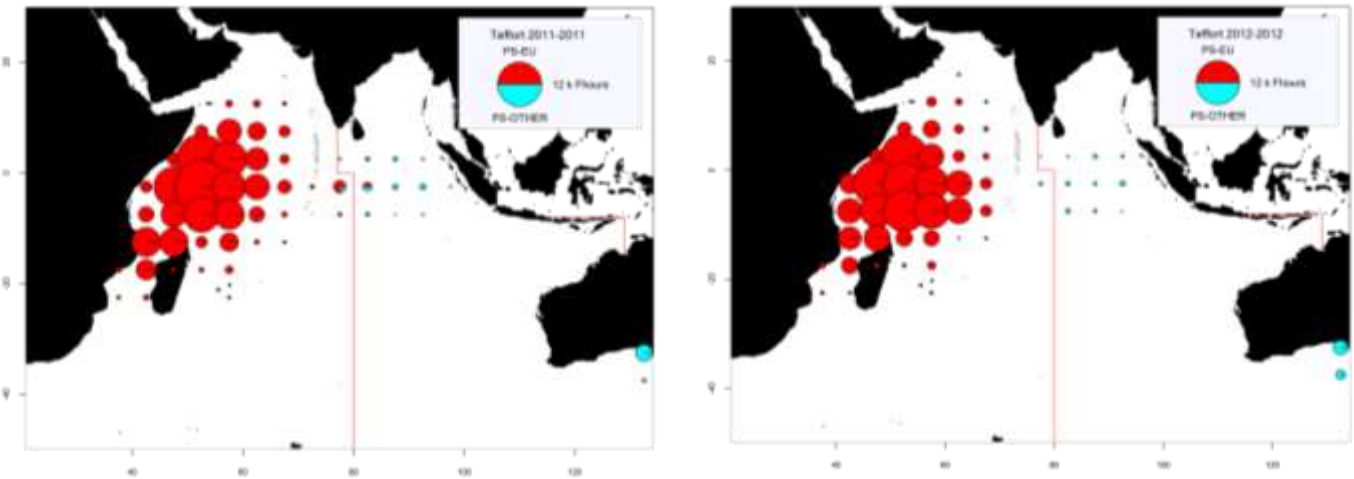

Fig. 8. Number of hours of fishing (Fhours) from purse seine vessels by 5 degree square grid and main fleets, for the years 2011 (left) and 2012 (right) (Data as of October 2013)
PS-EU (red): Industrial purse seiners monitored by the EU and Seychelles (operating under flags of EU countries, Seychelles and other flags)
PS-OTHER (green): Industrial purse seiners from other fleets (includes Japan, Mauritius and purse seiners of Soviet origin) (excludes effort data for purse seiners of Iran and Thailand)

Swordfish: Catch–per–unit–effort (CPUE) trends

The following CPUE series were used in the stock assessment models for 2011 (Figs. 9 and 10), while the relative weighting of the different CPUE series were left to the individual analyst to determine and justify.

- Japan data (1980–2009): Series 3.2 from document IOTC–2011–WPB09–14, which includes fixed latitude and longitude effects, plus environmental effects.
- Taiwan,China data (1995–2009): Model 10 from document IOTC–2011–WPB09–23, which includes fixed latitude and longitude effects, plus environmental effects.

- EU,Spain data (2001–2009): Series 5 from document IOTC–2011–WPB09–23, calculated for the southwest area only (includes sub-region factors and species ratio factors) area and run 1 for the assessment of whole Indian Ocean.
- EU,La Reunion data (1994–2000): Same series as last year (IOTC–2010–WPB–03).

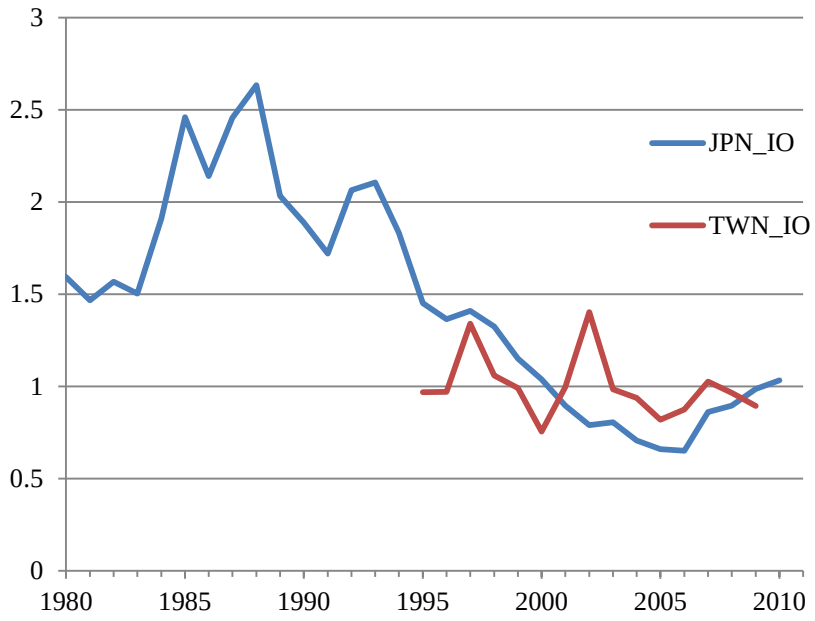

Fig. 9. Swordfish: Aggregate Indian Ocean CPUE series for swordfish. Series have been rescaled relative to their respective means from 1995–2010

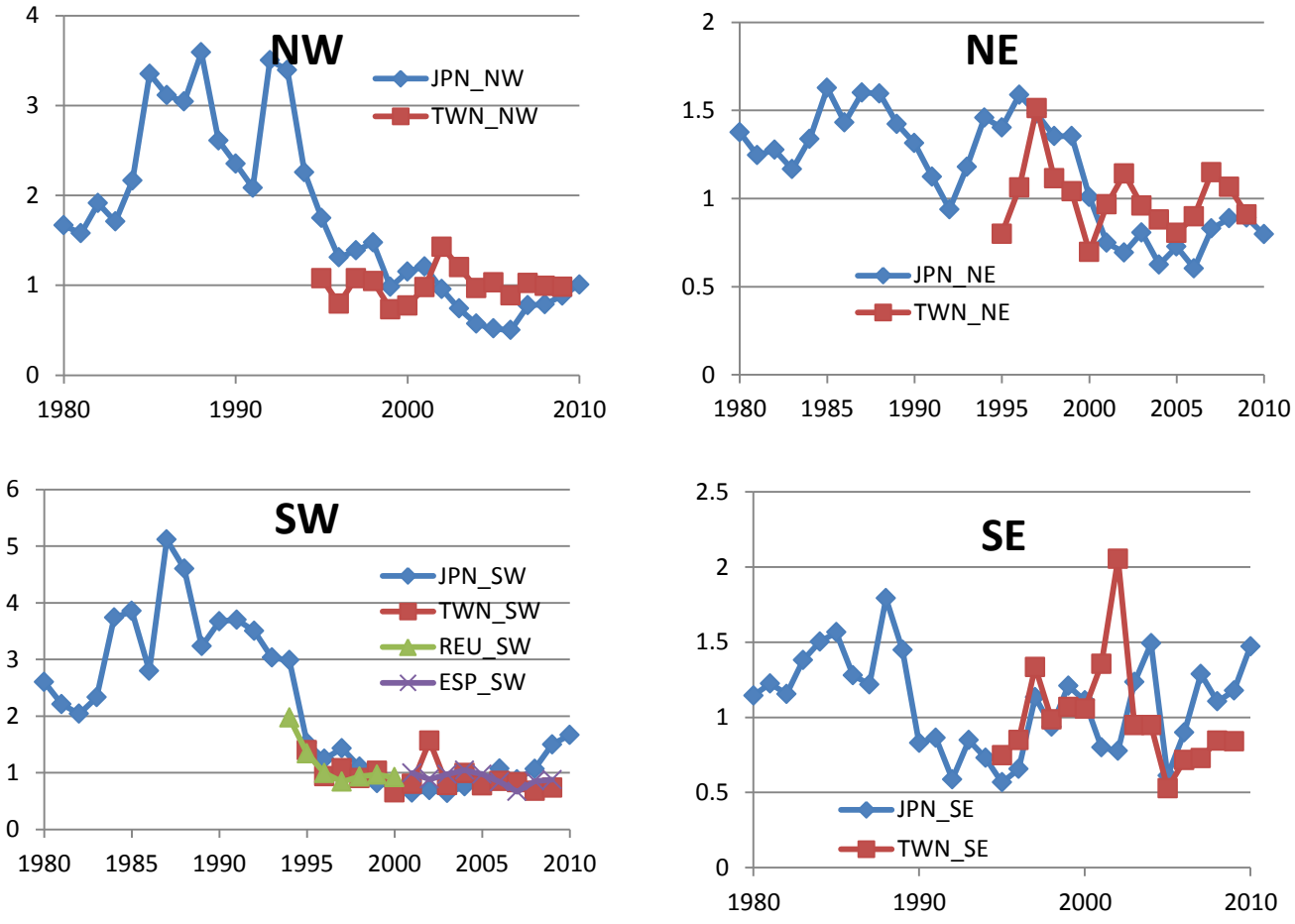

Fig. 10. Swordfish: CPUE series for Indian Ocean swordfish assessments by sub-region. Series have been rescaled relative to their respective means (for different overlapping time periods). NW – north-west; SW – south-west; NE – north-east; SE – south-east Indian Ocean.

STOCK ASSESSMENT

The stock structure of the Indian Ocean swordfish resource remains under investigation, but currently uncertain. The southwest region was identified as a management unit of particular concern, because it seems to be more depleted than other regions in the Indian Ocean, and may have limited mixing with other regions.

The range of quantitative modelling methods were applied to the swordfish assessment in 2011, ranging from the highly aggregated ASPIC surplus production model to the age-, sex- and spatially-structured SS3 analysis. The different assessments were presented to the WPB in documents IOTC–2011–WPB09–17, 18, 19 and 20. Each model is summarised in the report of the Ninth Session of the WPB (IOTC–2011–WPB09–R).

There is value of comparing different modelling approaches. The structured models are capable of a more detailed representation of complicated population and fishery dynamics, and integrate several sources of data and biological research that cannot be considered in the simple production models. However, there are a lot of uncertainties in basic swordfish biology (e.g. growth rates, M, stock recruitment relationship), and it is difficult to represent all of these uncertainties. In contrast, the production models often provide robust estimates regardless of uncertainties in basic biological characteristics. However, sometimes the ASPIC model can have difficulty fitting long time series, and production models in general cannot represent some important dynamics (e.g. arising from complicated recruitment variability).

The swordfish stock status was determined by qualitatively integrating the results of the various stock assessments undertaken in 2011. The WPB treated all analyses as equally informative, and focused on the features common to all of the results, as well as the latest catch and effort trends (Tables 1 and 8).

TABLE 8. Swordfish: Key management quantities from the 2011 Stock Synthesis 3 assessments, for the aggregate and southwest Indian Ocean. Values represent the 50^{th} (5^{th}–95^{th}) percentiles of the (plausibility-weighted) distribution of maximum posterior density estimates from the full range of the models examined

Management Quantity	Aggregate Indian Ocean	Southwest Indian Ocean
2012 catch estimate	26,184 t	6,662 t
Mean catch from 2008–2012	24,545 t	6,808 t
MSY	29,900– 34,200	7,100 t–9,400 t
Data period used in assessment	1951–2009	1951–2009
F_{2009}/F_{MSY}	0.50 (0.23–1.08)	0.64 (0.27–1.27)
B_{2009}/B_{MSY}	–	–
SB_{2009}/SB_{MSY}	1.59 (0.94–3.77)	1.44 (0.61–3.71)
B_{2009}/B_0	–	–
SB_{2009}/SB_0	0.35 (0.22–0.42)	0.29 (0.15–0.43)
$B_{2009}/B_{0,\ F=0}$	–	–
$SB_{2009}/SB_{0,\ F=0}$	–	–

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