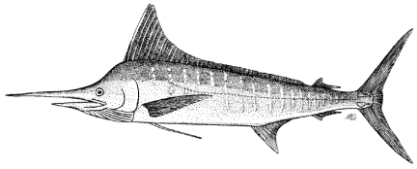
DRAFT EXECUTIVE SUMMARY: STRIPED MARLIN

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



Status of the Indian Ocean striped marlin (MLS: *Tetrapturus audax*) resource

TABLE 1. Striped marlin: Status of striped marlin (*Tetrapturus audax*) in the Indian Ocean.

Area[1]	Indicators		2015 stock status determination
Indian Ocean	Catch 2014: Average catch 2010–2014:	4,001 t 4,112 t	60%
	MSY (1,000 t) (80% CI): F_{MSY} (80% CI): B_{MSY} (1,000 t) (80% CI): F_{2014}/F_{MSY} (80% CI): B_{2014}/B_{MSY} (80% CI): B_{2014}/B_{1950} (80% CI):	5.22 t (5.18–5.59) 0.62 (0.59–1.04) 8.4 t (5.40–8.90) 1.09 (0.62–1.66) 0.65 (0.45–1.17) 0.24 (n.a.–n.a.)	

[1]Boundaries for the Indian Ocean = IOTC area of competence; n.a. = not available. Percentage of times the stock status from plausible model runs is in each respective quadrant of the Kobe plot shown below.

Colour key	Stock overfished ($B_{year}/B_{MSY} < 1$)	Stock not overfished ($B_{year}/B_{MSY} \geq 1$)
Stock subject to overfishing ($F_{year}/F_{MSY} > 1$)	**60%**	**0%**
Stock not subject to overfishing ($F_{year}/F_{MSY} \leq 1$)	**36%**	**4%**
Not assessed/Uncertain		

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

Stock status. Stock status is based on the new assessments undertaken in 2015. The standardised CPUE series suggest that there was a sharp decline in the early 1980s, followed by slower decline since 1990. In 2015 an ASPIC stock assessment confirmed the assessment results from 2012 and 2013 that indicated the stock is currently subject to overfishing and that biomass is below the level which would produce MSY, using catch data up until 2014. Two other approaches examined in 2015 came to similar conclusions, namely a Bayesian Surplus Production Model, and a data poor stock assessment method, Stock Reduction Analysis using only catch data. The Kobe plot (Fig. 1) from the ASPIC model indicated that the stock has been subject to overfishing for some years, and that as a result, the stock biomass is well below the B_{MSY} level and shows little signs of rebuilding despite the declining effort trend. Thus, on the weight-of-evidence available the stock is determined to remain as **overfished** and **subject to overfishing** (Table 1; Fig. 1).

Outlook. The decrease in longline catch and effort in the years 2009–11 lowered the pressure on the Indian Ocean stock as a whole, however, the increased catches reported in 2012, 2013 and 2014, combined with the concerning results obtained from the stock assessments carried out in 2012, 2013 and 2015, the outlook is pessimistic for the stock as a whole and a precautionary approach to the management of striped marlin should be considered by the Commission, to reduce catches well below MSY estimates to enable the stock to rebuild. There is a very high risk of exceeding the biomass MSY-based reference points by 2017 if catches increase further or are maintained at current levels (2014) until 2017 (>75% risk that $B_{2017} < B_{MSY}$, and $F_{2017} > F_{MSY} \approx 68\%$) (Table 2).

Management advice. A precautionary approach to the management of striped marlin should be considered by the Commission, to reduce catches below MSY estimates (~5,220 t), thereby ensuring the stock may rebuild to sustainable levels.

The following key points should be noted:

- **Maximum Sustainable Yield (MSY)**: estimate for the whole Indian Ocean is 5,220 t (5,180–5,590). However, the biomass is well below the B_{MSY} reference point and fishing mortality is in excess of F_{MSY} at recent catch levels, of around 4,401 t. Catches should be reduced to below 2,500 t.
- **Provisional reference points**: Although the Commission adopted reference points for swordfish in Resolution 15/10 *on target and limit reference points and a decision framework*, no such interim reference points, nor harvest control rules have been established for striped marlin.
- **Main fishing gear** (2011–14): Longline: 69%; Gillnet: 28% (of the total estimated striped marlin catch).

- **Main fleets** (2011–14): Indonesia: 32%; Taiwan,China: 26%; I.R. Iran 11%; Pakistan: 9% (of the total estimated striped marlin catch).

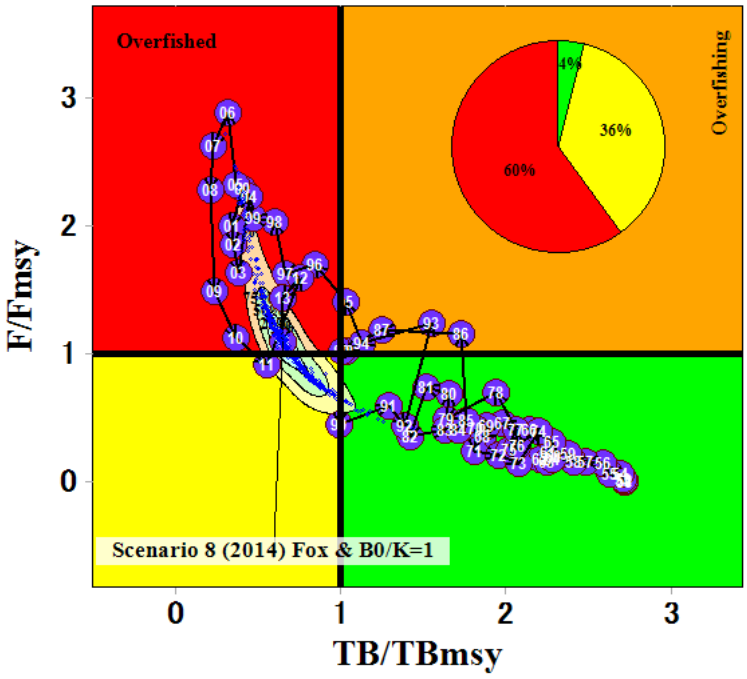


Fig. 1. Striped marlin: ASPIC aggregated Indian Ocean assessment Kobe plot with the confidence surface and compositions of its uncertainties in terms of 4 phases (pie chart).

TABLE 2. Striped marlin: ASPIC aggregated Indian Ocean assessment Kobe II Strategy Matrix. Probability (percentage) of violating the MSY-based reference points for nine constant catch projections (average catch level from 2012–14 (4,915 t), ± 10%, ± 20%, ± 30% and ± 40%) projected for 3 and 10 years.

Reference point and projection timeframe	**Alternative catch projections (relative to the average catch level from 2012–2014, 4,915 t) and probability (%) of violating MSY-based target reference points ($B_{targ} = B_{MSY}$; $F_{targ} = F_{MSY}$)**								
	60% (2,949 t)	**70%** (3,441 t)	**80%** (3,932 t)	**90%** (4,424 t)	**100%** (4,915 t)	**110%** (5,407 t)	**120%** (5,898 t)	**130%** (6,390 t)	**140%** (6,881 t)
$B_{2017} < B_{MSY}$	41	57	59	70	75	82	90	95	97
$F_{2017} > F_{MSY}$	10	19	23	41	68	90	98	100	100
$B_{2024} < B_{MSY}$	7	12	15	29	60	98	100	100	100
$F_{2024} > F_{MSY}$	7	12	14	26	53	99	100	100	100

APPENDIX I

SUPPORTING INFORMATION

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

CONSERVATION AND MANAGEMENT MEASURES

Striped marlin (*Tetrapturus audax*) in the Indian Ocean is currently subject to a number of Conservation and Management Measures adopted by the Commission, although none are species specific:

- Resolution 15/01 *on the recording of catch and effort by fishing vessels in the IOTC area of competence*
- Resolution 15/02 *mandatory statistical reporting requirements for IOTC Contracting Parties and Cooperating Non-Contracting Parties (CPC's)*
- Resolution 15/11 *on the implementation of a limitation of fishing capacity of Contracting Parties and Cooperating Non-Contracting Parties*
- Resolution 14/05 *concerning a record of licensed foreign vessels fishing for IOTC species in the IOTC area of competence and access agreement information*
- Resolution 11/04 *on a regional observer scheme*
- Resolution 10/08 *concerning a record of active vessels fishing for tunas and swordfish in the IOTC area*

FISHERIES INDICATORS

Striped marlin: General

Striped marlin (*Tetrapturus audax*) is a large oceanic apex predator that inhabits tropical and subtropical Indo-Pacific oceans (**Fig. 2**). **Table 3** outlines some key life history parameters relevant for management. There is limited reliable information on the catches of this species and no information on the stock structure or growth and mortality in the Indian Ocean.

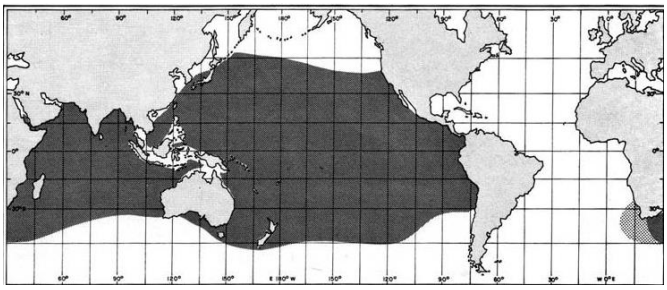


Fig. 2. Striped marlin: The worldwide distribution of striped marlin (Source: Nakamura, 1984).

TABLE 3. Striped marlin: Biology of Indian Ocean striped marlin (*Tetrapturus audax*).

Parameter	Description
Range and stock structure	A large oceanic apex predator that inhabits tropical and sub-tropical waters of the Indian and Pacific oceans. Some rare individuals have been reported in the Atlantic Ocean but there is no information to indicate the presence of a breeding stock in this area. Its distribution is different from other marlins in that it prefers more temperate or cooler waters however in the Indian Ocean it is common in tropical zone: off the east African coast (0-10ºS), the south and western Arabian Sea, the Bay of Bengal, and north-western Australian waters. Several transoceanic migrations were reported in the Indian Ocean (the longest is from Kenya to Australia). Therefore a single stock hypothesis apparently is most appropriate for stock assessement and management.
Longevity	~10 years. Females and males n.a.
Maturity (50%)	Age: 2–3 years. Females and males n.a.
Spawning season	Highly fecund batch spawner. Females may produce up to 20 million eggs. Usually spawn in the vicinity of oceanic islands, seamounts or coastal areas, associated with local increases in primary productivity. In the Indian Ocean larvae of this species was recorded off the Somalian coast, around Reunion and Mauritius and off north-western Australia.
Size (length and weight)	In the Indian Ocean documented maximum size for females 314 cm LJFL and 330 kg TW, for males 292 cm LJFL, 185 kg TW. However males longer than 260 cm LJFL are rare. Young fish grow very quickly in length then put on weight later in life. 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. L-W relationships for the Indian Ocean are: females TW=0.00000009*LJFL**3.76598 males TW=0.00005174*LJFL**2.59633, both sexes mixed TW=0.00000039*LJFL**3.50024, TW in kg, LJFL in cm.

n.a. = not available. Sources: Nakamura 1985, Gonzalez-Armas et al. 1999, Hyde et al. 2006, Froese & Pauly 2009, Kadagi et al. 2011, Romanov & Romanova 2012

Striped marlin: Fisheries and main catch trends

- Main fishing gear (2011–14): striped marlin are largely considered to be a non-target species of industrial fisheries. Longlines account for around 69% of total catches in the Indian Ocean, followed by gillnets (28%), with remaining catches recorded under troll and handlines. (**Table 3, Fig. 3**)

- Main fleets (and primary gear associated with catches): percentage of total catches (2011–14):

  Indonesia (drifting longline and coastal longline): 32%; Taiwan,China (drifting longline): 26%; I.R. Iran (gillnet): 11%; and Sri Lanka (gillnet): 10% (**Fig. 4**).

- Main fishing areas: The distribution of striped marlin catches has changed since the 1980's with most of the catch now taken in the north-west Indian Ocean (**Table 5**), although between 2007 – 2011 catches in this area have dropped markedly, in tandem with a reduction of longline effort due to piracy.

  Changes in fishing grounds (**Figs. 5, 6**) and catches are thought to be related to changes in access agreements to the EEZs of coastal countries in the Indian Ocean, rather than necessarily changes in the distribution of the species over time. Between the early-50s and the late-80s part of the Japanese fleet was licensed to operate within the EEZ of Australia, and reported relatively high catches of striped marlin in the area, in particular in waters off northwest Australia, as well in the Bay of Bengal. Catches by Japan has since declined dramatically.

- Retained catch trends:

  Catch trends are variable, ranging from 2000 t to 8000 t per year, which may reflect the level of reporting and the status of striped marlin as a non-target species.

  Similarly, catches reported under drifting longlines are highly variable, with lower catch levels between 2009 and 2011 largely due to declining catches reported by Taiwan,China, deep-freezing and fresh-tuna longliners. Catches of striped marlin have since increased in 2012 and 2013, as longline vessels have resumed operations in the north-west Indian Ocean.

- Discard levels**:** Low, although estimates of discards are unknown for most industrial fisheries, mainly longliners. Discards may also occur in the driftnet fishery of the I.R of Iran, as this species has no commercial value in this country.

Changes to the catch series**:** no major changes to the catches series since the WPB meeting in 2014[1].

TABLE 4. Striped marlin: best scientific estimates of catches by type of fishery for the period 1950–2014 (in metric tons). Data as of November 2015.

Fishery	By decade (average)						By year (last ten years)									
	1950s	1960s	1970s	1980s	1990s	2000s	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
LL	1,028	3,104	3,458	5,144	5,120	2,915	3,080	3,020	2,345	2,098	1,668	2,053	2,277	4,500	3,330	2,299
GN	5	8	16	22	161	541	876	807	479	389	407	331	542	984	1,169	1,351
HL	3	5	10	32	70	136	136	143	152	198	273	282	293	288	335	307
OT	0	0	0	6	10	20	20	21	23	29	41	42	44	43	48	44
Total	**1,036**	**3,117**	**3,485**	**5,204**	**5,361**	**3,612**	**4,112**	**3,990**	**2,999**	**2,714**	**2,389**	**2,708**	**3,154**	**5,815**	**4,882**	**4,001**

Fisheries: Longline (**LL**); Gillnet (**GN**); Hook-and-Line (includes handline, trolling, baitboat, and sport fisheries) (**HL**); Other gears (includes coastal purse seine, Danish purse seine, beach seine, and purse seine) (**OT**).

TABLE 5. Striped marlin: best scientific estimates of catches by fishing area for the period 1950–2014 (in metric tons). Data as of November 2015.

Fishery	By decade (average)						By year (last ten years)									
	1950s	1960s	1970s	1980s	1990s	2000s	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
NW	335	1,859	1,516	2,073	2,713	1,803	2,147	1,968	1,310	1,174	828	741	962	3,589	2,800	2,076
SW	9	124	159	162	659	244	177	199	157	124	224	299	557	363	309	179
NE	551	810	1,542	2,758	1,617	1,334	1,471	1,625	1,444	1,335	1,265	1,491	1,534	1,826	1,728	1,701
SE	141	324	268	211	372	230	317	199	88	80	71	178	101	37	46	44
Total	**1,036**	**3,117**	**3,485**	**5,204**	**5,361**	**3,611**	**4,112**	**3,991**	**2,999**	**2,713**	**2,388**	**2,709**	**3,154**	**5,815**	**4,882**	**4,001**

Areas: Northwest Indian Ocean (**NW**); Southwest Indian Ocean (**SW**); Northeast Indian Ocean (**NE**); Southeast Indian Ocean (**SE**).

[1] Any differences in the data series since the last WPB are changes to the nominal catch as a result of reallocation of catches reported as other billfish species or as aggregated billfish species groups reported by, e.g., Sri Lanka, and Pakistan to a lesser extent. These changes, however, did not lead to very significant changes in the total catch estimates for striped marlin.

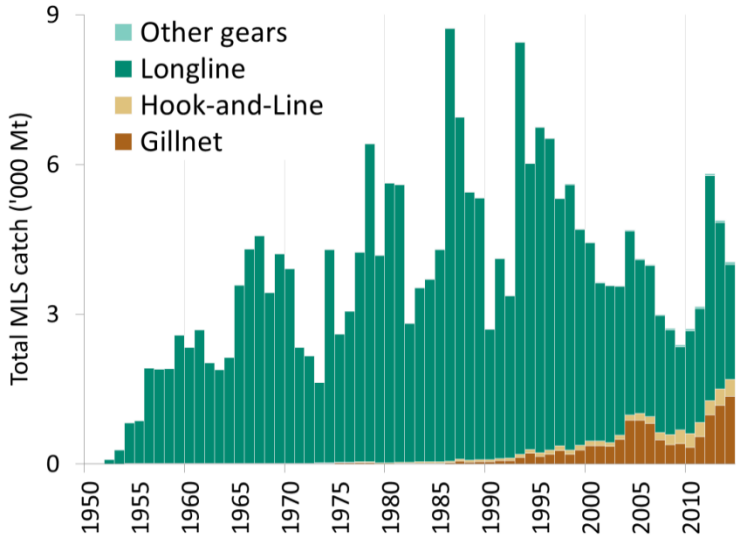


Fig. 3. Striped marlin: catches by gear and year recorded in the IOTC Database (1950–2014). Other gears includes: coastal purse seine, Danish purse seine, beach seine and purse seine.

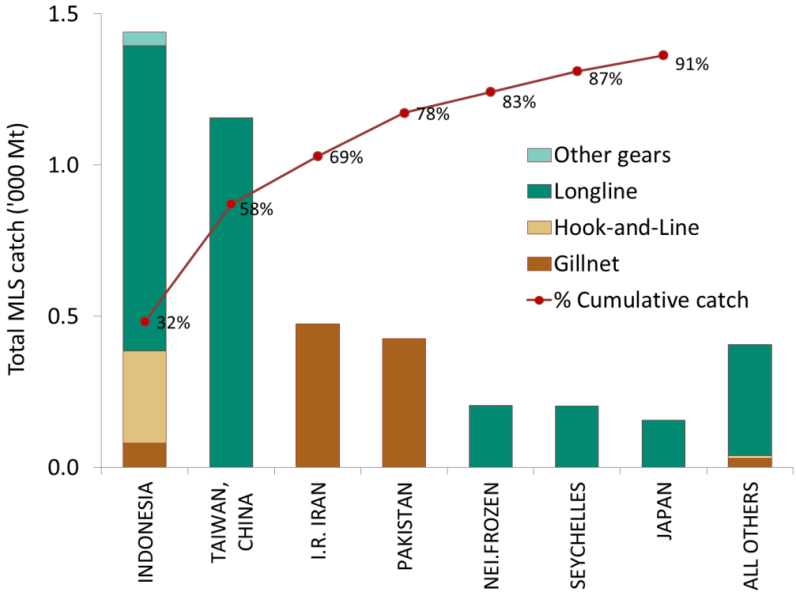


Fig. 4. Striped marlin: average catches in the Indian Ocean over the period 2011–14, by fleet and gear. Fleets are ordered from left to right, according to the volume of catches reported. The red line indicates the (cumulative) proportion of catches of striped marlin for the fleets concerned, over the total combined catches reported from all fleets and gears.

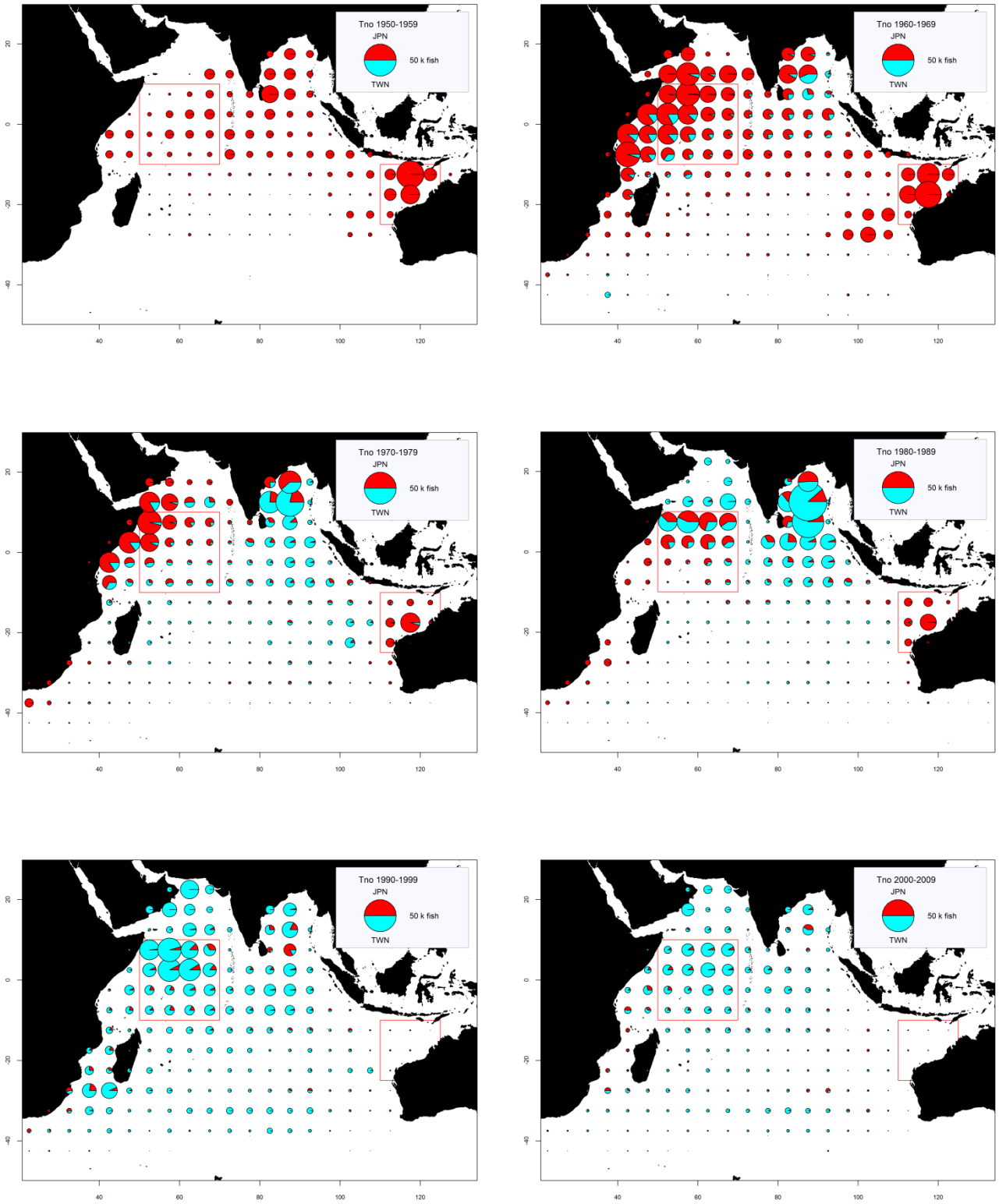


Fig. 5a-f. Time-area catches (in number of fish) of striped marlin as reported for the longline fisheries of Japan (JPN) and Taiwan,China (TWN) for the period 1950–2009, by decade and fleet. Red lines represent the marlin hotspots identified by the IOTC WPB.

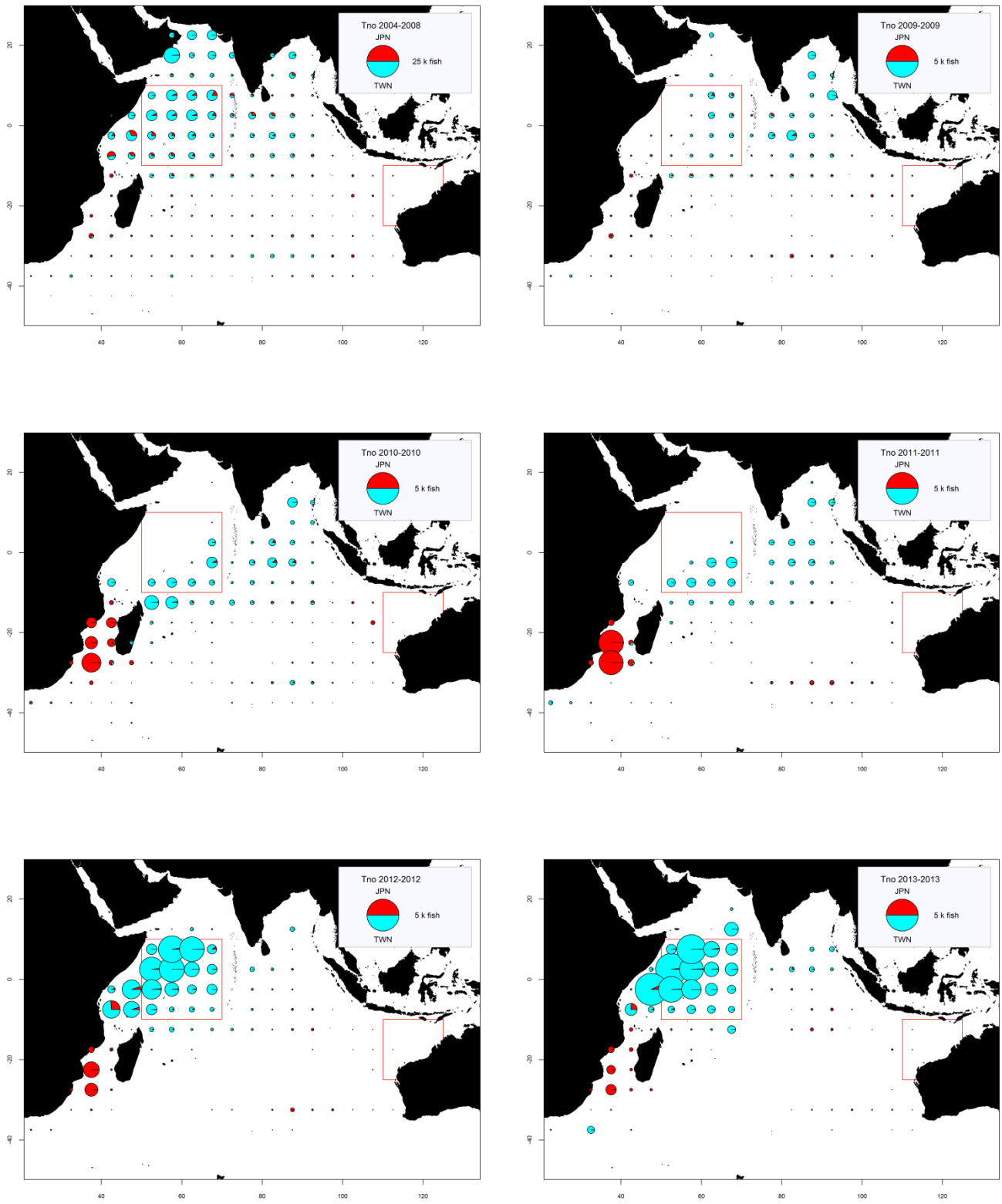


Fig. 6a-f. Time-area catches (in number of fish) of striped marlin as reported for the longline fisheries of Japan (JPN) and Taiwan,China (TWN) for the period 2004–08 by fleet and for 2009–13, by year and fleet. Red lines represent the marlin hotspots identified by the IOTC WPB.

Striped marlin: estimation of catches – data related issues

Retained catches – while the proportion of catches estimated, or adjusted, by the IOTC Secretariat are relatively low compared to other species of marlins (**Fig. 7a**), there are a number of uncertainties in the catches:

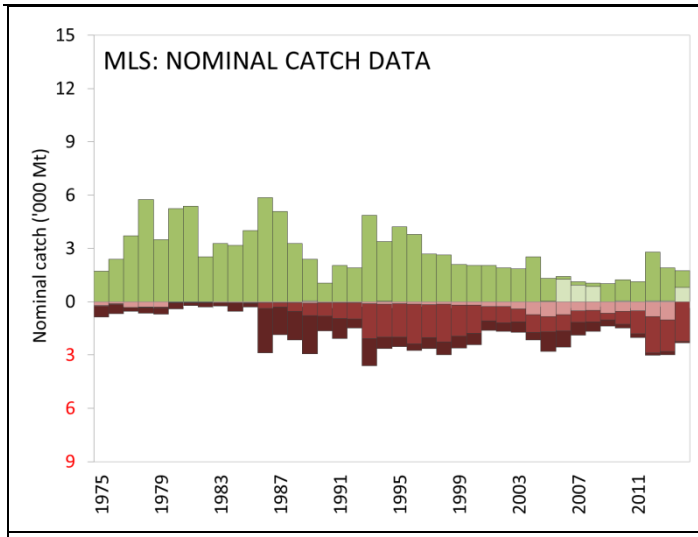
- Species aggregates: catch reports refer to total catches of all three marlin species; catches by species have to be estimated by the IOTC Secretariat for some industrial fisheries (longliners of Indonesia and Philippines).
- Non-reporting fleets: catches of non-reporting industrial longliners (e.g., India, NEI) and the gillnet fishery of Indonesia are estimated by the Secretariat using alternative information.
- Non-target species: catches are likely to be incomplete for industrial fisheries for which striped marlin is not a target species.
- Conflicting catch reports: longline catches from the Republic of Korea reported as nominal catches, and catch and effort reports are conflicting, with higher catches recorded in the catch and effort table. For this reason, the IOTC Secretariat revised the catches of striped marlin for the Republic of Korea over the time-series using both datasets. Although the new catches estimated by the Secretariat are thought to be more accurate, catches of striped marlin remain uncertain for this fleet.
- There are also conflicting catch reports for the drifting gillnet fishery of Pakistan, with very high catches of striped marlins reported by alternative sources (i.e., WWF funded sampling) derived from sampling in different locations in Pakistan. Catches of striped marlin reported by fleets using gillnets have been relatively low over the entire time-series (i.e. between 500 t and 1,400 t in recent years); however the recent data appears to indicate that gillnet catches of striped marlin in Pakistan may be much higher than those officially reported – although a comprehensive review of the catch series is required to confirm the catch levels for this species.
- Species mis-identification: difficulties in the identification of marlins also contribute to uncertainties in the catch estimates of striped marlin available to the Secretariat.

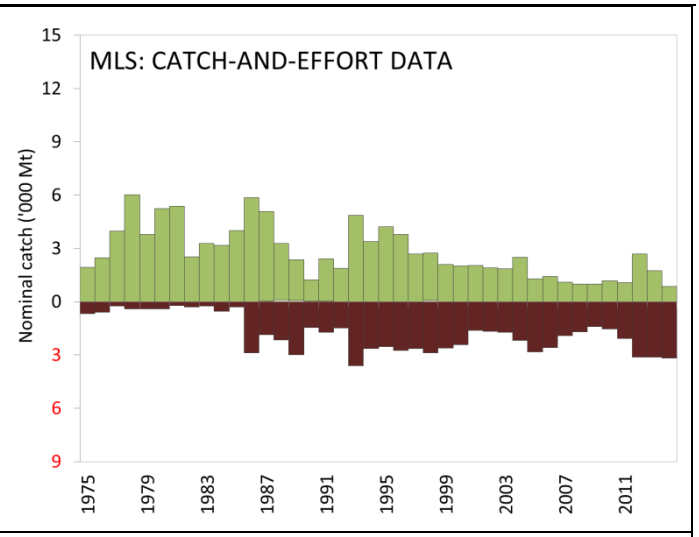
Striped marlin – Nominal catch-per-unit-effort (CPUE) trends

- Availability: Standardized CPUE series have been developed for the Japanese and Taiwanese longline fleets. Nominal CPUE series are available for some industrial longline fisheries, although catches are likely to be incomplete (as catches of non-target species are not always recorded in logbooks).
- No catch-and-effort data are available from sports fisheries, other than for partial data from the sports fisheries of Kenya; likewise no data are available for other artisanal fisheries (gillnet fisheries of Iran and Pakistan, gillnet/longlines of Sri Lanka, gillnets of Indonesia) or other industrial fisheries (NEI longliners and all purse seiners).
- Main CPUE series available: Japanese longline fleet.

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

- Average fish weight: can only be assessed for the longline fishery of Japan since 1970 and Taiwan,China since 1980. However, the number of specimens measured on Japanese longliners in recent years is very low. Also mis-identification of striped and blue marlin may be occurring in the Taiwanese longline fishery. Thirdly, the length frequency distributions derived from samples collected on Taiwanese longliners differ greatly from those collected on longliners flagged in Japan (**Fig. 8**).
- Catch-at-Size (Age) table: not available, due to lack of size samples and uncertainty over the reliability of retained catch estimates, or conflicting catch-and-effort data. Fish size is derived from various length and weight information, however the reliability of the size data is reduced for some fleets and when relatively few fish out of the total catch are measured.
- Sex ratio data: have not been provided to the Secretariat by CPCs.





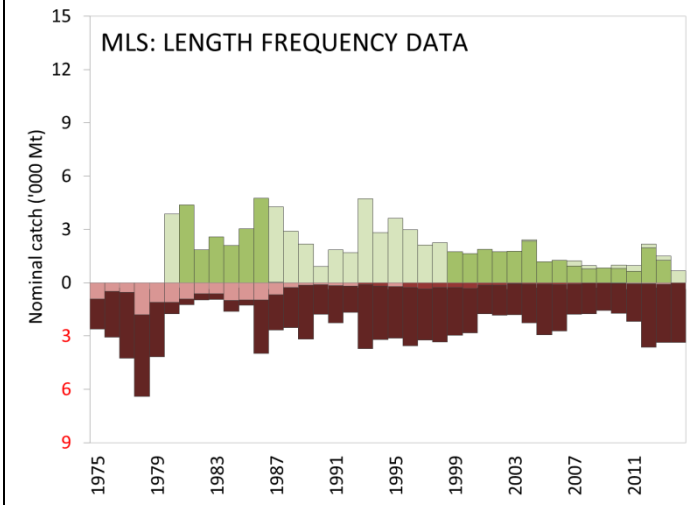


Fig. 7a-c. Striped marlin: data reporting coverage (1975–2014).
Each IOTC dataset (nominal catch, catch-and-effort, and length frequency) are assessed against IOTC reporting standards, where:
Score 0: indicates the amount of nominal catch associated with each dataset that is fully reported according to IOTC standards;
Scores: 2 – 6 refers to the amount of nominal catch associated with each dataset that is partially reported by gear and/or species (i.e., adjusted by gear and species by the IOTC Secretariat) or any of the other reasons provided in the document;
Score: 8 refers to the amount of nominal catch associated with catch-and-effort or size frequency data that is not available.
Data as of August 2015.

Key to IOTC Scoring system

Nominal Catch	By species	By gear
Fully available	0	0
Partially available (part of the catch not reported by species/gear)*	2	2
Fully estimated (by the IOTC Secretariat)	4	4

*Catch assigned by species/gear by the IOTC Secretariat; or 15% or more of the catches remain under aggregates of species

Catch-and-Effort	Time-period	Area
Available according to standards	0	0
Not available according to standards	2	2
Low coverage (less than 30% of total catch covered through logbooks)	2	
Not available at all	8	

Size frequency data	Time-period	Area
Available according to standards	0	0
Not available according to standards	2	2
Low coverage (less than 1 fish measured by metric ton of catch)	2	
Not available at all	8	

Key to colour coding

Total score is 0 (or average score is 0-1)
Total score is 2 (or average score is 1-3)
Total score is 4 (or average score is 3-5)
Total score is 6 (or average score is 5-7)
Total score is 8 (or average score is 7-8)

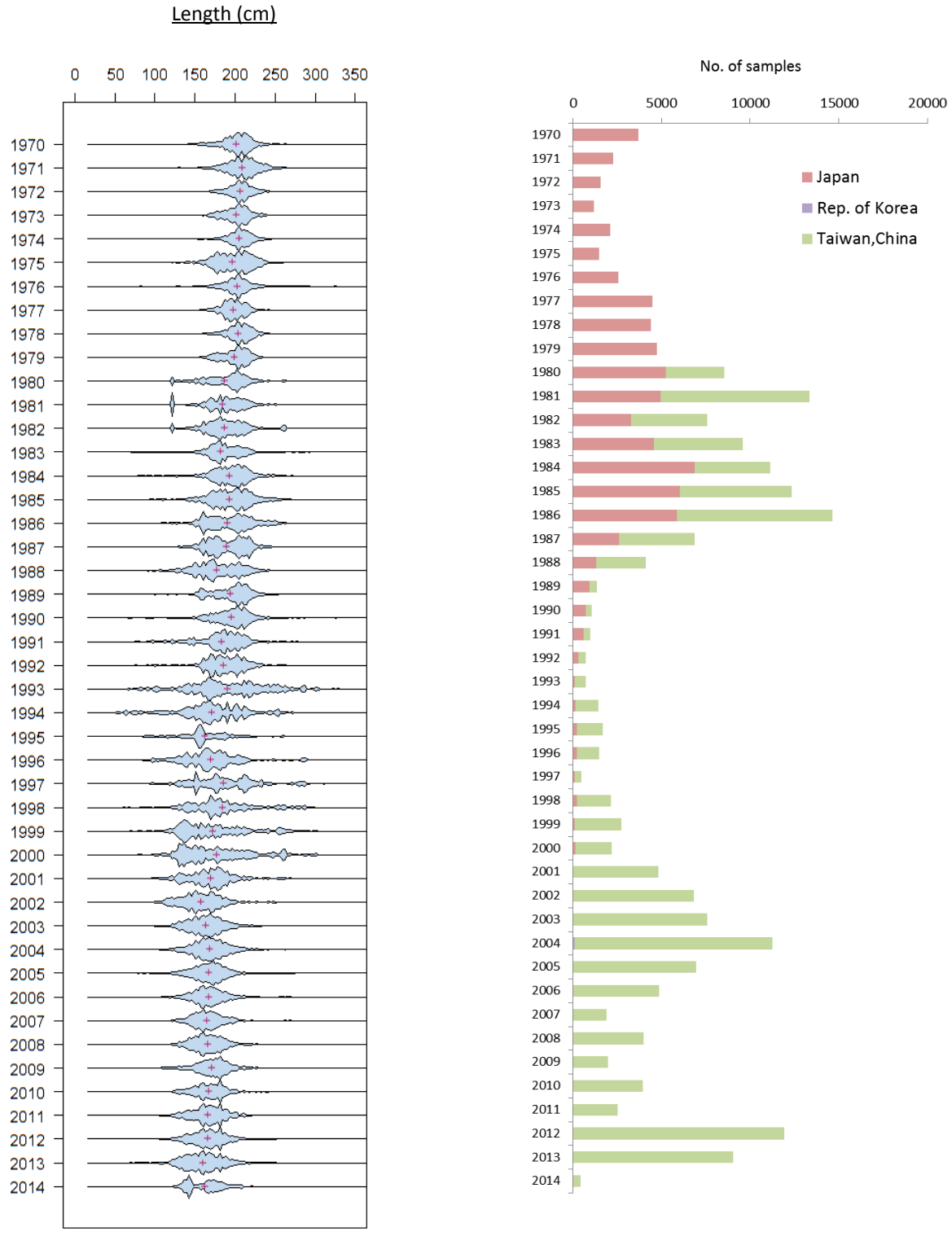


Fig. 8. Striped marlin: Longline catch-at-size length distributions (Data as of September 2015).

Striped marlin: Effort trends

Total effort from longline vessels flagged to Japan, Taiwan,China and EU,Spain by five degree square grid in 2013 and 2014 are provided in **Fig. 9**, 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 2013 and 2014 are provided in **Fig. 10**.

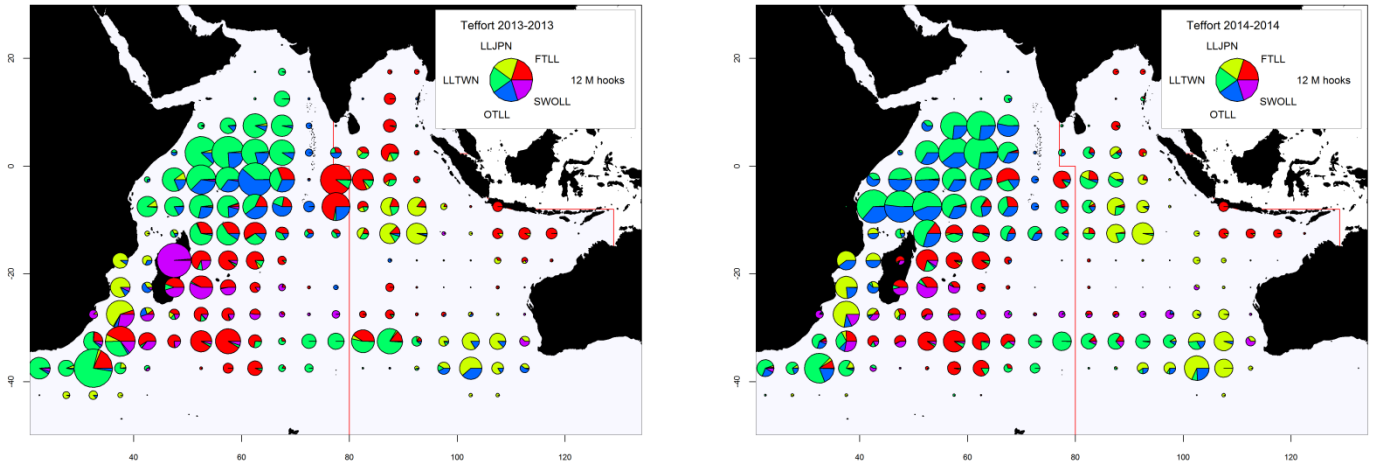


Fig. 9. Number of hooks set (millions) from longline vessels by five degree square grid and main fleets, for the years 2013 (left) and 2014 (right) (Data as of September 2015). **LLJP** (light green): deep-freezing longliners from Japan LLTW (dark green): deep-freezing longliners from Taiwan,China; **SWLL** (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).

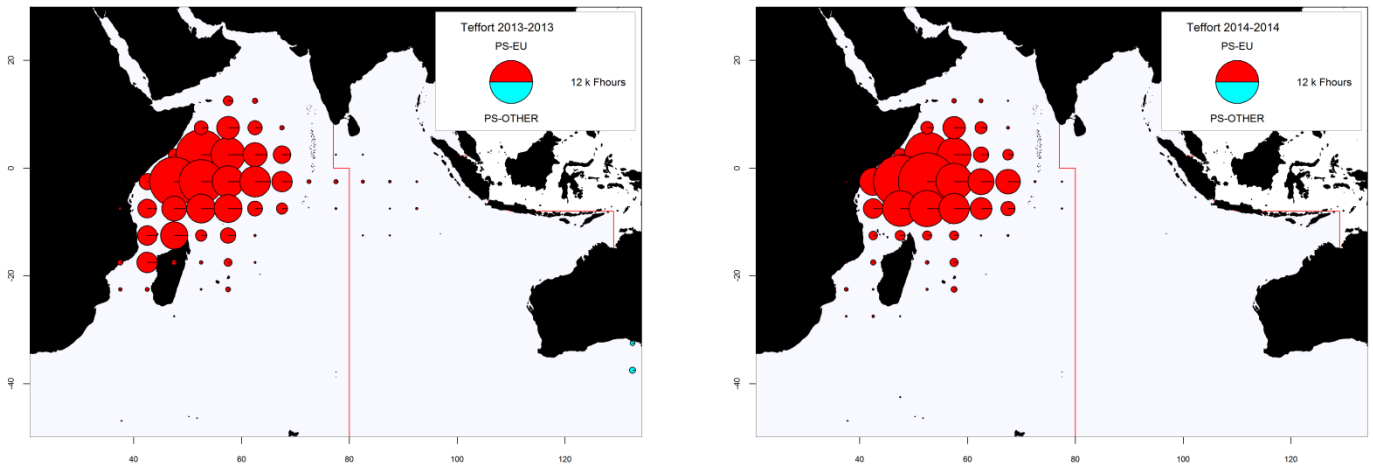


Fig. 10. Number of hours of fishing (Fhours) from purse seine vessels by 5 degree square grid and main fleets, for the years 2013 (left) and 2014 (right) (Data as of September 2015). **PS-EU** (red): Industrial purse seiners monitored by the EU and Seychelles (operating under flags of EU countries, Seychelles 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).

Striped marlin: Standardised catch–per–unit–effort (CPUE) trends

The following regarding the state of CPUE analysis for fleets with important catches of striped marlin in the IOTC area of competence should be noted:

- Uncertainty remains on the appropriate spatial units for the CPUE standardisation.
- Trends in standardised CPUE differ among fleets that operate in the same area, and efforts should be made to understand why there are these differences for the main longline fleets operating in similar areas.
- Fleet effects should be examined in subsequent years, and appropriate methods of dealing with zero catches using alternative methods, like the hurdle models (e.g. Delta approach), and zero inflated models should be used.

- In general the methods to deal with bycatch species in longline fisheries have improved substantially.

The study of environmental data (e.g. climate index and/or factors affecting catchability) in relation with CPUE changes should be encouraged as an important tool in understanding short-term CPUE spikes. The striped marlin CPUE series available for assessment purposes, the Japan and Taiwan,China series were used in the final stock assessment models investigated in 2015 (**Fig. 11**).

- Japan data (1976–2013) with a split at 1990 due to changes in catchability, and the 2011 standardised point removed, from document IOTC–2015–WPB13–17 Rev_1.
- Taiwan,China data (1980–2014) from document IOTC–2015–WPB13–31 Rev_1, with preliminary data for 2014 added in **Fig. 11**.

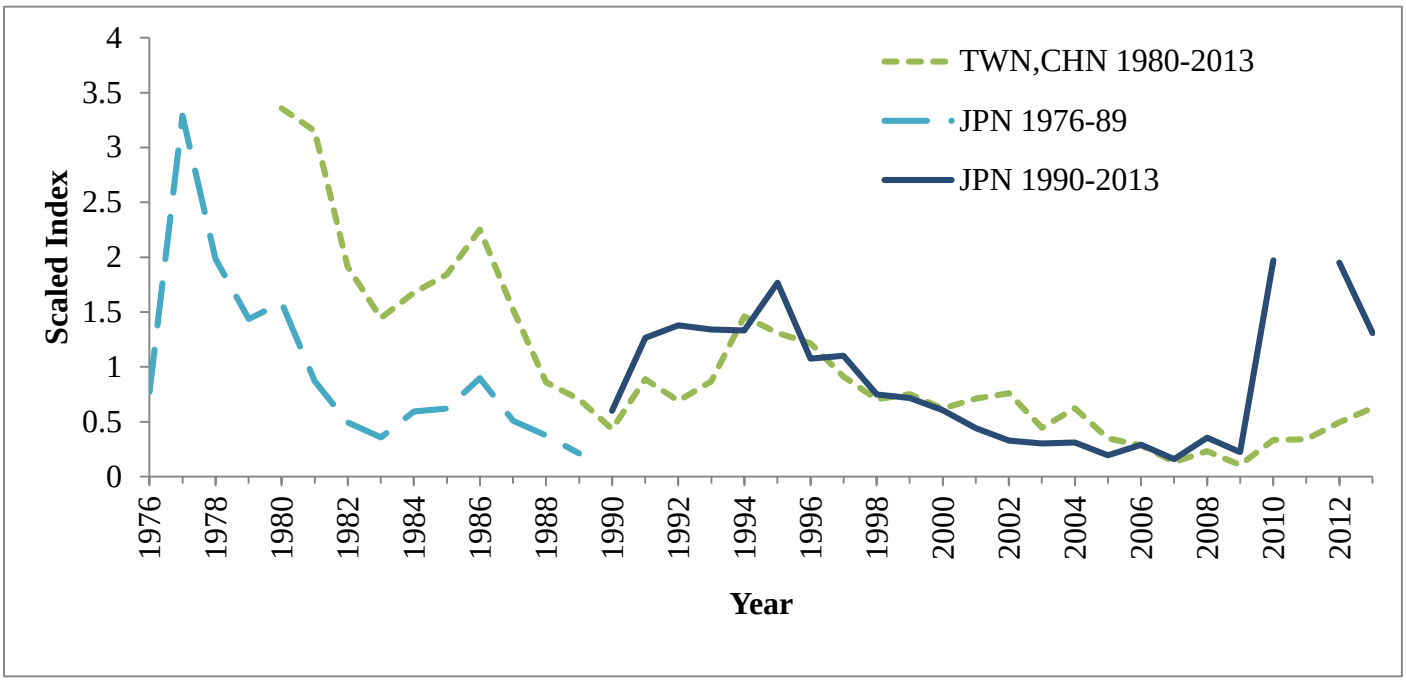


Fig. 11. Striped marlin: Standardised catch rates of striped marlin for Japan (JPN) and Taiwan,China (TWN,CHN) as calculated based on the IOTC catch and effort aggregated dataset (whole Indian Ocean). Values were scaled with respect to the mean of the period used for each series. Japan index was split due to different catchability before and after 1990, and the 2011 standardised point removed.

STOCK ASSESSMENT

The assessments carried out in 2015 continued development of approaches pursued in previous years for striped marlin. All models, except the ASIA model, were essentially giving the same outlook on the stock (and was similar to 2013 when striped marlin was last assessed (using data up until 2012)), and as such the ensemble of information from the assessment was used for developing stock status advice.

The key assessment results for A Stock-Production Model Incorporating Covariates (ASPIC) are shown below (**Table 6**).

TABLE 6. Striped marlin: Key management quantities from the ASPIC assessment, for the Indian Ocean.

Management Quantity	**Aggregate Indian Ocean**
2014 catch estimate (t)	4,049
Mean catch from 2010–2014 (t)	4,122
MSY (1000 t) (80% CI)	5.22 (5.18–5.59)
Data period (catch)	1950–2014
F_{MSY} (80% CI)	0.62 (0.59–1.04)
SB_{MSY} or $*B_{MSY}$ (1,000 t) (80% CI)	8.4* (5.4–8.9)

F_{2014}/F_{MSY} (80% CI)	1.09 (0.62–1.66)
B_{2014}/B_{MSY} (80% CI)	0.65 (0.45–1.17)
SB_{2014}/SB_{MSY} (80% CI)	n.a.
B_{2014}/B_{1950} (80% CI)	0.24 (n.a.–n.a.)
SB_{2014}/SB_{1950} (80% CI)	n.a.
$B_{2014}/B_{1950, F=0}$ (80% CI)	n.a.
$SB_{2014}/SB_{1950, F=0}$ (80% CI)	n.a.

n.a. = not available

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