BLUE MARLIN

SUPPORTING INFORMATION

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

CONSERVATION AND MANAGEMENT MEASURES

Blue marlin (*Makaira nigricans*) in the Indian Ocean is currently subject to a number of Conservation and Management Measures adopted by the Commission, of which only one (15/05) is 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 15/05: *On conservation measures for Striped marlin, Black marlin and Blue marlin*
- 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: C*oncerning a record of active vessels fishing for tunas and swordfish in the IOTC area*

FISHERIES INDICATORS

Blue marlin: General

Blue marlin (*Makaira nigricans*) is a large oceanic apex predator that inhabits tropical and subtropical waters of the Indian and Pacific oceans (**Fig. 1**). **Table 1** outlines some key life history parameters relevant for management.

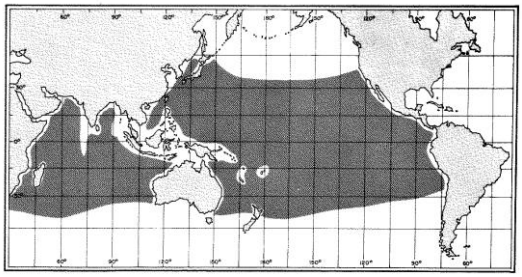


Fig. 1. Blue marlin: The worldwide distribution of blue marlin (Source: Nakamura 1984).

TABLE 1. Blue marlin: Biology of Indian Ocean blue marlin (*Makaira nigricans*).

Parameter	Description
Range and stock structure	Little is known on the biology of the blue marlin in the Indian Ocean. Blue marlin is a highly migratory, large oceanic apex predator that inhabits tropical and subtropical waters of the Indian and Pacific oceans. It is capable for long-distance migrations: in the Pacific Ocean a tagged blue marlin is reported to have travelled 3000 nm in 90 days. In the Indian Ocean a blue marlin tagged in South Africa was recaptured after 90 days at liberty off the southern tip of Madagascar crossing Mozambique Channel and travelling 1398 km with average speed 15.5 km/day. Other tagging off western Australia revealed potential intermixing of Indian Ocean and Pacific stocks: one individual was caught in the Pacific Indonesian waters. Blue marlin is a solitary species and prefers the warm offshore surface waters (>24°C); it is scarce in waters less than 100 m in depth or close to land. The blue marlin's prey includes octopuses, squid and pelagic fishes such as tuna and frigate mackerel. Feeding takes place during the daytime, and the fish rarely gather in schools, preferring to hunt alone. No information on stock structure is currently available in the Indian Ocean; thus for the purposes of assessment, one pan-ocean stock is assumed. However, spatial heterogeneity in stock indicators (catch–per–unit–effort trends) for other billfish species indicates that there is potential for localised depletion.
Longevity	~28 years; Females n.a.; Males n.a.
Maturity (50%)	**Age**: 2–4 years; females n.a. males n.a. **Size:** females ~50 cm LJFL (55 kg whole weight); males ~80 cm LJFL (40 kg total weight).
Spawning season	No spawning grounds have been identified in the Indian ocean. Females may produce up to 10 million eggs. In the Pacific ocean, blue marlin are thought to spawn between May and September off the coast of Japan.
Size (length and weight)	Maximum: Females 430 cm FL; 910 kg whole weight; males 300 cm FL; 200 kg whole weight. Young fish grow very quickly in length then put on weight later in life. Sexual dimorphism in size, growth rates and size and age at maturity - females reach larger sizes, grow faster and mature later than males. L-W relationships for the Indian Ocean are: females TW=0.00000026*LJFL^3.59846; males TW=0.00001303*LJFL^2.89258,

	both sexes mixed TW=0.00000084*LJFL^3.39404. TW in kg, LJFL in cm.

n.a. = not available. Sources: Nakamura 1985, Cry et al. 1990, Shimose et al. 2008, Froese & Pauly 2009, Romanov & Romanova 2012

Fisheries and main catch trends

- Main fishing gear (2012–16): Blue marlin are largely considered to be a non-target species of industrial and artisanal fisheries. Longline catches[1] account for around 72% of total catches in the Indian Ocean, followed by gillnets (25%), with remaining catches recorded under troll and handlines. (**Table 2; Fig. 2**)
- Main fleets (and primary gear associated with catches): percentage of total catches (2012–16): Taiwan,China (longline): 33%; Indonesia (fresh longline): 30%; Pakistan (gillnet): 12%; I.R. Iran (gillnet): 9%, and Sri Lanka (5%) (**Fig. 3**).
- Main fishing areas: Western Indian Ocean, in the main fishing areas operated by longliners.
- Retained catch trends: Catch trends are variable, which may reflect the level of reporting and the status of blue marlin as a non-target species.

  Catches reported by drifting longliners were more or less stable until the late-70s, at around 3,000 t to 4,000 t, and have steadily increased since then to reach values between 8,000 t and to over 10,000 t since the early 1990s. The highest catches reported by longliners have been recorded since 2012, and are likely to be the consequence of higher catch rates by some longline fleets which appear to have resumed operations in the western tropical Indian Ocean.
- Discard levels**:** Low, although estimates of discards are unknown for most industrial fisheries, mainly longliners. Discards may also occur in some gillnet fisheries.

***Changes to the catch series*:** no major changes to the catch series since the WPB meeting in 2014, when catches were revised substantially following new reports of catches-by-species for drifting gillnet fleets by Iran[2].
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 blue marlin.

TABLE 2. Blue marlin: best scientific estimates of catches by type of fishery for the period 1950–2016 (in metric tons).

Fishery	By decade (average)						By year (last ten years)									
	1950s	1960s	1970s	1980s	1990s	2000s	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
LL	2,567	3,535	3,409	4,545	6,982	7,406	6,407	6,369	6,664	6,675	7,282	12,224	10,217	11,345	11,192	11,845
GN	1	2	124	767	2,357	2,687	2,559	2,410	2,049	2,198	3,919	4,828	4,061	3,543	3,673	3,580
HL	5	9	17	105	174	154	167	205	277	303	269	265	339	501	688	874
OT	0	0	0	2	4	7	8	11	15	15	16	16	17	15	20	54
Total	**2,574**	**3,546**	**3,551**	**5,419**	**9,517**	**10,254**	**9,142**	**8,994**	**9,004**	**9,191**	**11,486**	**17,332**	**14,635**	**15,404**	**15,573**	**16,353**

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**).

[1] Including deep freezing longline (LL), exploratory longline (LLEX), fresh longline (FLL), longlines targeting sharks (SLL), and swordfish targeted longline (LLEX).

[2] Prior to 2013 I.R. Iran reported aggregated catches for all billfish species, which were estimated by species and gear by the IOTC Secretariat. Iran has provided catches by billfish species for the first time, from 2012 onwards, which significantly revised the catch-by-species previously estimated by the Secretariat: the main change being the higher proportions of black marlin, rather than blue marlin reported by I.R. Iran, assigned to the offshore gillnet fishery. As a result of changes in the catch series total catches of black marlin for I.R. Iran were revised upwards by as much as 30% to 50% for a number of years around the mid-2000's.

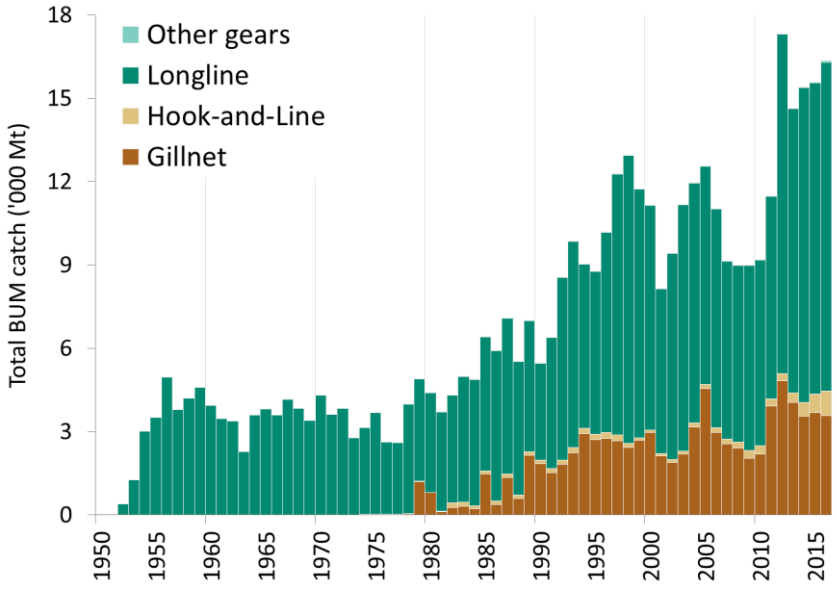


Fig. 2. Blue marlin: catches by gear and year recorded in the IOTC Database (1950–2016)[3].

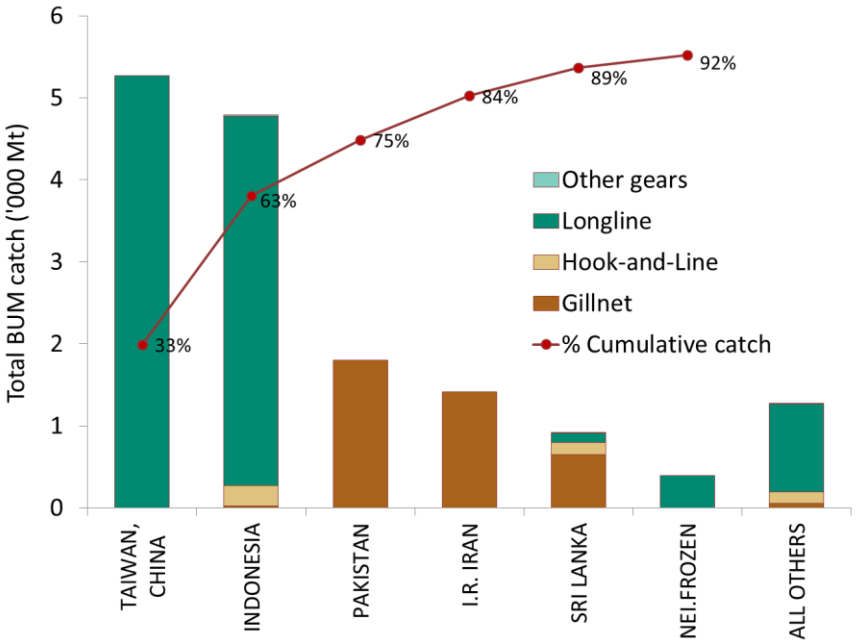


Fig. 3. Blue marlin: average catches in the Indian Ocean over the period 2012–16, by fleet and gear. Fleets are ordered from left to right, according to the volume of catches reported. The red line indicates the (cumulative) proportion of catches of blue marlin for the fleets concerned, over the total combined catches reported from all fleets and gears.

[3] **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**).

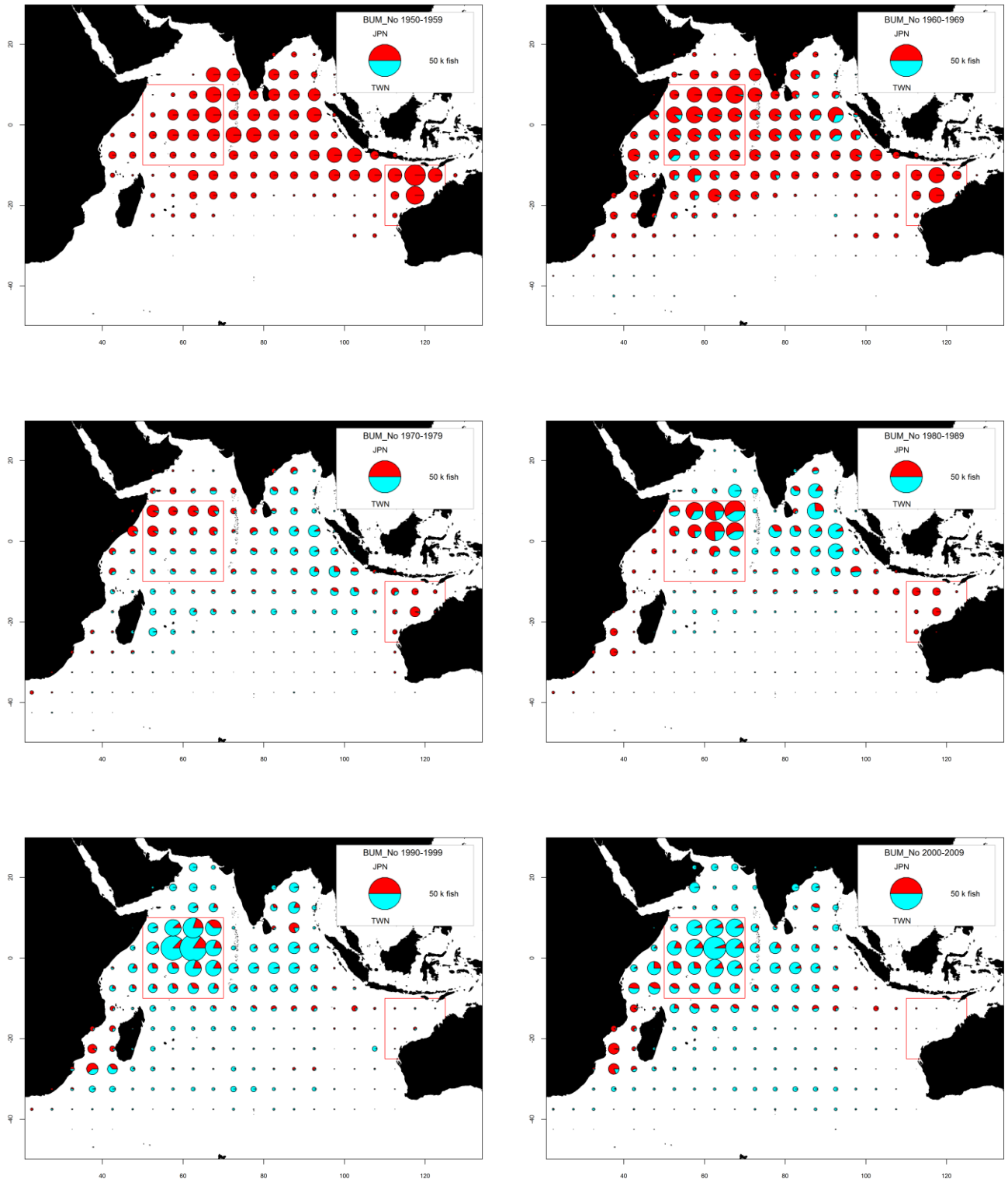


Fig. 4a-f. Time-area catches (in number of fish) of blue marlin as reported for the longline fisheries of Japan (JPN) and Taiwan,China (TWN) for the period 1950-2009, by decade and fleet. Red lines represent the marlin hotspots identified by the IOTC WPB. Source: IOTC catch and effort data.

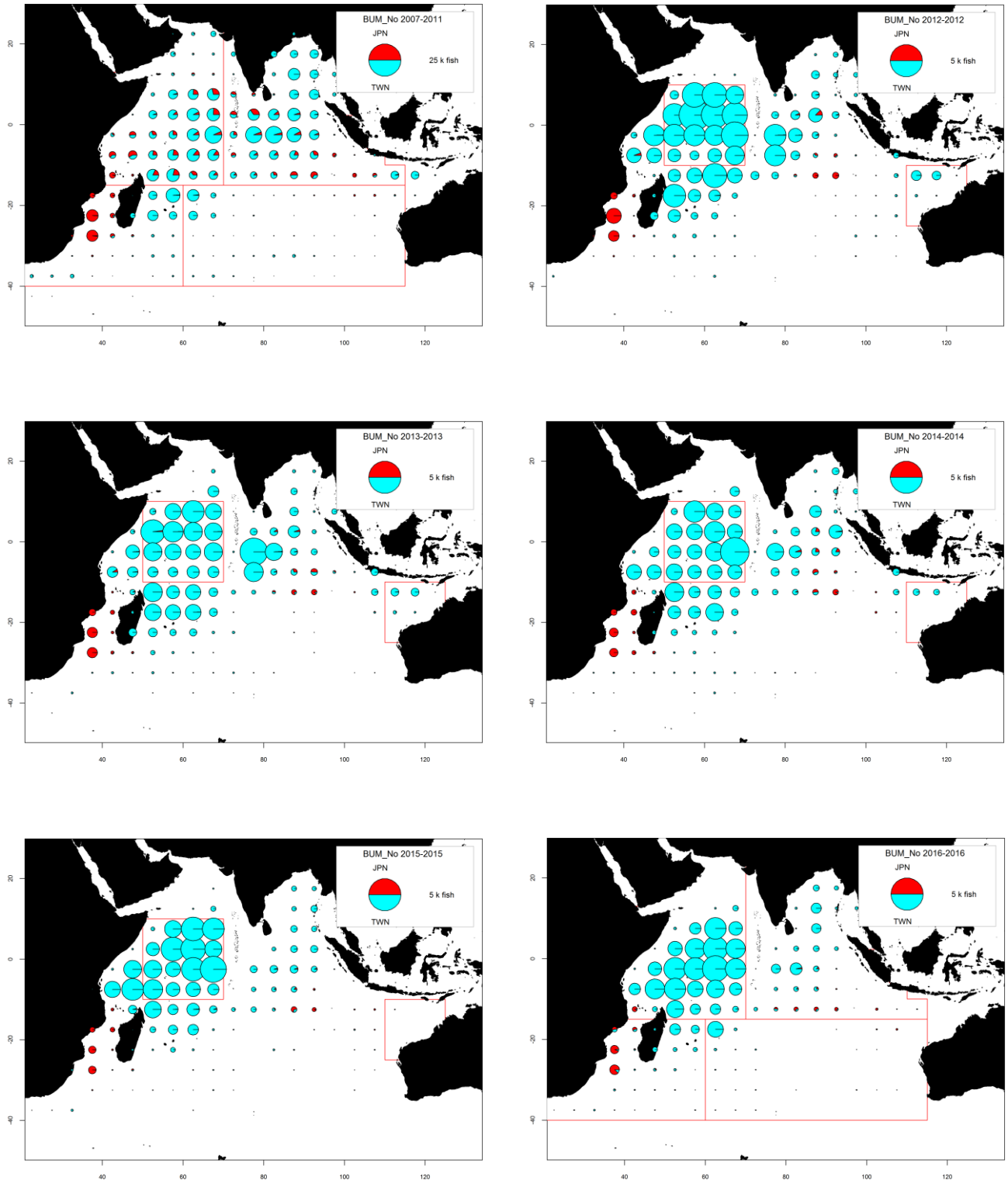


Fig. 5a-f. Time-area catches (in number of fish) of blue marlin as reported for the longline fisheries of Japan (JPN) and Taiwan,China (TWN) for the period 2007–11 by fleet and for 2012–16, by year and fleet. Red lines represent the marlin hotspots identified by the IOTC WPB. Source: IOTC catch and effort data.

Uncertainty of time–area catches

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 IOTC Secretariat.

Retained catches – a high proportion of the catches of blue marlin are estimated, or adjusted, by the IOTC Secretariat are (**Fig.6a**), due to a number of uncertainties in the catches:

- Species aggregates: catch reports often refer to total catches of all three marlin species combined or as an aggregate of all billfish species. Catches-by-species are estimated by the IOTC Secretariat for some years and artisanal fisheries (e.g., gillnet-longline fishery of Sri Lanka, artisanal fisheries of India, Iran and Pakistan) and industrial fisheries (e.g., 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 blue marlin is not a target species.
- Conflicting catch reports: longline catches from the Republic of Korea reported as nominal catches, and catch and effort are conflicting, with higher catches recorded in the catch and effort table. For this reason, the Secretariat revised the catches of blue 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 blue marlin remain uncertain for this fleet.
- Lack of catch data for most sport fisheries.
- Species misidentification: difficulties in the identification of marlins also contribute to uncertainties in the catch estimates of blue marlin.

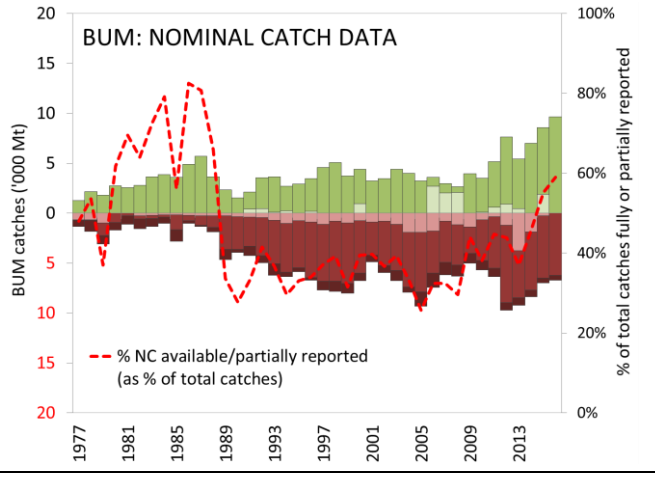
Blue marlin – Nominal catch-per-unit-effort (CPUE) trends

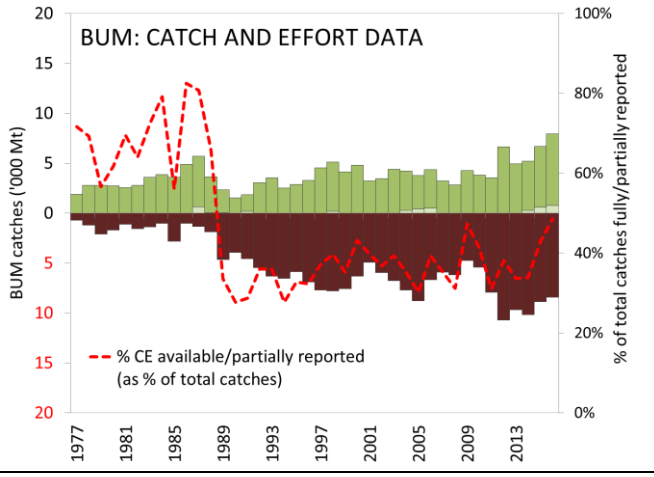
- Availability: Standardized CPUE series have not yet been developed. Nominal CPUE series are available for some industrial longline fisheries, although catches are likely to be incomplete (as catches of non-target species are not always recorded in logbooks).

  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 and Taiwanese longline fleet.

Blue 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 and misidentification of striped and blue marlin may occur in some longline fisheries. Also the length frequency distributions derived from samples collected by fishermen on Taiwanese longliners are likely to be biased.
- 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.





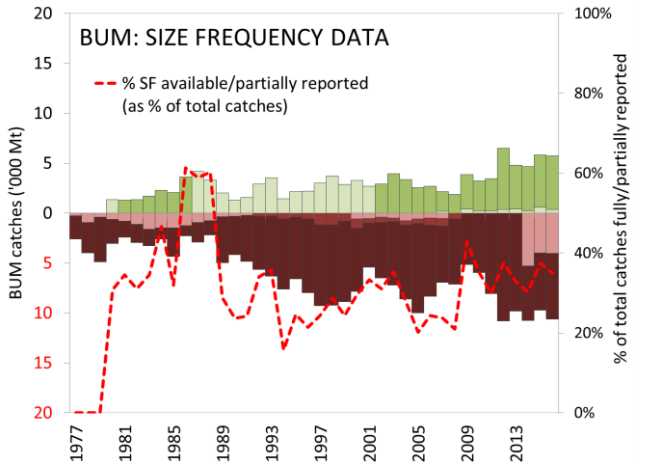


Fig. 6a-c. Blue marlin: data reporting coverage (1977–2016).

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.*

The red dotted line indicates the proportion of data (in terms of total catches) fully or partially reported for each dataset.

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)

Blue marlin (longline samples): size (in cm)

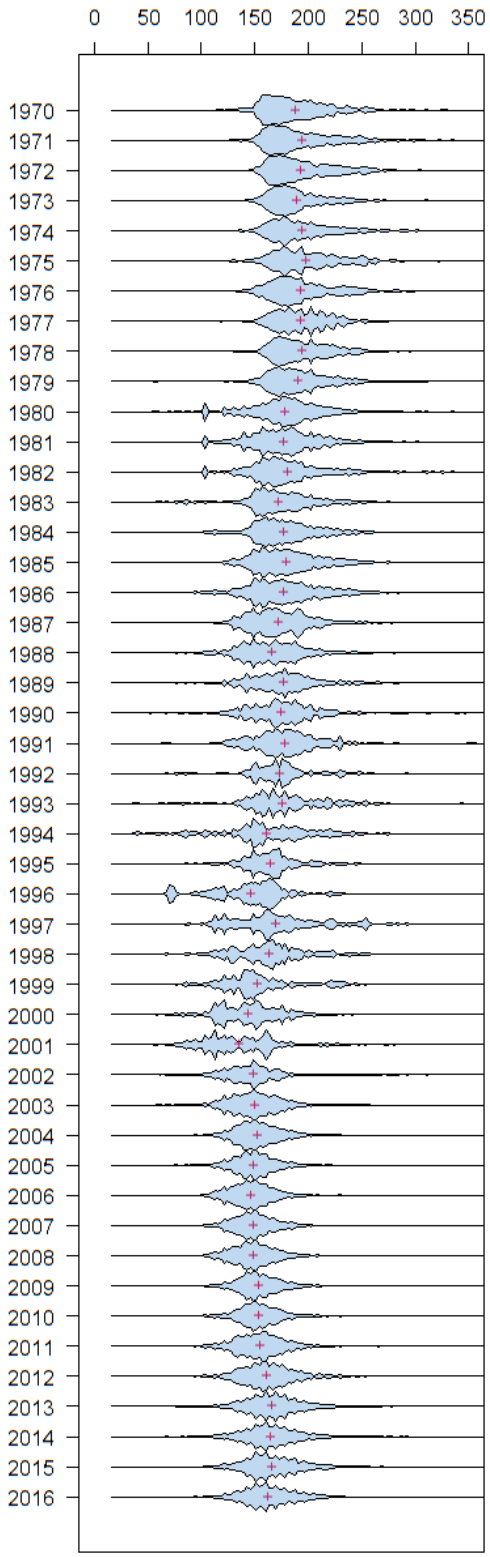


Fig. 7. Blue marlin: Length frequency distributions for gillnet fisheries (total amount of fish measured by 3cm length class) derived from data available at the IOTC Secretariat.

Fishing effort trends

Total effort from longline vessels flagged to Japan, Taiwan,China and EU,Spain by five degree square grid in 2015 and 2016 are provided in **Fig. 8**, 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 in 2015 and 2016 are provided in **Fig. 9**.

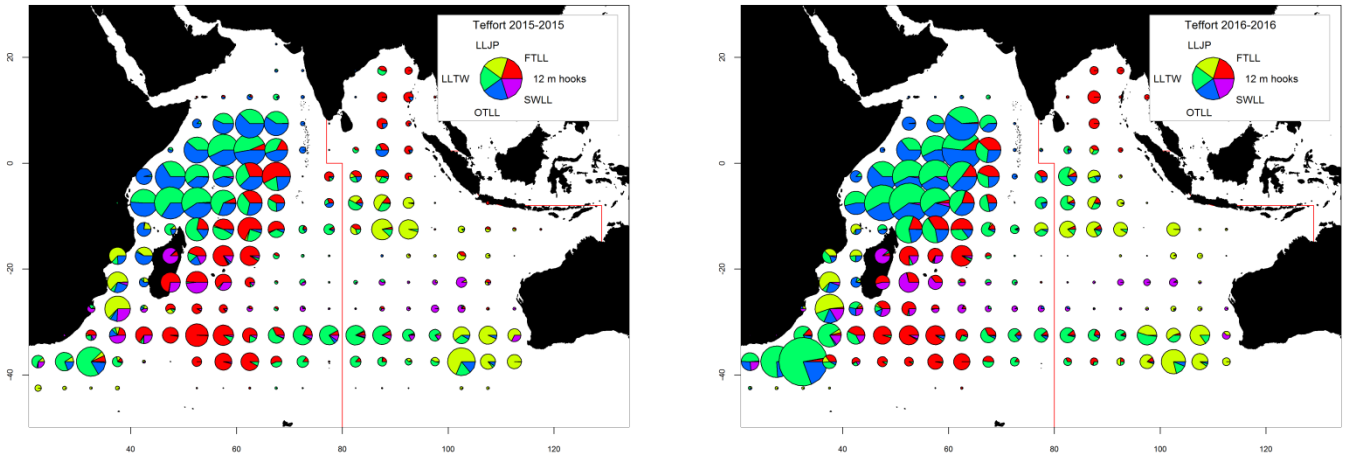


Fig.8. Number of hooks set (millions) from longline vessels by five degree square grid and main fleets, for the years 2015 (left) and 2016 (right). **LLJP** (light green): deep-freezing longliners from Japan; **LLTW** (dark green): deep-freezing longliners from Taiwan,China; **SWLL** (turquoise): swordfish 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).

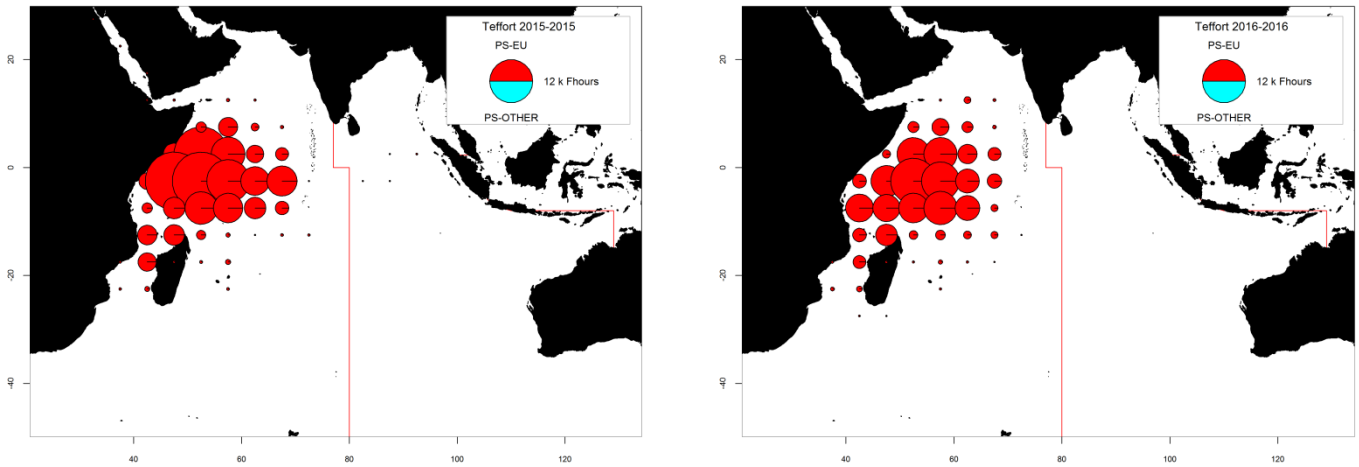


Fig.9. Number of hours of fishing (Fhours) from purse seine vessels by 5 degree square grid and main fleets, for the years 2015 (left) and 2016 (right). **PS-EU** (red): Industrial purse seiners monitored by the EU and Seychelles (operating under flags of EU countries, Seychelles and other flags); **PS-OTHER** (light blue): 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).

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

The sharp decline between 1952 and 1956 in the Japanese blue marlin CPUE series does not reflect the trend in abundance, although the gradual decline identified since 1970 until 2011 is more likely to represent actual declines in stock abundance (**Fig. 10**). The catches and CPUE series estimated for blue marlin were very similar between the longline fleets of Japan and Taiwan,China, although there were two peaks in the Taiwan,China data series. In particular the longline fleet data for Taiwan,China was highly variable and warranted further investigation and documentation.

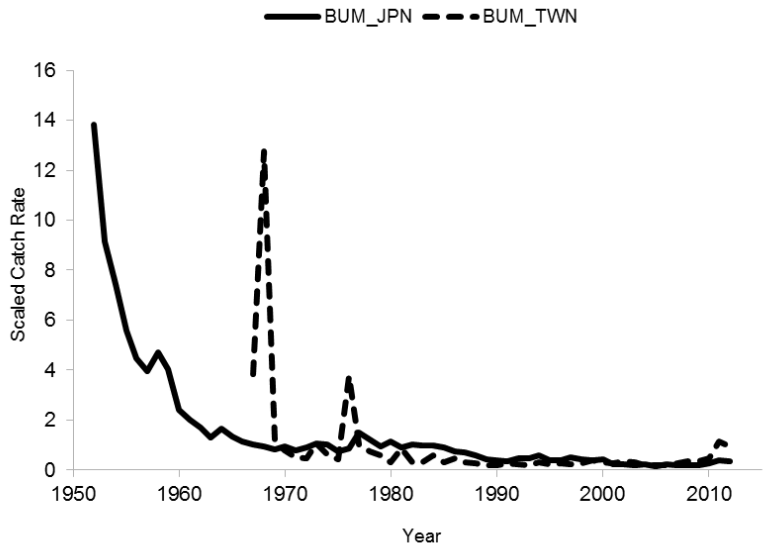


Fig. 10. Blue marlin: Standardised catch rates of blue marlin for Japan (JPN) and Taiwan,China (TWN) as calculated based on the IOTC catch and effort aggregated dataset. Values were scaled with respect to the mean of 1970–1979 period.

Of all the blue marlin CPUE series available for assessment purposes, the Japanese and Taiwan,China (TWN) CPUE series (**Fig. 11**) were used in the stock assessment model for 2016.

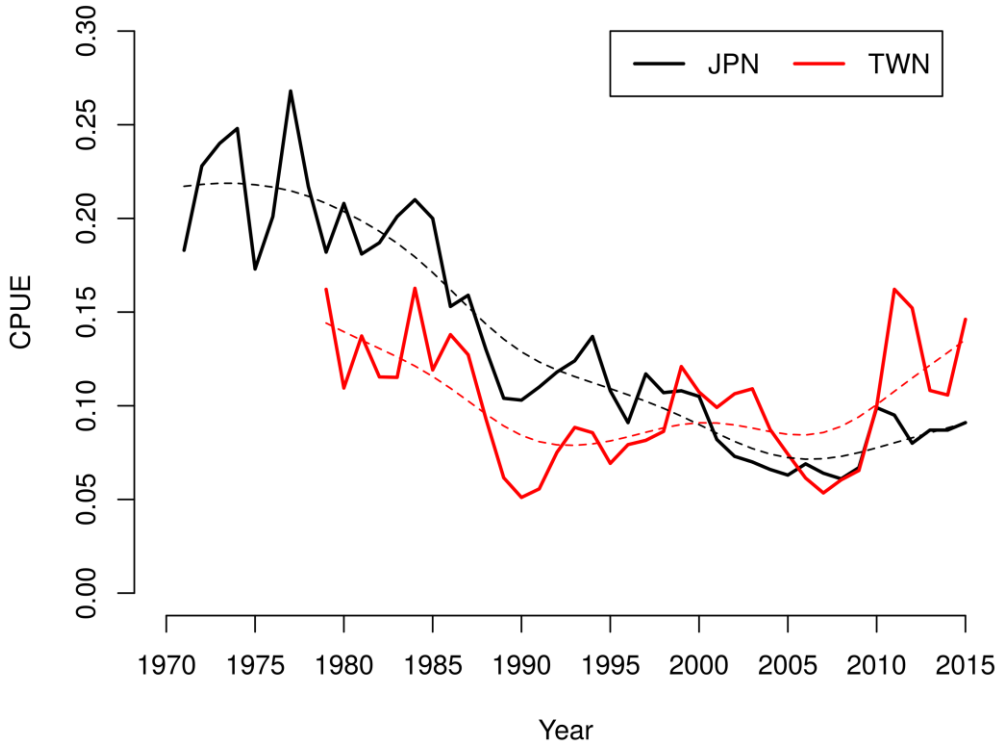


Fig. 11. Blue marlin: Comparison of the CPUE series for the longline fleets of Japan and Taiwan,China.

Both Japan and Taiwan,China undertook a historical review of their longline data and documented the changes in fleet dynamics for presentation at the WPB meeting. The historical reviews included the available explanatory information regarding changes in fishing areas, species targeting, gear changes and other fleet characteristics to assist the WPB understand the current fluctuations observed in the data.

STOCK ASSESSMENT

A range of quantitative modelling methods (SS3, ASPIC and Bayesian state space Surplus Production Model) were applied to the Blue marlin in 2016. These models showed similar stock trajectories, and based on the weight-of-evidence approach, the WPB agreed to use the results from the Bayesian state space Surplus Production Model for stock status advice (see **Table 3**). Further work needs to be conducted in future years to improve these assessments.

The standardised longline CPUE series indicate a decline in abundance in the early 1980s, followed by a constant or slightly increasing abundance over the last 20 years. In 2016, the BSP-SS stock assessment **did not confirm** the assessment results from 2013 that indicated the stock as being exploited at sustainable levels and that the stock was at the optimal biomass level.

Two other approaches examined in 2016 came to similar conclusions, namely SS3 and ASPIC. The Kobe plot from the BSP-SS model indicates that the stock was most likely subject to overfishing in the recent past. Thus, on the weight-of-evidence available to the WPB, the stock is determined to be **not overfished** but **subject to overfishing**.

However, the uncertainty in the data available for assessment purposes and the CPUE series suggests that the advice should be interpreted with caution as the stock might still be in an overfished state (biomass less than B_{MSY}). Research emphasis on improving indicators and further exploration of stock assessment approaches for data poor fisheries are still warranted.

Given the limited data being reported for gillnet fisheries, and the importance of sports fisheries for this species, efforts must be made to rectify these information gaps.

TABLE 3. Blue marlin (*Makaira nigricans*) key management quantities from the BSP-SS stock assessment (2016).

Management Quantity	Indian Ocean
2015 catch estimate	15,706
Mean catch from 2011–2015	14,847
MSY (1000 t) (80% CI)	11.926 (9.232 – 16.149)
Data period used in assessment	1950 – 2015
F_{MSY} (80% CI)	0.109 (0.076 – 0.160)
B_{MSY} (1000 t) (80% CI)	113.012 (71.721 – 161.946)
F_{2015}/F_{MSY} (80% CI)	1.18 (0.80 – 1.71)
B_{2015}/B_{MSY} (80% CI)	1.11 (0.90 – 1.35)
SB_{2015}/SB_{MSY}	n.a.
B_{2015}/B_{1950} (80% CI)	0.56 (0.44 – 0.71)
SB_{2015}/SB_{1950}	n.a.
$B_{2015}/B_{1950, F=0}$	n.a.
$SB_{2015}/SB_{1950, F=0}$	n.a.

LITERATURE CITED

Andrade, H.A. (2016): Preliminary stock assessment of blue marlin (*Makaira nigricans*) caught in the Indian Ocean using a Bayesian state-space production model IOTC–2016–WPB14–27, 20 p

Cyr EC, Dean JM, Jehangeer I, Nallee M (1990) Age, growth, and reproduction of blue marlin and black marlin from the Indian Ocean. In: Stroud RH (ed) Planning the future of billfishes. Research and management in the 90s and beyond. National Coalition for Marine Conservation, Savannah, GA, pp 309–316

Froese R, Pauly DE (2009) FishBase, version 02/2009, FishBase Consortium, <www.fishbase.org>

Kleiber P, Hinton MG, Uozumi Y (2003) Stock assessment of blue marlin (*Makaira nigricans*) in the Pacific using MULTIFAN-CL. Mar Freshw Res 54:349–360

Nakamura I (1985) FAO species catalogue. Billfish of the world. An annotated and illustrated catalogue of marlins, sailfishes, spearfishes, and swordfishes known to date. FAO Fish.Synop.125(5), 65 p

Romanov EV (2002) Bycatch in the tuna purse-seine fisheries of the western Indian Ocean. Fish Bull 100(1): 90–105

Romanov E, Romanova N (2012) Size distribution and length-weight relationships of some billfish (marlins, spearfish and swordfish) in the Indian Ocean. IOTC–2012–WPB10–19, 12 p

Shimose T, Fujita M, Yokawa K, Saito H, Tachihara K (2008) Reproductive biology of blue marlin *Makaira nigricans* around Yonaguni Island, southwestern Japan. Fish Sci 75: 109–119.