Report of the 16th Session of the IOTC Working Party on Billfish

Cape Town, South Africa, 4–8 September 2018

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Acronyms

ABF	African Billfish Foundation
ASPIC	A Stock-Production Model Incorporating Covariates
B	Biomass (total)
B_{MSY}	Biomass which produces MSY
BLM	Black marlin (FAO code)
BSP-SS	Bayesian Surplus Production Model – State-Space
BUM	Blue marlin (FAO code)
CE	Catch and effort
CI	Confidence Interval
CMM	Conservation and Management Measure (of the IOTC; Resolutions and Recommendations)
CPCs	Contracting parties and cooperating non-contracting parties
CPUE	Catch per unit of effort
current	Current period/time, i.e. $F_{current}$ means fishing mortality for the current assessment year.
EU	European Union
EEZ	Exclusive Economic Zone
F	Fishing mortality; F_{2010} is the fishing mortality estimated in the year 2010
FAO	Food and Agriculture Organization of the United Nations
F_{MSY}	Fishing mortality at MSY
GLM	Generalized linear model
HBF	Hooks between floats
IO	Indian Ocean
IOTC	Indian Ocean Tuna Commission
JABBA	Just Another Bayesian Biomass Assessment (a generalized Bayesian State-Space Surplus Production Model)
LL	Longline
M	Natural Mortality
MSY	Maximum sustainable yield
n.a.	Not applicable
NGO	Non-governmental organization
PS	Purse-seine
q	Catchability
r	Intrinsic rate of population increase
ROS	Regional Observer Scheme
SC	Scientific Committee of the IOTC
SB	Spawning biomass (sometimes expressed as SSB)
SB_{MSY}	Spawning stock biomass which produces MSY
SFA	Indo-Pacific sailfish (FAO code)
SS3	Stock Synthesis III
STM	Striped marlin (FAO code)
SWO	Swordfish (FAO code)
Taiwan,China	Taiwan, Province of China
WPB	Working Party on Billfish of the IOTC
WPEB	Working Party on Ecosystems and Bycatch of the IOTC

STANDARDISATION OF IOTC WORKING PARTY AND SCIENTIFIC COMMITTEE REPORT TERMINOLOGY

SC16.07 (para. 23) The SC **ADOPTED** the reporting terminology contained in Appendix IV and **RECOMMENDED** that the Commission considers adopting the standardised IOTC Report terminology, to further improve the clarity of information sharing from, and among its subsidiary bodies.

HOW TO INTERPRET TERMINOLOGY CONTAINED IN THIS REPORT

Level 1: From a subsidiary body of the Commission to the next level in the structure of the Commission:
RECOMMENDED, RECOMMENDATION: Any conclusion or request for an action to be undertaken, from a subsidiary body of the Commission (Committee or Working Party), which is to be formally provided to the next level in the structure of the Commission for its consideration/endorsement (e.g. from a Working Party to the Scientific Committee; from a Committee to the Commission). The intention is that the higher body will consider the recommended action for endorsement under its own mandate, if the subsidiary body does not already have the required mandate. Ideally this should be task specific and contain a timeframe for completion.

Level 2: From a subsidiary body of the Commission to a CPC, the IOTC Secretariat, or other body (not the Commission) to carry out a specified task:
REQUESTED: This term should only be used by a subsidiary body of the Commission if it does not wish to have the request formally adopted/endorsed by the next level in the structure of the Commission. For example, if a Committee wishes to seek additional input from a CPC on a particular topic, but does not wish to formalize the request beyond the mandate of the Committee, it may request that a set action be undertaken. Ideally this should be task specific and contain a timeframe for the completion.

Level 3: General terms to be used for consistency:
AGREED: Any point of discussion from a meeting which the IOTC body considers to be an agreed course of action covered by its mandate, which has not already been dealt with under Level 1 or level 2 above; a general point of agreement among delegations/participants of a meeting which does not need to be considered/adopted by the next level in the Commission's structure.
NOTED/NOTING: Any point of discussion from a meeting which the IOTC body considers to be important enough to record in a meeting report for future reference.

Any other term: Any other term may be used in addition to the Level 3 terms to highlight to the reader of and IOTC report, the importance of the relevant paragraph. However, other terms used are considered for explanatory/informational purposes only and shall have no higher rating within the reporting terminology hierarchy than Level 3, described above (e.g. **CONSIDERED**; **URGED**; **ACKNOWLEDGED**).

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EXECUTIVE SUMMARY

The 16th Session of the Indian Ocean Tuna Commission's (IOTC) Working Party on Billfish (WPB) was held in Cape Town, South Africa, from 4 to 8 September 2018. A total of 20 participants (25 in 2017) attended the Session. The meeting was opened on the 4th of September 2018 by the Chairperson, Dr Rui Coelho (Portugal), who welcomed participants to Cape Town.

The following are the complete recommendations from the WPB16 to the Scientific Committee, which are also provided at Appendix XII:

WPB 16.01 (para 9.): **RECALLING** that one of the Indian Ocean billfish species (shortbill spearfish, *Tetrapturus angustirostris*) is currently not listed among the species managed by IOTC, and considering the ocean-wide distribution of this species, its highly-migratory nature, and that it is a common bycatch in IOTC managed fisheries, the WPB reiterated it's previous **RECOMMENDATION** that the Scientific Committee consider requesting the Commission to include it in the list of species to be managed by the IOTC.

Genetic population structure for striped marlin

WPB 16.02 (para 61.): The WPB **NOTED** the low sample sizes of marlins (i.e., zero samples for striped marlin) in phase 1 sampling of the IOTC stock structure project and RECOMMENDED that marlins are prioritized in phase 2 in order to resolve the stock structure uncertainty for this species.

Revision of the WPB Program of work (2019–2023)

WPB 16.03 (para 139.): The WPB **RECOMMENDED** that the SC consider and endorse the WPB Program of Work (2019–2023), as provided at Appendix XI.

Review of the draft, and adoption of the Report of the 16th Session of the Working Party on Billfish

WPB16.04 (para. 146): The WPB **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPB16, provided at Appendix XII, as well as the management advice provided in the draft resource stock status summary for each of the five billfish species under the IOTC mandate, and the combined Kobe plot for the five species assigned a stock status in 2018 (Fig. 9):

- Swordfish (*Xiphias gladius*)– Appendix VI
- Black marlin (*Makaira indica*) – Appendix VII
- Blue marlin (*Makaira nigricans*) – Appendix VIII
- Striped marlin (*Tetrapturus audax*) – Appendix IX
- Indo-Pacific sailfish (*Istiophorus platypterus*) – Appendix X

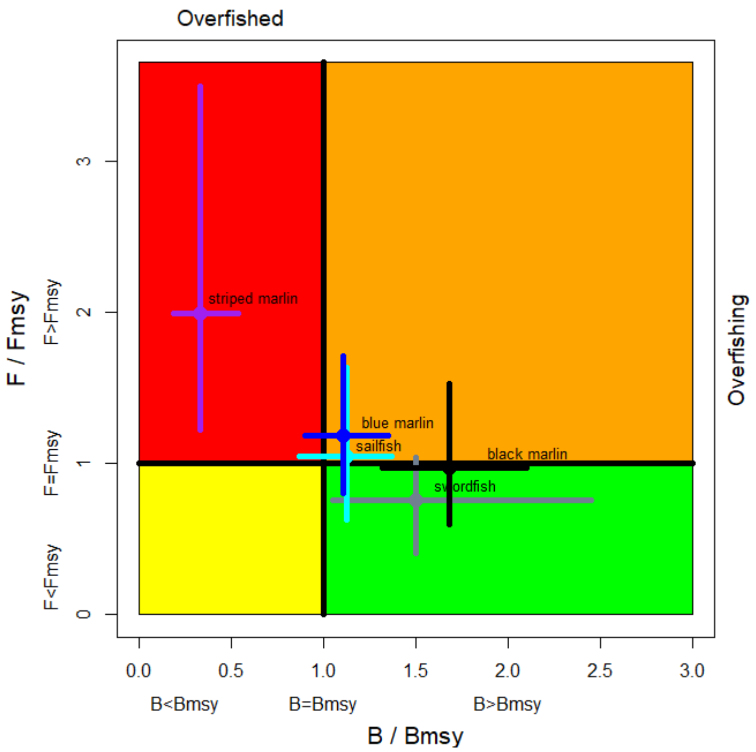

Fig. 9. Combined Kobe plot for swordfish (grey), indo-pacific sailfish (cyan), black marlin (black), blue marlin (blue) and striped marlin (purple) showing the 2016, 2017, and 2018 estimates of current stock size (SB or B, species assessment dependent) and current fishing mortality (F) in relation to optimal spawning stock size and optimal fishing mortality. Cross bars illustrate the range of uncertainty from the model runs.

Table 1. Status summary for billfish species under the IOTC mandate.

Stock	Indicators	2014	2015	2016	2017	2018	Advice to the Scientific Committee
Swordfish *Xiphias gladius*	Catch 2017: Average catch 2013–2017: MSY (1,000 t) (80% CI): F_{MSY} (1,000 t) (80% CI): SB_{MSY} (80% CI): F_{2015}/F_{MSY} (80% CI): SB_{2015}/SB_{MSY} (80% CI): SB_{2015}/SB_{1950} (80% CI):						***Stock status.*** No new stock assessment was carried out for swordfish in 2018, thus, the stock status is determined on the basis of the 2017 assessment and other indicators presented in 2018. In 2017 a stock synthesis assessment was conducted, with fisheries catch data up to 2015. The assessment uses a spatially disaggregated, sex explicit and age structured model. The SS3 model, used for stock status advice, indicated that MSY-based reference points were not exceeded for the Indian Ocean population (F_{2015}/F_{MSY}< 1; SB_{2015}/SB_{MSY}> 1). Most other models applied to swordfish also indicated that the stock was above a biomass level that would produce MSY. Spawning stock biomass in 2015 was estimated to be 26%–43% of the unfished levels. There are some uncertainties in the catch estimates from the Indonesian fresh tuna longline; an alternative catch history was used in the base case stock assessment. Most recent catches are at the MSY level (31,590 t). On the weight-of-evidence available in 2018, the stock is determined to be ***not overfished*** and ***not subject to overfishing***. ***Management advice.*** The most recent catches (34,782 t in 2017) are above the MSY level (31,590 t). However, given the uncertainty of most recent catches from Indonesian fresh tuna longline fisheries there is a possibility that total catches could already be 53, 658 t. The catches should not be increased beyond the MSY level (31,590 t). Click here for full stock status summary: Appendix VI
Black marlin *Makaira indica*	Catch 2017: Average catch 2013–2017: MSY (1000 t) (80% CI): F_{MSY} (80% CI): B_{MSY} (1000 t) (80% CI): F_{2017}/F_{MSY} (80% CI):						***Stock status.*** A stock assessment based on JABBA was conducted in 2018 for black marlin. This assessment suggests that the point estimate for the stock in 2017 is in the green zone in the Kobe plot with F/F_{MSY}=0.96 (0.77-1.12) and B/B_{MSY}=1.68 (1.32-2.10). The Kobe plot (Fig. 2) from the JABBA model indicated that the stock is not **subject to overfishing** and is currently not **overfished**, however these status estimates are

	B_{2017}/B_{MSY} (80% CI): B_{2017}/B_{1950} (80% CI):						subject to a high degree of uncertainty. As such, the results should be interpreted with caution. **Management advice.** The current catches (>20,000 t in 2017) are considerably higher than MSY (12,930 t). Projections were not carried out due to the poor predictive capabilities identified in the assessment diagnostics. Click here for full stock status summary: Appendix VII
Blue marlin *Makaira nigricans*	Catch 2017: Average catch 2013–2017: MSY (1000 t) (80% CI): F_{MSY} (80% CI): B_{MSY} (1,000 t) (80% CI): F_{2015}/F_{MSY} (80% CI): B_{2015}/B_{MSY} (80% CI): B_{2015}/B_{1950} (80% CI):						***Stock status.*** No stock assessment was carried out in 2018. The stock status based on BSP-SS stock assessment carried out in 2016 suggests that the stock status in 2015 is in the orange zone in the Kobe plot and both F and B are close to their MSYs, i.e., F/F_{MSY}=1.18 and B/B_{MSY}=1.11. Two other approaches examined in 2016 came to similar conclusions, namely ASPIC and SS3. The results from the BSP-SS model indicated that the stock has been **subject to overfishing** but **not overfished** in recent years. ***Management advice.*** Current catches are higher than MSY (11,926 t) estimated for 2015 and the stock is currently subject to overfishing (F_{2015} > F_{MSY}). If catches of blue marlin are reduced to a maximum value of 11,704 t (the average 2013-2015 catches at the time of the assessment in 2015), then the stock is expected to recover to the green zone of the Kobe Plot by 2025 (F_{2025} < F_{MSY} and B_{2025} > B_{MSY}) with at least a 50% probability. Click here for full stock status summary: Appendix VIII
Striped marlin *Tetrapturus audax*	Catch 2017: Average catch 2013–2017: MSY (1,000 t) (estimates): F_{MSY} (estimates): B_{MSY} (1,000 t) (estimates): F_{2017}/F_{MSY} (estimates): B_{2017}/B_{MSY} (estimates): SB_{2017}/SB_{MSY} (SS3): B_{2017}/B_{1950} (estimates): SB_{2017}/SB_{1950} (SS3):						***Stock status:*** A new stock assessment for striped marlin was carried out in 2018, based on two different models: JABBA, a Bayesian state-space production model; and SS3, an integrated length-based model. Both models were very consistent and confirmed the results from 2012, 2013, 2015 and 2017 assessments, indicating that the stock is subject to overfishing ($F>F_{MSY}$) and overfished, with the biomass for at least the past ten years is below the level which would produce MSY ($B<B_{MSY}$). On the weight-of-evidence available in 2018, the stock status of striped marlin is determined to be ***overfished*** and ***subject to overfishing***. ***Management advice.*** Current or increasing catches have a very high risk of further decline in the stock status. Current 2017 catches are lower than MSY (4,730 t) but the stock has been overfished for more than two decades and is now in a highly depleted state. If the Commission wishes to recover the stock to the green quadrant of the Kobe plot with a probability ranging from 60% to 90% by 2026, then the maximum annual catches have to be set to between 1,500 t – 2,200 t.

							Click here for full stock status summary: Appendix IX
Indo-Pacific Sailfish *Istiophorus platypterus*	Catch 2017: Average catch 2013–2017: 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):						***Stock status:*** No new stock assessment was carried out for Indo-Pacific sailfish in 2018, thus, the stock status is determined on the basis of the 2015 assessment and other indicators presented in 2018. In 2015, data poor methods for stock assessment using Stock Reduction Analysis (SRA) techniques indicated that the stock is not yet overfished, but is subject to overfishing. Aspects of the biology, productivity and fisheries for this species combined with the data poor status on which to base a more formal assessment are also a cause for concern. Research emphasis on further developing possible CPUE indicators from gillnet fisheries, and further exploration of stock assessment approaches for data poor fisheries are warranted. Given the limited data being reported for coastal gillnet fisheries, and the importance of sports fisheries for this species, efforts must be made to rectify these information gaps. The lack of catch records in the Persian Gulf should also be examined to evaluate the degree of localised depletion in Indian Ocean coastal areas. On the weight-of-evidence available in 2018, the stock is determined to be still ***not overfished*** but ***subject to overfishing***. **Management advise:** the same management advice for 2018 (i.e., that catches should be below MSY, 25,000 t) is kept for the next year (2019). Click here for full stock status summary: Appendix X

1. Indicates the last year taken into account for assessments carried out before 2012.
a. Low-case catch scenario: alternative catch series incorporating changes to IOTC Secretariat's estimates of Indonesia's fresh tuna longline catches.
b. High-case catch scenario: includes IOTC Secretariat catch estimates for Indonesian fresh tuna longliners derived from Taiwan,China.

Colour key	Stock overfished(SB_{year}/SB_{MSY}< 1)	Stock not overfished (SB_{year}/SB_{MSY}≥ 1)
Stock subject to overfishing(F_{year}/F_{MSY}> 1)		
Stock not subject to overfishing (F_{year}/F_{MSY}≤ 1)		
Not assessed/Uncertain		

1. OPENING OF THE SESSION

1. The 16th Session of the Indian Ocean Tuna Commission's (IOTC) Working Party on Billfish (WPB) was held in Cape Town, South Africa, from 4th to 8th September 2018. A total of 20 participants (25 in 2017) attended the Session. The list of participants is provided at Appendix I.. The meeting was opened by the Chairperson, Dr Rui Coelho (Portugal), who welcomed participants to Cape Town. Opening remarks were also given by Mr. Saasa Pheeha, Chief Director: Fisheries Research and Development of the Department of Agriculture, Forestry and Fisheries (DAFF), South Africa.

2. ADOPTION OF THE AGENDA AND ARRANGEMENTS FOR THE SESSION

2. The WPB **ADOPTED** the Agenda provided at Appendix II. The documents presented to the WPB16 are listed in Appendix III.

3. The WPB **NOTED** a brief introduction of the taxonomy of billfish species given by the Vice Chairperson, Dr Evgeny Romanov. The WPB **AGREED** that the IOTC species scientific names should be used in meeting papers.

3. THE IOTC PROCESS: OUTCOMES, UPDATES AND PROGRESS

3.1 Outcomes of the 20th Session of the Scientific Committee

4. The WPB **NOTED** paper IOTC–2018–WPB16–03 which describes the main outcomes of the 20th Session of the Scientific Committee (SC20), specifically related to the work of the WPB:

- ***Acquisition of data from sports fisheries***
  *The SC **AGREED** on the importance in supporting improvements in the data collection and reporting of sports fishing data to the IOTC, within the context of capacity building within national fisheries institutions, but that a full evaluation of the outcomes of the pilot project (which concluded in September 2017) are required before further resources are considered for follow-up activities (para. 48 of IOTC-2017-SC20-R).*

5. The WPB **NOTED** that the pilot project for the acquisition of catch effort and size data from sports fisheries has been completed and that the final report was presented during the WPDCS-13 meeting and 20th Session of the Scientific Committee, and is available for download from the IOTC meeting webpage.

- ***Review of the statistical data available for billfish***
  *Due to on-going uncertainties with the reliability of catches reported by Indonesia, particularly in the case of swordfish, the SC **REQUESTED** that the IOTC Secretariat, in collaboration with Indonesia, review the current methods for estimating catches of billfish for Indonesia in the IOTC database and provide an update at the next meeting of the WPB (para. 45 of IOTC-2017-SC20-R).*

6. The WPB **NOTED** paper IOTC-2018-WPB16-22, and alternative catch series (IOTC-2018-WPB16-DATA03b), which summarizes the revisions to Indonesia's billfish catches proposed by the IOTC Secretariat in response to the request from the WPB and SC.

- ***Resolution 15/05 conservation measures for billfish***
  *The SC **NOTED** that catches for Black Marlin, Blue Marlin, and Striped Marlin have increased in 2016 (and 2015) from the average level of 2009-2014. The catch in 2016 for Blue marlin was 3,510 t higher (27 % larger) than the average 2009-2014, 4,286 t larger (32 %) for Black marlin and 1,398 (36 %) for Striped marlin. Considering the status of these stocks the SC urgently **RECOMMENDED** that measures are agreed to recover the status of the stock of the three marlin species covered by Resolution 15/05 as per the management advice given in the Executive Summaries" (para. 58 of IOTC-2017-SC20-R)..*

7. The WPB **NOTED** with concern that catches for all species of marlins continue to exceed the average catch levels of 2009-2014 in recent years, and **AGREED** to update the SC on the status of latest catches in relation to Resolution 15/05.

8. The WPB **ACKNOWLEDGED** and **REITERATED** the request from the Scientific Committee for full compliance with Resolutions 15/01 and 15/02 and **REQUESTED** that all involved CPCs take immediate action to overcome any issues preventing the timely and complete reporting of all mandatory statistical data to the IOTC Secretariat.

9. **RECALLING** that one of the Indian Ocean billfish species (shortbill spearfish, *Tetrapturus angustirostris*) is currently not listed among the species managed by IOTC, and considering the ocean-wide distribution of this species, its highly-migratory nature, and that it is a common bycatch in IOTC managed fisheries, the WPB

reiterated it's previous **RECOMMENDATION** that the Scientific Committee consider requesting the Commission to include it in the list of species to be managed by the IOTC.

3.2 Outcomes of the 22st Session of the Commission

10. The WPB **NOTED** paper IOTC–2018–WPB16–04 which provided the main outcomes of the 22st Session of the Commission specifically related to the work of the WPB and **AGREED** to consider how best to provide the Scientific Committee with the information it needs, in order to satisfy the Commission's requests, throughout the course of the current WPB meeting.

11. The WPB **NOTED** the 10 Conservation and Management Measures (CMMs) adopted at the 22st Session of the Commission (consisting of 10 Resolutions and 0 Recommendations) as listed below:

IOTC Resolutions

- Resolution 18/01 *On an interim plan for rebuilding the Indian Ocean yellowfin tuna stock in the IOTC Area of Competence*
- Resolution 18/02 *On management measures for the conservation of blue shark caught in association with IOTC fisheries*
- Resolution 18/03 *On establishing a list of vessels presumed to have carried out illegal, unreported and unregulated fishing in the IOTC Area of Competence*
- Resolution 18/04 *On bioFAD experimental project*
- Resolution 18/05 *On management measures for the conservation for the conservation of billfish, striped marlin, black marlin, blue marlin and Indo-Pacific sailfish*
- Resolution 18/06 *On establishing a programme for transhipment by large-scale fishing vessels*
- Resolution 18/07 *On measures applicable in case of non-fulfilment of reporting obligations in the IOTC*
- Resolution 18/08 *Procedures on a fish aggregating devices (FADs) management plan, including a limitation on the number of FADs, more detailed specifications of catch reporting from FAD sets, and the development of improved fad design to reduce the incidence of entanglement of non-target species*
- Resolution 18/09 *On a scoping study of socio-economic indicators of IOTC fisheries*
- Resolution 18/10 *On vessel chartering in the IOTC Area of Competence*

12. The WPB **NOTED** that pursuant to Article IX.4 of the IOTC Agreement, the above mentioned Conservation and Management Measures shall become binding on Members, 120 days from the date of the notification communicated by the IOTC Secretariat.

13. Participants to WPB16 were **ENCOURAGED** to familiarise themselves with the adopted Resolutions, especially those most relevant to the WPB.

14. The WPB **NOTED** that the Commission also made a number of general comments and requests on the recommendations made by the Scientific Committee in 2017, which have relevance for the WPB (details as follows: paragraph numbers refer to the report of the Commission - IOTC–2018–S22–R).

    *The Commission **ENDORSED** the SC 2017 list of recommendations as its own, noting the additional activities requested by the Commission at this meeting (para. 26 of the S22 report).*

    Consideration of management measures related to Billfish

    *The Commission **ADOPTED** IOTC Resolution 18/05 On management measures for the conservation of billfish, stripped marlin, black marlin, blue marlin and Indo-Pacific sailfish. (para. 51 of the S22 report)*

15. The WPB **AGREED** that any advice to the Commission would be provided in the Management Advice section of each stock status summary.

3.3 Review of Conservation and Management Measures relevant to billfish

16. The WPB **NOTED** paper IOTC–2018–WPB16–05 which aimed to encourage participants at the WPB16 to review some of the existing Conservation and Management Measures (CMM) relevant to billfish, noting the CMMs referred to in document IOTC–2018–WPB16–05, and - as necessary - to 1) provide recommendations to the Scientific Committee on whether modifications may be required and 2) recommend whether other CMMs may be required.

17. The WPB **NOTED** the Commission **ADOPTED** IOTC Resolution 18/05 *On management measures for the conservation of billfish, stripped marlin, black marlin, blue marlin and Indo-Pacific sailfish*.

3.4 Progress on the recommendations of WPB15 and SC20

18. The WPB **NOTED** paper IOTC–2018–WPB16–06 which provided an update on the progress made in implementing the recommendations from the previous WPB meeting which were endorsed by the Scientific Committee, and **AGREED** to provide alternative recommendations for the consideration and potential endorsement by participants as appropriate given any progress.

19. The WPB **RECALLED** that any recommendations developed during a Session, must be carefully constructed so that each contains the following elements:

- a specific action to be undertaken (deliverable);
- clear responsibility for the action to be undertaken (i.e., a specific CPC of the IOTC, the IOTC Secretariat, another subsidiary body of the Commission or the Commission itself);
- a desired time from for delivery of the action (i.e., by the next Working Party meeting, or other date);
- if appropriate, an approximate budget for the activity, so that the IOTC Secretariat may be able to use it as a starting point for developing a proposal for the Commission's consideration.

20. The WPB **NOTED** that the requests included in Appendix 1 of the document IOTC–2018–WPB16–06 are only taken from the report of the previous year. Requests that are not addressed directly in the subsequent year are not carried over and therefore often neglected. As such, the WPB discussed and **REQUESTED** that unresolved or pending requests still relevant are included in a table in the body of the report so that they may be addressed the following year. The revised list of requests are therefore included in table 2 below.

Table 2: Review of requests requiring further attention

WPB15 Report reference	WPB15 REQUESTS	Update/Progress
Para. 18	***Billfish species identification*** The WPB **REQUESTED** that final copies of the species identification guides translated in Portuguese by WWF-Mozambique and in Sinhalese / Tamil by NARA are submitted to the IOTC Secretariat for printing.	Update: Species ID guides in Portuguese have been translated and reviewed and are ready for typesetting and printing. Translations in Sinhalese/Tamil are yet to be received by the IOTC Secretariat.
Para. 23	***Stock structure project*** At the same time the WPB **ENCOURAGED** interested countries to confirm their participation to the project and **REQUESTED** that they liaise with the leading scientists and institutions to further define the extent of their contribution and involvement in the project	Ongoing: Noted that for phase 1 there are no samples collected for certain marlin species (particularly striped marlin) so it is strongly encouraged that these are collected under phase 2 of the project
Para. 26	***African Billfish Foundation*** The WPB **ACKNOWLEDGED** the evidence of known quality issues related to the African Billfish Foundation tag data, and **REQUESTED** that a full assessment of the information be performed before this could effectively be used and disseminated to a broader audience.	No progress.
Para. 27	***Nominal and standardized CPUE indices - swordfish*** The WPB **NOTED** that Reunion (EU, France) had not provided the requested Swordfish CPUE series in time for the meeting, and **REQUESTED** Reunion (EU, France) to share the missing information in time for the next Swordfish stock assessment.	Ongoing: This work will be accomplished during 2019 and presented to the WPB next year.
Para. 36	The WPB **ACKNOWLEDGED** that there still are remarkable differences in the size-frequency distributions of Striped marlin caught and reported by the longline fisheries of Japan and Taiwan,China and therefore **REQUESTED** that further analysis are	Update: The IOTC Secretariat will be conducting a project in 2019 examining the potential inconsistencies in size frequency data reported by the distant water longline fleets, mostly in the context of tropical tunas, but could also in principle be extended to include billfish as well.

	performed to analyse the reason for these discrepancies and ensure that the available data could effectively be used for stock assessment purposes.	
Para. 46	***Sri Lanka billfish fishery*** **ACKNOWLEDGING** that there might be potential misidentification issues between some of the marlin species (in particular blue marlin and black marlin) the WPB **REQUESTED** Sri-Lanka to set up a protocol at port landings to verify the validity of specific catches reported in logbooks.	Ongoing: This work has been initiated and will be presented to the WPB by 2020.
Para. 47	The WPB **NOTED** that the implementation of electronic logbooks on multi-days Sri-Lanka vessels operating within the EEZ was in progress and **REQUESTED** the IOTC Secretariat to evaluate the possibility of adopting the same systematic approach for other fleets and fisheries in the region.	Update: Pending: Sri Lanka confirmed the possibility of sharing information in the future related to their electronic logbook systems with the IOTC Secretariat, for an assessment of its potential adoption as a regional tool for semi-industrial fisheries. It was noted that this initiative will require funding.
Para. 72	***Review new information on swordfish biology, stock structure, fisheries and associated environmental data*** Therefore, the WPB **REQUESTED** that a growth study be conducted on Indian Ocean swordfish and **NOTED** that about 300 otoliths had already been collected from the South Western Indian Ocean during the IOSSS project.	Ongoing: Hard structures sampling, including otoliths is ongoing in some laboratories. An age and growth study was prioritized in the program of work with funds requested for a small project on biology to complete this work.
Para. 142	***Development of management advice for swordfish and update of swordfish Executive Summary for the consideration of the Scientific Committee*** Therefore, the WPB **REQUESTED** CPCs to put efforts into combining CPUEs by area at the scale of the Indian Ocean, in order to avoid conflicting information between CPUEs	Update: The development of a joint-CPUE for swordfish (and other billfish) was recommended by the WPM in 2017. Funding for the work is still to be confirmed, as well as inclusion of the work in the WPM/WPB Program of Work. To be discussed further during the WPB in the 2019 meeting in terms of future priorities, before the next swordfish assessment in 2020.
Para. 207	***Development of options for alternative management measures (including closures) for billfish in the IOTC area of competence*** The WPB **ACKNOWLEDGED** the difficulties in finding a proper agreement among CPCs with respect to quota allocation criteria, that would otherwise represent a potentially effective and alternative output control measure. For this reason, the WPB **REQUESTED** to keep this agenda item open until WPB16 and beyond, **ACKNOWLEDGING** that alternative and practical measures should be explored in the near future.	No progress to date: A study on spawning locations and periods was prioritized in the program of Work and some funds requested. Such information could provide important information to address this request by the Commission.
Para. 211	Also, the WPB **ACKNOWLEDGED** that a number of swordfish otoliths has already been (and is currently being) collected and therefore **REQUESTED** the identification of potential funding sources to further support additional analysis and scientific studies for stock assessment purposes	Ongoing (also refer to para. 72 in table above): Biological studies were prioritized in the program of work with funds requested for small projects on age, growth, maturity and spawning location.
Para. 212	**ACKNOWLEDGING** the importance of correct species identification to improve the quality of data submitted to the IOTC Secretariat, the WPB **REQUESTED** to further discuss the potential development of identification guides for dressed billfish, and the completion of preliminary studies on this same matter.	No progress to date.

Sports fisheries

21. The WPB **NOTED** that a prototype data collection and reporting tool was finalized in 2017 and introduced to stakeholders from four countries in the south-west Indian Ocean (i.e., Kenya, Seychelles, Mauritius and La Réunion).

22. The WPB **NOTED** that progress within each of the project countries has been variable, and highly dependent on the availability of resources to collect and process the sports and recreational fisheries data.

23. The WPB **NOTED** that Kenya is including sports fisheries data collection and reporting within their integrated fisheries database (using a logbook format that matches the one proposed by the IOTC pilot project). The WPB also **NOTED** Mauritius is also ready to implement the logbook and database, subject to available personnel resources.

I.R. Iran billfish fishery

24. The WPB **NOTED** that, following a successful data compliance and support mission by the IOTC Secretariat in November 2017, I.R. Iran is now reporting catch-and-effort data fully disaggregated by month and area, including data for 2015-2017 that is currently being processed by the IOTC Secretariat. Data for previous years is also expected to be submitted in due course, and the IOTC Secretariat continues to work closely with Iranian colleagues to ensure that future data is submitted according to the requirements of Resolution 15/02 and incorporated into the IOTC database.

Review of the statistical data available for billfish

25. The WPB **NOTED** that the IOTC Secretariat is continuing to implement a number of revisions to the nominal catches that impact current estimates for billfish, including Comoros, Indonesia's fresh longline catches, as well as incorporating improvements in the catch-and-effort reported by I.R. Iran, and changes to the species composition submitted by Taiwan,China, and **REQUESTED** that an update is provided during the next WPB meeting.

26. The WPB **NOTED** the suggestions by the IOTC Executive Secretary to reduce and streamline the number of recommendations and requests made during each of the IOTC Working Party meetings to ensure they are more achievable.

4. NEW INFORMATION ON FISHERIES AND ASSOCIATED ENVIRONMENTAL DATA FOR BILLFISH

4.1 Review of the statistical data available for billfish

27. The WPB **NOTED** paper IOTC–2018–WPB16–07 which summarises the standing of a range of data and statistics received by the IOTC Secretariat for billfish, in accordance with IOTC Resolution 15/02 *Mandatory statistical requirements for IOTC Members and Cooperating non-Contracting Parties (CPC's)*, for the period 1950–2017. The paper also provided a summary of important reviews to series of historical catches for billfish species; a range of fishery indicators, including catch and effort trends, for fisheries catching billfish in the IOTC area of competence; and the range of equations used by the IOTC Secretariat to convert billfish measurements between non-standard and standard measurements used for each species. A summary of the supporting information for the WPB is provided in Appendix IV.

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

29. The WPB **NOTED** a number of on-going, or pending, data related priorities for the IOTC Secretariat that are likely have a fundamental impact on future billfish catch estimates; notably:

- Pakistan: A reconstructed catch series from the 1980s, submitted by the Government of Pakistan to the IOTC Secretariat in 2017, includes estimates of billfish catches that are 30%-70% *lower* than previous official catches reported by Pakistan to the IOTC. The IOTC Secretariat is currently in the process of evaluating the catches, prior to incorporating the revised data in the IOTC database, and intends to also conduct a mission to Pakistan during 2018 to address a number of issues concerning the reconstructed catch series. An update will be provided for the next WPB meeting in 2019.
- Indonesia: Following issues with the reliability of the IOTC Secretariat's estimates of billfish catches for Indonesia's fresh longline fleet during last year's WPB meeting, which saw catches of swordfish increase 400% between 2013-2016, the IOTC Secretariat has re-estimated the catches for Indonesia's longline fleet and provided the WPB-16 meeting with an alternative catch series (IOTC-2018-WPB16-DATA03b). Revisions to

the total catches mostly affect catches of swordfish, blue marlin, and striped marlin to a lesser extent, which have been revised downwards by as much as 30%. The WPB **NOTED** paper IOTC-2018-WPB16-22 which addresses this topic in detail.

- Taiwan,China: While number of Taiwanese fresh (small-scale) longline vessels has decreased by around 30% in recent years (from 307 vessels in 201, to 2012 vessels in 2016), longline catches remained at similar levels, raising average longline catches per vessel from 100 t in 2013 to around 175 t in 2016. Over the same period, the proportion of swordfish reported by Taiwanese fresh longline vessels increased from around 8% to over 30%, due to improvements in data collection and the estimation of catches by species, rather than changes in targeting. To avoid discontinuities in the estimates of catches by species, the WPB **REQUESTED** that Taiwan,China provide the IOTC Secretariat with revisions to the species composition of historical catches prior to the WPB meeting in 2019.

30. The WPB **NOTED** that in recent years the catches of black marlin have increased over 70%, from 13,500 t in 2012 to 23,000 in 2016, primarily due to increasing catches for I.R. Iran's offshore gillnet fishery between 2012–2014, and India's gillnet and longline coastal fisheries between 2015–2016.

31. The WPB **REQUESTED** that the IOTC Secretariat clarify with both India and I.R. Iran the reasons for the sudden increase in catches of black marlin; specifically whether the increases are the result of the development of a new fishery, or alternatively improvements in data collection and reporting in order to assess whether catches in earlier years may have been underestimated and require adjustments in order to maintain continuity with latest (higher) catches of black marlin.

32. The WPB **REQUESTED** that for the next WPB meeting in 2019, the IOTC Secretariat provide an information document to provide background information on the increase in catches of marlins in recent years, including revisions to the official data provided by CPCs, and any changes in the methodology for estimating catches conducted by the IOTC Secretariat.

33. The WPB **NOTED** that most billfish are non-target species and may be subject to widespread under-reporting, particularly in industrial fisheries, and that the overall trend of increasing catches of most billfish species may also reflect improvements in reporting rather than a real increase in actual catches. The WPB also **NOTED** that the general trend in billfish catches in the Indian Ocean appears contrary to many other fisheries whose catches peaked in the 1990's, rather than 2010's as in the case of IOTC billfish species, which suggests further evidence of possible under-reporting.

4.2 Review new information on fisheries and associated environmental data

Billfish biology from Chinese longline observer data

34. The WPB **NOTED** paper IOTC–2018–WPB16–09 which compared the biology of four billfish species in the Indian Ocean based on Chinese longline observer data, including the following abstract provided by the authors:

> *"This paper presented some aspects of biology of four billfish stocks based on fisheries data from Chinese tuna longline scientific observers in the Indian Ocean from 2013 to 2017. A total of 1,269 fishing operations and 153,543 observed baskets targeting bigeye or albacore tuna were examined with sampling numbers 350, 47, 375, and 151 for blue marlin, black marlin, striped marlin and Indo-Pacific sailfish, respectively. In this order, the sex ratios, i.e., proportion of female to total of male and female, were 0.38, 0.55, 0.42, and 0.37, respectively. LJFL frequency at different classes of fate status at haul-back were compared, demonstrating a weak relationship between body size and its alive status. Maturity schedule at size showed Indo-Pacific sailfish had a maximum 50% and 95% maturity length (192.6 and 254.4 cm) among that of all billfishes, followed by striped marlin (177.0 and 238.1 cm), black marlin (166.9 and 180.0 cm), and blue marlin (161.4 and 226.2 cm)"* (see paper for full abstract).

35. The WPB **NOTED** the implementation of observer data collection since 2013 by China which is providing important and interesting data and **CONGRATULATED** the Chinese scientist for the presentation of these results. China are, for example, noting the condition of species at capture (alive/dead; injured/not injured) which is valuable information to be able to assess discard survivorship in the future. China was **ENCOURAGED** to continue such data collection work by observers and to continue participating and presenting studies to future WPB meetings.

36. The WPB **NOTED** the increase in billfish catches in 2016, but also that the CPUE distribution map is unusual, which shows some higher CPUEs of blue marlin in southern/temperate waters in 2015, while blue marlin is mostly a tropical species. This distribution of catches corresponds to SBT fishing grounds where marlins are generally less commonly found. Since these distribution of catches and CPUE data correspond to logbook data, it raises concerns about species identification.

37. The WPB **NOTED** the size at maturity curved presented by China scientists, which represent the first example of size at maturity estimates for marlins in the Indian Ocean. The WPB **NOTED** that they can begin to prepare a response to the Commission with regards to the newly established minimum landing sizes for marlin (this issue is further discussed in point 6.2 below).

38. The WPB **ENCOURAGED** China to present sex specific size at maturity for blue marlin and striped marlin where sample sizes are sufficient to perform this analysis.

39. The WPB **ENCOURAGED** Chinese scientists to publish the results presented in a short note of a scientific journal.

I.R. Iran billfish fishery

40. The WPB **NOTED** that paper IOTC–2018–WPB15–09 which outlined the billfish gillnet fishery in the I.R. Iran, was not provided and therefore was **WITHDRAWN**. The WPB **NOTED** the following abstract provided by the authors:

> "*The total production of large pelagic fishes during 2017 was 296192 Mt of which 274589 Mt belongs to tuna and tuna-like fishes in the Indian Ocean areas. Those catch with 75.1% (222279 Mt) of Tunas, 11.3% (33514 Mt) of Seerfish, 6.3% (18795 Mt) of Billfish, 1.2% (3623 Mt) different species of shark and 6.1% (17981 Mt) other species and 93.6% of catch comes from gillnet gear, while around 2.1% of catch belong to purse seiners and 1.5% comes from trolling vessels and 2.8% comes from small artisanal gillnetter as a seasonal and temporal longliner to fish in coastal waters.*"

41. The WPB **ACKNOWLEDGED** the recent collaboration between the IOTC Secretariat and I.R. Iran and the improvements in the spatial resolution of time-area catches submitted to the IOTC for Iran's gillnet fishery. The WPB also **NOTED** that the IOTC Secretariat is planning a follow-up mission to Iran to explore the possibility of developing a standardized gillnet CPUE, primarily for neritic tunas, but which could in principle extended to include billfish species reported by the fishery, such as the Indo-Pacific sailfish.

Kenyan billfish fishery

42. The WPB **NOTED** paper IOTC–2018–WPB16–11 which summarised the high seas billfish catches by a Kenyan longliner**,** including the following abstract provided by the authors:

> "*A Kenyan long liner fished in the high seas during the period of July to November 2017. A total of 74 lines were set during the fishing voyage. The number of fish caught was 2,577 weighing a total weight of 51,278 Kg, recorded in the five months of fishing expendition. For the billfishes, a total of 164 pieces of fish with a total weight of 4,442 Kg belonging to three species were recorded. The species recorded included Makaira indica, Xiphias gladius and Istiophorus platypterus. Numerically, the three species had 73, 54, 37 pieces of fish respectively. In terms of weight, Xiphias gladius had 2,141Kg, Makaira indica had 1,916 Kg and 385 Kg was recorded for Istiophorus platyterus. Most of the weight was recorded in November (1,809Kg), September (1,215Kg) and August (673 Kg). October and July recorded the least weight of 515 Kg and 230 Kg respectively. Xiphias gladius was caught in all five months while Istiophorus platypterus was caught in three months. The billfish catches represented 8.7 % of the total catches during the five months fishing period*" (see paper for full abstract).

43. The WPB **NOTED** that only one species of marlin was reported, which seems unlikely in the area of fishing operations covered by the study where all species should be present, and that there may be a problem with the species identification of billfish species. The WPB further **NOTED** that for some samples very low weights were recorded, which are unlikely for black marlin, and that work is ongoing to improve the quality future data collection.

44. The WPB **NOTED** that information on Kenya's longline fleet, including nominal catches and time-area catch-and-effort, has not been reported to the IOTC Secretariat since 2010 and **REQUESTED** that Kenya submit these data to the IOTC Secretariat as a matter of priority.

Thailand billfish fishery

45. The WPB **NOTED** paper IOTC–2018–WPB16–21 which outlined the landings of billfish by foreign tuna longliners into Phuket, Thailand between 1994 to 2017, including the following abstract provided by the authors:

> "*Billfishes were landing in Phuket, Thailand almost from foreign tuna longline vessels. The first fishing entity is Taiwan,China. The high season occurred at the beginning of the year. The total billfishes unloaded in Phuket ports, Thailand was 893.99 tons (39.4% the whole landing). From the recorded data, billfishes*

can be classified into six species. Swordfish (Xiphias gladius) was the highest quantity equal 21.78 % of total landing in 2017, followed by Blue marlin (Makaira mazara), black marlin (M. indica), short bill spearfish (Tetrapturus angustirostris), striped marlin (Tetrapturus audax) and sailfish (Istiophorus platypterus) as 6.07%, 4.78%, 4.47%, 2.22% and 0.11%, respectively" (see paper for full abstract).

46. The WPB **NOTED** that landings from longliners in Thailand are mostly from foreign flagged vessels, and that the catches should be officially reported to the IOTC by the CPCs of the flag country; however catches reported by the coastal country where catches are unloaded are also useful for data verification and checking.

Indonesia's small-scale longline catch estimates

47. The WPB **NOTED** paper IOTC–2018–WPB16–22 which provided a revision to IOTC scientific estimates for Indonesia's small-scale longline catches, including the following abstract provided by the authors:

"The purpose of the paper is to provide participants at the Working Party on Billfish (WPB-16) with an overview of the IOTC Secretariat's estimation of Indonesia's longline catches, current issues related to the reliability of estimated catches, and proposed changes to the methodology in response to a request from the Scientific Committee."

48. The WPB **NOTED** that, accompanying this paper, the IOTC Secretariat has published an alternative nominal catch series (IOTC-2018-WPB16-DATA03b) that incorporates revisions to the Indonesia's fresh longline catches based on changes to the IOTC Secretariat's estimation methodology.

49. The WPB **NOTED** that alternative catch series mostly affects Indonesia's fresh longline catches of swordfish, blue marlin, and striped marlin to a lesser extent, which are estimated to be significantly lower in recent years than previous IOTC estimates. The WPB also **NOTED** that, as a consequence of the revisions to Indonesia, total catches across all fleets and gears have been revised downwards by as much as 30% for some billfish species.

50. The WPB **CONSIDERED** the results of the alternative catch series, and **REQUESTED** that the WPDCS consider endorsing the catch series.

Pakistan Billfish fisheries

51. The WPB **NOTED** paper IOTC–2018–WPB16–27 which provided a summary of the status of billfish fisheries of Pakistan, including the following abstract provided by the authors:

"Six species of billfishes including Indo-Pacific sailfish (Istiophorus platypterus), black marlin (Istiompax indica), striped marlin (Kajikia audax), Indo-Pacific blue marlin (Makaira mazara) and shortbill spearfish (Tetrapturus angustirostris) belonging to family Istiophoridae and swordfish (Xiphias gladius) belongs to family Xiphidae are known to occur in Pakistan, however, only two species i.e. Indo-Pacific sailfish and black marlin are dominating in the commercial catches. Both the species were found throughout the year, however, period between September through January is the peak season of their landing. It is estimated that about 4,500 m. tons of billfish are annually landed in Pakistan. Billfishes are not locally consumed but transported to neighboring country through land or sea route" (see paper for full abstract).

52. The WPB **NOTED** Pakistan's reconstructed catch data series from the 1980s, submitted by the Government of Pakistan to the IOTC Secretariat in 2017, and which estimates catches of billfish species between 30%-70% lower than previous official catches reported by Pakistan to the IOTC and recorded in the IOTC database.

53. The WPB further **NOTED** Pakistan's revised catches remain pending upload to the IOTC database, while the IOTC Secretariat evaluates the methodology used in the catch reconstruction, and the reasons for the differences with previous Government reported statistics and also the results of recent sampling conducted by WWF-Pakistan.

54. The WPB **ENCOURAGED** the Government of Pakistan and WWF-Pakistan to collaborate with the IOTC Secretariat in order to agree a common catch series to be disseminated for future IOTC Working Party meetings.

55. The WPB also **NOTED** possible double counting of landings of catches caught by Pakistan and sold to neighbouring countries, such as I.R. Iran, and that some studies are currently in progress to investigate this potential duplication of data.

4.3 New information on sport fisheries

56. The WPB **NOTED** that paper IOTC–2018–WPB16–24 on the assessment of the collection of sports fishery data in Kenyawas not provided by the authors and therefore was considered **WITHDRAWN**.

57. The WPB further **NOTED** that the final report from the IOTC sports fishery project was presented during the WPDCS-13 meeting and 20th Session of the Scientific Committee, and is available for download from the IOTC meeting webpage.

5. MARLINS

5.1 Review of new information on marlin biology, stock structure, fisheries and associated environmental data

Genetic population structure for striped marlin

58. The WPB **NOTED** paper IOTC–2018–WPB16–20 which provided the results of a study on the genetic population structure of striped marlin in the Indian Ocean including the following abstract provided by the authors:

> "*In this study, we surveyed genetic variation across nearly 4,000 single nucleotide polymorphism (SNP) molecular markers for striped marlin sampled from the eastern and western Indian Ocean (n = 46) to provide a statistically powerful evaluation of population structure in this region. We identified five genetically distinct populations, three of which corresponded with the western Indian Ocean, Oceania, and eastern central Pacific Ocean, and two of which corresponded with the North Pacific Ocean. The western Indian Ocean population displayed comparatively low genetic diversity and high genetic differentiation, suggesting a greater degree of isolation relative to other populations. The presence of a population in Oceania suggests a high level of genetic connectivity between striped marlin from the eastern Indian and western South Pacific oceans"* (see paper for full abstract).

59. The WPB **NOTED** the potential existence of two stocks of striped marlin in the Indian Ocean **-** one in the western Indian Ocean and the second one off Western Australia. However, the relatively small sample size (i.e., 8 individuals) used for identification of Western Australia stock was noted, as was the absence of sampling in the middle of the Indian Ocean which makes it difficult to delineate the borders of each stock.

60. The WPB **NOTED** the potential management implications associated with two stocks of striped marlin, however, postponed any changes regarding the (single stock) management approach until further information is collected by the IOTC EU-funded Indian Ocean stock structure project.

61. The WPB **NOTED** the low sample sizes of marlins (i.e., zero samples for striped marlin) in phase 1 sampling of the IOTC stock structure project and **RECOMMENDED** that marlins are prioritized in phase 2 in order to resolve the stock structure uncertainty for this species.

62. The WPB **NOTED** that a pool of striped marlin samples was collected in the La Réunion and provided to VIMS for genetic analysis, but were not processed due to shipping delays and the termination of the VIMS project.

63. The WPB **ENCOURAGED** the IOTC stock structure project to consider a potential collaboration with VIMS project scientists for treatment of non-processed samples and data exchange.

5.2 Review of new information on the status of marlins

5.2.1 Nominal and standardized CPUE indices

Black marlin

Indonesia longline CPUE

64. The WPB **NOTED** paper IOTC–2018–WPB16–12 providing a standardised CPUE indices for black marlin from 2005 to 2017 for the Indonesia tuna longline fisheries in the Indian Ocean, which included the following abstract provided by the authors:

> *"A Generalized Linear Model (GLM) was used to standardize the catch per unit effort (CPUE) and to calculate estimate relative abundance indices based on the Indonesian longline dataset. Data was collected from August 2005 to December 2017 through scientific observer program (2005-2017) and national observer program (2016-2017). Time trends of standardized CPUE as calculated using NB and ZINB models were similar from 2005 to 2016, however, time trends are conflictive at the very end (2017)"* (see paper for full abstract).

65. The WPB **THANKED** the authors for the CPUE series and **NOTED** its value to the assessment process due to the relative scarcity of CPUE series for black marlins.

66. The WPB **NOTED** that the standardised CPUE series exhibits unusual annual fluctuations and that these trends tend to follow the proportion of zero catches in the reported information. It was therefore suggested that the

predominance of zero catches could be driving the model outputs as the CPUE trends do not appear to be biologically plausible.

67. The WPB **SUGGESTED** that only data from coastal areas where relative catches are higher (such as Area 2) should be included in the CPUE standardisation. It appears that the model is struggling to account for the high proportion of zero catches when data for low abundance areas are included. The WPB **NOTED** that these low abundance areas may not be appropriate for inclusion as they may be located outside of the natural distribution of the species.

68. The WPB **NOTED** that, as with the CPUE standardisation presented in this paper, the inclusion of environmental data rarely improves the explanatory power of such models. It was further **NOTED** that future standardization of CPUE trends could alternatively examine spatial auto-correlation to include and account for environmental data.

Taiwan,China longline CPUE

69. The WPB **NOTED** paper IOTC–2018–WPB16–17 which provided standardised CPUE indices for black marlin from 1980 to 2017 for the Taiwanese tuna longline fisheries in the Indian Ocean, and which included the following abstract provided by the authors:

> *"In this study, the delta-gamma general linear models with the targeting effect derived from cluster analysis were used to conduct the CPUE standardization of black marlin caught by the Taiwanese large scale longline fishery in the Indian Ocean for 1979-2017. CPUE trends were obviously different for northern and southern Indian Ocean, while the area-aggregated CPUE fluctuated before early 1990s, gradually declined until late 2000s, and reveals an increasing trend in recent years"* (see paper for full abstract).

70. The WPB **THANKED** the authors for the update to the Tawain,China CPUE series which are integral inputs into the stock assessment models.

71. The WPB **NOTED** that the catches in the southern areas fluctuate unusually, but not on an annual basis. The catches in these areas are low, however, and it was **AGREED** that the CPUE series for the southern areas may not be appropriate for inclusion in the assessment models.

Japan longline CPUE

72. The WPB **NOTED** paper IOTC–2018–WPB16–26 which provided standardised CPUE indices for black marlin of the Indian Ocean over 1994-2017 from the Japanese tuna longline fishery, and which included the following abstract provided by the authors:

> "*To calculate standardized CPUE of the Indian Ocean black marlin, I analyzed Japanese longline logbook data. In this study, I changed three points of standardization methodology of the previous study. 1) I used shorter period datasets (1994-2017) because Japanese logbook was changed around 1994 and datasets of early period includes large uncertainty such as species definition. 2) I used a different area definition considering size distribution. 3) I used the zero-inflated negative binomial distribution rather than delta log-normal model because catch number is countable data. I also addressed model selection and validation. The selected model was well estimated, but there is substantial uncertainty after 2011."* (see paper for full abstract)

73. The WPB **NOTED** the important update to the Japanese black marlin CPUE series and thanked the authors for providing this information.

74. The WPB **NOTED** that for black marlin a single combined CPUE series was provided, in contrast to the CPUE series for striped marlin, as the fleet movement issues observed for striped marlin were not apparent in the data for black marlin. This was due to the fact that only data for the Western Indian Ocean was used, as this was the area where the CPUE trends were consistent with the trends in mean weight.

75. The WPB **NOTED** the different trends between the standardised CPUE and nominal CPUE, which is a positive sign that the covariates included in the standardized model are making a significant difference compared to the observed nominal CPUE. It was **FURTHER NOTED** that it is important to understand which variables included in the standardisation process are mostly driving the corrections. It was **SUGGESTED** that in the future, a stepwise selection of variables could be included to more easily demonstrate the effect of each variable in the model, although it would appear that in this case that the fleet and area variables have the most effect.

76. The WPB **NOTED** that from 2010 there was a major change in fishing operations and that the number of hooks per basket changed significantly during this time. The reduction of hooks per basket indicates that deep setting was virtually absent from the end of the time series. Due to this major change, the author considered the data after

2010 to be unreliable for tracking the abundance of the stock and it was therefore **SUGGESTED** that only the CPUE series until 2010 should be used for stock assessment purposes.

77. The WPB **SUGGESTED** that future standardisations could split the CPUE series by fishing operation (i.e., into deep sets and shallow sets), rather than by time period. This may be a more appropriate proxy for tracking the abundance of the stock than a temporal split in the series.

Striped marlin

Taiwan,China longline CPUE

78. The WPB **NOTED** paper IOTC–2018–WPB16–18 provided standardised CPUE indices for striped marlin from 1979 to 2017 for the Taiwanese tuna longline fisheries in the Indian Ocean, which included the following abstract provided by the authors:

> "*In this study, the delta-gamma general linear models with the targeting effect derived from cluster analysis were used to conduct the CPUE standardization of striped marlin caught by the Taiwanese longline fishery in the Indian Ocean for 1979-2017. The trends of CPUE series were obviously different for northern and southern Indian Ocean, while the area-aggregated CPUE series generally revealed decreasing trends since 1980s and fluctuated in recent years"* (see paper for full abstract).

79. The WPB **NOTED** that a clustering analysis was used in the standardisation procedure, but **SUGGESTED** that only the main targeted species should be included for the species composition information, in order to reduce noise in the input data and mitigate the potential for misidentification of by-catch species.

80. The WPB also **NOTED** that only the CPUE's from the northern areas (NE and NW) were used in the stock assessments, as these areas incorporate the main distribution areas of these species. The WPB **NOTED** in the JABBA model the CPUE's are treated as two different series, whereas in the SS3 model the CPUEs are aggregated into one series (i.e., as weighted by area).

Japan longline CPUE

81. The WPB **NOTED** paper IOTC–2018–WPB16–25 which provided standardised CPUE indices for striped marlin for four areas of the Indian Ocean between 1994–2017 for the Japanese tuna longline fishery, which included the following abstract provided by the authors:

> "*Using previous study procedures, I updated standardized CPUE of the Indian Ocean striped marlin (Tetrapturus audax) caught by Japanese longline fishery. The time-period of this study is between 1994 and 2017, and the selected models were Zero-inflated negative binomial GLMM. For additional research, I checked time-spatial changes of mean body weight (fish size) and Pearson residuals. The trends of mean body weight indicated Japanese longliners had caught zero age fish that is noise for CPUE standardization, but this result was different to size frequency data. Pearson residuals showed a time-spatial correlation. To evaluate the shrink of Japanese longliners coverage, I also calculated the standardized CPUE that period is 1994-2010. There is no substantial difference between two time-period CPUEs, but CPUE after 2010 still includes large uncertainties"* (see paper for full abstract).

82. The WPB **NOTED** that the authors only updated data for the recent time period (i.e., from 1994) as they did not consider there should be any changes to the historical series. In addition, the authors suggested that the standardized CPUE series should only be used up to 2010, and not up to 2017, due to uncertainties in the data in recent years. The authors further suggested that only data for the northern regions should be used for assessment purposes.

83. The WPB **SUGGESTED** that in the future, additional diagnostic information could be provided to better assess the series. In the current paper, all diagnostics are based on residuals, however it was suggested that other methods (such as plots of predicted versus observed distributions) could also be provided.

84. The WPB **NOTED** that especially for the NW area, there is a consistency in the trend of Japanese longliners with the Taiwanese CPUEs from that region, and **ENCOURAGED** the national scientists from Japan and Taiwan,China to consider a joint CPUE analysis, particularly for the NW region.

CPUE Summary discussion

85. The WPB **NOTED** the different trends seen in the longline CPUE series and discussed which might be considered more reliable (**Figures 1 & 2**). It was **FURTHER NOTED** that the trends in the CPUE for striped marlin between Japan and Taiwan,China in the northern region were consistent.

86. The WPB **AGREED** to use the updated Japanese longline series up to 2010 only, for both striped marlin and black marlin in the stock assessment models. For striped marlin, only the northern area CPUE would be used, while for black marlin the series was provided for a single region only, and not split into North and South.

87. The WPB **NOTED** that for striped marlin, a joint CPUE analysis between Japan and Taiwan,China would be useful and **ENCOURAGED** the national scientists to collaborate to achieve this.

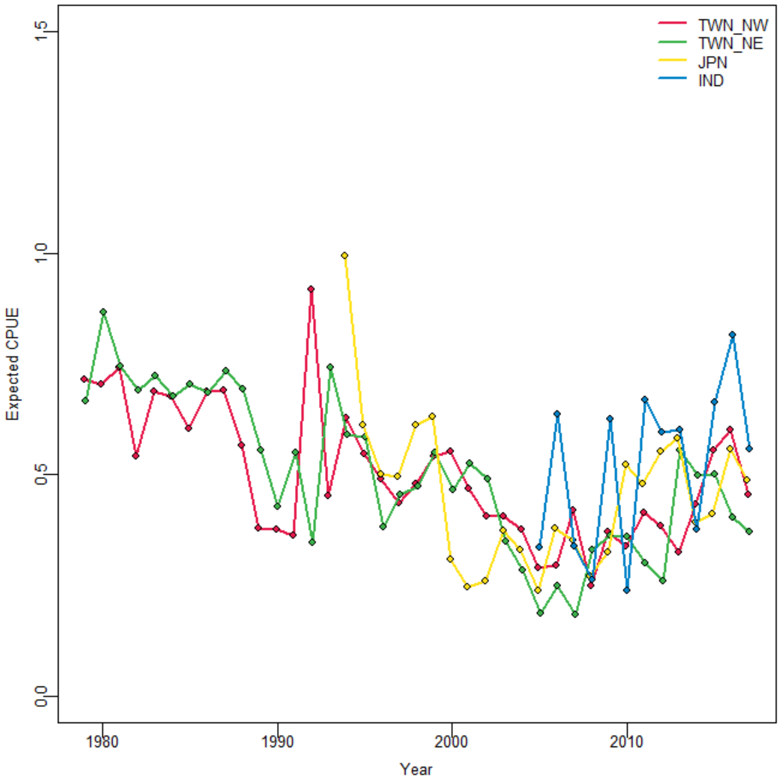

Figure 1. Standardized CPUE series of black marlin in the Indian Ocean. These series have been scaled to the mean for comparison**.**

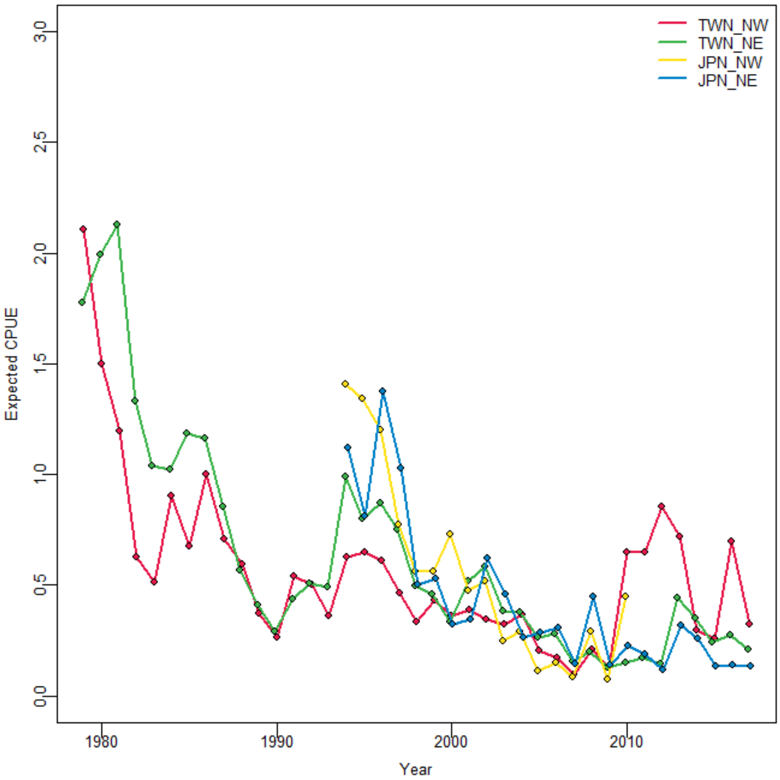

Figure 2. Standardized CPUE series of striped marlin in the Indian Ocean.

These series have been scaled to the mean.

5.2.2 Stock assessments

Black marlin: Summary of stock assessment models in 2018

Bayesian State Space Surplus Production Model (JABBA)

88. The WPB **NOTED** paper IOTC–2018–WPB16–15 which provided a stock assessment of black marlin in the Indian Ocean using Bayesian State Space Surplus Production Model (JABBA), which included the following abstract provided by the authors:

"*An initial assessment of the Indian Ocean black marlin (Makaira indica) was run using Bayesian State-Space Surplus Production Models in the open-source stock assessment tool JABBA. Four scenarios were selected based on alternative specifications of the Pella-Tomlinson model type that incorporated two differing nominal catch data time-series, three different priors for the intrinsic rate of population increase r and associated input values of BMSY/K, which determine the inflection point of the surplus production curve. 'drop one' sensitivity analysis on CPUE indices indicates that omitting either of the Taiwan,China indices (NE and NW) would influence the management reference point estimates B/BMSY and F/FMSY. The retrospective analysis produced an undesirable retrospective pattern as evident by systematic negative departures from the Reference Case predictions. This pattern becomes particularly strong from 2014 onward when the increase in total catch accelerated. Furthermore, an implausible trajectory is evident in all four Kobe biplots, which suggest that black marlin B/BMSY increases with an associated increase in F/FMSY for the period 2010-2017"* (see paper for full abstract).

89. The WPB **RECALLED** that in the last stock assessment conducted in 2016, both the ASPIC and the BSPM models of black marlin estimated that the stock was overfished, and the ASPIC model also estimated that the stock was subjected to overfishing.

90. The WPB **NOTED** that the four scenarios selected for the 2017 JABBA assessment incorporated two alternative catch series estimates[1], and three different priors for the intrinsic population growth rates *r*. The reference model (S2) was based on catch series IOTC-2018-WPB16-DATA11b (low catch scenario) and a *r* prior LN ~ (log (0.19), 0.30)):
    - **S1 (Cont.):** for B_{MSY}/K = 0.37 (h = 0.5), *r* prior *LN* ~ (log (0.19), 0.30)), catch data = Data 11a
    - **S2 (Ref.):** for B_{MSY}/K = 0.37 (h = 0.5), *r* prior *LN* ~ (log (0.19), 0.30)), catch data = Data 11b
    - **S3:** for B_{MSY}/K = 0.41 (h = 0.4), *r* prior *LN* ~ (log (0.16), 0.30)), catch data = Data 11b
    - **S4:** for B_{MSY}/K = 0.34 (h = 0.6), *r* prior *LN* ~ (log (0.21), 0.30)), catch data = Data 11b.

91. The WPB **NOTED** that the priors were derived from the ASEM simulations as described in paper IOTC-2018-WPB16-14. The WPB also **NOTED** all scenarios have incorporated four standardised CPUE series including the Taiwanese (NE and NW), Japanese, and Indonesian indices .

92. The WPB **NOTED** the key assessment results for the reference case (S2) of the Bayesian State Space Surplus-Production Model (JABBA) for black marlin as shown below (**Table 3; Figure 3**).

93. The WPB **NOTED** that the sensitivity analysis on CPUE indices indicates that excluding Taiwanese NE indices would provide more optimistic estimates of B/B_{MSY} and F/F_{MSY}, and omitting the Taiwanese NW indices would provide more pessimistic estimates of the management reference quantities.

94. The WPB **NOTED** that the estimated posterior distribution of *K* is very wide, indicating very high model uncertainty. Furthermore, the retrospective analysis produced an undesirable pattern, as evident by systematic departures from the reference case predictions (**Figure 4**). The WPB **NOTED** the retrospective pattern is caused by the inconsistent trend between the CPUE and catch series (e.g., the observed increasing CPUE and catch since 2010).

95. The WPB **AGREED** that the systematic deviations in the retrospective analysis provide little confidence in the predictive capabilities of the model, and as such the resultant fishery reference points for black marlin should be treated with caution. The WPB **REQUESTED** that the catch and effort data provided for this species be discussed

[1] IOTC-2018-WPB16-DATA11a (high catch scenario), and IOTC-2018-WPB16-DATA11b (low catch scenario) available at: http://www.iotc.org/meetings/16th-working-party-billfish-wpb16.

by the WPDCS in 2018 and revised information be submitted to the secretariat by CPCs that have catches of black marlin, prior to the next assessment of the species.

Table 3. Stock status summary table for the black marlin assessment (JABBA)

Management Quantity	JABBA (S2)
Current catch	19301
Mean catch over last 5 years	22444
MSY (1000 t)	12.93 (9.44 –18.20)
F_{MSY}	0.18 (0.11 – 0.30)
Current Data Period	1950 – 2017
$F_{Current}/F_{MSY}$	0.97 (0.60 – 1.53)
$B_{Current}/B_{MSY}$	1.68 (1.32 – 2.10)
$SB_{Current}/SB_{MSY}$	n.a.
$B_{Current}/B_0$	0.62 (0.49 – 0.78)
$SB_{Current}/SB_0$	n.a.

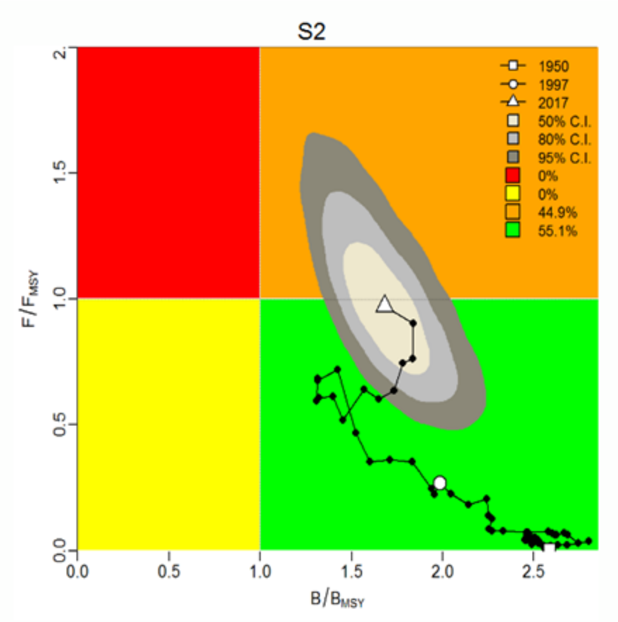

Figure 3. JABBA: Kobe stock status plot for the Indian Ocean for black marlin, from the final JABBA base case (Reference Scenario - S2). The black line traces the trajectory of the stock over time. Contours represent the smoothed probability distribution for 2017 (isopleths are probability relative to the maximum).

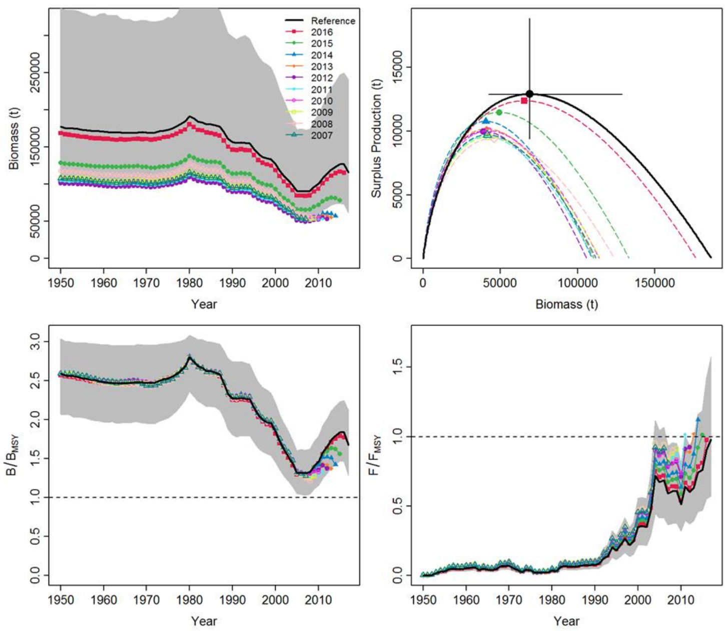

Figure 4: Retrospective analysis for stock biomass (t), surplus production function (maximum = MSY), B/B_{MSY} and F/F_{MSY} for the Indian Ocean black marlin JABBA Reference Scenario (S2).

Striped marlin: Summary of stock assessment models in 2018

Bayesian State Space Surplus Production Model (JABBA)

96. The WPB **NOTED** paper IOTC–2018–WPB16–16 which provided a stock assessment of striped marlin in the Indian Ocean using Bayesian State Space Surplus Production Model (JABBA), and which included the following abstract provided by the authors:

> "*Four scenarios were run using Bayesian State-Space Surplus Production Models to assess the Indian Ocean striped marlin (Tetrapturus audax) using the open-source stock assessment tool JABBA. A 'drop one' sensitivity analysis indicated that omitting any of the CPUE time-series would not significantly alter the stock status. Similarly, a retrospective analysis produced highly consistent results for stock status estimates back to 2007 and therefore provided no evidence for an undesirable retrospective pattern. As such, all CPUE time-series were used for all the scenarios run in this assessment. The results for the four alternative scenarios estimated MSY between 4 550 and 4 921 tons. Median estimates of B/BMSY from the four scenarios ranged between 0.27 - 0.39 and B/K between 0.09 - 0.11"* (see paper for full abstract).

97. The WPB **RECALLED** that in the last assessment conducted in 2017, all four models (SRA, ASPIC, SS3, SSBSP) of the Indian Ocean striped marlin estimated that the stock was overfished, and was subject to overfishing.

98. The WPB **NOTED** that the four scenarios selected for the 2017 JABBA assessment incorporated two alternative catch series estimates[2] and three different priors for the intrinsic population growth rates r. The reference model (S2) is based on nominal catch series 12b (low catch scenario) and an *r* prior LN ~ (log (0.25), 0.15)).
    - **S1 (Cont.):** for B_{MSY}/K = 0.37 (h = 0.5), r prior LN ~ (log (0.25), 0.15)), catch data = Data 12a_Rev1.
    - **S2 (Ref.):** for B_{MSY}/K = 0.37 (h = 0.5), r prior LN ~ (log (0.25), 0.15)), catch data = Data 12b.
    - **S3:** for B_{MSY}/K = 0.4 (h = 0.4), r prior LN ~ (log (0.21), 0.14)), catch data = Data 12b.
    - **S4:** for B_{MSY}/K = 0.23 (h = 0.86), r prior LN ~ (log (0.31), 0.16)), catch data = Data 12b.

99. The WPB **NOTED** that the priors were derived from the ASEM simulations as described in paper IOTC-2018-WPB16-14. The WPB also **NOTED** all scenarios have incorporated four standardised CPUE series including the Taiwanese (NE and NW) and Japanese indices (NE and NW for 1976-1993 and 1994-2017).

100. The WPB **NOTED** that of the four scenarios estimated, B2017 was below B_{MSY} and F_{2017} was above F_{MSY}. The WPB **NOTED** the models had a good fit to the Taiwanese CPUE indices but failed to fully describe the sharp initial decline in observed historical Japanese CPUE between the late 1970s and early 1980s.

101. The WPB suggested two additional scenarios (one-off change to S2):
    - **S5**: same as S2, but remove historical Japan (NE and NW) CPUE time series (1970-1993)
    - **S6:** same as S2, but increase the CV on initial depletion prior to 0.25.

102. The WPB **NOTED** that omitting the historical Japan indices did not significantly alter the stock status. The WPB **FURTHER NOTED** the use of the historical Japan CPUE time series as the index of abundance was not recommended by the original author and have not been included in the SS3 model for striped marlin. The WPB therefore **AGREED** that scenario S5 should be considered as the JABBA reference base case.

103. The WPB **NOTED** that relaxing the prior of *psi* (initial depletion) resulted in a decrease of the estimated initial depletion and subsequently produced an implausible trend in surplus production and B/B_{MSY} for the beginning of the catch time-series. This, however, had no effect on the B_{2017} and F_{2017} estimates.

104. The WPB **NOTED** the key assessment results for Bayesian State Space Surplus-Production Model (JABBA) for striped marlin from the base case (S5) as shown below (**Table 3; Figure 5**)

105. The WPB **NOTED** that the estimates of posterior distribution of *K* were precise and that the retrospective analysis produced highly consistent stock status estimates back to 2007, thus providing a degree of confidence in the predictive capabilities of the assessment (**Figure 6**).

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[2] IOTC-2018-WPB16-DATA12a_Rev1 (high catch scenario), and IOTC-2018-WPB16-DATA12b (low catch scenario) available at: http://www.iotc.org/meetings/16th-working-party-billfish-wpb16.

Table 3. Stock status summary table for the striped marlin assessment (JABBA).

Management Quantity	JABBA (S5)
Current catch	3,082
Mean catch over last 5 years	3,587
MSY (1000 t)	4.73 (4.27 –5.17)
F_{MSY}	0.26 (0.20 – 0.34)
Current Data Period	1950 – 2017
$F_{Current}/F_{MSY}$	1.99 (1.21 – 3.62)
$B_{Current}/B_{MSY}$	0.33 (0.18 – 0.54)
$SB_{Current}/SB_{MSY}$	n.a.
$B_{Current}/B_0$	0.12 (0.07 – 0.20)
$SB_{Current}/SB_0$	n.a.

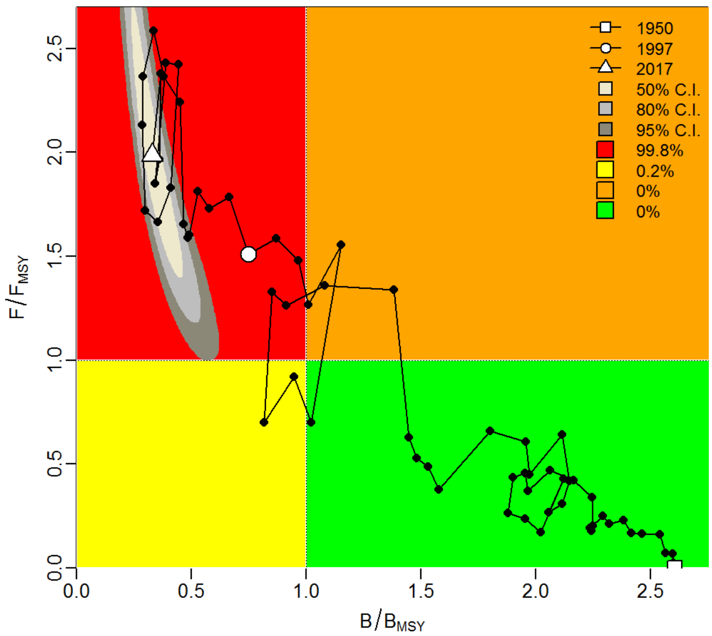

Figure 5. JABBA: Kobe stock status plot for the Indian Ocean for striped marlin for the JABBA base case model (S5). The black line traces the trajectory of the stock over time. Contours represent the smoothed probability distribution for 2017 (isopleths represent the probabilities relative to the maximum).

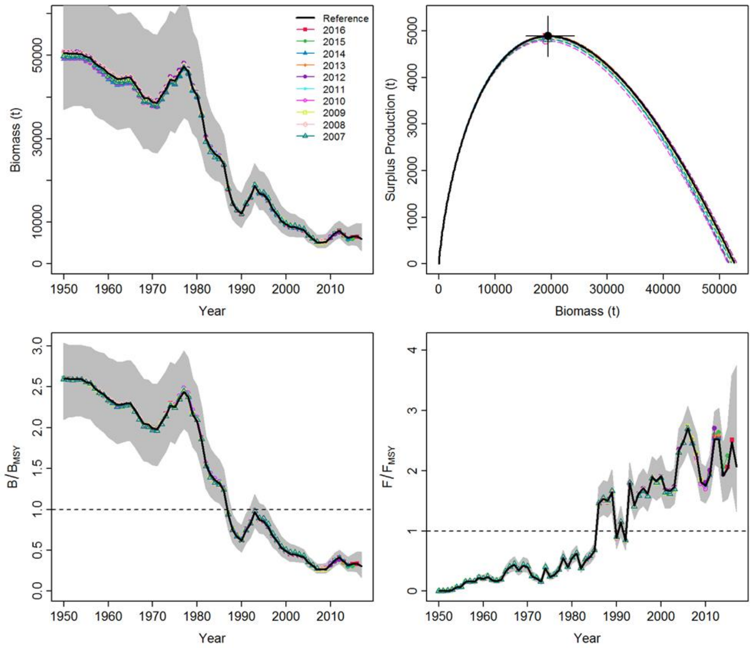

Figure 6: Retrospective analysis for stock biomass (t), surplus production function (maximum = MSY), B/B_{MSY} and F/F_{MSY} for the Indian Ocean black marlin JABBA model (reference case (S2)).

Stock synthesis (SS3)

106. The WPB **NOTED** paper IOTC–2018–WPB16–19 which provided a stock assessment of striped marlin in the Indian Ocean using Stock Synthesis 3, and which included the following abstract provided by the authors:

"In this study, Stock Synthesis (SS) was used to conduct the stock assessment for striped marlin in the Indian Ocean by incorporating historical catch, standardized CPUE series, length-frequency data and life-history parameters. The results indicated that the current spawning biomass is lower than the MSY level and the fishing mortality is higher the MSY level. However, the results are influenced by the assumptions of life-history parameters and assuming higher values of natural mortality and steepness of stock-recruitment relationship can lead to relatively optimistic stock status."

107. The WPB **NOTED** the SS3 model for striped marlin was configured as a single area, one sex model. The fisheries were grouped into three fleets: Taiwanese longline, Japanese longline, and others. The observational data included the standardised CPUE indices for the Taiwanese fleet (1979-2017, NW and NE series combined) and Japanese fleet (1994-2017), and size frequency data. The WPB further **NOTED** that the life history parameters were fixed at known estimates from the Pacific Ocean.

108. The WPB **NOTED** the model assumed dome-shaped selectivity for the Taiwanese and Japanese longline. Due to the lack of size data, the selectivity for the "others" fleet was assumed to be same as the Taiwanese fleet. The WPB **NOTED** the four scenarios were implemented with varying time-blocks for selectivity parameters as follows:
    - T1J1 (reference case), constant selectivity.
    - T1J2 (1950-1993 and 1994-2017 time blocks for Japanese longline selectivity).
    - T2J1 (1950-2000 and 2000-2017 time blocks for Taiwanese longline selectivity).
    - T2J2 (1950-1993 and 1994-2017 time blocks for Japanese longline selectivity, and 1950-2000 and 2000-2017 for time blocks for Taiwanese longline selectivity).

109. The WPB **NOTED** the model estimated a change in selectivity between the two time blocks for the Taiwanese longline fleet, but that estimates were uncertain for the Japanese longline fleet. The WPB further **NOTED** that sample sizes for the Japanese length data were very low in recent years. On that basis the WPB **AGREED** to drop the Japanese length frequency data from 2001-2017.

110. The WPB **NOTED** the model provides a good fit to the CPUE indices but did not adequately predict the right hand side of the (Taiwanese) length distribution. The WPB also **NOTED** a declining trend in recruitments from 1980 to 2010.

111. The WPB **NOTED** new estimates of maturity from the Indian Ocean (see IOTC-2018-WPB16-09 for further details) are consistent with the estimates from the Pacific Ocean, and suggested that the new estimates should be examined in the assessment. The WPB also suggested the low steepness values (0.4 and 0.5) should be examined, to be more consistent with the shape parameter used in the JABBA model.

112. The WPB **NOTED** some of the life-history parameters (e.g., M and steepness) for striped marlin are associated with a high degree of uncertainty and **AGREED** the following runs to be explored:
- 1 steepness 0.86, natural mortality 0.45 (T2J1)
- 2 steepness 0.5, natural mortality 0.45
- 3 steepness 0.4, natural mortality 0.45
- 4 steepness 0.4, natural mortality Lorenzo parameterization (average 0.45)
- 5 steepness 0.4, natural mortality Lorenzo parameterization (average 0.1)
- 6 steepness 0.4, natural mortality 0.25
- 7 steepness 0.86, natural mortality 0.45, new maturity estimates from the Indian Ocean
- 8 steepness 0.86, natural mortality Lorenzo parameterization (average 0.25)
- 9 steepness 0.5, natural mortality Lorenzo parameterization (average 0.25)

113. The WPB **NOTED** all the model runs estimated stock status being in the red KOBE quadrat except for model 4 (age-specific Lorenzo natural mortality with an average of 0.45). The WPB further **NOTED** that the results are highly influenced by the assumptions of life-history parameters – assuming higher values of natural mortality and steepness of stock-recruitment relationship can lead to more optimistic stock status.

114. The WPB **NOTED** the biology of striped marlin (growth, maturity, etc.) is known to be different between females and males, and **SUGGESTED** that future assessment should consider using a sex-specific model when the gender-specific data/parameters become available.

115. The WPB **NOTED** the key assessment results for SS3 for striped marlin as shown below (**Table 4; Figure 7**).

116. The WPB **NOTED** that the retrospective analysis produced generally consistent stock status estimates (**Figure 8**).

Table 4. Stock status summary table for the striped marlin assessment (reference case).

Management Quantity (model 9)	Aggregate Indian Ocean
2017 catch estimate	3,082[1] t
Mean catch from 2011–2015	3,587[1] t
MSY (1000 t) (80% CI)	4.564 (4.289, 4.839)
Data period (catch)	1950–2017
F_{MSY} (80% CI)	0.230 (0.214, 0.247)
SB_{MSY} (1,000 t) (80% CI)	14.973 (14.152, 15.788)
F_{2015}/F_{MSY} (80% CI)	1.755 (1.397, 2.112)
SB_{2015}/SB_{MSY} (80% CI)	0.346 (0.265, 0.437)
SB_{2015}/SB_{1950} (80% CI)	0.116 (0.090, 0.142)

[1] Low-case catch scenario (IOTC-2018-WPB16-DATA03b).

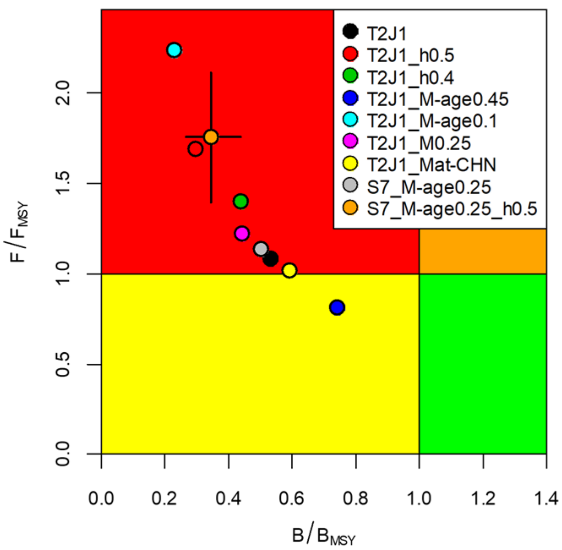

Figure 7. Stock synthesis: Kobe stock status plot for the Indian Ocean for striped marlin (all model runs). The black line traces the trajectory of the stock over time. Run *S7_M-age0.25_h0.5* is the reference model (9).

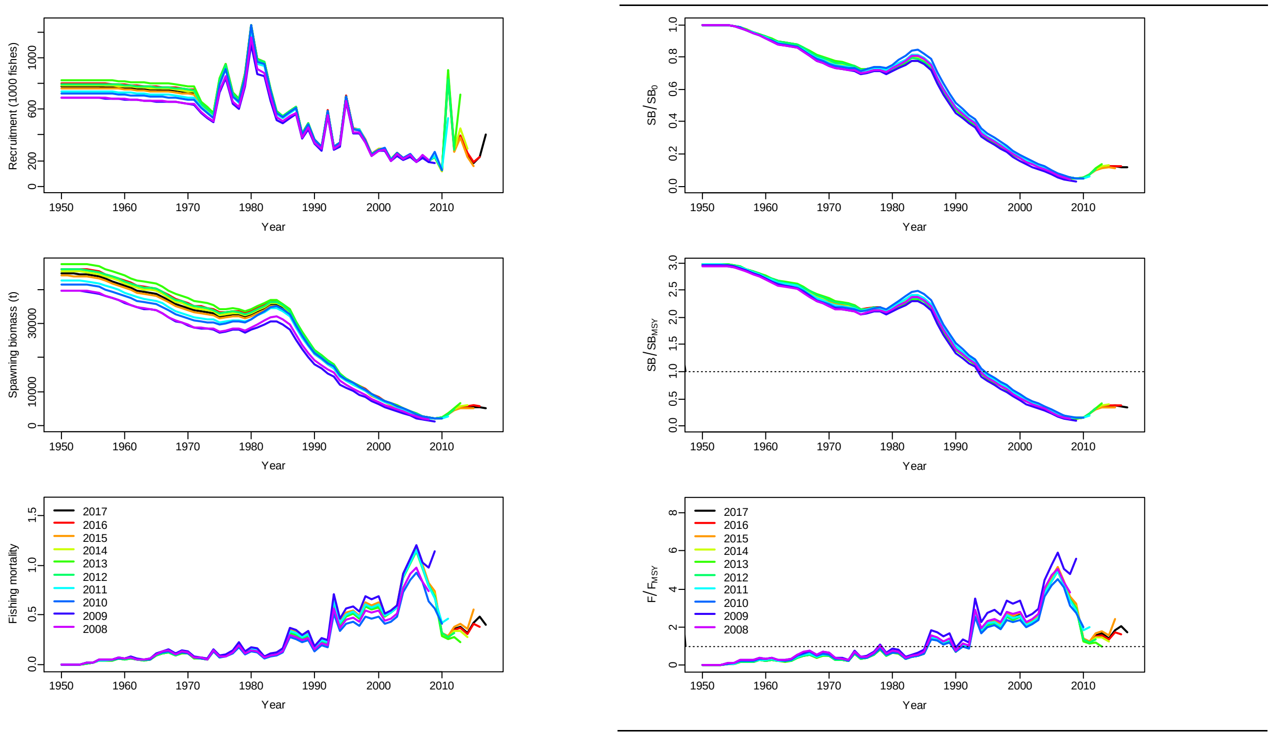

Figure 8: Retrospective analysis for recruitment, SB/SB0, Stock biomass (t), S*B/SB*$_{MSY}$, fishing mortality, *F/F*$_{MSY}$ for the Indian Ocean striped marlin SS3 model (reference case).

5.3 Development of management advice for marlins and update of marlin species Executive Summaries for the consideration of the Scientific Committee

Black marlin

117. The WPB **NOTED** the JABBA assessment model estimated that the current stock biomass is above B_{MSY}, and the current fishing mortality is below F_{MSY}.

118. The WPB **NOTED** that the recent catch levels appear to be inconsistent with the observed increase in CPUE, and that the historic catch estimates are highly uncertain. The WPB further **NOTED** the 2018 JABBA model diagnostics highlight the poor performance with regard to the robustness of management reference point estimates and these should be treated with extreme caution.

119. The WPB **NOTED** that the systematic deviations in the retrospective analysis provide little confidence in the predictive capabilities of the model, and as such model projections should not be used to provide management advice.

120. The WPB **NOTED** the management advice developed for black marlin (executive summary) at WPB16 :

"The current catches (>20,000 t in 2017) are considerably higher than MSY (12,930 t). Projections were not carried out due to the poor predictive capabilities identified in the assessment diagnostics."

- Black marlin (*Makaira indica*) – Appendix VII

Striped marlin

121. The WPB **NOTED** that all examined models were consistent, indicating that the stock has been subject to overfishing in the last two decades and that, as a result, the stock biomass is well below the B_{MSY} level. The WPB also **NOTED** the stock status estimates are consistent between the SS3 and the JABBA models.

122. On the weight-of-evidence available in 2018, the WPB **AGREED** that the stock status of striped marlin is determined to be overfished and subject to overfishing.

123. The WPB **AGREED** that projections are to be conducted using the base case (S5) of the JABBA model to provide management advice.

124. The WPB **NOTED** the management advice developed for striped marlin (executive summary) at WPB16:

"Current or increasing catches have a very high risk of further decline in the stock status. Current 2017 catches (Fig. 1) are lower than MSY (4,730 t) but the stock has been overfished for more than two decades and is now in a highly depleted state. If the Commission wishes to recover the stock to the green quadrant of the Kobe plot with a probability ranging from 60% to 90% by 2026, then the maximum annual catches have to be set to between 1,500 t – 2,200 t."

- Striped marlin (*Tetrapturus audax*) – Appendix IX

6. OTHER BILLFISHES (NEW INFORMATION FOR INFORMING FUTURE ASSESSMENTS)

6.1 Review of new information on other billfishes (swordfish, other marlins, I.P. sailfish) biology, stock structure, fisheries and associated environmental data (all)

125. The WPB **NOTED** paper IOTC-2018-WPB16-13 which described monsoon and temperature effects on swordfish (*Xiphias gladius*) catches in the high seas of Indian Ocean, and which included the following abstract provided by the authors:

"The present study was undertaken with the aim of understanding the monsoon and temperature effects on catch rates of Swordfish in high seas longline fishery of Sri Lanka. Spatial and temporal data with corresponding catch rates were obtained from the logbook data whereas Sea Surface Temperature (SST) data were obtained from ERA-interim of the European Centre for Medium-Range Weather Forecasts" (see paper for full abstract).

126. The WPB **NOTED** that this preliminary work combining logbook data and environmental information (i.e., temperature) is promising and **SUGGESTED** that habitat modelling approaches are used in future analyses, e.g., using General Additive Models. The WPB also **SUGGESTED** Sri Lanka account for the data within their EEZ in their analyses.

127. The WPB **NOTED** paper IOTC-2018-WPB16-23 which described a mathematical approach to understanding billfish population dynamics: a focus on Sailfish in Kenyan waters, was not received and thus was considered **WITHDRAWN.**

128. The WPB **NOTED** paper IOTC–2018–WPB16–14 which developed the surplus production model priors from a multivariate life history prediction model for IOTC billfish assessments with limited biological information, and which included the following abstract provided by the authors:

"*Here we present an approach to objectively incorporate available life history parameters into Bayesian surplus production model priors for the intrinsic rate of population increase r. First we use the R package FishLife to determine probable life history parameters from FishBase. The model is then updated with stock-specific estimates of the asymptotic length (Loo), as derived by fitting the recently proposed Length-based Bayesian estimator (LBB) to available size data for the Indian Ocean region. The resulting FishLife predictions of parameter means and their covariance are then used to propagate parameter uncertainty and correlation structure into the formulation of the r prior"* (see paper for full abstract).

129. The WPB **NOTED** that this study provides a novel and transparent methodology for the development of priors to inform the assessment models by incorporating life history information and region specific length data.

130. The WPB **NOTED** that the priors for steepness appeared to be quite low, but may still be plausible as marlins are observed to have lower productivity than tuna species. It was clarified that the three prior scenarios (i.e., low, reference, and high values) have been used in the JABBA models. The WPB **ENCOURAGED** the use of the lower *h* value in the SS model, as a sensitivity, to be consistent with this approach.

6.2 Review of any biological data in support of retention and transhipment bans for specimen below a minimum size, as per recent IOTC Resolutions

131. The WPB **NOTED** paper IOTC-2018-WPB16-09 which provided a table on maturity (**Table 3**). The WPB further **NOTED** Resolution 18/05 (specifically point 14.c which requests that the Scientific Committee provide advice on minimum landing sizes). This table, while preliminary provides new information regarding size-at-maturity for the three marlin species and Indo-Pacific sailfish. The WPB **ACKNOWLEGED** that this biological study is ongoing, with more sampling and updated analysis planned for the future.

Table 3. Marlin and IP sailfish table of maturity.

Species	Sample size (N)	LJFL range (in cm)		$P_i = 1/(1+\exp(-\ln 19(L_i - L_{50})/(L_{95} - L_{50})))$		$P_i = 1/(1+\exp(-r \times (L_i - L_{50})))$	
		Min	Max	L_{50}	L_{95}	L_{50}	r
Blue Marlin	197	98	325	**161.4**	226.2	161.4	0.045
Striped Marlin	121	144	240	**177.0**	238.1	177.0	0.048
Black Marlin	25	162	272	**166.9**	180.0	166.9	0.225
Indo-Pacific sailfish	53	150	230	**192.6**	254.4	192.6	0.048

132. The WPB **NOTED** that the limited volume of data collected does not permit the calculation of maturity curves separately by sex and **SUGGESTED** that as more data is collected, sex-specific maturity curves should be developed.

6.3 Review of new information on the status of other billfishes (swordfish, other marlins, IP sailfish) (all)

Swordfish

133. The WPB **AGREED** that, as no new information was presented for swordfish, the previous indicators, as well as the most recent catch estimates would be used to update the management advice from last year.

134. The WPB **NOTED** however that the revisions to catch estimates for Indonesia's fresh longline fleet provided by the IOTC Secretariat (IOTC-2018-WPB16-DATA03b, available on the IOTC meeting webpage) result in lower swordfish catches in recent years that may affect further stock assessment for SWO.

Blue marlin

135. The WPB **AGREED** that, as no new information was presented for blue marlin, the previous indicators, as well as the most recent catch estimates would be used to update the management advice from last year.

Indo-Pacific sailfish

136. The WPB **AGREED** that, as no new information was presented for Indo-Pacific sailfish, the previous indicators, as well as the most recent catch estimates would be used to update the management advice from last year.
    - Swordfish (*Xiphias gladius*) – Appendix VI
    - Blue marlin (*Makaira nigricans*) – Appendix VIII
    - Indo-Pacific sailfish (*Istiophorus platypterus*) – Appendix X

7. WPB PROGRAM OF WORK

7.1 Revision of the WPB Program of work (2019–2023)

137. The WPB **NOTED** paper IOTC–2018–WPB16–08 which provided an opportunity to consider and revise the WPB Program of Work (2019–2023), by taking into account the specific requests of the Commission, Scientific Committee, and the resources available to the IOTC Secretariat and CPCs.

138. The WPB **RECALLED** that the SC, at its 18th Session, made the following request to its working parties:

    "*The SC REQUESTED that during the 2016 Working Party meetings, each group not only develop a Draft Program of Work for the next five years containing low, medium and high priority projects, but that all High Priority projects are ranked. The intention is that the SC would then be able to review the rankings and develop a consolidated list of the highest priority projects to meet the needs of the Commission. Where possible, budget estimates should be determined, as well as the identification of potential funding sources.*" (SC18. Para 154).

139. The WPB **RECOMMENDED** that the SC consider and endorse the WPB Program of Work (2019–2023), as provided at Appendix XI.

7.2 Development of priorities for an Invited Expert at the next WPB meeting

140. The WPB **NOTED**, with thanks, the outstanding contributions of the invited expert for the meeting, Dr Evgeny Romanov from the CAP-RUN NEXA. Dr Romanov's work during the WPB16 meeting has greatly contributed to the group's understanding of billfish data and biology. Dr Romanov collaborated with the WPB, as the Invited Expert, on a voluntary basis and his expertise has been greatly appreciated.

141. The WPB **AGREED** to the following core areas of expertise and priority areas for contribution that need to be enhanced for the next meeting of the WPB in 2019 by an Invited Expert:

- **Expertise**: Stock assessment, including from regions other than the Indian Ocean; SS3 and data poor assessment approaches for marlins.
- **Priority areas for contribution**: Refining the information base, historical data series and indicators for billfish species for stock assessment purposes (species focus: blue marlin and Indo-Pacific sailfish).

142. The WPB **AGREED** that the selection of the invited expert for the WPB17 would be performed by advertising the position through the IOTC science list (as a priority channel) and finalized after receipt and assessment of résumés and supporting information for potential candidates, according to the deadlines set forth by the rules and procedures of the Commission.

8. OTHER BUSINESS

8.1 Date and place of the 17th and 18th Sessions of the Working Party on Billfish

143. The WPB **THANKED** South Africa (the Department of Agriculture, Forestry, and Fisheries) for hosting the 16th Session of the WPB and **COMMENDED** South African on the warm welcome, the excellent facilities and assistance provided for the organisation and running of the Session.

144. The WPB **AGREED** on the importance of having IOTC Working Party meetings within key CPCs catching IOTC species of relevance to the Working Party, in this case billfish. Following a discussion on who would host the 17th and 18th sessions of the WPB in 2018 and 2019 respectively, the WPB **ACKNOWLEDGED** the offer from La Réunion (France) to host the 17th session in conjunction with the Working Party on Ecosystems and Bycatch: the meeting locations and dates will be confirmed and communicated by the IOTC Secretariat to the SC for its consideration at its next session to be held in December 2018 (**Table 7**).

145. The WPB **NOTED** the importance of having a degree of stability in the participation of CPCs to each of the working party meetings and **ENCOURAGED** participants to regularly attend each meeting to ensure as much continuity as possible.

Table 7. Draft meeting schedule for the WPB (2019 and 2020).

	2019			2020		
Meeting	**No.**	**Date**	**Location**	**No.**	**Date**	**Location**
Working Party on **Billfish** (WPB)	17th	9-12 September (4d)	La Réunion (TBC)	18th	1-5 September (5d)	(TBC)
Working Party on **Ecosystems and Bycatch** (WPEB)	15th	3-7 September (5d)	La Réunion (TBC)	16th	7-11 September (5d)	(TBC)

8.2 Review of the draft, and adoption of the Report of the 16th Session of the Working Party on Billfish

146. The WPB **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPB16, provided at Appendix XII, as well as the management advice provided in the draft resource stock status summary for each of the five billfish species under the IOTC mandate, and the combined Kobe plot for the five species assigned a stock status in 2018 (Fig. 9):

- Swordfish (*Xiphias gladius*)– Appendix VI
- Black marlin (*Makaira indica*) – Appendix VII
- Blue marlin (*Makaira nigricans*) – Appendix VIII
- Striped marlin (*Tetrapturus audax*) – Appendix IX
- Indo-Pacific sailfish (*Istiophorus platypterus*) – Appendix X

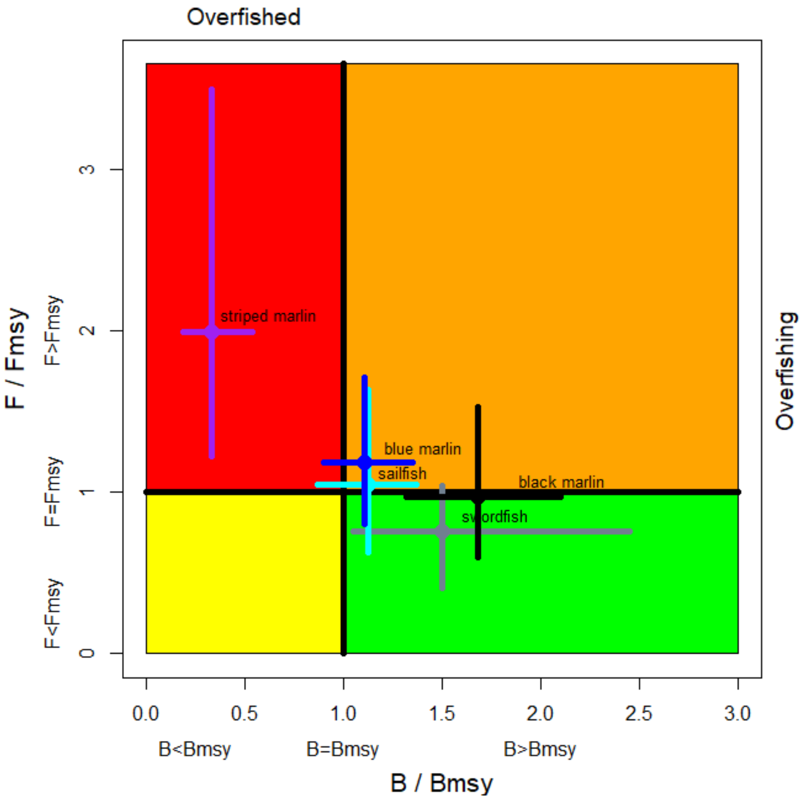

Fig. 9. Combined Kobe plot for swordfish (grey), indo-pacific sailfish (cyan), black marlin (black), blue marlin (blue) and striped marlin (purple) showing the 2016, 2017, and 2018 estimates of current stock size (SB or B, species assessment dependent) and current fishing mortality (F) in relation to optimal spawning stock size and optimal fishing mortality. Cross bars illustrate the range of uncertainty from the model runs.

147. The report of the 16th Session of the Working Party on Billfish (IOTC–2018–WPB16–R) was **ADOPTED** on the 7th of September 2018

APPENDIX I
LIST OF PARTICIPANTS

Chairperson:
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APPENDIX II
AGENDA FOR THE 16TH WORKING PARTY ON BILLFISH

Date: 4–7 September 2018
Location: Cape Town, South Africa
Venue: Protea Hotel, Victoria Junction
Time: 09:00 – 17:00 daily
Chair: Dr Rui Coelho (EU,Portugal); Vice-Chair: Dr Evgeny Romanov (EU,France)

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

2. **ADOPTION OF THE AGENDA AND ARRANGEMENTS FOR THE SESSION** (Chairperson)

3. **THE IOTC PROCESS: OUTCOMES, UPDATES AND PROGRESS**
   - 3.1 Outcomes of the 20th Session of the Scientific Committee (IOTC Secretariat)
   - 3.2 Outcomes of the 22th Session of the Commission (IOTC Secretariat)
   - 3.3 Review of Conservation and Management Measures relevant to billfish (IOTC Secretariat)
   - 3.4 Progress on the recommendations of WPB15 (IOTC Secretariat)

4. **NEW INFORMATION ON FISHERIES AND ASSOCIATED ENVIRONMENTAL DATA FOR BILLFISH**
   - 4.1 Review of the statistical data available for billfish (IOTC Secretariat)
   - 4.2 Review new information on fisheries and associated environmental data (general CPC papers)
   - 4.3 New information on sport fisheries (all)

5. **MARLINS (Priority species for 2018: Black marlin and Striped marlin)**
   - 5.1 Review new information on Marlin biology, stock structure, fisheries and associated environmental data (all)
   - 5.2 Review of any biological data in support of retention and transhipment bans for specimen below a minimum size, as per recent IOTC Resolutions (all)
   - 5.3 Review of new information on the status of marlins (all)
     - Nominal and standardised CPUE indices
     - Stock assessments
     - Selection of Stock Status indicators for marlins
   - 5.4 Development of management advice for marlins and update of marlin species Executive Summary for the consideration of the Scientific Committee , including discussion on current catch limits as per standing IOTC Resolutions (all)

6. **OTHER BILLFISHES (new information for informing future assessments)**
   - 6.1 Review of new information on other billfishes (swordfish, other marlins, I.P. sailfish) biology, stock structure, fisheries and associated environmental data (all)
   - 6.2 Review of any biological data in support of retention and transhipment bans for specimen below a minimum size, as per recent IOTC Resolutions (all)
   - 6.3 Review of new information on the status of other billfishes (swordfish, other marlins, IP sailfish) (all)
     - Nominal and standardised CPUE indices
     - Other indicators

7. **DEVELOPMENT OF OPTIONS FOR ALTERNATIVE MANAGEMENT MEASURES (INCLUDING CLOSURES) FOR BILLFISH IN THE IOTC AREA OF COMPETENCE**

8. WPB PROGRAM OF WORK

8.1 Revision of the WPB Program of Work (2019–2023) (Chairperson and IOTC Secretariat)

8.2 Development of priorities for an Invited Expert at the next WPB meeting (Chairperson)

9. OTHER BUSINESS

9.1 Date and place of the 17th and 18th Sessions of the Working Party on Billfish (Chairperson and IOTC Secretariat)

9.2 Review of the draft, and adoption of the Report of the 16th Session of the Working Party on Billfish (Chairperson)

APPENDIX III
LIST OF DOCUMENTS FOR THE 16TH WORKING PARTY ON BILLFISH

Last updated: 30th August 2018

Document	Title	Availability
IOTC-2018-WPB16-01a	DRAFT Agenda of the 16th Working Party on Billfish	✓(18 June 2018)
IOTC-2018-WPB16-01b	Annotated agenda of the 16th Working Party on Billfish	✓(8 August 2018) ✓(30 August 2018)
IOTC-2018-WPB16-02	List of documents of the 16th Working Party on Billfish	✓(8 August 2018) ✓(30 August 2018)
IOTC-2018-WPB16-03	Outcomes of the 20th Session of the Scientific Committee (IOTC Secretariat)	✓(8 August 2018)
IOTC-2018-WPB16-04	Outcomes of the 22nd Session of the Commission (IOTC Secretariat)	✓(8 August 2018)
IOTC-2018-WPB16-05	Review of Conservation and Management Measures relevant to billfish (IOTC Secretariat)	✓(8 August 2018)
IOTC-2018-WPB16-06_Rev1	Progress made on the recommendations and requests of WPB15 and SC20 (IOTC Secretariat)	✓(16 August 2018) ✓(17 August 2018)
IOTC-2018-WPB16-07	Review of the statistical data and fishery trends for billfish species (IOTC Secretariat)	✓(23 August 2018)
IOTC-2018-WPB16-08	Revision of the WPB Program of Work (2019-2023) (IOTC Secretariat)	✓(9 August 2018)
IOTC-2018-WPB16-09	Comparing the biology of four billfish species in the Indian Ocean based on Chinese longline observer data (Zhou C, Wang X, Wu F, Xu L, Zhu J)	✓(18 August 2018)
IOTC-2018-WPB16-10	Billfish by-catches of the Iran gillnet fishery in the IOTC area - an update (Rejaei F)	
IOTC-2018-WPB16-11	High seas billfish catches by Kenyan longliner (Ndoro C, Ndegwa S)	✓(20 August 2018)
IOTC-2018-WPB16-12	Update on standardized CPUE indices for Black marlin (*Makaira indica*) caught by Indonesian tuna longline fishery in the Eastern Indian Ocean (Setyadji B, Sadiyah L, Wibawa T-A, Fahmi Z)	✓(20 August 2018)
IOTC-2018-WPB16-13_Rev1	Monsoon and temperature effects on sword fish (*Xiphias gladius*) catches in the high seas of Indian Ocean: A case study in high seas longline fishery of Sri Lanka (Bandaranayake K, Weerasekera S, Jayathilaka R, Haputhantri S)	✓(20 August 2018) ✓(30 August 2018)
IOTC-2018-WPB16-14	Developing surplus production model priors from a multivariate life history prediction model for IOTC billfish assessments with limited biological information (Winker H)	✓(29 August 2018)
IOTC-2018-WPB16-15	Just Another Bayesian Biomass Assessment (JABBA) of the Indian Ocean black marlin (*Istiompax indica*) stock (Winker H)	
IOTC-2018-WPB16-16	Bayesian State-Space Surplus Production Model *JABBA* assessment of Indian Ocean Striped marlin (*Tetrapturus audax*) (Parker D, Winker H, Da Silva C, Kerwath S)	✓(27 August 2018)
IOTC-2018-WPB16-17	CPUE standardization of black marlin (*Makaira indica*) caught by Taiwanese large scale longline fishery in the Indian Ocean (Wang S-P)	✓(20 August 2018)
IOTC-2018-WPB16-18	CPUE standardization of striped marlin (*Tetrapturus audax*) caught by Taiwanese large scale longline fishery in the Indian Ocean (Wang S-P)	✓(20 August 2018)
IOTC-2018-WPB16-19	Stock assessment of striped marlin (*Tetrapturus audax*) in the Indian Ocean using the Stock Synthesis (Wang S-P)	✓(30 August 2018)
IOTC-2018-WPB16-20	Genetic population structure of striped marlin (*Kajikia audax*) in the Indian Ocean (Mamoozadeh R, McDowell J-R, Graves J-E)	✓(20 August 2018)
IOTC-2018-WPB16-21	Billfishes landings in Phuket ports by foreign vessel 2017 (Maeroh K, Hoimuk S, Somkliang N, Rodpradit S)	✓(16 August 2018)
IOTC-2018-WPB16-22	Revision to IOTC scientific estimates for Indonesia's small-scale longline catches (Geehan J, Setyadji B)	✓(1 September 2018)
IOTC-2018-WPB16-23	A mathematical approach to understanding billfish population dynamics: a focus on Sailfish in Kenyan waters (Kadagi N)	

Document	Title	Availability
IOTC-2018-WPB16-24	An assessment of the 2016 -2017 IOTC project on acquisition of catch-and-effort and size data from sport fisheries in the Western Indian Ocean (Kadagi N)	
IOTC-2018-WPB16-25	Standardized CPUE of the Indian Ocean striped marlin (*Tetrapturus audax*) caught by Japanese longline fishery: Update analysis between 1994 and 2017 (Ijima H)	✓(13 August 2018)
IOTC-2018-WPB16-26	Standardized CPUE of the Indian Ocean black marlin (*Istiompax indica*) caught by Japanese longline fisheries (Ijima H)	✓(13 August 2018)
Information papers		
Data sets		
IOTC-2018-WPB16-DATA01	Billfish datasets available	
IOTC-2018-WPB16-DATA02	IOTC Species data catalogues - availability of datasets	
IOTC-2018-WPB16-DATA03a	Nominal Catches per Fleet, Year, Gear, IOTC Area and species (scenario 1)	✓(14 August 2018)
IOTC-2018-WPB16-DATA03b	Nominal Catches per Fleet, Year, Gear, IOTC Area and species (scenario 2)	✓(16 August 2018)
IOTC-2018-WPB16-DATA04	Catch and effort data - vessels using drifting longlines	✓(14 August 2018)
IOTC-2018-WPB16-DATA05	Catch and effort data - surface fisheries	✓(14 August 2018)
IOTC-2018-WPB16-DATA06	Catch and effort data - vessels using other gears (e.g., gillnets, lines and unclassified gears)	✓(14 August 2018)
IOTC-2018-WPB16-DATA07	Catch and effort data - all gears	✓(14 August 2018)
IOTC-2018-WPB16-DATA08	Catch and effort - reference file	✓(14 August 2018)
IOTC-2018-WPB16-DATA09	Size frequency data - billfish species	✓(14 August 2018)
IOTC-2018-WPB16-DATA10	Size frequency - reference file	✓(14 August 2018)
IOTC-2018-WPB16-DATA11a	Data for the stock assessment of Black marlin (scenario 1)	✓(14 August 2018)
IOTC-2018-WPB16-DATA11b	Data for the stock assessment of Black marlin (scenario 2)	✓(16 August 2018)
IOTC-2018-WPB16-DATA12a_Rev1	Data for the stock assessment of Striped marlin (scenario 1)	✓(17 August 2018) ✓(18 August 2018)
IOTC-2018-WPB16-DATA12b	Data for the stock assessment of Striped marlin (scenario 2)	✓(18 August 2018)
IOTC-2018-WPB16-DATA13	Standardization of Black marlin CPUE by Japanese longline fishery in the Indian Ocean (1994-2017)	✓(18 July 2018)
IOTC-2018-WPB16-DATA14	Standardization of Black marlin CPUE by Taiwanese longline fishery in the Indian Ocean (1979-2017)	✓(18 July 2018)
IOTC-2018-WPB16-DATA15	Standardization of Black marlin CPUE by Indonesian longline fishery in the Indian Ocean (2005-2017)	✓(18 July 2018)
IOTC-2018-WPB16-DATA16	Standardization of Striped marlin CPUE by Japanese longline fishery in the Indian Ocean (1994-2017)	✓(18 July 2018)
IOTC-2018-WPB16-DATA17	Standardization of Striped marlin CPUE by Taiwanese longline fishery in the Indian Ocean (1979-2017)	✓(18 July 2018)
IOTC-2018-WPB16-DATA18	Billfish equations	✓(14 August 2018)

APPENDIX IVA
MAIN STATISTICS OF BILLFISH

(*Extract from IOTC–2018–WPB16–08*)

Fisheries and catch trends for billfish species

- Main species: Indo-Pacific sailfish and swordfish account for around two thirds of total catches of billfish species in recent years; followed by black marlin, blue marlin and striped marlin (**Fig. 1d**).

  The importance of some billfish species – in terms of share of total catches of billfish – has changed over time (**Fig. 1c**), mostly as a result of changes to the number of longline vessels active in the Indian Ocean. Catches of swordfish in particular increased during the 1990s as a result of changes in targeting by Taiwan,China, and the arrival of European longline fleets, increasing the swordfish share of total billfishes catch from 20–30% in the early 1990s to as much as 50% by the early-2000s. Catches of swordfish over the last decade have since declined back to around a third of total billfish catches, largely as a result of declines in the number of longline vessels operated by Taiwan,China. However in recent years the catches of swordfish have shown an increasing trend, which may be partly due to improvements in the estimation of catch-by-species reported by Taiwan,China.

  Relatively large catches of marlins have also been recorded since 2012 from increased activities by longliners in waters of the western central and northwest Indian Ocean as a consequence of improvements in security in the area off Somalia.

- Main fisheries: Up to the early-1980s longline vessels accounted for over 90% of the total billfish (largely as non-targeted catch); in the last 20 years the proportion has fallen to between 50% to 70% as billfish catches from offshore gillnet fisheries have become increasingly important for a number of fleets, such as I.R. Iran and Sri Lanka (**Fig. 2b-c**).

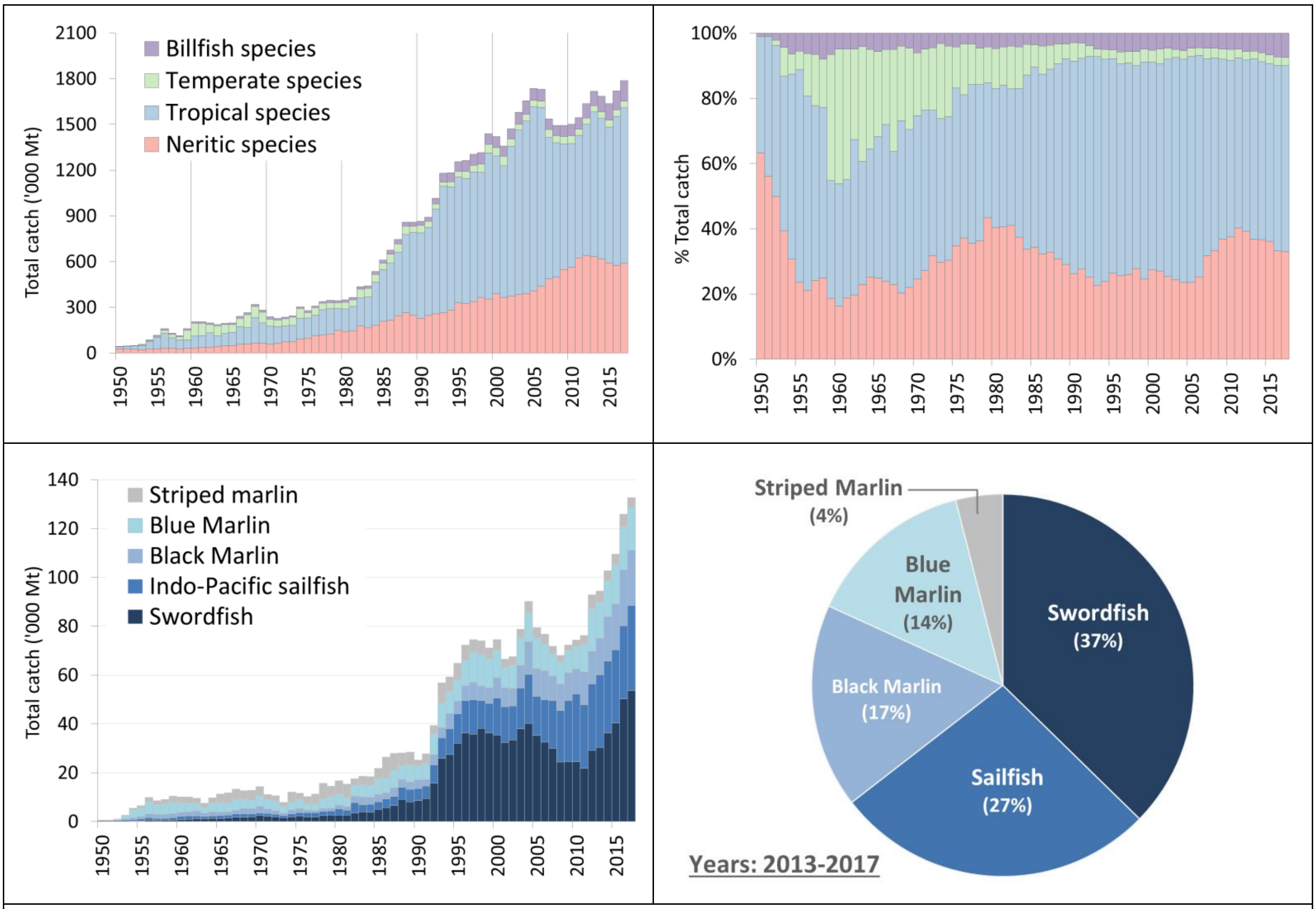
  In addition the number of longline vessels has also declined in recent years in response to the threat of Somali piracy in the western tropical Indian Ocean. Nevertheless, billfish catches are still dominated by a small number of longline fleets – namely Taiwan,China and European fleets[3] – that now appear to be resuming fishing activities in their main fishing grounds.

- Main fleets (i.e., highest catches in recent years):
  In recent years five fleets (Indonesia, I.R. Iran, India, Sri Lanka, and Taiwan,China) have reported around 75% of the total catches of billfish species from all IOTC fleets combined (Fig. 2a).

- Retained catch trends:
  The importance of catches of billfish species to the total catches of IOTC species in the Indian Ocean has remained relatively constant over the years (**Figs. 1a-b**) at between 5% – 7% of the total catch of IOTC species.

  Total catches of billfish species have generally increased in line with other species groups under the mandate of IOTC, increasing from around 25,000 t in the early 1990s to nearly 75,000 t in the mid-1990s. Since then, average catches per annum have remained relatively stable at between 70,000 t and 75,000 t. However since 2012 catches over 90,000 t have been reported, with the largest increases reported by I.R. Iran, Pakistan, and Taiwan,China (**Fig. 2a**).

[3] EU,Spain, EU,Portgual, EU,France(La Réunion), and EU,UK.



Figs. 1a-d. Billfish (all species):

Top: Contribution of the five billfish species under the IOTC mandate to the total catches of IOTC species in the Indian Ocean, over the period 1950–2017 (a. Top left: total catch; b. Top right percentage, same colour key as Fig. 1a).

Bottom: Contribution of each billfish species to the total combined catches of billfish (c. Bottom left: nominal catch of each species, 1950–2017; d. Bottom right: share of billfish catch by species, 2013–17 average catch)**.**

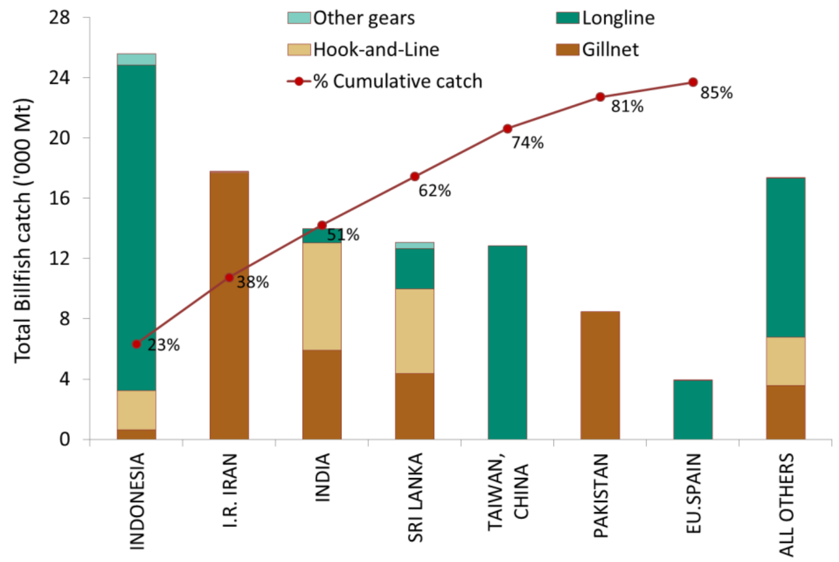


Fig. 2a: Billfish (all species): average catches in the Indian Ocean over the period 2013–17, by fleet and gear.

Fleets are ordered from left to right, according to the volume of catches reported. The red line indicates the (cumulative) proportion of catches of all billfish species for the fleets concerned, over the total combined catches reported from all fleets and gears.

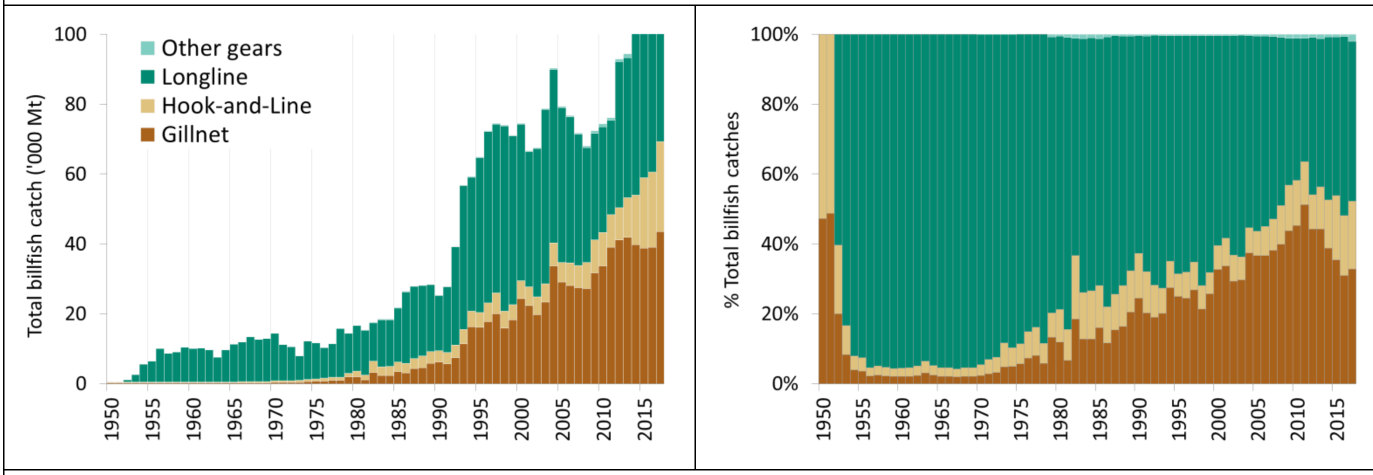


Fig. 2b-c: Billfish (all species): catches in the Indian Ocean over the period 1950–17, by gear. Fig 2b. Left: nominal catch of all billfish species, by gear; Fig. 2c. Right: percentage share of all billfish species catches, by gear**.**

APPENDIX IVB
MAIN STATISTICS OF SWORDFISH

(*Extract from IOTC–2018–WPB16–07*)

Fisheries and main catch trends

- Main fishing gear (2013–17): Longline catches[4] are currently estimated to comprise approximately 75% of total swordfish catches in the Indian Ocean. (**Table 1; Fig. 1**)
- Main fleets (and primary gear associated with catches): percentage of total catches (2013–17):
Indonesia (fresh longline): 32%; Taiwan,China (longline): 16%; Sri Lanka (longline-gillnet): 14%; EU,Spain (swordfish targeted longline): 9% (**Fig. 2**).
- Main fishing areas: Primary: Western Indian Ocean, in waters off Somalia, and the southwest Indian Ocean. In recent years (2009 – 2011) the fishery has moved eastwards due to piracy, a decrease in fish abundance, or a combination of both. Secondary: Waters off Sri Lanka, western Australia and Indonesia.
- Retained catch trends:
Before the 1990s, swordfish were mainly a non-targeted catch of industrial longline fisheries; catches increased relatively slowly in tandem with the development of coastal state and distant water longline fisheries targeting tunas.

  After 1990, catches increased sharply (from around 8,000 t in 1991 to 36,000 t in 1998) as a result of changes in targeting from tunas to swordfish by part of the Taiwan,China longline fleet, along with the development of longline fisheries in Australia, France(La Réunion), Seychelles and Mauritius and arrival of longline fleets from the Atlantic Ocean (EU,Portugal, EU,Spain the EU,UK and other fleets operating under various flags[5]).

  Since the mid-2000s annual catches have fallen steadily, largely due to the decline in the number of Taiwanese longline vessels active in the Indian Ocean in response to the threat of piracy; however since 2012 catches appear to show signs of recovery as a consequence of improvements in security in the area off Somalia.
- Discard levels: Low, although estimates of discards are unknown for most industrial fisheries, mainly longliners. Discards of may also occur in the driftnet fishery of I.R. Iran, as this species has no commercial value in this country.

***Changes to the catch series*:** Following issues with the reliability of catch estimates of Indonesia's fresh longline fleet, the IOTC Secretariat has provided the WPB-16 meeting with an alternative catch series based on a new estimation methodology developed in collaboration with Indonesia (IOTC-2018-WPB16-DATA03b available on the WPB meeting webpage). The revised catch series mostly affects catches of swordfish, striped marlin, and blue marlin estimated by the IOTC Secretariat for Indonesia.
Estimates for all three species have been reduced significantly for Indonesia's fresh longline fleet in recent years, while total catches across all fleets have also been revised downwards by as much as 30% for each species. Further details on the estimation methodology can be found in paper IOTC-2018-WPB16-22, but in the case of swordfish catches have been revised down in recent years from over 50,000 t to less than 35,000 t directly as a result of the revision to Indonesia's catches. A decision on which catch series to endorse will be discussed during the WPB meeting.

TABLE 1. Swordfish: best scientific estimates of catches by type of fishery for the period 1950–2017 (in metric tons). Data as of August 2018.

Fishery	By decade (average)						By year (last ten years)									
	1950s	1960s	1970s	1980s	1990s	2000s	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
ELL	-	-	-	9	1,841	9,736	7,655	7,637	9,031	6,835	7,643	7,876	7,420	6,618	6,257	6,181
LL	260	1,301	1,920	4,313	22,692	20,085	13,511	13,810	12,419	10,976	17,466	17,186	21,051	24,109	33,162	33,096
OT	37	39	186	807	1,989	2,819	3,261	3,019	3,033	4,061	4,068	5,275	7,868	9,595	10,858	14,381
Total	**297**	**1,340**	**2,106**	**5,130**	**26,521**	**32,640**	**24,427**	**24,466**	**24,483**	**21,872**	**29,177**	**30,338**	**36,339**	**40,322**	**50,278**	**53,658**

Definition of fisheries: Swordfish targeted longline (**ELL**); Longline (**LL**); Other gears (includes longline-gillnet, handline, gillnet, gillnet-longline, coastal longline, troll line, sport fishing, and all other gears) (**OT**).

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

[5] E.g., Senegal, Guinea, etc.

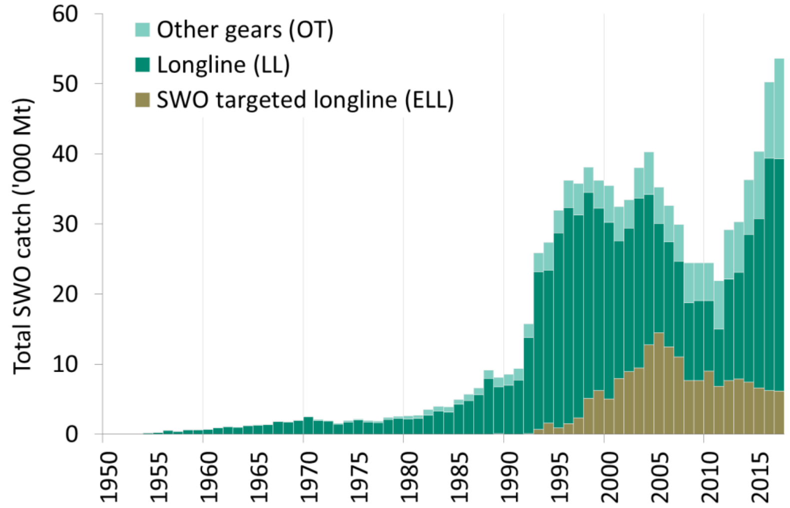


Fig. 1. Swordfish: catches by gear and year recorded in the IOTC Database (1950–2017).
Other gears includes: longline-gillnet, handline, gillnet, coastal longline, troll line, sport fishing, and all other gears.

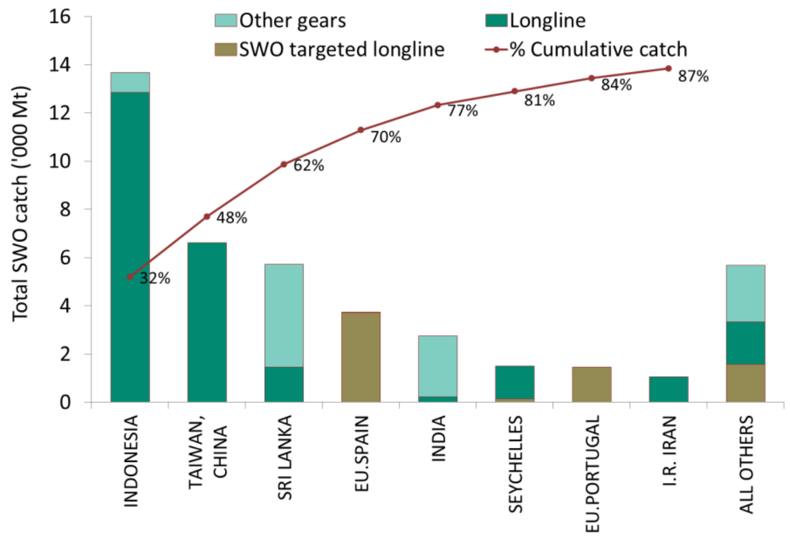


Fig. 2: Swordfish: average catches in the Indian Ocean over the period 2013–17, by fleet and gear. Fleets are ordered from left to right, according to the volume of catches reported.
The red line indicates the (cumulative) proportion of catches of swordfish for the fleets concerned, over the total combined catches reported from all fleets and gears.

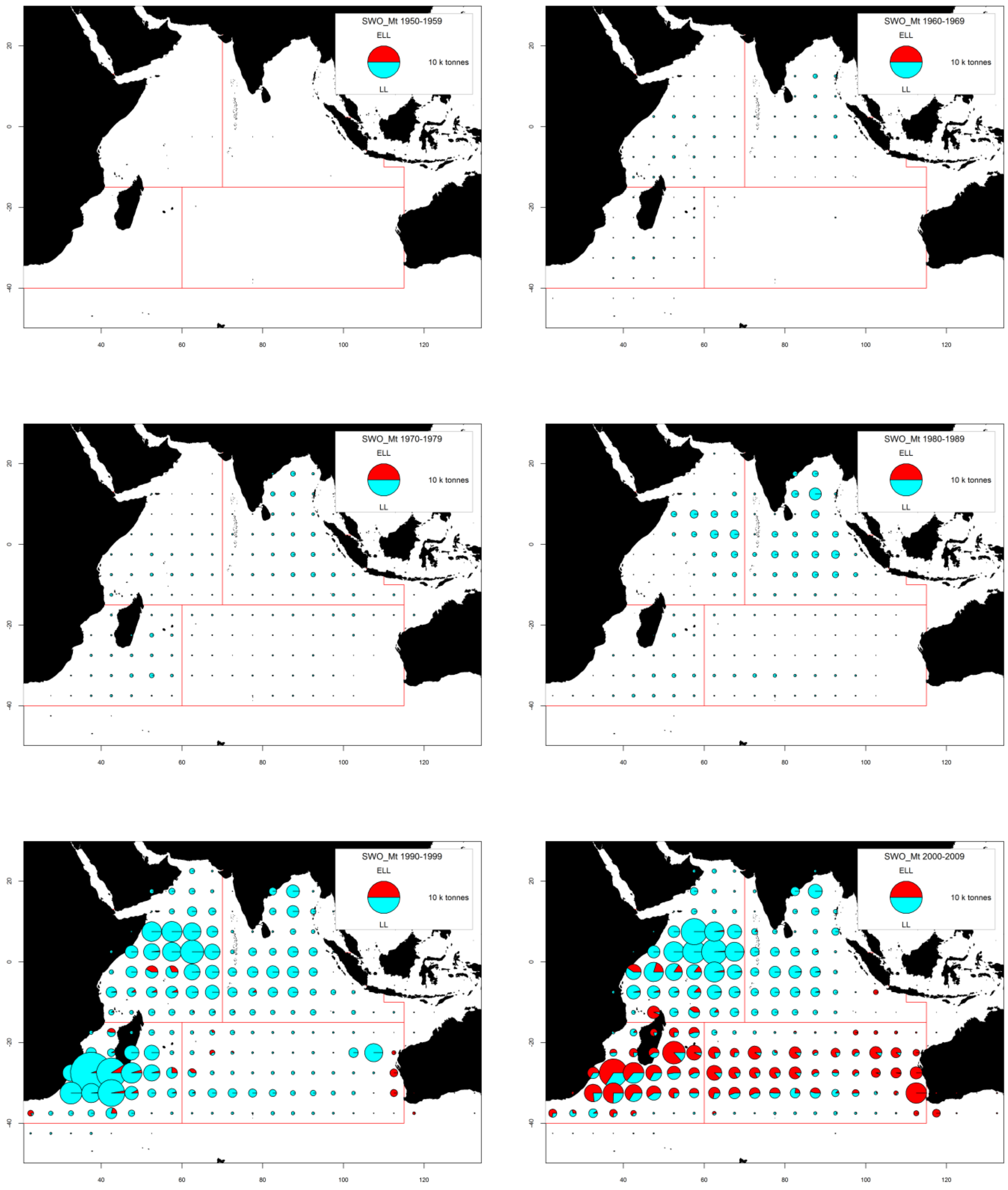


Fig. 3a-f: Swordfish: Time-area catches (total combined in tonnes) as reported for longline fisheries targeting swordfish (**ELL**), other longline fisheries (**LL**), for the period 1950-2009, by decade and type of gear. Red lines represent the areas used for the assessments of swordfish.

Source: IOTC catch-and-effort data. Does not include fleets non-reporting catch-and-effort data.

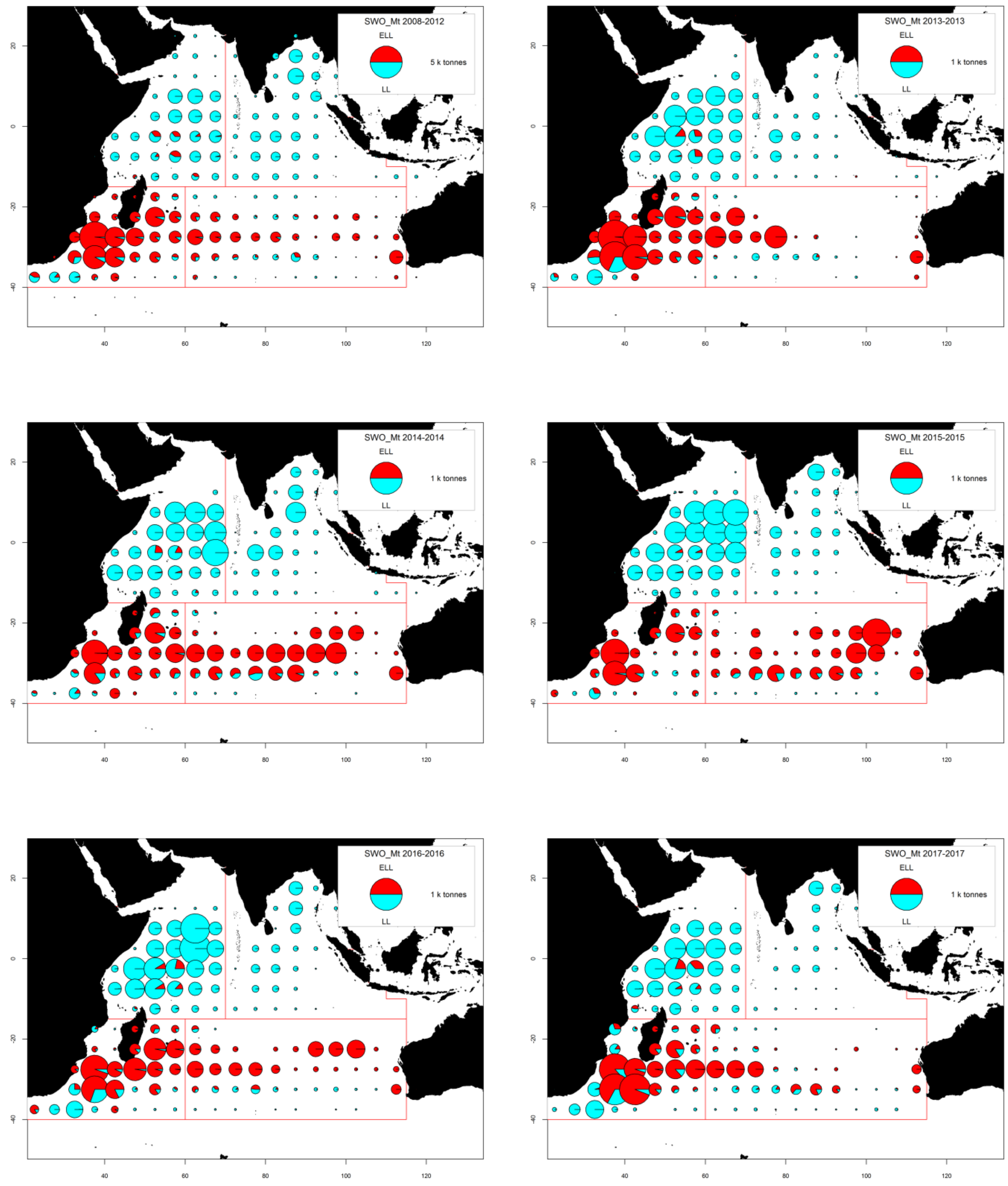


Fig. 4a-f: Swordfish: Time-area catches (total combined in tonnes) for longline fisheries targeting swordfish (**ELL**), other longline fisheries (**LL**), gillnet fisheries (**GI**), and for all other fleets combined (**OT**), for the period 2008-2012 by type of gear and for 20013-17, by year and type of gear. Red lines represent the areas used for the assessments of swordfish.
Source: IOTC catch-and-effort data (unraised). Does not include fleets non-reporting catch-and-effort data.

Swordfish: estimation of catches – data related issues

Retained catches – while the proportion of catches estimated, or adjusted, by the IOTC Secretariat are relatively low (**Fig.5a**), there are uncertainties for the following fisheries/fleets:

- I.R. Iran and Pakistan (Gillnet): the IOTC Secretariat used the catches of swordfish and marlins reported by I.R. Iran for the years 2012 and 2013 to rebuild historical catch series of billfish for this fishery. However, catch rates and species composition for the Iranian and Pakistani gillnet fisheries differ significantly from each other in terms of the species composition, and in the case of Pakistan, the catches by species and are also in contradiction with other estimates derived from WWF funded sampling conducted Pakistan in recent years.

  In 2017 Pakistan also submitted a revised catch series, dating back to the 1980s, and which are significantly lower than current estimates for billfish for Pakistan in the IOTC database, including swordfish. The data are currently pending upload to the IOTC database until further clarifications have been received regarding the catch revision estimation methodology, and particularly the scale of revisions for some billfish species.
- India (Longline): Incomplete catches and catch-and-effort data, especially for its commercial longline fishery. Catches in recent years represent less than 4% of the total catches of swordfish.
- Non-reporting fleets (NEI) (Longline): Catches estimated by the IOTC Secretariat, however the proportion of total catches associated with this fishery are thought to be low and do not have a significant impact on the overall catch series.

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

- Availability: Catch-and-effort series are available for some industrial longline fisheries (**Fig. 5b**).

For most other fisheries, catch-and-effort are either not available (e.g., longline fisheries of Indonesia, drifting gillnet fisheries of Iran and Pakistan), or they are considered poor quality – especially since the early-1990s (e.g., gillnet and longline fisheries of Sri Lanka, Taiwan,China fresh-tuna longliners, Non-reporting longliners (NEI)).

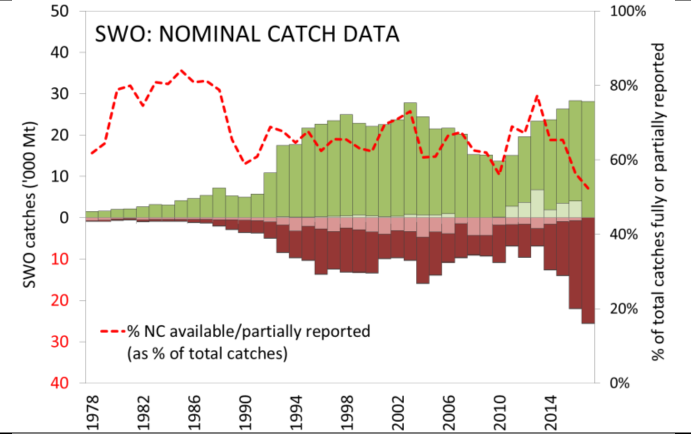
Swordfish – Fish size or age trends (e.g., by length, weight, sex and/or maturity)

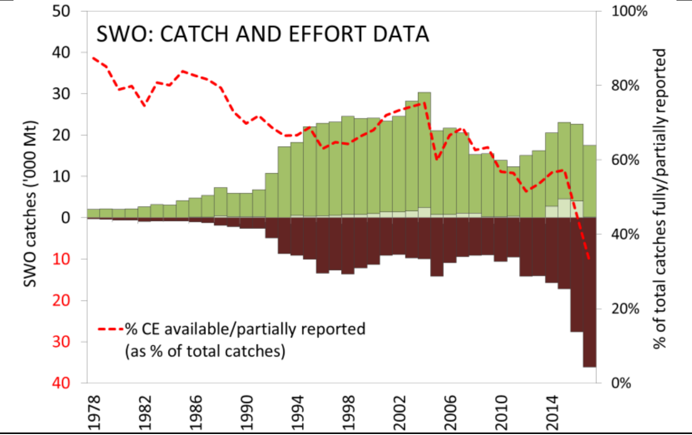
In general, the amount of catch for which size data for the species are available before 2005 is still very low and the number of specimens measured per stratum has been decreasing in recent years (**Fig. 5c**)

- 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 also in recent years (due low sampling coverage and time-area coverage of longliners from Japan). The average weights of swordfish are variable but show no clear trend..

- Catch-at-Size (Age) table: data are available but the estimates are thought to have been compromised for some years and fisheries due to:
  i. Uncertainty in the length frequency data recorded for longliners of Japan and Taiwan,China, in which average weights of swordfish derived from length frequency and catch-and-effort data are very different.
  ii. Uncertainties in the catches of swordfish for the drifting gillnet fisheries of I.R. Iran and the longline fishery of Indonesia.
  iii. The lack of size data before the early-70s and poor coverage before the early-80s and for most artisanal fisheries (e.g., Pakistan, India, Indonesia).
  iv. The paucity of size data available from industrial longliners since the early-1990s (e.g. Japan, Philippines, India and China).
  v. The lack of time-area catches for some industrial fleets (e.g. Indonesia, India, NEI fleets).
  vi. The paucity of biological data available, notably sex-ratio and sex-length-age keys.

- Sex ratio data: have not been provided to the Secretariat by CPCs.





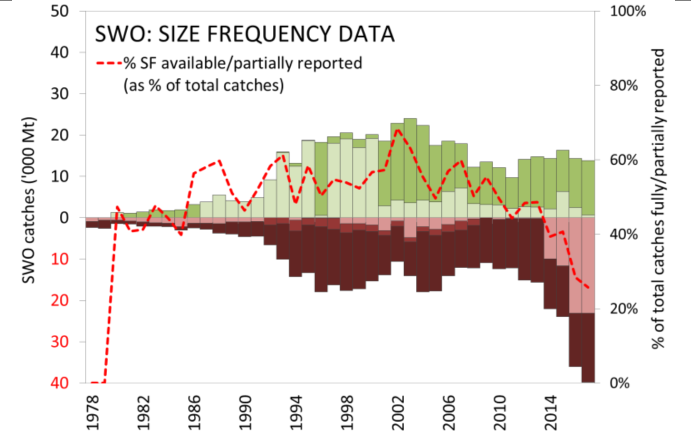


Fig. 5a-c. Swordfish: data reporting coverage (1978–2017).

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 2018.

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

(dark green)	Total score is 0 (or average score is 0-1)
(light green)	Total score is 2 (or average score is 1-3)
(pink)	Total score is 4 (or average score is 3-5)
(red)	Total score is 6 (or average score is 5-7)
(dark red)	Total score is 8 (or average score is 7-8)

APPENDIX IVC
MAIN STATISTICS OF STRIPED MARLIN

(*Extract from IOTC–2018–WPB16–07*)

Fisheries and main catch trends

- Main fishing gear (2013–17): striped marlin are largely considered to be a non-target species of industrial fisheries. Longlines account for around 66% of total catches in the Indian Ocean, followed by gillnets (27%), with remaining catches recorded under troll and handlines. (**Table 1, Fig. 1**)
- Main fleets (and primary gear associated with catches): percentage of total catches (2013–17):
  Indonesia (drifting longline and coastal longline): 37%; Taiwan,China (drifting longline): 19%; I.R. Iran (gillnet): 16%; and Pakistan (gillnet): 8% (**Fig. 2**).
- 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 2**), 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 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**:** Following issues with the reliability of catch estimates of Indonesia’s fresh longline fleet, the IOTC Secretariat has provided the WPB-16 meeting with an alternative catch series based on a new estimation methodology developed in collaboration with Indonesia (IOTC-2018-WPB16-DATA03b available on the WPB meeting webpage). The revised catch series mostly affects catches of swordfish, striped marlin, and blue marlin estimated by the IOTC Secretariat for Indonesia.
Estimates for all three species have been reduced significantly for Indonesia’s fresh longline fleet in recent years, while total catches across all fleets have also been revised downwards by as much as 30% for each species. Further details on the estimation methodology can be found in paper IOTC-2018-WPB16-22, but generally speaking estimates of striped marlin are revised downwards in the alternative catch series (Scenario 2), to between 5000 and 3000 t from 2012 onwards.

TABLE 1: Striped marlin: best scientific estimates of catches by type of fishery for the period 1950–2017 (in metric tons). Data as of August 2018.

Fishery	By decade (average)						By year (last ten years)									
	1950s	**1960s**	**1970s**	**1980s**	**1990s**	**2000s**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
LL	1,028	3,104	3,458	5,144	5,120	2,922	2,117	1,679	2,093	2,240	4,534	3,246	2,454	2,843	3,740	2,473
GN	5	8	16	22	161	541	389	407	331	900	978	1,182	1,238	1,263	1,098	1,209
HL	3	5	10	32	72	137	198	273	282	292	287	331	290	270	273	328
OT	0	0	0	6	10	20	29	41	42	44	43	48	40	39	35	77
Total	**1,036**	**3,117**	**3,485**	**5,204**	**5,362**	**3,620**	**2,733**	**2,400**	**2,748**	**3,475**	**5,843**	**4,807**	**4,022**	**4,415**	**5,146**	**4,087**

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 2: Striped marlin: best scientific estimates of catches by fishing area for the period 1950–2017 (in metric tons). Data as of August 2018.

Fishery	By decade (average)						By year (last ten years)									
	1950s	1960s	1970s	1980s	1990s	2000s	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
NW	335	1,859	1,516	2,073	2,713	1,807	1,177	840	748	1,330	3,619	2,775	1,787	1,684	3,060	2,058
SW	9	124	159	162	661	247	134	219	309	500	346	258	173	178	380	239
NE	551	810	1,542	2,752	1,609	1,331	1,336	1,266	1,505	1,540	1,837	1,725	2,014	2,386	1,659	1,738
SE	141	324	159	218	380	235	85	75	186	106	41	50	47	167	47	52
Total	**1,036**	**3,117**	**3,375**	**5,204**	**5,362**	**3,620**	**2,733**	**2,400**	**2,748**	**3,475**	**5,843**	**4,807**	**4,022**	**4,415**	**5,146**	**4,087**

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

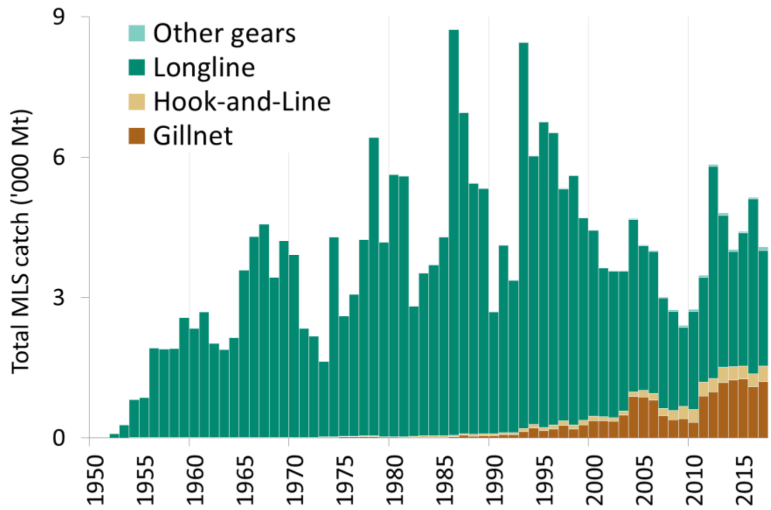


Fig. 1. Striped marlin: catches by gear and year recorded in the IOTC Database (1950–2017).
Other gears includes: coastal purse seine, Danish purse seine, beach seine and purse seine.

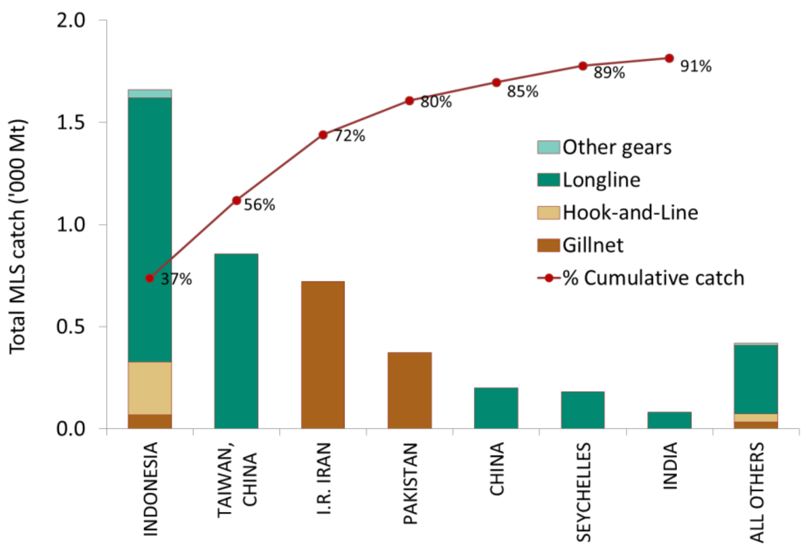


Fig. 2: Striped marlin: average catches in the Indian Ocean over the period 2013–17, by fleet and gear.
Fleets are ordered from left to right, according to the volume of catches reported.
The red line indicates the (cumulative) proportion of catches of striped marlin for the fleets concerned, over the total combined catches reported from all fleets and gears.

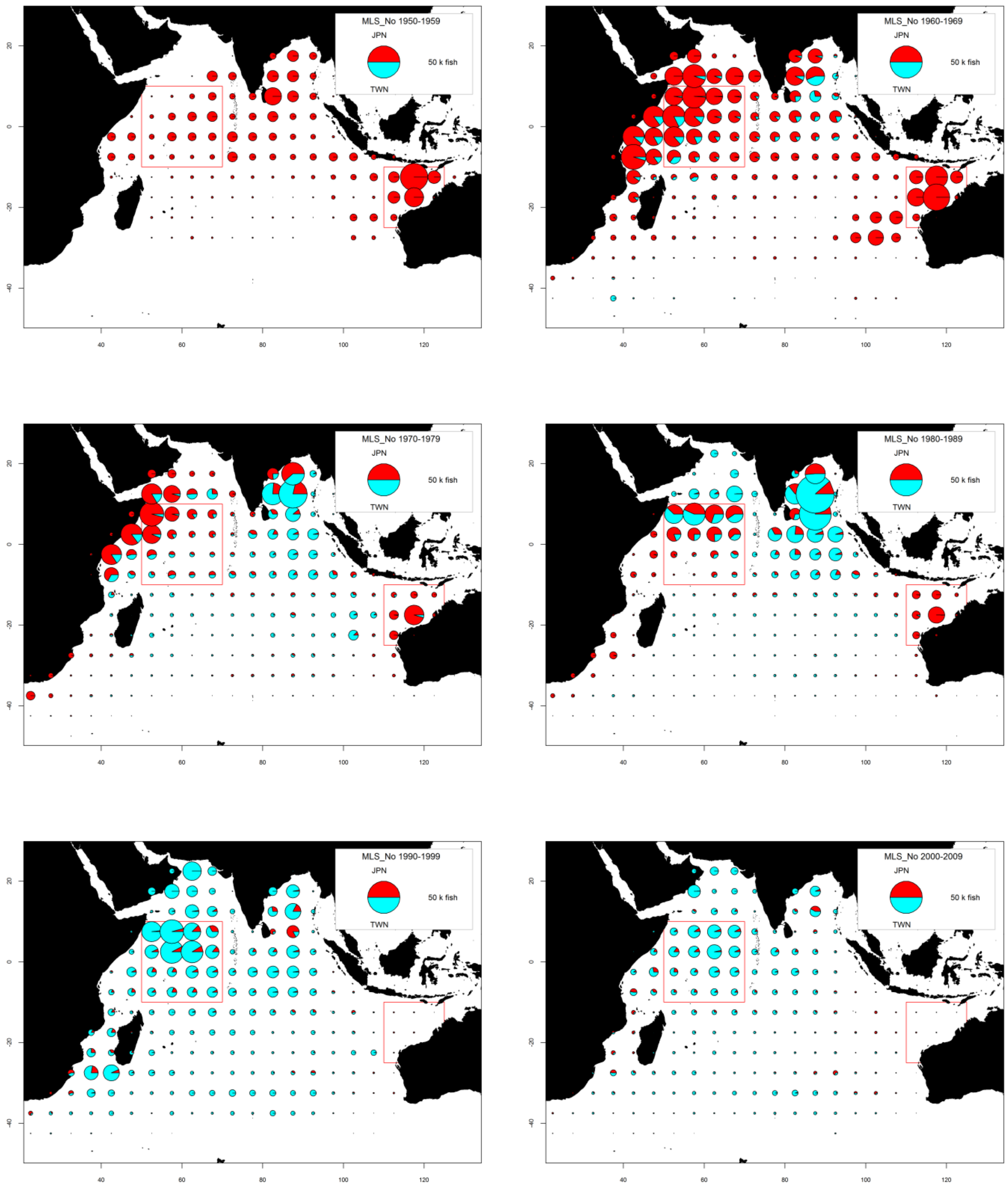


Fig. 3a-f. Time-area catches (in number of fish) of striped marlin as reported for the longline fisheries of Japan (JPN) and Taiwan,China (TWN) for the period 1950–2009, by decade and fleet. Red lines represent the marlin hotspots identified by the IOTC WPB.

Source: IOTC catch-and-effort data (unraised). Does not include fleets non-reporting catch-and-effort data.

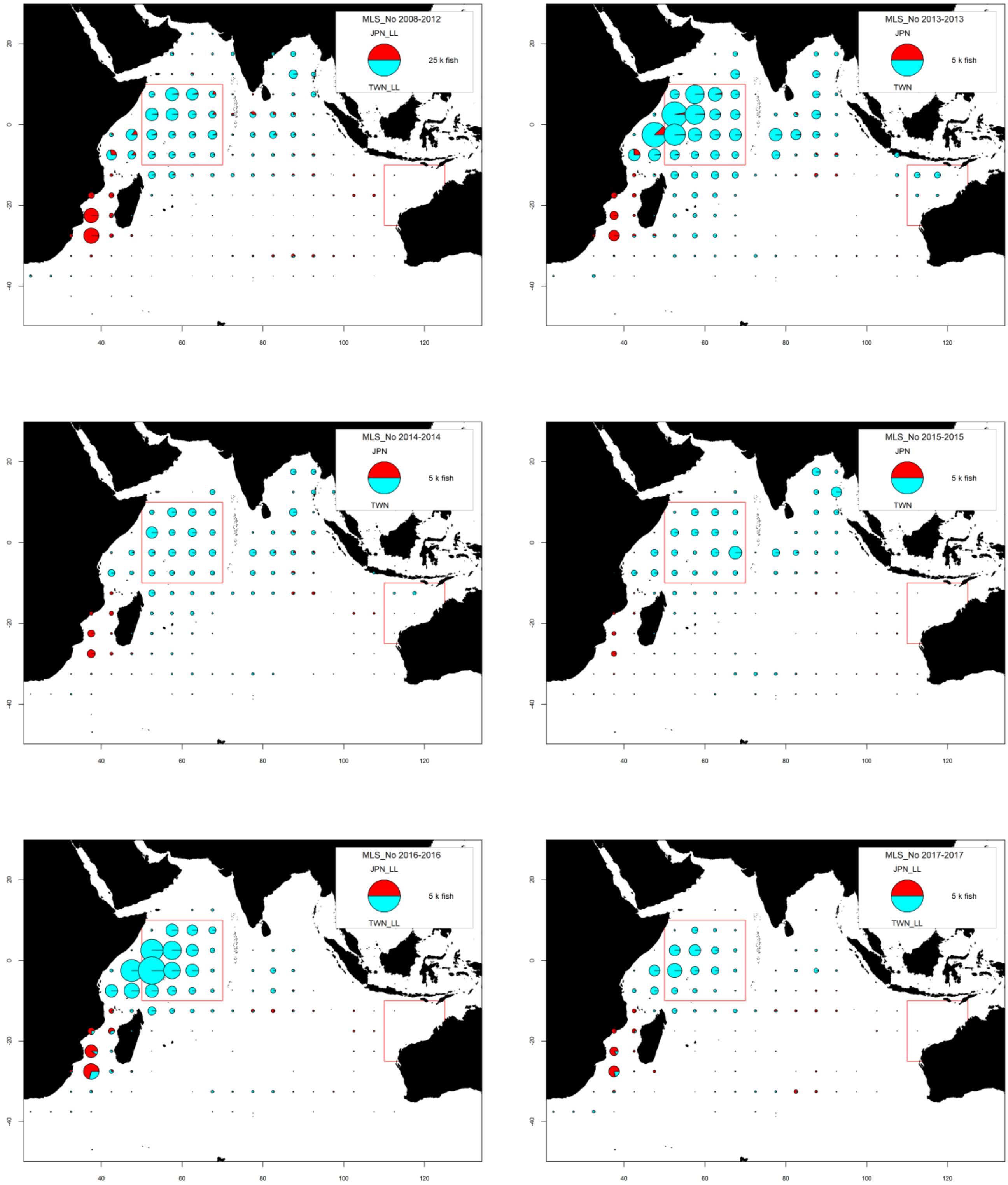


Fig. 4a-f. Time-area catches (in number of fish) of striped marlin as reported for the longline fisheries of Japan (JPN) and Taiwan,China (TWN) for the period 2008–12 by fleet and for 2013–17, by year and fleet. Red lines represent the marlin hotspots identified by the IOTC WPB.

Source: IOTC catch-and-effort data (unraised). Does not include fleets non-reporting catch-and-effort data.

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.5a**), 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 (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 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 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. These relatively high catch levels are in contradiction to a revised catch series submitted by the Government of Pakistan to the IOTC in 2017, which estimates much lower catches of billfish based on the results of a separate WWF-funded crew based observer scheme. The IOTC Secretariat is currently in the process of evaluating the revised catch series pending clarification on a number of issues regarding the scale of revisions to catches for some species, including striped marlin.
- Species mis-identification: difficulties in the identification of marlins also contribute to uncertainties in the catch estimates of striped marlin available to the Secretariat.

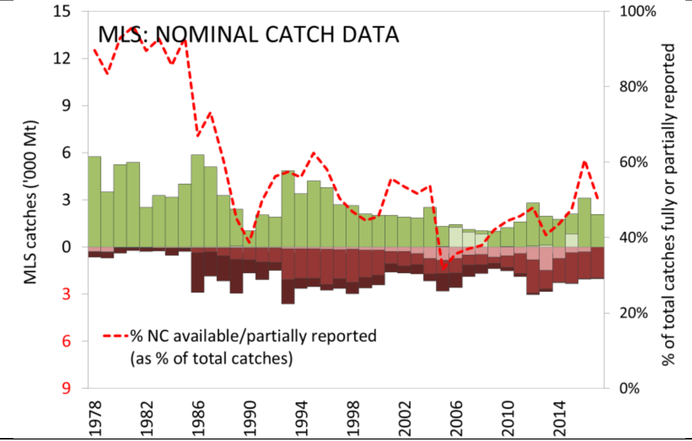
Striped marlin – Nominal catch-per-unit-effort (CPUE) trends

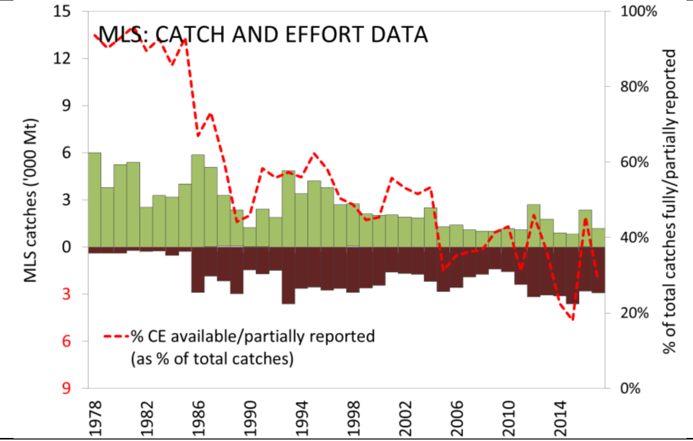
- Availability: Standardized CPUE series have been developed for the Japanese and Taiwanese longline fleets. Nominal CPUE series are available for some industrial longline fisheries, although catches are likely to be incomplete (as catches of non-target species are not always recorded in logbooks).

  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 (e.g., gillnet fisheries of Iran, Pakistan and Indonesia) or other industrial fisheries (NEI longliners and all purse seiners). Unreliable data from gillnet/longlines of Sri Lanka.
- Main CPUE series available: Japanese and Taiwanese 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.
- 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.





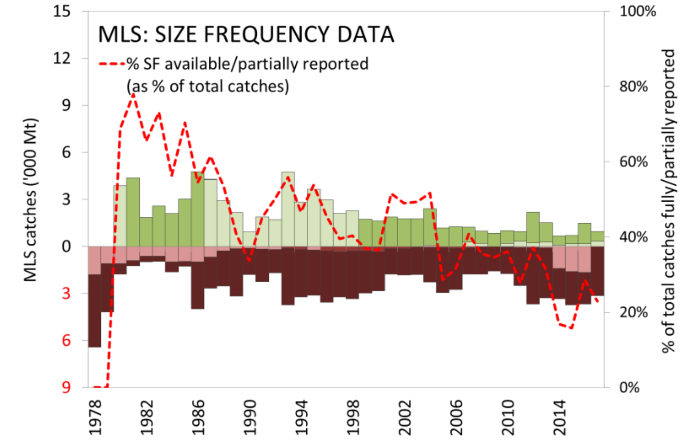


Fig. 5a-c. Striped marlin: data reporting coverage (1978–2017).

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 2018.

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)

APPENDIX IVD
MAIN STATISTICS OF BLACK MARLIN

(*Extract from IOTC–2018–WPB16–07*)

Fisheries and main catch trends

- Main fishing gear (2013–17): black marlin are largely considered to be a non-target species of industrial and artisanal fisheries. Gillnets account for around 50% of total catches in the Indian Ocean, followed by longlines (17%), with remaining catches recorded under troll and handlines. (**Table 1**, **Fig. 1**)
- Main fleets (and primary gear associated with catches): percentage of total catches (2013–17):
  India (gillnet and trolling): 27%; I.R. Iran (gillnet): 26%; Sri Lanka (gillnet and fresh longline): 18%; Indonesia (fresh longline and hand lines): 14% (**Fig. 2**).
- Main fishing areas:

  Primary: between the early-1950s and the late-1980s part of the Japanese fleet was licensed to operate within the EEZ of Australia, and reported very high catches in that area, in particular in waters off northwest Australia.

  Secondary: in recent years, deep-freezing longliners from Japan and Taiwan,China have reported catches of black marlin off the western coast of India and the Mozambique Channel.
- Retained catch trends:
  Since the 1990s catches have increased steadily, from 2,800 t in 1991 to over 10,000 t in 2004. In recent years catches have further increased sharply from around 15,000 t in 2013 to over 22,000 t in 2016 and 2017 – the highest catches recorded in the Indian Ocean for the species (**Table 1**) – largely due to increases reported by the offshore gillnet fisheries of I.R. Iran.

  Catches in Sri Lanka have also risen steadily since the mid-1990's as a result of the development of the fishery using a combination of drifting gillnets and longlines, from around 1,000 t in the early 1990s to over 3,000 t in recent years.
- Discard levels**:** Low, although estimates of discards are unknown for most industrial fisheries, mainly longliners. Negligible levels of discards have also been reported for some purse seine fleets. Discards may also occur in some gillnet fisheries.

***Changes to the catch series*:** Following issues with the reliability of catch estimates of Indonesia's fresh longline fleet, the IOTC Secretariat has provided the WPB-16 meeting with an alternative catch series based on a new estimation methodology developed in collaboration with Indonesia (IOTC-2018-WPB16-DATA03b available on the WPB meeting webpage). The revised catch series mostly affects catches of swordfish, striped marlin, and blue marlin estimated by the IOTC Secretariat for Indonesia.
Estimates for all three species have been reduced significantly for Indonesia's fresh longline fleet in recent years, while total catches across all fleets have also been revised downwards by as much as 30% for each species. The catches for black marlin are less affected, but have also been revised downwards by up to 6% from 2012 onwards.

TABLE 1. Black marlin: best scientific estimates of catches by type of fishery for the period 1950–2017 (in metric tons). Data as of August 2018.

Fishery	By decade (average)						By year (last ten years)									
	1950s	1960s	1970s	1980s	1990s	2000s	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
LL	862	1661	1391	1728	1571	1981	3033	1839	1868	1982	2174	2621	3549	3027	4690	4224
GN	26	31	44	439	2761	6917	6226	6935	6070	8957	8495	8567	9689	8892	10242	10052
HL	24	27	45	486	736	1017	1274	2147	1629	1864	2260	3058	4518	6505	7762	7663
OT	0	0	5	82	112	226	329	460	472	490	483	693	454	455	385	686
Total	**912**	**1,719**	**1,485**	**2,735**	**5,181**	**10,142**	**10,862**	**11,380**	**10,039**	**13,293**	**13,412**	**14,939**	**18,210**	**18,879**	**23,079**	**22,625**

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**).

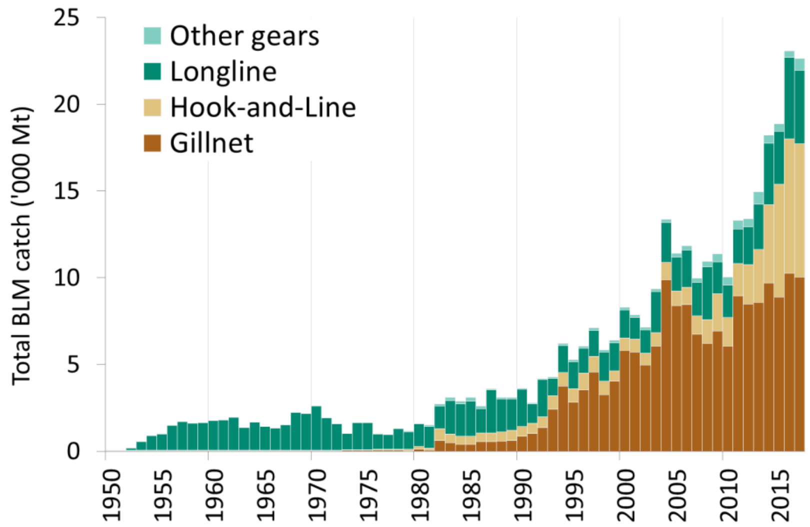


Fig. 1. Black marlin: catches by gear and year recorded in the IOTC Database (1950–2017).
Other gears includes: coastal purse seine, Danish purse seine, beach seine and purse seine.

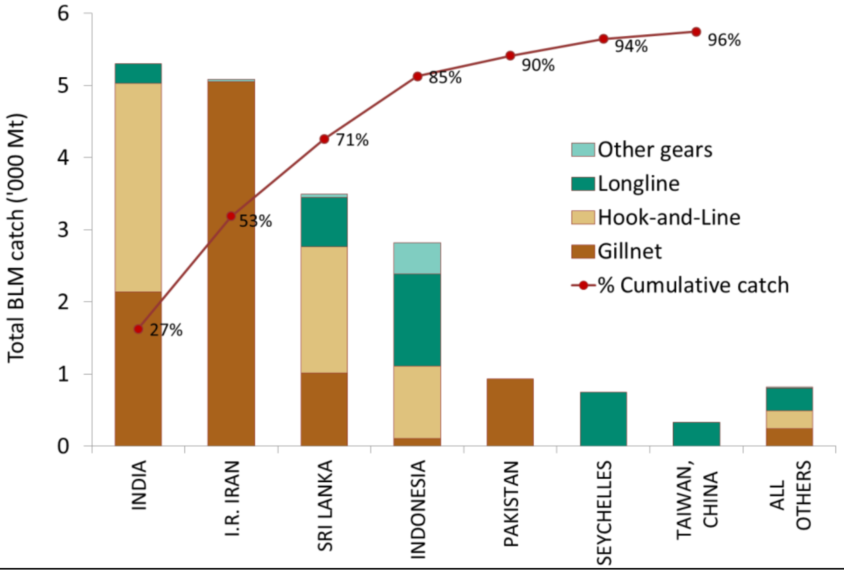


Fig. 2: Black marlin: average catches in the Indian Ocean over the period 2013–17, by fleet and gear.
Fleets are ordered from left to right, according to the volume of catches reported.
The red line indicates the (cumulative) proportion of catches of black marlin for the fleets concerned, over the total combined catches reported from all fleets and gears.

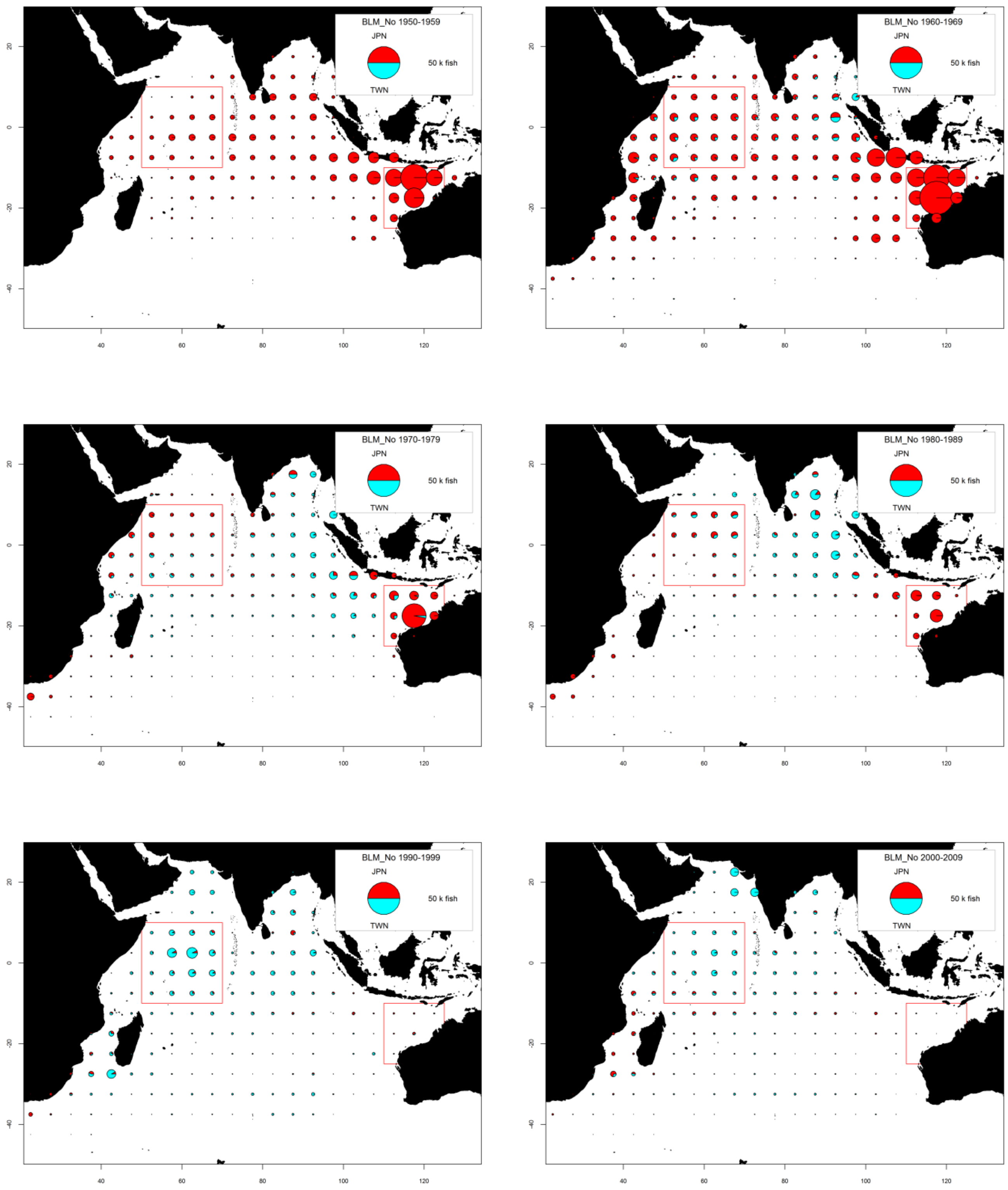


Fig. 3a-f. Time-area catches (in number of fish) of black marlin as reported for the longline fisheries of Japan (JPN) and Taiwan,China (TWN) for the period 1950–2009, by decade and fleet. Red lines represent the marlin hotspots identified by the IOTC WPB.

Source: IOTC catch-and-effort data. Does not include fleets non-reporting catch-and-effort data.

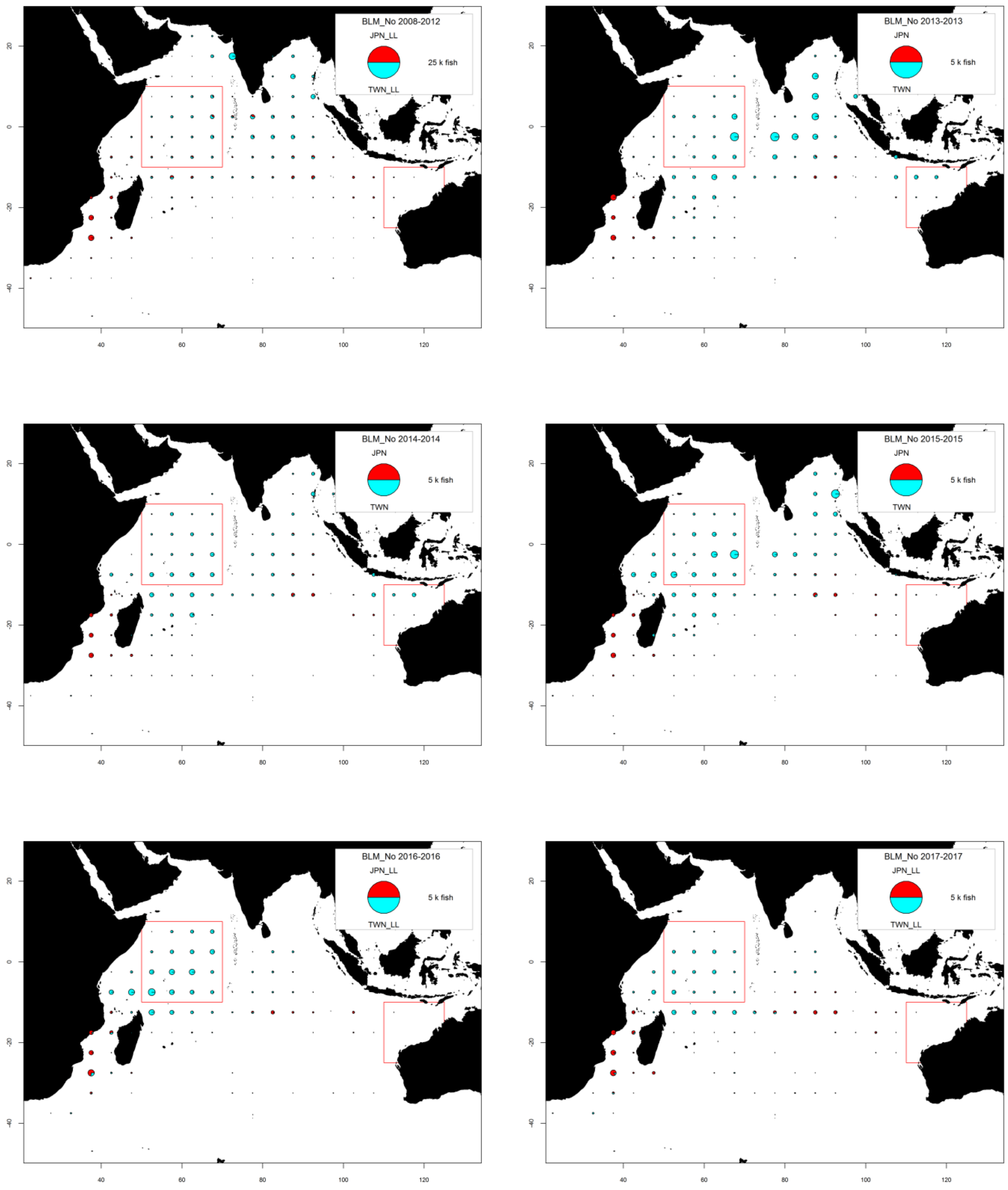


Fig. 4a-f. Time-area catches (in number of fish) of black marlin as reported for the longline fisheries of Japan (JPN) and Taiwan,China (TWN) for the period 2008–12 by fleet and for 2013–17, by year and fleet. Red lines represent the marlin hotspots identified by the IOTC WPB.

Source: IOTC catch-and-effort data (unraised). Does not include fleets non-reporting catch-and-effort data.

Black marlin: estimation of catches – data related issues

Retained catches – a very high proportion of the catches of black marlin are estimated, or adjusted, by the IOTC Secretariat are (**Fig.5a**), 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 Secretariat for some years and artisanal fisheries (e.g., gillnet/longline fishery of Sri Lanka and artisanal fisheries of India, I.R. 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 fleets) 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 black 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 Secretariat revised the catches of black 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.
- General lack of catch data for most sport fisheries, particularly in the Western Indian Ocean.
- Species mis-identification: difficulties in the identification of marlins also contribute to uncertainties in the catch estimates of black marlin available to the Secretariat.

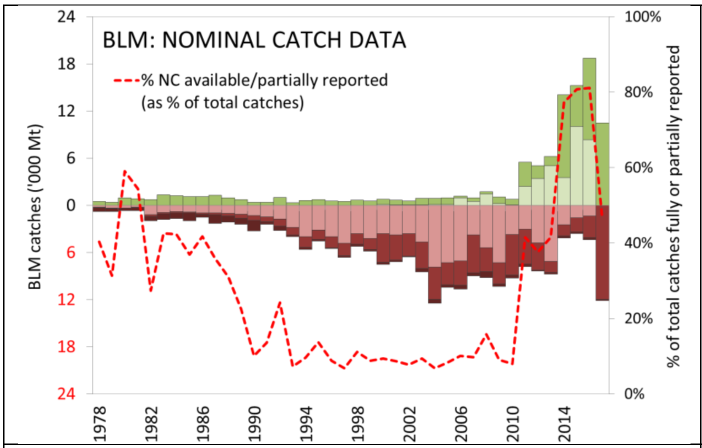
Black marlin – Nominal catch-per-unit-effort (CPUE) trends

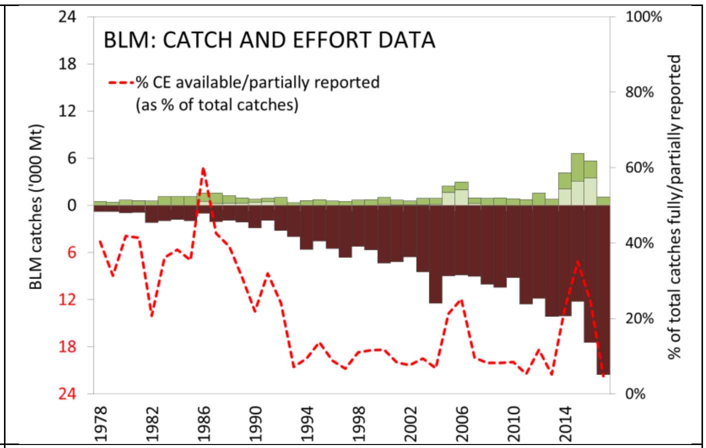
- Availability: Standardized CPUE series have been developed for Japanese and Taiwanese fleets. Nominal CPUE series are available for some industrial longline fisheries, although catches are likely to be incomplete (as catches of non-target species are not always recorded in logbooks).

  No catch-and-effort data are available from sports fisheries, other than partial data from the sports fisheries of Kenya; likewise no data are available for other artisanal fisheries (e.g., gillnet fisheries of Iran, Indonesia and Pakistan).
- Main CPUE series available: Japanese and Taiwan,China longline fleet.

Black 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 the length frequency distributions derived from samples collected by fishermen on Taiwanese longliners are also 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 sizes are derived from various length and weight information, however the reliability of the size data is uncertain for some fleets, particularly when relatively few fish out of the total catch are measured.
- Sex ratio data: have not been provided to the Secretariat by CPCs.





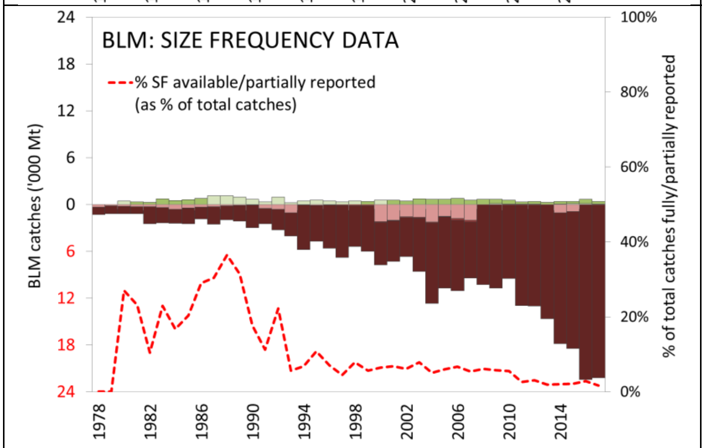


Fig. 5a-c. Black marlin: data reporting coverage (1978–2017).

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 2018.

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

(green)	Total score is 0 (or average score is 0-1)
(light green)	Total score is 2 (or average score is 1-3)
(pink)	Total score is 4 (or average score is 3-5)
(red)	Total score is 6 (or average score is 5-7)
(dark red)	Total score is 8 (or average score is 7-8)

APPENDIX IVE
MAIN STATISTICS OF BLUE MARLIN

(*Extract from IOTC–2018–WPB16–07*)

Fisheries and main catch trends

- Main fishing gear (2013–17): Blue marlin are largely considered to be a non-target species of industrial and artisanal fisheries. Longline catches[6] account for around 70% of total catches in the Indian Ocean, followed by gillnets (24%), with remaining catches recorded under troll and handlines. (**Table 1; Fig. 1**)
- Main fleets (and primary gear associated with catches): percentage of total catches (2012–15):
  Taiwan,China (longline): 34%; Indonesia (fresh longline): 31%; Pakistan (gillnet): 12%; I.R. Iran (gillnet): 9%, and Sri Lanka (6%) (**Fig. 2**).
- 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-70's, 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 1990's. 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. Negligible levels of discards have also been reported for some purse seine fleets. Discards may also occur in some gillnet fisheries.

Changes to the catch series**:** Catches have been revised in recent years (i.e., 2015) when catches estimates for blue marlin were revised substantially following new reports of catches-by-species for Iran's drifting gillnet fleet[7].
In addition, following issues with the reliability of catch estimates of Indonesia's fresh longline fleet, the IOTC Secretariat has provided the WPB-16 meeting with an alternative catch series based on a new estimation methodology developed in collaboration with Indonesia (IOTC-2018-WPB16-DATA03b available on the WPB meeting webpage). The revised catch series mostly affects catches of swordfish, striped marlin, and blue marlin estimated by the IOTC Secretariat for Indonesia.
Estimates for all three species have been reduced significantly for Indonesia's fresh longline fleet in recent years, while total catches across all fleets have also been revised downwards by as much as 30% for each species (including blue marlin).

TABLE 1: Blue marlin: best scientific estimates of catches by type of fishery for the period 1950–2017 (in metric tons). Data as of August 2018.

Fishery	By decade (average)						By year (last ten years)									
	1950s	**1960s**	**1970s**	**1980s**	**1990s**	**2000s**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
LL	2,567	3,535	3,409	4,545	6,982	7,410	6,369	6,664	6,675	7,281	12,226	10,232	10,789	11,508	13,167	10,976
GN	1	2	124	761	2,357	2,687	2,410	2,049	2,198	3,919	4,828	4,063	3,543	3,673	3,577	4,130
HL	5	9	17	105	168	150	195	277	303	269	265	341	497	684	818	1,533
OT	0	0	0	2	4	7	11	15	15	16	16	17	15	20	52	778
Total	**2,574**	**3,546**	**3,550**	**5,413**	**9,511**	**10,254**	**8,984**	**9,004**	**9,191**	**11,485**	**17,334**	**14,654**	**14,844**	**15,884**	**17,613**	**17,417**

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**).

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

[7] 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.

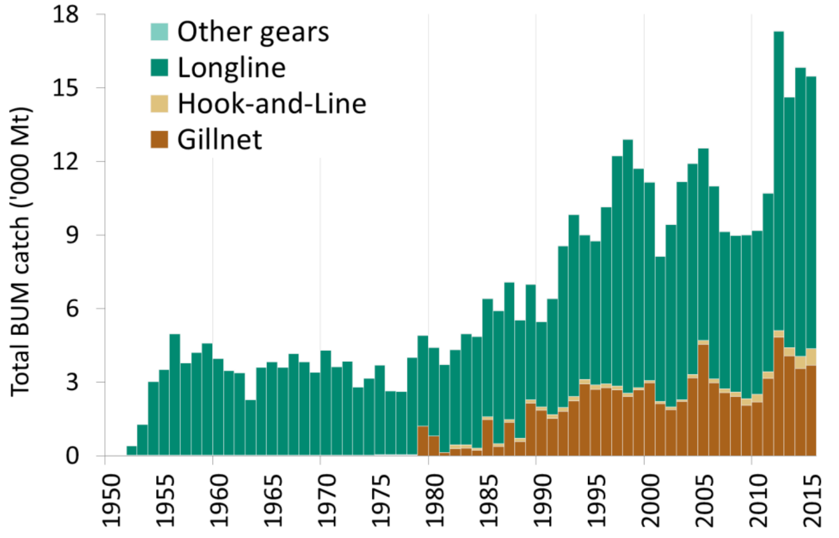


Fig. 1. Blue marlin: catches by gear and year recorded in the IOTC Database (1950–2017). Other gears includes: coastal purse seine, Danish purse seine, beach seine and purse seine.

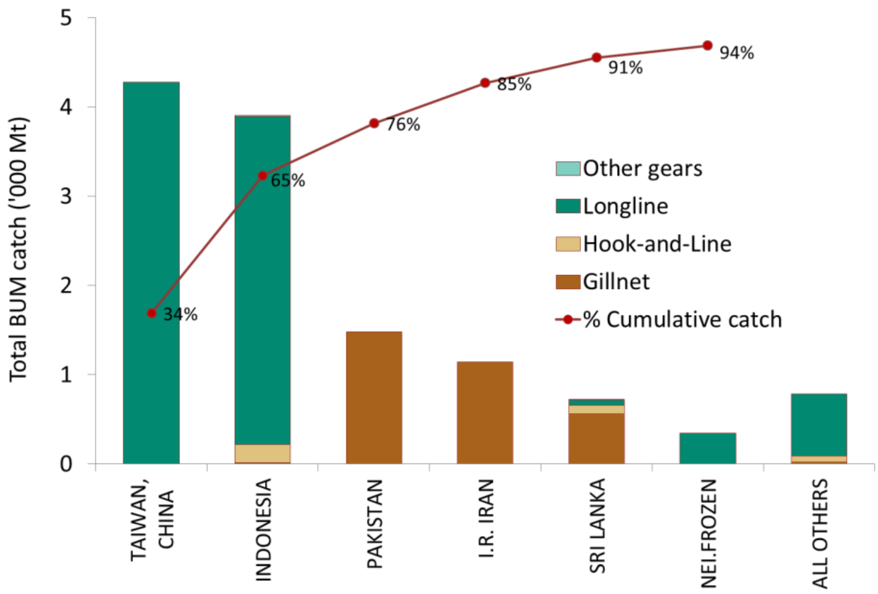


Fig. 2: Blue marlin: average catches in the Indian Ocean over the period 2013–17, by fleet and gear. Fleets are ordered from left to right, according to the volume of catches reported.
The red line indicates the (cumulative) proportion of catches of blue marlin for the fleets concerned, over the total combined catches reported from all fleets and gears.

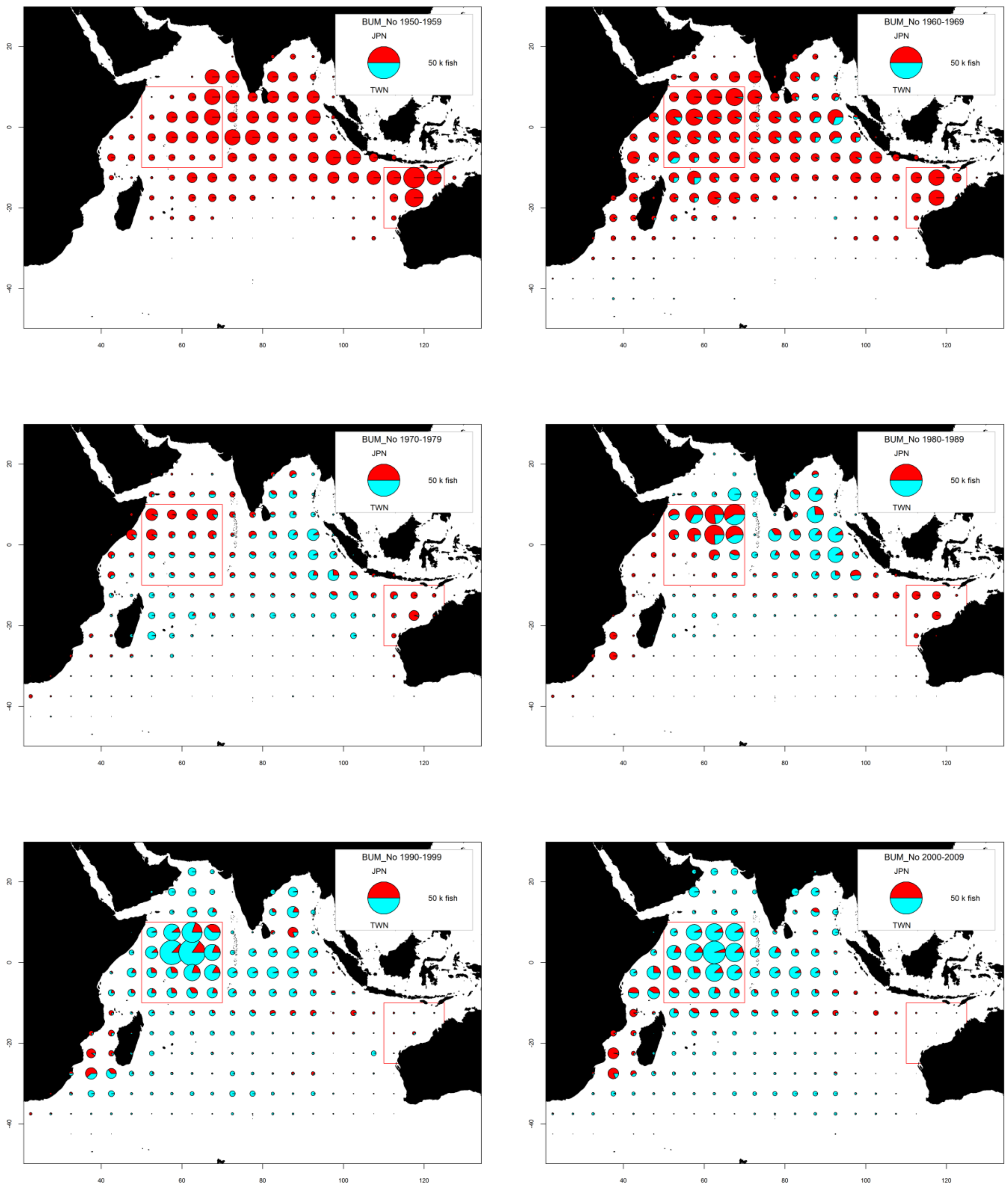


Fig. 3a-f. Time-area catches (in number of fish) of blue marlin as reported for the longline fisheries of Japan (JPN) and Taiwan,China (TWN) for the period 1950-2009, by decade and fleet. Red lines represent the marlin hotspots identified by the IOTC WPB.

Source: IOTC catch-and-effort data (unraised). Does not include fleets non-reporting catch-and-effort data.

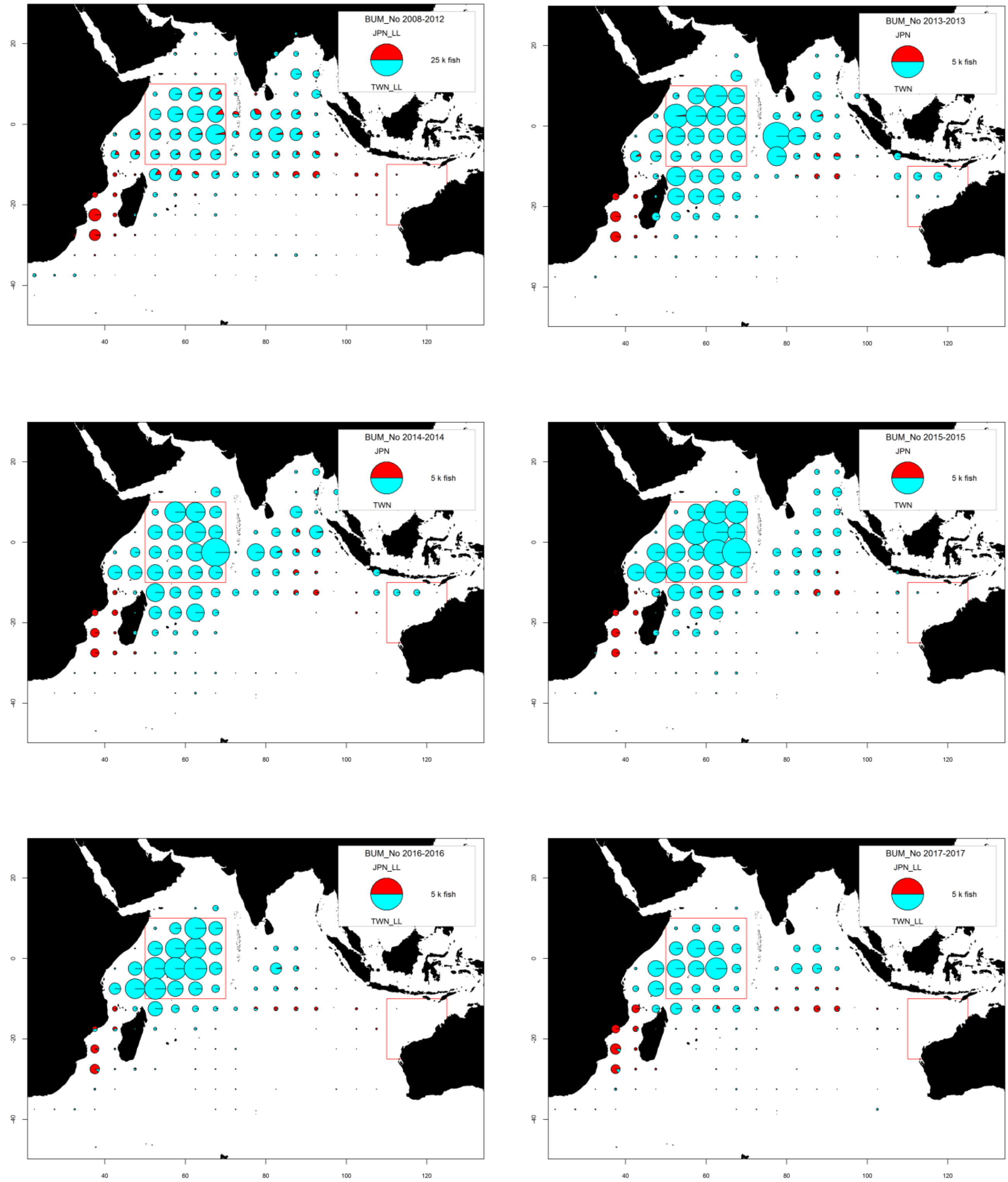


Fig. 4a-f. Time-area catches (in number of fish) of blue marlin as reported for the longline fisheries of Japan (JPN) and Taiwan,China (TWN) for the period 2008–12 by fleet and for 2013–17, by year and fleet. Red lines represent the marlin hotspots identified by the IOTC WPB.

Source: IOTC catch-and-effort data (unraised). Does not include fleets non-reporting catch-and-effort data.

Blue marlin: estimation of catches – data related issues

Retained catches – a high proportion of the catches of blue marlin are estimated, or adjusted, by the IOTC Secretariat are (**Fig.5a**), 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 mis-identification: 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 mis-identification 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 may not be representative of the total catches.
- 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.

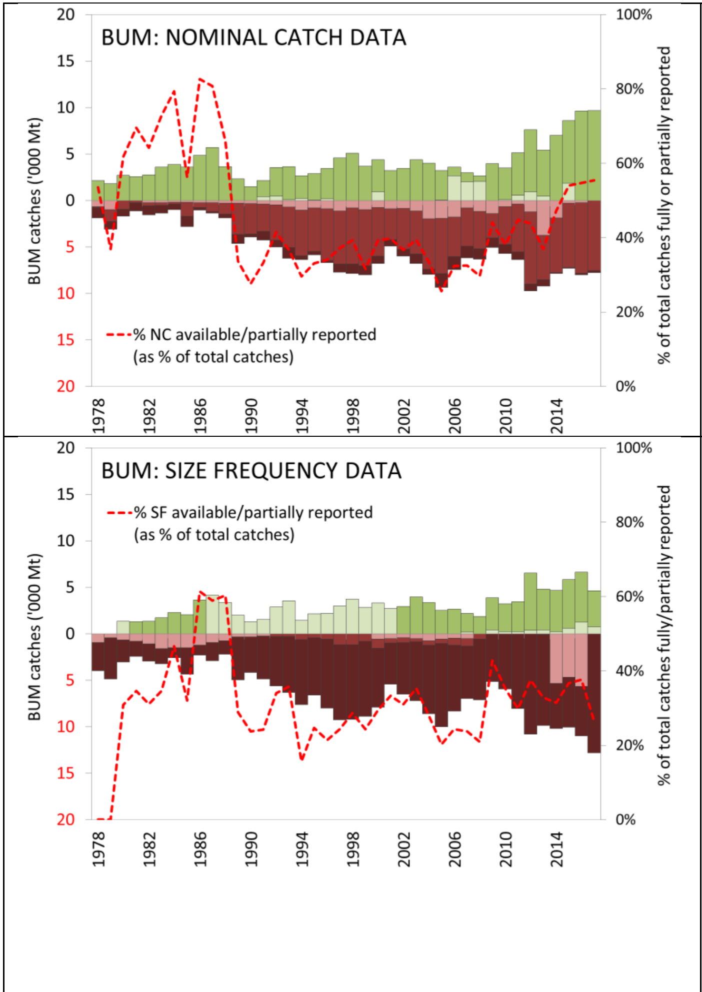


Fig. 5a-c. Blue marlin: data reporting coverage (1978–2017).

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 2018.

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)

APPENDIX IVF
MAIN STATISTICS OF INDO-PACIFIC SAILFISH

(*Extract from IOTC–2018–WPB16–07*)

Fisheries and main catch trends

- Main fishing gear (2013–2017): gillnets account for around 70% of total catches in the Indian Ocean, followed by troll and hand lines (21%), with remaining catches recorded under longlines and other gears (**Fig. 1**).
- Main fleets (and primary gear associated with catches): percentage of total catches (2013–17):
  Three quarters of the total catches of Indo-Pacific sailfish are accounted for by four countries situated in the Arabian Sea: I.R. Iran (gillnets): 31%; India (gillnets and trolling): 19%; Pakistan (gillnets): 16%; and Sri Lanka (gillnets and fresh longline): 9% (**Fig. 2**).

  This species is also a popular catch for sport fisheries (e.g. Kenya, Mauritius, and Seychelles).
- Main fishing areas: Primary: north-west Indian Ocean (Arabian Sea).
- Retained catch trends:
  Catches have increased sharply since the mid-1990's (from around 5,000 t in the early 1990s to nearly 30,000 t from 2011 onwards) (**Table 1**) – largely due to the development of a gillnet/longline fishery in Sri Lanka and, especially, the extension of Iranian gillnet vessels operating in areas beyond the EEZ of I.R. Iran. In the case of I.R. Iran, gillnet catches have increased from less than 1,000 t in the early 1990's to between 7,000 t and over 11,000 t since 2013.
  Catches from drifting longline fleets have also likely increased, but have been under reported as the species has little commercial value. In recent years, deep-freezing longliners from Japan have reported catches of Indo-Pacific sailfish in the central western Indian Ocean, between Sri Lanka and the Maldives and the Mozambique Channel.
- Discard levels**:** Moderate to high, however discard levels are largely unknown for most industrial fisheries (i.e., mostly longliners).

Changes to the catch series**:** Following issues with the reliability of catch estimates of Indonesia's fresh longline fleet, the IOTC Secretariat has provided the WPB-16 meeting with an alternative catch series based on a new estimation methodology developed in collaboration with Indonesia (IOTC-2018-WPB16-DATA03b[8] available on the WPB meeting webpage). The revised catch series mostly affects catches of swordfish, striped marlin, and blue marlin estimated by the IOTC Secretariat for Indonesia.
Estimates for all three species have been reduced significantly for Indonesia's fresh longline fleet in recent years, while total catches across all fleets have also been revised downwards by as much as 30% for each species. The catches of sailfish are less affected, but have also been revised downwards by up to 5% from 2012 onwards.

TABLE 1: Indo-Pacific sailfish: best scientific estimates of catches by type of fishery for the period 1950–2017 (in metric tons). Data as of August 2018.

Fishery	By decade (average)						By year (last ten years)									
	1950s	1960s	1970s	1980s	1990s	2000s	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
LL	297	804	385	256	1,400	1,416	2,534	1,257	656	455	700	903	2,674	1,709	3,593	3,748
GN	165	181	504	1,774	6,055	12,503	13,863	18,303	21,037	19,920	21,229	22,956	21,832	21,445	19,163	22,890
HL	171	213	456	1,427	2,470	3,927	4,445	5,412	5,999	5,477	5,048	5,581	4,638	6,708	6,916	7,892
OT	-	-	2	24	41	85	134	171	175	184	180	275	173	167	142	361
Total	**633**	**1,197**	**1,347**	**3,480**	**9,966**	**17,931**	**20,976**	**25,143**	**27,867**	**26,035**	**27,157**	**29,714**	**29,318**	**30,030**	**29,813**	**34,891**

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**).

[8] http://www.iotc.org/documents/WPB/16/data/03b-NC_Scenario2

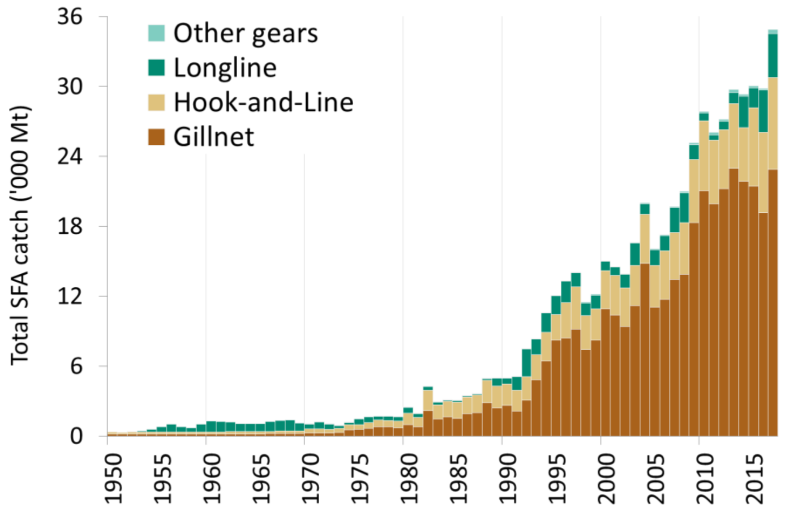


Fig. 1. Indo-Pacific sailfish: catches by gear and year recorded in the IOTC Database (1950–2017). Other gears includes: coastal purse seine, Danish purse seine, beach seine and purse seine.

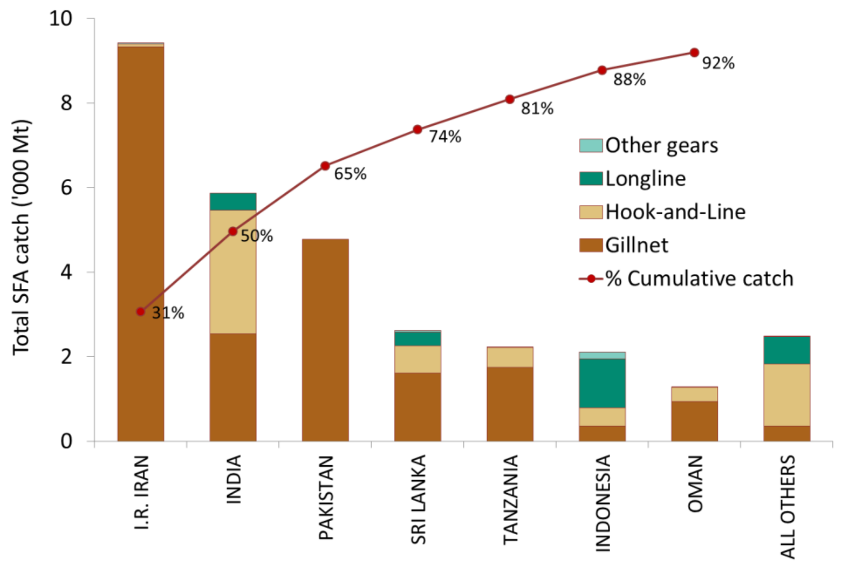


Fig. 2: Indo-Pacific sailfish: average catches in the Indian Ocean over the period 2013–17, by fleet and gear. Fleets are ordered from left to right, according to the volume of catches reported.
The red line indicates the (cumulative) proportion of catches of Indo-Pacific sailfish for the fleets concerned, over the total combined catches reported from all fleets and gears.

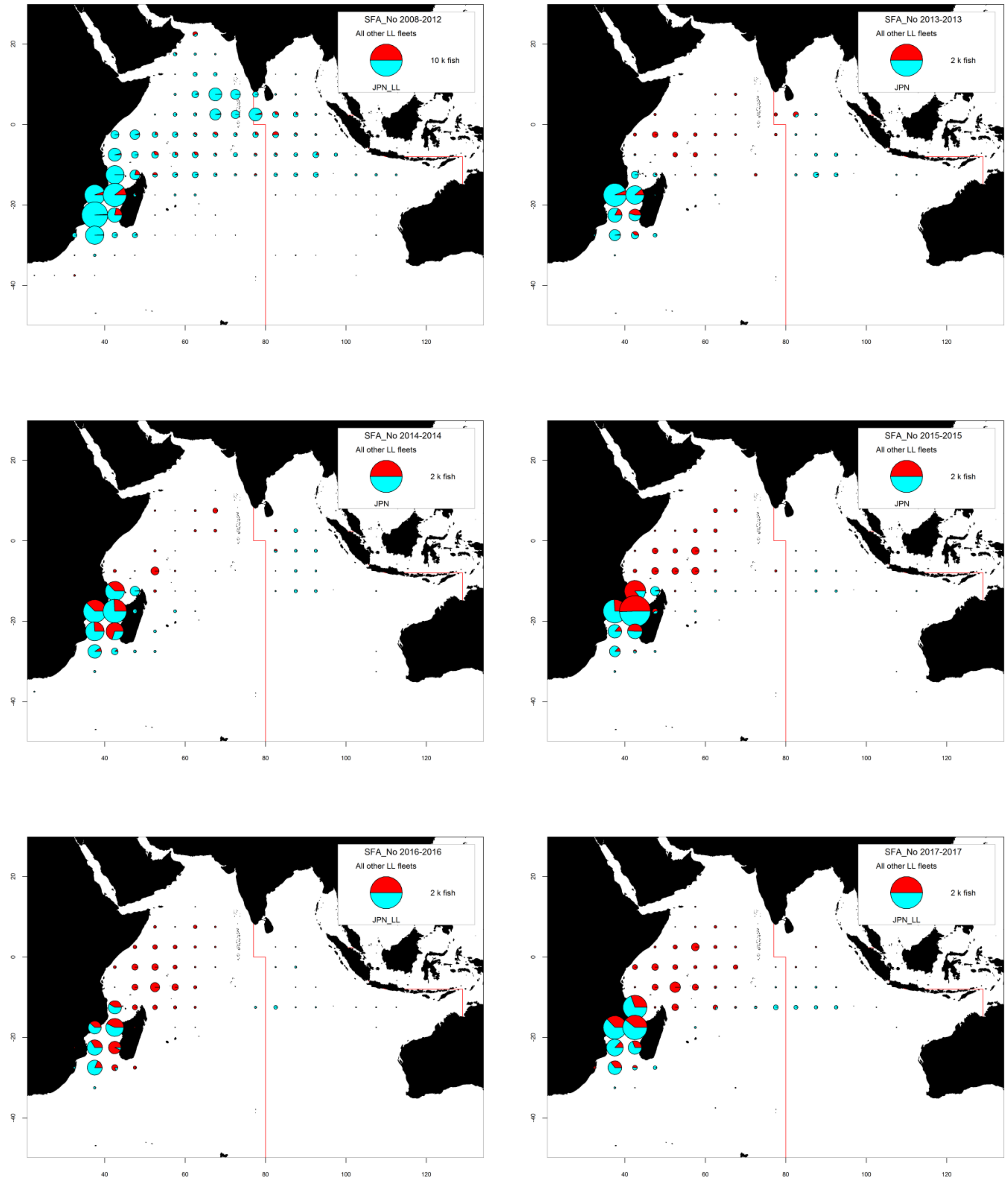


Fig. 3a-f. Time-area catches (in number of fish) of Indo-Pacific sailfish as reported for the longline fisheries of Japan (JPN) and all other longline fleets for the period 2008–12, by fleet and for 2012–17, by year and fleet. Red lines represent the IOTC Areas.

Source: IOTC catch-and-effort data (unraised). Does not include fleets non-reporting catch-and-effort data.

Indo-pacific sailfish: estimation of catches – data related issues

Retained catches – a very high proportion of the catches of Indo-Pacific sailfish are estimated, or adjusted, by the IOTC Secretariat are (**Fig.4a**), due to a number of uncertainties in the catches listed below. However, unlike the other billfish species, Indo-Pacific sailfish are more reliably identified because of the large and distinctive first dorsal fin that runs most of the length of the body:

- Species aggregates: catch reports often refer to total catches of all billfish species combined; catches by species are estimated by the Secretariat for some artisanal fisheries (e.g., gillnet/longline fishery of Sri Lanka and artisanal fisheries of India and Pakistan) and industrial fisheries (e.g., longliners of Indonesia and Philippines).

  Catches of Indo-Pacific sailfish reported for some fisheries may also refer to the combined catches of more than one species of billfish, in particular marlins and shortbill spearfish (i.e., in the case of coastal fisheries).
- Conflicting reports: In 2017 Pakistan also submitted a revised catch series, dating back to the 1980s, and which are significantly lower than current estimates for billfish for Pakistan in the IOTC database, and particularly catches of Indo-Pacific sailfish. The data are currently pending upload to the IOTC database until further clarifications have been received regarding the catch revision estimation methodology, and particularly the scale of revisions for some billfish species.
- Non-reporting fleets: catches of non-reporting industrial longliners (e.g., India, NEI fleets) 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 Indo-Pacific sailfish is not a target species.
- Missing or incomplete catches: catches are likely to be incomplete for some artisanal fisheries (e.g., Pakistan gillnets, Maldives pole-and-line) due to under-reporting.

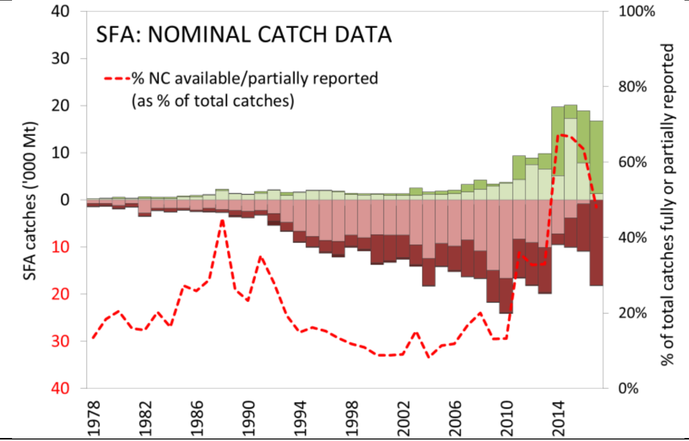
  There is also a lack of catch data for most sport fisheries.

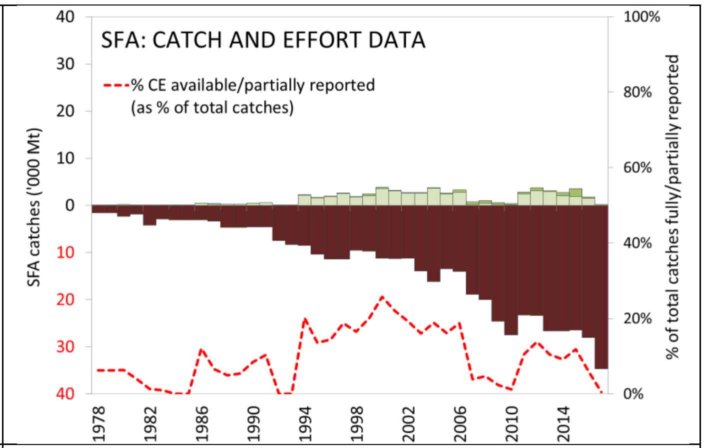
Indo-Pacific sailfish – Nominal catch-per-unit-effort (CPUE) trends

- Availability: Standardized and nominal CPUE series have not yet been developed. No catch and effort data are available from sports fisheries, other than partial data from the sports fisheries of Kenya; or other artisanal fisheries (e.g., I.R. Iran and Pakistan (gillnet), Sri Lanka (gillnet-longline), Indonesia (gillnet)) or industrial fisheries (NEI longliners and all purse seiners).

Indo-Pacific sailfish – 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 the gillnet/longline fishery of Sri Lanka since the late 1980s. The number of specimens measured on Japanese longliners in recent years is, however, very low. Furthermore, specimens discarded might be not accounted for in industrial fisheries, where they are presumed to be of lower size (leading to possible bias of existing samples).
- 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.





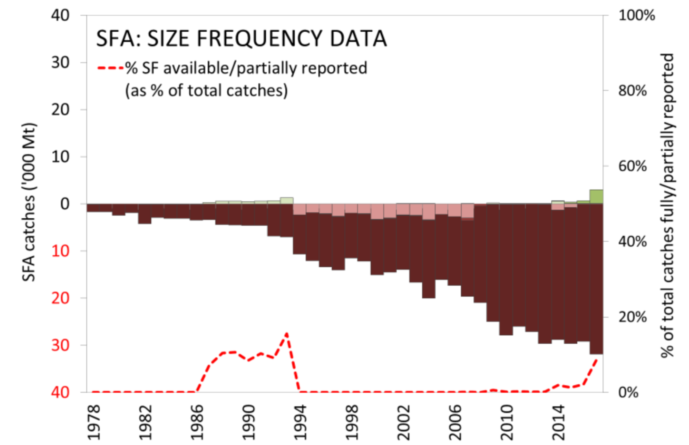


Fig. 4a-c. Indo-Pacific sailfish: data reporting coverage (1978–2017).

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 2018.

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)

APPENDIX V
MAIN ISSUES IDENTIFIED RELATING TO THE STATISTICS OF BILLFISH

(*Extract from IOTC–2018–WPB16–07*)

The following section provides a summary of the main issues that the IOTC Secretariat considers to negatively affect the quality of billfish statistics available at the IOTC, by type of dataset, for the consideration of the WPB.

Nominal (retained) catches

Artisanal fisheries (including Sports Fisheries)

- Sri Lanka (gillnet/longline): In recent years, Sri Lanka has been estimated to catch over 15% of catches of marlins in the Indian Ocean. Although catches of marlins by species have been reported for its gillnet/longline fishery, the catch ratio of blue marlin to black marlin has changed dramatically in recent years. This is thought to be a sign of frequent mis-identification rather than the effect of changes in catch rates or species composition for this fishery. Although the IOTC Secretariat has adjusted the catches of marlins using proportions derived from years known to have reliable data, the estimated catches remain uncertain.

- Indonesia (coastal fisheries): Catches of billfish reported by Indonesia for its artisanal fisheries in recent years are considerably higher than those reported in the past, at around 5% of the total catches of billfish in the Indian Ocean. In 2011 the Secretariat revised the nominal catch dataset for Indonesia, using information from various sources, including official reports. However the data quality of catches for artisanal fisheries of Indonesia is thought to be poor, with a likely underestimation of catches of billfish in recent years.

- Sport fisheries of Australia, France(La Réunion), India, Indonesia, Madagascar, Mauritius, Oman, Seychelles, Sri Lanka, Tanzania, Thailand and United Arab Emirates: Data has either never been submitted, or is available for only a limited number of years for sports fisheries in each of the referred CPCs. Sport fisheries are known to catch billfish species, and are particularly important for catches of blue marlin, black marlin and Indo-Pacific sailfish. Although some data are available from sport fisheries in the region (e.g., Kenya, Mauritius, Mozambique, South Africa), the information cannot be used to estimate levels of catch for other fisheries.

  To improve the quality and availability of data for sports fisheries, in 2017 the IOTC Secretariat commissioned a pilot project to develop tools and training materials to improve the collection of catch-and-effort and size frequency from sports fisheries in the Western Indian Ocean focused on a small number of CPCs, including La Réunion, Kenya, Mauritius and Seychelles.

- Drifting gillnet fisheries of I.R. Iran and Pakistan:

  In recent years both fisheries have reported catches of billfish at around 20,000 t (25% of the total catches). Catches for this component remain very uncertain:

  - I.R. Iran**:** In recent years I.R. Iran has reported catches of marlins and swordfish for it's gillnet fishery, (i.e., catches from 2012 onwards) which significantly revises the catch-by-species previously estimated by the IOTC Secretariat. While the IOTC Secretariat has used the new catch reports to re-build the historical series (pre-2012) for its offshore gillnet fishery, estimates for the historical series remain highly uncertain.
  - Pakistan: In 2017 Pakistan submitted revised catches dating back to the 1980s – however the data are significantly different to catches reported by WWF-Pakistan funded sampling in 2012, and also with previous official data reported by Pakistan to the IOTC Secretariat, particularly for swordfish, striped marlin and Indo-Pacific sailfish. Current IOTC catch estimates for Pakistan account for around 6% of the total catches of billfish in the Indian Ocean - however, based on the latest data submitted by Pakistan, catches are estimated to be much significantly lower. Verification of the data is currently being undertaken by the IOTC Secretariat to understand the reasons for the differences in reported data for Pakistan before further changes are made to the current estimates in the IOTC database.

Industrial (longline) fisheries

- Indonesia (fresh longline): Following issues with the reliability of catch estimates of Indonesia's fresh longline fleet in recent years, the IOTC Secretariat has provided the WPB-16 meeting with an alternative catch series, based on a new estimation methodology developed in collaboration with Indonesia (see IOTC-2018-WPB16-DATA03b available on the WPB meeting webpage). The revised catch series mostly affects Indonesia's catches of swordfish, striped marlin, and blue marlin estimated by the IOTC Secretariat.

The revised catches are significantly lower for Indonesia's fresh longline fleet in recent years compared to previous IOTC estimates, while total catches across all fleets have also been revised downwards by as much as 30% for each species as a consequence of the new estimation methodology. Further details on the alternative catch series can be found in paper IOTC-2018-WPB16-22. The alternative catch series will be discussed during the WPB and a recommendation made on which catch series to endorse for stock assessment purposes.

- Taiwan,China (fresh longline): The recent issues with IOTC's estimates of billfish for Indonesia relate to changes in the Taiwanese fresh-longline fleet, which in previous years has been used as a proxy fleet by the IOTC Secretariat to estimate the total catches and species composition (due to separate and unrelated issues with the reliability of Indonesia's officially reported catches).

  Despite a decrease in the number of Taiwanese fresh-longline vessels of around 30% between 2013-2016, catches have remained at similar levels, or even marginally increased as average catches per vessel have risen from 100 t in 2013 to around 175 t in 2016. Over the same period, the proportion of swordfish reported by the Taiwanese fresh longline fleet has risen from around 8% to over 30% due to improvements in the estimation of catches by species, according to official sources.

  Both these issues (i.e., the sharp increase in average catches per vessel, and also changes to the species composition) require further clarification before the changes are implemented within the IOTC database.

Catch-and-effort and CPUE series

For a number of fisheries important for billfish catches listed below, catch-and-effort remains either unavailable, incomplete (i.e., missing catches by species, gear, or fleet), or only partially reported according to the standards of IOTC Resolution 15/02, and therefore of limited value in deriving indices of abundance:

- EU,Spain (longline)**:** Incomplete catch-and-effort data is reported for the longline fishery of EU-Spain, which reports nominal catches for all billfish, but only time-area catches for swordfish.
- India (longline): In recent years, India has reported very incomplete catches and catch-and-effort data for its commercial longline fishery. The IOTC Secretariat has estimated total catches for this period using alternative sources, and the final estimated catches are significantly higher than those officially reported to the Secretariat.
- Republic of Korea (longline): The nominal catches and catch-and-effort data series for billfish for the longline fishery of Korea are conflicting, with nominal catches of swordfish and marlins lower than the catches reported as catch-and-effort for some years. Although in 2010 the IOTC Secretariat revised the nominal catch dataset to account for catches reported as catch-and-effort, the quality of the estimates remains unknown. However, the catches of longliners of the Republic of Korea in recent years are very small.

Size data from (all fisheries)

Size data for all billfish species is generally considered to be unreliable and insufficient to be of use for stock assessment purposes, as the numbers of samples for all species are below the minimum sampling coverage of one fish per tonne of catch recommended by IOTC. Also the quality of many of the samples collected by fishermen on commercial boats cannot be verified.

- Taiwan,China (longline): Size data have been available since 1980; however, the IOTC Secretariat has identified issues in the length frequency distributions, in particular fish recorded under various types of size class bins (e.g. 1cm, 2cm, 10cm, etc.) that are reported under identical class bins (e.g. 2cm, with all fish between 10-20 cm reported as 10-12cm). For this reason, the average weights estimated for this fishery are considered unreliable.
- I.R. Iran and Pakistan (gillnet): no size data reported for billfish species for gillnet fisheries since the 1980s.
- Sri Lanka (gillnet/longline)**:** Although Sri Lanka has reported length frequency data for swordfish and marlins in recent years, the lengths reported are considered highly uncertain, due to mis-identification of marlins and likely sampling bias (large specimens of swordfish and marlins are highly processed and not sampled for lengths, while small specimens are sampled).
- India and Oman (longline)**:** To date, India and Oman have not reported size frequency data for billfish from their commercial longline fisheries.
- Indonesia (longline): size frequency data has been reported for its fresh-tuna longline fishery in recent years. However, the samples cannot be fully disaggregated by fishing area (i.e., 5 degree square grid) due to being sampled in port (rather than on-board). For this reason the quality of the samples in the IOTC database are considered to be of limited value.

- <u>Taiwan,China (fresh-tuna longline)</u>**:** Taiwan,China recently submitted size frequency data for the fresh tuna longline for marlins and swordfish. In the case of data available for marlins, the data are considered uncertain due to the small number of samples for some species, or discrepancies in the size frequency distributions.
- <u>India and Indonesia (artisanal fisheries)</u>: To date, India and Indonesia have not reported any billfish size frequency data for their artisanal fisheries.

Biological data (all billfish species)

The IOTC Secretariat has previously used length-age keys, length-weight keys, and processed weight-live weight keys for billfish species from other oceans due to the general lack of biological data, and length frequency data by sex, available from the fisheries indicated below:

- <u>Industrial longline fisheries</u>: in particular Taiwan,China, Indonesia, EU(all fleets), China and the Republic of Korea.

Data issues: priorities and suggested actions

The IOTC Secretariat suggests the following actions as key to improving the quality of datasets for the assessment of billfish, with a focus on fleets considered important for catches of billfish and for which issues have been identified with the data reported or currently estimated by the IOTC Secretariat (as detailed above).

i. <u>I.R. Iran (gillnet fisheries)</u>: In previous years I.R. Iran has reported aggregated catches for all billfish species, which were estimated by species and gear by the IOTC Secretariat. Since 2012 Iran has now begun to report catches by billfish species, and which significantly revise the catches-by-species previously estimated by the IOTC Secretariat. The main changes are 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% during the mid-2000's.

   Following an IOTC Data Compliance and Support mission to Iran in late-2017, the IOTC Secretariat has begun to receive detailed time-area catches (i.e., catch-and-effort) in accordance with the reporting requirements of Resolution 15/02. Data is also expected to be reported for the historical time series, which in turn will be used to inform the recent revisions to the billfish catches reported by Iran, and whether catches need to be revised for years prior to 2012.

ii. <u>Pakistan (gillnet fisheries)</u>: In 2017 Pakistan submitted a revised catch series, dating back to the 1980s, and which significantly reduces estimates for billfish for Pakistan in the IOTC database – particularly for Indo-Pacific sailfish. The data are currently pending upload to the IOTC database until further clarifications have been received regarding the catch revision estimation methodology, and particularly the scale of revisions for some billfish species. The IOTC Secretariat has also proposed an IOTC Data Compliance and Support mission to Pakistan to address the current inconsistencies between Pakistan's official catch estimates and the current estimates in the IOTC database.

iii. <u>Indonesia (fresh longline)</u>: As previous mentioned above, due to issues with the reliability of catch estimates of Indonesia's fresh longline fleet in recent years, the IOTC Secretariat has provided the WPB-16 meeting with an alternative catch series, based on a new estimation methodology developed in collaboration with Indonesia (see IOTC-2018-WPB16-DATA03b available on the WPB meeting webpage). The revised catch series mostly affects Indonesia's catches of swordfish, striped marlin, and blue marlin estimated by the IOTC Secretariat.

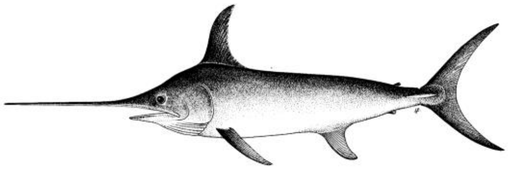
   The alternative catch series is significantly lower for Indonesia's fresh longline fleet in recent years compared to previous IOTC estimates, while total catches across all fleets have also been revised downwards by as much as 30% for each species as a consequence of the new estimation methodology. Further details can be found in paper IOTC-2018-WPB16-22, while the issue will be fully discussed during the WPB meeting and a recommendation made on which catch series to endorse for the purpose of stock assessment.

iv. <u>Taiwan,China (fresh longline)</u>: Despite a decrease in the number of Taiwanese fresh-longline vessels of around 30% between 2013-2016, catches have remained at similar levels, or even marginally increased, as average catches per vessel have risen from 100 t in 2013 to around 175 t in 2016. Over the same period, the proportion of swordfish reported by the Taiwanese flesh longline fleet has risen from around 8% to over 30% due to improvements in the estimation of catches by species, according to official sources.

Both these issues (i.e., the sharp increase in average catches per vessel, and also changes to the species composition) require further clarification before changes to the data are implemented within the IOTC database.

APPENDIX VI
[DRAFT] RESOURCE STOCK STATUS 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		2018 stock status determination
Indian Ocean	Catch 2017[2]: Average catch 2013-2017:	34,782[3] (53,658[4]) t 31,405[3] (42,187[4]) t	
	MSY (1,000 t) (80% CI): F_{MSY} (80% CI): SB_{MSY} (1,000 t) (80% CI): F_{2015}/F_{MSY} (80% CI): SB_{2015}/SB_{MSY} (80% CI): SB_{2015}/SB_{1950} (80% CI):	31.59 (26.30–45.50) 0.17 (0.12–0.23) 43.69 (25.27–67.92) 0.76 (0.41–1.04) 1.50 (1.05–2.45) 0.31 (0.26–0.43)	

[1] Boundaries for the Indian Ocean stock assessment are defined as the IOTC area of competence.
[2] Proportion of catch estimated or partially estimated by IOTC Secretariat in 2018: 48%.
[3] Low-case catch scenario (IOTC-2018-WPB16-DATA03b): alternative catch series incorporating changes to IOTC Secretariat's methodology for estimating for Indonesia's fresh tuna longline catches.
[4] High-case catch scenario (IOTC-2018-WPB16-DATA03a): includes IOTC Secretariat catch estimates for Indonesian fresh tuna longliners derived from a proxy fleet (i.e., Taiwan,China fresh tuna longliners).

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 ($F_{year}/F_{MSY} \leq 1$)		
Not assessed/Uncertain		

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

Stock status. No new stock assessment was carried out for swordfish in 2018, thus, the stock status is determined on the basis of the 2017 assessment and other indicators presented in 2018. In 2017 a stock synthesis assessment was conducted, with fisheries catch data up to 2015. The assessment uses a spatially disaggregated, sex explicit and age structured model. The SS3 model, used for stock status advice, indicated that MSY-based reference points were not exceeded for the Indian Ocean population ($F_{2015}/F_{MSY} < 1$; $SB_{2015}/SB_{MSY} > 1$). Most other models applied to swordfish also indicated that the stock was above a biomass level that would produce MSY. Spawning stock biomass in 2015 was estimated to be 26%–43% of the unfished levels.

There are some uncertainties in the catch estimates from the Indonesian fresh tuna longline (**Fig. 1b**); an alternative catch history was used in the base case stock assessment (**Fig. 1a**). Most recent catches are at the MSY level (31,590 t). On the weight-of-evidence available in 2018, the stock is determined to be ***not overfished*** and ***not subject to overfishing***.

Outlook. The decrease in longline catch and effort from 2005 to 2011 lowered the pressure on the Indian Ocean stock, and despite the recent increase in total recorded catches, current fishing mortality is not expected to reduce the population to an overfished state over the next decade. There is a very low risk of exceeding MSY-based reference points by 2026 if catches are maintained at 2015 levels (<1% risk that $SB_{2026} < SB_{MSY}$, and <1% risk that $F_{2026} > F_{MSY}$) (Table 2).

Management advice. The most recent catches (31,407 t in 2016) are at the MSY level (31,590 t). However, given the uncertainty of most recent catches from Indonesian fresh tuna longline fisheries there is a possibility that total catches could already be 39,777 t. The catches should not be increased beyond the MSY level (31,590 t).

The following key points should also be noted:

- **Maximum Sustainable Yield (MSY)**: estimate for the Indian Ocean is 31,590 t.
- **Provisional reference points**: Noting that the Commission in 2015 agreed to Resolution 15/10 *on target and limit reference points and a decision framework*, 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 below the provisional limit reference point of 1.4*F_{MSY} (**Fig. 2**).
    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. 2**).
- **Main fishing gear (average catches 2013-17)**: Longline catches are currently estimated to comprise approximately 75% of total swordfish catches in the Indian Ocean (or 69% according to the alternative low-case catch scenario) (Figs. 1a-b).
- **Main fleets (average catches 2013-17):**
  (High-case catch scenario): Indonesia (fresh longline): 32%; Taiwan,China (longline): 16%; Sri Lanka (longline-gillnet): 14%; EU,Spain (swordfish targeted longline): 9%.
  (Low-case catch scenario): Taiwan,China (longline): 21%; Sri Lanka (longline-gillnet): 18%; EU,Spain (swordfish targeted longline): 12%**;** Indonesia (fresh longline): 9%.

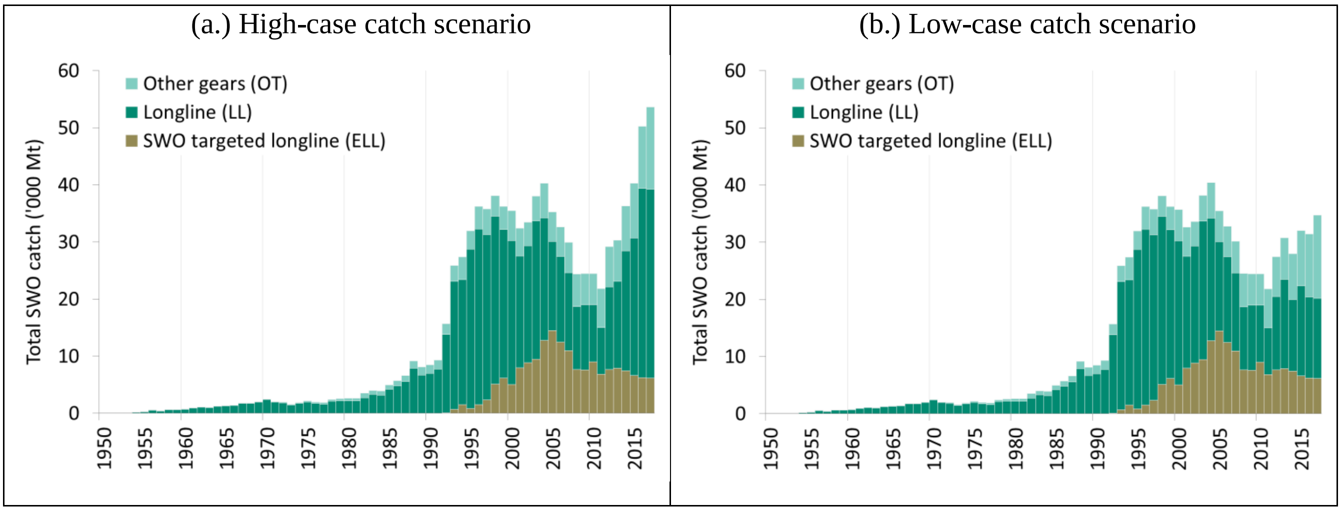


Fig. 1a-b. Swordfish catches by gear and year recorded in the IOTC database (1950–2017):

- (Left): High-case catch scenario (IOTC-2018-WPB16-DATA03a): includes IOTC Secretariat revised catch estimates for Indonesian fresh tuna.
- (Right): Low-case catch scenario (IOTC-2018-WPB16-DATA03b): alternative catch series incorporating changes to IOTC Secretariat's methodology for estimating for Indonesia's fresh tuna longline catches;

Note*: Other gears (OT) includes: longline-gillnet, handline, gillnet, coastal longline, troll line, sport fishing, and all other gears.*

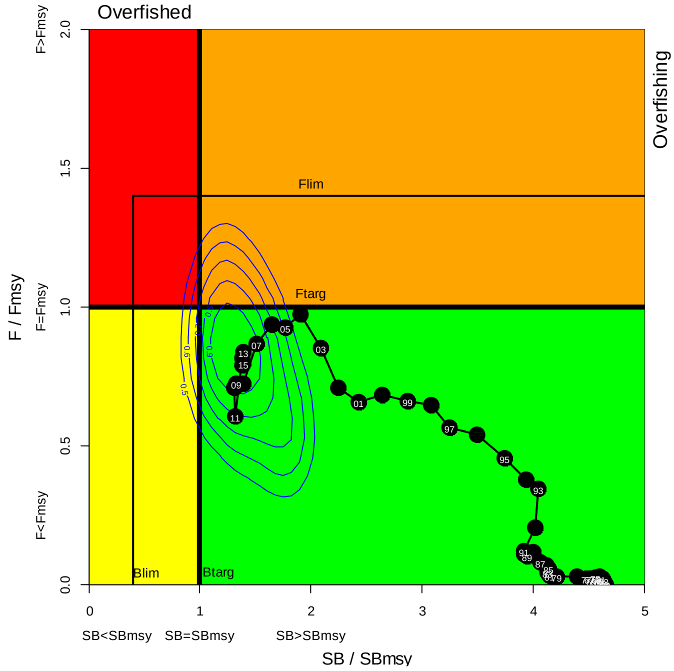


Fig. 2. Swordfish: SS3 Aggregated Indian Ocean assessment Kobe plot (contours are the 50, 60, 70, 80 and 90 percentiles of the 2015 estimate). Blue circles indicate the trajectory of the point estimates for the SB ratio and F ratio for each year 1950–2015. Interim target (F_{targ} and SB_{targ}) and limit (F_{lim} and SB_{lim}) reference points, as set by the Commission, are shown.

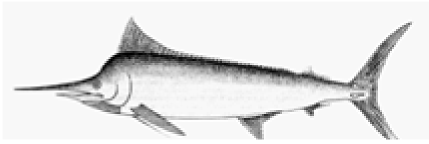
TABLE 2. Swordfish: SS3 aggregated Indian Ocean assessment Kobe II Strategy Matrix. Probability (percentage) of violating the MSY-based target (top) and limit (bottom) reference points for nine constant catch projections relative to 2015* catch level (32,129 t), ± 10%, ± 20%, ± 30% ± 40%) projected for 3 and 10 years.

Reference point and projection timeframe	**Alternative catch projections (relative to the average catch level from 2015* (32,129 t) and probability (%) of violating MSY-based target reference points (SBtarg = SBMSY; Ftarg = FMSY)**								
	60% (19,278 t)	**70%** (22,491 t)	**80%** (22,704 t)	**90%** (28,917 t)	**100%** (32,129 t)	**110%** (35,343 t)	**120%** (38,556 t)	**130%** (41,769 t)	**140%** (44,982 t)
$SB_{2018} < SB_{MSY}$	0	0	0	0	0	0	0	8	13
$F_{2018} > F_{MSY}$	0	0	0	0	13	33	42	58	71
$SB_{2025} < SB_{MSY}$	0	0	0	0	8	33	46	63	75
$F_{2025} > F_{MSY}$	0	0	0	4	38	54	71	83	88
Reference point and projection timeframe	**Alternative catch projections (relative to the average catch level from 2015* (32,129 t) and probability (%) of violating MSY-based limit reference points (SB_{lim} = 0.4 SB_{MSY}; F_{Lim} = 1.4 F_{MSY})**								
	60% (19,278 t)	**70%** (22,491 t)	**80%** (22,704 t)	**90%** (28,917 t)	**100%** (32,129 t)	**110%** (35,343 t)	**120%** (38,556 t)	**130%** (41,769 t)	**140%** (44,982 t)
$SB_{2018} < SB_{Lim}$	0	0	0	0	0	0	0	0	0
$F_{2018} > F_{Lim}$	0	0	0	0	0	0	0	13	33
$SB_{2025} < SB_{Lim}$	0	0	0	0	0	0	0	0	21
$F_{2025} > F_{Lim}$	0	0	0	0	0	21	42	63	75

** 2015 catches, at the time of the last swordfish assessment conducted in 2017.*

APPENDIX VII
[DRAFT] RESOURCE STOCK STATUS SUMMARIES – BLACK MARLIN

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



Status of the Indian Ocean black marlin (BLM: *Makaira indica*) resource

TABLE 1. Black marlin: Status of black marlin (*Makaira indica*) in the Indian Ocean.

Area[1]	Indicators		2018 stock status determination
Indian Ocean	Catch 2017[2]: Average catch 2013–2017:	21,250[3] (22,625[4]) t 18,673[3] (19,546[4]) t	55%*
	MSY (1,000 t) (80% CI): F_{MSY} (80% CI): B_{MSY} (1,000 t) (80% CI): F_{2017}/F_{MSY} (80% CI): B_{2017}/B_{MSY} (80% CI): B_{2017}/B_0 (80% CI):	12.93 (9.44-18.20) 0.18 (0.11-0.30) 72.66 (45.52-119.47) 0.96 (0.77-1.12) 1.68 (1.32-2.10) 0.62 (0.49-0.78)	

[1] Boundaries for the Indian Ocean = IOTC area of competence;
[2] Proportion of catch fully or partially estimated by IOTC Secretariat in 2018: 54%
[3] Low-case catch scenario (IOTC-2018-WPB16-DATA03b): alternative catch series incorporating changes to IOTC Secretariat's methodology for estimating for Indonesia's fresh tuna longline catches.
[4] High-case catch scenario (IOTC-2018-WPB16-DATA03a): includes IOTC Secretariat catch estimates for Indonesian fresh tuna longliners derived from a proxy fleet (i.e., Taiwan,China fresh tuna longliners).
* Estimated probability that the stock is in the respective quadrant of the Kobe plot (shown below), derived from the confidence intervals associated with the current stock status.

Colour key	Stock overfished(B_{year}/B_{MSY}< 1)	Stock not overfished (B_{year}/B_{MSY}≥ 1)
Stock subject to overfishing(F_{year}/F_{MSY}> 1)	0%	45%
Stock not subject to overfishing (F_{year}/F_{MSY}≤ 1)	0%	55%
Not assessed/Uncertain		

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

Stock status. A stock assessment based on JABBA was conducted in 2018 for black marlin. This assessment suggests that the point estimate for the stock in 2017 is in the green zone in the Kobe plot with F/F_{MSY}=0.96 (0.77-1.12) and B/B_{MSY}=1.68 (1.32-2.10). The Kobe plot (Fig. 2) from the JABBA model indicated that the stock is not **subject to overfishing** and is currently not **overfished** (Table 1; Fig. 2), however these status estimates are subject to a high degree of uncertainty. As such, the results should be interpreted with caution.

Outlook. The recent sharp increases in total catches (e.g., from 15,000 t in 2014 to over 20,000 t since 2016, mostly due to increases by I.R. Iran and India), and conflicts between CPUE and catch data lead to large uncertainties in the assessment outputs. This caused the point estimate of the stock status to change from the red to the green zones of the Kobe plot without any evidence of a rebuilding trend. While the recent high catches seem to be mainly due to developing coastal fisheries operating in the core habitat of the species, the CPUE indicators are from industrial fleets operating mostly offshore on the edges of the species distribution. However, the recent increases in catches are much higher than MSY and are a cause for concern and will likely continue to drive the population towards overfished status.

Management advice. The current catches (>20,000 t in 2017) (Figs. 1a & 1b) are considerably higher than MSY (12,930 t). Projections were not carried out due to the poor predictive capabilities identified in the assessment diagnostics.

The following key points should be noted:

- **Maximum Sustainable Yield (MSY)**: estimate for the whole Indian Ocean is 12,930 t.
- **Provisional reference points**: Although the Commission adopted reference points for black marlin 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 black marlin.
- **Main fishing gear (average catches 2013-17)**: Black marlin are largely considered to be a non-target species of industrial and artisanal fisheries. Gillnets account for around 49% of total catches in the Indian Ocean, followed by longlines (19%), with remaining catches recorded under troll and handlines (Fig. 1).
- **Main fleets (average catches 2013-17):**
  (High-case catch scenario): India (gillnet and trolling): 27%; I.R. Iran (gillnet): 26%; Sri Lanka (gillnet and fresh longline): 18%; Indonesia (fresh longline and hand lines): 14%.
  (Low-case catch scenario): India (gillnet and trolling): 28%; I.R. Iran (gillnet): 27%; Sri Lanka (gillnet and fresh longline): 19%; Indonesia (fresh longline and hand lines): 10%.

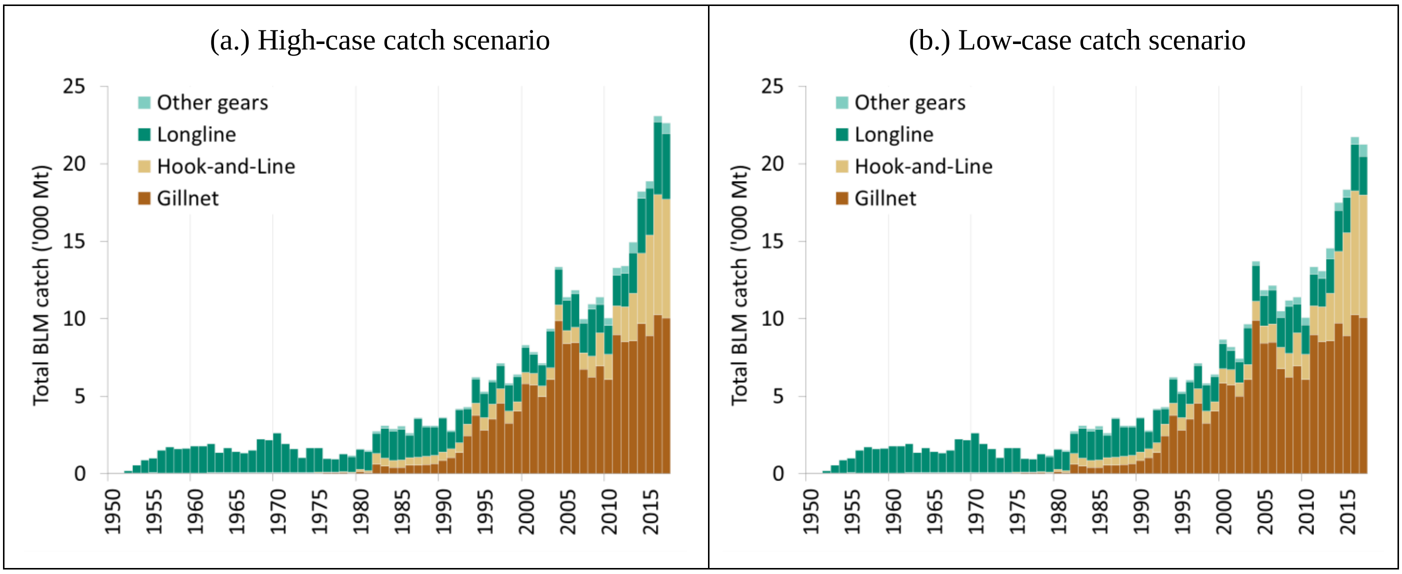


Fig. 1a-b. Black marlin catches by gear and year recorded in the IOTC database (1950–2017):

- (Left): High-case catch scenario (IOTC-2018-WPB16-DATA03a): includes IOTC Secretariat revised catch estimates for Indonesian fresh tuna.
- (Right): Low-case catch scenario (IOTC-2018-WPB16-DATA03b): alternative catch series incorporating changes to IOTC Secretariat's methodology for estimating for Indonesia's fresh tuna longline catches;

Notes*: Other gears (OT) includes: longline-gillnet, handline, gillnet, coastal longline, troll line, sport fishing, and all other gears.*

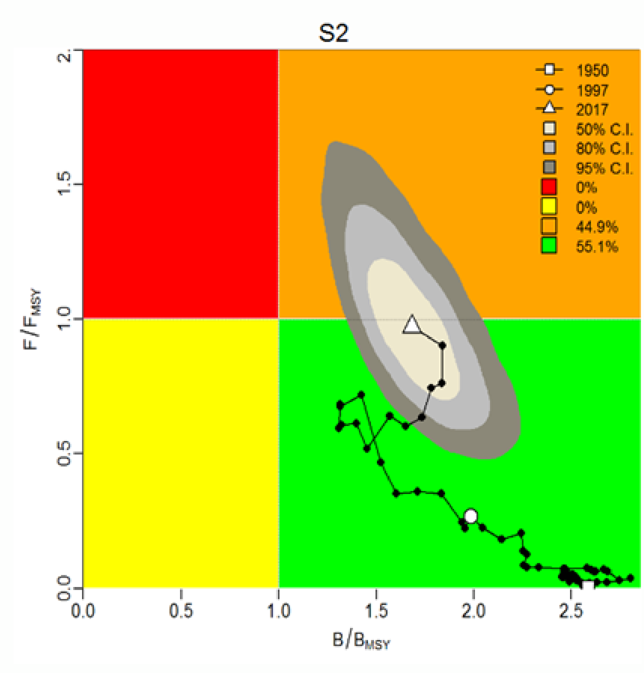
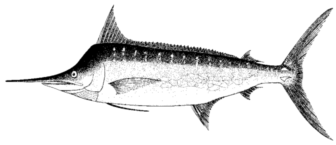


Fig. 2. Black marlin: JABBA Indian Ocean assessment Kobe plots for black marlin (contours are the 50, 80 and 95 percentiles of the 2017 estimate). Black line indicates the trajectory of the point estimates for the total biomass (B) ratio and F ratio for each year 1950–2017.

APPENDIX VIII
[DRAFT] RESOURCE STOCK STATUS SUMMARIES – BLUE MARLIN

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



Status of the Indian Ocean blue marlin (BUM: *Makaira nigricans*) resource

TABLE 1. Blue marlin: Status of blue marlin (*Makaira nigricans*) in the Indian Ocean.

Area[1]	Indicators		2017 stock status determination
Indian Ocean	Catch 2017[2]:	17,417[4] t (12,155[3]) t	**46.8%***
	Average catch 2013-2017:	16,082[4] t (11,635[3]) t	
	MSY (1,000 t) (80% CI):	11.93 (9.23–16.15)	
	F_{MSY} (80% CI):	0.11 (0.08 –0.16)	
	B_{MSY} (1,000 t) (80% CI):	113 (71.7 – 162.0)	
	H_{2015}/H_{MSY} (80% CI):	1.18 (0.80–1.71)	
	B_{2015}/B_{MSY} (80% CI):	1.11 (0.90–1.35)	
	B_{2015}/B_0 (80% CI):	0.56 (0.44 – 0.71)	

[1] Boundaries for the Indian Ocean = IOTC area of competence
[2] Proportion of catch estimated or partially estimated by IOTC Secretariat in 2017: 45%
[3] Low-case catch scenario (IOTC-2018-WPB16-DATA03b): alternative catch series incorporating changes to IOTC Secretariat's methodology for estimating for Indonesia's fresh tuna longline catches.
[4] High-case catch scenario (IOTC-2018-WPB16-DATA03a): includes IOTC Secretariat catch estimates for Indonesian fresh tuna longliners derived from a proxy fleet (i.e., Taiwan,China fresh tuna longliners).
* Estimated probability that the stock is in the respective quadrant of the Kobe plot (shown below), derived from the confidence intervals associated with the current stock status.

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)	24.6%	46.8%
Stock not subject to overfishing ($F_{year}/F_{MSY}\leq$ 1)	1.0%	27.6%
Not assessed/Uncertain		

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

Stock status. No stock assessment was carried out in 2018**.** Stock status based on BSP-SS stock assessment carried out in 2016 suggests that the stock status in 2015 is in the orange zone in the Kobe plot and both F and B are close to their MSYs, i.e., F/F_{MSY}=1.18 and B/B_{MSY}=1.11. Two other approaches examined in 2016 came to similar conclusions, namely ASPIC and SS3. The results from the BSP-SS model indicated that the stock has been **subject to overfishing** but **not overfished** in recent years (Table 1; Fig. 2).

Outlook. The uncertainty in the data available for assessment purposes and the CPUE series suggests that the advice should be interpreted with caution. The recent rapid increase of catch may bring the status of stock to the red zone (Kobe plot) in the near future if such high levels of catch continue. There is a high probability (70-80%) to exceed MSY-based reference points in next 10 years if the catch level at the time of the assessment is maintained. It is also noted that the 2017 catch (17, 417 t) exceeds the catch limit prescribed in Resolution 18/05 (11, 930t).

Management advice. Current catches (Fig.1) are higher than MSY (11,926 t) estimated for 2015 and the stock is currently subject to overfishing ($F_{2015} > F_{MSY}$). If catches of blue marlin are reduced to a maximum value of 11,704 t (the average 2013-2015 catches at the time of the assessment in 2015), then the stock is expected to recover to the green zone of the Kobe Plot by 2025 ($F_{2025} < F_{MSY}$ and $B_{2025} > B_{MSY}$) with at least a 50% probability.

The following key points should also be noted:

- **Maximum Sustainable Yield (MSY)**: estimate for the Indian Ocean blue marlin stock is 11,926 t (estimated range 9,232–16,149 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 blue marlin.
- **Main fishing gear (average catches 2013-17)**: Blue marlin are largely considered to be a non-target species of industrial and artisanal fisheries. Longline catches account for around 71% of total catches in the Indian Ocean, followed by gillnets (23%), with remaining catches recorded under troll and handlines (Fig. 1).

  Main fleets (average catches 2013-17):

  (High-case catch scenario): Taiwan,China (longline): 34%; Indonesia (fresh longline): 31%; Pakistan (gillnet): 12%; I.R. Iran (gillnet): 9%, and Sri Lanka (gillnet): 6%.

  (Low-case catch scenario): Taiwan,China (longline): 40%; Pakistan (gillnet): 15%; I.R. Iran (gillnet): 13%; Sri Lanka (gillnet): 10%; Indonesia (longline): 7%.

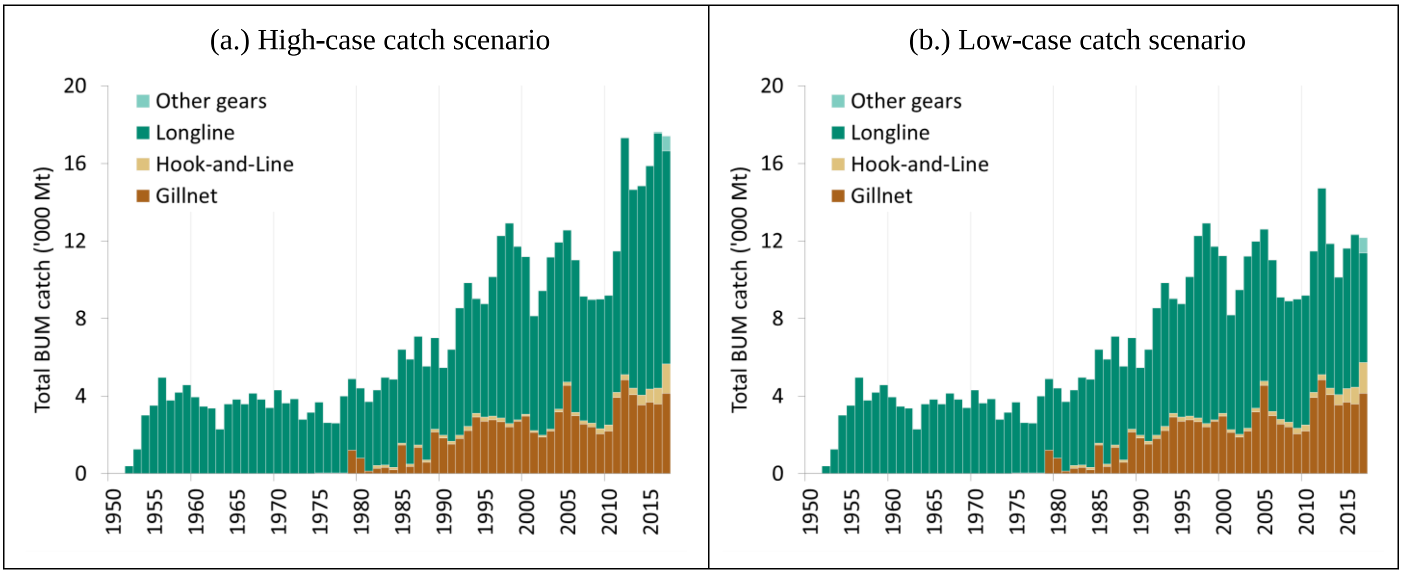


Fig. 1a-b. Blue marlin catches by gear and year recorded in the IOTC database (1950–2017):

- (Left): High-case catch scenario (IOTC-2018-WPB16-DATA03a): includes IOTC Secretariat revised catch estimates for Indonesian fresh tuna.
- (Right): Low-case catch scenario (IOTC-2018-WPB16-DATA03b): alternative catch series incorporating changes to IOTC Secretariat's methodology for estimating for Indonesia's fresh tuna longline catches.

Notes*: Other gears (OT) includes: longline-gillnet, handline, gillnet, coastal longline, troll line, sport fishing, and all other gears.*

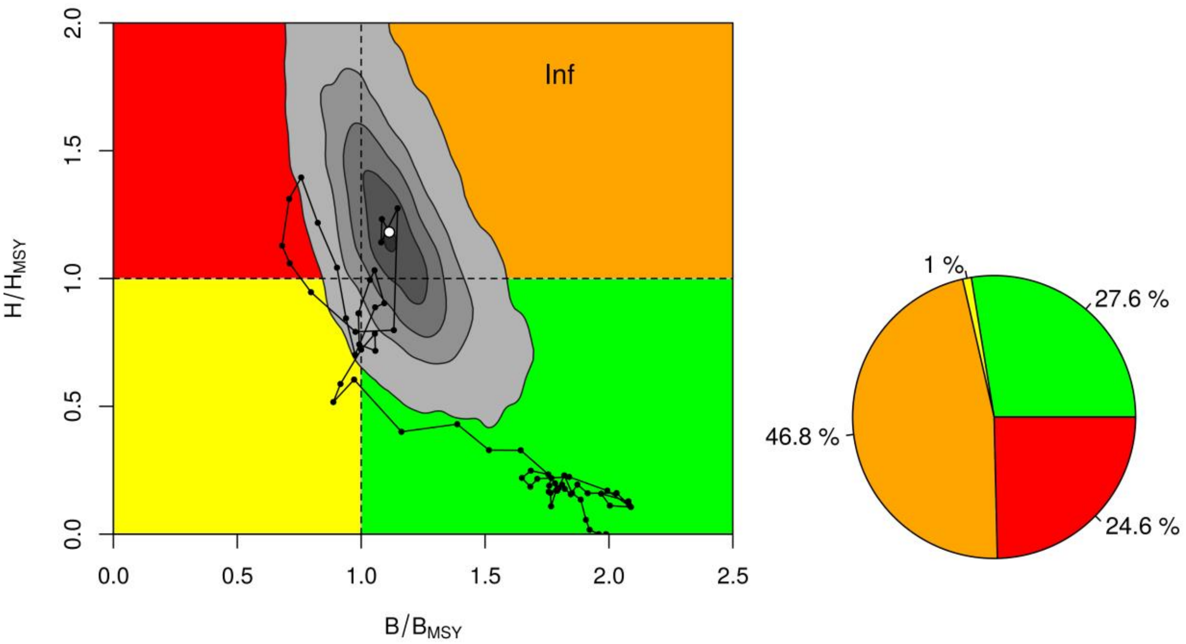


Fig. 2. Blue marlin: BSP-SS Aggregated Indian Ocean assessment Kobe plot for blue marlin (90% bootstrap confidence surfaces shown around 2015 estimate). Black line indicates the trajectory of the point estimates for the total biomass (B) ratio and Harvest ratio for each year 1950–2015.

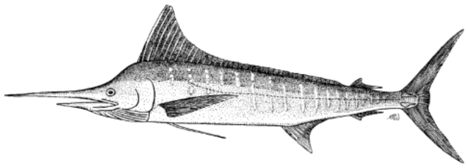
Table 2. Blue Marlin: Indian Ocean BSP-SS Kobe II Strategy Matrix. Probability (percentage) violating the MSY-based reference points for nine constant catch projections (average catch level from 2013 to 2015 - 15,401 t ± 10%, ± 20%, ± 30% ± 40%) projected for 3 and 10 years.

Reference point and projection timeframe	**Alternative catch projections (relative to the average catch from 2013 to 2015* (15,401 t) and probability (%) of violating MSY-based reference points**								
	60%	**70%**	**80%**	**90%**	**100%**	**110%**	**120%**	**130%**	**140%**
	9,240 t	10,780 t	12,321t	13,861 t	15,401 t	16,941 t	18,481 t	20,021 t	21,561 t
B_{2018}<B_{MSY}	26	31	37	43	48	54	59	64	69
F_{2018}> F_{MSY}	14	30	47	63	75	84	90	94	96
B_{2025}<B_{MSY}	16	30	46	60	73	82	88	93	95
F_{2025}> F_{MSY}	12	30	51	68	80	89	93	96	98

** Average catches for 2013–2015, at the time of the last blue marlin assessment conducted in 2016.*

APPENDIX IX
[DRAFT] RESOURCE STOCK STATUS SUMMARIES – 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**		**2018 stock status determination**
Indian Ocean	Catch 2017[2]:	3,082[3] (4,087[4]) t	**99.8%***
	Average catch 2013-2017:	3,587[3] (4,495[4]) t	
	MSY (1,000 t) (estimates):	4.73 (4.27–5.18)[5]	
	F_{MSY} (estimates):	0.26 (0.20–0.34)	
	B_{MSY} (1,000 t) (Estimates):	17.94 (14.21–23.13)	
	F_{2017}/F_{MSY} (estimates):	1.99 (1.21–3.62)	
	B_{2017}/B_{MSY} (estimates):	0.33 (0.18–0.54)	
	SB_{2017}/SB_{MSY} (SS3)[6]:	0.373	
	B_{2017}/B_{1950} (estimates):	0.12 (0.07–0.20)	
	SB_{2017}/SB_{1950} (SS3):	0.13 (0.09–0.14)	

[1] Boundaries for the Indian Ocean = IOTC area of competence
[2] Proportion of catch estimated or partially estimated by IOTC Secretariat in 2018: 41%
[3] Low-case catch scenario (IOTC-2018-WPB16-DATA03b): alternative catch series incorporating changes to IOTC Secretariat's methodology for estimating for Indonesia's fresh tuna longline catches.
[4] High-case catch scenario (IOTC-2018-WPB16-DATA03a): includes IOTC Secretariat catch estimates for Indonesian fresh tuna longliners derived from a proxy fleet (i.e., Taiwan,China fresh tuna longliners).
[5] Estimates are the range of central values shown in Figure 2.
[6] SS3 is the only model that used SB/SB_{MSY}, all others used B/B_{MSY}.
* Estimated probability that the stock is in the respective quadrant of the Kobe plot (shown below), derived from the confidence intervals associated with the current stock status.

Colour key	Stock overfished(B_{year}/B_{MSY}< 1)	Stock not overfished (B_{year}/B_{MSY}≥ 1)
Stock subject to overfishing(F_{year}/F_{MSY}> 1)	**99.8%**	**0.0%**
Stock not subject to overfishing (F_{year}/F_{MSY}≤ 1)	**0.2%**	**0.0%**
Not assessed/Uncertain		

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

Stock status. A new stock assessment for striped marlin was carried out in 2018, based on two different models: JABBA, a Bayesian state-space production model; and SS3, an integrated length-based model. Both models were very consistent and confirmed the results from 2012, 2013, 2015 and 2017 assessments, indicating that the stock is subject to overfishing ($F>F_{MSY}$) and overfished, with the biomass for at least the past ten years is below the level which would produce MSY ($B<B_{MSY}$). On the weight-of-evidence available in 2018, the stock status of striped marlin is determined to be ***overfished*** and ***subject to overfishing*** (**Table 1**; **Fig. 2**)

Outlook. The decrease in longline catches and fishing effort in the years 2009–11 reduced the pressure on the Indian Ocean stock. However, given the increase in catches reported since 2011 (mostly from coastal fisheries), combined with the results obtained from the last stock assessments conducted in 2012, 2013, 2015, 2017 and 2018, the outlook is pessimistic. As requested by IOTC Resolution 18-05, K2SM probabilities are provided with options to reduce fishing mortality with a view to recover and/or maintain the stocks in the green zone of the Kobe Plot with levels of probability ranging from 60% to 90% by 2026 at latest (Table 2).

Management advice. Current or increasing catches have a very high risk of further decline in the stock status. Current 2017 catches (Fig. 1) are lower than MSY (4,730 t) but the stock has been overfished for more than two decades and is now in a highly depleted state. If the Commission wishes to recover the stock to the green quadrant of the Kobe plot with a probability ranging from 60% to 90% by 2026, then the maximum annual catches have to be set to between 1,500 t – 2,200 t (Table 3).

The following key points should also be noted:

- **Maximum Sustainable Yield (MSY)**: estimates for the Indian Ocean stock are highly uncertain and estimates range between 4,270 t – 5,180 t. However, the current biomass is well below the B_{MSY} reference point and fishing mortality is in excess of F_{MSY} at recent catch levels.
- **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 have been established for striped marlin.
- **Main fishing gear (average catches 2013-17)**: Striped marlin are largely considered to be a non-target species of industrial fisheries. Longlines account for around 66% of total catches in the Indian Ocean (or 56% according to the alternative low-case catch scenario) with remaining catches recorded gillnets, and troll and handlines (Figs. 1a-b).
- **Main fleets (average catches 2013-17):**
  (High-case catch scenario): Indonesia (drifting longline and coastal longline): 37%; Taiwan,China (drifting longline): 19%; I.R. Iran (gillnet): 16%; and Pakistan (gillnet): 8%.
  (Low-case catch scenario): Taiwan,China (drifting longline): 24%; Indonesia (drifting longline and coastal longline): 21%; I.R. Iran (gillnet): 20%; and Pakistan (gillnet): 10%.

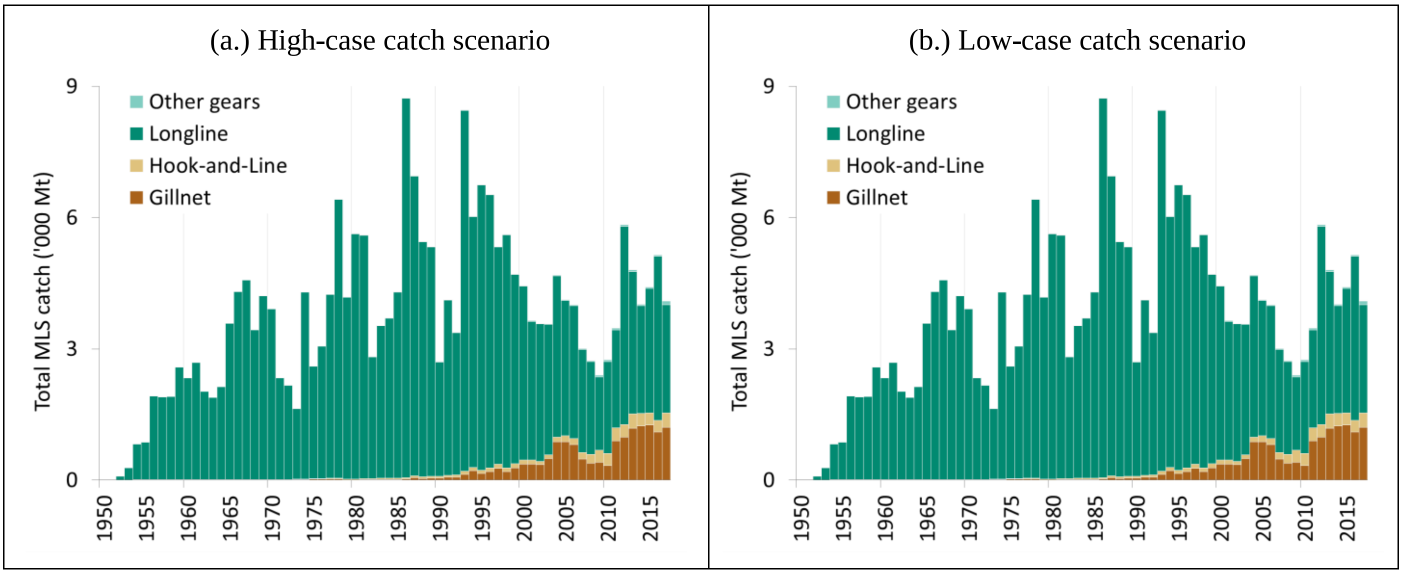


Fig. 1a-b. Striped marlin catches by gear and year recorded in the IOTC database (1950–2017):

- (Left): High-case catch scenario (IOTC-2018-WPB16-DATA03a): includes IOTC Secretariat revised catch estimates for Indonesian fresh tuna.
- (Right): Low-case catch scenario (IOTC-2018-WPB16-DATA03b): alternative catch series incorporating changes to IOTC Secretariat's methodology for estimating for Indonesia's fresh tuna longline catches;

***Notes**: Other gears (OT) includes: longline-gillnet, handline, gillnet, coastal longline, troll line, sport fishing, and all other gears.*

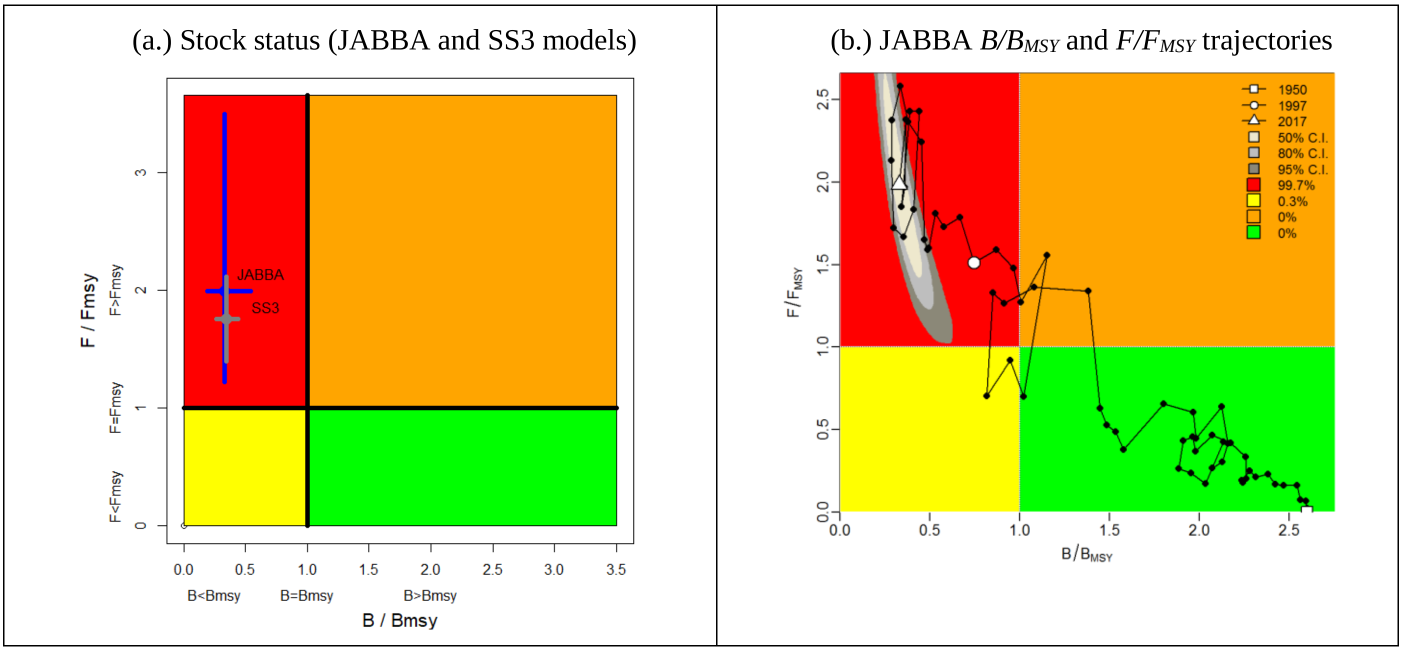


Fig. 2. (a): Striped marlin: Stock status from the Indian Ocean assessment JABBA (Bayesian State Space Surplus Production Model) and SS3 models with the confidence intervals (left); (b): Trajectories (1950-2017) of *B/B_{MSY} and F/F_{MSY}* from the JABBA model. NB: SS3 refers to SB/SB_{MSY} while the JABBA model correspond to B/B_{MSY}.

TABLE 2. Striped marlin: JABBA Indian Ocean assessment Kobe II Strategy Matrix. Probability (percentage) of violating the MSY-based target reference points for nine constant catch projections relative to the average 2015-2017 catch level (3,512 t)*, ± 10%, ± 20%, ± 30% ± 40%) projected for 3 and 10 years.

Reference point and projection timeframe	**Alternative catch projections (relative to the average catch level from 2015-2017* (3,512 t)) and probability (%) of violating MSY-based target reference points (SBtarg = SBMSY; Ftarg = FMSY)**								
	60% (2,107 t)	**70%** (2,459 t)	**80%** (2,810 t)	**90%** (3,161 t)	**100%** (3,512 t)	**110%** (3,864 t)	**120%** (4,215 t)	**130%** (4,566 t)	**140%** (4,917 t)
$SB_{2020} < SB_{MSY}$	99	100	100	100	100	100	100	100	100
$F_{2020} > F_{MSY}$	48	70	87	95	99	100	100	100	100
$SB_{2027} < SB_{MSY}$	25	43	64	81	92	97	99	100	100
$F_{2027} > F_{MSY}$	9	21	40	63	83	94	99	100	100

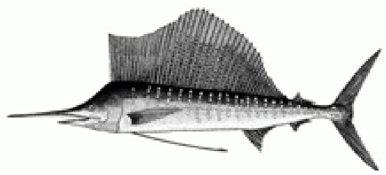
** 2015-2017 average catches, based on low catch scenario (IOTC-2018-WPB16-DATA03b).*

TABLE 3. Striped marlin: Probability (percentage) of achieving the KOBE green quadrat from 2018-2027 for a range of constant catch projections (JABBA).

TAC | Year	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
1500	0	0	2	11	29	51	70	83	90	94
1600	0	0	2	10	25	47	66	79	87	92
1700	0	0	2	8	23	42	61	75	84	90
1800	0	0	1	7	20	38	56	71	81	87
1900	0	0	1	6	17	34	52	66	77	84
2000	0	0	1	5	15	30	48	62	73	80
2100	0	0	1	4	13	26	42	56	68	76
2200	0	0	1	4	11	23	38	52	62	71
2300	0	0	1	3	9	20	33	46	57	66
2400	0	0	1	3	8	17	29	41	52	61
2500	0	0	1	3	7	15	25	36	47	55

APPENDIX X
[DRAFT] RESOURCE STOCK STATUS SUMMARY – INDO-PACIFIC SAILFISH

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



Status of the Indian Ocean Indo-Pacific sailfish (SFA: *Istiophorus platypterus*) resource

TABLE 1. Indo-Pacific sailfish: Status of Indo-Pacific sailfish (*Istiophorus platypterus*) in the Indian Ocean.

Area[1]	**Indicators**		**2018 stock status determination**
Indian Ocean	Catch 2017[2]:	33,280[3] t	
	Average catch 2013-2017:	29,873[3] t	
	MSY (1,000 t) (80% CI):	25.00 (16.18–35.17)	
	F_{MSY} (80% CI):	0.26 (0.15–0.39)	
	B_{MSY} (1,000 t) (80% CI):	87.52 (56.30–121.02)	
	$F_{current}/F_{MSY}$ (80% CI):	1.05 (0.63–1.63)	
	$B_{current}/B_{MSY}$ (80% CI):	1.13 (0.87–1.37)	
	$B_{current}/B_0$ (80% CI):	0.56 (0.44–0.67)	

[1] Boundaries for the Indian Ocean = IOTC area of competence.
[2] Proportion of catches estimated or partially estimated by IOTC Secretariat in 2018: 52%.
[3] Source: Nominal catches (IOTC-2018-WPB16-DATA03b).

Colour key	Stock overfished(B_{year}/B_{MSY}< 1)	Stock not overfished (B_{year}/B_{MSY}≥ 1)
Stock subject to overfishing(F_{year}/F_{MSY}> 1)		
Stock not subject to overfishing (F_{year}/F_{MSY}≤ 1)		
Not assessed/Uncertain		

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

Stock status. No new stock assessment was carried out for Indo-Pacific sailfish in 2018, thus, the stock status is determined on the basis of the 2015 assessment and other indicators presented in 2018. In 2015, data poor methods for stock assessment using Stock Reduction Analysis (SRA) techniques indicated that the stock is not yet overfished, but is subject to overfishing (**Table 1**). In addition, a Bayesian Surplus Production Model indicated that the stock could be severely overfished so this is a less pessimistic outlook on the stock status. The stock appears to show a continued increase catches which is a cause of concern (**Fig. 1**), indicating that fishing mortality levels may be becoming too high (**Fig. 2**). Aspects of the biology, productivity and fisheries for this species combined with the data poor status on which to base a more formal assessment are also a cause for concern. Research emphasis on further developing possible CPUE indicators from gillnet fisheries, and further exploration of stock assessment approaches for data poor fisheries are warranted. Given the limited data being reported for coastal gillnet fisheries, and the importance of sports fisheries for this species, efforts must be made to rectify these information gaps. The lack of catch records in the Persian Gulf should also be examined to evaluate the degree of localised depletion in Indian Ocean coastal areas. On the weight-of-evidence available in 2018, the stock is determined to be still **not overfished** but **subject to overfishing**.

Outlook. The estimated increase in coastal gillnet catch and effort in recent years is a substantial cause for concern for the Indian Ocean stock, however there is not sufficient information to evaluate the effect this will have on the resource. It is also noted that 2017 catches (34,891 t) exceed the catch limit prescribed in Resolution 18/05 (25,000 t).

Management advice. Resolution 18/05 prescribes a catch limit of 25,000t which is based on the management advice provided in 2017 (i.e., catches below MSY).

The following key points should also be noted:

- **Maximum Sustainable Yield (MSY):** estimate for the Indian Ocean stock is 25,000 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 have been established for I.P. sailfish.
- **Main fishing gear (average catches 2013-17)**: gillnets account for around 70% of total catches in the Indian Ocean, followed by troll and hand lines (21%), with remaining catches recorded under longlines and other gears (Fig. 1).
- **Main fleets (average catches 2013-17):** Three quarters of the total catches of Indo-Pacific sailfish are accounted for by four countries situated in the Arabian Sea: I.R. Iran (gillnets): 31%; India (gillnets and trolling): 19%; Pakistan (gillnets): 16%; and Sri Lanka (gillnets and fresh longline): 9%.

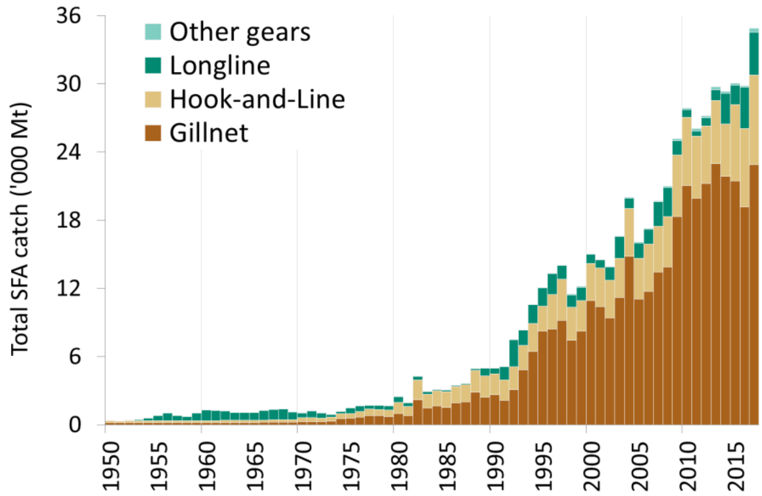


Fig. 1. Indo-Pacific sailfish: catches by gear and year recorded in the IOTC Database (1950–2017).
Notes: *Other gears (OT) includes: longline-gillnet, handline, gillnet, coastal longline, troll line, sport fishing, and all other gears*

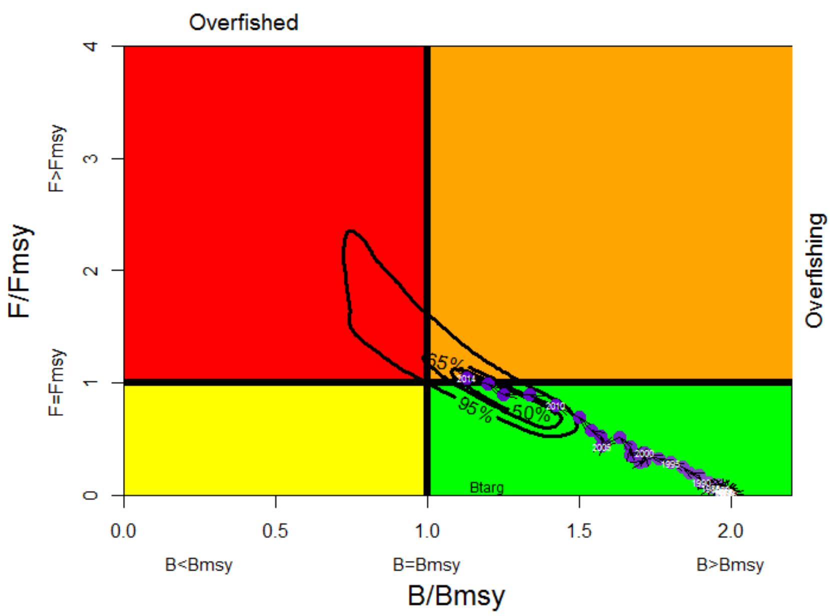


Fig.2. Indo-Pacific sailfish: Stock reduction analysis (Catch MSY Method) of aggregated Indian Ocean assessment Kobe plot (contours are the 50, 65 and 90 percentiles of the 2014 estimate). Black lines indicate the trajectory of the point estimates (blue circles) for the B ratio and F ratio for each year 1950–2014.

Table 2. Indo-Pacific sailfish: Indian Ocean stock reduction analysis Kobe II Strategy Matrix.Probability (percentage) of violating the MSY-based reference points for nine constant catch projections (relative to the average catch levels from 2012–2014 (29,164 t)*, ± 10%, ± 20%, ± 30% ± 40%) projected for 3 and 10 years.

Reference point and projection timeframe	**Alternative catch projections (relative to the average catch level from 2012–14* (29,164 t) and probability (%) of violating MSY-based reference points**								
	60%	**70%**	**80%**	**90%**	**100%**	**110%**	**120%**	**130%**	**140%**
	17,498 t	20,415 t	23,331 t	26,248 t	29,164 t	32,080 t	34,997 t	37,913 t	40,830 t
$B_{2017}<B_{MSY}$	10	15	20	25	30	35	41	47	53
$F_{2017}>F_{MSY}$	16	27	38	49	61	72	83	94	99
$B_{2024}<B_{MSY}$	6	16	28	41	55	68	81	91	97
$F_{2024}>F_{MSY}$	12	23	36	52	68	84	97	100	100

** Average catches for 2012-2014 at the time of the last I.P. sailfish assessment conducted in 2015.*

APPENDIX XI
WORKING PARTY ON BILLFISH PROGRAM OF WORK (2019–2023)

The Program of Work consists of the following, noting that a timeline for implementation would be developed by the SC once it has agreed to the priority projects across all of its Working Parties:

- **Table 1**: High priority topics for obtaining the information necessary to develop stock status indicators for billfish in the Indian Ocean; and
- **Table 2**: Stock assessment schedule.

Table 1. Priority topics for obtaining the information necessary to develop stock status indicators for billfish in the Indian Ocean

Topic	Sub-topic and project	Priority ranking	Est. budget and/or potential source	Timing				
				2019	2020	2021	2022	2023
1. Stock structure (connectivity and diversity)	1.1 Genetic research to determine the connectivity of billfish throughout their distribution (including in adjacent Pacific and Atlantic waters as appropriate) and the effective population size.		1.3 m Euro: (European Union)					
	1.1.1 Next Generation Sequencing (NGS) and nuclear markers (i.e. microsatellites) to determine the degree of shared stocks for billfish within the Indian Ocean and with the southern Atlantic Ocean and Pacific Ocean, as appropriate. Population genetic analyses to decipher inter- and intraspecific evolutionary relationships, levels of gene flow (genetic exchange rate), genetic divergence, and effective population sizes. Highest priority species: blue, black, striped marlin and sailfish.	High (15)						
	1.1.2 Initiate discussion (e.g., small workshop for CSIRO or request to present results in WPB) on the possibility to develop a close-kin mark recapture method (see *Bravington et al.* 2016) on marlins to estimates population size and other important demographic parameters..	High (14)						

		1.2 Tagging research (PSAT tags) to determine connectivity, movement rates and mortality estimates of billfish (Priority species: swordfish).	High (1)	US$400,000					
2.	Biological and ecological information (incl. parameters for stock assessment and provide answers to the Commission)	2.1 Age and growth research	High (2)						
		2.1.1 CPCs to provide further research on billfish biology, namely age and growth studies including through the use of fish otolith or other hard parts, either from data collected through observer programs, port sampling or other research programs. (Priority: all billfishes: swordfish, marlins and sailfish)		(CPCs: age & growth study = 50,000)					
		2.2 Reproductive biology study	High (3)						
		2.2.1 CPCs to conduct reproductive biology studies, which are necessary for billfish throughout its range to determine key biological parameters including length-at-maturity, age-at-maturity and fecundity-at-age, which will be fed into future stock assessments, as well as provide advice to the Commission on the established Minimum Retention Sizes (<u>Res 18-05, paragraphs 5 and 14c</u>). (Priority: marlins and sailfish)		(CPCs: Maturity study = 30,000)					
		2.3 Spawning time and locations	High (4)						
		2.3.1 Collect gonad samples from billfish to confirm the spawning time and location of the spawning area that are presently hypothesized for each billfish species. This will also provide advice to the Commission on the request for alternative management measures (<u>Res. 18-05, paragraph 6</u>)		(CPCs: Spawning study =30,000)					
3.	Historical data review	3.1 Changes in fleet dynamics							
		3.1.1 Continue the work with coastal countries to address recent changes and/or increases of marlins catches especially in some coastal fleets. The historical review should include as much explanatory information as possible 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 and very high increases in some species (e.g., black marlin mainly due to very high catches reported by India in recent years). Priority countries: India, Pakistan, Iran, I.R., Indonesia.	High (5)	WPDCS					

	3.2 Species identification		
	3.2.1 The quality of the data available at the IOTC Secretariat on marlins (by species) is likely to be compromised by species miss-identification. Thus, CPCs should review their historical data in order to identify, report and correct (if possible) potential identification problems that are detrimental to any analysis of the status of the stocks.	High (6)	(CPCs directly)
4. CPUE standardization	4.1 Develop and/or revise standardized CPUE series for each billfish species and major fisheries/fleets for the Indian Ocean.		
	4.1.1 Swordfish: Priority LL fleets: Taiwan,China, EU(Spain, Portugal, France), Japan, Indonesia	High (12)	(CPCs directly)
	4.1.2 Striped marlin: Priority fleets: Japan, Taiwan,China	High (13)	(CPCs directly)
	4.1.3 Black marlin: Priority fleets: Longline: Taiwan,China; Gillnet: I.R. Iran, Sri Lanka	High (10)	(CPCs directly)
	4.1.4 Blue marlin: Priority fleets: Japan, Taiwan,China	High (11)	(CPCs directly)
	4.1.5 I.P. Sailfish: Priority fleets: Priority gillnet fleets: I.R. Iran and Sri Lanka; Priority longline fleets: EU(Spain, Portugal, France), Japan, Indonesia;	High (9)	(CPCs directly)
	4.1.6 Joint analysis of operational catch and effort data from Indian Ocean longline fleets as recommended by WPM	High (8)	Consultant/ US$40K
5. Stock assessment / Stock indicators	5.1 Workshops on techniques for assessment including CPUE estimations for billfish species in 2019 and 2020. Priority fleets: Gillnet fisheries	High (7)	Consultant US$11,750
6 Target and Limit reference points	6.1 To advise the Commission, by end of 2016 at the latest on Target Reference Points (TRPs) and Limit Reference Points (LRPs).	High (16)	
	6.1.1.Assessment of the interim reference points as well as alternatives: Used when assessing the Swordfish stock status and when establishing the Kobe plot and Kobe matrices.		WPM
7 Management measure options	7.1 To advise the Commission, on potential management measures having been examined through the Management Strategy Evaluation (MSE) process.	High (17)	

	7.1.1 These management measures will therefore have to ensure the achievement of the conservation and optimal utilization of stocks as laid down in article V of the Agreement for the establishment of the IOTC and more particularly to ensure that, in as short a period as possible and no later than 2020, (i) the fishing mortality rate does not exceed the fishing mortality rate allowing the stock to deliver MSY and (ii) the spawning biomass is maintained at or above its MSY level.	WPM					

Table 2. Assessment schedule for the IOTC Working Party on Billfish (WPB)

Species	2019	2020	2021	2022	2023
Black marlin			**Full assessment**		
Blue marlin	**Full assessment**			**Full assessment**	
Striped marlin			**Full assessment**		
Swordfish	**Indicators**	**Full assessment**		**Indicators**	**Full assessment**
Indo-Pacific sailfish	**Full assessment***			**Full assessment***	

*Including data poor stock assessment methods; Note: the assessment schedule may be changed depending on the annual review of fishery indicators, or SC and Commission requests.

APPENDIX XII
CONSOLIDATED RECOMMENDATIONS OF THE 16TH SESSION OF THE WORKING PARTY ON BILLFISH

Note: Appendix references refer to the Report of the 16th Session of the Working Party on Billfish (IOTC–2018–WPB16–R)

WPB 16.01 (para 9.): **RECALLING** that one of the Indian Ocean billfish species (shortbill spearfish, Tetrapturus angustirostris) is currently not listed among the species managed by IOTC, and considering the ocean-wide distribution of this species, its highly-migratory nature, and that it is a common bycatch in IOTC managed fisheries, the WPB reiterated it's previous **RECOMMENDATION** that the Scientific Committee consider requesting the Commission to include it in the list of species to be managed by the IOTC.

Genetic population structure for striped marlin

WPB 16.02 (para 61.): The WPB **NOTED** the low sample sizes of marlins (i.e., zero samples for striped marlin) in phase 1 sampling of the IOTC stock structure project and RECOMMENDED that marlins are prioritized in phase 2 in order to resolve the stock structure uncertainty for this species.

Revision of the WPB Program of work (2019–2023)

WPB 16.03 (para 139.): The WPB **RECOMMENDED** that the SC consider and endorse the WPB Program of Work (2019–2023), as provided at Appendix XI.

Review of the draft, and adoption of the Report of the 16th Session of the Working Party on Billfish

WPB16.04 (para. 146): The WPB **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPB16, provided at Appendix XII, as well as the management advice provided in the draft resource stock status summary for each of the five billfish species under the IOTC mandate, and the combined Kobe plot for the five species assigned a stock status in 2018 (Fig. 9):

- Swordfish (*Xiphias gladius*)– Appendix VI
- Black marlin (*Makaira indica*) – Appendix VII
- Blue marlin (*Makaira nigricans*) – Appendix VIII
- Striped marlin (*Tetrapturus audax*) – Appendix IX
- Indo-Pacific sailfish (*Istiophorus platypterus*) – Appendix X

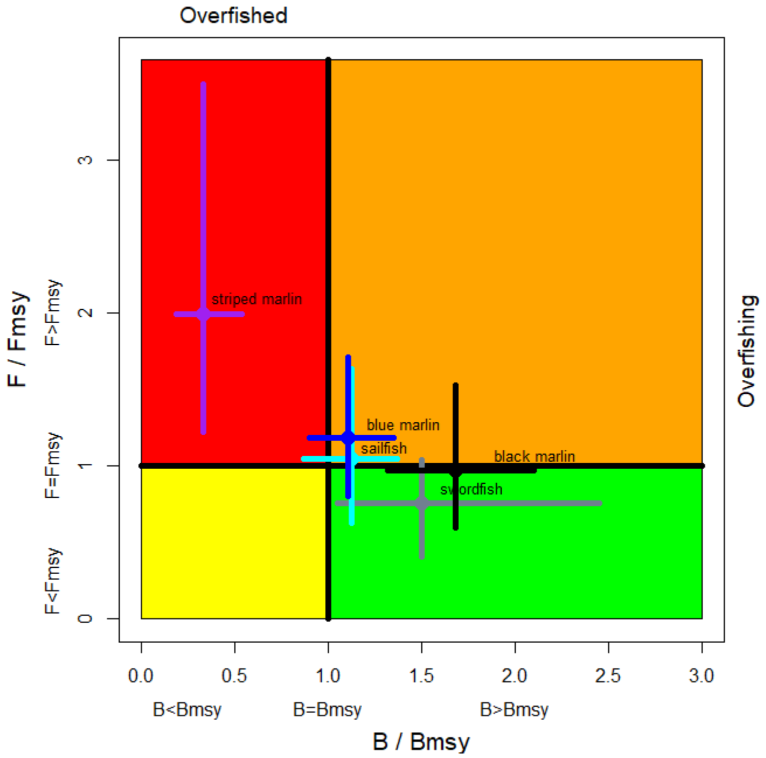


Fig. 9. Combined Kobe plot for swordfish (grey), indo-pacific sailfish (cyan), black marlin (black), blue marlin (blue) and striped marlin (purple) showing the 2016, 2017, and 2018 estimates of current stock size (SB or B, species assessment dependent) and current fishing mortality (F) in relation to optimal spawning stock size and optimal fishing mortality. Cross bars illustrate the range of uncertainty from the model runs.