Report of the 15th Session of the IOTC Working Party on Billfish

San Sebastian, Spain, 10–14 September 2017

DISTRIBUTION:

Participants in the Session
Members of the Commission
Other interested Nations and International Organizations
FAO Fisheries Department
FAO Regional Fishery Officers

BIBLIOGRAPHIC ENTRY

IOTC–WPB15 2017. Report of the 15th Session of the IOTC Working Party on Billfish. San Sebastian, Spain, 2017.
IOTC–2017–WPB15–R[E]: 106 pp.

Contact details:

Indian Ocean Tuna Commission
Le Chantier Mall
PO Box 1011
Victoria, Mahé, Seychelles
Ph: +248 4225 494
Fax: +248 4224 364
Email: IOTC-secretariat@fao.org
Website: http://www.iotc.org

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
LL	Longline
M	Natural Mortality
MSY	Maximum sustainable yield
n.a.	Not applicable
NGO	Non-governmental organization
PS	Purse-seine
q	Catchability
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**).

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The 15th Session of the Indian Ocean Tuna Commission's (IOTC) Working Party on Billfish (WPB) was held in San Sebastian, Spain, from 10 to 14 September 2017. A total of 25 participants (18 in 2016) attended the Session. The meeting was opened on the 10th of September 2017 by the Chairperson, Dr Tsutomu Nishida (Japan), who welcomed participants to San Sebastian.

The following are a subset of the complete recommendations from the WPB15 to the Scientific Committee, which are provided at Appendix XII.

Billfish species identification

WPB15.01 (para. 17): The WPB **AGREED** on the importance of the hard, waterproof copies of the IOTC species identification guides for observers and port samplers, and again **RECOMMENDED** that funds are allocated for further printing of the species ID guides for distribution to sports fishing clubs and recreational fisheries to improve the quality of data reported, and that additional funds be provided for the translation of these into the priority languages identified by the SC.

Review of the statistical data available for billfish

WPB15.02 (para. 35): (…) the WPB **RECOMMENDED** that Indonesia and the IOTC Secretariat closely liaise in the future to ensure that the current estimation process of Indonesian catches is properly documented and improved - if needed - in order to ensure that only the best scientific estimates are made available to scientists.

New information on sport fisheries

WPB15.03 (para. 62): The WPB **NOTED** that the pilot project is still ongoing and will be completed by October 2017, and **RECOMMENDED** that results and outcomes of its first phase be evaluated by the SC prior to the possible implementation of a second phase.

Swordfish: Grid-rNTP model

WPB15.05 (para. 108): The WPB **NOTED** that the uncertainty regarding the regional rescaling factor is difficult to fully evaluate in a single stock assessment, and **RECOMMENDED** that this is more formally addressed using a structured approach within a Management Strategy Evaluation framework.

Revision of the WPB Program of work (2018–2022)

WPB15.06 (para. 216): The WPB **RECOMMENDED** that future work continues on the marlins stock assessment in order to improve current models and other approaches such as delay-difference or age-structured production models are explored. Therefore the WPB **AGREED** that its plan of work be intersessionally amended for the consideration of the SC and a consultant be hired to further explore the data and models.

WPB15.07 (para. 217): The WPB **RECOMMENDED** that the SC consider and endorse the WPB Program of Work (2018–2022), as provided at Appendix XI.

Review of the draft, and adoption of the Report of the 15th Session of the Working Party on Billfish

WPB15.08 (para. 229): The WPB **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPB15, 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 2017 (Fig. 15):

- 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

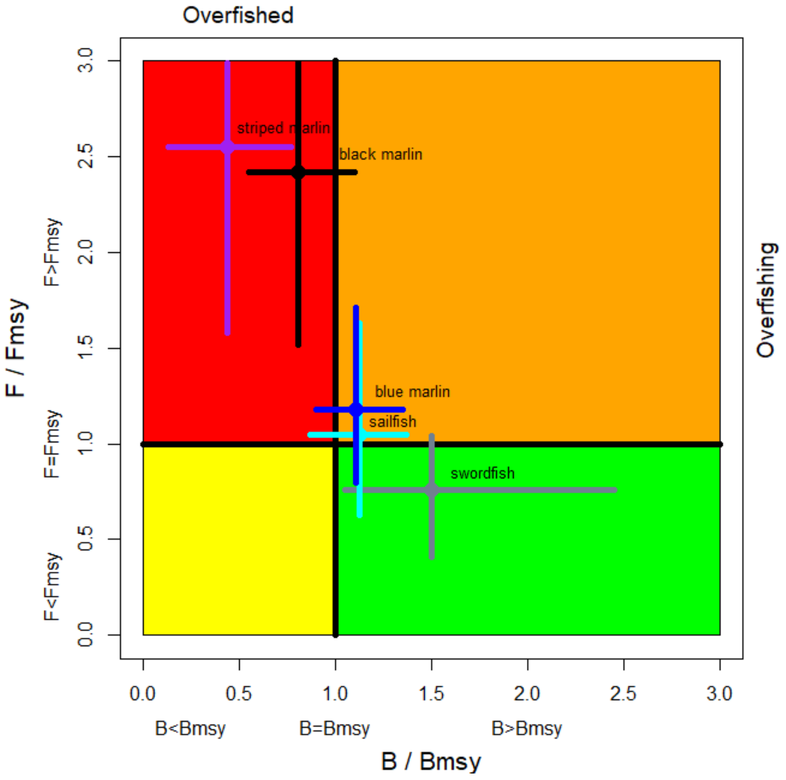


Fig. 15. Combined Kobe plot for swordfish (grey), indo-pacific sailfish (cyan), black marlin (black), blue marlin (blue) and striped marlin (purple) showing the 2016 and 2017 estimates of current stock size (SB or B, species assessment dependent) and current fishing mortality (F) in relation to optimal 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	Prev[1]	2012	2013	2014	2015	2016	2017	Advice to the Scientific Committee
Swordfish *Xiphias gladius*	Catch 2015: 32,129[a] (39,667[b]) t Average catch 2011–2015: 28,490[a] (31,463[b]) t MSY (1,000 t) (80% CI): 31.59[a] (26.30–45.50) F_{MSY} (1,000 t) (80% CI): 0.17[a] (0.12–0.23) SB_{MSY} (80% CI): 43.69[a] (25.27–67.92) F_{2015}/F_{MSY} (80% CI): 0.76[a] (0.41–1.04) SB_{2015}/SB_{MSY} (80% CI): 1.50[a] (1.05–2.45) SB_{2015}/SB_{1950} (80% CI): 0.31[a] (0.26–0.43) a. Indonesian fresh tuna longline catch assumed to be the same as in 2011–2014 b. Indonesian fresh tuna longline catch estimated using species composition from the Taiwanese fresh tuna longline in the same years	2011							A new assessment was undertaken in 2017 using stock synthesis with fisheries 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 as a whole (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. Catches in the last two years has remained similar to the previous two years, although there are some uncertainties in the catch estimates from the Indonesian fresh tuna longline (Fig. 1). Most recent catches of 32,129 t in 2015[a] are 540 t above the MSY level (31,590 t). On the weight-of-evidence available in 2017, the stock is determined to be ***not overfished*** and ***not subject to overfishing***. **Management advice:** the most recent catches in 2015 (32,129[a] t) are 539 t above the MSY level (31,590 t). Hence catches in 2018 should be reduced to MSY (31,590 t) or lower. However, given the uncertainty of most recent catches from Indonesian fresh tuna longline fisheries, more concrete advice should be developed after the next updated stock assessment scheduled in 2020. Click here for full stock status summary: Appendix VI
Black marlin *Makaira indica*	Catch 2015: 18,954 t Average catch 2011–2015: 15,397 t MSY (1000 t) (80% CI): 9.932 (6.963–12.153) F_{MSY} (80% CI): 0.211 (0.089–0.430) B_{MSY} (1000 t) (80% CI): 47.430 (27.435-100.109) F_{2015}/F_{MSY} (80% CI): 2.42 (1.52–4.06) B_{2015}/B_{MSY} (80% CI): 0.81 (0.55–1.10) B_{2015}/B_{1950} (80% CI): 0.30 (0.20–0.41)								In 2016, a BSP-SS stock assessment suggests that the stock in 2015 is in the red zone of the Kobe plot with F/F_{MSY}=2.42 and TB/TB_{MSY}=0.81. Another approach by ASPIC examined in 2016 came to similar conclusions. The Kobe plot from the BSP-SS model indicated that the stock has been ***subject to overfishing*** and ***overfished*** in recent years. **Management advice:** the current catches (17,373 t) (2013-2015 average) are considerably higher than MSY (9,932 t) and the stock is overfished and currently subject to overfishing. Even with a 40% reduction in current catches, it is very unlikely (less than 5%) to achieve the Commission objectives of being

									in the green zone of the Kobe Plot by 2025. Current catch levels are not sustainable and there is a need for urgent actions to decrease this catch levels. Click here for full stock status summary: Appendix VII
Blue marlin *Makaira nigricans*	Catch 2015: 15,482 t Average catch 2011–2015: 14,799 t MSY (1000 t) (80% CI): 11.926 (9.232-16.149) F_{MSY} (80% CI): 0.109 (0.076-0.160) B_{MSY} (1,000 t) (80% CI): 113.012 (71.721-161.946) F_{2015}/F_{MSY} (80% CI): 1.18 (0.80–1.71) B_{2015}/B_{MSY} (80% CI): 1.11 (0.90–1.35) B_{2015}/B_{1950} (80% CI): 0.56 (0.44-0.71)								In 2016, a BSP-SS stock assessment suggests that the stock in 2015 is in the orange zone of the Kobe plot and both F and TB are close to their MSYs, i.e., F/F_{MSY}=1.18 and TB/TB_{MSY}=1.11. Two other approaches examined in 2016 came to similar conclusions, namely ASPIC and SS3. The Kobe plot from the BSP-SS model indicated that the stock has been ***subject to overfishing*** but ***not overfished*** in recent years, while the stock biomass is slightly above the BMSY level. **Management advice:** the current catches (14,799 t) (2011-2015 average) are higher than MSY (11,926 t) and the stock is currently being overfished. In order to achieve the Commission objectives of being in the green zone of the Kobe Plot by 2025 with at least a 50% chance, the catches would have to be reduced by 24% compared to the average of the last 3 years, to a maximum value of 11,643 t. Click here for full stock status summary: Appendix VIII
Striped marlin *Tetrapturus audax*	Catch 2015: 4,369 t Average catch 2011–2015: 4,472 t MSY (1,000 t) (Range): (3.27–5.40) F_{MSY} (Range): (0.05–0.90) B_{MSY} (1,000 t) (Range): (1.82–34.3) F_{2015}/F_{MSY} (Range): (1.32–3.04) B_{2015}/B_{MSY} (Range): (0.24–0.62) B_{2015}/B_{1950} (Range): (0.09.–0.32)								A new stock assessment for striped marlin was carried out in 2017, based on four different models, specifically a data-limited catch only method (SRA - stock reduction analysis), two production models (ASPIC without process error and SSBSP, a Bayesian approach with process error) and SS3 (Stock Synthesis, an integrated length-based model). The ASPIC assessment confirmed the results from 2012, 2013 and 2015 that indicated the stock is subject to overfishing ($F>F_{MSY}$) and that biomass is below the level which would produce MSY ($B<B_{MSY}$). The other models examined in 2017 came to similar conclusions. All models were consistent in 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. In 2015 reported catches increased to 4,369 t. On the weight-of-evidence available in 2017, 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 maintain the stock overfished. In order to enable the stock to start rebuilding, the Commission should consider a drastic reduction of catch level*s* Click here for full stock status summary: Appendix IX

Indo-Pacific Sailfish *Istiophorus platypterus*	Catch 2015: 29,311 t Average catch 2011–2015: 28,689 t MSY (1,000 t) (80% CI): 25.00 (17.20–36.30) F_{MSY} (80% CI): 0.26 (0.15–0.39) B_{MSY} (1,000 t) (80% CI): 87.52 (56.30–121.02) F_{2014}/F_{MSY} (80% CI): 1.05 (0.63–1.63) B_{2014}/B_{MSY} (80% CI): 1.13 (0.87–1.37) B_{2014}/B_{1950} (80% CI): 0.57 (0.44–0.69)								In 2015, data poor methods for stock assessment using Stock reduction analysis (SRA) techniques indicate that the stock is not yet overfished, but is subject to overfishing. Records of stock extirpation in the Gulf should also be examined to determine the degree of localised depletion in Indian Ocean coastal areas. On the weight-of-evidence available in 2017, the stock is still determined to be ***not overfished*** but ***subject to overfishing***. **Management advise:** the same management advice for 2017 (catches below MSY, 25,000 t) is kept for the next year (2018). Click here for full stock status summary: Appendix X

[1.] This indicates the last year taken into account for assessments carried out before 2012

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 15th Session of the Indian Ocean Tuna Commission's (IOTC) Working Party on Billfish (WPB) was held in San Sebastian, Spain, from 10 to 14 September 2017. A total of 25 participants (18 in 2016) attended the Session. The list of participants is provided at Appendix I. The meeting was opened by the Chairperson, Dr Tsutomu Nishida (Japan), who welcomed participants to San Sebastian. The Chairperson also welcomed the Invited Expert for the meeting, Dr Toshihide Kitakado (Tokyo University of Marine Science and Technology, Japan) and the stock assessment consultant Dr Humber Andrade (URFPE, Brazil).

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 WPB15 are listed in Appendix III.

3. The IOTC process: Outcomes, updates and progress

3.1 Outcomes of the 19th Session of the Scientific Committee

3. The WPB **NOTED** paper IOTC–2017–WPB15–03 which describes the main outcomes of the 19th Session of the Scientific Committee (SC19), specifically related to the work of the WPB.

> ***Acquisition of data from sports fisheries***
>
> *The SC **NOTED** that the IOTC Secretariat is currently implementing a pilot project to improve the acquisition of catch- and-effort and size data from sports and recreational fisheries in the western Indian Ocean in four CPCs (Kenya, EU,France (La Réunion), Mauritius and Seychelles), and that the ABF has been hired to assist delivery of the Project. A full update of the outcomes of the Project will be delivered during the 2017 Working Party on Billfish. (para. 45 of IOTC-2016-SC19-R)*

4. The WPB **NOTED** that the pilot project for the acquisition of data from sports fisheries has been started and progress will be provided as part of the report to this meeting (see paper IOTC–2017–WPB15–13_Rev1)

5. The WPB **NOTED** the interpretation of Resolution 15/05 from the SC.

> ***Review of the statistical data available for billfish***
>
> *The SC further **NOTED** that many CPCs important for catches of billfish species do not submit to the Secretariat nominal catch data or catch-and-effort, particularly in the case of black marlin and Indo-Pacific sailfish. For those two species, the assessments currently only use data covering less than 15% of the estimated nominal catches. Therefore the SC strongly **REQUESTED** CPCs to fully comply with the data reporting standards of Resolutions 15/01 and 15/02. (para. 49 of IOTC-2016-SC19-R)*
>
> ***Resolution 15/05***
>
> *The SC **NOTED** that the WPB report considers that Resolution 15/05 established a catch limit for billfish, however, the SC **NOTED** that Resolution 15/05 only encourages catch restrictions:*
>
> *"Contracting Parties and Cooperating Non-Contracting Parties (CPCs) to make any possible effort to reduce in 2016 the level of catches of their vessels for the following species: striped marlin (Tetrapturus audax), black marlin (Makaira indica), and blue marlin (Makaira nigricans) to the baseline level of the average catches for the period between 2009 and 2014 " and that this cannot be considered a catch limit. (para. 47 of IOTC-2016-SC19-R)*

6. The WPB **ACKNOWLEDGED** the reiterated request from the SC for full compliance with Resolutions 15/01 and 15/02 and **REQUESTED** that all involved CPCs take immediate action to overcome any possible issue preventing a timely and complete reporting of all mandatory data to the Secretariat.

3.2 Outcomes of the 21st Session of the Commission

7. The WPB **NOTED** paper IOTC–2017–WPB15–04 which provided the main outcomes of the 21st 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.

8. The WPB **NOTED** the 8 Conservation and Management Measures (CMMs) adopted at the 21st Session of the Commission (consisting of 8 Resolutions and 0 Recommendations) as listed below:

IOTC Resolutions

- Resolution 17/01 *On an interim plan for rebuilding the Indian Ocean yellowfin tuna stock in the IOTC Area of Competence*
- Resolution 17/02 *Working party on the implementation of Conservation and Management Measures (WPICMM).*
- Resolution 17/03 *On establishing a list of vessels presumed to have carried out illegal, unreported and unregulated fishing in the IOTC Area of competence.*
- Resolution 17/04 *On a ban on discards of Bigeye tuna, Skipjack tuna, Yellowfin tuna, and non-targeted species caught by purse seine vessels in the IOTC Area of Competence*
- Resolution 17/05 *On the conservation of sharks caught in association with fisheries managed by the IOTC.*
- Resolution 17/06 *On establishing a programme for transhipment by large-scale fishing vessels*
- Resolution 17/07 *On the prohibition to use large-scale driftnets in the IOTC Area*
- Resolution 17/08 *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 designs to reduce the incidence of entanglement of non-target species*

9. 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 in IOTC Circular 2017–061 (i.e. 3 October 2017).

10. Participants to WPB15 were **ENCOURAGED** to familiarise themselves with the adopted Resolutions, especially those most relevant to the WPB.

11. The WPB **NOTED** that the Commission also made a number of general comments and requests on the recommendations made by the Scientific Committee in 2016, which have relevance for the WPB (details as follows: paragraph numbers refer to the report of the Commission - IOTC–2017–S21–R).

    *The Commission **CONSIDERED** the list of recommendations made by the SC19 in 2016 (IOTC–2016–SC19–R) that related specifically to the Commission. The Commission **ENDORSED** the list of recommendations as its own, while taking into account the range of issues outlined in this Report (IOTC-2017-S21-R) and incorporated within Conservation and Management Measures adopted during the Session and as adopted for implementation as detailed in the approved annual budget and Program of Work (para. 22 of the S21 report).*

    Consideration of management measures related to Billfish

    The Commission noted that IOTC–2017–S21–PropJ On the conservation and management of IOTC Billfish was withdrawn. There was only limited agreement with this proposal, even after a gear or management-based approach was explored. Some CPCs highlighted that implementation and effectiveness of this measure could be limited due to billfish being taken as bycatch by many CPCs; furthermore some billfish species are difficult to identify. Some CPCs expressed their concern that the proposal could set an unacceptable precedent for allocation by seeking to cap catches. (para. 41 of the S21 report).

12. 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

13. The WPB **NOTED** paper IOTC–2017–WPB15–05 which aimed to encourage participants at the WPB15 to review some of the existing Conservation and Management Measures (CMM) relevant to billfish, noting the CMMs referred to in document IOTC–2017–WPB15–04, 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.

14. The WPB **NOTED** the reasons given for the withdrawal of IOTC–2017–S21–PropJ *On the conservation and management of IOTC Billfish* at the Commission meeting in May 2017 and **AGREED** to formulate new advice for the management of billfish species this year, in particular for black marlin.

3.4 Progress on the recommendations of WPB14 and SC19

15. The WPB **NOTED** paper IOTC–2017–WPB15–06 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.

16. 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, and 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.

Billfish species identification

17. The WPB **AGREED** on the importance of the hard, waterproof copies of the IOTC species identification guides for observers and port samplers, and again **RECOMMENDED** that funds are allocated for further printing of the species ID guides for distribution to sports fishing clubs and recreational fisheries to improve the quality of data reported, and that additional funds be provided for the translation of these into the priority languages identified by the SC.

18. 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.

Sports fisheries

19. The WPB **NOTED** that Sri Lanka is in the process of regulating the recreational fisheries sector and **ACKNOWLEDGED** that this might eventually contribute to the improvement of the information collected for this fishery.

20. The WPB **NOTED** the updates on the status of the sports fishery sector in Seychelles, **ACKNOWLEDGING** the challenges posed by the current regulations under the direct responsibility of the Ministry of Tourism as well as the changes in fisheries legislation since 2014.

21. At the same time the WPB **ACKNOWLEDGED** the involvement of multiple stakeholders in the process of regulating the sector, and **REQUESTED** that proper initiatives are put in place to create and / or increase awareness on this topic.

Stock structure project

22. The WPB **ACKNOWLEDGED** that a formal agreement with FAO for the implementation and commencement of the project was made in January 2017, and also **NOTED** that various sampling collection activities have already started.

23. 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.

I.R. Iran billfish fishery

24. The WPB **ACKNOWLEDGED** that while catch data is provided according to the format specified in Resolution 15/02, there still are difficulties in providing monthly effort breakdown and therefore **REQUESTED** that I.R. Iran continues to closely work with the IOTC Secretariat to make every possible effort to improve the assessment of the areas and times fished by its fishery.

Kenyan sports fishery

25. The WPB **NOTED** that a data compliance and support mission to Kenya was completed during the early days of the meeting, and **ACKNOWLEDGED** that any updates to the status of the historical data for Kenyan sports fisheries - as collected during the mission - will eventually be incorporated within the IOTC database and reported back at the next session of the meeting.

African billfish foundation

26. 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.

Nominal and standardized CPUE indices - swordfish

27. 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.

Billfish bycatch in the French purse-seine fishery

28. The WPB **ACKNOWLEDGED** that the IOTC form for the collection and reporting of Nominal Catch statistics has been amended with the inclusion of a dedicated field for the reporting of the type of retained catch (landed, used for crew consumption or as bait, etc.) although this has not been formally shared with the CPCs, and **ENCOURAGED** the IOTC Secretariat to disseminate the new version of the form at its earliest convenience, **REQUESTING** reporting countries to familiarise with the new proposed standards.

Indonesia longline CPUE

29. The WPB **NOTED** that no progress on the inclusion of environmental variables in the model has been reported by Indonesia, and **ACKNOWLEDGED** that additional information will possibly be provided next year.

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

4.1 Review of the statistical data available for billfish

30. The WPB **NOTED** paper IOTC–2017–WPB15–07 which summarised 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 1950–2015. 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.

31. 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.

32. The WPB also **NOTED** the marked increase in Swordfish catches reported for 2014 and 2015 and **ACKNOWLEDGED** that this is a consequence of the estimation process put in place by the Secretariat, following a previous study[1] that suggested the estimation of Indonesian fresh and deep-freezing longline catches should be based on the species composition of catches of Taiwanese longliners vessels of the same type operating in the Eastern Indian Ocean.

33. The WPB was informed by the Indonesian scientist that there is no explicit evidence - from observer data - of the estimated increase in swordfish catches by Indonesian longliners in the last two years as derived from the catch ratio of Swordfish by Taiwanese longliners. Therefore, the WPB **AGREED** to rescale Indonesia fresh longline Swordfish catches for the last two years to the average of 2011 to 2013 catches and to use this estimation in the stock assessment.

34. At the same time, the WPB **ACKNOWLEDGED** that the current estimation process is not affecting the total yearly catches as officially reported by Indonesia, but it is affecting the species composition for some of the reported fisheries and therefore affects species-specific catches.

---

[1] *Report and documentation of the Indian Ocean Tuna Fisheries of Indonesia Albacore Catch Estimation Workshop: Review of Issues and Considerations* - Bogor, 21 June 2013 / Jakarta, 24-25 June 2013, IOTC CIRCULAR 2013–96 / CIRCULAIRE CTOI 2013–96

35. For this reason, the WPB **RECOMMENDED** that Indonesia and the IOTC Secretariat closely liaise in the future to ensure that the current estimation process of Indonesian catches is properly documented and improved - if needed - in order to ensure that only the best scientific estimates are made available to scientists.

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 and therefore **REQUESTED** that further analysis are performed to analyse the reason for these discrepancies and ensure that the available data could effectively be used for stock assessment purposes.

37. 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.

4.2 Review new information on fisheries and associated environmental data

I.R. Iran billfish fishery

38. The WPB **NOTED** paper IOTC–2017–WPB15–09 which outlined the billfish gillnet fishery in the I.R. Iran, including the following abstract provided by the authors:

> *"This paper reviews the landings of billfish made in large pelagic fisheries during the period 2012-2016. The annual production of large pelagic fishes in Iran was 274,500 Mt in 2016, which 234,000Mt belongs to tuna and tuna-like fishes in IOTC area competency. Although there is no target fishery for billfish, they are considered as by-catch species, it makes up to 5.4% of the total large pelagic landings in Iran. The Sailfish dominated the billfish catch with 7,809Mt, followed by Marlins about 6,145Mt, and Swordfish 887Mt. Although there is no target fishery for billfish, they are considered as by- catch species and according our regulation for Tuna species fishing, no part of billfish catch will be discarded by vessels."* (see paper for full abstract)

39. The WPB **NOTED** that Iran has already submitted to the IOTC Secretariat the number of boats by gross tonnage categories aiming to estimate the carrying capacity of each boat categories for the recent years.

40. The WPB **NOTED** that 94% of Iran pelagic species catch is made by gillnetters, and that billfish represent on average 6% of gillnet catch (14,841 Mt in 2016) with sailfish being the most common billfish with more than 50% for the last 5 years.

41. The WPB **NOTED** an important increase of billfish landings between 2012 and 2016 and therefore **REQUESTED** I.R. Iran to verify the data collection procedures used to calculate the deployed fishing effort in order to better understand the temporal trend in landings and CPUE.

42. The WPB **NOTED** that the reported seasonal trends in SWO, BLM and SFA catches are very similar and data have to be further checked to assess their correctness, **ACKNOWLEDGING** that gillnet fishing is known to be mainly performed during daytime for coastal fisheries and both during the day and at night for offshore fisheries.

43. The WPB **REQUESTED** that I.R. Iran provides gillnet effort (number of days) broken down by boat capacity and by province and month, **NOTING** that the work on gathering proper geo-referenced data is still ongoing.

Sri Lanka billfish fishery

44. The WPB **NOTED** paper IOTC-2017-WPB15-10 which outlined the results of exploring billfish spatial distribution from high-seas fisheries of Sri-Lanka, including the following abstract provided by the authors:

> "*Of the five major billfish species in local commercial landings, black marlin (Makaira indica), sailfish (Istiophorus platypterus) and swordfish (Xiphias gladius) are dominant in terms of their contribution to the total national production. There is lacking of studies focused to explore their spatial distribution in order to analyze the spatial variability of catch compositions. Therefore this study aimed to address it using 2016 logbook data and related spatial information.*" (see paper for full abstract)

45. The WPB **NOTED** the presentation of data of catches of mixed longline / gillnet fishery of Sri-Lanka reported on logbooks for high seas international waters.

46. **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.

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.

Malaysian billfish fishery

48. The WPB **NOTED** paper IOTC–2017–WPB15–11 which outlined the landings of billfish in 2016 by Malaysian tuna longliners in the Southwest Indian Ocean**,** including the following abstract provided by the authors:

> "*The total catch of billfishes by Malaysian tuna longliners in 2016 was 76 tonnes, decrease by 39% as to 2015. Only two species groups of billfish were recorded in the logbook of vessels operators; black marlin (Makaira indica) and swordfish (Xiphias gladius). The landings of black marlin and swordfish in 2016 were 42 tonnes and 34 tonnes respectively which accounted 2.37% and 1.95% of total landings by Malaysian tuna longliners. For sailfish species, it is believed that they were recorded as a 'mixed fish' catch. Average nominal CPUE of Black Marlin and Swordfish were 0.1 and 0.4 tonnes/1000hk respectively with maximum respectively at 0.33 and 1.21 t/1000hk."* (see paper for full abstract)

49. The WPB **NOTED** that landings by tropical tuna vessels were monitored by port officers in Penang, but that temperate tuna vessels were unloading at Port Louis (Mauritius) and therefore logbook data had to be used.

50. As no observers are currently used in the tuna longline fleet (comprising 5 to 10 vessels) while some are active in the domestic purse seine fishery, the WPB **ACKNOWLEDGED** Malaysia's intention to be part of the pilot scheme for the Regional Observer Programme and **REQUESTED** Malaysia to further coordinate with the IOTC Secretariat.

51. The WPB **NOTED** that marlins species are mainly reported as "*marlins*" in logbooks and that this raised some doubts on the accuracy of captures currently reported as *black marlin*. the WPB **ENCOURAGED** Malaysia to improve the quality of the reported species composition by deploying onboard the species identification cards developed by the IOTC Secretariat.

52. **ACKOWLEDGING** that Malaysia has not yet implemented an observer program, the WPB **NOTED** that landings and species composition on logbooks is controlled and validated by custom authorities at port. Therefore, the WPB **ENCOURAGED** Malaysia to compare data from logbooks and observer reports once the observer program will be fully implemented.

Thailand billfish fishery

53. The WPB **NOTED** paper IOTC–2017–WPB15–12 which outlined the landings of billfish by foreign tuna longliners into Phuket, Thailand from 1994 to 2016, including the following abstract provided by the authors:

> "*This paper summarizes the landing of billfishes in Phuket, Thailand, during 1994-2016. The retain catch and species composition including billfishes have been figured. The relevant information and activities, as well as obstacles on collecting information of billfishes, in particular the identification of species due to their presentation of frozen and plastic wrapped, are addressed. The paper also addresses the inspection at port of Phuket duly the Port State Measures and remarks the possible missed identification of billfishes species that may accordingly impacts the traceability scheme applied by Thailand. Lastly, the recommendations to accommodate the issues and enhance the port inspection are included.*" (see paper for full abstract)

54. The WPB **NOTED** that the difference in species composition of the landings in Phuket reflects the different foreign longline vessels that were monitored during unloading.

55. **ACKNOWLEDGING** that no swordfish were observed in 2016, while landings of shortbill spearfish (SSP) increased to over 600 tonnes, the WPB **NOTED** the difficulty in identification of frozen fish and **SUGGESTED** that ID guides be provided to assist with the identification of species at unloading.

56. The WPB also **NOTED** that there are currently no tuna longline vessels fishing from Thailand and **SUPPORTED** the idea of the development of a pilot project aiming to develop guides dedicated to the identification of frozen and dressed marlins, **ACKNOWLEDGING** that these will significantly improve the species breakdown of marlin catches in many fishing ports in the region.

57. The WPB **ENCOURAGED** Thailand to continue investing efforts in projects allowing the identification of species composition for marlin catches reported by Thailand flag vessels exploiting large pelagic fishes in the IOTC area of competence and **AGREED** to support the inclusion of shortbill spearfish (SSP) in the IOTC mandate**.**

Seychelles billfish fishery

58. The WPB **NOTED** paper IOTC–2017–WPB15–36 which outlined the catches of billfish by the Seychelles industrial tuna longliners, including the following abstract provided by the authors:

> *"Billfishes are incidental catches of Seychelles industrial longline fishery primarily targeting bigeye tuna. On average billfishes comprising of swordfish, marlins and sailfish accounted for 14% of the total catch of that fishery per year, since 2011 to 2016. The recent increases in catches of billfishes is noticeable in both swordfish and marlins catches with swordfish catches averaging to 1274Mt compared to 486Mt and 920Mt during the period 2008-2011 (the piracy threat period) and 2001-2007 respectively. Similarly marlin catches averaged to 1,013Mt per year over the last five years compared to 216Mt during the period (2008-2011) and 180Mt during the period (2001-2007)."* (see paper for full abstract)

59. The WPB **NOTED** the high quality of catch data in terms of geographical extent and spatial resolution of species reported on logbooks from the Seychelles industrial longline fishery, **ACKNOWLEDGING** the high coverage of reporting presented.
60. Therefore, the WPB **ENCOURAGED** Seychelles to submit standardized CPUE analysis for selected billfish species at the next WPB, based on the program of work currently defined by the WPB.

4.3 New information on sport fisheries

61. The WPB **NOTED** paper IOTC–2017–WPB15–13_Rev1 that described a pilot project in four countries to collect catch-and-effort and size data from sports fisheries in the western Indian Ocean, including the following abstract provided by the authors:

> *"The pilot project involving four western Indian Ocean countries commenced in August 2016, with the main objectives being to:*
>
> - *Build technical capacity (data collection and reporting mechanisms) for National fisheries institutions in the context of sports/recreational fisheries.*
> - *Strengthen IOTC's awareness of sport fisheries operations in the Western Indian Ocean*
> - *Improve management of IOTC species in the Indian Ocean.*
>
> *Four pilot countries were selected: Kenya, Seychelles, La Réunion and Mauritius. Each was visited by consultants in October/November 2016 in order to describe and document sport fishing activities, consider relevant historic data, and determine how better data might be collected from the sector in future."* (see paper for full abstract)

62. The WPB **NOTED** that the pilot project is still ongoing and will be completed by October 2017, and **RECOMMENDED** that results and outcomes of its first phase be evaluated by the SC prior to the possible implementation of a second phase.
63. Eventually, following the positive evaluation by the SC, the WPB **RECOMMENDED** future development of a network of country focal points for the distribution of data forms, the collection of the anonymized data and its submission to the IOTC Secretariat.
64. The WPB **NOTED** that the proposed data collection scheme is voluntary and **ACKNOWLEDGED** that recreational fishermen in some countries expressed concern about the possibility that the collected data might result in restrictive measures for the sector.
65. At the same time, the WPB **ACKNOWLEDGED** that creating proper awareness on the scientific goals of the project as well as establishing relationships of mutual trust between the IOTC Secretariat and local fishermen is a crucial aspect for the successful implementation of the project.
66. The WPB **NOTED** that SFA (Seychelles) is conducting a boat frame survey to be eventually followed by the introduction of a logbook system and a sampling program focused on sports fisheries in Seychelles.
67. The WPB also **NOTED** that SFA is planning to work with stakeholders to get access to historical data from the sports fisheries associations.

5. SWORDFISH

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

68. The WPB **NOTED** paper IOTC–2017–WPB15–INF01, which describes new growth and maturity information from swordfish in the southwest Pacific, including the following abstract provided by the authors:

"The aim of the project was to (i) determine the degree to which differences in swordfish growth and maturity parameters obtained by Young & Drake (2002; 2004) and DeMartini et al. (2000;2007) for swordfish in the southwest (SW) Pacific off Australia and the central North Pacific around Hawaii, respectively, were methodological or due to spatial variation in life-history, and (ii) to develop standardised protocols for interpreting fin rays (spines), otoliths and ovaries to re- estimate growth and maturity parameters for swordfish in the SW Pacific. The project also aimed to examine the effect of the different growth curves and maturity ogives on swordfish assessments and to make recommendations for future assessment and harvest strategy evaluation activities.

The project met all of its objectives, including the evaluation of otoliths to estimate the annual age of swordfish in the SW Pacific. Although direct validation of the ageing method was not possible in this project, the results of the otolith analysis suggest that swordfish live longer and grow slower than previously estimated. The project also evaluated ovaries and estimated a maturity ogive. The new estimate of length at 50% maturity is substantially lower than the preliminary estimate obtained by Young & Drake (2002) for swordfish in the SW Pacific." (see paper for full abstract)

69. The WPB **NOTED** that the estimated ages for larger fish are older when derived from otoliths and the close correspondence of the new growth curves with those from Hawaii, and **AGREED** that the stock assessment for swordfish should use the new estimates instead of those provided by Young and Drake (2004) which appeared to be biased for older ages.

70. Also, the WPB **NOTED** Table 2 providing an overview of updated growth and maturation parameters for swordfish and **AGREED** to consider other stock modelling variable for swordfish as follows:

- Max. observed length and age: 276 cm LJFL – 22 years
- Max. age for stock assessment: 25 years
- M: Lorenzen age structured M and M = 0.25
- Steepness: 0.7 – 0.8 – 0.9

Table 2. Growth and maturation parameters for swordfish

	Hard part	Sex	Max age	LAM (LJFL) 50%	AAM (Years) 50%	*L∞ (cm) LJFL*	*K*	*t0*
Farley et al., 2016	OTO	♂	17	-	-	213	0.235	-2.10
		♀	22*	181.5 cm	4.42	274.8*	0.157*	-2.13*
Poisson, Fauvel, 2009		♂	-	120 cm	~2			
		♀	-	170 cm*	~4*			

* Recommended values
LAM: Length-At-Maturity; AAM: Age-At-Maturity; LJFL: Lower-Jaw Fork Length

71. At the same time, the WPB **AGREED** that the CV of the growth curve should be carefully considered as it could have a strong influence on the stock assessment results.

72. 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.

73. The WPB also **NOTED** the maturity ogives for swordfish in the Indian Ocean from Poisson and Fauvel (2009) that had a similar 50% length as the Australian study from the southwest Pacific.

5.2 Review of new information on the status of swordfish

5.2.1 Nominal and standardized CPUE indices

74. The WPB **NOTED** paper IOTC–2017–WPB15–14 which provided standardised CPUE indices from 2000 to 2016 for swordfish taken by the Portuguese pelagic longline fleet, including the following abstract provided by the authors:

"The Portuguese pelagic longline fishery in the Indian Ocean started in the late 1990's, targeting mainly swordfish in the southwest. This document analyses the catch and effort, size distribution and standardized CPUE trends for that period. The final standardized CPUE trends show a general decreasing trend in the series, with an intermediate peak in the 2008 period." (see paper for full abstract)

75. The WPB **NOTED** that the standardisation changed the nominal CPUE in the early years and that the whole standardised series appeared to be inverted relative to the nominal values.

76. **NOTING** that this might be a result of the ratio variable which takes some signal from increased catch rates and interprets it as higher rates of targeting, the WPB **SUGGESTED** that independent data sources (e.g. type of bait and gear) may be required to quantify target behaviour.

77. The WPB **NOTED** paper IOTC–2017–WPB15–15 which provided standardised CPUE indices from 2005 to 2016 for swordfish taken by the Indonesian tuna longline fleet based on observer data, including the following abstract provided by the authors:

"In this paper, a Generalized Linear Model (GLM) was used to standardize the catch per unit effort (CPUE) and to estimate relative abundance indices based on the Indonesian longline dataset. Data was collected by scientific observers from August 2005 to December 2016. Most of the vessels monitored were based at Benoa Fishing Port, Bali. Catches are often equal to zero because swordfish is a bycatch for the Indonesian fleet. Both AIC and BIC suggested that the simple negative binomial (NB) model is the best option. The trends were relatively similar to the nominal series, but with smoother peaks. In general, there were tendency of slightly increasing catch trends in the last decade, with the series varying along the period." (see paper for full abstract)

78. The WPB **NOTED** that there were a large proportion of zeroes as the data come from a fishery targeting bigeye tuna with daylight sets, and that soak time was an explanatory variable reflecting the different fishing practices of the vessels.

79. Therefore the WPB **SUGGESTED** as an alternative option to define areas instead of assuming continuous variables for latitude and longitude.

80. The WPB **NOTED** paper IOTC–2017–WPB15–16 which provided standardised CPUE indices from 2001 to 2015 for the Spanish surface longline fleet targeting swordfish, including the following abstract provided by the authors:

*"Standardized catch rates of the Spanish surface longline fleet targeting swordfish are provided for the period 2001-2015. Generalized Linear Models (GLM) log-normal were used to update standardized catch rates in number of fish and in weight. Factors such as year, area, quarter, gear and bait, as well as the fishing strategy (based on the ratio between the most prevalent species and that appreciated most by skippers) and the interaction quarter*area were taken into account. The models explained 56% and 58% of CPUE variability in number and weight, respectively."* (see paper for full abstract)

81. The WPB **NOTED** that the Spanish and Portuguese fisheries overlap but that CPUE data show a different pattern.

82. Therefore, the WPB **ASKED** whether the interaction terms added as random effects in the GLMMs had any patterns across years, **NOTING** that if such yearly patterns exist, these might be a sign of missing main fixed effects in the model therefore **REQUESTING** that future works explore these issues.

83. The WPB **NOTED** that the authors used the GLMM as part of the sensitivity analyses.

84. The WPB **NOTED** paper IOTC–2017–WPB15–17 which provided standardised CPUE indices from 2001 to 2015 for swordfish in the Taiwanese longline fishery in the Indian Ocean, including the following abstract provided by the authors:

"In this study, the principal component analysis was conducted based on catch composition of Taiwanese longline fishery in the Indian Ocean. The results indicated that the principal component scores can represent the historical fishing pattern related to characteristics of targeting species. The delta-lognormal general linear models were used to conduct the CPUE standardization of swordfish caught by the Taiwanese longline fishery in the Indian Ocean for 1979-2016. The trends of CPUE series were obviously different by areas, while the trend of area-aggregated CPUE series generally revealed an increasing trend before the early 2000s, then substantially decreased and remained at a level lower than that in the early 1980s." (see paper for full abstract)

85. The WPB **NOTED** the results and welcomed this new type of approach using the results of principal component analysis (PCA) as covariates to account for changes in target species of Taiwanese vessels over years as well as regions.

86. The WPB **NOTED** that the third PCA component has a special meaning for the swordfish and that the PCA results might be different over regions, therefore **ENCOURAGING** the authors to conduct further analysis by area or by adding area / region as additional data in the PCA.

87. The WPB **NOTED** paper IOTC–2017–WPB15–19 which provided standardised swordfish CPUE indices for two periods (1976-93 and 1994-2015) from 4 areas of the Indian Ocean for the Japanese tuna longline fleet, including the following abstract provided by the authors:

> *"The IOTC has conducted the stock assessment of swordfish by dividing the Indian Ocean into four areas. For the benchmark stock assessment, I standardized the Japanese longline CPUE of swordfish for each of these regions. To properly handle information included by vessel names such as differences in targeting and equipment, and zero inflated catch data, I applied the GLM with negative binomial distribution, the GLMM with negative binomial distribution and the zero-inflated negative binomial distribution. The model selection was performed using the BIC, and the R software package lsmeans were used to calculate the standardized CPUE."* (see paper for full abstract)

88. The WPB **NOTED** that the number of vessels has decreased in recent years in the target tuna longline fisheries of the Indian Ocean and that the CPUE has been divided into two time series to reflect changes in the fishery during the early 1990s.

89. With regard to this analysis, the WPB **SUGGESTED** the following technical matters for consideration:

- the authors assumed in their analyses that vessel effects are treated as random effects, but the assumption that the effects have not changed over the years may not be practical and realistic;
- the authors mentioned that the interaction terms for quarter*area (among others) may have caused overfitting, although these issue might have been resolved by assuming broader area definitions;
- it might be useful – in terms of model selection – to evaluate the robustness of the results over candidate models.

90. The WPB **NOTED** paper IOTC–2017–WPB15–37_Rev2 which provided standardised CPUE indices for the South African fishery targeting swordfish from 2004-16, including the following abstract provided by the authors:

> *"Swordfish, Xiphias gladius is a target species of the South African pelagic longline fleet operating along the west and east coast of South Africa. A standardization of the CPUE of the South African swordfish-directed longline fleet for the time series 2004-2016 was carried out using a Generalized Additive Mixed Model (GAMM) with a Tweedie distributed error. Explanatory variables of the final model included year, month, geographic position (lat, long) and a targeting factor with two levels, derived by clustering of PCA scores of the root-root transformed, normalized catch composition. Vessel was included as a random effect. Swordfish CPUE had a definitive seasonal trend, with catch rates higher in winter and lower in summer. The standardised CPUE analysis indicates a declining trend over the period 2004-2016."* (see paper for full abstract)

91. The WPB **NOTED** that the South African swordfish fishery is a target fishery but that there are still a number of zero catches in the dataset.

92. The WPB **ACKNOWLEDGED** that the standardisation did not change the nominal data trend, which showed a slight decline over the period.

CPUE Summary discussion

93. The WPB **NOTED** the different trends seen in the CPUE data from the various fleets and that the main discussion points were related to the methods of determining targeting in the models, the definition of areas, the model selection and the use of random effects (mainly for vessels).

94. The WPB **NOTED** that separate CPUE series were presented at the meeting for four areas of the Indian Ocean over a range of time periods and that many of these showed quite different trends (Figure 1).

95. The WPB **AGREED** that, to use these data in the stock assessment, some selection and / or rejection be carried out to screen the available time series and ensure that the indices being used in the model are not conflicting (i.e. show opposite trends).

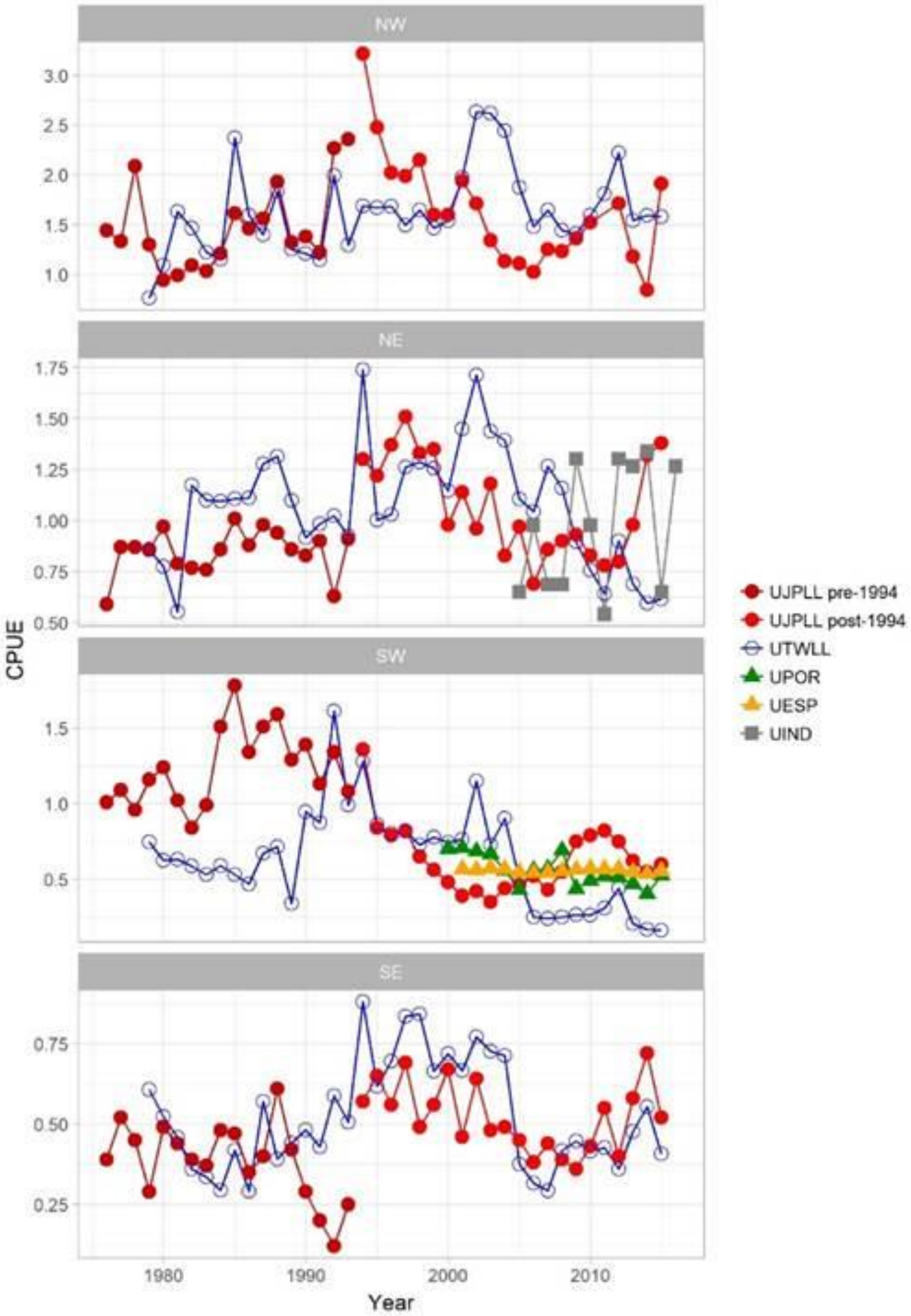


Figure 1. Longline catch-per-unit-effort for swordfish in the 4 areas of the Indian Ocean.

96. The WPB **ACKNOWLEDGED** that it was previously considered to use the Japanese longline series as a reference series, but that in recent years it was **AGREED** to split the series into an early period (1976-93) and a later series (1994-current year), **NOTING** that Taiwan, China also has a long time series of CPUE for swordfish (1979-2016).

97. The WPB also **NOTED** that new CPUE series were presented for the South African longline fishery from 2004 onwards, but that these were not available early enough to be used in the stock assessment modelling.

5.2.2 Stock assessments

Swordfish: stock assessment models in 2017

Stock Synthesis

98. The WPB **NOTED** paper IOTC–2017–WPB15–20_Rev1 which provided a stock assessment for swordfish in the Indian Ocean using Stock Synthesis 3 fitted to all the CPUE indices, including the following abstract provided by the authors:

"*This report presents a stock assessment for Indian Ocean swordfish (Xiphias gladius) using Stock Synthesis 3 (SS3). The assessment uses a spatially disaggregated, sex explicit, and age structured model that integrates several sources of fisheries and biological data into a unified framework. The model assumes that the Japanese CPUE indices are proportional to the population density of swordfish in each region. The assessment attempted to quantify uncertainty with respect to i) key assumptions that are difficult to justify, ii) parameters that are difficult to estimate, and iii) interactions among them in the permutations. Stock status was estimated for 162 models based on 3 CPUE reference cases (54 models each) running a permutation of the parameters; 3 growth/maturity/natural mortality options:, 3 values of stock recruit steepness, 3 recruitment sigma values and 2 alternative effective sample sizes for size composition data. Estimates from the majority of models under the three reference cases suggested the Indian Ocean Swordfish stock as a whole is currently not overfished, and not subject to overfishing."* (see paper for full abstract)

99. The WPB **NOTED** the key assessment results for Stock Synthesis (SS3) as shown below (Tables 3 to 8; Figures 2 to 5) for which one base case and two sensitivity runs are reported.

100. The WPB **NOTED** that the assessment model is age / sex structured, spatially partitioned into 4 areas (NW, NE, SW, SE) and describing differential depletion and recruitment by area, while not estimating movement between areas.

101. The WPB also **NOTED** the presence of 12 fisheries in the model, defined by fleet and region, and that a grid approach was used to quantify the uncertainties where each reference case is run over permutations of parameters and / or assumption options.

102. The WPB **NOTED** that each reference grid included 24 MPD runs covering three steepness values (0.7, 0.8, and 0.9), two growth/maturity options (otoliths-based estimates from the SW Pacific by Farley et al. (2016), spine-based estimates form Indian Ocean by Wang et al. (2010)), two recruitment variability (sigma=0.2 or 0.4), and two assumed effective sample size for length composition data (capped at 20 or 2). A constant M of 0.25 for all ages was used in all models. Each reference grid used the Japanese CPUE from 1994 to 2015, except that in the SW region, the Japanese indices from 2000 to 2015 were dropped and the Portugal indices from 2000-2015 were used instead.

Grid-NTP model

103. The WPB **NOTED** that area-specific scaling was applied to the Japanese CPUE series to convert the density indices to relative abundance indices that are comparable among areas, and to allow catchability to be shared among areas.

104. The WPB **ACKNOWLEDGED** that the validity of the assumption that density is uniform within each large sub-region is questionable, and that the changes in the CPUE standardisation methodologies have resulted in very different regional weighting being applied between assessments.

105. The WPB **AGREED** that the reference grid based on the area-specific weighting (grid-NTP) suggests that the stock is not overfished, and is not subject to overfishing. The management quantities for grid-NTP are given in Table 3.

Table 3. Stock status summary table for the assessment grid-NTP, based on the weighted combination of MPD models.

Management Quantity	Grid-NTP
Current catch	34,144
Mean catch over last 5 years	30,503
MSY (1000 t)	53.547 (33.070–101.600)
Current Data Period	1950–2015
$F_{Current}/F_{MSY}$	0.36 (0.15–0.62)
$B_{Current}/B_{MSY}$	n.a.
$SB_{Current}/SB_{MSY}$	2.46 (1.58–3.66)
$B_{Current}/B_0$	n.a.
$SB_{Current}/SB_0$	0.51 (0.41–0.65)

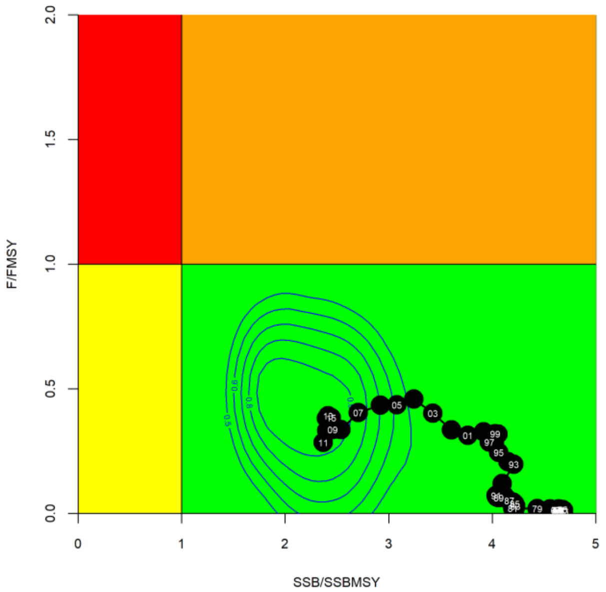


Figure 2. Stock synthesis grid-NTP. Weighted average Kobe stock status plot for the Indian Ocean for swordfish. Black circles represent the annual medians of the weighted aggregate distributions. Contours represent the smoothed probability distribution for 2015 (isopleths are probability relative to the maximum).

Table 4. Kobe 2 Strategy Matrix for Indian Ocean SWO assessment grid-NTP. Probability (expressed as a percentage of the distribution of models) of exceeding the MSY-based spawning biomass and fishing mortality reference points.

Grid-NTP	60%	80%	100%	120%	140%
$B_{2018} < B_{MSY}$	0	0	0	0	0
$F_{2018} > F_{MSY}$	0	0	0	0	0
$B_{2025} < B_{MSY}$	0	0	0	0	0
$F_{2025} > F_{MSY}$	0	0	0	0	0.08

Grid-rNTP model

106. The WPB **NOTED** an alternative regional weighting derived from unfished spawning biomass estimated using sub-regional models (one for each region and each model included catch and observational data from that region only) and that this regional weighting scheme is intended to relax the constraint of the shared catchability amongst the Japanese CPUE.

107. The WPB **ACKNOWLEDGED** the evidence of the reference grid (based on the Japanese indices rescaled by the alternative weighting factor (grid-rNTP)) suggesting that the stock is not overfished and is not subject to overfishing, **NOTING** the management quantities given in Table 5

108. The WPB **NOTED** that the uncertainty regarding the regional rescaling factor is difficult to fully evaluate in a single stock assessment, and **RECOMMENDED** that this is more formally addressed using a structured approach within a Management Strategy Evaluation framework.

109. For this reason, the WPB also **REQUESTED** that CPUE standardisation should continue to be improved to develop more robust regional weighting estimates.

Table 5. Stock status summary table for the assessment grid-rNTP, based on the weighted combination of MPD models.

Management Quantity	Grid-rNTP
Current catch	34,144
Mean catch over last 5 years	30,503
MSY (1000 t)	31.586 (26.302–45.500)
Current Data Period	1950–2015
$F_{Current}/F_{MSY}$	0.76 (0.41–1.04)
$B_{Current}/B_{MSY}$	n.a.
$SB_{Current}/SB_{MSY}$	1.50 (1.05–2.45)
$B_{Current}/B_0$	n.a.
$SB_{Current}/SB_0$	0.31 (0.26–0.43)

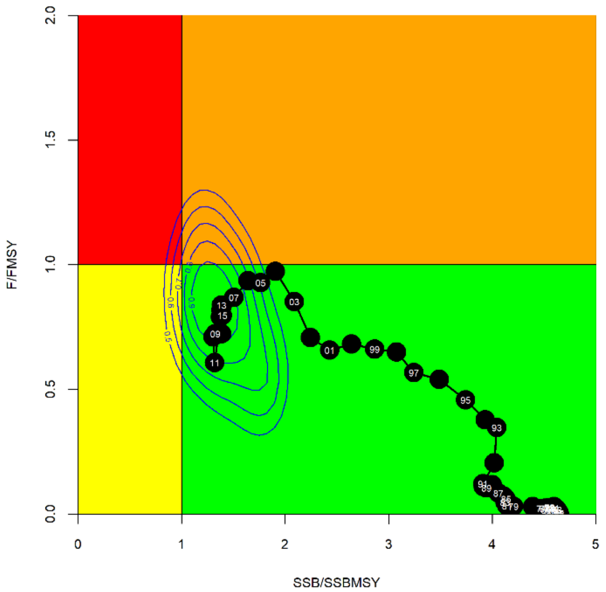


Figure 3. Stock synthesis grid-rNTP. Weighted average Kobe stock status plot for the Indian Ocean for swordfish. Black circles represent the annual medians of the weighted aggregate distributions. Contours represent the smoothed probability distribution for 2015 (isopleths are probability relative to the maximum).

Table 6. Kobe 2 Strategy Matrix for Indian Ocean SWO assessment grids-rNTP. Probability (expressed as a percentage of the distribution of models) of exceeding the MSY-based spawning biomass and fishing mortality reference points.

Grid-rNTP2

	60%	80%	100%	120%	140%
$B_{2018} < B_{MSY}$	0	0	0	0	0.13
$F_{2018} > F_{MSY}$	0	0	0.13	0.42	0.71
$B_{2025} < B_{MSY}$	0	0	0.08	0.46	0.75
$F_{2025} > F_{MSY}$	0	0	0.38	0.71	0.87

Grid-Catch

110. The WPB **NOTED** that swordfish catch from the Indonesian Fresh Tuna Longliners was estimated using the Taiwanese fresh longline as a proxy for gear / species disaggregation.

111. **ACKNOWLEDGING** that the Taiwanese fresh longline catch had a more than twofold increase from 2013 to 2014, the WPB **NOTED** the subsequent significant increase in Indonesian catch for the same period.

112. As a consequence of this process, the WPB **NOTED** that the estimated swordfish catches for the LL_NE fishery increased from 10,210 t in 2013 to 17,484 t in 2014 and 18,998 t in 2015, respectively, and **AGREED** that these results are very unlikely.

113. Therefore, the WPB **AGREED** that the average catch between 2011 and 2013 are used in the assessment as the catch level for the Indonesian Fresh Tuna Longline for the last two years, and that the catch estimates for the LL_NE fishery are reduced accordingly to 10,156t and 11,460t for 2014 and 2015.

114. The WPB also **SUGGESTED** that the original estimates (higher values) are used in a sensitivity grid-run (*grid-Catch*) whose management quantities are given in Table 7.

Table 7. Stock status summary table for the assessment grid-Catch, based on the weighted combination of MPD models.

Management Quantity	Grid-Catch
Current catch	39,667
Mean catch over last 5 years	31,463
MSY (1000 t)	56.193 (35.126–105.010)
Current Data Period	1950–2015
$F_{Current}/F_{MSY}$	0.40 (0.17–0.71)
$B_{Current}/B_{MSY}$	n.a.
$SB_{Current}/SB_{MSY}$	2.62 (1.77– 3.78)
$B_{Current}/B_0$	n.a.
$SB_{Current}/SB_0$	0.54 (0.43–0.67)

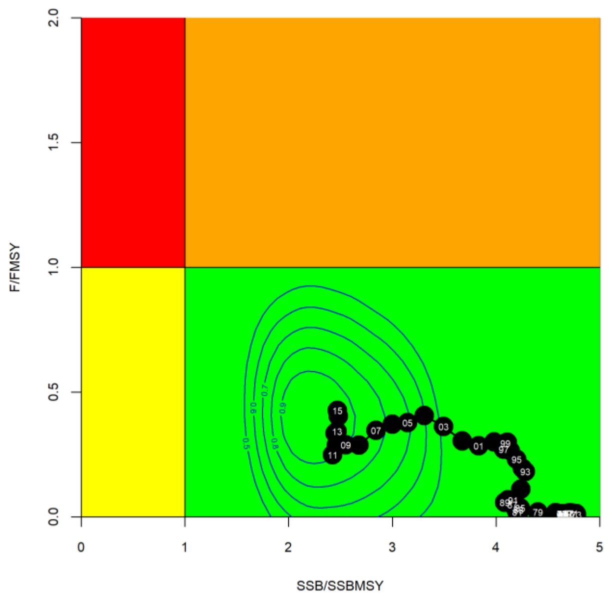


Figure 4. Stock synthesis grid-Catch. Weighted average Kobe stock status plot for the Indian Ocean for swordfish. Black circles represent the annual medians of the weighted aggregate distributions. Contours represent the smoothed probability distribution for 2015 (isopleths are probability relative to the maximum).

Table 8. Kobe 2 Strategy Matrix for Indian Ocean SWO assessment grid-Catch. Probability (expressed as a percentage of the distribution of models) of exceeding the MSY-based spawning biomass and fishing mortality reference points.

Grid-catch	60%	80%	100%	120%	140%
$B_{2018} < B_{MSY}$	0	0	0	0	0
$F_{2018} > F_{MSY}$	0	0	0	0	0.05
$B_{2025} < B_{MSY}$	0	0	0	0	0.11
$F_{2025} > F_{MSY}$	0	0	0	0.03	0.27

115. The WPB **NOTED** that the sensitivity *grid-Catch* estimated a biomass trend very similar to the model that used a lower catch estimate (Figure 4) and **AGREED** that the result is likely due to the Japanese CPUE indices being higher in 2014 and 2015 in the North East region, while the use of higher catch estimates has increased the biomass across all regions, thus mitigating the effect of using higher catch estimates on the stock status.

116. In any case, the WPB **NOTED** that the effect of using the higher catch estimates is more pronounced in the projection period.

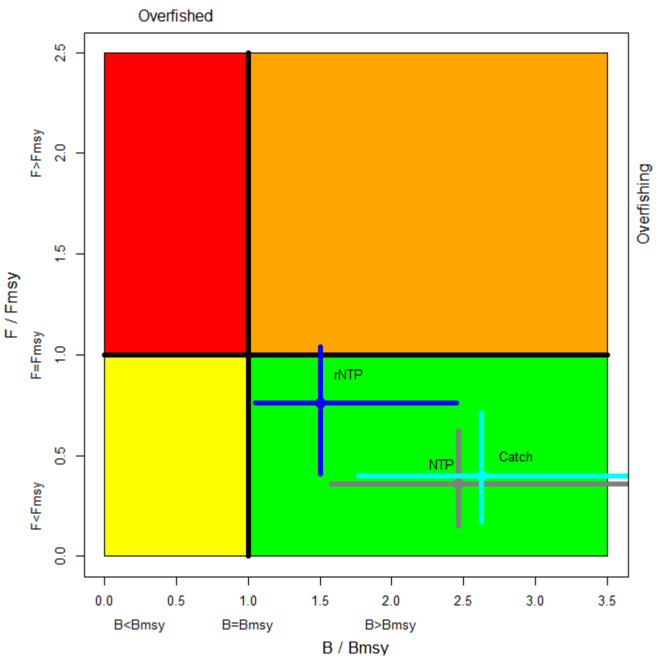


Figure 5. Kobe stock status plot for the three alternative models, base case (Grid-rNTP) and the two sensitivity runs (Grid-NTP and Grid-Catch) for swordfish in the Indian Ocean.

A Stock-Production Model Incorporating Covariates (ASPIC)

117. The WPB **NOTED** paper IOTC–2017–WPB15–21_Rev1 which provided a stock assessment for swordfish in the Indian Ocean using a stock production model incorporating covariates (ASPIC) fitted to all the CPUE indices, including the following abstract provided by the authors:

> *"A Stock-Production Model Incorporating Covariates (ASPIC) was used to conduct the stock assessment for swordfish in the Indian Ocean. The stock status became to be pessimistic because of substantial increase in catches in recent years, especially for the catches from Indonesia and other fleets. The stock assessment results were obviously influenced by the CPUE data and assumption of time-varying catchability. The results based on the scenario selected by WPB indicated the current status of swordfish in the Indian Ocean may be not overfishing and not subject to be overfished but there is a risk of being overfishing."* (see paper for full abstract).

118. The WPB **NOTED** the key assessment results for the ASPIC model for swordfish as shown below (Table 9; Fig. 6).

Table 9. Stock status summary table for the swordfish assessment (ASPIC)

Management Quantity	**Aggregate Indian Ocean**
2015 catch estimate	32,129
Mean catch from 2011–2015	28,493
MSY (1000 t) (80% CI)	32.2 (30.5-33.2)
Data period (catch)	1950–2015
F_{MSY} (80% CI)	1.304 (1.203,1.399)
B_{MSY} (1,000 t) (80% CI)	24.7 (21.9 – 27.1)
F_{2015}/F_{MSY} (80% CI)	0.754 (0.71 – 0.87)
B_{2015}/B_{MSY} (80% CI)	1.32 (1.22 – 1.36)
B_{2015}/B_{1950} (80% CI)	0.664 (0.62 – 0.69)

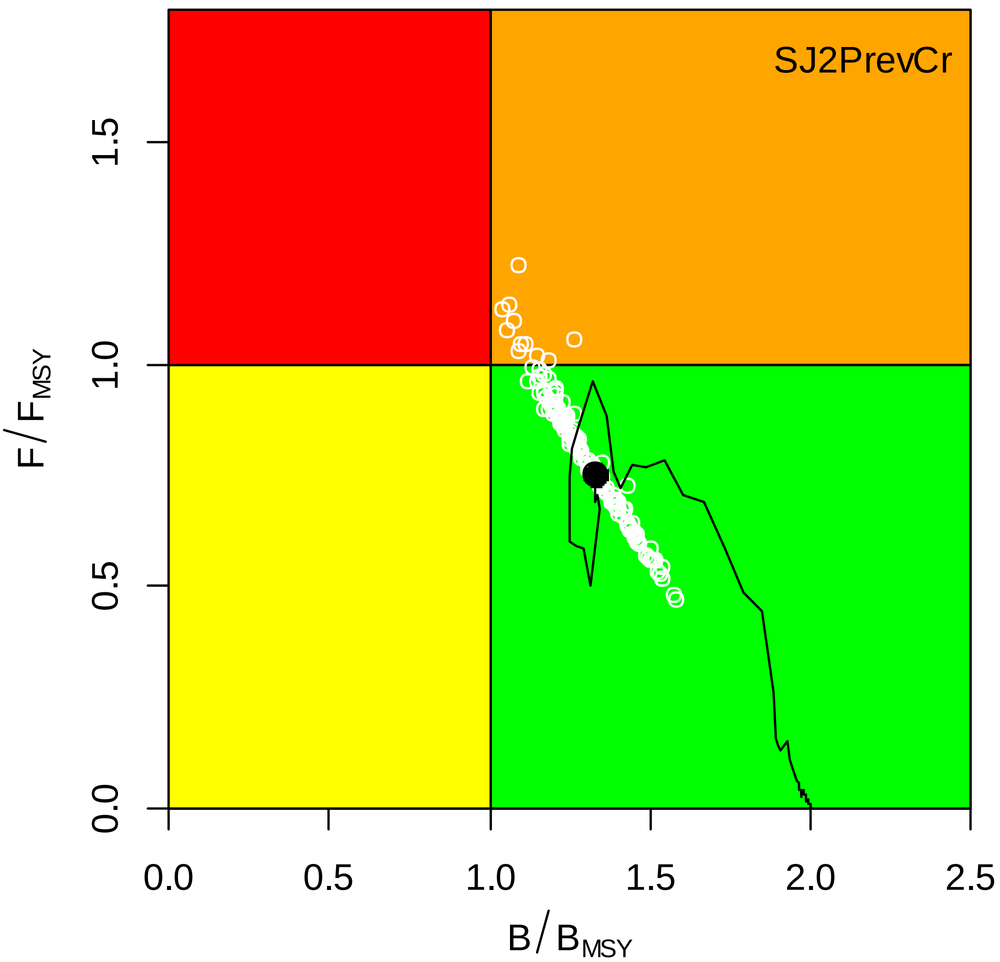


Figure 6. ASPIC model: Kobe stock status plot for the Indian Ocean for swordfish. The black line traces the trajectory of the stock over time while the white empty circles show the uncertainty in the last year.

119. The WPB **NOTED** the instability in the model estimates of initial biomass relative to K.

120. **NOTING** that starting the model at too low a depletion level seemed to create a problem, the WPB **SUGGESTED** that the model be started in 1950 when the stock would have been very close to unfished biomass.

121. The WPB also **NOTED** that the Portuguese indices were not used in this model and that the revised assessment presented here used the lower catches assumed for Indonesia for 2014 and 2015.

Statistical catch at age (SCAA)

122. The WPB **NOTED** paper IOTC–2017–WPB15–22 which provided a stock assessment for swordfish in the Indian Ocean using a Statistical Catch At Age (SCAA) model, using two alternative growth assumptions, including the following abstract provided by the authors:

"*Stock assessment of swordfish (Xiphias gladius) in the Indian Ocean was attempted using Statistical-Catch-At-Age (SCAA) with one stock hypothesis. We examined two different biological information, i.e., (a) previous growth curve by Wang et al (2010) and maturity-at-age by Poisson and Fauvel (2009), and (b) new growth curve and maturity-at-age by Farley et al (2016) by otolith. It was suggested that (a) produced plausible results, while (b) did not produce any convergences nor plausible results. Its conceivable reason is that CAA are estimated by the previous growth curve by Wang et al (2010) which might not be suitable for SCAA based on the new growth curve as current CAA is not estimated by the new growth curve. Results suggest that the stock status is in the orange zone in the Kobe plot (not overfished but overfishing).*" (see paper for full abstract).

123. The WPB **NOTED** the key assessment results for Statistical Catch At Age (SCAA) as shown below (Table 10; Figure 7).

Table 10. Stock status summary table for the swordfish assessment (SCAA)

Management Quantity	SCAA
Current catch	39,667
Mean catch over last 5 years	31,463
MSY (1000 t)	30.2
Current Data Period	1980–2015
$F_{Current}/F_{MSY}$	1.46
$B_{Current}/B_{MSY}$	n.a.
$SB_{Current}/SB_{MSY}$	1.09
$B_{Current}/B_0$	n.a.
$SB_{Current}/SB_0$	0.29 (SB_{2015}/SB_{1980})

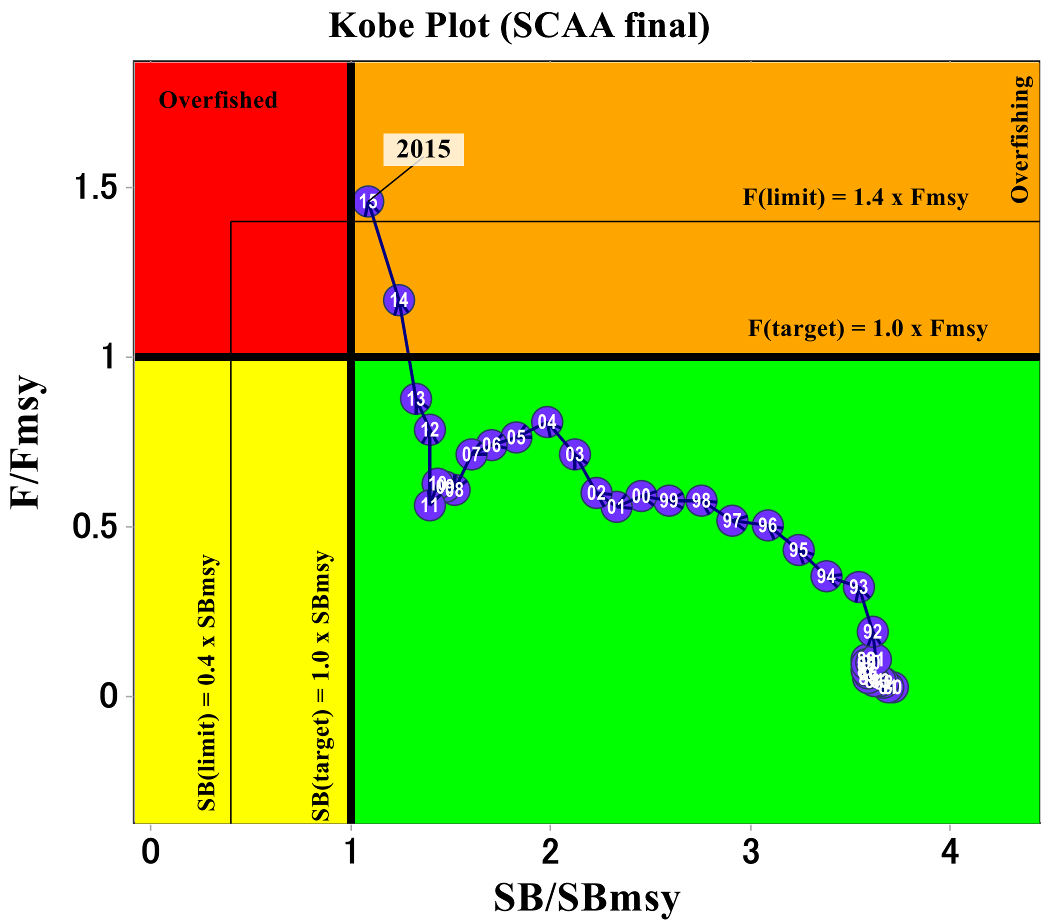


Figure 7. SCAA model: Kobe stock status plot for the Indian Ocean for swordfish. The blue line traces the trajectory of the stock over time to the current stock status (2015).

124. The WPB **NOTED** the difficulty in fitting the model to the catch-at-age data using the new growth curve and **ACKNOWLEDGED** that this was most likely due to the generation of the catch-at-age data using the older growth curve, with the size-at-age not matching the new growth rate.

Bayesian Surplus Production Model

125. The WPB **NOTED** document IOTC–2017–WPB15–24 presenting the results of a Bayesian Surplus Production Model, including the following abstract as provided by the author:

"*Bayesian state-space models were used to assess the swordfish (Xiphias gladius) caught in the Indian Ocean assuming that there is a single stock. Estimations of catches as reported in the IOTC database were used and the models were fitted to standardized catch-per-unit-effort (CPUE) available for the stock assessment. Catches and standardized CPUEs were conflictive in some periods. There are periods in which the CPUE increased but the catches increased as well. Different runs were conducted with several combinations of CPUE. Uncertain is high as indicated by the wide posteriors of parameters. Data does not convey much information about parameters r and k. Estimations indicate that swordfish is probably not overfished, but it is subject to overfishing. However the results might be carefully considered given the conflict between catch and CPUE time series which drives the results of such simple models*.".

126. The WPB **NOTED** the key assessment results for the Bayesian Surplus Production Model, as shown below (Table 11; Figure 8)

Table 11. Stock status summary table for the swordfish assessment(BSPM)

Management Quantity	BSPM
Current catch	39,667
Mean catch over last 5 years	31,463
MSY (1000 t)	34.5 (23.5 – 53.3)
F_{MSY}	0.12 (0.08 – 0.18)
Current Data Period	1950 – 2015
$F_{Current}/F_{MSY}$	1.01 (0.61 – 1.64)
$B_{Current}/B_{MSY}$	1.14 (0.96 – 1.32)
$SB_{Current}/SB_{MSY}$	n.a
$B_{Current}/B_0$	0.59 (0.48 – 0.7)
$SB_{Current}/SB_0$	n.a

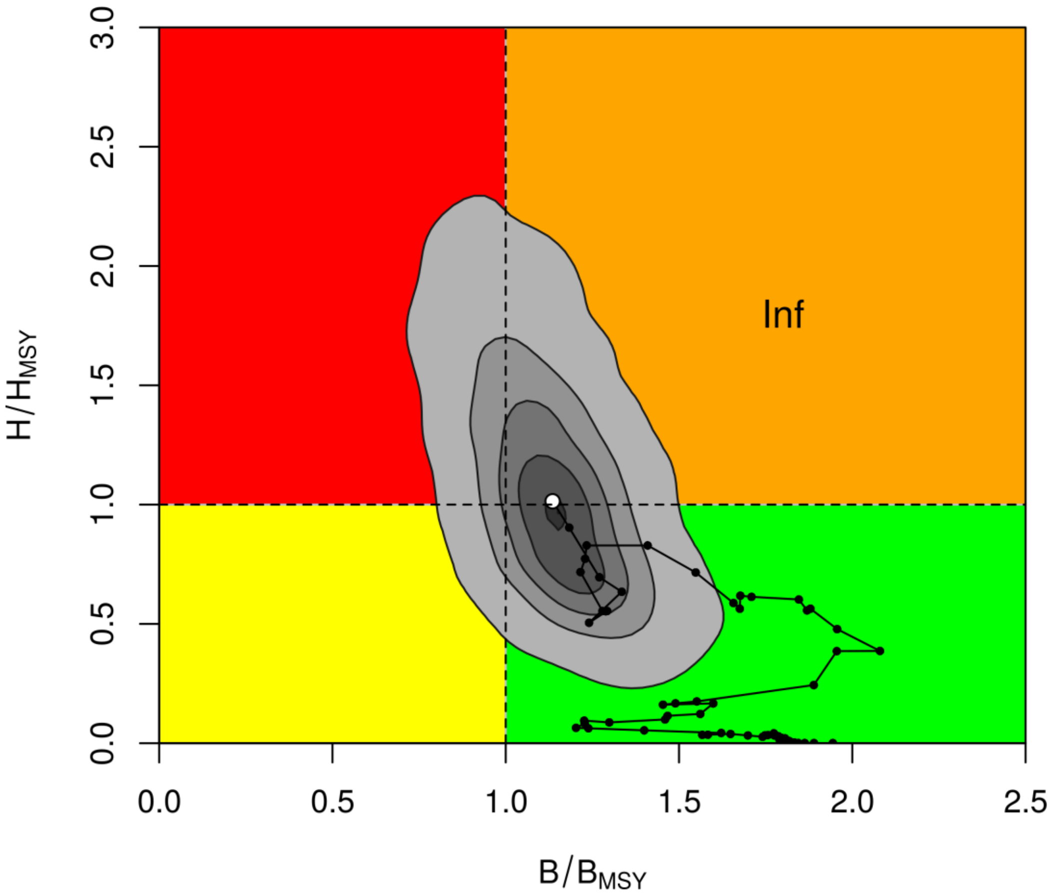


Figure 8. BSPM model: Kobe stock status plot for the Indian Ocean for swordfish. The black line traces the trajectory of the stock over time while the white circles show the status in the last year. Contours represent the smoothed probability distribution for 2015 (isopleths are probability relative to the maximum).

127. The WPB **NOTED** the high uncertainty concerning the estimations of the parameters and the status of the stock in 2015.

128. The WPB also **NOTED** that the results of such a simple model are driven only by catch and the CPUE series which were conflictive in some periods (e.g. increasing CPUE along with increasing catches). The WPB **SUGGESTED** to run the model with different combinations of CPUE series, including a set similar to that used in SS3 runs (NTP – only Japan and Portuguese CPUE time series).

129. The WPB **NOTED** that the results largely depend on the CPUE series selected to run the model, and that the NTP set of CPUEs does not result in the most reliable scenario, as the simple production model used does not allow the use of important information (e.g. area structure) like the SS3.

130. The WPB **NOTED** that, in general, the results concerning the stock status when including more CPUE series than only the Japan and Portuguese ones in the model were not conflictive with the results obtained with more complex models.

131. The WPB **NOTED** the Bayesian production model (JABBA) that was provided during the WPB session (IOTC-2017-WPB15-INF02) and **AGREED** that this provided useful results and corroborated the stock status in 2015 from the assessment models, therefore **ENCOURAGED** the authors to continue the work with this model.

Diagnostic tool for SS3 evaluation

132. The WPB **NOTED** paper IOTC–2017–WPB15–23 which examined the previous 2014 swordfish stock synthesis model outputs using two diagnostic tools, a likelihood profile on virgin recruitment and the fit of an ASPM to the parameters estimated by the original model, including the following abstract provided by the authors:

> "*We examined the two model diagnostics on the previous stock assessment model. R0 likelihood component profile showed a conflict between CPUE and size composition data. Age-structured production model diagnostic shows the fits to several CPUEs was poor. It is assumed that there are cause for the estimation of selectivity is not good.*" (see paper for full abstract)

133. The WPB **NOTED** the results of the analysis for the previous 2014 swordfish SS3 model, and the apparent poor fit to CPUE and the conflict with size data.

134. The WPB further **ACKNOWLEDGED** that the 2017 SS3 assessment uses a subset of the CPUE indices, rather than trying to fit conflicting CPUE trends, and has decreased the effective sample size for the size data. The diagnostic analyses should be repeated on the 2017 assessment model.

Stock assessment tool (BLUEBRIDGE project)

135. The WPB **NOTED** paper IOTC–2017–WPB15–26 which describes a tool being developed to allow easier access to Stock Synthesis 3 models for researchers using as an example the swordfish stock assessment for the Indian Ocean, including the following abstract provided by the authors:

> "*As very few stock assessment participants have the specific technical skills required to reproduce the outputs from complex stock assessment models, our aim has been to develop a Virtual Research Environment (VRE) that enables any user to easily parameterize and execute various steps of the stock assessment workflow using SS3 (a widely-used statistical catch-at-age model). We will repackage SS3 codes used for large pelagic species and provided by the Indian Ocean Tuna Commission and their consultants so that they can be parameterized, executed and edited online by anybody from a simple web page, with standardized data outputs. Here, we will show a mock-up of the VRE, using the last stock assessment of swordfish (SWO) as an example."* (see paper for full abstract)

136. The WPB **NOTED** the development of the stock assessment package and **ENCOURAGED** the ongoing development and maintenance of the tool.

137. **ACKNOWLEDGING** the benefits introduced by the novel approach presented by the authors, and considering the uncertainties about the future of the Bluebridge consortium currently managing and developing the framework (with a confirmed lifespan extending to 2018) the WPB **ENCOURAGED** the IOTC Secretariat and the other tRFMOs to coordinate and ensure the possible continuation of the project, at least for those parts considered of particular relevance to the scientific community.

5.2.3 Selection of stock status indicators for swordfish Stock assessments

138. The WPB **NOTED** Table 12, which provides an overview of the key features of each of the swordfish stock assessments presented in 2017 for the Indian Ocean-wide assessments (4 model types). Similarly, Table 13 provides a summary of the assessment results.

Table 12. Swordfish: Indian Ocean-wide assessments. Summary of final stock assessment model features as applied to the Indian Ocean swordfish resource in 2017.

Model feature	**SS3 (Doc #20 Rev1)**	**ASPIC (Doc #21)**	**SCAA (Doc #22)**	**BSPM (Doc #24)**
Software availability	NOAA toolbox	NOAA toolbox	SCAA/ASPM Soft (ver. 3.0)	H Andrade
Population spatial structure / areas	Yes	No	No	No
Number CPUE Series	7	3	1	7
Uses Catch-at-length/age	Yes	No	Yes	No
Catch 2014 & 2015*	Low	Low	High	High
Age-structured	Yes	No	Yes	No
Sex-structured	Yes	No	No	No
Number of Fleets	12	5	5	1
Stochastic Recruitment	Yes	No	Yes	No
B_{MSY}/B_{1950}	0.21	0.5	0.27	0.51 (0.47 – 0.58)

*Assumption concerning Indonesian catch levels in 2014 and 2015

Table 13. Swordfish: Indian Ocean-wide summary of key management quantities from the assessments undertaken in 2017.

Management quantity	SS3 (Doc #20 Rev1)	ASPIC (Doc #21)	SCAA (Doc #22)	BSPM (Doc #24)
Most recent catch estimate (t) (2015)	34,144	32,129	39,667	39,669
Mean catch over last 5 years (t) (2011–2015)	39,503	28,493	31,463	31,469
h (steepness)	0.7, 0.8, 0.9	n.a.	0.7	n.a.
MSY (1,000 t) (80% CI) [plausible range of values]	31.6 (26.3 – 45.5)	32.2 (30.5 – 33,2)	30.2	34.5 (23.5 – 53.3)
Data period (catch)	1950 - 2015	1950 - 2015	1980 - 2015	1950 - 2015
CPUE series	JPN (late) POR	JPN. TWN, SPN	JPN (late)	JPN (late) POR
CPUE period	JPN (1994 – 2015) POR (2000 – 2015)	JPN (1976 -2015) TWN (1979 - 2015) SPN (2001 – 2015)	1994 - 2015	JPN (1994 – 2015) POR (2000 – 2015)
F_{MSY}		1.304	0.217	0.12
SB_{MSY} or $*B_{MSY}$ (1,000 t)		24.7 (21.8 -27.1)	101.8	
F_{2015}/F_{MSY} (80% CI) [plausible range of values]	0.76 (0.41 – 1.04)	0.754 (0.71 – 0.87)	1.46	1.01 (0.61 – 1.64)
B_{2015}/B_{MSY} (80% CI) [plausible range of values]	n.a.	1.32 (1.22 – 1.36)		1.14 (0.96 – 1.32)
SB_{2015}/SB_{MSY} (80% CI) [plausible range of values]	1.5 (1.05 – 2.45)	n.a.	1.09	n.a.
B_{2015}/B_{1950} (80% CI) [plausible range of values]	n.a.	0.664 (0.62 – 0.69)	n.a.	0.59 (0.48 – 0.7)
SB_{2015}/SB_{1950} (80% CI) [plausible range of values]	0.31 (0.26 – 0.43)	n.a.	0.29 (SB_{2015}/SB_{1980})	n.a.
$SB_{2015}/SB_{current,\ F=0}$				

n.a. = not available

5.3 Development of management advice for swordfish and update of swordfish Executive Summary for the consideration of the Scientific Committee

139. The WPB **AGREED** that the final advice for the executive summary should be based on the stock synthesis (SS3) model, based on the availability of length data and biological data specific for the Indian Ocean as well as the availability of CPUE series for several fisheries and better description of population dynamic for Swordfish. Therefore the WPB supports the use of Stock Synthesis (SS3) for swordfish as data and information are available to run this type of complex model. Other models provide useful complementary information to support SS3 results and were in general in agreement in terms of stock status.

140. The WPB **NOTED** the selection of SS3 run *r-NTP* as the best case model and that it was chosen because the assumptions that the Japanese CPUE is indexing density in each area and that the density is uniform in each area, are questionable. This run estimated MSY at 31,586 t which is below the current catch level (32,129 t).

141. The WPB **NOTED** the importance to collect more data (e.g. growth, maturity) to improve the biological knowledge of the species and also that data about movements and migrations between areas would be critical to inform spatially-explicit models such as SS3.

142. 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.

143. **ACKNOWLEDGING** that in the base case model the assumed catch levels over the past two years have been reduced compared to the IOTC catch data, the WPB **NOTED** that there is no explicit evidence of the estimated increase in catches by Indonesia, which was derived from the catch ratio of billfish by Taiwan,China. The latter has substantially changed over the last two years without similar supporting evidence for such a change in the Indonesian fishery.

144. The WPB **NOTED** the Kobe matrix showing that with current catch levels, the stock will not be overfished nor subject to overfishing by 2025 and **ACKNOWLEDGED** that with a 20% increase in catch, there would be higher than 70% probability that the stock will be subject to overfishing by 2025 and almost 50% probability that the stock will be overfished.

145. The WPB **REQUESTED** that the IOTC Secretariat update the draft stock status summary for swordfish with the latest 2015 catch data, and for the summary to be provided to the SC as part of the draft Executive Summary for its consideration:

- Swordfish (*Xiphias gladius*) – Appendix VI

6. MARLINS

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

MSE for Indian Ocean striped marlin

146. The WPB **NOTED** paper IOTC–2017–WPB15–27 which provided the results of testing management procedures for the striped marlin stock using the DLMtool package, including the following abstract provided by the authors:

> "*In this study, the DLMtool package was used to test management procedures (MPs) and calculate catch limits for Indian Ocean striped marlin. Catch data (1950-2015), CPUE data (Japanese longline from 1976 to 2013 and Taiwanese longline from 1980 to 2013) and biological parameters were used to develop the Operating Model (OM) and/or alternative MPs. Twenty-one (21) alternative MPs were tested using simulations based on a 50-year projection.*" (see paper for full abstract)

147. The WPB **NOTED** the DLMtool software that has been developed to assist with MSE for data poor fisheries and that allows the selection of a wide range of biological parameters and catch and abundance data to start the simulations.

148. The WPB **ACKNOWLEDGED** that the striped marlin stock appears to be currently at a low level and therefore the starting point for the MSE should reflect the need to rebuild the stock from the current state to an agreed target level.

149. The WPB also **NOTED** that there is an agreed format for presenting results from MSE to the WPM and Scientific Committee.

Genetic population structure for striped marlin

150. The WPB **NOTED** paper IOTC–2017–WPB15–28 which provided the results of a study on the genetic population structure for striped marlin in the Indian Ocean including the following abstract provided by the authors:

> "*The Indian Ocean Tuna Commission currently recognizes a single ocean-wide stock of striped marlin (Tetrapturus audax) due to a lack of information on the intra-oceanic stock structure of this species. In this study, we assess the genetic population structure of striped marlin throughout the full species range using newly developed single nucleotide polymorphism (SNP) molecular markers that provide genome-wide representation. Preliminary results based on an exploratory dataset comprising 29 striped marlin*

suggest that striped marlin in the Indian Ocean represent a genetic stock distinct from Pacific Ocean fish. Evidence for stock structure within the Indian Ocean was not observed; however, sample collections from the eastern ocean basin are limited." (see paper for full abstract)

151. The WPB **NOTED** the preliminary results of the study that suggested the Indian Ocean has only one stock of striped marlin, also showing that Eastern Australian samples were similar to the Indian Ocean samples.
152. The WPB supported the completion of this study with larger sample sizes and **ENCOURAGED** members to provide samples of striped marlin from throughout the Indian Ocean to increase the sample size and the spatial distribution.
153. The WPB **SUGGESTED** that the collection of these samples could begin from samples collected from recreational fishing as well as commercial longline vessels.

6.2 Review of new information on the status of marlins

6.2.1 Nominal and standardized CPUE indices

Striped marlin

Taiwan,China longline CPUE

154. The WPB **NOTED** paper IOTC–2017–WPB15–29 providing a standardised CPUE indices for striped marlin from 1979 to 2016 for the Taiwanese tuna longline fisheries in the Indian Ocean including the following abstract provided by the authors:

"In this study, the delta-gamma general linear models with the targeting effect derived from principal component analysis were used to conduct the CPUE standardization of striped marlin caught by the Taiwanese longline fishery in the Indian Ocean for 1979-2016. The Trends of CPUE series were obviously different for northern and southern Indian Ocean, while the area-aggregated CPUE series revealed a decreasing trend since 1980s and slightly increased in recent years." (see paper for full abstract)

155. The WPB **NOTED** that the weighting for the final CPUE was carried out by area size (NE, NW, SE, SW) and **REQUESTED** the exploration of other types of weights, such as catches or effort.
156. The WPB **NOTED** that the author provided this during the meeting, and that detected changes in the CPUE series were relatively minor.
157. For this reason, the WPB **AGREED** to use the original area weighting in the final models. The WPB **REQUESTED** that, in the future, the proportion of zeros in the data are provided by year and region.
158. The WPB **CONSIDERED** the use of the principal components from the PCA inside the GLM standardisation in terms of their meaning (which species each component would be representing in terms of targeting) and whether or not the model coefficients for each component are positive or negative, **ACKNOWLEDGING** that this setup would allow better exploration of the relationships between target species and bycatch of striped marlin.
159. The WPB **NOTED** that the use of the gamma distribution provides better fits than the lognormal, and that the author provided further explanations in terms of model fitting, and the WPB **SUGGESTED** that residual analysis could also be provided in the future.

Gillnet CPUE

160. The WPB **NOTED** paper IOTC–2017–WPB15–30 providing an estimation of CPUE for striped marlin caught by gillnet fisheries in the Indian Ocean including the following abstract provided by the authors:

"Catches of striped marlin (Tetrapturus audax) of gillnet fleets increased fast in recent year. In 2015 close to 30% of all striped marlin reported were caught by fishermen which operates ordinary gillnets, offshore gillnets, or gillnets attached to longlines. In spite of the importance of the gillnet fisheries in the Indian Ocean, there are not catch and effort databases for striped marlin and other billfish. Therefore, estimations of catch-per-unit-effort (CPUE) in conventional ways are not feasible. However, the number of gillnet boats have been reported yearly to the Indian Ocean Tuna Commission (IOTC) which also have estimations of yearly catches" (see paper for full abstract)

161. The WPB **NOTED** that this approach is heavily dependent on the total catches and number of vessels reported and further **ACKNOWLEDGED** that while the number of boats may be well reported in recent years, there still is high uncertainty in the initial part of the time series.

162. The WPB **NOTED** that effort information in terms of size of gillnets could also be potentially used, **ACKNOWLEDGING** that this approach was already implemented by I.R. Iran in their logbook, although yielding results that still appear problematic.

163. At the same time, the WPB **NOTED** that this information is expected to be collected in the future by the new observer and port-sampling programs.

164. The WPB **NOTED** the importance of the effort of providing some indicators from these gillnets fleets, and **AGREED** to use it as sensitivity analysis in the assessment.

165. However, the WPB **ACKNOWLEDGED** that to successfully adopt such series these need to be split, as there are some large changes that cannot be fully explained by changes in biomass of the species.

166. The WPB **NOTED** that Pakistan fleet data prior to 1993 were estimated by the IOTC Secretariat and officially reported only following that year. For this reason the WPB **AGREED** that 1993 could be considered as an appropriate year to split the analysis for that fleet.

Japan longline CPUE

167. The WPB **NOTED** paper IOTC–2017–WPB15–31 which provided standardised CPUE indices for striped marlin for 4 areas of the |Indian Ocean over two periods (1976-93 and 1994-2016) from the Japanese tuna longline fishery, including the following abstract provided by the authors:

> "*The IOTC has conducted the stock assessment of striped marlin by dividing the Indian Ocean into four areas. For the benchmark stock assessment in 2017, I standardized the Japanese longline CPUE of striped marlin for each of these regions. In this analysis, I applied the negative binomial GLM, the negative binomial GLMM, and the zero-inflated negative binomial GLMM to properly handle information that was included by vessel names such as differences in targeting and equipment, and zero inflated catch data. I used the BIC for the model selection, and the R software package lsmeans to calculate the standardized CPUE."* (see paper for full abstract)

168. The WPB **NOTED** that the method used is similar to the one used for swordfish and adequate to standardise CPUEs of bycatch species (such as marlins) for the Japanese fleet.

169. The WPB **AGREED** that the series should be split in two time periods and only the series from the NW area should be used in production models.

170. It was also **AGREED** to not use the series after 2011 because of its low coverage, **NOTING** that in the SS3 model multiple CPUEs from various regions were used.

CPUE Summary discussion

171. The WPB **NOTED** the different trends seen in the CPUE series and discussed which CPUE might be considered more reliable.

172. The WPB has previously agreed about using the Japanese longline series as a reference series, but in recent years has **AGREED** to split the series into an early period (1976-93) and a later series (1994-current year).

173. **NOTING** that the Taiwanese series covers a longer time period, the WPB considered the gillnet CPUE much more uncertain and **REQUESTED** that this should not be used in current stock assessments.

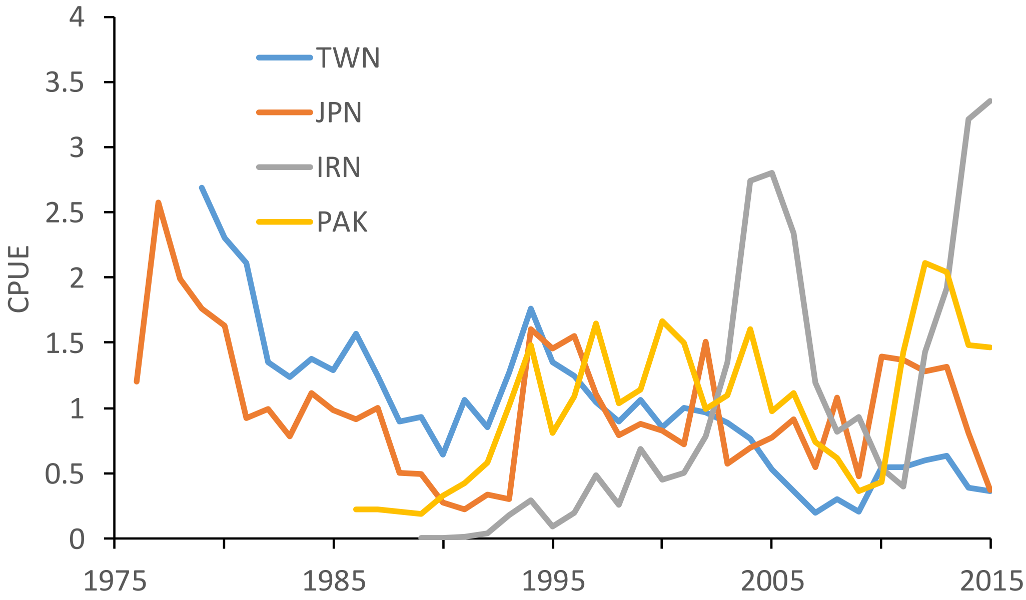


Figure 9. Standardized CPUE series of striped marlin in the Indian Ocean.

Black marlin

174. **NOTING** that black marlin was not a priority species in 2017 (it will be assessed in 2018 as per the Program of Work (see Appendix XI), no updated CPUE indices were submitted for consideration by the WPB in 2017.

Blue marlin

175. **NOTING** that blue marlin was not a priority species in 2017 (it will be assessed in 2019 as per the Program of Work (see Appendix XI), no updated CPUE indices were submitted for consideration by the WPB in 2017.

6.2.2 Stock assessments

Striped marlin: Summary of stock assessment models in 2017

Stock synthesis (SS3)

176. The WPB **NOTED** paper IOTC–2017–WPB15–32 which provided a stock assessment of striped marlin in the Indian Ocean using Stock Synthesis 3, including 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, CPUE and length-frequency data. The influences of CPUE series, time-varying catchability and selectivity assumption and life-history parameters on the assessment results were examined by various scenarios. The results of most scenarios indicated that the current stock status of striped marlin in the Indian may be overfished and overfishing already, except for the scenario of incorporating CPUE series of Iran and Pakistan." (see paper for full abstract).

177. The WPB **NOTED** the key assessment results for **Stock Synthesis** (SS3) as shown below (Table 14; Figures 10 and 11).

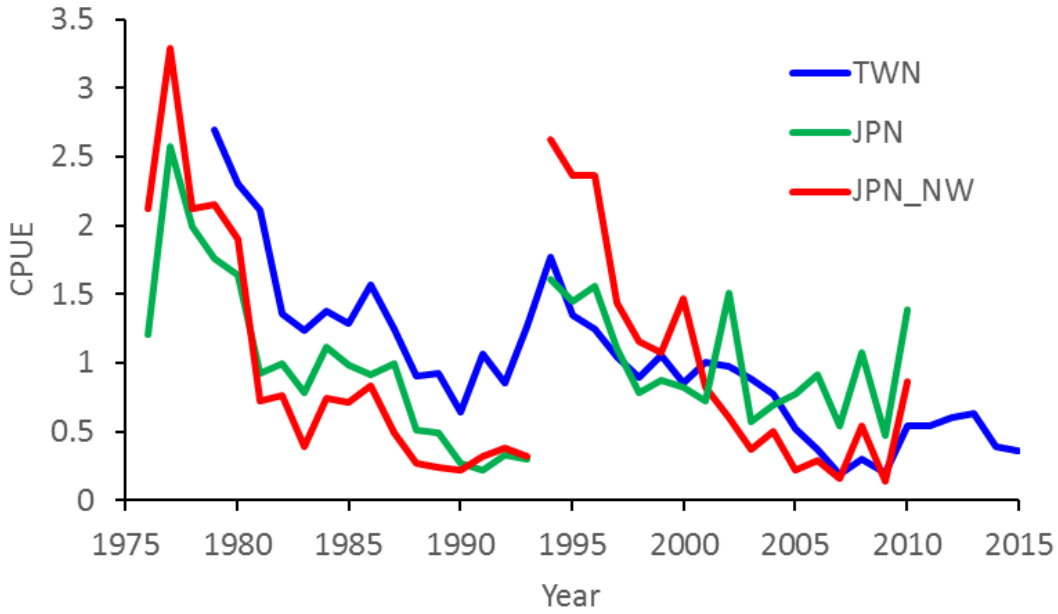


Fig. 10. CPUE series of Taiwanese and Japanese fleets used in the scenarios suggested by WPB.

Table 14. Stock status summary table for the striped marlin assessment (SS).

Management Quantity	Aggregate Indian Ocean
2015 catch estimate	4,369
Mean catch from 2011–2015	4,472
MSY (1000 t) (80% CI)	4.960 (4.762, 5.157)
Data period (catch)	1950–2015
F_{MSY} (80% CI)	0.900 (0.809 - 0.991)
SB_{MSY} (1,000 t) (80% CI)	1.82 (1.72 – 1.92)
F_{2015}/F_{MSY} (80% CI)	2.431 (1.632 - 3.23)
SB_{2015}/SB_{MSY} (80% CI)	0.373 (0.252 - 0.481)
SB_{2015}/SB_{1950} (80% CI)	0.063 (0.043 - 0.081)

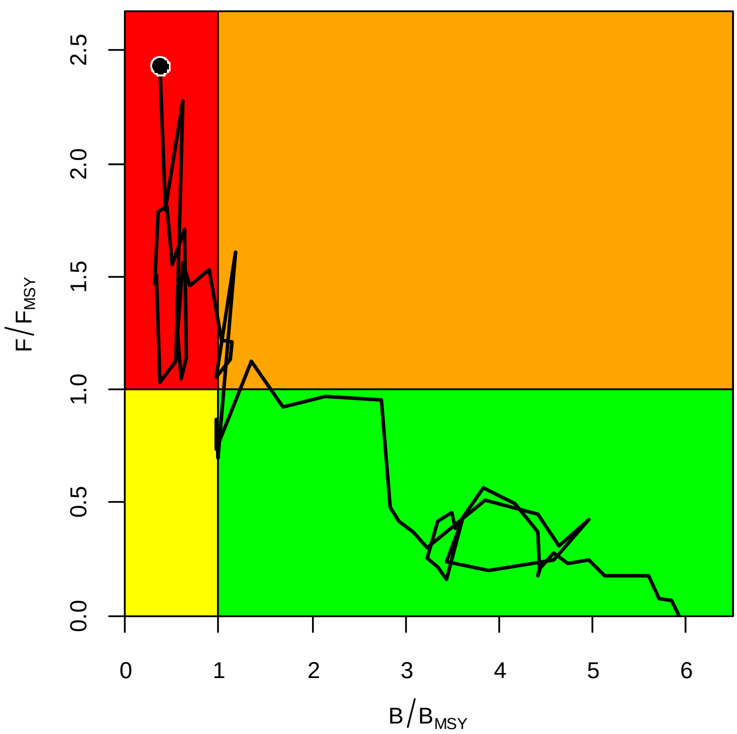


Figure 11. Stock synthesis: Kobe stock status plot for the Indian Ocean for striped marlin. The black line traces the trajectory of the stock over time.

178. The WPB **NOTED** that one major source of uncertainty regarding stock synthesis was in terms of the biology and population dynamics, including growth, maturity, steepness and mortality, currently using parameters from the Pacific and **ENCOURAGED** the authors to continue work with this model and try to improve those aspects in the future.

179. The WPB **NOTED** that there were no length data to fit a selectivity curve for the OTH fleet, which is now the largest component including the gillnet catches from Iran and Pakistan and therefore **AGREED** to use the Taiwan selectivity function as a proxy for the selectivity of the OTH fleet.

180. The WPB **AGREED** that there was not enough time at the meeting to explore the sensitivity of the model to this assumption. Furthermore, the WPB **REQUESTED** that some length information be collected from these fleets to allow an appropriate selectivity to be used in the model in the future.

A Stock-Production Model Incorporating Covariates (ASPIC)

181. The WPB **NOTED** paper IOTC–2017–WPB15–33 which provided a stock assessment of striped marlin in the Indian Ocean by A Stock-Production Model Incorporating Covariates (ASPIC), including the following abstract provided by the authors:

> *"In this study, a non-equilibrium production model (A Stock-Production Model Incorporating Covariates, ASPIC) (Prager, 2005) is applied to conduct the stock assessment of striped marlin (Kajikia audax) in the Indian Ocean using historical catch and standardized CPUE."* (see paper for full abstract)

182. The WPB **NOTED** the key assessment results for ASPIC as shown below (Table 15; Figure 12).

Table 15. Stock status summary table for the Striped marlin assessment (ASPIC)

Management Quantity	ASPIC
Current catch	4,369
Mean catch over last 5 years	4,472
MSY (1000 t)	5.400 (4.863 – 6.171)
F_{MSY}	0.572 (0.31 – 0.86)
Current Data Period	1950–2015
$F_{Current}/F_{MSY}$	1.324 (0.688 – 5.18)
$B_{Current}/B_{MSY}$	0.621 (0.06 – 1.175)
$SB_{Current}/SB_{MSY}$	n.a
$B_{Current}/B_0$	0.32
$SB_{Current}/SB_0$	n.a

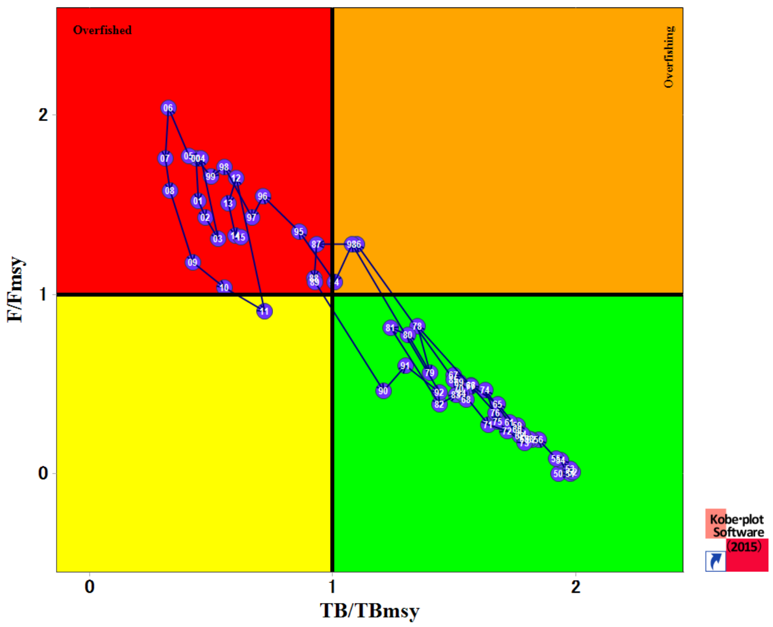


Figure 12. ASPIC: Kobe stock status plot for the Indian Ocean for striped marlin. The black line traces the trajectory of the stock over time.

Stock Reduction Analysis (SRA)

183. The WPB **NOTED** paper IOTC–2017–WPB15–34 which provided a stock assessment of striped marlin in the Indian Ocean using Stock Reduction Analysis (SRA), including the following abstract provided by the authors

"*In this paper a Stock Reduction Analysis (SRA) based on catch data and on prior information concerning the intrinsic growth rate (r) was used to estimate maximum sustainable yield of striped marlin (Tetrapturus audax) caught in the Indian Ocean. Three different assumptions concerning depletion of biomass in 2016 were considered in sensitivity runs. Results and the diagnostic of the status of the stock strongly depends on the assumptions, which might be carefully evaluated by the working group if the intention is to use SRA to assess the status of the stock."* (see paper for full abstract)

184. The WPB **NOTED** the key assessment results[2] for the **Stock Reduction Analysis** (SRA) for striped marlin as shown below (Table 16; Figure 13).

Table 16. Stock status summary table for the striped marlin stock assessment (SRA)

Management Quantity	SRA
Current catch	4,369
Mean catch over last 5 years	4,472
MSY (1000 t)	3.264 (2.542 – 4.051)
F_{MSY}	0.05 (0.03 – 0.1)
Current Data Period	1950 - 2015
$F_{Current}/F_{MSY}$	3.04 (1.51 – 9.16)
$B_{Current}/B_{MSY}$	0.44 (0.17 – 0.79)
$SB_{Current}/SB_{MSY}$	n.a.
$B_{Current}/B_0$	0.22 (0.08 – 0.4)
$SB_{Current}/SB_0$	n.a.

[2] The modes are shown in the Kobe plot, while the means are in the management table: as the joint distribution of F/F_{msy} and of B/B_{msy} in 2015 is strongly asymmetrical, the mean of F/F_{msy} is higher than the mode, while the mean of B/B_{msy} is lower than the mode

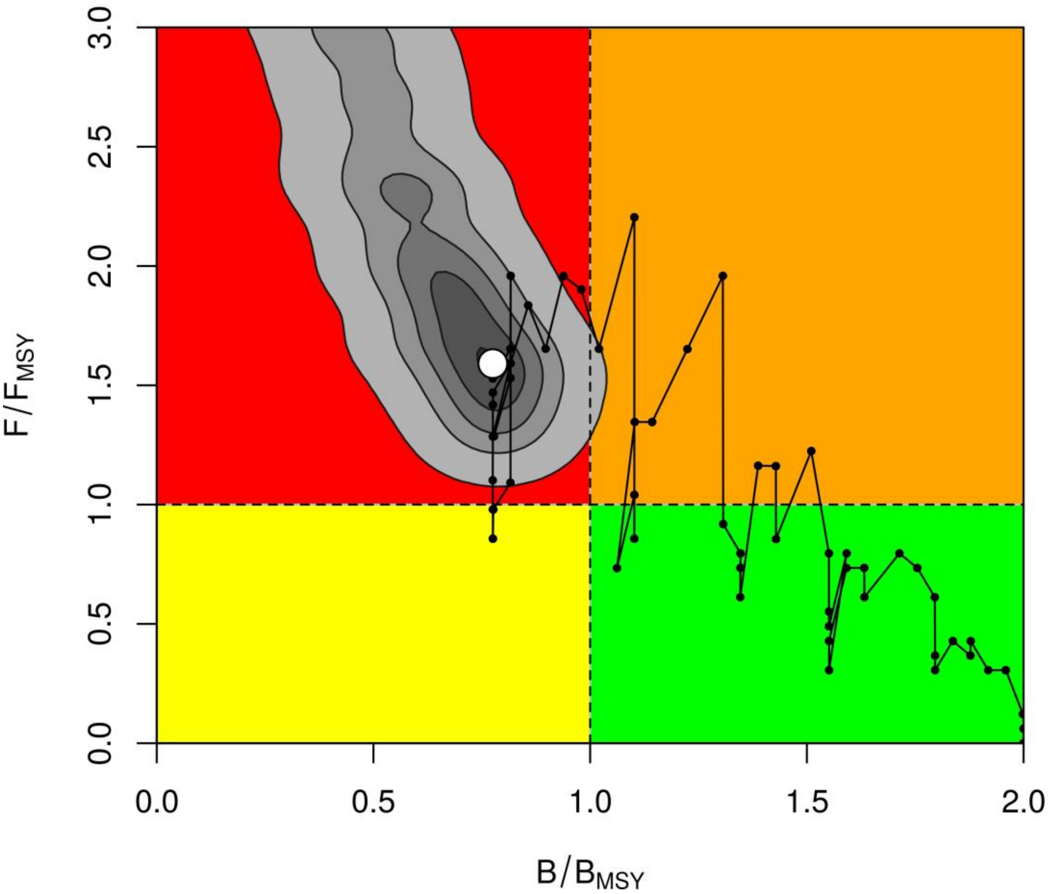


Figure 13. Stock reduction analysis: Kobe stock status plot for the Indian Ocean for striped marlin. The black line traces the trajectory of the stock over time. Contours represent the smoothed probability distribution for 2015 (isopleths are probability relative to the maximum).

185. The WPB **NOTED** that the results of this model were very sensitive to the assumed level of depletion and more optimistic that the BPSM model below, that used the CPUE series to estimate the decline in the stock.

Bayesian Surplus Production Model (BSPM)

186. The WPB **NOTED** paper IOTC–2017–WPB15–35 which provided a stock assessment of striped marlin in the Indian Ocean using Bayesian Surplus Production Model (BSPM), including the following abstract provided by the authors:

> "*Bayesian state-space models were used to assess the striped marlin (Tetrapturus audax) caught in the Indian Ocean assuming that there is a single stock. Estimations of catches as reported in the IOTC database were used and the models were fitted to standardized catch-per-unit-effort (CPUE) of striped marlin (Tetrapturus audax) caught by longline fleets in the Indian Ocean. Nominal catch rates of gillnet were also considered in exploratory runs. Catches and standardized CPUEs were conflictive in some parts of the time series. There are periods in which the CPUE indicated that there was a sharp decrease of biomass but the catches were not particularly high and was not showing an increasing trend. Uncertain is high as indicated by the wide posteriors of parameters. Data does not convey information about k. The preliminary estimations indicate that striped marlin stock has been overfished since 1990's. Estimations of recent catches were lower than MSY but are still higher than the recent surplus production, hence the results concerning the status of the stock are pessimistic"* (see paper for full abstract)

187. The WPB **NOTED** the key assessment results for Bayesian Surplus-Production Model (BSPM) for striped marlin as shown below (Table 17; Figure 14).

Table 17. Stock status summary table for the striped marlin assessment (BSPM)

Management Quantity	BSPM
Current catch	4,369
Mean catch over last 5 years	4,472
MSY (1000 t)	5.352 (4.33 – 6.89)
F_{MSY}	0.16 (0.11 – 0.24)
Current Data Period	1950 - 2015
$F_{Current}/F_{MSY}$	3.4 (2.45 – 4.75)
$B_{Current}/B_{MSY}$	0.24 (0.16 – 0.35)
$SB_{Current}/SB_{MSY}$	n.a.
$B_{Current}/B_0$	0.09 (0.06 – 0.13)
$SB_{Current}/SB_0$	n.a.

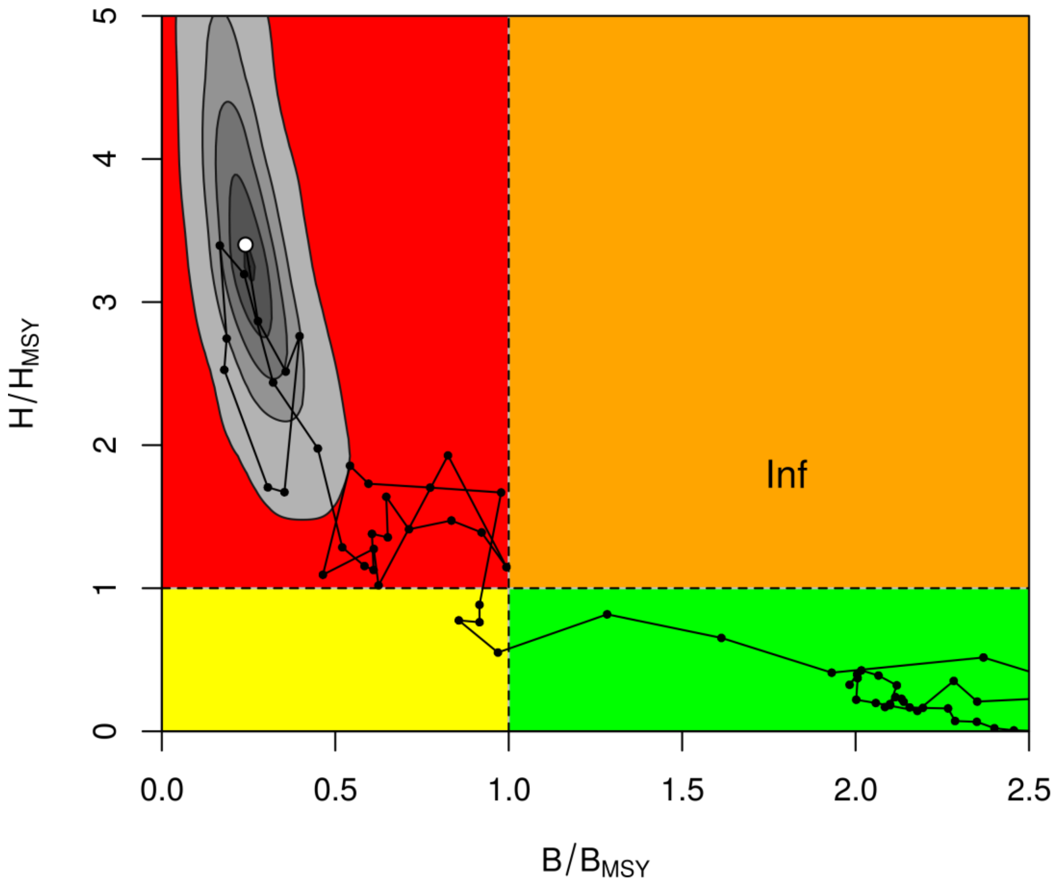


Figure 14. BSPM: Kobe stock status plot for the Indian Ocean for striped marlin. The black line traces the trajectory of the stock over time. Contours represent the smoothed probability distribution for 2015 (isopleths are probability relative to the maximum).

188. The WPB **NOTED** that the model includes observational and process errors, which allow for more flexibility when fitting the CPUE series than when using only observational error as in the ASPIC.

189. The WPB **NOTED** that the model was fitted to standardized CPUEs of longline fleet of Taiwan,China and Japan, but also to nominal CPUEs of gillnet fleets of Iran and Pakistan. The gillnet time series were not influential when calculating the F/F_{MSY} and B/B_{MSY} ratios, the exception was the Iran CPUEs which affect the estimations of F/F_{MSY} and B/B_{MSY} in the end of the time series. Therefore the WPB **AGREED** to fit the models to Taiwan,China and Japan CPUE series only, as the gillnet CPUEs were not standardized.

190. The WPB **NOTED** the strong conflict between the catch and the CPUE series, particularly before mid-1980s. The CPUE decreased fast in that period but the catches were not increasing or were particularly high. In the model that included process error, the fits to the data at the beginning part of the series were biased.

191. The WPB **NOTED** that data do not convey much information on the parameters and that the uncertainty is high.

192. The WPB also **NOTED** that, in general, the results of all the models runs indicated that the stock have been overfished and subject to overfishing in the last two decades.

193. The WPB **NOTED** the conflicts among CPUE and catch series are a critical issue for the reliability of stock assessment results conducted using such simple production models and **REQUESTED** that future studies investigate the source of these conflicts among CPUE and catch series.

Selection of stock status indicators for marlins

Striped marlin

194. The WPB **NOTED** Table 18, which provides an overview of the key features of each of the striped marlin stock assessments presented in 2017 for the Indian Ocean-wide assessments (4 model types). Similarly, Table 19 provides a summary of the assessment results.

Table 18. Striped marlin: **Indian Ocean-wide** assessments. Summary of final stock assessment model features as applied to the Indian Ocean striped marlin resource in 2017.

Model feature	**SS3 (Doc #32 Rev1)**	**ASPIC (Doc #33)**	**SRA (Doc #34)**	**BSPM (Doc #35)**
Software availability	NOAA toolbox	NOAA toolbox	H Andrade	H Andrade
Population spatial structure / areas	Yes	No	No	No
Number CPUE Series	2	2	2	2
Uses Catch-at-length/age	Yes	No	No	No
Age-structured	Yes	No	No	No
Sex-structured	Yes	No	No	No
Number of Fleets	3	1	1	1
Stochastic Recruitment	Yes	No	No	No
B_{MSY}/B_{1950}	0.17	0.52	0.5	0.38

Table 19. Striped marlin: **Indian Ocean-wide** summary of key management quantities from the assessments undertaken in 2017.

Management quantity	**SS3 (Doc #32 Rev1)**	**ASPIC (Doc #33)**	**SRA (Doc #34)**	**BSPM (Doc #35)**
Most recent catch estimate (t) (2015)	4,369	4,369	4,369	4,369
Mean catch over last 5 years (t) (2011–2015)	4,472	4,472	4,472	4,472
h (steepness)	0.86	n.a.	n.a.	n.a.
MSY (1,000 t) (80% CI) [plausible range of values]	4.96)4.76 – 5.16)	5.4 (4.9 – 6.2)	3.26 (2.54 – 4.05)	5.35 (4.33 – 6.89)
Data period (catch)	1950 - 2015	1950 - 2015	1950 - 2015	1950 - 2015
CPUE series	JPN,TWN (early and late)	JPN (late) TWN	JPN (late) TWN	JPN (late) NW only TWN
CPUE period	JPN (1976 - 1993) TWN (1979 -1993) JPN (1994 - 2010) TWN (1994 -2015)	JPN (1994- 2015) TWN (1979 -2016)	JPN (1994- 2010) TWN (1979 -2016)	JPN (1994- 2010) TWN (1979 -2016)
F_{MSY}	0.9 (0.81 – 0.99)	0.57 (0.31 – 0.86)	0.05 (0.03 0.1)	0.16 (0.11 – 0.24)
SB_{MSY} or $*B_{MSY}$ (1,000 t)	1.82 (1.72 - 1.92)	9.5 (6.4 – 5.2)	61.0 (40.3 – 82.5)	34.3 (21.4 – 54.7)
F_{2015}/F_{MSY} (80% CI) [plausible range of values]	2.43 (1.63 – 3.23)	1.324 (0.69 – 5.18)	3.04 (1.51 – 9.16)	3.4 (2.5 – 4.8)

B_{2015}/B_{MSY} (80% CI) [plausible range of values]	n.a.	0.62 (0.06 - 1.18)	0.44 (0.17 – 0.79)	0.24 (0.16 – 0.35)
SB_{2015}/SB_{MSY} (80% CI) [plausible range of values]	0.373 (0.25 – 0.48)	n.a.	n.a.	n.a.
B_{2015}/B_{1950} (80% CI) [plausible range of values]	n.a.	0.32	0.22 (0.08 – 0.4)	0.09 (0.06 – 0.13)
SB_{2015}/SB_{1950} (80% CI) [plausible range of values]	0.063 (0.043 – 0.08)	n.a.	n.a.	n.a.
$SB_{2015}/SB_{current,\ F=0}$	n.a.	n.a.	n.a.	n.a.

n.a. = not available

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

Striped marlin

195. The WPB **NOTED** that all examined models were consistent in 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 BMSY level. For this reason, the WPB **AGREED** that the final advice should come from all the explored models.

196. On the weight-of-evidence available in 2017, the WPB **AGREED** that the stock status of striped marlin is determined to be overfished and subject to overfishing.

197. **NOTING** that the recent catch levels appear to be inconsistent with the observed decline in CPUE and the pessimistic stock status in all the models, the WPB **ACKNOWLEDGED** that this anomaly has not been resolved in 2017.

198. The WPB **NOTED** the management advice developed for striped marlin at WPB15 :

> "C*urrent or increasing catches have a very high risk of maintain the stock overfished. In order to enable the stock to start rebuilding, the Commission should consider a drastic reduction of catch levels. A new stock assessment will be carried on in 2018."*

Black marlin

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

Blue marlin

200. 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.

201. The WPB **ADOPTED** the management advice developed for each marlin species as provided in the draft resource stock status summaries and **REQUESTED** that the IOTC Secretariat update the draft stock status summaries for each marlin species with the latest 2016 catch data and for the summaries to be provided to the Scientific Committee as part of the draft Executive Summary, for its consideration:

- Black marlin (*Makaira indica*) – Appendix VII
- Blue marlin (*Makaira nigricans*) – Appendix VIII
- Striped marlin (*Tetrapturus audax*) – Appendix IX

7. INDO-PACIFIC SAILFISH

7.1 Review of new information on the status of I.P. sailfish

202. **NOTING** that Indo-pacific sailfish was not a priority species in 2017 (it will be assessed in 2019 as per the Program of Work (see Appendix XI), no new information or updated CPUE indices were submitted for consideration by the WPB in 2017.

7.2 Selection of Stock Status indicators for I.P sailfish

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

7.3 Development of management advice for sailfish and update of sailfish species Executive Summaries for the consideration of the Scientific Committee

204. The WPB **ADOPTED** the management advice developed for Indo-Pacific sailfish (*Istiophorus platypterus*), as provided in the draft resource stock status summary and **REQUESTED** that the IOTC Secretariat update the draft stock status summary for Indo-Pacific sailfish with the latest 2016 catch data, and for the summary to be provided to the Scientific Committee as part of the draft Executive Summary, for its consideration:

- Indo-Pacific sailfish (*Istiophorus platypterus*) – Appendix X

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

205. The WPB **ACKNOWLEDGED** that the need to develop Alternative Management Measures (AMM) to commonly adopted catch-based approaches originates from a specific request of the Commission, following the unsafe status determined for some billfish species.

206. At the same time the WPB **NOTED** that input control measures (effort-based) were deemed as weak or not entirely effective, due to the difficulties in controlling and monitoring the number of vessels and the length of gillnets (among others).

207. 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.

9. WPB PROGRAM OF WORK

9.1 Revision of the WPB Program of work (2018–2022)

208. The WPB **NOTED** paper IOTC–2017–WPB15–08 Rev_1 which provided an opportunity to consider and revise the WPB Program of Work (2018–2022), by taking into account the specific requests of the Commission, Scientific Committee, and the resources available to the IOTC Secretariat and CPCs.

209. 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).

210. **NOTING** that the first phase of the sports fishery project has come to the expected end, the WPB **REQUESTED** that the final project report be evaluated by the next Scientific Committee prior to taking further actions for the identification of additional funding sources to support a potential second phase of the project.

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.

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.

213. The WPB **NOTED** that budget has been allocated for 2017 and 2018 for CPUE standardisation with coastal fleets and stock assessment including data-poor approaches.

214. The WPB **NOTED** the importance, for a correct implementation of the ROS pilot project, that CPCs coordinate with the IOTC Secretariat and **REQUESTED** interested CPCs to take proper action on this matter..

215. The WPB **NOTED** the proposal on the development of a tagging project with the objectives of determining levels of connectivity, movement rates, mortality for billfish stocks with Swordfish as a priority species and **AGREED** that this will be intersessionally developed for a presentation to the next Scientific Committee.

216. The WPB **RECOMMENDED** that future work continues on the marlins stock assessment in order to improve current models and other approaches such as delay-difference or age-structured production models are explored. Therefore the WPB **AGREED** that its plan of work be intersessionally amended for the consideration of the SC and a consultant be hired to further explore the data and models.

217. The WPB **RECOMMENDED** that the SC consider and endorse the WPB Program of Work (2018–2022), as provided at Appendix XI.

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

218. The WPB **NOTED**, with thanks, the outstanding contributions of the invited expert for the meeting, Dr Toshihide Kitakado from the Tokyo University of Marine Science and Technology. Dr Kitakado's work during the WPB15 meeting has greatly contributed to the group's understanding of billfish data and assessment methods. Dr Kitakado collaborated with the WPB, as the Invited Expert, on a voluntary basis and his expertise has been greatly appreciated having contributed substantially to the stock status determination of billfish under the IOTC mandate.

219. 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 2018, 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: black marlin and striped marlin).

220. The WPB **AGREED** that the selection of the invited expert for the next WPB16 would be performed by advertising the position through the IOTC science list (as a priority channel) and finalized after receipt and assessment of resumes and supporting information for potential candidates, according to the deadlines set forth by the rules and procedures of the Commission.

10. OTHER BUSINESS

10.1 Date and place of the 16th and 17th Sessions of the Working Party on Billfish

221. The WPB **THANKED** AZTI Tecnalia for hosting the 15th Session of the WPB and commended AZTI on the warm welcome, the excellent facilities and assistance provided for the organisation and running of the Session.

222. The WPB **AGREED** on the importance of having IOTC working party meetings within key CPCs catching species of relevance to the working party, in this case on billfish. Following a discussion on who would host the 16th and 17th sessions of the WPB in 2018 and 2019 respectively, the WPB **ACKNOWLEDGED** the offer from South Africa to host the 16th 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 November 2017 (Table 20).

Table 20. Draft meeting schedule for the WPB (2018 and 2019)

	2018			**2019**		
Meeting	**No.**	**Date**	**Location**	**No.**	**Date**	**Location**
Working Party on **Billfish** (WPB)	16th	4-8 September (5d)	South Africa (TBC)	17th	9-13 September (5d)	La Réunion (TBC)
Working Party on **Ecosystems and Bycatch** (WPEB)	14th	10-14 September (5d)	South Africa (TBC)	15th	3-7 September (5d)	La Réunion (TBC)

223. 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.

10.2 Election of a Chairperson and Vice-Chairperson for the next biennium (IOTC Secretariat)

Chairperson

224. The WPB **NOTED** that the first term of the current Chairperson, Dr Tsutomu Nishida, is due to expire at the end of the current WPB meeting and, as per the IOTC Rules of Procedure (2014), participants are required to elected a new Chairperson for the next biennium.

225. The WPB **THANKED** Dr Nishida for his Chairmanship over the past two years and looked forward to his continued engagement in the activities of the WPB in the future.

226. **NOTING** the Rules of Procedure (2014), the WPB CALLED for nominations for the newly vacated position of Chairperson of the IOTC WPB for the next biennium. Dr Rui Coelho was nominated, seconded and elected as Chairperson of the WPB for the next biennium.

Vice-Chairperson

227. The WPB **NOTED** that the first term of the current Vice-Chairperson, Dr Evgeny Romanov, is due to expire at the closing of the current WPB meeting and, as per the IOTC Rules of Procedure (2014), participants are required to elected a new Vice-Chairperson for the next biennium.

228. **NOTING** the Rules of Procedure (2014), the WPB **CALLED** for nominations for the position of the Vice Chairperson of the IOTC WPB for the next biennium. Dr Evgeny Romanov was nominated, seconded and re-elected as Vice-Chairperson of the WPB for the next biennium.

10.3 Review of the draft, and adoption of the Report of the 15th Session of the Working Party on Billfish

229. The WPB **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPB15, 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 2017 (Fig. 15):

   - 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

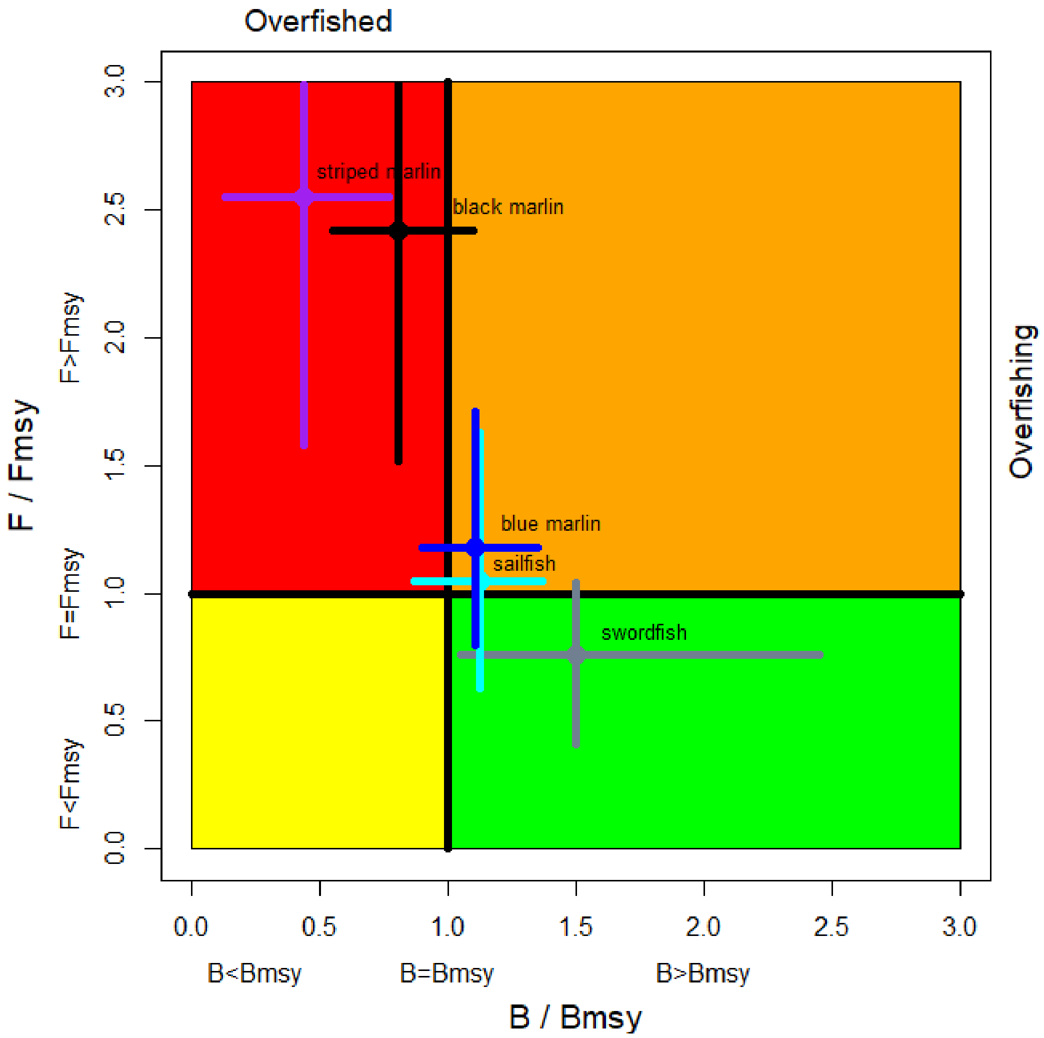


Fig. 15. Combined Kobe plot for swordfish (grey), indo-pacific sailfish (cyan), black marlin (black), blue marlin (blue) and striped marlin (purple) showing the 2016 and 2017 estimates of current stock size (SB or B, species assessment dependent) and current fishing mortality (F) in relation to optimal spawning stock size and optimal fishing mortality. Cross bars illustrate the range of uncertainty from the model runs.

230. The report of the 15th Session of the Working Party on Billfish (IOTC–2017–WPB15–R) was **ADOPTED** on the 14th of September 2017

APPENDIX I
LIST OF PARTICIPANTS

Chairperson:
Dr Tsutomu **Nishida**
National Research Institute of Far Sea Fisheries, Japan
Email: aco20320@par.odn.ne.jp

Vice-Chairperson:
Dr Evgeny **Romanov**
CAP-RUN - Hydro REUNION, Réunion, EU,France
Email : evgeny.romanov@ird.fr

Invited Expert:
Dr Toshihide **Kitakado**
Tokyo University of Marine Science and Technology, Japan
Email: kitakado@kaiyodai.ac.jp

Other Participants:
Dr Humber Agrelli **Andrade**
Universidade Federal Rural de Pernambuco – UFRPE, Brazil
Email: humber.andrade@gmail.com

Dr Pascal **Bach**
IRD, Institut de Recherche pour le Développement, Sète, EU,France
Email: pascal.bach@ird.fr

Mr Samsudin **Basir**
Department of Fisheries, Malaysia
Email: s_basir@yahoo.com

Dr Sylvain **Bonhommeau**
Institut Français de recherche pour l'exploitation de la mer, Réunion, EU,France
Email:
sylvain.bonhommeau@ifremer.fr

Dr Rui **Coelho**
IPMA, Portuguese Institute for the Ocean and Atmosphere, Olhao, EU,Portugal
Email: rpcoelho@ipma.pt

Mrs Charlene **Da Silva (Graham)**
DAFF, South Africa
Email: CharleneD@daff.gov.za

Mr Jose **Fernández Costa**
Instituto Español de Oceanografía, EU,Spain
Email: jose.costa@ ieo.es

Mr Fabio **Fiorellato**
IOTC Secretariat, Victoria, Seychelles
Email: fabio.fiorellato@fao.org

Mr Dan **Fu**
IOTC Secretariat, Victoria, Seychelles
Email: dan.fu@fao.org

Mrs Sandamali **Herath**
Department of Fisheries & Aquatic Resources, Sri Lanka
Email: hlsherath@gmail.com

Mrs Juliette **Lucas**
Seychelles Fishing Authority, Victoria, Seychelles
Email: jlucas@sfa.sc

Dr Hilario **Murua**
AZTI Tecnalia, San Sebastian, Eu,Spain
Email: hmurua@azti.es

Ms Sampan **Panjarat**
Department of Fisheries, Thailand
Email: spanjarat@yahoo.com

Mr Fariborz **Rajaei**
Iran Fisheries Organization, I.R. Iran
Email: rajaeif@gmail.com

Dr Philippe **Sabarros**
IRD, Institut de Recherche pour le Développement, Sète, EU,France
Email: philippe.sabarros@ird.fr

Mr Bram **Setyadji**
Research Institute for Tuna Fisheries, Indonesia
Email: bram.setyadji@gmail.com

Dr Reza **Shahifar**
Marine Resources Rehabilitation & Protection, I.R. Iran
Email: r.shahifar@gmail.com

Dr Kevin **Sullivan**
IOTC Secretariat, Victoria, Seychelles
Email: kevin.sullivan@fao.org

Dr Sheng-Ping **Wang**
Department of Environmental Biology and Fisheries Science, National Taiwan Ocean University, Keelung, Taiwan
Email: wsp@mail.ntou.edu.tw

Mr Madhura **Weerasekera**
National Aquatic Resources Research and Development Agency, Sri Lanka
Email: madhurapro@gmail.com

Mr Meng **Xia**
Shanghai Ocean University, China
Email: 459773299@qq.com

Dr Hiroki **Yokoi**
National Research Institute of Far Sea Fisheries, Japan
Email: yokoih@affrc.go.jp

APPENDIX II
AGENDA FOR THE 15TH WORKING PARTY ON BILLFISH

Date: 10–14 September 2017
Location: San Sebastian, Spain
Venue: AZTI, Pasaia
Time: 09:00 – 17:00 daily
Chair: Dr Tsutomu Nishida (Japan); **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 19th Session of the Scientific Committee (IOTC Secretariat)
   - 3.2 Outcomes of the 21th 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 WPB14 (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. **SWORDFISH**
   - 5.1 Review new information on swordfish biology, stock structure, fisheries and associated environmental data (all)
   - 5.2 Review of new information on the status of swordfish (all)
     - Nominal and standardised CPUE indices
     - Stock assessments
     - Selection of Stock Status indicators for swordfish
   - 5.3 Development of management advice for swordfish and update of swordfish Executive Summary for the consideration of the Scientific Committee (all)

6. **MARLINS (Priority species for 2017: Striped marlin)**
   - 6.1 Review new information on marlin biology, stock structure, fisheries and associated environmental data (all)
   - 6.2 Review of new information on the status of marlins (all)
     - Nominal and standardised CPUE indices
     - Stock assessments
     - Selection of Stock Status indicators for marlins
   - 6.3 Development of management advice for marlins and update of marlin species Executive Summaries for the consideration of the Scientific Committee (all)

7. **INDO-PACIFIC SAILFISH**
   - 7.1 Review new information on I.P. sailfish biology, stock structure, fisheries and associated environmental data (all)
   - 7.2 Review of new information on the status of IP sailfish (all)
     - Nominal and standardised CPUE indices
     - Selection of Stock Status indicators for IP sailfish
   - 7.3 Development of management advice for IP sailfish and update of IP sailfish species Executive Summaries for the consideration of the Scientific Committee (all)

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

9. WPB PROGRAM OF WORK

9.1 Revision of the WPB Program of Work (2018–2022) (Chairperson and IOTC Secretariat)

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

10. OTHER BUSINESS

10.1 Date and place of the 16th and 17th Sessions of the Working Party on Billfish (Chairperson and IOTC Secretariat)

10.2 Election of a Chairperson and Vice-Chairperson for the next biennium (IOTC Secretariat)

10.3 Review of the draft, and adoption of the Report of the 15th Session of the Working Party on Billfish (Chairperson)

APPENDIX III
LIST OF DOCUMENTS

Last updated: October 9th 2017

Document	Title	Availability
IOTC–2017–WPB15–01a	Agenda of the 15th Working Party on Billfish	✓(1 June 2017)
IOTC–2017–WPB15–01b	Annotated agenda of the 15th Working Party on Billfish	✓(14 August 2017) ✓(28 August 2017)
IOTC–2017–WPB15–02	List of documents of the 15th Working Party on Billfish	✓(14 August 2017) ✓(14 Sept. 2017)
IOTC–2017–WPB15–03	Outcomes of the 19th Session of the Scientific Committee (IOTC Secretariat)	✓(8 August 2017)
IOTC–2017–WPB15–04	Outcomes of the 21th Session of the Commission (IOTC Secretariat)	✓(9 August 2017)
IOTC–2017–WPB15–05	Review of Conservation and Management Measures relevant to billfish (IOTC Secretariat)	✓(10 August 2017)
IOTC–2017–WPB15–06	Progress made on the recommendations and requests of WPB14 and SC19 (IOTC Secretariat)	✓(11 August 2017)
IOTC–2017–WPB15–07_Rev1	Review of the statistical data and fishery trends for billfish species (IOTC Secretariat)	✓(26 August 2017) ✓(6 Sept. 2017)
IOTC–2017–WPB15–08	Revision of the WPB Program of Work (2018–2022) (IOTC Secretariat)	✓(16 August 2017)
IOTC–2017–WPB15–09	A brief overview of the large pelagic in Iran with the emphasis on billfish by-catches of the Iran gillnet fishery in the IOTC area (2012-2016) (Rajaei F)	✓(25 August 2017)
IOTC–2017–WPB15–10	Exploring the spatial distribution to analyze the spatial variability of catch compositions of three major billfish species; Swordfish (Xiphias gladius), Black marlin (Makaira indica) and Sailfish (Istiophorus platypterus) from high-seas multi-day fishery in Sri Lanka (Weerasekera S.J., Rathnasuriya M.I.G.)	✓(8 Sept. 2017) ✓(13 Sept. 2017)
IOTC–2017–WPB15–11	Billfishes landings in Southwestern Indian Ocean by Malaysian flag vessels (Basir S, Jamon S, Mohd Faizal E)	✓(11 August 2017)
IOTC–2017–WPB15–12	The Review of landing billfishes in Phuket ports, Thailand (Panjarat S, Rodpradit S)	✓(25 August 2017) ✓(11 Sept. 2017)
IOTC–2017–WPB15–36	Increased billfish by-catches of the Seychelles industrial longline fishery (Lucas J, Assan C)	✓(25 August 2017)
IOTC–2017–WPB15–13_Rev1	Facilitating the acquisition of catch-and-effort and size data from sports fisheries in the western Indian Ocean (Pepperell J, Griffiths S, Kadagi N)	✓(25 August 2017) ✓(1 Sept. 2017)
IOTC–2017–WPB15–14	Swordfish catches by the Portuguese pelagic longline fleet in 1998-2016 in the Indian Ocean: catch, effort and standardized CPUEs (Coelho R, Lino P. G., Rosa D.)	✓(26 July 2017)
IOTC–2017–WPB15–15	Standardised CPUE indices for Swordfish (Xiphias gladius) from the Indonesian tuna longline fishery (Setyadji B, Fahmi Z, Andrade H)	✓(25 August 2017)
IOTC–2017–WPB15–16	Updated standardized catch rates of Swordfish (Xiphias gladius) caught by the Spanish surface longline fleet in the Indian ocean during the 2001-2015 period (Fernández-Costa J, García-Cortés B, Ramos-Cartelle A, Mejuto J)	✓(24 August 2017)
IOTC–2017–WPB15–17_Rev1	CPUE standardization of Swordfish (Xiphias gladius) caught by Taiwanese longline fishery in the Indian Ocean (Wang S.P.)	✓(25 August 2017) ✓(13 Sept. 2017)
IOTC–2017–WPB15–18	Standardized CPUE for Swordfish using French longliner data from 1993 to 2016 (Bonhommeau S, Evano H, Huet J)	[WITHDRAWN]
IOTC–2017–WPB15–19	CPUE standardization of the Indian Ocean Swordfish (Xiphias gladius) by Japanese longline fisheries: Using negative binomial GLMM and zero inflated negative binomial GLMM to consider vessel effect (Ijima et al)	✓(25 August 2017)
IOTC–2017–WPB15–37_Rev2	Standardization of the catch per unit effort for Swordfish (Xiphias gladius) for the South African longline fishery (Da Silva C, Parker D, Winker H, West W, Kerwath S. E.)	✓(25 August 2017) ✓(1 Sept. 2017)
IOTC–2017–WPB15–20_Rev1	An age-, sex- and spatially-structured stock assessment of the Indian Ocean Swordfish fishery 1950-2015, using stock synthesis (IOTC Secretariat)	✓(25 August 2017) ✓(28 August 2017)

Document	Title	Availability
IOTC–2017–WPB15–21_Rev1	Stock assessment of Swordfish (Xiphias gladius) in the Indian Ocean using A Stock-Production Model Incorporating Covariates (ASPIC) (Wang S.P.)	✓(26 August 2017) ✓(13 Sept. 2017)
IOTC–2017–WPB15–22_Rev1	Stock assessments of Swordfish (Xiphias gladius) in the Indian Ocean using Statistical-Catch-At-Age (SCAA) (Nishida T et al)	✓(29 August 2017) ✓(5 Sept. 2017)
IOTC–2017–WPB15–23	Model diagnostic for Stock Synthesis in the assessment of the Indian Ocean swordfish (Xiphias gladius) (Yokoi et al)	✓(25 August 2017)
IOTC–2017–WPB15–24	Stock Assessment of Swordfish (Xiphias gladius) of the Indian Ocean using a Bayesian Surplus Production Model (Andrade H)	✓(14 Sept. 2017)
IOTC–2017–WPB15–25	Stock assessment of the Swordfish using a Virtual Population Analysis (Bonhommeau S, Nieblas A-E, Evano H, Huet J, Barde J)	[WITHDRAWN]
IOTC–2017–WPB15–26	An online tool to easily run stock assessment models, using SS3 and SWO as an example (Nieblas A-E, Bonhommeau S, Imzilen T, Fu D, Fiorellato F, Barde J)	✓(26 August 2017)
IOTC–2017–WPB15–27_Rev1	Management strategy evaluation for Indian Ocean Striped marlin (Tetrapturus audax) based on data limited methods (Xia M, Dai X, Zhu J)	✓(25 August 2017) ✓(13 Sept. 2017)
IOTC–2017–WPB15–28	Preliminary results from an assessment of genetic population structure for Striped marlin (Tetrapturus audax) in the Pacific and Indian oceans (Mamoozadeh N. R., McDowell J. R., Graves J. E.)	✓(25 August 2017)
IOTC–2017–WPB15–29_Rev1	CPUE standardization of Striped marlin (Tetrapturus audax) caught by Taiwanese longline fishery in the Indian Ocean (Wang S.P.)	✓(25 August 2017) ✓(13 Sept. 2017)
IOTC–2017–WPB15–30	Estimations of Catch per Unit Effort (CPUE) of Striped marlin (Tetrapturus audax) caught by gillnet fleets in the Indian Ocean (Andrade H)	✓(1 Sept. 2017)
IOTC–2017–WPB15–31	CPUE standardization of the Indian Ocean Striped marlin (Tetrapturus audax) by Japanese longline fisheries: Using negative binomial GLMM and zero inflated negative binomial GLMM to consider vessel effect (Ijima et al)	✓(25 August 2017)
IOTC–2017–WPB15–32_Rev1	Stock assessment of Striped marlin (Tetrapturus audax) in the Indian Ocean using the Stock Synthesis (Wang S.P.)	✓(31 August 2017) ✓(13 Sept. 2017)
IOTC–2017–WPB15–33	Stock assessments of Striped marlin (Tetrapturus audax) in the Indian Ocean using A Stock-Production Model Incorporating Covariates (ASPIC) (Yokoi et al)	✓(26 August 2017)
IOTC–2017–WPB15–34	Stock Reduction Analysis of Striped marlin (Tetrapturus audax) caught in the Indian Ocean (Andrade H)	✓(28 August 2017)
IOTC–2017–WPB15–35	Stock assessment of Striped marlin (Tetrapturus audax) of the Indian Ocean using a Bayesian Surplus Production Model (Andrade H)	✓(14 Sept. 2017)
Information papers		
IOTC-2017-WPB15-INF01	Determination of swordfish growth and maturity relevant to the southwest Pacific stock (Farley J, Clear N, Kolody D, Krusic-Golub K, Eveson P, Young J)	✓(19 July 2017)
IOTC-2017-WPB15-INF02_Rev1	JABBA: Just Another Bayesian Biomass Assessment for Indian Ocean swordfish (Winker H)	✓(10 Sept. 2017) ✓(9 October 2017)
Data sets		
IOTC–2017–WPB15–DATA01	Billfish datasets available	✓(1 August 2017)
IOTC–2017–WPB15–DATA02	IOTC Species data catalogues – availability of datasets	✓(1 August 2017)
IOTC–2017–WPB15–DATA03_Rev2	Nominal Catches per Fleet, Year, Gear, IOTC Area and species	✓(24 May 2017) ✓(31 August 2017)
IOTC–2017–WPB15–DATA04	Catch and effort data - vessels using drifting longlines	✓(24 May 2017)
IOTC–2017–WPB15–DATA05	Catch and effort data - surface fisheries	✓(24 May 2017)
IOTC–2017–WPB15–DATA06	Catch and effort data - vessels using other gears (e.g., gillnets, lines and unclassified gears)	✓(24 May 2017)
IOTC–2017–WPB15–DATA07	Catch and effort data - all gears	✓(24 May 2017)
IOTC–2017–WPB15–DATA08	Catch and effort – reference file	✓(24 May 2017)
IOTC–2017–WPB15–DATA09	Size frequency data - billfish species	✓(24 May 2017)
IOTC–2017–WPB15–DATA10_Rev1	Size frequency – reference file	✓(24 May 2017)
IOTC–2017–WPB15–DATA11_Rev1	Data for the stock assessment of Swordfish	✓(14 June 2017)
IOTC–2017–WPB15–DATA12_Rev1	Data for the stock assessment of Striped Marlin	✓(11 July 2017)
IOTC–2017–WPB15–DATA13	Standardization of Swordfish CPUE by Portuguese longline fishery in the Indian Ocean	✓(23 July 2017)

Document	**Title**	**Availability**
IOTC–2017–WPB15–DATA14	Standardization of Swordfish CPUE by Taiwanese longline fishery in the Indian Ocean	✓(25 July 2017)
IOTC–2017–WPB15–DATA15	Standardization of Striped Marlin CPUE by Taiwanese longline fishery in the Indian Ocean	✓(25 July 2017)
IOTC–2017–WPB15–DATA16	Standardization of Swordfish CPUE by Japanese longline fishery in the Indian Ocean	✓(27 July 2017)
IOTC–2017–WPB15–DATA17	Standardization of Striped Marlin CPUE by Japanese longline fishery in the Indian Ocean	✓(27 July 2017)
IOTC–2017–WPB15–DATA18	Standardization of Striped Marlin CPUE by Iranian gillnet fishery in the Indian Ocean	✓(27 July 2017)
IOTC–2017–WPB15–DATA19	Standardization of Striped Marlin CPUE by Pakistani gillnet fishery in the Indian Ocean	✓(27 July 2017)
IOTC–2017–WPB15–DATA20	Standardization of Swordfish CPUE by Indonesian tuna longline fishery in the Indian Ocean (2005-2016)	✓(31 July 2017)
IOTC–2017–WPB15–DATA21	Standardization of Striped Marlin CPUE by Taiwanese gillnet fishery in the Indian Ocean (1986-1992)	✓(1 August 2017)
IOTC–2017–WPB15–DATA22	Standardization of Swordfish CPUE by Spanish longline fishery in the Indian Ocean (2001-2015)	✓(4 August 2017)
IOTC–2017–WPB15–DATA23	Standardised CPUE indices for swordfish from South Africa domestic fleet (2004-2016)	✓(21 August 2017)
IOTC–2017–WPB15–DATA24	Billfish equations	✓(31 July 2017)

APPENDIX IVA
MAIN STATISTICS OF BILLFISH

(*Extract from IOTC–2017–WPB15–07 Rev_1*)

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 are showing increasing trend.

  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**).

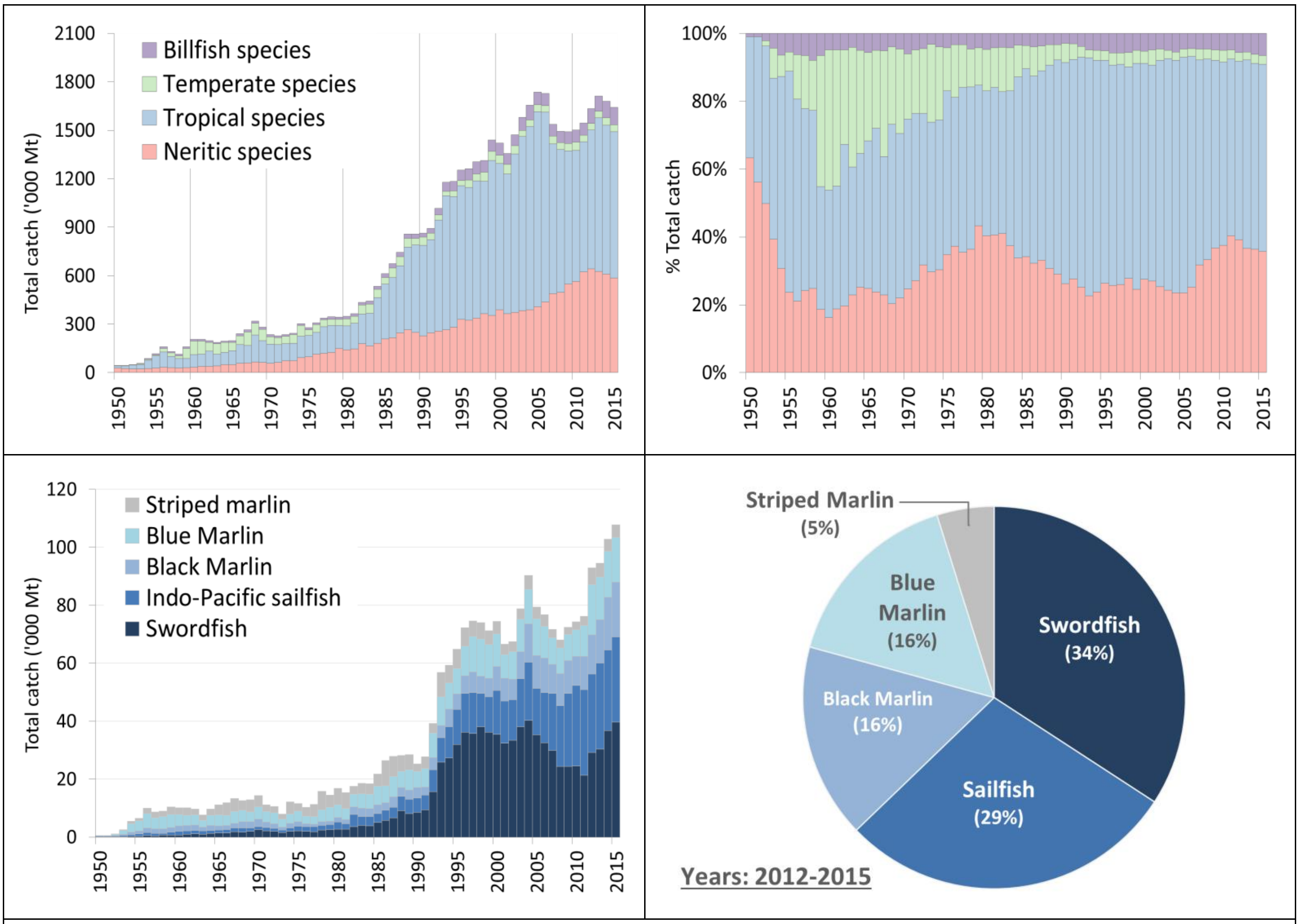
  In addition the number of longline vessels has also declined in recent years in response to the threat of Somali piracy in the western tropical Indian Ocean. Nevertheless, billfish catches are still dominated by a number of longline fleets – namely Taiwan,China and European fleets[3] that now seem to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

- Main fleets (i.e., highest catches in recent years):
  In recent years six fleets (Indonesia, I.R. Iran, Taiwan,China, Sri Lanka, India and Pakistan) have reported over 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 around 5% 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 highest catch of over 108,000 t in 2015 (with the largest increases reported by Indonesia, 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 1950–2015 (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, 1950–2015; d. Bottom right: share of billfish catch by species, 2012–15 average catch).

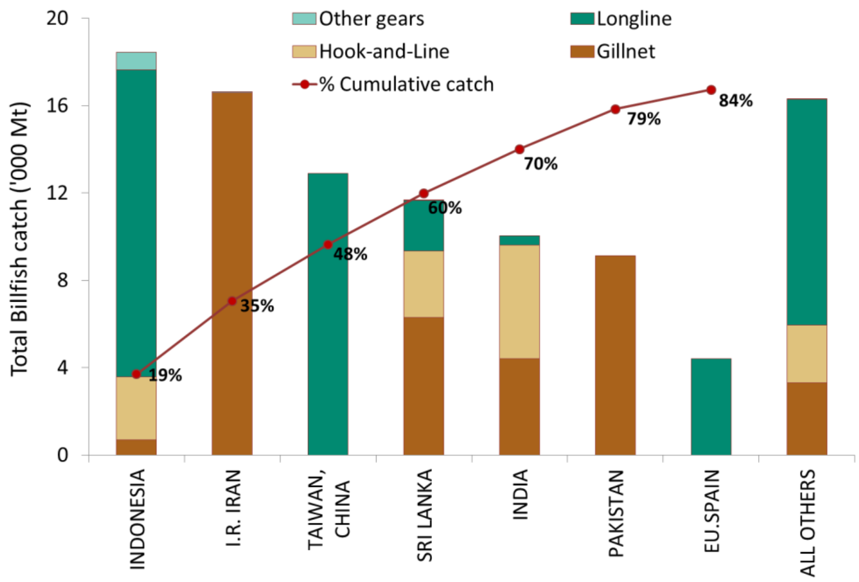
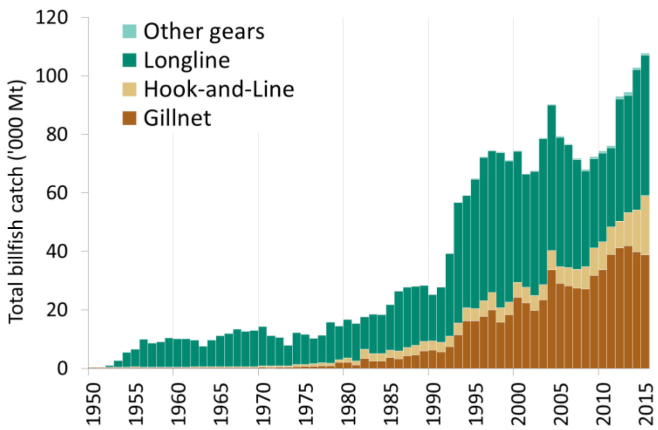


Fig. 2a: Billfish (all species): average catches in the Indian Ocean over the period 2012–15, by fleet and gear. Fleets are ordered from left to right, according to the volume of catches reported. The red line indicates the (cumulative) proportion of catches of all billfish species for the fleets concerned, over the total combined catches reported from all fleets and gears.



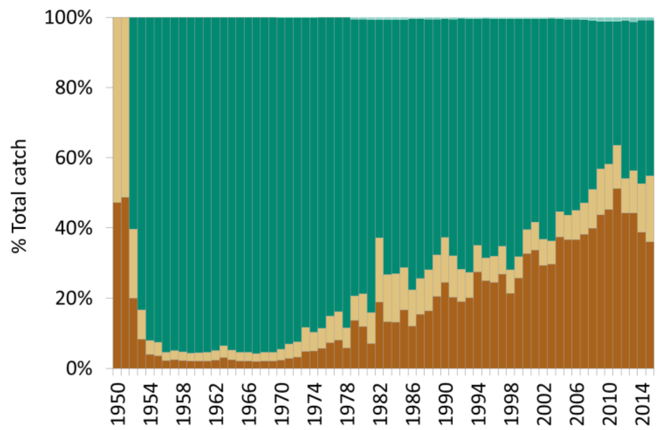


Fig. 2b-c: Billfish (all species): catches in the Indian Ocean over the period 1950–15, by gear. Fig 2b. Left: nominal catch of all billfish species, by gear; Fig. 2c. Right: percentage share of all billfish species catches, by gear.

APPENDIX IVB
MAIN STATISTICS OF SWORDFISH

(*Extract from IOTC–2017–WPB15–07 Rev_1*)

Fisheries and main catch trends

- Main fishing gear (2012–15): Longline catches[4] are currently estimated to comprise approximately 85% of total swordfish catches in the Indian Ocean. (**Table 1; Fig. 1**)
- Main fleets (and primary gear associated with catches): percentage of total catches (2012–15):
  Indonesia (fresh longline): 20%;Taiwan,China (longline): 17%; Sri Lanka (longline-gillnet): 12%;; EU,Spain (swordfish targeted longline): 12% (**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.(**Table 2**)
- 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*:** no major changes to the catch series since the WPB meeting in 2015.

TABLE 1. Swordfish: best scientific estimates of catches by type of fishery for the period 1950–2015 (in metric tons). Data as of August 2017.

Fishery	By decade (average)						By year (last ten years)									
	1950s	1960s	1970s	1980s	1990s	2000s	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
ELL	-	-	-	9	1,841	9,736	12,448	10,996	7,655	7,637	9,031	6,835	7,643	7,876	7,419	6,618
LL	260	1,301	1,920	4,313	22,692	20,085	17,227	16,123	13,511	13,810	12,419	10,976	17,466	17,186	21,539	23,480
OT	37	39	186	807	1,989	2,819	2,936	2,809	3,261	3,019	3,033	3,560	4,068	5,286	7,881	9,602
Total	**297**	**1,340**	**2,106**	**5,130**	**26,521**	**32,640**	**32,610**	**29,928**	**24,427**	**24,466**	**24,483**	**21,370**	**29,177**	**30,349**	**36,840**	**39,700**

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.

TABLE 2. Swordfish: best scientific estimates of catches by fishing area for the period 1950–2015 (in metric tons). Data as of August 2017.

Area	By decade (average)						By year (last ten years)									
	1950s	1960s	1970s	1980s	1990s	2000s	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
NW	90	470	630	1843	8262	10097	10,731	8,335	6,066	4,445	2,597	2,503	8,649	8,022	8,290	10,643
SW	9	227	392	606	8623	7308	8,388	6,833	5,371	5,555	7,708	6,325	6,291	6,606	4,353	3,708
NE	162	434	703	2155	6505	9211	8,897	9,293	8,882	10,923	10,611	9,517	11,611	12,065	19,060	20,456
SE	37	201	305	386	3044	6004	4,589	5,453	4,103	3,537	3,555	3,019	2,622	3,655	5,135	4,890
OT	0	7	76	140	88	20	6	14	5	6	11	7	4	1	1	2
Total	297	**1,340**	**2,106**	**5,130**	**26,521**	**32,640**	**32,610**	**29,928**	**24,427**	**24,466**	**24,483**	**21,370**	**29,177**	**30,349**	**36,840**	**39,700**

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

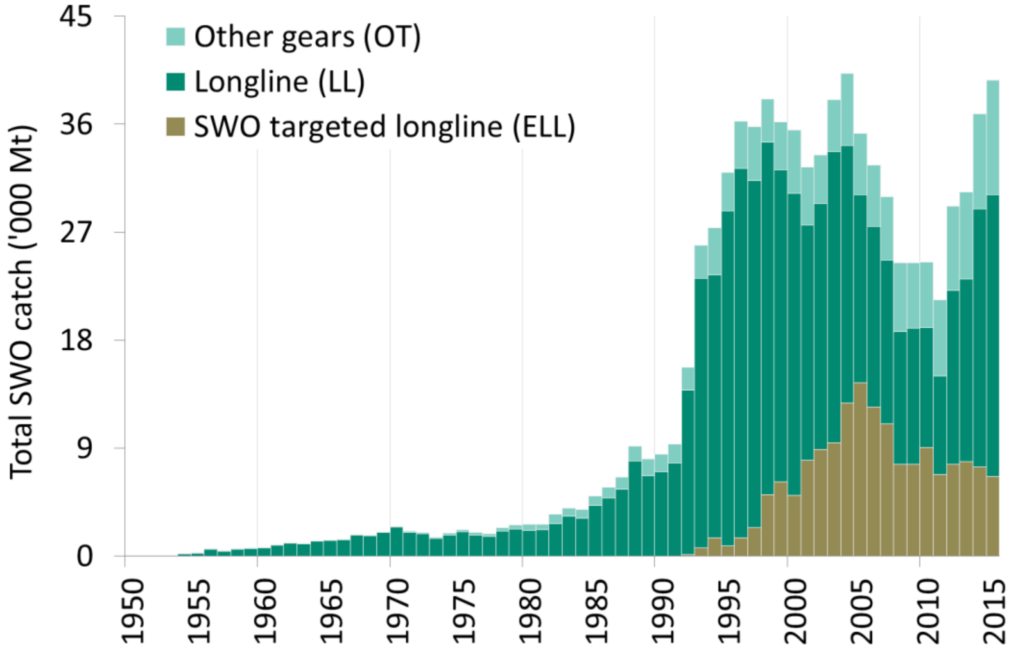


Fig. 1. Swordfish: catches by gear and year recorded in the IOTC Database (1950–2015).
Other gears includes: longline-gillnet, handline, gillnet, coastal longline, troll line, sport fishing, and all other gears.

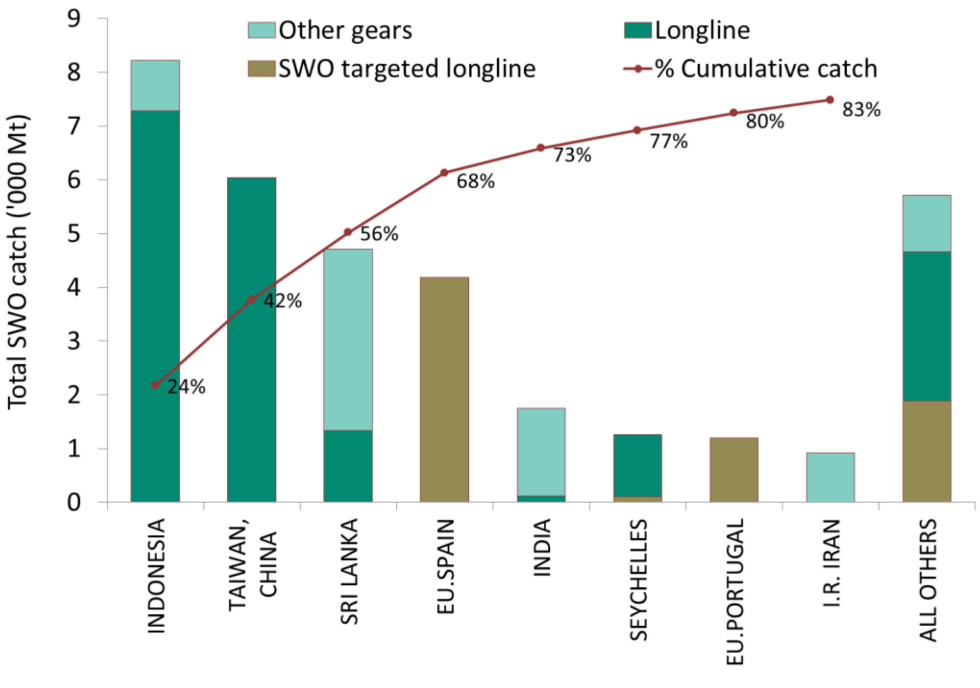


Fig. 2: Swordfish: average catches in the Indian Ocean over the period 2012–15, by fleet and gear. Fleets are ordered from left to right, according to the volume of catches reported. The red line indicates the (cumulative) proportion of catches of swordfish for the fleets concerned, over the total combined catches reported from all fleets and gears.

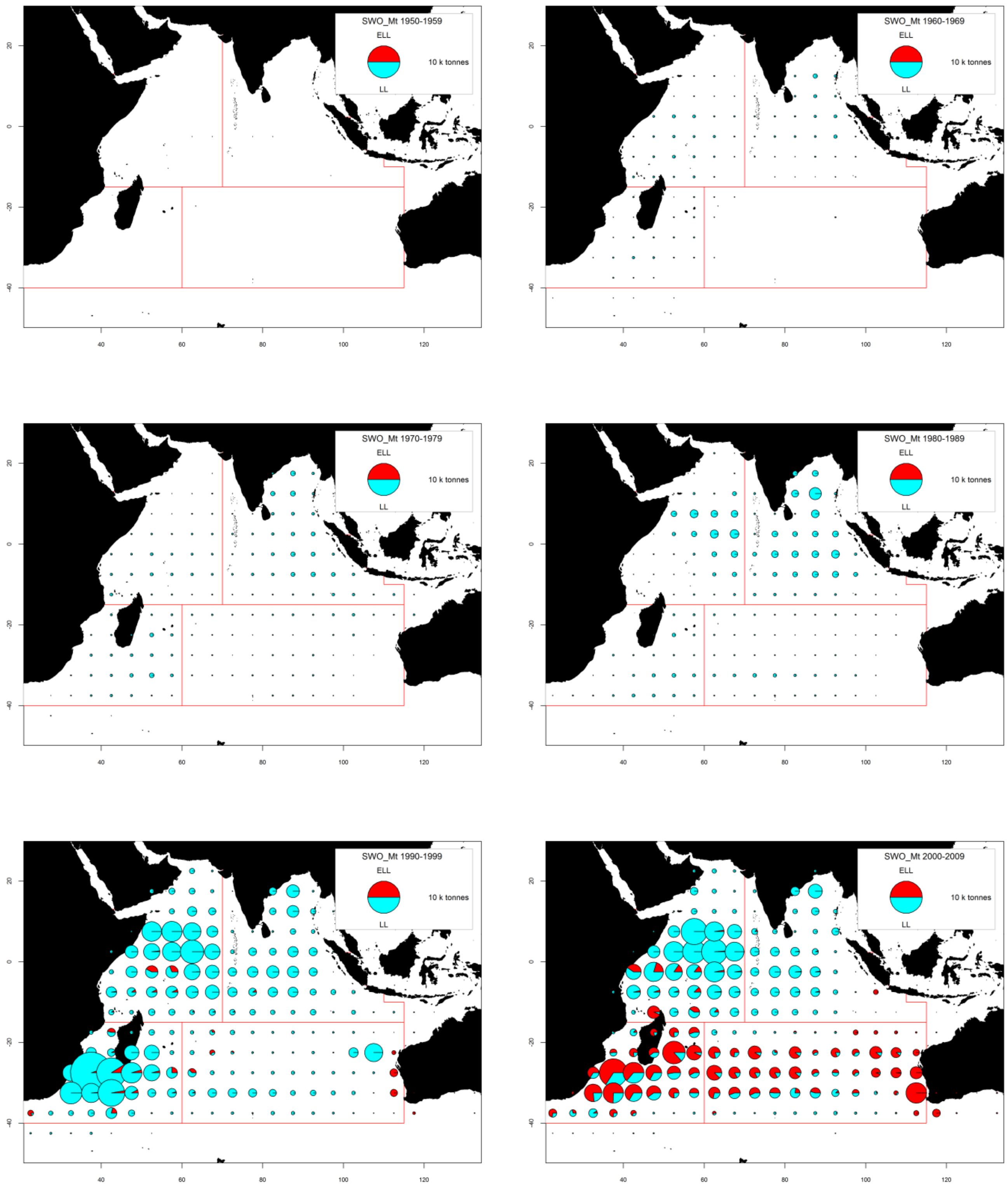


Fig. 3a-f: Swordfish: Time-area catches (total combined in tonnes) as reported for longline fisheries targeting swordfish (**ELL**) and other longline fisheries (**LL**), for the period 1950-2009, by decade and type of gear. Red lines represent the areas used for the assessments of swordfish.

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

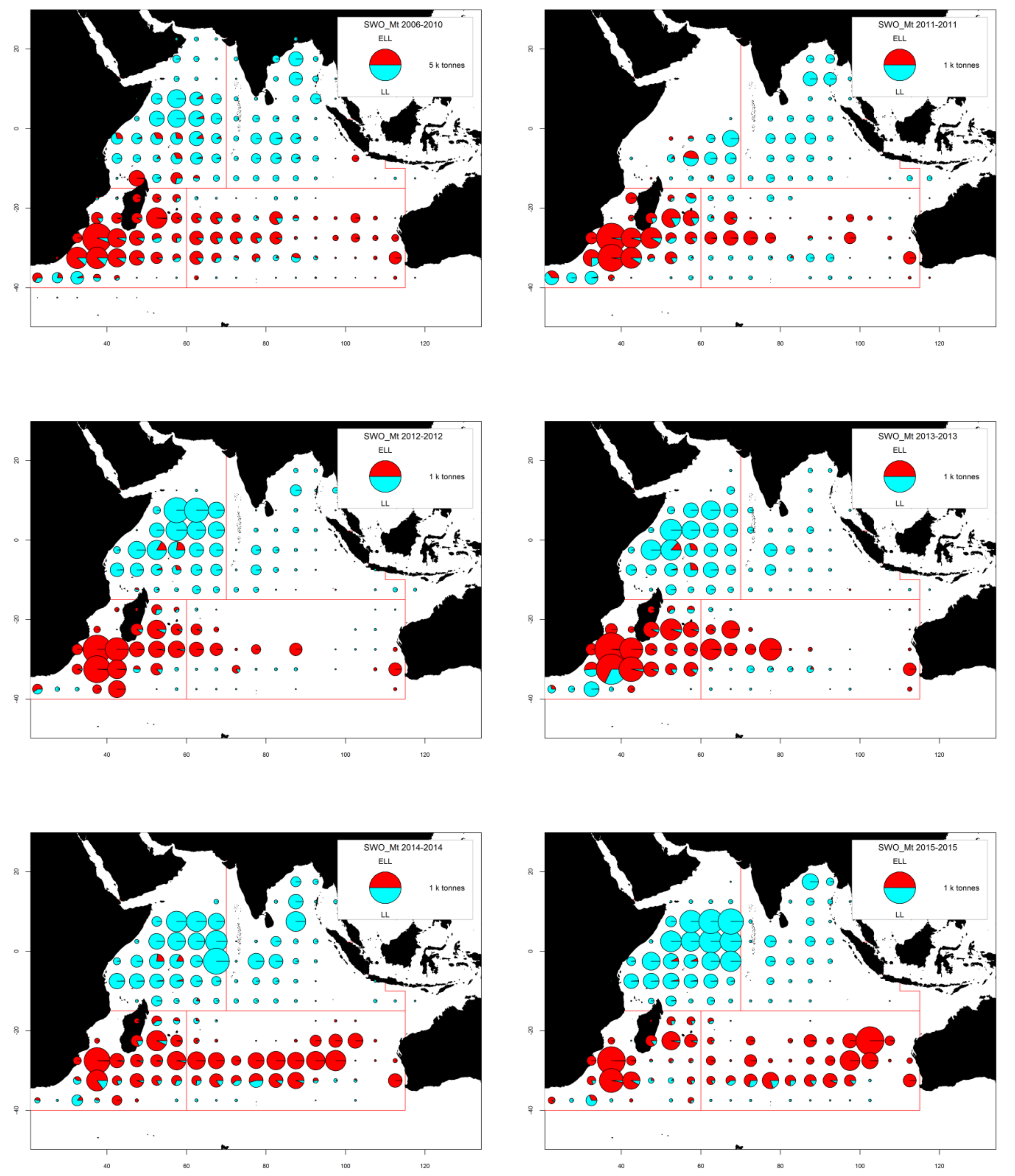


Fig. 4a-f: Swordfish: Time-area catches (total combined in tonnes) for longline fisheries targeting swordfish (**ELL**) and other longline fisheries (**LL)** for the period 2006-2010 by type of gear and for 2011-15, by year and type of gear. Red lines represent the areas used for the assessments of swordfish.

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

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.
- Indonesia (Longline): Catches possibly underestimated due to insufficient sampling coverage – especially in recent years (where they represent around 25% of the total catches).
- 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)).

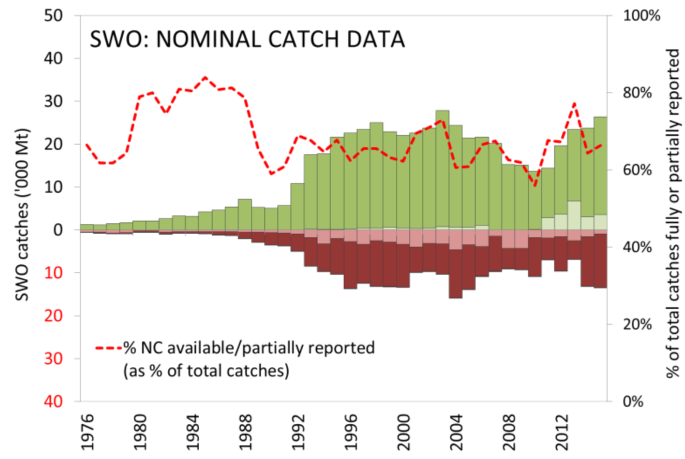
Swordfish – Fish size or age trends (e.g., by length, weight, sex and/or maturity)

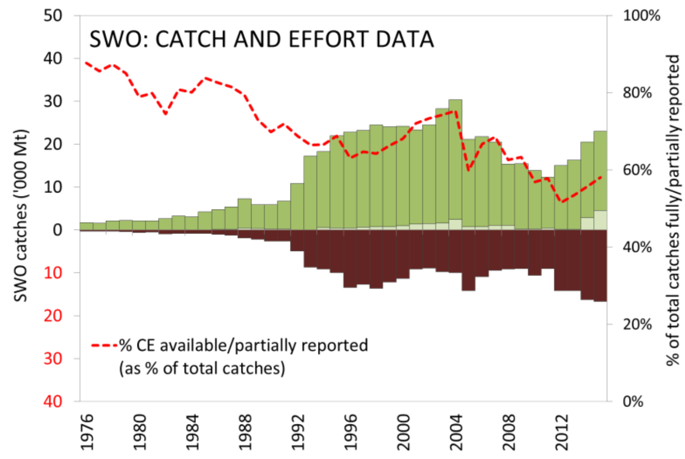
In general, the amount of catch for which size data for the species are available before 2005 is still very low and the number of specimens measured per stratum has been decreasing in recent years (**Fig. 5c**)

- 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: average weights of swordfish derived from length frequency and catch-and-effort data are very different;
    ii. uncertainty in the catches of swordfish for the drifting gillnet fisheries of I.R. Iran and the longline fishery of Indonesia;
    iii. the total 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.





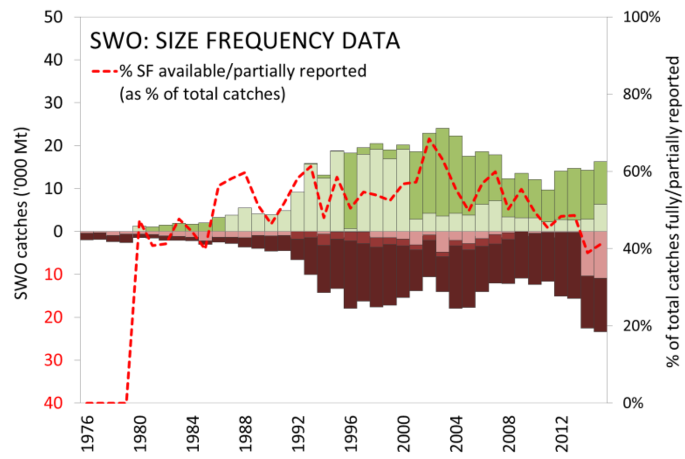


Fig. 5a-c. Swordfish: data reporting coverage (1976–2015).

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 July 2017.

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 IVC
MAIN STATISTICS OF STRIPED MARLIN

(*Extract from IOTC–2017–WPB15–07 Rev_1*)

Fisheries and main catch trends

- Main fishing gear (2012–15): striped marlin are largely considered to be a non-target species of industrial fisheries. Longlines account for around 69% of total catches in the Indian Ocean, followed by gillnets (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):
  Indonesia (drifting longline and coastal longline): 36%; Taiwan,China (drifting longline): 24%; I.R. Iran (gillnet): 14%; 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**:** no major changes to the catches series since the WPB meeting in 2016.

TABLE 1: Striped marlin: best scientific estimates of catches by type of fishery for the period 1950–2015 (in metric tons). Data as of August 2017.

Fishery	By decade (average)						By year (last ten years)									
	1950s	1960s	1970s	1980s	1990s	2000s	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
LL	1,028	3,104	3,458	5,144	5,120	2,921	3,036	2,356	2,117	1,679	2,096	2,253	4,539	3,242	2,635	2,789
GN	5	8	16	22	161	541	807	479	389	407	331	542	978	1,182	1,239	1,265
HL	3	5	10	32	70	136	143	152	196	273	282	292	288	330	294	275
OT	0	0	0	6	10	20	21	23	29	41	42	44	43	48	41	40
Total	**1,036**	**3,117**	**3,485**	**5,204**	**5,360**	**3,618**	**4,006**	**3,010**	**2,731**	**2,400**	**2,751**	**3,131**	**5,848**	**4,802**	**4,210**	**4,369**

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 1950–2015 (in metric tons). Data as of August 2017.

Fishery	By decade (average)						By year (last ten years)									
	1950s	1960s	1970s	1980s	1990s	2000s	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
NW	335	1859	1516	2073	2713	1808	1,971	1,315	1,178	845	750	976	3,623	2,775	1,827	1,713
SW	9	124	159	162	659	244	211	162	131	214	306	496	343	254	180	164
NE	551	810	1542	2752	1607	1330	1,618	1,438	1,335	1,264	1,506	1,550	1,840	1,724	2,154	2,283
SE	141	324	268	218	382	236	206	94	87	77	188	109	42	50	49	208
Total	**1,036**	**3,117**	**3,485**	**5,204**	**5,360**	**3,618**	**4,006**	**3,010**	**2,731**	**2,400**	**2,751**	**3,131**	**5,848**	**4,802**	**4,210**	**4,369**

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

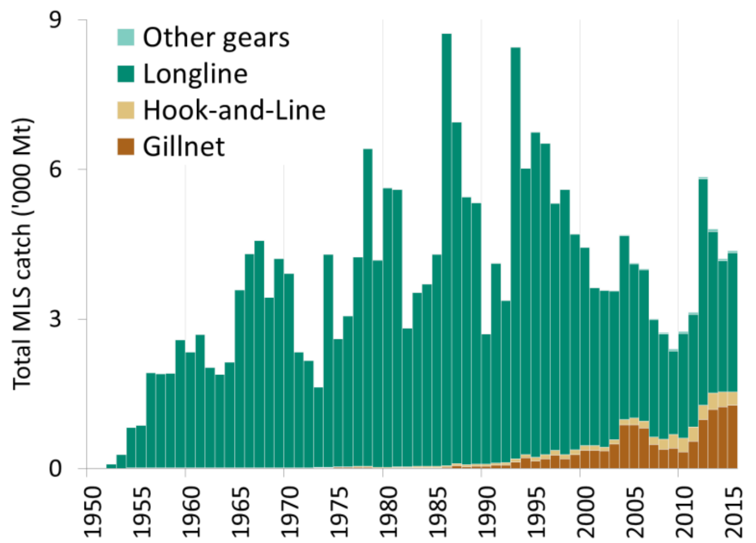


Fig. 1. Striped marlin: catches by gear and year recorded in the IOTC Database (1950–2015). Other gears includes: coastal purse seine, Danish purse seine, beach seine and purse seine.

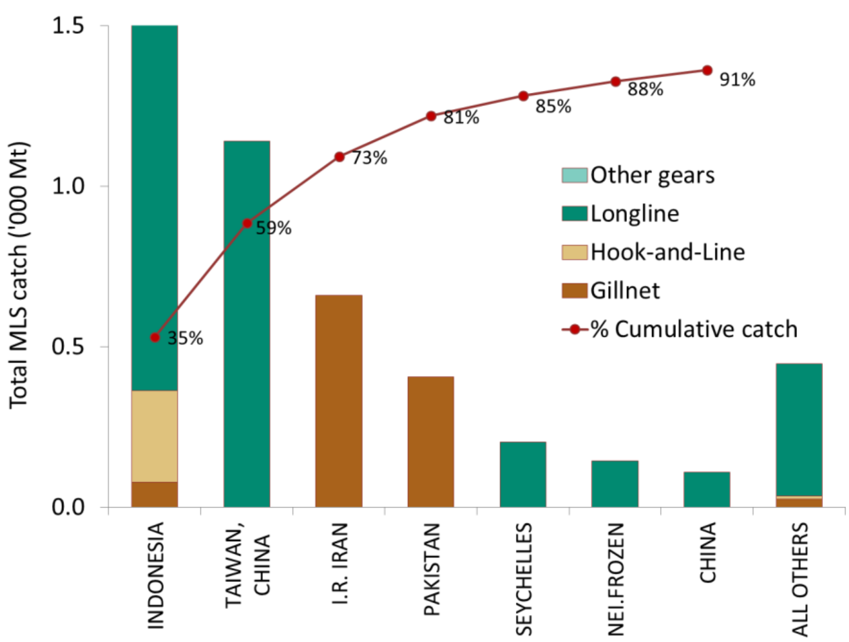


Fig. 2: Striped marlin: average catches in the Indian Ocean over the period 2012–15, by fleet and gear. Fleets are ordered from left to right, according to the volume of catches reported. The red line indicates the (cumulative) proportion of catches of striped marlin for the fleets concerned, over the total combined catches reported from all fleets and gears.

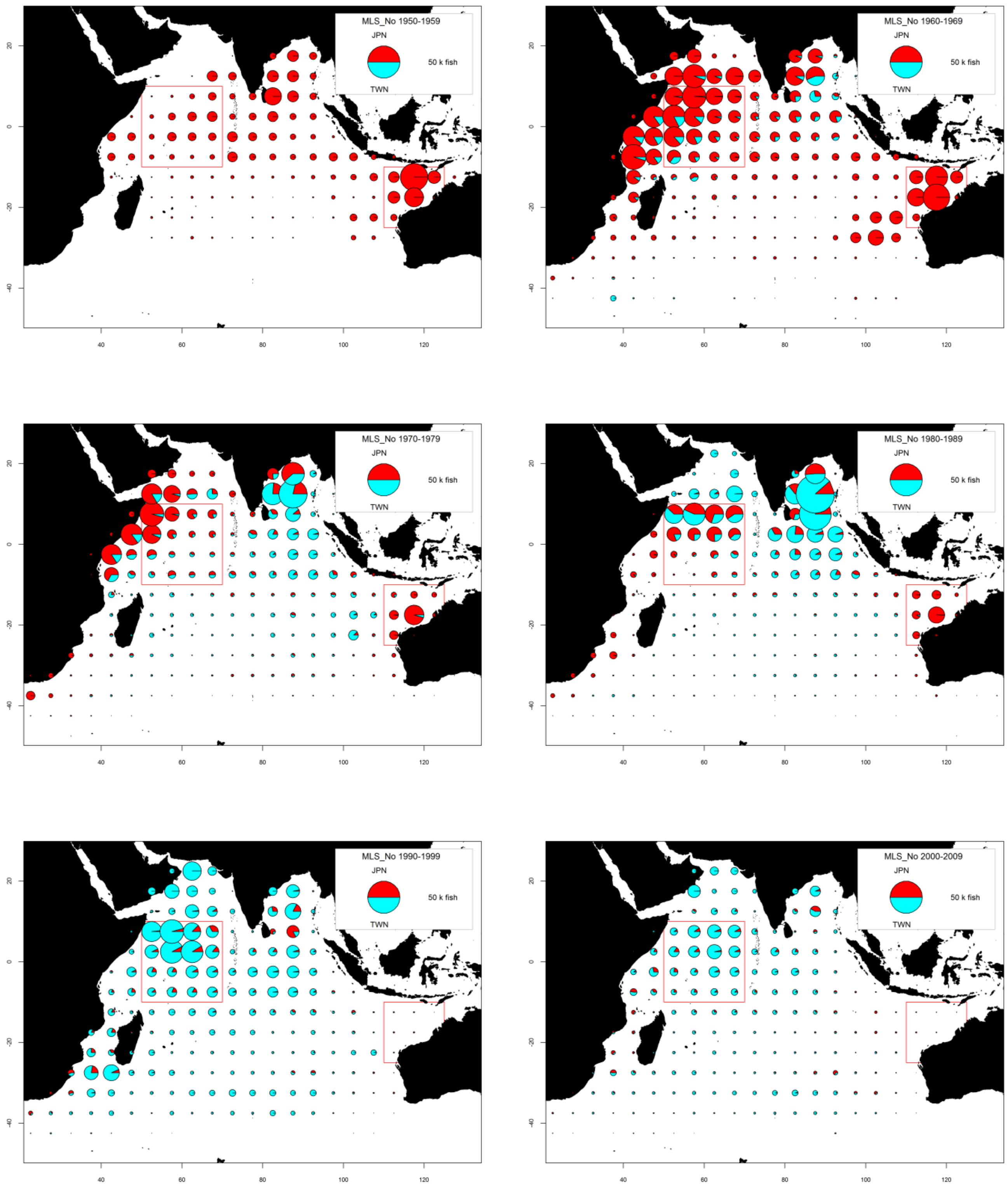


Fig. 3a-f. Time-area catches (in number of fish) of striped marlin as reported for the longline fisheries of Japan (JPN) and Taiwan,China (TWN) for the period 1950–2009, by decade and fleet. Red lines represent the marlin hotspots identified by the IOTC WPB.

Source: IOTC catch-and-effort data.

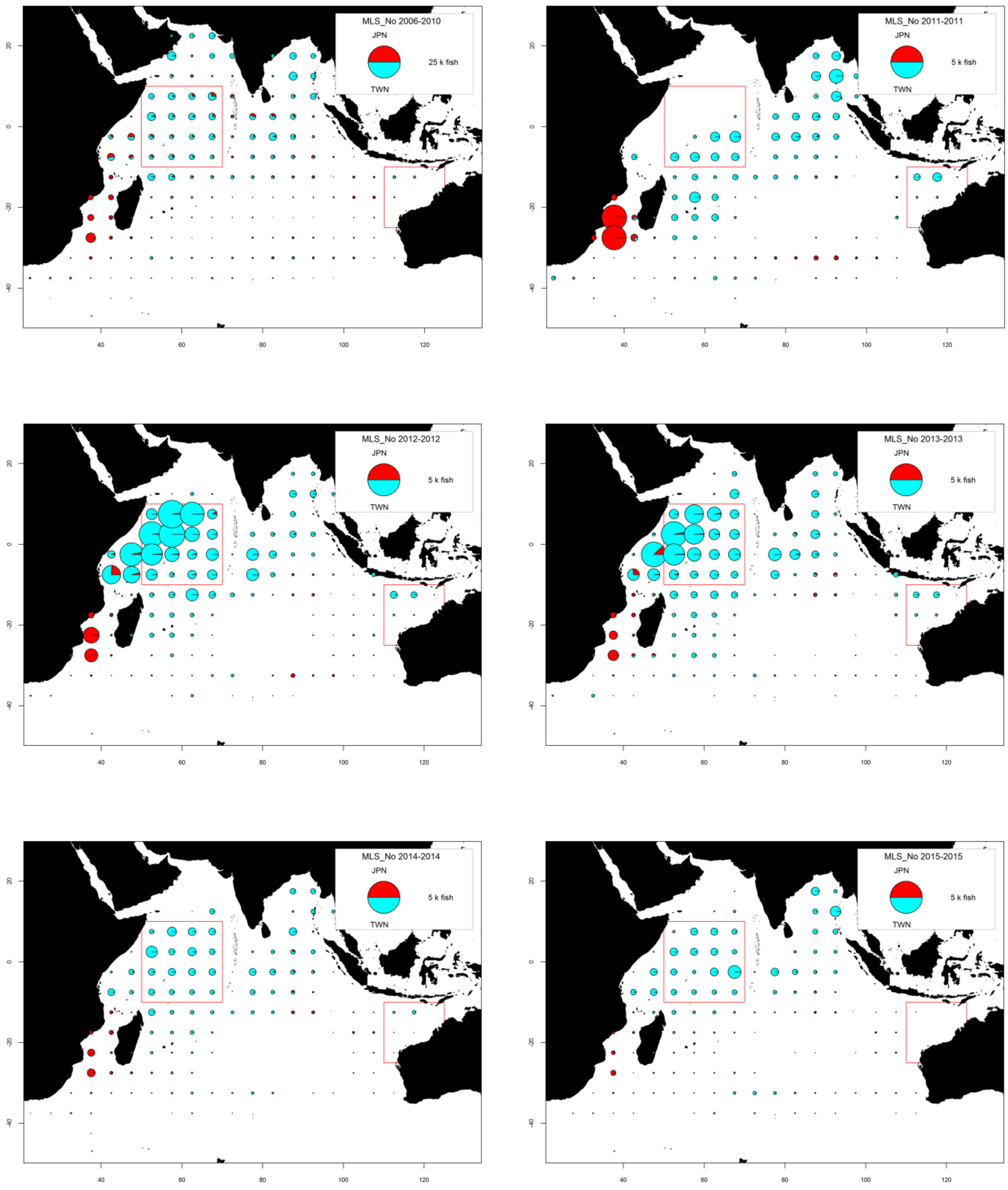


Fig. 4a-f. Time-area catches (in number of fish) of striped marlin as reported for the longline fisheries of Japan (JPN) and Taiwan,China (TWN) for the period 2006–10 by fleet and for 2011–15, by year and fleet. Red lines represent the marlin hotspots identified by the IOTC WPB.

Source: IOTC 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 (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. Catches of striped marlin reported by fleets using gillnets have been relatively low over the entire time-series (i.e., between 500 t and 1,400 t in recent years); however the recent data appears to indicate that gillnet catches of striped marlin in Pakistan may be much higher than those officially reported – although a comprehensive review of the catch series is required to confirm the catch levels for this species.
- Species misidentification: difficulties in the identification of marlins also contribute to uncertainties in the catch estimates of striped marlin available to the Secretariat.

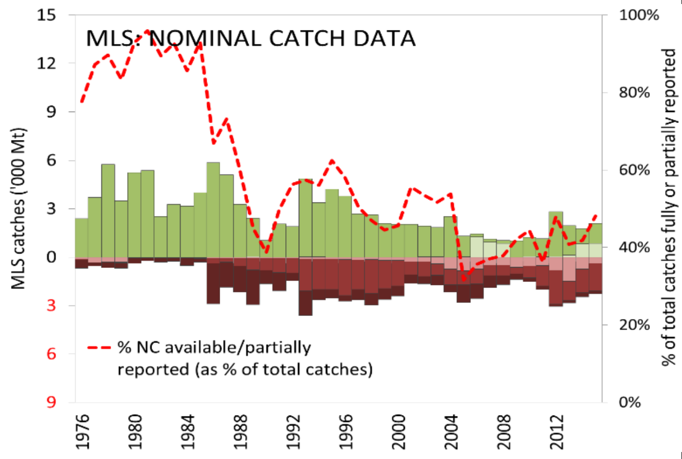
Striped marlin – Nominal catch-per-unit-effort (CPUE) trends

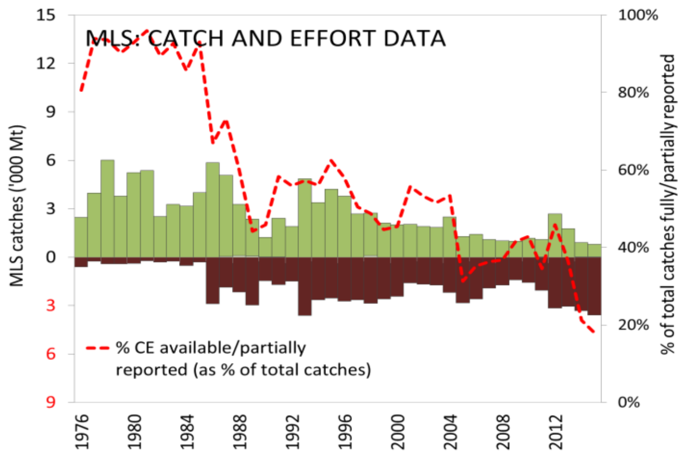
- Availability: Standardized CPUE series have been developed for the Japanese and Taiwanese longline fleets. Nominal CPUE series are available for some industrial longline fisheries, although catches are likely to be incomplete (as catches of non-target species are not always recorded in logbooks).

  No catch-and-effort data are available from sports fisheries, other than for partial data from the sports fisheries of Kenya; likewise no data are available for other artisanal fisheries (gillnet fisheries of Iran and Pakistan, gillnets of 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 misidentification 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.





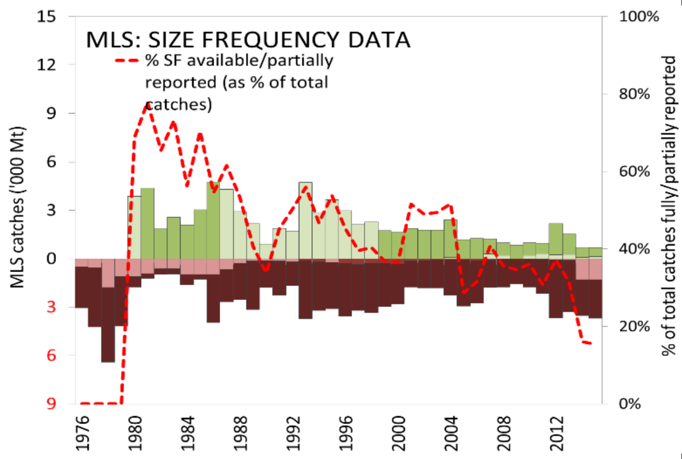


Fig. 5a-c. Striped marlin: data reporting coverage (1976–2015).

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 2017.

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–2017–WPB15–07 Rev_1*)

Fisheries and main catch trends

- Main fishing gear (2012–15): black marlin are largely considered to be a non-target species of industrial and artisanal fisheries. Gillnets account for around 54% of total catches in the Indian Ocean, followed by longlines (17%), with remaining catches recorded under troll and handlines. (**Fig. 1**)
- Main fleets (and primary gear associated with catches): percentage of total catches (2012–15):
Iran (gillnet): 29%; India (gillnet and troll): 20%; Sri Lanka (gillnet and fresh longline): 19%; Indonesia (fresh longline and hand lines): 15% (**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:
Catches have increased steadily since the 1990s, from 2,800 t in 1991 to over 10,000 t since 2004. The highest catches were recorded in 2015, at over 18,000 t (**Table 5**) – 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. Discards may also occur in some gillnet fisheries.

***Changes to the catch series*:** no major changes to the catch series since the WPB meeting in 2014, when catches were revised substantially following new reports of catches-by-species for drifting gillnet fleets by Iran[6].
Any differences in the data series since the last WPB are changes to the nominal catch as a result of reallocation of catches reported as other billfish species or as aggregated billfish species groups reported by, e.g., Sri Lanka, and Pakistan to a lesser extent. These changes, however, did not lead to very significant changes in the total catch estimates for black marlin.

TABLE 1. Black marlin: best scientific estimates of catches by type of fishery for the period 1950–2015 (in metric tons). Data as of August 2017.

Fishery	By decade (average)						By year (last ten years)									
	1950s	1960s	1970s	1980s	1990s	2000s	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
LL	862	1661	1391	1727	1571	1985	2173	1921	3033	1839	1871	1978	2180	2641	3525	3078
GN	26	31	45	452	2762	6917	8458	6738	6227	6935	6070	7115	8495	8566	9695	8898
HL	24	27	42	449	746	1035	983	1060	1366	2147	1630	1865	2260	3047	4535	6524
OT	0	0	4	65	112	226	237	257	329	460	472	490	483	693	461	454
Total	**912**	**1,719**	**1,482**	**2,693**	**5,191**	**10,163**	**11,852**	**9,976**	**10,955**	**11,381**	**10,044**	**11,447**	**13,418**	**14,948**	**18,217**	**18,954**

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] 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.

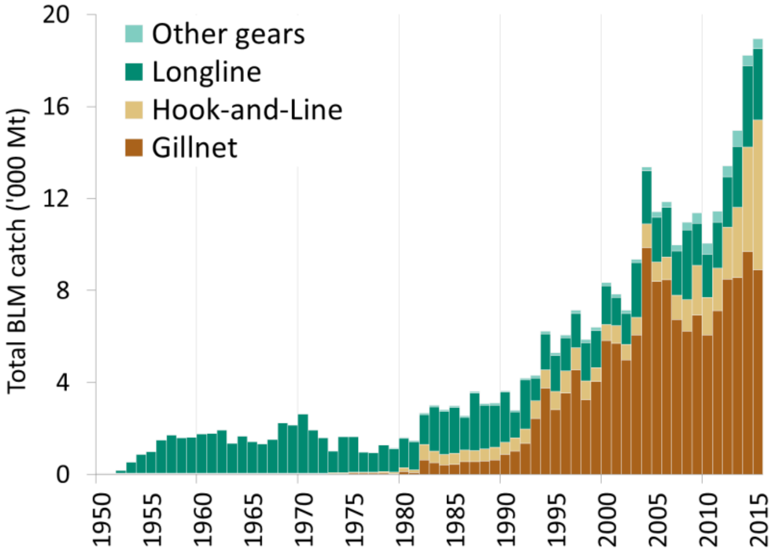


Fig. 1. Black marlin: catches by gear and year recorded in the IOTC Database (1950–2015). Other gears includes: coastal purse seine, Danish purse seine, beach seine and purse seine.

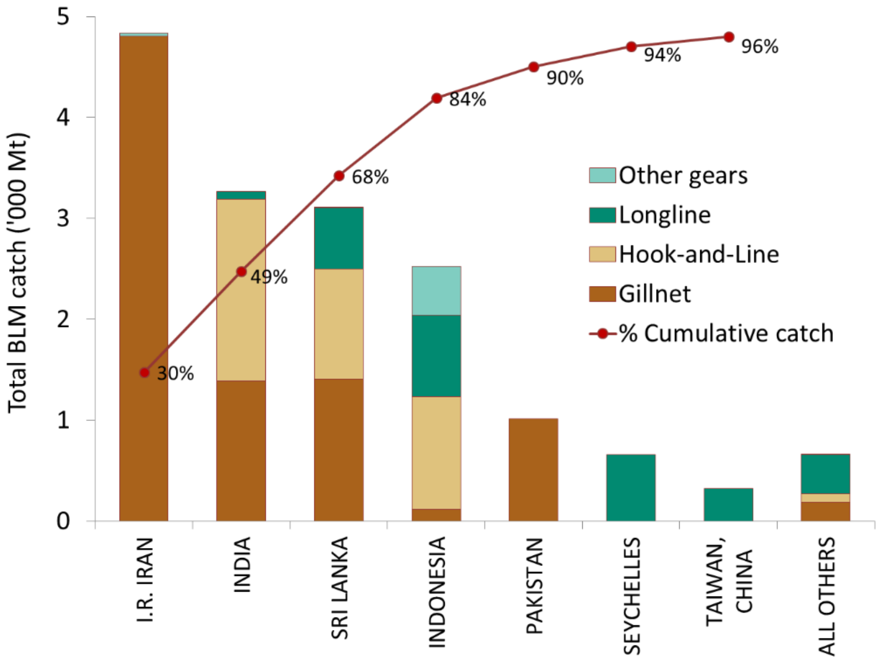


Fig. 2: Black marlin: average catches in the Indian Ocean over the period 2012–15, by fleet and gear. Fleets are ordered from left to right, according to the volume of catches reported. The red line indicates the (cumulative) proportion of catches of black marlin for the fleets concerned, over the total combined catches reported from all fleets and gears.

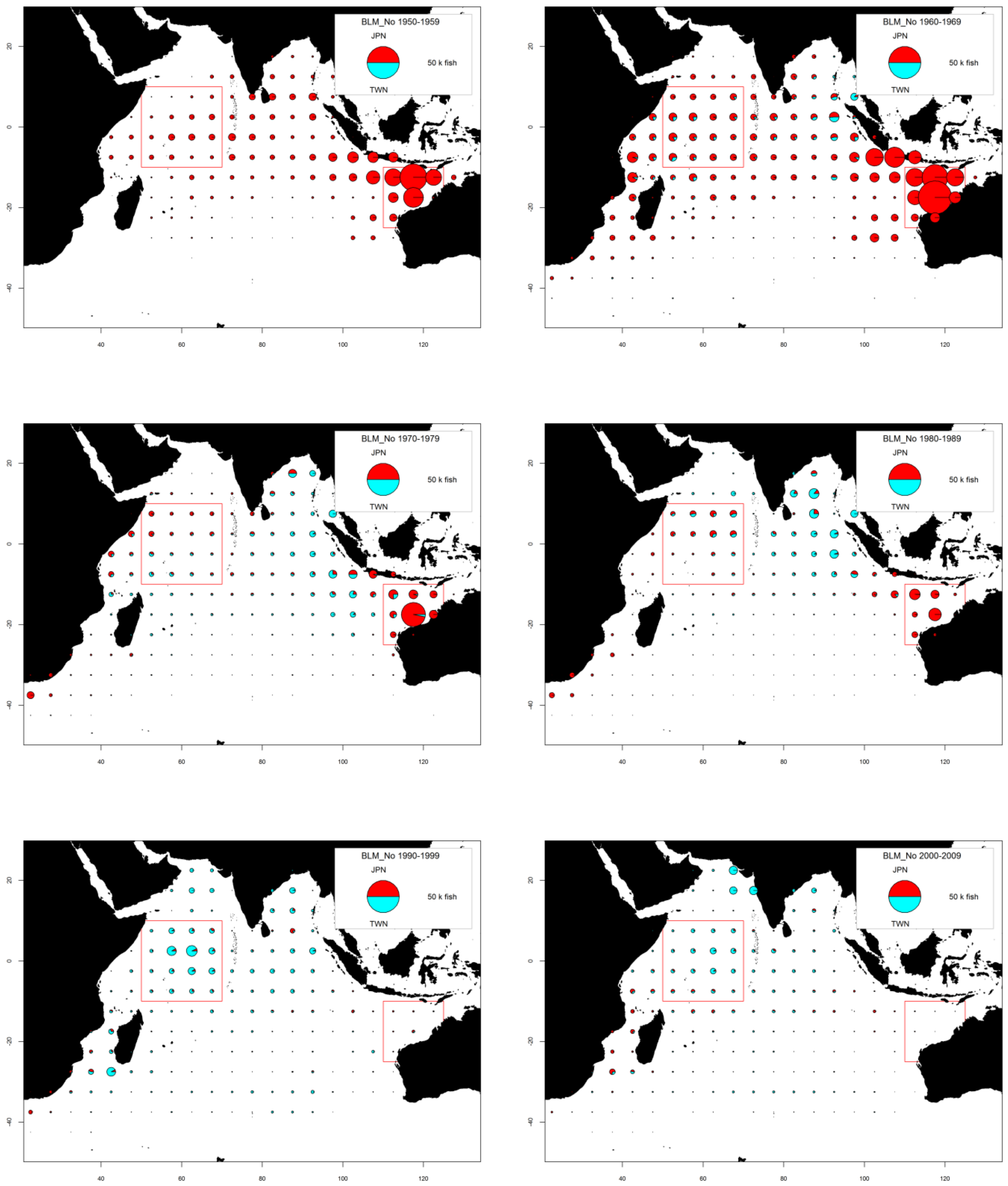


Fig. 3a-f. Time-area catches (in number of fish) of black marlin as reported for the longline fisheries of Japan (JPN) and Taiwan,China (TWN) for the period 1950–2009, by decade and fleet. Red lines represent the marlin hotspots identified by the IOTC WPB.

Source: IOTC catch-and-effort data.

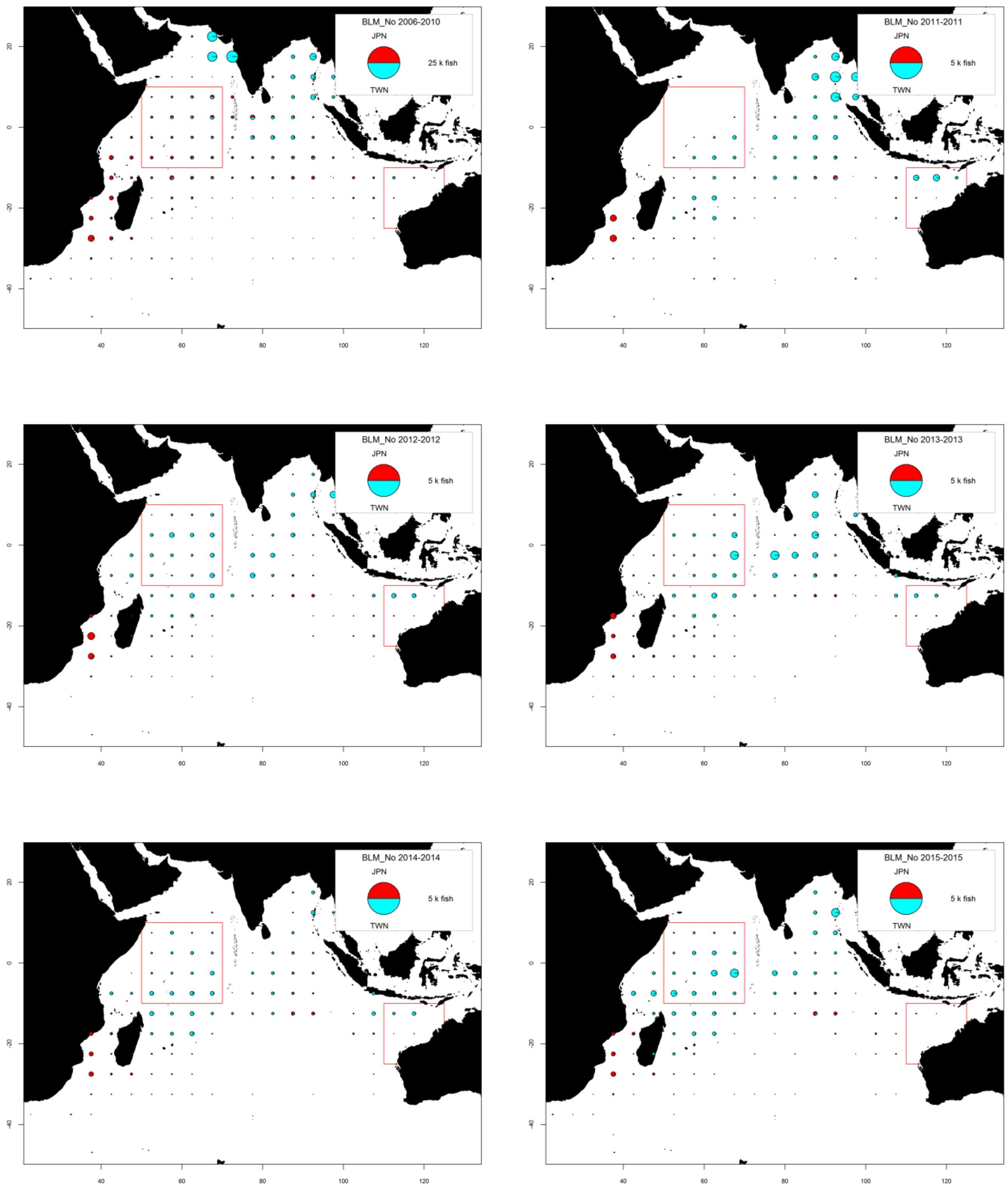


Fig. 4a-f. Time-area catches (in number of fish) of black marlin as reported for the longline fisheries of Japan (JPN) and Taiwan,China (TWN) for the period 2006–10 by fleet and for 2011–15, by year and fleet. Red lines represent the marlin hotspots identified by the IOTC WPB.

Source: IOTC 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, 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 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.
- Lack of catch data for most sport fisheries.
- Species misidentification: difficulties in the identification of marlins also contribute to uncertainties in the catch estimates of black marlin available to the Secretariat.

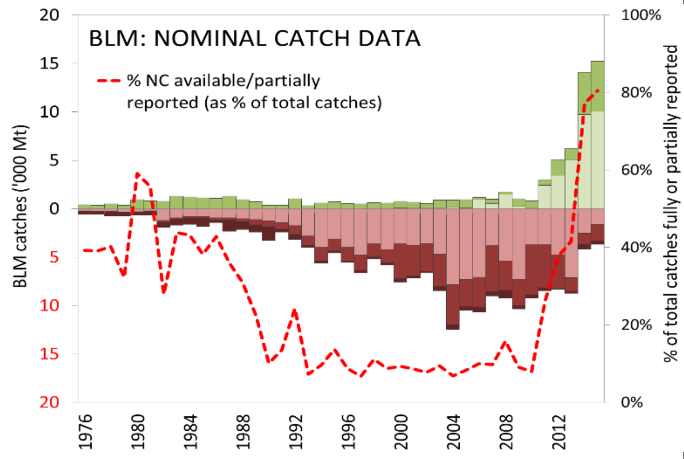
Black marlin – Nominal catch-per-unit-effort (CPUE) trends

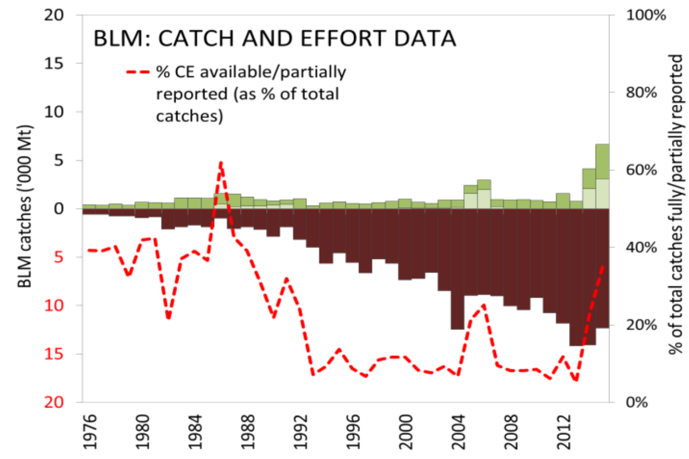
- Availability: Standardized CPUE series have been developed for Japanese and Taiwanese fleets. Nominal CPUE series are available for some industrial longline fisheries, although catches are likely to be incomplete (as catches of non-target species are not always recorded in logbooks).

  No catch-and-effort data are available from sports fisheries, other than for partial data from the sports fisheries of Kenya; likewise no data are available for other artisanal fisheries (gillnet fisheries of Iran, Indonesia and Pakistan). Unreliable data from offshore fisheries of Sri Lanka or other industrial fisheries (NEI longliners and all purse seiners).
- 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 likely to be biased (see figure 2.3-2.4 for more details).
- 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.





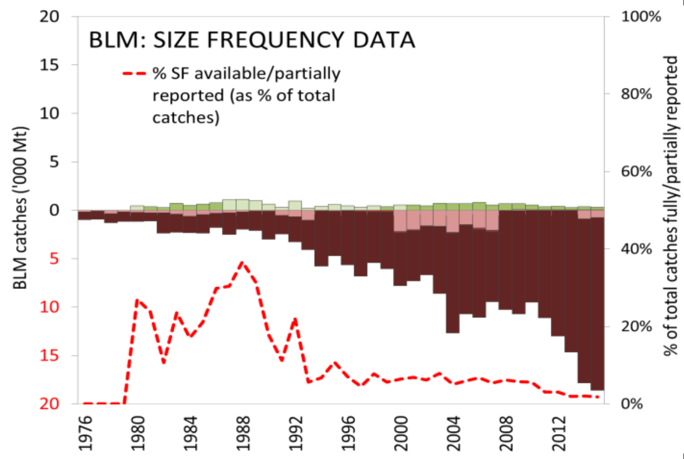


Fig. 5a-c. Black marlin: data reporting coverage (1976–2015).

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 2017.

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 IVE
MAIN STATISTICS OF BLUE MARLIN

(*Extract from IOTC–2016–WPB14–07 Rev_1*)

Fisheries and main catch trends

- Main fishing gear (2012–15): Blue marlin are largely considered to be a non-target species of industrial and artisanal fisheries. Longline catches[7] account for around 72% of total catches in the Indian Ocean, followed by gillnets (25%), 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): 30%; 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. Discards may also occur in some gillnet fisheries.

Changes to the catch series**:** no major changes to the catch series since the WPB meeting in 2014, when catches were revised substantially following new reports of catches-by-species for drifting gillnet fleets by Iran[8].
Any differences in the data series since the last WPB are changes to the nominal catch as a result of reallocation of catches reported as other billfish species or as aggregated billfish species groups reported by, e.g., Sri Lanka, and Pakistan to a lesser extent. These changes, however, did not lead to very significant changes in the total catch estimates for blue marlin.

TABLE 1: Blue marlin: best scientific estimates of catches by type of fishery for the period 1950–2015 (in metric tons). Data as of August 2017.

Fishery	By decade (average)						By year (last ten years)									
	1950s	**1960s**	**1970s**	**1980s**	**1990s**	**2000s**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
LL	2,567	3,535	3,409	4,545	6,982	7,406	7,857	6,407	6,369	6,664	6,669	7,276	12,216	10,215	11,778	11,095
GN	1	2	124	765	2,357	2,687	2,977	2,559	2,412	2,049	2,198	3,148	4,828	4,063	3,549	3,680
HL	5	9	17	105	155	143	153	167	187	276	303	268	264	343	501	688
OT	0	0	0	2	4	7	8	8	11	15	15	16	16	17	15	19
Total	**2,574**	**3,546**	**3,551**	**5,416**	**9,498**	**10,244**	**10,994**	**9,142**	**8,979**	**9,004**	**9,185**	**10,708**	**17,324**	**14,638**	**15,844**	**15,482**

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**).

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

[8] 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.

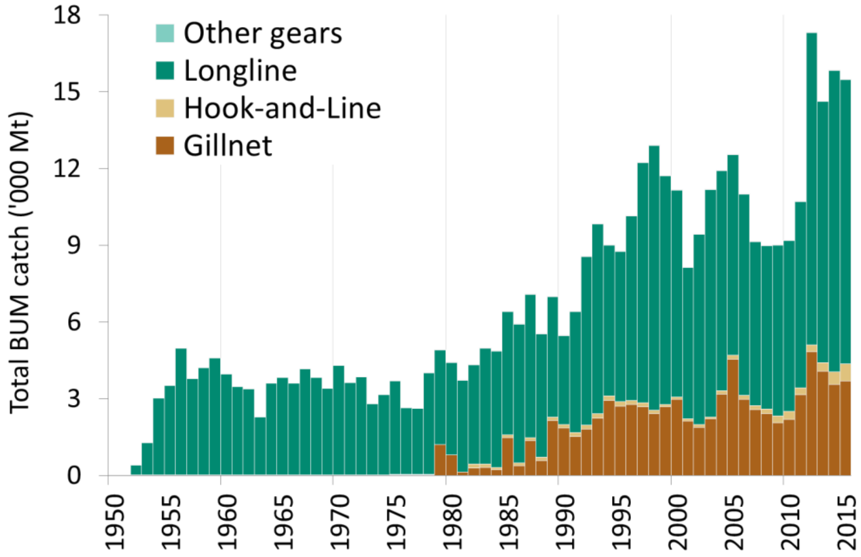


Fig. 1. Blue marlin: catches by gear and year recorded in the IOTC Database (1950–2015). Other gears includes: coastal purse seine, Danish purse seine, beach seine and purse seine.

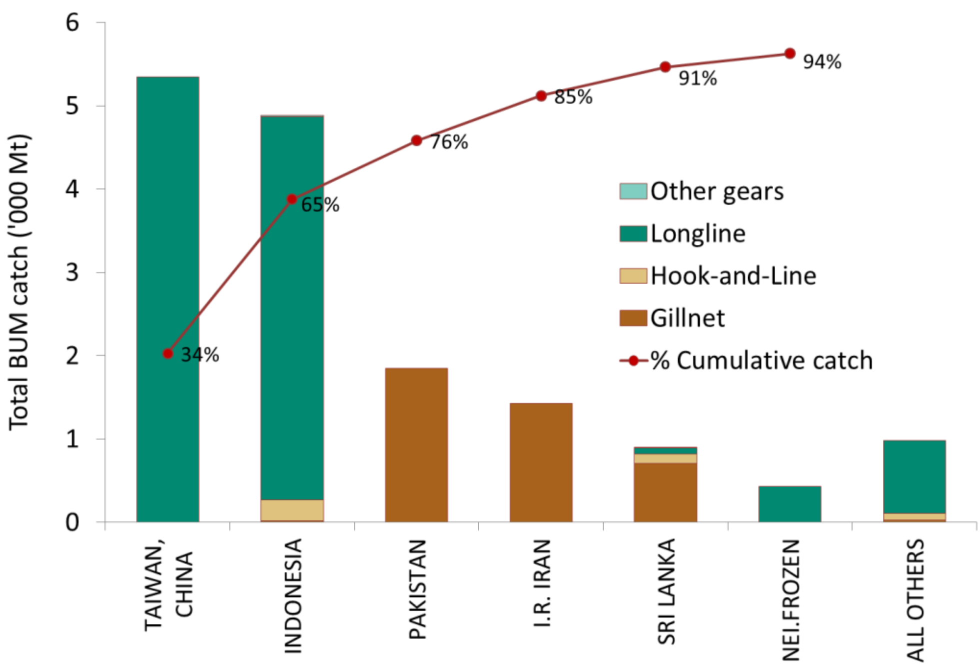


Fig. 2: Blue marlin: average catches in the Indian Ocean over the period 2012–15, by fleet and gear. Fleets are ordered from left to right, according to the volume of catches reported. The red line indicates the (cumulative) proportion of catches of blue marlin for the fleets concerned, over the total combined catches reported from all fleets and gears.

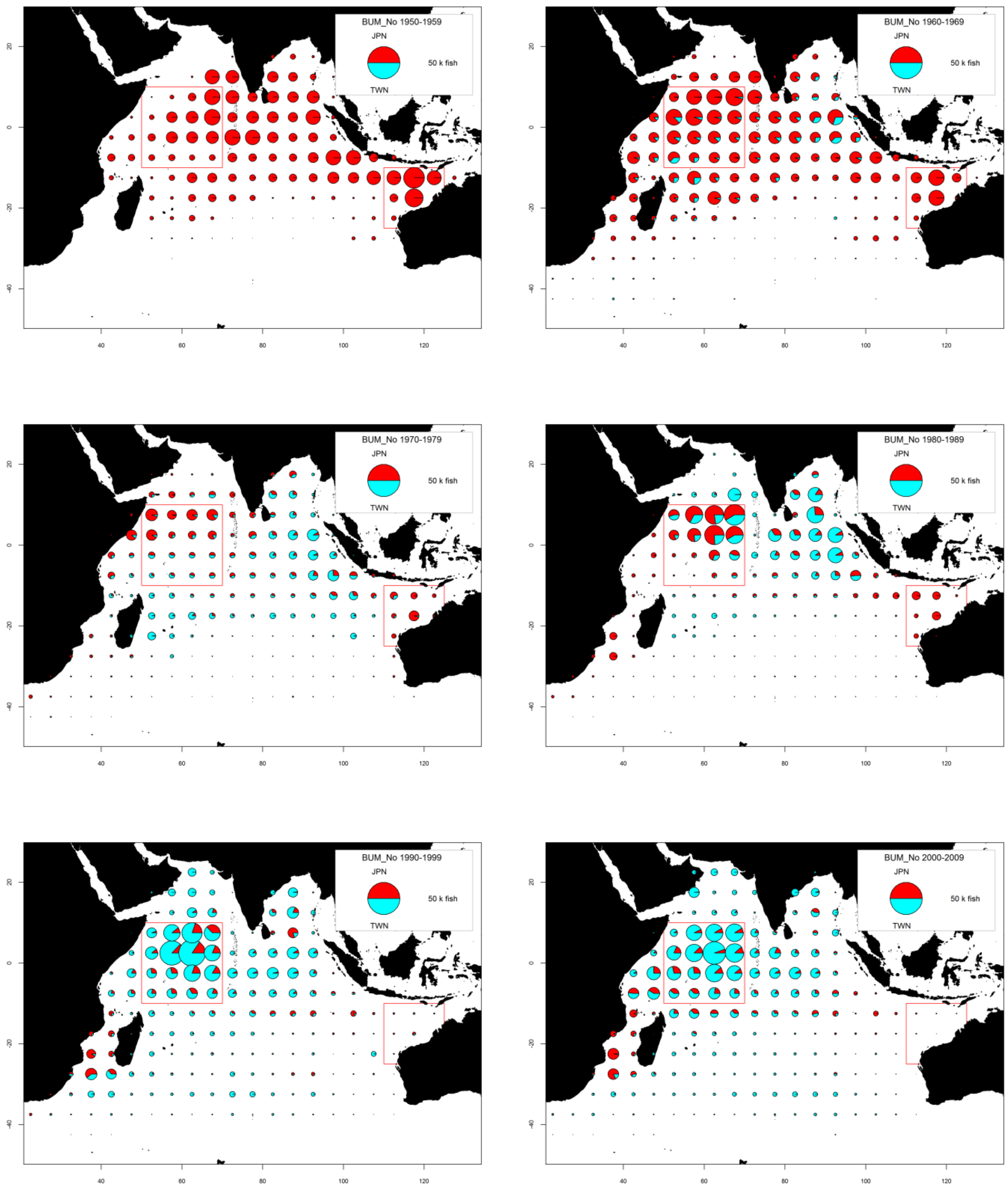


Fig. 3a-f. Time-area catches (in number of fish) of blue marlin as reported for the longline fisheries of Japan (JPN) and Taiwan,China (TWN) for the period 1950-2009, by decade and fleet. Red lines represent the marlin hotspots identified by the IOTC WPB.

Source: IOTC catch-and-effort data.

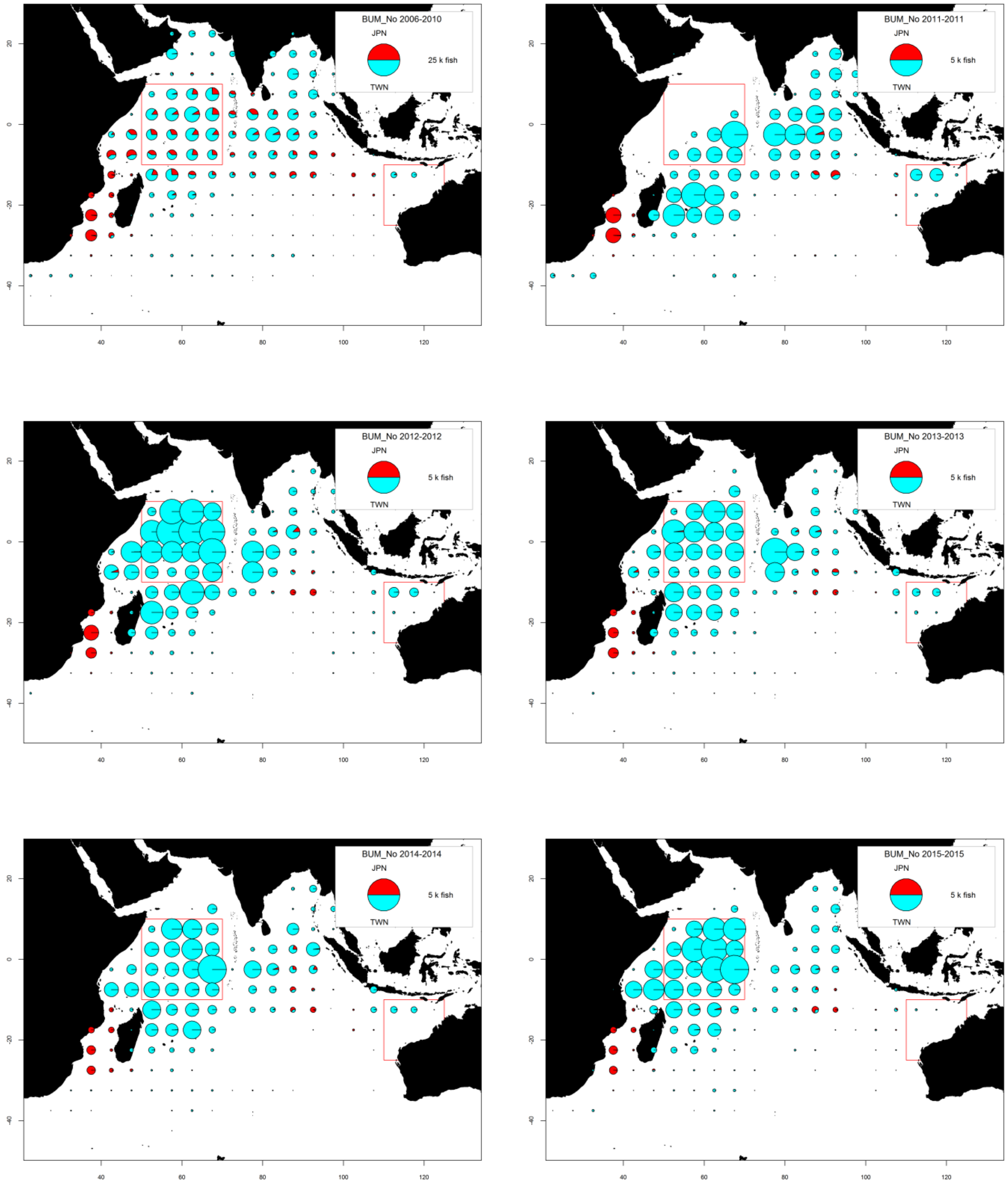


Fig. 4a-f. Time-area catches (in number of fish) of blue marlin as reported for the longline fisheries of Japan (JPN) and Taiwan,China (TWN) for the period 2006–10 by fleet and for 2011–15, by year and fleet. Red lines represent the marlin hotspots identified by the IOTC WPB.

Source: IOTC 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 misidentification: difficulties in the identification of marlins also contribute to uncertainties in the catch estimates of blue marlin.

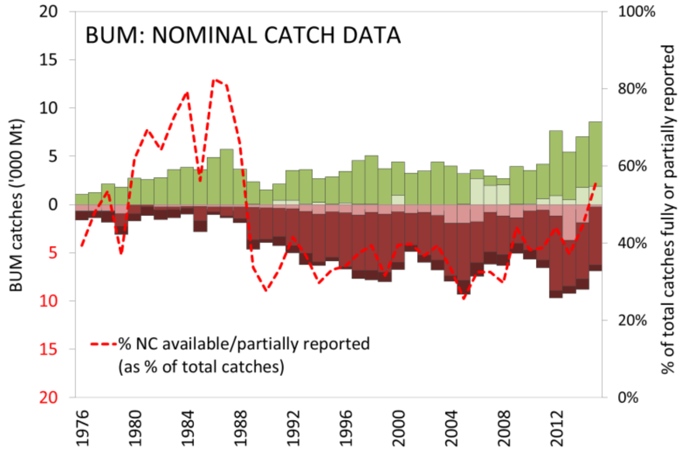
Blue marlin – Nominal catch-per-unit-effort (CPUE) trends

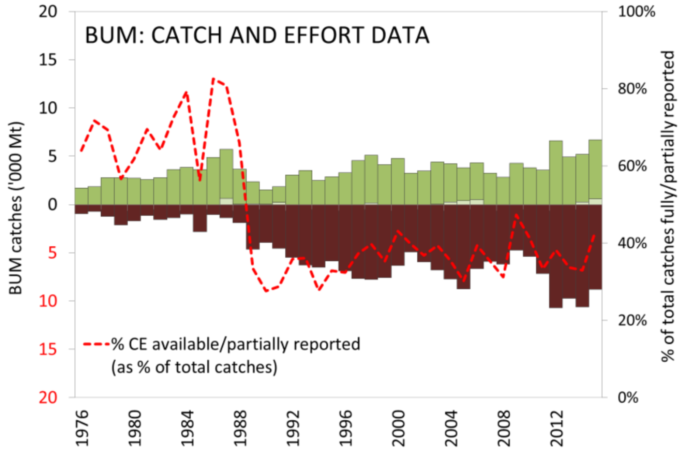
- Availability: Standardized CPUE series have not yet been developed. Nominal CPUE series are available for some industrial longline fisheries, although catches are likely to be incomplete (as catches of non-target species are not always recorded in logbooks).

  No catch-and-effort data are available from sports fisheries, other than for partial data from the sports fisheries of Kenya; likewise no data are available for other artisanal fisheries (gillnet fisheries of Iran and Pakistan, gillnet/longlines of Sri Lanka, gillnets of Indonesia) or other industrial fisheries (NEI longliners and all purse seiners).
- Main CPUE series available: Japanese longline fleet and Taiwanese longline fleet.

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

- Average fish weight: can only be assessed for the longline fishery of Japan since 1970 and Taiwan,China since 1980. However, the number of specimens measured on Japanese longliners in recent years is very low and misidentification of striped and blue marlin may occur in some longline fisheries. Also the length frequency distributions derived from samples collected by fishermen on Taiwanese longliners are likely to be biased (see figure 3.4 for more details).
- 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.





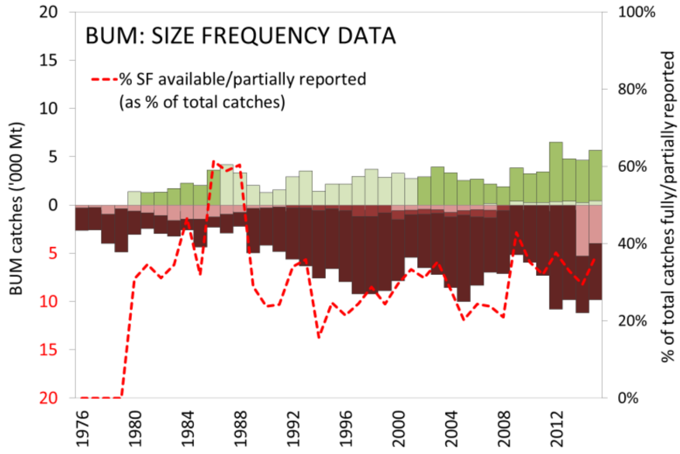


Fig. 5a-c. Blue marlin: data reporting coverage (1976–2015).

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 July 2017.

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–2017–WPB15–07 Rev_1*)

Fisheries and main catch trends

- Main fishing gear (2012–2015): gillnets account for around 77% of total catches in the Indian Ocean, followed by troll and hand lines (19%), with remaining catches recorded under longlines and other gears (**Fig. 1**).
- Main fleets (and primary gear associated with catches): percentage of total catches (2012–15):
  Three quarters of the total catches of Indo-Pacific sailfish are accounted for by four countries situated in the Arabian Sea: Iran (gillnet): 31%; Pakistan (gillnet): 18%; India (gillnet and troll): 17%; and Sri Lanka (gillnet and fresh longline): 10% (**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 2014.
  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, mainly longliners.

***Changes to the catch series*:** no major changes to the catch series since the WPB meeting in 2016[9].

TABLE 1: Indo-Pacific sailfish: best scientific estimates of catches by type of fishery for the period 1950–2015 (in metric tons). Data as of August 2017.

Fishery	By decade (average)						By year (last ten years)									
	1950s	**1960s**	**1970s**	**1980s**	**1990s**	**2000s**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
LL	297	804	385	257	1,400	1,416	1,299	2,165	2,534	1,257	656	449	698	903	1,045	881
GN	165	181	507	1,809	6,056	12,503	11,712	13,417	13,863	18,305	21,037	23,393	21,229	22,974	21,869	21,477
HL	171	213	456	1,428	2,477	3,930	4,197	4,024	4,445	5,410	5,999	5,477	5,048	5,583	4,651	6,783
OT	-	-	2	25	41	85	88	95	134	171	175	184	180	275	176	170
Total	**633**	**1,197**	**1,350**	**3,518**	**9,973**	**17,935**	**17,296**	**19,701**	**20,976**	**25,143**	**27,867**	**29,502**	**27,155**	**29,734**	**27,742**	**29,311**

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**).

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

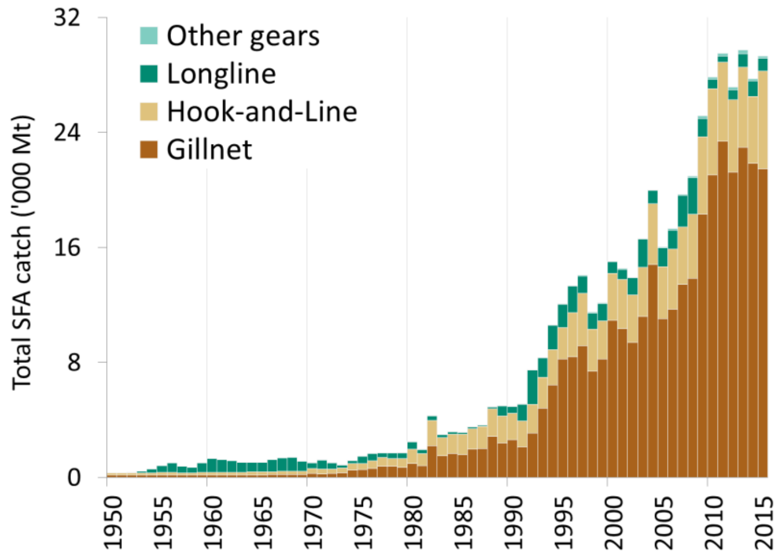


Fig. 1. Indo-Pacific sailfish: catches by gear and year recorded in the IOTC Database (1950–2015). Other gears includes: coastal purse seine, Danish purse seine, beach seine and purse seine.

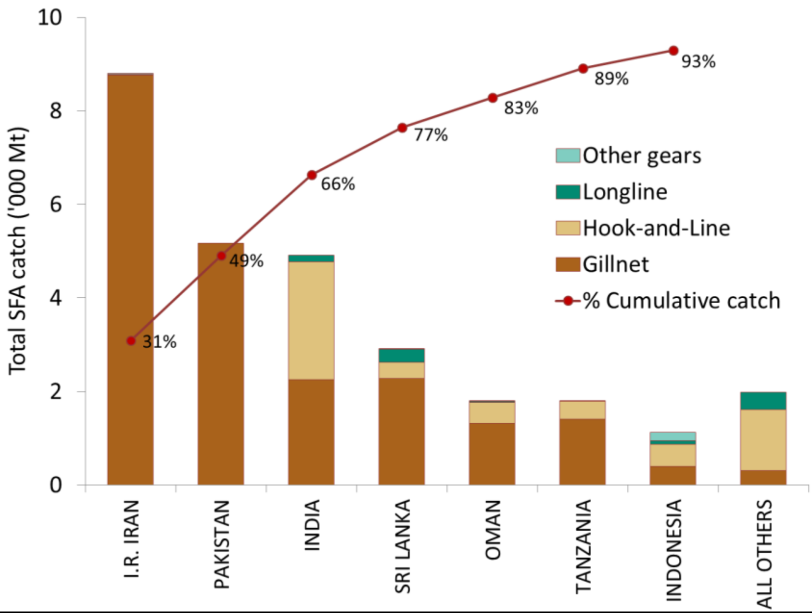


Fig. 2: Indo-Pacific sailfish: average catches in the Indian Ocean over the period 2012–15, by fleet and gear. Fleets are ordered from left to right, according to the volume of catches reported. The red line indicates the (cumulative) proportion of catches of Indo-Pacific sailfish for the fleets concerned, over the total combined catches reported from all fleets and gears.

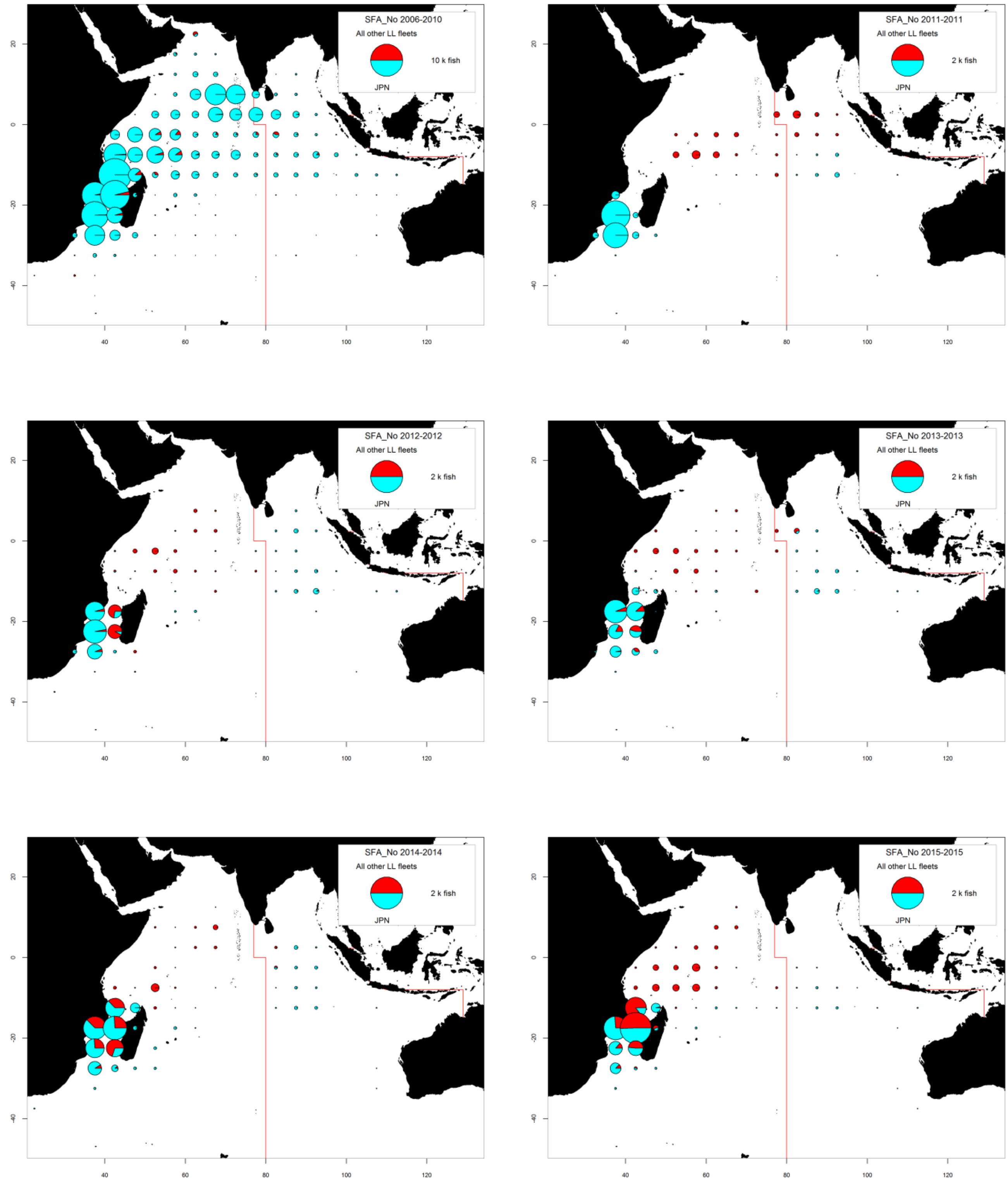


Fig. 3a-f. Time-area catches (in number of fish) of Indo-Pacific sailfish as reported for the longline fisheries of Japan (JPN) and all other longline fleets for the period 2006–10, by fleet and for 2011–15 by year and fleet. Red lines represent the IOTC Areas.

Source: IOTC catch-and-effort data. 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:

- <u>Species aggregates</u>: 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).
- <u>Non-reporting fleets</u>: catches of non-reporting industrial longliners (e.g., India, NEI) and the gillnet fishery of Indonesia are estimated by the Secretariat using alternative information.
- <u>Non-target species</u>: catches are likely to be incomplete for industrial fisheries for which Indo-Pacific sailfish is not a target species.
- <u>Missing or incomplete catches</u>: catches are likely to be incomplete for some artisanal fisheries (e.g. gillnets of Pakistan, pole and lines of Maldives) due to under-reporting.

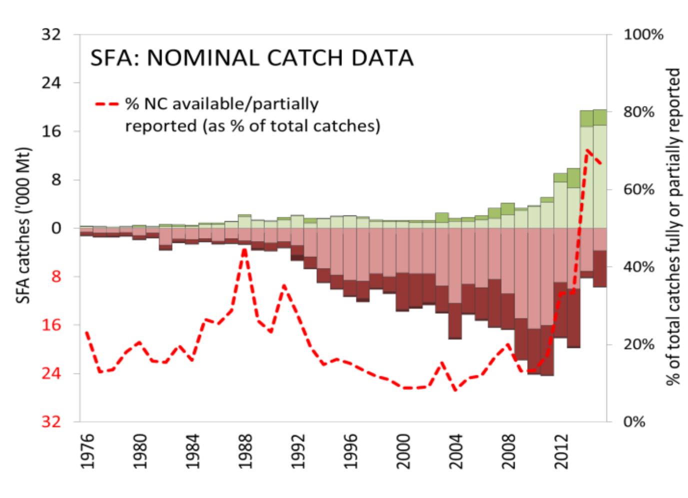
  There is also a lack of catch data for most sport fisheries.

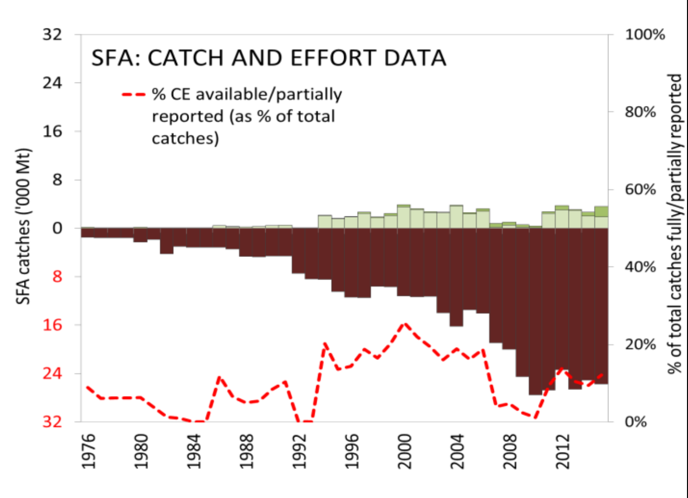
Indo-Pacific sailfish – Nominal catch-per-unit-effort (CPUE) trends

- <u>Availability</u>: 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)

- <u>Average fish weight</u>: 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).
- <u>Catch-at-Size (Age) table</u>: 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.
- <u>Sex ratio data</u>: have not been provided to the Secretariat by CPCs.





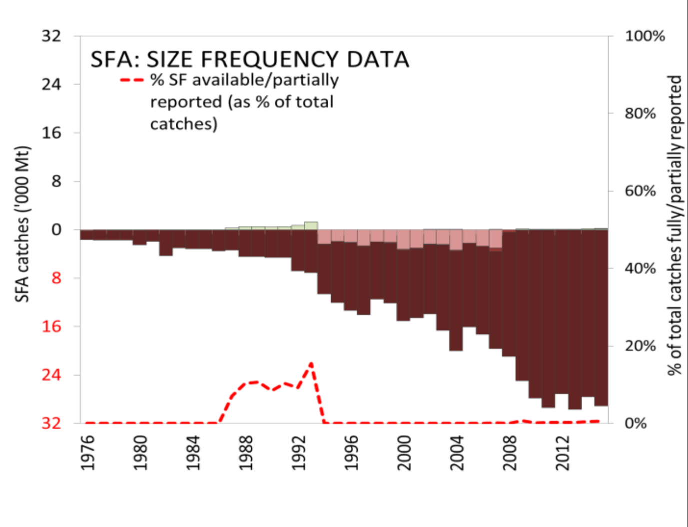


Fig. 4a-c. Indo-Pacific sailfish: data reporting coverage (1976–2015).

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 2017.

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–2017–WPB15–07 Rev_1*)

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 misidentification 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 with good monitoring of catches by species, the catches estimated 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, the IOTC Secretariat has commissioned a pilot Project to improve the collection of catch-and-effort and size frequency from sports fisheries in the Western Indian Ocean. For the initial phase, data collection is focused on sports fisheries in Seychelles, Kenya, Mauritius, and La Reunion. A full update on the Project, including results of the data collection, will be presented to the WPB in 2017.

- 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 its gillnet fishery, (i.e., catches from 2012 onwards) which significantly revises the catch-by-species previously estimates 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 (coastal/offshore fisheries): In 2016 Pakistan submitted catches for first time in recent years – 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. Data reported by WWF-Pakistan estimates catches from Pakistan account for around 6% of total billfish catches in the Indian Ocean. However, based on the latest data submitted by Pakistan, catches are estimated to be much lower than what has previously been reported by WWF-Pakistan. 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 any updates are implemented in 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 totally 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)**:** To date, the IOTC Secretariat has no complete catch-and-effort data (i.e., data for marlins and sailfish) for the longline fishery of EU,Spain.

- 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 catches estimated are considerably higher than those officially reported to the Secretariat.
- Indonesia (fresh longline): The catches of swordfish and marlins for the fresh tuna longline fishery of Indonesia may have been underestimated in the past due to not being sampled sufficiently in port and also the lack of logbook data from which to derive estimates. The catches of billfish estimated in recent years (all species combined) represent around 10% of the total catches in the Indian Ocean, especially swordfish and blue marlin. Catches for this component are considered to be highly uncertain.
- 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 number of samples for all species are below the minimum sampling coverage of one fish per tonne of catch recommended by IOTC; while 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 size frequency data for billfish for gillnet fisheries.
- 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 misidentification 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 month and fishing area (i.e., 5 degree square grid) and refer mostly to the component of the catch that is unloaded fresh. For this reason the quality of the samples in the IOTC database are considered unreliable.
- Taiwan,China (fresh-tuna longline)**:** Taiwan,China recently submitted size frequency data for the fresh tuna longline. Data are available for the marlins and swordfish species. However the data are considered uncertain.
- India and Indonesia (artisanal fisheries): To date, India and Indonesia have not reported 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:

- Industrial longline fisheries: 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).

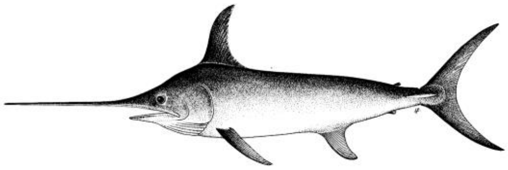
i. Sri Lanka (gillnet and costal fisheries): The IOTC Secretariat to liaise with Sri Lanka (NARA/MFARD) to further improve the estimation of catches of billfish, and revision to the historical time series (e.g., based on the results of 2012 review BOBLME funded sampling of coastal fisheries conducted since 2013).

ii. Indonesia (coastal fisheries): The IOTC Secretariat to continue working with DGCF to improve the quality of data for billfish and other IOTC species for coastal fisheries. A BOBLME/OFCF funded pilot sampling project concludes in October 2015; the results will be used to inform future revisions of catches of IOTC species for Indonesia's coastal fisheries.

iii. I.R. Iran and Pakistan (gillnet fisheries): The IOTC Secretariat to conduct data support missions with I.R. Iran and Pakistan to undertake an historical data review of billfish catches and resolve current inconsistencies in the catches reported to the IOTC Secretariat.

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		2017 stock status determination
Indian Ocean	Catch 2015: Average catch 2011–2015:	32,129[3] (39,667[4]) t 28,490[3] (31,463[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 2015: 39%
[3]Indonesian fresh tuna longline catch assumed to be the same as in 2011–2013
[4]Indonesian fresh tuna longline catch estimated using species composition from the Taiwanese fresh tuna longline in the same years

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		

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

Stock status. A new assessment was undertaken in 2017 using stock synthesis with fisheries 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 as a whole (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. Catches in the last two years has remained similar to the previous two years, although there are some uncertainties in the catch estimates from the Indonesian fresh tuna longline (Figure 1). Most recent catches of 32,129 t in 2015 are 540 t above the MSY level (31,590 t). On the weight-of-evidence available in 2017, the stock is determined to be ***not overfished*** and ***not subject to overfishing*** (Table 1, Figure 2).

Outlook. The decrease in longline catch and effort from 2005 to 2011 lowered the pressure on the Indian Ocean stock as a whole, 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 (32,129 t in 2015) are 539 t above the MSY level (31,590 t). Hence catches should be reduced to less than MSY (31,590 t). However, given the uncertainty of most recent catches from Indonesian fresh tuna longline fisheries, more concrete advice should be developed after the next updated stock assessment scheduled in 2020.

The following key points should be noted:

- **Maximum Sustainable Yield (MSY)**: estimate for the whole 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** (2012–15): Longline catches are currently estimated to comprise approximately 85% of the total estimated swordfish catch in the Indian Ocean.
- **Main fleets** (2012–15): Indonesia (fresh longline): 20%; Taiwan, China (longline): 17%; Sri Lanka (longline-gillnet): 12%; EU, Spain (swordfish targeted longline): 12% (of the total estimated swordfish catch).

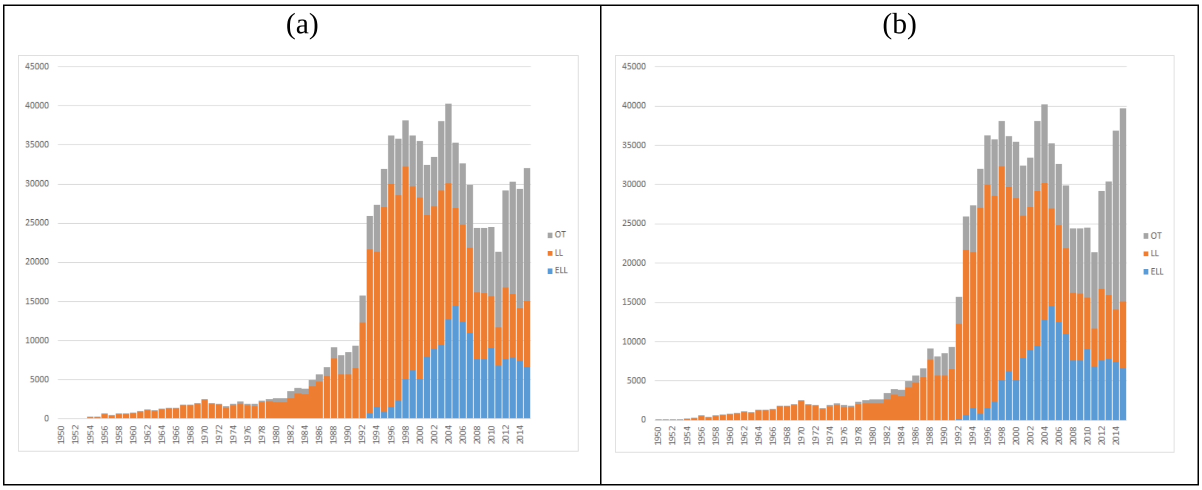


Fig. 1. Swordfish: catches by gear and year recorded in the IOTC Database (1950–2015): (a) the catch for Indonesian fresh tuna longline in 2014 and 2015 is assumed to be the average of 2011–2013; (b) the catch for Indonesian fresh tuna longline is estimated using species composition from the Taiwanese fresh tuna longline in the same years. Other gears (OT) includes: longline-gillnet, handline, gillnet, coastal longline, troll line, sport fishing, and all other gears.

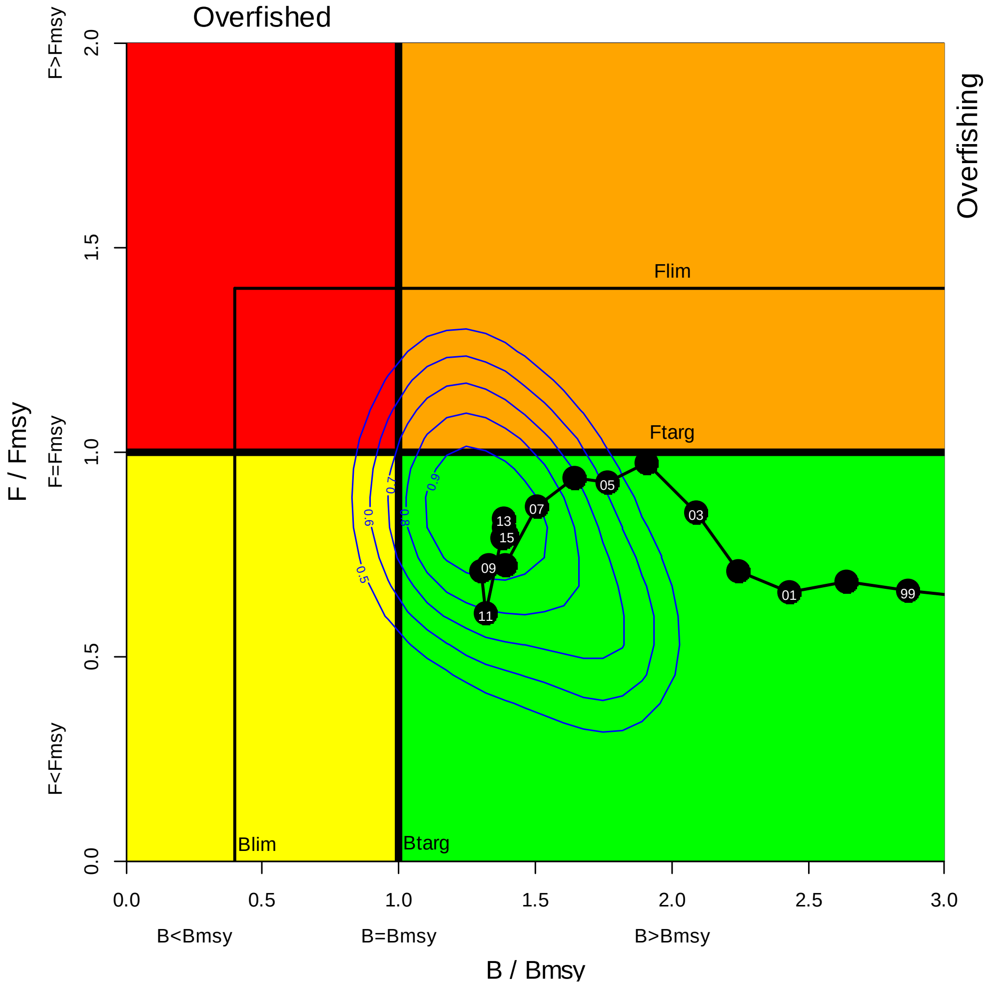


Fig. 2. Swordfish: SS3 Aggregated Indian Ocean assessment Kobe plot (contours are the 50, 60, 70, 80 and 90 percentiles of the 2015 estimate). Blue circles indicate the trajectory of the point estimates for the SB ratio and F ratio for each year 1950–2015. Interim target (F_{targ} and SB_{targ}) and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

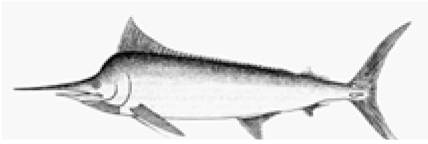
Table 2. Swordfish: SS3 aggregated Indian Ocean assessment Kobe II Strategy Matrix. Probability (percentage) of violating the MSY-based target (top) and limit (bottom) reference points for nine constant catch projections (2015 catch level: 32,129 t), ± 10%, ± 20%, ± 30% ± 40%) projected for 3 and 10 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	0.08	0.13
$F_{2018} > F_{MSY}$	0	0	0	0	0.13	0.33	0.42	0.58	0.71
$SB_{2025} < SB_{MSY}$	0	0	0	0	0.08	0.33	0.46	0.63	0.75
$F_{2025} > F_{MSY}$	0	0	0	0.04	0.38	0.54	0.71	0.83	0.88

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	0.13	0.33
$SB_{2025} < SB_{Lim}$	0	0	0	0	0	0	0	0	0.21
$F_{2025} > F_{Lim}$	0	0	0	0	0	0.21	0.42	0.63	0.75

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		2017 stock status determination
Indian Ocean	Catch 2015: Average catch 2011–2015:	18,954 t 15,397 t	*80%
	MSY (1,000 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):	9.932 (6.963-12.153) 0.211 (0.089-0.430) 47.430 (27.435-100.109) 2.42 (1.52-4.06) 0.81 (0.55-1.10) 0.30 (0.20-0.41)	

[1] Boundaries for the Indian Ocean = IOTC area of competence;
[2] Proportion of catch estimated or partially estimated by IOTC Secretariat in 2015: 22%
*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)	80%	19%
Stock not subject to overfishing ($F_{year}/F_{MSY}\leq$ 1)	0%	1%
Not assessed/Uncertain		

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

Stock status. Stock status based on BSP-SS stock assessment suggests that the stock in 2015 is in the red zone in the Kobe plot with F/F_{MSY}=2.42 and TB/TB_{MSY}=0.81. Another approach by ASPIC examined in 2016 came to similar conclusions. The Kobe plot (Figure 1) from the BSP-SS model indicated that the stock has been **subject to overfishing** and **overfished** in recent years (Table 1; Figure 1).

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 sharp increase of catch changed the status of stock to the red zone (Kobe plot). There are almost no chances to keep MSY levels for F and TB in the next 10 years, even if the current catch levels are reduced by 40% (Table 2).

Management advice. The current catches of BLM (average of 17,373 t in the last 3 years, between 2013-2015) are considerably higher than MSY (9,932 t) and the stock is overfished (B_{curr}< B_{MSY}) and currently subject to overfishing (F_{curr}> F_{MSY}). Even with a 40% reduction in current catches, it is very unlikely (less than 5%) to achieve the Commission objectives of being in the green zone of the Kobe Plot by 2025. Current catch levels are not sustainable and there is a need for urgent actions to decrease this catch levels.

The following key points should be noted:

- **Maximum Sustainable Yield (MSY)**: estimate for the whole Indian Ocean is 9,932 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 black marlin.
- **Main fishing gear** (2012–15): gillnet: 54%; Longline: 17% (take of the total estimated black marlin catch).

- **Main fleets** (2012–15): I.R. Iran (gillnet): 29%; India (gillnet and troll): 20%, Sri Lanka (gillnet and fresh longline): 19%; Indonesia (fresh longline and hand lines): 15% (take of the total estimated black marlin catch).

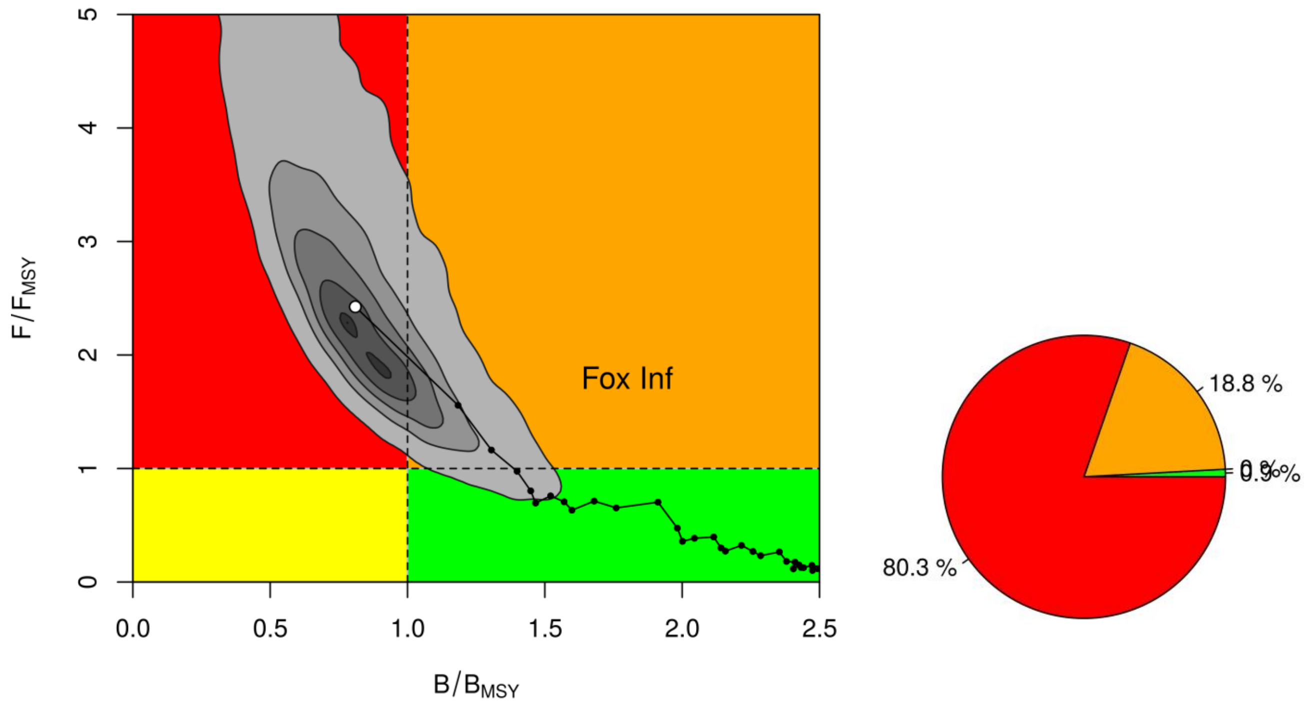


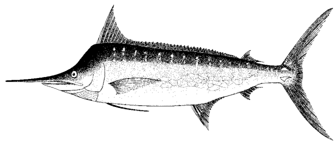
Fig. 1. Black marlin: BSP-SS aggregated Indian Ocean assessment Kobe plots for black marlin (contours are the 25, 50, 75 and 90 percentiles of the 2015 estimate). Black line indicates the trajectory of the point estimates (blue circles) for the spawning biomass (B) ratio and F ratio for each year 1950–2015.

Table 2. Black Marlin: Indian Ocean BSP-SS Kobe II Strategy Matrix.Probability (percentage) of violating the MSY-based target reference points for nine constant catch projections (average catch level from 2013–15 (17,171 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 2013–15, 17,171 t) and probability (%) of violating MSY-based target reference points ($B_{targ} = B_{MSY}$; $F_{targ} = F_{MSY}$)**								
	60%	**70%**	**80%**	**90%**	**100%**	**110%**	**120%**	**130%**	**140%**
	10,303 t	12,020 t	13,737 t	15,454 t	17,171 t	18,888 t	20,605 t	22,322 t	24,039 t
$SB_{2018} < SB_{MSY}$	91	94	96	97	98	98	99	99	99
$F_{2018} > F_{MSY}$	89	96	98	99	100	100	100	100	100
$SB_{2025} < SB_{MSY}$	98	100	100	100	100	100	100	100	100
$F_{2025} > F_{MSY}$	97	99	100	100	100	100	100	100	100

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**		**2016 stock status determination**
Indian Ocean	Catch 2015[2]:	15,482 t	*46.8%
	Average catch 2011–2015:	14,799 t	
	MSY (1,000 t) (80% CI):	11.926 (9.232–16.149)	
	F_{MSY} (80% CI):	0.109 (0.076 –0.160)	
	B_{MSY} (1,000 t) (80% CI):	113.012 (71.721 – 161.946)	
	F_{2015}/F_{MSY} (80% CI):	1.18 (0.80–1.71)	
	B_{2015}/B_{MSY} (80% CI):	1.11 (0.90–1.35)	
	B_{2015}/B_{1950} (80% CI):	0.56 (0.44 – 0.71)	

[1]Boundaries for the Indian Ocean = IOTC area of competence; n.a. = not available
[2]Proportion of catch estimated or partially estimated by IOTC Secretariat in 2015: 47%
*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)	24.6%	46.8%
Stock not subject to overfishing (F_{year}/F_{MSY}≤ 1)	1.0%	27.6%
Not assessed/Uncertain		

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

Stock status. Stock status based on BSP-SS stock assessment suggests that the stock 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 Kobe plot (Fig. 2) from the BSP-SS model indicated that the stock has been **subject to overfishing** but **not overfished** in recent years, while the stock biomass is slightly above the BMSY level (Table 1; Figure 1).

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 current catch level is continued. But if the catch level is reduced by 20%, then the risk will be reduced to close to or less than 50% (Table 2).

Management advice. The current catches of BUM (average of 14,799 t in the last 5 years, 2011-2015) are higher than MSY (11,926 t) and the stock is currently being overfished ($F_{curr} > F_{MSY}$). In order to achieve the Commission objectives of being in the green zone of the Kobe Plot by 2025 ($F_{2025} < F_{MSY}$ and $B_{2025} > B_{MSY}$) with at least a 50% chance, the catches of blue marlin would have to be reduced by 24% compared to the average of the last 3 years, to a maximum value of 11,643 t.

The following key points should be noted:

- **Maximum Sustainable Yield (MSY)**: estimate for the whole Indian Ocean 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** (2012–15): Longline: 72%; Gillnet: 25% (of the total estimated blue marlin catch).
- **Main fleets** (2012–15): Taiwan,China (longline): 34%; Indonesia (fresh longline): 30%; Pakistan (gillnet): 12%; I.R. Iran (gillnet): 9%; Sri Lanka: 6% (of the total estimated blue marlin catch).

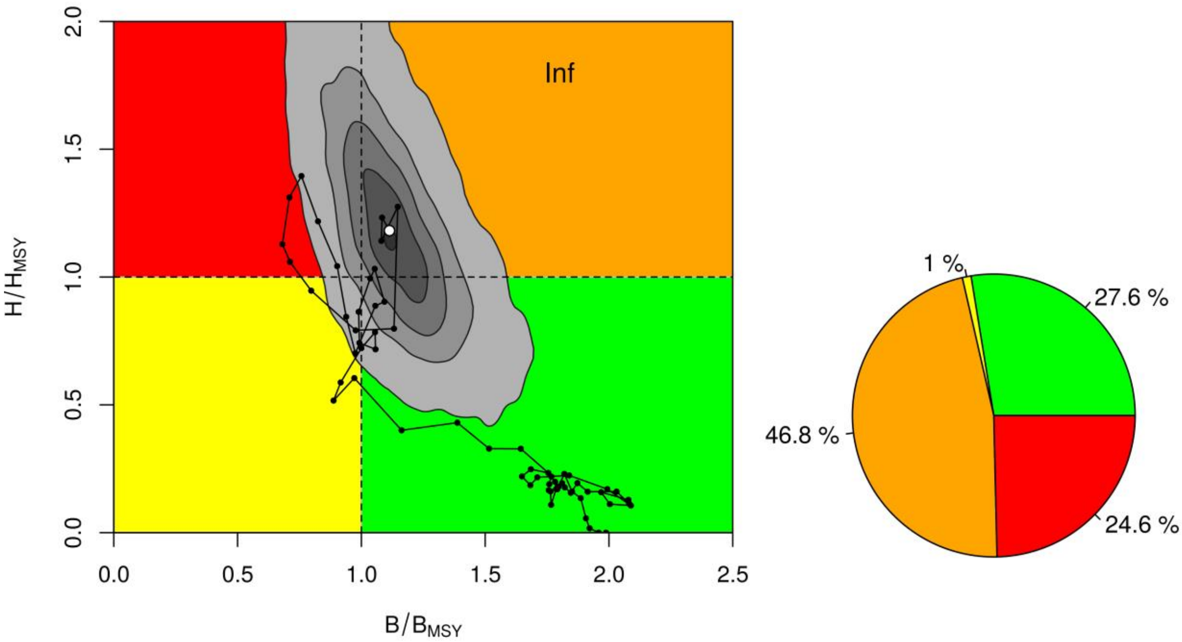


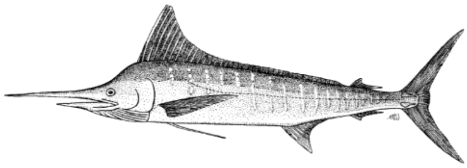
Fig. 1. Blue marlin: BSP-SS Aggregated Indian Ocean assessment Kobe plot for blue marlin (90% bootstrap confidence surfaces shown around 2015 estimate). Black line indicates the trajectory of the point estimates for the biomass (B) ratio (shown as TB) and F ratio for each year 1950–2015.

Table 2. Blue Marlin: Indian Ocean BSP-SS Kobe II Strategy Matrix. Probability (percentage) of violating the MSY-based target reference points for nine constant catch projections (average catch level from 2013–2015 (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 level from 2013–2015, 15,401 t) and probability (%) of violating MSY-based target reference points (B_{targ} = B_{MSY}; F_{targ} = F_{MSY})**								
	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

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		2017 stock status determination
Indian Ocean	Catch 2015[2]: Average catch 2011–2015:	4,369 t 4,472 t	
	MSY (1,000 t) (Range): F_{MSY} (Range): B_{MSY} (1,000 t) (Range): F_{2015}/F_{MSY} (Range): B_{2015}/B_{MSY} (Range): B_{2015}/B_{1950} (Range):	(3.27–5.40) (0.05–0.90) (1.82–34.3) (1.32–3.04) (0.24–0.62) (0.09.–0.32)	

[1]Boundaries for the Indian Ocean = IOTC area of competence; n.a. = not available.
[2]Proportion of catch estimated or partially estimated by IOTC Secretariat in 2015: 53%

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. A new stock assessment for striped marlin was carried out in 2017, based on four different models, specifically a data-limited catch only method (SRA - stock reduction analysis), two production models (ASPIC without process error and SSBSP a Bayesian approach with process error) and SS3 (Stock Synthesis, an integrated length-based model). The ASPIC assessment confirmed the results from 2012, 2013 and 2015 that indicated the stock is subject to overfishing ($F>F_{MSY}$) and that biomass is below the level which would produce MSY ($B<B_{MSY}$). The other models examined in 2017 came to similar conclusions. All models were consistent in 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. In 2015 reported catches increased to 4,369 t. On the weight-of-evidence available in 2017, the stock status of striped marlin is determined to be ***overfished*** and ***subject to overfishing*** (Table 1; Figure 1).

Outlook. The decrease in longline catch and effort in the years 2009–11 lowered the pressure on the Indian Ocean stock as a whole, however, given the increased catches reported since 2011, combined with the concerning results obtained from the last stock assessments (2012, 2013, 2015 and 2017), the outlook is pessimistic for the stock as a whole and management action for striped marlin should be considered. Projections from all the models show that there is a very high risk of remaining in *overfished* status unless catches are substantially decreased. However, K2SM probabilities are not provided because of uncertainty in quantitative results of the stock assessment models, which affected the projections estimates.

Management advice. Current or increasing catches have a very high risk of maintain the stock overfished. In order to enable the stock to start rebuilding, the Commission should consider a drastic reduction of catch levels. A new stock assessment will be carried on in 2018.

The following key points should be noted:

- **Maximum Sustainable Yield (MSY)**: point estimates for the whole Indian Ocean are highly uncertain and range between 3,270 t – 5,400 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 of around 4,369 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 striped marlin.
- **Main fishing gear** (2012–15): Longline: 69%; Gillnet: 24% (of the total estimated striped marlin catch).
- **Main fleets** (2012–15): Indonesia (drifting longline and coastal longline): 36%; Taiwan,China (drifting longline): 24%; I.R. Iran (gillnet): 14%; Pakistan (gillnet): 8% (of the total estimated striped marlin catch).

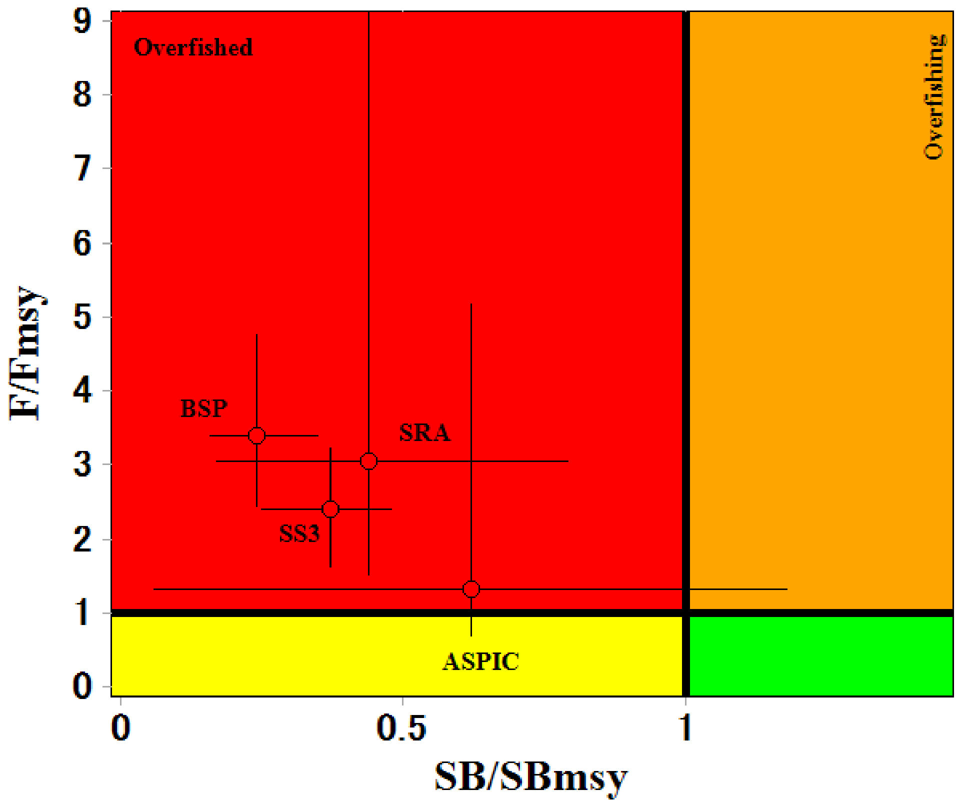


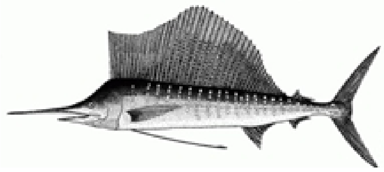
Fig. 1. Striped marlin: Stock status from the aggregated Indian Ocean assessment models with the confidence intervals.

Table 2. Striped marlin: ASPIC aggregated Indian Ocean assessment Kobe II Strategy Matrix. Probability (percentage) of violating the MSY-based reference points for nine constant catch projections (average catch level from 2013–15 (4,460 t), ± 10%, ± 20%, ± 30% and ± 40%) projected for 3 and 10 years.

Reference point and projection timeframe	Alternative catch projections (relative to the average catch level from 2013–2015, 4,460 t) and probability (%) of violating MSY-based target reference points ($B_{targ} = B_{MSY}$; $F_{targ} = F_{MSY}$)								
	60%	**70%**	**80%**	**90%**	**100%**	**110%**	**120%**	**130%**	**140%**
	2,676 t	3,122 t	3,568 t	4,014 t	4,460 t	4,906 t	5,352 t	5,798 t	6,244 t
$B_{2018} < B_{MSY}$									
$F_{2018} > F_{MSY}$									
$B_{2025} < B_{MSY}$									
$F_{2025} > F_{MSY}$									

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**		**2016 stock status determination**
Indian Ocean	Catch 2015[2]: Average catch 2011–2015:	29,311 t 28,689 t	
	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_0 (80% CI):	25.000 (16.18–35.17) 0.26 (0.15–0.39) 87.52 (56.30–121.02) 1.05 (0.63–1.63) 1.13 (0.87–1.37) 0.56 (0.44–0.67)	

[1]Boundaries for the Indian Ocean = IOTC area of competence.
[2]Proportion of catch estimated or partially estimated by IOTC Secretariat in 2015: 35%

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

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

Stock status. In 2015, data poor methods for stock assessment using Stock reduction analysis (SRA) techniques indicate that the stock is not yet overfished, but is subject to overfishing (Table 1). In using the SRA method for comparative purposes with other stocks, the use of the target reference points may be possible for the approach. 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 in catch rates which is a cause of concern (Figure 1), indicating that fishing mortality levels may be becoming too high (Table 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 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. Records of stock extirpation in the Gulf should also be examined to examine the degree of localised depletion in Indian Ocean coastal areas. On the weight-of-evidence available in 2016, 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 as a whole, however there is not sufficient information to evaluate the effect this will have on the resource.

Management advice. The same management advice for 2017 (catches below a MSY of 25,000 t) is kept for the next year (2018).

The following key points should be noted:

- **Maximum Sustainable Yield (MSY)**: estimate for the whole Indian Ocean 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** (2012–15): Gillnet: 77%; Troll and handlines: 19% (of the total estimated I.P. sailfish catch).
- **Main fleets** (2012–15): I.R. Iran (gillnet): 31%; Pakistan (gillnet): 18%; India (gillnet and troll): 17%; Sri Lanka (gillnet and fresh longline): 10% (of the total estimated I.P. sailfish catch).

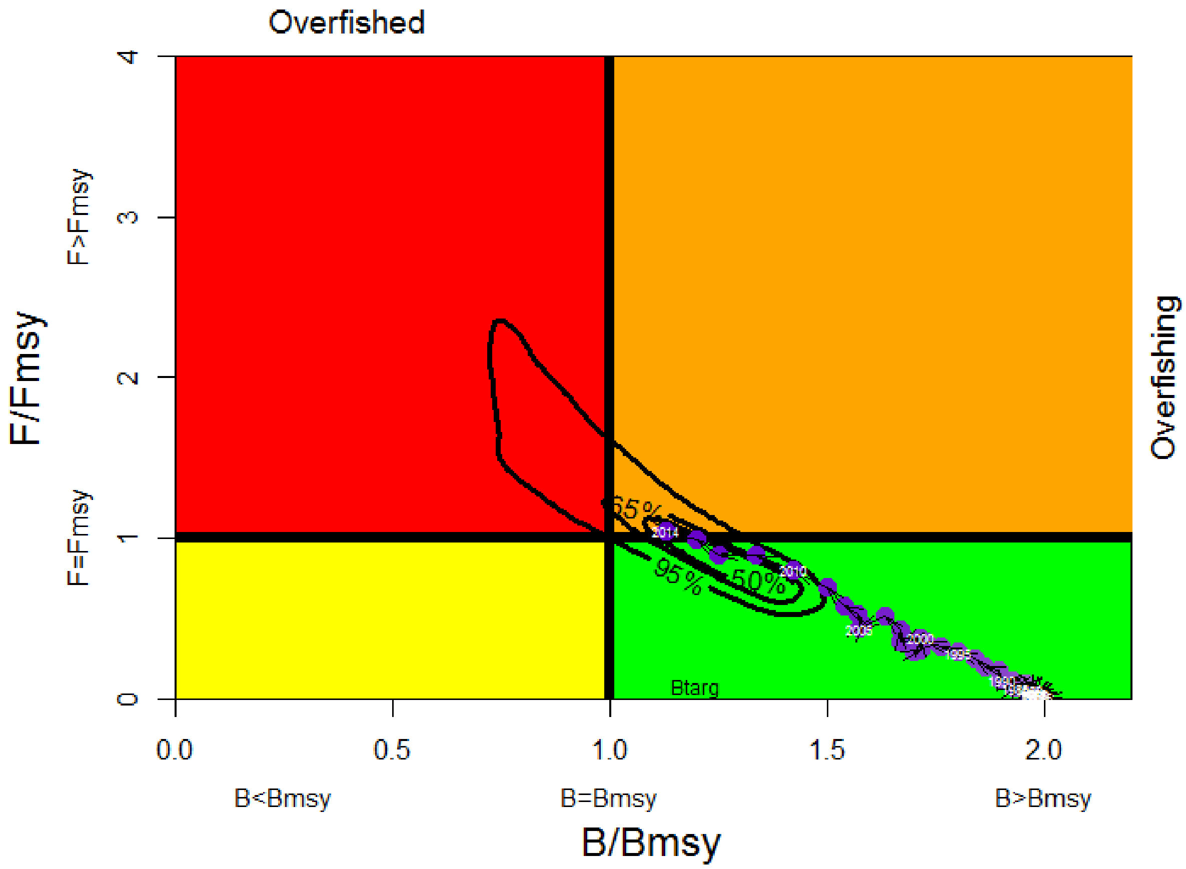


Fig. 1. Indo-Pacific sailfish: Stock reduction analysis (Catch MSY Method) of aggregated Indian Ocean assessment Kobe plot (contours are the 50, 65 and 90 percentiles of the 2014 estimate). Black lines indicate the trajectory of the point estimates (blue circles) for the B ratio and F ratio for each year 1950–2014.

Table 2. Indo-Pacific sailfish: Indian Ocean stock reduction analysis Kobe II Strategy Matrix.Probability (percentage) of violating the MSY-based target reference points for nine constant catch projections (average catch level 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 target reference points ($B_{targ} = B_{MSY}$; $F_{targ} = F_{MSY}$)								
	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

APPENDIX XI
WORKING PARTY ON BILLFISH PROGRAM OF WORK (2018–2022)

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				
				2018	2019	2020	2021	2022
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.	High (1)	1.3 m Euro: (European Union)					
	1.1.1 Next Generation Sequencing (NGS) to determine the degree of shared stocks for billfish in the Indian Ocean 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.	High (1)						
	1.1.2 Nuclear markers (i.e. microsatellite) to determine the degree of shared stocks for billfish (highest priority species: blue, black, striped marlin and sailfish) in the Indian Ocean with the southern Atlantic Ocean and Pacific Ocean, as appropriate.	High (1)						
	1.1.3 Develop a close-kin mark recapture method (*Bravington et al.* 2016) on marlins to estimates population size and other	High (1)						

		important demographic parameters. This method includes the sampling of juveniles and adult fish and genetic parenting analyses to estimate the population size from mark-recapture models.							
		1.2 Tagging research to determine connectivity, movement rates and mortality estimates of billfish.	High (2)	US$100,000					
		1.2.1 Tagging studies (PSAT)		(TBD)					
2.	Biological and ecological information (incl. parameters for stock assessment)	2.1 Age and growth research	High (7)						
		2.1.1 CPCs to provide further research reports 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 or other research programs.		(CPCs directly)					
		2.2 Age-at-Maturity	High (8)						
		2.2.1 Quantitative biological studies are necessary for billfish throughout its range to determine key biological parameters including age-at-maturity and fecundity-at-age/length relationships, age-length keys, age and growth, which will be fed into future stock assessments.		(CPCs directly)					
		2.3 Spawning time and locations	High (9)						
		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.		(CPCs directly)					
3.	Historical data review	3.1 Changes in fleet dynamics							
		3.1.1 Japan and Taiwan,China to undertake an historical review of their longline fleets and to document the changes in fleet dynamics. 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.	High (6)	(CPCs directly)					

	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 (5)	(CPCs directly)					
4. Sports/recreational fisheries	4.1 Fishery trends							
	4.1.1 The catch and effort data for sports/recreational fisheries targeting marlins and sailfish in the Indian Ocean should be submitted to the IOTC Secretariat to assist in future assessments for these species. CPCs with active sports/recreational fisheries targeting marlins and sailfish should undertake a comprehensive analysis for provision to the WPB.	High (First phase to be finalized in 2017)	Consultant US$TBD					
5. CPUE standardization	5.1 Develop and/or revise standardized CPUE series for each billfish species and major fisheries/fleets for the Indian Ocean.							
	5.1.1 Swordfish: Priority LL fleets: Taiwan,China, EU(Spain, Portugal, France), Japan, Indonesia	High (20)	(CPCs directly)					
	5.1.2 Striped marlin: Priority fleets: Japan, Taiwan,China	High (21)	(CPCs directly)					
	5.1.3 Black marlin: Priority fleets: Longline: Taiwan,China; Gillnet: I.R. Iran, Sri Lanka	High (13)	(CPCs directly)					
	5.1.4 Blue marlin: Priority fleets: Japan, Taiwan,China	High (14)	(CPCs directly)					
	5.1.5 I.P. Sailfish: Priority fleets: Priority gillnet fleets: I.R. Iran and Sri Lanka; Priority longline fleets: EU(Spain, Portugal, France), Japan, Indonesia;	High (12)	(CPCs directly)					
6. Stock assessment / Stock indicators	6.1 Develop and compare multiple assessment approaches to determining stock status for swordfish (SS3, ASPIC, etc.).	High (15)	US$??					

		6.2 Stock assessment on billfish species in 2018 and 2019	High (3)	Consultant/ US$16,250					
		6.3 Workshops on techniques for assessment including CPUE estimations for billfish species in 2018 and 2019.	High (4)	Consultant US$11,750					
7	Target and Limit reference points	7.1 To advise the Commission, by end of 2016 at the latest on Target Reference Points (TRPs) and Limit Reference Points (LRPs).	High (16)						
		7.1.1 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					
8	Management measure options	8.1 To advise the Commission, by end of 2016 at the latest, on potential management measures having been examined through the Management Strategy Evaluation (MSE) process.	High (17)						
		8.1.1 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	**2018**	**2019**	**2020**	**2021**	**2022**
Black marlin	**Full assessment**		**Full assessment**		**Full assessment**
Blue marlin		**Full assessment**			**Full assessment**
Striped marlin	**Full assessment**			**Full assessment**	
Swordfish		**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 15TH SESSION OF THE WORKING PARTY ON BILLFISH

Note: Appendix references refer to the Report of the 15thSession of the Working Party on Billfish (IOTC–2017–WPB15–R)

Billfish species identification

WPB15.01 (para. 17): The WPB **AGREED** on the importance of the hard, waterproof copies of the IOTC species identification guides for observers and port samplers, and again **RECOMMENDED** that funds are allocated for further printing of the species ID guides for distribution to sports fishing clubs and recreational fisheries to improve the quality of data reported, and that additional funds be provided for the translation of these into the priority languages identified by the SC.

Review of the statistical data available for billfish

WPB15.02 (para. 35): (…) the WPB **RECOMMENDED** that Indonesia and the IOTC Secretariat closely liaise in the future to ensure that the current estimation process of Indonesian catches is properly documented and improved - if needed - in order to ensure that only the best scientific estimates are made available to scientists.

New information on sport fisheries

WPB15.03 (para. 62): The WPB **NOTED** that the pilot project is still ongoing and will be completed by October 2017, and **RECOMMENDED** that results and outcomes of its first phase be evaluated by the SC prior to the possible implementation of a second phase.

WPB15.04 (para. 63): Eventually, following the positive evaluation by the SC, the WPB **RECOMMENDED** future development of a network of country focal points for the distribution of data forms, the collection of the anonymized data and its submission to the IOTC Secretariat.

Swordfish: Grid-rNTP model

WPB15.05 (para. 108): The WPB **NOTED** that the uncertainty regarding the regional rescaling factor is difficult to fully evaluate in a single stock assessment, and **RECOMMENDED** that this is more formally addressed using a structured approach within a Management Strategy Evaluation framework.

Revision of the WPB Program of work (2018–2022)

WPB15.06 (para. 216): The WPB **RECOMMENDED** that future work continues on the marlins stock assessment in order to improve current models and other approaches such as delay-difference or age-structured production models are explored. Therefore the WPB **AGREED** that its plan of work be intersessionally amended for the consideration of the SC and a consultant be hired to further explore the data and models.

WPB15.07 (para. 217): The WPB **RECOMMENDED** that the SC consider and endorse the WPB Program of Work (2018–2022), as provided at Appendix XI.

Review of the draft, and adoption of the Report of the 15thSession of the Working Party on Billfish

WPB15.08 (para. 229): The WPB **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPB15, 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 2017 (Fig. 15):

- 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

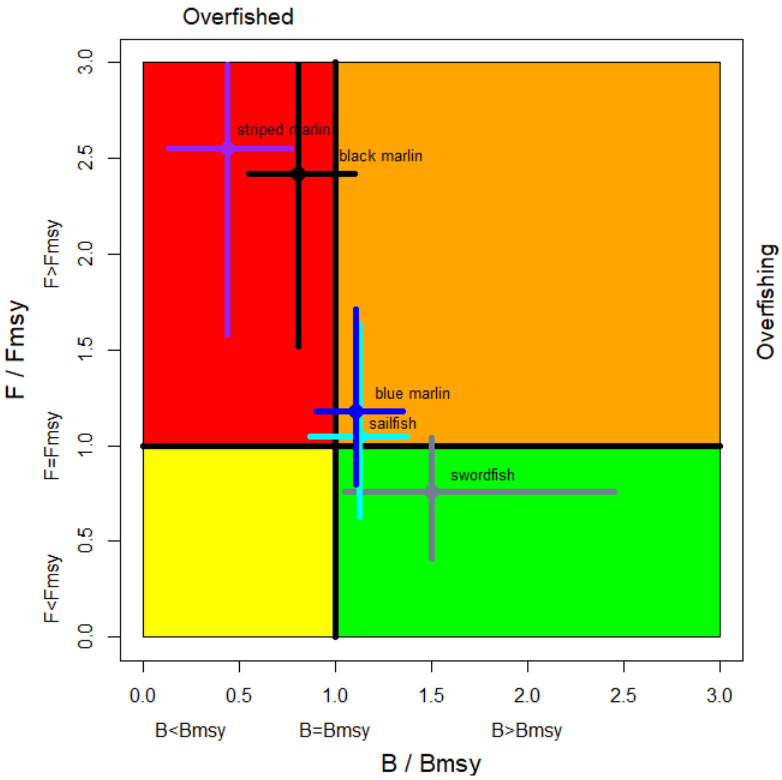


Fig. 15. Combined Kobe plot for swordfish (grey), indo-pacific sailfish (cyan), black marlin (black), blue marlin (blue) and striped marlin (purple) showing the 2016 and 2017 estimates of current stock size (SB or B, species assessment dependent) and current fishing mortality (F) in relation to optimal spawning stock size and optimal fishing mortality. Cross bars illustrate the range of uncertainty from the model runs.