Report of the 18th Session of the IOTC Working Party on Billfish

Microsoft Teams Online, 2–4 September 2020

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BIBLIOGRAPHIC ENTRY
IOTC–WPB18 2020. Report of the 18th Session of the IOTC Working Party on Billfish, Microsoft Teams Online, 2020.
IOTC–2020–WPB18–R[E]: 93pp.

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
JABBA	Just Another Bayesian Biomass Assessment (a generalized Bayesian State-Space Surplus Production Model)
LL	Longline
M	Natural Mortality
MSY	Maximum sustainable yield
n.a.	Not applicable
NGO	Non-governmental organization
PS	Purse-seine
q	Catchability
r	Intrinsic rate of population increase
ROS	Regional Observer Scheme
SC	Scientific Committee of the IOTC
SB	Spawning biomass (sometimes expressed as SSB)
SB_{MSY}	Spawning stock biomass which produces MSY
SFA	Indo-Pacific sailfish (FAO code)
SS3	Stock Synthesis III
STM	Striped marlin (FAO code)
SWO	Swordfish (FAO code)
Taiwan,China	Taiwan, Province of China
WPB	Working Party on Billfish of the IOTC
WPEB	Working Party on Ecosystems and Bycatch of the IOTC

STANDARDISATION OF IOTC WORKING PARTY AND SCIENTIFIC COMMITTEE REPORT TERMINOLOGY

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

HOW TO INTERPRET TERMINOLOGY CONTAINED IN THIS REPORT

Level 1: From a subsidiary body of the Commission to the next level in the structure of the Commission:

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

Level 2: From a subsidiary body of the Commission to a CPC, the IOTC Secretariat, or other body (not the Commission) to carry out a specified task:

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

Level 3: General terms to be used for consistency:

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

NOTED/NOTING: Any point of discussion from a meeting which the IOTC body considers to be important enough to record in a meeting report for future reference.

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

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EXECUTIVE SUMMARY

The 18th Session of the Indian Ocean Tuna Commission's (IOTC) Working Party on Billfish (WPB) was held online using the Microsoft Teams platform from the 2nd to 3rd September 2020. A total of 55 participants (25 in 2019 and 20 in 2018) attended the Session. The list of participants is provided at Appendix I. The meeting was opened by the Chairperson, Dr Denham Parker (South Africa), who welcomed participants.

The following are the complete recommendations from the WPB18 to the Scientific Committee, which are also provided at Appendix XII:

Outcome of the 22nd Session of the Scientific Committee

WPB18.01 (para 5): **RECALLING** that one of the Indian Ocean billfish species (shortbill spearfish, *Tetrapturus angustirostris*) is currently not listed among the species managed by IOTC, and considering the ocean-wide distribution of this species, its highly-migratory nature, and that it is a common bycatch in IOTC managed fisheries, the WPB reiterated it's previous **RECOMMENDATION** that the Scientific Committee consider requesting the Commission to include it in the list of species to be managed by the IOTC

Revision of the WPB Program of work (2020–2024)

WPB18.02 (para 112): The WPB **RECOMMENDED** that the SC consider and endorse the WPB Program of Work (2021–2025), as provided at Appendix XII.

Date and place of the 19th and 20th Sessions of the Working Party on Billfish

WPB18.03 (para 115) The WPB **NOTED** that the global Covid-19 pandemic has resulted in international travel being almost impossible and with no clear end to the pandemic in sight, it was impossible to finalise arrangements for the meeting in 2021. The Secretariat will continue to liaise with CPCs to determine their interest in hosting these meetings in the future when this once again becomes feasible. The WPB **RECOMMENDED** the SC consider early September 2021 as a preferred time period to hold the WPB19 in 2021. As usual it was also **AGREED** that this meeting should continue to be held back-to-back with the WPEB, with the WPEB taking place before the WPB in 2021.

Review of the draft, and adoption of the Report of the 18th Session of the Working Party on Billfish

WPB18.04 (para. 116): The WPB **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPB18, 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 2020 (Fig. 9):

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

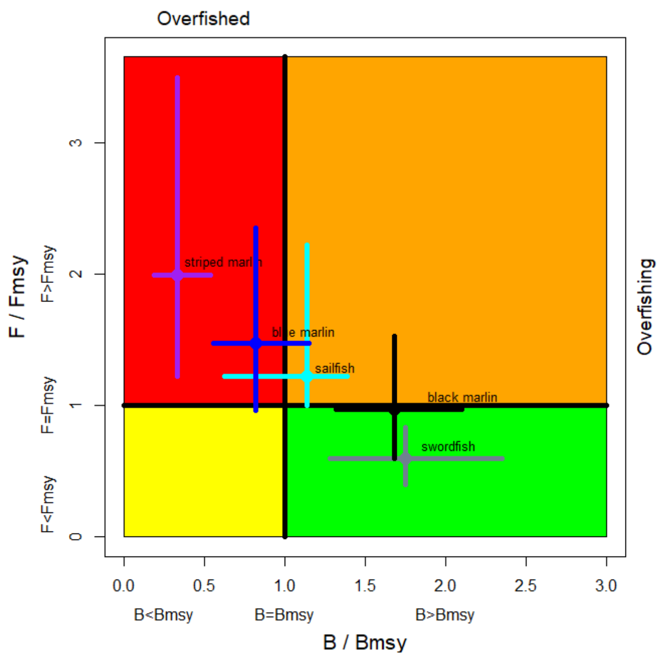


Fig. 4. Combined Kobe plot for swordfish (grey), Indo-pacific sailfish (cyan), black marlin (black), blue marlin (blue) and striped marlin (purple) showing the 2017, 2018, 2019, and 2020 estimates of current stock size (SB or B, species assessment dependent) and current fishing mortality (F) in relation 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	2016	2017	2018	2019	2020	Advice to the Scientific Committee
Swordfish *Xiphias gladius*	Catch 2018: 30,847 t Average catch 2014–2018: 30,632 t MSY (1,000 t) (80% CI): 33 (27–40) F_{MSY} (80% CI): 0.23 (0.15–0.31) SB_{MSY} (1,000t)(80% CI): 59 (41–77) F_{2018}/F_{MSY} (80% CI): 0.60 (0.40–0.83) SB_{2018}/SB_{MSY} (80% CI): 1.75 (1.28–2.35) SB_{2018}/SB_{1950} (80% CI): 0.42 (0.36–0.47)						***Stock status.*** A new assessment was undertaken in 2020 using stock synthesis with fisheries data up to 2018. 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_{2018}/F_{MSY}< 1; SB_{2018}/SB_{MSY}> 1). The two alternative models (ASPIC and JABBA) applied to swordfish also indicated that the stock was above a biomass level that would produce MSY. Spawning stock biomass in 2018 was estimated to be 40-83% of the unfished levels. Most recent catches of 30,847 t in 2018 are below the MSY level (33,000 t). On the weight-of-evidence available in 2020, the stock is determined to be ***not overfished*** and ***not subject to overfishing***. ***Management advice.*** The most recent catches (30,847 t in 2018) are below the MSY level (33,000 t). Under the current levels of catches, the stock biomass is projected to remain relatively stable, with a high probability of maintaining at or above the SB_{MSY} for the longer term. An increase of 40% or more from current catch levels will likely result in the biomass dropping below the SB_{MSY} level for the longer term (with approximately 50% probability). Taking into account the updated information regarding swordfish stock structure (IOTC-2020-WPB18-09), as well as the differential CPUE and biomass trends between regions, the WPB should continue to discuss the swordfish stock assessment model specifications and consider the feasibility of including a multi-stock assessment in 2023. Recognising that there is recurring evidence for localised depletion in the southern regions the WPB expresses concern and suggests this should be further monitored. Click here for full stock status summary: Appendix VI
Black marlin *Makaira indica*	Catch 2018: 18,841 t Average catch 2014–2018: 18,424 t MSY (1000 t) (80% CI): 12.93 (9.44-18.20) F_{MSY} (80% CI): 0.18 (0.11-0.30) B_{MSY} (1000 t) (80% CI): 72.66 (45.52-119.47) F_{2017}/F_{MSY} (80% CI): 0.96 (0.77-1.12) B_{2017}/B_{MSY} (80% CI): 1.68 (1.32-2.10) B_{2017}/B_{1950} (80% CI): 0.62 (0.49-0.78)						***Stock status.*** No new stock assessment was carried out for black marlin in 2020, thus, the stock status is determined on the basis of the 2018 assessment and other indicators presented in 2019. In 2018 a stock assessment based on JABBA was conducted for black marlin. This assessment suggests that the point estimate for the stock in 2017 is in the green zone in the Kobe plot with F/F_{MSY}=0.96 (0.77-1.12) and B/B_{MSY}=1.68 (1.32-2.10). The Kobe plot (Fig. 4) from the JABBA model indicated that the stock is not **subject to overfishing** and is currently not **overfished**, however these status estimates are subject to a high degree of uncertainty. As such, the results should be interpreted with caution. ***Management advice.*** The current catches (>14,600 t in 2017) are higher than MSY (12,930 t). Projections were not carried out due to the poor predictive capabilities identified in the assessment diagnostics. Click here for full stock status summary: Appendix VII

Blue marlin *Makaira nigricans*	Catch 2018: 8,492 t Average catch 2014–2018: 9,898 t MSY (1000 t) (80% CI): 9.98 (8.18 –11.86) F_{MSY} (80% CI): 0.21 (0.13 – 0.35) B_{MSY} (1,000 t) (80% CI): 47 (29.9 – 75.3) F_{2015}/F_{MSY} (80% CI): 1.47 (0.96 – 2.35) B_{2015}/B_{MSY} (80% CI): 0.82 (0.56 – 1.15) B_{2015}/B_{1950} (80% CI): 0.41 (0.28 – 0.57)						***Stock status.*** No new stock assessment was carried out for blue marlin in 2020, thus the stock status is determined on the basis of the 2019 assessment. The stock status is based on the Bayesian State-Space Surplus Production model JABBA that suggests that there is an 87% probability that the Indian Ocean blue marlin stock in 2017 is in the red zone of the Kobe plot, indicating the stock is ***overfished*** and ***subject to overfishing*** (B_{2017}/B_{MSY}=0.82 and F_{2017}/F_{MSY}=1.47). The most recent catch exceeds the estimate of MSY ($Catch_{2017}$ = 12,029 t; MSY = 9,984 t). The previous assessment of blue marlin (Andrade 2016[1]) concluded that in 2015 the stock was subject to overfishing but not overfished. The change in stock status can be attributed to increased catches for the period 2015-2017 as well as improved standardisation of CPUE indices, which includes the area disaggregation of JPN and TWN indices to account for fleet dynamics. ***Management advice.*** The current catches of blue marlin (average of 9,898 t in the last 5 years, 2014-2018) are higher than MSY (9,984 t) and the stock is currently overfished and subject to overfishing. In order to achieve the Commission objectives of being in the green zone of the Kobe Plot by 2027 (F_{2027} < F_{MSY} and B_{2027} > B_{MSY}) with at least a 60% chance, the catches of blue marlin would have to be reduced by 35% compared to the average of the last 3 years, to a maximum value of approximately 7,800 t. Click here for full stock status summary: Appendix VIII
Striped marlin *Tetrapturus audax*	Catch 2018: 2,769 t Average catch 2014–2018: 3,281 t MSY (1,000 t) (JABBA): 4.73 (4.27–5.18) F_{MSY} (JABBA): 0.26 (0.20–0.34) B_{MSY} (1,000 t) (JABBA): 17.94 (14.21–23.13) F_{2017}/F_{MSY} (JABBA): 1.99 (1.21–3.62) B_{2017}/B_{MSY} (JABBA): 0.33 (0.18–0.54) SB_{2017}/SB_{MSY} (SS3): 0.373 B_{2017}/B_{1950} (JABBA): 0.12 (0.07–0.20) SB_{2017}/SB_{1950} (SS3): 0.13 (0.09–0.14)						***Stock status:*** No new stock assessment was carried out for striped marlin in 2020, thus, the stock status is determined on the basis of the 2018 assessment and other indicators presented in 2019. The stock assessment for striped marlin carried out in 2018, based on two different models: JABBA, a Bayesian state-space production model; and SS3, an integrated length-based model. Both models were very consistent and confirmed the results from 2012, 2013, 2015 and 2017 assessments, indicating that the stock is subject to overfishing ($F>F_{MSY}$) and overfished, with the biomass for at least the past ten years is below the level which would produce MSY ($B<B_{MSY}$). On the weight-of-evidence available in 2018, the stock status of striped marlin is determined to be ***overfished*** and ***subject to overfishing***. ***Management advice.*** Current or increasing catches have a very high risk of further decline in the stock status. Current 2017 catches are lower than MSY (4,730 t) but the stock has been overfished for more than two decades and is now in a highly depleted state. If the Commission wishes to recover the stock to the green quadrant of the Kobe plot with a probability ranging from 60% to 90% by 2026, then the maximum annual catches have to be set to between 1,500 t – 2,200 t. Click here for full stock status summary: Appendix IX
Indo-Pacific Sailfish *Istiophorus platypterus*	Catch 2018: 33,807 t Average catch 2014–2018: 29,164 t MSY (1,000 t) (80% CI): 23.9 (16.1 – 35.4)						***Stock status:*** No new stock assessment was carried out for Indo-Pacific Sailfish in 2020, thus the stock status is determined on the basis of the 2019 assessment using the C-MSY model. The data poor stock assessment techniques indicated that F was above F_{MSY} (F/F_{MSY}=1.22) and B above B_{MSY} (B/B_{MSY}=1.14). Another alternative model using the Stock Reduction Analysis (SRA) techniques produced similar

[1] Andrade, HA (2016). Preliminary stock assessment of blue marlin (*Makaira nigricans*) caught in the Indian Ocean using a Bayesian state-space production model. IOTC-2016-WPB14-27.

	F_{MSY} (80% CI): 0.19 (0.14 - 0.24) B_{MSY} (1,000 t) (80% CI): 129 (81–206) F_{2017}/F_{MSY} (80% CI): 1.22 (1 – 2.22) B_{2017}/B_{MSY} (80% CI): 1.14 (0.63 – 1.39) B_{2017}/B_{1950} (80% CI): 0.57 (0.31 – 0.70)						results. The stock appears to show a continued increase catches which is a cause of concern, indicating that fishing mortality levels may be becoming too high. However both assessment models rely on catch data, which is considered to be highly uncertain. In addition, aspects of the biology, productivity and fisheries for this species combined with the data poor status on which to base a more formal assessment are also a cause for concern. On the weight-of-evidence available in 2019, the stock status cannot be assessed and is determined to be uncertain. ***Management advice***: Given the uncertainty in the catch estimates, the management advice is unchanged from 2018 (i.e., that catches should be below the current MSY level of 23,900 t). Click here for full stock status summary: Appendix X

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 18th Session of the Indian Ocean Tuna Commission's (IOTC) Working Party on Billfish (WPB) was held online using the Microsoft Teams platform from the 2nd to 3rd September 2020. A total of 55 participants (25 in 2019 and 20 in 2018) attended the Session. The list of participants is provided at Appendix I. The meeting was opened by the Chairperson, Dr Denham Parker (South Africa), who welcomed participants.

2. Adoption of the agenda and arrangements for the session

2. The WPB **ADOPTED** the Agenda provided in Appendix II. The documents presented to the WPB18 are listed in Appendix III.

3. The IOTC process: Outcomes, updates and progress

3.1 Outcomes of the 22nd Session of the Scientific Committee

3. The WPB **NOTED** paper IOTC–2020–WPB18–03 which describes the main outcomes of the 22nd Session of the Scientific Committee (SC22), specifically related to the work of the WPB:
   - ***Revision of catch levels of Marlins under Resolution 18/05***
     *The SC **RECALLED** that Resolution 18/05 On management measures for the conservation of billfish, striped marlin, black marlin, blue marlin and Indo-Pacific sailfish encourages CPCs to "…ensure that the overall catches, of the Indian Ocean Striped Marlin, Black Marlin, Blue Marlin and Indo Pacific Sailfish in any given year do not exceed either the MSY level or, in its absence, the lower limit of the MSY range of central values as estimated by the Scientific Committee…". Moreover, Resolution 18/05 also requires the SC to "…annually review the information provided and assess the effectiveness of the fisheries management measures reported by CPCs on striped marlin, black marlin, blue marlin and Indo-Pacific sailfish and, as appropriate, provide advice to the Commission".*
   - *SC **NOTED** that catches in recent years for Black Marlin, Blue Marlin, Striped Marlin and Indo-Pacific Sailfish have all exceeded the catch limits set by Resolution 18/05, and that current catch trends for all four species show no signs of decline in line with meeting the catch limits by 2020. As such, the SC urgently reiterates its **RECOMMENDATION** that measures are agreed to reduce current catches to the limits set for all four species covered by Resolution 18/05 as per the management advice given in the Executive Summaries*

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

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

3.2 Outcomes of the 23st Session of the Commission

6. The WPB **NOTED** paper IOTC–2020–WPB18–04 which provided the main outcomes of the 23rd Session of the Commission specifically related to the work of the WPB. The WPB further NOTED that the 24th Session of the Commission which was due to be held in June 2020 had been postponed until November and therefore no new outcomes or Resolutions are available since the 23rd session.

7. Participants to WPB18 were **ENCOURAGED** to familiarise themselves with the previously adopted Resolutions, especially those most relevant to 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 **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

9. The WPB **NOTED** paper IOTC–2019–WPB17–05 which aimed to encourage participants at the WPB17 to review some of the existing Conservation and Management Measures (CMM) relevant to billfish, noting the CMMs referred to in document IOTC–2019–WPB17–05, and - as necessary - to 1) provide recommendations to the Scientific Committee on whether modifications may be required and 2) recommend whether other CMMs may be required.

10. The WPB **NOTED** that the Commission **EXPRESSED** concern that catches for all billfish species (except striped marlin in 2017) in both 2016 and 2017 were higher than the limits outlined in Resolution 18/05.

3.4 Progress on the recommendations of WPB17 and SC22

11. The WPB **NOTED** paper IOTC–2020–WPB18–06 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.

12. The WPB **NOTED** that good progress had been made on these Recommendations, and that several of these, would be directly addressed by the assessment scientists when presenting the updated results for 2020.

13. The WPB participants were **ENCOURAGED** to review IOTC-2020-WPB18-06 during the meeting and report back on any progress in relation to requests or actions by CPCs that have not been captured by the report, and to note any pending actions for attention before the next meeting (WPB19).

14. The WPB **REQUESTED** that the IOTC Secretariat continue to annually prepare a paper on the progress of the recommendations arising from the previous WPB, incorporating the final recommendations adopted by the Scientific Committee and endorsed by the Commission.

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

4.1 Review of the statistical data available for billfish

15. The WPB **NOTED** paper IOTC–2020–WPB18–07 which summarises the standing of a range of data and statistics received by the IOTC Secretariat for billfish for the period 1950–2018, in accordance with IOTC Resolution 15/02 *Mandatory statistical requirements for IOTC Members and Cooperating non-Contracting Parties (CPC's)*. The paper also provided a summary of important reviews to the series of historical catches for billfish species, a range of fishery indicators (including catch-and-effort and average weight 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 measurement types used for each species. A summary of the supporting information for the WPB is provided in Appendix IV.

16. 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 (provided in Appendix V) and **REQUESTED** that the CPCs listed in the Appendix make efforts to remedy the identified data issues – with support from the IOTC Secretariat, when required – and report back to the WPB at its next meeting.

17. The WPB **NOTED** the persistent problems with the lack of data available for many species of billfish – in particular from gillnet fisheries catching the species close to coastal waters – and reiterated its **REQUEST** that CPCs fully comply with the data collection and reporting standards specified by Resolution 15/02 *Mandatory statistical reporting requirements for IOTC Contracting Parties and Cooperating Non-Contracting Parties (CPCs)*.

18. The WPB **RECALLED** that most billfish are non-target species and may be subject to widespread under-reporting, particularly in earlier years and also in the case of industrial fisheries where catches are considered to be relatively minor, **NOTING** that the overall trend of increasing catches of most billfish species may reflect improvements in reporting rather than an actual increase in retained catches.

19. The WPB **NOTED** that swordfish and Indo-Pacific sailfish account for over two thirds of total billfish catches in the last five years, with catches of the latter (Indo-Pacific sailfish) having exceeded 30,000 t in 2018 and mostly accounted for by the gillnet fishery of I.R. Iran, which contributed to the increase in the quality of data reporting for the species in recent years.

20. The WPB strongly **ENCOURAGED** CPCs to ensure catches of billfish are reported at species level, in accordance with Resolution 15/02, or alternatively provide support to the IOTC Secretariat in the process of breaking down catches reported for the generic *billfish* species aggregate into its species-specific components. This is

particularly important for the gillnet fishery of Pakistan (for which species-specific records are only available from 2018 onwards) and to a lesser extent for the gillnet fishery of I.R. Iran, **NOTING** that several other artisanal or semi-industrial fisheries also incur in the same reporting issue, particularly for what concerns marlin species (see Appendix V).

21. The WPB **NOTED** the abrupt decline in the effort exerted by the deep-freezing longline fishery of Japan in the North-West and South-West Indian Ocean swordfish assessment areas from the year 2010 onwards, and that – even though this decline can be well-explained as a consequence of the increased threat of piracy in areas around Somali waters – it seems instead to suggest a more radical change in behaviour for the fleet, that appears now to have left these historical fishing grounds with a level of effort that still have not recovered to the same levels recorded during pre-piracy years (as some other comparable fleets did, to some extent).

22. The WPB also **NOTED** that nominal swordfish CPUE series for the deep-freezing longline fisheries of Japan and Taiwan, as reported for the North-West Indian Ocean assessment area, show an increasing trend for the latter (from 0.2 to 0.7 fish / 1000 hooks between the late '60s and 2018) while the former shows a less clear trend.

23. Additionally, the WPB **ACKNOWLEDGED** that swordfish size-frequency data reported by the deep-freezing longline fishery of Japan before 2000 indicate a marked predominance of larger individuals, with an estimated average weight varying between 70 and 100 kg/fish, while the information available from 2001 onwards (almost exclusively collected by scientific observers) suggests that smaller individuals, with an estimated average weight varying between 50 and 70 kg/fish, are caught instead.

24. Furthermore, the WPB also **NOTED** that while size-frequency distributions of sampled swordfish recorded by scientific observers onboard Japanese and Taiwanese deep-freezing longliners are in accordance with each other, there appears to be a marked difference between the logbook data and the observer data reported by the Taiwanese longline fleet in recent years, which suggests that a potential measurement bias exists in a similar way to what has already been detected for tropical tuna species caught in this fishery.

25. For this reason the WPB **REQUESTED** an explorative analysis be carried out by the Secretariat in collaboration with all concerned CPCs, to identify the most accurate and indicative source of information (logbooks vs. observers) for this specific data set, and to better inform future stock assessments for the species.

26. **NOTING** that swordfish size-frequency data from the Spanish and French (La Réunion-based) swordfish longliners are quite comparable in terms of average weight of sampled individuals (between 50 and 60 kg/fish reported by both fleets from the year 2000 onwards) the WPB also **ACKNOWLEDGED** that data for the French component is a combination of observer-collected data and measurements taken at landing sites (one third and two third of the total sampled individuals, respectively, between the years 2016 and 2018).

27. The WPB also **NOTED** that frequently French swordfish-targeting longliners catch and eventually discard smaller, immature individuals and that due to a lack of observers onboard these are not recorded, therefore introducing a potential bias into the estimated size distribution and average weights calculated for the fishery.

28. In light of this, the WPB **THANKED** EU,France for their offer to provide the IOTC Secretariat with historical size-frequency data for the swordfish-targeting longline fishery of La Réunion, as collected by onboard observers from 2007 onwards, to complement the data currently available in the IOTC databases for this source.

29. The WPB also **NOTED** that previous EU,France data collection programmes, implementing self-sampling schemes onboard this same type of vessels, did not require crew members to measure retained individuals, and that when done this was exclusively for total weight estimation purposes and was not reported to IOTC.

30. At the same time the WPB **ACKNOWLEDGED** that Electronic Monitoring Systems were deployed onboard two longliners as part of a EU-funded pilot project, and that there is a potential for further size-measurement to be collected by these means in the future.

31. The WPB **NOTED** the updates to billfish species catch series introduced by the revision of historical catches for the gillnet fishery of Pakistan, endorsed by the 22nd session of the Scientific Committee in 2019, and how these affect the total catch level of all billfish species between the years of 1987 and 2018.

32. **NOTING** that billfish species have little to no commercial value in Pakistan, the WPB **ACKNOWLEDGED** that most of the billfish catches from the Pakistani gillnet fishery are exported to I.R. Iran (which could explain the difference in catch level magnitudes highlighted for the species between these two comparable fisheries) and that issues of double reporting might also exist, and require further documentation and analysis.

33. The WPB **NOTED** that the estimates of billfish catches from sports fishing in the region are quite substantial, **RECALLED** that a previous consultancy to improve reporting of data for the fishery was undertaken in recent years and that notwithstanding this, data reporting from sport fisheries in the region is still severely lacking.

34. The WPB also **ACKNOWLEDGED** that catches from sports fishing in Kenya have greatly declined since the onset of piracy in the Western Indian Ocean region, and that this was particularly true for swordfish, which was mainly caught during overnight expeditions.

35. The WPB **NOTED** that Resolution 18/05 "On management measures for the conservation of the billfishes: striped marlin, black marlin, blue marlin and Indo-Pacific sailfish" (superseding Resolution 15/05 "On conservation measures for striped marlin, black marlin and blue marlin") calls for CPCs to reduce yearly catches of all marlin species as well as Indo-Pacific sailfish, and to ensure that these do not exceed the species-specific, MSY-based catch limits indicated in paragraph 2 of the Resolution text.

36. The WPB **NOTED WITH CONCERN** that, based on currently available billfish catch data for 2018, two billfish species well exceeded their set limits, namely black marlin and Indo-Pacific sailfish, and that catch trends for both species appear to have been steadily increasing in recent years.

37. The WPB **RECALLED** that the increase in catch trends of billfish species primarily caught by coastal fisheries might in fact be a consequence of recent improvements in reporting rather than a reflection of actual increases in catches, and that for this reason it might be worth considering a revision to the estimated MSY-based catch limits as soon as new assessments are performed for the species of concern.

38. Also, the WPB **RECALLED** that reports of catches of aggregated billfish species are significant and common to several important fisheries, therefore **REQUESTED** that all concerned CPCs, in collaboration with the IOTC Secretariat, improve their own national data collection and reporting systems where required.

5. SWORDFISH

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

39. The WPB **NOTED** paper IOTC-2020-WPB18-09 on the Genetic Population Structure of Indian Ocean Swordfish Resolved through Analysis of Single Nucleotide Polymorphisms, including the following abstract provided by the authors:

> "*Swordfish, striped marlin and sailfish are the dominant billfish species caught in the Indian Ocean. These species are currently assessed and managed as single stocks. Evidence from population genetics studies to date has not provided evidence that a revision to this approach is warranted. Exploring and understanding the level of population heterogeneity is a priority for sustainable management of these fisheries. This paper presents results from a recent investigation of population structure of swordfish, striped marlin and sailfish using cutting-edge sequencing technology as part of a larger collaborative project "Population Structure of IOTC species and sharks of interest in the Indian Ocean (PSTBS-IO*)". – See document for full abstract.

40. The WPB **NOTED** genetic differences between Indian Ocean swordfish and the same species in the Atlantic and Pacific Ocean indicating stock separation between oceans.

41. The WPB **NOTED** a certain level of swordfish genetic differentiation between the northern and southern Indian Ocean that may indicate potential stock structure.

42. The WPB **NOTED** that swordfish genetic samples collected during the study showed a balanced sex ratio, therefore no sex-specific spatial separation or migratory behaviour was detected. The WPB **NOTED** that this is contradictory to previous literature which suggested a migration of female swordfish from tropical waters into cooler southern waters. The WPB **NOTED**, however, that the study was not aiming to address the question of migration, only genetic differentiation so it cannot provide concrete evidence on possible migration patterns of the species.

43. The WPB **NOTED** that what little is known about the migratory patterns of swordfish has come from tagging programmes in the equatorial and southern areas of the Indian Ocean and that swordfish are known to migrate long distances very fast. The WPB **NOTED** an upcoming project which aims to deploy satellite tags on swordfish around La Réunion and it is hoped that these results will be presented to the next WPB.

44. The WPB discussed how the potential North-South stock segregation observed might relate to the different CPUE indices determined for these regions highlighting the declining CPUE trend in the south which could point

to a local depletion in the potential southern stock. However, the WPB **NOTED** that further studies are necessary in order to fully identify the origin of observed genetic differences.

45. The WPB **NOTED** that while the SS3 assessment model did not address stock structure, the model is designed with a spatial split that is somewhat in line with the results shown from this stock structure study. The WPB **NOTED** the importance of determining the drivers of trends shown by the CPUE and expressed concern at the apparent difference in trends between the north and south.

46. The WPB **NOTED** that researchers in Pakistan have found that the majority of swordfish caught in that north-west region have been juveniles of less than 1 metre in length suggesting a potential size specific migration in the northern Indian Ocean or a potential spawning or nursery site.

47. The WPB **NOTED** paper IOTC-2020-WPB18-10 on the Microchemistry analyses of Indian Ocean swordfish, including the following abstract provided by the authors:

    "*Variation in otolith elemental fingerprints was investigated in the swordfish Xiphias gladius to complement genetic data obtained by next generation sequencing in the framework of a collaborative project on population stock structure of tuna, billfish and sharks of the Indian Ocean (PSTBS-IO). Swordfish specimens for this work were sampled in the southwest (SWI), west central (WCI) and southeast (SEI) regions of the Indian Ocean. A total of 70 otoliths (30 from SWI and 20 from each WCI and SEI) were selected and the elemental signatures of their cores were analysed by LA-ICP-MS to investigate potential differences in spawning origin among regions. Among the 15 chemical elements analysed, only Mg, P, Sr, Ba and B were above detection limits and significantly contributed to the variation in otolith core composition. Based on differences in these five elements, three groups of distinct multi-elemental signatures, denoting potentially discrete spawning origins (SpO), were identified using hierarchical clustering based on Euclidian distances*."
    – see document for full abstract

48. The WPB **NOTED** otolith microchemistry results also suggest some level of population structuring within the Indian Ocean for swordfish. The WPB further **NOTED** that combining all available data for swordfish such as size structure, reproduction patterns, genetic, and micro-chemical samples may provide important insights into understanding swordfish biology, in particular the location of spawning sites. The WPB **NOTED** the need for a good understanding of swordfish biology, ecology and stock structure for management purposes, highlighting the potential for the disproportionate depletion across the Indian Ocean if appropriate measures taking a holistic view of the situation are not implemented.

49. The WPB **AGREED** that further sampling efforts are necessary in order to improve knowledge on swordfish biology and stock structure.

50. The WPB **AGREED** that balanced sample design is essential to obtain robust results with samples taken during the same time period and for the same cohort of fish to avoid introducing further sources of uncertainty into results. The WPB also **NOTED** that it would be ideal to continue attempting to collect both genetic samples and otoliths from the same fish for complimentary genetic and microchemistry based analyses. The WPB **NOTED** challenges involved in properly coordinating the collection of samples spatially and temporally as well as the delicate nature of swordfish otoliths.

51. The WPB **ENCOURAGED** collaboration between scientists around the Indian Ocean to further this work and many members of the group came forward to offer their support in collecting necessary samples. The WPB **SUGGESTED** that the IOTC Secretariat could also provide support in coordinating the collection of further samples.

52. The WPB **NOTED** two relevant projects that have recently started and will be running for three years (BILLFISH-WIO and a PEW charitable trusts funded project) and **SUGGESTED** that it may be possible to integrate further sampling sites into these studies with help from the Secretariat and scientists from relevant CPCs.

53. The WPB **NOTED** that it is also important to look at what specimens research institutions already hold that could also be analysed in further studies. The WPB **NOTED** similar work being conducted in the Pacific and that it would be useful to apply lessons learnt from that to further work in the Indian Ocean**.**

5.2 *Review of new information on the status of swordfish*

- **Nominal and standardised CPUE indices**

54. The WPB **NOTED** paper IOTC-2020-WPB18-12 on Updated standardized catch rates of swordfish (*Xiphias gladius*) caught by the Spanish surface longline fleet in the Indian Ocean during the 2001-2018 period, including the following abstract provided by the authors:

“*Standardized catch rates of the Spanish surface longline fleet targeting swordfish are provided for the period 2001-2018. Generalized Linear Models (GLM) log-normal were used to update standardized catch rates in number of fish and in weight. Factors such as 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) were taken into account. The model explained 54% and 57% of CPUE variability in number and weight, respectively*.”

55. The WPB **NOTED** that the Spanish longline fishery expanded in the northwest area of the swordfish fishing grounds in some years but that the majority of the effort was exerted in the south and that the standardisation process was accounting for spatio-temporal changes through interaction terms.

56. The WPB **NOTED** paper IOTC-2020-WPB18-13 on Standardized catch per unit effort of Swordfish (*Xiphias gladius*) for the South African Pelagic Longline fishery, including the following abstract provided by the authors:

“*This paper presented a standardization of the CPUE of the South African swordfish directed longline fleet for the time series 2004-2019 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 (Fishing Tactic) with two levels, derived by clustering of PCA scores of the root-root transformed, normalized catch composition. Vessel was included as a random effect. The results indicate that the swordfish catch rates in the South African pelagic longline fishery have recently stabilized after an initial period of decline during 2004 to 2012*.”

57. The WPB **NOTED** that there were 17 longliners considered in the analysis and that the vessels may have strong differences in targeting and skipper ability depending on the company in relation to the existence of joint ventures with Japanese companies. The WPB **NOTED** the difficulty in assessing the efficiency of the different vessels and how it correlates with the different parameters of the model. Trials to include this factor have been carried out in the past.

58. The WPB **NOTED** that vessel was modelled as a random effect to account for the variability in fishing efficiency and the high turn-over in some vessels’ activities but that the use of a fixed effect could provide more information on the drivers of standardisation although previous analyses with vessel as fixed effect did not yield very different results.

59. The WPB **NOTED** that information used to delineate the admixture zone between the Indian and Atlantic Oceans where the swordfish longline occurs is described in a MSc. dissertation that can be found here: https://open.uct.ac.za/handle/11427/20432

60. The WPB **NOTED** that the nominal and standardized CPUE time series show opposite trends at the end of the time series and that this might be explained by the strong seasonal patterns in fishing due to some vessels operating during very short periods of time in the fishery.

61. The WPB **NOTED** that the use of influence plots to assess the effect of each individual covariate on the outputs would be useful to explain the variability and differences observed between nominal and standardised CPUE indices.

62. The WPB **NOTED** paper IOTC-2020-WPB18-14 on Japanese Longline CPUE Standardization (1979-2018) for Swordfish (*Xiphias gladius*) in the Indian Ocean using zero-inflated Bayesian hierarchical spatial model, including the following abstract provided by the authors:

“*This paper presented the standardization of the CPUE of Swordfish in the Indian Ocean by Japanese longliners using their logbook data for the period 1979-2018. The time series were divided the time-period into two periods, 1979-1993 and 1994-2018 for the analysis for four areas (NW, NE, SW, SE) of Indian Ocean because of apparent change of data-format of logbook around in 1994 and the change of fishing methods (e.g. materials of stem and branch lines and gear configuration such as number of hooks between floats)* *related to catchability: q not detailed in the logbook during the mid-1990s. A Bayesian hierarchical spatial model was used. No apparent trend in interannual variation of standardized CPUE was generally observed for each area. The uncertainties are much larger for the current spatial models due to consideration of spatial effect as compared to the past non-spatial models although the trend of point estimates is similar.* "

63. The WPB **ACKNOWLEDGED** the quality of this spatially explicit model to standardize CPUE and **NOTED** that the use of an auto-regressive process for year effect might however not be recommended for two main reasons: (i) the index will be used in the assessment model that also smooths the index, so it is harder to interpret assessment-model fits to an index that is already smoothed and (ii) the smoother will induce a positive partial correlation in the estimated index between adjacent years and tends to create hyperstable indices, and this estimation covariance is rarely passed to the stock assessment fitting the index. Therefore, the WPB **ENCOURAGED** the author to continue the work and consider the CPUE indices as independent among years.

64. The WPB also **NOTED** that the proportion of zero catch was very high (>90%) which could include cases where some vessels never caught swordfish at all and **SUGGESTED** the authors apply some filtering techniques on the data to limit this effect in future analyses. It was **ACKNOWLEDGED** that some vessels were targeting southern bluefin tuna during the summer season which can lead to this effect during this season.

65. The WPB **NOTED** paper IOTC-2020-WPB18-15 on CPUE standardization of swordfish (*Xiphias gladiu*s) caught by Taiwanese large-scale longline fishery in the Indian Ocean, including the following abstract provided by the authors:

"*This paper describes historical patterns of fishing operations and swordfish catches caught by Taiwanese large scale longline in the Indian Ocean. The cluster analysis was adopted to explore the targeting of fishing operations. In addition, the delta-gamma generalized linear models were selected to conduct the CPUE standardizations of swordfish caught by Taiwanese large scale longline fishery because large amounts of zero catches existed in the data sets, which resulted in skewed distributions for nominal CPUE. The results indicate that the effects of targeting (clusters) provided most significant contributions to the explanation of the variance of CPUE for the models with positive catches, while the catch probability might be mainly influenced by the latitude of fishing operations. The standardized CPUE series revealed different trends by areas but they obviously increased in recent years except for the Area SW*."

66. The WPB **NOTED** that the southwest area (SW) plays a major role in the assessment of the stock status as it is the most depleted area for swordfish according to the trends in standardised CPUE time series.

67. The WPB also **NOTED** the consistency between the Taiwanese and Japanese longline CPUE time series showing a strong decline in CPUE indices, especially in the SW Indian Ocean. The WPB **RECALLED** that there were concerns in the past assessment about how CPUEs observed in the southwest area reflect true stock abundance. At that time, the stock assessment was separated between areas and the stock status for the SW was pessimistic.

68. The WPB also **ACKNOWLEDGED** the possibility of disregarding certain years from the CPUE analyses in very specific cases, with respect to possibly disregarding the year 1992 in the Taiwanese CPUE as it was extremely high. However, in the present case, this option does not seem to be the right thing to do.

69. The WPB **NOTED** paper IOTC-2020-WPB18-19 on the Standardization of hooking rate for Swordfish (*Xiphias gladius*) caught around the Western Indian Ocean (Area 51) and Eastern Indian Ocean (Area 57) based on survey data collected through FSI surveys, including the following abstract provided by the authors:

"*This paper showed the analyses of swordfish (Xiphius gladius) catch in numbers and effort (hooks) data from 'Catch data sheet of FSI large longline fishing vessels operating in FAO area of 51 and 57 from 2007-2019'. Due to the large percentage of zero swordfish catch in the survey data, the hooking rate (HR) of sword, as the number of fish caught per 100 hooks, was standardized using GLM in R approach with a delta lognormal approximation. The presence/absence and abundance (CPUE) of swordfish were modeled separately. The variables used in the model take into account spatial and temporal variations as well as the abundance of coexisting species. In total, 3056 fishing operations were carried out between 2007 and 2019 of which 1274 and 1782 operations in the FAO area of 57 and 51 respectively. The main effects considered were temporal (year, quarters), spatial (longitude, latitude) and coexisting species i.e. hooking rate of skipjack tuna, marlins and skipjacks, besides remotely sensed variables chlorophyll a and sea surface temperature in the model. The results suggested that spatial (longitude & latitude), season (year and quarters) and soaking time significantly influenced the nominal hooking rate of swordfish whereas, coexisting species factors and remotely sensed* *variables particularly surface temperature and chlorophyll turned out to be insignificant and eventually dropped from the model. The high degree of temporal variability that is still shown in the standardized CPUE trends to suggest that the variables used in the GLM in R do not sufficiently account for all of the confounding factors, or the abundance may indeed be truly variable.*"

70. The WPB **NOTED** the quality of the document and **ACKNOWLEDGED** the survey index is not included in the assessment. However, the WPB **NOTED** it showed a different trend to other available indices in the northwest and northeast regions.

71. The WPB **NOTED** paper IOTC-2020-WPB18-20: Standardized CPUE of swordfish (*Xiphias gladius*) from Indonesian tuna longline fleets in the north-eastern Indian Ocean, including the following abstract provided by the authors:

"*This documents presented the data in recent years (2013-2017), from Indonesian fleets which are responsible for approximately 20% of the total catch of swordfish in the Indian Ocean (~8,000 MT), followed by Taiwan (17%), Sri Lanka (12%) and Spain (12%) (IOTC-WPB16, 2018). However, the total catch was revised to just under ~3,000 MT (9%) due to the refined methodology on catch estimation provided by the IOTC secretariat (IOTC-WPDCS14, 2018). In addition, the revision also aligned with the impact of Ministerial Regulation No. 56/2014 and No. 57/2014 about the moratorium on foreign fishing vessels and prohibition of transshipment at sea within Indonesia national jurisdiction, which resulted in a significant reduction of longline vessel operations from 584 in 2015 to 271 in 2016. This document objective was to investigate how the data-limited of swordfish fishery can construct a fairly robust relative abundance indices amid the "spatial gap" of the existing dataset for standardized CPUE in the eastern Indian Ocean (e.g., Japanese and Taiwanese longline dataset)*."

72. The WPB **NOTED** the quality of this approach and **ACKNOWLEDGED** the fact that the 2019 value was relatively high which suggested the data may be incomplete at the time of the analysis. The authors acknowledged that the data are complete, but further improvement in the data availability might impact the analyses.

73. The WPB **SUGGESTED** that the latitudinal and longitudinal effects should be differentiated as swordfish temporal distribution is more impacted by latitude than by longitude. It was suggested to use a 5x5° grid to analyse the catch rate data.

74. The WPB **NOTED** paper IOTC-2020-WPB18-11 on Update of the Swordfish Catch, Effort and Standardized CPUEs by the Portuguese Pelagic Longline Fleet Operating in the Indian Ocean, Between 1998 and 2018, including the following abstract provided by the authors:

"*This document presented the Portuguese pelagic longline fishery in the Indian Ocean started in the late 1990's, targeting mainly swordfish in the southwest. This document updates that analysis with regards to catch, effort and standardized CPUE trends for the Portuguese fleet operating in the Indian Ocean. Nominal annual CPUEs were calculated as kg/1000 hooks and were standardized with Generalized Linear Mixed Models (GLMMs) using year, quarter, area, ratios and area:season interactions. The vessel effects were used as random variables. The final standardized CPUE trends show a general decreasing trend in the series, with an intermediate peak in the 2008 period*."

75. The WPB **NOTED** the good level of overlap between the Portuguese longline CPUE where swordfish is the target species and the South African longline CPUE where swordfish is taken as bycatch and that the resultant CPUE trends from these fleets were relatively similar.

76. The WPB also **NOTED** some discrepancies between nominal and standardised CPUE. The WPB **SUGGESTED** the use of influence plots to determine which variables have changed and how they affect the standardisation process. The WPB **SUGGESTED** that the inclusion of one variable at a time in the model could be useful to understand the standardization process.

77. The WPB **REITERATED** the need to have abundance indices from every source of information. For instance, the EU,FRA longline fishery could be a valuable source of information for the southwest Indian Ocean and **REQUESTED** EU,FRA to work on a standardized CPUE. EU,FRA **ACKNOWLEDGED** this request and mentioned a contract was supposed to initiate this work this year but has been postponed to next year due to the health situation which prevented a contractor to work in La Réunion.

78. The WP **NOTED** that the fishing effort of the Portuguese longline fishery has been reported to the Secretariat in different effort units over the years (i.e. fishing days or number of hooks deployed) and **REQUESTED** EU,Portugal to assess the possibility of re-exporting the effort in number of hooks for the years 1998-2007 and 2013, **NOTING** also that the effort in number of operations is required to compute the observer coverage as per the IOTC Res. 11/04 and the IOTC form 3CE allows for an alternate effort to be reported.

- **Stock assessments**

Stock Synthesis

79. The WPB **NOTED** paper IOTC–2020–WPB18–16 which provided a stock assessment for swordfish in the Indian Ocean using Stock Synthesis 3, including the following abstract provided by the authors:

> "*This report presents a preliminary 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. The assessment model covers the period 1950–2018 and represents an update and revision of the 2017 assessment model with the inclusion of updated longline CPUE indices, and a revised fleet structure. A range of sensitivity models are also presented to explore the impact of key data sets and model assumptions.*" (see paper for full abstract)

80. The WPB **NOTED** the key assessment results for Stock Synthesis (SS3) as shown below (

81. **Table**;Figure 1) for which estimates from a model grid are reported.

82. The WPB **NOTED** that the assessment model is age / sex structured, spatially partitioned into 4 areas (NW, NE, SW, SE) to account for differential abundance and depletion levels among regions. Standardised CPUE series (as relative abundance indices) are available from the Japanese, Taiwanese, Portuguese, Spanish, South African, and Indonesia longline fleets. The WPB further **NOTED** that the model defined 15 fisheries, based on fleet and region.

83. The WPB **NOTED** the basic model defined for examining model performance and for assessing uncertainty arising from various assumption options. The WPB **NOTED** that the basic model included the Japanese (for 4 regions), Portuguese (SW), and South African (SW) CPUE indices. The WPB **NOTED** several sensitivity analyses conducted to evaluate the utility and impact of alternative CPUE options, including the Taiwanese, Spanish, Indonesian CPUE indices.

84. The WPB **NOTED** that there is a lack of large swordfish (> 200 cm) in the Taiwanese large-scale tuna longline size frequencies compared to other longline fleets (e.g. Japanese and EU fleets). The WPB **NOTED** that the quality of the historical Taiwanese longline size samples may have been very poor (the problem is more evident for tropical tuna species) and suggested that future assessment should investigate the utility of observer data. The WPB also suggested a sensitivity analysis to evaluate the potential bias in the Taiwanese size data by fixing the Taiwanese longline selectivity to the Japanese longline selectivity.

85. The WPB **NOTED** that a shared/common regional selectivity was assumed for each fleet, based on the similarity of commercial size frequency amongst regions. The WPB suggested this assumption could be relaxed to better account for the differences (albeit small) in the size structure between the North and South Indian Ocean. The WPB further **NOTED** that the fleet-specific selectivity can also be accommodated in an area-aggregated model using the fleet-as-area approach.

86. The WPB **NOTED** the dramatic drop on the right-hand limb of the Taiwanese selectivity and queried whether the selectivity is realistic. The WPB **NOTED** that the stationary selectivity assumption is rather simplistic, which aims to achieve a reasonable fit to the overall size frequency. The WPB further **NOTED** that due to the relatively small sample size and non-random sampling for many fleets/strata, the size composition is unlikely to accurately represent the complex geographical size distribution and selectivity pattern of the swordfish.

87. The WPB **NOTED** that the otolith-based growth estimate is preferred to the fin-ray based estimate for swordfish, as aging studies have confirmed that the latter is likely to underestimate longevity (thus overestimate growth). The WPB **NOTED** that the genetic difference between the Pacific and the Indian Ocean is unlikely to bias the growth estimate (the otolith-based estimates are based on Pacific samples). The WPB further **NOTED** that the final model options also included an alternative, fin-ray based growth estimated from samples in the Indian Ocean.

88. 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.

89. The WPB **NOTED** that the catchability is assumed to be constant in the assessment model. The WPB further **NOTED** the Japanese LL CPUE standardisation has accounted for the potential change of catchability by splitting the data series before and after 1994.

90. The WPB **NOTED** that a grid approach was used to quantify the uncertainties where the reference grid (gridIO4) is run over permutations of parameters and / or assumption options. Estimates of final stock status included both within and across model uncertainty.

91. The WPB **NOTED** that 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)[2], spine-based estimates form Indian Ocean by Wang et al. (2010))[3], two recruitment variability (sigma=0.2 or 0.4), and two assumed effective sample size for length composition data (capped at 20 or 5). The WPB **NOTED** that these options remain the same as the previous assessment.

92. The WPB **NOTED** that the estimated stock status appears to be more optimistic than the previous assessment. This is likely to be a result of the optimistic trend over the last few years in the CPUE indices for the northern regions, rather than the revisions to the model structure.

93. The WPB **NOTED** that the individual models in the grid were examined mainly through visual inspections whereas detailed diagnostics were performed to the basic model, including jittering analysis (for model convergency), likelihood profile, and retrospective analysis. The WPB further **NOTED** the Management Strategy Evaluation (MSE) of swordfish also involves building a large model grid and a structured approach to identify problematic models.

Table 2. Stock status summary table for the assessment final model grid (CI = confidence interval).

Catch (t) in 2018	30,847
Average catch (t) 2014–2018	30,632
MSY (1,000 t) (80% CI)	33 (27 –40)
F_{MSY}	0.23 (0.15–0.31)
SB_0 (1,000 t) (80% CI)	250 (210–295)
SB_{2018} (1,000 t) (80% CI)	102 (70–138)
SB_{MSY}	59 (41–77)
SB_{2018}/SB_0 (80% CI)	0.42 (0.36–0.47)
SB_{2018} / SSB_{MSY}	1.75 (1.28–2.35)
F_{2018} / F_{MSY}	0.60 (0.40–0.83)

[2] Farley, J., Clear, Naomi., Kolody, D., Krusic-Golub, K,. Eveson, Paige., Young, Jock. 2016. Determination of swordfish growth and maturity relevant to the southwest Pacific stock. R 2014/0821.

[3] Wang, S.P., Chi-Hong, L., Chiang, W.C. 2010. Age and growth analysis of swordfish (Xiphias gladius) in the Indian Ocean based on the specimens collected by Taiwanese observer program. Working paper IOTC-2010-WPB-08 (revision 1).

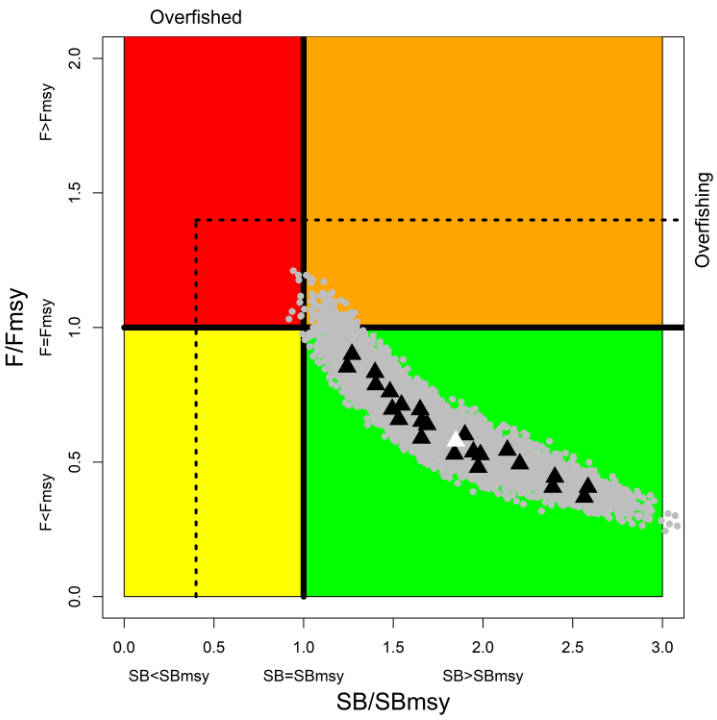


Figure 1. Stock synthesis grid-IO. Kobe stock status plot for the Indian Ocean for swordfish. Triangles represent Maximum Posterior Distribution estimates from individual models (white triangle represent the estimate from the basic model). Grey dots represent uncertainty from individual models. The dashed lines represent limit reference points for Indian Ocean swordfish (SB_{lim} = 0.4 SB_{MSY} and F_{lim} = 1.4 F_{MSY}).

A Stock-Production Model Incorporating Covariates (ASPIC)

94. The WPB **NOTED** paper IOTC–2020–WPB18–17 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 the substantial increase in catches in recent years but the stock assessment results were obviously influenced by the adoption of CPUE series. The assessment results obtained from Schaefer models were much pessimistic than those from Fox models. Based on the comparison of AIC values obtained in this study and the comments on the Schaefer model from previous studies, this study would recommend that the assessment results obtained from Fox models would be more appropriate to be considered evaluating the stock status of swordfish in the Indian Ocean. All scenarios of Fox models indicated that the current status of swordfish in the Indian Ocean may be not overfished and not subject to overfishing."

95. The WPB **NOTED** the key assessment results for the ASPIC model for swordfish as shown below (Table 3;Figure 2).

96. The WPB **THANKED** the author for providing an updated assessment for swordfish using the ASPIC model, and **ACKNOWLEDGED** the various sensitivity runs applied to quantify the influence of production function (Schaefer vs Fox) and various combinations of relative abundance (CPUE) indices had on the stock status.

97. The WPB **NOTED** that slightly different results of stock status were estimated between the assumptions of Schaefer (B_{MSY}/K=0.5) and Fox (B_{MSY}/K=0.368), where the results produced using the Fox model were marginally more optimistic. The WPB **NOTED** that a comparison of AIC tends to support the results of the Fox model.

98. The WPB **NOTED** that for most teleost species, maximum sustainable yield (MSY) is obtained at biomass levels substantially less than 50% under the assumption that the only density dependence in the population processes

is represented by Beverton–Holt recruitment (Maunder, 2003[4]; Wang et al., 2014[5]). Maunder (2003) and Wang et al. (2014) also found that the Schaefer production function is sensitive to biological processes and selectivity. The WPB **AGREED** that results obtained from Fox models would be more appropriate for evaluating the stock status of swordfish.

The WPB **NOTED** that the pessimistic results when including the TWN indices (scenarios STP and FTP) are largely driven by the substantial decrease in CPUE in the southwest Indian Ocean. The CPUE fits indicate the ASPIC model is unable to describe the full extent of the observed decline in the TWN southwest index and that the omission of this area-specific index would result in more optimistic results.

Table 3. Stock status summary table for the swordfish assessment (ASPIC) (CI = confidence interval)..

Catch (t) in 2018	30,847
Average catch (t) 2014–2018	30,632
MSY (1,000 t)	30
F_{MSY}	0.23
B_0(1,000 t)	354
B_{2018} (1,000 t)	170
B_{MSY}	130
B_{2018}/B_0 (95% CI)	0.48
B_{2018} / B_{MSY}	1.31
F_{2018} / F_{MSY}	0.77

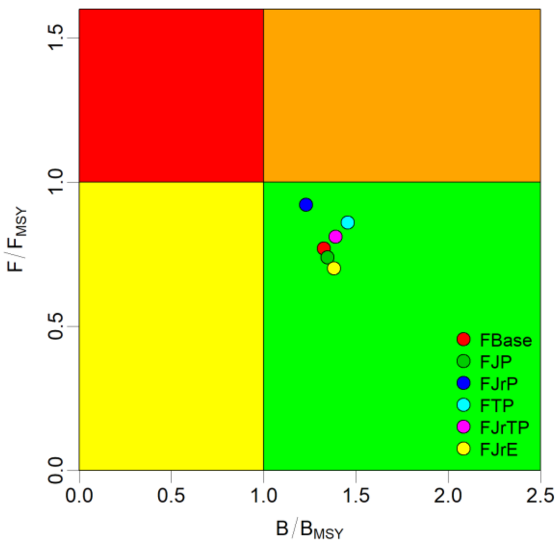


Figure 2**. ASPIC** model: Kobe stock status plot for the Indian Ocean for swordfish**.**

Bayesian Surplus Production Model (JABBA)

99. The WPB **NOTED** document IOTC–2020–WPB18–18 presenting the results of a Bayesian Surplus Production Model (JABBA), including the following abstract as provided by the author:

> *"Bayesian State-Space Surplus Production Models were fitted to Indian Ocean swordfish (Xiphias gladius) catch and CPUE data using the 'JABBA' R package. This document presents details on the model diagnostics*

[4] Maunder, M.N. (2003). Is it time to discard the Schaefer model from the stock assessment scientist's toolbox? Fish. Res. 61, 145–149

[5] Wang, S.P., Maunder, M.N., Aires-da-Silva, A. (2014). Selectivity's distortion of the production function and its influence on management advice from surplus production models. Fish. Res. 158: 181-193

and stock status estimates for a single 'Reference' model with a prior distribution for r of log(r) ~ N(log(0.42),0.4) and a fixed input value of BMSY/K = 0.4 (Pella-Tomlinson model type). Generally, the CPUE indices were consistent in showing a period of decline from early 1990s until mid-2000s, thereafter stabilizing and even increasing in the northeast and northwest areas. The model fit the CPUE data reasonably well (RMSE = 20.7%) with marginal data conflict between the CPUE indices in the last 5 years. The MSY estimate was 30,630 metric tons, which is very similar to the current catch (catch2018: 30,686 metric tons) and the current estimate of biomass as a proportion of "pristine" biomass was B2018/K = 0.47. Results from the Reference Model indicate that there is an 81% probability that the swordfish stock status currently falls within the green quadrant of the Kobe biplot (B2018>BMSY and F2018<FMSY). A retrospective analysis indicated a negligible retrospective pattern, and hindcasting cross-validation results suggested that the model has good prediction skill (MASE = 0.72). Various scenarios of CPUE input data were explored using a sensitivity analysis, and the trends in biomass and stock status estimates were fairly insensitive to variations in CPUE input data. Notably, the inclusion of all of the available CPUE indices produced estimates that were the most similar to the Reference Model, while the inclusion of the Indonesian CPUE index produced the most pessimistic results".

100. The WPB **NOTED** the key assessment results for the Bayesian Surplus Production Model, as shown below (Table 4; Figure 3)

101. The WPB **THANKED** the author for providing the JABBA assessment, and **NOTED** the importance of considering results from multiple model structures, ranging from simple to complex, to better understand swordfish stock status.

102. The WPB **NOTED** usefulness of providing sensitivity tests to the prior assumptions for key parameters such as intrinsic rate of population increase, "r", and **NOTED** that a scenario in which the variance of the "r" prior was inflated (mean = 0.42, CV = 1) was run in JABBA upon request of the WPB, so as to better understand the influence of this parameter on the assessment results. The results of this additional scenario were similar to that of the base case, suggesting that the parameter "r" is largely informed by the catch and effort data as opposed the predetermined prior distribution.

103. The WPB **NOTED** that JABBA-Select, which is an extension of the original JABBA that incorporates life history parameters and fishing selectivity and distinguishes between exploitable biomass (used to fit indices given fishery selectivity) and spawning biomass (used to predict surplus production). The WPB **SUGGESTED** that including JABBA-Select in future assessments would allow for a direct comparison with age-structured production models (ASPMs) and could therefore be an intermediate model between a fully age-aggregated model such as ASPIC and a fully comprehensive model such as SS3. The implementation of JABBA-Select requires biological information and fleet-specific selectivity, in addition to the conventional catch and effort data.

104. The WPB **NOTED** that a careful consideration is needed when comparing results from models with different "production" functions, which ultimately drive MSY-related quantities. The WPB **SUGGESTED** that when comparing results from various models, depletion (B/K or B/B0) estimates and trends in absolute biomass should be considered in addition to MSY-related estimates (B-ratio and F-ratio), to provide a fair comparison.

Table 4. Stock status summary table for the swordfish assessment (JABBA) (CI = confidence interval).

Catch (t) in 2018	30,847
Average catch (t) 2014–2018	30,632
MSY (1,000 t) (95% CI)	31 (27 –35)
F_{MSY}	0.30 (0.19–0.48)

B_0 (1,000 t) (95% CI)	255 (161–399)
B_{2018} (1,000 t) (95% CI)	120
B_{MSY}	102 (65–160)
B_{2018}/B_0 (95% CI)	0.47 (0.36–0.59)
B_{2018} / B_{MSY}	1.16 (0.89–1.45)
F_{2018} / F_{MSY}	0.87 (0.60–1.20)

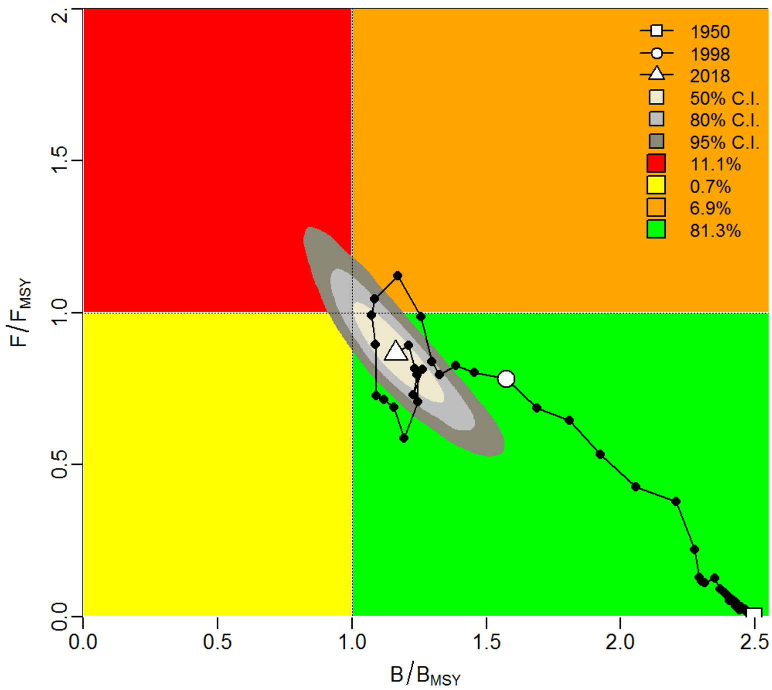


Figure 3. JABBA model: Kobe stock status plot for the Indian Ocean for swordfish. The black line traces the trajectory of the stock over time while the white empty circles show the uncertainty in the last year.

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

105. 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.

106. The WPB **NOTED** the selection of SS3 model assemble gridIO4 as the base case as that it captures most of the uncertainty identified in the assessment. This model grid estimated MSY at 33,000 t which is above the current catch level (30,847 t).

107. The WPB **NOTED** the importance to collect data about movements and migrations which would be critical to inform spatially explicit models such as SS3.

108. The WPB **NOTED** the projection stock status matrix showing that with current catch levels, the stock will not be overfished nor subject to overfishing by 2029 and **ACKNOWLEDGED** that Under the current levels of catches, the stock biomass is projected to remain relatively stable, with a high probability of maintaining at or above the SBMSY for the longer term. An increase of 40% or more from current catch levels will likely result in the biomass being dropping below the SBMSY level for the longer term (with approximately 50% probability).

109. The WPB **REQUESTED** that the IOTC Secretariat update the draft stock status summary for swordfish with the latest 2018 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. PROGRESS ON THE SWORDFISH MANAGEMENT STRATEGY EVALUATION

110. The WPB **NOTED** that limited progress had been made on the Swordfish MSE. The secretariat **CLARIFIED** that both the MSE Task Force meeting (a technical expert group of the WPM) and the TCMP meetings in 2020 had been cancelled due to the covid pandemic. In addition, the modeller working on the MSE was currently not available. As such, very little progress had been made since the 2019 SC meeting. The work is expected to resume in late 2020, early 2021.

7. WPB PROGRAM OF WORK

7.1 Revision of the WPB Program of work (2021–2025)

111. The WPB **NOTED** paper IOTC–2020–WPB18–08 which provided an opportunity to consider and revise the WPB Program of Work (2021–2025), by taking into account the specific requests of the Commission, Scientific Committee, and the resources available to the IOTC Secretariat and CPCs.

112. 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).

113. The WPB **RECOMMENDED** that the SC consider and endorse the WPB Program of Work (2021–2025), as provided at Appendix XI.

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

114. The WPB **NOTED** that an Invited Expert may be required to support the next WPB meeting and **AGREED** that the decision for the selection of the candidate for the WPB19 be considered inter-sessionally. Once decided, the selection will be performed by advertising the position through the IOTC science list (as a priority channel) and finalized after receipt and assessment of résumés and supporting information for potential candidates, according to the deadlines set forth by the rules and procedures of the Commission.

115. 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 2021 by an Invited Expert:

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

8. OTHER BUSINESS

8.1 Date and place of the 19th and 20th Sessions of the Working Party on Billfish

116. The WPB **NOTED** that the global Covid-19 pandemic has resulted in international travel being almost impossible and with no clear end to the pandemic in sight, it was impossible to finalise arrangements for the meeting in 2021. The Secretariat will continue to liaise with CPCs to determine their interest in hosting these meetings in the future when this once again becomes feasible. The WPB **RECOMMENDED** the SC consider early September 2021 as a preferred time period to hold the WPB19 in 2021. As usual it was also AGREED that this meeting should continue to be held back-to-back with the WPEB, with the WPEB taking place before the WPB in 2021.

8.2 Review of the draft, and adoption of the Report of the 18thSession of the Working Party on Billfish

117. The WPB **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPB18, 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 2020 (Fig. 4):

- 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

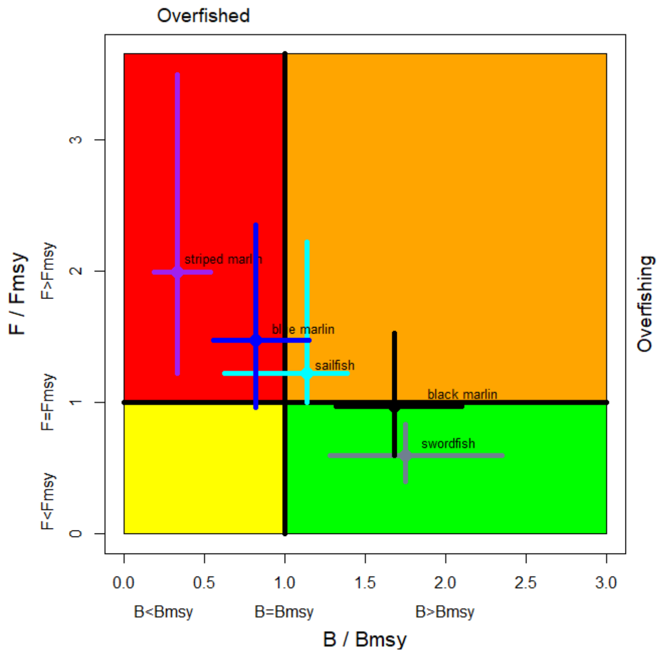


Fig. 4. Combined Kobe plot for swordfish (grey), indo-pacific sailfish (cyan), black marlin (black), blue marlin (blue) and striped marlin (purple) showing the 2017, 2018, 2019, and 2020 estimates of current stock size (SB or B, species assessment dependent) and current fishing mortality (F) in relation to optimal spawning stock size and optimal fishing mortality. Cross bars illustrate the range of uncertainty from the model runs.

118. The report of the 18th Session of the Working Party on Billfish (IOTC–2020–WPB18–R) was **ADOPTED** by correspondence.

APPENDIX I - LIST OF PARTICIPANTS

CHAIRPERSON
Dr. Denham **Parker**
DEFF
DenhamP@daff.gov.za

VICE-CHAIRPERSON
Dr. Jie **Cao**
North Carolina State University
jcao22@ncsu.edu

PARTICIPANTS
Mr. Mohamed **Ahusan**
Maldives Marine Research
Institutemohamed.ahusan@mmri.gov.mv

Mrs. Kishara **Bandaranayake**
National Aquatic Resources Research and Development Agency (NARA)
kisharabandaranayake@gmail.com

Dr. Sylvain **Bonhommeau**
IFREMER
sylvain.bonhommeau@ifremer.fr

Ms. Naomi **Clear**
CSIRO Oceans and Atmosphere
Naomi.Clear@csiro.au

Dr. Rui **Coelho**
Portuguese Institute for the Ocean and Atmosphere (IPMA)
rpcoelho@ipma.pt

Dr. Charlene **da Silva**
DEFF
CharleneD@DAFF.gov.za

Dr. Audrey **Darnaude**
CNRS
audrey.darnaude@cnrs.fr

Dr. Campbell **Davies**
CSIRO
campbell.davies@csiro.au

Mr. Thomas **Evans**
Key Traceability
t.evans@keytraceability.com

Ms. Paige **Eveson**
CSIRO Oceans and Atmosphere
Paige.Eveson@csiro.au

Mr. Jose Ramón **Fernández Costa**
Spanish Oceanographic Institute
jose.costa@ieo.es

Mr. Zhe **Geng**
Shanghai Ocean University
zhegeng1993@foxmail.com

Ms. Marta **González Carballo**
Instituto Español de Oceanografía
marta.gonzalez@ieo.es

Dr. Peter **Grewe**
CSIRO Oceans & Atmosphere
peter.grewe@csiro.au

Mr. Nicolas **Guillon**
CITEB
nicolas.guillon@citeb.re

Mr. Deepak **Gulati**
Fishery Survey of India
deegulatiin@yahoo.com

Ms. Sarah **Hashim**
Maldives Marine Research Institute
sarah.hashim@mmri.gov.mv

Dr. Pradeep **HD**
Fishery Survey of India
hdpradeep@gmail.com

Mrs. Sandamali **Herath**
Department of Fisheries & Aquatic Resources
hlsherath@gmail.com

Mr. Sichon **Hoimuk**
Department of Fisheries, Thailand
s.hoimuk@gmail.com

Dr. Glen **Holmes**
The Pew Charitable Trusts
gholmes@pewtrusts.org

Dr. Hirotaka **Ijima**
Japan Fisheries Research and Education Agency
ijima@affrc.go.jp

Dr. Nelly Isigi **Kadagi**
WWF-USA/African Billfish Foundation
nellykadagi@gmail.com

Dr. Maria Jose **Juan Jorda**
AZTI
mjuanjorda@gmail.com

Dr. Sven **Kerwath**
DEFF
SvenK@DAFF.gov.za

Mr. Muhammad Moazzam **Khan**
WWF-Pakistan
mmoazzamkhan@gmail.com

Dr. Toshihide **Kitakado**
Tokyo University of Marine Science and Technology
kitakado@kaiyodai.ac.jp

Ms. Chih-yuh **Lin**
National Taiwan Ocean University
hannah50358@gmail.com

Ms. Yi-Sin **Lu**
National Taiwan Ocean University
z5834211@gmail.com

Mr. Ariyarathna **Manage**
Department of Fisheries Sri Lanka
mma_fi@yahoo.com

Dr. Francis **Marsac**
IRD
francis.marsac@ird.fr

Mr. Stephen **Ndegwa**
Kenya Fisheries Service
ndegwafish@yahoo.com

Mr. Collins Kambu **Ndoro**
State Department for Fisheries, Aquaculture and The Blue Economy.
ndoroka@hotmail.com

Dr. Anne-Elise **Nieblas**
FAO
anne.nieblas@fao.org

Mr. Dinesh **Peiris**
Department of Fisheries and Aquatic Resources
dineshdfar@gmail.com

Mr. Fariborz **Rajaei**
Iran Fisheries Org.
rajaef@gmail.com

Mr. Hantra Julien **Rakotomanga**
Centre de Surveillance des Pêches
csp-soc@madagascar-scs-peche.mg

Dr. Sethuraman **Ramachandran**
Fishery Survey of India
marineramc1974@gmail.com

Dr. Evgeny **Romanov**
CAP RUN – CITEB
evgeny.romanov@citeb.re

Dr. Philippe **Sabarros**
IRD
philippe.sabarros@ird.fr

Mr. Bram **Setyadji**
RITF
bram.setyadji@gmail.com

Dr. Kenji **Taki**
National Research Institute of Far Seas Fisheries
takisan@affrc.go.jp

Dr. Nina **Wambiji**
Kenya Marine and Fisheries Research Institute (KMFRI)
nwambiji@gmail.com

Dr. Sammy **Wambua**
Pwani University
sammywambua@gmail.com

Dr. Sheng-Ping **Wang**
National Taiwan Ocean University
wsp@mail.ntou.edu.tw

Dr. Xuefang **Wang**
Shanghai ocean university
xfwang@shou.edu.cn

Dr. Jintao **Wang**
Shanghai Ocean University
jtwang@shou.edu.cn

Ms. Yang **Wang**
Shanghai Ocean University
shouwyh@163.com

Dr. Ashley **Williams**
CSIRO
ashley.williams@csiro.au

Mr. Arief **Wujdi**
Research institute for tuna fisheries
arief_wujdi@yahoo.com

Ms. Guo **Yingcong**
Shanghai Ocean University
cong1227@126.com

Dr. Cheng **Zhou**
Shanghai Ocean University
c-zhou@shou.edu.cn

Pr. Jiangfeng **Zhu**
Shanghai Ocean University
jfzhu@shou.edu.cn

IOTC SECRETARIAT

Dr Paul **de Bruyn**
Paul.Debruyn@fao.org

Mr Fabio **Fiorellato**
Fabio.fiorellato@fao.org

Mr Dan **Fu**
Dan.Fu.@fao.org

Dr Emmanuel **Chassot**
Emmanual.chassot@fao.org

Ms Lauren **Nelson**
Lauren.Nelson@fao.org

APPENDIX II - AGENDA FOR THE 18TH WORKING PARTY ON BILLFISH

Date: 2–4 September 2020

Location: Online

Time: 12:00 – 16:00 daily (Seychelles time)

Chair: Dr Denham Parker (South Africa); **Vice-Chair**: Dr Jie Cao (China)

1. OPENING OF THE MEETING

2. ADOPTION OF THE AGENDA AND ARRANGEMENTS FOR THE SESSION

3. THE IOTC PROCESS: OUTCOMES, UPDATES AND PROGRESS

- Outcomes of the 22nd Session of the Scientific Committee
- Progress on the recommendations of WPB17

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

- Review of the statistical data available for billfish with a focus on swordfish
- Review new information on fisheries and associated environmental data
- New information on sport fisheries

5. SWORDFISH

- Review of new information on swordfish biology, stock structure, fisheries and associated environmental data
- Review of new information on the status of swordfish
  - Nominal and standardised CPUE indices
  - Stock assessments
  - Selection of Stock Status indicators for swordfish
  - Development of management advice for swordfish and update of Executive Summaries for the consideration of the Scientific Committee, including discussion on current catch limits as per standing IOTC Resolutions

6. PROGRESS ON THE SWORDFISH MANAGEMENT STRATEGY EVALUATION

7. WPB PROGRAM OF WORK

- Revision of the WPB Program of Work (2021–2025)
- Development of priorities for an Invited Expert at the next WPB meeting

8. OTHER BUSINESS

- Date and place of the 19th and 20th Sessions of the Working Party on Billfish
- Review of the draft, and adoption of the Report of the 18th Session of the Working Party on Billfish

APPENDIX III - LIST OF DOCUMENTS FOR THE 18TH WORKING PARTY ON BILLFISH

Last updated: 17th October 2020

Document	Title
IOTC-2020-WPB18-01a	Agenda of the 18th Working Party on Billfish
IOTC-2020-WPB18-01b	Annotated agenda of the 18th Working Party on Billfish
IOTC-2020-WPB18-02	List of documents of the 18th Working Party on Billfish
IOTC-2020-WPB18-03	Outcomes of the 22nd Session of the Scientific Committee (IOTC Secretariat)
IOTC-2020-WPB18-04	Outcomes of the 23rd Session of the Commission (IOTC Secretariat)
IOTC-2020-WPB18-05	Review of Conservation and Management Measures relevant to billfish (IOTC Secretariat)
IOTC-2020-WPB18-06	Progress made on the recommendations and requests of WPB17 and SC22 (IOTC Secretariat)
IOTC-2020-WPB18-07	Review of the statistical data and fishery trends for billfish species (IOTC Secretariat)
IOTC-2020-WPB18-08	Revision of the WPB Program of Work (2020-2024) (IOTC Secretariat)
IOTC-2020-WPB18-09	Genetic population structure of sailfish, striped marlin, and swordfish in the Indian Ocean from the PSTBS-IO Project (Grewe P, Feutry P, Foster S, Aulich J, Lansdell M, Cooper S, Clear N, Eveson P, Darnaude AM, Nikolic N, Marsac F, Farley J, Davies C)
IOTC-2020-WPB18-10	Microchemistry analyses of Indian Ocean swordfish (Darnaude AM, Labonne M, Petit C and Marsac F)
IOTC-2020-WPB18-11	Update of the Swordfish Catch, Effort and Standardized CPUEs by the Portuguese Pelagic Longline Fleet Operating in the Indian Ocean, Between 1998 and 2018. (Coelho R and Rosa D)
IOTC-2020-WPB18-12	Updated standardized catch rates of swordfish (*Xiphias gladius*) caught by the Spanish surface longline fleet in the Indian Ocean during the 2001-2018 period (Ramos-Cartelle A, Fernández-Costa J, and Mejuto J)
IOTC-2020-WPB18-13	Standardized catch per unit effort of Swordfish (*Xiphias gladius*) for the South African Pelagic Longline fishery (Parker D)
IOTC-2020-WPB18-14	Japanese Longline CPUE Standardization (1979-2018) for Swordfish (*Xiphias gladius*) in the Indian Ocean using zero-inflated Bayesian hierarchical spatial model (Taki K, Ijima H, and Semba Y)
IOTC-2020-WPB18-15	CPUE standardization of swordfish (*Xiphias gladius*) caught by Taiwanese large scale longline fishery in the Indian Ocean (Wang S-P)
IOTC-2020-WPB18-16	Preliminary Indian Ocean Swordfish Stock Assessment 1950-2018 (Stock Synthesis) (Fu D)
IOTC-2020-WPB18-17	Stock assessment of swordfish (*Xiphias gladius*) in the Indian Ocean using A Stock-Production Model Incorporating Covariates (ASPIC) (Wang S-P)
IOTC-2020-WPB18-18	Preliminary stock assessment of the Indian Ocean Swordfish (*Xiphias gladius*) using the Bayesian state-space surplus production model JABBA (Parker D)
IOTC-2020-WPB18-19	Standardization of hooking rate for Swordfish (*Xiphias gladius*) caught around the Western Indian Ocean (Area 51) and Eastern Indian Ocean (Area 57) based on survey data collected through FSI surveys (Gulati S)
IOTC-2020-WPB18-20	Standardized CPUE of swordfish (*Xiphias gladius*) from Indonesian tuna longline fleets in the north-eastern Indian Ocean (Setyadji B, Parker D, Wang S-P, Fahmi Z).
Information papers	
IOTC-2020-WPB18-INF01	Status of fisheries of billfish in Pakistan with special reference to swordfish (*Xiphias gladius*) (Moazzam M)
IOTC-2020-WPB18-INF02	Exploratory Fishery Survey on Billfishes with special reference to Swordfish (*Xiphius gladius*) along west and east coast of India (Ramachandran S)

APPENDIX IVA - MAIN STATISTICS OF BILLFISH

(*Extract from IOTC–2020–WPB18–07*)

Fisheries and catch trends for billfish species

- Main species: Swordfish and Indo-Pacific sailfish account for around two thirds of total catches of billfish species in recent years, followed by black marlin, blue marlin and striped marlin (**Fig. A1d**).

  The importance of individual species – as a proportion of the total catches of billfish – has changed over time, mostly as a result of changes to the number of longline vessels active in the Indian Ocean (**Fig. A1c**). Catches of swordfish in particular increased during the '90s 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 '90s to around 50% by the early '00s. By the late '00s catches of swordfish declined to around a third of total billfish catches, largely as a result of the decline in the number of longline vessels operated by Taiwan,China. However since 2012 catches of swordfish have shown an increasing trend, which may be partly due to improvements in the estimation of catch-by-species reported by Taiwan,China.

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

- Main fisheries: Up to the mid '90s longline vessels accounted for over 90% of the total billfish (largely as non-targeted catch); in the last 20 years the proportion has fallen from about 70% in the early 2000s to less than 30% in 2018, 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. A2b-c**).

- Main fleets (i.e., highest catches in recent years):
  In recent years four fleets (I.R. Iran, India, Sri Lanka, and Taiwan,China) have reported more than 65% of the total catches of billfish species from all IOTC fleets combined (**Fig. A2a**).

- 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. A1a-b**) at between 5%–7% of the total catch of IOTC species.

  Total catches of billfish species have generally increased in line with other species groups under the mandate of IOTC, increasing from around 25,000 t in the early '90s to nearly 75,000 t in the late '90s. Since then, average catches per year have remained relatively stable at between 70,000 t and 75,000 t. However, since 2015 catches over 90,000 t have been reported, with the largest increases reported by Sri Lanka and India (**Fig. A2a**).

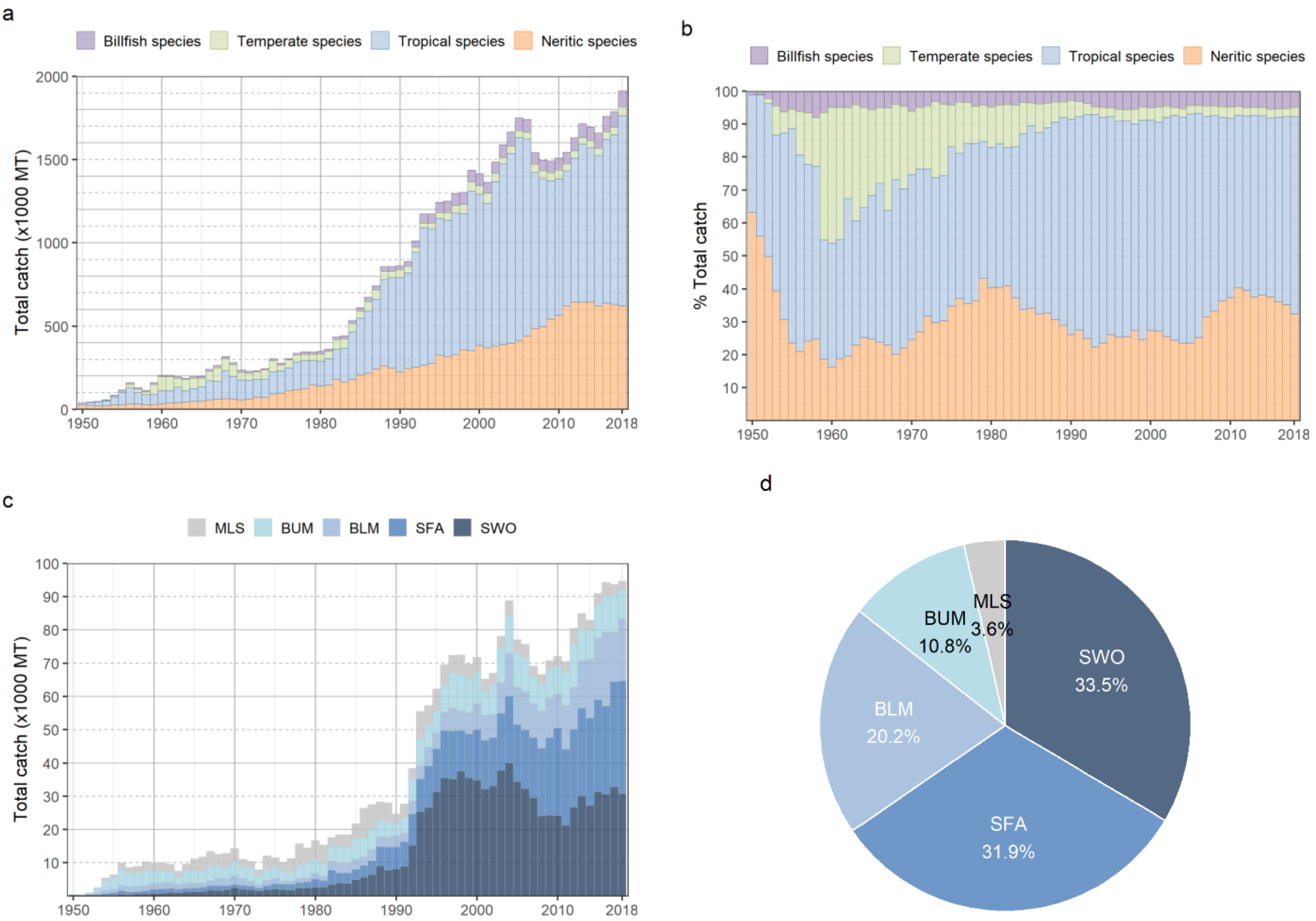


Fig. A1. Top: Contribution of billfish to the total catches of IOTC species in the Indian Ocean over the period 1950-2018. (a) Annual nominal catches (t) by group of species; (b) Percentage of the annual nominal catches by group of species. Bottom: Contribution of each billfish species to the total combined catches of billfish; (c) Annual nominal catches (t) by species, 1950-2018; (d) Percentage of the average annual catch by species, 2014-2018

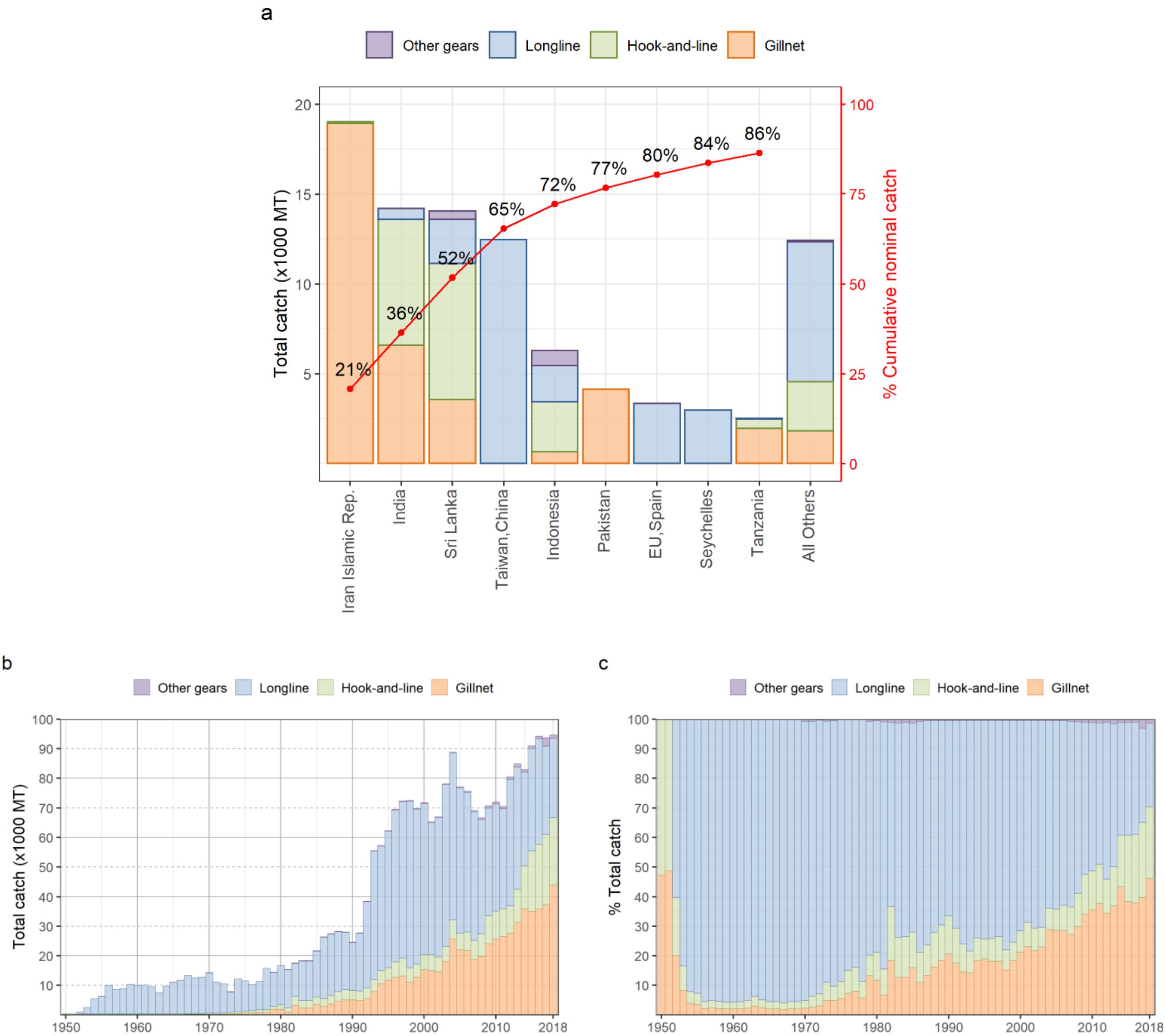


Fig. A2. (a) Average nominal catches (t) of billfish species over the period 2014–2018, by gear group and CPC ordered according to the importance of catches. The red solid line indicates the cumulative percentage of the total combined catches of the species for the CPCs concerned; (b) Annual time series of nominal catches (t) of billfish species by gear group recorded in the IOTC database, 1950–2018; (c) Percentage share of all billfish species catches, by gear, 1950-2018

APPENDIX IVB - MAIN STATISTICS OF SWORDFISH

(*Extract from IOTC–2020–WPB18–07*)

Fisheries and main catch trends

- Main fishing gear (2014–18): Longline catches[6] currently comprise around 46% of total swordfish catches in the Indian Ocean (**Table A1; Fig. A3**).
- Main fleets (and primary gear associated with catches): percentage of total catches (2014–18): Over 50% of swordfish catches are accounted for by three fleets: Taiwan,China (longline): 22%; Sri Lanka (longline-gillnet): 21%; EU,Spain (swordfish targeted longline): 10% (**Fig. A4**).
- Main fishing areas: Primary: Western Indian Ocean, in waters off Somalia, and the southwest Indian Ocean. During 2009 – 2011, the fishery moved eastwards due to piracy, a decrease in fish abundance, or a combination of both. Secondary: Waters off Sri Lanka, western Australia and Indonesia.
- Retained catch trends:
  - Before the '90s, 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 9,000 t in 1991 to 38,000 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, EU,UK and other fleets operating under various flags[7]).
  - Since the mid '00s 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, possibly as a consequence of the improvements in security in the area off Somalia.
- Discard levels: Low, although estimates of discards are unknown for most industrial fisheries, mainly longliners. Discards may also occur in the driftnet fishery of I.R. Iran, as this species has no commercial value in this country.

Changes to the catch series

Following issues with the reliability of catch estimates of Indonesia's fresh longline fleet, the IOTC Secretariat provided the WPB-16 meeting with an alternative catch series based on a new estimation methodology developed in collaboration with Indonesia[8]. The revised catch series mostly affects catches of swordfish, striped marlin, and blue marlin estimated by the IOTC Secretariat for Indonesia.

Estimates for all three billfish species have been reduced significantly for Indonesia's fresh longline fleet in recent years, while total catches across all fleets have also been revised downwards by as much as 30% for each species. Further details on the estimation methodology can be found in paper IOTC-2018-WPB16-22, but in the case of swordfish catches have been revised down in recent years from over 50,000 t to less than 35,000 t directly as a result of the revision to Indonesia's catches.

The government of Pakistan provided the IOTC Secretariat with revised catch series for their gillnet fleet from 1987 onwards, that were endorsed at the 22nd session of the IOTC Scientific Committee in 2019. These revisions, and the species composition estimates performed by the IOTC Secretariat for the reported aggregated billfish species, introduce marked changes in swordfish catches compared to what available at the previous WPB. In particular, swordfish captures appear now to be basically non-existent for the fleet, as opposed to the average 450 t /year reported by Pakistan prior to the revision.

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

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

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

TABLE A1. Best scientific estimates of the annual nominal catches (t) of swordfish by fishery for the period 1950–2018. Colour codes (yellow = lower, green = higher) describe the intensity of captures by fishery across decades (left) and years (right). ELL = swordfish targeted longline; LL = Longline; OT = Other gears, i.e. longline-gillnet, handline, gillnet, gillnet-longline, coastal longline, troll line, sport fishing, and all other gears. Data as of May 2020

Fishery	By decade (average)						By year (last ten years)									
	1950s	1960s	1970s	1980s	1990s	2000s	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
ELL	0	0	0	9	1,841	9,736	7,637	9,031	6,835	7,643	7,876	7,420	6,618	6,257	6,153	4,643
LL	260	1,301	1,905	4,128	19,682	14,940	8,459	6,633	4,875	9,123	8,095	6,677	8,457	9,007	8,039	7,980
OT	37	39	201	956	4,485	7,629	8,241	8,568	9,610	10,019	14,120	13,173	16,287	15,478	18,747	18,223
Total	**297**	**1,340**	**2,106**	**5,093**	**26,008**	**32,305**	**24,338**	**24,232**	**21,320**	**26,785**	**30,091**	**27,270**	**31,362**	**30,743**	**32,939**	**30,847**

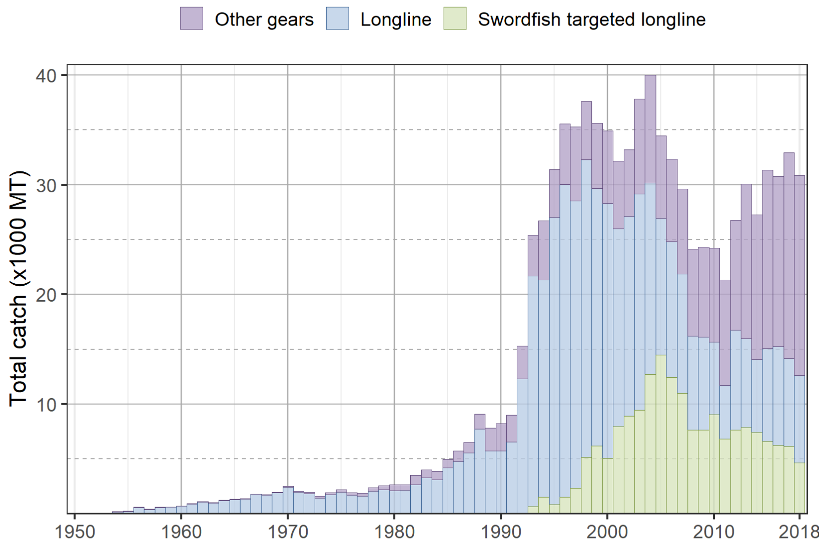


Fig. A3. Annual time series of nominal catches (t) of swordfish by gear group recorded in the IOTC database, 1950–2018. Other gears include longline-gillnet, handline, gillnet, coastal longline, troll line, sport fishing, and all other gears

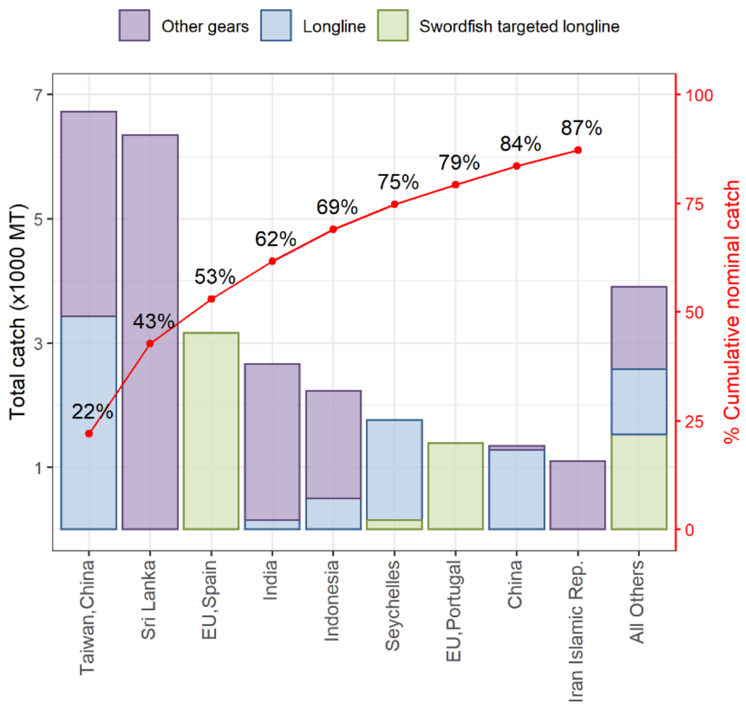


Fig. A4. Average nominal catches (t) of swordfish over the period 2014–2018, by gear group and CPC ordered according to the importance of catches. The red solid line indicates the cumulative percentage of the total combined catches of the species for the CPCs concerned

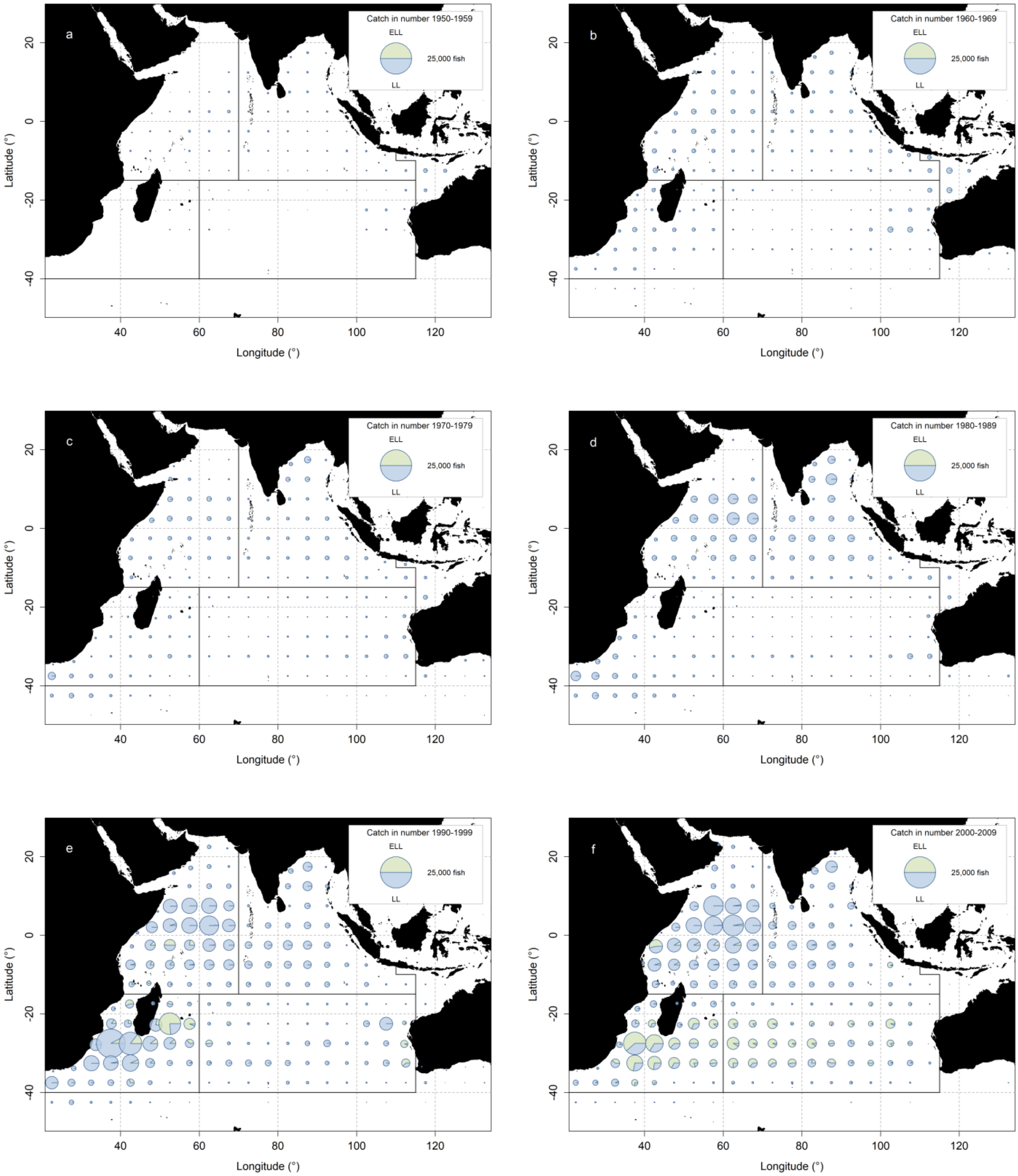


Fig. A5. Mean annual time-area catches of swordfish (in number of fish) as reported by the longline fisheries targeting swordfish (ELL) and other longline fisheries (LL) in the period 1950-2009, by decade and type of gear. Black solid lines represent the areas used for the assessments of swordfish. Does not include catches from fleets not reporting catch-and-effort data

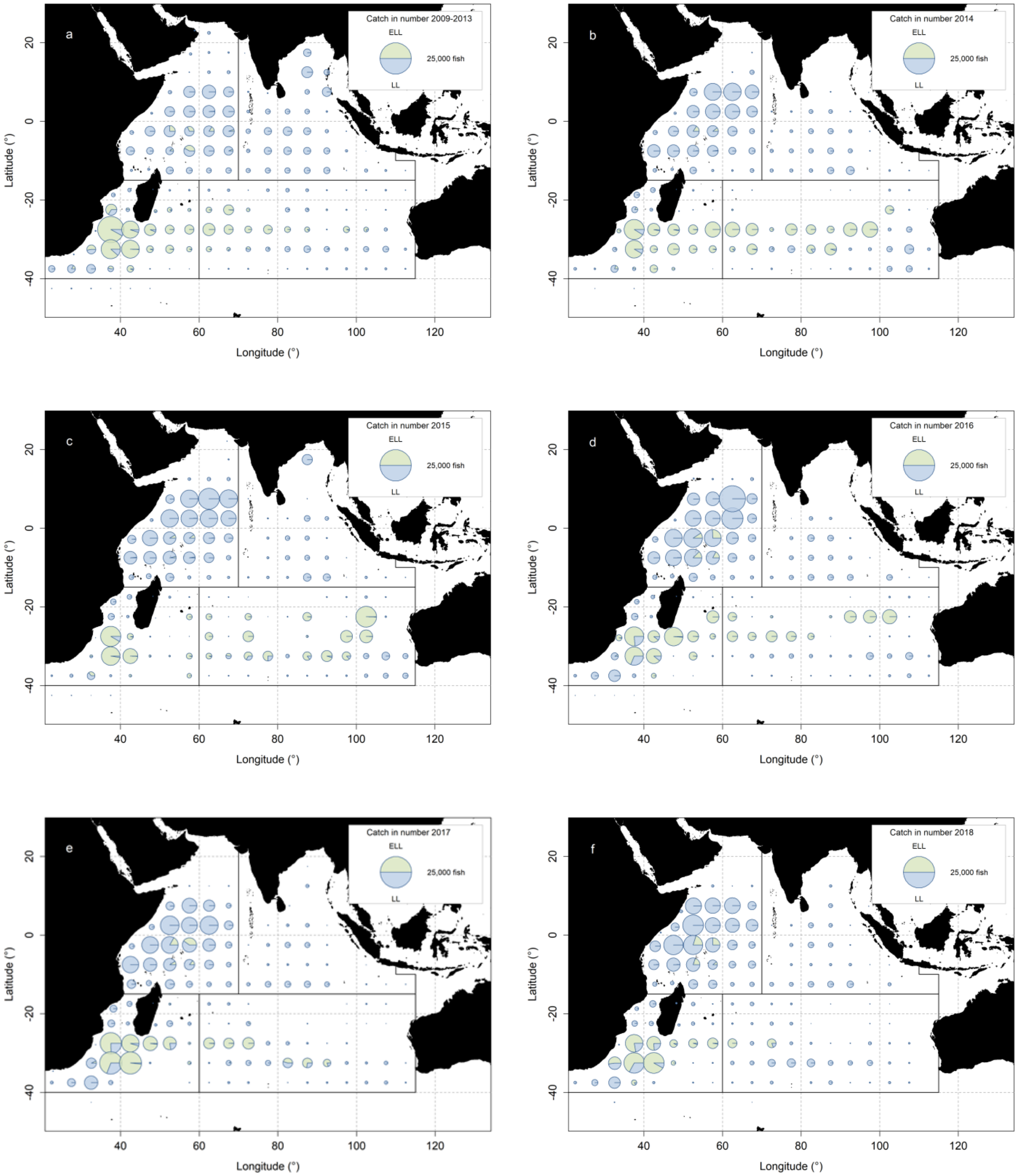


Fig. A6. Mean annual time-area catches of swordfish (in number of fish) as reported by the longline fisheries targeting swordfish (ELL) and other longline fisheries (LL) in the period 2009-2013, by type of gear and for 2014-18, by year and type of gear. Solid black lines represent the areas used for the assessments of swordfish. Does not include catches from fleets not reporting catch-and-effort data

Estimation of catches – data related issues

Retained catches – while the proportion of catches estimated, or adjusted, by the IOTC Secretariat are relatively low (**Fig. A7a**), there are uncertainties for the following fisheries/fleets:

- I.R. Iran and Pakistan (Gillnet): The IOTC Secretariat uses the catches of swordfish and marlins explicitly reported by Pakistan to estimate the actual species composition for the historical catch series of billfish for this fishery. However, as disaggregated records of billfish species are only available for 2018 and for few selected years in the timeframe subject to the revision, the result of this re-estimation is that little to no swordfish appears to be caught by the Pakistani gillnet fleet in recent years, which is considered to be inaccurate.
- 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.

Catch-per-unit-effort (CPUE) trends

- Availability: Catch-and-effort series are available for some industrial longline fisheries (**Fig. A7b**).

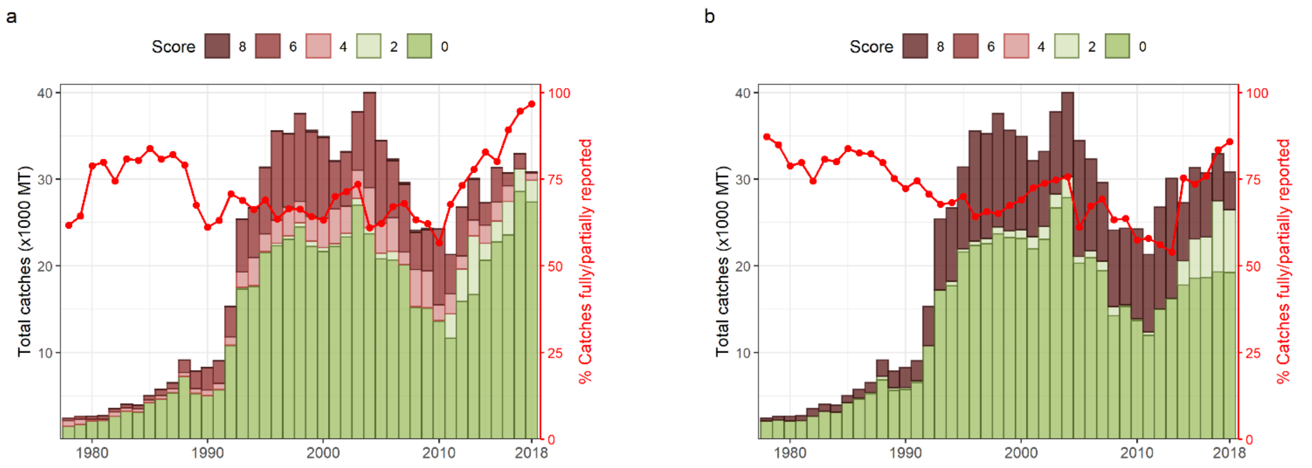
For most other fisheries, catch-and-effort time series for the species are not available at all or not provided up to IOTC standards (e.g., longline fisheries of Indonesia until 2017, drifting gillnet fisheries of Iran and Pakistan), or they considered poor quality, especially since the early '90s (e.g., gillnet and longline fisheries of Sri Lanka, Taiwan,China fresh-tuna longliners, and Non-reporting longliners (NEI)).

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. A7c**).

- 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:
    1. Uncertainty in the length frequency data recorded for longliners of Japan and Taiwan,China, in which average weights of swordfish derived from length frequency and catch-and-effort data are very different.
    2. Uncertainties in the catches of swordfish for the drifting gillnet fisheries of I.R. Iran and the longline fishery of Indonesia.
    3. The lack of size data before the early '70s and poor coverage before the early '80s and for most artisanal fisheries (e.g., Pakistan, India, Indonesia).
    4. The paucity of size data available from industrial longliners since the early '90s (e.g. Japan, Philippines, India and China).
    5. The lack of time-area catches for some industrial fleets (e.g. Indonesia, India, NEI fleets).
    6. 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.

Data quality (by dataset)



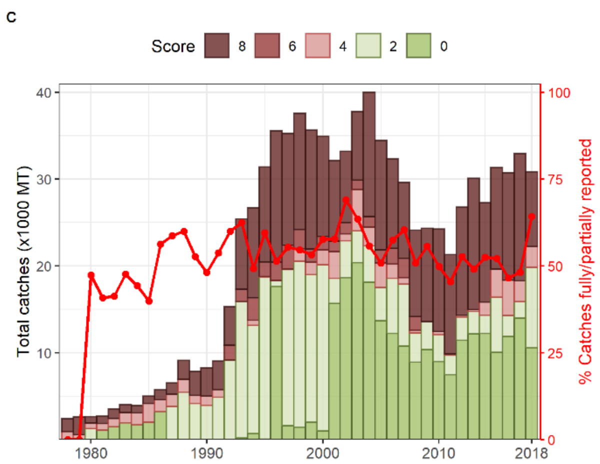


Fig. A7. Annual nominal catches (t) of swordfish estimated by quality score (barplot) and percentage of nominal catch fully/partially reported to the IOTC Secretariat (red line with circles) for all fisheries (1978–2018) for (a) Nominal Catch; (b) Catch-Effort and (c) Size-Frequency data.

Each IOTC dataset is 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 refer 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.*

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 BLUE MARLIN

(*Extract from IOTC–2020–WPB18–07*)

Fisheries and main catch trends

- Main fishing gear (2014–18): Blue marlin are largely considered to be a non-target species of industrial and artisanal fisheries. Longline catches[9] account for around 65% of total catches in the Indian Ocean, followed by gillnets (22%), with remaining catches recorded under troll and handlines (**Table A2; Fig. A9**).
- Main fleets (and primary gear associated with catches): Percentage of total catches (2014–18): Around 80% of the total catches of blue marlin are accounted for by four fleets: Taiwan,China (longline): 43%; Sri Lanka (gillnet, hook and line and longline): 16%; I.R. Iran (gillnet): 13%, and Indonesia (longline and hook-and-line): 6% (**Fig. A10**).
- Main fishing areas: Western Indian Ocean, in the main fishing areas operated by longliners.
- Retained catch trends: Catch trends are variable, which may reflect the level of reporting and the status of blue marlin as a non-target species.
  - Catches reported by drifting longliners were more or less stable until the late '70s, at around 3,000 t to 4,000 t, and have steadily increased since then to reach values between 8,000 t and to over 10,000 t in the late '90s. Some of the highest catches of blue marlin reported by longliners in recent years have been recorded between 2012 and 2016, and are likely to be the consequence of higher catch rates by some longline fleets which appear to have resumed operations in the western tropical Indian Ocean.
- Discard levels**:** Low, although estimates of discards are unknown for most industrial fisheries, mainly longliners. Negligible levels of discards have also been reported for some purse seine fleets. Discards may also occur in some gillnet fisheries.

Changes to the catch series

Catches have been revised in 2015 when catches estimates for blue marlin were revised substantially following new reports of catches-by-species for Iran's drifting gillnet fleet[10]

In addition, following issues with the reliability of catch estimates of Indonesia's fresh longline fleet, the IOTC Secretariat provided the WPB-16 meeting (2018) with an alternative catch series based on a new estimation methodology developed in collaboration with Indonesia. The revised catch series mostly affected catches of swordfish, striped marlin, and blue marlin estimated by the IOTC Secretariat for Indonesia. In the case of blue marlin, catches have been revised down by around 5,000 t per year from 2012 onwards.

The revisions provided by the Government of Pakistan for their gillnet fleet, endorsed at the 22nd session of the IOTC Scientific Committee in 2019, introduced marked changes to blue marlin catches compared to what available at the previous WPB. In particular, captures from the species appear now to be significantly lower for the fleet in the entire time range covered by the revision (1987-2018, **Fig. A8**)[11].

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

10 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 '00s.

[11] See also the corresponding paragraph under the Swordfish section for further details on the process performed by the Secretariat to re-estimate the species composition from the aggregates of billfish species reported by the revised catches.

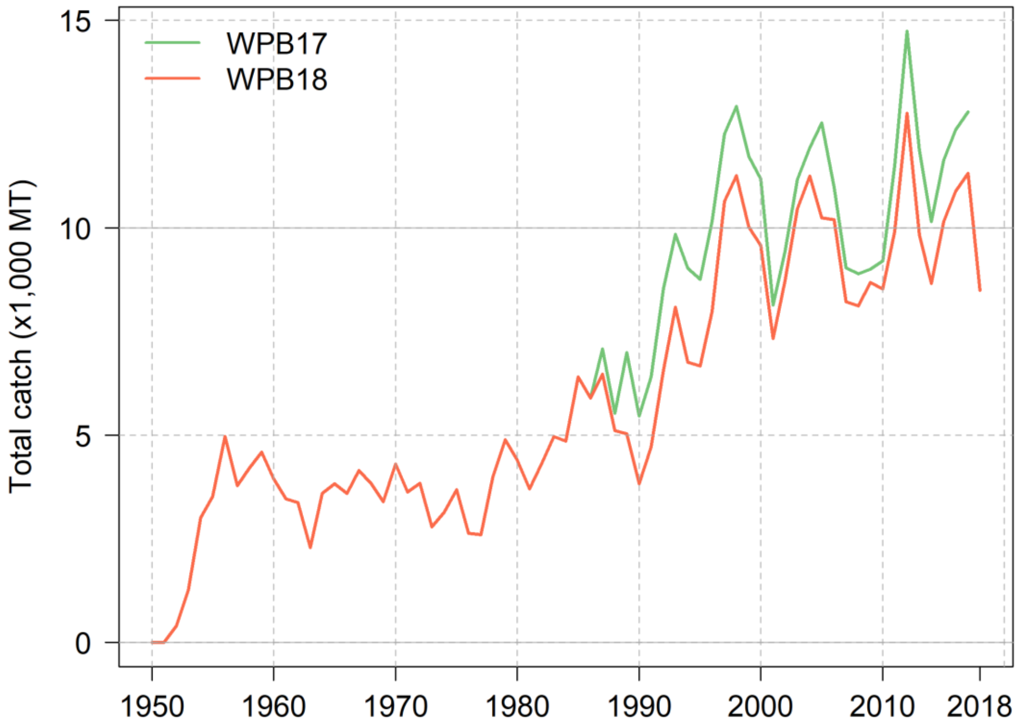


Fig. A8. Comparison of annual time series of total catches (t) of Indian Ocean blue marlin available at the 17th (WPB17, 2019) and 18th (WPB18, 2020) sessions of the IOTC Working Party on Billfish

TABLE A2. Best scientific estimates of the annual nominal catches (t) of blue marlin by fishery for the period 1950–2018. Colour codes (yellow = lower, green = higher) describe the intensity of captures by fishery across decades (left) and years (right). LL = Longline; GN = Gillnet; HL = Hook-and-Line (i.e. handline, trolling, baitboat, and sport fisheries); OT = Other gears (i.e. coastal purse seine, Danish purse seine, beach seine, and purse seine. Data as of May 2020

Fishery	By decade (average)						By year (last ten years)									
	1950s	1960s	1970s	1980s	1990s	2000s	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
LL	2,567	3,535	3,409	4,552	7,071	7,861	7,162	7,185	7,857	10,509	7,746	6,066	7,231	7,858	5,633	5,300
GN	1	2	124	454	409	1,260	1,225	1,018	1,761	1,967	1,726	2,055	2,187	2,101	2,934	1,726
HL	5	9	17	105	168	150	277	303	269	265	341	522	711	867	1,962	1,420
OT	0	0	0	2	4	7	15	15	16	16	18	16	21	55	781	47
Total	**2,574**	**3,546**	**3,550**	**5,113**	**7,652**	**9,278**	**8,679**	**8,521**	**9,902**	**12,757**	**9,831**	**8,659**	**10,150**	**10,881**	**11,310**	**8,492**

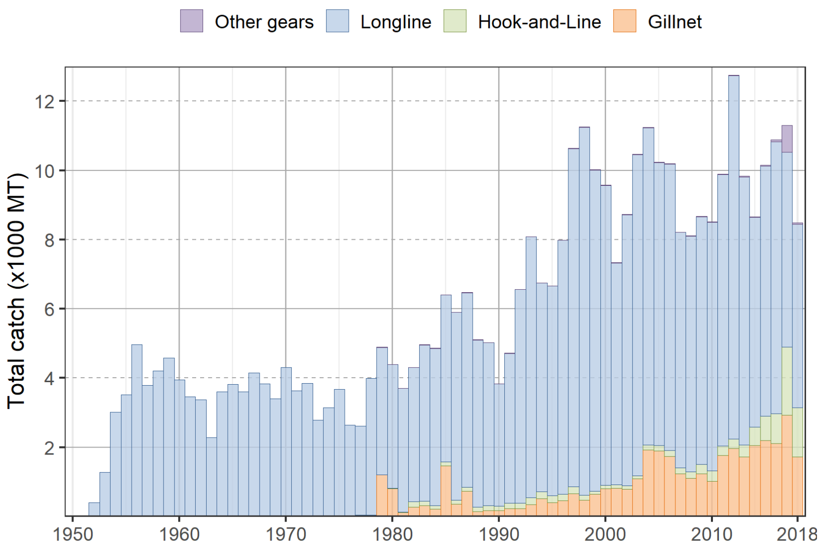


Fig. A9. Annual time series of nominal catches (t) of blue marlin by gear group recorded in the IOTC database, 1950–2018. Other gears include coastal purse seine, Danish purse seine, beach seine and purse seine

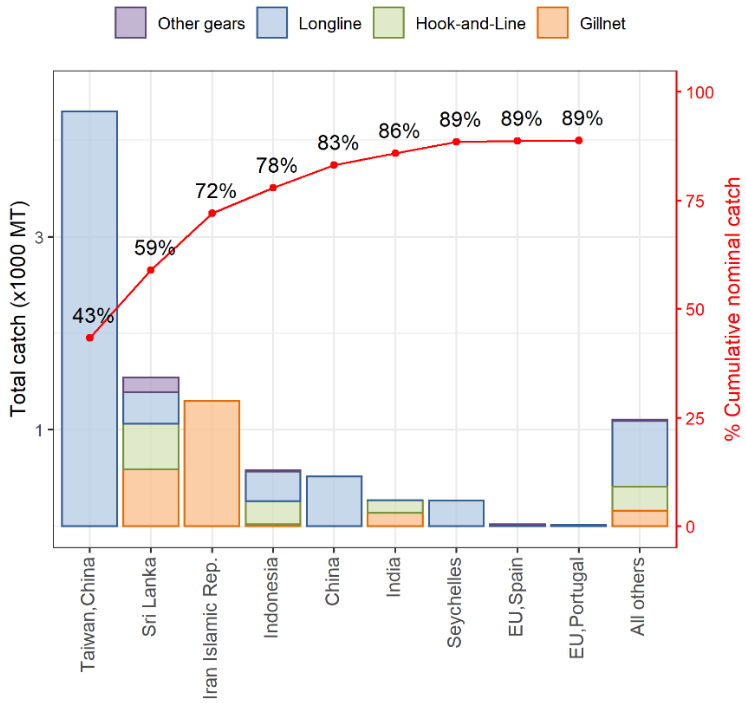


Fig. A10. Average nominal catches (t) of blue marlin over the period 2014–2018, by gear group and CPC ordered according to the importance of catches. The red solid line indicates the cumulative percentage of the total combined catches of the species for the CPCs concerned

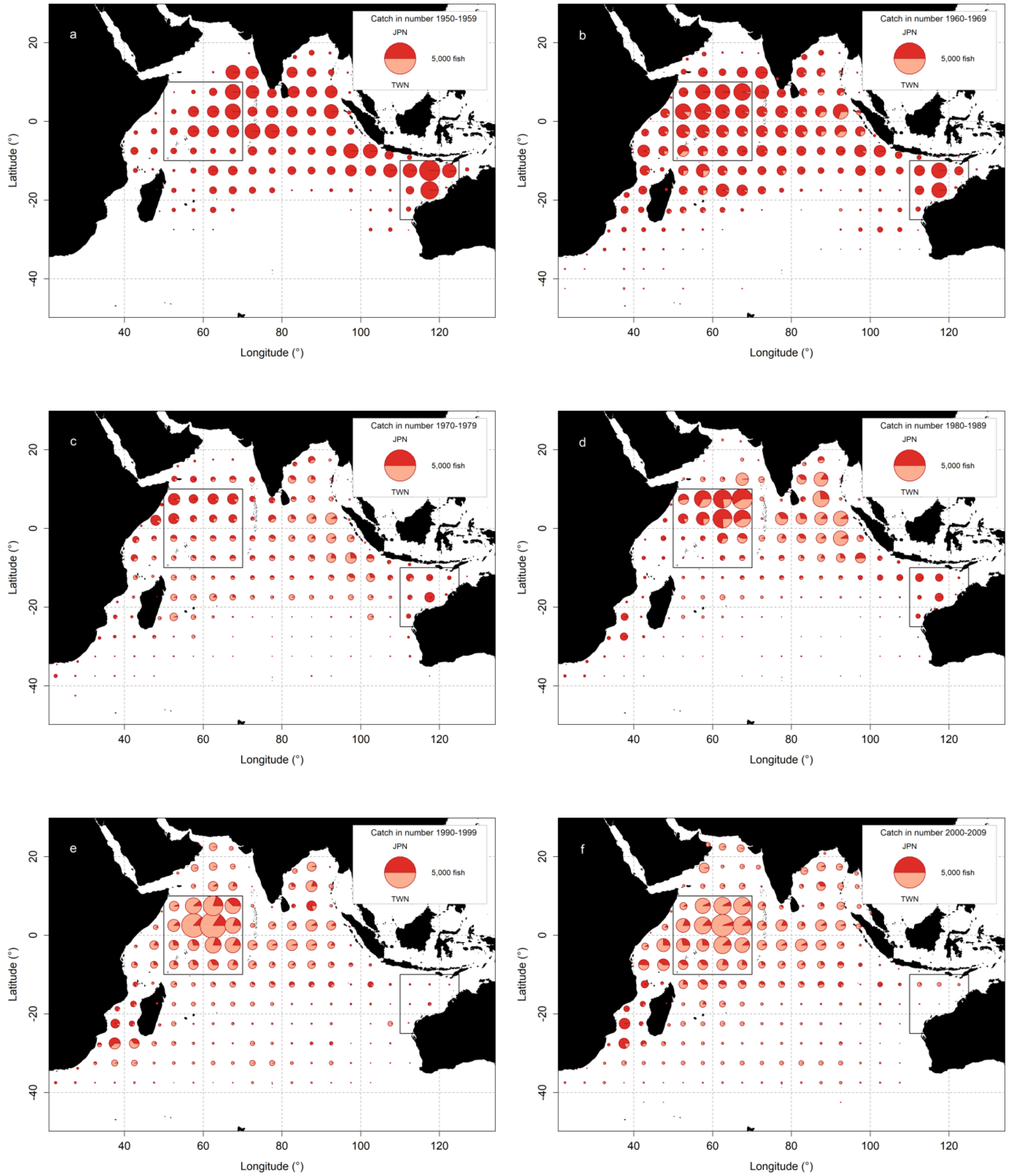


Fig. A11. Mean annual time-area catches (in number of fish) of blue marlin as reported for the longline fisheries of Japan (JPN) and Taiwan,China (TWN) for the period 1950-2009, by decade and fleet. Black solid lines represent the marlin main longline fishing grounds identified by the IOTC WPB. Does not include catches from fleets not reporting catch-and-effort data

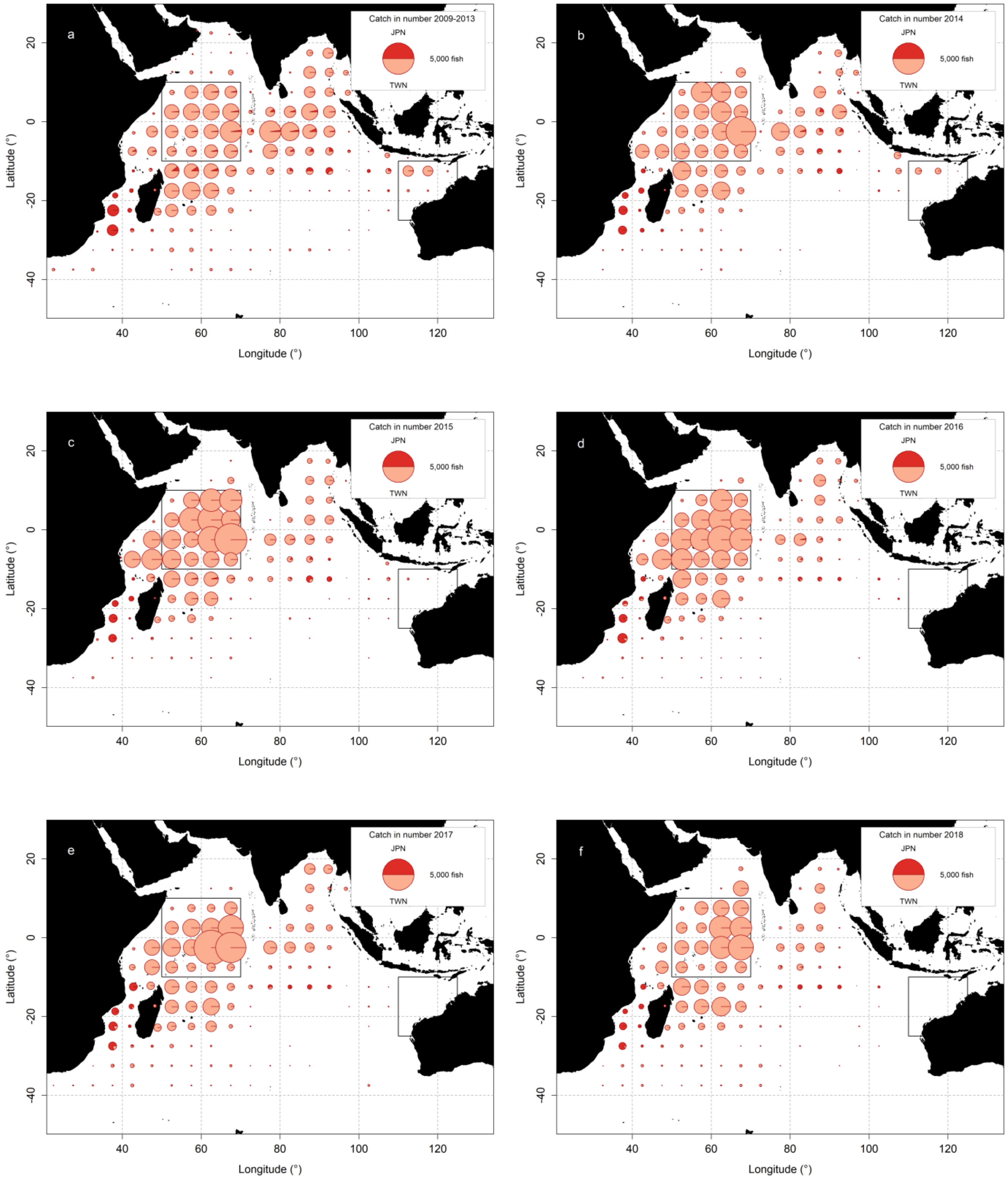


Fig. A12. Mean annual time-area catches (in number of fish) of blue marlin as reported for the longline fisheries of Japan (JPN) and Taiwan,China (TWN) for the period 2009–13 by fleet and for 2014–18, by year and fleet. Solid black lines represent the marlin main longline fishing grounds identified by the IOTC WPB. Does not include catches from fleets from not reporting catch-and-effort data

Estimation of catches – data related issues

Retained catches – a relatively high proportion of blue marlin catches have been estimated, or adjusted, by the IOTC Secretariat across the entire time series and until recent years (**Fig. A13a**), due to a number of uncertainties in the catches:

- Species aggregates: Catch reports often refer to total catches of all three marlin species combined or as an aggregate of all billfish species. Catches-by-species are estimated by the IOTC Secretariat for some years and artisanal fisheries (e.g., gillnet-longline fishery of Sri Lanka, artisanal fisheries of India, Iran and Pakistan) and industrial fisheries (e.g., longliners of Indonesia and Philippines).
- Non-reporting fleets: Catches of non-reporting industrial longliners (e.g., India, NEI) and the gillnet fishery of Indonesia are estimated by the Secretariat using alternative information.
- Non-target species: Catches are likely to be incomplete for industrial fisheries for which blue marlin is not a target species.
- Conflicting catch reports: Longline catches from the Republic of Korea reported as nominal catches, and catch and effort are conflicting, with higher catches recorded in the catch and effort table. For this reason, the Secretariat revised the catches of blue marlin for the Republic of Korea over the time-series using both datasets. Although the new catches estimated by the Secretariat are thought to be more accurate, catches of blue marlin remain uncertain for this fleet.
- Lack of catch data for most sport fisheries.
- Species mis-identification: Difficulties in the identification of marlins also contribute to uncertainties in the catch estimates of blue marlin.

Catch-per-unit-effort (CPUE) trends

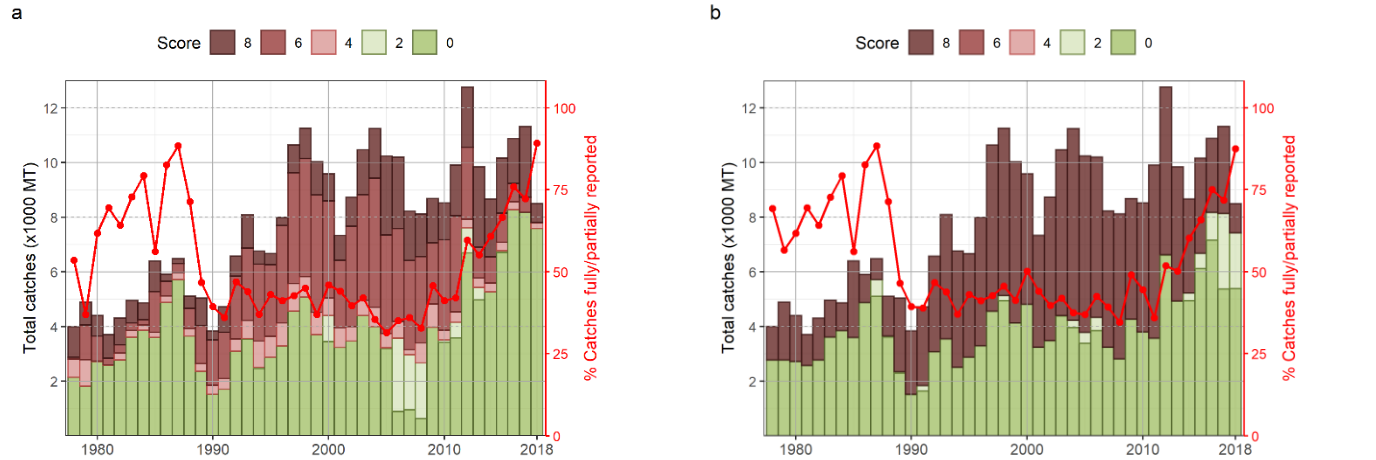
- Availability: Standardized CPUE series have not yet been developed. Nominal CPUE series are available for some industrial longline fisheries, although catches are likely to be incomplete (as catches of non-target species are not always recorded in logbooks) (**Fig. A13b**).

  No catch-and-effort data are available from sport fisheries, other than for partial data from the sport 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.

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

- Average fish weight: Can only be assessed for the longline fishery of Japan since 1970 and Taiwan,China since 1980. However, the number of specimens measured on Japanese longliners in recent years is very low and mis-identification of striped and blue marlin may occur in some longline fisheries. Also, the length frequency distributions derived from samples collected by fishermen on Taiwanese longliners may not be representative of the total catches.
- Catch-at-Size (Age) table: Not available, due to lack of size samples and uncertainty over the reliability of retained catch estimates, or conflicting catch-and-effort data (**Fig. A13c**). 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.

Data quality (by dataset)



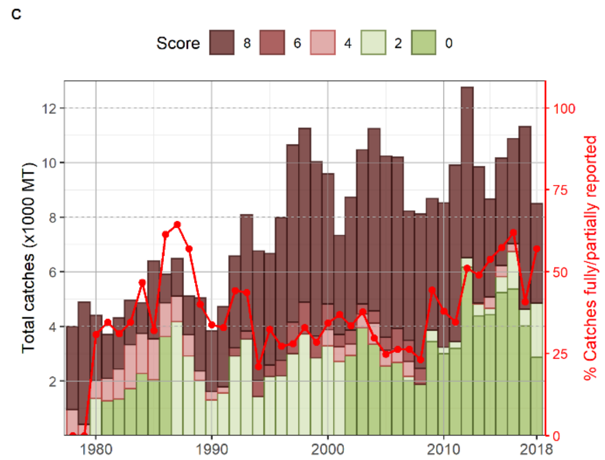


Fig. A13. Annual nominal catches (t) of blue marlin estimated by quality score (barplot) and percentage of nominal catch fully/partially reported to the IOTC Secretariat (red line with circles) for all fisheries (1978–2018) for (a) Nominal Catch; (b) Catch-Effort and (c) Size-Frequency data

Each IOTC dataset is 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.*

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–2020–WPB18–07*)

Fisheries and main catch trends

- Main fishing gear (2014–18): Black marlin is largely considered to be a non-target species of industrial and artisanal fisheries. Gillnets account for more than 50% of total catches in the Indian Ocean, followed by troll and handlines (32%), with remaining catches recorded under longlines (12%) (**Table A3; Fig. A15**).
- Main fleets (and primary gear associated with catches): percentage of total catches (2014–18):
  - More than 70% of the total catches of black marlin are accounted for by three fleets: I.R. Iran (gillnet): 30%; India (gillnet and trolling): 23%; Sri Lanka (gillnet and fresh longline): 21%.
- Main fishing areas:
  - Primary: Between the early '50s and the late '80s part of the Japanese longline 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 (**Fig. A17**).

    These historical fishing grounds of the longline fleet have almost disappeared since the early 1990s while the main fishing grounds now occur around I.R Iran, India and Sri Lanka although the lack of georeferenced data for the gillnet and hook-and-line fisheries of these CPCs limits the appraisal of the accurate spatial extent of the BLM fishery.
  - 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 (**Fig. A18**).
- Retained catch trends: Since the '90s catches have increased steadily, from 2,500 t in 1991 to around 13,000 t in 2004. In recent years catches have further increased sharply from around 13,000 t in 2012 to over 22,000 t in 2016 – the highest catches recorded in the Indian Ocean for the species – largely due to increases reported by the offshore gillnet fisheries of I.R. Iran. Catches decreased to 15,000 t in 2017 and re-increased to about 18,500 t in 2018 (**Table A3**). Catches in Sri Lanka have also risen steadily since the beginning of the '90s as a result of the development of the fishery using a combination of drifting gillnets and longlines, from around 1,000 t in 1991 to an average of around 3,900 t in recent years.
- Discard levels**:** Low, although estimates of discards are unknown for most industrial fisheries, mainly longliners. Negligible levels of discards have also been reported for some purse seine fleets. Discards may also occur in some gillnet fisheries.

Changes to the catch series

Catch estimates for black marlin have been largely unaffected by the recent revisions to Indonesia's fresh longline fleet (as opposed to other species such as swordfish and blue marlins), mostly as black marlins are generally more associated with gillnets operating in more coastal waters.

Also, the revisions provided by the Government of Pakistan for their gillnet fleet, endorsed at the 22nd session of the IOTC Scientific Committee in 2019, did not introduce relevant changes to blue marlin catches compared to what available at the previous WPB[12] (**Fig. A14**).

[12] See also the corresponding paragraph under the Swordfish section for further details on the process performed by the Secretariat to re-estimate the species composition from the aggregates of billfish species reported by the revised catches.

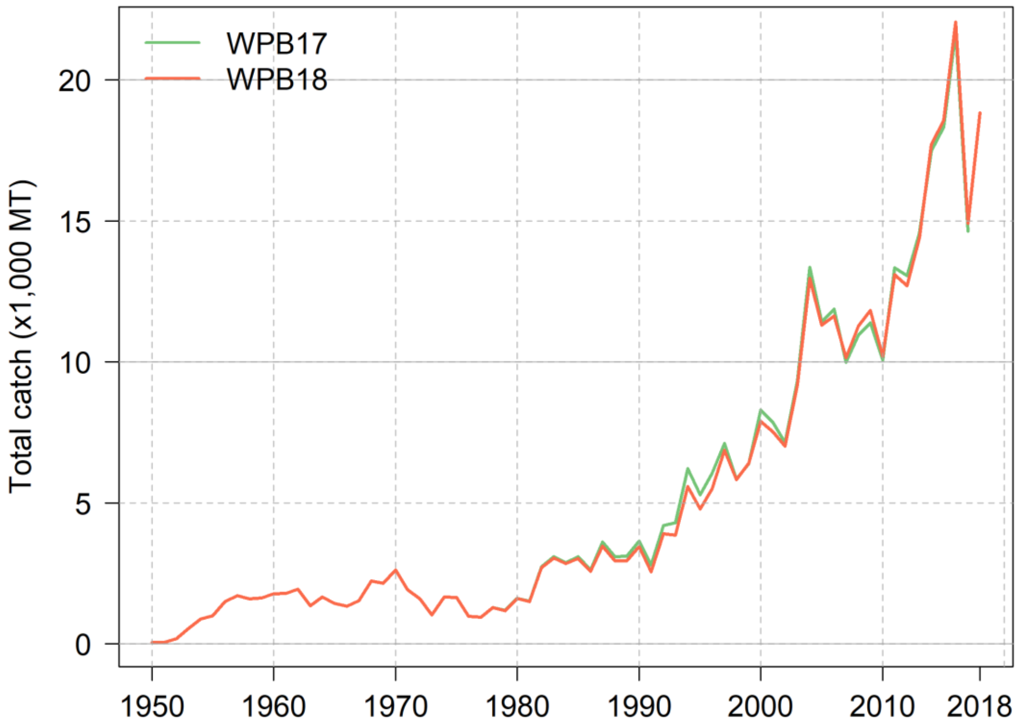


Fig. A14. Comparison of annual time series of total catches (t) of Indian Ocean black marlin available at the 17th (WPB17, 2019) and 18th (WPB18, 2020) sessions of the IOTC Working Party on Billfish

TABLE A3. Best scientific estimates of the annual nominal catches (t) of black marlin by fishery for the period 1950–2018. Colour codes (yellow = lower, green = higher) describe the intensity of captures by fishery across decades (left) and years (right). LL = Longline; GN = Gillnet; HL = Hook-and-Line (i.e. handline, trolling, baitboat, and sport fisheries); OT = Other gears (i.e. coastal purse seine, Danish purse seine, beach seine, and purse seine. Data as of May 2020

Fishery	By decade (average)						By year (last ten years)									
	1950s	1960s	1970s	1980s	1990s	2000s	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
LL	862	1,661	1,391	1,755	2,425	3,770	3,719	3,765	4,209	3,304	2,825	2,648	2,293	3,006	1,869	1,218
GN	26	31	44	368	1,597	5,053	5,507	4,340	6,537	6,652	7,777	9,931	9,156	10,596	7,614	11,083
HL	24	27	42	447	737	1,029	2,146	1,629	1,864	2,261	3,089	4,630	6,625	7,981	4,653	6,092
OT	0	0	7	97	113	226	460	472	490	484	702	503	508	480	784	449
Total	**912**	**1,719**	**1,483**	**2,668**	**4,872**	**10,078**	**11,832**	**10,207**	**13,100**	**12,701**	**14,394**	**17,712**	**18,582**	**22,063**	**14,920**	**18,841**

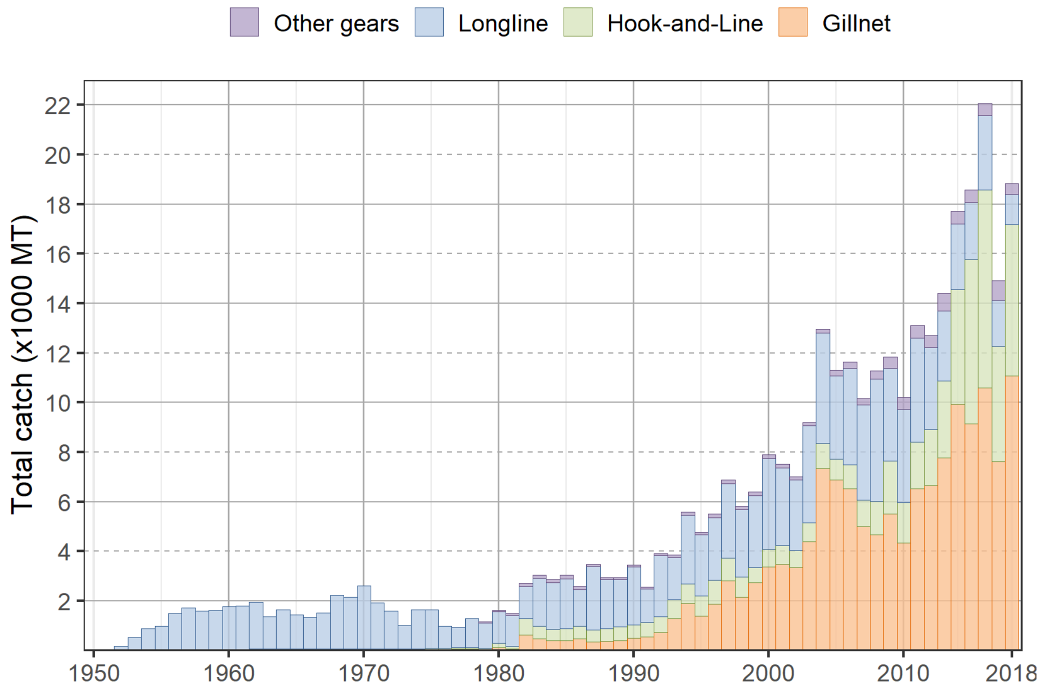


Fig. A15. Annual time series of nominal catches (t) of black marlin by gear group recorded in the IOTC database, 1950–2018. Other gears include coastal purse seine, Danish purse seine, beach seine and purse seine

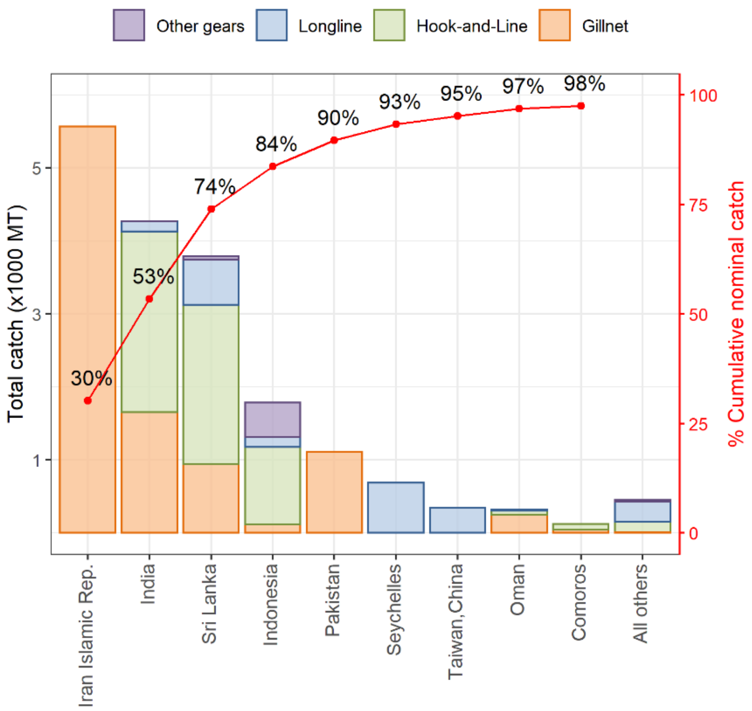


Fig. A16. Average nominal catches (t) of black marlin over the period 2014–2018, by gear group and CPC ordered according to the importance of catches. The red solid line indicates the cumulative percentage of the total combined catches of the species for the CPCs concerned

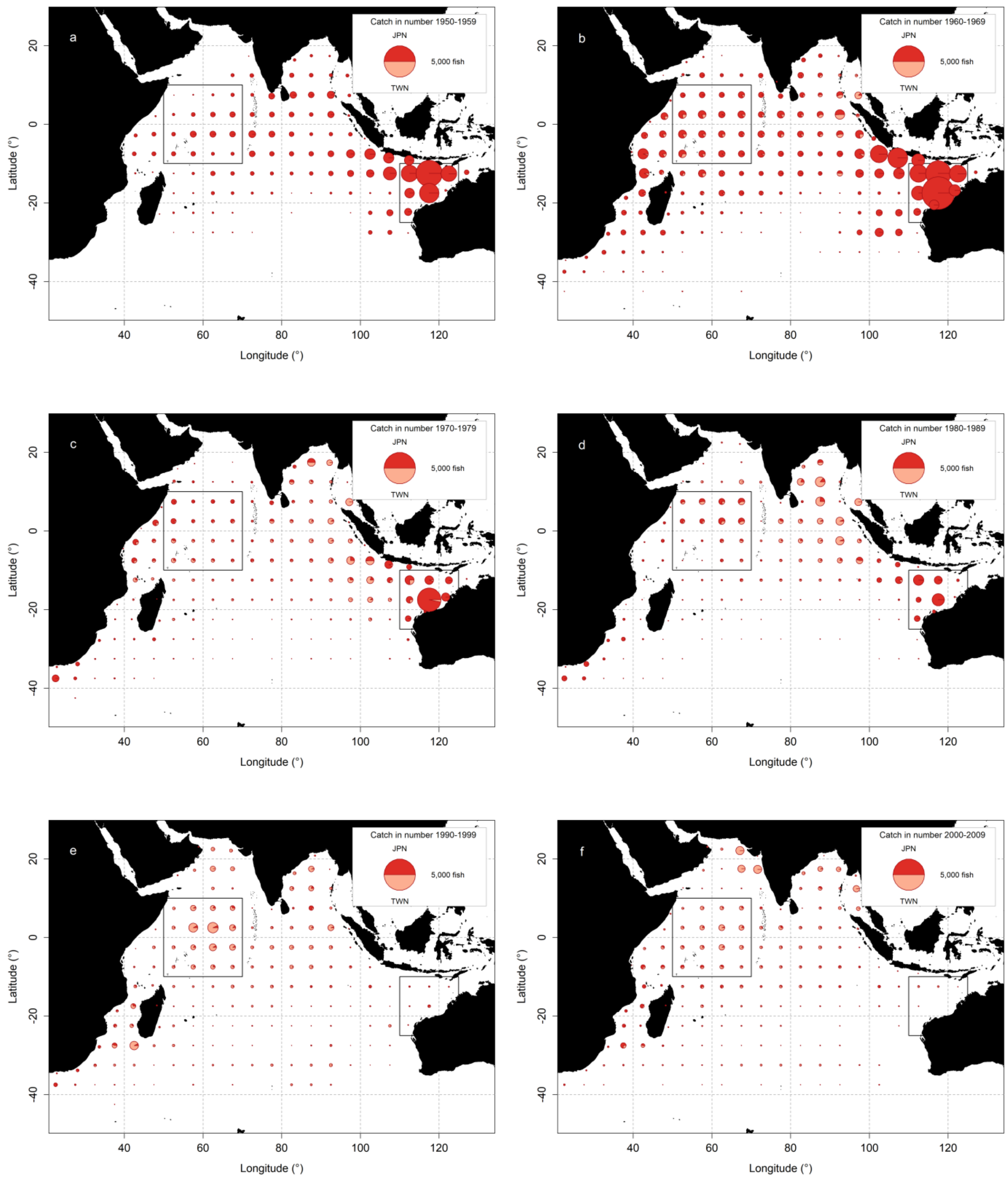


Fig. A17. Mean annual time-area catches (in number of fish) of black marlin as reported for the longline fisheries of Japan (JPN) and Taiwan,China (TWN) for the period 1950–2009, by decade and fleet. Black solid lines represent the marlin main longline fishing grounds identified by the IOTC WPB. Does not include catches from fleets not reporting catch-and-effort data

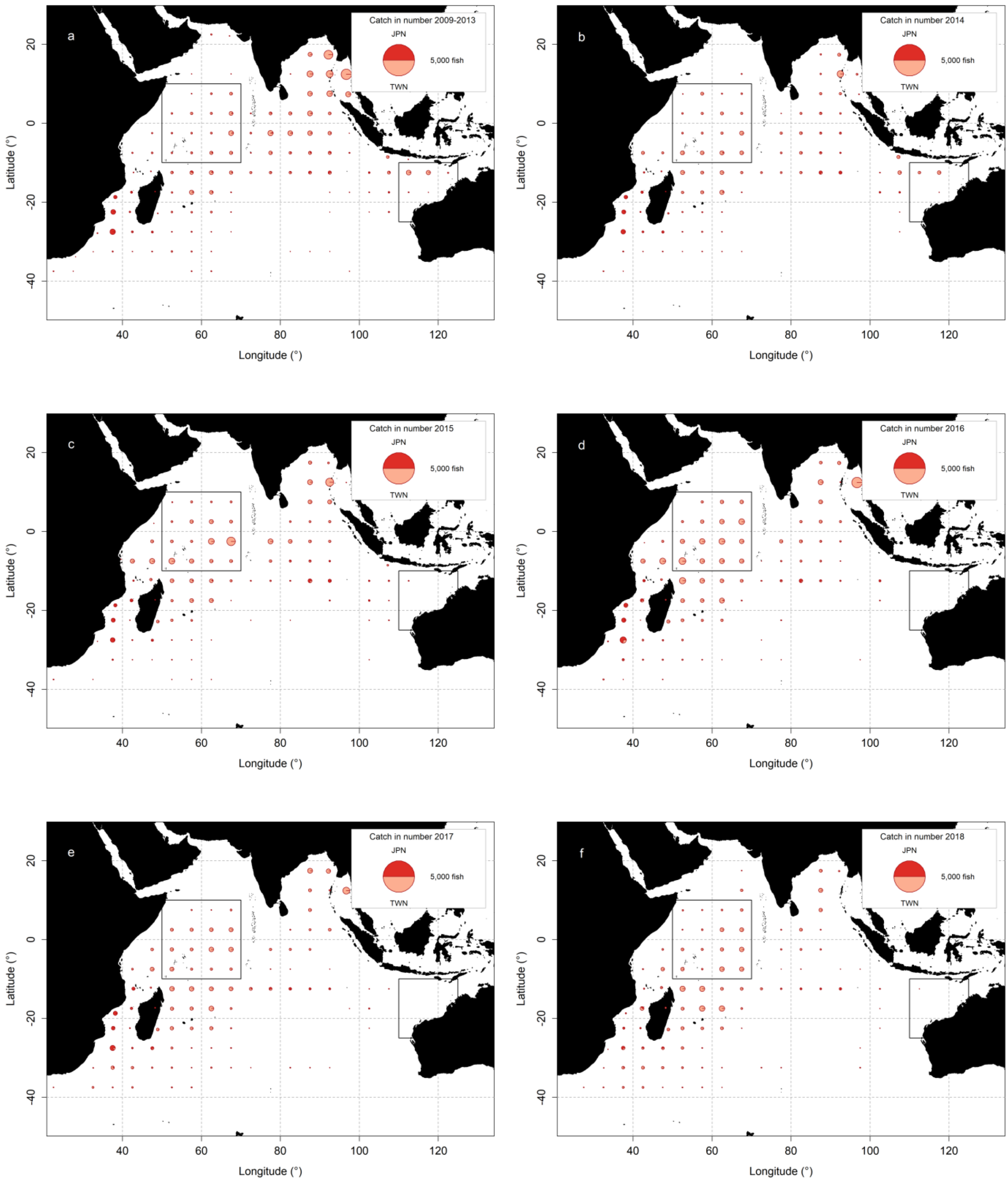


Fig. A18. Mean annual time-area catches (in number of fish) of black marlin as reported for the longline fisheries of Japan (JPN) and Taiwan,China (TWN) for the period 2009–13 by fleet and for 2014–18, by year and fleet. Black solid lines represent the marlin main longline fishing grounds identified by the IOTC WPB. Does not include catches from fleets not reporting catch-and-effort data

Estimation of catches – data related issues

Retained catches – current black marlin catches are relatively high however, a very high proportion of these catches were estimated, or adjusted, by the IOTC Secretariat (**Fig. A19a**) until 2010 due to a number of uncertainties in the catches:

- Species aggregates: Catch reports often refer to total catches of all three marlin species combined or as an aggregate of all billfish species; catches by species are estimated by the Secretariat for some years and artisanal fisheries (e.g., gillnet/longline fishery of Sri Lanka and artisanal fisheries of India, I.R. Iran and Pakistan) and industrial fisheries (e.g., longliners of Indonesia and Philippines).
- Non-reporting fleets: Catches of non-reporting industrial longliners (e.g., India, NEI fleets) and the gillnet fishery of Indonesia are estimated by the Secretariat using alternative information.
- Non-target species: Catches are likely to be incomplete for industrial fisheries for which black marlin is not a target species.
- Conflicting catch reports: Longline catches from the Republic of Korea reported as nominal catches, and catch and effort reports are conflicting, with higher catches recorded in the catch and effort table. For this reason, the Secretariat revised the catches of black marlin for the Republic of Korea over the time-series using both datasets. Although the new catches estimated by the Secretariat are thought to be more accurate, catches of black marlin remain uncertain for this fleet.
- General lack of catch data for most sport fisheries, particularly in the Western Indian Ocean.
- Species mis-identification: Difficulties in the identification of marlins also contribute to uncertainties in the catch estimates of black marlin available to the Secretariat.

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) (**Fig. A19b**).

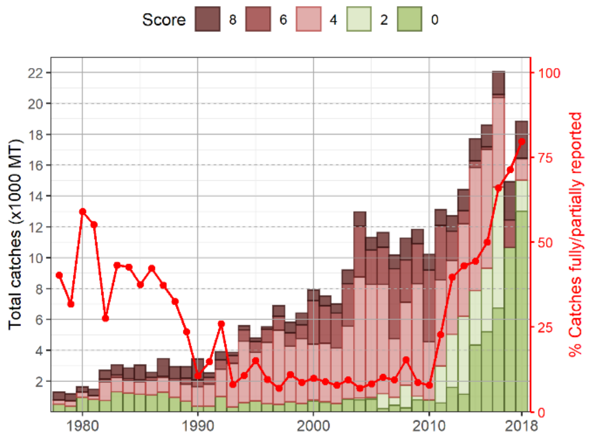
  No catch-and-effort data are available from sport fisheries, other than partial data from the sport fisheries of Kenya; likewise no data are available for other artisanal fisheries (e.g., gillnet fisheries of Indonesia and Pakistan). Detailed catch-and-effort data are available for the gillnet fishery of I.R. Iran since 2007, including details for the offshore component of the fleet.
- Main CPUE series available: Japanese and Taiwan,China longline fleet

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

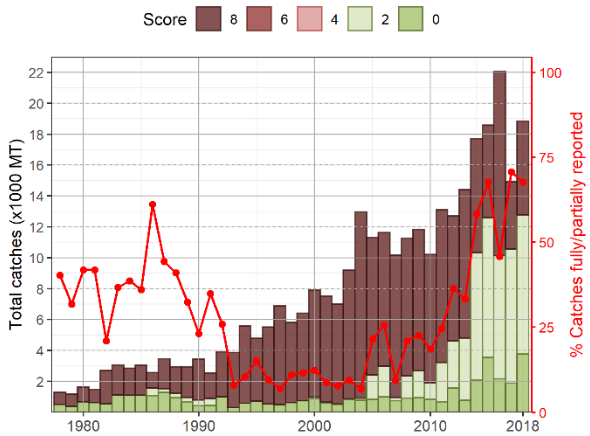
- Average fish weight: Can only be assessed for the longline fishery of Japan since 1970 and Taiwan,China since 1980. However, the number of specimens measured on Japanese longliners in recent years is very low. Also, the length frequency distributions derived from samples collected by fishermen on Taiwanese longliners are also likely to be biased.
- Catch-at-Size (Age) table: Not available, due to lack of size samples and uncertainty over the reliability of retained catch estimates, or conflicting catch-and-effort data (**Fig. A19c**). Fish sizes are derived from various length and weight information; however the reliability of the size data is uncertain for some fleets, particularly when relatively few fish out of the total catch are measured.
- Sex ratio data: Have not been provided to the Secretariat by CPCs.

Data quality (by dataset)

a



b



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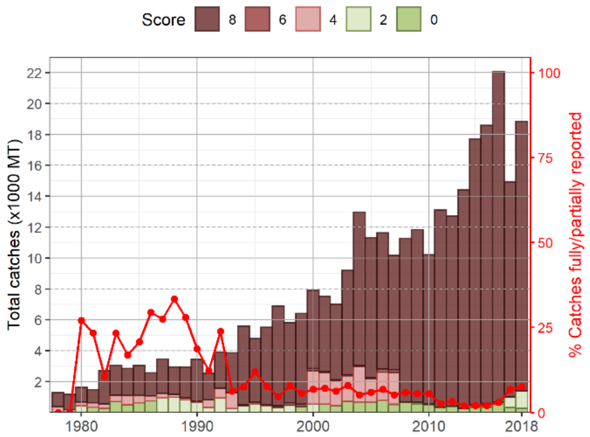


Fig. A19. Annual nominal catches (t) of black marlin estimated by quality score (barplot) and percentage of nominal catch fully/partially reported to the IOTC Secretariat (red line with circles) for all fisheries (1978–2018) for (a) Nominal Catch; (b) Catch-Effort and (c) Size-Frequency data.

Each IOTC dataset is 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.*

<u>Key to IOTC Scoring system</u>

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 STRIPED MARLIN

(*Extract from IOTC–2020–WPB17–07*)

Fisheries and main catch trends

- Main fishing gear (2014–18): Striped marlin is largely considered to be a non-target species of industrial fisheries. Gillnets account for about 50% of total catches in the Indian Ocean, followed by longlines (40%). The remaining catches are mostly recorded under troll and handlines (**Table A4, Fig. A21**).
- Main fleets (and primary gear associated with catches): percentage of total catches (2014–18): Around 75% of the total catches of striped marlin are accounted for by four fleets: I.R. Iran (gillnet): 25%; Taiwan,China (longline): 20%; Indonesia (longline): 18%; and Pakistan (gillnet): 12% (**Fig. A22**).
- Main fishing areas: The distribution of striped marlin catches has changed since the '80s with most of the catch now taken in the north-west Indian Ocean, although between 2007–2011 catches in this area have dropped markedly, in tandem with a reduction of longline effort due to piracy (**Figs. A23-24**).
  - 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 (**Fig. A23**).
- Retained catch trends: Catch trends are variable, ranging from 2,000 t to 8,000 t per year, which may reflect the level of reporting and the status of striped marlin as a non-target species, rather than actual catches. In particular, 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. Since 2012, catches of striped marlin have fluctuated between 3,000 t – 5,000 t per year.
- 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. Iran, as this species has no commercial value in this country.

Changes to the catch series

Following issues with the reliability of catch estimates of Indonesia's fresh longline fleet, the IOTC Secretariat provided the WPB-16 meeting with an alternative catch series based on a new estimation methodology developed in collaboration with Indonesia. The revised catch series mostly affects catches of swordfish, striped marlin, and blue marlin estimated by the IOTC Secretariat for Indonesia: in the case of striped marlin, catches have been revised downwards to between 3,000 t and 5,000 t from 2012 onwards.

Also, the revisions provided by the Government of Pakistan for their gillnet fleet, endorsed at the 22nd session of the IOTC Scientific Committee in 2019, did not introduce relevant changes to striped marlin catches compared to what available at the previous WPB[13] (**Fig. A20**).

[13] See also the corresponding paragraph under the Swordfish section for further details on the process performed by the Secretariat to re-estimate the species composition from the aggregates of billfish species reported by the revised catches.

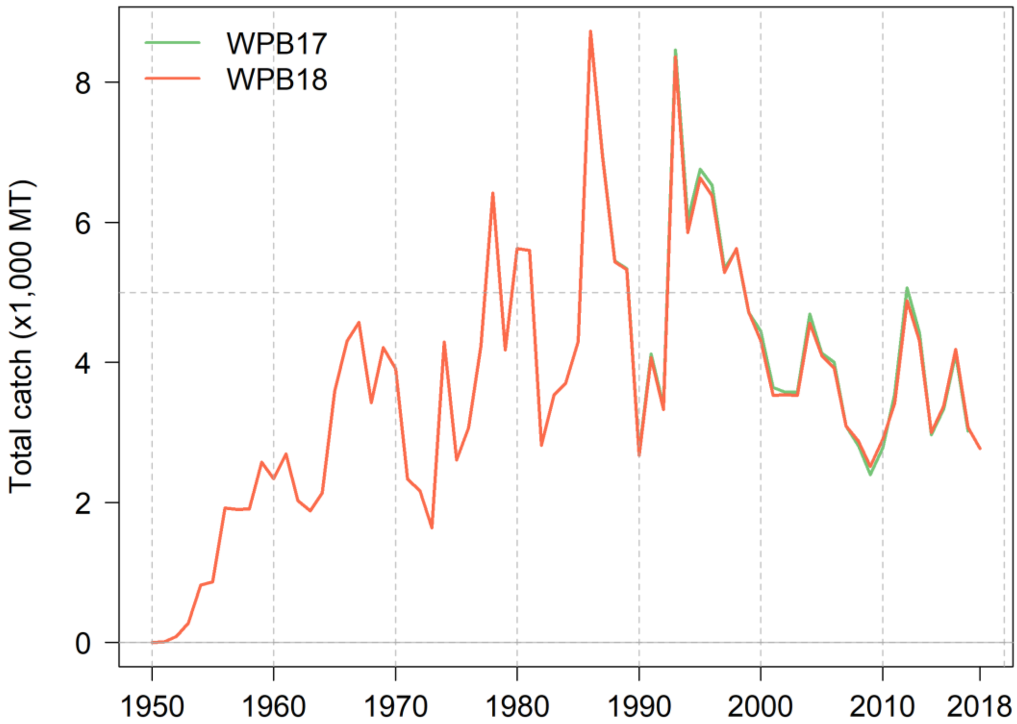


Fig. A20. Comparison of annual time series of total catches (t) of Indian Ocean striped marlin available at the 17th (WPB17, 2019) and 18th (WPB18, 2020) sessions of the IOTC Working Party on Billfish

TABLE A4. Best scientific estimates of the annual nominal catches (t) of striped marlin by fishery for the period 1950–2018. Colour codes (yellow = lower, green = higher) describe the intensity of captures by fishery across decades (left) and years (right). LL = Longline; GN = Gillnet; HL = Hook-and-Line (i.e. handline, trolling, baitboat, and sport fisheries); OT = Other gears (i.e. coastal purse seine, Danish purse seine, beach seine, and purse seine. Data as of May 2020

Fishery	By decade (average)						By year (last ten years)									
	1950s	1960s	1970s	1980s	1990s	2000s	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
LL	1,028	3,104	3,458	5,144	5,115	2,935	1,679	2,123	2,308	3,771	2,890	1,357	1,721	2,633	1,345	1,014
GN	5	8	16	20	96	506	526	453	767	777	1,040	1,280	1,313	1,182	1,297	1,431
HL	3	5	10	32	72	137	273	282	292	288	332	319	301	329	342	288
OT	0	0	0	6	10	20	41	42	44	43	49	45	44	44	86	36
Total	**1,036**	**3,117**	**3,485**	**5,202**	**5,293**	**3,599**	**2,519**	**2,900**	**3,412**	**4,880**	**4,311**	**3,000**	**3,379**	**4,188**	**3,070**	**2,769**

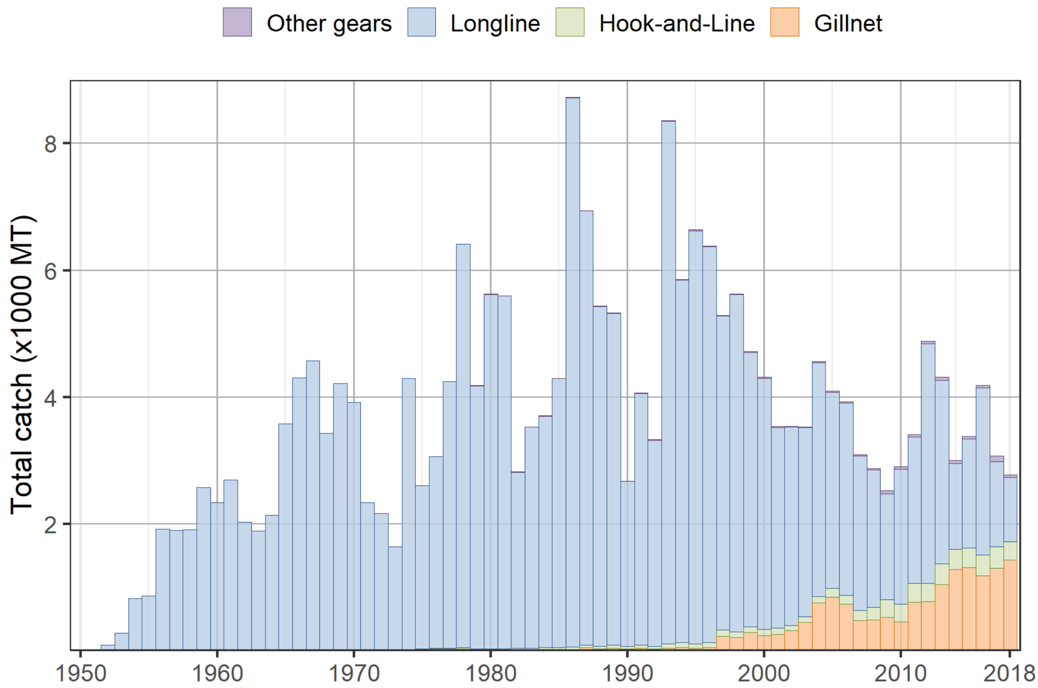


Fig. A21. Annual time series of nominal catches (t) of striped marlin by gear group recorded in the IOTC database, 1950–2018. Other gears include coastal purse seine, Danish purse seine, beach seine and purse seine

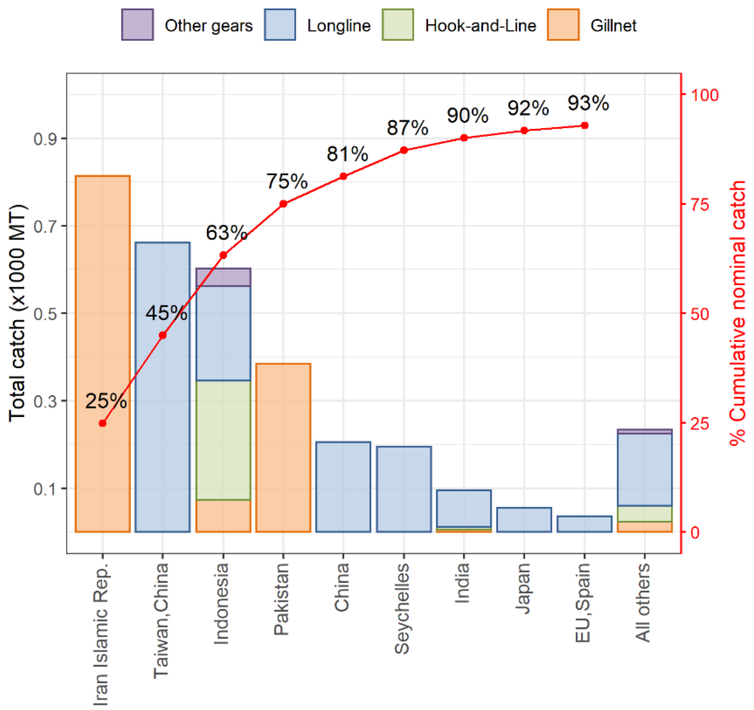


Fig. A22. Average nominal catches (t) of striped marlin over the period 2014–2018, by gear group and CPC ordered according to the importance of catches. The red solid line indicates the cumulative percentage of the total combined catches of the species for the CPCs concerned

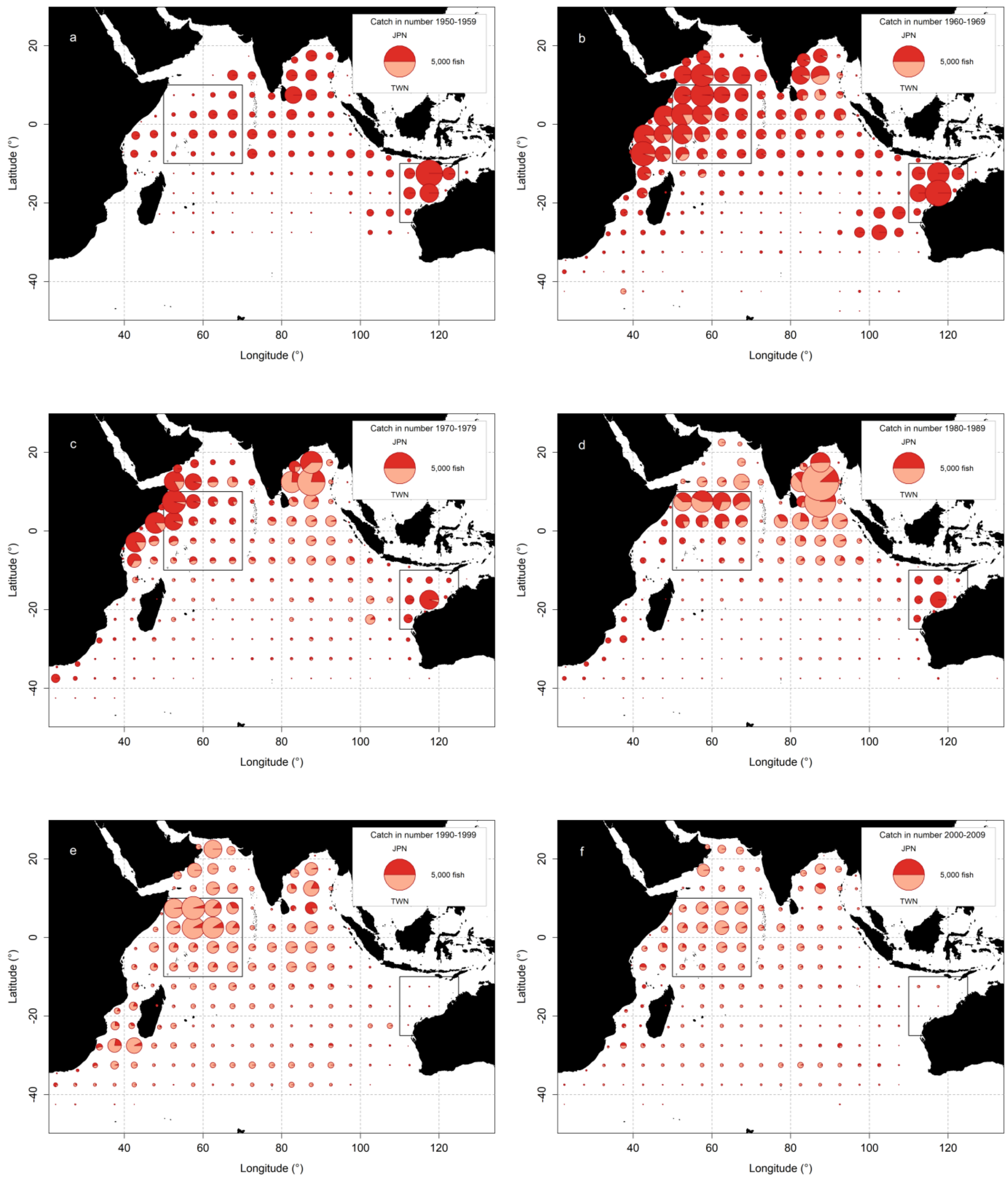


Fig. A23. Mean annual time-area catches (in number of fish) of striped marlin as reported for the longline fisheries of Japan (JPN) and Taiwan,China (TWN) for the period 1950–2009, by decade and fleet. Solid black lines represent the marlin main longline fishing grounds identified by the IOTC WPB. Does not include fleets non-reporting catch-and-effort data

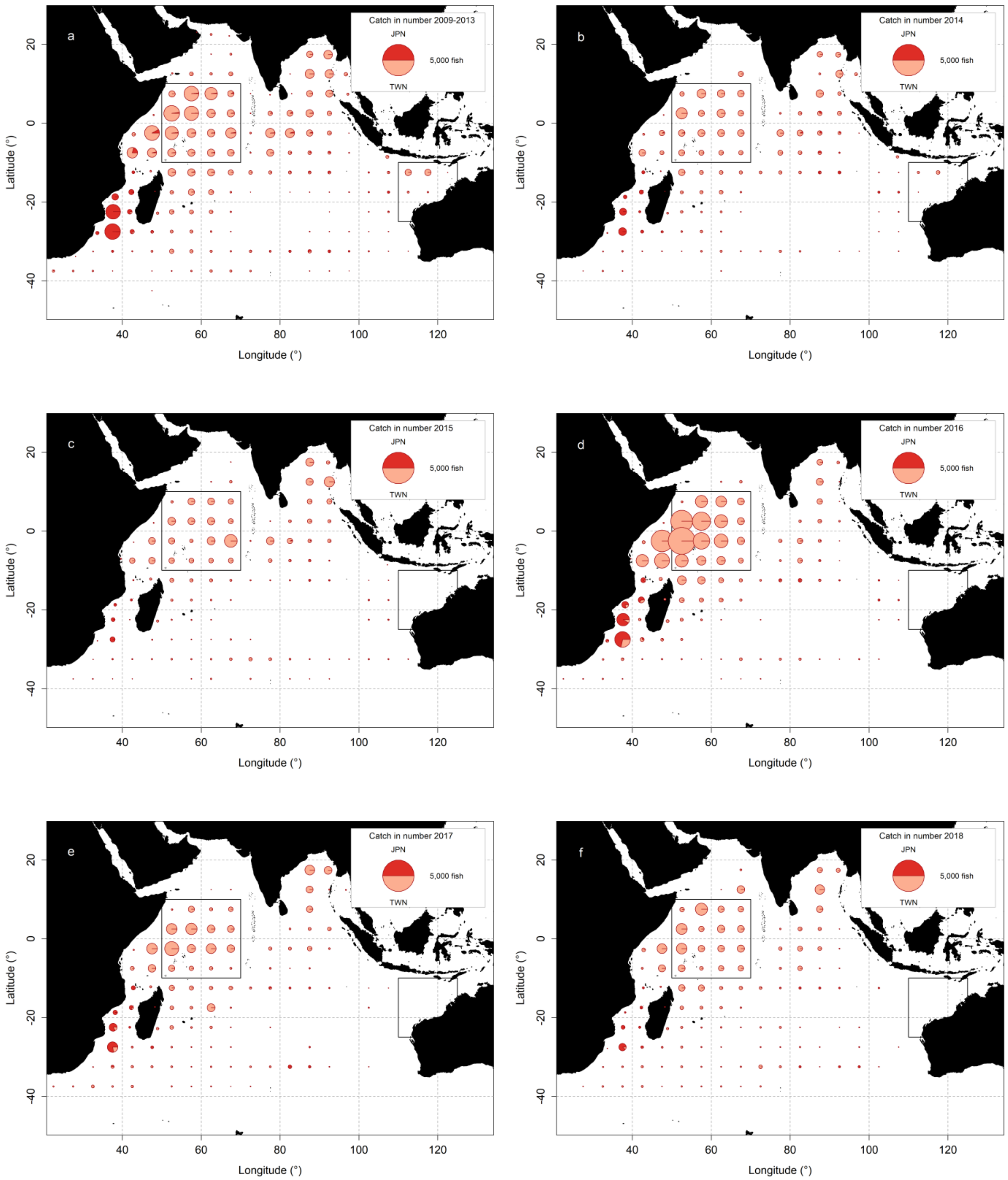


Fig. A24. Mean annual time-area catches (in number of fish) of striped marlin as reported for the longline fisheries of Japan (JPN) and Taiwan,China (TWN) for the period 2009–13 by fleet and for 2014–18, by year and fleet. Solid black lines represent the marlin main longline fishing grounds identified by the IOTC WPB. Does not include fleets non-reporting catch-and-effort data

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. A25a**), there are a number of uncertainties in the catches:

- Species aggregates: Catch reports refer to total catches of all three marlin species; catches by species have to be estimated by the IOTC Secretariat for some industrial fisheries (e.g., longliners of Indonesia and Philippines).
- Non-reporting fleets: Catches of non-reporting industrial longliners (e.g., India, NEI) and the gillnet fishery of Indonesia are estimated by the Secretariat using alternative information.
- Non-target species: Catches are likely to be incomplete for industrial fisheries for which striped marlin is not a target species.
- Conflicting catch reports: Longline catches from the Republic of Korea reported as nominal catches, and catch and effort reports are conflicting for some years (2000-2001, and 2010-2011), 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.
- Species mis-identification: Difficulties in the identification of marlins also contribute to uncertainties in the catch estimates of striped marlin available to the Secretariat.

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) (**Fig. A25b**).

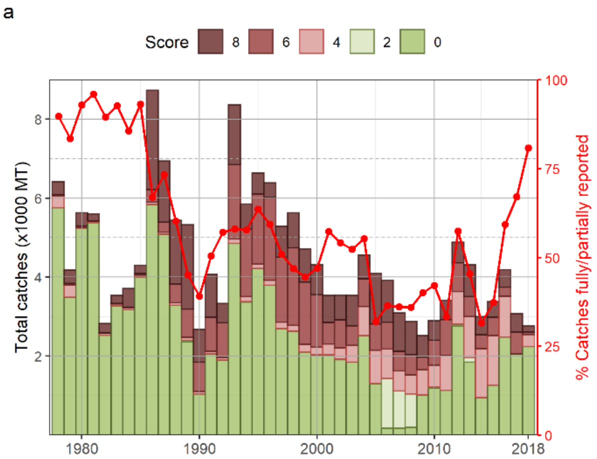
  No catch-and-effort data are available from sport fisheries, other than for partial data from the sport fisheries of Kenya; likewise no data are available for other artisanal fisheries (e.g., gillnet fisheries of Iran, Pakistan and Indonesia) or other industrial fisheries (NEI longliners and all purse seiners). Unreliable data from gillnet/longlines of Sri Lanka.

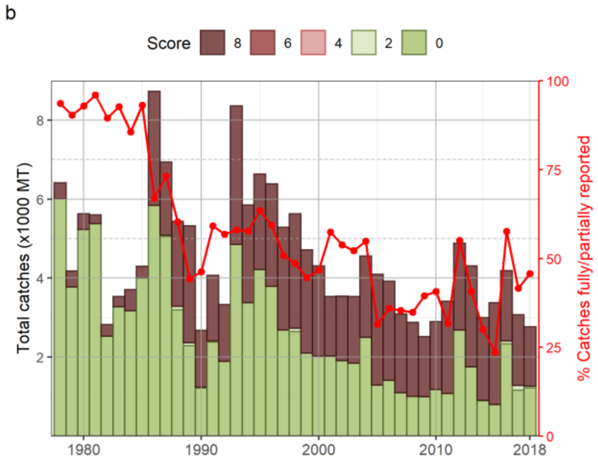
- Main CPUE series available: Japanese and Taiwanese longline fleet.

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

- Average fish weight: Can only be assessed for the longline fishery of Japan since 1970 and Taiwan,China since 1980. However, the number of specimens measured on Japanese longliners in recent years is very low. Also, mis-identification of striped and blue marlin may be occurring in the Taiwanese longline fishery. Thirdly, the length frequency distributions derived from samples collected on Taiwanese longliners differ greatly from those collected on longliners flagged in Japan.
- Catch-at-Size (Age) table: Not available, due to lack of size samples and uncertainty over the reliability of retained catch estimates, or conflicting catch-and-effort data. Fish size is derived from various length and weight information; however the reliability of the size data is reduced for some fleets and when relatively few fish out of the total catch are measured (**Fig. A25c**).
- Sex ratio data: Have not been provided to the Secretariat by CPCs.

Data quality (by dataset)





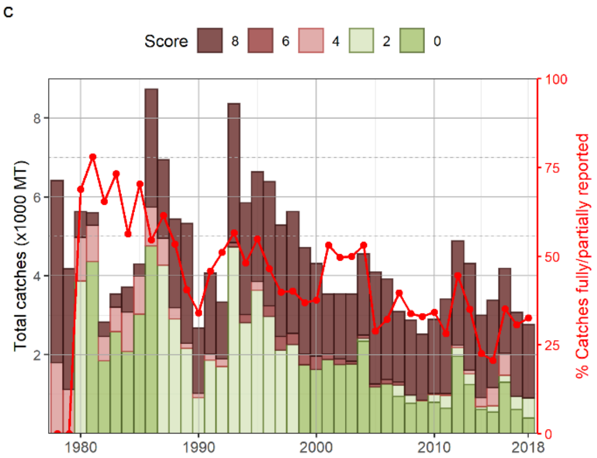


Fig. A25. Annual nominal catches (t) of striped marlin estimated by quality score (barplot) and percentage of nominal catch fully/partially reported to the IOTC Secretariat (red line with circles) for all fisheries (1978–2018) for (a) Nominal Catch; (b) Catch-Effort and (c) Size-Frequency data.

Each IOTC dataset is 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.*

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

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

APPENDIX IVF - MAIN STATISTICS OF INDO-PACIFIC SAILFISH

(*Extract from IOTC–2020–WPB18–07*)

Fisheries and main catch trends

- Main fishing gear (2014–2018): Gillnets account for around 70% of total catches in the Indian Ocean, followed by troll and hand lines (23%), with remaining catches recorded under longlines and other gears (**Table A5; Fig. A27**).
- Main fleets (and primary gear associated with catches): percentage of total catches (2014–18): If we exclude the Republic of Tanzania (whose catch data have been repeated in recent years by the Secretariat, due to the lack of explicit reporting from the country), then three quarters of the total catches of Indo-Pacific sailfish are accounted for by four countries situated in the Arabian Sea: I.R. Iran (gillnets): 35%; India (gillnets and trolling): 24%; Pakistan (gillnets): 9%; and Sri Lanka (gillnets and fresh longline): 9% (**Fig. A28**). 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 '90s, from around 7,000 t in the early '90s to over 26,000 t from 2010 onwards (**Table A5**). This increase is largely due to the development of the gillnet/longline fisheries in India and Sri Lanka as well as the reporting of consistent catches from Iranian gillnet vessels (in particular, for what concerns the offshore component of the fleet). In the case of I.R. Iran, gillnet catches have increased from less than 1,000 t in the early '90s to between 7,000 t and 12,000 t since 2013. Catches of the Sri Lankan gillnet fishery have significantly decreased in recent years, with a recent increase to levels around 1,000 t detected for years between 2014 and 2018, while the combined reported catch of the gillnet and hook-and-line fisheries of India reached 10,000 t in 2018.

  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 also reported catches of Indo-Pacific sailfish in the central western Indian Ocean, between Sri Lanka and the Maldives and the Mozambique Channel. In 2018, geo-referenced catches of Indo-Pacific sailfish were reported for the first time in both the small-scale and large-scale longline fisheries of China, showing that both fleets are also operating in the southern-central part of the Indian Ocean, i.e. south of 20° S and between 40-60° E.
- Discard levels**:** Moderate to high, however discard levels are largely unknown for most industrial fisheries (i.e., mostly longliners).

Changes to the catch series

Catch estimates for Indo-Pacific sailfish have been largely unaffected by the recent revisions to Indonesia's fresh longline fleet (as opposed to other species such as swordfish and blue marlins), mostly as sailfish are generally more associated with gillnet fisheries.

The revisions provided by the Government of Pakistan for their gillnet fleet, endorsed at the 22nd session of the IOTC Scientific Committee in 2019, introduced non-negligible changes to Indo-Pacific sailfish catches compared to what available at the previous WPB. In particular, captures from the species appear now to be significantly lower for the fleet in the entire time range covered by the revision (1987-2018, **Fig. A26**)[14]. It is worth mentioning that Indo-Pacific sailfish is the only billfish species explicitly reported in the revised Pakistan gillnet catches (1987-2017) as received by the Secretariat: starting from 2018, Pakistan is reporting distinct billfish species as opposed to the generic 'Billfish' aggregate used in the revised time series until 2017.

[14] See also the corresponding paragraph under the Swordfish section for further details on the process performed by the Secretariat to re-estimate the species composition from the aggregates of billfish species reported by the revised catches.

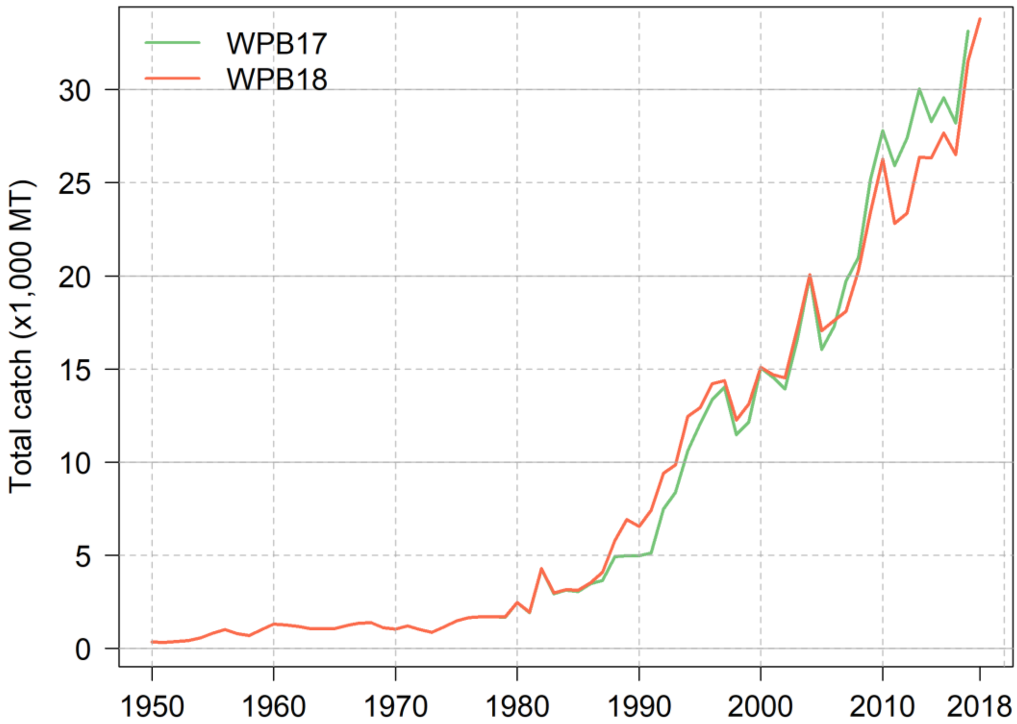


Fig. A26. Comparison of annual time series of total catches (t) of Indian Ocean Indo-Pacific sailfish available at the 17th (WPB17, 2019) and 18th (WPB18, 2020) sessions of the IOTC Working Party on Billfish

TABLE 5. Best scientific estimates of the annual nominal catches (t) of Indo-Pacific sailfish by fishery for the period 1950–2018. Colour codes (yellow = lower, green = higher) describe the intensity of captures by fishery across decades (left) and years (right). LL = Longline; GN = Gillnet; HL = Hook-and-Line (i.e. handline, trolling, baitboat, and sport fisheries); OT = Other gears (i.e. coastal purse seine, Danish purse seine, beach seine, and purse seine. Data as of May 2020

Fishery	By decade (average)						By year (last ten years)									
	1950s	**1960s**	**1970s**	**1980s**	**1990s**	**2000s**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
LL	297	804	385	270	1,815	2,467	2,313	1,638	1,557	1,731	2,130	1,530	1,121	1,790	1,095	1,251
GN	165	181	504	2,082	6,927	11,311	15,425	18,448	15,593	16,409	18,357	19,820	19,588	17,719	21,478	25,208
HL	171	213	427	1,427	2,471	3,934	5,479	5,999	5,477	5,049	5,515	4,791	6,632	6,764	8,530	7,121
OT	0	0	32	45	42	85	171	175	184	180	359	191	314	225	423	227
Total	**633**	**1,197**	**1,348**	**3,825**	**11,255**	**17,797**	**23,388**	**26,260**	**22,811**	**23,369**	**26,361**	**26,332**	**27,656**	**26,498**	**31,524**	**33,807**

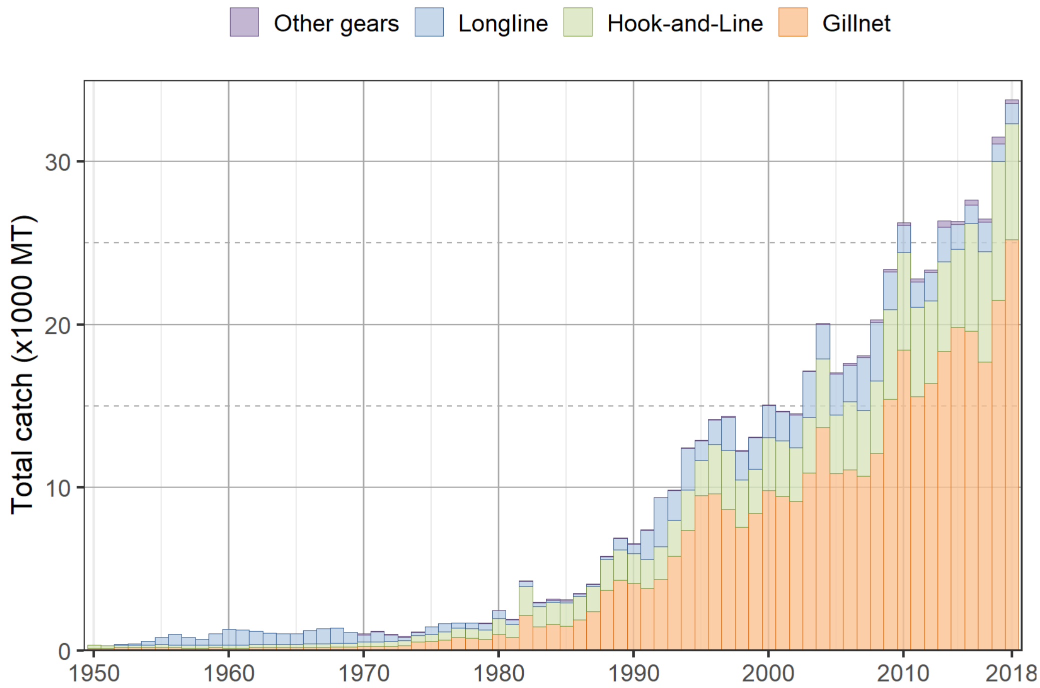


Fig. A27. Annual time series of nominal catches (t) of Indo-Pacific sailfish by gear group recorded in the IOTC database, 1950–2018. Other gears include coastal purse seine, Danish purse seine, beach seine and purse seine

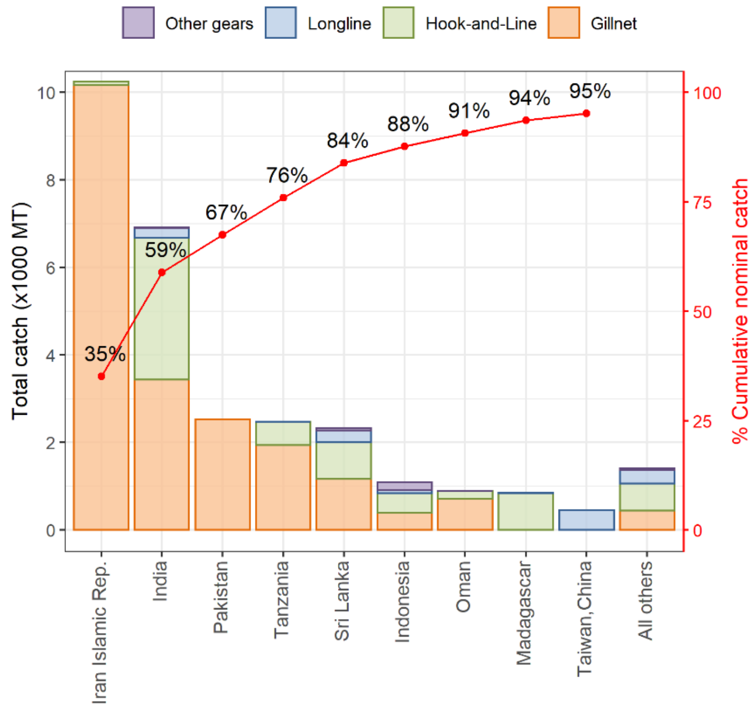


Fig. A28. Average nominal catches (t) of Indo-Pacific sailfish over the period 2014–2018, by gear group and CPC ordered according to the importance of catches. The red solid line indicates the cumulative percentage of the total combined catches of the species for the CPCs concerned

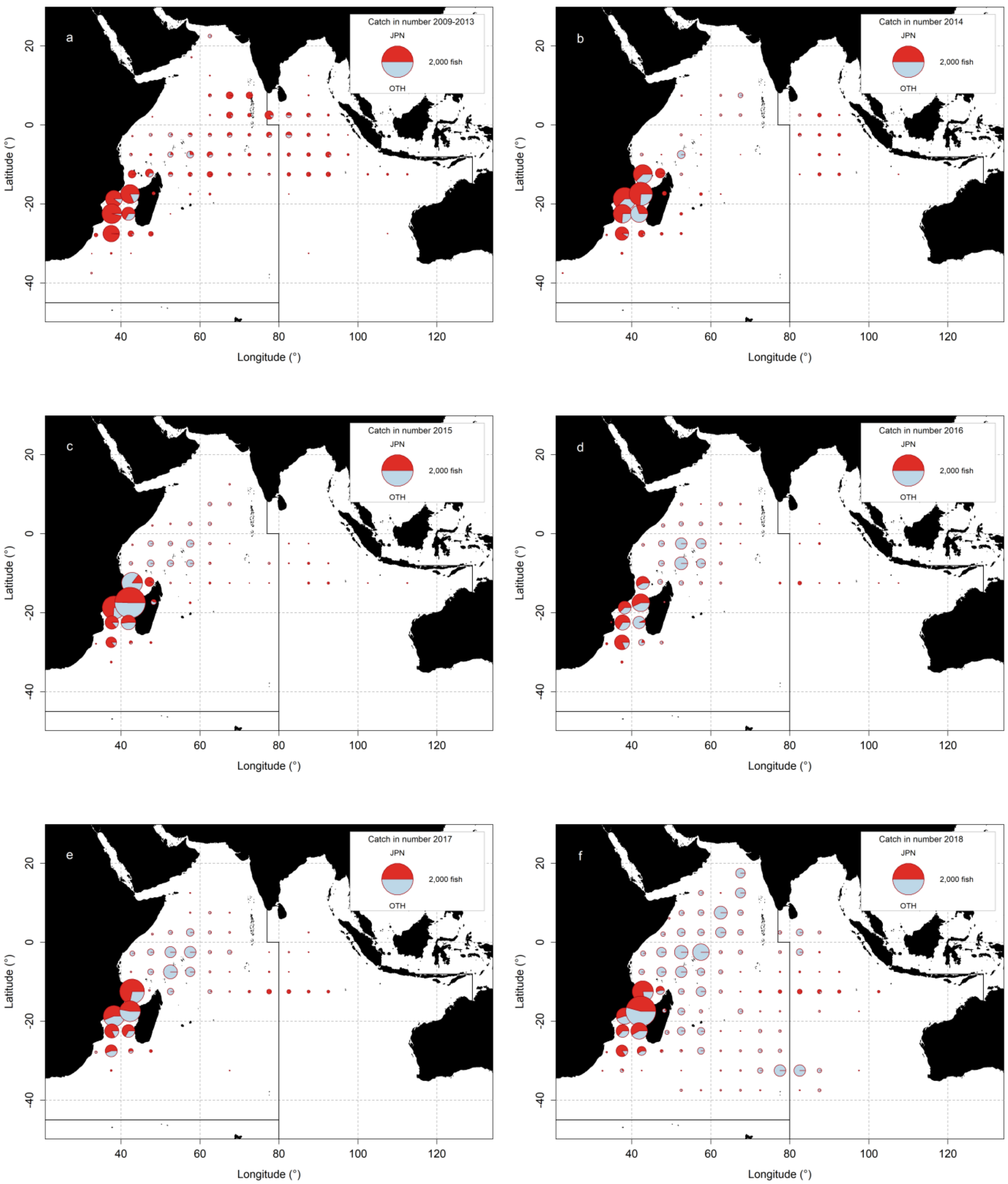


Fig. A29. Mean annual time-area catches (in number of fish) of Indo-Pacific sailfish as reported for the longline fisheries of Japan (JPN) and all other longline fleets for the period 2009–13, by fleet and for 2014–18, by year and fleet. Black solid lines represent the IOTC Areas. Does not include fleets non-reporting catch-and-effort data

Estimation of catches – data related issues

Retained catches – until 2015, a very high proportion of the catches of Indo-Pacific sailfish was estimated, or adjusted, by the IOTC Secretariat (**Fig. A30a**), 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, so species mis-identification is not an issue as with marlin species:

- Species aggregates: Catch reports often refer to total catches of all billfish species combined; catches by species are estimated by the Secretariat for some artisanal fisheries (e.g., gillnet/longline fishery of Sri Lanka and artisanal fisheries of India and Pakistan) and industrial fisheries (e.g., longliners of Indonesia and Philippines).
  Catches of Indo-Pacific sailfish reported for some fisheries may also refer to the combined catches of more than one species of billfish, in particular marlins and shortbill spearfish (i.e., in the case of coastal fisheries).
- Conflicting reports: In 2019 Pakistan submitted a revised catch series, dating back to the ‘80s, in which billfish catches were significantly lower than current estimates in the IOTC database, particularly for what concerns catches of Indo-Pacific sailfish. The revised catch series were officially endorsed at the 22nd Session of the IOTC Scientific Committee and have been included in IOTC database. The IOTC Secretariat is liaising with Pakistan to ensure a proper breakdown from the sources of all historical billfish revised catches into their specific components.
- Non-reporting fleets: Catches of non-reporting industrial longliners (e.g., India, NEI fleets) and the gillnet fishery of Indonesia are estimated by the Secretariat using alternative information.
- Non-target species: Catches are likely to be incomplete for industrial fisheries for which Indo-Pacific sailfish is not a target species.
- Missing or incomplete catches: Catches are likely to be incomplete for some artisanal fisheries (e.g., Pakistan gillnets, Maldives pole-and-line) due to under-reporting. There is also a generalized lack of catch data for most sport fisheries.

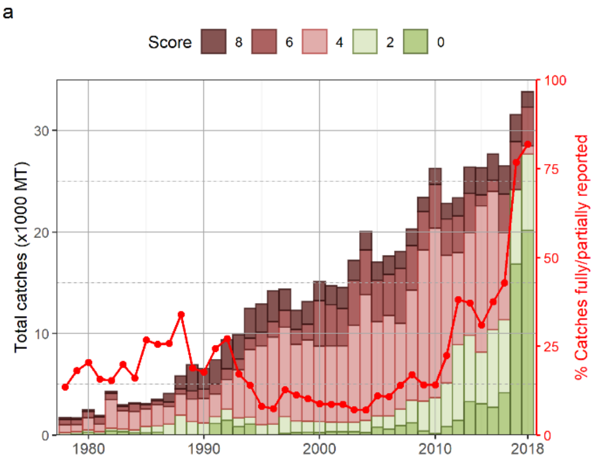
Catch-per-unit-effort (CPUE) trends

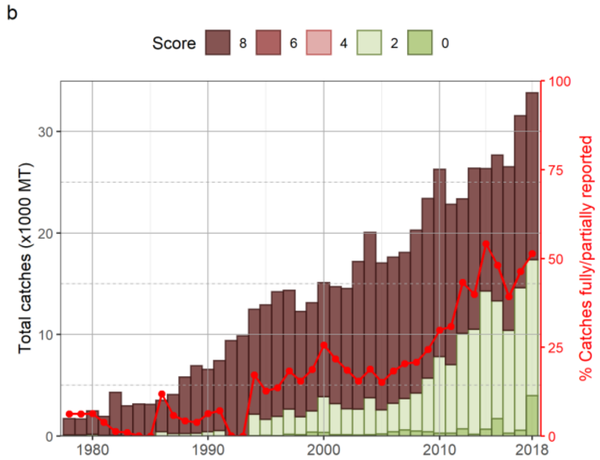
- Availability: Standardized and nominal CPUE series have not yet been developed. No catch and effort data are available from sport fisheries, other than partial data from the sport fisheries of Kenya; or other artisanal fisheries (e.g., I.R. Iran and Pakistan (gillnet), Sri Lanka (gillnet-longline), Indonesia (gillnet)) or industrial fisheries (NEI longliners and all purse seiners) (**Fig. A30b**).

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

- Average fish weight: Can only be assessed for the longline fishery of Japan since 1970 and the gillnet/longline fishery of Sri Lanka since the late ‘80s. The number of specimens measured on Japanese longliners in recent years is, however, very low. Furthermore, specimens discarded might be not accounted for in industrial fisheries, where they are presumed to be of lower size (leading to possible bias of existing samples).
- Catch-at-Size (Age) table: Not available, due to lack of size samples and uncertainty over the reliability of retained catch estimates, or conflicting catch-and-effort data (**Fig. A30c**). 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.

Data quality (by dataset)





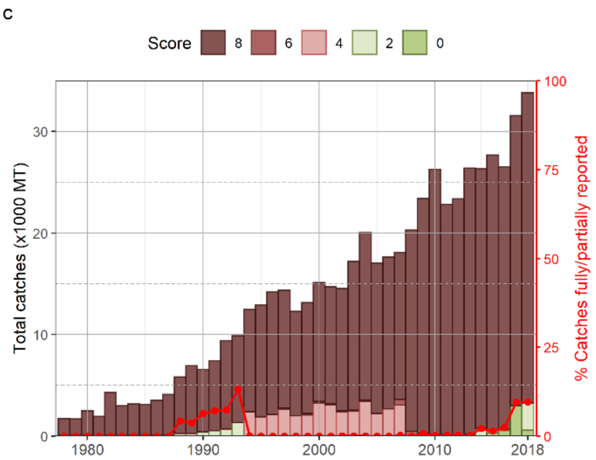


Fig. A30. Annual nominal catches (t) of Indo-Pacific sailfish estimated by quality score (barplot) and percentage of nominal catch fully/partially reported to the IOTC Secretariat (red line with circles) for all fisheries (1978–2018) for (a) Nominal Catch; (b) Catch-Effort and (c) Size-Frequency data.

Each IOTC dataset is 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.*

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–2020–WPB18–07*)

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

Nominal (retained) catches

Artisanal fisheries (including Sport 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 their gillnet/longline fishery, the catch ratio of blue marlin to black marlin has changed dramatically in recent years. This is thought to be a sign of frequent mis-identification rather than the effect of changes in catch rates or species composition for this fishery. Although the IOTC Secretariat has adjusted the catches of marlins using proportions derived from years known to have reliable data, the estimated catches remain uncertain.
- Indonesia (coastal fisheries): Catches of billfish reported by Indonesia for its artisanal fisheries in recent years are considerably higher than those reported in the past, at around 5% of the total catches of billfish in the Indian Ocean. In 2011 the Secretariat revised the nominal catch dataset for Indonesia, using information from various sources, including official reports. While Indonesia is implementing a number of improvements to the collection and validation of data for artisanal fisheries – including electronic logbooks and complete enumeration of catches at key landing sites – catches are considered to be uncertain for the small-scale fisheries.
- Sport fisheries of Australia, France(La Réunion), India, Indonesia, Madagascar, Mauritius, Oman, Seychelles, Sri Lanka, Tanzania, Thailand and United Arab Emirates: Data have either never been submitted, or are available for only a limited number of years for sport 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.

  In 2017 the IOTC Secretariat commissioned a pilot project to develop tools and training materials for CPCs to improve the collection and reporting of catch-and-effort and size frequency from sport fisheries in the Western Indian Ocean[15]. The Project focused on trialling specifically-developed data collection tools on a small number of CPCs, including La Réunion, Kenya, Mauritius and Seychelles – however data reporting continues to be an on-going issue for sports and recreational fisheries.
- Drifting gillnet fisheries of I.R. Iran and Pakistan:

  The gillnet fisheries of I.R. Iran and Pakistan are estimated to account for around 23,000 t of catches of billfish (equivalent to about 25% of the total billfish catches in the Indian Ocean). However, catches for this component remain uncertain:

  - I.R. Iran**:** In recent years I.R. Iran has reported catches of marlins and swordfish for their gillnet fishery (from 2012 onwards) which significantly revises the catch-by-species previously estimated by the IOTC Secretariat. While the IOTC Secretariat has used the new catch reports to re-build the historical series for its offshore gillnet fishery (pre-2012), the resulting estimates are thought to be highly uncertain.
  - Pakistan: In 2019, the IOTC working party on Data Collection and Statistics and the IOTC Scientific Committee endorsed the revised catch series (from 1987 onwards) provided by the Pakistan government for its gillnet fleet and based on the WWF-Pakistan funded data collection programme. This revised catch series introduces large differences in the reported catches of billfish species, in particular for what concerns swordfish, striped marlin and Indo-Pacific sailfish that are now far lower than what originally reported. Current catch estimates for Pakistan account for around 6% of the total catches of billfish in the Indian Ocean, and still suffer from the lack of per-species data until 2017 (catches are reported as "generic" billfish species until that year, with some explicit records of Indo-Pacific sailfish appearing throughout the revised time series).

[15] https://www.iotc.org/documents/facilitating-acquisition-catch-and-effort-and-size-data-sports-fisheries-western-indian

Industrial (longline) fisheries

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

  The revised catches are significantly lower for Indonesia's fresh longline fleet in recent years, compared to previous IOTC estimates, while total catches across all fleets have also been revised downwards by as much as 30% for each species as a consequence of the new estimation methodology. Further details on the alternative catch series can be found in paper IOTC-2018-WPB16-22[16].
- Taiwan,China (fresh longline): Recent issues with IOTC Secretariat's estimates of billfish for Indonesia relate to changes in the Taiwanese fresh-longline fleet, which in previous years has been used as a proxy fleet by the Secretariat to estimate the total catches and species composition (due to separate and unrelated issues with the reliability of Indonesia's officially reported catches).

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

  Both these issues (i.e., the sharp increase in average catches per vessel and changes to the species composition) require further clarification to ensure that the recent increase in average catches is valid.

Catch-and-effort and CPUE series

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

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

Size data (all fisheries)

Size data for all billfish species are generally considered to be unreliable and insufficient to be of use for stock assessment purposes, as the numbers of samples for all species are very often below the minimum sampling coverage of 1 fish per t of catch recommended by IOTC. Also, the quality of many of the samples collected by fishermen on commercial boats cannot be verified.

- Taiwan,China (longline): Size data have been available since 1980; however, the IOTC Secretariat has identified issues in the length frequency distributions, in particular fish recorded under various types of size class bins (e.g. 1 cm, 2 cm, 10 cm, etc.) that are reported under identical class bins (e.g. 2 cm, with all fish between 10-20 cm reported as 10-12 cm). For this reason, the average weights estimated for this fishery are considered unreliable.

[16] https://www.iotc.org/documents/revision-iotc-scientific-estimates-indonesias-fresh-longline-catches-0

In early 2019 an IOTC consultant was hired to review IOTC's longline size frequency data which, among other tasks, included visits to the national fisheries institutions of the key fleets collecting longline size data. The work has now been finalized and its final report will be presented at the IOTC Working Party on Tropical Tuna as well as at the Scientific Committee in 2020.

- I.R. Iran and Pakistan (gillnet): No size data reported for billfish species for gillnet fisheries since the '80s. I.R. Iran has started to provide (since 2020) properly georeferenced size-frequency data which are in the process of being incorporated in the IOTC databases: inclusion of historical data from the fleet is also planned.
- Sri Lanka (gillnet/longline)**:** Although Sri Lanka has reported length frequency data for swordfish and marlins in recent years, the lengths reported are considered highly uncertain, due to mis-identification of marlins and likely sampling bias (large specimens of swordfish and marlins are highly processed and not sampled for lengths, while small specimens are sampled).
- India and Oman (longline)**:** To date, India and Oman have not reported size frequency data for billfish from their commercial longline fisheries.
- Indonesia (longline): Size frequency data have been reported for its fresh-tuna longline fishery in recent years. However, the samples cannot be fully disaggregated by fishing area (i.e., 5-degree square grid) due to being sampled in port (rather than on-board). For this reason, the samples in the IOTC database are considered to be of limited value.
- Taiwan,China (fresh-tuna longline): In 2012 Taiwan,China started submitting size frequency data for marlins and swordfish for their fresh tuna longline fleet. In the case of data available for marlins, the data are considered uncertain due to the small number of samples for some species, or discrepancies in the size frequency distributions.
- India and Indonesia (artisanal fisheries): To date, India and Indonesia have not reported any billfish size frequency data for their artisanal fisheries.

Biological data (all billfish species)

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

- 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. I.R. Iran (gillnet fisheries): In previous years I.R. Iran has reported aggregated catches for all billfish species, which were estimated by species and gear by the IOTC Secretariat. Since 2012 Iran has now begun to report catches by billfish species, which significantly revise the catches-by-species previously estimated by the IOTC Secretariat. The main changes are higher proportions of black marlin, rather than blue marlin reported by I.R. Iran, assigned to the offshore gillnet fishery. As a result of changes in the catch series total catches of black marlin for I.R. Iran were revised upwards by as much as 30% to 50% during the mid '00s.

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

ii. Pakistan (gillnet fisheries): In 2019 Pakistan submitted a revised catch series, dating back to the '80s, and which significantly reduces estimates for billfish for Pakistan in the IOTC database – particularly for Indo-Pacific sailfish. As discussed earlier, billfish catches are reported as aggregated until 2017 included, with the exception of sporadic records of Indo-Pacific catches appearing throughout the time series. The IOTC Secretariat estimates the proportion of specific billfish species using a variety of different techniques (combining proxy years, fleets and areas) but a breakdown of aggregated catches provided straight from the source could contribute to increase the accuracy of the data.

While the new catch series is considered to be an improvement compared to the previous estimates, the composition of billfish species catches for Pakistan gillnet fleet remain uncertain and should be revisited as new information becomes available.

iii. Indonesia (fresh longline): Due to issues with the reliability of catch estimates of Indonesia's fresh longline fleet in recent years, the IOTC Secretariat provided the WPB-16 meeting with an alternative catch series, based on a new estimation methodology developed in collaboration with Indonesia. The revised catch series mostly affected Indonesia's catches of swordfish, striped marlin, and blue marlin estimated by the IOTC Secretariat.

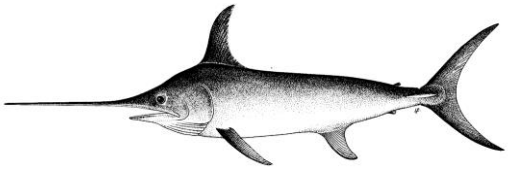
While the new catch series is considered to be an improvement compared to the previous estimates, catches for Indonesia's fresh longline fleet remain uncertain and should be revisited as new information becomes available.

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

Both these issues (i.e., the sharp increase in average catches per vessel and changes to the species composition) require further clarification to ensure that the recent increase in average catches is valid.

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 A6. Swordfish: Status of swordfish (*Xiphias gladius*) in the Indian Ocean.

Area[1]	Indicators		2020 stock status determination
Indian Ocean	Catch 2018[2] Average catch 2014-2018	30,847 t 30,632 t	
	MSY (1,000 t) (80% CI) F_{MSY} (80% CI) SB_{MSY} (1,000 t) (80% CI) F_{2018}/F_{MSY} (80% CI) SB_{2018}/SB_{MSY} (80% CI) SB_{2018}/SB_{1950} (80% CI)	33 (27–40) 0.23 (0.15–0.31) 59 (41–77) 0.60 (0.40–0.83) 1.75 (1.28–2.35) 0.42 (0.36–0.47)	

[1] Boundaries for the Indian Ocean stock assessment are defined as the IOTC area of competence.
[2] Proportion of catch estimated or partially estimated by IOTC Secretariat in 2018: 3.5%

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 2020 using stock synthesis with fisheries data up to 2018. 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 (F2018/F_{MSY}< 1; SB2018/SB_{MSY}> 1). The two alternative models (ASPIC and JABBA) applied to swordfish also indicated that the stock was above a biomass level that would produce MSY. Spawning stock biomass in 2018 was estimated to be 40-83% of the unfished levels. Most recent catches of 30,847 t in 2018 are below the *MSY* level (33,000 t). On the weight-of-evidence available in 2020, the stock is determined to be ***not overfished*** and ***not subject to overfishing*** (**Table A6**, **Fig. A31**).

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 2028 if catches are maintained at 2018 levels (<1% risk that SB2028< SB_{MSY}, and <1% risk that F2028> F_{MSY}) (**Table A72**). However, the Southern regions exhibit declining biomass trends which indicate higher depletion in these regions, compared to northern regions.

Management advice. The most recent catches (30,847 t in 2018) are below the MSY level (33,000 t). Under the current levels of catches, the stock biomass is projected to remain relatively stable, with a high probability of maintaining at or above the SB_{MSY} for the longer term. An increase of 40% or more from current catch levels will likely result in the biomass dropping below the SB_{MSY} level for the longer term (with approximately 50% probability). Taking into account the updated information regarding swordfish stock structure (IOTC-2020-WPB18-09), as well as the differential CPUE and biomass trends between regions, the WPB should continue to discuss the swordfish stock assessment model specifications and consider the feasibility of including a multi-stock assessment in 2023. Recognising that there is recurring evidence for localised depletion in the southern regions the WPB expresses concern and suggests this should be further monitored.

The following key points should also be noted:

- **Maximum Sustainable Yield (MSY)**: Estimate for the Indian Ocean is 33,000 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. A32**).
    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. A32**).
- **Main fishing gear (average catches 2014-18)**: Longline catches currently comprise around 46% of total swordfish catches in the Indian Ocean (**Fig. A32**).
- **Main fleets (average catches 2014-18):** Over 50% of swordfish catches are accounted for by three fleets: Taiwan,China (longline): 22%; Sri Lanka (longline-gillnet): 21%; EU,Spain (swordfish targeted longline): 10%.

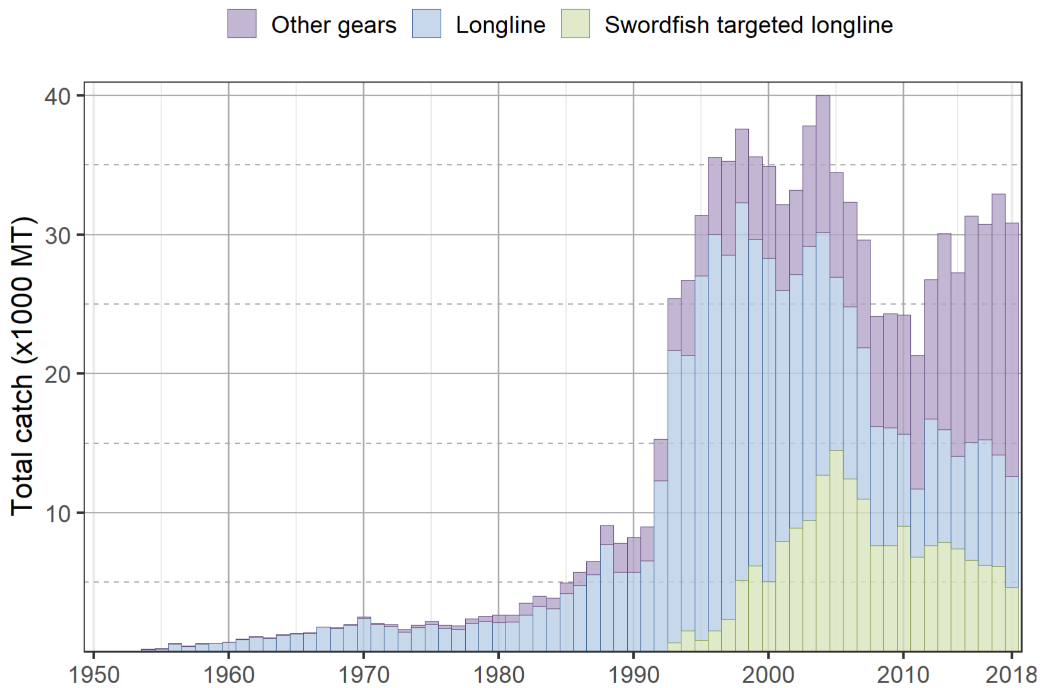


Fig. A31. Annual time series of nominal catches (t) of swordfish by gear group recorded in the IOTC database, 1950–2018. *Other gears* include longline-gillnet, handline, gillnet, coastal longline, troll line, sport fishing, and all other gears.

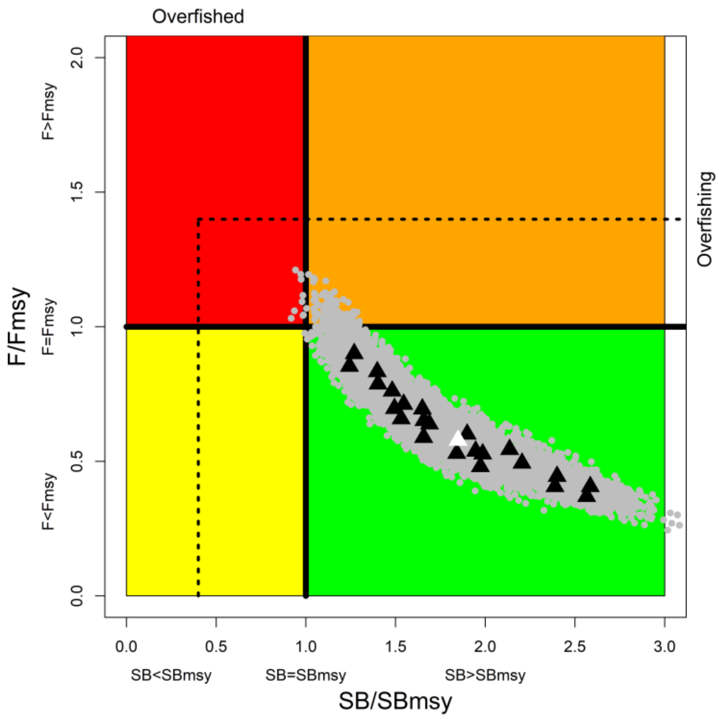


Fig. A32. Swordfish: current stock status, relative to SB_{MSY} (x-axis) and F_{MSY} (y-axis) reference points for the final model grid. Triangles represent MPD estimates from individual models (white triangle represent the estimate from the basic model). Grey dots represent uncertainty from individual models. The dashed lines represent limit reference points for Indian Ocean swordfish (SBlim = 0.4 SB_{MSY} and Flim = 1.4 FMSY).

TABLE A7. Swordfish: SS3 aggregated Indian Ocean assessment Kobe II Strategy Matrix. Probability (percentage) of violating the MSY-based target reference points for five constant catch projections relative to 2018* catch level (30,847 t), 0%, ± 20%, ± 40%) projected for 10 years.

Pr ($B<B_{MSY}$)

Catch	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**
60%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
80%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
100%	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02
120%	0.00	0.00	0.01	0.02	0.03	0.06	0.08	0.11	0.13	0.18
140%	0.00	0.01	0.01	0.04	0.10	0.17	0.25	0.32	0.40	0.47

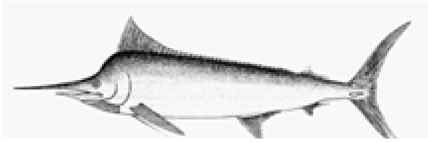
Pr ($F>F_{MSY}$)

Catch	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**
60%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
80%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
100%	0.02	0.03	0.04	0.04	0.04	0.05	0.06	0.07	0.06	0.07
120%	0.10	0.13	0.18	0.21	0.26	0.30	0.32	0.35	0.38	0.42
140%	0.25	0.34	0.44	0.51	0.57	0.62	0.66	0.70	0.73	0.78

** 2018 catches, at the time of the last swordfish assessment conducted in 2020.*

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 A8. Black marlin: Status of black marlin (*Makaira indica*) in the Indian Ocean.

Area[1]	Indicators		2020 stock status determination
Indian Ocean	Catch 2018[2] Average catch 2014–2018	18,841 t 18,424 t	
	MSY (1,000 t) (80% CI) F_{MSY} (80% CI) B_{MSY} (1,000 t) (80% CI) F_{2017}/F_{MSY} (80% CI) B_{2017}/B_{MSY} (80% CI) B_{2017}/B_0 (80% CI)	12.93 (9.44-18.20) 0.18 (0.11-0.30) 72.66 (45.52-119.47) 0.96 (0.77-1.12) 1.68 (1.32-2.10) 0.62 (0.49-0.78)	

[1] Boundaries for the Indian Ocean = IOTC area of competence;
[2] Proportion of catch fully or partially estimated by IOTC Secretariat in 2018: 22%

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

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

Stock status. No new stock assessment for black marlin was carried out in 2020, thus, the stock status is determined on the basis of the 2018 assessment based on JABBA and other indicators presented in 2019. This assessment suggests that the point estimate for the stock in 2017 is in the green zone in the Kobe plot with F/F_{MSY}=0.96 (0.77-1.12) and B/B_{MSY}=1.68 (1.32-2.10). The Kobe plot (**Fig. A34**) from the JABBA model indicated that the stock is not **subject to overfishing** and is currently not **overfished** (**Table A8**; **Fig. A34**), however these status estimates are subject to a high degree of uncertainty. The recent sharp increases in total catches (e.g., from 13,000 t in 2012 to over 21,000 t by 2016), and conflicts in information in CPUE and catch data lead to large uncertainties in the assessment outputs. This caused the point estimate of the stock status to change from the red to the green zones of the Kobe plot without any evidence of a rebuilding trend. **As such, the results of the assessment are uncertain and should be interpreted with caution.**

Outlook. While the recent high catches seem to be mainly due to developing coastal fisheries operating in the core habitat of the species, the CPUE indicators are from industrial fleets operating mostly offshore on the edges of the species distribution. However, the recent increases in catches are much higher than MSY and are a cause for concern and will likely continue to drive the population towards overfished status.

Management advice. Current catches (>14,600 t in 2017) (**Fig. A33**) are higher than MSY estimate (12,930 t), which is likely to associate with high uncertainty. The catch limits as stipulated in Resolution 18/05 have also been exceeded. The Commission should provide mechanisms to ensure that catch limits are not exceeded by all concerned fisheries. Projections were not carried out due to the poor predictive capabilities identified in the assessment diagnostics.

The following key points should be noted:

- **Maximum Sustainable Yield (MSY)**: Estimate for the whole Indian Ocean is 12,930 t.
- **Provisional reference points**: Although the Commission adopted reference points for 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 (average catches 2014-18)**:
  Black marlin are largely considered to be a non-target species of industrial and artisanal fisheries. Gillnets account for more than 50% of total catches in the Indian Ocean, followed by troll and handlines (32%), with remaining catches recorded under longlines (12%) (**Fig. A33**).
- **Main fleets (average catches 2014-18):**
  More than 70% of the total catches of black marlin are accounted for by three fleets: I.R. Iran (gillnet): 30%; India (gillnet and trolling): 23%; Sri Lanka (gillnet and fresh longline): 21%.

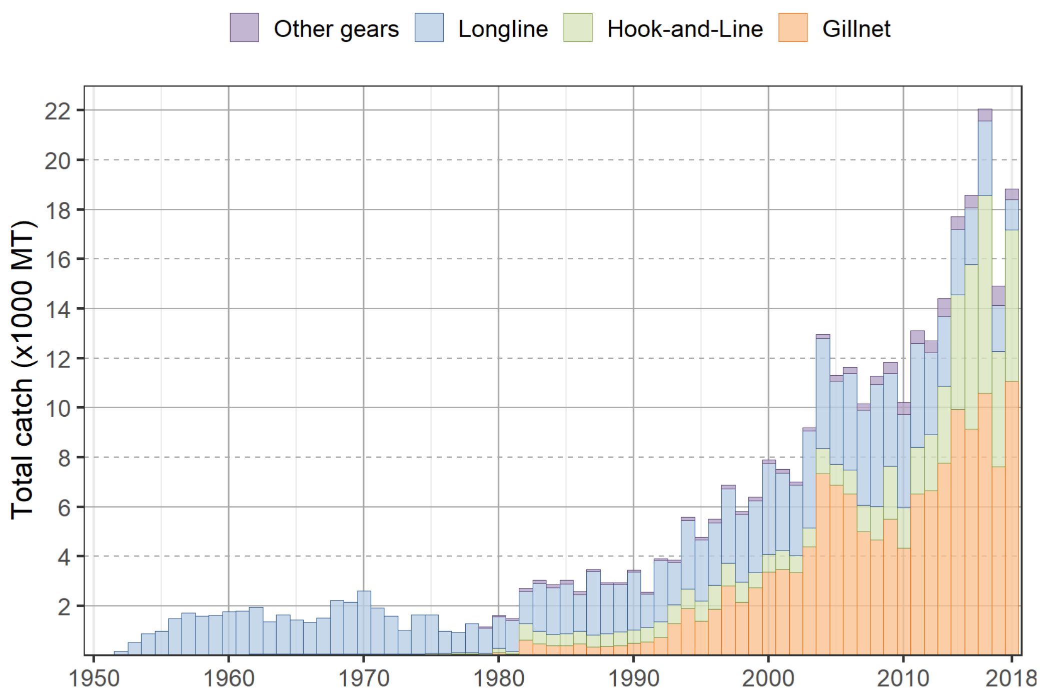


Fig. A33. Annual time series of nominal catches (t) of black marlin by gear group recorded in the IOTC database, 1950–2018. *Other gears* include coastal purse seine, Danish purse seine, beach seine and purse seine.

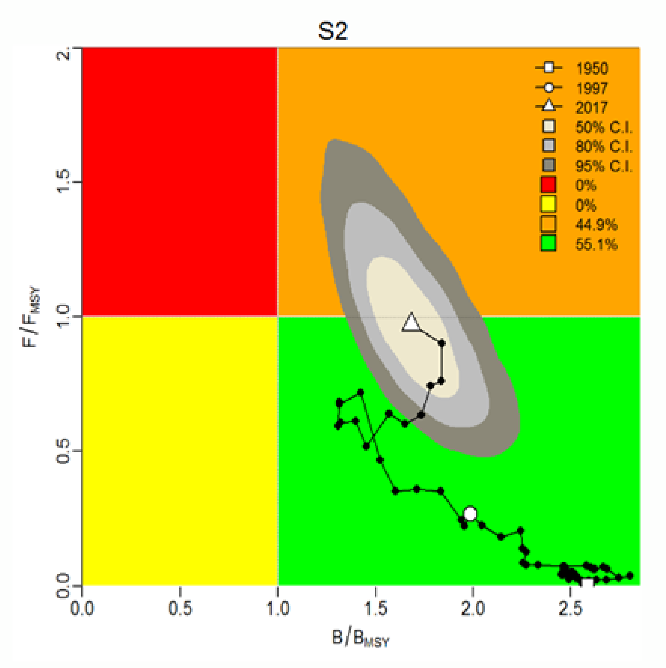
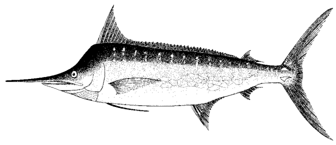


Fig. A34. Black marlin: JABBA Indian Ocean assessment Kobe plots for black marlin (contours are the 50, 80 and 95 percentiles of the 2017 estimate). Black line indicates the trajectory of the point estimates for the total biomass (B) ratio and fishing mortality (F) ratio for each year 1950–2017.

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

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



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

TABLE A9. Blue marlin: Status of blue marlin (*Makaira nigricans*) in the Indian Ocean.

Area[1]	Indicators		2020 stock status determination
Indian Ocean	Catch 2018[2]	8,492 t	87%*
	Average catch 2014-2018	9,898 t	
	MSY (1,000 t) (80% CI)	9.98 (8.18 –11.86)	
	F_{MSY} (80% CI)	0.21 (0.13 – 0.35)	
	B_{MSY} (1,000 t) (80% CI)	47 (29.9 – 75.3)	
	F_{2017}/F_{MSY} (80% CI)	1.47 (0.96 – 2.35)	
	B_{2017}/B_{MSY} (80% CI)	0.82 (0.56 – 1.15)	
	B_{2017}/B_0 (80% CI)	0.41 (0.28 – 0.57)	

[1] Boundaries for the Indian Ocean = IOTC area of competence.
[2] Proportion of catch estimated or partially estimated by IOTC Secretariat in 2018: 11%.
* 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)	87%	10%
Stock not subject to overfishing (F_{year}/F_{MSY}≤ 1)	0%	3%
Not assessed/Uncertain		

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

Stock status. Stock status based on the Bayesian State-Space Surplus Production model JABBA suggests that there is an 87% probability that the Indian Ocean blue marlin stock in 2017 is in the red zone of the Kobe plot, indicating the stock is **overfished** and **subject to overfishing (**B_{2017}/B_{MSY}=0.82 and F_{2017}/F_{MSY}=1.47) as shown in **Table A9** and **Fig. A36**. The most recent catch exceeds the estimate of MSY ($catch_{2017}$ = 12,796; MSY = 9,984). The previous assessment of blue marlin (Andrade 2016) concluded that in 2015 the stock was subject to overfishing but not overfished. The change in stock status can be attributed to increased catches for the period 2015-2017 as well as improved standardisation of CPUE indices, which includes the area disaggregation of JPN and TWN indices to account for fleet dynamics.

Outlook. The B_{2017}/B_{MSY} trajectory declined from the mid-1980s to 2008 and a steady increase of F/F_{MSY} since the mid-1980s has continued unabated. Periodic data conflict between the CPUE indices included in the assessment, particularly JPN and TWN, inflate uncertainty in B_{2017}/B_{MSY} and F_{2017}/F_{MSY} point estimates. However, a 'drop one' sensitivity analysis indicated that omitting any of the CPUE time-series would not alter the stock status.

Management advice. The current catches of blue marlin (average of 11,761 t in the last 5 years, 2013-2017) are higher than MSY (9,984 t) and the stock is currently overfished and subject to overfishing. In order to achieve the Commission objectives of being in the green zone of the Kobe Plot by 2027 ($F_{2027} < F_{MSY}$ and $B_{2027} > B_{MSY}$) with at least a 60% chance, the catches of blue marlin would have to be reduced by 35% compared to the average of the last 3 years, to a maximum value of approximately 7,800 t.

The following key points should also be noted:

- **Maximum Sustainable Yield (MSY)**: estimate for the Indian Ocean blue marlin stock is 9,980 t (estimated range 8,180–11,860 t).
- **Provisional reference points**: Although the Commission adopted reference points for swordfish in Resolution 15/10 *on target and limit reference points and a decision framework*, no such interim reference points, nor harvest control rules have been established for blue marlin.
- **Main fishing gear (average catches 2014-18)**: Blue marlin are largely considered to be a non-target species of industrial and artisanal fisheries. Longline catches account for around 65% of total catches in the Indian Ocean, followed by gillnets (22%), with remaining catches recorded under troll and handlines (**Fig. A35**).
- **Main fleets (average catches 2014-18):** Around 80% of the total catches of blue marlin are accounted for by four fleets: Taiwan,China (longline): 43%; Sri Lanka (gillnet, hook and line and longline): 16%; I.R. Iran (gillnet): 13%, and Indonesia (longline and hook-and-line): 6%.

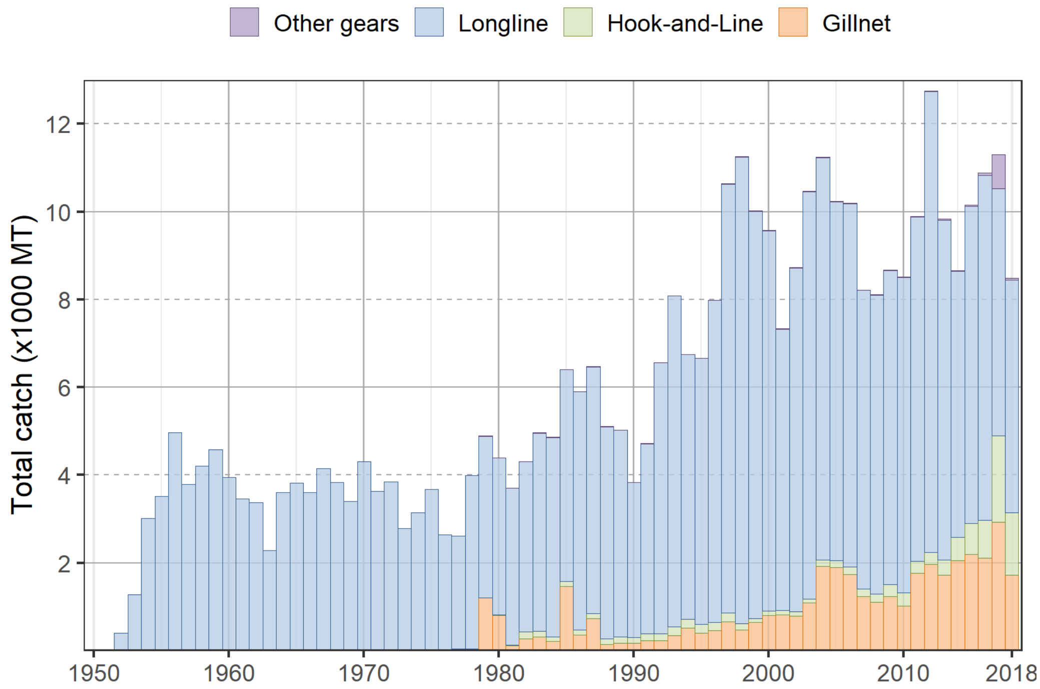


Fig. A35. Annual time series of nominal catches (t) of blue marlin by gear group recorded in the IOTC database, 1950–2018. *Other gears* include coastal purse seine, Danish purse seine, beach seine and purse seine.

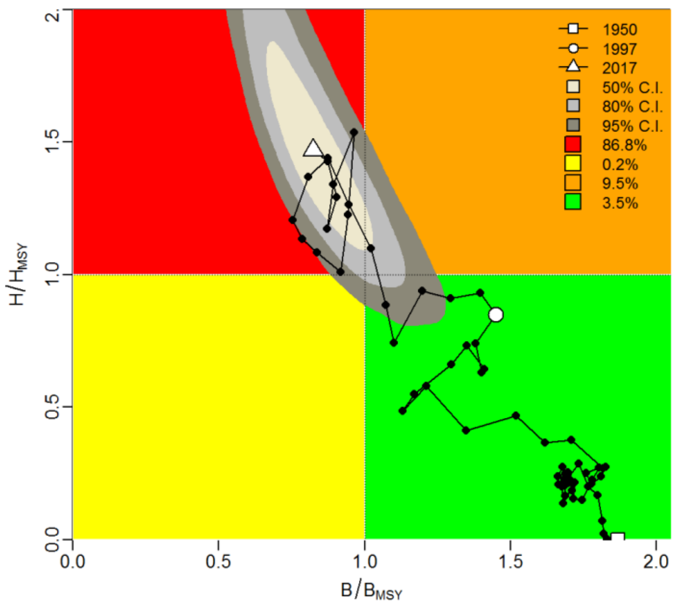


Fig. 2. Blue marlin: Kobe stock status plot for the Indian Ocean for blue marlin, from the final JABBA base case (the black line traces the trajectory of the stock over time. Contours represent the smoothed probability distribution for 2018 (isopleths are probability relative to the maximum).

Table A10. Blue Marlin: Indian Ocean JABBA Kobe II Strategy Matrix. Probability (percentage) of achieving the green quadrant of the KOBE plot nine constant catch projections, with future catch assuming to be 30–110% (in increments of 10%) of the 2017 catch level (12,029 t).

TAC | Year	2019	2020	2021	2022	2023	2024	2025	2026	2027
30% (3609)	20	39	58	71	81	87	91	93	95
40% (4812)	20	36	51	63	72	79	83	87	90
50% (6014)	21	33	44	54	62	68	73	77	81
60% (7217)	20	29	38	45	51	56	60	64	67
70% (8420)	20	26	32	37	41	45	47	50	52
80% (9623)	20	23	26	28	30	31	33	34	35
90% (10826)	17	18	19	19	20	20	20	20	20
100% (12029)	11	11	11	10	10	10	10	9	9
110% (13232)	7	6	6	6	5	5	4	4	4

APPENDIX IX - [DRAFT] RESOURCE STOCK STATUS SUMMARIES – STRIPED MARLIN

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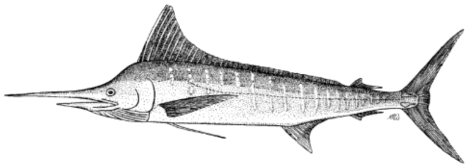


TABLE A11. Striped marlin: Status of striped marlin (*Tetrapturus audax*) in the Indian Ocean.

Area[1]	Indicators		2020 stock status determination
Indian Ocean	Catch 2018[2]	2,769 t	**99.8%***
	Average catch 2014-2018	3,281 t	
	MSY (1,000 t) (JABBA)	4.73 (4.27–5.18)[5]	
	F_{MSY} (JABBA)	0.26 (0.20–0.34)	
	B_{MSY} (1,000 t) (JABBA)	17.94 (14.21–23.13)	
	F_{2017}/F_{MSY} (JABBA)	1.99 (1.21–3.62)	
	B_{2017}/B_{MSY} (JABBA)	0.33 (0.18–0.54)	
	SB_{2017}/SB_{MSY} (SS3)[6]	0.373	
	B_{2017}/K(JABBA)	0.12 (0.07–0.20)	
	SB_{2017}/SB_{1950} (SS3)	0.13 (0.09–0.14)	

[1] Boundaries for the Indian Ocean = IOTC area of competence
[2] Proportion of catch estimated or partially estimated by IOTC Secretariat in 2018: 20%
[5] JABBA estimates are the range of central values shown in Figure 2.
[6] SS3 is the only model that used SB/SB_{MSY}, all others used B/B_{MSY}.
* Estimated probability that the stock is in the respective quadrant of the Kobe plot (shown below), derived from the confidence intervals associated with the current stock status.

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

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

Stock status. No new stock assessment for striped marlin was carried out in 2020, thus, the stock status is determined on the basis of the 2018 assessment and other indicators presented in 2019. In 2018 a stock assessment was conducted based on two different models: JABBA, a Bayesian state-space production model; and SS3, an integrated length-based model. Both models were very consistent and confirmed the results from 2012, 2013, 2015 and 2017 assessments, indicating that the stock is subject to overfishing ($F>F_{MSY}$) and overfished, with the biomass for at least the past ten years below the level which would produce MSY ($B<B_{MSY}$). On the weight-of-evidence available in 2018, the stock status of striped marlin is determined to be ***overfished*** and ***subject to overfishing*** (**Table A11**; **Fig. A38**)

Outlook. The decrease in longline catches and fishing effort in the years 2009–11 reduced the pressure on the Indian Ocean stock. However, given the increase in catches reported since 2011 (mostly from coastal fisheries), combined with the results obtained from the last stock assessments conducted in 2012, 2013, 2015, 2017 and 2018, the outlook is pessimistic. As requested by IOTC Resolution 18/05, K2SM probabilities are provided with options to reduce fishing mortality with a view to recover the stocks to the green zone of the Kobe Plot with levels of probability ranging from 60% to 90% by 2026 at latest (**Table A12**).

Management advice. Current or increasing catches have a very high risk of further decline in the stock status. Current 2017 catches (Fig. 1) are lower than MSY (4,730 t) but the stock has been overfished for more than two decades and is now in a highly depleted state. If the Commission wishes to recover the stock to the green quadrant of the Kobe plot with a probability ranging from 60% to 90% by 2026, it needs to provide mechanisms to ensure the maximum annual catches remain between 1,500 t – 2,200 t (**Table A13**).

The following key points should also be noted:

- **Maximum Sustainable Yield (MSY)**: estimates for the Indian Ocean stock are highly uncertain and estimates range between 4,270 t – 5,180 t. However, the current biomass is well below the B_{MSY} reference point and fishing mortality is in excess of F_{MSY} at recent catch levels.
- **Provisional reference points**: Although the Commission adopted reference points for swordfish in Resolution 15/10 *on target and limit reference points and a decision framework*, no such interim reference points have been established for striped marlin.
- **Main fishing gear (average catches 2014-18)**: Striped marlin is largely considered to be a non-target species of industrial fisheries. Gillnets account for about 50% of total catches in the Indian Ocean, followed by longlines (40%). The remaining catches are mostly recorded under troll and handlines (**Fig. A37**).
- **Main fleets (average catches 2014-18):** Around 75% of the total catches of striped marlin are accounted for by four fleets: I.R. Iran (gillnet): 25%; Taiwan,China (longline): 20%; Indonesia (longline): 18%; and Pakistan (gillnet): 12%

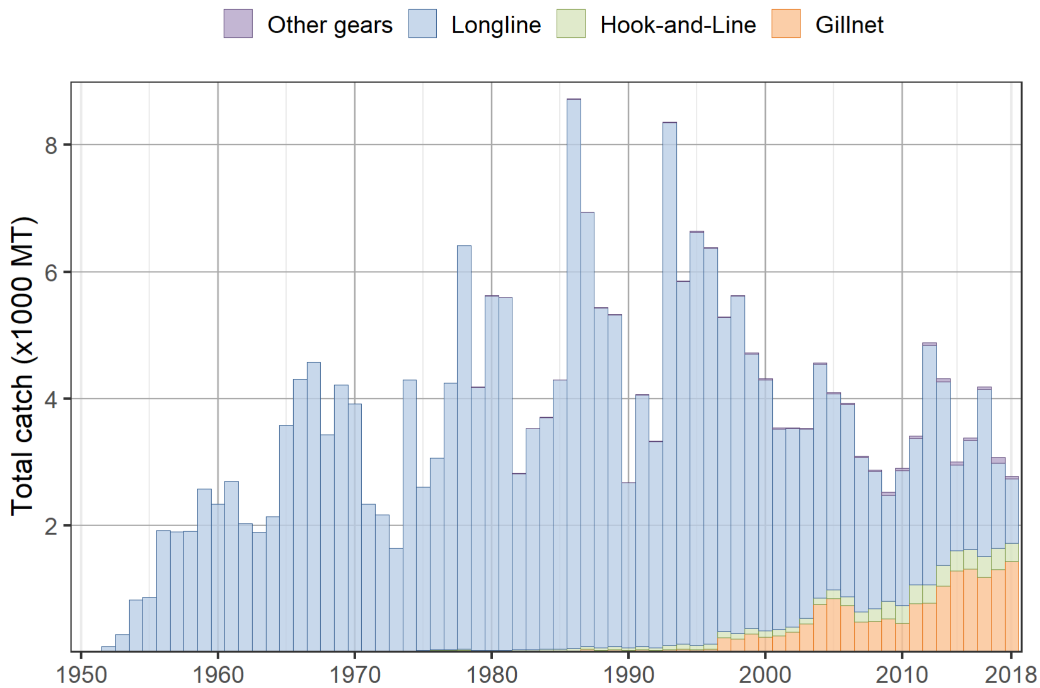


Fig. A37. Annual time series of nominal catches (t) of striped marlin by gear group recorded in the IOTC database, 1950–2018. Other gears include coastal purse seine, Danish purse seine, beach seine and purse seine

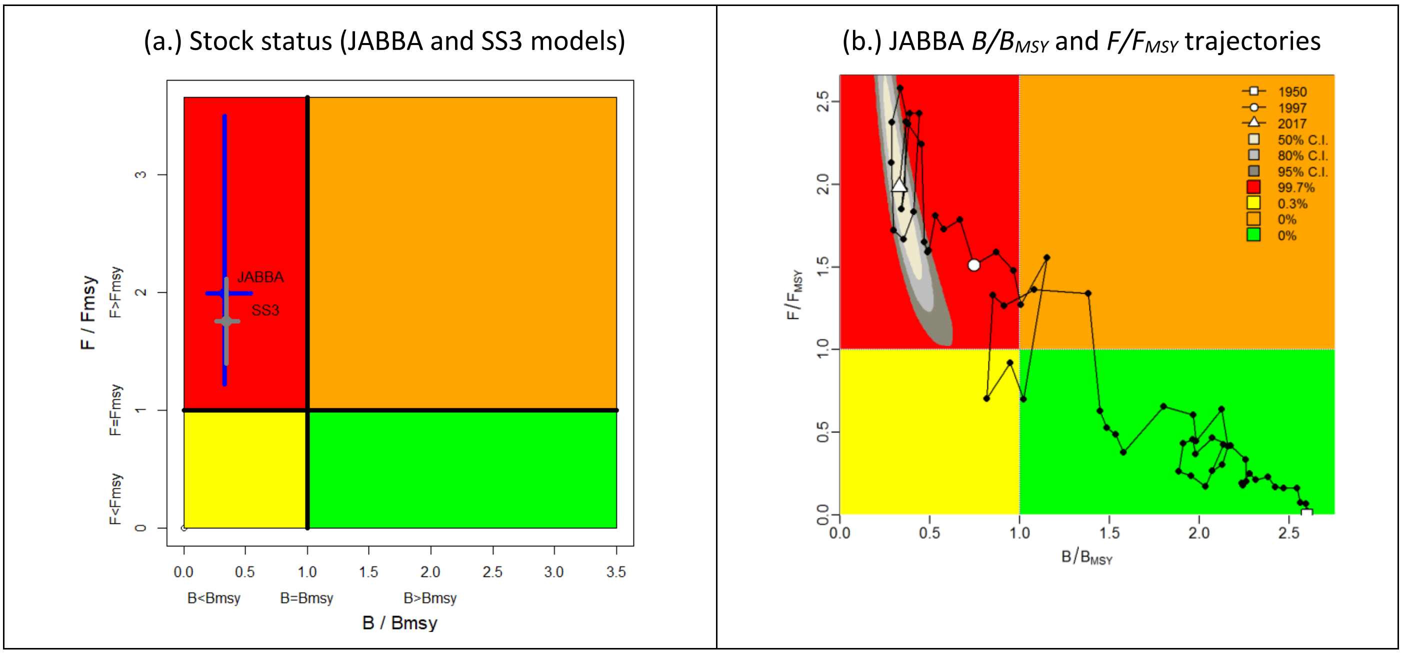


Fig. A38. (a): Striped marlin: Stock status from the Indian Ocean assessment JABBA (Bayesian State Space Surplus Production Model) and SS3 models with the confidence intervals (left); (b): Trajectories (1950-2017) of B/B_{MSY} *and* F/F_{MSY} from the JABBA model. NB: SS3 refers to SB/SB_{MSY} while the JABBA model's output refers to B/B_{MSY}.

TABLE A12. Striped marlin: JABBA Indian Ocean assessment Kobe II Strategy Matrix. Probability (percentage) of violating the MSY-based target reference points for nine constant catch projections relative to the average 2015-2017 catch level (3,512 t)*, ± 10%, ± 20%, ± 30% ± 40%) projected for 3 and 10 years.

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

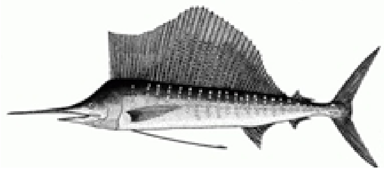
** 2015-2017 average catches, based on low catch scenario (IOTC-2018-WPB16-DATA03b).*

TABLE A13. Striped marlin: Probability (percentage) of achieving the KOBE green quadrat from 2018-2027 for a range of constant catch projections (JABBA).

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

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

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



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

TABLE A14. Indo-Pacific sailfish: Status of Indo-Pacific sailfish (*Istiophorus platypterus*) in the Indian Ocean.

Area[1]	Indicators		2020 stock status determination
Indian Ocean	Catch 2018[2]	33,807 t	
	Average catch 2014-2018	29,164 t	
	MSY (1,000 t) (80% CI)	23.9 (16.1 – 35.4)	
	F_{MSY} (80% CI)	0.19 (0.14 - 0.24)	
	B_{MSY} (1,000 t) (80% CI)	129 (81–206)	
	F_{2017}/F_{MSY} (80% CI)	1.22 (1 – 2.22)	
	B_{2017}/B_{MSY} (80% CI)	1.14 (0.63 – 1.39)	
	B_{2017}/B_0 (80% CI)	0.57 (0.31 – 0.70)	

[1] Boundaries for the Indian Ocean = IOTC area of competence.
[2] Proportion of catches estimated or partially estimated by IOTC Secretariat in 2018: 23%.

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)	17%	60%
Stock not subject to overfishing (F_{year}/F_{MSY}≤ 1)	5%	16%
Not assessed/Uncertain		

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

Stock status. No new stock assessment for Indo-Pacific sailfish was carried out in 2020, thus, the stock status is determined on the basis of the 2019 assessment using the C-MSY model. The data poor stock assessment techniques indicated that F was above F_{MSY} (F/F_{MSY}=1.22) and B is above B_{MSY} (B/B_{MSY}=1.14). Another alternative model using the Stock Reduction Analysis (SRA) techniques produced similar results. The stock appears to show a continued increase in catches which is a cause of concern (**Fig. A39**), indicating that fishing mortality levels may be becoming too high (**Fig. A40**). However both assessment models rely on catch data only, and the catch series is highly uncertain. In addition aspects of the biology, productivity and fisheries for this species, combined with the data poor status on which to base a more formal assessment, are also a cause for concern. On the weight-of-evidence available in 2019, the stock status cannot be assessed and is determined to be uncertain.

Outlook. Catches since 2009 have exceeded the estimated MSY, and have also increased by 58% between 2008 and 2017. This increase in coastal gillnet catches and fishing effort in recent years is a substantial cause for concern for the Indian Ocean stock, however there is not sufficient information to evaluate the effect this will have on the resource. It is also noted that 2017 catches (33,136 t) exceed the catch limit prescribed in Resolution 18/05 (25,000 t).

Management advice. The catch limits as stipulated in Resolution 18/05 have been exceeded. The Commission should provide mechanisms to ensure that catch limits are not exceeded by all concerned fisheries. Research emphasis on further developing possible CPUE indicators from gillnet fisheries, and further exploration of stock assessment approaches for data poor fisheries are warranted. Given the limited data being reported for coastal gillnet fisheries, and the importance of sports fisheries for this species, efforts must be made to rectify these information gaps. The lack of catch records in the Persian Gulf should also be examined to evaluate the degree of localised depletion in Indian Ocean coastal areas.

The following key points should also be noted:

- **Maximum Sustainable Yield (MSY):** Estimate for the Indian Ocean stock is 23,900 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 Indo-Pacific sailfish.
- **Main fishing gear (average catches 2014-18)**: Gillnets account for around 70% of total catches in the Indian Ocean, followed by troll and hand lines (23%), with remaining catches recorded under longlines and other gears (**Fig. A39**).
- **Main fleets (average catches 2014-18):** If we exclude the Republic of Tanzania (whose catch data have been repeated in recent years by the Secretariat, due to the lack of explicit reporting from the country), then three quarters of the total catches of Indo-Pacific sailfish are accounted for by four countries situated in the Arabian Sea: I.R. Iran (gillnets): 35%; India (gillnets and trolling): 24%; Pakistan (gillnets): 9%; and Sri Lanka (gillnets and fresh longline): 9%

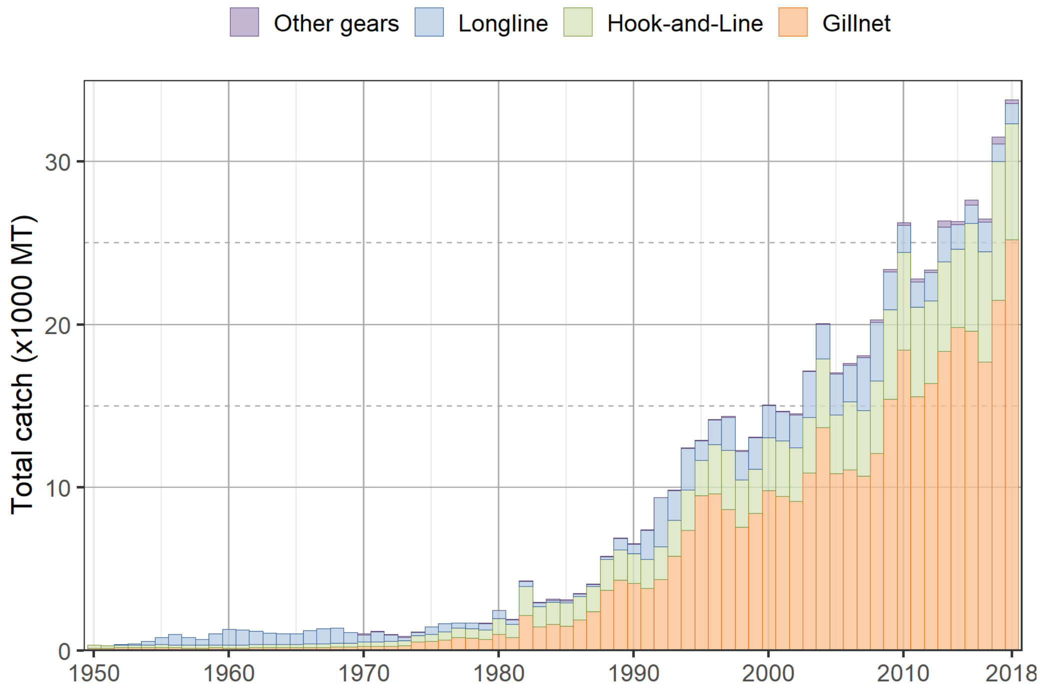


Fig. A39. Annual time series of nominal catches (t) of Indo-Pacific sailfish by gear group recorded in the IOTC database, 1950–2018. *Other gears* include coastal purse seine, Danish purse seine, beach seine and purse seine

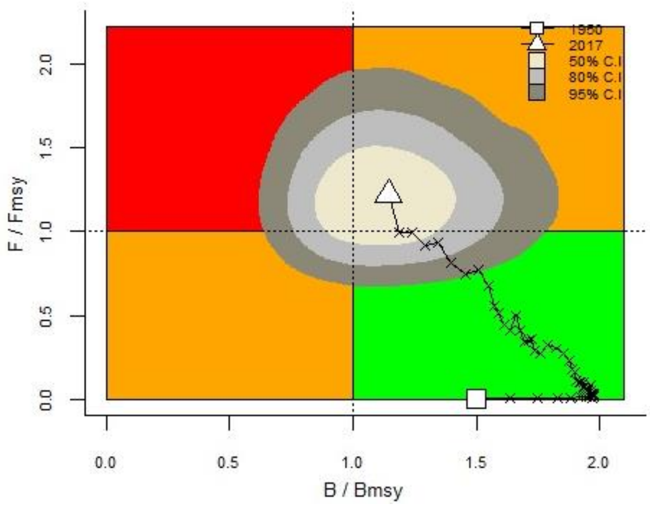


Fig. A40. Indo-Pacific sailfish: Stock reduction analysis (C-MSY Method) of aggregated Indian Ocean assessment Kobe plot (contours are the 50, 65 and 90 percentiles of the 2017 estimate). Black lines indicate the trajectory of the point estimates (blue circles) for the biomass (B) ratio and fishing mortality (F) ratio for each year 1950–2017.

APPENDIX XI
WORKING PARTY ON BILLFISH PROGRAM OF WORK (2021–2025)

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 in order of priority	Sub-topic and project	Timing				
		2021	2022	2023	2024	2025
1. Stock structure (connectivity and diversity)	Continue work on determining stock structure of Swordfish, using complimentary data sources, including genetic and microchemistry information as well as other relevant sources/studies.					
2. Biological and ecological information (incl. parameters for stock assessment and provide answers to the Commission)	Reproductive biology study CPCs to conduct reproductive biology studies, which are necessary for billfish throughout its range to determine key biological parameters including length-at-maturity, age-at-maturity and fecundity-at-age, which will be fed into future stock assessments, as well as provide advice to the Commission on the established Minimum Retention Sizes (Res 18-05, paragraphs 5 and 14c). (Priority: marlins and sailfish). Propose to have a two-day workshop to discuss the standard of billfish maturity staging intersessionally prior to the next WPB. Funding are needed to support the workshop participation of CPCs and expert(s) on billfish reproduction (expecting to have confirmation from the host organization).					
3. Stock structure (connectivity and diversity)	Tagging research (PSAT tags) to determine connectivity, movement rates and mortality estimates of billfish (Priority species: swordfish). Similar projects have been partially funded by EU, with a focus on epipelagic species. More tags are needed for swordfish.					
Other Future Research Requirements (not in order of priority)						
	1.1 Age and growth research					

1. Biological and ecological information (incl. parameters for stock assessment and provide answers to the Commission)	1.1.1 CPCs to provide further research on billfish biology, namely age and growth studies including through the use of fish otolith or other hard parts, either from data collected through observer programs, port sampling or other research programs. (Priority: all billfishes: swordfish, marlins and sailfish)					
	1.2 Spawning time and locations					
	1.2.1 Collect gonad samples from billfish to confirm the spawning time and location of the spawning area that are presently hypothesized for each billfish species. This will also provide advice to the Commission on the request for alternative management measures (Res. 18-05, paragraph 6). Partially supported by EU, on-going support and collaboration from CPCs are required.					
2. Historical data review	2.1 Changes in fleet dynamics					
	2.1.1 Continue the work with coastal countries to address recent changes and/or increases of marlins catches especially in some coastal fleets. The historical review should include as much explanatory information as possible regarding changes in fishing areas, species targeting, gear changes and other fleet characteristics to assist the WPB understand the current fluctuations observed in the data and very high increases in some species (e.g., black marlin mainly due to very high catches reported by India in recent years). The possibility of producing alternative catch histories should also be explored. Priority countries: India, Pakistan, Iran, I.R., Indonesia.					
	2.2 Species identification					
	2.2.1 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. Consider the application of DNA-Barcoding technology for billfish species identification.					
	2.3 Tagging data recovery from alternate sources (e.g. Billfish foundation) to supplement IOTC tagging database information.					

3.	Observer Training to improve data collection for billfish (and other) species	3.1 Training for observers with respect to billfish species identification, various length measurements and biological sampling (gonads, spines and otoliths).					
4.	CPUE standardization	4.1 Develop and/or revise standardized CPUE series for each billfish species and major fisheries/fleets for the Indian Ocean.					
		4.1.1 Swordfish: Priority LL fleets: Taiwan,China, EU(Spain, Portugal, France), Japan, Indonesia, South African					
		4.1.2 Striped marlin: Priority fleets: Japan, Taiwan,China					
		4.1.3 Black marlin: Priority fleets: Longline: Taiwan,China; Gillnet: I.R. Iran, Sri Lanka, Indonesia					
		4.1.4 Blue marlin: Priority fleets: Japan, Taiwan,China, Indonesia					
		4.1.5 I.P. Sailfish: Priority fleets: Priority gillnet fleets: I.R. Iran and Sri Lanka; Priority longline fleets: EU(Spain, Portugal, France), Japan, Indonesia;					
		4.1.6 Joint analysis of operational catch and effort data from Indian Ocean longline fleets as recommended by WPM					
5.	Stock assessment / Stock indicators	5.1 Workshops on techniques for assessment including CPUE estimations for billfish species in 2021 and 2022. Priority fleets: Gillnet fisheries					
6.	Target and Limit reference points	6.1 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.					
7.	Management measure options	7.1 To advise the Commission, on potential management measures having been examined through the Management Strategy Evaluation (MSE) process.					
		7.1.1 These management measures will therefore have to ensure the achievement of the conservation and optimal utilization of stocks as laid down in article V of the Agreement for the establishment of the IOTC and more particularly to ensure that, in as short a period as possible and no later than 2020, (i) the fishing mortality rate does not exceed the fishing mortality rate allowing the stock to deliver MSY and (ii) the spawning biomass is maintained at or above its MSY level.					

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

Species	2021	2022	2023	2024	2025
Black marlin	**Full assessment**			**Full assessment**	
Blue marlin		**Full assessment**			**Full assessment**
Striped marlin	**Full assessment**			**Full assessment**	
Swordfish		**Indicators****	**Full assessment**		**Indicators****
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.
** Including biological parameters, standardized CPUE, and other fishery trend.

APPENDIX XII
CONSOLIDATED RECOMMENDATIONS OF THE 18TH SESSION OF THE WORKING PARTY ON BILLFISH

Note: Appendix references refer to the Report of the 18th Session of the Working Party on Billfish (IOTC–2020–WPB18–R)

The following are the complete recommendations from the WPB18 to the Scientific Committee,:

Outcome of the 22nd Session of the Scientific Committee

WPB18.01 (para 5): **RECALLING** that one of the Indian Ocean billfish species (shortbill spearfish, *Tetrapturus angustirostris*) is currently not listed among the species managed by IOTC, and considering the ocean-wide distribution of this species, its highly-migratory nature, and that it is a common bycatch in IOTC managed fisheries, the WPB reiterated its previous **RECOMMENDATION** that the Scientific Committee consider requesting the Commission to include it in the list of species to be managed by the IOTC

Revision of the WPB Program of work (2020–2024)

WPB18.02 (para 112): The WPB **RECOMMENDED** that the SC consider and endorse the WPB Program of Work (2021–2025), as provided at Appendix XII.

Date and place of the 19th and 20th Sessions of the Working Party on Billfish

WPB18.03 (para 115) The WPB **NOTED** that the global Covid-19 pandemic has resulted in international travel being almost impossible and with no clear end to the pandemic in sight, it was impossible to finalise arrangements for the meeting in 2021. The Secretariat will continue to liaise with CPCs to determine their interest in hosting these meetings in the future when this once again becomes feasible. The WPB **RECOMMENDED** the SC consider early September 2021 as a preferred time period to hold the WPB19 in 2021. As usual it was also AGRRED that this meeting should continue to be held back-to-back with the WPEB, with the WPEB taking place before the WPB in 2021.

Review of the draft, and adoption of the Report of the 18th Session of the Working Party on Billfish

WPB18.04 (para. 116): The WPB **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPB18, 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 2019 (**Fig. 4**):

- 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

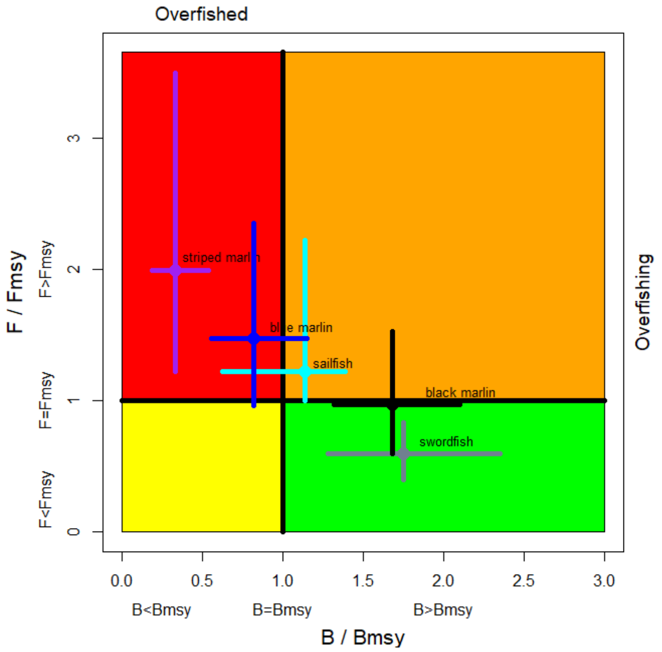


Fig. 4. Combined Kobe plot for swordfish (grey), indo-pacific sailfish (cyan), black marlin (black), blue marlin (blue) and striped marlin (purple) showing the 2017, 2018, 2019, and 2020 estimates of current stock size (SB or B, species assessment dependent) and current fishing mortality (F) in relation to optimal spawning stock size and optimal fishing mortality. Cross bars illustrate the range of uncertainty from the model runs.