Report of the 22nd Session of the IOTC Working Party on Billfish

Berjaya Beau Vallon Bay Hotel, Seychelles, 4–7 September 2024

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Acronyms

ABF	African Billfish Foundation
ASPIC	A Stock-Production Model Incorporating Covariates
B	Biomass (total)
B_{MSY}	Biomass which produces MSY
BLM	Black marlin (FAO code)
BSP-SS	Bayesian Surplus Production Model – State-Space
BUM	Blue marlin (FAO code)
CE	Catch and effort
CI	Confidence Interval
CMM	Conservation and Management Measure (of the IOTC; Resolutions and Recommendations)
CPCs	Contracting parties and cooperating non-contracting parties
CPUE	Catch per unit of effort
current	Current period/time, i.e. $F_{current}$ means fishing mortality for the current assessment year.
EU	European Union
EEZ	Exclusive Economic Zone
F	Fishing mortality; F_{2010} is the fishing mortality estimated in the year 2010
FAO	Food and Agriculture Organization of the United Nations
F_{MSY}	Fishing mortality at MSY
GLM	Generalized linear model
HBF	Hooks between floats
IO	Indian Ocean
IOTC	Indian Ocean Tuna Commission
JABBA	Just Another Bayesian Biomass Assessment (a generalized Bayesian State-Space Surplus Production Model)
LL	Longline
M	Natural Mortality
MLS	Striped marlin (FAO code)
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
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 22nd Session of the Indian Ocean Tuna Commission's (IOTC) Working Party on Billfish (WPB) was in Berjaya Beau Vallon Bay Hotel, Seychelles, using a hybrid format from the 4 to 7 September 2024. A total of 47 participants (97 in 2023, 51 in 2022, and 55 in 2021) attended the Session (of which 25 attended in person). The list of participants is provided at Appendix I. The meeting was opened by the Chairperson, Dr Jie Cao (China), who welcomed participants.

The following are the complete recommendations from the WPB22 to the Scientific Committee, which are also provided at Appendix X:

Review of new information on the status of black and striped marlins

WPB22.01 (para 148): In this context, the WPB **NOTED** that a Joint analysis of fleet specific CPUE could be useful because if catch effort data from multiple fleets were all representative of abundance, there should be no conflict between them. A Joint analysis based on a consistent statistical framework would help account for difference in catchability between fleets and can increase the power to identify potential factors that might explain the difference between fleets. Further, the fleets can complement each other in spatial and temporal coverage of the stock, thus increasing the chance of producing a representative abundance index using a unified modelling approach. As such, the WPB **RECOMMENDED** that the SC dedicate effort to harmonise the standardised methods for different fleets and to develop a joint analysis combining catch effort data from key fleets for major billfish species where feasible.

Resolution 18/05 Catch Limits

WPB22.02 (para 171): The WPB **NOTED** that the catch limits for black marlin and Indo-Pacific sailfish set by Resolution 18/05 have consistently been exceeded since its implementation. Therefore, the WPB **RECOMMENDED** that the SC advise the Commission to reassess the effectiveness of the current measures within this resolution. Additionally, the WPB **RECOMMENDED** that the SC advise the Commission of the need to revise Resolution 18/05 to update the catch limits based on the latest stock assessments and projections for the billfish species.

Revision of the WPB Program of work (2025–2029)

WPB22.03 (para 176): The WPB **RECOMMENDED** that the SC consider and endorse the WPB Program of Work (2025–2029), as provided in Appendix IX.

Date and place of the 23rd and 24th Sessions of the Working Party on Billfish

WPB22.04 (para 181): The WPB **RECOMMENDED** the SC consider early September as a preferred time period to hold the WPB23 in 2025. As usual it was also **AGREED** that this meeting should continue to be held back-to-back with the WPEB and that in 2025 WPB will be held in the week following the WPEB.

Review of the draft, and adoption of the Report of the 22st Session of the Working Party on Billfish

WPB22.05 (para 182): The WPB **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPB22, provided at Appendix X, 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 2024 (Fig. 5):

- Swordfish (*Xiphias gladius*)– Appendix IV
- Black marlin (*Istiompax indica*) – Appendix V
- Blue marlin (*Makaira nigricans*) – Appendix VI
- Striped marlin (*Kajikia audax*) – Appendix VII
- Indo-Pacific sailfish (*Istiophorus platypterus*) – Appendix VIII

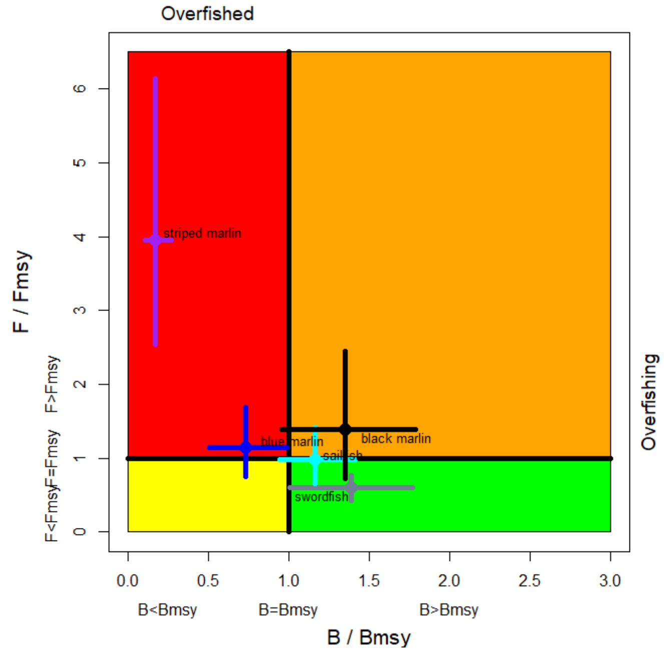

Fig. 5. Combined Kobe plot for swordfish (grey), Indo-pacific sailfish (cyan), black marlin (black), blue marlin (blue) and striped marlin (purple) showing the 2022, 2023, and 2024 estimates of current stock size (SB or B, species assessment dependent) and current fishing mortality (F) in relation to 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	2020	2021	2022	2023	2024	Advice to the Scientific Committee
Swordfish *Xiphias gladius*	Catch 2022 (t): 23,404 Average catch 2018-2022 (t): 28,922 MSY (1,000 t) (80% CI): 30 (26–33) F_{MSY} (80% CI): 0.16 (0.12–0.20) SB_{MSY} (1,000 t) (80% CI): 55(40–70) F_{2021}/F_{MSY} (80% CI): 0.60 (0.43–0.77) SB_{2021}/SB_{MSY} (80% CI): 1.39 (1.01–1.77) SB_{2021}/SB_{1950} (80% CI): 0.35 (0.32–0.37)					*97%*	***Stock status.*** No new stock assessment was carried out for Swordfish in 2024, thus, the stock status estimates are based on the assessment carried out in 2023. Two models were applied to the swordfish stock (ASPIC and Stock Synthesis (SS3)), with the SS3 stock assessment selected to provide scientific advice (as done previously). An update of the JABBA model was also conducted during the WPB meeting. The reported SS3 stock status is based on a grid of 48 model configurations designed to capture the uncertainty relating to steepness of the stock recruitment relationship (0.7, 0.8, and 0.9), recruitment variability (two levels), CPUE series (2 options), growth (2 options) and weighting of length composition data (two options). A number of the options included in the final grid were selected from a range of additional sensitivity runs that were conducted to explore uncertainties. Median spawning biomass in 2021 was estimated to be 35% (80% CI: 32-37%) of the unfished levels in 2021 and 1.39 (80% CI: 1.01-1.77) times higher than the level required to support MSY. Median fishing mortality in 2021 was estimated to be 60% (80% CI 43%-77%) of the FMSY level, and catch in 2021 (23,237 t) was well below the estimated MSY level of 29,856 t (80% CI: 26,319-33,393t). Taking into account the characterized uncertainty, and on the weight-of-evidence available in 2023, the swordfish stock is determined to be **not overfished** and **not subject to overfishing**. ***Management advice.*** The 2021 catches (23,237 t at the time of the assessment) were significantly lower than the estimated MSY level (29,856 t). Under those levels of catches, the spawning biomass was projected to likely increase, with a high probability of maintaining at or above the SBMSY for the longer term. There is a very low risk of exceeding MSY-based reference points by 2031 if catches are maintained at 2021 levels (<1% risk that SB_{2031}< SB_{MSY}, and <1% risk that F_{2021}> F_{MSY}). The projections indicate that an increase of 40% or more from 2021 catch levels will not likely result in the biomass dropping below the SBMSY level for the longer term (with a 15% probability). Catches in 2022 (23,597t) were still lower than the estimated MSY. Nevertheless, the Commission should consider monitoring the catches to ensure that the probability of exceeding the SBMSY target reference points in the long term remains minimal. Taking into account the differential CPUE and biomass trends between regions, the WPB noted that there is recurring evidence for localised depletion in the South Western region (which appears to be more depleted than other regions) and suggests this should be further monitored. Click here for full stock status summary: Appendix IV
Black marlin *Istiompax indica*	Catch 2022: 26,320 t Average catch 2018–2022: 18,235 t MSY (1000 t) (80% CI): 13.90 (8.73–28.51) FMSY (80% CI): 0.21 (0.15–0.30)					*62.2%*	***Stock status.*** A new stock assessment was carried out for black marlin in 2024, based on JABBA, a Bayesian state-space production model (using data up to 2022). The relative point estimates for this assessment are F/FMSY=1.39 (0.72-2.45) and B/BMSY=1.35 (0.96 -1.79). The Kobe plot indicated that the stock is currently not overfished but is subject overfishing (Table 1; Fig. 3). In 2022, the catch of black marlin surged to 26,320 t. Until 2024, fish stock status was characterised as "uncertain" due to

	BMSY (1,000 t) (80% CI):65.23 (46.43–101.84) F2022/FMSY (80% CI):1.39 (0.72–2.45) B2022BMSY (80% CI):1.35 (0.96–1.79) B2022/B0 (80% CI):0.49 (0.35–0.66)						significant uncertainties in past assessments (like those from 2018 and 2021). These uncertainties were attributed to both historical catch reporting from key fishing states and poor assessment diagnostics. However, there has been progress recently with black marlin catch data, particularly from coastal countries in the northern Indian Ocean, and the latest JABBA assessment shows it is now more reliable (with improved model fitting to the abundance indices and acceptable level of retrospective patterns). The assessment relied on CPUE indices from longline fisheries in which the black marlin is a bycatch species. On the weight-of-evidence available in 2024, the stock status of black marlin is determined to be **not overfished** but subject to **overfishing.** ***Management advice*.** The catch limits (9,932 t) as stipulated in Resolution 18/05 have been exceeded for three consecutive years since 2020, which as per resolution 18/05, requires a review of the resolution. Furthermore, these limits are not based on estimates of most recent stock assessment. Thus, it is recommended that the Commission urgently revise Res. 18/05 to incorporate limits that reflect the most recent stock assessment and projections, and review, and where necessary, revise the implementation and effectiveness of the measures contained in this Resolution. The stock is now subject to overfishing. 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 as per Resolution 18/05, it needs to provide mechanisms to ensure the maximum annual catches remain less than 10,626 t. Click here for full stock status summary: Appendix V
Blue marlin *Makaira nigricans*	Catch 2022: 5,658 t Average catch 2018–2022: 7,175 t MSY (1000 t) (80% CI):8.74 (7.14–10.72) FMSY (80% CI): 0.24 (0.14–0.39) BMSY (1,000 t) (80% CI) (35.8 (22.9–60.3) F2020/FMSY (80% CI):1.13 (0.75–1.69) B2020/BMSY (80% CI):0.73 (0.51–0.99) B2020/B0 (80% CI):0.36 (0.26–0.50)					***100%***	***Stock status.*** No new stock assessment was carried out for blue marlin in 2024, thus the stock status is determined on basis of the 2022 assessment which was based on two different models: JABBA, a Bayesian state-space production model (age-aggregated); and SS3, an integrated model (age-structured) (using data up to 2020). Uncertainty in the biological parameters is still evident and as such the JABBA model (B_{2020}/B_{MSY} = 0.73, F2020/F_{MSY} =1.13) was selected as the base case. Both models were consistent with regards to stock status. On the weight-of-evidence available in 2022, the stock is determined to be **overfished** and subject to **overfishing**. ***Management advice.*** The current catches of blue marlin (average of 7,045 t in the last 5 years, 2018-2022) are lower than MSY (8,740 t). The stock is currently overfished and subject to overfishing. According to K2SM calculated (Table 2), a reduction of 20% of catches (5,700 t) compared to 2020 catches (7,126 t) would recover the stock to the green quadrant by 2030 with a probability of 79% and if the catches are reduced by 10% (6,413 t) the probability would be 67%. The Commission should note that the current catch limit for blue marlin in Resolution 18/05 (11,930 t, which was established as the MSY value estimated in 2016 stock assessment) is 36% higher than the new MSY estimated by the latest stock assessment in 2022 (8,740 t). Thus, it is recommended that the Commission urgently revise Resolution 18/05 to incorporate limits that reflect the most recent stock assessment and projections and review and where necessary revise the implementation and effectiveness of the measures contained in this Resolution. Click here for full stock status summary: Appendix VI
Striped marlin *Kajikia audax*	Catch 2022: 3,225t Average catch 2018–2022: 2,856 t MSY (1,000 t) (JABBA): 4.73 (4.22–5.24)					***100%***	***Stock status:*** A new stock assessment was carried out for striped marlin in 2024, based on two different models: JABBA, a Bayesian state-space production model (age-aggregated); and SS3, an integrated model (age-structured) (using data up to 2022). Both models were generally consistent

	MSY (1,000 t) (SS3): 4.89 (4.48 – 5.30) F_{MSY} (JABBA): 0.26 (0.20–0.35) F_{MSY} (SS3): 0.22 (0.21–0.24) F_{2022}/F_{MSY} (JABBA): 3.95 (2.54–6.14) F_{2022}/F_{MSY} (SS3): 9.26 (5.38–13.14) B_{2022}/B_{MSY} (JABBA): 0.17 (0.11–0.27) SB_{2022}/SB_{MSY} (SS3): 0.27 (0.19–0.35) B2022/B0(JABBA): 0.06 (0.04–0.10) SB_{2022}/SB_0 (SS3): 0.036 (0.03–0.04)						with regards to stock status and confirmed the results from 2012, 2013, 2015, 2017, 2018, and 2021 assessments, indicating that the stock is subject to overfishing (F>FMSY) and is overfished, with the biomass being below the level which would produce MSY (B<BMSY) for over a decade. Both SS3 and JABBA assessments rely on CPUE indices from the longline fisheries in which the striped marlin are not the main target species. On the weight-of-evidence available in 2024, 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. The 2022 catches (3,225 t) are lower than MSY (4,730 t) but are very close the limit set by Resolution 18/05 (3, 260 t) which may be a concern if this trend continues. However, the limit is not based on estimates of most recent stock assessment. Thus, it is recommended that the Commission urgently revise Resolution 18/05 to incorporate limits that reflect the most recent stock assessment and projections and review and where necessary revise the implementation and effectiveness of the measures contained in this Resolution. The stock has been overfished for more than a decade 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% between 2027 and 2032 (as per Resolution 18/05), it needs to provide mechanisms to ensure the maximum annual catches to be below 30% of the current level (Table 3). [SC to revise the advice]. Click here for full stock status summary: Appendix VII
Indo-Pacific Sailfish *Istiophorus platypterus*	Catch 2022: 33,135t Average catch 2017–2022: 32,750t MSY (1,000 t) (80% CI): 25.9 (20.8–34.2) F_{MSY} (80% CI): 0.19 (0.15–0.24) B_{MSY} (1,000 t) (80% CI): 138 (108–186) F_{2019}/F_{MSY} (80% CI): 0.98 (0.65–1.42) B_{2019}/B_{MSY} (80% CI): 1.17 (0.94–1.42) B_{2019}/B_0 (80% CI): 0.58 (0.47–0.71)					54%	***Stock status:*** No new stock assessment was carried out for Indo-Pacific sailfish in 2024, thus the stock status is determined on basis of the 2022 stock assessment based on JABBA (using data up to 2019). Data poor methods (C-MSY and LB-SPR) applied to Indo-Pacific sailfish in 2019 rely on catch data only, which is highly uncertain for this species, and resulted in the stock status determined to be uncertain. To overcome the lack of abundance indices for this species, this assessment incorporated length-frequency data to estimate annual Spawning Potential Ratio (SPR). Normalised annual estimates of SPR were assumed to be proportional to biomass and incorporated as an index of relative abundance in the JABBA model (assuming no trends in annual recruitment in the long term). This is a novel technique applied to overcome the paucity of abundance data for SFA. The results indicate that there has been a 41% decline in SPR since 1970. B/B_{MSY} declined consistently from the early-1980s, while F/F_{MSY} gradually increased from 1980, peaking in 2018 at 1.1. The latest (2019) estimate of B/B_{MSY} was 1.17, while the F/F_{MSY} estimate was 0.98. On the weight-of-evidence available in 2022, the stock status of Indo-Pacific sailfish is determined to be **not overfished nor subject to overfishing.** ***Management advice*:** The catch limits as stipulated in Resolution 18/05 have been exceeded for three consecutive years since 2020, which as per resolution 18/05, requires a review of the resolution. Furthermore, these limits are not based on estimates of most recent stock assessment. Thus, it is recommended that the Commission urgently revise 18/05 to incorporate limits that reflect the most recent stock assessment and projections and review and where necessary revise the implementation and effectiveness of the measures contained in this Resolution. In spite of the Kobe green status of the stock, it is recommended that the Commission review the implementation and effectiveness of the measures contained in this Resolution and consider the adoption of additional conservation and management measures. 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 coastal gillnet and longline fisheries, and further exploration of stock assessment approaches for data poor fisheries are warranted. Given the limited data being reported for coastal fisheries, and the importance of sports fisheries for this species, efforts must be made to rectify these information gaps. Click here for full stock status summary: Appendix VIII

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 22nd Session of the Indian Ocean Tuna Commission's (IOTC) Working Party on Billfish (WPB) was in Berjaya Beau Vallon Bay Hotel, Seychelles, using a hybrid format from the 4 to 7 September 2024. A total of 47 participants (97 in 2023, 51 in 2022, and 55 in 2021) attended the Session (of which 25 attended in person). The list of participants is provided at Appendix I. The meeting was opened by the Chairperson, Dr Jie Cao (China), 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 WPB22 are listed in Appendix III.

3. The IOTC process: Outcomes, updates and progress

3.1 Outcomes of the 26th Session of the Scientific Committee

3. The WPB **NOTED** paper IOTC–2024–WPB22–03 which describes the main outcomes of the 26th Session of the Scientific Committee (SC26), specifically related to the work of the WPB:

"Report of the 21st Session of the Working Party on Billfish"

48. The SC **NOTED** the report of the 21st Session of the Working Party on Billfish (IOTC–2023–WPB21–R), including the consolidated list of recommendations provided as an appendix to the report. The meeting was attended by 97 participants (cf. 51 in 2022). Eight participants received funding through the MPF.

49. The SC **NOTED** that the WPB had reviewed evidence that shortbill spearfish (*Tetrapturus angustirostris*) is being caught in IOTC fisheries and that the species population size may be declining. The SC **ACKNOWLEDGED** that the addition of shortbill spearfish in the official list of IOTC species may require a review of the IOTC Agreement, which would be a complex administrative process and unlikely to occur in the near future. The SC **AGREED** that a way to move forward may be for the Commission to adopt the same approach as for the main pelagic sharks caught in tuna and tuna-like fisheries (e.g., blue shark) and mandate the SC with collating information on this species and providing scientific advice for its management. As such the SC **RECOMMENDED** that the Commission endorse the SC's approach to address the captures of shortbill spearfish in IOTC fisheries.

50. The SC **NOTED** that a new stock assessment [of the status of swordfish] was conducted in 2023 using SS3, an integrated age-structured model. The SC **ENDORSED** the results of the assessment model which indicated that the stock is not overfished and not subject to overfishing with a high probability (97%).

51. However, the SC **NOTED** that there was some key uncertainty in the assessment, particularly in one of the regions of the assessment where the Japanese longline CPUE time series showed some spikes over the last decade at a time when the catches were at a historically high level. The SC **NOTED** that this issue was considered to some extent in the assessment but **AGREED** that it would be useful to further explore it in the future.

52. The SC **NOTED** that an additional population model (i.e., ASPIC) was used for the assessment of the swordfish stock status, providing consistent results with SS3, and **ACKNOWLEDGED** that the use of multiple assessment models constitutes a good practice that should be continued in future Working Parties as much as possible.

53. 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*".

54. The SC **NOTED** that the catch limits stipulated in Res. 18/05 are based on estimates of MSY from older assessments that have subsequently been updated in 2021 (black marlin and striped marlin) and 2022 (blue marlin and Indo-Pacific sailfish), resulting in revised estimates of MSY.

55. The SC **NOTED** that for blue marlin and striped marlin, which are both assessed as overfished and subject to overfishing, the recent (2022) catches are significantly below (for blue marlin) or just above (for striped marlin) the Res. 18/05 catch limits. However, the 2021 assessments have also generated K2SM projections which have indicated that recent catches for both species have substantially exceeded the levels that would return those stocks into the Kobe green quadrant by year 2029 for striped marlin and 2030 for blue marlin.

56. The SC **NOTED** that for black marlin and Indo-Pacific sailfish, reported catches continue to exceed the limits set out in Resolution 18/05 since 2020. While K2SM projections have not been undertaken for either stock, recent catches have exceeded the most recent median estimates of MSY (from the 2022 assessments for blue marlin and Indo-Pacific sailfish and the 2021 assessment for black marlin). The SC further **NOTED** that catches of both species are predominantly taken by gillnet which have increased substantially in recent years.

57. Subsequently, the SC **RECOMMENDED** that Resolution 18/05 be urgently revised and updated so as to reflect MSY based catch limits for each species based on the most recent stock assessment and projections information available, and to contain provisions to ensure that catches do not exceed such limits. The SC **REQUESTED** that for Indo-Pacific sailfish, K2SM projections be provided based on the most recent assessment so as to inform revised limits for that stock, and that further work is undertaken to improve the black marlin assessment to generate status and catch limit information.

4. Regarding shortbill spearfish, the WPB **ACKNOWLEDGED** that this species is already covered under the reporting requirements for various fishing gear types in Resolutions 15/01 and 15/02. The IOTC database records annual catches of shortbill spearfish amounting to a few hundred tonnes. However, these figures likely significantly fall short of the actual catches due to data collection and reporting challenges. For instance, billfish are often processed and cut up at sea in gillnet fisheries in I.R. Iran and Sri Lanka, complicating accurate estimates of shortbill spearfish catches. This issue may be worsened by the relatively small quantities caught. It was noted, however, that IOTC compliance has developed identification guidelines for species processed at sea, which could be useful.

5. Therefore, the WPB strongly **URGES** the CPCs to enhance their data collection and reporting practices for this species. Improved data are crucial for conducting more effective research and assessment of the fish stock, leading to better scientific advice.

3.2 Outcomes of the 28th Session of the Commission

6. The WPB **NOTED** paper IOTC–2024–WPB22–04 which provided the main outcomes of the 28th Session of the Commission specifically related to the work of the WPB.

7. Participants to WPB22 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 **NOTED** that there was very little discussion related to the WPB and that the main items were the endorsement by the Commission of the SC information on stock status and Work Plan.

9. 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

10. The WPB **NOTED** paper IOTC–2024–WPB22–05 which aimed to encourage participants at the WPB22 to review some of the existing CMMs relevant to billfish, noting the CMMs referred to in document IOTC–2024–WPB22–05, and - as necessary - to 1) provide recommendations to the SC on whether modifications may be required and 2) recommend whether other CMMs may be required.

3.4 Progress on the recommendations of WPB21

11. The WPB **NOTED** paper IOTC–2024–WPB22–06 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 scientists when presenting the results for 2024.

13. The WPB participants were **ENCOURAGED** to review IOTC-2024-WPB22-06 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 (WPB23).

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 at the Secretariat

15. The WPB **NOTED** paper IOTC–2024–WPB22–07_Rev1 on a review of the statistical data available for Indian Ocean billfish (1951-2022), with the following abstract provided by the authors:

> *"The document provides an overview of the consolidated knowledge about fisheries catching billfish in the Indian Ocean since the early 1950s based on a range of data sets collected by the Contracting Parties and Cooperating Non-Contracting Parties (CPCs) of the IOTC and curated by the IOTC Secretariat. The reporting quality of fisheries statistics available for the five IOTC billfish species has strongly varied between 1950 and 2022, and improved substantially over the last decade. The catches from coastal gillnet and longline fisheries have steadily increased over time and now contribute to more than 60% of the total billfish catch of the Indian Ocean. Catches from industrial longline fisheries provide the bulk of the geo-referenced effort, catch, and size data available at the Secretariat. Additional details on the five billfish species under IOTC management mandate are provided in separate documents prepared for this meeting."*

16. The WPB **THANKED** the Secretariat for the overview of billfish data available from the 1950 to 2022, **NOTING** the continuous increase in the catch of billfish species, particularly from the coastal fisheries, despite the low quality of some datasets.

17. The WPB **NOTED** that the paper covers the period until 2022 but that preliminary data for 2023 have been used to update the time series of catches used in paper IOTC-2024-WPB22-INF04 focusing on Res. 18/05.

18. The WPB **RECALLED** that Res. 18/05, entered into force on 4th October 2018, calls for the non-retention of any specimen of marlins and sailfish smaller than 60 cm lower jaw fork length (*LJ*), and that the distribution of size frequencies shows the presence of these small fish in the catches of some fisheries. The WPB **NOTED** that very few billfish less than 60 cm have been reported to the Secretariat in recent years.

19. The WPB **NOTED** that I.R. Iran is the primary country catching billfish, particularly black and striped marlins, although these species are mainly taken as bycatch in Iranian gillnet fisheries, with a substantial increase observed in recent years. The WPB further **NOTED** that I.R. Iran plans to resubmit data using new reporting templates to enhance the quality of billfish data submitted to the Secretariat.

20. The WPB **NOTED** that the CPUE analysis performed with data available from the Iranian gillnet fishery has proven beneficial for neritic tuna species (IOTC–2019–WPNT09–17) and could also be applied to billfish species, **ENCOURAGING** the Secretariat to continue the collaboration with I.R. Iran to assess the possibility of developing abundance indices for billfish from gillnet fishery data. The WPB **AGREED** that the methodology for standardising gillnet CPUE data may require to include covariates such as panels and mesh size and would greatly benefit from accessing operational data.

21. The WPB **NOTED** that size frequency measurements for some billfish species may not conform to the standard measurement of lower jaw fork length (*LJ*), as most measurements are reported in eye-to-fork length (*EF*). Furthermore, the WPB **NOTED** that this variation in measurement could lead to misinterpretation when processing size-frequency data, emphasizing that CPCs should convert all size measurements to the standard

length before submission and provide information to the Secretariat on conversion methods used in data processing.

22. The WPB **NOTED** the concerns expressed by some countries regarding the potential double counting of catch data from the Arabian Sea. Vessels from Pakistan, I.R. Iran, and Oman may operate in one country's EEZ while landing catches in another, simultaneously providing catch data to their country of registration, where these catches are already accounted for in different landing ports. The WPB **ACKNOWLEDGED** that little can be done at the level of the Secretariat to verify this issue, as there is no evidence available and most vessels from these three countries are not listed in the IOTC Record of Authorized Vessels (RAV). The WPB **NOTED** that double counting is considered to be impossible in I.R. Iran regarding the licensing system in place and **ENCOURAGED** Pakistan to liaise directly with the I.R. Iran and provide further details on the matter.

23. The WPB **NOTED** that the data collected by the Secretariat are insufficient for conducting a CPUE analysis and that in-country missions are necessary to review the available data at the national level. Furthermore, the WPB **ACKNOWLEDGED** the upcoming mission to Sri Lanka, which will include a review of CPUE data from gillnet fisheries, allowing for comparison with CPUE data collected from I.R. Iran.

24. The WPB **NOTED** the historical quality issues identified for the size-frequency data of tropical tuna species collected by the crews onboard longline vessels from Taiwan,China, Korea, and Seychelles (IOTC-2021-WPTT23(AS)-07), **ACKNOWLEDGING** that such issues might also apply to the size data of billfish and **ENCOURAGING** similar analysis to be conducted for billfish species.

25. The WPB **RECALLED** that some major uncertainties in the catch levels of billfish stem from issues related to species identification and reporting and **NOTED** that the Secretariat is in the process of organising an IOTC regional workshop on species identification and best practices in sampling and sample management in December 2024 in Sri Lanka for the Western Indian Ocean CPCs, followed by another workshop in 2025 for the Eastern Indian Ocean CPCs, with a particular focus on billfish species.

26. The WPB **NOTED** paper IOTC–2024–WPB22–13 which provides an update on the billfish landings in Pakistan with special reference to the use of sub-surface gillnetting, with the following abstract provided by the authors:

> *"Annual landings of billfish are estimated to be about 4,520 m. tons which remained stable during the last 6 years. Of the six species of billfish occurring in Pakistan, Indo-Pacific sailfish (Istiophorus platypterus), black marlin (Istiompax indica), and striped marlin (Kajikia audax) are dominating in the commercial catches contributing about 92.30 % in the total landings of billfish. These three species were found throughout the year, however, the period between September through January is the peak season of their landing. Billfishes are not locally consumed but transported to neighboring country through land or sea routes. The introduction of subsurface gillnetting between 2014 and 2016, led to a major decrease in the landings of billfish in Pakistan. The decrease in billfish catches due to the use of subsurface gillnets is well compensated by the high catches of yellowfin and skipjack tuna."*

27. The WPB **NOTED** that the present study is based on the WWF-Pakistan Crew Based Programme and that no information on geo-referenced catches and size frequencies has been reported by Pakistan to the Secretariat since 1991.

28. The WPB **NOTED** that Indo-Pacific sailfish is the dominating species in the landings, followed by black marlin which contributing about 43 % and about 32 % of the total billfish landings of 2023 respectively, and the overall trend in the composition of various species remain almost similar during the period of this study (2018-2023).

29. The WPB **NOTED** a marked decreasing trend on billfish landings of the Pakistani tuna gillnet fisheries observed in recent years from 8,297 tonnes in 2018 to 3,514 tonnes in 2022.

30. The WPB **NOTED** that shift of the gillnet operation from surface to subsurface gillnetting, introduced as a means for reducing entanglement and mortality of cetaceans and turtles, results in a reduction of the catch per unit effort (kg/day) of major species caught by tuna gillnetting compensated by an increase in the yellowfin and skipjack tuna species.

31. The WPB **NOTED** that other benefits valued by fishers with the implementation of subsurface gillnetting are related with lower cost in the fishing operation in terms of materials (e.g. reduced number of floats, minimized loss of nets) and facilitating handling practices (e.g. entanglements in net loft during storage are minimized).

32. The WPB **NOTED** that as billfish are not consumed locally, changes to the gillnet operations could also provide more profitable returns for other species, particularly dolphinfish, which have increased in price on the local market in recent years.

33. The WPB **NOTED** the difficulties of collecting size frequency data by Pakistan, although the data collection is self-reporting by fishers and that any data collection should be verified before using.

34. The WPB **NOTED** paper IOTC–2024–WPB22–14 which describes a Large pelagic fishery assessment towards sustainable management of billfish fisheries in Iran, with the following abstract provided by the authors:

"The fishery for tuna and tuna-like species is a major component of large pelagic fisheries in Iran and is one of the most important activities in the Persian Gulf, Oman Sea, and the high seas. In 2023, the country produced nearly 1.4 million tonnes of aquatic products, with marine capture fisheries accounting for approximately 778 thousand tonnes. Additionally, aquaculture activities contributed 640 thousand tonnes to the national output. The production of large pelagic fishes amounted to around 332 thousand tonnes, representing approximately 43% of the country's total catch in 2023..." [see paper for full abstract]

35. The WPB **NOTED** that Indo-Pacific sailfish and black marlin are the dominant species of billfish reported by the Iranian gillnet fisheries but are not in good agreement with the information reported to the secretariat, therefore a review of species composition of the billfish catch needs to be considered.

36. The WPB **NOTED** that as part of I.R. Iran's development plan, involves gillnet fisheries will be transitioned to longline fisheries which will result into reducing bycatch such as billfish, and targeting tropical tuna, particularly yellowfin tuna, for Japanese market.

37. The WPB **NOTED** that the record of discards and the implementation of the IOTC forms for reporting of offshore gillnet fisheries is in course and will be submitted next year.

38. The WPB **ACKNOWLEDGED** the effort of I. R. Iran, initiating the collection of size frequency data of billfish species on board large gillnet vessels by fishers before processing. **NOTING** the poor conditions on-board these vessels, which could not accommodate observers.

39. The WPB **NOTED** the difficulty to identify as well to provide size data due the billfish specimens are cut and processed before landing.

40. **ACKNOWLEDGING** the contribution of Iranian gillnet fisheries to the total billfish catches, the WPB **REQUESTED** the Secretariat to work closely with Iranian and Sri Lanka scientist on the CPUE analysis including neritic and billfish species.

41. The WPB **NOTED** paper IOTC–2024–WPB22–15 which describes present context and research challenges for billfish fishery resources, with the following abstract provided by the authors:

"Billfish, an important bycatch resource in the Sri Lankan tuna fishery, currently contributes approximately 13% of the country's large pelagic fish production. Among the billfish landings, the swordfish (Xiphias gladius) has emerged as the dominant species, with 90% of the catch originating from tuna longlines. Other billfish species, such as sailfish (Istiophorus platypterus) and three marlin species—blue marlin (Makaira nigricans), black marlin (Istiompax indica), and striped marlin (Kajikia audax)—are commonly recorded in both longline and gillnet fisheries. The catch efficiency of billfish (measured in number of individuals per 1,000 hooks) is approximately twice as high during nighttime compared to daytime. Since most billfish harvested on longlines are cut open at sea for storage and available as pieces at the landing sites, obtaining length frequency data has become challenging. Efforts are ongoing to develop reliable length-length conversion metrics. Given the realities at landing sites, updating identification guides with the external appearance of billfish parts is crucial. Continuous monitoring of billfish landings is conducted through port sampling, but the de-headed and de-gutted condition of the landings hinders scientific research on some biological aspects of billfish. Understanding the essentiality of these biological aspects in fisheries management, it is recommended to strengthen billfish research through regional collaborations, with special focus on the development of standardized maturity keys, the maintenance of a regional-level database for biological aspects, and increased financial support."

42. **ACKNOWLEDGING** the importance of morphometric relationships in harmonising size-frequency data collected using different measurement types for billfish, due to varying dressing procedures, the WPB **REQUESTED** the

Secretariat to develop a new voluntary form for reporting individual morphometric data, to enhance the IOTC reference morphometric relationships.

43. The WPB **ACKNOWLEDGED** the effort of Sri Lanka to address the difficulties in sampling billfish species, due to billfish being landed dressed, and sampling being conducted at landing sites. The WPB **RECOGNISED** Sri Lankan project of using macroscopically observable characteristics of the billfish species, such as scales, fins size and location to identify from cut pieces, which are not currently listed in the guidelines.

44. The WPB **NOTED** that the use of macroscopically observable characteristics could be challenging for frozen fish, although if could be easily identified from fresh fish.

45. The WPB **ADVISED** Sri Lanka to liaise with OFCF which is developing a species identification App to identify most of the IOTC species, as the characteristics used could be part of the species identification guide.

46. The WPB **NOTED** that there are other subsample projects in the region, using genetics to identify species, such as the gut characteristic. **NOTING** the high margin of errors associated with such methods.

47. The WPB **NOTED** Sri Lanka's plan to continue training observers and data collection on the methodology to identify billfish species, **NOTING** that it could also be useful during the upcoming species identification workshop planned by the Secretariat in Sri Lanka.

48. The WPB **NOTED** paper IOTC–2024–WPB22–16 which describes billfish bycatch from different fishing methods of purse seine fishery in the Andaman Sea of Thailand, with the following abstract provided by the authors:

"The billfish bycatch from different purse seine methods in the Andaman Sea of Thailand was studied during 2021-2023. A total of 2,412 landing purse seiners were sampled for catch composition and length measurement of billfish. The results indicate that billfish were rarely caught by purse seines, accounting for approximately 0.05% of the total catch. Only black marlin and Indo-Pacific sailfish were found in the catches. Purse seines using the aggregating fishing method had a higher catch rate and greater variety of billfish compared to the schooling fishing method. The observed billfish were commonly found distributed near Phuket Island and the southern Andaman Sea of Thailand. The average length of the observed black marlin was 170 ± 49.50 cm, and the average length of Indo-Pacific sailfish was 136.79 ± 35.11 cm. The observed length of billfish showed no significant difference between the different fishing methods."

49. The WPB **THANKED** Thailand for the overview of the billfish bycatch from Thai coastal purse seine fisheries. **NOTING** the low catch of billfish from the fisheries, comprising of mainly sailfish and black marlin.

50. The WPB **NOTED** that also the catches are low and mainly recorded during research, the data are not incorporated into catch data reported to the Secretariat, considering that there is no discard from the fisheries.

4.2 New information on sports fisheries

51. The WPB **NOTED** that little to no information on billfish is officially reported by the various recreational fisheries operating in the Indian Ocean, notwithstanding the fact that IOTC made an attempt at establishing a region-wide data collection protocol for these fisheries in recent years.

52. The WPB **NOTED** the effort of the Secretariat to create a repository of sport fishing data, considering the effort of NGO and IFREMER to collect data through Shiny APP and the ongoing satellite tagging.

53. The WPB **NOTED** that Seychelles is in the process of revising its legal framework for sport fishing, which is currently under the management of the tourism department, with the objective of transferring it to the fisheries department and introducing logbook for data collection.

5. BILLFISH REPRODUCTIVE BIOLOGY WORKSHOP

54. The WPB **NOTED** presentation IOTC–2024–WPB22–09 which provides a review of past and recent studies applying gonad histology to define reproductive phases and maturity status in billfish species, with the following abstract provided by the author:

"Gonad histology continues to provide the most accurate assessment of ovarian and testicular maturation in teleost fishes. The first gonad histology investigations of billfishes focused on describing the sequence of ovarian and testicular maturation and classifying this progressive development of gametes into distinct reproductive phases. These earlier studies were based on six species of istiophorids sampled in the western

Indian Ocean (Merrett 1970, 1971) and western Atlantic Ocean (de Sylva & Breder 1997). Arocha (2000) provided histology-based descriptions of ovarian development and proposed reproductive phases for swordfish sampled in the western Atlantic Ocean. In the 40 years since the publications of Merrett (1970, 1971), 12 gonad histology studies to determine maturity status and length-at-maturity were conducted on swordfish and two istiophorid species. Gonad histology has also been used to validate non histology techniques that attempt to determine reproductive phase and maturity status based on whole oocyte size, the macroscopic appearance of gonads, and indices based on total gonad weight and fish length. These reproductive studies used differing gonadal reproductive phases; some based on earlier studies (Merrett 1970, 1971; Arocha 2002) and the remainder based on other teleosts including anchovy, tunas, and insular demersal species..” – see document for full abstract.

55. The WPB **THANKED** the invited expert for his comprehensive presentation and review on the maturity of billfish. The WPB asked what the best markers are to distinguish immature and mature individuals.

56. The WPB **NOTED** that during the immature phase of billfishes, oocytes are grouped in the shape of strings of beads whereas they are more packed together in the regeneration phase. The author confirmed that the necklace pattern is observed for the immature stage while it is not for mature individuals.

57. The WPB **NOTED** that the vitellogenic 3 stage is commonly used as a maturity marker. This means that hydrated oocytes and brown bodies are very good indicators of maturity. However, this may vary among studies. The WPB further **NOTED** that some studies consider that the 2nd vitellogenic stage marks the onset of maturity while other studies consider that individuals remain immature during the whole vitellogenic phase.

58. The WPB **NOTED** that if macroscopic observations are used to estimate maturity stages, validation with histological observations should have been previously done. The WPB **NOTED** that differentiating immature and regenerative stages using macroscopic classification can be difficult. The identification should be easier for most advanced stages when oocytes are close to hydration.

59. The WPB **NOTED** that gonads to be used for histology purposes can be frozen upon collection on board, preserved on crushed ice, or in a fixative such as formaldehyde/formalin or Glyo-Fixx. The best option would be using a fixative. The WPB further **NOTED** that the following steps (between the boat and analyses in the lab) are also crucial and need to be well respected in order to avoid samples getting spoiled and eventually being unusable. It was however acknowledged that the use of fixatives such as formaldehyde can be complicated onboard for safety issues. In case no fixative can be used onboard, the author recommended to first lead a pilot study to assess what gives best results. The author also mentioned that the section of billfish gonads can be large (a 1 cm width section is recommended) and not easy to store. The author recommended the use of square bottles. To enable the fixative to correctly perform, it was also recommended to limit the volume of the sample. To summarize, the proposed protocol if fixatives cannot be used onboard is to freeze onboard, unfreeze in a fridge and use formaldehyde to fix in the lab. Flash-freezing also seems a good option if available onboard. It was noted from the experience of Taiwanese scientists that the protocol using freezing can result in the loss of samples (20-30%) for Southern bluefin tuna. The author confirmed it is very difficult to collect samples from high-sea species. A balanced sampling in terms of sizes and gear type is also important for an adequate ogive and maturity curve estimate.

60. **ACKNOWLEDGING** that some studies are considering physiological maturity (most advanced gamete in CA) while others the functional maturity (gametes are in vtg3), the WPB **NOTED** that this would necessarily result in differences in the estimation of size-at-maturity (L50), i.e. increased L50 when the advanced vtg is used. The author insisted on the importance to have standards to be able to compare the results.

61. The WPB **NOTED** that histological analyses are time-consuming and require a substantial amount of human resources. The WPB further **NOTED** that histological slides can be scanned with high resolution scanners. Samples can therefore be analysed later on and such pictures can be enhanced to facilitate the identification of characteristic elements of the different maturity stages. The author also mentioned the option to subcontract the analysis work.

62. The WPB **NOTED** that there have been attempts to use the gonado-sometic index (GSI) to determine the maturity stage. The author explained that over the 9 studies on billfish maturity, only a few of them used GSI. He emphasized that the only way to validate maturity results is through histology. The author will provide to the WPB a list of references.

63. The WPB **NOTED** paper IOTC–2024–WPB22–10 which describes macroscopic visual criteria for the identification of the sex and maturity of billfish gonads, with the following abstract provided by the authors:

"Swordfish (Xiphias gladius) is the primary target species for large pelagic longliners operating around Réunion Island. Blue marlin (Makaira nigricans) is a significant bycatch for this fleet and a key target species for coastal fishers too. Other billfish species such as striped marlin (Kajikia audax), black marlin (Istiompax indica), and sailfish (Istiophorus platypterus), while being less known species, have raised attention in recent years and were thus included in the National Biological Monitoring Plan under the Data Collection Framework (DCF). However, the maturity scales currently in use in Reunion Islands were actually designed for fish from mainland France, which differ considerably from the tropical species caught in the French overseas departments and territories—particularly the large pelagics and billfish monitored by the IOTC. The purpose of this presentation is to discuss the technical fact sheets we designed to assist field observers in determining the sex and maturity of billfish in Reunion Island fisheries using macroscopic visual criteria of gonads. These facts sheets are based on the ICES WKASMSF 2018 scale which serves as the reference for European biological monitoring. The work on these species in the western Indian Ocean is still incomplete, particularly in terms of histological validation. However, this initiative could encourage collaborative efforts to develop standardized criteria based on various studies and regions, thereby contributing to a better understanding of these species."

64. The WPB expressed some concerns about the use of a macroscopic maturity scale without a validation with a histological approach. The WPB **NOTED** that the alternative approach consisting in using the gonado-somatic index (GSI) could be helpful to validate the macroscopic maturity scale.

65. **ACKNOWLEDGING** that the presented study uses the macroscopic maturity scale developed by ICES WKASMSF in 2018, the WPB **RECOGNIZED** that this work could be a reference for future studies. However, it was **AGREED** that the WPB should work towards a standardized macroscopic maturity key. Similar studies using macroscopic criteria have been used by Chinese scientists and it would be important to map the different macroscopic scales to be able to merge and analyse results.

66. The WPB **NOTED** that in the work presented by the authors, maturity is considered immediately beyond stage A (immature), meaning from the onset of the developing stage (B).

67. The WPB **NOTED** that for tuna species there may be important differences in the results obtained from macroscopic and histological (microscopic) analyses. The WPB further **NOTED** that macroscopic analyses are more subjective and may result in biases or errors, while histological analyses are more robust. However, histological analyses cannot be performed in the field. The WPB **RECOGNISED** that the development of an AI algorithm to determine maturity stages from pictures would be helpful to limit the subjectivity of the interpretation of histological slides by humans.

68. The WPB **NOTED** that there may be biases in sampling (e.g. gear), resulting in an unbalanced sample which needs to be taken into consideration. Some life stages can indeed be absent from the fishing/sampling grounds, or not being targeted depending on the gear and fishing strategy used.

69. The WPB **NOTED** that the mature biomass is used as a proxy of the spawning stock biomass which is needed for stock assessment purposes.

70. **ACKNOWLEDGING** that summaries of biological information of IOTC species based on literature review have been developed by the Secretariat, the WPB **AGREED** that these should also include studies presented to IOTC by CPCs, **RECOGNIZING** that it is important to keep track of the work done and presented at IOTC. Those summaries need to be updated because they are currently incomplete or fuzzy, which could be done by a consultant as **SUGGESTED** by the WPB.

71. The WPB **NOTED** fecundity is also an important component of stock assessment while few studies have focused on this biological parameter.

72. The WPB **NOTED** that for the moment, there is no maturity data transmitted to the IOTC Secretariat, but a biological database is under progress at IOTC and that this will be discussed at the WPDCS.

73. The WPB **NOTED** paper IOTC–2024–WPB22–11 which provides an Introduction to the gonadal staging standards of Chinese scientific observers for billfish and estimation of maturity size, with the following abstract provided by the authors:

"*L_{50} (size at 50% maturity) is an important concept in fish reproductive biology and a critical parameter in integrated stock assessment models. The estimation of L_{50} largely depends on the data sources and biological criteria used to determine maturity. This paper briefly introduces the gonadal staging standards for tuna and tuna-like species used in the China Scientific Observer Program, and estimated L_{50} for four billfish species based on functional and physiological maturity data in the Western Indian Ocean, respectively. Our results indicate* *that the estimated L_{50} based on functional maturity data for indo-pacific sailfish, black marlin, striped marlin, and blue marlin were 187.04 cm, 174.59 cm, 170.05 cm, and 179.95 cm, respectively. After adjusting 8, 1, 6, and 9 individuals with stage-III from immature to mature due to their larger body size, the estimated L_{50} based on physiological maturity data for the four billfish species were 177.55 cm, 172.67 cm, 166.52 cm and 175.02 cm, respectively. For observers at sea, visual staging based on gonadal appearance, while the simplest and quickest, is also the most subjective and uncertain. Accurate staging based on histology and other laboratory methods should be encouraged in the future*"

74. The WPB **NOTED** that size-at-maturity (L50) may change according to latitude, which should therefore be considered in the analyses. For instance, it has been noted changes in maturity for albacore with females smaller close to the equator.

75. The WPB **NOTED** that authors proposed conservative estimates of L50 preferring using the functional maturity rather than the physiological maturity.

76. The WPB **ACKNOWLEDGED** that stage 3 includes both functionally immature and physiologically mature fish which cannot be distinguished by observers. The WPB **NOTED** that the upper 25% quantile of the individuals in stage 3 (larger individuals) were reclassified as stage 4, hence considered mature to correct for potential misidentification of the maturity. The WPB **NOTED** that the 25% is arbitrary and can be checked through histological analyses. The WPB also **NOTED** that changing this percentage would directly impact the estimated L50.

77. The WPB **ASKED** the authors to provide confidence intervals of the estimated L50 based on physiological and functional maturity, to be reviewed and assessed during a future preparation meeting. The WPB **NOTED** however that this uncertainty cannot be included in the stock assessment model.

78. The WPB **ASKED** the sample size for the different billfish species, and it was clarified that it was 160 for BLM, 88 for MLS, 33 for BUM and 55 for SFA.

79. The WPB **AGREED** the L50 provided in this study could be assessed during the next data preparatory meeting for inclusion in the next stock assessment model.

80. The WPB **NOTED** paper IOTC–2024–WPB22–12 which provides an assessment of billfish reproductive biology for enhanced sustainable management, with the following abstract provided by the authors:

"Understanding the reproductive biology of billfish in Tanzanian waters is crucial for sustainable fisheries management. This study evaluates the size at first maturity (L50) of billfish using morphometric methods, analyzing length and weight data from the Deep Sea Fishing Authority (DSFA) database, FiS for neritic data sets. The results show that the estimated size at morphometric maturity is 157 cm, with a 95% confidence interval between 155 cm and 158.3 cm. The model's R-squared value of 0.68 indicates a reliable estimation, providing valuable insights for managing billfish populations in Tanzania."

81. The WPB **NOTED** the presence of very large individuals classified as immature, which would likely be due to species misidentification or mis-recording of the weight or length. The WPB **ENCOURAGED** the authors to investigate this issue and further clean the dataset. The author mentioned this work is still in progress and further data cleaning will be done to improve the results.

82. The WPB requested clarification on the type of length which was used for the analyses as it was indicated Fork Length in the document. The author will check the type of measurement that has been performed to confirm.

83. The WPB **ENCOURAGED** the authors to liaise with the Tanzanian fishery authorities in charge of data collection, notably to provide photos of the specimens to confirm identifications, and to verify the type of measurement taken for billfish in the field (LJFL vs FL), **RECOGNIZING** that further training and working towards a standardized protocol are needed to improve data collection. It was also **NOTED** that smartphones and tablets are used to collect the data but not to take photos so far. More training is needed for species identification, but the author explained that lots of fishers arrive at the same time to land which makes it difficult for the data collection. It was mentioned that observers in Hawaii also took pictures of the fish which then helped for species identification.

84. The WPB **NOTED** that the Secretariat has given thoughts on building a photo repository of species (storage, labelling, etc.). The WPB **RECOGNIZED** that a collaborative project would help progressing on that enterprise. A collaborative project funded by OFC Japan is currently under progress for that purpose. A cross RFMO project

to share pictures would be very beneficial to the scientific community and for communication with a large audience.

6. Marlins (Priority species for 2021: Black marlin and Striped marlin)

6.1 Review of new information on the status of black and striped marlins

Striped Marlin

- **Nominal and standardised CPUE indices**

85. The WPB **NOTED** paper IOTC-2024-WPB22-17_Rev2 on the CPUE standardization of striped marlin (*Tetrapturus audax*) caught by Taiwanese large scale longline fishery in the Indian Ocean, including the following abstract provided by the authors:

"This study aggregated and analyzed catch, effort and length data of striped marlin caught by Taiwanese large longline fisheries in the Indian Ocean and conducted CPUE standardization for striped marlin for 2005-2023. This paper briefly describes historical patterns of fishing operations and striped marlin catches caught by Taiwanese large-scale longline fishery in the Indian Ocean. The groups of data sets derived from cluster analysis based on species compositions were incorporated in the CPUE standardization models as a covariate for explaining the target to obtain the relative abundance indices for further stock assessments. Except for the delta-lognormal models, the standardized CPUE series obtained from different model assumptions revealed similar trends. The Standardized CPUE indices obtained from the delta-inverse Gaussian models should be more appropriate than other models based on statistical diagnostics. The CPUE series in both NW and NE areas generally increased from 2009 to 2013 and then decreased after 2013."

86. The WPB **THANKED** and **CONGRATULATED** the authors for the comprehensive study conducted with a good range of statistical models that aimed to account for the proportion of null catch records through the splitting of the data into two probability components: (i) zero occurrence and (ii) positive CPUE.

87. The WPB **NOTED** that operational catch and effort data were available for the period 1979-2023 but that the CPUE analysis was performed from 2005 due to quality issues identified for tropical tunas in the historical period (pre-2005), which were assumed to similarly affect the billfish data.

88. The WPB **NOTED** that most catches of striped marlin taken in the Taiwanese longline fishery come from the northwestern fishing area of the Indian Ocean (>15°S and <70°E).

89. The WPB **NOTED** that the area-specific CPUE time series standardised based on different models (i.e., delta-gamma, delta inverse gaussian, and delta lognormal) showed very similar trends and widely differed from the nominal values in some years. The CPUE shows a major decline since 2018 although it increased between 2022 and 2023.

90. The WPB **REQUESTED** the authors to provide a chart comparing the new time series of standardised CPUE index (2005-2023) with the previous one (2005-2020) derived with a similar approach (IOTC–2021–WPB19–13_Rev1) to assess the consistency in the trends and CPUE status in recent years.

91. The WPB **ACKNOWLEDGED** that striped marlins are a bycatch of the Taiwanese longline fishery and **DISCUSSED** the importance of accounting for the effects of targeting in the model when dealing with bycatch species, **AGREEING** that this contributes to a more accurate definition of the fishery during the estimation process.

92. The WPB **QUERIED** the reasons behind the sharp decline in catches of striped marlin following a significant increase in 2012-2013, **NOTING** that this was not due to a change in targeting. The WPB **ENCOURAGED** the authors to explore whether this major change was the result of a reduction in fishing effort or reporting rate, as a low reporting rate might mean the data were not representative of the fishery after 2012.

93. The WPB **NOTED** that the yearly maps of distribution of effort for the Taiwanese longline fishery showed significant changes in fishing grounds between 2009 and 2011 due to piracy threats. While the fishery operated across the entire northwestern Indian Ocean prior to 2009, it did not operate off the coasts of Somalia and in the Arabian Sea during 2010-2011, an area historically characterised by high nominal values of CPUE for longline fisheries (see document IOTC-2024-WPB22-18).

94. The WPB further **NOTED** that the very high CPUEs observed in 2012-2013 corresponded to the period of return of the fishing vessels closer to the coasts, a pattern also observed for bigeye tuna which could reflect more

abundance of fish or larger fish following the reduced effort exerted during the main period of piracy. The WPB **ACKNOWLEDGED** that these changes in effort allocation were not fully captured by the standardisation process.

95. The WPB **NOTED** that the use of an inverse Gaussian distribution is not common practice in CPUE standardisation and that there were significant trends in the residuals which would need to be addressed in the future. The WPB **ENCOURAGED** the authors to explore alternative model error structures.

96. The WPB **NOTED** that the "Other" species (OTH) included in the clustering analysis in the northwestern area were mainly composed of oilfish and shark species.

97. The WPB **NOTED** that the model did not include the number of hooks per basket as a covariate to account for changes in fishing depth, as it has been shown not to be directly correlated with depth in the Taiwanese fishery.

98. The WPB **NOTED** that interactions associated with the year effect were not considered in the CPUE models and **ENCOURAGED** the authors to develop spatio-temporal models in the future to better account for changes in the spatial allocation of effort over time.

99. The WPB **NOTED** that QQ plots were used to describe the model's residuals against a normal distribution, despite the model employing an inverse Gaussian error structure. As a result, QQ plots may not be appropriate for this model. The WPB **ENCOURAGED** the authors to refer to document IOTC-2024-WPTT26(DP)-11_Rev1, which provides alternative methodologies better suited for assessing models with non-normal error structures.

100. The WPB **NOTED** that the data were characterised by a large number of zeros, which may affect the model fits. The WPB **ENCOURAGED** the authors to scrutinise the data more closely, for example, by checking whether the zeros originated from a subset of fishing vessels. The WPB **NOTED** that striped marlins occur over very large areas, making it impossible to restrict the analysis to core areas of striped marlin occurrence in order to avoid issues related to the high number of zeros.

101. The WPB **NOTED** paper IOTC-2024-WPB22-18 on the Japanese longline CPUE Standardization (1979-2022) for striped marlin (*Tetrapturus audax*) in the Indian Ocean using Bayesian hierarchical spatial model, including the following abstract provided by the authors:

"The CPUE of striped marlin caught by Japanese longliners during 1979-2022 was standardized. Area definition is the same as that in the previous studies. Time-period was divided into two, 1979-1993 and 1994-2022. Bayesian hierarchical spatial models were applied. Considering high zero catch ratio, zero-inflated Poisson generalized linear mixed model (ZIP-GLMM) was used with the R-INLA package. Best model was selected from multiple models mainly using Widely Applicable Bayesian Information Criterion (WAIC). Gradual annual decline trend with interannual variation were generally observed for the standardized CPUEs. The trends of CPUEs were similar to those for the previous study."

102. The WPB **THANKED** the authors for the work and **CONGRATULATED** them for the implementation of sophisticated statistical models using powerful estimation methods.

103. The WPB **NOTED** that the model did not directly include environmental covariates, such as sea surface temperature, with environmental features being modelled instead through spatial (latitude/longitude) and temporal (quarter) covariates. Changes in fishing patterns were modelled through the number of hooks between floats (NHB) and spatial covariates.

104. The WPB **ACKNOWLEDGED** that changes in gear technology were partly accounted for by the individual vessel effect, while the NHB covariate aimed to account for changes in catchability. The WPB **AGREED** that the model did not fully account for effort creep but recognised that this factor is difficult to assess quantitatively and should be explored through sensitivity runs in the assessment.

105. The WPB **NOTED** that the authors used a temporal correlation structure (autoregressive model 'ar1') in the final statistical model selected, which is inconsistent with the assumption of independent year effects. The WPB **ENCOURAGED** the authors to remove this correlation structure from the model in the future.

- **Stock assessments**

Stock Synthesis

106. The WPB **NOTED** paper IOTC-2024-WPB22-23 which described the Stock assessment of striped marlin (*Tetrapturus audax*) in the Indian Ocean using the Stock Synthesis, including the following abstract provided by the authors:

"In this study, Stock Synthesis (SS) was applied to conduct the stock assessment for striped marlin in the Indian Ocean. The analyses were performed by updating the historical catch, standardized CPUE series and length-frequency data, while life-history parameters and model assumptions remained the same with the scenario for the previous stock assessment adopted in 2021. The results indicated that the current spawning biomass was lower than the MSY level and the fishing mortality was higher than the MSY level. In addition, the current stock status might be as pessimistic as that obtained from the previous stock assessment in 2021"

107. The WPB **RECALLED** that in the last assessment conducted in 2021, both models (JABBA, SS3) of the Indian Ocean striped marlin estimated that the stock was overfished and was subject to overfishing.

108. The WPB **NOTED** the SS3 model for striped marlin was configured as a single area, two-sex model. The fisheries were grouped into three fleets: Taiwanese longline, Japanese longline, and others. For the reference model, the observational data included the standardised CPUE indices for the Taiwanese fleet (2005-2022, NW and NE series combined) and Japanese fleet (1994-2022, NW), and size frequency data. The earlier CPUE index from the Japanese fleet (1979-1993) was used in sensitivities.

109. The WPB **NOTED** that most life history parameters in the assessment were based on known estimates from the Pacific Ocean. It was also noted that the Stock-Recruitment (S-R) steepness used in the reference case was set at 0.5, following the previous JABBA assessment.

110. The WPB **NOTED** that the steepness value of 0.5 might be low for marlin species, which are considered to be moderately fecund. However, there isn't much research available to inform steepness values for marlins. It was noted that a steepness of 0.70, derived from reproductive biology, was used for the South-west Pacific stripe marlin stock assessment.

111. The WPB **REQUESTED** for future assessments to document how the steepness value was determined and, if possible, to explore whether it is possible to derive steepness using existing reproductive and biological data. This would support more informed decisions regarding steepness values.

112. The WPB **REQUESTED** a sensitivity analysis using a steepness value of 0.6 and another to estimate steepness within the model. It was noted these tests yielded results similar to the reference model (i.e., relatively little impact of changing steepness) and found it interesting that the model could offer some insights into estimating steepness.

113. The WPB **NOTED** that the significant stock depletion estimated by the model seemed mainly due to the sharp decline in the Japanese index from 1994 to 2005. This index is crucial for informing the model about stock productivity (i.e., B0). For future assessments, The WPB **SUGGESTED** examining how much the model results depend on this particular index in this period.

114. The WPB **NOTED** that the current fleet structure (Taiwanese longline, Japanese longline, and others) might be too simple to reflect the variations in size data. Therefore, the WPB suggested considering a split in the Japanese fishery data before and after 1994 to capture potential changes in selectivity and catchability. The WPB **AGREED** that this approach should be looked into for future assessments.

115. The WPB **NOTED** the key assessment results for SS3 for striped marlin as shown below (**Table 2; Figure 1**).

Table 2. Stock status summary table for the striped marlin assessment with stock Synthesis (reference case). CI = Confidence interval

Management quantity	Aggregate Indian Ocean
2022 catch estimate (t)	3,225
Mean catch 2015–2019 (t)	2,878
MSY (1,000 t) (80% CI)	4893 (4488 – 5299)
Data period (catch)	1950–2022
F_{MSY} (80% CI)	0.22 (0.21–0.24)

SB_{MSY} (1,000 t) (80% CI)	15389 (14211 – 16567)
F_{2022}/F_{MSY} (80% CI)	9.26 (5.38–13.14)
SB_{2022}/SB_{MSY} (80% CI)	0.27 (0.19–0.35)
SB_{2022}/SB_{1950} (80% CI)	0.036 (0.03–0.04)

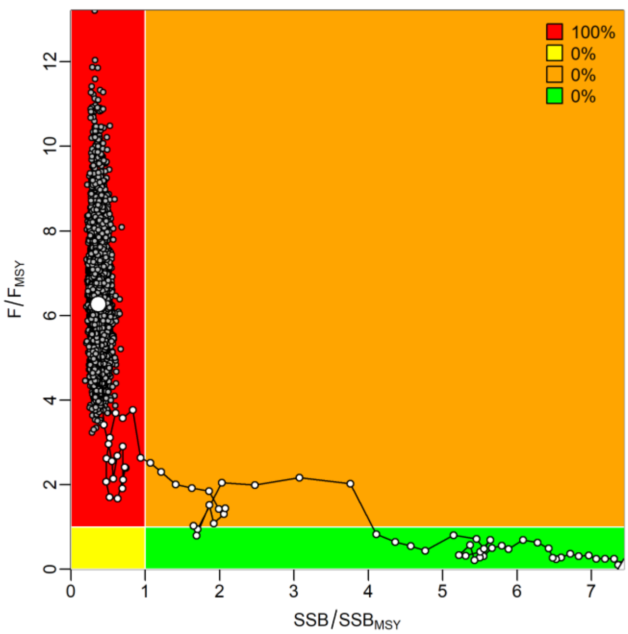

Figure 1. Stock synthesis: Kobe stock status plot for the Indian Ocean for striped marlin (reference case). The black line traces the trajectory of the stock over time.

Bayesian Surplus Production Model (JABBA)

116. The WPB **NOTED** document IOTC-2024-WPB22-24 which described the assessment of the Indian Ocean striped marlin (*Tetrapturus audax*) stock using JABBA, including the following abstract as provided by the author:

"In this study, the stock assessment for striped marlin in the Indian Ocean was conducted using Just Another Bayesian Biomass Assessment (JABBA) based on the model specifications from scenario S2 of Parker (2021), which was adopted by WPB as a reference case, with updated catches and standardized CPUE indices. Several scenarios were created based on the Pella-Tomlinson model, incorporating different assumptions related to CPUE indices, r priors, input values of BMSY/K, and process error. The results from all scenarios indicated that the current status of striped marlin in the Indian Ocean may be overfished and subject to overfishing"

117. The WPB **NOTED** that the assessment considered eight alternative specifications of the Pella-Tomlinson model type based on a single nominal catch data time-series, two differing CPUE indices combinations, three differing r priors and associated input values of BMSY/K, as well as a single scenario with inflated process error. The reference case has the following configuration:

- **S1 (Ref.):** for B_{MSY}/K = 0.37, *r* prior *LN* ~ (log (0.25), 0.15)), CPUE = TW_NW, TW_NE, JP_NW, JP_NE

118. The WPB **NOTED** that different model configurations have yielded similar stock status estimates, which align with the SS3 model results. This consistency might be due to consistent key parameters between the JABBA (BMSY/K and r) and SS3 models, such as steepness.

119. The WPB **NOTED** a range of intrinsic growth rates (r): low (0.21), medium (0.25), and high (0.31), and various production function models with BMSY/K values from 0.23 to 0.4, with the fox model (BMSY/K=0.37) as a reference case. These were based on steepness values between 0.4 and 0.86, following previous assessment decisions.

120. The WPB **NOTED** that the initial depletion in the first year (1950) was set to 1 with a variation (CV) of 0.10. This could result in some iterations showing the starting biomass much higher than the unfished equilibrium (K). To avoid this, it was suggested to set the initial depletion below 100% (e.g., 0.9).

121. The WPB **NOTED** some patterns in the residuals when fitting CPUE data. It was noted that the process error variance was fixed and suggested relaxing this assumption to improve the fit to the CPUE index.

122. The WPB **NOTED** a significant increase in fishing mortality in recent years, as a result of the biomass dropping to historically low levels, even as catches decreased during the same period.

123. The WPB **NOTED** that CPUE indices for the assessment were provided for specific sub-areas (NW, NE), and that the spatial stratification for standardizing CPUE was the same as that used for swordfish CPUE standardization and assessment. However, the WPB pointed out that the biomass dynamics model couldn't account for spatial differences, therefore, different regional indices might lead to internal inconsistencies. Even though in this case, the sub-area indices were similar, it could be better to combine them into a single index (as done in the SS3 model with TWN NW and NE using catch weighting) or assessing the impact of each index individually by excluding one at a time.

124. The WPB also **NOTED** that previous studies suggested the possibility of separate populations of stripe marlin in the eastern and western Indian Ocean. Therefore, separate CPUEs for east and west make sense. The WPB suggested developing a conceptual model based on an appropriate population structure to establish a sound spatial stratification for the assessment model.

125. The WPB **NOTED** the key assessment results for Bayesian State Space Surplus-Production Model (JABBA) for striped marlin from the base case (S2) as shown below (**Table 3; Figure 2**).

Table 3. Stock status summary table for the striped marlin assessment (JABBA) reference model (scenario 1). CI = Confidence interval

Management quantity	JABBA (scenario 1)
Current catch	3,225
Mean catch 2015–2022 (t)	2,878
MSY (1,000 t) (95% CI)	4725 (4222 - 5235)
F_{MSY} (95% CI)	0.26 (0.20 - 0.35)
Data period (catch)	1950–2022
F_{2022}/F_{MSY}	3.95 (2.54 - 6.14)
B_{2022}/B_{MSY} (95% CI)	0.17 (0.11 – 0.27)
SB_{2022}/SB_{MSY}	N/A
B_{2022}/B_0 (95% CI)	0.06 (0.04 – 0.10)
SB_{2022}/SB_0	N/A

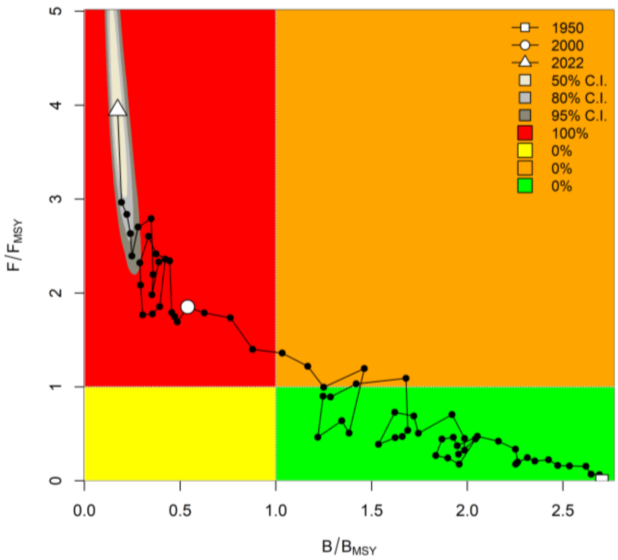

Figure 2. JABBA: Kobe stock status plot for the Indian Ocean for striped marlin for the JABBA reference case model (Scenario 1). The black line traces the trajectory of the stock over time. Contours represent the smoothed probability distribution for 2022 (isopleths represent the probabilities relative to the maximum)

Black Marlin

- **Nominal and standardised CPUE indices**

126. The WPB **NOTED** paper IOTC-2024-WPB22-19 on CPUE standardization of black marlin (*Makaira indica*) caught by Taiwanese large scale longline fishery in the Indian Ocean, including the following abstract provided by the authors:

"This paper briefly describes historical patterns of black marlin catches caught by Taiwanese large-scale longline fishery in the Indian Ocean. The cluster analysis was adopted to explore the targeting of fishing operations. In addition, the delta-inverse Gaussian generalized linear models were selected to conduct the CPUE standardizations of black marlin caught by Taiwanese large-scale longline fishery. The results indicate that the targeting effects (clusters) provided the 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 targeting of fishing operations. The standardized CPUE series obtained from different delta model assumptions revealed quite similar trends for all models except for the delta-lognormal model. The Standardized CPUE indices obtained from the delta-inverse Gaussian models should be more appropriate than other models based on statistical diagnostics. The CPUE series in the northern areas (NW and NE) gradually increased until the mid-2010s, then declined from 2015 to 2022, before rising again in the last year.""

127. The WPB **THANKED** the authors for the work and **NOTED** that the comments made for paper IOTC-2021-WPB19-13 and relative to data quality prior to the mid-2000s (i.e., time series length), analysis conducted independently in each area (i.e., potential issue of fishing effort displacements across areas), and impact of the zero catch records on the results, also applied to the CPUE analysis of black marlin.

128. The WPB **NOTED** that the proportion of zeros in the dataset was higher for black marlin than for striped marlin and **QUERIED** whether the authors had considered using a Tweedie model. The WPB **NOTED** that some trials were conducted in the past with such distributions, but they did not yield good results.

129. The WPB **ACKNOWLEDGED** that spatio-temporal models (e.g., Vector Autoregressive Spatio-Temporal models; VAST) should be developed and utilised in the future for the CPUE standardisation process to better account for changes in the distribution of fisheries effort. The WPB **NOTED** that some development of VAST models has been initiated as part of the joint collaborative CPUE work with some shared R scripts and examples to support the use of such models for deriving abundance indices in IOTC assessment models.

130. The WPB **NOTED** paper IOTC-2024-WPB22-20 regarding Japanese Longline CPUE Standardization (1979-2022) for black marlin (*Makaira indica*) in the Indian Ocean using Bayesian hierarchical spatial model, including the following abstract provided by the authors:

"CPUE of black marlin caught by Japanese longliners during 1979-2022 was standardized. Area definition is the same as that in the previous studies. Time-period was divided into two, 1979-1993 and 1994-2022. Bayesian

hierarchical spatial models were applied. Considering high zero catch ratio, zero-inflated Poisson generalized linear mixed model (ZIP-GLMM) was used with the R-INLA package. Best model was selected from multiple models mainly using Widely Applicable Bayesian Information Criterion (WAIC). Gradual annual declining trend with interannual variation were observed for the standardized CPUE during 1979-1993, while stable annual trends were observed for that during 1994-2022. The trend of the CPUE for 1994-2022 was similar to that for the previous study."

131. The WPB **THANKED** the authors for the study and **NOTED** that the technical comments were the same as for the application of the method to striped marlin as described in paper IOTC-2024-WPB22-18.

132. The WPB **NOTED** that more than 90% of Japanese longline fishing operations reported no catch of black marlin, and that the models were well-suited to handle this type of dataset.

133. The WPB **NOTED** paper IOTC-2024-WPB22-21_Rev1 on an update on CPUE Standardization of Black Marlin (*Istiompax indica*) from Indonesian Tuna Longline Fleets 2006-2020, including the following abstract provided by the authors:

"The black marlin (Istiompax indica) is a valuable by-catch in tuna longline fisheries, but its status is uncertain due to recent catch increases and conflicting data, particularly in the abundance index. Therefore, this study was intended to analyse the catch-per-unit-of-effort (CPUE) of black marlin, particularly in the north-eastern Indian Ocean, by utilising scientific observers data. The analysis hopefully can address the existing information gap associated with low coverage in this region. Catch and effort data from more than 3,000 sets were obtained from the Indonesian scientific observer program, spanning the years 2006 to 2023. These data were spatially disaggregated into one-degree blocks and were collected alongside commercial longline fleets. To analyse the dataset, Poisson and negative binomial models were considered, with number of fish as the response variable and total hooks as an offset. Six covariates were included in the models, i.e. year, quarter, cat_hbf, moon, lat, lon. The results showed that, despite inter-annual fluctuations, the trend in black marlin CPUE remained relatively stable over time but exhibited a decline in the past four years. The need for improved and continued monitoring is imminent to enhance our understanding and management of this important by-catch species."

134. The WPB **THANKED** and **CONGRATULATED** the authors for the study based on observer data which provides additional information on the population dynamics of black marlin in the eastern Indian Ocean for some fisheries other than Japan and Taiwan,China.

135. The WPB **NOTED** that funding availability and access to fishing vessels led to significant variability in the observer data for the study.

136. The WPB **ACKNOWLEDGED** that there were several data quality issues, with very low coverage in some years and highly unbalanced sampling, both of which affected the model outputs.

137. The WPB **NOTED** that the authors used Poisson and Negative Binomial models for CPUE standardisation, and that the moon effect was not found to be significant. The standardised index showed high inter-annual fluctuations without any clear trend.

138. The WPB **NOTED** that the nominal CPUEs were very low in 2023 and that some data checks should be performed for that year.

139. The WPB **NOTED** that the standardised index derived from the analysis was not included in the 2024 black marlin assessment, though there were improvements in the data. The WPB ENCOURAGED the authors to continue improving the work, with the possibility of including the data in a joint CPUE analysis.

- **Stock assessments**

Bayesian Surplus Production Model (JABBA)

140. The WPB **NOTED** document IOTC-2024-WPB22-25: Assessment of the Indian Ocean black marlin (*Makaira indica*) stock using JABBA, including the following abstract as provided by the author:

"In this study, the stock assessment for black marlin in the Indian Ocean was used to conduct using Just Another Bayesian Biomass Assessment (JABBA) based on the model specifications from scenario S2 of Parker (2021), which was adopted by WPB as a reference case, with updated catches and standardized CPUE indices. Five scenarios were created based on model specifications that incorporated three different r priors and associated input values of BMSY/K, and two different three different process error variance. The results from

most scenarios indicated that the current status of black marlin in the Indian Ocean is not overfished but may be subjected to overfishing"

141. The WPB **RECALLED** that in the last stock assessment conducted in 2018, the assessment was characterized by model uncertainty and consequently, the black marlin stock was classified as "Not assessed/Uncertain" in 2018.

142. The WPB **NOTED** that CPUE indices included in the assessment were based on the reference Model of the 2021 assessment: TWN_NW (2005-2022), TWN_NE (2005-2022), JPN (1994-2022) and IND (2006-2022).

143. The WPB **NOTED** that the assessment considered five alternative specifications of the Pella-Tomlinson model type based on a single nominal catch data time-series, three differing r priors and associated input values of BMSY/K, as well as a single scenario with inflated process error. CPUE data were used): TWN_NW (2005-2022), TWN_NE (2005-2022), JPN (1994-2022) and IND (2006-2022). The proposed reference case by the author has the following configuration:

- S1 (Ref.): for BMSY/K = 0.37 (h = 0.5), r prior LN ~ (log (0.19), 0.3), process error variance = 0.07

144. Following the discussion of the striped marlin assessment, the WPB **SUGGESTED** that future assessment investigate the possibility of deriving the production function using a steepness value that is based on the available information of the reproductive biology of the stock.

145. The WPB **NOTED** that fixed process error variance of 0.07 and 0.2 being examined in the reference case (S1) and as sensitivities (S4), respectively. An additional model (S5) was conducted to estimate process error variance. The WPB agreed that this is a good exercise to examine the posterior distribution of the estimated process error in order to evaluate its influence on the assessment. It was noted that a very low value of posterior process error variance was estimated and this is likely to be a result of the small prior mean (0.07) assumed (be consistent with the reference case). The WPB **NOTED** that the fixed process error of 0.07, which was recommended from the previous assessment appears to be sufficient to accommodate the additional variance in the CPUE series.

146. The WPB **NOTED** the relatively poor fits of the Japanese and Taiwanese CPUE indices in recent years. This is mainly due to their conflict with the Indonesian CPUE index. An additional model (S6) was requested which excluded the Indonesia index and this model has resulted in improvements to both indices, as expected.

147. Noting the noticeable conflict between the Indonesian and Japanese/Taiwanese index, The WPB discussed whether Indonesian index should or should not be included the reference model. One point of view is that Indonesian index cover somewhat different areas, and the difference may potentially reflect different regional trend. However, the WPB **AGREED** that the JABBA model cannot account for spatial structure and the general good practice is not to include conflicting indices in the same model. Further, the Indonesian index covered a local area, whereas the Japanese and Taiwanese have covered wider areas and are also consistent with each other. Therefore, the WPB **AGREED** that S6 should be considered as a reference case.

148. In this context, the WPB **NOTED** that a Joint analysis of fleet specific CPUE could be useful because if catch effort data from multiple fleets were all representative of abundance, there should be no conflict between them. A Joint analysis based on a consistent statistical framework would help account for difference in catchability between fleets and can increase the power to identify potential factors that might explain the difference between fleets. Further, the fleets can complement each other in spatial and temporal coverage of the stock, thus increasing the chance of producing a representative abundance index using a unified modelling approach. As such, the WPB **RECOMMENDED** that the SC dedicate effort to harmonise the standardised methods for different fleets and to develop a joint analysis combining catch effort data from key fleets for major billfish species where feasible.

149. The WPB **NOTED** that the early Japanese index (1979-2004) was not included in the assessment, following the recommendation from Japanese scientist which pointed out that there has been some changes in the logbook system in the early 1990s. The WPB **REQUESTED** a sensitivity to be concluded that include the early Japanese index (similar to the sensitivity run in the striped marlin assessment). This sensitivity leads to a more pessimistic estimate of the stock status. The WPB **REQUESTED** that the reason for excluding the early index in the stock assessment to be better documented to facilitate the assessment decisions as this might have an impact on many other species.

150. The WPB **NOTED** that respective analysis performed indicated no systematic departures from the reference case prediction (**Figure 3**). The WPB **AGREED** that the retrospective analysis provide some confidence in the stability

in the estimates of reference points as well as the predictive capabilities of the model (on the contrary, The WPB **RECALLED** that the 2021 assessment model produced a very undesirable pattern)

151. The WPB **NOTED** the key assessment results for the reference case (S6) of the Bayesian State Space Surplus-Production Model (JABBA) for black marlin as shown below (**Table 4; Figure 4**).

Table 4. Stock status summary table for the black marlin assessment (JABBA). CI = Confidence interval

Management quantity	JABBA (S1)
Current catch in assessment	26320
Mean catch 2020–2022 (t)	17709
MSY (1,000 t) (80% CI)	13878 (8733–28511)
F_{MSY} (80% CI)	0.21 (0.15 – 0.30)
Data period (catch)	1950 – 2022
F_{2022}/F_{MSY}	1.39 (0.72 – 2.45)
B_{2022}/B_{MSY} (80% CI)	1.35 (0.96– 1.79)
SB_{2022}/SB_{MSY}	N/A
B_{2022}/B_0 (80% CI)	0.49 (0.35 – 0.66)
SB_{2022}/SB_0	N/A

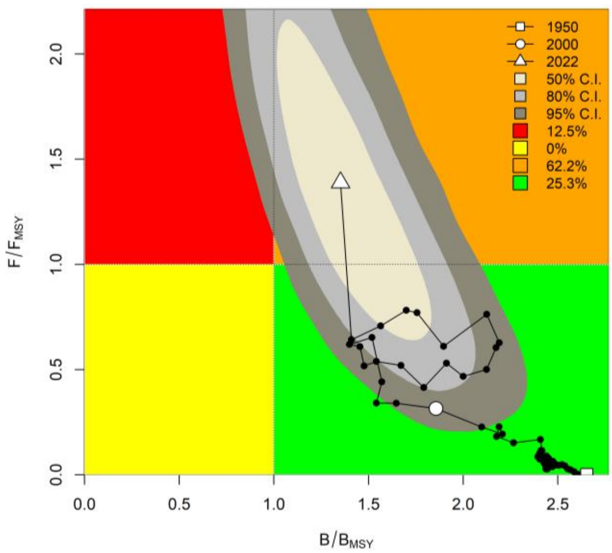

Figure 3: JABBA: Kobe stock status plot for the Indian Ocean for black marlin, from the final JABBA base case (Reference Scenario – S6). The black line traces the trajectory of the stock over time. Contours represent the smoothed probability distribution for 2022 (isopleths are probability relative to the maximum)

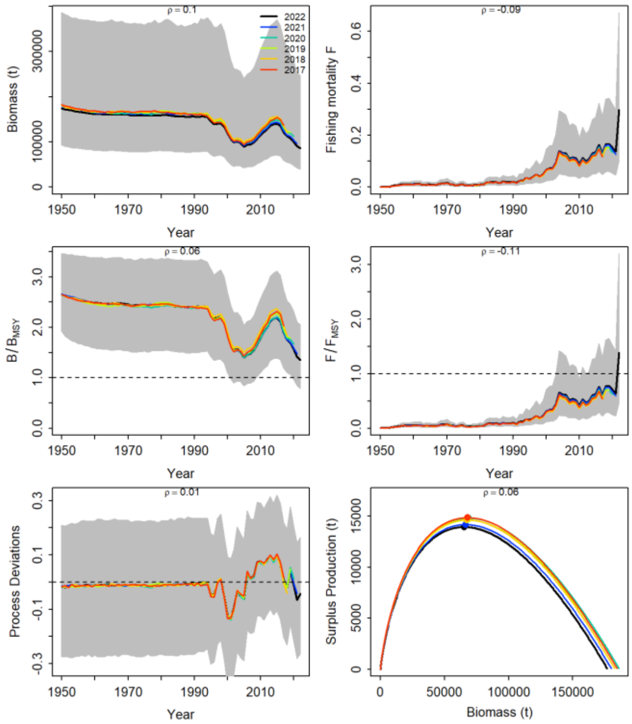

Figure 4: Retrospective analysis for stock biomass (t), surplus production function (maximum = MSY), B/BMSY and F/FMSY for the Indian Ocean black marlin JABBA Reference Scenario (S6)

6.2 Development of management advice for black and striped marlins and update of species Executive Summaries for the consideration of the Scientific Committee, including discussion on current catch limits as per standing IOTC Resolutions

Striped marlin

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

153. On the weight-of-evidence available in 2022, the WPB **AGREED** that the stock status of striped marlin is determined to be overfished and subject to overfishing. The WPB **AGREED** that projections are to be conducted using the base case (S2) of the JABBA model to provide management advice. However, the WPB **NOTED** that the age-structured model can better account for the lagging effect in stock recovery and requested the projections to also be conducted using the SS3 model in the future iteration of striped marlin assessment.

154. The WPB **ADOPTED** the management advice developed for striped marlin, as provided in the draft status summary and **REQUESTED** that the IOTC Secretariat update the draft stock status summary with the latest 2022 interaction data and the JABBA to be provided to the SC as part of the draft Executive Summary, for its consideration.
    - Striped marlin (*Kajikia audax*) – Appendix VII

Black marlin

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

156. The WPB also **NOTED** there was concern over the uncertainties related historical catch reporting of black marlin from key fishing states. However, there has been progress recently with black marlin catch data, particularly from coastal countries in the northern Indian Ocean.

157. The WPB further **NOTED** that the 2024 JABBA model diagnostics highlighted the improved performance with regards to the robustness of management reference point estimates compared to previous assessments. In particular, there is no systematic deviations in the retrospective analysis, which provided some confidence in

the predictive capabilities of the model, and as such model projections could be used to provide management advice.

158. The WPB **ADOPTED** the management advice developed for black marlin, as provided in the draft status summary and **REQUESTED** that the IOTC Secretariat update the draft stock status summary with the latest 2022 interaction data to be provided to the SC as part of the draft Executive Summary, for its consideration:
    - Black marlin (*Istiompax indica*) – Appendix V

7. PROGRESS MANAGEMENT PROCEDURE (RESOLUTION 24/08)

159. The WPB **NOTED** that the Resolution 24/08 species the Management Procedure (MP) for swordfish and also provides an implementation schedule for the MP. The implementation schedule requires an annual review of evidence of potential exception circumstances concerning the implementation of the MP.

160. The WPB **NOTED** the presentation on the purpose and process for undertaking an annual review to identify if there are any exceptional circumstances that might potentially impact the application and implementation of the IOTC swordfish MP.

161. The WPB **DISCUSSED** three key considerations as per the Exceptional Circumstance Guidelines (Appendix 6a of IOTC-2021-SC24-R_Rev1):

- Do we have new knowledge about the stock, population dynamics or biology?
- Have there been significant recent changes in fisheries or fishing operations?
- Have there been changes to input data to the MP, or missing data?

162. With respect to stock status the WPB **NOTED** that the estimates of recent stock status reference points are well aligned with the estimated status from the OMs and MSE.

163. With respect to population dynamics, the WPB **NOTED** that there has recently been research completed indicating the potential for population structuring into northern and southern Indian Ocean stocks. This research will soon be published in the scientific peer reviewed journal and will be presented to WPB in 2025 for review and discussion. The WPB considered that if the findings of the research are accepted to reflect the stock structure of Swordfish in the Indian Ocean, this is likely to constitute an Exceptional Circumstance. This is on the basis that the MSE and associated OMs used to test and tune the current MP were constructed under the assumption of a single stock.

164. With respect to changes in fisheries or fishing operations, the WPB **NOTED** concerns around the shift over time of swordfish catch from distant water fisheries to coastal fisheries and the implications this may have for the degree to which the Japanese CPUE in particular (drawn from the NW Indian Ocean) is representative of the abundance of the stock in that NW area, noting that the Japanese fleet catch and effort has significantly decreased over the past decade overall, but in particular in the north western region. It was **NOTED** that while that shift has been occurring for some years and may have been captured in the MSE, this issue should be notified to the WPM for consideration, and monitored into the future for its potential to trigger exceptional circumstances.

165. With respect to input data for the MP, the modellers confirmed that the standardised CPUE including up to 2023 had been completed, utilising the consistent methodology (to that used in MSE) and was available for running the MP. It was also confirmed that a total IOTC catch estimate for 2023 would be available for running the MP. It was **NOTED** that the standardised CPUE series submitted to WPB was missing a value for 2011 but that this was previously internally estimated by the standardisation protocol, due to there being no fishing in that region in 2011 (due to piracy issue) and does not impact the time series estimates nor the recent CPUE slope and distance to target (and therefore will not be an exceptional circumstance).

166. The WPB **REQUESTED** that in future, the WPB meeting agenda includes an agenda item for the annual review of "Exceptional Circumstances" and that that agenda item is supported by a paper (submitted to the meeting by the papers deadline) which reviews available recent data, information and evidence relevant to the key criteria outlined in the Exceptional Circumstance Guidelines. This will better facilitate discussion and provision of advice from WPB to WPM and the IOTC SC.

8. OTHER BILLFISHES

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

8.2 Resolution 18/05 Catch Limits

167. The WPB **NOTED** paper IOTC-2024-WPB22-INF04 on recent catches of billfish in relation to catch limits set out in Resolution 18/05.

168. The WPB **NOTED** that Resolution 18/05 applies to striped marlin, black marlin, blue marlin and Indo-Pacific sailfish and states that if the average annual catch of any of these species exceeds the limit for two consecutive years from 2020 onwards, the Commission shall review the implementation and effectiveness of the measures contained in the Resolution.

169. The WPB **NOTED** a continuous increase in catches of the four species, with black marlin and sailfish exceeding the limits established in resolution 18/05 since their implementation. Preliminary data for 2023 indicate a significant increase in black marlin catches, while sailfish catches show a slight decrease.

170. The WPB **NOTED** that coastal fisheries have consistently contributed over 90% of black marlin and Indo-Pacific sailfish catches in recent years, with gillnet fisheries accounting for more than 70%. **NOTING** that the increase in black marlin catches is attributed to heightened activity from Indian fisheries and Iranian gillnet operations, while the rise in Indo-Pacific sailfish catches is largely due to contributions from Sri Lankan fisheries.

171. The WPB **NOTED** that the catch limits for black marlin and Indo-Pacific sailfish set by Resolution 18/05 have consistently been exceeded since its implementation. Therefore, the WPB **RECOMMENDED** that the SC advise the Commission to reassess the effectiveness of the current measures within this resolution. Additionally, the WPB **RECOMMENDED** that the SC advise the Commission of the need to revise Resolution 18/05 to update the catch limits based on the latest stock assessments and projections for the billfish species.

9. WPB PROGRAM OF WORK

9.1 Revision of the WPB Program of Work (2025–2029) (Chairperson and IOTC Secretariat)

- IOTC-2024-WPB22-08: Revision of the WPB Program of Work (2025–2029) (IOTC Secretariat)

172. The WPB **NOTED** paper IOTC–2024–WPB22–08 which provided an opportunity to consider and revise the WPB Program of Work (2025–2029), by taking into account the specific requests of the Commission, Scientific Committee, and the resources available to the IOTC Secretariat and CPCs.

173. 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).

174. The WPB **NOTED** that several Working Parties had identified CPUE standardisation as a priority and therefore **REQUESTED** that the WPM consider facilitating a cross-cutting CPUE standardisation workshop.

175. **NOTING** this request for a CPUE standardisation workshop, and the need to optimise the running of stock assessments, the WPB **REQUESTED** that a data preparatory meeting is held in 2025 which could cover both the CPUE standardisation and data preparatory work for the upcoming assessments.

176. The WPB **RECOMMENDED** that the SC consider and endorse the WPB Program of Work (2025–2029), as provided in Appendix IX.

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

177. 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 WPB22 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.

178. 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 2025 by an Invited Expert:

- **Expertise**: CPUE standardisation.
- **Priority areas for contribution**: Providing expert input into CPUE standardisation work.

10. OTHER BUSINESS

10.1 Date and place of the 23rd and 24th Sessions of the Working Party on Billfish

179. The WPB **REQUESTED** that CPCs that may be interested in hosting the 23rd and 24th Working Party on Billfish meetings contact the Secretariat.

180. The WPB **NOTED** that the SC emphasized the importance of holding working party meetings in a hybrid format whenever feasible. However, the WPB further **NOTED** that this should not discourage CPCs from offering to host the meetings, even if they are unable to accommodate a hybrid format.

181. The WPB **RECOMMENDED** the SC consider early September as a preferred time period to hold the WPB23 in 2025. As usual it was also **AGREED** that this meeting should continue to be held back-to-back with the WPEB and that in 2025 WPB will be held in the week following the WPEB.

10.2 Review of the draft, and adoption of the Report of the 22nd Session of the Working Party on Billfish

182. The WPB **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPB22, provided at Appendix X, 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 2024 (Fig. 3):

  - Swordfish (*Xiphias gladius*)– Appendix IV
  - Black marlin (Istiompax *indica*) – Appendix V
  - Blue marlin (*Makaira nigricans*) – Appendix VI
  - Striped marlin (*Kajikia audax*) – Appendix VII
  - Indo-Pacific sailfish (*Istiophorus platypterus*) – Appendix VIII

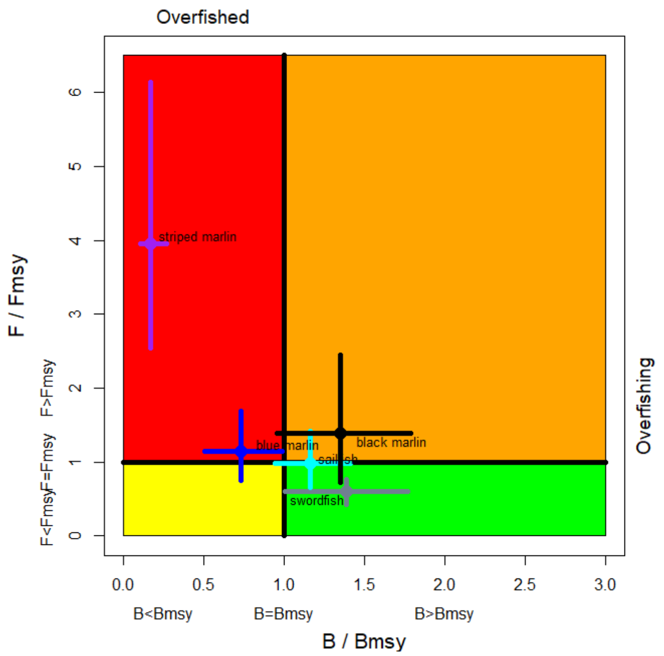

Fig. 5. Combined Kobe plot for swordfish (grey), indo-pacific sailfish (cyan), black marlin (black), blue marlin (blue) and striped marlin (purple) showing the 2022, 2023, and 2004 estimates of current stock size (SB or B, species assessment dependent) and current fishing mortality (F) in relation to optimal spawning stock size and optimal fishing mortality. Cross bars illustrate the range of uncertainty from the model runs.

183. The report of the 22nd Session of the Working Party on Billfish (IOTC–2024–WPB22–R) was **ADOPTED** by correspondence.

APPENDIX I - LIST OF PARTICIPANTS

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APPENDIX II - AGENDA FOR THE 22ND WORKING PARTY ON BILLFISH

Date: 4–7 September 2024
Location: Berjaya Beau Vallon Bay Hotel, Seychelles
Time: 09:00 – 17:00 daily (Seychelles time)
Chair: Dr Jie Cao (China); **Vice-Chair** Dr Sylvain Bonhommeau (France)**:**

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

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

3. **THE IOTC PROCESS: OUTCOMES, UPDATES AND PROGRESS**
   - 3.1. Outcomes of the 26th Session of the Scientific Committee (IOTC Secretariat)
   - 3.2. Outcomes of the 28th Session of the Commission (IOTC Secretariat)
   - 3.3. Review of Conservation and Management Measures relevant to billfish (IOTC Secretariat)
   - 3.4. Progress on the recommendations of WPB21 (IOTC Secretariat)

4. **NEW INFORMATION ON FISHERIES AND ASSOCIATED ENVIRONMENTAL DATA FOR BILLFISH**
   - 4.1. Review of the statistical data available for billfish at the Secretariat (IOTC Secretariat)
   - 4.2. New information on sport fisheries (all)

5. **BILLFISH REPRODUCTIVE BIOLOGY Workshop**

6. **MARLINS (Priority species for 2024: Black marlin and Striped marlin)**
   - 6.1. Review new information on marlin biology, stock structure, fisheries and associated environmental data (all)
   - 6.2. Review of new information on the status of black and striped marlins (all)
     - Nominal and standardised CPUE indices
     - Stock assessments
     - Selection of Stock Status indicators
   - 6.3. Development of management advice for black and striped marlins and update of species Executive Summaries for the consideration of the Scientific Committee, including discussion on current catch limits as per standing IOTC Resolutions (all)

7. **THE SWORDFISH MANAGEMENT Procedure (Resolution 24/08)**
   - 7.1. Process for running Resolution 24/08 on Swordfish MP

8. **OTHER BILLFISHES (new information for informing future assessments)**
   - 8.1. Review of new information on other billfishes (other marlins, I.P. sailfish) biology, stock structure, fisheries and associated environmental data (all)
   - 8.2. Resolution 18/05 Catch Limits

9. WPB PROGRAM OF WORK

9.1. Revision of the WPB Program of Work (2025–2029) (Chairperson and IOTC Secretariat)

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

10. OTHER BUSINESS

10.1. Election of the Chairperson and Vice-Chairperson of the WPB for the next biennium (Secretariat)

10.2. Date and place of the 23rd and 24th Sessions of the Working Party on Billfish (Chairperson and IOTC Secretariat)

10.3. Review of the draft, and adoption of the Report of the 22nd Session of the Working Party on Billfish (Chairperson)

APPENDIX III - LIST OF DOCUMENTS FOR THE 22ST WORKING PARTY ON BILLFISH

Document	Title
IOTC-2024-WPB22-01a	Agenda of the 22nd Working Party on Billfish
IOTC-2024-WPB22-01b	Annotated agenda of the 22nd Working Party on Billfish
IOTC-2024-WPB22-02	List of documents of the 22nd Working Party on Billfish
IOTC-2024-WPB22-03	Outcomes of the 26th Session of the Scientific Committee (IOTC Secretariat)
IOTC-2024-WPB22-04	Outcomes of the 28th Session of the Commission (IOTC Secretariat)
IOTC-2024-WPB22-05	Review of Conservation and Management Measures relevant to billfish (IOTC Secretariat)
IOTC-2024-WPB22-06	Progress made on the recommendations and requests of WPB21 and SC26 (IOTC Secretariat)
IOTC-2024-WPB22-07	Review of the statistical data and fishery trends for billfish species (IOTC Secretariat)
IOTC-2024-WPB22-08	Revision of the WPB Program of Work (2025-2029) (IOTC Secretariat)
IOTC-2024-WPB22-09	Review of past and recent studies applying gonad histology to define reproductive phases and maturity status in billfish species (R Humphreys)
IOTC-2024-WPB22-10	Macroscopic visual criteria for the identification of the sex and maturity of billfish gonads, used in Reunion Island, following the ICES WKASMSF 2018 scale (B Brisset, H Evano).
IOTC-2024-WPB22-11	Introduction to the gonadal staging standards of Chinese scientific observers for billfish and estimation of maturity size (X Wang, Z Chen)
IOTC-2024-WPB22-12	Assessment of Billfish Reproductive Biology for Enhanced Sustainable Management (M Silas)
IOTC-2024-WPB22-13	An update on the billfish landings in Pakistan with special reference to the use of sub-surface gillnetting (M Moazzam)
IOTC-2024-WPB22-14	Towards Sustainable Management of Billfish Fisheries in Iran: A Large Pelagic Fishery Assessment (R Dafrazi)
IOTC-2024-WPB22-15	Bill Fish Fishery Resources; Present Context and Research Challenges (K Bandaranayake)
IOTC-2024-WPB22-16	Billfish bycatch from different fishing methods of purse seine fishery in the Andaman Sea of Thailand (W Thitipongtrakul, S Hoimuk)
IOTC-2024-WPB22-17	CPUE standardization of striped marlin (*Tetrapturus audax*) caught by Taiwanese large-scale longline fishery in the Indian Ocean. (Y Chen, S Wang, W Xu, C Lin)
IOTC-2024-WPB22-18	Japanese longline CPUE Standardization (1979-2022) for striped marlin (*Tetrapturus audax*) in the Indian Ocean using Bayesian hierarchical spatial model. (T Matsumoto, K Taki, H Ijima, M Kai)
IOTC-2024-WPB22-19	CPUE standardization of black marlin (*Makaira indica*) caught by Taiwanese large-scale longline fishery in the Indian Ocean. (W Xu, S Wang, C Lin, Y Chen)
IOTC-2024-WPB22-20	Japanese longline CPUE Standardization (1979-2022) for black marlin (*Makaira indica*) in the Indian Ocean using Bayesian hierarchical spatial model (T Matsumoto, K Taki, H Ijima, M. Kai)
IOTC-2024-WPB22-21	Update on CPUE standardization of black marlin (Makaira indica) from Indonesian (B Setyadji, M Spencer, S Ferson, L Kell, S Wright)

Document	**Title**
IOTC-2024-WPB22-23	Stock assessment of Striped marlin (*Tetrapturus audax*) in the Indian Ocean using the Stock Synthesis. (W Xu, S Wang, C Lin, Y Chen)
IOTC-2024-WPB22-24	Stock assessment of Striped marlin (*Tetrapturus audax*) in the Indian Ocean using the JABBA. (Y Chen, S Wang, W Xu, C Lin)
IOTC-2024-WPB22-25	Stock assessment of black marlin (*Makaira indica*) in the Indian Ocean using the JABBA. (Y Chen, S Wang, W Xu, C Lin)
IOTC-2024-WPB22-INF01	A Standardized Terminology for Describing Reproductive Development in Fishes (N Brown-Peterson, D Wyanski, F Saborido-Rey, B Macewicz, S Lowerre-Barbieri)
IOTC-2024-WPB22-INF02	A unified framework and terminology for reproductive traits integral to understanding fish population productivity (S Lowerre-Barbieri, N Brown-Peterson, D Wyanski, H Moncrief-Cox, K Kolmos, H Menendez, B Barnett, C Friess)
IOTC-2024-WPB22-INF03	Draft technical report on the re-estimation of Indonesia's annual catch data for period 1950-2022
IOTC-2024-WPB22-INF04	Status of marlins and sailfish catches- resolution 18/05
IOTC-2024-WPB22-INF05	Review of the statistical data available for Indian Ocean black marlin (1950-2022)
IOTC-2024-WPB22-INF06	Review of the statistical data available for Indian Ocean blue marlin (1950-2022)
IOTC-2024-WPB22-INF07	Review of the statistical data available for Indian Ocean striped marlin (1950-2022)
IOTC-2024-WPB22-INF08	Review of the statistical data available for Indian Ocean indo-pacific sailfish (1950-2022)
IOTC-2024-WPB22-INF09	Review of the statistical data available for Indian Ocean swordfish (1950-2022)

APPENDIX IV - [DRAFT] RESOURCE STOCK STATUS SUMMARY – SWORDFISH

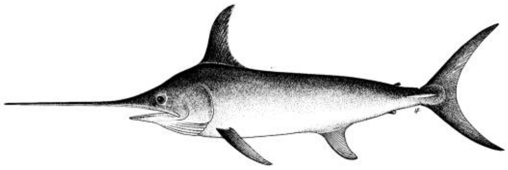

TABLE 1. Status of swordfish (*Xiphias gladius*) in the Indian Ocean.

Area[1]	Indicators		2023 stock status determination
Indian Ocean	Catch 2022[2] (t) Average catch 2018-2022 (t)	23,404 28,922	**97%**
	MSY (1,000 t) (80% CI) F_{MSY} (80% CI) SB_{MSY} (1,000 t) (80% CI) F_{2021}/F_{MSY} (80% CI) SB_{2021}/SB_{MSY} (80% CI) SB_{2021}/SB_{1950} (80% CI)	30 (26–33) 0.16 (0.12–0.20) 55 (40–70) 0.60 (0.43–0.77) 1.39 (1.01–1.77) 0.35 (0.32–0.37)	

[1] Boundaries for the Indian Ocean stock assessment are defined as the IOTC area of competence
[2] Proportion of 2022 catch estimated or partially estimated by IOTC Secretariat: 19.3%
[3]2021 is the final year that data were available for this assessment

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)	0.2%	0
Stock not subject to overfishing (F_{year}/F_{MSY}≤ 1)	3%	97%
Not assessed/Uncertain/Unknown		

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

Stock status. No new stock assessment was conducted for swordfish in 2024 thus the stock status estimates are based on the assessment carried out in 2023. Two models were applied to the swordfish stock (ASPIC and Stock Synthesis (SS3)), with the SS3 stock assessment selected to provide scientific advice (as done previously). An update of the JABBA model was also conducted during the WPB meeting. The reported SS3 stock status is based on a grid of 48 model configurations designed to capture the uncertainty relating to steepness of the stock recruitment relationship (0.7, 0.8, and 0.9), recruitment variability (two levels), CPUE series (2 options), growth (2 options) and weighting of length composition data (two options). A number of the options included in the final grid were selected from a range of additional sensitivity runs that were conducted to explore uncertainties. Median spawning biomass in 2021 was estimated to be 35% (80% CI: 32-37%) of the unfished levels (**Table 1**) and 1.39 times (80% CI: 1.01-1.77) the level required to support MSY. Median fishing mortality in 2021 was estimated to be 60% (80% CI 43%-77%) of the FMSY level, and catch in 2021 (23,237 t) was well below the estimated MSY level of 29,856 t (80% CI: 26,319-33,393t). Taking into account the characterized uncertainty, and on the weight-of-evidence available in 2023, the swordfish stock is determined to be ***not overfished*** and ***not subject to overfishing*** (**Table 1**, **Fig. 3**).

Outlook. The significant decrease in recent longline catch and effort from 2019 to 2022 (a 33% reduction from 35,256t to 23,597t) substantially lowered the pressure on the Indian Ocean stock as a whole, and current fishing mortality is not expected to reduce the population to an overfished state over the next decade. (**Table 1**). The estimated recent recruitment (2010-2020) was above the long-term average although this appears to be mainly driven by the sharp increase in the Japanese longline CPUE in the northern region. The WPB expressed concern over whether that CPUE index accurately represents the change of abundance in that region which may require further investigation. Further, the South-western region, which is one of the sub-regions used in the model, exhibit a declining biomass trend which indicate higher depletion in this region, compared to other regions.

Management advice. The 2021 catches (23,237t at the time of the assessment) were significantly lower than the estimated MSY level (29,856 t). Under those levels of catches, the spawning biomass was projected to likely increase, with a high probability of maintaining at or above the SB_{MSY} for the longer term. There is a very low risk of exceeding MSY-based reference points by 2031 if catches are maintained at 2021 levels (<1% risk that SB_{2031}< SB_{MSY}, and <1% risk that F_{2021}> F_{MSY}). The projections indicate that an increase of 40% or more from 2021 catch levels will not likely result in the biomass dropping below the SB_{MSY} level for the longer term (with a 15% probability). Catches in 2022 (23,597t) were still lower than the estimated MSY. Nevertheless, the Commission should consider monitoring the catches to ensure that the probability of exceeding the SB_{MSY} target reference points in the long term remains minimal. Taking into account the differential CPUE and biomass trends between regions, the WPB noted that there is recurring evidence for localised depletion in the South Western region (which appears to be more depleted than other regions) 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 29,856 t.
- **Provisional reference points**: noting that the Commission in 2015 agreed to Resolution 15/10 *on target and limit reference points and a decision framework*, the following should be noted:
    a. **Fishing mortality**: current fishing mortality is considered to be below the provisional target reference point of F_{MSY} and below the provisional limit reference point of 1.4*F_{MSY} (**Fig. 2**).
    b. **Biomass**: current spawning biomass is considered to be above the target reference point of SB_{MSY}, and therefore above the limit reference point of 0.4*SB_{MSY} (**Fig. 2**).
- **Main fisheries (mean annual catch 2018-2022)**: swordfish are caught using longline (53.6%), followed by line (30.1%) and gillnet (15.8%). The remaining catches taken with other gears contributed to 0.5% of the total catches in recent years (**Fig. 1**).
- **Main fleets (mean annual catch 2018-2022)**: the majority of swordfish catches are attributed to vessels flagged to Sri Lanka (27.4%) followed by Taiwan,China (17%) and Yemen (6.2%). The 25 other fleets catching swordfish contributed to 49.5% of the total catch in recent years (**Fig. 2**).

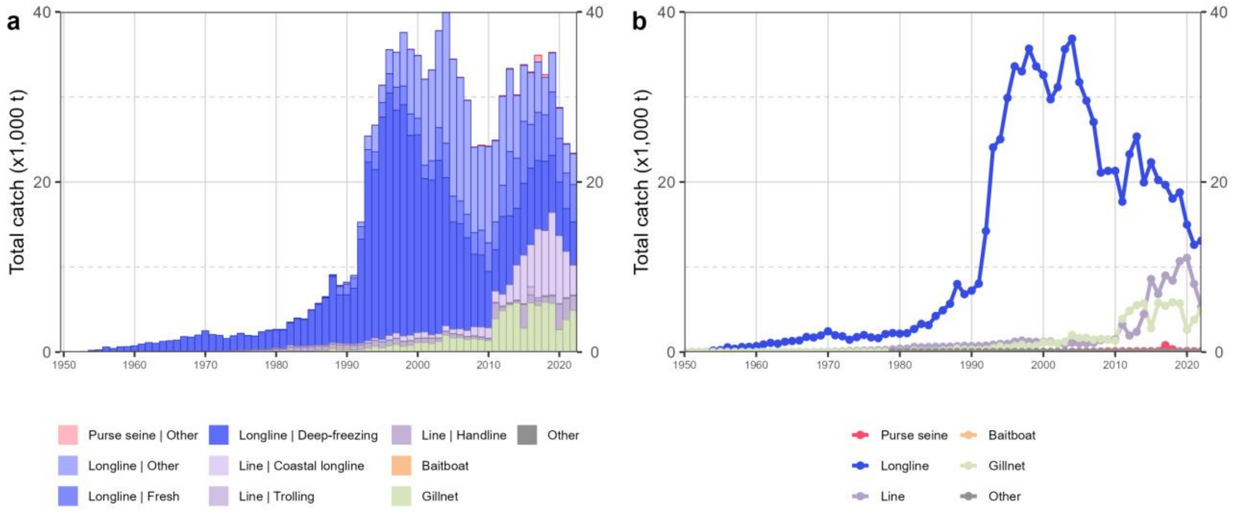

Fig. 1. Annual time series of (a) cumulative nominal catches (metric tons; t) by fishery and (b) individual nominal catches (metric tons; t) by fishery group for swordfish during 1950–2022. Longline|Other: swordfish and sharks-targeting longlines; Other: all remaining fishing gears

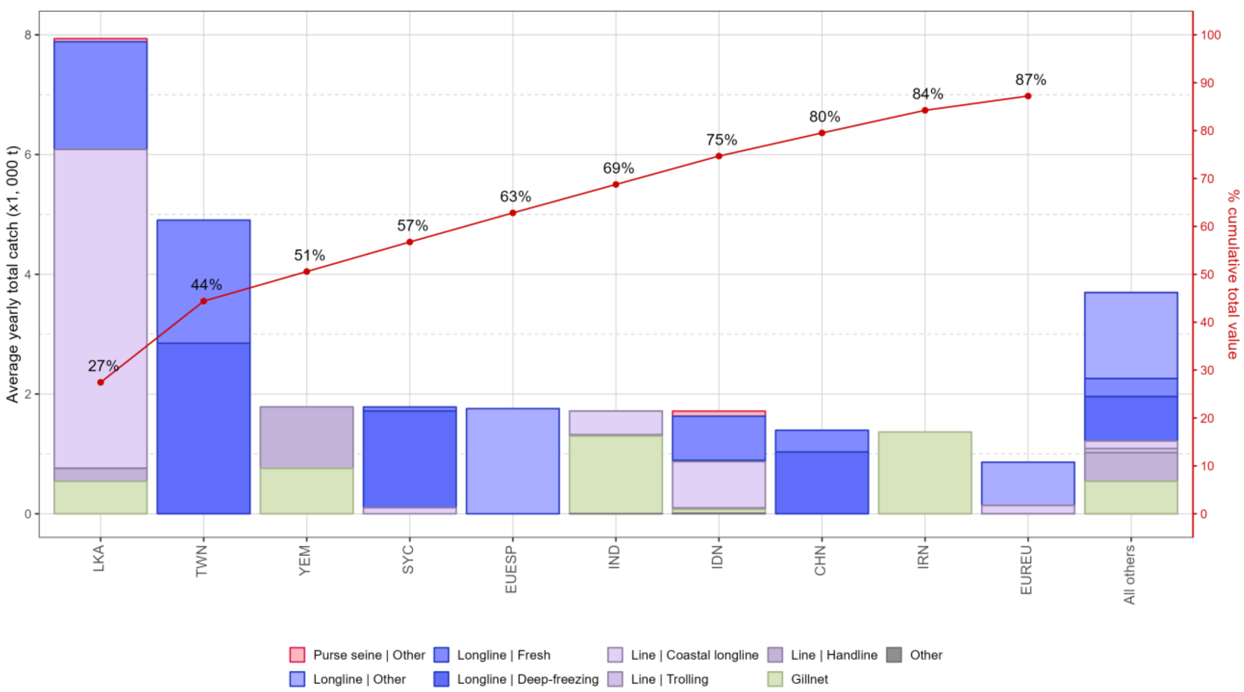

Fig. 2. Mean annual catches (metric tons; t) of swordfish by fleet and fishery between 2018 and 2022, with indication of cumulative catches by fleet. Longline | Other: swordfish and sharks-targeted longlines; Other: all remaining fishing gears

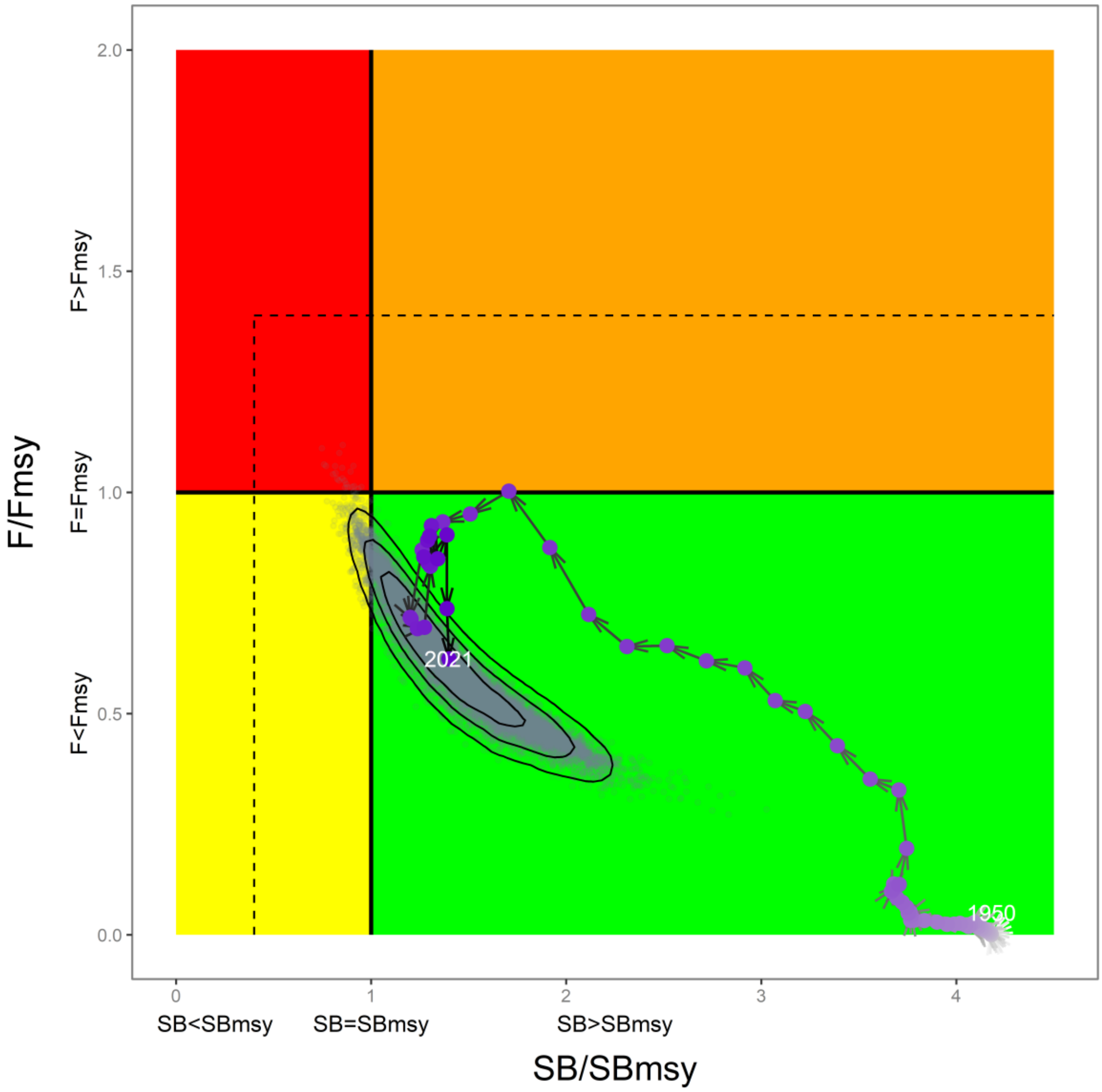

Fig. 3. Swordfish: 2021 stock status, relative to SB_{MSY} (x-axis) and F_{MSY} (y-axis) reference points for the final model grid. Grey dots represent uncertainty from individual models with 50%, 80% and 95% contours lines. The arrowed line represents the time series of stock trajectory from the reference model. The dashed lines represent limit reference points for Indian Ocean swordfish (SB_{lim} = 0.4 SB_{MSY} and F_{lim} = 1.4*FMSY)

Table 2. Swordfish: SS3 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 2021 catch level (23 237 t)*, 0%, ± 20%, ± 40%) projected for 3 and 10 years.

Reference point and projection timeframe	**Alternative catch projections (relative to the 2019 catch of 3,001 t) and probability (%) of violating MSY-based target reference points (Btarg = B_{MSY}; Ftarg = F_{MSY})**				
	60% (13 942 t)	**80%** (18 590 t)	**100%** (23 237 t)	**120%** (27 884 t)	**140%** (32 532 t)
$B_{2024} < B_{MSY}$	0	0	1	1	2
$F_{2024} > F_{MSY}$	0	0	0	5	24
$B_{2031} < B_{MSY}$	0	0	0	3	15
$F_{2031} > F_{MSY}$	0	0	0	8	30

APPENDIX V - [DRAFT] RESOURCE STOCK STATUS SUMMARIES – BLACK MARLIN

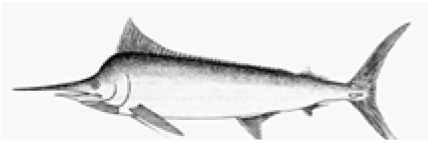

TABLE 1. Status of black marlin (*Istiompax indica*) in the Indian Ocean.

Area[1]	Indicators		2024 stock status determination[3]
Indian Ocean	Catch 2022 (t)[2] Average catch 2018–2022 (t)	26,320 18,235	62.2%
	MSY (1,000 t) (80% CI) F_{MSY} (80% CI) B_{MSY} (1,000 t) (80% CI) F_{2022}/F_{MSY} (80% CI) B_{2022}/B_{MSY} (80% CI) B_{2022}/B_0 (80% CI)	13.90 (8.73 – 28.51) 0.21 (0.15 - 0.30) 65.23 (46.43-101.84) 1.39 (0.72 – 2.45) 1.35 (0.96 – 1.79) 0.49 (0.35 – 0.66)	

[1] Boundaries for the Indian Ocean stock assessment are defined as the IOTC area of competence
[2] Proportion of 2022 catch fully or partially estimated by the IOTC Secretariat: 21.7%
[3]2020 is the final year that data were available for this assessment

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)	12.5%	**62.2%**
Stock not subject to overfishing (F_{year}/F_{MSY}≤ 1)	0	25.3%
Not assessed/Uncertain/Unknown		

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

Stock status. A new stock assessment was carried out for black marlin in 2024, based on JABBA, a Bayesian state-space production model (using data up to 2022). The relative point estimates for this assessment are F/FMSY=1.39 (0.72-2.45) and B/BMSY=1.35 (0.96 -1.79). The Kobe plot indicated that the stock is currently not overfished but is subject overfishing (Table 1; Fig. 3). In 2022, the catch of black marlin surged to 26,320 tons. Until 2024, fish stock status was characterised as “uncertain” due to significant uncertainties in past assessments (like those from 2018 and 2021). These uncertainties were attributed to both historical catch reporting from key fishing state and poor assessment diagnostics. However, there's been progress recently with black marlin catch data, particularly from coastal countries in the northern Indian Ocean, and the latest JABBA assessment shows it's now more reliable (with improved model fitting to the abundance indices and acceptable level of retrospective patterns). The assessment relied on CPUE indices from longline fisheries in which the black marlin is a bycatch species. On the weight-of-evidence available in 2024, the stock status of black marlin is determined to be not overfished but subject to overfishing (Table 1; Fig. 3).

Outlook. While the recent high catches seem to be mainly due to developing coastal fisheries operating in the core habitat of the species (mainly IR.Iran, India and Sri Lanka), the CPUE indicators are from industrial fleets with lower catches of black marlin operating mostly offshore. There has been a substantial increase of catches of black marlin from coastal countries. The outlook is likely to remain uncertain in the absence of CPUE indices from gillnet and coastal longline fleets to inform stock assessment models. Moreover, catches remain substantially higher than the limits stipulated in Res 18/05 and are a cause for concern as this will likely continue to drive the population towards overfished status.

Management advice. The catch limits (9932 t) as stipulated in Resolution 18/05 have been exceeded for three consecutive years since 2020, which as per resolution 18/05, requires a review of the resolution. Furthermore, these limits are not based on estimates of most recent stock assessment. Thus, it is recommended that the Commission urgently revise 18/05 to incorporate limits that reflect the most recent stock assessment and projections and review and where necessary revise the implementation and effectiveness of the measures contained in this Resolution. The stock is now subject to overfishing. 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 as per Resolution 18/05, it needs to provide mechanisms to ensure the maximum annual catches remain less than 10 626 t (**Table 3**).

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The following key points should be noted:

- **Maximum Sustainable Yield (MSY)**: estimate for the whole Indian Ocean is 13,900 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 nor harvest control rules have been established for black marlin.
- **Main fisheries** (mean annual catch 2018-2022): black marlin are caught using gillnet (63.3%), followed by line (25%) and longline (7%). The remaining catches taken with other gears contributed to 4.7% of the total catches in recent years (**Fig. 1**).
- **Main fleets** (mean annual catch 2018-2022): the majority of black marlin catches are attributed to flagged to I. R. Iran (42.7%) followed by India (19.4%) and Sri Lanka (12.2%). The 27 other fleets catching black marlin contributed to 25.4% of the total catch in recent years (**Fig. 2**).

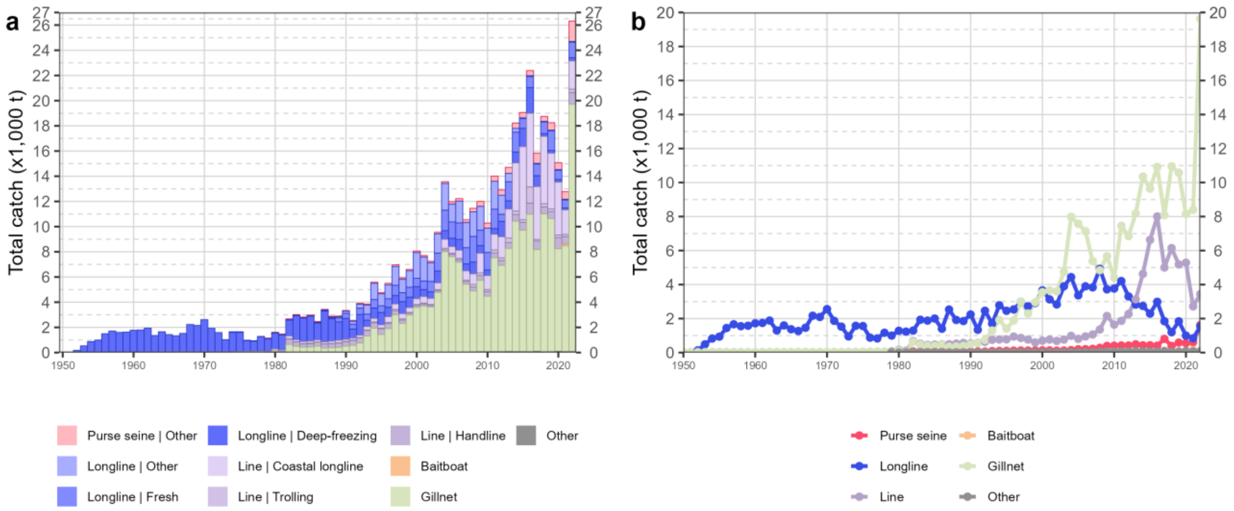

Fig. 1. Annual time series of (a) cumulative nominal catches (metric tons; t) by fishery and (b) individual nominal catches (metric tons; t) by fishery group for black marlin during 1950-2022. Longline | Other: swordfish and sharks-targeted longlines; Other: all remaining fishing gears

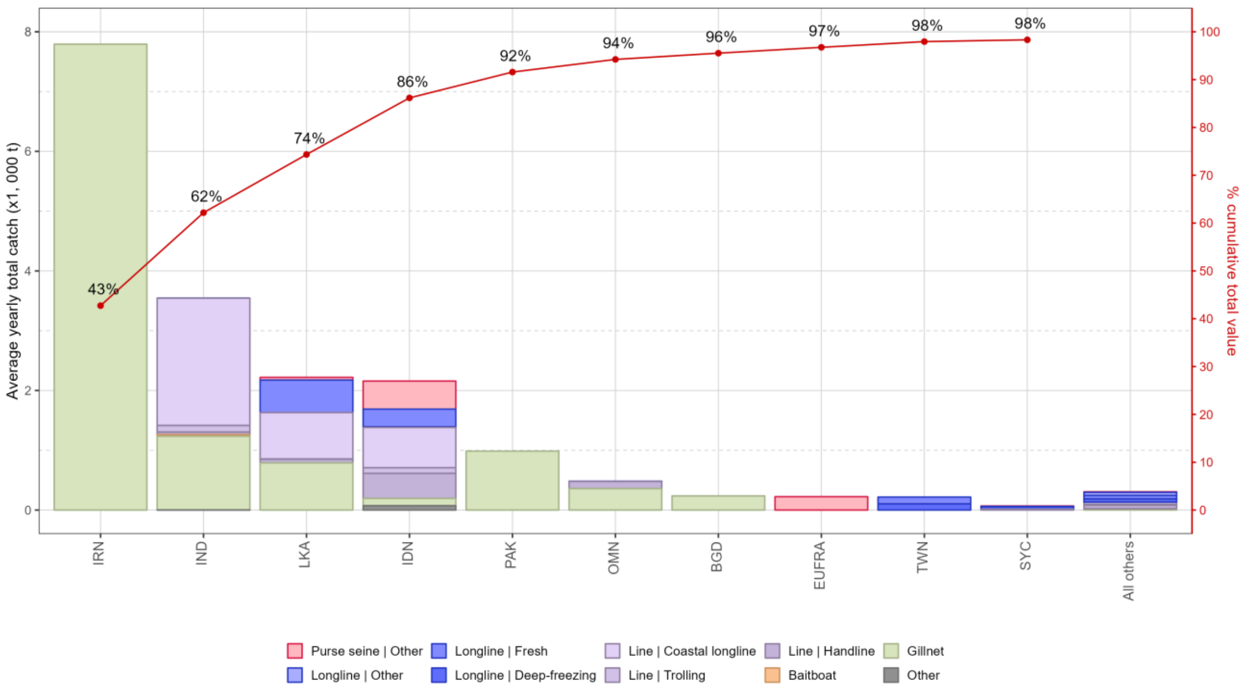

Fig. 2. Mean annual catches (metric tons; t) of black marlin by fleet and fishery between 2018 and 2022, with indication of cumulative catches by fleet. Longline | Other: swordfish and sharks-targeted longlines; Other: all remaining fishing gears

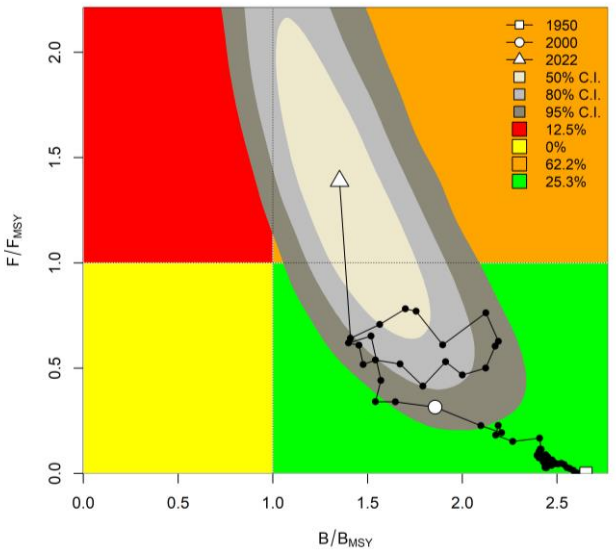

Fig. 3. JABBA Indian Ocean assessment Kobe plots for black marlin (contours are the 50, 80 and 95 percentiles of the 2022 estimate). Black line indicates the trajectory of the point estimates for the total biomass ratio (B/B_{MSY}) and fishing mortality ratio (F/F_{MSY}) for each year 1950–2022.

Table 2. Black 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 catch level of 2020 – 2022 (17710 t) * ± 20%, ± 40%,± 60%) projected for 3 and 10 years.

Reference point and projection timeframe	**Alternative catch projections (relative to the average catch level of 2020–2022 of 17710 t) and probability (%) of violating MSY-based target reference points (Btarg = B_{MSY}; Ftarg = F_{MSY})**						
	40% (7084 t)	**60%** (10626 t)	**80%** (14168 t)	**100%** (17710 t)	**120%** (21252 t)	**140%** (24794 t)	**160%** (28336 t)
$B_{2025} < B_{MSY}$	23	31	40	49	57	64	70
$F_{2025} > F_{MSY}$	6	23	45	63	76	84	89
$B_{2032} < B_{MSY}$	8	25	48	67	80	88	92
$F_{2032} > F_{MSY}$	4	21	49	71	84	91	95

Table 3. Black marlin: Probability (percentage) of achieving the KOBE green quadrat from 2023-2032 for a range of constant catch projections (JABBA).

Catch (t)| Year	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
7084 (40%)	65	72	77	81	85	87	89	90	91	92
10626 (60%)	63	66	68	70	71	72	73	74	74	75
14168 (80%)	55	54	53	53	52	52	51	50	50	50
17710(100%)	42	39	37	35	33	32	31	30	29	29
21252 (120%)	30	27	24	22	21	19	18	17	17	16
24794 (140%)	22	19	16	14	13	12	11	10	9	9
28336 (160%)	16	13	11	9	8	7	7	6	6	5

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

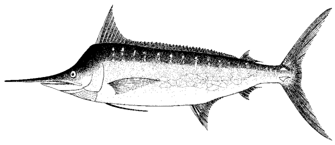

Table 1. Status of blue marlin (*Makaira nigricans*) in the Indian Ocean

Area[1]	Indicators		2022 stock status determination[3]
Indian Ocean	Catch 2022[2] (t)	5,658	72%*
	Average catch 2018-2022 (t)	7,175	
	MSY (1,000 t) (80% CI)	8.74 (7.14 –10.72)	
	F_{MSY} (80% CI)	0.24 (0.14 – 0.39)	
	B_{MSY} (1,000 t) (80% CI)	35.8 (22.9 – 60.3)	
	F_{2020}/F_{MSY} (80% CI)	1.13 (0.75 – 1.69)	
	B_{2020}/B_{MSY} (80% CI)	0.73 (0.51 – 0.99)	
	B_{2020}/B_0 (80% CI)	0.36 (0.26 – 0.50)	

[1] Boundaries for the Indian Ocean are defined as the IOTC area of competence
[2] Proportion of 2022 catch estimated or partially estimated by IOTC Secretariat: 34.5%
[3]2020 is the final year that data were available for this assessment
* 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)	**72%**	**0%**
Stock not subject to overfishing (F_{year}/F_{MSY}≤ 1)	**26%**	**2%**
Not assessed/Uncertain/Unknown		

The percentages are calculated as the proportion of model terminal values that fall within each quadrant with model weights taken into account

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

Stock status. No new stock assessment was carried out for blue marlin in 2024, thus the stock status is determined on basis of the 2022 assessment which was based on two different models: JABBA, a Bayesian state-space production model (age-aggregated); and SS3, an integrated model (age-structured) (using data up to 2020). Uncertainty in the biological parameters is still evident and as such the JABBA model (B2020/BMSY = 0.73, F2020/FMSY =1.13) was selected as the base case. Both models were consistent with regards to stock status. On the weight-of-evidence available in 2022, the stock is determined to be ***overfished*** and ***subject to overfishing*** (**Table 1** and **Fig. 3**).

Outlook. The B/B_{MSY} trajectory declined from the mid-1980s to 2007. A short-term increase in B/B_{MSY} occurred from 2007 to 2012, which is thought to be linked to the NW Indian Ocean Piracy period. Thereafter, the B/B_{MSY} trajectory again declines to the current estimate **of 0.73**. F/F_{MSY} increased since the mid-1980s and despite a recent decline, F/F_{MSY} remains above 1. The majority of CPUE indices have shown a declining trend since 2015.

Management advice. The current catches of blue marlin (average of 7,045 t in the last 5 years, 2018-2022) are lower than MSY (8,740 t). The stock is currently overfished and subject to overfishing. According to K2SM calculated (Table 2), a reduction of 20% of catches (5,700 t.) compared to 2020 catches (7,126t.) would recover the stock to the green quadrant by 2030 with a probability of 79% and if the catches are reduced by 10% (6,413 t.) the probability would be 67%. The Commission should note that the current catch limit for blue marlin in Resolution 18/05 (11,930 t, which was established as the MSY value estimated in 2016 stock assessment) is 36% higher than the new MSY estimated by the latest stock assessment in 2022 (8,740 t). Thus, It is recommended that the Commission urgently revise Resolution 18/05 to incorporate limits that reflect the most recent stock assessment and projections and review and where necessary revise the implementation and effectiveness of the measures contained in this Resolution.

The following key points should also be noted:

- **Maximum Sustainable Yield (MSY)**: estimate for the Indian Ocean blue marlin stock is 8,740 t (estimated range 7,140–10,720 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 fisheries (mean annual catch 2018-2022)**: blue marlin are caught using longline (50.4%), followed by line (25.6%) and gillnet (22.5%). The remaining catches taken with other gears contributed to 1.5% of the total catches in recent years (**Fig. 1**).
- **Main fleets (mean annual catch 2018-2022)**: the majority of blue marlin catches are attributed to vessels flagged to Taiwan,China (25.9%) followed by Sri Lanka (22.5%) and India (17.8%). The 25 other fleets catching blue marlin contributed to 33.7% of the total catch in recent years (Fig. 2).

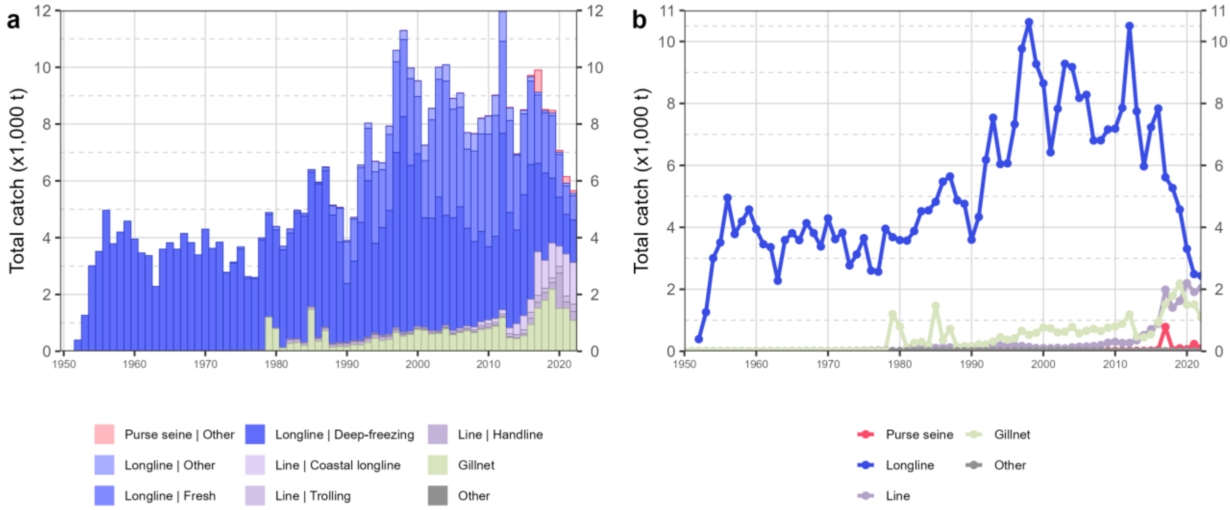

Fig. 1. Annual time series of (a) cumulative nominal catches (metric tons; t) by fishery and (b) individual nominal catches (metric tons; t) by fishery group for blue marlin during 1950-2022. Longline | Other: swordfish and sharks-targeted longlines; Other: all remaining fishing gears

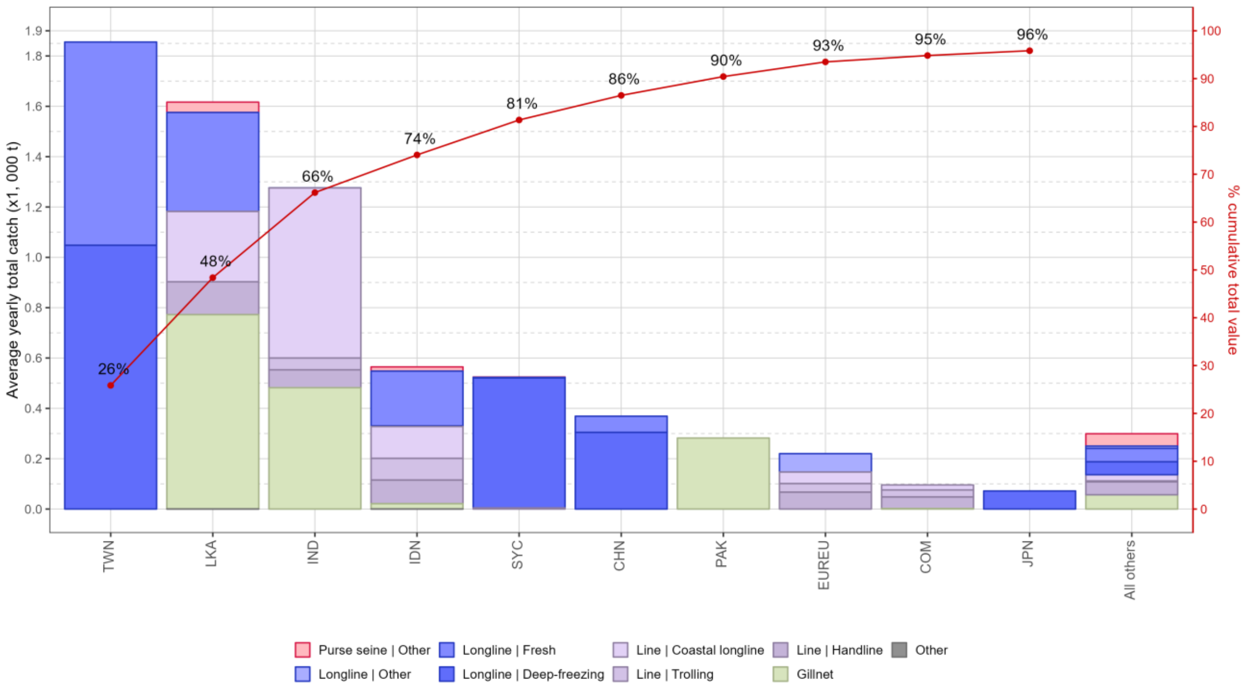

Fig. 2. Mean annual catches (metric tons; t) of blue marlin by fleet and fishery between 2018 and 2022, with indication of cumulative catches by fleet. Longline | Other: swordfish and sharks-targeted longlines; Other: all remaining fishing gears

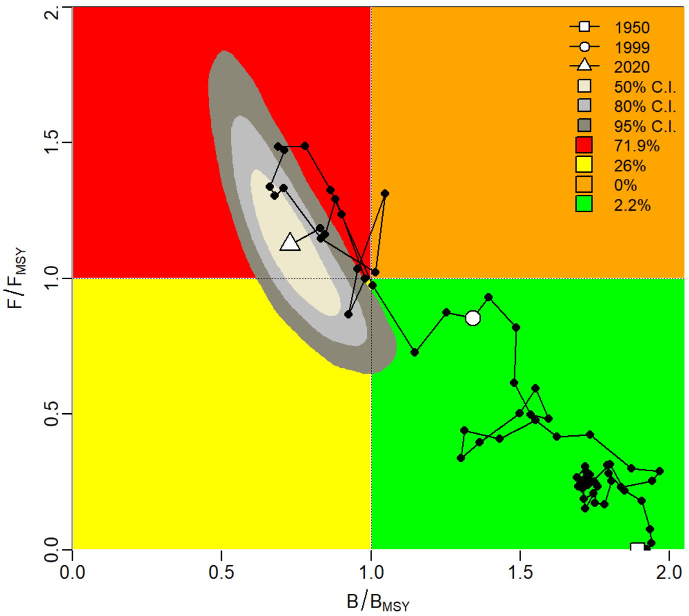

Fig. 3. Kobe stock status plot for the Indian Ocean stock of blue marlin, from the final JABBA base case (the black line traces the trajectory of the stock over time). Contours represent the smoothed probability distribution for 2020 (isopleths are probability relative to the maximum).

Table 2. 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 2020 catch level (7,126 t)

TAC (t) | Year	2023	2024	2025	2026	2027	2028	2029	2030
2137	65	81	90	94	96	98	99	99
2850	59	76	85	91	94	96	97	98
3563	54	70	80	87	90	93	95	96
4275	48	63	73	80	86	89	91	93
4998	42	55	65	72	78	82	85	88
5700	36	47	56	63	69	73	77	79
6413	30	40	46	53	57	61	65	67
7126	25	32	37	41	45	48	51	53
7838	21	24	28	31	33	35	37	38

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

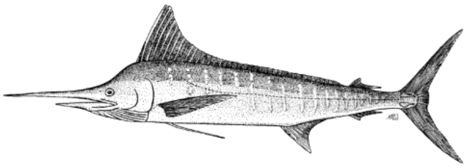

Table 1. Status of striped marlin (*Kajikia audax*) in the Indian Ocean

Area[1]	Indicators		2024 stock status determination[5]
Indian Ocean	Catch 2022[2] (t) Average catch 2018-2022 (t)	3,225 2,856	**100%***
	MSY (1,000 t) (JABBA) MSY (1,000 t) (SS3) F_{MSY} (JABBA) F_{MSY} (SS3) F_{2022}/F_{MSY} (JABBA) F_{2022}/F_{MSY} (SS3) B_{2022}/B_{msy} (JABBA) SB_{2022}/SB_{MSY} (SS3)[4] B_{2022}/B_0(JABBA) SB_{2022}/SB_0 (SS3)	4.73 (4.22 – 5.24)[3] 4.89 (4.48-5.30) 0.26 (0.20–0.35) 0.22 (0.21–0.24) 3.95 (2.54 - 6.14) 9.26 (5.38-13.14) 0.17 (0.11 - 0.27) 0.27 (0.19-0.35) 0.06 (0.04 – 0.10) 0.036 (0.03-0.04)	

[1] Boundaries for the Indian Ocean are defined as IOTC area of competence
[2] Proportion of 2022 catch estimated or partially estimated by IOTC Secretariat: 15.4%
[3] Range estimates in the table are 80% confidence interval
[4] SS3 is the only model that used SB/SB_{MSY}, all others used B/B_{MSY}
[5] 2022 is the final year that data were available for this assessment
* 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)	**100%**	**0.0%**
Stock not subject to overfishing (F_{year}/F_{MSY}≤ 1)	**0.0%**	**0.0%**
Not assessed/Uncertain/Unknown		

The percentages are calculated as the proportion of model terminal values that fall within each quadrant with model weights taken into account

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

Stock status. A new stock assessment was carried out for striped marlin in 2024, based on two different models: JABBA, a Bayesian state-space production model (age-aggregated); and SS3, an integrated model (age-structured) (using data up to 2022). Both models were generally consistent with regards to stock status and confirmed the results from 2012, 2013, 2015, 2017, 2018, and 2021 assessments, indicating that the stock is subject to overfishing ($F>F_{MSY}$) and is overfished, with the biomass being below the level which would produce MSY ($B<B_{MSY}$) for over a decade. Both SS3 and JABBA assessments rely on CPUE indices from the longline fisheries in which the striped marlin are not the main target species. On the weight-of-evidence available in 2024, the stock status of striped marlin is determined to be ***overfished*** and ***subject to overfishing*** (**Table 1**; **Fig. 3**).

Outlook. Biomass estimates of the Indian Ocean striped marlin stock have likely been below BMSY since the late 90's – the stock has been severely depleted (B/B_0 = 0.06; JABBA model). The level of depletion has increased since the previous assessment and is currently the worst among IOTC species. There has been a substantial increase of catches of stripe marlin from coastal fleets in recent years. The outlook is very pessimistic, and a substantial decrease in fishing mortality is required to ensure a reasonable chance of stock recovery in the foreseeable future (**Table 2**). It should be noted that point estimates from SS3 indicate that F_{curr}/F_{MSY} are much higher than those estimated by JABBA.

Management advice. Current or increasing catches have a very high risk of further decline in the stock status. The 2022 catches (3,225 t) are lower than MSY (4,730 t) but are very close the limit set by Resolution 18/05 (3, 260 t) which may be a concern if this trend continues. However, the limit is not based on estimates of most recent stock assessment. Thus, It is recommended that the Commission urgently revise Resolution 18/05 to incorporate limits that reflect the most recent stock assessment and projections and review and where necessary revise the implementation and effectiveness of the measures contained in this Resolution.

The stock has been overfished for more than a decade 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% between 2027 and 2032 (as per Resolution 18/05), it needs to provide mechanisms to ensure the maximum annual catches to be below 30% of the current level (**Table 3**). [SC to revise the advice]

The following key points should also be noted:

- **Maximum Sustainable Yield (MSY)**: estimates for the Indian Ocean stock are uncertain and estimates range between 4,220 - 5,240 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 fisheries (mean annual catch 2018-2022)**: striped marlin are caught using gillnet (66%), followed by longline (20.3%) and line (12%). The remaining catches taken with other gears contributed to 1.6% of the total catches in recent years (**Fig. 1**).
- **Main fleets (mean annual catch 2018-2022)**: the majority of striped marlin catches are attributed to vessels flagged to I. R. Iran (36.5%) followed by Pakistan (25.2%) and Indonesia (17.2%). The 25 other fleets catching striped marlin contributed to 20.8% of the total catch in recent years (**Fig. 2**).

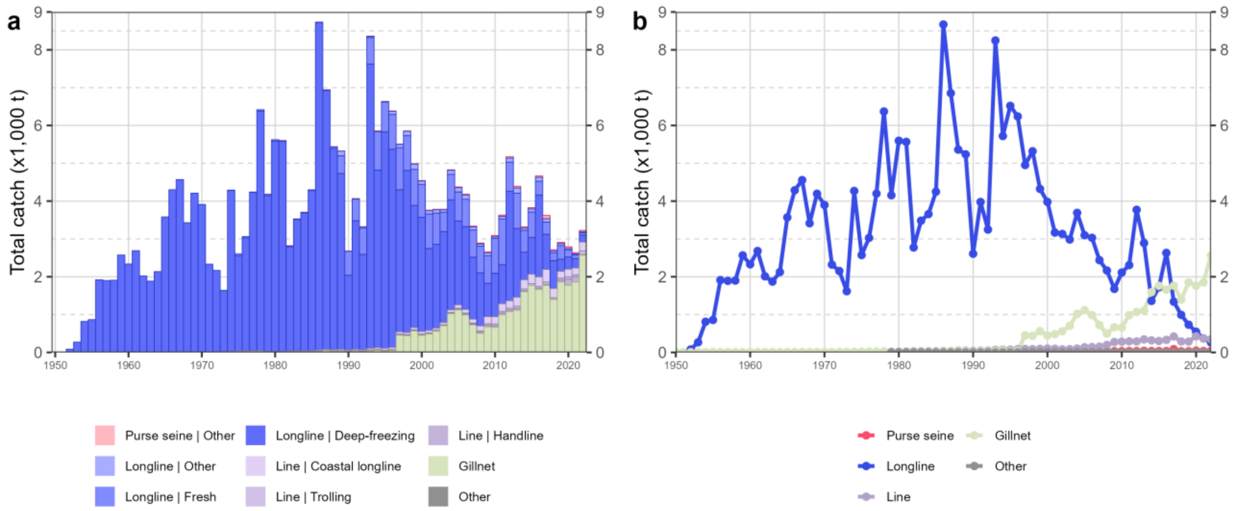

Fig. 1. Annual time series of (a) cumulative nominal catches (metric tons; t) by fishery and (b) individual nominal catches (metric tons; t) by fishery group for striped marlin during 1950-2022. Longline | Other: swordfish and sharks-targeted longlines; Other: all remaining fishing gears

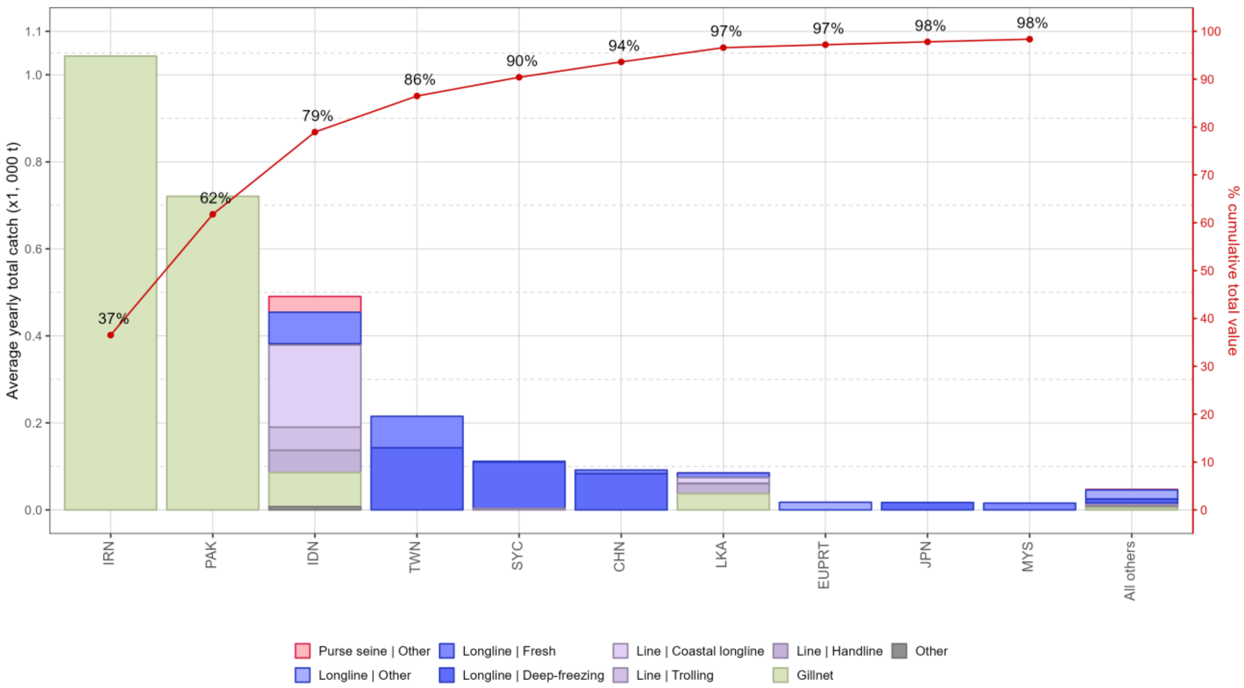

Fig. 2. Mean annual catches (metric tons; t) of striped marlin by fleet and fishery between 2018 and 2022, with indication of cumulative catches by fleet. Longline | Other: swordfish and sharks-targeted longlines; Other: all remaining fishing gears

(a) Stock status (JABBA and SS3 models) (b) JABBA B/B_{MSY} and F/F_{MSY} trajectories

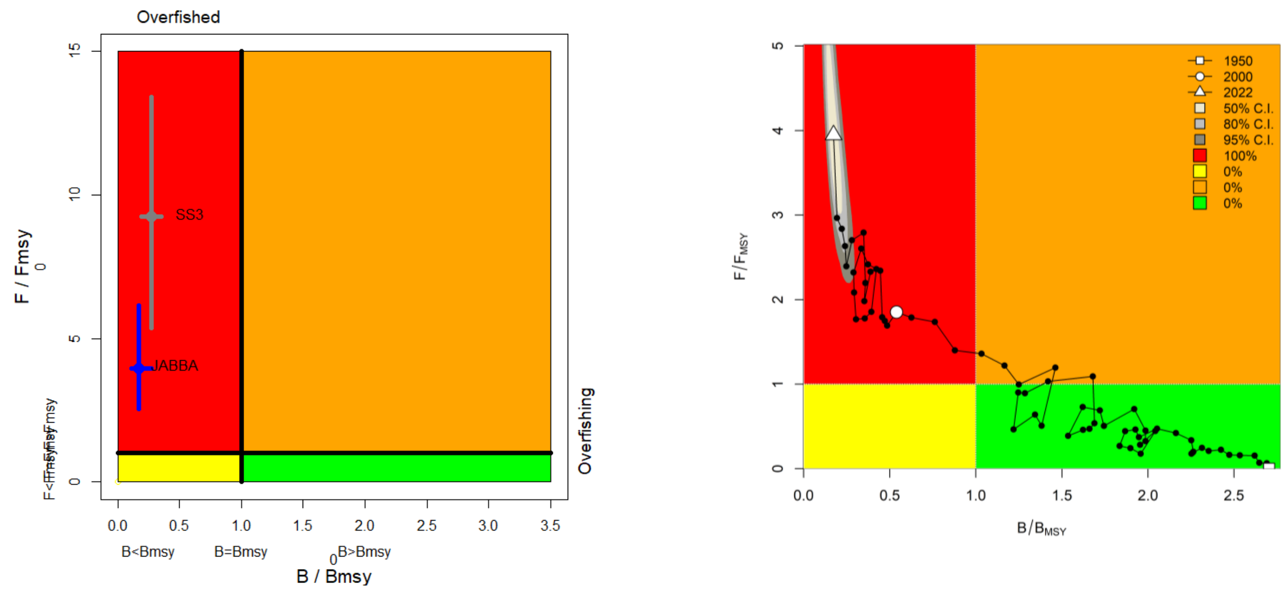

Fig. 3. (a) Striped marlin: Stock status from the Indian Ocean assessment JABBA (Bayesian State Space Surplus Production Model) and SS3 models with the confidence intervals (left); (b) Trajectories (1950-2022) of *B/B_{MSY} and F/F_{MSY}* from the JABBA model. NB: SS3 refers to SB/SB_{MSY} while the JABBA model's output refers to B/B_{MSY}

Table 2. Striped marlin: JABBA Indian Ocean assessment Kobe II Strategy Matrix. Probability (percentage) of violating the MSY-based target reference points for nine constant catch projections relative to the average catch level of 2020–2022 (2891 t) (100%, 80%, then 70%–10% in decrement of 10%) projected for 3 and 10 years.

Reference point and projection timeframe	Alternative catch projections (relative to the 2020-2022 catch of 3,001 t) and probability (%) of violating MSY-based target reference points (Btarg = B_{MSY}; Ftarg = F_{MSY})								
	10% (289 t)	**20%** (578 t)	**30%** (867 t)	**40%** (1157 t)	**50%** (1446 t)	**60%** (1735 t)	**70%** (2024 t)	**80%** (2313 t)	**100%** (2891 t)
$B_{2025} < B_{MSY}$	100	100	100	100	100	100	100	100	100
$F_{2025} > F_{MSY}$	3	12	35	66	88	97	99	100	100
$B_{2032} < B_{MSY}$	3	9	22	42	64	83	93	98	100
$F_{2032} > F_{MSY}$	0	4	8	18	35	57	78	91	99

Table 3. Striped marlin: Probability (percentage) of achieving the KOBE green quadrat from 2023-2032 for a range of constant catch projections (JABBA).

Catch (t)| Year	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
289 (10%)	0	0	0	0	7	31	63	84	94	97
578 (20%)	0	0	0	0	3	17	44	68	84	91
867 (30%)	0	0	0	0	1	8	26	48	66	78
1157 (40%)	0	0	0	0	0	4	13	28	45	58
1446 (50%)	0	0	0	0	0	1	5	13	25	36
1735 (60%)	0	0	0	0	0	0	2	5	11	17
2024 (70%)	0	0	0	0	0	0	1	2	4	7
2313 (80%)	0	0	0	0	0	0	0	0	1	2

3470 (100%)	0	0	0	0	0	0	0	0	0	0

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

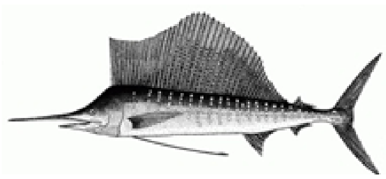

Table 1. Status of Indo-Pacific sailfish (*Istiophorus platypterus*) in the Indian Ocean

Area[1]	Indicators		2022 stock status determination
Indian Ocean	Catch 2022[2] (t) Average catch 2018-2022 (t)	33,135 32,750	**54%**
	MSY (1,000 t) (80% CI) F_{MSY} (80% CI) B_{MSY} (1,000 t) (80% CI) F_{2019}/F_{MSY} (80% CI) B_{2019}/B_{MSY} (80% CI) B_{2019}/B_0 (80% CI)	25.9 (20.8 – 34.2) 0.19 (0.15 - 0.24) 138 (108–186) 0.98 (0.65 – 1.42) 1.17 (0.94 – 1.42) 0.58 (0.47 – 0.71)	

[1] Boundaries for the Indian Ocean stock assessment are defined as the IOTC area of competence
[2] Proportion of 2021 catch estimated or partially estimated by IOTC Secretariat: 39.5%

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)	7%	39%
Stock not subject to overfishing (F_{year}/F_{MSY}≤ 1)	0%	54%
Not assessed/Uncertain		

The percentages are calculated as the proportion of model terminal values that fall within each quadrant with model weights taken into account

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

Stock status. No new stock assessment was carried out for Indo-Pacific Sailfish in 2024, thus the stock status is determined on basis of the 2022 stock assessment based on JABBA (using data up to 2019). Data poor methods (C-MSY and SFA) applied to Indo-Pacific Sailfish in 2019 rely on catch data only, which is highly uncertain for this species, and resulted in the stock status determined to be uncertain. To overcome the lack of abundance indices for this species, this assessment incorporated length-frequency data to estimate annual Spawning Potential Ratio (SPR). Normalised annual estimates of SPR were assumed to be proportional to biomass and incorporated as an index of relative abundance in the JABBA model (assuming no trends in annual recruitment in the long term). This is a novel technique applied to overcome the paucity of abundance data for SFA. The results indicate that there has been a 41% decline in SPR since 1970. B/B_{MSY} declined consistently from the early-1980s, while F/F_{MSY} gradually increased from 1980, peaking in 2018 at 1.1. The latest (2019) estimate of B/B_{MSY} was 1.17, while the F/F_{MSY} estimate was 0.98.
On the weight-of-evidence available in 2022, the stock status of Indo-Pacific sailfish is determined to be ***not overfished nor subject to overfishing*** (**Table 1**; **Fig. 3**).

Outlook. Catches have exceeded the estimated MSY since 2013 and the current catches (average of 32,386 t in the last 5 years, 2018-2022) are substantially higher than the current MSY estimate of 25,905 t. This increase in coastal gillnet longline 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 the 2020, 2021 and 2022 catches 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 for three consecutive years since 2020, which as per resolution 18/05, requires a review of the resolution. Furthermore, these limits are not based on estimates of most recent stock assessment. Thus, it is recommended that the Commission urgently revise 18/05 to incorporate limits that reflect the most recent stock assessment and projections and review and where necessary revise the implementation and effectiveness of the measures contained in this Resolution In spite of the Kobe green status of the stock, it is recommended that the Commission review the implementation and effectiveness of the measures contained in this Resolution and consider the adoption of additional conservation and management measures. 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 coastal gillnet and longline fisheries, and further exploration of stock assessment approaches for data poor fisheries are warranted. Given the limited data being reported for coastal fisheries, and the importance of sports fisheries for this species, efforts must be made to rectify these information gaps.

The following key points should also be noted:

- **Maximum Sustainable Yield (MSY):** estimate for the Indian Ocean stock is 25,905 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 fisheries (mean annual catch 2018-2022):** Indo-Pacific sailfish are using gillnet (70.9%), followed by line (25%) and longline (3.2%). The remaining catches taken with other gears contributed to 1% of the total catches in recent years (**Fig. 1**)**.**
- **Main fleets (mean annual catch 2018-2022)**: the majority of Indo-Pacific sailfish catches are attributed to vessels flagged to I. R. Iran (41.1%) followed by India (23.3%) and United republic of Tanzania (6.6%). The 33 other fleets catching Indo-Pacific sailfish contributed **to 29**% of the total catch in recent years (**Fig. 2**).

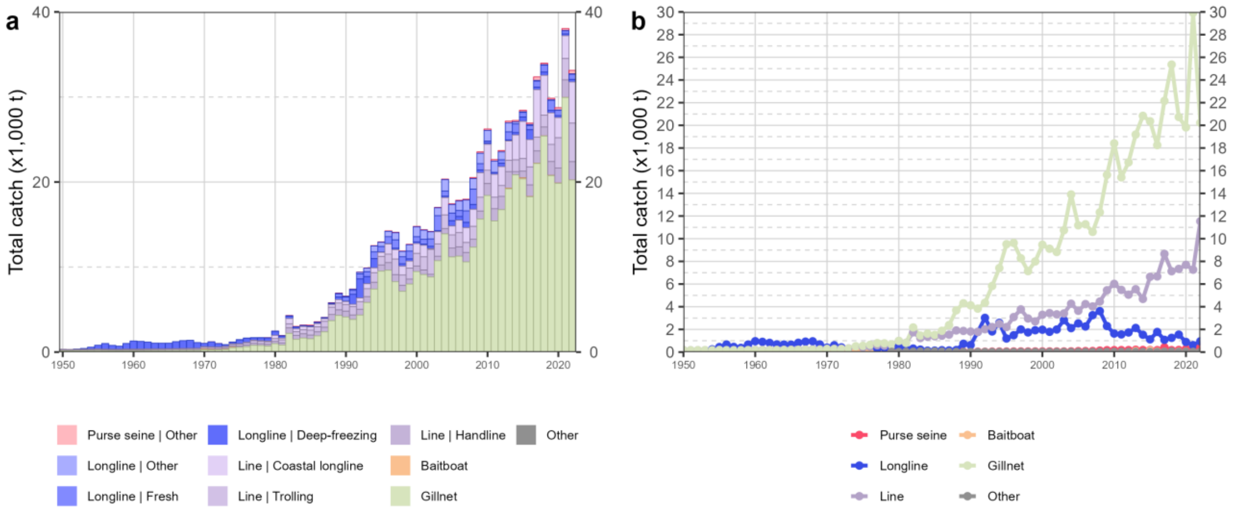

Fig. 1. Annual time series of (a) cumulative nominal catches (metric tons; t) by fishery and (b) individual nominal catches (metric tons; t) by fishery group for Indo-Pacific sailfish during 1950-2022. Longline | Other: swordfish and sharks-targeted longlines; Other: all remaining fishing gears

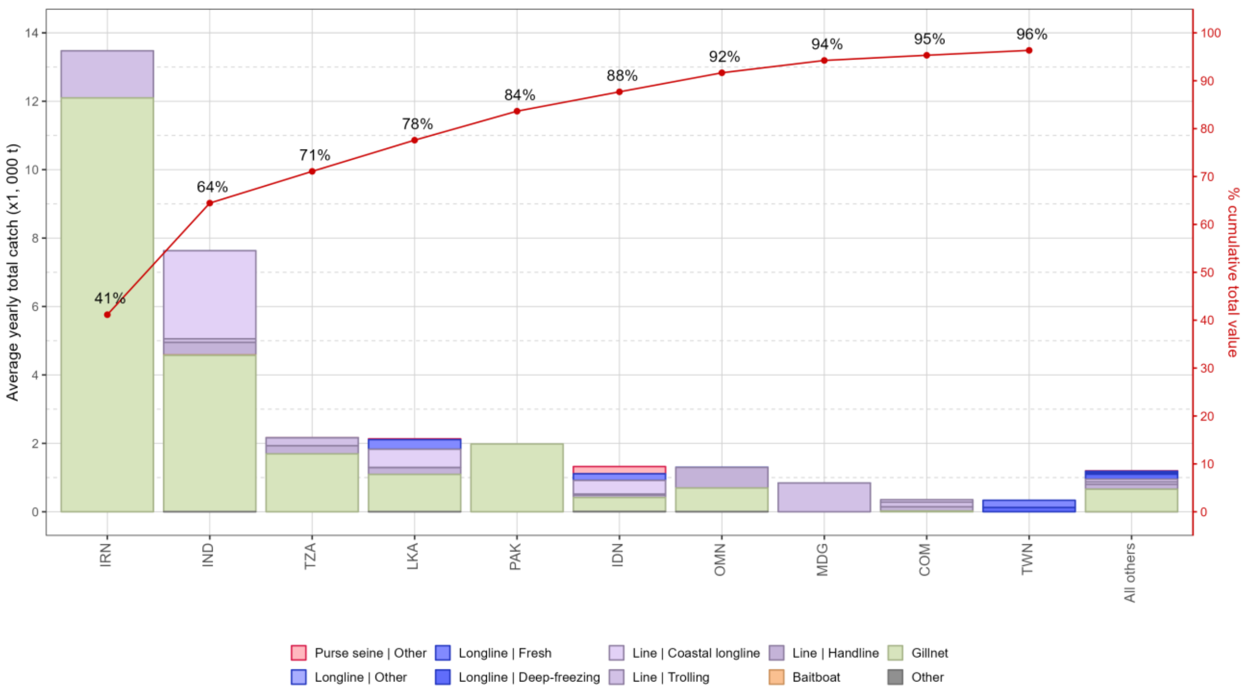

Fig. 2. Mean annual catches (metric tons; t) of Indo-Pacific sailfish by fleet and fishery between 2018 and 2022, with indication of cumulative catches by fleet. Longline | Other: swordfish and sharks-targeted longlines; Other: all remaining fishing gears

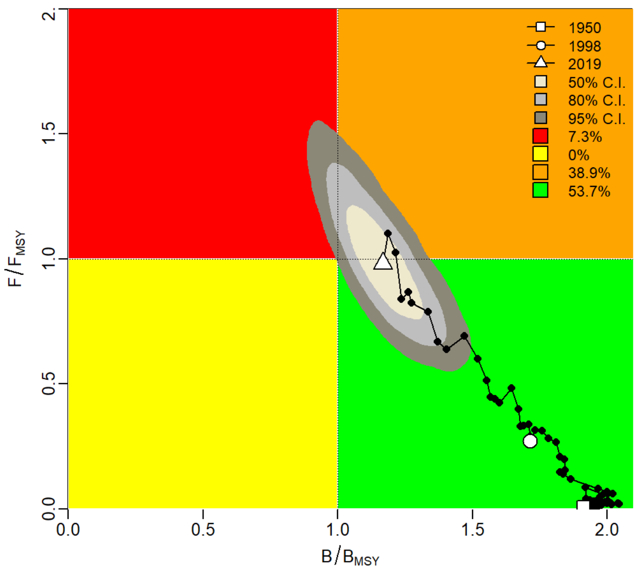

Fig. 3. Indo-Pacific sailfish: Kobe plot showing estimated trajectories (1950-2019) of B/B_{MSY} and F/F_{MSY}. Different grey shaded areas denote the 50%, 80%, and 95% credibility interval for the terminal assessment year. The probability of terminal year points falling within each quadrant is indicated in the figure legend.

APPENDIX IX WORKING PARTY ON BILLFISH PROGRAM OF WORK (2025–2029)

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				
		2025	2026	2027	2028	2029
1. CPUE standardization	1.1 Develop and/or revise standardized CPUE series for each billfish species and major fisheries/fleets in the Indian Ocean and develop Joint CPUE series where feasible 1.1.1 Swordfish: Priority LL fleets: Taiwan,China, EU(Spain, Portugal, France), Japan, Indonesia, South African 1.1.2 Striped marlin: Priority fleets: Japan, Taiwan,China 1.1.3 Black marlin: Priority fleets: Longline: Taiwan,China; Gillnet: I.R. Iran, Sri Lanka, Indonesia 1.1.4 Blue marlin: Priority fleets: Japan, Taiwan,China, Indonesia 1.1.5 I.P. Sailfish: Priority fleets: Priority gillnet fleets: I.R. Iran and Sri Lanka; Priority longline fleets: EU(Spain, Portugal, France), Japan, Indonesia;					
2. Biological and ecological information	2.1 Age and growth research 2.1.1 CPCs to provide further research on billfish biology, namely age and growth studies including through the use of fish otolith or other hard parts, either from data collected through observer programs, port sampling or other research programs. (Priority: all billfishes: swordfish, marlins and sailfish)					
	2.2 Spawning time and locations					

	2.2.1 Collect gonad samples from billfish or utilise any other scientific means to confirm the spawning time and location of the spawning areas 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. 2.3 Literature review of biological parameters for billfish 2.3.1. Conduct a literature review of biological parameters for billfish through a consultancy and update the supplementary information that companies with species Executive Summaries.					
	2.3 Stock structure (connectivity and diversity) 2.3.1 Continue work on determining stock structure of Billfish species, using complimentary data sources, including genetic and microchemistry information as well as other relevant sources/studies.					
3. Billfish bycatch mitigation	WPB and CPCs scientists to firstly, review and summarise existing information on billfish bycatch mitigation, including also factors influencing at-haul and post-release mortality of billfish, and secondly to undertake further research to inform gaps in understanding on potential effective mitigation approaches, to provide options for the Commission to reduce fishing mortality for species where that is required (e.g. Black Marlin, Striped Marlin and Sailfish) focusing on gillnet and longline fisheries but also including recreational and sport fishing activities .					
Other Future Research Requirements (not in order of priority)						
1. Data mining and processing – (Development of subsequent CPUE indices)	Data on gillnet fisheries are available in Pakistan (and potentially other CPCs) and the recovery of this information and the development of gillnet CPUE indices would improve species assessments, particularly for: • Black marlin • Sailfish					
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. 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.					
4. Billfish as bycatch	How to provide scientific advice to management on billfish caught as bycatch					

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

Species	2025	2026	2027	2028	2029
Black marlin			Full assessment		
Blue marlin	Full assessment			Full assessment	
Striped marlin			Full assessment		
Swordfish		Full assessment	Run MP		Full assessment
Indo-Pacific sailfish	Full assessment			Full assessment	

APPENDIX X
CONSOLIDATED RECOMMENDATIONS OF THE 22ND SESSION OF THE WORKING PARTY ON BILLFISH

Note: Appendix references refer to the Report of the 22ND Session of the Working Party on Billfish (IOTC–2024–WPB22–R)

The following are the complete recommendations from the WPB22 to the Scientific Committee:

Review of new information on the status of black and striped marlins

WPB22.01 (para 148): In this context, the WPB **NOTED** that a Joint analysis of fleet specific CPUE could be useful because if catch effort data from multiple fleets were all representative of abundance, there should be no conflict between them. A Joint analysis based on a consistent statistical framework would help account for difference in catchability between fleets and can increase the power to identify potential factors that might explain the difference between fleets. Further, the fleets can complement each other in spatial and temporal coverage of the stock, thus increasing the chance of producing a representative abundance index using a unified modelling approach. As such, the WPB **RECOMMENDED** that the SC dedicate effort to harmonise the standardised methods for different fleets and to develop a joint analysis combining catch effort data from key fleets for major billfish species where feasible.

Resolution 18/05 Catch Limits

WPB22.02 (para 171): The WPB **NOTED** that the catch limits for black marlin and Indo-Pacific sailfish set by Resolution 18/05 have consistently been exceeded since its implementation. Therefore, the WPB **RECOMMENDED** that the SC advise the Commission to reassess the effectiveness of the current measures within this resolution. Additionally, the WPB **RECOMMENDED** that the SC advise the Commission of the need to revise Resolution 18/05 to update the catch limits based on the latest stock assessments and projections for the billfish species.

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Revision of the WPB Program of work (2025–2029)

WPB22.03 (para 176): The WPB **RECOMMENDED** that the SC consider and endorse the WPB Program of Work (2025–2029), as provided in Appendix IX.

Date and place of the 23nd and 24rd Sessions of the Working Party on Billfish

WPB22.04 (para 181): The WPB **RECOMMENDED** the SC consider early September as a preferred time period to hold the WPB23 in 2025. As usual it was also **AGREED** that this meeting should continue to be held back-to-back with the WPEB and that in 2025 WPB will be held in the week following the WPEB.

Review of the draft, and adoption of the Report of the 22st Session of the Working Party on Billfish

WPB22.05 (para 182): The WPB **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPB22, provided at Appendix X, 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 2024 (Fig. 5):

- Swordfish (*Xiphias gladius*)– Appendix IV
- Black marlin (*Istiompax indica*) – Appendix V
- Blue marlin (*Makaira nigricans*) – Appendix VI
- Striped marlin (*Kajikia audax*) – Appendix VII
- Indo-Pacific sailfish (*Istiophorus platypterus*) – Appendix VIII

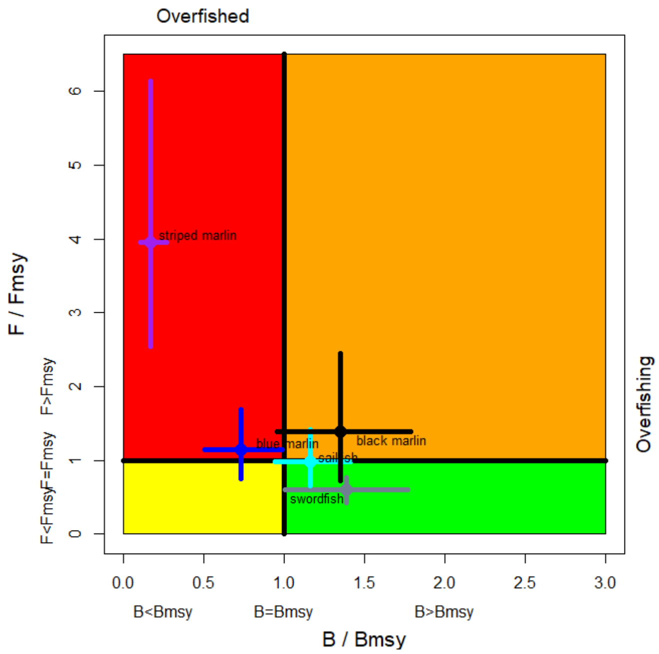

Fig. 5. Combined Kobe plot for swordfish (grey), indo-pacific sailfish (cyan), black marlin (black), blue marlin (blue) and striped marlin (purple) showing the 2022, 2023, and 2024 estimates of current stock size (SB or B, species assessment dependent) and current fishing mortality (F) in relation to optimal spawning stock size and optimal fishing mortality. Cross bars illustrate the range of uncertainty from the model runs.