Food and Agriculture Organization of the United Nations

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

APPENDIX 4
EXECUTIVE SUMMARY: YELLOWFIN TUNA (2024)

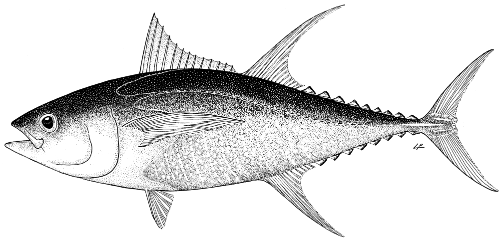

Table 1. Status of yellowfin tuna (*Thunnus albacares*) in the Indian Ocean

Area[1]	Indicators		2024 stock status determination[3]
Indian Ocean	Catch 2023[2] (t) Mean annual catch 2019-2023 (t)	400,950 423,142	**89%***
	MSY_{recent}[4] (1,000 t) (80% CI) F_{MSY} (80% CI) SB_{MSY_recent}[4] (1,000 t) (80% CI) F_{2023} / F_{MSY} (80% CI) $SB_{2023} / SB_{MSY\_recent}$ (80% CI) SB_{2023} / SB_0 (80% CI)	421 (416-430) 0.2 (0.16-0.26) 1,063 (890-1,361) 0.75 (0.58-1.01) 1.32 (1.00-1.59) 0.44 (0.40-0.50)	

[1]Boundaries for the Indian Ocean stock assessment are defined as the IOTC area of competence
[2]Proportion of 2023 catch fully or partially estimated by IOTC Secretariat: 33.4%
[3]2023 is the final year that data were available for this assessment
[4] Recent refers to the most recent 20 years (2003-2022)

Colour key	Stock overfished ($SB_{2023} / SB_{MSY}<1$)	Stock not overfished ($SB_{2023} / SB_{MSY} \geq 1$)
Stock subject to overfishing ($F_{2023} / F_{MSY} \geq 1$)	7.9%	3.3%
Stock not subject to overfishing ($F_{2023} / F_{MSY} \leq 1$)	0%	88.8%
Not assessed / Uncertain / Unknown		

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

Stock status. A new stock assessment was carried out for yellowfin tuna in 2024. The 2024 stock assessment was carried out using Stock Synthesis III (SS3), a fully integrated model that is currently used to provide scientific advice for the three tropical tunas stocks in the Indian Ocean. The model used in 2024 is based on the model developed in 2021 with a series of revisions that were discussed during the WPTT in 2024. The new model represents a marked improvement over the previous model available in 2021, as demonstrated using a number of statistical diagnostic analyses. These revisions addressed many of the recommendations of the independent review of the yellowfin stock assessment carried out in 2023. The model uses four types of data: catch, size frequency, tagging and CPUE indices. The proposed final assessment model options correspond to a combination of model configurations, including alternative assumptions about the selectivity of longline fisheries (2 options on size frequency data prior and post 2000), longline catchability (effort creep (0% and 0.5% per year)) and steepness values (0.7, 0.8, and 0.9). The model ensemble (a total of 12 models) encompasses a range of plausible hypotheses about stock and fisheries dynamics.

A number of sensitivity runs were conducted to understand additional uncertainties not captured in the model grid, including two alternative natural mortalities (based on maximum age of 18 years and the natural mortality used in 2021), the CPUE used in 2021, a model that started in 1975, the influence of the tagging data and the revised catch information for Indonesia. In general, the sensitivity runs did not suggest that other parameters should be included in the reference grid and the group decided not to include any additional axes of uncertainty.

The model estimates of current stock status are predominantly informed by the new abundance index derived from the Joint CPUE estimated for longline fleets. It was noted that the new index was significantly different to the index used in 2021 (**Fig. 6**), especially for the Northwestern region of the Indian Ocean for the periods 2005-2015 and 2019-2020 (this is further discussed, below). In addition, the new index suggests a marked increase of abundance for yellowfin in the last three years (2021-2023).

With regards to the differences in the modelling choices, the new SS3 model includes a new growth model, natural mortality and maturity. All these have been updated from recent biological studies, as agreed by the WPTT in the 2024 data preparatory meeting.

For the 2024 model, a new approach was applied to the derivation of the MSY and associated biomass-based reference point (SBMSY) based on the magnitude of recruitment estimated for the recent 20-year period (see Para 89–100 of IOTC-2024-WPTT26-R for details). The derivation of MSY is in line with the recommendations of the 2023 review. MSY was estimated to be 421,000 t. Recent annual catches of 401,000 t are below the estimated MSY. Differences in the estimates of MSY and BMSY using recent and long-term recruitment levels introduce additional uncertainty in the estimates of stock status relative to BMSY. This is highlighted in Tables 2 and 3 which indicate, for example, that while SB/SBMSY is estimated to be higher (1.47) under long-term recruitment assumption, MSY is estimated to be lower (374,000 t). However, fishing mortality-based estimates of stock status are insensitive to those assumptions.

Table 2. Reference points for yellowfin tuna (*Thunnus albacares*) in the Indian Ocean based on long term and 20 year conditions

Long term MSY (t)	Recent 20 yr MSY (t)	Long term SSBmsy (t)	Recent 20 yr SSBMSY (t)
374,421	420,623	986,599	1094,844

Table 3. Status of yellowfin tuna (*Thunnus albacares*) in the Indian Ocean using equivalent (i.e. long-term) recruitment trends

Indicators	
Catch 2023[2] (t) Mean annual catch 2019-2023 (t)	400,950 423,142
MSY_{eq} (1,000 t) (80% CI) SB_{MSY_eq} (1,000 t) (80% CI) SB_{2023} / SB_{MSY_eq} (80% CI)	374 (350-411) 987 (791-1,247) 1.47 (1.21-1.65)

The recent 20 year period was selected for the estimation of recent benchmarks (SB_{MSY} and MSY) on the basis that the period encompassed the most reliable series of catch and size composition data and, as such, provided the best available information regarding the prevailing productivity of the stock.

According to the information available to the 2024 assessment, the total catch has remained within the estimated recent (20 year average) MSY since 2007 (i.e., between 402,000 t and 427,000 t), with the exception of 2018 (443,252 t) and 2019 catch (450,586 t), the latter being the largest since 2006 and above the estimated recent MSY (for details see WPTT23 report).

Overall stock biomass declined substantially during the 1980s and 1990s. The stock is estimated to have been in an overfished state from 2007 to 2019 (**Fig. 4**). Spawning biomass increased considerably after 2021 following recent strong recruitment (informed by the recent increase in LL CPUE). Correspondingly, overfishing was occurring from 2003 until 2020. Fishing mortality was estimated to be below the FMSY level in 2021-2023. The recent strong recruitments also contribute to a continued increase in projected biomass in the forthcoming years. The magnitude of the recent annual recruitments (2020-2022) is unprecedented in the time series.

Overall stock status estimates differ substantially from the previous assessment. Spawning biomass in 2023 was estimated to be on average 44% of the initial (1950) levels (**Table 1**). Spawning biomass in 2023 was estimated to be 32% higher than the level that supports the maximum sustainable yield (SB_{2023}/SB_{MSY} = 1.32). Current fishing mortality is estimated to be 25% lower than F_{MSY} (F_{2023}/F_{MSY} = 0.75). The probability of the stock being in the green Kobe quadrant in 2023 is estimated to be 89%. On the weight-of-evidence available in 2024, the yellowfin tuna stock is determined to be **not-overfished** and **not-subject to overfishing** (**Table 1** and **Fig. 4**).

It is noted that there are still important uncertainties relating to the data used for this stock assessment. There are uncertainties in relation to the CPUE standardisation in 2024 that could not be addressed during the meeting which are recognised in the SCs catch limit advice (in the stock status summary and SC general recommendations). The use of the 2021 CPUE index in the current model results in a significantly more pessimistic biomass up to 2020 compared to the 2024 CPUE indices (-23% SB_{2021}/SB_{MSY}), but there is no clear understanding or agreement for why the two indices are significantly different (especially in Region 1). However, it is noted that the exploratory runs discussed during the SC meeting indicate that the other data used in the stock assessment (catch and length frequency data) also indicate an increase in biomass in recent years, albeit a smaller increase (21% and 11% respectively) than the increase driven by the 2024 CPUE index (+79%).

It is noted that there is also considerable uncertainty in the reported catches by some fisheries. In particular, catch estimates for several artisanal fisheries have increased substantially in recent years, the implication of which should be further investigated.

Outlook.

Assumptions on recent productivity were used to make 10 year projections and evaluate the impact of alternative catch levels. The results of these projections are shown in **Fig. 7** and summarized in the K2SM (**Table 3**). For each catch scenario, the probability of the biomass being below the SB_{MSY} level and the probability of fishing mortality being above F_{MSY} were determined over the projection horizon using the delta-MVLN estimator (Walter & Winker 2020), based on the variance-covariance derived from estimates of SB/SB_{MSY} and F/F_{MSY} across the model grid.

Management advice

Noting the pending advice to be provided by the SC to the 2026 Commission meeting on the need, if any, to update the yellowfin tuna stock assessment in 2026, results of the K2SM should not be considered as catch advice until the uncertainties in the CPUE index are resolved. As such, the following advice was recommended:

- If catches are maintained within the estimated MSY range (416,000-430,000 tons) there is more than a 50% probability that the stock will remain above SB_{MSY} in 2033.
- Higher levels of catch are predicted to lead the stock to an overfished state in the long term.
- The probability of breaching the biological limit reference point ($0.4SB_{MSY}$) with recent catches is 0% by 2033. The probability of breaching the F limit reference point ($1.4\ F_{MSY}$) with recent catch is 0% by 2033.
- However, in order to account for the uncertainty of the projections (e.g., relating to whether estimated high recruitment will be maintained) and uncertainty not captured in the assessment grid (e.g. relating to the new CPUE indices), the Commission should set an initial one year (2026) TAC that does not exceed the median recent MSY estimate, , task the SC to investigate and resolve CPUE uncertainty in 2025, and advise the 2026 Commission on future catch levels.

The Commission has an interim plan for the rebuilding the yellowfin stock, with catch limitations based on 2014 and other reference levels (Resolution 21/01 which superseded 19/01, 18/01 and 17/01). Some of the fisheries subject to catch reductions have achieved a decrease in catches in 2023 in accordance with the levels of reductions specified in the Resolution; however, these reductions were offset by increases in the catches from CPCs exempt from and some CPCs subject to limitations on their catches of yellowfin tuna.

The following key points should also be noted:

- Maximum Sustainable Yield (MSY): estimate for the Indian Ocean stock is 421,000 t with a range between 416,000 and 430,000 t (**Table 1**). The 2021-2023 average catches (413,000 t) were within the estimated recent MSY level.
- **Interim reference points**: Noting that the Commission in 2015 adopted Resolution 15/10 on target and limit reference points and a decision framework, the following should be noted:
- **Fishing mortality**: 2023 fishing mortality is considered to be 25% below the interim target reference point of F_{MSY}, and below the interim limit reference point of $1.4{*}F_{MSY}$ (**Fig. 4**).
- **Biomass**: 2023 spawning biomass is considered to be 32% above the interim target reference point of SB_{MSY} and above the interim limit reference point of $0.4{*}SB_{MSY}$ (**Fig. 4**).

- **Catch data uncertainty:** the overall quality of the nominal catches of yellowfin tuna shows some large variability between 1950 and 2023. In some years, a large portion of the nominal catches of yellowfin tuna had to be estimated, and catches reported using species or gear aggregates had to be further broken down. The data quality was particularly poor between 1994 and 2002 when less than 70% of the nominal catches were fully or partially reported, with most reporting issues coming from coastal fisheries. The reporting rate has generally improved over the last decade however detailed information on data collection procedures, which determines the quality of fishery statistics, is still lacking.
- **Main fisheries (mean annual catch 2019-2023)**: yellowfin tuna are caught using line and coastal longline (40%), followed by purse seine (33%) and gillnet (15%). The remaining catches taken with other gears contributed to 12% of the total catches in recent years (**Fig. 1**). The fishery impact plot is shown in **Fig. 8**.
- **Main fleets (mean annual catch 2019-2023)**: the majority of yellowfin tuna catches are attributed to vessels flagged to Sultanate of Oman (15%) followed by I. R. Iran (11%) and EU (Spain) (10%). The 32 other fleets catching yellowfin tuna contributed to 64% of the total catch in recent years (**Fig. 2**).

References

Walter, J., Winker, H., 2020. Projections to create Kobe 2 Strategy Matrices using the multivariate log-normal approximation for Atlantic yellowfin tuna. Collect. Vol. Sci. Pap. ICCAT, 76(6): 725-739

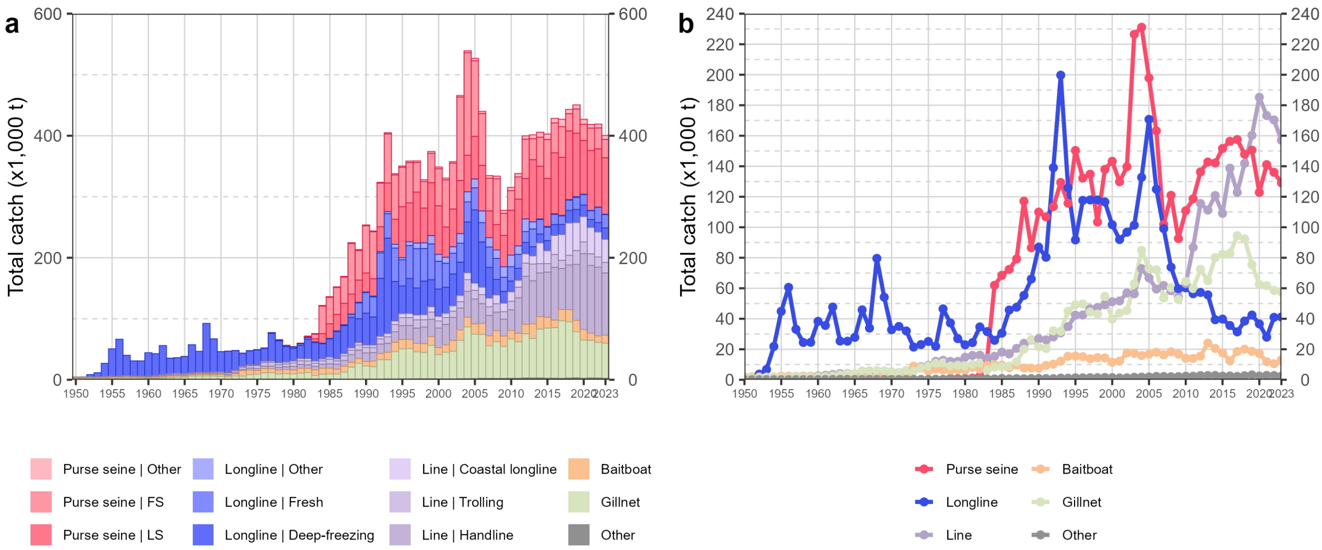

Fig. 1. Annual time series of (a) cumulative nominal catches (metric tonnes; t) by fishery and (b) individual nominal catches (metric tonnes; t) by fishery group for yellowfin tuna during 1950-2023. FS = free-swimming school; LS = school associated with drifting floating objects. Purse seine | Other: coastal purse seine, purse seine of unknown association type, ring net; Longline | Other: swordfish and sharks-targeted longlines; Other: all remaining fishing gears

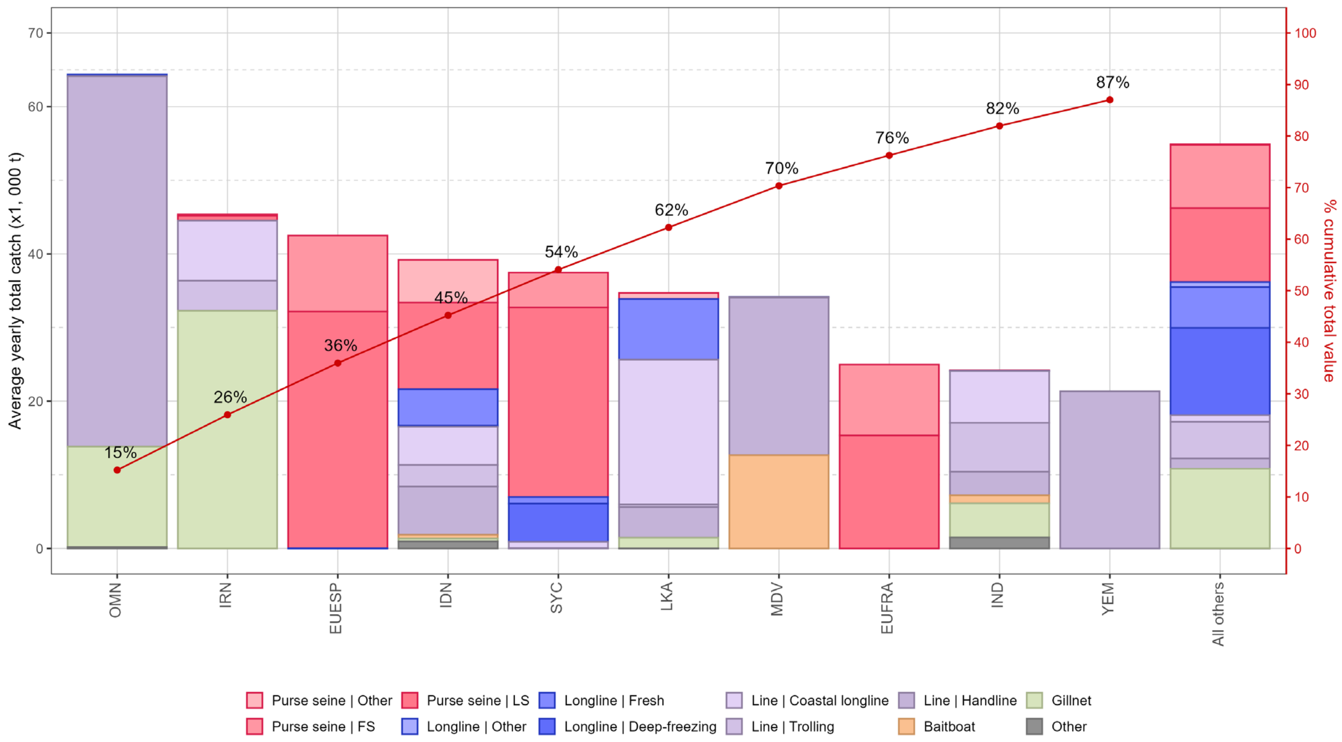

Fig. 2. Mean annual catches (metric tonnes; t) of yellowfin tuna by fleet and fishery between 2019 and 2023, with indication of cumulative catches by fleet. FS = free-swimming school; LS = school associated with drifting floating objects. Purse seine | Other: coastal purse seine, purse seine of unknown association type, ring net; Longline | Other: swordfish and sharks-targeted longlines; Other: all remaining fishing gears

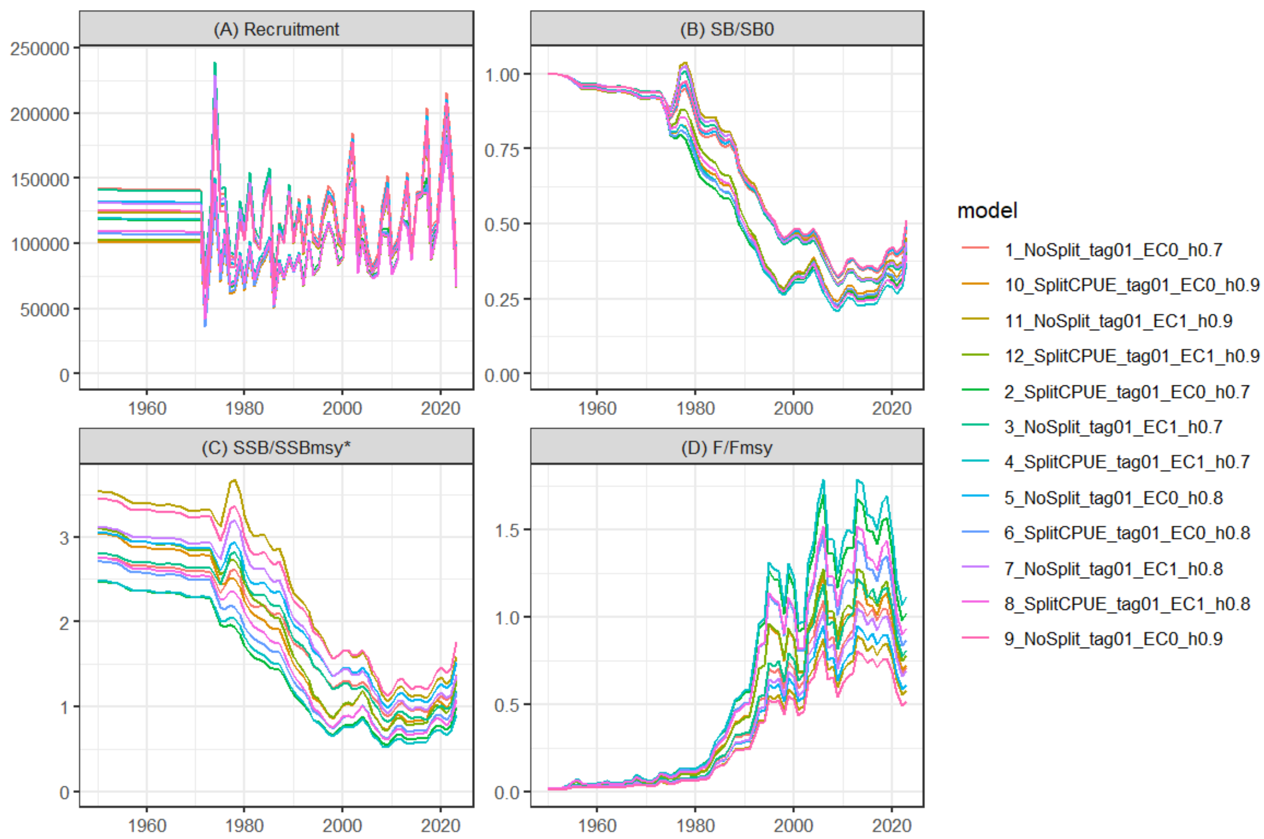

Fig 3. Estimated time series (1950-2023) of recruitment, spawning stock biomass relative to virgin biomass and to spawning stock biomass at MSY and fishing mortality relative to fishing mortality at MSY of yellowfin tuna from the reference models of the 2024 assessment.

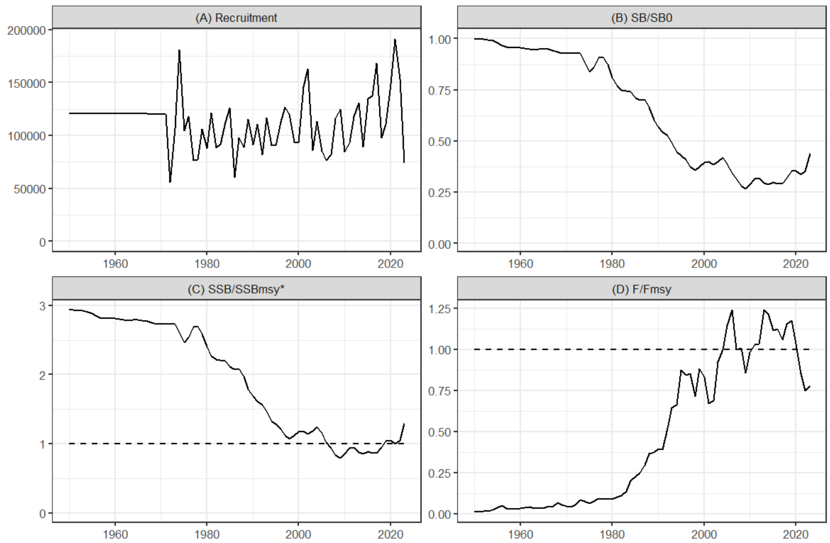

Fig 4. Estimated time series (1950-2023) of recruitment, spawning stock biomass and fishing mortality of yellowfin tuna from the reference model of the 2024 assessment.

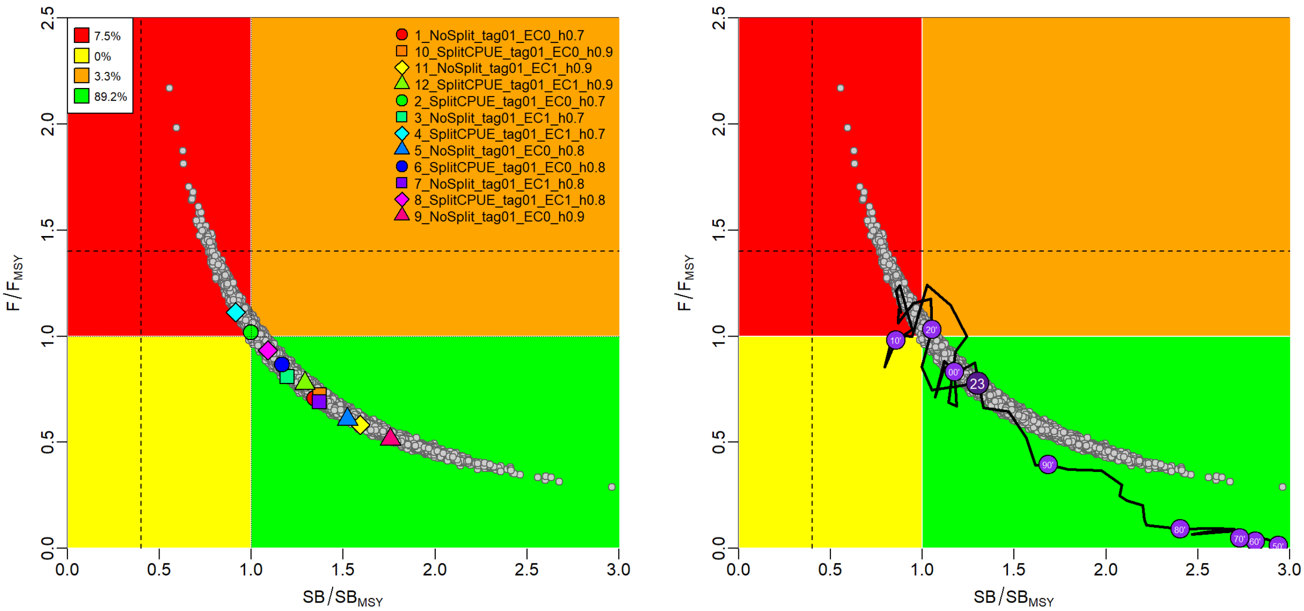

Fig. 5. Yellowfin tuna: SS3 Indian Ocean assessment Kobe plot: (left): current (2023) stock status, relative to SB_{MSY} (x-axis) and F_{MSY} (y-axis) reference points for the final model options. Coloured symbols represent Maximum posterior density (MPD) estimates from individual models Grey dots represent the statistical uncertainty from individual models (20,000 replicates from each). The dashed lines represent limit reference points for IO yellowfin tuna (SBlim = 0.4 SB_{MSY} and Flim = 1.4 F_{MSY}); (right) mean stock trajectory from the model grid.

Fig 6. Standardised CPUE indices used in the final assessment models: Joint longline CPUE indices by region 1975-2023 (The red lines are indices used in 2021 assessment 1975 – 2020).

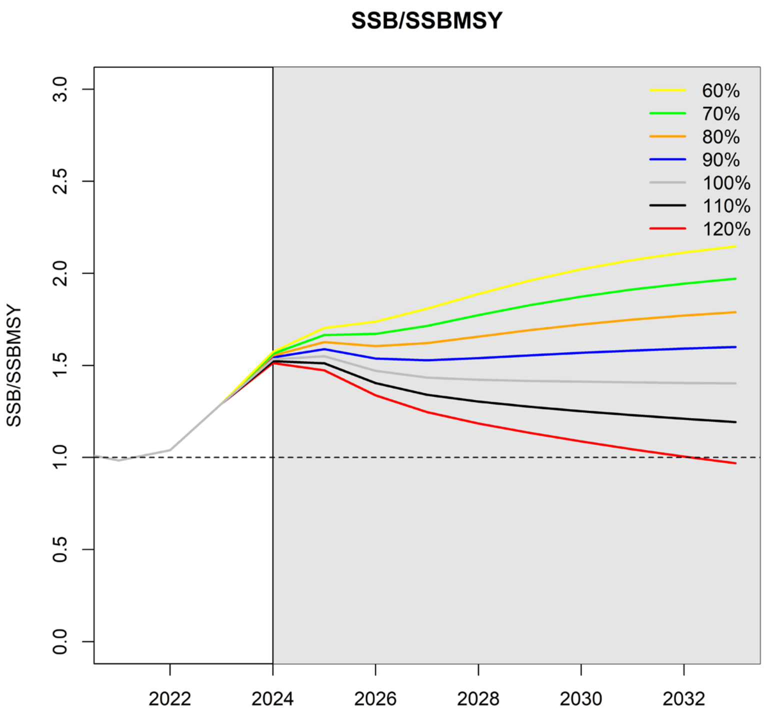

Fig 7. Trajectory showing the impact of alternative catch levels on spawning stock biomass relative to spawning stock biomass at MSY relative to the catch level from 2023

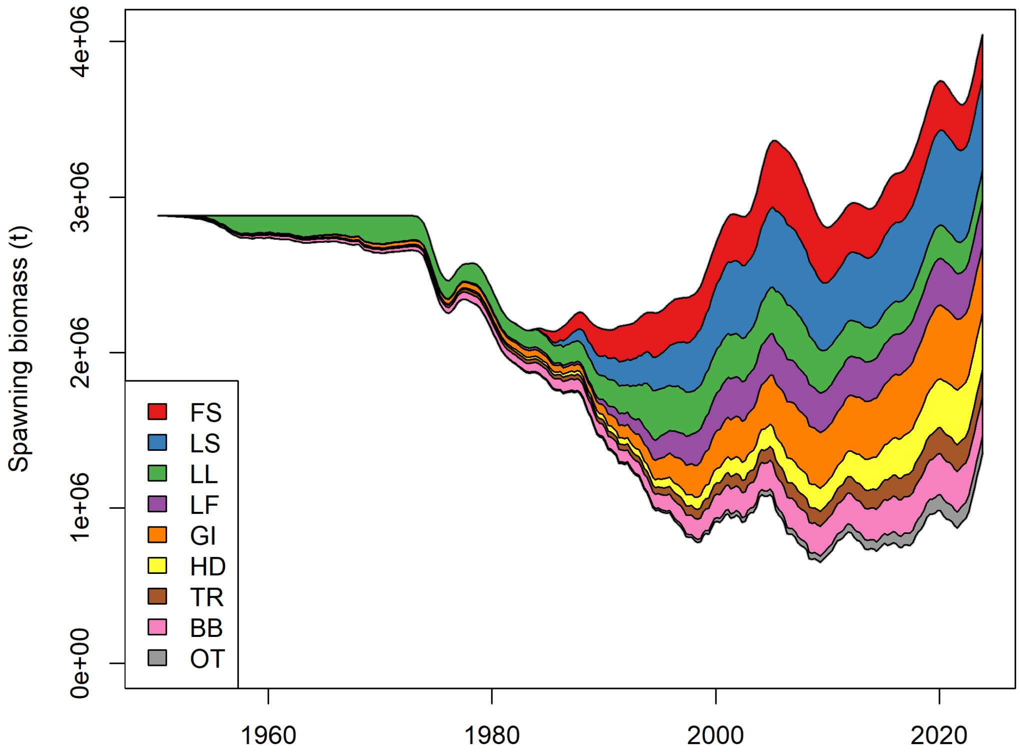

Fig 8. Fishery Impact Plot: Estimates of reduction in spawning biomass due to fishing over all regions attributed to various fishery groups for the assessment model.

TABLE 3. Yellowfin tuna: Stock synthesis assessment Kobe II Strategy Matrix. Probability of violating the MSY-based target (top) and limit (bottom) reference points for constant catch projections (relative to the catch level from 2023 -40%, - 30%, -20%, -10%, 0%, +10%, +20%) projected for 3 and 10 years

Alternative catch projections (relative to the catch level from 2023) and probability of violating MSY-based target reference points ($SB_{targ} = SB_{MSY}$; $F_{targ} = F_{MSY}$)							
Reference point and projection timeframe	60%	70%	80%	90%	100%	110%	120%
$SB_{2026} < SB_{MSY}$	0	0	0.1	0.1	0.6	1.3	4
$F_{2026} > F_{MSY}$	0	0	0	0	2.5	11.2	30.9
$SB_{2033} < SB_{MSY}$	0	0	0	0	0.1	13.1	66.7
$F_{2033} > F_{MSY}$	0	0	0	0	1.3	31.6	84.9
Alternative catch projections (relative to the catch level from 2023) and probability of violating MSY-based limit reference points ($SB_{lim} = 0.4\ SB_{MSY}$; $F_{Lim} = 1.4\ F_{MSY}$)							
Reference point and projection timeframe	60%	70%	80%	90%	100%	110%	120%
$SB_{2026} < SB_{Lim}$	0	0	0	0	0	0	0
$F_{2026} > F_{Lim}$	0	0	0	0	0	0.1	0.9

$SB_{2033} < SB_{Lim}$	0	0	0	0	0	0	0
$F_{2033} > F_{Lim}$	0	0	0	0	0	0.3	24.1