APPENDIX 2
EXECUTIVE SUMMARY: BIGEYE TUNA (2021)

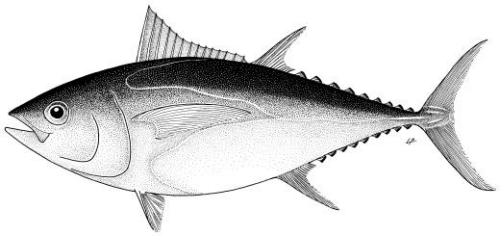

Table 1. Status of bigeye tuna (*Thunnus obesus*) in the Indian Ocean

Area[1]	Indicator	Value	Status[3]
Indian Ocean[1]	Catch in 2020 (t)[2]	83,498	38.2%*
	Average catch 2016-2020 (t)	86,880	
	MSY (1,000 t) (80% CI)	87 (75-108)	
	F_{MSY} (80% CI)	0.24 (0.18-0.36)	
	SB_{MSY} (1,000 t) (80% CI)	503 (370-748)	
	F_{2018} / F_{MSY} (80% CI)	1.20 (0.70-2.05)	
	SB_{2018} / SB_{MSY} (80% CI)	1.22 (0.82-1.81)	
	SB_{2018} / SB_0 (80% CI)	0.31 (0.21-0.34)	

[1]Boundaries for the Indian Ocean stock assessment are defined as the IOTC area of competence
[2]Proportion of catch estimated or partially estimated by IOTC Secretariat for catches in 2019: 17%
[3]The stock status refers to the most recent years' data used in the assessment conducted in 2019, i.e. 2018
*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 (SB_{2018} / SB_{MSY}<1)	Stock not overfished (SB_{2018} / SB_{MSY}≥ 1)
Stock subject to overfishing (F_{2018} / F_{MSY}≥ 1)	34.6%	38.2%
Stock not subject to overfishing (F_{2018} / F_{MSY}≤ 1)	0%	27.2%
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

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Stock status. In 2019 a new stock assessment was carried out for bigeye tuna in the IOTC area of competence to update the stock status undertaken in 2016. Two models were applied to the bigeye stock (JABBA and Stock Synthesis (SS3)). The stock assessment selected to provide scientific advice was carried out using SS3, a fully integrated model used to provide scientific advice for the three tropical tunas stocks in the Indian Ocean. The reported stock status is based on the SS3 model formulation using a grid of 18 model configurations designed to capture the uncertainty on stock recruitment relationship, the influence of tagging information and selectivity of longline fleets. Due to concerns on the reported catch data for 2018, the stock status is based on SS3 model formulations using the best catch estimate by the Scientific Committee (for details see WPTT report). Spawning biomass in 2018 was estimated to be 31% of the unfished levels in 2018 (**Table 1**) and 122% (82–181%) of the level that can support MSY. The assessment outcome is qualitatively different to the stock assessment conducted in 2016 due to the increase of catch of small size, changes in modelling assumptions about longline selectivity, and the abundance index developed in 2019. Considering the characterized uncertainty, the assessment indicates that SB_{2018} is above SB_{MSY} with high probability (65.4%) and that fishing mortality is above F_{MSY} also with high probability (72.8%). The median value of MSY from the model runs presented with SS3 was 87,000 t with a range between 75,000 and 108,000 t (a median level 16% lower than the estimate in 2016). Catches in 2018 (~81,413 t) remain lower than the estimated median MSY values from the stock assessment conducted in 2019 but within the range of estimated MSY. The average catch over the previous five years (2014–18; ~89,717 t) is just above the estimated median MSY and within the range of estimated values. Thus, on the weight-of-evidence available in 2019, the bigeye tuna stock is determined to be **not overfished** but **subject to overfishing** (**Table 1**).

Outlook. Declines in longline effort since 2007, particularly from the Japanese, Taiwanese and Rep. of Korea longline fleets lowered the pressure on the Indian Ocean bigeye tuna stock since 2007. However, recent increase in catch from purse seine fleets have increased this pressure and the stock is estimated to be subject to overfishing. The estimated MSY has declined significantly (16%) from the previous estimate (from 2016) due to the increase of purse seine catch in the overall change in catch composition, changes in modelling assumptions about longline selectivity, and the inclusion of a more pessimistic abundance index in the western tropical region. The Kobe strategy matrix (K2SM) based on the plausible model runs from SS3 in 2019 illustrates the levels of quantified risk associated with varying catch levels over time that could be used to inform future management actions (**Table 2**). The projections produced to estimate the K2SM (**Table 2**) are, in the short term, driven by the below average recruitment estimated for the recent years. The SS3 projections from the 2019 assessment show that there is a risk of breaching MSY-based reference points by 2021, and 2028 if catches are maintained at 2018 levels at the2018 selectivity and therefore size distribution of catch (**Table 2**). Should the management objective of maintaining biomass at levels higher than SB_{MSY} with more than 50% probability in 2028 be pursued, the overall catch should be reduced 10% from 2018 levels (73,272 t).

Management advice. The stock status determination changed qualitatively in 2019 to not overfished but subject to overfishing. If catches remain at 2018 levels there is a risk of breaching MSY reference points with 58.9% and 60.8% probability in 2021 and 2028. Maintaining catches of at least 10% below 2018 levels will likely reduce the probabilities of breaching reference levels to 49.1% in 2028. Continued monitoring and improvement in data collection, reporting and analyses is required to reduce the uncertainty in assessments (**Table 2**).

The following key points should also be noted:

- **Maximum Sustainable Yield (MSY):** estimate for the Indian Ocean stock is 87,000 t with a range between 75,000–108,000 t for SS3 (**Table** 1). The average 2014-2018 catches of ≈89,717 t, and catches for each year since 2012 are within the range of the estimated MSY level.
- **Interim 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:
  - **Fishing mortality**: Current fishing mortality is considered to be at 120% of the interim target reference point of F_{MSY}, and 92% of the interim limit reference point of 1.3*F_{MSY} (**Fig. 2**).
  - **Biomass**: Current spawning biomass is considered to at 122% of the interim target reference point of SB_{MSY} and well above the interim limit reference point of 0.5*SB_{MSY} (**Fig. 2**).
- **Main fisheries** (average catches 2016-2020): purse seine (41.4%) (Log/FAD schools = 28.6%; free school = 6.4%), deep-freezing longline (27.5%), fresh longline (9.5%), coastal longline (9.3%) (**Fig. 1**);
- **Main fleets** (average catches 2016-2020): EU (45%) (Spain (16.9%), France (4.5%), Italy (0.5%), Indonesia (23.1%), Taiwan,China (15.7%), Seychelles (13.6%), Sri Lanka (5.7%).

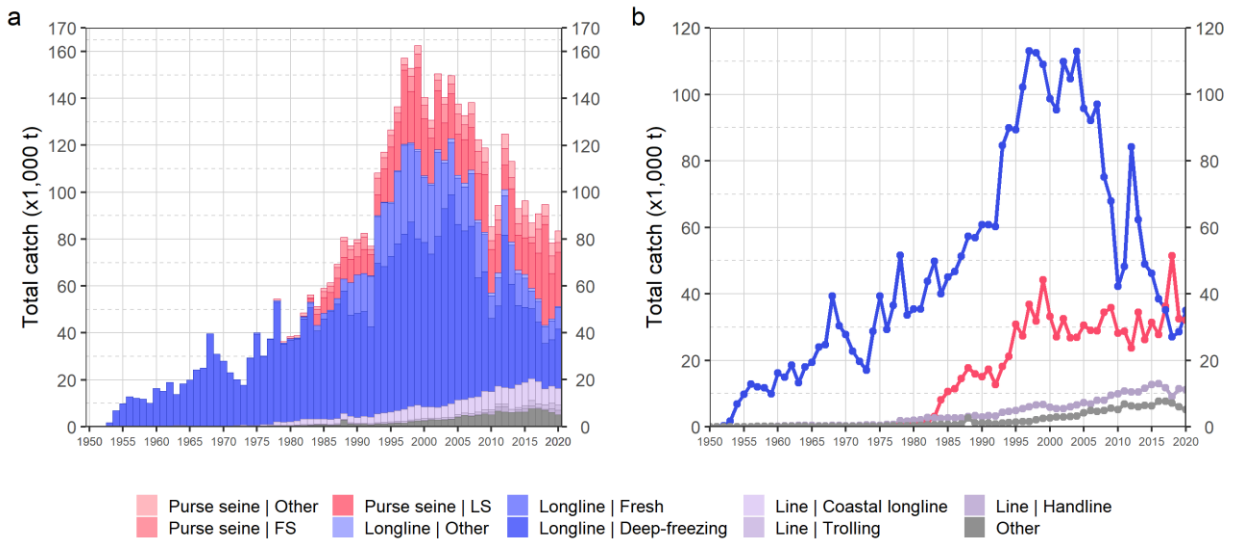

Fig. 1. Annual time series of (a) cumulative nominal catches (t) by fishery and (b) individual nominal catches (t) by fishery group for bigeye tuna during 1950–2020. LS = drifting log or FAD-associated school and FS = free-swimming school. Purse seine other: coastal purse seine, purse seine, ring net; Longline: deep-freezing and fresh longlines, swordfish and sharks-targeted longlines; Line: coastal longline, trolling and handline; Other: all remaining fishing gears

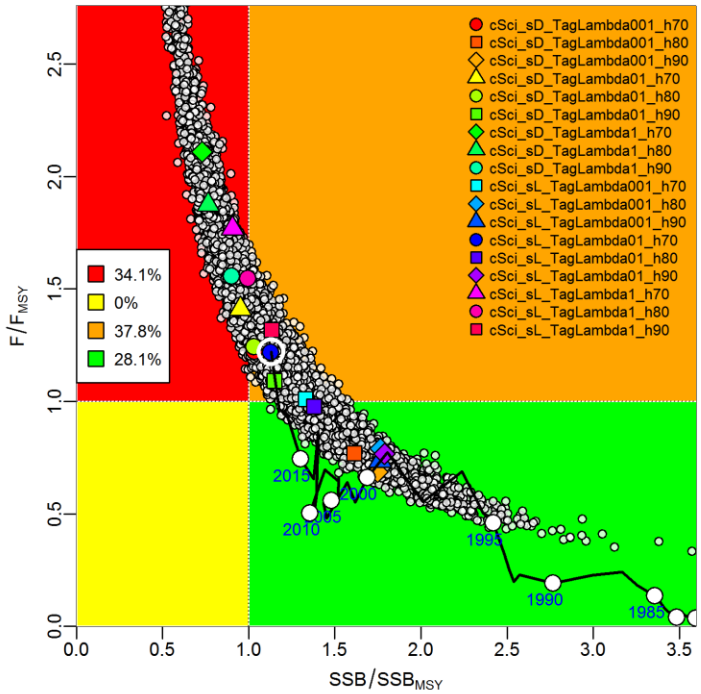

Fig. 2. Bigeye tuna: SS3 Aggregated Indian Ocean assessment Kobe plot. The coloured points represent stock status estimates from the 18 model options. The grey dots represent 5,000 estimates of 2018 stock status from the multivariate normal approximation from the mean and variance-covariance of the 18 model options. The legend indicates the estimated probability of the stock status being in each of the Kobe quadrant. The white circle (around the blue dot) represents the median stock status in 2018

Table 2. Bigeye tuna: Stock Synthesis base case Indian Ocean assessment Kobe II Strategy Matrix. Probability (percentage) of violating the MSY-based target (top) and limit (bottom) reference points for constant catch projections (relative to average catch level from 2018 (81,413 t); -10%, -20%, -30%, -40%) projected for 3 and 10 years

Reference point and projection timeframe	**Alternative catch projections (relative to the catch level from 2018) and weighted probability (%) scenarios that exceed reference point**				
	60% (48,848 t)	**70%** (56,990 t)	**80%** (65,130 t)	**90%** (73,272 t)	**100%** (81,413 t)
$SB_{2021} < SB_{MSY}$	51.1	53.3	54.2	57.1	58.9
$F_{2021} > F_{MSY}$	7.3	17.8	32	47.9	62.8
$SB_{2028} < SB_{MSY}$	8	19.5	35.1	49.1	60.8
$F_{2028} > F_{MSY}$	1.1	6.9	19.8	37.7	55.6
Reference point and projection timeframe	**Alternative catch projections (relative to the catch level from 2018) and probability (%) of violating MSY-based limit reference points (SB_{lim} = 0.5 SB_{MSY}; F_{Lim} = 1.3 F_{MSY})**				
	60% (48,848 t)	**70%** (56,990 t)	**80%** (65,130 t)	**90%** (73,272 t)	**100%** (81,413 t)
$SB_{2021} < SB_{LIM}$	0	0	0	0	0
$F_{2021} > F_{LIM}$	6.0	11.0	17.0	28.0	39.0
$SB_{2028} < SB_{LIM}$	0.0	0.0	6.0	11.0	22.0
$F_{2028} > F_{LIM}$	0.0	6.0	17.0	22.0	39.0