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IOTC–2022–WPTmT08(DP)–17

A review of the data availability, model configuration and parameterization of the 2019 Indian Ocean albacore tuna (Thunnus alalunga), stock assessment in the Indian Ocean.

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Executive summary

This paper presents a review of the data availability, model configuration and parameterization of the 2019 Indian Ocean albacore tuna (Thunnus alalunga), stock assessment in the Indian Ocean. This review covers the basics of the 2019 assessment, for details concerning the history of the fishery and the assessment history the reader is referred to the actual assessment document (IOTC–2019–WPTmT07(AS)–11). The conclusions, stock status and findings presented here are directly from the Report of the Seventh Session of the IOTC Working Party on Temperate Tunas: Assessment Meeting (IOTC–2019–WPTmT07(AS)–R[E])

Introduction and Overview of the 2019 Assessment.

The time period covered by the assessment is 1950- 2017 representing the period for which catch data are available from the commercial fishing fleets. The model was further stratified by quarter of the calendar year (Jan-Mar, Apr-Jun, Jul-Sep, Oct-Dec) and the various data sets (i.e., catch, CPUE, and size data) were compiled accordingly.

The 2019 albacore tuna assessment model initially incorporated four regions of the Indian Ocean which were used to define the spatial domain of the model fisheries and define the region specific longline data sets for the CPUE analysis (Hoyle et al 2016 and 2019). The spatial structure of the model was explored thoroughly via incorporation of multi-region models as well as a single region model. The multi-region model configurations (including 4-region and 2-region model) requires the temporal variations in regional recruitment (or movement) to be estimated in order to account for the differential trend in regional LL CPUE indices. The assessment report indicates that limited information is available to estimate regional dynamics (recruitment and movement), which impacts the reliability of the multi region models. There are apparent differences in the trends in albacore CPUE indices between the two southern areas over the last decade. The WPTmT proposed the four final model configuration options.

i. Model 1 - CPUE-Northwest, LL and PS LF included

ii. Model 2 - CPUE-Southwest, LL and PS LF included

iii. Model 3 - CPUE-Northwest, LL and PS LF excluded (selectivity fixed at values from initial fit)

iv. Model 4 - CPUE-Southwest, LL and PS LF excluded (selectivity fixed at values from initial fit)

All four models adopted a single-region model structure, based on the reference model presented in the initial assessment report (Table 1) In addition to the four final models proposed at the WPTmT meeting, the initial assessment report included a number of sensitivities (Table 1). The 4 region spatial stratification (Figure 1) was used to define fisheries based on region and fishing gear and the same fleet structure was used across models with different spatial configurations . These "fisheries" are considered to represent relatively homogeneous fishing units, with similar selectivity and catchability characteristics. A total of eleven fisheries were defined, including a single aggregate longline fishery in each region (Table 2).

Catch data were compiled by IOTC secretariat based on the fishery definitions (IOTC-2019-WPTmT07-DATA12 - SA.xlsx). All catches were expressed in metric tonnes (mt). There were minor changes in the gear specific catch histories from the previous assessment (Langley & Hoyle 2016). The most notable change was a redistribution of the annual longline catches amongst the model regions due to a revision of the spatial catches from the longline fleet.

The available data for the 2019 assessment consisted of the fisheries landings (summarized in Table 2), and CPUE indices for LLCPUE1, LLCPUE2, LLCPUE3, LLCPUE4, DNCPUE. Length data used in the 2019 assessment is summarized in Figure 2.

Results

These next paragraphs are directly from the WPTmT 07 report, with minor editorial changes.

The WPTmT 07 report NOTED that Model 4 results were significantly different from Models 1 – 3. This was due to the fact that the selectivity of the southwestern LL fishery doesn't include the large/old component of the population. The CPUE does not therefore monitor that component of the stock. As there is a lack of information in the size frequencies to inform the model of the upper range of the biomass levels, the results from this model are highly uncertain. This model was therefore excluded from the management advice. The combined estimates of stock status derived from the remaining 3 models are therefore effectively more weighted by the northwest CPUE.

The WPTmT REQUESTED that future stock status estimates incorporate a wider range of uncertainty, including additional natural mortality options and steepness values. Due to a lack of time during the assessment meeting, this was not possible.

The WPTmT NOTED the key assessment results for the Stock Synthesis III model (SS3) as shown below (Table 5.; Figure 3).

The WPTmT NOTED the selectivity has changed over time particularly in recent time where a shift has been to target smaller fish, which is influential on the definition of FMSY. Therefore the WPTmT REQUESTED a KOBE plot based on a time varying FMSY and BMSY be provided.

The WPTmT NOTED the recruitment in the terminal years of the assessment model are estimated to be well below average levels and this is projected to cause the stock to decline considerably over the short term. However, these recruitment estimates are poorly determined. Therefore the WPTmT NOTED the results of the K2SM (see workshop report Table 11) and cautioned that the short term projections are more influenced by the recent low recruitment levels, whereas the long term projections are more determined by the assumptions of average recruitment levels over the longer term period.

References

Collaborative study of albacore tuna CPUE from multiple Indian Ocean longline fleets in 2019. Seventh Working Party on Temperate Tunas: Data Preparatory Meeting, Kuala Lumpa, Malaysia, 14–17 January 2019. Indian Ocean Tuna Commission. IOTC-2019-WPTmT07(DP)-19.

Hoyle, S.D. Yin Chang, Doo Nam Kim, Sung Il Lee, Takayuki Matsumoto, Kaisuke Satoh, and Yu-Min Yeh (2016). Collaborative study of albacore tuna CPUE from multiple Indian Ocean longline fleets. Sixth Working Party on Temperate Tunas, Shanghai, China, 18–21 July 2016. Indian Ocean Tuna Commission. IOTC-WPTmT06-19a.

Hoyle, S.D.; Chassot, E.; Fu, D.; Kim, D.N.; Lee, S.; Matsumoto, T.; Satoh, K.; Wang, S.; Kitakado, T. (2019).

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Langley, A.D. (2019). Stock assessment of albacore tuna in the Indian Ocean using Stock Synthesis. Seventh Working Party on Temperate Tunas, Shimizu, Japan 23–26 July 2019. Indian Ocean Tuna Commission. IOTC–2019–WPTmT07(AS)–11.

Tables

Table 1. Reproduced from IOTC–2019–WPTmT07(AS)–11. Main structural assumptions of the albacore tuna reference model and details of estimated parameters. The specifications of the contrasting four region model are in grey italics.

Category	Assumptions	Parameters
Spatial Structure	Single Region *Four Regions*	
Recruitment	Occurs at the start of fourth quarter as 0 age fish. Recruitment is a function of Beverton-Holt stock-recruitment relationship (SRR). Temporal recruitment deviates from SRR, 1975-2015. *Overall regional recruitment distribution.* *Temporal variation in regional recruitment distribution 1980-2015*	LNR0 No prior; h = 0.80 SigmaR = 0.3, 41 deviates. *4 parameters (3 estimated, 1 fixed)* *108 parameters*
Initial population	A function of the equilibrium recruitment assuming population in an unexploited state prior to 1950. Initial fishing mortality fixed at zero for all fisheries.	
Age and growth	Two sexes with 14 age-classes, with the last representing a plus group. Growth parameterised using VonBert growth model. CV of length-at-age based varies as a linear function of age. Mean weights (W_j) from the weight-length relationship $W = aL^b$.	Female Lage1 = 52.60, Linfinity = 103.8cm, k = 0.38 Male Lage1 = 52.04, Linfinity = 110.6cm, k = 0.34 CVyoung =0.06, CVold =0.025 a = 1.3718e-05, b = 3.0973
Natural mortality	Invariant with age.	Fixed parameter 0.30

Reproductive potential	Length based female reproductive potential. Fecundity is directly related to female biomass (Wt) i.e. eggs=Wt*(a+b*Wt) with a=0 and b=1.	Specified by length class
Movement	*Age specific*	*Estimated*
Selectivity	Length based selectivity, parameterised with double normal function. LL3 and LL4 fisheries (and CPUE) share a common double normal selectivity. LL1 and LL2 fisheries share a common double normal selectivity constrained to approximate full selectivity for the largest length classes. Drift net fisheries have common selectivity. Double normal. Purse seine double normal selectivity. Other (1-4) fisheries fixed selectivity, equivalent to DN. *All LL fisheries (and CPUE) share a common selectivity. Constrained to approximate full selectivity for the largest length classes*	4 estimated parameters, no priors. 4 estimated parameters, no priors. 3 estimated parameters, no priors. 3 estimated parameters, no priors. *4 estimated parameters, no priors*.
Catchability	No seasonal variation in catchability for LL CPUE. LL CPUE indices have CV of 0.2. Shared base catchability estimated for four sets of LL CPUE indices.	1 base parameter estimated
Fishing mortality	Hybrid approach (method 3, see Methot & Wetzel 2013).	
Length composition	Multinomial error structure. Length samples assigned an ESS of Nfish/400 with a maximum ESS of 5. Nfish is the number of fish sampled.	

Table 2. Reproduced from IOTC–2019–WPTmT07(AS)–11. Definition of fisheries for the albacore assessment models.

#	Fishery	Nationality	Gear	Area
1	LL1	All	Longline 2	1
2	LL2	All	Longline 2	2
3	LL3	All	Longline 3	3
4	LL4	All	Longline 4	4
5	DN3	CN-TW	Drift net	3
6	DN4	CN-TW	Drift net	4
7	PS1	All	Purse seine	1
8	Other1	All	Other gears	1
9	Other2	All	Other gears	2
10	Other3	All	Other gears	3
11	Other4	All	Other gears	4

Table 3: Reproduced from IOTC–2019–WPTmT07(AS)–11. Recent albacore tuna catches (mt) by fishery included in the stock assessment model. The annual catches are presented for 2016 and 2017 and the average annual catch is presented for 2013-17.

	Fishery	Time Period		
		2013-17	2016	2017
1	LL1	8,519	7,774	9,033
2	LL2	1,857	1,333	1,477
3	LL3	14,803	16,145	17,286
4	LL4	9,462	9,030	9,320
5	DN3	0	0	0
6	DN4	0	0	0
7	PS1	488	433	438
8	Other1	99	87	142
9	Other2	507	476	472
10	Other3	3	6	0
11	Other4	0	0	0
Total		35,737	35,284	38,168

Table 4: Reproduced from IOTC–2019–WPTmT07(AS)–11. A description of the model sensitivities relative to the single region reference model (base model).

Model	Description	Base model parameters	Alternative parameters
LengthAtAge	Increase variation in length-at-age for males and females.	CVs for length-at-age CV_young 0.06 CV_old 0.025	CV_young 0.10 CV_old 0.10
LengthWeight	Use length-weight parameters from Kitakado et al. (2019)	*a* = 1.3718e-05 *b* = 3.0973	*a* = 6.9e-06 *b* = 3.2263
LLqIncrease	Increase effective effort of LL3 CPUE indices by 1% per annum.		
Mature1	Use maturity at length from recent western Indian Ocean study (rather than South Pacific reproductive potential at length)	Length based Reproductive Potential from South Pacific albacore.	Length based maturity ogive from Dhrumeea et al (2016)
NatMort1	Decrease natural mortality from 0.30 to 0.2207	*M* = 0.30 all ages	*M* = 0.2207 all ages
NatMort2	Age specific natural mortality from 0.40 to 0.2207 (Hybrid)	*M* = 0.30 all ages	*M* = 0.2207 4+ ages
SelectDN50	Constrain LL3/LL4 selectivity to 50% selection for largest length classes.		Constraint on terminal parameter of selectivity.
SelectLL2	Estimate separate length based selectivities for LL1 and LL2. Approx. logistic form.	Selectivity shared LL1 and LL2.	Separate selectivities for LL1 and LL2.
SigmaR60	Increase *SigmaR* to 0.60	*SigmaR* = 0.30	*SigmaR* = 0.60
SigmaR80	Increase *SigmaR* to 0.80	*SigmaR* = 0.30	*SigmaR* = 0.80
Steepness70	SRR Steepness 0.70	*h* = 0.80	*h* = 0.70
Steepness90	SRR Steepness 0.90	*h* = 0.80	*h* = 0.90
CPUE_South	Incorporate LL3 and LL4 CPUE indices in single region model.	LL3 CPUE only	LL3 and LL4 CPUE indices.
CPUE_West	Incorporate LL1 and LL3 CPUE indices in single region model.	LL3 CPUE only	LL1 and LL3 CPUE indices.
LengthComp_exLL2	Exclude length composition data from LL2 fishery.	LL2 LF data included	No LL2 LF data
LengthComp_exTWLF	Exclude all Taiwanese LL logsheet length composition data.	Include TWLF data in length comp	Exclude TWLF data from length comp
PSLFdownweight	Decrease the influence of the PS LF data in the model fit.	PS LF lambda = 1.0	PS LF lambda = 0.5
PSLFupweight	Increase the influence of the PS LF data in the model fit.	PS LF lambda = 1.0	PS LF lambda = 2.0

Table 5. From WPTmT 07 Report. Table 10 Albacore: Key management quantities from the SS3 assessment, for the Indian Ocean. Values are based on the median of the combined outputs of 3 model options: Models 1, 2 and 3.

Management Quantity	Indian Ocean
2017 catch estimate	38,168
Mean catch from 2013–2017	35,737
MSY (1000 t) (95% CI)	35.7 (27.3-44.4)
Data period used in assessment	1950–2017
F_{MSY} (95% CI)	0.213 (0.195-0.237)
SB_{MSY} (1000 t) (95% CI)	23.2 (17.6-29.2)
F_{2017}/F_{MSY} (95% CI)	1.346 (0.588-2.171)
B_{2017}/B_{MSY} (95% CI)	n.a.
SB_{2017}/SB_{MSY} (95% CI)	1.281 (0.574-2.071)
B_{2017}/B_{1950} (95% CI)	0.333 (-)
SB_{2017}/SB_{1950} (95% CI)	0.262 (–)
$B_{2017}/B_{1950,\ F=0}$	n.a.
SB_{2017}/SB2017$_{,\ F=0}$	0.272

n.a. not available
* For SS3 SB is defined as mature female biomass.

Figures

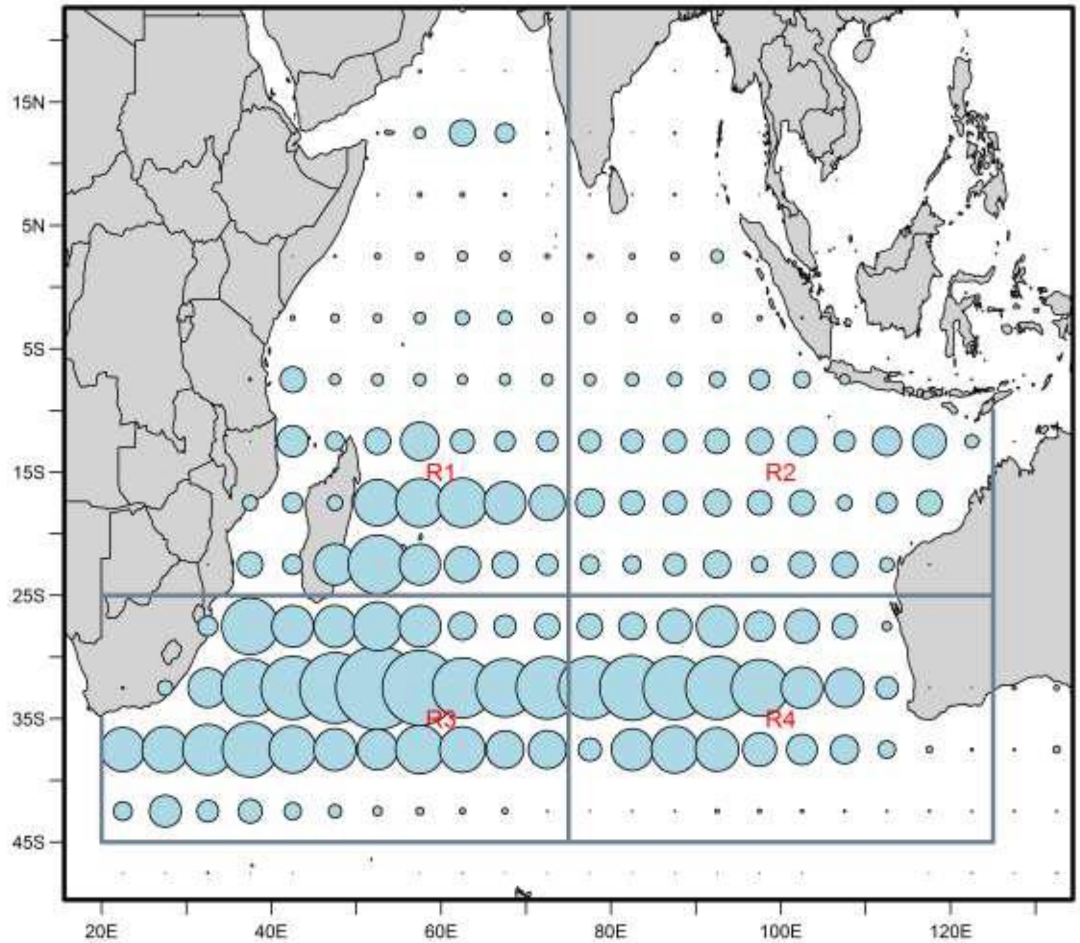

Figure 1. From the assessment report IOTC–2019–WPTmT07(AS)–11. Spatial stratification of the Indian Ocean for the definition of the fisheries. The blue circles represent the aggregated Japanese and TW LL albacore catch (numbers of fish) by 5 degree cell from 1952-2017. The area of the circle is proportional to the magnitude of the catch (the largest circle represents a catch of 2.45 million fish).

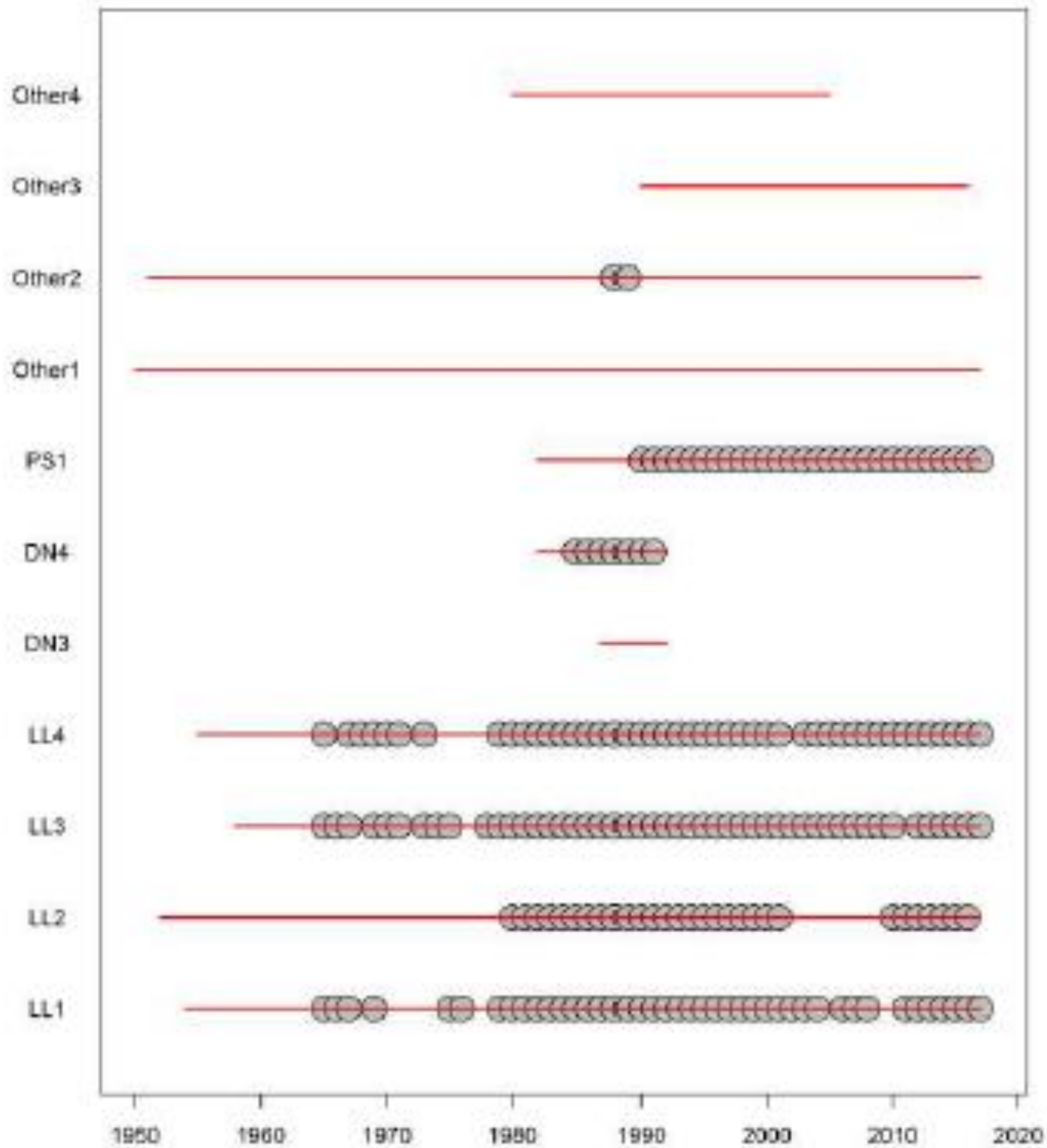

Figure 2. Reproduced from IOTC–2019–WPTmT07(AS)–11 Figure 11 The availability of length sampling data from each fishery by year. The grey circles denote the presence of samples in a specific year. The red horizontal lines indicate the time period over which each fishery operated.

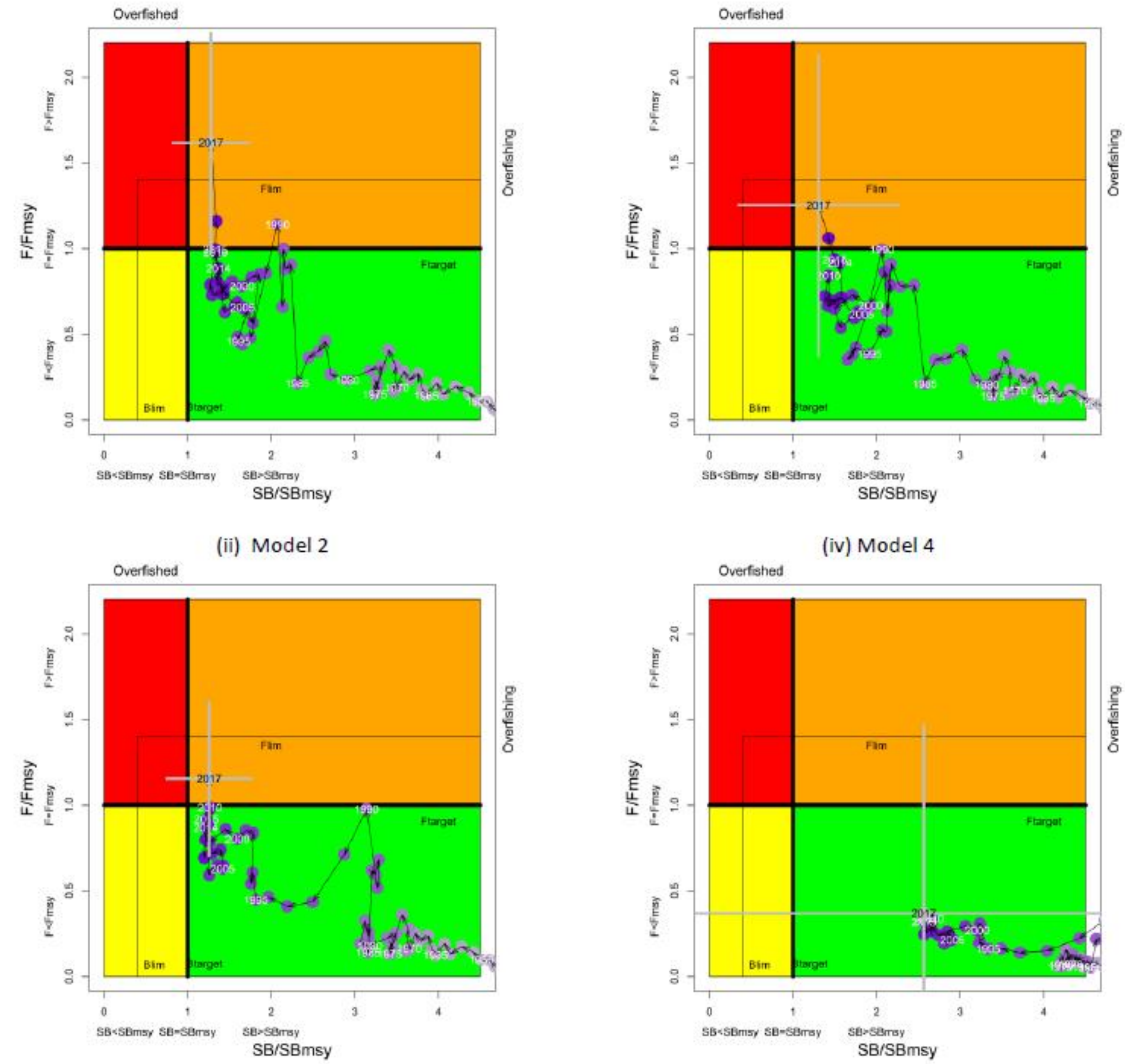

Figure 3. Reproduced from IOTC–2019–WPTmT07(AS)–R[E] Fig. 6. Albacore: SS3 Indian Ocean assessment Kobe plot for the four model options: (i) Model 1 (ii) Model 2 (iii) Model 3 (iv) Model 4. Blue circles indicate the trajectory of the point estimates for the SB ratio and F ratio for each year 1950–2017 (the grey lines represent the 95 percentiles of the 2017 estimate). Target (F_{targ} and SB_{targ}) and limit (F_{lim} and SB_{lim}) reference points are shown.