INDIAN OCEAN YELLOWFIN TUNA SS3 MODEL PROJECTIONS

PREPARED BY DAN FU[1], ADAM LANGLEY[2], GORKA MERINO[3], AGURTZANE URTIZBEREA IJURCO[4]

20 NOVEMBER 2018

[1] IOTC Secretariat, Dan.Fu@fao.org;
[2] IOTC Consultant, Adam.Langley@gmail.com;
[3] AZTI, gmerino@azti.es;
[4] AZTI, aurtizberea@azti.es;

Executive Summary

This document presents projections and K2SM for the 2018 Indian Ocean tuna Stock Synthesis assessment model. Deterministic projections were conducted for the 24 reference grid scenarios for 2018 – 2027 assuming a constant level of catch at 60%–120% of the 2017 catch level. The projection incorporates the range of uncertainty among model selection but does not describe uncertainty due to parameter estimation error, or stochastic future recruitment variability.

1. INTRODUCTION

At the 20th IOTC Working Party on Tropical tuna (WPTT), a preliminary stock assessment for yellowfin tuna (*Thunnus albacares*) in the Indian Ocean was presented (Fu et al, 2018). The assessment was implemented using the Stock Synthesis software with the inclusion of fishery data up to 2017 (final model year). The WPTT agreed to adopt a reference grid of 24 models to capture major sources of uncertainty and to assist the formulation of management advice (IOTC–WPTT20 2018). The model grid incorporated alternative levels of steepness, initial tag mortality, tag weighting (lambda), and longline CPUE catchability scenarios. The overall stock status conclusions do not differ substantially from the previous assessment: the stock is currently overfished (median SSB/SSBMSY= 0.83) and is subject to overfishing (median F/FMSY=1.20). Subsequently, the WPTT requested SS3 projections to be conducted intersessionally, and the results to be presented in a separate working document to the Scientific Committee, including Kobe2 Strategy Matrix probabilities.

2. METHODS

Projections were conducted for a 10-year period (2018–2027) from the Maximum Posterior Density (MPD) estimates of all grid models at a constant level of catch as a multiple of the fishery catches in 2017 (a total of 409,567t). 11 levels of catch were investigated representing 60% to 120% of the 2017 catch level (in increment of 5% until 100% and with an increment of 10% afterwards). The catch allocations among fisheries were based on the catch shares in 2017 amongst fleets defined in the SS3 model. The projections used deterministic recruitment from the stock recruitment relationship. The Kobe2 Strategy Matrix probabilities were calculated from the 24 reference grid scenarios giving a relative weight of 75% to Q1 CPUE scenario compared to 25 % weight to Q2 in the grid results (IOTC–WPTT20 2018). The projections were summarised in terms of a weighted average of results that describe the proportion of scenarios in which the spawning stock biomass falls below the target and limit reference points (SSBMSY and 0.4SSBMSY respectively), and the fishing mortality exceeds the target and limit reference points (FMSY and 1.4FMSY).

3. RESULTS

The results of projections of the 24 grid SS3 are provided in the form of probabilities that F > FMSY and SSB < SSBMSY in a K2SM framework (Table 1-3). The projections indicated that the catch at the current level and/or above are not sustainable – the stock has a high probability of violating both the target and limit reference points in the short term (the SSB crashed during the projection period or at least one fishery was not able to take the catch due to absence of vulnerable fish for most models) (Tables 1 and 2). With 20% catch reduction or more, there is an over 50% probability for the SSB to recover to be above BMSY at the end of the projection period (Table 3).

4. DISCUSSIONS

The projections ignored the statistical uncertainty in the parameter estimates and future recruitment variability, but incorporated the model selection uncertainty which is usually greater than other sources of uncertainty. Walter et al. (2018) described an approach to capture both structural and statistical uncertainty using a multivariate normal (MVN) approximation obtained from the variance-covariance matrix across each of the model in the grid. That approach was not attempted here as the preliminary investigation suggested the variance-covariance appeared to poorly estimate later in the projection period for most models with progressively high catch scenarios.

5. REFERENCES

Fu, D., Langley, A., Merino, G., Ijurco, A. 2018. Preliminary Indian Ocean yellowfin tuna stock assessment 1950-2017 (stock synthesis). IOTC–2018–WPTT20–33.

John Walter, J., Hiroki, Y., Satoh, K., Matsumoto, T., Winker, H., Ijurco, A., Schirripa, Michael. 2018. ATLANTIC BIGEYE TUNA STOCK SYNTHESIS PROJECTIONS AND KOBE 2 MATRICES. SCRS-2018-162.

IOTC–WPTT20 2018. Report of the 20th Session of the IOTC Working Party on Tropical Tunas. Seychelles, 29 October – 3 November 2018. IOTC–2018–WPTT20–R[E]: 127 pp

Table 1: Projected stock status: the probability of violating the MSY-based target reference points (Top: the probability of being below SB_{MSY}; bottom: the probability of being above F_{MSY}) from 2018-2027 for a range of constant catch projections for the IO yellowfin assessment model grid.

P(SSB < SSBMSY)

Catch | Year	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**
120% (491,480t)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00*	1.00*	1.00*
110% (450,523t)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00*	1.00*
100% (409,567t)	1.00	0.98	0.98	0.98	0.98	0.98	0.98	0.98	1.00	1.00
95% (389,089t)	1.00	0.98	0.98	0.96	0.96	0.96	0.96	0.96	0.98	0.98
90% (368,610t)	1.00	0.98	0.96	0.85	0.85	0.79	0.79	0.79	0.79	0.79
85% (348,132t)	1.00	0.96	0.85	0.79	0.73	0.58	0.58	0.56	0.56	0.56
80% (327,654t)	0.98	0.90	0.85	0.63	0.48	0.48	0.48	0.48	0.42	0.42
75% (307,175t)	0.98	0.85	0.73	0.48	0.48	0.25	0.25	0.25	0.25	0.25
70% (286,697t)	0.98	0.85	0.48	0.46	0.25	0.23	0.23	0.23	0.08	0.08
65% (266,218t)	0.98	0.85	0.48	0.25	0.23	0.08	0.08	0.08	0.08	0.08
60% (245,740t)	0.98	0.79	0.48	0.23	0.08	0.08	0.08	0.06	0.00	0.00

P(F > FMSY)

Catch | Year	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**
120% (491,480t)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00*	1.00*	1.00*
110% (450,523t)	1.00	1.00	1.00	1.00	1.00	0.98	1.00	1.00	1.00*	1.00*
100% (409,567t)	0.96	0.98	0.98	0.96	1.00	0.92	0.94	0.98	1.00	1.00
95% (389,089t)	0.85	0.85	0.96	0.96	0.98	0.98	0.98	0.98	0.98	1.00
90% (368,610t)	0.79	0.79	0.79	0.85	0.85	0.79	0.79	0.85	0.85	0.85
85% (348,132t)	0.54	0.56	0.56	0.63	0.63	0.63	0.63	0.63	0.63	0.63
80% (327,654t)	0.44	0.48	0.48	0.48	0.48	0.48	0.42	0.42	0.42	0.42
75% (307,175t)	0.29	0.29	0.25	0.25	0.25	0.25	0.25	0.23	0.23	0.23
70% (286,697t)	0.23	0.23	0.23	0.23	0.23	0.08	0.08	0.08	0.08	0.08
65% (266,218t)	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.06	0.06
60% (245,740t)	0.08	0.08	0.08	0.06	0.06	0.00	0.00	0.00	0.00	0.00

** stock crashed or at least one fishery not able to take the catch due to absence of vulnerable fish in the projection period for all models. The probability levels are not well determined, but likely progressively high as the catch level increases beyond 100%.*

Table 2: Projected stock status: the probability of violating the MSY-based limit reference points (Top: the probability of being below *SB_{MSY}*; bottom: the probability of being above *F_{MSY}*) from 2018-2027 for a range of constant catch projections for the IO yellowfin assessment model grid.

P(SSB < 0.4SSBMSY)

Catch | Year	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**
120% (491,480t)	0.00	0.17	0.38	0.52	0.94	0.98	1.00	1.00*	1.00*	1.00*
110% (450,523t)	0.00	0.15	0.42	0.60	0.79	0.88	0.96	1.00	1.00*	1.00*
100% (409,567t)	0.00	0.08	0.23	0.23	0.40	0.50	0.58	0.73	0.88	0.90
95% (389,089t)	0.00	0.06	0.15	0.25	0.42	0.48	0.63	0.63	0.71	0.83
90% (368,610t)	0.00	0.00	0.06	0.17	0.33	0.33	0.42	0.48	0.50	0.50
85% (348,132t)	0.00	0.00	0.00	0.06	0.21	0.31	0.40	0.40	0.40	0.42
80% (327,654t)	0.00	0.00	0.00	0.00	0.00	0.15	0.17	0.23	0.27	0.27
75% (307,175t)	0.00	0.00	0.00	0.06	0.06	0.08	0.08	0.08	0.08	0.08
70% (286,697t)	0.00	0.00	0.00	0.00	0.00	0.06	0.06	0.06	0.06	0.06
65% (266,218t)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60% (245,740t)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

P(F > 1.4FMSY)

Catch | Year	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**
120% (491,480t)	0.79	0.94	1.00	1.00	0.98	1.00	1.00	1.00*	1.00*	1.00*
110% (450,523t)	0.48	0.77	0.92	0.98	1.00	0.98	1.00	1.00	1.00*	1.00*
100% (409,567t)	0.29	0.48	0.63	0.75	0.92	0.90	0.92	0.96	1.00	0.94
95% (389,089t)	0.23	0.42	0.56	0.63	0.71	0.77	0.85	0.92	0.92	0.94
90% (368,610t)	0.15	0.23	0.42	0.54	0.56	0.56	0.56	0.63	0.63	0.65
85% (348,132t)	0.08	0.23	0.23	0.40	0.42	0.42	0.50	0.50	0.50	0.50
80% (327,654t)	0.06	0.08	0.21	0.23	0.23	0.25	0.27	0.40	0.40	0.42
75% (307,175t)	0.00	0.08	0.08	0.08	0.08	0.15	0.15	0.17	0.23	0.23
70% (286,697t)	0.00	0.06	0.06	0.08	0.08	0.08	0.08	0.08	0.08	0.08
65% (266,218t)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60% (245,740t)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

** stock crashed or at least one fishery not able to take the catch due to absence of vulnerable fish in the projection period for all models in the grid. The probability levels are not well determined, but likely progressively high as the catch level increases beyond 100%.*

TABLE 3. Yellowfin tuna: Stock synthesis 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 the catch level from 2017 (409,567t), -35%, - 30%, -25%, -20%, -15%, ± 10%, -5%) projected for 3 and 10 years.

Reference point and projection timeframe	**Alternative catch projections (relative to the catch level from 2017) and probability (%) of violating MSY-based target reference points ($B_{targ} = B_{MSY}$; $F_{targ} = F_{MSY}$)**								
	65% (266,218t)	70% (286,697t)	75% (307,175t)	80% (327,654t)	85% (348,132t)	90% (368,610t)	95% (389,089t)	100% (409,567t)	110% (450,523t)
$B_{2020} < B_{MSY}$	0.48	0.48	0.73	0.85	0.85	0.96	0.98	0.98	1.00
$F_{2020} > F_{MSY}$	0.08	0.23	0.25	0.48	0.56	0.79	0.96	0.98	1.00
$B_{2027} < B_{MSY}$	0.08	0.08	0.25	0.42	0.56	0.79	0.98	1.00	1.00*
$F_{2027} > F_{MSY}$	0.06	0.08	0.23	0.42	0.63	0.85	1.00	1.00	1.00*
Reference point and projection timeframe	**Alternative catch projections (relative to the catch level from 2017) and probability (%) of violating MSY-based limit reference points ($B_{lim} = 0.4\ B_{MSY}$; $F_{Lim} = 1.4\ F_{MSY}$)**								
	65% (266,218t)	70% (286,697t)	75% (307,175t)	80% (327,654t)	85% (348,132t)	90% (368,610t)	95% (389,089t)	100% (409,567t)	110% (450,523t)
$B_{2020} < B_{Lim}$	0.00	0.00	0.00	0.00	0.00	0.06	0.15	0.23	0.42
$F_{2020} > F_{Lim}$	0.00	0.06	0.08	0.21	0.23	0.42	0.56	0.63	0.92
$B_{2027} < B_{Lim}$	0.00	0.06	0.08	0.27	0.42	0.50	0.83	0.90	1.00*
$F_{2027} > F_{Lim}$	0.00	0.08	0.23	0.42	0.50	0.65	0.94	0.94	1.00*

** stock crashed or at least one fishery not able to take the catch due to absence of vulnerable fish in the projection period for all models. The probability levels are not well determined, but likely progressively high as the catch level increases beyond 100%.*