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CURRENT AND PROJECTED STOCK STATUS OF WCPO SKIPJACK TUNA TO INFORM CONSIDERATION OF AN UPDATED TARGET REFERENCE POINT

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SPC-OFP
Pacific Community (SPC), Noumea, New Caledonia

Executive Summary

CMM 2015-06 calls for a review of the interim target reference point for WCPO skipjack tuna no later than 2019. Relevant to this review, a new assessment of this stock was presented and agreed at the 15th Scientific Committee meeting. That assessment incorporated new information on the biology of the stock (e.g. the pattern of maturity-at-length), a new spatial structure, and new model settings. In a similar way to the assessment of WCPO bigeye tuna performed in 2017, this changed the perception of the status of the stock and its productivity compared to the model upon which decisions on the skipjack TRP was based. This paper compares the results of the 2014, 2016 and 2019 assessments to illustrate this.

This paper also presents the results of analyses requested by SC15 to assist WCPFC16 in its review of the performance of the interim skipjack tuna TRP. It presents a comparable analysis to that presented to WCPFC-MOW-WP-03 using the agreed 2019 skipjack assessment, and indicates changes in effort and biomass from 2012 and 'recent' levels, and median equilibrium yield (as a proportion of MSY) associated with strategies that maintain a median of spawning biomass depletion ($SB/SB_{F=0}$) of 40%, 45%, 50%, and 55%. These are compared to the results under 2012 'baseline' fishing levels (2012 effort levels in the purse seine fishery, recent catch levels in Indonesia/Philippines/Vietnam domestic fisheries).

Under baseline fishing levels the stock will on average fall slightly compared to 'recent' levels (44% $SB_{F=0}$), to 42% $SB_{F=0}$. This is very slightly below 2012 levels, but is an equivalent % $SB_{F=0}$ value at 2 decimal places. Examining the four depletion levels requested by SC15 (55%, 50%, 45% and 40% $SB_{F=0}$), median depletion levels between 45% and 55% $SB_{F=0}$ implied reductions in effort from 2012 levels of between 13 to 40%, and led to increases in spawning biomass from both 2012 and recent (2015-2018 average) levels by between 3 and 31%. Total equilibrium yield would reduce compared to the baseline levels, to 62-74% MSY. To achieve the lower level of 40% $SB_{F=0}$, effort would need to increase by 5% relative to baseline levels, biomass would fall by between 5 to 9% compared to 2012 and recent levels respectively, while yield would be 89% of MSY. There was no risk of falling below the LRP associated with any of these depletion levels based on the current uncertainty framework.

It is worth noting that 40%$SB_{F=0}$ represents conditions estimated to have only very recently been experienced within the fishery (this level was estimated in 2017 only), and hence the consequences of this level for stock and fishery are not fully understood.

Median skipjack tuna depletion levels ($SB/SB_{F=0}$) and corresponding change in biomass from 2012 and 2015-18 average levels, change in purse seine effort (scalar), median equilibrium yield (total yield as % of MSY) and risk of falling below the LRP under baseline fishery conditions (shaded row) and for SC15-nominated depletion levels.

Median depletion level (%$SB_{F=0}$)	Change in spawning biomass (%$SB_{F=0}$) from 2012 levels	Change in spawning biomass (%$SB_{F=0}$) from 2015-2018 average	Change in PS effort from 2012 levels*	Median total equilibrium yield (%MSY)	Risk $SB/SB_{F=0}$ < LRP
55%	+31%	+25%	-40%	62%	0%
50%	+18%	+13%	-25%	69%	0%
45%	+7%	+3%	-13%	74%	0%
42%	-2%	-5%	0%	84%	0%
40%	-5%	-9%	+5%	89%	0%

* '2012' conditions as described in the main text. No future 'effort creep' assumed, i.e. CPUE is assumed proportional to abundance.

Introduction

Target reference points, in conjunction with limit reference points (i.e. TRPs and LRPs), harvest control rules (HCRs) and acceptable levels of risk, form critical components of a management strategy. In 2015, WCPFC defined the interim target reference point level for WCPO skipjack tuna at 50 per cent of the estimated recent average spawning biomass in the absence of fishing ($SB_{F=0, t1-t2}$). This decision was based upon analyses presented in MOW3-WP/03 (SPC-OFP, 2014), which estimated catch, effort and stock status against a potential range of TRPs from 40-60% $SB_{F=0}$. CMM 2015-06 requires the target reference point to be reviewed by the Commission no later than 2019.

In 2019, a new assessment of the WCPO skipjack stock was discussed and agreed at the 15th Scientific Committee meeting (Vincent et al., 2019). This assessment included a number of changes when compared to the previous assessments in 2014 (Rice et al., 2014) and 2016 (McKechnie et al., 2016): the incorporation of a new spatial structure for the model; incorporation of new information on the pattern of maturity of the stock; and new model settings. In a similar way to the incorporation of new knowledge of growth for WCPO bigeye tuna, the incorporation of this new information changed the perception of the status of the skipjack stock, although to a smaller degree than for bigeye tuna.

Following agreement of the 2019 WCPO skipjack tuna assessment, and as requested in the Harvest Strategy Work plan ("SC to advise on required analyses to support TRP review"), SC15 requested the SSP undertake the following to assist WCPFC16 in its review of the performance of the interim skipjack tuna TRP:

- Update Table 4 in SPC-OFP (2019) (Current and projected stock status of skipjack to inform consideration of target reference points; MOW3-WP-03) based on the updated skipjack tuna assessment agreed by SC15. This table should indicate changes in effort and biomass from 2012 and the recent levels and median equilibrium yield (as a proportion of MSY) associated with strategies that maintain a median of spawning biomass depletion ($SB/SB_{F=0}$) of 40%, 45%, 50%, and 55%.

This paper aims to:

1. Summarise current skipjack stock status from the 2019 assessment;
2. Provide projections of the skipjack stock to compare fishery performance metrics for the four stock levels specified by SC15, as well as possible levels of future abundance under 'baseline' fishing levels.

Approach

We used the 2019 stock assessment for skipjack tuna, incorporating a grid of the 54 model runs selected by the Scientific Committee (SC15) as the basis for reporting our uncertainty in current and historical stock status. SC15 also provided plausibility weights for each of these models based on expert opinion of how plausible they were relative to the diagnostic case model (see Annex 1 for details of the models and plausibility weights).

Evaluation of current skipjack stock status

We summarise current WCPO skipjack stock status relative to the agreed TRP level defined by CMM 2015-06, based upon the SC15 report and associated figures. The trajectory of skipjack stock depletion over time ($SB/SB_{F=0}$) from the 2019 assessment is also compared to that estimated within the 2014 and 2016 assessments.

Projections of the skipjack stock under 'baseline' fishing levels and four specific stock levels

Stock projections were performed under five different future scenarios for purse seine fishing effort. For each, the stock was projected into the future using the following procedure:

1. Run 100 simulations that went 30 years into the future for each of the 54 stock assessment models - each simulation representing a possible 'future' trajectory for recruitment;
2. Run those simulations assuming long term recruitment patterns (future recruitment is defined by the estimated stock recruitment relationship, with variability around it defined by recruitment estimates over the period 1982-2017);
3. Assume catchability remains constant into the future – i.e. no effort creep occurs in WCPO fisheries;
4. Taking into account the SC15 plausibility weightings, combine the results across each assessment model run and calculate the median level of terminal biomass compared to $SB_{F=0}$.

The potential future skipjack stock and fishery implications under a 'baseline' fishing level was used to provide a comparison to the four specific stock levels requested by SC15. Fishing levels equivalent to those in 2012 (effort levels for purse seine fisheries, catch levels for all other fisheries in the assessment model) were selected as requested by SC15, and consistent with the baseline used in SPC-OFP (2014) and key purse seine management regimes within the WCPO. However, we note that the latest catch estimates for domestic fisheries in Indonesia/Philippines/Vietnam have indicated higher catches of skipjack in recent years compared to those in 2012. As a result, we have assumed levels equivalent to the 2016-2018 average for those fisheries continue into the future in this analysis (see Annex 2 for further details).

To examine the consequences for the skipjack stock and fishery of the four specific stock levels requested by SC15, the level of purse seine fishing in the future was adjusted from the baseline so that the median stock size was equivalent to the candidate TRP level at the end of the projection period. The level of change in average spawning biomass and effort from 2012 and more recent levels, the risk to the stock relative to the agreed limit reference point level[1] and the total equilibrium yield relative to MSY, were estimated.

Results

Evaluation of current skipjack stock status.

SC15 noted that the 2019 assessment for WCPO skipjack indicated the stock was not overfished, and not subject to overfishing (Figure 1).

The median depletion level from the weighted uncertainty grid of the agreed SC15 WCPO skipjack assessment was 44% ($SB_{recent}/SB_{F=0}$, where recent is the average SB over the period 2015-2018), and a probable range of 37% to 53% (80% of runs fell within this range). The median is therefore below the interim TRP (50% $SB_{F=0}$), while the range of estimates spans that interim TRP.

[1] The level of risk is defined by the current level of uncertainty captured through the range of models included within the assessment grid, and modelled variability in future recruitment levels. However, this likely underestimates the uncertainty within the assessment and in future conditions.

To illustrate the influence of changes in the 2019 assessment model assumptions to the perception of stock status, Table 1 and Figure 2 compare the depletion estimates across time and in specific years from the 2014, 2016 and 2019 stock assessments. The change in perception of stock productivity resulting from new biological information, changes in model assumptions and settings implies a lower stock status for recent years within the 2019 assessment compared to the historical assessments.

Projections of the skipjack stock under 'baseline' fishing levels and four specific stock levels

The baseline projections illustrate where the stock may end up on average if those baseline fishing levels continue (2012 effort levels in the purse seine fishery, recent catch levels in Indonesia/Philippines/Vietnam domestic fisheries). The stock will on average fall slightly compared to 'recent' levels, to 42% $SB_{F=0}$. This is very slightly below 2012 levels, but an equivalent % $SB_{F=0}$ value at 2 decimal places, and has no associated risk of falling below the LRP (Table 2).

Examining the four depletion levels requested by SC15 (55%, 50%, 45% and 40% $SB_{F=0}$), median depletion levels between 45% and 55% $SB_{F=0}$ implied reductions in effort from 2012 levels from between 13 to 40%, and led to increases in spawning biomass from both 2012 and recent (2015-2018 average) levels by between 3 and 31%. Total equilibrium yield would reduce compared to the baseline levels, to 62-74% MSY. To achieve the lower level of 40% $SB_{F=0}$, effort would need to increase by 5% relative to baseline levels, biomass would fall by between 5 to 9% compared to 2012 and recent levels respectively, while yield would be 89% of MSY. There was no risk of falling below the LRP associated with any of these depletion levels, based on the current uncertainty framework (Table 2).

It is worth noting that 40%$SB_{F=0}$ represents conditions we may have only very recently experienced within the fishery (this level was estimated in 2017 only), and hence the consequences of this level for stock and fishery are not fully understood.

References

McKechnie, S., Hampton, J., Pilling, G.M. and Davies, N. (2016). Stock assessment of skipjack tuna in the western and central Pacific Ocean. WCPFC-SC12-2016/SA-WP-04.

Rice, J., Harley, S., Davies, N. and Hampton, J. (2014). Stock assessment of skipjack tuna in the western and central Pacific Ocean. WCPFC-SC10-2014/SA-WP-05.

SPC-OFP (2019). Current and projected stock status of skipjack tuna to inform consideration of Target Reference Points (MOW3-WP/03, 14 Nov 2014). WCPFC-SC15-2019/MI-IP-09.

Vincent, M.T., Pilling, G.M. and Hampton, J. (2019). Stock assessment of skipjack tuna in the western and central Pacific Ocean. WCPFC-SC15-2019/SA-WP-05-Rev2.

Vincent, M.T., Pilling, G. and Hampton, J. (2018). Incorporation of updated growth information within the 2017 WCPO bigeye stock assessment grid, and examination of the sensitivity of estimates to alternative model spatial structures. WCPFC-SC14-2018/SA-WP-03.

Tables and figures

Table 1. Summary of median depletion levels for the reference case model (2014) and across the uncertainty grids of the 2016 and 2019 WCPO skipjack stock assessments in specific years, weighted as specified by Scientific Committee.

Year	$SB_{year}/SB_{F=0,\ year\text{-}1\ to\ year\text{-}10}$		
	2014 assessment	2016 assessment	2019 assessment
2012	51%	48%	42%
2015	-	51%	47%
2018	-	-	42%

Table 2. Median depletion levels of skipjack tuna ($SB/SB_{F=0}$) and corresponding change in biomass from 2012 and 2015-18 average levels, change in purse seine effort (scalar), median total equilibrium yield (as a proportion of MSY) and the risk of falling below the LRP under baseline fishery conditions (shaded row) and for the four SC15-nominated depletion levels.

Median depletion level (%$SB_{F=0}$)	Change in spawning biomass (%$SB_{F=0}$) from 2012 levels	Change in spawning biomass (%$SB_{F=0}$) from 2015-2018 average	Change in PS effort from 2012 levels*	Median total equilibrium yield (%MSY)	Risk $SB/SB_{F=0}$ < LRP
55%	+31%	+25%	-40%	62%	0%
50%	+18%	+13%	-25%	69%	0%
45%	+7%	+3%	-13%	74%	0%
42%	-2%	-5%	0%	84%	0%
40%	-5%	-9%	+5%	89%	0%

* 2012 conditions assumed for purse seine (effort) and most other fisheries (catch), 2015-18 average levels assumed for domestic ID/PH. This also assumes no 'effort creep' occurs and hence CPUE is assumed proportional to stock abundance.

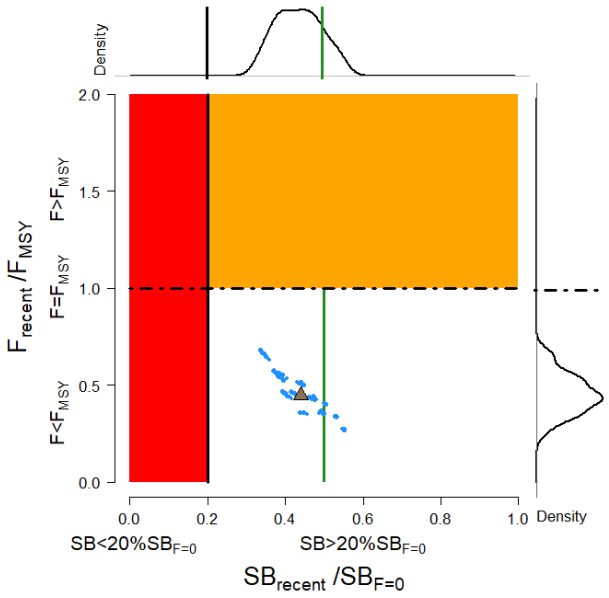

Figure 1. Majuro plot of the recent spawning potential (2015 – 2018) summarizing the results for each of the models in the structural uncertainty grid with weighting. The plots represent estimates of stock status in terms of spawning potential depletion and fishing mortality, and marginal distributions of each are presented. Vertical green line denotes the interim TRP. Brown triangle indicates the weighted median of the estimates.

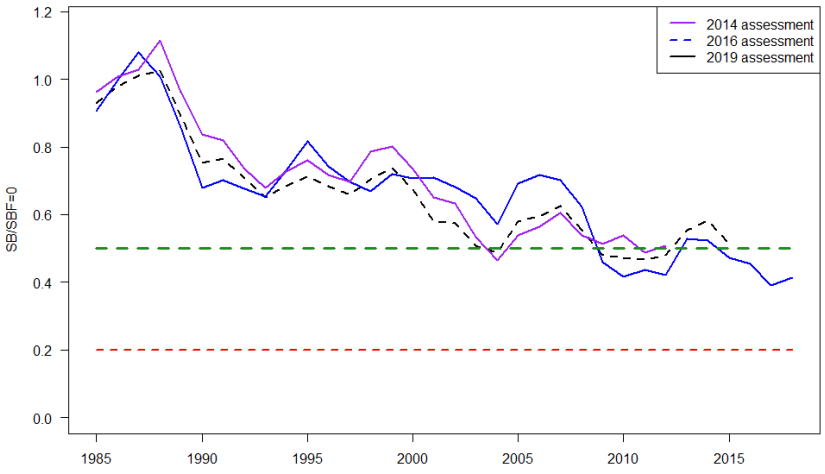

Figure 2. Comparison of depletion trajectories from the 2014, 2016 and 2019 assessments over the period 1985 to the end of each assessment. $SB_{F=0}$ calculated consistent with the approach defined for the limit (red horizontal line) and target (green horizontal line) reference points (i.e. $SB_{F=0,\ t\text{-}1\ to\ t\text{-}10}$).

Annex 1: Model runs and weights defined by SC15 and used for the analysis

Axis	Value	Relative weight
Steepness	0.65	0.8
	0.80	1.0
	0.95	0.8
Growth	Low	1.0
	Diagnostic	1.0
	High	1.0
Length composition scalar	50	0.8
	100	1.0
	200	1.0
Tag mix	1	1.0
	2	1.0

Annex 2. Pattern of catches estimates for the domestic fisheries of Indonesia, Philippines and Vietnam within the 2019 skipjack stock assessment.

The table below presents the catch scalar for the three domestic fleets in the western tropical region (Region 5) within the 2019 skipjack stock assessment. This scalar represents the multiplier required to scale the 2012 catch levels up to the average catch estimated over the period 2016 to 2018.

Fishery number	Fishery description	Scalar from 2012 catch to match 2016-18 average catches
F10	Domestic Philippines in Region 5	1.22
F11	Domestic Indonesia in Region 5	1.23
F16	Domestic Vietnam in Region 5	2.03