DEVELOPMENT OF A NEW WCPFC TROPICAL TUNA MEASURE
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UPDATES TO WCPO SKIPJACK TUNA PROJECTED STOCK STATUS TO INFORM CONSIDERATION OF AN UPDATED TARGET REFERENCE POINT

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

[1] REV1 replaces the original version published on 26 March 2021 (this was meeting pager **WCPFC17-2020-11** issued 6 November 2020). REV1 provides the information requested at WCPFC17 for the SPC to update the skipjack TRP work by including additional candidates, including 36%, 38% and 40% in the median depletion table.

Executive Summary

This paper presents the results of analyses requested by WCPFC17, WCPFC16 and SC16 to evaluate the performance of the interim skipjack tuna TRP, in particular examining candidate revised interim skipjack TRPs of between 36% and 50% of $SB/SB_{F=0}$. In turn, it re-presents further requested information to aid discussions (paras 258 and 259 of the WCPFC16 Summary Report) on:

- the formulation of TRPs for skipjack tuna, noting:
    - SC15 advice on a skipjack tuna TRP "that the Commission may identify a reference year, or set of years, which may be appropriate to use as a baseline for a skipjack TRP" and
    - the approach to the formulation of a skipjack tuna TRP proposed in WCPFC16-2019-DP01; and
- [the impact of] effort creep estimated in relation to the TRPs.

The WCPO skipjack tuna assessment agreed at the 15th Scientific Committee meeting 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 stock status and its productivity compared to the model upon which decisions on the skipjack iTRP were based (CMM 2015-06). This paper compares the results of the 2014, 2016 and 2019 assessments to illustrate this.

As requested by WCPFC16 and WCPFC17, this paper also presents a comparable analysis to that of WCPFC-MOW-WP-03, using the agreed 2019 skipjack assessment, and indicates changes in effort and biomass (depletion) from 2012 and recent (2015-2018 average) levels, and median equilibrium yield (as a proportion of MSY) associated with strategies that maintain a median of spawning biomass depletion ($SB/SB_{F=0}$) at Commission-specified depletion levels. 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 (2012) fishing levels the stock is predicted, on average, to fall slightly compared to 'recent' (2015-2018) levels (44% $SB_{F=0}$), to 42% $SB_{F=0}$. This is very slightly below 2012 depletion levels but is an equivalent % $SB_{F=0}$ value at 2 decimal places. Examining the four other median depletion levels requested by WCPFC16 (50%, 48%, 46% and 44% $SB_{F=0}$), these levels imply reductions in purse seine effort from 2012 levels of 7 to 25%, lead to predicted increases in spawning biomass from 2012 levels of between 3 and 18%, and either maintained biomass at recent levels, or predict an increase by 5 to 13%. Total equilibrium yield is predicted to reduce compared to that under 2012 'baseline' levels, to 78-95% of MSY. For the three median depletion levels requested by WCPFC17 (36%, 38% and 40%), these levels imply increases in purse seine effort from 2012 levels of between 5 and 30%, and lead to predicted decreases in spawning biomass from 2012 levels of between 5 and 14%. Total equilibrium yield is predicted to increase very slightly compared to that under 2012 'baseline' levels, to 98% of MSY (reaching the flatter peak of the yield curve). There was no risk of falling below the LRP associated with any of these depletion levels based on the current uncertainty framework.

SC16 requested additional information comparing TRP levels to baseline years used for other tropical tuna stocks in CMM 2018-01 (2012-2015 average conditions), and an indication of the recent effort levels relative to the 2012 baseline used here. For the former, a column has been added to the results table. For the latter, recent effort levels in terms of numbers of sets in the tropical purse seine fishery have been 87% (2015-2018 average) and 98% (2019 levels) of those in 2012. SC16 also requested an analysis of the

TRP where fishing mortality (rather than fishing effort/catch) was maintained. The results of that analysis are presented in Annex 3.

Regarding the additional two requests from WCPFC16:

SC15 advised that WCPFC16 might "identify a reference year, or set of years, which may be appropriate to use as a baseline for a skipjack TRP". WCPFC16-2019-DP01 called for a TRP "that is consistent with the level of fishing effort for skipjack in 2012 and the condition of the skipjack stock in 2012". The text defining a TRP should refer to the management objectives that the TRP is designed to achieve. The formulation as specified in WCPFC16-2019-DP01 does that and is suitably explicit in that it allows the technical re-estimation of the appropriate TRP-consistent stock depletion value when new knowledge of the stock is obtained (as for skipjack here). It is broadly consistent with the approach adopted for South Pacific albacore. However, we note two things:

- The assumption has been made that 2012 fishing effort levels are those in the purse seine fishery specifically, as this is not specified within the TRP text.
- As examined within this paper, this formulation is consistent (2012 fishing conditions lead to an 'equilibrium' stock status equal to that in 2012), but care must be taken if the incorporation of increased biological or fishery understanding within the skipjack assessment meant this consistency was then lost. Therefore, the weighting of each objective (the fishing effort and 2012 stock status) should be specified.

WCPFC16 requested advice on whether effort creep should be considered when identifying TRP levels. In theory, where the primary management objective was to maintain a level of CPUE within the fishery, this might need to be considered. In practice, this is not feasible as the future level of effort creep within the purse seine fishery is not known. Estimates of historical trends (if available) do not necessarily indicate future fishery performance, while assuming some arbitrary level of effort creep within an analysis could lead to an inappropriate TRP level if that effort creep assumption were to prove incorrect. Therefore, effort creep within the purse seine fishery has not been assumed in these analyses. To ensure objectives are met if effort creep occurs, an adaptive approach where the management settings are reviewed as required over time is suggested as the most appropriate. This would occur automatically within the harvest strategy framework, where management procedures robust to effort creep can be identified, and the monitoring strategy can identify whether the adopted management procedure is effective.

Median skipjack tuna depletion levels ($SB/SB_{F=0}$) and corresponding change in biomass from 2012, 2012-15 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 WCPFC16-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 2012-2015 average	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
50%	+18%	+2%	+13%	-25%	78%	0%
48%	+14%	-1%	+10%	-21%	81%	0%
46%	+9%	-6%	+5%	-15%	87%	0%
44%	+3%	-10%	0%	-7%	95%	0%
42%	-2%	-15%	-5%	0%	97%	0%
40%	-5%	-18%	-8%	+5%	98%	0%
38%	-10%	-22%	-13%	+20%	98%	0%
36%	-14%	-25%	-16%	+30%	98%	0%

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

** Recalculated using estimated equilibrium catch at defined fishing level

Introduction

Target reference points, in conjunction with limit reference points (i.e. TRPs and LRPs), a management procedure (data collection, estimation ('assessment') model and harvest control rule (HCR)) and acceptable levels of risk, form critical components of a harvest strategy. In 2015, WCPFC defined the interim target reference point level for WCPO skipjack tuna at 50% of the estimated recent average spawning biomass in the absence of fishing ($SB_{F=0,\ t1\text{-}t2}$). 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 required 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). These changes included:

- the incorporation of a new spatial structure;
- incorporation of new information on the pattern of maturity of the stock; and,
- some 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 Workplan ("SC to advise on required analyses to support TRP review"), the SSP undertook the SC15 requested work to assist WCPFC16 in its review of the performance of the interim skipjack tuna TRP. This formed the results presented in WCPFC16-2020-14. Following discussions, WCPFC16 and WCPFC17 requested examination of specific candidate revised interim skipjack TRPs of between 36% and 50% of $SB/SB_{F=0}$. In addition, WCPFC16 (paras 258 and 259 of the WCPFC16 Summary Report) requested SC16 provide advice to WCPFC17 on:

- the formulation of TRPs for skipjack tuna, noting:
  - the SC15 advice on a skipjack tuna TRP "that the Commission may identify a reference year, or set of years, which may be appropriate to use as a baseline for a skipjack TRP."; and
  - the approach to the formulation of a skipjack tuna TRP proposed in WCPFC162019-DP01.
- [the impact of] effort creep estimated in relation to the TRPs.

SC16 reviewed the results of WCPFC16-requested analyses (SC16-MI-WP-02) and requested some additional information and analysis, which are also presented here.

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 stock levels requested by the Commission, as well as possible levels of future abundance under 'baseline' fishing levels.
3. Provide further information to underpin discussions, as requested by the Commission and SC16.

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 the 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 for 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 from the stock assessment 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 spawning biomass compared to $SB_{F=0}$.

The potential future skipjack stock and fishery implications under a 'baseline' fishing level were 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 specific stock levels requested by the Commission, 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 depletion and effort from 2012 and more recent levels, the risk to the stock relative to the agreed limit reference point level[2] and the total equilibrium yield relative to MSY, were estimated. For the current analysis, yield was estimated from equilibrium calculations relative

[2] 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 MSY, rather than the sum of the estimated 'equilibrium' fleet catch presented in previous analyses. This approach was felt more consistent with the approach to estimating MSY[3].

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.

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 specified 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, 2012 catches in other fisheries except for Indonesia/Philippines/Vietnam domestic fisheries where recent catch levels were assumed). The stock will on average fall slightly compared to 'recent' levels, to 42% $SB_{F=0}$. This is marginally below 2012 levels, but is an equivalent % $SB_{F=0}$ value at 2 decimal places, and has no associated risk of falling below the LRP (Table 2).

Examining the other depletion levels requested by the Commission, the median depletion levels requested by WCPFC16 (50%, 48%, 46% and 44% $SB_{F=0}$), implied reductions in purse seine effort from 2012 levels of between 7 to 25%, led to increases in spawning biomass from 2012 levels of between 3 and 18%, and either maintained biomass at recent (2015-2018 average) levels, or implied an increase by 5 to 13%. Total equilibrium yield would reduce compared to the baseline levels, to 78-95% 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).

[3] In the current analysis, the catch (and MSY estimate) is an equilibrium calculation based upon a single region, with overall recruitment, and averaged fishing mortality over a specified period. There is obviously no movement. The previous fleet-estimated catch was a dynamic model calculation that achieved equilibrium after 30 years of projection. However, total recruitment in that case was assigned to regions according to mean region-specific proportion parameters, with fishing mortality also being region-specific. Yield-per-recruit therefore varied among regions. Movement also occurred among regions that re-distributed recruitments, impacting on the region-specific YPR and hence the total spawning biomass among regions, compared to the equilibrium approach now used.

The median depletion levels requested by WCPFC17 (36%, 38% and 40%) implied increases in purse seine effort from 2012 levels by 5 to 30%, and led to predicted decreases in spawning biomass from 2012 levels of between 5 and 14%. Total equilibrium yield was predicted to increase very slightly compared to that under 2012 'baseline' levels, to 98% of MSY (having reached the flat peak of the yield curve). There was again no risk of falling below the LRP associated with any of these depletion levels based on the current uncertainty framework.

SC16 requested additional information comparing TRP levels to baseline years used for other tropical tuna stocks in CMM 2018-01 (2012-2015 average conditions), and an indication of the recent effort levels relative to the 2012 effort used here. For the former, a column has been added to Table 2. For the latter, recent effort levels in terms of numbers of sets in the tropical purse seine fishery have been 87% (2015-2018 average) and 98% (2019 levels) of those in 2012. SC16 also requested an analysis of the TRP where fishing mortality (rather than fishing effort/catch) was maintained. The results of that analysis are presented in Annex 3.

The formulation of TRPs for skipjack tuna

WCPFC16 requested SC16 provide advice on the appropriate formulation of text for the skipjack TRP, noting:

- SC15 advice "that the Commission may identify a reference year, or set of years, which may be appropriate to use as a baseline for a skipjack TRP."; and
- the approach to the formulation of a skipjack tuna TRP proposed in WCPFC16-2019-DP01.

Text defining a TRP should refer to the balance of management objectives that the TRP value achieves. This means the text should be sufficiently explicit to allow the technical re-estimation of the appropriate TRP-consistent stock depletion value (or other stock/fishery value) when new knowledge is obtained, as for skipjack within the 2019 assessment. Text should therefore avoid open statements such as '… the risk of falling below the limit reference point should be very low'.

The use of a specific year, or set of years, within a TRP definition provides a tangible reference to a stock size or fishery condition that managers and stakeholders feel achieved the most important management objectives or represented the best trade-off between them. Where the year refers to fishery levels or conditions (e.g. 'the level of purse seine effort in 2012'), testing needs to be undertaken to ensure that those conditions do not drive the stock to undesirable levels, which would mean that the fishery performance in that reference year would not then be achieved.

The formulation as specified in WCPFC16-2019-DP01 is tied to the specific objectives for the fishery highlighted by that stakeholder group. WCPFC16-2019-DP01 uses a baseline year of 2012, noting that the TRP should be "…consistent with the level of fishing effort for skipjack in 2012 and the condition of the skipjack stock in 2012". It is broadly consistent with the approach adopted for South Pacific albacore.

The formulation is suitably explicit in that it has allowed the re-estimation of the skipjack TRP ($SB/SB_{F=0}$ level), but we note two things:

- The assumption has been made that 2012 fishing effort levels are those in the purse seine fishery specifically, as this is not specified within the text.
- As examined within this paper, this formulation is consistent (2012 fishing conditions lead to a stock status equal to that in 2012), but care must be taken if the incorporation of improved

biological or fishery understanding within the skipjack assessment meant this consistency was then lost. Therefore, the weighting of each objective (the fishing effort and 2012 stock status) should be specified.

Effort creep estimated in relation to the TRPs

WCPFC16 requested SC16 provide advice on whether effort creep should be considered when identifying TRP levels.

In theory, where the primary management objective was to maintain a level of CPUE within the fishery, effort creep might be considered since effort creep could maintain fishery CPUE in the face of a declining stock (i.e. the CPUE would be maintained at more depleted stock levels in the future due to increases in fishing efficiency). If effort creep were sufficient, the stock (and TRP) may decline until it reached the 'minimum TRP' level defined by the maximum permissible level of risk of falling below the limit reference point, as defined by an over-riding stock sustainability management objective.

In practice, considering effort creep within the TRP calculation is not feasible. This is because the future level of effort creep within the purse seine fishery is not known. Estimates of historical trends (if available) do not necessarily indicate future fishery performance, while assuming some arbitrary level of effort creep within an analysis could lead to an inappropriate TRP level if that assumption proves incorrect. Therefore, effort creep within the purse seine fishery has not been included when estimating the skipjack TRP within this paper. To ensure objectives are met if effort creep occurs, an adaptive approach where the management settings are reviewed as required over time is viewed as the most appropriate. This would occur automatically within the harvest strategy framework, where management procedures robust to effort creep can be identified, and the monitoring strategy can identify whether the adopted management procedure is being effective.

Finally, given the witnessed advances in technology, effort creep is currently considered likely to be most significant within the WCPO purse seine fishery (Vidal et al., 2019) rather than the longline fishery. Balancing this when calculating TRPs where both gears are exploiting a stock would further limit the feasibility of including effort creep when considering TRPs.

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 (2014). Current and projected stock status of skipjack tuna to inform consideration of Target Reference Points. MOW3-WP/03.

Vidal, T., Muller, B., Pilling, G. and the PNAO (2019). Evaluation of effort creep indicators in the WCPO tuna fishery. WCPFC-SC15-2019/MI-IP-05.

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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[1] in biomass from 2012 and 2015-18 average levels, change in purse seine effort (scalar), median total equilibrium yield (as a percentage of MSY) and the risk of falling below the LRP under baseline fishery conditions (shaded row) and for the four other WCPFC16-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 2012-2015 average	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
50%	+18%	+2%	+13%	-25%	78%	0%
48%	+14%	-1%	+10%	-21%	81%	0%
46%	+9%	-6%	+5%	-15%	87%	0%
44%	+3%	-10%	0%	-7%	95%	0%
42%	-2%	-15%	-5%	0%	97%	0%
40%	-5%	-18%	-8%	+5%	98%	0%
38%	-10%	-22%	-13%	+20%	98%	0%
36%	-14%	-25%	-16%	+30%	98%	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.

[1] 'Change' calculated as a percentage, as: [Median level of indicator at defined stock depletion] / [Defined base level of indicator]

** Recalculated using estimated equilibrium catch at defined fishing level

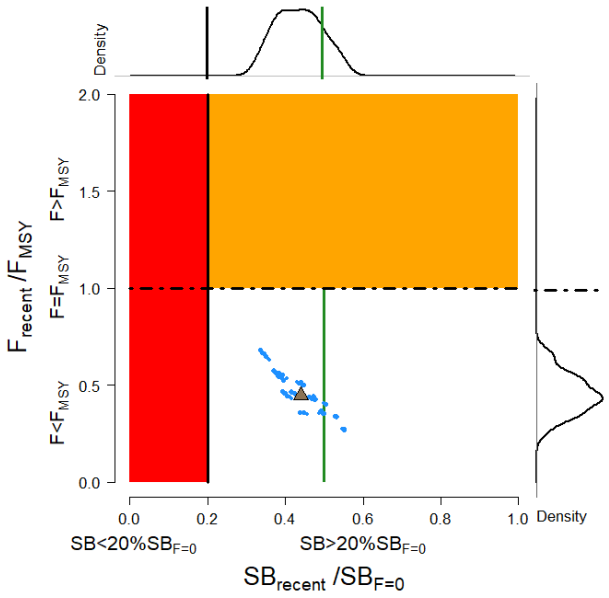

Figure 1. Majuro plot of the recent spawning potential (2015 – 2018) summarizing the results for each of the models in the structural uncertainty grid with weighting. The plots represent estimates of stock status in terms of spawning potential depletion and fishing mortality, and marginal distributions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

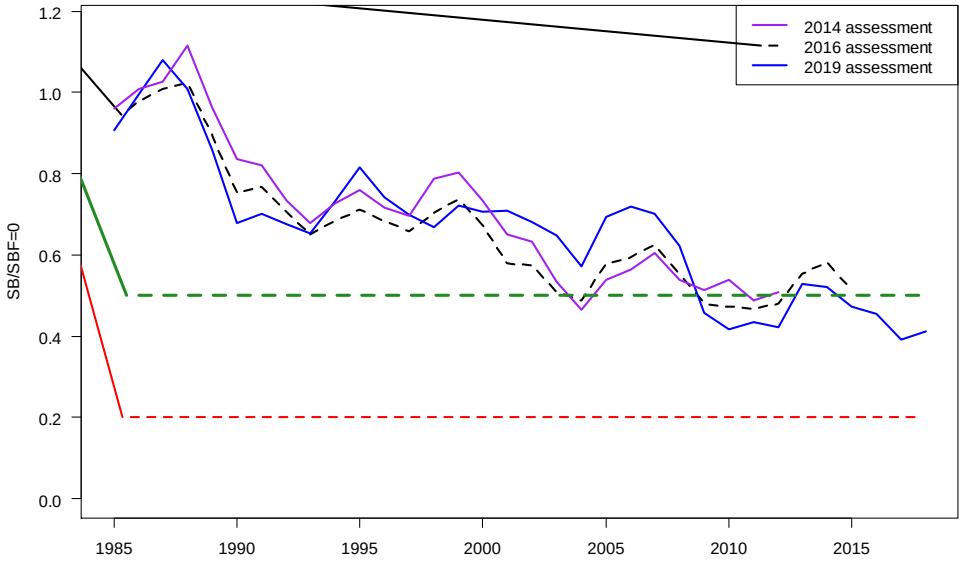

Figure 2. Comparison of depletion trajectories from the 2014, 2016 and 2019 assessments over the period 1985 to the end of each assessment. $SB_{F=0}$ calculated consistent with the approach defined for the limit (red horizontal line) and previous interim target (green horizontal line) reference points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

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

Annex 3. Additional requests from SC16

During SC16, the following requests were made for inclusion in the paper to WCPFC17 (SC16 summary report para 85):

ii) One CCM noted that in CMM-2018-01 the interim management objective adopted was using the 2012-2015 average as the base line years and requested that an additional table be included in the working paper based on an analysis using these reference years. Another CCM requested that an indication of the recent effort levels relative to the 2012 effort also be included.

iii) In response to a request from one CCM to make the projections based on recent fisheries mortality rather than the 2012 effort (i.e. number of PS sets), the Scientific Services Provider noted that this may be difficult but would investigate the possibility of doing so.

Responses to ii) are provided within the main text.

To evaluate iii) multipliers on recent effort and catch across all fisheries were identified that maintained aggregate fishing mortality at 'recent' levels, as calculated within the 2019 stock assessment (average aggregate F over the period 2014-2017). Resulting equilibrium outcomes are presented in the table below. Note the column 'change in PS effort from 2012 levels' has been removed as this analysis corresponded to changes in all gears, not just purse seine, to maintain recent fishing mortality patterns.

Median skipjack tuna depletion levels ($SB/SB_{F=0}$) and corresponding change in biomass under 'constant recent fishing mortality' conditions, median equilibrium yield (total yield as % of MSY) and risk of falling below the LRP.

Median depletion level ($\%SB_{F=0}$)	Change in spawning biomass ($\%SB_{F=0}$) from 2012 levels	Change in spawning biomass ($\%SB_{F=0}$) from 2012-2015 average	Change in spawning biomass ($\%SB_{F=0}$) from 2015-2018 average	Median total equilibrium yield (%MSY)	Risk $SB/SB_{F=0}$ < LRP
41%	-2%	-15%	-5%	97%	0%