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EVALUATIONS TO SUPPORT DECISIONS ON THE WCPO SKIPJACK TUNA TARGET REFERENCE POINT BASED UPON THE 2022 STOCK ASSESSMENT

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

Executive Summary

SC18 adopted a new assessment and associated structural uncertainty grid for WCPO skipjack. Noting the Commission is scheduled to adopt a target reference point (TRP) for skipjack tuna in 2022, SC18 requested the Scientific Service Provider update SC18-MI-WP-09 (Table 2) to include evaluations based on the 2022 skipjack assessment using the same settings as in that paper and include the projected outcomes for a set of candidate TRP options ranging between 40% to 60% depletion ratios, and to provide the results to WCPFC19.

The 1st WCPFC Science Management Dialogue (SMD01) meeting provided further specifications for both this work and for the wider harvest strategy evaluations, requesting that the use of effort controls be considered for pole and line fisheries, and a baseline of 2001-2004 effort levels be evaluated for those fisheries.

This paper presents results of those evaluations using the 2022 WCPO skipjack stock assessment model, using as a baseline the following future fishing levels:

- 2012 effort level for purse seine fisheries (SC18 request)
- 2001-2004 average effort level for pole and line fisheries (SMD01 request)
- 2016-2018 average catch level for small scale fisheries in Region 5 of the model (Indonesia, Philippines, Vietnam. Assumption consistent with SC18-MI-WP-09).

Under these 'baseline' fishing levels the stock is predicted, on average, to fall very slightly compared to 'recent' levels (being the 2018-2021 average spawning biomass depletion = 51% $SB_{F=0}$), to 50% $SB_{F=0}$. This is 17% below 2012 depletion levels (61%$SB_{F=0}$). Examining the ten other median depletion levels requested by SC18:

- depletion levels of 40% to 48% $SB_{F=0}$ imply increases in purse seine effort from 2012 levels by 10 to 52% and imply declines of 6 to 21% in spawning biomass depletion compared to recent assessed levels. Total equilibrium yield is predicted to increase compared to that under 'baseline' levels, to 77-84% of MSY. Risk of falling below the LRP is 1 and 2% at depletion levels of 42% and 40% $SB_{F=0}$, respectively.
- Depletion levels of 52% to 60% $SB_{F=0}$ imply decreases in purse seine effort from 2012 levels by 10 to 40% and imply increases in spawning biomass depletion compared to recent assessed levels. Total equilibrium yield is predicted to decrease compared to that under 'baseline' levels, to 61-72% of MSY. There was no assessed risk of falling below the LRP associated with any of these depletion levels based on the current uncertainty framework.

All requested candidate depletion levels are below the median depletion level estimated in 2012 (61%$SB_{F=0}$).

For background information, details requested by WCPFC16 to aid TRP discussions (paras 258 and 259 of the WCPFC16 Summary Report), which have been reported to previous meetings, are provided in Annex 1 and cover the formulation of TRPs and the impact of effort creep estimated in relation to TRPs. We also take this opportunity to provide some details on the role of the TRP value within the monitoring strategy of the harvest strategy framework in that Annex.

Median spawning biomass depletion levels of skipjack tuna ($SB/SB_{F=0}$) and corresponding change in spawning biomass depletion from different specified historical levels, change in purse seine effort (scalar), resulting median total equilibrium yield (as a percentage of MSY) and the risk of falling below the LRP. Results under baseline fishery conditions indicated by the shaded row.

Median spawning biomass depletion level ($\%SB_{F=0}$)	Change in PS effort from 2012 levels*	Median total equilibrium yield (%MSY)**	Risk $SB/SB_{F=0}$ < LRP	Change in spawning biomass depletion ($\%SB_{F=0}$) from				
				2007-2009 average levels	2012 levels	2012-2015 average levels	2016-2018 average levels	2018-2021 average levels
60%	-40%	61%	0%	-16%	-1%	-2%	+14%	+18%
58%	-35%	63%	0%	-18%	-3%	-4%	+12%	+15%
56%	-27%	66%	0%	-21%	-7%	-8%	+8%	+11%
54%	-20%	69%	0%	-23%	-10%	-11%	+4%	+7%
52%	-10%	72%	0%	-27%	-14%	-15%	0%	+3%
50%	0%	75%	0%	-30%	-17%	-18%	-5%	-2%
48%	+10%	77%	0%	-33%	-21%	-22%	-9%	-6%
46%	+20%	79%	0%	-36%	-24%	-25%	-13%	-10%
44%	+30%	81%	0%	-38%	-27%	-28%	-16%	-13%
42%	+40%	83%	1%	-41%	-30%	-31%	-19%	-17%
40%	+52%	84%	2%	-43%	-33%	-34%	-23%	-21%

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

** Recalculated using estimated equilibrium catch at the 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 key components of a harvest strategy. In 2015, WCPFC defined the interim target reference point for WCPO skipjack tuna at 50% of the estimated recent median spawning biomass in the absence of fishing (SBF=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% SBF=0. Since that time, the value of the skipjack TRP has been reviewed and associated analyses have been provided following the agreement of a new assessment of the skipjack stock in 2019, and as requested to support discussions at subsequent Commission meetings. However, no updated TRP value has been adopted.

SC18 agreed a new stock assessment and associated structural uncertainty grid for WCPO skipjack (Castillo-Jordán et al., 2022). The overall median estimated recent spawning biomass depletion ($SB_{recent}/SB_{F=0}$) was 0.51. No grid models were below the limit reference point (LRP) of 0.20 $SB_{F=0}$. The median estimate of F_{recent}/F_{MSY} was 0.32. The 2022 stock assessment of skipjack tuna for the WCPO indicated that according to WCPFC reference points the stock is not overfished, nor undergoing overfishing.

Noting the Commission is scheduled to adopt a target reference point (TRP) for skipjack tuna in 2022, SC18 requested the Scientific Service Provider to update SC18-MI-WP-09 (Pilling et al. 2022; Table 2) to include evaluations based on the 2022 skipjack assessment using the same settings as in that paper and include the projected outcomes from a set of candidate TRP options ranging between 40% to 60% depletion ratios. The results should continue to assess the change in purse-seine effort from 2012 levels for the different candidate TRPs, the change in depletion relative to 'recent' (2018-2021) average levels, as well as the projected impacts on equilibrium yields and the risk of breaching the LRP, to ultimately allow the Commission to 'take appropriate management action to ensure that the spawning biomass depletion level fluctuates around the TRP (e.g., through the adoption of a harvest control rule)'.

The 1st WCPFC Science Management Dialogue (SMD01) meeting provided further specifications for this work and for the wider harvest strategy evaluations, requesting that the use of effort controls be modelled for pole and line fisheries, and a baseline of 2001-2004 effort levels be evaluated for this fishery group.

This paper presents results of those evaluations.

For brevity, information requested by WCPFC16 to aid discussions (paras 258 and 259 of the WCPFC16 Summary Report), which remain relevant, are not repeated in the main body of the paper, but are provided in Annex 1 and cover information 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."
- [the impact of] effort creep estimated in relation to the TRPs.

We also take this opportunity to provide commentary on the role of the TRP within the harvest strategy process within that Annex.

Approach

We used the agreed 2022 stock assessment for skipjack tuna incorporating the grid of 18 model runs selected by the Scientific Committee (SC18), as the basis for the evaluations. SC18 and SMD01 specified the 'baseline' levels of specific modelled fisheries as the basis for the assumption of future fishing levels:

- 2012 effort level for purse seine fisheries (SC18 request)
- 2001-2004 average effort level for pole and line fisheries (SMD01 request)
- 2016-2018 average catch level for small scale fisheries in Region 5 of the model (Indonesia, Philippines, Vietnam). (Assumption consistent with SC18-MI-WP-09).

An indication of the overall scalars for these fishery groups is provided in Table 2[1].

To examine the consequences for the skipjack stock and fishery of the specific spawning biomass depletion levels requested by SC18, stock projections were performed under eleven 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 18 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 1982-2020);
3. Assume catchability remains constant into the future, i.e. no effort creep occurs in WCPO fisheries;
4. Combine the results across each assessment model run and calculate the median level of terminal spawning biomass compared to $SB_{F=0}$.

Pole and line effort and small-scale fishery catch were assumed constant into the future at baseline levels within these evaluations. The level of purse seine fishing in the future was adjusted from the 2012 baseline so that the median stock depletion at the end of the projection period was equivalent to the candidate TRP level. The level of change in purse seine effort from 2012 levels, the level of average spawning biomass depletion implied by the requested depletion levels relative to that in a range of historical time periods, 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 to MSY, rather than the sum of the estimated 'equilibrium' fleet regional catch presented in previous analyses. This approach was more consistent with the approach used to estimate MSY[3].

[1] Note this table reflects the overall scalar that would be required to achieve baseline conditions from 2021 levels for these fishery groups, for information. Actual scalars were developed for each of the relevant 31 fisheries represented in the WCPO skipjack assessment. They reflect the data available to the WCPO assessment in mid-2022, and do not capture data updates received since that time.

[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.

[3] In the current analysis, the catch (and MSY estimate) is an equilibrium calculation based upon a single region (and hence no movement), with overall recruitment, and averaged fishing mortality over a specified period.

Results

The baseline scenario illustrates where the stock may end up on average if those baseline fishing levels continue (2012 effort levels in the purse seine fishery, 2016-18 average catches in Indonesia/Philippines/Vietnam domestic fisheries, 2001-2004 average effort levels in pole and line fisheries). The stock is projected to reach a median level of 50% $SB_{F=0}$, very slightly below 'recent' levels (2018-2021 average = 51% $SB_{F=0}$). This is 17% below 2012 depletion levels (61%$SB_{F=0}$). At that resulting stock level, there was no assessed risk of the stock falling below the LRP (Table 1).

Examining the ten other median depletion levels requested by SC18:

- depletion levels of 40% to 48% $SB_{F=0}$ imply increases in purse seine effort from 2012 levels by 10 to 52% and imply declines of 6 to 21% in spawning biomass depletion compared to recent assessed levels. Total equilibrium yield is predicted to increase compared to that under 'baseline' levels, to 77-84% of MSY. Risk of falling below the LRP is 1 and 2% at depletion levels of 42% and 40% $SB_{F=0}$, respectively.
- Depletion levels of 52% to 60% $SB_{F=0}$ imply decreases in purse seine effort from 2012 levels by 10 to 40% and imply increases in spawning biomass depletion compared to recent assessed levels. Total equilibrium yield is predicted to decrease compared to that under 'baseline' levels, to 61-72% of MSY. There was no assessed risk of falling below the LRP associated with any of these depletion levels based on the current uncertainty framework.

All requested candidate depletion levels are below the median spawning biomass depletion level estimated in 2012 (61%$SB_{F=0}$).

References

Castillo-Jordan, C., Teears, T., Hampton, J., Davies, N., Scutt Phillips, J., McKechnie, S., Peatman, T., Macdonald, J., Day, J., Magnusson, A., Scott, R., Scott, F., Pilling, G. and Hamer, P. (2022). Stock assessment of skipjack tuna in the western and central Pacific Ocean: 2022. WCPFC-SC18-2022/SA-WP-01 (REV5).

Pilling, G. Scott, R, Hamer, P. Hampton, J. (2022). Further updates to WCPO skipjack tuna projected stock status to inform consideration of an updated target reference point. WCPFC-SC18-2022/MI-WP-09.

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

Tables

Table 1. Median spawning biomass depletion levels of skipjack tuna ($SB/SB_{F=0}$) and corresponding change[1] in spawning biomass depletion from 2007-2009, 2012, 2012-15, 2016-18 and 2018-21 average levels, change in purse seine effort relative to 2012 levels (scalar), resulting median total equilibrium yield (as a percentage of MSY) and the risk of falling below the LRP. Results under 'baseline' fishery conditions indicated by shaded row.

Median spawning biomass depletion level ($\%SB_{F=0}$)	Change in PS effort from 2012 levels*	Median total equilibrium yield (%MSY)**	Risk $SB/SB_{F=0}$ < LRP	Change in spawning biomass depletion ($\%SB_{F=0}$) from				
				2007-2009 average levels	2012 levels	2012-2015 average levels	2016-2018 average levels	2018-2021 average levels
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52%	-10%	72%	0%	-27%	-14%	-15%	0%	+3%
50%	0%	75%	0%	-30%	-17%	-18%	-5%	-2%
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40%	+52%	84%	2%	-43%	-33%	-34%	-23%	-21%

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

* 2012 conditions assumed for purse seine (effort), 2016-18 average levels assumed for domestic ID/PH catches, and 2001-2004 average effort levels assumed for pole and line fisheries. This also assumes no 'effort creep' occurs and hence CPUE is assumed directly proportional to stock abundance.

** Recalculated using estimated equilibrium catch at defined fishing level.

Table 2. Scalars required to achieve baseline conditions from 2021 levels for key combined WCPO fleets in the skipjack stock assessment.

Note: scalars are based upon provisional 2021 catch and effort estimates as available up to SC18 and do not reflect updated data provisions since that time, in particular for small scale and pole and line fisheries.

Gear group	Catch or effort?	Baseline period	Overall multiplier (baseline/2021)
Pole and Line*	Effort (days)	2001-04 avg	2.59
Tropical purse seine	Effort (sets)	2012	1.17
Small scale fisheries**	Catch	2016-18 avg	1.12

* Note that 2021 data are subject to pending updates, given Covid-related delays in data processing.

** Gears represented vary by country, but include handline, longline, troll, gillnet, purse seine, 'other'.

Annex 1. Additional requests from WCPFC16

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 TRP (stock depletion or other stock/fishery value) when new knowledge is obtained, as for skipjack within the 2019 and 2022 assessments. 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 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 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.
- 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 recalibrating the skipjack TRP. 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, within key fisheries exploiting tropical tunas, effort creep is currently considered likely to be most significant within the WCPO purse seine fishery and potentially the pole and line fishery, rather than the longline fishery. Balancing this when calculating TRPs where two key gears are exploiting a stock (e.g. bigeye, yellowfin) would further limit the feasibility of including effort creep when considering TRPs.

Role of TRPs as WCPFC moves towards harvest strategies

The TRP represents a stock level around which desired management objectives (and their trade-offs) are most likely to be achieved. As the stock moves away from the TRP (in either direction) it becomes less likely that those desired outcomes will be realised.

The Commission and Scientific Committee have reviewed TRPs for both WCPO skipjack and South Pacific albacore following the agreement of new assessments in 2019 and 2021 respectively. Ongoing improvements to the stock assessments, the data used within them, and improved knowledge on the biology of WCPO tuna stocks - all of which are necessary to ensure the best available science is provided for management decision making – can lead to changes in the perception of the historical status of these stocks and may influence the absolute value of the TRP. However, it is the status of the stock *relative* to the TRP, rather than the absolute TRP value itself, that is the key focus. The logic and settings underpinning the development of the assessment and TRP therefore need to be consistent, and hence the re-calibration exercise is appropriate.

As WCPFC moves towards a harvest strategy for tuna stocks, the status of the stock identified through the stock assessment relative to the TRP will become an important indicator of stock status within the monitoring strategy. This indicator of stock status can be compared to the pattern of comparable results already obtained through the testing of an adopted management procedure to ensure that relative status remains within the range of values expected, thereby indicating the performance of that management procedure is as anticipated.

To allow the consistent development of TRP values both from updated stock assessments and within the harvest strategy testing, the use of a historical baseline as the basis of the definition of a TRP is therefore useful (see above).