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CURRENT AND PROJECTED STOCK STATUS OF SKIPJACK TUNA TO INFORM CONSIDERATION OF TARGET REFERENCE POINTS

WCPFC-SC15-2019/MI-IP-09
(MOW3-WP/03, 14 Nov 2014)

SPC-OFP

WCPFC
THIRD MANAGEMENT OBJECTIVES WORKSHOP

Faleata Sports Complex, Apia, Samoa
28th November 2014

Current and projected stock status of skipjack tuna to inform consideration of Target Reference Points

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MOW3-WP/03
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Overview:

Target reference points, in conjunction with limit reference points (TRPs and LRPs), harvest control rules (HCRs), and acceptable levels of risk form critical components of a management strategy (**Figure 1**). These components are often tightly linked and the determination of one value will influence the value of the others.

A target reference point can be defined as "the level where we would like to see our stocks and fisheries maintained in order to achieve our management objectives". The purpose of this paper is to support WCPFC consideration and adoption of a TRP for the skipjack stock. Specifically, WCPFC requested SPC to evaluate skipjack stock status against the potential range of TRPs from 40-60% $SB_{F=0}$.

The analysis covered three specific areas: 1) evaluation of current stock status from the skipjack stock assessment model against the potential TRP levels; 2) projections of the skipjack stock into the future under two 'status-quo' scenarios to identify the stock status that results; and 3) estimates of catch, effort, stock status and fish size that might be expected 'on average' at TRPs of 40, 50, and 60% $SB_{F=0}$.

In the purse seine skipjack fishery we have observed generally increasing catch rates (mt per day at sea) over time, while other data sources indicate that the population is declining in size. These conflicting signals in CPUE and stock status can be caused by a number of factors, including the increasing efficiency of vessels over time ('effort creep'). This process has important implications for even 'status-quo' projections and our ability to maintain stocks and fisheries at TRP levels, and we touch on these in this paper.

This paper aims to:

1. Provide estimates of current skipjack stock status with respect to the range of TRP levels requested at WCPFC10;
2. Provide projections of the skipjack population to indicate possible levels of future abundance under 'status-quo' conditions;
3. Provide a comparison of very basic fishery performance metrics against different candidate TRPs; and
4. Highlight the importance of developing Harvest Control Rules so that we can more fully evaluate the implications of particular levels of skipjack TRPs – particularly their robustness to uncertainty in the stock assessments and our scientific understanding of the purse seine fishery, and how best to meet management objectives.

Approach:

We used the most recent stock assessment for skipjack tuna and the small set of model runs that the Scientific Committee (SC10) chose as the basis for reporting our uncertainty in current and historical stock status. SC10 also provided plausibility weights for each of these models based on 'expert opinion' of how plausible they were relative to the base case model (see **Annex 1** for details of the model runs and plausibility weights). The three analyses performed were as follows:

1. Evaluation of current skipjack stock status against the candidate TRPs

To examine current stock status relative to the range of TRP levels requested by WCPFC10, we report the current and historical stock status for each model run against $SB_{F=0}$, using the range of 40-60%$SB_{F=0}$ for reference.

2. Projections of the skipjack stock under a range of 'status-quo' scenarios to identify the resulting stock status

A basic definition of status-quo is "*the existing state of affairs*" so status-quo projections are typically an attempt to keep 'fishing' at the current level into the future. However, in the context of purse seine fishing in general, and specifically what has been observed in the WCPO, what represents 'status quo' is uncertain; the trend of increasing catch rates per day in the face of falling stock sizes, potentially due to 'effort creep' resulting from technological advances in fishing techniques, suggests that conditions will not remain constant in the future. We therefore consider two scenarios that could reflect 'status quo' (**Table 1**). The first is that effort will remain constant in the future. The second scenario examines increasing efficiency in purse seine vessels, whereby the level of effective effort increases over time, here by 1% per year.

For each 'status quo' scenario, the stock was projected into the future using the following procedure:

- Run 200 simulations that went 30 years into the future for each stock assessment model run – each simulation representing a possible 'future' trajectory for recruitment;
- Run those simulations over two assumptions for future recruitment, based upon the long term SRR, and on recent recruitment levels;
- Taking into account the SC10 plausibility weightings, combine the results across each assessment model run and calculate the median level of terminal biomass compared to $SB_{F=0}$.

3. Estimates of catch, effort and stock status that might be expected 'on average' at TRPs of 40, 50, and 60% $SB_{F=0}$

To examine the consequences for the skipjack stock and fishery of the three candidate TRP levels requested by WCPFC10, the level of fishing in the future was adjusted so that the stock size was on average equivalent to the candidate TRP level at the end of the projection period. As for the 'status quo' analyses, projections were performed as follows:

- Run 200 simulations that went 30 years into the future for each stock assessment model run – each simulation representing a possible 'future' trajectory for recruitment where that recruitment was consistent with the long-term SRR;
- When examining the consequences of alternative target reference point levels, the level of change in average spawning biomass and effort from 2012 levels, average fish size, and the equilibrium yield relative to MSY, were estimated.

Analysis:

The current stock status (2011) relative to $SB_{F=0}$ from the 2014 assessment ranged from 46% to 51%, dependent upon the biological assumptions behind the model run (**Table 2**). This 'snapshot' of the assessed status in 2011 suggests the stock was around the candidate target 50%$SB_{F=0}$ level.

The 'status quo' projections illustrate where the stock may end up if current conditions continue (**Table 3**). If effort is considered to be constant in the future (and no effort creep occurs), the stock will on average remain around 50%$SB_{F=0}$. However, if effective effort is increasing over time at an assumed rate of 1% per year due to technological advances that lead to increased catch rates, then the impact on the stock is greater than expected. In these scenarios, the stock falls to 45%$SB_{F=0}$. Under all status quo scenarios examined, there was zero risk of falling below the limit reference point (**Figure 2**), although the inclusion of an effort creep assumption led to estimated stock status levels slightly closer to the LRP. However, maintaining the stock so that it meets the TRP on average (and thus more broadly meets the management objectives embodied by the TRP) would require fishing effort to be reduced in the face of increasing efficiency. Understanding the extent of efficiency changes in the fishery is therefore important for developing management strategies, and the relationship between CPUE and stock abundance for purse seine fishing needs to be better understood.

In the case of skipjack, the results of the status quo projections were not greatly affected by the choice of sampling from long-term versus short-term recruitment as the basis for specifying future recruitment. We therefore used only the long-term recruitment option for the subsequent evaluation of candidate TRP levels.

Examining the candidate TRP levels requested by WCPFC10, recent effort levels are consistent with achieving a target of 50%$SB_{F=0}$ (**Table 4**). At that level, spawning biomass increases slightly from 2012 levels, and the expected equilibrium (average) yield was 90% of that at MSY. To achieve a target of 60%$SB_{F=0}$, effort would need to be reduced by 33% from 2012 levels, spawning biomass would increase by 22% and equilibrium yield would be 76% of MSY. To achieve the lower target of 40%$SB_{F=0}$, effort would need to be increased by 50% from 2012 levels, spawning biomass would fall by 18%, and equilibrium yield would be very close to MSY. It is worth noting that 40%$SB_{F=0}$ represents conditions we have not yet experienced within the fishery, and hence the consequences of this level for stock and fishery are not well known. Finally, the mean size of skipjack caught within the western equatorial free school purse seine fishery, presented here as an example, declines by 2 cm across the TRPs examined.

The analyses presented here provide some information on the potential social and economic implications of adopting a given TRP, through the average catch, effort and fish size associated with the three candidate TRP levels. Additional information has been provided on the implications of skipjack TRP options for yellowfin and bigeye tuna stock status (MOW3-WP-05). Operationalisation of TRPs involves the development and implementation of harvest control rules (HCRs). A detailed analysis of candidate HCRs will provide an understanding of the robustness of those management strategies to uncertainties and indicate performance trade-offs involving, e.g., mean catch (or catch value) and catch (or catch value) variability. Some initial work in this area has already been done using the previous (2011) skipjack stock assessment model (see MOW2-WP-3).

Discussion points:

- WCPFC10 identified a range of candidate TRPs for evaluation. The performance of those candidate TRPs has been presented here in terms of spawning biomass, mean size of fish in the catch, equilibrium yield levels and predicted change in effort from 2012 levels. Which performance measures are most useful for choosing between potential TRPs and what other performance metrics would be useful for making decisions of this kind?
- This study highlights the importance of understanding the extent of efficiency changes in the fishery and the relationship between CPUE and stock abundance. How can managers ensure TRPs are robust to the uncertainties examined in the ‘status quo’ analyses, or react to the likely impacts on stocks?

Table 1. Scenarios examined within 'status quo' projections.

Future scenario	Comments
Effort fixed at current levels	Typical assumption
Effort increasing at 1% per year	Example of 'effort creep'

Table 2. Estimated SB_{2011}/SBF=0 from the 2014 stock assessment, by model run as selected by SC10.

Model run	$SB_{2011}/SB_{F=0}$
Reference case	48%
Low steepness	46%
High steepness	50%
Slow mixing	50%
Slow mixing/low steepness	48%
Slow mixing/high steepness	51%

Table 3. Median levels of spawning biomass depletion ($SB/SB_{F=0}$) associated with a given status-quo projection scenario.

	Median $SB/SB_{F=0}$	
Status-quo scenario	**Long-term recruitment**	**Recent recruitment**
Effort fixed at current levels	50%	51%
Effort increasing at 1% per year	45%	47%

Table 4. Change in effort, biomass from 2012 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, 50, and 60%. Recruitment in the projection period was sampled from the long-term time series and influenced by the SRR.

Median depletion level (%SBF=0)	Change in spawning biomass from 2012 levels	Change in effort from 2012 levels*	Median equilibrium yield (%MSY)	Mean size of fish**
60%	+22%	-33%	76%	54cm
50%	+2%	0	90%	53cm
40%	-18%	+50%	98%	52cm

* This assumed the CPUE was proportional to abundance which is unlikely to be true; further analysis is required with more plausible relationships

** estimated mean size of skipjack in the free school catch of purse seine vessels in the western equatorial region (Region 2 of the MFCL assessment model, not including the far-west or archipelagic waters of PNG and the Solomon Islands)

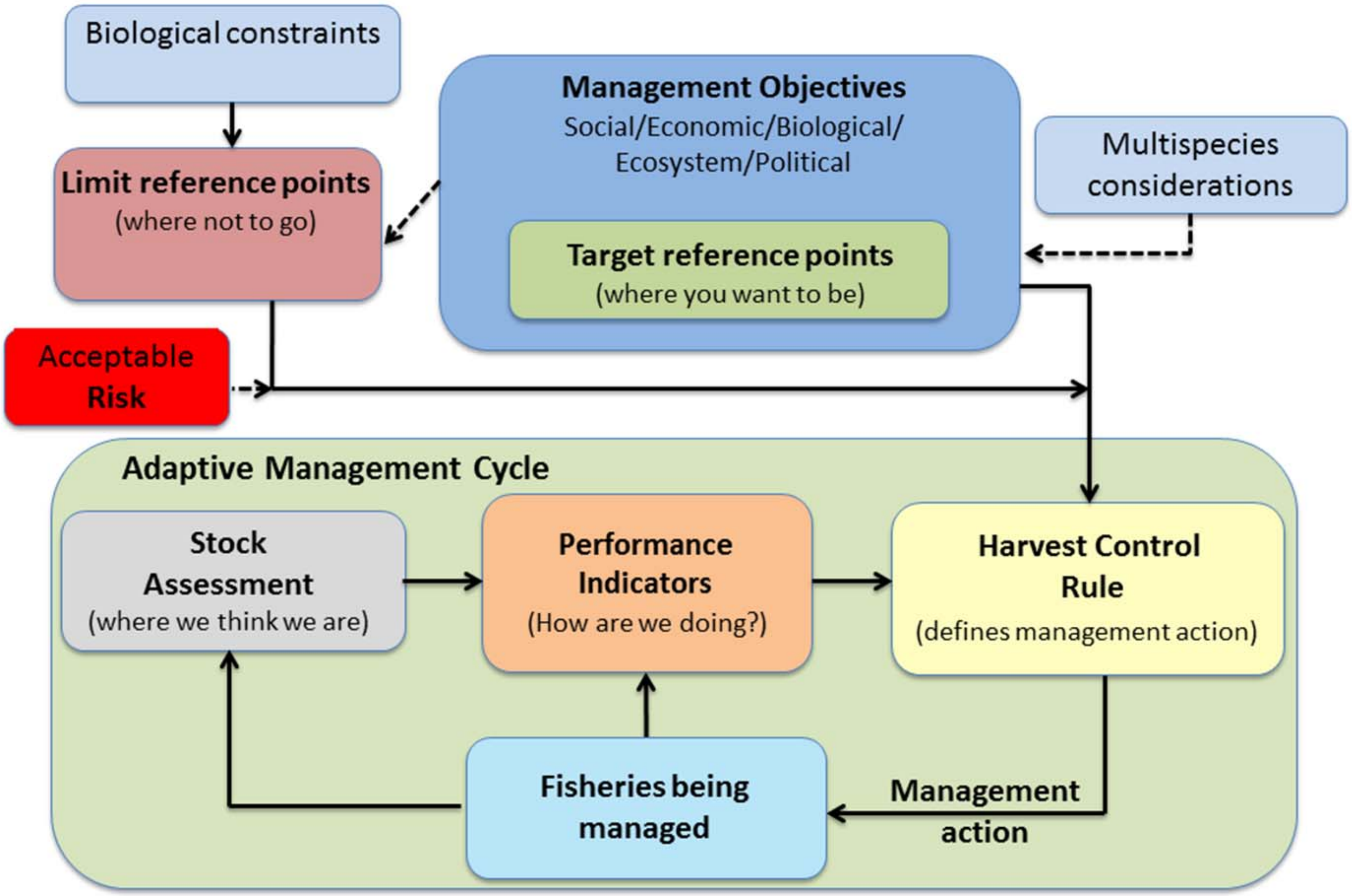

Figure 1. The management framework.

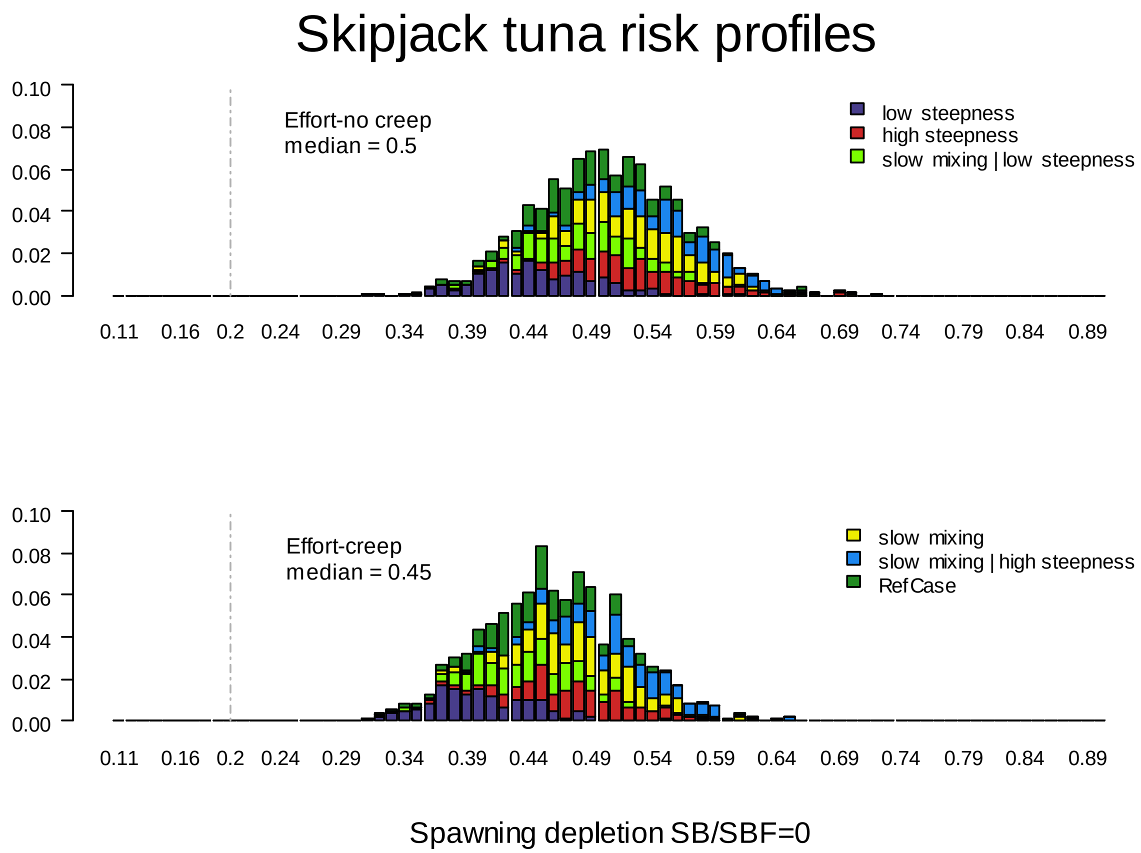

Figure 2. Histograms of the distribution of $SB/SB_{F=0}$ in the final year of the projections for skipjack under the two 'status quo' scenarios. Different colours indicate the results from the different assessment model runs included within the analysis for each species (see also Annex 1). The vertical grey line represents the limit reference point level ($0.2SB_{F=0}$). The median $SB/SB_{F=0}$ is indicated for each scenario. Recruitment in the projection period was sampled from the long-term time series and influenced by the SRR.

Annex 1: Model runs and weights used for the analysis

Skipjack tuna		
Run name	**Description**	**Relative weight**
RefCase	Reference case	1.0
001_L0W0T0M1	Low steepness	0.8
023_L0W0T0M2	High steepness	0.8
032_L0W0T1M0	Slow mixing	1.0
031_L0W0T1M1	Slow mixing | low steepness	0.8
033_L0W0T1M2	Slow mixing | high steepness	0.8