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Assessing a candidate target reference point for skipjack tuna consistent with PNA management objectives

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SPC, Oceanic Fisheries Programme (OFP)[1] and the **Parties to the Nauru Agreement (PNA)**[2]

[1] Secretariat of the Pacific Community, Noumea, New Caledonia
[2] PNA Office PO Box 3992, Majuro, Marshall Islands MH 96960

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Abstract

This paper evaluates a candidate Target Reference Point (TRP) for the WCPO skipjack stock and fishery, based upon management objectives developed by PNA members and consistent with the PNA's stated intentions to limit the tropical purse seine fishery to 2010 effort levels.

Using stochastic stock projections, and the 2011 stock assessment of skipjack, it examines the implications of maintaining 2010 effort levels within the fishery[3]. A TRP was estimated taking account of uncertainty in the biology of skipjack, its current status, and future fishery conditions. The TRP was estimated on the same basis as the agreed biomass Limit Reference Point - as a percentage of recent average unfished adult (spawning stock) biomass levels. The potential consequences of that TRP for the PNA management objectives were evaluated.

Key findings were:

- A Target Reference Point consistent with the average impact of 2010 effort levels on the WCPO skipjack stock was ~0.52 $SB_{F=0,2000-2009}$. Given the uncertainties within the system, a level of $0.5SB_{F=0,2000-2009}$ would therefore appear consistent.
- This TRP was calculated a the median outcome across the 200 stochastic projections undertaken for six selected sensitivity runs from the 2011 skipjack stock assessment. Across these projections, the main range of SB/ $SB_{F=0,2000-2009}$ was 0.34-0.70.
- None of the simulations fell below the WCPFC-agreed 20% $SB_{F=0,2000-2009}$ limit reference point. The TRP is therefore sufficiently distant from the LRP to ensure the population does not fall below the LRP given the uncertainty examined here.
- Both the estimated catch value per day and catch value per tonne consistent with this TRP were comparable to those estimated in 2010.
- There was little difference in the overall mean length of the purse seine catch in 2040 compared to that modelled in 2010.
- Vulnerable biomass within the purse seine fishery (a CPUE proxy) was estimated to increase slightly in the western equatorial Pacific. This assumes that CPUE will change proportionally to abundance.

The 2014 skipjack stock assessment became available in time to examine the sensitivity of the candidate target reference point to changes in the assessment. The consequences of 2010 effort within the purse seine fishery were examined for the candidate base case assessment run only,

[3] We note that the actual levels of effort in the future required to manage the fishery to achieve a given TRP may differ from the 2010 levels - i.e., it is unlikely that future effort can purely be maintained at 2010 levels - due to e.g. recruitment variation.

due to time constraints. The Target Reference Point consistent with the average impact of 2010 effort levels on the WCPO skipjack stock remained comparable at 0.52 $SB_{F=0,2002-2011}$.

Introduction

The PNA have discussed reference points and harvest control rules for the WCPO skipjack tuna fishery over the last three years, and agreed and progressed work in this area as a tool for PNA fisheries management. Key outcomes from those discussions were the following desirable management objectives:

a) Stability in PAE/TAE;
b) Resource sustainability (economically and biologically), noting the importance of avoiding the point where the stock is fished down below the LRP;
c) Economic goals;
d) Limiting impacts on the distribution of SKJ (e.g., due to range contraction);
e) Being risk adverse.

There is therefore an overall objective for no increases in catch, maintaining current levels of effort, and limiting impact on other species.

Work in this area has been presented at the two WCPFC Management Objectives Workshops (see also WCPFC-SC10/MI-WP-02). The current paper presents further analyses examining the implications of 2010 effort levels on future skipjack stock status. Consistent with decisions on incorporating uncertainty made at WCPFC SC9, it takes account of both the uncertainty within stock assessment results, and of future variability due to both the biology of skipjack and variations in fishing patterns. The work is designed to provide a basis for the adoption of a target reference point for skipjack by the PNA, and to contribute to the Commission's consideration and adoption of a TRP and HCR for skipjack at WCPFC 11. The work was performed by SPC on behalf of the PNA.

Methods

This work concentrated on the 2011 skipjack stock assessment (Hoyle et al., 2011). The development of a new stock assessment for consideration at SC10 (Rice et al., 2014) allowed the sensitivity of the candidate TRP to be tested based on the latest information.

To identify the target reference point, a series of stochastic projections were run for the skipjack tuna stock, based on the 2011 stock assessment. These set the effort within the purse seine fishery (20°N – 20°S), and projected those levels into the future, including different sources of uncertainty. The main assumptions were:

- The level of future effort in the total tropical purse seine fishery was set consistent with 2010 fishing effort levels across the fishery.

Scenario	Effort level (days)[i]
2010	51,846

[i] from Table 1 of WCPFC10-2013-12

Levels of activity in other fisheries were also kept constant at 2010 levels.

- Uncertainty in our knowledge of 'current' skipjack stock status was examined by running projections across selected model runs from the 2011 stock assessment (structural uncertainty). Consistent with the recommendations of the 9th Scientific Committee (WCPFC, 2013a), selected 'key one-off sensitivity' runs were examined[4], which aimed to capture the main uncertainties:

Assessment run	Description
Reference case	As used for scientific advice by SC7
SBEST	Without spill sample adjustment
Binomial CPUE	Alternative CPUE time series
Tanabe growth	Alternative growth model
Steepness = 0.65	Steepness set at 0.65
Steepness = 0.95	Steepness set at 0.95

  These runs were re-fitted to take into account the latest refinements to the MFCL software package (lognormal bias correction, constraints to regional recruitment distribution, unfished calculations scaled according to the stock-recruitment relationship; Davies et al., 2014).
- Projections were stochastic, incorporating two main sources of future variability:
  - future recruitments were drawn from the assumed stock-recruitment relationship with deviations from that defined level as estimated in the last 25 years, thereby better reflecting 'current' conditions;
  - future patterns of FAD/free school fishing were drawn from those seen in the years 2010-2012 (i.e. incorporated a three month FAD closure).

  200 projections were run for each stock assessment model to examine the influence of these uncertainties.
- Long-term projections were run until 2040 to allow equilibrium with fishing conditions to be achieved.
- 'Actual' conditions in 2011 and 2012 of tropical purse seine fishery were used to project through those years. 2010 effort levels were then applied into the future. This refinement affects the short-term post-2012 conditions, but does not significantly impact the main performance measures from the projection period.
- Catchability (which can have a trend in the historical component of the model) was assumed to remain constant in the projection period at the level estimated in the last year of the assessment model.

Consistent with the WCPFC-agreed limit reference point ($20\%SB_{F=0}$), the target reference point level was calculated in terms of the proportion of unfished levels. As per the recommendations of SC9, the historical period over which the average unfished level was calculated was 2000-2009[5].

[4] Ultimately it would be best - if more computationally intensive - to examine the uncertainty across the 'grid' of model runs created by these that combine these 'one off' sensitivities from the reference case.

[5] Note that in the stochastic projections, future recruitments were defined by the stock recruitment relationship from the assessment, with variability incorporated using deviates around that line sampled from the past. As a result, the

Results were evaluated over a range of performance metrics of relevance to the stated PNA management objectives, and included economic catch value, estimated catch rates, and the size of fish within the catch.

The 2014 stock assessment for WCPO skipjack (Rice et al., 2014) became available in sufficient time to allow evaluation of the sensitivity of the candidate target reference point to the new assessment structure and data. The consequences of 2010 effort levels were again evaluated through stochastic projections using the settings described above, but projected from the reference case assessment run only and for 20 years (noting that equilibrium was still achieved). Uncertainty in current status (structural uncertainty) was therefore not captured within the analysis. The historical period over which the average unfished level was calculated was 2002-2011, consistent with the recommendations of SC9.

Results

The consequences of fishing at 2010 effort levels into the future were examined for the stock status (adult (spawning) biomass relative to unfished levels) to identify a consistent target reference point. In turn, the consequences of this TRP for a variety of 'performance measures', including basic fishery economics, was examined.

Target reference point

The candidate target reference point was calculated as the median across the 200 simulations for the six skipjack assessment models examined (Table 1), to capture key sources of uncertainty. Values are also presented for each assessment run.

The resulting median $SB_{2040}/SB_{F=0,2000-2009}$ was 0.52 (Figure 1); approximate 95% confidence intervals were 0.34-0.70, indicating the range of future states that could result purely due to the uncertainty included within this analysis. In none of the simulations did the 2040 spawning stock biomass fall below 20% of $SB_{F=0,2000-2009}$ (the agreed limit reference point level for this stock; Figure 1). If used as a target, 0.52 $SB_{F=0,2000-2009}$ should be sufficiently above the LRP to ensure that the LRP is not breached. The distributions of status for each assessment run that combine to provide this overall distribution are presented in Appendix 1.

Under the assumption of recruitment patterns seen in the more recent period (last 25 years of the assessment), the Target reference point represents an adult population size that is consistent with the population size seen in 2010.

Re-evaluation of the consequences of 2010 effort levels on future skipjack stock status resulted in a median $SB_{2032}/SB_{F=0,\ 2002-2011}$ across the 200 projections of 0.52 (range 0.39-0.68). Note that the range of future stock levels is narrower than in the analysis above, partly due to the lack of the inclusion of structural uncertainty.

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biology of the stock will not change markedly in the future, and the use of the 2000-2009 period for calculation of the unfished adult biomass would be a reasonable assumption.

Examining the potential consequences of a population around the target reference point level

Economic performance

The approximate value of the catch per purse seine fishing day (calculated from the overall catch value and the number of days modelled within the purse seine fishery), and the catch value per ton, consistent with the proposed target reference point level are shown in Figure 2 and Figure 3. These are calculated across FAD and free school sets. This calculation takes into account the predicted sizes of fish taken and differential value of commercial size categories. Based upon higher 2013 skipjack prices, the value of the average catch per day based upon the modelled age structure is US$ 41,777 (Table 2). In a relative sense, this is comparable to the price per day estimated based on model outputs in 2010 (Figure 2, right). The average catch value per day falls by 40% to US$ 25,066 when early 2014 lower prices were used within the calculation (Table 2).

Examining value per tonne of skipjack (Figure 3), the median value is US$ 1,934. Again, this is comparable to the modelled price per tonne in 2010 (Figure 3, right). The 2040 price per tonne falls 58% to US$ 818 when lower early 2014 prices were used (Table 2).

Fish size

The consequences of the target reference point level on the size of fish in the tropical purse seine catch were examined using the mean overall length in the catch, where that mean length was weighted by the value of fish in each commercial size category (i.e. a greater number of fish in the most valuable larger size category would increase the overall mean). Mean sizes in 2040 were comparable to, if slightly smaller than, the weighted mean size of the catch modelled in 2010.

Vulnerable biomass (CPUE proxy)

The vulnerable skipjack biomass for each purse seine fishery relative to the level of vulnerable biomass calculated in 2010 is presented in Figure 4. Under conditions consistent with the proposed TRP, in both fleets the vulnerable biomass on average increases by 10% compared to 2010 conditions in region 2, and is comparable to 2010 conditions in region 3. It is not known how this will impact fishery performance, i.e. the relationship between vulnerable biomass in purse seine fisheries and catch rates is not fully understood.

Discussion

This analysis is based upon the management objective of maintaining the fishery at levels experienced in 2010. Recent effort in the fishery as a whole is greater than those levels (e.g. WCPFC, 2013b), which will in theory lead to stock sizes below the candidate target reference point level defined here.

We note that the candidate target reference point appeared relatively robust to the changes in the new stock assessment. However, the results were limited to runs from the 2014 reference case assessment run only, and hence underestimate uncertainty in stock biology (structural uncertainty) and hence current stock conditions. A fuller comparison requires the analysis to be repeated over a wider selection of plausible assessment runs.

Any advice on a target reference point on the basis of the current paper should be preliminary pending the outcome of that analysis.

Acknowledgements

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References

Davies, N., Fournier, D., Hampton, J., Bouyé, F., and Harley, S. 2014. Recent developments in the MULTIFAN-CL stock assessment software. WCPFC SC10-SA-IP-08, Majuro, Republic of the Marshall Islands, 6 – 14 August 2014.

Hoyle, S., Kleiber, P., Davies, N., Langley, A. and Hampton, J. 2011. Stock assessment of skipjack tuna in the western and central Pacific Ocean. WCPFC-SC7-2011/SA-WP-04

Rice, J., Hampton, J., Davies, N., and McKechnie, S. 2014. Stock assessment of skipjack tuna in the western and central Pacific Ocean. WCPFC SC10-SA-WP-05, Majuro, Republic of the Marshall Islands, 6 – 14 August 2014.

WCPFC. 2013a. Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean. Scientific Committee, Ninth Regular Session, Pohnpei, Federated States of Micronesia, 6–14 August 2013. Summary Report. 231p.

WCPFC. 2013b. Data summaries in support of discussions on the CMM on tropical tunas. Commission Tenth Regular Session, Cairns, Australia, 2-6 December 2013. 35p.

Tables and Figures

Table 1. Median $SB_{2040}/SB_{F=0,2000-2009}$ across sensitivity runs and overall

Sensitivity run	$SB_{2010}/SB_{F=0,2000-2009}$	$SB_{2040}/SB_{F=0,2000-2009}$	% change from 2010
Reference case	0.49	0.50	+2%
SBEST	0.49	0.53	+8%
Binomial CPUE	0.50	0.53	+6%
Tanabe growth	0.57	0.60	+5%
Steepness h=0.65	0.44	0.40	-9%
Steepness h=0.95	0.51	0.53	+4%
OVERALL	**0.50**	**0.52**	**+4%**

Table 2. Impact of price used within the calculation of catch value

	2013 prices	2014 prices
Median value of catch per day (US$/day)	41,777	25,066
Median value of catch per tonne (US$/mt)	1,934	818

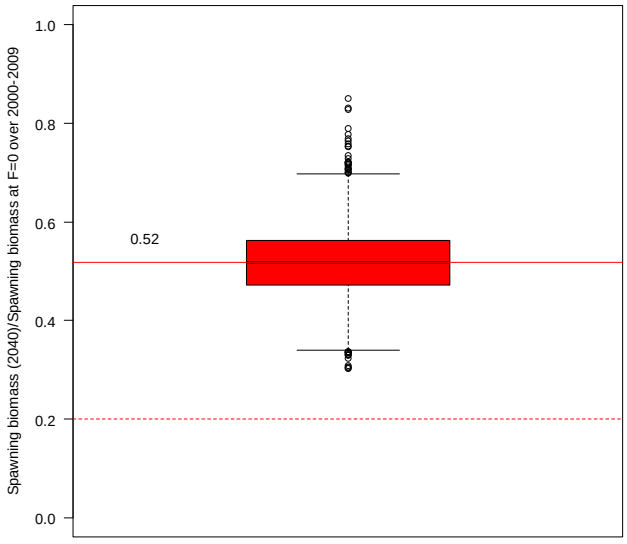

Figure 1. Skipjack $SB_{2040}/SB_{F=0,2000-2009}$ resulting from 2010 effort conditions, with the range of potential stock level outcomes under the range of uncertainty examined. Value shown is the median value. Dotted horizontal line at 0.2 represents the Limit Reference Point, which is not breached.

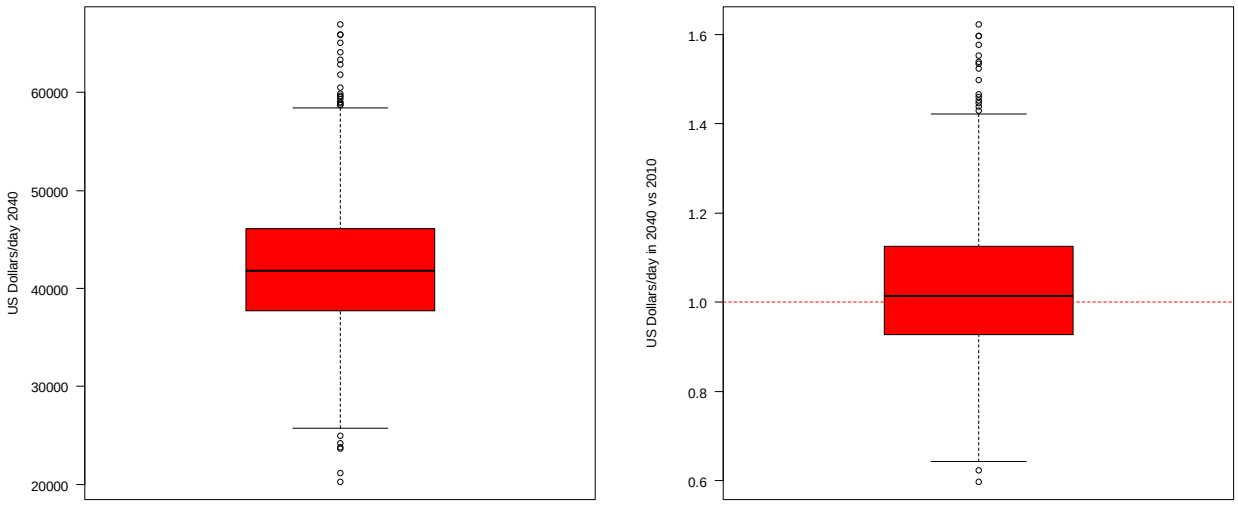

Figure 2. Left: Value (US$) per day for the purse seine fishery in 2040 across sensitivity runs, assuming early 2013 (higher) skipjack prices. Right: Value per day in 2040 relative to that in 2010. Note that the skipjack price has been assumed constant over time.

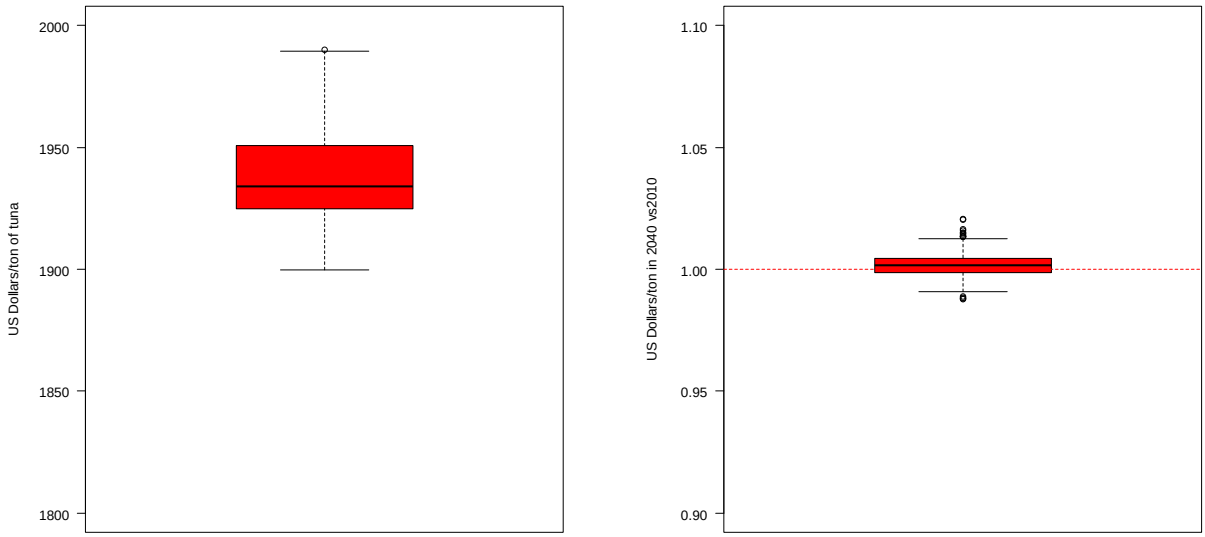

Figure 3. Value (US$/ton) of tuna in 2040 (left), and relative to the estimated value/ton in 2010 (right). This calculation takes into account the size structure of the catch.

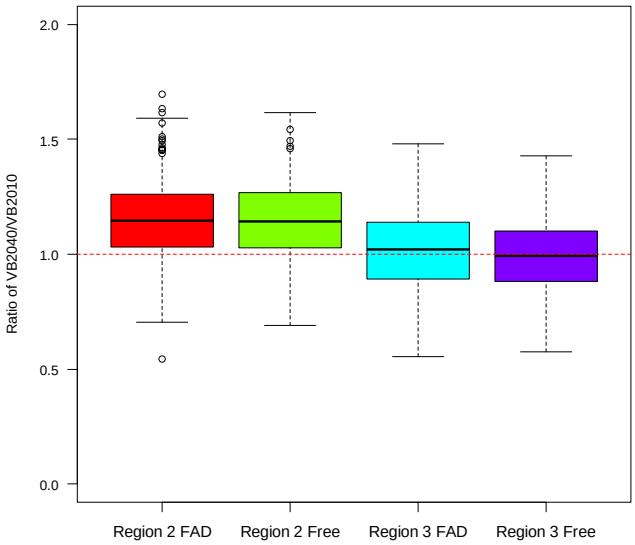

Figure 4. **VB_{2040}/VB_{2010} by tropical purse seine fishery (region and set type) across sensitivity runs.**

Appendix 1. Individual distributions of $SB_{2040}/SB_{F=0,\ 2000\text{-}2009}$ for the sensitivity runs examined from the 2011 stock assessment.

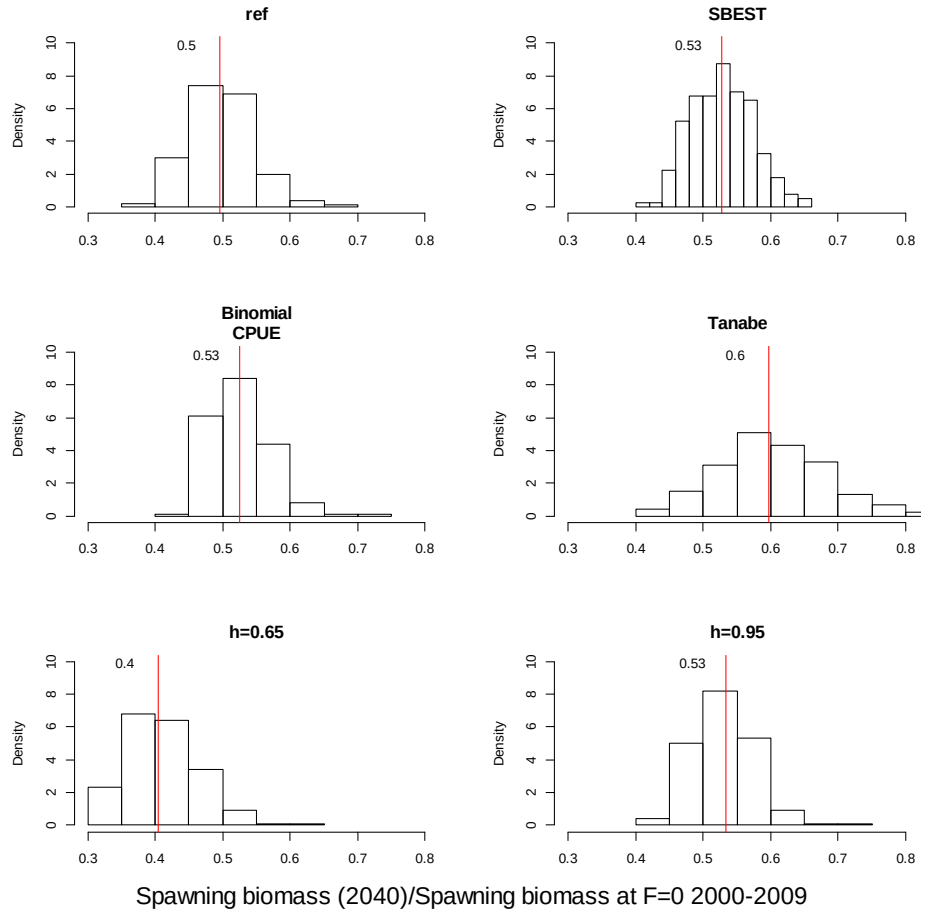

Figure A1. $SB_{2040}/SB_{F=0,2000\text{-}2009}$ for each of the selected six sensitivity runs. Vertical red line and value = median of each distribution.