SCIENTIFIC COMMITTEE
TENTH REGULAR SESSION

Majuro, Republic of the Marshall Islands
6-14 August 2014

Status quo stochastic projections for bigeye, skipjack and yellowfin tunas

WCPFC-SC10-2014/SA-WP-06

Graham M. Pilling, Shelton J. Harley, Nick Davies, Joel Rice and John Hampton

Oceanic Fisheries Programme (OFP)
Secretariat of the Pacific Community, Noumea, New Caledonia

Status quo stochastic projections for bigeye, skipjack and yellowfin tunas

Graham M. Pilling, Shelton J. Harley Nick Davies, Joel Rice and John Hampton

Oceanic Fisheries Programme, SPC

Abstract

We assess the potential consequences of recent (2012) fishing conditions on the future biological status of the three tropical tuna stocks, based upon the new tropical tuna stock assessments. Projected status in 2032 is reported relative to spawning biomass and fishing mortality reference points in absolute terms (as a median of the projection outcomes) and in probabilistic terms.

Here, we have used a single assessment model run (the reference case model) from which to project future stock status. Only uncertainty arising from future recruitment scenarios (assumed to be consistent with actual recruitments estimated over the period 2002-2011, or to follow the estimated stock recruitment relationship with randomly selected deviates from a longer time period) is therefore captured in results.

Under 2012 conditions, stochastic projection results indicate:

- BET: dependent upon the recruitment assumption, the stock was either very likely (>90%; long-term recruitment deviate assumption) or unlikely (<25%; recent recruitment assumption) to fall below both the LRP and SB_{MSY} levels by 2032. Under both recruitment assumptions, it was virtually certain (>99%) that fishing mortality would be above the F_{MSY} level in 2032.
- SKJ: it was exceptionally unlikely (<1%) that the skipjack stock would fall below either the limit reference point level or SB_{MSY} level by 2032, or that fishing mortality will increase above F_{MSY} levels, under either future recruitment assumption.
- YFT: it was exceptionally unlikely (<1%) that the yellowfin stock would fall below the limit reference point level or that fishing mortality would increase above the F_{MSY} level by 2032, and dependent upon the future recruitment assumption, it was exceptionally unlikely (<1%; long-term recruitment deviate assumption) or very unlikely (<10%; recent recruitment assumption) to fall below SB_{MSY}.

Introduction

New stock assessments for the three main WCPO tropical tuna species - bigeye, skipjack and yellowfin tuna - have estimated the status of these stocks using data up to 2012 (Harley et al., 2014, Rice et al., 2014 and Davies et al., 2014, respectively). To examine the potential impact of

current fishing levels on their future status, we perform stochastic projections using the corresponding reference case assessment run. We note that:

- the WCPFC-SC has yet to decide which model run(s) to use for the provision of management advice. Results may differ if an alternative model run is selected;
- Due to time constraints, only a single model run is used as the basis of the stochastic projections performed here. The full level of structural uncertainty (e.g. in biological parameters, and hence current stock conditions) is therefore not captured in these evaluations and will not be reflected in estimates of probabilities relative to reference points, nor in median estimated values.

Methodology

For each tropical tuna stock, the general features of the stochastic projections were:

- projections were run from a single assessment run (the reference case model run); i.e. underlying biological assumptions for each stock were as assumed within that reference case model;
- 200 projections were performed for each stock;
- variability in future recruitment was captured using two alternative approaches:
    - as stochastic deviations around the estimated Beverton and Holt stock-recruitment relationship, where those deviations were taken from the time period over which that stock-recruitment relationship was estimated within the stock assessment run (see the assessment reports for more details);
    - by randomly resampling from historical recruitment estimates over the period 2002-2011, consistent with the period used to estimate the limit reference point;
- projections were run from 2012 (last year of the assessment) for 20 years;
- conditions in longline fisheries and those of Indonesia, Philippines and Vietnam were projected based upon catch. Conditions in purse seine and pole and line fisheries were projected based upon effort;
- status quo was considered to be conditions in 2012 (the last year of full data) to capture the latest estimates of catchability for each gear[1];
- 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 terminal year of the assessment model.

The stock status at the end of the projection period (2032) was assessed relative to:

- the agreed biomass limit reference point (20% $SB_{F=0,2002-2011}$) calculated consistent with the recommendations of SC9 (WCPFC SC9, 2013); and
- F_{MSY} and SB_{MSY}.

For continuity with previous practice, and while the SC and WCPFC consider the use of target and limit reference points, we have included SB_{MSY} and F_{MSY} as 'default' benchmark levels.

[1] We acknowledge that SC9 requested "projections use data up to and including 2013" (para 76 of the SC9 report). However, data for 2013 were not finalised in sufficient time to complete this work. We expect further projection updates following SC10 decisions on the reference case run, through other activities (e.g. related to MI-WP-01), which will incorporate the 2013 data.

The probability of falling below each biomass reference level, or rising above the fishing mortality reference level, was calculated as the proportion of the 200 projection runs where that state occurred in 2032. Median parameter estimates relative to reference levels were calculated.

Results

Future population trends from the reference case assessment runs under 2012 conditions are presented in Figure 1 to Figure 3, by stock and by assumption on future recruitment patterns. Corresponding probabilities of the adult biomass or fishing mortality falling below or increasing above reference levels respectively are summarised in Table 1, and the median values of these relative levels presented in Table 2.

Under 2012 conditions, stochastic projection results from the reference case model for each stock indicate:

- BET: dependent upon the recruitment assumption, the stock was either very likely (>90%; long-term recruitment deviate assumption) or unlikely (<25%; recent recruitment assumption) to fall below both the LRP and SB_{MSY} levels by 2032 (Table 1). The difference results from relatively large recruitments modelled in the most recent time period of the bigeye assessment, which allows the stock to recover under that assumption (see Figure 1). Under both recruitment assumptions, it was virtually certain (>99%) that fishing mortality would be above the F_{MSY} level in 2032.
- SKJ: it was exceptionally unlikely (<1%) that the skipjack stock would fall below either the limit reference point level or SB_{MSY} level by 2032, or that fishing mortality will increase above F_{MSY} levels (Table 1, Figure 1), under either future recruitment assumption.
- YFT: it was exceptionally unlikely (<1%) that the yellowfin stock would fall below the limit reference point level or that fishing mortality would increase above the F_{MSY} level by 2032, and dependent upon the recruitment assumption, it was exceptionally unlikely (<1%; long-term recruitment deviate assumption) or very unlikely (<10%; recent recruitment assumption) to fall below SB_{MSY} (Table 1, Figure 1). Recent recruitment estimates have been relatively low (i.e. have negative residuals from the stock-recruitment relationship) and hence imply a more pessimistic future state than when the stock-recruitment relationship is incorporated.

When considering median parameter estimates in 2032 (Table 2):

- BET: dependent upon the assumption of future recruitment, adult biomass in 2032 was either 60% of the level at the LRP and 54% of the level at MSY (long term recruitments), or 25% above the level at the LRP and 18% above that at MSY (recent recruitments). Under either assumption, fishing mortality in 2032 was above that at F_{MSY}, by 80% and 27%, respectively.
- SKJ: under both recruitment scenarios, median adult biomass levels in 2032 were 150% above the level at the LRP and 79% above the level at MSY, while median fishing mortality was around 58% of F_{MSY}.
- YFT: under both recruitment scenarios, adult biomass levels in 2032 were above the levels at the LRP (by 170% and 110%) and MSY (by 81% and 31%), while fishing mortality was below that at F_{MSY} (being 71% and 76% of that level).

Discussion

As noted by Berger et al. (2013), the approach used within analyses to describe uncertainty will influence perceptions of management risks. A fuller analysis of uncertainty, including the use of multiple model runs, is planned as part of the work on risk described within Pilling et al. (2014), and should involve the selection of those model runs considered by the Scientific Committee to best capture relevant uncertainties.

Acknowledgements

We would like to acknowledge funding for this work from the WCPFC and from the Australian Aid (AusAID) Fisheries for Food Security programme.

References

Berger, A.M., Pilling, G.M., Harley, S.J. and Kirchner, C. (2013a). Approaches to describe uncertainty in current and future stock status. WCPFC-SC9-2013/MI-WP-04.

Davies, N., Harley, S., Hampton, J., and McKechnie, S. 2014. Stock assessment of yellowfin tuna in the western and central Pacific Ocean. WCPFC SC10-SA-WP-04, Majuro, Republic of the Marshall Islands, 6 – 14 August 2014.

Harley, S., Davies, N., Hampton, J., and McKechnie, S. 2014. Stock assessment of bigeye tuna in the western and central Pacific Ocean. WCPFC SC10- SA-WP-01, Majuro, Republic of the Marshall Islands, 6 – 14 August 2014.

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.

Pilling, G.M., Harley, S.J. and Hampton, J. 2014. Evaluation of risks of exceeding limit reference points for south Pacific albacore, bigeye, yellowfin and skipjack tunas with implications for target reference points: a case study using south Pacific albacore. WCPFC SC10-MI-WP-01, Majuro, Republic of the Marshall Islands, 6 – 14 August 2014.

WCPFC. 2013. 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.

Tables and Figures

Table 1. Probabilities of spawning stock biomass in 2032 falling below the WCPFC-adopted biomass limit reference point, $0.2SB_{F=0,\ 2002\text{-}2011}$, and SB_{MSY} reference point levels, and probabilities of the fishing mortality increasing above the default F_{MSY} reference level. Results for each stock presented for the two alternative future recruitment assumptions.

Stock	Recruitment assumption	Probabilities		
		$P(SB_{2032} < 0.2SB_{F=0,\ 2002\text{-}2011})$	$P(SB_{2032} < SB_{MSY})$	$P(F_{2032} > F_{MSY})$
Bigeye	Long-term rec. devs	0.94	0.96	1.00
	Recent 2002-2011 rec.	0.13	0.20	1.00
Skipjack	Long-term rec. devs	0	0	0
	Recent 2002-2011 rec.	0	0	0
Yellowfin	Long-term rec. devs	0	0	0
	Recent 2002-2011 rec.	0	0.02	0

Table 2. Median values of spawning biomass in 2032 relative to the unfished levels over the period 2002-2011 (noting that the LRP = $0.2SB_{F=0,\ 2002\text{-}2011}$) and SB_{MSY} levels, and median fishing mortality rate in 2032 relative to F_{MSY}. Results for each stock presented for the two alternative future recruitment assumptions.

Stock	Recruitment assumption	Median values		
		$SB_{2032}/SB_{F=0,\ 2002\text{-}2011}$	SB_{2032} / SB_{MSY}	F_{2032} / F_{MSY}
Bigeye	Long-term rec. devs	0.12	0.54	1.80
	Recent 2002-2011 rec.	0.25	1.18	1.27
Skipjack	Long-term rec. devs	0.50	1.79	0.56
	Recent 2002-2011 rec.	0.50	1.79	0.58
Yellowfin	Long-term rec. devs	0.54	1.81	0.71
	Recent 2002-2011 rec.	0.42	1.37	0.76

Bigeye

Recruitment deviates from SRR period

Estimated recruitments from 2002-2011

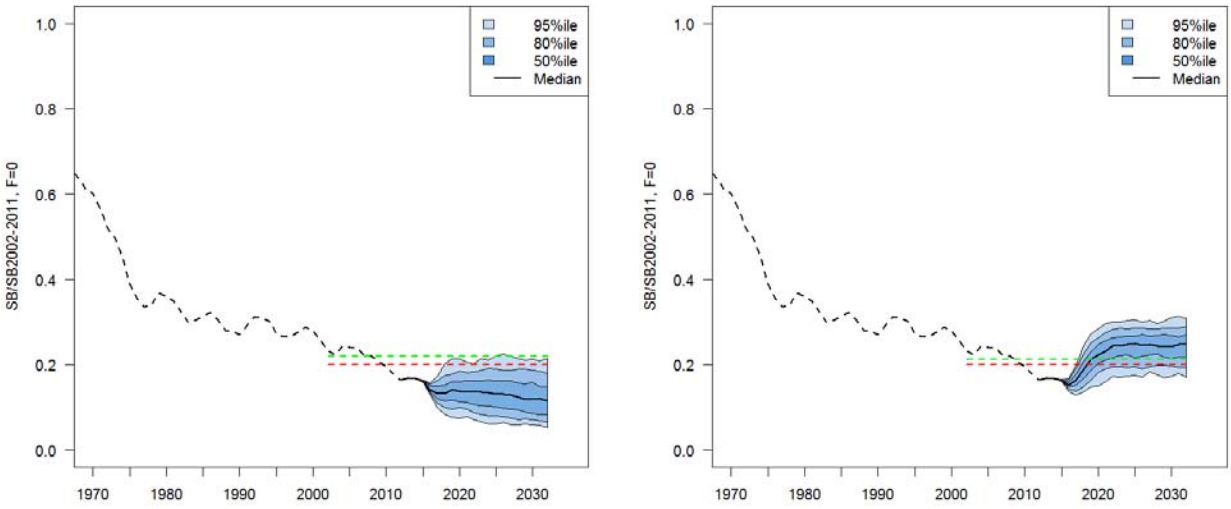

Figure 1. Bigeye spawning stock biomass trajectory expressed relative to the average unexploited stock biomass level estimated over the period 2002-2011 (equivalent to the Limit Reference Point). Trajectory from the assessment shown as dashed line. Future recruitment modelled as deviations estimated across the long-term period used to develop the stock-recruitment relationship (left) or sampled from the actual recruitments over the period 2002-2011 (right). Median and range of future stochastic projection outputs presented by specific percentiles. Red dashed line indicates the biomass Limit Reference Point (20% $SB_{F=0,\ 2002\text{-}2011}$). Green dashed line indicates the SB_{MSY} equivalent level calculated in the stock assessment.

Skipjack

Recruitment deviates from SRR period

Estimated recruitments from 2002-2011

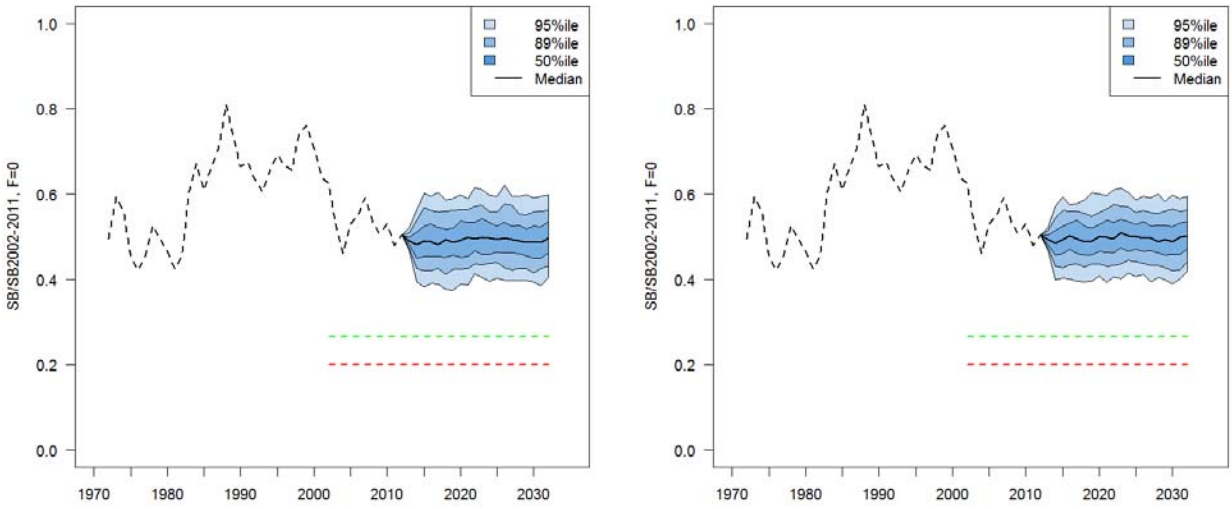

Figure 2. Skipjack spawning stock biomass trajectory expressed relative to the average unexploited stock biomass level estimated over the period 2002-2011 (equivalent to the Limit Reference Point). Trajectory from the assessment shown as dashed line. Future recruitment modelled as deviations estimated across the long-term period used to develop the stock-recruitment relationship (left) or sampled from the actual recruitments over the period 2002-2011 (right). Median and range of future stochastic projection outputs presented by specific percentiles. Red dashed line indicates the biomass Limit Reference Point (20% $SB_{F=0,\ 2002\text{-}2011}$). Green dashed line indicates the SB_{MSY} equivalent level calculated in the stock assessment.

Yellowfin

Recruitment deviates from SRR period

Estimated recruitments from 2002-2011

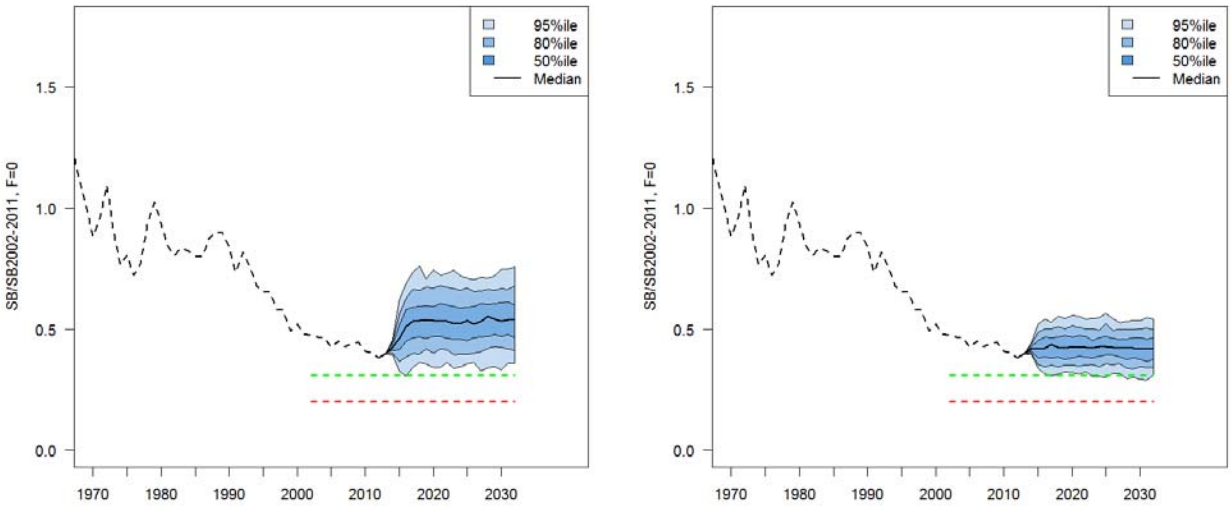

Figure 3. Yellowfin spawning stock biomass trajectory expressed relative to the average unexploited stock biomass level estimated over the period 2002-2011 (equivalent to the Limit Reference Point). Trajectory from the assessment shown as dashed line. Future recruitment modelled as deviations estimated across the long-term period used to develop the stock-recruitment relationship (left) or sampled from the actual recruitments over the period 2002-2011 (right). Median and range of future stochastic projection outputs presented by specific percentiles. Red dashed line indicates the biomass Limit Reference Point (20% $SB_{F=0,\ 2002\text{-}2011}$). Green dashed line indicates the SB_{MSY} equivalent level calculated in the stock assessment.