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Stochastic status quo projections for bigeye tuna

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Executive summary

The structural uncertainty grid for the 2017 bigeye tuna assessment was constructed from 5 axes comprising steepness (3 settings), growth/maturity (2), tagging data overdispersion (2), size data weighting (2) and regional structure (2). At this stage, the projection results do not include the size frequency data weighting (divisor of 20) option that was used for the diagnostic case model. The assessment runs for this option were completed recently. If time permits, additional projection runs will be conducted and an updated version of this paper will be re-submitted.

Stochastic projections were run for each of the assessment models that make up the uncertainty grid (48 models). The projections were run for a 30 year period. Two time periods were used for the re-sampling of recruitment deviates, consistent with SC12 requests: Long-term recruitment deviates were sampled for the period 1964:2014 corresponding to the time period over which the SRR was fit in the assessment; and Short-term recruitment deviates were sampled for the period 2005:2014, corresponding to the last 10 years of the assessment for which estimates of recruitment have generally been greater than predicted by the SRR.

Across the full grid of model runs, for both the long-term and short-term recruitment scenarios median stock status remains above the LRP throughout the projection period. The spread of potential stock status values is, however, very wide and in the case of long-term recruitment the tails of the distribution include $SB/SB_{F=0}$ levels ranging from over 50%, to crashing the stock completely.

The more optimistic short-term recruitment scenario provides estimates of future stock status that are slightly higher and slightly less variable than those for the long-term. Scenarios based on new growth show higher stock status than the old growth scenarios for which none of the simulations achieve levels as high as 50%. The risk of falling below the LRP is around 50% for the old growth and long-term recruitment scenarios and almost zero for the new growth and short-term recruitment scenarios (see table below).

Table: Proportion of runs that fall below the LRP ($SB/SB_{F=0} = 0.2$) in 2020, 2030 and 2045 for stochastic projections based on either long-term (1964:2014) or short-term (2005:2014) recruitment deviates

	Long-term Rctmnt			Short-term Rctmnt		
Model Group	2020	2030	2045	2020	2030	2045
All	0.23	0.33	0.39	0.23	0.18	0.21
New Growth	0.00	0.14	0.22	0.00	0.00	0.01
Old Growth	0.47	0.53	0.56	0.43	0.34	0.38

1 Introduction

Stochastic projections run from the final assessment model are often presented for WCPFC stock assessments to provide an indication of the potential future trajectory of the stock given the most recent estimates of stock status and fishery dynamics (Pilling et al., 2016). For previous assessments these projections have typically been conducted only for the reference case assessment model. However, for the 2017 assessments, inferences about stock status and recommendations for management advice have been based on the complete set of models comprising the structural uncertainty grid, rather than on an individual reference case model. The projection summaries presented here are therefore based on projections conducted for each of the assessments in the uncertainty grid. Development and analysis of these projections therefore took considerably more time than in previous years, and hence the results presented here are focussed on the bigeye assessment specifically, to inform discussions of stock status advice.

1.1 Uncertainty grid

Stock assessments of pelagic species in the WCPO in recent years have utilised an approach to assess the structural uncertainty in the assessment model by running a "grid" of models to explore the interactions among selected "axes" of uncertainty. The grid contains all combinations of two or more parameter settings or assumptions for each uncertainty axis. The axes are generally selected from those factors explored in the one-off sensitivities with the aim of providing an approximate understanding of variability in model estimates due to assumptions in model structure not accounted for by statistical uncertainty estimated in a single model run, or over a set of one-off sensitivities.

The structural uncertainty grid for the 2017 bigeye tuna assessment (McKechnie et al., 2017) was constructed from 5 axes (Table 1) comprising steepness (3 settings), growth/maturity (2), tagging data overdispersion (2), size data weighting (2) and regional structure (2). The final grid thus consisted of 48 models. Note that due to the very large computational load of running the grid, with each model requiring significant run time, the size frequency data weighting level for the diagnostic case model (divisor of 20) was not initially included within the assessment analysis. It has subsequently been added to the assessment grid in a series of additional runs, but has not yet been included in the projections presented in this report.

Table 1: 2017 bigeye tuna assessment uncertainty grid.

Code	Axis	0	1	2
A	steepness	0.8	0.65	0.95
B	growth	new	old	
C	overdispersion	default	OD2	
D	size weighting	10	50	(20)
E	regional structure	2017	2014	

2 Basis of the projections

Projections were run for a 30 year period (2016 to 2045) under status quo catch and effort assumptions (i.e. with future catch (longline, domestic Indonesian and Philippine fisheries) or

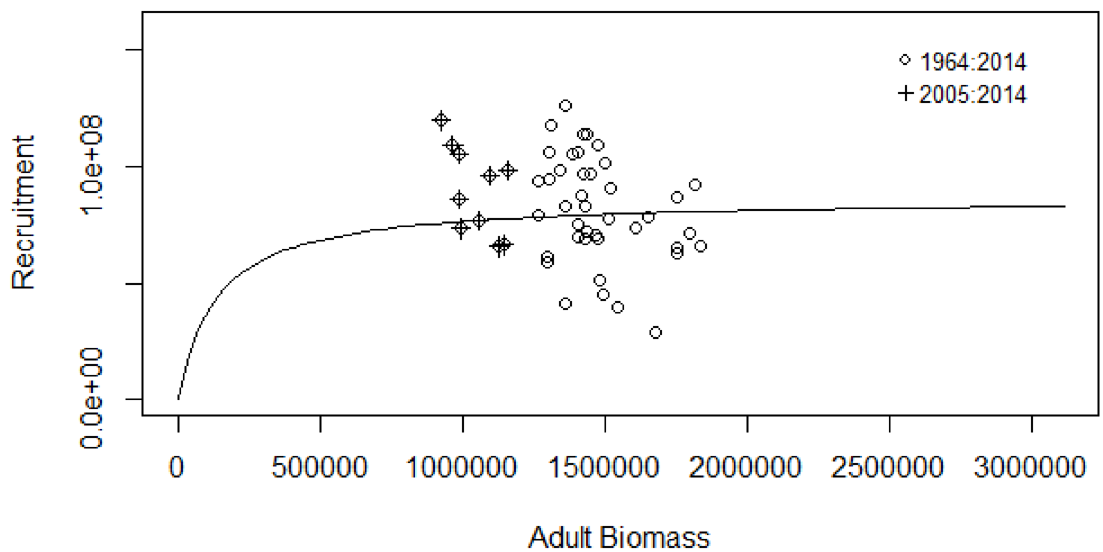


Figure 1: Stock and recruitment relationship for bigeye tuna in the western and central Pacific Ocean (from one of the assessment models comprising the grid). Stock and recruitment pairs are shown for the periods 1964 to 2014 and 2005 to 2014.

effort (purse seine, pole and line fisheries) assumed to be fixed at the level of the terminal year of the assessment). 200 projections were performed from each assessment model in the grid with variability in future recruitment implemented by randomly re-sampling from historical deviations from the stock recruitment relationship (SRR). Growth, maturity and natural mortality were fixed at the values corresponding to the assessment being projected and were assumed to remain constant throughout the projection period. Similarly, catchability was assumed to remain constant in the projection period at the level estimated in the terminal year of the assessment model.

Two time periods were used for the re-sampling of recruitment deviates (Figure 1). Long-term recruitment deviates were sampled for the period 1964:2014 corresponding to the time period over which the SRR was fit in the assessment. Short-term recruitment deviates were sampled for the period 2005:2014, corresponding to the last 10 years of the assessment for which estimates of recruitment have generally been greater than predicted by the SRR.

In total, around 19,200 projections were run (based on an uncertainty grid of 48 models, 200 iterations and 2 assumptions for future recruitment). However a small number of projections failed to run (around 4%), in particular for the long-term recruitment scenarios. We are currently investigating the cause of these failed runs although a likely reason is that for some of the runs the stock was driven to very low levels at which it was no longer possible to achieve the fishery catches specified for the projection. Exclusion of these runs implies a slight positive bias to the results.

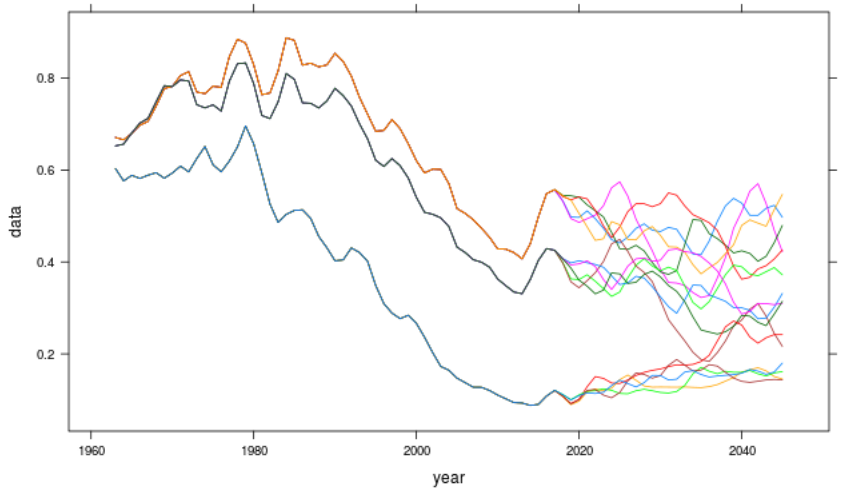


Figure 2: Example illustration showing stock trajectories for 5 iterations of stochastic projections for 3 different model runs.

3 Results

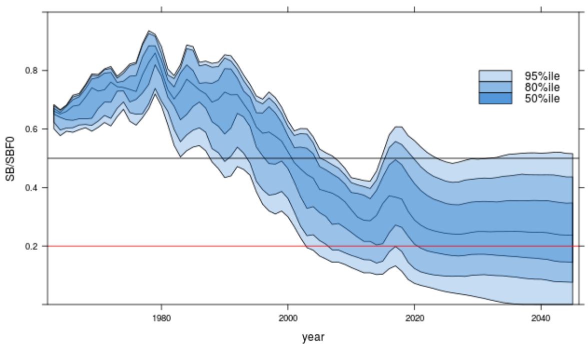
The format of the results presented here differ slightly from previous presentations of stochastic projections. Because a range of alternative model structures has been used we present confidence intervals for the historical estimates of stock status as well as the projection period. Uncertainty within the historical period is therefore across the 48 grid model runs. Uncertainty within the projection period is across the 19,200 projections. Figure 2 illustrates a simplified case showing results for 3 different models each having 5 stochastic iterations for the projection period. The results in Figure 3(a), for example, are based on 48 models and 200 iterations.

A moving 10 year window has been applied for the calculation of stock status ($SB/SB_{F=0}$). Stock status in a given year has therefore been calculated as adult biomass in that year divided by the average of adult unfished biomass for the previous 10 years. For this reason the plots of stock status go back only as far as 1962.

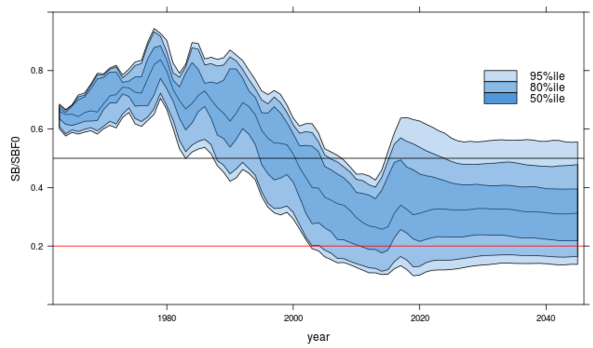
Across the full grid of model runs, for both the long-term and short-term recruitment scenarios (Figures 3(a) and 3(b)) median stock status remains above the LRP throughout the projection period. The spread of potential stock status values is, however, very wide and in the case of long-term recruitment the tails of the distribution include values above 50% and crashing the stock completely.

The more optimistic short-term recruitment scenario provides estimates of future stock status that are slightly higher and slightly less variable than those for the long-term. The new growth scenarios (Figures 3(c) and 3(d)) show higher stock status than the old growth scenarios (Figures 3(e) and 3(f)) for which none of the simulations achieve levels as high as 50%. The risk of falling below the LRP (Table 2) is around 50% for the old growth and long-term recruitment scenarios and almost zero for the new growth and short-term recruitment scenarios.

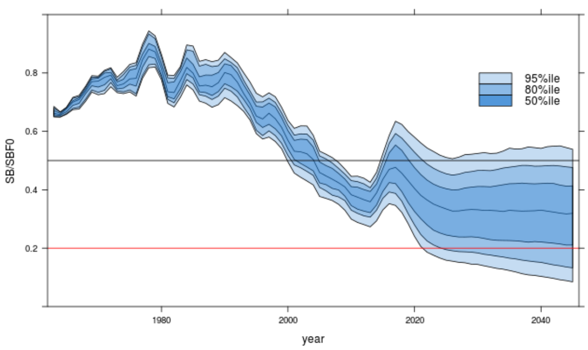
In Figure 4 and Table 3, the results from four combinations of growth and regional structure assumptions are presented.



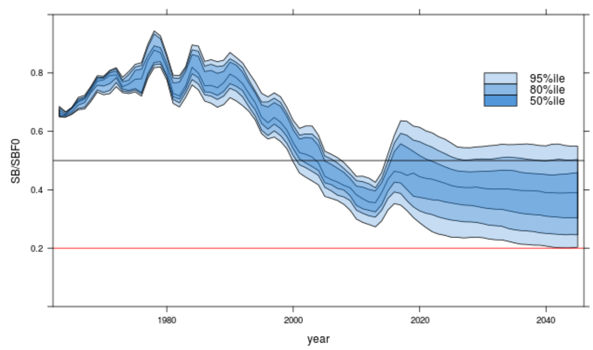
(a) Rec 1964:2014, All



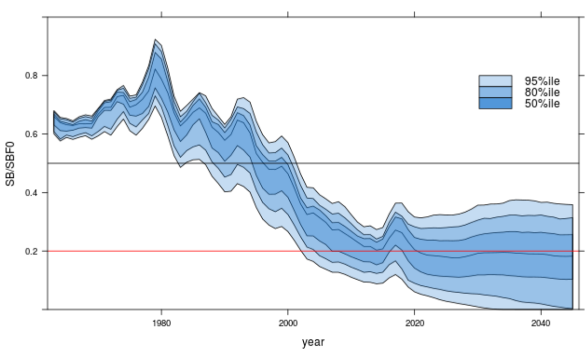
(b) Rec 2005:2014, All



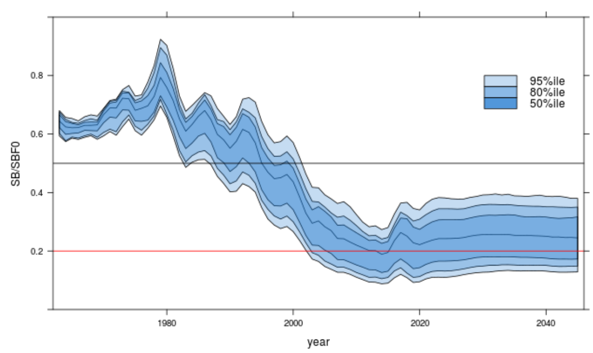
(c) Rec 1964:2014, new growth



(d) Rec 2005:2014, new growth

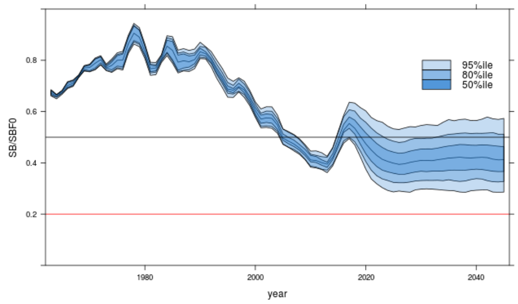


(e) Rec 1964:2014, old growth

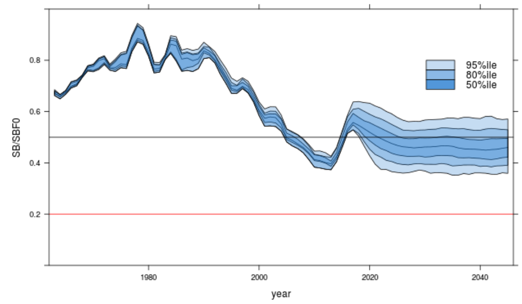


(f) Rec 2005:2014, old growth

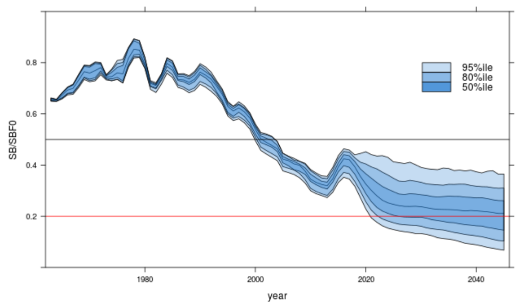
Figure 3: Results of stochastic projections based on long-term recruitment deviates (left column) and short-term recruitment deviates (right column), across the whole grid of 48 assessment models (top row) and for the new growth (middle row) and old growth (bottom row) model configurations (see Table 1)



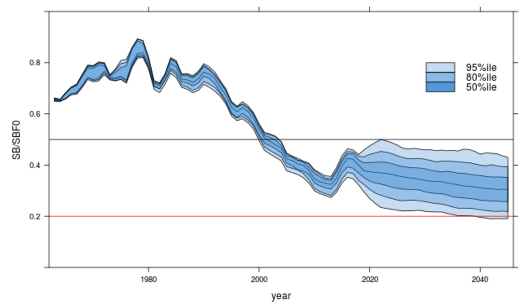
(a) Rec 1964:2014, new growth, 2017



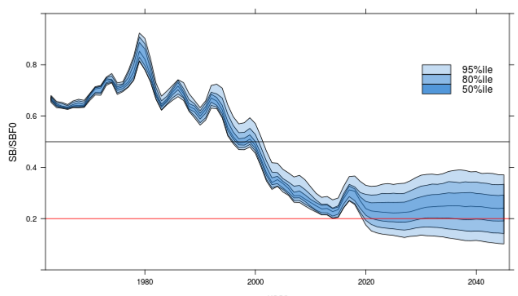
(b) Rec 2005:2014, new growth, 2017



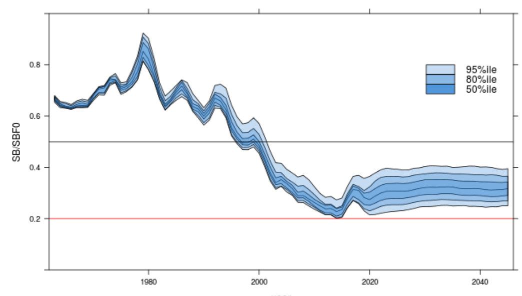
(c) Rec 1964:2014, new growth, 2014



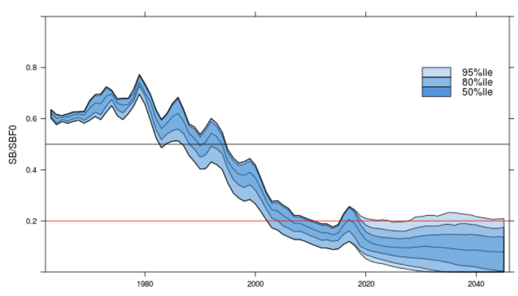
(d) Rec 2005:2014, new growth, 2014



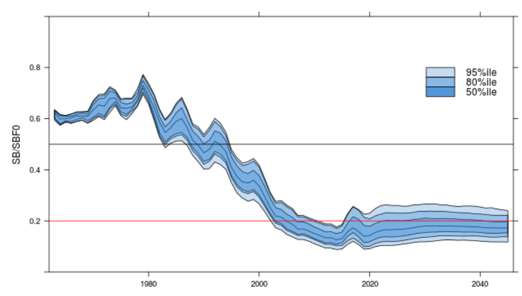
(e) Rec 1964:2014, old growth, 2017



(f) Rec 2005:2014, old growth, 2017



(g) Rec 1964:2014, old growth, 2014



(h) Rec 2005:2014, old growth, 2014

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All	0.23	0.33	0.39	0.23	0.18	0.21
New Growth, 2017 structure	0.00	0.00	0.00	0.00	0.00	0.00
New Growth, 2014 structure	0.00	0.26	0.44	0.00	0.00	0.04
Old Growth, 2017 structure	0.15	0.26	0.29	0.00	0.00	0.00
Old Growth, 2014 structure	0.95	0.95	0.96	0.87	0.67	0.77

4 Discussion

The projections presented here are based on a grid of models that represents the structural uncertainty in the assessment. Uncertainty in stock status is therefore presented for the historical period of the assessment as well as for the future projection. We note that the uncertainty in stock status progressively increases through time but does not show a marked increase, or decrease, at the transition from historical estimation to future projection indicating that model uncertainty, as represented by the uncertainty grid, is comparable to uncertainty in the projection due to recruitment variability.

The 2017 bigeye assessment (McKechnie et al., 2017) shows a slight increase in adult biomass for the most recent years, potentially as a consequence of recent high recruitment. The projections show that this increase in adult biomass continues, and is more pronounced for the new growth scenarios, but does not persist. For all scenarios there is a subsequent decline in stock status although the decline is most pronounced in the long-term recruitment runs. Outputs are, clearly, influenced by whether the recent high recruitment pulse will continue. We also note that the long term increasing trend in recruitments seen in previous bigeye stock assessments is less marked within the 2017 assessment.

It should be noted that the projections presented here do not include the size frequency data weighting (divisor of 20) option that was used for the diagnostic case model. The assessment runs for this option were completed at a later date. If time permits, additional projection runs will be conducted and an updated version of this paper will be re-submitted.

References

McKechnie, S., Pilling, G., and Hampton, J. (2017). Stock assessment of bigeye tuna in the western and central Pacific Ocean. WCPFC-SC13-2017/SA-WP-05, Rarotonga, Cook Islands, 9–17 August 2017.

Pilling, G., Scott, R., Davies, N., and Hampton, J. (2016). Approaches used to undertake management projections of WCPO tuna stocks based upon MULTIFAN-CL stock assessments. WCPFC-SC12-2016/MI-IP-04, Bali, Indonesia, 3–11 August 2016.