SCIENTIFIC COMMITTEE
ELEVENTH REGULAR SESSION

Pohnpei, Federated States of Micronesia
5-13 August 2015

Short-term stochastic projections for skipjack, yellowfin and bigeye tunas

WCPFC-SC11-2015/SA-WP-04

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Executive Summary

In 2014 stock assessments were conducted for the three tropical tuna stocks using catch and effort data through 2012. Here we assess the potential consequences of recent (2013 and 2014) catches on the current biological status of these stocks using three year stochastic projections (2013 to 2015) and catch multipliers for future years calculated as the ratio of 2013 and 2014 to 2012 catches. The resulting stock status is reported relative to spawning biomass depletion estimates commonly used in the Scientific Committee (SC), in particular the formal limit reference point (LRP) of 20% $SB_{F=0,2002-2011}$.

A single assessment model (the reference case model) was used to project future stock status for each of the tropical tuna stocks. The projections were stochastic with uncertainty in future recruitment based upon random re-sampling of recent (2002-2011) observed recruitment.

Based on the assumption that 2014 catches continue to apply in 2015, the following conclusions were reached for each stock:

Skipjack tuna The current spawning stock biomass is likely to be very slightly greater than that estimated from the 2014 assessment. It is exceptionally unlikely (<1%) that the skipjack stock would fall below the LRP in 2015 (95% confidence limits for $SB_{2015}/SB_{F=0,2002-2011}$ are 0.40 – 0.64).

Yellowfin tuna The current spawning stock biomass is likely to be slightly greater than that estimated from the 2014 assessment. It is exceptionally unlikely (<1%) that the yellowfin stock would fall below the LRP in 2015 (95% confidence limits for $SB/SB_{F=0,2002-2011}$ are 0.35 – 0.58).

Bigeye tuna The current spawning stock biomass is likely to be very slightly greater than that estimated from the 2014 assessment, however, it is highly likely (>99%) that the bigeye stock will remain below the LRP in 2015 (95% confidence limits for $SB_{2015}/SB_{F=0,2002-2011}$ are 0.16 – 0.18).

We invite the SC to consider the utility of such analyses to provide updated information on stock status in between stock assessments. We note that if short-term projections such as these are to be continued, structure within the recruitment time series, e.g., autocorrelation and seasonality may need to be included in projection dynamics.

1 Introduction

Updated stock assessments for the stocks of skipjack (Rice et al., 2014), yellowfin (Davies et al., 2014), and bigeye (Harley et al., 2014) tuna were presented to SC10 in 2014. The assessments included catch and effort data only up to 2012 because at the time the assessments were conducted, data for 2013 and 2014 were incomplete. Pilling et al. (2014) described results from stochastic projections that were conducted for the reference case models for each of the tropical tuna assessments. The stochastic projections were run over a 20 year time period and were based on status quo assumptions for future catch and effort. That is, the catch and effort levels for 2012 were assumed to remain constant into the future. Stochasticity was included in the projections through variability in future recruitment.

In this paper we present the results of similar stochastic projections conducted for the 2014 tropical tuna assessments, except that in this instance fleet based catch multipliers corresponding to the latest 2013 and 2014 catch estimates have been taken as the basis of the projections.

These short-term stochastic projections are presented here as a possible mechanism to provide updated information on stock status in between stock assessments.

2 Methods

2.1 Catch Multipliers

Quarterly catch and effort data for skipjack, yellowfin and bigeye, for all years up to and including 2014, were extracted from databases housed at SPC. These extractions, which included the latest data for years 2013 and 2014, were checked against the extraction used to compile the 2014 assessment input files. Changes in extracted data can occur over time due, for example, to updates and corrections made to the database.

Catch and effort extractions for all three species were generally consistent with extractions conducted for the 2014 assessment. However, some notable differences were apparent.

For yellowfin and bigeye, differences were found for the Philippines and Indonesia fleets (fisheries 19, 24 and 25). Some purse seine fisheries also showed minor differences to previous extractions although the extent of these differences was small.

For skipjack, the most notable differences were also associated with Indonesia and the Philippines. In addition the longline fisheries had catches fixed at 500 individuals for all years which precluded the calculation of catch multipliers.

Annual catch multipliers for 2013 and 2014 (see Tables 1, 2) were calculated for each fishery relative to the catch in 2012 in accordance with equation (1) below. Catch multipliers for 2014 were assumed to continue into 2015.

$$CM_{y,f} = \frac{\sum_q C_{y,q,f}}{\sum_q C_{2012,q,f}} \tag{1}$$

For some fleets where catches are very small, variability in annual catch can lead to very large catch multipliers, for example the 2014 yellowfin multiplier for fishery 32 for which catches in 2012 were very low. The overall impact of these large multipliers on the projections is very small. Even with the very large catch multiplier determined for 2014 the projected catch for this fleet is less than 0.006% of the total catch in that year.

A multiplier of 1 was assumed for each of the fisheries for which catch multipliers could not be calculated for 2013 due to data issues. Where a catch multiplier could not be determined for 2014, the 2013 multiplier was assumed to apply.

2.2 Running the Projections

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

- Projections were run from the reference case assessment model.
- Projections were run from 2012, the last year of the assessment, for 3 years.
- Projections were based on catch for all fisheries. The 2014 catch was assumed to apply in 2015. This is in contrast to Pilling et al. (2014) where conditions in purse seine and pole and line fisheries were projected based upon effort.
- 200 projections were performed for each stock.
- Variability in future recruitment was implemented by randomly re-sampling from the historical recruitment estimates over the period 2002-2011 (consistent with the period used to determine the limit reference point).
- 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 over the period of the projection was assessed relative to the agreed biomass limit reference point (LRP, 20% $SB_{F=0,2002-11}$), calculated consistent with the recommendations of SC9 (WCPFC, 2013).

3 Results

Future population trends from catch based projections of the reference case assessments (Figures 1, 2, and 3) are presented for each stock relative to the LRP. Corresponding probabilities of the adult biomass falling below, or increasing above the LRP in 2015 are summarized in Table 3.

3.1 Skipjack

Based on the assumption that 2014 skipjack catches by fishery continue to apply in 2015, the spawning stock biomass is expected on average to be maintained at levels similar to those estimated for 2012. Uncertainty in future recruitment produces a wide spread of potential spawning biomass levels in 2015. $SB_{2015}/SB_{F=0}$ was on average 0.52. Under the assumptions described in the methods, it is exceptionally unlikely (<1%) that the skipjack spawning stock biomass would fall below the LRP in 2015.

3.2 Yellowfin

Based on the assumption that 2014 yellowfin catches continue to apply in 2015, spawning stock biomass levels are expected to have increased slightly over time. $SB_{2015}/SB_{F=0}$ was on average 0.45. It is exceptionally unlikely (<1%) that the yellowfin spawning stock biomass would fall below the LRP in 2015.

3.3 Bigeye

Based on the assumption that 2014 bigeye catches continue to apply in 2015, spawning stock biomass levels are anticipated to have increased slightly in 2013 and 2014, and subsequently declined in 2015. Bigeye reach maturity at older ages than either skipjack or yellowfin and consequently recruitment variability during the projection period results in only a small spread of potential biomass in 2015. $SB_{2015}/SB_{F=0}$ was on average 0.17. Under the assumptions described above, it is highly likely (>99%) that the bigeye spawning stock biomass will remain below the LRP in 2015.

4 Discussion

The data used for the analysis are the most recent data currently available, however, catch and effort data for 2013 and 2014 are still considered preliminary and further updates are anticipated, particularly for 2014, as more catch records become available.

Recruitment variability affects each of the projections differently and has relatively little impact on the bigeye projections over the time period considered, as discussed above.

We invite the SC to consider the utility of such analyses to provide updated information on stock status in between stock assessments. We note that if short-term projections such as these are to be continued, structure within the recruitment time series, e.g., autocorrelation and seasonality may need to be included in projection dynamics.

Acknowledgements

The authors would like to acknowledge Peter Williams and Sam McKechnie for assistance with data extracts, Nick Davies for assistance with the projections, and Steven Hare for comments on the report.

References

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

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

Pilling, G. M., Harley, S., Davies, N., Rice, J., and Hampton, J. (2014). Status quo stochastic projections for bigeye, skipjack and yellowfin tunas. WCPFC SC10-SA-WP-06, 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.

WCPFC (2013). Report of the Scientific Committee ninth regular session. Summary report, Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean., Pohnpei, Federated States of Micronesia, 6–14 August 2013.

Table 1: Fishery based catch multipliers for 2013 and 2014 relative to 2012 for skipjack. Longline fisheries, which have catches fixed at 500 individuals for all years were fixed at a catch multiplier of 1 throughout the projection period.

			Skipjack		
fishery	method	flag	2012	2013	2014
1	PL	JP	1	0.82	0.25
2	PS	All	1	1.05	1.27
3	LL	JP	1	1.00	1.00
4	PL	JP	1	0.63	0.63
5	PS_ASS	All	1	1.30	1.10
6	PS_UNA	All	1	1.61	0.89
7	LL	JP	1	1.00	1.00
8	PL	ALL	1	0.76	0.76
9	PS_ASS	All	1	0.78	0.51
10	PS_UNA	All	1	0.89	0.79
11	LL	JP	1	1.00	1.00
12	PL	All	1	0.61	0.61
13	PS_ASS	All	1	0.69	1.23
14	PS_UNA	All	1	0.49	1.53
15	LL	JP	1	1.00	1.00
16	Dom	PH	1	1.22	1.47
17	Dom	ID	1	0.78	0.59
18	PS	IDID_PHPH	1	2.09	1.68
19	PL	All	1	0.87	0.79
20	PS_ASS	no(PHPH_IDID_ VN)	1	0.90	2.48
21	PS_UNA	no(PHPH_IDID_ VN)	1	3.22	5.03
22	DOM (!L)	VN	1	1.29	1.29
23	LL	JP	1	1.00	1.00

Table 2: Fishery based catch multipliers for 2013 and 2014 relative to 2012 for yellowfin and bigeye.

			Yellowfin			Bigeye		
fishery	method	flag	2012	2013	2014	2012	2013	2014
1	L	All	1	1.32	0.84	1	0.92	1.27
2	L	All	1	0.70	0.83	1	1.45	1.58
3	L	US	1	0.98	0.63	1	1.00	1.19
4	L	All	1	1.24	1.57	1	0.98	2.07
5	L	OS	1	0.85	1.25	1	0.79	1.19
6	L	OS	1	1.11	0.75	1	0.75	0.42
7	L	All	1	1.05	1.56	1	0.79	1.28
8	L	All	1	0.42	0.19	1	0.60	0.23
9	L	All	1	0.74	1.13	1	0.71	0.64
10	L	US	1	0.57	0.60	1	0.84	1.14
11	L	AU	1	0.84	1.24	1	0.87	0.95
12	L	All	1	0.57	0.52	1	0.92	0.44
13	L	All	1	0.94	1.19	1	0.79	0.42
14	S-ASS	All	1	1.84	1.49	1	1.44	1.13
15	S-UNA	All	1	1.09	0.68	1	1.18	1.13
16	S-ASS	All	1	0.85	1.08	1	0.96	1.18
17	S-UNA	All	1	0.18	0.92	1	0.10	0.81
18	Misc	PH	1	1.28	1.27	1	0.61	0.61
19	HL	ID-PH	1	0.84	1.74	1	0.71	0.71
20	S	JP	1	0.55	0.28	1	0.80	1.38
21	P	JP	1	0.78	0.61	1	0.97	0.97
22	P	All	1	0.60	0.60	1	0.64	0.64
23	P	All	1	0.86	0.86	1	0.01	0.01
24	Misc	ID	1	1.11	0.74	1	0.77	0.77
25	S	ID-PH	1	1.47	0.98	1	1.74	1.74
26	S-ASS	All	1	1.08	0.79	1	0.94	0.50
27	S-UNA	All	1	1.09	1.05	1	1.52	1.14
28	L	AU	1	1.20	1.60	1	0.62	1.59
29	P	All	1	0.60	0.66	1	1.00	1.00
30	L	All	1	1.00	1.00	1	1.00	1.00
31	S-ASS	All	1	0.19	0.98	1	0.55	0.40
32	S-UNA	All	1	0.54	62.41	1	1.10	6.20
33	Misc	VN	1	1.12	1.12	1	0.87	0.87

Table 3: Median SB/$SB_{F=0,2002-11}$ for skipjack, yellowfin and bigeye in 2012 and 2015 (5th and 95th percentiles shown in brackets) and the probability of SB_{2015} less than $SB_{F=0}$ in 2015.

	Median $SB/SB_{F=0}$		$P(SB_{2015} < SB_{F=0})$
	2012	**2015**	**2015**
Skipjack	0.51	0.52 (0.40 – 0.64)	<1%
Yellowfin	0.38	0.45 (0.35 – 0.58)	<1%
Bigeye	0.16	0.17 (0.16 – 0.18)	>99%

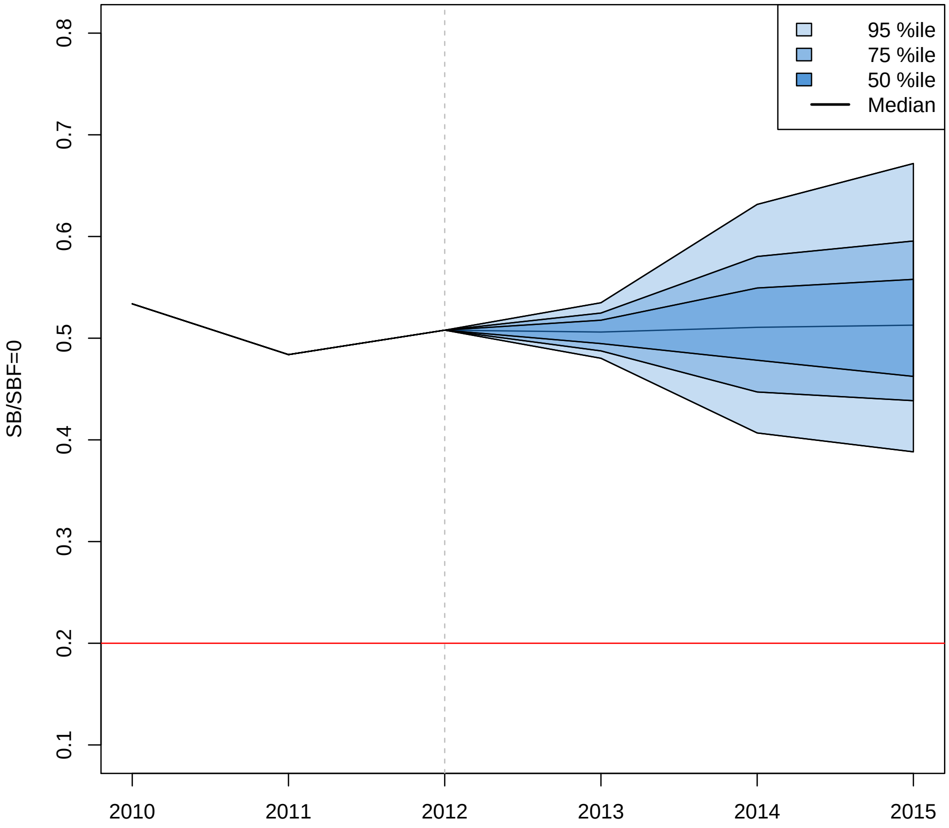

Figure 1: Skipjack spawning stock biomass trajectory expressed relative to the average unexploited spawning stock biomass between 2002-11 (equivalent to the limit reference point). The population is projected forward from the last assessment year (2012) with future recruitment sampled from actual recruitment over the 2002-11 period. The horizontal red line indicates the biomass limit reference point (20% $SB_{F=0,2002-11}$).

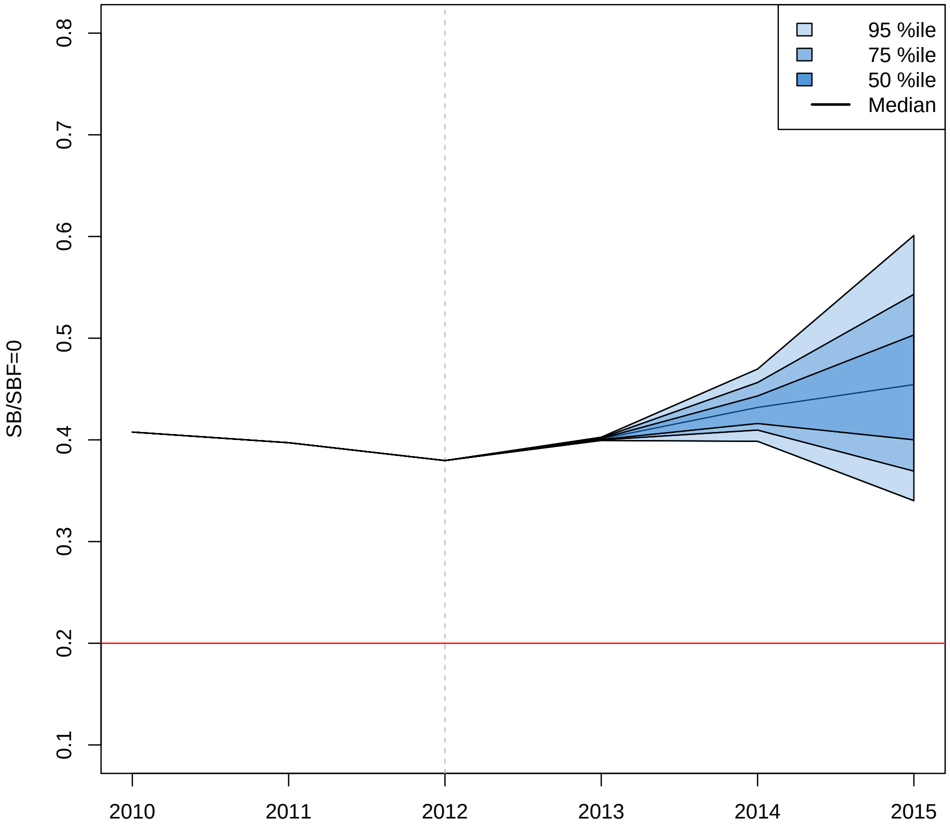

Figure 2: Yellowfin spawning stock biomass trajectory expressed relative to the average unexploited spawning stock biomass between 2002-11 (equivalent to the limit reference point). The population is projected forward from the last assessment year (2012) with future recruitment sampled from actual recruitment over the 2002-11 period. The horizontal red line indicates the biomass limit reference point (20% $SB_{F=0,2002-11}$).

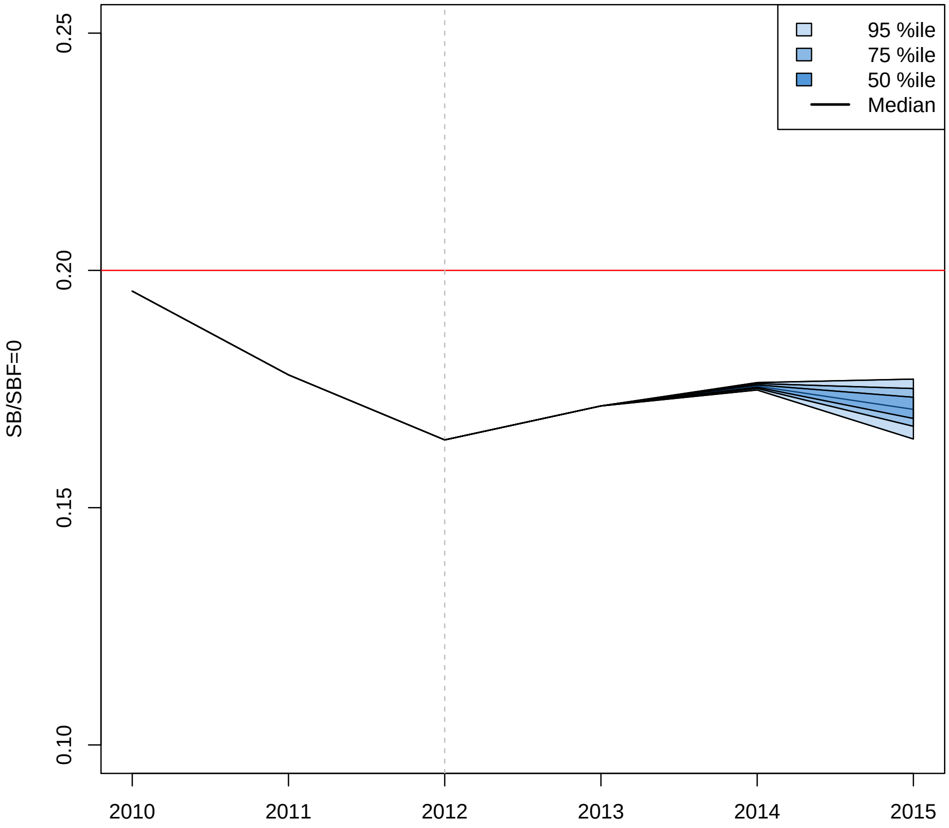

Figure 3: Bigeye spawning stock biomass trajectory expressed relative to the average unexploited spawning stock biomass between 2002-11 (equivalent to the limit reference point). The population is projected forward from the last assessment year (2012) with future recruitment sampled from actual recruitment over the 2002-11 period. The horizontal red line indicates the biomass limit reference point (20% $SB_{F=0,2002-11}$).