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Projections based on the 2011 stock assessments

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Oceanic Fisheries Programme – SPC

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Summary

This paper provides a brief overview of the generic forward projections that were undertaken using the reference case models for the 2011 assessments for bigeye, skipjack, and yellowfin tunas. These models were adopted by SC7 for the provision of management advice. Similar methods were used as in previous years and the results are provided in the form of an excel spreadsheets with a separate worksheet for each species. Of particular interest from the projections is that maintenance of bigeye tuna catch and effort levels observed in the fishery in 2009 results in F/F_{MSY} remaining high and is at a projected level of 1.39 in 2021. However, for the scenario best approximating the reported catch and effort in the fishery in 2010, F/F_{MSY} declines and is at a projected level of 0.97 in 2021. For scenarios that mimic a total purse seine closure, there is a relatively small incremental reduction in F/F_{MSY} compared to that achieved by a FAD closure. However, this comes at a cost of substantial reductions in total catch.

Introduction

The results from forward projections of stock status based upon stock assessment models outputs have formed one of the pieces of information used by the Commission to inform management decisions. In this paper we present projection results based on the 2011 stock assessments of bigeye, skipjack and yellowfin tuna within the WCPO, as requested by SC7. We provide an overview of the basic methodology employed and the key assumptions made. Some key results are also discussed, but the full set of results are not described in detail within this paper – they are provided in an accompanying excel spreadsheet.

Methods

Similar assumptions were made in the current projections as in previous analyses (e.g. OFP 2010). The main assumptions were:

- The reference case model from each stock assessment was used[1] - these models were those adopted by SC7 for the provision of management advice;
- The projections were deterministic in that no process or estimation error was assumed;
- The projections were run for ten years after the full implementation of CMM2008-01, i.e. from 2012-2021;

[1] See SA-WP-2 (bigeye), SA-WP-03 (yellowfin), and SA-WP-04 (skipjack) for further information

- Two sets of results were generated for two hypotheses regarding future recruitment: (1) recruitment was assumed to occur at the average of the level estimated over the period 2000-2009, as recommended by SC6; and (2) recruitment was assumed to occur according to the stock-recruitment relationship estimated/assumed in the reference case assessments. There are separate spreadsheets available for each of these recruitment hypotheses. In this paper, we refer only to the first hypothesis (recent average recruitment).
- 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 projections started from the beginning of 2012, after the final year of reductions in fishing impact under CMM2008-01, allowing the investigation of management options following on from that CMM's implementation. A key assumption was the levels of catch and effort for 2011 and we assumed that the levels of catch and effort reported in 2010 would continue through to 2011. For the projection period of 2012-2021, we chose 2009 as the base year rather than 2010 (as recommended by SC7) for several reasons: a) there is considerable uncertainty in reported longline catches for 2010, and final estimates are not yet available for some key fleets; b) the proportion of total purse seine effort that was based on FADs was abnormally low in 2010 and there is uncertainty as to whether this change in behaviour will persist into the future; and c) the use of 2009 means that results are more comparable to the previous analysis (OFP 2010) which also used 2009 as a base. However we stress that the choice of base year is not critical for the projections, as a wide range of catch/effort levels are explored in the various scenarios. The choice of 2009 as the base year simply means that all other catch or effort levels used in the projections are expressed relative to their respective levels in 2009. For each species, catch was used in projections for all longline fisheries and the fisheries in Indonesian and Philippines archipelagic waters, while effort was used for all others. The SC7 request, along with our comments and explanations for deviating from the request, are provided in Appendix 1.

For the generic projections, we applied catch or effort scalars (i.e. multipliers of the 2009 base values) to each of the (grouped) longline fisheries, purse seine fisheries, Indonesia and Philippines domestic fisheries and other fisheries (predominantly non-Indonesian pole-and-line and purse seine fisheries outside of 20^{o}N – 20^{o}S). The overall design of the projections is shown in Table 1.

The application of the catch or effort scalars for the respective fishery groups shown in Table 1 in all possible combinations resulted in 768 (8x8x2x2x3) projection scenarios for each of bigeye and yellowfin tuna, and 96 (8x2x2x3) projection scenarios for skipjack (there are no commercially significant longline fisheries in the skipjack assessment, so this factor is omitted). The actual levels of catch and effort corresponding to the various scalars, and their observed values from 2001 to 2010 are shown in Table 2.

Two scenarios for the application of scalars to purse seine effort were modeled in the projections. In the first (denoted “transfer”), the scalars for the purse seine fishery were applied to the associated set effort, and the effort so removed (added) was added to (subtracted from) the unassociated set effort. This maintained total purse seine effort at a constant level and is intended to mimic the use of FAD closures with complete mobility of effort between set types. In the second scenario (denoted “managed”), the same scalars were applied simultaneously to both the purse seine associated set and unassociated set effort. This was intended to mimic a total purse seine closure measure, or other control on total purse seine effort that maintains the same composition of associated and unassociated sets in the total purse seine effort.

Performance statistics for all projections included F_{2021}/F_{MSY}, total estimates of spawning biomass, and catches for different fisheries groups. Because of the use of recent average recruitment in the projections, the historical estimates of SB_{MSY} and SB_0 are no longer valid, especially when there is a considerable difference between the recent average recruitment level and the long-term average level (e.g. in the bigeye tuna assessment). In this circumstance, a depletion estimate ($SB_y/SB_{F=0}$) would be more appropriate and this is included in the spreadsheet columns labeled “SB2021_SBF0”. Also included are the spawning biomass per recruit (SPR) reference points recommended by SC7 at three alternative levels of SPR depletion – 20%, 30% and 40% of unfished levels. These are provided in the spreadsheet columns labeled “spr20”, “spr30” and “spr40”. The values provided are the ratios of the fishing mortality in 2021 to the fishing mortality that results in reduction of SPR to 20%, 30% and 40% of unfished levels.

Results and Discussion

Projection of 2009 and 2010 conditions

Figures 1-3 show the projected values of F/F_{MSY} for each species for the base (2009) conditions and an approximation to 2010 conditions (given by scenario (0.8, 0.7, 1.34, 0.7, 1.2) for bigeye and yellowfin and scenario (1, 0.7, 1.32, 0.7, 1.2) for skipjack. Maintenance of 2009 conditions results in F_{2021}/F_{MSY} of 1.39, 0.5 and 0.74 for bigeye, skipjack and yellowfin tuna respectively. For the scenario approximating 2010 conditions as currently reported, we obtain F_{2021}/F_{MSY} of 0.97, 0.47 and 0.62 for bigeye, skipjack and yellowfin tuna respectively. Therefore, 2010 as currently reported (see Table 2) provides a good example of the sort of regime that would meet MSY-based reference points as have been applied to date. In addition, under 2010 conditions, F_{2021} for bigeye is projected to be less than the SPR20 and SPR30 reference levels but above the SPR40 level. For skipjack and yellowfin, F_{2021} is well below all of the SPR reference levels.

Total purse seine closure vs FAD closure

It is of interest to some Delegations to quantify the incremental advantage of a total closure of the purse seine fishery over a FAD closure. We investigated this by comparing the “transfer” and “managed” options for purse seine effort reductions (equivalent to FAD and total closures, respectively), both in terms of their impact on bigeye tuna (F_{2021}/F_{MSY}) and on the total catch of bigeye, skipjack and yellowfin tuna (Table 3). The results indicate small percentage reductions in bigeye tuna F_{2021}/F_{MSY} by applying a total closure instead of a FAD closure. For example, for a 6 month closure, F_{2021}/F_{MSY} is 0.98 for a FAD closure and 0.88 for a total closure, representing an incremental 10.3% reduction in F_{2021}/F_{MSY} of a 6 month total closure over a 6 month FAD closure. However, the incremental reduction in total catch of a 6 month total closure is 22.2%. This is because, with a FAD closure, purse seiners can continue to fish on unassociated tuna schools, whereas with a total closure, the catch during the closure is zero. Interestingly, the projections predict that total catch is quite stable (and in fact increases slightly) for increasing duration of FAD closure. This is because of the higher yield per recruit that is achieved for all species resulting from the larger average size of tuna taken in unassociated sets compared to FAD sets (Hampton and Williams 2011). On the other hand, total catch drops sharply for increasing total closure duration. Therefore, it can be concluded that a total closure results in a small incremental reduction in bigeye tuna fishing mortality compared to a FAD closure, but the price that must be paid in terms of total catch reduction is relatively large.

Effect of exemptions

In a previous analysis (OFP 2010), we attempted to quantify the impact of the exemptions on the performance of CMM 2008-01. In this analysis, it was argued that scalars of 1.0 for longline catch, 1.0 for purse seine effort and 0.9 for the fisheries based in Indonesia and Philippines were consistent with CMM 2008-01 as written. Further, a hypothetical "no exemptions" set of scalars was estimated to be 0.9, 0.9 and 0.8, respectively for the above three fishery groups. Using these scalars in the current analysis (and retaining a scalar of 1.0 for other fisheries in both scenarios), we obtain the following results:

Fishery group	CMM 2008-01	No exemptions
Scalars		
Longline	1.0	0.9
Purse seine	1.0	0.9
Indonesia and Philippines domestic	0.9	0.8
Other fisheries	1.0	1.0
Bigeye F_{2021}/F_{MSY}	1.35	1.17

Therefore, the removal of the exemptions is estimated to potentially remove approximately 50% of the overfishing estimated to occur under CMM 2008-01. This is a similar result to that obtained in OFP (2010).

References

Hampton, J. and P. Williams. 2011. Analysis of purse seine set type behavior in 2009 and 2010. WCPFC-SC7-MI-WP-01.

OFP. 2010. Review of the implementation and effectiveness of CMM2008-01. WCPFC7-2010/15 (rev 1).

Williams, P. 2011a. Problems with longline aggregated catch and effort data submitted by China. WCPFC-SC7-ST-IP-03.

Williams, P. 2011b. Changes to the data available for stock assessment. WCPFC-SC7-SA-IP-04.

Williams, P. and P. Terawasi. 2011. Overview of tuna fisheries in the western and central Pacific Ocean, including economic conditions – 2010. WCPFC-SC7-GN-WP-1.

Table 1. Combinations of catch and effort used for fishery groups modelled in the projections.

Factor	Options	Dimensions
Longline catch	1.2, 1.1, 1.0, 0.9, 0.8, 0.7, 0.6, and 0.5 times **2009** catches	8
Purse seine FAD effort 20N - 20S	1.2, 1.1, 1.0, 0.9, 0.8, 0.7, 0.6, and 0.5 times **2009** effort	8
Purse seine UNA effort 20N - 20S	Identical reduction as for FAD effort and perfect reallocation of FAD effort changes	2
Indonesia & Philippines domestic fisheries	1 and 0.7 times **2009** catch	2
Other fisheries (Pole and line, and purse seine outside 20N - 20S)	1.2, 1.0, and 0.8 times **2009** effort	3
TOTAL RUNS		768

Table 2. Catch and effort levels of projected fishery groups associated with the various scalars. The two columns for purse seine unassociated (PS UNA) effort refer to the alternative projection scenarios: 1. ASS effort changes are transferred to UNA effort, thus maintaining total PS effort at a constant level (transfer); and 2. The same scalars are simultaneously applied to both PS ASS and PS UNA effort (managed). The observed values of catch and effort for the projected fishery groups for 2001-2010 are provided in the lower panel. Note that catches are reported for 'Other' fisheries to indicate their relative contribution to the overall fishery; in the projections, effort was specified rather than catch.

Scalar/ Year	Longline catch (mt)		PS ASS effort	PS UNA effort (transfer)	PS UNA effort (managed)	Indonesia-Philippines catch (mt)			Other catch (mt)		
	Bigeye	Yellowfin	(days)	(days)	(days)	Bigeye	Yellowfin	Skipjack	Bigeye	Yellowfin	Skipjack
1.2	80,200	92,674	30,646	17,405	27,016				2,046	7,236	103,466
1.1	73,516	84,951	28,092	19,959	24,764						
1.0	66,833	77,228	25,538	22,513	22,513	17,777	142,085	392,295	1,705	6,030	86,222
0.9	60,150	69,505	22,984	25,067	20,262						
0.8	53,466	61,782	20,430	27,621	18,010				1,364	4,824	68,978
0.7	46,783	54,060	17,877	30,174	15,759	12,444	99,460	274,606			
0.6	40,100	46,337	15,323	32,728	13,508						
0.5	33,417	38,614	12,769	35,282	11,257						
2001	62,080	66,717	15,714	17,501		15,842	139,692	256,630	2,326	5,307	187,817
2002	79,267	69,526	18,633	17,875		13,550	140,803	275,630	2,992	5,199	175,217
2003	71,488	74,748	20,292	18,829		14,907	154,612	284,983	2,302	6,118	225,645
2004	80,193	75,300	29,177	12,932		15,385	158,754	297,347	4,161	5,162	142,558
2005	66,213	66,893	23,087	20,299		18,552	175,458	297,568	1,788	6,491	195,976
2006	70,819	62,677	24,208	16,628		19,272	170,310	350,973	4,849	6,369	158,185
2007	69,872	58,915	21,870	20,924		14,791	186,763	368,893	3,767	4,391	152,345
2008	73,314	60,526	23,332	22,749		17,866	180,175	396,051	1,845	7,203	140,778
2009	66,833	77,228	25,538	22,513		17,777	142,085	392,295	1,705	6,030	86,222
2010	55,420	78,313	17,415	33,739		11,897	112,569	324,661	2,432	4,119	109,596

Table 3. Effect on F2021/FMSY and total catch of FAD only and total purse seine closures of different durations. The columns labeled "Increment (%)" provide the percentage change of a total closure over a FAD closure. Catch levels for the longline, Indonesia-Philippines and other fisheries were held at the base level (scalar = 1.0).

Scalar	Closure duration (months additional to 2009 closure)	Bigeye F_{2021}/F_{MSY}			Total catch (mt)		
		FAD closure	Total closure	Increment (%)	FAD closure	Total closure	Increment (%)
1.0	-	1.39	1.39	-	2,357,314	2,357,314	-
0.9	1.2	1.31	1.29	-1.4	2,366,335	2,284,568	-3.5
0.8	2.4	1.23	1.19	-3.1	2,375,026	2,201,002	-7.3
0.7	3.6	1.14	1.09	-5.1	2,383,381	2,104,842	-11.7
0.6	4.8	1.06	0.98	-7.5	2,391,384	1,993,985	-16.6
0.5	6.0	0.98	0.88	-10.3	2,399,029	1,865,933	-22.2

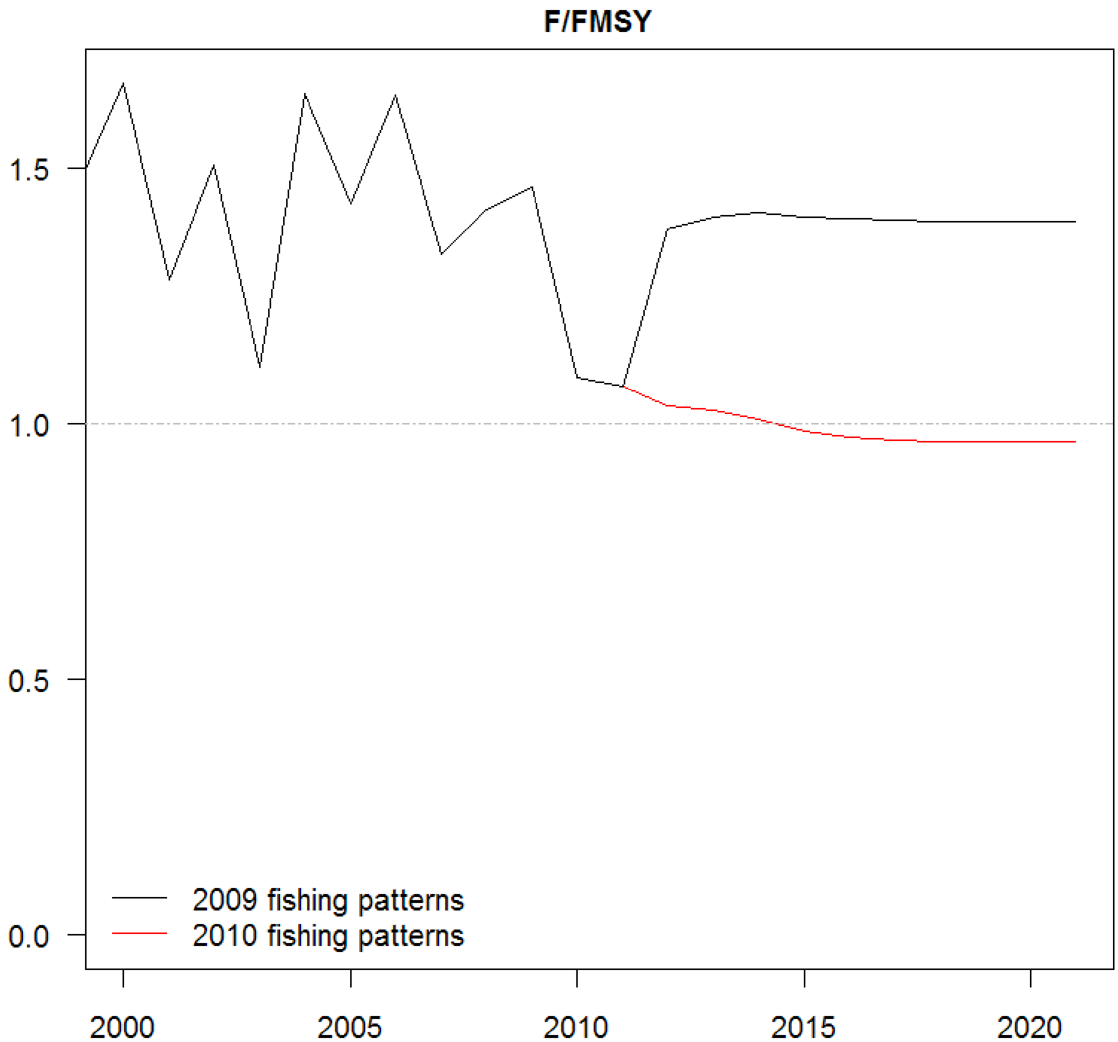

Figure 1: Recent historical and projected F/F_{MSY}, for bigeye tuna under the status quo projections for each recruitment hypothesis

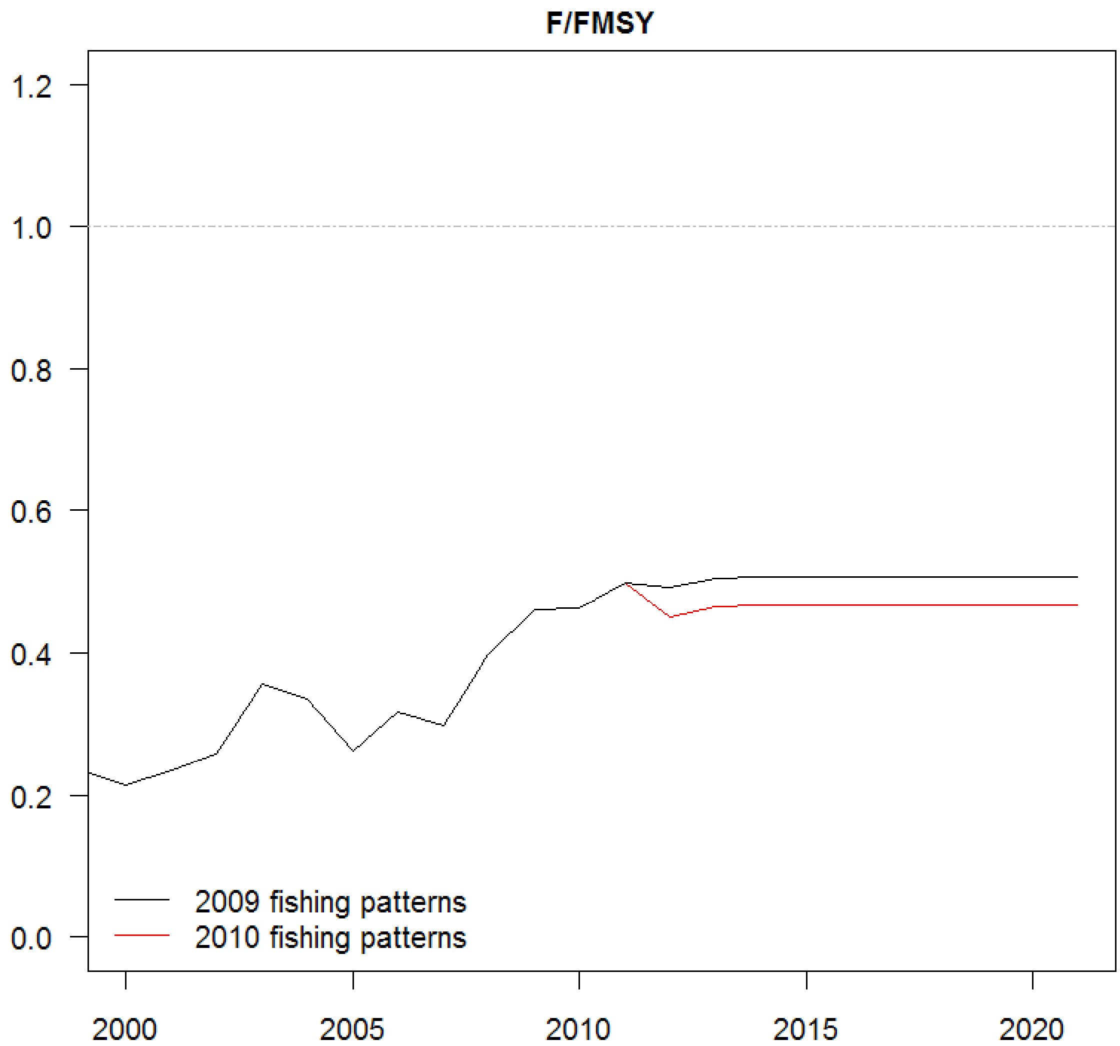

Figure 2: Recent historical and projected F/F_{MSY}, for skipjack tuna under the status quo projections for each recruitment hypothesis

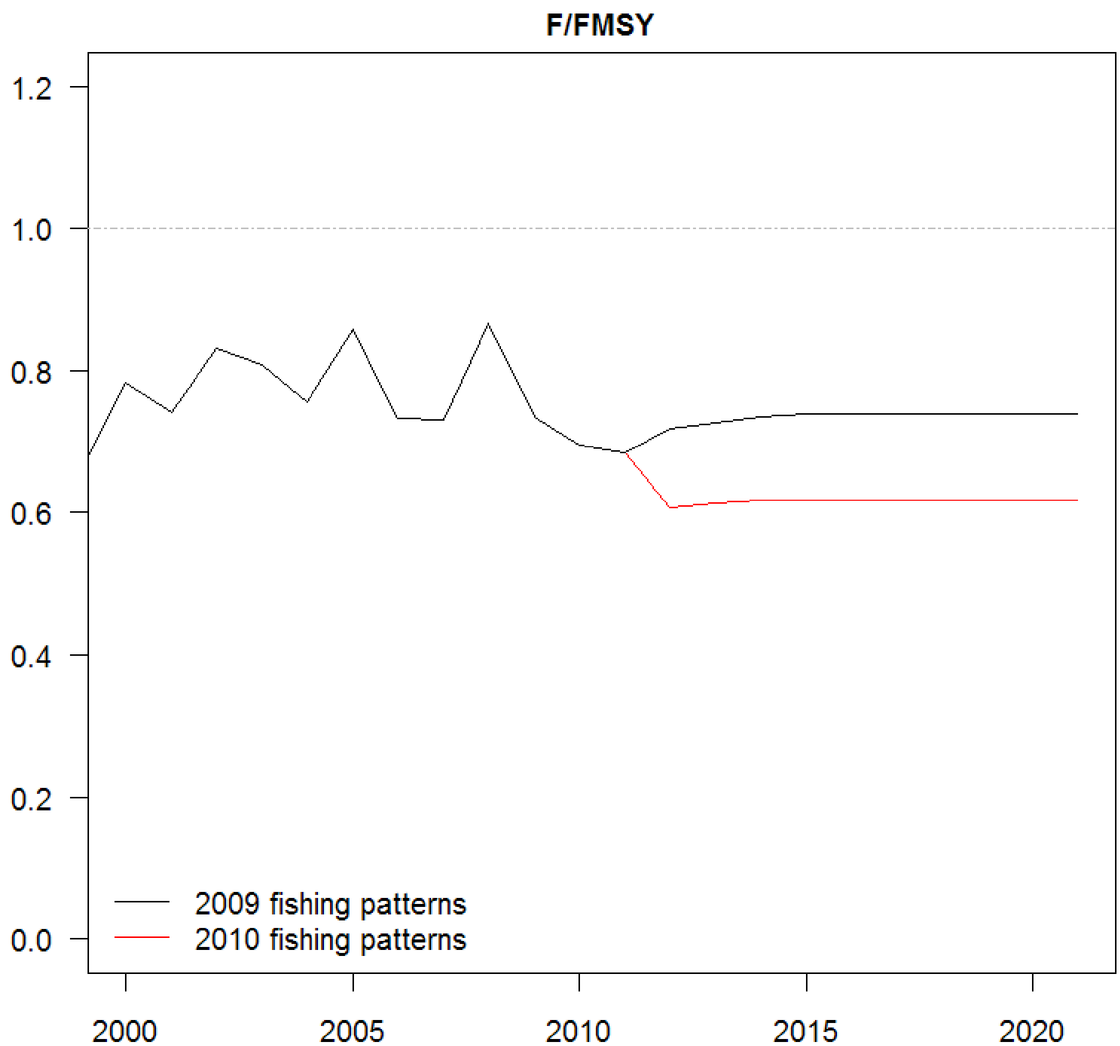

Figure 3: Recent historical and projected F/F_{MSY}, for yellowfin tuna under the status quo projections for each recruitment hypothesis

APPENDIX 1. Comments on the SC7 Projections Request

The request from SC7 for analyses to be presented to TCC7 and WCPFC8 was summarized in paragraph 365 of the SC7 report.

The 24,000 runs equated to over 30 days of continuous model runs – excluding the time taken to compile the results in tables etc. In order to have results available for TCC, and recognizing that some scenarios can be approximated by either specific sets of scalars or through linear interpolation, some minor changes were made and are described in the comments section of the table.

No stochastic projections have been possible at this stage.

Factor	**Options**	**Dimensions**	**Comments**
Model runs	Base case model	1	Done as requested
Species	BET, SKJ, YFT	3	Done as requested
Recruitment	Recent average and SRR	2	SRR runs were done, and a separate spreadsheet supplied, but the results are not referred in the paper
Longline catch	1.2, 1.1, 1.0, 0.9, 0.8 times 2010 catches	5	Due to the considerably uncertainty around the 2010 catch estimates we preferred to use 2009, but included a wider range of scalars (0.5 – 1.2; 8 levels). However, 2010 is approximated by a longline scalar of 0.8. Longline variations were not required for skipjack.
Purse seine total effort (excl. ID/PH ex-APW)	2009 (low); 2010 (high)	2	We used 2009 effort levels of total effort with a wider range of scalars (0.5 – 1.2; 8 levels). FAD effort was either transferred to UNA effort (to simulate a FAD closure) or UNA effort had the same scalar applied (to simulate a total closure). 2010 FAD effort is consistent with a scalar of 0.7.
FAD/UNA set effort split (outside FAD closure)	2009 (high FAD use); 2010 (low FAD use)	2	
Purse seine FAD effort (including ID/PH ex-APW)	1.2, 1.1, 1.0, 0.9, 0.8, times total effort (with redistribution)	5	
ID/PH APW fisheries	2009 and 2010 catch	2	We used 2009 catches with scalars of 1 and 0.7 – the latter approximated 2010 catches.
Other fisheries (e.g. Pole and line and JP coastal PS)	1.2, 1.1, 1.0, 0.9, 0.8 times 2010 effort	5	Initial projections results were relatively insensitive so only scalars of 1.2, 1.0, and 0.8 were used. 2009 was used as the base.