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Evaluation of CMM 2013-01

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Overview

CMM 2013-01 has the stated objective that "bigeye, yellowfin and skipjack tuna stocks are, at a minimum, maintained at levels capable of producing their maximum sustainable yield as qualified by relevant environmental and economic factors including the special requirements of developing States …". In addition, the CMM states that the level of fishing mortality on these stocks "will be maintained at a level no greater than F_{MSY}, i.e. $F/F_{MSY} \leq 1$."

To achieve these objectives, the CMM comprises a number of individual measures to be implemented over the period 2014-2017. The measures of substance for the purpose of this evaluation comprise:

- Seasonal FAD closures, or annual FAD set limits;
- A FAD closure on the high seas (or verifiable reductions in purse seine bigeye catch) (from 2017);
- Purse seine effort restrictions in EEZs to historical levels – 2010 for PNA countries; 2010 or 2001-2004 average for non-PNA countries with purse seine effort exceeding 1,500 days annually over the period 2006-2010; and self-declared EEZ purse seine limits for all other countries;
- Specified purse seine effort limits for non-SIDS for the high seas; and
- Flag-based longline bigeye catch limits – for flag states that caught >2,000 mt of bigeye in 2004, the limits are specified (China, Indonesia, Japan, Korea, Chinese Taipei and United States). Non-SIDS that caught <2,000 mt of bigeye in 2004, are limited to 2,000 mt (Australia, EU, New Zealand, Philippines. The domestic fleets of SIDS are exempted from this measure.

This paper aims to:

1. Estimate in simple terms the levels of associated (ASS) and unassociated (UNA) set purse seine effort and longline bigeye catch that would result from adherence to the CMM. This estimation requires a number of simplifying assumptions that are detailed in the paper. Since our evaluation uses long-term indicators, we estimate the levels of catch and effort resulting from the full (as at 2017) implementation of the CMM and assume that these would be in place thereafter.
2. Express these levels of purse seine effort and longline bigeye catch as scalars relative to observed (or reported) levels of these quantities for 2012.
3. Use the estimated purse seine effort and longline catch scalars in bigeye tuna stock projections to evaluate the outcomes in relation to the stated objectives of the CMM regarding bigeye tuna. The main indicators used are the spawning biomass at the end of the 20 year projection in relation to the average unfished level in 2002-2011 ($SB_{2032}/SB_{F=0}$, and specifically in relation to the agreed limit reference point of 0.2) and the fishing mortality at the end of the projection period in relation to the fishing mortality at maximum sustainable yield (F_{2032}/F_{MSY}). The outcomes of the CMM for skipjack and yellowfin tuna are not covered explicitly in this paper, but are dealt with elsewhere.

The key findings are that

- If future recruitment remains on average consistent with recent (2002-2011) levels, the CMM will reduce the risk of the spawning biomass falling below the limit reference point (LRP) to 4%,

relative to the status quo (2012) risk of 32%, and will reduce the median level of fishing mortality to approximately the MSY level.

- If future recruitment occurs at a lower level consistent with the long-term estimates, the CMM will reduce the risk of breaching the LRP, but the reduced risk (74%) is still high. Also, the CMM will reduce the level of fishing mortality, but it would remain above the MSY level.
- It is suggested that, for the purpose of evaluating the CMM and any proposed alternatives, the Commission focus on the recent recruitment projection scenarios, as recommended by SC6.

Evaluation approach

Estimating purse seine effort and longline catch levels consistent with CMM 2013-01

Undertaking a quantitative evaluation of the outcomes of CMM 2013-01 requires some interpretation of the text of the CMM in order to estimate the most likely resulting purse seine effort and longline catch levels that would result. The following table outlines the approach that has been taken in relation to the relevant paragraphs of the CMM. Since we are evaluating the long-term impact of maintaining the measures of the CMM using equilibrium indicators, it is appropriate just to consider the final form of the measures (i.e., 2017) and assume that this is maintained into the future.

Relevant paragraphs of CMM 2013-01	Evaluation Approach
Objectives	
1	We use the spawning biomass depletion ratio, SB/SBF0, since this is the metric of the limit reference point (LRP) formally adopted by WCPFC (0.2SBF0). Projections are run to equilibrium over 20 years. The indicators are for the end of this period.
3	F_{MSY} is also a performance indicator.
Area of application	
11	The area of application does not include archipelagic waters (AW). The evaluation will necessarily be for the WCPO rather than the WCPFC Convention Area because of the structure of the assessment models.
12	No guidance is given regarding level of AW reductions; we assume 2012 levels of effort will continue.
Overlap area	
13	The catch and effort data used in tropical tuna assessments do NOT include activities in the overlap area. Therefore, the evaluation of the measure is for the WCPO not the WCPFC Convention Area. This will not significantly impact the results of the evaluation.
FAD set management	
14-17	A FAD closure of 4 months in 2014 (Jul-Oct). FAD set restriction in lieu of 4th month has been chosen only by Japan, FSM and Kiribati. There is an additional 2 month closure from 2015 (Jan-Feb) and October drops off as a closure month, however implementation of this measure is conditional upon WCPFC11 agreeing to arrangements to ensure that a disproportionate burden on conservation action is not transferred onto SIDS. Since we are interested in long-term performance, we do not evaluate the effect of transitional measures, just the final (2017) total measure. Also, the alternative year-round FAD-set limit that can be chosen in lieu of the Jan-Feb closure for simplicity is assumed to be equivalent in effect (if any CCM choses this) to the closure. We assume therefore that the long-term measure is equivalent to a 5 month (Jan-Feb, Jul-Sep) FAD closure.
18	The high seas FAD closure scheduled for introduction in 2017 could result in some reduction in purse seine FAD effort; however it is difficult to say to what extent this will occur.
19	As noted above, we do not attempt to explicitly model FAD set limits. We assume recent average ASS/UNA mix, and that FAD closures adopted by everyone will be equivalent in effect to a small number of CCMs opting for FAD set measures.
Purse seine effort control	
20-27	For simplicity, we assume that purse seine total effort in EEZs and high seas will be as per 2010, which represents a substantial decrease on 2013 (and likely 2014). This assumption means that we

	do not expect EEZs where purse seine effort has been less than 1500 days annually over 2006-2010 to suddenly attract a lot of effort. Effort in AW is assumed to be as per 2012.
Longline fishery – bigeye catch limits	
40-42	Longline catch limits are not completely specified. We have assumed that those fleets with specified limits in excess of 2,000 mt will take those limits and all other fleets will continue to operate at 2012 levels.
Other commercial fisheries	
46-48	There are neither estimates of capacity nor effort for the majority of fisheries in this category; therefore, we assume continuation of 2012 catch levels.
Capacity management	
49-55	Not relevant to the evaluation, assuming that total effort and catch measures are adhered to.

Estimation of scalars for purse seine associated effort and longline catch

For **purse seine effort**, it is estimated that the extension of the FAD closure to 5 months would reduce 2012 ASS purse seine effort by a factor of **0.78**. In other words, it is estimated that the amount of purse seine ASS effort allowed by the CMM is 78% of the 2012 level of purse seine ASS effort. It is further assumed that UNA purse seine effort would rise by an amount equivalent to the ASS decrease, thus maintaining the total amount of purse seine effort at the 2012 level (which is very close to the 2010 level). Embedded in this calculation is the assumption that purse seine ASS effort in archipelagic waters would remain at the 2012 level since it is beyond the scope of the measure. We note that the adoption of the Jan-Feb FAD closure in addition of the Jul-Sep closure in conditional on a decision by WCPFC11, and so it is not certain to be implemented. If it is not, then the 2014 arrangements of a Jul-Sep closure, plus an Oct closure or flag-based annual FAD set limits, will continue. If this occurs, then the extent of reduction in purse seine ASS effort will have been over-estimated by the 0.78 scalar. On the other hand, we have not attempted in this evaluation to model the high-seas FAD closure scheduled for introduction in 2017. This could result in some reduction in purse seine FAD fishing if such activity is not simply transferred into EEZs. If such a reduction does result from this measure, then the extent of reduction in purse seine ASS effort may be somewhat under-estimated by the 0.78 scalar.

For **longline catch**, we assume that the catches of those fleets having 2,000 mt limits and the fleets of SIDS for which no limits are defined by the CMM, are continued at their 2012 levels. Catches by Vietnam are included in the 2014 bigeye tuna stock assessment, but are not limited by the CMM due to the uncertain status of the South China Sea in the WCPFC Convention. The reported 2012 catch by Vietnam of 3,761 mt is assumed to continue. Under these assumptions, the longline catch would be reduced to 87% of the 2012 catch, therefore the scalar is **0.87**. It is noted that flag States with longline catches of bigeye of less than 2,000 mt could increase to this level and remain compliant with the CMM. Also, SIDS longline fleets are currently unrestricted and could increase to any level under the CMM. If either of these things should occur, then the extent of reduction of longline catch will be over-estimated by the 0.87 scalar.

For all other fisheries, it is assumed that 2012 catches are continued into the future.

Projections

The analysis of the impact of the potential reductions of purse seine ASS effort and longline catch is conducted using the full uncertainty framework approach endorsed by SC10, i.e.

- Projections are conducted using 9 separate model runs, and weighted as per the decision of SC10:

Run name	Model Description	Relative weight
037_L0W0T0M0H0	Reference case	1.0
038_L0W0T0M0H1	Low steepness	0.8
039_L0W0T0M0H2	High steepness	0.8
043_L0W0T1M0H0	Fast mixing	0.8
044_L0W0T1M0H1	Fast mixing | low steepness	0.64
045_L0W0T1M0H2	Fast mixing | high steepness	0.64
049_L0W0T2M0H0	Exclude Coral Sea	1.0
050_L0W0T2M0H1	Exclude Coral Sea | low steepness	0.8
051_L0W0T2M0H2	Exclude Coral Sea | high steepness	0.8

- For each model run, 200 projections are run for the estimated purse seine ASS effort and longline catch provisions of CMM 2013-01. The outputs of the projections – $SB_{2032}/SB_{F=0}$ and F_{2032}/F_{MSY} – are combined across the 9 model runs, weighted as shown in the table above.
- Future recruitment in the projections is determined by randomly sampling from either (i) the 2002-2011 recruitment deviations from the stock-recruitment relationship estimated in the 2014 assessment model runs shown in the table above; or (ii) the 1962-2011 recruitment deviations from the stock recruitment relationship estimated in the 2014 assessment model runs. These alternatives have previously been shown to have quite different projection outcomes (Pilling et al. 2014), with alternative (i) effectively assuming that the above-average recruitment conditions of the past 10 years will continue into the future, and alternatively (ii) assuming that the long-term average recruitment conditions, which are lower than in the past 10 years, will determine future recruitment. The outcomes from both of these future recruitment hypotheses are presented.

Results

Figure 1 shows the aggregate distributions of the reference point variables in 2032 for both the status quo (2012) and the purse seine ASS effort and longline catch assumed to occur under CMM 2013-01, under the hypothesis that future recruitment remains on average consistent with 2002-2011 conditions. The impact of the CMM conditions is apparent by shifting of the $SB_{2032}/SB_{F=0}$ distribution to the right towards higher relative biomass levels and shifting of the F_{2032}/F_{MSY} distribution to the left, towards lower fishing mortality. Under this future recruitment hypothesis, the risk of breaching the LRP is reduced from 32% to 4% (Table 1) and the median value of $SB_{2032}/SB_{F=0}$ increased from 0.24 to 0.31 (Table 2). The probability of fishing mortality exceeding F_{MSY} is reduced from 72% under the status quo to 48% under CMM 2013-01 (Table 1) while the median F_{2032}/F_{MSY} is reduced from 1.21 to 0.99 (Table 2).

Figure 2 shows the same set of distributions, but under the alternative hypothesis that future recruitment remains on average consistent with long-term (1962-2011) conditions. In this case, the impact of the CMM is also evident, with the biomass and fishing mortality distributions shifted to higher and lower levels of biomass and fishing mortality, respectively. However, while the risk of breaching the

LRP is reduced (from 94% to 74% - Table 1) it still remains high, with the median value of $SB_{2032}/SB_{F=0}$ increased from 0.08 to 0.15 (Table 2). Also, the CMM would reduce the median F_{2032}/F_{MSY} from 1.91 to 1.44 (Table 2), i.e., it would remain above the MSY level.

Discussion

CMM 2013-01 has been evaluated using stochastic projections (incorporating random variation of future recruitment from assumed distributions) across a range of weighted models as agreed by SC10. This approach is superior to the previous approach of evaluating management measures using deterministic projections for just a base-case model because it incorporates the essential elements of uncertainty and can thus express the results in the form of a risk assessment (consistent with the Kobe 2 Strategy Matrix approach).

Two main difficulties were encountered in evaluating the CMM. First, it is not possible to define precisely what levels of purse seine effort and longline catch will result from the CMM. There are a numbers of "either/or" choices, exemptions or exclusions and decisions yet to be made with respect to some measures that make it impossible to predict the outcomes in terms of actual future catch and effort levels. We have made hopefully sensible assumptions, but there is obviously no certainty that they are correct.

The second difficulty encountered is the very different outcomes that are obtained for the different underlying assumptions of how future recruitment might occur. The assumption that future recruitment will generally be consistent with recent (2002-2011) levels indicates that the CMM will reduce the risk of spawning biomass falling below the agreed LRP of 0.2 $SB_{F=0}$ to an acceptable level of 4%. However, if future recruitment would be more consistent with the lower long-term conditions, the risk of the spawning biomass remaining below the LRP would remain high (74%). When these alternatives were discussed previously at SC6 in the context of undertaking deterministic projections, it was agreed that the recent recruitment scenario was more appropriate because of the possibility of some bias in the estimates of early recruitment in the bigeye tuna stock assessment. While this issue has been alleviated to an extent in the 2014 assessment, the preference for using the recent recruitment conditions may still be valid.

References

Pilling, G. M., S. J. Harley, N. Davies, J. Rice and J. Hampton. 2014. Status quo stochastic projections for bigeye, skipjack, and yellowfin tunas. WCPFC-SC10-SA-WP-06. http://www.wcpfc.int/system/files/SC10-SA-WP-06%20Status%20quo%20projections%20BE%20YF%20SKJ.pdf

Table 1. Risk of breaching reference points in 2032 under two future harvest scenarios (2012 status quo and CMM 2013-01) and future recruitment hypotheses (long-term [1962-2011] recruitment and short-term [2002-2011] recruitment).

	Recruitment Deviations	LRP ($0.2SB_{F=0}$)	F_{MSY}
Status quo	Long term	94%	93%
CMM 2013-01	Long term	74%	81%
Status quo	Short term	32%	72%
CMM 2013-01	Short term	4%	48%

Table 2. Median values of reference point variables in 2032 under two future harvest scenarios (2012 status quo and CMM 2013-01) and future recruitment hypotheses (long-term [1962-2011] recruitment and short-term [2002-2011] recruitment).

	Recruitment Deviations	$SB_{2032}/SB_{F=0}$	F_{2032}/F_{MSY}
Status quo	Long term	0.08	1.91
CMM 2013-01	Long term	0.15	1.44
Status quo	Short term	0.24	1.21
CMM 2013-01	Short term	0.31	0.99

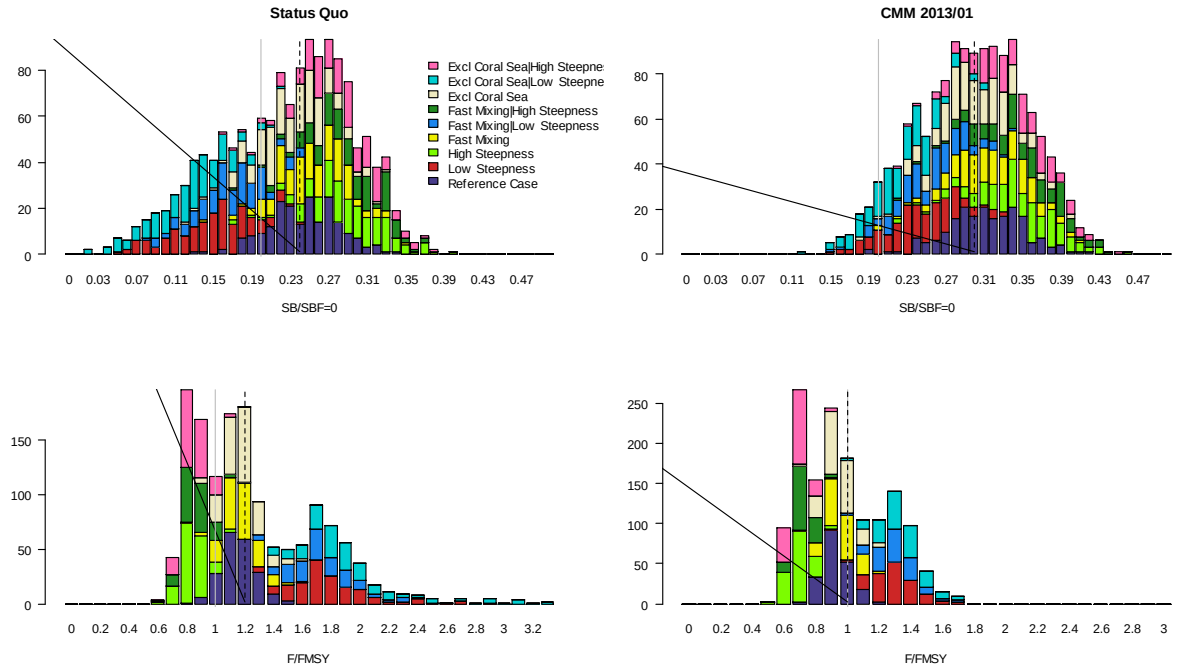

Figure 1. 2002-2011 recruitment deviations: Histograms of the predicted distribution of $SB_{2032}/SB_{F=0}$ and F_{2032}/F_{MSY} for bigeye tuna for 2 effort scenarios; the first representing the 2012 status quo (left column) and the second representing conditions consistent with CMM 2013-01 (right column). Different colours indicate the results from different stock assessment model runs. The vertical dotted line indicates the overall median value across all model runs. Vertical grey lines indicate 0.2 $SB_{F=0}$ and F_{MSY}, respectively.

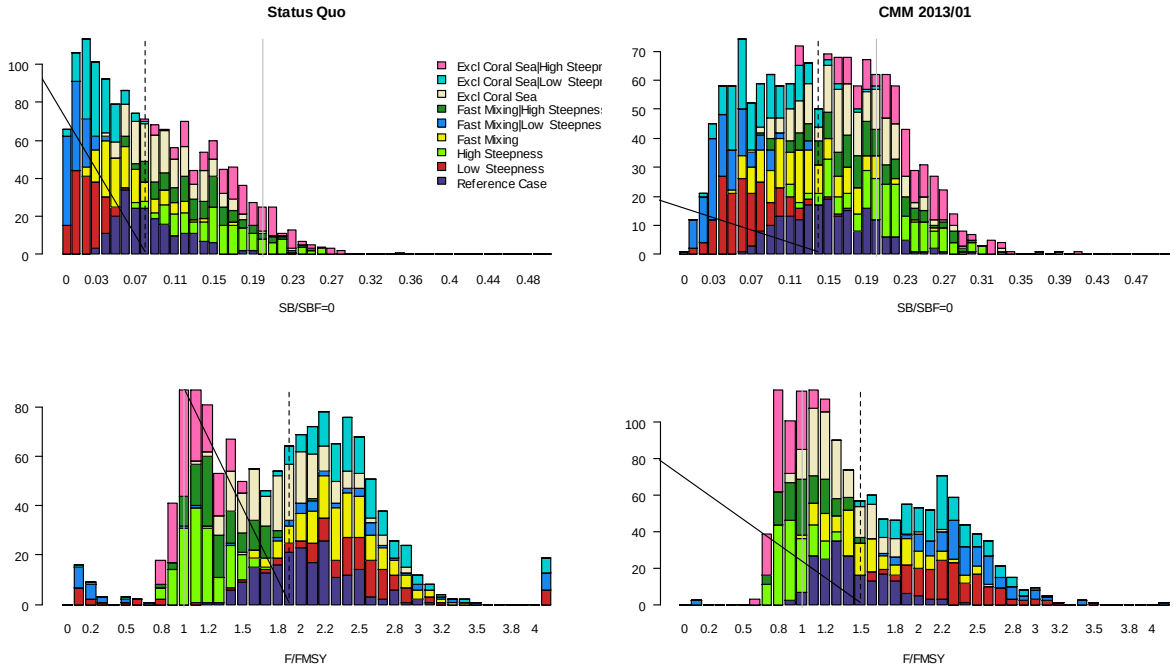

Figure 2. 1962-2011 recruitment deviations: Histograms of the predicted distribution of $SB_{2032}/SB_{F=0}$ and F_{2032}/F_{MSY} for bigeye tuna for 2 effort scenarios; the first representing the 2012 status quo (left column) and the second representing conditions consistent with CMM 2013-01 (right column). Different colours indicate the results from different stock assessment model runs. The vertical dotted line indicates the overall median value across all model runs. Vertical grey lines indicate 0.2 $SB_{F=0}$ and F_{MSY}, respectively.