COMMISSION

TWELFTH REGULAR SESSION

Stones Hotel, Kuta, Bali, INDONESIA

3 - 8 December 2015

EVALUATION OF CMM 2014-01 FOR BIGEYE TUNA

WCPFC12-2015-12_Rev1[1]

18 November 2015

Paper by SPC Oceanic Fisheries Programme

[1] Revision 1: correction to Table 3 (2014 purse seine performance) and associated text, noting that Korea selected the FAD set limit in 2014. This affects the 'on track' status of the purse seine fishery in 2014. Updates to the body of the text have been made to reflect those changes.

1. EXECUTIVE SUMMARY

The objectives of CMM 2014-01 are that "bigeye, yellowfin and skipjack tuna stocks are, at a minimum, maintained at levels capable of producing their maximum sustainable yield…" and that fishing mortality on these stocks will be "at a level no greater than F_{MSY}, i.e. $F/F_{MSY} \leq 1$." To achieve objectives, until they are amended or replaced by Target Reference Points, the CMM comprises a number of individual measures to be implemented over the period 2014-2017, in particular:

- Seasonal FAD closures, or annual FAD set limits, which CCMs can choose between each year;
- 2017 FAD closure on the high seas (or verifiable purse seine bigeye catch reductions);
- Purse seine effort restrictions, and specified non-SIDS purse seine high seas effort limits; and
- Flag-based longline bigeye catch limits for flag states that caught >2,000 mt of bigeye in 2004 (China, Indonesia, Japan, Korea, Chinese Taipei and United States) and upper limits (2000 mt) for other non-SIDS. Domestic SIDS fleets are exempted.

Here we attempt to lay out a framework by which Members may come to a shared understanding as to:

- Step 1. How we attempt to quantify provisions of the measure – i.e., how we take the words and turn them into levels of catch or effort;
- Step 2. How we evaluate potential effectiveness of the measure over the medium and long-term – i.e., will objectives be achieved (e.g., reductions in fishing mortality) and by when; and
- Step 3. How the Commission may track the annual implementation of TT-CMM provisions using the predictions and/or assumptions made under Step 1, and determine whether changes are necessary to ensure objectives are achieved.

In light of this evaluation, areas where the Measure could be strengthened are suggested.

STEP 1: QUANTIFYING PROVISIONS OF THE MEASURE

Many of the Measure's provisions for 2015 onward have been revised since the last evaluation[2]. In turn, the availability of CCM choice between purse seine FAD closure duration and annual FAD set limits can lead to a collective increase/smaller decrease as individual CCMs maximise potential FAD sets while implementing the Measure's FAD requirements. We therefore took a detailed approach in this evaluation.

As we evaluate the long-term impact of maintaining CMM measures, using equilibrium indicators, we consider the Measure's final form (i.e., 2017) and assume those conditions are maintained into the future. The challenge is that it is not possible to define precisely what levels of purse seine effort and longline catch will result, due to "either/or" choices, exemptions or exclusions, and decisions yet to be made. We therefore evaluated three different scenarios for 2017 conditions to examine this implementation uncertainty, but there is clearly no certainty any of them will be correct. The scenarios are summarised as:

'Pessimistic': everyone takes the maximum they are allowed to under the Measure. Purse seine CCMs maximise FAD sets through their FAD closure duration/annual FAD set limits choices, including the average 2010-2012 FAD set ceiling for those who choose the FAD closure option; limited longline non-SIDS CCMs take their entire 2017 specified/2000 mt limits, 2014 level for SIDS.

'2015 choices': purse seine CCMs apply the FAD closure duration/annual FAD set limits choice they made in 2015. This results in lower FAD sets in particular, because some CCMs did not choose the option that would

[2] Implementation of longer FAD closure periods/alternative FAD set limits (para 17) were conditional upon arrangements ensuring no disproportionate burden on conservation action was transferred onto SIDS (para 15), which have not been agreed. See also WCPFC Circular No.: 2015/07.

maximise their FAD sets in 2015 (based on our evaluation). Limited longline CCMs take the lower of their catch limit or 2014 level.

'Optimistic': purse seine CCMs maximise FAD sets through their FAD closure duration/annual FAD set limits choices, but those that choose the FAD closure do not increase FAD sets outside the closure period; longline CCMs take their catch limit or 2014 level if lower. This scenario assumes the Measure works 'as intended' and FAD closures remove FAD sets from the fishery.

High seas FAD closure is applied in all cases, and is assumed to remove FAD sets from the fishery, rather than transferring them to EEZs. Resulting scalars on purse seine FAD effort and longline bigeye catch relative to 2012 levels are shown in the table below.

STEP 2: EVALUATE THE POTENTIAL EFFECTIVENESS OF THE MEASURE ON THE BIGEYE TUNA STOCK

We evaluate the potential consequences of applying the scalars under each 2017 scenario through stochastic bigeye stock projections using the approach recommended by SC10. The results, including those for the status quo (2012 purse seine effort and longline catch levels continue) are summarised below. Only under the optimistic scenario are CMM objectives achieved by 2032, with F less than F_{MSY} and the risk of the spawning biomass being below the Limit Reference Point at 2%.

Scenario	Scalars relative to 2012		Average F_{2032}/F_{MSY}	Average $SB_{2032}/SB_{F=0}$	Risk SB_{2032} < LRP
	Purse seine	Longline			
Status quo	1	1	1.21	0.24	32%
Pessimistic	1.02	0.97	1.18	0.25	28%
2015 choices	0.95	0.84	1.06	0.29	11%
Optimistic	0.76	0.84	0.93	0.33	2%

We stress that we are projecting assumed 2017 conditions into the future. This does not imply that the bigeye stock will achieve the projected final status in 2017. Examining the trajectory of F/F_{MSY} assuming the optimistic scenario conditions continue after 2017, CMM 2014-01 objectives would be achieved on average 10 years after the end of the Measure, i.e. in 2027. As WCPFC stock assessments generally report fishing mortality conditions three years in the past, this would imply that only in 2030 would stock assessments identify whether the CMM had been successful. However, earlier stock assessments should identify if the trajectory of F/F_{MSY} and risk of SB < LRP are 'on track' to achieve objectives.

STEP 3: TRACK THE ANNUAL IMPLEMENTATION OF THE PROVISIONS

At this stage, we can evaluate fishery performance relative to conditions specified within the Measure for the first year: 2014. Note this does not reflect whether full implementation of the CMM will ultimately achieve its overall objectives, which is the separate analysis summarised above.

The number of FAD sets estimated for 2014 was 16,143, 118 sets greater than 'expected' with selected FAD options (2014 4th month closure or annual FAD set limit) and a 3% increase on the 2010-2012 average sets baseline. However, purse seine FAD set numbers are within 1% of the predicted impact of the Measure in 2014, based upon the CCM FAD set options selected in that year, and hence appear almost 'on track'.

For longliners overall, the 2014 total longline bigeye catch estimate was 88% of that in 2012. While there were CCM-specific issues, and non-limited CCM catch had increased by 3% over 2012 levels, longline catches appear to be a qualified 'on track', mostly due to the combined catch of those fleets with specified catch restrictions being well below their 2014 limit.

2. QUANTIFYING THE PROVISIONS OF THE MEASURE

To understand how the provisions of the measure are quantified, there is a need to understand the basic principles of how the results will be used when evaluating the potential effectiveness of the measure (Step 2). All evaluations of the Measure are undertaken with the same stock assessment model that we used to determine the status of the relevant tuna stock. This involves projecting the abundance of a species (bigeye, yellowfin, or skipjack tuna) into the future (typically 20 years) under particular levels of either catch or effort within the fisheries modelled in that stock assessment.

Therefore, the two parts of Step 1 are:

1. Estimate the levels of associated (FAD) and unassociated (free school) set purse seine effort and longline bigeye catch that would result from the provisions of the Measure. This estimation requires interpretation of the CMM text to estimate the most likely purse seine effort and longline catch levels that would result. 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 kept 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.

The previous evaluation of CMM 2013-01 presented to WCPFC11 (WCPFC11-2014-15) took a straightforward approach to developing purse seine FAD effort and longline bigeye catch scalars based on assumed 2017 conditions. However, following that analysis, many of the Measure's provisions for years 2015 onward have been reviewed. In turn, after 18 months of implementation, it has become clear that the availability of CCM choice within the Measure with respect to purse seine FAD set levels in particular has been used to maximise the potential FAD sets that a CCM can make while implementing the Measure's FAD requirements. In this evaluation, therefore, we take a closer look at the implications of CCM choice on the potential outcomes from the CMM.

The following table outlines the approach that has been taken in relation to the relevant paragraphs of the CMM. As noted, 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 these are maintained into the future.

Relevant paragraphs of CMM 2014-01	Evaluation Approach
Objectives	
1	We use the spawning biomass depletion ratio, $SB/SB_{F=0}$, since this is the metric of the limit reference point (LRP) formally adopted by WCPFC ($0.2SB_{F=0}$). Projections are run to equilibrium over 20 years. The indicators are for the end of this period.
3	F/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 should not significantly impact the results of the evaluation.
FAD set management	
14-17	Unlike the evaluation of CMM2013-01 presented to WCPFC11, (WCPFC11-2014-15) here we explicitly evaluated as far as possible the impact of choice, specifically a CCM's choice of a FAD closure period or a FAD set limit, as permitted within the Measure. CCM options are EITHER: • A FAD closure of 4 months in 2017 (Jul-Oct), modelled as 8/9 * average FAD sets in 2010-2012. (Implementation of longer closure periods was conditional upon WCPFC agreeing to arrangements to ensure that a disproportionate burden on conservation action is not transferred onto SIDS (para 15). As this was not agreed in 2014, we have assumed that will remain the case in 2017, and a 4 month FAD closure would remain); OR: • For the FAD set limit option, following WCPFC Circular No.: 2015/07, those CCMs that choose a 3 month FAD closure and annual FAD set limits will be limited to the number of FAD sets detailed in Attachment A, Column A in 2017. In addition, the theoretical reduction in FAD set numbers due to the high seas FAD closure was applied to BOTH the 4 month FAD closure option AND the FAD set limit in 2017 (see para 18, below). • We assume the overall FAD set ceiling for non-SIDS CCMs choosing the FAD closure under para 17a (average number of FAD sets in 2010-2012; Attachment A, column D) holds for 2017, but note that in reality this may no longer be the case. • We have assumed that footnote 4 of para 16b (CCMs with small fleets) continues to apply as per Attachment A, Columns A and D. • We did not attempt to model footnote 3 of para 16 (small purse seine and SIDS CCM new vessel entrant exemption), given the unknown number of vessels that would be operating under this exemption in 2017. However, this exemption is likely to lead to more pessimistic conditions for bigeye in the future[3]. We assume that CCMs will choose from these two options (4 month FAD closure, annual FAD set limit) the one that maximises the number of FAD sets they can make in a given year. Within that choice structure, **three** options for 2017 were examined: • **Pessimistic**: non-SIDS CCMs opted for i) the maximum of the FAD closure option (8/9*avg 2010-12 sets + high seas FAD closure), or the prescribed annual limit (as permitted under para 17a, Attachment A, column D) + high seas FAD closure, or ii) the FAD set limit (column A) + high seas FAD closure, whichever of i) or ii) was higher; SIDS opted for i) the maximum of the 4 month FAD closure option (8/9*avg 2010-12 sets + high seas FAD closure), the average 2010-12 level (Attachment A, column D) + high seas FAD closure, or their 2014 FAD set numbers + high seas FAD closure (given no overall FAD set cap is specified within the measure where the FAD closure period is chosen), or ii) the FAD set limit (column A) + high seas FAD closure, whichever of i) or ii) was higher; • **2015 choices**: FAD effort levels as per the 'pessimistic' scenario, but the choices between FAD closures and FAD set limit options were identical to those made by CCMs in 2015: FSM, Japan, Kiribati and Republic of Korea chose the FAD set limit, all others chose the FAD closure option; • **Optimistic**: CCMs opted for the maximum of i) 4 month closure (reducing FAD sets to 8/9 2010-2012 average)+ high seas FAD closure, or the number of FAD sets estimated for 2014 + high seas FAD closure, whichever was lower, or ii) the FAD set limit (column A), or the number of FAD sets estimated for 2014 + high seas FAD closure, whichever was lower.
18	The high seas FAD closure scheduled for introduction in 2017 could result in some reduction in purse seine FAD effort. We have assumed that **high seas FAD sets were not transferred into EEZs, but were removed from the fishery**, specifically from the eastern tropical Region 4 of the assessment model. We based the number of high seas FAD sets on the recent average sets in the high seas by flag over 2012-2014 (slightly higher than the average 2010-2012). The number of high seas FADs were deducted from the 4 month FAD closure option, the Attachment A column A set numbers and all other FAD set levels assumed in 2017 (see above). Kiribati flagged vessels were

[3] From WCPFC Circular No: 2015/47, 24 vessels were notified to the Commission Secretariat as exempted from the additional FAD measures in 2015, and which will be managed outside of the annual FAD set limits.

	assumed exempt (para 18). Footnote 5 (HS FAD closure does not apply to CCMs that reduce their purse seine bigeye catch by 55% relative to the 2010-2012 average) was not applied based upon current data, but might in the future apply due to reflagging of vessels to SIDS, or departure of vessels from WCPFC waters. Note Appendix 2 presents an analysis of the implications of removing high seas FAD sets only.
Purse seine effort control	
20-27	For simplicity, we did not assume that the purse seine total effort in EEZs and high seas would increase to the total 65,867 days (see Pilling and Harley, 2015), given that we assumed purse seine FAD set limits would be effective and the impact of increased free school set effort on bigeye would be relatively small. For simplicity, therefore, we assumed effort (including within archipelagic waters) would remain at 2012 effort levels (e.g. if FAD effort was reduced within a scenario, that effort was transferred onto free schools to maintain overall 2012 effort levels). 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.
Longline fishery – bigeye catch limits	
40-42	Longline catch limits are not completely specified. We have assumed that non-limited fleets (those without limits specified in Attachment F, or the upper limit of 2,000 mt) will continue to operate at 2014 levels (total bigeye catches by non-limited CCMs in 2014 were comparable to those in 2012). Comparable to purse seine assumptions, two options for 2017 conditions were examined: • **Pessimistic**: Limited CCMs took their 2017 catch limit/2,000 mt catch limit, SIDS CCMs took their 2014 catch level. • **Optimistic**: Limited CCMs took their 2017 catch limit/2,000 mt catch limit, or their 2014 catch level whichever was lower, and others took their 2014 catch level. This was also used for the **2015 choices** option. We note that SIDS longline fleets are currently unrestricted and could legitimately increase to any level under the CMM. If this occurs, then the extent of reduction of longline catch will be over-estimated even under the pessimistic scalar.
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

The interpretations made within the table above result in specific levels of assumed purse seine associated effort and longline catch levels in 2017 for each of the three scenarios ('pessimistic', '2015 choices' and 'optimistic'). The tables used to estimate these values are presented in Appendix 1 and are based upon data as of 1st November 2015. Resulting scalars are calculated relative to 2012 fishing levels. The scalars developed were:

	Pessimistic	**2015 choices**	**Optimistic**
Purse seine	1.02	0.95	0.76
Longline	0.97	0.84	0.84

The optimistic scalars are similar to those applied in the previous CMM evaluation (which were purse seine = 0.78; longline = 0.87). However, they result from different underlying assumptions. Unlike the previous CMM analysis, we are now explicitly modelling CCM choice in purse seine FAD set number options, and assuming:

- There is no 5th month of the FAD closure (equivalent to a 1/9th reduction in FAD sets = loss of a maximum 11% reduction in FAD sets from 2012 levels, noting that CCM choice may erode that reduction) and there is no reduction in FAD set limits that would have resulted from the move to Appendix A column B (loss of a maximum 20% reduction in FAD sets from 2012 levels);
- The high seas FAD closure in 2017 will result in the REMOVAL of those FAD sets from the overall FAD set effort. This is applied in the eastern tropical region (region 4 of the assessment model) (equates to a removal of 823 FAD sets from 2012 levels, 4.7% of FAD sets);
- Bigeye catch by unlimited longline fleets in 2014, while close to that in 2012, is 2% higher. In turn, 2012 catch levels have been updated. These will affect scalars.

3. EVALUATION OF THE POTENTIAL EFFECTIVENESS OF THE MEASURE

We use the purse seine associated (FAD) effort and longline catch scalars estimated in Step 1 within 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 $SB_{F=0}$) 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}). Outcomes of the CMM for skipjack and yellowfin tuna are not examined in this paper.

Analysis of the impact of potential reductions in purse seine associated 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 2014-01 (scalars estimated in Step 1), applied to 2012 conditions). 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 ONLY the 2002-2011 recruitment deviations from the stock-recruitment relationship estimated in the 2014

assessment model runs shown in the table above, consistent with WCPFC SC decisions[4]. This effectively assumes that the above-average recruitment conditions of the past 10 years will continue into the future.

We stress that we are projecting 2017 conditions into the future. This is therefore not implying that the bigeye stock will achieve the projected final status in 2017. Indeed, the fishing level in the years before 2017 will have some small impact on the time taken to achieve F_{MSY}, as the stock could be driven further down in that period if fishing reductions are not made, and hence the stock would have a longer road to recovery.

RESULTS

Figure 1 shows the aggregate distributions of the reference point variables in 2032 for the three potential scenarios examined under CMM 2014-01, where future recruitment is hypothesised to remain on average consistent with 2002-2011 conditions. Moving from the pessimistic scenario, through the scenario where purse seine options chosen in 2015 continue, to the most optimistic scenario, the $SB_{2032}/SB_{F=0}$ distribution is shifted to the right towards higher relative biomass levels, while the F_{2032}/F_{MSY} distribution shifts to the left, towards lower fishing mortality.

Under the recent recruitment level hypothesis, the risk of breaching the LRP is reduced from 32% under status quo (2012) conditions to 28% (pessimistic), 11% (2015 choices) and 2% (optimistic) (Table 1) and the median value of $SB_{2032}/SB_{F=0}$ increased from 0.24 under status quo to 0.25 (pessimistic), 0.29 (2015 choices) and 0.33 (optimistic) (Table 2).

The probability of fishing mortality exceeding F_{MSY} is reduced from 72% under the status quo through to 71% (pessimistic), 60% (2015 choices) and 38% (optimistic) (Table 1) while the median F_{2032}/F_{MSY} is reduced from 1.21 (status quo) through to 1.18 (pessimistic), 1.06 (2015 choices) and 0.93 (optimistic) (Table 2).

Therefore, only in the case of the optimistic scenario are the CMM objectives achieved by 2032. Examining the trajectory of F/F_{MSY}, the weighted average of F was reduced to F_{MSY} around 10 years after the optimistic conditions were applied to the stock. This implies that CMM2014-01 objectives would be achieved on average 10 years after the end of the measure if the conditions within the fishery under that scenario continued, i.e. in 2027. Although one might expect the change in fishing mortality to be more rapid, we note that this calculation is also affected by the value of F_{MSY}, which will be influenced by the relative combination of gears within the fishery and their selectivities.

WCPFC stock assessments generally report stock conditions two years in the past and fishing mortality levels three years in the past (e.g. the 2014 bigeye stock assessment provided information on the status of the stock in 2012 and F/F_{MSY} conditions up to 2011). This would imply that only in 2030 would stock assessments identify whether the CMM had been successful. However, stock assessments in the interim should be able to identify if the trajectory of F/F_{MSY} and $SB/SB_{F=0}$ are moving in the right direction.

[4] We note that the choice of recent or long-term recruitment has quite different projection outcomes (Pilling et al., 2014), with the 2002-2011 recent average recruitment conditions being more optimistic than the long term average.

4. ANNUAL IMPLEMENTATION OF THE PROVISIONS OF CMM 2014-01

Stock assessments should be able to identify whether or not the bigeye stock and fishery impacts are moving towards achieving CMM objectives. In turn, implementation of the measure in each year can also be evaluated.

At this stage in the implementation of CMM 2014-01, we can evaluate the fishery performance relative to the first year of the measure: 2014. CMM 2013-01 (which became CMM 2014-01) specified different levels of bigeye catch (longline) or effort (purse seine FAD sets) for that year. We evaluate for purse seine and longline fleet segments, the 'expectation' resulting from our interpretation of the letter of the measure, and the latest data available for that year. We stress that this does not reflect whether full implementation of the CMM will achieve its overall objectives (see Sections 2 and 3).

PURSE SEINE

For purse seiners, the measure in place in 2014 was a 4 month FAD closure, or a 3 month FAD closure plus the corresponding annual FAD set limit choice. It should be noted that the assumption in the early stages of CMM 2013-01 development (and in the previous CMM evaluation) was that the 4 month FAD closure and the annual FAD set limit were, overall, equivalent and equated to 8/9 x 2010-2012 average sets by each CCM (ignoring exemptions). In Table 3, this is column 1 ('4 month FAD closure'). This assumption would equate to 13,912 sets (an 11% reduction from the 2010-2012 average).

The FAD set restriction in lieu of 4th month FAD closure was chosen by Japan, FSM, Korea and Kiribati in 2014[5], and their allowable FAD sets are defined in Attachment A, column A of the CMM. All other CCMs chose the 4 month FAD closure option, which is modelled as in Column 1. This is column 2 of Table 3 ('CMM 2014-01'). Allowing choice between the 4 month FAD closure and 2014 FAD set limit provides for an estimated 16,025 sets (an extra 2,113 sets; a 2% increase from the 2010-2012 average).

The actual number of FAD sets estimated for 2014 is presented in column 3 of Table 3 ('actual 2014 estimate'). Comments where the actual number of sets by a CCM in 2014 is greater than those in Column 2 ('CMM 2014-01') are made in the final column. The actual number of FAD sets estimated in 2014 was estimated at 16,143, 118 sets greater than that 'expected' through selection of limits within CMM 2014-01, and a 3% increase on the 2010-2012 average. However, estimated purse seine FAD set numbers in 2014 are within 1% of the predicted impact of the Measure in 2014, based upon the CCM FAD set options selected in that year, and hence the purse seine fishery as a whole appears almost 'on track'.

Two out of the four CCMs that had notified their choice of an annual FAD set limit under the measure, had also notified of new vessels operating as part of their domestic fleet (flagged and chartered) so the FAD sets for these vessels were not to be counted within the CCMs' annual FAD set limit under the measure. In addition, CCMs that chose the 4th month FAD closure were also not subject to an annual FAD set limit ('ceiling'). Consequently in Table 3, although there are instances where actual 2014 set numbers (Column 3) for a CCM exceed the numbers in Column 2, this does not necessarily imply that a purse seine CCM was operating in contravention of the annual FAD limits in the Measure during in 2014, as explained in the notes accompanying Table 3 (see also para 16b of the Measure).

[5] TCC Paper "Summary of Reporting received by WCPFC under tropical tuna CMMs" WCPFC-TCC11-2015-IP07 (1 September 2015), Table 2 confirms that four fleets had notified of their choice of annual FAD set limits during 2014 – Federated States of Micronesia, Japan, Kiribati and Korea.

LONGLINE

For longliners, the measure in place for 2014 limited the bigeye catch of six CCMs to a total of 65,022 mt. The actual estimated bigeye catch for those CCMs in 2014 is shown in Table 4. 2014 catch estimates indicate that one CCM was above their 2014 limit.

The 2014 catch of three of the limited CCMs were already below their 2017 limits (see Table 4), noting that the Indonesian catch limit is 'provisional and may be subject to revision following data analysis and verification'. Three of the limited CCMs would therefore need to reduce their catch from 2014 levels to achieve their 2017 limits.

The catch of other non-SIDS CCMs was limited to a maximum of 2,000 mt (excluding Belize due to their CNM status; paragraph 6 of the Measure), while the catch by SIDS fleets was not limited within the Measure. Of the four non-SIDS CCMs each with a 2,000 mt limit, their total 2014 catch was 913 mt, 11% of the theoretical 8,000 mt total limit. The 2014 bigeye catch of non-limited fleets was 3% higher than that in 2012. Overall, however, the current 2014 total longline bigeye catch estimate was 88% of that in 2012. Therefore longline fishery catches appear to be a 'qualified on track', mostly due to CMM limited fleets generally being well below their limits. This is qualified by the fact that: there are CCMs whose fleets have no limit within the measure, and whose bigeye catches have increased since 2012; and that while we are working with the latest 2014 longline data, CCM bigeye longline catch data for the most recent years tends to be revised upwards over time.

5. AREAS WHERE THE TROPICAL TUNA CMM DESIGN RESULTS IN LIMITS THAT ARE LESS RESTRICTIVE THAN EXPECTED.

During this evaluation, it has become clear that there are two main areas where the approach that the Commission has chosen in the implementation of a particular tropical tuna CMM provision has led to an outcome where the catch or effort reductions are less than is required. These are: Individual flag or coastal state choice (e.g. purse seine FAD closure versus FAD set limit); and the application of provisions to a subset of the fishery (e.g., exemptions).

Recommendations for consideration when developing the current and future TT-CMMs, therefore, are:

- To consider whether provisions are easily quantifiable or ambiguous and open to interpretation. It is acknowledged that there may be specific reasons for designing 'open' provisions (e.g., implementation of Article 30 of the Convention), however it is preferable to have specific limits (e.g., numbers) contained within the measure.
- Recognize that in some instances the achievement of particular objectives (e.g., fishing mortality reductions or stock increases) may only occur over the medium term (e.g., 5-10 years), and it will take even longer until the data are available and the stock assessments conducted to measure this.
- Specify the desired time to achieve the objectives of a CMM, to allow a clearer evaluation of whether fishery conditions during the CMM period will achieve the Measure's objective within that time period. The Measure currently states (Para 3) "the fishing mortality rate for bigeye tuna will be reduced to a level no greater than F_{msy}, i.e. $F/F_{msy} \leq 1$. This objective shall be achieved through step by step approach through 2017 in accordance with this Measure". However, this is open to interpretation as it implies that the 'step by step approach' will be applied through 2017 (as detailed within the Measure for each of those years) rather than explicitly stating that the objective of $F/F_{msy} \leq 1$ be achieved by the end of 2017.

In turn, when evaluating TT-CMMs, there should be a focus on its annual implementation – in particular how actual levels of catch and effort compare to those that were predicted in the analysis of effectiveness. In instances where catch/effort levels differ from those predicted (especially when they exceed them), there is a need to determine whether particular provisions of the measure might need to be adjusted.

6. DISCUSSION

We have described the approach to evaluating CMM 2014-01 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 use of 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).

The key difficulty encountered in evaluating the CMM was that it is not possible to define precisely what levels of purse seine effort and longline catch will result from the CMM. The presence of "either/or" choices, exemptions or exclusions and decisions yet to be made with respect to some measures makes it impossible to predict the outcomes in terms of actual future catch and effort levels. We have made hopefully sensible assumptions to develop three different options to examine this implementation uncertainty, but there is clearly no certainty that any of them will be correct. The fact that only in the optimistic case are the CMM's objectives achieved provides clear indication of the conditions required within the fishery to achieve those objectives.

We note that only the results for the assumption that future recruitment will generally be consistent with recent (2002-2011) levels is presented here. This is an 'optimistic' assumption. Previous analyses (WCPFC11-2014-15) indicated that 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%), even under conditions close to those of the optimistic scenario presented here. 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[6]. While this issue has been alleviated to an extent in the 2014 assessment, the preference for using the recent recruitment conditions is still considered to be valid.

7. 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

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SPC-OFP. 2014. Evaluation of CMM 2013-01. WCPFC11-2014-15. http://www.wcpfc.int/system/files/WCPFC11-2014-14%20SPC_OFP%20Evaluation%20of%20CMM%202013-01.pdf

[6] We note that information on numbers of small fish provided by purse seine fishery data that may improve recruitment estimates was only available once that fishery began later in the time series.

Tables

TABLE 1. RISK OF BREACHING REFERENCE POINTS IN 2032 UNDER THREE FUTURE HARVEST SCENARIOS ('PESSIMISTIC', '2015 CHOICES', 'OPTIMISTIC') AND THE SHORT-TERM [2002-2011] RECRUITMENT HYPOTHESIS.

	LRP ($0.2SB_{F=0}$)	F_{MSY}
Status quo	32%	72%
Pessimistic	28%	71%
2015 choices	11%	60%
Optimistic	2%	38%

TABLE 2. MEDIAN VALUES OF REFERENCE POINT VARIABLES IN 2032 UNDER THREE FUTURE HARVEST SCENARIOS ('PESSIMISTIC', '2015 CHOICES', 'OPTIMISTIC') AND THE SHORT-TERM [2002-2011] RECRUITMENT HYPOTHESIS.

	$SB_{2032}/SB_{F=0}$	F_{2032}/F_{MSY}
Status quo	0.24	1.21
Pessimistic	0.25	1.18
2015 choices	0.29	1.06
Optimistic	0.33	0.93

TABLE 3. FAD SETS BY CCM: COLUMN 1 - 8/9 X 2010-2012 AVERAGE FAD SETS (ASSUMED 4 MONTH FAD CLOSURE = FAD SET LIMIT NUMBERS); COLUMN 2 – ACTUAL CHOICE UNDER CMM 2014-01 (FAD SET LIMITS HERE AS PER CMM ATTACHMENT A, COLUMN A); AND COLUMN 3 - ACTUAL 2014 FAD SET ESTIMATES. FIGURES IN COLUMN 2 AND COLUMN 3 DO NOT NECESSARILY REFLECT CONSIDERATION OF CMM 2013-01 FOOTNOTE 3 NOTIFICATIONS

CCM	**FAD set numbers**			**Notes where 2014 actual > CMM**
	Column 1	**Column 2**	**Column 3**	
	4 month FAD closure	CMM2014-01 (choice)	Actual 2014 estimate	
China	1,131	1,131	1,484	4 mth FAD closure, no associated FAD set limit in CMM for 2014
Ecuador	310	310	338	4 mth FAD closure, no associated FAD set limit in CMM for 2014
El Salvador	149	149	313	4 mth FAD closure, no associated FAD set limit in CMM for 2014
Federated States of Micronesia #	604	604	596	
Japan #	1,116	2,139	1,031	
Kiribati #	375	493	821	FAD set limit, exemption for newly flagged or chartered vessels
Marshall Islands	1,028	1,028	1,257	4 mth FAD closure, no associated FAD set limit in CMM for 2014
New Zealand	154	154	143	
Papua New Guinea	1,531	1,531	1,722	4 mth FAD closure, no associated FAD set limit in CMM for 2014
Philippines (distant-water)	287	287	389	4 mth FAD closure, no associated FAD set limit in CMM for 2014 (Note: Attachment C limits only HSP1 vessel numbers and fishing days for Philippines traditional fresh/ice chilled group vessels)
Republic of Korea #	1,314	2,286	1,068	
Solomon Islands	145	145	102	
EU (Spain)	430	430	430	
Chinese Taipei	2,322	2,322	2,639	4 mth FAD closure, no associated FAD set limit in CMM for 2014
Tuvalu	50	50	54	4 mth FAD closure, no associated FAD set limit in CMM for 2014
United States of America	2,721	2,721	3,527	4 mth FAD closure, no associated FAD set limit in CMM for 2014
Vanuatu	245	245	229	
Total	**13,912**	**16,025**	**16,143**	
Change from 2010-12 average	**-11%**	**+2%**	**+3%**	

- notified that choice of additional FAD set reduction was to be annual FAD set limit in 2014

TABLE 4. INFORMATION FOR THE SIX CCMS WITH LONGLINE BIGEYE CATCHES LIMITS IN CMM2014-01. '2014 LIMIT' AND '2017 LIMIT' COLUMN VALUES ARE DEFINED BY CMM2014-01 ATTACHMENT F. ACTUAL 2014 CATCH ESTIMATES SHOWN IN COLUMN '2014 ACTUAL'. THE DIFFERENCE BETWEEN THE CCM 2017 LIMITS AND CCM CATCHES IN 2014 ARE SHOWN IN THE FINAL COLUMN.

CCM	BET catch levels			
	2014 limit	2014 actual	2017 limit	2014 actual vs 2017 limit
China	9,398	9,370	7,049	-2,321
Indonesia	5,889	2,603	5,889	+3,266
Japan	19,670	15,046	16,860	+1,814
Republic of Korea	15,014	12,779	12,869	+90
Chinese Taipei	11,288	10,018	9,675	-343
USA	3,763	3,815	3,345	-470
Total	**65,022**	**53,631**	**55,687**	

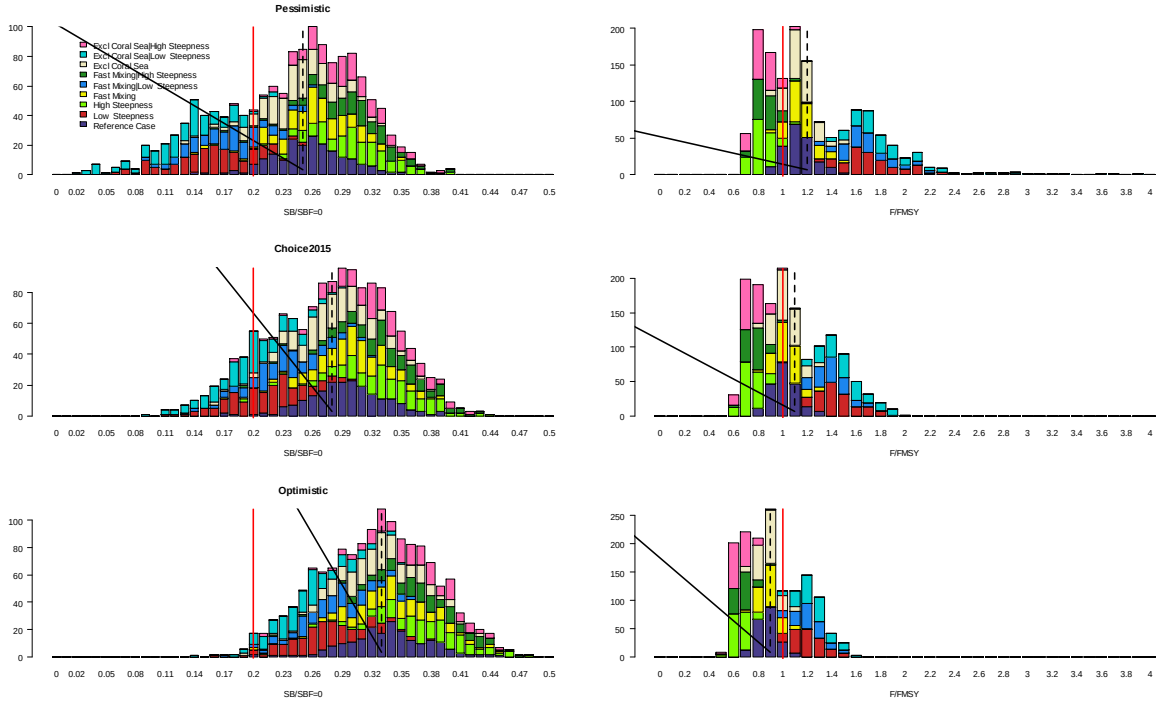

FIGURE 1. 2002-2011 RECRUITMENT DEVIATIONS: HISTOGRAMS OF THE PREDICTED DISTRIBUTION OF $SB_{2032}/SB_{F=0}$ (LEFT COLUMN) AND F_{2032}/F_{MSY} (RIGHT COLUMN) FOR BIGEYE TUNA FOR 3 FUTURE SCENARIOS: THE PESSIMISTIC SCENARIO (TOP ROW); CONDITIONS CONSISTENT WITH CCM CHOICES MADE IN 2015 (MIDDLE ROW); AND THE OPTIMISTIC SCENARIO (BOTTOM ROW). DIFFERENT COLOURS INDICATE THE RESULTS FROM DIFFERENT STOCK ASSESSMENT MODEL RUNS. VERTICAL RED LINES INDICATE 0.2 $SB_{F=0}$ AND F_{MSY}, RESPECTIVELY. VERTICAL BLACK DOTTED LINE REPRESENTS THE CORRESPONDING MEDIAN VALUE ACROSS ALL MODEL RUNS. NOTE VALUES ARE ROUNDED TO 1 DECIMAL PLACE WHEN PLOTTED AND HENCE THE PLOTTED MEDIAN IS BIASED; REFER TO TABLE 2 FOR ACTUAL MEDIAN VALUES.

APPENDIX 1. CONDITIONS UNDER 2017 SCENARIOS.

Purse seine FAD set numbers assumed for CCMs, and corresponding scalars relative to 2012 under the three scenarios.

Pessimistic purse seine scenario

	Non-SIDS		SIDS					
	Max(4 Mnth FAD closure + HS closure, Appendix A column D + HS closure)	FAD set limit (Attachment A column A + HS closure)	Max (4 Mnth FAD closure + HS closure, Appendix A column D + HS closure or 2014+HS closure)	FAD set limit (Attachment A column A + HS closure)	FAD closure + HS closure	FAD set limit + HS closure	Maximum	Basis
CHINA	1,271	845			1,271	845	1,271	Column D - HS
ECUADOR	287	98			287	98	287	Column D - HS
EL SALVADOR	128	41			128	41	128	Column D - HS
FSM			678	603	678	603	678	Column D - HS
JAPAN	1,254	2,136			1,254	2,136	2,136	FAD set limit - HS
KIRIBATI			821	493	821	493	821	2014 (no HS reduction)
MARSHALL ISLANDS			1,257	1,028	1,257	1,028	1,257	2014 - HS
NEW ZEALAND	174	167			174	167	174	Column D - HS
PAPUA NEW GUINEA			1,719	2,210	1,719	2,210	2,210	FAD set limit - HS
PHILIPPINES (distant-water)	322	462			322	462	462	FAD set limit - HS
REPUBLIC OF KOREA	1,468	2,268			1,468	2,268	2,268	FAD set limit - HS
SOLOMON ISLANDS			186	165	186	165	186	Column D - HS
SPAIN	238	80			238	80	238	Column D - HS
CHINESE TAIPEI	2,597	2,402			2,597	2,402	2,597	Column D - HS
TUVALU			73	127	73	127	127	FAD set limit - HS
USA	2,743	2,260			2,743	2,260	2,743	Column D - HS
VANUATU			392	349	392	349	392	Column D - HS
					15,607	**15,733**	**17,973**	
					Scalar from 2012		**1.02**	

2015 choices purse seine scenario

	Non-SIDS		SIDS					
	Max(4 Mnth FAD closure + HS closure, Appendix A column D + HS closure)	FAD set limit (Attachment A column A + HS closure)	Max (4 Mnth FAD closure + HS closure, Appendix A column D + HS closure or 2014+HS closure)	FAD set limit (Attachment A column A + HS closure)	FAD closure + HS closure	FAD set limit + HS closure	Maximum	Basis
CHINA	1,271	845			1,271	845	1,271	4mth - HS
ECUADOR	287	98			287	98	287	4mth - HS
EL SALVADOR	128	41			128	41	128	FAD closure-HS
FSM			678	603	678	603	603	FAD closure-HS
JAPAN	1,254	2,136			1,254	2,136	2,136	FAD closure (no HS reduction)
KIRIBATI			821	493	821	493	493	4mth - HS
MARSHALL ISLANDS			1,257	1,028	1,257	1,028	1,257	4mth - HS
NEW ZEALAND	174	167			174	167	174	4mth - HS
PAPUA NEW GUINEA			1,719	2,210	1,719	2,210	1,719	4mth - HS
PHILIPPINES (distant-water)	322	462			322	462	322	4mth - HS
REPUBLIC OF KOREA	1,468	2,268			1,468	2,268	2,268	FAD closure-HS
SOLOMON ISLANDS			186	165	186	165	186	4mth - HS
SPAIN	238	80			238	80	238	4mth - HS
CHINESE TAIPEI	2,597	2,402			2,597	2,402	2,597	4mth - HS
TUVALU			73	127	73	127	73	4mth - HS
USA	2,743	2,260			2,743	2,260	2,743	4mth - HS
VANUATU			392	349	392	349	392	4mth - HS
					15,607	**15,733**	**16,886**	
					Scalar from 2012		**0.95**	

Optimistic purse seine scenario

	Non-SIDS		SIDS					
	Min(4 Mnth FAD closure + HS closure, 2014 + HS closure)	**Attachment A column A + HS closure**	**Min (4 Mnth FAD closure + HS closure or 2014+HS closure)**	**Attachment A column A + HS closure**	**FAD closure + HS closure**	**FAD set limit + HS closure**	**Maximum**	**Basis**
CHINA	1,130	845			1,130	845	1,130	4mth - HS
ECUADOR	255	98			255	98	255	4mth - HS
EL SALVADOR	103	41			103	41	103	2014 - HS
FSM			595	595	595	595	595	Equal
JAPAN	1,030	1,030			1,030	1,030	1,030	Equal
KIRIBATI			375	493	375	493	493	Column A (no HS reduction)
MARSHALL ISLANDS			1,028	1,028	1,028	1,028	1,028	Equal
NEW ZEALAND	131	131			131	131	131	Equal
PAPUA NEW GUINEA			1,528	1,718	1,528	1,718	1,718	Column A - HS
PHILIPPINES (distant-water)	287	389			287	389	389	Column A - HS
REPUBLIC OF KOREA	1,060	1,060			1,060	1,060	1,060	Equal
SOLOMON ISLANDS			102	102	102	102	102	Equal
SPAIN	203	80			203	80	203	2014 - HS
CHINESE TAIPEI	2,309	2,402			2,309	2,402	2,402	Column A - HS
TUVALU			50	54	50	54	54	Column A - HS
USA	2,438	2,260			2,438	2,260	2,438	4mth - HS
VANUATU			229	229	229	229	229	Equal
					12,849	**12,553**	**13,358**	
					Scalar from 2012		**0.76**	

Longline bigeye catches assumed for CCMs, and corresponding scalars relative to 2012 under the three scenarios.

CCM	Pessimistic 2017		2015 choices and Optimistic 2017	
	BET catch	Basis	BET catch	Basis
AMERICAN SAMOA	327	2014 level	327	2014 level
AUSTRALIA	2,000	2000 mt limit	440	2014 level
BELIZE	803	CNM limit (para 6)	217	2014 level
CHINA	7,049	CMM 2017 level	7,049	CMM 2017 level
COOK ISLANDS	194	2014 level	194	2014 level
EU-PORTUGAL	2,000	2000 mt limit	71	2014 level
EU-SPAIN	-	(combined EU flag)	65	2014 level
FSM	1,388	2014 level	1,388	2014 level
FIJI	1,698	2014 level	1,698	2014 level
FRENCH POLYNESIA	741	2014 level	741	2014 level
INDONESIA	5,889	CMM 2017 level	3,673	2014 <CMM 2017 level
JAPAN	16,860	CMM 2017 level	14,555	2014 <CMM 2017 level
KIRIBATI	268	2014 level	268	2014 level
MARSHALL ISLANDS	0	2014 level	0	2014 level
NAURU	0	2014 level	0	2014 level
NEW CALEDONIA	58	2014 level	58	2014 level
NEW ZEALAND	2,000	2000 mt limit	122	2014 level
NIUE	0	2014 level	0	2014 level
NORTHERN MARIANAS	1,000	2014 level	1,000	2014 level
PALAU	0	2014 level	0	2014 level
PAPUA NEW GUINEA	52	2014 level	52	2014 level
PHILIPPINES	63	2014 level	63	2014 level
REPUBLIC OF KOREA	12,869	CMM 2017 level	12,779	2014 <CMM 2017 level
SAMOA	48	2014 level	48	2014 level
SENEGAL	0	2014 level	0	2014 level
SOLOMON ISLANDS	3,054	2014 level	3,054	2014 level
TONGA	22	2014 level	22	2014 level
TUVALU	76	2014 level	76	2014 level
CHINESE TAIPEI	9,675	CMM 2017 level	9,675	CMM 2017 level
USA	3,345	CMM 2017 level	3,345	CMM 2017 level
VANUATU	3,419	2014 level	3,419	2014 level
WALLIS AND FUTUNA	0	2014 level	0	2014 level
Total	74,898		64,399	
Scalar from 2012	**0.97**		**0.84**	

APPENDIX 2. EVALUATION OF THE IMPLICATIONS OF REMOVING HIGH SEAS FAD SETS ONLY.

We evaluated the potential reduction in bigeye overfishing resulting from the implementation of the high seas FAD closure on its own (para 18 of CMM 2014-01).

Within this analysis, we assumed that **high seas FAD sets were not transferred into EEZs, but were removed from the fishery**, specifically from the eastern tropical Region 4 of the assessment model. All other fisheries components were assumed to continue at 2012 levels, including both longline bigeye catches and overall purse seine effort. High seas FAD effort within stock assessment model Region 4 was transferred to the free school purse seine fishery to maintain 2012 effort levels.

We estimated the number of high seas FAD sets removed from the fishery as the average number sets in the high seas by flag over the period 2012-2014 (slightly higher than the average 2010-2012). Kiribati flagged vessels were assumed exempt (para 18). We assumed that no flags achieved the 55% bigeye catch reduction that would exempt them from the high seas closure (footnote 5 of the CMM).

The assumptions made above imply that this analysis represents the 'best case' scenario of the impact of the high seas FAD closure on bigeye status.

Implementation of the high seas FAD closure alone was estimated to reduce F/F_{MSY} levels from 1.21 (status quo conditions) to 1.17 (high seas FAD closure). This equated to 18% of overfishing being removed by 2032.