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EVALUATION OF CMM 2015-01 FOR BIGEYE TUNA

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1. EXECUTIVE SUMMARY

CMM 2015-01 objectives 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 these, until amended or replaced by Target Reference Points, the CMM defines measures implemented over the period 2014-2017:

- A three-month FAD closure, plus a fourth month FAD closure 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.

We use the framework developed in WCPFC12-2015-12 to:

- Step 1. quantify provisions of the measure – i.e., how we take the words and turn them into levels of catch or effort;
- Step 2. 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. track the annual implementation of TT-CMM provisions, and determine whether changes are necessary to ensure objectives are achieved.

In light of this evaluation, areas where future Measures could be strengthened are suggested.

STEP 1: QUANTIFYING PROVISIONS OF THE MEASURE

The last CMM evaluation (WCPFC12-2015-12) highlighted the implications of CCM choice between purse seine FAD closure duration and annual FAD set limits on stock outcomes. We repeat that detailed evaluation approach here. 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. Since the last CMM evaluation, there have been new and updated data and clarity on the application of CMM2015-01 footnote 5, and these are incorporated within the analysis. 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 three-month FAD closure option; limited longline non-SIDS CCMs and US Territories take their entire 2017 specified/2000 mt limits, 2015 level for other SIDS.

'2016 choices': purse seine CCMs apply the FAD closure duration/annual FAD set limits choice they made in 2016[1]. This results in lower FAD sets in particular, because some CCMs did not choose the option that would maximise their FAD sets in 2016 (based on our evaluation). CCMs with longline limits take the lower of their 2017 catch limit or 2015 level.

[1] WCPFC-TCC12-2016-IP07 notes some CCMs have not notified the WCPFC Secretariat of their 2016 choice of additional FAD set reduction option (para 16 of CMM 2015-01). We assume 2015 choices continue.

'Optimistic': purse seine CCMs maximise FAD sets through FAD closure/FAD set limits choices (or 2015 FAD set numbers), but those that choose the fourth-month FAD closure do not increase FAD sets outside the closure period; CCMs with longline limits take their 2017 catch limit or 2015 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. However, CCMs whose purse seine fleet TCC12 noted had achieved the bigeye catch reduction consistent with CMM footnote 5 were assumed exempt from the closure. The number of high seas FAD sets made in 2015 by those CCMs was assumed in the future, consistent as far as possible with maintaining the bigeye catch reductions to 55% from the 2010-12 average. 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 potential consequences of applying scalars under each scenario through stochastic bigeye stock projections. The results, including those for the status quo (2012 purse seine effort and longline catch levels continue) are summarised below. Only the optimistic scenario achieves CMM objectives by 2032, with F below F_{MSY} and no risk of spawning biomass being below the Limit Reference Point.

Scenario	Scalars relative to 2012		Average F_{2032}/F_{MSY}	Average $SB_{2032}/SB_{F=0,2022\text{-}2031}$[1]	Risk SB_{2032} < LRP[1]
	Purse seine	Longline			
Status quo	1	1	1.21	0.26	21%
Pessimistic	1.02	1.08	1.25	0.24	31%
2016 choices	0.95	0.80	1.04	0.31	<1%
Optimistic	0.64	0.80	0.83	0.39	0%

[1] Note a 10 year 'moving window' was used to calculate $SB_{F=0}$, consistent with CMM2015-06 and recent stock assessment practice.

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 2015-01 objectives would be achieved on average after 7 years of maintaining the 2017 conditions after the end of the Measure, i.e. in 2024. As WCPFC stock assessments generally report fishing mortality conditions three years in the past, only by 2027 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

We evaluate fishery performance relative to conditions specified within the Measure for 2015. Note this does not reflect whether full implementation of the CMM will ultimately achieve its overall objectives, which is the separate analysis summarised above. We note that 2015 was a strong El Niño year, and fishing patterns were different to those seen in previous years.

The number of FAD sets estimated for 2015 was 12,252; 3,773 sets less than 'expected' with selected FAD options (4th month closure or annual FAD set limit) and a 22% reduction on the 2010-2012 average sets baseline. Hence the purse seine fishery as a whole appears 'on track'.

For longliners overall, the 2015 total longline bigeye catch estimate was 81% of that in 2012. While non-limited CCM catch had increased by 41% over 2012 levels, longline catches overall appear to be a qualified 'on track', mostly due to the combined catch of those fleets with specified catch restrictions being below their 2015 limits.

2. QUANTIFYING THE PROVISIONS OF THE MEASURE

Evaluation of the Measure is undertaken with the bigeye stock assessment model as used to determine stock status. The abundance of the bigeye stock is projected into the future (typically 20 years) under particular levels of either catch or effort within the different fisheries modelled in the 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 same detailed approach used in the evaluation of CMM 2014-01 presented to WCPFC12 (WCPFC12-2015-12_rev1) was repeated. New data were available for 2015 along with updated data for previous years, while discussions at TCC12 provided clarity on high seas purse seine FAD closure assumptions under CMM 2015-01 footnote 5. As in the previous CMM evaluation, 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, the implications of CCM choice on the potential outcomes from the CMM are again examined.

The following table outlines the approach 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 those measures (i.e., 2017) and assume that these are maintained into the future.

Relevant paragraphs of CMM 2015-01	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	As in the evaluation of CMM2014-01 presented to WCPFC12, (WCPFC12-2015-12_rev1) 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 to, 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 the 4 month FAD closure option, the FAD set limit in 2017, AND 2015 FAD set levels, updated for discussions related to CMM 2015-01 footnote 5 (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[2]. 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 2015 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; • **2016 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 and assumed to hold in 2016: FSM, Japan, Kiribati and Republic of Korea chose the FAD set limit, all others chose the fourth-month 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 2015 + high seas FAD closure, whichever was lower, or ii) the FAD set limit (column A), or the number of FAD sets estimated for 2015 + 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. 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 assumed exempt (para 18). We based the number of high seas FAD sets on the recent average sets in the high seas by flag over 2013-2015 (approximately three times higher than the average 2010-2012, due to relatively large high seas FAD set numbers in 2015). 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 applied to those CCMs that TCC12 noted had achieved this reduction: European Union, Ecuador, El Salvador, Marshall Islands, New Zealand, Solomon

[2] From WCPFC Circular No: 2015/47, for example, 24 vessels were notified to the Commission Secretariat as exempted from the additional FAD measures.

	Islands, Tuvalu and Vanuatu. For these CCMs, it was assumed that the catch reduction would continue into the future. For these exempted CCMs, therefore, their (lower) number of high seas FAD sets made in 2015 were assumed to continue into the future.
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 2015 levels (total bigeye catch by non-limited CCMs in 2015 was 41% higher than that 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, other CCMs took their 2015 catch level. • **Optimistic**: Limited CCMs took their 2017 catch limit/2,000 mt catch limit, or their 2015 catch level whichever was lower, and others took their 2015 catch level. This was also used for the **2016 choices** option. Noting that a 2.000 mt limit has been applied to US Territories in US domestic legislation (see main text) these limits have been applied consistent with the approach taken for other CCMs with a 2,000 mt limit. We note that in general, 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', '2016 choices' and 'optimistic'). The tables used to estimate these values are presented in Appendix 1 and are based upon data in WCPFC-TCC12-2016-IP08_rev1. Resulting scalars are calculated relative to 2012 fishing levels. The scalars developed were:

	Purse Seine	Longline
Pessimistic	1.02	1.08
2016 choices	0.95	0.80
Optimistic	0.64	0.80

The scalars are similar to those applied in the evaluation of CMM 2014-01. However, there are differences due to:

- FAD set numbers and longline catches were lower in 2015 compared to previous years (down 24% and 7% on 2014, respectively), which will lower scalars for scenarios where flag-specific 2015 values are chosen as the lower option (e.g. optimistic scenario in particular);
- The effect of the high seas FAD closure in 2017, while still assumed to remove FAD sets from the overall FAD set effort, is potentially reduced compared to the analysis of CMM 2014-01 by the effect of exemptions under footnote 5 of the Measure (see evaluation approach for para 18 of the Measure). For exempted CCMs, future high seas set numbers are assumed to be at the (lower) levels seen in 2015. Under the footnote 5 exemptions, 790 FAD sets (5.0% of FAD sets) are assumed removed, compared to the removal of 1125 (7.2% of FAD sets) in the absence of the exemption. However, increased overall high-seas FAD set activity was seen in 2015. The impact of the exemption is therefore offset by the increased assumed impact of a FAD closure on non-exempted flags, and scalars are therefore comparable to those calculated for the analysis of CMM 2014-01. Appendix 2 presents an analysis of the implications of the high seas FAD closure exemption under footnote 5 of the CMM;
- Bigeye catch by unlimited longline fleets in 2015 is 41% higher than in 2012.
- US Territories have been limited to 2000 mt catch by longliners, and this catch level is assumed for those Territories within the pessimistic scenario[3].

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 ($SB_{2032}/SB_{F=0}$[4], 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.

[3] WPFMC and NMFS 2014. Amendment 7 to the Fishery Ecosystem Plan for Pelagic Fisheries of the Western Pacific Region, Regarding the Use and Assignment of Catch and Effort Limits of Pelagic Management Unit Species by the U.S. Pacific Island Territories and Specification of Annual Bigeye Tuna Catch Limits for the U.S. Pacific Island Territories, Including an Environmental Assessment and Regulatory Impact Review. March 27, 2014; and NOAA (2016). Pacific Island Pelagic Fisheries; 2016 U.S. Territorial Longline Bigeye Tuna Catch Limits. Federal Register Vol. 81, No. 178, 63145.

[4] $SB_{F=0}$ was calculated consistent with the approach defined in CMM 2015-06, and as used within recent stock assessments, whereby the 10 year averaging period was shifted relative to the year in which the SB was evaluated; i.e. adult biomass in future year *y* was related to the adult biomass in the absence of fishing averaged over the period *y*-10 to *y*-1 (e.g. $SB_{2032}/SB_{F=0,\ 2022\text{-}2031}$). Likewise for F_{2032}/F_{MSY}, F_{MSY} was computed for the final year of the projection period (2032).

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 performed for the estimated purse seine ASS effort and longline catch provisions of CMM 2015-01 (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[5]. This effectively assumes that the above-average recruitment conditions of the past 10 years will continue into the future. As requested by SC12, a sensitivity analysis assuming more pessimistic long-term recruitment patterns continue into the future is presented in Appendix 3.

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}.

RESULTS

Figure 1 shows the aggregate distributions of the reference point variables in 2032 for the three potential scenarios examined under CMM 2015-01, 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 2016 continue, to the most optimistic scenario, the $SB_{2032}/SB_{F=0,\ 2022\text{-}2031}$ 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 changes from 21% under status quo (2012) conditions up to 31% (pessimistic), then down to near zero % risk (2016 choices) and no

[5] 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.

risk (optimistic) (Table 1) and the median value of $SB_{2032}/SB_{F=0}$ changed from 0.26 under status quo down to 0.24 (pessimistic), then up to 0.31 (2016 choices) and 0.39 (optimistic) (Table 2).

The probability of fishing mortality exceeding F_{MSY} changed from 72% under the status quo up to 76% (pessimistic), and down to 56% (2016 choices) and 27% (optimistic) (Table 1) while the median F_{2032}/F_{MSY} changed from 1.21 (status quo) up to 1.25 (pessimistic), and down to 1.04 (2016 choices) and 0.83 (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 7 years after the optimistic conditions were applied to the stock. This implies that CMM2015-01 objectives would be achieved on average 7 years after the end of the measure if the conditions within the fishery under that scenario continued, i.e. in 2024. 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 2027 would a stock assessment 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. ANNUAL IMPLEMENTATION OF THE PROVISIONS OF CMM 2015-01

We evaluate the actual annual fishery performance, relative to the Measure's provisions for 2015. CMM 2015-01 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 2015 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 the development of this CMM 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 2015[6]; their allowable FAD sets are defined in Attachment A, column A of the CMM. All other CCMs chose the 4 month FAD closure option (modelled as in Column 1). This is Column 2 of Table 3 ('CMM 2015-01'). Allowing choice between the 4 month FAD closure and 2015 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 2015 is presented in Column 3 of Table 3 ('actual 2015 estimate'). Comments where the actual number of sets by a CCM in 2015 is greater than those in Column 2

[6] TCC 12 Paper "Summary of Reporting received by WCPFC under tropical tuna CMMs" WCPFC-TCC12-2016-IP07 (8 September 2016), Table 1.

('CMM 2015-01') are made in the final column. The actual number of FAD sets estimated in 2015 was 12,252, 3,773 sets less than that 'expected' through selection of limits within CMM 2015-01, and a 22% reduction on the 2010-2012 average. Hence the purse seine fishery as a whole appears 'on track'.

Two out of the four CCMs that had notified their choice of an annual FAD set limit under the measure, had also in 2015 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 2015 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 2015, as explained in the notes accompanying Table 3 (see also para 16b of the Measure).

LONGLINE

For longliners, the measure in place for 2015 limited the bigeye catch of six CCMs to a total of 60,355 mt. The actual estimated bigeye catch for those CCMs in 2015 is shown in Table 4. 2015 catch estimates indicate that no CCM was above their 2015 limit.

The 2015 catch of four 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'. Two of the limited CCMs would therefore need to reduce their catch from 2015 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; their limit is defined through paragraph 6 of the Measure), while the catch by SIDS fleets was not limited within the Measure[7]. Of the four limited non-SIDS flag CCMs, their total 2015 catch was 852 mt, 13% of the theoretical 6,803 mt total limit. The 2015 bigeye catch of non-limited fleets was 41% higher than that in 2012. Overall, however, the current 2015 total longline bigeye catch estimate was 81% of that in 2012. Therefore longline fishery catches appear to be '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 2015 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.

As noted in WCPFC12-2015-12, it is 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 may be 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 future TT-CMMs, therefore, are:

[7] Noting that US Territories have been limited to 2000 mt longline bigeye catch

- 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 2015-01 using stochastic projections (incorporating random variation of future recruitment from assumed distributions) across a range of model runs weighted as agreed by SC10. This approach is superior to the use of deterministic projections run from 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, although we note that '2016 choices' also comes close. We note that in this evaluation, the 'optimistic' scenario is more optimistic than that estimated in the evaluation of CMM 2014-01. This results from the lower purse seine FAD effort and longline catches in 2015 relative to 2014.

We note that only the results for the assumption that future recruitment will generally be consistent with recent (2002-2011) levels is presented here. 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. 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[8]. While this issue has been alleviated to an extent in the 2014 stock assessment, the preference for using the recent recruitment conditions is still considered to be valid. However, SC12 requested that a 'sensitivity' run be performed assuming more pessimistic longer-term recruitment patterns continue. The results of this analysis are presented in Appendix 3.

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. 2015. Evaluation of CMM 2014-01 for bigeye tuna. WCPFC12-2015-12_Rev1. https://www.wcpfc.int/node/26988

[8] 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.

TABLE 1. RISK OF BREACHING REFERENCE POINTS IN 2032 UNDER THREE FUTURE HARVEST SCENARIOS ('PESSIMISTIC', '2016 CHOICES', 'OPTIMISTIC') AND THE SHORT-TERM [2002-2011] RECRUITMENT HYPOTHESIS.

	LRP ($0.2SB_{F=0,2022-2031}$)	F_{MSY}
Status quo	21%	72%
Pessimistic	31%	76%
2016 choices	<1%	56%
Optimistic	0%	27%

TABLE 2. MEDIAN VALUES OF REFERENCE POINT VARIABLES IN 2032 UNDER THREE FUTURE HARVEST SCENARIOS ('PESSIMISTIC', '2016 CHOICES', 'OPTIMISTIC') AND THE SHORT-TERM [2002-2011] RECRUITMENT HYPOTHESIS.

	$SB_{2032}/SB_{F=0,2022-2031}$	F_{2032}/F_{MSY}
Status quo	0.26	1.21
Pessimistic	0.24	1.25
2016 choices	0.31	1.04
Optimistic	0.39	0.83

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 2015-01 (FAD SET LIMITS HERE AS PER CMM ATTACHMENT A, COLUMN A); AND COLUMN 3 - ACTUAL 2015 FAD SET ESTIMATES. FIGURES IN COLUMN 2 AND COLUMN 3 DO NOT NECESSARILY REFLECT CONSIDERATION OF CMM 2015-01 FOOTNOTE 3 NOTIFICATIONS

CCM	**FAD set numbers**			**Notes where 2015 actual > CMM**
	Column 1	**Column 2**	**Column 3**	
	4 month FAD closure	CMM2015-01 (choice)	Actual 2015 estimate	
China	1,131	1,131	1,002	
Ecuador	310	310	131	
El Salvador	149	149	104	
Federated States of Micronesia #	604	604	615	FAD set limit, exemption for newly flagged or chartered vessels
Japan #	1,116	2,139	665	
Kiribati #	375	493	950	FAD set limit, exemption for newly flagged or chartered vessels
Marshall Islands	1,028	1,028	1,102	4 mth FAD closure, no associated FAD set limit in CMM for 2015
New Zealand	154	154	36	
Papua New Guinea	1,531	1,531	1,282	
Philippines (distant-water)	287	287	368	4 mth FAD closure, no associated FAD set limit in CMM for 2015 (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	1,528	
Solomon Islands	145	145	107	
EU (Spain)	430	430	327	
Chinese Taipei	2,322	2,322	1,752	
Tuvalu	50	50	36	
United States of America	2,721	2,721	2,125	
Vanuatu	245	245	122	
Total	**13,912**	**16,025**	**12,252**	
Change from 2010-12 average	**-11%**	**+2%**	**-22%**	

- notified that choice of additional FAD set reduction was to be annual FAD set limit in 2015

TABLE 4. INFORMATION FOR THE SIX CCMS WITH LONGLINE BIGEYE CATCHES LIMITS SPECIFIED IN CMM2015-01. '2015 LIMIT' AND '2017 LIMIT' COLUMN VALUES ARE DEFINED BY CMM2015-01 ATTACHMENT F. ACTUAL 2015 CATCH ESTIMATES SHOWN IN COLUMN '2015 ACTUAL'. THE DIFFERENCE BETWEEN THE CCM 2017 LIMITS AND CCM CATCHES IN 2015 ARE SHOWN IN THE FINAL COLUMN.

CCM	BET catch levels			
	2015 limit	2015 actual	2017 limit	2015 actual vs 2017 limit
China	8,224	8,210	7,049	+1,161
Indonesia	5,889	3,701	5,889	-2,188
Japan	18,265	12,327	16,860	-4,533
Republic of Korea	13,942	7,745	12,869	-5,124
Chinese Taipei	10,481	9,434	9,675	-241
USA	3,504[1]	3,426	3,345	+81
Total	**65,305**	**44,843**	**55,687**	

[1] 2015 limit reduced by 50 mt to 3,504 mt take into account the overage in bigeye catch from 2014

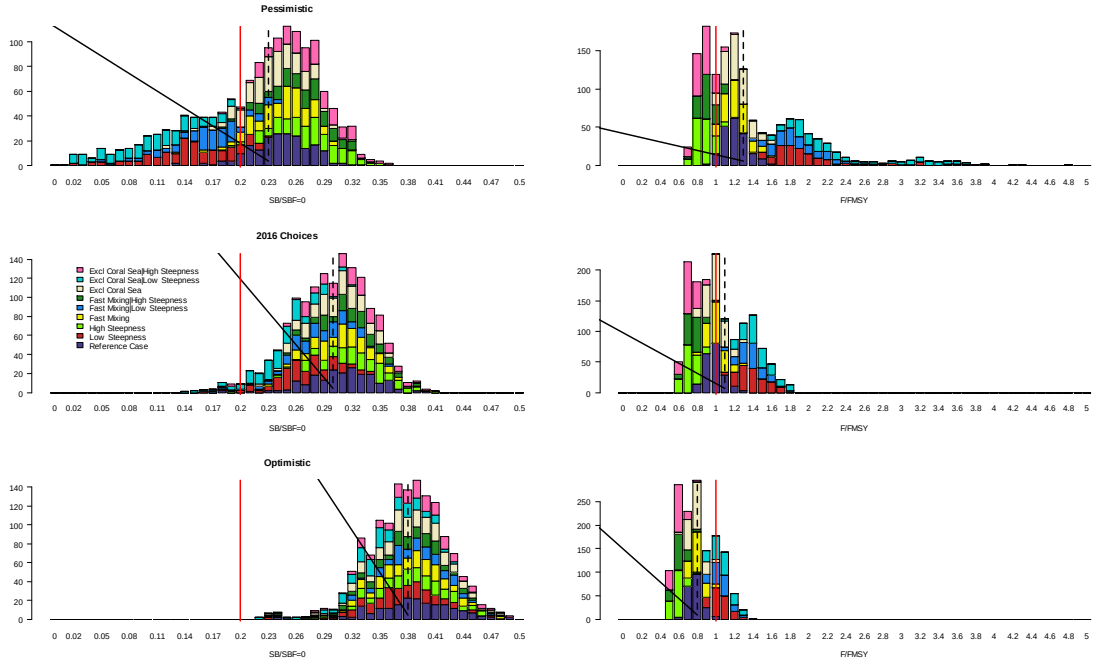

FIGURE 1. 2002-2011 RECRUITMENT DEVIATIONS: HISTOGRAMS OF THE PREDICTED DISTRIBUTION OF $SB_{2032}/SB_{F=0,2022-2031}$ (LEFT COLUMN) AND F_{2032}/F_{MSY} (RIGHT COLUMN) FOR BIGEYE TUNA FOR 3 FUTURE SCENARIOS: THE PESSIMISTIC SCENARIO (TOP ROW); CONDITIONS CONSISTENT WITH CCM CHOICES MADE IN 2016 (MIDDLE 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 2015+HS closure)	FAD set limit (Attachment A column A + HS closure)	FAD closure + HS closure	FAD set limit + HS closure	Maximum	Basis
CHINA	1,263	839			1,263	839	1,263	4mth - HS
ECUADOR	321	109			321	109	321	4mth - HS (exemption)
EL SALVADOR	174	56			174	56	174	4mth - HS (exemption)
FSM			655	582	655	582	655	4mth - HS
JAPAN	1,251	2,131			1,251	2,131	2,131	FAD set limit - HS
KIRIBATI			950	493	950	493	950	2015 (HS exemption)
MARSHALL ISLANDS			1,157	1,028	1,157	1,028	1,157	4mth - HS (exemption)
NEW ZEALAND	184	176			184	176	184	4mth - HS (exemption)
PAPUA NEW GUINEA			1,659	2,133	1,659	2,133	2,133	FAD set limit - HS
PHILIPPINES (distant-water)	322	461			322	461	461	FAD set limit - HS
REPUBLIC OF KOREA	1,445	2,233			1,445	2,233	2,233	FAD set limit - HS
SOLOMON ISLANDS			186	165	186	165	186	4mth - HS (exemption)
EU (SPAIN)	334	112			334	112	334	4mth - HS (exemption)
CHINESE TAIPEI	2,584	2,390			2,584	2,390	2,584	4mth - HS
TUVALU			73	127	73	127	127	FAD set limit - HS (exemption)
USA	2,554	2,105			2,554	2,105	2,554	4mth - HS
VANUATU			381	339	381	339	381	4mth - HS (exemption)
					15,491	**15,480**	**17,826**	
					Scalar from 2012		**1.02**	

2016 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 2015+HS closure)	FAD set limit (Attachment A column A + HS closure)	FAD closure + HS closure	FAD set limit + HS closure	Maximum	Basis
CHINA	1,263	839			1,263	839	1,263	4mth - HS
ECUADOR	321	109			321	109	321	4mth - HS (exemption)
EL SALVADOR	174	56			174	56	174	4mth - HS (exemption)
FSM			655	582	655	582	582	FAD set limit-HS
JAPAN	1,251	2,131			1,251	2,131	2,131	FAD set limit-HS
KIRIBATI			950	493	950	493	493	FAD set limit (HS exemption)
MARSHALL ISLANDS			1,157	1,028	1,157	1,028	1,157	4mth - HS (exemption)
NEW ZEALAND	184	176			184	176	184	4mth - HS (exemption)
PAPUA NEW GUINEA			1,659	2,133	1,659	2,133	1,659	4mth - HS
PHILIPPINES (distant-water)	322	461			322	461	322	4mth - HS
REPUBLIC OF KOREA	1,445	2,233			1,445	2,233	2,233	FAD set limit-HS
SOLOMON ISLANDS			186	165	186	165	186	4mth - HS (exemption)
EU (SPAIN)	334	112			334	112	334	4mth - HS (exemption)
CHINESE TAIPEI	2,584	2,390			2,584	2,390	2,584	4mth - HS
TUVALU			73	127	73	127	73	4mth - HS (exemption)
USA	2,554	2,105			2,554	2,105	2,554	4mth - HS
VANUATU			381	339	381	339	381	4mth - HS (exemption)
					15,491	**15,480**	**16,630**	
					Scalar from 2012		**0.95**	

Optimistic purse seine scenario

	Non-SIDS		SIDS					
	Min(4 Mnth FAD closure + HS closure, 2015 + HS closure)	**Min(Attachment A column A + HS closure, 2015 + HS closure)**	**Max(4 Mnth FAD closure + HS closure, 2015 + HS closure)**	**Max(Attachment A column A + HS closure, 2015 + HS closure)**	**FAD closure + HS closure**	**FAD set limit + HS closure**	**Maximum**	**Basis**
CHINA	995	839			995	839	995	2015 - HS
ECUADOR	131	109			131	109	131	2015 - HS (exemption)
EL SALVADOR	104	56			104	56	104	2015 - HS (exemption)
FSM			582	582	582	582	582	Equal
JAPAN	663	663			663	663	663	2015 - HS
KIRIBATI			375	493	375	493	493	4 mth (HS exemption)
MARSHALL ISLANDS			1,028	1,028	1,028	1,028	1,028	2015 - HS (exemption)
NEW ZEALAND	36	36			36	36	36	2015 - HS (exemption)
PAPUA NEW GUINEA			1,235	1,235	1,235	1,235	1,235	2015 - HS
PHILIPPINES (distant-water)	286	368			286	368	368	2015 - HS
REPUBLIC OF KOREA	1,284	1,493			1,284	1,493	1,493	2015 - HS
SOLOMON ISLANDS			107	107	107	107	107	2015 - HS (exemption)
EU (SPAIN)	284	112			284	112	284	4 mth (HS exemption)
CHINESE TAIPEI	1,733	1,733			1,733	1,733	1,733	2015 - HS
TUVALU			36	36	36	36	36	2015 - HS (exemption)
USA	1,773	1,773			1,773	1,773	1,773	2015 - HS
VANUATU			122	122	122	122	122	2015 - HS (exemption)
					10,774	**10,785**	**11,183**	
					Scalar from 2012		**0.64**	

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	2,000	2000 mt limit[1]	515	2015 level
AUSTRALIA	2,000	2000 mt limit	719	2015 level
BELIZE	803	CNM limit (para 6)	0	2015 level
CHINA	7,049	CMM 2017 level	7049	CMM 2017 level
COOK ISLANDS	151	2015 level	151	2015 level
EU-PORTUGAL	2,000	2000 mt limit	70	2015 level
EU-SPAIN	-	(combined EU flag)	-	2015 level
FSM	1,473	2015 level	1473	2015 level
FIJI	1,184	2015 level	1184	2015 level
FRENCH POLYNESIA	800	2015 level	800	2015 level
GUAM	2,000	2000 mt limit[1]	831	2015 level
INDONESIA	5,889	CMM 2017 level	3701	2015 <CMM 2017 level
JAPAN	16,860	CMM 2017 level	12327	2015 <CMM 2017 level
KIRIBATI	556	2015 level	556	2015 level
MARSHALL ISLANDS	0	2015 level	0	2015 level
NAURU	0	2015 level	0	2015 level
NEW CALEDONIA	63	2015 level	63	2015 level
NEW ZEALAND	2,000	2000 mt limit	122	2015 level
NIUE	0	2015 level	0	2015 level
NORTHERN MARIANAS	2,000	2000 mt limit[1]	1000	2015 level
PALAU	0	2015 level	0	2015 level
PAPUA NEW GUINEA	15	2015 level	15	2015 level
PHILIPPINES	0	2015 level	0	2015 level
REPUBLIC OF KOREA	12,869	CMM 2017 level	7745	2015 <CMM 2017 level
SAMOA	48	2015 level	48	2015 level
SENEGAL	0	2015 level	0	2015 level
SOLOMON ISLANDS	4,390	2015 level	4390	2015 level
TONGA	25	2015 level	25	2015 level
TUVALU	187	2015 level	187	2015 level
CHINESE TAIPEI	9,675	CMM 2017 level	9434	2015 <CMM 2017 level
USA	3,345	CMM 2017 level	3345	CMM 2017 level
VANUATU	5,603	2015 level	5603	2015 level
WALLIS AND FUTUNA	0	2015 level	0	2015 level
Total	82,985		61,353	
Scalar from 2012	**1.08**		**0.80**	

[1] Amendment 7 to the US Fishery Ecosystem Plan for Pelagic Fisheries of the Western Pacific Region (PFEP) established the framework to specify catch and/or effort limits for pelagic fisheries in the US Participating Territories

APPENDIX 2. EVALUATION OF REMOVING HIGH SEAS FAD SETS ONLY AND IMPLICATIONS OF CMM 2015-01 FOOTNOTE 5.

The previous analysis of CMM 2014-01 (WCPFC12-2015-12-Rev1) evaluated the potential reduction in bigeye overfishing resulting from the implementation of the high seas FAD closure on its own. Within that analysis, **high seas FAD sets were again not transferred into EEZs, but were removed from the fishery**, specifically from the eastern tropical Region 4 of the assessment model. The number of high seas FAD sets removed from the fishery through the closure were estimated as the average number of sets in the high seas by flag over the period 2012-2014. Kiribati flagged vessels were assumed exempt (para 18), but that analysis assumed that footnote 5 did not apply to any CCM. Implementation of the high seas FAD closure alone under those conditions 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.

As noted in the main text, TCC12 identified specific CCMs that had achieved the level of bigeye catch reductions required to be exempted from the high seas closure in 2017 under footnote 5 of CMM 2015-01. To evaluate the implications of those exemptions, we used similar assumptions to the previous high seas only evaluation described above, but removed a reduced number of FAD sets from the high seas (again specifically from eastern tropical Region 4 of the assessment model). We assumed future high seas FAD set numbers of exempted CCMs were at the (lower) levels seen in 2015 – i.e. the reduced bigeye FAD catches in 2015 were assumed to continue into the future. Under footnote 5 exemptions, 790 FAD sets (5.0% of FAD sets) are assumed removed, compared to the removal of 1125, or 7.2% of sets, in the absence of the exemption. Using the same projection settings as described above, the additional 335 sets allowed under the exemption reduced the effectiveness of the high seas FAD closure slightly, with F/F_{MSY} levels reduced from 1.21 (status quo conditions) to 1.18 (high seas FAD closure with exemptions). This equated to 14% of overfishing being removed by 2032.

APPENDIX 3. EVALUATION RESULTS UNDER THE ALTERNATIVE LONG-TERM RECRUITMENT ASSUMPTION

The analyses described in the main text were repeated under the assumption that future recruitments would follow the less optimistic longer-term (1962 – 2011) pattern. The calculation of $SB_{F=0}$ is again based upon the estimated unexploited adult biomass levels over a shifted 10 year window of 2022-2031. Resulting stock status is shown in Table 5 and Table 6.

TABLE 5. RISK OF BREACHING REFERENCE POINTS IN 2032 UNDER THREE FUTURE HARVEST SCENARIOS ('PESSIMISTIC', '2016 CHOICES', 'OPTIMISTIC') AND THE LONG-TERM [1962-2011] RECRUITMENT HYPOTHESIS.

	LRP ($0.2SB_{F=0,\ 2022\text{-}2031}$)	F_{MSY}
Status quo	85%	94%
Pessimistic	90%	94%
2016 choices	64%	88%
Optimistic	26%	63%

TABLE 6. MEDIAN VALUES OF REFERENCE POINT VARIABLES IN 2032 UNDER THREE FUTURE HARVEST SCENARIOS ('PESSIMISTIC', '2016 CHOICES', 'OPTIMISTIC') AND THE LONG-TERM [1962-2011] RECRUITMENT HYPOTHESIS.

	$SB_{2032}/SB_{F=0,\ 2022\text{-}2031}$	F_{2032}/F_{MSY}
Status quo	0.10	1.99
Pessimistic	0.09	2.05
2016 choices	0.17	1.64
Optimistic	0.27	1.12