DEVELOPMENT OF A NEW TROPICAL TUNA MEASURE WORKSHOP 2 (TTMW2)

Electronic Meeting

6-10 September 2021

RESULTS OF ANALYSES REQUESTED BY TTMW1

Revision 4

WCPFC-TTMW2-2021-01_rev4[1]
6 September 2021

SPC-OFP
Pacific Community (SPC), Noumea, New Caledonia

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[1] REV1 - Update to section on 'high seas effort' analysis using an alternative 2012 PS baseline effort level (see Table 12)
REV2 – Update to skipjack status in Table 6, Table 7, Table 11 and Table 12 to correct errors in scalar calculation.
REV3 – Clarification of text in section 'high seas effort'
REV4 – Responding to comments and requests received on Day 1 of TTMW2, addition of: skipjack fishing mortality estimates relative to recent estimated levels in the 'Additional metrics/scalars' section (Figure 7, Table 17), additional graphs of JP and KR bigeye longline CPUE time series and effort in the 'CPUE' section (Figure 12), and correction to the footnote of Table 23.

Summary

The 1st workshop on the Development of New WCPFC Tropical Tuna Measure (TTMW1) requested specific analyses from the SSP to help inform Commission members on options for the new Measure (Attachment 2 of the TTMW1 report). The results of those analyses are presented here, grouped into the different categories provided in the Chair's report of TTMW1 (see Appendix 1 of this paper, and the summary provided at the beginning of each section). For each, a short methodological summary is provided where necessary, particularly where interpretation of the request by the SSP was necessary to perform the analysis. This is then followed by the results and where appropriate, key points for CCMs to note when interpreting those results.

TRPs

Request
BET TRP as **average depletion 2000-2004**, determine MSY, and F, as a proportion of recent levels (2014-2017), projected to achieve this TRP. Overall, region, fish size (juv/ad)
BET TRP as **median depletion 2000-2004**, determine MSY, and F, as a proportion of recent levels (2014-2017), projected to achieve this TRP. Overall, region, fish size (juv/ad)
BET Evaluate **2007-2009 fishing level** in terms of median depletion level and the corresponding change in spawning biomass from 2012-2015 average, recent and long-term recruitment conditions
SKJ Evaluate applying purse seine effort 2007-2009 ave., equlib yield v MSY, LRP risks for **50%, 48%, 46%, 44% and 42%$SB_{F=0}$, plus 36, 38 and 40%** (Tokelau)

For the analysis of bigeye, an approach comparable to that described in SC17-MI-WP-01 was used to identify the identical scalars on purse seine effort and longline catch off 2016-2018 average fishing levels that led to the bigeye stock achieving on average the stock depletion level (%$SB_{F=0}$) specified in the request. Corresponding change from the 2012-2015 average biomass level, yield as a % of MSY, F/F_{MSY}, and risk of falling below the limit reference point (20%$SB_{F=0}$) were identified. Stock-wide fishing mortality at age was computed and adjusted by the corresponding population juvenile/adult numbers-at-age and time period to calculate the average fishing mortality across those age groups. Further technical details are provided in SC17-MI-WP-02.

For skipjack, a full description of the work is provided in SC17-MI-WP-02. In summary, stock projections were performed under different future scenarios for purse seine fishing effort. For each, the stock was projected into the future using the following procedure:

1. Run 100 simulations for 30 years into the future for each of the 54 stock assessment models - each simulation representing a possible 'future' trajectory for recruitment;
2. Run those simulations assuming long-term recruitment patterns (future recruitment is defined by the estimated stock recruitment relationship, with variability around it defined by recruitment estimates from the stock assessment over the period 1982-2017);
3. Assume catchability remains constant into the future – i.e. no effort creep occurs in WCPO fisheries;
4. Taking into account the SC15 plausibility weightings, combine the results across each assessment model run and calculate the median level of terminal spawning biomass compared to $SB_{F=0}$;

5. Adjust the level of purse seine fishing in the future from the 2012 baseline level so that the median stock size was equivalent to the candidate TRP level at the end of the projection period, while maintaining other fisheries at 2012 levels with the exception of domestic fisheries in Indonesia/Philippines/Vietnam which were maintained at 2016-2018 average levels in the assumption that recent estimates better reflected improvements in data collection.

Results and figures for bigeye (under recent and long term recruitment assumptions) are provided first, then those for skipjack.

Bigeye

Requested results are presented for bigeye under the assumption of ‘recent’ (Table 1, Figure 1) and ‘long-term’ (Table 2, Figure 2) recruitment patterns. All requested depletion levels imply stock sizes larger than those in the ‘recent’ period estimated within the stock assessment, by between 16 and 30%.

Under ‘recent’ recruitment assumptions, for the first two levels, purse seine effort and longline catch was either maintained at 2016-2018 average levels or decreased slightly, while to achieve the third level (median depletion over 2007-2009), effort and catch needed to be increased by 17% relative to that baseline (Table 1).

Under ‘long term’ recruitment assumptions, for the first two levels, purse seine effort and longline catch needed to be reduced relative to 2016-2018 average levels, by up to 17%, while to achieve the third level (median depletion over 2007-2009), effort and catch could be maintained at 2016-2018 levels (Table 2).

Table 1. Fishery metrics under specified bigeye tuna depletion levels ($SB/SB_{F=0}$) where recent recruitments were assumed to continue.

Request	Depletion level ($SB/SB_{F=0}$)	PS/LL scalar (cf 2016-18)	Change in spawning biomass (%$SB_{F=0}$) from 2012-2015 average	Median total equilibrium yield (%MSY)	F/F_{MSY}	Risk $SB/SB_{F=0}$ < LRP	Juvenile $F_{2048}/F_{2014-2017}$	Adult $F_{2048}/F_{2014-2017}$
Average depletion 2000-2004	0.48	1	+30%	95%	0.69	0	1.18	0.81
Median depletion 2000-2004	0.49	0.96	+34%	94%	0.67	0	1.13	0.77
Median depletion 2007-2009	0.43	1.17	+17%	97%	0.81	0	1.50	1.01

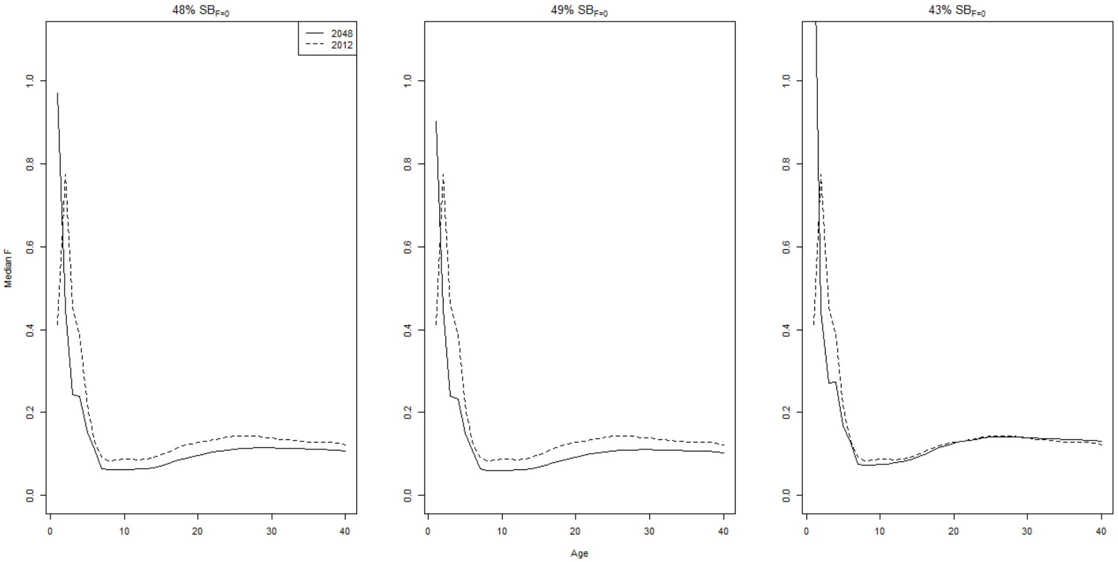


Figure 1. Pattern of (median) overall fishing mortality-at-age (quarter) for the three bigeye proposed depletion levels. Dotted line presents estimated 2014-2017 F-at-age, solid line the projected 2048 F-at-age under the assumption that recent recruitment levels continue.

Table 2. Fishery metrics under specified bigeye tuna depletion levels ($SB/SB_{F=0}$) where long term recruitments were assumed to continue.

Request	Depletion level ($SB/SB_{F=0}$)	PS/LL scalar (from 2016-18)	Change in spawning biomass (%$SB_{F=0}$) from 2012-2015 average	Median total equilibrium yield (%MSY)	F/F_{MSY}	Risk $SB/SB_{F=0}$ < LRP	Juvenile $F_{2048}/F_{2014-2017}$	Adult $F_{2048}/F_{2014-2017}$
Average depletion 2000-2004	0.48	0.85	+30%	96%	0.79	2%	1.52	0.78
Median depletion 2000-2004	0.49	0.83	+34%	96%	0.78	1%	1.50	0.76
Median depletion 2007-2009	0.43	1	+17%	97%	0.89	5%	1.65	0.97

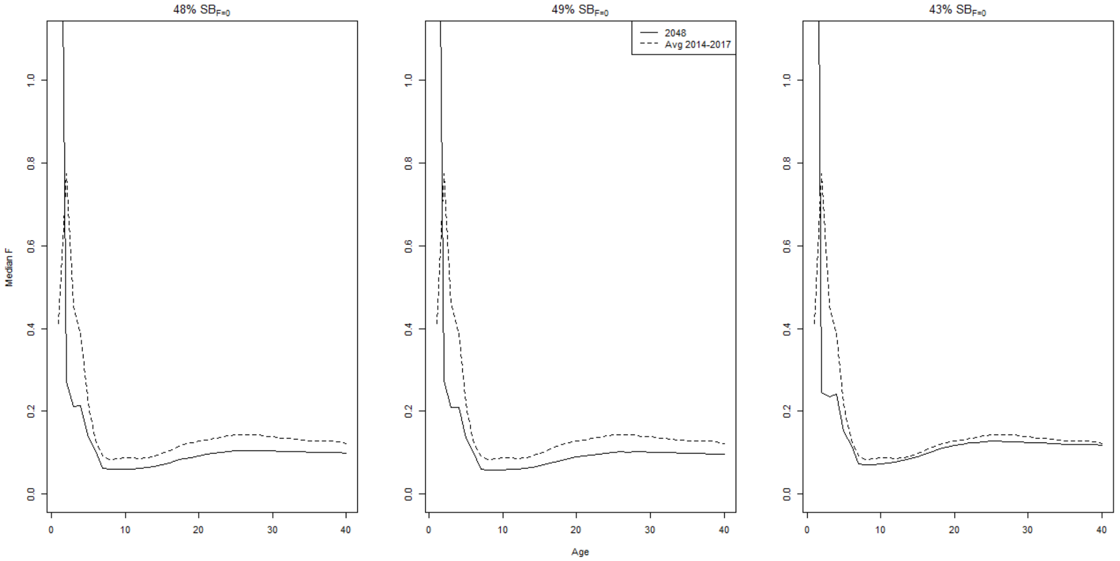


Figure 2. Pattern of (median) overall fishing mortality-at-age (quarter) for the three bigeye proposed depletion levels. Dotted line presents estimated 2014-2017 F-at-age, solid line the projected 2048 F-at-age under the assumption that long term recruitment levels continue.

Skipjack

The summary of results is presented in Table 4. Under baseline (2012) fishing levels the stock is predicted, on average, to fall slightly compared to 'recent' (2015-2018) levels (44% $SB_{F=0}$), to 42% $SB_{F=0}$. This is very slightly below 2012 depletion levels but is an equivalent % $SB_{F=0}$ value at 2 decimal places. Examining the four other median depletion levels requested by WCPFC16 (50%, 48%, 46% and 44% $SB_{F=0}$), these levels imply reductions in purse seine effort from 2012 levels of 7 to 25%, lead to predicted increases in spawning biomass from 2012 levels of between 3 and 18%, and either maintained biomass at recent assessed levels, or predict an increase in biomass by 5 to 13%. Total equilibrium yield is predicted to reduce compared to that under 2012 'baseline' levels, to 78-95% of MSY. For the three median depletion levels requested by WCPFC17 (36%, 38% and 40%), these levels imply increases in purse seine effort from 2012 levels of between 5 and 30%, and lead to predicted decreases in spawning biomass from 2012 levels of between 5 and 14%. Total equilibrium yield is predicted to increase very slightly compared to that under 2012 'baseline' levels, to 98% of MSY (reaching the flat peak of the yield curve). There was no risk of falling below the LRP associated with any of these depletion levels based on the current uncertainty framework.

Resulting stock-wide age-averaged F for juvenile and adult components of the population and median F-at-age are presented in Table 3 and Figure 3. Interpretation of the results is challenging given that future fishing mortality is strongly influenced by the required settings within the projection, in particular that future domestic fishery and pole-and-line catches continue at specified levels (2016-2018 and 2012 respectively), while purse seine is projected on effort. The composition of gears within the projected fishery and their impacts on the stock will therefore change relative to that in the historical (2012) period. This is clear when examining the relative change in fishing mortality in juvenile and adult segments of the population, with that on juveniles increasing notably at all examined depletion levels. This was driven by significant increases in fishing mortality within Region 5 of the skipjack assessment model (western tropical WCPO encompassing Indonesia and Philippines), where future domestic fishery catches continue at 2016-2018 levels (Figure 4, Figure 5).

Table 3. Fishing mortality estimated under each median skipjack tuna depletion level ($SB/SB_{F=0}$), calculated as the stock-wide age-averaged F for juveniles and adults in 2048, presented as a multiplier from that estimated in 2012, or the average estimated over 2012-2015.

Median depletion level (%$SB_{F=0}$)		Juvenile F_{2048}/F_{2012}	Juvenile $F_{2048}/F_{2012-2015}$		Adult F_{2048}/F_{2012}	Adult $F_{2048}/F_{2012-2015}$
50%		1.20	1.06		0.89	0.90
48%		1.24	1.10		0.92	0.93
46%		1.31	1.15		0.97	0.98
44%		1.39	1.22		1.02	1.04
42%		1.48	1.30		1.08	1.09
40%		1.53	1.35		1.11	1.13
38%		1.74	1.54		1.22	1.24
36%		1.92	1.69		1.29	1.31

As requested by SC17, Table 5 provides the Annual Catch Estimates (ACE) for key Region 5 fisheries by flag and gear in 2012 and 2016-2018 (average), as used within the stock assessment model for these fisheries.

Table 4. Median depletion levels of skipjack tuna ($SB/SB_{F=0}$) and corresponding change in biomass from 2007-2009, 2012, 2012-15 and 2015-18 average levels, change in purse seine effort (scalar), resulting median total equilibrium yield (as a percentage of MSY) and the risk of falling below the LRP. Results under baseline fishery conditions indicated by shaded row.

Median depletion level ($\%SB_{F=0}$)	Change in spawning biomass ($\%SB_{F=0}$) from 2007-2009 levels	Change in spawning biomass ($\%SB_{F=0}$) from 2012 levels	Change in spawning biomass ($\%SB_{F=0}$) from 2012-2015 average	Change in spawning biomass ($\%SB_{F=0}$) from 2015-2018 average	Change in PS effort from 2012 levels*	Median total equilibrium yield (%MSY)**	Risk $SB/SB_{F=0}$ < LRP
50%	-17%	+18%	+2%	+13%	-25%	78%	0%
48%	-19%	+14%	-1%	+10%	-21%	81%	0%
46%	-23%	+9%	-6%	+5%	-15%	87%	0%
44%	-27%	+3%	-10%	0%	-7%	95%	0%
42%	-30%	-2%	-15%	-5%	0%	97%	0%
40%	-32%	-5%	-18%	-8%	+5%	98%	0%
38%	-35%	-10%	-22%	-13%	+20%	98%	0%
36%	-39%	-14%	-25%	-16%	+30%	98%	0%

* ‘2012’ conditions as described in the main text. No future ‘effort creep’ assumed, i.e. CPUE is assumed to be consistently proportional to abundance.

** Recalculated using estimated equilibrium catch at defined fishing level

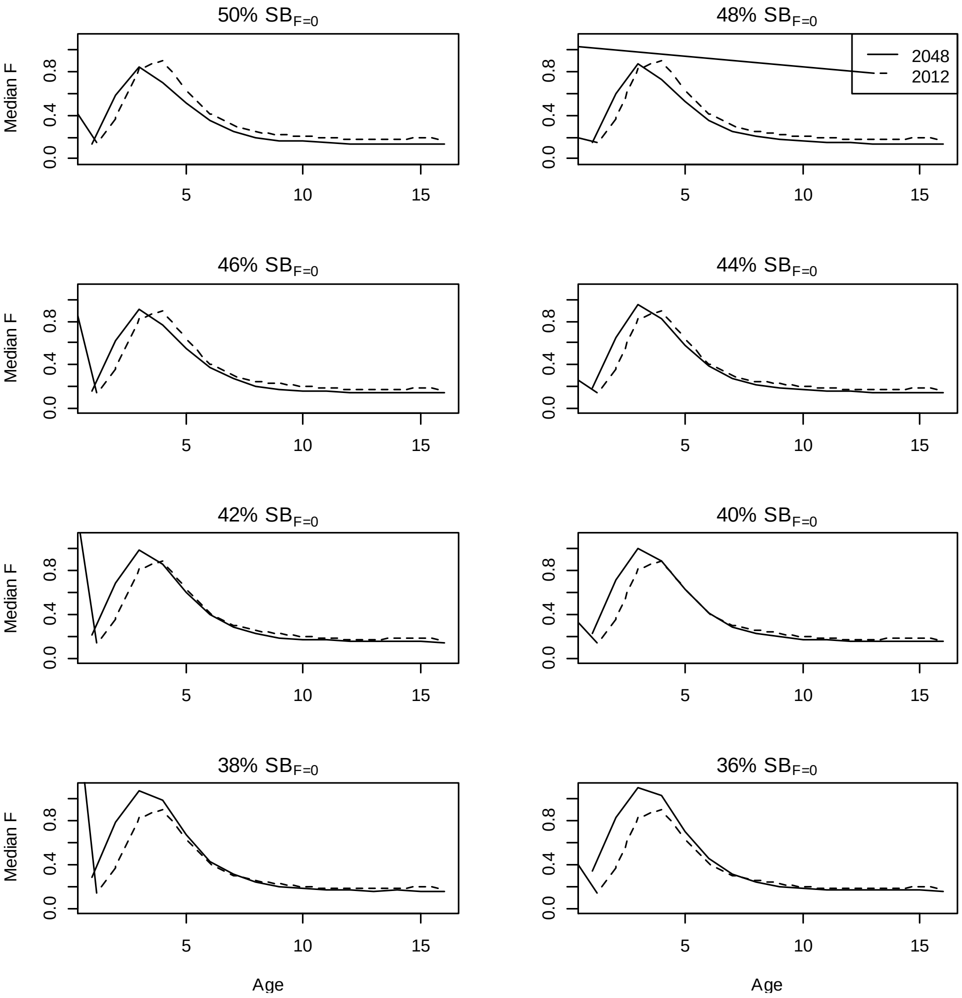


Figure 3. Pattern of (median) overall fishing mortality-at-age (quarter) for each candidate TRP depletion level. Dotted line presents estimated 2012 F-at-age, solid line the projected 2048 F-at-age.

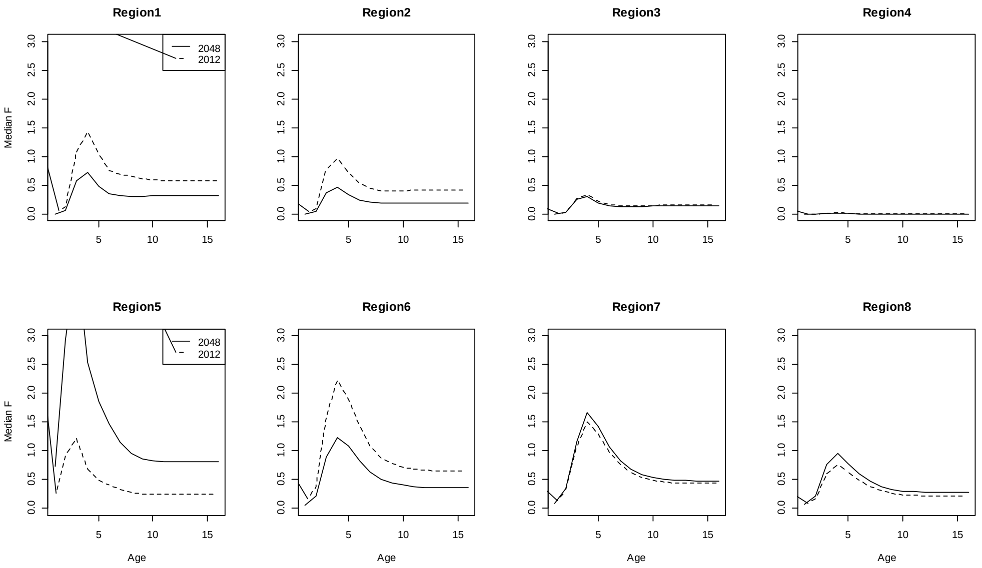


Figure 4. Pattern of (median) fishing mortality-at-age (quarter) by skipjack model region under conditions achieving 42% $SB_{F=0}$ depletion. Dotted line presents estimated 2012 F-at-age, solid line the projected 2048 F-at-age.

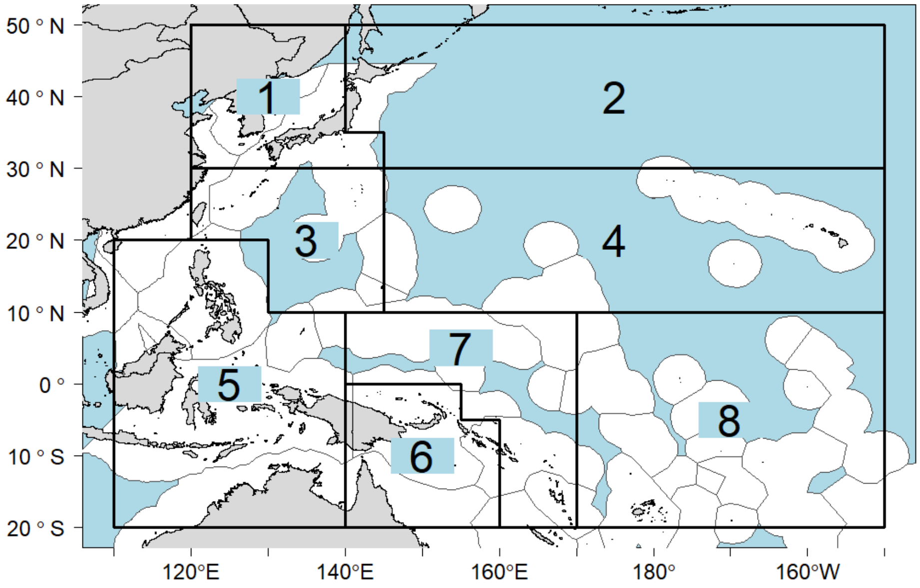


Figure 5. The geographical area covered by the stock assessment and the boundaries for the 8 region assessment model.

Table 5. Table of Annual Catch Estimates for key fisheries within Region 5 of the skipjack stock assessment model for 2012 and averaged over the period 2016-2018 period.

		Skipjack catch (t.) used in assessments from Annual catch estimates				
flag_id	**Gear**	**2012**	**Average 2016-2018**	**Increase / Decrease**	**%**	**% of total**
ID	Gillnet	0	0	0		
	Handline	0	0	0		
	Hook-and-line	0	38,817	38,817		
	Longline	0	2,185	2,185		
	OTHER Small-scale gears	109,732	93,993	-15,739		
	Pole-and-line	100,857	83,027	-17,830		
	Purse seine	69,058	91,985	22,927		
ID Total		279,647	310,006	30,359	11%	8%
PH	Handline	439	2,639	2,200		
	Hook-and-line	10,600	9,418	-1,182		
	Longline	0	0	0		
	OTHER Small-scale gears	3,078	5,136	2,058		
	Ringnet	23,255	26,738	3,483		
	Purse seine	39,062	37,229	-1,833		
PH Total		76,434	81,161	4,727	6%	1%
VN	Gillnet	20,998	39,836	18,838		
	Longline	0	0	0		
	Purse seine	22,638	50,672	28,034		
VN Total		43,636	90,507	46,871	107%	12%
				0		
Total		**399,717**	**481,674**	**81,957**	**21%**	**21%**

FAD closure

Request
Adding months, projected change in **future depletion** for **SKJ, BET, YFT; HS x 6 months, EEZ x 3 months**
Adding months, projected change in **future depletion** for **SKJ, BET, YFT; HS x 5 months, EEZ x 4 months**
Adding months, projected change in **future depletion** for **SKJ, BET, YFT**; **HS x 6 months, EEZ x 4 months**
Reduce FAD closure implications on **SKJ, BET, YFT** future depletion; **status quo (3 months EEZ/HS + 2 months HS)** **+ a sensitivity with the 2019 effort and catch levels.**
Reduce FAD closure implications on **SKJ, BET, YFT** future depletion; **1 month reduction (EEZ and HS)** **+ a sensitivity with the 2019 effort and catch levels.**
Reduce FAD closure implications on **SKJ, BET, YFT** future depletion; **complete removal (both EEZ and HS** **+ a sensitivity with the 2019 effort and catch levels.**
Reduce FAD closure implications on **SKJ, BET, YFT** future depletion; **2 months EEZ, 3 months HS** **+ a sensitivity with the 2019 effort and catch levels.**
Reduce FAD closure implications on **SKJ, BET, YFT** future depletion; **2 months HS, 2 months EEZ** **+ a sensitivity with the 2019 effort and catch levels.**
Reduce FAD closure implications on **SKJ, BET, YFT** future depletion; **1 month HS, 1 month EEZ** **+ a sensitivity with the 2019 effort and catch levels.**
Changed FAD closure implications on **SKJ, BET, YFT** future depletion; **5 months HS, 5 months EEZ** **+ a sensitivity with the 2019 effort and catch levels.**
Changed FAD closure implications on **SKJ, BET, YFT** future depletion; **4 months HS, 4 months EEZ** **+ a sensitivity with the 2019 effort and catch levels.**
Changed FAD closure implications on **SKJ, BET, YFT** future depletion; **3 months HS, 3 months EEZ** **+ a sensitivity with the 2019 effort and catch levels.**
Changed FAD closure implications on **SKJ, BET, YFT** future depletion; **2 months HS, 3 months EEZ** **+ a sensitivity with the 2019 effort and catch levels.**
Changed FAD closure implications on **SKJ, BET, YFT** future depletion; **3 months HS, 4 months EEZ** **+ a sensitivity with the 2019 effort and catch levels.**
Changed FAD closure implications on **SKJ, BET, YFT** future depletion; **3 months HS, 5 months EEZ** **+ a sensitivity with the 2019 effort and catch levels.**
Assess the trade-off between increases in longline bigeye catch and length of FAD closure, include results for SKJ, BET, YFT

Alternative in-zone and high seas FAD closure durations

To evaluate the impact of changing the FAD closure on purse seine effort, an approach comparable to the analysis of the existing tropical tuna CMM was undertaken (see SC17-MI-IP-03 for full details).

Baseline purse seine effort levels were set at the 2016-2018 average unless otherwise requested as a sensitivity. Increases in FAD sets were therefore compensated for by decreases in free school sets (and vice versa) to maintain overall effort levels. Within these settings, the impact of the purse seine fishery component on the three tropical tuna stocks varied.

The changes in FAD sets primarily affect the results for bigeye. For this stock, the change in FAD closure period and variations in overall effort from the 2016-2018 average baseline are assumed to be multiplicative – e.g. a decrease in the number of 'days fished' and a decrease in the period within which FAD sets can be made both reduce the number of FAD sets. We therefore assume that the general pattern of fishing remains consistent into the future, and the number or proportion of FAD sets made outside the closure is not increased, despite specified changes in FAD closure length (see column 'Overall PS scalar' in Table 6 and Table 7).

Depletion outcomes resulting from the different combinations of FAD closure periods are presented in Table 6 and Table 7 for bigeye under recent and long-term recruitment assumptions, respectively. Longline and other fishery levels were assumed as specified in the table for each scenario (we interpreted the request for a sensitivity analysis of 2019 levels as applying to both purse seine and longline fisheries and applied this variation to ALL requested scenarios detailed in the request table above).

For yellowfin and skipjack, previous analyses (SC10-MI-WP-05; SC11-MI-WP-05) have indicated that with regards to purse seine impacts, it is the overall effort by this gear that is the primary influence on stock status rather than the proportion of FAD sets. Therefore, in these analyses we only account for the impact of overall purse seine effort changes for these stocks (see column 'PS effort and HS PS effort v 2016-18 avg' in Table 6 and Table 7).

Results for each stock are interpreted based upon the relevant scalars estimated, with reference to Tables 1 to 6 in WCPFC-TTMW1-2021-02_rev1 (bigeye and yellowfin) and Table 2 in WCPFC-TTMW1-2021-04_rev1.

We note that in this and other spatial FAD-related analyses presented within this document, we do not specifically apply, for example, the high seas FAD closure only to those regions of the bigeye stock assessment model where the high seas are primarily located. For simplicity, the change is distributed across the tropical regions. However, we note that the impact of changes in high seas FAD closure duration would primarily be felt in the eastern region of the tropics where bigeye catch-per-set is generally above the average for the tropical region (see Figure 9). To an extent, the impact of the high seas FAD closure on the bigeye stock will be under-estimated within this analysis as a result.

Table 6. Combinations of specified EEZ and high seas FAD closure periods, purse seine effort and longline catch scenarios, and resulting depletion levels for bigeye (recent recruitment assumption), yellowfin and skipjack tuna.

Scenario combinations					Resulting Scalars					BET outcomes			YFT outcomes			SKJ outcomes	
EEZ PS effort	**EEZ FAD closure**	**HS FAD closure**	**LL catch**	**Other catch**	**PS effort & HS PS effort v 2016-18 avg**	**FAD closure scalar**	**Overall PS scalar**	**LL catch scalar**	**Other catch scalar**	**BET depletion**	**Result v 2012-15 avg**	**LRP risk**	**YFT depletion**	**Result v 2012-15 avg**	**LRP risk**	**SKJ depletion**	**LRP risk**
2016-18 levels	3mth	6mth	2016-18 levels	2016-18 levels	1	1.1	1.1	1	1	0.47	1.27	0%	0.59	1.07	0%	0.44	0%
2016-18 levels	4mth	5mth	2016-18 levels	2016-18 levels	1	1	1	1	1	0.48	1.30	0%	0.59	1.07	0%	0.44	0%
2016-18 levels	4mth	6mth	2016-18 levels	2016-18 levels	1	0.99	0.99	1	1	0.48	1.30	0%	0.59	1.07	0%	0.44	0%
2016-18 levels	3mth	5mth	2016-18 levels	2016-18 levels	1	1.11	1.11	1	1	0.47	1.27	0%	0.59	1.07	0%	0.44	0%
2016-18 levels	2mth	4mth	2016-18 levels	2016-18 levels	1	1.24	1.24	1	1	0.44	1.19	0%	0.59	1.07	0%	0.44	0%
2016-18 levels	0mth	0mth	2016-18 levels	2016-18 levels	1	1.51	1.51	1	1	0.41	1.10	0%	0.59	1.07	0%	0.44	0%
2016-18 levels	2mth	3mth	2016-18 levels	2016-18 levels	1	1.25	1.25	1	1	0.44	1.19	0%	0.59	1.07	0%	0.44	0%
2016-18 levels	2mth	2mth	2016-18 levels	2016-18 levels	1	1.26	1.26	1	1	0.44	1.19	0%	0.59	1.07	0%	0.44	0%
2016-18 levels	1mth	1mth	2016-18 levels	2016-18 levels	1	1.38	1.38	1	1	0.42	1.14	0%	0.59	1.07	0%	0.44	0%
2016-18 levels	5mth	5mth	2016-18 levels	2016-18 levels	1	0.88	0.88	1	1	0.5	1.35	0%	0.59	1.07	0%	0.44	0%
2016-18 levels	4mth	4mth	2016-18 levels	2016-18 levels	1	1.01	1.01	1	1	0.48	1.30	0%	0.59	1.07	0%	0.44	0%
2016-18 levels	3mth	3mth	2016-18 levels	2016-18 levels	1	1.13	1.13	1	1	0.46	1.24	0%	0.59	1.07	0%	0.44	0%
2016-18 levels	3mth	2mth	2016-18 levels	2016-18 levels	1	1.14	1.14	1	1	0.46	1.24	0%	0.59	1.07	0%	0.44	0%
2016-18 levels	4mth	3mth	2016-18 levels	2016-18 levels	1	1.01	1.01	1	1	0.48	1.30	0%	0.59	1.07	0%	0.44	0%
2016-18 levels	5mth	3mth	2016-18 levels	2016-18 levels	1	0.9	0.90	1	1	0.5	1.35	0%	0.59	1.07	0%	0.44	0%
2019 levels	3mth	6mth	2019 levels	2016-18 levels	0.93	1.1	1.02	1.1	1	0.47	1.27	0%	0.59	1.07	0%	0.46	0%
2019 levels	4mth	5mth	2019 levels	2016-18 levels	0.93	1	0.93	1.1	1	0.48	1.34	0%	0.59	1.07	0%	0.46	0%
2019 levels	4mth	6mth	2019 levels	2016-18 levels	0.93	0.99	0.92	1.1	1	0.49	1.34	0%	0.59	1.07	0%	0.46	0%
2019 levels	3mth	5mth	2019 levels	2016-18 levels	0.93	1.11	1.03	1.1	1	0.46	1.27	0%	0.59	1.07	0%	0.46	0%
2019 levels	2mth	4mth	2019 levels	2016-18 levels	0.93	1.24	1.15	1.1	1	0.44	1.19	0%	0.59	1.07	0%	0.46	0%
2019 levels	0mth	0mth	2019 levels	2016-18 levels	0.93	1.52	1.41	1.1	1	0.41	1.10	0%	0.59	1.07	0%	0.46	0%
2019 levels	2mth	3mth	2019 levels	2016-18 levels	0.93	1.25	1.16	1.1	1	0.44	1.19	0%	0.59	1.07	0%	0.46	0%
2019 levels	2mth	2mth	2019 levels	2016-18 levels	0.93	1.26	1.17	1.1	1	0.44	1.19	0%	0.59	1.07	0%	0.46	0%
2019 levels	1mth	1mth	2019 levels	2016-18 levels	0.93	1.39	1.29	1.1	1	0.42	1.14	0%	0.59	1.07	0%	0.46	0%
2019 levels	5mth	5mth	2019 levels	2016-18 levels	0.93	0.88	0.82	1.1	1	0.5	1.35	0%	0.59	1.07	0%	0.46	0%
2019 levels	4mth	4mth	2019 levels	2016-18 levels	0.93	1.01	0.94	1.1	1	0.48	1.30	0%	0.59	1.07	0%	0.46	0%
2019 levels	3mth	3mth	2019 levels	2016-18 levels	0.93	1.13	1.05	1.1	1	0.46	1.24	0%	0.59	1.07	0%	0.46	0%
2019 levels	3mth	2mth	2019 levels	2016-18 levels	0.93	1.14	1.06	1.1	1	0.46	1.24	0%	0.59	1.07	0%	0.46	0%
2019 levels	4mth	3mth	2019 levels	2016-18 levels	0.93	1.02	0.95	1.1	1	0.48	1.30	0%	0.59	1.07	0%	0.46	0%
2019 levels	5mth	3mth	2019 levels	2016-18 levels	0.93	0.9	0.84	1.1	1	0.49	1.34	0%	0.59	1.07	0%	0.46	0%

Table 7. Combinations of specified EEZ and high seas FAD closure periods, purse seine effort and longline catch scenarios, and resulting depletion levels for bigeye (long-term recruitment assumption), yellowfin and skipjack tuna

Scenario combinations					Resulting Scalars					BET outcomes			YFT outcomes			SKJ outcomes	
EEZ PS effort	EEZ FAD closure	HS FAD closure	LL catch	Other catch	PS effort & HS PS effort v 2016-18 avg	FAD closure	Overall PS scalar	LL catch scalar	Other catch scalar	BET depletion	Result v 2012-15 avg	LRP risk	YFT depletion	Result v 2012-15 avg	LRP risk	SKJ depletion	LRP risk
2016-18 levels	3mth	6mth	2016-18 levels	2016-18 levels	1	1.1	1.1	1	1	0.42	1.14	6%	0.59	1.07	0%	0.44	0%
2016-18 levels	4mth	5mth	2016-18 levels	2016-18 levels	1	1	1	1	1	0.43	1.16	5%	0.59	1.07	0%	0.44	0%
2016-18 levels	4mth	6mth	2016-18 levels	2016-18 levels	1	0.99	0.99	1	1	0.43	1.16	5%	0.59	1.07	0%	0.44	0%
2016-18 levels	3mth	5mth	2016-18 levels	2016-18 levels	1	1.11	1.11	1	1	0.42	1.14	6%	0.59	1.07	0%	0.44	0%
2016-18 levels	2mth	4mth	2016-18 levels	2016-18 levels	1	1.24	1.24	1	1	0.39	1.05	9%	0.59	1.07	0%	0.44	0%
2016-18 levels	0mth	0mth	2016-18 levels	2016-18 levels	1	1.52	1.52	1	1	0.36	0.97	12%	0.59	1.07	0%	0.44	0%
2016-18 levels	2mth	3mth	2016-18 levels	2016-18 levels	1	1.25	1.25	1	1	0.39	1.05	9%	0.59	1.07	0%	0.44	0%
2016-18 levels	2mth	2mth	2016-18 levels	2016-18 levels	1	1.26	1.26	1	1	0.39	1.05	9%	0.59	1.07	0%	0.44	0%
2016-18 levels	1mth	1mth	2016-18 levels	2016-18 levels	1	1.39	1.39	1	1	0.37	1.00	11%	0.59	1.07	0%	0.44	0%
2016-18 levels	5mth	5mth	2016-18 levels	2016-18 levels	1	0.88	0.88	1	1	0.45	1.22	4%	0.59	1.07	0%	0.44	0%
2016-18 levels	4mth	4mth	2016-18 levels	2016-18 levels	1	1.01	1.01	1	1	0.43	1.16	5%	0.59	1.07	0%	0.44	0%
2016-18 levels	3mth	3mth	2016-18 levels	2016-18 levels	1	1.13	1.13	1	1	0.41	1.10	7%	0.59	1.07	0%	0.44	0%
2016-18 levels	3mth	2mth	2016-18 levels	2016-18 levels	1	1.14	1.14	1	1	0.41	1.10	7%	0.59	1.07	0%	0.44	0%
2016-18 levels	4mth	3mth	2016-18 levels	2016-18 levels	1	1.02	1.02	1	1	0.43	1.16	5%	0.59	1.07	0%	0.44	0%
2016-18 levels	5mth	3mth	2016-18 levels	2016-18 levels	1	0.9	0.90	1	1	0.45	1.22	4%	0.59	1.07	0%	0.44	0%
2019 levels	3mth	6mth	2019 levels	2016-18 levels	0.93	1.1	1.02	1.1	1	0.42	1.14	7%	0.59	1.07	0%	0.46	0%
2019 levels	4mth	5mth	2019 levels	2016-18 levels	0.93	1	0.93	1.1	1	0.43	1.16	5%	0.59	1.07	0%	0.46	0%
2019 levels	4mth	6mth	2019 levels	2016-18 levels	0.93	0.99	0.92	1.1	1	0.43	1.16	5%	0.59	1.07	0%	0.46	0%
2019 levels	3mth	5mth	2019 levels	2016-18 levels	0.93	1.11	1.03	1.1	1	0.41	1.10	7%	0.59	1.07	0%	0.46	0%
2019 levels	2mth	4mth	2019 levels	2016-18 levels	0.93	1.24	1.15	1.1	1	0.39	1.05	9%	0.59	1.07	0%	0.46	0%
2019 levels	0mth	0mth	2019 levels	2016-18 levels	0.93	1.52	1.41	1.1	1	0.36	0.97	13%	0.59	1.07	0%	0.46	0%
2019 levels	2mth	3mth	2019 levels	2016-18 levels	0.93	1.25	1.16	1.1	1	0.39	1.05	9%	0.59	1.07	0%	0.46	0%
2019 levels	2mth	2mth	2019 levels	2016-18 levels	0.93	1.26	1.17	1.1	1	0.39	1.05	9%	0.59	1.07	0%	0.46	0%
2019 levels	1mth	1mth	2019 levels	2016-18 levels	0.93	1.39	1.29	1.1	1	0.37	1.00	11%	0.59	1.07	0%	0.46	0%
2019 levels	5mth	5mth	2019 levels	2016-18 levels	0.93	0.88	0.82	1.1	1	0.45	1.22	4%	0.59	1.07	0%	0.46	0%
2019 levels	4mth	4mth	2019 levels	2016-18 levels	0.93	1.01	0.94	1.1	1	0.42	1.14	6%	0.59	1.07	0%	0.46	0%
2019 levels	3mth	3mth	2019 levels	2016-18 levels	0.93	1.13	1.05	1.1	1	0.41	1.10	7%	0.59	1.07	0%	0.46	0%
2019 levels	3mth	2mth	2019 levels	2016-18 levels	0.93	1.14	1.06	1.1	1	0.41	1.10	7%	0.59	1.07	0%	0.46	0%
2019 levels	4mth	3mth	2019 levels	2016-18 levels	0.93	1.02	0.95	1.1	1	0.42	1.14	6%	0.59	1.07	0%	0.46	0%
2019 levels	5mth	3mth	2019 levels	2016-18 levels	0.93	0.9	0.84	1.1	1	0.44	1.19	5%	0.59	1.07	0%	0.46	0%

Trade-off between bigeye longline catch and the FAD closure period

The trade-off request was interpreted in two ways.

The first component evaluated the level of change required in one gear, relative to 2016-2018 baseline conditions, to maintain the depletion of bigeye tuna (under the two recruitment scenarios) at a specific level. For this analysis, the depletion level under 'baseline' 2016-2018 levels was used, to reflect the differing impacts of the recruitment assumptions being examined on future stock productivity. This therefore mirrored a specific 'diagonal line' of Figures 1 and 3 in WCPFC-TTMW1-2021-02_rev1 (maintaining BET depletion at 'baseline' 0.48 and 0.43 $SB_{F=0}$ for 'recent' and 'long-term' recruitment scenarios, respectively). The request indicated increases in longline catch, so additional catch increments of approximately +6,000 mt (10% of the 2016-2018 average) were evaluated, up to a set of scalars that fell within the 0.5 - 2 range examined within WCPFC-TTMW1-2021-02_rev1.

The approach identifies trade-offs in terms of the impact on the bigeye stock, i.e. maintaining the stock at specific depletion levels, to best reflect the differential impacts purse seine and longline fishing has on that stock. An approach that equated to the impact in terms of equal catch, for example, would ignore the fact that to take a comparable level of catch (mt), the longline fleet would take fewer larger fish given its selectivity, and hence would have a different impact on the stock to the removal of an equivalent weight of smaller fish by the purse seine fishery.

The request asked for the corresponding impacts on yellowfin and skipjack stocks. An assumption of this evaluation is that overall purse seine effort remains constant at 2016-2018 levels, with increased FAD closure duration equating to an increased number of sets being transferred to free school sets to maintain the overall effort. Under this assumption there is no differential impact on skipjack tuna, and hence the consequences for this stock are not presented. For yellowfin, this assumption means that the main impact is through the change in longline catch. For this analysis, the assumption is made that changes in yellowfin longline catch are equal to the assumed change in bigeye longline catch. Under that strong assumption, the consequences for yellowfin are included within the tables.

Table 8. Evaluation of the change in FAD sets (and equivalent FAD closure period) required to maintain bigeye depletion at levels resulting under 'baseline' conditions given set increases in longline bigeye catch, where 'recent' recruitment is assumed. Potential consequences for the yellowfin stock where changes in longline catch mirror those for bigeye are shown.

Approximate LL BET catch (mt)	LL scalar from 2016-18 average	Scalar for PS FAD sets to maintain BET at 'recent' depletion levels	Approximate equivalent additional months of PS FAD closure period (and approx. total*)	Resulting yellowfin $SB/SB_{F=0}$
65,000	1.1	0.95	0.42 (4.12)	0.59
71,000	1.2	0.85	1.25 (4.95)	0.58
77,000	1.3	0.80	1.67 (5.37)	0.58
83,000	1.4	0.70	2.50 (6.2)	0.57
89,000	1.5	0.65	2.92 (6.62)	0.57
95,000	1.6	0.60	3.33 (7.03)	0.56
101,000	1.7	0.50	4.17 (7.87)	0.56
107,000	1.8	-	-	0.56

* assumes approximate average FAD closure period of 3.7mths over 2016-2018

Table 9. Evaluation of the change in FAD sets (and approximate equivalent FAD closure period) required to maintain bigeye depletion at levels resulting under 'baseline' conditions given set increases in longline bigeye catch, where 'long-term' recruitment is assumed. Potential consequences for the yellowfin stock where changes in longline catch mirror those for bigeye are shown.

Approximate LL BET catch (mt)	LL scalar from 2016-18 average	Scalar for PS FAD sets to maintain BET at 'long term' depletion levels	Approximate equivalent additional months of PS FAD closure period (and approx. total*)	Resulting yellowfin $SB/SB_{F=0}$
65,000	1.1	0.90	0.83 (4.53)	0.59
71,000	1.2	0.80	1.67 (5.37)	0.58
77,000	1.3	0.75	2.08 (5.78)	0.58
83,000	1.4	0.65	2.92 (6.62)	0.57
89,000	1.5	0.6	3.33 (7.03)	0.57
95,000	1.6	0.50	4.17 (7.87)	0.56
101,000	1.7	-	-	0.56

* assumes approximate average FAD closure period of 3.7mths over 2016-2018

The second component evaluated the length of FAD closure that would have an equivalent impact on the stock as a specified increase in longline catch. To examine this, the impact of the specified change in longline catch in terms of bigeye depletion was evaluated, assuming the purse seine effort remained at the 2016-2018 average level. Then the corresponding change in purse seine FAD effort required to achieve the same level of bigeye depletion was identified, assuming longline catch remained at the 2016-2018 average level. This was evaluated under 'recent' and 'long-term' recruitment scenarios (Table 10). As the FAD closure was the focus, the implications were evaluated for bigeye only (under the assumption that overall purse seine effort remains constant, results for yellowfin would be as detailed in Table 9).

Table 10. Evaluation of the equivalent change in FAD sets (and approximate equivalent FAD closure period) that had the same impact on bigeye stock depletion as set increases in longline bigeye catch, under 'recent' and 'long-term' recruitment assumptions.

Approximate LL BET catch (mt)	LL scalar from 2016-18 average	Resulting bigeye tuna depletion ($SB/SB_{F=0}$)		Equivalent purse seine effort scalar (and approx. FAD duration*)	
		Recent recruitment	Long term recruitment	Recent recruitment	Long term recruitment
65,000	1.1	0.47	0.42	1.1 (2.87)	1.1 (2.87)
71,000	1.2	0.45	0.40	1.2 (2.04)	1.2 (2.04)
77,000	1.3	0.44	0.38	1.3 (1.21)	1.35 (0.80)
83,000	1.4	0.43	0.37	1.35 (0.80)	1.4 (0.38)
89,000	1.5	0.41	0.35	1.5 (0)	1.6 (0)
95,000	1.6	0.40	0.34	1.6 (-)	1.7 (-)
101,000	1.7	0.38	0.32	1.7 (-)	1.95 (-)

* assumes approximate average FAD closure period of 3.7mths over 2016-2018

High seas effort

Request
Maintaining EEZ PS effort, evaluate the impact of varying effort on the high seas between 0 and **10,000** days (increment by **2,000** days)

The analysis assumed that changes on the high seas occurred relative to the patterns of fishing over the period 2016 to 2018. Within those patterns, the effort in EEZs was assumed to remain at the 2016-2018 level, while effort on the high seas changed as specified by the TTMW1 request. Changes in high seas effort were not therefore assumed to lead to increased or decreased fishing within EEZs.

To calculate the number of FAD sets that resulted, the specified number of days available on the high seas in each year were proportioned to each flag operating in 2016-2018, relative to the pattern of effort between flags seen in each year (e.g. WCPFC-TTMW1-2021-IP02, Table 2), and the average flag-level FAD sets per day (averaged over 2016 and 2018, given the high seas closure in 2017) were applied to those days to get the overall change in FAD sets (EEZ + high seas) relative to the 2016-2018 baseline. Given the aim of the analysis is to evaluate the potential impact on the bigeye stock (in particular), this approach was taken for all flags and ignores allocation issues or exemptions.

The scalar for purse seine reflected the estimated change in the number of FAD sets relative to the 2016-2018 average level. Longline and other fisheries were assumed to maintain 2016-2018 average catches (scalar = 1). Impacts are therefore due to changes in the purse seine fishery only.

Changes in effort on the high seas may also lead to impacts for skipjack tuna. To simplify that analysis, we assumed that the relative pattern of (FAD and free school) sets per day would remain constant at the average over 2016-2018. Hence the scalar influencing skipjack status could be calculated using the change in the annual number of fishing days relative to that seen over the 2016-2018 period, where again the number of days fished within EEZs remained constant, and those on the high seas changed as specified by the TTMW1 request (see WCPFC-TTMW1-2021-IP02, Table 1).

Table 11. Implications of alternative levels of high seas purse seine effort on overall purse seine fishing levels and consequences for bigeye tuna (under the two hypotheses of future recruitment) and skipjack tuna depletion levels, with a 2016-18 average baseline EEZ effort level.

HS effort (days)	PS FAD set scalar relative to 2016-2018 average	Resulting BET $SB/SB_{F=0}$		PS (days) scalar relative to		Resulting SKJ $SB/SB_{F=0}$
		Recent recruitment	Long-term recruitment	2016-2018 average	2012	
0	0.92	0.50	0.45	0.87	0.80	0.48
2,000	0.95	0.49	0.44	0.91	0.84	0.46
4,000	0.98	0.48	0.43	0.94	0.87	0.46
6,000	1.01	0.48	0.43	0.98	0.91	0.44
8,000	1.04	0.47	0.42	1.02	0.94	0.44
10,000	1.07	0.47	0.42	1.06	0.98	0.42

A key assumption in the above analysis is the use of the 2016-2018 average levels for in-EEZ purse seine effort. An alternative would be to assume 2012 purse seine effort levels within EEZs. Applying 2012 in-zone purse seine effort (FAD sets or days) and the average flag-level high seas FAD sets per day (averaged over 2016 and 2018 to capture recent fishing patterns), outcomes are presented in Table 12. Note that the application of spatially specific FAD set scalars in this analysis required a different approach to that used for e.g. Table 6.

Table 12. Implications of alternative levels of high seas purse seine effort on overall purse seine fishing levels and consequences for bigeye tuna (under the two hypotheses of future recruitment) and skipjack tuna depletion level, with 2012 EEZ effort levels.

HS effort (days)	PS FAD set scalar relative to 2016-2018 average	Resulting BET $SB/SB_{F=0}$		PS (days) scalar relative to		Resulting SKJ $SB/SB_{F=0}$
		Recent recruitment	Long-term recruitment	2016-2018 average	2012	
0	1.12	0.47	0.42	1.04	0.96	0.43
2,000	1.15	0.46	0.41	1.08	1.00	0.42
4,000	1.18	0.45	0.40	1.11	1.03	0.41
6,000	1.21	0.45	0.40	1.15	1.07	0.40
8,000	1.23	0.44	0.39	1.19	1.10	0.39
10,000	1.26	0.44	0.39	1.23	1.14	0.38

FAD definitions

Request
Impact of the exclusion of floating objects that do not have a tracking buoy attached from the definition of FAD

The assumption was made that the exclusion of floating objects that do not have a tracking buoy attached from the definition of a FAD would equate to the removal of logs from that definition (e.g. see Figure 3.2.2 of SC17-GN-IP-01). For 2016-2018, the raised annual number of log sets (excluding archipelagic waters and the domestic fisheries of Philippines, Indonesia and Vietnam) within the tropical region of the WCPFC-CA was calculated. The corresponding average number of sets per month (considering the variable annual FAD closures over that period) was estimated. The resulting average number of log sets per month was then applied to the length of the FAD closure period in each year (Table 13). The resulting increased number of sets was estimated as a scalar applied to the 2016-2018 average, and the corresponding impact on bigeye tuna depletion assessed under the two future recruitment scenarios.

Table 13. Estimation of the purse seine FAD set scalar resulting from the exclusion of 'log sets' from the definition of a FAD, for the years 2016-2018.

Year	Estimated raised log sets per year (excl. AW)	FAD closure period (approx.)	Log sets per remaining month	Increased sets per annum	Annual 'updated' total FAD sets
2016	1,864	4months	233	932	13,547
2017	1,374	4months	172	687	16,099
2018	1,741	3months	193	580	17,742
				Average:	15,796
				Scalar from 2016-2018:	1.05

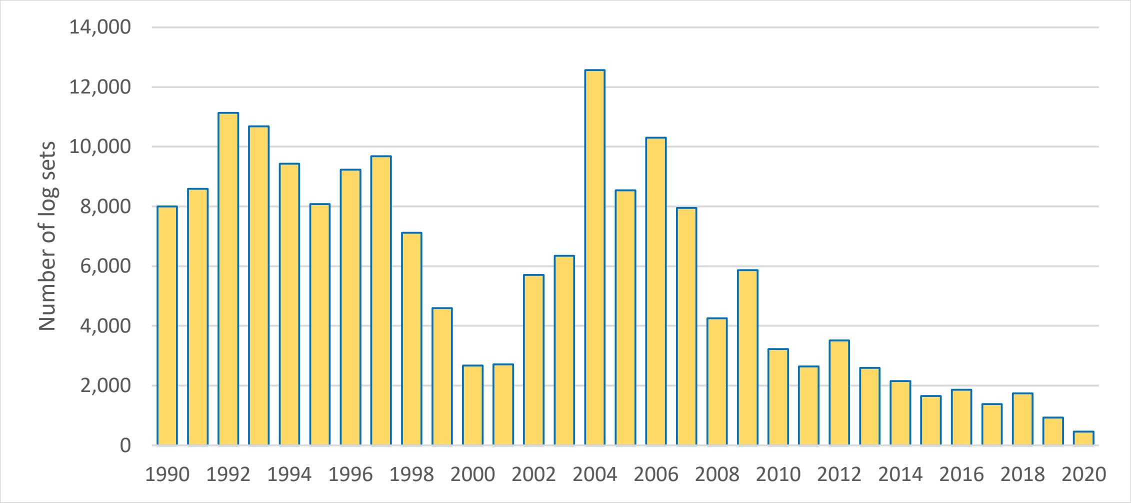
The resulting BET depletion level, assuming the catch of longline and other fisheries remain at 2016-18 average levels, is presented in Table 14.

Table 14. Implications for bigeye tuna of the exclusion of 'log sets' from the definition of a FAD (under the two hypotheses of future recruitment).

PS FAD set scalar relative to 2016-2018 average	Resulting BET $SB/SB_{F=0}$	
	Recent recruitment	Long term recruitment
1	0.48	0.43
1.05	0.47	0.42

This analysis assumes that the pattern of log sets seen over the 2016-2018 period remains consistent into the future, and that the exclusion of these sets from the definition of a FAD does not change the behaviour of vessels in the future. We also note that the number of log sets will be affected by the overall level of purse seine effort – assumed to be constant at the 2016-2018 average level here – as well as the location of fishing within the tropical WCPO.

To examine how well the recent period reflects the potential levels of log fishing that might occur during the FAD closure period if definitions were changed, the historical trend in the number of log sets made per annum, and both the proportion of log sets to total purse seine sets and proportion of log sets to days fishing in the tropical WCPFC-CA are plotted in Figure 6. The number of log sets declined and the proportion of sets on drifting FADs increased over the period, with the 2016-2018 average being 37% of the 2000-2019 average level. If vessels changed fishing behaviour and returned to historical long-term average levels of log setting within the FAD closure period, this would equate to a scalar of 1.07 (2000-2019 average).



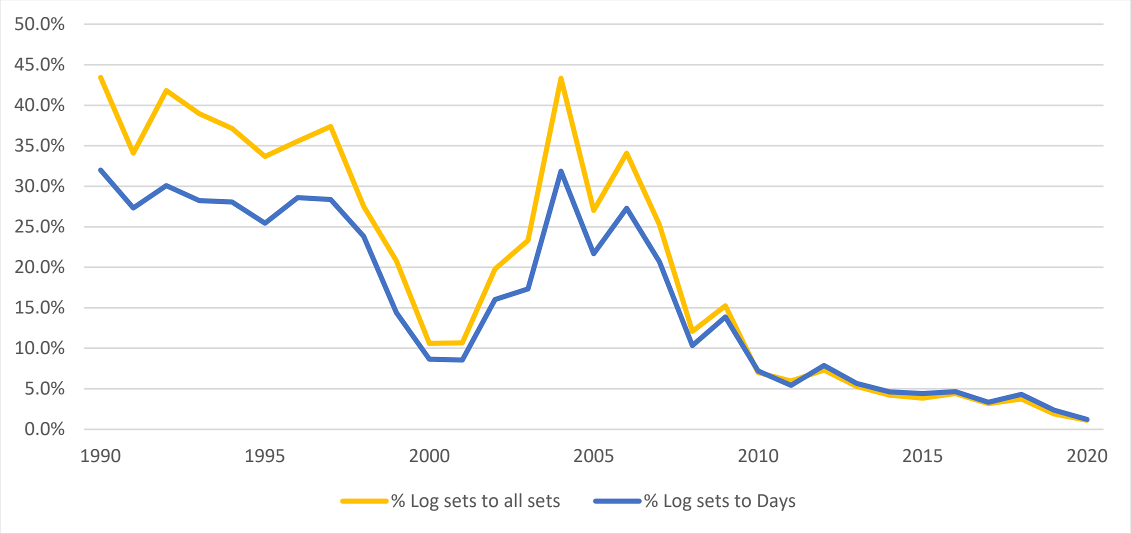


Figure 6. Number of log sets per annum (top), and log sets as a proportion of total sets and proportion of log sets to the total number of days fishing (bottom) in the tropical WCPFC purse seine fishery since 1990 (excludes AWs and domestic fisheries of Philippines, Indonesia and Vietnam).

Exemptions

Request
Consequence on the projected stock status on the exemption from 20% of the 35% cuts applied to the bigeye catch limits of other major longline fleets from the baseline limits in CMM 2008-01 for any fleet in accordance with para 35 of CMM 2008-01.

Paragraph 35 of CMM 2008-01 states "Further to paragraph 34, the reductions specified in paragraph 33 for 2010 and 2011 shall not apply to fleets of members with a total longline bigeye tuna catch limit as stipulated in Attachment F of less than 5,000 tonnes and landing exclusively fresh fish, provided that the details of such fleets and their operational characteristics are registered with the Commission by 31 December 2008 and that the number of licenses authorized in such fisheries does not increase from current levels. In such cases, catch limits specified in Attachment F shall continue to be applied." The specification of landing fresh fish focuses this Paragraph on specific CCMs.

The pattern of longline bigeye catches over time by relevant CCMs, and the tropical tuna CMM limits in accordance with paragraph 35 of CMM 2008-01 are presented in Table 16. Using this as the basis, the level of catch that would have been taken under CMM 2008-01 conditions relative to actual catch levels over that period (on average a difference of 652 mt) is calculated as a scalar relative to 2016-2018 average conditions, and the resulting bigeye stock status estimated assuming purse seine and other gears continued at 2016-2018 average fishing levels (scalar=1; Table 15).

Table 15. Longline catch scalar relative to 2016-2018 average conditions that would have been taken under CMM 2008-01 Para 35 limits.

Scenario	LL bigeye catch (mt)	Longline scalar	Resulting bigeye depletion ($SB/SB_{F=0}$)	
			Recent recruitment	Long term recruitment
2016-2018 average	59,312	1	0.48	0.43
CMM 2008-01 Para 35	58,661	0.99	0.48	0.43

Table 16. Reported total longline bigeye catches (mt) and TT CMM limits in accordance with para 35 of CMM 2008-01 for affected CCMs.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Reported BET catches	4,649	3,741	3,577	3,565	3,660	3,612	3,823	3,427	3,747	2,968	3,393	3,460	3,548
TT CMM Limits (Para 35 CMM 2008-01)	4,181	3,763	3,345	2,927	2,927	2,927	2,927	2,927	2,718	2,718	2,718	2,718	2,718

Additional metrics/scalars

Request
SKJ[1] WP04 – A calculation of recent fishing mortality levels as proportions of 2012 and 2012-2015 levels, overall region, fish size (juv/ad)
Alternative values for estimating future depletion levels against alternative catch and effort baselines **Purse seine** 1-month EEZ FAD closure; 1-month High seas FAD closure 1-month High seas + EEZ FAD closure; and
Alternative values for estimating future depletion levels against alternative catch and effort baselines **Longline catch equivalents for:** 1-month EEZ FAD closure; 1-month High seas FAD closure 1-month High seas + EEZ FAD closure; and
Current equivalent scalars - what scalars should apply relative to the 2016-18 "starting point" for 2019 conditions (for both catch and effort).

[1] this request has been responded to under the 'TRP' section above.

Skipjack

Figure 7 presents a time series of median juvenile and adult skipjack fishing mortality from the agreed model grid of the 2019 stock assessment (1972 to 2018), and for the projection period (2019 to 2048) where stock depletion outcomes are consistent with a candidate TRP of 42%$SB_{F=0}$. Weighting of individual assessment model outputs, as adopted by SC15, are applied here.

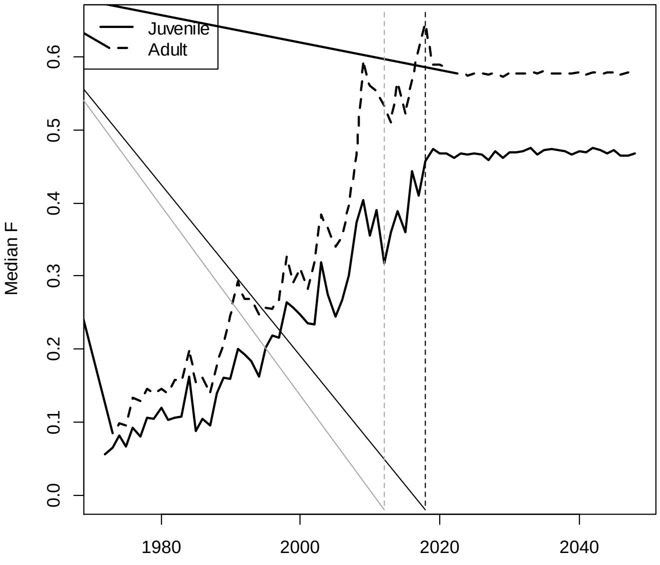


Figure 7. Time series of median (weighted) fishing mortality for juvenile and adult skipjack tuna across the WCPO model region. Vertical dotted black line = 2018 (last year of the assessment period). Vertical dotted grey line = 2012.

Table 17 presents the ratio of 'recent' fishing mortality levels (assumed to be the average over 2014-2017, as defined by SC15 when providing management advice) relative to estimated levels in 2012, and the average over 2012-2015. Estimated (weighted) median fishing mortality levels for all stock components were lower in 2012 or 2012-2015 relative to the recent period (values are less than 1).

Table 17. Table of recent fishing mortality levels (average over the period 2014-2017, consistent with the definition of the 'recent' period used by SC15) relative to that in 2012, and the average over 2012-2015.

Fishing mortality ratio	Stock component		
	Juvenile	Adult	Total
$F_{2012}/F_{2014\text{-}2017}$	0.79	0.94	0.80
$F_{2012\text{-}2015}/F_{2014\text{-}2017}$	0.89	0.94	0.90

Purse seine/longline equivalents

Scalars on purse seine associated effort resulting from changes in the FAD closure arrangement were calculated relative to 2016-2018 average conditions, using the same approach as described for the 'FAD closure' analyses above. Under the assumption that the longline catch remains constant at 2016-2018 average levels, the resulting bigeye depletion level was calculated.

To estimate the longline catch change 'equivalent' to each FAD closure arrangement, the reduction in longline catch necessary to achieve that same resulting bigeye depletion level was estimated under the assumption that the purse seine associated effort was maintained at 2016-2018 average levels.

Evaluations were performed under the two assumptions of future bigeye recruitment.

Table 18. Purse seine scalar resulting from different FAD closure characteristics, resulting depletion level, and equivalent scalar on longline bigeye catch that would lead to the same stock depletion level, under the two assumptions for future bigeye recruitment.

Increase in FAD closure duration	Approx PS FAD set scalar (relative to 2016-18 levels)	Recent recruitment			Long term recruitment		
		Resulting BET SB/SB$_{F=0}$	Approx equivalent longline BET catch scalar	Approx longline BET catch (mt)*	Resulting BET SB/SB$_{F=0}$	Approx equivalent longline BET catch scalar	Approx longline BET catch (mt)*
1 month EEZ FAD closure	0.89	0.50	0.87	51,600	0.45	0.90	53,400
1 month HS FAD closure	0.99	0.48	1.00	59,300	0.43	1.00	59,300
1 month EEZ and HS FAD closure	0.87	0.51	0.80	47,500	0.46	0.85	50,400

* Calculated based upon Table 5 of SC17-MI-IP-11, and excluding Vietnam

Current equivalent scalars

The scalars representing overall purse seine effort in 2019, and the pattern of purse seine associated and unassociated set numbers in that year, and for longline bigeye catch levels under 2019 conditions were calculated relative to the 2016-2018 baseline, based upon information available in SC17-MI-IP-11 adjusted to best reflect the calculations made within the TT CMM evaluation.

Table 19. Scalars of fishery components in 2019 relative to the 2016-2018 average baseline.

Fishery component	Scalar 2019 v 2016-2018 avg
PS total effort (days)	0.93
PS ASS effort (sets)	0.91
PS UNA effort (sets)	1.13
LL bigeye catch (mt)	1.10

CPUE

Request
Request during WS1: compile informative BET CPUE time series

To address this request, we present a range of nominal and standardised bigeye CPUE time series for the key fishing gears from recent papers (SC17-SA-IP-15; SC16-SA-WP-03; SC16-SA-IP-07), and provide further information on the spatial pattern of bigeye CPUE in the WCPO relative to the stock assessment's tropical regions. The spatial pattern will influence the time series of specific fleets, particularly those that have shifted activities from east (higher CPUE) to west (lower CPUE) within the region over time.

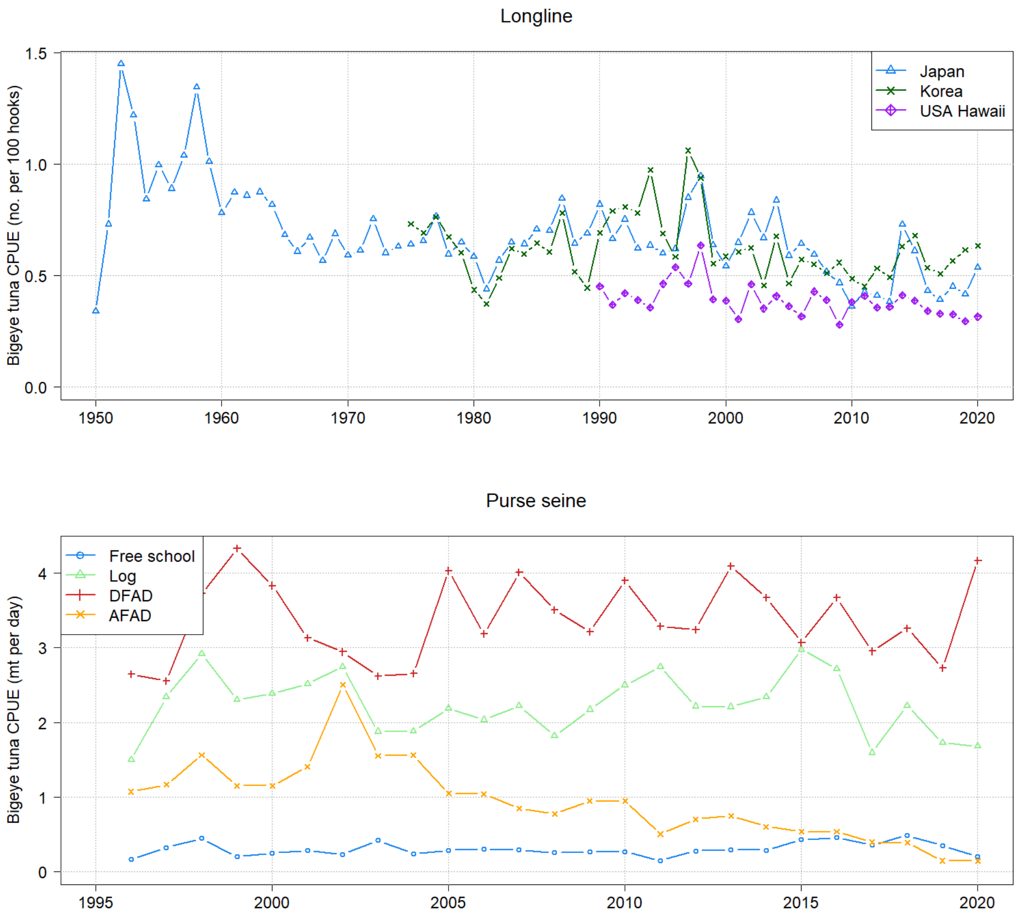
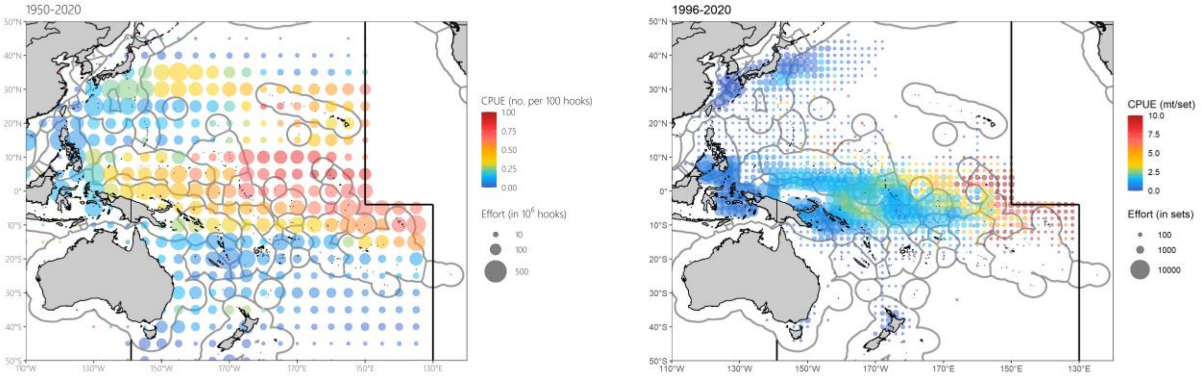


Figure 8. Evolution of bigeye CPUE by key tropical longline (20°N to 10°S) fleets (top) and tropical purse seine (20°N to 20°S) fleets by set type (bottom) over time.

Longline CPUE (1950-2020) Purse seine (1996-2020)



Longline CPUE (2016-2020) Purse seine (2016-2020)

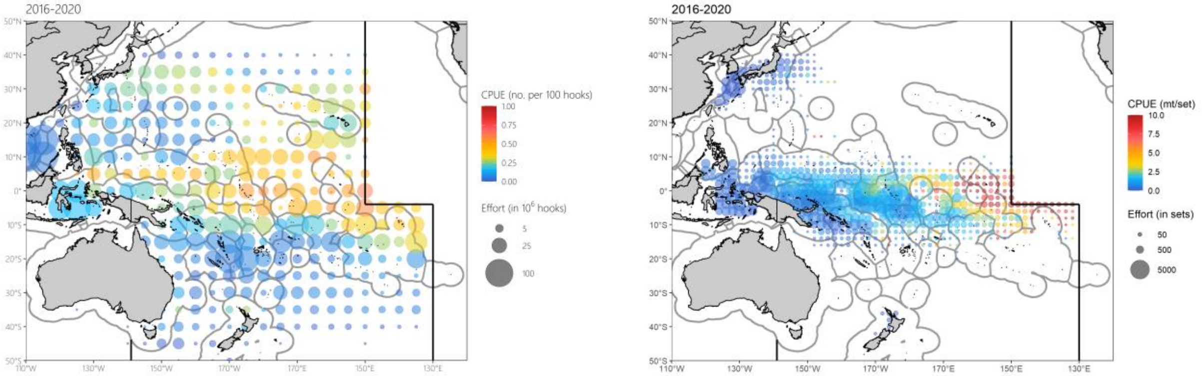


Figure 9. Distribution of 5°x5° longline effort (circle size) and bigeye tuna CPUE (number of fish per 100 hooks; colour) from longline fisheries across different time periods (left), and comparable plot for purse seine fisheries at 2° x 2° (right).

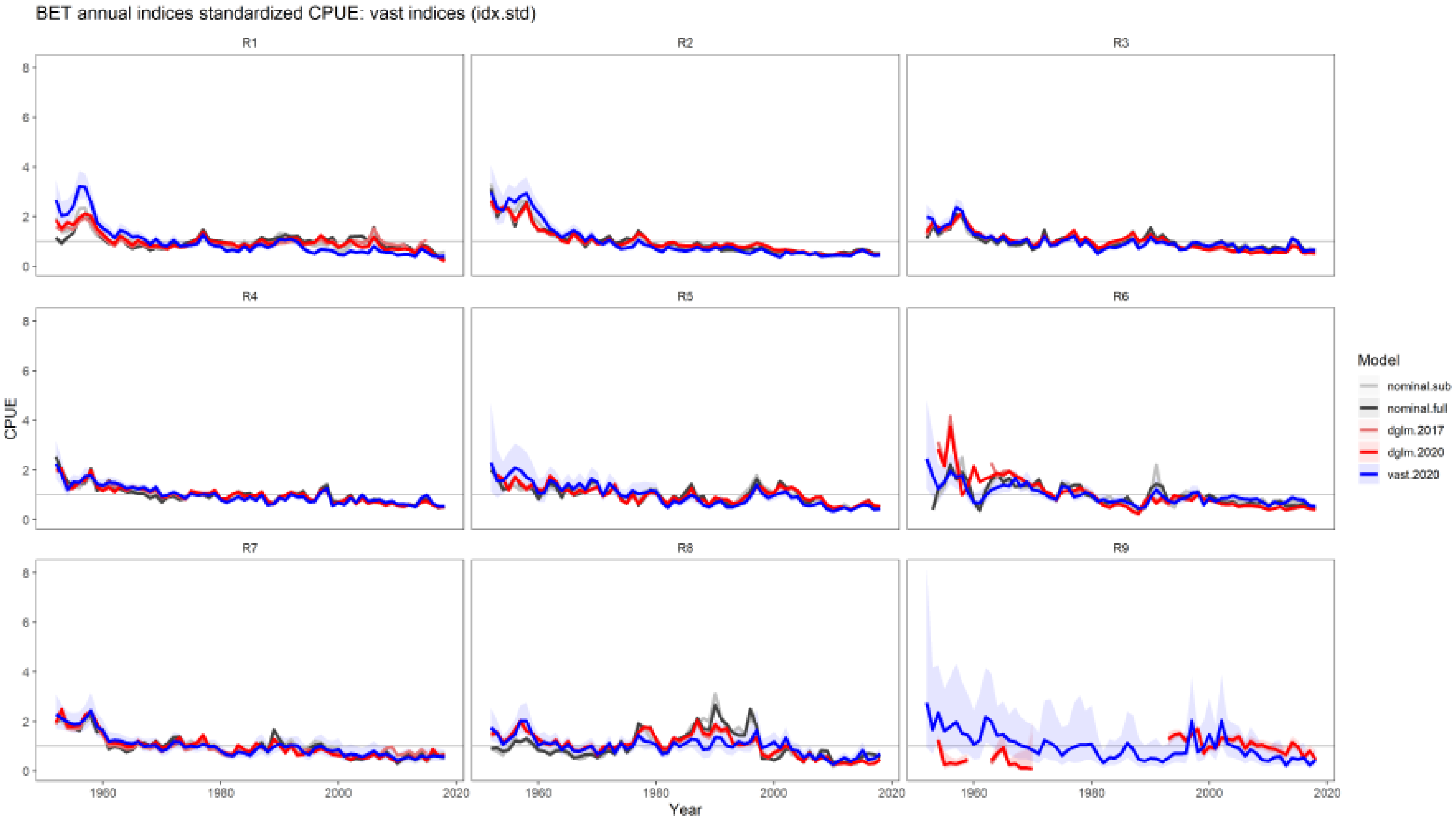


Figure 10. Nominal and standardised abundance indices for bigeye tuna as used within the 2020 WCPO bigeye stock assessment, by model region. The nominal index corresponding to the subset of data that the standardization model was fit to is shown in light gray (nominal.sub). The nominal index from the full data set is shown in dark gray (nominal.full). The delta-GLM index used in the 2017 stock assessment is shown in light red (dglm.2017). The delta-GLM index used in the data update step of the 2020 stock assessment is shown in red (dglm.2020). The VAST spatiotemporal index used in the diagnostic case of the 2020 stock assessment is shown in blue. (vast.2020). The asymptotic 95% confidence intervals are shown via the corresponding shaded polygon.

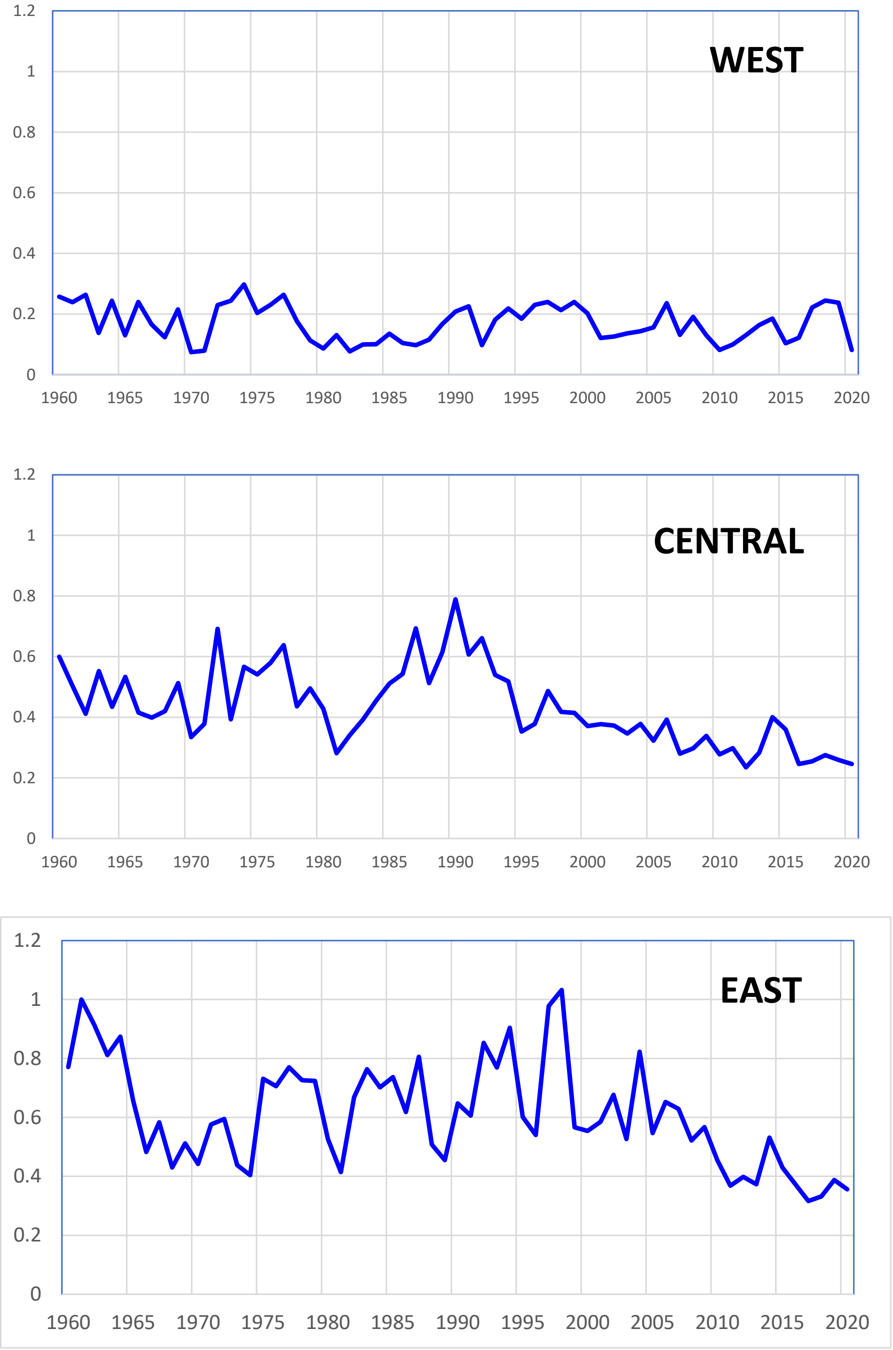


Figure 11. Annual trends in nominal bigeye tuna CPUE (number of fish per 100 hooks) in the tropical WCPFC LONGLINE fishery, by assessment region: "WEST" = Assessment Region 7: 10°S–20°N, 110°–140°E; "CENTRAL" = Assessment Region 3: 10°S–10°N, 130°–170°E; "EAST" = Assessment Region 4: 10°S–10°N, 170°E–150°W).

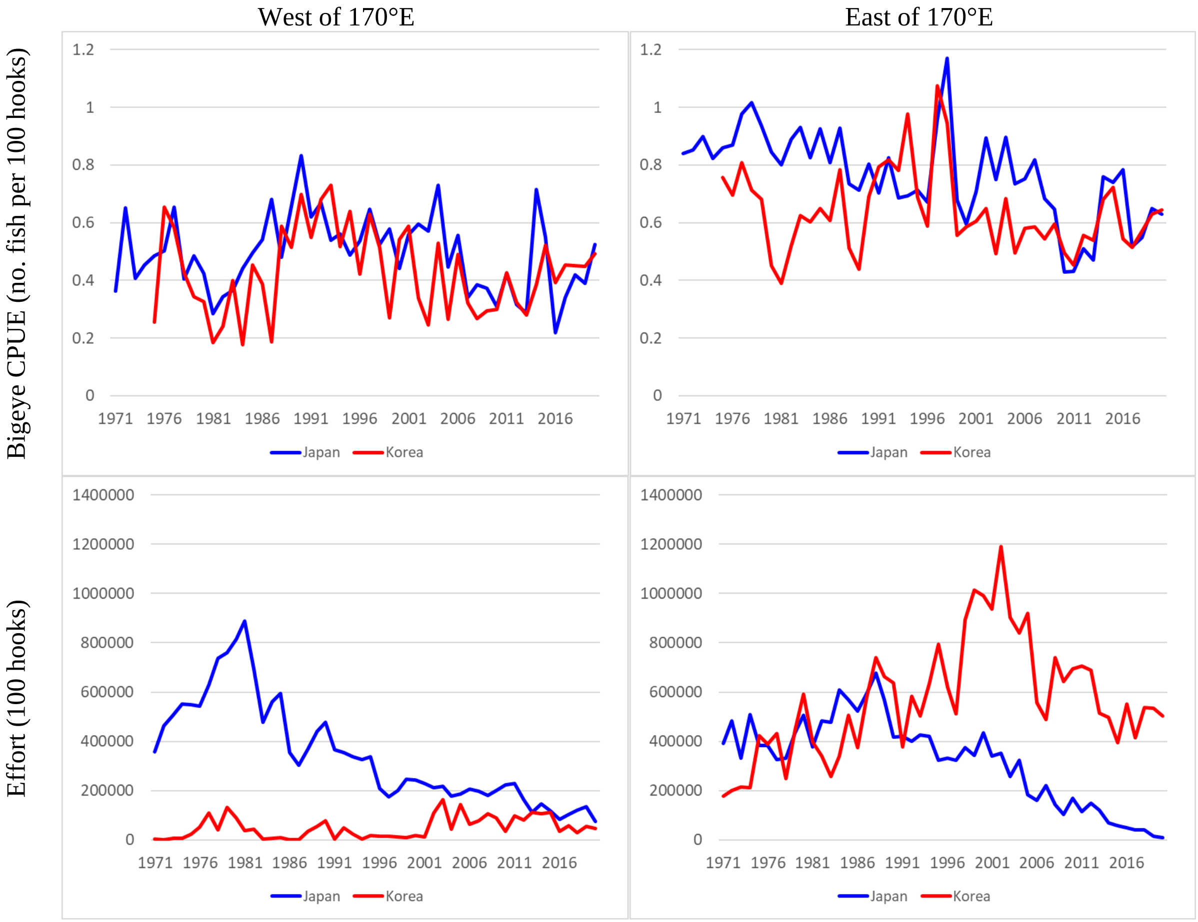


Figure 12. Annual trends in: (top row) nominal bigeye tuna CPUE (number of fish per 100 hooks) for the Japan and Korean longline fleets in the tropical fishery (20°N to 10°S); and (bottom row) effort ('00 hooks) for fishing west of 170°E (left) and east of 170°E (right). Data in the final year of the time series (2020) is likely incomplete.

High seas

Request
Schedule of high seas effort by US vessels against the US limits in applicable CMMs since 2012
Evaluate the removal of the FAD sets in 2019 in the HS for flags not in Table 2 of the measure (i.e., not bound by limits).

The schedule of high seas effort by US vessels against CMM-specified limits is provided in Table 20.

Table 20. Schedule of HS effort by US vessels from CMM tables, versus US limits in applicable CMMs since 2012.

Category	2012	2013	2014	2015	2016	2017	2018	2019	2020
HS Days	1,241	1,016	1,153	1,664	1,445	842	1,587	1,543	1,658
Limit			1,270	1,270	1,270	1,270	1,370	1,270	1,270

Notes

1. The USA notified WCPFC in November 2020 of their choice of IATTC measures in the overlap area, so the 2020 HS days excludes HS days in the WCPFC-IATTC overlap area

To calculate the impact of the removal of high seas FAD sets for those flags not in Table 2 of the Measure, the anticipated number of total FAD sets in 2019 was first calculated using the approach used in the 'FAD closure' section of this report (i.e. under conditions of a 3 month in zone closure and 5 month high seas closure; see also Table 6). The number of high seas FAD sets made by fleets not in Table 2 of the measure in 2019 was then subtracted. This assumes that those fleets do not transfer FAD sets in-zone during the year.

The scalar for the 2019 total FAD sets and FAD sets minus 'non-Table 2' fleets were then calculated relative to the 2016-2018 baseline period. As those scalars are relative to the 2016-18 baseline, a period that had higher overall purse seine effort than in 2019 (Table 19), the same approach as applied in Table 6 was used to scale values back to the overall level of effort in 2019 (Table 21). The potential impact on future bigeye stock status was then evaluated for the two future recruitment scenarios. This therefore assumed that purse seine overall effort and the period available to set on FADs were at 2019 levels, and longline catch was similarly at 2019 levels (see also Table 6).

Table 21. Impact of removing high seas FAD sets by non-Table 2 fleets from 2019 fishing levels on future bigeye depletion.

Scenario	2019 PS effort relative to 2016-2018	Expected 2019 PS FAD set scalar relative to 2016-2018	Overall PS scalar relative to 2016-2018	LL 2019 scalar relative to 2016-2018	Resulting bigeye depletion ($SB/SB_{F=0}$)	
					Recent recruitment	Long term recruitment
2019 baseline	0.93	1.11	1.03	1.10	0.46	0.41
2019 minus HS FAD sets from unlimited fleets	0.93	1.04	0.97	1.10	0.48	0.42

Other

Request
Table of the number of purse seine vessels as fishing in the Convention Area between 20N-20S by CCMs listed in Table 2 of Attachment 1 of CMM 2020-01 from 2012
Results shown in table 15 and table 14 in WCPFC-TTMW1-2021-01_rev3 be merged.
IP02: Two plain graphs expressing the percentage of effort in (EEZ+AW) and HS (split between CCMs with limits, PH, CCMs without limits)
IP02: update of figure 3 taking into account the FADs sets estimated for footnote 1 of CMM 2018-01.

The requested tables and figures are provided below.

Table 22. Numbers of purse seine vessels as fishing in the Convention Area between 20N-20S by CCMs listed in Table 2 of Attachment 1 of CMM 2020-01 from 2012 – 2020, by fleet

Fleet	2012	2013	2014	2015	2016	2017	2018	2019	2020
China	13	14	19	20	2	3	3	0	0
Ecuador	8	7	7	7	2	4	4	8	4
EU-Spain	4	4	4	4	2	2	2	2	2
Japan	41	41	40	40	37	38	34	36	36
Republic of Korea	28	27	28	25	25	26	27	26	27
New Zealand	4	4	5	2	2	1	1	1	1
Philippines	21	27	27	23	17	12	12	12	6
El Salvador	2	4	4	2	3	1	1	2	2
Chinese Taipei	34	34	34	34	34	31	27	30	29
USA	39	40	40	39	37	34	34	31	23
	194	202	208	196	161	152	145	148	130

Table 23. Future purse seine scalars (under the CMM two scenarios) that may result where the equivalent number of FAD sets are removed from (Footnote 1 and Para 17) or added (HS CMM limits and Patterns of HS effort) to the calculations. Note: the addition of the scenario where flags with HS limits have those limits set to zero (bottom row).

	Approx. FAD set change	Optimistic scenario	Pessimistic scenario	Approximate equivalent main FAD closure period
CMM evaluation scalars		1.11	1.13	3 months
Footnote 1 (2019)	-638	1.07	1.09	~ 2.6 months
Footnote 1 (2020)	-1072	1.04	1.06	~ 2.4 months
Paragraph 17[1] (2019)	-447	1.08	1.10	~ 2.8 months
Paragraph 17 (2020)	-370	1.09	1.11	~ 2.8 months
High seas CMM limits (2019)	+12 opt -213 pess	1.11	1.12	~2.9 - 3.0 months
High seas CMM limits (2020)	+372 opt +147 pess	1.14	1.14	~3.1 - 3.2 months
Patterns of high seas effort (2019)	+310 opt +85 pess	1.14	1.14	~3.0 - 3.2 months
Patterns of high seas effort (2020)	+704 opt +479 pess	1.16	1.16	~3.3 - 3.4 months
Addition of table 15[1]				
HS effort limits set to zero for limited flags (see table 12)	-875	na	1.07	~ 2.5 months

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[1] The estimate of the implication of setting high seas limits for limited flags in table 12 of WCPFC-TTMW2-2021-IP07 to zero is added for comparison with the other exemptions and high seas scenarios.

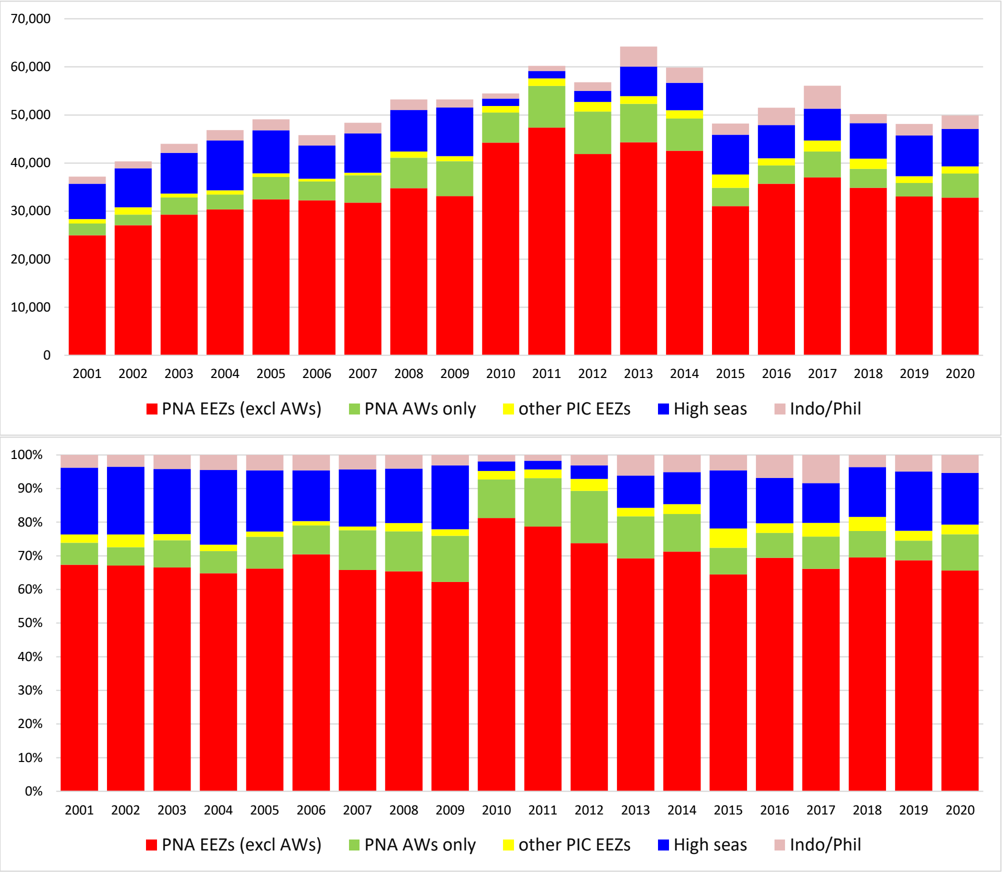

Figure 13. Purse seine effort in waters under national jurisdiction (EEZs and AWs) and in high seas (20°N-20°S). Days fished (top) and percentage of days fished (bottom)

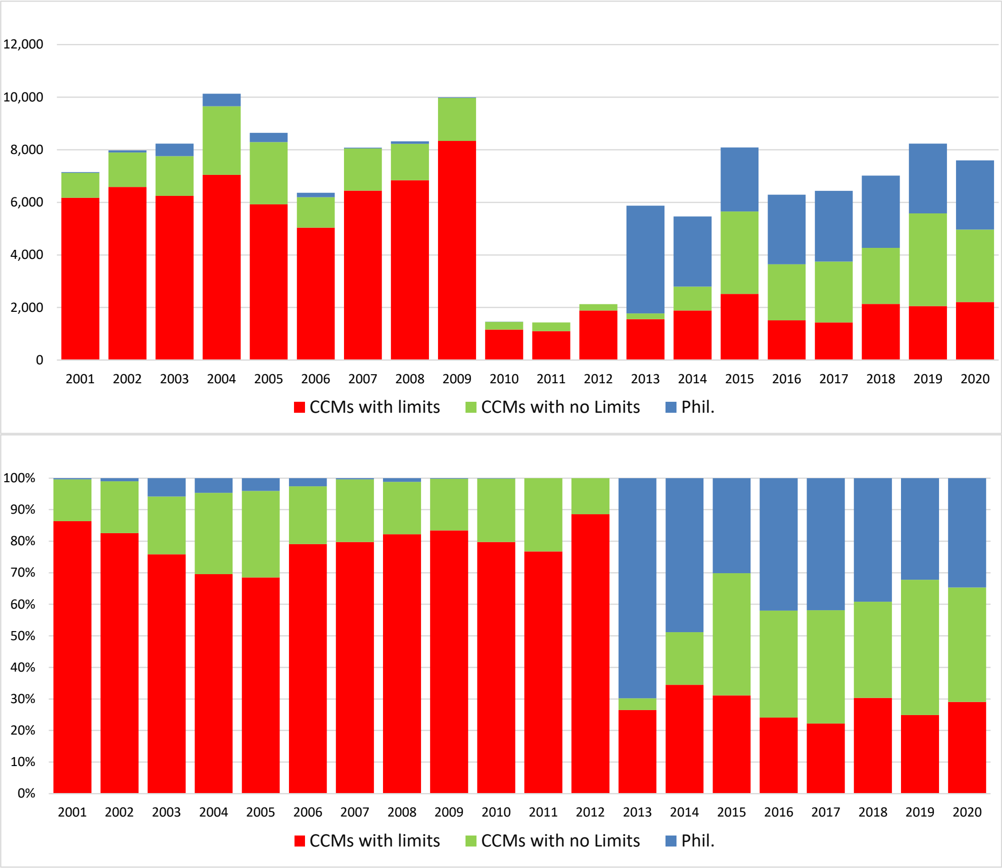

Figure 14. Purse seine effort in high seas (20°N–20°S), by fleet category.

(days fished–top and percentage days fished–bottom)

("CCMs with no limits" are Pacific Island fleets fishing in high seas adjacent to their home waters; Philippines effort data prior to 2013 are not available or underreported)

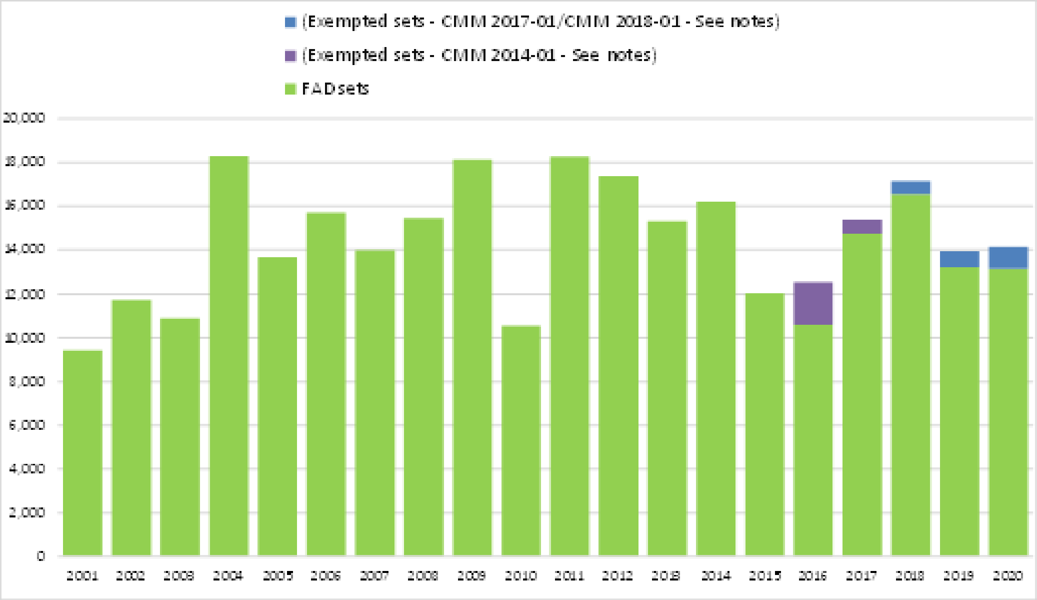

Figure 15. Estimated FAD sets undertaken in the tropical purse seine fishery (20°N-20°S), by fleet category.

Appendix 1. Summary table of SSP requests from TTMW1

Approved Requests to SSP

Considering the capacity of the SSP it is not possible to complete all the ‘Short’ requests by the next meeting. With this is mind, the remaining ‘Short’ requests have been scored by the SSP in relation to their difficulty/time requirements, i.e., the ‘Points’ column. The meeting selected a priority list of requests that total no more than 20 points. The SSP would expect to complete these requests in the available time before the next meeting.

Category	**Request**	**CCM making request**	**Technical feasibility**	**Time scale**[2]	**Points**
TRPs	**BET** TRP as **average depletion 2000-2004**, determine, MSY, F, as a proportion of recent levels (2014-2017), projected to achieve this TRP. Overall, region, fish size (juv/ad)	Japan	**Technically feasible**	Short	2
TRPs	**BET** TRP as **median depletion 2000-2004**, determine, MSY, F, as a proportion of recent levels (2014-2017), projected to achieve this TRP. Overall, region, fish size (juv/ad)	Japan	**Technically feasible**	Short	
TRPs	**SKJ** Evaluate applying purse seine effort 2007-2009 ave., equlib yield v MSY, LRP risks 50%, 48%, 46%, 44% and 42%SBF=0, plus 36, 38 and 40% (Tokelau)	Korea	**Technically feasible**	Short	1
TRPs	**BET** Evaluate 2007-2009 fishing level in terms of median depletion level and the corresponding change in spawning biomass from 2012-2015 average, recent and long-term recruitment conditions	Korea	**Technically feasible**	Short	1
FAD closure	Adding months, projected change in **future depletion** for **SKJ, BET, YFT** **HS x 6 months, EEZ x 3 months**	Japan	**Technically feasible**	Short	~~2~~
FAD closure	Adding months, projected change in **future depletion** for **SKJ, BET, YFT** **HS x 5 months, EEZ x 4 months**	Japan	**Technically feasible**	Short	
FAD closure	Adding months, projected change in **future depletion** for SKJ, BET, YFT **HS x 6 months, EEZ x 4 months**	Japan	**Technically feasible**	Short	

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[2] **Short** – next meeting; **Medium** – commission; **Long**- 2022?

Category	Request	CCM making request	Technical feasibility	Time scale[2]	Points
FAD closure	Reduce FAD closure implications on **SKJ, BET, YFT** future depletion **status quo (3 mths EEZ/HS + 2 mths HS)** **+ a sensitivity with the 2019 effort and catch levels.**	PNA	**Technically feasible**	Short	
FAD closure	Reduce FAD closure implications on **SKJ, BET, YFT** future depletion **1 month reduction (EEZ and HS)** **+ a sensitivity with the 2019 effort and catch levels.**	PNA	**Technically feasible**	Short	
FAD closure	Reduce FAD closure implications on **SKJ, BET, YFT** future depletion **complete removal (both EEZ and HS** **+ a sensitivity with the 2019 effort and catch levels.**	PNA	**Technically feasible**	Short	
FAD closure	Reduce FAD closure implications on **SKJ, BET, YFT** future depletion **2 mo EEZ, 3 mo HS** **+ a sensitivity with the 2019 effort and catch levels.**	PNA	**Technically feasible**	Short	
FAD closure	Reduce FAD closure implications on **SKJ, BET, YFT** future depletion **2 mo HS, 2 mo EEZ** **+ a sensitivity with the 2019 effort and catch levels.**	PNA	**Technically feasible**	Short	
FAD closure	Reduce FAD closure implications on **SKJ, BET, YFT** future depletion **1 mo HS, 1 mo EEZ** **+ a sensitivity with the 2019 effort and catch levels.**	PNA	**Technically feasible**	Short	
FAD closure	Changed FAD closure implications on **SKJ, BET, YFT** future depletion **5 mo HS, 5 mo EEZ** **+ a sensitivity with the 2019 effort and catch levels.**	EU	**Technically feasible**	Short	
FAD closure	Changed FAD closure implications on **SKJ, BET, YFT** future depletion **4 mo HS, 4 mo EEZ** **+ a sensitivity with the 2019 effort and catch levels.**	EU	**Technically feasible**	Short	
FAD closure	Changed FAD closure implications on **SKJ, BET, YFT** future depletion **3 mo HS, 3 mo EEZ** **+ a sensitivity with the 2019 effort and catch levels.**	EU	**Technically feasible**	Short	

Category	Request	CCM making request	Technical feasibility	Time scale[2]	Points
FAD closure	Changed FAD closure implications on **SKJ, BET, YFT** future depletion **2 mo HS, 3 mo EEZ** **+ a sensitivity with the 2019 effort and catch levels.**	EU	**Technically feasible**	Short	
FAD closure	Changed FAD closure implications on **SKJ, BET, YFT** future depletion **3 mo HS, 4 mo EEZ** **+ a sensitivity with the 2019 effort and catch levels.**	EU	**Technically feasible**	Short	
FAD closure	Changed FAD closure implications on **SKJ, BET, YFT** future depletion **3 mo HS, 5 mo EEZ** **+ a sensitivity with the 2019 effort and catch levels.**	EU	**Technically feasible**	Short	
FAD closure	Assess the trade-off between increases in longline bigeye catch and length of FAD closure, include results for SKJ, BET, YFT	PNA	**Technically feasible**	Short	1
High Seas effort	Maintaining EEZ PS effort, evaluate the impact of varying effort on the high seas between 0 and **10,000** days (increment by **2000** days)	FFA	**Technically feasible**	Short	1
FAD definitions	Impact of the exclusion of floating objects that do not have a tracking buoy attached from the definition of FAD	Korea	**Technically feasible**	Short	2
Exemptions	Consequence on the projected stock status on the exemption from 20% of the 35% cuts applied to the bigeye catch limits of other major longline fleets from the baseline limits in CMM 2008-01 for any fleet in accordance with para 35 of CMM 2008-01.	PNA	**Technically feasible**	Short	2
Additional metrics/scalars	**SKJ** WP04 – A calculation of recent fishing mortality levels as proportions of 2012 and 2012-2015 levels, overall region, fish size (juv/ad)	Japan	**Technically feasible**	Short	2
Additional metrics/scalars	Alternative values for estimating future depletion levels against alternative catch and effort baselines **Purse seine** 1-month EEZ FAD closure; 1-month High seas FAD closure 1-month High seas + EEZ FAD closure; and	PNA	**Technically feasible**	Short	1

Category	**Request**	**CCM making request**	**Technical feasibility**	**Time scale[2]**	**Points**
Additional metrics/scalars	Alternative values for estimating future depletion levels against alternative catch and effort baselines **Longline catch equivalents for:** 1-month EEZ FAD closure; 1-month High seas FAD closure 1-month High seas + EEZ FAD closure; and	PNA	**Technically feasible**	Short	
Additional metrics/scalars	Current equivalent scalars - what scalars should apply relative to the 2016-18 "starting point" for 2019 conditions (for both catch and effort).	PNA	**Technically feasible**	Short	0
CPUE	**Request during WS1**: compile informative BET CPUE time series	**Japan**	**Technically feasible**	Short	1
High seas	Schedule of high seas effort by US vessels against the US limits in applicable CMMs since 2012	**PNA**	**Technically feasible**	Short (SPC or Secretariat)	0
High seas	Evaluate the removal of the FAD sets in 2019 in the HS for flags not in table 2 of the measure (i.e., not bound by limits).	**EU**	**Technically feasible**	Short (SPC or Secretariat)	(1- evaluate?)
Other	Table of the number of purse seine vessels as fishing in the Convention Area between 20N-20s by CCMs listed in Table 2 of Attachment 1 of CMM 2020-01 from 2012	**PNA**	**Technically feasible**	Short (SPC or Secretariat)	1
Other	Results shown in table 15 and table 14 in WCPFC-TTMW1-2021-01_rev3 be merged.	**EU**	**Technically feasible**	Short	1
Other	IP02: Two plain graphs expressing the percentage of effort in (EEZ+AW) and HS (split between CCMs with limits, PH, CCMs without limits)	**EU**	**Technically feasible**	Short	
Other	IP02: update of figure 3 taking into account the FADs sets estimated for footnote 1 of CMM 2018-01.	**EU**	**Technically feasible**	Short	