WCPFC
THIRD MANAGEMENT OBJECTIVES WORKSHOP

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Multi-species implications of reference points: what might a target reference point of 50%SBF=0 for skipjack tuna mean for bigeye and yellowfin tuna

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Overview

Target and limit reference points (TRPs and LRPs), and harvest control rules (HCRs), form key components of the management framework (**Figure 1**). They are concepts discussed in a simplistic single-species context, but in reality most fisheries are multi-species in nature and WCPO tuna fisheries are no exception. Skipjack, bigeye and yellowfin tuna are caught together throughout the Western and Central Pacific Ocean, but the proportion of each species in the catch varies for different fisheries. Consequently, management measures that are designed around a TRP for one species may not be compatible with the reference point levels for other species.

This paper explores this concept by looking at the consequences for bigeye and yellowfin tuna of managing the skipjack tuna stock at a candidate target reference point of 0.5$SB_{F=0}$. We project the three stocks into the future for a range of different levels of associated (FAD) and unassociated (free-school) purse seine effort that result in skipjack achieving the candidate TRP. In this analysis we specifically focus on the potential consequences for bigeye and yellowfin tuna stocks.

The key findings are that purse seine effort levels that are consistent with the skipjack TRP would likely result in yellowfin tuna remaining at a good stock status but, depending on the mix of FAD and free school effort, not all of these scenarios were consistent with maintaining the bigeye stock above the agreed LRP.

This paper aims to:

1. Highlight the importance of multi-species impacts when considering TRPs and [later] harvest control rules in WCPO fisheries;
2. Motivate the need for analyses – both biological and economic – to assist in this wider process; and
3. Support WCPFC11's consideration of a TRP for skipjack tuna and the development of management measures for the three tropical tuna stocks.

Approach:

20 year deterministic projections were conducted for the period 2012 to 2032, using the 2014 reference case assessment run for WCPO skipjack, bigeye and yellowfin stocks. The projections were deterministic in that future recruitment was held constant and assumed to be the mean of recruitment over the last 10 years. Future fishing conditions in purse seine fisheries were adjusted, with scalars applied to effort levels in associated (FAD) and unassociated (free school) purse seine fisheries independently. A 20 year projection period was chosen to ensure that stocks had sufficient time to reach an equilibrium age structure given the recruitment and effort conditions applied.

The spawning biomass in 2032 (the last year of the projection period) was assessed relative to $SB_{F=0}$, calculated as the average spawning biomass between 2002 and 2011 that would have been present in the absence of fishing.

An initial analysis was conducted to identify the combinations of associated and unassociated purse seine fishing effort that would satisfy the candidate target reference point management objective for skipjack of 0.5$SB_{F=0}$ in 2032. Skipjack projections for combinations of purse seine associated and unassociated effort were run, scaling from 2012 effort levels. Those scalars ranged between 0.5 and 2.0, at intervals of 0.02, yielding a 76 by 76 matrix of purse seine effort combinations from which only those combinations that achieved 0.5$SB_{F=0}$ in 2032 were selected (41 combinations in total, see **Table 1**). Subsequent deterministic projections were conducted for bigeye and yellowfin using the same assumptions for future conditions as for skipjack, but using only those 41 effort combinations to determine the likely consequences of achieving the skipjack management target for those other species.

Throughout the analysis, for each species, changes were made only to the levels of associated and unassociated purse seine fishing effort. Effort for longline and other gears remained unchanged at 2012 levels. No attempt was made to scale the purse seine effort in the projections to an overall total effort limit. Therefore some effort scenarios represent an overall reduction in effort from 2012 levels whilst others represent an increase in effort. However, of the 41 effort combinations that were consistent with achieving $0.5SB_{F=0}$, projected purse seine effort differed from 2012 effort levels by no more than +8.5% and -10.8% (**Table 1**).

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Analysis

Changes in the levels of purse seine fishing effort between associated and unassociated sets can have an impact on the catches and future biomass of skipjack. <u>There are many combinations of associated and unassociated set purse seine effort that are consistent with achieving the candidate skipjack TRP of $0.5SB_{F=0}$ and these are close to 2012 overall purse seine effort levels</u>.

Across all of the selected scenarios that achieve the skipjack TRP, bigeye $SB/SB_{F=0}$ values in 2032 varied between 0.18 and 0.31, whilst yellowfin remained relatively stable at 0.43 (**Figure 2**). Increases in the proportion of associated purse seine sets resulted in declining bigeye spawning biomass (**Figure 3**). Those scenarios imply that, under the assumption that recent average recruitment continues into the future, yellowfin spawning biomass will remain on average above the limit reference point of $0.2SB_{F=0}$. <u>Yellowfin tuna stocks are predicted to remain at or above current levels across the range of combinations of purse seine effort compatible with the skipjack TRP</u>.

Under the assumption that recent average recruitment continues into the future, bigeye may recover above the LRP under most scenarios, except when the proportion of associated sets is high (i.e. associated sets greater than 1.16 and un-associated sets less than 0.78 times their 2012 levels, for those combinations achieving the skipjack TRP; **Table 1**). <u>The impacts for bigeye tuna are sensitive to the mix of FAD and free-school effort – some combinations (with higher associated set proportions) would cause the bigeye stock to remain below the LRP</u>.

Catches for both yellowfin and skipjack were highest, over a 20 year projection period, under effort combinations favouring unassociated sets. Catches of these species were relatively insensitive to the redistribution of effort between associated and unassociated purse seine fishing. By comparison, catches of bigeye over the same period were highest under effort combinations favouring associated sets. This analysis therefore suggests that increased catches can be achieved, over a 20 year period, through the re-distribution of effort between associated and unassociated purse seine sets. However, this result is based on deterministic projections for which future recruitment was maintained at a constant level. No account has been taken of future recruitment variability. In addition the analyses do not consider factors that might have economic impacts such as catch variability. <u>Evaluation of these types of multispecies impacts is most appropriately done in a framework that considers current uncertainty, future variability, and economic factors</u>.

Discussion Points

- How can multispecies impacts best be examined when developing single-species TRPs?
    - The study highlights the importance of considering gear specific considerations when developing candidate TRPs for individual species. While the longline fishery has a very limited impact on the skipjack stock and has not been considered in detail in this analysis, it will be an important consideration in the development of candidate TRPs for yellowfin and bigeye.
- What other factors may need to be considered?

    - For example, the current study examines the biological consequences of a single-species TRP within a multispecies fishery. Given the wider impacts on catch levels and catch rates, other objectives including those relating to economics should also be considered.
- Do the findings help the WCPFC develop a TRP for skipjack tuna, and how may they influence the development of tropical tuna management measures?
- How might sustainability concerns over bigeye and yellowfin be incorporated into management strategies for skipjack?

For further information

Hampton J. and Pilling G. 2014. Relative impacts of FAD and free-school purse seine fishing on yellowfin tuna stock status. WCPFC-SC10-2014/MI-WP-05 (http://www.wcpfc.int/node/19013)

Table 1. Effort scalar combinations for associated and unassociated purse seine fishing and the resulting $SB/SB_{F=0}$ for skipjack, yellowfin and bigeye tuna in 2032 determined from 20 year deterministic projections. Shaded region shows those combinations for which $SB/SB_{F=0}$ are less than 0.2 for either skipjack, yellowfin or bigeye.

Purse Seine Effort Scalars		***% change in Purse Seine Effort from 2012 level***			***SB/SB F=0***		
Associated	***Unassociated***	***Skipjack***	***Yellowfin***	***Bigeye***	***Skipjack***	***Yellowfin***	***Bigeye***
0.50	1.52	8.44	8.59	8.59	0.500	0.431	0.306
0.52	1.50	8.15	8.29	8.29	0.500	0.431	0.302
0.54	1.48	7.86	7.99	7.99	0.500	0.431	0.297
0.58	1.42	6.13	6.25	6.25	0.500	0.431	0.289
0.60	1.40	5.84	5.95	5.95	0.500	0.431	0.285
0.62	1.38	5.54	5.65	5.65	0.500	0.431	0.281
0.64	1.36	5.25	5.36	5.36	0.500	0.431	0.277
0.66	1.34	4.96	5.06	5.06	0.500	0.431	0.273
0.68	1.32	4.67	4.76	4.76	0.500	0.430	0.269
0.70	1.30	4.38	4.46	4.46	0.500	0.430	0.265
0.74	1.24	2.65	2.72	2.72	0.500	0.431	0.259
0.76	1.22	2.36	2.42	2.42	0.500	0.431	0.255
0.78	1.20	2.06	2.12	2.12	0.500	0.431	0.252
0.80	1.18	1.77	1.83	1.83	0.500	0.431	0.249
0.82	1.16	1.48	1.53	1.53	0.500	0.431	0.245
0.84	1.14	1.19	1.23	1.23	0.500	0.430	0.242
0.86	1.12	0.90	0.93	0.93	0.500	0.430	0.239
0.90	1.06	-0.83	-0.81	-0.81	0.500	0.431	0.234
0.92	1.04	-1.12	-1.11	-1.11	0.500	0.431	0.231
0.94	1.02	-1.42	-1.41	-1.41	0.500	0.431	0.228
0.96	1.00	-1.71	-1.70	-1.70	0.500	0.431	0.225
0.98	0.98	-2.00	-2.00	-2.00	0.500	0.431	0.222
1.00	0.96	-2.29	-2.30	-2.30	0.500	0.431	0.220
1.02	0.94	-2.58	-2.59	-2.59	0.500	0.431	0.217
1.04	0.92	-2.88	-2.89	-2.89	0.500	0.430	0.215
1.08	0.86	-4.60	-4.64	-4.64	0.500	0.432	0.210
1.10	0.84	-4.90	-4.93	-4.93	0.500	0.432	0.208
1.12	0.82	-5.19	-5.23	-5.23	0.500	0.432	0.206
1.14	0.80	-5.48	-5.53	-5.53	0.500	0.431	0.203
1.16	0.78	-5.77	-5.83	-5.83	0.500	0.431	0.201
1.18	0.76	-6.06	-6.12	-6.12	0.500	0.431	0.199
1.20	0.74	-6.36	-6.42	-6.42	0.500	0.431	0.197
1.22	0.72	-6.65	-6.72	-6.72	0.500	0.431	0.195
1.24	0.70	-6.94	-7.02	-7.02	0.500	0.431	0.193
1.30	0.62	-8.96	-9.06	-9.06	0.500	0.433	0.188
1.32	0.60	-9.25	-9.35	-9.35	0.500	0.433	0.186
1.34	0.58	-9.54	-9.65	-9.65	0.500	0.432	0.184
1.36	0.56	-9.84	-9.95	-9.95	0.500	0.432	0.183
1.38	0.54	-10.13	-10.25	-10.25	0.500	0.432	0.181
1.40	0.52	-10.42	-10.55	-10.55	0.500	0.432	0.179
1.42	0.50	-10.71	-10.84	-10.84	0.500	0.433	0.178

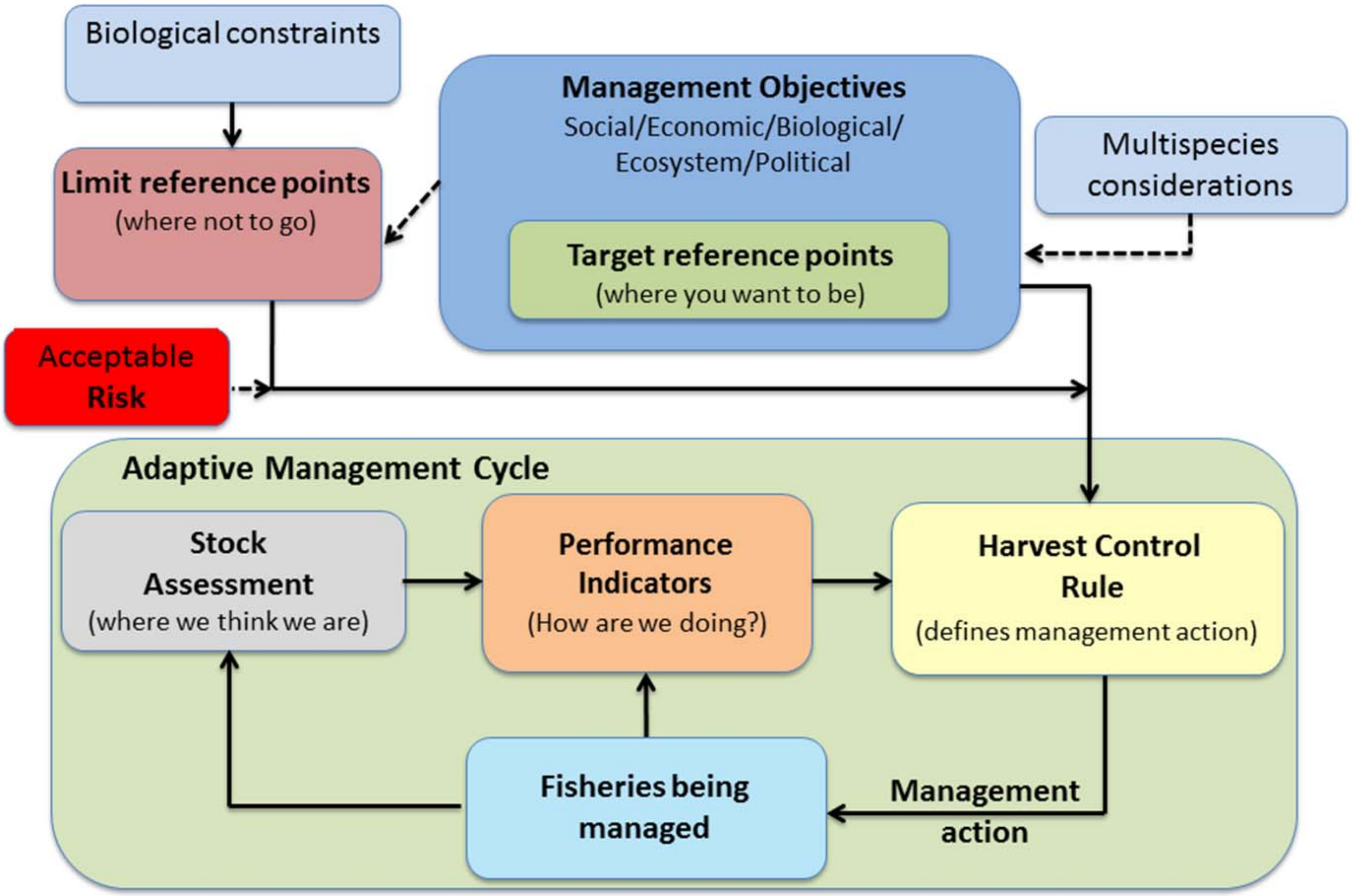

Figure 1. The management framework.

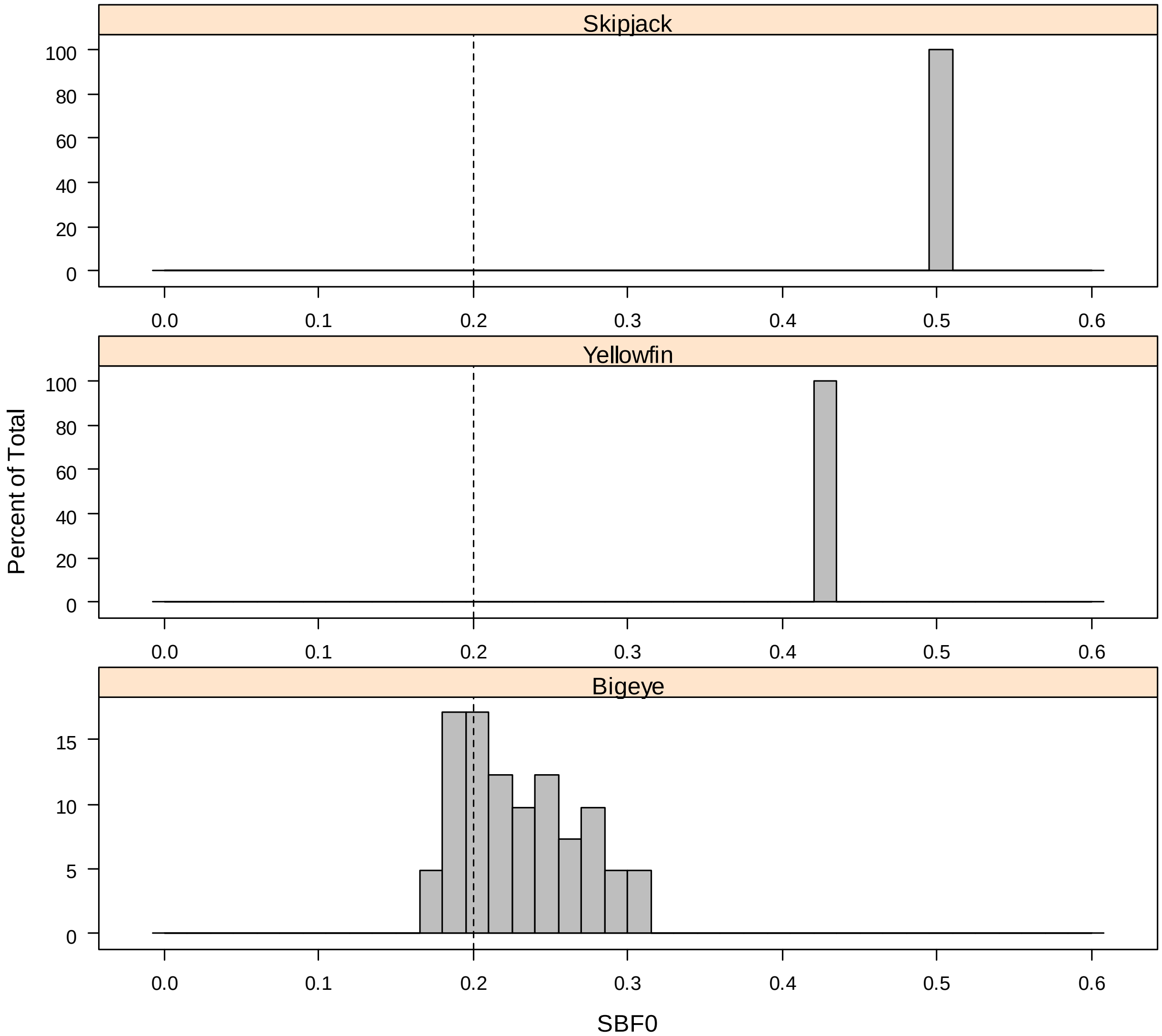

Figure 2. Distribution of $SB/SB_{F=0}$ in 2032 for skipjack, yellowfin and bigeye tuna from the 41 deterministic projections that achieve the candidate target reference point of $0.5SB_{F=0}$, representing a range of effort scalars for associated and unassociated purse seine fishing. Vertical dotted line indicates the agreed limit reference point of $0.2SB_{F=0}$ for each species where $SB_{F=0}$ is calculated as the average spawning biomass between 2002 and 2011 that would have occurred in the absence of fishing.

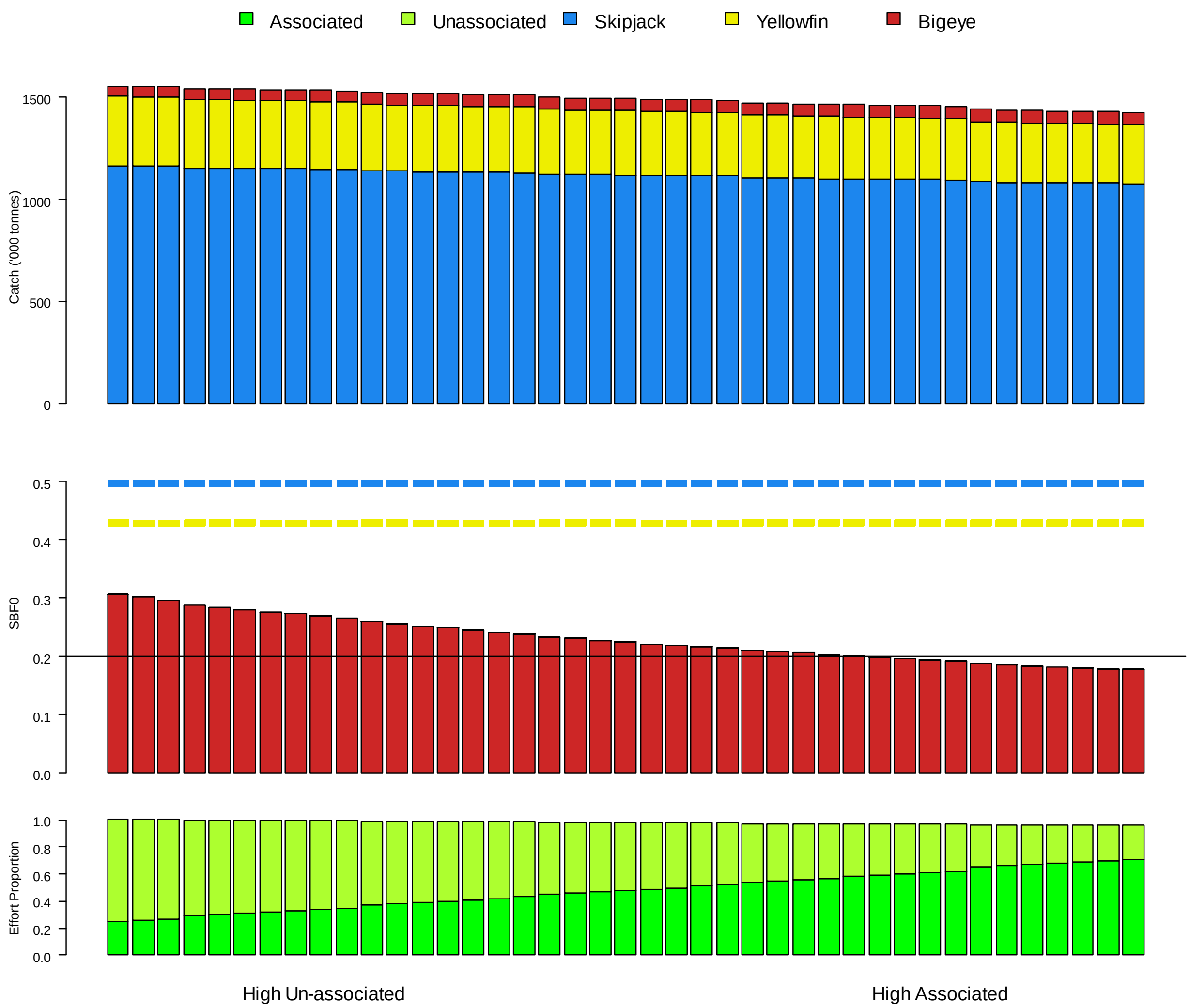

Figure 3. Catch and $SB/SB_{F=0}$ for skipjack, yellowfin and bigeye in 2032 corresponding to each of the 41 purse seine effort scalar combinations (x-axis). Bottom panel shows the effort scalar combinations that were applied to associated and un-associated purse seine fishing. Middle and top panels show the resulting $SB/SB_{F=0}$ and estimated purse seine catch (respectively) for each effort scenario. Bigeye $SB/SB_{F=0}$ are shown in bars. Yellowfin and skipjack $SB/SB_{F=0}$ do not vary and are therefore shown as horizontal dashed lines. The horizontal black line indicates the agreed LRP of $0.2SB_{F=0}$.