Indian Ocean Albacore Tuna Management Procedures Evaluation: Status Report*

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IOTC-2019-TCMP03-09-Rev.1

Summary of MSE work status

- An evaluation of Management Procedures (MPs) for Indian Ocean albacore tuna is being carried out. The analysis attempts to simulation-test a full MP, consisting on data collection, an specified mechanism to evaluate stock status and/or trends, and a decision rule.
- The base case Operating Model (OM) for albacore is being developed by the Working Party on Methods (WPM) with input from the Working Party on Temperate Tuna (WPTmT). The current base case is likely to be updated following the new stock assessment for this stock to be carried out by WPTmT in July 2019. This will update the OM to the start of 2018 without the current extension from the 2014 stock status estimates.
- Two types of MPs are being evaluated and presented here. They mainly differ in the method used to assess stock status: trends in the main CPUE series, or a surplus production stock assessment. Both depend on the availability of an index of abundance generated in a similar manner to what is currently being used by WPTmT for the albacore stock assessment. One of them also requires good estimates of total catches from all fleets.
- Further work on this MSE exercise will require financial resources to be made available. Development has so far been funded in kind by the European Commission's DG MARE and DG JRC, but this is unlikely to continue due to staff changes from July 2019.

Selection of MPs according to guidance from TCMP01 (2017)

The tuning objective refers to a key management objective that the MP can be expected to achieve precisely (e.g. achieving $SB \geq SB_{MSY}$ with a 50% probability by 2024). The tuning objective normally relates to a desirable biomass (in terms of the risk of exceeding reference points and/or a rebuilding timeframe), and has a very strong influence on the obtainable yield (because biomass risk and attainable catch are closely related). Tuning ensures that candidate MPs are identical with respect to this high priority objective, making it easier to select among MPs on the basis of performance with respect to secondary management objectives (e.g. yield and catch stability). Ideally the Commission will have narrowed down the tuning objectives to 1 or 2 before selection.

The 1st session of the TCMP in 2017 defined 4 interim tuning objectives for exploration:

- A1: Pr(mean(SB(2019:2038)>=SB(MSY)) = 0.5. Average SB over the period 2019-2038 exceeds SB MSY in exactly 50% of the simulations).

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- A2: Pr(Kobe green zone 2019:2038) = 0.5. The stock status is in the Kobe green quadrant over the period 2019-2038 exactly 50% of the time (averaged over all simulations).
- A3: Pr(Kobe green zone 2019:2038) = 0.6. The stock status is in the Kobe green quadrant over the period 2019-2038 exactly 60% of the time (averaged over all simulations).
- A4: Pr(Kobe green zone 2019:2038) = 0.7. The stock status is in the Kobe green quadrant over the period 2019-2038 exactly 70% of the time (averaged over all simulations).

TCMP01 (2017) further recognized the desirability of other MP constraints:

- Total Allowable Catch (TAC) to be set every 3 years (and held constant between settings).
- A maximum of 15% change to the TAC (increase or decrease) relative to the previous TAC.

Candidate Management Procedures

M class (model-based) MPs

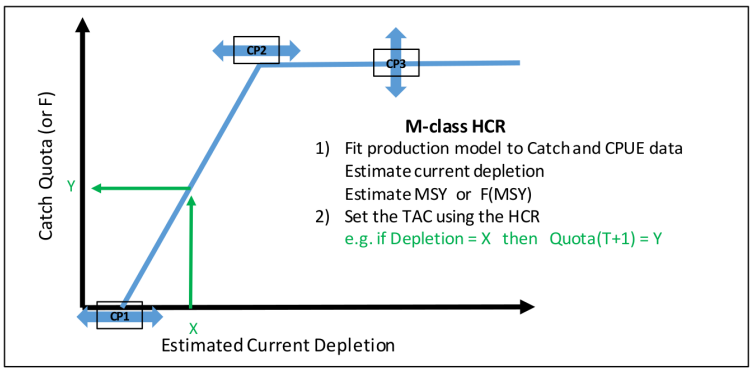

Figure 1: The model-based (M-class) MPs involve two steps: 1) fitting a simple surplus production model, and 2) applying a Harvest Control Rule (HCR) to the model estimates. The individual M-class MPs differ in terms of the Control Parameters (CP1-CP3) that define the shape of the HCR.

D class (data-based) MPs

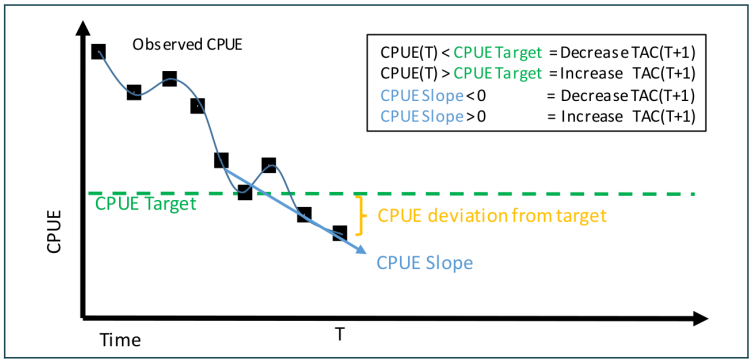

Figure 2: The data-based (D-class) MPs attempt to manage the fishery to achieve a target value of (standardized longline) CPUE. The next TAC is increased relative to the current TAC if current CPUE is above the target CPUE and the CPUE trend is increasing. Conversely, the next TAC is decreased relative to the current TAC if current CPUE is below the target CPUE and the CPUE trend is decreasing. If the CPUE location relative to the target and CPUE slope are in opposite directions, the TAC change could be in either direction, depending on the magnitude of these indicators, and the associated control parameters. Control parameters include: 1) the number of years in the CPUE slope calculation, 2) responsiveness to CPUE target deviation, 3) responsiveness to CPUE slope and 4) the CPUE target.

Summary of albacore candidate MP performance

MP rankings against key performance indicators are presented in Table 1 and figs. 3-9 illustrate performance characteristics. More detailed performance tables are included in Appendix 1 (summarized over different time windows).

We would like to highlight a few key points:

- The tuning levels defined by TCMP02 appear to span a reasonable range of the performance trade-off space, given the stock status at the start of the simulation period.
- Tuning performance is being computed over a shorter time period (2030-2034), as suggested for bigeye, to avoid forcing the stock to come down from current levels so that average peformance levels are achieved.
- The tuning levels are generally more important than the MP class in determining performance.
- Average catches are at or right above current levels, but uncertainties can also lead to lower average catches over the period.
- Both expected catch and risk levels are clearly related to the choice of objective, with safer long term perspectives obtained in exchange for lower average yield.
- All MPs appear to be able to maintain the stock on average at very stable levels on average, but there is a non-zero probability of the stock being driven down even by the most conservative MP.
- Note that this year's session of WPTmT is likely to recommend some level of revision of the current Operating Model. This is not expected to alter greatly our perception of the productivity of the stock, but will have implications in term of workload and resources.

Feedback Requests for the TCMP

The following points are provided to suggest the type of questions on which scientists could benefit from feedback and dialogue with TCMP03.

- Is TCMP willing to reduce the current four objectives to one or two? Are the current identified trade-offs enough to guide TCMP in such a decision?
- Are there any other considerations that scientists should incorporate in the next step of the analysis?

Results of MP tuning

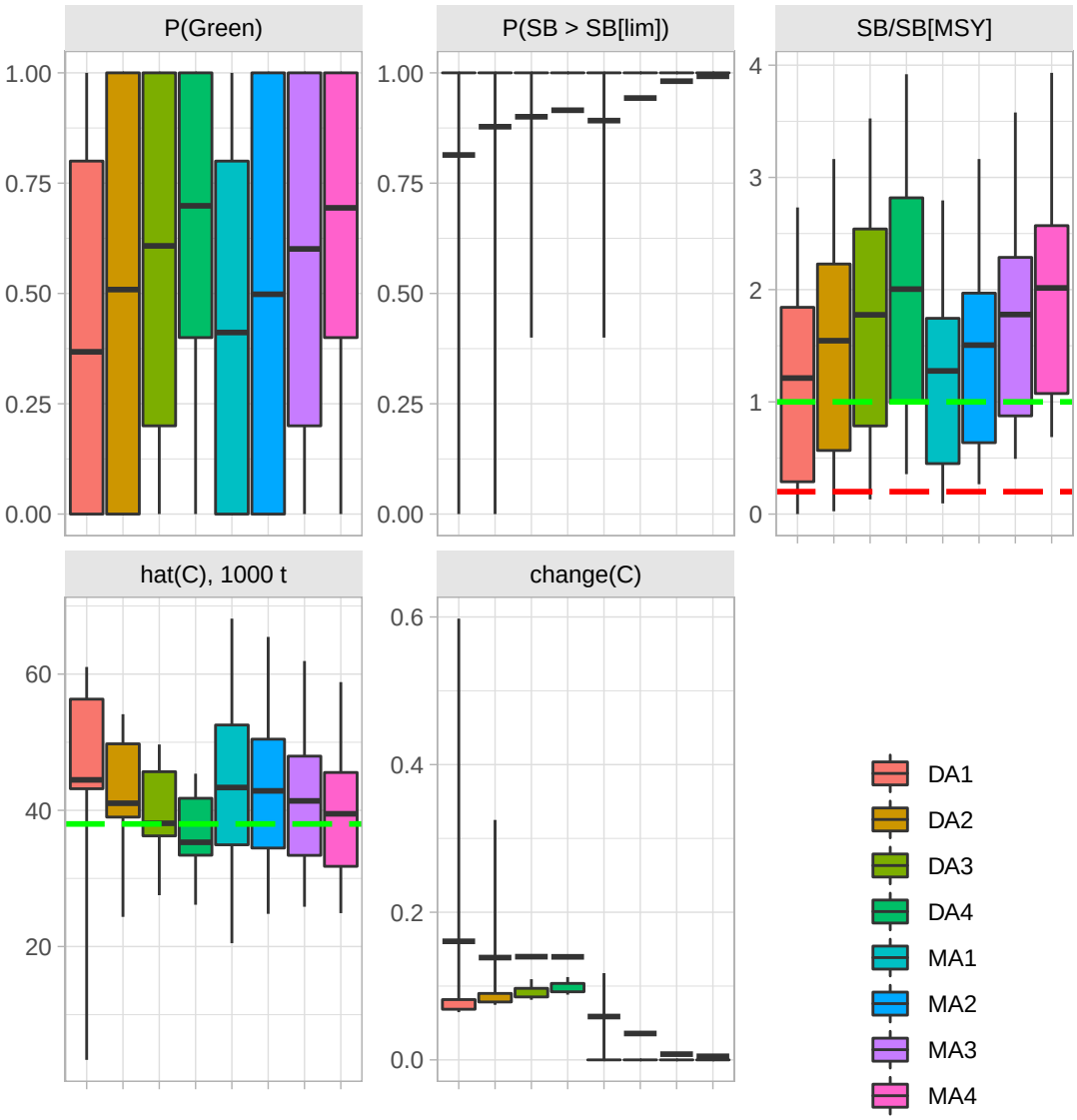

Figure 3: Boxplot comparing the performance of the eight candidate management procedures, from two families (M and D), tuned for the four management objectives (A1-A4), and along five performance indicators averaged over the 2019-2038 period. Horizontal line is the median, while boxes represent the 25^{th}-75^{th} percentiles, and thin lines the 10^{th}-90^{th} percentiles. Red and green horizontal lines represent the interim limit and target reference points for the mean SB/SB_{MSY} performance measure.

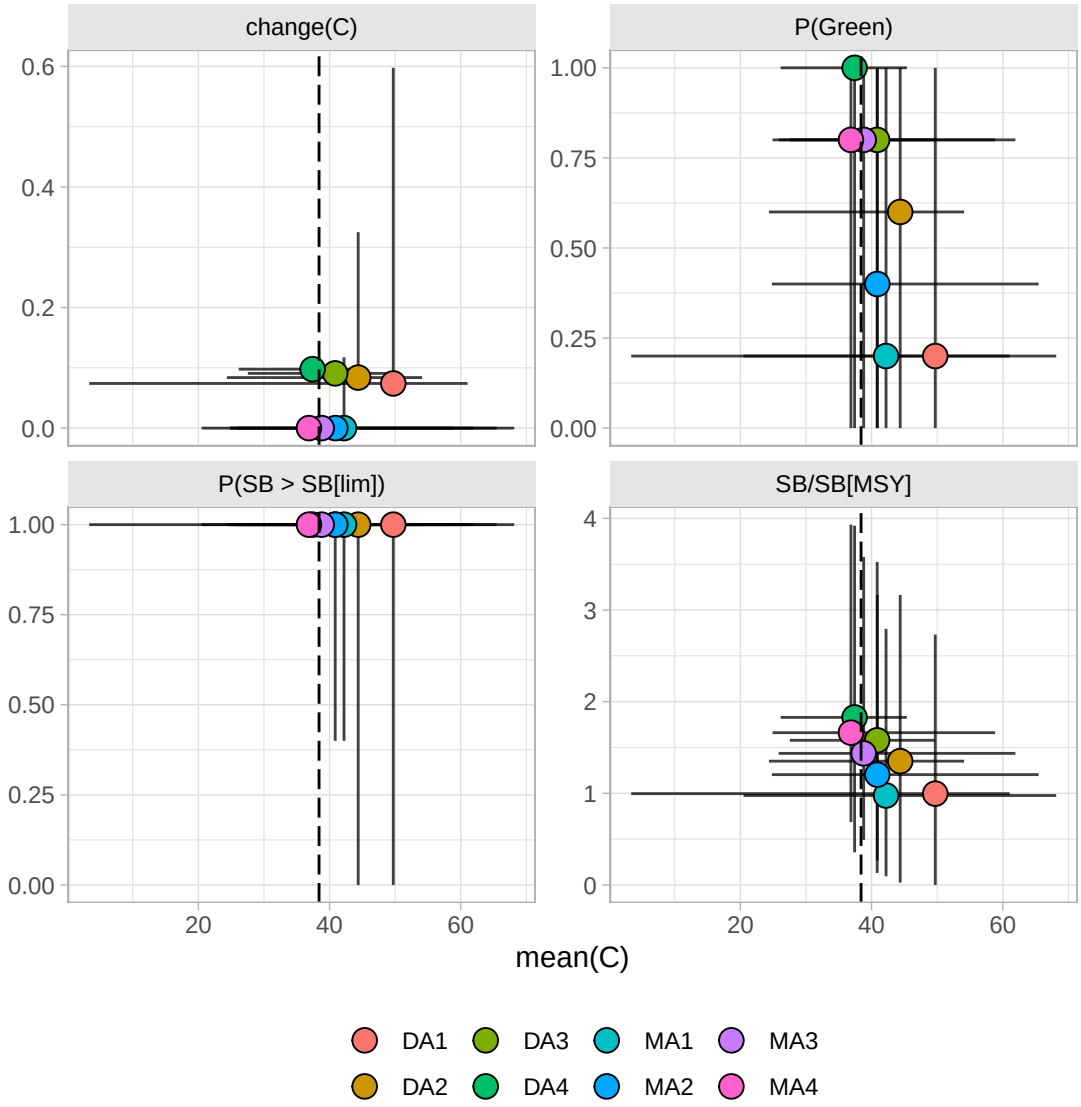

Figure 4: Trade-off plots comparing the performance of the eight candidate management procedures, from two families (M and D), tuned for the four management objectives (A1-A4), and for mean catch against four performance indicators, all averaged over the 2019-2038 period. The circle shows the median value, while lines represent the 10^{th}-90^{th} percentiles. Red and green horizontal lines represent the interim limit and target reference points for the mean SB/SB MSY performance measure.

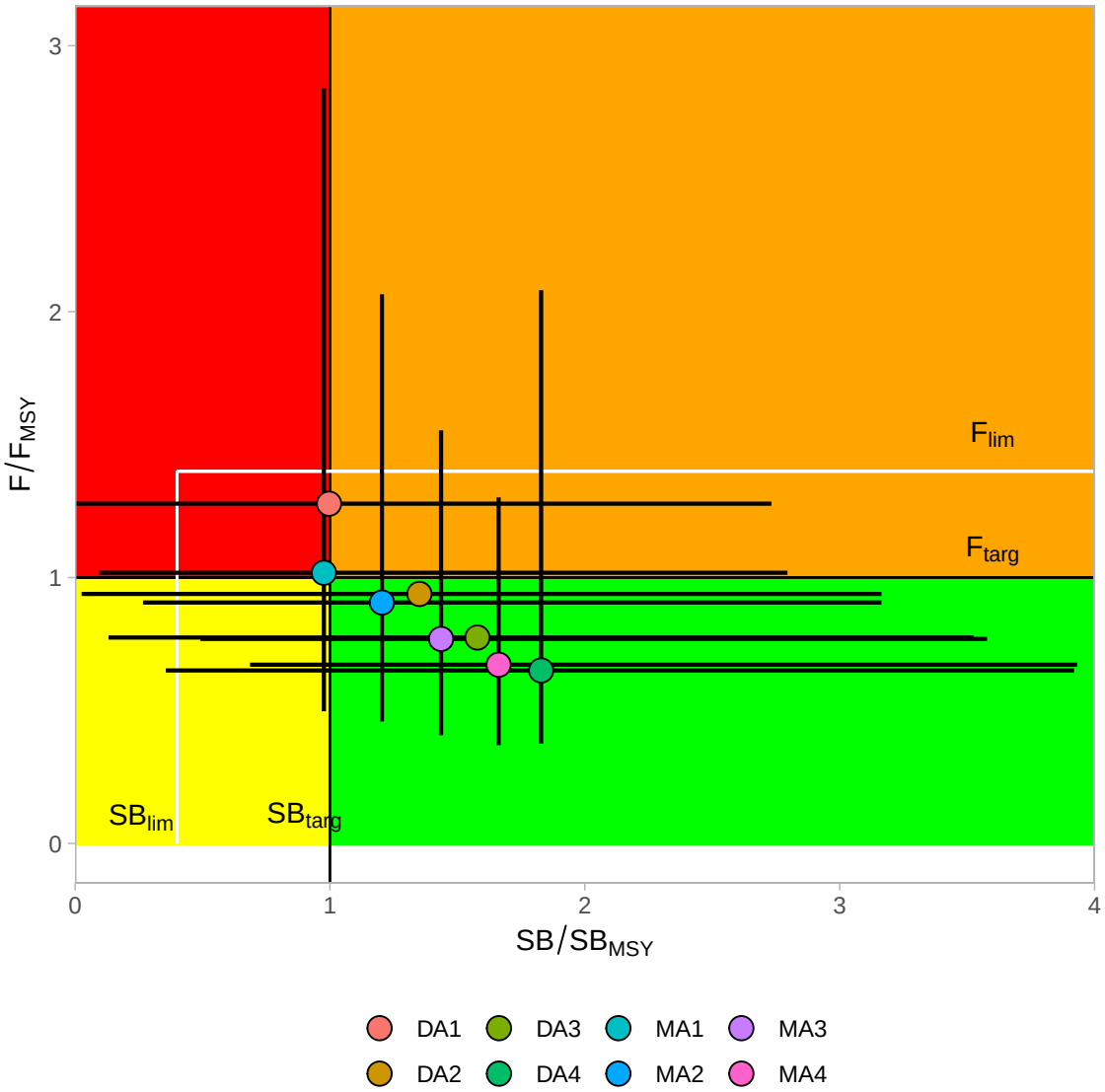

Figure 5: Kobe plot comparing the performance of the eight candidate management procedures, from two families (M and T), and tuned for the four management objectives (A1-A4), averaged over the 2019-2038 period. The circle shows the median value, while lines represent the 10^{th}-90^{th} percentiles. Black lines show the limit reference points along the two dimensions

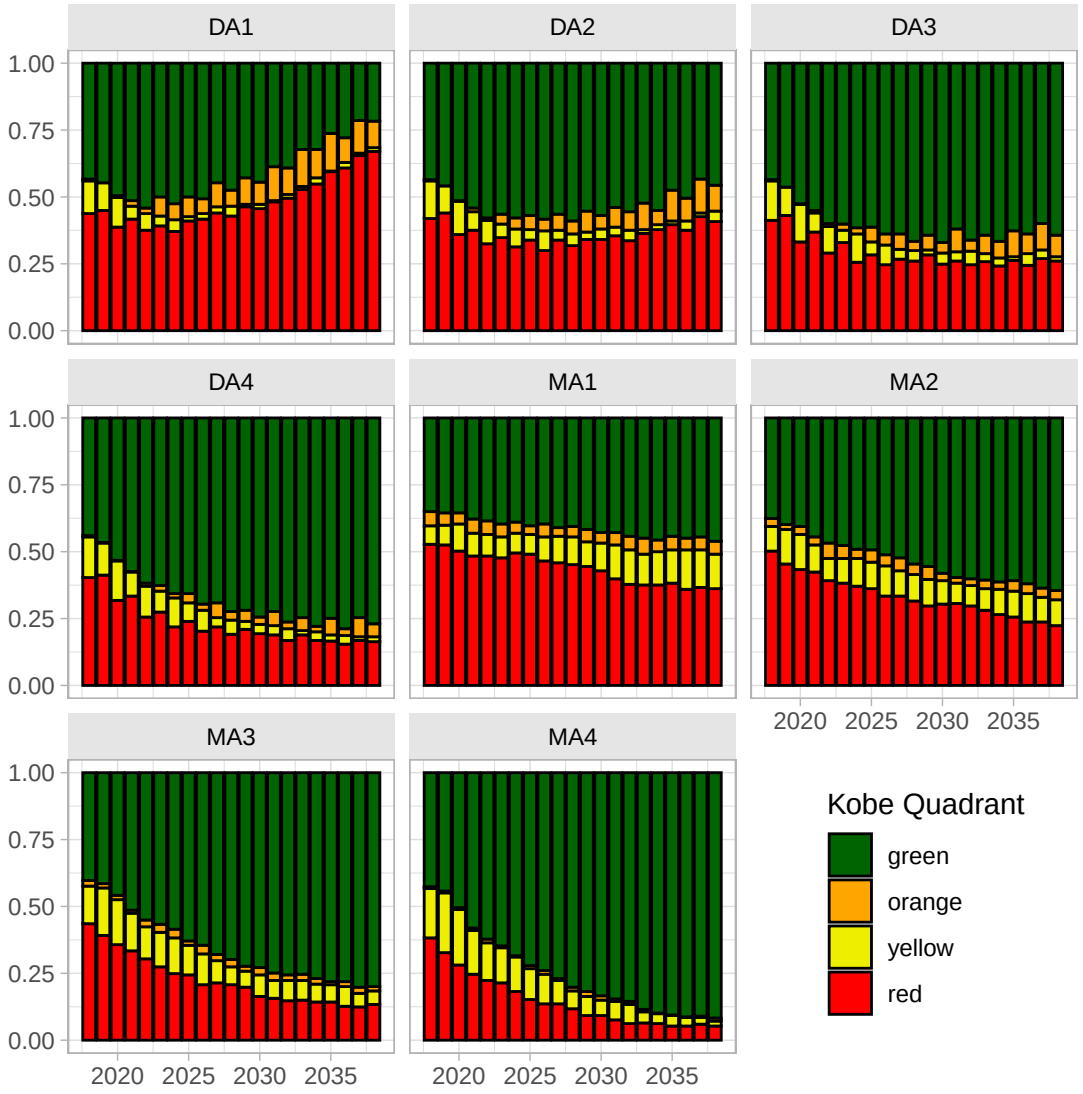

Figure 6: Proportion over time of simulations in each of the Kobe quadrants over time for each of the candidate MPs from two families (M and D), and tuned for the four management objectives (A1-A4).

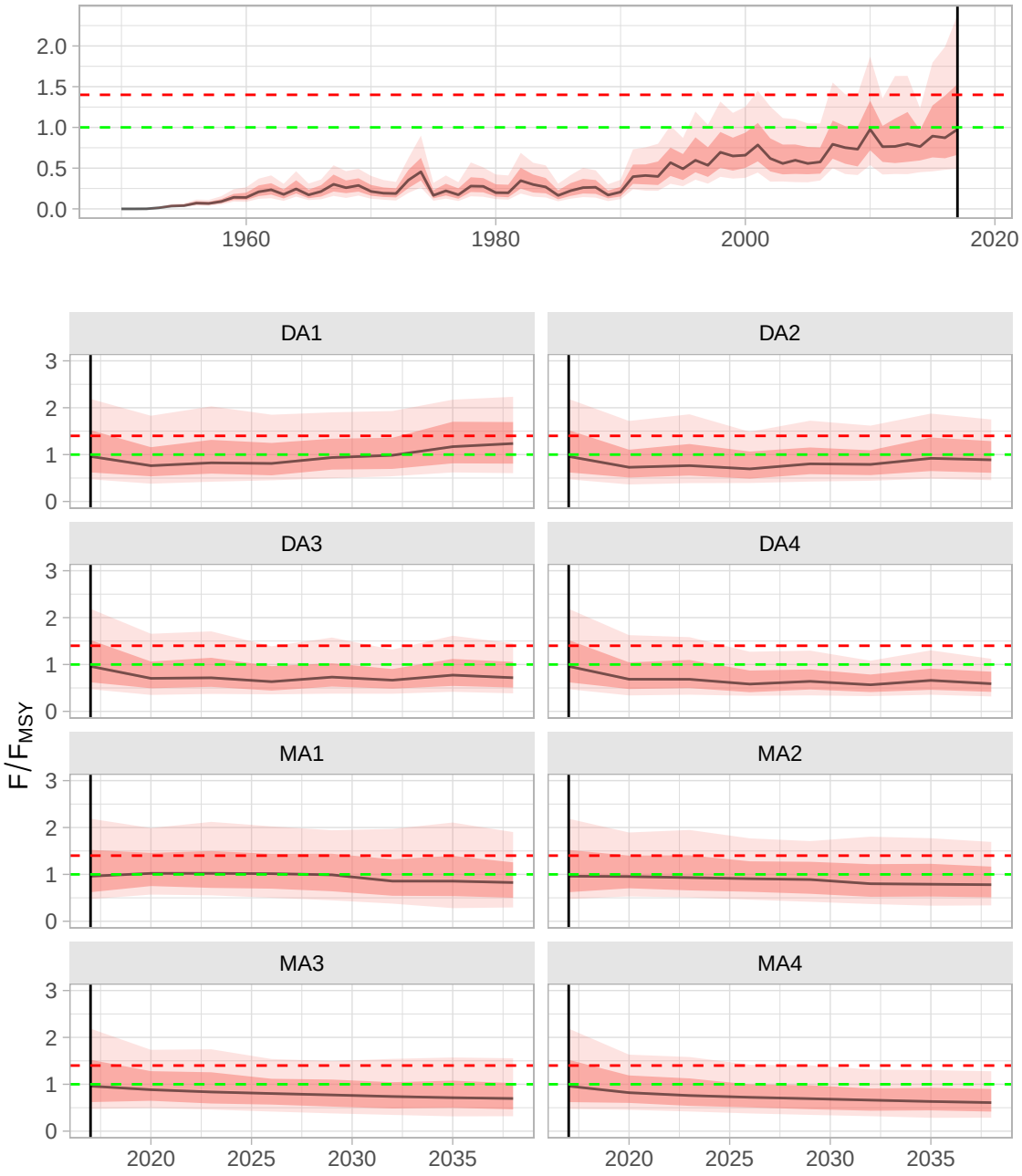

Figure 7: Time series of fishing mortality over that at MSY (F/F_{MSY}). Top panel shows the trajectory for the OM, while the lower panels show them for each of the eight candidate management procedures, from two families (M and D), and tuned for the four management objectives (A1-A4). The black circle shows the median value, while shaded areas represent the 25^{th}-75^{th} percentiles and the 10^{th}-90^{th} percentiles. Red and green horizontal lines represent the interim limit and target reference points for F/F_{MSY}.

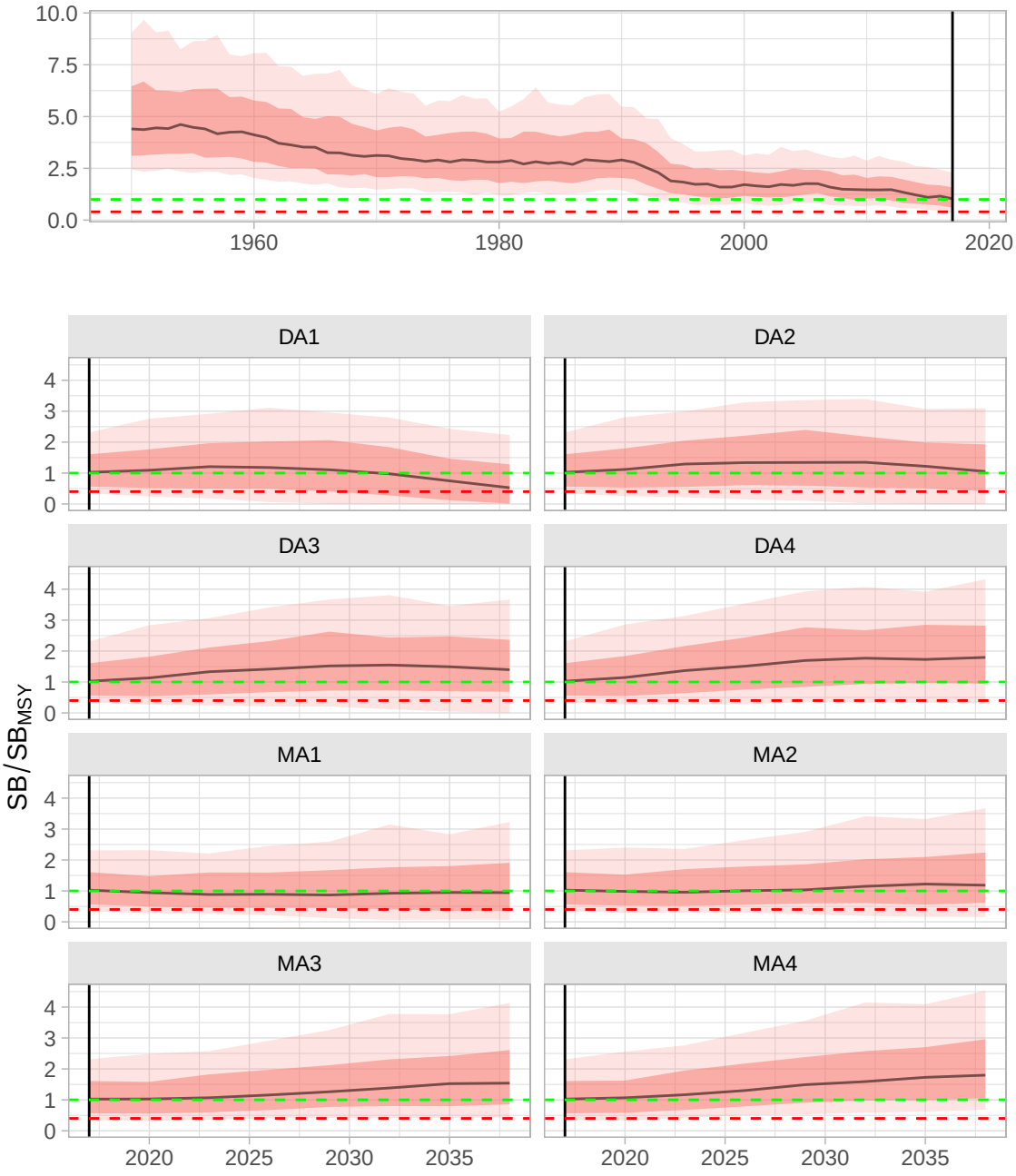

Figure 8: Time series of spawning biomass over that at MSY (SB/SB_{MSY}). Top panel shows the trajectory for the OM, while the lower panels show them for each of the eight candidate management procedures, from two families (M and D), and tuned for the four management objectives (A1-A4). The black circle shows the median value, while shaded areas represent the 25^{th}-75^{th} percentiles and the 10^{th}-90^{th} percentiles. Red and green horizontal lines represent the interim limit and target reference points for SB/SB_{MSY}.

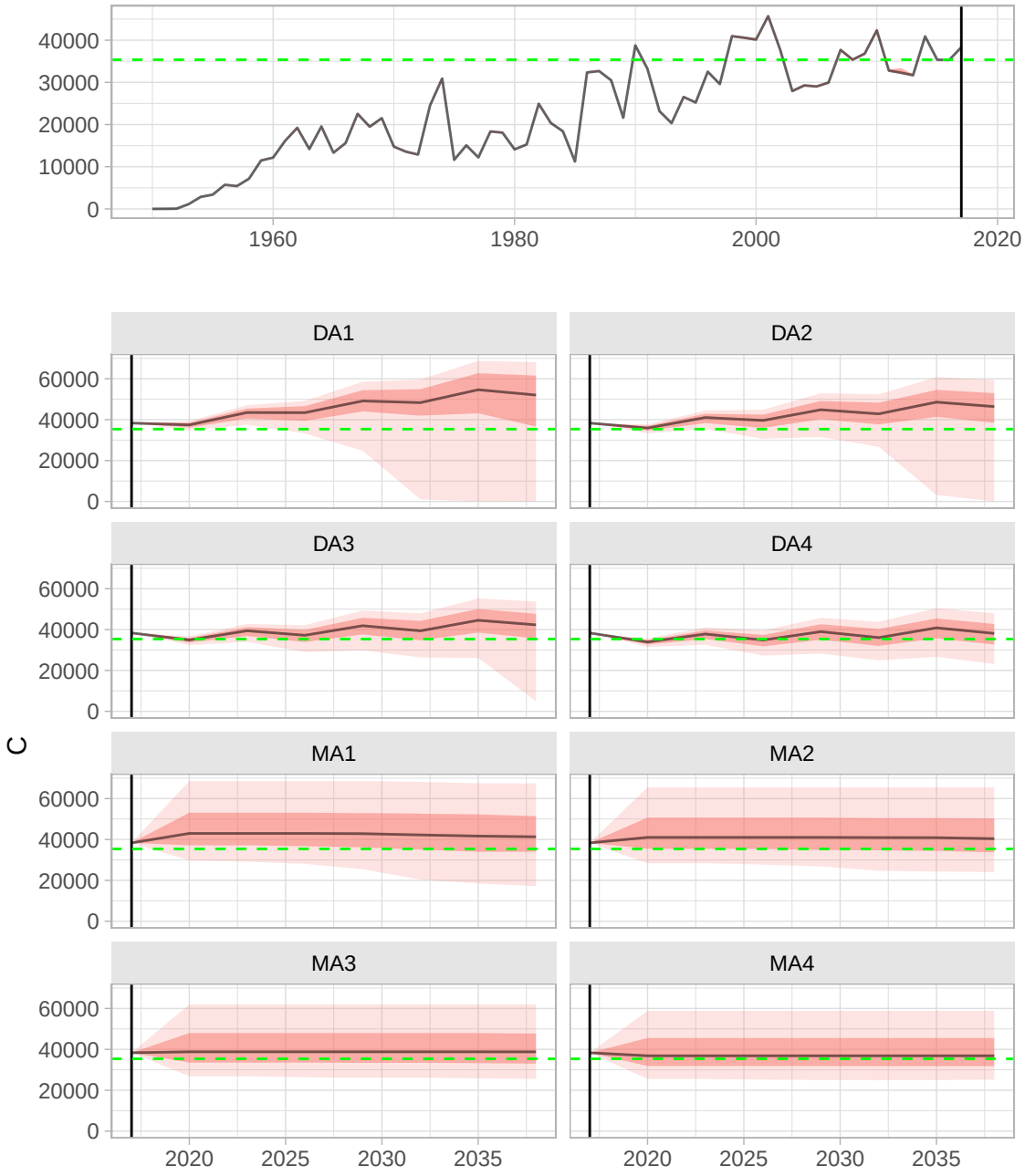

Figure 9: Time series of total catch (C). Top panel shows the trajectory for the OM, while the lower panels show them for each of the eight candidate management procedures, from two families (M and D), and tuned for the four management objectives (A1-A4). The black circle shows the median value, while shaded areas represent the 25^{th}-75^{th} percentiles and the 10^{th}-90^{th} percentiles. The green horizontal line represent the level of current (2017) catches.

Table 1: Performance of the eight candidate MPs with respect to key performance measures, averaged over the period 2019-2038.

mp	$P(SB > SB_{lim})$	$CV(C)$	$P(Green)$	$\hat{C}, 1000t$	SB/SB_{MSY}
DA1	> 0.99 (0.00-1.00)	0.25	0.37	49.71 (3.36-61.05)	1.2
DA2	> 0.99 (0.00-1.00)	0.18	0.51	44.36 (24.35-54.11)	1.5
DA3	> 0.99 (0.40-1.00)	0.17	0.61	40.86 (27.54-49.67)	1.8
DA4	> 0.99 (0.98-1.00)	0.16	0.7	37.41 (26.14-45.38)	2
MA1	> 0.99 (0.40-1.00)	0.12	0.41	42.20 (20.49-68.15)	1.3
MA2	> 0.99 (0.98-1.00)	0.056	0.5	40.88 (24.80-65.46)	1.5
MA3	> 0.99 (0.98-1.00)	0.015	0.6	38.79 (25.84-61.92)	1.8
MA4	> 0.99 (0.98-1.00)	0.0074	0.69	36.85 (24.90-58.83)	2

Table 2: Performance indicators for the eight candidate MPs over the first 5 years, 2019-2023.

	5 year average		DA1	DA2	DA3	DA4	MA1	MA2	MA3	MA4
1	Mean spawner biomass relative to unfished	SB/SB_0	0.25	0.26	0.26	0.27	0.21	0.22	0.24	0.25
2	Mean spawnwer biomass relative to SBMSY	SB/SB_{MSY}	1.30	1.34	1.37	1.39	1.09	1.15	1.22	1.29
3	Mean fishing mortality relative to target	F/F_{target}	1.45	1.34	1.27	1.20	1.29	1.17	1.05	0.95
4	Mean fishing mortality relative to FMSY	F/F_{MSY}	1.45	1.34	1.27	1.20	1.29	1.17	1.05	0.95
5	Probability of being in Kobe green quadrant	$P(Green)$	0.49	0.52	0.53	0.54	0.35	0.40	0.44	0.48
6	Probability of being in Kobe red quadrant	$P(Red)$	0.39	0.37	0.35	0.32	0.48	0.44	0.37	0.32
7	Probability of SB greater or equal than SBMSY	$P(SB >= SB_{MSY})$	0.56	0.58	0.58	0.60	0.46	0.48	0.55	0.56
8	Probability of spawner biomass being above 20 SB[0]	$P(SB > 0.20 \cdot SB_0)$	0.55	0.56	0.57	0.57	0.44	0.47	0.51	0.55
9	Probability of spawner biomass being above SBlim	$P(SB > SB_{lim})$	0.95	0.95	0.96	0.96	0.99	0.99	1.00	1.00
10	Mean catch over years (1000 t)	$\hat{C}, 1000t$	39.27	37.66	36.59	35.53	46.18	44.10	41.72	39.63
11	Mean proportion of MSY	C/MSY	1.35	1.30	1.26	1.23	1.59	1.52	1.44	1.37
12	Catch variability	$CV(C)$	0.09	0.08	0.08	0.08	0.00	0.00	0.00	0.00
13	Probability of fishery shutdown	$P(C < 0.1 \cdot MSY)$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 3: Performance indicators for the eight candidate MPs over the first 10 years, 2019-2028.

	10 year average		DA1	DA2	DA3	DA4	MA1	MA2	MA3	MA4
1	Mean spawner biomass relative to unfished	SB/SB_0	0.26	0.28	0.29	0.30	0.21	0.23	0.26	0.28
2	Mean spawnwer biomass relative to SBMSY	SB/SB_{MSY}	1.36	1.45	1.51	1.58	1.11	1.22	1.34	1.45
3	Mean fishing mortality relative to target	F/F_{target}	1.71	1.51	1.39	1.27	1.41	1.21	1.03	0.91
4	Mean fishing mortality relative to FMSY	F/F_{MSY}	1.71	1.51	1.39	1.27	1.41	1.21	1.03	0.91
5	Probability of being in Kobe green quadrant	$P(Green)$	0.49	0.54	0.57	0.60	0.38	0.43	0.50	0.56
6	Probability of being in Kobe red quadrant	$P(Red)$	0.40	0.36	0.32	0.29	0.47	0.41	0.33	0.27
7	Probability of SB greater or equal than SBMSY	$P(SB >= SB_{MSY})$	0.56	0.62	0.65	0.67	0.49	0.54	0.61	0.67
8	Probability of spawner biomass being above 20 SB[0]	$P(SB > 0.20 \cdot SB_0)$	0.56	0.59	0.61	0.63	0.45	0.50	0.56	0.61
9	Probability of spawner biomass being above SBlim	$P(SB > SB_{lim})$	0.92	0.93	0.93	0.94	0.96	0.98	0.99	1.00
10	Mean catch over years (1000 t)	$\hat{C}, 1000t$	40.34	37.98	36.44	34.92	45.91	43.98	41.67	39.61
11	Mean proportion of MSY	C/MSY	1.39	1.31	1.26	1.21	1.58	1.52	1.44	1.37
12	Catch variability	$CV(C)$	0.17	0.14	0.13	0.12	0.02	0.01	0.00	0.00
13	Probability of fishery shutdown	$P(C < 0.1 \cdot MSY)$	0.03	0.03	0.02	0.02	0.00	0.00	0.00	0.00

Table 4: Performance indicators for the eight candidate MPs over the full 20 years, 2019-2038.

	20 year average		DA1	DA2	DA3	DA4	MA1	MA2	MA3	MA4
1	Mean spawner biomass relative to unfished	SB/SB_0	0.24	0.28	0.31	0.34	0.23	0.27	0.31	0.34
2	Mean spawnwer biomass relative to SBMSY	SB/SB_{MSY}	1.23	1.47	1.63	1.80	1.22	1.39	1.60	1.78
3	Mean fishing mortality relative to target	F/F_{target}	2.44	1.85	1.59	1.38	1.47	1.23	1.01	0.85
4	Mean fishing mortality relative to FMSY	F/F_{MSY}	2.44	1.85	1.59	1.38	1.47	1.23	1.01	0.85
5	Probability of being in Kobe green quadrant	$P(Green)$	0.40	0.52	0.59	0.65	0.40	0.48	0.56	0.63
6	Probability of being in Kobe red quadrant	$P(Red)$	0.47	0.37	0.30	0.24	0.45	0.38	0.30	0.23
7	Probability of SB greater or equal than SBMSY	$P(SB >= SB_{MSY})$	0.56	0.65	0.71	0.75	0.49	0.59	0.71	0.78
8	Probability of spawner biomass being above 20 SB[0]	$P(SB > 0.20 \cdot SB_0)$	0.50	0.59	0.65	0.69	0.47	0.54	0.62	0.69
9	Probability of spawner biomass being above SBlim	$P(SB > SB_{lim})$	0.85	0.90	0.92	0.93	0.93	0.96	0.99	1.00
10	Mean catch over years (1000 t)	$\hat{C}, 1000t$	42.64	39.93	37.71	35.50	44.43	43.32	41.51	39.56
11	Mean proportion of MSY	C/MSY	1.47	1.38	1.30	1.23	1.53	1.49	1.43	1.36
12	Catch variability	$CV(C)$	0.34	0.26	0.23	0.20	0.09	0.04	0.01	0.00
13	Probability of fishery shutdown	$P(C < 0.1 \cdot MSY)$	0.08	0.06	0.06	0.05	0.03	0.01	0.00	0.00