IOTC Yellowfin Tuna Management Procedure (MP) Evaluation Update June 2019[1]

Management Procedure Evaluation Status

- Management Procedure (MP) evaluation is being pursued in the strict sense (i.e. as in the International Whaling Commission and Commission for the Conservation of Southern Bluefin Tuna), in which the data to be input to the MP, the analysis, and the Harvest Control Rule (HCR) are all defined in advance and simulation-tested together.
- The yellowfin reference set Operating Model (simulator) is being iteratively developed in line with IOTC technical working party requests (WPTT and WPM) and stock assessment process. The latest iteration was recommended by the informal MSE Task Force (steering committee), but has not yet been endorsed by the formal working parties or Scientific Committee. The intent has been to represent a much broader range of uncertainty than the stock assessment, however, if the assessment review process identifies substantial flaws in the assessment assumptions and/or data inputs, the implications for the Operating Model will need to be examined.
- Several generic MPs have been evaluated for each of the tuning objectives requested by TCMP-02 (2018). A small subset, 2 MPs per tuning objective, are presented here, to illustrate typical performance, and facilitate feedback for the next iteration.
- The main feedback priority for TCMP-03 is to refine management objectives and MP tuning targets.
- Scientific and technical support funding ends in Dec 2019.

Yellowfin MP Development Guidance from TCMP-02 (2018)

Tuning objectives refer to a key management objective that the MPs can achieve precisely (e.g. achieving SB ≥ 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 MP selection. This will allow MP developers to focus MP development. TCMP-02 defined 3 interim yellowfin tuning objectives, which differ in terms of the rate of rebuilding:

Y1: Pr(SB(2024)>=SB(MSY)) = 0.5 (SB in 2024 exceeds SB_{MSY} in exactly 50% of the simulations).

Y2: Pr(SB(2029)>=SB(MSY)) = 0.5 (SB in 2029 exceeds SB_{MSY} in exactly 50% of the simulations).

Y3: Pr(SB(2034)>=SB(MSY)) = 0.5 (SB in 2034 exceeds SB_{MSY} in exactly 50% of the simulations).

TCMP-02 (2018) also 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

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Management Procedure Labels

The first character of the candidate MP name designates the MP class, and the next two characters indicate the tuning criterion, e.g. **DY1: data-based MP (lower panel below) tuned to achieve Y1 (defined above)**. Usually the tuning objective is more important than the MP type in determining management performance.

"M" class (model-based) MPs

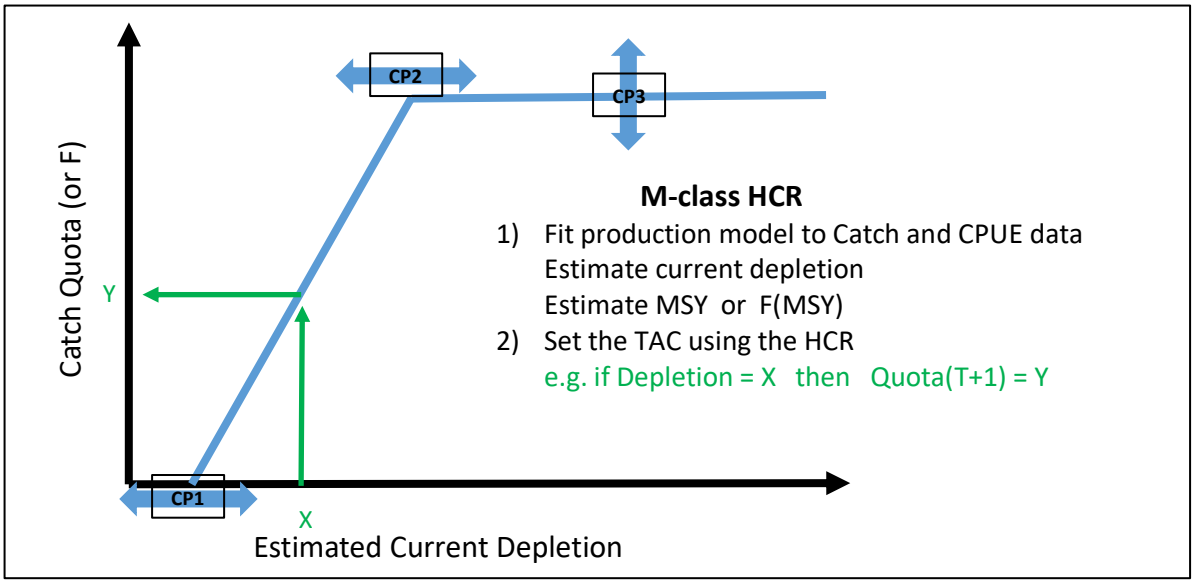

Figure 1. The model-based (M-class) MPs involve two steps: 1) fitting a simple surplus production model, and 2) applying a Harvest Control Rule (HCR) to the model estimates. The individual M-class MPs differ in terms of the Control Parameters (CP1-CP3) that define the shape of the HCR (and potentially the TAC change constraints). In the examples presented here, CP1 and CP2 were constant (at a range of different levels in different candidate MPs), while numerical optimization was used to find the value of CP3 that achieves the precise tuning objective.

"D" class (data-based) MPs

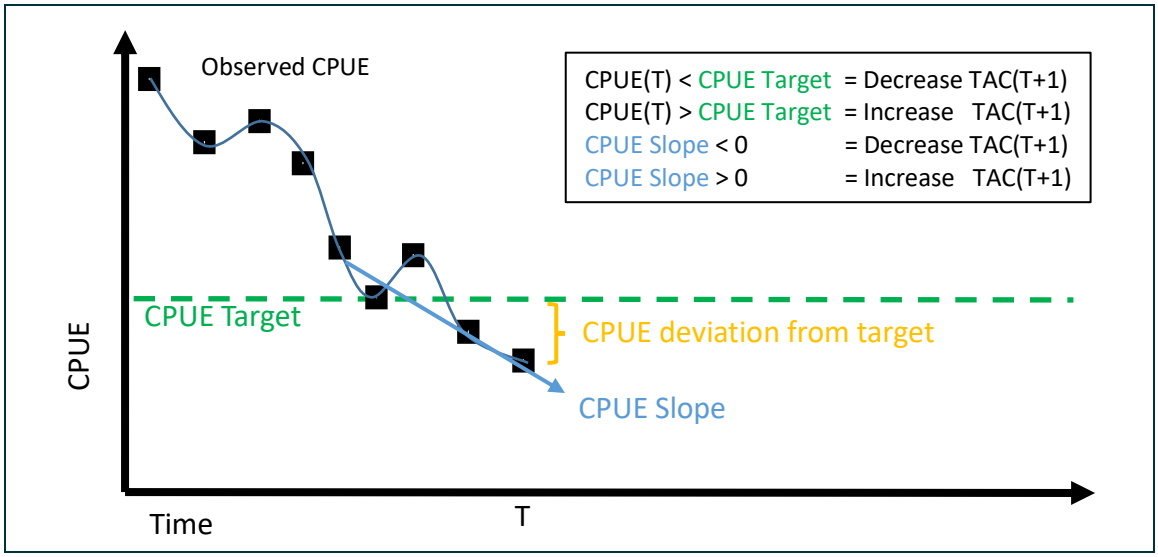

Figure 2. The data-based (D-class) MPs attempt to manage the fishery to achieve a target value of standardized longline CPUE (annual, regionally-averaged). The next TAC is increased relative to the current TAC if current CPUE is above the target CPUE and the CPUE trend is increasing. Conversely, the 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 (the tuning parameter in this case). The TAC change constraint will also affect MP behaviour.

Summary of Candidate Yellowfin MP Performance

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

- All of the MPs require substantial immediate catch reductions to reach the rebuilding objectives, and average catches over 2021-2040 are projected to be substantially lower than current catches.
- None of the MPs could rebuild the population fast enough to attain the tuning objectives with the requested 15% TAC change constraints. TAC change constraints had to be increased to:
    - 50-90% for Y1.
    - 25-50% for Y2.
    - 15-25% for Y3.
- All MPs have a substantial risk of exceeding biomass limit reference points (~50% per year) over the next 5-15 years. The high risk level is sustained for a longer duration with the slower rebuilding objectives.
- All of the MPs presented are likely to substantially overshoot the biomass targets after rebuilding has been achieved (with the expense of lost future catch opportunity).
- MP behaviour is usually strongly driven by the choice of tuning objective. This is true for yellowfin, but there may be considerable flexibility in how to meet a single year rebuilding objective (i.e. you can draw many lines through a single point, but a multi-year average is more restrictive).

Feedback Requests for the TCMP

It is possible that the yellowfin stock assessment review process may have important implications for the Operating Model and future MSE results. However, the current results are the best available, and it remains possible that management will have to work with the range of uncertainties presented here. Accordingly, the MP developers seek TCMP feedback on:

1) Are the current rebuilding-based tuning objectives the most appropriate, and if so is it possible to further reduce the number of tuning objectives to one or two?

2) MP developers recognize that the biomass overshoot (and lost catch opportunity) following rebuilding is probably not desirable, and will seek to find alternative MPs that minimize this outcome. Are there other characteristics that the TCMP can identify for improving MPs?

Table 1. Performance of candidate MPs with respect to key performance measures (averaged over the period 2021-2040). Shading indicates the relative performance (darker = better). Note that 2017 catch was 409 000 t, and the mean catch from 1992-2016 was 374 000 t.

	Performance Measure				
Management Procedure	SB/SB_{MSY}	Prob(Green)	Prob(SB>limit)	Mean Catch	Catch Variability
MY1	1.46 (1.30-1.64)	0.78	0.92	166.1 (63.2-217.5)	16.28
DY1	1.75 (1.32-2.05)	0.73	0.91	27.2 (13.8-163.4)	24.32
MY2	0.96 (0.78-1.13)	0.43	0.77	239.0 (119.8-273.0)	15.18
DY2	1.23 (0.87-1.53)	0.53	0.78	123.0 (70.9-194.6)	14.68
MY3	0.87 (0.56-1.12)	0.39	0.69	182.4 (113.5-263.9)	8.04
DY3	0.84 (0.48-1.18)	0.35	0.66	153.1 (110.8-209.3)	8.50

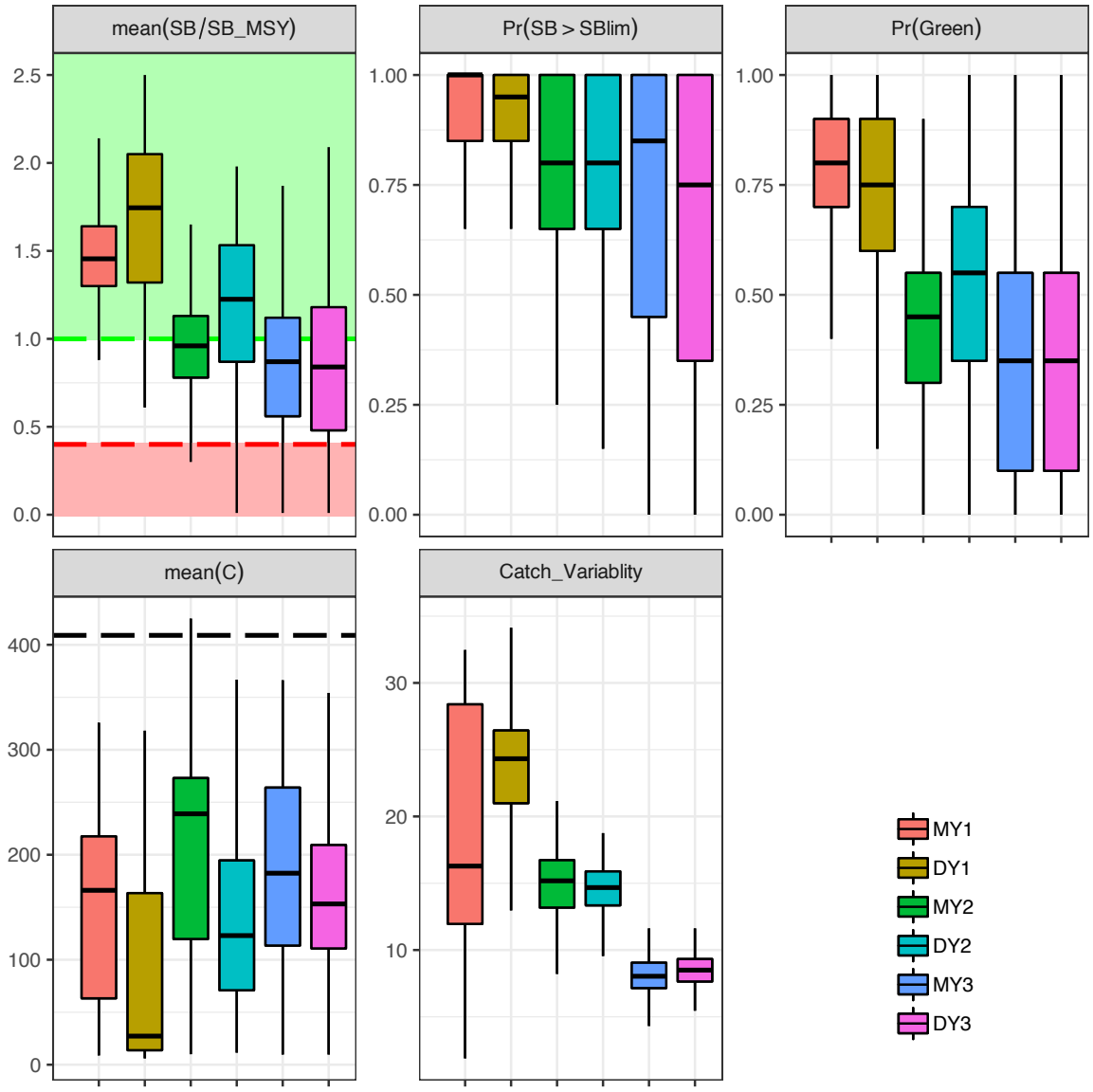

Figure 3. Boxplots comparing candidate MPs with respect to key performance measures averaged over the period 2021 - 2040. Horizontal line is the median, boxes represent 25th - 75th percentiles, thin lines represent 10th - 90th percentiles. Red and green horizontal lines represent the interim limit and target reference points. The horizontal dashed black line is 2017 catch.

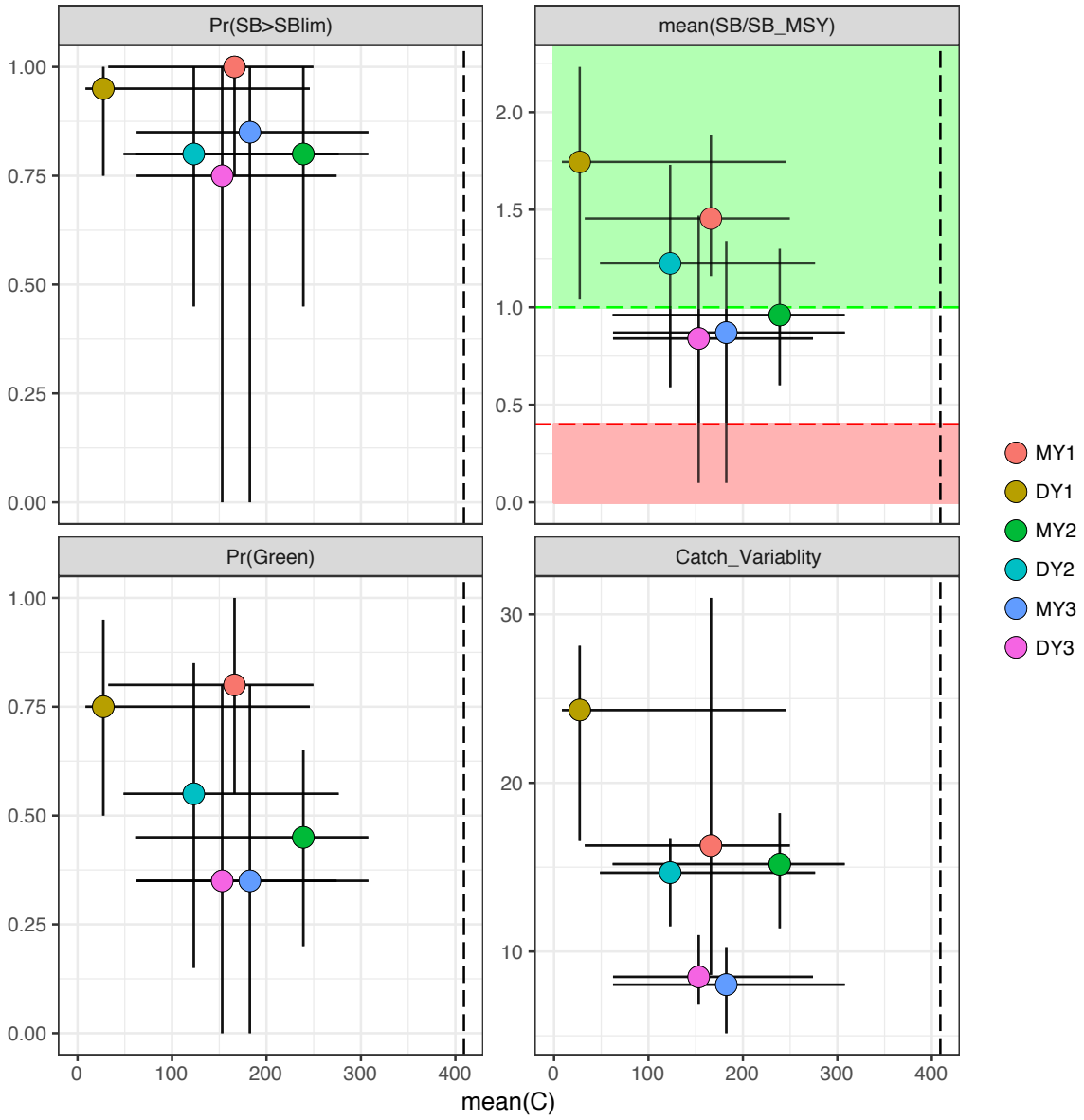

Figure 4. Trade-off plots comparing candidate MPs with respect to catch on the X-axis, and 4 other key performance measures on the Y-axis, each averaged over the period 2021 - 2040. Circle is the median, lines represent 10th-90th percentiles. Red and green horizontal lines represent the interim limit and target reference points. The dashed vertical black line is 2017 catch.

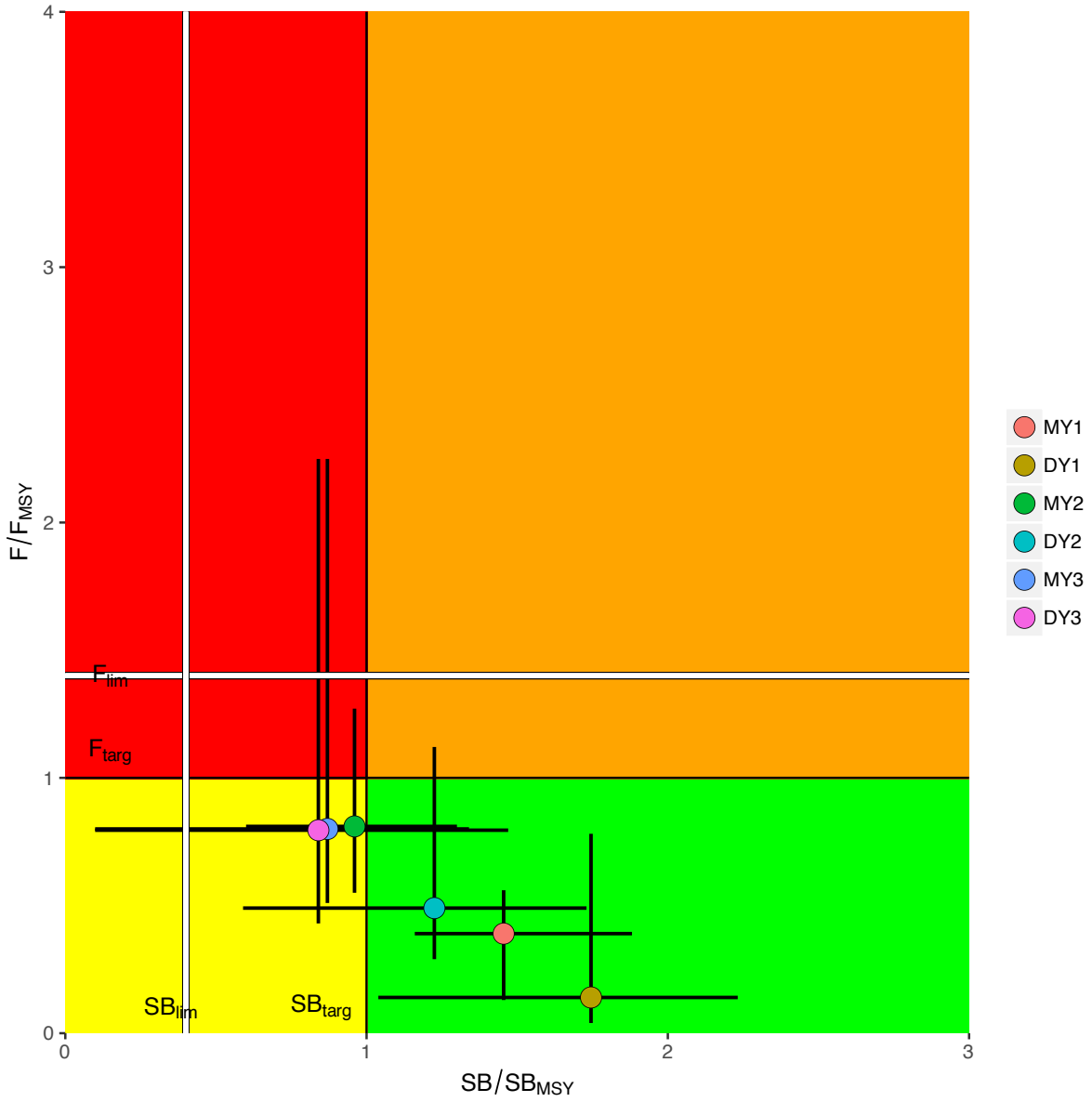

Figure 5. Kobe plot comparing candidate MPs on the basis of the expected 20 year average (2021-2040) performance. Circle is the median, lines represent 10th-90th percentiles.

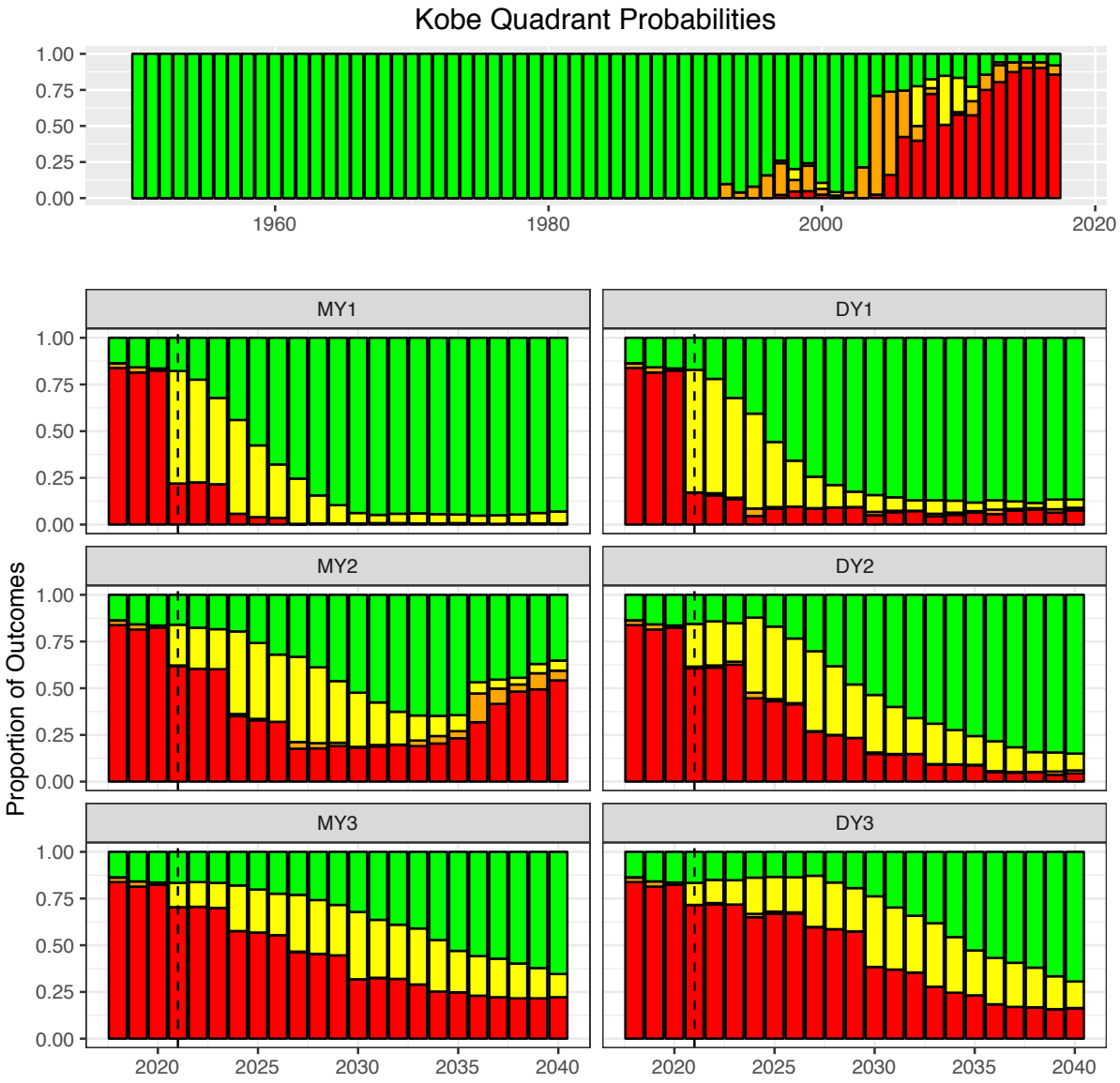

Figure 6. Proportion of simulations in each of the Kobe quadrants over time for each of the candidate MPs. Historical estimates are included in the top panel.

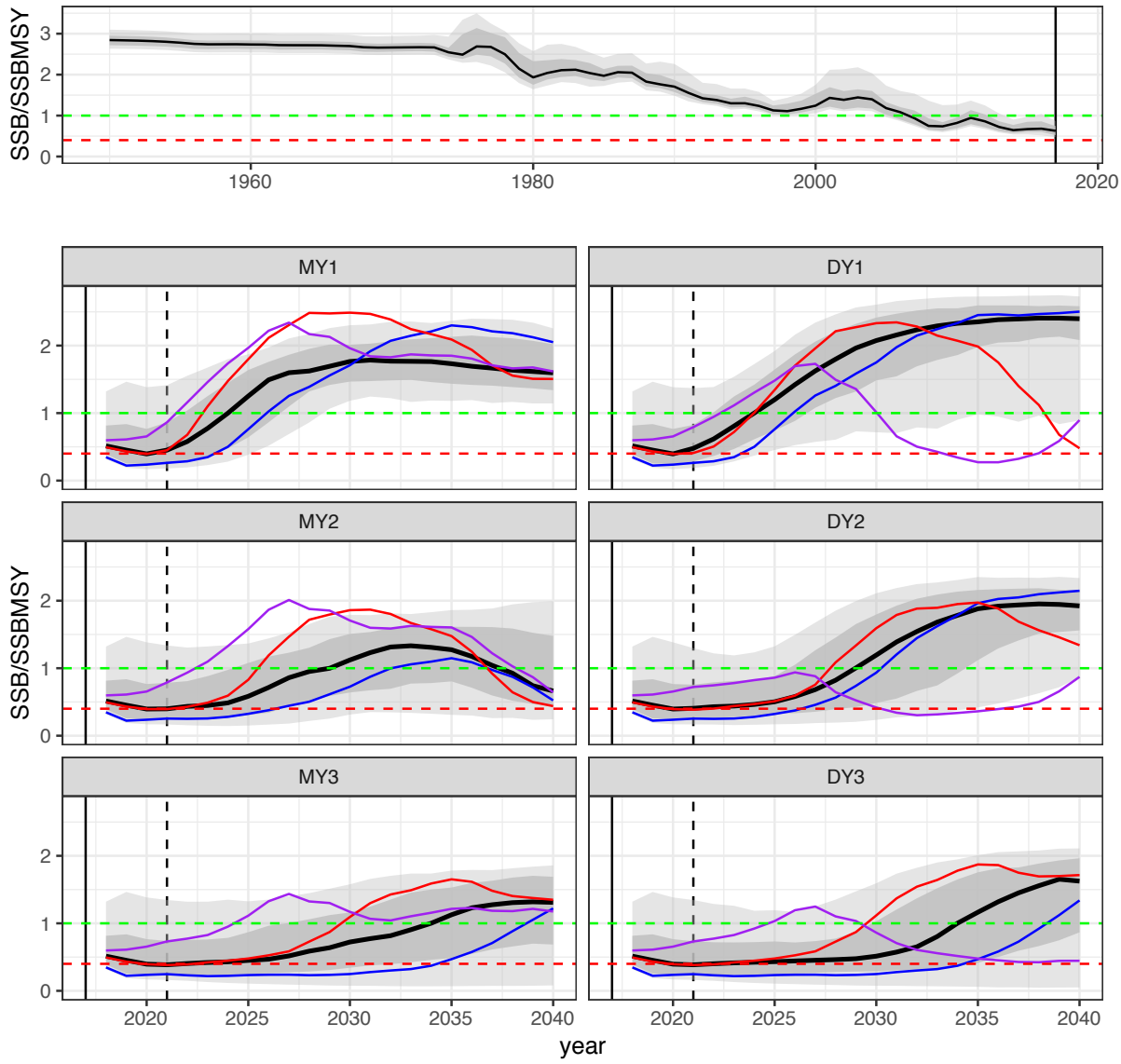

Figure 7. Time series of spawning stock size for the candidate MPs. The top panel represents the historical estimates from the reference case operating model, and lower plots represent the projection period. The solid vertical line represents the last year used in the historical conditioning. The broken vertical line represents the first year that the MP is applied. The median is represented by the bold black line, the dark shaded ribbon represents the 25th-75th percentiles, the light shaded ribbon represents the 10th-90th percentiles. Thick broken lines represent the interim target (green) and limit (red) reference points. The 3 thin coloured lines represent examples of individual realizations (the same OM scenarios across MPs and performance measures), to illustrate that individual variability greatly exceeds the median.

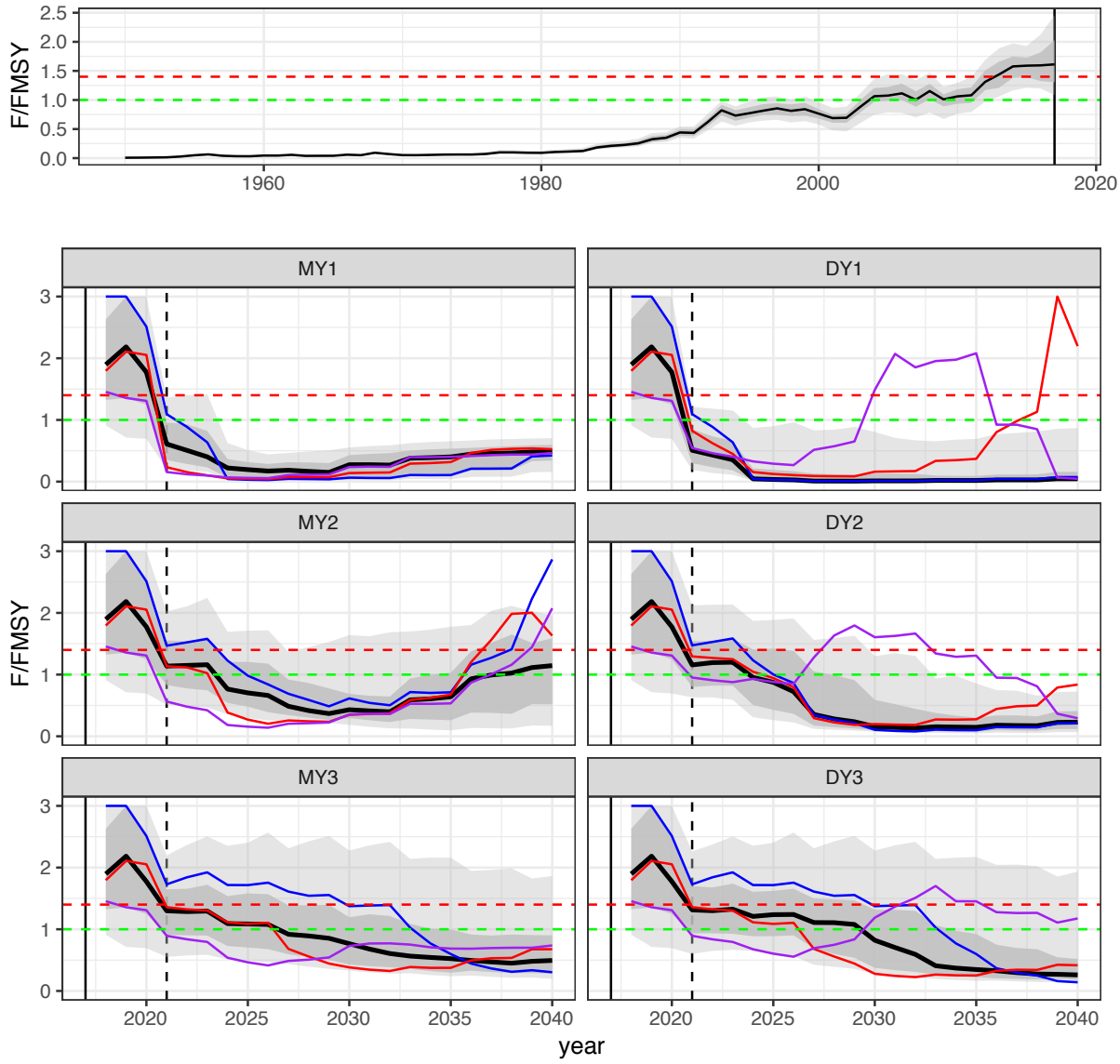

Figure 8. Time series of fishing intensity (Upper bound truncated at F = 3) for the candidate MPs. The top panel represents the historical estimates from the reference case operating model, and lower plots represent the projection period. The solid vertical line represents the last year used in the historical conditioning. The broken vertical line represents the first year that the MP is applied. The median is represented by the bold black line, the dark shaded ribbon represents the 25th-75th percentiles, the light shaded ribbon represents the 10th-90th percentiles. Thick broken lines represent the interim target (green) and limit (red) reference points. The 3 thin coloured lines represent examples of individual realizations (the same OM scenarios across MPs and performance measures), to illustrate that individual variability greatly exceeds the median.

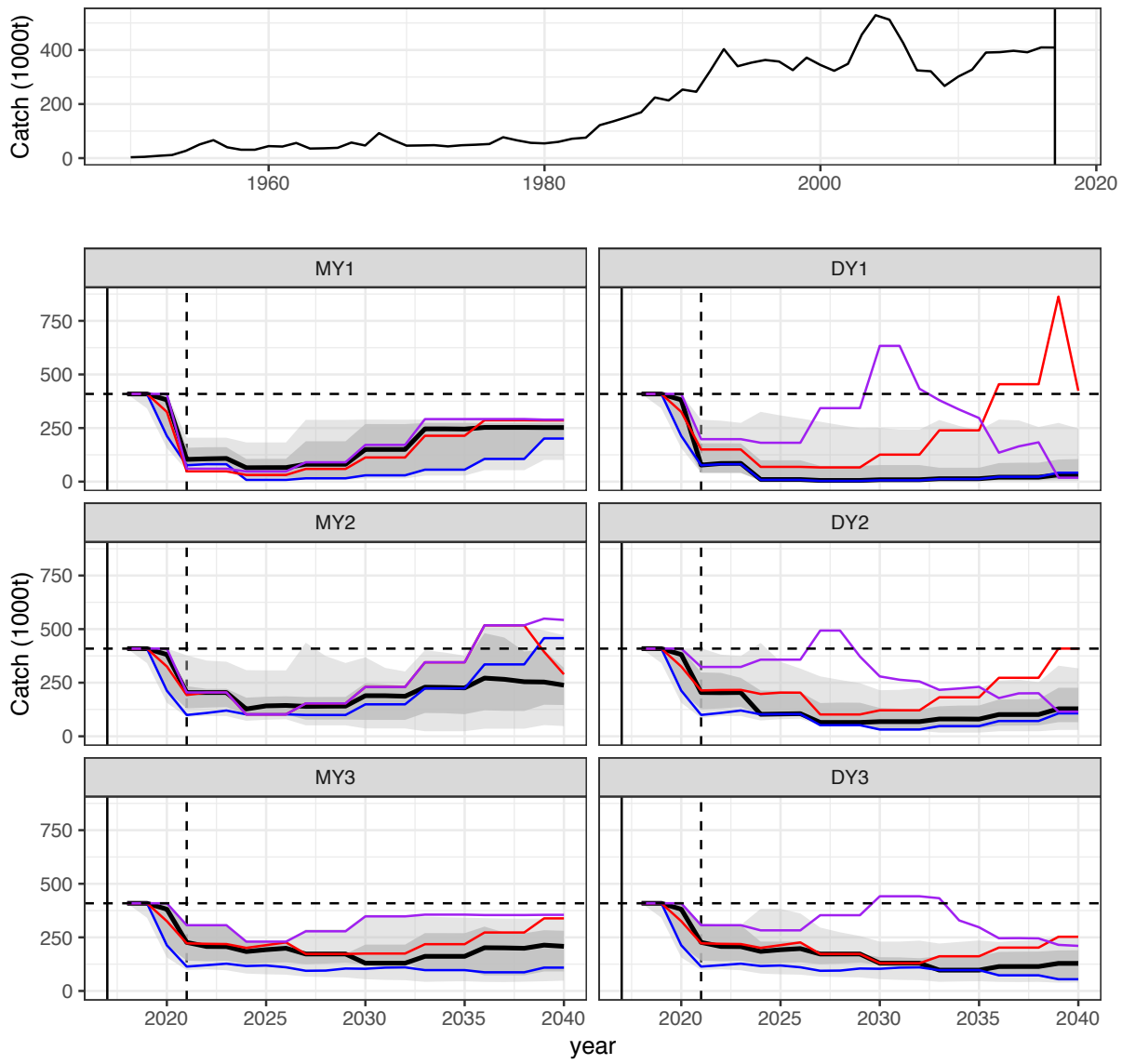

Figure 9. Time series of catch for the candidate MPs. The top panel represents the historical estimates from the reference case operating model, and lower plots represent the projection period. The solid vertical line represents the last year used in the historical conditioning. The broken vertical line represents the first year that the MP is applied. The median is represented by the bold black line, the dark shaded ribbon represents the 25th-75th percentiles, the light shaded ribbon represents the 10th-90th percentiles. The broken black horizontal line represents recent (2017) catch. The 3 thin coloured lines represent examples of individual realizations (the same OM scenarios across MPs and performance measures), to illustrate that individual variability greatly exceeds the median.

Appendix 1. Candidate Management Procedure summary performance tables for a range of time periods (aggregated over regions and fisheries).

Table A1a. Candidate MP performance for standard IOTC performance measures for the year 2021.

Status : maximise stock status		**1 year average**					
		MY1	**DY1**	**MY2**	**DY2**	**MY3**	**DY3**
Mean spawner biomass relative to pristine	SB/SB_0	0.15	0.17	0.14	0.14	0.13	0.13
Minimum spawner biomass relative to pristine	SB/SB_0	0.15	0.17	0.14	0.14	0.13	0.13
Mean spawner biomass relative to SBMSY	SB/SB_{MSY}	0.45	0.48	0.40	0.41	0.39	0.39
Mean fishing mortality relative to FMSY	F/F_{tar}	0.61	0.51	1.14	1.16	1.30	1.31
Mean fishing mortality relative to target	F/F_{MSY}	0.61	0.51	1.14	1.16	1.30	1.31
Probability of being in Kobe green quadrant	SB,F	0.20	0.19	0.17	0.16	0.17	0.17
Probability of being in Kobe red quadrant	SB,F	0.22	0.17	0.62	0.61	0.70	0.72
Safety : maximise the probability of remaining above low stock status (i.e. minimise risk)							
Probability of spawner biomass being above 20% of SB0	SB	0.41	0.42	0.35	0.35	0.34	0.34
Probability of spawner biomass being above BLim	SB	0.55	0.59	0.50	0.50	0.49	0.49
Yield : maximise catches across regions and gears							
Mean catch (1000 t)	C	103.65	77.14	204.17	204.02	226.54	226.54
Mean relative CPUE (aggregate)	C	0.29	0.24	0.52	0.53	0.63	0.63
Mean catch relative to MSY	C/MSY	0.53	0.54	0.48	0.49	0.48	0.48
Stability: maximise stability in catches to reduce commercial uncertainty							
Mean absolute proportional change in catch	C	58.58	68.45	37.43	34.94	25.00	25.00
% Catch coefficient of variation	C	NA	NA	NA	NA	NA	NA
Probability of shutdown	C	0.01	0.00	0.00	0.00	0.00	0.00

Table A1b. Candidate MP performance for standard IOTC performance measures averaged over the years 2021-2025.

Status : maximise stock status		**5 year average**					
		MY1	**DY1**	**MY2**	**DY2**	**MY3**	**DY3**
Mean spawner biomass relative to pristine	SB/SB_0	0.28	0.30	0.16	0.17	0.14	0.14
Minimum spawner biomass relative to pristine	SB/SB_0	0.15	0.16	0.14	0.13	0.13	0.13
Mean spawner biomass relative to SBMSY	SB/SB_{MSY}	0.83	0.85	0.48	0.47	0.42	0.42
Mean fishing mortality relative to FMSY	F/F_{tar}	0.36	0.34	0.97	1.09	1.22	1.27
Mean fishing mortality relative to target	F/F_{MSY}	0.36	0.34	0.97	1.09	1.22	1.27
Probability of being in Kobe green quadrant	SB,F	0.39	0.38	0.21	0.16	0.19	0.16
Probability of being in Kobe red quadrant	SB,F	0.15	0.12	0.50	0.55	0.65	0.70
Safety : maximise the probability of remaining above low stock status (i.e. minimise risk)							
Probability of spawner biomass being above 20% of SB0	SB	0.60	0.66	0.40	0.39	0.35	0.34
Probability of spawner biomass being above BLim	SB	0.72	0.78	0.57	0.57	0.53	0.52
Yield : maximise catches across regions and gears							
Mean catch (1000 t)	C	101.99	53.71	163.89	163.16	207.18	207.18
Mean relative CPUE (aggregate)	C	0.31	0.17	0.48	0.45	0.57	0.57
Mean catch relative to MSY	C/MSY	0.94	1.05	0.54	0.60	0.51	0.50
Stability: maximise stability in catches to reduce commercial uncertainty							
Mean absolute proportional change in catch	C	23.07	31.72	16.19	17.21	10.10	10.35
% Catch coefficient of variation	C	0.36	0.77	0.20	0.21	0.13	0.12
Probability of shutdown	C	0.12	0.27	0.00	0.00	0.01	0.01

Table A1c. Candidate MP performance for standard IOTC performance measures averaged over the years 2021-2030.

Status : maximise stock status		**10 year average**					
		MY1	**DY1**	**MY2**	**DY2**	**MY3**	**DY3**
Mean spawner biomass relative to pristine	SB/SB_0	0.45	0.45	0.26	0.25	0.18	0.17
Minimum spawner biomass relative to pristine	SB/SB_0	0.15	0.14	0.13	0.12	0.13	0.12
Mean spawner biomass relative to SBMSY	SB/SB_{MSY}	1.30	1.28	0.77	0.70	0.54	0.48
Mean fishing mortality relative to FMSY	F/F_{tar}	0.33	0.20	0.76	0.77	1.00	1.17
Mean fishing mortality relative to target	F/F_{MSY}	0.33	0.20	0.76	0.77	1.00	1.17
Probability of being in Kobe green quadrant	SB,F	0.62	0.59	0.33	0.29	0.24	0.17
Probability of being in Kobe red quadrant	SB,F	0.08	0.10	0.36	0.40	0.55	0.63
Safety : maximise the probability of remaining above low stock status (i.e. minimise risk)							
Probability of spawner biomass being above 20% of SB0	SB	0.77	0.78	0.55	0.50	0.42	0.37
Probability of spawner biomass being above BLim	SB	0.84	0.87	0.68	0.65	0.58	0.55
Yield : maximise catches across regions and gears							
Mean catch (1000 t)	C	99.70	30.99	160.76	114.90	188.98	188.98
Mean relative CPUE (aggregate)	C	0.30	0.09	0.43	0.33	0.53	0.53
Mean catch relative to MSY	C/MSY	1.49	1.63	0.88	0.95	0.63	0.61
Stability: maximise stability in catches to reduce commercial uncertainty							
Mean absolute proportional change in catch	C	27.00	25.82	16.44	16.33	9.91	10.00
% Catch coefficient of variation	C	0.46	1.13	0.30	0.41	0.15	0.20
Probability of shutdown	C	0.23	0.48	0.02	0.03	0.03	0.03

Table A1d. Candidate MP performance for standard IOTC performance measures averaged over the years 2021-2040.

Status : maximise stock status		**20 year average**					
		MY1	**DY1**	**MY2**	**DY2**	**MY3**	**DY3**
Mean spawner biomass relative to pristine	SB/SB_0	0.52	0.61	0.34	0.43	0.32	0.29
Minimum spawner biomass relative to pristine	SB/SB_0	0.15	0.13	0.11	0.11	0.12	0.12
Mean spawner biomass relative to SBMSY	SB/SB_{MSY}	1.46	1.75	0.96	1.23	0.87	0.84
Mean fishing mortality relative to FMSY	F/F_{tar}	0.39	0.14	0.81	0.49	0.80	0.80
Mean fishing mortality relative to target	F/F_{MSY}	0.39	0.14	0.81	0.49	0.80	0.80
Probability of being in Kobe green quadrant	SB,F	0.78	0.73	0.43	0.53	0.39	0.35
Probability of being in Kobe red quadrant	SB,F	0.04	0.08	0.35	0.24	0.40	0.43
Safety : maximise the probability of remaining above low stock status (i.e. minimise risk)							
Probability of spawner biomass being above 20% of SB0	SB	0.88	0.86	0.65	0.68	0.57	0.53
Probability of spawner biomass being above BLim	SB	0.92	0.91	0.77	0.78	0.69	0.66
Yield : maximise catches across regions and gears							
Mean catch (1000 t)	C	166.11	27.24	238.99	122.98	182.41	153.14
Mean relative CPUE (aggregate)	C	0.49	0.08	0.65	0.35	0.51	0.44
Mean catch relative to MSY	C/MSY	1.85	2.14	1.19	1.53	1.13	1.16
Stability: maximise stability in catches to reduce commercial uncertainty							
Mean absolute proportional change in catch	C	16.28	24.32	15.18	14.68	8.04	8.50
% Catch coefficient of variation	C	0.50	0.93	0.47	0.50	0.21	0.28
Probability of shutdown	C	0.18	0.56	0.06	0.11	0.06	0.06