IOTC Albacore Management Strategy Evaluation Update[1]

5th Session IOTC TCMP – 13 & 14 May 2022

Status of the MSE work

- The reference operating model for the Indian Ocean albacore tuna stock was developed over the last two years and has been endorsed by the IOTC scientific committee. The OM was developed based on the 2019 WPTmT SS3 assessment, and covers the dynamics of the stock until the year 2017.
- This OM has been updated to the current year by projecting the stock forward based on the reported catches for 2018, 2019 and 2020, and then assuming fishing mortality in 2021 was equal to that of 2020. Model runs in the grid that could not explain the 2018-2020 reported catches, or could only do so with increases in effort of over 50% per year, were eliminated from the OM. Less than 10% of the model runs in the original grid remain in the final OM after the selection procedure.
- Further developments to the albacore MSE included the development and application of three types of candidate MPs, one data-based and two model-based, and the tuning of these MPs (i.e. defining the MP parameters that achieve a certain management goal) for a range of management objectives over the next 11 to 16 years. The two model-based MPs differ in the form of the Harvest Control Rule. One employs the standard hockey-stick, while the other responds to trends in estimated depletion. The later is being proposed given the apparent need for a recovery phase in this stock.
- Technical difficulties were encountered when running the model based MPs, and the results presented below were obtained from simulation in which a perfect stock assessment is assumed, instead of the outcome of the stock assessment proposed for this stock.
- The main feedback priority for the TCMP-05 is to get confirmation on the range of proposed MPs, including the acceptability of new trend-based HCRs, as well as on the current management objectives to be achieved by the tuning procedure.

Albacore MP Development Guidance from TCMP-04 (2021)

The TCMP ENDORSED the values of 50%, 60%, and 70% for the tuning objectives of the albacore Management Procedure with the percentages corresponding to the percentage of time the stock status is in the Kobe green quadrant over the reference years (i.e. 2030-2034 or 11 – 15 years from model terminal year).

The TCMP REQUESTED the albacore OM developer to explore the effects of having values different than 15% in TAC change constraint, including some values varying with stock status, and report to the WPM and SC.

[1] Iago Mosqueira, Thomas Brunel. Wageningen Marine Research. Haringkade 1, Postbus 68, 1976CP, IJmuiden, The Netherlands. iago.mosqueira@wur.nl

Candidate Management Procedures

The albacore MSE analyses presented here have evaluated three types of MPs. First, a model-free MP informed directly by trends in the main index of abundance, the NW LL CPUE. The other two are model-based, and based on the information on stock status provided by a surplus production model fitted to two CPUE series (NW and SW LL standardized CPUEs):

- One employing a hockey-stick harvest control rule that proposes a TAC depending on the estimated level of depletion.
- Another in which the harvest control rule responds to changes in stock status, measured again using the estimated depletion level, and responds to changes in the trend in depletion over the last five years by increasing or decreasing the TAC.

The three types of MPs are presented below and were furthermore implemented:

- With a 3 year advice cycle (TAC set for a period of 3 years)
- With a inter-annual TAC variation limit of 15 %, whereby when the implementation of the MP leads to a change in TAC larger (in absolute values) that 15%, the TAC applied is that corresponding to the max 15% change (increase or decrease).
- Assuming that in a given year, y, when advice has to be given for the 3 following years, y+1 to y+3, data are available until two years prior, y-2 (i.e. a 2 year data lag), as it is currently the case for this stock.

Data-based MP

- Definition

The data-based MPs attempt to manage the fishery to achieve a target value of catch rates over a chosen CPUE series. 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: CP1) the number of years in the CPUE slope calculation, CP2) responsiveness to CPUE target deviation, CP3) responsiveness to CPUE slope and CP4) the CPUE target.

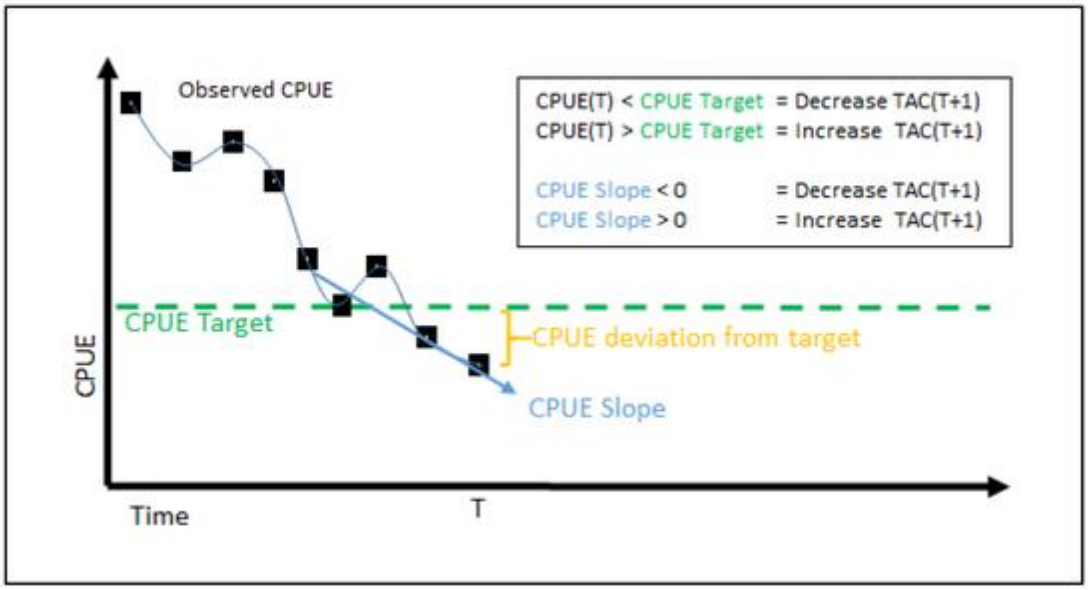

Figure 2 : illustration of the data-based MP

- Implementation in the albacore case

The control parameters defining the responsiveness of the MP to both the current distance from the target CPUE and to the slope of the CPUE over the recent years were all set. The MP was tuned to estimate the target CPUE value for the same three management objectives as for the model based MPs.

Model-based hockey stick MP

- Definition

The first model-based MP (figure 1) involves two steps: 1) fitting a surplus production model to estimate current depletion rate, and 2) applying a hockey stick Harvest Control Rule (HCR) to the model estimates of current depletion. The shape of the HCR is defined by three control parameters :

CP1: minimum stock level below which no fishing (or the least possible) should take place,

CP2: trigger stock level below which Catch advice should be decreased proportionally to current depletion

CP3: maximum catch that can be taken when the stock is estimated to be above the trigger level.

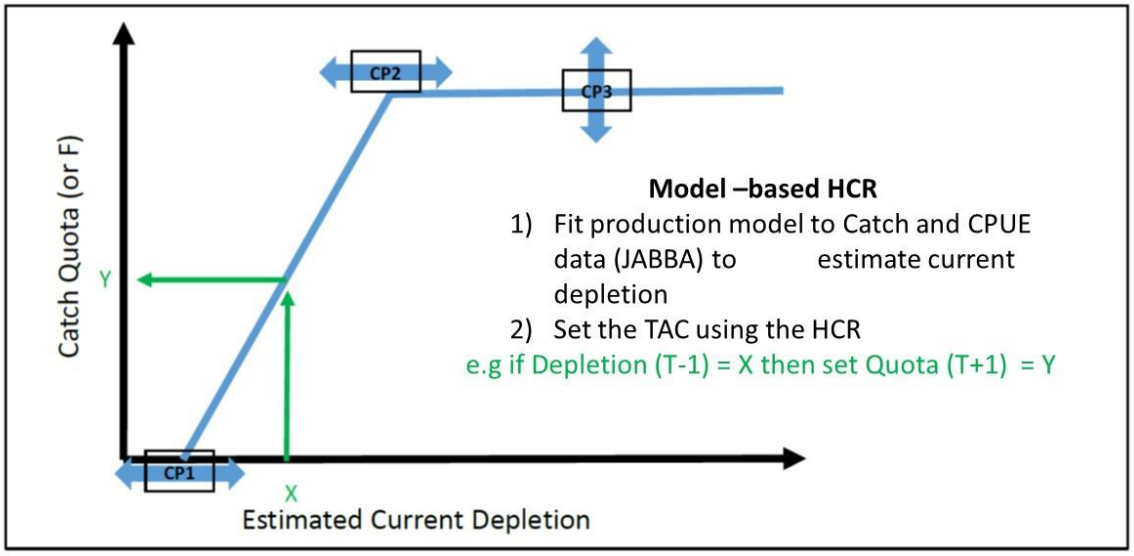

Figure 1. Harvest control rules used in the hockey stick model-based MP.

- Implementation in the albacore case

For the albacore MSE, the current depletion rate is estimated by the surplus production model JABBA, as SB/SB0 (SB0 =virgin biomass). The limit and trigger depletion rates were set at CP1 = 0.1 (a proxy for SB=Blim) and CP2 = 0.4 (a proxy for SB=SB_{MSY}) The maximum catch, CP3, was obtained by tuning the MP to achieve the particular management objectives. In agreement with the decision made by the TCMP-04 (2021), the MP was tuned for three tuning objectives corresponding to a probability of being is in the green quadrant of the Kobe plot over the period 2034:2039 of exactly 50%, 60% and 70% (on average over all stock replicates) respectively.

- Technical issues encountered and adaptation

The incorporation of the JABBA stock assessment into the methodological framework used for the albacore MSE is an ongoing task in the new contract covering work for this stock, started in March 2022. Trial MSE runs indicated that there were no issues with the implementation of JABBA as estimator, but the procedure failed to fit the model in a number of replicates. Further work is ongoing to fine tune the behavior of this model as basis for the albacore model-based MPs. In order to get a first approximation of the performance of MPs based on the hockey-stick HCR for albacore, simulations were run assuming a perfect assessment, meaning that the depletion SB/SB0 that is used in the HCR is not estimated by an assessment method, but directly observed without error from the true stock (OM). The results presented therefore do not incorporate the impact of the errors in the stock assessment, that can also have a substantial impact on the performance of the MP. Initial tests of the model indicate, however, that the bias in the estimation of depletion is fairly constant, which would be easily corrected by the tuning procedure.

Model-based trend MP

- Definition

This MP follows closely the mechanics of the one applied to Southern bluefin tuna (SBT). A candidate TAC is set based on the trend in depletion level estimated over the last five years, as a negative or positive slope in a linear regression, and a set of parameters that control its behavior in both cases, and the strength of response to negative trends.

- Implementation in the albacore case

The control parameters defining the responsiveness of the MP to both the current distance from the target CPUE and to the slope of the CPUE over the recent years were all set. The MP was tuned to estimate the target CPUE value for the same three management objectives as for the model based MPs.

- Technical issues encountered and adaptation

The computational issues mentioned above in the application of the chosen surplus production model also apply to this MP. The results presented for this MP are based on perfect observations of the depletion level and not estimates from the assessment model.

Summary of albacore Candidate MP Performance

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

- Management objective was more important in determining the main performance criteria (probability of Kobe green, ratio of biomass over biomass at MSY) while the choice of MP had an effect on the levels and variability in catch.
- The update of the OM to the current year by projecting for the reported nominal catches of the 2018-2020 period, showed the inability of many OM iterations to sustain those catches. Exclusion of those model runs has led to an OM much reduced in terms of the representation of uncertainty. Pending the findings of the 2022 WPTmT stock assessment update for albacore, this stock could be a good candidate for the application of the methodology being discussed for use in the conditioning of a yellowfin tuna OM.
- The presented MPs still apply a 15% limit on TAC changes per management cycle. Although TCMP04 expressed its interest in relaxing this assumption, the developers considered that those runs would be most informative once only a reduced number of MPs, and maybe management objectives, remain under consideration. A question remains if asymmetric TAC constraints, or

those that apply only once the stock is over a safe level, should also be tested in this case, where the stock appears to be in need of a recovery phase.

Feedback Requests for the TCMP

The following points are provided to suggest the type of feedback that would be most useful for scientists for the next iteration:

1) The developers would welcome any feedback on the 2 types of MPs proposed, and would like to know if the commission request them to test alternatives MPs. Specially, on the acceptability of the trend-based HCR presented here.
2) Are the tuning objectives agreed up on in previous TCMPs still considered relevant? Or could they be limited given the apparent risks involved?
3) In the hockey-stick HRC, should there be a minimum catch allowed when depletion rate is below CT1, to take into account, for example, subsistence fisheries or bycatch, and if so, what should be the basis TCMP considers useful to set this minimum catch.
4) If the exploration of alternative TCA constraints should also explore formulations in which either (a) TAC can decrease more than be increased (e.g. 15% up but 30% down), or (b) that TAC constraints only apply once the stock is at a safe level and not when they could slow its recovery from some level of over-exploitation.

Table 1: performance of candidate MPs with respect to key performance measures (averaged over the period 2034-2039).

MP	prob(SB>SB_{limit})	Catch Variability	prob(Green)	Mean Catch	SB/SB_{MSY}
MP1	>0.99	3.8	0.51	33041 (19457-36045)	1.3
MP2	>0.99	3.9	0.59	31685 (24850-34557)	1.3
MP3	>0.99	4.1	0.71	29873 (23596-32548)	1.4
MP4	>0.99	1.9	0.49	46143 (36160-48281)	1.9
MP5	>0.99	1.7	0.6	44542 (36040-45547)	2
MP6	>0.99	1.5	0.7	43096 (35507-43359)	2
MP7	>0.99	6.7	0.49	41833 (26148-60921)	1.6
MP8	>0.99	6	0.59	38139 (25072-53412)	1.7
MP9	>0.99	5.5	0.7	34874 (22742-46431)	1.8

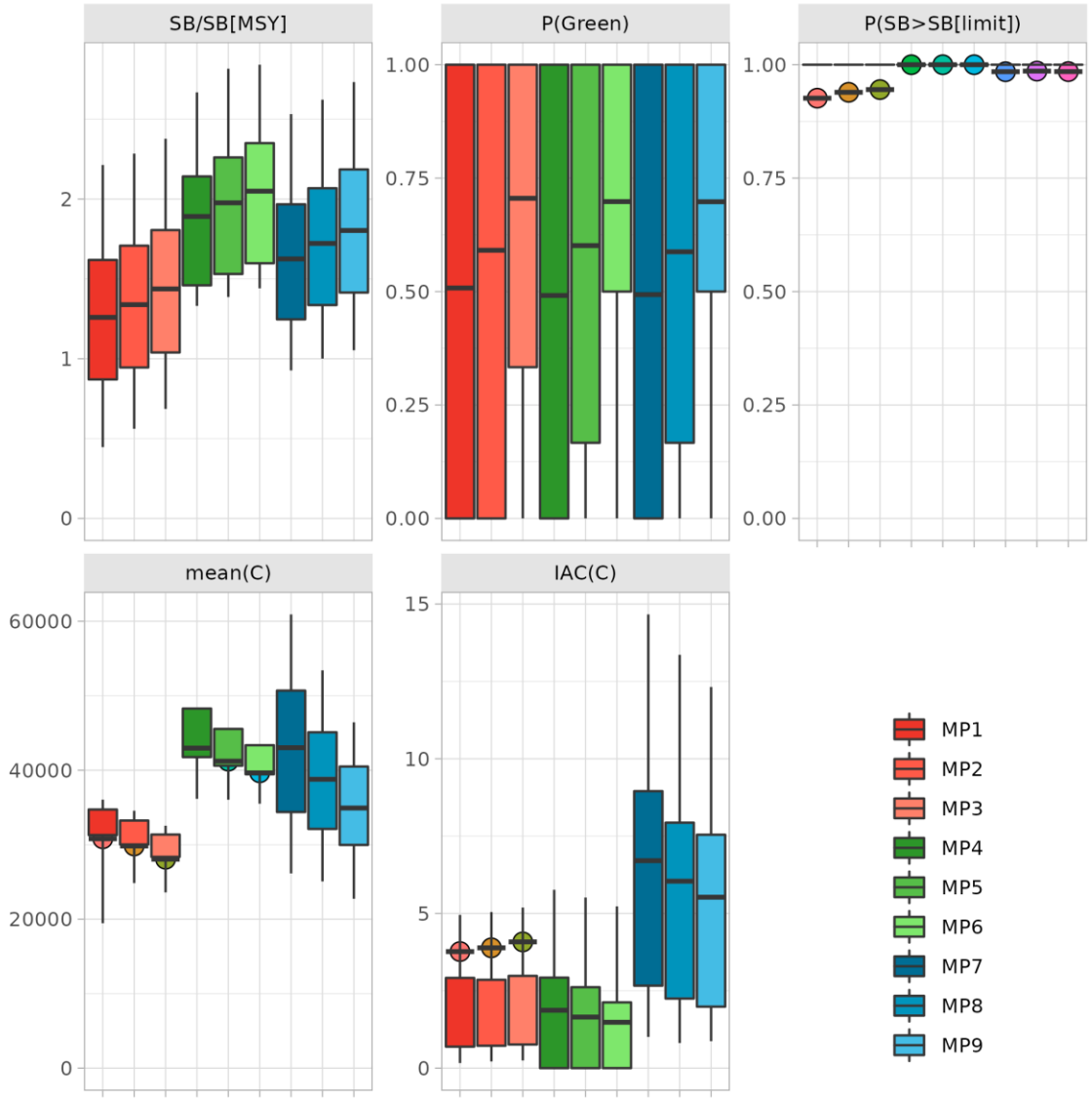

Figure 3. Boxplots comparing candidate MPs with respect to key performance measures averaged over the period 2034-2039. Horizontal line is the mean, boxes represent 25th - 75th percentiles, thin lines represent 10th - 90th percentiles. The data based MPs are depicted in red and model-based MPs are depicted in Green

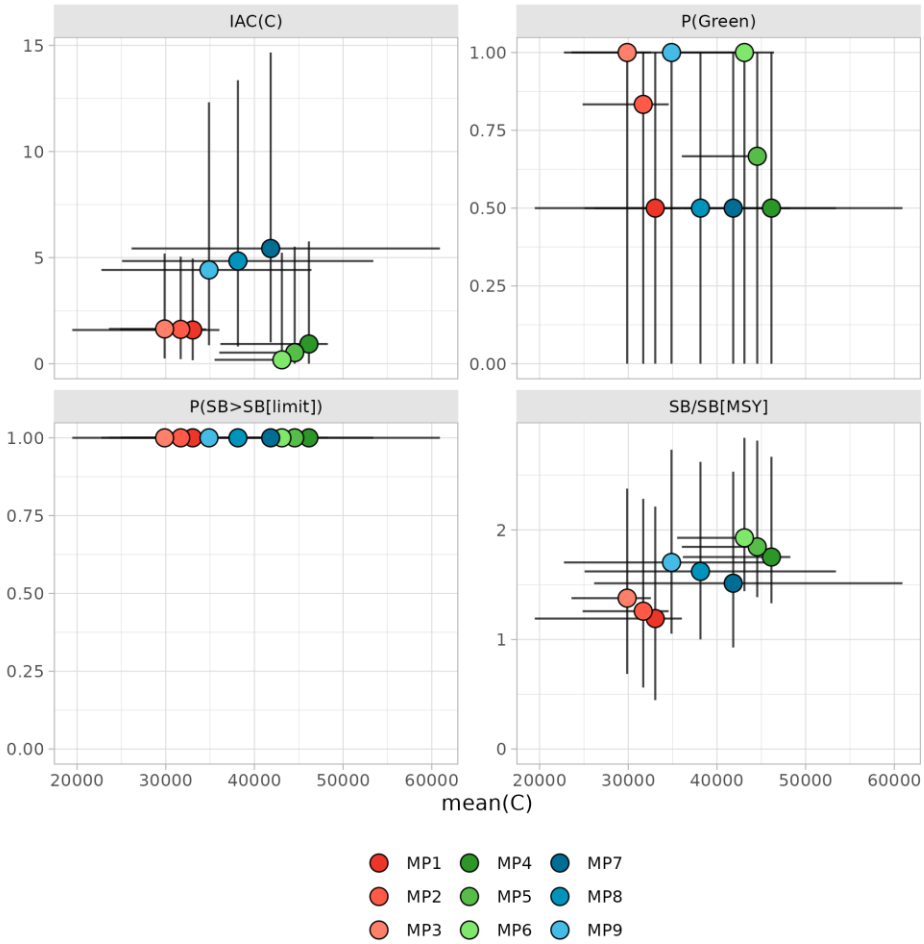

Figure 4. Trade-off plots comparing candidate MPs with respect to catch on the X-axis, and 4 other key performance measures on the Y-axis, each averaged over the period 2034-39. Circle is the median, lines represent 10th-90th percentiles..

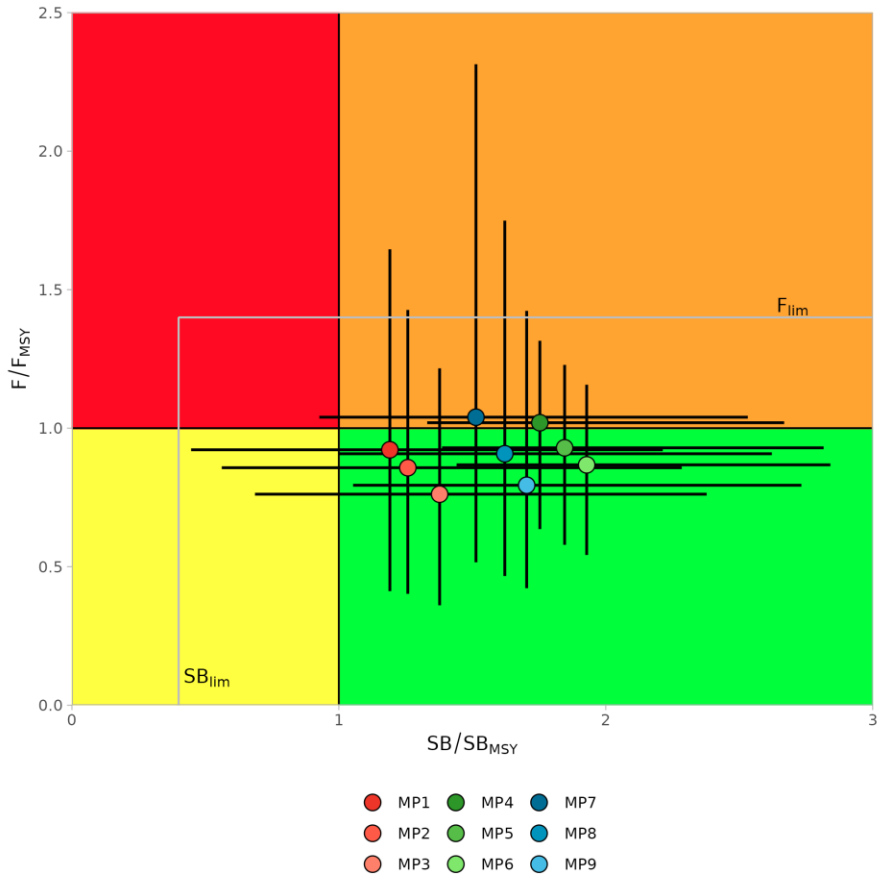

Figure 5. Kobe plot comparing candidate MPs on the basis of the expected 2034-2039 average performance. Circle is the median, lines represent 10th-90th percentiles.

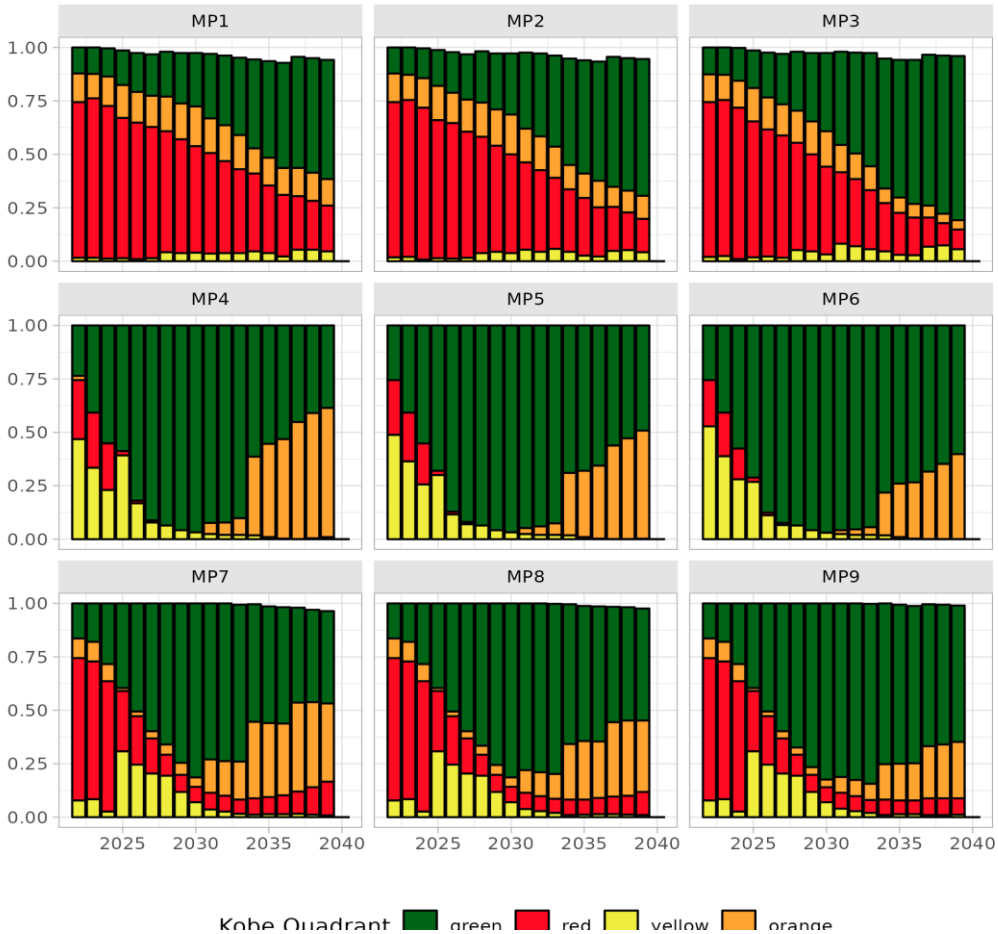

Figure 6. Proportion of simulations in each of the Kobe quadrants over time for each of the candidate MPs.

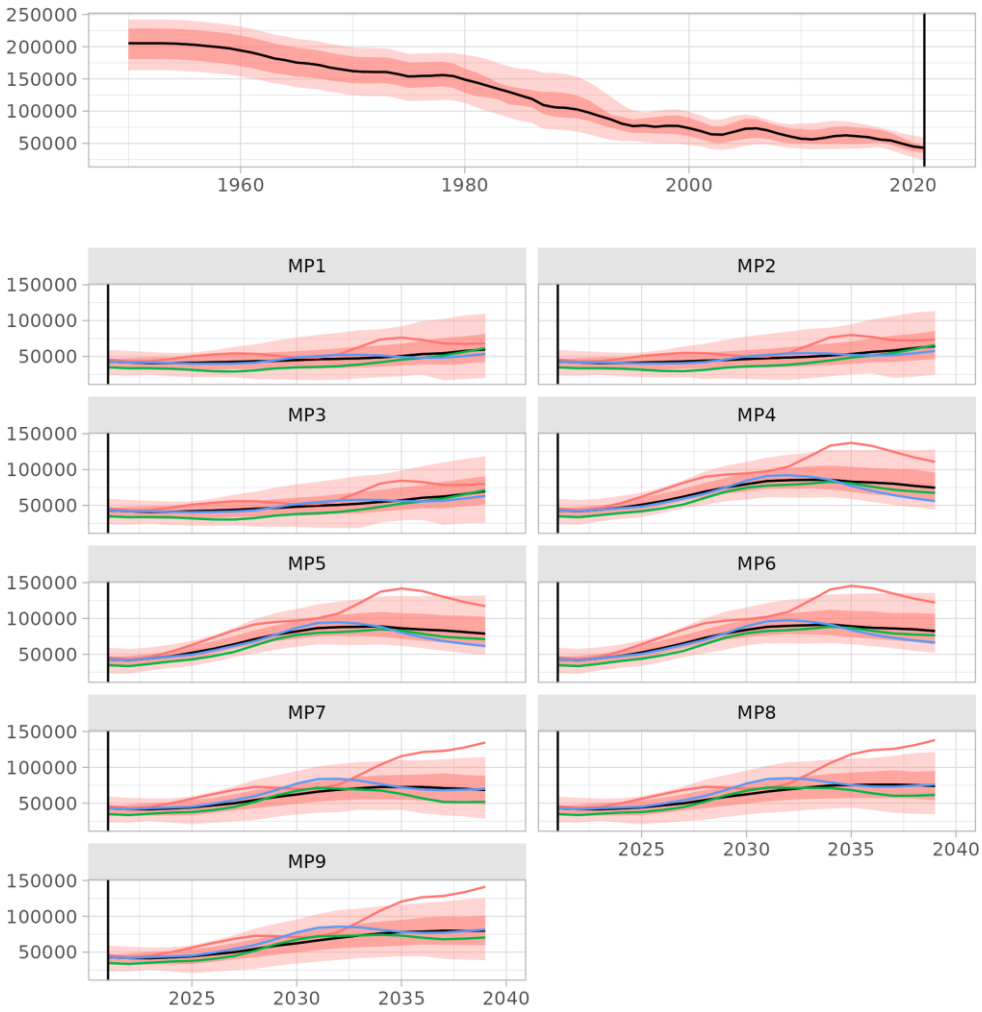

Figure 7. Time series of spawning stock size for the candidate MPs. The top panel represents the historical estimates from the reference case operating model, and lower plots represent the projection period. The solid vertical line represents the last year used in the historical conditioning. The median is represented by the bold black line, the darker red shaded ribbon represents the 25th-75th percentiles, the lighter red shaded ribbon represents the 10th-90th percentiles. The 3 thin coloured lines represent examples of individual realizations (the same OM scenarios across MPs and performance measures), to illustrate the range of expected realizations in stock trajectory.

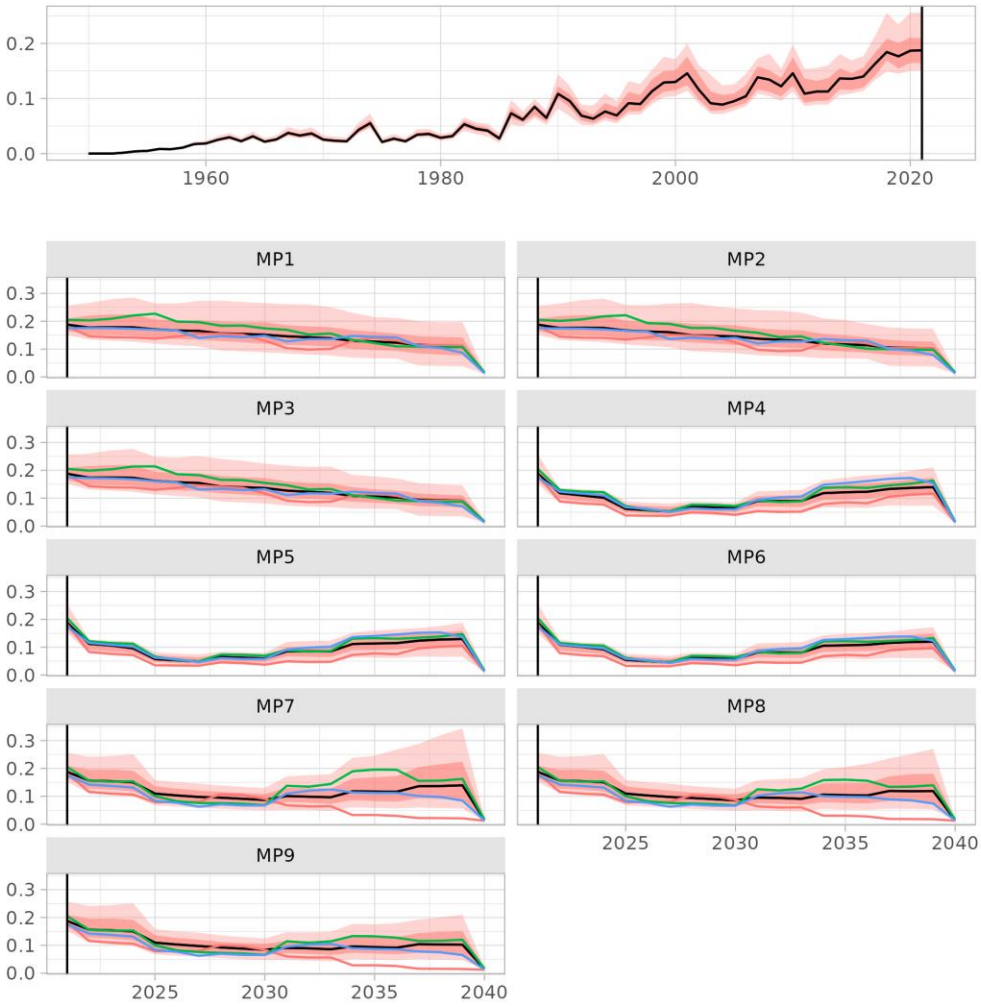

Figure 8. Time series of fishing intensity for the candidate MPs. The top panel represents the historical estimates from the reference case operating model, and lower plots represent the projection period. The solid vertical line represents the last year used in the historical conditioning. The median is represented by the bold black line, the darker red shaded ribbon represents the 25th-75th percentiles, the lighter red shaded ribbon represents the 10th-90th percentiles. The 3 thin coloured lines represent examples of individual realizations (the same OM scenarios across MPs and performance measures), to illustrate the range of expected realizations in stock trajectory.

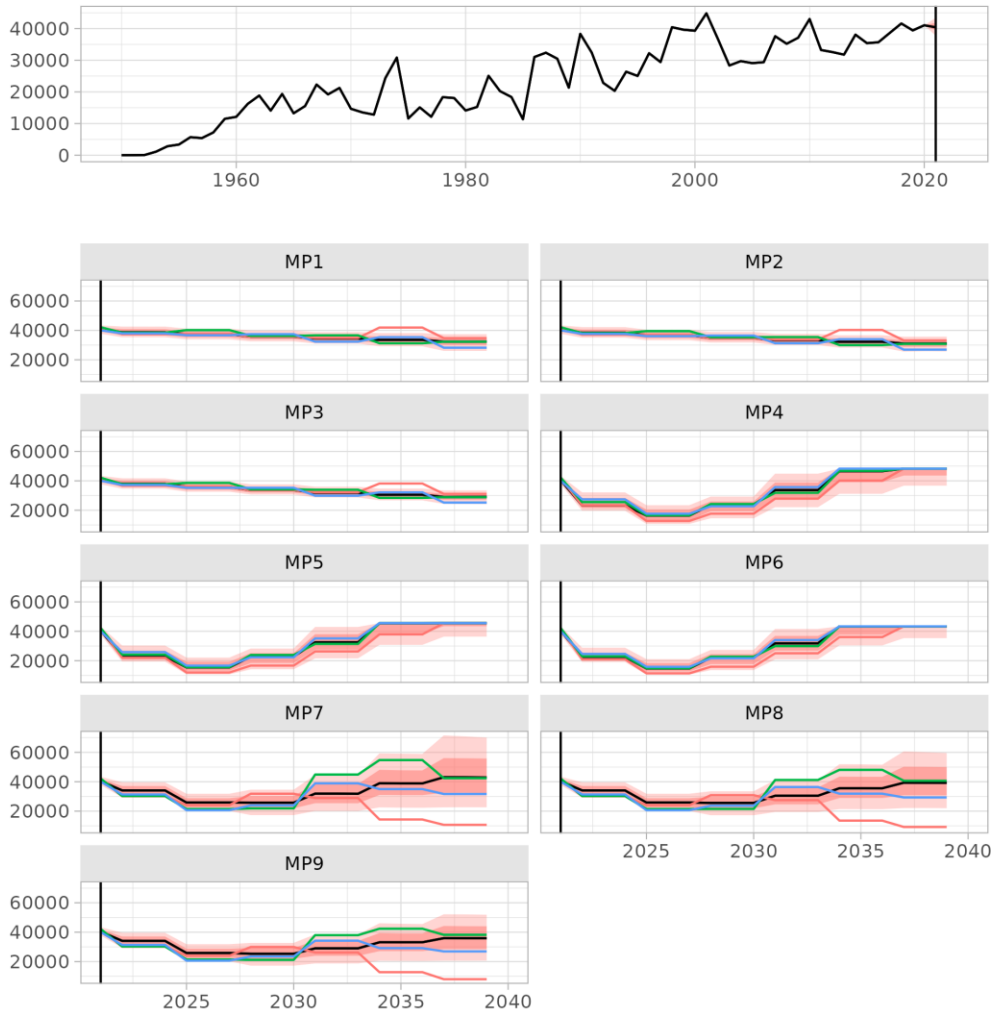

Figure 9. Time series of catch for the candidate MPs. The top panel represents the historical estimates from the reference case operating model, and lower plots represent the projection period. The solid vertical line represents the last year used in the historical conditioning. The median is represented by the bold black line, the darker red shaded ribbon represents the 25th-75th percentiles, the lighter red shaded ribbon represents the 10th-90th percentiles. The 3 thin coloured lines represent examples of individual realizations (the same OM scenarios across MPs and performance measures), to illustrate the range of expected realizations in stock trajectory.

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 years 2022-2026.

Performance statistic	name	MP1	MP2	MP3	MP4	MP5	MP6	MP7	MP8	MP9
Mean catch over years	mean(C)	38297	37842	37259	22573	21530	20735	30706	30706	30706
Mean fishing mortality relative to FMSY	F/FMSY	1.74	1.73	1.68	0.73	0.70	0.67	1.13	1.13	1.13
Mean fishing mortality relative to target	F/Ftarget	1.74	1.73	1.68	0.73	0.70	0.67	1.13	1.13	1.13
Mean proportion of MSY	C/MSY	1.13	1.12	1.10	0.66	0.63	0.60	0.90	0.90	0.90
Mean spawner biomass relative to un-fished	SB/SB0	0.21	0.21	0.21	0.24	0.25	0.25	0.22	0.22	0.22
Mean spawner biomass relative to SBMSY	SB/SBMSY	0.92	0.92	0.93	1.09	1.11	1.12	0.98	0.98	0.98
Minimum spawner biomass relative to unfished	min(SB/SB0)	0.20	0.20	0.20	0.21	0.21	0.21	0.20	0.20	0.20
Percentage inter-annual change in catch	IAC(C)	1.83	1.87	1.93	7.48	7.62	7.77	6.05	6.05	6.05
Probability of being in Kobe green quadrant	P(Green)	0.14	0.15	0.16	0.52	0.55	0.57	0.31	0.31	0.31
Probability of being in Kobe red quad-rant	P(Red)	0.70	0.69	0.68	0.16	0.14	0.12	0.49	0.49	0.49
Probability of fishery shutdown	P(shutdown)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Probability that spawner biomass is above 20% SB[0]	P(SB > 0.20 x SB0)	0.57	0.57	0.58	0.79	0.79	0.79	0.65	0.65	0.65
Probability that spawner biomass is above SBlim	P(SB>SBlimit)	0.97	0.97	0.97	0.98	0.98	0.98	0.98	0.98	0.98

Table A1b. Candidate MP performance for standard IOTC performance measures for the years 2022-2031.

Performance statistic	name	MP1	MP2	MP3	MP4	MP5	MP6	MP7	MP8	MP9
Mean catch over years	mean(C)	36843	36192	35298	23239	22268	21478	28839	28545	28281
Mean fishing mortality relative to FMSY	F/FMSY	1.68	1.64	1.53	0.63	0.60	0.57	0.94	0.94	0.93
Mean fishing mortality relative to target	F/Ftarget	1.68	1.64	1.53	0.63	0.60	0.57	0.94	0.94	0.93
Mean proportion of MSY	C/MSY	1.09	1.07	1.04	0.67	0.65	0.62	0.85	0.84	0.83
Mean spawner biomass relative to unfished	SB/SB0	0.21	0.22	0.22	0.31	0.32	0.33	0.26	0.26	0.26
Mean spawner biomass relative to SBMSY	SB/SBMSY	0.96	0.97	0.99	1.43	1.46	1.48	1.18	1.18	1.18
Minimum spawner biomass relative to unfished	min(SB/SB0)	0.19	0.19	0.19	0.21	0.21	0.21	0.20	0.20	0.20
Percentage inter-annual change in catch	IAC(C)	2.95	2.97	3.06	10.91	11.15	11.35	8.91	8.48	8.11
Probability of being in Kobe green quadrant	P(Green)	0.19	0.21	0.24	0.73	0.75	0.76	0.51	0.51	0.52
Probability of being in Kobe red quadrant	P(Red)	0.62	0.59	0.57	0.08	0.07	0.06	0.29	0.29	0.29
Probability of fishery shutdown	P(shutdown)	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Probability that spawner biomass is above 20% SB[0]	P(SB > 0.20 x SB0)	0.59	0.61	0.63	0.88	0.88	0.88	0.77	0.77	0.77
Probability that spawner biomass is above SBlim	P(SB>SBlimit)	0.96	0.96	0.97	0.99	0.99	0.99	0.99	0.99	0.99

Table A1c. Candidate MP performance for standard IOTC performance measures for the years 2022-2041.

Performance statistic	name	MP1	MP2	MP3	MP4	MP5	MP6	MP7	MP8	MP9
Mean catch over years	mean(C)	34550	33700	32442	30879	29633	28565	33729	32046	30519
Mean fishing mortality relative to FMSY	F/FMSY	1.56	1.50	1.34	0.75	0.71	0.67	1.10	1.01	0.93
Mean fishing mortality relative to target	F/Ftarget	1.56	1.50	1.34	0.75	0.71	0.67	1.10	1.01	0.93
Mean proportion of MSY	C/MSY	1.02	0.99	0.96	0.90	0.87	0.84	0.99	0.94	0.90
Mean spawner biomass relative to unfished	SB/SB0	0.24	0.25	0.26	0.37	0.38	0.39	0.31	0.31	0.32
Mean spawner biomass relative to SBMSY	SB/SBMSY	1.07	1.10	1.15	1.65	1.70	1.74	1.38	1.41	1.44
Minimum spawner biomass relative to unfished	min(SB/SB0)	0.19	0.19	0.20	0.21	0.21	0.21	0.20	0.20	0.20
Percentage inter-annual change in catch	IAC(C)	3.45	3.50	3.58	7.09	7.05	7.02	9.13	8.39	7.82
Probability of being in Kobe green quadrant	P(Green)	0.31	0.35	0.42	0.67	0.72	0.76	0.53	0.57	0.61
Probability of being in Kobe red quadrant	P(Red)	0.48	0.44	0.40	0.04	0.04	0.03	0.21	0.20	0.19
Probability of fishery shutdown	P(shutdown)	0.02	0.02	0.02	0.01	0.01	0.01	0.00	0.00	0.00
Probability that spawner biomass is above 20% SB[0]	P(SB > 0.20 x SB0)	0.64	0.68	0.71	0.93	0.93	0.93	0.83	0.84	0.85
Probability that spawner biomass is above SBlim	P(SB>SBlimit)	0.95	0.95	0.95	0.99	0.99	0.99	0.99	0.99	0.99

\