Initial robustness trial of empirical MPs for Indian Ocean skipjack tuna

IOTC 14th Working Party on Methods

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Wageningen University & Research Centre, IJmuiden

Background and motivation

Overall objective

Develop a Management Procedure for Indian Ocean SKJ tuna.

1. Integrate suggestions from the TCMP 2022 into the current evaluation framework:
    - Tune the MPs to the 50%, 60% and 70% criteria, including appropriate levels of positively biased catches ("implementation error"); see Point 67 of IOTC–2022–TCMP05–R[E];
    - Evaluate performance of the MPs to recruitment decline in the presence of implementation error;
2. With feedback from the WPM, present an update to the TCMP/MSETF (Feb/March 2023);
3. Following update to the SKJ stock assessment, include the 2023 assessment in the OM;
4. Propose candidate MPs to the TCMP (May 2023), along with an implementation cycle.

Funded by: Indian Ocean Tuna Commission (project MTF/INT/661/MUL).

Time frame: October 2022 to June 2023

Relevant background

Terminology:

- **Robustness:** whether an MP is able to meet performance objectives despite the presence of uncertainty;
- **Robustness trial/testing:** stress-testing of the MP to ensure it is "robust" to additional pre-defined uncertainties.

Previously MPs tuned to be "robust" to implementation error.

Objective of the current work is to provide an illustrative "robustness trial" to evaluate performance under an extreme scenario of stock collapse/recruitment failure.

Edwards, C. T. T. (2022). Presentation of empirical MPs for Indian Ocean skipjack tuna accounting for implementation error. *Research Report (IOTC–2022–WPM13–09)*

Relevant background

Harvest Control Rule

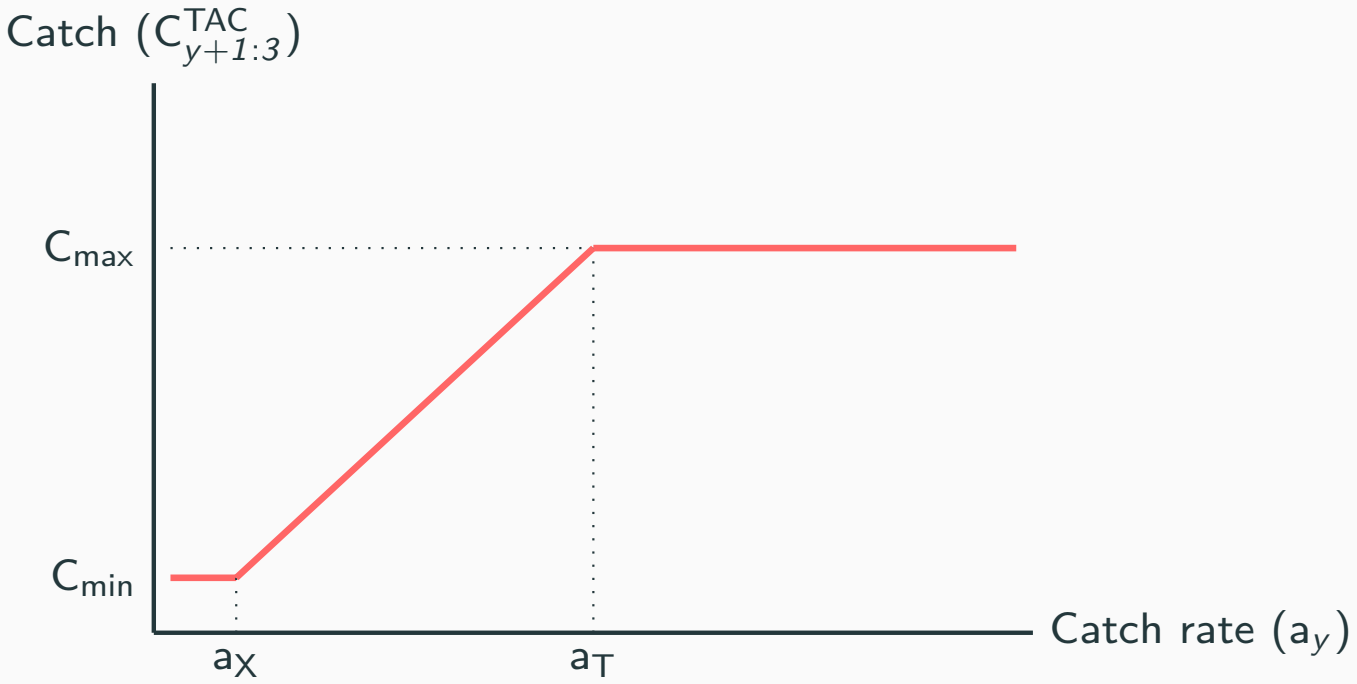

Figure 1: Schematic representation of the empirical Harvest Control Rule being proposed as part of the MPs.

Relevant background

Design of current set of candidate MPs

Based on known catches relative to the TAC in 2018–2020, candidate MPs were generated by tuning to the 50%, 60% and 70% Pr. Target Green criteria under the following assumed implementation errors:

R01: 10% positive catch error from 2021 to 2040;

R02: 20% positive catch error from 2021 to 2040;

R03: 30% positive catch error from 2021 to 2040;

R04: 40% positive catch error from 2021 to 2040;

This generated a total of nine candidate MPs, applicable to 12 tuning/error scenarios.

Relevant background

Table 1: Tuning parameters for MPs that matched the 70%, 60% and 50% tuning criteria.

MP (tuning)	Imp. error	C_{min}	C_{max}	a_X	a_T
MP9 (Target 50%)	R01 (10%)	53.21	516.11	-5.00	-1.70
MP8 (Target 60%)	R01 (10%)	53.21	473.55	-5.00	-1.70
MP5 (Target 70%)	R01 (10%)	53.21	430.98	-5.00	-1.70
MP7 (Target 50%)	R02 (20%)	53.21	452.26	-5.00	-1.70
MP6 (Target 60%)	R02 (20%)	53.21	436.30	-5.00	-1.70
MP4 (Target 70%)	R02 (20%)	53.21	404.38	-5.00	-1.70
MP5 (Target 50%)	R03 (30%)	53.21	430.98	-5.00	-1.70
MP4 (Target 60%)	R03 (30%)	53.21	404.38	-5.00	-1.70
MP3 (Target 70%)	R03 (30%)	53.21	388.41	-5.00	-1.70
MP4 (Target 50%)	R04 (40%)	53.21	404.38	-5.00	-1.70
MP2 (Target 60%)	R04 (40%)	53.21	383.09	-5.00	-1.70
MP1 (Target 70%)	R04 (40%)	53.21	356.49	-5.00	-1.70

Relevant background

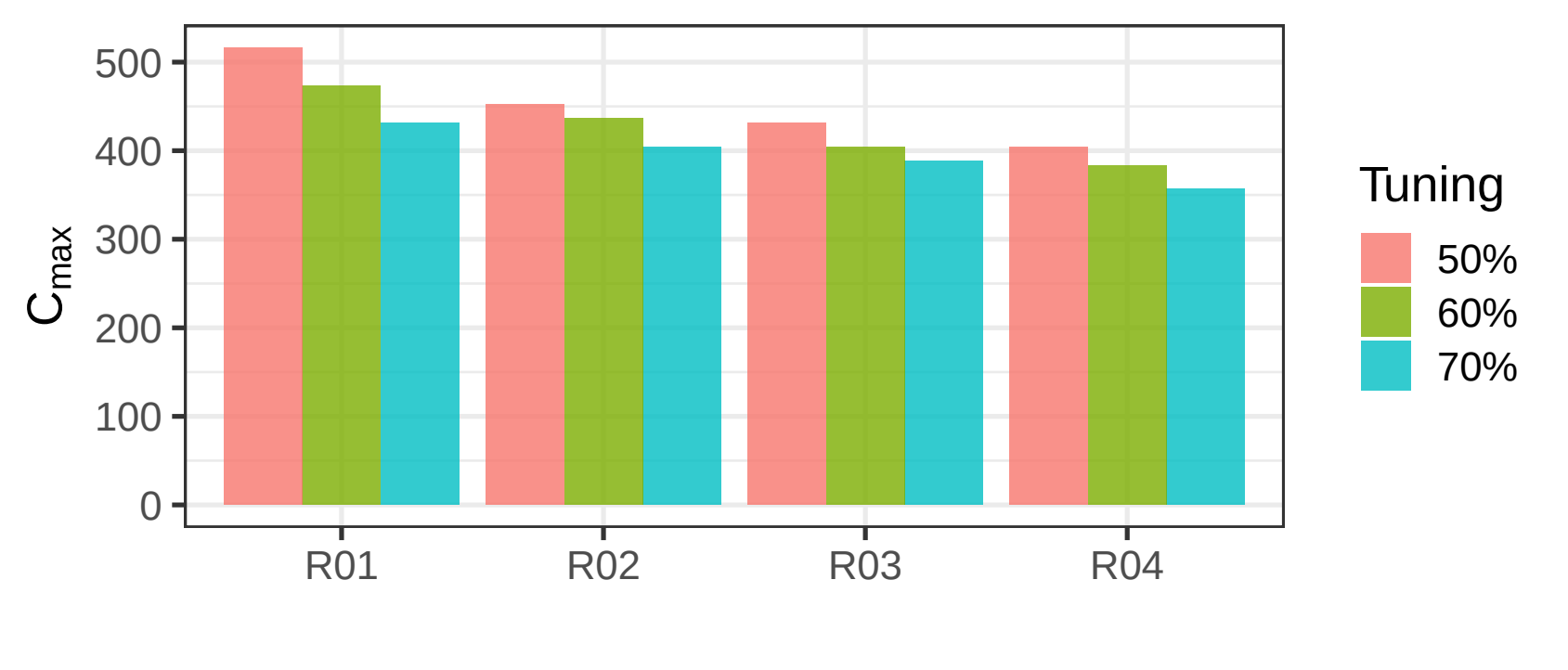

Figure 2: Relationship between C_{max} tuning parameter, tuning criteria (50%, 60% and 70%) and the assumed implementation error (R01 to R04).

Robustness testing

Setup

Engineered stock collapse:

- Assumed a 50% drop in recruitment between 2023 and 2025.
- Recruitment to the fishery and to the spawning population is at age 1+ $\implies$ drop in SSB 2024 – 2026.
- First year of MP implementation is 2024 using CPUE in the previous year $\implies$ MP does not anticipate the drop in SSB and stock crashes.
- First TAC cut in response to stock crash is 2027 – 2029.

Summary statistics calculated from 2024 to 2040 inclusive.

Results: dynamics

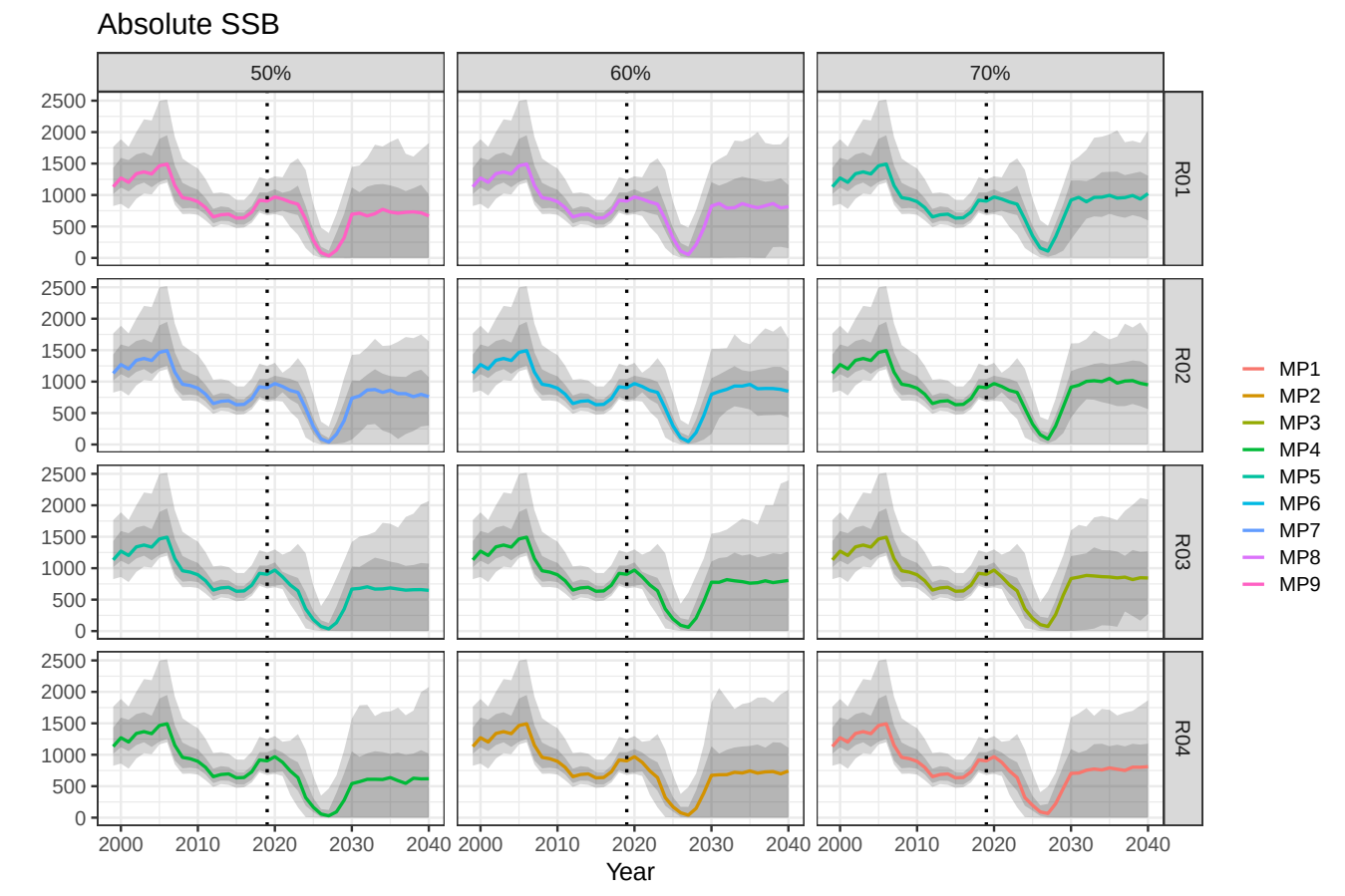

Figure 3: Spawning stock biomass dynamics following projection under each MP, showing stock crash following recruitment failure in years 2023 – 2025.

Results: dynamics

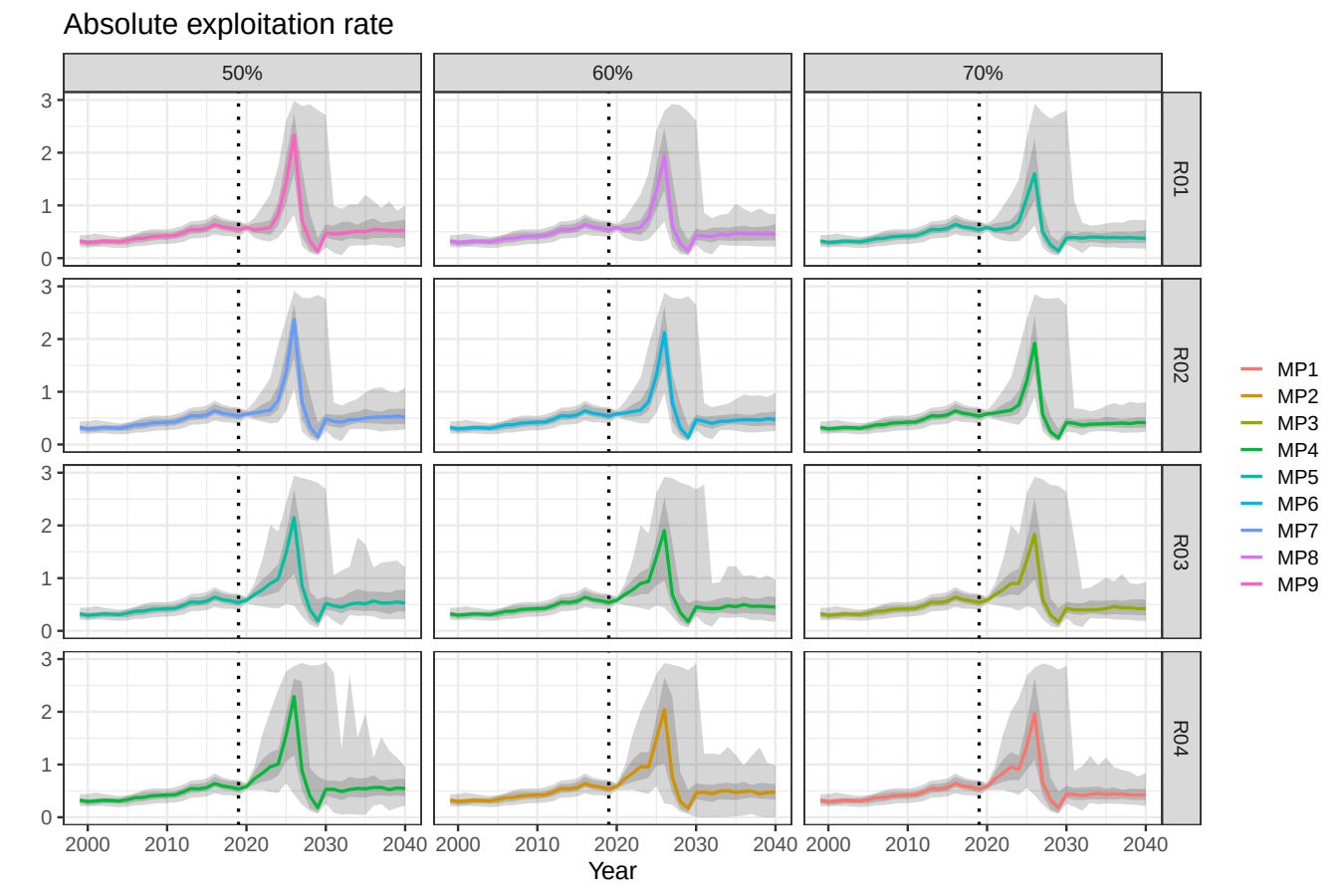

Figure 4: Exploitation rate dynamics following projection under each MP, showing spike in exploitation for 2024 – 2026 followed by decline in 2027 as a result of MP response.

Results: dynamics

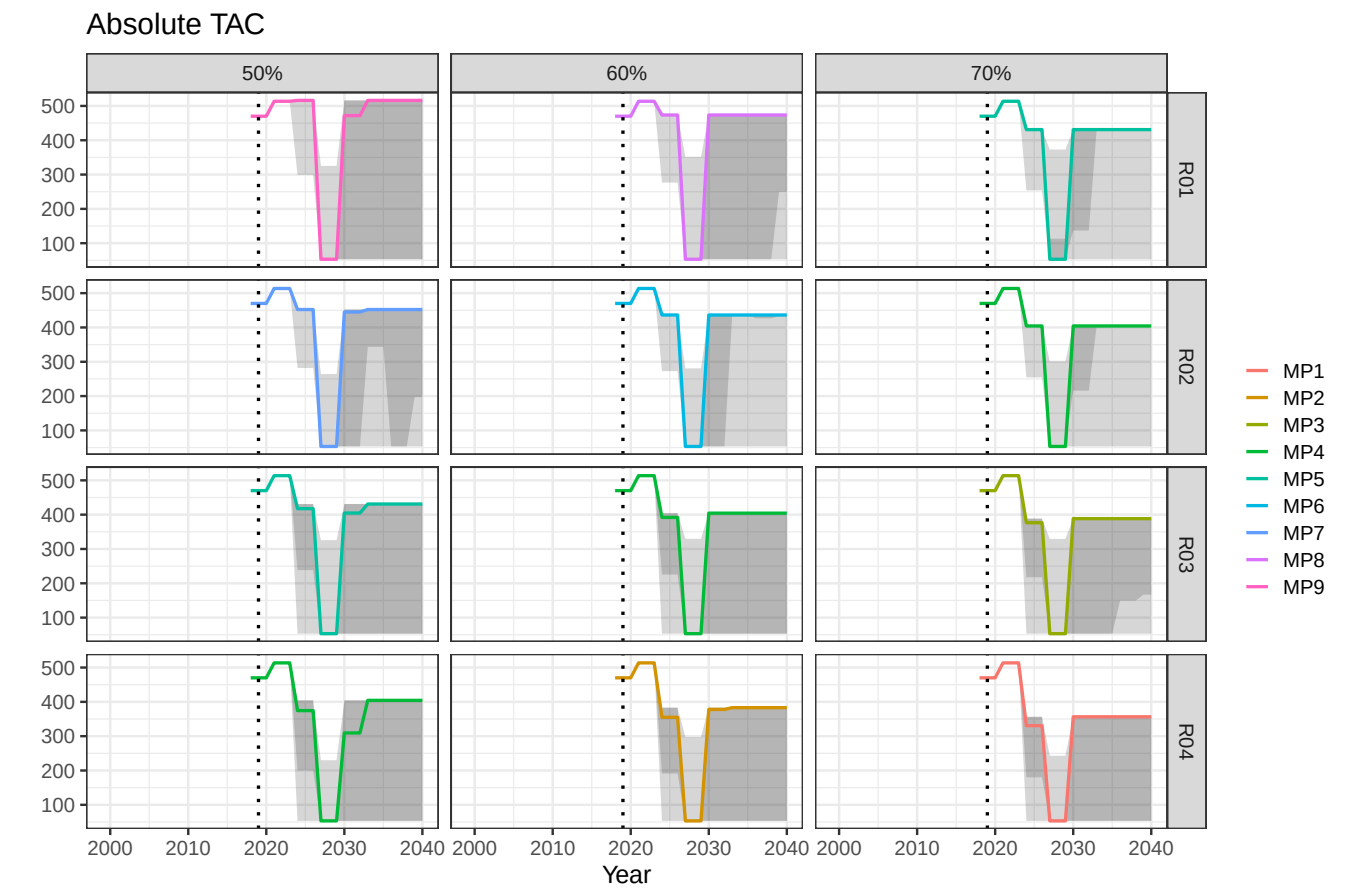

Figure 5: Total Allowable Catch dynamics following projection under each MP. The TAC is assumed to be 513,572 tonnes for 2021–2023. The first year of MP implementation is 2024.

Results: dynamics

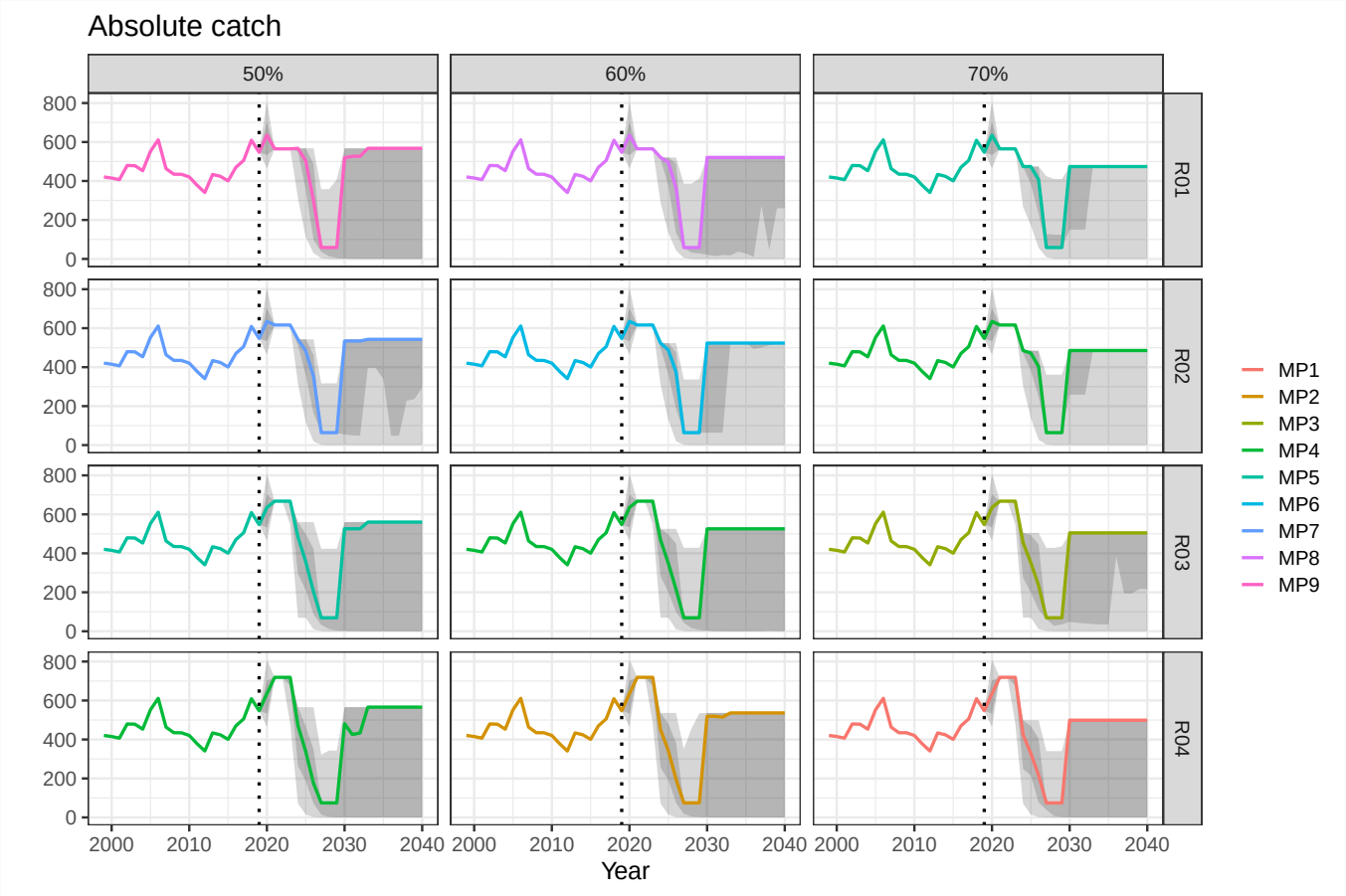

Figure 6: Realised catch dynamics following projection under each MP.

Comparative Results: Absolute values (Tuning)

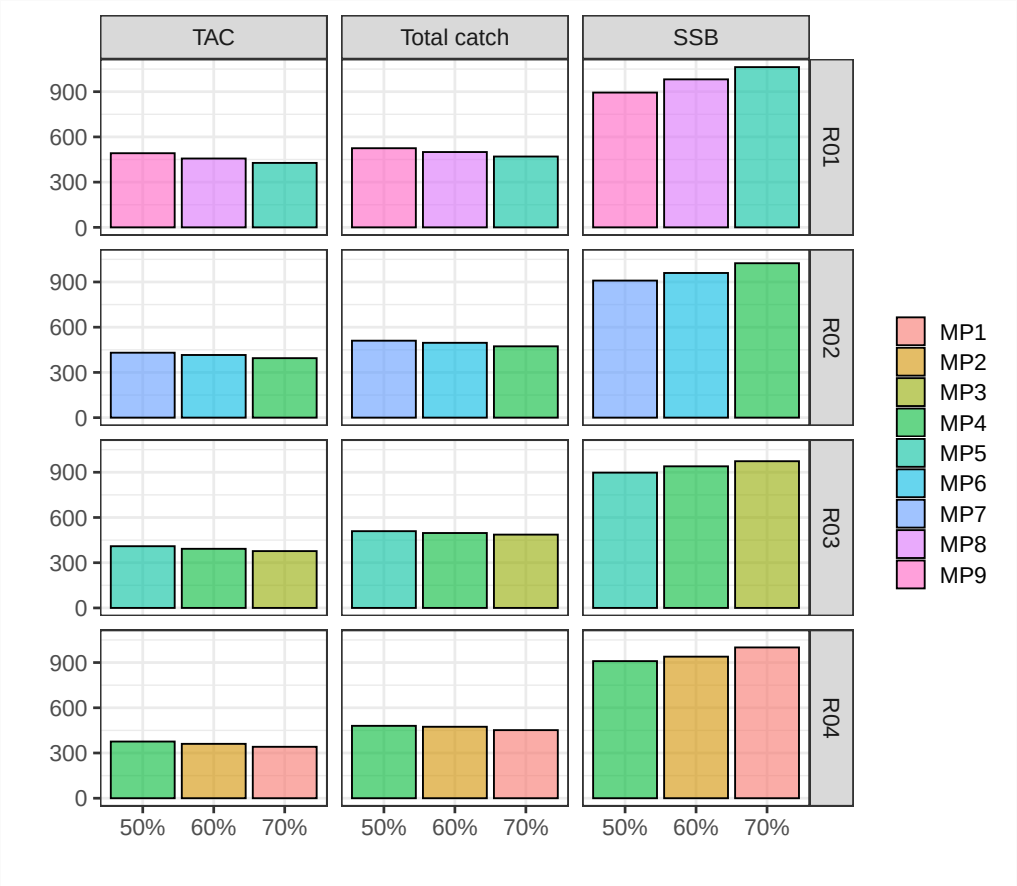

Figure 7: Bar plots of performance diagnostics for each MP, showing slight reduction in performance when tuned to higher implementation error.

Comparative Results: Absolute values (Robustness testing)

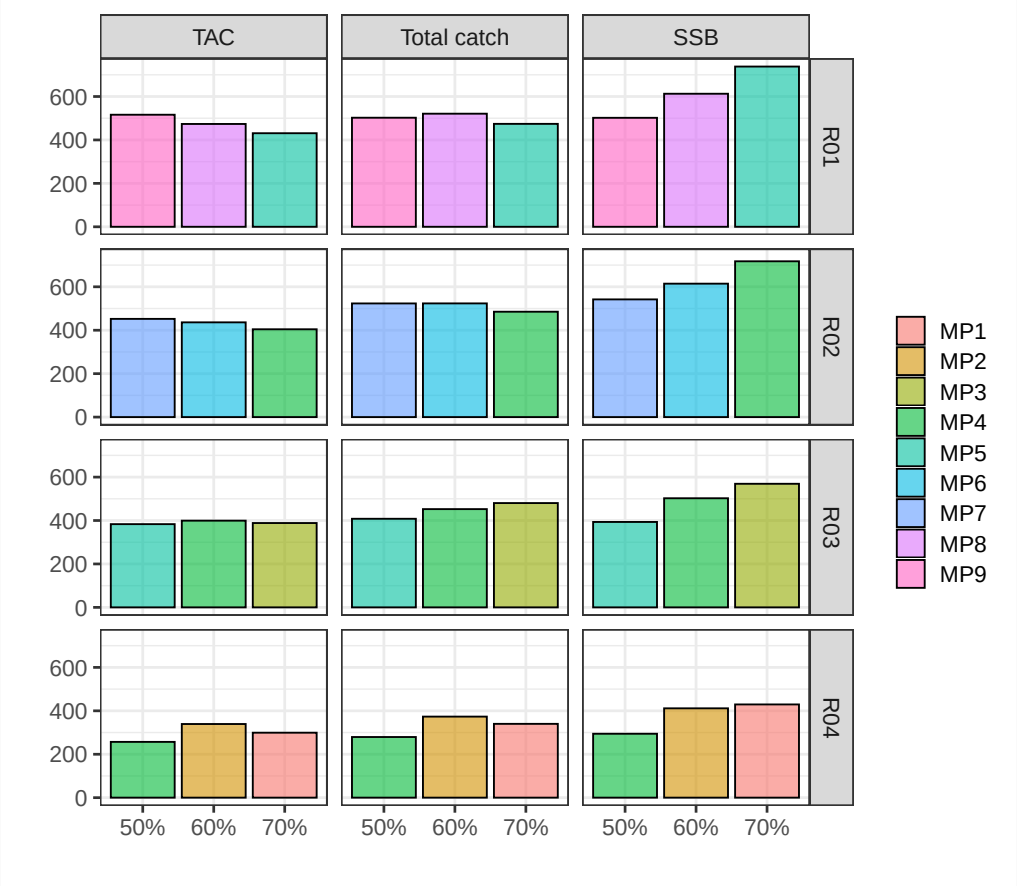

Figure 8: Bar plots of performance diagnostics for each MP, indicating that when tuned to higher levels of implementation error, MPs are less able to recover the stock following a crash.

Comparative Results: Absolute values (Robustness testing)

Table 2: Probabilities of stock being above 10% of B0 is lower for R03/R04 scenarios (Pr. $> B_{10\%} \approx 1.00$ for all cases during tuning).

MP (tuning)	Imp. error	C_{max}	Pr. $> B_{10\%}$
MP9 (Target 50%)	R01 (10%)	516.11	0.63
MP8 (Target 60%)	R01 (10%)	473.55	0.67
MP5 (Target 70%)	R01 (10%)	430.98	0.74
MP7 (Target 50%)	R02 (20%)	452.26	0.65
MP6 (Target 60%)	R02 (20%)	436.30	0.69
MP4 (Target 70%)	R02 (20%)	404.38	0.74
MP5 (Target 50%)	R03 (30%)	430.98	0.59
MP4 (Target 60%)	R03 (30%)	404.38	0.63
MP3 (Target 70%)	R03 (30%)	388.41	0.66
MP4 (Target 50%)	R04 (40%)	404.38	0.54
MP2 (Target 60%)	R04 (40%)	383.09	0.59
MP1 (Target 70%)	R04 (40%)	356.49	0.59

Comparative Results: Relative values (Tuning)

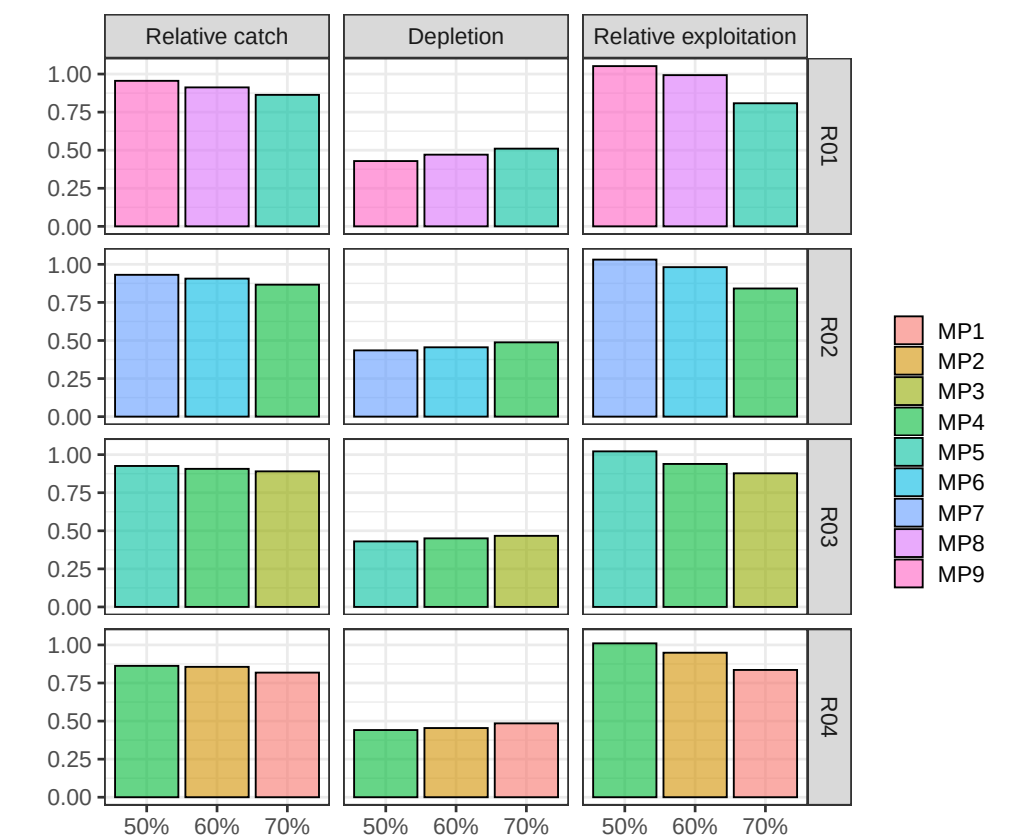

Figure 9: Bar plots of performance diagnostics for each MP, showing slight reduction in performance when tuned to higher implementation error.

Comparative Results: Relative values (Robustness testing)

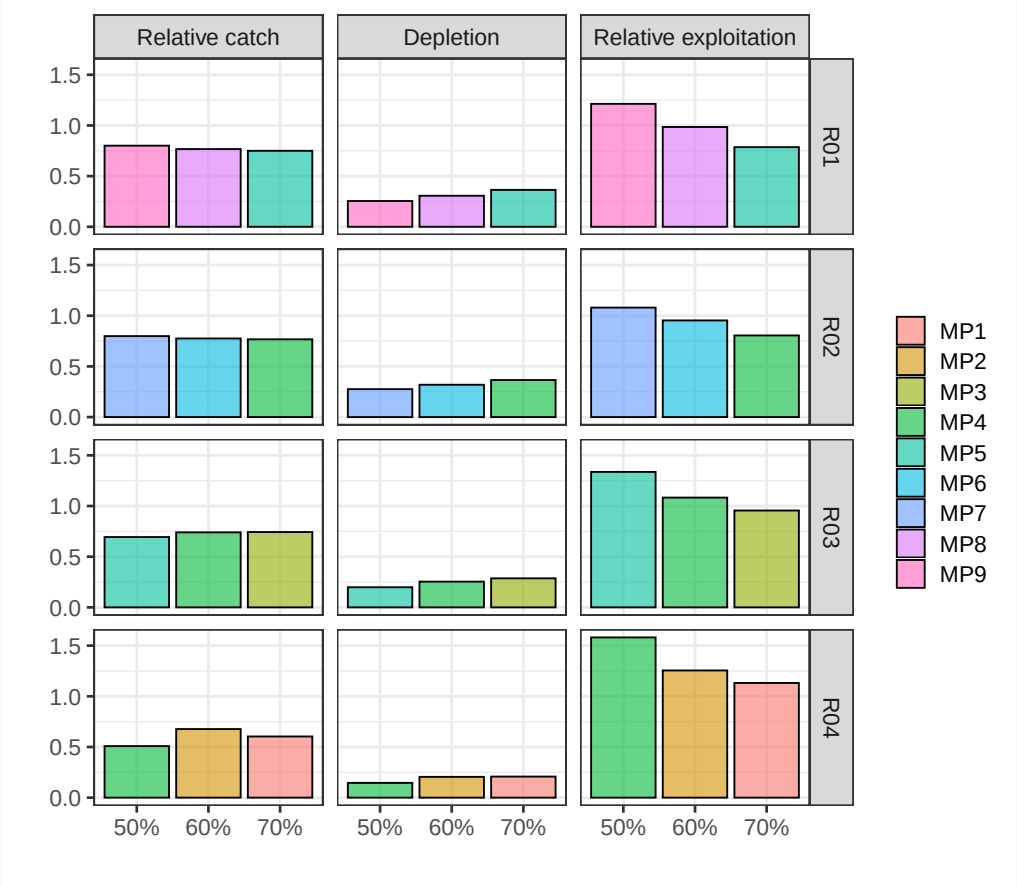

Figure 10: Bar plots of performance diagnostics for each MP, indicating that when tuned to higher levels of implementation error, MPs yield a higher level of exploitation following a crash.

Further work

Further robustness testing:

- Each MP tuned to be "robust" to implementation error, can be put through an implementation error "robustness trial," with the anticipation that MPs tuned to higher implementation error will be more robust (conservative).
- The assumed recruitment failure needs to be properly defined because it appears to be relevant to MP performance.

Definition of exceptional circumstances.

Further work

Further project objectives:

1. Integrate suggestions from the TCMP 2022 into the current evaluation framework;
2. With feedback from the WPM, present an update to the TCMP/MSETF (Feb/March 2023);
3. Following update to the SKJ stock assessment, include the 2023 assessment in the OM;
4. Propose candidate MPs to the TCMP (May 2023), along with an implementation cycle.

Acknowledgements

Thanks to Dan Fu (IOTC) for providing the SS III files, to Alistair Dunn (Ocean Environmental) for providing computer support and to the support of other colleagues working on MSE for IOTC (Iago Mosqueira, Richard Hillary, Ann Preece and Ashley Williams).

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