IOTC-2023-TCMP06-08

Candidate empirical MPs for Indian Ocean skipjack tuna

IOTC Technical Committee on Management Procedures

Charles T T Edwards

5 - 6 May, 2023

Mauritius and Online

Background and motivation

Overall objective

Develop a Harvest Control Rule for Indian Ocean SKJ tuna, including specification of the data inputs, that has been fully tested using a Management Strategy Simulation framework.

1. Integrate suggestions from the TCMP (2022) into the current evaluation framework:
   - tune the MPs to 50%, 60% and 70% tuning criteria;
   - evaluate robustness to implementation error and recruitment failure.
2. Propose a set of candidate Management Procedures to the TCMP (2023) for potential adoption by the Commission.

Funded by: Indian Ocean Tuna Commission (project MTF/INT/661/MUL).
Time frame: October 2022 to June 2023

Background and motivation

Overall objective

Develop a Harvest Control Rule for Indian Ocean SKJ tuna, including specification of the data inputs, that has been fully tested using a Management Strategy Simulation framework.

Previously presented to the TCMP:

- an operating model (OM) based on the 2020 SS III stock assessment;
- preliminary empirical MPs based on CPUE indices used in the stock assessment;
- preliminary robustness testing against over-catch (implementation error) and recruitment failure.

Background and motivation

Overall objective

Develop a Harvest Control Rule for Indian Ocean SKJ tuna, including specification of the data inputs, that has been fully tested using a Management Strategy Simulation framework.

Additional suggestions from the WPM and WPM (MSETF):

- include a 2-3 year implementation lag;
- include MSY-based reference points and diagnostics;
- update terminology so that tuning is to the "target quadrant;"
- include a symmetric 15% limit on the possible change in the TAC in any given implementation.

Summary of recent progress

A simulation framework has been developed and a set of empirical MPs have been tuned:

- data input generated from PL and PSLS CPUE indices assuming a 2-year lag;
- MPs tuned so that Pr(Target Quadrant 2030 to 2034) is equal to 50%, 60% or 70%;
- tuning assumes no implementation error;
- simulations indicate the familiar trade-offs between catch, stock biomass and catch stability;
- robustness testing indicates that excessive implementation error leads to decline in performance.

Summary of recent progress

Still to do:

- explore implications of a 3-year lag in availability of the CPUE data;
- include recruitment failure in the presence of implementation error, in the robustness testing.

Empirical MPs for SKJ

Components of an MP

- **Data inputs:** empirical CPUE data from the PL and PSLS fisheries;
- **Outputs:** a recommended TAC;
- **Harvest Control Rule:** to convert the data inputs into the output;
- **Meta-rules:** a 15% limit on the possible TAC change;
- **Exceptional circumstances:** a formal definition of when the MP is invalidated because the system is outside of the region in which testing and development has taken place (not considered here).

Harvest Control Rule

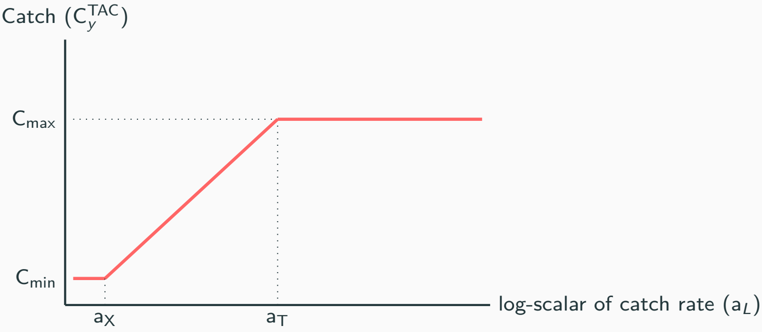
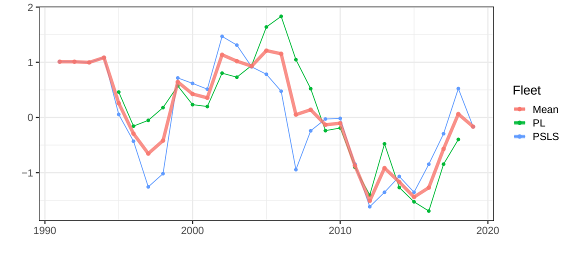


Figure 1: Schematic representation of the empirical Harvest Control Rule being proposed as part of the MPs. MP was tuned by adjusting C_{max}.

Catch rate data

Mean of the log-normalised catch rate from:

- Maldivian Pole and Line (PL, Medley et al., 2020a, 2020b);
- European Purse Seine Log School (PSLS, Guery, 2020; Guery et al., 2020).



Close linear and positive correlation with depletion.

MP tuning parameters

Table 1: List of tuning parameters

Safety (a_X)	Threshold (a_T)	C_{min}	C_{max}	% change limit
-5.0	-1.7	53.21	425.66	15
			⋮	
			611.89	

A total of 36 MPs were constructed based on these tuning parameter combinations.

MP tuning criteria

Tuning previously conducted using the probability of the stock being in the "Kobe Green Quadrant:"

$$\text{Pr. Kobe Green} = B > B_{40\%} \quad \text{and} \quad E < E_{40\%}$$

based on the argument that $B_{40\%} \approx E_{MSY}$ and $E_{40\%} \approx E_{MSY}$.

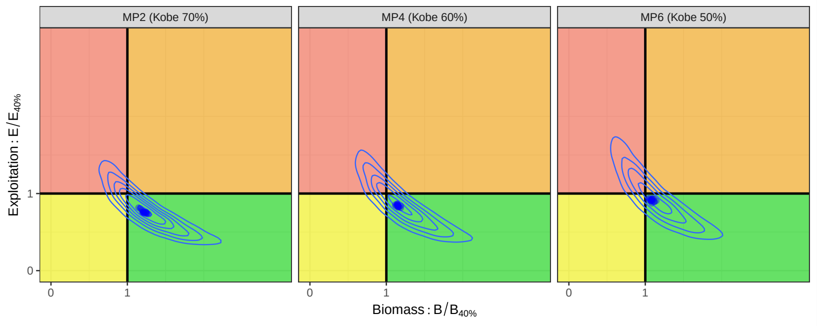


Figure 2: Kobe Phase plots for each MP presented at TCMP05.

MP tuning criteria

This terminology is updated in the current report:

$$\text{Pr. Kobe Green} = B > B_{MSY} \quad \text{and} \quad E < E_{MSY}$$

$$\text{Pr. Target Quadrant} = B > B_{40\%} \quad \text{and} \quad E < E_{40\%}$$

The “Target Quadrant” is used for tuning; the “Kobe Quadrant” is used for diagnostic ouputs, with B_{MSY} and E_{MSY} estimated by SS III.

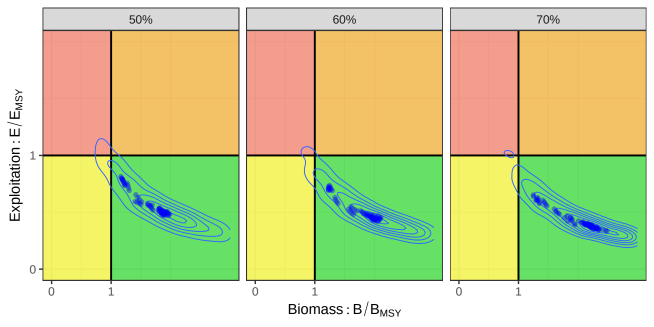


Figure 3: Kobe Phase plots for each MP presented at TCMP06.

Operating models

Operating models

Based on the SKJ stock assessment of Fu, 2020; IOTC, 2020 (1950-2019) with a grid of 24 assessment runs.

- Projection over 21 year period (2020-2040 inclusive);
- Recommended catch from 2021 to 2023 set to 513,572 (SC, 2020);
- Recommended TAC set for three year periods starting in 2024;
- 2 year data lag for setting the catches (i.e. the most recent CPUE data is assumed to be two years prior to the year the TAC is being set).

Results

Results: Tuning

MP	C_{min}	C_{max}	a_X	a_T	Pr. Target Quadrant	Tuning criteria
MP1-70%	53.21	484.19	-5.00	-1.70	0.71	70%
MP2-60%	53.21	532.08	-5.00	-1.70	0.60	60%
MP3-50%	53.21	564.00	-5.00	-1.70	0.51	50%

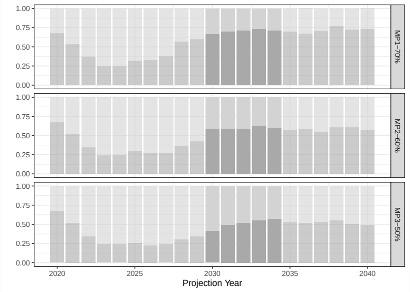


Figure 4: Simulated average Target quadrant probabilities for tuning.

Results: Tuning

MP	C_{min}	C_{max}	a_X	a_T	Pr. Target Quadrant	Tuning criteria
MP1-70%	53.21	484.19	-5.00	-1.70	0.71	70%
MP2-60%	53.21	532.08	-5.00	-1.70	0.60	60%
MP3-50%	53.21	564.00	-5.00	-1.70	0.51	50%

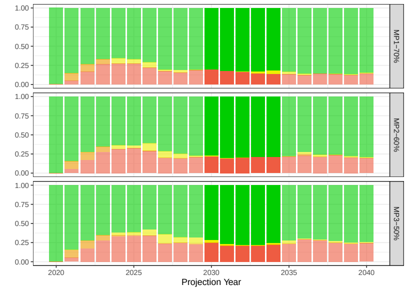


Figure 5: Simulated average Kobe quadrant probabilities.

Results: Overall performance

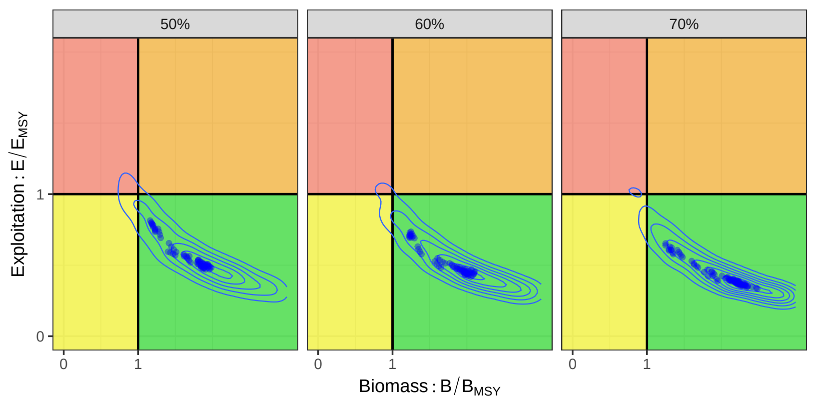


Figure 6: Kobe Phase plots for each MP, showing the distribution of simulated biomass and exploitation rate values between 2024 and 2040.

Results: Overall performance

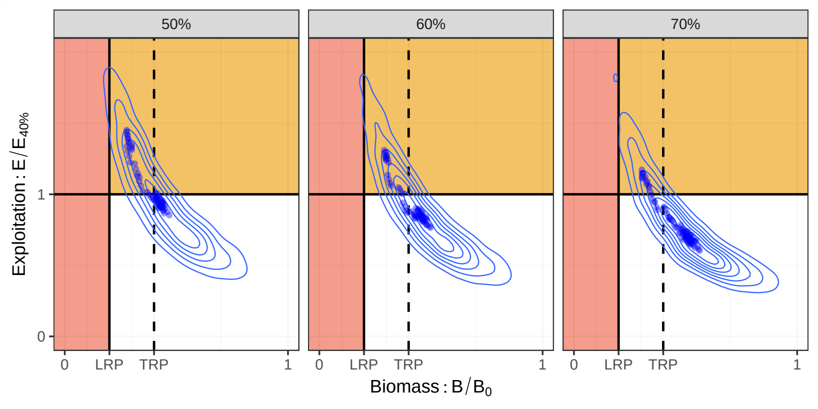


Figure 7: Majuro Phase plots for each MP, showing the distribution of simulated biomass and exploitation rate values between 2024 and 2040. Target Reference Point = $B_{40\%}$; Limit Reference Point = $B_{20\%}$.

Results: summary diagnostics

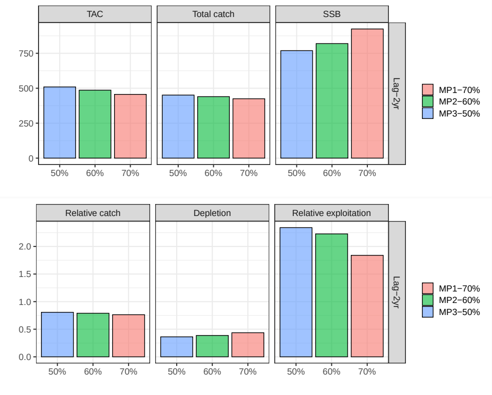


Figure 8: Bar plots of performance diagnostics for each MP.

Results: trade-off plots

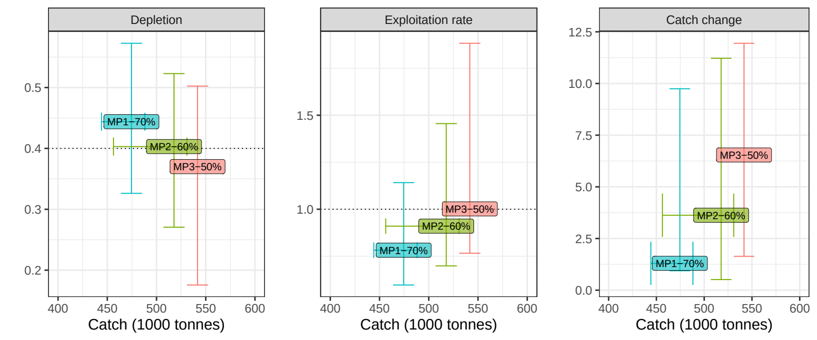


Figure 9: Trade-off plots for each MP.

Results: dynamics

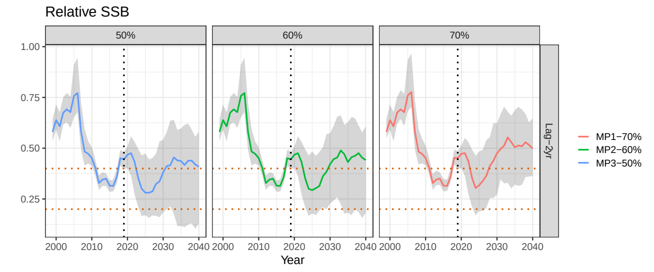


Figure 10: Spawning stock biomass dynamics following projection under each MP. Relative values are given according to B_0 for each run. Depletion reference points of 20% and 40% are shown as horizontal dashed lines.

Results: dynamics

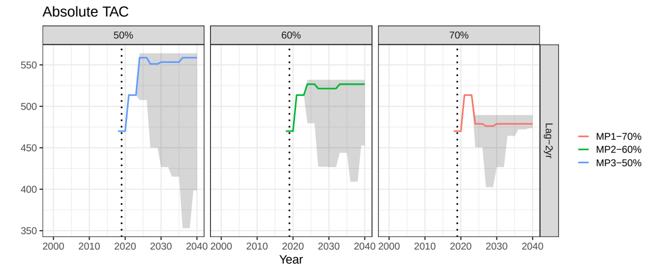


Figure 11: Total Allowable Catch dynamics following projection under each MP. The TAC is assumed to be 470,029 tonnes for 2018–2020 and 513,572 tonnes for 2021–2023. The first year of MP implementation is 2024.

Results: dynamics

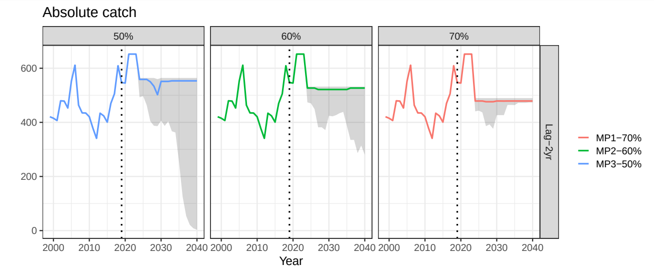


Figure 12: Realised catch dynamics following projection under each MP.

Results

Main result:

This work has presented summary statistics and performance diagnostics for three MPs that passed the 50%, 60% and 70% target tuning criteria.

Tuning to the 50% criteria has a higher chance of leading to overfishing and stock decline.

Familiar performance trade-offs between catch, catch stability and abundance.

Robustness tests

Implementation error

Empirical data from the fishery indicate that previous TAC recommendations have been exceeded by 20%–30%. Robustness testing was conducted to evaluate the likely consequences:

R01: 10% positive catch error from 2024 to 2040;

R02: 20% positive catch error from 2024 to 2040;

R03: 30% positive catch error from 2024 to 2040;

R04: 40% positive catch error from 2024 to 2040;

Results: summary diagnostics

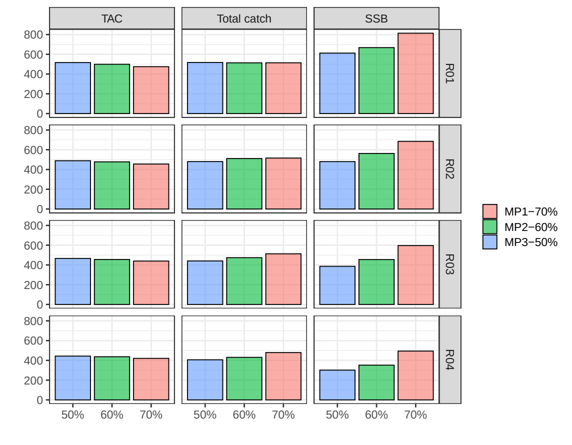


Figure 13: Bar plots of performance diagnostics for each MP.

Results: summary diagnostics

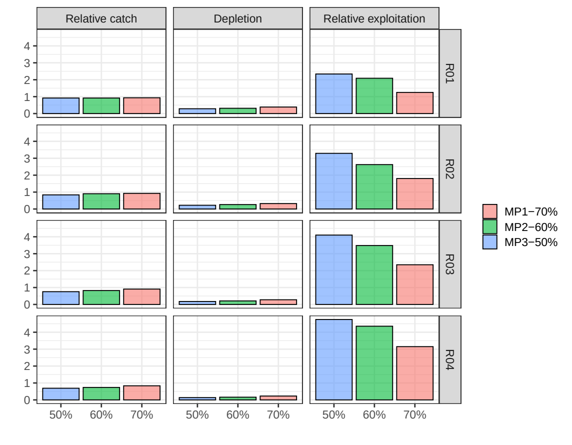


Figure 14: Bar plots of performance diagnostics for each MP.

Results

Robustness to implementation error:

Performance of the MPs in maintaining the stock status is undermined when catches exceed the recommended TAC.

Positive catch error can lead to a reduction in both the catch and the stock biomass, because of overfishing; this is more pronounced for more aggressive MPs (i.e. MP3-50%).

A more conservative MP would be more suitable if implementation error is presumed to be high.

Conclusions

Candidate MPs have been presented that are tuned to the 50%, 60% and 70% target criteria:

- which is considered the most appropriate for setting catches?

Robustness tests indicate that over-catch of the TAC will likely be detrimental to MP performance:

- in general, the more conservative MP is more robust to over-catch of the TAC.

Performance is dependent on the availability of standardised CPUE data. Currently exploring collaboration with the CPUE data providers to ensure:

- consistency in the data provision;
- an appropriate MP implementation schedule and known data lag.

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Appendices

References

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