Report of the MSE workshop, July 14-18, 2025

2025-07-31

1 Executive summary

The Jack Mackerel Management Strategy Evaluation (MSE) Technical Workshop brought together scientists, technical experts, and external reviewers to review recent progress and refine the MSE framework being developed under SPRFMO. The primary goal of the workshop was to ensure that the modeling framework and management procedures (MPs) are scientifically sound, technically transparent, and aligned with management priorities as outlined by the Commission (e.g., SPRFMO Jack Mackerel Working Group (2025).

1.0.1 Key Outcomes and Advancements

1. **MSE Framework Consolidation**
   Participants reviewed the jmMSE software package, confirming that it provides a robust and flexible platform for conducting MSEs. The package includes a reference set of operating models conditioned to historical data using MCMC, an efficient MP tuning algorithm, and tools for visualizing and comparing results.

2. **Robustness Testing**
   The workshop clarified the role and scope of robustness tests. These tests are intended to explore how CMPs perform under a range of plausible yet uncertain scenarios rather than represent definitive alternative models. Scenarios reflecting changes in recruitment, spatial availability, environmental regime shifts (e.g., El Niño), and stock structure were reviewed and refined for implementation.

3. **Indicator-Driven MPs and HCR logic**
   Empirical MPs based on one or more indicators were evaluated, with focus on two formulations:

   - TAC as a product of a target and a multiplier from an index.
   - TAC adjusted incrementally from the previous year based on index signals.

   We noted that the high current stock status (well within the "green" zone) tended to increase catch levels when tuning to achieve a desired P(Green). This can result in declining stock trends later in the projection period, even when the short-term performance criteria are met.

4. **Recommendations and Refinements**
   The group recommended additional diagnostics and refinements, including:

- Adding plots of how index trajectories relate to TACs.
- Including new performance metrics that reflect stock status and trends in the final projection years.
- Ensuring consistent treatment of selectivity, weights-at-age, and catch splits in both projections and reference point calculations.
- Exploring robustness scenarios that account for variability in fleet selectivity and biological assumptions, particularly where CPUE is used as an input.

5. **Documentation and Transparency**

   The group emphasized the importance of transparency in documenting model assumptions, data sources, and MP structure. The group agreed on priorities for improving documentation and sharing annotated examples of MP behavior.

6. **Next Steps and Implementation**

   The next phase of work will focus on finalizing the candidate MPs, running the robustness tests, and summarizing trade-offs across key performance indicators. In discussions we also identified future reporting needs, including summary tables and figures for managers, and exploration of reference points and evaluation criteria beyond the green zone probability.

2 Background on the 2025 Commission meeting proposal

During the 2025 Commission meeting (COMM13), Chile proposed a deviation from the established Management Procedure (MP) guidance by recommending a Total Allowable Catch (TAC) for *Trachurus murphyi* of 1.785 million tonnes for 2025[1]. This proposal exceeded the 15% year-on-year TAC change limit adopted by the Commission as part of its management framework[2]. Chile based its proposal on Article 4.3 of the Convention, asserting the need to consider measures by coastal states and highlighting that the stock had remained above MSY reference levels for over five consecutive years[3].

Chile also cited Scientific Committee (SC) analysis, particularly paragraph 136 of the SC12 Report, which indicated that the stock was in Tier 3 of the adopted Harvest Control Rule (HCR), theoretically allowing for a much higher TAC (up to 4.997 Mt) if the full HCR were applied[4]. However, as per the Commission's directive to the SC (COMM3-Annex C), catch advice was constrained to not exceed a 15% increase, consistent with the MP in place[5].

The Scientific Committee Chair emphasized in plenary that the SC's advice adhered to the current MP, limiting TAC changes to $\pm 15\%$ to account for uncertainties, including potential model misspecification. Paragraphs 136 and 137 of the SC12 report note that this constraint was not intended to account for rebuilding potential, but rather to ensure precautionary stability and reduce the risk of large interannual TAC fluctuations[6].

Chile revised its proposal multiple times (COMM13-Prop01_rev1 through rev5) to address Member concerns, including scientific justification, process adherence, and future management stability. Nevertheless, many Members expressed concern that implementing a TAC increase beyond 15% ahead of finalizing the MSE would undermine the credibility of the HCR framework and create challenges for future rule-based decisions.

Chile also referred to Table 37 of Annex 7 of the SC12 report, which showed that biomass remained above target levels under various fishing scenarios. However, the SC Chair cautioned that these projections were illustrative only and not intended for management advice[7]. The

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[1]COMM13-Prop01 and COMM13-Prop01_rev5 (Annex 10d)
[2]COMM3-Annex C
[3]SPRFMO Convention, Article 4.3
[4]SC12 Report, Paragraph 136
[5]COMM3-Annex C
[6]SC12 Report, Paragraph 137
[7]SC12 Report, Table 37 of Annex 7

SC further stressed that alternative scenarios outside the adopted HCR should be evaluated through MSE before informing decisions.

Following intensive discussions and compromises, the Commission adopted a revised proposal (COMM13-Prop01_rev5), establishing a one-year TAC of 1.785 Mt for 2025 while reaffirming:

- The importance of completing the MSE and adopting a revised MP and HCR by 2026;
- The temporary nature of the 2025 deviation;
- The application of Article 20(5) of the Convention to enable responsive management should the stock decline[8].

This episode highlighted both the limitations of static MP rules under changing stock and socioeconomic conditions, and the importance of timely completion of the MSE process to provide more flexible and scientifically robust guidance.

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[8]SPRFMO Convention, Article 20(5)

3 Workshop introduction

Management Strategy Evaluation (MSE) has emerged as a critical tool for fisheries management, especially in contexts where data are limited or uncertainty is high. Foundational software frameworks like FLR were developed to facilitate reproducible, cross-disciplinary evaluation of management strategies through simulation and decision analysis (Kell et al. 2007). Building on this foundation, recent advances have expanded FLR's capacity for data-rich and data-limited systems alike, improving accessibility and integration with other tools (Hillary et al. 2023). Complementing these developments, a structured framework for evaluating methods and risk in data-limited fisheries has been proposed, providing practical guidance on the application of MSE in real-world settings (Carruthers et al. 2023).

The SCW15 Jack Mackerel MSE Technical Workshop was convened in response to the Scientific Committee's request for progress on developing and evaluating management procedures (MPs) for jack mackerel under the SPRFMO framework. The meeting was held over five days (14–18 July 2025) and hosted in a hybrid format, with active participation from in-person attendees in Seattle and remote collaborators from SPRFMO Member States and invited experts. This event followed on previous technical work, including the SCW14 benchmark, and focused on finalizing the reference set of operating models (OMs), implementing robustness tests, and refining MP candidates using the jmMSE software package.

Throughout the week, participants engaged in live coding sessions, software validation, model tuning, and scenario refinement. The agenda was intentionally flexible, allowing the group to respond dynamically to technical challenges—such as issues with index generation, selectivity artifacts, and catch variability under different MP formulations. The workshop emphasized transparency, reproducibility, and documentation, with clear objectives to improve the utility and credibility of the MSE outputs ahead of Scientific Committee and Commission review.

By way of review, we provide a general outline for the workflow for defining and evaluating Management Procedures (MPs). We divided the process into three main stages (Figure 1).

The workshop participants recognized that all of the pieces for this exercise were available and implemented. However, the group struggled with getting the candidate MPs defined relative to available indices ("stage 1" in the diagram).

The appendices provide the participants, the agenda, and the daily summary activities in the workshop minutes. A summary review written by the external experts is also provided here.

The following sections detail the discussion on how best to incorporate some environmental effects for projecting from the operating model. Specifically, we considered how to account
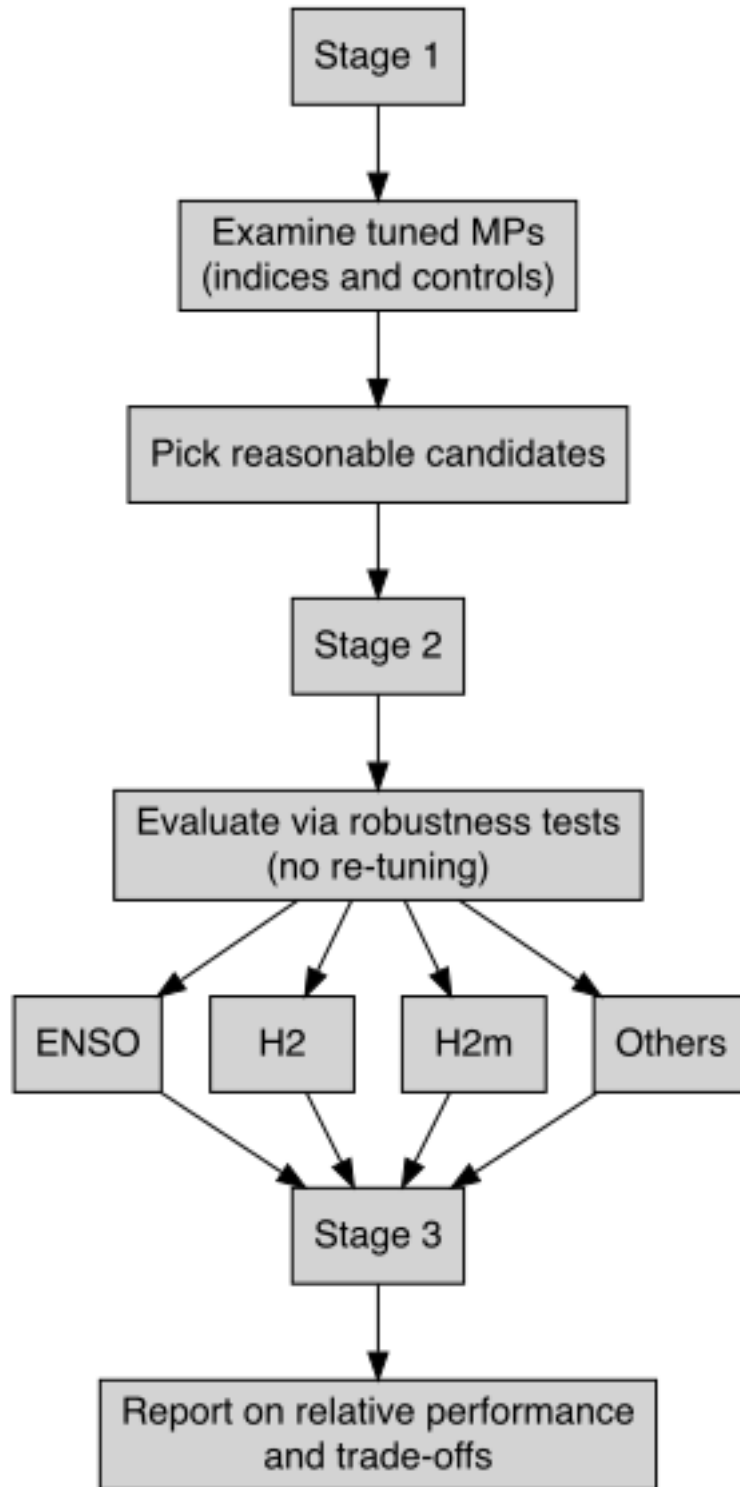
Figure 1: Workflow for evaluating and selecting candidate management procedures (MPs).

for the effects of El Niño on recruitment and catchability/availability. We follow this with a sections reviewing the OM and then some results from applying existing and refined MPs. We conclude with a set of recommendations for the SC to consider.

4 Simulating El Niño effects in the Operating Model

To incorporate climate-driven variability into the Operating Model (OM) projections, we defined a scenario simulating El Niño–like events every five years beginning in 2030. These events affect primarily recruitment and distribution options. Based on the work of Iago and available literature, we proposed biological and fishery processes that may relate to El Niño conditions. The group discussed these and noted that they could be evaluated in the next round of stock assessment benchmark and for future MSE work.

The table below summarizes the proposed effects of simulated El Niño conditions on the OM, categorizing them by their expected direction, biological or fishery-based justification, and evaluation priority. The table is divided into two sections: effects that are prioritized for immediate evaluation and those deferred for further study.

The first items highlights two key El Niño-driven effects: A 30% increase in recruitment with a one-year lag, linked to ENSO-related early life stage survival (Figure 2). Shifts in catchability, with coastal regions experiencing increased availability and offshore regions seeing declines, reflecting observed onshore movement of fish during warm anomalies. This is also high-priority, with a focus on quantifying impacts on fishery removals.

The deferred effects were discussed and included the potential for reduced weight-at-age (potentially due to prey scarcity), earlier maturity (a stress response observed in small pelagics), and increased natural mortality (from predation or environmental stress). These are flagged for future study, pending historical data checks or further evidence. The table succinctly organizes hypotheses while clarifying immediate next steps for the OM framework.

The following tables summarizes the key effects, their expected directions, and justification.

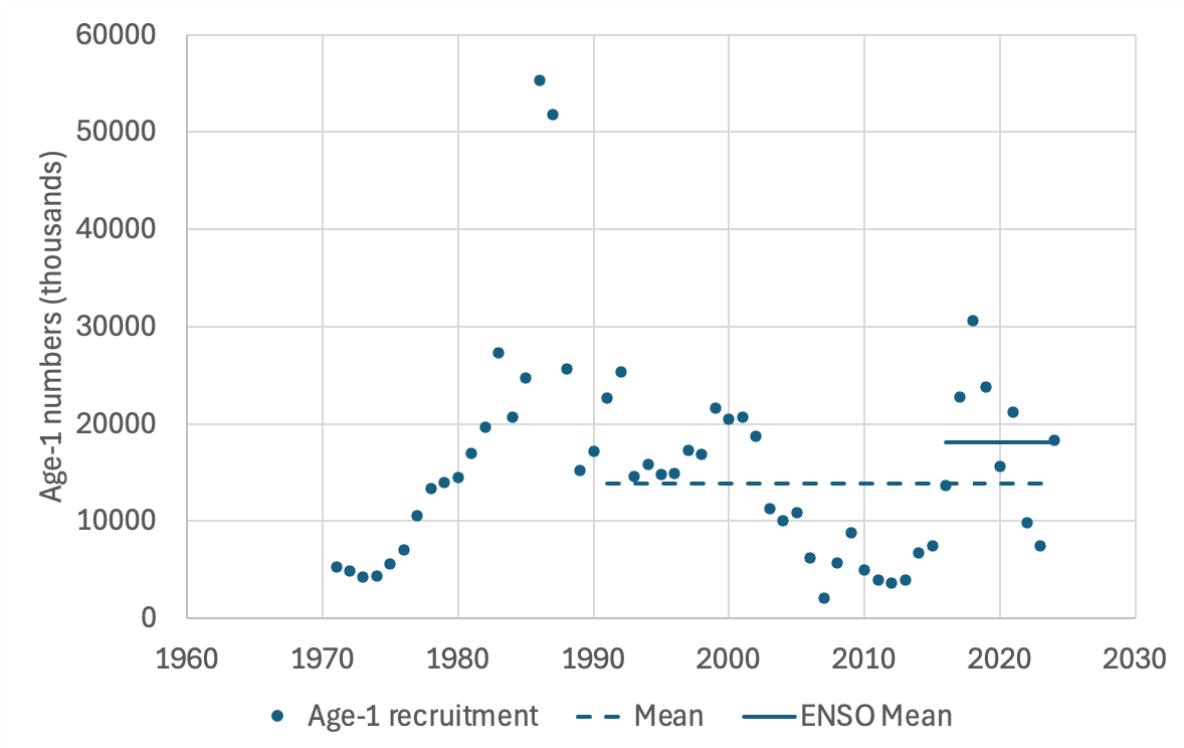| Effect	Direction	Justification
Recruitment ↑20%	↑ 1-year lag	ENSO-linked early life stage effects on recruitment
Regional availability	Coast catchability ↑ and offshore ↓	Onshore shift during warm anomalies

Discussed but deferred for further study

Figure 2: Recruitment estimates and mean values (horizontal lines) used to estimate the impact of ENSO effects.

Effect	Direction	Justification	Notes
Weight-at-age	↓Productivity	Lower prey density and observed condition declines	Check historical WAA anomalies
Age-1 maturity	Earlier maturity	Stress response seen in small pelagics	similar impact on Recruitment
Coastal selectivity	Age 1–2 sel ↑	Spatial contraction, availability change	Confirm from CPUE by age?
M ↑30%/20%	↓ Survival	Stress-induced mortality, predation	

4.1 Estimating Relative Availability from Catch Proportions

Taking an assumption that over a recent period that changes in a smoothed proportion of catch by coastal and offshore areas roughly relates to the effective catchability q (which includes both true catchability and availability) of the fishery, i.e.:

$$\text{Catch}_{\text{fleet}} \propto q_{\text{fleet}}$$

Thus, observed catch proportions can serve as a proxy for relative availability.

Table 4.3: **5-year moving averages of the proportion of the catch occurring in the "coastal" areas compared to the offshore fleet.**

Year Range	Coastal (%)	Offshore (%)
2004–2008	81	19
2005–2009	78	22
2006–2010	74	26
2007–2011	76	24
2008–2012	78	22
2009–2013	82	18
2010–2014	84	16
2011–2015	86	14
2012–2016	86	14
2013–2017	85	15
2014–2018	86	14
2015–2019	87	13
2016–2020	91	9
2017–2021	93	7

Year Range	Coastal (%)	Offshore (%)
2018–2022	94	6
2019–2023	94	6
2020–2024	94	6
Mean	**85**	**15**

4.1.1 Range of Change in Estimated Availability

Given this pattern we can assume a relative catchability due to an environmental effect. We note that the

- **Coastal effective catchability** increased from a low of **74%** (2006–2010) to a high of **94%** (2018–2024), a **+20 percentage point** change.
- **Offshore effective catchability** declined from **26%** to **6%**.

As a sensitivity, we could propose that the effective availability to the offshore fleet drops from 15% of the biomass (the mean) to gradually to 6% during El Niño periods (a 60% decline in q). This would apply to the data generated for offshore CPUE index in the simulations. For the coastal zones, the effect of El Niño would correspond to an 11% increase in the availability of fish relative to the mean (85%). These changes would apply to the Chilean SC CPUE index and the Peruvian CPUE index data generation. This is one proposal among many that could be imagined. For example a slightly more conservative range could be based on the 10th and 90th percentiles of estimated effective catchability (from proportional catches):

```
Coastal:
•    10th percentile: 77%
•    90th percentile: 94%
Offshore:
•    10th percentile: 6%
•    90th percentile: 23%
```

These shifts may provide some scope for showing the impact of changes in the relative abundance indicators in index values. These reflect patterns over the past two decades, possibly due to environmental changes.

5 Review of the Operating Model specifications

The workshop reviewed the current specifications of the OMs. In particular, the assumptions for the reference point calculations were discusssed and contrasted with the 2024 assessment results and reports (South Pacific Regional Fisheries Management Organisation (2024)). Due to the terminal (2024) estimates of fisheries selectivities, the assessment report had anomalously high values for F_{MSY}

While the 2024 stock assessment produced high estimates of potential catch under the third tier of the harvest control rule—exceeding 4,900 kt based on F_{MSY}—this result was considered unrealistic due to likely upward bias in F_{MSY} estimates caused by strong selection on older fish. As a result, the Scientific Committee recommended constraining the 2025 TAC to be at or below 1,428 kt, representing only a 15% increase from 2024 levels and aligned with the Commission's guidance. In developing the OM, reference points such as F_{MSY} were instead based on longer-term averages to avoid the influence of short-term variability or cohort effects, ensuring more stable and precautionary management advice consistent with the MSE framework (Figure 3).

Several issues were identified with the current stock assessment that warrant further attention ahead of the next benchmark. Key among them are uncertainties in catch-at-age data stemming from differences in age determination methods across laboratories, as well as assumptions about mean body weight at age. The Scientific Committee emphasized the need for standardizing CPUE indices and improving data collection protocols, particularly regarding fleet-specific efficiency changes. Sensitivities to early age composition data—especially from the pre-1990 period—remain unresolved, with residual patterns noted for the North Chilean fleet. In addition, assumptions underlying selectivity and recruitment regimes were highlighted as critical sources of uncertainty, with substantial influence on reference points and management advice. Finally, the Committee underscored the importance of continued evaluation of single-stock versus two-stock model structures using simulation and MSE tools.
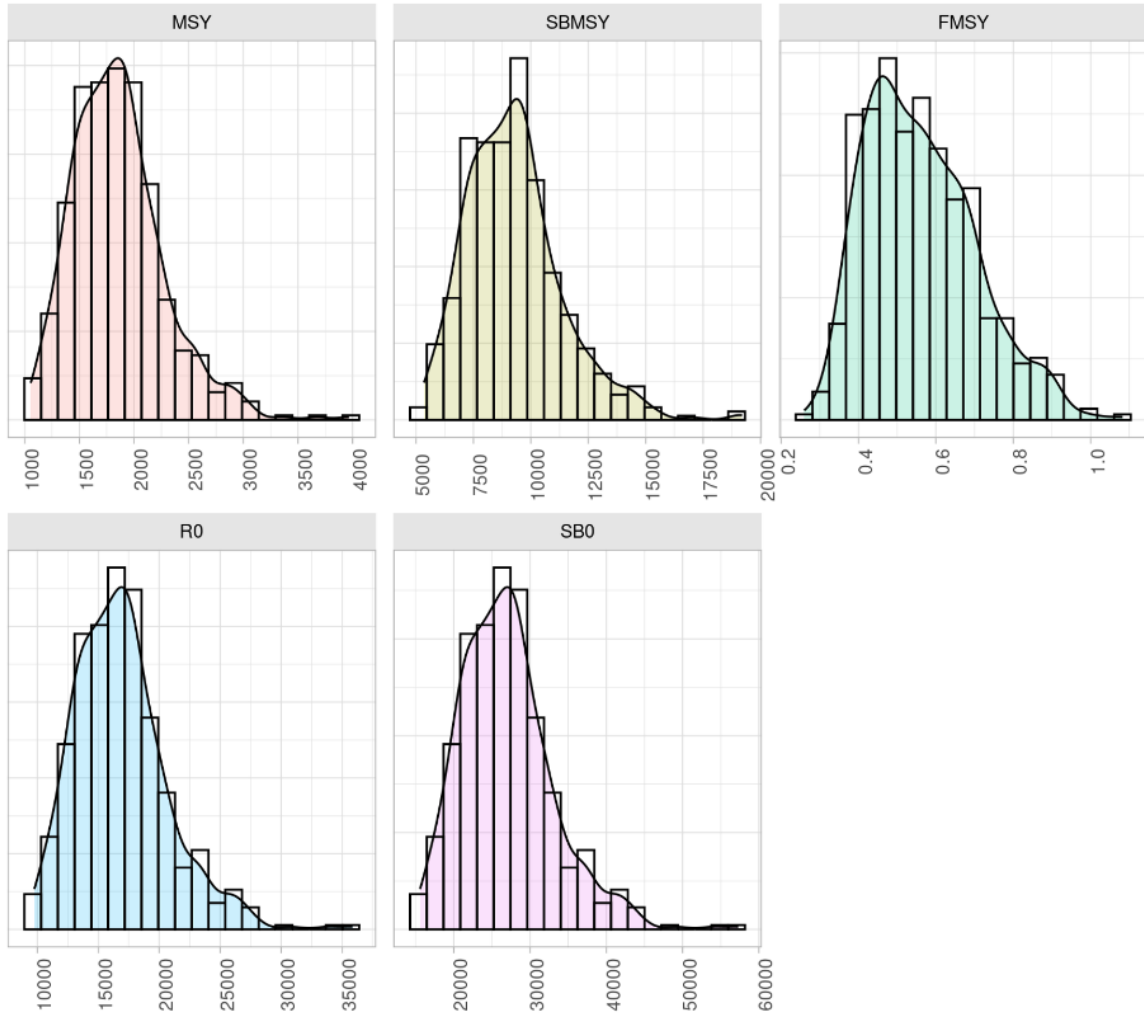
Figure 3: Distribution of reference points from the operating model accepted by the workshop.

6 Summary of Workshop Outcomes

The SCW15 workshop provided a venue for progressing the Jack Mackerel MSE work, resolving some technical issues, and evaluating multiple MP configurations. A key outcome was the identification of problems in how MPs interacted with the OMs. This raised the need for either resolution of MP specification issues prior to the SC and/or holding a separate follow-up technical meeting, ideally in person. This would focus discussion on narrowing MP options. Depending on this direction, it may mean that such a meeting would have to occur after February 2026 and the Commission meeting.

Regarding the ability and facility for member scientists to use and evaluate the MSE framework, the group noted that the development of the jmMSE package was exceptionally well done. We found that difficulties inherent to the jack mackerel resource and assessment created unique problems. Specifically, the variable resource distribution, available data, and specifications of projection conditions (e.g., mean body mass-at-age, fishery selectivity at age) complicated how MPs could be evaluated. We noted that such specifications would be problematic for any other MSE framework as well.

6.0.1 Software and Technical Recommendations

- Continue using **FLR** as the main MSE engine unless there is a dedicated effort to migrate to **openMSE** or another platform.

- Improve naming conventions in code to reduce ambiguity. For example:

    - Functions like `cpuescore2.ind` and `cpuescore3.ind` could better reflect their purpose.

6.0.2 MSE Development Timeline and Deliverables

The group noted that MSE funding (in the form of providing support from external developers) may be available but would be contingent on:

- Coordination with the current analyst (Iago).

- Collaboration with the technical team.

- Openness to using **openMSE**.

- Clear timelines and deliverables.

Proposed deliverables and deadlines include:

- **Reference OMs** (no multistock): End of July

- **Robustness OMs** (no multistock): End of August

- **Shortcut calibration** to the JJM assessment: End of August

- **Range of shortcut MPs** run for all reference OMs: End of July

Planned products:

- Technical documentation and reports:

    - Draft Technical Summary Document (TSD) by end of July.

    - Technical working papers and presentations for:

        * Shortcut calibration to JJM

        * Reference set OM results for MP archetypes

        * Robustness OM results

        * MP performance summaries

    - Slick MSE results summary.

    - TSD v1 by end of September.

6.0.3 Near term tasks

Participants were encouraged to document their activities during the workshop, including the methods explored and tuning targets used. Work tasked identified included:

- **All** continue to evaluate MPs to the extent practical ensuring that they can be tuned to achieve a 60% green status and are consistent with the available OM data stream projections.

- **Jim** evaluated 9 MPs (including `bufferdelta2`, `cpuescore2`, test acoustic, and combinations of CPUE indices with different `delta_TAC` values), all tuned to achieve 60% green status.

- **Chilean analysts** apply shortcut tuning methods as a demonstration. This was completed and provided in Section 8.

This table illustrates how an array of MPs might be evaluated for summarization:

Year	Method	Metric	Tuning Parameter	Other Parameters	Score Index	Comments
2024+	`buffer.hcr`	depletion	target	bufflow, buffup, limit	`cpuescore3.idx`	Original pkg function
2024+	`bufferdelta.hcr`	depletion	width	sloperatio	`cpuescore3.idx`	Modified; not compatible with z-score metrics
2024+	`bufferdelta2.hcr`	zscore	width	sloperatio	`cpuescore2.idx`	New; not compatible with depletion
2024+	`buffer2.hcr`	zscore	target	width (affects buffer)	`cpuescore2.idx`	Original; adjusted for zscore (limit = -2 SD)

The SC Chair, Ricardo developed some enhancements to the jmMSE demo framework after the workshop. These introduce greater flexibility and diagnostic power through two key components: performance2() and evaluate_mp(). The performance2() function extends standard summary outputs by computing a richer set of indicators—such as mean relative biomass and fishing mortality, catch, the probability of remaining in the green zone of the Kobe plot, and the longest duration spent outside it. The evaluate_mp() function wraps the full MP simulation while allowing multi-parameter optimization of Harvest Control Rule (HCR) settings, and it incorporates a customizable objective function that accounts for discounted catch, stability (via IACV), conservation thresholds (e.g., probability of being "green"), and duration outside target reference points. This setup allows for filtering out implausible simulations, facilitates adaptive MP tuning, and supports rapid exploration of trade-offs in management performance. Together, these tools make the MSE evaluation process more transparent, efficient, and tailored to decision-maker priorities.

This and other work conducted after the workshop encountered problems with the magnitude of recruitment variability which led to unreasonably high levels of biomass in a significant number of the simulations. This was something that required further investigation and resolution in collaboration with the developer (Iago).

6.0.4 Medium term tasks

The group agreed to continue working on the MSE framework, with a focus on the following tasks: - **Consider how reference set of OMs could be regenerated** conditioned to historical data using MCMC methods. - **Implement robustness tests** to evaluate how MPs perform under a range of plausible yet uncertain scenarios. - **Refine MP candidates** using the jmMSE software package, ensuring they are scientifically sound and technically transparent. - **Document and share** the MSE framework, including model assumptions, data sources, and MP structure. - **Explore additional diagnostics** and refinements, including new performance metrics that reflect stock status and trends in the final projection years.

6.1 Further recommendations to consider

6.1.1 For the SC:

- Adopt the current proposal structure with flexibility for future adjustment.

- Recommend a shortlist of MP options to simplify the selection process at the Commission level.

- Consider a placeholder method for calculating the 2026 TAC if MSE work is not yet finalized.

6.1.2 For Members:

- Commit to a shared MSE software base (FLR or openMSE).

- Engage in pre-SC online meetings to broaden participation in MSE discussions.

6.1.3 For Analyst (Iago):

- Prioritize enhancements discussed during the workshop:

  - Code clarity and naming conventions

  - Logical parameter usage across MPs

  - Refinement of FLR-to-dataframe functions

- Identify successor strategy after contract ends in 2025.

7 References

Blue Matter Science. 2024. "Slick: Interactive Visualization of MSE Results." Blue Matter Science. https://slick.bluematterscience.com/index.html.

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Hillary, Richard M., José M. Castro, James T. Thorson, Sean C. Anderson, and Laurence T. Kell. 2023. "The FLR Software Framework for Building Management Strategy Evaluation Systems: Recent Advances and Application to Data-Rich and Data-Limited Fisheries." *Fisheries Research* 263: 106585. https://doi.org/10.1016/j.fishres.2023.106585.

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Mosqueira, Iago. 2022. "Mseviz: Plots and Tools for Visualizing MSE Outputs." FLR Project; https://github.com/flr/mseviz. https://github.com/flr/mseviz.

South Pacific Regional Fisheries Management Organisation. 2024. "SC12 Report Annex 07: Jack Mackerel Technical Annex." SPRFMO; https://sprfmo.int/assets/Meetings/02-SC/12th-SC-2024/SC12-Report-Annex-07-JM-Technical-Annex.pdf.

SPRFMO Jack Mackerel Working Group. 2025. "2025-07-03 JMWG MSE Science and Managers Session." South Pacific Regional Fisheries Management Organisation (SPRFMO); https://southpacificrfmo.sharepoint.com/sites/SPRFMOSCJackMackerelWorkingGroup/Shared%20Documents/MSE/2025%20Work/2025_07_03%20JMWG%20MSE%20Science%20and%20Managers%20Session.

8 Examples of Shortcut MPs

This section was compiled by Ignacio Payá and colleagues from Chile. It summarizes an example implementation of "shortcut" management procedures (MPs) that simplify the estimation and harvest control rule (HCR) steps using buffered depletion-based control. It also illustrates how FLR-based tools can be used to define control logic, evaluate HCR targets, and visualize results using the `Slick` (Blue Matter Science (2024)) and `mseviz` (Mosqueira (2022)) R packages. for performance evaluation. Each section below includes code, explanation, and figures that demonstrate specific aspects of the approach.

8.1 Shortcut MP Definition

This section defines the MP structure using `mpCtrl()` with shortcut estimation (`shortcut.sa`), a buffer-based HCR, and a split implementation system (ISYS). Deviations are defined using a lognormal AR(1) process.

8.1.1 HCR Target Exploration

To evaluate MP performance under various Total Allowable Catch (TAC) values, the control object from Section 8.1 is tested across a set of TAC multipliers. The target range brackets the 2025 CMM level. This produces comparative projection plots for four candidate TAC levels (Figure 4).

Now we test this with a simple limit on the annual change in TAC, which is a common requirement in many fisheries management systems. These results compare similarly to those without any TAC constraint (Figure 5). A clearer evaluation of these two sets is shown in the next section using the `Slick` package.
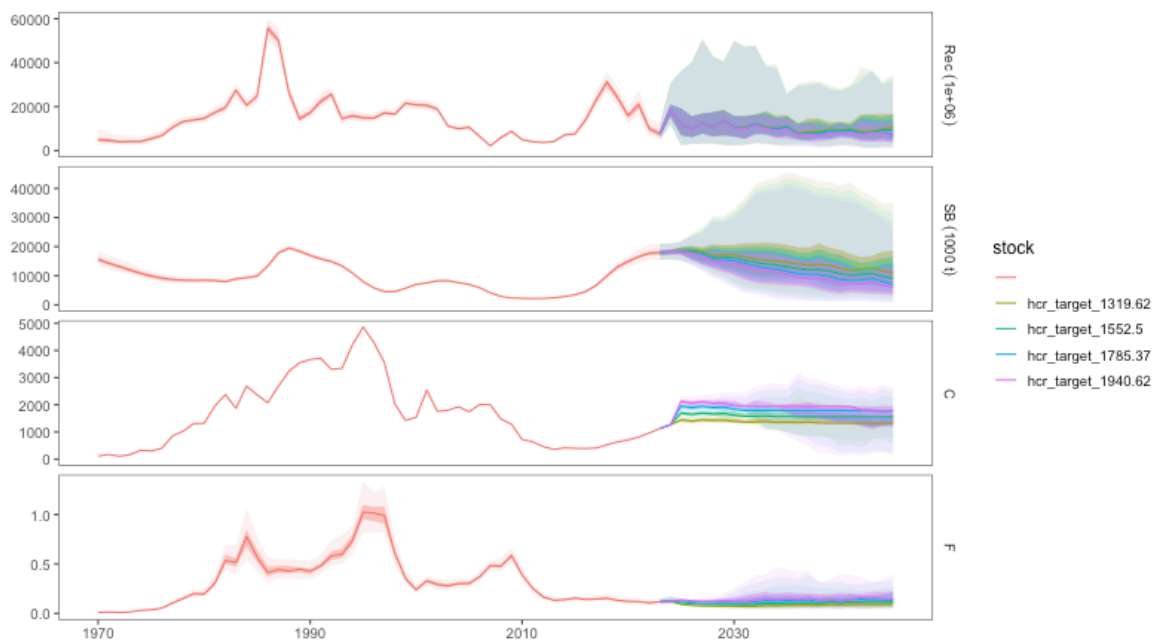
Figure 4: Projections for TAC 2025 scenarios using buffer HCR.
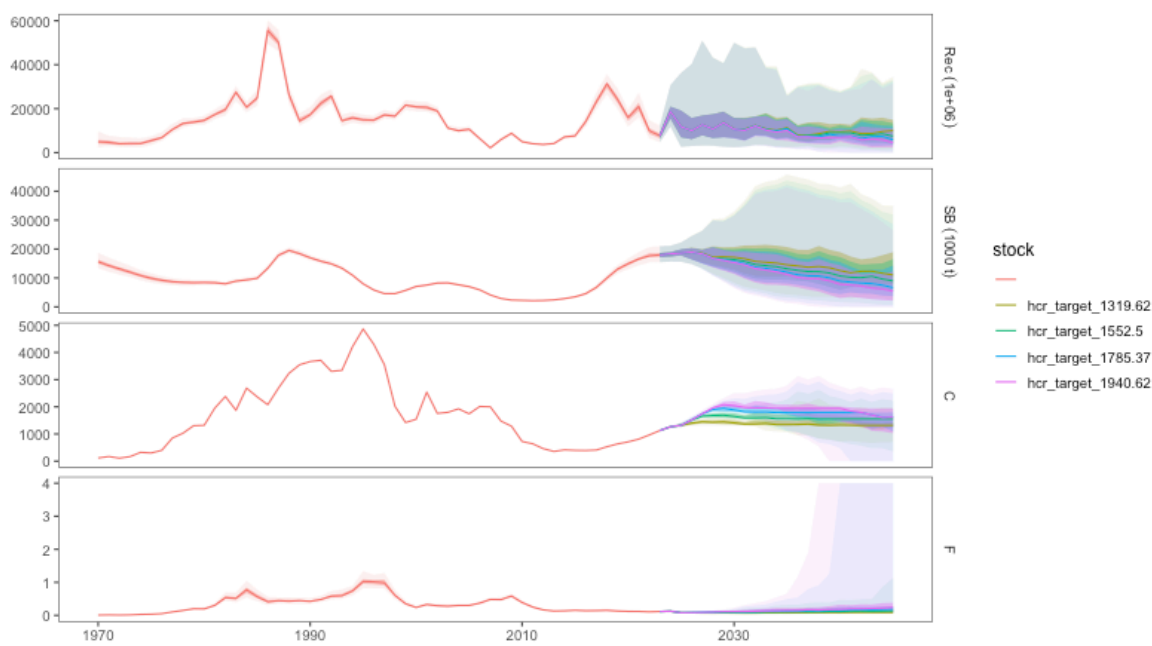

Figure 5: Projections for TAC 2025 scenarios using buffer HCR with TAC change limit at 15 percent.
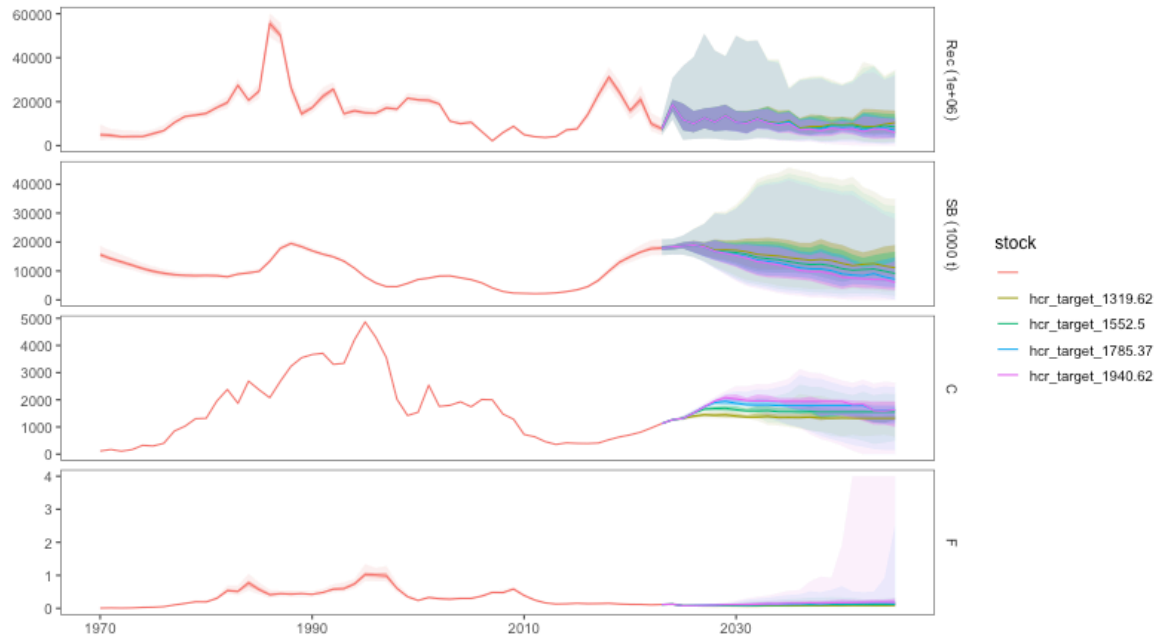
Figure 6: Projections for TAC 2025 scenarios using buffer HCR with TAC change limit at 25%
(downward) and 15% increases.

```
args(ctrl$hcr)[c("dlow", "dupp")] <- c(0.85, 1.15)
targets_lim15 <- mps(om, oem, ctrl=ctrl, args=mseargs,
            hcr=list(target=c(TAC2025*0.85, TAC2025, TAC2025*1.15, TAC2025*1.25)))
png("images/Projections_Sc_har_Around_TAC2025_lim.png", width=800, height=450)
  plot(om, targets_lim15) + ggthemes::theme_few()
dev.off()
##--Now with 25% change down, 15% uupper
args(ctrl$hcr)[c("dlow", "dupp")] <- c(0.75, 1.15)
targets_lim2515 <- mps(om, oem, ctrl=ctrl, args=mseargs,
            hcr=list(target=c(TAC2025*0.85, TAC2025, TAC2025*1.15, TAC2025*1.25)))

png("images/Projections_Sc_har_Around_TAC2025_lim2515.png", width=800, height=450)
  plot(om, targets_lim2515) + ggthemes::theme_few()
dev.off()
##--Now with 25% change down, 15% uupper
```

8.1.2 Using openMSE's Slick Output

Using the `Slick` package (Blue Matter Science (2024)), performance metrics such as catch, fishing mortality, and spawning biomass can be summarized across operating models and MPs. As one illustration of the application, we presents a Kobe-style status time series from `Slick`. We compare three shortcut management procedures (MPs) all tuned to the 2025 TAC level (1.55 million t) but differing in constraints on interannual TAC changes (Figure 7). The panels from left to right represent: (1) no constraint (1.0), (2) symmetric $\pm 15\%$ TAC change limit (1.0_d15), and (3) asymmetric $-25\%/+15\%$ limit (1.0__d2515). Each panel shows the proportion of simulations over time falling into the green (safe), yellow (overfished or overfishing), and red (overfished and overfishing) zones. While all three MPs maintain a majority of simulations in the green zone, applying TAC constraints leads to a slight increase in the proportion of years falling into the red zone—particularly under the asymmetric constraint. This reflects the trade-off where increased catch stability may slightly elevate biological risk under certain scenarios. We provide a copy of the slick file on the repository under MS Teams at [tbd].
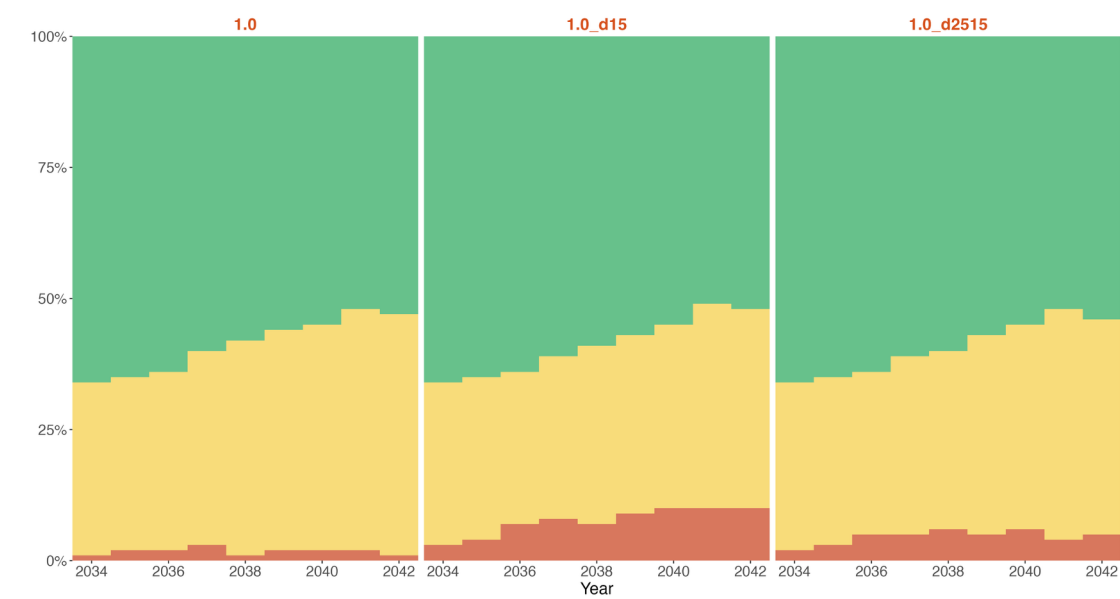

Figure 7: Shortcut application tuned to the 2025 TAC (1,552,500 t) but with different constraints on TAC changes. Left most is no constraint, middle is 15% increase and decrease, right-most is 25% decrease and 15% increase.

```
library(Slick)
targs_lim2515 <- FLmses(targets_lim2515, statistics=statistics,
             years=2024:2045, metrics=mets, type="scgb_d2515")
```

```
targs_lim <- FLmses(targets_lim15, statistics=statistics,
                years=2024:2045, metrics=mets, type="scgb_d15")

targs <- FLmses(targets, statistics=statistics,
                years=2024:2045, metrics=mets, type="scgb_d00")
perf <- rbind(performance(targs),performance(targs_lim))
omperf <- performance(om, statistics=statistics[c("C", "F", "SB")])
writePerformance(perf, file="demo/targets.dat.gz")
head(perf)
tail(perf)
unique(perf$mp)

sli <- getSlick(perf, omperf, kobeyrs=2034:2042)
sli@MPs@Label
sli@MPs@Label <- c("0.85", "1.0", "1.15", "1.25", "0.85_d15", "1.0_d15", "1.15_d15", "1.25_d
sli@MPs@Description <- sli@MPs@Label
sli@MPs@Code <- sli@MPs@Label
App(slick = sli)

#--Now show contrasts for current TAC limit (1,552,500 t)

performance(targs_lim2515)
perf <- rbind(performance(targs),performance(targs_lim),performance(targs_lim2515))
# ptmp <- perf |> filter(str_detect(mp, "1552.5"))
# unique(ptmp$mp)
sli <- getSlick(perf, omperf, kobeyrs=2034:2042)
sli@MPs@Label
sli@MPs@Label <- c("0.85", "1.0", "1.15", "1.25",
                   "0.85_d15", "1.0_d15", "1.15_d15", "1.25_d15",
                   "0.85_d2515", "1.0_d2515", "1.15_d2515", "1.25_d2515"  )
sli@MPs@Description <- sli@MPs@Label
sli@MPs@Code <- sli@MPs@Label
App(slick = sli)

saveRDS(sli, file="demo/PayaShortCuts_2.slick")
```

8.1.3 Other tools for viewing performance indicators

This section summarizes performance using FLR tools from the `mseviz` package (Mosqueira
(2022)). Average values are computed for specified periods and used in BRP (Biological Ref-
erence Point) and tradeoff plots.

```r
library(mseviz)
writePerformance(perf,"demo/performance.dat.gz")
periods <- list(
  tuning = 2034:2045,
  short  = 2025:2027,
  medium = 2027:2032,
  long   = 2033:2045
)
```

```r
perf <- readPerformance("demo/performance.dat.gz")
perf <- perf |> mutate(data=ifelse((statistic=='F'&data>2),2,data))
#unique(perf$statistic)
perf<-  perf %>%
  mutate(
    # Extract the part after "_d" and before "_hcr"
    d_part = str_extract(mp, "(?<=_d)[^_]+"),
    # Extract the trailing number after the last "_"
    target_num = str_extract(mp, "[0-9.]+$"),
    # Create short name by combining them
    mp  = paste0("d", d_part, "_",
                 ifelse(target_num==1319.62,"0.85",
                 ifelse(target_num==1552.5,"1.0",
                 ifelse(target_num==1785.37,"1.15","1.25"))))
  )
perf <- periodsPerformance(perf, periods)
# perf |> filter(period=='tuning', statistic %in% c("SB","C", "IACC"),  mp %in% c("d00_1.0",
#   ggplot(aes(x=as.factor(mp),y=data,fill=mp)) + geom_boxplot(outlier.shape=NA) + ggthemes:
#   facet_wrap(.~statistic, scales="free_y")

png("images/sc_delta_TAC.png", width=900, height=800)
plotBPs(perf |>
          filter(period=='tuning',  mp %in% c(
            "d00_1.0",
            "d15_1.0",
            "d2515_1.0"
            )) , statistics=c(
            "C",
            "IACC",
            "F",
            "PTAClimit",
            "SB"
            )) +
```

```
  ggtitle("Shortcut MPs for Tuning Period (2034-2045)") + ggthemes::theme_few(base_size = 16)
  theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
  scale_fill_flr() + ylim(c(0,NA)) + xlab("MP")

dev.off()

png("images/sc_targ_TAC.png", width=900, height=800)
plotBPs(perf |>
        filter(period=='tuning',  mp %in% c(
          "d00_0.85",
          "d00_1.0",
          "d00_1.15",
          "d00_1.25"
          )) , statistics=c(
          "C",
          "IACC",
          "F",
          "SB"
          )) +
  ggtitle("Shortcut MPs for Tuning Period (2034-2045)") + ggthemes::theme_few(base_size = 16)
  theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
  scale_fill_flr() + ylim(c(0,NA)) + xlab("MP")

dev.off()
```

The performance of shortcut management procedures (MPs) over the tuning period (2034–2045) were contrasted as an example. Here, each MP was run with catch "targets" at different level relative to the 2025 TAC (1.5525 million t). They ranged from 85% (d00_0.85) to 125% (d00_1.25), with no constraints on interannual TAC changes. As expected, higher catch targets result in greater average catches (mean(C)), but also increased interannual variability (IAC(C)), as well as higher fishing mortality (F) (Figure 8). Conversely, spawning biomass (SB) declines with increasing catch target, suggesting a clear trade-off between yield and stock conservation. While d00_1.0 balances moderate catch with more stable biomass and fishing pressure, higher targets (d00_1.15 and d00_1.25) achieve larger catches at the cost of reduced SB and greater volatility—highlighting the importance of considering both yield and stability objectives when selecting candidate MPs.

We then compared performance of shortcut MPs all tuned to the 2025 TAC target (1.5525 million t), but with different constraints on interannual changes in TAC. These included (as in the previous figure) no constraint on TAC changes (d00), a symmetric $\pm15\%$ constraint (d15), and an asymmetric $-25\%/+15\%$ constraint (d2515). While mean catch (mean(C)) is similar across all three MPs, the application of TAC constraints notably reduces interannual

variability (IAC(C)) compared to the unconstrained case (Figure 9). This stability comes with trade-offs—particularly a modest increase in the probability of hitting a predefined TAC floor (P(TAClimit)) for d15 and d2515. Spawning biomass (SB) and fishing mortality (F) remain broadly similar across scenarios, suggesting that moderate TAC constraints can improve catch stability without severely compromising stock status. Overall, the results highlight the stabilizing benefit of delta-TAC constraints, with d15 offering the most consistent balance of catch, stability, and conservation performance.

As an alternative, we show figures that highlight short-term (2025–2027) trade-offs among shortcut MPs based on either different TAC targets (Figure 10) or different TAC change constraints (Figure 11). Increasing the TAC target from 85% to 125% of the 2025 TAC results in expected increases in catch, but also in fishing mortality (F) and interannual catch variability (IAC(C)), with slight declines in spawning biomass (SB). All options show negligible probability of hitting the TAC floor (P(TAClimit)). In contrast, comparing MPs with the same TAC target (2025 level) but different delta-TAC constraints (Figure 11). While d00_1.0 provides slightly higher short-term catch, it exhibits greater catch variability and a marginally higher risk of triggering the TAC limit compared to d15_1.0 and d2515_1.0. These results suggest that in the short term, applying TAC constraints can enhance stability and reduce the risk of severe TAC cuts, albeit in catch—highlighting a management choice between maximizing short-term yield and reducing volatility.

While the general patterns observed in the short-term persist, the medium-term results show reduced separation across MPs in all performance metrics. For instance, in the TAC target comparison (top panel), differences in fishing mortality (F), interannual catch variability (IAC(C)), and spawning biomass (SB) across catch targets narrow considerably. This suggests that the system has begun to stabilize, with stock status and catch performance converging even under different TAC target levels (Figure 12). Similarly, in the delta-TAC constraint comparison (Figure 13), the three strategies (d00, d15, d2515) yield almost indistinguishable outcomes across all metrics, aside from slightly higher uncertainty in the risk of hitting the TAC limit for d15_1.0. This convergence indicates that the influence of TAC constraints diminishes as the system settles, implying that short-term trade-offs in volatility and yield may be more relevant than medium-term differences when selecting among MPs.

```
png("images/sc_delta_TO.png", width=900, height=450)
plotTOs(perf |>
         filter(period=='short',  mp %in% c(
           "d00_1.0",
           "d15_1.0",
           "d2515_1.0"
           )) , x="C",
      y=c(
           "IACC",
           "F",
```
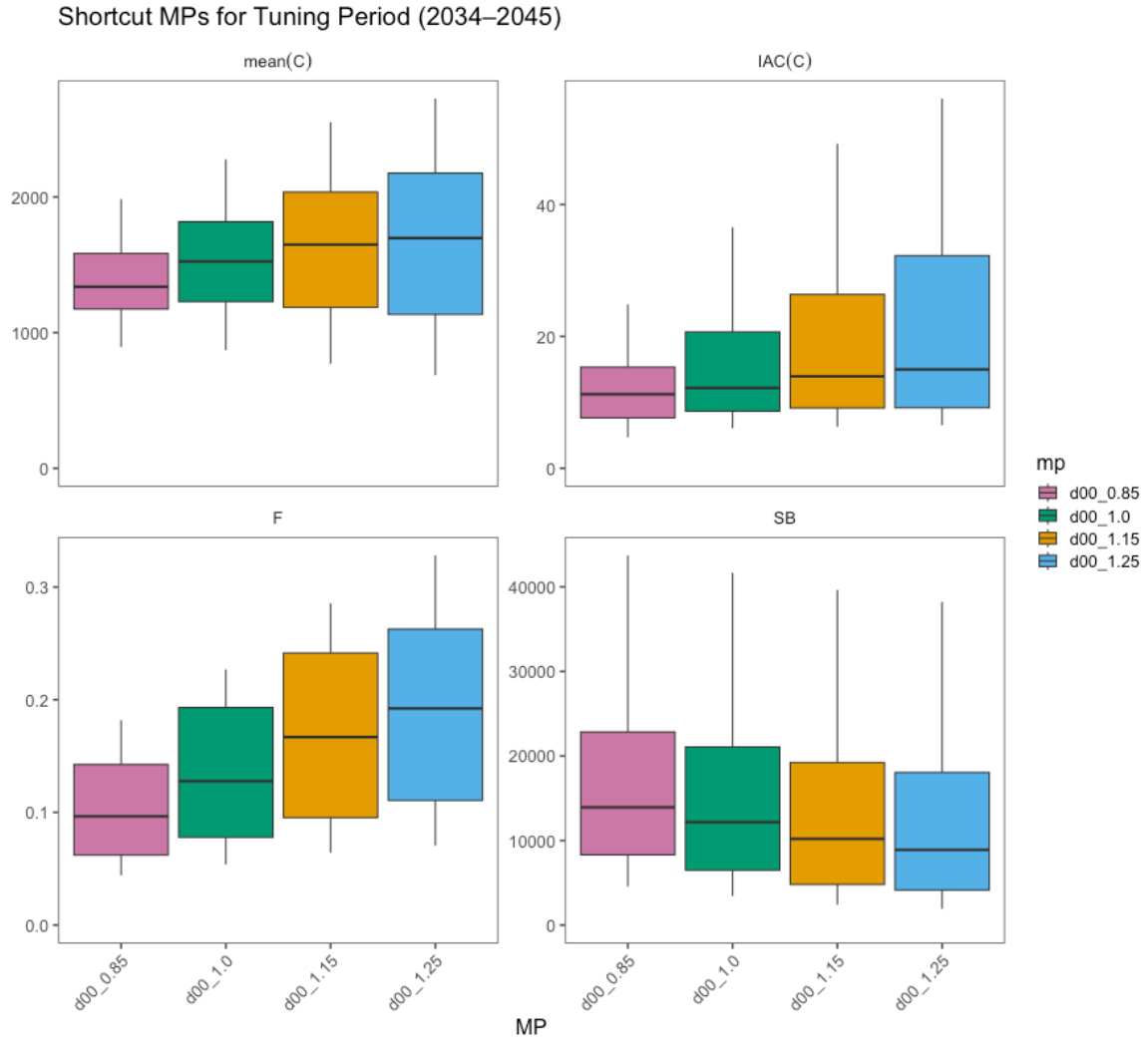
Figure 8: Boxplots for shortcut MP with target catches set to different multipliers of the 2025 TAC (e.g., 0.85 is 85% of the 2025 TAC (1.5525 million t).
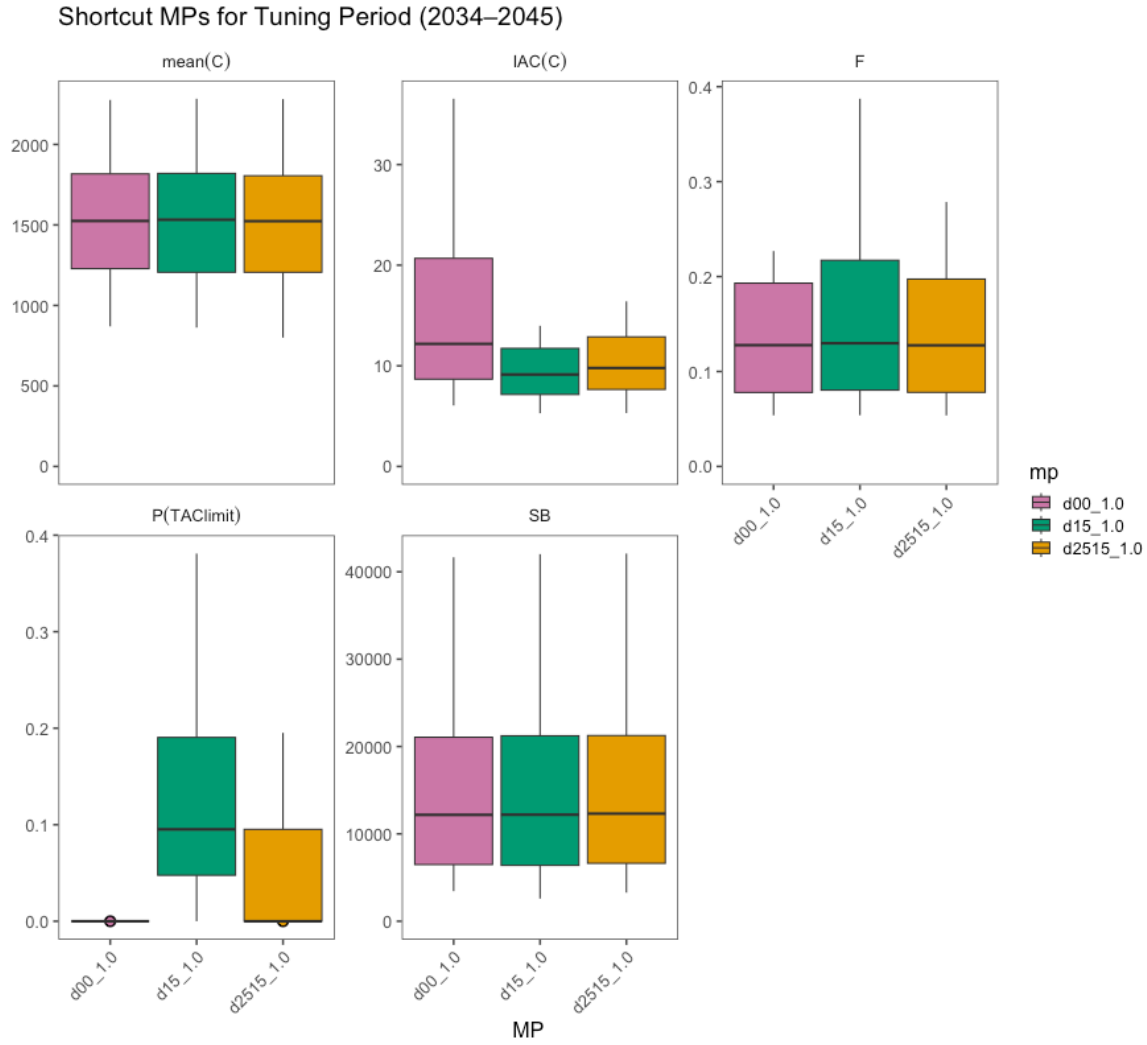
Figure 9: Boxplots for shortcut MP with target catches set to the 2025 TAC (1.5525 million t) and with different constraints on annual TAC changes.
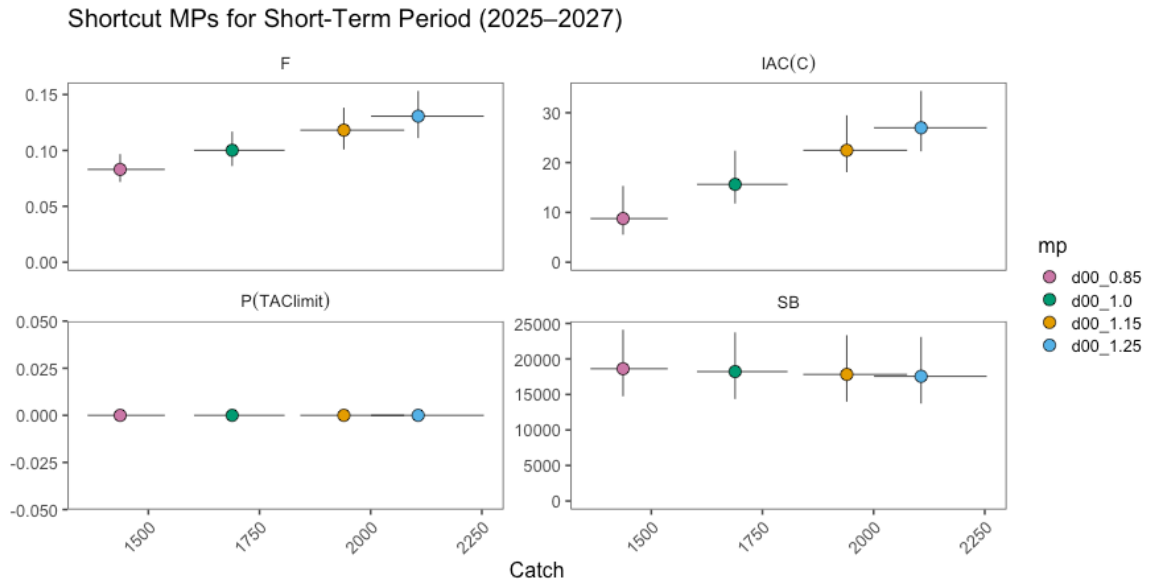
Figure 10: "Trade-off plots for short term results from the shortcut method and different targets relative to the 2025 TAC (1.5525 million t).
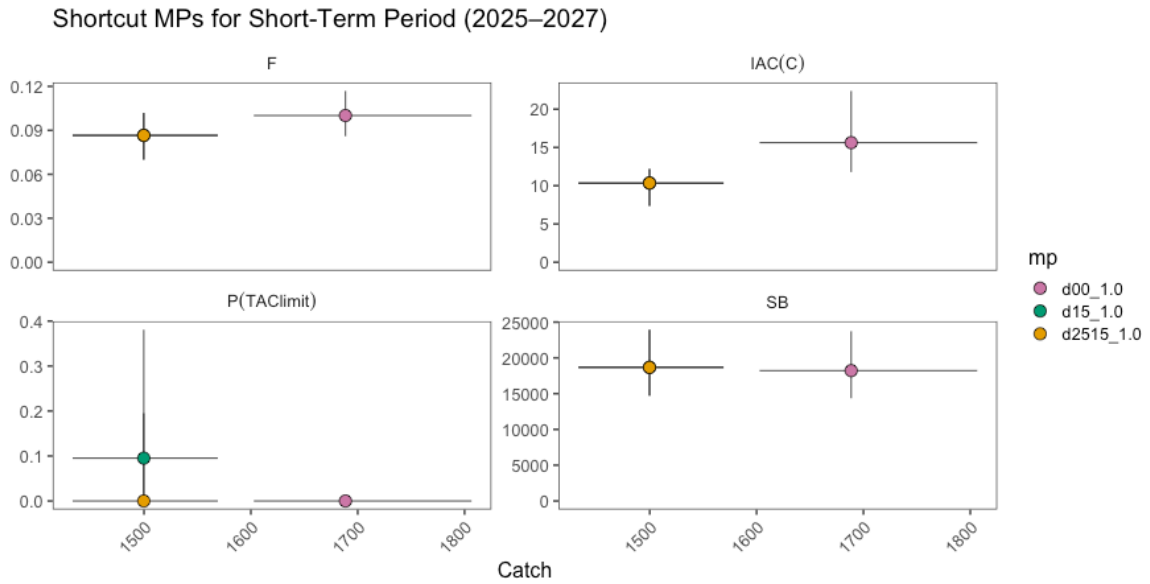

Figure 11: "Trade-off plots for short term results from the shortcut method and different constraints on annual TAC changes).
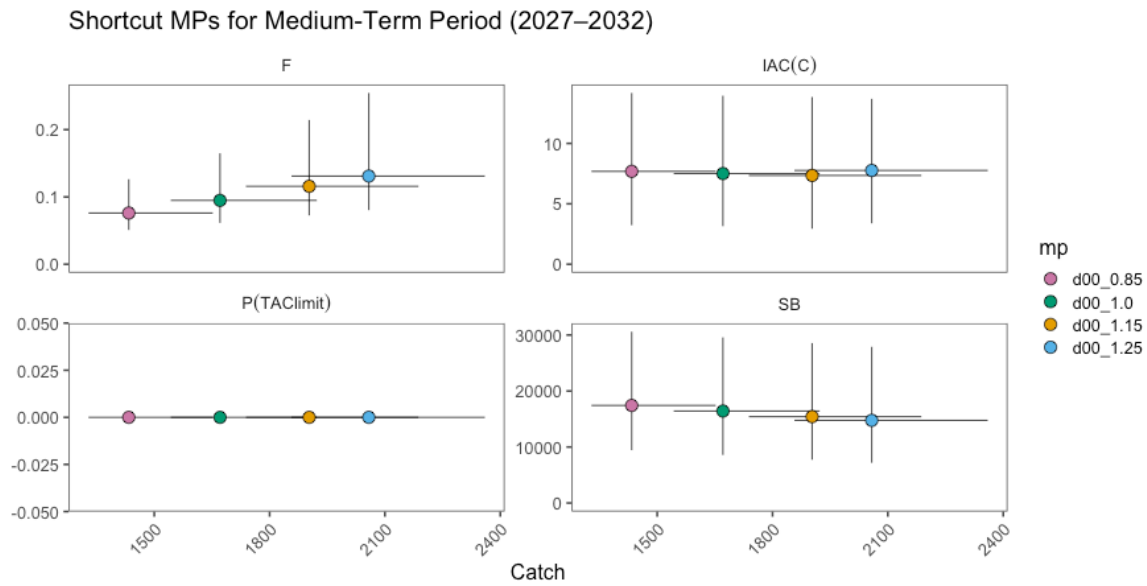
Figure 12: "Trade-off plots for medium term results from the shortcut method and different targets relative to the 2025 TAC (1.5525 million t).
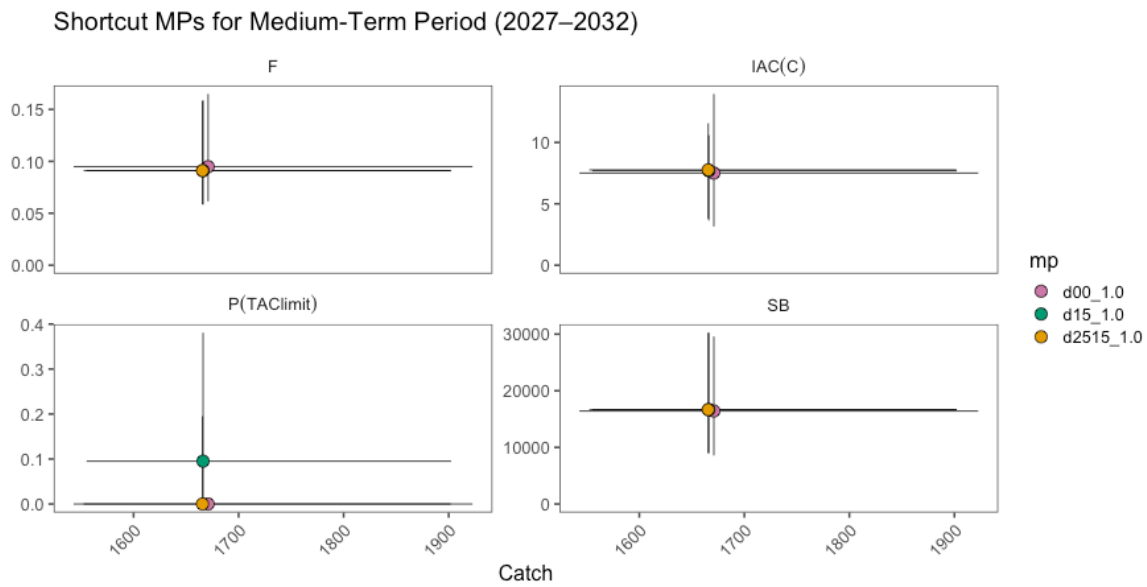

Figure 13: "Trade-off plots for medium term results from the shortcut method and different constraints on annual TAC changes).

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```r
            "PTAClimit",
            "SB"
            )) +
  ggtitle("Shortcut MPs for Short-Term Period (2025-2027)") + ggthemes::theme_few(base_size =
  theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
  scale_fill_flr() + ylim(c(0,NA)) + xlab("Catch")
dev.off()


png("images/sc_targs_TO_med.png", width=900, height=450)
plotTOs(perf |>
          filter(period=='medium',  mp %in% c(
            "d00_0.85",
            "d00_1.0",
            "d00_1.15",
            "d00_1.25"
            )) , x="C",
        y=c(
            "IACC",
            "F",
            "PTAClimit",
            "SB"
            )) +
  ggtitle("Shortcut MPs for Medium-Term Period (2027-2032)") + ggthemes::theme_few(base_size
  theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
  scale_fill_flr() + ylim(c(0,NA)) + xlab("Catch")
dev.off()


png("images/sc_delta_TO_med.png", width=900, height=450)
plotTOs(perf |>
          filter(period=='medium',  mp %in% c(
            "d00_1.0",
            "d15_1.0",
            "d2515_1.0"
            )) , x="C",
        y=c(
            "IACC",
            "F",
            "PTAClimit",
            "SB"
            )) +
```

```
  ggtitle("Shortcut MPs for Medium-Term Period (2027-2032)") + ggthemes::theme_few(base_size
  theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
  scale_fill_flr() + ylim(c(0,NA)) + xlab("Catch")
dev.off()


png("images/sc_targs_TO.png", width=900, height=450)
plotTOs(perf |>
        filter(period=='short',  mp %in% c(
          "d00_0.85",
          "d00_1.0",
          "d00_1.15",
          "d00_1.25"
          )) , x="C",
      y=c(
          "IACC",
          "F",
          "PTAClimit",
          "SB"
          )) +
  ggtitle("Shortcut MPs for Short-Term Period (2025-2027)") + ggthemes::theme_few(base_size
  theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
  scale_fill_flr() + ylim(c(0,NA)) + xlab("Catch")
dev.off()
```

These diagnostics provide visual summaries of CMP performance across time horizons. This addendum presents a full example of how shortcut methods can be configured and evaluated in the jmMSE framework. The use of buffered harvest control, lognormal deviations, and simplified estimation methods make these examples especially useful for scoping and tuning phases of MSE development. Future iterations could generalize the estimation block or integrate OpenMSE for better interoperability.