# Evaluating Management Strategies for Atlantic Bluefin Tuna

*Report 9: Reconditioning of operating models, code review,
AI CMPs, OM weighting, Shiny app development, tuning
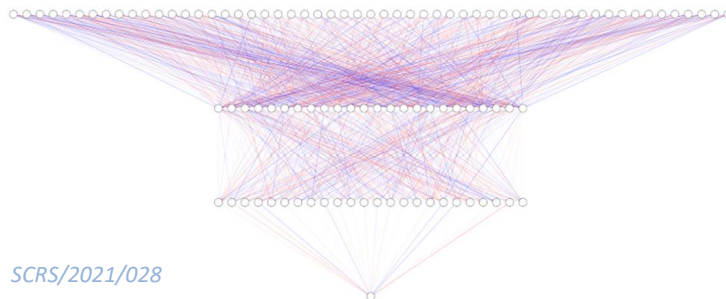OMs, consolidating online documentation.*

December 15th 2021

SHORT-TERM CONTRACT FOR THE
MODELLING APPROACHES: SUPPORT TO BLUEFIN TUNA STOCK ASSESSMENT
(GBYP 02/2021) OF THE ATLANTIC-WIDE RESEARCH PROGRAMME FOR BLUEFIN TUNA (ICCAT
GBYP – Phase 11)
-FINAL REPORT-

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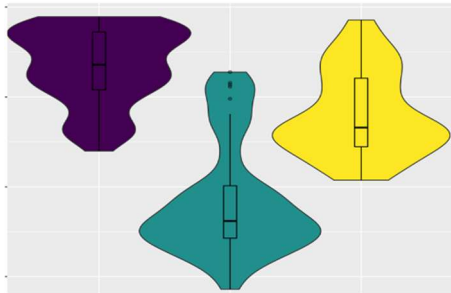
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Tom Carruthers[1]

bluematter

[1] tom@bluematterscience.com 2150 Bridgman Ave, North Vancouver, Canada. +1 604 822-6903

Executive Summary

This contract saw a major consolidation of the modelling foundations of the MSE including reconditioning of all operating models, integration of OM weighting, the refinement of seven CMPs authored by five independent developer groups and a comprehensive external code review.

The most recent bluefin data were provided by the Secretariat and all operating models were reconditioned to 2019 and a full set of before/after comparisons were presented to the group.

Following the Delphi approach, the operating model weightings were incorporated in both the code to conduct CMP tuning and the presentation of CMP results.

Materials and documentation were prepared to support a comprehensive, independent code review that found no notable coding errors.

Presentation of MSE results and documentation was improved by additions to the ABTMSE Shiny app and the production of an MSE splash page, serving as a hub for all relevant ABT MSE documentation and links.

Further refining of CMPs to follow Panel 2 guidance on area-based caps, production of tables and figures for characterising CMP performance and selecting CMPs, and addition of robustness OMs are key priorities for 2022.

All tasks and deliverables listed in the contract were completed on time with the exception of the conditioning of a single requested robustness test that was not feasible for technical reasons.

Principal developments

- Reconditioned all reference grid OMs to include data up to 2019 and included these in an updated ABTMSE R package.

- A complete before-after reconditioning comparison documented in an SCRS and presented to the group (Appendices E and H)

- Consolidation and presentation of CMP performance (Appendices B, C, K)

- M3 Code Review completed successfully

- Updated trial specifications document (Appendix A)

- New artificial intelligence (AI) CMP tuned to development targets (Appendices P & Q).

- Model-based surplus production (SP) CMP tuned to development targets (Appendix R).

- Index-based multi-stock CMP (TC) tuned to development targets (Appendix S).

- Almost all robustness set OMs coded and fitted (Appendix F).

- Incorporated OM weighting, into CMP tuning tools and presentation of results in the Shiny app.

- Coded new additions to the Shiny app including: downloadable MSE results data, sortable CMP selection and 'results normalized by selection'.

- Hosted an updated ABT MSE Shiny App on an online server: http://142.103.48.20:3838/ABTMSE/

- Developed an ABT MSE splash page providing a location for updated links to the latest documentation, packages and App: https://iccat.github.io/abft-mse/

- In total, eight SCRS papers (Appendices D, E, F, P, R, S, T, U), three working documents (Appendices A, L, O) and nine presentations (Appendices B, C, G, H, I, J, K, M, N, Q) were produced covering updated OMs, new CMPs, and presentation of CMP performance.

Contents

1   Review of contract activities

1.1   Presentation of updated CMP results prior to reconditioning, technical team meeting (March 2021)

An MSE technical team meeting was convened to allow CMP developers to share findings and present current results of the TC and BR CMPs (Appendix B). The meeting provided an opportunity to describe new ABTMSE code for the running of MSEs in parallel on clusters / virtual machines (an approached used successfully by the Canadian CMP development team to design and tune a front-running CMP).

In collaboration with other working group member an analysis was also presented that demonstrated the likely impact of OM weighting on conclusions regarding CMP performance (Appendix U).

1.2   Presentation of updated CMP results, first intersessional meeting of the bluefin tuna species group (April 2021)

Prior to the intersessional meeting of the bluefin tuna species group, TC CMPs were further refined. The meeting provided an opportunity to update the group on progress with OM reconditioning and present the very latest CMP results (Appendices C & D).

1.3   Preliminary presentation of reconditioning results, informal MSE webinar (June 2021)

Prior to the informal MSE webinar, the latest fishery catch and index data sets were provided by the ICCAT secretariat and these were processed to be compatible with the M3 conditioning model. All reference grid operating models were reconditioned and code written to provide side-by-side comparisons with the previous set of operating models. These comparisons were presented at the informal MSE webinar (Appendix E) to obtain feedback from the smaller group on the necessary level of detail in these comparisons and any other diagnostic plots that may be useful ahead of the technical MSE meeting in July.

At total of 11 robustness tests had been previously requested by the bluefin working group. These are intended to be applied to a small grid of 4 reference grid OMs resulting in a total of 44 robustness OMs. Of the 44, 40 were fitted without problem. The exception was the 'non linear indices' test which did not converge when the conditioning was attempted. Additionally, the 'Brazilian catches' test was implemented but did not include historical catches prior to 1965 as these were not available. The results of the robustness OM fitted was presented to the group (Appendix F).

1.4   Code review (May – July 2021)

An independent, external code review was scheduled for 2021. To facilitate this review, the trial specifications document (TSD, Appendix A) was updated and code in the package was fully documented, commented and cross-referenced with the TSD. Code was updated on the ICCAT GitHub repository (https://github.com/ICCAT/abft-mse). A guide to the package and conditioning model was also written to assist the external reviewer in navigating the various folders, R scripts and packages.

The code review was completed in June 2021. No consequential coding errors were found. Recommended changes to the TSD were made.
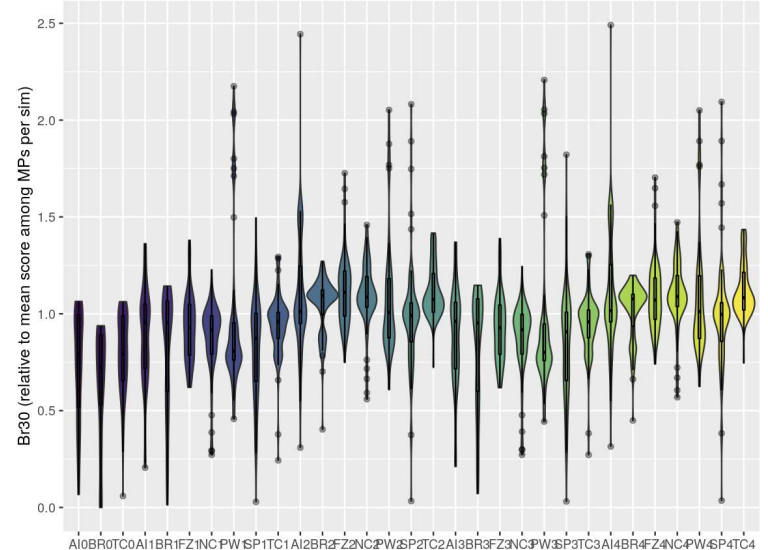
1.5   Reconditioning of operating models, technical MSE meeting (July 2021)

Prior to the technical MSE meeting, the Shiny app was updated to allow for the downloading of MSE results data, a clearer representation of relative performance via 'Normalize by simulation' feature, the inclusion of East-West performance trade-off plots, the option of OM weighting in results calculation and the ability to filter CMPs by type and tuning (Table 1).

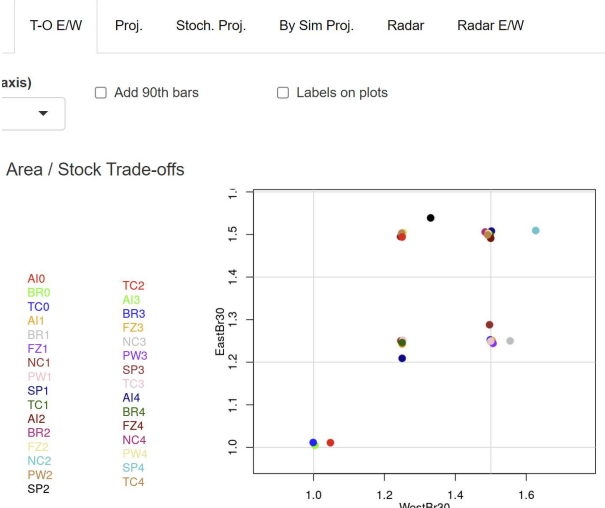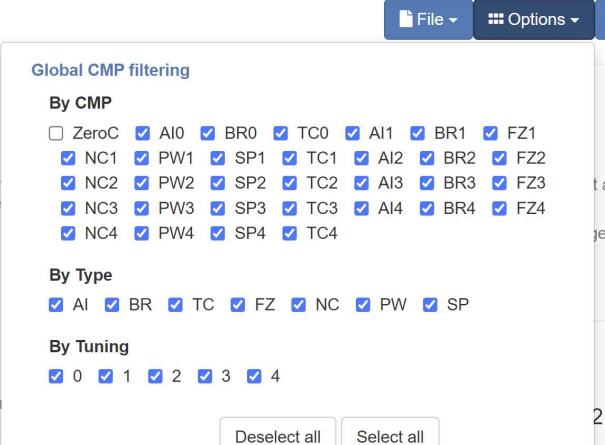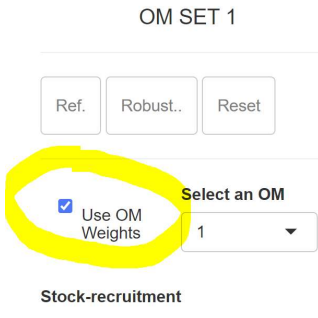The newly reconditioned OMs were built into an updated version of the ABTMSE R package including code to allow CMPs to be tuned given OM weightings. All CMPs were retuned to the reconditioned OMs and the results consolidated in the Shiny app.

A progress report on MSE contract activities was presented to the group at the MSE technical meeting in July 9 (Appendix G). A refined presentation on reconditioning results was presented (Appendix H) in addition to an updated CMP comparison paper and presentation (Appendix I). Furthermore a 'does it matter' analysis was undertaken to demonstrate that an ad-hoc data weighting (that was necessary for a single operating model OM #35, to fit the data satisfactorily) was not consequential to CMP performance outcomes (Appendix T).

Table 1. New additions to the Shiny app (https://apps.bluematterscience.com/ABTMSE/)

Addition to File dropdown menu - Downloading of results data	
Zeh plot normalized by simulation.	

Tab panel – East / West trade-off plots	
CMP sorting and filtering by type and tuning level	
OM weighting as an option in the presentation of CMP performance results	

1.6 New CMP results given OM weighting and reconditioned OMs and proposals for a tuning set of OMs, second intersessional meeting of the bluefin tuna species group (September 2021)

The second intersessional meeting of the bluefin tuna species group was an opportunity to update the larger group on the progress completed thus far in 2021 (Appendix J). Before the meeting, further refinements to CMPs were made by most developers and these results were synthesized, updated in the Shiny app and also presented to the species group (Appendix K).

A key conclusion arising from the initial days of the meeting was that the approach to CMP tuning using the deterministic operating models did not lead to consistent correspondence with the stochastic results (the

deterministic biomass tunings neither matched up with the stochastic outcomes and these were consistent among CMPs). To address this problem a proposal for stochastic tuning was documented and presented (Appendices L and M). This would be subsequently refined and incorporated into the ABTMSE R package as a separate set of tuning operating models with a small number of stochastic replicates.

To further discussions regarding CMP shortlisting and selection, a demonstration approach to satisficing was presented to the group (Appendices N and O).

In support of an appendix to the meeting report documenting the equations of all CMPs, three SCRS papers were submitted that detailed the assumptions, equations and parameterization of a new model-based CMP (SP – using a surplus production model, Appendix R), an index-based CMP that accounts for mixing (TC, Appendix S) and a new index-based approach using an artificial neural network to estimate regional biomass (AI, Appendices P & Q).

The group requested an example of a CMP performance summary table that is color coded to highlight trade-offs among CMPs and potentially aid in CMP short-listing and selection. R markdown code was developed to generate such tables across multiple CMPs (Figure 2). The code for this is compatible with the R Shiny app and may be later incorporated to facilitate interactive CMP selection within the app.

CMP	Mean Ranking	West area / western stock			East area / Eastern stock		
		AvC30 0.00	AAVC 0.00	Br30 5% 1.94	AvC30 0.00	AAVC 0.00	Br30 5% 2.51
Br30 1.00 - 1.00 (Western - Eastern) development tuning							
AH1	2.7	3.51	3.69	0.43	46.60	0.00	0.41
AI1	4.0	3.80	6.29	0.43	44.85	0.00	0.04
BR1	5.8	3.76	16.95	0.36	46.83	0.00	0.20
HA1	3.2	3.40	0.00	0.15	49.01	0.00	0.06
LW1	4.8	3.28	9.18	0.43	43.73	18.87	0.05
ND1	4.3	2.80	2.91	0.29	50.21	11.61	0.09
PW1	6.2	3.31	8.28	0.29	49.08	14.46	0.46
TN1	4.3	3.20	9.77	0.08	45.86	13.60	0.07
TC1	5.5	3.41	6.78	0.40	50.83	3.53	0.05
Br30 1.25 - 1.25 (Western - Eastern) development tuning							
AI2	2.7	3.38	7.70	0.76	44.02	0.00	0.32
BR2	4.2	3.24	10.63	0.61	41.47	0.00	0.46
BR2capW	5.2	2.90	9.94	0.55	41.46	0.00	0.45
LW2	5.0	2.71	6.36	0.64	38.50	15.51	0.61
PW2	4.3	2.94	7.55	0.49	43.30	12.40	0.68
SP2	3.7	3.26	2.32	0.60	42.33	0.00	0.22
TN2	6.0	3.10	9.96	0.18	43.01	13.99	0.33
TC2	4.0	3.09	8.34	0.63	47.19	6.62	0.38

Figure 1. An example markdown table for the purposes of CMP performance comparison.

1.7   Development of stochastic tuning OMs

A complete set of stochastic operating models was developed that had only 4 simulations per OM (there are 48 simulations per OM in the full reference grid of stochastic operating models). Tuning to these obtained comparable results for the full stochastic grid of OMs (Figure 2) and these were adopted as the new basis for CMP tuning. These OMs labelled with subscript _t (e.g. OM_1t, OM_2t, …) were included in an updated R package and example code for tuning to these was provided to the group and included in an updated CMP developers guide (Appendix V).

|	Western stock					Eastern stock		
	Tuning	Stochastic	Ratio			Tuning	Stochastic	Ratio
TC1	1.25	1.21	0.968		TC1	1.24	1.19	0.960
TC2	1.25	1.21	0.968		TC2	1.53	1.45	0.948
TC3	1.5	1.46	0.973		TC3	1.26	1.2	0.952
TC4	1.51	1.47	0.974		TC4	1.54	1.47	0.955
AI1	1.25	1.27	1.016		AI1	1.25	1.21	0.968
AI2	1.25	1.25	1.000		AI2	1.48	1.49	1.007
AI3	1.49	1.49	1.000		AI3	1.26	1.22	0.968
AI4	1.51	1.5	0.993		AI4	1.5	1.51	1.007
SP1	1.25	1.23	0.984		SP1	1.24	1.26	1.016
SP2	1.27	1.24	0.976		SP2	1.5	1.45	0.967
SP3	1.5	1.51	1.007		SP3	1.24	1.24	1.000
SP4	1.51	1.5	0.993		SP4	1.56	1.44	0.923
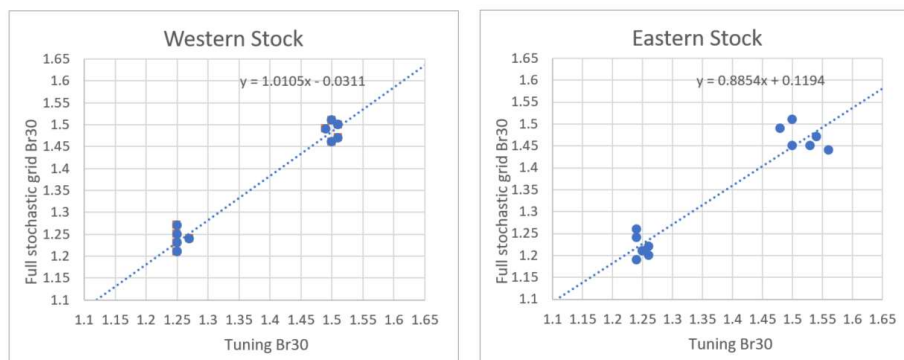
Figure 2. Correspondence of Br30 (biomass relative to BMSY after 30 projected years) between the tuning OMs (x axis) and the full stochastic grid (y axis) for four tunings and three CMP types.

2   Progress with respect to tasks and deliverables

All contracted tasks (Table 2) and deliverables (Table 3) were completed on time.

The exception to this was Deliverable 10 regarding the specification and fitting of operating models. Of the 11 robustness tests (44 OMs in total) all were completed except for 1 (4 OMs) – the non-linear indices OM would not converge and an alternative is being investigated where only future changes in index linearity are simulated.

Table 2. Status of 2021 contract tasks/activities. Green denotes a completed task.

Task / activity	Status
1. Attending meetings (including preparation)	
2. Reconditioning (including reporting of individual OMs, comparisons among OMs and index fits)	
3. Comparative analysis on of reconditioned OMs with previous OMs (+ SCRS paper)	
4. Reconstructing R package with new OM grid and OMs	
5. Revise package documentation include CMP dev guide	
6. CMP development (+SCRS paper)	
7. Assisting in code review (commenting code / cross-referencing TSD, working with reviewer)	
8. Remake the ABTMSE shiny App with the new design of reference OM grid	
9. Consolidate CMP results and upload to ABTMSE shiny R app	
10. Specify and fit robustness OMs	
11. Final Report of activities	

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Table 3. Status of 2021 contract deliverables (green denotes completed, yellow are preliminary but not finalized, red are not completed).

Deliverable	Date	Status
1. Data reconditioning with individual and comparative OM reports	31 May 2021	**See splash page for OM reports.**
2. Comparative analysis of old versus new conditionings (SCRS paper submitted for TT MSE meeting)	5 July 2021	**Appendices E, H**
3. Reconstructed R package (two weeks prior to July 5th TT MSE meeting)	20 June 2021	**See splash page for links to R package**
4. Package documentation including CMP developers guide (two weeks prior to TT MSE meeting)	20 June 2021	**Appendix V, see splash page for further documentation**
5. CMP development and refinement (SCRS paper on revised CMP for BFT intersessional meeting)	1 Sept 2021	**Appendices B, C, D, I, K**
6. Remake Shiny App for new OM grid	1 Sept 2021	**See revised Shiny app**
7. Consolidation of CMP results and upload to new Shiny App (for BFT intersessional meeting)	1 Sept 2021	**See revised Shiny app**
8. Annotated code cross-referenced with annotated TSD	15 July 2021	**Appendix A. Annotated code is available on the ICCAT GitHub: https://github.com/ICCAT/abft-mse**
9. Overview report of the results of the code review and any applied changes	31 Dec 2021	**No substantive changes to code necessary. TSD documentation changes made.**
10. Specify and fit robustness OMs (for BFT intersessional meeting)	1 Sept 2021	**Appendix F.**
11. Final report	31 Dec 2021	**This document.**

3   MSE development priorities and 'carry over' requests

While all aspects of the ABTMSE framework are improved and now provide a suitable basis for CMP selection, the progress map is essentially unchanged from that reported at the end of Phase 10 (Figure 3).

The MSE framework is complete but all components downstream of the Management Procedures and the Management Objectives are currently not finalized (Figure 3).

3.1   Further CMP development and tuning

Following instruction from Panel 2 meetings, CMP developers have guidance on appropriate caps on East area TAC. These should be codified in CMPs and these retuned to development tuning targets.

3.2   Tools in support of CMP shortlisting and selection

Further tables, graphics and figures will be necessary to support the necessary process of reducing the list of candidate MPs. These tools could include methods of satisficing or CMP ranking and will evolve following feedback from the MSE technical team, the species working group and commissioners.

3.3 Shiny App

The importance of a centralized location for the presentation of MSE results cannot be underestimated. The Shiny App should be revised to account for OM plausibility weighting, other performance metrics and any suggested additional results plots and tables.

3.4 Additional Robustness OMs

At the September intersessional meeting, the group identified two additional robustness operating models for development, one that is forced to fit the US_RR_66_144 index and another that does not include the ad-hoc weighting required by the single operating model (OM #35) during reconditioning.

A modification of the non-linear indices robustness test should also be investigated that does not necessarily require refitting but rather imposes non-linearity in projected indices only.
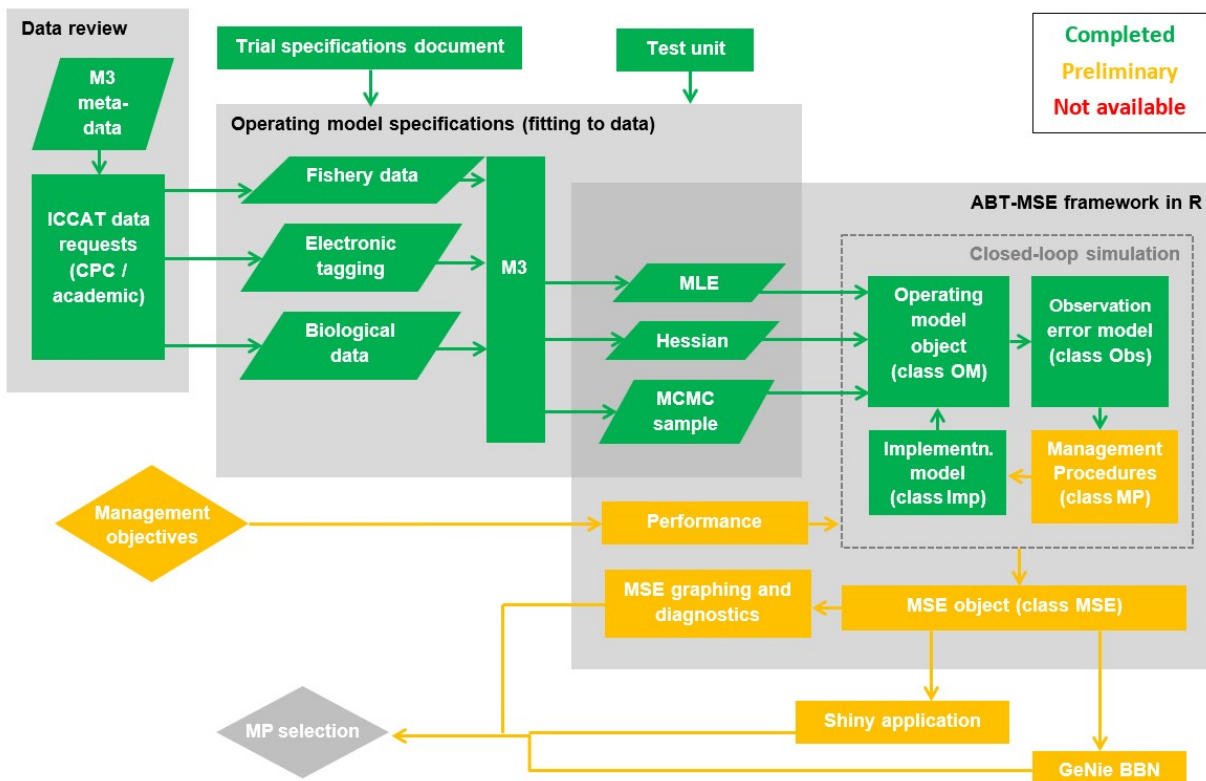

Figure 3. Current status of the components of the ABT MSE framework given that candidate MPs are still in development (and hence all components downstream are still not finalized).

Acknowledgments

4 Appendices

Appendix A BFTMSE_TSD21-03_9Sept2021.docx
Appendix B SCRS_2021_P_X1_CMP results and further refinement of BR and TC CMPs.pptx
Appendix C SCRS_2021_P_46_CMP results comparison Carruthers.pptx
Appendix D SCRS_2021_046 Updated CMP Results.docx
Appendix E SCRS_2021_124 Overview of Reconditioning Results v8.docx
Appendix F SCRS_2021_125 Overview of Robustness OMs 2021_v2.docx
Appendix G Progress since April and June Agenda 2.pptx
Appendix H Review of Reconditioning Agenda 3_1 - 3_3.pptx
Appendix I CMP results Agenda 4_2 - 4_3.pptx
Appendix J SCRS_2021_P_050 BFT MSE Consultant's update on work since July meeting Carruthers.ppt
Appendix K SCRS_2021_P_051 Updated CMP results Carruthers.pptx
Appendix L Proposal for a dedicated stochasting tuning OM v3.docx
Appendix M Proposal to develop a dedicated stochastic tuning OM.pptx
Appendix N An illustrative example of satisficing.pptx
Appendix O An illustrative example of satisficing v3.docx
Appendix P SCRS_2021_028_Carruthers.pdf
Appendix Q SCRS_2021_P_28 AI CMP Carruthers.pptx
Appendix R SCRS_2021_xx SPx_CMPs Carruthers.docx
Appendix S SCRS_2021_xx TCx_CMPs Carruthers.docx
Appendix T SCRS_2021_0XX Ad-hoc DIM Carruthers v3.docx
Appendix U SCRS_2021_022_Butterworth_et_al.pdf
Appendix V CMP-Developers-Guide.html