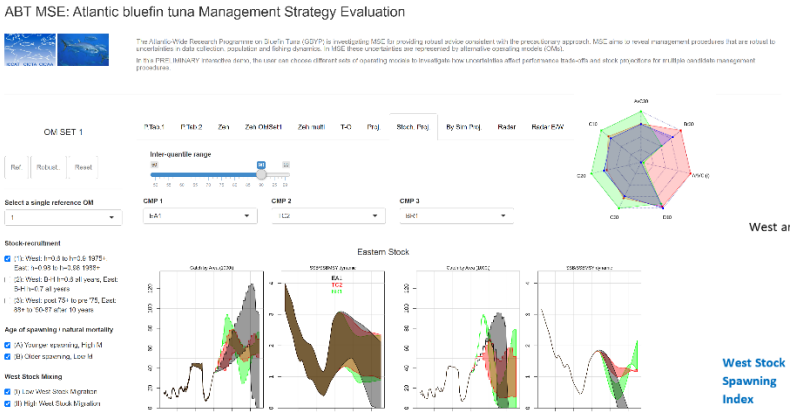
Evaluating Management Strategies for Atlantic Bluefin Tuna

Report 8: a comprehensive interim reference OM grid, flexible multi-stock CMP and an interactive online Application for MSE results.

December 9th 2020

SHORT-TERM CONTRACT FOR THE
MODELLING APPROACHES: SUPPORT TO BLUEFIN TUNA STOCK ASSESSMENT
(GBYP 06/2020)
OF THE ATLANTIC-WIDE RESEARCH PROGRAMME FOR BLUEFIN TUNA (ICCAT GBYP – Phase 10)

This project is co-funded by the European Union



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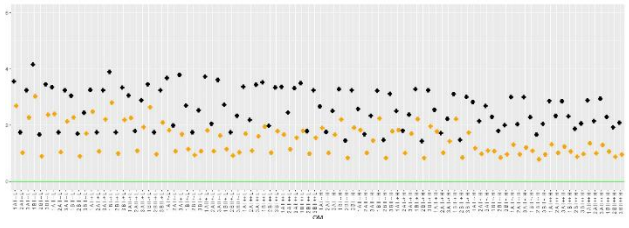

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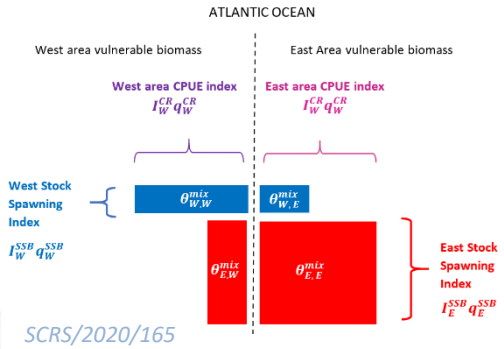

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Executive Summary

This contract saw the most substantial step forward yet in the development of a comprehensive and defensible MSE framework from which to provide management advice.

Firstly, an interim reference operating model grid was identified that passed the majority of the 'red-face' tests identified by the group spanning axes of uncertainty relating to recruitment regime, stock productivity (somatic growth and natural mortality rate), western stock mixing, scale and weighting of the length composition data. Secondly, six independent developer groups initiated the development and then tuning of more than 25 CMPs. Thirdly, the online Shiny App for presenting MSE results was fully updated and then revised adding features requested by the group. Lastly, functions were created that allow CMP developers to run MSEs locally and then load these to the Shiny App to view results.

A 2021 reconditioning of the operating models, a code review and further CMP development are the key remaining hurdles prior to the potential selection and implementation of an MP for Atlantic bluefin tuna.

All tasks and deliverables listed in the contract were completed on time.

Principal developments

- Updated M3 model to version 6 with added stock-specific scale as an OM prior.
- Now comprehensive trial specifications document (Appendix A)
- A new grid of reference set OMs coded and fitted.
- New robustness set OMs coded and fitted.
- Produced extensive index fit diagnostic reports to support index selection and OM plausibility rating (Appendix B)
- Provided functions for visualizing MSE projections of biomass, recruitment and simulated indices.
- Developed an MP that accounts for stock mixing and provides amongst the most promising performance of the current preliminary set of operating models (Appendix C).
- Updated MSE ABTMSE R package to (1) include the revised Shiny App so that it can be run locally, (2) perfect OM matching of the estimation model and (3) include MSE results compilation functions for uploading to the online Shiny App.
- Hosted the ABT MSE Shiny App on an online server: http://142.103.48.20:3838/ABTMSE/
- An extensive 'does it matter' analysis where potentially problematic model behavior was corrected and MSE projections undertaken to detect whether these scenarios were influential in CMP behavior.
- Comprehensively address issues raised in a partial and unofficial code review by Dr Fernandez.
- Update OM report to include model estimates of relative abundance in the South Atlantic area, fraction of spawning biomass in the natal area, and other pertinent red-face tests.
- Developed code to assist developers in tuning their CMPs.
- Developed an exceptional circumstances protocol using only existing indices, with considerable power to detect scenarios where western biomass is depleted to low levels.
- Five SCRS papers and six presentations covering OM reconditioning, a multi-stock CMP, the 'does it matter' analysis and relative performance of CMPs (Appendices C-E).

Extra-Contract Tasks

More than 100 model, CMP, shiny App and data changes following requests from the Bluefin Tuna Working Group and MSE Technical Group.

Contents

1 Review of contract activities

1.1 A new reference OM grid including east-west scale MSE TT meeting (February 2020)

Arguably the most pivotal point in the MSE development process was the finding that the data provide only weak information about the scale of the East and West stocks, requiring prior ranges for stock scale. A revised M3 model (v6.6.x) includes such a prior and from February onwards the scale of the East and West stocks was adopted as an axis of uncertainty in the interim reference OM grid (Figure 1). The new grid is documented in the latest update to the Trial Specifications document which now comprehensively addresses most sections that were previously missing text (Appendix A). Adding priors for stock scale greatly improves the reliability of OM conditioning and removes much of the concern regarding model instability that may arise from reconditioning.

New Grid

New, coming in to meeting after Feb WebEx

New, during meeting

	Western stock	Eastern stock
Recruitment		
1	B-H with h=0.6 ("high R0") switches to h = 0.9 ("low R0") starting from 1975	50-87 B-H h=0.98 switches to 88+ B-H *h*=0.98
2	B-H with h=0.6 fixed, high	B-H with h=0.7 fixed, high R0
3	Historically as in Level 1. In projections, "low R0" switches back to "high R0" after 10 years	Historically as in Level 1. In projections, 88+ B-H with *h*=0.98 switches back to 50-87 B-H with *h*=0.98 after 10 years.
Spawning fraction both stocks		Natural Mortality rate both stocks
A	Younger (E+W same)	High
B	Older (E+W older but different for the 2 stocks)	Low
Western stock mixing into East area		
I	1% western stock biomass in east area on average from 1965-2016	
II	20% western stock biomass in east area on average from 1965-2016	
Scale	Western area	Eastern area
--	15kt	200kt
-+	15kt	400kt
+-	50kt	200kt
++	50kt	400kt
Length composition weight		
L	0.05	
H	1	

Figure 1. Latest interim reference grid of OMs (TSD, Appendix A).

1.2 Relative abundance index selection and simulation MSE TT meeting (February 2020)

A key task undertaken at the start of 2020 was the formal examination of the various relative abundance indices. A number of diagnostics and standardized reports were developed by the MSE technical group from which a standardized index evaluation report was developed (Figure 2, see Appendix B for an example report).

3 Standard Deviation of Residuals

Table 1. Standard deviation in log residuals

CSV Excel

OM	R	P	M	S	L	MOR POR TRAP	JPN LL NEAtl2	US RR 66 114	US RR 115 144	US RR 177	US GOM PLL2	JPN LL West2	CAN GSL	CAN SWNS	FR AER SUV2	MED LAR SUV	CAN ACO SUV	GOM LAR SUV	GBYP AER SUV BAR
1	1	A	I	--	L	0.3	0.54	0.77	0.72	0.64	0.47	0.47	0.75	0.54	0.66	0.32	0.29	0.55	0.43
2	2	A	I	--	L	0.25	0.43	0.71	0.62	0.65	0.47	0.79	0.89	0.62	0.85	0.34	0.3	0.56	0.26
4	1	B	I	--	L	0.32	0.33	0.8	0.72	0.65	0.45	0.46	0.73	0.58	0.66	0.36	0.28	0.57	0.41
5	2	B	I	--	L	0.28	0.52	0.67	0.62	0.72	0.47	0.73	0.97	0.69	0.79	0.42	0.31	0.58	0.17
13	1	A	I	-+	L	0.29	0.56	0.76	0.71	0.63	0.47	0.47	0.73	0.53	0.65	0.32	0.3	0.55	0.42
14	2	A	I	-+	L	0.25	0.46	0.75	0.63	0.66	0.47	0.79	0.88	0.57	0.83	0.36	0.3	0.55	0.26
16	1	B	I	-+	L	0.31	0.34	0.8	0.73	0.65	0.45	0.46	0.71	0.56	0.66	0.35	0.28	0.57	0.36
17	2	B	I	-+	L	0.27	0.45	0.73	0.63	0.69	0.47	0.8	0.96	0.61	0.83	0.4	0.33	0.57	0.22
25	1	A	I	+-	L	0.31	0.52	0.79	0.73	0.66	0.49	0.48	0.77	0.53	0.66	0.32	0.29	0.6	0.44
26	2	A	I	+-	L	0.25	0.39	0.73	0.62	0.65	0.47	0.8	0.84	0.6	0.88	0.33	0.28	0.56	0.27
28	1	B	I	+-	L	0.32	0.35	0.69	0.62	0.55	0.6	0.53	0.84	0.58	0.74	0.32	0.3	0.7	0.28
29	2	B	I	+-	L	0.28	0.43	0.7	0.63	0.72	0.48	0.71	0.94	0.66	0.82	0.39	0.3	0.59	0.16
37	1	A	I	++	L	0.3	0.55	0.78	0.72	0.66	0.49	0.48	0.74	0.52	0.65	0.32	0.29	0.6	0.42
38	2	A	I	++	L	0.26	0.46	0.75	0.65	0.69	0.48	0.77	0.89	0.56	0.85	0.33	0.28	0.57	0.22
40	1	B	I	++	L	0.31	0.34	0.81	0.72	0.66	0.5	0.47	0.77	0.54	0.67	0.3	0.31	0.63	0.35
41	2	B	I	++	L	0.27	0.46	0.76	0.65	0.71	0.48	0.78	0.9	0.58	0.86	0.38	0.31	0.58	0.2

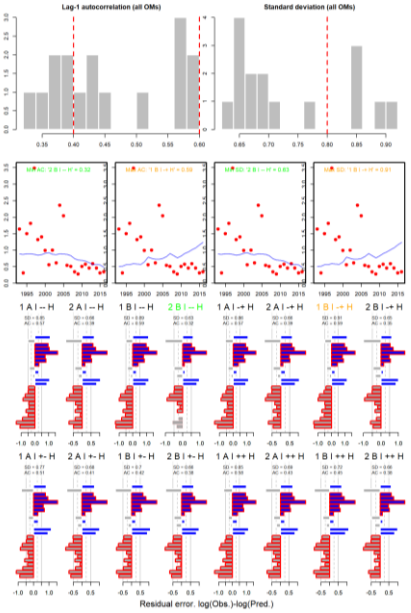


Figure 2. An example of an index diagnostic table and figures from the index summary report.

The index fitting reports also provided an important reference for evaluating the plausibility of various operating models.

1.3 Demonstration of exact estimation model replication in the R MSE framework presented at the Species Group webinar (March 2020).

During the previous contract, a rushed attempt to update MSE projection code led to mismatches in the model fits versus the dynamics recreated in the R MSE framework. To provide the necessary transparency and reassurance to the group, a number of plots were produced demonstrating exact reproduction of estimated dynamics in the R framework for any OM (Figure 3).

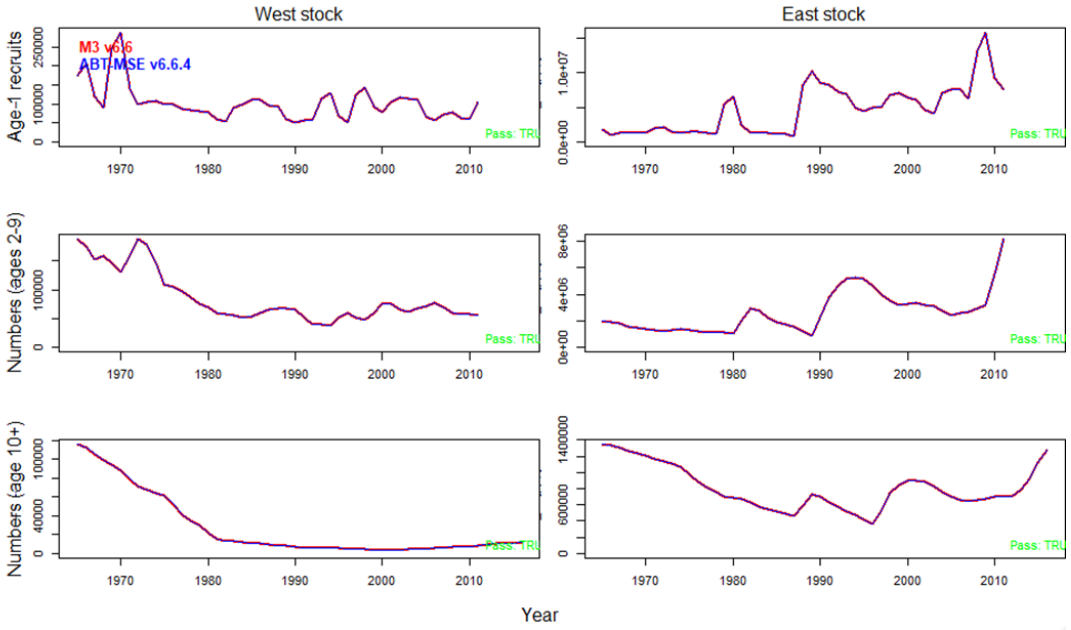


Figure 3. Model matching diagnostics in the new ABTMSE R package.

1.4 Diagnostics for index and biomass simulation in MSE projections MSE TT webinar (May 2020)

Similarly to matching of dynamics it was considered essential to be able to show index simulation in MSE projection years. All simulated index observations are now stored in the MSE object and an index plotting function was added to the ABT MSE R package that shows the 'perfect information' vulnerability trend in addition to the simulated index observations (Figure 4)

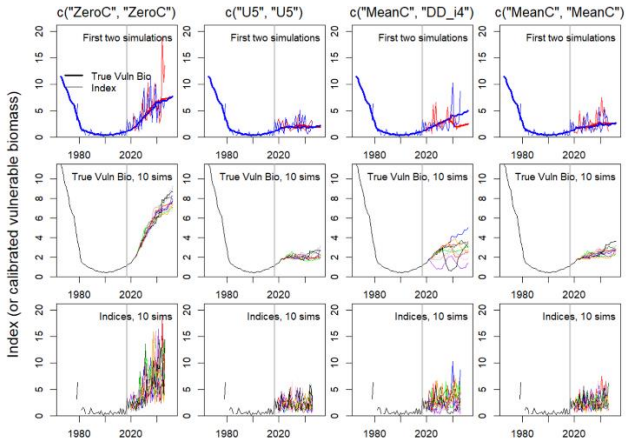


Figure 4. The simulated index plotting features.

In addition to the plotting of simulated indices, the group requested plots to verify that future biomass projections were being calculated as intended and also to better understand the various unfished biomass statistics such as 'dynamic SSB0' (Figure 5).

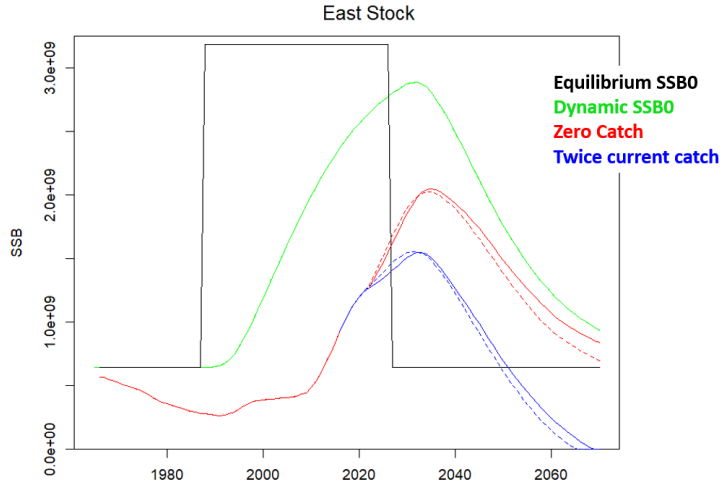
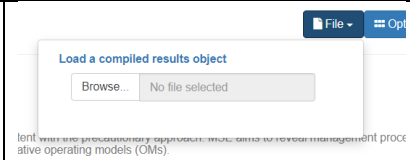
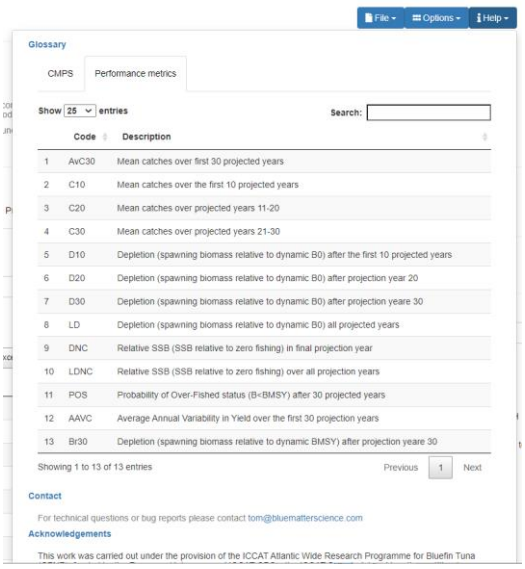
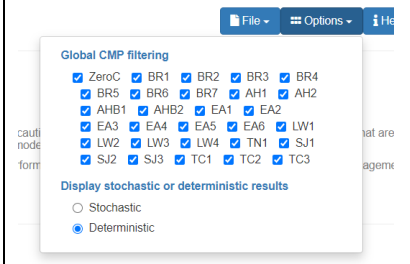
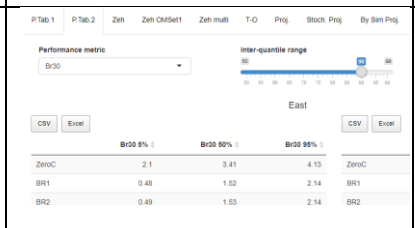
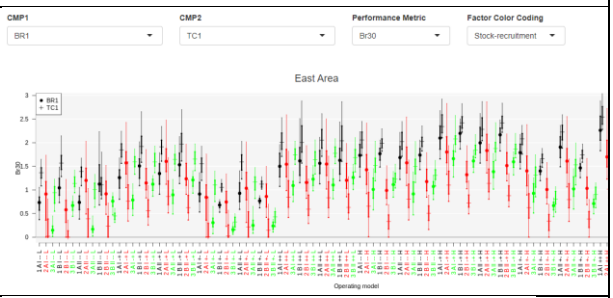
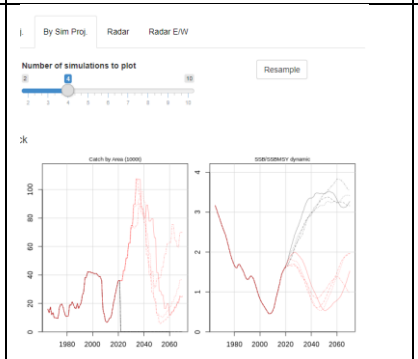
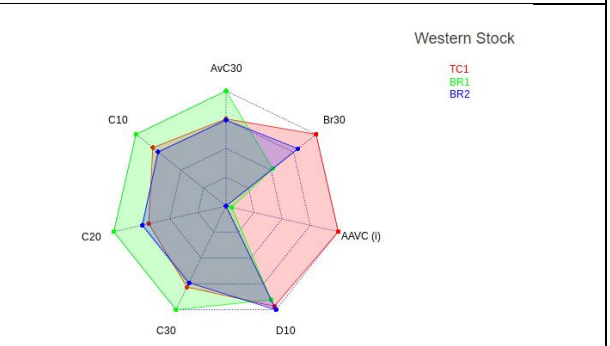
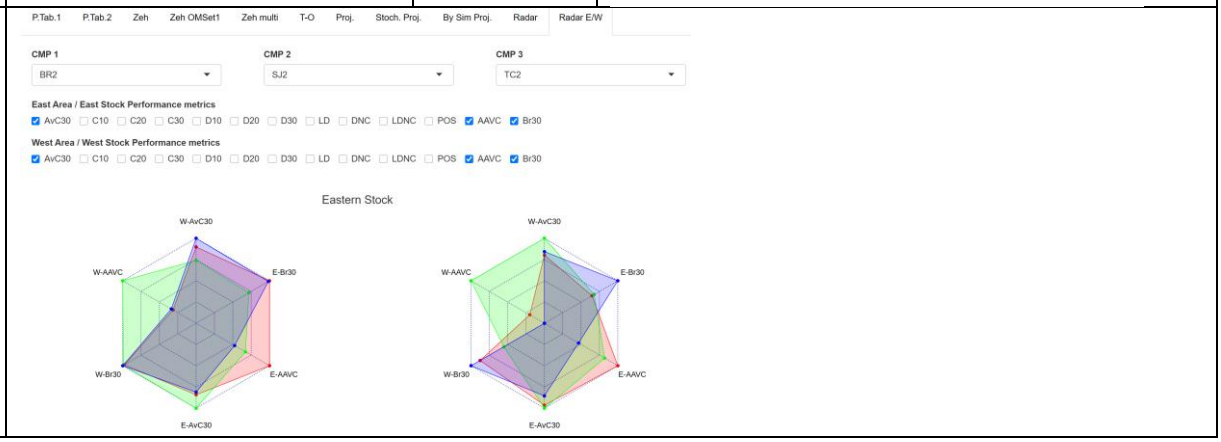


Figure 5. The spawning biomass and recruitment plotting features.

1.5 Updated Shiny App, hosted on an online server http://142.103.48.20:3838/ABTMSE/ and presented at the MSE TT webinar (May 2020)

Table 1. New additions to the Shiny App:

Menu dropdown - File I/O allowing users to upload their results to the App		Menu dropdown – glossary of Performance Metrics and CMPs	
Menu dropdown - Filtering of CMPs and stoch. vs deter. simulations.			
Tab panel – uncertainty in performance metrics with user-specified range		Tab panel – CMP comparison among OMs with factor level color coding	
Tab panel – simulation specific outcomes with adjustable simulation numbers		Tab panel – multi-metric radar plots of CMP performance were added	
Tab panel – cross-stock trade-off evaluation via radar plots			

1.6 'Does it matter' analysis presented at the Species Group webinar (July 2020).

A number of group members expressed concern about specific OM model estimates for example, the fraction of the stock found in the South Atlantic area, the fraction of spawning stock biomass entering the natal area in the spawning season and the fraction of western age-1 fish found in the East area. The M3 model was revised to include priors for these phenomena and modified OMs were fitted that forced estimates to alternative values. In all cases these model attributes were not consequential in determining CMP performance or created severe mis-fits to data.

OM	Rec	Prod	Mix	Scale	Lcomp	East.Br30	East.Dif	West.Br30	West.Dif	nLL.Dif
4a	R1	B	MixI	"--"	L	1.92	-0.07	0.85	0.18	430
4b	R1	B	MixI	"--"	L	1.59	-0.4	0.61	-0.06	249
4c	R1	B	MixI	"--"	L	0.84	-1.15	0.51	-0.16	1025
4d	R1	B	MixI	"--"	L	1.63	-0.36	0.76	0.09	127
4	R1	B	MixI	"--"	L	1.99	0	0.67	0	0
5a	R2	B	MixI	"--"	L	0.85	0.12	0.46	0.07	198
5b	R2	B	MixI	"--"	L	0.75	0.02	0.41	0.02	-87
5c	R2	B	MixI	"--"	L	0.7	-0.03	0.36	-0.03	475
5d	R2	B	MixI	"--"	L	0.87	0.14	0.41	0.02	-180
5	R2	B	MixI	"--"	L	0.73	0	0.39	0	0
6a	R3	B	MixI	"--"	L	1.24	-0.2	0.24	0.1	430
6b	R3	B	MixI	"--"	L	0.82	-0.61	0.09	-0.05	249
6c	R3	B	MixI	"--"	L	0.24	-1.19	0.01	-0.13	1025
6d	R3	B	MixI	"--"	L	0.97	-0.46	0.17	0.03	127
6	R3	B	MixI	"--"	L	1.43	0	0.14	0	0

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Figure 6. An example of the 'does it matter analysis'. For operating models #4-6 four derivations a-d were fitted that had priors for certain model estimates. The table shows the difference in biomass outcomes from the default OM that does not include a-d in its name.

1.7 CMP comparisons and tuning exercises at the MSE Technical Team WebEx (September 2020).

All CMP results were compiled prior to the meeting and results demonstrated in an updated Shiny App (Figure 7). The results of preliminary CMP tunings were presented to the group and default tunings for the Western stock biomass only, were proposed for presentation at the December species group meeting.

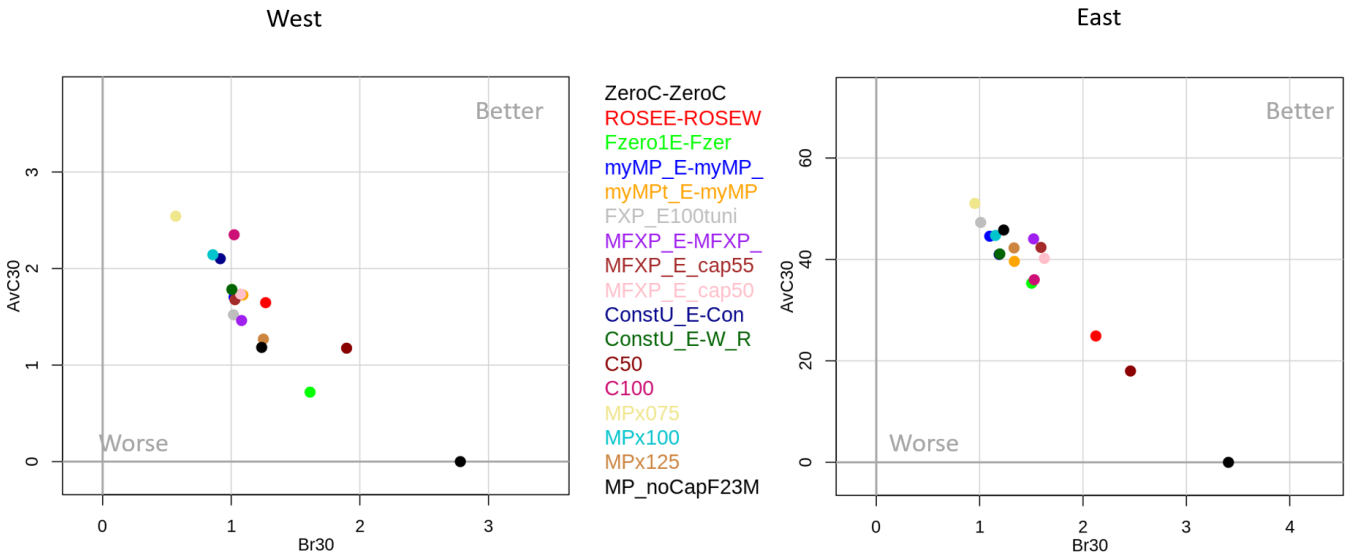


Figure 7. CMP trade-offs between average 30 year projected yield and biomass relative to dynamic BMSY after 30 years.

1.8 Robustness OMs, Alternative tunings, CMP comparisons and evaluation of OM estimates at the Species Group Webinar (December 2020).

A the model estimates and fit of the robustness OM estimates was presented to the group, concluding that there were no immediate indications that they were remarkably different from the reference set OMs (Figure 8).

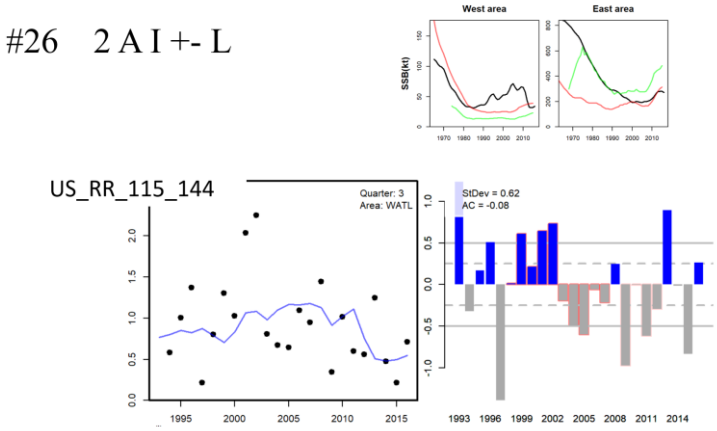


Figure 8. The western trend phenomenon and empirical support according to a West Area index.

More than 29 CMPs were presented to the group according to their tunings. The clear message arising from this was that tuning was beneficial exercise and clearly shows where CMP developers have the opportunity to borrow ideas form one another to improve performance (Figure 9).

A detailed evaluation of OM estimates of West area trend was carried out to establish whether there was empirical evidence for these trends in the data. It was concluded that trends inconsistent with previous assessments were possible in a mixed stock model and consistent with at least some of the data in the West Atlantic.

CMP results median Western Br30 ~ 1

	West Area / Western Stock		East Area / Eastern Stock	
CMP	AvC30	Br30	AvC30	Br30
ZeroC	0.00	2.78	0.00	3.41
BR1	1.74	1.00	44.54	1.52
AH1	1.50	1.14	29.46	1.57
AHB1	1.97	1.03	31.56	1.66
EA1	1.73	0.99	44.57	1.10
EA2	1.90	0.98	39.59	1.33
LW1	1.57	1.00	44.68	1.00
TN1	1.80	0.97	41.22	1.19
SJ1	1.59	0.99	45.08	1.00
TC1	2.00	1.06	36.19	1.36

Varying average yields

Varying Eastern Outcomes

Figure 9. Comparison of biomass and yield outcomes for 9 CMPs tuned to Br30 =1 in the West.

2 Progress with respect to tasks and deliverables

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

Table 2. Status of 2020 contract tasks. Green denotes a completed task.

Task	Status
1. Condition reference set OMs and key Robustness set OMs for presentation shortly before the February TT Meeting	
2. Complete TS doc updates, particularly specification of revised OMs, equations for OM conditioning and simulation of future data before the February TT Meeting.	
3. Create presentations for new OMs and simulation of future data – both ppts and documents for the February meeting and possible prior webinar	
4. Attend February TT Meeting and update analyses there as directed by the meeting	
5. Update OM conditioning as directed by February meeting prior to April	
6. Repackage ABT MSE R framework for forward projection 3 weeks prior to May [April] BFT working group meeting to allow CMP developers to attempt initial usage and provide feedback comments to the April meeting	
7. Develop own preliminary CMP for testing, time permitting	
8. Attend April meeting and update analyses there as directed by the meeting	
9. If necessary, update coding (including of the Package) and conditioning as directed by the April meeting, prior to July meeting	
10. Use example results from May [April] CMPs and the Package to reformulate the Shiny App for presenting results, prior to July meeting	
11. Host (given access to a suitable server) the App so that the group can easily interact with it prior to July meeting	
12. Refine own CMP and provide technical assistance to other developers	
13. Create presentation on early CMP results (including both own CMP, and results provided by other CMP developers) with respect to reference set and key robustness set uncertainties, prior to July meeting	
14. Attend July meeting and update analyses there as directed by the meeting	
15. If necessary, update coding (including of the Package) and conditioning as directed by the July meeting, prior to September meeting	
16. Reformulate the Shiny App for presenting results, if so directed by the July meeting, prior to September meeting	
17. Further refine own CMP and provide technical assistance to other developers	
18. Create presentation on early CMP results (including both own CMP, and results provided by other CMP developers) with respect to reference set and key robustness set uncertainties, prior to September meeting	
19. Attend September MSE meeting and update analyses there as directed by the meeting	
20. Work with Chairs at and after that meeting to create a concise summary of progress for the Commission	
21. Implement any pertinent recommendations for coding and computations that may arise from the September-October MSE meeting, bluefin species group and SCRS meetings, before the end of the Contract	

Table 3. Status of 2020 contract deliverables (green denotes completed, yellow are preliminary but not finalized, red are not completed).

Deliverable	Date	Status
1. Updated Trial Specifications Document.	20 Feb 2020	Appendix A
2. PP presentations – new OMs and simulation of future data.	20 Feb 2020	Appendix F
3. Updated ABT_MSE R framework (forward projection). V6.6.x	27 Mar 2020	
4. Updated Shiny App, published on web server.	17 July 2020	
5. PP presentation – early CMP results	17 July 2019	Appendix G
6. PP presentation – early CMP results	14 Sept 2020	Appendix H
7. Draft final report	10 Dec 2020	
8. Final report	28 Dec 2020	

3 MSE development priorities and 'carry over' requests

Although the credibility, objectivity and behavior of the conditioned operating model (M3) and the data inputs are now sufficiently improved to be used in CMP selection, the progress map is essentially unchanged from that reported at the end of Phase 9 (Figure 10).

The MSE framework is complete but all components downstream of the Management Procedures and the Management Objectives are currently not finalized (Figure 10).

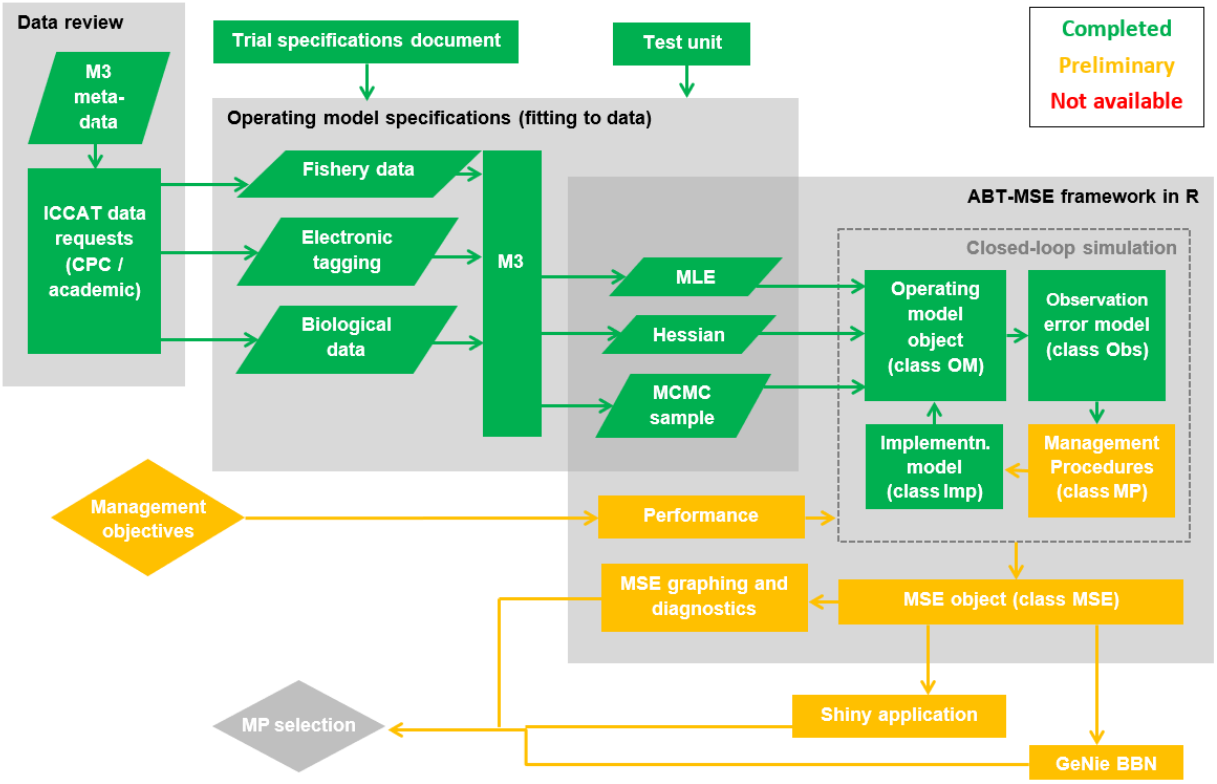


Figure 10. Current status of the components of the ABT MSE framework showing the preliminary nature of Management Procedures and Management objectives (and hence all components downstream).

3.1 OM reconditioning

The group has approved a reconditioning of operating models to update data to 2018 and include recalculated indices. The magnitude of this task is not yet known exactly because data are not available with which to conduct exploratory model fitting. This task will require the production of a fresh suite of OM reports including summaries of what has changed due to reconditioning.

3.2 CMP development and tuning

Developers require the opportunity to borrow ideas and further refine their CMPs to maximize performance. Tuning specifications for the eastern stock may be necessary in addition to the western stock given that there appears to be a cost of eastern catches on western biomass.

3.3 OM plausibility weighting

An OM plausibility weighting approach following the 'Delphi approach' has been suggested that will require the weighting of OMs in the presentation of results.

3.4 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.

Acknowledgments

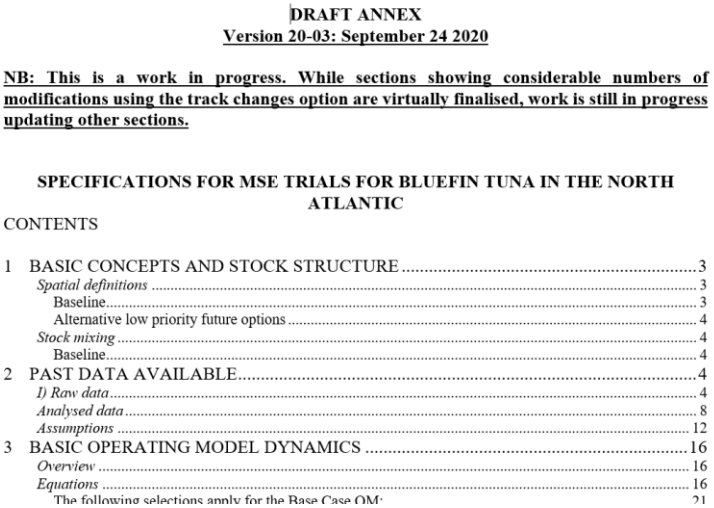
Many thanks in particular to Ai Kimoto and Mauricio Ortiz for technical support, Francisco Alemany for directing the project, Carmen Fernandez for her hard work in checking the M3 estimation models and Doug Butterworth for organizing all aspects of MSE framework development. Thanks also to the various CMP developer teams for their willingness to take on computational work and submit results.

This work has been carried out under the ICCAT Atlantic-Wide Research Programme for Bluefin Tuna (GBYP), which is funded by the European Union, several ICCAT CPCs, the ICCAT Secretariat, and other entities (see https://www.iccat.int/gbyp/en/overview.asp). The content of this paper does not necessarily reflect ICCAT's point of view or that of any of the other sponsors, who carry no responsibility. In addition, it does not indicate the Commission's future policy in this area.

4 Appendices

4.1 Appendix A: (Deliverable 1) Updated Trial Specifications Document

A revised TSD now has details about catch allocations, index observation error models and catch redistribution algorithms.



DRAFT ANNEX
Version 20-03: September 24 2020

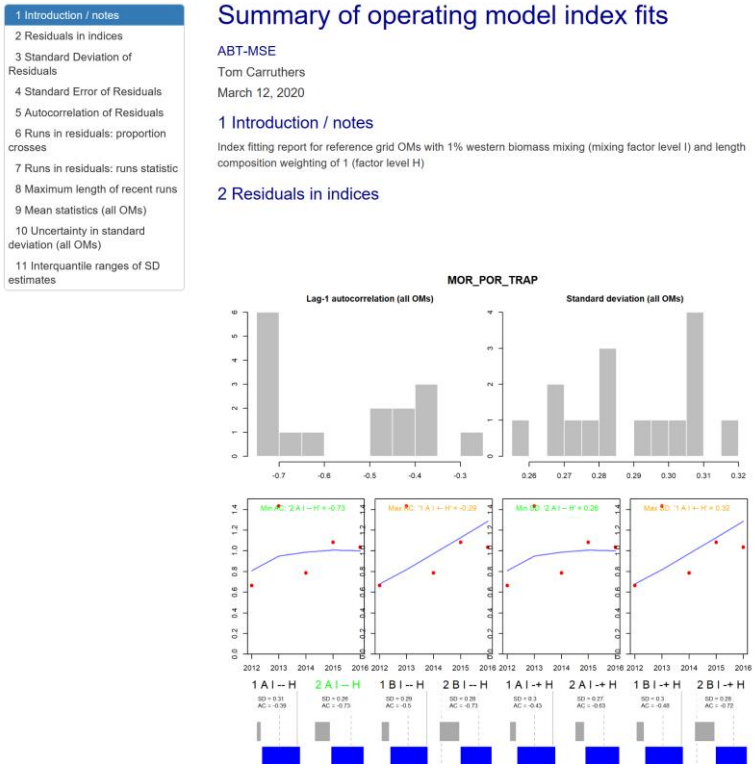
NB: This is a work in progress. While sections showing considerable numbers of modifications using the track changes option are virtually finalised, work is still in progress updating other sections.

SPECIFICATIONS FOR MSE TRIALS FOR BLUEFIN TUNA IN THE NORTH ATLANTIC

CONTENTS

4.2 Appendix B: An example of a detailed index fitting report

A standardized report allowing for detailed statistical comparison of OM fits to the various indices.



Summary of operating model index fits

ABT-MSE

Tom Carruthers

March 12, 2020

1 Introduction / notes

Index fitting report for reference grid OMs with 1% western biomass mixing (mixing factor level I) and length composition weighting of 1 (factor level H)

2 Residuals in indices

MOR_POR_TRAP

Lag-1 autocorrelation (all OMs)

Standard deviation (all OMs)

1 A I -- H 2 A I -- H 1 B I -- H 2 B I -- H 1 A I -+ H 2 A I -+ H 1 B I -+ H 2 B I -+ H

4.3 Appendix C: SCRS on a Multi-stock CMP and exceptional circumstances protocol

A full mathematical description of the MPx CMP, the results of the tuned CMPs and also a powerful index-based exceptional circumstances protocol.

SCRS/2020/165

DESIGNING AND TESTING A MULTI-STOCK SPATIAL MANAGEMENT PROCEDURE FOR ATLANTIC BLUEFIN TUNA

T. R. Carruthers[1]

SUMMARY

The MPx CMP was updated and tuned to three biomass targets for the western stock and then run for both the deterministic and stochastic operating models of the reference set. Yield and biomass metrics showed a linear trade-off in the west among the tuned CMPs. The CMPs provided almost identical performance with respect to eastern stock and East area metrics. Operating models that assumed a single historical and future recruitment regime (recruitment level II) often led to simulations dropping below half BMSY for the Western stock. Stock status outcomes were generally worse under the stochastic operating models in comparison to the deterministic operating models. Two demonstration exceptional circumstances protocols were investigated. The protocol based on the level and slope of the GOM_LAR_SUV index provide a high probability of detecting western stock levels below 50% BMSY.

KEYWORDS

Management Strategy Evaluation, bluefin tuna, operating model, management procedure

4.4 Appendix D: SCRS on CMP development tuning

A demonstration of CMP tuning and an explanation for the rationale and benefits.

SCRS/2020/149

DEMONSTRATION OF CMP DEVELOPMENT TUNING FOR ATLANTIC BLUEFIN TUNA

Tom Carruthers, Rebecca Rademeyer and Doug Butterworth

SUMMARY

When evaluating Candidate Management Procedures (CMPs), a fundamental trade-off exists between catch performance (what is taken from a fish stock) and biomass performance (what remains after catches). CMPs typically include control parameters that alter how management advice is calculated from data, for example providing higher catches at the cost of long-term biomass. The control parameters of two functionally different CMPs were tuned so that the CMPs obtained comparable biological performance outcomes. In doing so the performance of the CMPs could be more clearly evaluated on a 'level playing field' at the same location in the catch-biomass performance trade-off.

KEYWORDS

Atlantic bluefin tuna, CMPs, tuning

4.5 Appendix E: (Deliverable 2) SCRS providing a review of reference set operating models

Description of estimates and fitting diagnostics for the full set of 96 reference OMs

SCRS/2020/018

REFERENCE SET OPERATING MODELS (VERSION 6.5) FOR ATLANTIC BLUEFIN TUNA ASSUMING PRIORS FOR AREA-SPECIFIC SCALE AND WESTERN STOCK MIXING

Tom Carruthers[1]

SUMMARY

In this paper a relatively large reference set of operating models (version 6.5) are presented that have been conditioned on various data as well as informative "priors" for scale and western mixing. The derivation of these "priors" (actually sets of a few alternative values considered to span the plausible range) is described, and the results of the reference operating models fitted are presented. The purpose of this document is to provide sufficient information to begin a process of narrowing operating model specifications into a smaller (than the current 48 member), more manageable reference set for use in CMP development and testing. A central objective of these operating model runs is to facilitate the choice of a suitable lower bound for western mixing. Previously 5% was presented as a suitable lower bound, but a lower level still might be desirable to provide a more rigorous test of CMP performance.

Keywords: Atlantic bluefin tuna, MSE, mixing, Operating Model

4.6 Appendix F: (Deliverable 2) Reference Set OM Development.pptx

4.7 Appendix G: (Deliverable 5) Comparison of results using the Shiny App.pptx

4.8 Appendix H: (Deliverable 6) CMP results Agenda 4 updated.pptx