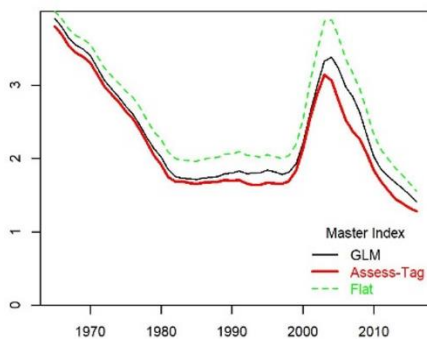


Evaluating Management Strategies for Atlantic Bluefin Tuna

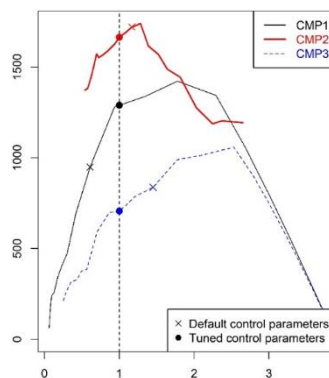
Report 7: fine-tuning operating models, data weighting and data conflicts.

December 17th 2019

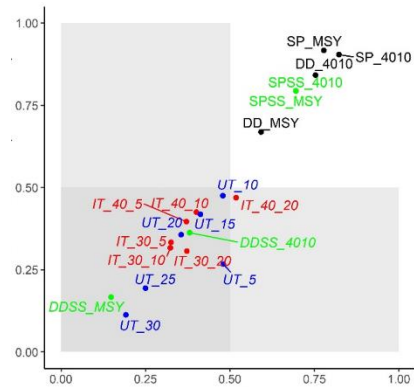
SHORT-TERM CONTRACT FOR MODELLING APPROACHES: SUPPORT TO BLUEFIN TUNA STOCK ASSESSMENT (GBYP 01/2019) OF THE ATLANTIC-WIDE RESEARCH PROGRAMME ON BLUEFIN TUNA (ICCAT-GBYP – Phase 9)



SCRS/2019/131



SCRS/2019/XX2



SCRS/2019/XX1

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Executive Summary

This contract saw the final adjustments to model configuration and data weighting. Over the course of 5 revisions, including more than 100 individual changes to the input data and model, an estimation model was developed in November and presented in December that could pass necessary red-face tests and span the range of uncertainties of the reference set operating models and recreate the scenarios of the robustness set operating models.

Completed Tasks

- Data processing checks.
- Engage in dialogue with data providers to confirm that the data are processed correctly for M3 OM conditioning.
- Update Trial Specifications document.
- Updated M3 model to version 5.
- New reference set OMs coded and fitted.
- New robustness set OMs coded and fitted.
- Fit interim grid OMs, sensitivity runs and the existing robustness set OMs.
- Updated ABT-MSE framework.
- Fully debug and add M3-ABTMSE check mode.
- Check and implement basis for transforming biennial estimates of variance and correlation in recruitment.
- Update OM report to include estimated movement probabilities, observed tag recaps and recruitment.
- Add latest interim grid OMs and robustness OMs to the package.
- Incorporate further performance statistics agreed by the March 2019 Panel 2 meeting in the package.
- SCRS paper with results for multiple alternative Master indices.
- SCRS paper on a simple model-based CMP.
- Develop an SCRS paper fully defining protocols for CMP tuning.

Extra-Contract Tasks

More than 100 model and data changes following requests from the Bluefin Tuna Working Group ('The Group')(of which the most significant are listed in Tables 2-4)

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1 Review of contract activities 2018 - 2019

1.1 Revision 1: Model and data changes requested by February 2019 MSE meeting (April - July 2019)

The February Technical Team meeting raised a number of key avenues for OM development focusing on the initialization of the model using the 'Master Index'. The group requested an investigation of the sensitivity of the model to varying master indices. A new model structure was developed that allowed for annual deviations in the fishing mortality rate pattern informed by the Master Index. This new model was tested for three widely varying Master Indices for varying levels of prior precision in the Master Index (SCRS/2019/031, Appendix 1). The results showed that model estimates were largely invariant to the choice of index given prior precisions (coefficient of variations) greater than 0.8. The model was also changed to accommodate a number of sensitivity tests and development of a range of robustness OMs (Table 2).

1.2 Revision 2: Bluefin MSE technical team meeting, St Andrews (July 2019).

During the Bluefin MSE Technical Team meeting in St Andrews two concerns surfaced regarding the fit to length composition data and the selectivity applied to the French Aerial Survey index in the Mediterranean. A number of fundamental model changes were implemented including truncation of selectivities, truncation of index selectivities and mirroring of the French Aerial Survey selectivity to match the small US RR fleet in the West. Given the data weightings of the model at that time, new fits of the model produced a 'scale issue' where the model failed to fit long-term indices, thereby no longer having to reconcile observed catches with abundance changes, leading to a gross overestimation of stock size, particularly for the Western Stock. A key recommendation arising from this finding was that a new data weighting was required and any revised data weighting should follow a transparent and principled approach that could be followed and approved by the group.

1.3 Revision 3: Model and data changes requested by July TT meeting (July – September 2019).

Following the St Andrews meeting, various data weightings were investigated and a new revision to the data was carried out by the Secretariat that split the Japanese longline fleet into older / more recent fleets to better reflect the impact of regulatory changes between these time periods.

1.4 Revision 4: MSE Technical Team and Working Group meeting (September 2019).

A fully described process for data weighting was presented to the Technical Team in September. The group requested two fundamental changes to the model to improve model parsimony and impose seasonality in Mediterranean and Gulf of Mexico biomass. A final seasonal vector was proposed for the Gulf of Mexico and a preliminary vector was proposed for the Mediterranean. The model and data input files were modified to accommodate these priors, and implement a movement exclusion matrix preventing unobserved transitions of fish.

1.5 Revision 5: Model and data changes following code review (October-November 2019).

A comprehensive review of the M3 estimation model was carried out by Dr Carmen Fernandez highlighting various areas where the model could be revised to more strictly follow best practices for parameter estimation. Dr Fernandez also identified a number of areas where the model could be simplified and estimation speed improved.

1.6 Technical team WebEx (December 2019).

A newly weighted operating model was developed including all revised changes that passed nominal red-face tests and fitted most data types as well as previous 'best case' fitted models. The model, its weighting and sensitivities were presented in a WebEx to a technical group in December. Critical feedback arising from this included the need to fit to a revised seasonal prior for the Mediterranean.

2 Progress with respect to deliverables

All deliverables were completed with the exception of the updated Shiny App which requires finalized reference set and robustness set operating models and CMPs.

Table 1. Status of 2019 contract deliverables (as with all progress tables in this document: green denotes completed, yellow are preliminary but not finalized, red are not completed).

Deliverable	Date	Status
1. Updated Trial Specifications Document.	16 May 2019	
2. Updated M3 Model (version 5).	16 May 2019	
3. Updated ABT_MSE framework.	16 July 2019	
4. Progress report (presentation and short report summarizing current status of deliverables and actions required to achieve them).	15 July 2019	
5. SCRS paper with multiple alternative Master indices.	15 July 2019	Appendix 1
6. SCRS paper on a single model-based CMP	15 July 2019	Appendix 2
7. SCRS paper fully defining protocols for CMP tuning	15 Aug 2019	Appendix 3
8. Updated Shiny App.	15 Sep 2019	
9. Draft final report.	10 Dec 2019	
10. Definitive final report	20 Dec 2019	

3 Progress with respect to February 2019 meeting requests (Revision 1)

The majority of requests from the February 2019 technical team meeting were either completed or were no longer applicable due to changes in the reference grid of operating models or for technical reasons (e.g. a scenario requested would not converge when fitted to data)(Table 2).

Of the outstanding requests that were not completed, the majority relate to presentation and reporting of results and can be addressed in future contracts following prioritisation of OM finalization (e.g. projection plots of catches, length composition and simulated indices).

Table 2. Requests arising from the February Technical Team (documented the report of that meeting). Red items have yet to be included, yellow items have been included but not tested, green items have been included and fully tested

Request	Status
Sensitivity OMs	
Investigate the impact of master index on results	Appendix 1
Alternative catch reconstruction from 1864 and 1964	
Match current selectivity of JPN LL post 2010 (monitoring of size composition)	Coded
Half mixing of eastern stock in the West Area and no western stock in East area	Did not converge
Exploration of the M-at-age from CCSBT	Robustness OM
Other weightings of the length composition data	Robustness OM
Pulse-like recruitment dynamics	Coded
Three lines Stock Recruitment model (Porch and Laretta, 2016)	
Correlation between recruitment in the 2 stocks	
Sensitivity runs	
Upweight length compositions	Robustness OM
Individually downweight the stock of origin data and electronic tagging data	Robustness OM
Upweight landings	Robustness OM
The six robustness tests of the TSD	Robustness OMs
Put the old PSAT transistion matrix into the new OMs	Was incorrect

Code MSY for Hockey stick SRR (if possible, post meeting)	Not in OMs now
Senescence: (a) age structure of current and unfished population	Coded
(b) adopting the CCSBT older age M schedule	Robustness OM

Desirable tests and further outputs

MCMC plots of B/BMSY and U/UMSY	Not completed
OM reports must show seasonality in biomass	Now in OM Rep
Allocation of future catches in projection plots	
Past and future length composition should be plotted by fleet	
OM reports should include plots for stock mixing	Now in OM Rep
Compare master index with the model implied trends	SCRS App. 1
Seasonal distribution plots	Now in OM Rep

Diagnostics

Checks of data input	OM check mode
Likelihood fits – examine contribution of various likelihood components	Now in OM Rep

Other Diagnostics not requested in February Meeting report

Produce pie charts of the spatial and seasonal distribution by stock in projection	
Future projections of simulated indices should be generated	
Unavailable (cryptic) biomass to be calculated	

4 Requests made during (Revision 2) and after (Revision 3) the July Technical team meeting in St Andrews.

During the St Andrews Technical Team meeting, a number of modelling changes were requested to address various ‘red face’ issues relating to fit to indices, catch composition data and recreation of the correct selectivity of indices (Revision 2. Table 3).

Further changes were made subsequent to this meeting that split the recent Japanese longline fleet to better approximate regulatory changes affecting fleet behavior, changed the prescribed asymptotic fleet to the rod and reel Canadian fleet and reset prior weightings to 1 in all cases (simplifying comparison of model likelihood components to just those relating to data).

Table 3. Requests made during and after the July Technical Team meeting.

Request	
Revision 2	
Truncated selectivities	
Per-datum weighted of all data (e.g. control of individual indices)	
Correct CPUE vulnerability by length	
New assumed selectivity of FR_AER (mirrors RRUSFS)	
Revision 3	
New asymptotic fleet (RRCAN)	
Revised catch and composition data (18 fleet model – JP LL split)	
All prior weighting set to 1	

5 Requests made during (Revision 4) and after (Revision 5) September Technical team / working group meeting in Madrid.

The September Technical team meeting identified spatial model estimates as a central area for development that could be potentially solved by prescribing seasonal priors for the distribution of biomass in the Gulf of Mexico and the Mediterranean (solving a ‘red-face’ issue relating to a lack of seasonal fluctuations in biomass in spawning areas) and simplifying the movement matrix by limiting movement to only those transitions that have previously been observed (Table 4). After the September meeting the M3 model and default data sets were subject to detailed review by Dr Fernandez leading to a number of changes to coding that while not necessarily consequential to outcomes, allowed the model to run 20% faster and ensured that model code and equations are technically correct (Table 4).

Table 4. Requests made during and after the September Technical and Bluefin tuna Working Group meetings.

Request	
Revision 4	
Seasonal priors for Gulf of Mexico and Mediterranean	
Movement exclusion matrix (only transitions that have been observed)	
Revision 5 (post code review of Dr Fernandez)	
MLE q estimation	
Very strong seasonal prior	
Seasonal prior now exactly related to ages (rather than length approx.)	
Tighter selectivity truncation (and asymptotic for USRRFS)	
All prior weighting set to 1	

6 Current status of objectives

Objectives relating to the inclusion of up to date OMs in the package are incomplete as these OMs are currently being refitted following revision 5 changes advised by the group (Table 5). The current state of the package still allows for the testing of CMP functional forms and debugging but not against the revised OMs (expected in early 2020).

Table 5. The status of objectives of phase 9.

Objective		Tasks
i	0% To ensure the OM scenarios agreed by the CMG in 2016 and revised in 2017, 2018 and 2019 by the Technical MSE Group and the MSE BFT Group, can be run	OM scenarios are up-to-date and a set of revisions have been suggested for 2019.
ii	50% That third parties can use the OM to evaluate candidate MPs (CMPs) of their own specifications	The R package has been updated (v4.4.5) to include the latest (February 2019) set of operating models.
iii	100% To provide/output a set of agreed summary statistics that can be used by decision makers to identify the MP, including data and knowledge requirements, that robustly meets the management objectives.	Performance metrics are up to date in the latest R package (v4.4.5) and include a very wide range of possible quantities (14 metrics relating to long and short-term yield, variation in yield and stock biomass)

7 MSE development priorities and ‘carry over’ requests

Although the credibility, objectivity and behavior of the conditioned operating model (M3) and the data inputs are much improved, the status of the MSE framework is essentially unchanged from that reported at the end of Phase 8.

The MSE framework is complete but all components downstream of the Management Procedures and the Management Objectives are currently not finalized (Figure 1).

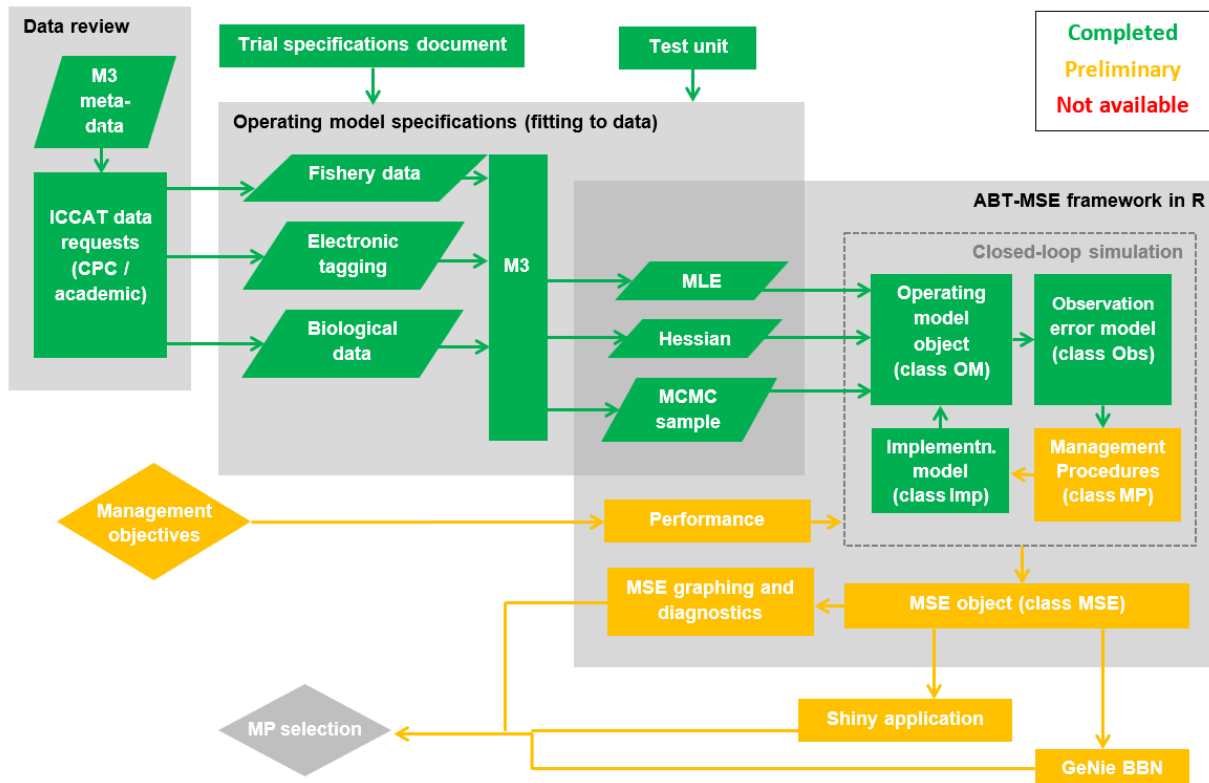


Figure 1. Current status of the components of the ABT MSE framework showing the preliminary nature of Management Procedures and Management objectives (and hence all components downstream).

7.1 Finalized reference OMs / robustness OMs

A key outcome of early 2020 meetings is the finalization of reference set and robustness set operating models to ensure the availability of an R package for CMP development but also crucially, a basis for understanding which uncertainties are critical to the outcomes of MSE (to streamline analyses and results to only those uncertainties that are consequential, ending the ‘assessment’ type of iteration that has characterized OM development thus far).

7.2 Trial Specifications update

The Trial Specifications document has been subject to substantial review (principally Drs Duprey, Fernandez and Butterworth) and careful revision.

This should be updated prior to a February technical team meeting to reflect recent changes and also include details about projection equations including the simulation of future indices and the allocation of management recommendations to fleets and regions.

7.3 R package update

Following the February 2020 Technical team meeting at which OMs are scheduled for approval, the ABT MSE package should be updated to match the latest conditioned M3 model and include any approved OMs in order to allow for CMP development.

7.4 Visualization of projected outcomes

A number of requests made by the bluefin Working Group during this contract could not be completed and relate to the visualization of MSE projections including: allocation of TACs spatially and among fleets; length compositions of fleets, simulated indices.

7.5 CMP development

A clear future priority is to finalize the R package including operating models such that CMP developers can start the process of designing, testing and tuning management procedures. A revised package also allows the wider Bluefin Tuna Working Group to better understand which of the reference set and robustness set uncertainties are impactful in determining CMP performance and their relative ranking, that may allow for a streamlining of the process to consider only those uncertainties that are consequential.

7.6 Shiny App

A Shiny App has been developed previously that can comparatively present the results of MSE outcomes across multiple OMs, CMPs and performance metrics. Given a finalized package, preliminary performance metrics and candidate management procedures, this App should be updated to provide an accessible tool for investigating MSE outcomes for a wider group of stakeholders.

Acknowledgments

Many thanks in particular to Ai Kimoto and Mauricio Ortiz for technical support, Francisco Alemany for directing the project, Nick Duprey for advancing the Trial Specifications document, Carmen Fernandez for her hard work in checking the M3 estimation models and Doug Butterworth for organizing all aspects of MSE framework development.

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8 References

- Carruthers, T.R. 2019. Master Indices for initializing spatial seasonal, multi-fleet, multi-stock models: alternative indices and sensitivities. SCRS/2019/131.
- Carruthers, T.R. 2019. Considerations for the development of model-based management procedures with examples. SCRS/2019/XX1.
- Carruthers, T.R. & Butterworth, D.S. 2019. An overview and demonstration of protocols for the tuning of candidate management procedures. SCRS/2019/XX2.

9 Appendices

9.1 Appendix 1: SCRS/2019/131. A new 'Master index' invariant operating model

A research paper describing a new operating model structure and demonstrating invariance to the values of a Master Index that is used to initialize the model.

SCRS/2019/131

Collect. Vol. Sci. Pap. ICCAT, ??(?): ???-??? (2019)

MASTER INDICES FOR INITIALIZING SPATIAL, SEASONAL, MULTI-FLEET, MULTI-STOCK MODELS: ALTERNATIVE INDICES AND SENSITIVITIES

Tom Carruthers¹

SUMMARY

Version 5 of the M3 model is presented that now calculates apical fishing mortality rates based on annual deviations from a spatial-seasonal index of abundance – the master index. Multiple indices and index weightings are proposed to test whether the model estimates of M3 version 5 are dependent on the choice of master index, a model input that has not yet been subject to detailed peer review. Three master indices of varying seasonal-spatial distribution and trend were constructed from varying data sources. When the influence of these indices was down-weighted by prescribing a large coefficient of variation in the annual deviations, M3 model predictions were similar, independent of the master index used.

KEYWORDS

Abundance indices, Spatial modelling, Operating model, sensitivity analysis, bluefin tuna, stock assessment

9.2 Appendix 2: SCRS/2019/XX1. Description and performance of model-based CMPs

A research paper describing 6 model-based CMPs and a closed-loop test of their performance for OMs with varying stock depletion and future productivity.

SCRS/2019/XX1

Collect. Vol. Sci. Pap. ICCAT, ??(?): ???-??? (2019)

CONSIDERATIONS FOR THE DEVELOPMENT OF MODEL-BASED MANAGEMENT PROCEDURES WITH EXAMPLES

Tom Carruthers¹

SUMMARY

Using operating models various in their stock status and future recruitment strength, 8 Model-based MPs and 12 empirical MPs were comparatively tested by closed-loop simulation. Model-based MPs generally out-performed empirical MPs. Empirical MPs aiming for fixed exploitation rate generally outperformed those aiming for a target index level. Model-based MPs that modelled process errors (state-space assessments) did not necessarily outperform their 'observation error only' counterparts.

KEYWORDS

Management procedure, stock assessment, management strategy evaluation, bluefin tuna

9.3 Appendix 3. SCRS/2019/XX2.

The necessity of tuning CMPs is explained and demonstrated. Code is appended that is applicable to both Bluefin and Swordfish MSE processes.

SCRS/2019/XX2

Collect. Vol. Sci. Pap. ICCAT, ??(?): ???-??? (2019)

AN OVERVIEW AND DEMONSTRATION OF PROTOCOLS FOR THE TUNING OF CANDIDATE MANAGEMENT PROCEDURES

Tom Carruthers¹, Doug Butterworth²

SUMMARY

Tuning of candidate management procedures is required to compare their performance (Stage-1 tuning) and to maximise their performance over a reference set of operating models (Stage-2 tuning). Reproducible examples of Stage-1 and Stage-2 tuning are provided here using open-source MSE software to demonstrate the necessity for tuning and to highlight important tuning considerations.

KEYWORDS

Management procedure, tuning, management strategy evaluation, bluefin tuna