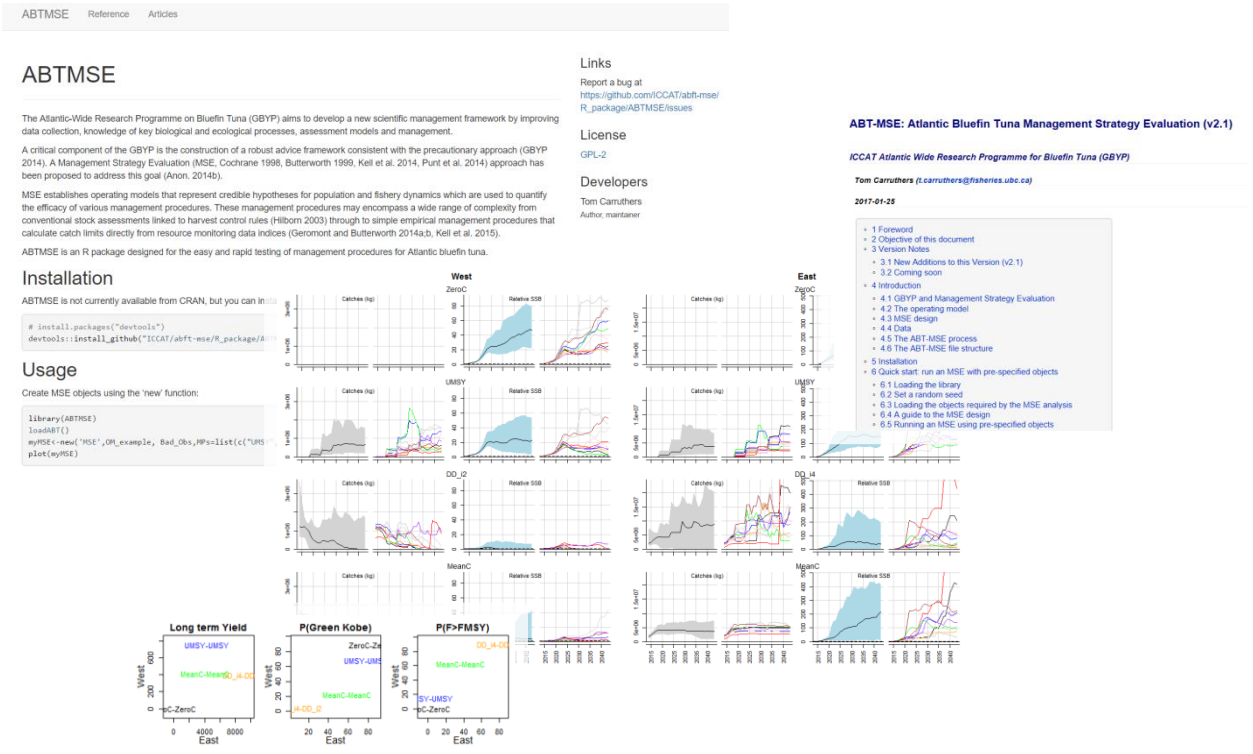
Evaluating Management Strategies for Atlantic Bluefin Tuna

Report 4: An MSE framework for investigating custom operating models, performance metrics and management procedures.

February 20th 2017

SHORT-TERM CONTRACT FOR MODELLING APPROACHES: SUPPORT TO BFT ASSESSMENT (GBYP 02/2016) OF THE ATLANTIC-WIDE RESEARCH PROGRAMME ON BLUEFIN TUNA (ICCAT-GBYP – Phase 6)



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Executive Summary

The focus of this contract was finalizing the technical aspects of the operating modelling and producing a user-friendly and fully functional MSE framework that could provide a basis for feedback and collaboration from a wider group of stakeholders. In this regard, a number of major milestones were achieved in this contract:

Data

- Following the data preparatory meeting the fleet structure and data formats were finalized and the meta-database was updated.
- The fishery, survey, tagging and stock of origin data were formatted for use with the operating model
- A draft SCRS paper was written that provides a full account of the derivation of the 'master index' that is central to the operational modelling (Appendix 1)
- The online meta-data summary was linked to the corresponding sources of data in the GitHub repository.

Operational modelling

- A final operating model structure (M3 v1.3) was designed following feedback from the Core Modelling Group including a new model initialization by stock reduction analysis to account for catches before 1960
- The new operating model was simulation tested to check for coding errors, identifiability and to establish suitable data weightings
- The trial specifications document was updated following feedback from the core modelling group (Appendix 2)

MSE development

- The 18 reference operating models were fitted to data and reproducible R scripts are available that describe this process.
- A standard operating model fitting report was developed in R markdown and these were generated for each reference operating model.
- A comprehensive set of R functions were developed to allow for the simple and rapid design of operating models, fitting of operating models to data, design of management procedures, specification of performance metrics and the running of Management Strategy Evaluation
- All of the R code, data and objects were compiled into a single R package (ABTMSE) with complete documentation for all functions, objects and data to be used in MSE analyses (Appendix 3)
- The raw data, R scripts, Reports, help documentation and the R package were assembled in a single directory which can be downloaded from the ICCAT GitHub repository.

Documentation

- An extensive user guide was developed in R markdown that describes the file structure, the project and guides users through the various functions of the R package including worked examples of the 7 steps of MSE development (of Punt and Donovan, 2007)(Appendix 4).
- A fully documented website was produced using 'pkgdown' that can act as the front page of the ICCAT abft-mse repository and has links to various documentation including all the functions and objects of the R package (Appendix 5)
- Software design documentation for the M3 assessment model, ABTMSE R package and an M3 guide.

Contents

1 Review of contract activities 2016 - 2017

1.1 Data preparatory meeting (July 24th – 29th)

Two papers were presented at the data preparatory meeting demonstrating the successful simulation testing of the M3 multi-stock operating model (SCRS/2016/144) and another highlighting the outstanding issues pertinent to the conditioning of operating models on real data (SCRS/2016/145).

Following the data-preparatory meeting (July 24-29) all data for fitting operating models were made available to the core modelling group (CMG). This allowed for an update in the meta-data summary, the preliminary fitting of operating models to real data and a revision of the Trial Specifications document, for example the definition of fleets and the start / end dates for the data to be used in the operational modelling.

Together, the update in the Trial Specifications document and the provision of data allowed for the fitting of preliminary operating models (large grey shaded box 'Operating model specifications' of Figure 1). Code was developed to link these outputs to the ABTMSE R package (the linkages through MLE, Hessian and MCMC sample boxes of Figure 1 below).

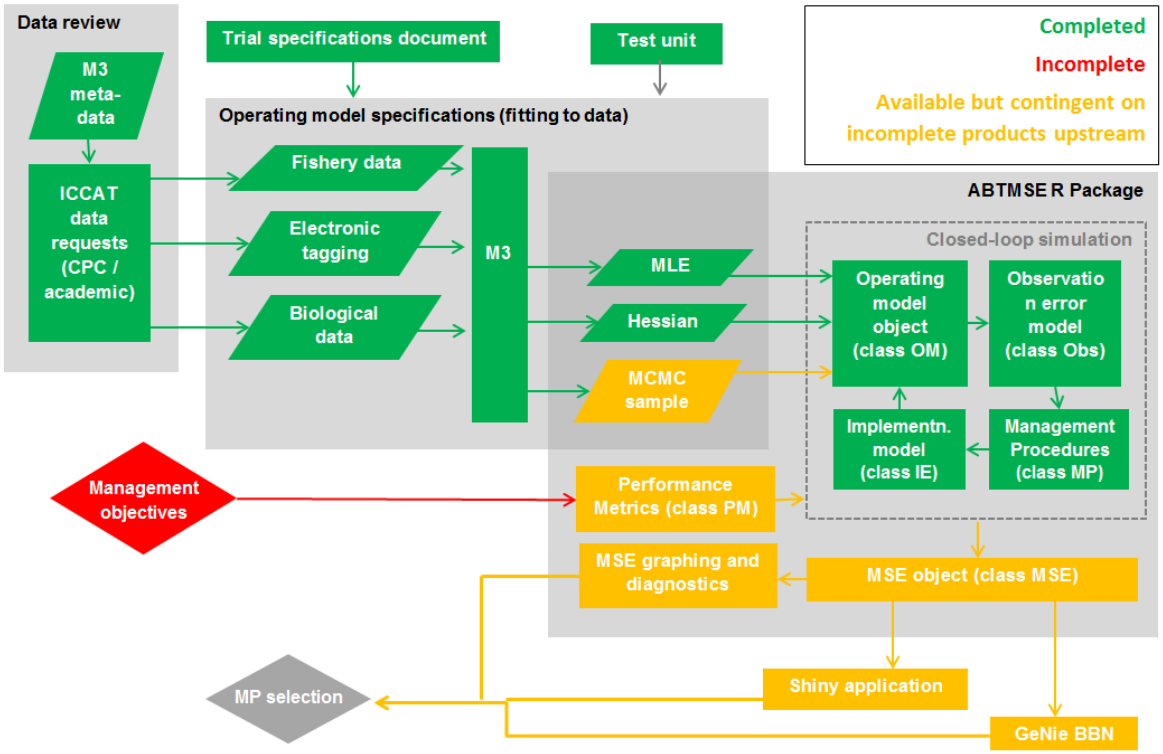


Figure 1. Current status of the components of the ABT MSE framework.

1.2 Species group meetings (September 26th – 30th)

A pair of papers were presented describing the opportunities for operational modelling (SCRS/2016/204) and a new approach for imputing stock of origin to electronic tags using their spatial fingerprint (SCRS/2016/205). Following feedback from members of the CMG the R ABTMSE framework was updated as was the meta-data base which is now linked to the real data on the ICCAT GitHub page.

1.3 Meeting of the Core Modelling Group (November 5thth – 6th)

The 18 reference operating models were fitted to data and a standardized report was designed using R markdown, which allows any user to rapidly produce model diagnostics and estimates of management reference points. These fitted operating models were presented to the CMG following the Tuna MSE working group meeting.

Feedback from the CMG focused on finalizing the Trial Specifications document and reconfiguring the operating models. A substantial change in M3 operating model structure was proposed relating to model initialization. Rather than assuming a stable rate of fishing mortality rate prior to 1960 the model is now initialized by stock reduction analysis (SRA, the deterministic subtraction of catches) accounting for removals from 1860 to 1959. The operating model would also now be fitted to CPUE indices that are used in the stock assessments.

1.4 Developments since November 2016

As requested by the CMG, an SCRS paper was drafted describing in greater detail the derivation of the 'master index' that is used to condition the operating models (Appendix 1). The paper discusses the advantages and disadvantages of the approach and highlights future priorities for research.

Since the CMG meeting at the start of November, the Trial Specifications document (latest version is attached in Appendix 2), operating model and R ABTMSE framework were reconfigured to incorporate this change in model structure. The OM fitting report was also refined to include better diagnostics of fit to length composition data.

A series of improvements to the R MSE framework were implemented. These include custom classes for operating model inputs, performance metrics, observation models and management procedures. The observation model was updated to generate future indices based on the statistical properties of model fit to prospective indices (e.g. the real Mediterranean larval survey). A range of new management procedures were added that make use of these indices including new surplus production, delay-difference and catch-based MPs (there are now 23 example MPs).

The R MSE framework was consolidated into a single R package (ABTMSE) in which all functions and objects are documented including worked examples (Appendix 3). MSE diagnostics were produced that match those of the Trial Specifications document including performance metrics, performance summary tables and projection plots.

A user guide was produced in R markdown (Appendix 4) that describes and demonstrates the package functionality including the '7 steps of MSE' as described by Punt and Donovan (2007):

> (1) qualitative specification and prioritization of the management objectives, as derived from legislation, legal decisions, and international standards and agreements;
>
> (2) quantification of the qualitative management objectives in the form of performance measures;
>
> (3) development and parameterization of a set of "operating models" that represent different plausible alternatives to the dynamics of the "true" resource and fishery being managed;
>
> (4) identification of candidate management procedures, including monitoring strategies;
>
> (5) simulation of the future use of each candidate management procedure, involving for each time-step during the projection period: (a) generation of assessment data; (b) determination of the management action (i.e. assessment and application of some HCR); and (c) evaluation of the biological implications of the management action by removing the catch from the population as represented in the operating model;
>
> (6) summary of the performance of the candidate MPs in terms of values for the performance measures; and
>
> (7) selection of the management procedure that best meets the specified objectives.

Using a pre-release R package pkgdown a website was produced for the ABTMSE package. This allows for automated online documentation each time the package is updated. It can also serve as a splash page for the ICCAT/abft-mse repository (Appendix 5 – to view the website download /docs folder and open docs/index.html).

Software design documents were updated for the ICCAT ABTMSE R framework and M3 assessment model.

2 Progress with respect to deliverables

Deliverable 1	July 20, 2016 (100%)
i	Workplan outlining the actions required to complete the 5 components of deliverable 3
ii	Presentation and short report summarizing current status of deliverables and actions required to achieve them

(i) The workplan was presented in Progress Report 5 (Section 5)

(ii) This deliverable was addressed in Progress Report 4 and accompanying presentations.

Deliverable 2	September 23, 2016 (100%)
i	Updated presentations and short report summarizing current status of deliverables and actions required to achieve them (100%)
ii	Demonstrator showing the MSE running, should include examples of the 6 steps of developing an MSE (100%)
iii	Draft papers on applications (100%)

(i) The purpose of Progress Report 5 and accompanying presentations was to summarize current status.

(ii) The R package and user guide not only demonstrate the MSE working, but provide users with an opportunity to design their own operating models, performance metrics and management procedures.

On a more conceptual level, the **shiny app** also provides users with a rapid investigation of MSE design and outputs.

(iii) A review paper discussing the potential future applications of bluefin tuna operating models was presented at the September 2016 species group meeting (SCRS/2016/204).

Deliverable 3	Draft: February 13, 2017 Final: February 21, 2017 (100%)
i	Repository with version control for software development http://github.com/ICCAT/abt-mse containing the OM (~100%)
ii	SDP (Software Development Plan) that will be reviewed by external experts, as agreed at Monterey meeting (~100%)
iii	Test Unit so that code can be validated (100%)
iv	Meta Database summarizing all parameters and assumptions used http://github.com/ICCAT/GBYP-MetaDB (100%)
v	Management Procedures Support the implementation of 3rd parties. Written up as SCRS paper and code available in repository (100%)

(i) Following the completion of version 1.0 of the M3 operating model, the ICCAT MSE GitHub site is now subject to regular updates following developments to code and software documentation (current version is 1.3). Branching, merging, pulls, commits etc. may be managed either by me the Technical Assistant or ICCAT staff.

The new automatically generated website can be used as the splash page for the GitHub site (linking the master branch to ICCAT/abft-mse/docs) and offers a user-friendly front-end with access to supporting documentation.

(ii) The software development plan is currently being revised in light of the recently launched R package. This revision is necessary because R packaging offers many new opportunities and several constraints.

Updated software design documents and manuals (abft-mse/Manuals_and_design_documents/) are available for the latest version of the M3 operating model (v1.3).

(iii) A test unit has been developed that matches the new features of the latest M3 model (v1.3). The simulator is built into the R ABT-MSE framework and uses streamlined operating model objects (OM definition objects) to generate simulations and calculate reference points.

Note that the test unit has not yet been built into the R ABTMSE package.

(iv) The meta-database is available as a publically editable google worksheet. Several scientists have contributed to refining the metadata.

In instances where data are used by the operating models, the google sheet now contains hyperlinks to the real data that are stored on the ICCAT GitHub repository.

3 Current status of objectives

Objective		Tasks (bold are completed)
a (100%)	Continue the development of the OM based on the MSE trial specifications document (TS)	**Added (M3 v1.3):** **age-based movement, plus group, model initialization at equilibrium estimated F, recruitment predicted from SSB in previous year, a prior for depletion to allow the model to fit specified depletion.**
b (100%)	Develop a test unit to validate the age-based movement model	**Test unit updated to match developments in the operating model above (a)**
c (0%)	Work with third parties to add MPs to the MSE framework including empirical control rules and simple stock assessment methods	Reach out to national scientists, members of the BFT WG (possibly leverage the chairs of Eastern and Western WGs) and the CMG to develop new MPs or to incorporate existing MPs (e.g. CCSBT). It may be appropriate to attempt this objective during the MSE demonstration workshop aimed at achieving (d) below.
d (0%)	Run the MSE in collaboration with BFT Species group	This objective requires a dedicated workshop in 2017. A precursor to such a workshop is finalization of the reference operating models (approving acceptable fit to data), fitting the robustness set of operating models and the integration of these into the R ABT-MSE framework.
e (100%)	Collaborate with the SCRS to develop interactive graphics (e.g. Shiny apps) to communicate MSE results to stakeholders based on the performance metrics of the trial specifications document	**A preliminary Shiny App is now available at:** **http://rscloud.iccat.int:3838/gbyp-mse/** The App should be modified following finalization of the reference and robustness operating models. The App should include sufficient flexibility to allow users to define their own OMs and investigate value of information.
f (100%)	Work with other to update and maintain the meta database of the available bluefin data and knowledge https://github.com/ICCAT/GBYP-MetaDB	**The meta database has been made publically available and editable** https://docs.google.com/spreadsheets/d/13pFaM3BTnzQ1BNQGoYn4O2n1IeD18V3VTbN9Hv7139U/edit#gid=1352276725 The google sheet has been updated by myself and H. Arrizabalaga to reflect the latest status of BFT data.
g (100%)	Work with SCRS to help develop 3 prototype examples	The user guide has several worked examples of MP development . The ABTMSE R package also includes 23 examples of MPs each of which has accompanying documentation.

The underlying objective of this contract was to provide an accessible, flexible and powerful MSE framework to allow scientists and stakeholder the opportunity to test new management procedures, design new operating models and investigate performance metrics. To achieve this objective, a number of deliberate design choices were made:

- The formulation of a single file structure containing all data, code and documentation maximises the portability and accessibility of the ABT MSE framework.
- By developing an R package all of the code, functions, MSE objects and worked examples are available in a single file that may be easily distributed. Since all data and functions have documentation there is local support for developers that wish to design their own management procedures, operating models or performance metrics.
- By packaging the MSE framework in R, the code is accessible to a wide range of scientists and they can easily use the powerful and varied additional packages and functions of the R statistical environment.
- By producing documentation in R markdown, tutorials are reproducible and transparent allowing new users to be guided step-by-step through the various steps of MSE analysis.
- One-click web page production means that with every package revision, the supporting documentation can be easily updated online.
- By staging the software in GitHub, users can track changes to the package, get news on updates, submit 'issues' to the developer when errors are found and branch the code to make customised changes.

Two objectives were not yet met, namely

(c) 3rd party MP development and

(d) running of MSEs in collaboration with the BFT species group.

However due to progress in this contract, the MSE framework is in excellent shape to deliver these objectives in the near future.

4 Priorities for the MSE process

4.1 Finalising operating models (approving fit and predictions)

During the CMG meeting in November 2016, feedback was provided on the fit of the existing operating models to data and the apparent divergence in model predictions from recent stock assessments. A core recommendation arising from this meeting was that the operating model (the M3 estimation model) should be restructured to account for historical catches prior to 1960 and that it should be fitted to stock assessment CPUE indices of abundance.

Since that meeting there has not been an opportunity for the CMG to examine and approve the latest operating model fits to data. Indeed these models appear to fit the assessment data but also disagree to a certain extent with recent assessments (albeit less so than the previous model formulation). Because it is the remit of the CMG to approve the operating models, my time has been spent producing a workable MSE framework that can integrate any fitted operating model. Once final decisions on acceptable operating model fits have been obtained (e.g. a decision to up-weight the fit to assessment indices) it is straightforward and quick to re-fit the models and incorporate these into the MSE R framework.

This remains a leading priority.

4.2 Stakeholder specification of OMs and MPs

This contract has focused on producing an accessible framework for engaging stakeholders in the MSE process. A leading priority going forward is to schedule seminars and workshops to facilitate the engagement and collaboration of stakeholders.

5 MSE development priorities

5.1 Review of code and MSE bug checking

It is possible to develop an MSE framework that appears sound but provides spurious results due to coding errors or model misspecification. It is important to both review the code line-by-line (the package is new and has not yet been carried out) and also produce a series of diagnostic checks that can be run each time the package is formulated. For example, a simple check would be to produce several management procedures all with increasing levels of constant catches and confirm the expected increasing impact on predicted stock biomass. Similarly, another test could be to change the configuration of fleets toward those that catch smaller fish and check for the corresponding shift in simulated catch composition.

5.2 Incorporating the test unit into the R package (major)

Currently the test unit (which validates the operating model by simulation testing) is not integrated into the ABTMSE R package. This is a valuable addition that adds credibility to the operational modelling.

5.3 Development of inverse age-length keys (major)

Currently the inverse age-length keys (probability of a fish being of length class given age class) were derived by myself using a very naïve approach. A 10% coefficient of variation was superimposed around the maximum likelihood fit of the Richards growth curve following (Allioud et al.). More defensible inverse age-length keys are desirable that have documentation about how they were derived. For example, time-varying inverse age-length keys are accepted by the M3 operating model that could be derived empirically from raw age-length data.

5.4 Implement the max / min TAC changes of the Trial specifications document (minor)

The Trial Specifications document requires that the MSE impose maximum and minimum changes in TAC among TAC updates by MPs. This is to prevent management overhead from trivial changes in TAC and prevent unrealistically large swings in TAC. This is straightforward to include in the current MSE framework.

5.5 More extensive MSE diagnostics and reporting (major)

Currently the ABTMSE R package includes quite basic MSE analysis, reporting and diagnostics. The current reporting options are the minimum required to meet the outputs described in the Trial Specifications document. However there are some useful additional outputs that could be developed in the near-term to greatly improve the power and flexibility of the package including:

- Pencil plots showing biomass and exploitation rate projections (similar to the existing shiny app)
- Convergence diagnostics that confirm the MSE results are stable given additional simulations
- Value of information analysis demonstrating which observation processes and operating model parameters are the primary drivers of performance
- A standard MSE report document designed in markdown (similar to the operating model fitting report)

5.6 Data-rich MPs (major)

Many of the management procedures that are currently specified operate on few data or are simple stock assessments that do not account for process error. It would be desirable to develop MPs that represent current stock assessment for Atlantic bluefin stocks (a VPA) or those that can account for process error (e.g. a state-space delay-difference assessment).

5.7 Updating of the shiny app and the Bayesian Belief Network (major)

The current shiny app provides an early example of the type of outputs that can be produced to illicit feedback from a wider group of scientists and stakeholders that are less likely to participate in coding their own operating models and management procedures. Once the operating models are finalized (e.g. their fit is considered acceptable by the CMG) the shiny app should be updated to reflect the configuration and results of the latest MSE analyses.

Although there appears to be a preference for presentation of MSE analyses by the shiny app, it is straightforward to update the Genie Bayesian Belief Network. The BBN has additional value because it allows users to define and investigate custom utility functions which is much less straightforward in a Shiny app.

5.8 Update the OM fitting report (minor)

The operating model fitting report should be revised following feedback on the desired representation of fits to indices (comment from D. Butterworth) and the order of presentation.

5.9 Better characterization of observation processes, for example what is an appropriate / credible degree of bias in age at maturity BMSY/B0, FMSY/M etc (major)

Currently the MSE generates simulated data subject to naïve observation error models, particularly annual catch data, catch-at-length and catch-at-age data. The models should be revised to include more complex processes that are representative of data-collection protocols for Atlantic bluefin tuna.

Acknowledgments

Many thanks to my coauthors of the various SCRS papers. Thanks in particular to Laurie Kell for technical support, Antonio di Natale for directing the project and Doug Butterworth for advancing the Trial Specifications document.

This work was carried out under the provision of the ICCAT Atlantic-Wide Research Programme for Bluefin Tuna (GBYP), funded by the European Union, by several ICCAT CPCs, the ICCAT Secretariat and by other entities (see: http ://www.iccat.int/GBYP/en/Budget.htm). The content of this report does not necessarily reflect the point of view of ICCAT or of the other funders, which have no responsibility for it, neither does it necessarily reflect the views of the funders and in no way anticipates the Commission's future policy in this area.

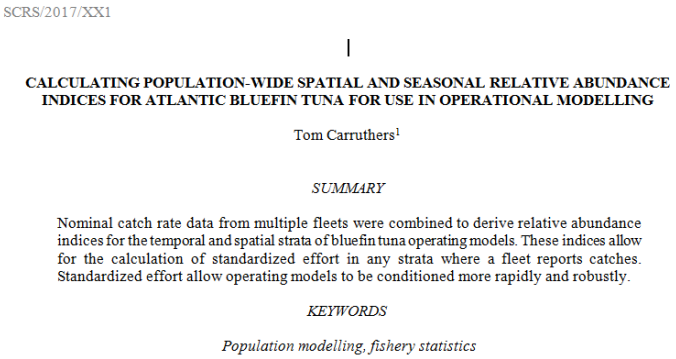
6 Appendices

All appendix material is available on the ICCAT/abft-mse repository and is contained in a single file structure that can also be downloaded here.

6.1 Appendix 1: Master Index

The draft SCRS paper describing the derivation of the master index:
https://github.com/abft-mse/Submissions/SCRS_2017_XX1 Carruthers Master Indices Atlantic Bluefin.docx

Also available here.



SCRS/2017/XX1

CALCULATING POPULATION-WIDE SPATIAL AND SEASONAL RELATIVE ABUNDANCE INDICES FOR ATLANTIC BLUEFIN TUNA FOR USE IN OPERATIONAL MODELLING

Tom Carruthers[1]

SUMMARY

Nominal catch rate data from multiple fleets were combined to derive relative abundance indices for the temporal and spatial strata of bluefin tuna operating models. These indices allow for the calculation of standardized effort in any strata where a fleet reports catches. Standardized effort allow operating models to be conditioned more rapidly and robustly.

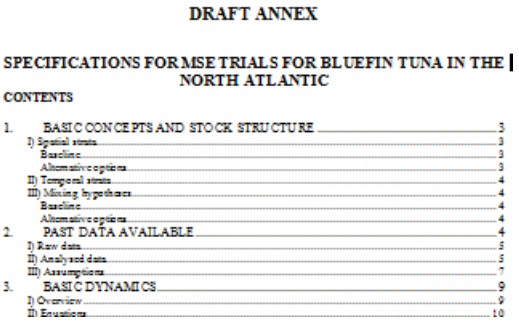
KEYWORDS

Population modelling, fishery statistics

6.2 Appendix 2: Trial Specifications

The latest version of the MSE Trial Specifications document:
https://github.com/abft-mse/Manuals_and_design_documents/Trial Specifications.docx

Also available here.



DRAFT ANNEX

SPECIFICATIONS FOR MSE TRIALS FOR BLUEFIN TUNA IN THE NORTH ATLANTIC

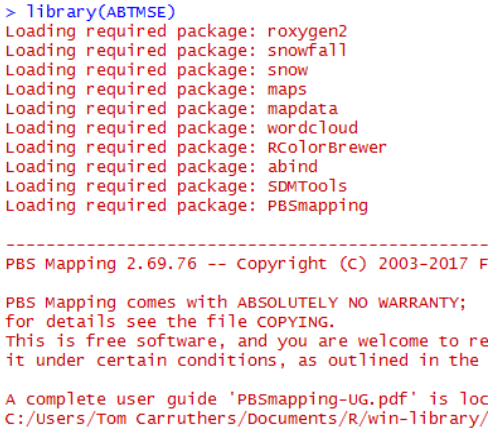
CONTENTS

6.3 Appendix 3: ABTMSE R package

The ABTMSE R package contains all data, objects and function for users to replicate the MSE work so far and design and test their own management procedures. The R package source files are available at:
https://github.com/abft-mse/R_package/ABTMSE/

The package tar ball (for installation in R) is also available:
https://github.com/abft-mse/R_package/ABTMSE_2.1.0.tar.gz

Alternatively both are accessible here.



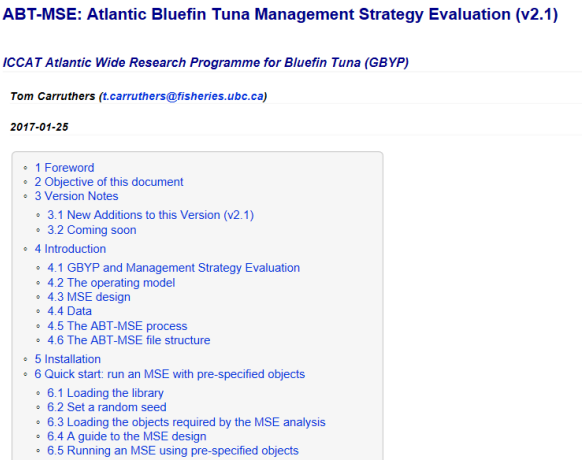
```
> library(ABTMSE)
Loading required package: roxygen2
Loading required package: snowfall
Loading required package: snow
Loading required package: maps
Loading required package: mapdata
Loading required package: wordcloud
Loading required package: RColorBrewer
Loading required package: abind
Loading required package: SDMTools
Loading required package: PBSmapping

------------------------------------------------
PBS Mapping 2.69.76 -- Copyright (C) 2003-2017 F

PBS Mapping comes with ABSOLUTELY NO WARRANTY;
for details see the file COPYING.
This is free software, and you are welcome to re
it under certain conditions, as outlined in the

A complete user guide 'PBSmapping-UG.pdf' is loc
C:/Users/Tom Carruthers/Documents/R/win-library/
```

6.4 Appendix 4: R package user guide

The user guide explains the design of the ABT MSE and provides worked examples of the R package functions. The user guide demonstrates the 7 steps of MSE covering custom management procedures, performance metrics and operating models. The user guide is accessible from the R package (the package vignette) or the ICCAT GitHub site

https://github.com/abft-mse/ReadMe.html

A copy is also available here.



ABT-MSE: Atlantic Bluefin Tuna Management Strategy Evaluation (v2.1)

ICCAT Atlantic Wide Research Programme for Bluefin Tuna (GBYP)

Tom Carruthers (t.carruthers@fisheries.ubc.ca)

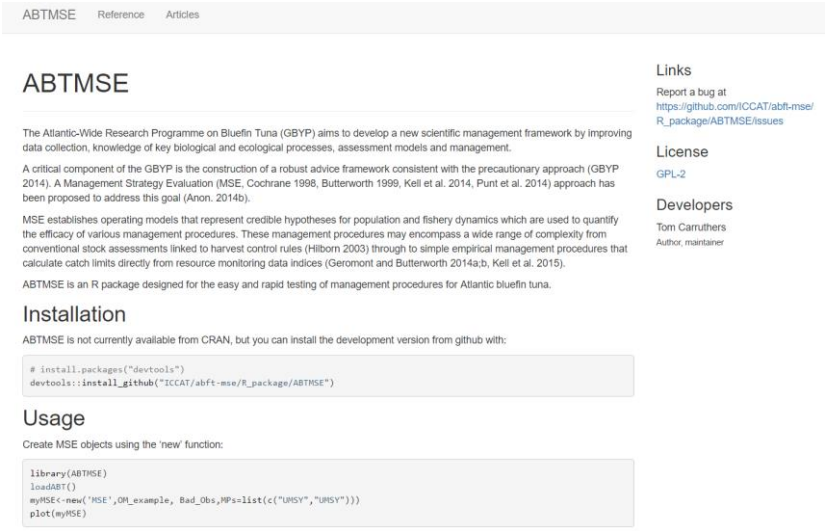
2017-01-25

6.5 Appendix 5: Web site

The website acts as a splash page for the ICCAT/abft-mse GitHub repository and provides background and links to help documentation and worked examples.

This can be accessed from the ICCAT GitHub site https://github.com/abft-mse/docs/index.html

The website can also be accessed from here. To preview the site, you must download the /docs folder to your computer and open /docs/index.html in a web browser.



ABTMSE Reference Articles

ABTMSE

The Atlantic-Wide Research Programme on Bluefin Tuna (GBYP) aims to develop a new scientific management framework by improving data collection, knowledge of key biological and ecological processes, assessment models and management.

A critical component of the GBYP is the construction of a robust advice framework consistent with the precautionary approach (GBYP 2014). A Management Strategy Evaluation (MSE, Cochrane 1998, Butterworth 1999, Kell et al. 2014, Punt et al. 2014) approach has been proposed to address this goal (Anon. 2014b).

MSE establishes operating models that represent credible hypotheses for population and fishery dynamics which are used to quantify the efficacy of various management procedures. These management procedures may encompass a wide range of complexity from conventional stock assessments linked to harvest control rules (Hilborn 2003) through to simple empirical management procedures that calculate catch limits directly from resource monitoring data indices (Geromont and Butterworth 2014a;b, Kell et al. 2015).

ABTMSE is an R package designed for the easy and rapid testing of management procedures for Atlantic bluefin tuna.

Installation

ABTMSE is not currently available from CRAN, but you can install the development version from github with:

```
# install.packages("devtools")
devtools::install_github("ICCAT/abft-mse/R_package/ABTMSE")
```

Usage

Create MSE objects using the 'new' function:

```
library(ABTMSE)
loadABT()
myMSE<-new('MSE',OM_example, Bad_Obs,MPs=list(c("UMSY","UMSY")))
plot(myMSE)
```

Links

Report a bug at https://github.com/ICCAT/abft-mse/R_package/ABTMSE/issues

License

GPL-2

Developers

Tom Carruthers

Author, maintainer

6.6 Appendix 6: SCRS papers

The SCRS papers for this contract period (SCRS/2016/144; 145; 204; 205) are available in the GitHub repository: https://github.com/abft-mse/Submissions

These are also available here.

6.7 Appendix 7: Software design documents

The software design document for the latest M3 model is available on the ICCAT GitHub repository: https://github.com/abft-mse/Manuals_and_design_documents/M3 Software Design Specification v1_3.docx

It is also available [here](#)

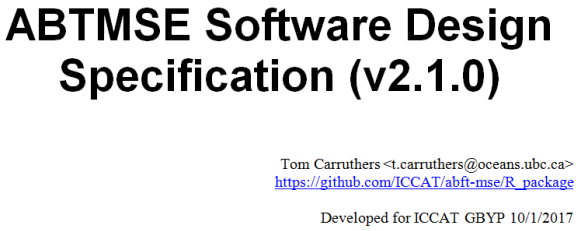
M3 Software Design Specification (v1.3)

Tom Carruthers <t.carruthers@oceans.ubc.ca>
https://github.com/ICCAT/abft-mse

Developed for ICCAT GBYP 6/1/2017

The software design specification for the ABTMSE R package is available on the ICCAT GitHub repository: https://github.com/abft-mse/Manuals_and_design_documents/ABTMSE (R package) Software Design Specification v2_1_0.docx

It is also available [here](#).



ABTMSE Software Design Specification (v2.1.0)

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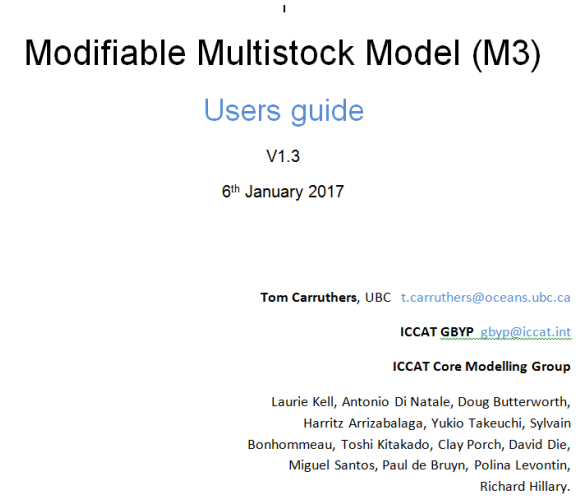
https://github.com/ICCAT/abft-mse/R_package

Developed for ICCAT GBYP 10/1/2017

The M3 user guide is also published on the ICCAT GitHub repository: https://github.com/abft-mse/Manuals_and_design_documents/M3 Users guide v1_3.docx

It is also available [here](#).



Modifiable Multistock Model (M3)

Users guide

V1.3

6th January 2017

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