ABT-MSE: AN R PACKAGE FOR ATLANTIC BLUEFIN TUNA MANAGEMENT STRATEGY EVALUATION

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SUMMARY

Software for developing and testing management procedures is presented including worked examples.

RÉSUMÉ

Le logiciel pour développer et tester les procédures de gestion est présenté, y compris des exemples détaillés.

RESUMEN

Se presenta el programa informático para desarrollar y probar procedimientos de ordenación y se incluyen los ejemplos desarrollados.

KEYWORDS

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

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* The development of the MSE for North Atlantic bluefin tuna remains an ongoing process at this time. This document is therefore not final, but relates to the extent of development of the work immediately prior to the September 2017 bluefin session which preceded the ICCAT SCRS meeting.

* Le développement de la MSE pour le thon rouge de l’Atlantique Nord reste à ce stade un processus en cours. Ce document n’est donc pas définitif, mais se rapporte à l’ampleur du développement des travaux immédiatement avant la session sur le thon rouge de septembre 2017 qui a précédé la réunion du SCRS de l’ICCAT.

* En este momento prosigue el proceso de desarrollo de la MSE para el atún rojo del Atlántico norte. Por tanto, este documento no es final, sino que está relacionado con la medida de desarrollo de este trabajo inmediatamente antes de la sesión de atún rojo de septiembre de 2017, que precedió a la reunión del SCRS de ICCAT.
1. **Introduction**

A Management Strategy Evaluation (MSE, Butterworth 1999, Cochrane 1998) approach has been proposed for Atlantic bluefin tuna as a suitable framework for providing robust management advice consistent with the precautionary approach (GBYP 2017a).

A critical step in MSE is the development of candidate management procedures (CMPs) which can provide management advice from fishery data. MSE processes are strengthened by comparative testing of multiple CMPs developed by scientists. To facilitate this, an R MSE package has been developed to enable design and testing of CMPs for Atlantic bluefin tuna (ABT-MSE).

In this paper a series of worked examples demonstrate how the R framework may be used to test CMPs. A comprehensive user guide (Carruthers 2017) is available from a GitHub repository where all code and data are also freely available. A brief installation guide is included in the Appendix of this document. For a full description of operating model equations and parameters we refer users to the Trial specifications document (CMG 2017) and other supporting papers (Carruthers *et al.*, 2016). See GBYP (2017b) for a summary of the data used by the operating models.

2. **Methods**

**Format of simulated data**

In the ABT-MSE framework, CMPs must access simulated data and provide a TAC recommendation. Various data are simulated and stored in an object `dset`, that can be accessed by CMPs (Table 1). The principal data types that may be used by MPs are provided for both East and West management areas and include previous TAC recommendations and observed relative abundance indices.

CMPs often use indices of relative abundance as the primary basis for adjusting the TAC. In total 7 indices have at present been agreed as potential inputs to be simulated in the ABT-MSE framework (Carruthers and Butterworth, in press a) (Table 2).

**MP design**

In the ABT-MSE framework, management procedures are functions that have two arguments, the first is the simulation number x, the second is the simulated data set. There are two remaining requirements, the first is that the last line of the MP function is the TAC recommendation (a point value) and that immediately after the MP it is assigned the class 'MP'. Two simple constant catch MPs are provided in Figure 1, an example of an index target MP (EMP1, Carruthers and Butterworth, in press b) is provided in Figure 2.

**MP testing**

Before attempting to apply an MP in the MSE you can test it using simulated data to check for errors (e.g. Figure 4). A number of example datasets are included in the ABT-MSE package for testing purposes.

**Running an MSE and calculating performance**

In relatively few lines an MSE can be run and performance plotted and saved to disk (Figure 5).

3. **Acknowledgements**

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References


GBYP. 2017b. Data to inform operating models for North Atlantic bluefin tuna. ICCAT Atlantic Wide Research Programme for Bluefin Tuna. Available at: https://drive.google.com/drive/folders/0B0TXcs-MLRi3anc2Sjc0Yjk1ZTA [accessed September 2017]
Table 1. Principal simulated data in the simulated dataset object.

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cobs</td>
<td>Observed annual catches</td>
<td>sim x year</td>
</tr>
<tr>
<td>TAC</td>
<td>Historical TAC recommendations</td>
<td>sim x year</td>
</tr>
<tr>
<td>Iobs</td>
<td>Observed relative abundance indices</td>
<td>sim x index x year</td>
</tr>
<tr>
<td>CAA</td>
<td>Catch-At-Age samples</td>
<td>sim x age x year</td>
</tr>
</tbody>
</table>

Table 2. The indices simulated the MSE framework.

<table>
<thead>
<tr>
<th>No</th>
<th>Name</th>
<th>Area</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>JPN_LL_NEAtl2</td>
<td>East</td>
<td>Fishery-dependent</td>
<td>Japanese Longline in the North East Atlantic</td>
</tr>
<tr>
<td>2</td>
<td>FR_AER_SUV</td>
<td>East</td>
<td>Fishery-independent</td>
<td>French Aerial Survey</td>
</tr>
<tr>
<td>3</td>
<td>MED_LAR_SUV</td>
<td>East</td>
<td>Fishery-independent</td>
<td>Mediterranean Larval Survey</td>
</tr>
<tr>
<td>4</td>
<td>MED_AER_SUV</td>
<td>East</td>
<td>Fishery-independent</td>
<td>Mediterranean Aerial Survey</td>
</tr>
<tr>
<td>5</td>
<td>JPN_LL2</td>
<td>West</td>
<td>Fishery-dependent</td>
<td>Japanese Longline in the western Atlantic</td>
</tr>
<tr>
<td>6</td>
<td>US_RR_66_114</td>
<td>West</td>
<td>Fishery-dependent</td>
<td>US Rod and Reel 66cm – 114cm West Atlantic</td>
</tr>
<tr>
<td>7</td>
<td>GOM_LAR_SUV</td>
<td>West</td>
<td>Fishery-independent</td>
<td>Gulf of Mexico Larval Survey</td>
</tr>
</tbody>
</table>

Figure 1. Two constant catch MPs. Management procedures are functions that must have two arguments, the first of which is the simulation number $x$, the second is the simulated data, $dset$. The first MP ‘Const_Cur_TAC’ sets the new TAC recommendation to the first ever (current, 2016) TAC level. The second ‘MeanCat’ is simply the mean historical annual catches for simulation $x$. 

```r
const_Cur_TAC = function(x, dset){
  dset$TAC[x, 1]
}
class(Const_Cur_TAC) = "MP" # Assign Const_Cur_TAC a class 'MP'

MeanCat <- function(x, dset){
  mean(dset$cobs[x, ])
}
class(MeanCat) = "MP" # Assign MeanCat a class 'MP'
```
Management procedures are functions that must have two arguments, the first of which is the simulation number \( x \), the second is the simulated data, \( dset \). The last line of every MP function in the ABT-MSE framework must be the TAC recommendation. The MP must also be assigned the right class ‘MP’ after the function is defined.

**Figure 2.** Example Management Procedure 1 represented in R code.

```r
EMP1 <- function(x, dset){
  xnum = 4.8;
  ny = dim(dset)$[3];
  Jmu = mean(dset$x[1,(-4:0),ny])
  Jratio = Jmu/Jtarg
  cury = dim(dset)$[2];
  previousTAC = dset$TAC[x,cury]
  if(Jratio > 0.6 & Jratio < 1.4){
    TAC = previousTAC
  } else if(Jratio < 0.6){
    TAC = previousTAC * 0.9
  } else{
    TAC = previousTAC * 1.1
  }
  TAC
  class(EMP1) = "MP"
}
```

**Figure 3.** Example Management Procedure 2 represented in R code.

```r
EMP2 <- function(x, dset, IndexNo = 11, Jtarg = 0.6,
                 Up = 0.05, Down = 0.15,
                 pUp = 0.05, pDown = 0.15){
  ny = dim(dset)$[3];
  Ind = dset$x[1,(-5:0),ny]
  linmod = lm(y ~ x, data = data.frame(y = log(Ind), x = 1:6))
  SLP = linmod$coefficients[2]
  Jratio = mean(dset$x[1,IndexNo,(-4:0),ny]) / Jtarg
  cury = dim(dset)$[2];
  previousTAC = dset$TAC[x,cury]
  if(SLP > 0){
    smod = pUp*SLP
  } else{
    smod = pDown*SLP
  }
  if(Jratio > 1){
    Jmod = pUp*(Jratio-1)
  } else{
    Jmod = pDown*(Jratio-1)
  }
  Tmod = Jmod - smod
  TAC = previousTAC - Tmod
  class(EMP2) = "MP"
}
```
Figure 4. MP testing.

```
library(ABTMSE)  # Load library
loadABT()       # Load all the package data
nsim = nrow(dset_example_EastSTAC)  # Get the number of example simulations
sapply(1:nsim, EMP1, dset = dset_example_East)  # Make sure EMP1 works with an example dataset
sapply(1:nsim, EMP2, dset = dset_example_west)  # Make sure EMP1 works with an example dataset
```

Figure 5. Running an MSE and plotting results.

```
library(ABTMSE)  # Load library
loadABT()       # Load all the package data
sFInit(parallel = T, cpus=detectCores())  # Start up the cluster for parallel computing

MPs = list(c("MeanCat", "MeanCat"),
           c("EMP1",
             "EMP2"))  # First MP is mean historical catches in the East and West
myMSE = new("MSE", OM_1, MPs-mps)  # Run MSE with OM_1

plot(myMSE)     # Projection plot
PPlot(myMSE)    # Performance plot
TPlot(myMSE)    # Trade-off plot
perf = getperf(myMSE)  # Calculate the mean performance tables
write.csv(perf[[1]], "C:/East_perf.csv")  # Write the eastern performance table to disk
write.csv(perf[[2]], "C:/West_perf.csv")  # Write the western performance table to disk
save(myMSE, "C:/temp/myMSE.Rdata")  # Save the MSE object
```
Software installation
Download and install the latest version of R:
https://cran.r-project.org/bin/windows/base/
Download and install the latest version of RStudio:
https://www.rstudio.com/products/rstudio/download/#download

Package installation
Save the library file ‘ABTMSE_2.1.0.tar.gz’ to disk and then install from the R prompt in RStudio
> install.packages("C:/Downloads/ABTMSE_2.1.0.tar.gz", repos = NULL, type="source")

Required at the start of each R session
> library(ABTMSE) # load the ABT-MSE library
> loadABT() # load all of the data objects
> sfInit(parallel = TRUE, cpus = detectCores () ) # setup multicore processing

Check package installation
> checkMSE = new('MSE') # run a test MSE
> plot(checkMSE) # plot the results

Getting help
> readme() # open the user guide in your internet browser
> class?MSE # get help on a class of ABTMSE objects
> class?OM

Finding objects
> avail('OM') # list all of the available operating models
> Design # examine the design of the reference operating models