A DESCRIPTION OF 4 CANDIDATE MANAGEMENT PROCEDURES FOR BLUEFIN TUNA

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SUMMARY

Four candidate management procedures for western and eastern bluefin tuna stocks are described.

RÉSUMÉ

Quatre procédures de gestion potentielles pour les stocks de thon rouge de l'Ouest et de l'Est sont décrites.

RESUMEN

Se describen cuatro procedimientos de ordenación candidatos para los stocks de atún rojo oriental y occidental.

KEYWORDS

Management procedure, MSE, Bluefin tuna

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1. Introduction

This document provides the structural details of cMPs developed for testing on a reference set and robustness set of operating models as defined in a management strategy evaluation framework developed for Bluefin tuna (ABTMSE version 6.6.17). The reference set of OMs represents a factorial design of the levels from 5 axes of uncertainty and are described as follows:

A) Recruitment
1: West: h=0.6 to h=0.9 1975+, East: h=0.98 for 1987- to h=0.98 1988+
2: West: B-H h=0.6 all years, East: B-H h=0.7 all years
3: West: post 75+ changes to pre '75 after 10 yrs, East: 88+ to '50-87 after 10 yr

B) Scale
--: mean SSB 15kt West, 200kt East
-+: mean SSB 15kt West, 400kt East
+-: mean SSB 50kt West, 200kt East
++: mean SSB 50kt West, 400kt East

C) Spawning Fraction/Natural Mortality
A: Younger spawning, High M
B: Older spawning, Low M

D) Mixing
I: Low West Stock Migration
II: High West Stock Migration

E) Length Composition
L: Low length composition weight of 1/20
H: High length composition weight of 1

The robustness operating models cross four reference set operating models with three robustness scenarios, namely:

Senescence - an increase in M for older fish similar to that used in CCSBT.
West stock growth - assumed for the East stock and
'Brazilian catches' - catches in the South Atlantic during the 1950s are reallocated from the West Area to the East area.

2. Method

The following represents the pseudo code describing 4 cMPs developed for the Bluefin tuna MSE. A cMP consists of a pair of procedures, one for the west and the other for the east management area. In general these paired procedures are fairly similar so rather than describe each separately, we describe one and note where they differ.

RoseW and RoseE

This cMP depends on the R package changepoint.

```
# Definition of parameters
Indicators for West area:   IndexID_a = GOM_LAR_SUV,     IndexID_j = JPN_LL_West2
Indicators for East area:   IndexID_a = MED_LAR_SUV,     IndexID_j = JPN_LL_NEAtl2
Number of years of data:    ny = length(dset$Cobs)
Number of years of historical data: nyears = 52
Subset of years used in HCR:        ind_a = (ny - 3):ny,          ind_j = (ny - 3):ny
Subset of years used in reference:  ind_ref = (nyears-yrsmth+1):nyears)
Index for vectors:          yind = 1:4
TAC:    TAC = dset$TAC[length(dset$TAC)-1]

# Identify regime shift in JPLL index 12 (west) or JPN_LL_NEAtl2 (east)
# and calculate scalar of the reference value. If a change point is not detected, the default scalar is applied
```

```
# to the reference value (here we reduce it by 10%). If a change point is detected, a scalar is estimated.
data = IndexID_j
data = ifelse(is.na(data),0,data)
mv1.binseg=cpt.meanvar(data,test.stat='Normal',method='BinSeg',Q=2,penalty="SIC")
pts = sum(mv1.binseg@cpts>48)
val = mv1.binseg@param.est$mean
if(pts>1){
        val1 = mv1.binseg@param.est$mean[2]
        val2 = rev(mv1.binseg@param.est$mean)[1]
 if(rev(mv1.binseg@param.est$mean)[1]>mv1.binseg@param.est$mean[2]){
        val1 = mv1.binseg@param.est$mean[2]
        val2 = rev(mv1.binseg@param.est$mean)[1]
        MSYadj = 1/(val2/val1)
}
 else { MSYadj = 1.1}
}
else { MSYadj = 1.1}

# Vector for determining stock state and trend
State of stock:    I_dat_a = IndexID_a[ind_a]
Trend of stock:    I_dat_j = IndexID_j[ind_j]

# Calculate reference value for determining status
Reference value:  I_msy_a = mean(IndexID_a[ind_ref]) /MSYadj

# Calculate status and slope of indicators over last 4 years
slope = coef(lm(y ~ scale(x, center = F), data=data.frame(x=yind, y=scale(I_dat_j) )))[2]
state  = mean(I_dat_a)/I_msy_a

# Calculate OFL based using HCR
Limit reference values:    lim = c(.1,.4,1)
Control parameters:        alp = c(0.75, 0.6, 0.5)

        # Healthy Zone rules
          if (state >= lim[3]& sign(slope)<0)
            OFL = TAC
          if (state >= lim[3]& sign(slope)>=0)
            OFL = (1+alp[3]/(1+exp(-slope))-alp[3]/2)*TAC  #Logistic with max of .5/2 = 25%
        # Cautious Zone rules
          if (state < lim[3] & state >=lim[2] & sign(slope)<0)
            OFL = (1+alp[2]/(1+exp(-slope))-alp[2]/2)*TAC  #Logistic with max of .6/2 = 30%
          if (state < lim[3] & state >=lim[2] & sign(slope)>=0)
            OFL = TAC
        # Critical Zone rules
          if (state < lim[2] & state >=lim[1])
            OFL = alp[1]*TAC
          if (state <lim[1])
            OFL = 0
```

Fzero1W and Fzero1E

This cMP depends on the R package fishmethods for the ypr function used to estimate the F0.1 reference point.

```
# Definition of parameters
Indicators for West area F0.1 calculation:
        IndexID_y = US_RR_66_114,
        IndexID_m = US_RR_115_144,
        IndexID_o = US_RR_177
```

Indicators for East area F0.1 calculation:
IndexID_a = FR_AER_SUV2,
IndexID_j = US_RR_115_144,
IndexID_o = MED_LAR_SUV
West area indicator for state: IndexID_bio = GOM_LAR_SUV
East area indicator for state: IndexID_bio = MED_LAR_SUV
Number of years of data: ny = length(dset$Cobs)
Subset of years used in F0.1 calculation: ind_a = (ny - 2):ny
Number of years of historical data: nyears = 52

Required functions
Range Normalization:

```
RangeNorm = function(x,maxN=1,minN=0){
 maxD = max(x, na.rm=T)
 minD = min(x, na.rm=T)
 (( (x-minD)*(maxN-minN))/(maxD-minD)) + minN
}
```

F0.1 estimation:
The ypr function for the west area requires the following inputs:
wgt - is the weight at age in 2015 from west VPA
M - is scaled to the Lorenzen function SCRS/2017/176
age - is as defined in the 2015 West VPA
partial - is calculated from indicators

```
BFT_yprW = function(Small=1,Med=1,Large=1){
 wgt = c(3.1,9.8,15.1,19.9,43.3,60.5,89.9,111.6,144.8,174,201.1,225.5,247.7,264,283.5,340)
 M = c(0.40, 0.33, 0.27, 0.23, 0.20, 0.18, 0.16, 0.14, 0.13, 0.12, 0.12, 0.11,
     0.11, 0.11, 0.11, 0.11)
 age = c(1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16)
 partial = c(rep(Small,4), rep(Med,2),rep(Large,10))
 if(sum(is.na(c(Small,Med,Large)))==0) {
  ypr(age=age, wgt = wgt, partial = partial, M = M, plus=TRUE,
     oldest = 16, maxF = 10, incrF=0.01, graph=F)$Reference_Points[1,1]
 } else {0}
}
```

The ypr function for the east area requires the following inputs:
wgt - is the weight at age in 2017 from east VPA
M - is scaled to the Lorenzen function SCRS/2017/176
age - is as defined in the 2015 East VPA
partial - is calculated from indicators

```
BFT_yprE = function(Small=1,Med=1,Large=1){
 wgt=c(3., 10., 19., 35., 50., 69., 90., 113., 138., 205.)
 M = c(0.40, 0.33, 0.27, 0.23, 0.20, 0.18, 0.16, 0.14, 0.13, 0.12)
 age = c(1,2,3,4,5,6,7,8,9,10)
 partial = c(rep(Small,4), rep(Med,2),rep(Large,4))
  if(sum(is.na(c(Small,Med,Large)))==0) {
     ypr(age=age, wgt = wgt, partial = partial, M = M, plus=TRUE,
        oldest = 10, maxF = 10, incrF=0.01, graph=F)$Reference_Points[1,1]
   } else {0}
  }

# Range normalization of indicators indexing young, medium and old fish.
# Keeping mean of most recent 3 years.
 Small = mean(RangeNorm(dset$Iobs[x,IndexID_y,])[ind_a])
 Med = mean(RangeNorm(dset$Iobs[x,IndexID_m,])[ind_a])
 Large = mean(RangeNorm(dset$Iobs[x,IndexID_o,])[ind_a])
 Total = Small + Med + Large
```

```
# Calculate fraction harvested by age group
fSmall = (Small/Total)
fMed = (Med/Total)
fLarge = (Large/Total)

# Calculate F0.1 provided there is catch
if(!is.na(Total)==T){
F01 = BFT_yprW(Small=fSmall,Med=fMed,Large=fLarge) # BFT_yprE is used for east
}else{F01 = .2}

# New TAC is F01*I/q, where I is the most recent value of the index used to represent the stock.
# (the appropriate q must be used for the east and west area indicator)
        For the west area:
           q = 0.608E-6 # from 2015 VPA continuity run
        For the east area:
           q = 0.25E-6 # from 2015 VPA continuity run

TAC =F01*(dset$Iobs[x,IndexID_bio,][ny]/q)
```

FIW and FIE

This cMP has no dependency's.

```
# Definition of parameters
Indicator for West area:     IndexID_i = GOM_LAR_SUV, IndexID_bio = GOM_LAR_SUV
Indicator for East area:     IndexID_i = MED_LAR_SUV, IndexID_bio = MED_LAR_SUV
F: F = 0.5
Number of years of data:   ny = length(dset$Cobs)
Subset of years used in Iratio calculation:     ind_a  = (ny - 2):ny
Number of years of historical data: nyears = 52

# Required functions
Range Normalization:
   RangeNorm = function(x,maxN=1,minN=0){
     maxD = max(x, na.rm=T)
     minD = min(x, na.rm=T)
     (( (x-minD)*(maxN-minN))/(maxD-minD)) + minN
   }

# Calculate Iratio, the current indicator value relative to mean of recent 3 years.
   Iratio = dset$Iobs[x,IndexID_i,][ind_a][3]/mean(dset$Iobs[x,IndexID_i,][ind_a])

# Calculate Bref. (the appropriate q must be used for the east and west area indicator)
For the west area:
   q = 0.608E-6 # from 2015 VPA continuity run
For the east area:
   q = 0.25E-6 # from 2015 VPA continuity run
   Bref = dset$Iobs[x,IndexID_bio,][ny]/q

# New TAC is F*Bref*Iratio
   TAC =F*Bref*Iratio
```

RebuildW and RebuildE

This cMP has no dependency's.

```
RebuildW:
 OFL = 1750000 kg
RebuildE:
  OFL = 23000000 kg
```

References

Carruthers, T. (2020). ABTMSE: Atlantic Bluefin Tuna Management Strategy Evaluation. R package version 6.6.17.

Killick R, Haynes K, Eckley IA (2016). _changepoint: An R package for changepoint analysis. R package version 2.2.2, <URL: https://CRAN.R-project.org/package=changepoint>.

Nelson, Gary A. (2019). fishmethods: Fishery Science Methods and Models. R package version 1.11-1. https://CRAN.R-project.org/package=fishmethods.