SPECIFICATIONS FOR ABTMSE MANAGEMENT PROCEDURES

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SUMMARY

Two candidate management procedures for the Eastern and Western Atlantic Bluefin tuna stock are described and performance relative to Br30 and C20 metrics provided.

RÉSUMÉ

Deux procédures de gestion potentielles pour le stock de thon rouge de l'Atlantique Est et Ouest sont décrites et les performances relatives aux paramètres Br30 et C20 sont fournies.

RESUMEN

Se describen dos procedimientos de ordenación candidatos para el stock de atún rojo del Atlántico oriental y occidental y se proporciona el desempeño con respecto a las mediciones Br30 y C20.

KEYWORDS

Bluefin tuna MSE, management procedure

1. Introduction

This document provides a mathematical description of 2 candidate management procedures (cMP) tuned to a reference grid of 48 operating models (OM) that reflect alternate states of reality for the Atlantic Bluefin tuna population. The framework for cMP development and testing is provide by the *ABTMSE* package (Carruthers, 2021).

Both cMPs were tuned so that the median biomass ratio (Br30) across all OMs in the 30th projected year was approximately 1 for both the eastern and western Atlantic Bluefin tuna stocks. Performance of the cMPs with respect to yield and stock status is discussed briefly.

2. Candidate Management Procedures

2.1. An $F_{0.1}$ based cMP

This cMP sets the TAC using an estimate of $F_{0.1}$ and the current abundance of the stock. The $F_{0.1}$ calculation depends on choosing 3 indicators from each management area that index the relative abundance of young, middle aged and older stock components. Prior to use, these indicators are subjected to a range normalization and the average value for the most recent 3 years is determined:

$$I'_{sm} = (I_{sm} - \min(I_{sm}))/(\max(I_{sm}) - \min(I_{sm}))$$

$$I'_{md} = (I_{md} - \min(I_{md}))/(\max(I_{md}) - \min(I_{md}))$$

$$I'_{lg} = \left(I_{lg} - \min\left(I_{lg}\right)\right)/(\max\left(I_{lg}\right) - \min\left(I_{lg}\right))$$

$$\overline{I'_{sm}} = \frac{1}{3}\sum_{N-2}^{N} I'_{sm}$$

$$\overline{I'_{md}} = \frac{1}{3}\sum_{N-2}^{N} I'_{md}$$

$$\overline{I'_{lg}} = \frac{1}{3}\sum_{N-2}^{N} I'_{lg}$$

$$I_{tot} = \overline{I'_{sm}} + \overline{I'_{md}} + \overline{I'_{lg}}$$

$F_{0.1}$ is a calculation based on a yield-per-recruit analysis from *fishmethods* (Nelson, 2019) that follows the modified Thompson-Bell algorithm :

$$Z_a = M_i + PR_a * F_a$$

$$N_{a+1} = N_a * e^{-Z_a}$$

$$\overline{N}_a = (1 - e^{-Z_a}) * \frac{N_a}{Z_a}$$

$$\overline{N}_{a+} = \frac{N_{a+}}{Z_{a+}}$$

$$C_a = (N_a - N_{a+1}) * \frac{PR_a * F_a}{Z_a}$$

$$Y_a = \overline{W}_a C_a = PR_a * \overline{F}_a B_a$$

where the ages *a* for each management area are as defined in the 2015 VPA,
Y_a , C_a , N_a , B_a = Yield, Catch, Numbers and Biomass at age respectively,
W_a = Weight at age is from the 2015 VPA for the west and 2017 VPA for the east,
F_a = Fishing mortality at age,
M_a = Natural mortality at age scaled to the Lorenzen function (Walter et. al. 2018),
Z_a= Total mortality at age (F_a+M_a),
$PRe_{1:10}$ = the partial recruitment vector applied to fishing mortality (F) to obtain partial F-at-age is calculated from the east MP indicators,
$PRw_{1:16}$ = the partial recruitment vector applied to fishing mortality (F) to obtain partial F-at-age is calculated from the east MP indicators,
q = an index and stock specific tuning parameter.

East values

$$a = \{1,2,3,4,5,6,7,8,9,10)\}$$

$$W_{1:10} = \{3.0, 10.0, 19.0, 35.0, 50.0, 69.0, 90.0, 113.0, 138.0, 205.0)\}$$

$$M_{1:10} = \{0.40, 0.33, 0.27, 0.23, 0.20, 0.18, 0.16, 0.14, 0.13, 0.12\}$$

$$PRe_{1:10} = \begin{Bmatrix} \frac{\overline{I'_{sm}}}{I_{tot}}_{1:4} & \frac{\overline{I'_{md}}}{I_{tot}}_{5:6} & \frac{\overline{I'_{lg}}}{I_{tot}}_{7:10} \end{Bmatrix}$$

$$I_{sm,md,lg} = \{\, FR\_AER\_SUV2, JPN\_LL\_NEAtl2, MED\_LAR\_SUV \,\}$$

$$I_{bm} = \{\, MED\_LAR\_SUV \,\}$$

$$q = 1.875\text{E} - 7$$

West values

$$a = \{1,2,3,4,5,6,7,8,9,1011,12,13,14,15,16)\}$$

$$W_{1:16} = \{3.1,9.8,15.1,19.9,43.3,60.5,89.9,111.6,144.8,174,201.1,225.5,247.7,264,283.5,340\}$$

$$M_{1:16} = \{0.40, 0.33, 0.27, 0.23, 0.20, 0.18, 0.16, 0.14, 0.13, 0.12, 0.12, 0.11, 0.11, 0.11, 0.11, 0.11\}$$

$$PRw_{1:16} = \left\{ \frac{\overline{I'_{sm}}}{I_{tot}}_{1:4} \quad \frac{\overline{I'_{md}}}{I_{tot}}_{5:6} \quad \frac{\overline{I'_{lg}}}{I_{tot}}_{7:16} \right\}$$

$$I_{sm,md,lg} = \{\, US\_RR\_66\_144, CAN\ SWNS, MEXUS\_GOM\_PLL \,\}$$

$$I_{bm} = \{\, MEXUS\_GOM\_PLL \,\}$$

$$q = 2.136444\text{e} - 07$$

The $F_{0.1}$ estimate is based on yield-per-recruit calculation for F ranging from 0 to 10 in increments of 0.01. The last age in the *a* vector is a plus group and the oldest age in the plus group is 35.

Western area TAC

$$TAC_{N+1} = \begin{cases} F_{0.1} * \dfrac{I_{bm,N}}{q},\ I_{tot} > 0 \\ 0.2 * \dfrac{I_{bm,N}}{q}, I_{tot} = 0 \end{cases}$$

Eastern area TAC

$$TAC_{N+1} = \begin{cases} F_{0.1} * \dfrac{I_{bm,N}}{q},\ I_{tot} > 0\ \wedge\ \dfrac{TAC_{N+1} - TAC_N}{TAC_N} \leq 0.2 \\ \dfrac{1}{4}(TAC_{N+1} - TAC_N) + TAC_N,\ I_{tot} > 0\ \wedge\ \dfrac{TAC_{N+1} - TAC_N}{TAC_N} > 0.2 \\ 0.2 * \dfrac{I_{bm,N}}{q}, I_{tot} = 0 \wedge \dfrac{TAC_{N+1} - TAC_N}{TAC_N} \leq 0.2 \\ \dfrac{1}{4}(TAC_{N+1} - TAC_N) + TAC_N, I_{tot} = 0 \wedge \dfrac{TAC_{N+1} - TAC_N}{TAC_N} > 0.2 \\ 50{,}000{,}000, TAC_{N+1} > 50{,}000{,}000 \end{cases}$$

2.2 A simple indicator based cMP

This cMP tracks the relative abundance of an indicator and sets a TAC based on the ratio of the most recent 3 years of index values relative to the 3 years prior to that. A tuning parameter F is used to adjust the performance.

Eastern management procedure values

$$I_{bm} = \{\, MOR\_POR\_TRAP \,\}$$

$$F = 1.072$$

Western management procedure values

$$I_{bm} = \{\ MEXUS\_GOM\_PLL\ \}$$

$$F = 1.05$$

The basis for the TAC calculation is the I_{ratio} estimate and depends on the most recent 6 years of index values:

$$I_{ratio} = \left(\frac{1}{3}\sum_{N-2}^{N} I_{bm}\right) \Big/ \left(\frac{1}{3}\sum_{N-5}^{N-3} I_{bm}\right)$$

For the Eastern area TAC a maximum TAC of 80 kt was imposed as well as a reduction to the new TAC (TAC_{N+1}) when the increase between management periods was greater than 20%. These adjustments were made to prevent the Eastern area TAC from increasing too fast and achieving levels that were unsustainable.

Western area TAC

$$TAC_{N+1} = I_{ratio} * TAC_N * F$$

Eastern area TAC

$$TAC_{N+1} = \begin{cases} I_{ratio} * TAC_N * F, & \frac{TAC_{N+1} - TAC_N}{TAC_N} \leq 0.2 \\ \frac{1}{4}(TAC_{N+1} - TAC_N) + TAC_N, & \frac{TAC_{N+1} - TAC_N}{TAC_N} > 0.2 \\ 80{,}000{,}000, TAC_{N+1} > 80{,}000{,}000 & \end{cases}$$

2.3 Tuning adjustments

Each of the cMPs presented above were tuned to allow for comparisons between the cMPs and other cMPs being developed as part of the BFT MSE. Tuning was performed through an iterative process involving the whole reference OM grid where the objective was to ensure that the median Br30 equaled the tuning target for both the eastern and western stock.

Here we present the results of tuning to a Br30 target of 1 for both the Eastern and Western stocks (Figures 1 and 2). The other tuning options requested in Report of the first 2021 intersessional meeting of the BFT species group are both Western and Eastern Br30 of 1.25 and 1.50; Br30 Western = 1.25 and Br30 Eastern = 1.50.

3. Discussion

During the tuning process it was attempted to limit the eastern TAC increases to be no more than 20% of the current TAC in order to prevent excessively high eastern management area harvests. This rule resulted in the eastern management area TAC stabilizing at 36,000 MT and a median Br30 of ~2. In order to reach the Br30 tuning target of 1, the TAC increase restriction was modified to allow larger harvests but a TAC threshold was imposed.

For the simple indicator based cMP, R1 and R3 OMs easily support Eastern and Western C20 above current catch levels (Eastern = 36 kt and western = 2.35 kt). However for R1 a few of the OMs have their Br30 reduced below 1.0 (West OM=10; East OMs=1, 10, 13, 22) and R3 showed most OMs having the Eastern Br30 heavily depleted below 1.0. It may be possible to further refine the cMP to improve its ability to correct the TAC while the biomass is dropping; currently it does not appear to be able to react fast enough to the declining population biomass. For example including a lower eastern TAC cap, closer to the cap used in the F0.1 based CMP, may help improve the ability of the R3 OMs to maintain Br30s closer to 1.0.

References

Carruthers Tom (2021). ABTMSE: Atlantic Bluefin Tuna Management Strategy Evaluation. R package version 7.1.,3.

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

Walter, J., Sharma, R. and Ortiz, M. (2018) Western Atlantic Bluefin Tuna Stock Assessment 1950-2015 using Stock Synthesis. Collect. Vol. Sci. Pap. ICCAT, 74(6): 3305-3404.

Figure 1. Biomass ratio for the eastern and western stock at the 30th year of projections for each reference grid OM. The performance of the 2 cMPs is based on a 1:1 Br30 tuning.

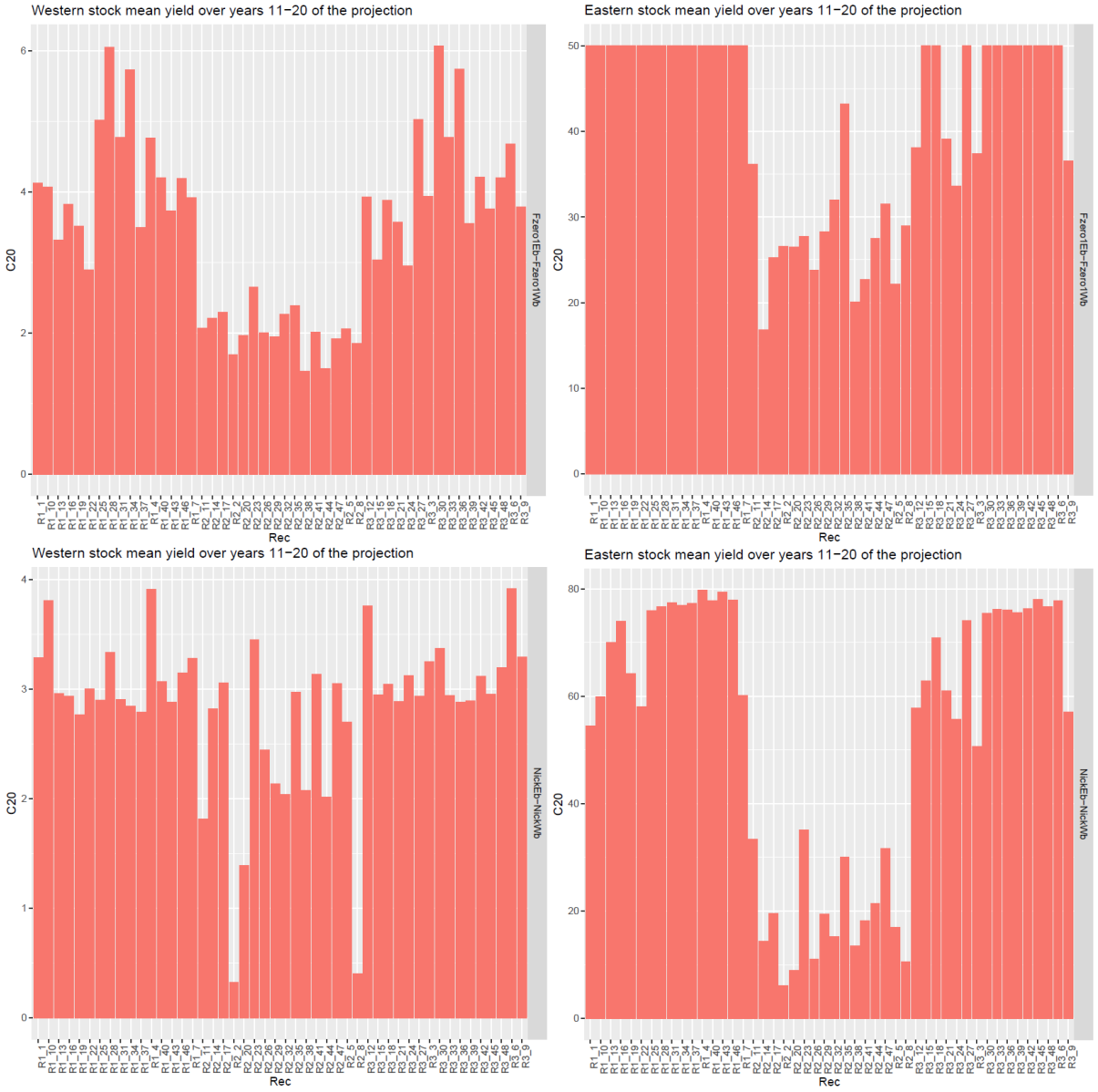

Figure 2. Average yield from the eastern and western management area in years 11 to 20 of the projection for each reference grid OM. The performance of the 2 cMPs is based on a 1:1 Br30 tuning.