MATHEMATICAL DESCRIPTION AND TUNING RESULTS OF A CANDIDATE MANAGEMENT PROCEDURE (TN_X) FOR MSE OF ATLANTIC BLUEFIN TUNA

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SUMMARY

This document consists of mathematical description of a candidate management procedure (CMP) and its tuning results for western stock across 96 operating models for management strategy evaluation of Atlantic bluefin tuna. The basic concept of this CMP is easy to understand and simple to use. TAC from this CMP can be calculated by three indices and one tuning parameters for eastern and western area, respectively. Tuning result of CMP are also described in this document, which tunes median of Br30 to 1.00, 1.25, 1.50.

RÉSUMÉ

Ce document consiste en une description mathématique d'une procédure de gestion potentielle (CMP) et de ses résultats de calibrage pour le stock occidental au moyen de 96 modèles opérationnels pour l'évaluation de la stratégie de gestion du thon rouge de l'Atlantique. Le concept de base de cette CMP est facile à comprendre et simple à utiliser. Le TAC découlant de cette CMP peut être calculé par trois indices et un paramètre de calibrage pour la zone orientale et la zone occidentale, respectivement. Le résultat du calibrage de la CMP est également décrit dans ce document, qui calibre la médiane de Br30 à 1,00, 1,25, 1,50.

RESUMEN

Este documento consiste en la descripción matemática de un procedimiento de ordenación mediante 96 modelos operativos para la evaluación de la estrategia de ordenación del atún rojo del Atlántico El concepto básico de este CMP es fácil de comprender y simple de utilizar. El TAC establecido a partir de este CMP puede ser calculado mediante tres índices para la zona oriental y occidental, respectivamente. En este documento también se describe el resultado de la calibración del CMP, que calibra la mediana de Br30 en 1,00, 1,25, 1,50.

KEYWORDS

Atlantic bluefin tuna, Management Strategy Evaluation, Management Procedure

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Introduction

Management strategy evaluation (MSE) is widely considered to be the most appropriate way to evaluate the trade-offs achieved by alternative management strategies and to assess the consequences of uncertainty for achieving management goals (Punt et al. 2014). The MSE for Atlantic bluefin tuna (ABT) is now under the development by SCRS (Rec [15-07], Anon 2019). The management procedure (MP) involves assessing the consequences of alternative options for management actions, for example determination of total allowable catch (TAC) (Rademeyer et al. 2007).

Currently several groups of scientists in ABTWG are creating candidate management procedure (CMP). While developing operating model (OM) are now on-going work, exercise for creating and tuning CMPs has already begun in parallel with OM development. This paper presents a CMP for ABT which is simple and empirical developed by Japanese scientists. The simple and empirical MP makes it easy not only to obtain the indices sustainably but also promotes the understanding of managers and stakeholders. In this paper, the results of the candidate MP were calculated by R package "ABTMSE" ver. 6.6.19.

Concept and details of CMP

The primary objective of this CMP is to conserve western stock for its recruitment and spawning stock biomass (SSB) by using USRR_66_114 and GOM_LAR_SUV indices, while Japanese longline index either in western or eastern area is used as indicator of SSB in each area. The trend in SSB at year, *y*, is determined by the ratio of the averaged values in recent period, y-2 to y-6, to that in previous period from y-5 to y-9. Using 5 years average would be enough to reduce the effect of uncertainty and outlier in the indices. TACs will change every 2 years under the current default setting.

$$JLL\ ratio = \frac{mean(Japanese\ longline\ index[y-2{:}y-6])}{mean(Japanese\ longline\ index[y-5{:}y-9])} \quad (1)$$

Firstly, when ratio of trend in GOM_LAV_SUV is less than α, which currently is set 0.8 for western area and 0.6 for eastern area, TACs will be decreased by 20% when JLL ratio is more than 0.8. If JLL ratio is less than 0.9, the reduction ratio is not 10% but base on JLL ratio. When this is not applicable, there is another threshold to evaluate the degree of recruitment in western area by USRR_66_114 only in western area CMP. Once recruitment index in recent 5 years is lower than the historical third lowest one, TAC in western area is automatically reduced by 10%. If JLL ratio is less than 0.9, the reduction ratio is not 10% but base on JLL ratio. Currently, ABT fisheries catch large individuals and hence TAC reduction based on recruitment will be multiplied at least twice until recruitment fish grows up to be main fisheries targets. The failure of recruitment also might affect the adult index after growing up. Therefore, high reduction based on recruitment would be extremely conservative and hence the reduction ratio based on recruitment is lower than that for SSB. These two TAC changes are kinds of emergency rule when indices detect drastic drop of SSB, extremely low recruitment or something like those in western stock.

When two thresholds regarding conservation of Western stock are not applicable, the ratio of trend in JPN LL and tuning parameter *k*, either *k_west* or *k_east*, in each area are used to determine the TAC in each area. Although mathematical description and explanation here is written as single *k* for the sake of simplicity, *k_east* and *k_west* are separately given and independent of each other. When the ratio of trend is between 95% and 105%, there will be no change in TACs. Once fluctuation of ratio is over 5%, TAC will change depending on JLL ratio and parameter *k* in each area to determine the ratio of TAC changes.

When JLL ratio is less than 0.95, *k* is multiplied as inversed value. On the other hand, When JLL ratio is larger than 1.05, *k* is just multiplied to JLL ratio. Under this equation, TAC is easy to go up and hard to go down when *k* is more than 1 and vice versa when *k* is less than 1. If *k* is equal to 1, ratio of TAC change is just JLL ratio (**Figure 1**). This simple calculation using linear coefficients sometimes makes TAC change quite bigger than original JLL ratio. Therefore, 50% increase and decrease are limitations of changing ratio.

$$(Ratio\ of\ TAC\ change) = \begin{cases} JLL\ ratio\ * k^{-1} - (0.95 * k^{-1} - 0.95) & if\ JLL\ ratio \leq 0.95 \\ JLL\ ratio\ * k - (1.05 * k - 1.05) & if\ JLL\ ratio \geq 1.05 \end{cases} \quad (2)$$

The flowchart of this CMP in each west and east area are shown in **Figures 2** and **3**, respectively.

CMP Tuning

The initial parameter for tuning CMP was set to 0.95 for *k_west* and 1.59 for *k_east*, which was used for previous tuning and setting to that value could get approximately 1.0 in Br30 for western stock (Tsukahara and Nakatsuka, 2020). Each value of the parameter was incremented or decremented empirically and iteratively.

Results

As a result of iterative process, the values of *k_west* to tune Br30 for Western stock to 1.00, 1.25 and 1.50 were 0.855, 0.330 and 0.030, respectively, while those of *k_east* were 1.57, 0.52 and 0.045. Average catches over 30 years in each area (AvC30) were different according to tuning results (**Figures 4** and **5**). In the case of west area, the values in max of AvC30 had larger differences across tuning objective than that in median. On the other hand, in the case of east area, the values in max of AvC30 had as large different as that in median. It indicates that it is important to reduce the chance of TAC increasing in western area and to decrease TAC in East area to increase Br30 in western stock.

Reference

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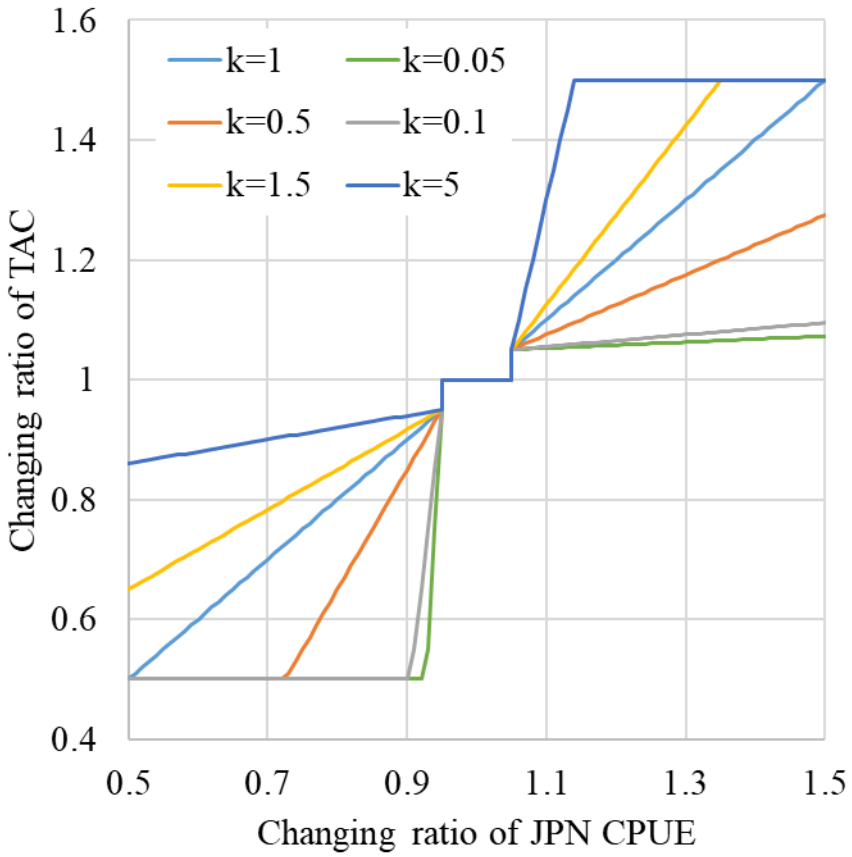

Figure 1. The differences of CMP performance by tuning parameter *k*.

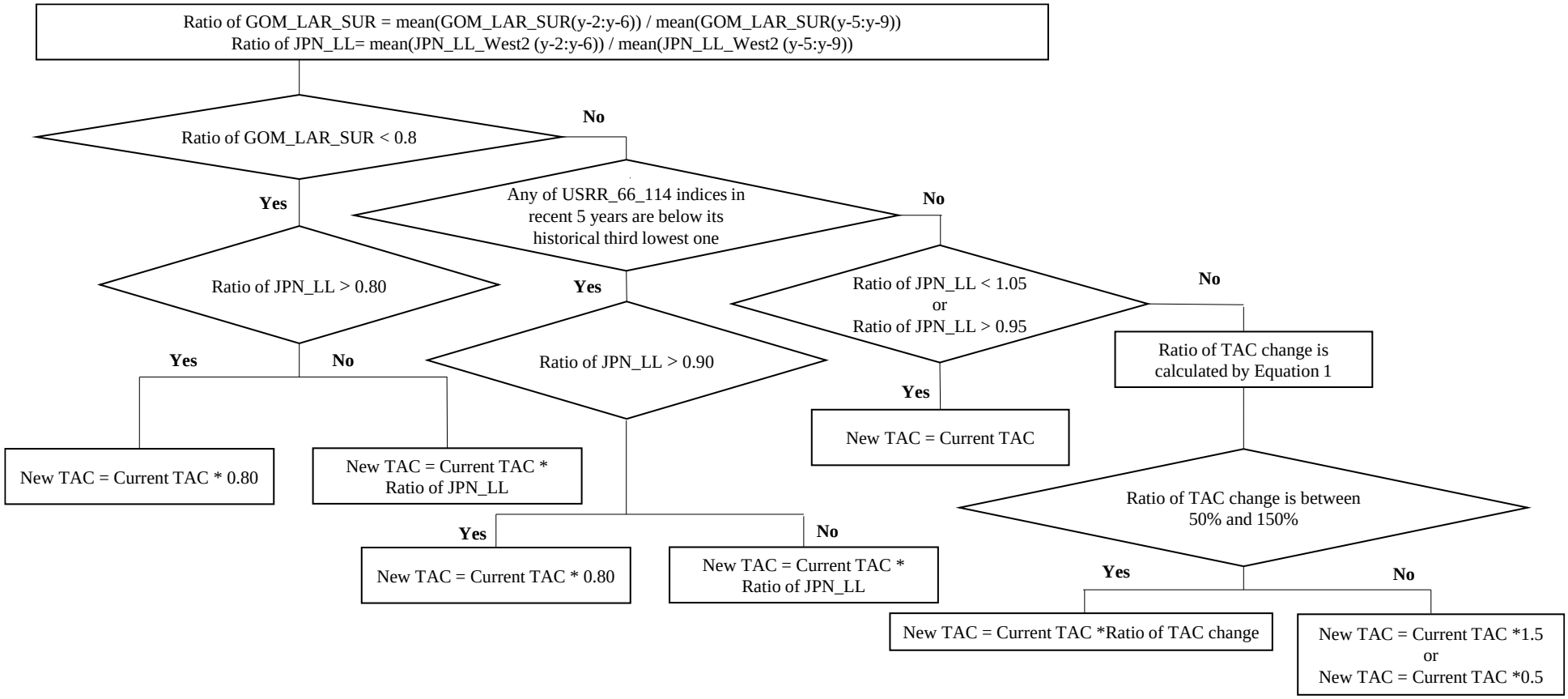

Figure 2. Flowchart of calculation of Western TAC.

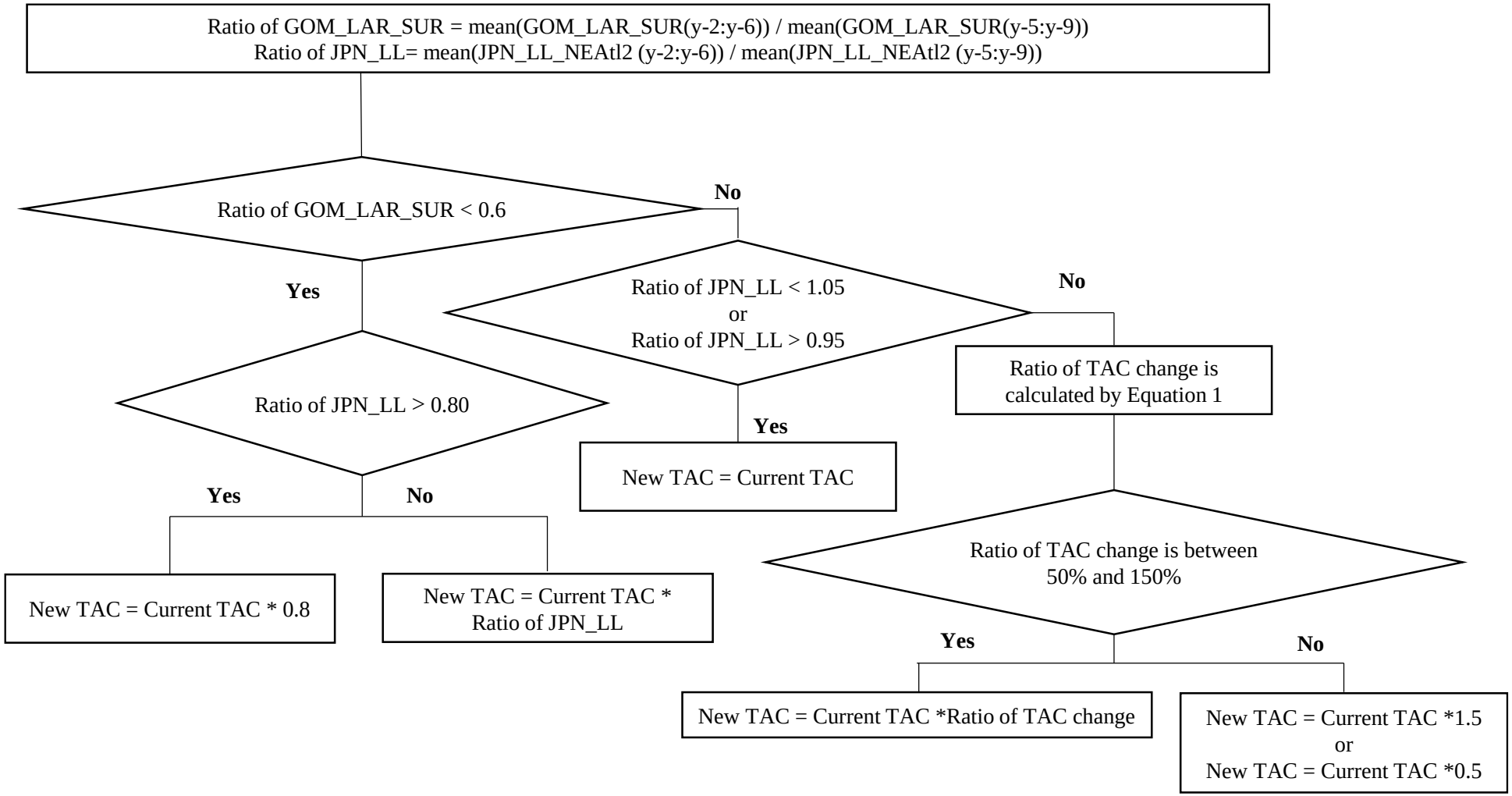

Figure 3. Flowchart of calculation of Eastern TAC.

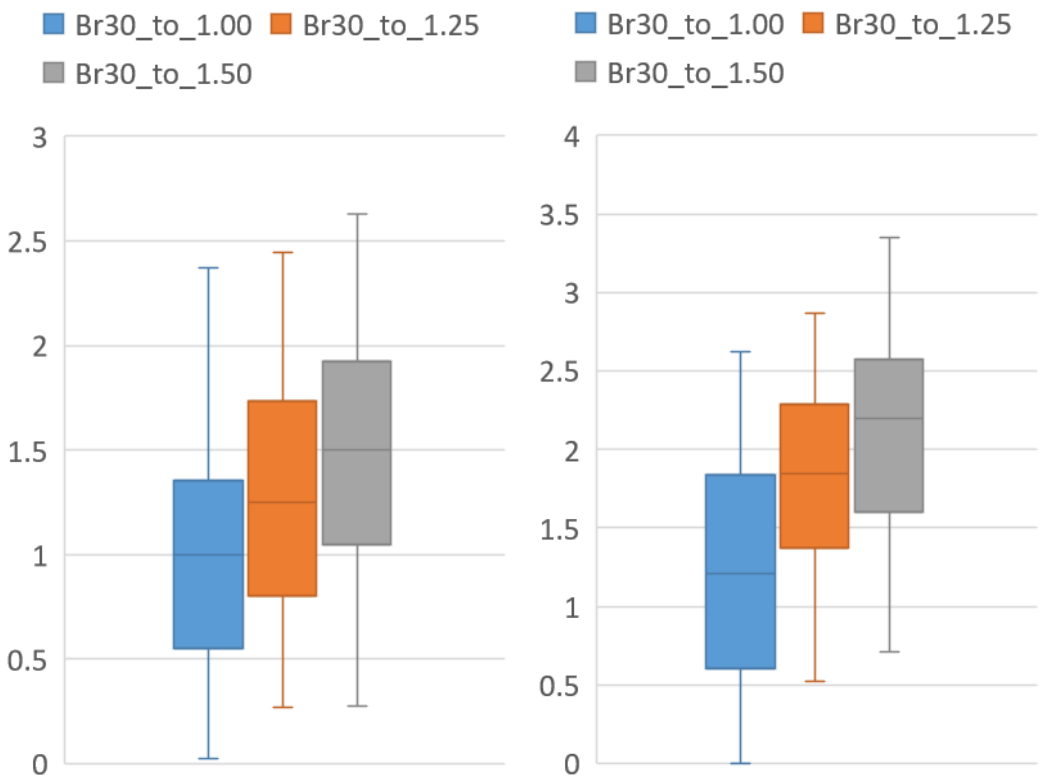

Figure 4. The boxplot for 3 tuning results of (left panel) Br30 in western stock, (right panel) Br30 in easter stock across 96 OMs.

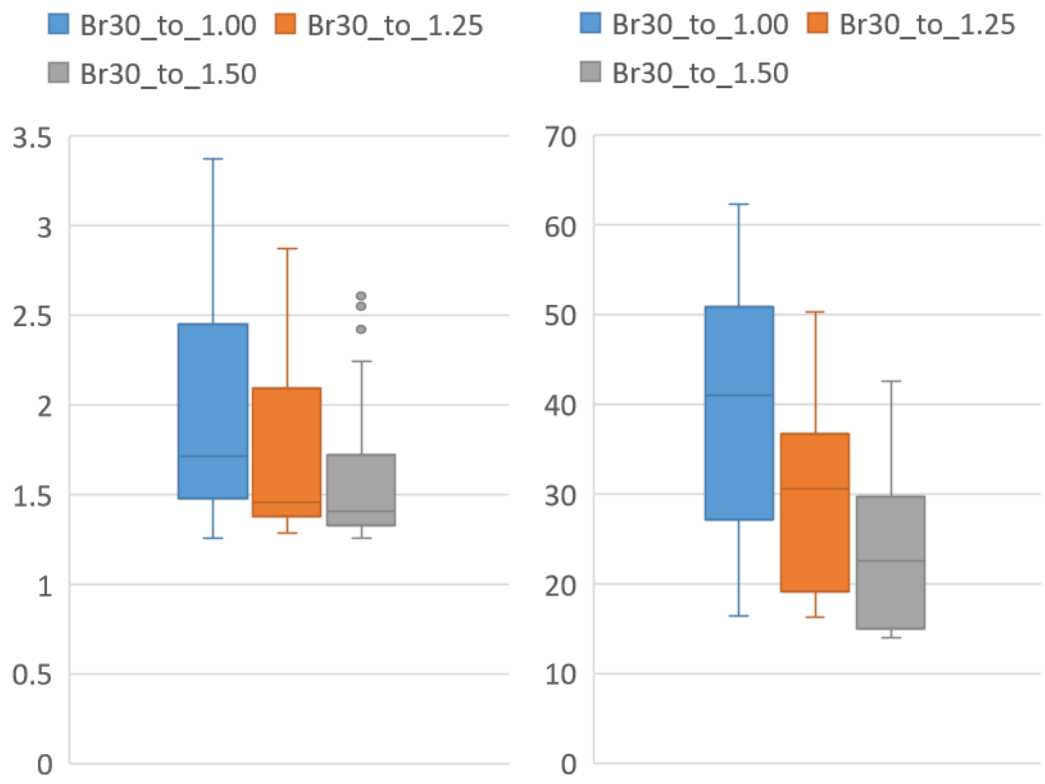

Figure 5. The boxplot for 3 tuning results of (left panel) AvC30 (kilo ton) in western area, (right panel) AvC30 (kilo ton) in eastern area across 96 OMs.

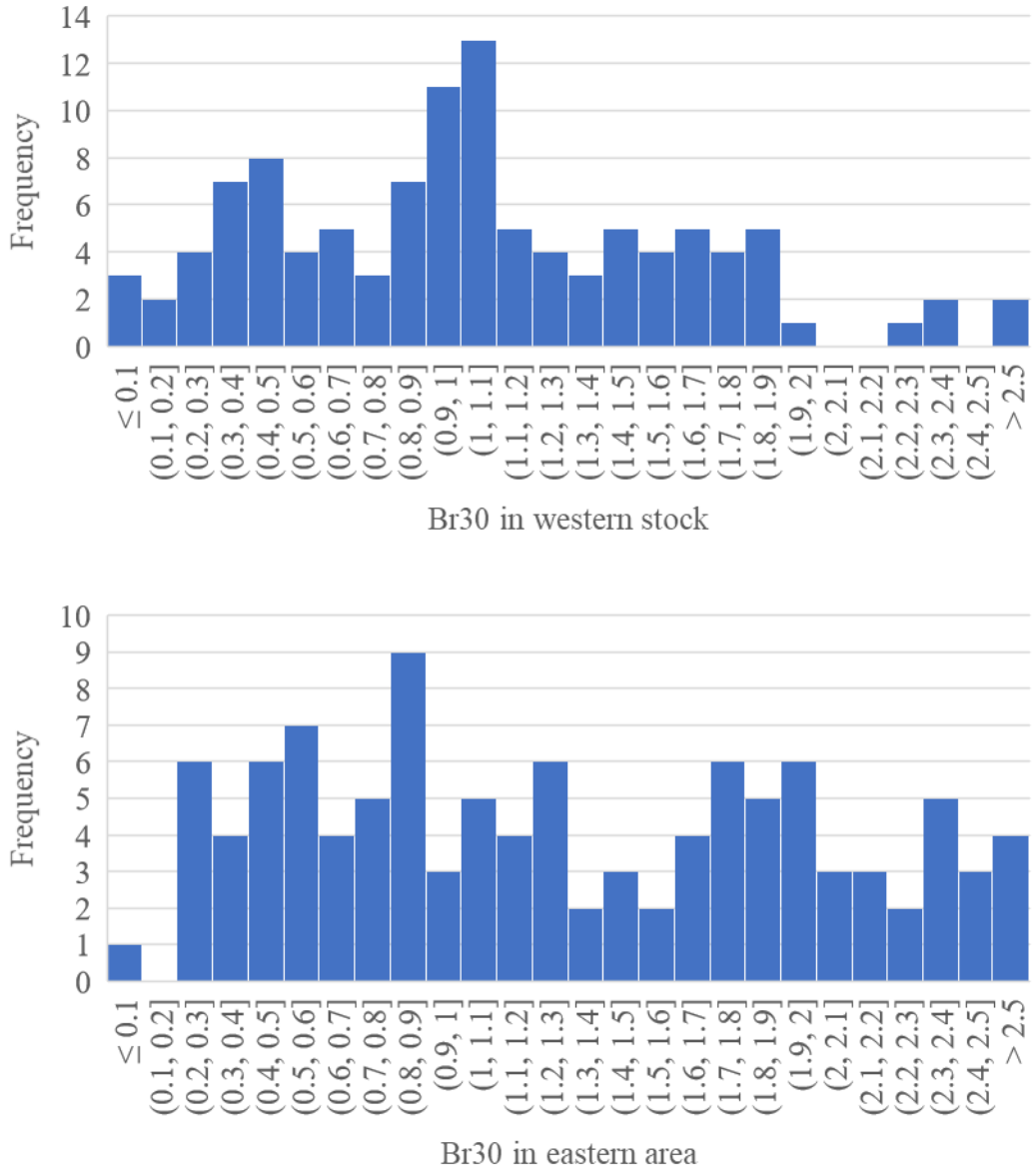

Figure 6. Distribution of Br 30 in each OM and ROM with *k_west* = -0.05 and *k_east* = 0.9. Top panel shows Br30 in western stock. Bottom panel shows Br30 in eastern stock.