MATHEMATICAL DEFINITION AND UPDATED PROGRESS OF THE 'EA' cMPs

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SUMMARY

This paper provides the mathematical definition of the EA cMPs, developed by the group of European scientist and already shown in previous presentations shown and discussed at ICCAT BFT WG meetings since 2019. Results of the development tuning exercises carried out during the last year are also shown, focusing mainly on performance statistics Br30 and AvC30. In a first exercise, the EA cMPs have first been tuned to the agreed development tuning targets of median values for Br30 West of 1.00, 1.25 and 1.50. Results showed that achieving these management objectives for the West was not significantly affecting the East in terms of catches (AvC30). However, the variability associated to the two metrics used was quite high yet. Additionally, when tuning one of the cMPs (EA5), difficulties appeared evidencing that it was impossible to reach the management objective of Br30_West=1. The last exercise focused on keeping both stocks at current management objectives, defined as Br30=1 for both, the East and the West. Results of this last exercise showed greater differences in catch levels for the East when applying both cMPs.

RÉSUMÉ

Le présent document fournit la définition mathématique des cMP EA, développée par le groupe de scientifiques européens et déjà présentée dans les précédentes présentations montrées et discutées lors des réunions du Groupe d'espèces sur le thon rouge de l'ICCAT depuis 2019. Les résultats des exercices de calibrage du développement effectués au cours de l'année dernière sont également présentés, en se concentrant principalement sur les statistiques de performance Br30 et AvC30. Dans un premier exercice, les cMP EA ont d'abord été calibrés sur les objectifs de calibrage du développement convenus, à savoir des valeurs médianes pour Br30 Ouest de 1,00, 1,25 et 1,50. Les résultats ont montré que la réalisation de ces objectifs de gestion pour l'Ouest n'avait pas d'incidence significative sur l'Est en termes de captures (AvC30). Cependant, la variabilité associée aux deux métriques utilisées était encore assez élevée. De plus, lors du calibrage de l'une des cMP (EA5), des difficultés sont apparues, montrant qu'il était impossible d'atteindre l'objectif de gestion de Br30_Ouest=1. Le dernier exercice visait à maintenir les deux stocks aux objectifs de gestion actuels, définis comme Br30=1 pour l'Est et l'Ouest. Les résultats de ce dernier exercice ont montré des différences plus importantes dans les niveaux de capture pour l'Est lors de l'application des deux cMP.

RESUMEN

Este documento proporciona la definición matemática de los cMP EA, desarrollada por el grupo de científicos europeos y ya mostrada en presentaciones anteriores mostradas y discutidas en las reuniones del Grupo de especies de atún rojo de ICCAT desde 2019. También se muestran los resultados de los ejercicios de calibración de desarrollo realizados durante el último año, centrados principalmente en las estadísticas de desempeño Br30 y AvC30. En un primer ejercicio, los cMP EA se han calibrado primero con los objetivos de calibración de desarrollo acordados de valores de las medianas para Br30 oeste de 1,00, 1,25 y 1,50. Los resultados mostraron que la consecución de estos objetivos de ordenación para el oeste no afectaba significativamente al este en términos de capturas (AvC30). Sin embargo, la variabilidad asociada a las dos mediciones utilizadas era aún bastante elevada. Además, al calibrar uno de los cMP (EA5), aparecieron dificultades que evidenciaron la imposibilidad de alcanzar el objetivo de ordenación de Br30_West=1. El último ejercicio se centró en mantener ambos stocks en los objetivos de ordenación actuales, definidos como Br30=1 para ambos, el este y el oeste. Los resultados de este último ejercicio mostraron mayores diferencias en los niveles de capturas para el este cuando se aplicaron ambos cMP.

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KEYWORDS

Candidate Management Procedure, index-based, Bluefin tuna, Tuning, Performance statistics

Introduction

The ICCAT BFT WG supported by the MSE Technical group is making progress towards the development of candidate management procedures (cMPs) that will provide Total Allowable Catch (TAC) based advice for both the East and West areas of Atlantic Bluefin tuna (ABT). In this paper we formally define two empirical EAx cMPs (EA_{2n+1} and EA_{2n}) that set TACs by area as fixed proportions of abundance as indicated by an aggregate of abundance indices.

In addition to the full description of the EAx cMPs, outcomes from different tuning exercises are shown: (1) tuning the two cMPs to achieve a management objective of Br30 levels of 1.00, 1.25 and 1.5 for the western stock; (2) tuning the two cMPs to achieve current management goals, defined as Br30 levels of 1.00 for both, the East and the West stocks; (3) upweighting indices that best reflect the dynamics of the juvenile fraction of the two populations (stocks). Results of exercises 1 and 2 are already available in the shiny-app.

1. Mathematical description of the base case generic EAx cMPs

Both cMPs, EA_{2n+1} and EA_{2n} are empirical, based on inputs related to abundance indices which are first standardised for magnitude, then aggregated by way of a weighted average of all indices available for the East and the West areas. TACs are then set based on the concept of taking a fixed proportion of the abundance present, as indicated by these aggregated abundance indices. The details are set out below.

1.1 Data sets

Same four indices have been selected for each stock in each of the two cMPs, aiming at best reflecting the dynamics of each of the stocks. For the East, the French Aerial Survey (FR_AER_SUV2), the Mediterranean Larval (MED_LAR_SUV), the Moroccan-Portuguese Trap (MOR_POR_TRAP) and the Japanese Longline (North East Atlantic - JPN_LL_NEAtl2) indices are used. For the West, the Gulf of Mexico Larval (GOM_LAR_SUV), the US Rod & Reel 66-114 (US_RR_66_114), the US Gulf of Mexico Pelagic Long Line (US_GOM_PLL2) and the Japanese Longline (West - JPN_LL_West2) indices are selected. The standard deviation and the autocorrelation values estimated for each of these indices have been published in the report of the MSE Technical Group meeting hold in February 2020 (ICCAT, 2020) and can be found in **Table 1**.

1.2 Status Estimator: the aggregated abundance index

1.2.1 The EA_{2n+1} cMP

An aggregate abundance index is developed for each of the East and the West areas by first standardising each index available for that area by the average value of the last 4 years of historical observations and then taking a weighted mean of the results for each index (see Equation 2). Then the weighted mean of all indices was used to calculate the status estimator *Irat*. The weight of each of the indices is inversely proportional to the variance of the residuals. Future values of the indices are generated considering both the variance and autocorrelation (see Equations 3 & 4).

In the *EA_{2n+1} cMP, the aggregated abundance index is then calculated as follows:*

$$Irat_{\,y} = \frac{\sum_i^n w_i * I_{i,y}^*}{\sum_i^n w} \tag{1}$$

where

$$I_{i,y}^* = \frac{I_{i,y}}{\sum_{y=1}^{i} I_{i,y}} \tag{2}$$

and

$$w = \frac{1}{\sigma_i^2} \tag{3}$$

being

$$\sigma_i = \frac{SD_i}{(1 - AC_i)} \tag{4}$$

The actual index used in the EA_{2n+1} *cMP*, $Irat_{av,y}$, for both the East and the West area, is the average over the last three years for which data would be available at the time the MP would be applied:

$$Irat_{av,y} = \frac{1}{3}(Irat_y + Irat_{y-1} + Irat_{y-2}) \tag{5}$$

1.2.2 The EA_{2n} cMP

The difference with the previous cMP is that the status estimator is now calculated as the weighted median of the aggregated index, which is previously standardized in the same way that the EA_{2n+1} one. SO, the mathematical description of this cMP is similar to the previous one, but replacing the weighted mean by a weighted median.

1.3 The Harvest Control Rule (HRC)

The EAx cMPs tested set the TAC every second year simply as a multiple of the $Irat_{av}$ value for the area at the time, but subject to a maximum TAC change of 20% (up or down) for each area. The TAC is then defined as follows:

$$TAC_{y+1} = \begin{cases} TAC_y * \propto Irat_n & if \;\; 0.8 < Irat_n < 1.2 \\ 0.8 * TAC_y & if \;\; Irat_n \leq 0.8 \\ 1.2 * TAC_y & if \;\; Irat_n \geq 1.2 \end{cases} \tag{6}$$

where

$$Irat_n = \gamma * Irat + (1 - \gamma) \tag{7}$$

and

$$\propto = 1/Itar \tag{8}$$

2. Analysis

From these two base cases, different exercises have been done aiming at tuning these two cMPs to achieve different management objectives. In a third exercise a new cMP was tested, for which the weights of the indices that more directly reflect the dynamics of the juvenile fraction of the population were kept similar, but other indices were down-weighted in an order or magnitude (divided by 10). For all these exercised the value of the γ parameter was set in 0.15, and all based only in deterministic runs.

2.1 Tuning to Br30 levels in the West

In a first exercise, the two cMPs were tuned to achieve Br30 levels of 1.00, 1.25 and 1.5 for the West. No tunning was considered for the East.

2.2 Tuning to BR30 levels for the two stocks

In this second exercise, the two cMPs have been tuned to achieve results consistent to current management objectives (both stocks around MSY), by keeping median values of Br30 of 1.00 for both the East and the West. In this case, the weight of the JPN_LL_NEAtl2 was also decreased in one point, compared to that one reflected in **Table 1**, just to be closer to the weight of the other CPUE indices used.

2.3 Upweighting juvenile indices

In this preliminary exercise, the weights of the juvenile indices (FR_AER_SUR and US_RR_66-114 for the East and West respectively) were kept similar but for other indices, the weight was divided by 10. Values of tuning parameters were kept similar to the ones obtained from exercise 2 for the two EAx cMPs for comparison purposes, but in this last exercise the cMPs were not tuned to achieve any particular management goal.

3. Results and conclusions

3.1 Tuning to Br30 levels in the West

Six cMPs have resulted from this exercise, referred to the three tuning levels for the two cMPs, being EA1, EA3 and EA5 the EA_{2n+1}-type cMPs that correspond to median Br30 values for the West of 1.00, 1.25 and 1.5 respectively. EA2, EA4 and EA6 are EA_{2n}-type cMPs that correspond to median Br30 values for the West of 1.00, 1.25 and 1.5 respectively.

Mean values of the Br30 and AvC30 metrics for each of these simulations can be found in **Table 2. Figure 1** shows the Zeh plot with Br30 and AvC30 values of each EAx cMPs for both the East and West areas. In **Figure 2,** the projections in terms of SSB/SSB_{MSY} and catch for the two stocks are provided. Note that SSB_{MSY} is dynamic for all OMs. A further analysis of these projections was made, aiming at better understanding the dynamics of the different Recruitment type (R1, R2 or R3) OMs in **Figure 2** projections. **Figure 3** shows projections of SSB/SSB_{MSY} by recruitment type. In **Figure 3a** the mean biomass and catch values across all OMs with Recruitment type 1 (R1) are shown. **Figure 3b** show the mean values of the same metrics but across all Recruitment type 2 (R2) OMs. And Figure 3.c shows similar results obtained across all Recruitment type 3 (R3) OMs. From this figure, it is easily noted that R2 and R3 are the ones that might be causing the big decrease in catches that can be mainly driven by R2 and R3 OMs.

With regards to the existing differences between the two EAx cMPs, **Figure 4** illustrates focusing on the first two cMPs, EA1 and EA2, that in terms of BR30 values obtained from each OM, for both the East and the West, no high differences can be found. However, most significant differences relate to R1 and R3 type OMs in the East (black and green colored points respectively). **Figure 5** show same results that **Figure 4**, but different colors reflecting now different length composition weight scenarios. It shows that, most of the differences between Br30 values occur in the East and related to OMs with low length composition weight, excluding R2-type OMs (see **Figure 4**), which have always the worst performance values, along with eventually some R3-type OMs for the two cMPs tested, EA1 and EA2.

3.2 Tuning to BR30 levels for the two stocks

Two new cMPs have resulted from the exercise of tuning the two base case cMPs to close-to-current management objectives for the two stocks, i.e., Br30=1. EA9 is an EA_{2n+1}-type cMP and EA10 corresponds to an EA_{2n}-type cMP.

Mean values of the Br30 and AvC30 metrics for each of these simulations can be found in **Table 3**. **Figure 6** shows the Zeh plot with Br30 and AvC30 values of each EA7 and EA8 cMPs for both the East and West areas. In **Figure 7,** the projections in terms of SSB/SSB_{MSY} and catch for the two stocks are provided. Note that SSB_{MSY} is dynamic for all OMs.

With regards to the existing differences between the two EA7 and EA8 cMPs, **Figure 8** shows that higher differences in terms of BR30 values obtained from each OMs can be found for the East. Again, higher differences relate to R1 and R3 OMs, but the weight of the length composition seem not to play such a clear role now (see **Figure 9**).

Lowest Br30 values for the East area are related to R2 and eventually R3 scenarios (see **Figure 8**), and also to (--) and (+-) scale OMs (see **Figure 10**).

3.3 Upweighting juvenile indices

Mean values of the Br30 and AvC30 metrics for each simulation can be found in **Table 4. Figure 11** shows the Zeh plot with Br30 and AvC30 values of each EA9 and EA10 cMPs for both the East and West areas. In **Figure 12,** the projections in terms of SSB/SSB_{MSY} and catch for the two stocks are provided. Note that SSB_{MSY} is dynamic for all OMs.

With regards to the existing differences between the two EA9 and EA10 cMPs, **Figure 13** shows higher differences can be found in the East, and again related to R1 and R3 OMs. However, these differences appear to be smaller than those obtained in previous exercises.

Worse performance of both cMPs seem to be even more clearly related to R2 than in exercise 2, again in particular for the East The weight of the length composition seem not to play such a clear role in this case, since the differences are found across all OMs (see **Figure 14**), but the worse Br30 values were again related to (--) and (+-) scale OMs.

References

ICCAT. 2020. Report of the 2020 intersessional meeting of the ICCAT Bluefin tuna MSE technical group. February 2020. Madrid (Spain).

Table 1. Indices used to estimate the aggregated index for each ABF area, together with the σ and w values obtained from equations 3 and 4, using the information published in the ICCAT BFT MSE Technical Group meeting report (ICCAT, 2020).

	Sigma (σ)	Weight (w)
EAST		
FR_AER_SUV2	1.00	1.00
MED_LAR_SUR	0.56	3.189
MOR_POR_TRAP	0.56	3.189
JPN_LL_NEAtl2	0.45	4.939
WEST		
GOM_LAR_SUR	0.58	2.977
US_RR_66-114	1.47	0.463
US_GOM_PLL2	0.98	1.041
JPN_LL_West2	0.62	2.601

Table 2. Mean of the Br30 and AvC30 performance metrics over all simulations from tuning exercise 1- EA1 to EA6 cMPs (only using the Reference Grid).

	EAST		WEST	
	AvC30	Br30	AvC30	Br30
EA1	44.57	1.1	1.73	0.99
EA2	39.59	1.33	1.9	0.98
EA3	44.61	1.1	1.4	1.18
EA4	39.64	1.34	1.56	1.19
EA5	44.66	1.11	1.07	1.4
EA6	39.71	1.35	1.17	1.39

Table 3. Mean of the Br30 and AvC30 performance metrics over all simulations from tuning exercise 2 – EA7 and EA8 cMPs (only using the Reference Grid).

	EAST		WEST	
	AvC30	Br30	AvC30	Br30
EA7	45.81	1.01	1.7	1
EA8	44.84	1.01	1.69	1

Table 4. Mean of the Br30 and AvC30 performance metrics over all simulations from tuning exercise 3 – EA9 and EA10 cMPs (only using the Reference Grid).

	EAST		WEST	
	AvC30	Br30	AvC30	Br30
EA9	33.34	1.66	2.01	1.08
EA10	26.8	2.05	2.08	1.2

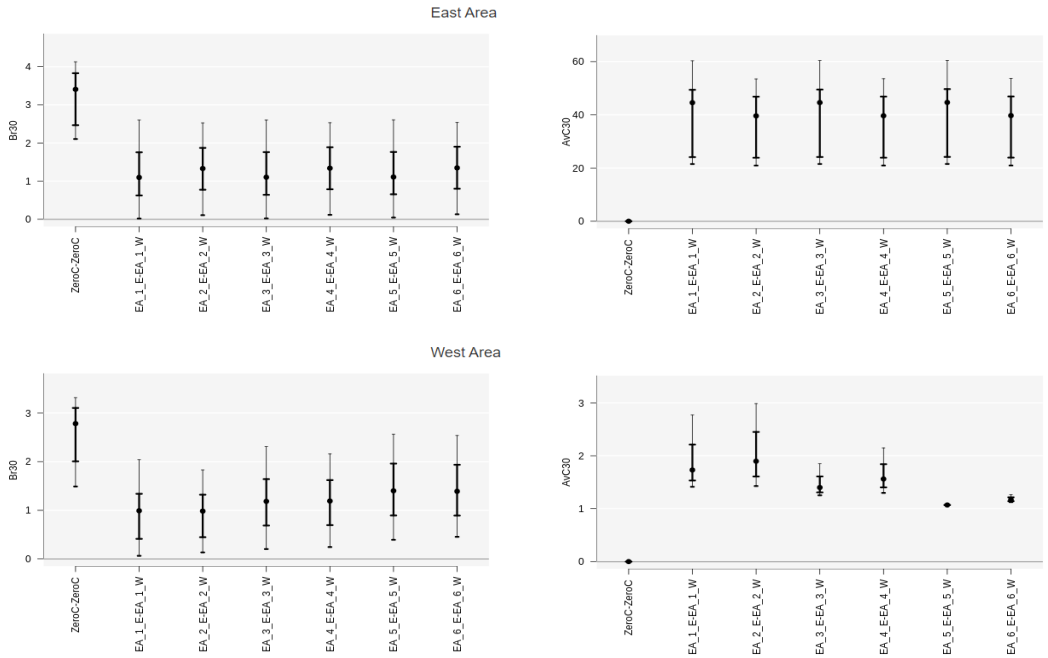

Figure 1. Performance statistics from all cMPs [EA1-EA6] for both the East and the West, resulting from exercise 1.

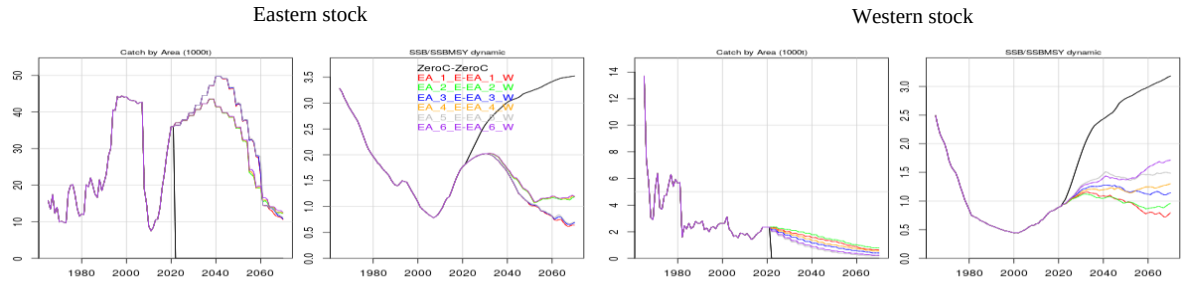

Figure 2. Projected mean catch and SSB/SSB_{MSY} values estimated across all OMs for both stocks and the 6 cMPs tested [EA1-EA6], resulting from exercise 1.

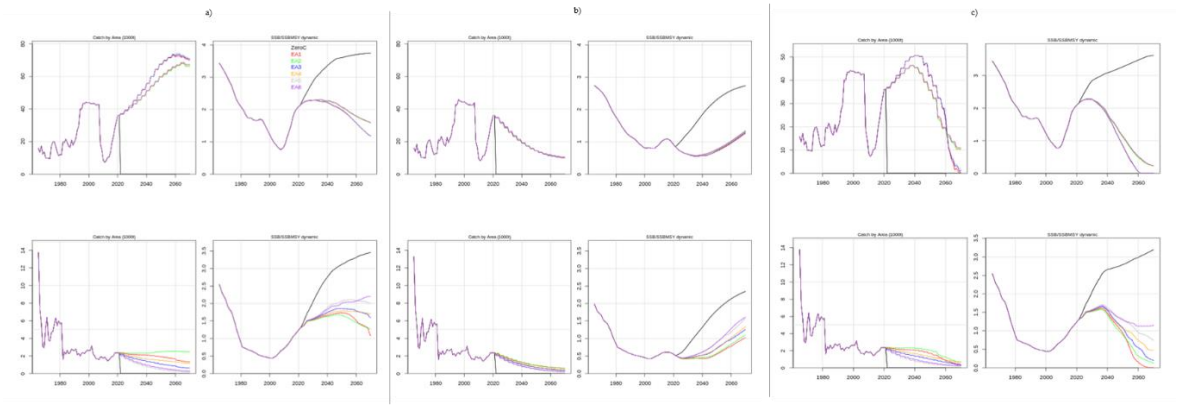

Figure 3. Projected mean catch and SSB/SSB_{MSY} values estimated across for both stocks and the 6 cMPs tested [EA1-EA6], by Recruitment scenario R1 (a), R2 (b) and R3 (c), resulting from exercise 1. Note that all figures in the upper line are related to the Eastern stock, whereas the ones in the second line are from Western stock.

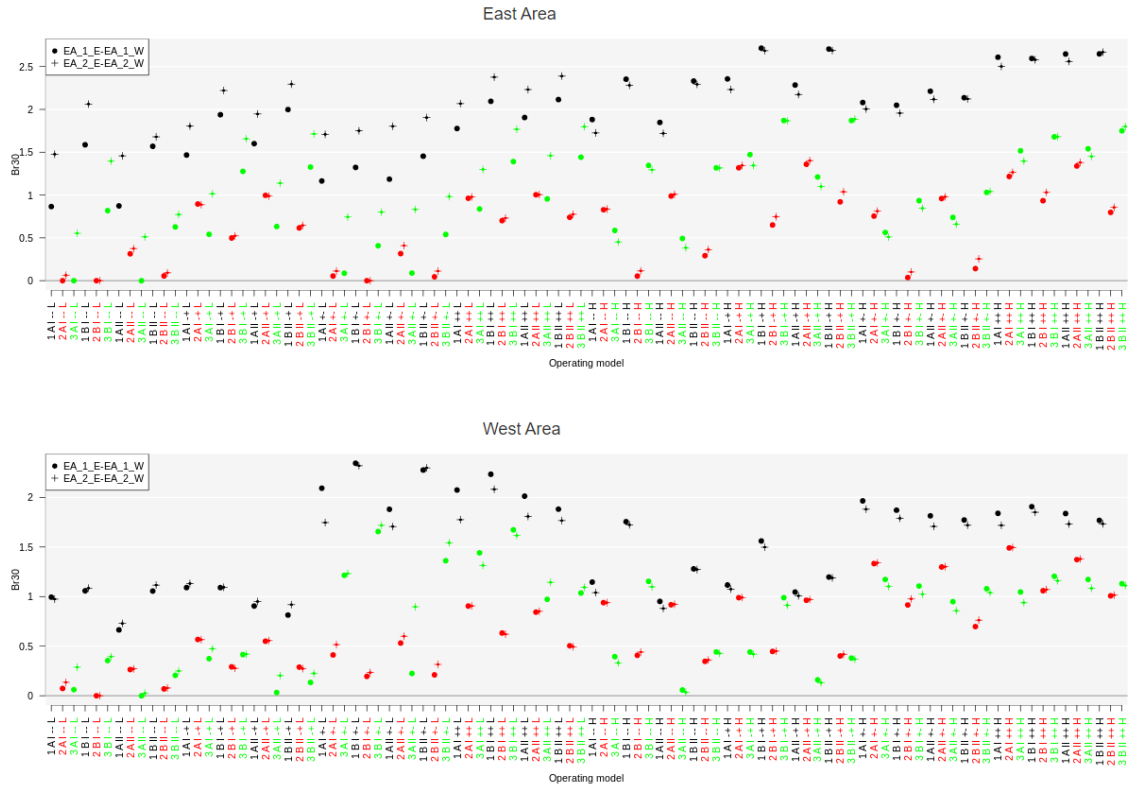

Figure 4. Comparison between Br30 values obtained for all OMs and both EA1 and EA2 cMPs (EA1 represented with dots and EA2 with crosses), resulting from exercise 1. Different colors represent different recruitment scenarios: R1 (black), R2 (red) and R3 (green).

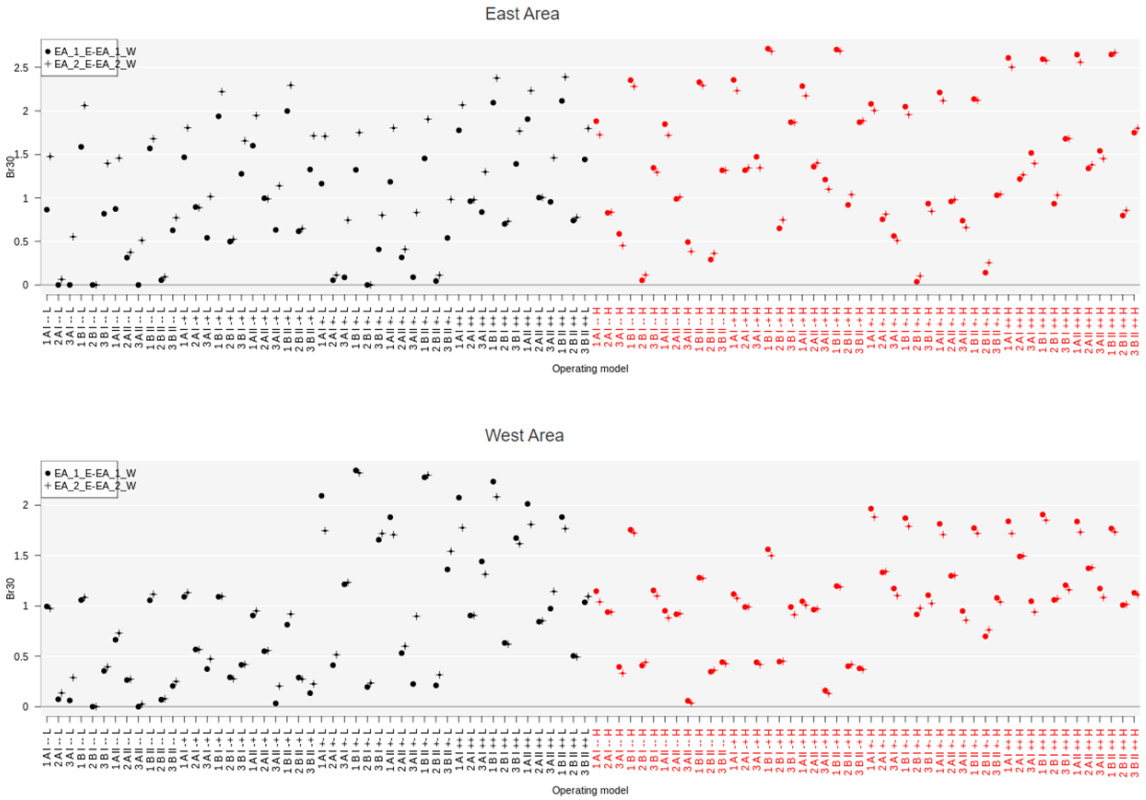

Figure 5. Comparison between Br30 values obtained for all OMs and both EA1 and EA2 cMPs (EA1 represented with dots and EA2 with crosses), resulting from exercise 1. Different colors represent different Length composition weight scenarios: Low (L-black) and High (H -red).

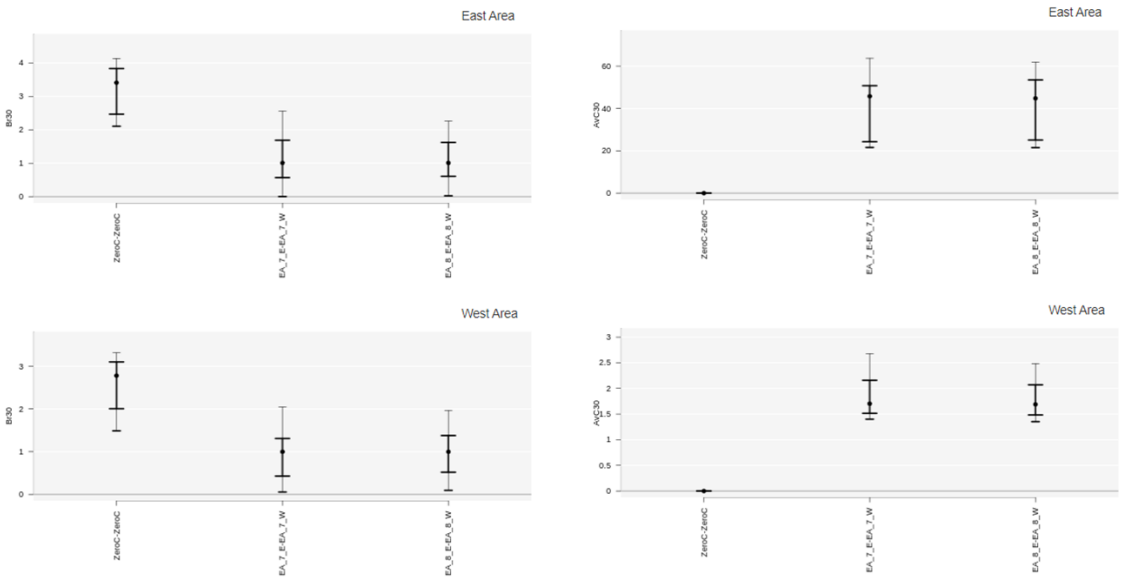

Figure 6. Performance statistics from EA7 and EA8 cMPs, compared to the ZeroCatch cMP, for both the East and the West, resulting from exercise 2.

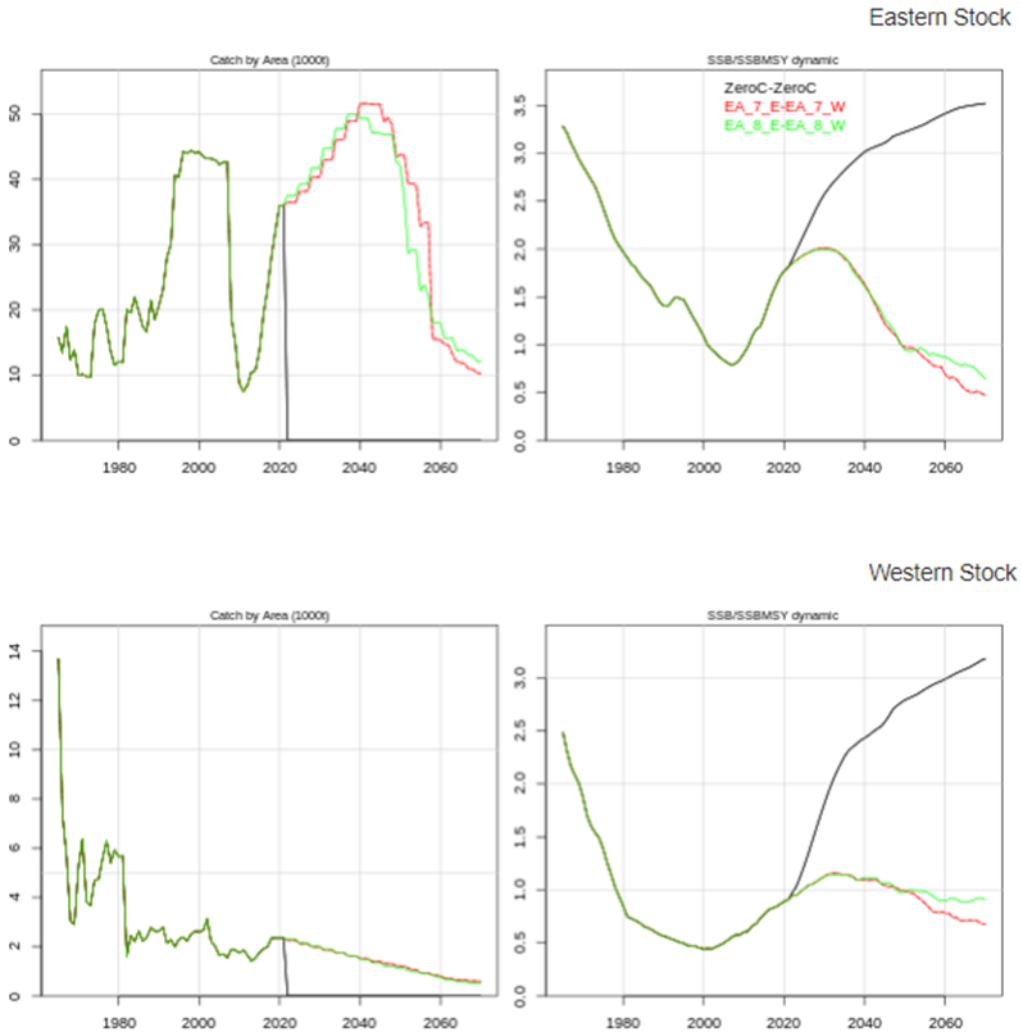

Figure 7. Projected mean catch and SSB/SSB_{MSY} values estimated across all OMs for both stocks and the two cMPs tested [EA7 and EA8], resulting from exercise 2.

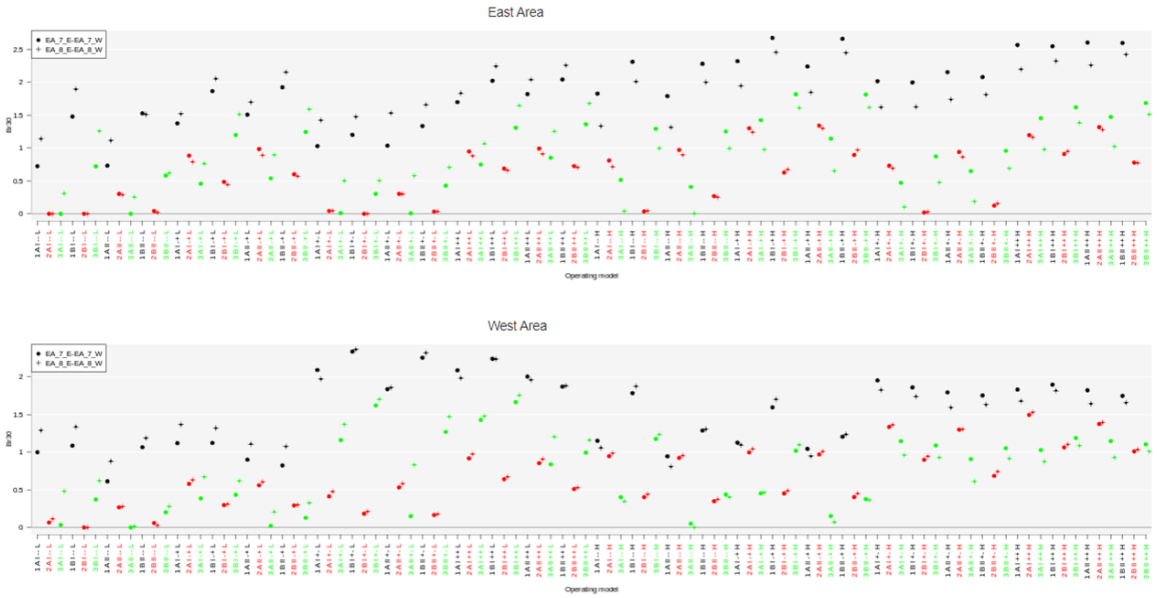

Figure 8. Comparison between Br30 values obtained for all OMs and both EA7 and EA8 cMPs (EA7 represented with dots and EA8 with crosses), resulting from exercise 2. Different colors represent different recruitment scenarios: R1 (black), R2 (red) and R3 (green).

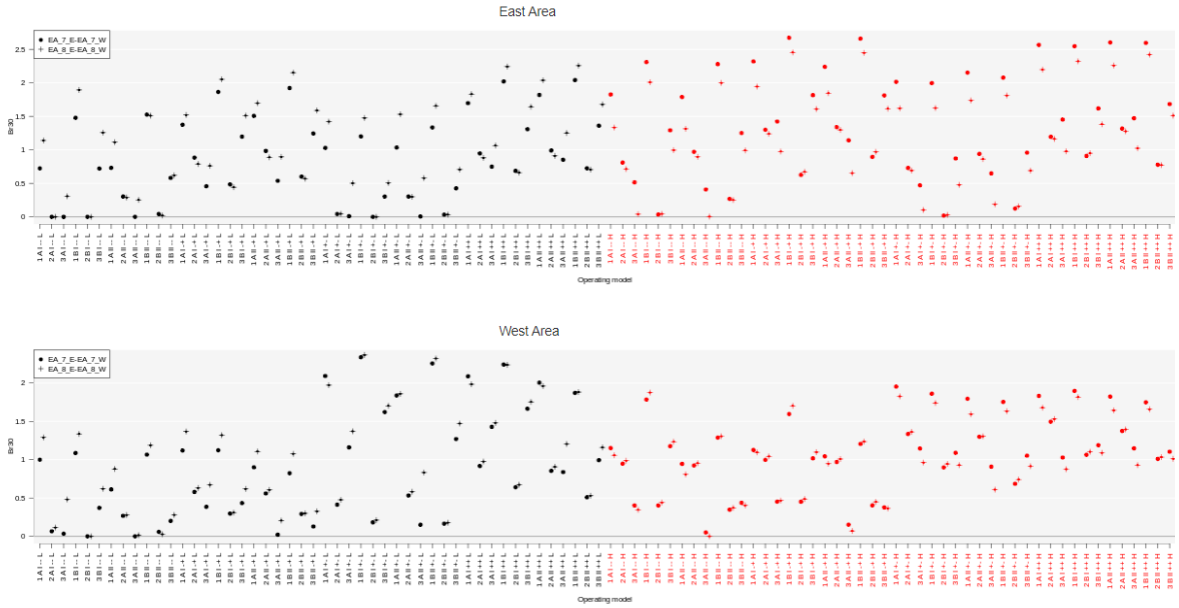

Figure 9. Comparison between Br30 values obtained for all OMs and both EA7 and EA8 cMPs (EA7 represented with dots and EA8 with crosses), resulting from exercise 2. Different colors represent different Length composition weight scenarios: Low (L-black) and High (H -red).

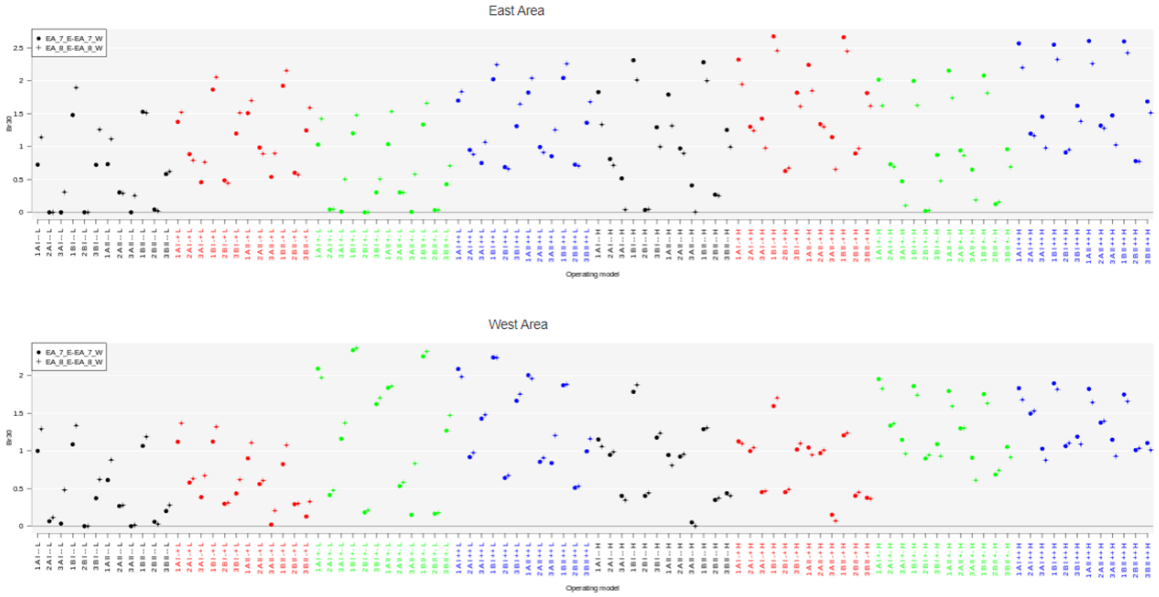

Figure 10. Comparison between Br30 values obtained for all OMs and both EA7 and EA8 cMPs (EA7 represented with dots and EA8 with crosses), resulting from exercise 2. Different colors represent different Scale scenarios: being (--) in black, (-+) in red, (+-) in green and (++) in blue.

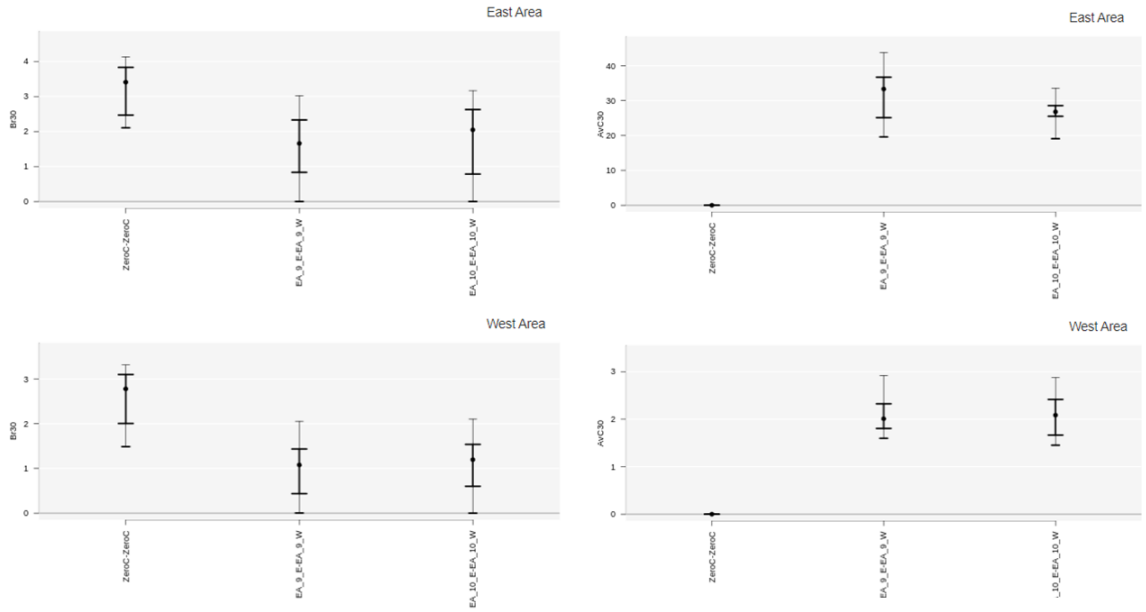

Figure 11. Performance statistics from EA9 and EA10 cMPs, compared to the ZeroCatch cMP, for both the East and the West, resulting from exercise 3.

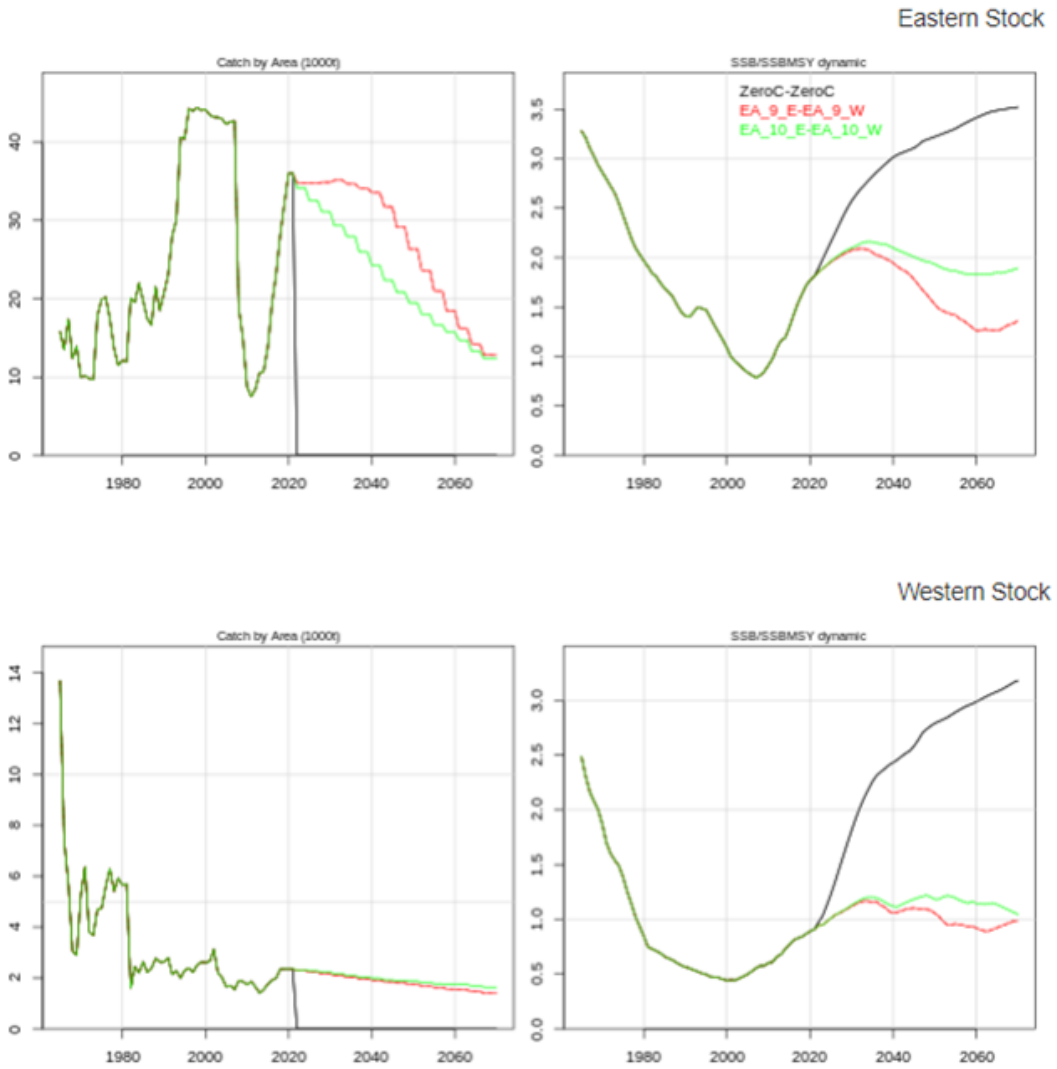

Figure 12. Projected mean catch and SSB/SSB_{MSY} values estimated across all OMs for both stocks and the two cMPs tested [EA9 and EA10], resulting from exercise 3.

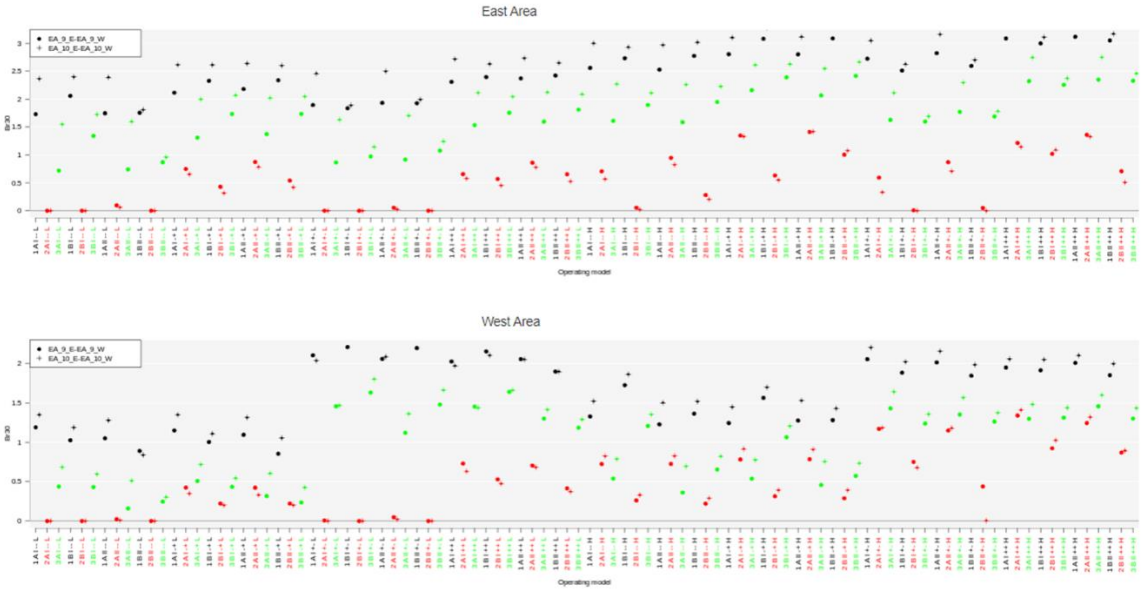

Figure 13. Comparison between Br30 values obtained for all OMs and both EA9 and EA10 cMPs (EA9 represented with dots and EA10 with crosses), resulting from exercise 3. Different colors represent different recruitment scenarios: R1 (black), R2 (red) and R3 (green).

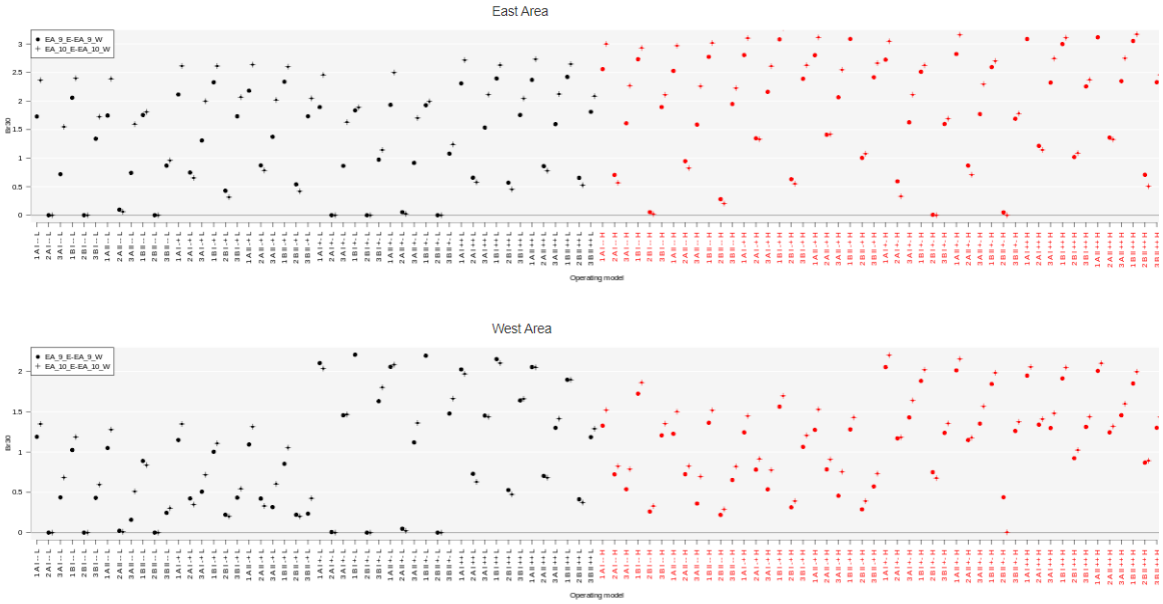

Figure 14. Comparison between Br30 values obtained for all OMs and both EA9 and EA10 cMPs (EA9 represented with dots and EA10 with crosses), resulting from exercise 3. Different colors represent different Length composition weight scenarios: Low (L-black) and High (H -red).

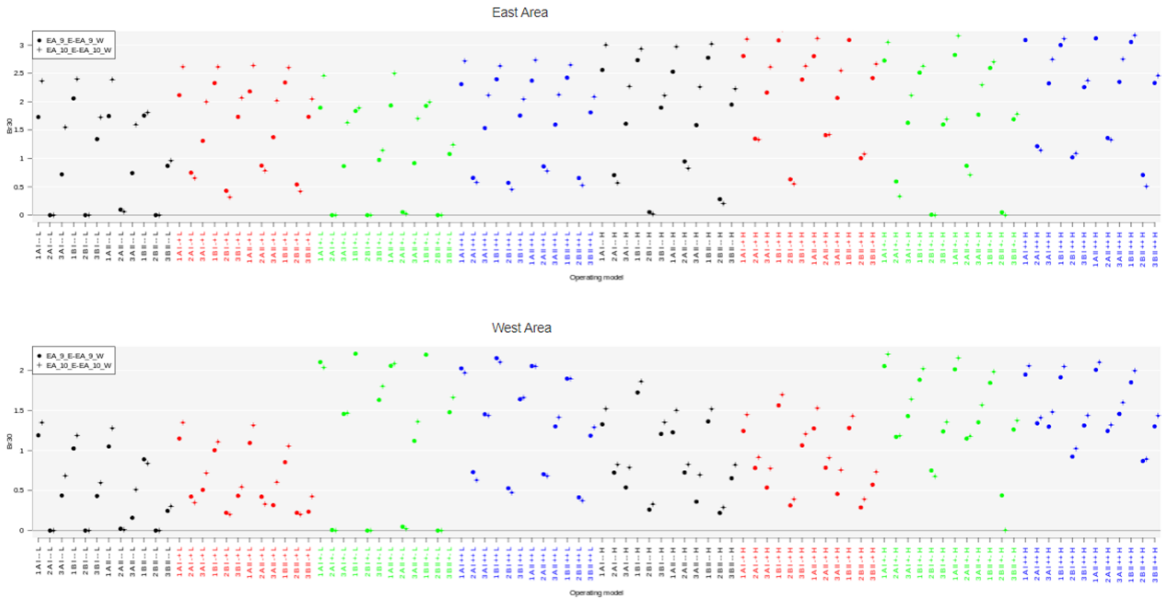

Figure 15. Comparison between Br30 values obtained for all OMs and both EA9 and EA10 cMPs (EA9 represented with dots and EA10 with crosses), resulting from exercise 3. Different colors represent different Scale scenarios: being (--) in black, (-+) in red, (+-) in green and (++) in blue.