Collect. Vol. Sci. Pap. ICCAT, 82(4), SCRS/2025/049: 1-9 (2025)

A BRIEF INITIAL ANALYSIS OF 'DOES THE WEST CKMR ESTIMATE MATTER FOR THE ABFT MSE?'

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SUMMARY

The West CKMR estimate is taken into account in the ABFT MSE computations using a simple likelihood weighting approach. This suggests that this estimate does "matter", as the associated calculations indicate that notably higher TACs for the West area might be possible. The availability of a CKMR estimate for the East would likely have important implications for the MP performance for the East. Fewer future GBYP aerial surveys in the East would lead to a slight deterioration in conservation performance there, though this could be ameliorated by a minor retuning of the MP. It must, however, be emphasised that these CKMR-related results are dependent on a simple and approximate method for taking the West CKMR estimate into account. The reliability of this approach therefore needs to be checked by repeating these computations under formal re-conditioning of the OMs to incorporate the West CKMR estimate.

RÉSUMÉ

L'estimation de la CKMR occidentale est prise en compte dans les calculs de la MSE pour le thon rouge de l'Atlantique au moyen d'une simple approche de pondération de la vraisemblance. Cela suggère que cette estimation est « importante », car les calculs associés indiquent que des TAC nettement plus élevés pour la zone Ouest pourraient être possibles. La disponibilité d'une estimation de la CKMR pour l'Est aurait probablement des implications importantes pour les résultats des MP pour l'Est. La diminution du nombre de prospections aériennes du GBYP dans l'Est entraînerait une légère détérioration des résultats en matière de conservation dans cette région, bien qu'elle puisse être améliorée par un léger recalibrage de la MP. Il faut cependant souligner que ces résultats liés à la CKMR dépendent d'une méthode simple et approximative de prise en compte de l'estimation de la CKMR de l'Ouest. La fiabilité de cette approche doit donc être vérifiée en répétant ces calculs dans le cadre d'un reconditionnement formel des OM afin d'intégrer l'estimation de la CKMR de l'Ouest.

RESUMEN

La estimación de CKMR para el oeste se tiene en cuenta en los cálculos de la MSE para el atún rojo del Atlántico utilizando un enfoque de ponderación de verosimilitud simple. Esto sugiere que esta estimación "importa", ya que los cálculos asociados indican que podrían ser posibles TAC notablemente más elevados para la zona occidental. La disponibilidad de una estimación de CKMR para el este tendría probablemente importantes implicaciones para los resultados del MP para el este. Un menor número de futuras prospecciones aéreas del GBYP en el este provocaría un ligero deterioro de los resultados de conservación en esa zona, aunque esto podría mejorarse con una pequeña recalibración del MP. No obstante, hay que subrayar que estos resultados relacionados con el CKMR dependen de un método sencillo y aproximado para tener en cuenta la estimación del CKMR para el oeste. Por lo tanto, es necesario comprobar la fiabilidad de este enfoque repitiendo estos cálculos con un nuevo condicionamiento formal de los OM para incorporar la estimación de CKMR para el oeste.

KEYWORDS

Atlantic bluefin tuna, CKMR estimate, management procedure, performance

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1. Introduction

Given that 'scale' of the population size is the most critical ABFT uncertainty it is likely that having an informed scale estimate would be impactful on the ABFT MP performance. With the presentation of an initial Close-kin mark recapture (CKMR) estimate of the western bluefin tuna spawning biomass, the Bluefin Working group included in its workplan to conduct an evaluation of whether the estimate is impactful on the performance of the existing Butterworth-Rademeyer ABFT Management procedure. This short contribution describes a simple approximate evaluation method to address this by revising the operating model weights that would have been used had the CKMR estimate been available at the time of initial OM conditioning. These revised weights are then used to evaluate the resultant change in MP performance, and hence to inform preliminarily on whether this CKMR estimate 'matters'.

2. Methods

OMs re-weighting based on the WBFT CKMR estimate

Use the initial estimate of the western stock (WBFT) SSB for 2018 (23500 mt, CV = 0.19 – note that this was subsequently revised slightly) follows the outline below:

1. Work with the baseline set of weighted OMs used in the final tests of the MP adopted, for which there are already performance statistics plus some plots.

2. Next further weight each of those OMs by a multiplicative factor corresponding to the relative probability of each OM (OM_i) being compatible with the CKMR estimate and its CV:

$$w_i^{CKMR} = exp\left(-0.5\frac{(lnCKMR-lnOM_i)^2}{\sigma^2}\right) \text{ where}$$

   CKMR is the estimate of spawning biomass from the CKMR analysis, and the associated CV. OM_i is the 2018 spawning biomass estimate for that OM.

   The original and new weights (with the latter being termed Original*WCKMR weights) are listed in **Table 1**, and plotted as a function of the 2018 western stock SSB in **Figure 1**.

3. Then compare the resultant performance statistics calculated from the re-weighted OMs and results with those in step 1.

OMs re-weighting based on the WBFT CKMR estimate and a potential EBFT CKMR estimate

As described above for the WBFT CKMR estimate, the OMs are further reweighted by a multiplicative factor for an East CKMR evaluation. The EBFT CKMR estimate is taken to be either 50%, 100% or 150% of the median eastern SSB for 2018 across the 48 OMs of the Reference Set (485910, 971720 and 1457730 mt respectively), with a CV twice that of CKMR west CV, i.e. 0.38. This greater uncertainty for the eastern stock was assumed because initial estimates for the eastern stock will be based on fewer data than are currently available for the western stock.

Impact of the GBYP aerial survey on the performance of the BR MP

The impact of a) a 2-year cycle and b) the total removal of the GBYP aerial survey is investigated by running the BR MP excluding some or all the GBYP aerial survey results from 2026 onwards. As detailed in the MP specifications, in the case of a missing index value in year *y*, the average index over the five series used to compute the TAC, $J_y^{E/W}$, is calculated by setting w_i in the formula below to zero, i.e., that index is disregarded when averaging over indices for that year only.

$$J_y^{E/W} = \frac{\sum_i^n w_i \times I_y^{i*}}{\sum_i^n w_i}$$

3. Results

OMs re-weighting based on the WBFT CKMR estimate

The CKMR estimate for WBFT results in a narrower distribution of 2018 SSB than that originally indicated for the OMs. The extent of uncertainty is therefore greatly reduced, while the central tendency of the distribution is somewhat higher than for the original OM grid. When converted to a new weighting scheme, this narrows the range for the potential spawning biomass, reducing the weights given to OMs with very low biomass and to several OMs with very high biomass.

Running the BR MP under the existing tuning leads to the revised performance results shown in **Table 2**. The median PGK for WBFT increases from 0.60 to 0.85 and BR30, LD10% and LD15% are all higher for the western stock (**Table 2**). Median PGK for the eastern stock is unchanged but LD*10% and LD*15% are now lower; this warrants further consideration as there are a few low biomass OMs (and one in particular, OM15) that are leading to this change.

Figure 2 compares the projected SSB (by stock) and catch trajectories (by area) under the BR MP for two OM weightings: "original" and "original*CKMR".

Performance statistics for OM15 on its own and for the Reference Set excluding OM15 are provided in **Table 3** (because of the relatively large influence of OM15 (L, +-, A, Rec: 3) on the "original*CKMR" results).

BR is retuned (BR*) to achieve a WBFT PGK of 60% (leaving the East unchanged), and then further retuned (BR**) to achieve both a WBFT PGK of 60% and LD*15%>=0.4 for both WBFT and EBFT. Results are given in **Table 2**. **Figure 3** compares the projected SSB and catch trajectories (by area) for the "original*CKMR" weighting, under the BR and BR** (tuned for both the East and the West when using the CKMR weights) MPs.

OMs re-weighting based on WBFT CKMR estimate and a potential EBFT CKMR estimate

The effect of the availability of a potential CKMR estimate for the east is shown in **Table 4**. Performance statistics are compared for OM weightings that include, as for the western stock, an eastern stock CKMR estimate. Results are presented for three possible values of the east CKMR estimate.

Impact of the GBYP aerial survey on the performance of the BR MP

Performance statistics under 1) the BR MP, including the GBYP aerial survey (the MP adopted), 2) excluding the GBYP aerial survey and 3) including GBYP aerial survey results every second year are compared in **Table 5**.

4. Discussion

Table 1 shows that reweighting by the west CKMR estimate results in very low (normalized) weights for many of the OMs, so that consequently a relatively small number only become rather heavily weighted. The latter group includes the consequentially influential OM15.

For the west, the result in **Table 2** of a higher PGK value following this CKMR weighting is not unexpected, given the effective exclusion of many of the OMs with low western stock biomass. The results for the east do come with something of a surprise, however, as initially one might not have expected an abundance estimate for the west to influence performance in the east substantially. The PGK value for the east is unchanged, but the LD values decrease markedly. The OM15 results are the primary reason for this; from **Table 3**, even for the original performance statistics PGK was zero, but this was hardly evident in summaries at the time when the MP was adopted because this OM had a relative weight of only 0.75%. Moving on to the west CKMR weighting, however, this weight increases to 4.31%.

An important result in **Table 2** is that with the CKMR weighting coupled with retuning to get PGK for the west back down to 0.60 (the BR* MP), the expected average catch in the west over the management period is increased by about 50%. For BR*, such average catches in the east also increase, but with further retuning to secure a LD*15% value of 0.40 for the eastern stock (BR**), those average catches return to close to what was reported for the BR MP when originally adopted.

Table 4, which gives performance statistics for different results for a potential CKMR estimate for the eastern stock, shows very poor PGK and LD*15% results for the eastern stock if that estimate is only 50% of the median across the current OMs. This points to the importance of obtaining such a CKMR estimate for absolute abundance of the eastern stock.

Table 5 shows some (though limited) deterioration in conservation performance in the east if future GBYP aerial survey are fewer in frequency or discontinued.

Summary

Important outcomes are as follows:

- The west CKMR estimate does "matter" for the ABFT MSE results, indicating that notably higher TACs for the west area might be possible.
- The availability of a CKMR estimate for the east would quite possibly have important implications for the MP performance for the east.
- Fewer future GBYP aerial surveys in the east would lead to a slight deterioration in conservation performance there, which could be ameliorated by a minor retuning the MP.

It must, however, be emphasised that these results are dependent on a simple and approximate method (likelihood weighting) for taking the west CKMR estimate into account. This method may not be too reliable, as it leads to dominance of the performance statistics output by a relatively few of the then more highly weighted OMs. The reliability of this approach therefore needs to be checked by repeating these computations under formal re-conditioning of the OMs to incorporate the west CKMR estimate.

Table 1. Weights for each OM by scenario.

OM	Western SSB (2018)	Original weights	Original * WCKMR weights	Normalised original weights (in %)	Normalised original * WCKMR weights (in %)
1	7938	300	0.0	3.00	0.00
2	8497	300	0.0	3.00	0.00
3	8493	150	0.0	1.50	0.00
4	4919	300	0.0	3.00	0.00
5	10387	300	0.0	3.00	0.00
6	4919	150	0.0	1.50	0.00
7	7920	300	0.0	3.00	0.00
8	8935	300	0.0	3.00	0.00
9	7920	150	0.0	1.50	0.00
10	4866	300	0.0	3.00	0.00
11	9406	300	0.0	3.00	0.00
12	4866	150	0.0	1.50	0.00
13	22703	150	147.5	1.50	8.61
14	18516	150	68.3	1.50	3.98
15	22703	75	73.8	0.75	4.31
16	12889	150	1.0	1.50	0.06
17	18154	150	59.6	1.50	3.48
18	12889	75	0.5	0.75	0.03
19	21070	250	212.0	2.50	12.37
20	16415	250	42.0	2.50	2.45
21	21070	125	106.0	1.25	6.19
22	15850	250	29.2	2.50	1.70
23	17503	250	75.1	2.50	4.38
24	15850	125	14.6	1.25	0.85
25	9228	300	0.0	3.00	0.00
26	21186	300	258.5	3.00	15.09
27	9228	150	0.0	1.50	0.00
28	5592	300	0.0	3.00	0.00
29	8347	300	0.0	3.00	0.00
30	5592	150	0.0	1.50	0.00
31	9215	300	0.0	3.00	0.00
32	11052	300	0.1	3.00	0.01
33	9215	150	0.0	1.50	0.00
34	5720	300	0.0	3.00	0.00
35	10671	300	0.1	3.00	0.00
36	5720	150	0.0	1.50	0.00
37	25078	150	141.5	1.50	8.26
38	49948	150	0.1	1.50	0.00
39	25078	75	70.7	0.75	4.13
40	15165	150	10.5	1.50	0.61
41	42775	150	1.0	1.50	0.06
42	15165	75	5.3	0.75	0.31
43	24221	250	246.9	2.50	14.41
44	49717	250	0.1	2.50	0.01
45	24221	125	123.4	1.25	7.20
46	15113	250	16.8	2.50	0.98
47	46678	250	0.4	2.50	0.02
48	15113	125	8.4	1.25	0.49

Table 2. Stochastic Br30, AvC30, LD*15%, LD*10% and VarC values (weighted medians and 90%iles for the OM grid across all simulations) for BR, BR* (tuned to West PGK=0.6) and BR** (tuned to West PGK=0.6 and East LD*15%>=0.4) across all OMs in the grid, for the original weights and the original*WCKMR weights. AvC30 values are in '000 mt.

		PKG	Br30	LD*15%	LD*10%	AvC30	VarC
	EAST						
BR	Original weights	**0.60**	1.17 (0.33; 2.20)	0.41	0.33	41.35 (12.38; 72.23)	19.23 (10.26; 30.30)
	Original*WCKMR weights	0.60	1.25 (0.13; 2.45)	0.29	0.21	48.08 (11.43; 72.46)	19.57 (10.80; 33.67)
BR*	Original weights	0.59	1.16 (0.40; 2.19)	0.42	0.35	42.26 (13.02; 72.27)	19.55 (10.76; 30.72)
	Original*WCKMR weights	0.59	1.26 (0.31; 2.44)	0.32	0.24	48.51 (11.80; 72.74)	19.94 (11.41; 34.20)
BR**	Original weights	0.78	1.48 (0.68; 2.56)	0.56	0.47	34.48 (11.54; 57.30)	17.59 (7.17; 32.16)
	Original*WCKMR weights	0.78	1.56 (0.49; 2.80)	**0.40**	0.31	40.82 (11.01; 57.29)	16.25 (7.51; 34.95)
	WEST						
BR	Original weights	**0.60**	1.25 (0.43; 2.37)	0.40	0.27	2.46 (0.86; 3.60)	11.07 (4.89; 32.07)
	Original*WCKMR weights	0.85	1.71 (0.84; 2.69)	0.65	0.60	2.33 (1.17; 2.90)	9.98 (5.15; 25.21)
BR*	Original weights	0.27	0.77 (0.21; 1.84)	0.24	0.19	3.56 (1.19; 4.93)	13.24 (7.98; 25.66)
	Original*WCKMR weights	**0.60**	1.28 (0.58; 2.14)	0.55	0.50	3.48 (1.56; 4.37)	10.89 (7.15; 20.75)
BR**	Original weights	0.27	0.78 (0.23; 1.84)	0.26	0.21	3.86 (1.25; 5.25)	13.07 (8.01; 23.15)
	Original*WCKMR weights	**0.60**	1.27 (0.62; 2.12)	0.56	0.52	3.74 (1.63; 4.68)	11.01 (7.20; 19.50)

Table 3. Stochastic Br30, AvC30, LD*15%, LD*10% and VarC values reporting (weighted) medians and 90%iles for the OM grid across all simulations for BR for OM15 only, across the full RS of OMs, for the RS with the west CKMR weighting added, and finally excluding OM15 for first the original weighting and then including the west CKMR weighting. AvC30 values are in '000 mt.

	PKG	Br30	LD*15%	LD*10%	AvC30	VarC
EAST						
OM 15 only	0.00	0.00 (0.00; 0.00)	0.00	0.00	46.39 (42.94; 51.14)	33.62 (22.65; 46.95)
Original weights: RS	**0.60**	1.17 (0.33; 2.20)	0.41	0.33	41.35 (12.38; 72.23)	19.23 (10.26; 30.30)
Original*CKMR weights: RS	0.60	1.25 (0.13; 2.45)	0.29	0.21	48.08 (11.43; 72.46)	19.57 (10.80; 33.67)
Original weights: RS excl. OM15	0.60	1.17 (0.37; 2.20)	0.42	0.34	40.96 (12.38; 72.26)	19.17 (10.26; 29.98)
Original*CKMR weights: RS excl. OM15	0.63	1.30 (0.45; 2.45)	0.36	0.27	49.28 (11.43; 72.46)	18.51 (10.78; 32.90)
WEST						
OM 15 only	0.00	0.94 (0.78; 1.25)	0.82	0.81	1.86 (1.64; 2.08)	11.54 (7.76; 15.08)
Original weights: RS	**0.60**	1.25 (0.43; 2.37)	0.40	0.27	2.46 (0.86; 3.60)	11.07 (4.89; 32.07)
Original*CKMR weights: RS	0.85	1.71 (0.84; 2.69)	0.65	0.60	2.33 (1.17; 2.90)	9.98 (5.15; 25.21)
Original weights: RS excl. OM15	0.61	1.25 (0.43; 2.37)	0.39	0.27	2.46 (0.86; 3.61)	11.06 (4.89; 32.08)
Original*CKMR weights: RS excl. OM15	0.89	1.75 (0.85; 2.69)	0.64	0.60	2.35 (1.17; 2.90)	9.83 (5.02; 25.31)

Table 4. Stochastic Br30, AvC30, LD*15%, LD*10% and VarC values (weighted) medians and 90%iles for the OM grid across all simulations for BR across all OMs in the grid, 1) for the original weighting, 2) including the West CKMR weighting, 3) including the West and East CKMR weighting (50% below 2018 median), 4) including the West and East CKMR weighting (at 2018 median), and 5) including the West and East CKMR weighting (50% above 2018 median). AvC30 values are in '000 mt.

	PKG	Br30	LD*15%	LD*10%	AvC30	VarC
EAST						
Original weights	**0.60**	1.17 (0.33; 2.20)	0.41	0.33	41.35 (12.38; 72.23)	19.23 (10.26; 30.30)
Original*CKMR weights (West only)	0.60	1.25 (0.13; 2.45)	0.29	0.21	48.08 (11.43; 72.46)	19.57 (10.80; 33.67)
Original*CKMR weights (West+50%East)	0.30	0.73 (0.00; 1.96)	0.10	0.00	20.59 (11.01; 65.48)	23.40 (12.90; 35.00)
Original*CKMR weights (West+100%East)	0.66	1.32 (0.30; 2.39)	0.54	0.43	54.28 (14.46; 75.63)	16.94 (10.46; 28.71)
Original*CKMR weights (West+150%East)	0.81	1.50 (0.73; 2.52)	0.94	0.84	56.03 (30.26; 75.97)	15.82 (10.11; 25.33)
WEST						
Original weights	**0.60**	1.25 (0.43; 2.37)	0.40	0.27	2.46 (0.86; 3.60)	11.07 (4.89; 32.07)
Original*CKMR weights (West only)	0.85	1.71 (0.84; 2.69)	0.65	0.60	2.33 (1.17; 2.90)	9.98 (5.15; 25.21)
Original*CKMR weights (West+50%East)	0.66	1.17 (0.76; 2.34)	0.56	0.53	1.63 (1.03; 2.31)	14.15 (7.04; 28.91)
Original*CKMR weights (West+100%East)	0.93	1.87 (0.97; 2.86)	1.12	0.82	2.49 (1.25; 2.97)	9.10 (4.92; 20.53)
Original*CKMR weights (West+150%East)	0.99	1.91 (1.41; 2.87)	1.53	1.46	2.58 (2.16; 3.00)	8.26 (4.64; 14.34)

Table 5. Stochastic Br30, AvC30, LD*15%, LD*10% and VarC values (weighted (original weights)) medians and 90%iles for the OM grid across all simulations for 1) BR, 2) BR excluding the GBYP survey from 2026 onwards, and 3) BR excluding the GBYP every second year from 2026 onwards, across all OMs in the grid. AvC30 values are in '000 mt.

	PKG	Br30	LD*15%	LD*10%	AvC30	VarC
EAST						
BR	**0.60**	1.17 (0.33; 2.20)	0.41	0.33	41.35 (12.38; 72.23)	19.23 (10.26; 30.30)
BR no GBYP	0.51	1.08 (0.33; 2.11)	0.39	0.32	45.16 (13.36; 75.31)	19.10 (11.27; 30.08)
BR GBYP every 2nd yr	0.56	1.13 (0.38; 2.16)	0.41	0.34	43.94 (13.24; 73.93)	19.12 (11.07; 29.99)
WEST						
BR	**0.60**	1.25 (0.43; 2.37)	0.40	0.27	2.46 (0.86; 3.60)	11.07 (4.89; 32.07)
BR no GBYP	0.58	1.24 (0.47; 2.37)	0.42	0.31	2.46 (0.97; 3.59)	10.72 (5.56; 27.54)
BR GBYP every 2nd yr	0.59	1.25 (0.47; 2.38)	0.42	0.32	2.47 (0.97; 3.60)	10.62 (5.49; 27.74)

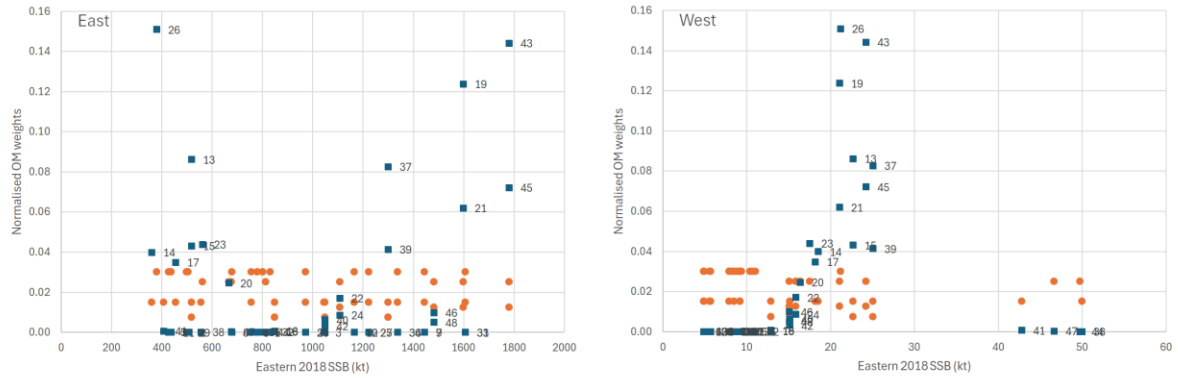

Figure 1. "Original" (orange dots) and "Original*CKMR" (blue square) weights plotted against median 2018 SSB for each OM in the Reference Set, for the eastern and western stocks. The labels on the blue dots are the OM numbers.

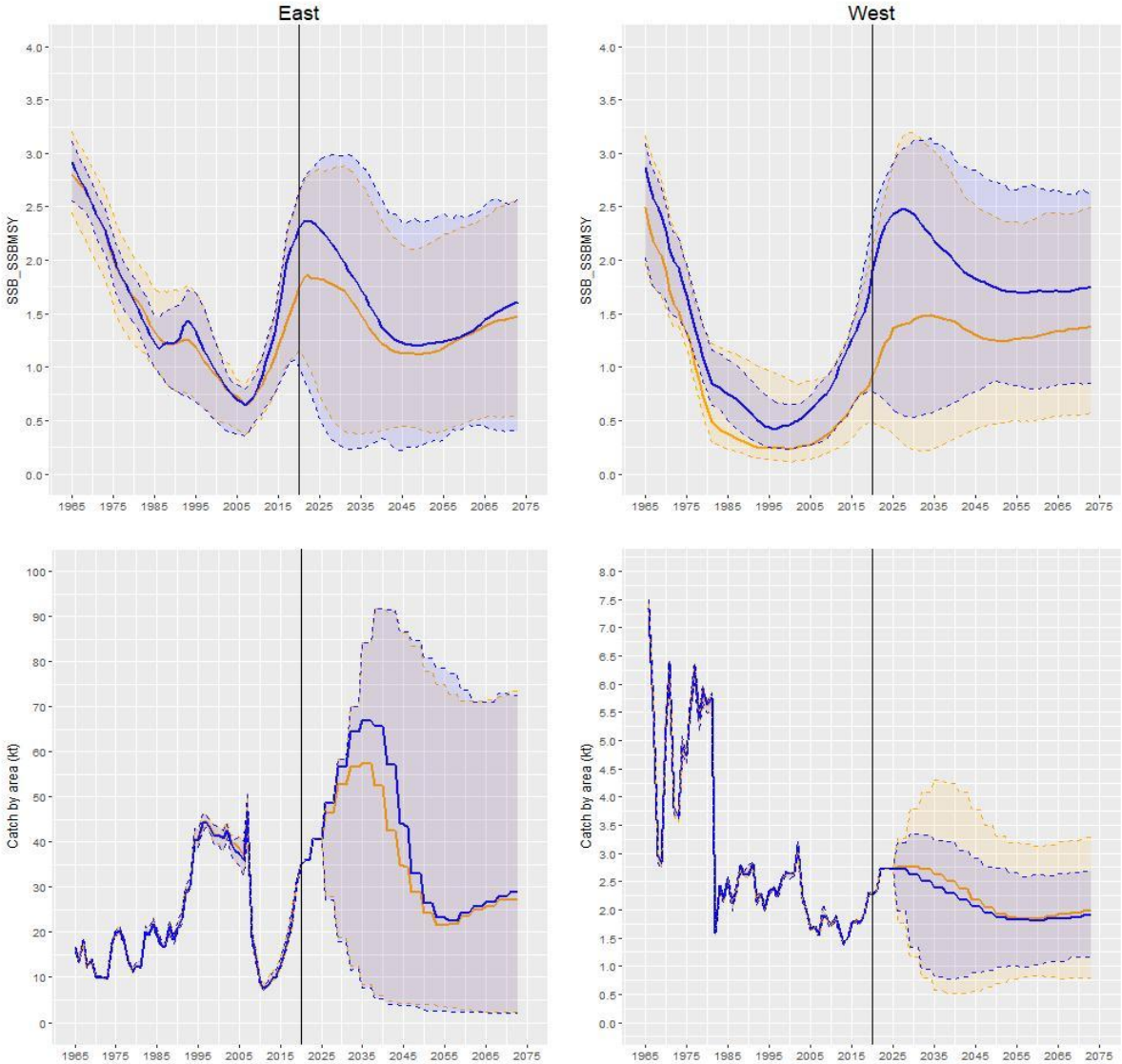

Figure 2. Median and 90%iles SSB (by population) and catch (by area) trajectories for the weighted average over all OMs in the grid and the replicate simulations with projections under the BR MP. Orange lines and shaded area represent the "original" weighting, while blue lines and shaded area represent the "original*CKMR" weighting. The vertical line marks the start of the projections.

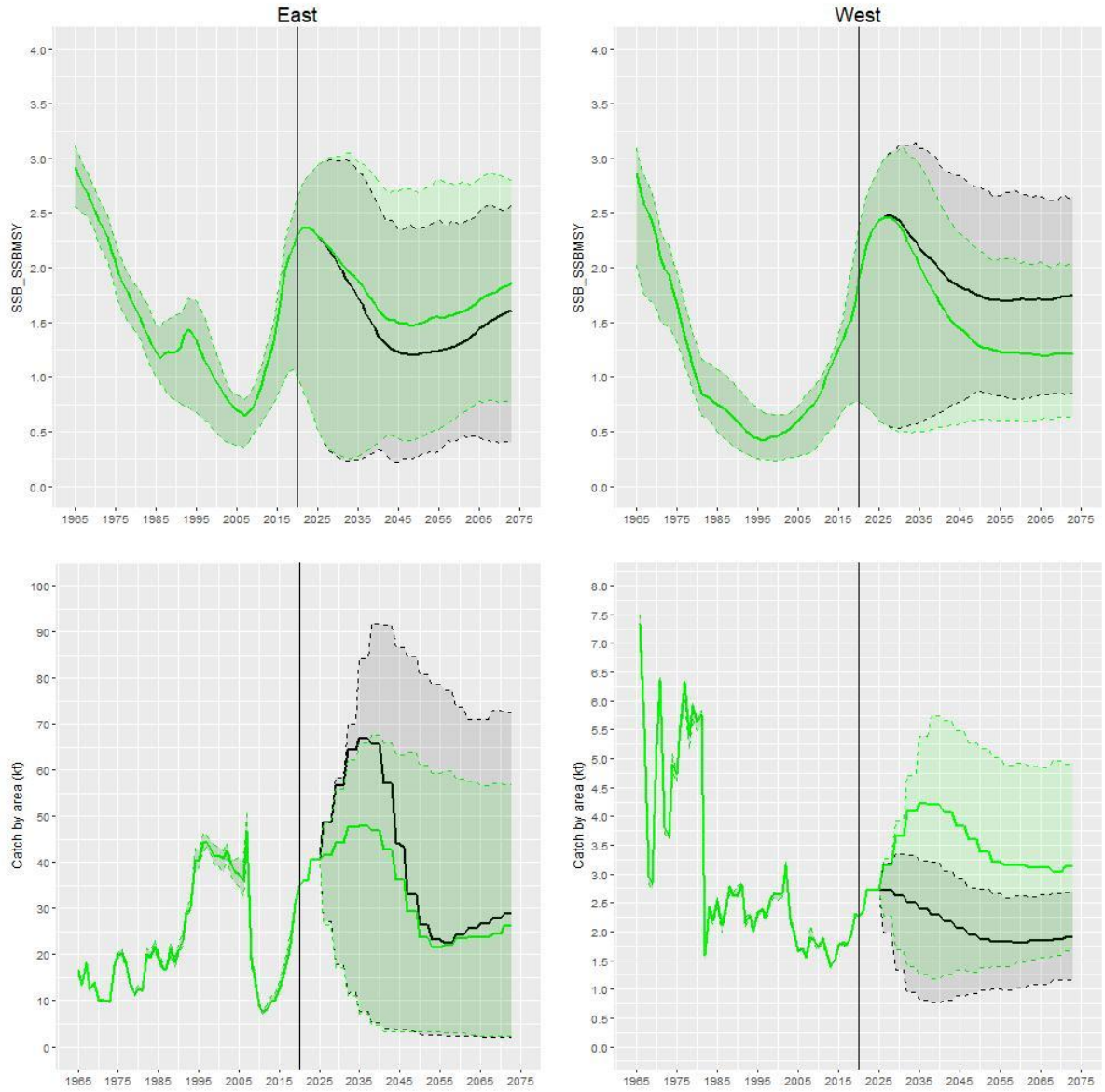

Figure 3. Median and 90%iles SSB (by population) and catch (by area) trajectories for the weighted average over all OMs in the grid and the replicate simulations with projections under the BR MP. The black lines and grey shaded area represent the BR MP, while green lines and shaded area represent the BR** MP (tuned when using the WCKMR weights to both the West and the East). Both are weighted with the "original*CKMR" weights. The vertical line marks the start of the projections[2].

[2] It might surprise that some differences for BR and BR** results shown in these plots are rather greater than might have been expected from perusing the results shown in **Table 2**. For example, results there for AvC30 for the east do not differ greatly for BR and BR**, whereas in the plots above the catches for the east are notably lower under BR**than under BR. The reason is related to mean/median differences. For **Table 2**, the standard agreed approach of taking a weighted median over all OMs and their replicates for the 30-year average is used. In contrast, the Figure evaluates distribution medians each year taking account of CKMR weighting; given the highly skewed distribution of these weights across all the OMs, it is not surprising that mean-median differences that are not insubstantial can arise.