THE ATLANTIC-WIDE RESEARCH PROGRAMME FOR BLUEFIN TUNA (GBYP Phase 14 - 2025)

SHORT-TERM CONTRACT FOR THE ADDITIONAL BFT MSE WORK FOR 2025 WITHIN GBYP PHASE 14

Final Report

Prof. Douglas Stuart Butterworth

14 October 2025

Narrative

The Work required under the contract divides conveniently into two parts.

i) Re-tune the BR CMP on reconditioned models

This work progressed iteratively in line with successive updating of the reconditioning of the Operating Models.

Results are provided in the following documents submitted to the ICCAT SCRS

Butterworth DS and Rademeyer RA. BR MP RUNS UNDER THE OPERATING MODELS FOR ATLANTIC BLUEFIN TUNA MSE RE-CONDITIONED TO INCLUDE THE CLOSE-KIN MARK RECAPTURE ESTIMATE OF WESTERN STOCK SCALE. Document SCRS/2025/154 (and associated Addendum) (**Annex 1**)

Butterworth DS and Rademeyer RA. BR MP RUNS UNDER THE OPERATING MODELS FOR ATLANTIC BLUEFIN TUNA MSE RE-CONDITIONED TO INCLUDE THE CLOSE-KIN MARK RECAPTURE ESTIMATE OF WESTERN STOCK SCALE WITH BOTH OM29 AND OM35 UPDATEDNOW INCLUDED (ABTMSE v8.1.0) Document SCRS/2025/167 (**Annex 2**)

Butterworth DS and Rademeyer RA. BR MP RUNS UNDER THE OPERATING MODELS FOR ATLANTIC BLUEFIN TUNA MSE RE-CONDITIONED TO INCLUDE THE CLOSE-KIN MARK RECAPTURE ESTIMATE OF WESTERN STOCK SCALE assuming a CKMR CV of 0.2 (ABTMSE v8.2.3) Document SCRS/2025/220 (**Annex 3**)

ii) Test 'value of information in MSE'

a) Impact of a 2-year cycle for GBYP aerial survey for the BR MP
b) Test impact of removal of GBYP aerial survey for BR MP
c) Test impact of BFT-E CKMR

The associated results are provided in the following document submitted to the ICCAT SCRS

Butterworth DS and Rademeyer RA. A BRIEF INITIAL ANALYSIS OF 'DOES THE WEST CKMR ESTIMATE MATTER FOR THE ABFT MSE?' Document SCRS/2025/049 (**Annex 4**)

BR MP RUNS UNDER THE OPERATING MODELS FOR ATLANTIC BLUEFIN TUNA MSE RE-CONDITIONED TO INCLUDE THE CLOSE-KIN MARK RECAPTURE ESTIMATE OF WESTERN STOCK SCALE

D S Butterworth and R A Rademeyer[1]

Summary

The current BR MP for Atlantic bluefin tuna is retuned using the re-conditioned OMs provided recently by Carruthers, which take the west close-kin mark recapture scale estimate for the western stock into account. A number of retuning targets are considered, of which that (BRn3) most likely to be considered comparable to the existing MP tunes to a PGK value for the western stock of 0.60, but slightly higher for the eastern stock to ensure that LD*15% for that stock is not less than 0.40. The resultant tuning parameters are more positive for the East and especially for the West area. Illustrative and preliminary (as not all indices are available yet) calculations indicate that using BRn3 in place of the current MP, the values of C1 (the 2026 TAC), the TAC for the East area would remain unchanged with a 20% increase, whereas that for the West area would change from a 6% decrease to a 5% increase.

Key words: Atlantic bluefin tuna; CKMR estimate; management procedure; performance

[1] Marine Resource Assessment and Management Group (MARAM), Department of Mathematics and Applied Mathematics, University of Cape Town, Rondebosch 7701, South Africa

Introduction

Following the recent-re-conditioning by Tom Carruthers of the ABFT OMs to include the CKMR estimate of western stock scale (these are termed "new OMs" hereafter), results are presented here for a series of MPs based on the BR MP:

1) BR: the original BR MP which was used to provide TAC recommendation for 2023-2025 (tuned to Western and Eastern stock PGK values of 0.60);
2) BRn1: as BR, but with tuning parameter $\Delta\beta$ adjusted so that the Western stock PGK=0.60 for the new OMs;
3) BRn2: as BR but with tuning parameters $\Delta\beta$ and $\Delta\alpha$ adjusted so that the Western AND Eastern stock PGK=0.60 for the new OMs; and
4) BRn3: as BR but with tuning parameters $\Delta\beta$ and $\Delta\alpha$ adjusted so that the Western stock PGK=0.60 AND the East ern stock LD*15%=0.40 for the new OMs.

For the BR MP, results are also compared between those for the old OM with the original weights, and the version with the "CKMR" weights (see Butterworth and Rademeyer, 2025) – the latter was a first approximation approach to take account of the effect of the west CKMR estimate on the conditioning

Results and Discussion

Histograms of the 2016 SSB/SSBMSY values for the Western stock under the old and new OMs are shown in **Figure 1**. The old Reference Set includes 32 fitted OMs (two scale values for the West), while the new Reference Set has only 16 fitted OMs only (one scale value for the West); hence for easier comparison, the frequencies for the new OMs have been doubled. Whereas in 2016, the median SSB/SSBMSY over the old OMs was 0.75, i.e. the western stock was broadly considered to be below its MSY level and hence as needing to recover further, for the new OMs this value increases to 1.12 (above the MSY level). Consequently, catches can be set higher than was previously thought necessary to achieve management targets, and the MP tuning parameter for the West area ($\Delta\beta$) changes from negative (tending to decrease TACs for the West) to positive, with the opposite effect.

The results for the primary MP performance statistics are shown in **Table 1**. Values for the tuning parameters $\Delta\alpha$ and $\Delta\beta$ are also given (there are no changes to the other MP parameters compared to those for the current BR MP). The following points are perhaps worth noting.

- Using the new OMs yields fairly similar results to those for the simple approach of Butterworth and Rademeyer (2025) (Old OMs*CKMR weights) (under BR) for the West, but ones that are slightly more positive for the East, particularly in terms of LD*15%.
- The median PGK for the Western stock increases from 0.60 to 0.87 (compared to 0.85 for the earlier simple approach) and BR30, LD10% and LD15% are all higher for this stock.
- Median PGK for the Eastern stock is slightly improved (to 0.66), with LD*10% and LD*15% basically unchanged.
- When tuned to a PGK value of 0.60 for both the Western and Eastern stock (BRn2), the LD*15% statistic for the Eastern stock is slightly below the 0.40 threshold requirement. Consequently, BRn3 has been developed, being tuned so that the Eastern stock LD*15% = 0.40.
- When the BR MP is tuned with the new OMs, AvC30 in both the East and the West are increased, with the latter by a greater proportion.

  C1 values under BR (as at present) and BR3n (potential for the future) MPs are listed in **Table 2**, with the index values used for these calculations given in **Table 3**. Note that the most recent values shown there have yet to be confirmed by the SCRS (and a few values are not yet available), so that these results are shown as **illustrative** examples only and are **NOT final/definitive**. These illustrative calculations indicate that using BRn3, C1 for the East area would remain unchanged with a 20% increase, whereas that for the West area would change from a 6% decrease to a 5% increase.

Reference

Butterworth DS and Rademeyer RA. 2025. A brief initial analysis of 'does the west CKMR estimate matter for the ABFT MSE'?. Doc SCRS/2025/049.

Table 1: Stochastic Br30, AvC30, LD*15%, LD*10% and VarC values (weighted medians with 5%- and 95%iles for the OM grid across all simulations) for a series of MPs across all OMs in the grid, for the "old OMs" with original weights, the "old OMs" with WCKMR weights (see Butterworth and Rademeyer, 2025) and the new OMs. AvC30 values are in '000 mt. The tuning parameters Δα and Δβ are also shown (the other tuning parameters are all as for the BR MP).

			PGK	Br30			LD*15%	LD*10%	AvC30			VarC		
EAST		*Δα*												
Old OMs*original weights	BR	0.204	**0.60**	1.17	(0.33;	2.20)	0.41	0.33	41.35	(12.38;	72.23)	19.23	(10.26;	30.30)
Old OMs*CKMR weights	BR	0.204	0.60	1.25	(0.13;	2.45)	0.29	0.21	48.08	(11.43;	72.46)	19.57	(10.80;	33.67)
New OMs	BR	0.204	0.66	1.27	(0.33;	2.25)	0.42	0.34	43.49	(12.25;	70.77)	19.16	(10.21;	27.99)
	BRn1	0.204	0.65	1.25	(0.31;	2.23)	0.41	0.33	43.40	(12.18;	70.60)	19.23	(10.23;	28.06)
	BRn2	0.250	**0.60**	1.17	(0.24;	2.15)	0.38	0.28	45.10	(12.66;	73.57)	18.63	(10.68;	28.03)
	BRn3	0.220	0.63	1.23	(0.29;	2.20)	**0.40**	0.31	44.00	(12.35;	71.70)	18.99	(10.29;	28.31)
	WEST	*Δβ*												
Old OMs*original weights	BR	-0.0320	**0.60**	1.25	(0.43;	2.37)	0.40	0.27	2.46	(0.86;	3.60)	11.07	(4.89;	32.07)
Old OMs*CKMR weights	BR	-0.0320	0.85	1.71	(0.84;	2.69)	0.65	0.60	2.33	(1.17;	2.90)	9.98	(5.15;	25.21)
New OMs	BR	-0.0320	0.87	1.63	(0.78;	2.80)	0.68	0.61	2.33	(1.20;	3.03)	9.47	(5.10;	22.59)
	BRn1	0.0272	**0.60**	1.20	(0.57;	2.24)	0.58	0.52	3.31	(1.50;	4.31)	10.98	(6.34;	19.86)
	BRn2	0.0243	**0.60**	1.21	(0.57;	2.24)	0.58	0.52	3.24	(1.44;	4.24)	11.20	(6.26;	19.91)
	BRn3	0.0270	**0.60**	1.20	(0.57;	2.24)	0.58	0.52	3.29	(1.48;	4.29)	11.05	(6.38;	20.61)

Note: Results for the old OMs are based on the OMs in version 7.7.1 of the ABTMSE package (as used for the development of the current MP in 2022, and therefore identical to those results on which the current MP was selected). Results for the new OMs are based on Carruthers' lite-reconditioned OMs in version 8.0.4 of the ABTMSE package.

Table 2: West and East C1 (2026 TAC) values (in thousand tons) under BR and BRn2. The % changes are with respect to the current TACs. (West 2.726 and East 40.57 thousand tons).

	West C1	East C1
BR	2.556 (-6%)	48.689 (+20%)
BRn3	2.855 (+5%)	48.689 (+20%)

Table 3: Indices used in the C1 computations (recent values kindly provided by J Walter). For some indices their 2024 values are not yet available. Calculations of C1 have assumed those instances being treated as set down in the MP prescription for dealing with missing index values.

	EAST					WEST				
	FR_AER_ SUV2	MED_LAR_ SUV	GBYP_AER _SUV_BAR	MOR_POR_ TRAP	JPN_LL_ NEAtl2	GOM_LAR_ SUV	US_RR_ 66_144	MEXUS_ GOM_PLL	JPN_LL_ West2	CAN_SWNS
2006	-	-	-	-	-	0.562	0.667	0.810	-	1.016
2007	-	-	-	-	-	0.459	0.636	0.470	-	0.728
2008	-	2.293	-	-	-	0.337	0.631	0.750	-	0.804
2009	0.018	-	-	-	-	0.605	0.504	0.640	-	1.246
2010	0.014	-	1659	2.214	2.254	0.300	0.800	0.470	0.553	1.470
2011	0.026	10.894	1392	3.754	3.942	1.149	0.711	0.910	1.879	1.170
2012	0.018	31.314	-	8.229	8.609	0.269	0.773	1.560	2.476	1.074
2013	-	49.742	2393	6.807	7.123	0.983	1.225	0.720	1.987	0.709
2014	0.063	24.029	-	7.747	8.219	0.267	0.733	1.330	2.126	0.939
2015	0.027	41.620	4766	6.241	6.526	0.391	0.353	1.980	1.320	0.973
2016	0.107	36.934	-	5.772	5.898	2.389	0.541	1.580	3.287	1.101
2017	0.069	83.684	9300	7.034	7.401	0.989	0.856	1.240	3.668	1.019
2018	0.031	-	15569	8.412	8.882	2.022	0.627	1.530	6.771	0.927
2019	0.063	54.592	13797	8.074	8.477	1.484	1.161	1.720	5.682	1.231
2020	0.136	118.557	-	5.944	6.205	-	1.570	1.350	4.375	1.429
2021	0.097	-	5325	6.138	6.067	1.953	2.020	1.780	3.616	1.563
2022	0.054	52.086	10375	4.696	12.783	-	0.944	2.320	3.552	1.498
2023	0.101	109.587	10597	2.940	16.104	3.076	0.744	1.890	2.425	1.562
2024	-	-	2200	5.400	13.377	1.550	2.249	-	7.123	1.408

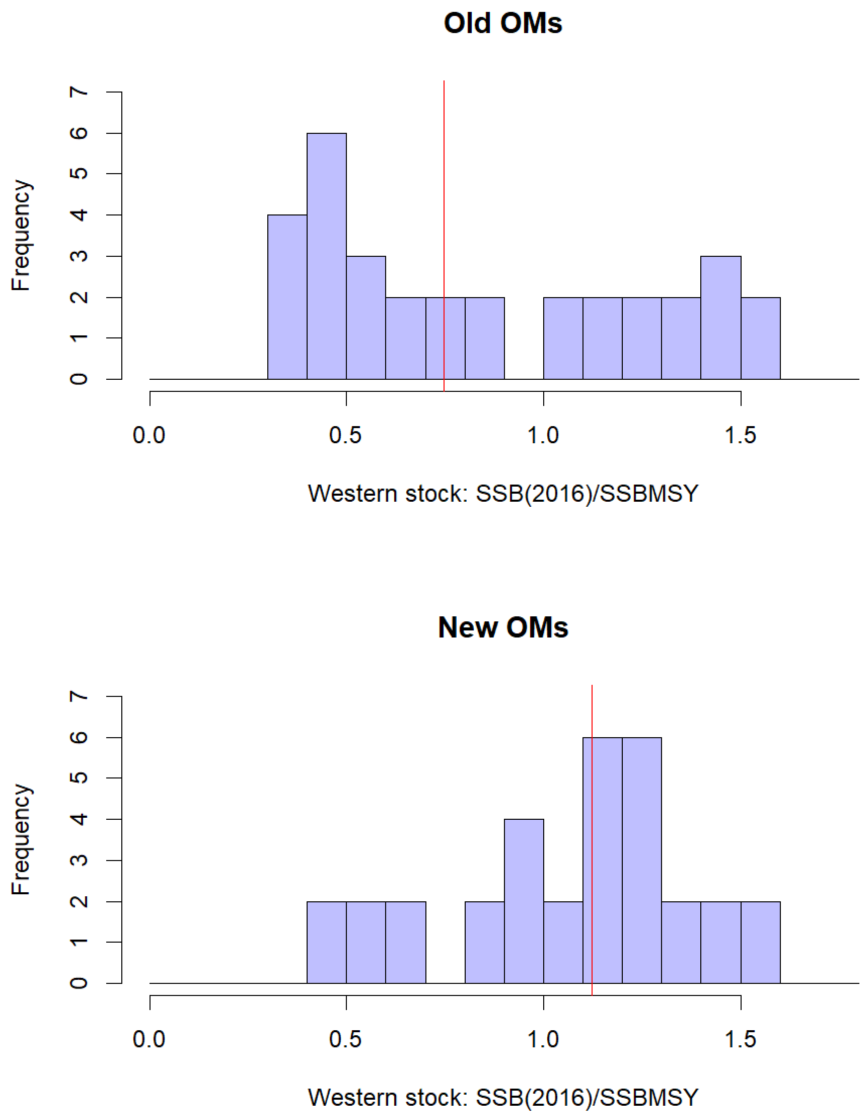

Figure 1: Western stock 2016 SSB/SSBMSY estimates across OMs for the old and new Reference Sets. The old Reference Set includes 32 fitted OMs (two scale values for the Western stock), while the new Reference Set has 16 fitted OMs only (one scale value for the Western stock). For ease of comparison, the frequencies of the new OMs have been doubled. The vertical red lines indicate medians. The SSB/SSBMSY values have been extracted from the OM report files provided by Carruthers.

SCRS/2025/154

ADDENDUM TO:

BR MP RUNS UNDER THE OPERATING MODELS FOR ATLANTIC BLUEFIN TUNA MSE RE-CONDITIONED TO INCLUDE THE CLOSE-KIN MARK RECAPTURE ESTIMATE OF WESTERN STOCK SCALE

D S Butterworth and R A Rademeyer[1]

Summary

An alternative re-tuning of the ABFT MP is considered that sets the West Area control parameter $\Delta\beta$=0, and instead changes the value of the β parameter. For the new OMs that take account of the west CKMR estimate, this alternative is also able to meet the same performance thresholds in terms of PGK and LD*15% than were met by the original BR MP for the earlier OMs. In the short term, TACs for the West Area are somewhat greater under this alternative MP than for the BRn3 MP of the main text.

Key words: Atlantic bluefin tuna; CKMR estimate; management procedure; performance

[1] Marine Resource Assessment and Management Group (MARAM), Department of Mathematics and Applied Mathematics, University of Cape Town, Rondebosch 7701, South Africa

Introduction

BR, BRn1, BRn2, BRn3 are as described in the main document. In BRn4 and BRn5, for the West Area TAC, the $\Delta\beta$ parameter is set to 0 and the MP is tuned for the west using the β parameter only

1) BRn4: as BR but with tuning parameters $\Delta\beta$=0, and β and $\Delta\alpha$ adjusted so that for the Western and Eastern stocks PGK=0.60 for the new OMs that include the west CKMR estimate.
2) BRn5: as BR but with tuning parameters $\Delta\beta$=0, and β and $\Delta\alpha$ adjusted so that for the Western stock PGK=0.60 AND for the Eastern stock LD*15%=0.40 for the new OMs that include the west CKMR estimate.

The original BR MP was developed in a situation when the Western stock was considered to be below B_{MSY}, This necessitated the introduction of the $\Delta\beta$ parameter into the MP to reduce TACs in the short term to secure rebuilding, while avoiding very large TAC reductions. Now that the OMs updated with the west CKMR information suggest instead that the Western stock exceeds B_{MSY}, this may no longer be necessary, and may impede optimal MP performance. This motivates the consideration of MPs fixing $\Delta\beta$=0.

Results and Discussion

The results for the MP performance statistics are shown in **Table Add1**. Values for the tuning parameters α, $\Delta\alpha$, β and $\Delta\beta$ are also given (there are no changes to the other MP parameters compared to those for the current BR MP).

SSB and TAC projections (medians and lower 5%iles) are shown in Figure Add1 for BR3n and BR5n. Both of these meet the same performance thresholds in terms of PGK and LD*15% than were met by the original BR MP for the earlier OMs. Note that in the short term, TACs for the West Area are somewhat greater under BR5n than for BR3n.

The Appendix provides a full specification of the BR MP approach.

Table Add1: Stochastic Br30, AvC30, LD*15%, LD*10% and VarC values (weighted medians with 5%- and 95%iles for the OM grid across all simulations) for a series of MPs across all OMs in the grid, for the new OMs. AvC30 values are in '000 mt. The tuning parameters α, $\Delta\alpha$, β and $\Delta\beta$ are also shown (the other tuning parameters are all as for the BR MP).

				PGK	Br30		LD*15%	LD*10%	AvC30		VarC	
EAST		α	$\Delta\alpha$									
New OMs	BR	1.235	0.204	0.66	1.27	(0.33; 2.25)	0.42	0.34	43.49	(12.25; 70.77)	19.16	(10.21; 27.99)
	BRn1	1.235	0.204	0.65	1.25	(0.31; 2.23)	0.41	0.33	43.40	(12.18; 70.60)	19.23	(10.23; 28.06)
	BRn2	1.235	0.250	**0.60**	1.17	(0.24; 2.15)	0.38	0.28	45.10	(12.66; 73.57)	18.63	(10.68; 28.03)
	BRn3	1.235	0.220	0.63	1.23	(0.29; 2.20)	**0.40**	0.31	44.00	(12.35; 71.70)	18.99	(10.29; 28.31)
	BRn4	1.235	0.250	**0.60**	1.17	(0.23; 2.14)	0.38	0.28	45.08	(12.64; 73.53)	18.91	(10.76; 28.11)
	BRn5	1.235	0.220	0.63	1.23	(0.29; 2.21)	**0.40**	0.31	43.99	(12.34; 71.68)	18.88	(10.28; 28.16)
	WEST	β	$\Delta\beta$									
New OMs	BR	0.81	-0.0320	0.87	1.63	(0.78; 2.80)	0.68	0.61	2.33	(1.20; 3.03)	9.47	(5.10; 22.59)
	BRn1	0.81	0.0272	**0.60**	1.20	(0.57; 2.24)	0.58	0.52	3.31	(1.50; 4.31)	10.98	(6.34; 19.86)
	BRn2	0.81	0.0243	**0.60**	1.21	(0.57; 2.24)	0.58	0.52	3.24	(1.44; 4.24)	11.20	(6.26; 19.91)
	BRn3	0.81	0.0270	**0.60**	1.20	(0.57; 2.24)	0.58	0.52	3.29	(1.48; 4.29)	11.05	(6.38; 20.61)
	BRn4	0.97	**0.0000**	**0.60**	1.20	(0.57; 2.24)	0.56	0.50	3.28	(1.44; 4.31)	11.37	(7.19; 20.88)
	BRn5	0.98	**0.0000**	**0.60**	1.21	(0.57; 2.24)	0.56	0.50	3.32	(1.47; 4.36)	11.32	(7.14; 20.84)

Note: Results for the new OMs are based on Carruthers' lite-reconditioned OMs in version 8.0.4 of the ABTMSE package.

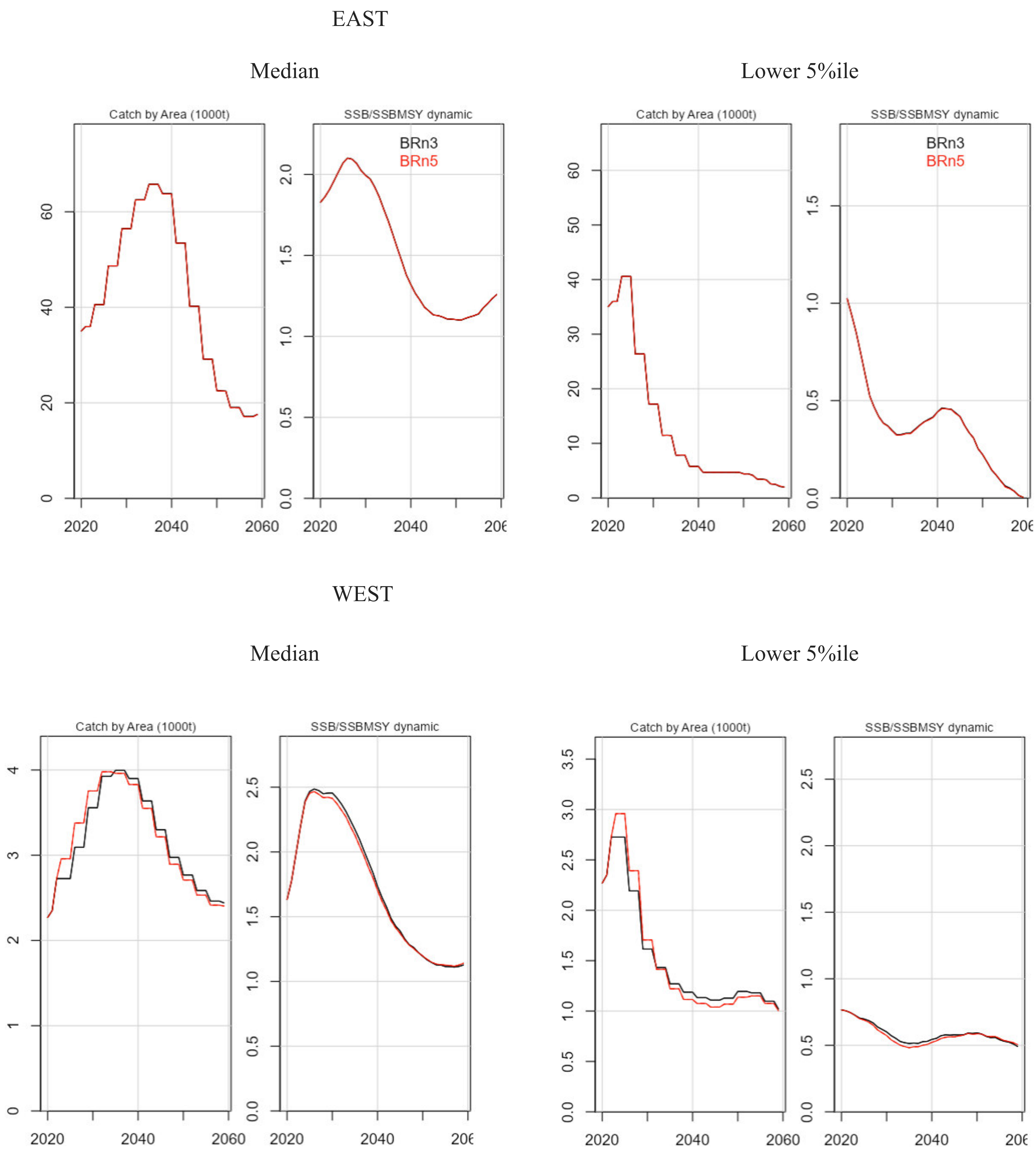

Figure Add1: Median (LHS) and lower 5%ile (RHS) catch (by area) and SSB (by population) projections averaged over all new OMs in the grid and the replicate simulations for BRn3 and BRn5.

APPENDIX

BR CMP Mathematical Descriptions (TAC calculation)

The BR CMP is 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 or for the West areas as appropriate (Table A1, 5 indices in each management area), and finally smoothed over years to reduce observation error variability effects. TACs are then set based on the concept of taking a fixed proportion of the abundance present, as indicated by these aggregated and smoothed abundance indices.

Aggregate abundance indices

An aggregate abundance index is developed for each of the East and the West areas by first standardising each index available for that area to an average value of 1 over the past years for which the index appeared reasonably stable, and then taking a weighted average of the results for each index, where the weight is inversely proportional to the variance[2] of the residuals used to generate future values of that index in the future modified to take into account the loss of information content as a result of autocorrelation. The mathematical details are as follows.

The indices, I_y^i, are first standardised to an average value of 1 over the past years for which the index appeared reasonably stable:

$$I_y^{i*} = \frac{I_y^i}{\sum_{y_1^i}^{y_2^i} I_y^i \Big/ (y_2^i - y_1^i + 1)} \quad \text{(A1)}$$

where y_1^i and y_2^i specify the period to which each index (*i*) is standardised (Table A1).

$J_y^{E/W}$ is an average index over *n* series (*n*=5 for the East area and *n*=5 for the West area):

$$J_y^{E/W} = \frac{\sum_i^n w_i \times I_y^{i*}}{\sum_i^n w_i} \quad \text{(A2)}$$

where $w_i = \frac{1}{\sqrt{\sigma^i}}$ (i.e., effective inverse variance to the power ¼ weighting). σ^i is computed as $\sigma^i = \frac{SD^i}{1-AC^i}$, where SD^i is the standard deviation of the residuals in log space and AC^i is their autocorrelation, averaged over the OMs, as used for generating future pseudo-data. Table A1 lists these values for w_i.

For the West, the weights computed above for US_RR_66_144, JPN_LL_West2 and CAN_SWNS have been multiplied by 3 (i.e., $w_i \rightarrow 3w_i$). This change has been implemented to avoid a steep drop in the median TAC for the West area during the 2030s.

In case of a missing index value in year y, $J_y^{E/W}$, is computed by setting w_i to zero, i.e., that index is disregarded when averaging over indices for that year only.

The actual index used in the CMPs, $J_{av,y-2}^{E/W}$, is the average over the last three years for which data would be available at the time the MP would be applied, hence:

$$J_{av,y-2}^{E/W} = \frac{1}{3}\left(J_{y-2}^{E/W} + J_{y-3}^{E/W} + J_{y-4}^{E/W}\right) \quad \text{(A3)}$$

[2] This is modified somewhat in a few cases to provide the smoother TAC trend over time., as explained further below.

where the $J^{E/W}_{av,y-2}$ applies either to the East or to the West area.

CMP specifications

The BR Fixed Proportion CMP variants set the TAC (in mt) every management cycle simply as a multiple of the J_{av} value for the area at the time (Figure A1), but subject to the change in the TAC for each area being restricted to a maximum of 20% up and 30% down (10% down for the phase-in period, and 35% down only for PGK 60% with a 3-year management cycle).

For the East area:

$$TAC_{E,y} = \begin{cases} \left(\frac{35032.31}{J^E_{2017}}\right) \cdot \alpha_y \cdot J^E_{av,y-2} & \text{for } J^E_{av,y-2} \geq T^E \\ \left(\frac{35032.31}{J^E_{2017}}\right) \cdot \alpha_y \cdot \frac{\left(J^E_{av,y-2}\right)^2}{T^E} & \text{for } J^E_{av,y-2} < T^E \end{cases} \quad \text{(A4a)}$$

$$\alpha_y = \begin{cases} \alpha_0 + \Delta\alpha(y - 2021) & \text{for } 2021 \leq y \leq 2025 \\ \alpha_0 + 4\Delta\alpha & \text{for } y > 2025 \end{cases}$$

For the West area:

$$TAC_{W,y} = \begin{cases} \left(\frac{2269.362}{J^W_{2017}}\right) \cdot \beta_y \cdot J^W_{av,y-2} & \text{for } J^W_{av,y-2} \geq T^W \\ \left(\frac{2269.362}{J^W_{2017}}\right) \cdot \beta_y \cdot \frac{\left(J^W_{av,y-2}\right)^2}{T^W} & \text{for } J^W_{av,y-2} < T^W \end{cases} \quad \text{(A4b)}$$

$$\beta_y = \begin{cases} \beta_0 + \Delta\beta(y - 2021) & \text{for } 2021 \leq y \leq 2028 \\ \beta_0 + 7\Delta\beta & \text{for } y > 2028 \end{cases}$$

The values $35032.314\ mt$ and $2269.362\ mt$ used in equations A4a and b respectively are the ICCAT Task1 catch by management area in 2020 as at April 2022.

Note that in equation (A4a), setting $\alpha_y = 1$ would amount to keeping the East area TAC the same as the corresponding catch in 2020 (as explained above) if the abundance indices stayed at their 2017 level. If α_y or $\beta_y > 1$ harvesting would be more intensive than at that time, and for α_y or $\beta_y < 1$ it would be less intensive.

Below *T*, the law is parabolic rather than linear at low abundance (i.e., below some threshold, so as to reduce the proportion taken by the fishery as abundance drops); this is to better enable resource recovery in the event of unintended depletion of the stock. For the BR CMP, the choices of $T^E = 1$ and $T^W = 1$ have been made.

Constraints on the extent of TAC increase and decrease

$$\Delta TAC^{E/W} = \frac{TAC^{E/W}_y}{TAC^{E/W}_{y-1}} \quad \text{(A5)}$$

with $TAC^{E/W}_y$ from equation A4. $\Delta TAC^{E/W}$ is then modified as follows:

$$\Delta TAC^{E/W\prime} = \exp\left(\ln(\Delta TAC^{E/W}) VarCadj\right) \quad \text{(A6)}$$

with a control parameter, *VarCadj*, taken for the BR CMP to be 0.5.

$\Delta TAC^{E/W\prime}$ is then constrained to a maximum of 20% up and 30% down (10% down for the phase-in period[3], and 35% down only for PGK 60% with 3-year management cycle)

$$\text{if } \Delta TAC^{E/W\prime} > (1 + maxUp^{E/W}) \text{ then } \Delta TAC^{E/W\prime} = (1 + maxUp^{E/W}), \text{ or}$$

$$\text{if } \Delta TAC^{E/W\prime} < (1 - maxDown^{E/W}) \text{ then } \Delta TAC^{E/W\prime} = (1 - maxDown^{E/W})$$

The TAC is then computed as:

$$TAC_y^{E/W\prime} = TAC_{y-1}^{E/W} \cdot \Delta TAC^{E/W\prime} \quad \text{(A7)}$$

If minimum TAC change constraints are accepted, the following revisions to these TACs apply:

$$\text{if} \quad \left|TAC_{y-1}^{E/W} - TAC_y^{E/W\prime}\right| < min\Delta TAC^{E/W} \quad \text{(A8)}$$

$$\text{then} \quad TAC^{E/W\prime\prime} = TAC_{y-1}^{E/W}$$

where values suggested for $min\Delta TAC^{E/W}$ have been 100 mt for the West and 1000 mt for the East.

[3] This is for two cycles if the cycle period is two years, but only one cycle if this period is three years.

Table A1. The index periods y_1^i and y_2^i (equation A1).and w^i weights used when averaging over the indices to provide composite indices for the East and the West areas (equation A2).

	East				West			
i	Index	y_1^i	y_2^i	w^i	Index	y_1^i	y_2^i	w^i
1	FR_AER_SUV2	2014	2017	1.33	GOM_LAR_SUV	2006	2017	1.33
2	MED_LAR_SUV	2012	2016	1.66	US_RR_66_144	2006	2018	2.55
3	GBYP_AER_SUV_BAR[4]	2015	2018	1.06	MEXUS_GOM_PLL2	2006	2018	1.39
4	MOR_POR_TRAP	2012	2018	1.43	JPN_LL_West2	2010	2019	3.96
5	JPN_LL_NEAtl2	2012	2019	1.33	CAN_SWNS	2006	2017	2.88

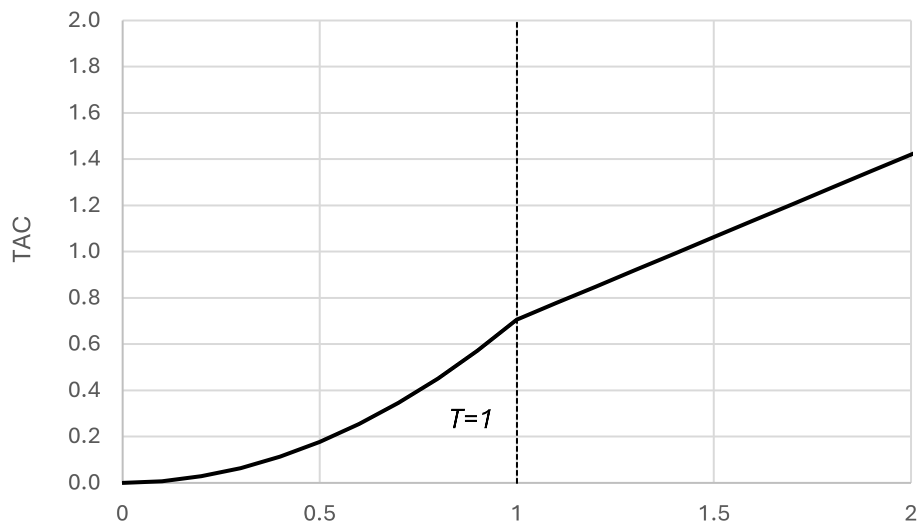

Figure A1. Illustrative relationship (the "catch control law") of *TAC* against $J_{av,y}$ for the BR CMPs, which includes the parabolic decrease below *T*.

[4] For the GBYP aerial survey, there is no value for 2016 and that year was therefore omitted from this averaging.

BR MP RUNS UNDER THE OPERATING MODELS FOR ATLANTIC BLUEFIN TUNA MSE RE-CONDITIONED TO INCLUDE THE CLOSE-KIN MARK RECAPTURE ESTIMATE OF WESTERN STOCK SCALE WITH BOTH OM29 AND OM35 UPDATED NOW INCLUDED (ABTMSE v8.1.0)

D S Butterworth and R A Rademeyer[1]

Summary

The re-tuning of the ABFT MP as previously advised (to take account of the inclusion of the west CKMR estimate in the OM conditioning) is updated to take account of recent updates in the conditioning of OM29 and OM35 as advised by Carruthers. The retuning hardly affects the performance statistics for the West, but those for the East become a little more conservative in terms of catches.

Key words: Atlantic bluefin tuna; CKMR estimate; management procedure; performance

[1] Marine Resource Assessment and Management Group (MARAM), Department of Mathematics and Applied Mathematics, University of Cape Town, Rondebosch 7701, South Africa

Introduction

All the results provided are for the OMs including the west CKMR. V8.1.0 has the updated versions of OM29 and OM35.

1) BR: the original BR MP which was used to provide TAC recommendation for 2023-2025 (tuned to Western and Eastern stock PGK values of 0.60);
2) BRn3: **tuned under v8.0.4**: as BR but with tuning parameters $\Delta\beta$ and $\Delta\alpha$ adjusted so that the Western stock PGK=0.60 and the Eastern stock LD*15%=0.40 for the new OMs.
3) BRn5: **tuned under v8.0.4:** as BR but with tuning parameters β ($\Delta\beta$=0) and $\Delta\alpha$ adjusted so that the Western stock PGK=0.60 and the East ern stock LD*15%=0.40 for the new OMs.
4) BRn6: BRn3 equivalent but **tuned under v8.1.0**.
5) BRn7: BRn5 equivalent but **tuned under v8.1.0**.

Results and Discussion

The retuning hardly affects performance statistics for the West, but those for the East become a little more conservative in terms of expected catches. This is because the PGK value for the East increases to 0.70 so that the LD*15% threshold can be met for the Eastern stock (see Table 1).

Trajectory plots for Catch and for SSB/SSBMSY for the previous and the now updated OMs for the different MPs are shown in Figure 1.

Table 1: Stochastic Br30, AvC30, LD*15%, LD*10% and VarC values (weighted medians with 5%- and 95%iles for the OM grid across all simulations) for a series of MPs across all OMs in the grid, for the new OMs. AvC30 values are in '000 mt. The tuning parameters α, $\Delta\alpha$, β and $\Delta\beta$ are also shown (the other tuning parameters are all as for the BR MP).

					PGK	Br30		LD*15%	LD*10%	AvC30		VarC	
EAST			α	$\Delta\alpha$									
New OMs	v8.0.4	BR	1.235	0.204	0.66	1.27	(0.33; 2.25)	0.42	0.34	43.49	(12.25; 70.77)	19.16	(10.21; 27.99)
		BRn3	1.235	0.22	0.63	1.23	(0.29; 2.20)	**0.40**	0.31	44.00	(12.35; 71.70)	18.99	(10.29; 28.31)
		BRn5	1.235	0.25	0.63	1.23	(0.29; 2.21)	**0.40**	0.31	43.99	(12.34; 71.68)	18.88	(10.28; 28.16)
	v8.1.0	BR	1.235	0.204	0.65	1.25	(0.30; 2.22)	0.36	0.29	43.49	(11.56; 70.77)	19.09	(10.21; 29.17)
		BRn3	1.235	0.220	0.62	1.21	(0.26; 2.17)	0.34	0.27	44.00	(11.68; 71.70)	18.78	(10.29; 29.37)
		BRn5	1.235	0.250	0.62	1.21	(0.26; 2.17)	0.34	0.27	43.99	(11.67; 71.68)	18.79	(10.28; 29.40)
		BRn6	1.235	0.150	0.70	1.33	(0.41; 2.29)	**0.40**	0.32	41.13	(11.41; 66.79)	18.29	(9.12; 31.88)
		BRn7	1.235	0.145	0.70	1.34	(0.41; 2.30)	**0.40**	0.32	40.89	(11.41; 66.29)	18.31	(8.94; 31.96)
		WEST	β	$\Delta\beta$									
New OMs	v8.0.4	BR	0.81	-0.0320	0.87	1.63	(0.78; 2.80)	0.68	0.61	2.33	(1.20; 3.03)	9.47	(5.10; 22.59)
		BRn3	0.81	0.0270	**0.60**	1.20	(0.57; 2.24)	0.58	0.52	3.29	(1.48; 4.29)	11.05	(6.38; 20.61)
		BRn5	0.98	**0.0000**	**0.60**	1.21	(0.57; 2.24)	0.56	0.50	3.32	(1.47; 4.36)	11.32	(7.14; 20.84)
	v8.1.0	BR	0.81	-0.0320	0.88	1.62	(0.81; 2.72)	0.71	0.64	2.33	(1.18; 3.03)	9.46	(5.06; 22.65)
		BRn3	0.81	0.0270	0.60	1.17	(0.58; 2.11)	0.59	0.54	3.29	(1.46; 4.29)	11.23	(6.58; 20.62)
		BRn5	0.98	**0.0000**	0.60	1.18	(0.58; 2.12)	0.57	0.52	3.32	(1.45; 4.36)	11.42	(7.23; 20.70)
		BRn6	0.81	0.0300	**0.60**	1.17	(0.59; 2.10)	0.59	0.53	3.42	(1.50; 4.43)	11.18	(6.52; 19.56)
		BRn7	1.01	**0.0000**	**0.60**	1.17	(0.59; 2.10)	0.57	0.51	3.48	(1.51; 4.53)	11.28	(7.00; 20.45)

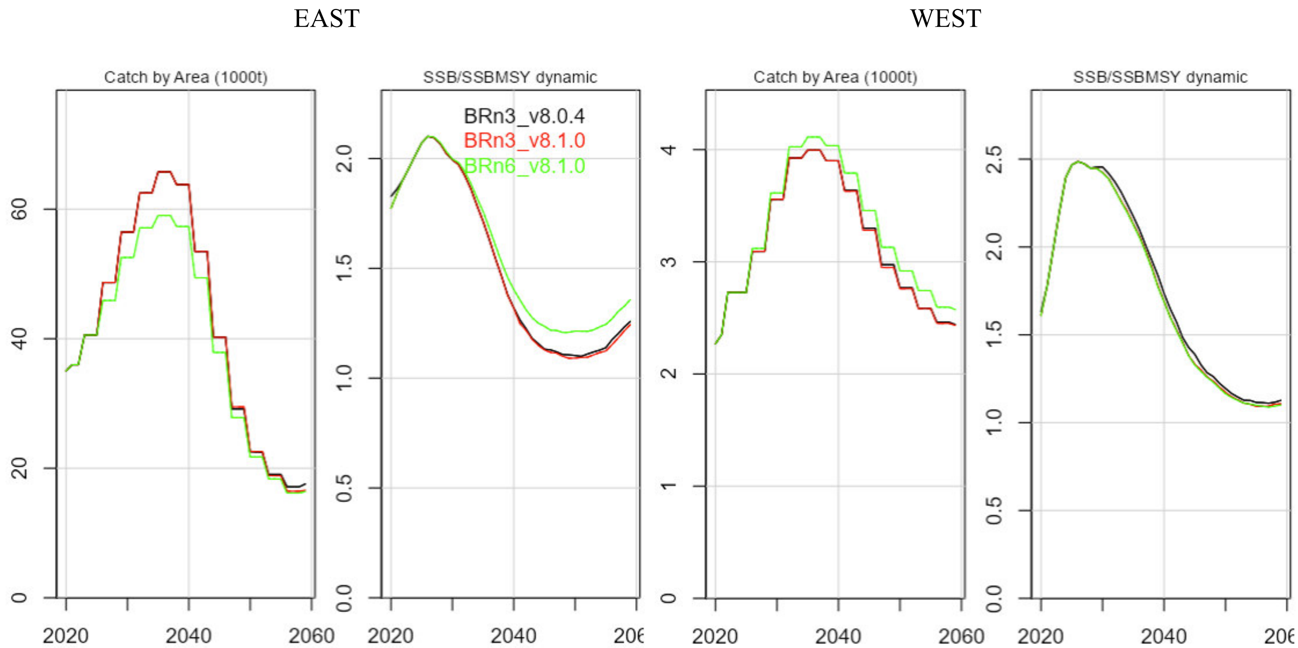

Figure 1a: Median catch (by area) and SSB (by stock) projections averaged over all OMs in the grid and the replicate simulations for BRn3, under v8.0.4 OMs (in black) and v8.1.0 OMs (in red) and BRn6 under v8.1.0 (in green).

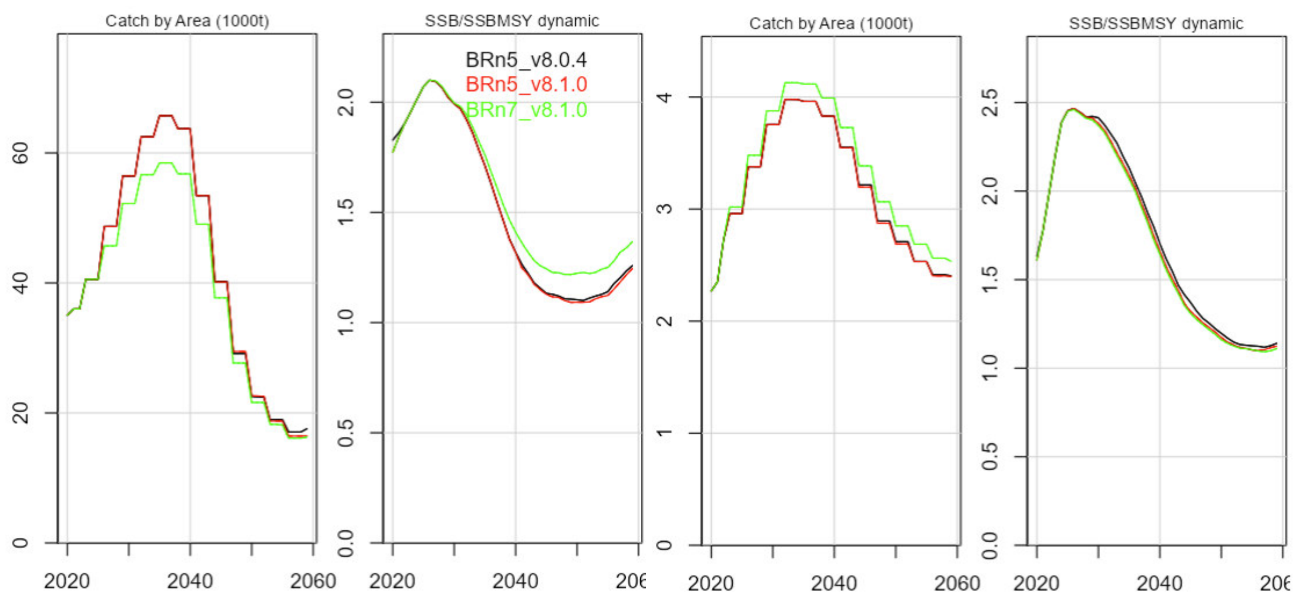

Figure 1b: Median catch (by area) and SSB (by stock) projections averaged over all OMs in the grid and the replicate simulations for BRn5, under v8.0.4 OMs (in black) and v8.1.0 OMs (in red) and BRn7 under v8.1.0 (in green).

Annex 3

BR MP RUNS UNDER THE OPERATING MODELS FOR ATLANTIC BLUEFIN TUNA MSE RE-CONDITIONED TO INCLUDE THE CLOSE-KIN MARK RECAPTURE ESTIMATE OF WESTERN STOCK SCALE assuming a CKMR CV of 0.2 (ABTMSE v8.2.3)

D S Butterworth and R A Rademeyer[1]

Summary

The BR MP is retuned under the most recent re-conditioning of the ABFT OMs which set the CV of the western stock CKMR estimate to 0.20 rather than the 0.05 specified previously for that re-conditioning. This results in an MP which is slightly more conservative, i.e. slightly lower catches, for both the East and the West areas.

Key words: Atlantic bluefin tuna; CKMR estimate; management procedure; performance

[1] Marine Resource Assessment and Management Group (MARAM), Department of Mathematics and Applied Mathematics, University of Cape Town, Rondebosch 7701, South Africa

Introduction

Results are compared for the OMs including the CKMR in ABTMSE version V8.1.0 (CV_{CKMR} = 0.05) and the most recent version V8.2.3 (CV_{CKMR} =0.2).

1) BR: the original BR MP which was used to provide TAC recommendation for 2023-2025 (tuned to Western and Eastern stock PGK values of 0.60);
2) BRn6: **tuned under v8.1.0**: as BR but with tuning parameters $\Delta\beta$ and $\Delta\alpha$ adjusted so that the Western stock PGK=0.60 and the Eastern stock LD*15%=0.40 for the new OMs.
3) BRn7: **tuned under v8.1.0:** as BR but with tuning parameters β ($\Delta\beta$=0) and $\Delta\alpha$ adjusted so that the Western stock PGK=0.60 and the East ern stock LD*15%=0.40 for the new OMs.
4) BRn8: BRn6 equivalent but **tuned under the most recent v8.2.3**.
5) BRn9: BRn7 equivalent but **tuned under the most recent v8.2.3**.

Results and Discussion

Comparative results for the previous (CV=0.05) and current (CV=0.20) re-conditionings are shown in Table 1 with associated time series of median catches and SSB/SSBmsy values compared in Figure 1; the second sets of results set $\Delta\beta$=0.

Performance under the current re-conditioning is slightly more conservative, i.e. catches are a little lower.

Table 1: Stochastic Br30, AvC30, LD*15%, LD*10% and VarC values (weighted medians with 5%- and 95%iles for the OM grid across all simulations) for a series of MPs across all OMs in the grid, for the previous (v8.1.0; CKMR CV=0.05) and the most recent (v8.2.3; CKMR CV=0.20)versions of the new OMs. AvC30 values are in '000 mt. The tuning parameters α, $\Delta\alpha$, β and $\Delta\beta$ are also shown (the other tuning parameters are all as for the original BR MP).

					PGK	Br30	LD*15%	LD*10%	AvC30	VarC
EAST			α	$\Delta\alpha$						
New OMs	v8.1.0	BR	1.235	0.204	0.65	1.25 (0.30; 2.22)	0.36	0.29	43.49 (11.56; 70.77)	19.09 (10.21; 29.17)
		BRn6	1.235	0.150	0.70	1.33 (0.41; 2.29)	**0.40**	0.32	41.13 (11.41; 66.79)	18.29 (9.12; 31.88)
		BRn7	1.235	0.145	0.70	1.34 (0.41; 2.30)	**0.40**	0.32	40.89 (11.41; 66.29)	18.31 (8.94; 31.96)
	v8.2.3	BR	1.235	0.204	0.63	1.22 (0.25; 2.18)	0.34	0.26	43.41 (11.75; 70.57)	19.00 (10.57; 31.01)
		BRn6	1.235	0.150	0.68	1.29 (0.36; 2.26)	0.37	0.29	41.08 (11.41; 66.58)	18.39 (9.37; 29.24)
		BRn7	1.235	0.145	0.69	1.30 (0.36; 2.27)	0.38	0.29	40.85 (11.41; 66.14)	18.29 (9.32; 29.36)
		BRn8	1.235	0.125	0.62	1.35 (0.41; 2.33)	**0.40**	0.31	40.01 (11.41; 64.57)	18.16 (8.61; 30.82)
		BRn9	1.235	0.125	0.60	1.35 (0.41; 2.33)	**0.40**	0.31	40.00 (11.41; 64.55)	18.18 (8.59; 30.88)
		WEST	β	$\Delta\beta$						
New OMs	v8.1.0	BR	0.81	-0.0320	0.88	1.62 (0.81; 2.72)	0.71	0.64	2.33 (1.18; 3.03)	9.46 (5.06; 22.65)
		BRn6	0.81	0.0300	**0.60**	1.17 (0.59; 2.10)	0.59	0.53	3.42 (1.50; 4.43)	11.18 (6.52; 19.56)
		BRn7	1.01	**0.0000**	**0.60**	1.17 (0.59; 2.10)	0.57	0.51	3.48 (1.51; 4.53)	11.28 (7.00; 20.45)
	v8.2.3	BR	0.81	-0.0320	0.85	1.53 (0.84; 2.49)	0.76	0.67	2.41 (1.21; 3.12)	9.56 (5.11; 21.65)
		BRn6	0.81	0.0300	0.53	1.09 (0.54; 1.88)	0.58	0.52	3.50 (1.57; 4.49)	11.46 (6.57; 19.24)
		BRn7	1.01	**0.0000**	0.53	1.09 (0.53; 1.88)	0.56	0.50	3.56 (1.58; 4.60)	11.48 (7.17; 19.65)
		BRn8	0.81	0.021	**0.60**	1.16 (0.59; 1.98)	0.62	0.55	3.35 (1.53; 4.33)	10.78 (6.37; 19.58)
		BRn9	0.95	**0.0000**	**0.60**	1.16 (0.59; 1.97)	0.60	0.54	3.39 (1.54; 4.39)	11.09 (6.98; 19.31)

EAST WEST

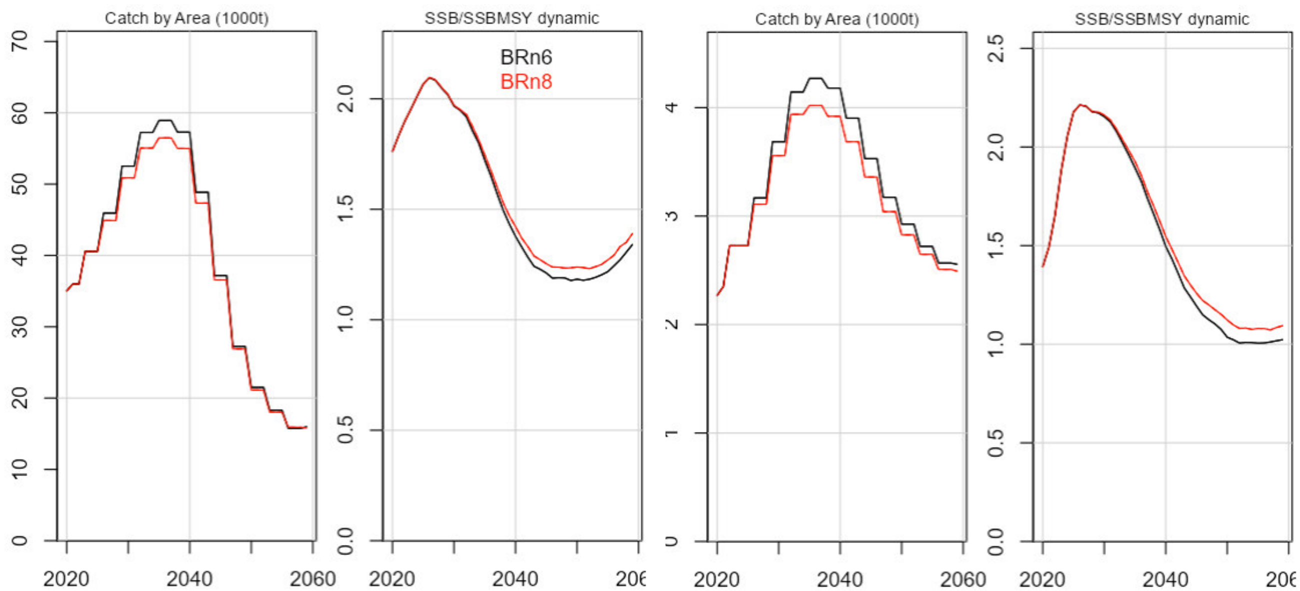

Figure 1a: Median catch (by area) and SSB (by stock) projections averaged over all OMs in the grid and the replicate simulations for BRn6 tuned to v8.1.0 OMs (in black) and BRn8 tuned under v8.2.3 (in red).

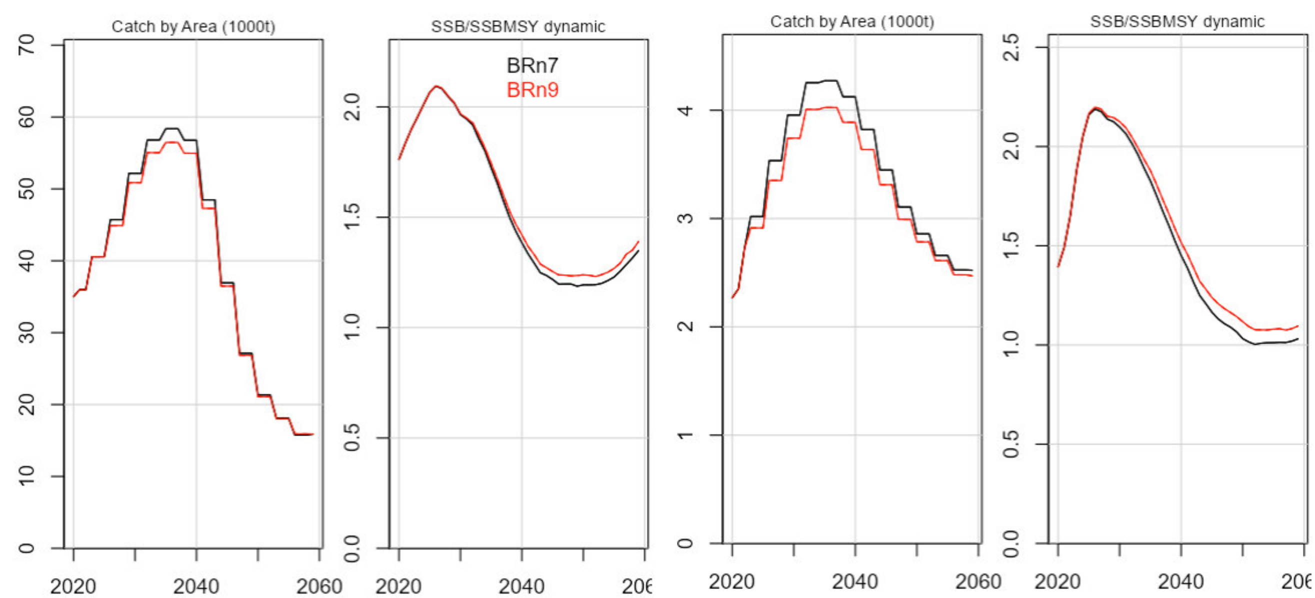

Figure 1b: Median catch (by area) and SSB (by stock) projections averaged over all OMs in the grid and the replicate simulations for BRn7 ($\Delta\beta$=0) tuned to v8.1.0 OMs (in black) and BRn9 ($\Delta\beta$=0) tuned under v8.2.3 (in red).

A brief initial analysis of 'does the west CKMR estimate matter for the ABFT MSE'?

D S Butterworth and R A Rademeyer[1]

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 the MP. It must, however, be emphasised that these 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.

Key words: Atlantic bluefin tuna; CKMR estimate; management procedure; performance

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'.

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) 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:

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

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

[1] Marine Resource Assessment and Management Group (MARAM), Department of Mathematics and Applied Mathematics, University of Cape Town, Rondebosch 7701, South Africa

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.

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

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 tha 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 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**.

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 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)

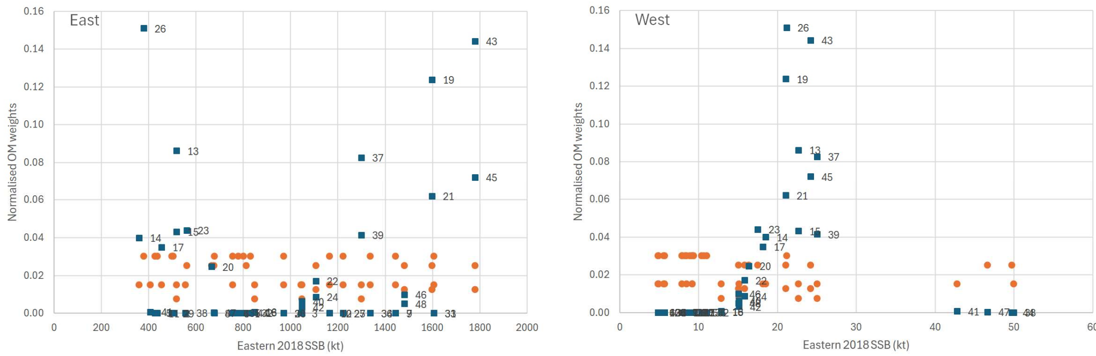

Figure 1: "Original" (orange dots) and "Original*CKMR" (blue square) weights plotted against median 2018 SSB for each OM in the Reference Set, for the eastern and western stocks. The labels on the blue dots are the OM numbers.

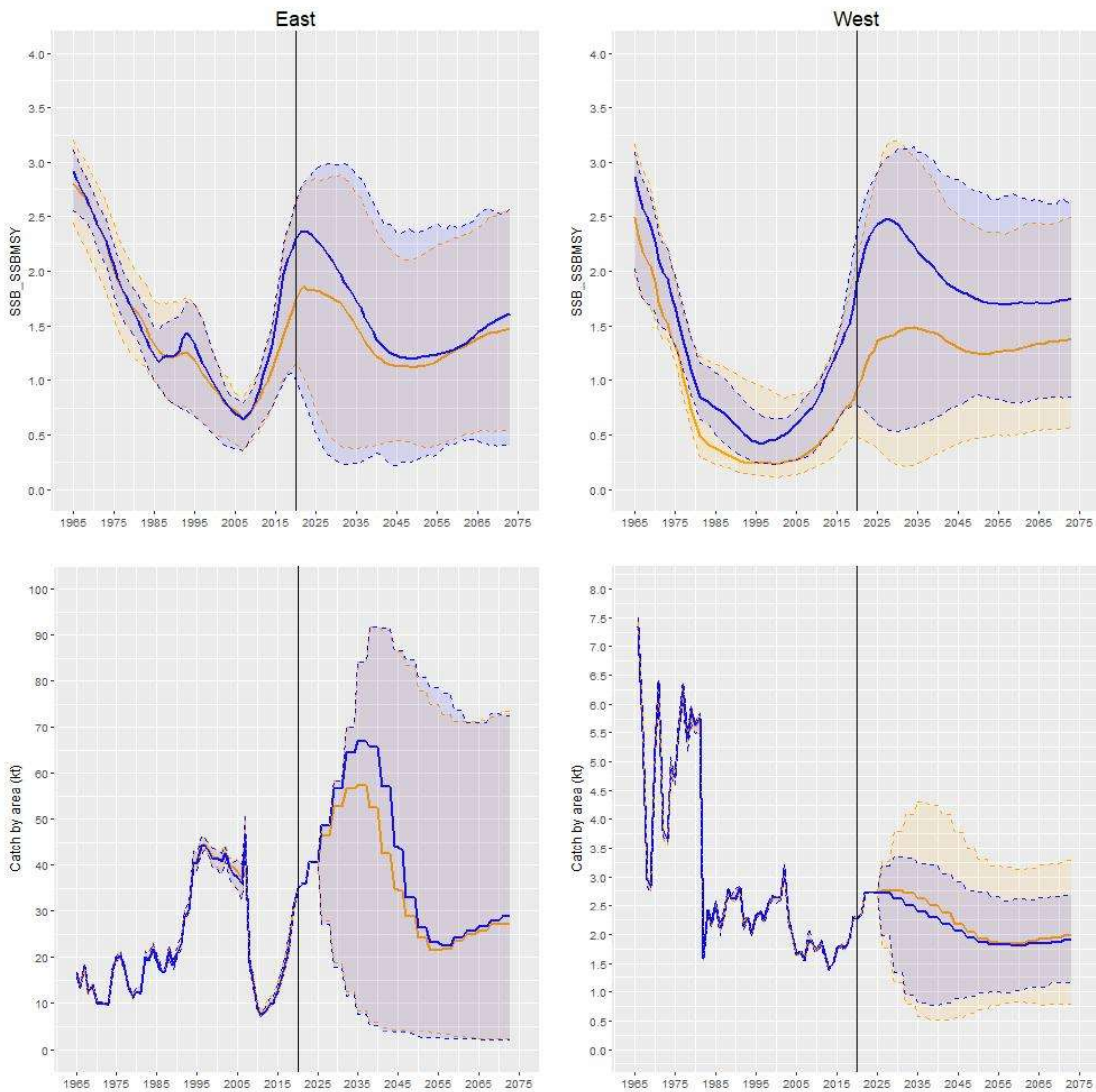

Figure 2: Median and 90%iles SSB (by population) and catch (by area) trajectories for the weighted average over all OMs in the grid and the replicate simulations with projections under the BR MP. Orange lines and shaded area represent the "original" weighting, while blue lines and shaded area represent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

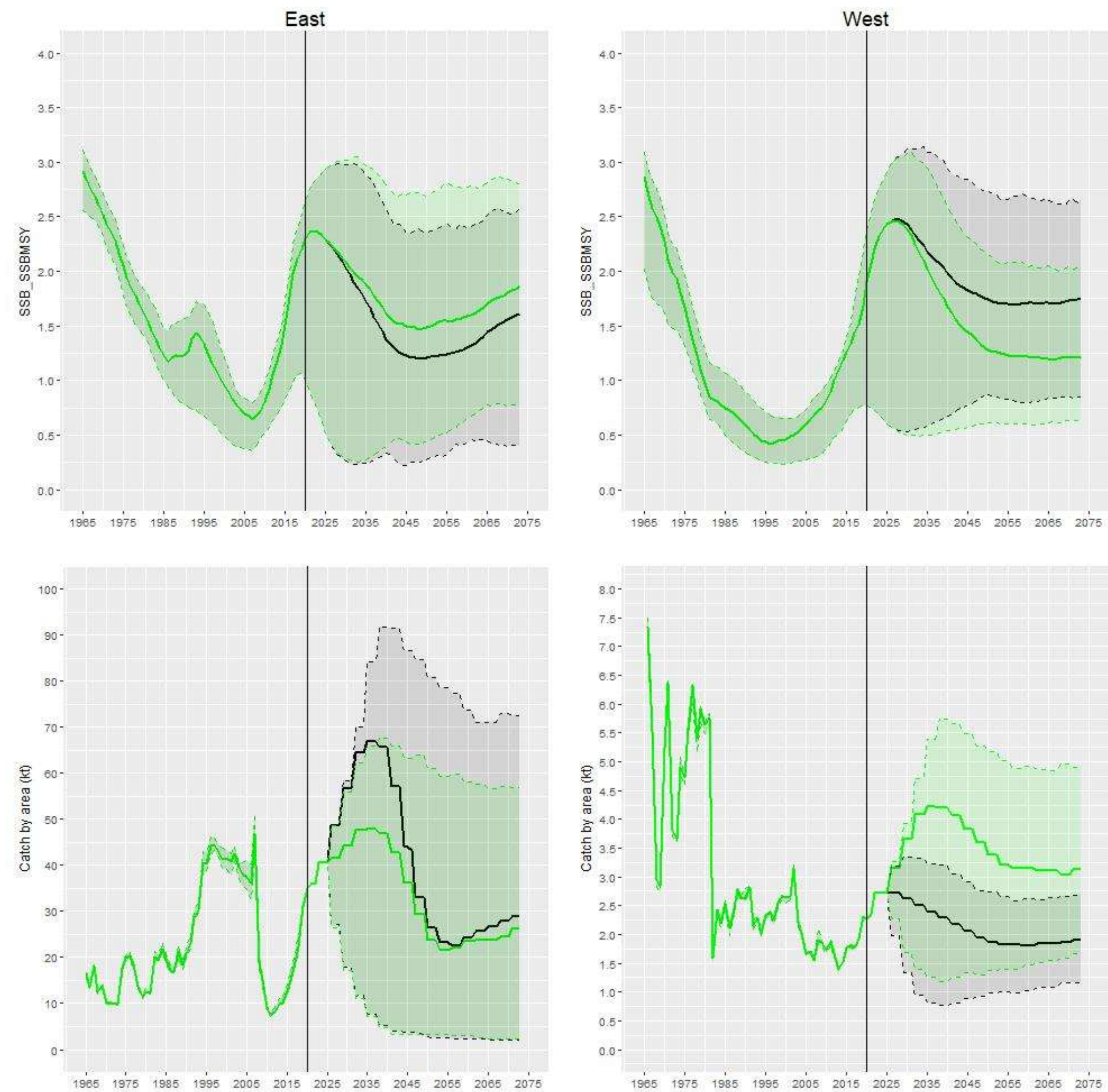

Figure 3: Median and 90%iles SSB (by population) and catch (by area) trajectories for the weighted average over all OMs in the grid and the replicate simulations with projections under the BR MP. The black lines and grey shaded area represent the BR MP, while green lines and shaded area represent the 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.