SCRS/2020/147 Collect. Vol. Sci. Pap. ICCAT, 77(2): 803-815 (2020)

REFINING THE FXP (FIXED PROPORTION) CMP

D S Butterworth, and R A Rademeyer[1]

SUMMARY

Various refinements to the FXP CMP are considered to attempt to improve its resource conservation performance in particular. For the "100 tuning" variant (Br30 = 1 for both Eastern and Western stocks for deterministic projections of OM1), either or both stocks can be rendered (near) extinct for some OMs. The OMs that lead to the greatest conservation difficulties for these CMPs have a low abundance scale for the Western stock, especially those that also incorporate the R3 scenario where a regime shift occurs in the future. Introducing two modifications to the CMP – a linear decrease in the fishing proportion and allowance for greater than 20% decreases in TACs when the aggregate abundance index drops below a threshold for the area concerned – considerably improves conservation performance for the Eastern stock. However, some problematic R3-scenarios OMs remain when considering conservation performance for the Western stock. Placing a cap on the East area TAC can assist marginally in that respect, but also introduces some associated disadvantages. Suggestions are made for additional areas of investigation to refine the performance of this CMP further.

RÉSUMÉ

Plusieurs améliorations apportées à la CMP FXP sont envisagées pour tenter d'améliorer ses performances en matière de conservation des ressources en particulier. Pour la variante « 100e calibrage » (Br30 = 1 pour les stocks de l'Est et de l'Ouest pour les projections déterministes de OM1), l'un ou l'autre ou les deux stocks peuvent (presque) disparaître selon certains OM. Les OM qui entraînent les plus grandes difficultés de conservation pour ces CMP ont une faible échelle d'abondance pour le stock de l'Ouest, en particulier ceux qui intègrent également le scénario R3 qui prévoit un changement de régime à l'avenir. L'introduction de deux modifications de la CMP - une diminution linéaire de la proportion de pêche et la possibilité de diminuer les TAC de plus de 20 % lorsque l'indice d'abondance global tombe en dessous d'un seuil pour la zone concernée - améliore considérablement les résultats en matière de conservation du stock de l'Est. Toutefois, certains scénarios R3 problématiques des OM subsistent lorsque l'on considère les performances de conservation du stock de l'Ouest. Le plafonnement du TAC de la zone Est peut être d'une aide marginale à cet égard, mais présente également certains inconvénients connexes. Des suggestions sont faites pour des domaines d'investigation supplémentaires afin d'affiner davantage les performances de cette CMP.

RESUMEN

Se consideran diversos refinamientos al CMP FXP para intentar mejorar su desempeño de conservación del recurso en particular. Para la variante «calibración 100» (Br30 = 1 para los stocks oriental y occidental para proyecciones deterministas de OM1) uno o los dos stocks pueden hacerse (casi) extintos para algunos OM. Los OM que producen mayores dificultades en cuanto a conservación para estos CMP tienen una escala de baja abundancia para el stock occidental, especialmente los que también incorporan el escenario R3, en el que en el futuro se produce un cambio de régimen. Introducir dos modificaciones al CMP - un descenso lineal en la proporción de pesca y permitir descensos en los TAC de más del 20 % cuando el índice de abundancia agregado cae por debajo de un umbral para el área afectada - mejora considerablemente el desempeño de conservación para el stock oriental. Sin embargo, algunos escenarios R3 problemáticos de los OM permanecen al considerar el desempeño de conservación para el stock occidental. Limitar el TAC del área oriental puede ayudar marginalmente en este sentido, pero también introduce algunas desventajas asociadas. Se hacen sugerencias para otros campos de investigación con el fin de refinar más el desempeño de este CMP.

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

KEYWORDS

Management Strategy Evaluation, Candidate Management Procedure, Operating Model grid, Atlantic bluefin tuna, development tuning

Introduction

This document reports on deterministic results for refinements of the original fixed proportion FXP CMP for a 100 tuning (i.e. Br30=1 for both Western and Eastern stocks) for OM1 (see SCRS/2020/148 and 149). At basis, this CMP sets TACs by area as fixed proportions of abundance, as indicated by an aggregate of abundance indices for the (East or West) area concerned. First full specifications of the resultant CMP are given, including rationales for each of the refinements now introduced. This is followed by the results with some discussion of a few initial implementations. Note that the purpose of the refinements is to try to narrow the range of Br30 results across the OMs of the interim grid, and in particular to attempt to ameliorate instances of Br30 falling very low – even to zero – for some of those OMs.

Description of FXP CMP

a) Original form of CMP

The 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, separately for the East and for the West areas, 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. The details are set out below.

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[2], and then taking a weighted average of the results for each index, where the weight is inversely proportional to the variance of the residuals used to generate future values of that index in the future as modified to take into account the loss of information content as a result of autocorrelation. The mathematical details are as follows.

J_y is an average index over *n* series (*n*=5 for the East area and *n*=7 for the West area) [3]:

$$J_y = \frac{\sum_i^n w_i \times I_y^{i*}}{\sum_i^n w_i} \qquad (1)$$

where

$$w_i = \frac{1}{(\sigma^i)^2}$$

and where the standardised index for each index series (*i*) is:

$$I_y^{i*} = {I_y^i}\Big/{Average\ of\ historical\ I_y^i}$$

σ^i is computed as $\sigma^i = \frac{SD^i}{1-AC^i}$

[2] These years are for the Eastern indices: 2014-2017 for FR_AER_SUV2, 2012-2016 for MED_LAR_SUV, 2015-2018 for GBYP_AER_SUV_BAR, 2012-2018 for MOR_POR_TRAP and 2012-2019 for JPN_LL_NEAtl2; and for the Western indices: 2006-2017 for GOM_LAR_SURV, 2006-2018 for all US_RR and US_GOM_PLL2 indices, 2010-2019 for JPN_LL_West2 and 2006-2017 for CAN_SWNS..

[3] For the aerial surveys, there is no value for 2013, 2018 and 2019 (French) and 2017-2019 (Mediterranean). For GBYP aerial survey there is no value for 2012, 2014, 2016 and 2019. For MOR_POR_TRAP survey, there is no value for 2019. These years were omitted from this averaging where relevant.

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 1** lists these values for σ^i.

The actual index used in the CMPs, J_{av}, is the average over the last three years for which data would be available at the time the MP would be applied, so that:

$$J_{av,y} = \frac{1}{3}\left(J_y + J_{y-1} + J_{y-2}\right) \tag{2}$$

where the J applies either to the East or to the West area.

CMP specifications

The Fixed Proportion (FXP) CMPs tested set the TAC every second year simply as a multiple of the J_{av} value for the area at the time (see Figure 1), but subject to the change in the TAC for each area being restricted to a maximum of 20% (up or down). The formulae are given below.

For the East area:

$$TAC_{E,y} = \left(\frac{TAC_{E,2018}}{J_{E,2017}}\right) \cdot \alpha \cdot J^E_{av,y-2} \tag{3a}$$

If $TAC_{E,y} \geq 1.2 * TAC_{E,y-1}$ then $TAC_{E,y} = 1.2 * TAC_{E,y-1}$

If $TAC_{E,y} \leq 0.8 * TAC_{E,y-1}$ then $TAC_{E,y} = 0.8 * TAC_{E,y-1}$

For the West area:

$$TAC_{W,y} = \left(\frac{TAC_{W,2018}}{J_{W,2017}}\right) \cdot \beta \cdot J^W_{av,y-2} \tag{3b}$$

If $TAC_{W,y} \geq 1.2 * TAC_{W,y-1}$ then $TAC_{W,y} = 1.2 * TAC_{W,y-1}$

If $TAC_{W,y} \leq 0.8 * TAC_{W,y-1}$ then $TAC_{W,y} = 0.8 * TAC_{W,y-1}$

Note that in equation (3a), setting $\alpha = 1$ will amount to keeping the TAC the same as for 2018 until the abundance indices change. If α or $\beta > 1$ harvesting will be more intensive than at present and for α or $\beta < 1$ it will be less intensive.

b) Refinements to original CMP

Different combinations of the following refinements to the original FXP as detailed above have now been implemented. These refinements are described below.

Parabolic component of catch control law

The modification shown on the left side of **Figure 1** is introduced to render this law parabolic rather than linear at low abundance (i.e. below some threshold, to reduce the proportion of the resource taken by the fishery as its abundance drops) so as to better enable resource recovery in the event of unintended depletion of the stock.

For the East area:

Equation 3a is now modified if $J^E_{av,y} < T^E$ to:

$$TAC_{E,y} \rightarrow TAC_{E,y} \frac{J^E_{av,y}}{T^E} \tag{4a}$$

and similarly for the West area, equation 3b is now modified if $J^W_{av,y} < T^W$ to:

$$TAC_{W,y} \rightarrow TAC_{W,y} \frac{J^W_{av,y}}{T^E} \qquad (4b)$$

For the results presented here, the choices $T^E = 1$ and $T^W = 1$ have been made.

Maximum extent of TAC decrease

In the original FXP CMP, the maximum interannual increase or decrease in TAC is constrained to 20% (see equations 3a and 3b). This restriction can prove problematic if it prevents the TAC being reduced sufficiently, and sufficiently quickly, should abundance drop below some threshold. Accordingly, this restriction is modified to allow for a greater decrease if the average index falls below $J_{i,2017}$.

If $TAC_{i,y} \leq 0.8 * TAC_{i,y-1}$

then $TAC_{i,y} = (1 - maxdecr) * TAC_{i,y-1}$ (5)

where

$$maxdecr = \begin{cases} 0.2 & J^i_{av,y-2} \geq J_{i,2017} \\ \text{linear btw 0.2 and 0.5} & 0.5J_{i,2017} < J^i_{av,y-2} < J_{i,2017} \\ 0.5 & J^i_{av,y-2} \leq 0.5J_{i,2017} \end{cases} \qquad (6)$$

Maximum TAC

A cap on the maximum allowable TAC is set. This can potentially improve performance, particularly in the event of a shift to a lower productivity regime, by ensuring that TACs have not risen so high that they cannot be reduced sufficiently rapidly following such an event to adjust for the lower resource productivity. In investigations to date, this has been found to be useful to implement only for the East area, where TACs can otherwise rise to in excess of 70 kt.

Results and Discussion

The additional flexibility introduced by the refinement options described above allow for choices of many combinations of these through different selections for their associated control parameters. What follows constitutes only some initial exploration over a limited set of three possible refined versions of the original "100 tuning" FXP CMP; it is not intended to provide a final CMP proposal. **Table 2** shows the control parameter values for these three versions. At this stage, the results are provided for deterministic projections only.

Figures 2 and 3 show values for Br30 and AvC30 respectively for east and west for each of the 96 OMs of the interim grid. In the interests of less clutter, results for a cap of 55 kt to the TAC for the East area are not shown in these Figures – they are intermediate between those for the Modified-max decr and 50 kt cap CMP versions.

A number of important features are immediately evident from these Figures.

- In terms of resource conservation, the poorer performance occurs amongst OMs 1-24 for both the Eastern and Western stocks, and to a lesser extent for OMs 49-72 for the Western stock, i.e. the key factors driving such poorer performance are a low abundance scale for the Western stock, particularly if coupled to a low weight for the length composition data in the likelihood.

- Furthermore, the worst of such poorer performances are generally for the R3 OMs, i.e. those for which a regime shift occurs in the future.

- The combination of the parabolic form of the catch control law at low abundance with allowance for a greater TAC reduction if abundance is low (i.e. the Modified-max decrease CMP version) is alone sufficient to avoid instances of (near) extinction of the Eastern stock which occurred under the original FXP CMP for 100-tuning.

- Nevertheless (near) extinction still occurs for the Western stock for OMs 9 and 24, with performance for OMs 12 and 21 also very poor in terms of especially low abundance after 30 years.

Imposing a cap on the TAC for the East area sees yet further improvement in performance for the Eastern stock for especially the problematic R3 OMs, but this comes with two price tags. First, the tuning criterion for the Eastern stock can no longer be met, with catches being kept too low to reduce SSB for OM1 down to Bmsy. Secondly, probably because a lower Eastern stock abundance following a regime shift leads to a greater proportion of catches in the West area being comprised of Western bluefin, conservation performance for the Western stock generally deteriorates somewhat if such a cap is introduced, e.g. for OM12 and OM72. Only for the most problematic OM (OM9) is there some (though very small) improvement with the introduction of these caps.

For the AvC30 results shown in **Figure 3**, trends across the CMP versions are generally in reverse to those discussed above for Br30, as might be expected. For some OMs for the CMP version with a 50 kt cap on the TAC for the East area, the AvC30 value there can drop to as low as 10 kt.

These results are summarized by the use of Zeh plots showing percentiles of the distributions for the 96 interim grid OMs in Figure 4. The refinements introduced do achieve their objective of increasing Br30 medians compared those for the original FXP CMP, and in particular the variances of the distributions for these refined versions are reduced, with especially the lower percentiles moving to larger values for the Eastern stock. This effect is stronger still for the Western stock for the Modified-max decrease CMP version, but this is weakened if a cap is imposed on the TAC for the East area.

The AvC30 plots (**Figure 4**) show that a price has to be paid in terms of average catch when these refinements are introduced. The Modified-max decrease CMP version sees reductions for both areas, though larger for the East area. When a cap on the East area TAC is added, AvC30 reduces further for this area, but increases somewhat for the West area.

Figure 5 repeats the summary of **Figure 4** across the interim grid OMs, except that the R3 future regime shift scenario OMs are omitted. Conservation performance is generally much improved compared to the distributions shown in Figure 4, which points to the important influence that these OMs have on CMP choice, given that this choice needs to allow for such possibilities.

Despite the improvements which the refinements have brought to FXP CMP performance overall, many OMs still show Br30 values below (and often quite substantially below) the target value of 1 which corresponds to Bmsy. Some such results are unavoidable unless control parameter values corresponding to a very low catches were to be adopted. However, an important consideration in such cases is whether at the end of the 30-year projection period, a stock reduced to a low abundance is showing an upward trend. Figure 6 illustrates this for two OMs with low Br30 values for the Western stock: OM5 and the especially problematic OM9. For OM5, this desirable behaviour is evident, but for OM9 any such increase is minimal, essentially because earlier catches grew too large and were then not reduced sufficiently rapidly.

Moving forward

Some points for discussion that arise from these results are as follows.

1) Are the R3 scenarios with a future regime shift, which lead to poor conservation performance for the Western stock for the low abundance scale OMs, being accorded too much weight? Attempting to attain better performance for those requires (at least as far as this work has been taken) choices of CMP control parameter values that lead to considerable sacrifices in the size of the catches which could otherwise be taken.

2) Notwithstanding the caps placed on the East area TACs failing to lead to improvements in performance which are relatively substantial, particularly for the Western stock, the question needs to be asked whether management should be aiming for Bmsy for the Eastern stock, given that this can result in TACs appreciably higher than catches taken in the East area in the past?

3) Note that the previous point has implications for the OM choice for defining development tuning targets. A choice other than OM1 might allow for Br30 for the Eastern stock to approach 1 more closely if a TAC cap is imposed for the East area.

4) Performance for the Western stock can nevertheless be worse than desirable for some OMs, and this performance needs to be improved. One underlying reason for this difficulty is the role of Eastern stock bluefin in abundance indices for the West area, which in turn impact the TACs set for the West area. A possibility for future investigations is to link downward TAC adjustments for the East area, when that is a result of the CMP refinement mechanisms introduced in this paper, to associated further downward adjustments to the TAC for the West area.

5) Clearly the wide set of additional control parameters introduced in conjunction with the modification options to the FXP CMP added in this paper offer considerable scope for further investigation. Variation in the development tuning target (100 tuning, with Br30 = 1 for both Western and Eastern stocks) also needs to be addressed to show the overall catch *vs* resource abundance target trade-off, as well as extensions from deterministic to stochastic projections.

Table 1. σ^i values used in weighting when averaging over the indices to provide composite indices for the East and the West areas (see equation 1).

EAST		WEST	
Index name	σ^i	Index name	σ^i
MOR_POR_TRAP	0.56	GOM_LAR_SUV	0.58
JPN_LL_NEAtl2	0.45	JPN_LL_West2	0.62
FR_AER_SUV2	1.00	US_RR_66_114	1.47
GBYP_AER_SUV_B.	0.56	US_RR_115_144	0.71
MED_LAR_SUV	0.56	US_RR_177	1.29
		US_GOM_PLL2	0.89
		CAN SWNS	1.71

Table 2. Parameter values for each of the CMPs presented here. The tunings are for deterministic results. Note that the final two CMPs incorporate the modification (to the catch control law) as well as to the maximum decrease in the TAC; "cap 55", for example, then refers to the addition of a maximum TAC of 55 kt permitted in the East area. For reasons explained in the text, only the β control parameter values is varied to tune for the Western stock alone for these final two CMPs.

OM1 tuning	CMP name	α	β
1 (E and W)	100tuning	1.3	0.565
1 (E and W)	Modified - max decr	1.3	0.565
1 (W only)	cap 55 - tuned	1.3	0.680
1 (W only)	cap 50 - tuned	1.3	0.710

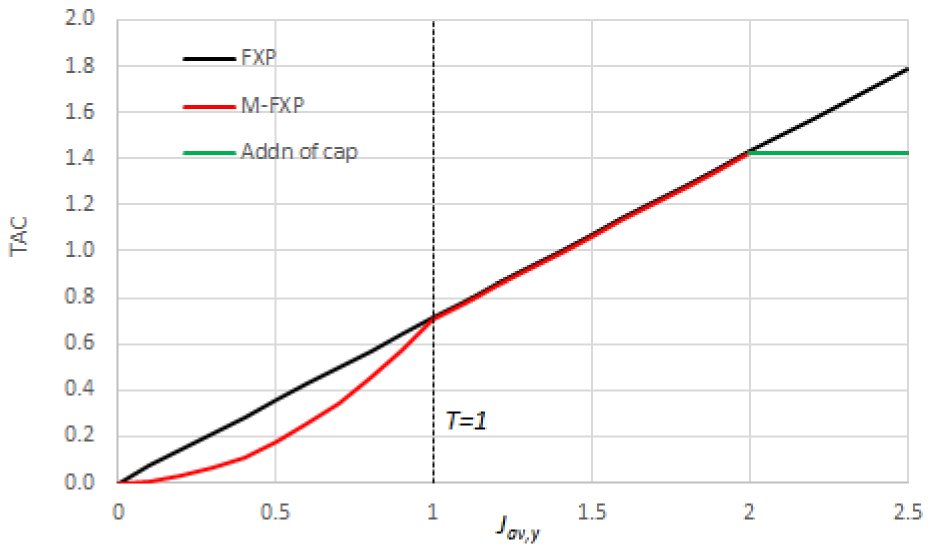


Figure 1. Illustrative relationship (the "catch control law") of *TAC* against $J_{av,y}$ for the original FXP and its modified form denoted here at M-FXP. The right-hand side of the plot shows the modification to cap the TAC so as not to exceed some maximum value.

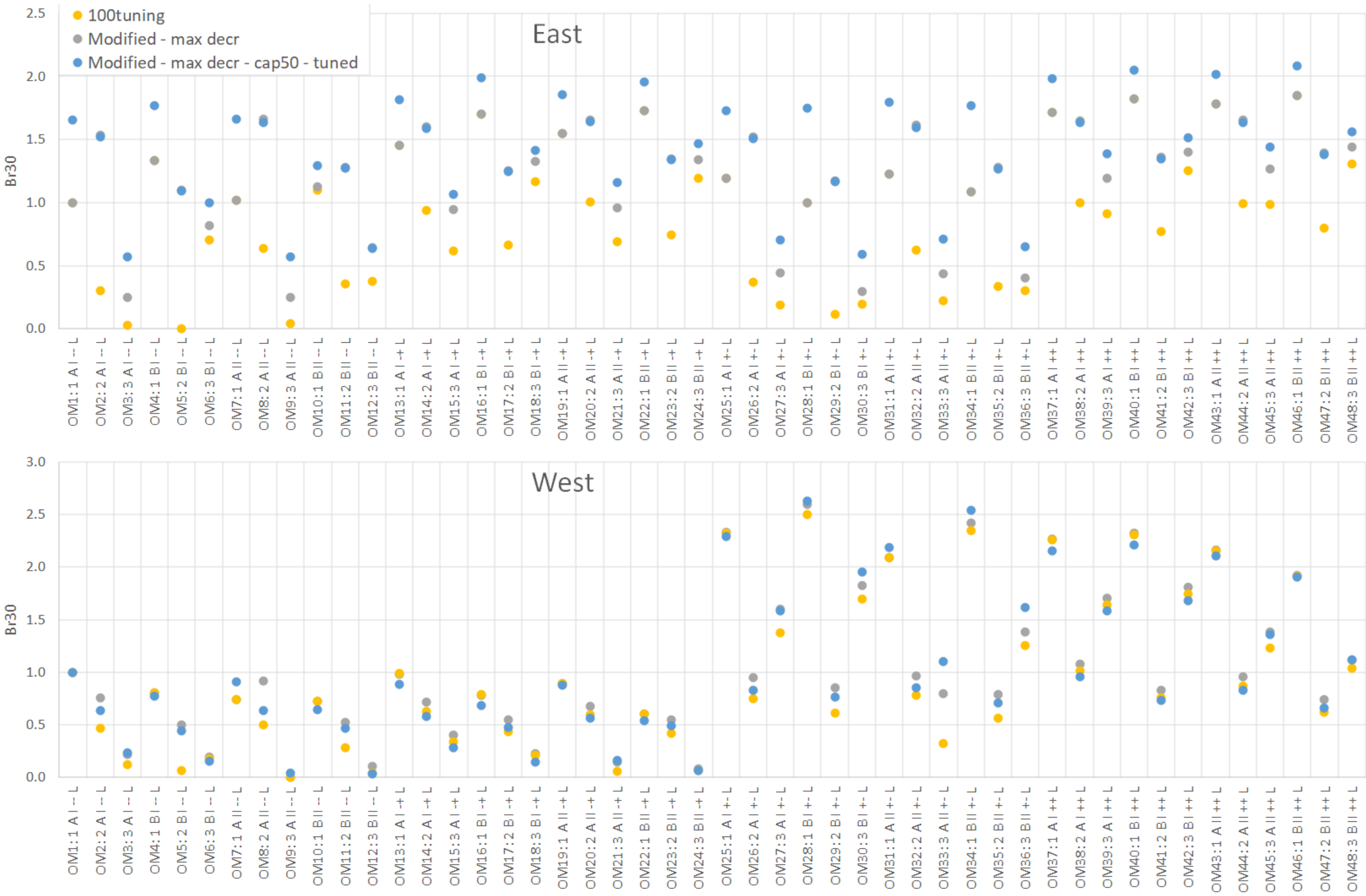


Figure 2a. Deterministic Br30 values for three CMPs for OM1 to OM48.

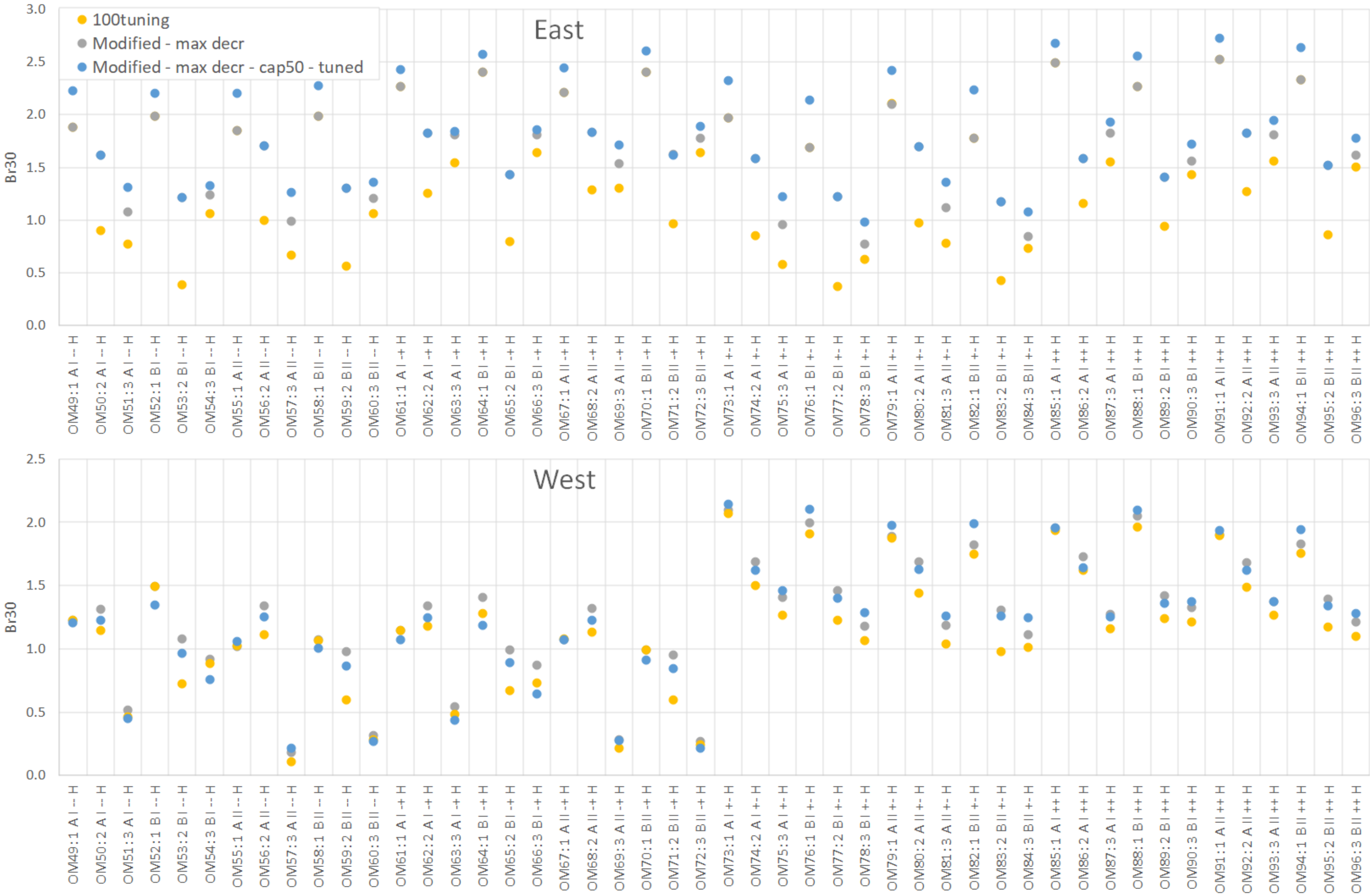


Figure 2b. Deterministic Br30 values for three CMPs for OM49 to OM96.

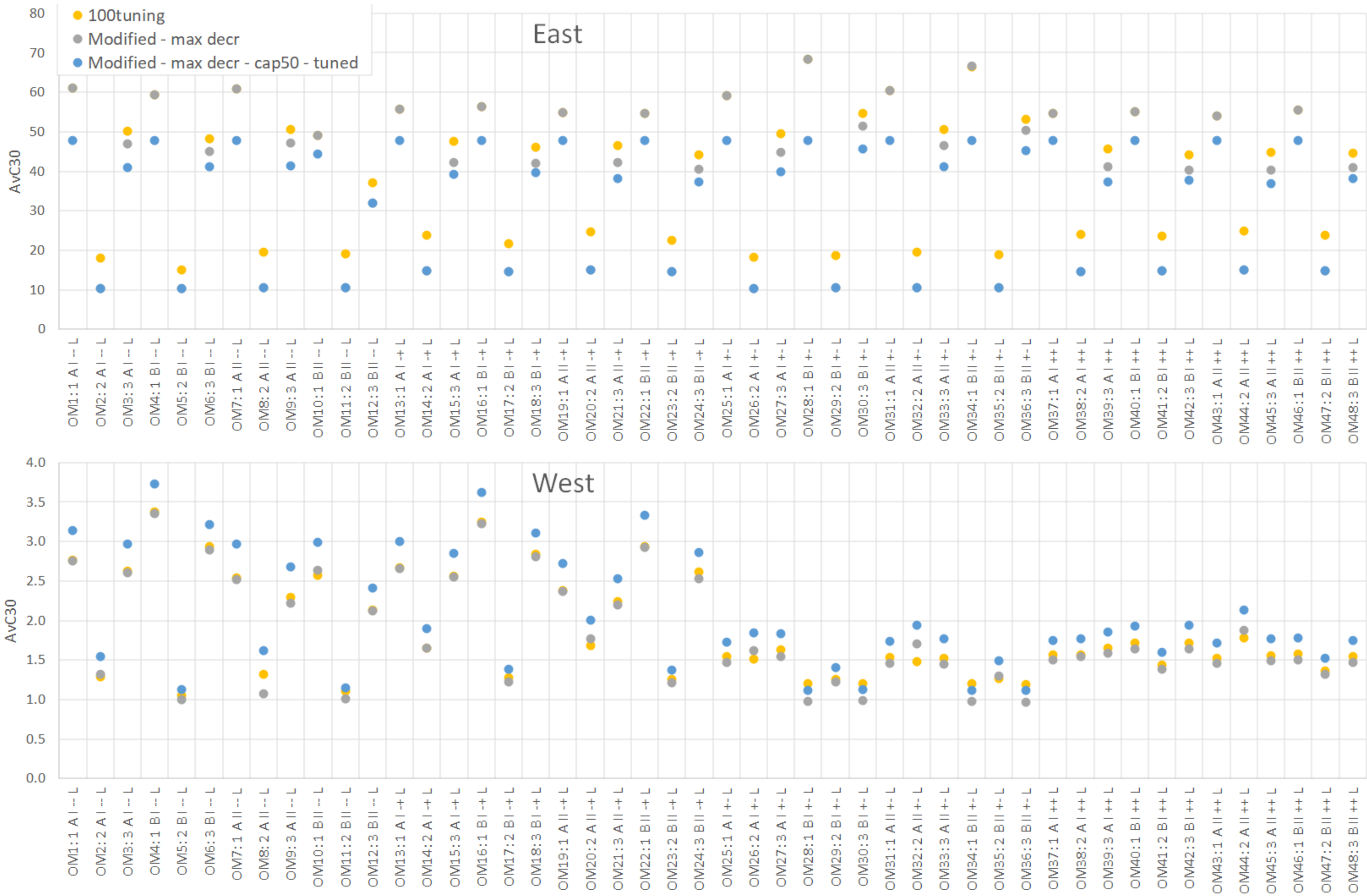


Figure 3a. Deterministic AvC30 values (in kt) for three CMPs for OM1 to OM48.

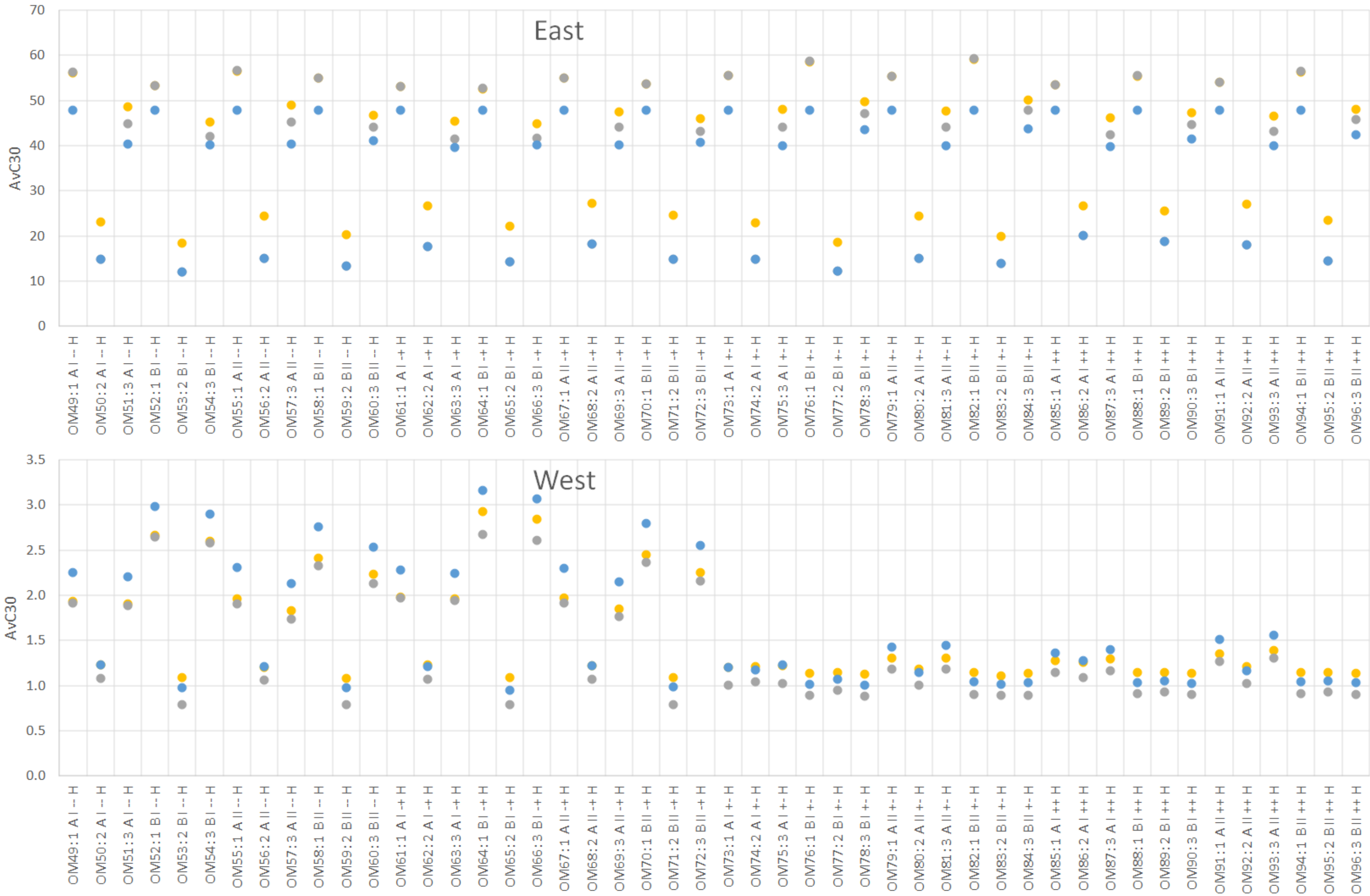


Figure 3b. Deterministic AvC30 values (in kt) for three CMPs for OM49 to OM96.

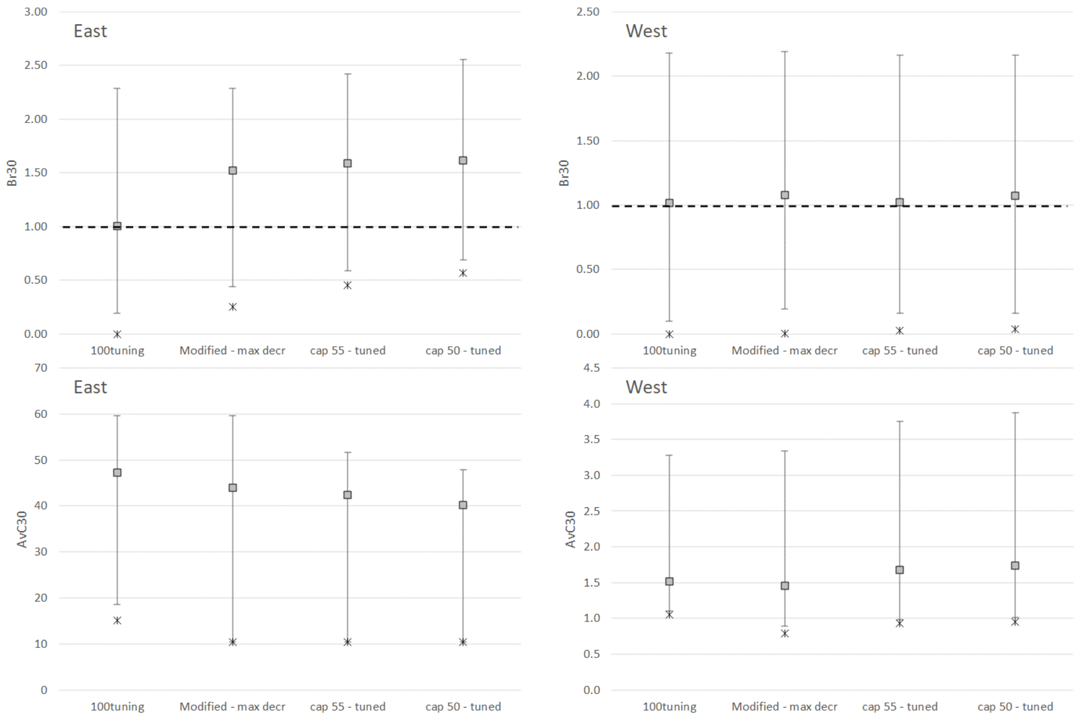


Figure 4. Medians and 90%iles deterministic results for Br30 (top row) and AvC30 (bottom row, in kt) for the four CMPs considered, together with the original unmodified FXP procedure (”100tuning”), applied to the full set of 96 OMs for the interim grid. The dashed horizontal line corresponds to Bmsy. For each CMP, the minimum value across the interim grid is shown as a cross.

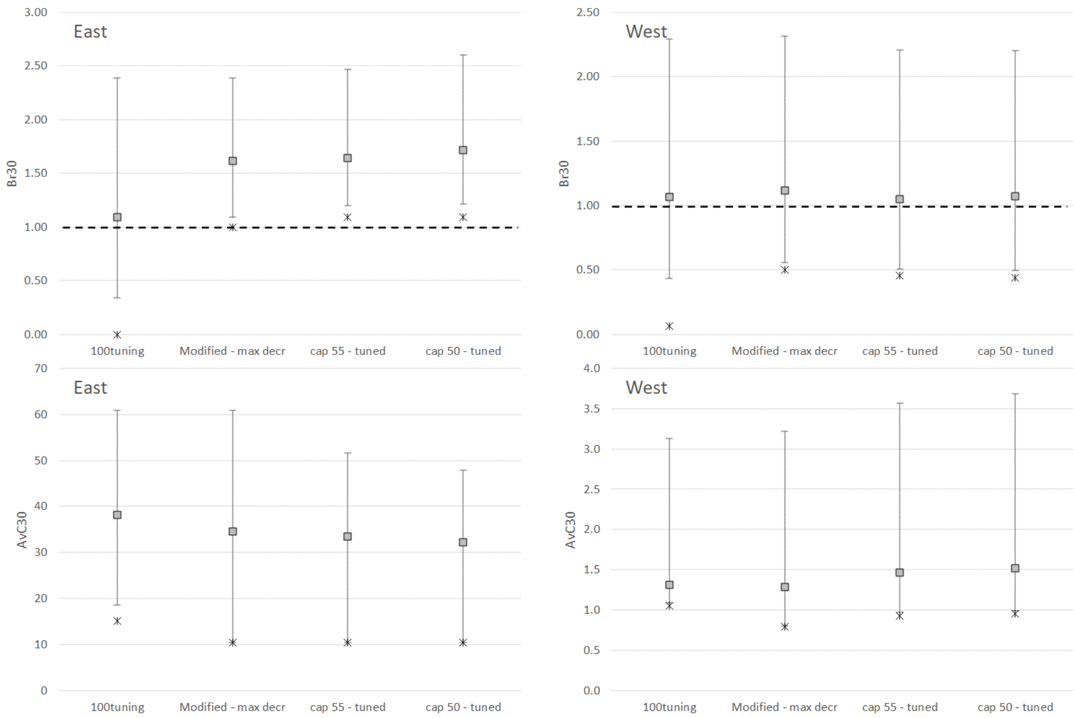
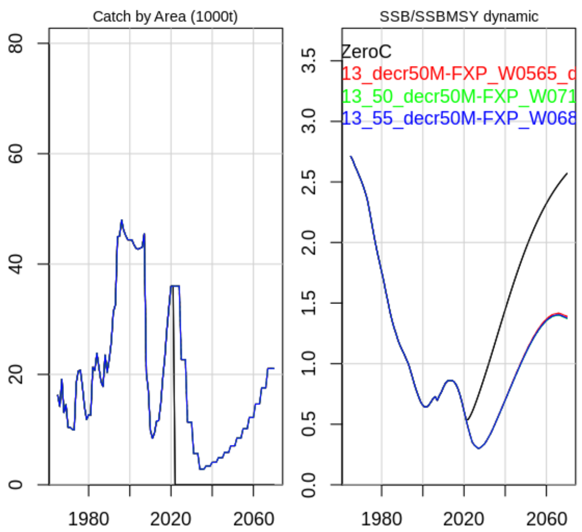


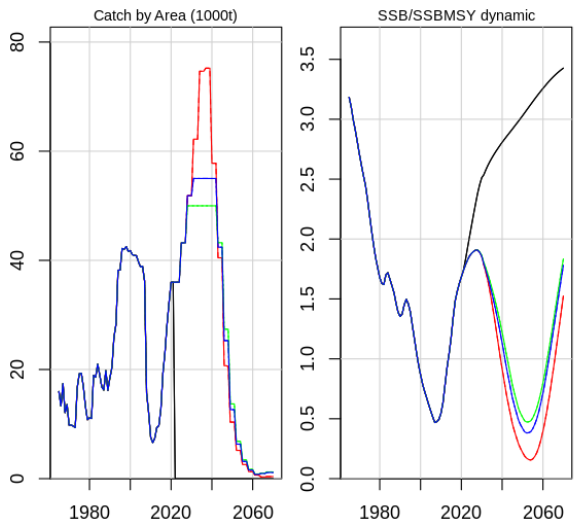
Figure 5. As for Figure 4, except omitting all OMs with the R3 recruitment scenario.

Eastern stock

OM5: R2 B I – L

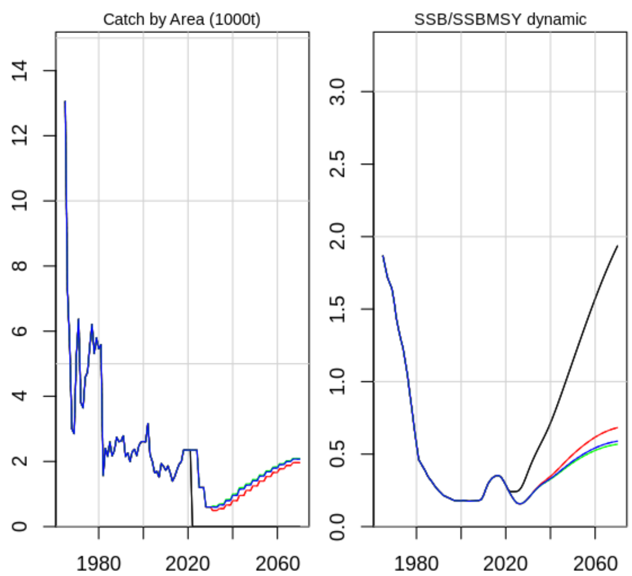


OM9: R3 A II -- L



Western stock

OM5: R2 B I – L



OM9: R3 A II -- L

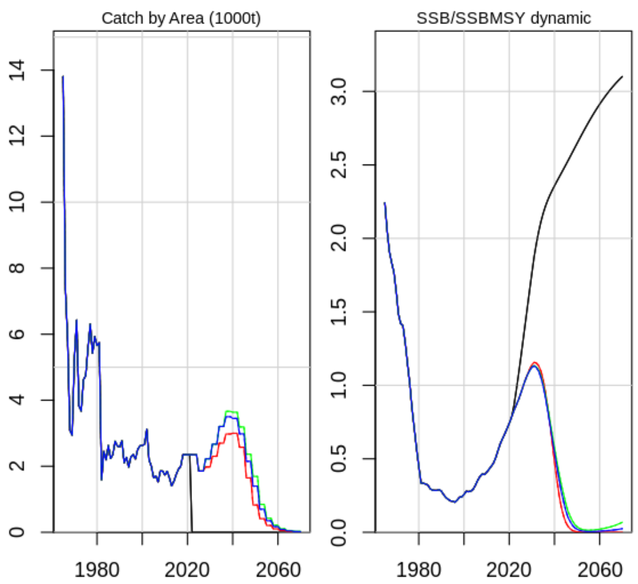


Figure 6. Projected catch and SSB/SSBmsy for OM5 and OM9 under zero catch (black lines), “modified max decr” (red lines), “cap55 – tuned” (blue lines) and “cap50 – tuned” (green lines).