SHORT-TERM CONSTANT CATCH PROJECTIONS FOR THE ATLANTIC BLUEFIN STOCKS BASED ON THE RECONDITIONED MSE OPERATING MODELS

D S Butterworth and R A Rademeyer

SUMMARY

The reconditioned MSE Operating Models (OMs) for Atlantic bluefin are used to provide SSB trend estimates for the two stocks of origin under different constant catches for the west area for the next five years. The purpose is to complement results from refined and updated conventional assessment methods. The result for a west area TAC of 2,350t (i.e., unchanged from 2021) is a median (across the weighted OMs) increase in the western stock of 10.6% or 4.5% from 2022 to 2023, with a 21% or 31% probability of a decrease, depending on whether or not results from R3 OMs are included in the computations. The median for the eastern stock either increases or drops slightly, respectively. When the R3 OMs are excluded, and allowance is made for an east area TAC increase to 40,000t from 2023 onwards, an annual west area TAC of 3,000t would, in median terms, maintain increases in the abundance of the western SSB for the next five years. The advantages and disadvantages of this approach compared to the conventional area-based assessment methods are discussed briefly.

RÉSUME

Les modèles opérationnels (OM) reconditionnés de la MSE pour le thon rouge de l'Atlantique sont utilisés pour fournir des estimations de la tendance de la SSB des deux stocks d'origine dans le cadre de différentes captures constantes pour la zone Ouest pour les cinq prochaines années. L'objectif était de compléter les résultats à partir de méthodes d'évaluation conventionnelles affinées et actualisées. Le résultat pour un TAC de 2.350 t pour la zone Ouest (inchangé depuis 2021) est une augmentation de la médiane (parmi tous les OM pondérés) dans le stock Ouest de 10,6% ou 4,5% de 2022 à 2023, avec une probabilité de réduction de 21% ou 31%, en fonction de l'inclusion, ou non, des résultats des OM R3 dans les calculs. La médiane pour le stock Est augmente ou diminue légèrement, respectivement. Lorsque les OM R3 sont exclus et qu'une tolérance est accordée pour porter le TAC de la zone Est à 40.000 t à compter de 2023, un TAC annuel pour la zone Ouest de 3.000 t maintiendrait, à moyen terme, des augmentations de l'abondance de la SSB de l'Ouest au cours des cinq prochaines années. Les avantages et inconvénients de cette approche par rapport aux méthodes d'évaluation traditionnelles basées sur la zone sont brièvement discutés.

RESUMEN

Los modelos operativos (OM) de la MSE recondicionados para el atún rojo del Atlántico se utilizan para proporcionar estimaciones de la tendencia de la SSB para los dos stocks de origen en el marco de capturas constantes diferentes para la zona occidental para los próximos cinco años. El objetivo es complementar los resultados de los métodos de evaluación convencionales perfeccionados y actualizados. El resultado para un TAC de la zona occidental de 2.350 t 8 (es decir, igual al de 2021) es un aumento de la mediana (entre todos los OM ponderados) en el stock occidental del 10,6 % o del 4,5 % desde 2022 a 2023, con una probabilidad del 21 % o del 31 % de un descenso, dependiendo de si los resultados de los OM R3 están incluidos en los cálculos. La mediana para el stock oriental o aumenta o cae ligeramente, respectivamente. Cuando se excluyen los OM R3, y se permite una tolerancia para un aumento del TAC de la zona oriental de 40.000 t desde 2023 en adelante, un TAC anual de la zona occidental de 3.000 t mantendría, en términos de la mediana, aumentos en la abundancia de la SSB occidental para los próximos cinco años. Se discuten brevemente las ventajas y desventajas de este enfoque en comparación con los métodos de evaluación convencionales basados en el área.

KEYWORDS

Management Strategy Evaluation, Candidate Management Procedure, Operating Model grid, Atlantic bluefin tuna, constant catch

Introduction

The fundamental requirement of an assessment is to provide a basis to predict resource behaviour (trends) under alternative future catches. This is planned for the west Atlantic using the conventionally applied area-based assessment methods of VPA and SS3.

However, the bluefin MSE process has used the M3 model to provide a Reference grid of now 48 Operating Models (OMs) to span the major uncertainties about the bluefin resource and its fishery in the North Atlantic (and Mediterranean). These provide a basis to complement the information that will be forthcoming from the conventional assessments. Hence, the basic idea here is to provide resource abundance predictions for different constant catch levels using the OMs from the MSE grid. Since the immediate objective for the bluefin working group is to provide a basis for a recommendation for the west area TAC for 2022 alone (because the plan is for an MP to be used to provide such recommendations for 2023 and thereafter), strictly projections to the start of 2023 only are needed. However, these can be readily extended for some further years to show the differing consequences of different catch levels both more clearly and for a longer period.

Methods

The M3/"MSE" approach uses the current ABT-MSE v7.3.2 package with its catch inputs as it stands, so that where projections are reported (here for a five year period), these are from 2022 to 2027. These projections also require (constant) future catches for the east area to be specified. These are taken to be the current east area TAC of 36000t already agreed to 2022; but as a sensitivity, results are also shown where this TAC is increased to 40000t from 2023 onwards.

The medians across OMs that are shown incorporate the plausibility weightings as agreed at the July 2021 meeting of the Bluefin Tuna MSE Technical Group, and now incorporated in the v7.3.2 package. It is debatable whether or not the R3 scenarios should be included in developing the distributions of interest for this document, and their associated statistics. On the one hand, OM weights are properties of the scenarios themselves, so should not be changed dependent on the situation being considered. On the other hand, when (as here) looking ahead for five years at most (before the regime shift considered under R3 occurs), equally weighting the R1 and R2 scenarios only seems a more desirable approach. The results that follow are presented for both options.

Results

Table 1 list the pre-2023 catches made or assumed by the Package (in the analyses presented, the west area catch for 2022 is varied), while **Figure 1** shows the historical and future west area catches considered.

Table 2 provides summary statistics of the distributions of spawning biomass in 2023 relative to that in 2022 for different west area catch levels. **Table 3** gives the weighted median annual percentage increase in spawning biomass over 2022 to 2026 under the different west area catch levels considered. The results are shown across the 48 OMs of the Grid, as well as across 32 OMs when excluding the R3 scenarios. In **Table 4**, similar results are provided but the east area catch is taken to be 40000t from 2023 onwards instead of 36000t. **Table 5** gives equivalent results for the eastern origin stock to **Table 4** for the western origin stock,

Figure 2 plots the distribution of the 2023/2022 estimated spawning biomass ratios for the western and eastern origin stocks across all 48 OMs of the Reference grid, as well as across 32 OMs of the grid when excluding the R3 scenarios.

Figure 3 shows historical and future spawning biomass trajectories for the western and eastern origin stocks for different future catches by area for weighted medians over the Reference grid of OMs, as well as when excluding the R3 scenarios.

Figure 4 for the western and eastern origin stocks show the projected biomass trajectories for individual OMs, each relative to their 2022 spawning biomass value.

The distributions of the ratios for 2023/2022 and 2027/2022 of the estimated spawning biomass for the western stock under 0t, 2350t and 3000t constant future catches in the west area (and 36000t in the east area) are plotted as histograms in **Figure 5.**

Discussion

Continuation of the current TAC of 2350 t for the west area for 2022 is predicted to result in a 10.5% increase in the spawning biomass of the western stock in (weighted) median terms across all 48 OMs over that year, with a 21% probability of a reduction (**Table 2 and Figure 2**). If the R3 OMs are omitted, the median increase drops to 4.6%, and the probability of a decline increases to 31%. The 10 OMs which show a reduction all relate to R2 recruitment scenarios.

Projecting further into the future results in essentially the same picture for the western stock (**Table 2 and Figure 3**), with lower increases in abundance as the TAC is increased above the current 2350t. These changes in the west area TACs hardly impact the eastern stock, for which the median shows either an increase or a slight decrease depending on whether the R3 OMs are included. **(Figure 3**). **Table 4b** shows that in median terms, excluding the R3 OMs and allowing for an east area TAC increase to 40000t from 2023, an annual west area TAC of 3000t would maintain increases in the abundance of the western origin spawning biomass for the next five years. However, consideration of these results should extend beyond medians alone – both **Figures 4 and 5** indicate wide variation in trends across the full set of OMs.

Use of M3 in this way to provide projections offers several advantages compared to refinements to and updates of the conventional assessment methods.

- M3 gives spawning biomass projection results for stocks (which is what are of fundamental importance from a conservation standpoint) rather than for (west and east) areas.
- M3 takes inter-area movements of eastern and western origin bluefin into account.
- The M3 OMs cover a more realistic range of uncertainty than standard area-based best assessments, because the OMs coverage of structural (process) uncertainty is larger than is typically the case for "best assessments".
- Basing recommendations for the 2022 west area on the M3 OMs is consistent with the process to be used for TAC recommendations for following years based on an MP.

On the downside, this approach does not incorporate estimation uncertainty for individual OMs, as would be the case for the conventional methods. However, the size of that effect is typically appreciably less than covered under structural (process) uncertainties considered here.

Table 1: MSE catches for the west and east areas, as per the Package version 7.3.2. Note that for the MSE, although fixed catches are input to the conditioning, that conditioning allows for possible errors in those catches, so that earlier catches do differ marginally amongst OMs (hence the reference to "median catches" in the corresponding column header).

	MSE median catches (t)	
	West	East
2015	1758	12449
2016	1826	15041
2017	1759	18727
2018	1921	22263
2019	2350	32240
2020	2179	36000
2021	2350	36000
2022	2350	36000

Table 2: Weighted median a) across the 48 OMs of the Grid, and b) across 32 OMs of the Grid when excluding the R3 scenarios), of the percentage increase in western spawning stock biomass from the start of 2022 to the start of 2023 (with 95% PI in parenthesis) under a series of west area 2022 TACs (in t). The probability of a decrease in SSB from 2022 to 2023 is also shown. The east area 2022 TAC is fixed at 36 000t.

a) Across the 48 OMs of the Grid

2022 TAC	Weighted median % increase in SSB from 2022 to 2023 (with 95%PI in parenthesis)	Prob. of decrease in SSB from 2022 to 2023
0	11.6% (-1.0%; 17.0%)	0.13
2000	11.4% (-5.2%; 15.5%)	0.21
2350	10.5% (-5.8%; 15.3%)	0.21
2500	10.4% (-6.2%; 15.2%)	0.23
3000	10.1% (-7.2%; 14.9%)	0.23
3500	9.8% (-8.3%; 14.6%)	0.27
4000	9.4% (-9.3%; 14.2%)	0.27

b) Excluding the R3 scenarios

2022 TAC	Weighted median % increase in SSB from 2022 to 2023 (with 95%PI in parenthesis)	Prob. of decrease in SSB from 2022 to 2023
0	4.9% (-0.8%; 17.0%)	0.19
2000	4.8% (-4.0%; 15.4%)	0.31
2350	4.6% (-4.5%; 15.1%)	0.31
2500	4.5% (-4.8%; 15.0%)	0.34
3000	4.4% (-5.8%; 14.7%)	0.34
3500	4.2% (-6.8%; 14.3%)	0.41
4000	4.0% (-7.7%; 13.9%)	0.41

Table 3: Weighted median a) across the 48 OMs of the Grid, and b) across 32 OMs of the Grid when excluding the R3 scenarios), of the percentage yearly increase in western spawning stock biomass from 2023 to 2027, under a series of fixed west area TACs (in t) from 2022 to 2026. The east area TAC is fixed at 36 000t from 2022 to 2026.

a) Across the 48 OMs of the Grid

	Weighted median % yearly increase in SSB				
2022 TAC	2022 to 2023	2023 to 2024	2024 to 2025	2025 to 2026	2026 to 2027
0	11.6%	9.8%	9.3%	8.9%	9.3%
2000	11.4%	10.2%	4.5%	4.3%	3.9%
2350	10.5%	10.0%	4.2%	3.6%	3.6%
2500	10.4%	9.6%	4.1%	3.5%	3.5%
3000	10.1%	6.3%	3.4%	3.1%	2.9%
3500	9.8%	4.9%	3.5%	2.3%	1.0%
4000	9.4%	4.2%	2.6%	1.2%	0.2%

b) Excluding the R3 scenarios

	Weighted median % yearly increase in SSB				
2022 TAC	2022 to 2023	2023 to 2024	2024 to 2025	2025 to 2026	2026 to 2027
0	4.9%	6.7%	6.0%	7.8%	9.0%
2000	4.8%	3.8%	2.5%	1.8%	1.3%
2350	4.6%	3.5%	2.4%	1.6%	1.0%
2500	4.5%	3.4%	2.3%	1.5%	0.7%
3000	4.4%	2.9%	2.1%	0.8%	0.0%
3500	4.2%	2.5%	0.6%	0.1%	-0.7%
4000	4.0%	2.1%	0.0%	-0.6%	-1.4%

Table 4: Weighted median a) across the 48 OMs of the Grid, and b) across 32 OMs of the Grid when excluding the R3 scenarios), of the percentage yearly increase in western spawning stock biomass from 2023 to 2027, under a series of fixed west area TACs from 2022 to 2026. The east area TAC is fixed at 36 000t for 2022 and then at **40 000t** for 2023 to 2026.

a) Across the 48 OMs of the Grid

	Weighted median % yearly increase in SSB				
2022 TAC	2022 to 2023	2023 to 2024	2024 to 2025	2025 to 2026	2026 to 2027
2000	11.4%	6.8%	4.3%	3.2%	3.7%
3000	10.1%	5.9%	3.2%	3.0%	2.8%
4000	9.4%	4.1%	2.5%	1.2%	0.2%

b) Excluding the R3 scenarios

	Weighted median % yearly increase in SSB				
2022 TAC	2022 to 2023	2023 to 2024	2024 to 2025	2025 to 2026	2026 to 2027
2000	4.8%	3.6%	2.3%	1.6%	1.2%
3000	4.4%	2.8%	2.0%	0.7%	0.0%
4000	4.0%	2.0%	0.0%	-0.7%	-1.6%

Table 5: Weighted median percentage yearly increase in **eastern** spawning stock biomass from 2023 to 2027 across the 48 OMs of the Grid (LHS), and across 32 OMs of the Grid when excluding the R3 scenarios (RHS), under a series of fixed west area TACs from 2022 to 2026, with the east area TAC fixed at 36 000t for 2022 and then either continuing at 36 000t (a) and b)) or at 40 000t (c) and d)) for 2023 to 2026.

East area TAC fixed at 36 000t:

a) Across the 48 OMs of the Grid

West 2022 TAC	Weighted median % yearly increase in SSB				
	2022 to 2023	2023 to 2024	2024 to 2025	2025 to 2026	2026 to 2027
2000	1.6%	2.0%	1.3%	0.9%	0.6%
3000	1.6%	1.9%	1.3%	0.9%	0.6%
4000	1.6%	1.9%	1.3%	0.8%	0.6%

b) Excluding the R3 scenarios

West 2022 TAC	Weighted median % yearly increase in SSB				
	2022 to 2023	2023 to 2024	2024 to 2025	2025 to 2026	2026 to 2027
2000	0.2%	-0.6%	-0.8%	-2.1%	-1.1%
3000	0.1%	-0.7%	-0.9%	-2.2%	-1.2%
4000	0.1%	-0.8%	-0.9%	-2.2%	-1.3%

East area TAC fixed at 36 000t for 2022 and 40 000t thereafter:

c) Across the 48 OMs of the Grid

West 2022 TAC	Weighted median % yearly increase in SSB				
	2022 to 2023	2023 to 2024	2024 to 2025	2025 to 2026	2026 to 2027
2000	1.6%	1.7%	1.1%	0.7%	0.5%
3000	1.6%	1.6%	1.1%	0.7%	0.5%
4000	1.6%	1.6%	1.0%	0.7%	0.4%

d) Excluding the R3 scenarios

West 2022 TAC	Weighted median % yearly increase in SSB				
	2022 to 2023	2023 to 2024	2024 to 2025	2025 to 2026	2026 to 2027
2000	0.2%	-1.0%	-1.2%	-2.8%	-1.6%
3000	0.1%	-1.1%	-1.3%	-2.8%	-1.7%
4000	0.1%	-1.2%	-1.3%	-2.9%	-1.7%

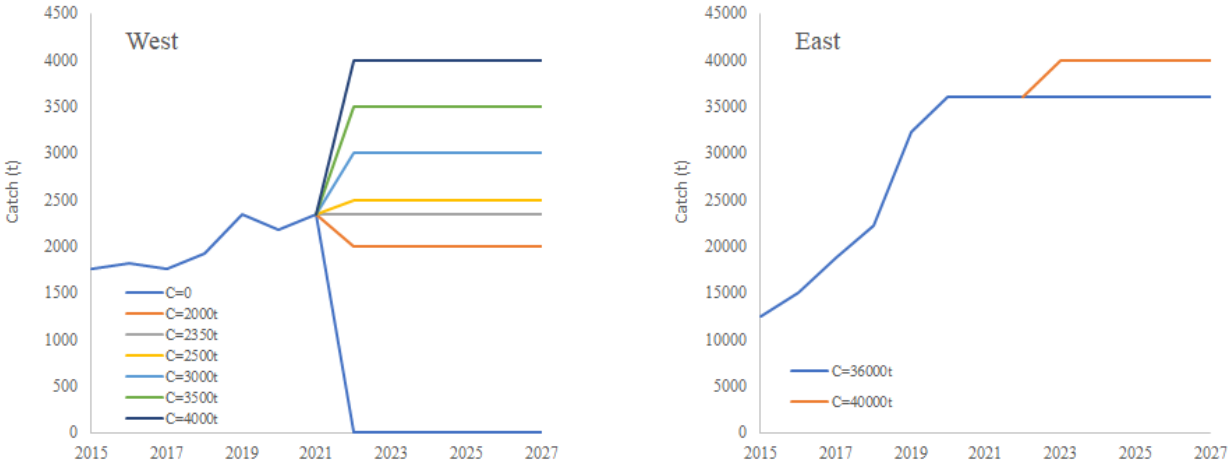

Figure 1: MSE median catches of Atlantic bluefin tuna in the west and east areas, with the post-2021 catches considered in projections.

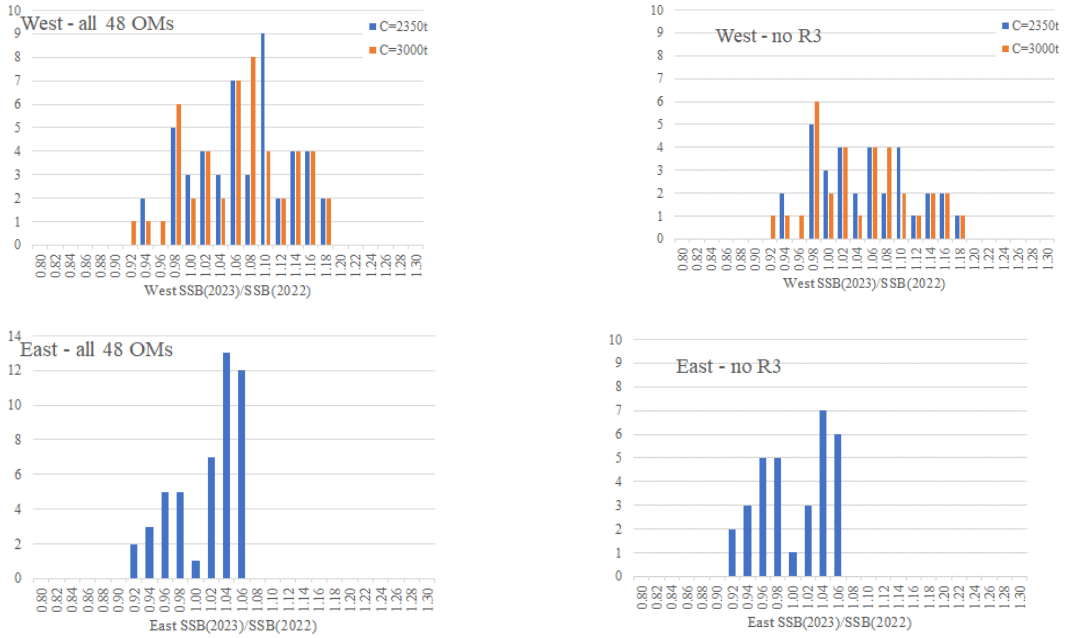

Figure 2: Histogram of west (top row) and east (bottom row) SSB(2023)/(SSB(2022) ratios across all 48 OMs of the reference grid (LHS) and across 32 OMs of the Grid when excluding the R3 scenarios (RHS). Note that the horizontal axis labels correspond to the upper limit of each division, e.g. the label "1.00" includes values within the range [0.98;1.00]. The OMs for which there is a reduction under a future west area catch of 2350t are OM2, OM8, OM5, OM26, OM20, OM44, OM38, OM17, OM11, OM14 and OM23.

Figure 3: Spawning stock biomass trajectories (weighted medians across all 48 OMs (LHS) and across 32 OMs of the Grid when excluding the R3 scenarios (RHS)), for the western (top row) and eastern (bottom row) stocks. For the western stock, results are shown for a fixed east area annual catch of 36000t. For the eastern stock, results are indistinguishable for different values for the west area catch.

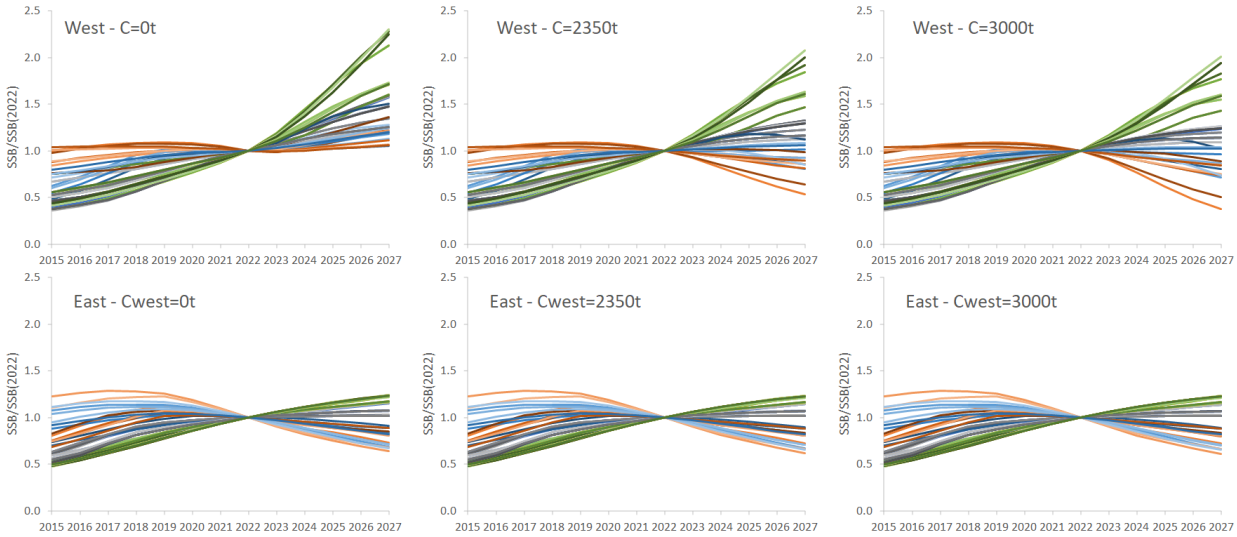

Figure 4: Western (top row) and eastern (bottom row) spawning stock biomass trajectories relative to 2022 for each of the 48 OMs in the grid under future constant catches in the west area of C=0, C=2350t and C=3000t and C=36 000t in the east area. Note that the R3 scenario trajectories simply duplicate the corresponding R1 trajectories, so that their omission would not alter these plots.

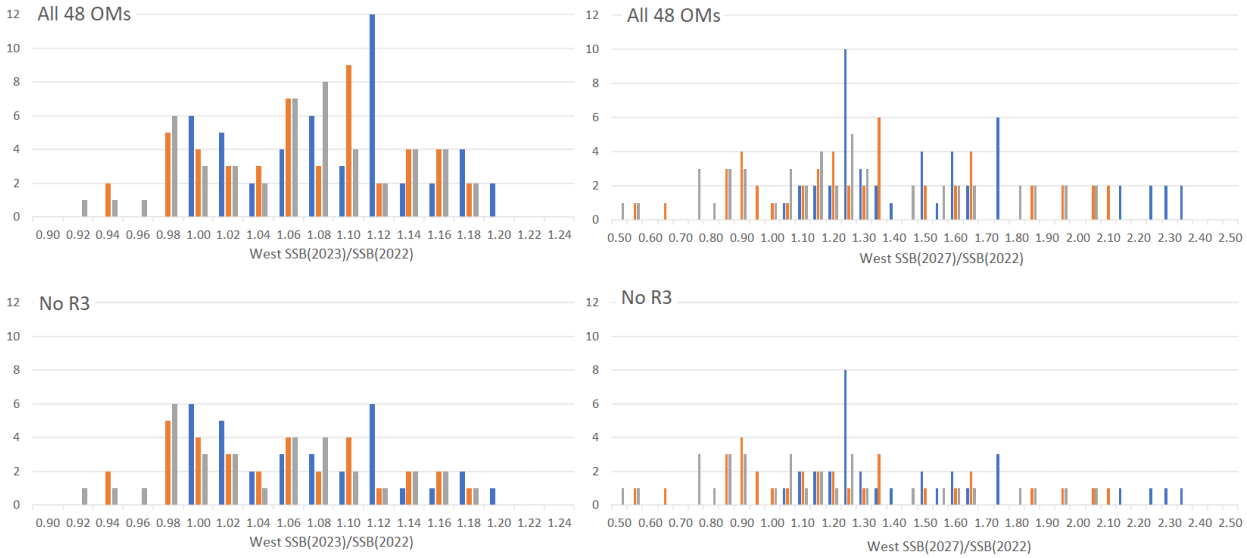

Figure 5: Histogram of western stock SSB(2023)/(SSB(2022) (LHS) and SSB(2027)/(SSB(2022) (RHS) ratios under future constant catches from 2023 in the west area of 0t (blue), 2350t (orange) and 3000t (grey) across all 48 OMs of the reference grid (top row) and excluding the R3 scenarios (bottom row). The east area catch in 36000t for all years.