

RECONDITIONING OF OPERATING MODELS FOR ATLANTIC BLUEFIN TUNA MSE TO INCLUDE THE CLOSE-KIN MARK RECAPTURE ESTIMATE OF WESTERN STOCK SCALE

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SUMMARY

Atlantic bluefin tuna operating models were reconditioned to a close-kin mark recapture (CKMR) estimate of western stock scale (21 kt in 2018). Operating models were fitted to a CKMR prior coefficient of variation of 0.2 but starting from initial values determined by fits assuming a CV of 0.05. With one exception, all operating models obtained an MLE estimate of Western stock scale within the 95% probability interval of the CKMR prior.

RÉSUMÉ

Les modèles opérationnels pour le thon rouge de l'Atlantique ont été reconditionnés en une estimation basée sur le marquage-recapture de spécimens étroitement apparentés (CKMR) de l'échelle du stock occidental (21.000 t en 2018). Les modèles opérationnels ont été ajustés à un coefficient de variation de 0,2 de la distribution a priori de CKMR, mais en partant de valeurs initiales déterminées par des ajustements postulant un CV de 0,05. À une exception près, tous les modèles opérationnels ont obtenu une estimation de la vraisemblance maximale (MLE) de l'échelle du stock occidental dans l'intervalle de probabilité de 95 % de la distribution a priori de CKMR.

RESUMEN

Los modelos operativos de atún rojo del Atlántico se recondicionaron para obtener una estimación mediante el marcado y recaptura de individuos estrechamente emparentados (CKMR) de la escala del stock occidental (21.000 t en 2018). Los modelos operativos se ajustaron a un coeficiente de variación de 0,2 de la distribución previa de CKMR, pero partiendo de valores iniciales determinados por ajustes que asumían un CV de 0,05. Con una excepción, todos los modelos operativos obtuvieron una estimación de máxima verosimilitud de la escala del stock occidental dentro del intervalo de probabilidad del 95 % de la distribución previa de CKMR.

KEYWORDS

*Management strategy evaluation;
management procedure; reference set operating models*

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Introduction

The management strategy evaluation (MSE) framework for North Atlantic bluefin tuna requires the conditioning of a spatial, seasonal, two-stock operating model on various data sources including annual catches, length compositions, fishery-dependent indices, surveys and genetics stock of origin data. Previous conditioning processes revealed that these data could only weakly inform the scale (exploitation rate) of the western and eastern stocks. Since operating models are intended to span a range of plausible scenarios for exploitation and stock size, area-based stock assessments were used to specify priors for spawning stock biomass of West and East area scale, creating four scale scenarios that included all combinations of small/large biomass in the west and east areas (--, +-, -+, ++), where, for example, -+ denotes an operating model with the small west area spawning biomass prior and the large east area spawning biomass prior (Carruthers 2023).

More recently, close-kin genetic mark recapture (CKMR) has provided an estimate of Western stock size in 2018 (age 8+ biomass of 21kt, CV of approximately 0.2; Laretta *et al.* 2025). In their preliminary investigations of the potential impact on MP performance Butterworth and Rademeyer (2025) post-hoc reweighted the existing operating models and found that the update in western scale could substantially affect MP performance. Based on these results it was considered necessary to conduct further exploration, including a full reconditioning of the previous operating models to include this new data point on western stock scale.

Preliminary attempts to include the CKMR prior either led to range of operating model estimates of western stock scale that were either too wide or too narrow given the prior specification. The objective of this revision was to find a reconditioning approach that could determine a range of western scale estimates that approximately span the range of credible levels implied by the CKMR prior.

Methods

Reconfiguring the conditioning approach

The inclusion of a western scale data point is in conflict with the prior specification for west area spawning biomass and necessitates dropping the 'West area' axis of scale in the operating models. This effectively reduces the reference grid to half of its previous size (24 rather than 48 operating models) (**Table 1**). Since only two of the three recruitment levels require fitting to data (recruitment level 3 is a change in recruitment parameters in the projection and therefore are not different than the operating models with recruitment level 1), therefore reconditioning only required the fitting of 16 operating models (**Table 1**).

The modifiable multi-stock model (M3, Carruthers 2015, now version 8.0) was reconfigured to allow for a prior on age 8+ stock specific biomass. In previous operating model conditioning, scale priors for area-specific spawning stock biomass required high precision to consistently obtain operating model estimates at specified levels.

Estimation steps

Operating models were first reconditioned with a prior CV of 0.05 to provide initial values for a second run with a CV of 0.2. This approach appeared to overcome a problem where the numerical optimization was converging on local minima at the tails of the CKMR estimate.

The reconditioned operating models are available in ABTMSE R package (v8.2.3). The revised package and OM conditioning reports are available from a shared drive (ABTMSE 2025).

Results

With the exception of one operating model (2 A CK- H) estimates of age 8+ western stock biomass were mostly within the 95% probability interval of the CKMR prior (**Figures 1** and **2**). The mean of the OM estimates of western 8+ biomass (20.35kt) was comparable to the mean of the CKMR estimate (21kt) (**Figure 2**).

The historical trends in western and eastern stock 8+ biomass were comparable to previous operating models without the CKMR prior (**Figure 1**). For operating model 2 A CK- H, western scale was not consistent with the CKMR prior, but was very similar to that of the previously conditioned operating model with high (H) West area scale (**Figure 1**).

Discussion

The conditioning model was successfully reconfigured to fit operating models to an estimate of western stock biomass, replacing the existing west area scale axis. Revised estimates of scale were broadly consistent with the CKMR estimate.

Given the benefit of hindsight, the range of uncertainty in west area scale assumed by the previous operating models appears to have been broadly appropriate, spanning the range of the newly provided CKMR estimate.

The CKMR estimate provides the basis for dropping the Western scale axis of uncertainty and halving the size of the reference grid of operating models, hence providing substantial reductions in the computation required for MSE processes such as MP tuning. All packages and MSE Shiny apps also benefit from a reduction in size and responsiveness.

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Table 1. Previous and reconditioned operating models with the new close-kin (CK) estimate for west stock scale. Reconditioned operating models have a single western stock scale, which replaces the previous high and low scale scenarios for the west area, and hence there are duplicates in the previous 48-OM grid (yellow shaded boxes). Only recruitment levels 1 and 2 require fitting (green shaded boxes); recruitment level 3 is recruitment level 1 with a future regime shift.

OM #	Old OM codes	New OM codes	Duplicate of OM#	OM #	Old OM codes	New OM codes	Duplicate of OM#
1	1 A -- L	1 A CK- L		25	1 A -- H	1 A CK- H	
2	2 A -- L	2 A CK- L		26	2 A -- H	2 A CK- H	
3	3 A -- L	3 A CK- L		27	3 A -- H	3 A CK- H	
4	1 B -- L	1 B CK- L		28	1 B -- H	1 B CK- H	
5	2 B -- L	2 B CK- L		29	2 B -- H	2 B CK- H	
6	3 B -- L	3 B CK- L		30	3 B -- H	3 B CK- H	
7	1 A +- L	1 A CK+ L		31	1 A +- H	1 A CK+ H	
8	2 A +- L	2 A CK+ L		32	2 A +- H	2 A CK+ H	
9	3 A +- L	3 A CK+ L		33	3 A +- H	3 A CK+ H	
10	1 B +- L	1 B CK+ L		34	1 B +- H	1 B CK+ H	
11	2 B +- L	2 B CK+ L		35	2 B +- H	2 B CK+ H	
12	3 B +- L	3 B CK+ L		36	3 B +- H	3 B CK+ H	
13	1 A ++ L	1 A CK- L	1	37	1 A +- H	1 A CK- H	25
14	2 A +- L	2 A CK- L	2	38	2 A +- H	2 A CK- H	26
15	3 A +- L	3 A CK- L	3	39	3 A +- H	3 A CK- H	27
16	1 B +- L	1 B CK- L	4	40	1 B +- H	1 B CK- H	28
17	2 B +- L	2 B CK- L	5	41	2 B +- H	2 B CK- H	29
18	3 B +- L	3 B CK- L	6	42	3 B +- H	3 B CK- H	30
19	1 A ++ L	1 A CK+ L	7	43	1 A ++ H	1 A CK+ H	31
20	2 A ++ L	2 A CK+ L	8	44	2 A ++ H	2 A CK+ H	32
21	3 A ++ L	3 A CK+ L	9	45	3 A ++ H	3 A CK+ H	33
22	1 B ++ L	1 B CK+ L	10	46	1 B ++ H	1 B CK+ H	34
23	2 B ++ L	2 B CK+ L	11	47	2 B ++ H	2 B CK+ H	35
24	3 B ++ L	3 B CK+ L	12	48	3 B ++ H	3 B CK+ H	36

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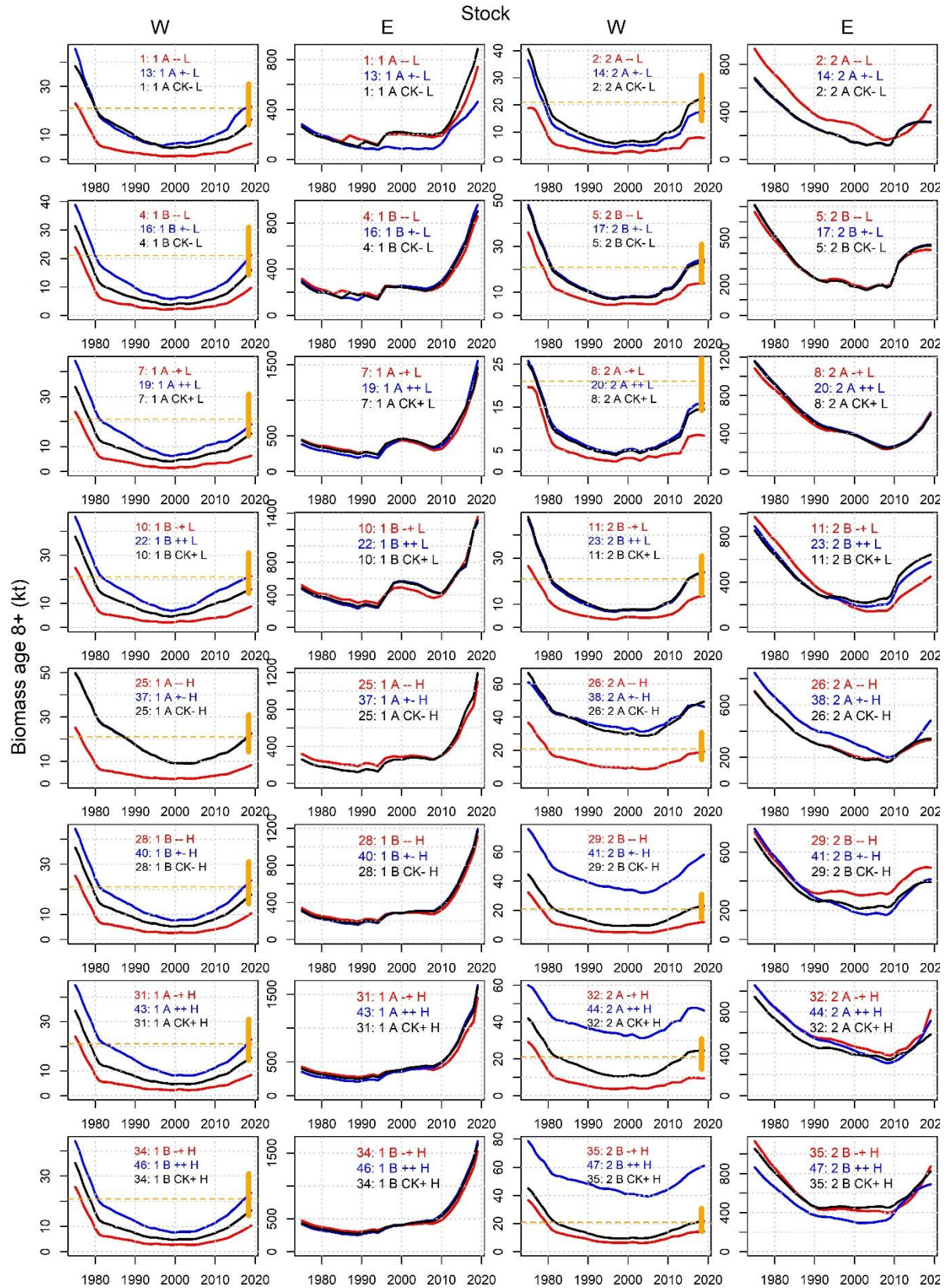


Figure 1. Estimates of western stock biomass of age 8+ fish for the previous operating models with high (blue) and low (red) West area scale, and the new reconditioned (black line) operating models that are fitted to the close-kin estimate of age 8+ western stock biomass (horizontal dashed orange line is the CKMR mean estimate of 21kt, vertical orange line is the 95% interval of the CK estimate with CV 0.2).

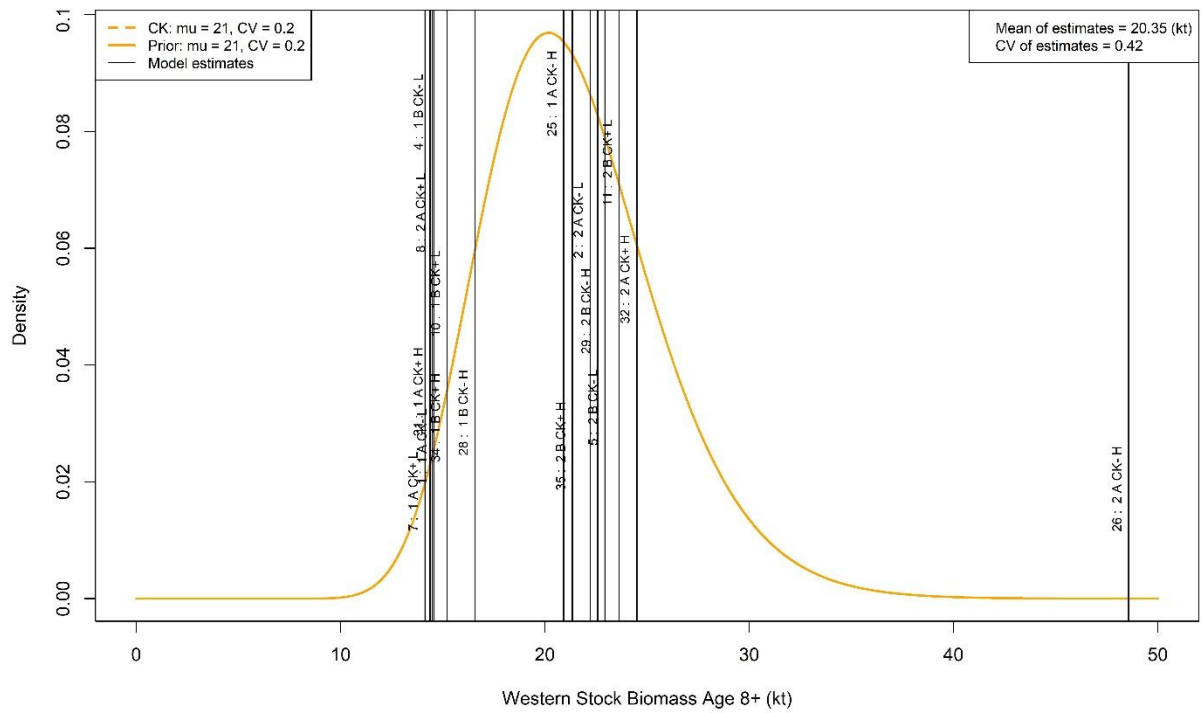


Figure 2. Estimates of age 8+ western stock biomass for the new reconditioned (black line) operating models that are fitted to the close-kin estimate. The orange line represents the CKMR estimate and prior with CV of 0.2.