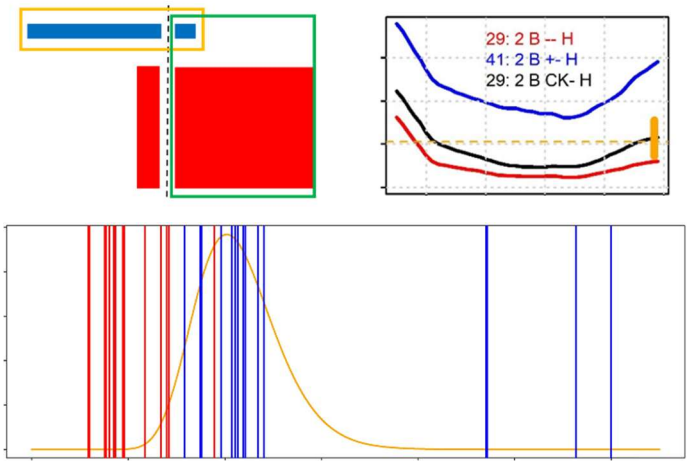
Final Report of Activities: Short-Term Contract for Additional BFT MSE Work for 2025 Within GBYP Phase 14

ICCAT-GBYP CIRCULAR #G-00123/2025



24th October 2025

Tom Carruthers

bluematter

Overview

The contract deliverables were divided between Blue Matter and University of Cape Town (UCT) analytical teams. All tasks and deliverables assigned to Blue Matter were completed with the exception of the final task of Deliverable 3: the exceptional circumstances protocols (ECP). Under the instruction of the Eastern and Western Chairs, Blue Matter resources were reallocated to additional operating model refinement and updating the ABTMSE Shiny app (see table below), with the ECP work undertaken by the ICCAT secretariat instead.

Contract deliverables and tasks.

Completed	Tasks
Deliverable 1. Evaluate BFT-W CKMR results a) Code incorporation of WBFT CKMR estimate into MSE Operating models	
100%	*Modify the M3 conditioning model to accept absolute spawning biomass estimates by stock.* The ADMB code was updated and tested against simulated data to ensure that the new CKMR estimate could reliably update the reference set of operating models. The revised M3 model is available in the latest R package (v8.2.0) available here (Carruthers 2025a).
100%	*Recondition existing 48 OMs with updated western prior replicating existing OM structure.* The package, OM input files and structure were reconfigured to the lesser dimensions required by the CKMR revision. All OMs, reports and fitting objects are available here.
100%	*Redefine and recondition the ABTMSE operating models, removing the western scale axis and refitting the newly reduced reference set of 24 operating models to the absolute spawning abundance estimate of the CKM analysis.* All OMs, reports and fitting objects are available here.
100%	*Update ABTMSE R package objects and documentation.* All OMs, reports (including OM comparison reports) and fitting objects are available here.
100%	*Summarize results in an SCRS paper and presentation.* The paper (SCRS/2025/138, Carruthers 2025b) has been submitted to Redbooks for publication and is available in Appendix A along with its accompanying presentation in Appendix B.

Deliverable 2. 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	
NA	*Worked conducted by UCT team*
Deliverable 3. 'Lite'-reconditioning a) Consider a de minimis reconditioning to possibly include: i. BFT-W CKMR ii. Existing indices up to 2023 iii. Revised indices up to 2023 b) Re-tune BR CMP on reconditioned models c) Obtain 2026-2028 TAC on retuned MP d) Develop new projections related to existing Exceptional Circumstances provisions, consistent with the lite-reconditioning	
100% Completed in #1 above	Include only CKMR in all operating models and rebuild reference set. Evaluate whether it changes view points of status and exploitation rate.
100% (unused)	*Process and update M3 input files to include existing indices to 2023 and recondition operating models.* Code was developed to bring existing indices into OM conditioning. This however was later not considered necessary for the purposes of the species group meeting that was to focus on OMs that only included updates in the CKMR.
100% (unused)	*Process and update M3 input files to include updated indices to 2023.* As above, this code was developed but left unused due to a shift in priorities.
NA	*Use built-in ABTMSE function to retune BR MP. [work to be completed by UCT team]*
NA	*Calculate TAC from data and produce an advice document. [work to be completed by UCT team]*
Redirected to additional tasks	*Calculate posterior predicted data and update exceptional circumstances protocols (ECP).* ECP figures were updated by ICCAT secretariat and presented to the group.
Additional tasks requested by Eastern and Western Chairs and the MSE coordinator	
100%	Reference set OM revision 1: Obtain numerical stability in estimates (alternative initial values). Operating model conditioning was initialized from the values of the previous operating models to improve convergence speed and numerical stability.
100%	Reference set OM revision 2: tighter CV to achieve estimates close to CKMR prior. The first conditioning was not considered acceptable due to OM estimates that were too far from the CKMR mean.
100%	Reference set OM revision 3: hybrid approach using the original CKMR precision and initial values obtained by a run with a higher precision.
100%	Update ABT Shiny App. The ABTMSE shiny app was recoded to drop the scale axis for the Western stock and make outputs compatible with the revised OMs.

References

Carruthers, T.R. 2025a. ABTMSE version 8 R package (CKMR update), operating model reports and revised Shiny App. Available from: https://drive.google.com/drive/folders/1YOP1Bak9sWx9K2ttuwOAKr732b1V8fCf?usp=drive_link

Carruthers, T.R. 2025b. Reconditioning of operating models for Atlantic Bluefin Tuna MSE to include the close-kin recapture estimate of western stock scale. SCRS/2025/138.

Appendix A.

Attached: Carruthers 2025b.

Appendix B.

Attached: SCRS/2025/P/138. “Reconditioning of operating models for Atlantic Bluefin Tuna MSE to include the close-kin recapture estimate of western stock scale”.

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

T. R. Carruthers[1]

SUMMARY

Atlantic bluefin tuna operating models were reconditioned to a close-kin mark recapture (CKMR) estimate of western stock scale (21kt 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.

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; Lauretta 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 withing 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.

Acknowledgments

Many thanks to Doug Butterworth, Rebecca Rademeyer, John Walter and Tristan Trouyer for comments on several earlier iterations of this work.

This research was carried out under the provision of the ICCAT Atlantic Wide Research Programme for Bluefin Tuna (GBYP), funded by the European Union, several ICCAT CPCs, the ICCAT Secretariat and by other entities (see: http://www.iccat.int/GBYP/en/Budget.htm). The contents of this paper do not necessarily reflect the point of view of ICCAT or other funders and in no ways anticipate ICCAT future policy in this area.

References

ABTMSE. 2025. Updated ABTMSE R package version 8.2.3 and reconditioned operating model reports. Available here

Butterworth, D.S., Rademeyer, R.A. 2025 A brief initial analysis of 'does the west CKMR estimate matter for the ABFT MSE'? Working paper, ICCAT bluefin tuna intersessional meeting. SCRS/2025/049.

Carruthers, T.R. et al. 2017. Structure and Estimation Framework for Atlantic Bluefin Tuna Operating Models. SCRS/2015/179. Available here

Carruthers, T.R. 2023. ABTMSE Splash Page: documents, code and apps in support of the Atlantic Bluefin Tuna MSE framework. Available from: Atlantic Bluefin Tuna MSE

Lauretta, M., et al. 2025. Close-kin mark-recapture spawning stock abundance estimates of western Atlantic Bluefin Tuna (*Thunnus thynnus*). SCRS/2025/070.

Tables

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

fitted
duplicate

Figures

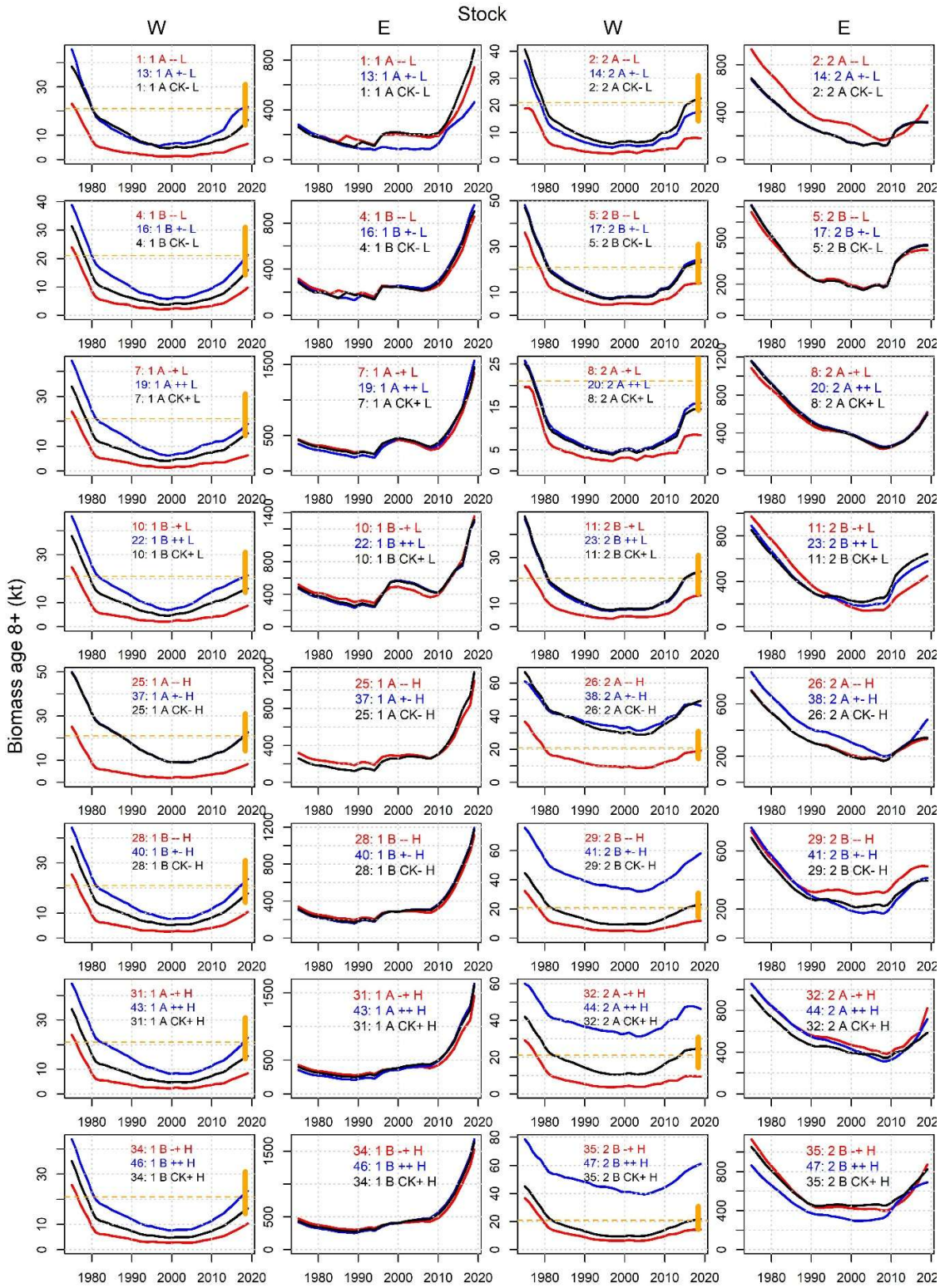


Figure 1. Estimates of western stock biomass of age 8+ fish for the previous operating models with high (blue) and low (red) West area scale, and the new reconditioned (black line) operating models that are fitted to the close-kin estimate of age 8+ western stock biomass (horizontal dashed orange line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

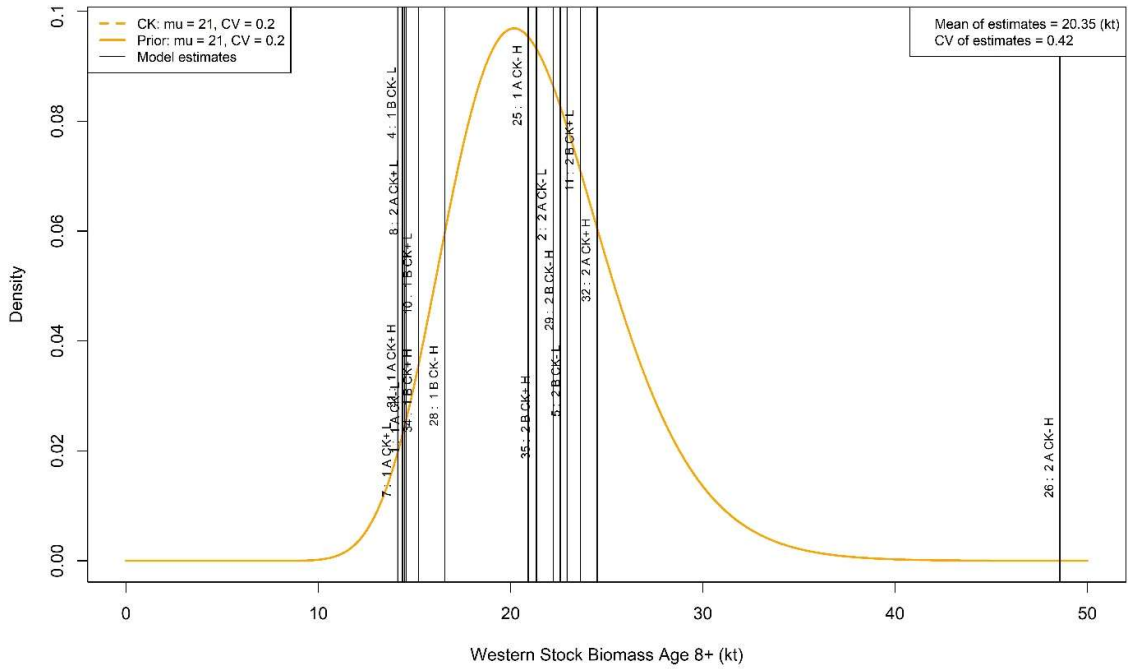
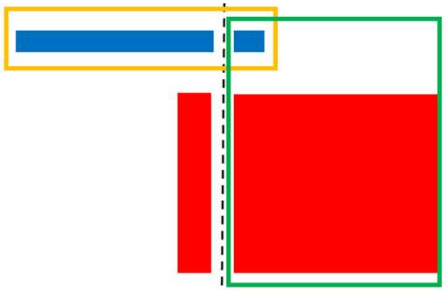


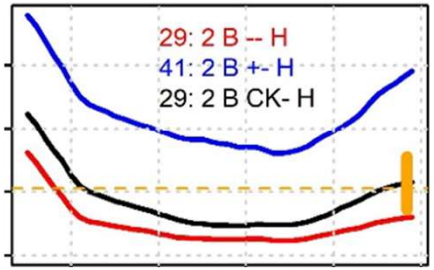
Figure 2. Estimates of age 8+ western stock biomass for the new reconditioned (black line) operating models that are fitted to the close-kin estimate. The orange line represents the CKMR estimate and prior with CV of 0.2.

Revised Reconditioning of Operating Models for Atlantic Bluefin Tuna to Include the Close-Kin Mark Recapture Estimate of Western Stock Scale

ICCAT SCRS/2025/138

Tom Carruthers





24th September 2025, ICCAT BFT Species Group

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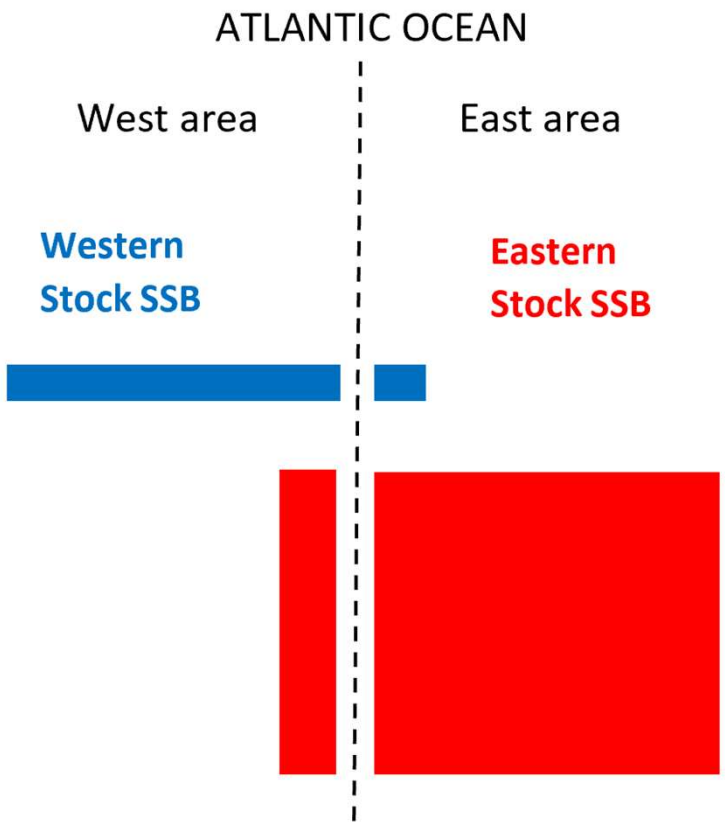
Contents

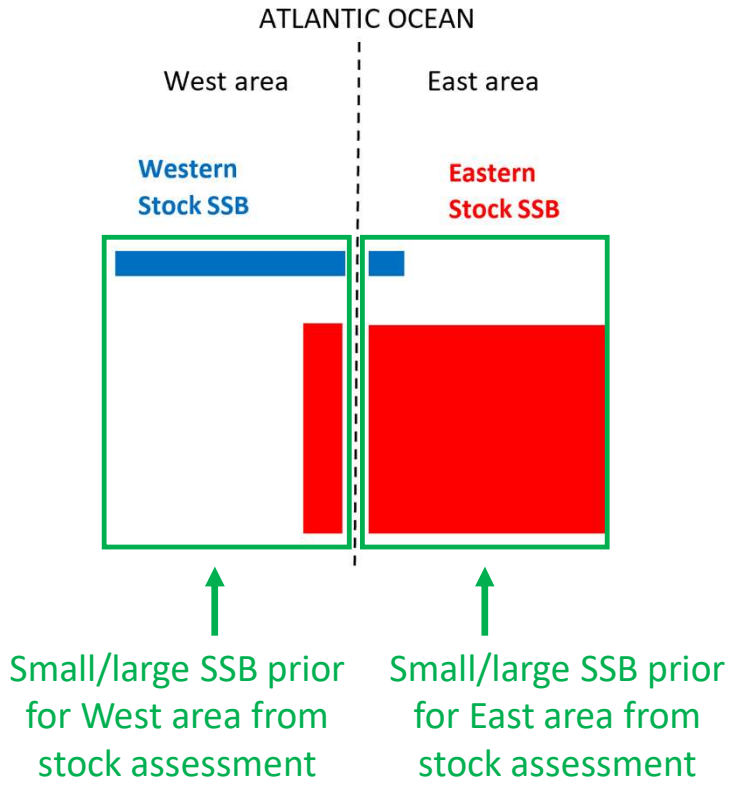
1. Quick reminder of stock and area definitions
2. Methods
3. Results

Stocks, management areas and the scale axis



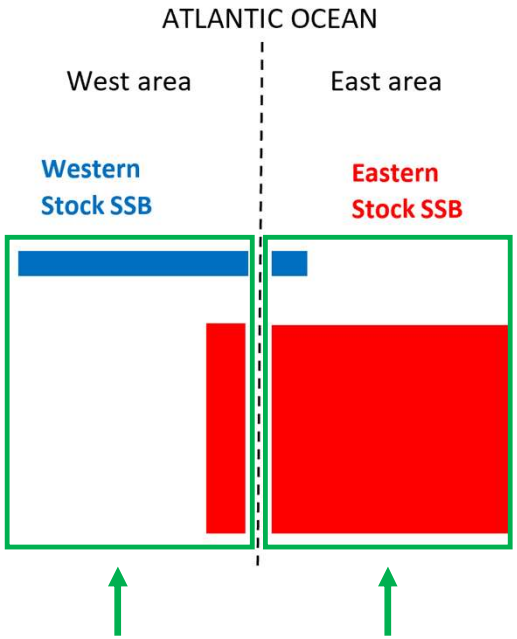
Stocks, management areas and the scale axis

Old OMs (n = 4: --, +-, -+, ++)



Stocks, management areas and the scale axis

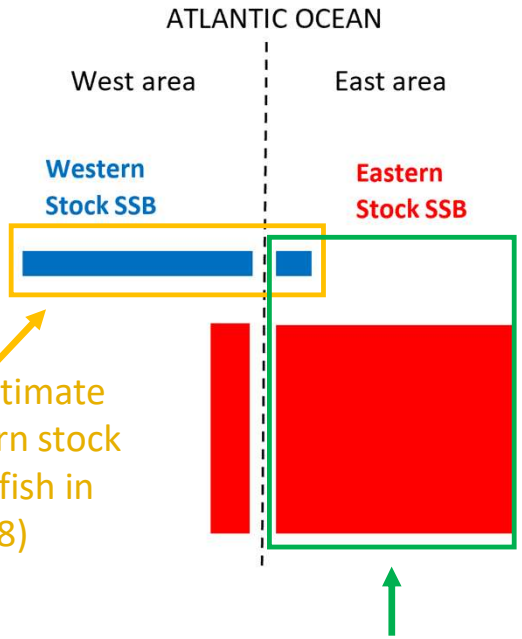
Old OMs (n = 4: --, +-, -+, ++)



Small/large SSB prior for West area from stock assessment

Small/large SSB prior for East area from stock assessment

New OMs (n = 2: CK-, CK+)



CKMR estimate for western stock (age 8+ fish in 2018)

Small/large SSB prior for East area from stock assessment

Methods: a new, smaller OM grid.

The full grid including duplicates was provided to Rebecca in ABT-MSE v8.2.3 so that any downstream code for tuning etc. was compatible.

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
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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

fitted
duplicate

16 newly conditioned OMs

Methods

- An updated conditioning model (M3 v 8.0). The code includes a hard-wired exception such that the SSB prior (previous scale axis) is area-based SSB for the East area and stock-based (age 8+ biomass) for the western stock.
- Revised R Shiny App. Updated to the new 24-OM grid with the latest results from Rebecca and Doug (ABTMSE package version 8.2.4). App available locally.
- Two-step estimation approach was used where OMs were fitted assuming a tighter CKMR CV of 0.05. These estimates were then used as initial values for OM conditioning assuming the CKMR CV of 0.2.

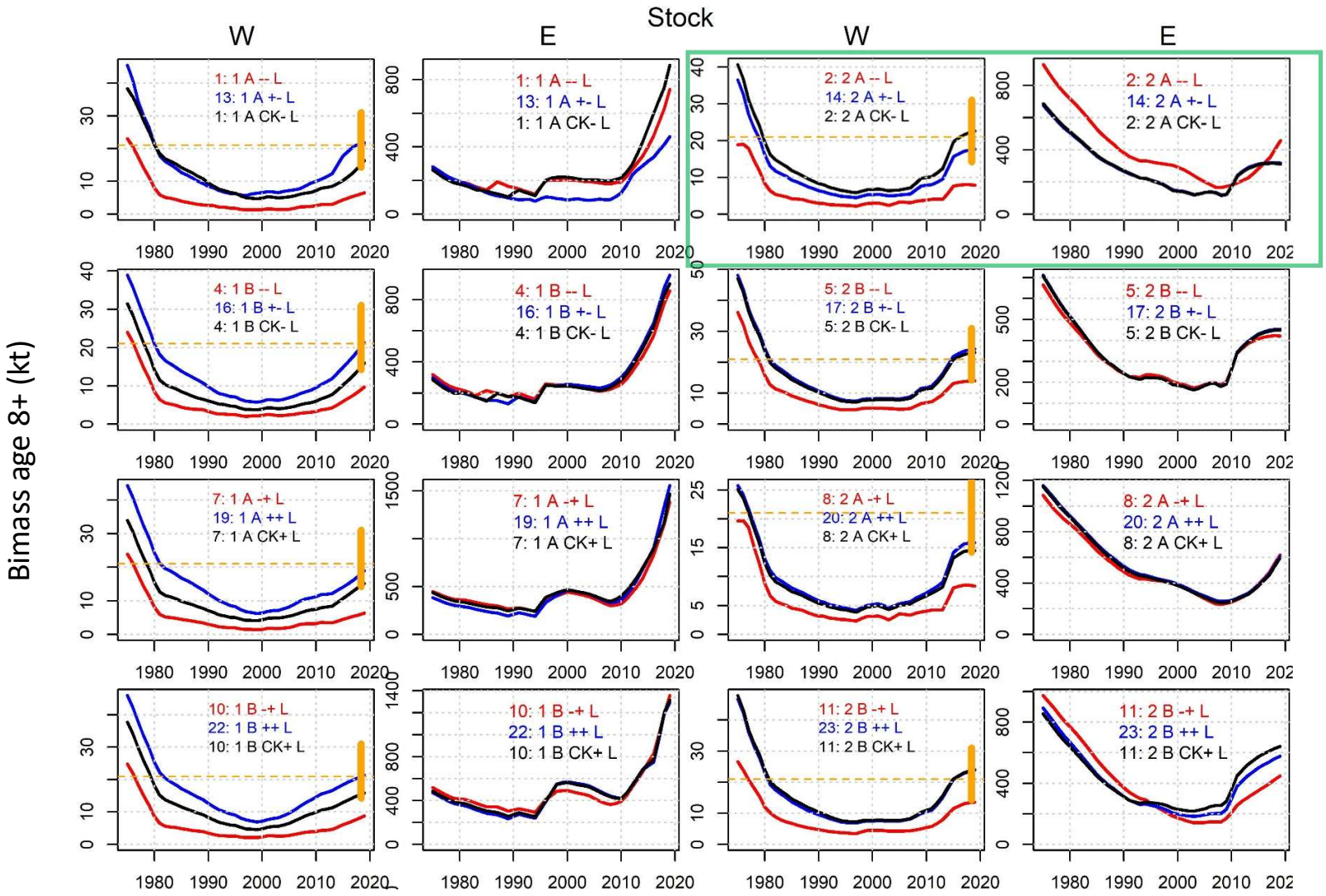
Comparison of stock trends

Small scale west area

Large scale west area

New CKMR west stock

CKMR estimate with CV 0.2 (95% intervals)



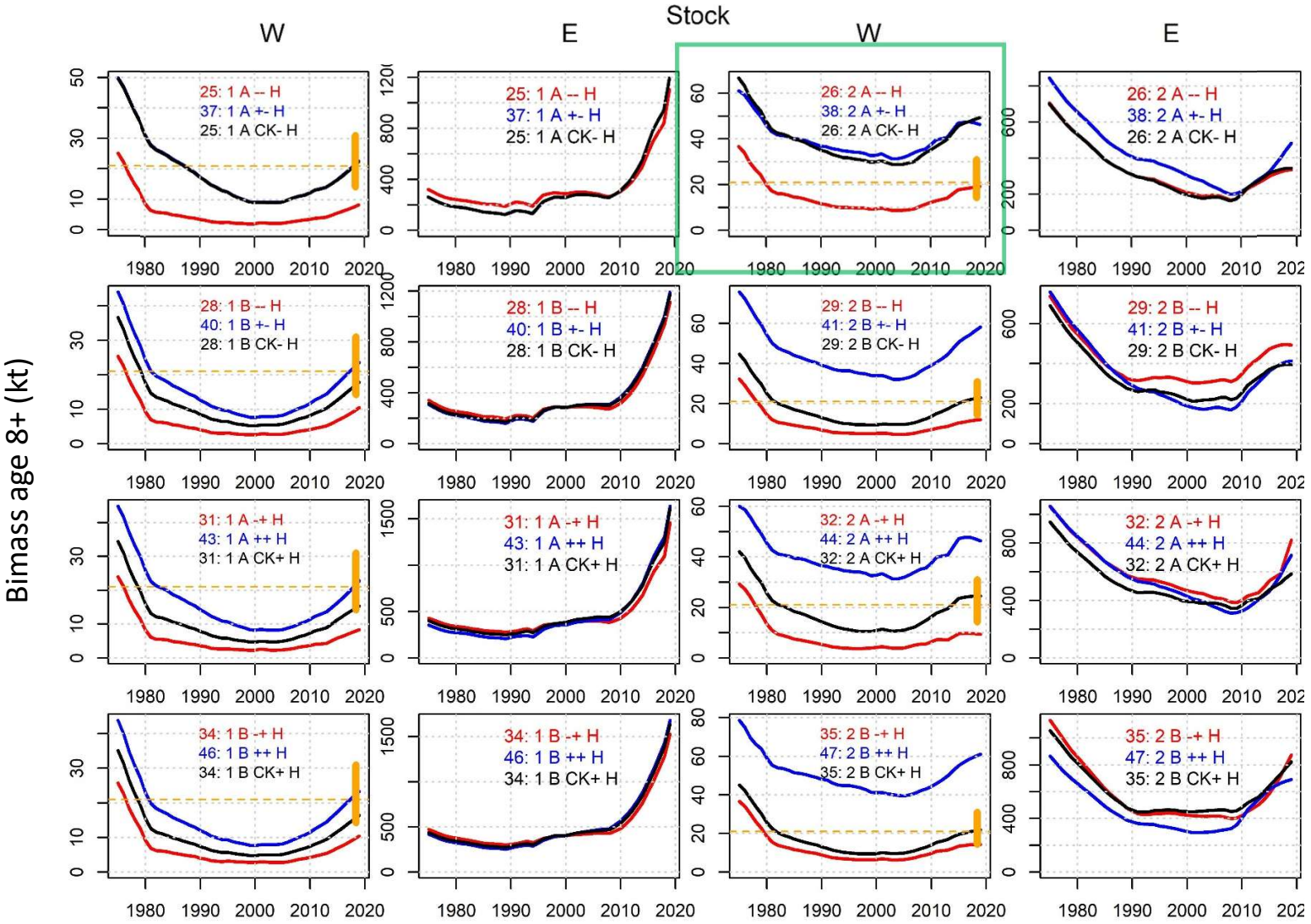
Comparison of stock trends

Small scale west area

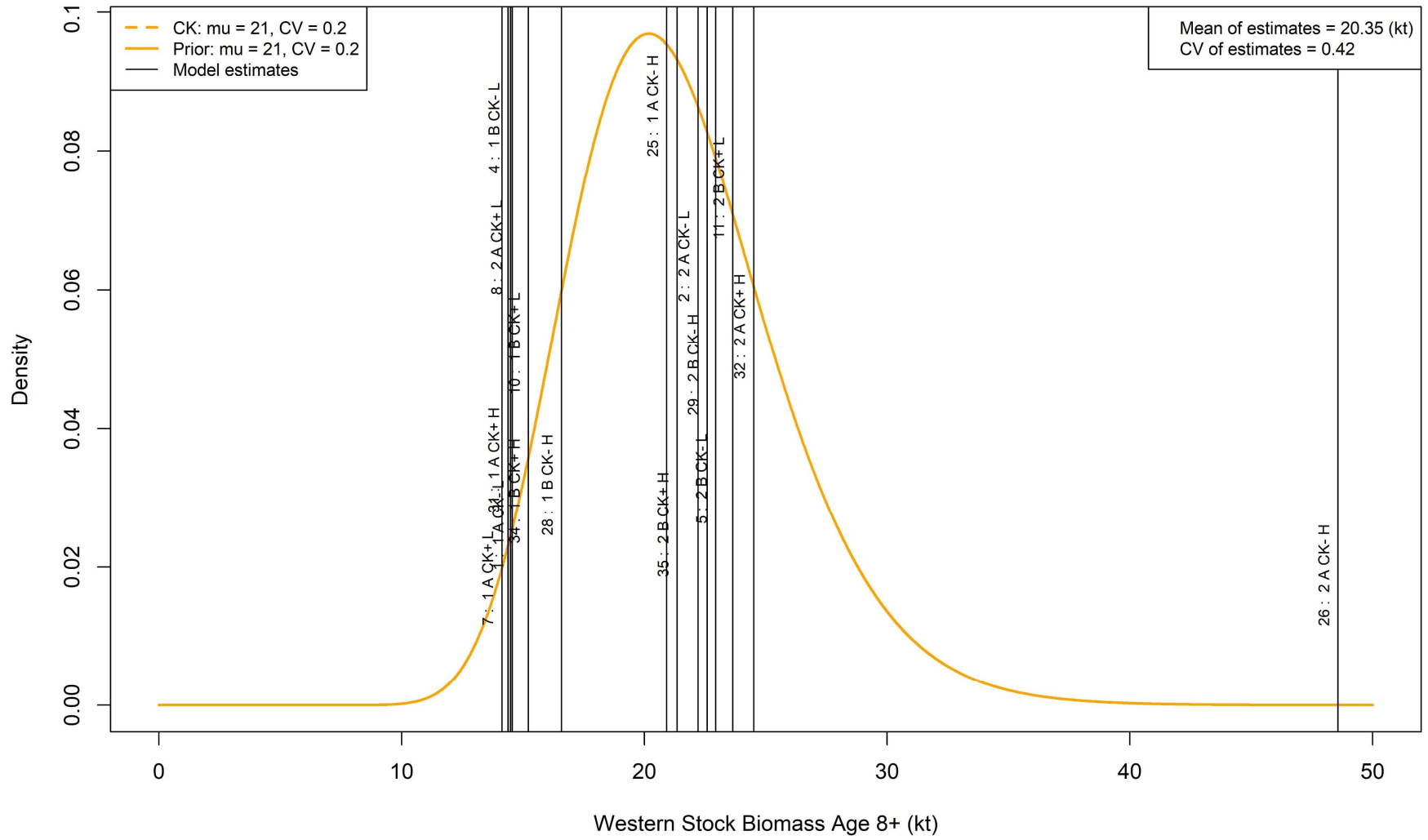
Large scale west area

New CKMR west stock

CKMR estimate with CV 0.2 (95% intervals)



Results


CK: mu = 21, CV = 0.2
Prior: mu = 21, CV = 0.2
Model estimates
Mean of estimates = 20.35 (kt)
CV of estimates = 0.42
Density
0.00
0.02
0.04
0.06
0.08
0.1
0
10
20
30
40
50
Western Stock Biomass Age 8+ (kt)
7 : 1 A CK+ L
1 : 1 A CK+ L
31 : 1 A CK+ H
34 : 1 B CK+ H
10 : 1 B CK+ L
8 : 2 A CK+ L
4 : 1 B CK- L
28 : 1 B CK- H
35 : 2 B CK+ H
25 : 1 A CK- H
5 : 2 B CK- L
29 : 2 B CK- H
2 : 2 A CK- L
11 : 2 B CK+ L
32 : 2 A CK+ H
26 : 2 A CK- H

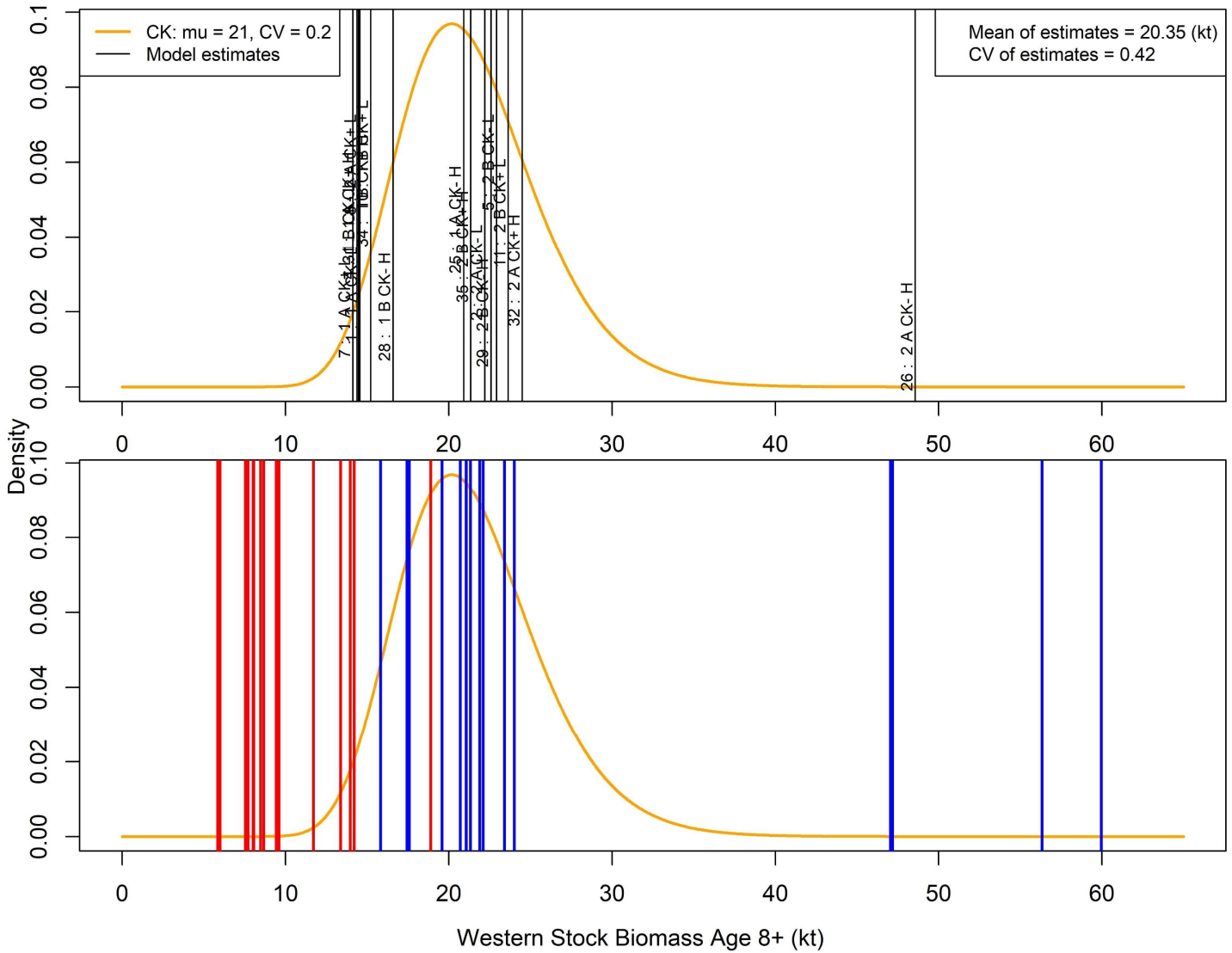
Results

Small scale west area

Large scale west area

New CKMR west stock

CKMR estimate



Results summary

- Comparable trend in biomass for eastern and western stocks given revised operating models.
- Mean of operating model estimates (20.35 kt) is comparable to CKMR mean of 21 kt.
- 15 of 16 operating model estimates are within the 95% interval.
- OM #26 (2 A CK- H) is inconsistent with CKMR estimate and similar to previous round of operating models.

Acknowledgements

Many thanks to the contributions of the MSE technical team.

Particular thanks to Carmen Fernandez, Doug Butterworth, John Walter, Tristan Rouyer and Matt Lauretta on earlier versions of these methods and results.

Thanks to The Ocean Foundation for supporting my travel to this meeting.

Running the Shiny App

1) Download the R package (ABTMSE v8.2.4) from the google drive

2) Run the following code:

```
library(ABTMSE)
Shiny('ABTMSE')
```

Contact tom@bluematterscience.com for support