SC/59/RMP1

Results of Additional Bryde's Whale *Implementation Simulation Trials*

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ABSTRACT
Additional Bryde's whale *Implementation Simulation Trials* are conducted as recommended by the Second Intersessional Workshop on the Western North Pacific Bryde's whale *Implementation.* These trials: (a) assess the conservation performance of RMP variant 2 (sub-area 2 is taken to be a *Small Area* and the complete sub-area 1 is treated as a *Small Area*) when it is used for 10 years after which management is based on variants 1, 3 and 4 (after a five-year phase-out period), (b) evaluate the implications of different ways of modelling stochastic mixing, and (c) evaluate the implications of conditioning the operating model to the estimates of survival rate in absolute terms.

INTRODUCTION

The Second Intersessional Workshop on the Western North Pacific Bryde's whale *Implementation* (IWC, 2008) reviewed the results of the *Implementation Simulation Trials* finalized during the 2006 meeting of the Scientific Committee. The objectives of this workshop were to develop recommendations for consideration by the full Committee on:

(1) management areas;
(2) RMP variants (e.g. catch-cascading, catch-capping);
(3) associated operational constraints (e.g. temporal restrictions);
(4) suggestions for future research (either within or outside whaling operations) to narrow the range of plausible hypotheses / eliminate some hypotheses; and
(5) 'less conservative' variants(s) with their associated required research programs and associated duration.

The four management variants considered during the workshop were:

a) Variant 1: sub-areas 1W, 1E[1] and 2 are *Small Areas* and catch limits are set by *Small Area*.
b) Variant 2: sub-area 2 is taken to be a *Small Area* and the complete sub-area 1 is treated as a *Small Area*; for this management option, all of the future catches in sub-area 1 are taken from sub-area 1W.
c) Variant 3: sub-area 2 is taken to be a *Small Area* and sub-area 1 is taken to be a *Combination area*. Sub-areas 1W and 1E are *Small Areas*, with *catch-cascading* applied.
d) Variant 4: sub-areas 1 and 2 (combined) are taken to be a *Combination area*, and sub-area 2 and sub-areas in 1W and 1E are *Small Areas*, with *catch-cascading* applied

[1] Defined to be 140^0E-165^0E and 165^0-180^0 irrespective of the true boundary used to define the structure of the populations in the operating model.

The workshop agreed that management variants 1, 3 and 4 all performed 'acceptably' from a conservation perspective, and recommended these to the full Committee. After the Workshop, the Government of Japan informed the Chair (Donovan) that it wished consideration be given to the possibility of using variant 2 'with research', in accordance with the Committee's Guidelines (IWC, 2005).

This paper first examines the performance of variant 2 when it is combined with variants 1, 3 and 4 in terms of its conservation performance on those trials for which its performance was 'unacceptable' (Trials BR13, BR15 and BR17; see Table 1 for the specifications of the trials).

The workshop also modified the specifications for the trials in which there is stochastic mixing (trials BR05, BR06, BR13 and BR14) because the behaviour of these trials as they were originally specified was questionable (IWC, 2008). Instead of only one of two "extreme" mixing matrices (V_1 and V_2) applying in a particular year, the workshop specified that the mixing matrix for an given year would be $V_1 + 2xV_2$ (normalized so that the sum over sub-areas equals 1 for each stock), where x is a random number generated from U[0,1]. The matrix V_1 has zeros for sub-areas in which mixing occurs so $V_1 + 2xV_2$ is equivalent to $yV_1 + (1\text{-}y)V_2$. However, it also agreed that additional trials should be examined in which mixing is closer to the original specifications. The second section of this document provides specifications and results for these additional trials.

Finally, the workshop modified the specifications for the trials incorporating spatial age-dependence (trials BR09, BR10, BR27 and BR28) by giving a high weight to the operating model mimicking the ratio of the survival rate estimate for sub-area 1E to that for sub-area 1W, i.e. S_{1E}/S_{1W}. The workshop also recommended that additional sensitivity tests be conducted in which the input value for the rate of natural mortality, M, was modified so that the operating model could mimic the absolute survival rates. The third section of this document provides specifications and results for these additional trials.

Given the focus on conservation performance, results shown in this document are only for trials based on the assumption $MSYR_{\text{mat}}$=1%.

IMPACT OF USING VARIANT 2 FOR TEN YEARS

Variant 2 could be 'acceptable with research' if the Committee decides that a) it is feasible to design a research programme that could address the uncertainties on which the trials on which this variant performed poorly (in this case trials BR13, BR15 and BR17) and b) if the performance, assuming that management is based on variant 2 for 10 years after which management reverts, via a five-year phase-out process, to one of the other variants, is 'acceptable' from a conservation perspective (IWC, 2005).

Fig. 1 compares the results for the no-catch scenario and` the four variants listed above, as well as variants that involve applying variant 2 for 10 years after which management reverts to each of variants 1, 3 and 4 (referred to as variants 2-1, 2-3, and 2-4) after a 5-year phase-out for trials BR13, BR15 and BR17. Fig. 1 assesses the conservation performance of each variant using the procedure for defining 'acceptable', 'borderline' and 'unacceptable' performance (IWC, 2007). This plot has panels for each stock and the

two performance statistics on which the thresholds selected by IWC (2007) are based (the lower 5th percentile of the final depletion distribution and the lower 5th percentile of the scaled lowest depletion distribution). The values for the performance statistics for each variant (and the no-catch scenario) are represented as dots, and horizontal lines indicate the thresholds (upper line: 'acceptable'; lower line: 'borderline'). The shaded area in this plot indicates 'unacceptable' performance.

ALTERNATIVE STOCHASTIC MIXING TRIALS

The alternative stochastic mixing trials are based on trials BR05 and BR13. Rather than defining the mixing matrix for an given year to be $V_1 + 2xV_2$, where x is random number generated from U[0,1], it is defined as $V_1 + 2xV_2$ where x is random number from a Beta distribution with mean 0.5 and pre-specified CV^2 (a CV^2 of 1/3 corresponds to a uniform distribution). Figs 3 and 4 show the results of the conditioning of these trials (along with the conditioning and projection results for the original trials with stochastic mixing and $MSYR_{mat}$=1%) and compares the conservation performance of the four RMP variants for cases in which the CV^2 is 1/3, 0.36 and 0.49 (see Fig. 2 for the density functions for the random number x). The upper limit for the CV^2 was chosen to be 0.49 because higher values for the CV^2 led to unreasonable behaviour. For example, there is evidence for a 'pigtail' in trial BR13c (Figure 3f) even for a CV^2 of 0.49: a marked narrowing in the 90% interval for 1995 (the year for which an estimate of abundance is available) was one reason for modifying trials BR05 and BR13 during the workshop.

TRIALS FITTED TO ABSOLUTE SURVIVAL RATES

The alternative versions of the trials with age-dependent mixing (trials BR09a and BR27a) involve conditioning the operating model to the survival rates for sub-areas 1W and 1E in absolute terms. The value of M for these trials is set equal to 0.11yr^{-1} (rather than its base-case value of 0.08yr^{-1}). This value was selected by trial-and-error so that the operating model is able to fit the survival rates.

Figure 5 shows the results of conditioning these trials along with those conditioning results for trials BR09 and BR27. Figure 5 shows plots of the standardized residuals about the fits to the survival estimates in addition to plots showing how well the estimates of abundance are mimicked. Figure 6 compares the conservation performance of the four RMP variants for trials BR09, BR09a, BR27, and BR27a.

REFERENCES

IWC 2005. Requirements and Guidelines for Implementations. Appendix 2 to Report of the Sub-Committee on the Revised Management Procedure. Annex D to the report of the Scientific Committee. *J. Cetacean Res. Manage.* 7 (Suppl). 83-92.

IWC 2007. Amendment to the Requirements and Guidelines for Implementations. Appendix 3 to Report of the Sub-Committee on the Revised Management Procedure. Annex D to the report of the Scientific Committee. *J. Cetacean Res. Manage.* 9 (Suppl). 00-00.

IWC 2008. Western North Pacific Bryde's Whale Implementation: Report of the Second Intersessional Workshop. *J. Cetacean Res. Manage.* 10 (Suppl.): 00-00.

Table 1 The *Implementation Simulation Trials* for the western North Pacific Bryde's whales.

Trial No.	Stocks	Sub-stocks	$MSYR_{mat}$	Mixing matrix	Process error	Stochastic mixing in 1W/1E	Catch series	Age-dependent Mixing?	1W / 1E boundary	Comment	Trial Weight
BR01	1	No	1	A	Baseline	No	Best	No	165°E	Stock structure hypothesis 1	M
BR02	1	No	4	A	Baseline	No	Best	No	165°E	Stock structure hypothesis 1	**H**
BR03	2	No	1	B	Baseline	No	Best	No	165°E	Stock structure hypothesis 2	M
BR04	2	No	4	B	Baseline	No	Best	No	165°E	Stock structure hypothesis 2	**H**
BR05	2	No	1	C	Baseline	No	Best	No	165°E	Stock structure hypothesis 3 *	M
BR06	2	No	4	C	Baseline	No	Best	No	165°E	Stock structure hypothesis 3 *	**H**
BR07	2	Yes	1	D	Baseline	No	Best	No	155°E	Stock structure hypothesis 4	M
BR08	2	Yes	4	D	Baseline	No	Best	No	155°E	Stock structure hypothesis 4	M
BR09	2	No	1	B	Baseline	No	Best	**Yes**	165°E	B + Age-dependent mixing	M
BR10	2	No	4	B	Baseline	No	Best	**Yes**	165°E	B + Age-dependent mixing	**H**
BR11	2	Yes	1	D	$\sigma_p = 0.9$	No	Best	No	155°E	D + Additional process error	M
BR12	2	Yes	4	D	$\sigma_p = 0.9$	No	Best	No	155°E	D + Additional process error	M
BR13	2	Yes	1	D	Baseline	**Yes**	Best	No	155°E	D + Stochastic mixing *	M
BR14	2	Yes	4	D	Baseline	**Yes**	Best	No	155°E	D + Stochastic mixing *	M
BR15	2	Yes	1	D	Baseline	No	Best	No	**160°E**	D + Alternative Boundary 1	M
BR16	2	Yes	4	D	Baseline	No	Best	No	**160°E**	D + Alternative Boundary 1	M
BR17	2	Yes	1	D	Baseline	No	Best	No	**165°E**	D + Alternative Boundary 2	M
BR18	2	Yes	4	D	Baseline	No	Best	No	**165°E**	D + Alternative Boundary 2	M
BR19	2	Yes	1	D	Baseline	No	**Low**	No	155°E	D + Low catch series	M
BR20	2	Yes	4	D	Baseline	No	**Low**	No	155°E	D + Low catch series	M
BR21	2	Yes	1	D	Baseline	No	**High**	No	155°E	D + High catch series	M
BR22	2	Yes	4	D	Baseline	No	**High**	No	155°E	D + High catch series	M
BR23	2	No	1	B	Baseline	No	**High**	No	165°E	B + High catch series	M
BR24	2	No	4	B	Baseline	No	**High**	No	165°E	B + High catch series	**H**
BR25	2	No	1	B	$\sigma_p = 0.9$	No	Best	No	165°E	B + Additional process error	M
BR26	2	No	4	B	$\sigma_p = 0.9$	No	Best	No	165°E	B + Additional process error	**H**
BR27	2	No	1	B	Baseline	No	**High**	**Yes**	165°E	B + Age-dep.mixing+high catch	M
BR28	2	No	4	B	Baseline	No	**High**	**Yes**	165°E	B + Age-dep.mixing+high catch	**H**

* With stochastic mixing

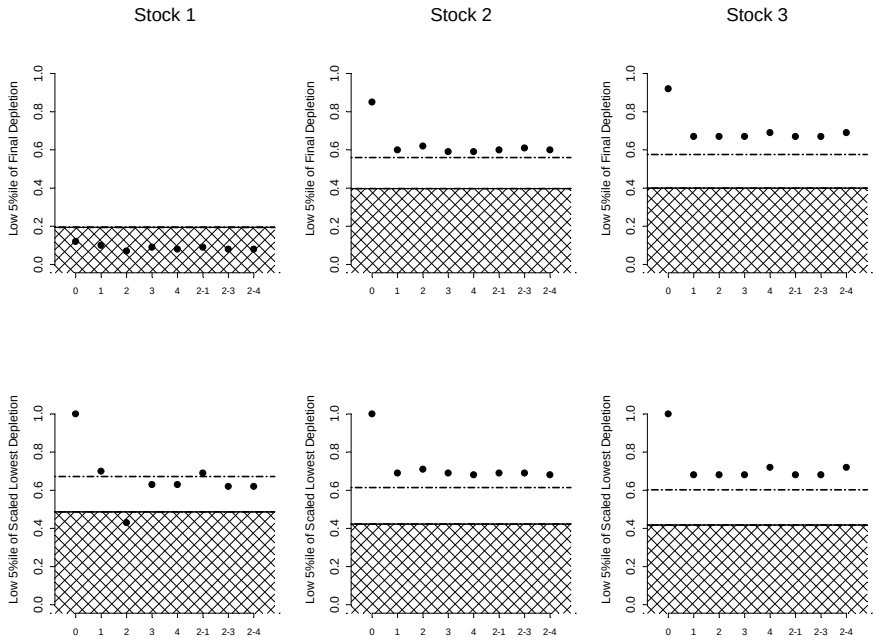
Table 2 The alternative *Implementation Simulation Trials* on which this document is based.

Trial No.	Stocks	Sub-stocks	$MSYR_{mat}$	Mixing matrix	Process error	Stochastic mixing in 1W/1E	Catch series	Age-dependent Mixing?	1W / 1E boundary	Comment
BR05a	2	No	1	C	Baseline	No	Best	No	165°E	Stock structure hypothesis 3 * (CV^2=1/3)
BR05b	2	No	1	C	Baseline	No	Best	No	165°E	Stock structure hypothesis 3 * (CV^2=0.36)
BR05c	2	No	1	C	Baseline	No	Best	No	165°E	Stock structure hypothesis 3 * (CV^2=0.49)
BR13a	2	Yes	1	D	Baseline	**Yes**	Best	No	155°E	D + Stochastic mixing * (CV^2=1/3)
BR13b	2	Yes	1	D	Baseline	**Yes**	Best	No	155°E	D + Stochastic mixing * (CV^2=0.36)
BR13c	2	Yes	1	D	Baseline	**Yes**	Best	No	155°E	D + Stochastic mixing * (CV^2=0.49)
BR9a	2	No	1	B	Baseline	No	Best	**Yes**	165°E	B + Age-dependent mixing #
BR27a	2	No	1	B	Baseline	No	**High**	**Yes**	165°E	B + Age-dep.mixing+high catch #

* With stochastic mixing

\# Fit to survival rates in absolute terms

(a) Trial BR13 (Baseline D; boundary at 155^0E)



(b) Trial BR15 (Baseline D; boundary at 160^0E)

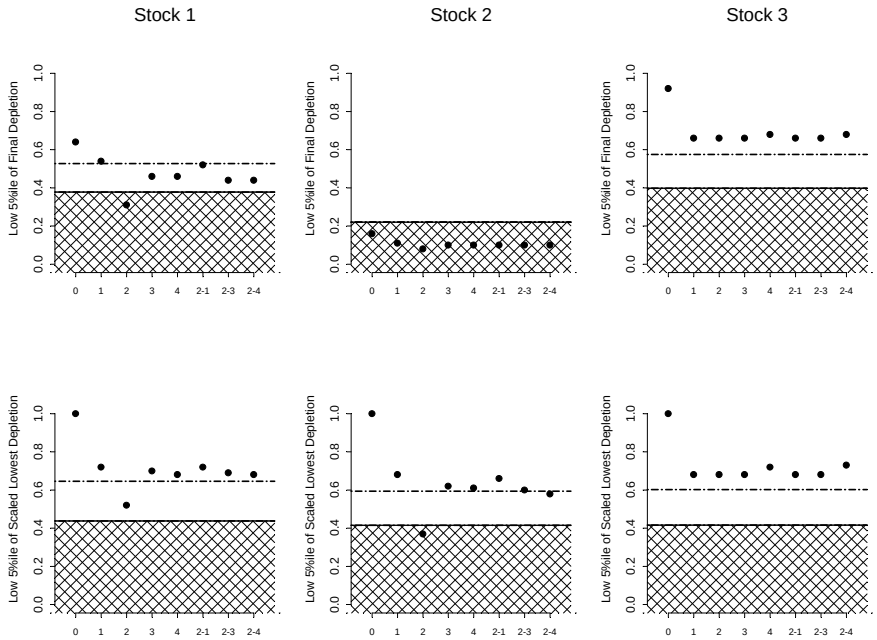
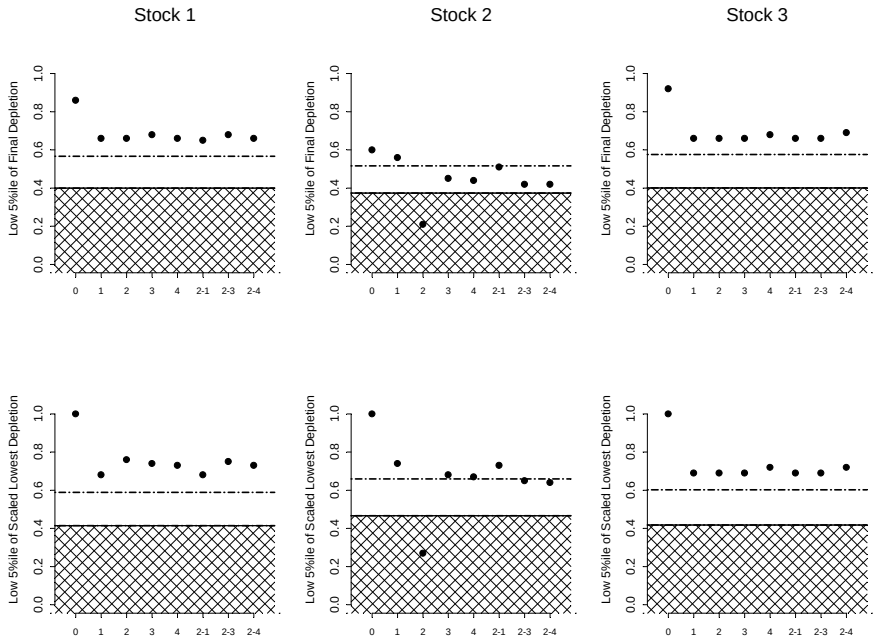


Figure 1.
Comparison of the conservation performance of the no-catch scenario (‘0’), the original four RMP variants (‘1’- ‘4’), and the variants in which variant 2 is applied for ten years after which catch limits are based on variants 1, 3 or 4 (‘2-1’,’2-3’,’2-4’).

(c) Trial BR17 (Baseline D; boundary at 165^0E)



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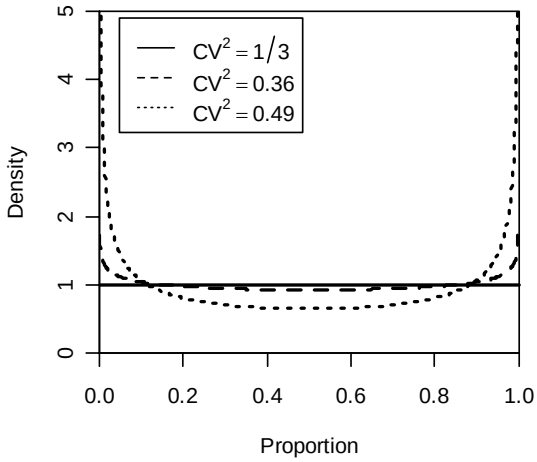
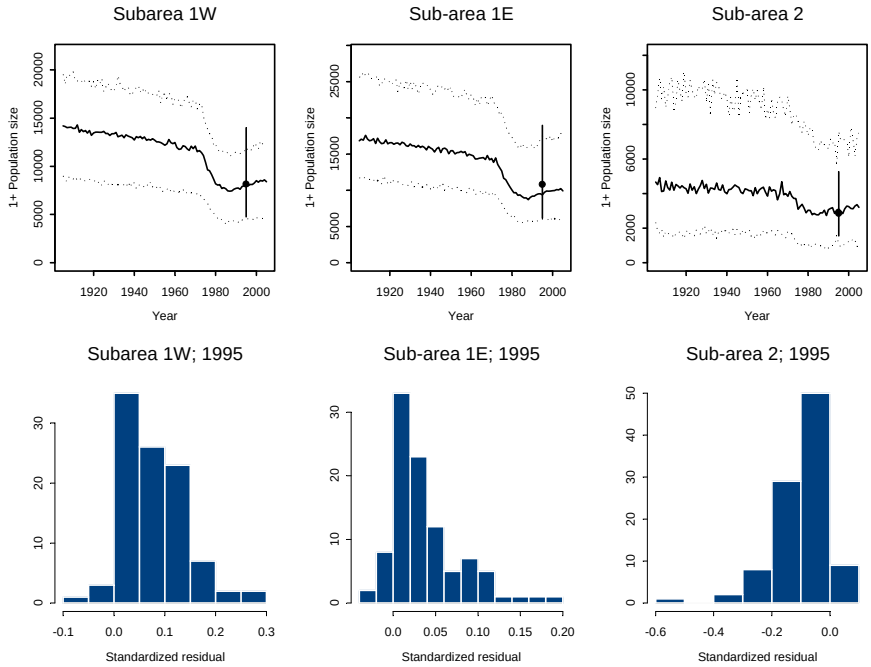


Figure 2
Density functions for the random numbers on which the revised trials with stochastic mixing are based.

(a) Trial BR05



(b) Trial BR05a (Baseline C; CV^2=1/3)

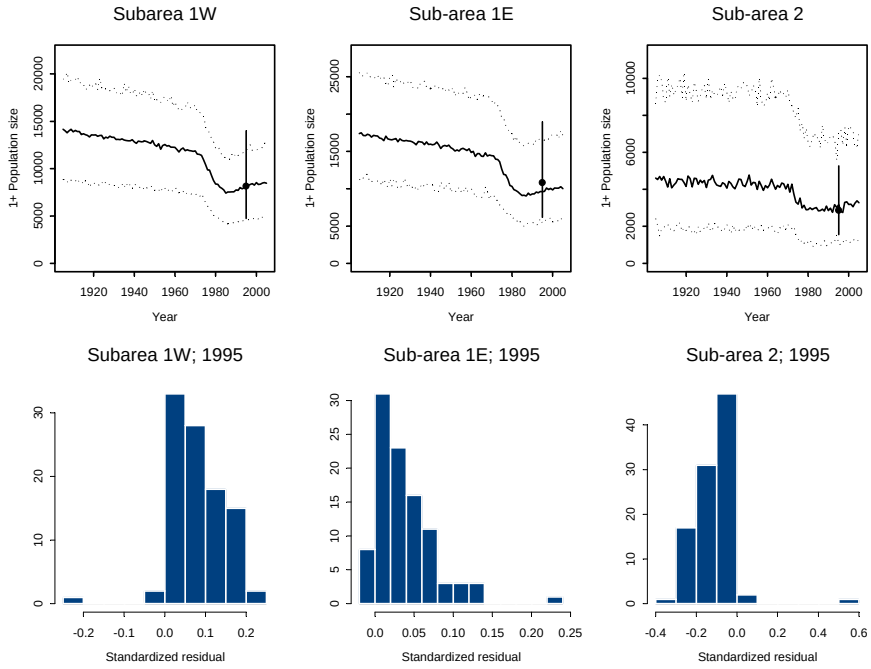
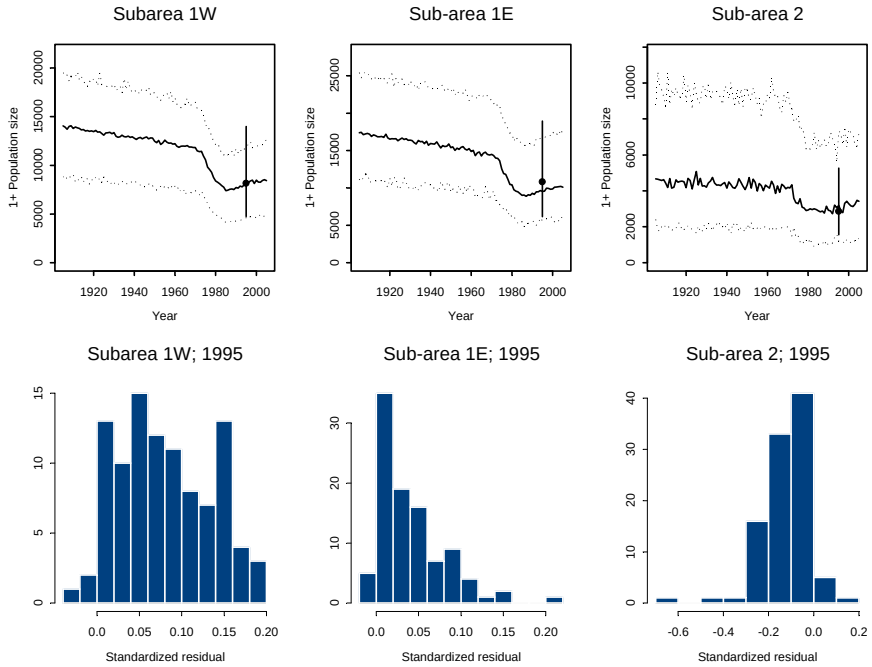
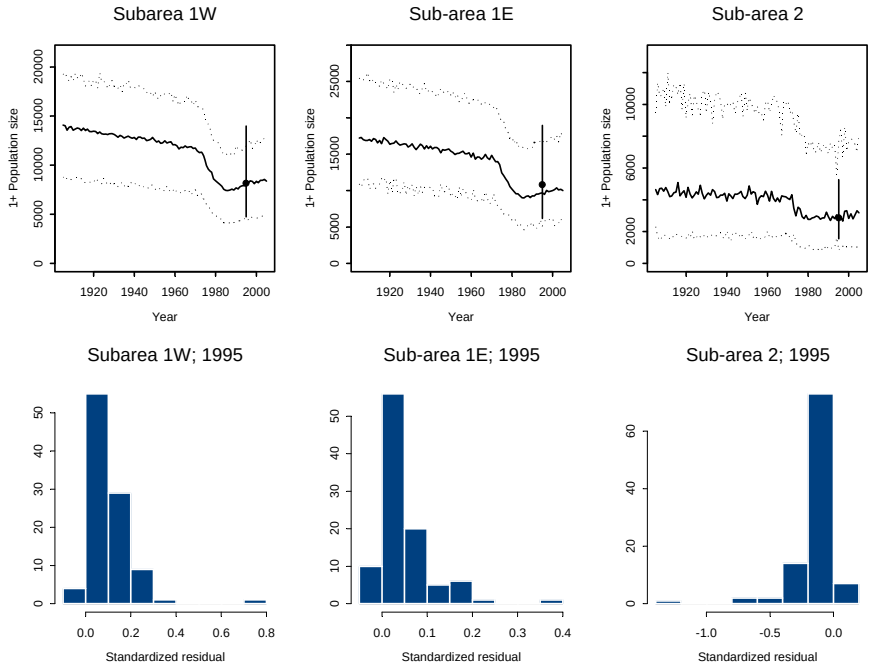


Figure 3
Diagnostic statistics related to conditioning the trials in which the operating model involves stochastic mixing (see Table 2 for the specifications of the trials).

(c) Trial BR05b (Baseline C; CV^2=0.36)



(d) Trial BR05c (Baseline C; CV^2=0.49)



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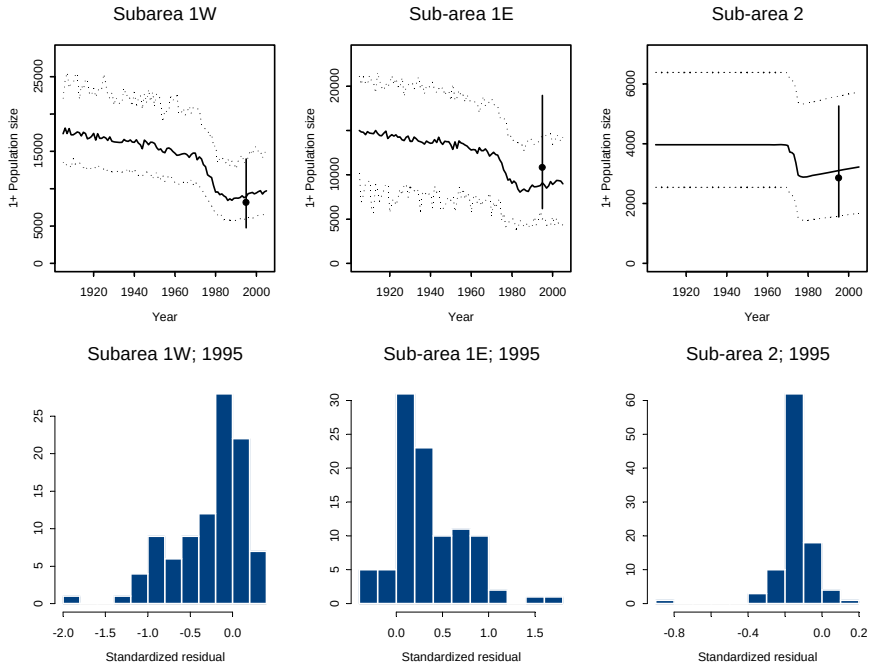
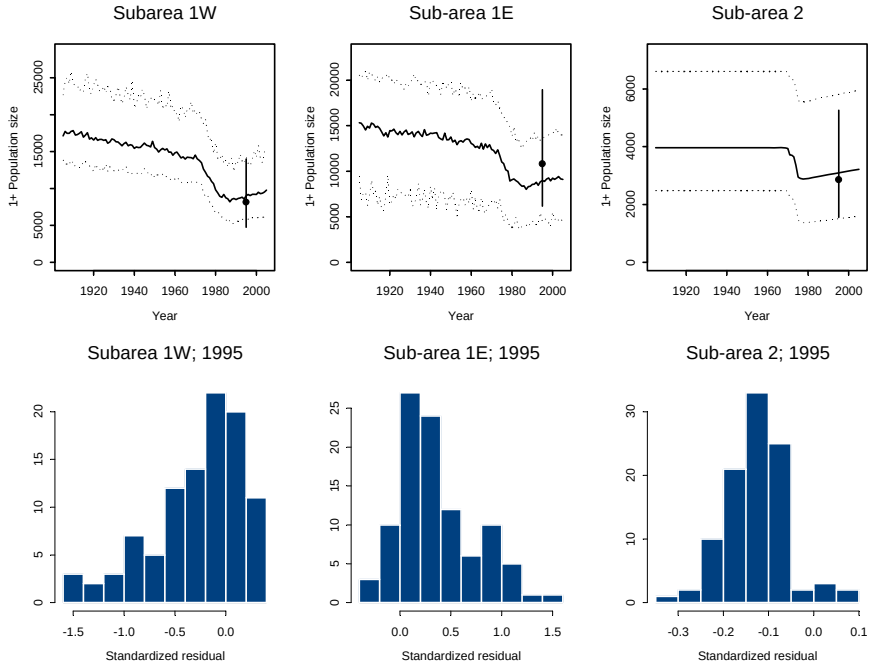
(e) Trial BR13



(f) Trial BR13a (Baseline D; Boundary=155^0E; CV^2=1/3)



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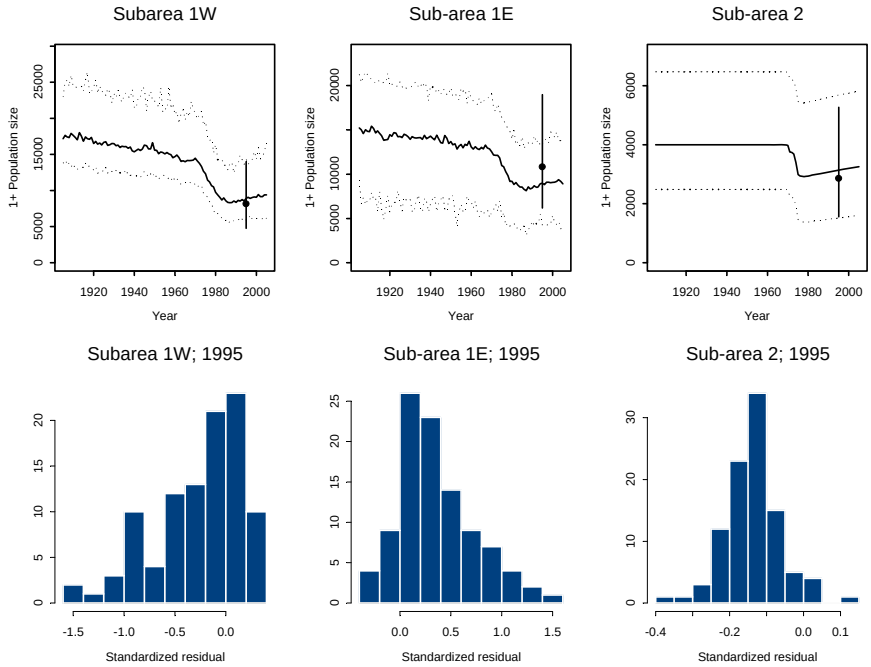
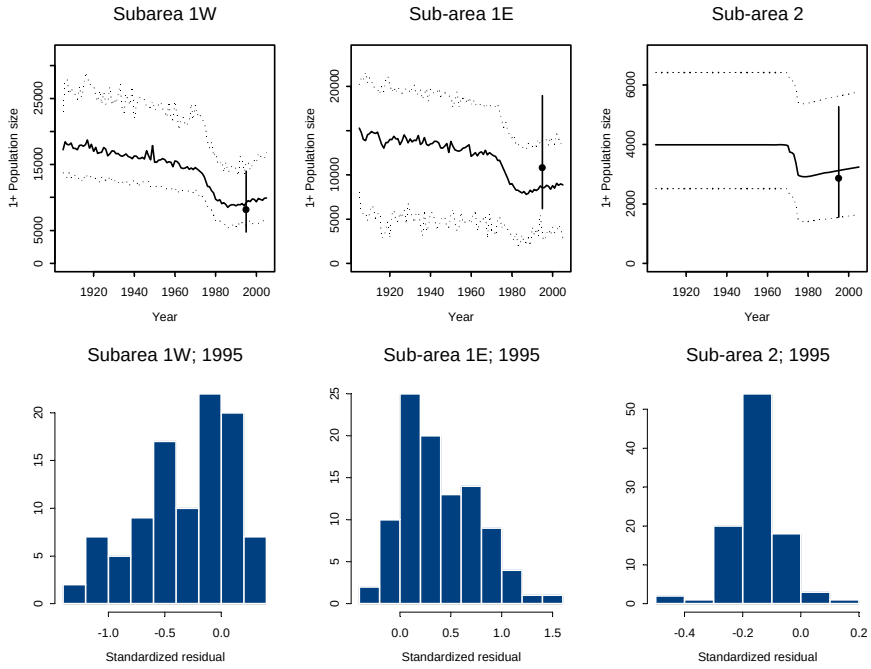
(g) Trial BR13b (Baseline D; Boundary=155^0E; CV^2=0.36)

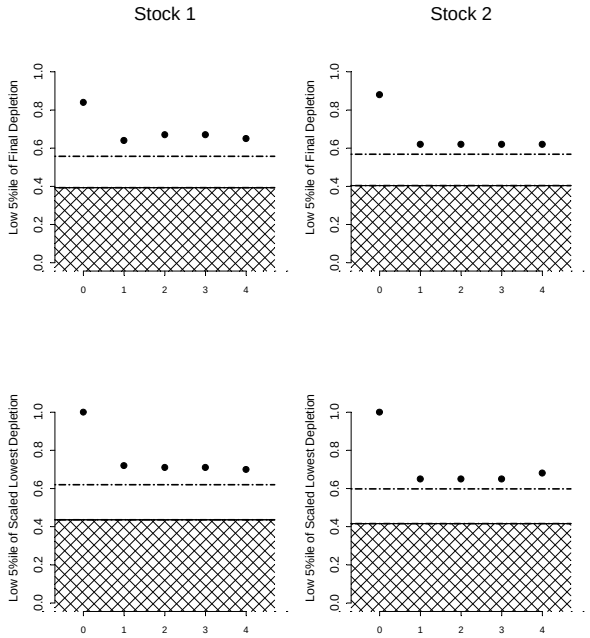


(h) Trial BR13c (Baseline D; Boundary=155^0E; CV^2=0.49)



(Figure 3 Continued)

(a) Trial BR05



(b) Trial BR05a (Baseline C; CV^2=1/3)

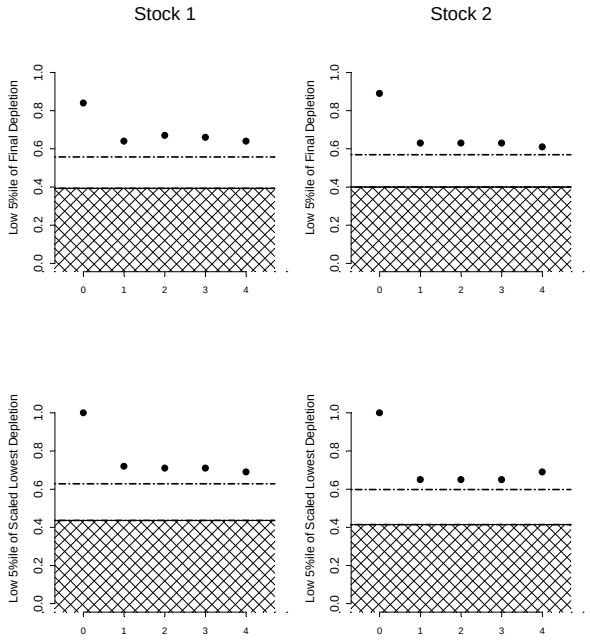
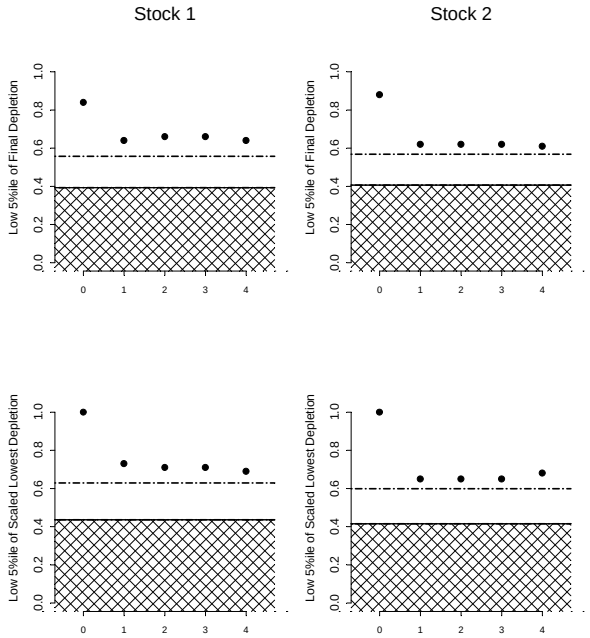
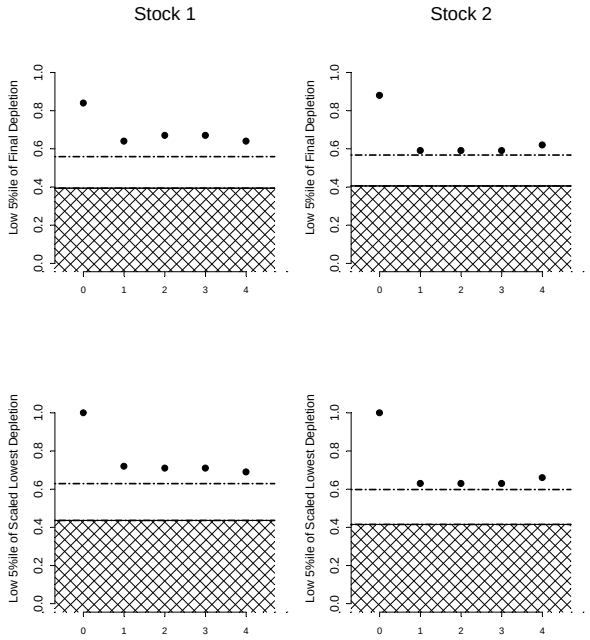


Figure 4.
Comparison of the conservation performance of the no-catch scenario ('0') and the original four RMP variants ('1' – '4') for the trials in which there is stochastic mixing.

(c) Trial BR05b (Baseline C; CV^2=0.36)



(d) Trial BR05c (Baseline C; CV^2=0.49)



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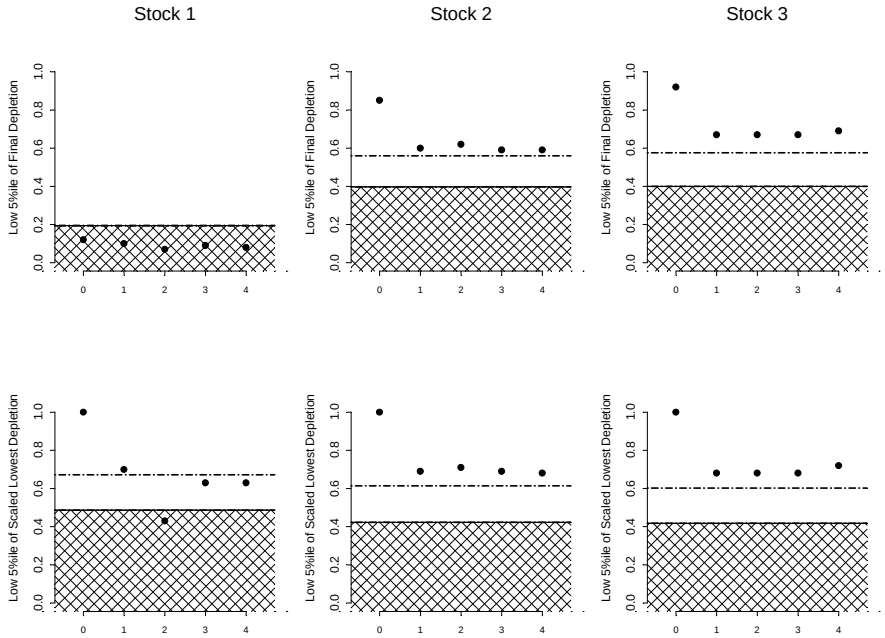
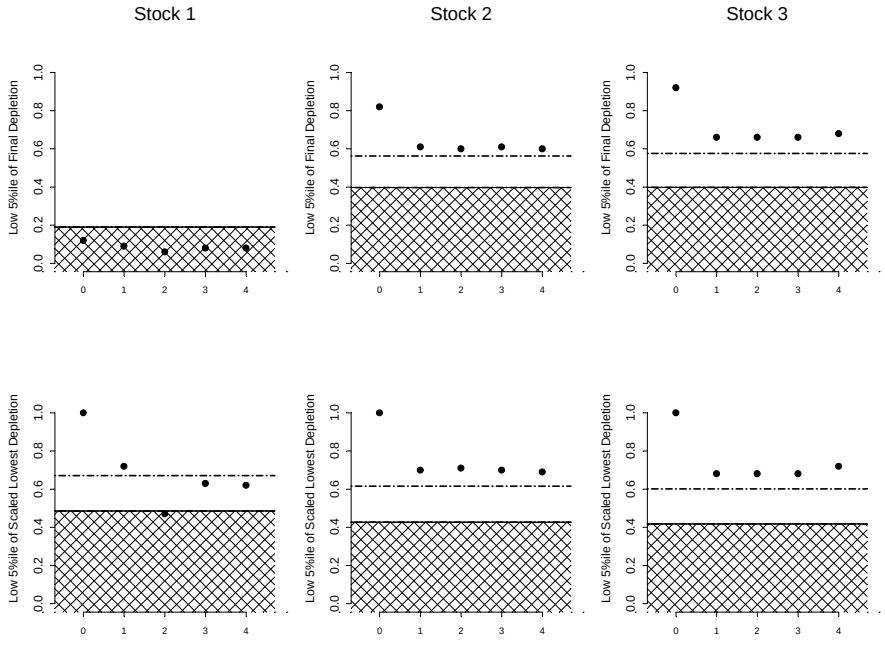
(e) Trial BR13



(f) Trial BR13a (Baseline D; Boundary=155^0E; CV^2=1/3)



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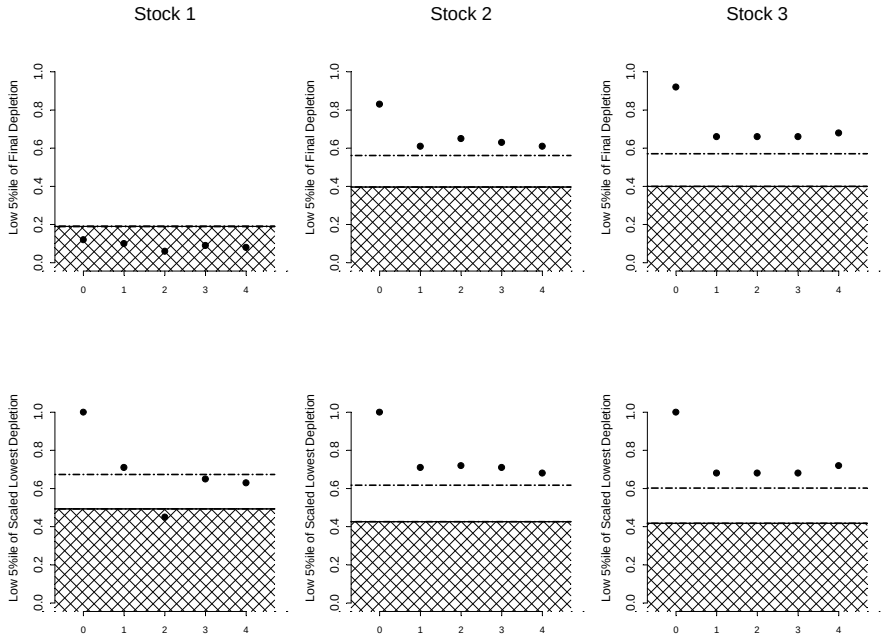
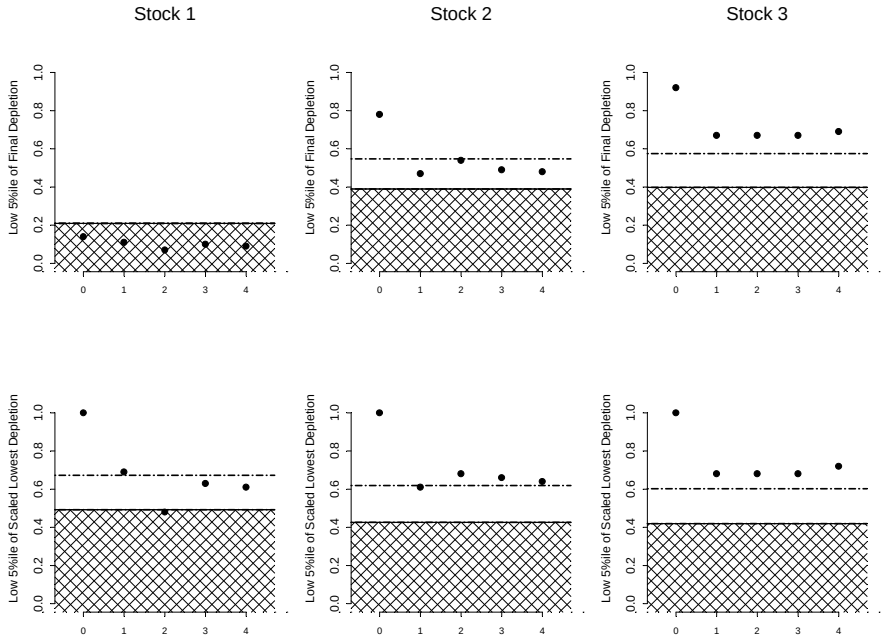
(g) Trial BR13b (Baseline D; Boundary=155^0E; CV^2=0.36)



(h) Trial BR13c (Baseline D; Boundary=155^0E; CV^2=0.49)



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(a) Trial BR09 (Baseline B; age-dependent mixing)

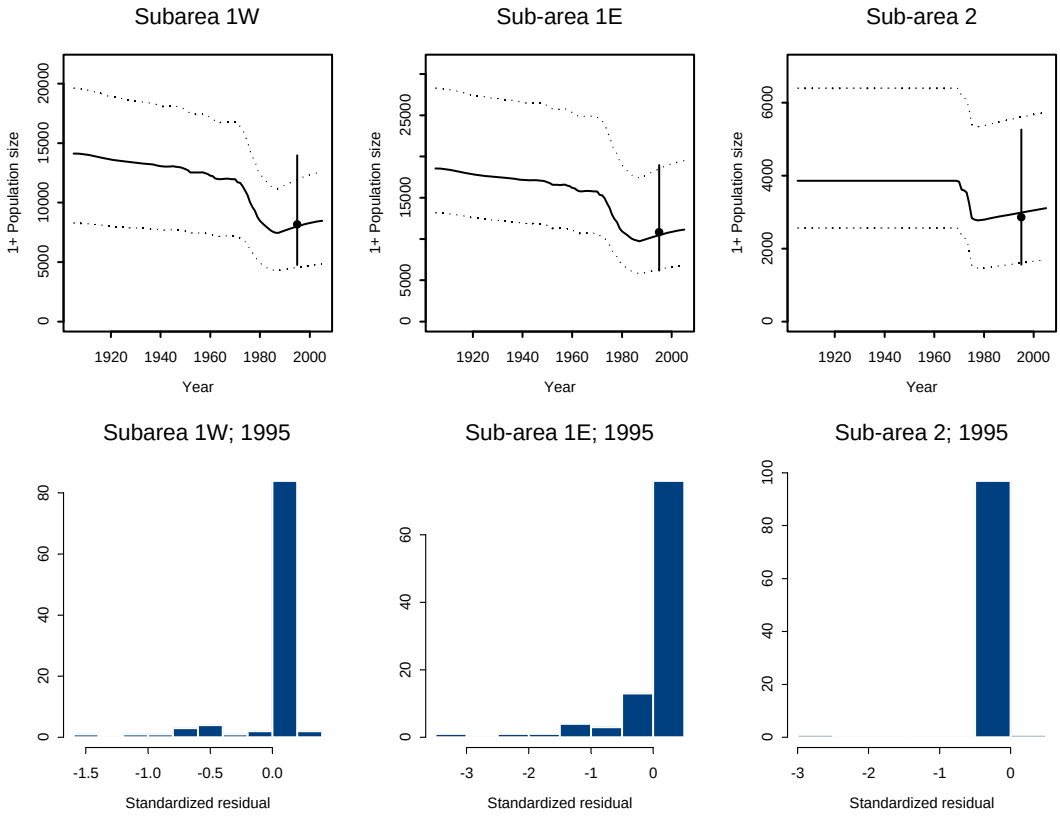
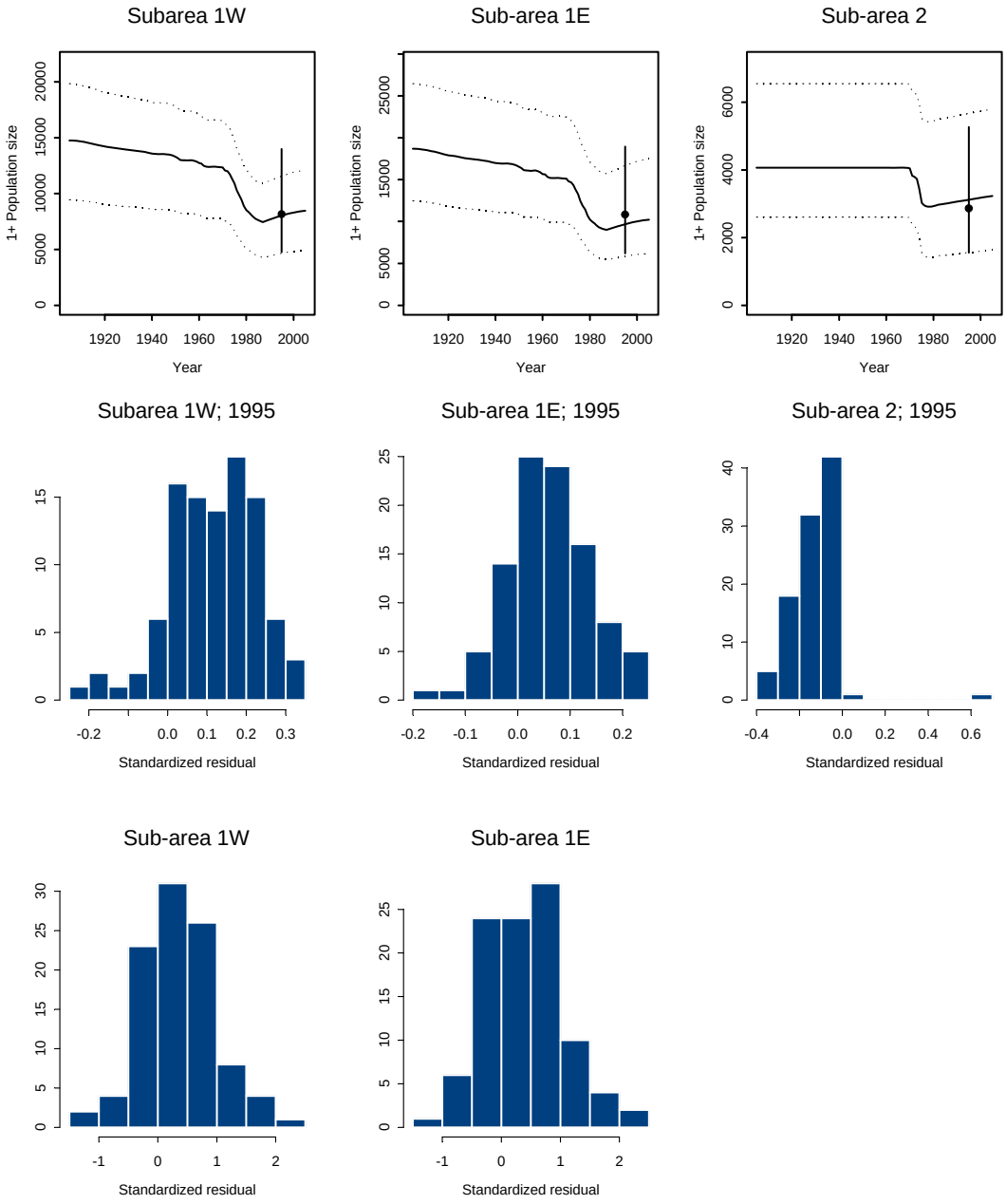


Figure 5
Diagnostic statistics related to conditioning trials BR09 and BR27 and the trials in which the operating model is fitted to the estimates of survival rate (in absolute terms). For the trials in which the operating model is fitted to the absolute survival estimates (trials BR09a and BR27a), the upper two rows of bar charts pertain to the estimates of absolute abundance and the last row of bar charts shows the standardized residuals about the fit to the survival rate estimates.

(b) Trial BR09a (Baseline B; age-dependent mixing)



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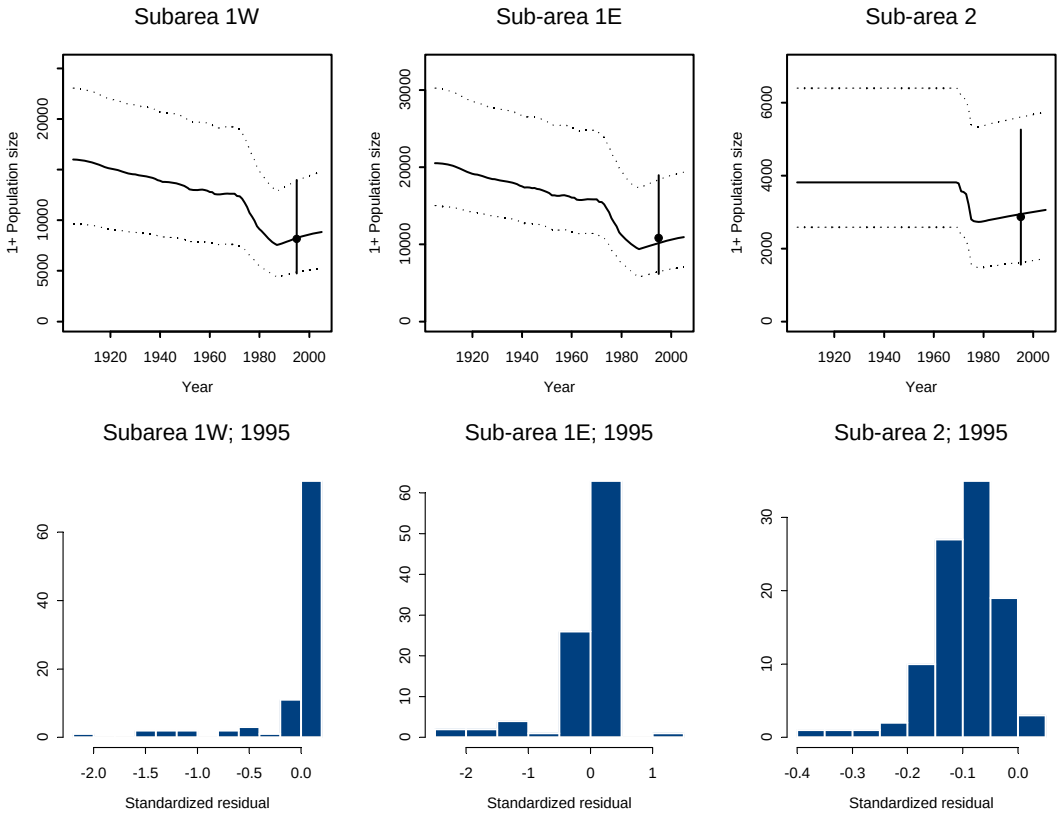
(c) Trial BR27 (Baseline B; high catches; age-dependent mixing)



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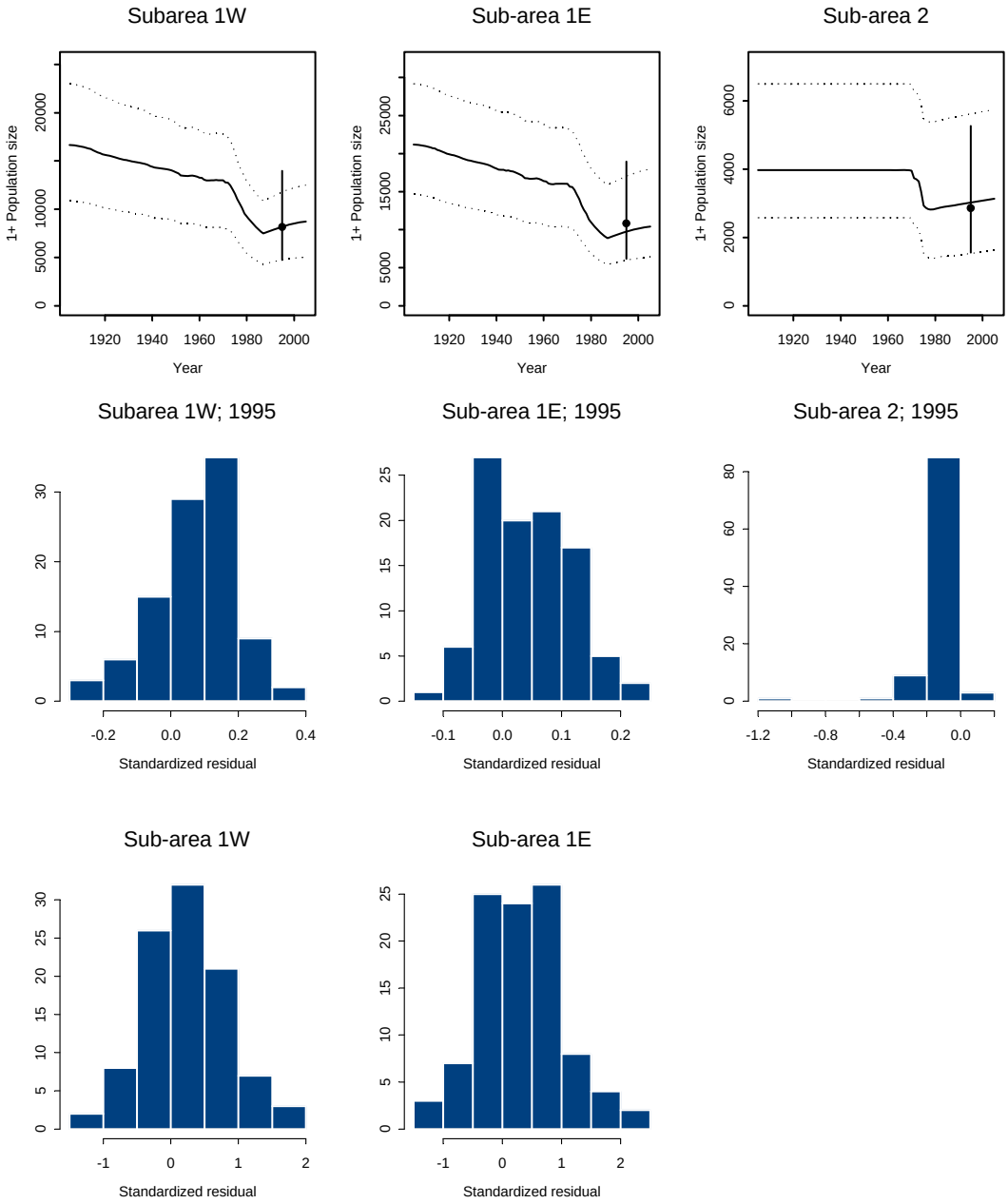
(d) Trial BR27a (Baseline B; high catches; age-dependent mixing)



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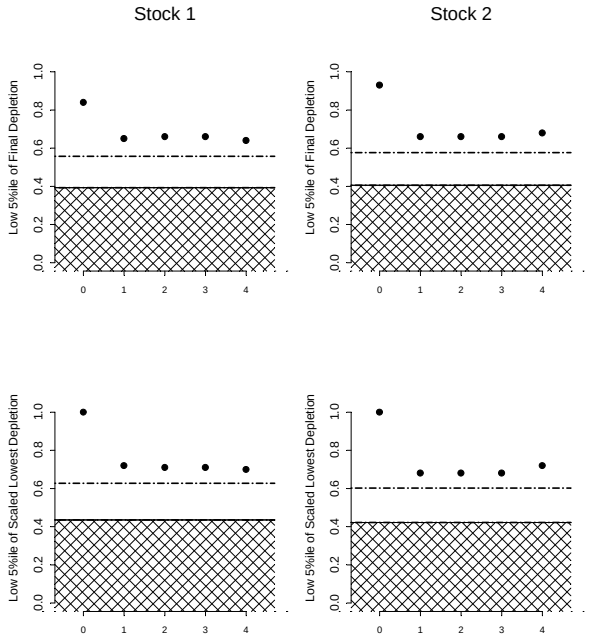
(a) Trial BR09 (Baseline B; age-dependent mixing)



(b) Trial BR09a (Baseline B; age-dependent mixing)

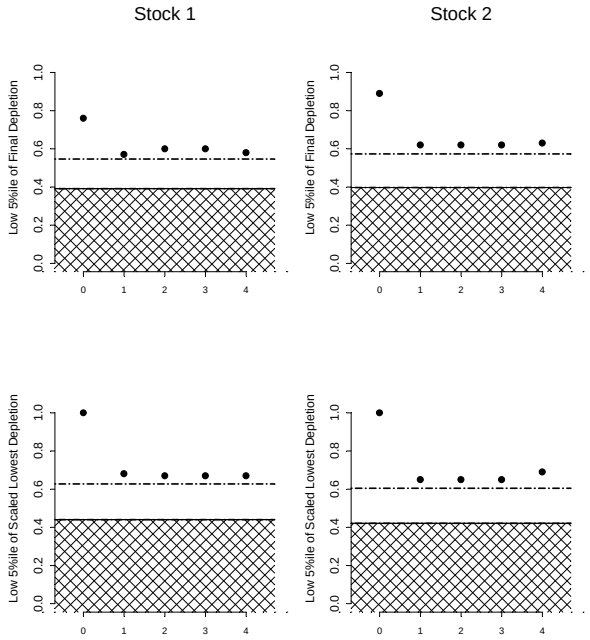
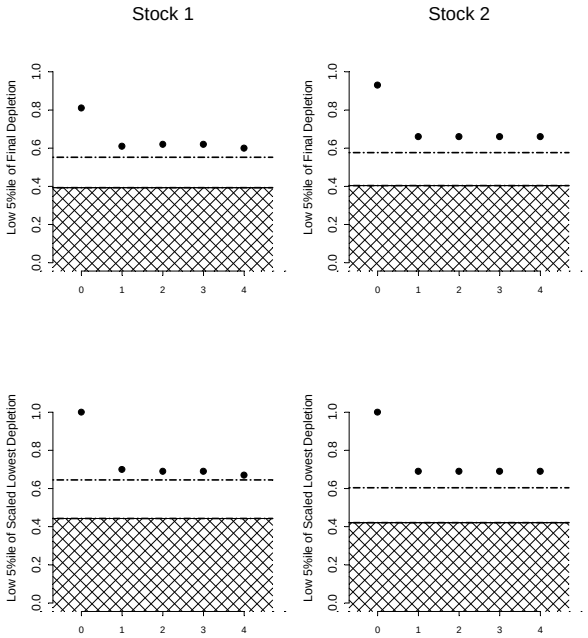
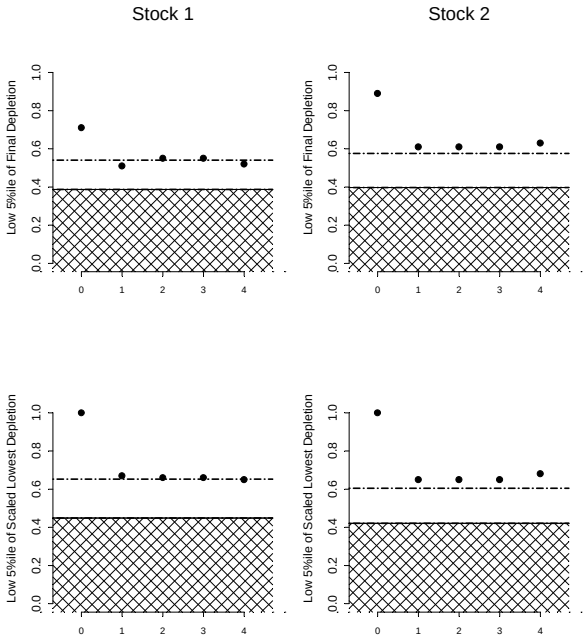


Figure 6
Comparison of the conservation performance of the no-catch scenario (‘0’) and the original four RMP variants (‘1’ – ‘4’) for trials BR09 and BR27 and the trials in which the operating model is fitted to the estimates of survival rate (in absolute terms).

(c) Trial BR27



(d) Trial BR27a (Baseline B; high catches; age-dependent mixing)



(Figure 6 Continued)