Recent assessment and projection sensitivities pursued for West Coast rock lobster

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Summary

This document investigates the implications for assessments and projections for super-area A8+ for various sensitivity tests which include a square root relationship of CPUE to biomass, and different approaches to estimating recent recruitments whose values lead to a large impact on projections. A likelihood profile for the ratio of the most recent recruitment estimate relative to pristine recruitment is also reported.

1) Super-area A8+ sensitivity test to assume $CPUE \propto q\sqrt{B}$

The BC model assumes $CPUE \propto qB$. A sensitivity test for which $CPUE \propto q\sqrt{B}$ has been run. This assumption applies to the trap and hoop CPUE, but NOT FIMS because this is a stratified random survey. The sensitivity is run for super-area A8+.

Results

Table 1 compares various statistics, including the various –lnL values for the BC and sensitivity models. Figure 1 compares the B75m/B75m(K) trajectories. Figure 2 compares model estimates to the trap, hoop and FIMS CPUE data. Figure 3 compares the Recruitment estimates (relative to that in 1910) for A8+ for two these CPUE scenarios. Figure 4 compares the B75m deterministic projections of the A8+ biomass under a future CC=161 MT for the BC and sensitivity models.

- Overall –lnL is worse for the $\sqrt{B}$ model, although better for the TRAP CPUE.
- The $\sqrt{B}$ model estimates a more pessimistic current biomass – 48% lower than for the BC.

2) Likelihood profile of $\bar{R}$ for A8+

Results

Figure 5a and b show the likelihood profile of $\bar{R}$ for A8+. These show:

- Evidence of local minima, which could lead to global maximum convergence difficulties, and also means that Hessian-based approaches could give unreliable results.
- An extremely skewed profile
- An $\bar{R}$ [1]MLE with 95% PI: 0.19 [0.15; 0.98] – i.e. very wide PI.

[1] Note that $\bar{R}$ refers to the pristine R(2010) recruitment value.

3) Sensitivity of super-area A8+ assessment fits to data and projections when R2010 is fixed

The current assessment model estimates a number of recruitment parameters over time, including those for years 2004, 2007 and 2010. It is known that these estimates have very poor precision from examination of the associated likelihood profiles. The values for these recent recruitment parameters do, however, have a large effect on FUTURE projections of the resource. What are the impacts on the assessment for fixed values of R2010 and subsequent impacts on projections (at CC=0, 161[2] and 717[3] MT)?

Results

Table 2a compares the values of the likelihood components between various models for which R2010 is fixed with those for the MLE.

Figure 6a compares projections (at a CC=161 MT) for super-area A8+ for four fixed values of R2010 (0.1, 0.3, 0.6 and 0.9) with those for the MLE.

- It is clear that the value of the R2010 parameter has little impact on –lnL for the assessment model fit to data, and hence is poorly determined.
- However, the R2010 parameter has a large impact on future projections.

4) Sensitivity of super-area A8+ assessment fits to data and projections when R2010 and R2007 are fixed

Is there a similar effect evident for the R2007 parameter? The R2007 recruitment parameter is set equal to the R2010 parameter, and both are fixed at values of 0.1, 0.3, 0.6 and 0.9.

Results

Table 2b compares the values of the likelihood components between various models for super-area A8+ for which R2007=R2010 are fixed with those for the MLE.

Figure 6b compares projections (at CC=161 MT) for super-area A8+ for four fixed values of R2007=R2010 (0.1, 0.3, 0.6 and 0.9) as well as the MLE.

- Again it is clear that the value of the R2007 parameter has similarly little impact on –lnL for the assessment results (except perhaps to exclude values below 0.3), but a large impact on the projections.

[2] 161 MT is the super-are A8+ second level of the two-step TAC (244 MT across all super-areas) which the SWG recommended in 2018. Future poaching is assumed to continue at its estimated 2018 level.
[3] 717 MT corresponds to the TAC of 1084 MT that the government has implemented for the 2019 season.

5) Sensitivity of super-area A8+ assessment fits to data and projections when R2004, R2010 and R2007 are fixed

Is there a similar effect evident for the R2004 parameter? The R2004 recruitment parameter is set equal to the R2007 and R2010 parameters, and fixed at values of 0.1, 0.3, 0.6 and 0.9.

Results

Table 2c compares the values of the likelihood components between various models for super-area A8+ for which R2004=R2007=R2010 are fixed, with those for the MLE.

Figure 6c compares projections (at CC=161 MT) of super-area A8+ for four fixed values of R2004=R2007=R2010 (0.1, 0.3, 0.6 and 0.9), as well as the MLE.

- Again it is clear that the value of the R2004 parameter similarly has little impact on the –lnL for the assessment results (except perhaps to exclude values below 0.3 and above 0.6), but a large impact on the projections.

6) Sensitivity of super-area A8+ assessment to fixing recent R2004, R2007 and R2010 recruitment parameters compared to estimating them

Given the poor precision with which the recent recruitment estimates are estimated, an alternative approach would be to fix these at the average of preceding years instead ("CONST 3"). Hence 2004, 2007 and 2010 are fixed at an average of the 1985, 1990, 1995 and 2001 values estimated in the fit. Deterministic projections for a future CC=0, 161 and 717 MT are then calculated.

Results

Table 3a compares the BC model and the model described above fits to data, current abundance levels and B75m(2025/2006) projections under a future CC=161 MT. Figure 7a plots the R estimates (relative to that in 1910) for A8+ for the two models. Figure 7b compares the estimated B75m trajectories and projected biomass for CC=161 MT.

- The CONST 3 model fits the data appreciably worse than the BC model.
- The impact which recent recruitment values have on future projections is readily evident.

7) Sensitivity of super-area A8+ assessment to fixing recent R2007 and R2010 recruitment parameters compared to estimating them

Given the poor precision with which the recent recruitment estimates are estimated, an alternative approach would be to fix these at the average of preceding years instead ("CONST 2"). Hence 2007 and 2010 are fixed at an average of the 1985, 1990, 1995 and 2001 values estimated in the fit. Deterministic projections for a future CC=0, 161 and 717 MT are then calculated.

Results

Table 3b compares the BC model and the model described above fits to data, current abundance levels and B75m(2025/2006) projections under a future CC=161 MT. Figure 8a plots the R estimates

(relative to that in 1910) for A8+ for the two models. Figure 8b compares the estimated B75m trajectories and projected biomass for CC=161 MT.

- The CONST 2 model fits to the data is somewhat worse than that for the BC model (but considerably better than for the CONST 3 model).
- The impact which recent recruitment values have on future projections is readily evident.

Table 1: Super-area A8+ assessment and projection results for two different assumptions regarding the CPUE-abundance relationship.

	BC $\boldsymbol{CPUE \propto qB}$	**Sensitivity** $\boldsymbol{CPUE \propto q\sqrt{B}}$
-lnL total	-62.589	-56.319
Trap CPUE –lnL	-38.528	-39.826
Hoop CPUE –lnL	-39.525	-33.692
FIMS CPUE –lnL	-13.273	-14.453
R_2007	0.685	0.646
R_2010	0.386	0.342
$\bar{R}$	0.542	0.505
B75m(2018) (B75m(2018)/K)	4920 (0.021)	2047 (0.009)
B75m(2025)/B75m(2006) CC=0 MT; future R = $\bar{R}$.	1.813	1.037
B75m(2025)/B75m(2006) CC=161 MT[4]; future R = $\bar{R}$.	1.229	0.926
B75m(2025)/B75m(2006) CC=717 MT[5]; future R = $\bar{R}$.	0.914	0.541
	nn.for p8.res (8v2.res)	Newn.for Ss8.res

[4] 161 MT is the super-area A8+ second level of the two-step TAC (244 MT across all super-areas for the 2019 season) which the SWG recommended in 2018. Future poaching is assumed to continue at its estimated 2018 level.

[5] 717 MT for A8+ corresponds to the TAC of 1084 MT that the government has implemented for the 2019 season.

Table 2a: Super-area A8+ assessment and projection results for different values of R2010 (either fixed or MLE).

	R2010=0.1	**R2010=0.3**	**BC MLE=0.386**	**R2010=0.6**	**R2010=0.9**
-lnL total	-62.521	-62.505	-62.589	-62.601	-62.565
Trap CPUE –lnL	-39.119	-39.017	-38.528	-39.103	-38.895
Hoop CPUE –lnL	-38.702	-38.871	-39.525	-38.715	-38.790
FIMS CPUE –lnL	-13.331	-13.277	-13.273	-13.175	-13.083
Trap male CAL –lnL	3.114	3.107	1.393	3.598	2.797
Trap female CAL –lnL	31.546	31.250	31.031	30.865	31.223
Hoop male CAL –lnL	-6.981	-7.101	-6.266	-6.838	-6.844
Hoop female CAL –lnL	6.977	6.993	7.051	6.989	6.995
FIMS male CAL –lnL	53.916	54.446	57.092	53.690	52.670
FIMS female CAL –lnL	30.483	30.918	30.729	29.971	29.622
R_1910	773 x 10^6	763 x 10^6	761 x 10^6	759 x 10^6	763 x 10^6
R_2007	0.672	0.681	0.685	0.654	0.622
R_2010	**0.10 (fixed)**	**0.30 (fixed)**	0.386	**0.60 (fixed)**	**0.90 (fixed)**
$\bar{R}$	0.545	0.547	0.542	0.549	0.545
B75m(2018) (B75m(2018)/K)	4920 (0.021)	4928 (0.021)	4920 (0.021)	4844 (0.021)	4904 (0.022)
B75m(2025)/B75m(2006) CC=0 MT; future R = $\bar{R}$.	1.576	1.797	1.813	1.890	2.029
B75m(2025)/B75m(2006) CC=161 MT; future R = $\bar{R}$.	1.084	1.266	1.229	1.375	1.550
B75m(2025)/B75m(2006) CC=717 MT; future R = $\bar{R}$.	0.887	0.959	0.914	1.065	1.240
	R10.for R01.res	R10.for R03.res	nn.for 8v2.res	R10.for R06.res	R10.for R09.res

Table 2b: Super-area A8+ assessment and projection results for different values of fixed R2007=R2010 (as well as the MLE)

	R2007=R2010 =0.1	**R2007=R2010 =0.3**	**BC MLE R2007=0.685 R2010=0.386**	**R2007=R2010 =0.6**	**R2007=R2010 =0.9**
-lnL total	-60.637	-61.467	-62.589	-62.534	-62.229
Trap CPUE –lnL	-38.740	-38.66	-38.528	-38.637	-38.994
Hoop CPUE –lnL	-38.168	-38.147	-39.525	-38.800	-39.385
FIMS CPUE –lnL	-13.639	-13.855	-13.273	-13.320	-12.299
Trap male CAL –lnL	6.369	7.956	1.393	3.178	2.356
Trap female CAL –lnL	30.904	30.396	31.031	31.041	31.765
Hoop male CAL –lnL	-6.537	-6.084	-6.266	-7.014	-7.065
Hoop female CAL –lnL	7.021	6.988	7.051	6.986	7.008
FIMS male CAL –lnL	53.311	51.842	57.092	53.209	55.568
FIMS female CAL –lnL	35.610	32.047	30.729	29.878	29.742
R_1910	772 x 10^6	770 x 10^6	761 x 10^6	769 x 10^6	763 x 10^6
R_2007	**0.1 (fixed)**	**0.3 (fixed)**	**0.685**	**0.6 (fixed)**	**0.9 (fixed)**
R_2010	**0.1 (fixed)**	**0.3 (fixed)**	**0.386**	**0.6 (fixed)**	**0.9 (fixed)**
$\bar{R}$	0.564	0.552	0.542	0.547	0.545
B75m(2018) (B75m(2018)/K)	4710 (0.021)	4832 (0.021)	4920 (0.021)	4851 (0.021)	5114 (0.22)
B75m(**2025**)/B75m(2006) CC=0 MT; future R = $\bar{R}$.	1.527	1.600	1.813	1.879	2.179
B75m(**2025**)/B75m(2006) CC=161 MT; future R = $\bar{R}$.	0.885	1.017	1.229	1.346	1.752
B75m(**2025**)/B75m(2006) CC=717 MT; future R = $\bar{R}$.	0.591	0.736	0.914	1.036	1.440
	R07.for R71.res	R07.for R73.res		R07.for R76.res	R07.for R79.res

Table 2c: Super-area A8+ assessments and projections results for different values of R2004=R2007=R2010 (as well as BC MLE).

	R2004=R2007=R2010=0.1	**R2004=R2007=R2010=0.3**	**BC MLE R2004=0.447 R2007=0.685 R2010=0.386**	**R2004=R2007=R2010=0.6**	**R2004=R2007=R2010=0.9**
-lnL total	-58.005	-61.146	-62.589	-61.366	-57.221
Trap CPUE –lnL	-36.756	-38.175	-38.528	-39.171	-37.563
Hoop CPUE –lnL	-36.416	-37.999	-39.525	-37.972	-35.823
FIMS CPUE –lnL	-13.091	-13.702	-13.273	-13.872	-15.237
Trap male CAL –lnL	14.885	10.353	1.393	-0.865	14.434
Trap female CAL –lnL	29.921	31.010	31.031	32.436	30.998
Hoop male CAL –lnL	-5.241	-6.000	-6.266	-7.787	-3.099
Hoop female CAL –lnL	6.927	6.991	7.051	7.003	7.109
FIMS male CAL –lnL	47.105	49.254	57.092	57.761	58.597
FIMS female CAL –lnL	28.385	29.223	30.729	33.793	36.245
R_1910	805 x 10^6	775 x 10^6	761 x 10^6	749 x 10^6	699 x 10^6
R_2004	**0.1 (fixed)**	**0.3 (fixed)**	**0.447**	**0.6 (fixed)**	**0.9 (fixed)**
R_2007	**0.1 (fixed)**	**0.3 (fixed)**	**0.685**	**0.6 (fixed)**	**0.9 (fixed)**
R_2010	**0.1 (fixed)**	**0.3 (fixed)**	**0.386**	**0.6 (fixed)**	**0.9 (fixed)**
$\bar{R}$	0.562	0.563	0.542	0.536	0.440
B75m(2018) (B75m(2018)/K)	4446 (0.019)	4740 (0.022)	4920 (0.021)	5172 (0.023)	6058 (0.029)
B75m(**2025**)/B75m(2006) CC=0 MT; future R = $\bar{R}$.	0.887	1.089	1.813	1.470	1.433
B75m(**2025**)/B75m(2006) CC=161 MT; future R = $\bar{R}$.	0.808	1.006	1.229	1.379	1.349
B75m(**2025**)/B75m(2006) CC=717 MT; future R = $\bar{R}$.	0.534	0.719	0.914	1.057	1.059
	R04.for R41.res	R43.res		R46.res	R49.res

Table 3a: Super-area A8+ assessment and projection results for two different methods for modelling recent recruitment: BC and CONST 3.

	BC **R2004, R2007 and R2010 are estimated parameters**	**CONST 3** **R2004, R2007 and R2010 are fixed at the R1985...R2001 average**
-lnL total	-62.589	-53.262
Trap CPUE –lnL	-38.528	-35.121
Hoop CPUE –lnL	-39.525	-34.946
FIMS CPUE –lnL	-13.273	-12.402
R_2007	0.685	0.331
R_2010	0.386	0.331
$\bar{x}$	0.542	0.571
B75m(2018) (B75m(2018)/K)	4920 (0.021)	4553 (0.020)
B75m(2025)/B75m(2006) CC=0 MT; future R = $\bar{R}$.	1.813	0.714
B75m(2025)/B75m(2006) CC=161 MT; future R = $\bar{R}$.	1.229	0.642
B75m(2025)/B75m(2006) CC=717 MT; future R = $\bar{R}$.	0.914	0.391
	nn.for p8.res (8v2.res)	Fix.for Fix1.res

Table 3b: Super-area A8+ assessment and projection results for two different methods for modelling recent recruitment: BC and CONST 2.

	BC **R2004, R2007 and R2010 are estimated parameters**	**CONST 2** **R2007 and R2010 are fixed at the R1985...R2001 average**
-lnL total	-62.589	-57.616
Trap CPUE –lnL	-38.528	-37.689
Hoop CPUE –lnL	-39.525	-36.786
FIMS CPUE –lnL	-13.273	-13.545
R_2004		0.520
R_2007	0.685	0.287
R_2010	0.386	0.287
$\bar{x}$	0.542	0.545
B75m(2018) (B75m(2018)/K)	4920 (0.021)	4652 (0.020)
B75m(2025)/B75m(2006) CC=0 MT; future R = $\bar{R}$.	1.813	0.777
B75m(2025)/B75m(2006) CC=161 MT; future R = $\bar{R}$.	1.229	0.696
B75m(2025)/B75m(2006) CC=717 MT; future R = $\bar{R}$.	0.914	0.415
	nn.for p8.res (8v2.res)	Fix2.for Fix2.res

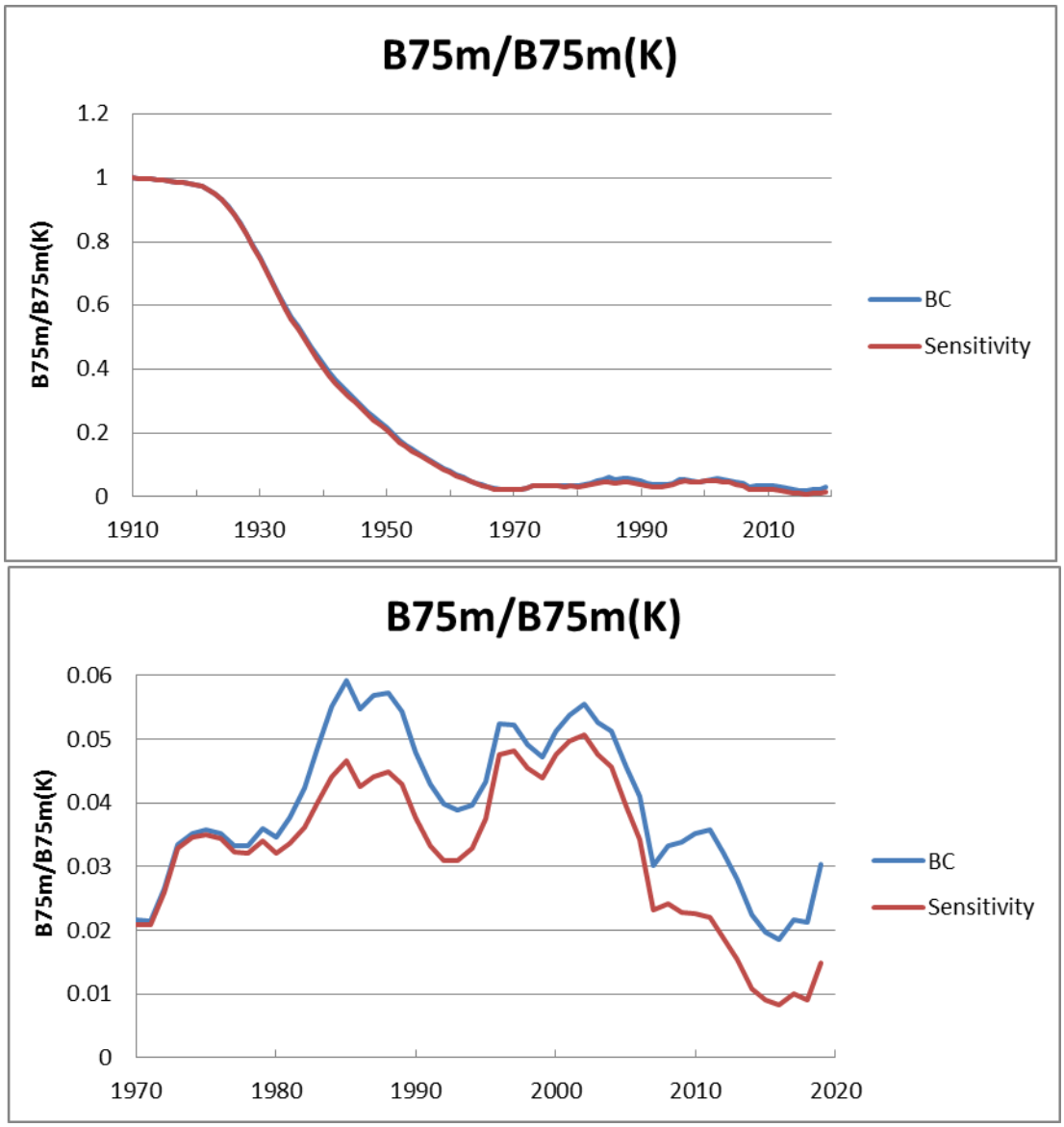

Figure 1: Super-area A8+ B75m/B75m(K) trajectories for the BC and Sensitivity scenario of Table 1 for two different assumptions regarding the CPUE-abundance relationship. The bottom plot shows the 1970+ period only.

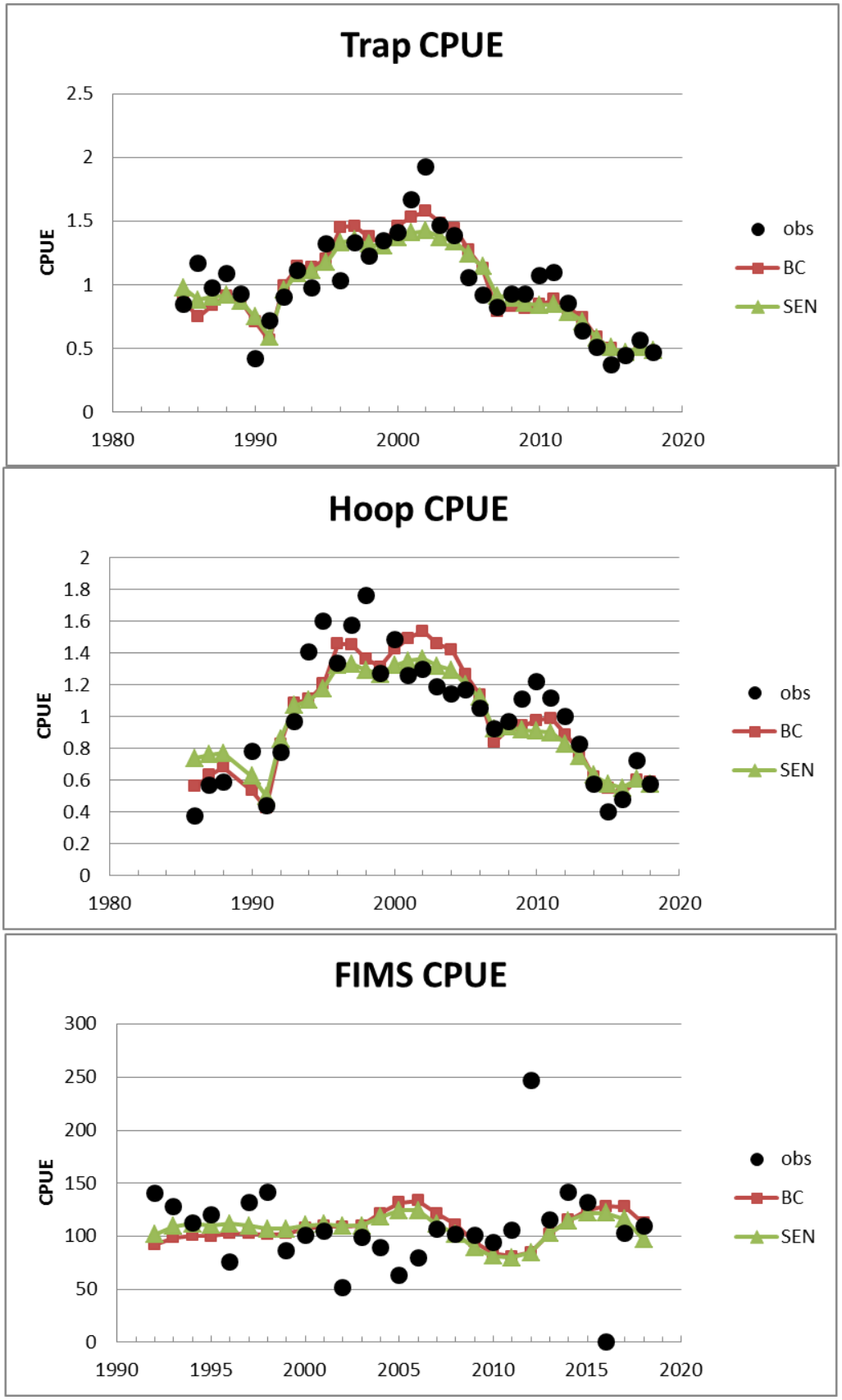

Figure 2: Comparison of fits to super-area A8+ CPUE as per Table 1 for two different assumptions (BC and a sensitivity run: CPUE proportional to biomass and the square root of biomass respectively) regarding the CPUE-abundance relationship.

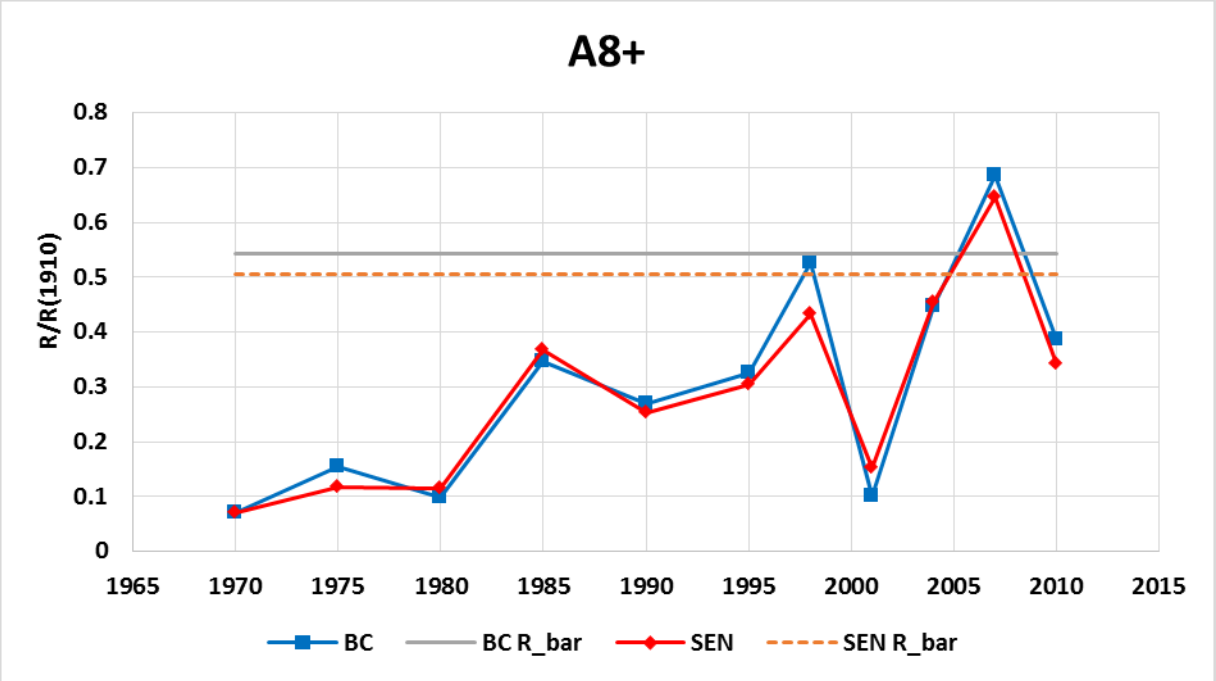

Figure 3: R estimates (relative to that in 1910) for super-area A8+ for two different assumptions regarding the CPUE-abundance relationship in Table 1 (proportional to biomass and to its square root)

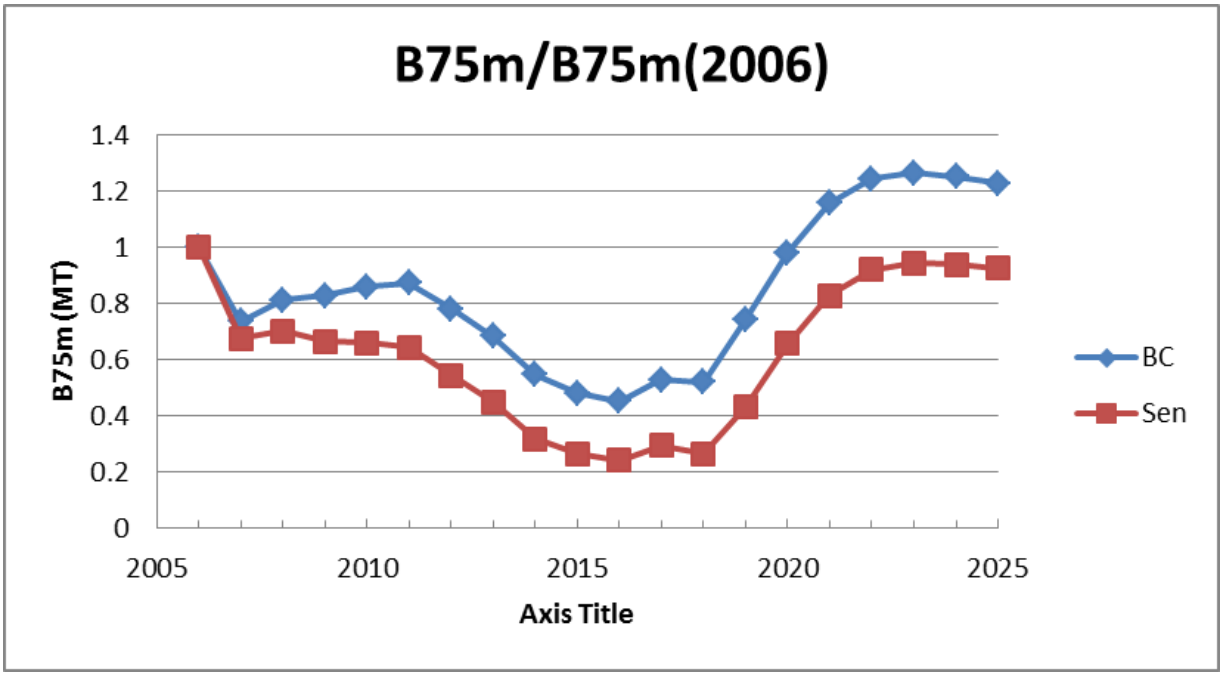

Figure 4: B75m deterministic projections of super-area A8+ biomass under a future CC=161 MT for two different assumptions regarding the CPUE-abundance relationship (proportional to biomass and to its square root).

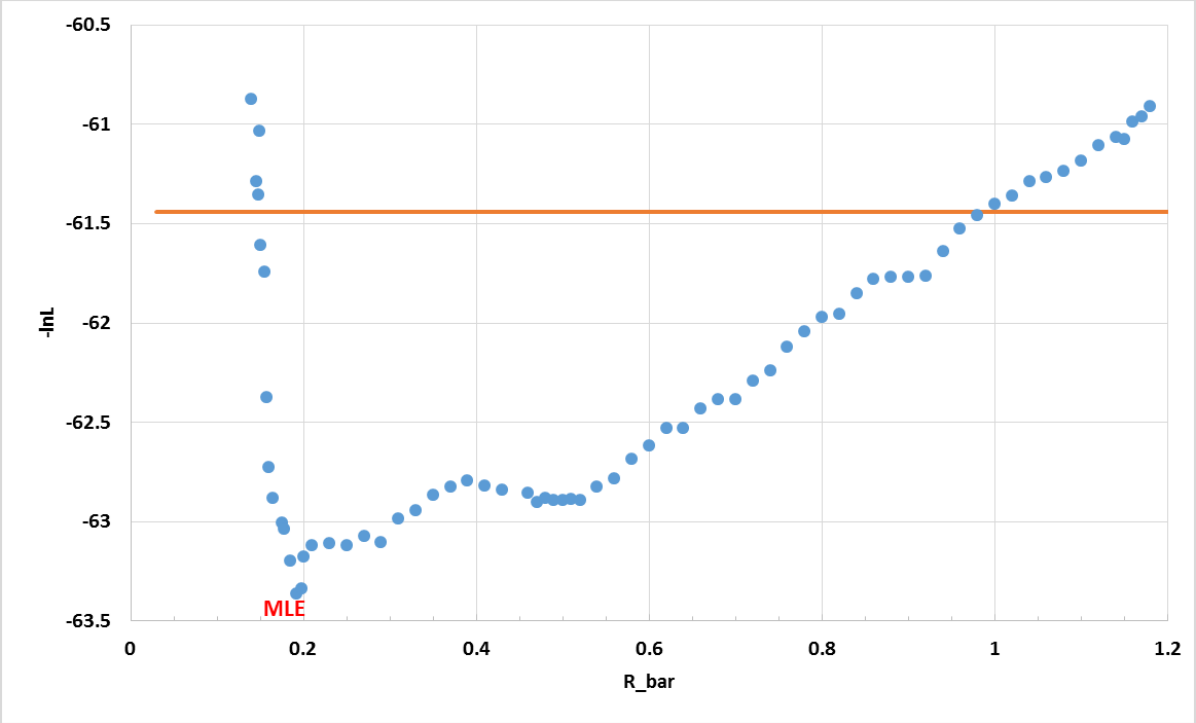

Figure 5a: The likelihood profile of $\bar{R}$ for super-area A8+. The horizontal line is 1.92 log-likelihood units above the minimum (MLE) value.

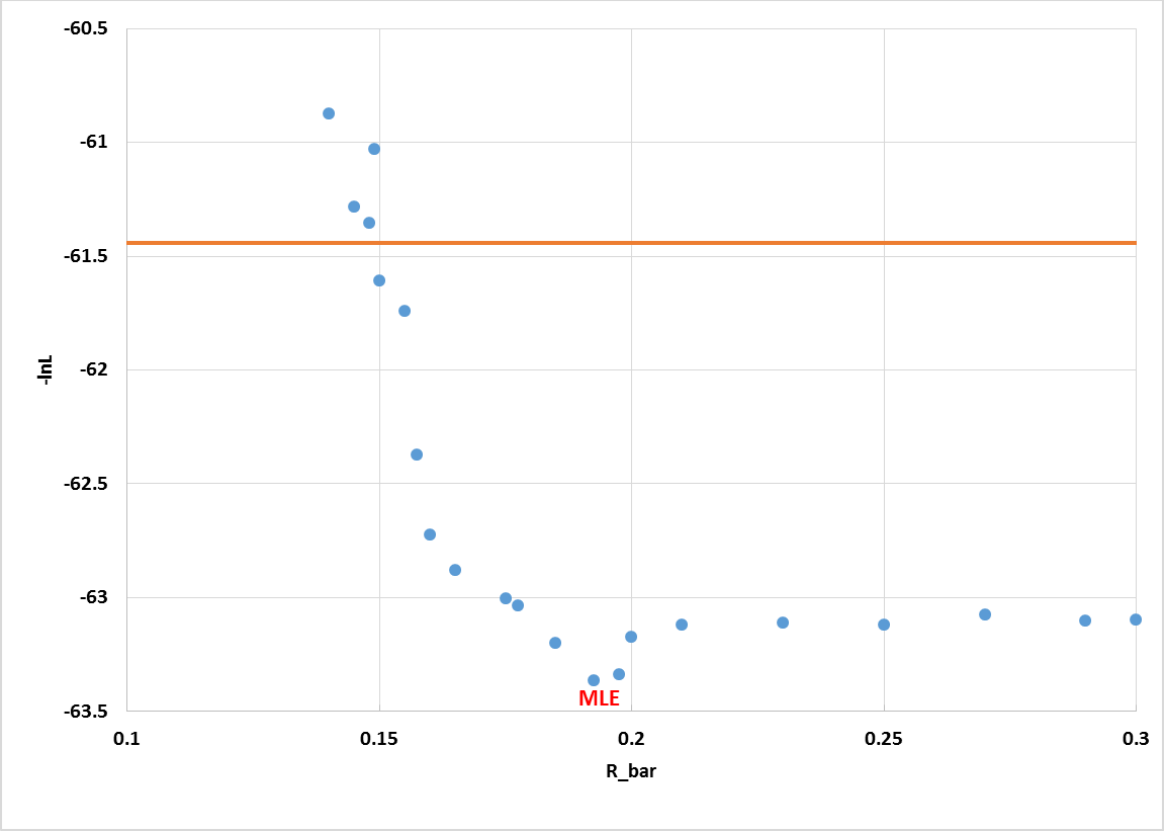

Figure 5b: A zoom in on Figure 6a above for the likelihood profile of $\bar{R}$ for super-area A8+.

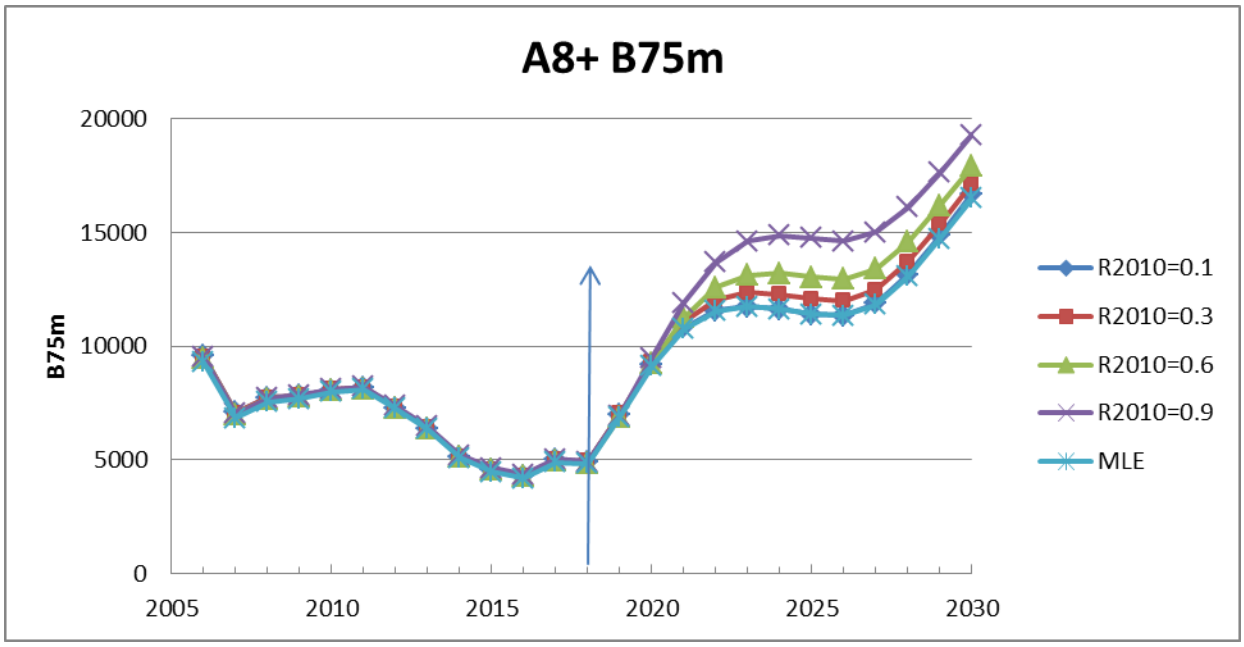

Figure 6a: Super-area A8+ B75m projections (at CC=161 MT) for the MLE and for four fixed values of R2010 (0.1, 0.3, 0.6 or 0.9) – corresponds to Table 2a.

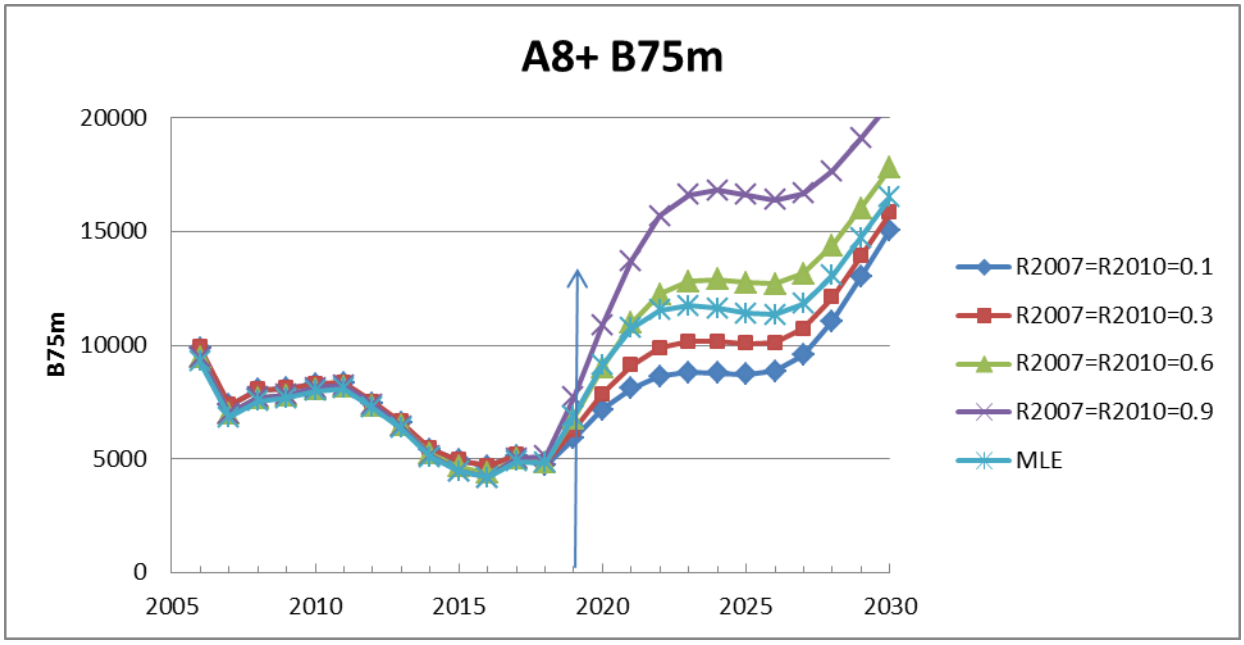

Figure 6b: Super-area A8+ B75m projections (at CC=161 MT) for the MLE and for four fixed values of R2007=R2010 (0.1, 0.3, 0.6 or 0.9) – corresponds to Table 2b.

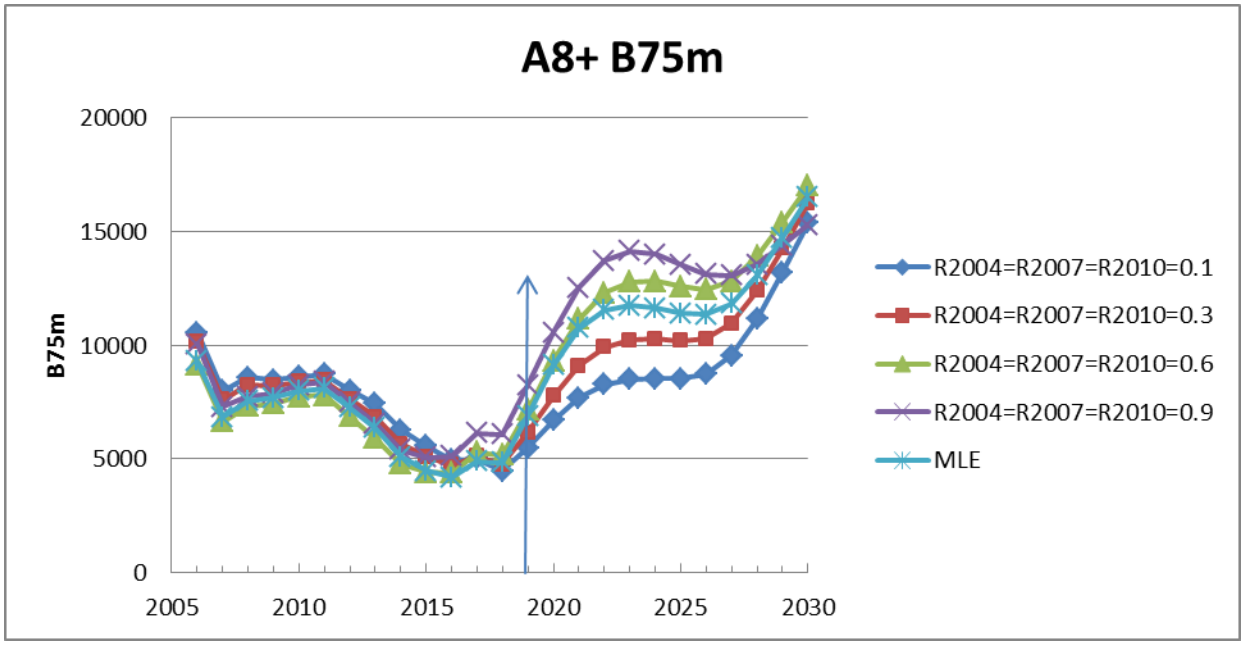

Figure 6c: Super-area A8+ B75m projections (at CC=161 MT) for the MLE and for four fixed values of R2004=R2007=R2010 (0.1, 0.3, 0.6 or 0.9) – corresponds to Table 2c.

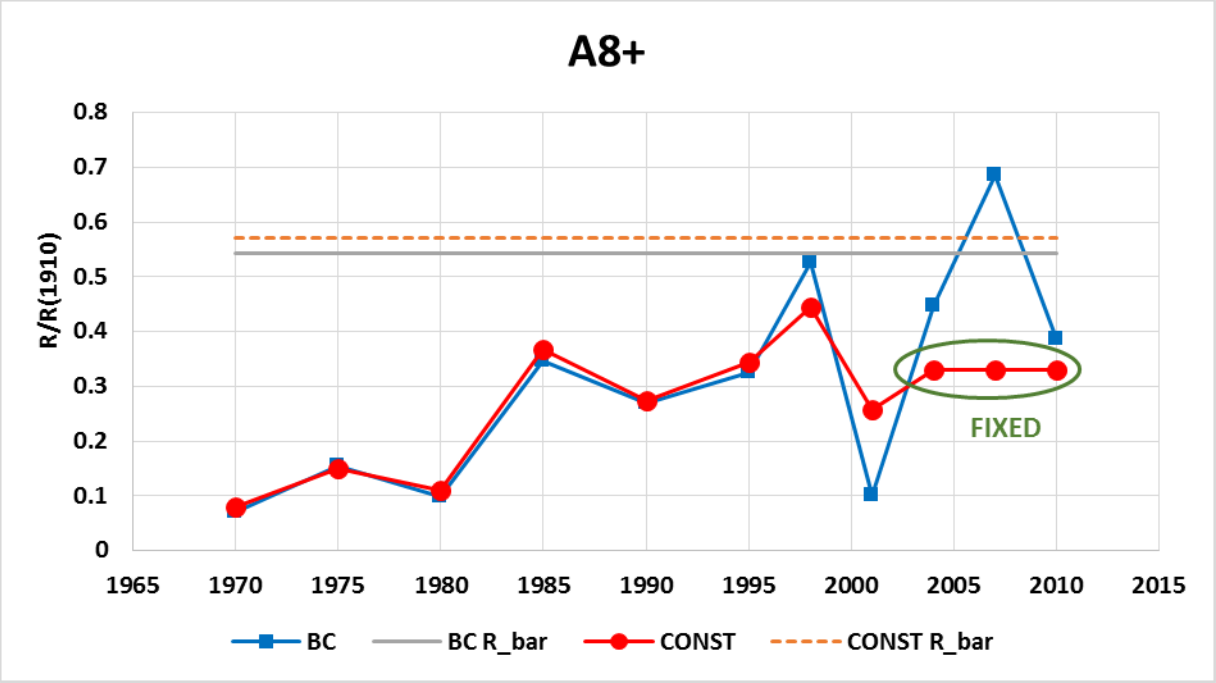

Figure 7a: R estimates (relative to that in 1910) for super-area A8+ for the BC and CONST 3 models. For the latter R2004, R2007 and R2010 are FIXED to equal each other.

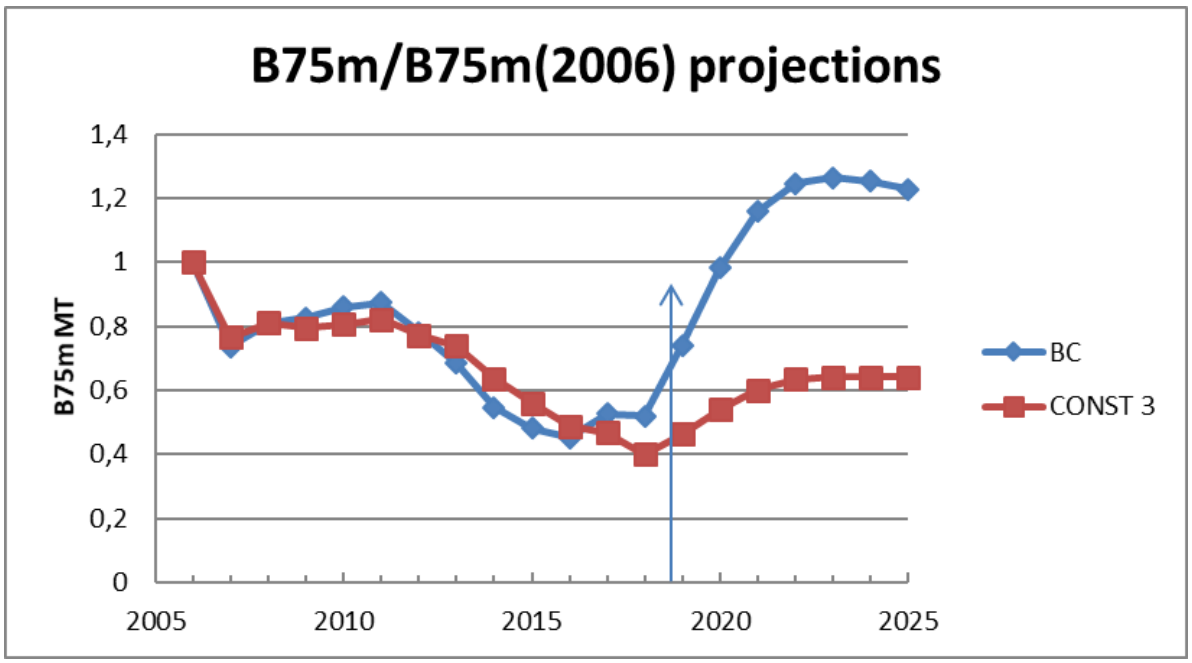

Figure 7b: Comparison between the super-area A8+ BC and the CONST 3 model for a future CC of 161 MT.

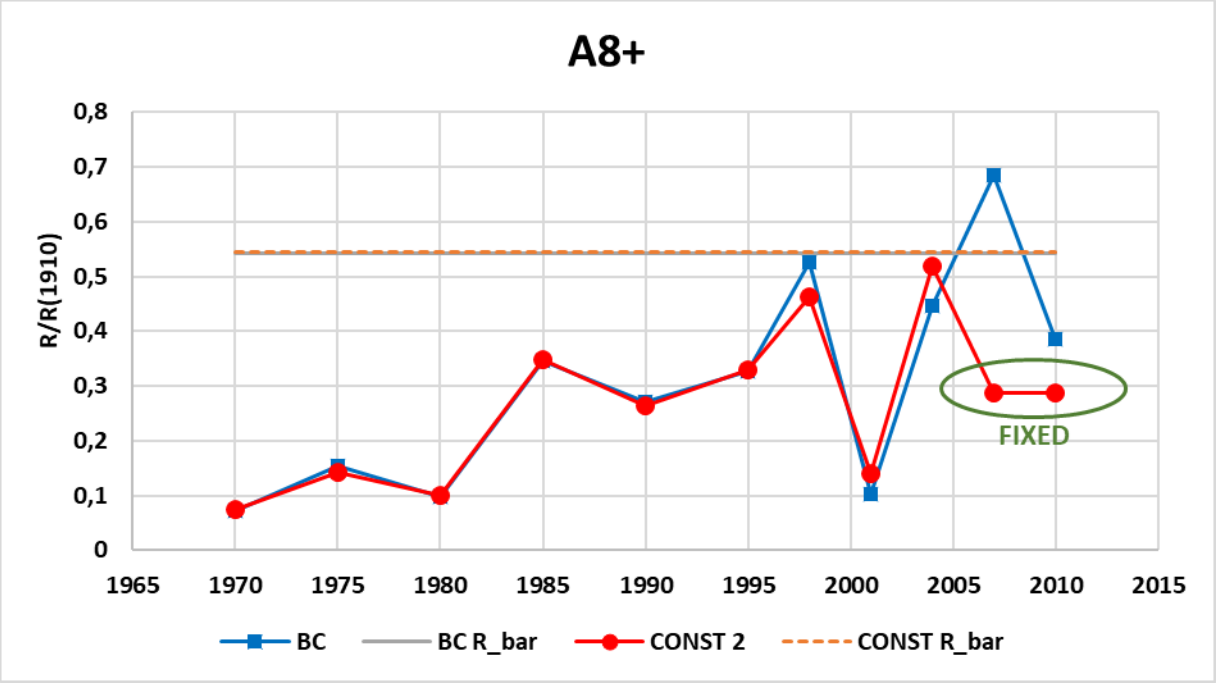

Figure 8a: R estimates (relative to that in 1910) for super-area A8+ for the BC and CONST 2 models. For the latter R2007 and R2010 are FIXED to equal each other.

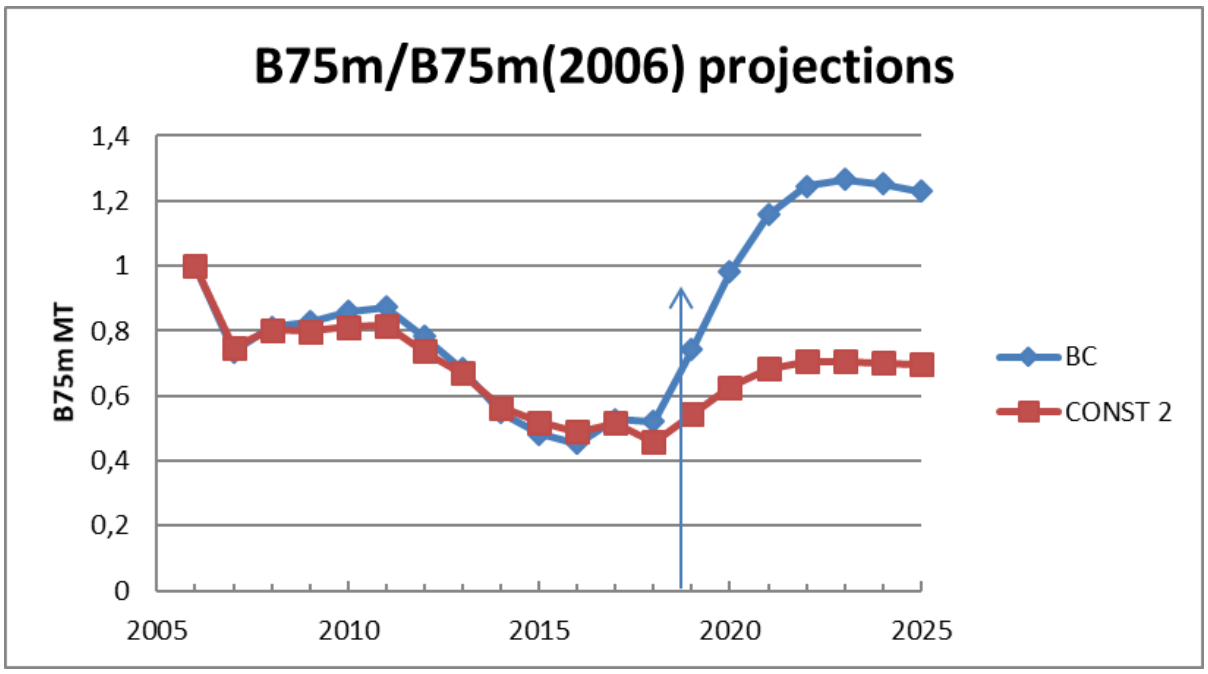

Figure 8b: Comparison between the super-area A8+ BC and the CONST 2 model for a future CC of 161 MT.