Updated 2020 horse mackerel assessments and projections

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Summary

This document reports updated 2020 horse mackerel assessments, along with constant midwater catch projections for the base case model and seven model sensitivities. These models include exploring alternative values for natural mortality at age, and fixing 2015 and 2016 recruitment residuals to zero, and changing the values assumed for the catchability for Autumn survey and for the stock-recruitment steepness.

INTRODUCTION

This document provides updated assessments for the Base Case (BC) and seven sensitivity models (three of which were run last year). Updated data and the full model description can be found in FISHERIES/2020/OCT/SWG-DEM/18.

ASSESSMENT MODELS

BC The previous 2019 BC which assumes a catchability change over 2014 to 2016. The model estimates two survey selectivity functions. The "OLD" selectivity function is used for surveys conducted with the old gear, with the "NEW" selectivity function used for surveys conducted with the new gear. The old gear selectivity function is assumed to apply to the demersal fisheries bycatches taken.

VAR 1 BC model, but natural mortality M_{10+} = 2.0 (M_a for other ages remain 0.3), i.e. the size of the plus group is much reduced.

VAR 2 BC model, but natural mortality for all ages is increased to M_a = **0.5**.

VAR 3: BC model, but fix last two estimated recruitment residuals (2015 and 2016) to zero.

VAR 4: BC model, but the demersal q_{aut} value is fixed at **0.5** (BC q_{aut}=0.75).

VAR 5: BC model, but the demersal q_{aut} value is fixed at **1.0** (BC q_{aut}=0.75).

VAR 6: BC model, but the h value is fixed at **0.6** (BC h=0.75).

VAR 7: BC model, but the h value is fixed at **0.9** (BC h=0.75).

The motivation for sensitivities VAR 4 to VAR 7 is that these reflect the original uncertainty ranges assumed for the parameters concerned, whose averages were later taken to apply for the BC.

PROJECTIONS

Projections are reported for the BC model as well as VAR1-3. For each projection scenario, the resource is projected ahead for 10 years, and the projections are repeated 1000 times with noise added to the future recruitment and incorporating uncertainty about future CPUE estimates.

The rules to compute future simulated catches under various management approaches are set out below.

1) Pelagic bycatches

Figure 1 below plots pelagic bycatches (in 1000 MT) against annual horse mackerel recruitment (in billions).

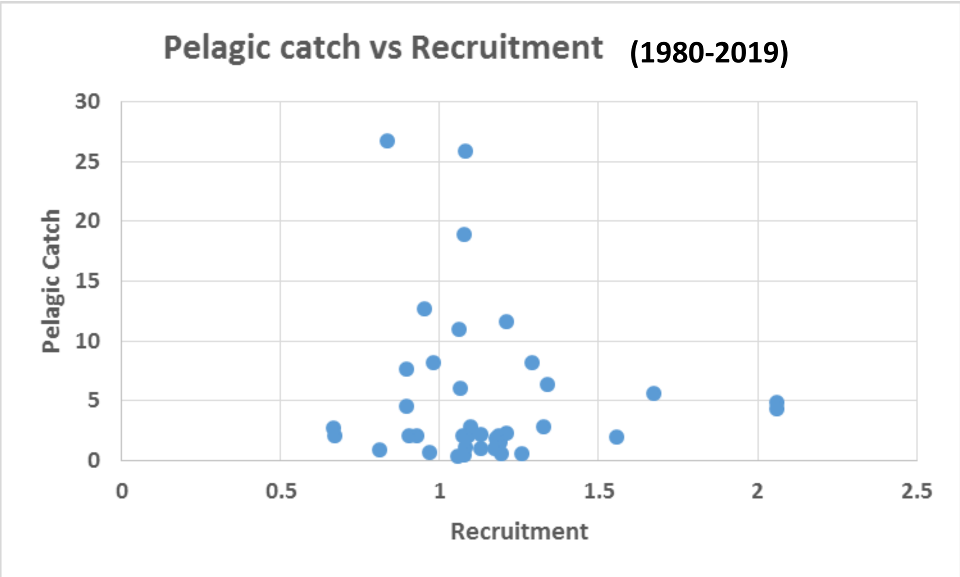

Figure 1: Pelagic catches versus recruitment (BC model).

- Note that there is no clear relationship between pelagic bycatches and recruitment.
- Hence future (2020+) pelagic bycatches are set by drawing at random with replacement from the set of pelagic bycatches for the period 2000-2019, except that a value generated which is in excess of $PUCL_{y+1}$ below is reduced to $PUCL_{y+1}$, where:

  $PUCL_{y+1}$=12 000 - C_y^{pel} - C_{y-1}^{pel}.   (Units: MT)

Note 12 000 (previously called $PULC_3$) is the total amount in MT that may be caught over a three-year period (see FISHERIES/2015/MAR/SWG-DEM/03).

2) Incidental trawl/Demersal bycatches – constant proportion of HM biomass

As recommended in FISHERIES/2016/OCT/SWG-DEM/79, the average reported incidental bycatches for the period 2000-2019 should be considered in the averaging used in order to produce a more representative $\bar{F}_{trawl}$ exploitation rate value. Table 1 below reports the demersal bycatches, BC estimated horse mackerel biomass values, and the resultant exploitation proportion F=C/B. The median and upper 95th percentile of the F values over the years calculated (assuming a normal distribution) are reported. It was agreed (in 2018) that the upper 95th percentile (to allow for catchability fluctuations) of the 2000-2017 (now 2000-2019) F values (which turns out to be **0.0309**) would be the $\bar{F}_{trawl}$ value used in future equations to calculate the future demersal bycatches, i.e.:

Future demersal bycatches = $\bar{F}_{trawl} * B_{exp}^{dem}$

Table 1: BC model estimates of biomass, demersal catches and resultant F (=catch/biomass).

	Demersal catch	**Demersal biomass (t)**	**F**
2000	9229	271426	0.0340
2001	8814	290127	0.0304
2002	4863	321342	0.0151
2003	3562	228880	0.0156
2004	4933	223962	0.0220
2005	5280	232036	0.0228
2006	4133	234415	0.0176
2007	4812	259684	0.0185
2008	4449	323571	0.0137
2009	4129	381611	0.0108
2010	5596	383527	0.0146
2011	5228	349513	0.0150
2012	4941	314738	0.0157
2013	2695	312844	0.0086
2014	3087	292037	0.0106
2015	4747	289413	0.0164
2016	5203	305547	0.0170
2017	5703	302382	0.0189
2018	4626	289273	0.0160
2019	3114	295042	0.0106
		median	0.0158
		upper 95%ile	**0.0309**

Midwater directed catches

Projections for a series of future constant annual catches of 0, 10, 20, 30 and 40 thousand MT are reported.

RESULTS

Tables 2a and b provide a summary of results for the different assessments. Figures 1a-b compare the model fits to the *Desert Diamond* (DD) CPUE values. Figures 2a-b compare the model fits to the Dual Rights vessels' CPUE values. Figures 3a-b and 4a-b compare the model fits to the Autumn and Spring survey biomass estimates respectively. Figures 5a and b plot the spawning biomass estimates and the spawning biomass estimates relative to pristine for different assessment models. Figures 6a and b and 7a and b plot the demersal exploitable biomass and midwater exploitable biomass respectively, for different assessment models. Figures 8a and b plot the spawning biomass (B^{sp}), exploitable demersal (B^{exp_d}) and exploitable midwater (B^{exp_m}) biomass trajectories for the Base Case and sensitivity models.

Figure 9 compares the spawning biomass (B^{sp}), exploitable demersal (B^{exp_d} – related also to surveys) and exploitable midwater (B^{exp_m} – pertinent to the Desert Diamond) biomass trajectories for the BC model.

Figures 10a and b plot the estimated stock-recruit residuals for the different assessments.

Figure 11 reports the estimated (and input) selectivity functions for the BC model.

Figure 12a shows projection results for the BC model. Results are shown for various projected levels of constant annual midwater catches. Plots of median and lower 5 %ile B^{sp}/K^{sp}, median CPUE and median midwater catches are shown. Note that the future spawning biomass uncertainty shown takes account of future stock-recruitment variability about the stock-recruitment curve only. Figure 12b shows projection results for the VAR2 sensitivity model.

Figure 13a compares B^{sp}/K^{sp} median (left) and lower 5th %ile (right) projections for either future midwater constant catch of 20 000 MT (top row) or 30 000 MT (bottom row). Results are shown for the BC and VAR1-VAR3 assessment models. Figure 13b similarly compares these statistics for VAR4-VAR7. Figure 13c is similar to Figure 13a except comparisons are between the 2019 and 2020 BC model estimated projections.

DISCUSSION

The following points merit noting.

- The evidence for poor recruitment (Figure 10a) for the last two years for which recruitment is estimated (2015 and 2016) continues to be very weak for the BC (little deterioration in -lnL when these residuals are set to zero for VAR 3 – see Table 2), and these recruitment estimates impact recent spawning biomasses only very slightly (Figure 5a). For M increased to 0.5 (VAR 2), the recruitment deviations for these two years are estimated to be close to zero.
- Increasing M sees the absolute magnitudes of the estimated spawning biomasses drop (Figure 5a). With senescence (a high M at large ages), the resource is estimated to have been more heavily depleted historically, though this change in assumptions hardly impacts estimates of the depletion (B^{sp}/K^{sp}) at present; however, for M higher at 0.5, the depletion estimate at present increases from about 63% to 76% (Figure 6a).
- Over the last decade, the spawning biomass has increased by over 70%, whereas the survey and midwater exploitable components of biomass have been near constant (Figure 5a). This is a consequence of doming in the selectivities for these last two components, which consequently are reflections more of “throughput” than of standing stock.
- The results from changes to h and q_{aut} are as expected, both for the assessment results and the projections: those with lower h are more pessimistic, while those with lower q_{aut} (corresponding to higher abundance in absolute terms) are more optimistic.

- All the future (non-zero) levels of midwater catch considered lead to a reduction in spawning biomass (and CPUE) in median terms. For annual midwater catches 30 000 MT, this would not be of concern in terms of stock status (which would still remain well above the corresponding MSY level), though CPUE would be expected to drop by about 15% (Figure 7a). These results are not sensitive to variations of the new BC assessment, except insofar as depletions are estimated to be about 5-10% higher if *M* is increased to 0.5 (Figure 7c). However, these projections are rather more pessimistic if the lower 5%-iles rather than the medians of the depletion distributions are considered.
- In median terms the 2020 BC model projections are near identical to those estimated by the 2019 BC model (Figure 13c). The 2020 BC model projections at the lower 5th %ile are however some 10-15% more optimistic.

REFERENCE

Johnston, S.J. and Butterworth, D.S. 2020. Updated 2020 horse mackerel data and model description. FISHERIES/2020/OCT/SWG-DEM/18

Table 2a: Summary of results for the BC and VAR1-VAR3 sensitivity models. All variants fix q_{aut} = 0.75 and h = 0.75. "SR" and "CAL" refer to stock-recruitment and catch-at-length contributions respectively. Biomass units are thousand MT. The 2019 BC results are shown in first shaded column for comparison.

	2019 BC M_a = 0.3	**BC** M_a = 0.3	**VAR1** M_a = 0.3 except M_{10+} = 2.0	**VAR2** M_a = 0.5	**VAR3** SR residuals = 0 for 2015 and 2016
# estimable parameters	42	42	42	42	40
q_{aut}	0.75	0.75	0.75	0.75	0.75
h	0.75	0.75	0.75	0.75	0.75
-ln L :Total	-257.571	-266.948	-266.846	-265.082	-266.786
-ln L :Spr survey	0.461	0.483	0.032	-0.278	0.546
-ln L :Aut survey	-7.927	-5.574	-5.683	-4.269	-5.233
-ln L :CPUE	-9.850	-11.114	-11.101	-11.181	-11.408
-lnL Dual Rights	-7.212	-7.315	-7.336	-6.919	-7.233
-ln L :CAL Spr survey	-46.447	-46.303	-45.908	-45.426	-45.988
-ln L :CAL Aut survey	-85.354	-89.176	-88.988	-88.133	-89.098
-ln L :CAL commercial	-82.493	-89.158	-88.967	-89.862	-89.452
-ln L :SR residuals	-18.747	-18.792	-18.897	-19.015	-18.920
K^{sp} (KT)	799	773	578	442	779
B^{sp}_{2018} (KT)	**525**	500	391	**347**	**502**
B^{sp}_{2019} (KT)	**-**	**488**	**382**	**335**	**504**
$MSYL^{sp}$ (KT)	196	**189**	**153**	107	191
MSY (KT)	58	56	58	65	56
B^{sp}_{2018}/K^{sp}	**0.658**	0.646	**0.677**	**0.786**	**0.545**
B^{sp}_{2019}/K^{sp}	**-**	**0.632**	**0.661**	**0.758**	**0.647**
q_2 (applies to 2014)	0.272*q_{CPUE}	0.269*q_{CPUE}	0.271*q_{CPUE}	0.272*q_{CPUE}	0.272*q_{CPUE}
	2019 xHorse.tpl	2020 xHorse.tpl	Xh1.tpl	Xh3.tpl	Xh4.tpl

Table 2b: Summary of results for the BC and VAR4-VAR7 sensitivity models. "SR" and "CAL" refer to stock-recruitment and catch-at-length contributions respectively. Biomass units are thousand MT.

	BC q_{aut}=0.75 h=0.75	**VAR4** q_{aut}=0.5	**VAR5** q_{aut}=1.0	**VAR6** h=0.6	**VAR7** h=0.9
# estimable parameters	42	42	42	42	42
q_{aut}	0.75	**0.50**	**1.00**	0.75	0.75
h	0.75	0.75	0.75	**0.6**	**0.9**
-ln L :Total	-266.948	-267.882	-264.550	-266.635	-266.257
-ln L :Spr survey	0.483	0.527	0.483	0.492	0.380
-ln L :Aut survey	-5.574	-6.357	-3.274	-5.573	-5.682
-ln L :CPUE	-11.114	-11.080	-11.237	-11.229	-10.591
-lnL Dual Rights	-7.315	-7.221	-7.275	-7.156	-7.162
-ln L :CAL Spr survey	-46.303	-46.219	-46.384	-46.153	-46.469
-ln L :CAL Aut survey	-89.176	-89.348	-88.536	-89.039	-89.031
-ln L :CAL commercial	-89.158	-89.557	-89.178	-89.278	-88.954
-ln L :SR residuals	-18.792	-18.628	-19.150	-18.701	-18.747
K^{sp} (KT)	773	993	753	898	753
B^{sp}_{2018} (KT)	500	801	462	499	539
B^{sp}_{2019} (KT)	488	783	458	489	523
$MSYL^{sp}$ (KT)	189	243	184	273	130
MSY (KT)	56	71	55	51	68
B^{sp}_{2018}/K^{sp}	0.646	0.807	0.614	0.555	0.715
B^{sp}_{2019}/K^{sp}	0.632	0.788	0.608	0.544	0.693
q_2 (applies to 2014)	0.269*q_{CPUE}	0.266*q_{CPUE}	0.268*q_{CPUE}	0.270*q_{CPUE}	0.272*q_{CPUE}
	2020 xHorse.tpl	Q2a.tpl	Q2b.tpl	H6.tpl	H6b.tpl

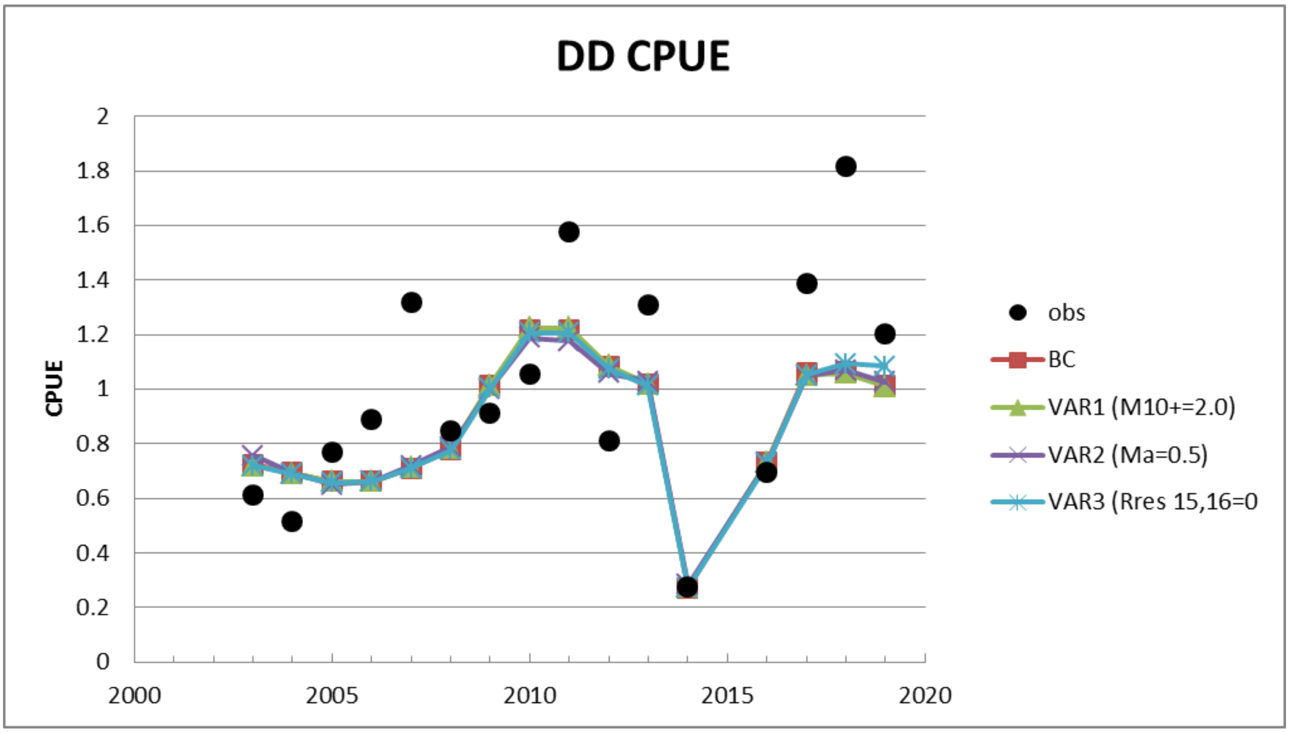

Figure 1a: Comparisons between the BC and VAR1-VAR3 sensitivity model fits to the *Desert Diamond* (DD) CPUE values.

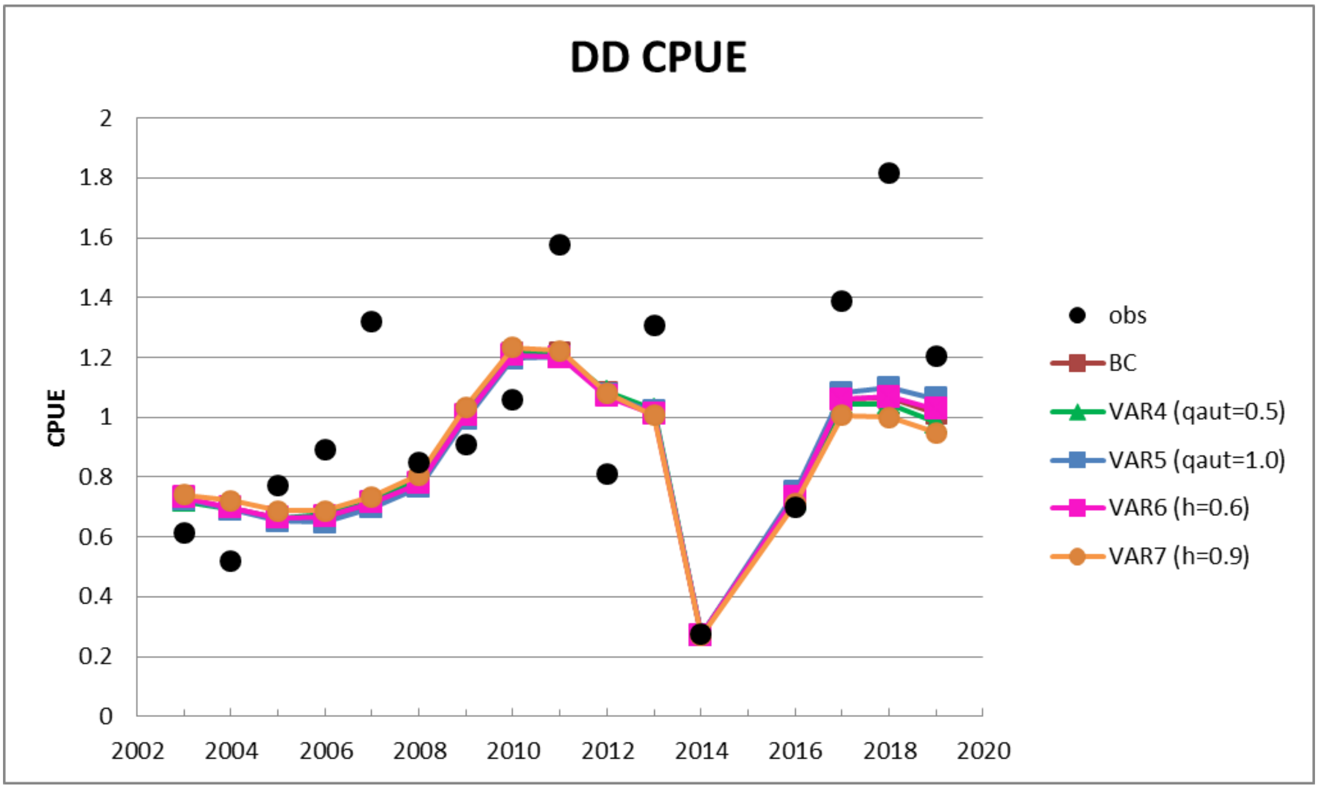

Figure 1b: Comparisons between the BC and VAR4-VAR7 sensitivity model fits to the *Desert Diamond* (DD) CPUE values.

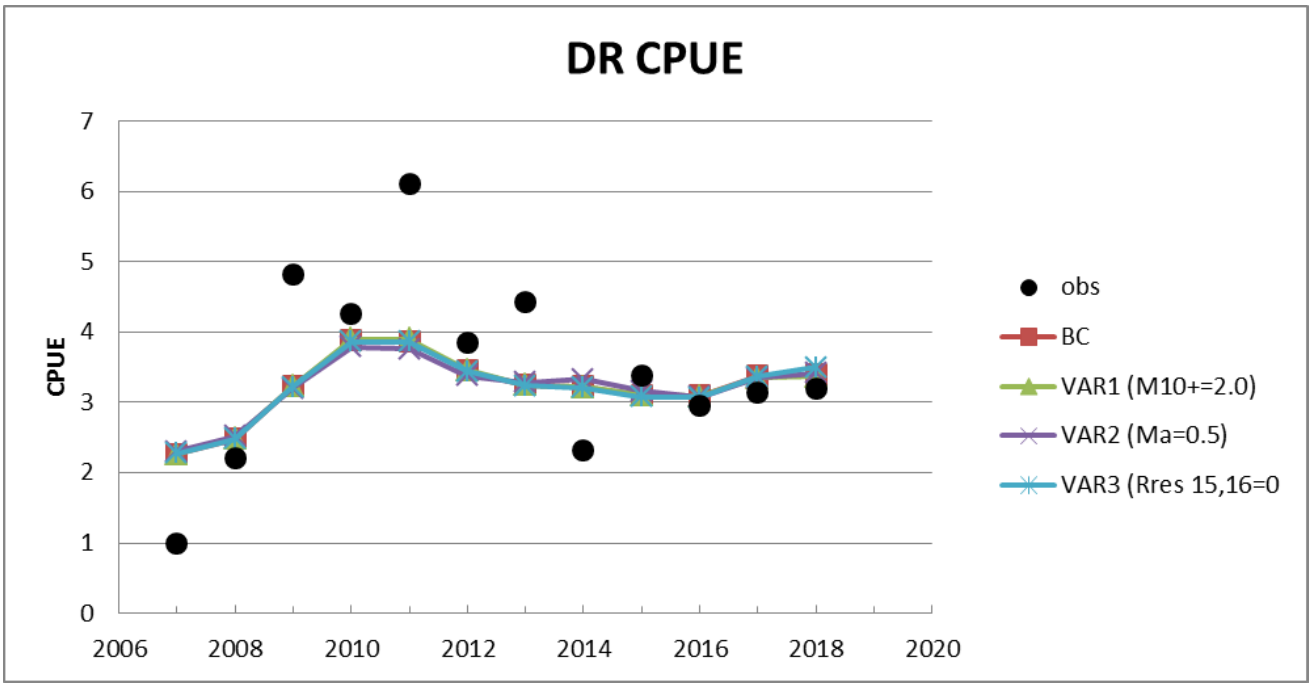

Figure 2a: Comparisons between the BC and VAR1-VAR3 sensitivity model fits to the Dual Rights (DR) vessels' CPUE values.

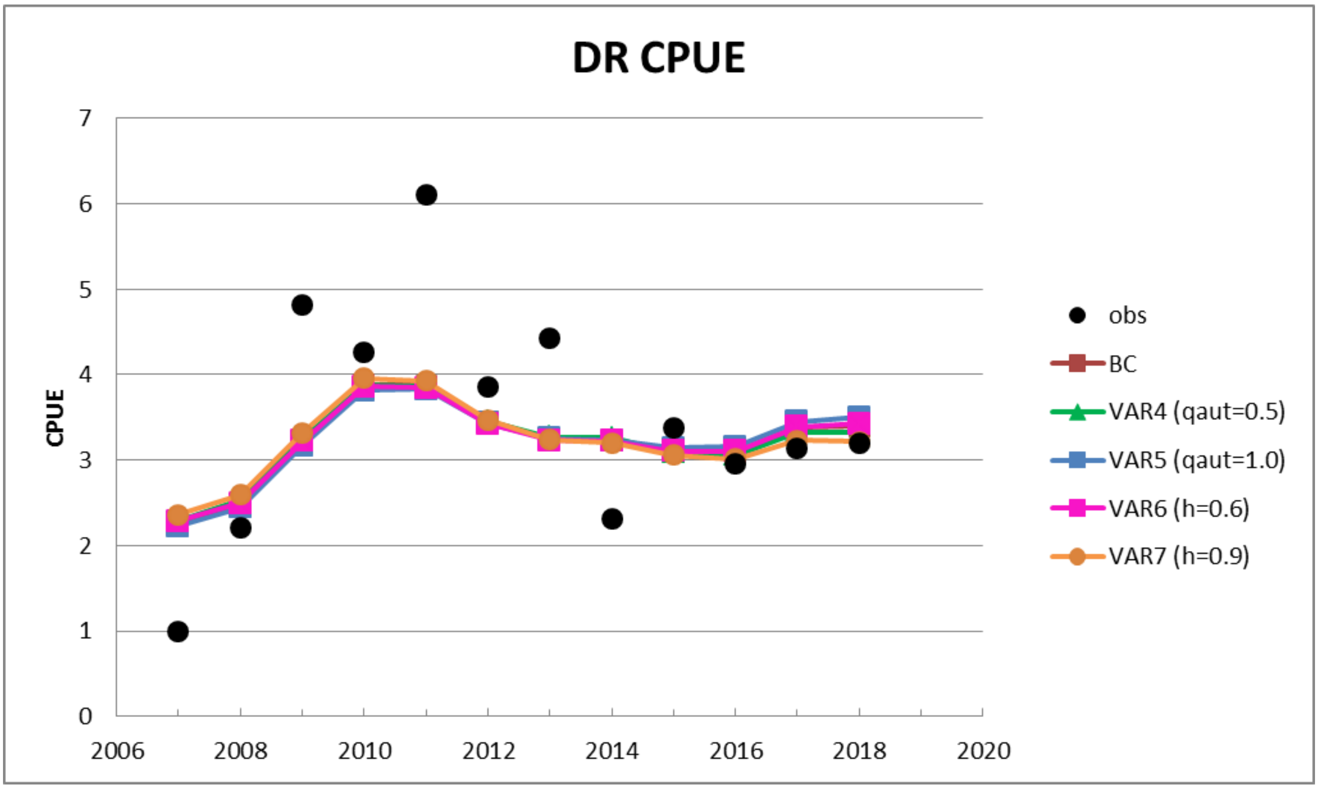

Figure 2b: Comparisons between the BC and VAR4-VAR7 sensitivity model fits to the Dual Rights (DR) vessels' CPUE values.

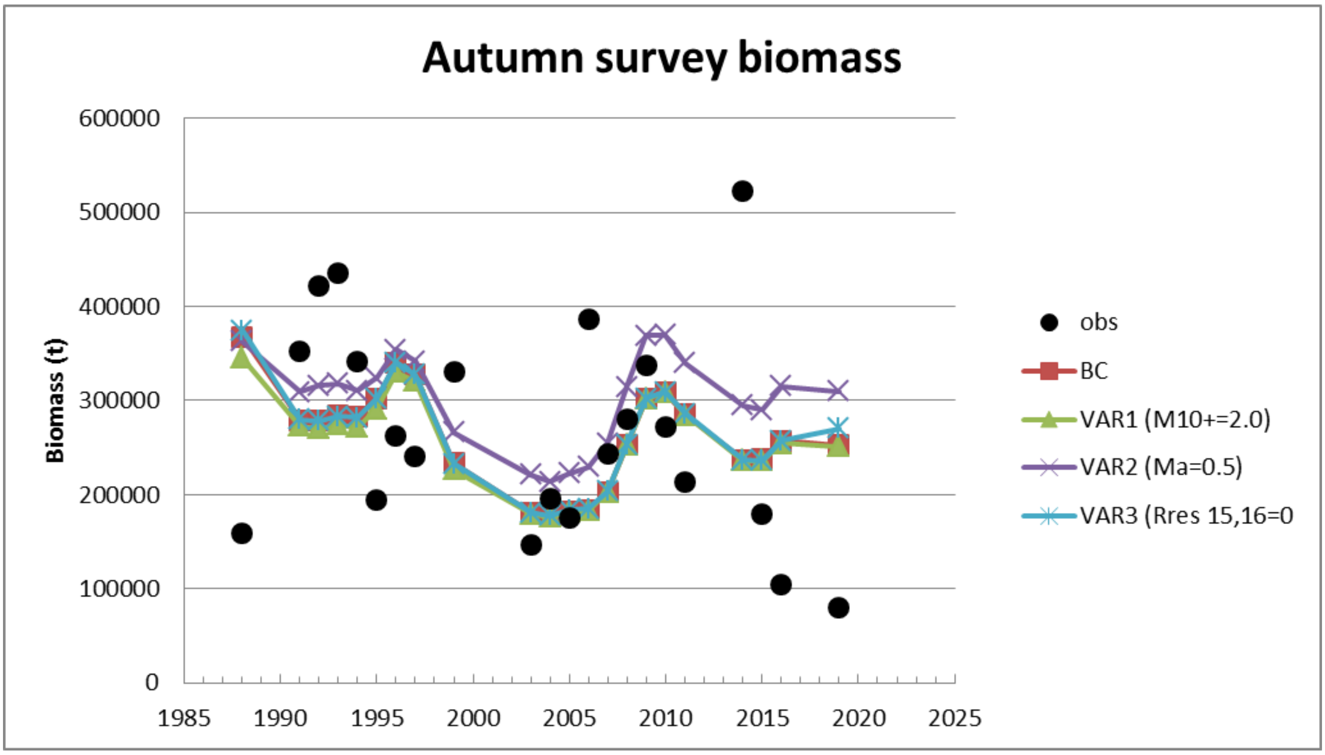

Figure 3a: BC model and VAR1-VAR3 sensitivity model fits to the Autumn survey biomass estimates.

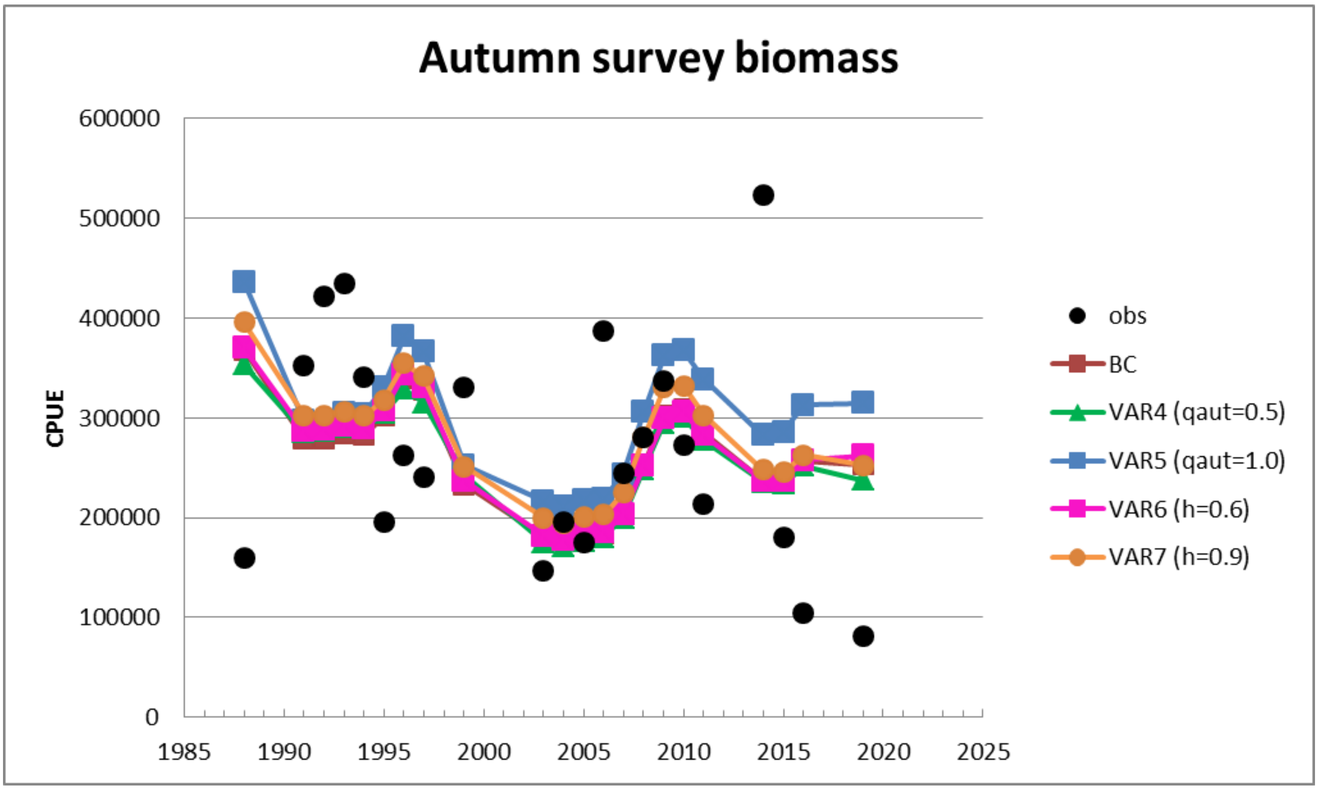

Figure 3b: BC model and VAR4-VAR7 sensitivity model fits to the Autumn survey biomass estimates.

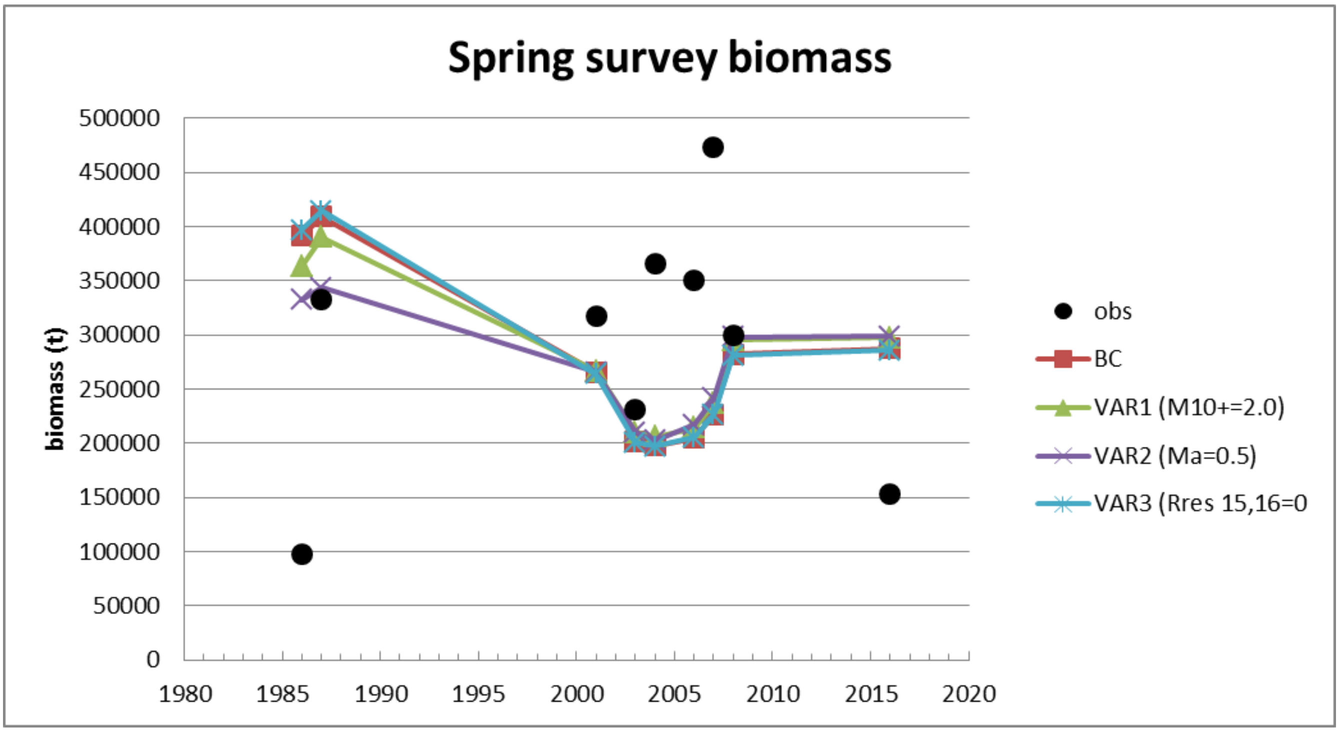

Figure 4a: BC model and VAR1-VAR3 sensitivity model fits to the Spring survey biomass estimates.

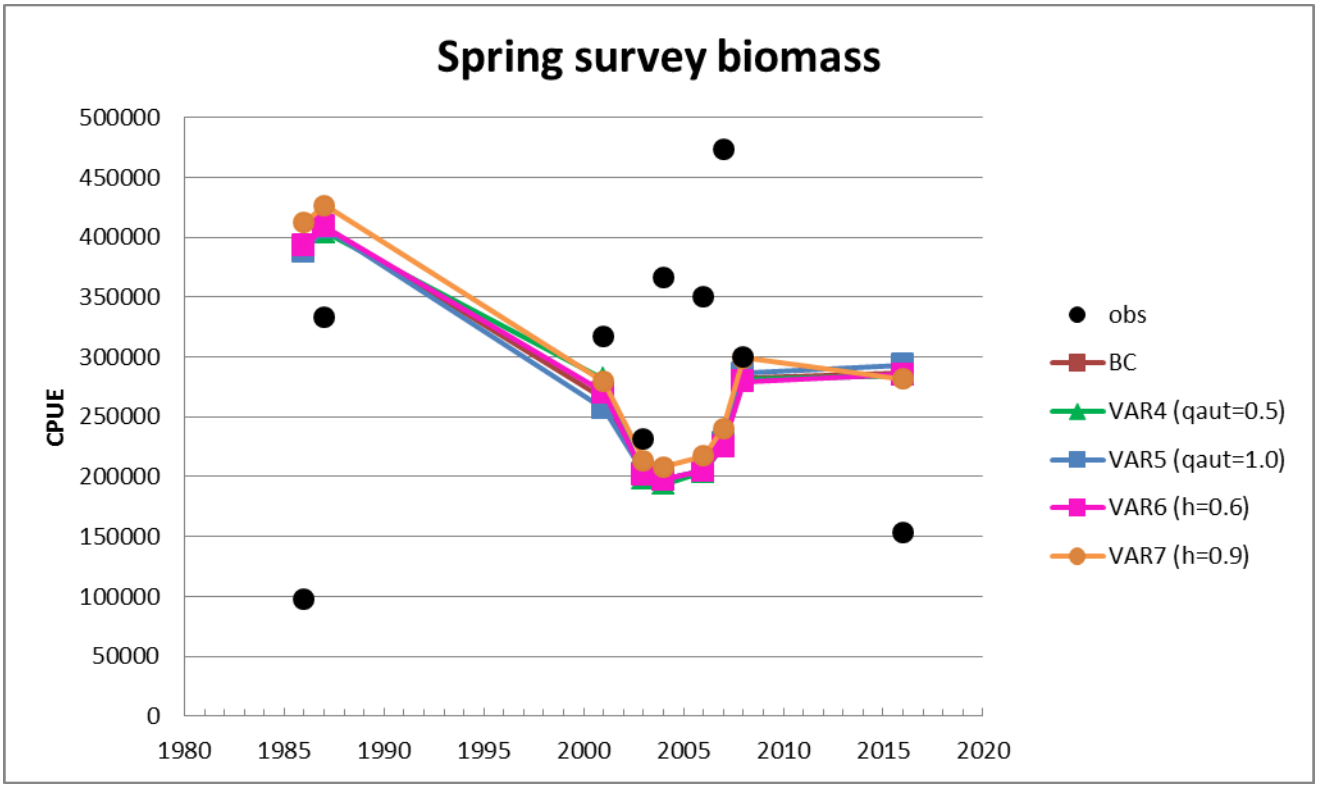

Figure 4b: BC model and VAR4-VAR7 sensitivity model fits to the Spring survey biomass estimates.

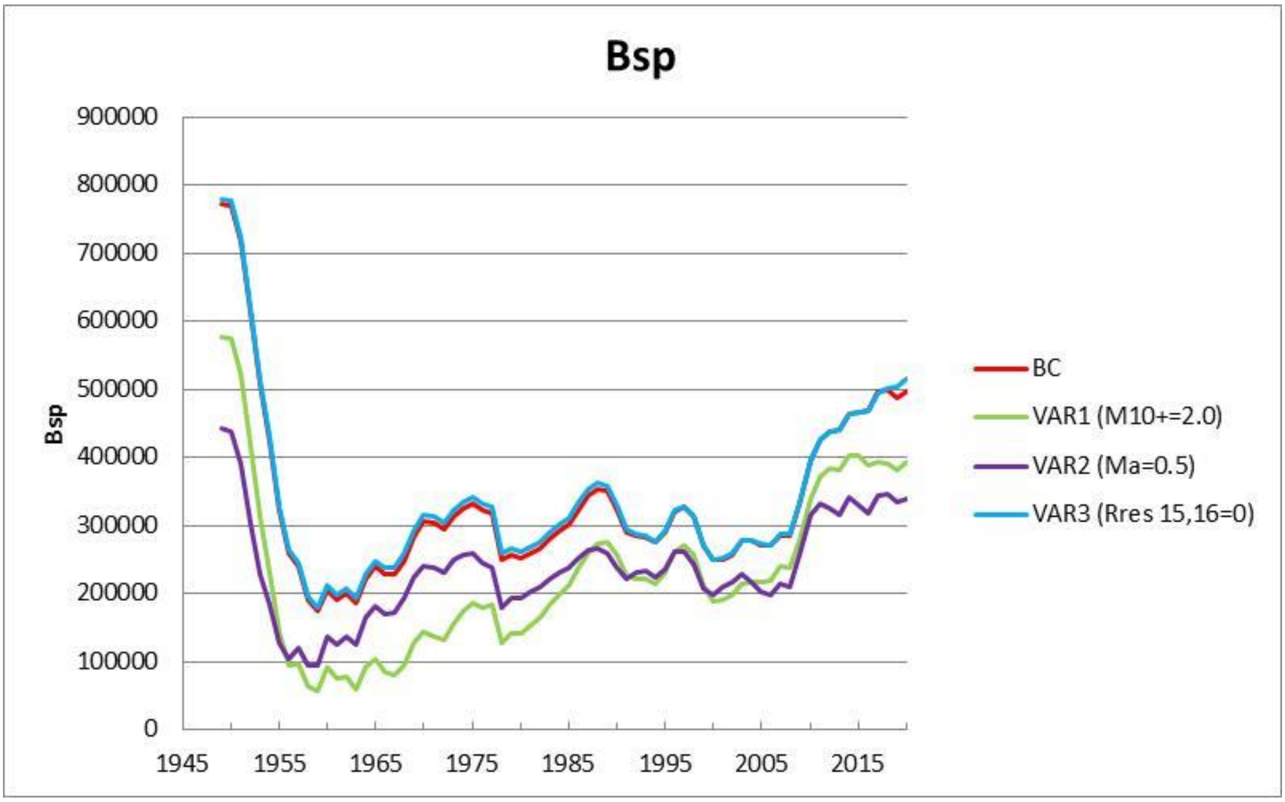

Figure 5a: Spawning biomass estimates for the BC and VAR1-VAR3 sensitivity models.

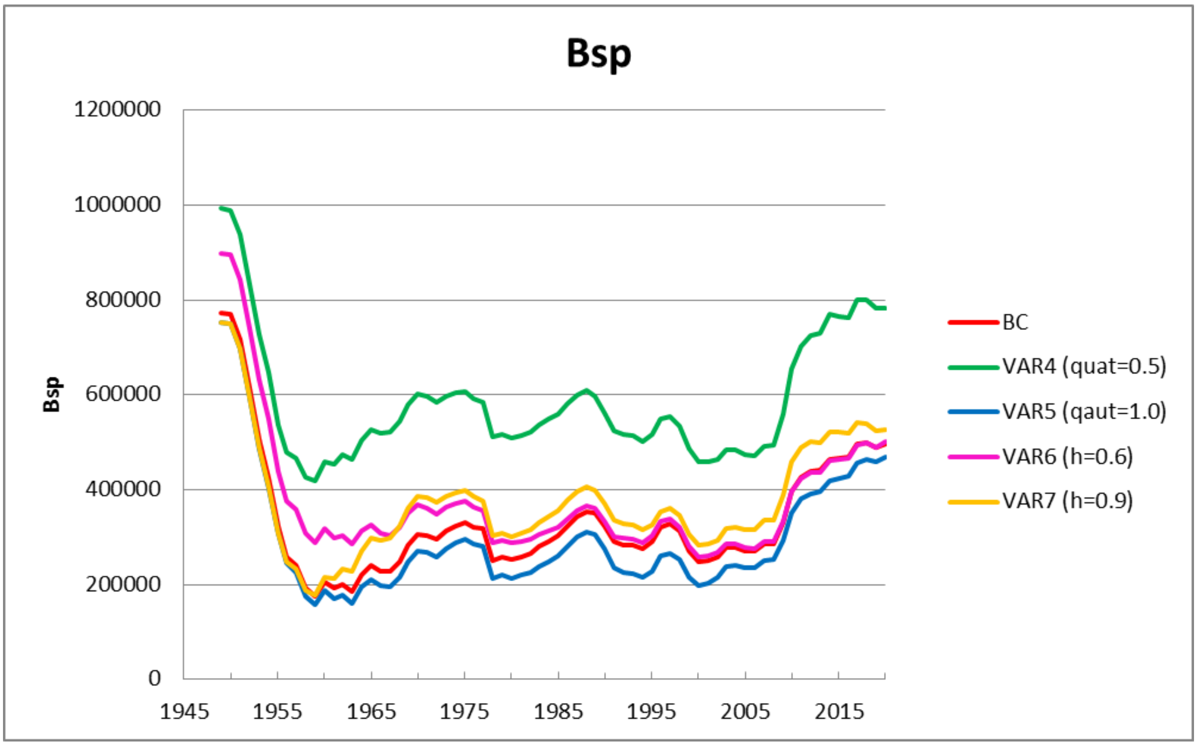

Figure 5b: Spawning biomass estimates for the BC and VAR4-VAR7 sensitivity models.

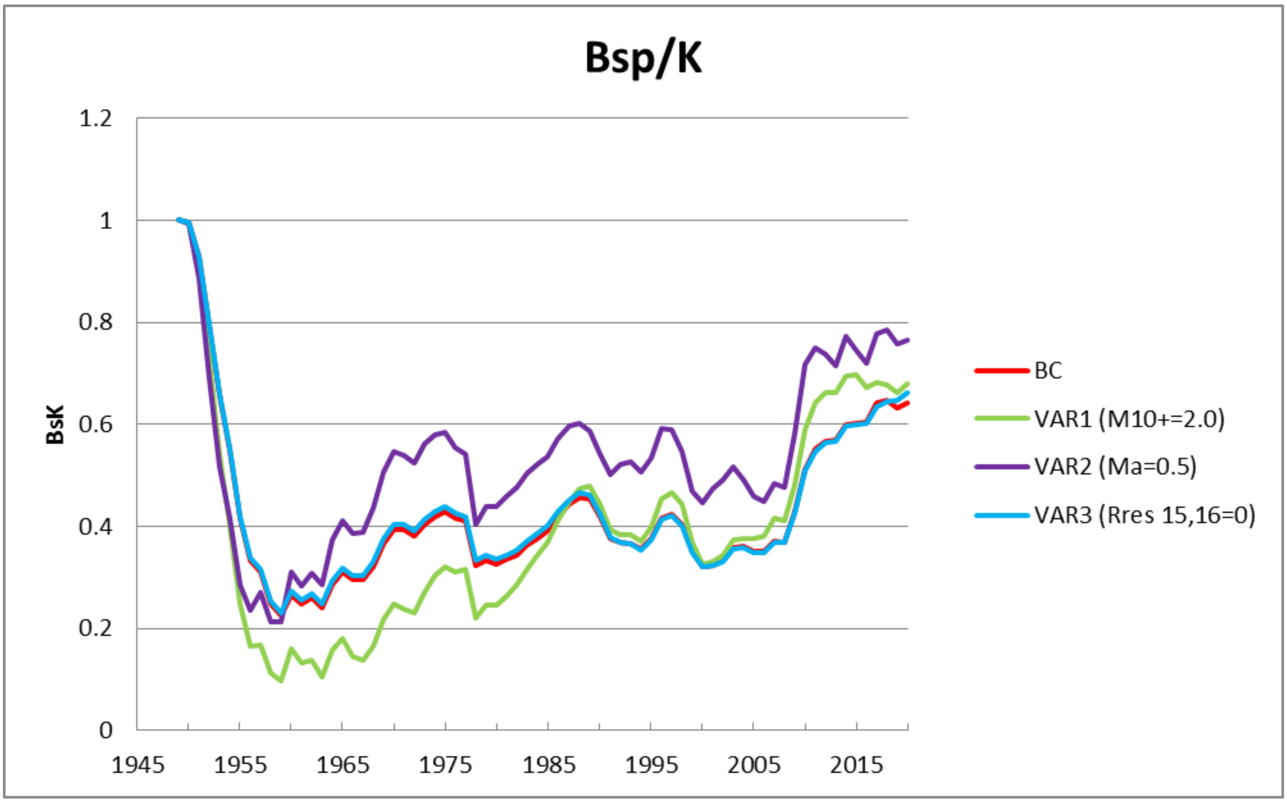

Figure 6a: Spawning biomass relative to K^{sp} estimates for the BC and VAR1-VAR3 assessment models.

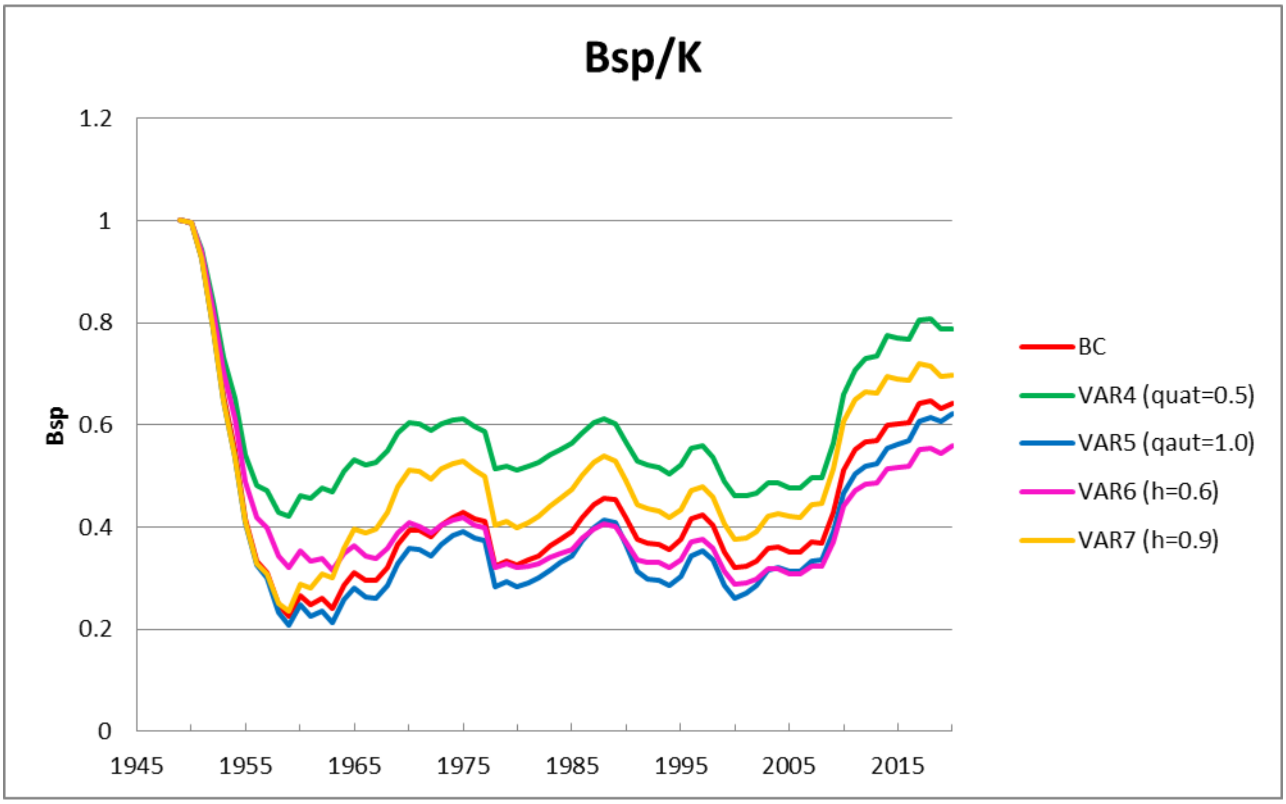

Figure 6b: Spawning biomass relative to K^{sp} estimates for the BC and VAR4-VAR7 sensitivity models.

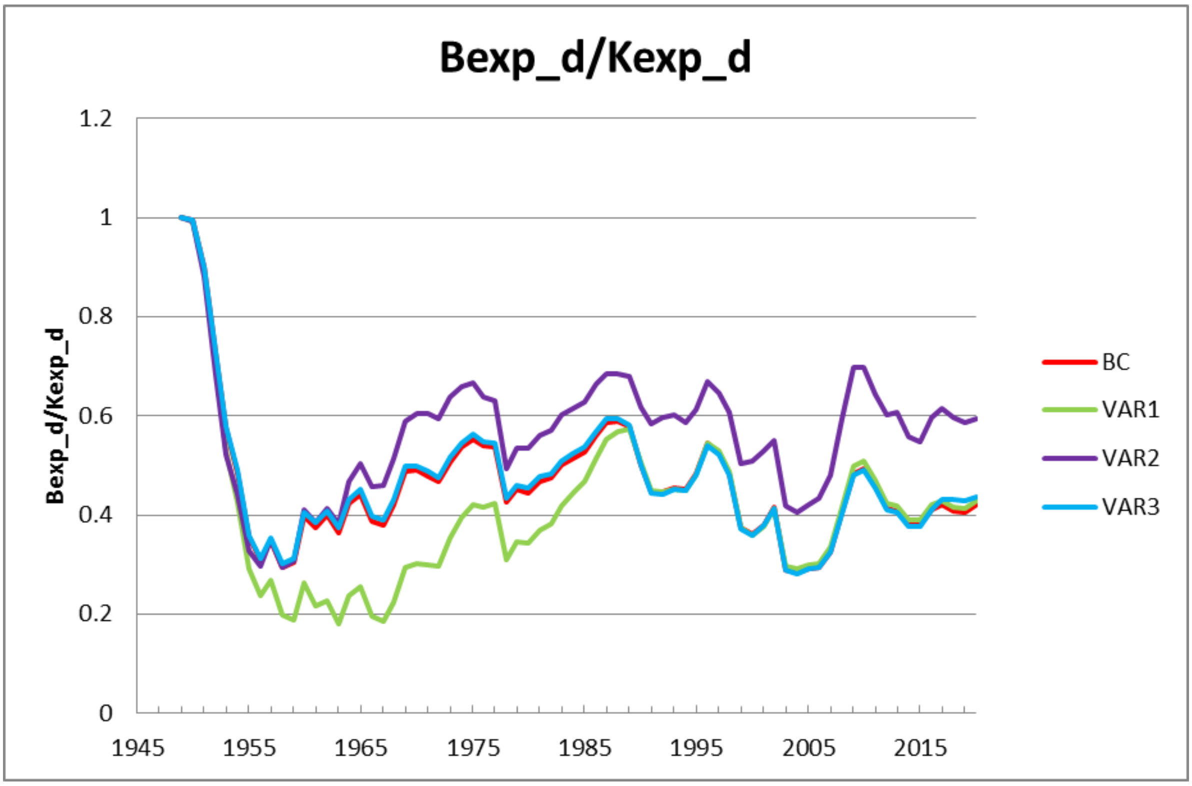

Figure 7a: Demersal exploitable biomass relative to K^{exp_d} estimates for the BC and VAR1-VAR3 sensitivity models.

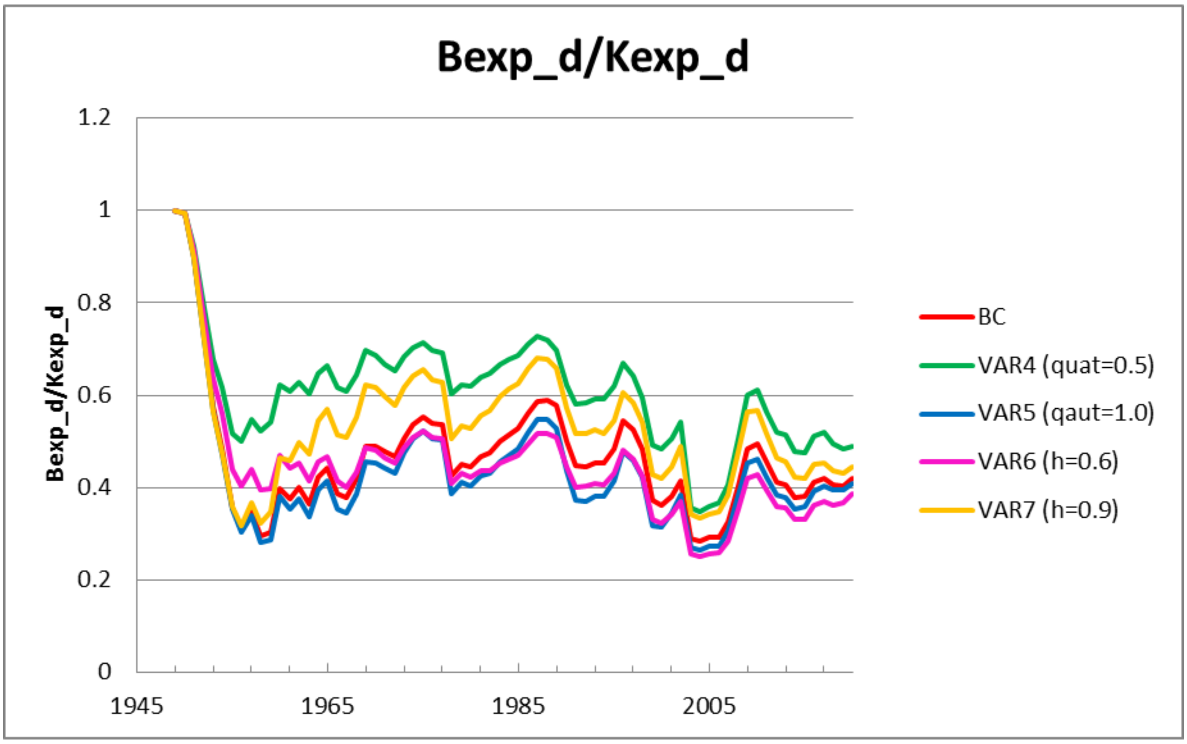

Figure 7b: Demersal exploitable biomass relative to K^{exp_d} estimates for the BC and VAR4-VAR7 sensitivity models.

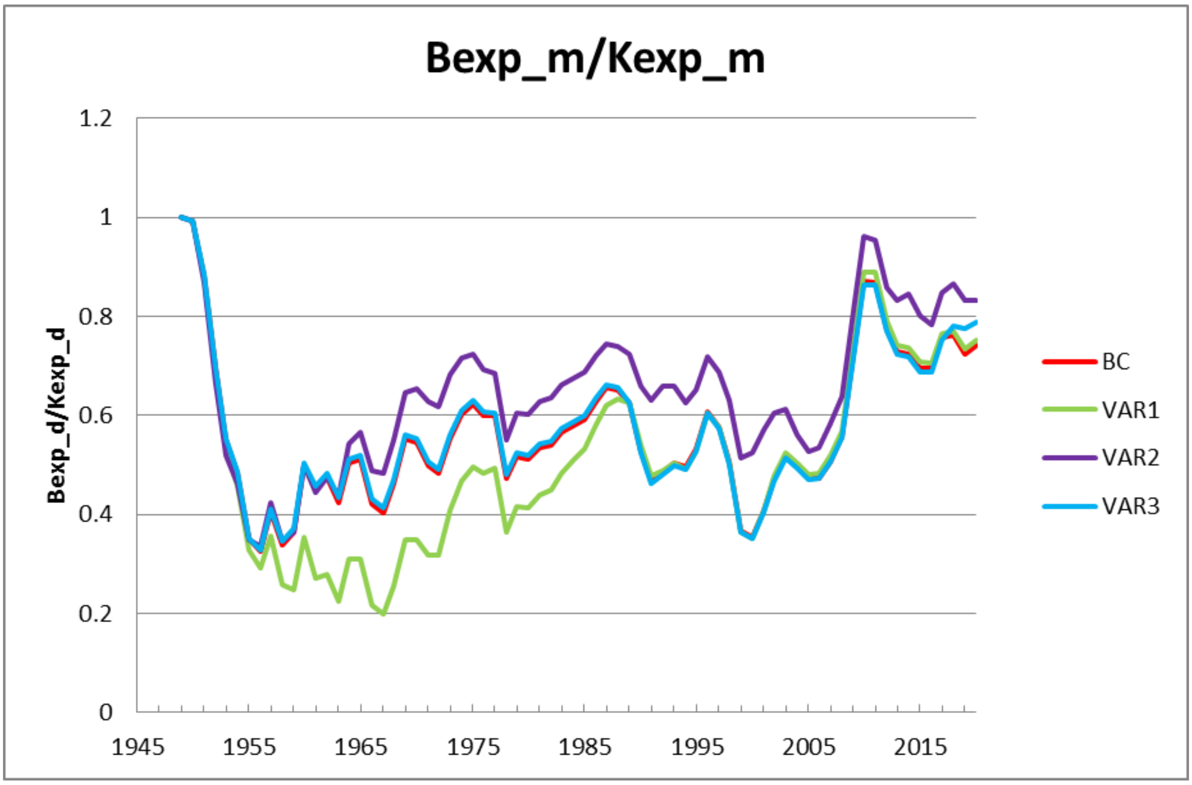

Figure 8a: Midwater exploitable biomass relative to K estimates for the BC and VAR1-VAR3 sensitivity models.

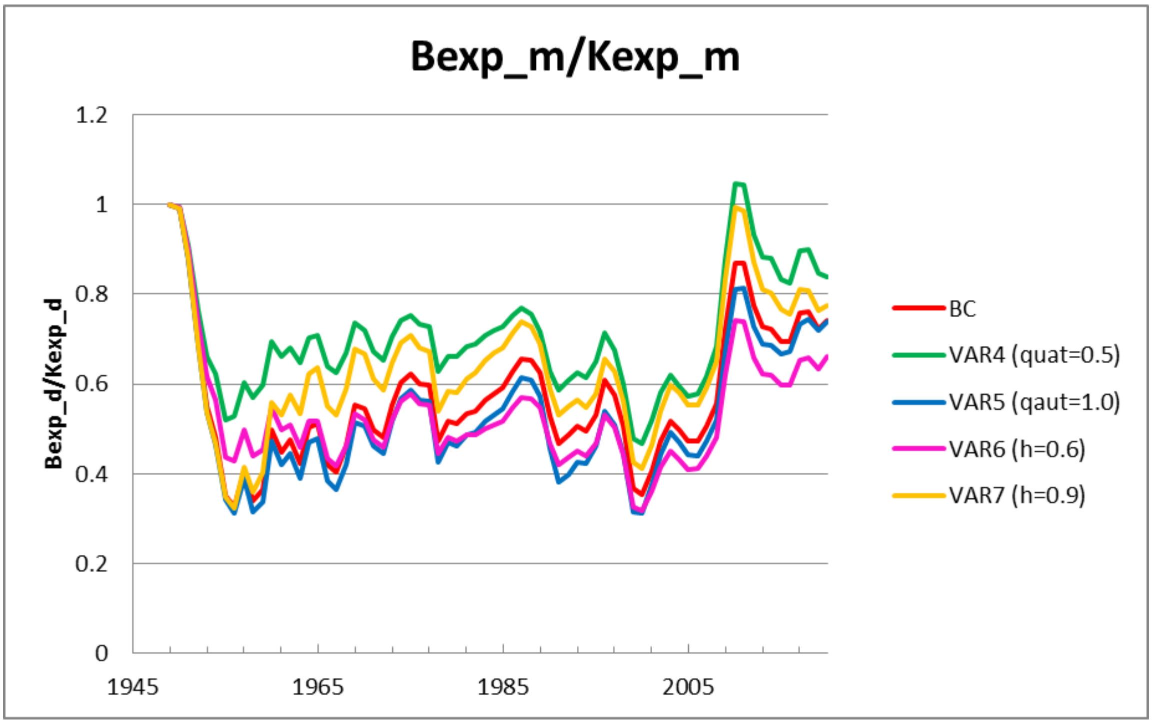

Figure 8b: Midwater exploitable biomass relative to K estimates for the BC and VAR4-VAR7 sensitivity models.

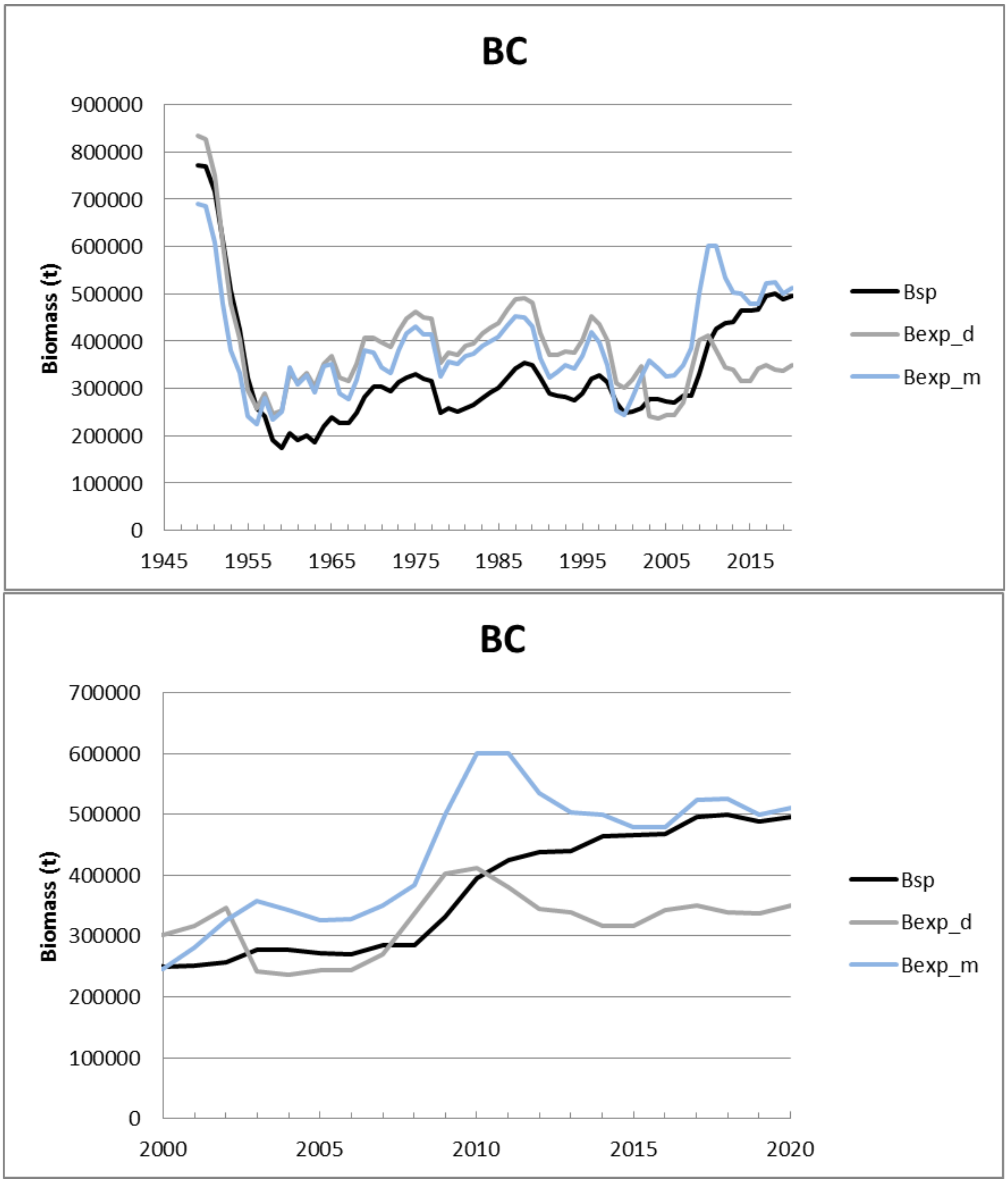

Figure 9: Spawning biomass (B^{sp}), exploitable demersal (B^{exp_d} – related also to surveys) and exploitable midwater (B^{exp_m} – pertinent to the Desert Diamond) biomass trajectories for the BC model.

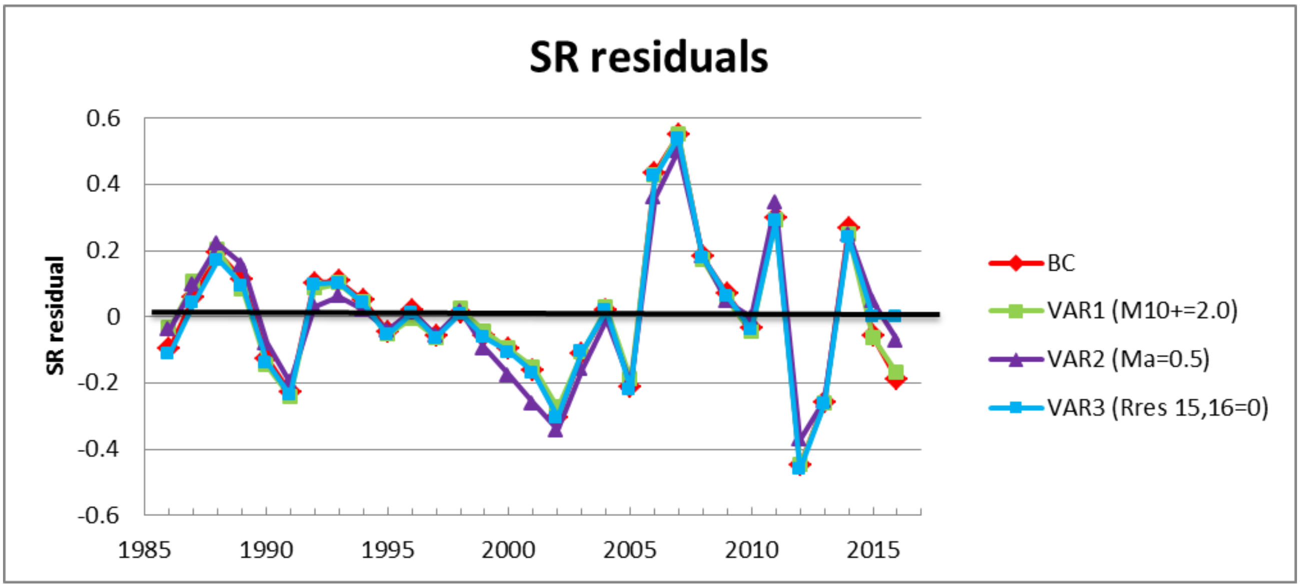

Figure 10a: Estimated stock-recruit residuals for the BC and VAR1-VAR3 sensitivity models (these are fixed to zero for 2015 and 2016 for VAR3).

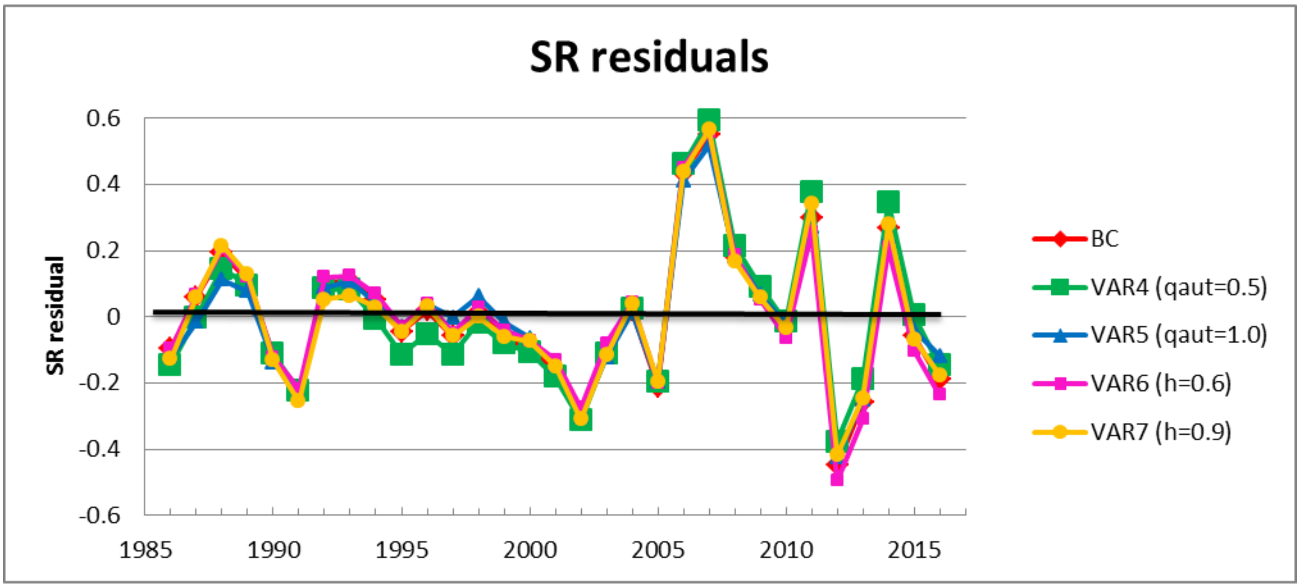

Figure 10b: Estimated stock-recruit residuals for the BC and VAR4-VAR7 sensitivity models.

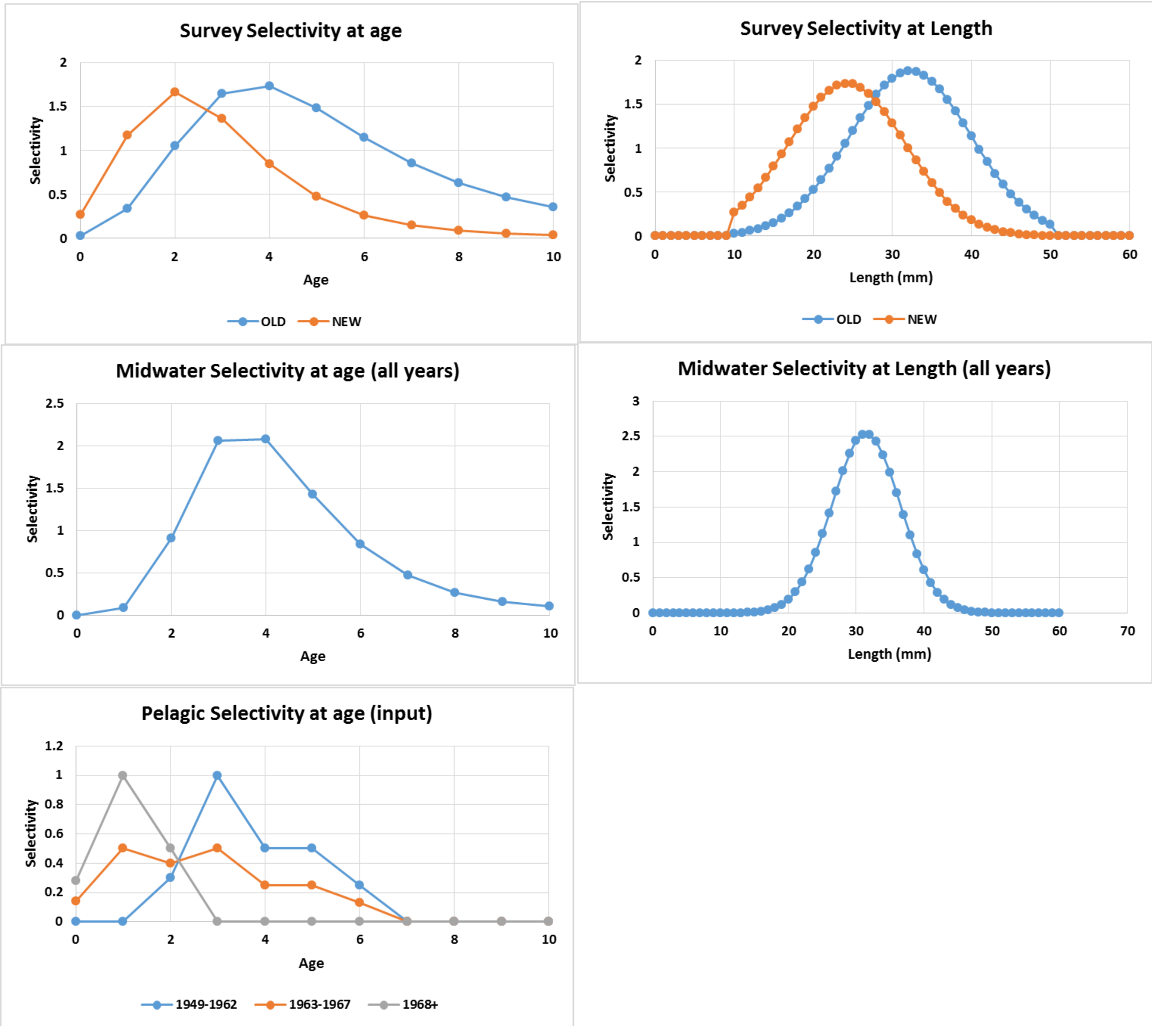

Figure 11: BC model selectivity functions. The old gear (OLD) survey selectivity plot applies also to the demersal bycatch.

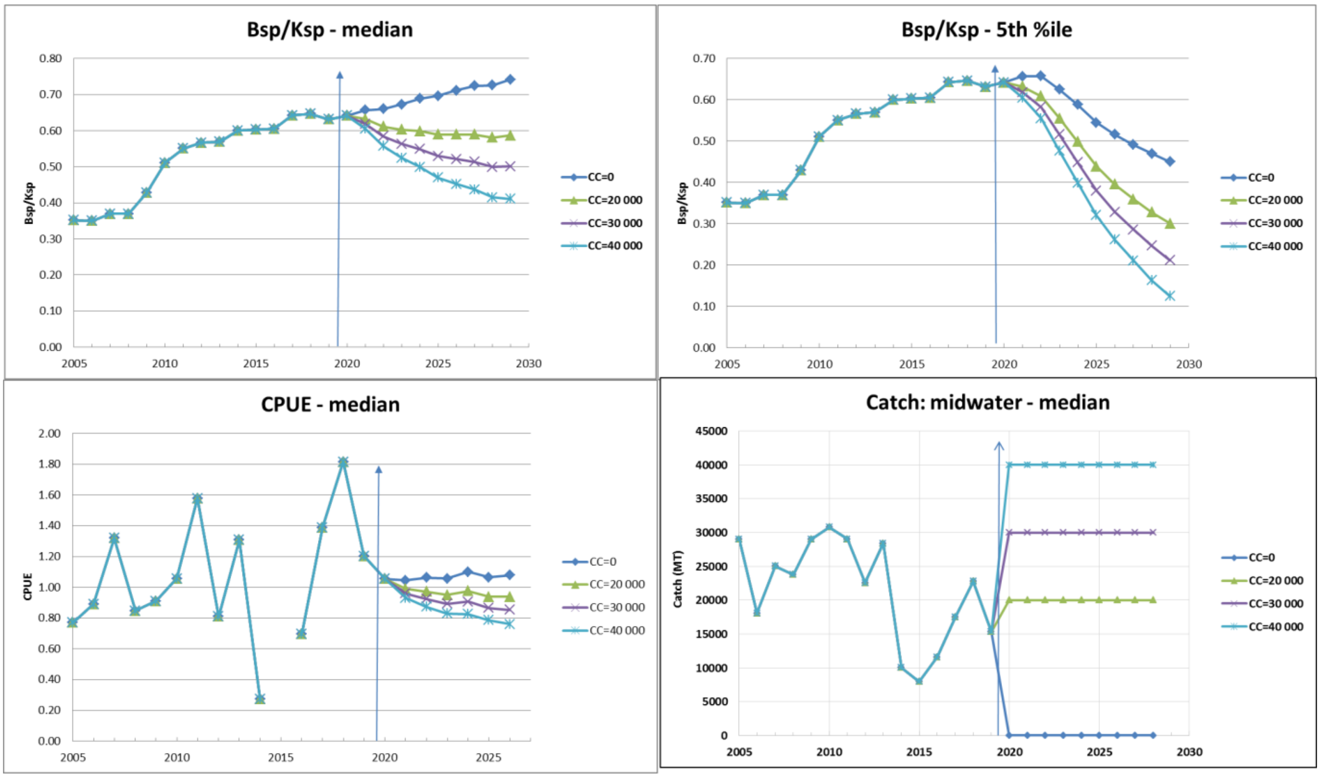

Figure 12a: **BC** model projections for different constant future levels of annual midwater catch.

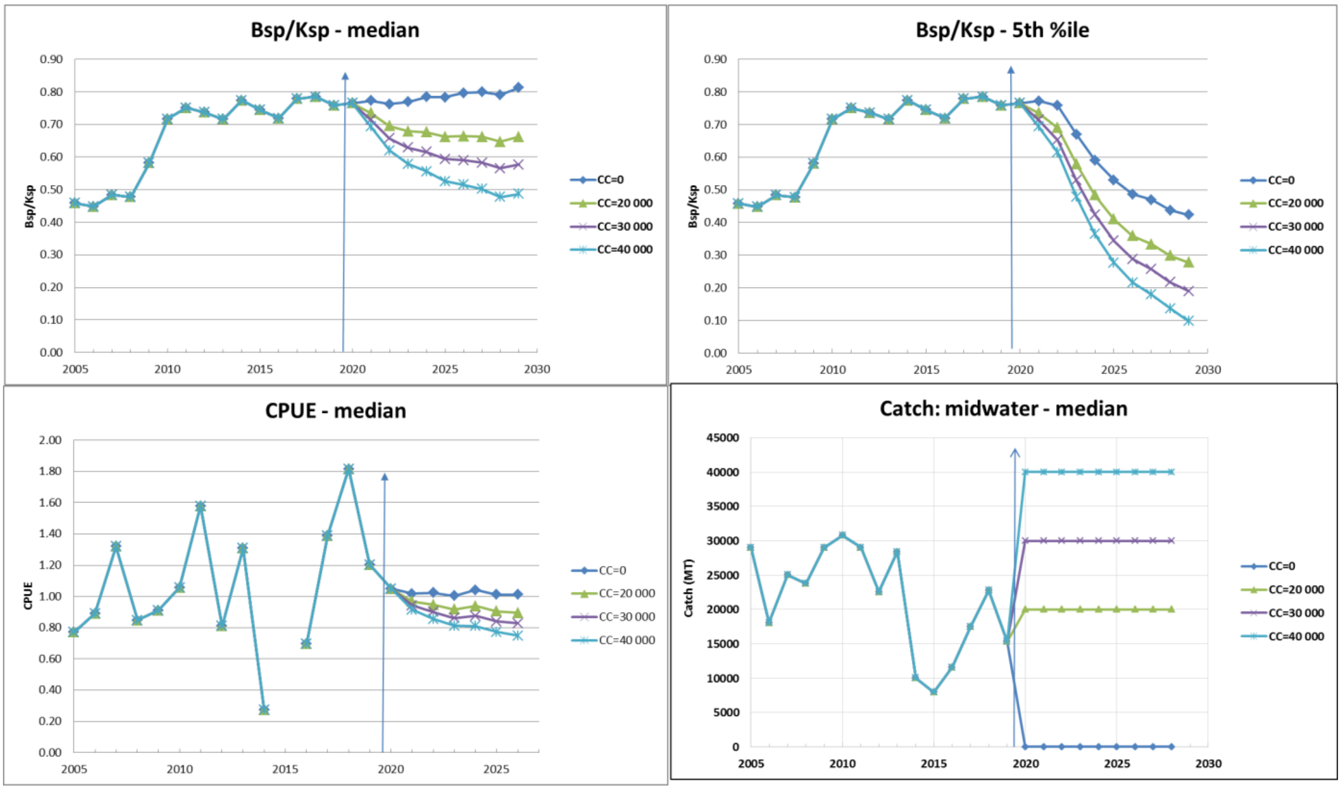

Figure 12b: **VAR2** (*M*=0.5) model projections for different constant future levels of annual midwater catch (in MT).

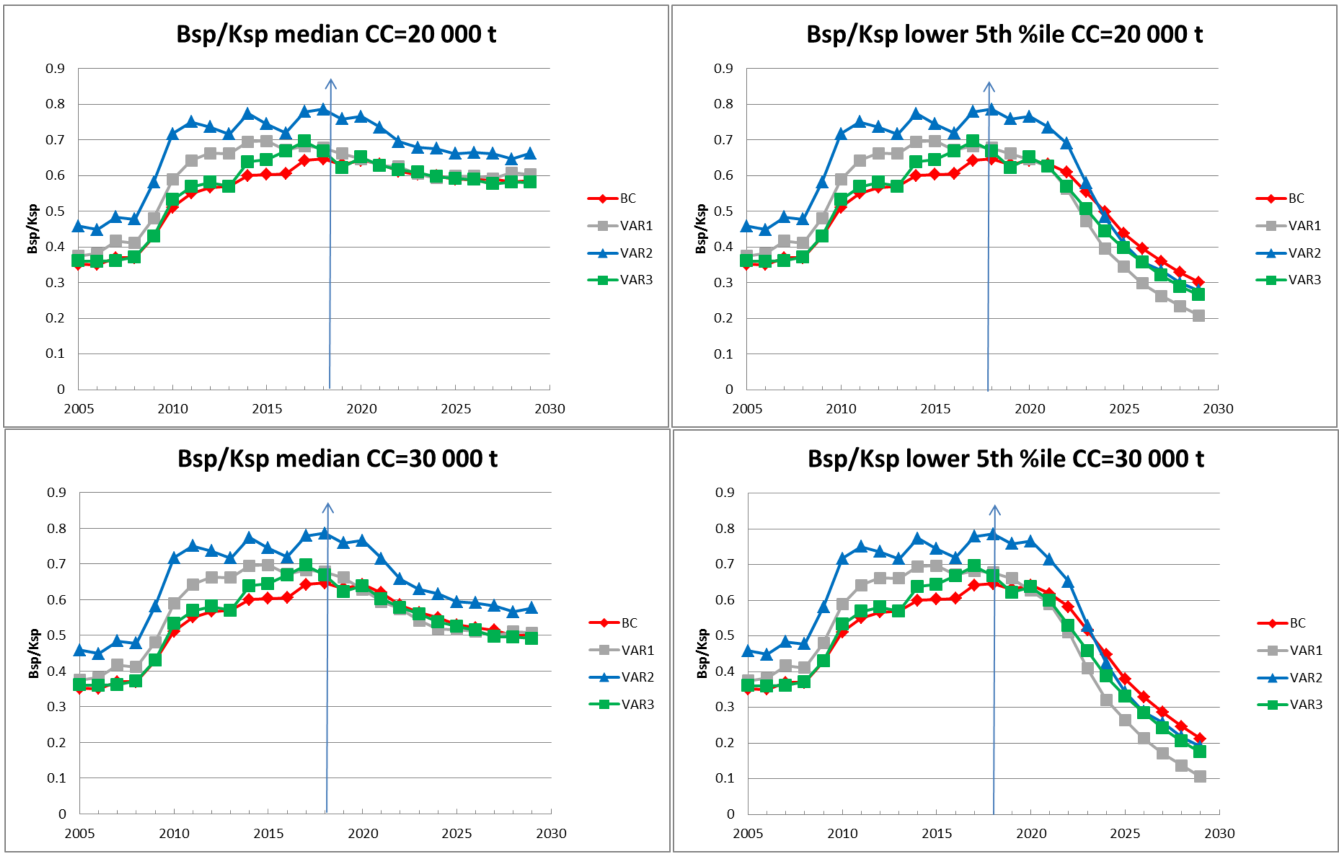

Figure 13a: B^{sp}/K^{sp} median (left) and lower 5th %ile (right) projections for either future midwater constant catch of 20 000 t (top row) or 30 000 t (bottom row). Results are shown for the BC and VAR1-VAR3 sensitivity models.

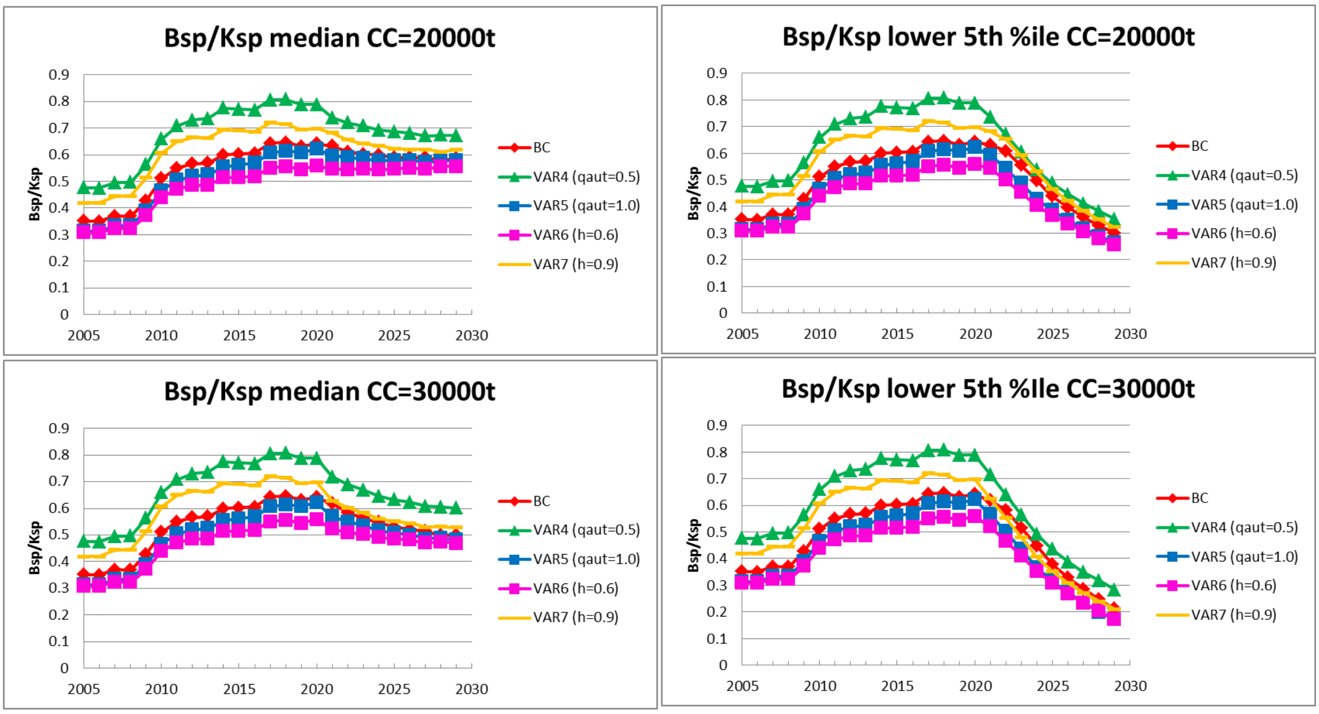

Figure 13b: B^{sp}/K^{sp} median (left) and lower 5th %ile (right) projections for either future midwater constant catch of 20 000 t (top row) or 30 000 t (bottom row). Results are shown for the BC and VAR4-VAR7 sensitivity models.

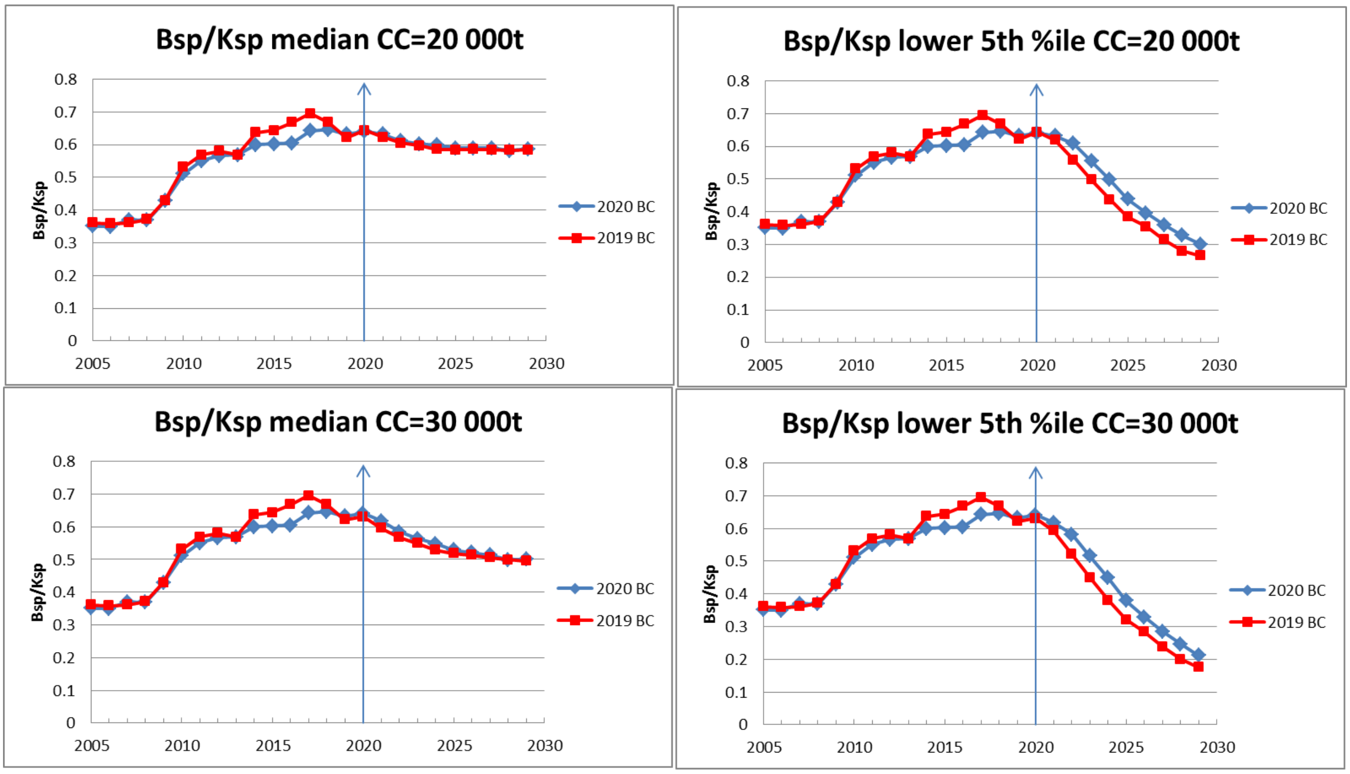

Figure 13c: B^{sp}/K^{sp} median (left) and lower 5th %ile (right) projections for either future midwater constant catch of 20 000 t (top row) or 30 000 t (bottom row). Results are compared between the **2019** and **2020** BC models.