Updated 2021 horse mackerel assessments and projections

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Summary

This document reports updated 2021 horse mackerel assessments, along with constant midwater catch projections for the updated base case model and various model variants.

Key words: horse mackerel, assessment, projections

INTRODUCTION

This document provides updated horse mackerel assessments for the Base Case (BC) and various alternate model variants. Updated data and the full model description can be found in FISHERIES/2021/OCT/SWG-DEM/14.

ASSESSMENT MODELS

BC The previous 2019 and 2020 BC, which assumed 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 ones with the new gear. The old gear selectivity function is assumed to apply to the demersal fisheries' bycatches taken.

Alt1 Uses the "alternate" Dual Rights CPUE series that Tracey Fairweather (pers. commn) provided.

Alt2 Fits additionally to the WC Summer survey series (treated as a further CPUE series).

Alt3 BC but excludes fitting to the SC Autumn survey series.

Alt4 BC but excludes fitting to the DD CPUE series.

Three further sensitivity models are examined. These were selected from those run in past years for which some differences in the results were observed.

Sen1: BC but natural mortality increased from 0.3 to 0.5 for all ages.

Sen2: BC model, but the demersal q_{aut} value is fixed at 0.5 (BC q_{aut}=0.75).

Sen3: BC model, but the demersal q_{aut} value is fixed at 1.0 (BC q_{aut}=0.75).

PROJECTIONS

Projections are reported for the BC model as well as the Alt2-Alt4 models, and Sen1-3 sensitivity models. 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).

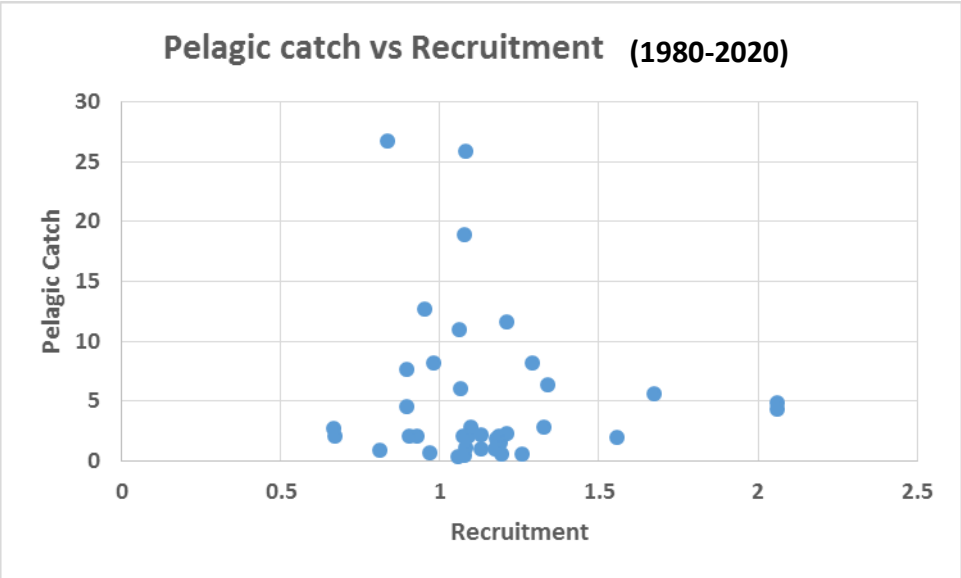

Figure 1: Pelagic catches versus recruitment (BC model).

- Note that there is no clear relationship between pelagic bycatches and recruitment.
- Hence future (2021+) pelagic bycatches are set by drawing at random with replacement from the set of pelagic bycatches for the period 2000-2020, except that a value generated which is in excess of $PUCL_{y+1}$ below is reduced to $PUCL_{y+1}$, where:

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

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 2000-2013 (now updated to 2000-2013) 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 2016) that the upper 95th percentile (to allow for catchability fluctuations) of the 2000-2020 F values (which turns out to be **0.0273**) 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: Demersal catches (MT), BC model estimates of biomass, and resultant F (=catch/biomass).

	Demersal catch	BC demersal biomass	F
2000	9229	304678	0.0303
2001	8814	323176	0.0273
2002	4863	351877	0.0138
2003	3562	243856	0.0146
2004	4933	234743	0.0210
2005	5280	236391	0.0223
2006	4133	233138	0.0177
2007	4812	255437	0.0188
2008	4449	316472	0.0141
2009	4129	378954	0.0109
2010	5596	390339	0.0143
2011	5228	360990	0.0145
2012	4941	321761	0.0154
2013	2695	313459	0.0086
2014	3087	291865	0.0106
2015	4747	293988	0.0161
2016	5230	330829	0.0158
2017	5703	369469	0.0154
2018	4528	395662	0.0114
2019	4720	411637	0.0115
2020	4301	411218	0.0105
		median	0.0146
		upper 95%ile	**0.0273**

Midwater directed catches

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

RESULTS

Tables 2a and b provide a summary of results for the different assessment models. Figure 1a-c compare the model fits to survey series as well as the *Desert Diamond* (DD) CPUE and Dual rights (DR) series.

Figure 2 plots the BC standardised residuals for the BC model fits in Figure 1a.

Figures 3a-c plot the spawning biomass estimates relative to pristine, the exploitable demersal and the exploitable midwater biomasses (both relative to K) for the different assessment models.

Figures 4a-c plot the estimated stock-recruit residuals for the different assessments.

Figure 5 reports the estimated (and input) selectivity functions for the BC model.

Figures 6a-c report the standardised residual plots for the three different CAL series.

Figures 7a- b compare 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, Alt1 and Alt2 (Figure 7a), for the BC, Alt3 and Alt4 assessment models (Figure 7b) and for the BC, Sen1-3 models in Figure 7c.

DISCUSSION

- Current spawning biomass is estimated to be 69% of K^{sp} (for the BC model). Given that B_{MSY} is estimated to around 0.24 K^{sp}, the resource is in a very healthy position.
- For *M* higher at 0.5 (Sen1), the depletion estimate at present increases from about 69% to 87% (Table 3c).
- Over the last decade, the spawning biomass has increased by over 70%, whereas the survey and midwater exploitable components of biomass have increased by 4% and 30% respectively (Figure 3a). This is a consequence of doming in the selectivities for these last two components, which consequently are reflections more of "throughput" of biomass from one age group to another, than of the overall spawning stock abundance.
- The recent exploitable biomass estimates for the 2021 assessment are larger than those estimated by the previous 2020 assessment (Figure 3b) – this is likely driven mainly by the more optimistic recent DD CPUE, though note that the most recent SC autumn survey result (not fitted in the assessment – see Figure 1c) is also appreciably higher.

REFERENCE

Johnston, S.J. and Butterworth, D.S. 2021. Updated 2021 horse mackerel data and model description. FISHERIES/2021/OCT/SWG-DEM/14.

Table 2a: Summary of results for the BC and ALT31 and ALT4 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 2020 BC results are shown in first shaded column for comparison. Italics values are not comparable as different data are used.

	2020 BC	2021 **BC**	**Alt1** Alternate DR CPUE	**Alt2** Fit WC Summer survey data	**Alt3** Exclude SC Autumn survey	**Alt4** Exclude DD CPUE
# estimable parameters	42	43	43	43	43	43
q_{aut}	0.75	0.75	0.75	0.75	-	0.75
q_{spr}	0.837	0.855	0.860	0.922	0.913	0.843
q_{WC}	-	-	-	0.133	-	-
q_2 (applies to 2014)	0.269*q_{CPUE}	0.233	0.232	0.272	0.239	0.272
h	0.75	0.75	0.75	0.75	0.75	0.75
-ln L :Total	-266.948	-271.242	*-273.758*	*-253.181*	*-268.183*	*-263.079*
-ln L :SC Spr survey	0.483	0.586	0.639	0.084	0.866	0.698
-ln L :SC Aut survey	-5.574	-4.272	-4.119	-5.429	(35.587)	-4.613
-lnL: WC Sum survey	-	-	-	16.527	-	-
-ln L :CPUE	-11.114	-9.822	-9.433	-8.507	-9.796	*(-6.454)*
-lnL Dual Rights	-7.315	-7.819	-10.941	-6.919	-8.911	-7.896
-ln L :CAL Spr survey	-46.303	-45.292	-45.633	-44.897	-45.730	-46.915
-ln L :CAL Aut survey	-89.176	-88.800	-88.877	-88.705	-89.911	-89.132
-ln L :CAL commercial	-89.158	-96.493	-96.303	-96.123	-96.615	-96.347
-ln L :SR residuals	-18.792	-19.329	-19.089	-19.215	-18.485	-18.972
K^{sp} (KT)	773	773	773	756	750	768
$MSYL^{sp}$ (KT)/$MSYL^{sp}/K^{sp}$	189/0.24	189/0.24	188/0.24	185/0.24	183/0.24	187/0.24
MSY (KT)	56	56	56	55	55	55
B^{sp}_{2019} (KT)	488	483	0.478	427	474	470
B^{sp}_{2020} (KT)	-	520	0.520	443	527	481
B^{sp}_{2021} (KT)	-	533	0.535	453	544	488
B^{sp}_{2019}/K^{sp}	0.632	0.624	0.619	0.564	0.631	0.611
B^{sp}_{2020}/K^{sp}	-	0.671	0.672	0.586	0.703	0.626
B^{sp}_{2021}/K^{sp}	-	0.690	0.692	0.600	0.726	0.634
	2020 xHorse.tpl	xhorse.tpl	Alt1.tpl	Alt2.tpl	Alt3.tpl	Alt4.tpl

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

	2021 BC	Sen1 M_a = 0.5	Sen2 q_{aut} fixed at 0.5	Sen3 q_{aut} fixed at 1.0
# estimable parameters	43	43	43	43
q_{aut}	0.75	0.75	0.5	1.0
q_{spr}	0.855	0.722	0.574	0.802
q_2 (applies to 2014)	0.233	0.231	0.230	0.272
h	0.75	0.75	0.75	0.75
-ln L :Total	-271.242	-270.149	-271.602	-265.586
-ln L :SC Spr survey	0.586	-0.150	0.604	0.758
-ln L :SC Aut survey	-4.272	-3.117	-4.956	-2.300
-ln L :CPUE	-9.822	-9.7-1	-9.688	-7.945
-lnL Dual Rights	-7.819	-7.705	-7.507	-6.769
-ln L :CAL Spr survey	-45.292	-44.901	-45.121	-46.477
-ln L :CAL Aut survey	-88.800	-88.279	-88.867	-88.936
-ln L :CAL commercial	-96.493	-97.046	-96.86	-94.475
-ln L :SR residuals	-19.329	-19.252	-19.180	-19.441
K^{sp} (KT)	773	440	997	755
$MSYL^{sp}$ (KT)$/MSYL^{sp}/K^{sp}MSYL^{sp}$	189/0.24	106/0.24	243/0.24	185/0.25
MSY (KT)	56	65	71	55
B^{sp}_{2019} (KT)	483	352	775	467
B^{sp}_{2020} (KT)	520	389	824	473
B^{sp}_{2021} (KT)	533	385	836	477
B^{sp}_{2019}/K^{sp}	0.624	0.799	0.778	0.619
B^{sp}_{2020}/K^{sp}	0.671	0.883	0.826	0.627
B^{sp}_{2021}/K^{sp}	0.690	0.874	0.838	0.632
	2021 xhorse.tpl	Alt1.tpl	Alt2.tpl	Alt2.tpl0

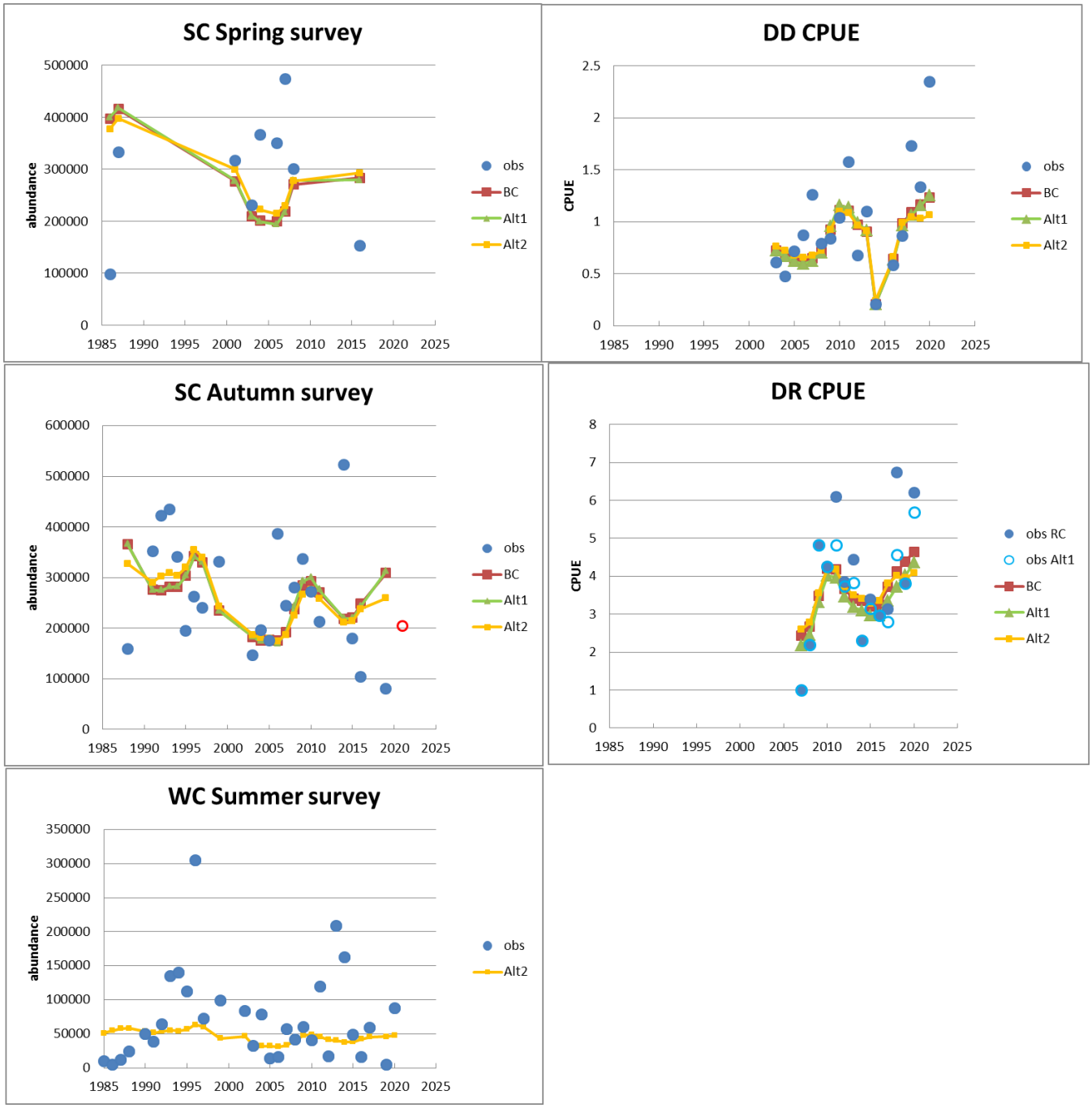

Figure 1a: Model fits (BC, Alt1 (uses alternative DR CPUE) and Alt2 (includes fitting to WC survey)) to survey and CPUE series. Note that the open red circle for the SC Autumn survey is the latest 2021 estimate which is not used in the model-fitting procedure.

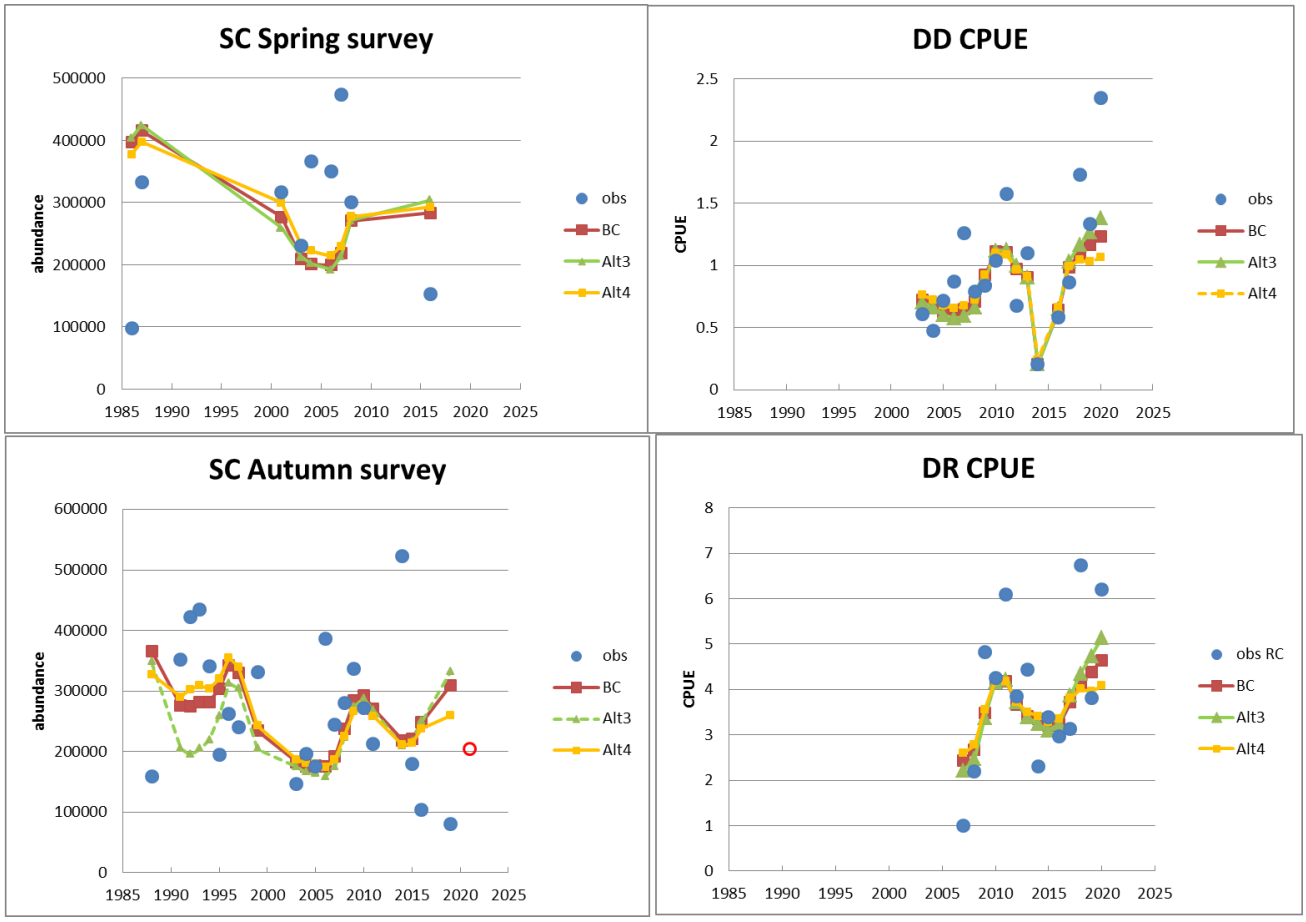

Figure 1b: Model fits (BC, Alt3 (excludes Autumn survey) and Alt4 (excludes DD CPUE)) to survey and CPUE series. Note that the open red circle for the SC Autumn survey is the latest 2021 estimate which is not used in the model-fitting procedure. The dashed lines indicate model-estimated values which are generated for interest, but are NOT used as part of the likelihood/model fitting procedure.

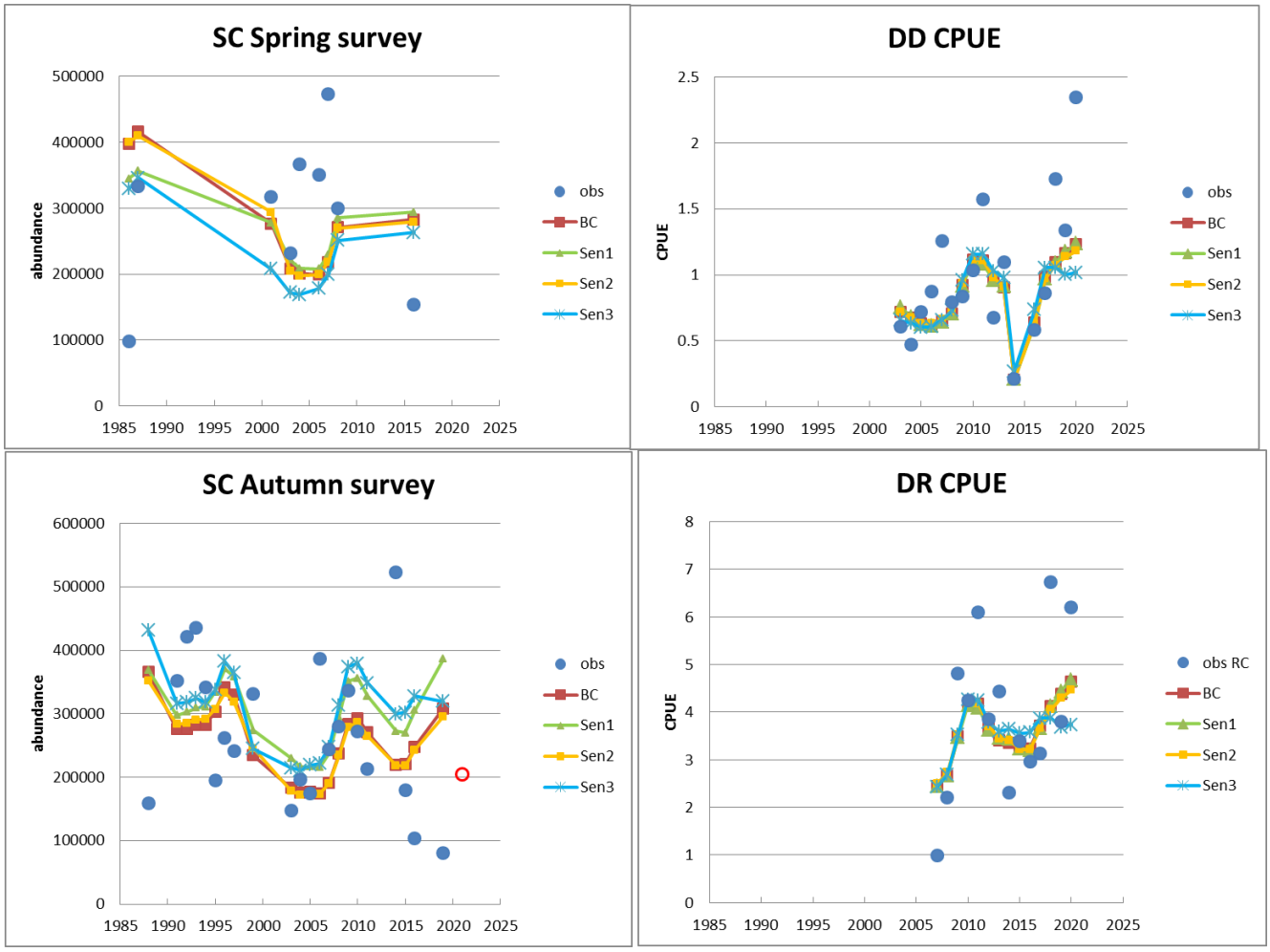

Figure 1c: Model fits for the BC, Sen1 (natural mortality = 0.5), Sen2 (q_{aut} =0.5) and Sen3 (q_{aut} =1.0) to survey and CPUE series. Note that the open red circle for the SC Autumn survey is the latest 2021 estimate which is not used in the model-fitting procedure.

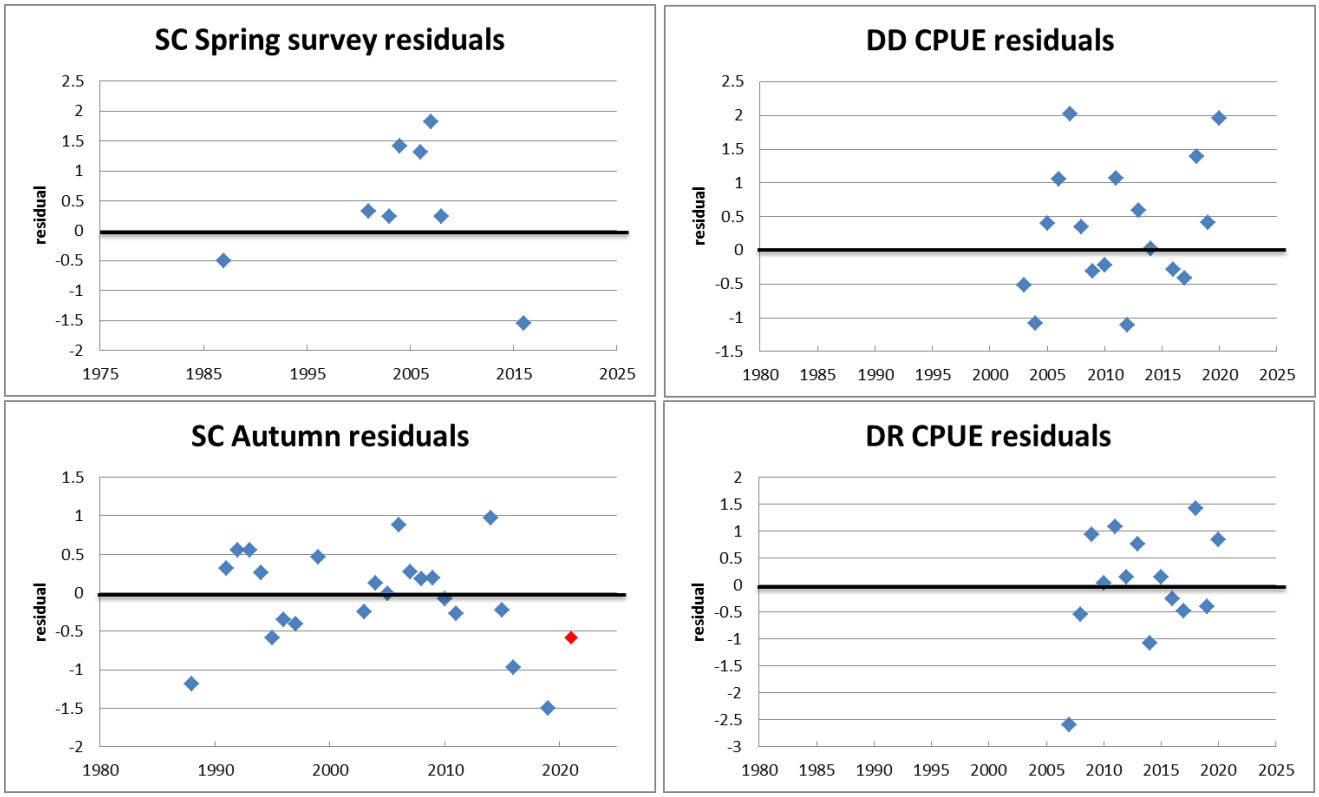

Figure 2: Standardised residuals for the **BC** model fit to the survey and CPUE series. The SC Autumn residual for 2021 is indicated as red as this value was not included in the likelihood fit.

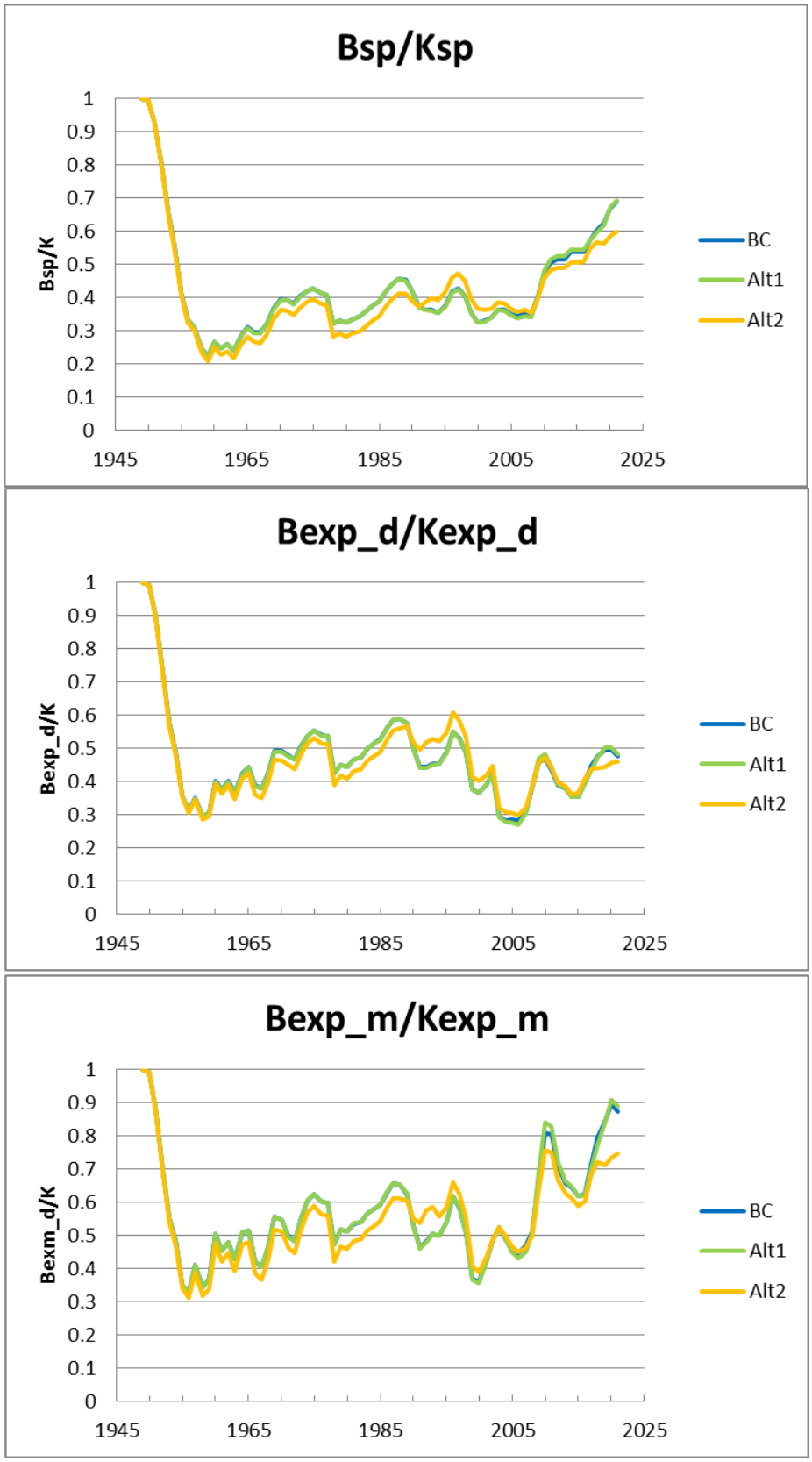

Figure 3a: Spawning biomass (relative to K), exploitable demersal biomass (relative to K) and exploitable midwater biomass (relative to K) for the BC, Alt1 (uses alternative DR CPUE) and Alt2 (includes fitting to WC survey)) assessment models.

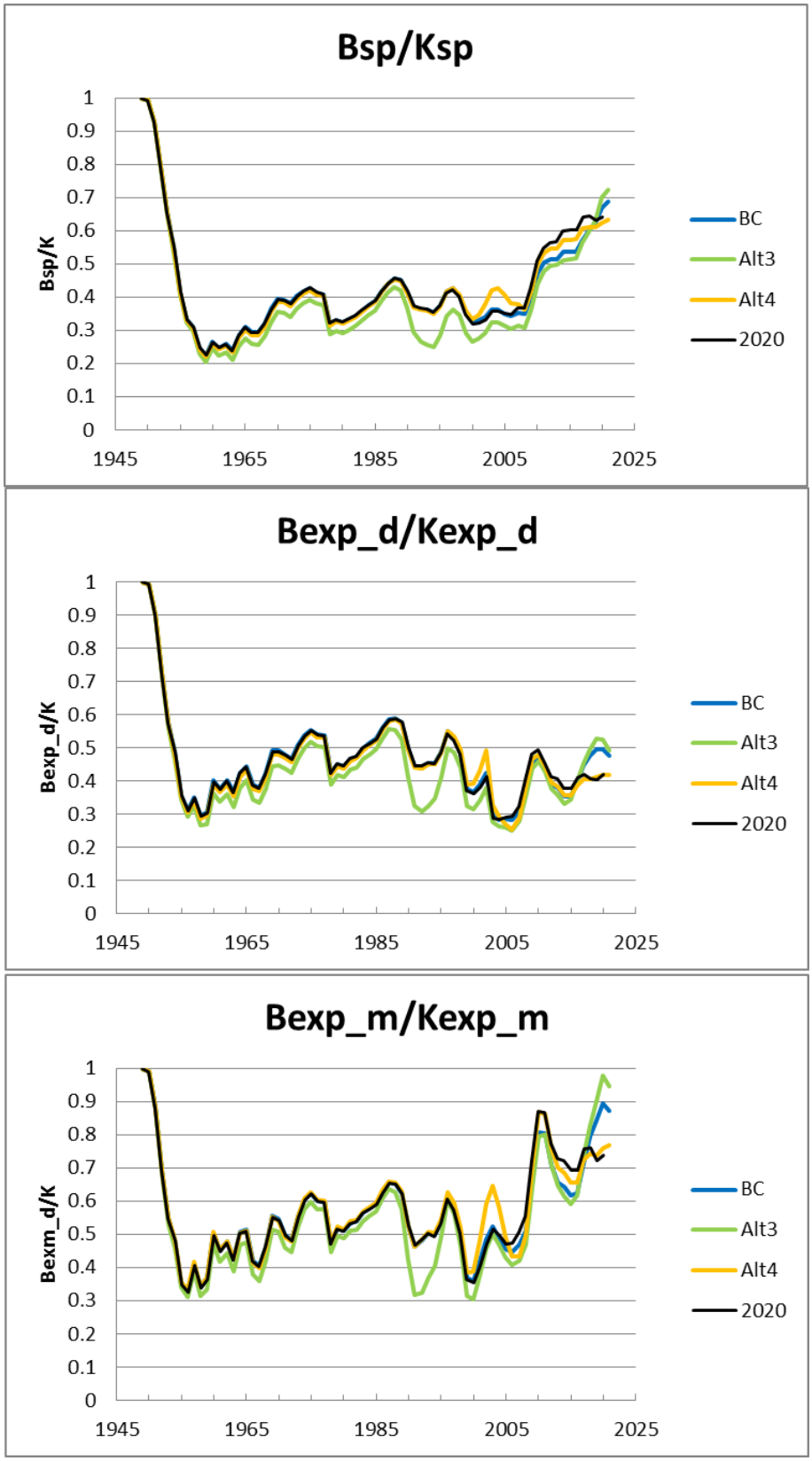

Figure 3b: Spawning biomass (relative to K), exploitable demersal biomass (relative to K) and exploitable midwater biomass (relative to K) for the BC, Alt3 (exclude Autumn survey) and Alt4 (exclude DD CPUE) assessment models. The estimates obtained in the 2020 assessment are also plotted.

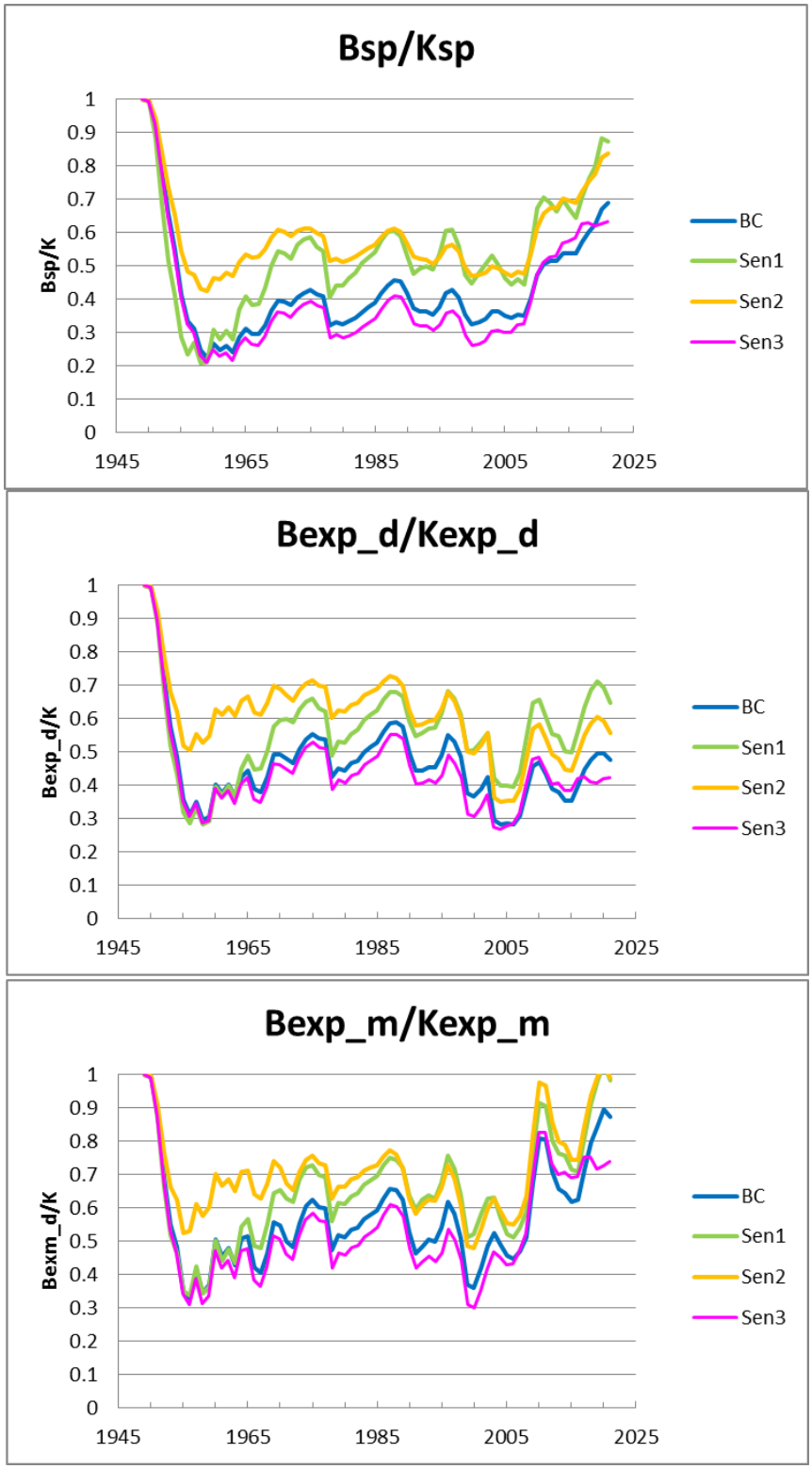

Figure 3c: Spawning biomass (relative to K), exploitable demersal biomass (relative to K) and exploitable midwater biomass (relative to K) for the BC, Sen1 (natural mortality = 0.5), Sen2 (q_{aut} =0.5) and Sen3 (q_{aut} =1.0) models.

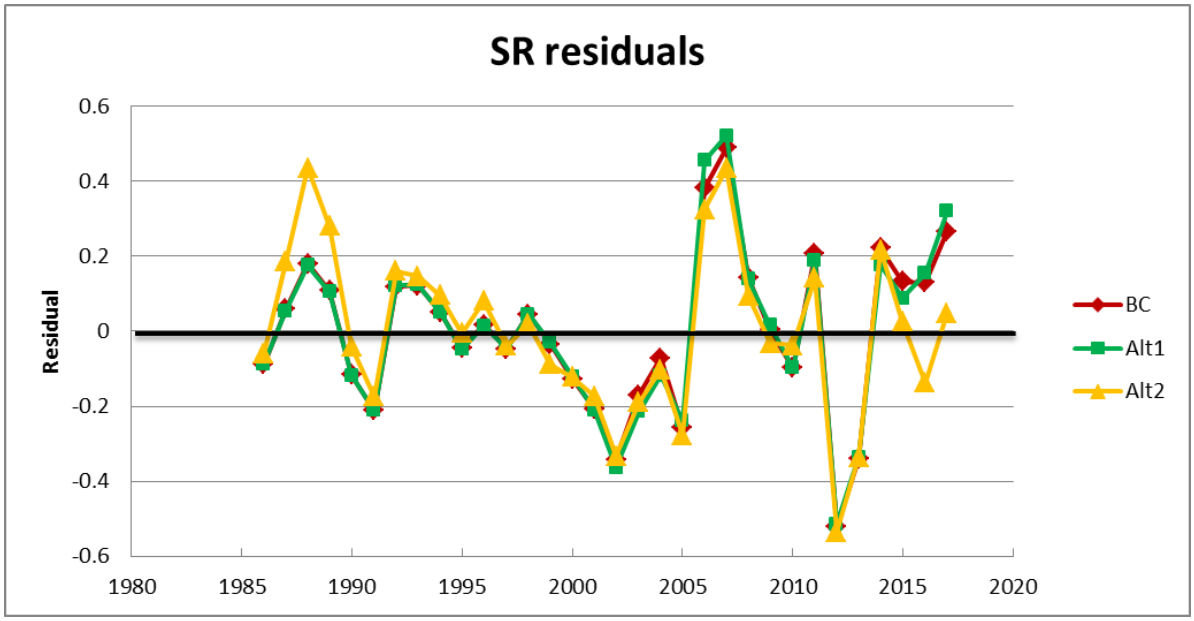

Figure 4a: Estimated stock-recruit residuals for the BC, Alt1 (uses alternative DR CPUE) and Alt2 (includes fitting to WC survey)) models.

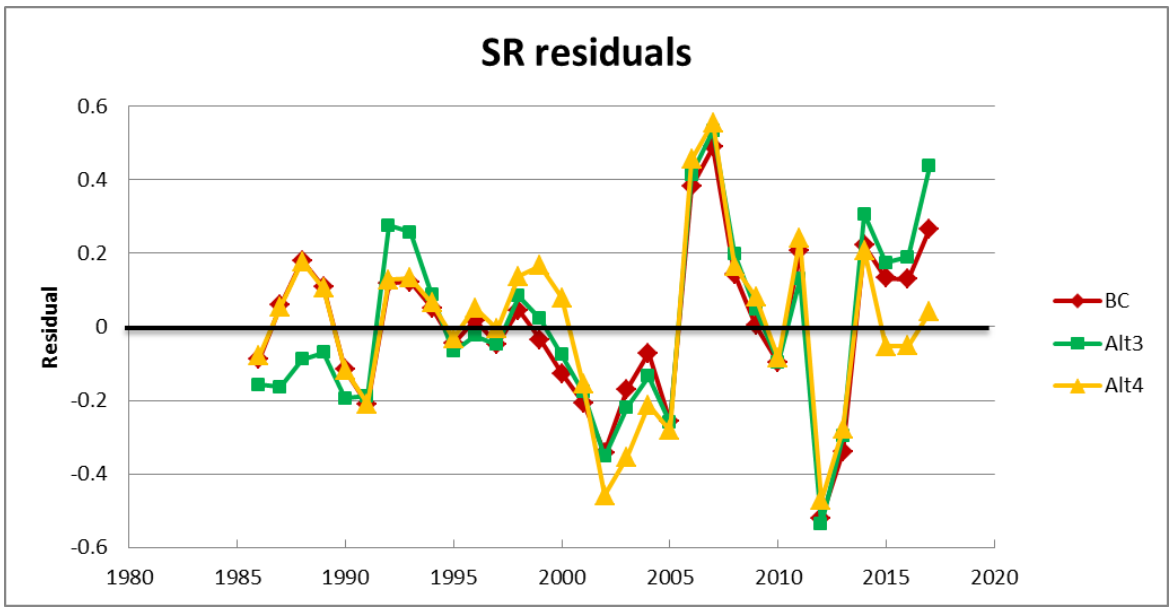

Figure 4b: Estimated stock-recruit residuals for the BC, Alt3 (exclude Autumn survey) and Alt4 (exclude DD CPUE) BC, Alt3 (exclude Autumn survey) and Alt4 (exclude DD CPUE) assessment models.

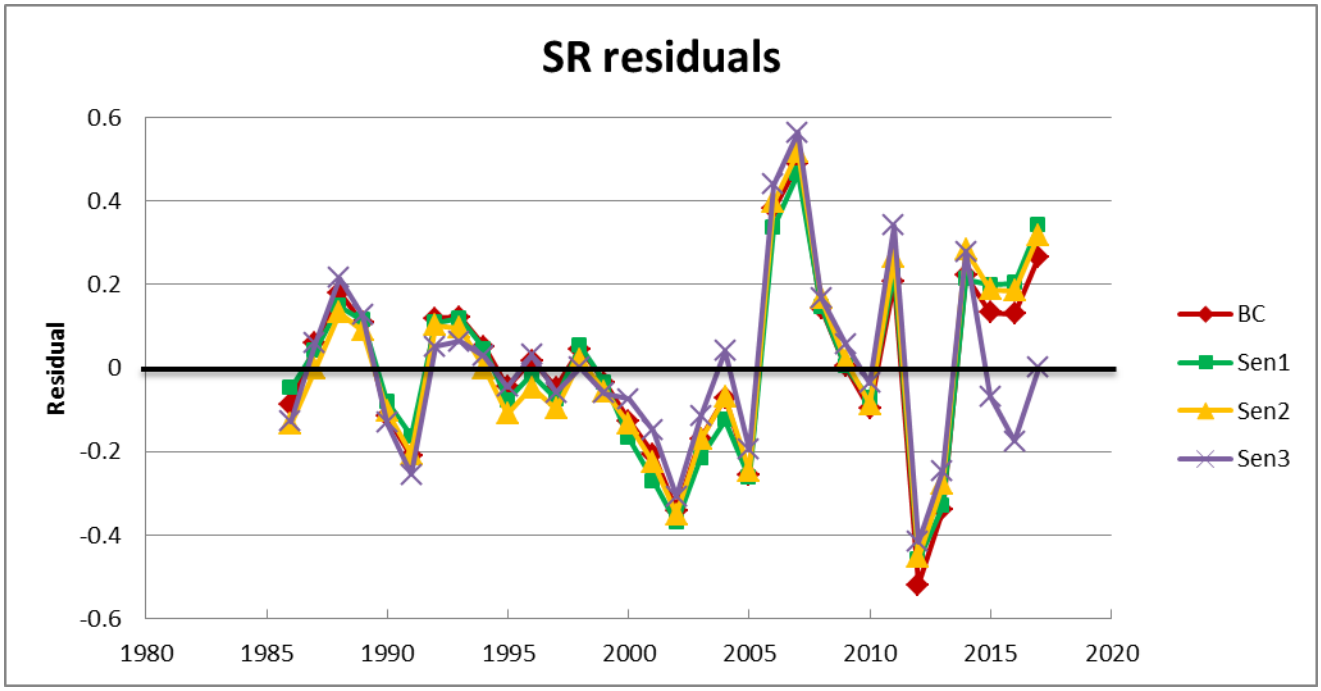

Figure 4c: Estimated stock-recruit residuals for the BC, Sen1 (natural mortality = 0.5), Sen2 (q_{aut} =0.5) and Sen3 (q_{aut} =1.0) models.

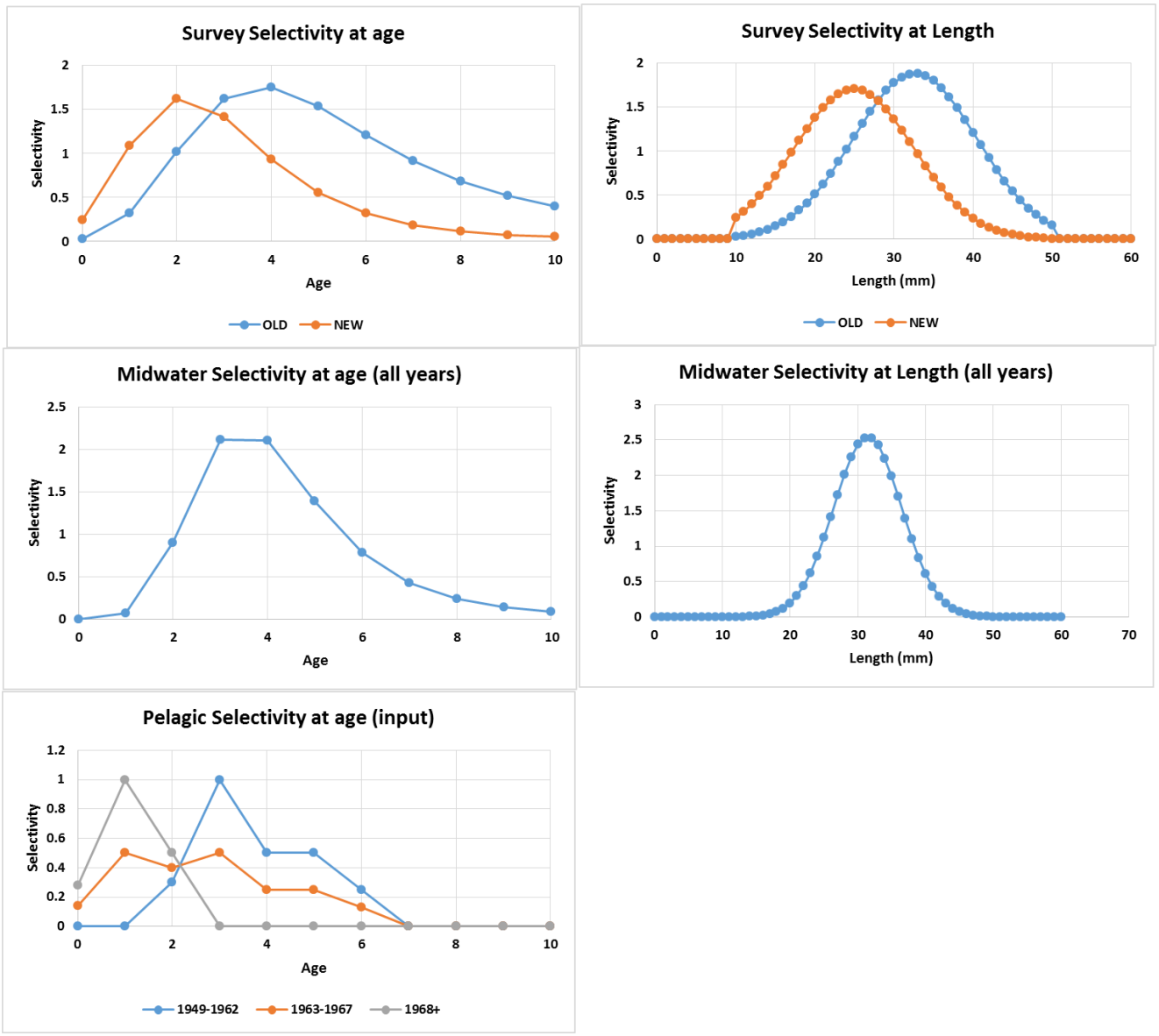

Figure 5: BC model selectivity functions. The old gear (OLD) survey selectivity plot applies also to the demersal bycatch.

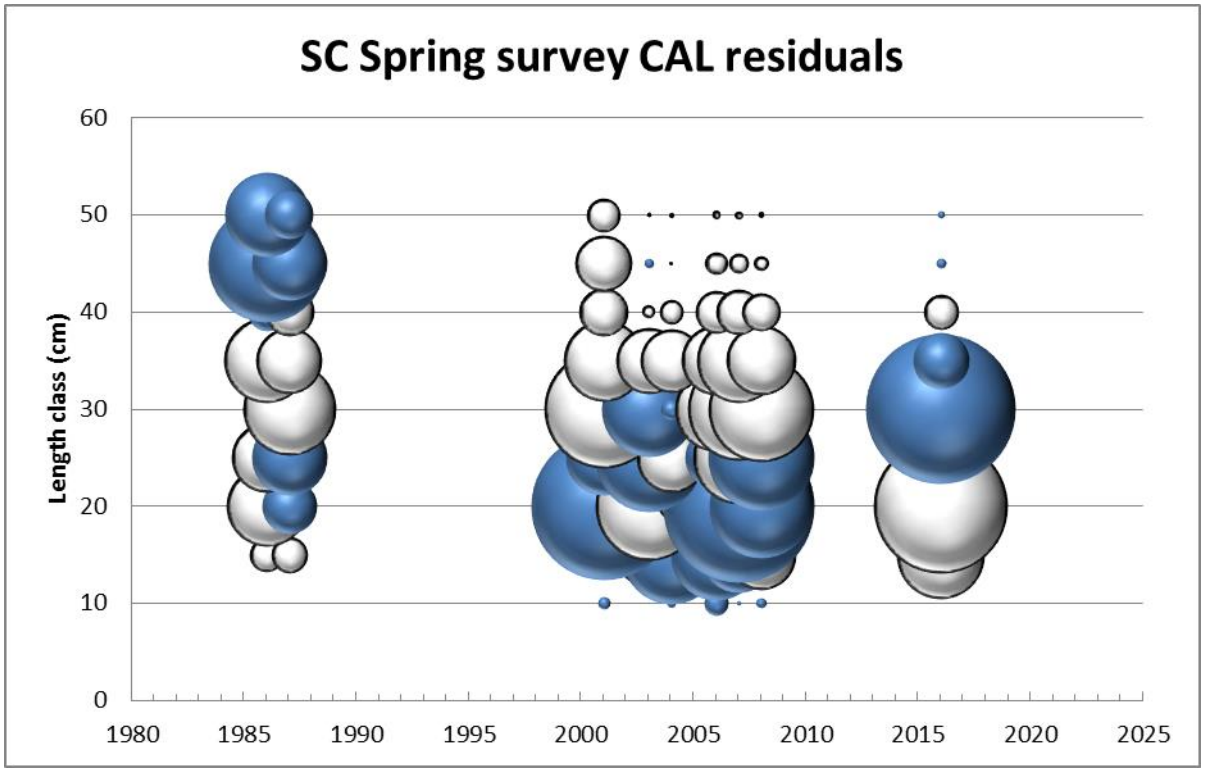

Figure 6a: BC Standardised residual plots for the SC spring survey CAL data. The dashed lines indicate surveys using the new trawl net. Blue indicates negative and white indicates positive residuals.

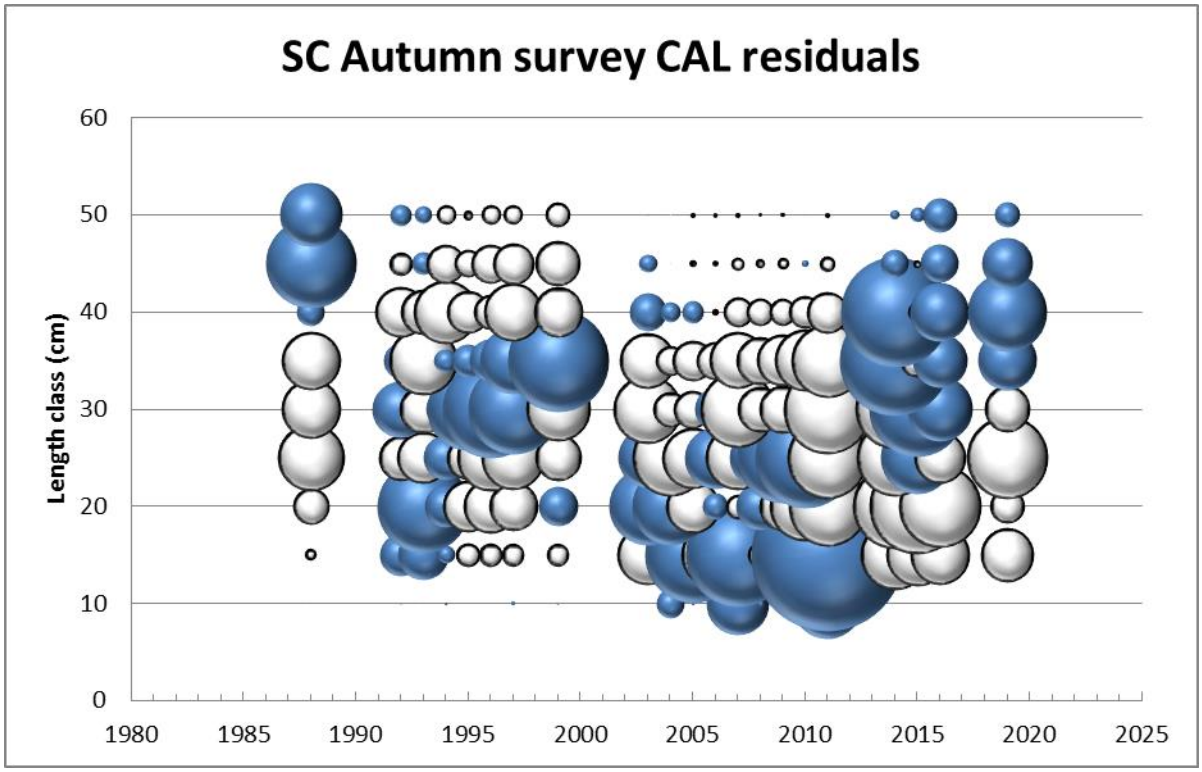

Figure 6b: BC Standardised residual plots for the SC Autumn survey CAL data. The dashed lines indicate surveys using the new trawl net. Blue indicates negative and white indicates positive residuals.

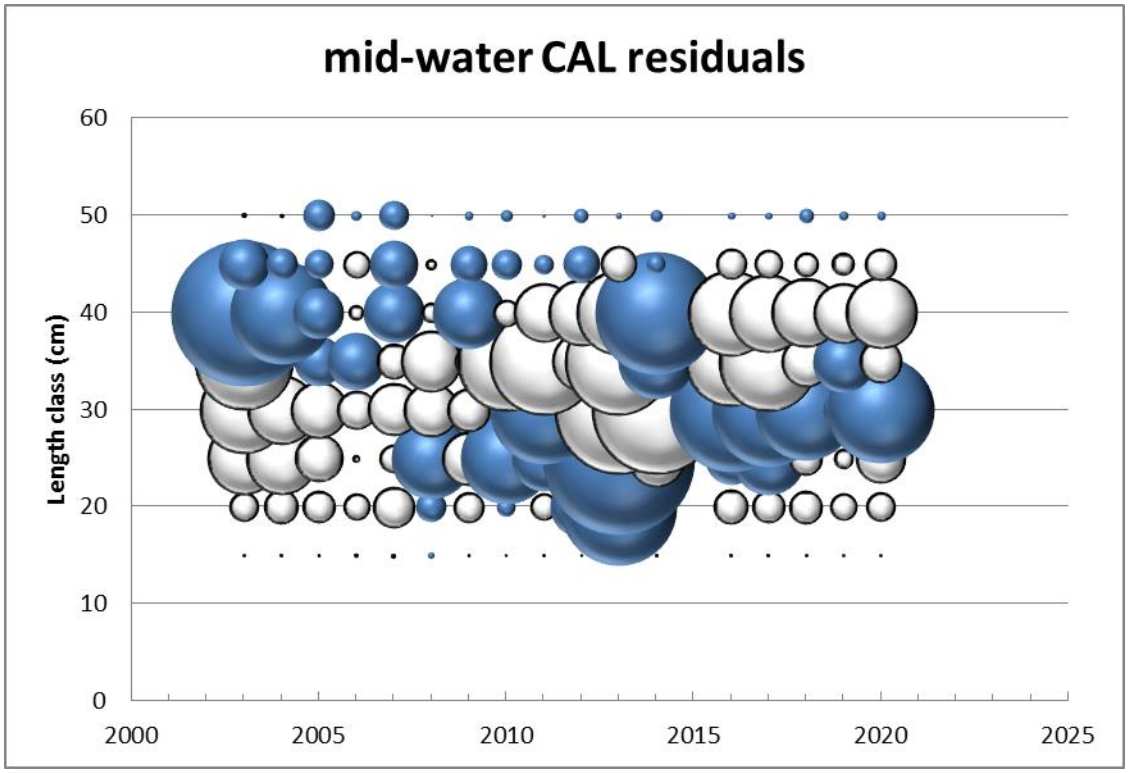

Figure 6c: BC Standardised residual plots for the Mid-water CAL data (from the Desert Diamond). Blue indicates negative and white indicates positive residuals.

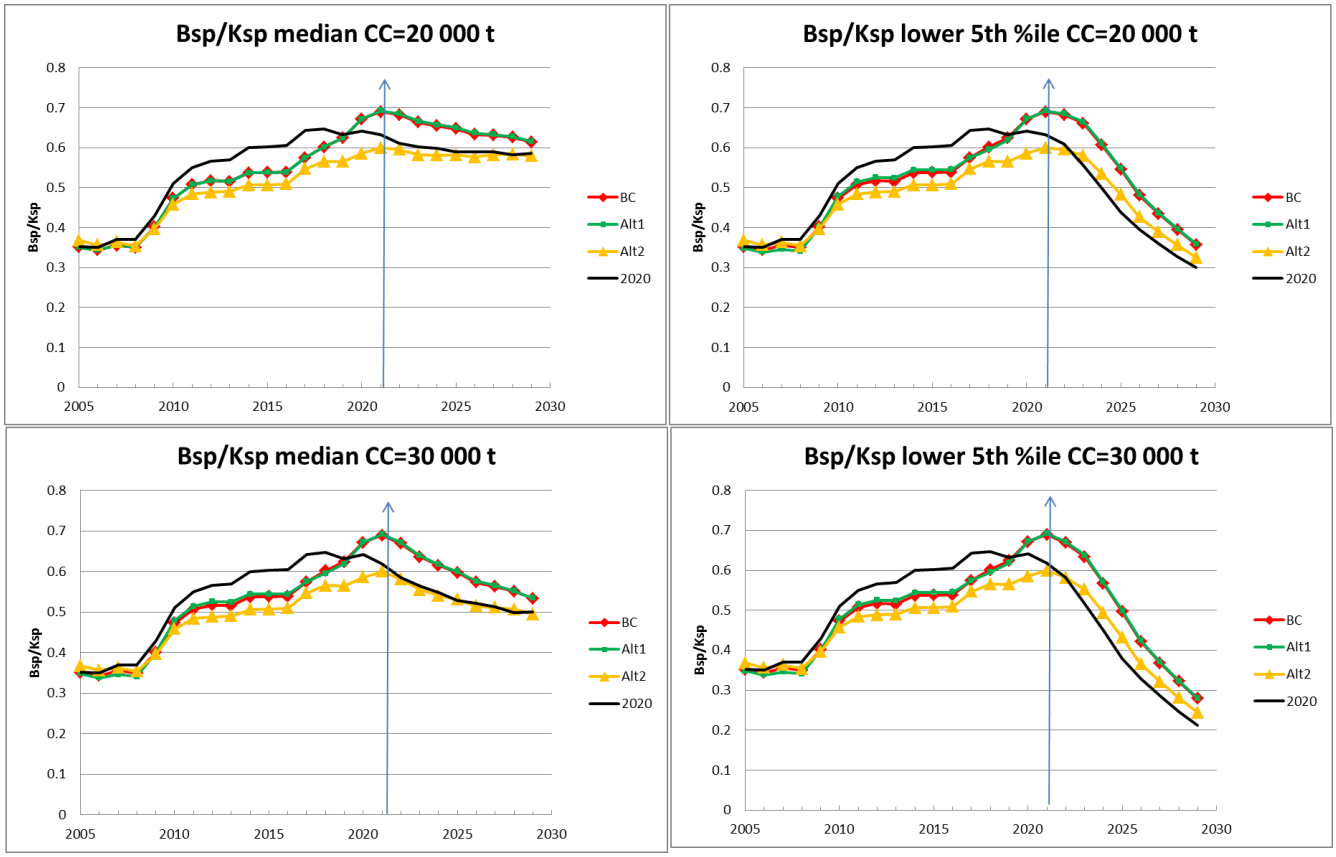

Figure 7a: B^{sp}/K^{sp} median (left) and lower 5th %ile (right) projections for either future midwater constant catch of 20 000 t (top row) or 30 000 t (bottom row). Results are shown for the BC, Alt1 (uses alternative DR CPUE) and Alt2 (includes fitting to WC survey)) models. Comparative results reported in 2020 are shown as the black lines.

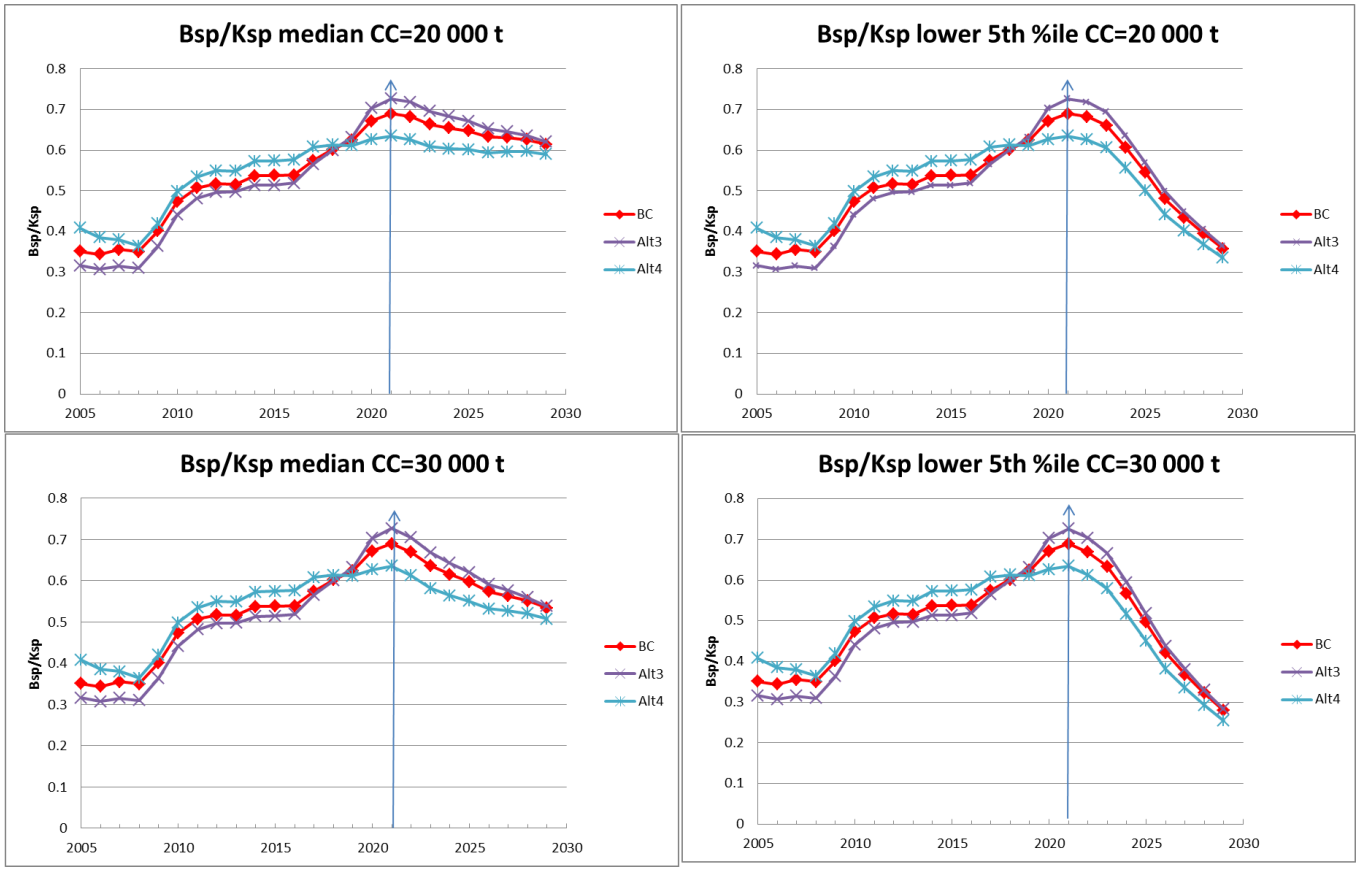

Figure 7b: B^{sp}/K^{sp} median (left) and lower 5th %ile (right) projections for either future midwater constant catch of 20 000 t (top row) or 30 000 t (bottom row). Results are shown for the BC, Alt3 (exclude Autumn survey) and Alt4 (exclude DD CPUE) models.

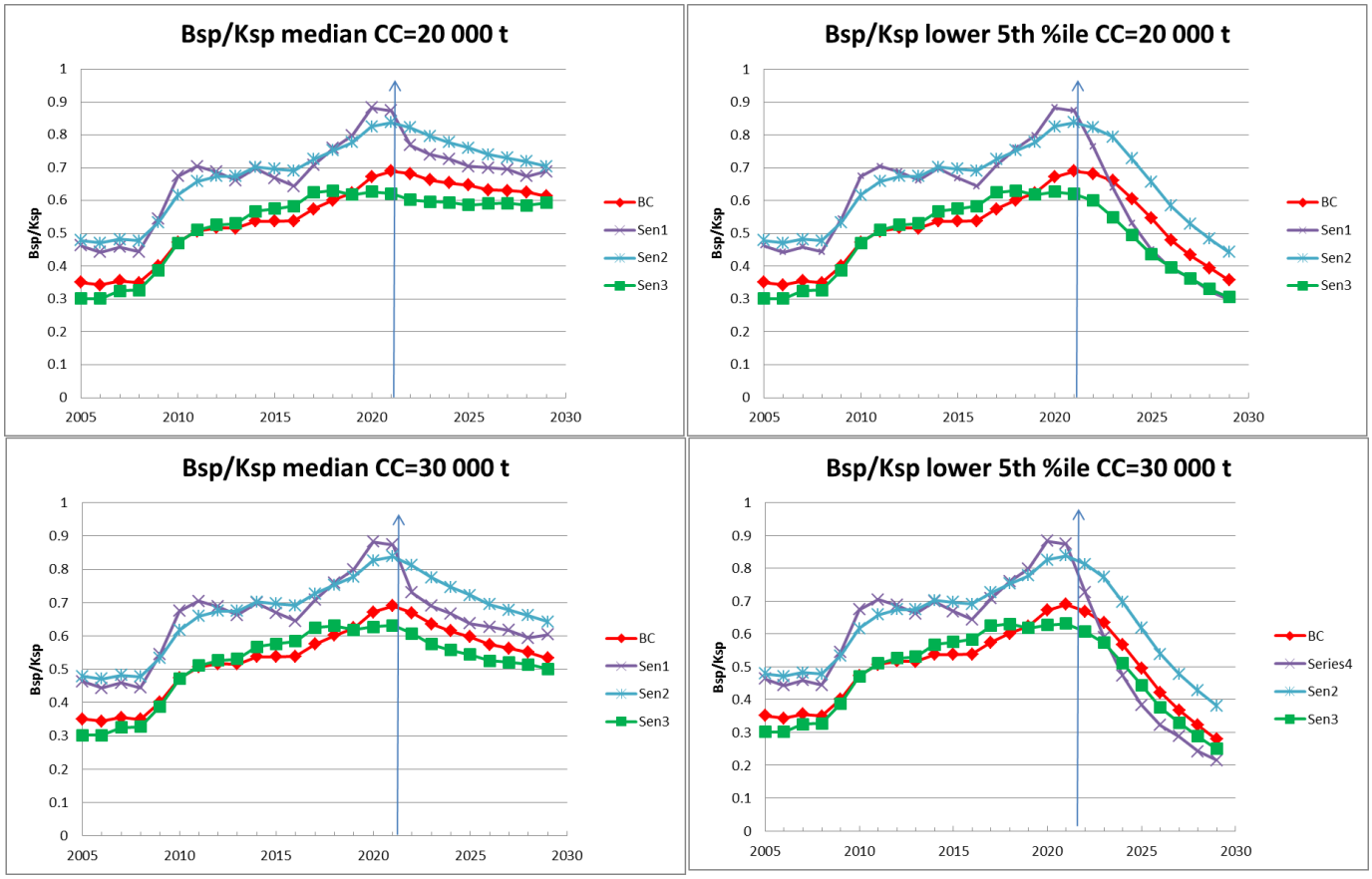

Figure 7c: B^{sp}/K^{sp} median (left) and lower 5th %ile (right) projections for either future midwater constant catch of 20 000 t (top row) or 30 000 t (bottom row). Results are shown for the BC, Sen1 (natural mortality = 0.5), Sen2 (q_{aut} =0.5) and Sen3 (q_{aut} =1.0) models.