Conditioning of the hake OMP2018 Reference Set models with the Model A6b input data

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Summary

Results are provided for the reconditioning of the hake OMP 2018 Reference Set with "data" forthcoming from the species splitting algorithm Model A6b. The results are similar to the ones provided previously in FISHERIES/2018/MAY/SWG-DEM/21. Models starting in 1978 have been excluded at this point in time as some issues have arisen in fitting these that require further investigation. It is preliminarily proposed to remove these models from the Reference Set and consider them instead for robustness tests only.

Introduction

The results of FISHERIES/2018/MAY/SWG-DEM/21 are updated using the GLM CPUE and catch "data" forthcoming from the species splitting algorithm Model A6b (DEM/21 used the data from Model A6). Some further detail of the models can be found in DEM/21. Results for the models starting in 1978 can be found in the addendum at the end of this document. Given the difficulties experienced with these models (e.g. certain parameters needing to be fixed owing to estimation instability), it is preliminarily proposed that these models starting in 1978 be removed from the Reference Set and included instead as robustness tests.

For the results reported in this document, there are thus **three** options for the central year.

1. Centre of the shift occurred in 1952[1].
2. Centre of the shift occurred in 1958.
3. Centre of the shift occurred in 1963.

As for DEM/21, there are two options for the form of the stock-recruitment function.

1. Modified Ricker
2. Beverton-Holt (h fixed at 0.90 and h fixed at 0.70)

Results and Discussion

Table 1a and b list key parameter outputs for the nine models reported on in this document, while Table 2 lists the negative log-likelihood components of the models.

Figure 1 shows the female spawning biomass trajectories for all nine models in blue (solid lines for Ricker models, dashed lines for Beverton-Holt models), contrasted against the Oct 2017 Reference Case model in black. Figure 2 includes the female spawning biomass trajectories for the nine RS models only, showing the median and range of these models. Figure 3a and b also show the spawning biomass trajectories, but broken into smaller groups.

[1] The central years tested for OMP2014 were 1950, 1958 and 1965. It was found, however, that the fits to the GLM CPUE data became markedly worse when the central year was later than 1963. Hence 1963 was taken as the third option instead of 1965, and 1950 was similarly adjusted to 1952 to maintain the same symmetry as for the previous set.

Figure 4a and b show the recruitment plots for *M. paradoxus* and *M. capensis* respectively, while Figure 5 shows the fits to the CPUE data.

Overall, the results for models run with the Model A6b species splitting algorithm are fairly similar to those run with the model A6 data in FISHERIES/2018/MAY/SWG-DEM/21. The only notable difference is for models RS05b and RS06b for which the *M. capensis* estimates of depletion are quite different. This is not entirely unexpected, as the *M. capensis* population trajectory has in the past exhibited multi-modality where very different model results can have very similar negative log-likelihoods. However, the estimates of depletion for the species of conservation concern, *M. paradoxus,* are much more stable.

The table below summarises some key features, with the left-hand column listing comments made in DEM/21 for reference (note that these comments have been updated to exclude the results from models starting in 1978), while the right-hand column contrasts the results from this document.

Original comments in DEM/21 (for species splitting Algorithm Model A6)	**Results reported in this document (for species splitting algorithm Model A6b)**
Current depletion for *M. paradoxus* ranges from **0.26** to **0.41** for (generalised) Ricker and from **0.15** to **0.37** for Beverton Holt stock-recruitment models.	Current depletion for *M. paradoxus* ranges from **0.26** to **0.39** for (generalised) Ricker and from **0.15** to 0**.41** for Beverton Holt stock-recruitment models.
Current depletion for *M. capensis* ranges from **0.69** to **0.74** for Ricker and from **0.08** to **0.74** for Beverton-Holt models (note the very wide range in this case).	Current depletion for *M. capensis* ranges from **0.68** to **0.74** for Ricker and from **0.08** to **0.76** for Beverton-Holt models (note the very wide range in this case).
The Beverton-Holt based OMs are generally worse than Ricker-based OMs in terms of the negative log-likelihood and many of the Beverton-Holt models show little effect of changes in spawning biomass on expected recruitment.	This is still the case.
Beverton-Holt models with h=0.9 result in B_{MSY}/K^{sp} estimates that are very low (~10% for *M. paradoxus*). Fixing h at 0.7 has the effect of increasing these estimates (to ~20%). Beverton-Holt with h=0.9 is generally better in total negative log-likelihood points.	This is still the case.
M. paradoxus is consistently estimated above B_{MSY}. *M. capensis* is above B_{MSY} except for the runs Beverton-Holt that produce a very flat biomass trajectory where biomass has little impact on recruitment.	This is still the case.
Models RS02 (the Ricker model with central year 1958) and RS03 (the Ricker model with central year 1963) are the best in terms of the total negative log-likelihood.	This is still the case, although the margin between RS02 and RS03 is slightly larger. The difference in negative log-likelihood for the three Ricker models is just less than 3, as was the case for the Ricker models in DEM/21.

Acknowledgements

Funding of the Claude Leon Foundation is gratefully acknowledged. Computations were performed using facilities provided by the University of Cape Town's ICTS High Performance Computing team: *hpc.uct.ac.za*.

Table 1a: Key parameter estimates for the RS models (biomass units are thousand tons). Cases where the current spawning biomass is below its MSY value are in bold font, marked with an asterisk.

			M. paradoxus								*M. capensis*							
Model name	Central Year	Stock Recruit	K^{sp}	B^{sp}_{MSY}	B^{sp}_{2017}	B^{tot}_{2017}	B^{sp}_{2017}/K^{sp}	$B^{sp}_{2017}/B^{sp}_{MSY}$	B^{sp}_{MSY}/K^{sp}	MSY	K^{sp}	B^{sp}_{MSY}	B^{sp}_{2017}	B^{tot}_{2017}	B^{sp}_{2017}/K^{sp}	$B^{sp}_{2017}/B^{sp}_{MSY}$	B^{sp}_{MSY}/K^{sp}	MSY
(0) Oct 2017	1958	Ricker	515	115	127	245	0.25	1.11	0.22	137	196	63	141	334	0.72	2.23	0.32	81
(1) RS01	1952	Ricker	340	53	88	196	0.26	1.65	0.16	144	412	96	294	647	0.71	3.06	0.23	112
(2) RS02	1958		318	55	93	206	0.29	1.67	0.17	145	290	86	198	446	0.68	2.30	0.30	84
(3) RS03	1963		266	63	103	223	0.39	1.62	0.24	146	465	142	343	750	0.74	2.42	0.31	106
(4) RS04a	1952	Beverton-Holt (h=0.9)	520	50	77	181	0.15	1.53	0.10	141	418	84	35	104	0.08	**0.42***	0.20	53
(5) RS05a	1958		527	51	84	194	0.16	1.64	0.10	140	1213	215	877	1874	0.72	4.07	0.18	134
(6) RS06a	1963		540	51	95	219	0.18	1.85	0.10	142	1553	274	1180	2507	0.76	4.31	0.18	170
(7) RS04b	1952	Beverton-Holt (h=0.7)	77	16	26	165	0.34	1.67	0.20	153	536	154	90	217	0.17	**0.58***	0.29	48
(8) RS05b	1958		82	17	30	177	0.36	1.78	0.20	154	1442	398	1045	2224	0.72	2.63	0.28	120
(9) RS06b	1963		88	18	36	216	0.41	2.07	0.20	165	746	217	59	152	0.08	**0.27***	0.29	69

Table 1b: Some further parameter estimates.

			M. paradoxus			*M. capensis*		
Model name	Central Year	Stock Recruit	K^{sp}	h	γ	K^{sp}	h	γ
(0) Oct 2017	1958	Ricker	515	1.26	0.38	196.03	1.34	0.86
(1) RS01	1952	Ricker	340	1.50	0.34	412	2.00	0.58
(2) RS02	1958		318	1.62	0.42	290	2.00	0.85
(3) RS03	1963		266	1.90	0.71	465	1.60	0.79
(5) RS04a	1952	Beverton-Holt (h=0.9)	520	0.90	NA	418	0.90	NA
(6) RS05a	1958		527	0.90	NA	1213	0.90	NA
(7) RS06a	1963		540	0.90	NA	1553	0.90	NA
(9) RS04b	1952	Beverton-Holt (h=0.7)	77	0.70	NA	536	0.70	NA
(10) RS05b	1958		82	0.70	NA	1442	0.70	NA
(11) RS06b	1963		88	0.70	NA	746	0.70	NA

Table 2: Negative log-likelihood components are shown for the RS models. Grey font and italics have been used to show values that are not comparable across the models. For the Oct 2017 model the incomparability is as a result of the old treatment of the catch-at-length data. The values in brackets in the "Total -lnL" column indicate the difference between the comparable -lnL for a given run with the minimum across the RS.

Model name	Central Year	Stock Recruit	Total -lnL		historical CPUE*	GLM CPUE	Survey	Comm. CAL*	Comm. Sex-disagg CAL	Survey CAL	Survey sex-disagg CAL	Age-length Keys*	Rec. Resid.
(0) Oct 2017	1958	Ricker	*-5251.5*	(-)	-40.8	-191.4	-35.1	*-1330.6*	*-1110.6*	*-709.7*	*-1968.3*	124.5	10.4
(1) RS01	1952	Ricker	-3151.2	(2.9)	-37.5	-200.9	-34.4	-823.6	-682.0	-413.3	-1090.7	122.3	8.9
(2) RS02	1958		-3154.1	(0.0)	-37.7	-202.9	-34.5	-825.6	-681.6	-413.3	-1090.0	122.0	9.4
(3) RS03	1963		-3153.0	(1.2)	-36.9	-202.7	-34.4	-823.2	-682.1	-413.3	-1090.9	121.8	8.5
(4) RS04a	1952	BH (h=0.9)	-3134.9	(19.3)	-40.2	-183.5	-33.4	-827.9	-681.3	-416.9	-1087.3	123.1	12.6
(5) RS05a	1958		-3122.8	(31.4)	-36.0	-172.0	-32.6	-821.3	-686.1	-416.8	-1094.4	124.2	12.2
(6) RS06a	1963		-3120.1	(34.0)	-37.0	-167.9	-32.0	-821.0	-685.5	-417.0	-1094.7	124.3	10.7
(7) RS04b	1952	BH (h=0.7)	-3122.2	(31.9)	-37.7	-185.6	-35.0	-826.5	-680.1	-417.2	-1092.5	139.2	13.1
(8) RS05b	1958		-3106.6	(47.6)	-35.5	-174.0	-33.4	-821.4	-681.6	-418.6	-1096.5	140.8	13.6
(9) RS06b	1963		-3117.8	(36.3)	-37.5	-181.4	-33.8	-830.8	-677.7	-418.3	-1091.4	141.2	11.3

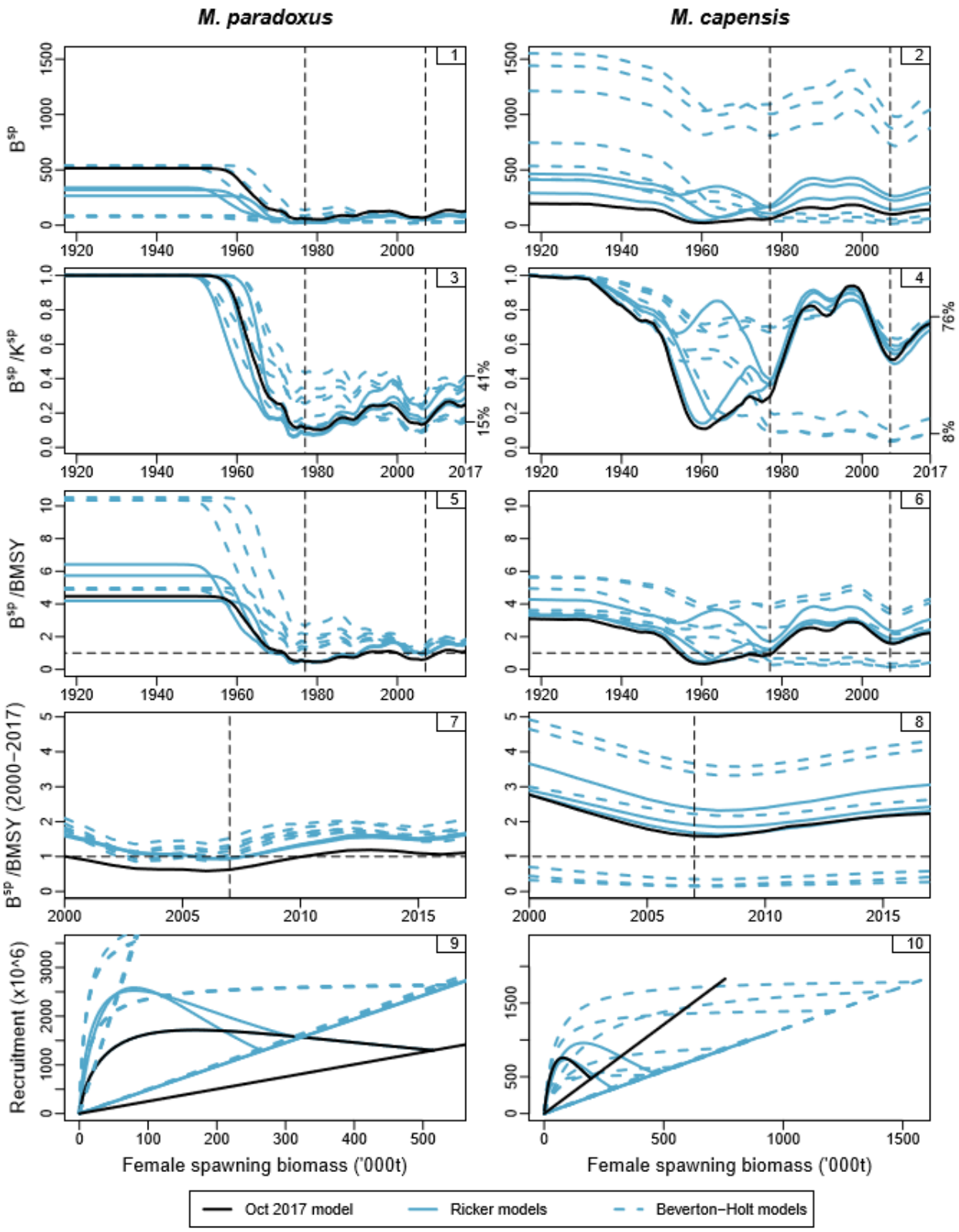

Figure 1: Female spawning biomass trajectories are shown for all the nine models reported on here with the purpose of comparing the 2017 model (black curves) with the 2018 RS models (blue curves) run with the Model A6b GLM CPUE and catch data. Recruitment is also shown plotted against spawning biomass.

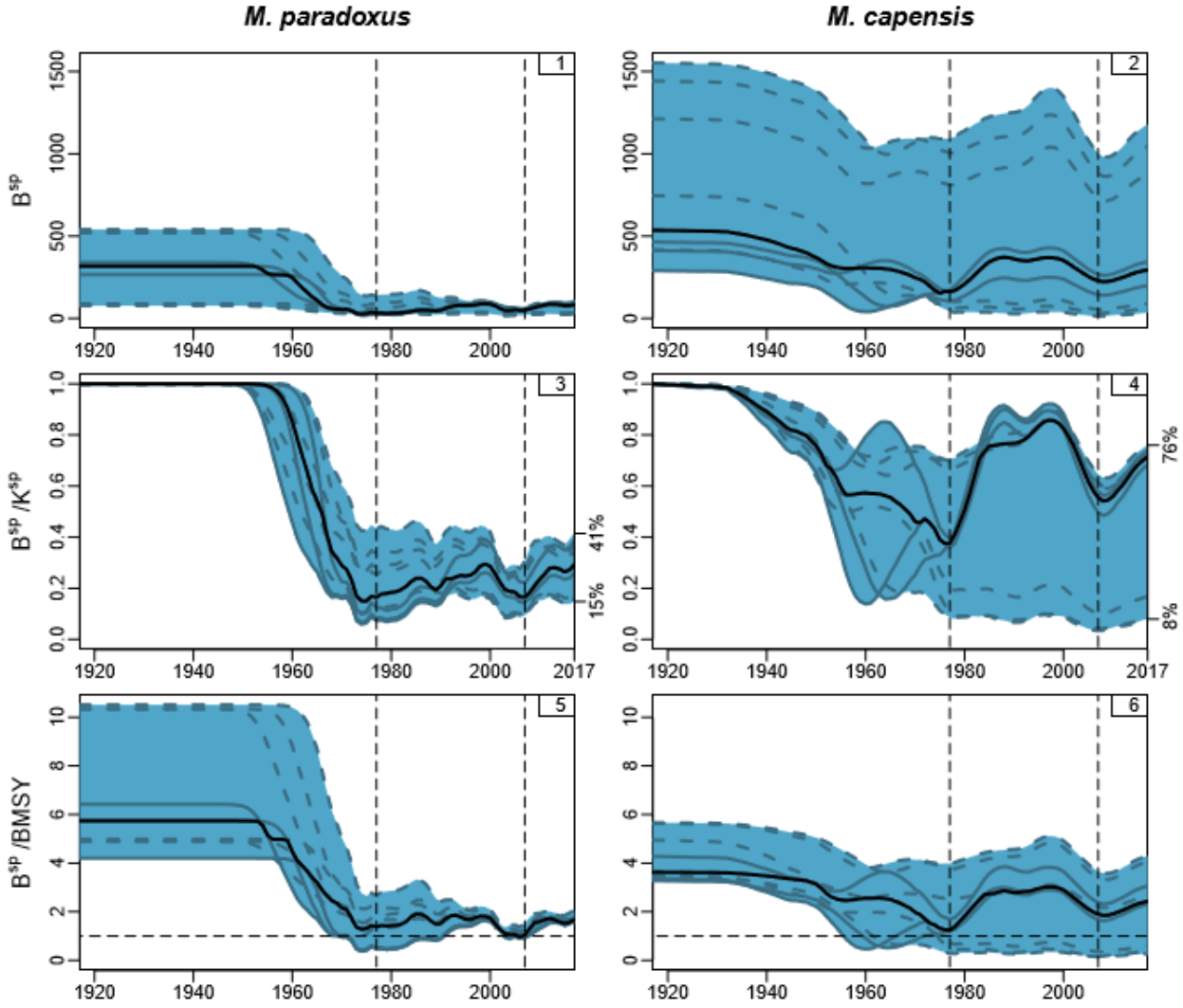

Figure 2: Repeat of the first three rows of Figure 1, but showing only the RS models (i.e. excluding the Oct 2017 model). The black solid line shows the **median** across the nine models for each year and the blue shaded area shows the range (min to max).

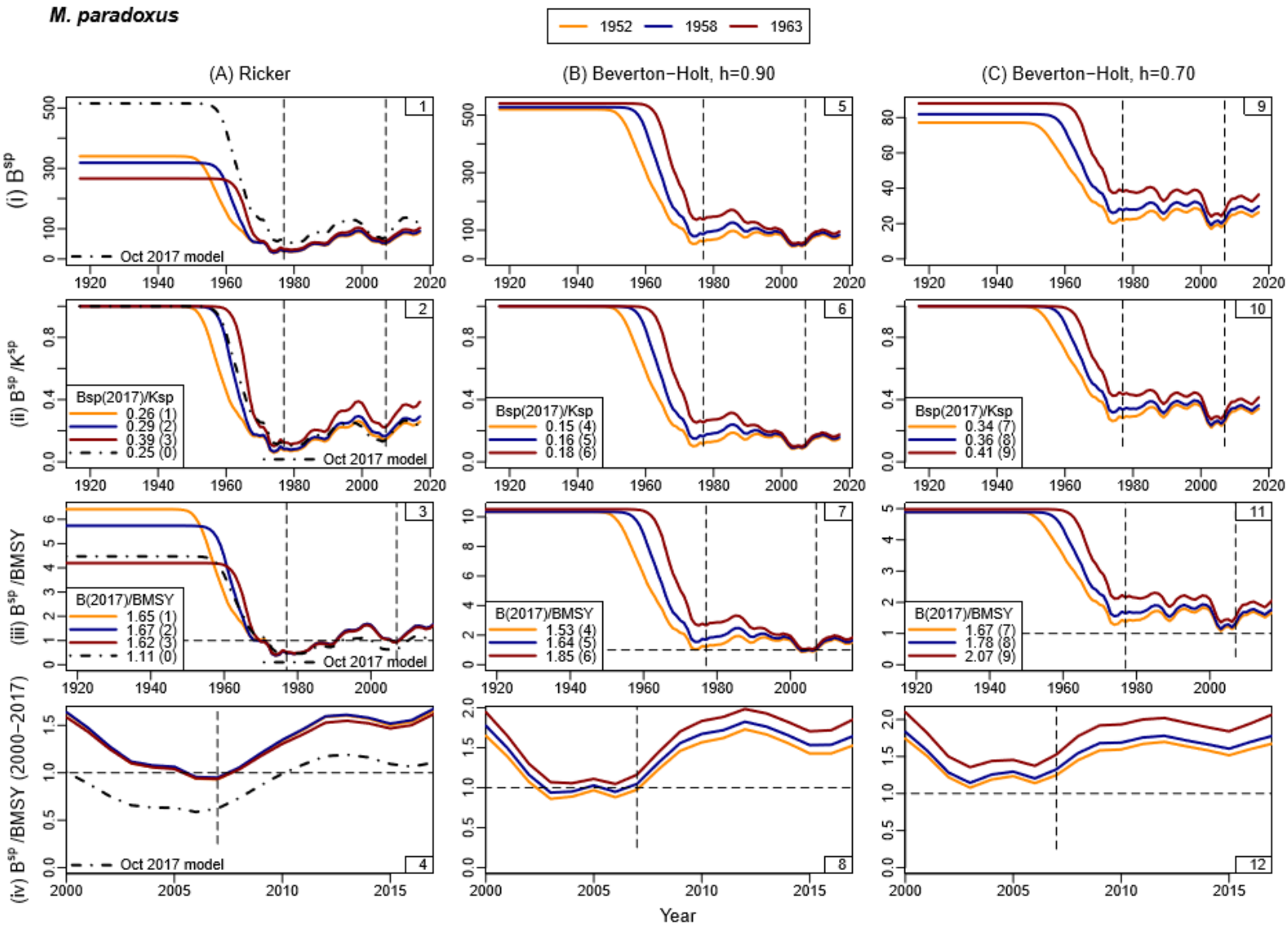

Figure 3a: Female spawning biomass trajectories are shown for ***M. paradoxus*** for smaller groupings of models. In the plots, yellow lines have been used for the models with the central year of shift occurring in 1952, blue lines for the 1958 models and red lines for the 1963 models. The Oct 2017 model has been included in the first column with the RS Ricker models (black dash-dot lines).

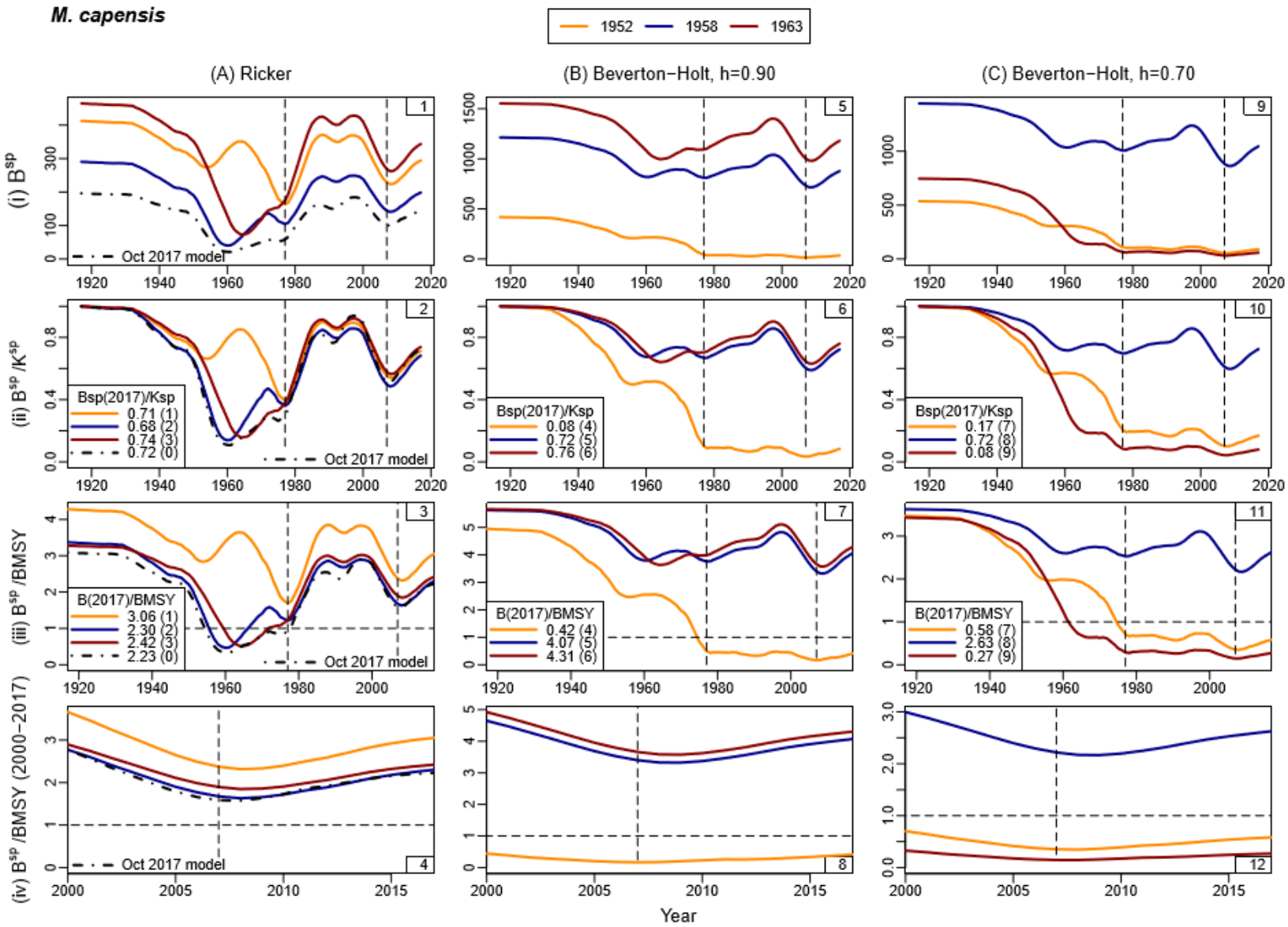

Figure 3b: Female spawning biomass trajectories are shown for ***M. capensis*** for the smaller groupings of models (as in Figure 2a).

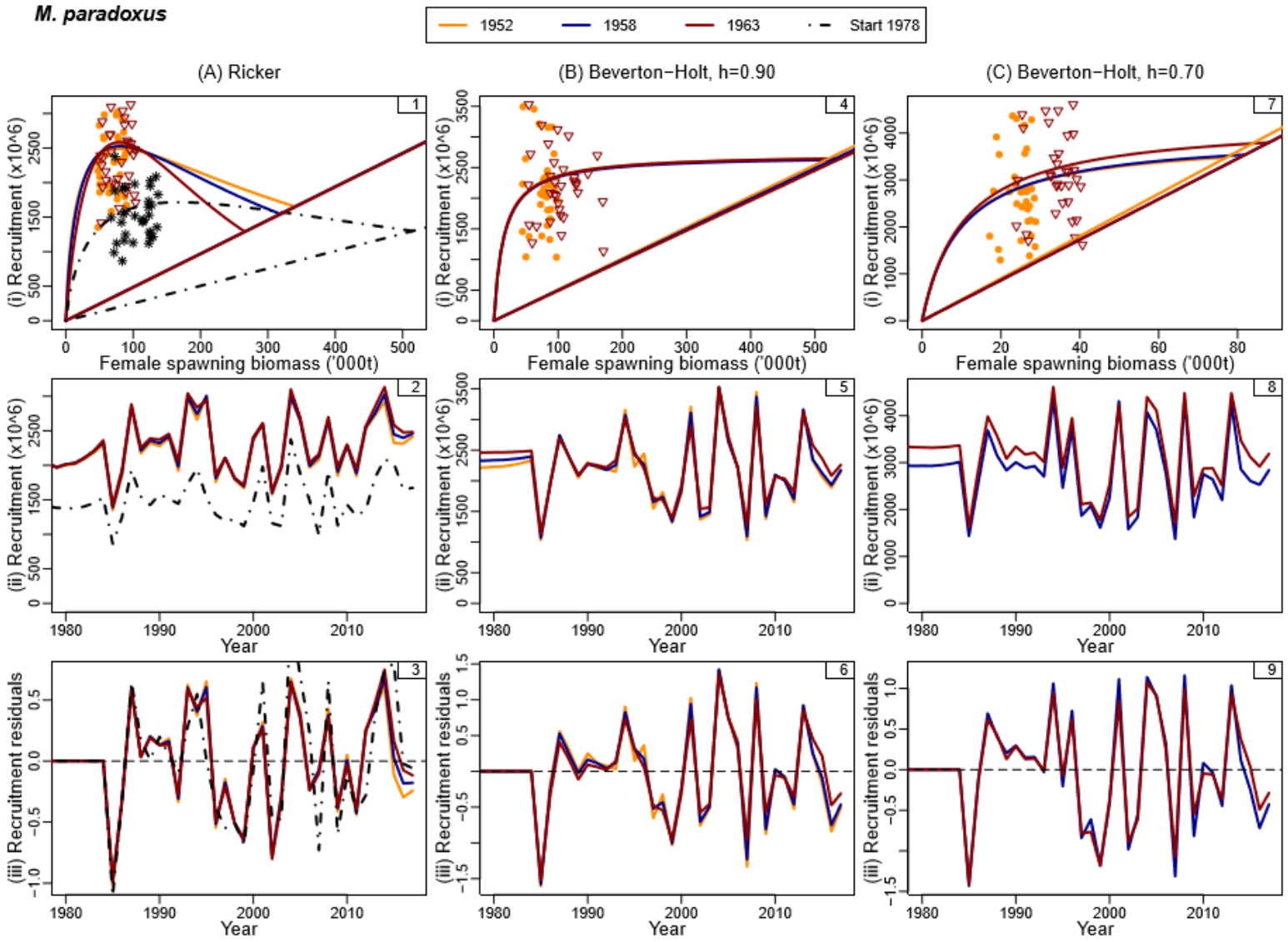

Figure 4a: Stock-recruitment plots together with recruitment time series and residuals about the stock-recruitment curves are shown for ***M. paradoxus*** for the smaller groupings of models. In the interest of clarity, the "data" are shown for a selection of models only. The straight lines through the origin in the stock-recruitment plots are replacement lines.

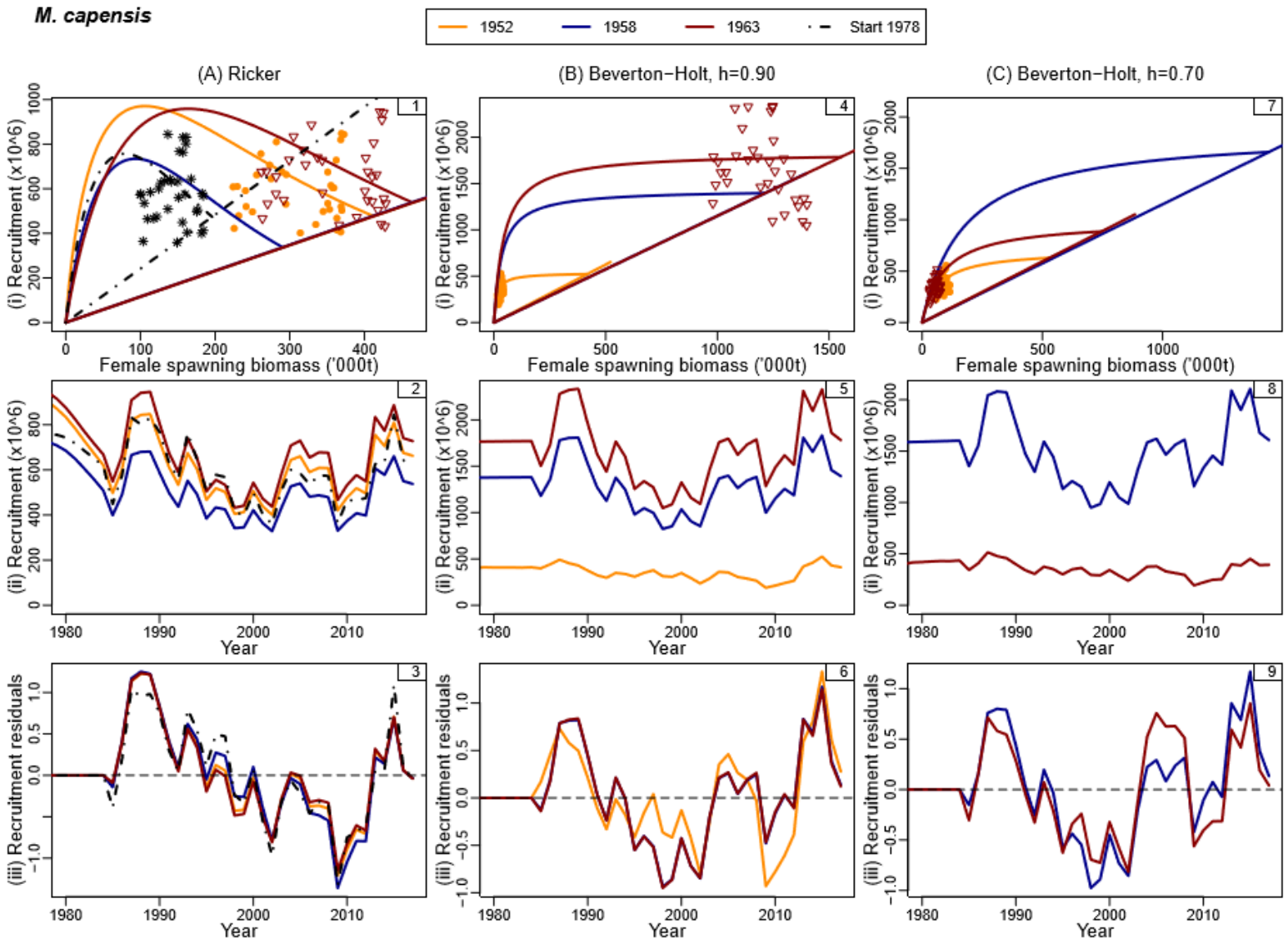

Figure 4b: Stock recruitment plots are shown for ***M. capensis*** for the smaller groupings of models (as in Figure 3a).

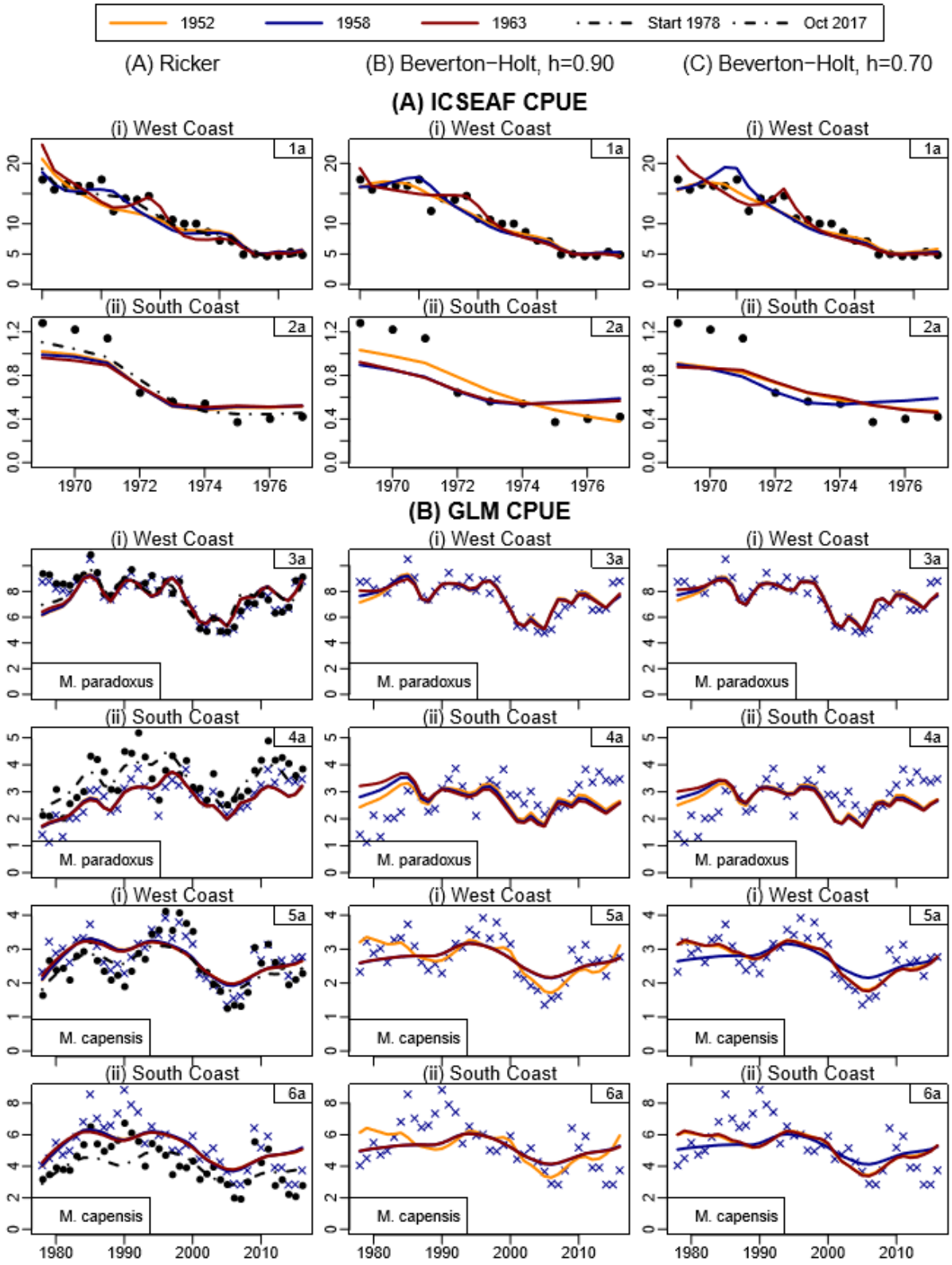

Figure 5: Fits to the ICSEAF and commercial CPUE data. All three columns show the new data for the GLM CPUE. The first column, which shows the Ricker models including the Oct 2017 model, additionally shows the old data with the black squares.

ADDENDUM: Results for the models starting in 1978

This addendum gives the results of the models starting in 1978 alongside those of the other nine models in the RS as reported in the main document. Table 1a and Table 1b list key parameter estimates, while Table 2 gives the negative log-likelihood components. Figure 3a and b show the spawning biomass trajectories for *M. paradoxus* and *M. capensis* respectively, and Figure 5 shows the fits to the CPUE data.

Results for RS04 (Ricker model starting in 1978) and RS08a (Beverton-Holt with h=0.9) are relatively comparable with the other models in their respective groups. RS08b however shows very different trends. Care should be taken when interpreting these results, as many parameters had to be fixed owing to estimation instability (see FISHERIES/2018/MAY/SWG-DEM/21 for more details). It is in light of these issues that the preliminary proposal is made to remove the models starting in 1978 from the RS and keep them rather as robustness tests.

Table 3a(add): Key parameter estimates for the RS models (biomass units are thousand tons), including the runs starting in 1978. Cases where the current spawning biomass is below its MSY value are in bold font and marked with an asterisk.

Model name	Central Year	Stock Recruit	*M. paradoxus*								*M. capensis*							
			K^{sp}	B^{sp}_{MSY}	B^{sp}_{2017}	B^{tot}_{2017}	B^{sp}_{2017}/K^{sp}	$B^{sp}_{2017}/B^{sp}_{MSY}$	B^{sp}_{MSY}/K^{sp}	MSY	K^{sp}	B^{sp}_{MSY}	B^{sp}_{2017}	B^{tot}_{2017}	B^{sp}_{2017}/K^{sp}	$B^{sp}_{2017}/B^{sp}_{MSY}$	B^{sp}_{MSY}/K^{sp}	MSY
(0) Oct 2017	1958	Ricker	515	115	127	245	0.25	1.11	0.22	137	196	63	141	334	0.72	2.23	0.32	81
(1) RS01	1952	Ricker	340	53	88	196	0.26	1.65	0.16	144	412	96	294	647	0.71	3.06	0.23	112
(2) RS02	1958		318	55	93	206	0.29	1.67	0.17	145	290	86	198	446	0.68	2.30	0.30	84
(3) RS03	1963		266	63	103	223	0.39	1.62	0.24	146	465	142	343	750	0.74	2.42	0.31	106
(4) RS04	Start `78		308	53	72	165	0.23	1.36	0.17	143	234	69	146	337	0.63	2.11	0.30	68
(5) RS05a	1952	Beverton-Holt (h=0.9)	520	50	77	181	0.15	1.53	0.10	141	418	84	35	104	0.08	**0.42***	0.20	53
(6) RS06a	1958		527	51	84	194	0.16	1.64	0.10	140	1213	215	877	1874	0.72	4.07	0.18	134
(7) RS07a	1963		540	51	95	219	0.18	1.85	0.10	142	1553	274	1180	2507	0.76	4.31	0.18	170
(8) RS08a	Start `78		624	81	81	184	0.13	1.00	0.13	142	408	76	137	316	0.34	1.80	0.19	47
(9) RS05b	1952	Beverton-Holt (h=0.7)	77	16	26	165	0.34	1.67	0.20	153	536	154	90	217	0.17	**0.58**	0.29	48
(10) RS06b	1958		82	17	30	177	0.36	1.78	0.20	154	1442	398	1045	2224	0.72	2.63	0.28	120
(11) RS07b	1963		88	18	36	216	0.41	2.07	0.20	165	746	217	59	152	0.08	**0.27***	0.29	69
(12) RS08b	Start `78		2004	489	98	224	0.05	**0.20***	0.24	315	501	142	112	264	0.22	**0.79***	0.28	44

Table 1b(add): Some further parameter estimates. Note that B^{sp}_{1978}/K^{sp} is a model output for the first three models in each group and an estimable parameter (θ) for the last in each group where the assessment starts in 1978.

			M. paradoxus					*M. capensis*				
Model name	Central Year	Stock Recruit	K^{sp}	h	γ	B^{sp}_{1978}/K^{sp}	φ	K^{sp}	h	γ	B^{sp}_{1978}/K^{sp}	φ
(0) Oct 2017	1958	Ricker	514.9826	1.264696	0.382267	0.111883	NA	196	1.342332	0.856512	0.342578	NA
(1) RS01	1952	Ricker	340	1.50	0.34	0.07	NA	412	2.00	0.58	0.41	NA
(2) RS02	1958		318	1.62	0.42	0.08	NA	290	2.00	0.85	0.37	NA
(3) RS03	1963		266	1.90	0.71	0.12	NA	465	1.60	0.79	0.42	NA
(4) RS04	Start `78		308	1.62	0.42	0.13	0.39	234	2.00	0.85	0.40	0.25
(5) RS05a	1952	Beverton-Holt (h=0.9)	520	0.90	NA	0.13	NA	418	0.90	NA	0.09	NA
(6) RS06a	1958		527	0.90	NA	0.18	NA	1213	0.90	NA	0.67	NA
(7) RS07a	1963		540	0.90	NA	0.27	NA	1553	0.90	NA	0.71	NA
(8) RS08a	Start `78		624	0.90	NA	0.07	0.37	408	0.90	NA	0.25	0.26
(9) RS05b	1952	Beverton-Holt (h=0.7)	77	0.70	NA	0.29	NA	536	0.70	NA	0.19	NA
(10) RS06b	1958		82	0.70	NA	0.35	NA	1442	0.70	NA	0.70	NA
(11) RS07b	1963		88	0.70	NA	0.44	NA	746	0.70	NA	0.08	NA
(12) RS08b	Start `78		2004	0.70	NA	0.02	0.47	501	0.70	NA	0.21	0.22

Table 4add: Negative log-likelihood components are shown for the RS models. For the models starting in 1978, the historical CPUE data are not relevant as they end in 1978, neither are the Age-length key as the growth curve parameters have been fixed for these models. Additionally, three years' of South Coast offshore catch-at-length data are ignored in the 1978 model, as this series starts in 1975 – hence the commercial catch-at-length value is also not comparable with the other RS models. These columns are marked with a star to indicate that the incomparability of the Start '78 runs, and additionally grey font and italics have been used to show values that are not comparable across the models. For the Oct 2017 model the incomparability is as a result of the old treatment of the catch-at-length data. The values in brackets indicate the difference between the comparable -lnL for a given run with the minimum across the RS.

Model name	Central Year	Stock Recruit	Total -lnL		historical CPUE*	GLM CPUE	Survey	Comm. CAL*	Comm. Sex-disagg CAL	Survey CAL	Survey sex-disagg CAL	Age-length Keys*	Rec. Resid.
(0) Oct 2017	1958	Ricker	*-5251.5*	(-)	-40.8	-191.4	-35.1	*-1330.6*	*-1110.6*	*-709.7*	*-1968.3*	124.5	10.4
(1) RS01	1952	Ricker	-3151.2	(2.9)	-37.5	-200.9	-34.4	-823.6	-682.0	-413.3	-1090.7	122.3	8.9
(2) RS02	1958		-3154.1	(0.0)	-37.7	-202.9	-34.5	-825.6	-681.6	-413.3	-1090.0	122.0	9.4
(3) RS03	1963		-3153.0	(1.2)	-36.9	-202.7	-34.4	-823.2	-682.1	-413.3	-1090.9	121.8	8.5
(4) RS04	Start `78		-	-	NA	-193.0	-36.1	*-804.2*	-682.0	-411.8	-1090.6	NA	9.5
(5) RS05a	1952	BH (h=0.9)	-3134.9	(19.3)	-40.2	-183.5	-33.4	-827.9	-681.3	-416.9	-1087.3	123.1	12.6
(6) RS06a	1958		-3122.8	(31.4)	-36.0	-172.0	-32.6	-821.3	-686.1	-416.8	-1094.4	124.2	12.2
(7) RS07a	1963		-3120.1	(34.0)	-37.0	-167.9	-32.0	-821.0	-685.5	-417.0	-1094.7	124.3	10.7
(8) RS08a	Start `78		-	-	NA	-195.4	-36.6	*-801.8*	-681.8	-411.8	-1090.4	NA	7.5
(9) RS05b	1952	BH (h=0.7)	-3122.2	(31.9)	-37.7	-185.6	-35.0	-826.5	-680.1	-417.2	-1092.5	139.2	13.1
(10) RS06b	1958		-3106.6	(47.6)	-35.5	-174.0	-33.4	-821.4	-681.6	-418.6	-1096.5	140.8	13.6
(11) RS07b	1963		-3117.8	(36.3)	-37.5	-181.4	-33.8	-830.8	-677.7	-418.3	-1091.4	141.2	11.3
(12) RS08b	Start `78		-	-	NA	-207.0	-37.0	*-799.8*	-680.9	-413.0	-1089.8	0.0	7.7

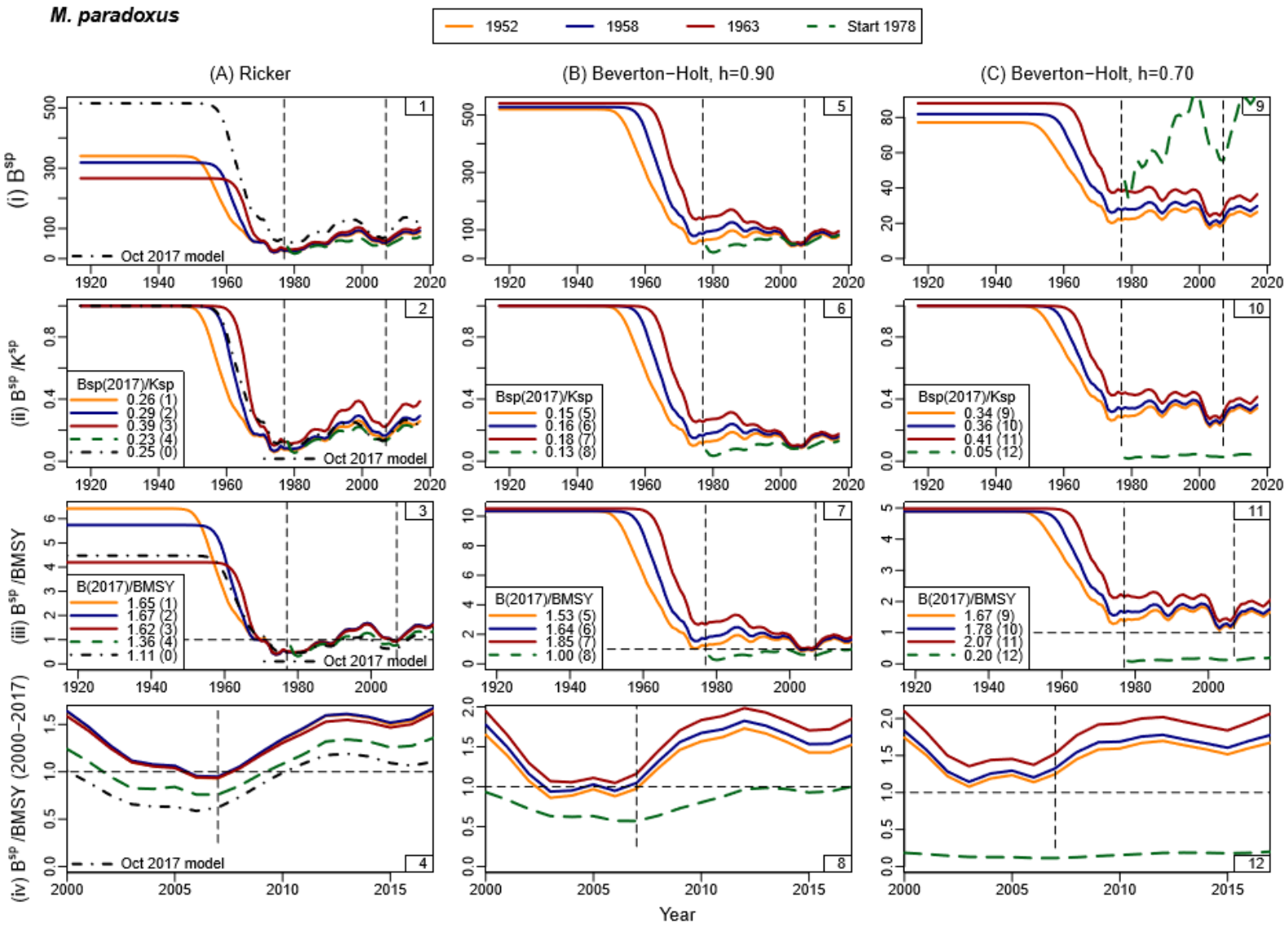

Figure 6a(add): Female spawning biomass trajectories are shown for ***M. paradoxus***. In the plots, yellow lines have been used for the models with the central year of shift occurring in 1952, blue lines for the 1958 models and red lines for the 1963 models. Dashed green lines have been used for the model starting in 1978. The Oct 2017 model has been included in the first column with the RS Ricker models (black dash-dot lines).

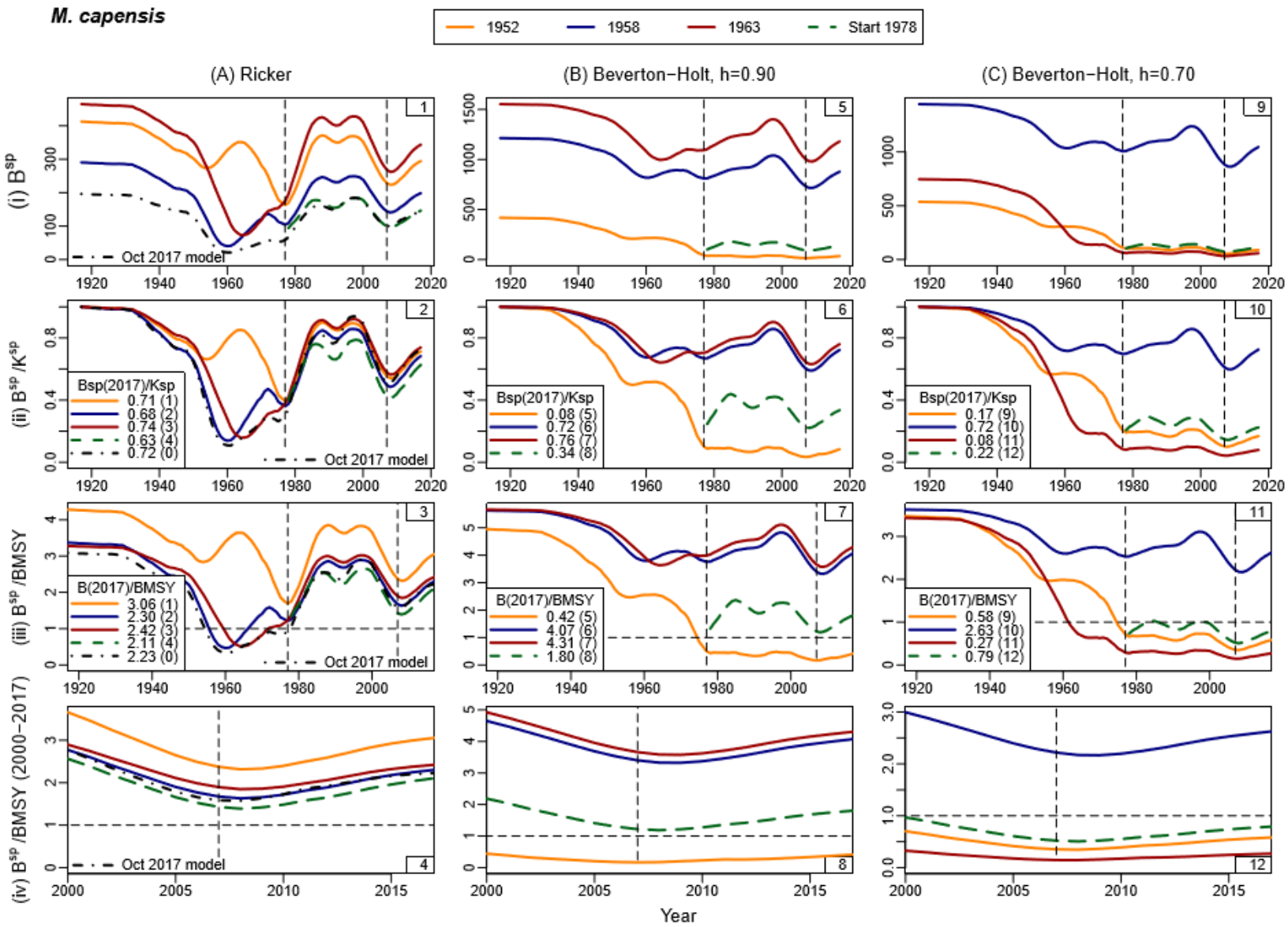

Figure 3b(add): Female spawning biomass trajectories are shown for ***M. capensis*** (as in Figure 2a).

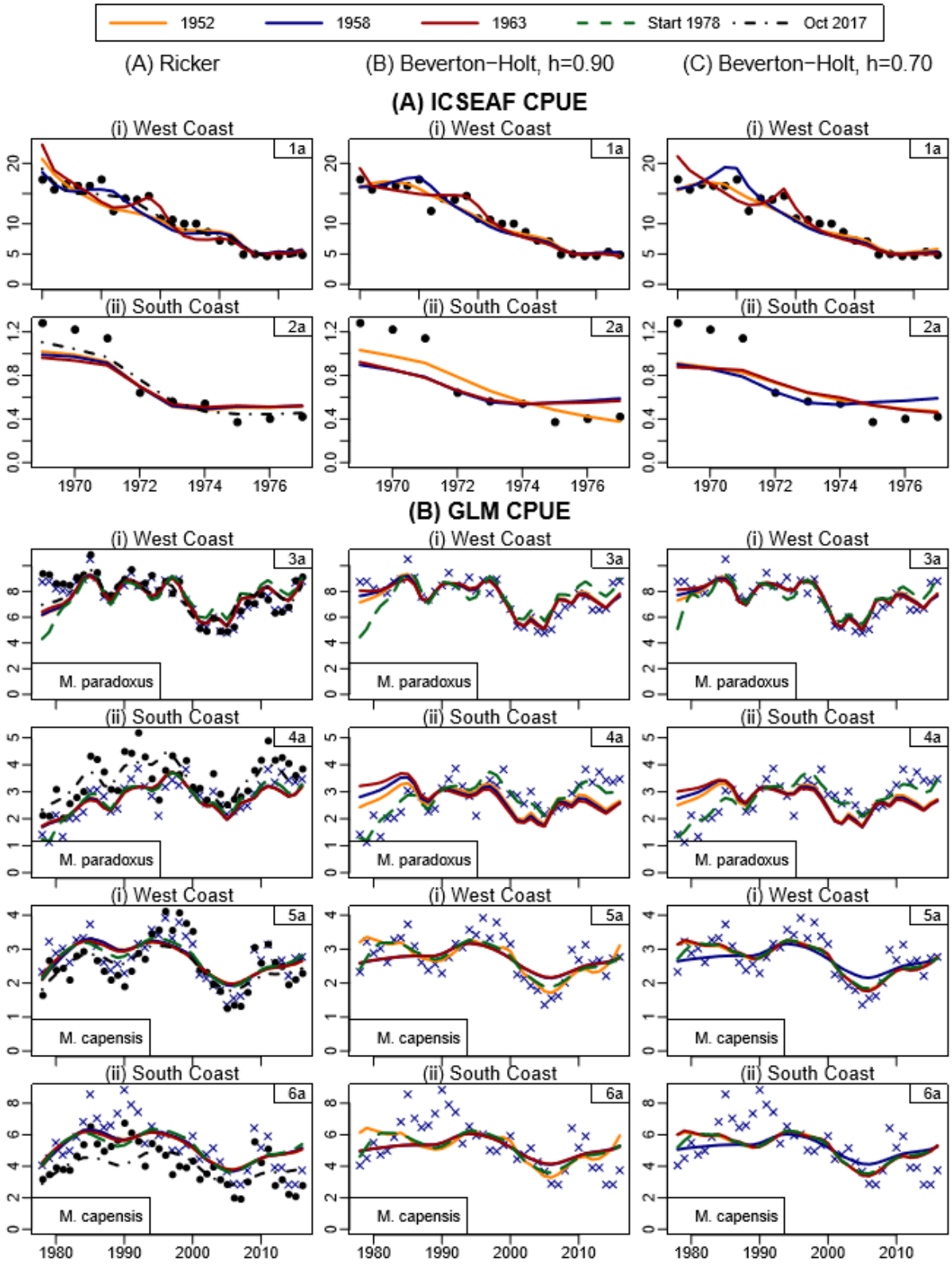

Figure 7add: Fits to the ICSEAF and commercial CPUE data. All three columns show the new data for the GLM CPUE. The first column, which shows the Ricker models including the Oct 2017 model, additionally shows the old data with the filled circles.