Further Hake Projections under four Candidate OMPs

R.A. Rademeyer and D.S. Butterworth

MARAM (Marine Resource Assessment and Management Group)
Department of Mathematics and Applied Mathematics
University of Cape Town, Rondebosch 7701, South Africa

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Introduction

This paper provides performance statistics for a variety of candidates OMPs applied to the New Reference Set trials and four robustness tests. These OMPs include OMP1, OMP5 and OMP7 for which some results were previously reported in WG/09/06/D:H:38, together with one new candidate (OMP11). Each of these four candidate OMPs has been tuned to three different **median** recovery level for *M. paradoxus* (15%, 20% and 25%) of *K* after 20 years.

Because of time constraints, results four only four of the six robustness tests presented in WG/09/06/D:H:39 are presented here. Robustness tests A1b (discards in the past) and "Decr in *K*" (decrease in the carrying capacity for *M. capensis* from 1992 onwards) have been omitted as they showed the lesser differences to the Reference Set results, or were less pertinent to risk considerations.

Results

The specifications and control parameter values for each of candidate OMPs and their tunings are given in Table 1.

Key comparative results for the variety of OMPs considered may be found in Table 2 and Fig. 1. Medians of projections under the different candidates for a comparable **median** 20% recovery tuning for *M. paradoxus* are compared in Fig. 2 for the Reference Set. Figs 3 and 4 compare median trajectories for the three recovery tunings for *M. paradoxus* for an application of OMP1 and OMP7 respectively, for the Reference Set.

Table 3 gives the probability of projected changes in TAC over five year intervals for each of the candidate OMPs, for the Reference Set.

Tables 4-7 report performance statistics for each of the robustness trials in turn for all the candidate OMPs, and these results are presented graphically in Figs 5-8.

Table 8 gives the probability of projected changes in TAC over five year intervals for an application of OMP1_20% (i.e. **median** recovery to 20% of *K* for *M. paradoxus* after 20 years) to the Reference Set and the four robustness tests.

Full graphical sets of projections for each of the candidates for the Reference Set are reproduced in Appendix A. Similar plots are also shown for an application of OMP1_20% to each of the four robustness tests.

Table 1: Tuning parameters for each candidate OMP presented in this paper. δ_1, δ_2 and δ_3 are the rate parameters of the year-dependent tuning parameter, λ_y .

Case		Fixed phase down	*p*	¬*1*	¬*2*	¬*3*	Yr_join	Target incr para	Target incr cap	Y	Max incr	Max decr1	Max decr2	Limit1	Limit2
OMP1	15%	-	6	0.50	2	1.1	10	0.0183	0	10	10%	10%	-	-	-
	20%	-	6	0.50	2	1.1	10	0.0240	0	15	10%	10%	-	-	-
	25%	-	6	0.50	2	1.1	10	0.0303	0	20	10%	10%	-	-	-
OMP5	15%	-	6	0.50	3	1.1	10	0.0090	0	10	10%	10%	20%	0.8	0.6
	20%	-	6	0.50	3	1.1	10	0.0176	0	15	10%	10%	20%	0.8	0.6
	25%	-	6	0.50	3	1.1	10	0.0243	0	20	10%	10%	20%	0.8	0.6
OMP7	15%	3x7.5%	6	0.50	4	1.1	10	0.0080	0	10	5%	5%	15%	0.8	0.6
	20%	3x7.5%	6	0.50	4	1.1	10	0.0190	0	15	5%	5%	15%	0.8	0.6
	25%	3x7.5%	6	0.50	4	1.1	10	0.0298	0	20	5%	5%	15%	0.8	0.6
OMP11	15%	1x20'000t	6	0.50	3	1.1	10	0.0065	0	10	10%	10%	-	-	-
	20%	1x20'000t	6	0.50	3	1.1	10	0.0163	0	15	10%	10%	-	-	-
	25%	1x20'000t	6	0.50	3	1.1	10	0.0238	0	20	10%	10%	-	-	-

Note: “Max decr1”, “Max decr2”, “Limit1” and “Limit2” correspond to D_1, D_2, L_1 and L_2 respectively from equation 4 in document WG/09/06/D:H:33. The shape of the function of the maximum annual decrease in TAC as a function of relative CPUE is shown below

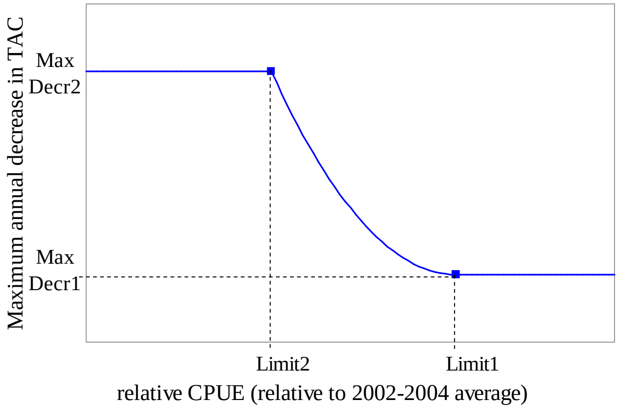


Table 2: Summary of performance statistics for the full combination of four candidate OMPs and three median recovery tuning for *M. paradoxus*, for the **Reference Set**. For each statistic, the median and 90% PIs are shown.

		OMP1			OMP5			OMP7			OMP11		
		15%	20%	25%	15%	20%	25%	15%	20%	25%	15%	20%	25%
Species combined	avTAC	129.52	125.19	120.78	129.85	125.77	122.11	128.09	123.89	119.63	130.10	126.34	121.81
		113.22	108.82	104.80	109.76	106.15	102.28	102.14	98.43	94.83	114.59	110.26	105.66
		144.51	139.43	134.32	145.18	140.55	136.02	143.55	139.80	134.61	146.34	141.28	135.21
	AAV	5.10	5.03	4.92	5.37	5.29	5.21	4.09	4.10	4.04	5.47	5.31	5.29
		3.35	3.45	3.31	3.54	3.76	3.49	3.19	3.23	3.12	3.87	4.01	3.65
		7.01	6.85	6.73	7.55	7.44	7.50	5.85	5.95	6.11	7.19	7.12	7.07
	$CPUE_{2016}/CPUE_{2005}$	1.53	1.57	1.60	1.55	1.60	1.64	1.47	1.50	1.53	1.55	1.61	1.67
		1.24	1.26	1.30	1.25	1.30	1.34	1.17	1.21	1.24	1.29	1.33	1.36
		1.91	1.95	1.99	1.99	2.05	2.10	1.87	1.91	1.94	1.95	1.99	2.05
	C_{2007}	135.00	135.00	135.00	134.97	134.97	134.97	138.75	138.75	138.75	130.00	130.00	130.00
		-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	-	-	-
	C_{2008}	121.50	121.50	121.50	121.47	121.47	121.47	128.34	128.34	128.34	117.00	117.00	117.00
		121.50	121.50	121.50	118.94	118.54	118.54	128.34	128.34	128.34	117.00	117.00	117.00
		130.86	129.99	128.88	131.47	129.11	127.75	128.34	128.34	128.34	127.39	124.82	123.29
	C_{2009}	112.31	111.02	109.88	109.33	109.33	109.21	118.72	118.72	118.72	106.61	105.30	105.30
		109.35	109.35	109.35	102.64	102.20	102.20	118.72	118.72	118.72	105.30	105.30	105.30
		128.66	127.86	126.98	128.22	126.84	125.88	118.72	118.72	118.72	125.22	122.50	121.47
M. paradoxus	B_{2027}/K	**0.150**	**0.200**	**0.250**	**0.150**	**0.200**	**0.250**	**0.150**	**0.200**	**0.250**	**0.150**	**0.200**	**0.250**
		0.069	0.121	0.167	0.059	0.109	0.165	0.061	0.111	0.167	0.050	0.111	0.160
		0.259	0.313	0.372	0.283	0.334	0.389	0.353	0.396	0.420	0.250	0.305	0.364
	B_{2027}/B_{2007}	2.13	2.88	3.79	2.11	2.91	3.65	2.18	3.05	3.82	2.07	2.86	3.65
		1.21	1.96	2.54	1.07	1.81	2.43	1.19	1.82	2.42	0.98	1.88	2.51
		3.82	4.86	5.98	4.05	5.03	6.16	5.90	6.68	7.87	3.76	4.79	6.02
M. capensis	B_{2027}/K	0.67	0.70	0.72	0.67	0.70	0.72	0.69	0.72	0.73	0.67	0.70	0.72
		0.56	0.59	0.61	0.55	0.58	0.60	0.56	0.59	0.61	0.55	0.58	0.61
		0.82	0.85	0.87	0.82	0.84	0.87	0.84	0.86	0.88	0.81	0.84	0.87
	B_{2027}/B_{2007}	1.42	1.49	1.54	1.43	1.49	1.54	1.45	1.51	1.56	1.42	1.48	1.53
		1.17	1.22	1.26	1.16	1.21	1.26	1.20	1.24	1.29	1.16	1.20	1.25
		1.70	1.78	1.84	1.72	1.79	1.84	1.75	1.81	1.86	1.70	1.77	1.83

Table 3: Probability of projected TAC a) increase, and decrease b) between 0 and 5%, c) between 5% and 10%, d) between 10% and 15% and e) greater than 15% over five year intervals, for an application of each combination of candidate OMPs and recovery level for the Reference Set. Note that values necessarily zero in terms of the OMP's TAC change rules are shown in bold.

			Probability that the percentage change in TAC is:				
			>0	between 0 and -5%	between -5 and -10%	between -10 and -15%	< -15%
OMP1	15%	2007-2011	0.23	0.15	0.61	**0**	**0**
		2012-2016	0.65	0.23	0.12	**0**	**0**
		2017-2021	0.71	0.20	0.09	**0**	**0**
		2022-2026	0.57	0.26	0.17	**0**	**0**
	20%	2007-2011	0.22	0.15	0.63	**0**	**0**
		2012-2016	0.64	0.24	0.13	**0**	**0**
		2017-2021	0.60	0.29	0.12	**0**	**0**
		2022-2026	0.66	0.23	0.11	**0**	**0**
	25%	2007-2011	0.20	0.14	0.66	**0**	**0**
		2012-2016	0.62	0.25	0.13	**0**	**0**
		2017-2021	0.59	0.29	0.11	**0**	**0**
		2022-2026	0.53	0.30	0.17	**0**	**0**
OMP5	15%	2007-2011	0.26	0.11	0.25	0.35	0.02
		2012-2016	0.71	0.18	0.10	0.00	0.01
		2017-2021	0.69	0.21	0.09	0.00	0.01
		2022-2026	0.55	0.27	0.16	0.02	0.00
	20%	2007-2011	0.24	0.10	0.27	0.37	0.03
		2012-2016	0.70	0.18	0.11	0.00	0.01
		2017-2021	0.64	0.26	0.10	0.00	0.00
		2022-2026	0.64	0.24	0.12	0	0
	25%	2007-2011	0.23	0.09	0.27	0.39	0.03
		2012-2016	0.68	0.19	0.12	0.00	0.01
		2017-2021	0.64	0.25	0.10	0.00	0.00
		2022-2026	0.54	0.29	0.17	0	0
OMP7	15%	2007-2011	0.21	0.11	0.65	0.03	**0**
		2012-2016	0.64	0.27	0.07	0.02	**0**
		2017-2021	0.71	0.27	0.02	0.00	**0**
		2022-2026	0.64	0.35	0.01	0.00	**0**
	20%	2007-2011	0.19	0.12	0.66	0.04	**0**
		2012-2016	0.61	0.28	0.08	0.03	**0**
		2017-2021	0.65	0.33	0.01	0.00	**0**
		2022-2026	0.71	0.28	0.00	0	**0**
	25%	2007-2011	0.16	0.13	0.67	0.04	**0**
		2012-2016	0.55	0.33	0.08	0.04	**0**
		2017-2021	0.63	0.36	0.01	0.00	**0**
		2022-2026	0.58	0.43	0	0	**0**
OMP11	15%	2007-2011	0.29	0.11	0.40	0.20*	**0**
		2012-2016	0.76	0.17	0.08	**0**	**0**
		2017-2021	0.66	0.24	0.11	**0**	**0**
		2022-2026	0.53	0.26	0.21	**0**	**0**
	20%	2007-2011	0.27	0.10	0.43	0.20*	**0**
		2012-2016	0.74	0.17	0.09	**0**	**0**
		2017-2021	0.62	0.27	0.11	**0**	**0**
		2022-2026	0.62	0.25	0.13	**0**	**0**
	25%	2007-2011	0.24	0.09	0.47	0.20*	**0**
		2012-2016	0.73	0.17	0.10	**0**	**0**
		2017-2021	0.62	0.27	0.11	**0**	**0**
		2022-2026	0.53	0.30	0.18	**0**	**0**

* This reflects the 20 000 ton decrease for this OMP for 2007; thereafter the rules for this OMP do not allow TAC changes to exceed 10%.

Table 4: Summary of performance statistics for the full combination of four candidate OMPs and three median recovery tuning for *M. paradoxus*, for the **SR1 robustness test**. For each statistic, the median and 90% PIs are shown. Results integrate over **only four** of the 24 Reference Set scenarios.

		OMP1			OMP5			OMP7			OMP11		
		15%	20%	25%	15%	20%	25%	15%	20%	25%	15%	20%	25%
Species combined	avTAC	140.69	136.98	132.02	141.04	137.87	134.03	137.37	132.81	128.89	141.21	137.86	133.13
		126.56	121.78	117.13	126.26	123.39	119.29	125.04	120.65	117.17	127.10	123.68	118.44
		155.52	150.40	144.69	155.91	152.04	146.86	150.29	145.85	141.40	155.79	151.24	146.05
	AAV	5.07	5.07	5.01	5.25	5.29	5.16	4.15	4.12	4.10	5.39	5.38	5.29
		3.31	3.46	3.42	3.50	3.59	3.59	3.38	3.30	3.32	3.72	3.82	3.73
		6.57	6.66	6.40	6.93	6.89	6.51	4.74	4.71	4.66	6.86	6.74	6.49
	$CPUE_{2016}/CPUE_{2005}$	1.46	1.51	1.55	1.43	1.50	1.54	1.66	1.69	1.71	1.48	1.57	1.61
		1.21	1.26	1.31	1.15	1.23	1.28	1.29	1.32	1.33	1.21	1.30	1.35
		1.85	1.89	1.95	1.85	1.90	1.96	2.17	2.19	2.20	1.88	1.98	2.03
	C_{2007}	135.00	135.00	135.00	134.97	134.97	134.97	138.75	138.75	138.75	130.00	130.00	130.00
		-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	-	-	-
	C_{2008}	128.68	127.57	126.35	128.24	125.85	123.99	128.34	128.34	128.34	124.29	121.66	119.66
		121.50	121.50	121.50	120.81	120.74	120.67	128.34	128.34	128.34	117.00	117.00	117.00
		135.49	135.11	134.69	136.08	135.51	135.06	128.34	128.34	128.34	131.25	130.63	130.15
	C_{2009}	128.41	126.88	125.21	127.85	125.08	123.92	118.72	118.72	118.72	124.31	120.75	119.68
		113.38	111.59	109.76	109.82	109.33	109.33	118.72	118.72	118.72	106.99	105.30	105.30
		141.29	140.46	139.55	142.60	141.35	140.38	118.72	118.72	118.72	137.82	136.45	135.41
M. paradoxus	B_{2027}/K	**0.154**	**0.211**	**0.258**	**0.139**	**0.198**	**0.242**	**0.195**	**0.238**	**0.282**	**0.143**	**0.208**	**0.258**
		0.074	0.121	0.170	0.069	0.113	0.152	0.106	0.151	0.187	0.065	0.111	0.160
		0.247	0.303	0.365	0.240	0.294	0.354	0.321	0.367	0.413	0.253	0.310	0.362
	B_{2027}/B_{2007}	2.03	2.81	3.46	1.85	2.58	3.28	2.47	3.21	3.79	1.96	2.72	3.40
		1.21	2.03	2.56	1.05	1.78	2.33	1.59	2.04	2.55	0.99	1.79	2.43
		3.36	4.45	5.29	3.24	4.11	4.94	4.54	5.47	6.19	3.45	4.35	5.23
M. capensis	B_{2027}/K	0.63	0.67	0.69	0.62	0.66	0.68	0.65	0.68	0.70	0.62	0.66	0.68
		0.53	0.56	0.59	0.52	0.55	0.58	0.55	0.57	0.59	0.52	0.56	0.58
		0.79	0.82	0.84	0.78	0.81	0.84	0.82	0.84	0.87	0.78	0.81	0.84
	B_{2027}/B_{2007}	1.41	1.48	1.54	1.40	1.47	1.52	1.45	1.50	1.56	1.41	1.47	1.53
		1.18	1.24	1.28	1.16	1.22	1.27	1.19	1.23	1.27	1.17	1.22	1.27
		1.66	1.78	1.84	1.63	1.75	1.81	1.77	1.85	1.92	1.64	1.75	1.82

Table 5: Summary of performance statistics for the full combination of four candidate OMPs and three median recovery tuning for *M. paradoxus*,, for the **robustness test with a Ricker stock-recruitment curve (A7b)**. For each statistic, the median and 90% PIs are shown. Results integrate over **only four** of the 24 Reference Set scenarios.

		OMP1			OMP5			OMP7			OMP11		
		15%	20%	25%	15%	20%	25%	15%	20%	25%	15%	20%	25%
Species combined	avTAC	134.68	128.77	122.98	135.95	130.56	124.34	133.19	127.94	122.92	136.19	129.04	123.24
		116.57	111.53	107.27	117.02	112.83	108.70	111.45	107.83	105.42	117.45	112.63	108.03
		150.77	143.31	138.06	151.13	144.38	139.51	147.62	140.92	135.38	151.19	144.31	138.23
	AAV	4.66	4.68	4.54	4.84	4.86	4.76	3.95	3.84	3.81	4.99	5.02	4.96
		3.39	3.24	3.21	3.45	3.39	3.42	3.17	3.07	2.99	3.59	3.71	3.58
		6.28	6.18	6.01	6.39	6.49	6.42	4.95	4.83	4.73	6.44	6.55	6.41
	$CPUE_{2016}/CPUE_{2005}$	1.42	1.46	1.50	1.41	1.47	1.51	1.43	1.45	1.48	1.43	1.50	1.55
		1.25	1.28	1.32	1.22	1.27	1.31	1.15	1.18	1.21	1.26	1.32	1.35
		1.69	1.73	1.76	1.68	1.73	1.77	1.68	1.73	1.75	1.72	1.77	1.81
	C_{2007}	135.00	135.00	135.00	134.97	134.97	134.97	138.75	138.75	138.75	130.00	130.00	130.00
		-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	-	-	-
	C_{2008}	123.58	122.49	121.51	121.48	121.47	121.47	128.34	128.34	128.34	117.11	117.00	117.00
		121.50	121.50	121.50	120.26	120.26	120.25	128.34	128.34	128.34	117.00	117.00	117.00
		133.02	132.65	132.23	132.96	132.40	131.95	128.34	128.34	128.34	128.25	127.63	127.15
	C_{2009}	117.06	115.58	113.97	114.77	112.41	110.76	118.72	118.72	118.72	112.41	109.09	107.17
		109.35	109.35	109.35	107.72	106.75	106.75	118.72	118.72	118.72	105.30	105.30	105.30
		134.24	133.47	132.62	135.46	134.29	133.39	118.72	118.72	118.72	130.93	129.65	128.67
M. paradoxus	B_{2027}/K	**0.362**	**0.455**	**0.537**	**0.344**	**0.440**	**0.519**	**0.373**	**0.455**	**0.531**	**0.351**	**0.452**	**0.538**
		0.249	0.335	0.429	0.209	0.323	0.406	0.219	0.297	0.383	0.221	0.342	0.422
		0.524	0.630	0.728	0.516	0.608	0.704	0.571	0.642	0.712	0.510	0.611	0.704
	B_{2027}/B_{2007}	2.25	2.84	3.33	2.12	2.71	3.17	2.20	2.64	3.14	2.20	2.77	3.24
		1.47	2.01	2.46	1.29	1.90	2.30	1.37	1.92	2.41	1.36	1.92	2.38
		2.95	3.51	3.99	2.88	3.42	3.87	3.43	3.69	4.04	3.01	3.48	3.95
M. capensis	B_{2027}/K	0.76	0.79	0.81	0.76	0.78	0.80	0.78	0.80	0.82	0.76	0.77	0.80
		0.68	0.70	0.73	0.68	0.70	0.72	0.69	0.71	0.74	0.68	0.70	0.72
		0.90	0.94	0.96	0.90	0.93	0.95	0.90	0.93	0.95	0.90	0.92	0.95
	B_{2027}/B_{2007}	1.14	1.17	1.21	1.13	1.16	1.20	1.15	1.19	1.22	1.12	1.16	1.19
		1.00	1.05	1.08	1.00	1.04	1.07	1.02	1.05	1.09	1.00	1.03	1.07
		1.36	1.41	1.45	1.36	1.39	1.43	1.36	1.40	1.44	1.35	1.39	1.43

Table 6: Summary of performance statistics for the full combination of four candidate OMPs and three median recovery tuning for *M. paradoxus*, for the **robustness test with recruitment variability σ_R=0.4 in the past and in the projections (B7)**. For each statistic, the median and 90% PIs are shown. Results integrate over **only four** of the 24 Reference Set scenarios.

		OMP1			OMP5			OMP7			OMP11		
		15%	20%	25%	15%	20%	25%	15%	20%	25%	15%	20%	25%
Species combined	avTAC	127.92	123.27	118.94	127.68	123.46	118.43	124.95	121.16	116.60	129.02	123.83	119.14
		101.11	97.24	94.34	96.33	92.60	89.43	83.39	80.22	78.40	101.52	97.56	94.73
		148.94	143.13	138.20	148.90	142.80	137.62	145.44	141.47	136.90	148.60	143.26	137.87
	AAV	5.63	5.65	5.49	5.97	6.01	5.90	4.35	4.30	4.24	5.88	5.95	5.77
		3.97	4.18	3.86	4.25	4.27	4.12	3.45	3.43	3.29	4.54	4.39	4.38
		7.73	7.65	7.47	9.00	9.09	9.15	6.87	7.10	7.22	7.73	7.83	7.57
	$CPUE_{2016}$/ $CPUE_{2005}$	1.67	1.71	1.75	1.72	1.79	1.84	1.62	1.67	1.69	1.71	1.80	1.83
		1.14	1.16	1.18	1.25	1.29	1.34	1.08	1.10	1.11	1.20	1.28	1.29
		2.38	2.41	2.44	2.57	2.64	2.69	2.41	2.47	2.53	2.47	2.50	2.53
	C_{2007}	135.00	135.00	135.00	134.97	134.97	134.97	138.75	138.75	138.75	130.00	130.00	130.00
		-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	-	-	-
	C_{2008}	121.50	121.50	121.50	121.47	121.47	121.47	128.34	128.34	128.34	117.00	117.00	117.00
		121.50	121.50	121.50	119.61	119.46	119.36	128.34	128.34	128.34	117.00	117.00	117.00
		129.64	128.53	127.30	129.84	127.44	125.57	128.34	128.34	128.34	125.82	123.23	121.20
	C_{2009}	110.94	109.99	109.35	109.12	108.55	108.00	118.72	118.72	118.72	105.30	105.30	105.30
		109.35	109.35	109.35	97.17	96.80	96.80	118.72	118.72	118.72	105.30	105.30	105.30
		126.53	124.48	122.23	127.11	122.72	119.36	118.72	118.72	118.72	124.27	119.50	115.92
M. paradoxus	B_{2027}/K	**0.155**	**0.214**	**0.259**	**0.174**	**0.230**	**0.273**	**0.188**	**0.239**	**0.275**	**0.162**	**0.208**	**0.255**
		0.051	0.095	0.143	0.054	0.105	0.146	0.067	0.115	0.159	0.048	0.088	0.134
		0.325	0.377	0.425	0.374	0.443	0.470	0.472	0.514	0.543	0.331	0.391	0.434
	B_{2027}/B_{2007}	2.51	3.36	4.23	2.64	3.42	4.05	2.80	3.60	4.30	2.48	3.21	4.10
		1.06	1.66	2.31	1.12	1.85	2.51	1.18	1.74	2.22	0.94	1.61	2.43
		5.29	6.29	7.28	6.31	7.16	8.20	8.54	9.31	10.04	5.10	6.31	7.07
M. capensis	B_{2027}/K	0.59	0.62	0.65	0.60	0.63	0.65	0.61	0.64	0.67	0.59	0.62	0.64
		0.46	0.49	0.52	0.47	0.50	0.52	0.46	0.48	0.50	0.47	0.49	0.52
		0.84	0.88	0.90	0.84	0.87	0.90	0.88	0.90	0.92	0.84	0.87	0.90
	B_{2027}/B_{2007}	1.51	1.59	1.66	1.60	1.65	1.71	1.62	1.67	1.71	1.51	1.58	1.65
		1.21	1.28	1.32	1.21	1.30	1.35	1.22	1.28	1.33	1.19	1.27	1.33
		1.95	2.07	2.17	2.02	2.09	2.16	2.14	2.20	2.28	1.98	2.05	2.15

Table 7: Summary of performance statistics for the full combination of four candidate OMPs and three median recovery tuning for *M. paradoxus*, for the **robustness test with a 30% decrease in *K* in the future (B8)**. For each statistic, the median and 90% PIs are shown. Results integrate over **all 24** Reference Set scenarios. The ratios associated with the estimates of K^{sp} are for the present K^{sp}, i.e. before the future decrease in carrying capacity.

		OMP1			OMP5			OMP7			OMP11		
		15%	20%	25%	15%	20%	25%	15%	20%	25%	15%	20%	25%
Species combined	avTAC	106.33	103.42	100.98	105.68	103.73	100.91	106.12	104.61	102.10	107.05	104.72	101.76
		95.68	93.29	90.16	93.22	89.54	86.41	88.89	87.82	85.25	97.09	94.81	91.18
		119.68	116.30	112.89	119.89	116.49	113.63	120.43	118.05	115.96	120.35	117.25	113.88
	AAV	5.30	5.30	5.30	5.65	5.62	5.53	4.76	4.52	4.50	5.65	5.59	5.51
		3.68	3.66	3.83	3.97	3.98	4.01	3.52	3.36	3.48	4.08	4.14	4.05
		7.16	7.08	6.80	8.80	8.38	7.90	7.62	7.10	6.73	7.83	7.39	7.08
	$CPUE_{2016}$/ $CPUE_{2005}$	1.24	1.27	1.31	1.26	1.31	1.34	1.19	1.23	1.27	1.26	1.32	1.36
		1.03	1.05	1.08	1.02	1.08	1.11	0.95	0.99	1.02	1.04	1.08	1.12
		1.53	1.57	1.61	1.57	1.64	1.65	1.48	1.52	1.56	1.56	1.61	1.65
	C_{2007}	135.00	135.00	135.00	134.97	134.97	134.97	138.75	138.75	138.75	130.00	130.00	130.00
		-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	-	-	-
	C_{2008}	121.50	121.50	121.50	121.47	121.47	121.47	128.34	128.34	128.34	117.00	117.00	117.00
		121.50	121.50	121.50	118.94	118.54	118.54	128.34	128.34	128.34	117.00	117.00	117.00
		130.86	129.99	128.88	131.47	129.11	127.75	128.34	128.34	128.34	127.39	124.82	123.29
	C_{2009}	112.31	111.02	109.88	109.33	109.33	109.21	118.72	118.72	118.72	106.61	105.30	105.30
		109.35	109.35	109.35	102.64	102.20	102.20	118.72	118.72	118.72	105.30	105.30	105.30
		128.66	127.86	126.98	128.22	126.84	125.88	118.72	118.72	118.72	125.22	122.50	121.47
M. paradoxus	B_{2027}/K	**0.100**	**0.138**	**0.172**	**0.103**	**0.138**	**0.171**	**0.080**	**0.111**	**0.144**	**0.098**	**0.133**	**0.169**
		0.035	0.073	0.104	0.040	0.072	0.106	0.014	0.040	0.071	0.019	0.066	0.097
		0.175	0.215	0.255	0.182	0.222	0.260	0.181	0.217	0.253	0.171	0.218	0.258
	B_{2027}/B_{2007}	1.49	1.98	2.55	1.54	2.05	2.54	1.19	1.71	2.13	1.46	1.94	2.51
		0.67	1.23	1.70	0.67	1.30	1.74	0.29	0.78	1.26	0.36	1.11	1.71
		2.48	3.37	4.11	2.70	3.42	4.18	2.63	3.29	4.15	2.42	3.21	4.01
M. capensis	B_{2027}/K	0.48	0.50	0.52	0.48	0.50	0.52	0.47	0.49	0.51	0.47	0.50	0.51
		0.39	0.42	0.44	0.40	0.42	0.44	0.38	0.41	0.42	0.38	0.42	0.43
		0.59	0.61	0.63	0.59	0.61	0.62	0.59	0.60	0.62	0.59	0.61	0.62
	B_{2027}/B_{2007}	1.02	1.08	1.11	1.03	1.07	1.11	1.01	1.05	1.09	1.01	1.07	1.10
		0.82	0.85	0.88	0.84	0.87	0.90	0.82	0.85	0.89	0.81	0.85	0.88
		1.22	1.27	1.31	1.23	1.27	1.31	1.22	1.27	1.30	1.22	1.27	1.30

Table 8: Probability of projected TAC a) increase, and decrease b) between 0 and 5%, c) between 5% and 10%, d) between 10% and 15% and e) greater than 15% over five year intervals, for an application of **OMP1_20%** to the **Reference Set and four robustness tests**. Values which are necessarily zero in terms of the OMP's TAC change rules are shown in bold.

			Probability that the percentage change in TAC is:				
			>0	between 0 and -5%	between -5 and -10%	between -10 and -15%	< -15%
(4 scenarios only)	RS	2007-2011	0.21	0.14	0.64	**0**	**0**
		2012-2016	0.65	0.22	0.13	**0**	**0**
		2017-2021	0.62	0.30	0.08	**0**	**0**
		2022-2026	0.67	0.21	0.12	**0**	**0**
	SR1	2007-2011	0.51	0.14	0.35	**0**	**0**
		2012-2016	0.52	0.23	0.25	**0**	**0**
		2017-2021	0.29	0.39	0.32	**0**	**0**
		2022-2026	0.69	0.20	0.11	**0**	**0**
	Ricker	2007-2011	0.32	0.13	0.55	**0**	**0**
		2012-2016	0.61	0.26	0.13	**0**	**0**
		2017-2021	0.54	0.37	0.09	**0**	**0**
		2022-2026	0.70	0.20	0.11	**0**	**0**
	$_R$ =0.4	2007-2011	0.17	0.13	0.70	**0**	**0**
		2012-2016	0.62	0.22	0.16	**0**	**0**
		2017-2021	0.61	0.27	0.12	**0**	**0**
		2022-2026	0.66	0.22	0.13	**0**	**0**
(24 scenarios)	RS	2007-2011	0.22	0.15	0.63	**0**	**0**
		2012-2016	0.64	0.24	0.13	**0**	**0**
		2017-2021	0.60	0.29	0.12	**0**	**0**
		2022-2026	0.66	0.23	0.11	**0**	**0**
	Decr in *K* in future	2007-2011	0.28	0.11	0.61	**0**	**0**
		2012-2016	0.58	0.23	0.19	**0**	**0**
		2017-2021	0.24	0.30	0.47	**0**	**0**
		2022-2026	0.54	0.26	0.20	**0**	**0**

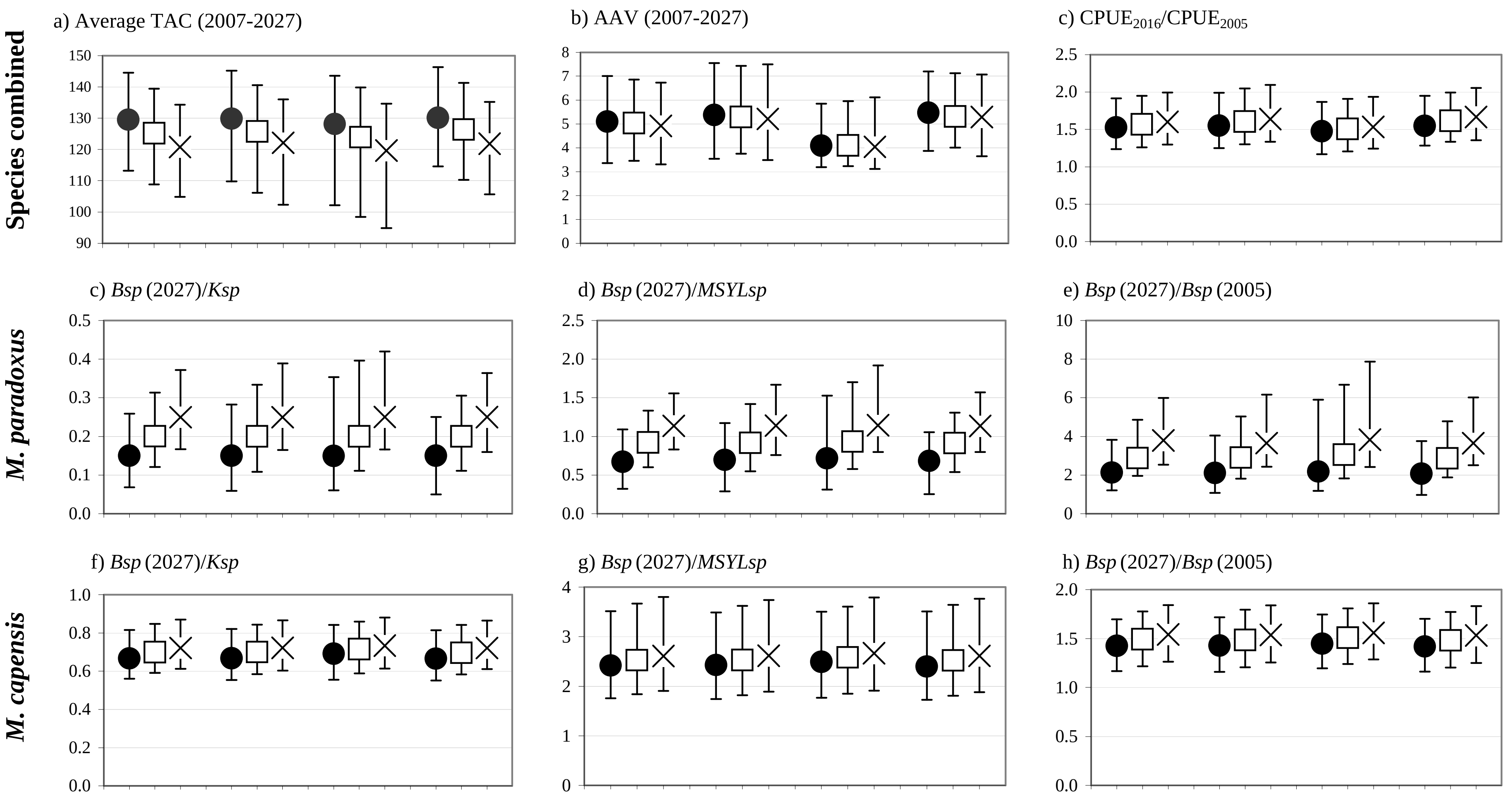


Fig. 1: Graphical summary of performance statistics for the full combination of four candidate OMPs (OMP1, OMP5, OMP7 and OMP11 from left to right) and three **median** recovery tunings (15%, 20% and 25% of *K* from left to right) for *M. paradoxus* for the **Reference Set**. Each panel shows medians together with 90% PIs.

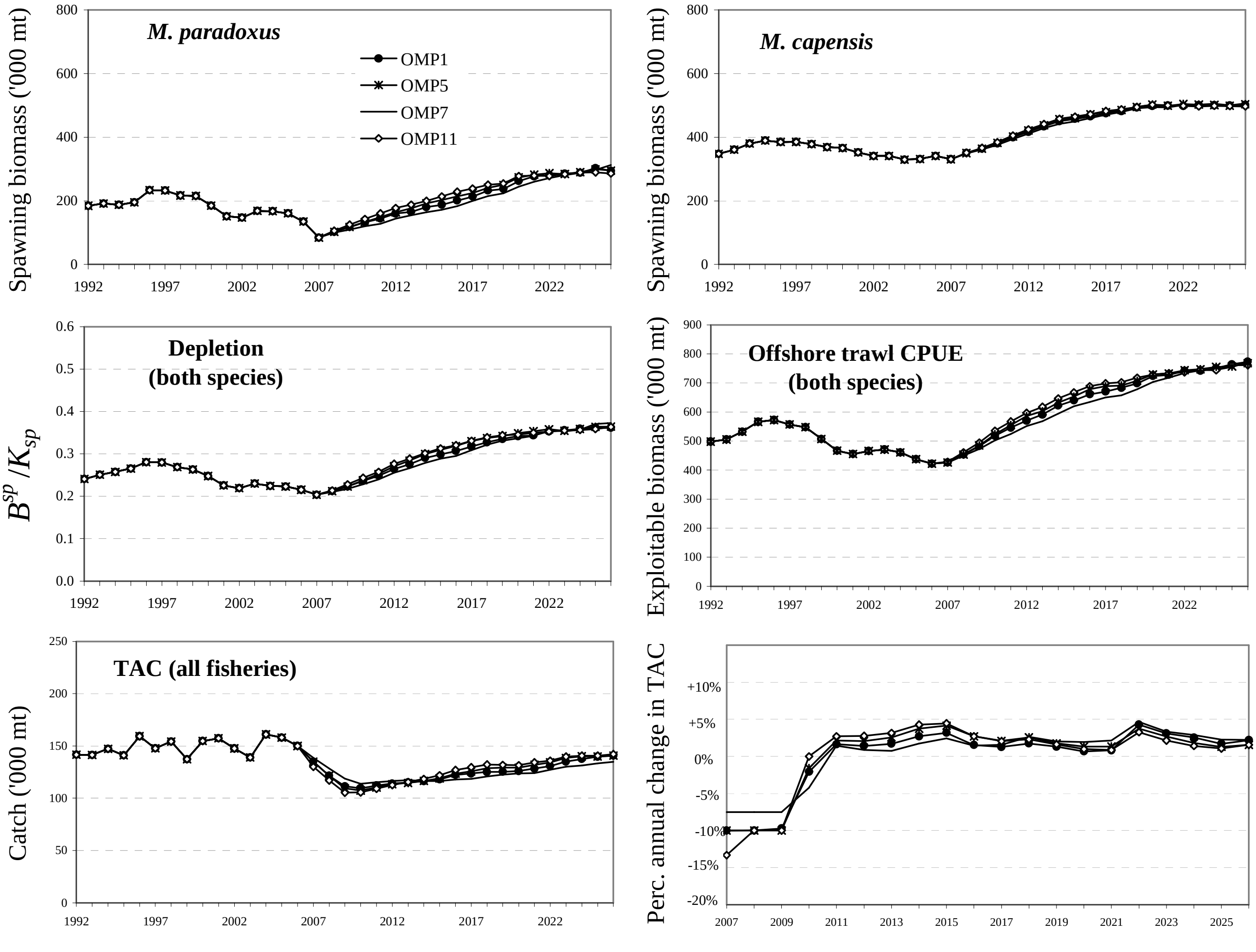


Fig. 2: Median trajectories of resource abundance, CPUE, catch and variation in catch for an application of **OMP1**, **OMP5**, **OMP7** and **OMP11** for a comparable **median 20%** of *K* recovery tuning for *M. paradoxus* for the **Reference Set**. Note units for species combined CPUE are those of the exploitable biomass to which it corresponds. Pre-2007, the average spawning biomass and species combined CPUE trajectories of the Reference Set and the actual species disaggregated CPUE and total catch are also shown.

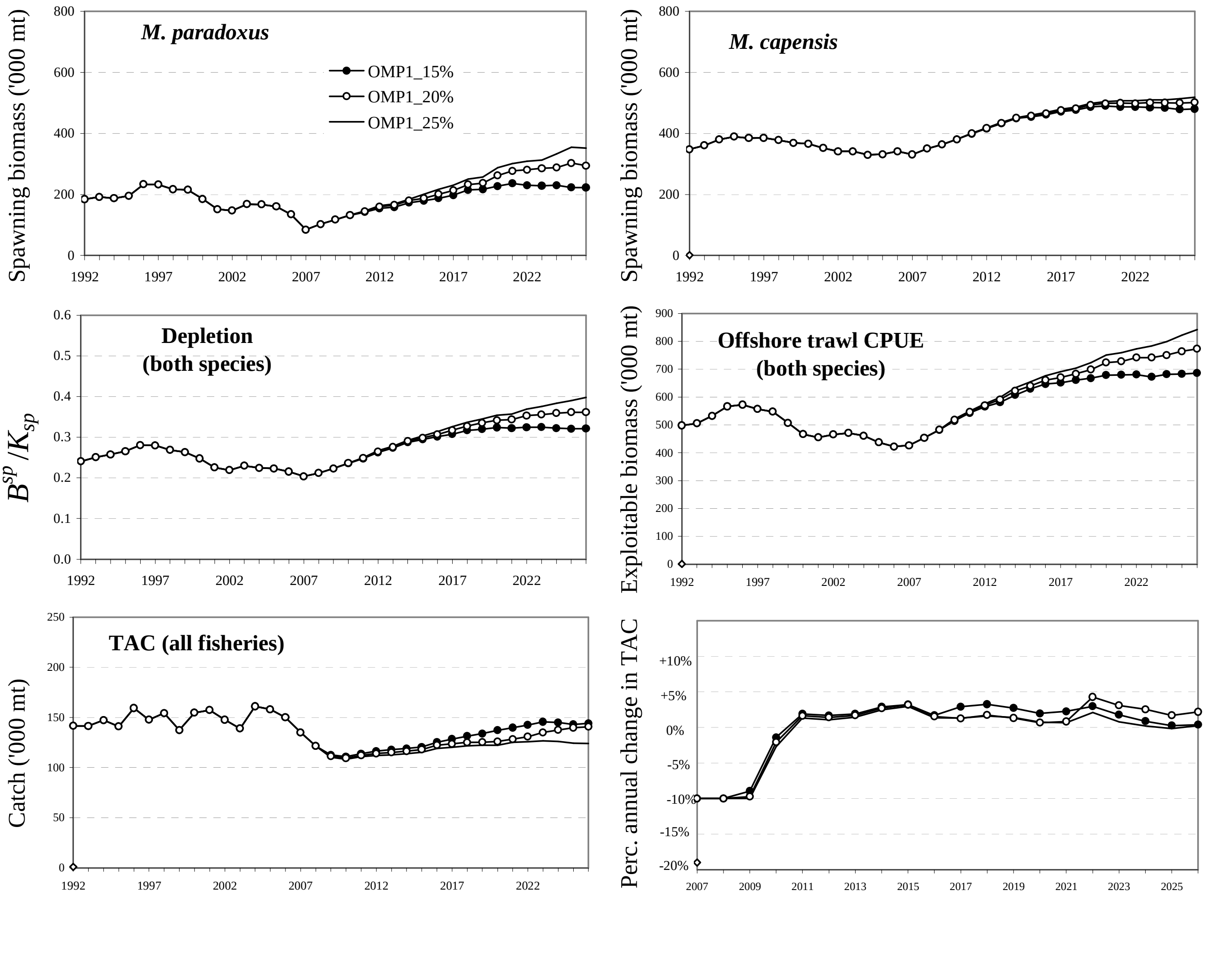


Fig. 3: Median trajectories of resource abundance, CPUE, catch and variation in catch for an application of **OMP1** for three median recovery tunings for *M. paradoxus* for the **Reference Set**. Note units for species combined CPUE are those of the exploitable biomass to which it corresponds. Pre-2007, the average spawning biomass and species combined CPUE trajectories of the Reference Set and the actual species disaggregated CPUE and total catch are also shown.

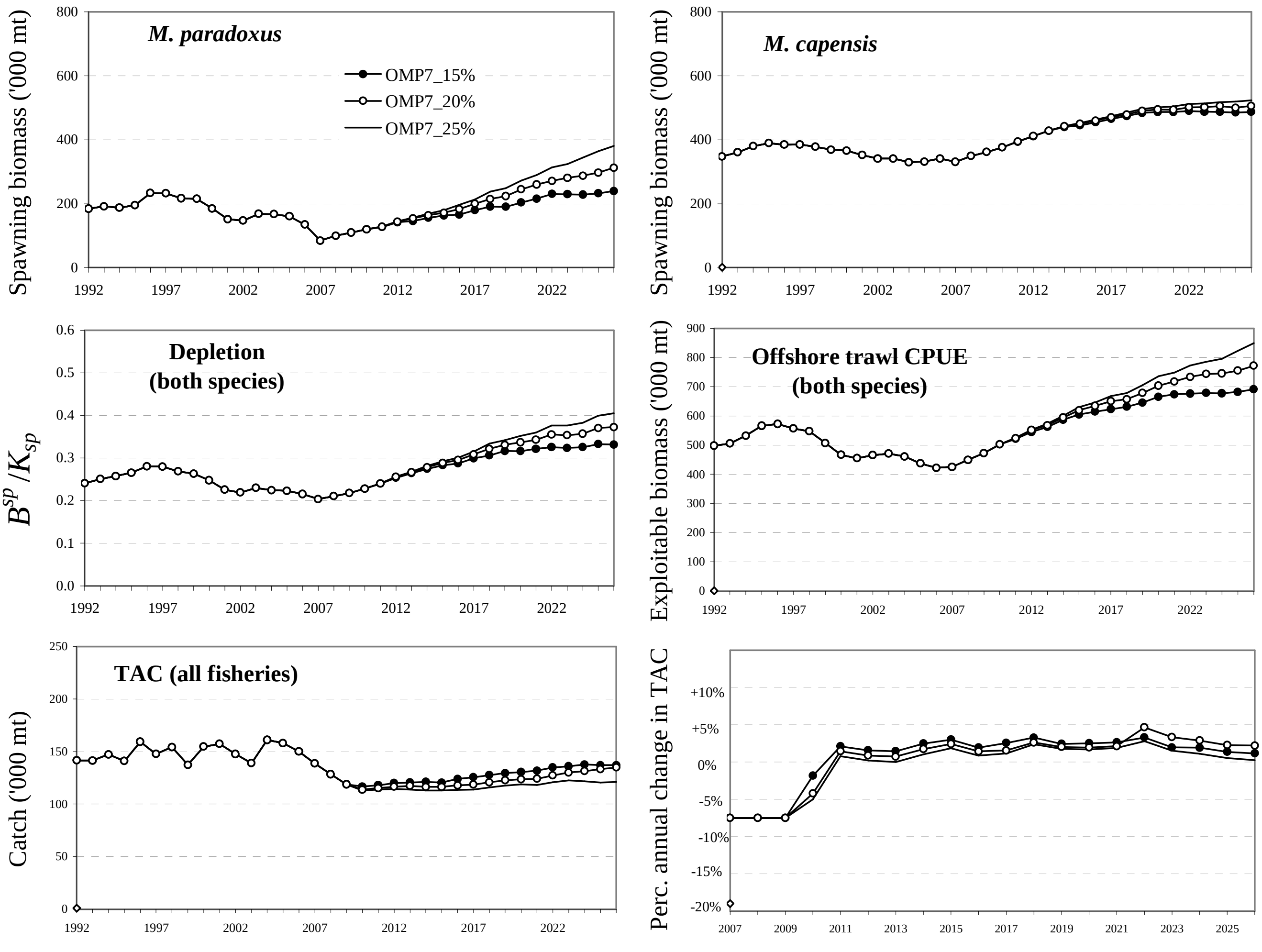


Fig. 4: Median trajectories of resource abundance, CPUE, catch and variation in catch for an application of **OMP7** for three median recovery tunings for *M. paradoxus* for the **Reference Set**. Note units for species combined CPUE are those of the exploitable biomass to which it corresponds. Pre-2007, the average spawning biomass and species combined CPUE trajectories of the Reference Set and the actual species disaggregated CPUE and total catch are also shown.

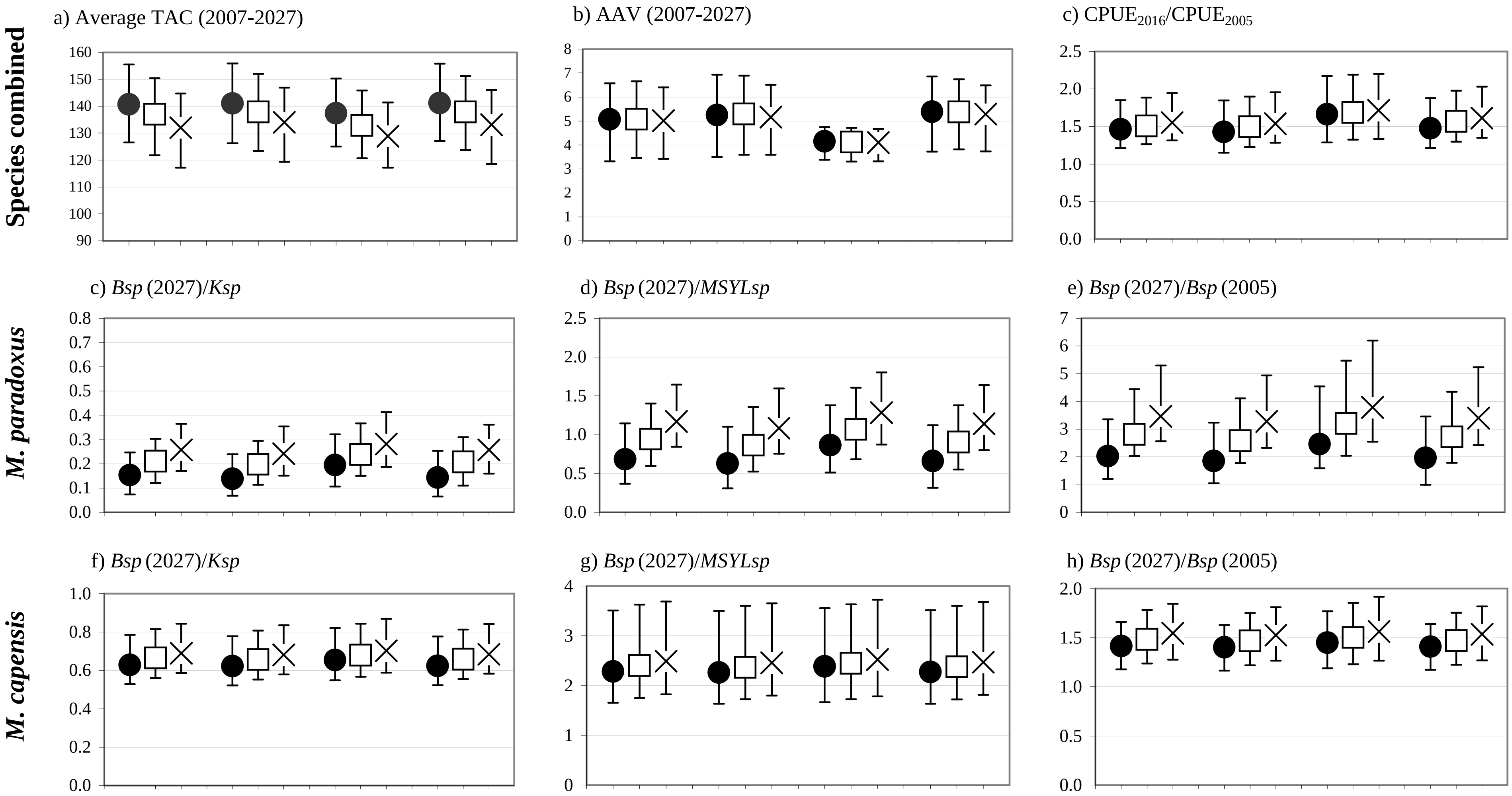


Fig. 5: Graphical summary of performance statistics for the full combination of four candidate OMPs and three median recovery tunings for *M. paradoxus* for the **SR1 robustness test**. Each panel shows medians together with 90% PIs. Results integrate over **only four** of the 24 Reference Set scenarios. The ordering of the OMPs and tunings is as for Fig. 1.

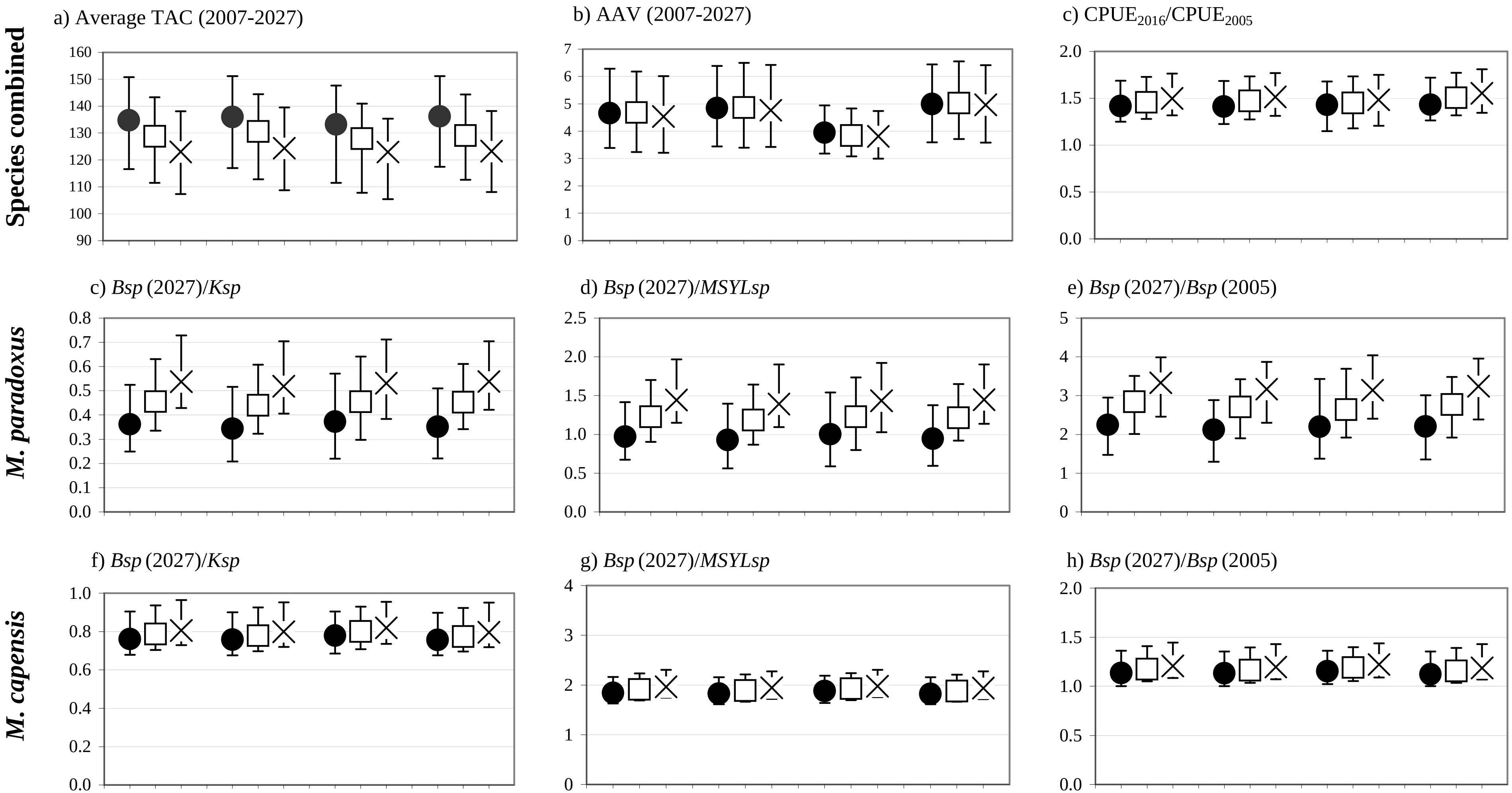


Fig. 6: Graphical summary of performance statistics for the full combination of four candidate OMPs and three median recovery tunings for *M. paradoxus* for the **robustness test with a Ricker stock-recruitment curve (A7b)**. Each panel shows medians together with 90% PIs. Results integrate over **only four** of the 24 Reference Set scenarios. The ordering of the OMPs and tunings is as for Fig. 1.

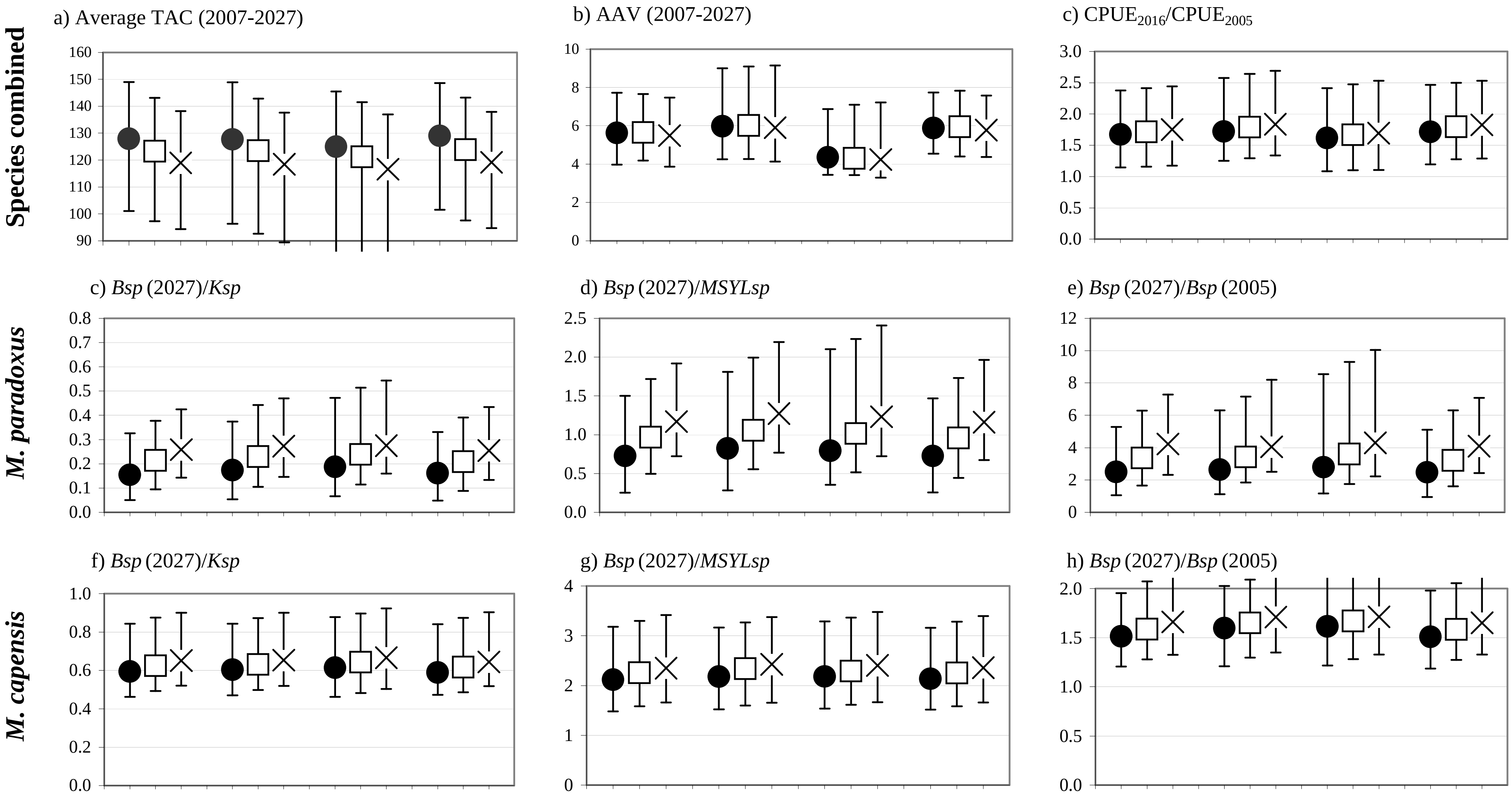


Fig. 7: Graphical summary of performance statistics for the full combination of four candidate OMPs and three median recovery tunings for *M. paradoxus* for the **robustness test with σ_R=0.4 in the past and in the projections (B7)**. Each panel shows medians together with 90% PIs. Results integrate over **only four** of the 24 Reference Set scenarios. The ordering of the OMPs and tunings is as for Fig. 1.

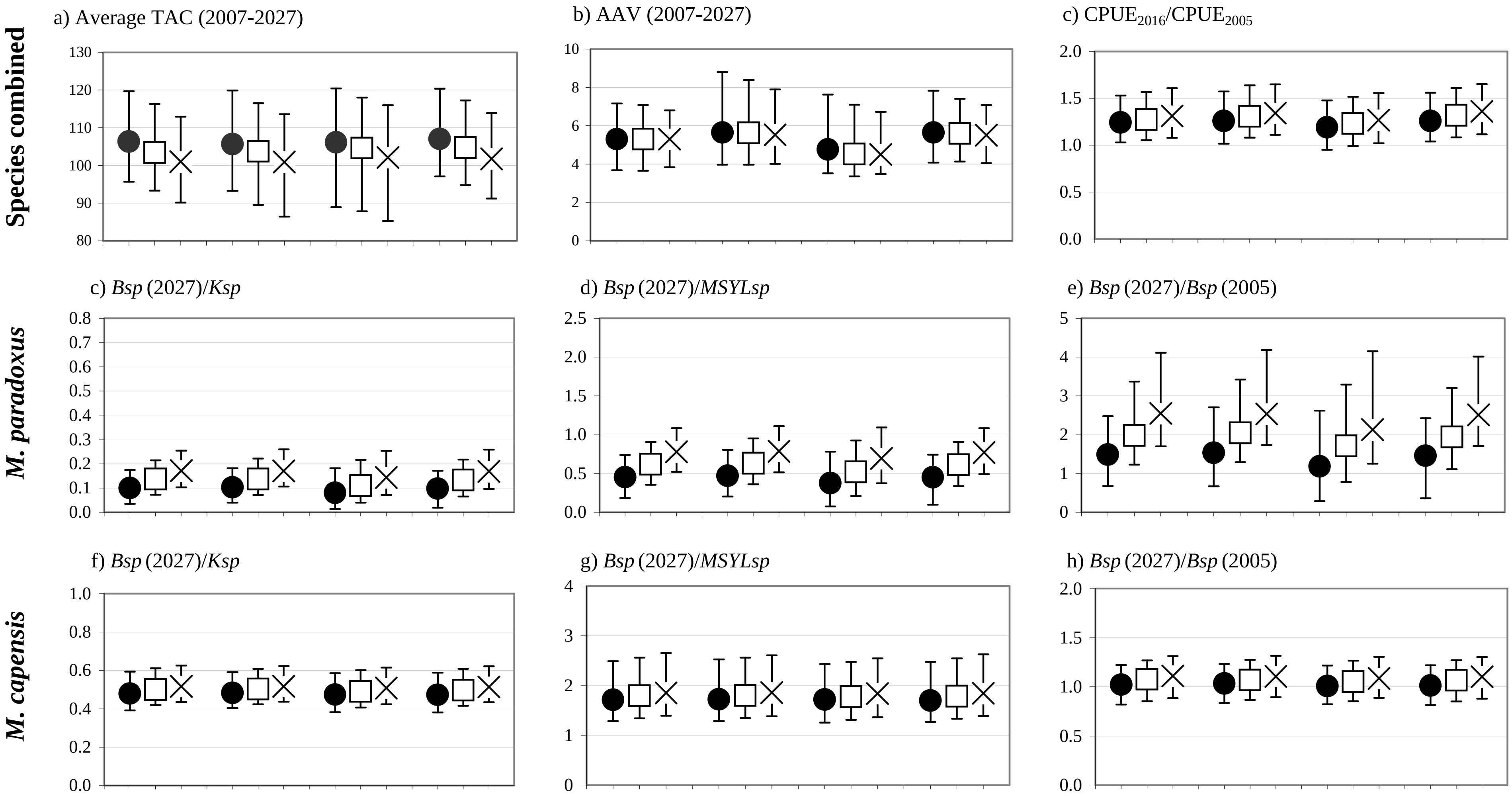
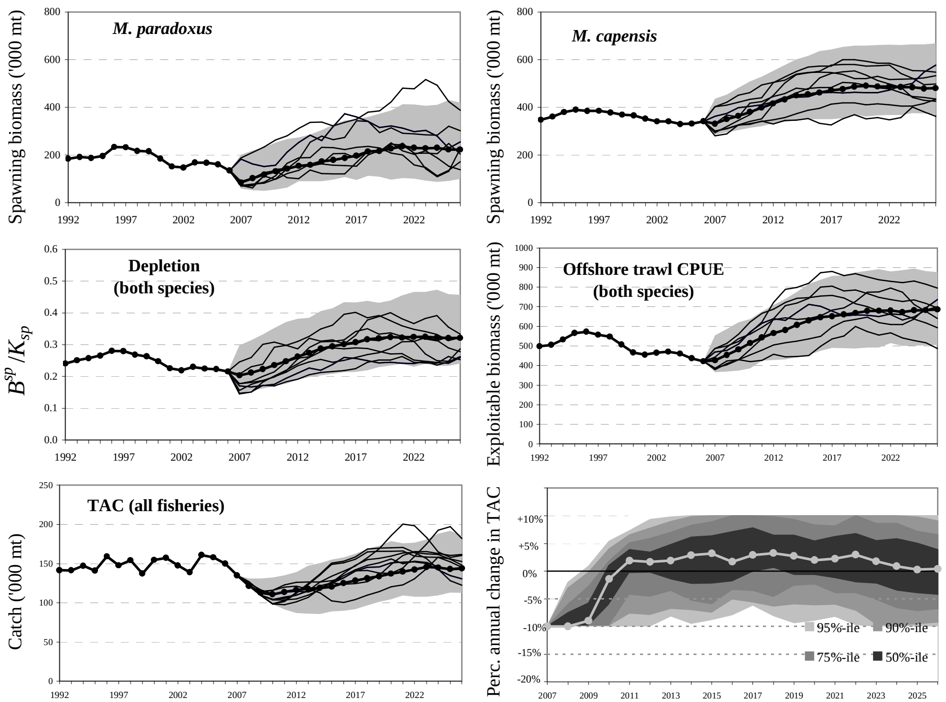


Fig. 8: Graphical summary of performance statistics for the full combination of four candidate OMPs and three median recovery tunings for *M. paradoxus* for the **robustness test with a 30% decrease in *K* in the future (B8)**. Each panel shows medians together with 90% PIs. Results integrate over **all 24** Reference Set scenarios. The ratios associated with the estimates of K^{sp} are for the present K^{sp}, i.e. before the future decrease in carrying capacity. The ordering of the OMPs and tunings is as for Fig. 1.

Appendix A

OMP1_15%



OMP1_20%

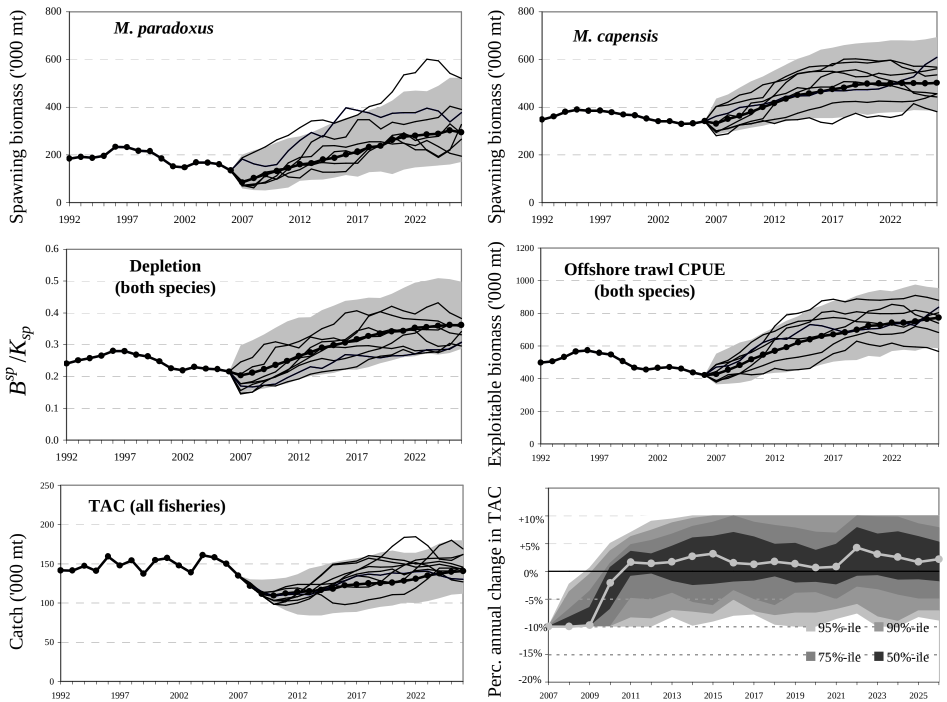


Fig. A1a: Trajectories of resource abundance, CPUE, catch and variation in catch for an application of **OMP1_15%** and **OMP1_20%** to the updated Reference Set. Ten individual trajectories are shown, with the median a dark dotted line; the shaded areas show 90% PIs. Note units for species-combined CPUE are those of the exploitable biomass to which it corresponds. Pre-2007, the average spawning biomass and species combined CPUE trajectories of the Reference Set and the actual species disaggregated CPUE and total catch are also shown.

OMP1_25% **OMP5_15%**

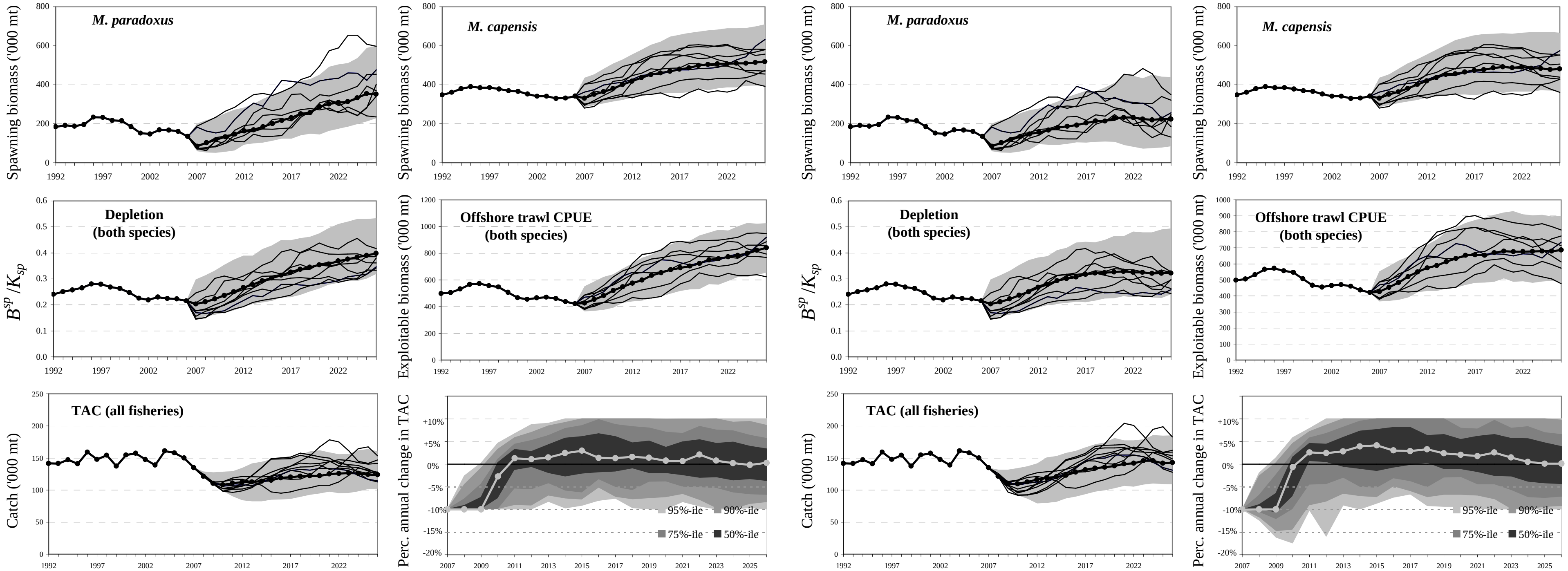


Fig. A1b: Trajectories of resource abundance, CPUE, catch and variation in catch for an application of **OMP1_25%** and **OMP5_15%** to the updated Reference Set. Ten individual trajectories are shown, with the median a dark dotted line; the shaded areas show 90% PIs. Note units for species-combined CPUE are those of the exploitable biomass to which it corresponds. Pre-2007, the average spawning biomass and species combined CPUE trajectories of the Reference Set and the actual species disaggregated CPUE and total catch are also shown.

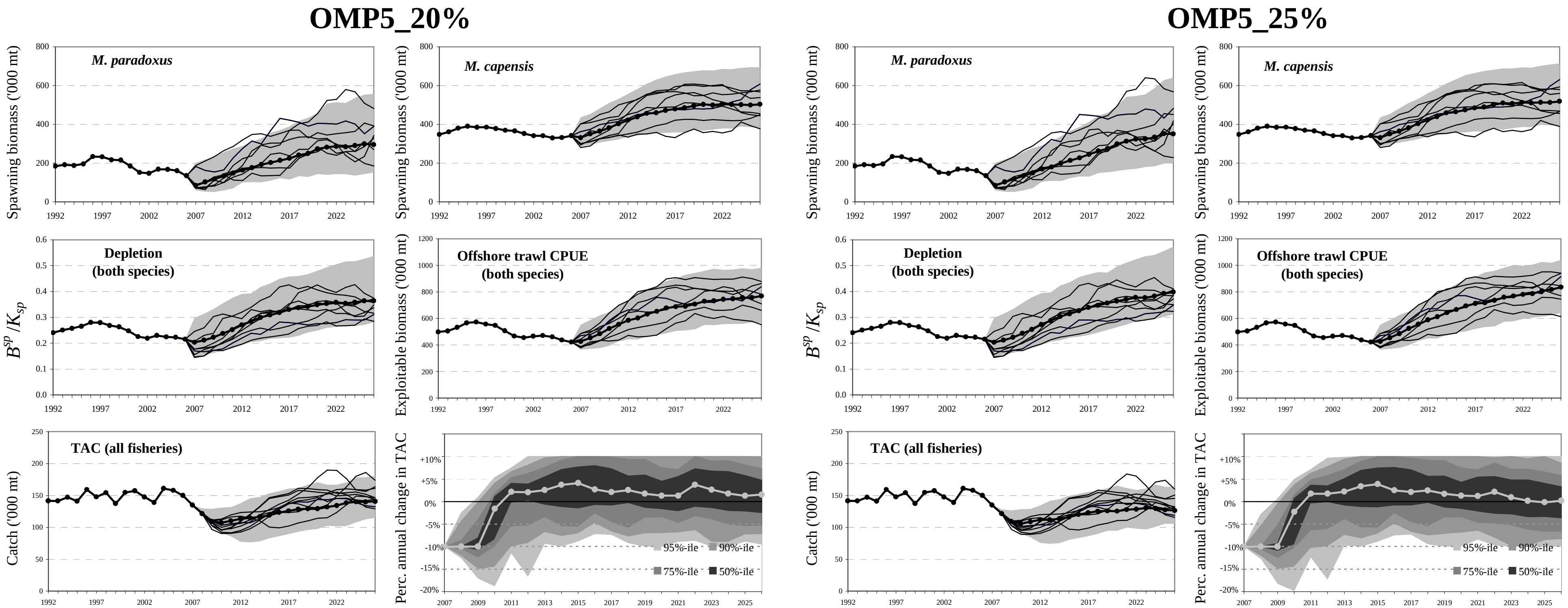


Fig. A1c: Trajectories of resource abundance, CPUE, catch and variation in catch for an application of **OMP5_20%** and **OMP5_25%** to the updated Reference Set. Ten individual trajectories are shown, with the median a dark dotted line; the shaded areas show 90% PIs. Note units for species-combined CPUE are those of the exploitable biomass to which it corresponds. Pre-2007, the average spawning biomass and species combined CPUE trajectories of the Reference Set and the actual species disaggregated CPUE and total catch are also shown.

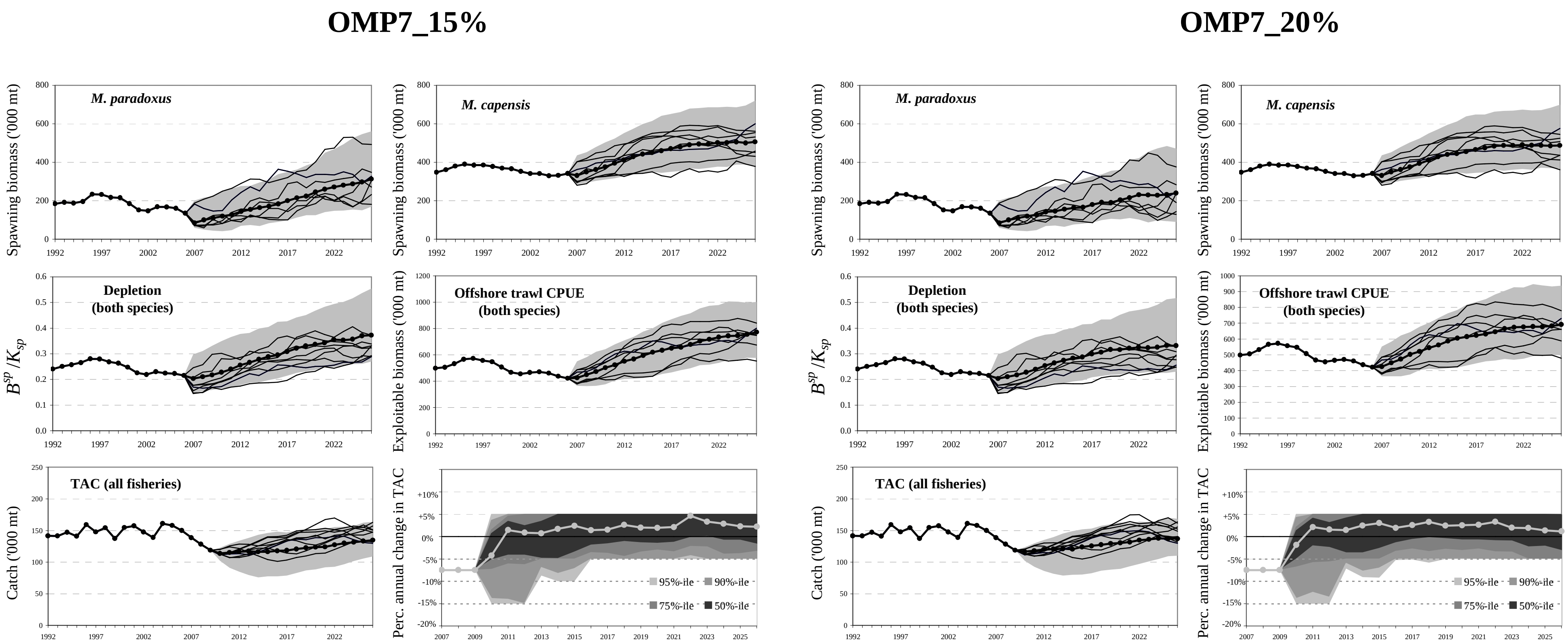


Fig. A1d: Trajectories of resource abundance, CPUE, catch and variation in catch for an application of **OMP7_15%** and **OMP7_20%** to the updated Reference Set. Ten individual trajectories are shown, with the median a dark dotted line; the shaded areas show 90% PIs. Note units for species-combined CPUE are those of the exploitable biomass to which it corresponds. Pre-2007, the average spawning biomass and species combined CPUE trajectories of the Reference Set and the actual species disaggregated CPUE and total catch are also shown.

OMP7_25% **OMP11_15%**

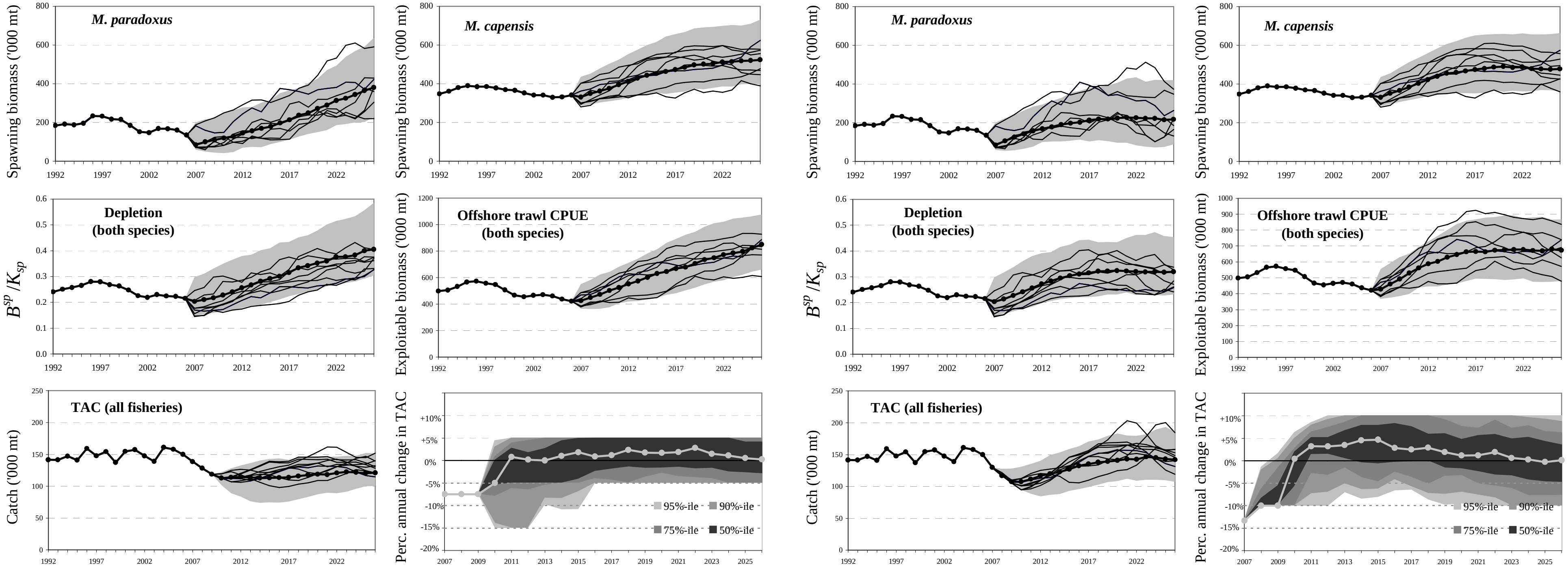


Fig. A1e: Trajectories of resource abundance, CPUE, catch and variation in catch for an application of **OMP7_25%** and **OMP11_15%** to the updated Reference Set. Ten individual trajectories are shown, with the median a dark dotted line; the shaded areas show 90% PIs. Note units for species-combined CPUE are those of the exploitable biomass to which it corresponds. Pre-2007, the average spawning biomass and species combined CPUE trajectories of the Reference Set and the actual species disaggregated CPUE and total catch are also shown.

OMP11_20% **OMP11_25%**

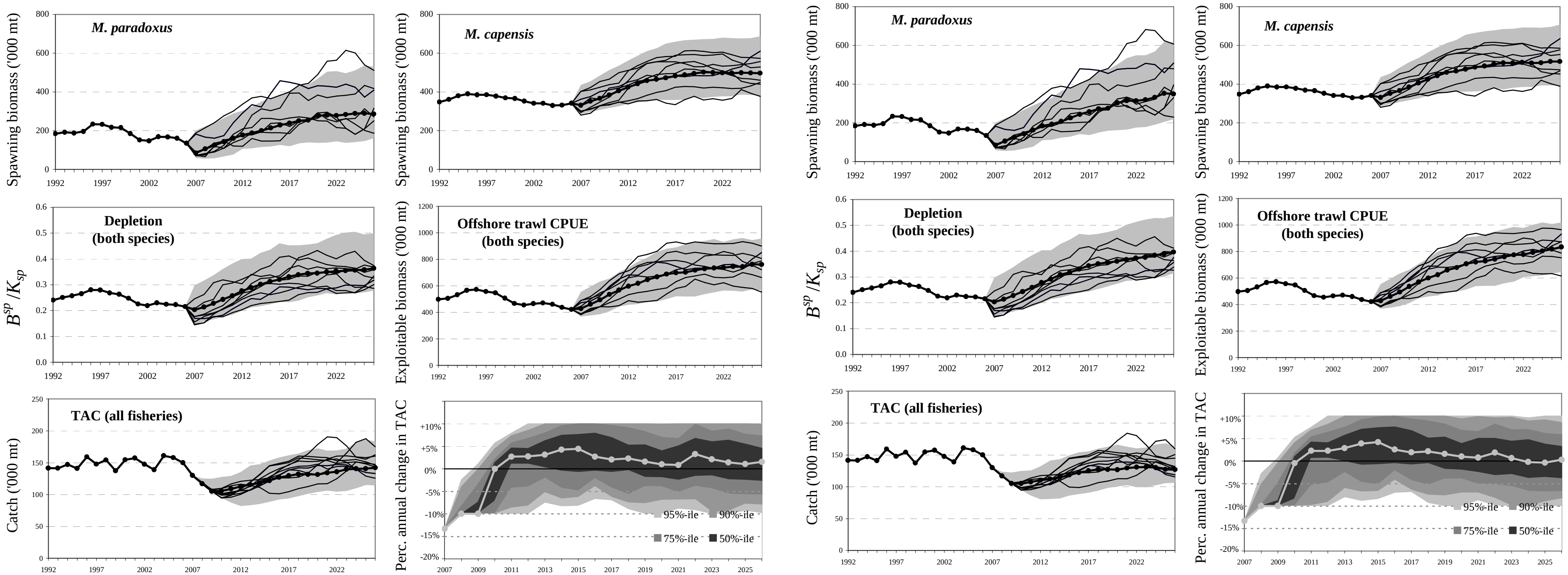


Fig. A1f: Trajectories of resource abundance, CPUE, catch and variation in catch for an application of **OMP11_20%** and **OMP11_25%** to the updated Reference Set. Ten individual trajectories are shown, with the median a dark dotted line; the shaded areas show 90% PIs. Note units for species-combined CPUE are those of the exploitable biomass to which it corresponds. Pre-2007, the average spawning biomass and species combined CPUE trajectories of the Reference Set and the actual species disaggregated CPUE and total catch are also shown.

OMP1_20%-SR1 OMP1_20%-Ricker

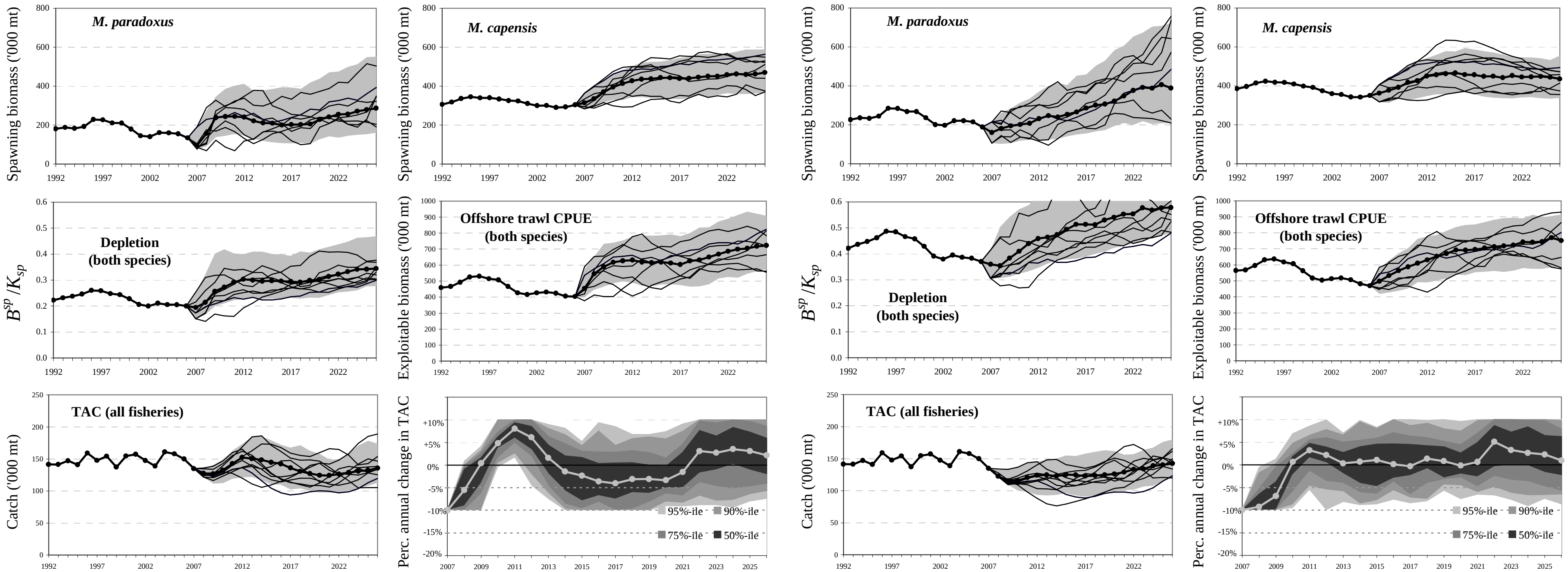
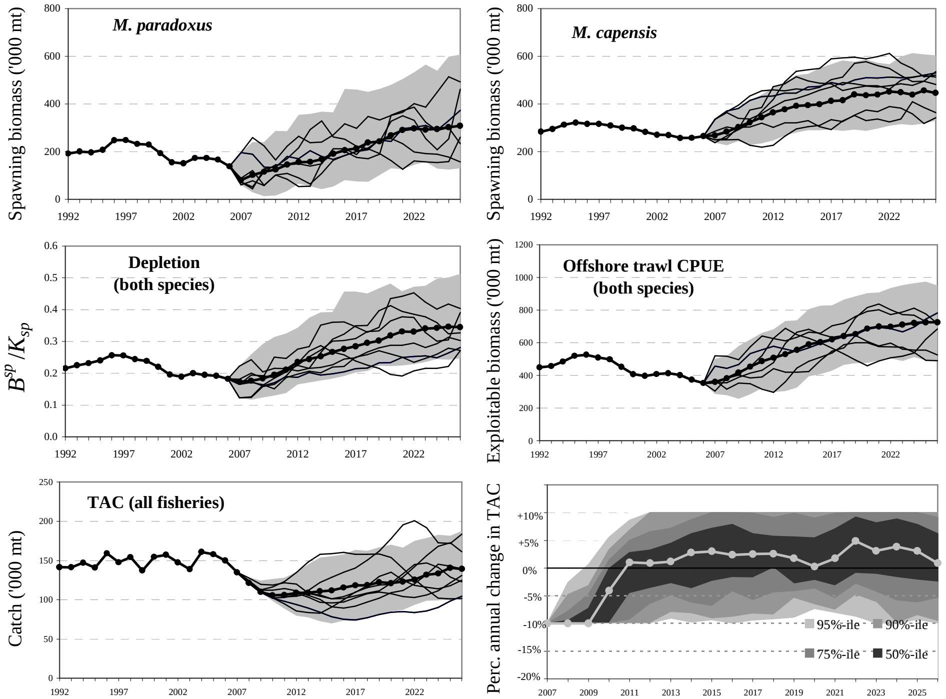


Fig. A2a: Trajectories of resource abundance, CPUE, catch and variation in catch for an application of **OMP1_20%** to the updated **SR1 and Ricker robustness tests**. Ten individual trajectories are shown, with the median a dark dotted line; the shaded areas show 90% PIs. Note units for species-combined CPUE are those of the exploitable biomass to which it corresponds. Pre-2007, the average spawning biomass and species combined CPUE trajectories of the Reference Set and the actual species disaggregated CPUE and total catch are also shown. Results integrate over **only four** of the 24 Reference Set scenarios**.**

OMP1_20%- σ_R=0.4



OMP1_20%-Decr in *K* in future

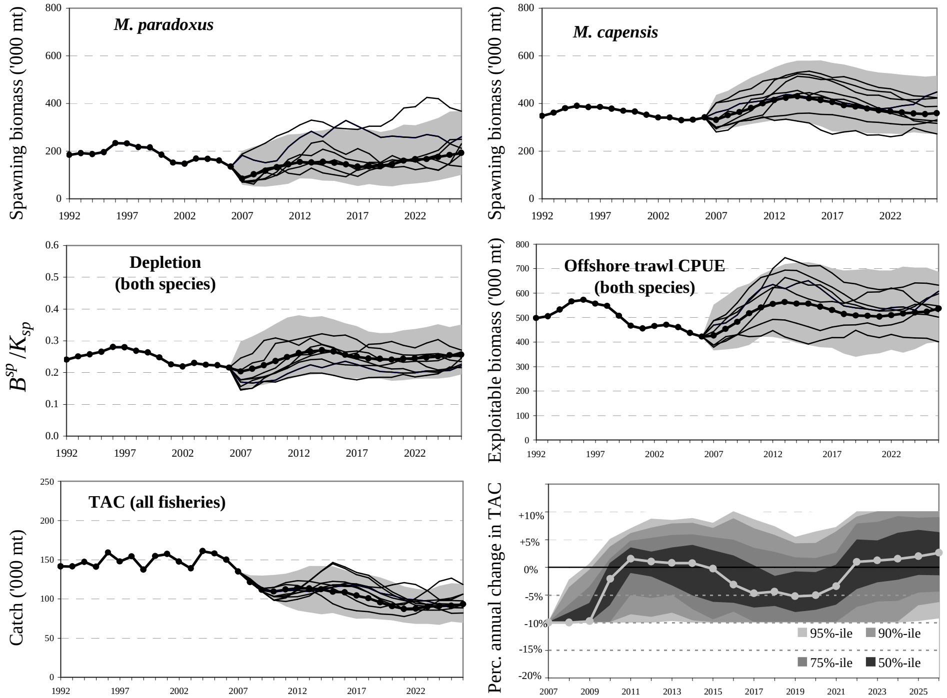


Fig. A2b: Trajectories of resource abundance, CPUE, catch and variation in catch for an application of **OMP1_20%** to the robustness tests with σ_R**=0.4** (results integrate over **only four** of the 24 Reference Set scenarios) and the robustness test with a **30% decrease in future *K*** (results integrate over **all 24** Reference Set scenarios). Ten individual trajectories are shown, with the median a dark dotted line; the shaded areas show 90% PIs. Note units for species-combined CPUE are those of the exploitable biomass to which it corresponds. Pre-2007, the average spawning biomass and species combined CPUE trajectories of the Reference Set and the actual species disaggregated CPUE and total catch are also shown.