Projections for the South African Hake Resource for the 2010 Reference Set of Operating Models under Constant Catch Strategies

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Outline

Rademeyer and Butterworth (2010a) presented results for projections of the South African hake resource for a constant catch of 118 500 t scenario. Here, results are compared for three constant catch scenarios (118 500t, 135 000t and 150 000t) under the RS (Rademeyer and Butterworth, 2010a).

As discussed in the May demersal SWG meeting, further performance statistics and performance plots are presented compared to those described in Rademeyer and Butterworth (2010c):

Performance statistics:

1. E_{2020} / E_{2009} and E_{2030} / E_{2009} where effort $E_y = TAC_y \big/ B_y^{\exp}$ (where $B_y^{\exp}$ is the offshore trawl, species combined, exploitable biomass);
2. $P_{lowCPUE}$: the probability that $CPUE_y < 1.2CPUE_{2003-2005}$;
3. P_{unexp} : the proportion of occasions the TAC goes down when six or more of the indices go up, or vice versa, i.e. some measure of the proportion of occasions the TAC changes in the unexpected direction; and
4. $B_{2027}^{sp} / B_{2007}^{sp}$ expressed for males rather than females.

Performance plots:

1. B_y^{sp} / B_{MSY}^{sp} ;
2. Future recruitment for each species normalised to the 2009 recruitment (virtually on the stock-recruitment curve): R_y^{sp} / R_{2009}^{sp};
3. Effort trend with time: E_y ; and
4. Economic performance with time (see Appendix I)

Results

Performance statistics related to spawning biomass projections relative to the levels estimated for 2007 and for MSY, together with the offshore trawler CPUE projection to 2016, are reported in Tables 1a-c for the constant catches of 118 500t, 135 000t and 150 000t respectively. These are split by RSa (RS1 – RS10) and RSb

(RS11 – RS12), where RSb includes scenarios for which the current status of the *M. capensis* resource is estimated to be poor.

Fig. 1a-c plots these projections: medians and 95% Probability Interval (PI) envelopes - for catch and spawning biomass (as estimated relative to its pre-exploitation level and to MSY level) by species for the Reference Case (RS1), together with CPUE for the offshore trawlers (taken to be proportional to the coast- and species-combined exploitable biomass) relative to its average value over 2003-2005, offshore trawlers effort and economic performance.

Fig 2a-c contrasts median projections across different operating models, with a) covering RSa (RS1 – RS5), b) RSa (RS6 - RS10) and c) RSb (RS11 – RS12). Fig. 3a-c integrates results for spawning biomass and CPUE across each of RSa and RSb, where the component operating models within these sets each receive equal weighting.

Discussion

References

Rademeyer RA and Butterworth DS. 2010a. Projections for the South African Hake resource for the 2010 Reference Set of Operating Models under a Constant Catch equal to the current TAC. Unpublished report, Marine and Coastal Management, South Africa. MCM/2010/MAY/SWG-DEM/24.

Rademeyer RA and Butterworth DS. 2010b. Proposed Reference Set for the South African hake resource to be used in OMP-2010 testing. Unpublished report, Marine and Coastal Management, South Africa. MCM/2010/FEB/SWG-DEM/05.

Rademeyer RA and Butterworth DS. 2010c. Candidate Management Procedures for the South African hake resource: Draft objectives and testing methodology. Unpublished report, Marine and Coastal Management, South Africa. MCM/2010/MAY/SWG-DEM/22(Rev).

Table 1a: Results (median, 95% PI) for the Reference Set under a projected constant catch of **118 500t**.

		RS1		RS2		RS3		RS4		RS5		RS6	
C fixed		118.5		118.5		118.5		118.5		118.5		118.5	
Females	both	2.40	(1.89; 3.00)	1.86	(1.53; 2.19)	1.91	(1.65; 2.25)	1.51	(1.30; 1.76)	1.75	(1.55; 2.02)	2.50	(2.11; 3.08)
$B^{sp}_{2027}/B^{sp}_{2007}$	para	3.43	(2.32; 4.82)	3.25	(2.31; 4.35)	3.58	(2.33; 5.38)	1.87	(1.41; 2.48)	2.30	(1.67; 3.09)	3.76	(2.83; 4.90)
	cap	1.60	(1.24; 1.93)	1.41	(1.27; 1.61)	1.61	(1.40; 1.87)	1.33	(1.19; 1.51)	1.57	(1.37; 1.83)	1.36	(1.02; 1.67)
Males	both	2.11	1.69 2.57	1.74	1.45 2.08	1.71	1.44 2.02	1.47	1.24 1.72	1.61	1.38 1.88	2.33	1.81 2.88
$B^{sp}_{2027}/B^{sp}_{2007}$	para	2.70	1.82 3.72	3.35	2.10 4.90	2.06	1.36 2.90	1.95	1.31 2.81	1.76	1.26 2.32	3.82	2.57 5.32
	cap	1.59	1.28 1.85	1.41	1.23 1.61	1.57	1.38 1.89	1.32	1.16 1.50	1.54	1.34 1.84	1.38	1.05 1.71
B^{sp}_{2020}/B_{MSY}	both	1.85	(1.50; 2.37)	2.12	(1.77; 2.49)	3.13	(2.61; 3.65)	2.95	(2.60; 3.40)	4.82	(4.06; 5.56)	1.54	(1.29; 1.86)
	para	1.48	(1.00; 2.17)	1.12	(0.81; 1.52)	1.41	(0.95; 1.94)	1.83	(1.42; 2.38)	4.08	(3.08; 5.29)	1.21	(0.92; 1.59)
	cap	2.63	(2.18; 3.17)	4.15	(3.59; 4.79)	5.17	(4.41; 6.02)	4.44	(3.87; 5.11)	5.32	(4.56; 6.17)	2.28	(1.94; 2.67)
B^{sp}_{2027}/B_{MSY}	both	1.95	(1.83; 2.43)	2.45	(2.02; 2.89)	3.39	(2.92; 4.00)	3.24	(2.79; 3.78)	4.97	(4.40; 5.74)	1.62	(1.37; 2.00)
	para	1.82	(1.23; 2.55)	1.54	(1.09; 2.06)	1.77	(1.16; 2.66)	2.26	(1.70; 2.99)	4.38	(3.18; 5.90)	1.63	(1.23; 2.13)
	cap	2.18	(1.69; 2.62)	4.25	(3.82; 4.86)	5.21	(4.55; 6.09)	4.53	(4.08; 5.15)	5.32	(4.64; 6.19)	1.54	(1.16; 1.89)
B^{sp}_{2030}/K^{sp}	both	0.55	(0.44; 0.68)	0.57	(0.47; 0.66)	0.63	(0.53; 0.75)	0.65	(0.57; 0.74)	0.69	(0.61; 0.80)	0.49	(0.40; 0.60)
	para	0.46	(0.32; 0.61)	0.40	(0.28; 0.53)	0.37	(0.24; 0.49)	0.47	(0.35; 0.61)	0.47	(0.35; 0.60)	0.44	(0.34; 0.57)
	cap	0.81	(0.66; 1.03)	0.84	(0.77; 0.96)	0.88	(0.79; 1.02)	0.88	(0.81; 1.01)	0.88	(0.79; 1.02)	0.70	(0.53; 0.86)
$CPUE_{16}/CPUE_{03-05}$		1.67	(1.32; 2.06)	1.43	(1.18; 1.68)	1.44	(1.20; 1.70)	1.39	(1.20; 1.64)	1.44	(1.24; 1.66)	1.83	(1.55; 2.19)
AAV		0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)
P_{unexp}		0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)
E_{2020}/E_{2009}		0.61	(0.50; 0.75)	0.65	(0.56; 0.77)	0.69	(0.58; 0.83)	0.72	(0.63; 0.84)	0.71	(0.62; 0.85)	0.53	(0.44; 0.62)
E_{2030}/E_{2009}		0.57	(0.48; 0.69)	0.58	(0.49; 0.69)	0.63	(0.54; 0.76)	0.70	(0.62; 0.80)	0.70	(0.61; 0.81)	0.51	(0.42; 0.64)
$P_{lowCPUE}$		0.05	(0.00; 0.20)	0.10	(0.05; 0.33)	0.08	(0.00; 0.35)	0.10	(0.05; 0.40)	0.05	(0.00; 0.28)	0.05	(0.05; 0.15)

		RS7		RS8		RS9		RS10		RS11		RS12	
C fixed		118.5		118.5		118.5		118.5		118.5		118.5	
Females	both	1.47	(1.20; 1.75)	2.27	(2.02; 2.61)	2.18	(1.83; 2.65)	1.57	(1.41; 1.82)	3.02	(2.17; 3.91)	2.99	(2.14; 3.88)
$B^{sp}_{2027}/B^{sp}_{2007}$	para	1.43	(0.99; 1.99)	1.62	(1.31; 2.00)	2.79	(2.02; 3.43)	1.78	(1.35; 2.42)	3.31	(2.30; 4.40)	3.29	(2.27; 4.37)
	cap	1.49	(1.16; 1.77)	2.86	(2.49; 3.32)	1.83	(1.42; 2.32)	1.48	(1.31; 1.74)	2.04	(1.49; 2.69)	1.99	(1.39; 2.65)
Males	both	1.87	1.48 2.35	1.39	1.21 1.60	1.87	1.58 2.24	1.51	1.30 1.77	2.85	1.99 4.03	2.87	1.97 4.07
$B^{sp}_{2027}/B^{sp}_{2007}$	para	2.02	1.30 2.91	2.82	2.12 3.50	1.96	1.39 2.42	1.59	1.14 2.14	3.42	2.14 5.03	3.41	2.12 5.01
	cap	1.72	1.13 2.27	1.14	0.92 1.35	1.83	1.43 2.40	1.47	1.28 1.76	1.94	1.33 2.72	1.93	1.27 2.77
B^{sp}_{2020}/B_{MSY}	both	1.58	(1.22; 1.99)	1.84	(1.58; 2.14)	1.64	(1.36; 1.96)	2.43	(2.10; 2.76)	0.95	(0.72; 1.29)	0.93	(0.70; 1.27)
	para	1.74	(1.10; 2.65)	1.88	(1.54; 2.34)	1.41	(1.01; 1.85)	1.68	(1.32; 2.06)	1.08	(0.77; 1.49)	1.08	(0.77; 1.49)
	cap	1.42	(1.02; 1.87)	1.80	(1.50; 2.15)	1.95	(1.62; 2.40)	3.02	(2.58; 3.50)	0.61	(0.46; 0.79)	0.55	(0.41; 0.72)
B^{sp}_{2027}/B_{MSY}	both	0.52	(0.41; 0.65)	0.68	(0.58; 0.77)	1.94	(1.62; 2.36)	2.55	(2.29; 2.96)	1.33	(0.96; 1.73)	1.30	(0.93; 1.69)
	para	0.36	(0.22; 0.49)	0.61	(0.49; 0.72)	1.62	(1.17; 1.99)	1.85	(1.41; 2.51)	1.53	(1.06; 2.04)	1.53	(1.06; 2.03)
	cap	0.99	(0.72; 1.20)	0.75	(0.61; 0.89)	2.37	(1.85; 3.00)	3.05	(2.70; 3.58)	0.79	(0.58; 1.04)	0.72	(0.50; 0.96)
B^{sp}_{2030}/K^{sp}	both	1.99	(1.55; 2.47)	1.58	(1.35; 1.80)	0.81	(0.69; 0.97)	0.76	(0.66; 0.87)	0.39	(0.29; 0.50)	0.39	(0.28; 0.49)
	para	2.86	(1.79; 3.89)	2.62	(2.10; 3.08)	0.61	(0.47; 0.73)	0.55	(0.41; 0.68)	0.40	(0.27; 0.53)	0.40	(0.27; 0.53)
	cap	1.57	(1.15; 1.91)	1.15	(0.94; 1.37)	1.13	(0.91; 1.41)	0.92	(0.83; 1.06)	0.36	(0.25; 0.46)	0.33	(0.22; 0.43)
$CPUE_{16}/CPUE_{03-05}$		1.58	(1.29; 1.92)	1.93	(1.67; 2.33)	1.59	(1.36; 1.88)	1.35	(1.16; 1.55)	1.37	(1.13; 1.68)	1.35	(1.11; 1.66)
AAV		0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)
P_{unexp}		0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)
E_{2020}/E_{2009}		0.68	(0.54; 0.90)	0.62	(0.53; 0.72)	0.80	(0.66; 1.01)	0.75	(0.66; 0.90)	0.59	(0.45; 0.78)	0.60	(0.46; 0.79)
E_{2030}/E_{2009}		0.57	(0.46; 0.72)	0.70	(0.59; 0.85)	0.61	(0.50; 0.73)	0.73	(0.64; 0.85)	0.45	(0.34; 0.60)	0.45	(0.34; 0.61)
$P_{lowCPUE}$		0.10	(0.05; 0.35)	0.05	(0.00; 0.30)	0.05	(0.00; 0.28)	0.10	(0.00; 0.50)	0.20	(0.05; 0.45)	0.20	(0.05; 0.48)

Table 1b: Results (median, 95% PI) for the Reference Set under a projected constant catch of **135 000t**.

		RS1		RS2		RS3		RS4		RS5		RS6	
C fixed		135.0		135.0		135.0		135.0		135.0		135.0	
Females	both	2.01	(1.45; 2.64)	1.61	(1.27; 1.92)	1.69	(1.41; 2.04)	1.38	(1.17; 1.63)	1.63	(1.43; 1.90)	2.06	(1.63; 2.61)
$B^{sp}_{2027}/B^{sp}_{2007}$	para	2.57	(1.41; 4.03)	2.36	(1.38; 3.35)	2.37	(1.07; 4.10)	1.52	(1.06; 2.11)	1.92	(1.32; 2.69)	2.84	(1.87; 3.87)
	cap	1.57	(1.22; 1.90)	1.36	(1.21; 1.56)	1.55	(1.35; 1.82)	1.30	(1.16; 1.48)	1.53	(1.33; 1.79)	1.37	(1.00; 1.67)
Males	both	1.78	1.34 2.29	1.51	1.23 1.85	1.54	1.25 1.88	1.34	1.11 1.58	1.51	1.29 1.78	1.91	1.41 2.44
$B^{sp}_{2027}/B^{sp}_{2007}$	para	2.04	1.16 3.08	2.30	1.14 3.81	1.54	0.79 2.39	1.48	0.88 2.29	1.53	1.04 2.07	2.74	1.54 4.22
	cap	1.56	1.26 1.82	1.35	1.18 1.56	1.52	1.31 1.82	1.29	1.13 1.47	1.51	1.31 1.81	1.38	1.04 1.72
B^{sp}_{2020}/B_{MSY}	both	1.55	(1.19; 2.07)	1.88	(1.54; 2.25)	2.80	(2.31; 3.33)	2.73	(2.39; 3.19)	4.50	(3.75; 5.23)	1.29	(1.05; 1.61)
	para	1.11	(0.64; 1.79)	0.83	(0.54; 1.22)	0.97	(0.52; 1.48)	1.53	(1.12; 2.06)	3.41	(2.45; 4.60)	0.92	(0.66; 1.29)
	cap	2.47	(2.04; 2.99)	4.00	(3.45; 4.65)	4.99	(4.21; 5.81)	4.36	(3.79; 5.01)	5.19	(4.43; 6.03)	2.15	(1.81; 2.53)
B^{sp}_{2027}/B_{MSY}	both	1.63	(1.51; 2.14)	2.12	(1.67; 2.53)	2.99	(2.50; 3.62)	2.95	(2.50; 3.49)	4.62	(4.05; 5.40)	1.34	(1.06; 1.70)
	para	1.36	(0.75; 2.13)	1.12	(0.66; 1.59)	1.18	(0.53; 2.03)	1.84	(1.28; 2.54)	3.66	(2.52; 5.14)	1.23	(0.81; 1.68)
	cap	2.14	(1.66; 2.59)	4.09	(3.65; 4.70)	5.02	(4.39; 5.90)	4.43	(3.97; 5.06)	5.19	(4.52; 6.06)	1.55	(1.14; 1.90)
B^{sp}_{2030}/K^{sp}	both	0.46	(0.33; 0.61)	0.49	(0.39; 0.59)	0.55	(0.44; 0.68)	0.59	(0.51; 0.69)	0.64	(0.56; 0.75)	0.41	(0.32; 0.52)
	para	0.35	(0.18; 0.52)	0.29	(0.16; 0.42)	0.25	(0.12; 0.37)	0.38	(0.27; 0.52)	0.40	(0.28; 0.52)	0.33	(0.22; 0.46)
	cap	0.79	(0.64; 1.01)	0.81	(0.74; 0.93)	0.85	(0.74; 0.99)	0.86	(0.79; 0.99)	0.86	(0.77; 1.00)	0.71	(0.54; 0.88)
$CPUE_{16}/CPUE_{03-05}$		1.52	(1.18; 1.92)	1.35	(1.10; 1.59)	1.35	(1.11; 1.61)	1.34	(1.16; 1.59)	1.38	(1.19; 1.60)	1.66	(1.39; 2.03)
AAV		0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)
P_{unexp}		0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)
E_{2020}/E_{2009}		0.78	(0.62; 0.98)	0.82	(0.69; 0.98)	0.86	(0.72; 1.06)	0.85	(0.74; 0.99)	0.85	(0.74; 1.02)	0.68	(0.55; 0.82)
E_{2030}/E_{2009}		0.73	(0.60; 0.92)	0.75	(0.61; 0.91)	0.80	(0.67; 1.05)	0.83	(0.73; 0.95)	0.83	(0.72; 0.98)	0.68	(0.54; 0.87)
$P_{lowCPUE}$		0.10	(0.00; 0.38)	0.13	(0.05; 0.55)	0.10	(0.00; 0.68)	0.10	(0.05; 0.53)	0.10	(0.00; 0.45)	0.10	(0.05; 0.28)

		RS7		RS8		RS9		RS10		RS11		RS12	
C fixed		135.0		135.0		135.0		135.0		135.0		135.0	
Females	both	1.25	(1.01; 1.54)	2.09	(1.83; 2.44)	1.93	(1.38; 2.46)	1.49	(1.33; 1.74)	2.13	(1.22; 3.01)	2.09	(1.18; 2.98)
$B^{sp}_{2027}/B^{sp}_{2007}$	para	1.02	(0.57; 1.54)	1.31	(1.02; 1.70)	2.11	(0.91; 3.02)	1.54	(1.13; 2.17)	2.31	(1.20; 3.36)	2.28	(1.16; 3.34)
	cap	1.46	(1.14; 1.72)	2.80	(2.43; 3.25)	1.80	(1.41; 2.28)	1.46	(1.29; 1.72)	1.54	(0.93; 2.20)	1.45	(0.81; 2.12)
Males	both	1.61	1.20 2.09	1.32	1.14 1.52	1.72	1.23 2.12	1.44	1.23 1.70	1.95	1.09 3.12	1.92	1.03 3.13
$B^{sp}_{2027}/B^{sp}_{2007}$	para	1.54	0.83 2.39	2.32	1.54 3.00	1.61	0.74 2.18	1.39	0.94 1.93	2.22	1.00 3.85	2.20	0.97 3.83
	cap	1.67	1.18 2.21	1.14	0.92 1.35	1.80	1.39 2.37	1.45	1.26 1.74	1.50	0.90 2.29	1.43	0.78 2.28
B^{sp}_{2020}/B_{MSY}	both	1.31	(0.96; 1.71)	1.70	(1.45; 1.97)	1.40	(1.14; 1.72)	2.32	(2.00; 2.66)	0.70	(0.48; 1.04)	0.68	(0.46; 1.02)
	para	1.17	(0.57; 2.04)	1.57	(1.19; 2.02)	1.05	(0.63; 1.49)	1.47	(1.13; 1.85)	0.77	(0.49; 1.18)	0.77	(0.49; 1.18)
	cap	1.39	(1.00; 1.83)	1.80	(1.48; 2.15)	1.89	(1.57; 2.34)	2.97	(2.54; 3.45)	0.51	(0.37; 0.68)	0.45	(0.32; 0.62)
B^{sp}_{2027}/B_{MSY}	both	0.43	(0.32; 0.56)	0.63	(0.53; 0.72)	1.71	(1.23; 2.19)	2.42	(2.16; 2.83)	0.94	(0.54; 1.33)	0.91	(0.51; 1.30)
	para	0.25	(0.11; 0.37)	0.53	(0.39; 0.65)	1.23	(0.53; 1.76)	1.60	(1.17; 2.26)	1.07	(0.55; 1.56)	1.06	(0.54; 1.55)
	cap	0.92	(0.69; 1.14)	0.75	(0.61; 0.89)	2.34	(1.83; 2.95)	3.00	(2.66; 3.53)	0.60	(0.36; 0.85)	0.53	(0.30; 0.77)
B^{sp}_{2030}/K^{sp}	both	1.62	(1.22; 2.11)	1.48	(1.23; 1.68)	0.72	(0.52; 0.89)	0.72	(0.62; 0.83)	0.28	(0.16; 0.39)	0.27	(0.15; 0.38)
	para	1.96	(0.91; 2.96)	2.26	(1.66; 2.77)	0.50	(0.20; 0.64)	0.47	(0.34; 0.61)	0.28	(0.14; 0.41)	0.28	(0.14; 0.41)
	cap	1.47	(1.10; 1.81)	1.15	(0.94; 1.37)	1.09	(0.87; 1.36)	0.91	(0.81; 1.05)	0.26	(0.15; 0.37)	0.23	(0.13; 0.34)
$CPUE_{16}/CPUE_{03-05}$		1.44	(1.15; 1.78)	1.85	(1.58; 2.24)	1.48	(1.25; 1.78)	1.32	(1.13; 1.52)	1.18	(0.93; 1.48)	1.16	(0.92; 1.46)
AAV		0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)
P_{unexp}		0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)
E_{2020}/E_{2009}		0.85	(0.67; 1.17)	0.74	(0.63; 0.88)	1.00	(0.81; 1.34)	0.88	(0.77; 1.06)	0.84	(0.61; 1.21)	0.85	(0.61; 1.24)
E_{2030}/E_{2009}		0.75	(0.57; 0.98)	0.82	(0.68; 1.01)	0.75	(0.59; 1.02)	0.85	(0.75; 1.01)	0.68	(0.48; 1.13)	0.70	(0.49; 1.21)
$P_{lowCPUE}$		0.15	(0.05; 0.65)	0.10	(0.00; 0.35)	0.15	(0.00; 0.65)	0.10	(0.00; 0.63)	0.35	(0.05; 1.00)	0.40	(0.07; 1.00)

Table 1c: Results (median, 95% PI) for the Reference Set under a projected constant catch of **150 000t**.

		RS1		RS2		RS3		RS4		RS5		RS6	
C fixed		150.0		150.0		150.0		150.0		150.0		150.0	
Females	both	1.55	(0.94; 2.24)	1.35	(1.00; 1.67)	1.45	(1.10; 1.80)	1.25	(1.04; 1.49)	1.51	(1.31; 1.79)	1.61	(1.16; 2.13)
$B^{sp}_{2027}/B^{sp}_{2007}$	para	1.64	(0.42; 3.19)	1.51	(0.55; 2.55)	1.16	(0.64; 2.63)	1.21	(0.73; 1.75)	1.57	(1.01; 2.34)	1.91	(0.95; 2.96)
	cap	1.49	(1.13; 1.81)	1.29	(1.13; 1.50)	1.46	(1.17; 1.74)	1.26	(1.13; 1.45)	1.49	(1.30; 1.75)	1.36	(1.01; 1.64)
Males	both	1.44	0.96 1.96	1.29	1.03 1.63	1.35	1.00 1.70	1.22	1.00 1.46	1.43	1.20 1.69	1.51	1.05 2.03
$B^{sp}_{2027}/B^{sp}_{2007}$	para	1.34	0.47 2.48	1.35	0.41 2.80	0.97	0.61 1.93	1.07	0.52 1.83	1.31	0.85 1.85	1.74	0.67 3.19
	cap	1.50	1.17 1.80	1.29	1.10 1.50	1.44	1.13 1.74	1.26	1.10 1.44	1.47	1.28 1.77	1.36	1.03 1.70
B^{sp}_{2020}/B_{MSY}	both	1.27	(0.91; 1.80)	1.66	(1.33; 2.04)	2.51	(2.00; 3.05)	2.53	(2.20; 2.99)	4.21	(3.47; 4.93)	1.07	(0.82; 1.39)
	para	0.76	(0.32; 1.44)	0.57	(0.32; 0.95)	0.58	(0.30; 1.09)	1.26	(0.87; 1.78)	2.83	(1.91; 3.98)	0.66	(0.42; 1.02)
	cap	2.31	(1.87; 2.81)	3.86	(3.30; 4.51)	4.78	(3.89; 5.56)	4.27	(3.70; 4.92)	5.06	(4.30; 5.89)	2.00	(1.66; 2.40)
B^{sp}_{2027}/B_{MSY}	both	1.26	(1.14; 1.82)	1.78	(1.32; 2.21)	2.57	(1.96; 3.20)	2.68	(2.22; 3.20)	4.30	(3.73; 5.08)	1.05	(0.76; 1.39)
	para	0.87	(0.22; 1.69)	0.71	(0.26; 1.21)	0.58	(0.32; 1.30)	1.46	(0.88; 2.11)	3.00	(1.93; 4.45)	0.83	(0.41; 1.29)
	cap	2.03	(1.53; 2.47)	3.90	(3.41; 4.51)	4.75	(3.81; 5.65)	4.32	(3.85; 4.95)	5.06	(4.41; 5.94)	1.54	(1.14; 1.86)
B^{sp}_{2030}/K^{sp}	both	0.35	(0.20; 0.53)	0.41	(0.30; 0.51)	0.46	(0.34; 0.58)	0.53	(0.45; 0.63)	0.59	(0.51; 0.71)	0.31	(0.20; 0.42)
	para	0.22	(0.04; 0.41)	0.17	(0.06; 0.30)	0.12	(0.06; 0.26)	0.30	(0.17; 0.44)	0.33	(0.21; 0.44)	0.22	(0.10; 0.34)
	cap	0.75	(0.58; 0.96)	0.77	(0.69; 0.89)	0.80	(0.62; 0.96)	0.84	(0.77; 0.97)	0.84	(0.75; 0.98)	0.71	(0.54; 0.87)
$CPUE_{16}/CPUE_{03-05}$		1.39	(1.05; 1.78)	1.26	(1.00; 1.50)	1.26	(1.02; 1.53)	1.30	(1.11; 1.54)	1.33	(1.14; 1.55)	1.51	(1.24; 1.87)
AAV		0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.41)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)
P_{unexp}		0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)
E_{2020}/E_{2009}		0.99	(0.77; 1.30)	1.00	(0.83; 1.22)	1.06	(0.86; 1.35)	0.98	(0.85; 1.16)	0.99	(0.85; 1.20)	0.86	(0.68; 1.08)
E_{2030}/E_{2009}		0.94	(0.72; 1.46)	0.95	(0.76; 1.25)	1.03	(0.82; 1.40)	0.97	(0.84; 1.12)	0.97	(0.84; 1.15)	0.90	(0.68; 1.25)
$P_{lowCPUE}$		0.18	(0.00; 0.80)	0.25	(0.05; 0.95)	0.30	(0.02; 1.00)	0.15	(0.05; 0.80)	0.15	(0.00; 0.63)	0.15	(0.05; 0.63)

		RS7		RS8		RS9		RS10		RS11		RS12	
C fixed		150.0		150.0		150.0		150.0		150.0		150.0	
Females	both	1.06	(0.81; 1.34)	1.92	(1.66; 2.28)	1.47	(0.53; 2.16)	1.42	(1.24; 1.66)	1.18	(0.37; 2.21)	1.12	(0.35; 2.17)
$B^{sp}_{2027}/B^{sp}_{2007}$	para	0.67	(0.33; 1.14)	1.04	(0.74; 1.43)	0.98	(0.20; 2.33)	1.31	(0.87; 1.93)	1.26	(0.37; 2.49)	1.22	(0.37; 2.44)
	cap	1.41	(1.08; 1.65)	2.75	(2.38; 3.18)	1.69	(0.67; 2.16)	1.44	(1.27; 1.69)	0.99	(0.24; 1.71)	0.86	(0.20; 1.60)
Males	both	1.36	0.89 1.84	1.23	1.03 1.44	1.35	0.55 1.94	1.37	1.15 1.63	1.05	0.41 2.24	0.99	0.37 2.21
$B^{sp}_{2027}/B^{sp}_{2007}$	para	1.07	0.63 1.93	1.75	0.90 2.58	0.87	0.20 1.92	1.20	0.76 1.73	1.09	0.41 2.73	1.04	0.43 2.70
	cap	1.61	0.99 2.12	1.13	0.91 1.34	1.70	0.78 2.28	1.43	1.24 1.71	1.00	0.25 1.81	0.88	0.19 1.74
B^{sp}_{2020}/B_{MSY}	both	1.06	(0.67; 1.43)	1.51	(1.26; 1.82)	1.16	(0.90; 1.46)	2.22	(1.90; 2.57)	0.47	(0.27; 0.80)	0.46	(0.25; 0.78)
	para	0.67	(0.31; 1.45)	1.19	(0.76; 1.66)	0.68	(0.27; 1.18)	1.29	(0.96; 1.68)	0.50	(0.24; 0.89)	0.49	(0.24; 0.89)
	cap	1.35	(0.90; 1.74)	1.80	(1.47; 2.15)	1.81	(1.51; 2.23)	2.93	(2.49; 3.41)	0.40	(0.24; 0.59)	0.35	(0.19; 0.53)
B^{sp}_{2027}/B_{MSY}	both	0.33	(0.23; 0.45)	0.57	(0.46; 0.67)	1.30	(0.47; 1.92)	2.30	(2.02; 2.70)	0.52	(0.16; 0.97)	0.49	(0.15; 0.95)
	para	0.14	(0.05; 0.25)	0.42	(0.25; 0.57)	0.57	(0.12; 1.35)	1.37	(0.90; 2.01)	0.58	(0.17; 1.15)	0.57	(0.17; 1.13)
	cap	0.84	(0.58; 1.08)	0.75	(0.61; 0.90)	2.20	(0.87; 2.80)	2.96	(2.62; 3.48)	0.38	(0.09; 0.66)	0.31	(0.07; 0.58)
B^{sp}_{2030}/K^{sp}	both	1.26	(0.86; 1.71)	1.34	(1.08; 1.58)	0.54	(0.18; 0.79)	0.68	(0.58; 0.80)	0.14	(0.04; 0.28)	0.13	(0.04; 0.27)
	para	1.10	(0.43; 2.02)	1.78	(1.06; 2.45)	0.22	(0.03; 0.49)	0.40	(0.26; 0.53)	0.14	(0.04; 0.29)	0.13	(0.04; 0.28)
	cap	1.33	(0.93; 1.71)	1.15	(0.93; 1.37)	0.98	(0.37; 1.30)	0.89	(0.80; 1.04)	0.15	(0.03; 0.29)	0.11	(0.02; 0.25)
$CPUE_{16}/CPUE_{03-05}$		1.31	(1.02; 1.64)	1.77	(1.51; 2.17)	1.35	(1.11; 1.66)	1.29	(1.10; 1.49)	1.00	(0.76; 1.30)	0.98	(0.74; 1.28)
AAV		0.00	(0.00; 0.47)	0.00	(0.00; 0.00)	0.00	(0.00; 0.54)	0.00	(0.00; 0.00)	0.00	(0.00; 4.45)	0.00	(0.00; 5.27)
P_{unexp}		0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)
E_{2020}/E_{2009}		1.06	(0.81; 1.49)	0.87	(0.73; 1.04)	1.29	(1.00; 1.96)	1.01	(0.87; 1.21)	1.22	(0.81; 1.99)	1.26	(0.82; 2.04)
E_{2030}/E_{2009}		1.00	(0.72; 1.49)	0.95	(0.78; 1.24)	1.07	(0.72; 2.47)	0.98	(0.85; 1.18)	1.28	(0.70; 2.27)	1.40	(0.72; 2.41)
$P_{lowCPUE}$		0.35	(0.05; 1.00)	0.25	(0.00; 0.45)	0.40	(0.02; 0.95)	0.15	(0.00; 0.83)	1.00	(0.10; 1.00)	1.00	(0.12; 1.00)

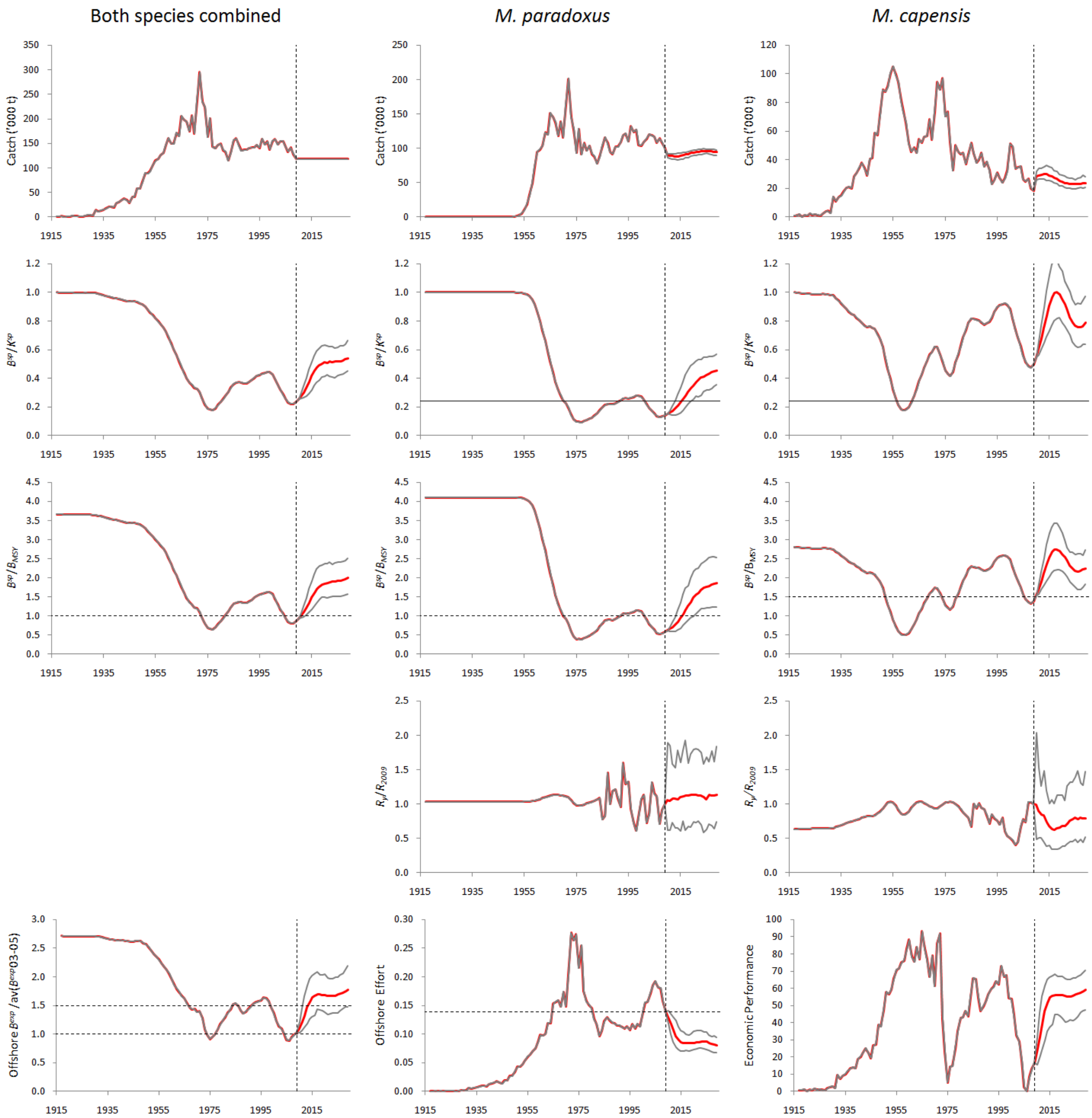

Fig. 1a: For the Reference Case (**RS1**) under a projected constant catch of **118 500 t**, time-trajectories (median and 95% PI) for the total catch (top row, species combined, then by species), the female spawning biomass relative to its pre-exploitation level (middle row, species combined, then by species) and offshore trawl exploitable biomass (species and coast combined). On the species-disaggregated spawning biomass plots, the estimated MSYLs are also shown. The dashed horizontal line in the offshore effort plot shows the current (2009) effort.

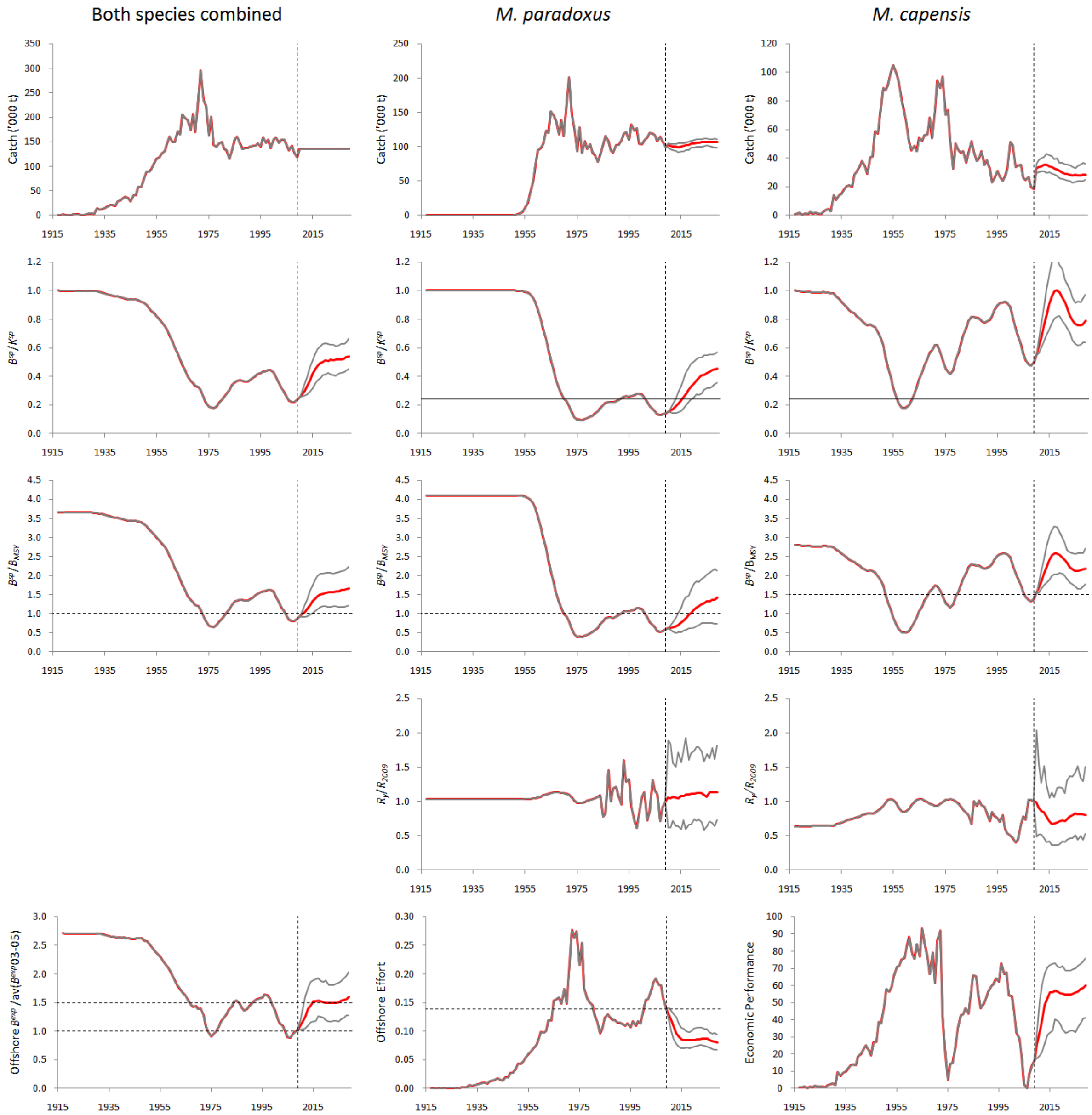

Fig. 1b: For the Reference Case (**RS1**) under a projected constant catch of **135 000 t**, time-trajectories (median and 95% PI) for the total catch (top row, species combined, then by species), the female spawning biomass relative to its pre-exploitation level (middle row, species combined, then by species) and offshore trawl exploitable biomass (species and coast combined). On the species-disaggregated spawning biomass plots, the estimated MSYLs are also shown. The dashed horizontal line in the offshore effort plot shows the current (2009) effort.

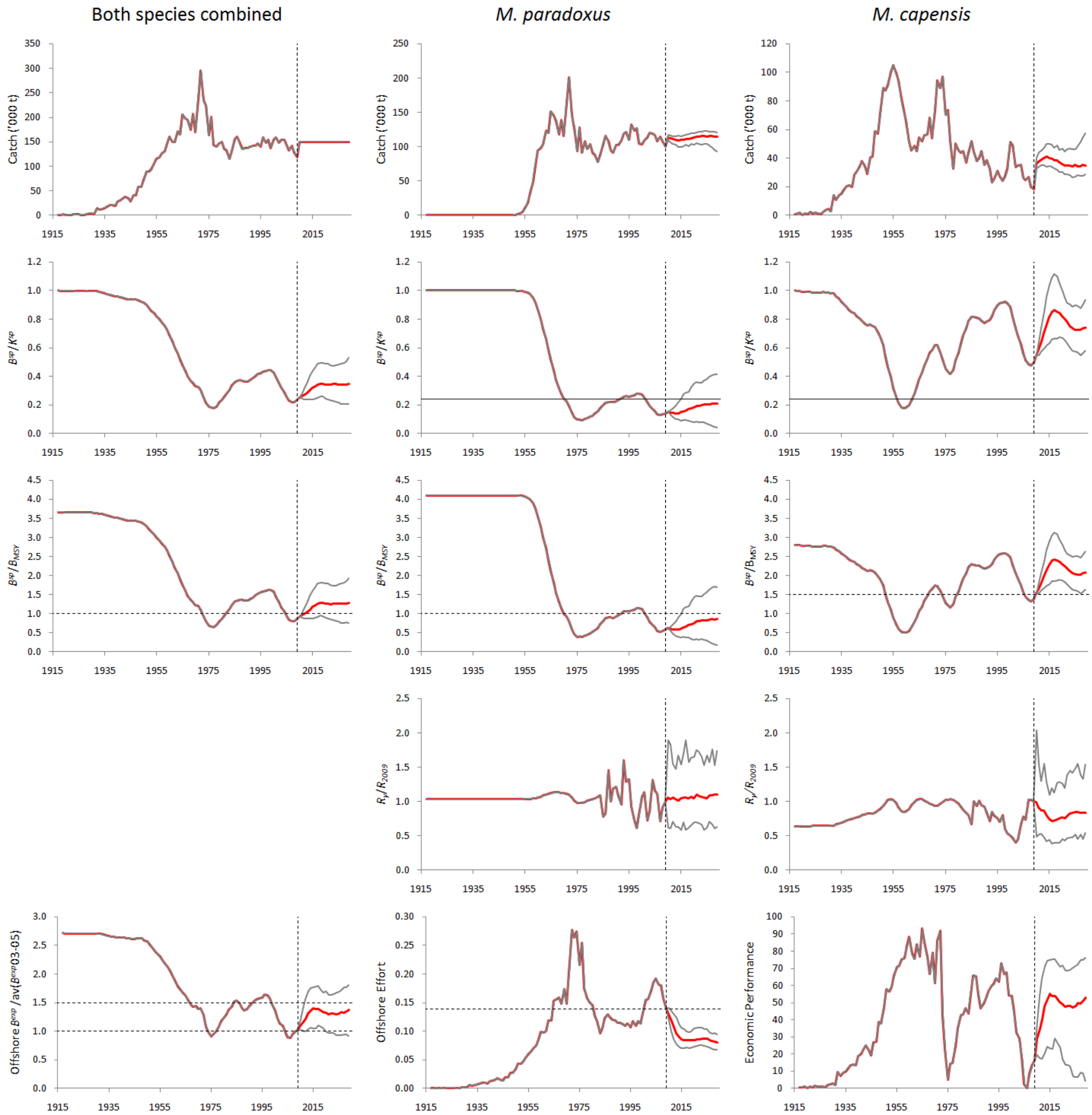

Fig. 1c: For the Reference Case (**RS1**) under a projected constant catch of **150 000 t**, time-trajectories (median and 95% PI) for the total catch (top row, species combined, then by species), the female spawning biomass relative to its pre-exploitation level (middle row, species combined, then by species) and offshore trawl exploitable biomass (species and coast combined). On the species-disaggregated spawning biomass plots, the estimated MSYLs are also shown. The dashed horizontal line in the offshore effort plot shows the current (2009) effort.

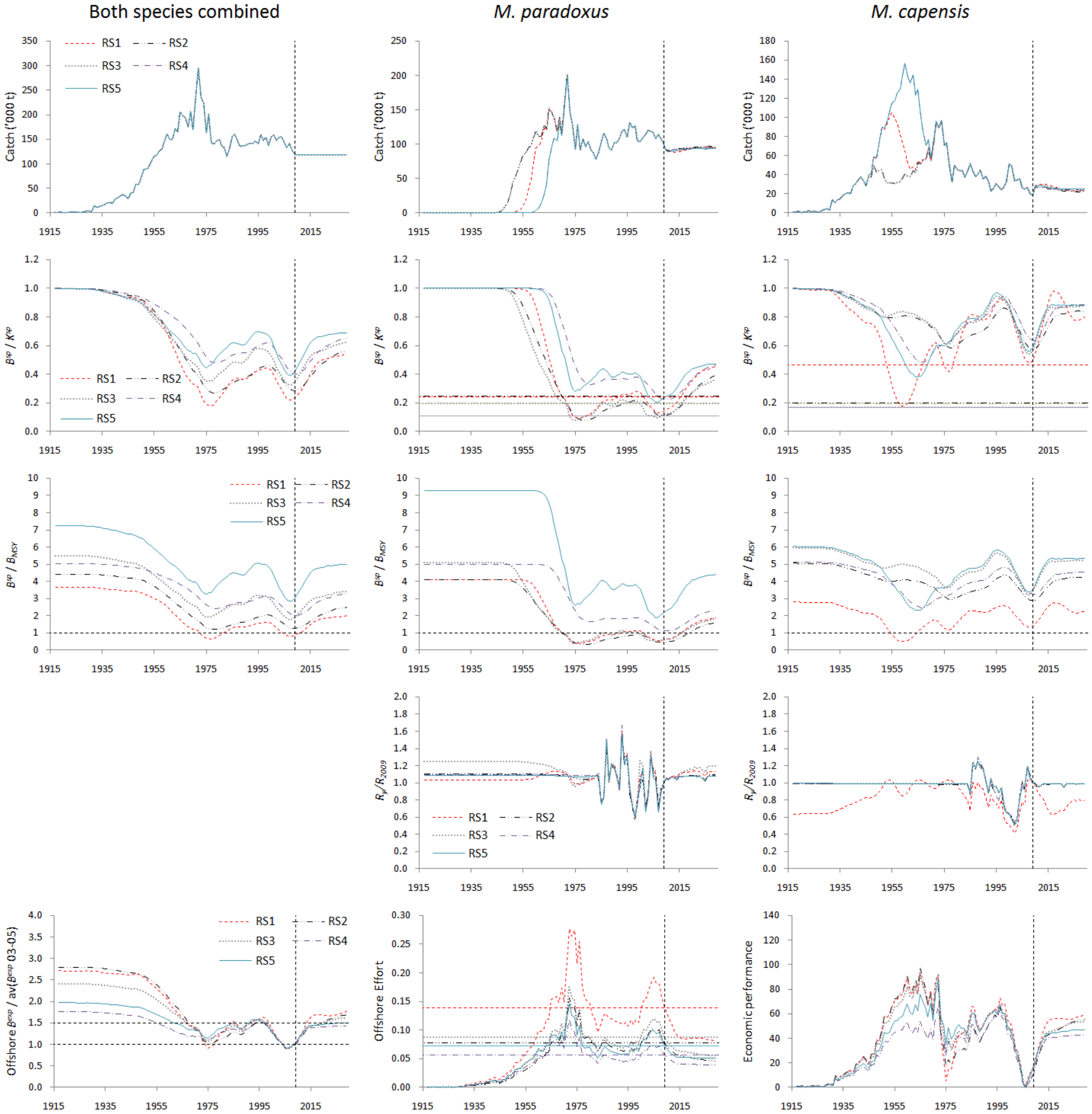

Fig. 2a.i: For the first five OMs of RSa (**RS1 to RS5**) under a projected constant catch of **118 500 t**, median time-trajectories for the total catch (top row, species combined, then by species), the female spawning biomass relative to its pre-exploitation level (middle row, species combined, then by species) and offshore trawl exploitable biomass (species and coast combined). On the species-disaggregated spawning biomass plots, the estimated MSYLs are also shown. The dashed horizontal lines in the offshore effort plot show the current (2009) effort.

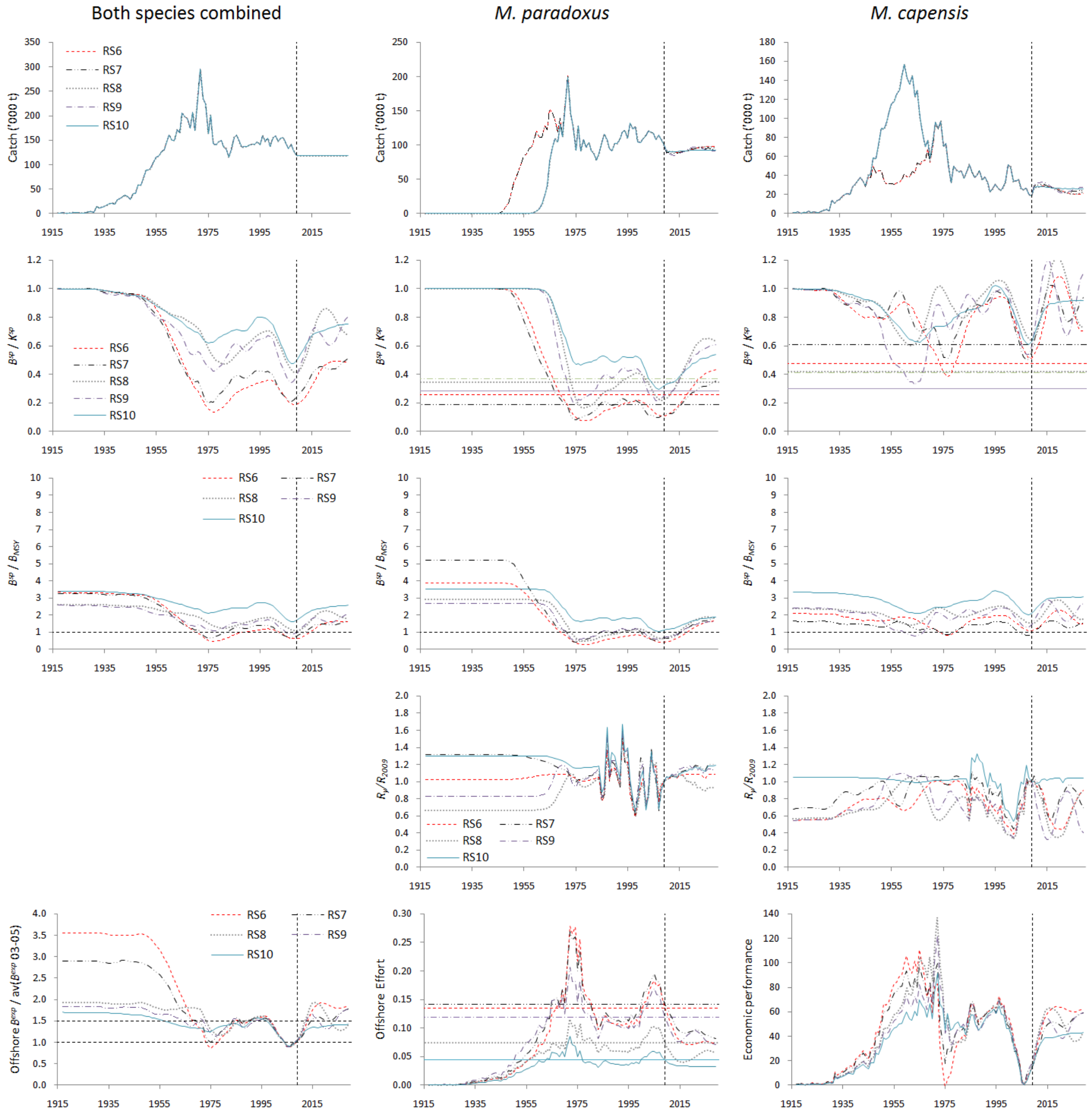

Fig. 2a.ii: For the last five OMs of RSa (**RS6 to RS10**) under a projected constant catch of **118 500 t**, median time-trajectories for the total catch (top row, species combined, then by species), the female spawning biomass relative to its pre-exploitation level (middle row, species combined, then by species) and offshore trawl exploitable biomass (species and coast combined). On the species-disaggregated spawning biomass plots, the estimated MSYLs are also shown. The dashed horizontal lines in the offshore effort plot show the current (2009) effort.

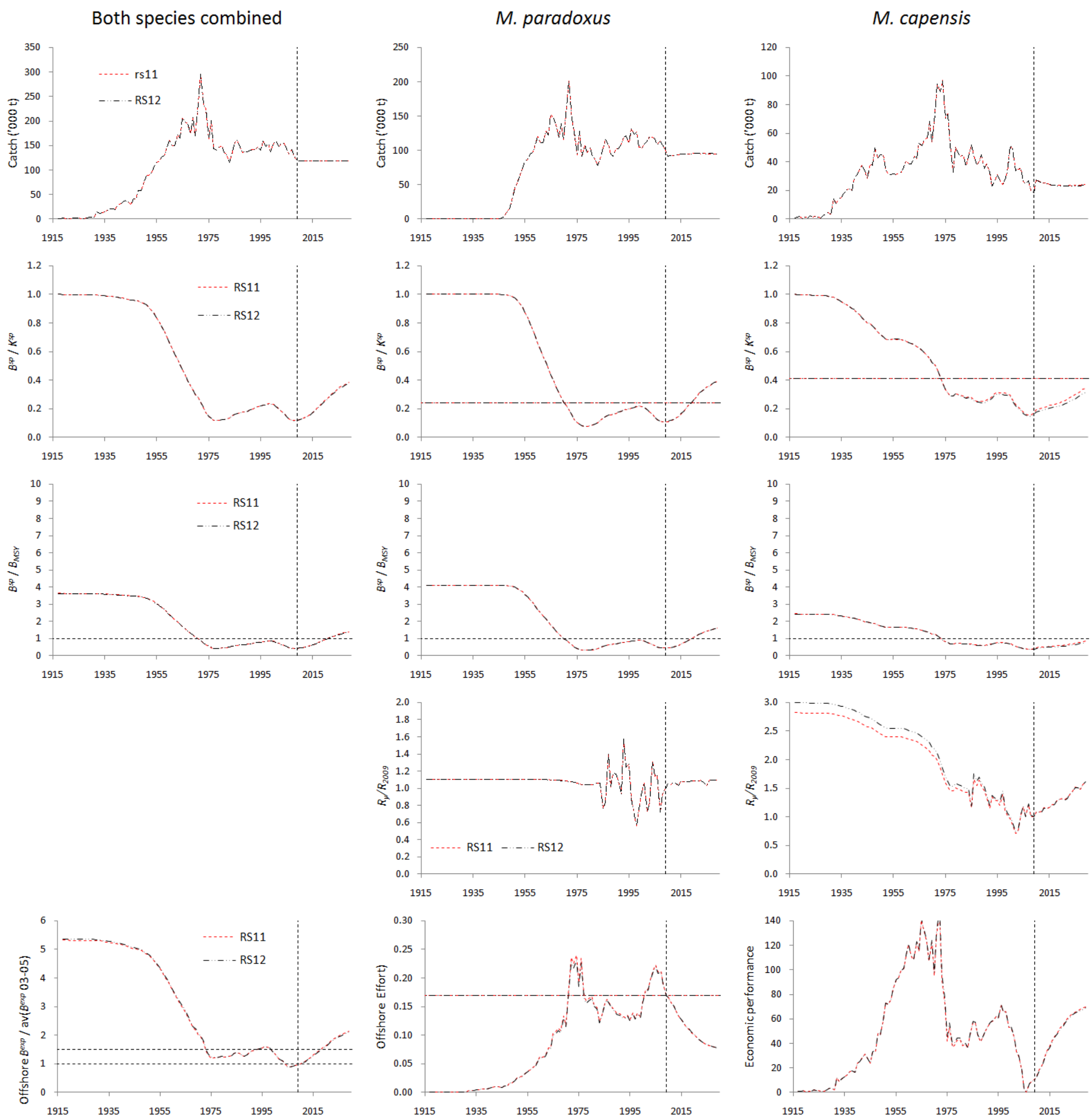

Fig. 2a.iii: For the two OMs of RSb (**RS11 and RS12**) under a projected constant catch of **118 500 t**, median time-trajectories for the total catch (top row, species combined, then by species), the female spawning biomass relative to its pre-exploitation level (middle row, species combined, then by species) and offshore trawl exploitable biomass (species and coast combined). On the species-disaggregated spawning biomass plots, the estimated MSYLs are also shown. The dashed horizontal lines in the offshore effort plot show the current (2009) effort.

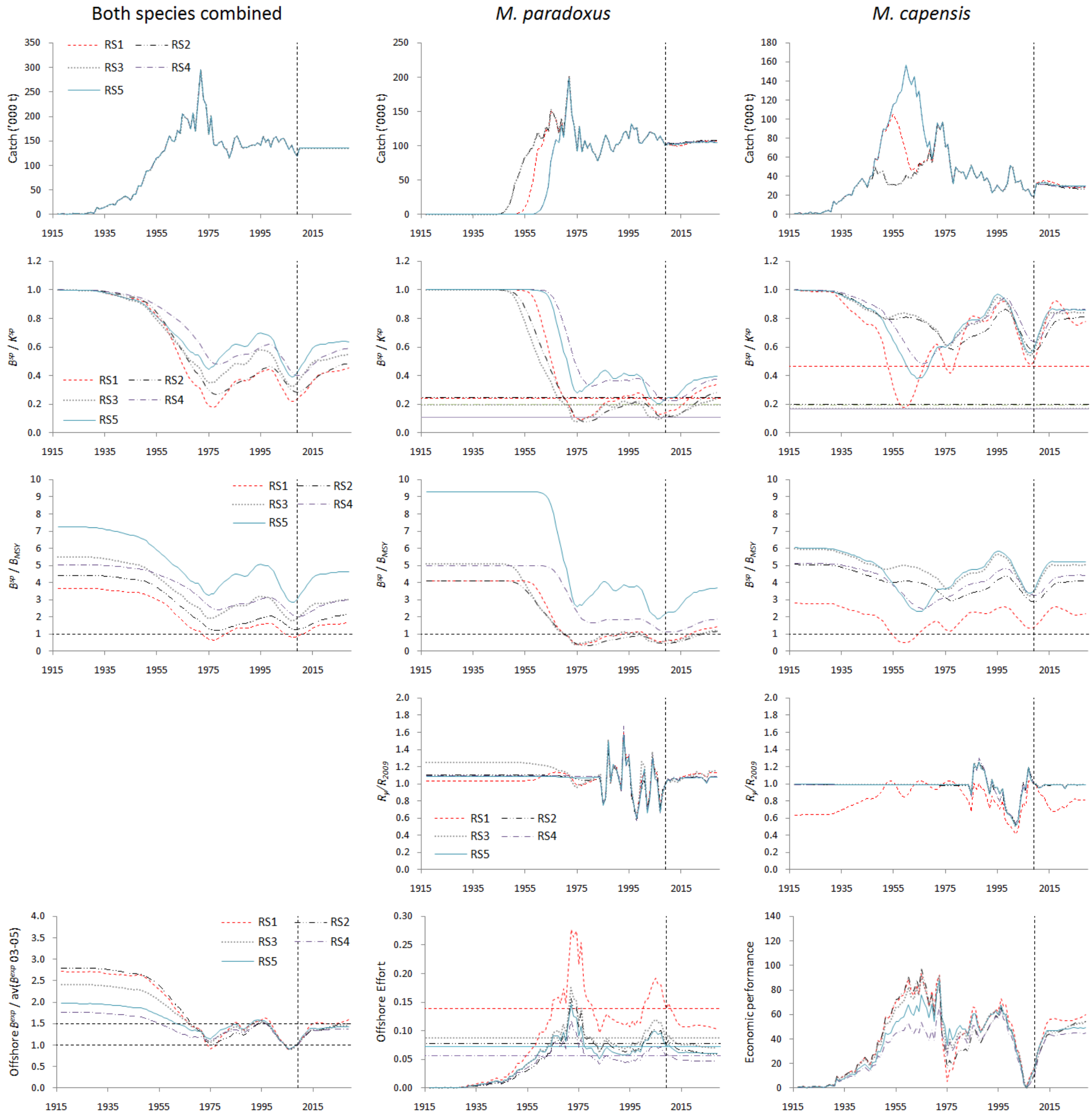

Fig. 2b.i: For the first five OMs of RSa (**RS1 to RS5**) under a projected constant catch of **135 000 t**, median time-trajectories for the total catch (top row, species combined, then by species), the female spawning biomass relative to its pre-exploitation level (middle row, species combined, then by species) and offshore trawl exploitable biomass (species and coast combined). On the species-disaggregated spawning biomass plots, the estimated MSYLs are also shown. The dashed horizontal lines in the offshore effort plot show the current (2009) effort.

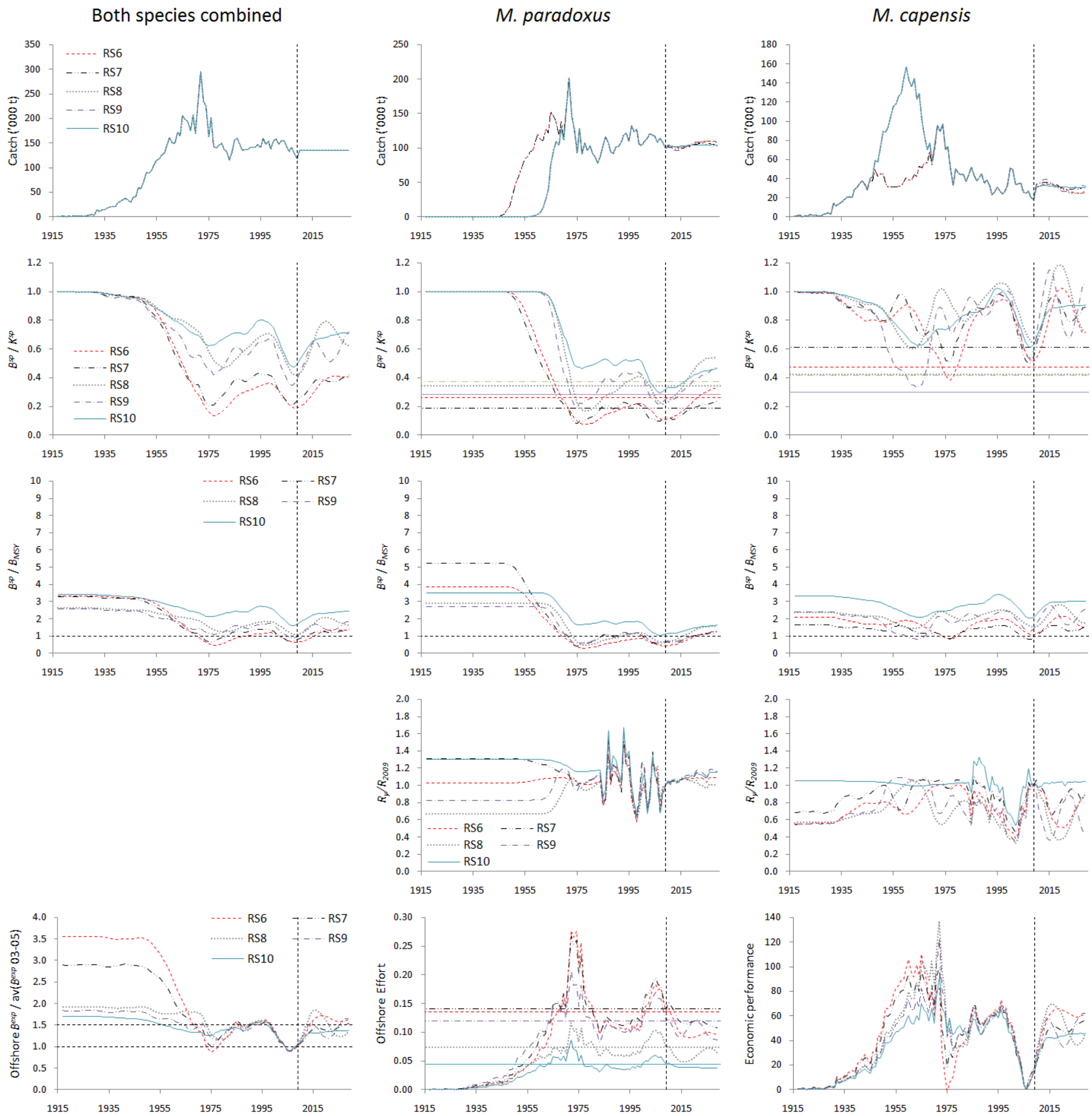

Fig. 2b.ii: For the last five OMs of RSa (**RS6 to RS10**) under a projected constant catch of **135 000 t**, median time-trajectories for the total catch (top row, species combined, then by species), the female spawning biomass relative to its pre-exploitation level (middle row, species combined, then by species) and offshore trawl exploitable biomass (species and coast combined). On the species-disaggregated spawning biomass plots, the estimated MSYLs are also shown. The dashed horizontal lines in the offshore effort plot show the current (2009) effort.

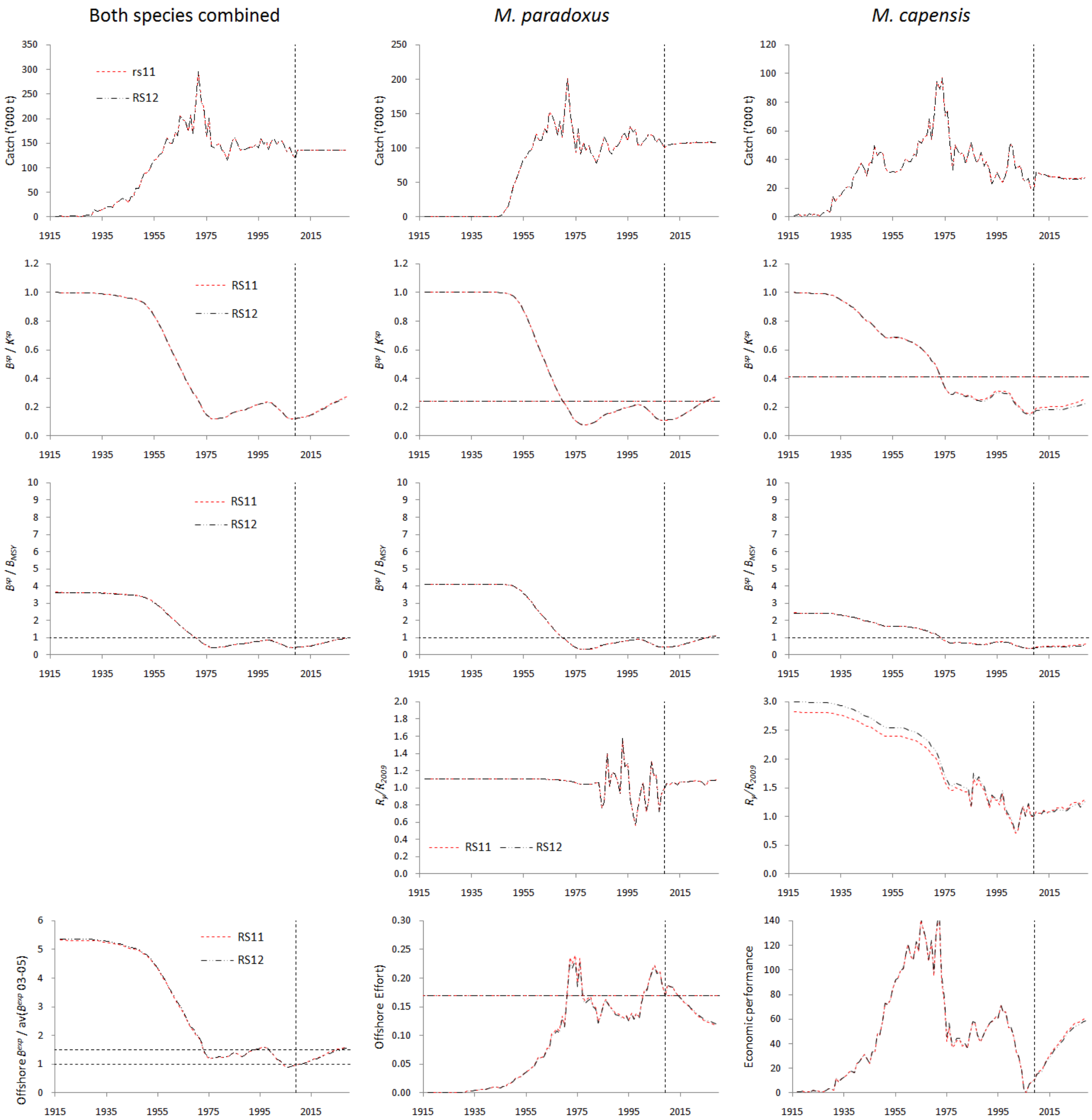

Fig. 2b.iii: For the two OMs of RSb (**RS11 and RS12**) under a projected constant catch of **135 000 t**, median time-trajectories for the total catch (top row, species combined, then by species), the female spawning biomass relative to its pre-exploitation level (middle row, species combined, then by species) and offshore trawl exploitable biomass (species and coast combined). On the species-disaggregated spawning biomass plots, the estimated MSYLs are also shown. The dashed horizontal lines in the offshore effort plot show the current (2009) effort.

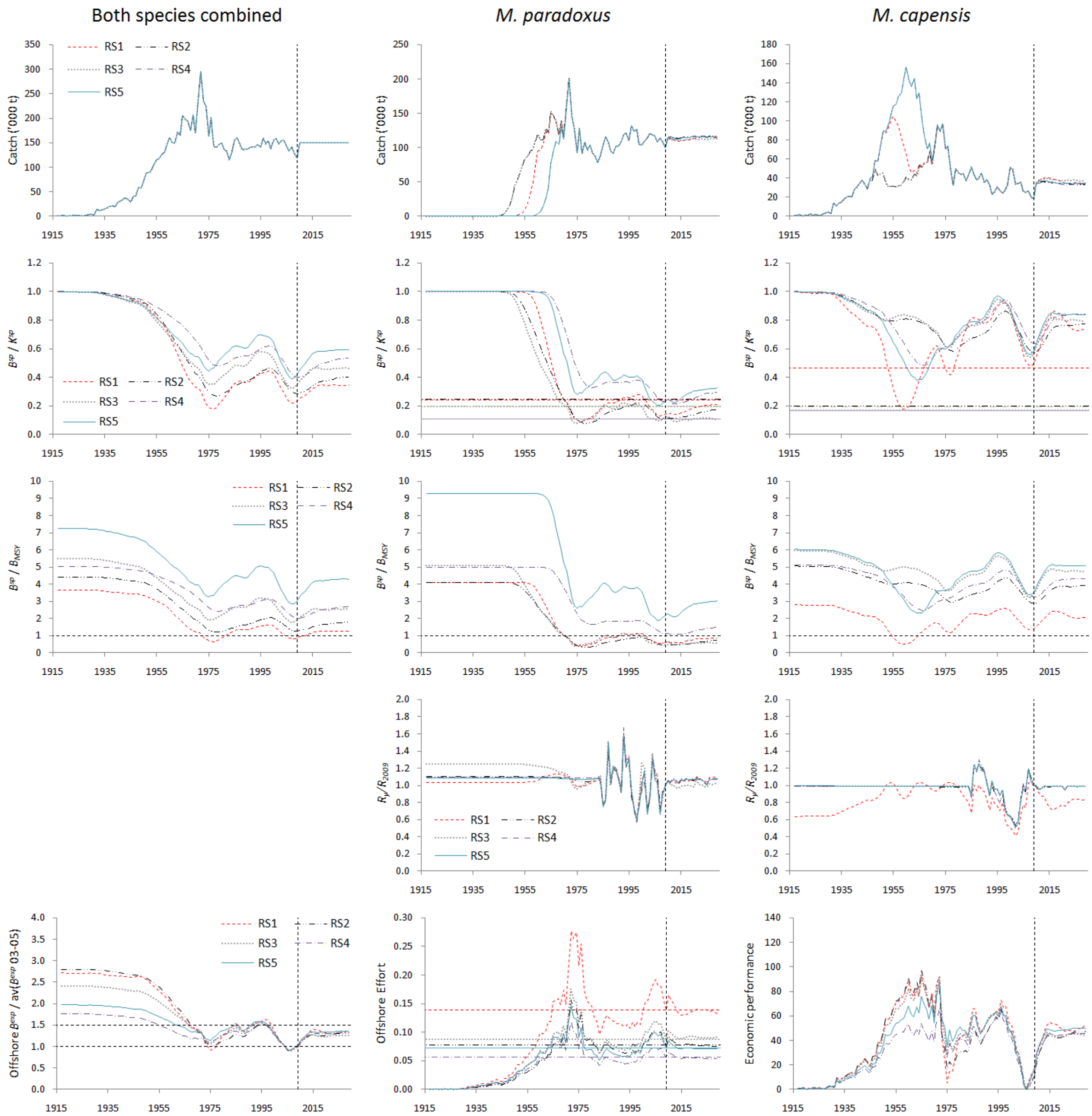

Fig. 2c.i: For the first five OMs of RSa (**RS1 to RS5**) under a projected constant catch of **150 000 t**, median time-trajectories for the total catch (top row, species combined, then by species), the female spawning biomass relative to its pre-exploitation level (middle row, species combined, then by species) and offshore trawl exploitable biomass (species and coast combined). On the species-disaggregated spawning biomass plots, the estimated MSYLs are also shown. The dashed horizontal lines in the offshore effort plot show the current (2009) effort.

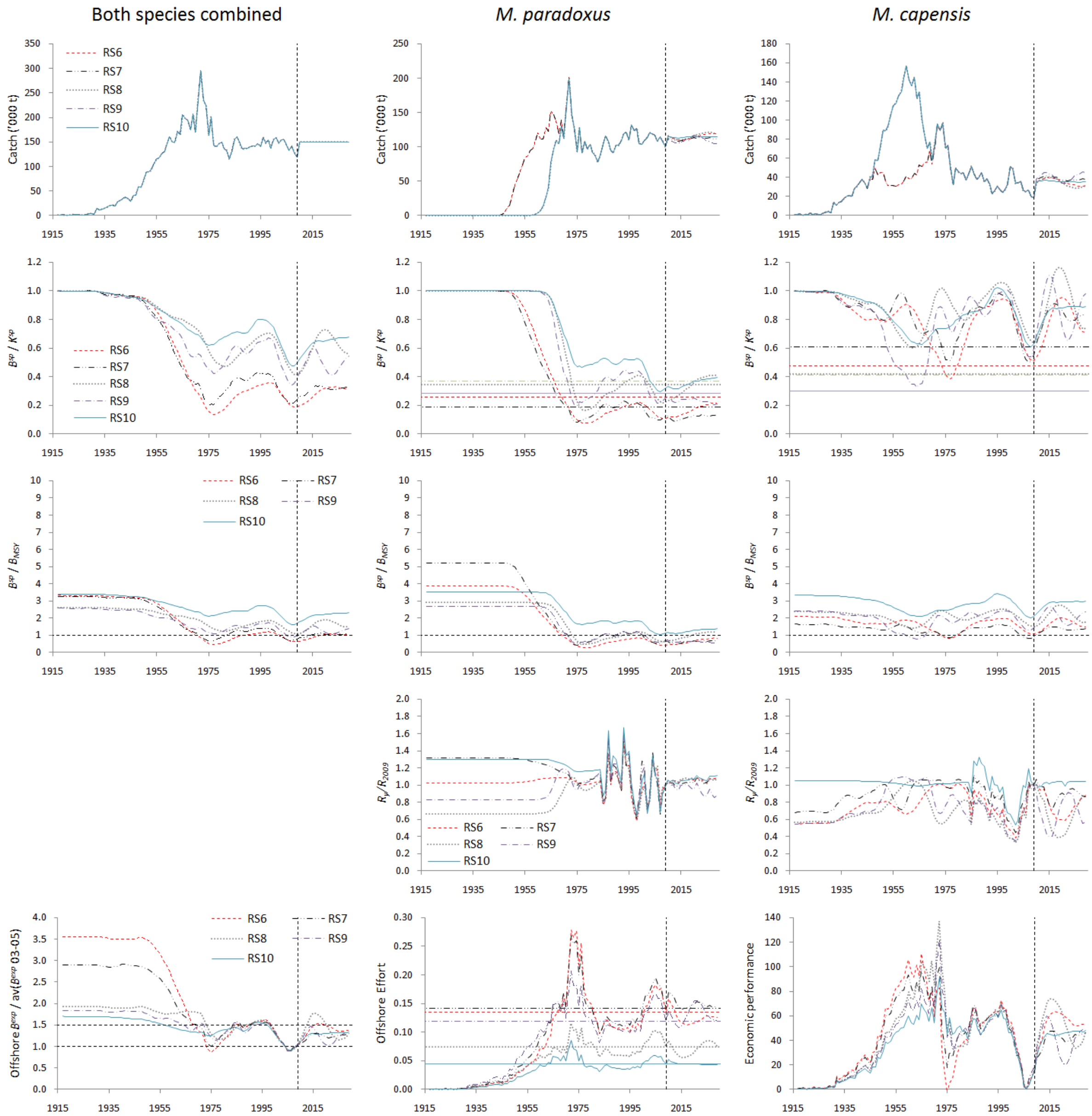

Fig. 2c.ii: For the last five OMs of RSa (**RS6 to RS10**) under a projected constant catch of **150 000 t**, median time-trajectories for the total catch (top row, species combined, then by species), the female spawning biomass relative to its pre-exploitation level (middle row, species combined, then by species) and offshore trawl exploitable biomass (species and coast combined). On the species-disaggregated spawning biomass plots, the estimated MSYLs are also shown. The dashed horizontal lines in the offshore effort plot show the current (2009) effort.

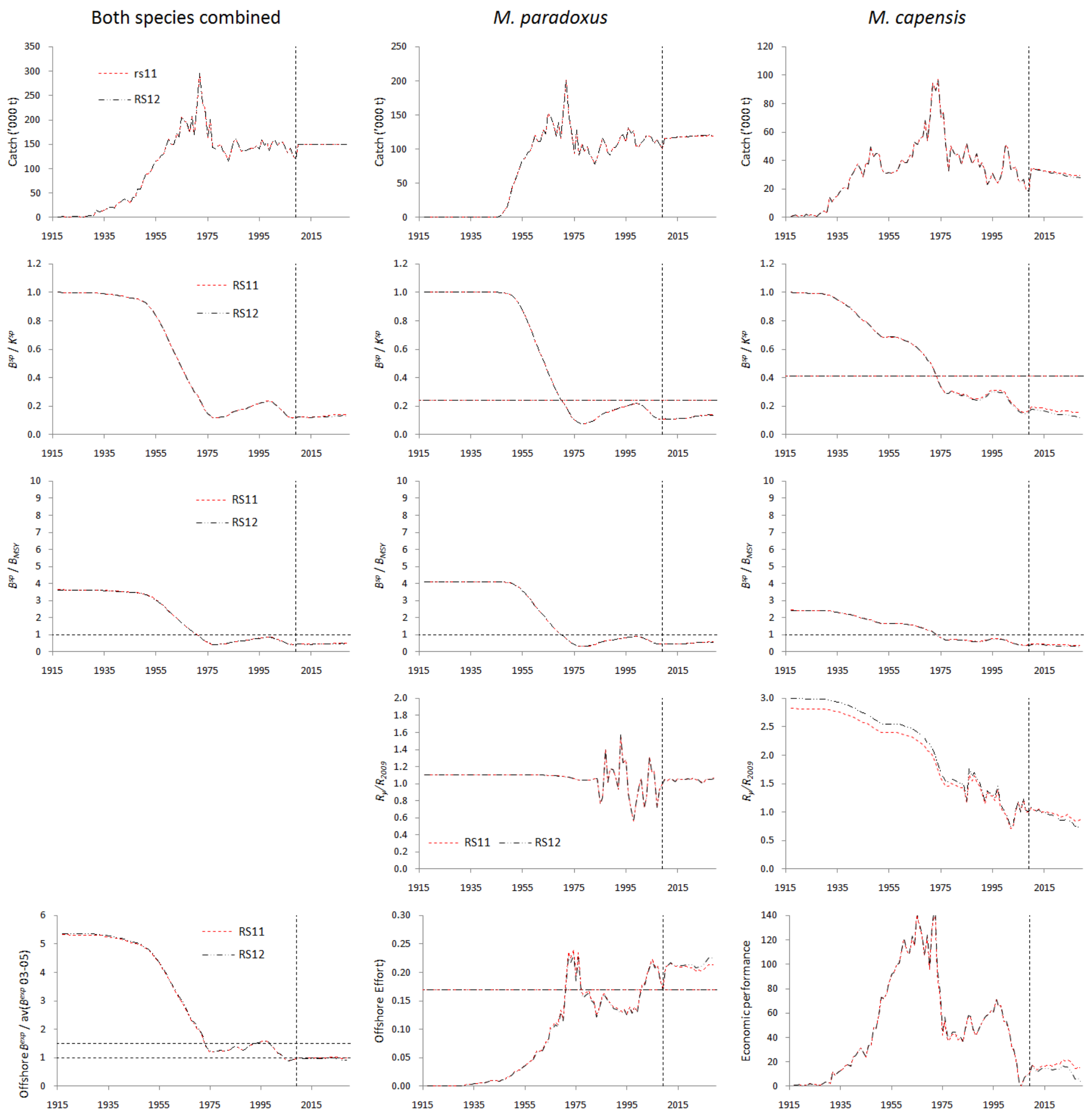

Fig. 2c.iii: For the two OMs of RSb (**RS11 and RS12**) under a projected constant catch of **150 000 t**, median time-trajectories for the total catch (top row, species combined, then by species), the female spawning biomass relative to its pre-exploitation level (middle row, species combined, then by species) and offshore trawl exploitable biomass (species and coast combined). On the species-disaggregated spawning biomass plots, the estimated MSYLs are also shown. The dashed horizontal lines in the offshore effort plot show the current (2009) effort.

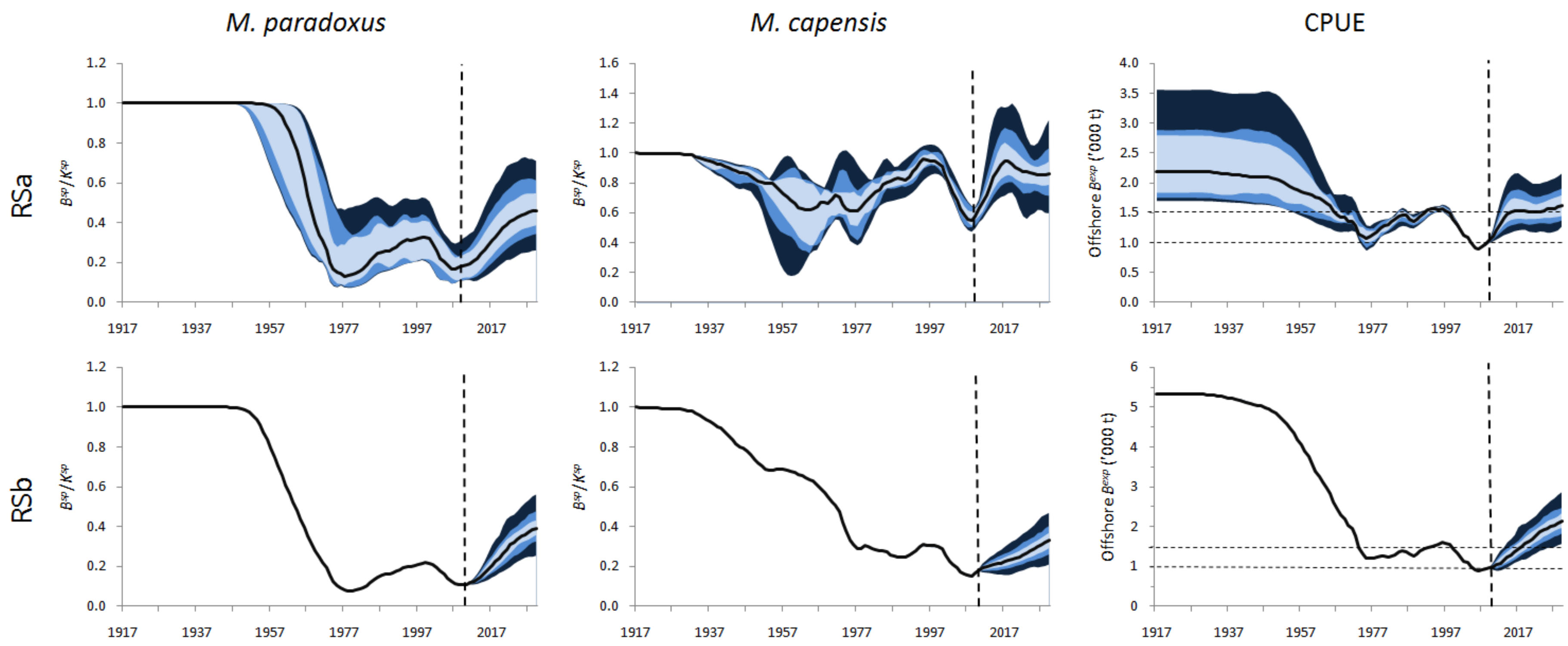

Fig. 3a: 95%, 75% and 50% PI (from darker to lighter blue) and median (black line) accross RSa (top row) and RSb (bottom row) for spawning biomass relative to pre-exploitation level and for the CPUE improvement index under a projected constant catch of **118 500 t**.

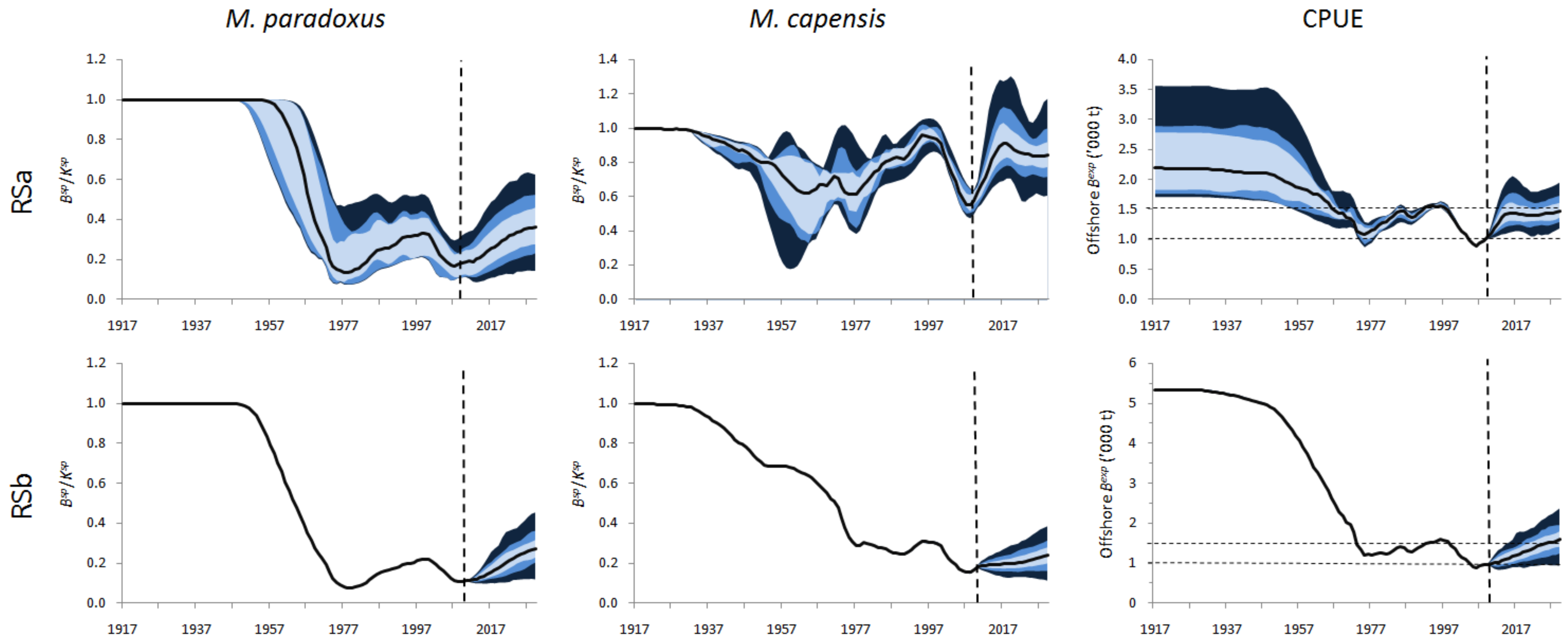

Fig. 3b: 95%, 75% and 50% PI (from darker to lighter blue) and median (black line) accross RSa (top row) and RSb (bottom row) for spawning biomass relative to pre-exploitation level and for the CPUE improvement index under a projected constant catch of **135 000 t**.

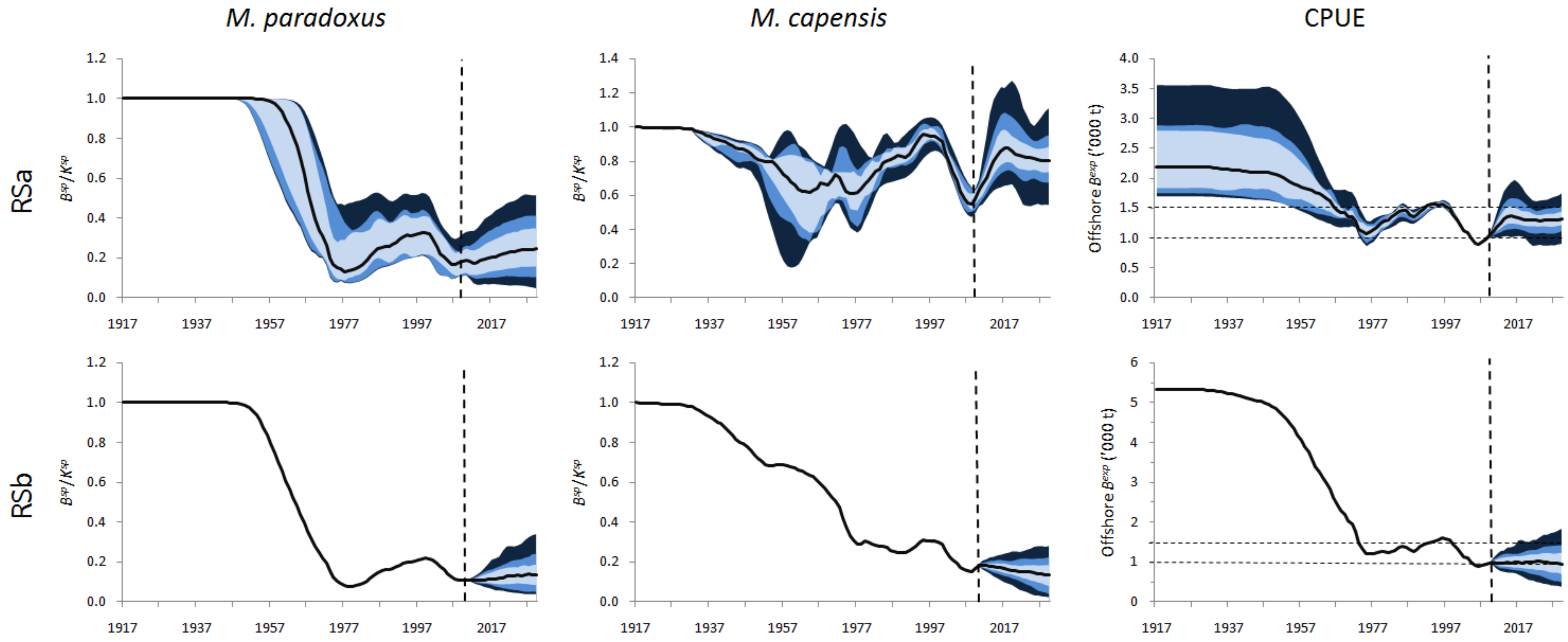

Fig. 3c: 95%, 75% and 50% PI (from darker to lighter blue) and median (black line) accross RSa (top row) and RSb (bottom row) for spawning biomass relative to pre-exploitation level and for the CPUE improvement index under a projected constant catch of **150 000 t**.

APPENDIX I - Economic performance statistics

$$profit_y = p \cdot c - c \cdot E_y \qquad \text{(App.I.1)}$$

where

c is the cost of fishing (assumed constant);

p is the price of the fish; and

E_y is the effort in year *y*.

The annual economic performance index $EcoPerf_y$ can be defined as

$$EcoPerf_y = C_y - \frac{c}{p} E_y \qquad \text{(App.I.2)}$$

$\frac{c}{p}$ is input, and is computed so that the lowest $EcoPerf_y$ in the last 10 years is equal to zero, i.e.

$$\frac{c}{p} = \min \left[C_y / E_y^* \right] \qquad \text{(App.I.3)}$$

where

$$E_y^* = \frac{C_y}{B_y^{ex} \cdot ratio} \qquad \text{(App.I.4)}$$

with

$$ratio = \sum_{2003}^{2005} \left[\frac{CPUE_y}{\sum_{y'=1978}^{2008} CPUE_{y'} \Big/ 31} \right] \Bigg/ \sum_{2003}^{2005} \left[\frac{B_y^{ex}}{\sum_{y'=1978}^{2008} B_{y'}^{ex} \Big/ 31} \right] \qquad \text{(App.I.5)}$$

APPENDIX II - Corrections to projections specifications

A correction is made to the procedure to follow (described in Rademeyer and Butterworth, 2010c), in situations where the catch specified is not small relative to the resource abundance, to ensure that in any one year no more than 90% of any cohort can be taken by the fishery as a whole.

The equation numbering has been kept as in Rademeyer and Butterworth (2010c) for ease of comparing and the modifications are highlighted.

First to see whether this situation has arisen, for each species and age, check that:

$$\left[N^g_{ya}e^{-M^g_a/2} - \sum_f C^g_{fya}\right] \geq 0.1 N^g_{ya}e^{-M^g_a/2} \qquad (10)$$

if $\left[N^g_{ya}e^{-M^g_a/2} - \sum_f C^g_{fya}\right] < 0.1 N^g_{ya}e^{-M^g_a/2}$ for any age *a* then:

$$N^{*g}_{y,a} = N^g_{y*a}e^{-M^g_a/2} \qquad (11)$$

For each fleet in the following order: west coast longline, south coast longline, west coast offshore, south coast offshore, south coast inshore and south coast handline, go through equations 12 to 18:

A]. if $\sum_{f=1}^{currf} F^{para}_{fy} > 0.9$ and $\sum_{f=1}^{currf} F^{cap}_{fy} \leq 0.9$, otherwise go to **B**]

$$F^{para}_{currf} = 0.9 - \sum_{f=1}^{currf-1} F^{para}_{fy} \qquad (12)$$

$$F'^{cap}_{currf,y} = \frac{C_{currf,y} - F'^{para}_{currf,y}\sum_g\sum_{a=0}^{m} w^{para,g}_{a+1/2}\, N^{*para,g}_{ya}\,\tilde{S}^{para,g}_{currf,ya}}{\sum_g\sum_{a=0}^{m} w^{cap,g}_{a+1/2}\, N^{*cap,g}_{ya}\,\tilde{S}^{cap,g}_{currf,ya}} \qquad (13)$$

if $\sum_{f=1}^{currf} F'^{cap}_{fy} > 0.9$ then go to **C**].

B]. if $\sum_{f=1}^{currf} F^{cap}_{fy} > 0.9$ and $\sum_{f=1}^{currf} F^{para}_{fy} \leq 0.9$

$$F'^{cap}_{currf,y} = 0.9 - \sum_{f=1}^{currf-1} F^{cap}_{fy} \qquad (14)$$

$$F'^{para}_{currf,y} = \frac{C_{currf,y} - F'^{cap}_{currf,y}\sum_g\sum_{a=0}^{m} w^{cap,g}_{a+1/2}\, N^{*cap,g}_{ya}\,\tilde{S}^{cap,g}_{currf,ya}}{\sum_g\sum_{a=0}^{m} w^{para,g}_{a+1/2}\, N^{*para,g}_{ya}\,\tilde{S}^{para,g}_{currf,ya}} \qquad (15)$$

if $\sum_{f=1}^{currf} F'^{para}_{fy} > 0.9$ then go to **C**].

C]. if $\sum_{f=1}^{currf} F_{fy}^{cap} > 0.9$ and $\sum_{f=1}^{currf} F_{fy}^{para} > 0.9$

$$F_{currf,y}^{'cap} = 0.9 - \sum_{f=1}^{currf-1} F_{fy}^{cap} \quad \text{and} \quad F_{currf,y}^{'cap} = 0.9 - \sum_{f=1}^{currf-1} F_{fy}^{cap} \tag{16}$$

$$C_{currf,ya}^{g} = N_{ya}^{*g} F_{currf,y}^{'} \tilde{S}_{currf,ya}^{g} \tag{17}$$

$$N_{y,a}^{'g} = N_{ya}^{*g} - C_{currf,ya}^{g} \tag{18}$$

In equations 13, 15 and 17, $N_{y,a}^{*g}$ is replaced by $N_{y,a}^{'g}$.

Start the next fleet and continue through all the fleets.

$$N_{y+1,a+1}^{g} = N_{ya}^{'g} e^{-M_a^g/2} \qquad \text{for } 0 \le a \le m - 2 \tag{19}$$

$$N_{y+1,m}^{g} = N_{y,m-1}^{'g} e^{-M_{m-1}^g/2} + N_{y,m}^{'g} e^{-M_m^g/2} \tag{20}$$