Robustness Tests to be used in OMP testing for the South African *Merluccius paradoxus* and *M. capensis* Resources

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Working Group document WG/03/06/D:H:6 gave results (under a fixed catch scenario) for a series of robustness tests developed from discussions in the Demersal Working Group for the South African *M. paradoxus* and *M. capensis* resources. The Demersal Working Group agreed to exclude some of the robustness tests for which results do not differ substantially from those from the RS. Furthermore, extra robustness tests have been suggested (marked with ** below). This document presents a consequently amended list of robustness tests to be used in OMP testing.

Assessment results are presented only for those robustness tests for which results are not reported in Working Group document WG/02/06/06. Furthermore, a set of performance statistics under the scenario of a constant future catch of 142 thousand tons is shown for all the robustness tests listed.

In all cases, the lower bound for natural mortality has been raised from 0.1 to 0.2. Indeed, having a lower bound of 0.1 led to unrealistic high pristine biomass for *M. paradoxus* in some robustness tests (A8b, A8c, A8e and A10d).

A Task Group appointed at the last Working Group meeting agreed that candidate OMP performance will be examined for the following robustness tests:

1) "**A4 – decr K in past**"
The carrying capacity of both species is assumed to have decreased linearly by 30% over the 1980 to 2000 period.

2**) "**A7b –Ricker forced**"
Instead of the Beverton-Holt stock-recruit relationship used in the RS, the stock-recruit relationship in this robustness test is of the Ricker form: $R = \alpha B_{sp} e^{-\beta B_{sp}}$. Furthermore, the stock-recruit curve for each species is constrained so that maximum recruitment occurs when the spawning biomass is at 45% of pristine level.

3**) "**A8b – force para depl 0.3** "
The spawning biomass of *M. paradoxus* in 2004 is forced to 30% of its pre-exploitation level through the use of penalty functions.

4**) "**A8c – force cap depl 0.3** "
The spawning biomass of *M. capensis* in 2004 is forced to 30% of its pre-exploitation level through the use of penalty functions.

5**) "**A8d – force cap depl 0.2** "
The spawning biomass of *M. capensis* in 2004 is forced to 20% of its pre-exploitation level through the use of penalty functions.

6**) "**A8e – force depl 0.3** "
The spawning biomasses of *M. paradoxus* and *M. capensis* in 2004 are forced to 30% of their pre-exploitation level (i.e. for both species) through the use of penalty functions.

7**) "**A8f – cap depl 0.2, h=0.7** "
The spawning biomass of *M. capensis* in 2004 is forced to 20% of its pre-exploitation level through the use of penalty functions and the steepness parameter for this species is fixed at 0.7.

8) "**A9a – dens dep mat**"
In the RS, the maturity-at-age is assumed to be independent of stock density for all ages. In this robustness test, the assumption is made that 0% of fish of age 3 are mature at B^{4+} = pristine, and 100% are mature at B^{4+}=0, with a linear relationship in between these two extremes.

9) "**A10a – size-dep spawning**"
An egg production index is used for input to the stock-recruitment relationship instead of spawning biomass; this is obtained by multiplying numbers-at-age by an age-dependent fecundity index obtained from Osborne (2004):

M. paradoxus : $Y_a = 8.02 L_a^{2.67}$

M. capensis : $Y_a = 0.15 L_a^{3.49}$

10**) "**A10d – mat age = 7**"
The age-at-maturity is taken to be 7+ throughout, instead of 4+ in the RS.

11) "**B3a – disc1**"
Discarding is considered to occur for the offshore and inshore trawlers only. Discarding for both fleets is modelled as an increase in commercial selectivity of 0.2 for ages 1 and 2 for catches of both *M. capensis* and *M. paradoxus*. Thus the amount of catch discarded is not an input, but computed within the assessment from the fishing mortality estimated for the offshore and inshore trawlers to take their recorded landings. This discarding is assumed to occur from the beginning of the fishery to the present. Future discards are taken to occur in terms of the same assumptions as used for the past.

12) "**B3b – disc2**"
As B3a above, discarding is considered to occur for the offshore and inshore trawlers, but the loss of fish from longlines is also included by doubling the fishing mortality from this fleet. Future discards are also taken to occur in terms of the same assumptions as used for the past.

13) "**B3c – disc3**"

As B3a above, but from 1996 onwards, the offshore and inshore trawl fleets are assumed to discard age 3 as well. As in B3a above, this is modelled by increasing the commercial selectivity by 0.2 for age 3 for catches of both *M. capensis* and *M. paradoxus*. Future discards are also taken to occur in terms of the same assumptions as used for the past.

14) "**B3d – disc3**"

As B3c above, but the discarding of 3-yr-olds (only) is reduced by 50% in the future.

15) **B4a – cal factor=0.6**"
The calibration factor between the *Africana* with the old gear and the *Africana* with the new gear for *M. capensis* is decreased from 0.8 to 0.6.

16) "**B4b – cal factor=0.9**"

The calibration factor between the *Africana* with the old gear and the *Africana* with the new gear for *M. capensis* is increased from 0.8 to 0.9.

17) "**B7 – fut σ_R=0.4**"
In conjunction with increased variability for the stock-recruitment fluctuations in the past, future variability is also increased (σ_R=0.4).

18) "**B1 – no fut surv**"
Biomass and catch-at-age information from research surveys are assumed not to become available in the future.

19) "**B2 – CPUE trend**"
Future changes in fishing efficiency are not detected. This is modelled by assuming an undetected upward trend in catching efficiency of 2% per year, so that for future data generated:

$$CPUE(y) \rightarrow CPUE(y)\exp[0.02(y-2004)]$$

20) "**B5a – Fratio decr**"
In the RS, future catches are disaggregated by species using a constant F_{ratio} ($F_{ratio} = F_{para} / F_{cap}$), which has been calculated as the average of the 2002-2004 estimates. In this robustness test, the F_{ratio} for the offshore fleet is decreased by 30% to model an increase in *M. capensis* catches.

21) "**B5b – Fratio incr**"
Here the F_{ratio} for the offshore fleet is increased by 30% to model a decrease in *M. capensis* catches.

22) "**B8 – decr K in past**"
The carrying capacity *K* for both species is assumed to decrease linearly by 30%, starting in 2005, to reach the reduced level in 2009.

Results and Discussion

Note: The robustness tests which affect past dynamics have been run for only two of the 48 RS scenarios (as running all 48 scenarios for each robustness test would take too much time). These two cases are **M1**/C3a/H1/SR2 and **M4**/C3a/H1/SR2. For the rest of the robustness tests, the past estimates are not affected, and can be projected forward for all 48 scenarios constituting the RS without an excessive computational burden.

Robustness tests assessments

Results are presented here only for those robustness tests for which results are not reported in Working Group document WG/02/06/06.

Table 1 compares the results of the different robustness tests, Table 1a is for scenario M1/C3a/H1/SR2 and Table 1b is for scenario M4/C3a/H1/SR2 (those two cases were chosen as perhaps the most plausible of these in the RS). To aid the reader, estimates of K^{sp}, MSY, B^{sp}_{2004}/K^{sp}, $MSYL^{sp}$, $B^{sp}_{2004}/MSYL^{sp}$ and the 2004 species ratios (B^{sp} and B^{4+}) for both species are highlighted where they differ by more than 15% from the RS estimates. The total log-likelihood and the contribution of each data source for each of these tests are compared in Tables 2a (scenario M1/C3a/H1/SR1) and 2b (M4/C3a/H1/SR2). Again, to aid the reader, cases for which the total negative log-likelihood differs by more than 5 points from that of the RS are highlighted.

Fig. 1 compares the 7+ and 4+ biomass trajectories for robustness test A10d, in which the age-at-maturity is taken to be 7 instead of 4 in the RS.

The Ricker stock-recruit curves for robustness test A7b are shown in Fig. 2.

Robustness tests projections

For the robustness tests for which only two scenarios have been considered, 50 replicates (for each scenario) have been run – giving a total of 100 trajectories. For comparison purposes, the same has been done for the two associated RS cases. For the rest of the robustness tests, 3 replicates of the whole RS have been run.

A set of performance statistics under the scenario of a constant future catch of 142 thousand tons is shown graphically in Fig 3.

Table 1a: Estimates of management quantities of the *M. paradoxus* and *M. capensis* coast-combined resources for the robustness tests which affect the past assessment, for option M1/C3a/H1/SR2. MSY and associated quantities are given for the offshore fleet. Cells are shaded in cases where of K^{sp}, MSY, B^{sp}_{2004}/K^{sp} , $MSYL^{sp}$, $B^{sp}_{2004}/MSYL^{sp}$ and the 2004 species ratios (B^{sp} and B^{4+}) differ by more than 15%, or –lnL differs by more then 5 points, from the RS estimates.

		RS	A4 (decr K in past)	A7b (Ricker forced)	A8b (force para depl 0.3)	A8c (force cap depl 0.3)	A8d (force cap depl 0.2)	A8e (force both depl 0.3)	A8f (cap depl 0.2, h=0.7)	A10d (age mat = 7)
-lnL total		-169.5	-152.9	-158.9	-156.7	-169.1	-163.6	-156.4	-153.3	-166.5
M. paradoxus	K^{sp}	2406	2347	2002	8345	2416	2440	8313	2400	4602
	h	0.95	0.95	0.95	0.79	0.95	0.95	0.79	0.95	0.95
	MSY	155	109	190	210	156	158	210	155	186
	B^{sp}_{2004}/K^{sp}	0.07	0.07	0.20	0.30	0.07	0.07	0.30	0.07	0.05
	$MSYL^{sp}$	0.20	0.21	0.39	0.27	0.20	0.20	0.26	0.20	0.19
	$B^{sp}_{2004}/MSYL^{sp}$	0.33	0.10	0.51	1.13	0.33	0.33	1.14	0.33	0.24
	M 0	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	1	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	2	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	3	0.40	0.40	0.40	0.35	0.40	0.40	0.35	0.40	0.35
	4	0.34	0.34	0.34	0.26	0.34	0.34	0.26	0.34	0.26
	5+	0.30	0.30	0.30	0.20	0.30	0.30	0.20	0.30	0.20
M. capensis	K^{sp}	860	795	657	858	841	815	842	949	692
	h	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.70	0.95
	MSY	61	36	73	61	59	58	59	53	60
	B^{sp}_{2004}/K^{sp}	0.35	0.30	0.62	0.34	0.30	0.21	0.30	0.20	0.28
	$MSYL^{sp}$	0.20	0.21	0.39	0.27	0.20	0.20	0.26	0.20	0.19
	$B^{sp}_{2004}/MSYL^{sp}$	1.38	1.32	1.48	1.36	1.19	0.81	1.19	0.62	1.56
	M 0	0.50	0.49	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	1	0.50	0.49	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	2	0.50	0.49	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	3	0.40	0.39	0.40	0.40	0.40	0.40	0.40	0.40	0.40
	4	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34
	5	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
	6	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
	7+	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
	SC survey *q*	1.06	1.10	0.86	1.07	1.16	1.43	1.16	1.30	1.02
2004 species ratio	B^{sp}	1.89	1.42	1.04	0.12	1.59	1.05	0.10	1.23	0.92
	B^{2+}	1.11	0.85	0.80	0.13	0.96	0.67	0.11	0.75	0.73

Table 1b: Estimates of management quantities of the *M. paradoxus* and *M. capensis* coast-combined resources for the robustness tests which affect the past assessment, for option M4/C3a/H1/SR2. MSY and associated quantities are given for the offshore fleet. Cells are shaded in cases where of K^{sp}, MSY, B^{sp}_{2004}/K^{sp} , $MSYL^{sp}$, $B^{sp}_{2004}/MSYL^{sp}$ and the 2004 species ratios (B^{sp} and B^{4+}) differ by more than 15%, or –lnL differs by more then 5 points, from the RS estimates.

		RS	A4 (decr K in past)	A7b (other Ricker-like)	A8b (force para depl 0.3)	A8c (force cap depl 0.3)	A8d (force cap depl 0.2)	A8e (force both depl 0.3)	A8f (cap depl 0.2, h=0.7)	A10d (age mat = 7)
-lnL total		-179.5	-166.7	-171.0	-168.9	-176.6	-172.4	-165.8	-163.7	-175.8
M. paradoxus	K^{sp}	1360	1376	588	6173	1377	1413	1058	1390	3430
	h	0.95	0.95	0.95	0.81	0.95	0.95	0.76	0.95	0.95
	MSY	127	96	145	194	127	129	133	132	164
	B^{sp}_{2004}/K^{sp}	0.08	0.12	0.28	0.30	0.09	0.08	0.30	0.08	0.05
	$MSYL^{sp}$	0.17	0.16	0.36	0.25	0.17	0.17	0.24	0.16	0.18
	$B^{sp}_{2004}/MSYL^{sp}$	0.52	0.23	0.77	1.23	0.52	0.50	1.24	0.49	0.27
	M 0	1.00	1.00	1.00	1.00	0.96	1.00	1.00	1.00	1.00
	1	1.00	1.00	1.00	1.00	0.96	1.00	1.00	1.00	1.00
	2	1.00	1.00	1.00	1.00	0.96	1.00	1.00	1.00	1.00
	3	0.67	0.68	0.75	0.60	0.65	0.67	0.75	0.67	0.60
	4	0.48	0.49	0.60	0.36	0.47	0.47	0.60	0.48	0.36
	5+	0.35	0.36	0.50	0.20	0.35	0.34	0.50	0.35	0.20
M. capensis	K^{sp}	592	625	503	614	700	686	702	616	314
	h	0.85	0.81	0.95	0.92	0.95	0.95	0.95	0.70	0.95
	MSY	76	48	79	74	62	62	62	63	70
	B^{sp}_{2004}/K^{sp}	0.53	0.50	0.67	0.49	0.30	0.20	0.30	0.21	0.33
	$MSYL^{sp}$	0.22	0.16	0.38	0.19	0.20	0.21	0.20	0.30	0.10
	$B^{sp}_{2004}/MSYL^{sp}$	2.30	1.95	1.69	2.45	1.36	0.92	1.36	0.69	3.14
	M 0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	3	0.75	0.73	0.69	0.72	0.68	0.68	0.68	0.74	0.75
	4	0.60	0.56	0.51	0.56	0.48	0.48	0.48	0.58	0.60
	5	0.49	0.45	0.38	0.45	0.35	0.35	0.35	0.48	0.50
	6	0.49	0.45	0.38	0.45	0.35	0.35	0.35	0.48	0.50
	7+	0.49	0.45	0.38	0.45	0.35	0.35	0.35	0.48	0.50
	SC survey *q*	0.72	0.73	0.77	0.78	1.17	1.61	1.17	2.08	0.74
2004 species ratio	B^{sp}	2.73	1.88	2.08	0.16	1.78	1.20	0.67	1.17	0.65
	B^{2+}	1.44	1.08	1.00	0.21	0.93	0.70	0.47	0.75	0.96

Table 2a: Log-likelihood contributions for resources for the robustness tests which affect the past assessment, for scenario M1/C3a/H1/SR2. Cells are shaded in cases for which the total negative log-likelihood differs by more than 5 points from that of the RS.

		RS	A4 (decr K in past)	A7b (other Ricker-like)	A8b (force para depl 0.3)	A8c (force cap depl 0.3)	A8d (force cap depl 0.2)	A8e (force depl 0.3)	A8f (cap depl 0.2, h=0.7)	A10d (age mat = 7)
-lnL: Total		-169.5	-152.9	-158.9	-156.7	-169.1	-163.6	-156.4	-153.3	-166.5
-lnL: CPUE	WC historic (spp combined)	-10.0	-10.1	-9.7	-10.0	-10.2	-10.3	-10.2	-9.8	-9.6
	SC historic (spp combined)	-29.4	-28.8	-26.5	-26.7	-29.2	-28.9	-26.7	-29.5	-29.3
	M. paradoxus GLM	-41.7	-39.7	-42.8	-42.7	-41.6	-41.4	-42.7	-41.6	-41.5
	M. capensis GLM	-41.7	-41.8	-44.0	-41.6	-41.2	-37.4	-41.0	-25.7	-41.1
-lnL: Survey	*M. paradoxus*, WC summer	-8.0	-6.4	-7.9	-6.4	-8.0	-7.9	-6.4	-8.0	-7.5
	M. paradoxus, WC winter	-4.0	-3.3	-3.9	-3.5	-4.0	-3.9	-3.5	-4.0	-3.8
	M. paradoxus, WC *Nansen*	-1.8	-1.5	-1.8	-1.6	-1.8	-1.8	-1.6	-1.8	-1.8
	M. paradoxus, SC spring	-0.5	0.2	-0.5	-0.1	-0.5	-0.5	-0.1	-0.5	-0.3
	M. paradoxus, SC autumn	6.7	5.7	6.7	6.9	6.7	6.7	6.9	6.7	6.6
	M. capensis, WC summer	-1.8	-0.7	-1.4	-1.8	-1.7	-1.6	-1.8	-1.4	-1.8
	M. capensis, WC winter	0.4	0.3	0.4	0.4	0.4	0.5	0.4	0.4	0.4
	M. capensis, WC *Nansen*	-1.4	-1.4	-1.4	-1.4	-1.4	-1.5	-1.4	-1.5	-1.4
	M. capensis, SC spring	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.7	-1.6
	M. capensis, SC autumn	-7.8	-7.9	-7.8	-7.8	-7.9	-8.2	-7.9	-8.3	-7.8
-lnL: commercial CAA	species combined, offshore	-38.9	-36.6	-34.0	-29.7	-38.8	-38.4	-29.5	-39.2	-37.0
	M. capensis, inshore	-22.4	-22.7	-20.5	-22.5	-23.1	-24.9	-23.1	-23.2	-22.3
	M. capensis, longline	-14.4	-15.5	-12.6	-14.5	-14.9	-15.6	-14.9	-15.3	-14.3
-lnL: survey CAA	*M. paradoxus*, WC summer	-11.8	-9.6	-11.2	-13.4	-11.8	-11.9	-13.4	-11.7	-12.3
	M. paradoxus, WC *Nansen*	-11.7	-12.5	-11.8	-11.8	-11.7	-11.7	-11.8	-11.7	-11.6
	M. paradoxus, SC spring	-4.2	-3.3	-2.7	-3.7	-4.2	-4.3	-3.7	-4.3	-4.2
	M. paradoxus, SC autumn	30.2	29.6	31.3	30.8	30.2	30.2	30.8	30.2	29.7
	M. capensis, WC summer	83.8	84.3	83.1	83.8	84.0	85.0	84.0	84.8	83.8
	M. capensis, WC winter	7.0	7.3	6.1	7.0	7.3	8.4	7.3	7.4	7.0
	M. capensis, WC *Nansen*	-6.2	-6.7	-6.2	-6.2	-6.0	-5.4	-6.0	-5.8	-6.2
	M. capensis, SC spring	-7.6	-6.9	-7.6	-7.6	-7.9	-9.0	-7.9	-8.4	-7.6
	M. capensis, SC autumn	-30.0	-29.0	-30.9	-30.0	-30.0	-29.5	-30.0	-29.2	-30.0
Recruit residual penalty		10.9	15.1	11.2	12.1	11.3	12.3	12.4	11.0	11.1

Table 2b: Log-likelihood contributions for resources for the robustness tests which affect the past assessment, for scenario M4/C3a/H1/SR2. Cells are shaded in cases for which the negative log-likelihood increases by more than 5 points from that of the RS.

		RS	A4 (decr K in past)	A7b (other Ricker-like)	A8b (force para depl 0.3)	A8c (force cap depl 0.3)	A8d (force cap depl 0.2)	A8e (force depl 0.3)	A8f (cap depl 0.2, h=0.7)	A10d (age mat = 7)
-lnL: Total		-179.5	-166.7	-171.0	-168.9	-176.6	-172.4	-165.8	-163.7	-175.8
-lnL: CPUE	WC historic (spp combined)	-10.1	-10.1	-9.8	-10.1	-10.4	-10.2	-10.3	-10.3	-9.7
	SC historic (spp combined)	-29.5	-29.2	-27.0	-26.9	-28.9	-28.8	-27.7	-28.9	-29.3
	M. paradoxus GLM	-42.3	-41.0	-43.6	-43.3	-42.4	-42.1	-42.9	-41.7	-42.3
	M. capensis GLM	-43.6	-42.6	-43.3	-43.8	-43.6	-41.9	-43.5	-34.6	-43.7
-lnL: Survey	*M. paradoxus*, WC summer	-8.7	-7.5	-9.6	-6.4	-8.6	-8.5	-8.2	-8.4	-7.5
	M. paradoxus, WC winter	-4.1	-3.8	-4.2	-3.5	-4.1	-4.1	-3.9	-4.0	-3.8
	M. paradoxus, WC *Nansen*	-1.9	-1.8	-2.0	-1.6	-1.9	-1.9	-1.8	-1.9	-1.8
	M. paradoxus, SC spring	-0.5	0.1	-0.7	-0.1	-0.5	-0.5	-0.6	-0.5	-0.3
	M. paradoxus, SC autumn	6.6	6.3	6.8	6.9	6.6	6.6	6.7	6.6	6.6
	M. capensis, WC summer	-1.9	-1.5	-1.4	-1.9	-1.8	-1.9	-1.8	-1.9	-2.0
	M. capensis, WC winter	0.4	0.5	0.4	0.4	0.5	0.6	0.5	0.6	0.4
	M. capensis, WC *Nansen*	-1.4	-1.4	-1.4	-1.4	-1.4	-1.5	-1.4	-1.5	-1.4
	M. capensis, SC spring	-1.5	-1.6	-1.6	-1.5	-1.6	-1.6	-1.6	-1.6	-1.5
	M. capensis, SC autumn	-7.7	-8.1	-7.8	-7.7	-7.7	-8.0	-7.8	-8.5	-7.7
-lnL: commercial CAA	species combined, offshore	-42.1	-39.8	-37.8	-35.4	-42.1	-41.3	-35.9	-40.1	-39.4
	M. capensis, inshore	-26.2	-26.3	-23.3	-25.5	-25.3	-27.3	-25.3	-28.7	-26.4
	M. capensis, longline	-15.6	-15.8	-15.2	-15.6	-15.5	-15.9	-15.5	-16.2	-15.6
-lnL: survey CAA	*M. paradoxus*, WC summer	-10.9	-9.3	-10.7	-13.3	-10.9	-11.1	-10.5	-11.2	-12.1
	M. paradoxus, WC *Nansen*	-11.8	-12.4	-11.7	-11.8	-11.8	-11.8	-12.7	-11.8	-11.6
	M. paradoxus, SC spring	-3.6	-3.2	-2.4	-3.5	-3.5	-3.6	-2.3	-4.1	-3.6
	M. paradoxus, SC autumn	29.7	29.8	30.8	30.6	29.7	29.7	31.7	30.0	29.6
	M. capensis, WC summer	84.3	85.4	83.6	84.2	84.2	85.4	84.2	87.5	84.3
	M. capensis, WC winter	7.2	7.4	6.1	7.1	7.5	8.6	7.6	9.2	7.3
	M. capensis, WC *Nansen*	-6.2	-6.4	-6.2	-6.2	-5.9	-5.2	-5.9	-4.4	-6.1
	M. capensis, SC spring	-7.9	-7.6	-7.7	-7.8	-8.2	-9.5	-8.2	-12.2	-7.9
	M. capensis, SC autumn	-29.5	-28.3	-30.3	-29.6	-30.1	-29.2	-30.1	-26.7	-29.4
Recruit residual penalty		10.0	10.7	9.9	11.8	11.9	13.1	11.6	11.7	10.9

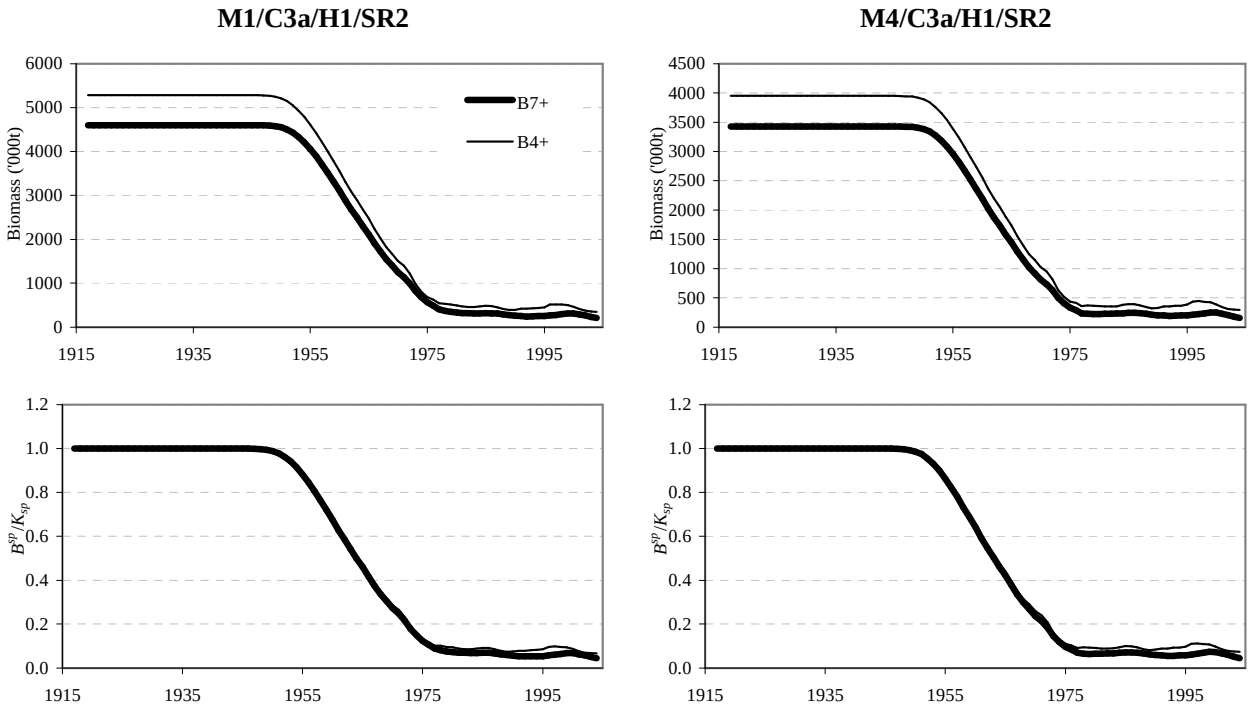

Fig. 1a: *M. paradoxus* 7+ and 4+ biomass trajectories (in absolute terms and in terms of pre-exploitation level) for cases M1/C3a/H1/SR2 and M4/C3a/H1/SR2 of the robustness test A10d, in which the age-at-maturity is taken to be 7.

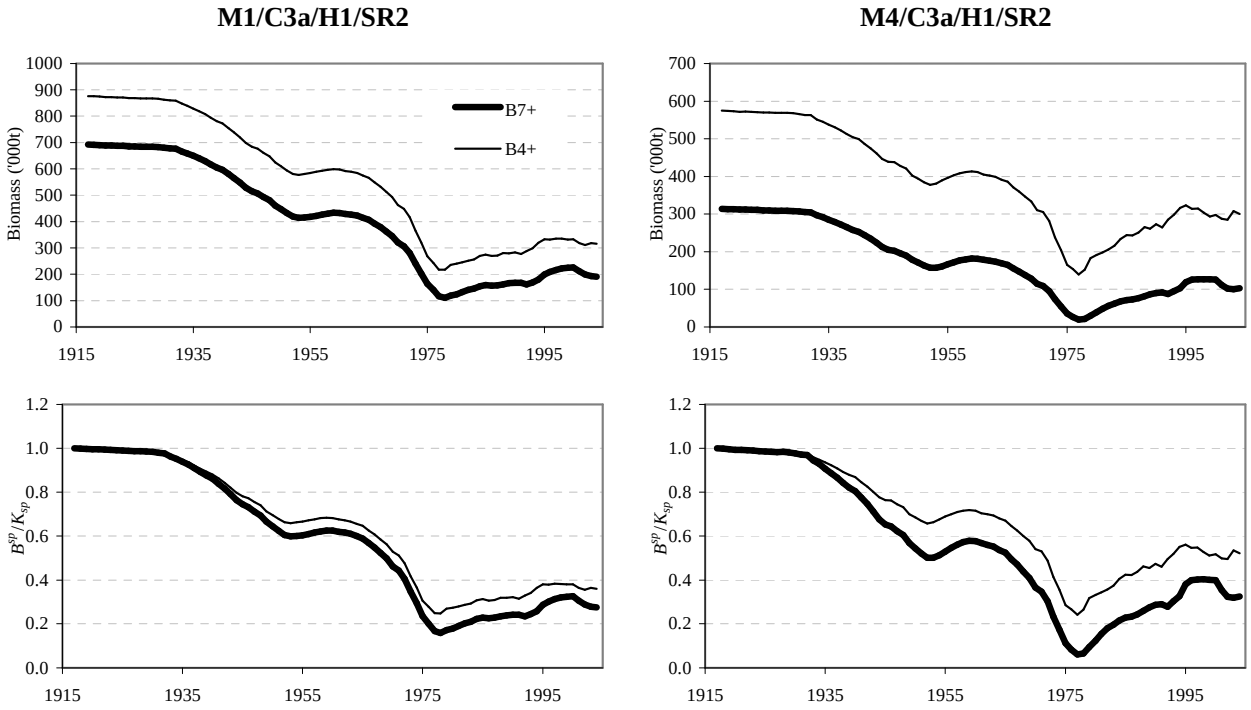

Fig. 1b: *M. capensis* 7+ and 4+ biomass trajectories (in absolute terms and in terms of pre-exploitation level) for cases M1/C3a/H1/SR2 and M4/C3a/H1/SR2 of the robustness test A10d, in which the age-at-maturity is taken to be 7.

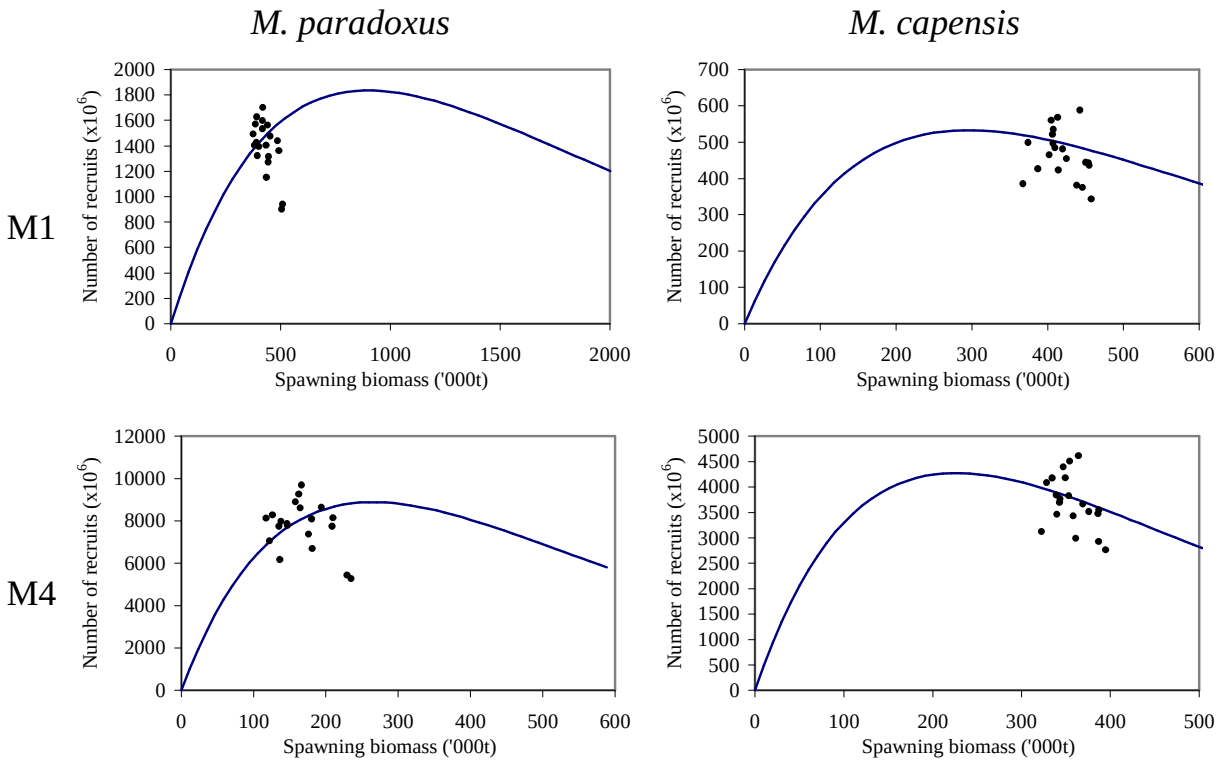

Fig. 2: Stock-recruit curves and "observed" recruits (for years in which stock-recruit residuals are estimated) for *M. paradoxus* and *M. capensis* for cases M1/C3a/H1/SR2 and M4/C3a/H1/SR2.

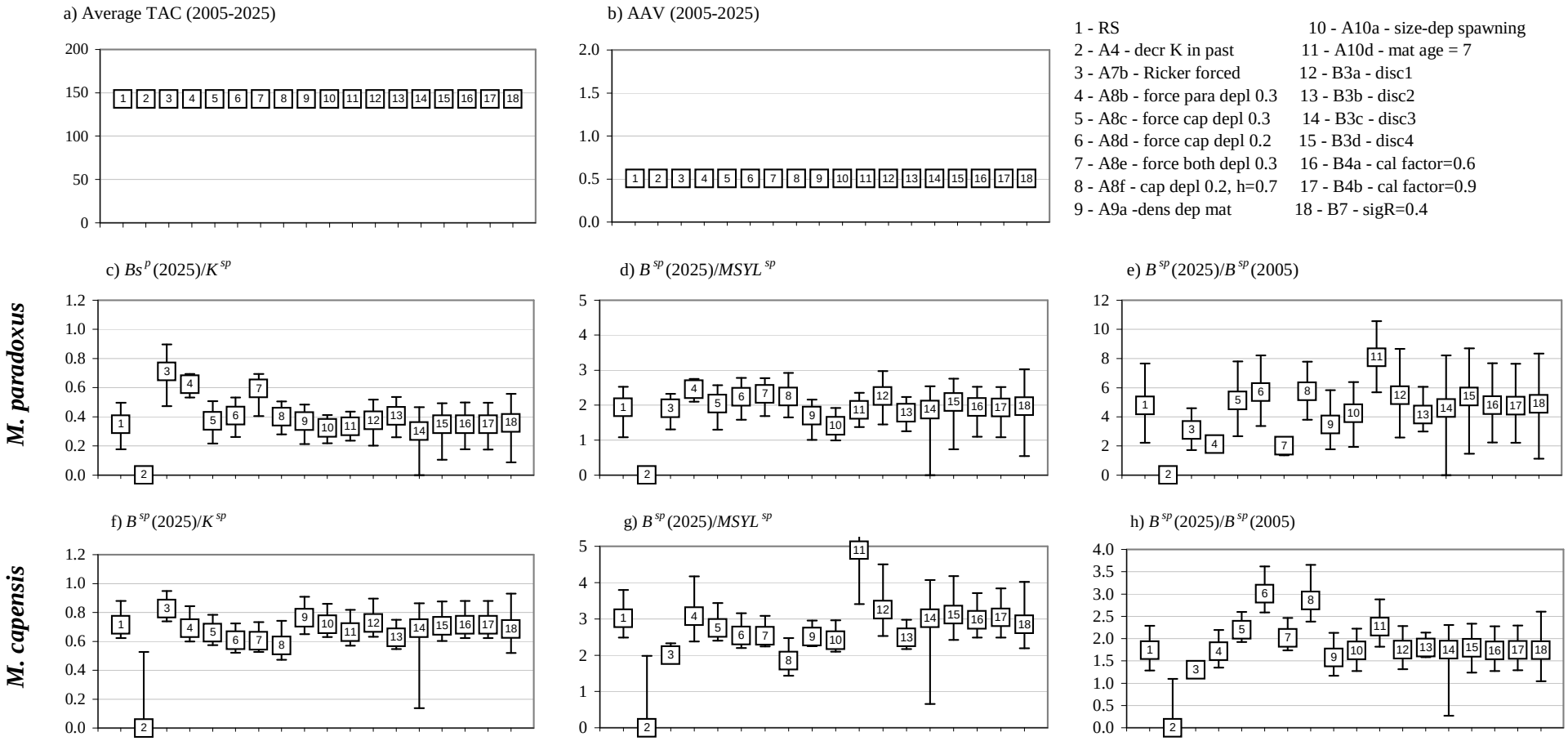

Fig. 3a: Graphical summary of catch performance statistics (median and 95% CI) under a future constant catch of 142 000 t, for a series of robustness tests, for two scenarios within the RS. Note: AAV is not zero because of the change in TAC from 2004 to 2006.

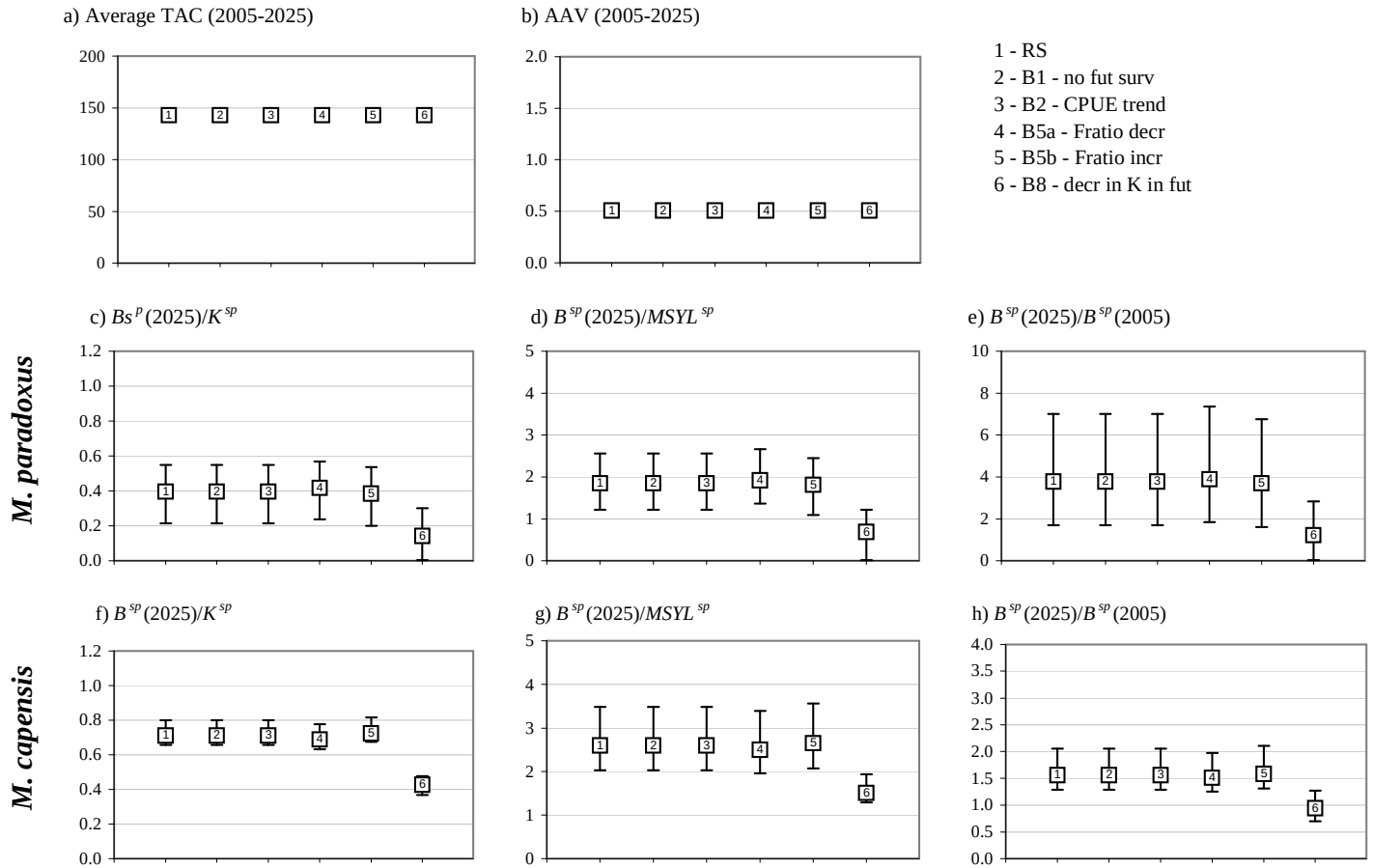

Fig. 3b: Graphical summary of catch performance statistics (median and 95% CI) under a future constant catch of 142 000 t, for a series of robustness tests, for all of the 48 scenarios of the RS. Note: AAV is not zero because of the change in TAC from 2004 to 2006.