Proposed Update of the Proposed Revised Reference Set for the Joint Assessment of the South African *Merluccius paradoxus* and *M. capensis* Resources for Use in OMP Testing

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January 2006

ABSTRACT

The plus-group for *M. paradoxus* and *M. capensis* in the joint assessment of these resources has been extended to age 15 (from 5+ for *M. paradoxus* and 7+ for *M. capensis*). Some results are presented for a subset of the proposed set of scenarios to be included in a revised Reference Set, that would then be used in subsequent OMP testing.

INTRODUCTION

During the December Demersal Working Group meeting, it was suggested that the plus-group used in the joint assessment of the hake resources be extended from the 5+ and 7+ currently used for *M. paradoxus* and *M. capensis* respectively. Results are presented here for a subset of the proposed Reference Set (see WG/06/12/D:H:57) using age 15 as the plus-group for both species[1].

METHODS

As there is not enough data to inform on the fishing selectivities (survey and commercial) and natural mortalities at ages above 5 and 7 for *M. paradoxus* and *M. capensis* respectively, some assumptions are necessary:

Natural mortality:
The natural mortalities estimated for age 5 for *M. paradoxus* and age 7 for *M. capensis* are assumed to apply to older ages as well.

Survey selectivities:
An exponential decrease in selectivity is assumed from age 5 for *M. paradoxus* and age 7 for *M. capensis*, with the slope parameters fixed at 0.5 and 1.0 yr^{-1} respectively. These values have been computed roughly

[1] Note: Extending the age-range increases computer running time appreciably. Extensions to age 10 only were run, but showed non-trivial differences in results to extensions to 15. Extensions beyond 15 were considered both computationally wasteful and not biologically necessary.

from the average (over surveys and scenarios) decrease from age 4 to 5 for *M. paradoxus* and age 6 to 7 for *M. capensis* estimated in scenarios C3 of document WG/12/05/D:H:57.

Commercial selectivities:

1) Offshore trawl fleet:

The selectivity for this fleet is assumed to decrease exponentially from age 3 for *M. paradoxus*, with a slope parameter estimated in the model fitting procedure . For this species, this exponential decrease is assumed to continue to age 15. For *M. capensis*, the selectivity for this fleet is assumed to be flat for older ages.

2) Inshore trawl fleet:

For this fleet, the selectivity is allowed to decrease exponentially from age 5. This exponential decrease, which is estimated in the model fitting procedure is assumed to continue to age 15.

3) Longline fleet:

The selectivity for the longline fleet is assumed to be flat for older ages (same selectivity assumed for both species).

4) Handline fleet:

As there are no catch-at-age data available to estimate a selectivity vector, the assumption is made that the selectivity for this fleet is intermediate between the inshore trawl and longline selectivities, as previously.

Sensitivities to these slope value assumptions are tested.

RESULTS AND DISCUSSION

Table 1 compares results of one scenario (M1-H1-C3-SR1) from the "old" RS (using the 5+ and 7+ plus-groups) and the "new" RS (15+ plus-group), while Fig. 1 plots the spawning biomass trajectories for these two cases. Extending the plus-group to age 15 has an important impact on the assessment results, particularly for *M. capensis* for which the spawning biomass, both in absolute terms and in relation to pristine level, is notably different from the old RS.

Results are presented for a subset of the RS. The subset includes the following scenarios[2]:

Natural mortality: M1 and M4
Steepness: H1, H2, H3 and H4
Catch series: C3
Recent stock-recruitment residuals: SR1

Estimates of management quantities for this subset of the new RS are shown in Table 2. Note that extending the plus-group ages results in a lower current ratio of the *M. capensis* to *M. paradoxus* spawning biomass, and further that if the 2+ biomass is considered, this ratio drops close to 1 in median terms. Fig. 2 plots the corresponding biomass trajectories, focusing on the median, maximum and minimum values for each year. Fig. 3 shows the survey and commercial fishing selectivities while Fig. 4 plots the estimated losses to natural mortality for ages 0, 1 and 2.

The plots in Fig. 4 show that the estimates of losses to natural mortality at the younger ages are highly uncertain in absolute terms, and further show little trend overtime. The reason for the latter behaviour is the combination of the facts that there is little commercial take of these younger fish[3] and that steepness *h* is quite high, so that over this age range natural mortality losses are effectively from constant recruitment and hence stay relatively constant.

The assumptions made above about trends in selectivity for ages above 5 and 7 for *M. paradoxus* and *M. capensis* respectively are somewhat arbitrary. Table 3 compares the estimates of management quantities for one scenario (M1-H1-C3-SR1) of the RS and two variants of this scenario in which the selectivity at older ages is increased to be flat overall ("no slope") or decreased ("double slope") (see Fig. 5). Although

[2] These were selected as they spanned the Reference Set factors for which results to extending the plus group ages seemed likely to be the most sensitive.

[3] Admittedly these assessments do not take discarding of young hake by the trawl fishery into account, but note that a level of discards of 10 or even 20% of the commercial catch by mass would still be almost an order of magnitude less than typical levels of natural mortality losses indicated by Fig. 4.

assuming a flat selectivity at older ages does give slightly different results, the assessments which assume a different decrease in selectivity at older ages do not differ substantially.

IMPLICATIONS

The primary purpose of this paper is to seek agreement for specifications of an updated Reference Set **before** undertaking the computational load of fitting all 48 constituent model variants (note that results for only 8 of these variants have been reported here).

It is proposed that the Reference Set be amended as developed in this paper:

- The plus-group age be extended to 15, as this seems biologically more defensible and has important impacts on results.
- RS selectivity assumptions for the extended ages be adopted (with “no slope” being a robustness test).
- Fixed rather than estimated steepness (*h*) for *M. paradoxus* and *M. capensis* be maintained at 0.8 and 0.7 respectively.

Note that extending the plus-group age range results in more precise estimation of *h* than previously, particularly for *M. capensis*, but not to the extent that it is considered necessary to modify previous selections for the fixed value choices for *h* in the Reference Set.

The plots in Fig. 4 of annual losses to natural mortality, with their relative lack of temporal trends and high uncertainty in absolute terms, consequently suggest that considerations of sufficient young hake for food for older hake will not be able to discriminate between assessment variants, at least as far as the current *M. capensis:M. paradoxus* biomass ratio is concerned.

REFERENCE

Rademeyer RA and Butterworth DS. 2005. Proposed Revised Reference Set for the Joint Assessment of the South African *Merluccius paradoxus* and *M. capensis* Resources for Use in OMP Testing. Unpublished MCM Demersal Working Group document, WG/12/05/D:H:57.

Table 1: Comparison of estimates of management quantities of the *M. paradoxus* and *M. capensis* coast-combined resources for one scenario of the proposed revised Reference Set (M1-H1-C3-SR1) for a) the "old" Reference Set (with plus-groups of age 5 and 7 for *M. paradoxus* and *M. capensis* respectively) and b) for the "new" Reference Set which extends the plus-group for both species to age 15. *MSY* and associated quantities are given for the offshore fleet. Biomass units are thousand tons.

			1 M1 C3 H1 SR1	2 M1 C3 H2 SR1	3 M1 C3 H3 SR1
	-lnL total		-175.8	-171.8	-176.0
M. paradoxus	K^{sp}		2404	2319	2420
	h		0.95	0.95	0.95
	MSY		155	153	155
	B^{sp}_{2004}/K^{sp}		0.07	0.09	0.06
	$B^{sp}_{2004}/MSYL^{sp}$		0.34	0.42	0.32
	M	0	0.50	0.50	0.50
		1	0.50	0.50	0.50
		2	0.50	0.50	0.50
		3	0.40	0.40	0.40
		4	0.34	0.34	0.34
		5+	0.30	0.30	0.30
M. capensis	K^{sp}		861	857	858
	h		0.95	0.95	0.95
	MSY		61	60	61
	B^{sp}_{2004}/K^{sp}		0.35	0.34	0.35
	$B^{sp}_{2004}/MSYL^{sp}$		1.41	1.36	1.41
	M	0	0.50	0.50	0.50
		1	0.50	0.50	0.50
		2	0.50	0.50	0.50
		3	0.40	0.40	0.40
		4	0.34	0.34	0.34
		5	0.30	0.30	0.30
		6	0.30	0.30	0.30
		7+	0.30	0.30	0.30
	SC survey q		1.05	0.98	1.08
	2004 *cap* / *para* ratio		1.88	1.37	2.02

Table 2: Estimates of management quantities of the *M. paradoxus* and *M. capensis* coast-combined resources for a subset of the proposed revised Reference Set. *MSY* and associated quantities are given for the offshore fleet. Biomass units are thousand tons.

		1 M1 C3 H1 SR1	2 M1 C3 H2 SR1	3 M1 C3 H3 SR1	4 M1 C3 H4 SR1	5 M4 C3 H1 SR1	6 M4 C3 H2 SR1	7 M4 C3 H3 SR1	8 M4 C3 H4 SR1	Median
	-lnL total	-175.8	-167.8	-169.5	-159.7	-185.6	-179.6	-184.9	-178.2	-177.0
M. paradoxus	K^{sp}	2404	3316	2366	3278	1360	1092	1352	1080	1863
	h	0.95	0.80	0.95	0.80	0.95	0.80	0.95	0.80	0.87
	MSY	155	170	153	169	126	129	127	129	141
	B^{sp}_{2004}/K^{sp}	0.07	0.12	0.07	0.12	0.09	0.16	0.09	0.16	0.10
	$B^{sp}_{2004}/MSYL^{sp}$	0.34	0.46	0.34	0.47	0.54	0.69	0.53	0.68	0.50
	M 0	0.50	0.50	0.50	0.50	1.00	1.00	1.00	1.00	0.75
	1	0.50	0.50	0.50	0.50	1.00	1.00	1.00	1.00	0.75
	2	0.50	0.50	0.50	0.50	1.00	1.00	1.00	1.00	0.75
	3	0.40	0.40	0.40	0.40	0.67	0.73	0.67	0.73	0.53
	4	0.34	0.34	0.34	0.34	0.47	0.57	0.48	0.57	0.41
	5+	0.30	0.30	0.30	0.30	0.34	0.46	0.35	0.47	0.32
M. capensis	K^{sp}	861	853	1081	1025	631	601	633	625	743
	h	0.95	0.95	0.70	0.70	0.92	0.89	0.70	0.70	0.80
	MSY	61	60	60	57	75	74	68	67	64
	B^{sp}_{2004}/K^{sp}	0.35	0.34	0.46	0.40	0.52	0.51	0.50	0.48	0.47
	$B^{sp}_{2004}/MSYL^{sp}$	1.41	1.35	1.39	1.21	2.58	2.36	1.71	1.64	1.52
	M 0	0.50	0.50	0.50	0.50	1.00	1.00	1.00	1.00	0.75
	1	0.50	0.50	0.50	0.50	1.00	1.00	1.00	1.00	0.75
	2	0.50	0.50	0.50	0.50	1.00	1.00	1.00	1.00	0.75
	3	0.40	0.40	0.40	0.40	0.72	0.73	0.75	0.75	0.56
	4	0.34	0.34	0.34	0.34	0.56	0.57	0.60	0.60	0.45
	5	0.30	0.30	0.30	0.30	0.44	0.47	0.50	0.50	0.37
	6	0.30	0.30	0.30	0.30	0.44	0.47	0.50	0.50	0.37
	7+	0.30	0.30	0.30	0.30	0.44	0.47	0.50	0.50	0.37
	SC survey q	1.05	1.09	0.76	0.86	0.74	0.76	0.72	0.76	0.76
2004 *cap*/*para* ratio	B^{sp}	1.88	0.73	3.10	1.02	2.77	1.79	2.76	1.80	1.84
	B^{2+}	1.06	0.57	1.65	0.77	1.31	0.99	1.37	1.02	1.04

Table 3: Comparison of estimates of management quantities of the *M. paradoxus* and *M. capensis* coast-combined resources for one scenario of the proposed revised Reference Set (M1-H1-C3-SR1) for three different assumptions about fishing selectivity at older ages: a) as proposed new Reference Set ("Reference Set"), b) with flat selectivity at older ages ("no slope") and c) with selectivity slope double that of a) ("double slope). *MSY* and associated quantities are given for the offshore fleet. Biomass units are thousand tons.

			M1-C3-H1-SR1		
			a) Reference Set	b) no slope	c) double slope
	-lnL total		-175.8	-171.8	-176.0
M. paradoxus	K^{sp}		2404	2319	2420
	h		0.95	0.95	0.95
	MSY		155	153	155
	B^{sp}_{2004}/K^{sp}		0.07	0.09	0.06
	$B^{sp}_{2004}/MSYL^{sp}$		0.34	0.42	0.32
	M	0	0.50	0.50	0.50
		1	0.50	0.50	0.50
		2	0.50	0.50	0.50
		3	0.40	0.40	0.40
		4	0.34	0.34	0.34
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M. capensis	K^{sp}		861	857	858
	h		0.95	0.95	0.95
	MSY		61	60	61
	B^{sp}_{2004}/K^{sp}		0.35	0.34	0.35
	$B^{sp}_{2004}/MSYL^{sp}$		1.41	1.36	1.41
	M	0	0.50	0.50	0.50
		1	0.50	0.50	0.50
		2	0.50	0.50	0.50
		3	0.40	0.40	0.40
		4	0.34	0.34	0.34
		5	0.30	0.30	0.30
		6	0.30	0.30	0.30
		7+	0.30	0.30	0.30
	SC survey q		1.05	0.98	1.08
2004 *cap*/*para* ratio		B^{sp}	1.88	1.37	2.02
		B^{2+}	1.06	0.88	1.09

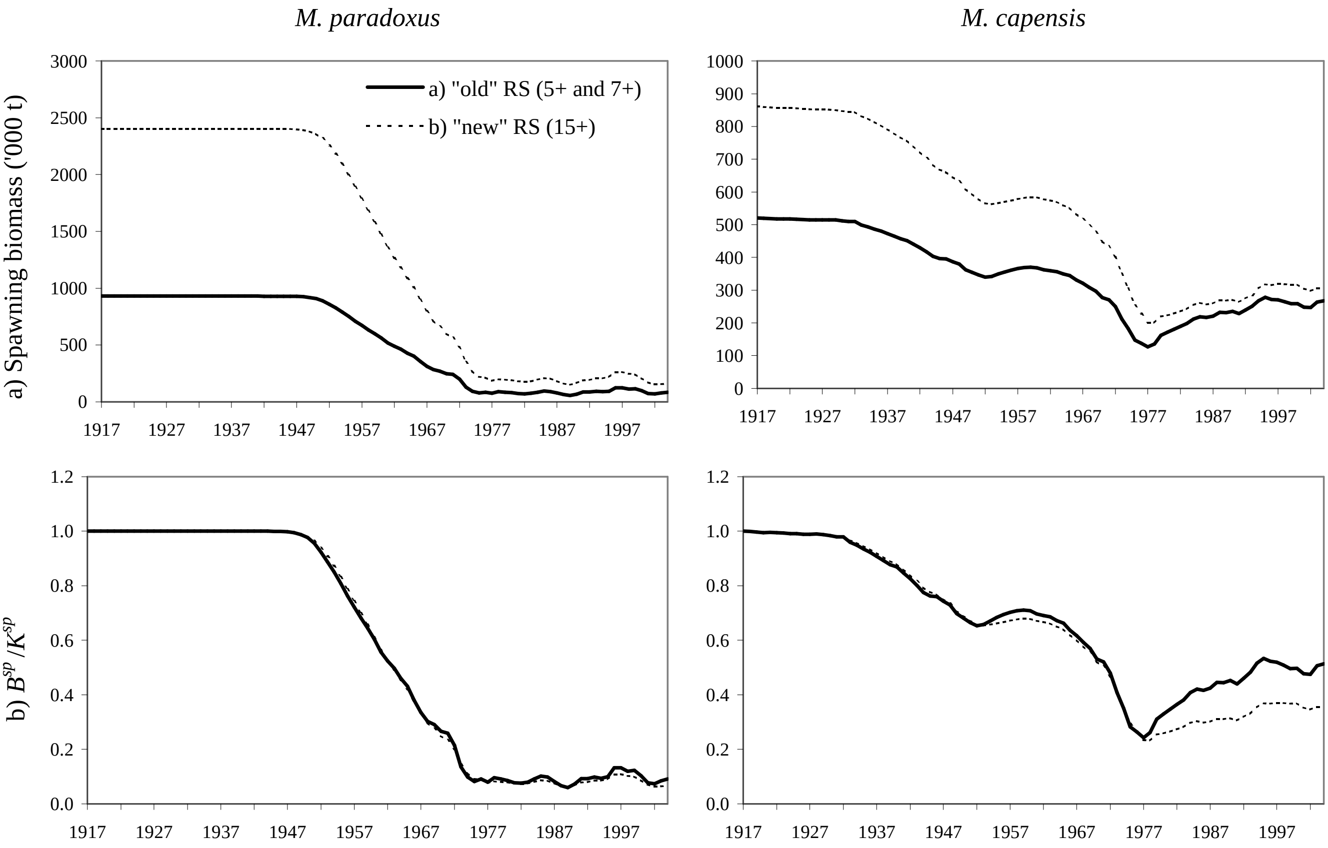

Fig. 1: Trajectories of resource abundance for one scenario of the proposed revised Reference Set (M1-H1-C3-SR1) for the "old" Reference Set (with plus-groups of age 5 and 7 for *M. paradoxus* and *M. capensis* respectively) and for the "new" Reference Set which extends the plus-group for both species to age 15. Resource abundance is expressed in terms of a) spawning biomass and b) of spawning biomass as a proportion of its pre-exploitation level.

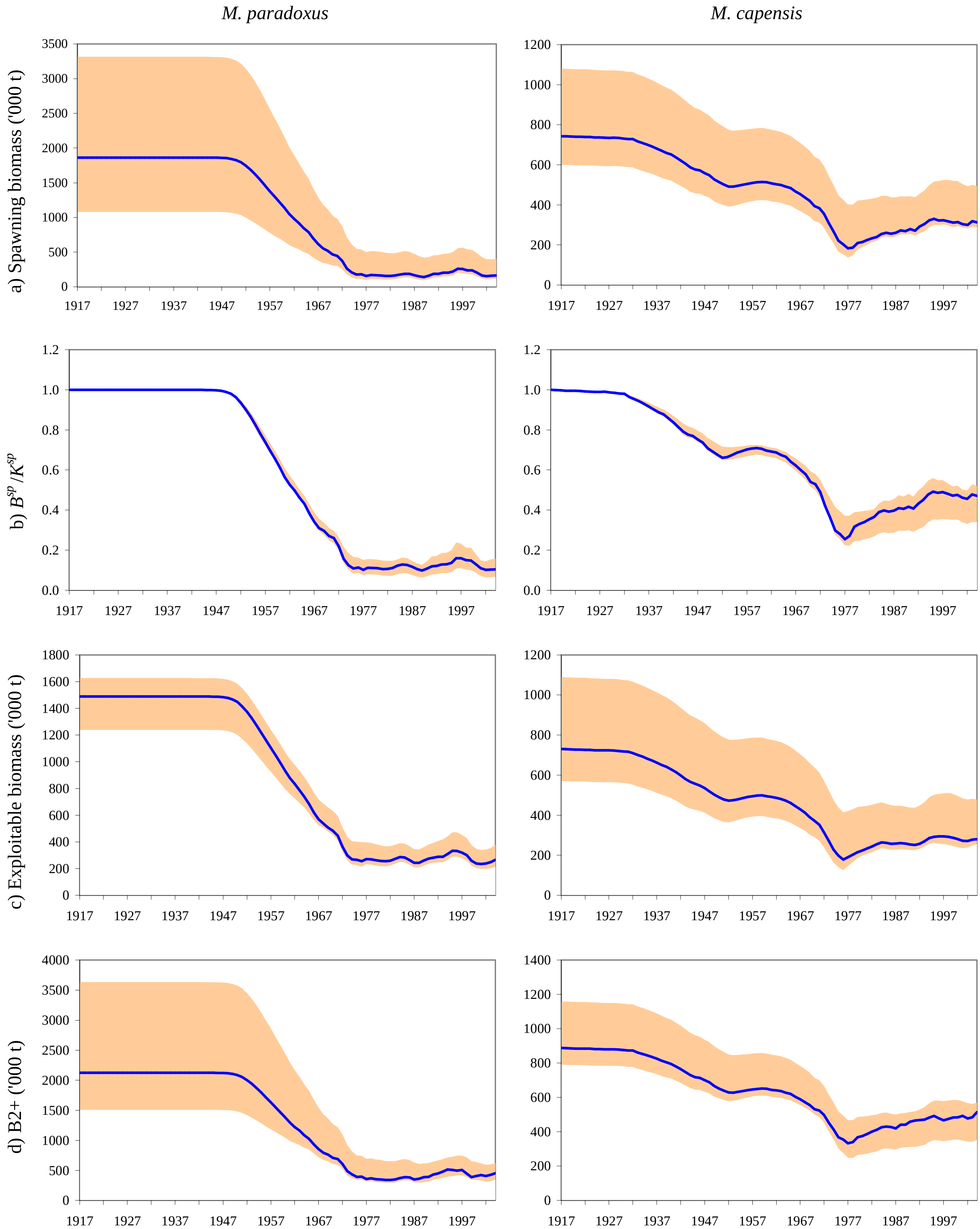

Fig. 2: Trajectories of resource abundance for a subset of the Revised Reference Set. Resource abundance is expressed in terms of a) spawning biomass, b) spawning biomass as a proportion of its pre-exploitation level, c) exploitable biomass and d) biomass of fish of age 2 and above. The median is indicated by a thick line while the shaded area represents the full uncertainty of the subset of the Revised Reference Set (minimum and maximum for each year).

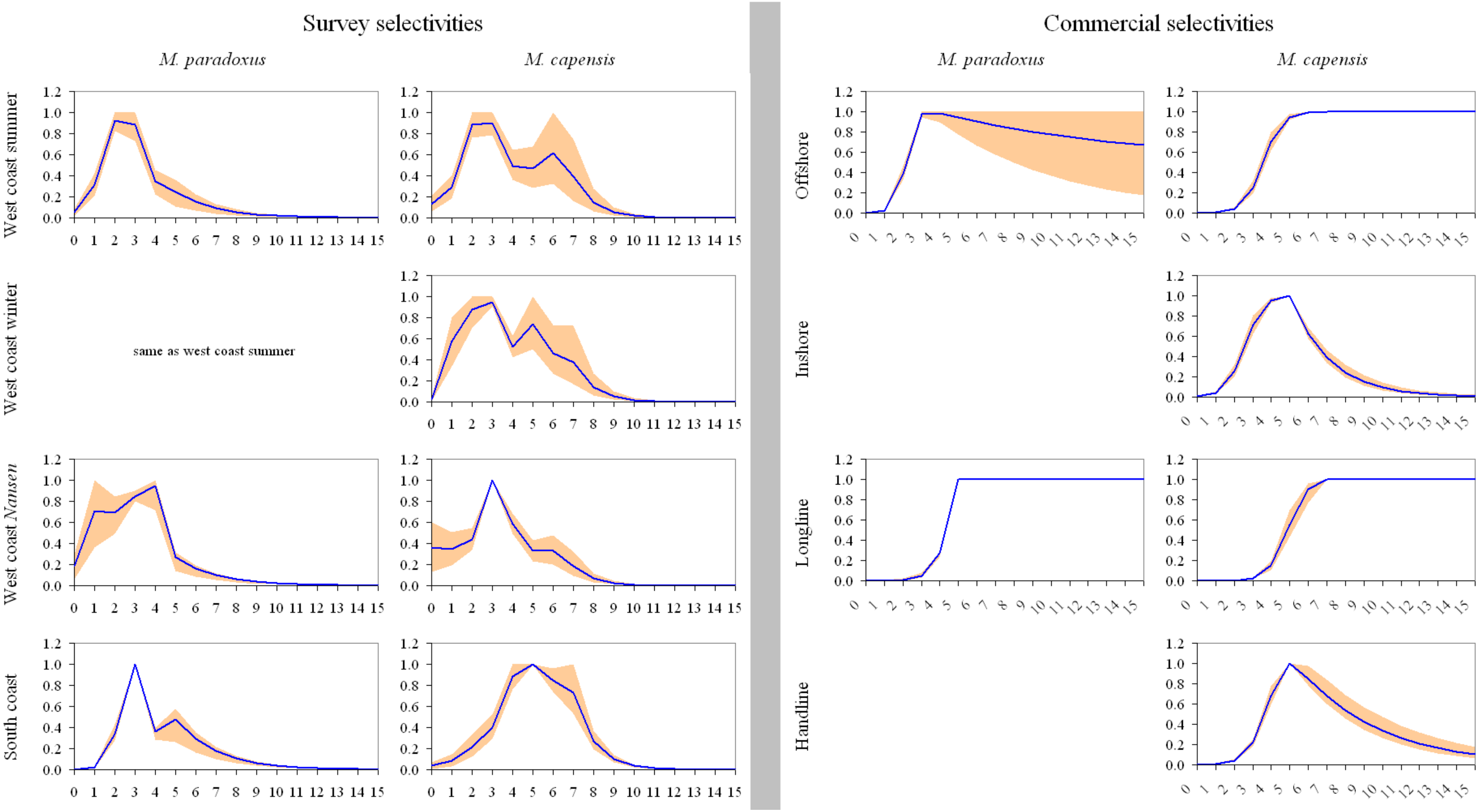

Fig. 3: Estimated survey and commercial fishing selectivities for a subset of the Revised Reference Set. The median is indicated by a thick line while the shaded area represents the full uncertainty of the subset of the Revised Reference Set (minimum and maximum for each age).

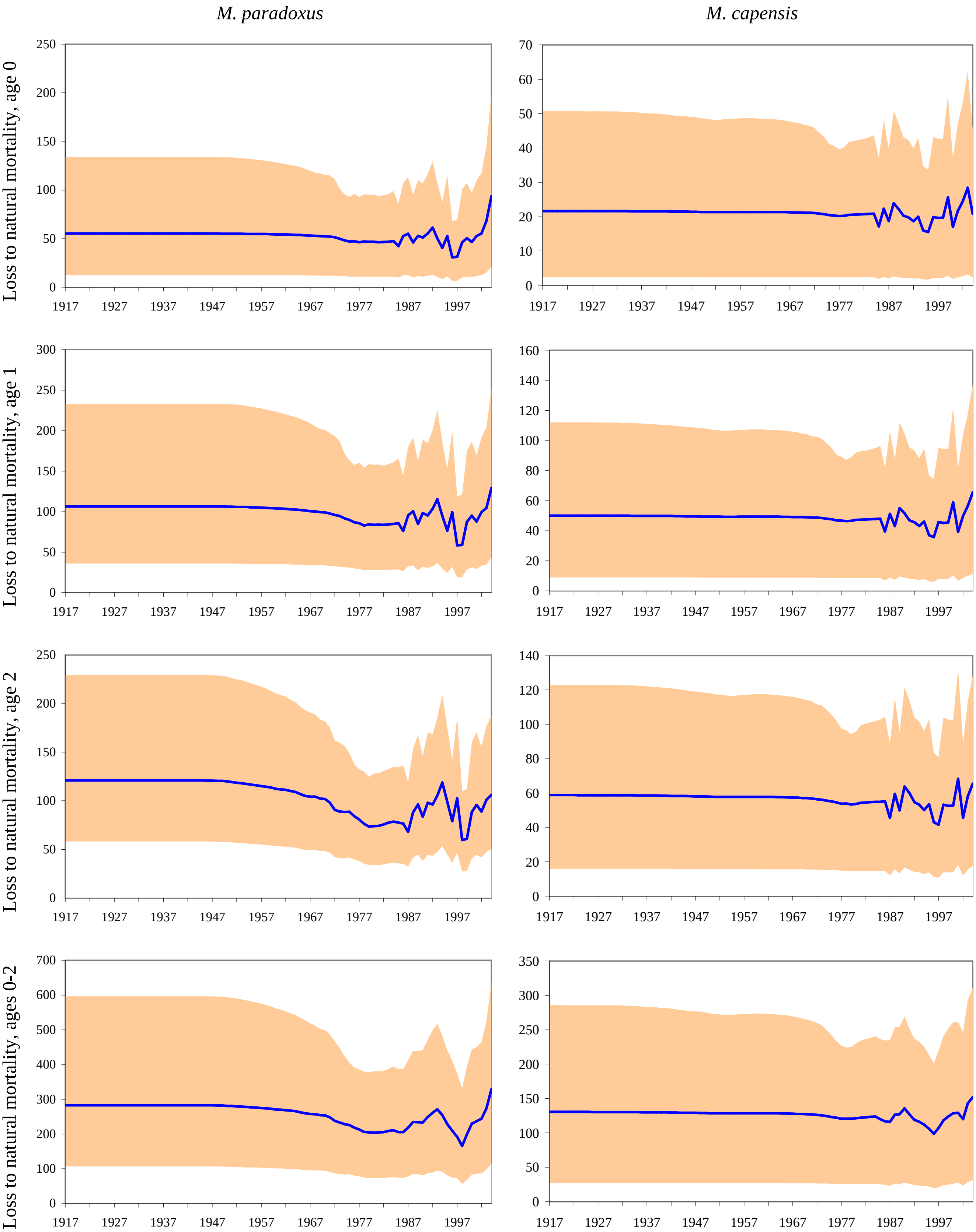

Fig. 4: Loss to natural mortality for ages 0, 1, 2 and 0-2 for a subset of the Revised Reference Set. The median is indicated by a thick line while the shaded area represents the full uncertainty of the subset of the Revised Reference Set (minimum and maximum for each year).

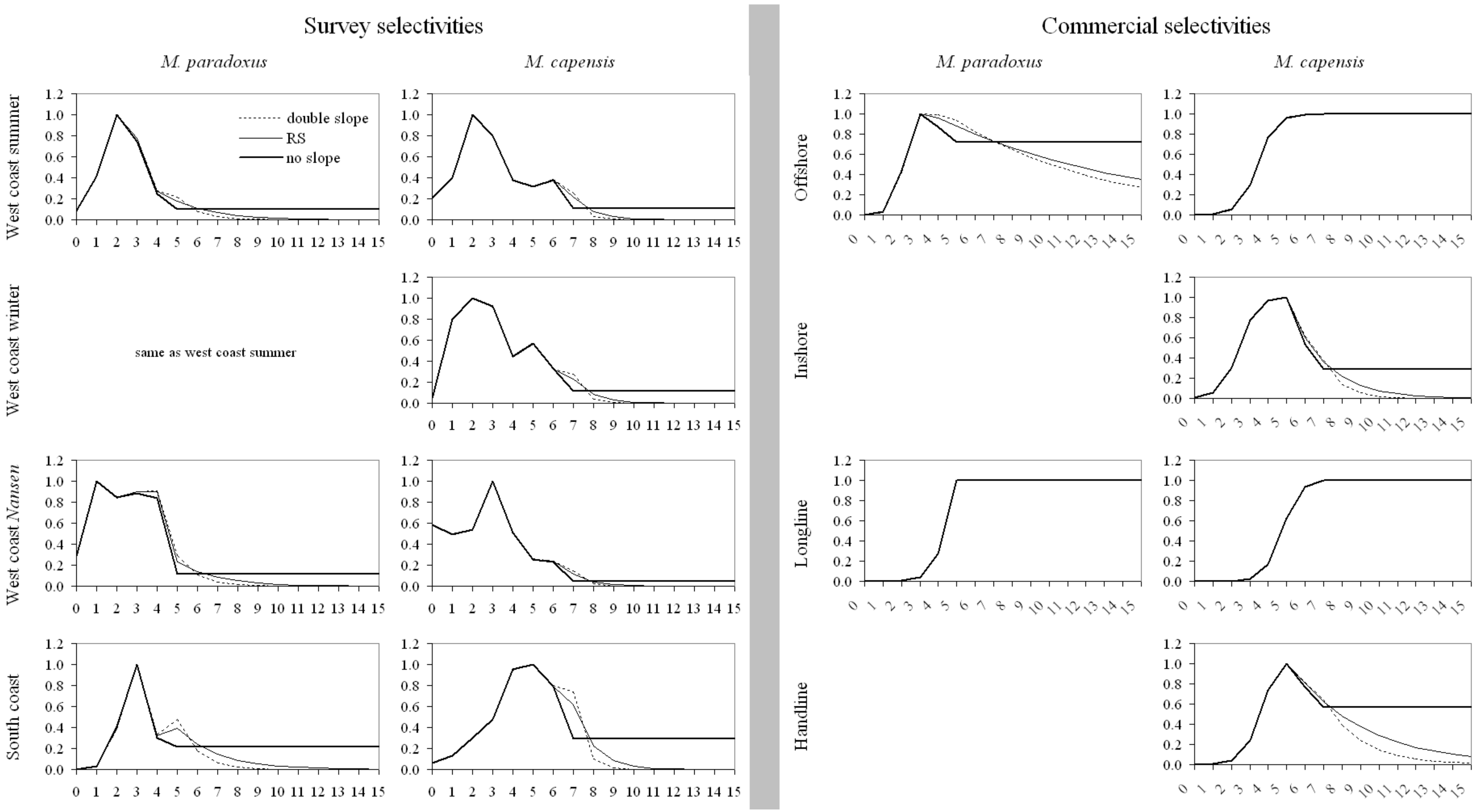

Fig. 5: Estimated survey and commercial fishing selectivities for one scenario of the proposed revised Reference Set (M1-H1-C3-SR1) for three different assumptions about fishing selectivity at older ages: a) as proposed new Reference Set ("Reference Set"), b) with flat selectivity at older ages ("no slope") and c) with selectivity slope double that of a) ("double slope").

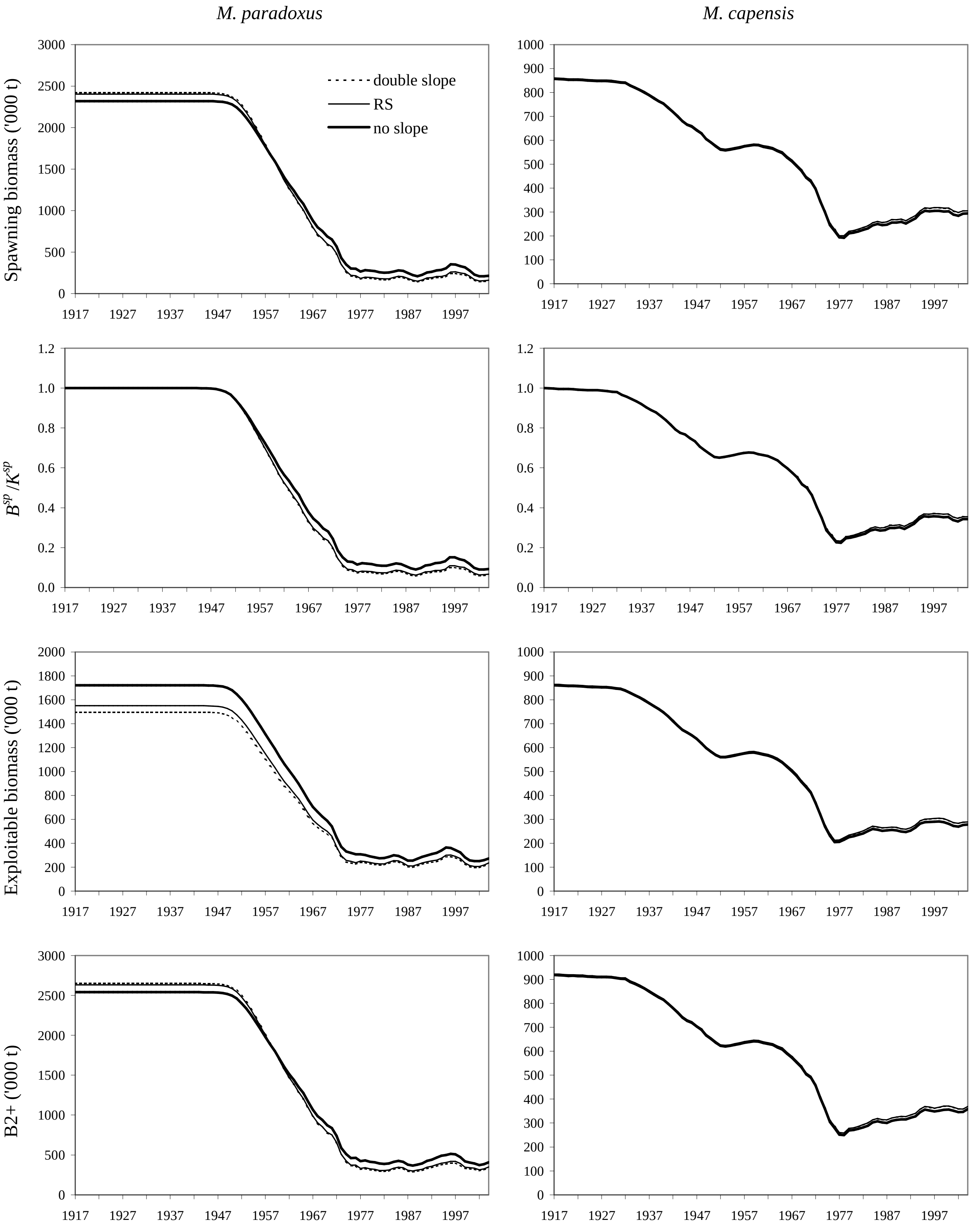

Fig. 6: Trajectories of resource abundance for one scenario of the proposed revised Reference Set (M1-H1-C3-SR1) for three different assumptions about fishing selectivity at older ages: a) as proposed new Reference Set ("Reference Set"), b) with flat selectivity at older ages ("no slope") and c) with selectivity slope double that of a) ("double slope"). Resource abundance is expressed in terms of a) spawning biomass and b) of spawning biomass as a proportion of its pre-exploitation level.