Further Candidate Management Procedures Projections for the South African hake resource

RA Rademeyer and DS Butterworth

August 2014

Summary

This document reports further developments in the hake OMP revision process. First the requested 150 000t upper cap is placed on the TAC, and tunings to different average TACs over the next 10 years are contrasted, together with options for a pre-fixed TAC for the next two years. The option of a soft lower cap on the TAC of 125 000t is explored, linked to a metarule for overriding this if the overall abundance index for *M. paradoxus* falls below a specified threshold. While it seems more likely than not that the introduction of this soft lower cap would make for a more stable fishery, there remains an appreciable chance that it may necessitate larger TAC reductions, and to lower TAC levels, than would otherwise be the case. Options to reduce the "lag" effects between changes in resource trends and in the TAC are explored, but with little success; basing the control rule on abundance index averages over the last two rather than last three years leads to greater interannual TAC variability. Results for an initial exploration of robustness to decreases in carrying capacity (a possible effect of climate change) point to the importance of further development of metarules to override the constraint on the 5% maximum downward TAC adjustment.

Introduction

This paper extends the results shown for various CMPs as reported in Rademeyer and Butterworth (2014) in the light of comments made when that document was reviewed by the DAFF Demersal Working Group.

It first gives details of the baseline Candidate Management Procedure (CMP), and then describes variants to that CMP which have been explored and reports the results obtained. Finally some inferences drawn from these results are summarized.

Note: Appendix A is included in response to a question asked at that last DWG meeting. It shows how the exploitable biomass (to which CPUE is proportional) and the spawning biomass can show different trends as they reflect different proportions of the age-classes within the population.

The Baseline CMP

A description of the baseline CMP is given below. The only change made compared to CMP1$_{135}$ presented in Rademeyer and Butterworth (2014) is introduction of the upper cap of 150 000t on the TAC.

The formula for computing the TAC for the baseline CMP is as follows:

$$TAC_y = C_y^{para} + C_y^{cap} \qquad (1)$$

with

$$C_y^{spp} = b^{spp}\left(J_y^{spp} - J_0^{spp}\right) \tag{2}$$

where

TAC_y is the total TAC recommended for year *y*,

C_y^{spp} is the intended species-disaggregated TAC for species *spp* year *y*,

J_0^{spp} and b^{spp} are tuning parameters, and

J_y^{spp} is a measure of the immediate past level in the abundance indices for species *spp* that is available to use for calculations for year *y.*

J_y^{spp} for the abundance indices is computed as follows:

$$J_y^{para} = \frac{1.0J_y^{WC\_CPUE,para} + 0.75J_y^{SC\_CPUE,para} + 0.5J_y^{WC\_surv,para} + 0.25J_y^{SC\_surv,para}}{2.5} \tag{3}$$

$$J_y^{cap} = \frac{1.0J_y^{WC\_CPUE,cap} + 0.75J_y^{SC\_CPUE,cap} + 0.5J_y^{WC\_surv,cap} + 1.0J_y^{SC\_surv,cap}}{3.25} \tag{4}$$

with

$$J_y^{WC/SC\_CPUE,spp} = \sum_{y'=y-4}^{y-2} I_y^{WC/SC\_CPUE,spp} \Bigg/ \sum_{y=2010}^{2012} I_y^{WC/SC\_CPUE,spp} \tag{5}$$

$$J_y^{WC/SC\_surv,spp} = \sum_{y'=y-3}^{y-1} I_y^{WC/SC\_surv,spp} \Bigg/ \sum_{y=2011}^{2013} I_y^{WC/SC\_surv,spp} \tag{6}$$

Thus the weighting of the different indices (denoted by *I*) is taken to be the same as for OMP-2010, and the normalization is such that a value of *J*=1 reflects resource abundance about the same as in 2011/2012.

The maximum allowable annual increase in TAC is 10%, and the maximum allowable annual decrease in TAC is 5%. An upper cap on the TAC is imposed, so that the TAC cannot exceed 150 000t.

Results for various CMPs

1) Three tunings: 140, 135, 130 thousand tons for 2015-2024 average TAC

Results for three baseline CMP variants under the Reference Set (RS) are compared in Table 1 and Figure 1. These three CMPs have been tuned to obtain an average 2015-2024 TAC (in median terms) of 130 000t (CMP2a$_{130}$), 135 000t (CMP2a$_{135}$) and 140 000t (CMP2a$_{140}$). Note that “Base Risk” (or BR) refers to the lower 2.5%-ile value for *M. paradoxus* B^{sp}_{2024}/B_{MSY}, which is 0.64. Shade plots showing 95% and 75% PIs for a series of statistics are given in Figure 2 for CMP2a$_{135}$.

2) "Gradient" of the target based formula

The tuning parameters b^{spp} (equation 2) reflect the gradient of the TAC vs *J* relationship, and are related to how reactive the formula is to changes in the relative abundance indices. For CMP2a$_{130/135/140}$ $b^{para} = 88.83$ and $b^{cap} = 33.33$, so that the CMPs correspond approximately to a constant *F* strategy (see Figure 3). Variations on this "gradient" parameter have been investigated (see Figure 3). Results for "lower gradient" ($b^{para} = 29.94$ and $b^{cap} = 10$) and "higher gradient" ($b^{para} = 107.78$ and $b^{cap} = 43.33$) options under the RS and for a tuning of 135 000t are compared in Table 2 and Figure 4.

3) Fixed catches in 2015 and 2016

The effect of fixing the 2015 and 2016 TACs to 145 000t and 147 500t are illustrated in Figure 5 and Table 3. These CMPs have been re-tuned to the BR. For the 147 500t option however, BR could not be achieved with the 5% constraint on maximum interannual decrease in TAC, so that for this particular CMP only, this constraint was increased to 6%.

4) Soft lower cap at a TAC of 125 000t

A CMP variant has been developed in which a cap of 125 000t on the TAC is imposed provided J_y^{para} (the measure of the immediate past level in the *M. paradoxus* biomass indices) is above a threshold value $J^{thresh1}$. If $J_y^{para} < J^{thresh1}$ then the TAC is allowed to decrease below 125 000t and the maximum decrease constraint is not limited to 5%. I.e. if the TAC output by equation 1 (TAC$_y$) is less than 125 000t after the 5% decrease constraint ($TAC_y^{5\%constr}$), then the actual TAC (TAC_y^{act}) is computed as follows.

If $TAC_y < TAC_{y-1}$ and if $TAC_y^{5\%constr} < 125000t$, then the following constraints apply:

$$\text{constraints} = \begin{cases} 125000t & \text{if } J_y \geq J^{thresh1} \\ MaxDecr_y 125000t & \text{if } J_y < J^{thresh1} \end{cases} \tag{7}$$

with

$$MaxDecr_y = \begin{cases} \text{linear between 25\% and 0\%} & \text{if } J^{thresh2} \leq J_y < J^{thresh1} \\ 25\% & \text{if } J_y < J^{thresh2} \end{cases}$$

Results for this CMP with different threshold levels, are illustrated in Figures 6-8 and Table 4, with CMP3a$_{135}$: $J^{thresh1} = 0.9$ and $J^{thresh2} = 0.8$;

CMP3b$_{135}$: $J^{thresh1} = 0.8$ and $J^{thresh2} = 0.7$; and

CMP3c$_{135}$: $J^{thresh1} = 0.78$ and $J^{thresh2} = 0.68$.

5) Dealing with the lag between changes in resource size and the TAC

In this CMP variant , the more recent years are given more weight that earlier years in the computation of J_y^{spp}, i.e. equations 5 and 6 are replaced by:

$$J_y^{WC/SC\_CPUE,spp} = \sum_{y'=y-4}^{y-2} w_y^{CPUE} I_y^{WC/SC\_CPUE,spp} \Bigg/ \theta^{spp} \sum_{y=2010}^{2012} \frac{I_y^{WC/SC\_CPUE,spp}}{3} \qquad (8)$$

$$J_y^{WC/SC\_surv,spp} = \sum_{y'=y-3}^{y-1} w_y^{surv} I_y^{WC/SC\_surv,spp} \Bigg/ \theta^{spp} \sum_{y=2011}^{2013} \frac{I_y^{WC/SC\_surv,spp}}{3} \qquad (9)$$

where

$$w_{y-4}^{CPUE} = w_{y-3}^{surv} = 0.15$$

$$w_{y-3}^{CPUE} = w_{y-2}^{surv} = 0.35$$

and

$$w_{y-2}^{CPUE} = w_{y-1}^{surv} = 0.50$$

Results, tuned to Base Risk, are compared to CMP2a135 in Table 5 and Figure 9.

6) Average abundance indices based on 2 years

For CMP2a, the average abundance indices used in the target formula are based on a 3 year average. Alternative CMPs have been run in Rademeyer and Butterworth (2014), taking 4 or 5 year averages instead. Here results for a CMP2a variant taking 2 year averages and tuned to BR are given in Table 5 and Figure 10.

7) Relative impact of possible changes in the sector splits of hake catch

A more realistic scenario than the extremes presented in Rademeyer and Butterworth (2014) assumes that the quota allocated to the inshore trawl sector is instead added to the offshore trawl sector. The west and south coast offshore splits are then kept the same. CMP2a135 is retuned to Base Risk under this scenario. Results are compared in Table 6 and Figure 11.

8) What if the TAC was capped at 150 000t in OMP-2010

The RC (RS1) has been rerun assuming that no TAC over the past four years had been set above 150 000t, i.e. with C_{2013}=150 000t instead of 156 076t (the TAC for that year). Furthermore, in the projections, the 2014 TAC is also taken to be 150 000t (instead of the 155 280t TAC awarded). CMP2a135 is then retuned to BR. Results, including indications of the impact on the starting abundances for each species, are compared for RS1 only in Table 7 and Figure 12.

9) Effort limitation

To check whether the existing effort limitation prescription would likely affect the future catches, CMP2a$_{140}$ (for which this is the most likely to occur) was run checking if there were instances when:

$$TAC_y > 1.7 B_y \sum_{2008}^{2011} C_y \Big/ \sum_{2008}^{2011} B_y$$

where

B_y is the sum of the offshore trawl exploitable biomasses for *M. paradoxus* and *M. capensis*. This corresponds to the existing limitation which essentially limits effort to no more than 70% more than required (in median terms) to catch the TACs over 2008-2011.

There were no instances when this occurred for trials of CMPs considered thus far under the RS. This "flag" is being retained in the code to check for any instances that might occur for robustness tests.

10) Some major robustness tests

The robustness tests assuming changes in carrying capacity (in the past or in the future) were amongst the robustness tests found to present the greatest challenges from a resource conservation perspective during the development of OMP-2011 (Rademeyer and Butterworth, 2013).

Results for projections under CMP2a$_{135}$ and CMP3c$_{135}$ for robustness tests B.others.2 (30% linear decrease in K for both species between 1980 and 2000, based on RS1 only) and C.future.5 (20% linear decrease in *K* for both species between 2015 and 2020, based on the whole RS) are given in Tables 8 and 9 and Figures 13, 14 and 15.

Discussion

Key inferences to be drawn from the results presented are as follows.

- Imposing the TAC cap of 150 000t leads to a minimal decrease in the BR value (up from 0.63 to 0.64) for an average TAC over 2015-2024 of 135 000t (Table 1).
- Key features and differences amongst tunings to different average TAC values for the 2015-2024 period of 130 000, 135 000 and 140 000t are (Table 1 and Figures 1 and 2) as follows.
    a) All reach B$_{msy}$ in median terms, but in different years: 2021, 2022 and 2028 respectively.
    b) Compared to 2013, the median expectation is an increase of some 10% in CPUE and decrease of some 20% in fishing effort.
    c) The key trade-offs between, for example, CMP2a$_{135}$ and CMP2a$_{140}$ are (latter *vs* former) 5000t extra catch annually, a longer period to return to B$_{msy}$, and a 3% lower CPUE.
    d) TAC reductions are more likely than not for the next five years.
    e) The "worst case" scenario (lower 5%-ile) reflects TACs in the 90 – 100 000 t range, and a CPUE down by about 15% of its 2013 value by the end of the decade.

- The gradient parameter choices for the CMP2a variants seem appropriate as they correspond closely to constant fishing mortality strategies, and also seem close to achieving minimum resource risk (in terms of BR) (Table 2 and Figs 3, 4).

- The choices investigated for a fixed TAC for the next two years virtually guarantee a higher TAC for 2016 than would be the case under CMP2a$_{135}$. However there is a later price to pay if BR is to be maintained: the average annual catch for the next 10 years could need to drop by about 2000t, and the lowest value to which the TAC might need to be reduced is some 4 000t lower. Further, for the higher of the two fixed choices considered (147 500t), the constraint on the maximum downward interannual TAC change has to be raised from 5% to 6% to achieve the CMP2a$_{135}$ BR (Table 3 and Figure 5).

- The various options for introducing a soft lower cap of 125 000t on the TAC are attractive in reducing interannnual catch variability, with the median AAV value falling from 4 to 3%. However rules have to be introduced which can override this constraint if abundance drops below some threshold (see equation 7). Even given the extra flexibility introduced through these rules, it proved difficult to achieve BR as for CMP2a$_{135}$, so first equivalent risk was reconsidered in terms of the lower 5%- rather than the lower 2.5%-ile for the *M. paradoxus* spawning biomass; then later results were tuned to the same average TAC over 2015 to 2024 (see Table 4). The basic picture that emerges from these results is that it is more likely than not that the introduction of this soft lower cap would make for a more stable fishery. However, there remains an appreciable chance (in the 5-15% range) that it may necessitate larger TAC reductions, and to lower TAC levels, than would otherwise be the case (Figures 6, 7 and 8).

- Neither of the options introduce to attempt to reduce the lag effect seems to achieve much success, with a high and option-independent proportion of cases where the TAC is adjusted in a direction opposite to that in which the species-combined spawning biomass is moving (Table 5 and Figures 9 and 10). Using the last two rather than last three years values of the indices of abundance in the control rule does however increase the median interannual TAC change from 4% to 5% - a lesser stability for the fishery without any other obvious gain. It may be though that alternative performance statistics which provide more sensitive indices of the lag effect need to be developed.

- If all inshore quotas were transferred to the offshore fleet, to maintain the same BR value (since such transfers would result in relatively greater catches of *M. paradoxus*), the average annual TAC over the next decade would need to be about 2 500t lower (Table 6 and Figure 11).

- Had the last two years' TACs been restricted not to exceed 150 000t, the current *M. paradoxus* spawning biomass would be about 1% higher, and an increase in the average annual TAC over the next decade of about 1 500t would have been possible (Table 7 and Figure 12).

- Consideration of the results of robustness tests involving decreases in carrying capacity, whether in the past or in the future, make clear that the baseline CMPs (e.g. CMP2a$_{\mathbf{135}}$), which retain a 5% constraint on any interannual downward constraint on the TAC, are inadequate as they can result in the resource being depleted to a very low level. Consequently they have to include metarules which can override this constraint should there be evidence of a large drop in abundance (Tables 8 and 9, and Figures 14a and 15a).

- Such metrules may be able to rectify the situation, as is evident from results for the past decrease in carrying capacity shown in Table 8 and Figures 14b and c when a CMP (CMP3c$_{135}$)

which includes provisions to override the 5% downward TAC constraint is considered. The TACs are then reduced sufficiently quickly to allow full resource recovery. However this CMP is only partially effective (compared to the poorly performing CMP2a$_{135}$) given future decreases in carrying capacity, and further refinement of the CMPs to deal better with this situation remains needed (Table 9 and Figures 15b and c).

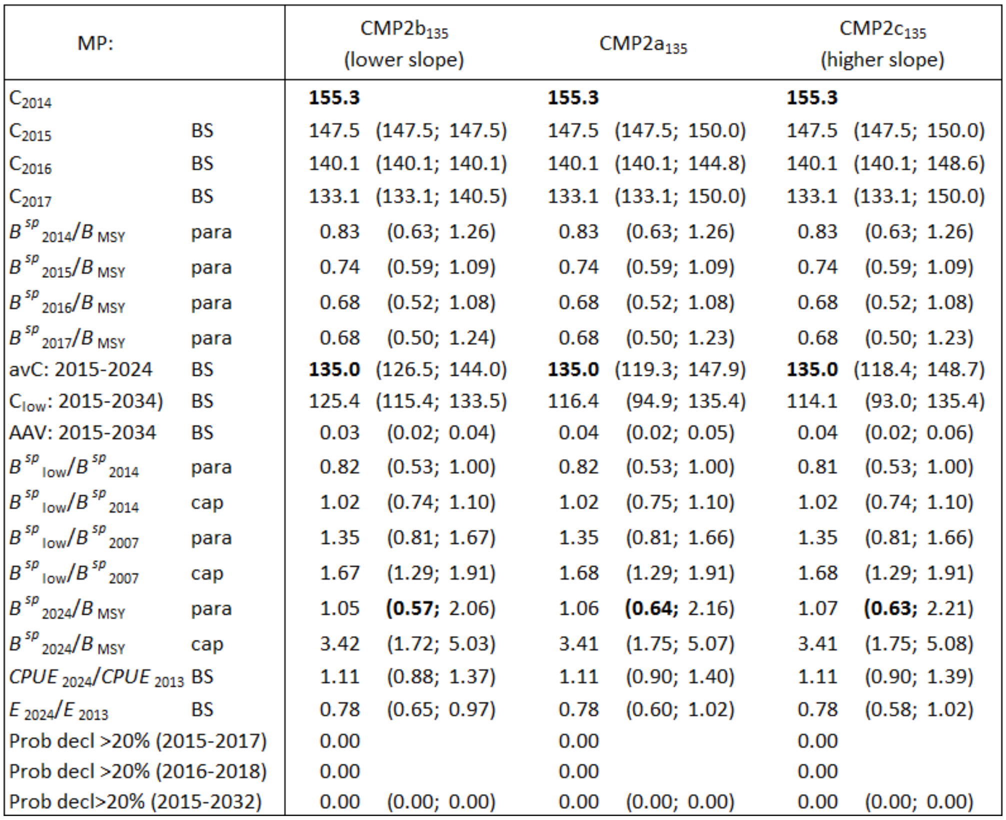
Reference

Rademeyer, RA and Butterworth, DS. 2014. Candidate Management Procedures projections for the South African hake resource. Document FISHERIES/2014/AUG/SWG-DEM/33. 15pp.

Table 1: Median and 95% PIs for a series of performance statistics under the RS, for CMP1$_{135}$ (old baseline) and three CMPs including an upper cap on the TAC of 150 000t tuned to different 2015-2024 average TACs.

				Include an upper cap of 150 000t					
MP:		CMP1$_{135}$		CMP2a$_{130}$		CMP2a$_{135}$		CMP2a$_{140}$	
C_{2014}		**155.3**		**155.3**		**155.3**		**155.3**	
C_{2015}	BS	147.5	(147.5; 157.2)	147.5	(147.5; 147.5)	147.5	(147.5; 150.0)	147.5	(147.5; 150.0)
C_{2016}	BS	140.1	(140.1; 149.4)	140.1	(140.1; 140.1)	140.1	(140.1; 144.8)	140.1	(140.1; 150.0)
C_{2017}	BS	133.1	(133.1; 152.5)	133.1	(133.1; 142.1)	133.1	(133.1; 150.0)	133.1	(133.1; 150.0)
B^{sp}_{2014}/B_{MSY}	para	0.83	(0.63; 1.26)	0.83	(0.63; 1.26)	0.83	(0.63; 1.26)	0.83	(0.63; 1.26)
B^{sp}_{2015}/B_{MSY}	para	0.74	(0.59; 1.09)	0.74	(0.59; 1.09)	0.74	(0.59; 1.09)	0.74	(0.59; 1.09)
B^{sp}_{2016}/B_{MSY}	para	0.68	(0.52; 1.08)	0.68	(0.52; 1.08)	0.68	(0.52; 1.08)	0.68	(0.52; 1.08)
B^{sp}_{2017}/B_{MSY}	para	0.68	(0.50; 1.23)	0.68	(0.50; 1.23)	0.68	(0.50; 1.23)	0.68	(0.50; 1.23)
avC: 2015-2024	BS	**135.0**	(119.1; 159.0)	**130.0**	(118.4; 145.4)	**135.0**	(119.3; 147.9)	**140.0**	(121.6; 149.4)
C_{low}: 2015-2034)	BS	114.1	(93.4; 133.1)	111.6	(91.0; 130.0)	116.4	(94.9; 135.4)	122.2	(99.6; 142.0)
AAV: 2015-2034	BS	0.05	(0.04; 0.06)	0.04	(0.02; 0.06)	0.04	(0.02; 0.05)	0.03	(0.01; 0.05)
$B^{sp}_{low}/B^{sp}_{2014}$	para	0.79	(0.52; 0.99)	0.82	(0.53; 1.00)	0.82	(0.53; 1.00)	0.79	(0.53; 1.00)
$B^{sp}_{low}/B^{sp}_{2014}$	cap	1.01	(0.74; 1.10)	1.03	(0.76; 1.10)	1.02	(0.75; 1.10)	1.01	(0.73; 1.10)
$B^{sp}_{low}/B^{sp}_{2007}$	para	1.30	(0.81; 1.65)	1.36	(0.81; 1.67)	1.35	(0.81; 1.66)	1.32	(0.81; 1.65)
$B^{sp}_{low}/B^{sp}_{2007}$	cap	1.66	(1.26; 1.90)	1.69	(1.31; 1.92)	1.68	(1.29; 1.91)	1.66	(1.28; 1.90)
B^{sp}_{2024}/B_{MSY}	para	1.05	(**0.63;** 2.09)	1.17	(**0.68;** 2.29)	1.06	(**0.64;** 2.16)	0.97	(**0.55;** 2.00)
B^{sp}_{2024}/B_{MSY}	cap	3.41	(1.75; 5.06)	3.47	(1.79; 5.11)	3.41	(1.75; 5.07)	3.33	(1.70; 4.98)
$CPUE_{2024}/CPUE_{2013}$	BS	1.10	(0.89; 1.37)	1.15	(0.93; 1.43)	1.11	(0.90; 1.40)	1.08	(0.87; 1.35)
E_{2024}/E_{2013}	BS	0.81	(0.59; 1.13)	0.72	(0.54; 0.95)	0.78	(0.60; 1.02)	0.83	(0.65; 1.06)
Prob decl >20% (2015-2017)		0.00		0.00		0.00		0.00	
Prob decl >20% (2016-2018)		0.00		0.00		0.00		0.00	
Prob decl>20% (2015-2032)		0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)

Table 2: Median and 95% PIs for a series of performance statistics under the RS, for CMP2a$_{135}$ and two alternative CMP varying the gradient parameter b^{spp} of the control rule - all tuned to 2015-2024 average TAC of 135 000t.



MP:		CMP2b$_{135}$ (lower slope)		CMP2a$_{135}$		CMP2c$_{135}$ (higher slope)	
C_{2014}		**155.3**		**155.3**		**155.3**	
C_{2015}	BS	147.5	(147.5; 147.5)	147.5	(147.5; 150.0)	147.5	(147.5; 150.0)
C_{2016}	BS	140.1	(140.1; 140.1)	140.1	(140.1; 144.8)	140.1	(140.1; 148.6)
C_{2017}	BS	133.1	(133.1; 140.5)	133.1	(133.1; 150.0)	133.1	(133.1; 150.0)
B^{sp}_{2014}/B_{MSY}	para	0.83	(0.63; 1.26)	0.83	(0.63; 1.26)	0.83	(0.63; 1.26)
B^{sp}_{2015}/B_{MSY}	para	0.74	(0.59; 1.09)	0.74	(0.59; 1.09)	0.74	(0.59; 1.09)
B^{sp}_{2016}/B_{MSY}	para	0.68	(0.52; 1.08)	0.68	(0.52; 1.08)	0.68	(0.52; 1.08)
B^{sp}_{2017}/B_{MSY}	para	0.68	(0.50; 1.24)	0.68	(0.50; 1.23)	0.68	(0.50; 1.23)
avC: 2015-2024	BS	**135.0**	(126.5; 144.0)	**135.0**	(119.3; 147.9)	**135.0**	(118.4; 148.7)
C_{low}: 2015-2034)	BS	125.4	(115.4; 133.5)	116.4	(94.9; 135.4)	114.1	(93.0; 135.4)
AAV: 2015-2034	BS	0.03	(0.02; 0.04)	0.04	(0.02; 0.05)	0.04	(0.02; 0.06)
$B^{sp}_{low}/B^{sp}_{2014}$	para	0.82	(0.53; 1.00)	0.82	(0.53; 1.00)	0.81	(0.53; 1.00)
$B^{sp}_{low}/B^{sp}_{2014}$	cap	1.02	(0.74; 1.10)	1.02	(0.75; 1.10)	1.02	(0.74; 1.10)
$B^{sp}_{low}/B^{sp}_{2007}$	para	1.35	(0.81; 1.67)	1.35	(0.81; 1.66)	1.35	(0.81; 1.66)
$B^{sp}_{low}/B^{sp}_{2007}$	cap	1.67	(1.29; 1.91)	1.68	(1.29; 1.91)	1.68	(1.29; 1.91)
B^{sp}_{2024}/B_{MSY}	para	1.05	**(0.57;** 2.06)	1.06	**(0.64;** 2.16)	1.07	**(0.63;** 2.21)
B^{sp}_{2024}/B_{MSY}	cap	3.42	(1.72; 5.03)	3.41	(1.75; 5.07)	3.41	(1.75; 5.08)
$CPUE_{2024}/CPUE_{2013}$	BS	1.11	(0.88; 1.37)	1.11	(0.90; 1.40)	1.11	(0.90; 1.39)
E_{2024}/E_{2013}	BS	0.78	(0.65; 0.97)	0.78	(0.60; 1.02)	0.78	(0.58; 1.02)
Prob decl >20% (2015-2017)		0.00		0.00		0.00	
Prob decl >20% (2016-2018)		0.00		0.00		0.00	
Prob decl>20% (2015-2032)		0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)

Table 3: Median and 95% PIs for a series of performance statistics under the RS, for CMP2a$_{135}$ and two alternative CMPs fixing the 2015 and 2016 TACs. Note that for the second of these alternatives (the final column) the maximum annual TAC reduction is increased to 6%.

MP:		CMP2a$_{135}$		2015 and 2016 TACs fixed at 145 000t (tuned to Base Risk)		2015 and 2016 TACs fixed at 147 500t (tuned to Base Risk)	
C_{2014}		**155.3**		**155.3**		**155.3**	
C_{2015}	BS	147.5	(147.5; 150.0)	**145.0**		**147.5**	
C_{2016}	BS	140.1	(140.1; 144.8)	**145.0**		**147.5**	
C_{2017}	BS	133.1	(133.1; 150.0)	137.8	(137.8; 146.3)	138.7	(138.7; 150.0)
B^{sp}_{2014}/B_{MSY}	para	0.83	(0.63; 1.26)	0.83	(0.63; 1.26)	0.83	(0.63; 1.26)
B^{sp}_{2015}/B_{MSY}	para	0.74	(0.59; 1.09)	0.74	(0.59; 1.09)	0.74	(0.59; 1.09)
B^{sp}_{2016}/B_{MSY}	para	0.68	(0.52; 1.08)	0.69	(0.53; 1.09)	0.68	(0.52; 1.08)
B^{sp}_{2017}/B_{MSY}	para	0.68	(0.50; 1.23)	0.68	(0.50; 1.23)	0.66	(0.49; 1.21)
avC: 2015-2024	BS	**135.0**	(119.3; 147.9)	**132.6**	(121.7; 146.8)	**134.3**	(120.2; 148.2)
C_{low}: 2015-2034)	BS	116.4	(94.9; 135.4)	113.4	(92.1; 133.0)	115.2	(90.7; 135.2)
AAV: 2015-2034	BS	0.04	(0.02; 0.05)	0.04	(0.02; 0.06)	0.04	(0.02; 0.06)
$B^{sp}_{low}/B^{sp}_{2014}$	para	0.82	(0.53; 1.00)	0.82	(0.51; 1.00)	0.81	(0.50; 1.00)
$B^{sp}_{low}/B^{sp}_{2014}$	cap	1.02	(0.75; 1.10)	1.03	(0.75; 1.10)	1.03	(0.75; 1.10)
$B^{sp}_{low}/B^{sp}_{2007}$	para	1.35	(0.81; 1.66)	1.35	(0.78; 1.66)	1.33	(0.76; 1.66)
$B^{sp}_{low}/B^{sp}_{2007}$	cap	1.68	(1.29; 1.91)	1.68	(1.31; 1.92)	1.68	(1.30; 1.92)
B^{sp}_{2024}/B_{MSY}	para	1.06	**(0.64;** 2.16)	1.11	**(0.64;** 2.20)	1.08	**(0.64;** 2.20)
B^{sp}_{2024}/B_{MSY}	cap	3.41	(1.75; 5.07)	3.43	(1.76; 5.08)	3.41	(1.75; 5.07)
$CPUE_{2024}/CPUE_{2013}$	BS	1.11	(0.90; 1.40)	1.13	(0.91; 1.41)	1.12	(0.91; 1.41)
E_{2024}/E_{2013}	BS	0.78	(0.60; 1.02)	0.74	(0.57; 0.97)	0.75	(0.57; 0.99)
Prob decl >20% (2015-2017)		0.00		0.00		0.00	
Prob decl >20% (2016-2018)		0.00		0.00		0.00	
Prob decl>20% (2015-2032)		0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)

Table 4: Median and 95% PIs for a series of performance statistics under the RS, for CMP2a$_{135}$ and alternative CMPs including a soft cap at 125 000t.

				With 125 000t soft cap					
				CMP3a$_{135}$		CMP3b$_{135}$		CMP3c$_{135}$	
		CMP2a$_{135}$		$J^{thresh1}$=0.90, $J^{thresh2}$=0.80		$J^{thresh1}$=0.80, $J^{thresh2}$=0.70		$J^{thresh1}$=0.78, $J^{thresh2}$=0.68	
C_{2014}		**155.3**		**155.3**		**155.3**		**155.3**	
C_{2015}	BS	147.5	(147.5; 150.0)	147.5	(147.5; 150.0)	147.5	(147.5; 150.0)	**147.5**	(147.5; 150.0)
C_{2016}	BS	140.1	(140.1; 144.8)	140.1	(140.1; 142.6)	140.1	(140.1; 142.5)	**140.1**	(140.1; 142.5)
C_{2017}	BS	133.1	(133.1; 150.0)	133.1	(133.1; 150.0)	133.1	(133.1; 150.0)	**133.1**	(133.1; 150.0)
B^{sp}_{2014}/B_{MSY}	para	0.83	(0.63; 1.26)	0.83	(0.63; 1.26)	0.83	(0.63; 1.26)	0.83	(0.63; 1.26)
B^{sp}_{2015}/B_{MSY}	para	0.74	(0.59; 1.09)	0.74	(0.59; 1.09)	0.74	(0.59; 1.09)	0.74	(0.59; 1.09)
B^{sp}_{2016}/B_{MSY}	para	0.68	(0.52; 1.08)	0.68	(0.52; 1.08)	0.68	(0.52; 1.08)	0.68	(0.52; 1.08)
B^{sp}_{2017}/B_{MSY}	para	0.68	(0.50; 1.23)	0.68	(0.50; 1.23)	0.68	(0.50; 1.23)	0.68	(0.50; 1.23)
avC: 2015-2024	BS	**135.0**	(119.3; 147.9)	**135.0**	(107.6; 147.4)	**135.0**	(118.6; 147.3)	**135.1**	(125.8; 147.3)
C_{low}: 2015-2034)	BS	116.4	(94.9; 135.4)	125.0	(71.1; 133.7)	125.0	(82.6; 133.3)	125.0	(94.0; 133.3)
AAV: 2015-2034	BS	0.04	(0.02; 0.05)	0.03	(0.02; 0.08)	0.03	(0.02; 0.07)	0.03	(0.02; 0.06)
$B^{sp}_{low}/B^{sp}_{2014}$	para	0.82	(0.53; 1.00)	0.81	(0.54; 1.00)	0.81	(0.53; 1.00)	0.81	(0.53; 1.00)
$B^{sp}_{low}/B^{sp}_{2014}$	cap	1.02	(0.75; 1.10)	1.02	(0.75; 1.10)	1.02	(0.74; 1.10)	1.02	(0.74; 1.10)
$B^{sp}_{low}/B^{sp}_{2007}$	para	1.35	(0.81; 1.66)	1.35	(0.81; 1.66)	1.35	(0.81; 1.66)	1.35	(0.81; 1.66)
$B^{sp}_{low}/B^{sp}_{2007}$	cap	1.68	(1.29; 1.91)	1.67	(1.29; 1.91)	1.67	(1.29; 1.91)	1.67	(1.29; 1.91)
B^{sp}_{2024}/B_{MSY}	para	1.06	(**0.64;** 2.16)	1.08	(**0.61;** 2.26)	1.05	(**0.58;** 2.21)	1.04	(**0.58;** 2.16)
90%iles			(**0.66;** 1.96)		(**0.66;** 2.14)		(**0.62;** 1.91)		(**0.61;** 1.90)
B^{sp}_{2024}/B_{MSY}	cap	3.41	(1.75; 5.07)	3.42	(1.75; 5.11)	3.40	(1.73; 5.04)	3.40	(1.73; 5.04)
$CPUE_{2024}/CPUE_{2013}$	BS	1.11	(0.90; 1.40)	1.12	(0.90; 1.41)	1.11	(0.88; 1.39)	1.11	(0.88; 1.39)
E_{2024}/E_{2013}	BS	0.78	(0.60; 1.02)	0.78	(0.52; 1.01)	0.79	(0.62; 1.01)	0.79	(0.63; 1.01)
Prob decl >20% (2015-2017)		0.00		0.00		0.00		0.00	
Prob decl >20% (2016-2018)		0.00		0.00		0.00		0.00	
Prob decl>20% (2015-2032)		0.00	(0.00; 0.00)	0.00	(0.00; 0.11)	0.00	(0.00; 0.11)	0.00	(0.00; 0.06)

Table 5: Median and 95% PIs for a series of performance statistics under the RS, for CMP2a$_{135}$ and alternative CMPs. The "lag probability" statistic is the probability of a TAC adjustment in the opposite direction to the change in the sum of the spawning biomasses for *M. paradoxus* and *M. capensis* over the 2015-2024 period.

MP:		CMP2a$_{135}$		Lag effect - more weight to last year's data point (tuned to Base Risk)		Two year average for indices (tuned to Base Risk)	
C_{2014}		155.3	(155.3; 155.3)	155.3	(155.3; 155.3)	155.3	(155.3; 155.3)
C_{2015}	BS	147.5	(147.5; 150.0)	147.5	(147.5; 150.0)	147.5	(147.5; 150.0)
C_{2016}	BS	140.1	(140.1; 144.8)	140.1	(140.1; 145.9)	140.1	(140.1; 150.0)
C_{2017}	BS	133.1	(133.1; 150.0)	133.1	(133.1; 150.0)	133.1	(133.1; 150.0)
B^{sp}_{2014}/B_{MSY}	para	0.83	(0.63; 1.26)	0.83	(0.63; 1.26)	0.83	(0.63; 1.26)
B^{sp}_{2015}/B_{MSY}	para	0.74	(0.59; 1.09)	0.74	(0.59; 1.09)	0.74	(0.59; 1.09)
B^{sp}_{2016}/B_{MSY}	para	0.68	(0.52; 1.08)	0.68	(0.52; 1.08)	0.68	(0.52; 1.08)
B^{sp}_{2017}/B_{MSY}	para	0.68	(0.50; 1.23)	0.68	(0.50; 1.23)	0.68	(0.50; 1.23)
avC: 2015-2024	BS	**135.0**	(119.3; 147.9)	**134.4**	(119.1; 147.3)	**133.8**	(118.9; 146.9)
C_{low}: 2015-2034)	BS	116.4	(94.9; 135.4)	115.8	(94.1; 133.1)	114.1	(93.0; 133.1)
AAV: 2015-2034	BS	0.04	(0.02; 0.05)	0.04	(0.02; 0.06)	0.05	(0.02; 0.06)
$B^{sp}_{low}/B^{sp}_{2014}$	para	0.82	(0.53; 1.00)	0.82	(0.53; 1.00)	0.82	(0.53; 1.00)
$B^{sp}_{low}/B^{sp}_{2014}$	cap	1.02	(0.75; 1.10)	1.02	(0.75; 1.10)	1.03	(0.75; 1.10)
$B^{sp}_{low}/B^{sp}_{2007}$	para	1.35	(0.81; 1.66)	1.35	(0.81; 1.66)	1.35	(0.81; 1.67)
$B^{sp}_{low}/B^{sp}_{2007}$	cap	1.68	(1.29; 1.91)	1.68	(1.30; 1.92)	1.69	(1.30; 1.92)
B^{sp}_{2024}/B_{MSY}	para	1.06	**(0.64;** 2.16)	1.08	**(0.64;** 2.18)	1.09	**(0.64;** 2.19)
B^{sp}_{2024}/B_{MSY}	cap	3.41	(1.75; 5.07)	3.42	(1.76; 5.09)	3.42	(1.76; 5.10)
$CPUE_{2024}/CPUE_{2013}$	BS	1.11	(0.90; 1.40)	1.12	(0.91; 1.40)	1.12	(0.91; 1.41)
E_{2024}/E_{2013}	BS	0.78	(0.60; 1.02)	0.77	(0.59; 1.00)	0.76	(0.58; 0.97)
Prob decl >20% (2015-2017)		0.00		0.00		0.00	
Prob decl >20% (2016-2018)		0.00		0.00		0.00	
Prob decl>20% (2015-2032)		0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.00)
Lag probability (2015-2032)		0.50	(0.20; 0.80)	0.50	(0.20; 0.80)	0.50	(0.20; 0.80)

Table 6: Median and 95% PIs for a series of performance statistics for CMP2a$_{135}$ under the RS and for a robustness test in which all the inshore quota is allocated to offshore trawl.

MP:		CMP2a$_{135}$		Inshore trawl quota allocated to offshore trawl (tuned to Base Risk)	
C_{2014}		**155.3**		**155.3**	
C_{2015}	BS	147.5	(147.5; 150.0)	147.5	(147.5; 150.0)
C_{2016}	BS	140.1	(140.1; 144.8)	140.1	(140.1; 142.5)
C_{2017}	BS	133.1	(133.1; 150.0)	133.1	(133.1; 148.1)
B^{sp}_{2014}/B_{MSY}	para	0.83	(0.63; 1.26)	0.83	(0.63; 1.26)
B^{sp}_{2015}/B_{MSY}	para	0.74	(0.59; 1.09)	0.73	(0.58; 1.07)
B^{sp}_{2016}/B_{MSY}	para	0.68	(0.52; 1.08)	0.67	(0.50; 1.05)
B^{sp}_{2017}/B_{MSY}	para	0.68	(0.50; 1.23)	0.66	(0.49; 1.20)
avC: 2015-2024	BS	**135.0**	(119.3; 147.9)	**132.6**	(118.5; 146.7)
C_{low}: 2015-2034)	BS	116.4	(94.9; 135.4)	114.1	(93.0; 133.1)
AAV: 2015-2034	BS	0.04	(0.02; 0.05)	0.04	(0.02; 0.06)
$B^{sp}_{low}/B^{sp}_{2014}$	para	0.82	(0.53; 1.00)	0.80	(0.50; 1.00)
$B^{sp}_{low}/B^{sp}_{2014}$	cap	1.02	(0.75; 1.10)	1.04	(0.77; 1.10)
$B^{sp}_{low}/B^{sp}_{2007}$	para	1.35	(0.81; 1.66)	1.31	(0.75; 1.65)
$B^{sp}_{low}/B^{sp}_{2007}$	cap	1.68	(1.29; 1.91)	1.70	(1.32; 1.93)
B^{sp}_{2024}/B_{MSY}	para	1.06	**(0.64;** 2.16)	1.08	**(0.64;** 2.19)
B^{sp}_{2024}/B_{MSY}	cap	3.41	(1.75; 5.07)	3.57	(1.83; 5.22)
$CPUE_{2024}/CPUE_{2013}$	BS	1.11	(0.90; 1.40)	1.14	(0.91; 1.43)
E_{2024}/E_{2013}	BS	0.78	(0.60; 1.02)	0.74	(0.57; 0.99)
Prob decl >20% (2015-2017)		0.00		0.00	
Prob decl >20% (2016-2018)		0.00		0.00	
Prob decl>20% (2015-2032)		0.00	(0.00; 0.00)	0.00	(0.00; 0.00)

Table 7: Median and 95% PIs for a series of performance statistics for CMP2a$_{135}$ under **RS1** and for a robustness test (based on RS1 too) in which OMP-2010 is assumed to have had a cap of 150 000t (tuned to RS1 Base Risk - BR).

MP:		CMP2a$_{135}$		What if OMP-2011 had a 150 000t cap	
C_{2014}		**155.3**		**150.0**	
C_{2015}	BS	147.5	(147.5; 150.0)	142.5	(142.5; 150.0)
C_{2016}	BS	140.1	(140.1; 144.6)	135.4	(135.4; 146.4)
C_{2017}	BS	133.1	(133.1; 149.1)	128.6	(128.6; 150.0)
B^{sp}_{2014}	para	129.7	(129.7; 129.7)	131.9	(131.9; 131.9)
B^{sp}_{2014}	cap	173.7	(173.7; 173.7)	174.2	(174.2; 174.2)
B^{sp}_{2014}/B_{MSY}	para	0.85		0.86	
B^{sp}_{2015}/B_{MSY}	para	0.74	(0.69; 0.81)	0.77	(0.72; 0.83)
B^{sp}_{2016}/B_{MSY}	para	0.68	(0.57; 0.82)	0.72	(0.61; 0.86)
B^{sp}_{2017}/B_{MSY}	para	0.67	(0.51; 0.91)	0.72	(0.56; 0.96)
avC: 2015-2024	BS	**132.5**	(119.5; 147.1)	**134.2**	(118.6; 147.0)
C_{low}: 2015-2034)	BS	114.1	(95.1; 130.1)	116.1	(96.7; 131.9)
AAV: 2015-2034	BS	0.04	(0.02; 0.05)	0.04	(0.02; 0.05)
$B^{sp}_{low}/B^{sp}_{2014}$	para	0.77	(0.56; 0.93)	0.79	(0.62; 0.95)
$B^{sp}_{low}/B^{sp}_{2014}$	cap	0.97	(0.81; 1.07)	0.95	(0.79; 1.07)
$B^{sp}_{low}/B^{sp}_{2007}$	para	1.35	(0.98; 1.63)	1.40	(1.10; 1.69)
$B^{sp}_{low}/B^{sp}_{2007}$	cap	1.68	(1.40; 1.85)	1.66	(1.38; 1.86)
B^{sp}_{2024}/B_{MSY}	para	1.05	**(0.71;** 1.62)	1.04	**(0.71;** 1.63)
B^{sp}_{2024}/B_{MSY}	cap	2.35	(1.96; 2.84)	2.35	(1.97; 2.83)
$CPUE_{2024}/CPUE_{2013}$	BS	1.05	(0.92; 1.27)	1.05	(0.90; 1.26)
E_{2024}/E_{2013}	BS	0.80	(0.62; 1.02)	0.86	(0.69; 1.08)
Prob decl >20% (2015-2017)		0.00		0.00	
Prob decl >20% (2016-2018)		0.00		0.00	
Prob decl>20% (2015-2032)		0.00	(0.00; 0.00)	0.00	(0.00; 0.00)

Table 8: Median and 95% PIs for a series of performance statistics for **CMP2a_{135}** and **CMP3c_{135} (with a soft cap at 125 000t -** which includes a provision to allow override of the 5% maximum downward constraint of interannual changes in the TAC) under **RS1** and for robustness test **B.others.2** (decrease in *K* in the past, also based on RS1).

	CMP	CMP2a_{135}				CMP3c_{135} (with 125 000t soft cap)			
	OM	RS1		30% *K* decrease in the past (based on RS1)		RS1		30% *K* decrease in the past (based on RS1)	
C_{2014}		**155.3**		155.3	(147.7*; 155.3)	**155.3**		155.3	(147.7*; 155.3)
C_{2015}	BS	147.5	(147.5; 150.0)	147.5	(137.2; 147.5)	147.5	(147.5; 150.0)	147.5	(137.2; 147.5)
C_{2016}	BS	140.1	(140.1; 144.6)	140.1	(130.3; 140.1)	140.1	(140.1; 143.2)	140.1	(130.3; 140.1)
C_{2017}	BS	133.1	(133.1; 149.1)	133.1	(121.1; 133.1)	133.1	(133.1; 147.0)	133.1	(96.7; 133.1)
B^{sp}_{2014}/B_{MSY}	para	0.85	(0.85; 0.85)	0.82	(0.82; 0.82)	0.85	(0.85; 0.85)	0.82	(0.82; 0.82)
B^{sp}_{2015}/B_{MSY}	para	0.74	(0.69; 0.81)	0.60	(0.52; 0.72)	0.74	(0.69; 0.81)	0.60	(0.52; 0.72)
B^{sp}_{2016}/B_{MSY}	para	0.68	(0.57; 0.82)	0.45	(0.38; 0.71)	0.68	(0.57; 0.82)	0.45	(0.38; 0.71)
B^{sp}_{2017}/B_{MSY}	para	0.67	(0.51; 0.91)	0.38	(0.30; 0.90)	0.67	(0.51; 0.91)	0.38	(0.30; 0.90)
avC: 2015-2024	BS	**132.5**	(119.5; 147.1)	**118.4**	(106.2; 141.0)	**132.8**	(125.9; 146.5)	**104.9**	(75.1; 140.6)
C_{low}: 2015-2034)	BS	114.1	(95.1; 130.1)	87.3	(64.0; 116.6)	125.0	(99.6; 129.4)	55.0	(38.2; 125.0)
AAV: 2015-2034	BS	0.04	(0.02; 0.05)	0.06	(0.04; 0.07)	0.03	(0.02; 0.05)	0.10	(0.03; 0.13)
$B^{sp}_{low}/B^{sp}_{2014}$	para	0.77	(0.56; 0.93)	0.39	(0.12; 0.80)	0.77	(0.57; 0.94)	0.40	(0.20; 0.73)
$B^{sp}_{low}/B^{sp}_{2014}$	cap	0.97	(0.81; 1.07)	0.90	(0.47; 1.06)	0.96	(0.81; 1.07)	0.91	(0.60; 1.06)
$B^{sp}_{low}/B^{sp}_{2007}$	para	1.35	(0.98; 1.63)	0.49	(0.15; 1.01)	1.34	(0.99; 1.64)	0.50	(0.25; 0.93)
$B^{sp}_{low}/B^{sp}_{2007}$	cap	1.68	(1.40; 1.85)	1.58	(0.82; 1.85)	1.67	(1.41; 1.85)	1.59	(1.05; 1.86)
B^{sp}_{2024}/B_{MSY}	para	1.05	(**0.71;** 1.62)	0.73	(**0.12;** 2.49)	1.03	(**0.61;** 1.58)	1.27	(**0.49;** 2.81)
B^{sp}_{2024}/B_{MSY}	cap	2.35	(1.96; 2.84)	1.66	(0.93; 2.26)	2.35	(1.94; 2.81)	1.86	(1.46; 2.43)
$CPUE_{2024}/CPUE_{2013}$	BS	1.05	(0.92; 1.27)	1.02	(0.62; 1.59)	1.05	(0.91; 1.28)	1.21	(0.84; 1.68)
E_{2024}/E_{2013}	BS	0.80	(0.62; 1.02)	0.64	(0.47; 0.88)	0.82	(0.69; 1.02)	0.46	(0.23; 0.93)
Prob decl >20% (2015-2017)		0.00		0.08*		0.00		0.13	
Prob decl >20% (2016-2018)		0.00		0.09*		0.00		0.46	
Prob decl>20% (2015-2032)		0.00	(0.00; 0.00)	0.00	(0.00; 0.00)	0.00	(0.00; 0.06)	0.17	(0.00; 0.28)

* The C2014 lower 2.5%ile below 155 300t and the non-zero values for the probability of a decline in TAC of more than 20% over 4 years ("Prob decl >20%") come from the fact that in some cases, the TAC cannot be caught (*F*>0.9), since the 5% downward constraint would preclude a decline of more than 20% over 4 years.

Table 9: Median and 95% PIs for a series of performance statistics for CMP2a$_{135}$ and the alternative CMP with a soft cap at 125 000t, CMP3a$_{135}$, (which includes a provision to allow override of the 5% maximum downward constraint of interannual changes in the TAC) under the RS and robustness test C.future.5 (decrease in *K* in the future, based on the whole RS). Results for a C=0 scenario are included here to show the highest level the resource could attain were this change to occur.

CMP		CMP2a135				CMP3c$_{135}$ (with 125 000t soft cap)				C=0	
	OM	RS		20% *K* decrease in the future (based on RS)		RS		20% *K* decrease in the future (based on RS)		20% *K* decrease in the future (based on RS)	
C_{2014}		**155.3**		**155.3**		**155.3**		**155.3**		**155.3**	
C_{2015}	BS	147.5	(147.5; 150.0)	147.5	(147.5; 150.0)	147.5	(147.5; 147.5)	147.5	(147.5; 150.0)	**0.0**	
C_{2016}	BS	140.1	(140.1; 144.8)	140.1	(140.1; 144.8)	140.1	(140.1; 140.1)	140.1	(140.1; 142.5)	**0.0**	
C_{2017}	BS	133.1	(133.1; 150.0)	133.1	(126.4; 150.0)	133.1	(133.1; 140.8)	133.1	(126.4; 150.0)	**0.0**	
B^{sp}_{2014}/B_{MSY}	para	0.83	(0.63; 1.26)	0.83	(0.63; 1.26)	0.83	(0.63; 1.26)	0.83	(0.63; 1.26)	0.83	(0.63; 1.26)
B^{sp}_{2015}/B_{MSY}	para	0.74	(0.59; 1.09)	0.74	(0.59; 1.09)	0.74	(0.59; 1.09)	0.74	(0.59; 1.09)	0.74	(0.59; 1.09)
B^{sp}_{2016}/B_{MSY}	para	0.68	(0.52; 1.08)	0.68	(0.52; 1.08)	0.68	(0.52; 1.08)	0.68	(0.52; 1.08)	0.97	(0.67; 1.59)
B^{sp}_{2017}/B_{MSY}	para	0.68	(0.50; 1.23)	0.68	(0.50; 1.23)	0.68	(0.50; 1.23)	0.68	(0.50; 1.23)	1.31	(0.80; 2.37)
avC: 2015-2024	BS	**135.0**	(119.3; 147.9)	**117.6**	(102.0; 138.6)	**131.4**	(106.6; 145.0)	**112.1**	(80.7; 136.8)	**0.0**	(0.0; 0.0)
C_{low}: 2015-2034)	BS	116.4	(94.9; 135.4)	58.2	(44.9; 82.2)	125.0	(67.1; 129.1)	33.6	(18.1; 55.5)	0.0	(0.0; 0.0)
AAV: 2015-2034	BS	0.04	(0.02; 0.05)	0.07	(0.05; 0.08)	0.03	(0.01; 0.08)	0.11	(0.08; 0.14)	0.00	(0.00; 0.00)
$B^{sp}_{low}/B^{sp}_{2014}$	para	0.82	(0.53; 1.00)	0.24	(0.08; 0.54)	0.82	(0.54; 1.00)	0.27	(0.11; 0.56)	0.91	(0.73; 1.01)
$B^{sp}_{low}/B^{sp}_{2014}$	cap	1.02	(0.75; 1.10)	0.39	(0.20; 0.62)	1.03	(0.75; 1.10)	0.43	(0.24; 0.65)	0.63	(0.45; 1.09)
$B^{sp}_{low}/B^{sp}_{2007}$	para	1.35	(0.81; 1.66)	0.40	(0.12; 0.88)	1.36	(0.81; 1.67)	0.47	(0.16; 0.90)	1.54	(1.10; 1.69)
$B^{sp}_{low}/B^{sp}_{2007}$	cap	1.68	(1.29; 1.91)	0.66	(0.35; 0.95)	1.69	(1.30; 1.92)	0.72	(0.42; 1.05)	1.04	(0.75; 1.74)
B^{sp}_{2024}/B_{MSY}	para	1.06	**(0.64;** 2.16)	0.24	**(0.10;** 0.60)	1.13	**(0.61;** 2.38)	0.27	**(0.15;** 0.60)	2.27	**(1.56;** 3.18)
B^{sp}_{2024}/B_{MSY}	cap	3.41	(1.75; 5.07)	1.36	(0.55; 2.01)	3.45	(1.78; 5.12)	1.40	(0.63; 2.16)	2.55	(1.32; 4.35)
$CPUE_{2024}/CPUE_{2013}$	BS	1.11	(0.90; 1.40)	0.40	(0.27; 0.58)	1.14	(0.90; 1.42)	0.43	(0.30; 0.60)	1.00	(0.64; 1.36)
E_{2024}/E_{2013}	BS	0.78	(0.60; 1.02)	1.32	(0.96; 2.16)	0.75	(0.42; 0.96)	0.77	(0.27; 1.72)	0.00	(0.00; 0.00)
Prob decl >20% (2015-2017)		0.00		0.00		0.00		0.00		1.00	
Prob decl >20% (2016-2018)		0.00		0.16*		0.00		0.06		0.00	
Prob decl>20% (2015-2032)		0.00	(0.00; 0.00)	0.00	(0.00; 0.17*)	0.00	(0.00; 0.11)	0.28	(0.17; 0.39)	0.00	(0.00; 0.00)

* The non-zero values come from the fact that in some cases, the TAC cannot be caught (*F*>0.9), since the 5% downward constraint would preclude a decline of more than 20% over 4 years.

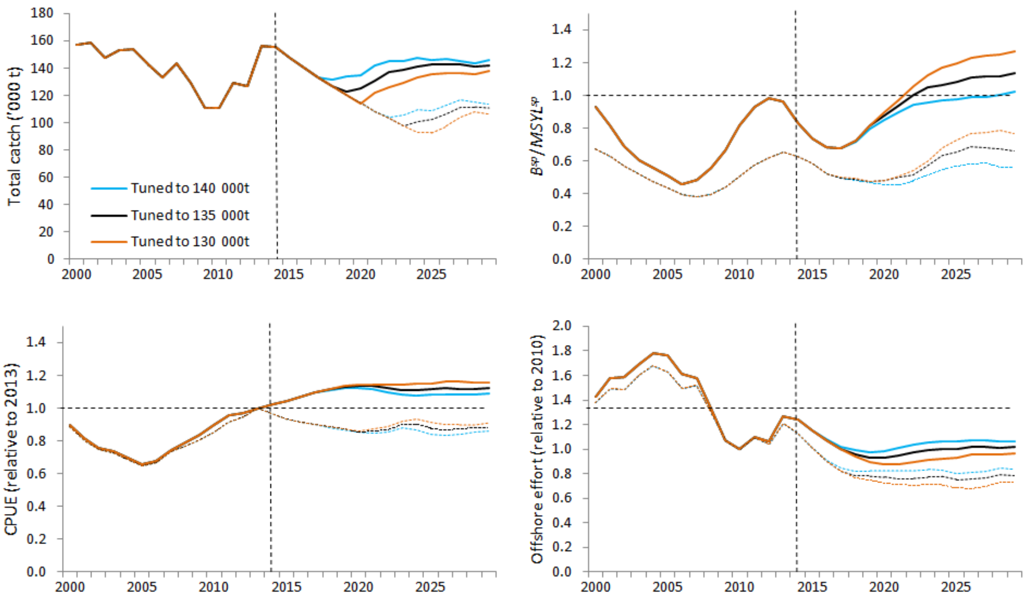


Figure 1: Medians (full lines) and lower 2.5%iles (dotted lines) for total catch (top row, LHS), *M. paradoxus* spawning biomass (relative to MSYL level - top row, RHS), CPUE (relative to 2013, bottom row, LHS) and effort (relative to 2010, bottom row, RHS) for the RS under **CMP2a$_{140}$**, **CMP2a$_{135}$** and **CMP2a$_{130}$** (2015-2024 average TAC of 140 000t, 135 000t and 130 000t respectively).

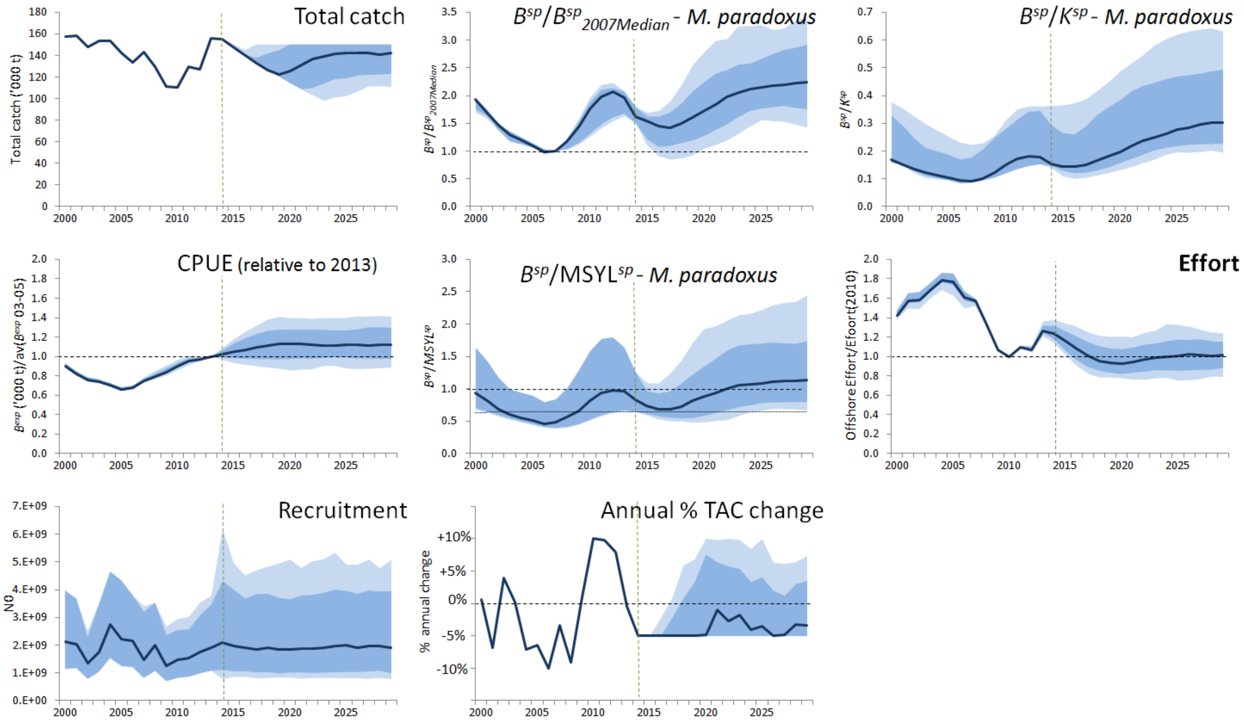


Figure 2: 95% and 75% PI envelopes and medians for the RS under **CMP2a$_{135}$** (2015-2024 average TAC of 135 000t).

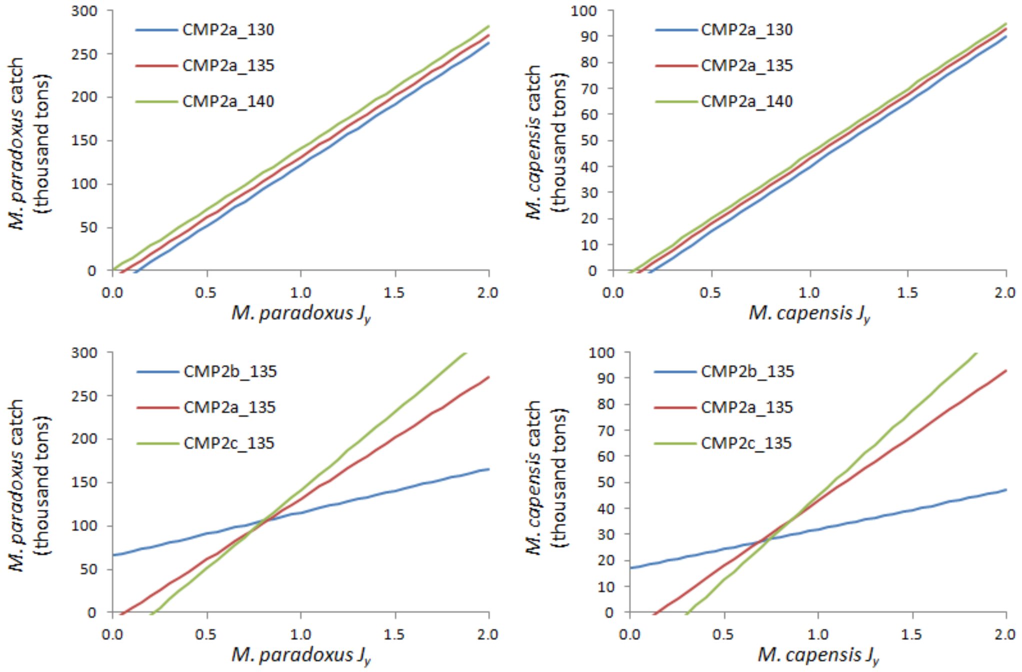


Figure 3: Basic catch (before application of TAC change constraints) as a function of the relative index level *J* (see equation 2) for each species, for a series of CMPs. The upper plots change the 2015-2024 average TAC target, whereas the lower plots maintain this target at 135 thousand tons while varying the gradient of the control rule.

Figure 4: Medians (full lines) and lower 2.5%iles (dotted lines) for total catch (top row, LHS), *M. paradoxus* spawning biomass (relative to MSYL level - top row, RHS), CPUE (relative to 2013, bottom row, LHS) and effort (relative to 2010, bottom row, RHS) for the RS under **CMP2a$_{135}$**, **CMP2b$_{135}$** (lower b^{spp} gradient parameter) and **CMP2c$_{135}$** (higher b^{spp} gradient parameter).

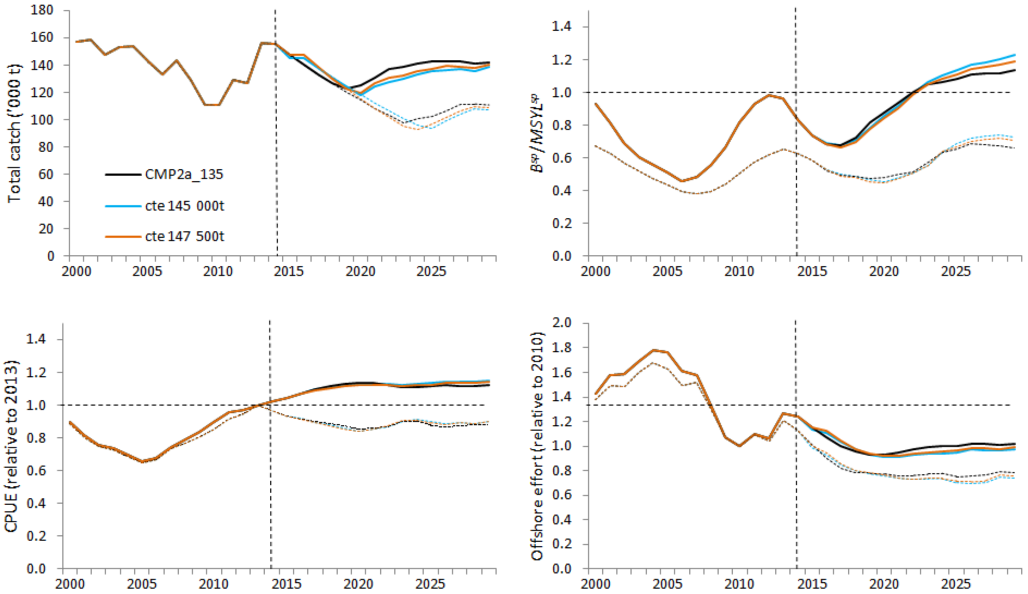


Figure 5: Medians (full lines) and lower 2.5%iles (dotted lines) for total catch (top row, LHS), *M. paradoxus* spawning biomass (relative to MSYL level - top row, RHS), CPUE (relative to 2013, bottom row, LHS) and effort (relative to 2010, bottom row, RHS) for the RS under **CMP2a$_{135}$** and **two alternative CMPs with fixed catches in 2015 and 2016.**

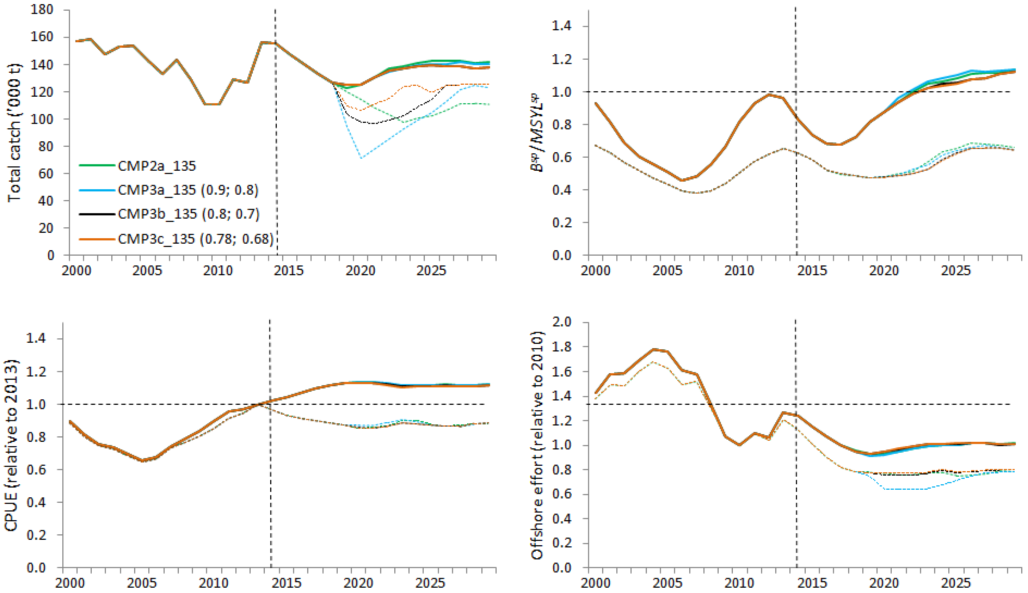


Figure 6: Medians (full lines) and lower 2.5%iles (dotted lines) for total catch (top row, LHS), *M. paradoxus* spawning biomass (relative to MSYL level - top row, RHS), CPUE (relative to 2013, bottom row, LHS) and effort (relative to 2010, bottom row, RHS) for the RS under **CMP2a$_{135}$** and three **alternative CMPs with a soft lower TAC cap at 125 000t**.

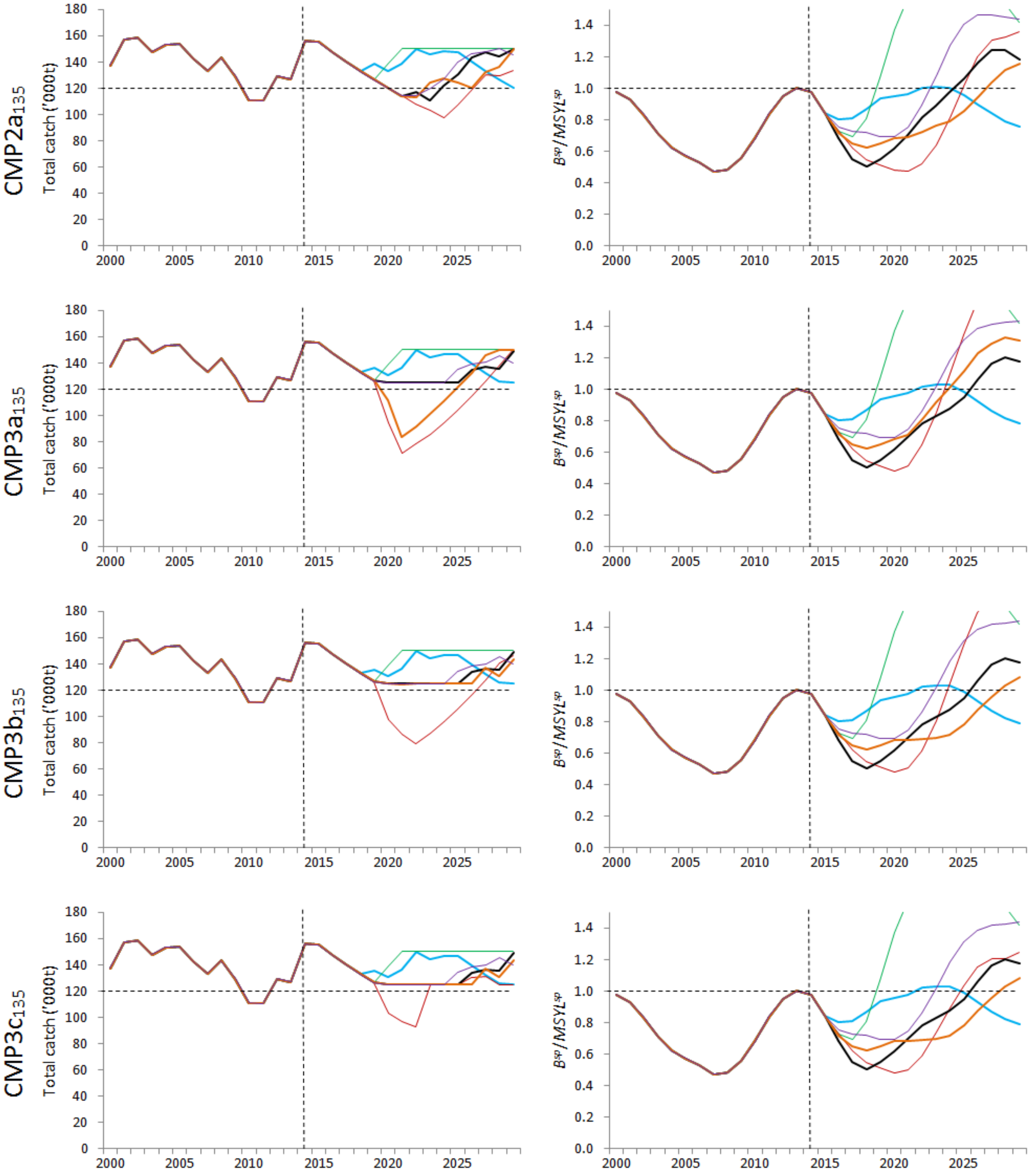


Figure 7: Worm plots for total catch (LHS) and *M. paradoxus* spawning biomass (relative to MSYL level - RHS) for the RS under **CMP2a$_{135}$** (top row) and the three **alternative CMPs with a soft lower TAC cap at 125 000t**.

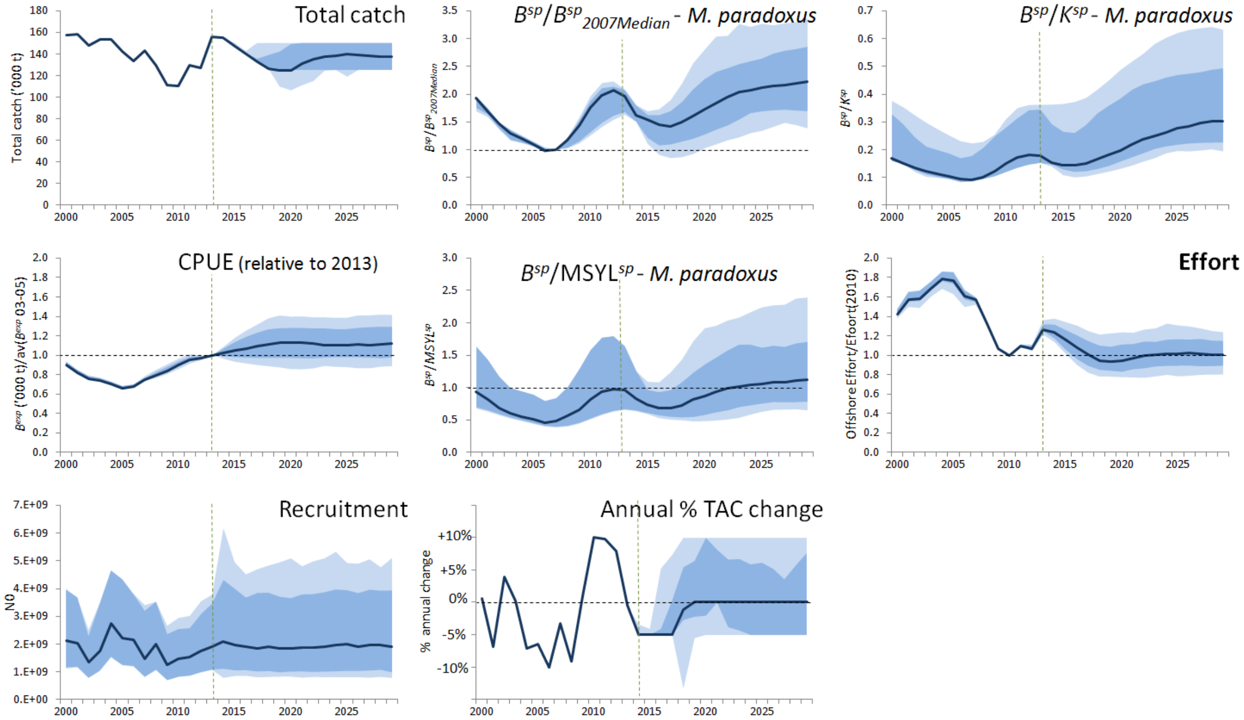


Figure 8: **Figure 2**: 95% and 75% PI envelopes and medians for the RS under **CMP3c$_{135}$** (2015-2024 average TAC of 135 000t).

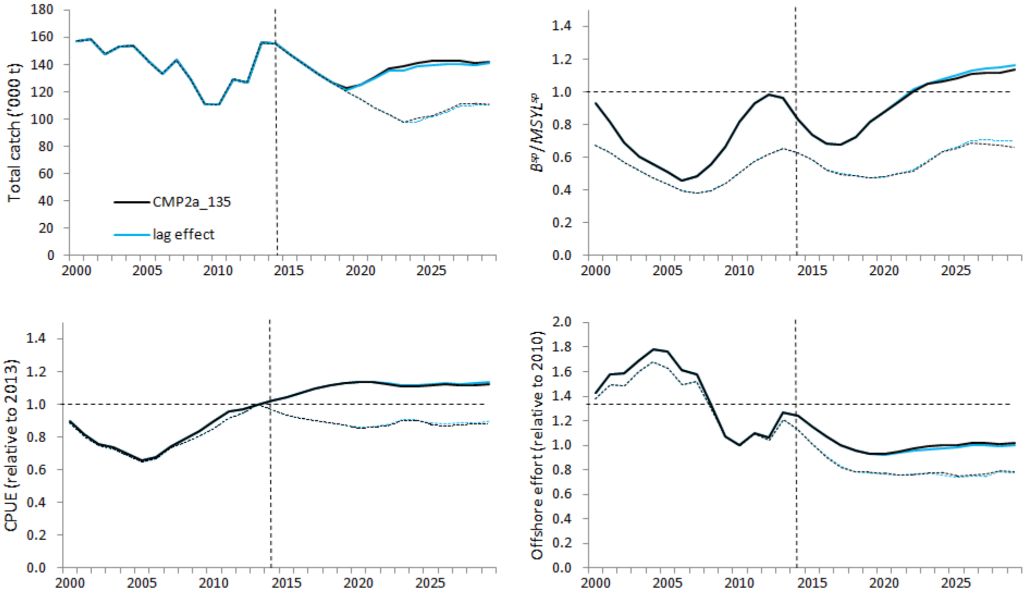


Figure 9: Medians (full lines) and lower 2.5%iles (dotted lines) for total catch (top row, LHS), *M. paradoxus* spawning biomass (relative to MSYL level - top row, RHS), CPUE (relative to 2013, bottom row, LHS) and effort (relative to 2010, bottom row, RHS) for the RS under **CMP2a$_{135}$** and the **alternative CMP attempting to take account of the lag effect**.

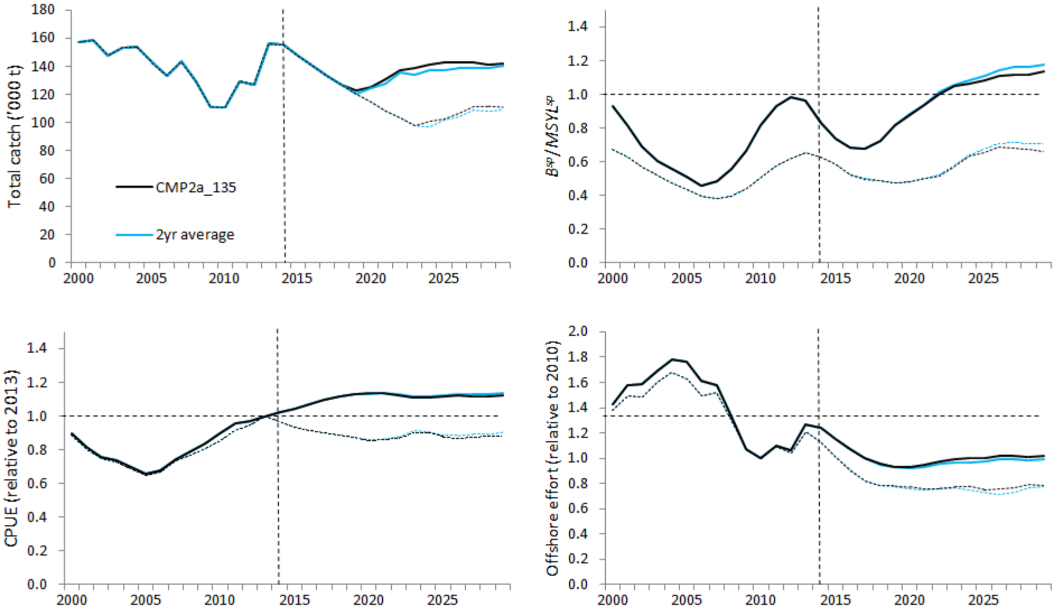


Figure 10: Medians (full lines) and lower 2.5%iles (dotted lines) for total catch (top row, LHS), *M. paradoxus* spawning biomass (relative to MSYL level - top row, RHS), CPUE (relative to 2013, bottom row, LHS) and effort (relative to 2010, bottom row, RHS) for the RS under **CMP2a$_{135}$** and the **alternative CMP in which the average indices are based on a two-year average**.

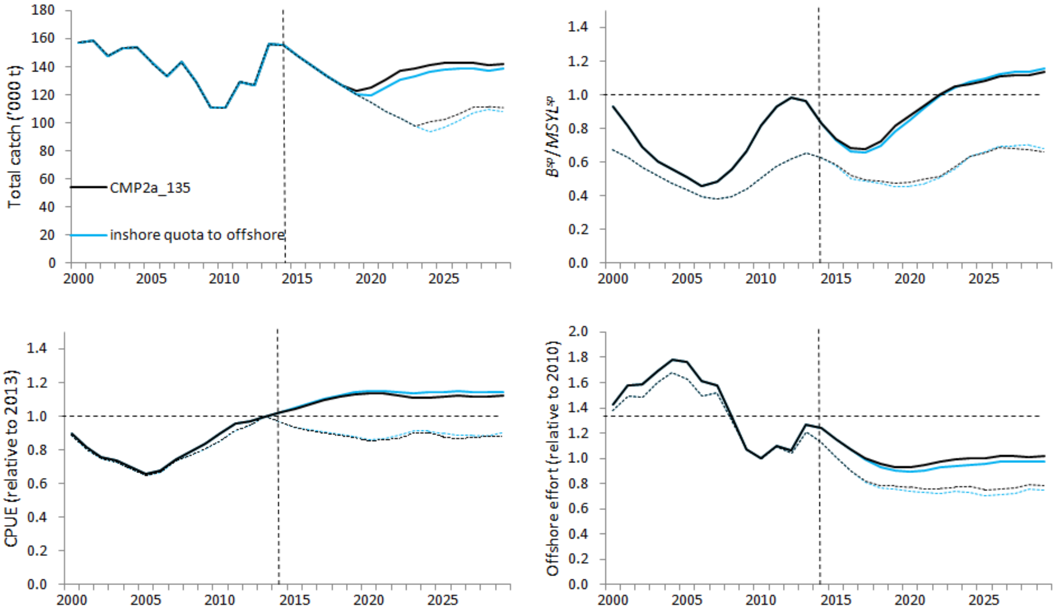


Figure 11: Medians (full lines) and lower 2.5%iles (dotted lines) for total catch (top row, LHS), *M. paradoxus* spawning biomass (relative to MSYL level - top row, RHS), CPUE (relative to 2013, bottom row, LHS) and effort (relative to 2010, bottom row, RHS) for the RS under CMP2a$_{135}$ and the sensitivity in which all the future inshore quotas are taken by the offshore fleet.

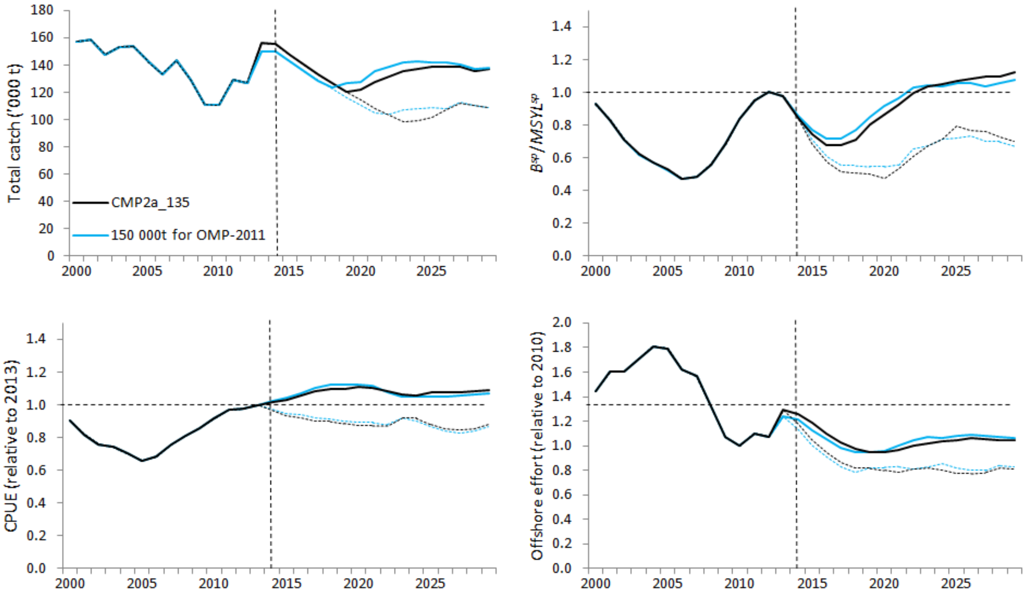


Figure 12: Medians (full lines) and lower 2.5%iles (dotted lines) for total catch (top row, LHS), *M. paradoxus* spawning biomass (relative to MSYL level - top row, RHS), CPUE (relative to 2013, bottom row, LHS) and effort (relative to 2010, bottom row, RHS) for **RS1** under CMP2a$_{135}$ and the sensitivity in which OMP-2011 is taken to have had a cap at 150 000t.

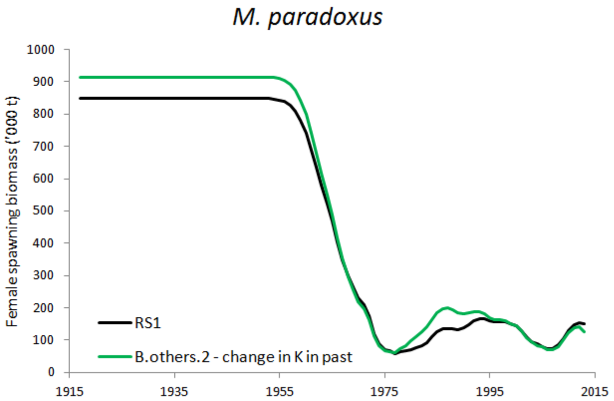


Figure 13: Female spawning biomass trajectories for RS1 and robustness test B.other.2 for which a 30% decrease in carrying capacity (for both species) is assumed between 1980 and 2000.

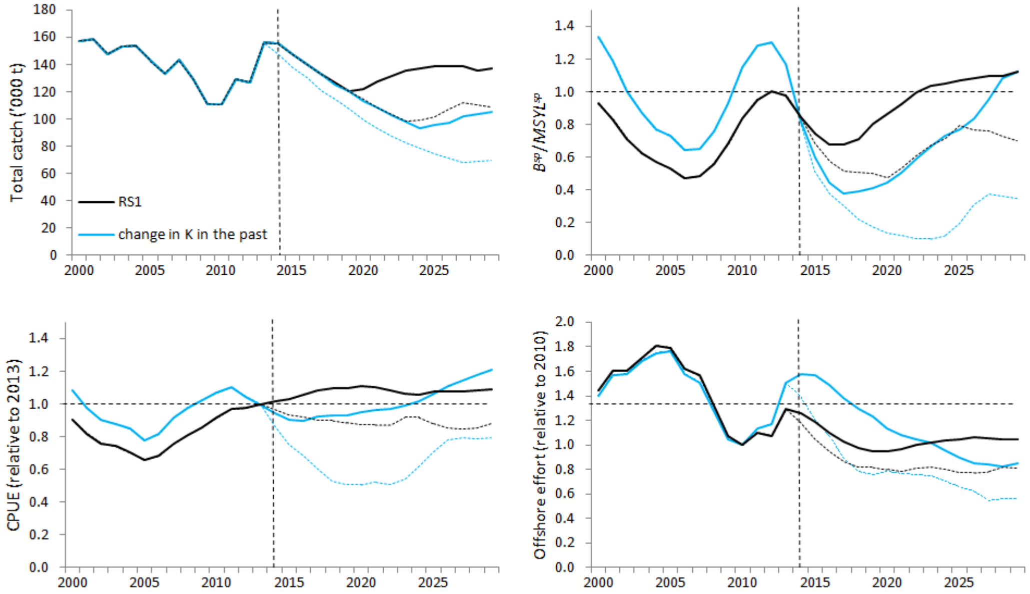


Figure 14a: Medians (full lines) and lower 2.5%iles (dotted lines) for total catch (top row, LHS), *M. paradoxus* spawning biomass (relative to MSYL level - top row, RHS), CPUE (relative to 2013, bottom row, LHS) and effort (relative to 2010, bottom row, RHS) under **CMP2a$_{135}$** for **RS1** and **robustness test B.others.2 (change in *K* in the past) (based on RS1).**

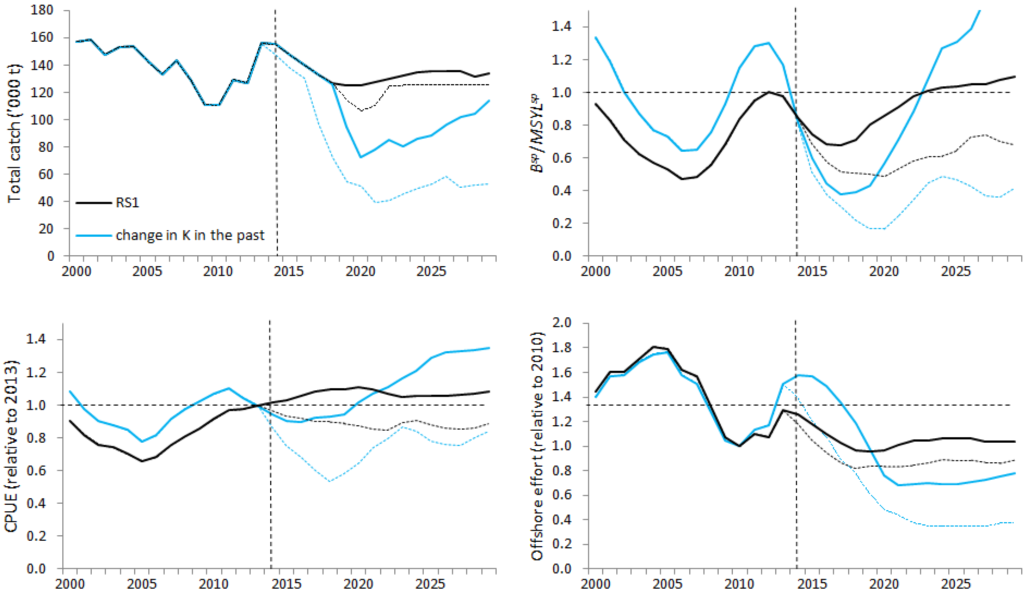


Figure 14b: Medians (full lines) and lower 2.5%iles (dotted lines) for total catch (top row, LHS), *M. paradoxus* spawning biomass (relative to MSYL level - top row, RHS), CPUE (relative to 2013, bottom row, LHS) and effort (relative to 2010, bottom row, RHS) under **CMP3c$_{135}$ (with a soft cap at 125 000t**) for **RS1** and **robustness test B.others.2 (change in *K* in the past) (based on RS1).**

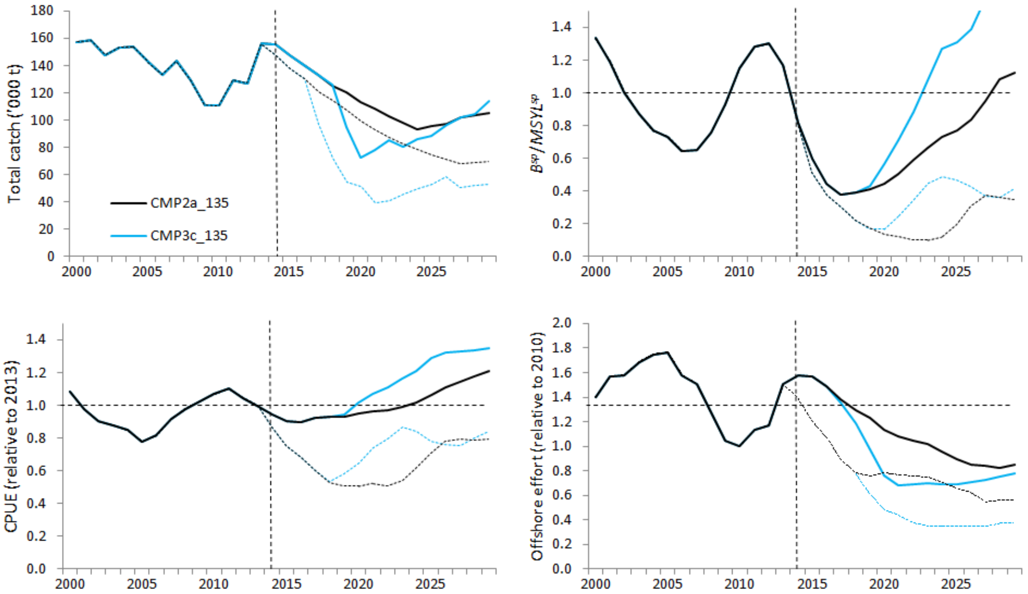


Figure 14c: Medians (full lines) and lower 2.5%iles (dotted lines) for total catch (top row, LHS), *M. paradoxus* spawning biomass (relative to MSYL level - top row, RHS), CPUE (relative to 2013, bottom row, LHS) and effort (relative to 2010, bottom row, RHS) under **CMP2a135** and **CMP3c$_{135}$ (with a soft cap at 125 000t**) for **robustness test B.others.2 (change in *K* in the past) (based on RS1).**

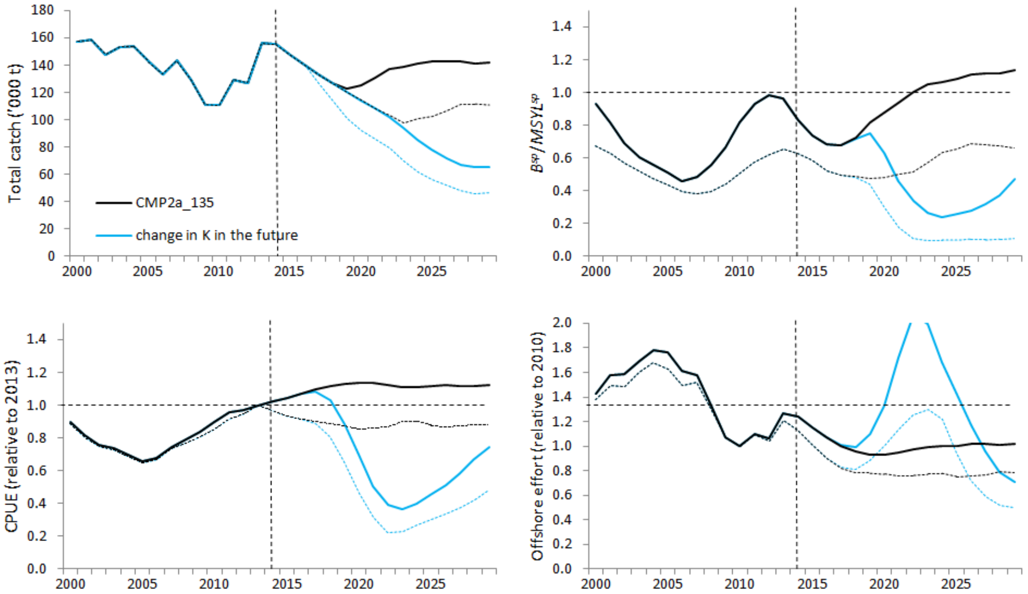


Figure 15a: Medians (full lines) and lower 2.5%iles (dotted lines) for total catch (top row, LHS), *M. paradoxus* spawning biomass (relative to MSYL level - top row, RHS), CPUE (relative to 2013, bottom row, LHS) and effort (relative to 2010, bottom row, RHS) under **CMP2a$_{135}$** for the **RS** and **robustness test C.future.5 (change in *K* in the future) (based on RS).**

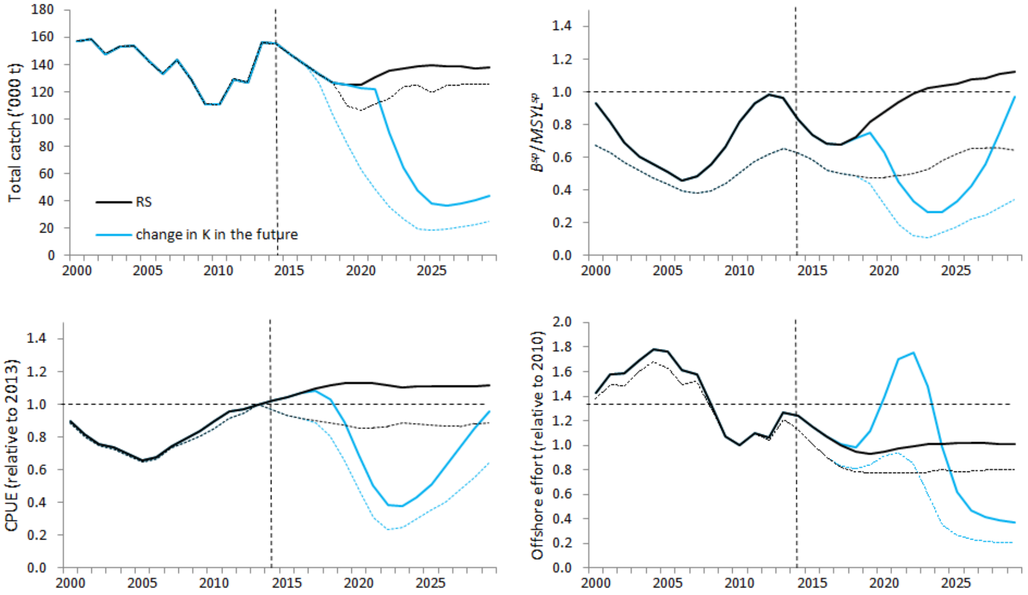


Figure 15b: Medians (full lines) and lower 2.5%iles (dotted lines) for total catch (top row, LHS), *M. paradoxus* spawning biomass (relative to MSYL level - top row, RHS), CPUE (relative to 2013, bottom row, LHS) and effort (relative to 2010, bottom row, RHS) under **CMP3c$_{135}$ (with a soft cap at 125 000t**) for the **RS** and **robustness test C.future.5 (change in *K* in the future) (based on RS).**

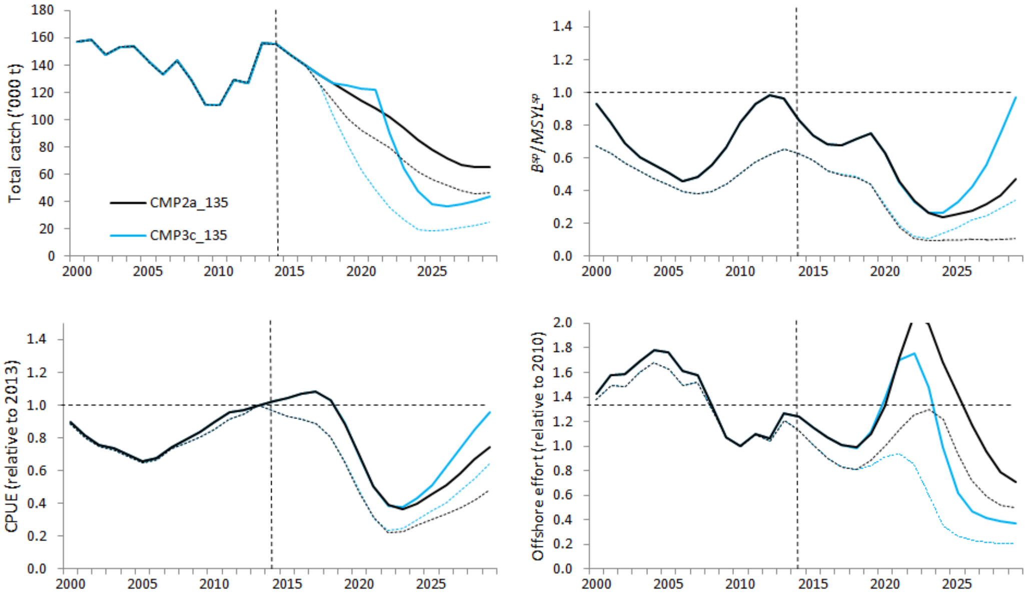


Figure 15c: Medians (full lines) and lower 2.5%iles (dotted lines) for total catch (top row, LHS), *M. paradoxus* spawning biomass (relative to MSYL level - top row, RHS), CPUE (relative to 2013, bottom row, LHS) and effort (relative to 2010, bottom row, RHS) **robustness test C.future.5 (change in *K* in the future) (based on RS)** for **CMP2a135** and **CMP3c$_{135}$ (with a soft cap at 125 000t**).

Appendix A

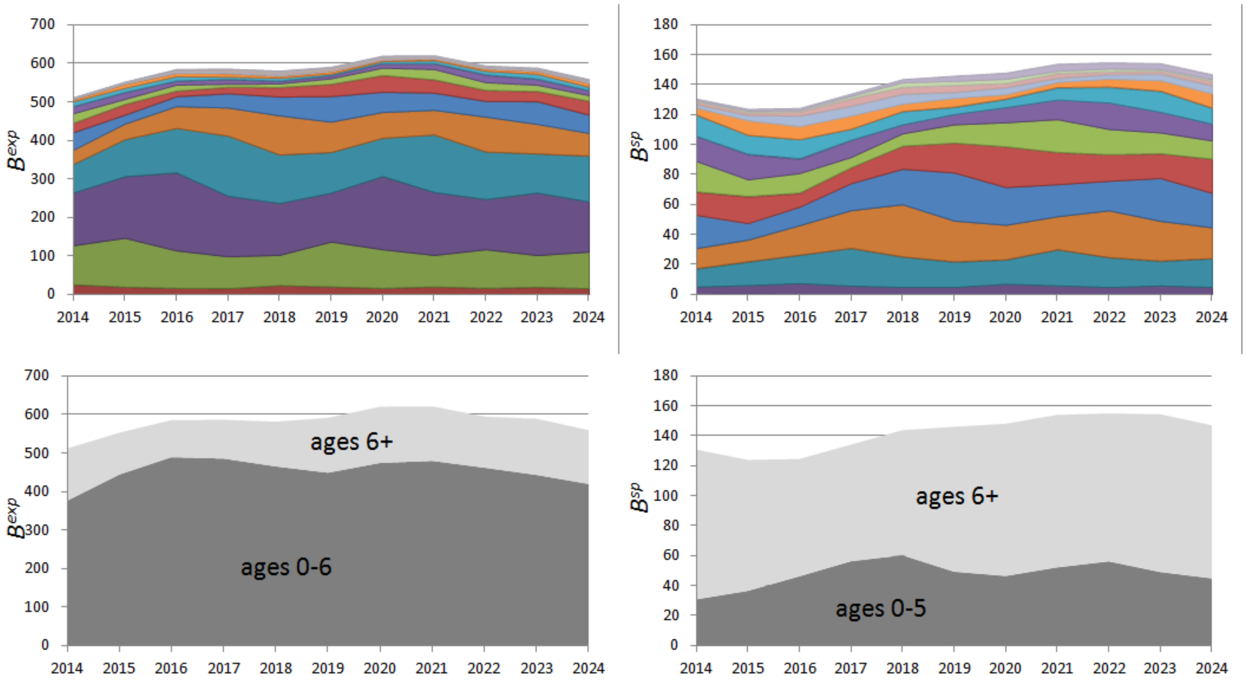


Figure A1: Projected *M. paradoxus* exploitable and spawning biomasses by age (top row, the shaded areas go from age 0 at the bottom to age 15+ at the top - note that ages 0 and 1 (bottom red and green areas in the B^{exp} plot) are basically absent in the B^{sp} plot) for one example simulation under CMP2a$_{135}$.