Results for the revised set of CMPs, including a CMP with no cap

A. Ross-Gillespie and D.S. Butterworth[1]

Email: mlland028@myuct.ac.za

Summary

Performance statistics are contrasted for seven CMPs: three options for the b control parameter crossed with two options for the cap on the TAC, and further a no cap option for the b+5% option. Despite a higher average catch, the no cap option seems undesirable because of poor lower 5%ile depletion and high AAV values. Instances of low 5%ile depletion values for *M. capensis* are shown to be linked to three likely less plausible OMs amongst the nine OMs that make up the Reference Set. However, in those cases, with the 2017 starting *M. capensis* spawning biomasses below B_{MSY}, the CMPs would seem to secure a recovery towards B_{MSY}.

Introduction

Results are shown for projections under seven CMPs, all incorporating a rule that the 2019 and 2020 TACs are fixed at the 2018 TAC value increased by 10%. There are two options for a cap (150 000t and 160 000t) and three options for the tuning parameter *b* (same as OMP2014, increased by 5% and increased by 10%) resulting in six CMPs. Additionally, a CMP is tested where there is no cap and *b* is increased by 5%.

Results

The results can be divided into three sections.

Main results

The primary performance statistics for the seven CMPs are listed in Table 1, while Table 2 lists catch, effort and CPUE output. Graphic illustrations of the performance statistics for first six CMPs (i.e. excluding the no cap CMP) are given in Figure 1a, while those for the no cap CMP are contrasted with the 150 000t and 160 000t caps in Figure 1b for the *b*+5% variant. Figure 2 plots the projected TACs for each of the next four years for the seven CMPs, while Figure 3 plots the mean and median "catch trajectories"[2] for the next 25 years along with probability envelopes and worm plots of a random selection of simulations. Figure 4 plots the median "trajectories", probability envelopes and some worm plots for B/B_{MSY}, effort and CPUE. Note that biomass B refers to (female) spawning biomass.

Results for the "pessimistic" M. capensis OMs

At the last DWG meeting, the issue was raised that the *M. capensis* depletion statistics span a very large range, with the lower end of the probability intervals often well below one. This large range is due to the fact that six of the RS OMs estimate an optimistic starting (2017) status for the *M. capensis* resource, while the remaining three (two Beverton-Holt with *h* fixed at 0.70 and one Beverton-Holt with *h* fixed at 0.90) estimate the B_{2017}/B_{MSY} to lie below one. Table 3 lists a selection of performance statistics for three groupings: an equal weighting across all nine RS models, an equal weighting across the six "optimistic" OMs and an equal weighting across the three "pessimistic" OMs. Figure 5 contrasts the performance statistics from these three groups and Figure 6 shows the (female) spawning biomass trajectories for the first CMP with a cap of 150 000t and no increase in *b*.

Further catch statistics

Table 4 lists some further TAC statistics relating to what is to be expected over the next four years, in particular whether the TAC is likely to go up or down after the proposed two years' fixed TAC in 2019 and 2020, and the extent

[1] Marine Resource Assessment and Management Group, Department of Mathematics and Applied Mathematics, University of Cape Town, Rondebosch.

[2] The reason for placing trajectories in quotes here is that the means and medians here do not reflect actual achieved trajectories in some simulation, but rather joining the mean or median values from the predicted distributions for successive future years.

to which the TAC is then likely to change. Figure 7 plots histograms for the catch over the next four years to help illustrate the statistics from Table 4.

For a small percentage of the simulations (of the order of 2-3%), not all TAC is caught when the fishing mortality rate becomes too large. The frequency and magnitude of this occurrence is reported in Table 5.

Discussion

A few key points evident from the results are listed below.

1. Note should be taken of the large variability in projected TACs illustrated in Figure 3 and Figure 7, as well as in future effort and CPUE in Figure 4 . The points made below are, however, based on means and medians across the simulations.
2. If the cap is removed, this results in higher TACs as might be expected, but also a higher AAV (which increases from 0.025 (0.008, 0.048) with a cap of 160 000t to 0.062 (0.050, 0.079) with the cap removed). Projected effort also increases with time, while CPUE is projected to trend down after an initial increase (Figure 4). Additionally, the *M. paradoxus* resource becomes more depleted, with the lower end of the 90% probability envelope for B_{2042}/B_{MSY} falling below one. It seems clearly advisable to keep some cap in place, so that this last "no cap" CMP will be disregarded from the further comparison discussed below.
3. Cap: 150 000t or 160 000t
    a. From a *M. paradoxus* resource status point of view, all six CMPs seem defensible, although with a cap of 160 000t the resource is likely to be slightly more depleted but still well above B_{MSY} at the end of the projection period.
    b. TAC is naturally projected to be higher with a cap of 160 000t, at the cost of a slightly higher AAV (Figure 1a), slightly higher effort (Table 2) and slightly lower CPUE (Table 2). These trade-offs need to be considered quantitatively: relatively speaking, increasing the cap from 150 000t to 160 000t is projected to lead to roughly a 4% higher average catch over the next 25 years, with roughly a 50% increase in AAV over the next 25 years, a 10% increase in effort after 25 years and just under a 6% decrease in CPUE after 25 years.
4. *b* parameter
    a. Increasing the *b* parameter also results in higher TACs as would be expected, but with generally lower AAVs as the cap limits are hit more frequently thus reducing the variance.
    b. Increasing *b* by 5 or 10% reduces the probability of TAC going down in 2021 (Figure 2 and Table 4).
5. *M. capensis* resource status
    a. The large range of possible *M. capensis* depletion values (Figure 1a) might seem somewhat concerning. However Figure 5 andFigure **6** show that this large range is entirely a result of three of the nine RS OMs, which estimate a much more pessimistic resource status for *M. capensis* than the other RS OMs. Currently, the statistics are based on an equal weighting across the nine RS models, but arguably the three Ricker models are more credible (their fits have higher likelihoods) given that the *h* value for the Beverton-Holt models tended to be unrealistically high when estimated so had to be fixed at 0.90 and 0.70 for greater plausibility. Most importantly though, the bottom plots in Figure 6 show that if the current *M. capensis* status is indeed poor, the population does recover towards B_{MSY} over time (at least under the first CMP).

Table 1: Performance statistics for the seven CMPs. All statistics are reported as medians of the equally weighted simulations from the nine RS models (i.e. medians of 9x100 values) with their 90% probability intervals, except for the second columns under TAC_{av}(25 yrs) and TAC_{av} (4yrs) where the means and standard deviations are also listed.

		M. paradoxus						*M. capensis*					
Cap	b	B_{2042}/B_{MSY}		B_{2022}/B_{MSY}		B_{low}/B_{MSY}		B_{2042}/B_{MSY}		B_{2022}/B_{MSY}		B_{low}/B_{MSY}	
150	+0%	2.93	(1.55,5.15)	2.12	(1.01,3.46)	1.57	(0.96,2.19)	3.06	(1.07,6.76)	2.95	(0.39,5.18)	2.44	(0.32,4.52)
	+5%	2.90	(1.51,5.15)	2.12	(1.01,3.46)	1.55	(0.92,2.18)	3.05	(1.05,6.76)	2.95	(0.39,5.18)	2.44	(0.32,4.52)
	+10%	2.87	(1.48,5.15)	2.12	(1.01,3.46)	1.53	(0.90,2.18)	3.04	(1.03,6.76)	2.94	(0.39,5.18)	2.44	(0.32,4.52)
160	+0%	2.71	(1.42,4.82)	2.11	(1.01,3.43)	1.50	(0.92,2.15)	3.01	(0.94,6.71)	2.95	(0.39,5.18)	2.41	(0.32,4.52)
	+5%	2.67	(1.37,4.81)	2.10	(1.01,3.43)	1.47	(0.90,2.15)	3. 01	(0.91,6.70)	2.94	(0.39,5.18)	2.40	(0.32,4.52)
	+10%	2.63	(1.31,4.81)	2.10	(1.01,3.43)	1.45	(0.86,2.14)	3.00	(0.89,6.67)	2.94	(0.38,5.18)	2.39	(0.32,4.52)
no cap	+5%	1.98	(0.95,3.42)	2.10	(1.01,3.43)	1.16	(0.73,1.79)	2.93	(0.47,6.62)	2.94	(0.39,5.18)	2.12	(0.31,4.52)

		Species combined											
		TAC_{av}(25 yrs)				TAC_{av} (4 yrs)							
Cap	b	Median	(90% P.I)	Mean	(sd)	Median	(90% P.I)	Mean	(sd)	AAV(25 years)		AAV(4 years)	
150	+0%	146.55	(135.43,149.70)	145.09	(4.89)	145.55	(140.21,148.22)	144.59	(3.66)	0.020	(0.005,0.043)	0.043	(0.031,0.056)
	+5%	147.58	(137.36,149.70)	146.03	(4.42)	146.53	(140.97,148.22)	145.26	(3.55)	0.017	(0.005,0.040)	0.037	(0.031,0.056)
	+10%	148.30	(139.00,149.70)	146.77	(3.99)	148.22	(141.21,148.22)	145.87	(3.39)	0.014	(0.005,0.038)	0.031	(0.031,0.056)
160	+0%	152.28	(138.47,158.87)	150.95	(6.70)	145.86	(140.21,153.22)	146.37	(5.50)	0.029	(0.008,0.050)	0.048	(0.038,0.063)
	+5%	154.08	(140.59,158.87)	152.33	(6.16)	148.13	(140.97,153.22)	147.50	(5.48)	0.025	(0.008,0.048)	0.048	(0.038,0.063)
	+10%	155.20	(142.55,158.87)	153.47	(5.66)	150.87	(141.21,153.22)	148.54	(5.29)	0.021	(0.008,0.045)	0.048	(0.038,0.063)
no cap	+5%	171.01	(146.18, 205.61)	172.42	(18.50)	148.16	(140.97,158.00)	149.01	(7.15)	0.062	(0.050,0.079)	0.054	(0.038,0.076)

Table 2: Print out of the catch, effort (taken to be proportional to *M. paradoxus* West Coast fishing mortality rate) and CPUE values after 4, 10, 15 and 25 years of projections. The values are the means for catch and medians for effort and CPUE of the equally weighted 9x100 values across the nine RS OMs. The 90% probability intervals are given in parentheses. Catch is in thousand tons, effort is reported relative to the 2017 values and CPUE relative to the 2016 value.

Cap	b	Catch in 2022 (4 years)	Catch in 2028 (10 years)	Catch in 2033 (15 years)	Catch in 2042
150	+0%	141.86 (132.64, 150.00)	145.30 (123.07, 150.00)	144.55 (123.09, 150.00)	146.19 (126.04, 150.00)
	+5%	143.41 (132.64, 150.00)	146.40 (128.39, 150.00)	145.53 (125.80, 150.00)	146.91 (129.31, 150.00)
	+10%	144.77 (132.64, 150.00)	147.16 (129.91, 150.00)	146.40 (129.31, 150.00)	147.46 (132.69, 150.00)
160	+0%	145.83 (132.64, 160.00)	152.31 (123.34, 160.00)	150.91 (124.50, 160.00)	153.74 (125.54, 160.00)
	+5%	148.31 (132.64, 160.00)	153.76 (128.19, 160.00)	152.22 (126.48, 160.00)	154.64 (130.18, 160.00)
	+10%	150.50 (132.64, 160.00)	154.85 (130.96, 160.00)	153.32 (129.40, 160.00)	155.35 (131.33, 160.00)
no cap	+5%	153.90 (132.64, 177.78)	183.38 (128.39, 253.12)	176.23 (125.88, 252.08)	177.17 (123.93, 247.95)
Cap	b	Effort in 2022 (4 years)	Effort in 2028 (10 years)	Effort in 2033 (15 years)	Effort in 2042
150	+0%	0.67 (0.44, 1.10)	0.63 (0.38, 1.10)	0.59 (0.36, 1.10)	0.56 (0.33, 1.05)
	+5%	0.68 (0.44, 1.10)	0.64 (0.38, 1.11)	0.60 (0.36, 1.10)	0.57 (0.33, 1.07)
	+10%	0.69 (0.44, 1.14)	0.65 (0.38, 1.11)	0.60 (0.36, 1.12)	0.57 (0.33, 1.07)
160	+0%	0.69 (0.46, 1.10)	0.68 (0.40, 1.20)	0.63 (0.40, 1.11)	0.62 (0.37, 1.12)
	+5%	0.71 (0.47, 1.14)	0.69 (0.41, 1.20)	0.65 (0.40, 1.14)	0.63 (0.37, 1.13)
	+10%	0.72 (0.47, 1.15)	0.71 (0.42, 1.21)	0.66 (0.40, 1.18)	0.64 (0.38, 1.15)
no cap	+5%	0.73 (0.50, 1.16)	0.86 (0.52, 1.77)	0.87 (0.53, 1.53)	0.84 (0.54, 1.55)
Cap	b	CPUE in 2022 (4 years)	CPUE in 2028 (10 years)	CPUE in 2033 (15 years)	CPUE in 2041
150	+0%	1.13 (0.67, 2.16)	1.25 (0.71, 2.31)	1.42 (0.80, 2.28)	1.45 (0.77, 2.61)
	+5%	1.13 (0.67, 2.16)	1.25 (0.71, 2.29)	1.40 (0.79, 2.28)	1.44 (0.76, 2.61)
	+10%	1.13 (0.67, 2.15)	1.24 (0.70, 2.29)	1.39 (0.78, 2.28)	1.43 (0.77, 2.61)
160	+0%	1.13 (0.67, 2.16)	1.23 (0.70, 2.27)	1.37 (0.78, 2.24)	1.37 (0.76, 2.45)
	+5%	1.13 (0.67, 2.16)	1.21 (0.69, 2.24)	1.35 (0.77, 2.23)	1.36 (0.74, 2.44)
	+10%	1.12 (0.67, 2.15)	1.20 (0.68, 2.22)	1.34 (0.76, 2.19)	1.35 (0.74, 2.44)
no cap	+5%	1.12 (0.67, 2.16)	1.10 (0.65, 1.98)	1.13 (0.70, 1.96)	1.10 (0.65, 1.96)

Table 3: Performance statistics are listed for the seven CMPs, calculated for an equal weighting across (a) all nine RS models, (b) only the "optimistic" *M. capensis* RS OMs where the B_{2017}/B_{MSY} estimate is greater than one (six OMs in total) and (c) only the "pessimistic OMs where the *M. capensis* B_{2017}/B_{MSY} estimate is less than one (three OMs in total). All statistics are reported as medians with 90% probability intervals, except for the TAC_{av} statistics where the means and standard deviations are listed. These performance statistics are illustrated in Figure 5.

			M. paradoxus				*M. capensis*			
	Cap	b	B_{2042}/B_{MSY}		B_{low}/B_{MSY}		B_{2042}/B_{MSY}		B_{low}/B_{MSY}	
(a) All RS OMs	150	+0%	2.93	(1.55,5.15)	1.57	(0.96,2.19)	3.06	(1.07,6.76)	2.44	(0.32,4.52)
		+5%	2.90	(1.51,5.15)	1.55	(0.92,2.18)	3.05	(1.05,6.76)	2.44	(0.32,4.52)
		+10%	2.87	(1.48,5.15)	1.53	(0.90,2.18)	3.04	(1.03,6.76)	2.44	(0.32,4.52)
	160	+0%	2.71	(1.42,4.82)	1.50	(0.92,2.15)	3.01	(0.94,6.71)	2.41	(0.32,4.52)
		+5%	2.67	(1.37,4.81)	1.47	(0.90,2.15)	3.01	(0.91,6.70)	2.40	(0.32,4.52)
		+10%	2.63	(1.31,4.81)	1.45	(0.86,2.14)	3.00	(0.89,6.67)	2.39	(0.32,4.52)
	no	+5%	1.98	(0.95,3.42)	1.16	(0.73,1.79)	2.93	(0.47,6.62)	2.12	(0.31,4.52)
(b) Only optimistic mcap OMs	150	+0%	2.65	(1.47,4.77)	1.55	(0.96,2.11)	3.87	(2.24,7.13)	2.77	(1.84,4.55)
		+5%	2.62	(1.43,4.74)	1.52	(0.91,2.08)	3.86	(2.24,7.13)	2.77	(1.83,4.55)
		+10%	2.60	(1.38,4.71)	1.50	(0.90,2.08)	3.86	(2.23,7.13)	2.77	(1.82,4.55)
	160	+0%	2.46	(1.37,4.34)	1.47	(0.92,2.05)	3.85	(2.21,7.06)	2.77	(1.79,4.55)
		+5%	2.42	(1.30,4.25)	1.42	(0.90,2.02)	3.84	(2.20,7.06)	2.77	(1.77,4.55)
		+10%	2.36	(1.23,4.23)	1.39	(0.86,2.01)	3.83	(2.20,7.06)	2.77	(1.77,4.55)
	no	+5%	1.99	(0.94,3.46)	1.15	(0.74,1.71)	3.80	(1.99,6.90)	2.74	(1.33,4.55)
(c) Only pessimistic mcap OMs	150	+0%	3.35	(2.04,5.45)	1.60	(0.95,2.35)	1.64	(0.83,3.04)	0.58	(0.30,0.68)
		+5%	3.34	(2.01,5.45)	1.59	(0.93,2.35)	1.63	(0.82,3.04)	0.58	(0.30,0.68)
		+10%	3.31	(2.01,5.44)	1.59	(0.92,2.35)	1.63	(0.82,3.01)	0.58	(0.30,0.68)
	160	+0%	3.12	(1.81,5.01)	1.58	(0.94,2.29)	1.47	(0.74,2.76)	0.58	(0.30,0.68)
		+5%	3.09	(1.80,5.01)	1.58	(0.92,2.29)	1.46	(0.72,2.73)	0.58	(0.30,0.68)
		+10%	3.06	(1.76,5.00)	1.56	(0.89,2.29)	1.45	(0.70,2.68)	0.57	(0.30,0.68)
	no	+5%	1.93	(1.00,3.33)	1.19	(0.70,1.93)	0.76	(0.35,1.49)	0.48	(0.25,0.68)
			Species combined							
			TAC_{av} (25 years)		TAC_{av} (4 years)					
	Cap	b	Mean	(sd)	Mean	(sd)	AAV (25 years)		AAV (4 years)	
(a) All RS OMs	150	+0%	145.09	(4.89)	144.59	(3.66)	0.020	(0.005,0.043)	0.043	(0.031,0.056)
		+5%	146.03	(4.42)	145.26	(3.55)	0.017	(0.005,0.040)	0.037	(0.031,0.056)
		+10%	146.77	(3.99)	145.87	(3.39)	0.014	(0.005,0.038)	0.031	(0.031,0.056)
	160	+0%	150.95	(6.70)	146.37	(5.50)	0.029	(0.008,0.050)	0.048	(0.038,0.063)
		+5%	152.33	(6.16)	147.50	(5.48)	0.025	(0.008,0.048)	0.048	(0.038,0.063)
		+10%	153.47	(5.66)	148.54	(5.29)	0.021	(0.008,0.045)	0.048	(0.038,0.063)
	no	+5%	172.42	(18.50)	149.01	(7.15)	0.062	(0.050,0.079)	0.054	(0.038,0.076)
(b) Only optimistic mcap OMs	150	+0%	143.99	(4.98)	144.55	(3.79)	0.025	(0.005,0.045)	0.042	(0.031,0.056)
		+5%	145.16	(4.58)	145.18	(3.68)	0.021	(0.005,0.042)	0.037	(0.031,0.056)
		+10%	146.08	(4.18)	145.79	(3.51)	0.018	(0.005,0.039)	0.031	(0.031,0.056)
	160	+0%	149.17	(6.56)	146.39	(5.66)	0.033	(0.013,0.052)	0.048	(0.038,0.063)
		+5%	150.85	(6.14)	147.46	(5.63)	0.030	(0.012,0.049)	0.048	(0.038,0.063)
		+10%	152.23	(5.74)	148.48	(5.43)	0.027	(0.009,0.046)	0.048	(0.038,0.062)
	no	+5%	166.60	(14.94)	149.02	(7.31)	0.062	(0.049,0.079)	0.055	(0.038,0.076)
(c) Only pessimistic mcap OMs	150	+0%	147.28	(3.86)	144.68	(3.38)	0.010	(0.005,0.035)	0.043	(0.031,0.056)
		+5%	147.76	(3.49)	145.43	(3.29)	0.009	(0.005,0.032)	0.037	(0.031,0.056)
		+10%	148.14	(3.16)	146.02	(3.13)	0.008	(0.005,0.029)	0.031	(0.031,0.056)
	160	+0%	154.52	(5.45)	146.32	(5.16)	0.016	(0.008,0.043)	0.048	(0.037,0.065)
		+5%	155.31	(5.03)	147.58	(5.18)	0.013	(0.008,0.041)	0.048	(0.036,0.063)
		+10%	155.95	(4.62)	148.66	(5.02)	0.012	(0.008,0.039)	0.048	(0.038,0.063)
	no	+5%	184.08	(19.43)	149.00	(6.82)	0.062	(0.050,0.081)	0.054	(0.036,0.076)

Table 4: Some additional statistics for the TACs for the next four years under the seven different CMPs. Here "uu" means $TAC_{2021} \geq TAC_{2020}$ and $TAC_{2022} \geq TAC_{2021}$, "dd" means $TAC_{2021} < TAC_{2020}$ and $TAC_{2022} < TAC_{2021}$, "ud" means $TAC_{2021} \geq TAC_{2020}$ and $TAC_{2022} < TAC_{2021}$ and "du" means $TAC_{2021} < TAC_{2020}$ and $TAC_{2022} \geq TAC_{2021}$. Note that the range of change in TAC (in thousand tons) might be a little counter-intuitive. For example, for a cap of 150 000t, if TAC_{2020}=146 431t, then the maximum increase one would expect in 2021 would be 150 000-146 431=3569 and yet the maximum of the range is 10 270t. This is because there is a rule built into the projection code that the total fleet-summed fishing mortality rate cannot exceed 0.90, and if it does then the catch is reduced. Thus TAC_{2020} could at times be less than 146 431. Table 5 below reports some statistics regarding instances of the TAC not being caught.

		Proportion of 900 simulations				TAC2021-TAC2020		TAC2022-TAC2021	
		uu	dd	ud	du	Mean ('000 t)	Range ('000 t)	Mean ('000 t)	Range ('000 t)
150	+0%	0.38	0.40	0.04	0.17	-2.49	(-18.32,10.27)	-1.62	(-27.83,13.65)
	+5%	0.46	0.31	0.06	0.17	-1.35	(-18.32,10.56)	-1.22	(-27.83,12.62)
	+10%	0.55	0.23	0.08	0.14	-0.30	(-18.32,13.85)	-0.91	(-27.83,12.62)
160	+0%	0.35	0.40	0.07	0.17	0.65	(-18.32,14.26)	-0.80	(-27.83,14.79)
	+5%	0.43	0.31	0.09	0.17	2.70	(-18.32,14.26)	-0.37	(-27.83,14.80)
	+10%	0.52	0.23	0.11	0.14	4.68	(-18.32,14.26)	-0.16	(-27.83,14.79)
no cap	+5%	0.43	0.31	0.09	0.17	3.15	(-18.32,14.93)	4.77	(-27.83,16.42)

Table 5: Summary of the TAC projected not to be caught over the next four years (TAC is not caught in a given simulation when the total fleet-summed fishing mortality rate exceeds 0.90). For each year, the percentage of the 9x100 simulations for which the TAC is not caught fully is listed, as well as the average value of the catch not caught (in thousand tons) and the range of the catch not caught. For 2018 to 2020 the statistics are the same for the seven CMPs, as the CMP rules effectively come into play only from 2021 only.

Year			Percentage of 9x100 simulations for which not all TAC is caught	Average TAC not caught ('000 t)	Range TAC not caught ('000 t)
2018			1.78	5.76	(4.61, 7.07)
2019	NA		2.11	7.33	(4.61, 9.22)
2020			2.33	7.53	(3.65, 10.56)
2021		+0%	2.33	6.67	(3.84, 11.30)
	150	+5%	2.44	7.29	(3.84, 17.19)
		+10%	2.67	7.46	(3.84, 18.16)
		+0%	2.33	6.69	(4.21, 11.30)
	160	+5%	2.44	7.32	(4.21, 17.19)
		+10%	2.67	7.64	(4.21, 20.28)
	no cap	+5%	2.44	7.32	(4.21, 17.19)
2022		+0%	2.33	5.52	(3.26, 7.76)
	150	+5%	2.56	5.68	(3.39, 8.04)
		+10%	2.89	6.08	(3.70, 9.85)
		+0%	2.33	5.59	(3.26, 7.76)
	160	+5%	2.56	5.79	(3.39, 8.04)
		+10%	3.11	6.27	(3.70, 9.85)
	no cap	+5%	2.56	5.89	(3.39, 9.22)

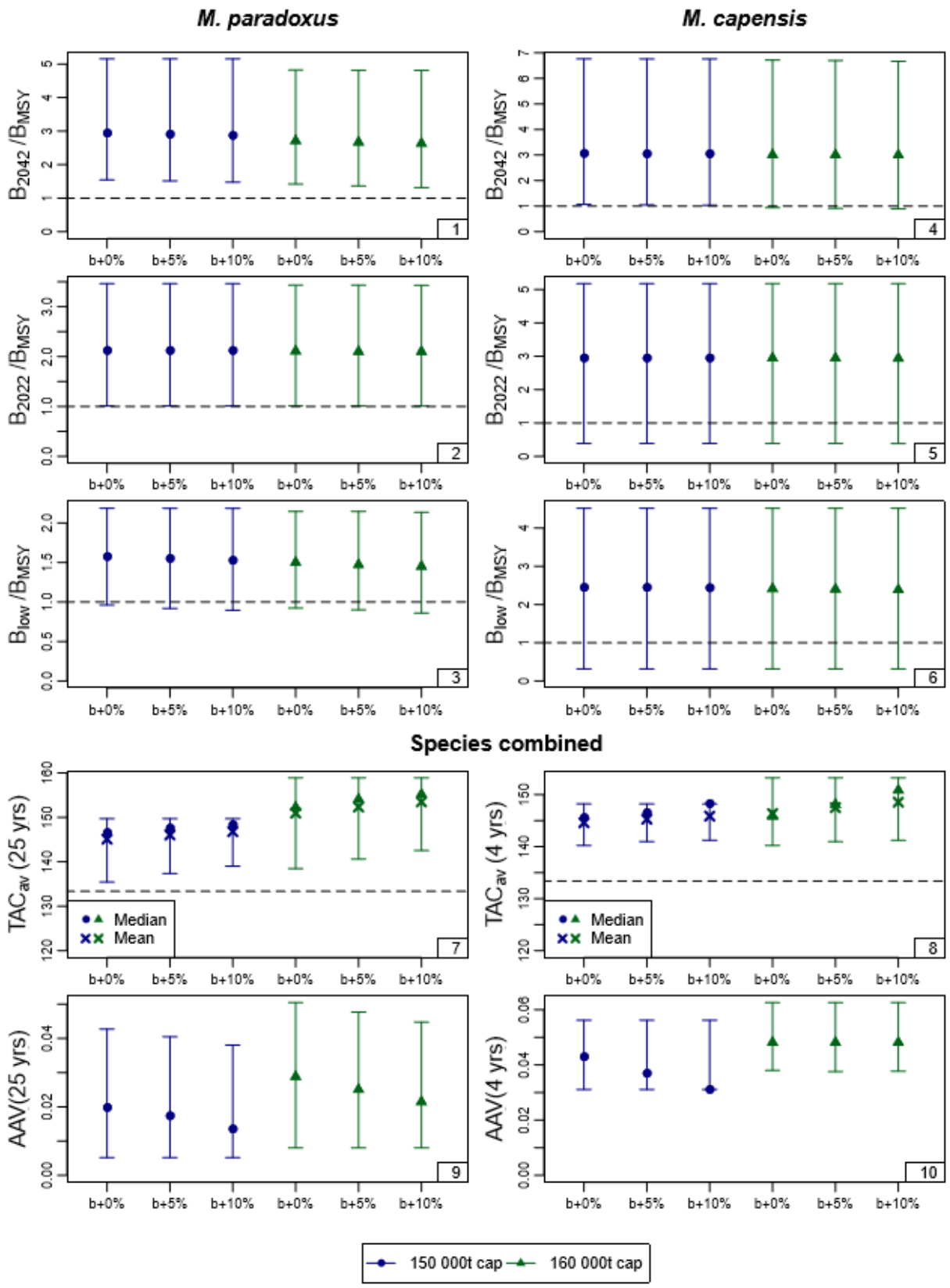

Figure 1a: Zeh plots of the performance statistics from Table 1. The statistics are B^{sp}/B_{MSY} for 2042 and 2022 (i.e. at the planned end of OMP2018 application), $B^{sp}(low)/B_{MSY}$ (the lowest value of this statistic in the projection period to 2042), TAC_{av} (the average catch over the projection period (25 years) and over the next four years) and AAV (the average inter-annual proportional change in catch over the projection period (25 years) and over the next four years). Medians and 90% probability intervals are shown. For TAC_{av}, the means are also shown by crosses.

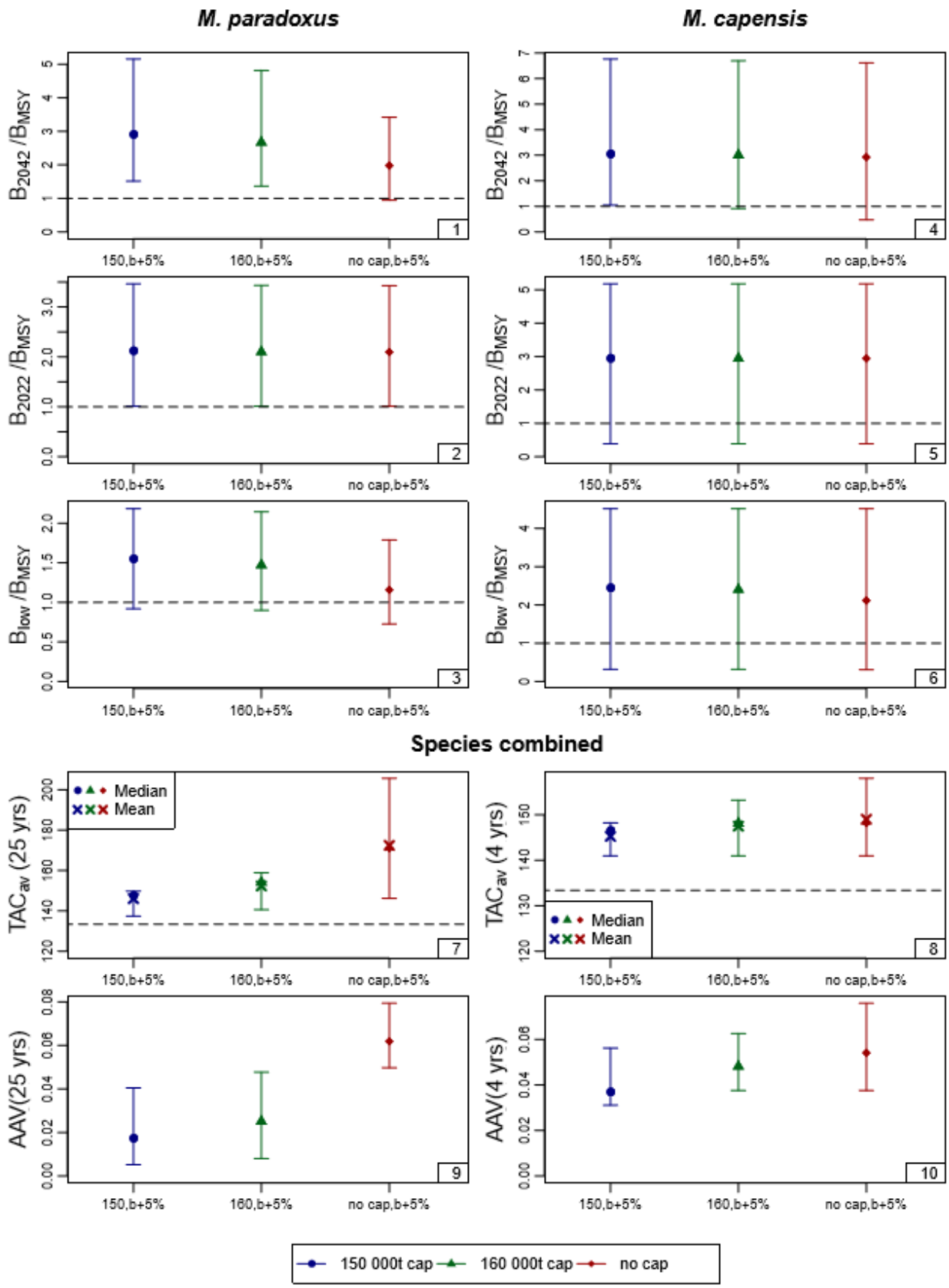

Figure 1b: Zeh plots of the performance statistics from Table 1, comparing the CMPS with a cap of 150 00t, 160 000t and no cap, all for *b*+5%.

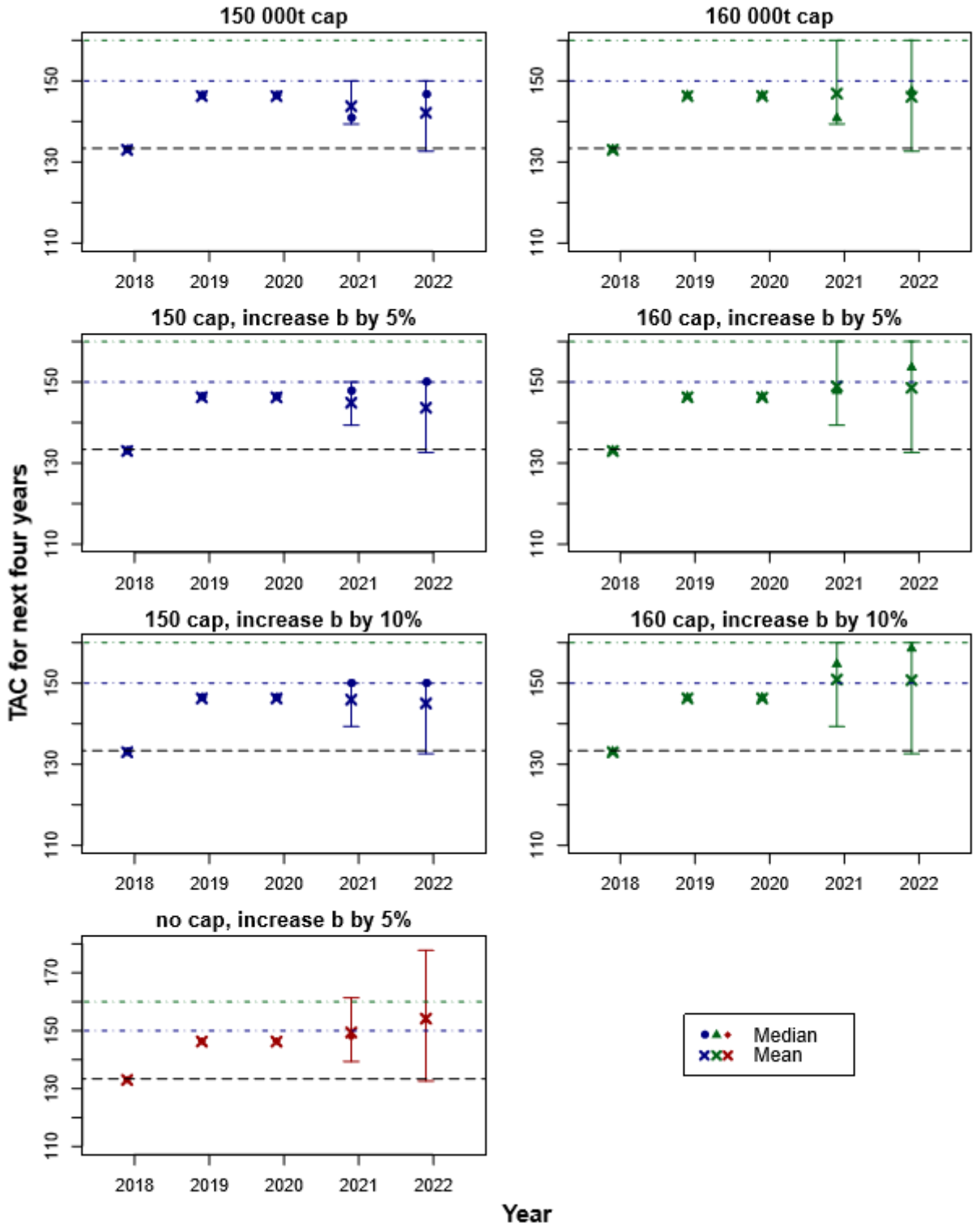

Figure 2: Median estimates and 90% probability intervals for the projected catch for each of the next four years (i.e. the planned life span of OMP2018) for the seven CMPs.

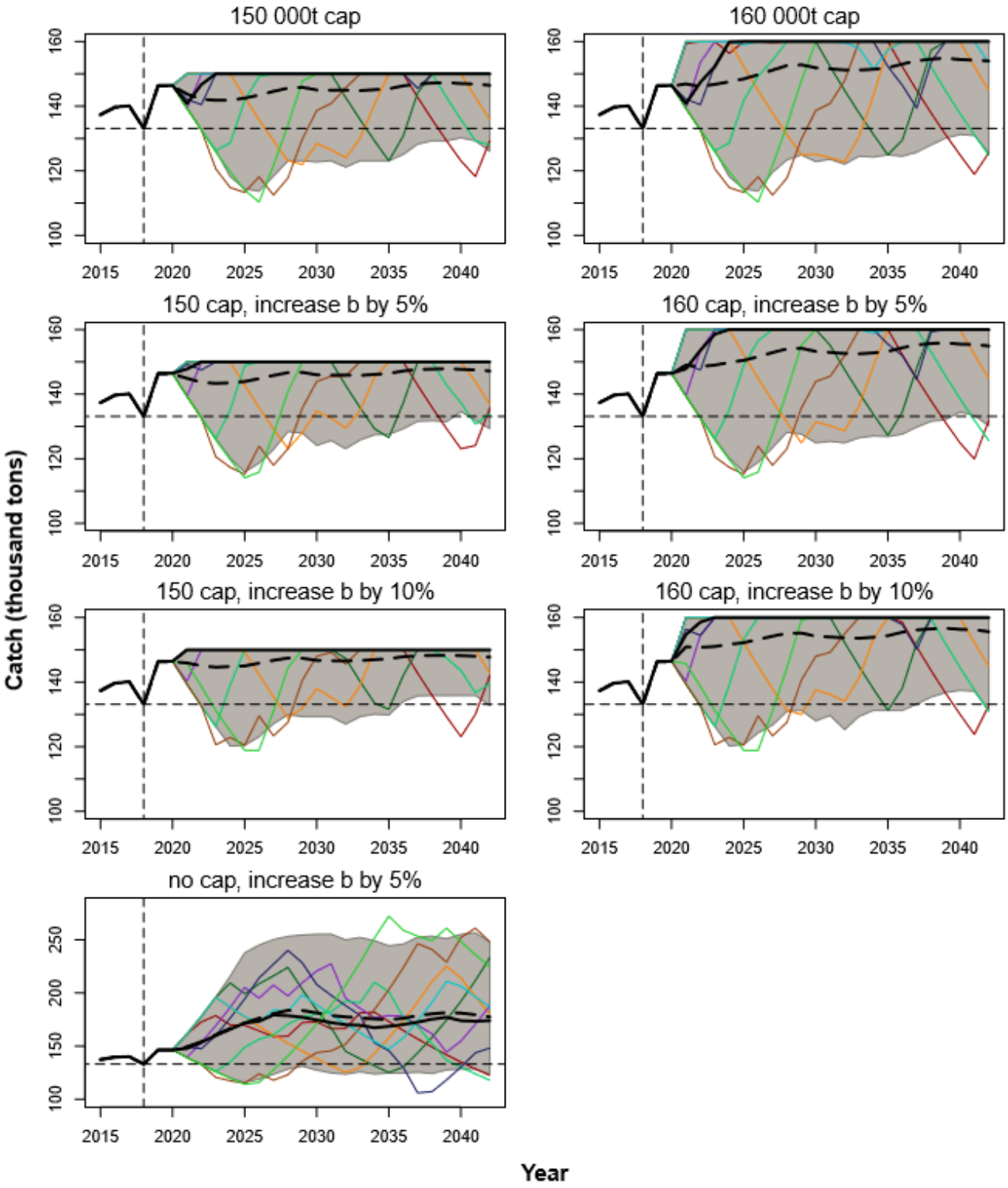

Figure 3: Projected trajectories for catch for the seven CMPs. In each plot, the black line shows the median catch "trajectory", while the dashed line shows the mean catch "trajectory". The 90% probability envelop (PE) is shown by the grey shaded area. The worm plots show a selection of simulations, with one simulation drawn at random from each of the nine RS OMs.

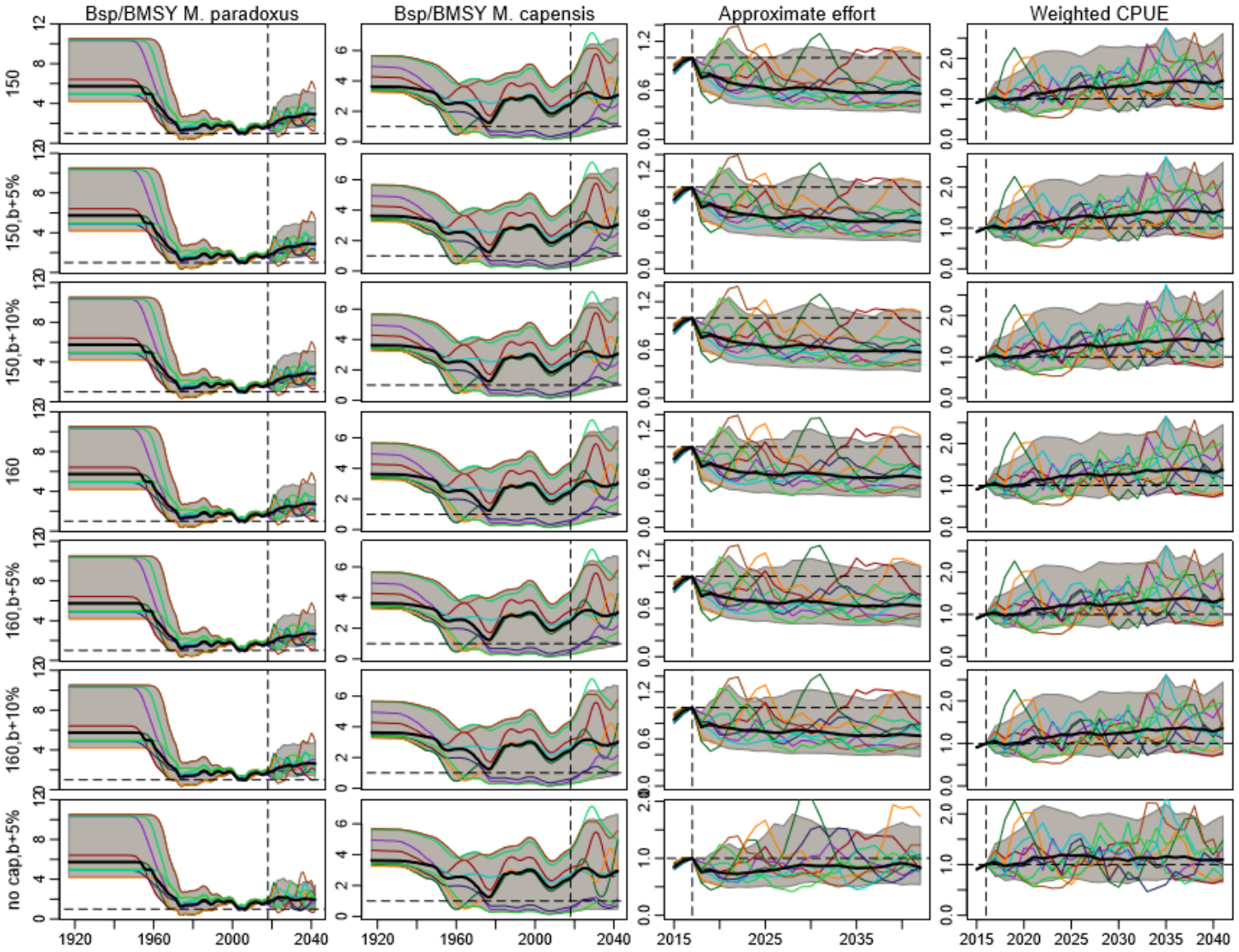

Figure 4: Projected trajectories for B^{sp}/B_{MSY}, effort and CPUE. In each plot, the black line and grey shaded area show the median trajectory and 90% probability envelop (PE) respectively. The measure of effort is taken to be proportional to the *M. paradoxus* West Coast offshore fishing mortality rate and is normalised to be one in 2017 (last year in the OM). The CPUE series normalised to be one in 2016 (last year of data currently available).

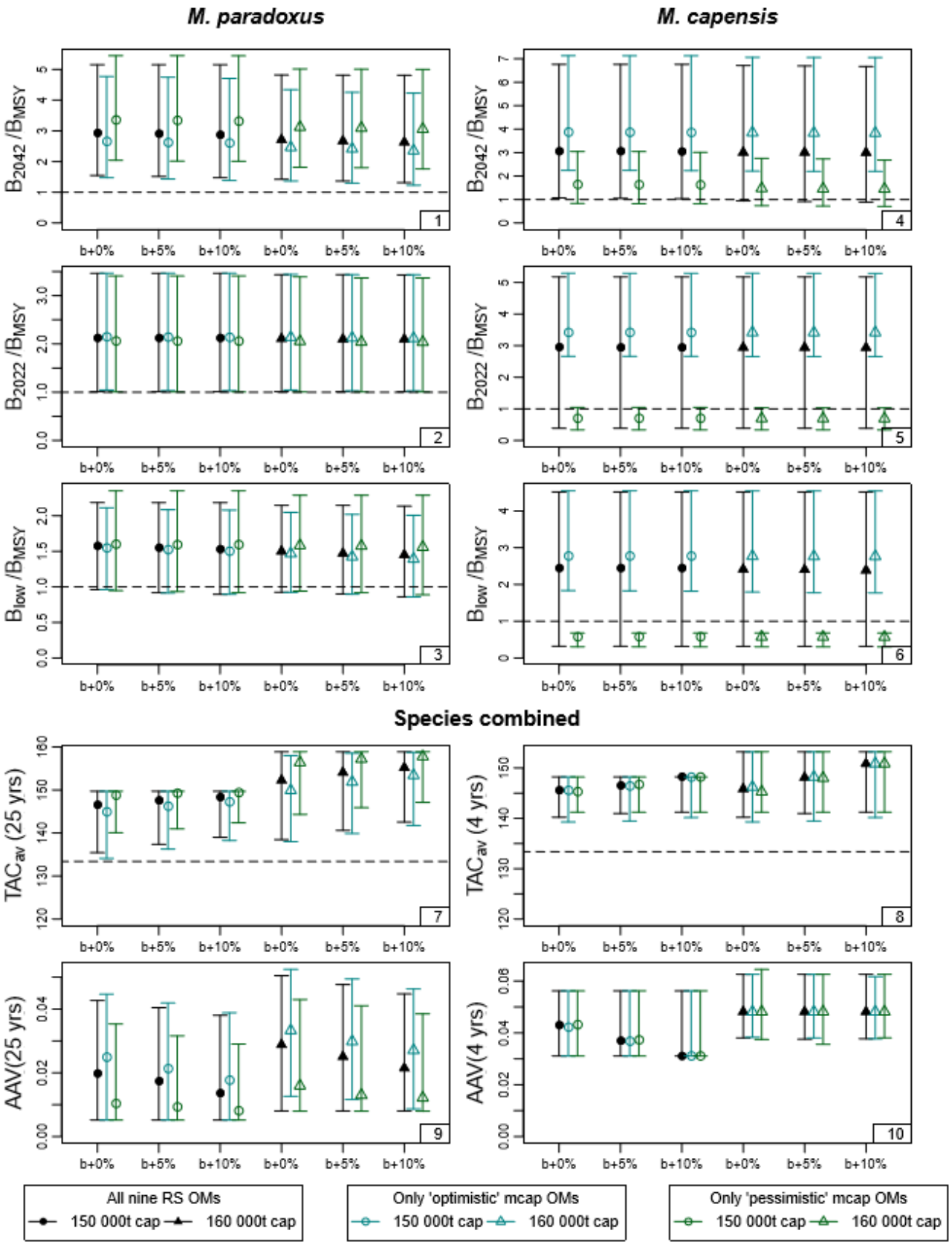

Figure 5: Performance statistics for Table 3, where results are shown for an equal weighting across (a) all nine RS models, (b) only the "optimistic" *M. capensis* RS OMs where the B_{2017}/B_{MSY} estimate is greater than one (six OMs in total) and (c) only the "pessimistic" OMs where the *M. capensis* B_{2017}/B_{MSY} estimate is less than one (three OMs in total). All statistics are reported as medians with 90% probability intervals.

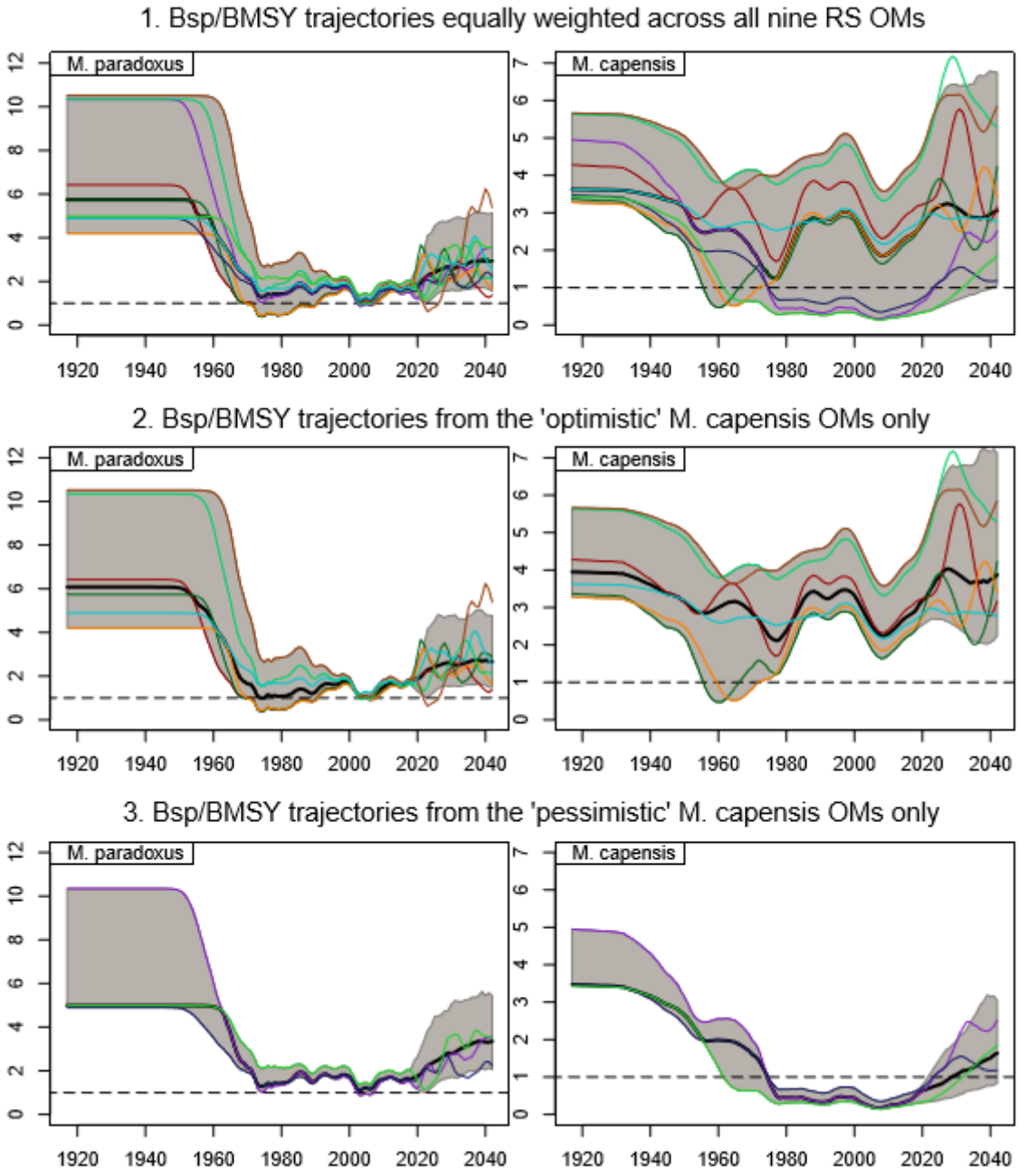

Figure 6: Trajectories for B^{sp}/B_{MSY} are shown for the three grouping options from Figure 5. The black lines and grey shaded areas show the median "trajectories" and 90% P.E's. The worm plots show a selection of simulations with one simulation drawn at random from each OM. The results shown here are for the first CMP with a cap of 150 000t and no increase in *b*.

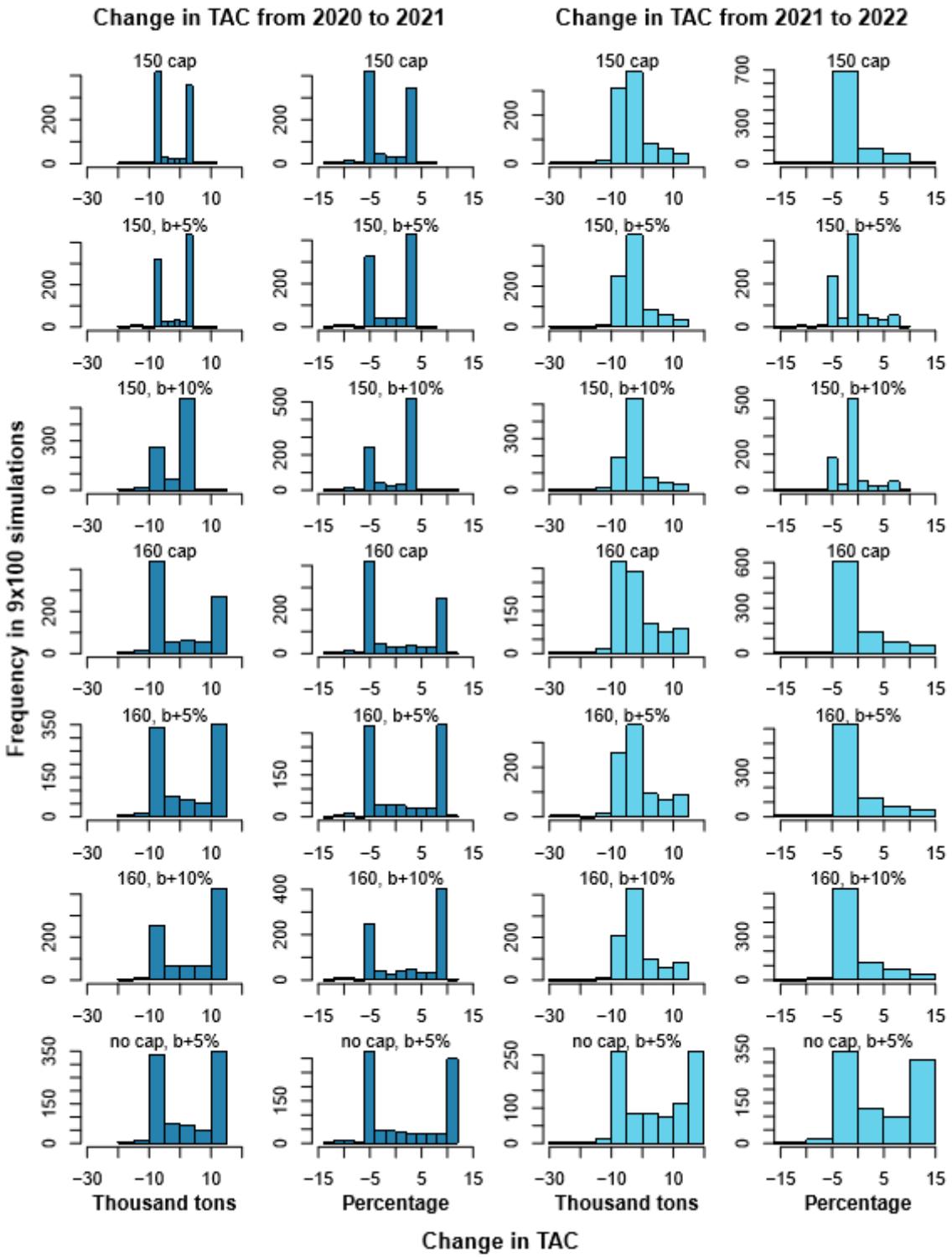

Figure 7: Histograms of the projected change in TAC for the duration of OMP2018 for the seven CMPs. The TAC in 2019 and 2020 is to be fixed at the 2018 value increased by 10%, so that the changes shown here are for 2020 to 2021 (first two columns in dark blue) and for 2021 to 2022 (second two columns in light blue). The change in TAC is shown in absolute terms (thousand tons) and as a percentage.