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FC Working Group on Greenland Halibut Management

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Greenland Halibut MSE Results for Updated SCAA Reference Case and Robustness Test Operating Models:

Comparison of Preferred MP Candidates as Advised by EU Consultant and Canadian Scientists

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INTRODUCTION

Canadian scientists (P. Shelton, pers. commn) have suggested that consideration of alternative MP candidates for Greenland halibut by the NAFO WGMSE WG meeting in Halifax over 16-17 September, 2010, would be facilitated by each group of developers advising their three preferred candidates, and then presenting a comparison of the resultant six MPs for the operating models which they had developed.

This paper provides such a summary for six MPs under the SCAA operating models (Butterworth and Rademeyer, 2010a). The three MPs selected by the EU consultant scientists Butterworth and Rademeyer are mp12, mp14 and mp16 (with mp14 their most preferred), where the details of these are described In Butterworth and Rademeyer (2010b). As noted in that document, these selections do not necessarily reflect the preferences of the EU. The three preferred Canadian MPs are ld1.25_lu1.3, ld1.25_lu1.1 and ld1.5_lu1.5, which are described in Shelton *et al*. (2010); as these are not necessarily Canada's final three preferred selections (P. Shelton, pers. commn), we have referred to them as "Canadian scientists' selections" for the purposes of this document.

RESULTS

Table 1 compares performance across the six MPs first under the Base Case SCAA operating model (SCAA0) and then under the "difficult" robustness test SCAA5 (lower Beverton-Holt stock-recruitment steepness h = 0.6) for which the EU consultants' preferred MP options failed to meet the biomass recovery target (Butterworth and Rademeyer, 2010b). Table 2 shows results for each MP in turn across the full set of SCAA robustness tests.

The first three sets of Figures compare the performances of the four MPs one by one using what has come to be the accepted graphical format used to facilitate selection amongst MP candidates in the CCSBT. First in Fig. 1a biomass and catch projections are shown for each of the MPs under SCAA0 in the form of 10 "worm plots" (individual realizations to make the extent of TAC variability to be expected evident) together with medians and 80% probability interval envelopes. This is repeated in Fig. 1b for SCAA5. Fig. 2a provides similar comparisons under SCAA0 showing all six MPs on the same plot, first for their medians and then for their lower 2.5%iles, with Fig. 2b repeating this for SCAA5. Fig. 3 shows these same SCAA0 and SCAA5 performance statistics comparisons in an alternative form that makes for readier quantitative comparison amongst alternative MPs. Fig. 4 is similar to Fig. 1 except that greater detail has been added to show the probability envelopes for different probability intervals; further in addition to abundance and catch trajectories, the annual percentage TAC change trajectories are also included.

DISCUSSION

A clear feature of the results in Table 1 is the failure of the Canadian scientists' MP choices to meet most of the performance targets for restrictions on the extent of TAC changes. This is the case to an even greater extent under SCAA5 than under the Base Case SCAA0. Furthermore, as for the EU consultants' preferred MPs, the Canadian scientists' preferences fail to meet the recovery target under SCAA5, though by a lesser extent than those put forward by the EU consultants. Table 2 shows that performances are similar across the robustness tests for any of the MPs, except for SCAA5 for which long-term average catches are lower, and to a greater extent for the Canadian scientists' choices.

The contrast between the two sets of suggested MPs is probably most clearly evident from inspection of Fig. 2, where the sets separate clearly into greater biomass recovery for the Canadian scientists' choices, compared to larger median catches with steadier trends for the EU consultants' selections, which in particular do not show large decreases in catch over the first few years. Fig. 3 confirms this dichotomy between the two sets, indicating also that the average inter-annual variation in TACs (the AAV statistic) typically doubles in median terms for the Canadian scientists' compared to the EU consultants' selections.

Fig. 4a also confirms these marked contrasts/trade-offs between the two sets of MP options. For the Base Case SCAA operating model, the EU consultants' selection trades-off less long-term biomass recovery to forgo the Canadian scientists' opting for lower short- to medium-term catches and in particular large decreases in TACs over the first few years, where these reductions can reach up to 45% in a single year. These differences are exacerbated in Fig. 4b for SCAA5. Here the large perturbation induced by a very rapid reduction in catches over the first few years does create a sufficient contrast for the derivative-based TAC control rule to secure biomass recovery under the Canadian scientists' MP choices, but this is an the expense of inter-annual TAC reductions which can exceed 55%.

REFERENCES

Butterworth DS and Rademeyer RA. 2010a. Greenland halibut updated SCAA Reference Case and robustness tests. NAFO document FCWGMSE WP 10/14.

Butterworth DS and Rademeyer RA. 2010b. Greenland halibut MSE results for updated SCAA Reference Case and robustness test operating models. NAFO document FCWGMSE WP 10/13.

Shelton P, Miller D, Healey B and Brodie B. 2010. Performance statistics for NAFO Greenland halibut for management strategy evaluation from XSA-conditioned operating models. NNNAFO document FCWGMSE WP 10/16.

Table 1a: Performance statistics for the 6 preferred MPs for the Base Case SCAA operating model (**SCAA0**), where these are reported in a format that relates to specified targets in NAFO (2010). Instances where those targets are not met are shown shaded. Catches are in mt.

	1		2a			2b			2c				3		4
	Prob	Prob*	Prob*	Prob	Prob	Prob	Prob	Prob	Prob	Prob	Prob	$C_{2011\text{-}2015}$	$C_{2016\text{-}2020}$	$C_{2011\text{-}2030}$	Prob
SCAA0	$B^{5\text{-}9}$	(2011-2015)	(2010-2014)	(2011-2030)	(2010-2029)	(2010-2027)	2011	2012	2013	2014	2015				$P_{achieved}/P_{milestone}$
mp12	1%	0%	20%	0%	5%	22%	0%	0%	0%	0%	0%	14513	16211	17485	17%
mp14	2%	0%	20%	0%	5%	14%	0%	0%	0%	0%	0%	15857	17218	18102	20%
mp16	2%	0%	0%	0%	0%	28%	0%	0%	0%	0%	0%	15746	15561	15930	3%
ld1.25_1u1.3	0%	60%	60%	30%	35%	50%	0%	7%	66%	72%	65%	10736	10688	12317	2%
ld1.25_1u1.1	0%	40%	60%	25%	30%	44%	0%	7%	66%	72%	65%	10696	10117	11503	2%
ld1.5_1u1.5	0%	60%	80%	40%	40%	56%	0%	25%	84%	85%	76%	9812	9530	11298	2%

Table 1b: Performance statistics for the 6 preferred MPs for the **SCAA5** (low steepness), where these are reported in a format that relates to specified targets in NAFO (2010). Instances where those targets are not met are shown shaded. Catches are in mt.

	1		2a			2b			2c				3		4
	Prob	Prob*	Prob*	Prob	Prob	Prob	Prob	Prob	Prob	Prob	Prob	$C_{2011\text{-}2015}$	$C_{2016\text{-}2020}$	$C_{2011\text{-}2030}$	Prob
SCAA5	$B^{5\text{-}9}$	(2011-2015)	(2010-2014)	(2011-2030)	(2010-2029)	(2010-2027)	2011	2012	2013	2014	2015				$P_{achieved}/P_{milestone}$
mp12	11%	0%	20%	0%	5%	19%	0%	0%	0%	0%	0%	14243	13288	14590	100%
mp14	14%	0%	20%	0%	5%	11%	0%	0%	0%	0%	0%	15579	14355	15366	100%
mp16	12%	0%	0%	0%	0%	33%	0%	0%	0%	0%	0%	15398	12329	12990	100%
ld1.25_1u1.3	0%	60%	80%	30%	35%	50%	0%	16%	90%	96%	95%	9458	6559	8126	70%
ld1.25_1u1.1	0%	60%	80%	25%	30%	44%	0%	16%	90%	96%	95%	9448	6350	7726	63%
ld1.5_1u1.5	0%	60%	80%	35%	40%	56%	0%	42%	95%	98%	97%	8482	5225	6933	52%

Table 2: Performance statistics for the 6 preferred MPs for the Base Case SCAA operating model its associated robustness tests, where these are reported in a format that relates to specified targets in NAFO (2010). Instances where those targets are not met are shown shaded. Catches are in mt.

	1		2a			2b			2c				3		4
mp12	Prob $B^{5\text{-}9}$	Prob* (2011-2015)	Prob* (2010-2014)	Prob (2011-2030)	Prob (2010-2029)	Prob (2010-2027)	Prob 2011	Prob 2012	Prob 2013	Prob 2014	Prob 2015	$C_{2011\text{-}2015}$	$C_{2016\text{-}2020}$	$C_{2011\text{-}2030}$	Prob $P_{achieved}/P_{milestone}$
SCAA0	1%	0%	20%	0%	5%	22%	0%	0%	0%	0%	0%	14513	16211	17485	17%
SCAA1	3%	0%	20%	0%	5%	22%	0%	0%	0%	0%	0%	14423	15443	17077	21%
SCAA2	1%	0%	20%	0%	5%	28%	0%	0%	0%	0%	0%	14422	15859	18815	2%
SCAA3	0%	0%	20%	0%	5%	22%	0%	0%	0%	0%	0%	14659	17723	17819	17%
SCAA4	0%	0%	20%	0%	5%	28%	0%	0%	0%	0%	0%	14468	16477	18256	25%
SCAA5	11%	0%	20%	0%	5%	19%	0%	0%	0%	0%	0%	14243	13288	14590	100%
SCAA6	1%	0%	20%	0%	5%	28%	0%	0%	0%	0%	0%	14570	16637	18096	10%
SCAA7	0%	0%	20%	0%	5%	28%	0%	0%	0%	0%	0%	14500	16532	18414	15%

	1		2a			2b			2c				3		4
mp14	Prob $B^{5\text{-}9}$	Prob* (2011-2015)	Prob* (2010-2014)	Prob (2011-2030)	Prob (2010-2029)	Prob (2010-2027)	Prob 2011	Prob 2012	Prob 2013	Prob 2014	Prob 2015	$C_{2011\text{-}2015}$	$C_{2016\text{-}2020}$	$C_{2011\text{-}2030}$	Prob $P_{achieved}/P_{milestone}$
SCAA0	2%	0%	20%	0%	5%	14%	0%	0%	0%	0%	0%	15857	17218	18102	20%
SCAA1	4%	0%	20%	0%	5%	17%	0%	0%	0%	0%	0%	15756	16314	17816	22%
SCAA2	2%	0%	20%	0%	5%	22%	0%	0%	0%	0%	0%	15765	16676	19198	1%
SCAA3	2%	0%	20%	0%	5%	17%	0%	0%	0%	0%	0%	16016	18306	18329	17%
SCAA4	2%	0%	20%	0%	5%	17%	0%	0%	0%	0%	0%	15812	17310	18776	27%
SCAA5	14%	0%	20%	0%	5%	11%	0%	0%	0%	0%	0%	15579	14355	15366	100%
SCAA6	2%	0%	20%	0%	5%	17%	0%	0%	0%	0%	0%	15923	17636	18598	6%
SCAA7	2%	0%	20%	0%	5%	17%	0%	0%	0%	0%	0%	15847	17450	18849	16%

	1		2a			2b			2c				3		4
mp16	Prob $B^{5\text{-}9}$	Prob* (2011-2015)	Prob* (2010-2014)	Prob (2011-2030)	Prob (2010-2029)	Prob (2010-2027)	Prob 2011	Prob 2012	Prob 2013	Prob 2014	Prob 2015	$C_{2011\text{-}2015}$	$C_{2016\text{-}2020}$	$C_{2011\text{-}2030}$	Prob $P_{achieved}/P_{milestone}$
SCAA0	2%	0%	0%	0%	0%	28%	0%	0%	0%	0%	0%	15746	15561	15930	3%
SCAA1	4%	0%	0%	0%	0%	28%	0%	0%	0%	0%	0%	15623	14644	15492	7%
SCAA2	1%	0%	0%	0%	0%	28%	0%	0%	0%	0%	0%	15621	14945	16695	0%
SCAA3	1%	0%	0%	0%	0%	28%	0%	0%	0%	0%	0%	15849	16891	16119	3%
SCAA4	1%	0%	0%	0%	0%	28%	0%	0%	0%	0%	0%	15661	15561	16552	11%
SCAA5	12%	0%	0%	0%	0%	33%	0%	0%	0%	0%	0%	15398	12329	12990	100%
SCAA6	2%	0%	0%	0%	0%	28%	0%	0%	0%	0%	0%	15793	16057	16498	0%
SCAA7	0%	0%	0%	0%	0%	28%	0%	0%	0%	0%	0%	15729	15849	16744	2%

Table 2 contd

ld1.25_lu1.3	1 Prob B^{5-9}	2a Prob* (2011-2015)	2a Prob* (2010-2014)	2a Prob (2011-2030)	2b Prob (2010-2029)	2b Prob (2010-2027)	2c Prob 2011	2c Prob 2012	2c Prob 2013	2c Prob 2014	2c Prob 2015	3 $C_{2011-2015}$	3 $C_{2016-2020}$	3 $C_{2011-2030}$	4 Prob $P_{achieved}/P_{milestone}$
SCAA0	0%	60%	60%	30%	35%	50%	0%	7%	66%	72%	65%	10736	10688	12317	2%
SCAA1	0%	60%	60%	30%	35%	50%	0%	8%	77%	86%	83%	10145	9369	11558	2%
SCAA2	0%	60%	80%	35%	40%	56%	0%	12%	83%	91%	87%	9946	9223	12889	0%
SCAA3	0%	40%	60%	35%	35%	50%	0%	4%	49%	58%	46%	11497	13032	13037	2%
SCAA4	0%	60%	60%	30%	35%	50%	0%	7%	77%	83%	76%	10241	10306	12749	3%
SCAA5	0%	60%	80%	30%	35%	50%	0%	16%	90%	96%	95%	9458	6559	8126	70%
SCAA6	0%	40%	60%	30%	35%	50%	0%	7%	57%	66%	58%	11094	11336	13119	5%
SCAA7	0%	60%	60%	33%	35%	50%	0%	7%	73%	77%	67%	10490	10865	13212	2%

ld1.25_lu1.1	1 Prob B^{5-9}	2a Prob* (2011-2015)	2a Prob* (2010-2014)	2a Prob (2011-2030)	2b Prob (2010-2029)	2b Prob (2010-2027)	2c Prob 2011	2c Prob 2012	2c Prob 2013	2c Prob 2014	2c Prob 2015	3 $C_{2011-2015}$	3 $C_{2016-2020}$	3 $C_{2011-2030}$	4 Prob $P_{achieved}/P_{milestone}$
SCAA0	0%	40%	60%	25%	30%	44%	0%	7%	66%	72%	65%	10696	10117	11503	2%
SCAA1	0%	60%	60%	28%	30%	50%	0%	8%	77%	86%	85%	10135	8856	10723	1%
SCAA2	0%	60%	60%	30%	35%	50%	0%	12%	83%	91%	88%	9945	8836	11818	0%
SCAA3	0%	40%	60%	25%	30%	44%	0%	4%	49%	59%	50%	11431	12191	12267	2%
SCAA4	0%	60%	60%	25%	30%	44%	0%	7%	77%	83%	78%	10234	9716	11756	2%
SCAA5	0%	60%	80%	25%	30%	44%	0%	16%	90%	96%	95%	9448	6350	7726	63%
SCAA6	0%	40%	60%	25%	30%	44%	0%	7%	57%	67%	59%	11082	10790	12336	2%
SCAA7	0%	60%	60%	25%	30%	44%	0%	7%	73%	77%	71%	10475	10206	12223	2%

ld1.5_lu1.5	1 Prob B^{5-9}	2a Prob* (2011-2015)	2a Prob* (2010-2014)	2a Prob (2011-2030)	2b Prob (2010-2029)	2b Prob (2010-2027)	2c Prob 2011	2c Prob 2012	2c Prob 2013	2c Prob 2014	2c Prob 2015	3 $C_{2011-2015}$	3 $C_{2016-2020}$	3 $C_{2011-2030}$	4 Prob $P_{achieved}/P_{milestone}$
SCAA0	0%	60%	80%	40%	40%	56%	0%	25%	84%	85%	76%	9812	9530	11298	2%
SCAA1	0%	60%	80%	40%	43%	56%	0%	32%	91%	95%	93%	9221	8067	10459	2%
SCAA2	0%	60%	80%	40%	45%	61%	0%	34%	92%	95%	94%	9036	7954	11964	0%
SCAA3	0%	60%	60%	40%	45%	61%	0%	18%	66%	67%	57%	10649	11952	12136	2%
SCAA4	0%	60%	80%	40%	45%	61%	0%	31%	90%	94%	90%	9350	9047	11729	2%
SCAA5	0%	60%	80%	35%	40%	56%	0%	42%	95%	98%	97%	8482	5225	6933	52%
SCAA6	0%	60%	70%	35%	40%	61%	0%	18%	76%	73%	68%	10280	10286	12255	5%
SCAA7	0%	60%	80%	40%	45%	58%	0%	28%	88%	90%	82%	9583	9656	12219	2%

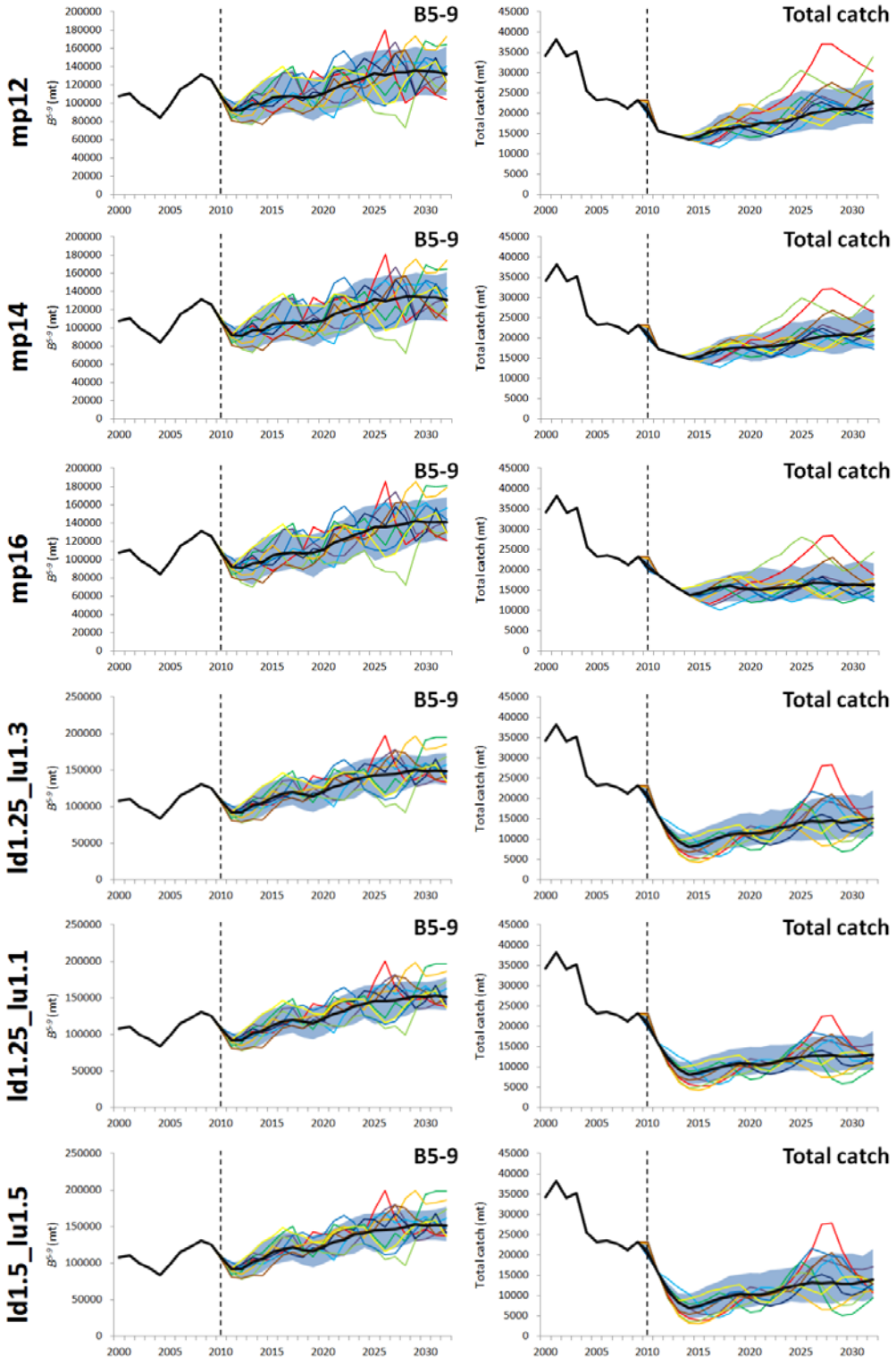

Fig. 1a: 80% PIs (blue shading), medians (thick black line) and 10 random worm trajectories for the exploitable biomass and total catch projections for mp12, mp14, mp16 and the three Canadian scientists' preferred MPs for **SCAA0**.

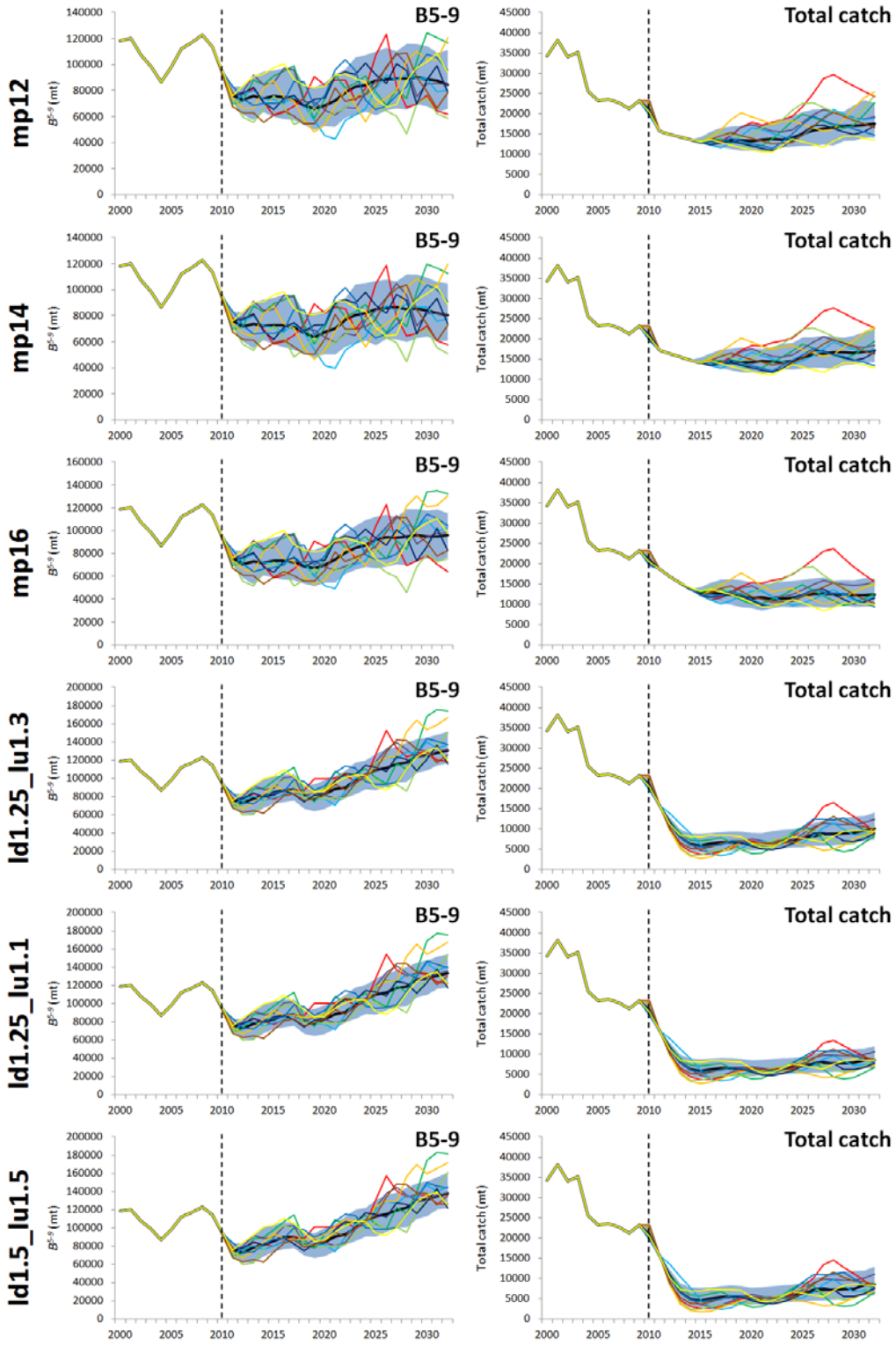

Fig. 1b: 80% PIs (blue shading), medians (thick black line) and 10 random worm trajectories for the exploitable biomass and total catch projections for mp12, mp14, mp16 and the three Canadian scientists' preferred MPs for **SCAA5**.

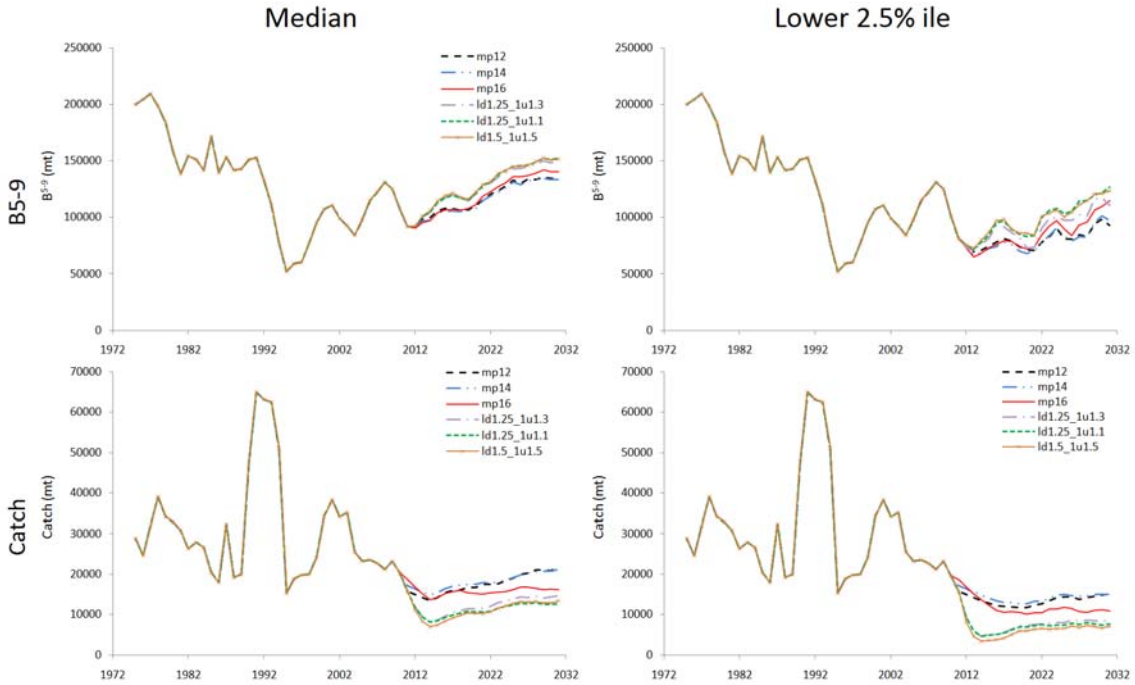

Fig. 2a: Medians (left) and lower 2.5%iles (right) TAC and exploitable biomass for the six preferred MPs for **SCAA0**.

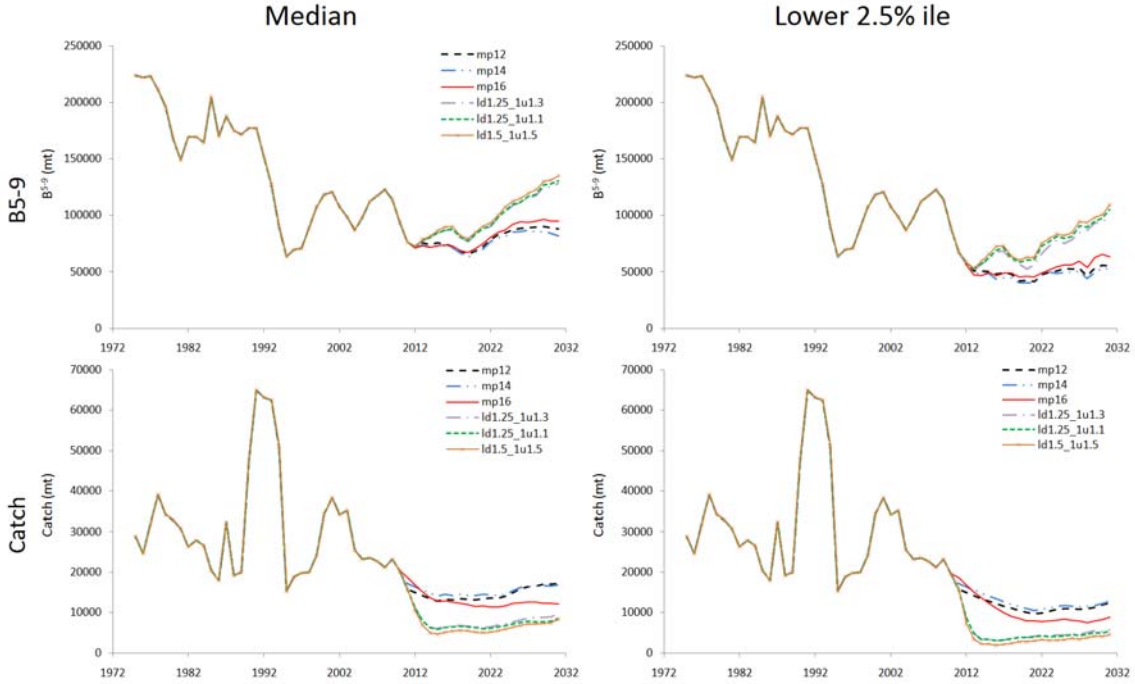

Fig. 2b: Medians (left) and lower 2.5%iles (right) TAC and exploitable biomass for the six preferred MPs for **SCAA5**.

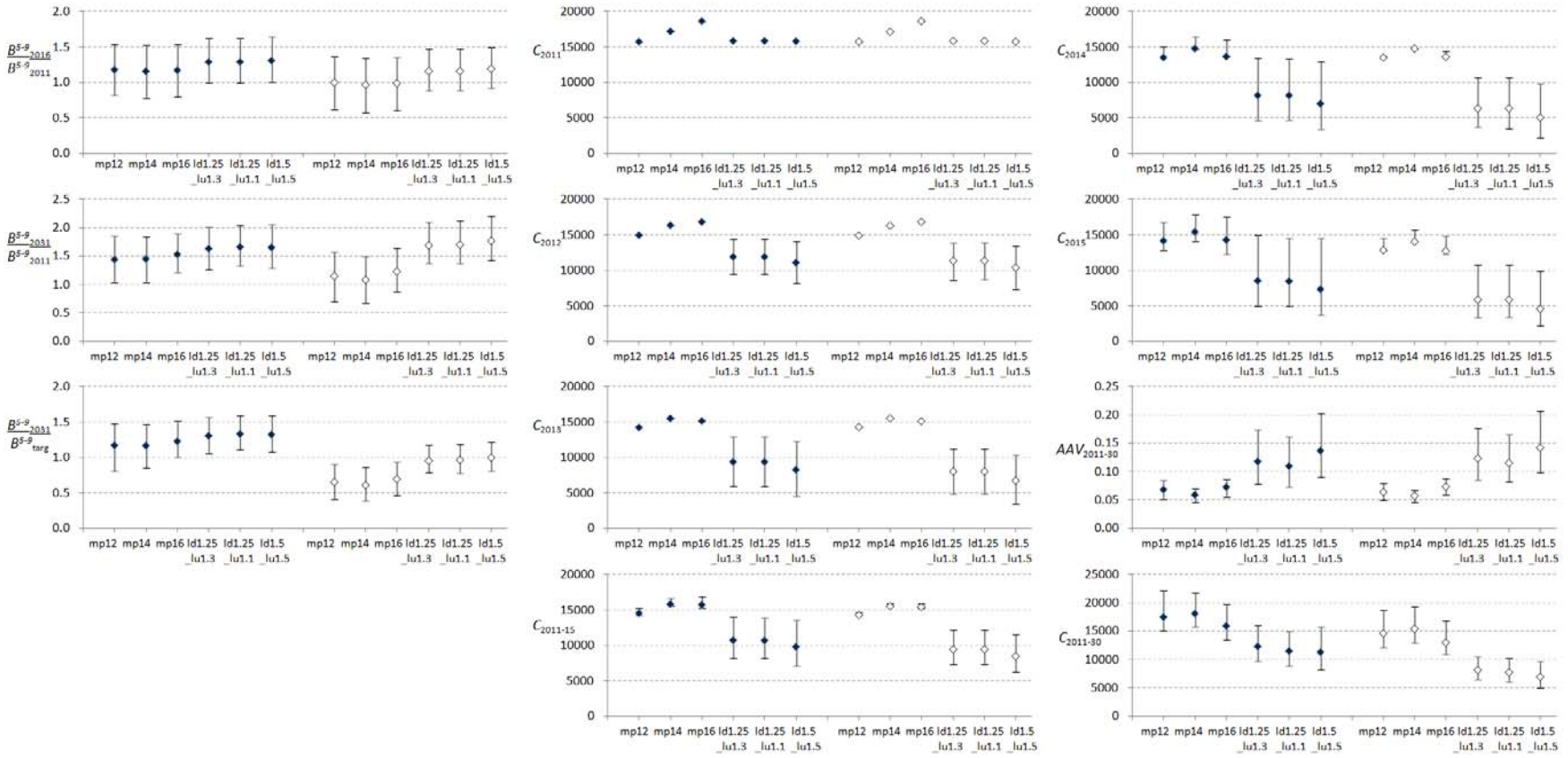

Fig. 3: Median and 95%-iles for a series of performance statistics for the six preferred MPs for the Base Case SCAA (**SCAA0**) (filled circles) and robustness test **SCAA5** (low steepness) (open circles).

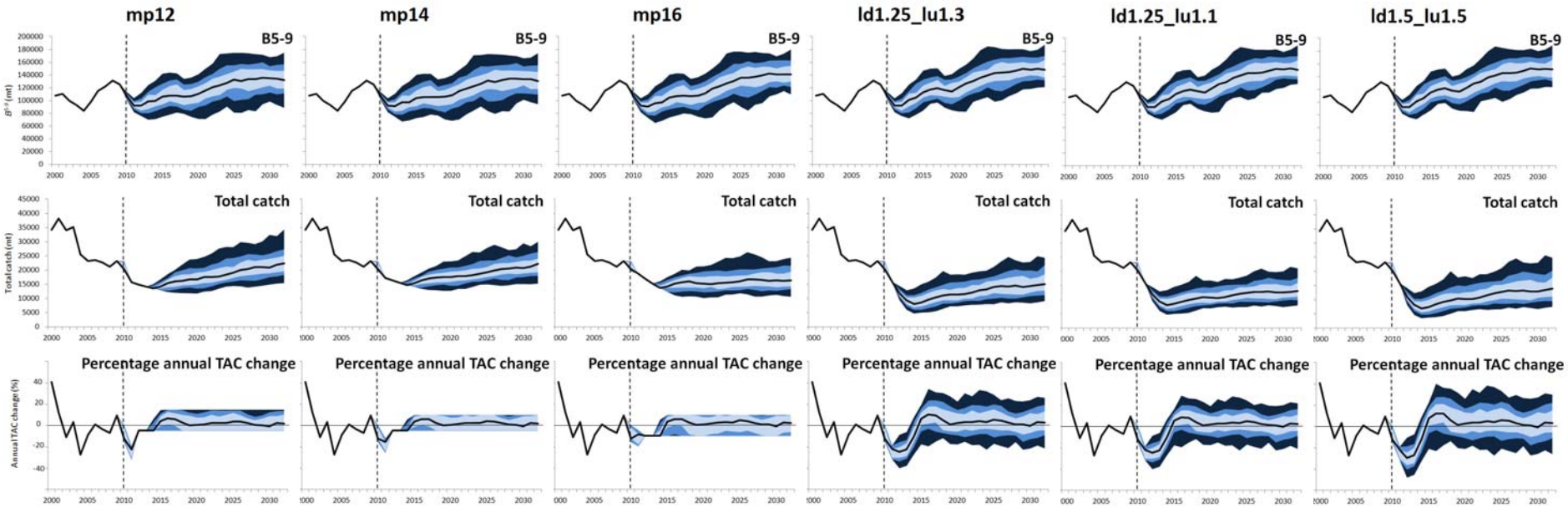

Fig. 4a: 95, 75 and 50% PIs and medians for the exploitable biomass , total catch and percentage annual TAC change projections for the six preferred MPs for **SCAA0**.

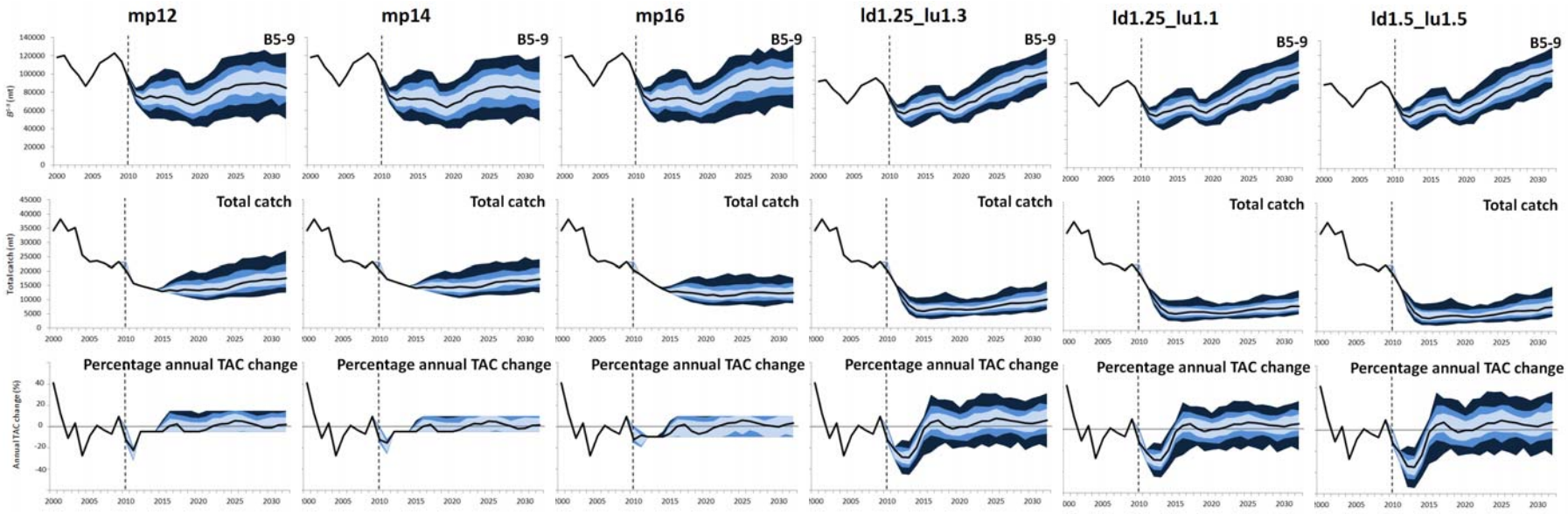

Fig. 4b: 95, 75 and 50% PIs and medians for the exploitable biomass , total catch and percentage annual TAC change projections for the six preferred MPs for **SCAA5**.