# Results on the Development of Candidate Management Procedures for the Canadian Pollock in the in the Western Component (4Xopqrs+5Zc) for the May 2011 Meeting

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## Abstract

Results for five different Candidate Management Procedures (CMPs) for pollock which contrast achievable performance (catch *vs* resource recovery and catch *vs* time) trade-offs in relation to greater/lesser conservatism and earlier/later pain in terms of catch allocation reductions if needed. The results incorporate recent decisions concerning the reporting of performance statistics and the addition of further operating models (OMs) which reflect better future recruitment.

## Introduction

This document has been prepared for discussion at the meeting in St Andrews on 9-10 May. It presents results for five alternative Candidate Management Procedures (CMPs) in forms that incorporate discussions at and following recent conference calls. Specifically:

i) Exploitable biomass $B^{4\text{-}8}$ projections are now reported also relative to their 1982-2010 average (in plots though not (yet) in Tables), and plots now also show lower 25%-iles.
ii) Two new Operating Models (OMs) have been added, each reflecting better average future recruitment than observed over the last 10 years for which reliable estimates are available.
iii) Two further CMP tunings have been added reflecting more (CMP_high) and less (CMP_low) conservative approaches than does CMPR.

## Background

Three Appendices are provided as background.

Appendix A lists the OMs (this text will later be expanded to provide full details on each of these OMs). It also lists alongside each OM a measure of the future variability (see the Appendix for more details) in recruitment and the survey index of abundance about its expected level that has been used for projections.

Appendix B details the projection methodology used, and provides details of previously agreed performance statistics (the latter may need updating following further discussions).

Appendix C gives full specifications of the five CMPs considered in this paper, and includes a plot of the relationships between the TAC (pre- the application of interannual constraints on catch allocation changes) and the three-year average survey index. Note that in a change from earlier practice, these CMPs are now all based on geometric rather than arithmetic averages of survey abundances indices, as this was found to reduce the risk of unintended resource reduction slightly without compromising catches.

**Results**

Detailed results are reported in Appendix D.

Of the Tables which list performance statistics:
D1 covers the five CMPs plus C=0 applied to the Reference Set (RS) of OMs
D2 contrasts results for each of the OMs in the RS separately under CMPR
D3 shows results for CMPR applied to all the other robustness tests
D4 shows results for the five CMPs plus the C=0 scenario for a particularly pessimistic (OM15) and similarly optimistic (OM18) scenario.

Figures relate to the following:
D1a-e: "Shade" projection outcome plots showing probability envelopes for various statistics for each of the five CMPs under the RS.
D2: For CMPR, median and lower 25%- and 2.5%-iles for catch and exploitable biomass, contrasting the range of earlier/later "pain" in the CMPs (CMPR-, CMPR and CMPR+) and conservation (CMPR_high, CMPR and CMPR_low) under the RS.
D3: Format as for D2, but here for CMPR under the RS contrasting projections under each of the six OMs constituting the RS.
D4: "Bar" plots contrasting performance statistics for the five CMPs under the RS.
D5: "Bar" plots as in D4, but here for application of CMPR to every OM (both those in the RS and other robustness tests).
D6: A comparison of median, lower 25%- and lower 2.5%-ile projections of catch and exploitable biomass across application of CMPR to every OM.
D7: "Shade" probability interval plots for projected survey abundance indices and average ages in the catch and the surveys under application of CMPR to the RS, where the statistics are shown individually, and as geometric means over the last two and last three years (this is for contrast to aid consideration for possible use for defining Exceptional Circumstances provisions).

## Discussion

A key area of discussion at the May 9-10 meeting will be seeking to achieve consensus on an appropriate choice amongst CMPs to provide a preferred trade-off between competing objectives. The five CMPs for which results are projected in this document have been chosen to illustrate two major trade-off axes.

The first of these is the degree of conservatism, which trades off the level of catch in the medium term against the extent of resource recovery. This is reflected across CMPR_low, CMPR, CMPR_high, with the relationship between mean catch over and exploitable biomass after the first 10 years of operation of an MP illustrated in the upper panel of Fig. 1 for application of these CMPs to the RS.

Furthermore, on application of CMPR to the RS, in median terms the predicted catch allocated shows a decline. The extent of this decline in reflected across CMPR-, CMPR and CMPR+ in the lower panel of Fig. 1 which shows the relationship between the average catch over the first five years (2011-2015) and that in year eleven (2021) of operation of the MP. This shows the earlier pain *vs* later pain trade-off axis, whereby (IF the RS is an good reflection of the underlying resource dynamics) an immediate fairly large cut-back in catches can be avoided, but this would need to be followed by larger drop in catches later (see also Fig. D2a).

The MP finally chosen does not need to be one of the five CMPs for which results are presented here. Rather, if consensus can be reached about desired trade-offs across these two axes, the control parameters of the CMPs of Appendix C can be adjusted to seek to achieve those preferred trade-offs in performance. Thus for example, if on the first day the meeting can make an initial attempt to develop such agreement, it might be possible to "tune" the CMP control parameters in time to be able to show results at the start of the second day.

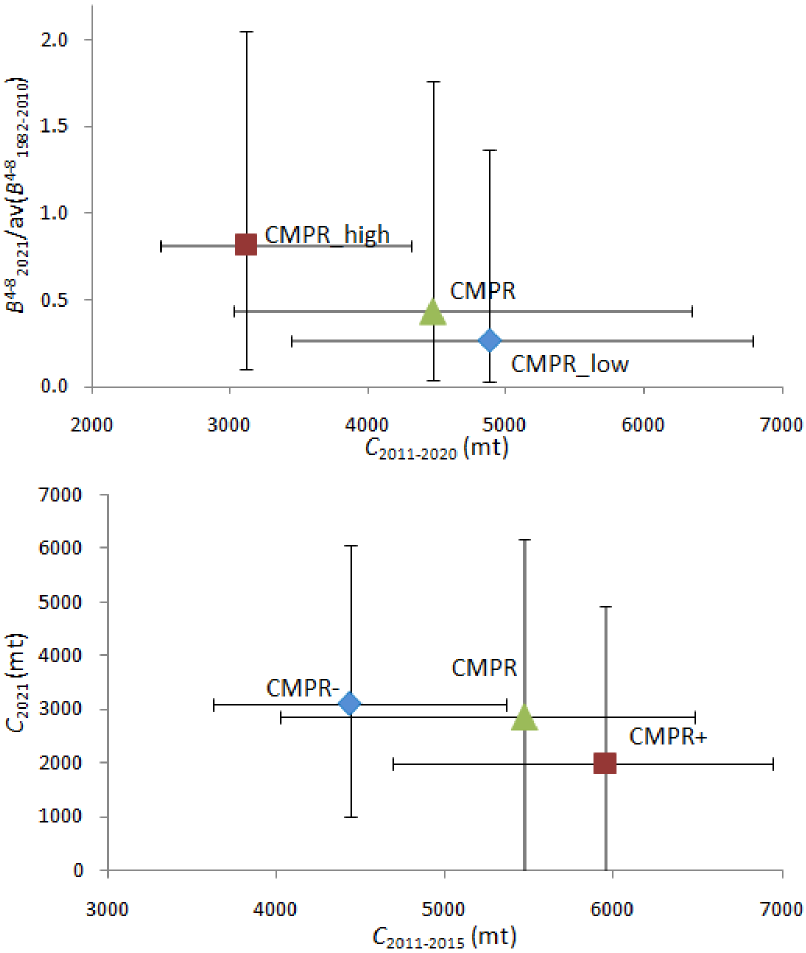


*Fig. 1: Plots showing the trade-off between "aggressive" vs "conservative" CMPs (upper panel) and "earlier pain" vs "later pain" CMPs (lower panel). The crosses reflect medians and 50%iles for the RS.*

## APPENDIX A: List of Operating Models

Table A1 summarises the different OMs and Rob3. [Complete details will be added in a later version of this Appendix.]

The Table lists values of $\sigma_R$ and $\sigma_{survey}$ for each OM. These indicate the extents to which future recruitment varies about its expected value and survey results vary about the underlying (survey-selectivity weighted) biomass when projecting, and are inferred from these variabilities as evident from past trends in recruitment and surveys about expected values in the assessment corresponding to the OM concerned. Technically they reflect the standard deviations of the logs of the quantities concerned about their expected values. Roughly speaking a $\sigma$ value of 0.4 corresponds to a 95% probability interval between half to double of the expected value, and 0.8 from a quarter to four times this amount.

*Table A1: Summary of the different OMs and Rob3.*

| | Included in RS | Caracteristics | Stock-recruitment relationship | $\sigma_R$ | $\sigma_{survey}$ |
|---|---|---|---|---|---|
| OM1 | √ | RAD1 (Rademeyer and Butterworth, 2010): no bias correction, *M* =0.2, including 2010 survey estimate | based on last 10 reliable years (1999-2008) | 0.40 | 0.78 |
| OM2 | √ | Stone (Stone, 2010): with bias correction, *M* =0.2, including 2010 survey estimate | based on last 10 reliable years (1999-2008) | 0.72 | 0.80 |
| OM3 | √ | Stone (Stone, 2010): with bias correction, *M* =0.2, excluding 2010 survey estimate; | based on last 10 reliable years (1999-2008) | 0.25 | 0.76 |
| OM4 | | Survey abundance: square root | based on last 10 reliable years (1999-2008) | 0.49 | 0.76 |
| OM5 | | Survey abundance: power (square) | based on last 10 reliable years (1999-2008) | 0.26 | 1.56 |
| OM6 | | Survey abundance: mixture distribution for future | based on last 10 reliable years (1999-2008) | 0.40 | 0.44 - 0.53 |
| OM7 | | *M* =0.2 age 6 or less, age 7-13 *M* =0.675 – no change in future | based on last 10 reliable years (1999-2008) | 0.38 | 0.71 |
| OM8 | √ | *M* =0.2 for ages 4 or less, *M* =0.579 for ages 5 and 6 and *M*= 0.617 for ages 7 and above - no change in future | based on last 10 reliable years (1999-2008) | 0.37 | 0.71 |
| OM9 | | *M* as in OM7 but all back to 0.2 after 5 years | based on last 10 reliable years (1999-2008) | 0.38 | 0.71 |
| OM10 | | *M* as in OM8 but all back to 0.2 after 5 years | based on last 10 reliable years (1999-2008) | 0.37 | 0.71 |
| OM12 | | Dome–shaped survey | based on last 10 reliable years (1999-2008) | 0.40 | 0.78 |
| OM13 | √ | As OM1 | based on last five reliable years (2004-2008) | 0.57 | 0.78 |
| OM14 | √ | As OM1 | Beverton-Holt, fit up to a max value corresponding to the average values for $B^{sp}$ | 0.49 | 0.78 |
| OM15 | | As OM8 | based on last five reliable years (2004-2008) | 0.70 | 0.71 |
| OM16 | | M=0.2 age 6 or less, age 7-13 M=0.76 – no change in future | based on last five reliable years (2004-2008) | 0.38 | 0.72 |
| OM17 | | As OM1 | based on all reliable years (1984-2008) | 0.61 | 0.78 |
| OM18 | | As OM1 | based on 1984-1994 period | 0.21 | 0.78 |
| Rob3 | | for each OM in the RC | based on last 10 reliable years (1999-2008) but recruitment in the first eight years of projections is assumed to be at the level of the lowest recruitment over the 1999-2008 period | - | - |

## APPENDIX B: Candidate Management Procedures Testing Methodology for Canadian Pollock in the Western Component (4Xopqrs+5Zc)

### Projection methodology

Projections into the future under a specific Candidate Management Procedure (CMP) are to be evaluated using the following steps.

Step 1: Begin-year numbers at age

The components of the numbers-at-age vector at the start of 2010 ( $N_{2010,a}$ : $a$ = 2,…, $m$) are obtained from the MLE of an assessment of the resource using VPA. The 2010 recruitment ( $N_{2010,2}$) is generated deterministically from the estimated stock-recruitment relationship (see below). Error is included for ages 2 to 7 because these are poorly estimated in the assessment given limited information on these year-classes, i.e.:

$$N_{2010,a} \rightarrow N_{2010,a} e^{\varepsilon_a} \qquad \varepsilon_a \text{ from } N\left(0,(\sigma_R)^2\right) \tag{B1}$$

where $\sigma_R$ is estimated in the process of fitting a stock-recruitment relationship to the outputs from that assessment as described below. Equation B1 is approximate in that it omits to adjust for past catches from the year-class concerned, but these are so small that the differential effect is negligible.

Step 2: Catch

These numbers-at-age are projected one year forward at a time given a catch for the year concerned.

For 2010:

A catch of 4200t is assumed.

For 2011:

A catch of 6000t is assumed.

From 2012 onwards:

$C_y$ is as specified by the CMP.

This requires specification of how the catch is disaggregated by age to obtain $C_{y,a}$ , and how future recruitments are specified.

Step 3: Catch-at-age

The selectivity each year is selected randomly from the selectivity vectors for the last 10 years (2000 to 2009) estimated in the assessment. The selectivity vectors for 2000 to 2009 are computed as follows:

$$S_{y,a} = F_{y,a} / \max\left(F_{y,a}\right) \tag{B2}$$

where the maximum is taken across the ages for that year.

From this it follows that:

$$F_y = C_y / \sum_a w_{y,a}^{mid} N_{y,a} e^{-M_a/2} S_{y,a} \qquad \text{(B3)}$$

where $w_{y,a}^{mid}$ is each year selected randomly from the weight-at-age vectors for the last 10 years (2000 to 2009) used in the assessment (Table B1) , and hence that:

$$C_{y,a} = N_{y,a} e^{-M_a/2} S_{y,a} F_y \qquad \text{(B4)}$$

If $F_y > 0.95$, i.e. unrealistically large, some modifications are necessary. First, the maximum catch for that year is computed assuming all ages are fully selected and a fishing proportion of 0.95:

$$C_y^{\max} = \sum_a 0.95 N_{y,a} w_{y,a}^{mid} e^{-M_a/2} \qquad \text{(B5)}$$

If $C_y^{\max} < C_y$, the TAC for that year cannot be caught giving: $S_{y,a}^* = 1$ and $F_y^* = 0.95$ and a catch that year of $C_y^{\max}$.

If $C_y^{\max} \ge C_y$, then:

$$S_{y,a}^* = (1 - g_y) S_{y,a} + g_y \qquad \text{(B6)}$$

Solving for $g_y$:

$$g_y = \frac{\left(\sum_a S_{y,a} w_{y,a}^{mid} 0.95 N_{y,a} e^{-M_a/1}\right) - C_y}{\left(\sum_a S_{y,a} w_{y,a}^{mid} 0.95 N_{y,a} e^{-M_a/1}\right) - \left(\sum_a w_{y,a}^{mid} 0.95 N_{y,a} e^{-M_a/1}\right)} \qquad \text{(B7)}$$

and hence:

$$C_{y,a} = N_{y,a} e^{-M_a/2} S_{y,a}^* 0.95 \qquad \text{(B8)}$$

The numbers-at-age can then be computed for the beginning of the following year (*y*+1):

$$N_{y+1,2} = R_{y+1} \qquad \text{(B9)}$$

$$N_{y+1,a+1} = \left(N_{y,a} e^{-M_a/2} - C_{y,a}\right) e^{-M_a/2} \qquad \text{for } 2 \le a \le m-1 \qquad \text{(B10)}$$

These equations reflect Pope's approximation.

The maximum age *m* is 13 (not a plus-group).

Step 4: Recruitment

Future recruitments (age 2) are provided by a Hockey-stick or a capped Beverton-Holt stock-recruitment relationship with autocorrelation in the stock-recruitment residuals:

$$R_y = \begin{cases} Ae^{(\varepsilon_y^{SR} - \sigma_R^2/2)} & \text{if } B_{y-2}^{sp} \geq B_{\min}^{sp} \\ \dfrac{A}{B_{\min}^{sp}} B_{y-2}^{sp} e^{(\varepsilon_y^{SR} - \sigma_R^2/2)} & \text{if } B_{y-2}^{sp} < B_{\min}^{sp} \end{cases} \tag{B11}$$

for the Hockey-stick, and

$$R_y = \begin{cases} \dfrac{\alpha B_{y-2}^{sp}}{\beta + B_{y-2}^{sp}} e^{(\varepsilon_y^{SR} - \sigma_R^2/2)} & \text{if } \dfrac{\alpha B_{y-2}^{sp}}{\beta + B_{y-2}^{sp}} < R_{\max} \\ R_{\max} e^{(\varepsilon_y^{SR} - \sigma_R^2/2)} & \text{if } \dfrac{\alpha B_{y-2}^{sp}}{\beta + B_{y-2}^{sp}} \geq B_{\min}^{sp} \end{cases} \tag{B12}$$

for the capped Beverton-Holt,

where

$$\varepsilon_y^{SR} = \rho \varepsilon_{y-1}^{SR} + \sqrt{1-\rho^2}\, \zeta_y$$

with $\zeta_y$ from $N\left(0, \sigma_R^2\right)$,

$$A = \exp\left( \sum_{y=y1}^{y2} \ln R_y \Big/ (y2 - y1 + 1) \right) ,$$

$B_{\min}^{sp} = \min\left(B_y^{sp}\right)$ for the period (y1-2) to (y2-2) and

$$R_{\max} = \exp\left( \sum_{y=1984}^{2009} if\,(B_{y-2}^{sp} > 2000) \ln(R_y) \Big/ n \right) \tag{B13}$$

$\rho$ is obtained by minimising the following negative log-likelihood function:

$$-\ln L^{SR} = \sum_{1984}^{2009} \left[ \ln \sigma_R + \left( \frac{\varepsilon_y^{SR} - \rho \varepsilon_{y-1}^{SR}}{\sqrt{1-\rho^2}} \right)^2 \Big/ 2\sigma_R^2 \right] \tag{B14}$$

with

$$\sigma_R = \sqrt{ \sum_{y=y1}^{y2} \left(\varepsilon_y^{SR}\right)^2 \Big/ (y2 - y1 + 1) } \tag{B15}$$

$$B_y^{sp} = \sum_{a=1}^{m} f_a w_{y,a} N_{y,a} \tag{B16}$$

where $w_{y,a}$ is each year selected randomly from the weight-at-age vectors for the last 10 years (2000 to 2009) used in the assessment (Table B2), and

$f_a$ is the maturity-at-age, taken to be 0 to age 3 and 1 from age 4 and above.

Step5:

The information obtained in Step 1 is used to generate a value of the abundance indice $I_{2011}$ (summer survey, in terms of biomass). Indices of abundance in future years will not be exactly proportional to true abundance, as they are subject to observation error. Log-normal observation error is therefore added to the expected value of the abundance index evaluated:

$$I_y^i = q^i B_y^i e^{\varepsilon_y^i} \quad \text{(B17)}$$

$$\varepsilon_y^i \quad \text{from } N\left(0,\left(\sigma^i\right)^2\right) \quad \text{(B18)}$$

where

$B_y^i$ is the biomass (or numbers) available to the survey:

$$B_y^{summer} = \sum_{a=1}^{m} w_{y,a}^{mid} S_{y,a}^{surv} N_{y,a} e^{-M_a/2}\left(1 - S_{y,a} F_y /2\right) \quad \text{(B19)}$$

The survey selectivities are taken as the catchabilities ($q_a^i$) estimated in that assessment, renormalized so that $\max(q_a^i) = 1$. The survey selectivity is assumed to be zero for age 2, and for ages 9 and above, the selectivity is assumed to remain flat at the age 8 level.

The constant of proportionality $q^i$ is as estimated for the assessment in question by:

$$\ell n\, \hat{q}^i = 1/27 \sum_{y=1984}^{2010}\left(\ln I_y^i - \ln \hat{B}_y^i\right) \quad \text{(B20)}$$

$$\hat{\sigma}^i = \sqrt{1/27 \sum_{y=1984}^{2010}\left(\varepsilon_y^i\right)^2} \quad \text{(B21)}$$

$$\varepsilon_y^i = \ell n(I_y^i) - \ell n(q^i \hat{B}_y^i) \quad \text{(B22)}$$

where the survey index of biomass $I_y^i$ is given in Table B3.

Step 6:

Given the new survey indices $I_{y+1}^i$ compute $TAC_{y+1}$ using the CMP.

Step 7:

Steps 1-6 are repeated for each future year in turn for as long a period as desired, and at the end of that period the performance of the candidate MP under review is assessed by considering statistics such as the average catch taken over the period and the final spawning biomass of the resource.

## Performance Targets and Statistics

*[Note that these will be updated after choices are made amongst some of the variants for which results are currently being shown]*

During the September 2010 Halifax meeting it was suggested that four properties should be evaluated in a risk management context:

I) the risk of decline of the exploitable biomass (ages 4 to 8) below the 1974-1994 average be kept moderately low;

II) the risk of annual average catch variation of greater than 25% be kept moderately low;

III) the magnitude of the average catch in the short, medium term and long term be maximized;

A number of mathematical expressions (Performance Statistics) were then proposed to capture these four properties:

(a) $\frac{P_{2031}}{P_{2010}}$, where $P_y$ is the population size in year *y*;

(b) $\frac{P_{2016}}{P_{2010}}$;

(c) $\frac{P_{low}}{P_{2010}}$, where $P_{low}$ is the lowest population size during evaluation period (2010-2031);

(d) $\frac{P_{2031}}{P_{\text{target}}}$, where $P_{\text{target}}$ is pre-defined recovery target population size, for which 1984-1994 will be used;

In each of them, population can be measured as the exploitable biomass ($B_y^{4-8}$), spawning biomass ($B_y^{sp}$) or survey biomass ($B_y^{surv}$), where:

$$B_y^{4-8} = \sum_{a=4}^{8} w_{y,a}^{mid} N_{y,a} \quad \text{(B23)}$$

$$B_y^{sp} = \sum_{a=1}^{m} f_{y,a} w_{y,a}^{mid} N_{y,a} \quad \text{(B24)}$$

$$B_y^{surv} = \sum_{a=1}^{m} w_{y,a}^{mid} S_{y,a}^{surv} N_{y,a} e^{-M_a/2} \left(1 - S_{y,a} F_y / 2\right) \quad \text{(B25)}$$

The primary PS above can be captured by:

(e) (Average) annual catch over short, medium and long terms:

$$C_{2011},\ C_{2012},\ \sum_{y=2011}^{2015} C_y \Big/ 5,\ \sum_{y=2016}^{2020} C_y \Big/ 5,\ \sum_{y=2011}^{2020} C_y \Big/ 5 \text{ and } \sum_{y=2011}^{2030} C_y \Big/ 20$$

(f) Average annual variation in catch over short and long terms:

$$AAV_{2011-2015} = \frac{1}{5}\sum_{y=2011}^{2015} \left| C_y - C_{y-1} \right| / C_{y-1}$$ and

$$AAV_{2011-2030} = \frac{1}{20}\sum_{y=2011}^{2030} \left| C_y - C_{y-1} \right| / C_{y-1}$$

*Table B1: Mid-year weights-at-age (kg) matrix for Canadian Pollock in the Western Component (4Xopqrs+5Zc). Note: a missing value for age 12 in 2008 has been replaced by the average of the five previous years, while missing values for age 13 have been replaced by 11.*

| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1982 | 0.943 | 1.427 | 2.529 | 3.462 | 4.211 | 4.772 | 5.681 | 6.239 | 7.687 | 8.622 | 10.621 | 10.802 |
| 1983 | 0.881 | 1.349 | 1.983 | 3.373 | 4.367 | 5.105 | 5.651 | 6.624 | 7.220 | 8.381 | 8.886 | 9.188 |
| 1984 | 0.914 | 1.635 | 2.331 | 3.005 | 4.078 | 5.401 | 6.062 | 6.208 | 6.661 | 7.230 | 9.725 | 8.091 |
| 1985 | 0.974 | 1.615 | 2.462 | 3.169 | 3.695 | 4.296 | 6.022 | 7.315 | 7.185 | 7.968 | 9.343 | 9.401 |
| 1986 | 0.738 | 1.554 | 2.306 | 3.095 | 3.929 | 4.530 | 5.791 | 6.651 | 7.161 | 7.322 | 8.698 | 6.835 |
| 1987 | 0.943 | 1.475 | 2.266 | 3.046 | 3.564 | 4.315 | 4.907 | 5.300 | 6.794 | 7.482 | 7.909 | 8.806 |
| 1988 | 1.195 | 1.549 | 2.240 | 3.096 | 3.807 | 4.191 | 4.979 | 5.886 | 7.073 | 8.169 | 8.454 | 8.467 |
| 1989 | 0.880 | 1.313 | 2.095 | 3.068 | 3.885 | 4.491 | 4.869 | 6.012 | 6.334 | 8.911 | 7.133 | 10.715 |
| 1990 | 0.571 | 1.263 | 2.055 | 2.894 | 3.657 | 4.766 | 5.818 | 6.371 | 6.966 | 7.625 | 9.770 | 9.070 |
| 1991 | 0.906 | 1.344 | 2.153 | 2.866 | 3.736 | 4.730 | 5.711 | 6.460 | 6.815 | 8.060 | 9.030 | 9.778 |
| 1992 | 1.033 | 1.271 | 1.831 | 2.615 | 3.509 | 4.614 | 5.466 | 6.141 | 6.864 | 8.164 | 9.189 | 8.947 |
| 1993 | 0.761 | 1.110 | 1.666 | 2.312 | 3.143 | 3.754 | 4.723 | 5.492 | 6.704 | 7.704 | 8.131 | 8.606 |
| 1994 | 0.805 | 1.250 | 1.586 | 2.163 | 3.058 | 3.765 | 4.219 | 4.854 | 6.268 | 6.082 | 7.846 | 8.539 |
| 1995 | 0.671 | 1.132 | 1.806 | 2.296 | 3.038 | 3.941 | 4.796 | 5.389 | 7.348 | 8.573 | 8.781 | 9.392 |
| 1996 | 0.896 | 1.336 | 1.795 | 2.353 | 3.057 | 3.665 | 5.205 | 6.296 | 8.502 | 9.561 | 11.422 | 11.474 |
| 1997 | 0.915 | 1.388 | 1.938 | 2.446 | 3.288 | 3.976 | 5.101 | 7.763 | 10.058 | 6.737 | 11.915 | 11.000 |
| 1998 | 0.867 | 1.103 | 1.720 | 2.361 | 3.144 | 4.219 | 5.159 | 5.640 | 8.615 | 8.833 | 12.063 | 11.000 |
| 1999 | 0.806 | 1.193 | 1.682 | 2.419 | 3.245 | 4.288 | 5.659 | 7.057 | 9.939 | 9.943 | 10.000 | 11.000 |
| 2000 | 0.757 | 1.247 | 1.796 | 2.478 | 3.166 | 4.168 | 5.412 | 5.745 | 9.003 | 9.821 | 10.000 | 11.000 |
| 2001 | 0.453 | 1.039 | 1.987 | 2.929 | 3.734 | 4.775 | 6.532 | 8.118 | 8.539 | 9.026 | 10.788 | 13.067 |
| 2002 | 0.280 | 0.931 | 1.592 | 2.528 | 3.714 | 4.829 | 6.328 | 6.936 | 8.663 | 10.872 | 11.081 | 16.975 |
| 2003 | 0.590 | 0.977 | 1.536 | 2.376 | 3.528 | 4.780 | 6.289 | 7.427 | 9.281 | 10.090 | 8.875 | 11.000 |
| 2004 | 0.475 | 0.873 | 1.621 | 2.210 | 3.125 | 4.290 | 6.509 | 7.369 | 8.699 | 9.077 | 12.027 | 15.595 |
| 2005 | 0.391 | 0.955 | 1.439 | 2.152 | 2.801 | 4.087 | 5.479 | 5.956 | 9.216 | 14.277 | 14.277 | 11.000 |
| 2006 | 0.654 | 0.931 | 1.722 | 2.180 | 3.101 | 3.715 | 4.680 | 5.186 | 9.121 | 9.906 | 10.851 | 11.000 |
| 2007 | 0.660 | 0.948 | 1.573 | 2.525 | 2.973 | 3.944 | 4.567 | 6.229 | 7.352 | 10.195 | 13.091 | 11.000 |
| 2008 | 0.758 | 1.202 | 1.681 | 2.299 | 3.191 | 3.819 | 4.907 | 5.552 | 5.985 | 8.832 | 11.824 | 11.000 |
| 2009 | 0.585 | 1.137 | 1.884 | 2.451 | 3.318 | 4.153 | 4.558 | 5.074 | 5.324 | 11.959 | 12.974 | 13.123 |
| 2010 | 0.683 | 1.026 | 1.754 | 2.456 | 3.091 | 3.804 | 4.358 | 4.471 | 4.969 | 6.365 | 10.252 | 11.000 |

*Table B2: Begin-year weights-at-age (kg) matrix for Canadian Pollock in the Western Component (4Xopqrs+5Zc).*

| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1982 | 0.284 | 0.811 | 1.693 | 2.988 | 3.818 | 4.483 | 5.207 | 5.954 | 6.925 | 8.141 | 9.569 | 10.809 |
| 1983 | 0.303 | 1.235 | 1.660 | 2.949 | 3.888 | 4.637 | 5.193 | 6.134 | 6.712 | 8.027 | 8.753 | 10.809 |
| 1984 | 0.360 | 0.944 | 2.615 | 2.730 | 3.709 | 4.857 | 5.563 | 5.923 | 6.643 | 7.225 | 9.028 | 9.887 |
| 1985 | 0.323 | 0.807 | 2.301 | 2.900 | 3.332 | 4.186 | 5.703 | 6.659 | 6.679 | 7.285 | 8.219 | 10.343 |
| 1986 | 0.423 | 0.900 | 1.608 | 3.136 | 3.529 | 4.091 | 4.988 | 6.329 | 7.238 | 7.253 | 8.325 | 10.138 |
| 1987 | 0.185 | 0.642 | 1.884 | 2.554 | 3.321 | 4.118 | 4.715 | 5.540 | 6.722 | 7.320 | 7.610 | 9.782 |
| 1988 | 0.572 | 0.696 | 1.364 | 2.704 | 3.405 | 3.865 | 4.635 | 5.374 | 6.123 | 7.450 | 7.953 | 9.327 |
| 1989 | 0.366 | 0.750 | 1.901 | 2.688 | 3.468 | 4.135 | 4.517 | 5.471 | 6.106 | 7.939 | 7.633 | 9.643 |
| 1990 | 0.254 | 0.656 | 1.323 | 2.784 | 3.350 | 4.303 | 5.112 | 5.570 | 6.471 | 6.950 | 9.331 | 8.858 |
| 1991 | 0.366 | 0.590 | 1.154 | 2.416 | 3.288 | 4.159 | 5.217 | 6.131 | 6.589 | 7.493 | 8.298 | 10.367 |
| 1992 | 0.331 | 0.776 | 1.374 | 1.990 | 3.171 | 4.152 | 5.085 | 5.922 | 6.659 | 7.459 | 8.606 | 9.966 |
| 1993 | 0.444 | 0.560 | 1.168 | 2.202 | 2.867 | 3.629 | 4.668 | 5.479 | 6.416 | 7.272 | 8.148 | 10.054 |
| 1994 | 0.309 | 0.693 | 1.108 | 1.617 | 2.659 | 3.440 | 3.980 | 4.788 | 5.867 | 6.385 | 7.775 | 9.457 |
| 1995 | 0.213 | 0.482 | 1.183 | 1.967 | 2.563 | 3.472 | 4.249 | 4.768 | 5.972 | 7.331 | 7.308 | 9.290 |
| 1996 | 0.200 | 0.613 | 1.042 | 1.951 | 2.649 | 3.337 | 4.529 | 5.495 | 6.769 | 8.382 | 9.896 | 9.828 |
| 1997 | 0.204 | 0.974 | 1.340 | 2.102 | 2.782 | 3.486 | 4.324 | 6.357 | 7.958 | 7.568 | 10.673 | 11.209 |
| 1998 | 0.375 | 0.604 | 0.971 | 2.016 | 2.773 | 3.725 | 4.529 | 5.364 | 8.178 | 9.426 | 9.015 | 11.448 |
| 1999 | 0.222 | 0.607 | 1.191 | 1.828 | 2.768 | 3.672 | 4.886 | 6.034 | 7.487 | 9.255 | 9.398 | 11.519 |
| 2000 | 0.264 | 0.697 | 1.209 | 1.838 | 2.767 | 3.678 | 4.817 | 5.702 | 7.971 | 9.880 | 9.972 | 10.488 |
| 2001 | 0.313 | 0.525 | 1.479 | 2.353 | 3.042 | 3.888 | 5.218 | 6.628 | 7.004 | 9.015 | 10.293 | 10.488 |
| 2002 | 0.257 | 0.605 | 1.173 | 2.115 | 3.298 | 4.246 | 5.497 | 6.731 | 8.386 | 9.635 | 10.001 | 10.894 |
| 2003 | 0.220 | 0.708 | 1.175 | 2.101 | 2.986 | 4.213 | 5.511 | 6.856 | 8.023 | 9.349 | 9.823 | 11.040 |
| 2004 | 0.205 | 0.566 | 1.430 | 1.906 | 2.725 | 3.890 | 5.578 | 6.808 | 8.038 | 9.178 | 11.016 | 9.881 |
| 2005 | 0.227 | 0.597 | 1.243 | 1.891 | 2.465 | 3.542 | 4.724 | 6.120 | 8.083 | 11.144 | 11.384 | 11.502 |
| 2006 | 0.350 | 0.702 | 1.393 | 1.926 | 2.524 | 3.196 | 4.335 | 5.194 | 7.245 | 9.372 | 12.447 | 12.532 |
| 2007 | 0.223 | 0.700 | 1.441 | 2.191 | 2.542 | 3.490 | 4.118 | 5.422 | 6.175 | 9.643 | 11.388 | 10.925 |
| 2008 | 0.370 | 0.772 | 1.342 | 1.966 | 2.835 | 3.365 | 4.390 | 5.034 | 6.132 | 8.058 | 10.979 | 12.000 |
| 2009 | 0.455 | 0.869 | 1.666 | 2.113 | 2.762 | 3.640 | 4.172 | 4.990 | 5.437 | 8.460 | 10.705 | 11.405 |
| 2010 | 0.073 | 0.750 | 1.550 | 2.180 | 2.753 | 3.553 | 4.254 | 4.514 | 5.021 | 5.821 | 11.073 | 11.946 |

*Table B3: Stratified mean catch per tow (kg) of pollock from the DFO summer research vessel survey in 4X strata corresponding to the western component.*

| Year | Stratified mean wt/tow |
|---|---|
| 1984 | 35.65 |
| 1985 | 39.23 |
| 1986 | 36.59 |
| 1987 | 37.27 |
| 1988 | 93.07 |
| 1989 | 31.70 |
| 1990 | 86.20 |
| 1991 | 30.48 |
| 1992 | 13.86 |
| 1993 | 37.15 |
| 1994 | 18.20 |
| 1995 | 14.35 |
| 1996 | 64.51 |
| 1997 | 8.84 |
| 1998 | 6.10 |
| 1999 | 5.30 |
| 2000 | 5.79 |
| 2001 | 14.84 |
| 2002 | 6.13 |
| 2003 | 18.37 |
| 2004 | 20.86 |
| 2005 | 15.16 |
| 2006 | 121.01 |
| 2007 | 23.90 |
| 2008 | 40.44 |
| 2009 | 47.04 |
| 2010 | 5.39 |

**APPENDIX C: Technical Specifications of Candidate Management Procedures**

The target-based Candidate Management Procedures (CMPs) formulae for computing the TAC each year are as follows:

$$C_{y+1} = \lfloor a + b(J_y - J_0) \rfloor - pen \qquad \text{(C1)}$$

with

$$pen = \begin{cases} 0 & \text{if } J_y \geq J_0 \\ c(J_y - J_o)^2 & \text{if } J_y < J_0 \end{cases} \qquad \text{(C2)}$$

where

$C_y$ is the total TAC recommended for year *y*,

$a$ , $b$ and $c$ are tuning parameters,

$J_0$ is a tuning parameter, and

$J_y$ is a measure of the immediate past level in the survey abundance index relative to a target level as available to use for calculations for year *y*:

$$J_y = \frac{\exp\left(\sum_{y-2}^{y} \ln(I_y) \Big/ 3\right)}{\exp\left(\sum_{1984}^{1994} \ln(I_y) \Big/ 11\right)} \qquad \text{(C3)}$$

where $I_y$ is the survey abundance index in year *y*.

Note: $I_{2009}$ is set to 15 in all the CMPs presented here for enhanced stability of the TAC in the short term and $I_{2010}$ is also set to 15 in CMPR+.

*Maximum allowable interannual change in TAC*

The maximum allowable annual increase in TAC is set to 20% or 500t, whichever is the greatest - this is so that the TAC can recover (reasonable quickly given appropriate survey results) after going down to very low values. Furthermore, a cap (upper bound) on the TAC of 20,000t has been imposed.

The maximum allowable decrease in TAC from one year to the next is:

$$MaxDecr_y = \begin{cases} 20\% & \text{if } J_y \geq Q_{\min} \\ \text{linear between 20\% and x\%} & \text{if } Q_{\min} - 0.1 \leq J_y < Q_{\min} \\ 100\% & \text{if } J_y < Q_{\min} - 0.1 \end{cases} \qquad \text{(C4)}$$

where

$Q_{\min}$ is a tuning parameter.

The tuning parameters for each CMP presented in this paper are given in Table C1

In the event of the TAC reaching zero, the annual contribution that year to the Average Annual Variation, AAV, cannot be calculated because of dividing by zero. If the TAC the following year is also zero, then the Annual Variation for that year is obviously set to zero, if not the Annual Variation is set to 25%.

*Table C1: Tuning parameter values for each CMP*

| | | | | | | | | | Interannual change constraints | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Initial | a | b | c | $J_0$ | $I_{2009}$ | $I_{2010}$ | $Q_{min}$ | *MaxIncr* | *MaxDecr* | Cap |
| CMPR- | 6000 | 6000 | 24000 | 70000 | 0.40 | 15 | 5.39 | 0.2 | +20%/500t | -20%/-50%/-100% | 20000t |
| CMPR | 6000 | 6000 | 8000 | 200000 | 0.30 | 15 | 5.39 | 0.2 | +20%/500t | -20%/-40%/-100% | 20000t |
| CMPR+ | 6000 | 6000 | 8000 | 200000 | 0.30 | 15 | 15 | 0.2 | +20%/500t | -20%/-40%/-100% | 20000t |
| CMPR_low | 6000 | 6000 | 8000 | 200000 | 0.22 | 15 | 5.39 | 0.2 | +20%/500t | -20%/-40%/-100% | 20000t |
| CMPR_high | 6000 | 6000 | 8000 | 200000 | 0.65 | 15 | 5.39 | 0.2 | +20%/500t | -20%/-40%/-100% | 20000t |

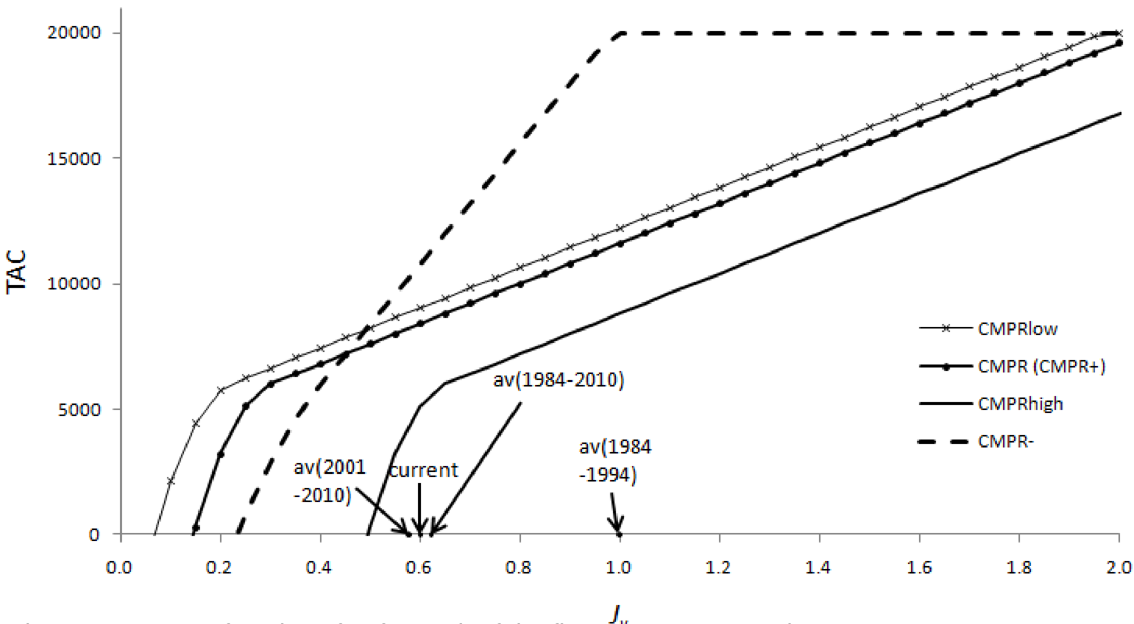


*Fig. C1: TAC as a function of $J_y$ for each of the five CMPs presented.*

## APPENDIX D: Full set of results

*Table D1: Projections results (median and 95% PI in parenthesis) for a series of performance statistics for different CMPs under the RS. [Note that the new first row relates to the target used for tuning the different variants.]*

| | | C=0 | | CMPR- | | CMPR | | CMPR+ | | CMPR_low | | CMPR_high | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $B^{4\text{-}8}_{(av2016\text{-}2031)}/B^{4\text{-}8}_{2000}$ | | 3.25 | (1.25; 6.08) | 1.61 | (0.37; 4.39) | 1.39 | (0.26; 4.14) | 1.32 | (0.29; 3.99) | 0.99 | (0.15; 3.44) | 2.12 | (0.49; 4.87) |
| $P_{2021}/P_{target}$ | $B^{4\text{-}8}$ | 0.79 | (0.24; 1.58) | 0.38 | (0.03; 1.22) | 0.30 | (0.03; 1.15) | 0.26 | (0.03; 1.01) | 0.18 | (0.02; 0.92) | 0.56 | (0.06; 1.36) |
| | $B^{sp}$ | 1.45 | (0.55; 2.75) | 0.44 | (0.03; 1.69) | 0.31 | (0.03; 1.47) | 0.27 | (0.03; 1.38) | 0.18 | (0.02; 1.13) | 0.72 | (0.09; 1.86) |
| $P_{2016}/P_{2000}$ | $B^{4\text{-}8}$ | 2.86 | (1.13; 5.70) | 1.66 | (0.19; 4.12) | 1.28 | (0.08; 3.87) | 0.97 | (0.06; 3.29) | 0.88 | (0.05; 3.23) | 1.88 | (0.22; 4.48) |
| | $B^{sp}$ | 4.08 | (1.53; 8.55) | 1.95 | (0.23; 5.27) | 1.51 | (0.09; 4.67) | 1.12 | (0.07; 4.14) | 1.01 | (0.06; 4.10) | 2.25 | (0.25; 6.01) |
| $P_{2021}/P_{2000}$ | $B^{4\text{-}8}$ | 3.11 | (1.03; 6.76) | 1.48 | (0.13; 5.05) | 1.15 | (0.11; 4.94) | 1.02 | (0.14; 4.30) | 0.70 | (0.09; 3.84) | 2.20 | (0.28; 5.74) |
| | $B^{sp}$ | 7.68 | (2.15; 14.30) | 1.95 | (0.14; 8.88) | 1.45 | (0.14; 7.83) | 1.31 | (0.17; 7.36) | 0.87 | (0.12; 5.87) | 3.41 | (0.49; 9.67) |
| $P_{2031}/P_{2000}$ | $B^{4\text{-}8}$ | 3.10 | (0.91; 7.07) | 1.34 | (0.14; 5.04) | 1.36 | (0.11; 4.96) | 1.45 | (0.13; 5.13) | 0.94 | (0.07; 4.78) | 1.85 | (0.18; 5.68) |
| | $B^{sp}$ | 7.84 | (2.05; 16.17) | 1.87 | (0.16; 8.37) | 1.83 | (0.13; 8.05) | 1.96 | (0.16; 8.31) | 1.22 | (0.10; 7.31) | 2.62 | (0.23; 10.17) |
| Prob$<P_{2000}$ | $B^{4\text{-}8}$ | 0.05 | (0.00; 0.43) | 0.29 | (0.00; 0.95) | 0.38 | (0.00; 1.00) | 0.43 | (0.00; 1.00) | 0.57 | (0.00; 1.00) | 0.14 | (0.00; 0.95) |
| | $B^{sp}$ | 0.00 | (0.00; 0.14) | 0.24 | (0.00; 0.81) | 0.29 | (0.00; 0.91) | 0.33 | (0.00; 0.90) | 0.43 | (0.00; 1.00) | 0.10 | (0.00; 0.71) |
| Prob$<1.5P_{2000}$ | $B^{4\text{-}8}$ | 0.14 | (0.00; 0.81) | 0.52 | (0.10; 1.00) | 0.62 | (0.05; 1.00) | 0.62 | (0.05; 1.00) | 0.76 | (0.14; 1.00) | 0.33 | (0.00; 1.00) |
| | $B^{sp}$ | 0.10 | (0.00; 0.29) | 0.38 | (0.05; 0.95) | 0.48 | (0.00; 1.00) | 0.48 | (0.00; 1.00) | 0.62 | (0.05; 1.00) | 0.24 | (0.00; 0.95) |
| Prob$<2.0P_{2000}$ | $B^{4\text{-}8}$ | 0.24 | (0.00; 1.00) | 0.69 | (0.24; 1.00) | 0.76 | (0.24; 1.00) | 0.81 | (0.24; 1.00) | 0.90 | (0.33; 1.00) | 0.52 | (0.00; 1.00) |
| | $B^{sp}$ | 0.14 | (0.00; 0.48) | 0.52 | (0.14; 1.00) | 0.62 | (0.10; 1.00) | 0.62 | (0.10; 1.00) | 0.76 | (0.19; 1.00) | 0.38 | (0.00; 1.00) |
| $C_{2011}$ | | 6000 | (6000; 6000) | 6000 | (6000; 6000) | 6000 | (6000; 6000) | 6000 | (6000; 6000) | 6000 | (6000; 6000) | 6000 | (6000; 6000) |
| $C_{2012}$ | | 0 | (0; 0) | 4800 | (4009; 7200) | 5655 | (4273; 7200) | 6682 | (4800; 7200) | 6431 | (4670; 7200) | 4800 | (4273; 4800) |
| $C_{2013}$ | | 0 | (0; 0) | 3840 | (0; 8460) | 4991 | (0; 8245) | 6251 | (3247; 8640) | 6141 | (1589; 8640) | 3840 | (0; 5760) |
| $C_{2014}$ | | 0 | (0; 0) | 3589 | (0; 10063) | 5353 | (0; 9734) | 5851 | (0; 10368) | 6452 | (0; 10368) | 3072 | (0; 6912) |
| $C_{2015}$ | | 0 | (0; 0) | 3686 | (0; 11222) | 5220 | (0; 11155) | 4862 | (0; 12442) | 6188 | (0; 11888) | 2458 | (0; 7645) |
| $C_{2016}$ | | 0 | (0; 0) | 3545 | (0; 12991) | 4577 | (0; 11975) | 4144 | (0; 12815) | 5699 | (0; 13061) | 1966 | (0; 7802) |
| $C_{2021}$ | | 0 | (0; 0) | 3104 | (0; 15404) | 2867 | (0; 11860) | 2000 | (0; 10396) | 1637 | (0; 10837) | 2709 | (0; 11011) |
| $C_{2011\text{-}2015}$ | | 1200 | (1200; 1200) | 4439 | (2063; 8394) | 5470 | (2153; 8345) | 5951 | (2865; 8930) | 6200 | (2757; 8772) | 4034 | (2087; 6181) |
| $C_{2016\text{-}2020}$ | | 0 | (0; 0) | 3428 | (0; 11879) | 3736 | (0; 10477) | 2951 | (0; 10038) | 3661 | (100; 10378) | 2199 | (0; 8959) |
| $C_{2011\text{-}2020}$ | | 600 | (600; 600) | 3940 | (1411; 9758) | 4468 | (1595; 8731) | 4276 | (1740; 8730) | 4878 | (1825; 8997) | 3113 | (1340; 7116) |
| $C_{2021\text{-}2030}$ | | 0 | (0; 0) | 4120 | (50; 12369) | 3405 | (135; 11612) | 2982 | (213; 10965) | 2643 | (300; 10301) | 4345 | (50; 11930) |
| $AAV_{2012\text{-}2020}$ | | 14.3 | (14.3; 14.3) | 23.8 | (18.2; 32.9) | 23.3 | (13.5; 32.7) | 22.7 | (13.3; 32.3) | 24.5 | (12.9; 38.2) | 22.8 | (18.8; 29.7) |
| $AAV_{2013\text{-}2020}$ | | 11.1 | (11.1; 11.1) | 21.7 | (15.5; 31.8) | 21.1 | (10.2; 31.5) | 20.5 | (10.0; 31.2) | 22.4 | (9.6; 37.7) | 20.6 | (16.1; 28.2) |
| $AAV_{2021\text{-}2030}$ | | 0.0 | (0.0; 0.0) | 20.7 | (4.1; 30.5) | 20.5 | (7.5; 30.6) | 21.0 | (8.3; 30.8) | 22.5 | (10.5; 38.7) | 20.2 | (2.4; 26.7) |

*Table D2: Projections results (median and 95% PI in parenthesis) for a series of performance statistics for **CMPR** for each OM in the RS.*

| | | OM1 | | OM2 | | OM3 | | OM8 | | OM13 | | OM14 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $B^{4\text{-}8}_{(av2016\text{-}2031)}/B^{4\text{-}8}_{2000}$ | | 1.62 | (0.82; 2.82) | 1.66 | (0.26; 6.05) | 1.87 | (0.87; 2.62) | 1.21 | (0.49; 1.75) | 0.69 | (0.13; 2.09) | 1.25 | (0.22; 4.15) |
| $P_{2021}/P_{target}$ | $B^{4\text{-}8}$ | 0.33 | (0.02; 0.90) | 0.40 | (0.03; 1.80) | 0.29 | (0.03; 0.67) | 0.42 | (0.09; 0.89) | 0.12 | (0.02; 0.60) | 0.21 | (0.03; 0.93) |
| | $B^{sp}$ | 0.35 | (0.02; 1.23) | 0.53 | (0.06; 2.48) | 0.27 | (0.02; 0.69) | 0.40 | (0.08; 0.85) | 0.15 | (0.02; 0.69) | 0.26 | (0.03; 1.06) |
| $P_{2016}/P_{2000}$ | $B^{4\text{-}8}$ | 1.50 | (0.09; 3.36) | 1.62 | (0.08; 5.35) | 1.98 | (1.05; 3.10) | 1.23 | (0.32; 2.22) | 0.54 | (0.05; 2.37) | 0.86 | (0.07; 2.75) |
| | $B^{sp}$ | 1.70 | (0.11; 4.26) | 1.78 | (0.10; 6.75) | 2.66 | (1.32; 4.43) | 1.39 | (0.38; 2.52) | 0.64 | (0.05; 3.13) | 0.98 | (0.08; 3.50) |
| $P_{2021}/P_{2000}$ | $B^{4\text{-}8}$ | 1.44 | (0.10; 3.91) | 1.69 | (0.14; 7.71) | 1.22 | (0.11; 2.86) | 1.15 | (0.24; 2.42) | 0.53 | (0.10; 2.61) | 0.91 | (0.13; 4.02) |
| | $B^{sp}$ | 1.84 | (0.13; 6.54) | 2.76 | (0.31; 12.89) | 1.41 | (0.13; 3.59) | 1.32 | (0.27; 2.84) | 0.77 | (0.13; 3.68) | 1.37 | (0.16; 5.66) |
| $P_{2031}/P_{2000}$ | $B^{4\text{-}8}$ | 1.70 | (0.12; 4.50) | 0.73 | (0.06; 6.96) | 2.66 | (0.76; 4.90) | 0.90 | (0.18; 2.80) | 0.70 | (0.07; 2.92) | 1.57 | (0.15; 5.29) |
| | $B^{sp}$ | 2.42 | (0.13; 6.74) | 1.09 | (0.08; 9.76) | 4.11 | (0.84; 8.30) | 1.07 | (0.20; 3.24) | 0.94 | (0.09; 3.37) | 2.27 | (0.18; 9.50) |
| Prob<$P_{2000}$ | $B^{4\text{-}8}$ | 0.31 | (0.05; 0.67) | 0.38 | (0.05; 1.00) | 0.19 | (0.00; 0.53) | 0.48 | (0.12; 0.93) | 0.71 | (0.10; 1.00) | 0.50 | (0.00; 1.00) |
| | $B^{sp}$ | 0.24 | (0.00; 0.48) | 0.31 | (0.00; 0.98) | 0.14 | (0.00; 0.43) | 0.38 | (0.05; 0.83) | 0.52 | (0.05; 0.95) | 0.33 | (0.00; 0.93) |
| Prob<1.5$P_{2000}$ | $B^{4\text{-}8}$ | 0.52 | (0.17; 0.91) | 0.55 | (0.07; 1.00) | 0.29 | (0.00; 0.64) | 0.76 | (0.36; 1.00) | 0.90 | (0.26; 1.00) | 0.71 | (0.00; 1.00) |
| | $B^{sp}$ | 0.43 | (0.10; 0.83) | 0.43 | (0.05; 1.00) | 0.24 | (0.00; 0.57) | 0.62 | (0.29; 1.00) | 0.71 | (0.17; 1.00) | 0.52 | (0.00; 1.00) |
| Prob<2.0$P_{2000}$ | $B^{4\text{-}8}$ | 0.67 | (0.36; 1.00) | 0.67 | (0.14; 1.00) | 0.50 | (0.14; 0.81) | 0.95 | (0.69; 1.00) | 1.00 | (0.57; 1.00) | 0.86 | (0.19; 1.00) |
| | $B^{sp}$ | 0.52 | (0.21; 0.91) | 0.52 | (0.05; 1.00) | 0.33 | (0.02; 0.67) | 0.81 | (0.57; 1.00) | 0.90 | (0.31; 1.00) | 0.67 | (0.00; 1.00) |
| $C_{2011}$ | | 6000 | (6000; 6000) | 6000 | (6000; 6000) | 6000 | (6000; 6000) | 6000 | (6000; 6000) | 6000 | (6000; 6000) | 6000 | (6000; 6000) |
| $C_{2012}$ | | 5674 | (4343; 7080) | 5034 | (4069; 6949) | 6458 | (4800; 7200) | 5212 | (4335; 6804) | 5764 | (4315; 7129) | 5713 | (4313; 7105) |
| $C_{2013}$ | | 5010 | (2772; 7143) | 3559 | (0; 7357) | 6938 | (4345; 8610) | 4299 | (2731; 6500) | 4648 | (0; 7549) | 4807 | (1252; 7345) |
| $C_{2014}$ | | 5389 | (1750; 8045) | 2659 | (0; 8828) | 8258 | (5213; 10332) | 4604 | (1691; 7152) | 4270 | (0; 8995) | 4592 | (0; 8625) |
| $C_{2015}$ | | 4194 | (238; 8765) | 2606 | (0; 9280) | 8991 | (5845; 11989) | 3723 | (500; 7654) | 3066 | (0; 9373) | 3466 | (0; 9189) |
| $C_{2016}$ | | 3482 | (0; 10166) | 1090 | (0; 10428) | 8770 | (6173; 13664) | 3284 | (857; 8640) | 675 | (0; 9810) | 784 | (0; 9718) |
| $C_{2021}$ | | 3337 | (0; 11725) | 3188 | (0; 15468) | 6190 | (0; 12092) | 4037 | (0; 8754) | 1000 | (0; 7341) | 1500 | (0; 9056) |
| $C_{2011\text{-}2015}$ | | 5297 | (3213; 7061) | 3953 | (2020; 7551) | 7399 | (5322; 8742) | 4837 | (3209; 6627) | 4529 | (2160; 7554) | 4646 | (2390; 7320) |
| $C_{2016\text{-}2020}$ | | 3123 | (100; 8771) | 1731 | (0; 10986) | 7034 | (3970; 11195) | 3061 | (589; 7694) | 527 | (0; 7168) | 408 | (0; 8073) |
| $C_{2011\text{-}2020}$ | | 4214 | (2103; 7682) | 2699 | (1260; 8859) | 7491 | (5726; 9369) | 3881 | (2080; 6699) | 3060 | (1585; 6666) | 3130 | (1641; 7498) |
| $C_{2021\text{-}2030}$ | | 4937 | (638; 9505) | 4123 | (240; 14671) | 3079 | (750; 8255) | 4208 | (525; 7550) | 2307 | (24; 7437) | 3679 | (50; 11989) |
| $AAV_{2012\text{-}2020}$ | | 22.8 | (18.5; 31.5) | 24.4 | (18.0; 34.9) | 18.9 | (13.7; 30.4) | 24.1 | (20.0; 31.6) | 24.2 | (17.9; 32.4) | 24.0 | (17.8; 32.7) |
| $AAV_{2013\text{-}2020}$ | | 20.6 | (15.8; 30.2) | 22.3 | (15.2; 34.0) | 16.2 | (10.5; 29.0) | 22.0 | (17.4; 30.4) | 22.1 | (15.1; 31.2) | 21.9 | (15.1; 31.6) |
| $AAV_{2021\text{-}2030}$ | | 20.5 | (14.2; 28.6) | 20.1 | (13.5; 31.1) | 20.8 | (14.0; 30.5) | 21.0 | (15.1; 30.1) | 21.0 | (14.8; 30.9) | 20.0 | (13.0; 31.6) |

*Table D3a: Projections results (median and 95% PI in parenthesis) for a series of performance statistics for **CMPR** for the robustness tests.*

| | | OM4 | | OM5 | | OM6 | | OM7 | | OM9 | | OM10 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $B^{4\text{-}8}_{(av2016\text{-}2031)}/B^{4\text{-}8}_{2000}$ | | 0.80 | (0.22; 3.08) | 2.09 | (1.36; 3.37) | 1.56 | (0.61; 2.87) | 1.47 | (0.83; 2.46) | 1.59 | (0.79; 2.58) | 1.95 | (0.84; 3.09) |
| $P_{2021}/P_{target}$ | $B^{4\text{-}8}$ | 0.17 | (0.01; 0.83) | 0.41 | (0.06; 0.94) | 0.33 | (0.05; 0.93) | 0.37 | (0.03; 0.91) | 0.41 | (0.06; 0.90) | 0.75 | (0.14; 1.46) |
| | $B^{sp}$ | 0.17 | (0.01; 1.06) | 0.43 | (0.06; 1.53) | 0.35 | (0.05; 1.16) | 0.37 | (0.03; 0.98) | 0.44 | (0.05; 1.24) | 0.89 | (0.13; 1.95) |
| $P_{2016}/P_{2000}$ | $B^{4\text{-}8}$ | 1.90 | (0.18; 4.66) | 1.14 | (0.08; 3.51) | 1.61 | (0.25; 3.46) | 1.41 | (0.20; 2.76) | 1.83 | (0.45; 3.45) | 2.33 | (0.99; 3.77) |
| | $B^{sp}$ | 2.26 | (0.25; 6.09) | 1.35 | (0.09; 4.69) | 1.82 | (0.28; 4.25) | 1.60 | (0.21; 3.16) | 2.13 | (0.56; 4.49) | 2.81 | (1.22; 4.87) |
| $P_{2021}/P_{2000}$ | $B^{4\text{-}8}$ | 0.72 | (0.05; 3.61) | 1.79 | (0.25; 4.08) | 1.42 | (0.24; 4.03) | 1.40 | (0.12; 3.47) | 1.55 | (0.21; 3.44) | 2.03 | (0.37; 3.96) |
| | $B^{sp}$ | 0.91 | (0.05; 5.64) | 2.28 | (0.29; 8.16) | 1.85 | (0.29; 6.15) | 1.68 | (0.13; 4.52) | 2.02 | (0.24; 5.70) | 2.98 | (0.42; 6.50) |
| $P_{2031}/P_{2000}$ | $B^{4\text{-}8}$ | 0.43 | (0.04; 4.41) | 2.67 | (0.59; 5.00) | 1.46 | (0.12; 4.75) | 1.31 | (0.10; 4.03) | 1.81 | (0.14; 4.59) | 1.57 | (0.18; 3.97) |
| | $B^{sp}$ | 0.55 | (0.05; 5.39) | 4.65 | (0.74; 8.42) | 2.16 | (0.14; 7.01) | 1.54 | (0.11; 4.60) | 2.39 | (0.17; 6.88) | 2.16 | (0.20; 5.57) |
| Prob<$P_{2000}$ | $B^{4\text{-}8}$ | 0.57 | (0.00; 0.93) | 0.19 | (0.00; 0.41) | 0.33 | (0.00; 0.79) | 0.33 | (0.02; 0.71) | 0.24 | (0.00; 0.62) | 0.14 | (0.00; 0.62) |
| | $B^{sp}$ | 0.48 | (0.00; 0.81) | 0.14 | (0.00; 0.31) | 0.24 | (0.00; 0.62) | 0.24 | (0.00; 0.64) | 0.19 | (0.00; 0.48) | 0.05 | (0.00; 0.43) |
| Prob<1.5$P_{2000}$ | $B^{4\text{-}8}$ | 0.74 | (0.10; 1.00) | 0.33 | (0.05; 0.64) | 0.57 | (0.21; 0.95) | 0.57 | (0.29; 0.95) | 0.52 | (0.14; 0.86) | 0.38 | (0.05; 0.83) |
| | $B^{sp}$ | 0.57 | (0.00; 0.95) | 0.24 | (0.00; 0.48) | 0.43 | (0.10; 0.90) | 0.48 | (0.14; 0.88) | 0.31 | (0.00; 0.69) | 0.24 | (0.00; 0.67) |
| Prob<2.0$P_{2000}$ | $B^{4\text{-}8}$ | 0.86 | (0.19; 1.00) | 0.52 | (0.19; 0.79) | 0.71 | (0.40; 1.00) | 0.76 | (0.48; 1.00) | 0.69 | (0.33; 1.00) | 0.57 | (0.19; 1.00) |
| | $B^{sp}$ | 0.67 | (0.00; 1.00) | 0.38 | (0.12; 0.67) | 0.57 | (0.29; 1.00) | 0.67 | (0.33; 1.00) | 0.52 | (0.10; 0.95) | 0.43 | (0.07; 0.93) |
| $C_{2011}$ | | 6000 | (6000; 6000) | 6000 | (6000; 6000) | 6000 | (6000; 6000) | 6000 | (6000; 6000) | 6000 | (6000; 6000) | 6000 | (6000; 6000) |
| $C_{2012}$ | | 6048 | (4610; 7188) | 6854 | (3958; 7200) | 4944 | (4494; 7200) | 5363 | (4360; 6925) | 5996 | (4547; 7167) | 5814 | (4487; 7094) |
| $C_{2013}$ | | 5954 | (3300; 7652) | 6955 | (0; 8640) | 4597 | (2839; 7271) | 4409 | (2781; 6726) | 5725 | (3164; 7545) | 5611 | (3091; 7466) |
| $C_{2014}$ | | 6845 | (2975; 9094) | 7836 | (0; 10368) | 4985 | (1728; 8676) | 4833 | (1726; 7592) | 6511 | (2675; 8586) | 6437 | (2811; 8529) |
| $C_{2015}$ | | 6924 | (3383; 10367) | 7426 | (0; 12442) | 5394 | (1255; 9006) | 4465 | (0; 8223) | 6277 | (2642; 9836) | 6577 | (2953; 9753) |
| $C_{2016}$ | | 7262 | (3650; 10966) | 6627 | (0; 14851) | 5258 | (0; 10125) | 3790 | (0; 9134) | 6402 | (2028; 10893) | 7210 | (3306; 10975) |
| $C_{2021}$ | | 5845 | (0; 12324) | 1000 | (0; 14479) | 4636 | (0; 11143) | 3585 | (0; 9157) | 6034 | (0; 12255) | 9211 | (3212; 17836) |
| $C_{2011\text{-}2015}$ | | 6299 | (4197; 7766) | 6878 | (2398; 8930) | 5302 | (3295; 7385) | 5067 | (3226; 6778) | 6114 | (4022; 7490) | 6057 | (3940; 7411) |
| $C_{2016\text{-}2020}$ | | 6864 | (2924; 9774) | 2635 | (0; 10236) | 4799 | (705; 9069) | 3707 | (100; 7767) | 5995 | (1295; 9647) | 8353 | (4372; 12412) |
| $C_{2011\text{-}2020}$ | | 6504 | (4379; 8266) | 4886 | (2151; 8724) | 4920 | (2069; 8010) | 4457 | (1924; 6826) | 6007 | (3266; 8308) | 7160 | (4484; 9597) |
| $C_{2021\text{-}2030}$ | | 4205 | (955; 8977) | 2982 | (1050; 10741) | 4096 | (915; 9097) | 3816 | (591; 7486) | 4946 | (619; 9891) | 9482 | (1572; 14755) |
| $AAV_{2012\text{-}2020}$ | | 17.9 | (10.8; 26.6) | 25.4 | (17.2; 33.9) | 22.7 | (13.2; 30.9) | 23.2 | (13.4; 33.1) | 19.3 | (11.7; 27.3) | 18.0 | (12.0; 23.1) |
| $AAV_{2013\text{-}2020}$ | | 15.2 | (7.2; 24.8) | 23.4 | (14.4; 32.9) | 20.5 | (10.0; 29.6) | 21.0 | (10.1; 32.0) | 16.7 | (8.2; 25.5) | 15.2 | (8.5; 20.9) |
| $AAV_{2021\text{-}2030}$ | | 21.4 | (8.4; 33.8) | 20.5 | (14.5; 28.5) | 20.5 | (9.7; 28.0) | 20.5 | (7.6; 28.7) | 20.6 | (8.5; 29.1) | 16.7 | (9.0; 28.2) |

*Table D3b: Projections results (median and 95% PI in parenthesis) for a series of performance statistics for* ***CMPR*** *for the robustness tests.*

| | | OM12 | | OM15 | | OM16 | | OM17 | | OM18 | | Rob3 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $B^{4\text{-}8}_{(av2016\text{-}2031)}/B^{4\text{-}8}_{2000}$ | | 1.64 | (0.71; 2.89) | 0.24 | (0.03; 1.71) | 1.07 | (0.41; 1.60) | 2.28 | (0.89; 4.88) | 3.88 | (2.22; 5.58) | 1.25 | (0.19; 3.12) |
| $P_{2021}/P_{target}$ | $B^{4\text{-}8}$ | 0.33 | (0.05; 0.91) | 0.08 | (0.01; 0.64) | 0.49 | (0.06; 1.00) | 0.46 | (0.02; 1.76) | 1.02 | (0.42; 1.51) | 0.20 | (0.02; 0.43) |
| | $B^{sp}$ | 0.36 | (0.05; 1.27) | 0.08 | (0.02; 0.59) | 0.45 | (0.05; 0.93) | 0.53 | (0.02; 2.37) | 1.16 | (0.41; 2.22) | 0.23 | (0.02; 0.48) |
| $P_{2016}/P_{2000}$ | $B^{4\text{-}8}$ | 1.57 | (0.11; 3.38) | 0.31 | (0.05; 1.38) | 1.11 | (0.39; 2.13) | 2.70 | (0.42; 7.12) | 4.11 | (2.21; 6.04) | 0.31 | (0.04; 0.93) |
| | $B^{sp}$ | 1.79 | (0.12; 4.28) | 0.36 | (0.06; 1.60) | 1.22 | (0.44; 2.46) | 3.13 | (0.50; 9.04) | 4.76 | (2.63; 7.13) | 0.41 | (0.05; 1.44) |
| $P_{2021}/P_{2000}$ | $B^{4\text{-}8}$ | 1.44 | (0.21; 3.94) | 0.22 | (0.03; 1.72) | 1.03 | (0.13; 2.08) | 1.99 | (0.11; 7.61) | 4.43 | (1.82; 6.53) | 0.87 | (0.09; 1.84) |
| | $B^{sp}$ | 1.94 | (0.24; 6.78) | 0.28 | (0.06; 1.96) | 1.16 | (0.14; 2.39) | 2.84 | (0.13; 12.63) | 6.19 | (2.19; 11.80) | 1.22 | (0.10; 2.54) |
| $P_{2031}/P_{2000}$ | $B^{4\text{-}8}$ | 1.73 | (0.15; 4.50) | 0.19 | (0.01; 1.60) | 0.85 | (0.13; 2.55) | 1.62 | (0.17; 8.03) | 2.79 | (0.21; 5.91) | 1.90 | (0.08; 5.35) |
| | $B^{sp}$ | 2.58 | (0.18; 6.70) | 0.24 | (0.01; 1.90) | 0.98 | (0.15; 2.82) | 2.54 | (0.21; 11.01) | 3.50 | (0.24; 7.70) | 2.88 | (0.09; 9.34) |
| Prob<$P_{2000}$ | $B^{4\text{-}8}$ | 0.29 | (0.05; 0.71) | 0.95 | (0.26; 1.00) | 0.52 | (0.14; 1.00) | 0.24 | (0.00; 0.67) | 0.05 | (0.00; 0.26) | 0.52 | (0.24; 1.00) |
| | $B^{sp}$ | 0.19 | (0.00; 0.52) | 0.90 | (0.14; 1.00) | 0.43 | (0.10; 0.90) | 0.19 | (0.00; 0.57) | 0.00 | (0.00; 0.22) | 0.38 | (0.19; 0.90) |
| Prob<1.5$P_{2000}$ | $B^{4\text{-}8}$ | 0.52 | (0.17; 0.93) | 1.00 | (0.48; 1.00) | 0.81 | (0.45; 1.00) | 0.38 | (0.07; 0.81) | 0.10 | (0.05; 0.41) | 0.71 | (0.38; 1.00) |
| | $B^{sp}$ | 0.38 | (0.10; 0.74) | 1.00 | (0.38; 1.00) | 0.71 | (0.38; 1.00) | 0.29 | (0.00; 0.69) | 0.05 | (0.00; 0.33) | 0.52 | (0.24; 1.00) |
| Prob<2.0$P_{2000}$ | $B^{4\text{-}8}$ | 0.71 | (0.31; 1.00) | 1.00 | (0.71; 1.00) | 0.98 | (0.76; 1.00) | 0.52 | (0.12; 0.95) | 0.14 | (0.05; 0.50) | 0.86 | (0.48; 1.00) |
| | $B^{sp}$ | 0.52 | (0.19; 0.95) | 1.00 | (0.59; 1.00) | 0.93 | (0.64; 1.00) | 0.38 | (0.05; 0.81) | 0.10 | (0.05; 0.43) | 0.62 | (0.33; 1.00) |
| $C_{2011}$ | | 6000 | (6000; 6000) | 6000 | (6000; 6000) | 6000 | (6000; 6000) | 6000 | (6000; 6000) | 6000 | (6000; 6000) | 6000 | (6000; 6000) |
| $C_{2012}$ | | 5582 | (4324; 7060) | 5175 | (4211; 6954) | 5083 | (4307; 6750) | 5762 | (4404; 7160) | 5677 | (4368; 7056) | 5743 | (4234; 7200) |
| $C_{2013}$ | | 4632 | (2738; 7076) | 4037 | (0; 7499) | 4127 | (1269; 6464) | 5409 | (2900; 7843) | 5243 | (2907; 7225) | 4919 | (0; 8139) |
| $C_{2014}$ | | 5396 | (808; 7986) | 3376 | (0; 8565) | 4571 | (783; 7125) | 6270 | (2031; 9327) | 6029 | (2280; 8467) | 4612 | (0; 9630) |
| $C_{2015}$ | | 4957 | (0; 8653) | 1895 | (0; 8662) | 4557 | (500; 8064) | 6388 | (2021; 10399) | 6546 | (2668; 9563) | 3529 | (0; 10438) |
| $C_{2016}$ | | 4444 | (0; 10141) | 0 | (0; 8024) | 4370 | (885; 8645) | 6617 | (1001; 12216) | 7440 | (3202; 10845) | 694 | (0; 9888) |
| $C_{2021}$ | | 3658 | (0; 11337) | 0 | (0; 6016) | 4176 | (0; 8623) | 7768 | (0; 19385) | 11753 | (6635; 19141) | 500 | (0; 3600) |
| $C_{2011\text{-}2015}$ | | 5409 | (3191; 7027) | 4166 | (2057; 7378) | 4956 | (2696; 6716) | 6032 | (3595; 7980) | 5942 | (3743; 7426) | 4852 | (2047; 8101) |
| $C_{2016\text{-}2020}$ | | 4189 | (143; 8758) | 376 | (0; 5214) | 4611 | (1076; 7800) | 7196 | (927; 13477) | 9376 | (4765; 13286) | 730 | (0; 6119) |
| $C_{2011\text{-}2020}$ | | 4512 | (2005; 7653) | 2411 | (1210; 5624) | 4466 | (2106; 6849) | 6747 | (2493; 10462) | 7668 | (4219; 9681) | 2821 | (1328; 6563) |
| $C_{2021\text{-}2030}$ | | 4181 | (899; 9856) | 84 | (0; 5967) | 4031 | (98; 8002) | 6313 | (750; 16547) | 12754 | (5994; 16393) | 2360 | (456; 5781) |
| $AAV_{2012\text{-}2020}$ | | 22.4 | (13.5; 31.6) | 22.7 | (16.9; 34.6) | 22.3 | (13.4; 32.3) | 20.2 | (12.8; 29.4) | 18.5 | (12.8; 24.7) | 24.2 | (17.2; 32.2) |
| $AAV_{2013\text{-}2020}$ | | 20.1 | (10.2; 30.4) | 20.5 | (14.1; 33.7) | 20.0 | (10.1; 31.2) | 17.6 | (9.5; 27.9) | 15.8 | (9.4; 22.7) | 22.2 | (14.4; 31.0) |
| $AAV_{2021\text{-}2030}$ | | 20.5 | (11.0; 28.8) | 12.5 | (0.0; 32.9) | 20.3 | (6.3; 28.7) | 20.4 | (3.9; 28.5) | 15.8 | (9.7; 24.8) | 21.5 | (12.5; 31.1) |

*Table D4a: Projections results (median and 95% PI in parenthesis) for a series of performance statistics for different CMPs for **OM15** (higher natural mortality and recruitment based on the last 5 reliable years).*

| OM15 | | C=0 | | CMPR- | | CMPR | | CMPR+ | | CMPR_low | | CMPR_high | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $B^{4\text{-}8}_{(av2016\text{-}2031)}/B^{4\text{-}8}_{2000}$ | | 0.99 | (0.12; 2.92) | 0.29 | (0.04; 2.02) | 0.24 | (0.03; 1.71) | 0.24 | (0.05; 1.63) | 0.16 | (0.03; 1.21) | 0.38 | (0.04; 2.37) |
| $P_{2021}/P_{target}$ | $B^{4\text{-}8}$ | 0.35 | (0.04; 1.21) | 0.10 | (0.01; 0.88) | 0.08 | (0.01; 0.64) | 0.07 | (0.01; 0.48) | 0.06 | (0.01; 0.35) | 0.12 | (0.01; 0.99) |
| | $B^{sp}$ | 0.38 | (0.06; 1.23) | 0.10 | (0.01; 0.80) | 0.08 | (0.02; 0.59) | 0.08 | (0.02; 0.46) | 0.06 | (0.01; 0.33) | 0.13 | (0.02; 0.97) |
| $P_{2016}/P_{2000}$ | $B^{4\text{-}8}$ | 0.90 | (0.37; 2.39) | 0.39 | (0.03; 1.62) | 0.31 | (0.05; 1.38) | 0.25 | (0.04; 1.08) | 0.23 | (0.04; 1.01) | 0.43 | (0.06; 1.79) |
| | $B^{sp}$ | 1.13 | (0.45; 3.06) | 0.45 | (0.03; 1.89) | 0.36 | (0.06; 1.60) | 0.27 | (0.05; 1.25) | 0.26 | (0.04; 1.16) | 0.48 | (0.07; 2.11) |
| $P_{2021}/P_{2000}$ | $B^{4\text{-}8}$ | 0.95 | (0.11; 3.28) | 0.26 | (0.04; 2.38) | 0.22 | (0.03; 1.72) | 0.20 | (0.04; 1.30) | 0.15 | (0.02; 0.96) | 0.32 | (0.04; 2.68) |
| | $B^{sp}$ | 1.27 | (0.22; 4.10) | 0.35 | (0.05; 2.67) | 0.28 | (0.06; 1.96) | 0.26 | (0.07; 1.52) | 0.19 | (0.02; 1.11) | 0.42 | (0.06; 3.23) |
| $P_{2031}/P_{2000}$ | $B^{4\text{-}8}$ | 0.88 | (0.04; 3.51) | 0.23 | (0.02; 2.15) | 0.19 | (0.01; 1.60) | 0.19 | (0.01; 1.83) | 0.09 | (0.01; 1.28) | 0.36 | (0.01; 2.37) |
| | $B^{sp}$ | 1.26 | (0.06; 4.10) | 0.29 | (0.02; 2.80) | 0.24 | (0.01; 1.90) | 0.22 | (0.02; 2.25) | 0.12 | (0.01; 1.51) | 0.47 | (0.02; 3.14) |
| Prob<$P_{2000}$ | $B^{4\text{-}8}$ | 0.57 | (0.00; 1.00) | 0.95 | (0.17; 1.00) | 0.95 | (0.26; 1.00) | 0.95 | (0.31; 1.00) | 1.00 | (0.38; 1.00) | 0.95 | (0.02; 1.00) |
| | $B^{sp}$ | 0.33 | (0.00; 1.00) | 0.86 | (0.07; 1.00) | 0.90 | (0.14; 1.00) | 0.90 | (0.21; 1.00) | 0.95 | (0.28; 1.00) | 0.86 | (0.00; 1.00) |
| Prob<1.5$P_{2000}$ | $B^{4\text{-}8}$ | 0.88 | (0.10; 1.00) | 1.00 | (0.40; 1.00) | 1.00 | (0.48; 1.00) | 1.00 | (0.52; 1.00) | 1.00 | (0.78; 1.00) | 1.00 | (0.24; 1.00) |
| | $B^{sp}$ | 0.67 | (0.00; 1.00) | 1.00 | (0.29; 1.00) | 1.00 | (0.38; 1.00) | 1.00 | (0.45; 1.00) | 1.00 | (0.64; 1.00) | 1.00 | (0.10; 1.00) |
| Prob<2.0$P_{2000}$ | $B^{4\text{-}8}$ | 1.00 | (0.31; 1.00) | 1.00 | (0.59; 1.00) | 1.00 | (0.71; 1.00) | 1.00 | (0.76; 1.00) | 1.00 | (0.90; 1.00) | 1.00 | (0.50; 1.00) |
| | $B^{sp}$ | 0.90 | (0.14; 1.00) | 1.00 | (0.48; 1.00) | 1.00 | (0.59; 1.00) | 1.00 | (0.62; 1.00) | 1.00 | (0.86; 1.00) | 1.00 | (0.36; 1.00) |
| $C_{2011}$ | | 6000 | (6000; 6000) | 6000 | (6000; 6000) | 6000 | (6000; 6000) | 6000 | (6000; 6000) | 6000 | (6000; 6000) | 6000 | (6000; 6000) |
| $C_{2012}$ | | 0 | (0; 0) | 4800 | (3917; 6454) | 5275 | (4211; 6954) | 6500 | (4800; 7200) | 6302 | (4493; 7200) | 4800 | (4211; 4800) |
| $C_{2013}$ | | 0 | (0; 0) | 3553 | (0; 6202) | 3944 | (0; 7499) | 5346 | (3138; 8640) | 5468 | (1423; 8139) | 3649 | (0; 3840) |
| $C_{2014}$ | | 0 | (0; 0) | 2151 | (0; 7127) | 2559 | (0; 8565) | 3624 | (0; 9037) | 4444 | (0; 9214) | 2441 | (0; 4608) |
| $C_{2015}$ | | 0 | (0; 0) | 1305 | (0; 8045) | 1747 | (0; 8662) | 0 | (0; 9347) | 3211 | (0; 9788) | 1618 | (0; 5530) |
| $C_{2016}$ | | 0 | (0; 0) | 0 | (0; 8041) | 0 | (0; 8024) | 0 | (0; 7714) | 122 | (0; 8361) | 0 | (0; 6387) |
| $C_{2021}$ | | 0 | (0; 0) | 0 | (0; 4769) | 250 | (0; 6016) | 0 | (0; 4590) | 1250 | (0; 4513) | 0 | (0; 2899) |
| $C_{2011\text{-}2015}$ | | 1200 | (1200; 1200) | 3375 | (2005; 6475) | 3794 | (2057; 7378) | 4532 | (2788; 7803) | 4809 | (2587; 7744) | 3570 | (2057; 4956) |
| $C_{2016\text{-}2020}$ | | 0 | (0; 0) | 76 | (0; 4791) | 249 | (0; 5214) | 50 | (0; 4598) | 300 | (0; 5735) | 0 | (0; 4247) |
| $C_{2011\text{-}2020}$ | | 600 | (600; 600) | 1928 | (1124; 5046) | 2307 | (1210; 5624) | 2376 | (1423; 5637) | 2736 | (1458; 5976) | 1942 | (1028; 4583) |
| $C_{2021\text{-}2030}$ | | 0 | (0; 0) | 131 | (0; 5563) | 317 | (0; 5967) | 240 | (0; 5560) | 450 | (0; 5092) | 0 | (0; 4573) |
| $AAV_{2012\text{-}2020}$ | | 14.3 | (14.3; 14.3) | 26.7 | (18.7; 35.4) | 22.7 | (18.3; 34.6) | 21.3 | (18.3; 30.3) | 27.6 | (17.1; 41.7) | 23.1 | (18.3; 32.6) |
| $AAV_{2013\text{-}2020}$ | | 11.1 | (11.1; 11.1) | 24.9 | (16.0; 34.6) | 20.5 | (15.6; 33.7) | 18.9 | (15.6; 28.9) | 25.9 | (14.2; 41.5) | 21.0 | (15.6; 31.5) |
| $AAV_{2021\text{-}2030}$ | | 0.0 | (0.0; 0.0) | 2.8 | (0.0; 30.5) | 12.5 | (0.0; 32.9) | 14.5 | (0.0; 31.5) | 17.9 | (2.8; 36.9) | 0.0 | (0.0; 30.1) |

*Table D4b: Projections results (median and 95% PI in parenthesis) for a series of performance statistics for different CMPs for **OM18** (future recruitment based on recruitments over the 1984-1984 period).*

| OM18 | | C=0 | | CMPR- | | CMPR | | CMPR+ | | CMPR_low | | CMPR_high | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $B^{4-8}_{(av2016-2031)}/B^{4-8}_{2000}$ | | 6.66 | (5.67; 7.55) | 3.55 | (1.99; 5.87) | 3.88 | (2.22; 5.58) | 3.75 | (2.08; 5.15) | 3.42 | (1.74; 4.74) | 5.15 | (3.62; 6.29) |
| $P_{2021}/P_{target}$ | $B^{4-8}$ | 1.52 | (1.19; 1.99) | 1.15 | (0.53; 1.64) | 1.02 | (0.42; 1.51) | 0.97 | (0.32; 1.46) | 0.88 | (0.23; 1.36) | 1.34 | (1.02; 1.72) |
| | $B^{sp}$ | 3.09 | (2.53; 3.70) | 1.54 | (0.58; 2.57) | 1.16 | (0.41; 2.22) | 1.07 | (0.31; 1.96) | 0.93 | (0.22; 1.64) | 2.06 | (1.40; 2.84) |
| $P_{2016}/P_{2000}$ | $B^{4-8}$ | 6.64 | (4.80; 8.53) | 4.76 | (2.92; 6.73) | 4.11 | (2.21; 6.04) | 3.68 | (1.86; 5.46) | 3.59 | (1.92; 5.33) | 5.27 | (3.48; 6.83) |
| | $B^{sp}$ | 8.43 | (6.41; 10.59) | 5.59 | (3.53; 7.88) | 4.76 | (2.63; 7.13) | 4.26 | (2.14; 6.44) | 4.11 | (2.26; 6.29) | 6.19 | (4.22; 7.97) |
| $P_{2021}/P_{2000}$ | $B^{4-8}$ | 6.59 | (5.14; 8.61) | 4.99 | (2.28; 7.11) | 4.43 | (1.82; 6.53) | 4.23 | (1.39; 6.32) | 3.79 | (1.02; 5.90) | 5.80 | (4.41; 7.48) |
| | $B^{sp}$ | 16.41 | (13.43; 19.67) | 8.22 | (3.07; 13.68) | 6.19 | (2.19; 11.80) | 5.71 | (1.67; 10.44) | 4.95 | (1.19; 8.71) | 10.95 | (7.47; 15.10) |
| $P_{2031}/P_{2000}$ | $B^{4-8}$ | 6.48 | (5.06; 9.18) | 1.63 | (0.37; 4.84) | 2.79 | (0.21; 5.91) | 2.83 | (0.41; 6.14) | 2.63 | (0.38; 5.78) | 3.55 | (0.29; 6.59) |
| | $B^{sp}$ | 16.10 | (13.30; 19.69) | 1.85 | (0.40; 7.02) | 3.50 | (0.24; 7.70) | 3.67 | (0.45; 8.84) | 3.25 | (0.43; 7.98) | 5.06 | (0.33; 9.61) |
| Prob<$P_{2000}$ | $B^{4-8}$ | 0.00 | (0.00; 0.05) | 0.10 | (0.00; 0.31) | 0.05 | (0.00; 0.26) | 0.05 | (0.00; 0.29) | 0.05 | (0.00; 0.36) | 0.00 | (0.00; 0.17) |
| | $B^{sp}$ | 0.00 | (0.00; 0.00) | 0.05 | (0.00; 0.26) | 0.00 | (0.00; 0.22) | 0.00 | (0.00; 0.19) | 0.00 | (0.00; 0.29) | 0.00 | (0.00; 0.14) |
| Prob<1.5$P_{2000}$ | $B^{4-8}$ | 0.10 | (0.05; 0.10) | 0.19 | (0.05; 0.45) | 0.10 | (0.05; 0.41) | 0.10 | (0.05; 0.45) | 0.10 | (0.05; 0.48) | 0.10 | (0.05; 0.26) |
| | $B^{sp}$ | 0.05 | (0.00; 0.10) | 0.14 | (0.00; 0.43) | 0.05 | (0.00; 0.33) | 0.05 | (0.00; 0.33) | 0.05 | (0.00; 0.43) | 0.05 | (0.00; 0.19) |
| Prob<2.0$P_{2000}$ | $B^{4-8}$ | 0.10 | (0.05; 0.12) | 0.29 | (0.10; 0.52) | 0.14 | (0.05; 0.50) | 0.14 | (0.05; 0.57) | 0.19 | (0.05; 0.64) | 0.10 | (0.05; 0.29) |
| | $B^{sp}$ | 0.10 | (0.05; 0.10) | 0.24 | (0.05; 0.48) | 0.10 | (0.05; 0.43) | 0.10 | (0.05; 0.45) | 0.14 | (0.05; 0.52) | 0.10 | (0.05; 0.26) |
| $C_{2011}$ | | 6000 | (6000; 6000) | 6000 | (6000; 6000) | 6000 | (6000; 6000) | 6000 | (6000; 6000) | 6000 | (6000; 6000) | 6000 | (6000; 6000) |
| $C_{2012}$ | | 0 | (0; 0) | 4800 | (4151; 6767) | 5674 | (4368; 7056) | 6696 | (4800; 7200) | 6441 | (4923; 7200) | 4800 | (4368; 4800) |
| $C_{2013}$ | | 0 | (0; 0) | 3840 | (2466; 5760) | 4895 | (2907; 7225) | 6312 | (3887; 8597) | 6172 | (3519; 7850) | 3840 | (2907; 3840) |
| $C_{2014}$ | | 0 | (0; 0) | 4608 | (1831; 6912) | 5874 | (2280; 8467) | 6500 | (2978; 9431) | 7158 | (4223; 9109) | 3072 | (2198; 4608) |
| $C_{2015}$ | | 0 | (0; 0) | 5372 | (1744; 8294) | 6302 | (2668; 9563) | 6794 | (3322; 10519) | 7461 | (4861; 10292) | 3072 | (1759; 5530) |
| $C_{2016}$ | | 0 | (0; 0) | 6447 | (2127; 9953) | 7375 | (3202; 10845) | 7292 | (3637; 11506) | 8004 | (5705; 11936) | 3691 | (1719; 6636) |
| $C_{2021}$ | | 0 | (0; 0) | 14045 | (5448; 19552) | 14935 | (6635; 19141) | 13595 | (5872; 19307) | 13995 | (6241; 18956) | 8339 | (3665; 14230) |
| $C_{2011-2015}$ | | 1200 | (1200; 1200) | 4956 | (3382; 6545) | 5932 | (3743; 7426) | 6456 | (4301; 8064) | 6642 | (4867; 7875) | 4157 | (3478; 4956) |
| $C_{2016-2020}$ | | 0 | (0; 0) | 8723 | (3246; 14272) | 9577 | (4765; 13286) | 9091 | (5357; 13346) | 9951 | (6617; 13739) | 5493 | (2224; 9876) |
| $C_{2011-2020}$ | | 600 | (600; 600) | 7102 | (3441; 10419) | 7651 | (4219; 9681) | 7772 | (5071; 9974) | 8301 | (6452; 10268) | 4825 | (3002; 7416) |
| $C_{2021-2030}$ | | 0 | (0; 0) | 13469 | (7666; 18272) | 12545 | (5994; 16393) | 12746 | (5419; 16139) | 11867 | (4195; 15774) | 12897 | (9042; 16489) |
| $AAV_{2012-2020}$ | | 14.3 | (14.3; 14.3) | 22.2 | (19.7; 26.7) | 18.5 | (15.8; 24.7) | 17.0 | (13.4; 22.8) | 16.6 | (12.5; 22.8) | 22.3 | (22.3; 25.5) |
| $AAV_{2013-2020}$ | | 11.1 | (11.1; 11.1) | 19.9 | (17.1; 24.9) | 15.8 | (12.8; 22.7) | 14.2 | (10.2; 20.6) | 13.7 | (9.1; 20.5) | 20.0 | (20.0; 23.6) |
| $AAV_{2021-2030}$ | | 0.0 | (0.0; 0.0) | 16.4 | (10.0; 26.6) | 15.8 | (12.1; 24.8) | 16.0 | (12.1; 24.2) | 15.5 | (11.3; 32.0) | 17.0 | (13.9; 20.0) |

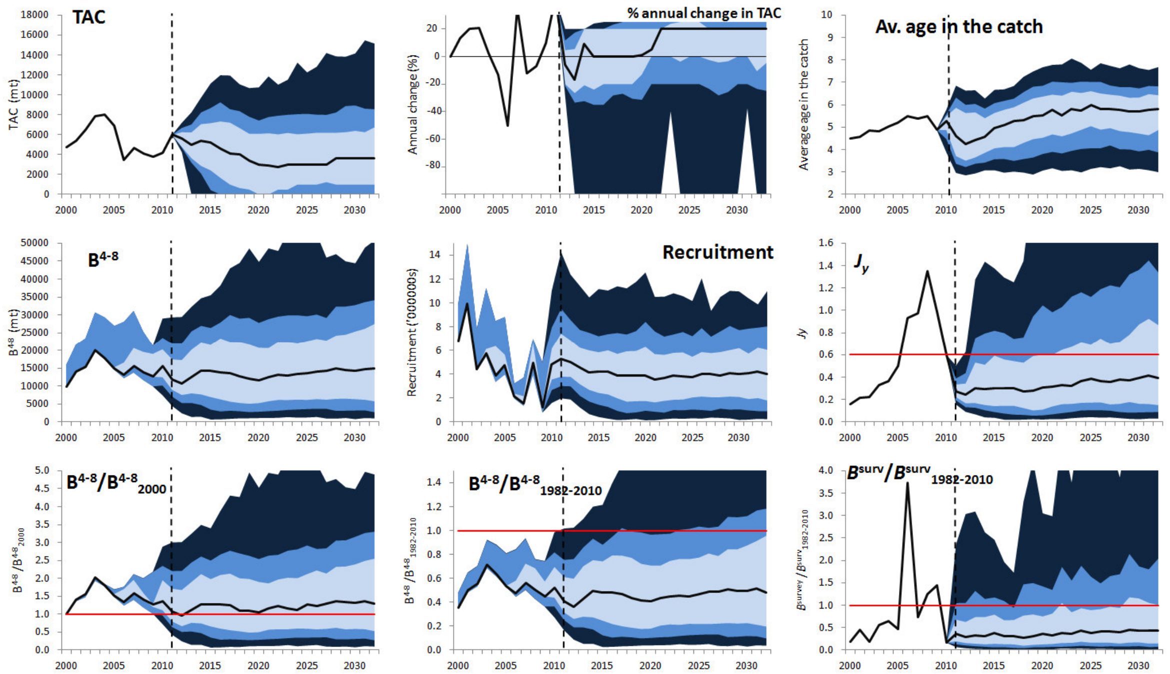


*Fig. D1a: 95, 75, 50% PI and median for a series of performance statistics for **CMPR** under the **RS**. See Appendix C, equation (C3) for the definition the normalised average survey index $J_y$ used in the formula for the TAC. The horizontal red line in the plot of $J_y$ represents the geometric mean over the past decade (0.60).*

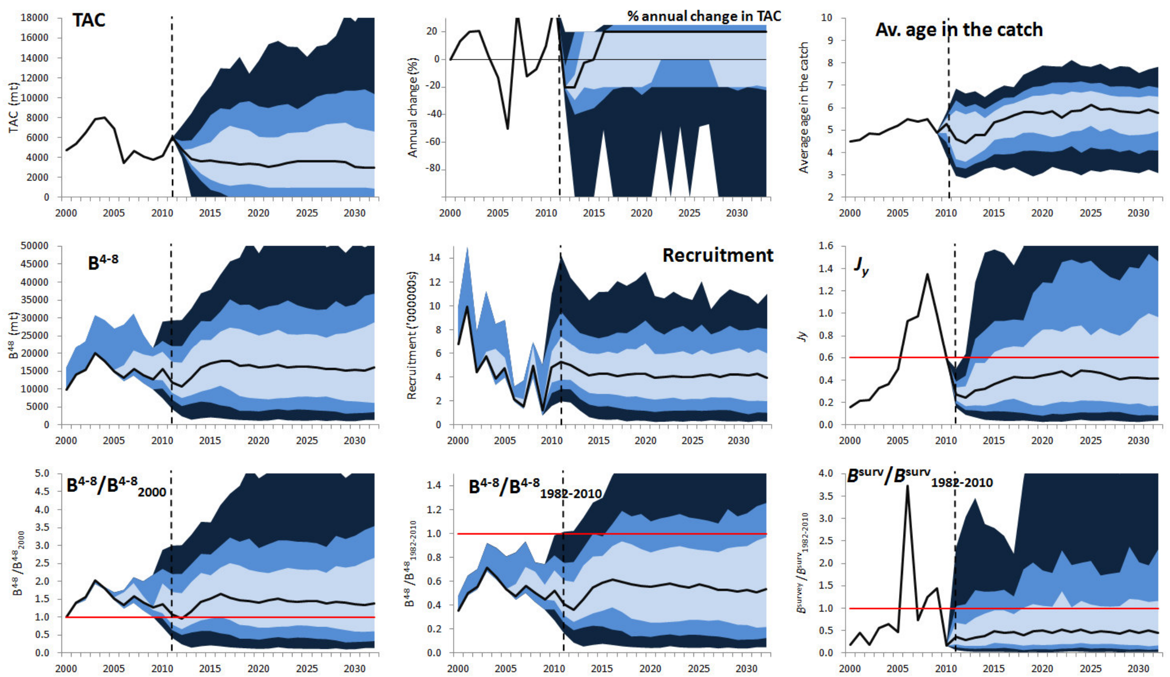


*Fig. D1b: 95, 75, 50% PI and median for a series of performance statistics for **CMPR-** under the **RS**. See Appendix C, equation (C3) for the definition the normalised average survey index $J_y$ used in the formula for the TAC. The horizontal red line in the plot of $J_y$ represents the geometric mean over the past decade (0.60).*

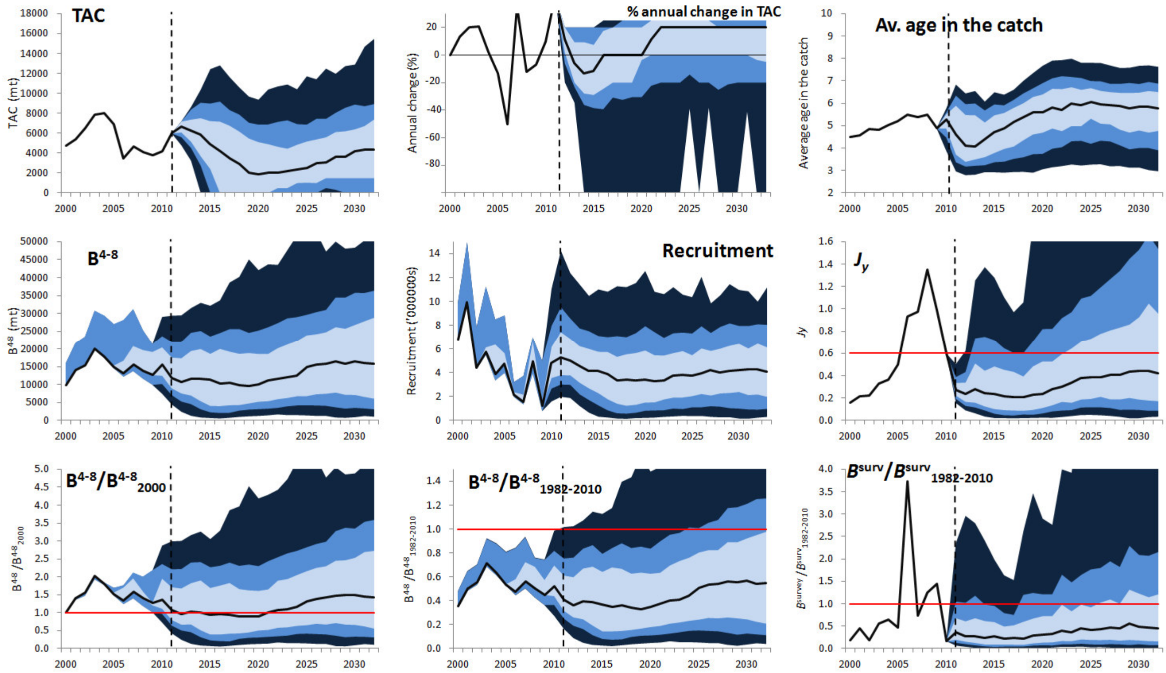


*Fig. D1c: 95, 75, 50% PI and median for a series of performance statistics for* ***CMPR+*** *under the* ***RS****. See Appendix C, equation (C3) for the definition the normalised average survey index $J_y$ used in the formula for the TAC. The horizontal red line in the plot of $J_y$ represents the geometric mean over the past decade (0.60).*

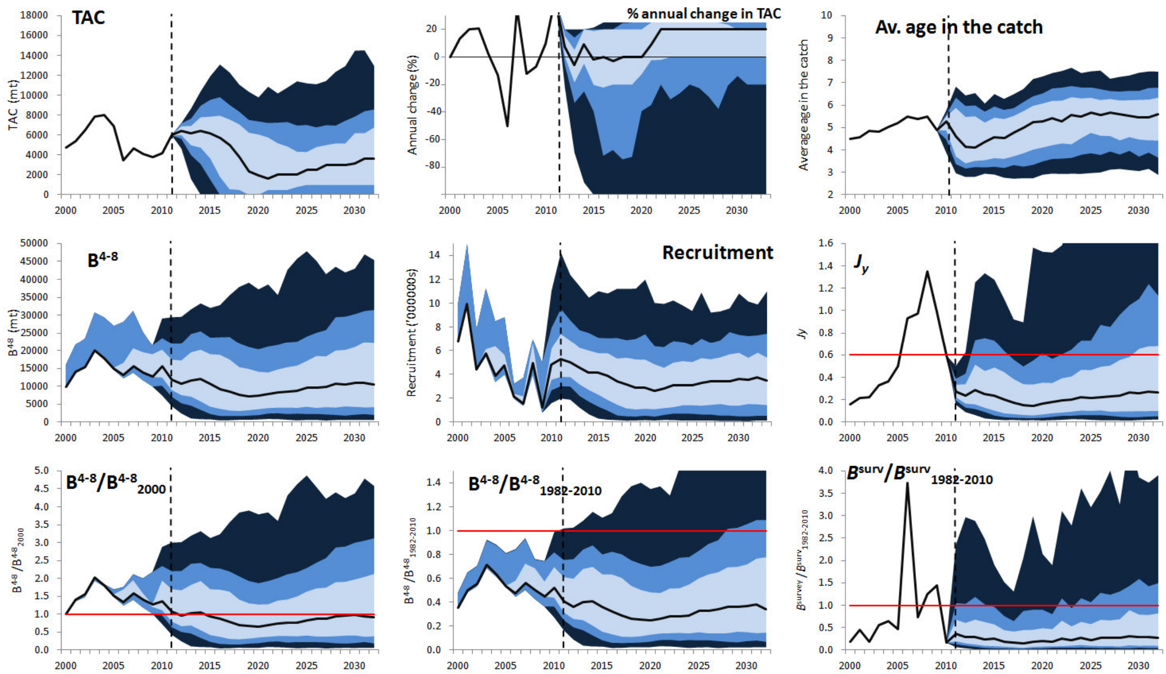


*Fig. D1d: 95, 75, 50% PI and median for a series of performance statistics for* ***CMPR_low*** *under the* ***RS****. See Appendix C, equation (C3) for the definition the normalised average survey index $J_y$ used in the formula for the TAC. The horizontal red line in the plot of $J_y$ represents the geometric mean over the past decade (0.60).*

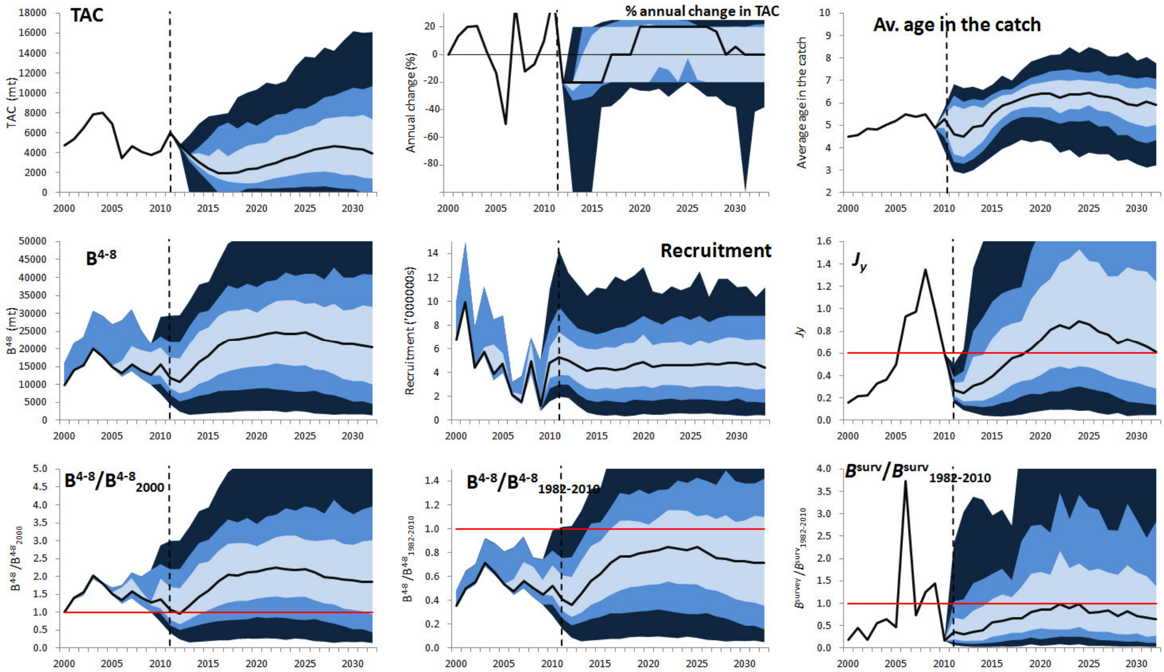


*Fig. D1e: 95, 75, 50% PI and median for a series of performance statistics for **CMPR_high** under the **RS**. See Appendix C, equation (C3) for the definition the normalised average survey index $J_y$ used in the formula for the TAC. The horizontal red line in the plot of $J_y$ represents the geometric mean over the past decade (0.60).*

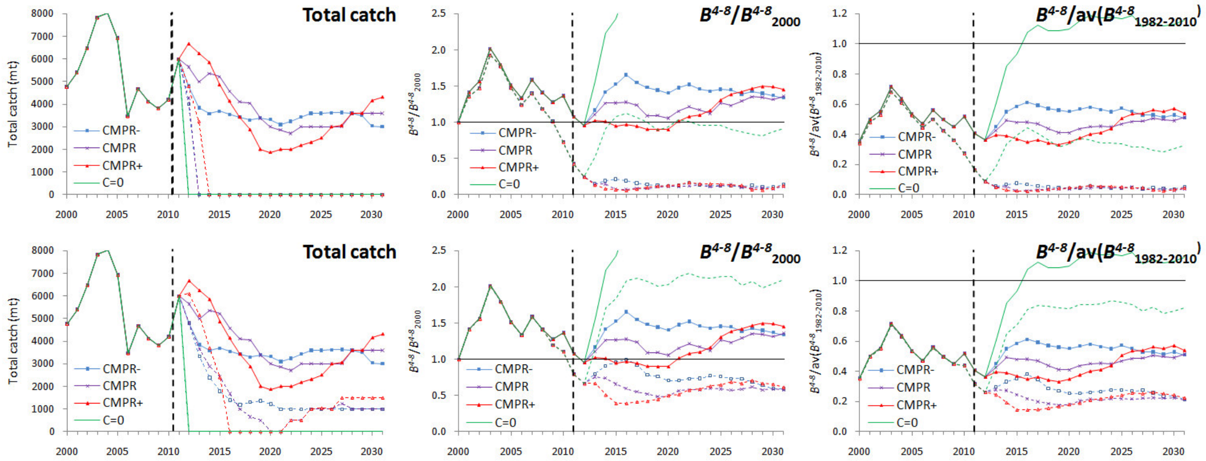


*Fig. D2a: Median (full lines) and lower 2.5%iles (top row) or lower 25%iles (bottom row) (dashed lines) TAC and exploitable (ages 4 to 8) biomass (relative to 2000 level and the average 1982-2010 level) for* ***CMPR-****,* ***CMPR*** *and* ***CMPR+*** **applied to the RS.**

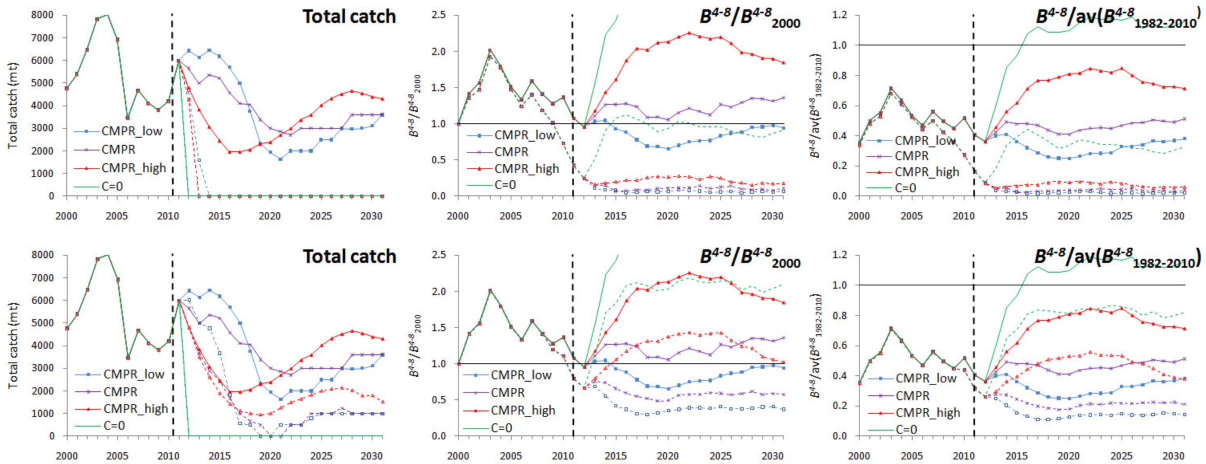


*Fig. D2b: Median (full lines) and lower 2.5%iles (top row) or lower 25%iles (bottom row) (dashed lines) TAC and exploitable (ages 4 to 8) biomass (relative to 2000 level and the average 1982-2010 level) for* ***CMPR_low****,* ***CMPR*** *and* ***CMPR_high*** **applied to the RS.**

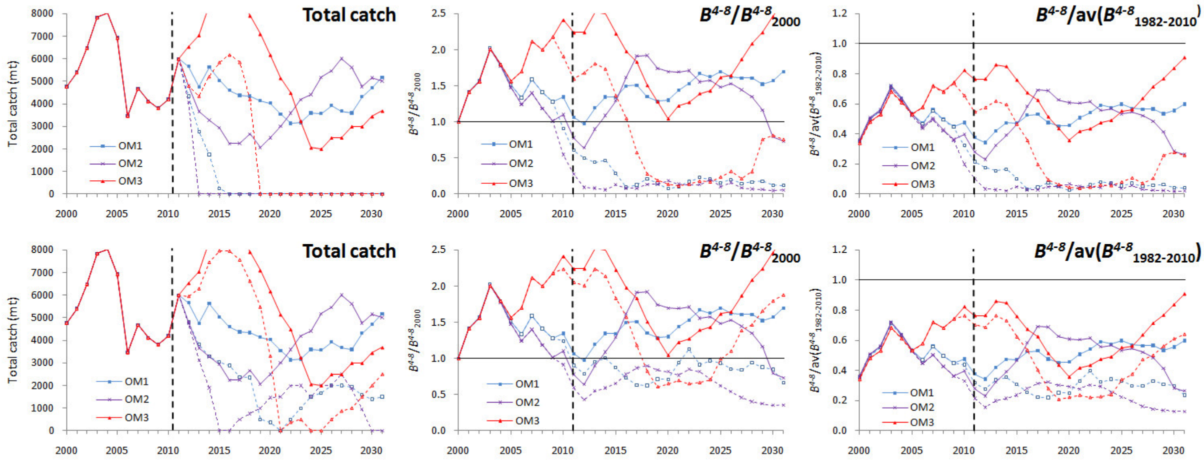


*Fig. D3a: Median (full lines) and lower 2.5%iles (top row) or lower 25%iles (bottom row) (dashed lines) TAC and exploitable (ages 4 to 8) biomass (relative to 2000 level and the average 1982-2010 level) for **CMPR** for **OM1**, **OM2** and **OM3 from the RS**.*

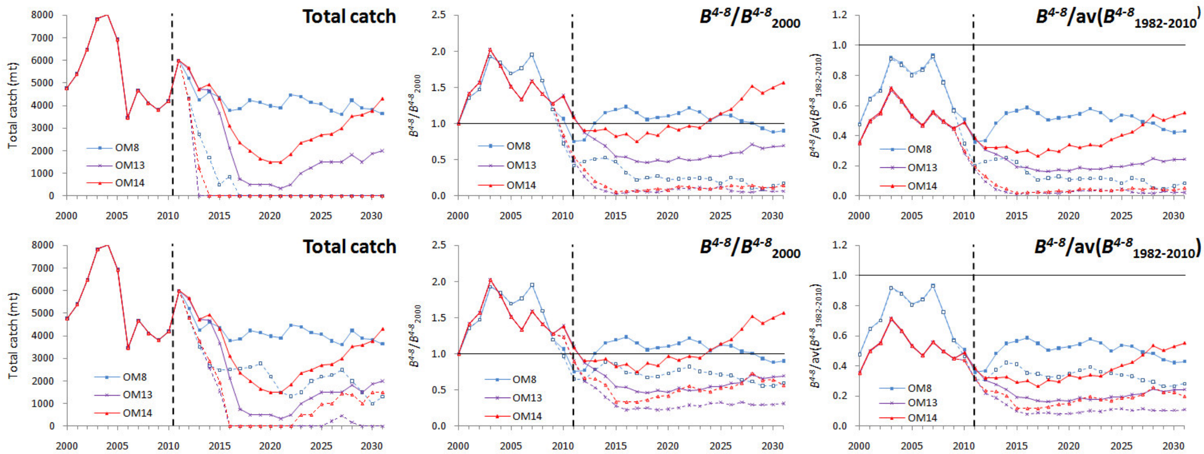


*Fig. D3b: Median (full lines) and lower 2.5%iles (top row) or lower 25%iles (bottom row) (dashed lines) TAC and exploitable (ages 4 to 8) biomass (relative to 2000 level and the average 1982-2010 level) for **CMPR** for **OM8**, **OM13** and **OM14 from the RS**.*

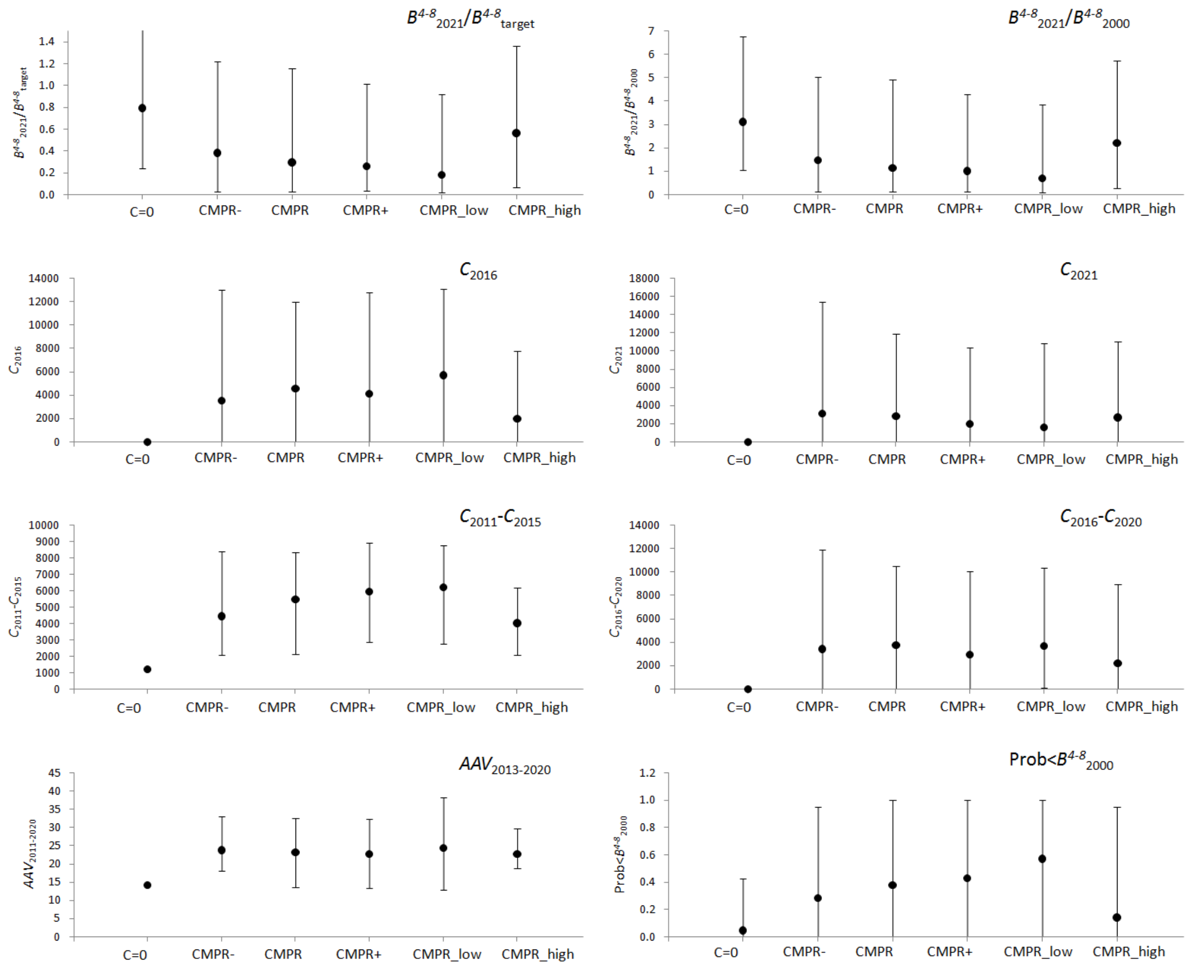


*Fig. D4a: Medians and **95% PI** (error bars) for a series of performance statistic for different CMPs applied to the **RS**.*

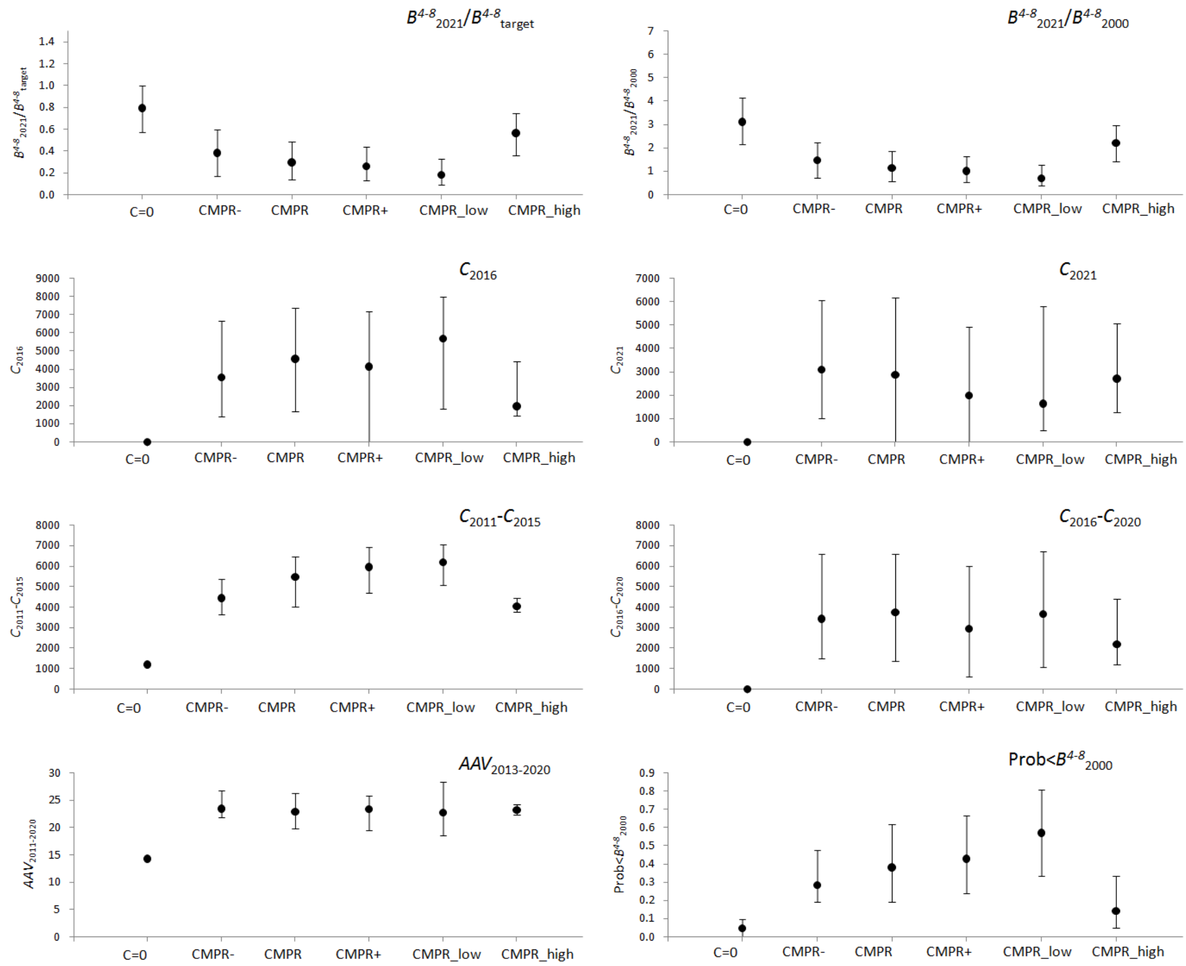


*Fig. D4b: Medians and **50% PI** (error bars) for a series of performance statistic for different CMPs applied to the **RS**.*

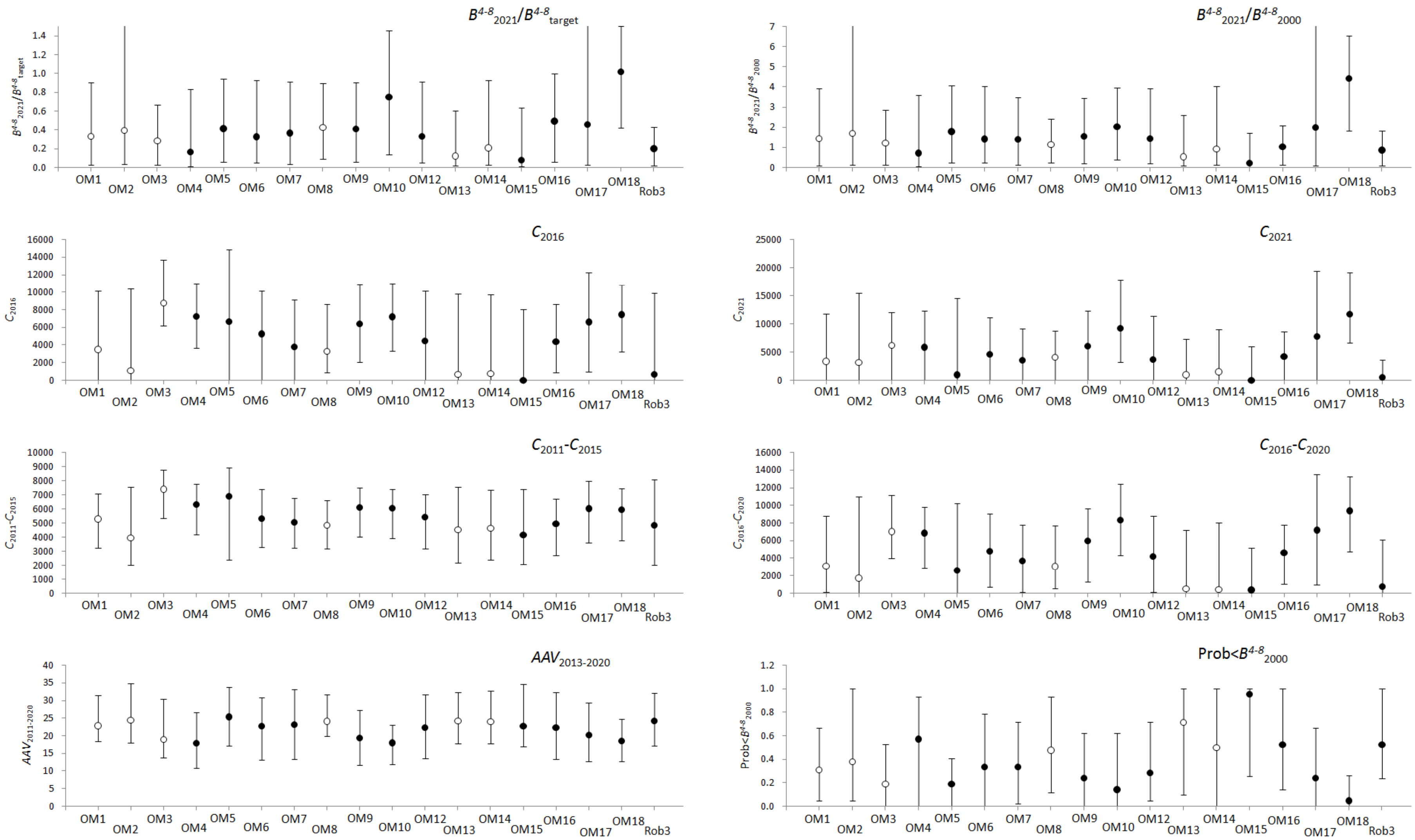


*Fig. D5a: Medians and **95% PI** (error bars) for a series of performance statistic for **CMPR** applied to each OM in the RS and the robustness tests. The white dots show the OMs that are in the RS.*

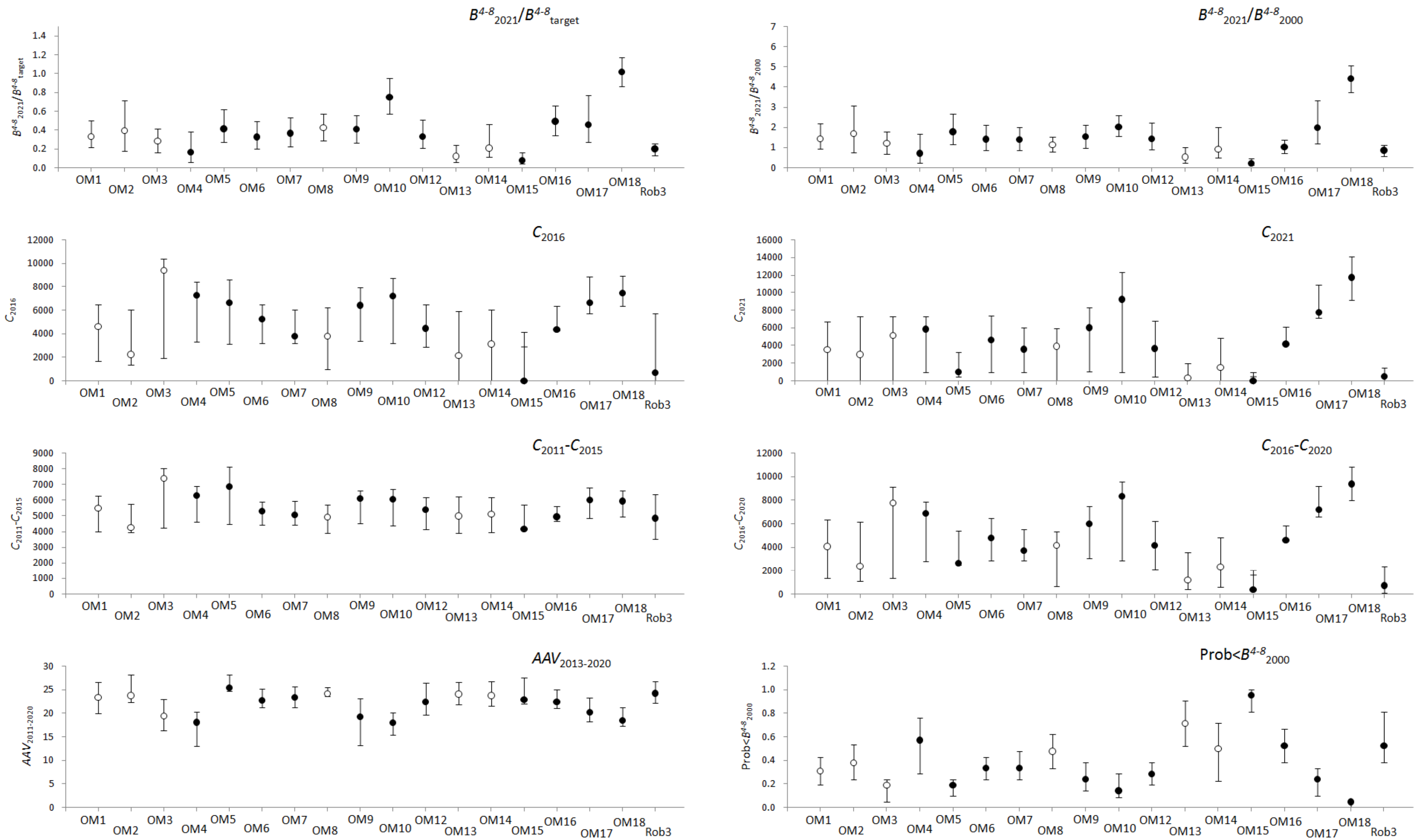


*Fig. D5b: Medians and **50% PI** (error bars) for a series of performance statistic for **CMPR** applied to each OM in the RS and the robustness tests. The white dots show the OMs that are in the RS.*

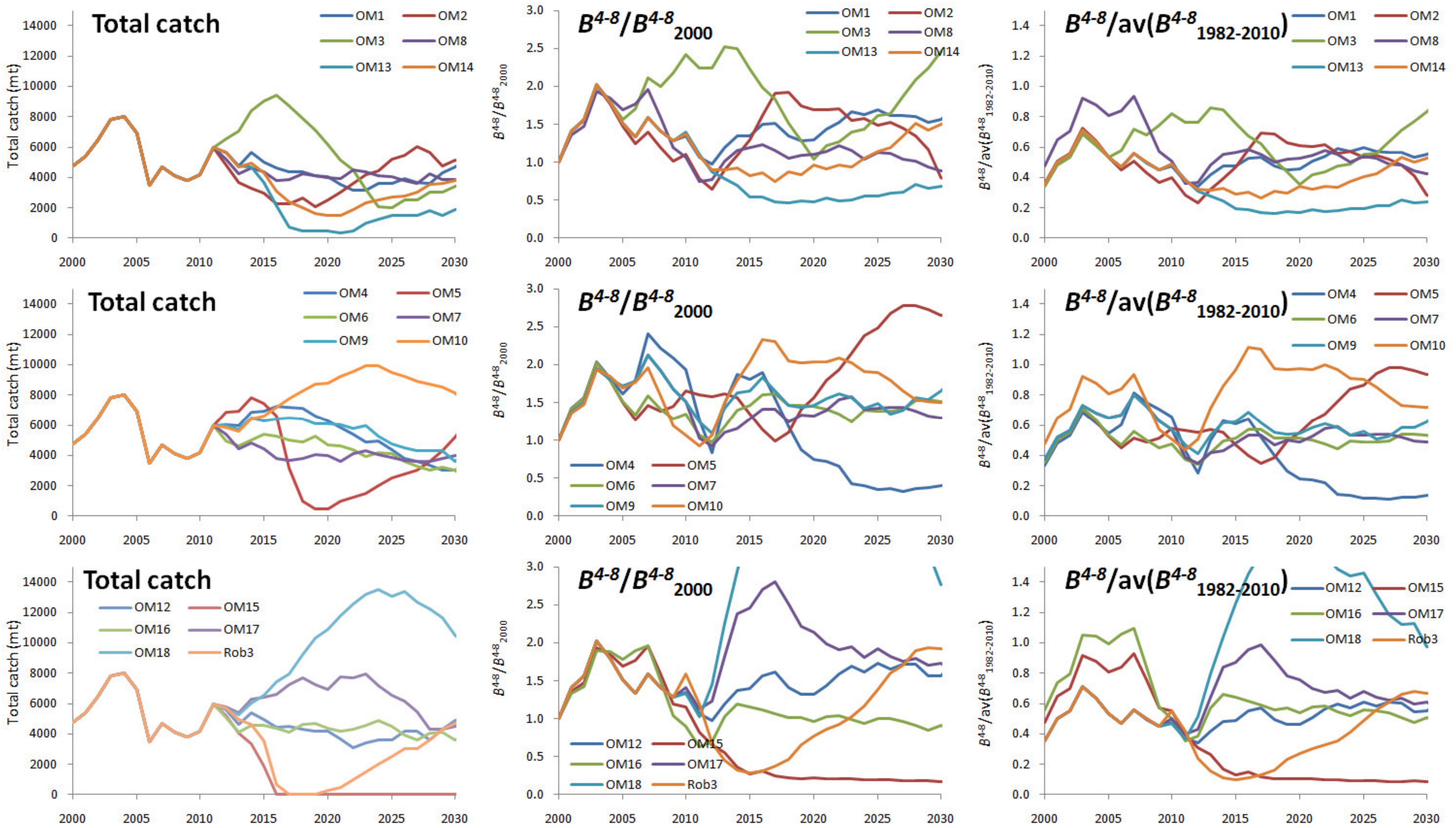


*Fig. D6a: **Median** TAC and exploitable (ages 4 to 8) biomass (relative to 2000 level and the average 1982-2010 level) for **CMPR** for OM in the RS and the robustness tests.*

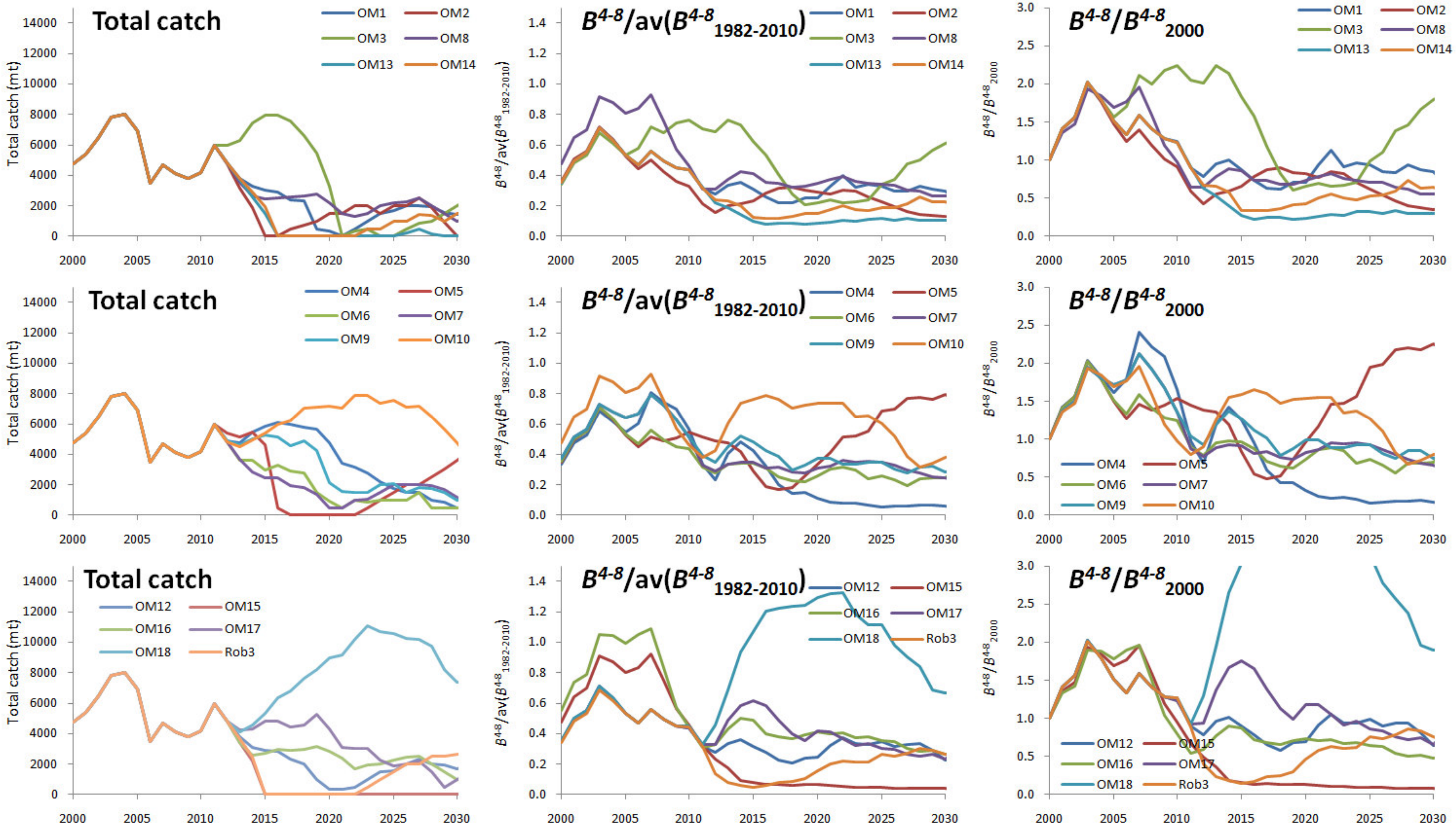


*Fig. 6b: **Lower 25%-ile** TAC and exploitable (ages 4 to 8) biomass (relative to 2000 level and the average 1982-2010 level) for **CMPR** for OM in the RS and the robustness tests.*

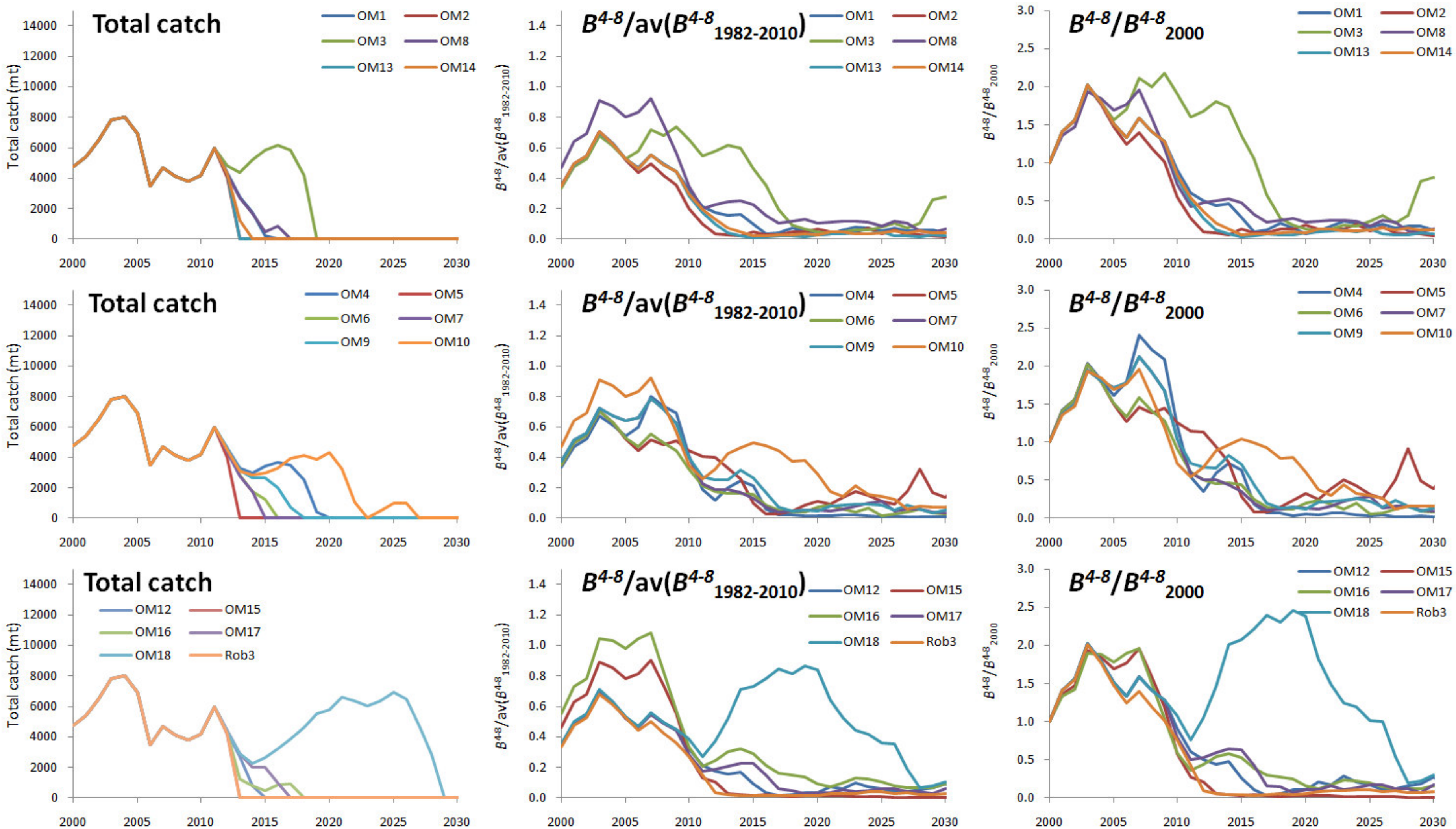


*Fig. D6c: Lower 2.5%-ile TAC and exploitable (ages 4 to 8) biomass (relative to 2000 level and the average 1982-2010 level) for **CMPR** for OM in the RS and the robustness tests.*

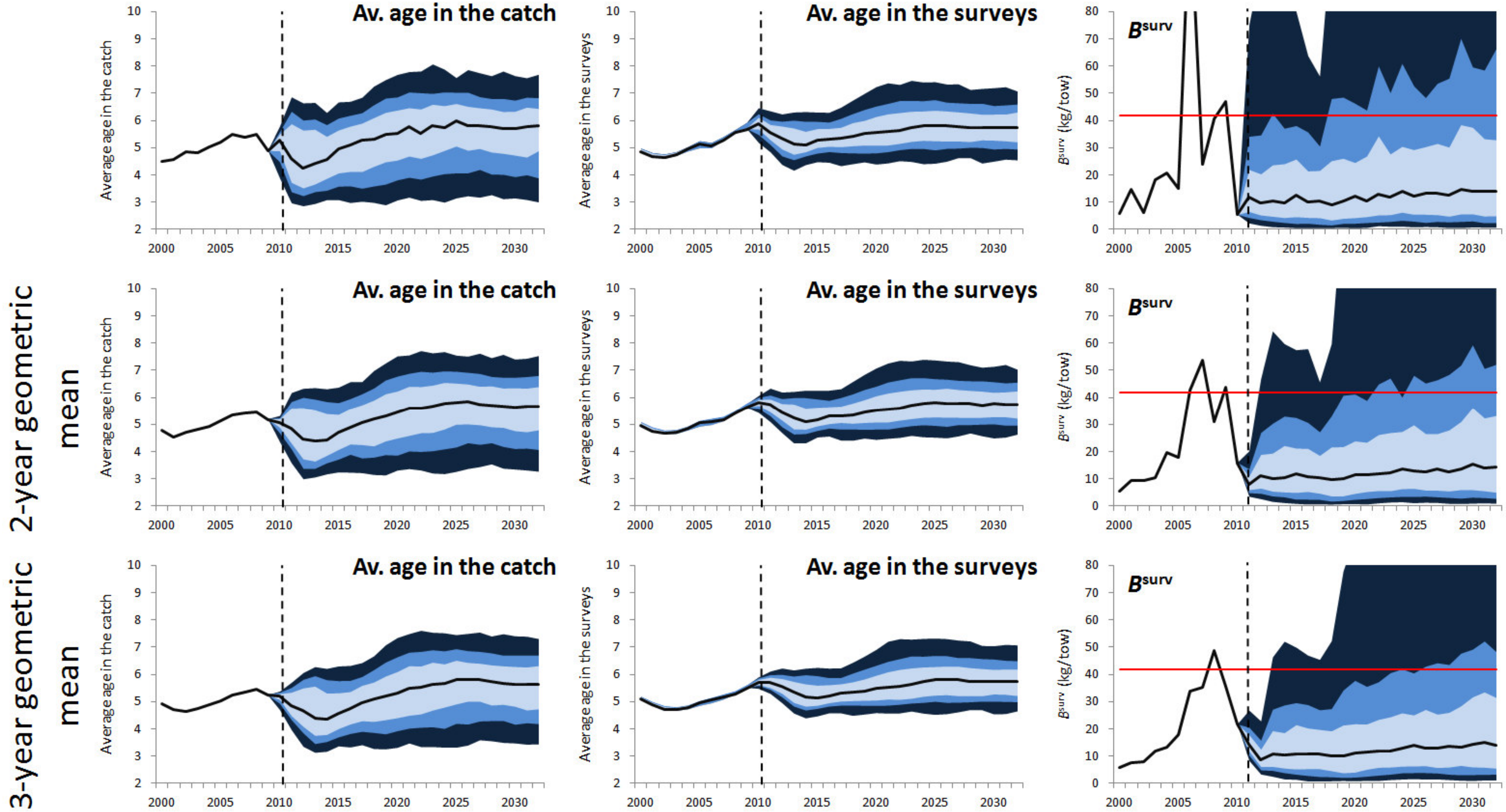


*Fig. D7: 95, 75, 50% PI and median for a series of performance statistics for **CMPR** under the **RS.***