Initial SCRL OMP-2014 results

S.J. Johnston and D.S. Butterworth

MARAM, DEPARTMENT OF MATHEMATICS AND APPLIED MATHEMATICS, UNIVERSITY OF CAPE TOWN

This document presents some preliminary OMP-2014 results for the south coast rock lobster fishery. The operating model which has been used to test alternative OMPs is model RC1 reported in Johnston (2013). The current OMP (OMP-2010) is described in the Appendix for reference to aid comparison. Note that the OMP-2010 has as its management target *Bsp*(2025/2006)=1.20 (in median terms).

Previous OMPs have been selected by examining projection results where the "past" is assumed to be the maximum likelihood best fit model (RC), and future trajectories of biomass are calculated by adding noise to various future quantities (e.g. future recruitment). This approach has thus assumed that the current biomass is known exactly, whilst in reality there is a fair amount of uncertainty associated with all estimated levels of biomass. A preferred method (and one that is used for many other fisheries such as the SA small pelagics), is for one to accept that the RC model is not a single "best fit model", but rather that there is uncertainty associated with estimates of the current status of the resource as reflected by a Bayesian assessment implemented using MCMC.

Here, due to time constraints, 30 000 initial MCMC chains were run with every 20th simulation saved. From this, a "burn in period" was allowed and a final set of 1000 simulation was selected for projection purposes. Each of the 1000 simulations is associated with a particular realisation of the resource and a unique set of input parameter values. The median, 5th and 95th percentiles for all parameters and biological measures of concern can be produced – both for the past and for the future projections.

The Bayesian posterior estimates of quantities of interest for management are:

Bsp(2006)/*K* = 0.32 (0.29; 0.35)

Bsp(2013)/*K* = 0.45 (0.39; 0.51)

MOVING TO A TARGET BASED OMP

The current OMP is a slope-based OMP, meaning that the slope of recent CPUE trend is used to decide whether the TAC should be adjusted up or down. The OMP is tuned to produce a certain median biomass recovery, with the current target being *Bsp*(2025)/*Bsp*(2006)=1.20.

With a **target** based OMP, the decision whether to increase or decrease the TAC depends on where recent CPUE values are relative to a particular pre-specified target CPUE value. The TAC setting equation thus becomes:

$$TAC_{y+1} = TAC_y\left[1 + \alpha \frac{\overline{CPUE}_y - CPUE_{targ}}{CPUE_{targ}}\right] \tag{1}$$

where

$$\overline{CPUE}_y = \frac{1}{3}\sum_{y'=y-3}^{y-1}\sum_{A=1}^{3}\lambda_A CPUE_{y'}^A$$ as for previous OMP (see equation A6)

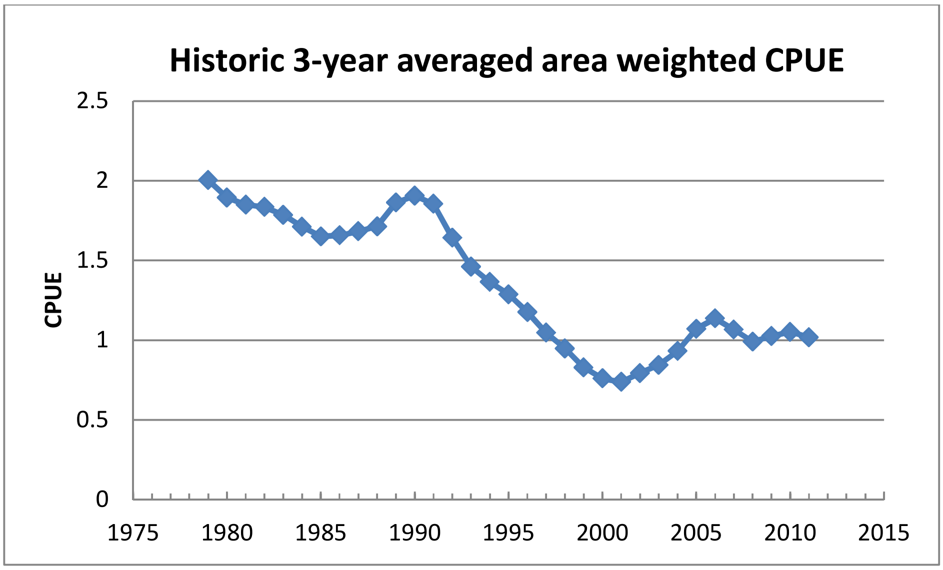
and $CPUE_{targ}$ is the selected target CPUE of the OMP.

A tuning parameter α controls how responsive the OMP is to CPUE deviations from the CPUE target.

Initial results are reported here for a range of $CPUE_{targ}$ (1.0, 1.125, 1.32 and 1.50) and $\alpha = 1.0$ (see Table 1 and Figures 1-5).

Choice of target CPUE?

The plot below shows the historic 3-year averaged area weighted CPUE trend for SCRL.



Results

Figure 1 reported results for a $CPUE_{targ}$ of 1.125 (CMP1). Figure 1b shows that there is clearly a problem with the biomass trajectories for Areas A1E and A1W if no constraint is placed on how much TAC is taken in these two areas (black circles) – it would appear that too much TAC is being apportioned into those areas. Recall that the method used for splitting the TAC between areas is currently modelled as follows, based on patterns in the fishery over 2007-2011.

For 2012+, the total TAC for each season is split between the three areas is:

$$C_y^A = C_y^T \frac{\bar{F}^A B_{exp,y}^A}{(\bar{F}^{A1E} B_{exp,y}^{A1E} + \bar{F}^{A1W} B_{exp,y}^{A1W} + \bar{F}^{A2+3} B_{exp,y}^{A2+3})} \qquad (2)$$

where

$$\bar{F}^A = \frac{\sum_{y=2007}^{y=2011} F_y^A}{5}$$

A modification to the target-based OMP is added as follows to give CMP2:

IF TAC in A1E > 50 MT fix TAC in A1E = 50 MT and add the remaining amount to A2+3

IF TAC in A1W > 100 MT fix TAC in A1E = 100 MT and add the remaining amount to A2+3.

Table 1 and Figure 1b show the results of adding this upper TAC constraint for A1E and A1W (dotted lines).

A further range of $CPUE_{targ}$ values is reported in Table 1 and Figure 2 (in conjunction with the TAC areal distribution modification rule rule described above):

CMP3: $CPUE_{targ}$ =1.00 (black circles) – the *Bsp* trajectory shows a sharp decline.

CMP4: $CPUE_{targ}$ =1.50 (grey line) – the *Bsp* shows a steady increase.

CMP5: $CPUE_{targ}$ =1.32 (dashed line) – this OMP shows a more defensible “flat” *Bsp* trajectory.

The $CPUE_{targ}$ =1.32 option shown in Figure 2 does however show a median decrease in TAC for the first two years. Two further variants were therefore run and CMP6 is reported in Figure 3:

CMP6: $a)$ $CPUE_{targ}$ =1.32 but no TAC decrease is allowed in first year (2014) (dashed line).

CMP7: $b)$ $CPUE_{targ}$ =1.32 but the TAC cannot be lower than current TAC(2013) value for first two years (2014, 2015) (grey line).

Figure 4 shows these two variants have a minimal impact on the *Bsp* trajectory.

Finally, Figure 5 shows the stock recruit residuals for both the past and future: medians and 5th and 95th percentiles are shown. The bottom plot shows the first five simulations.

Reference

Johnston, S.J. 2013. Final 2013 updated South Coast rock lobster assessment results and description of OMP simulation framework. FISHERIES/2013/AUG/SWG-SCRL/06. 24pp.

Table 1: Target based OMP results for a number of OMP variants. Median results are reported, with 5th and 95th percentiles in parentheses.

	$CPUE_{targ}$	α	**Inter-annual TAC variability constraint**	**Constraint on A1E and A1W TACs**	**Bsp(2025/2006)**	**Bsp(2025/K)**	**Cave (2014-2025)**	**AAV(2014-2025)**	**A1E Bexp(2025)/K Lower 5th%ile**	**A1E Bexp(2025)/K Lower 5th%ile**	**A2+3 Bexp(2025)/K Lower 5th%ile**
CMP1	1.125	1	5% ↑↓	None	1.25 (0.69; 2.74)	0.40 (0.21; 0.89)	429 (326; 476)	4.72 (3.96; 5.00)	0.051	0.237	0.181
CMP2	1.125	1	5% ↑↓	**TAC A1E max 50MT TAC A1W max 100 MT**	1.25 (0.71; 2.74)	0.40 (0.23; 0.88)	423 (320; 476)	4.69 (3.97; 5.00)	0.108	0.302	0.117
CMP3	**1.00**	1	5% ↑↓	TAC A1E max 50MT TAC A1W max 100 MT	1.14 (0.61; 2.66)	0.37 (0.19; 0.84)	463 (376; 476)	4.92 (4.28; 5.00)	0.088	0.298	0.054
CMP4	**1.50**	1	5% ↑↓	TAC A1E max 50MT TAC A1W max 100 MT	1.58 (1.03; 3.05)	0.50 (0.33; 0.98)	295 (249; 392)	4.72 (3.89; 5.00)	0.187	0.361	0.281
CMP5	**1.32**	1	5% ↑↓	TAC A1E max 50MT TAC A1W max 100 MT	1.44 (0.91; 2.93)	0.46 (0.29; 0.95)	354 (253; 428)	4.67 (3.89; 5.00)	0.150	0.332	0.222
CMP6	**1.32a)**	1	5% ↑↓	TAC A1E max 50MT TAC A1W max 100 MT	1.40 (0.87; 2.86)	0.45 (0.28; 0.93)	367 (264; 445)	4.25 (3.49; 4.58)	0.140	0.327	0.200
CMP7	**1.32b)**	1	5% ↑↓	TAC A1E max 50MT TAC A1W max 100 MT	1.37 (0.84; 2.85)	0.43 (0.27; 0.91)	377 (273; 445)	3.92 (3.10; 4.49)	0.133	0.322	0.191

a) $CPUE_{targ}$ =1.32 but no TAC decrease is allowed in first year (2014).

b) $CPUE_{targ}$ =1.32 but TAC cannot be lower than current TAC(2013) value for first two years.

Figure 1a: Results for CMP1 ($CPUE_{targ}$=1.125) with no areal TAC split constraint (solid black circles), and forCMP2 where a constraint is imposed for which the TAC in A1E is restricted to a maximum of 50 MT, and the TAC in A1W limited to a maximum of 100 MT (dotted line). Median values are shown. Note that the results differ only slightly, so that the plots frequently overlay.

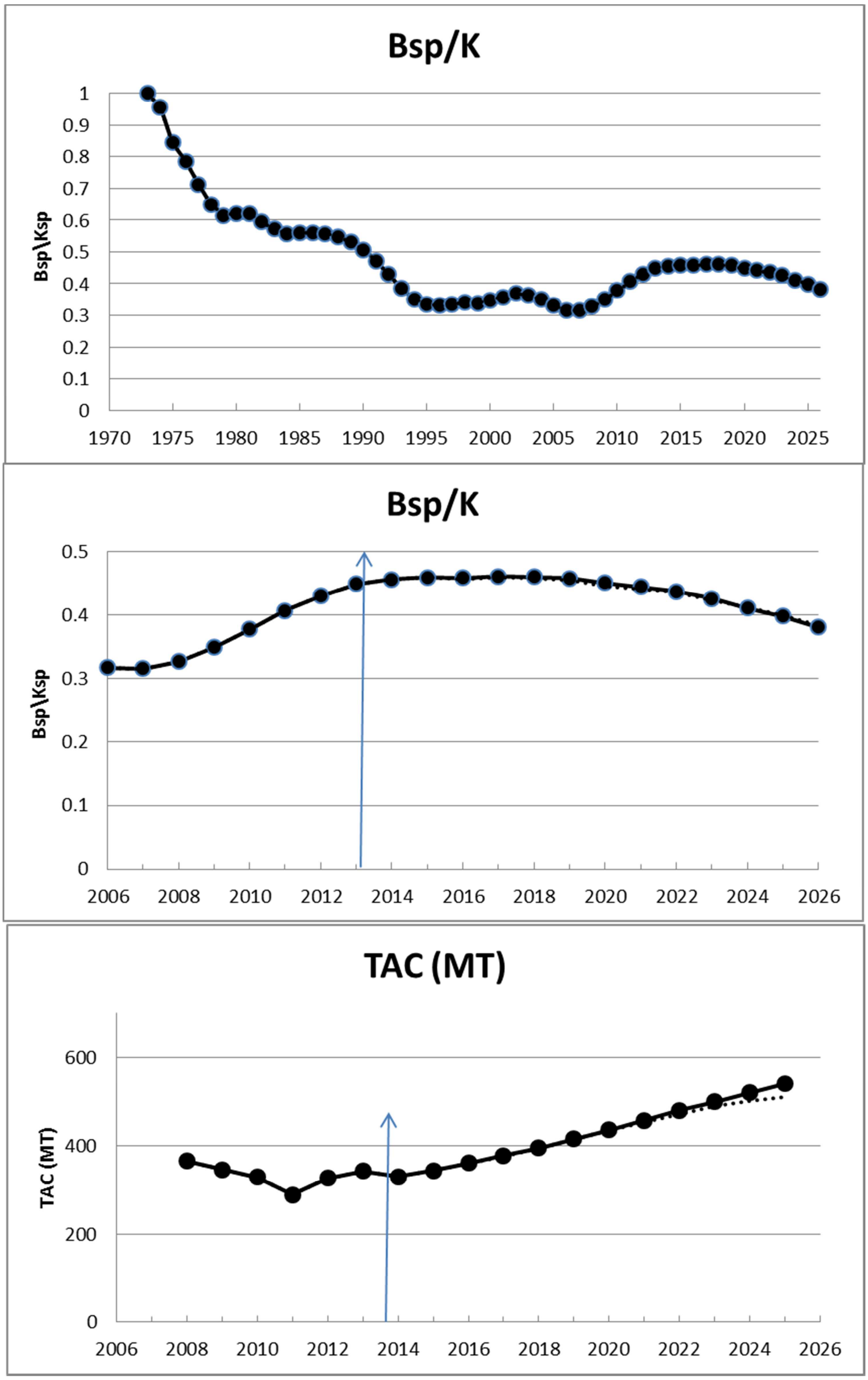


Figure 1b: Results for CMP1 ($CPUE_{targ}$=1.125) with no areal TAC split constraint (solid black circles), and for CMP2 where a constraint is imposed for which the TAC in A1E is restricted to a maximum of 50 MT, the and TAC in A1W limited to a maximum of 100 MT (dotted line).

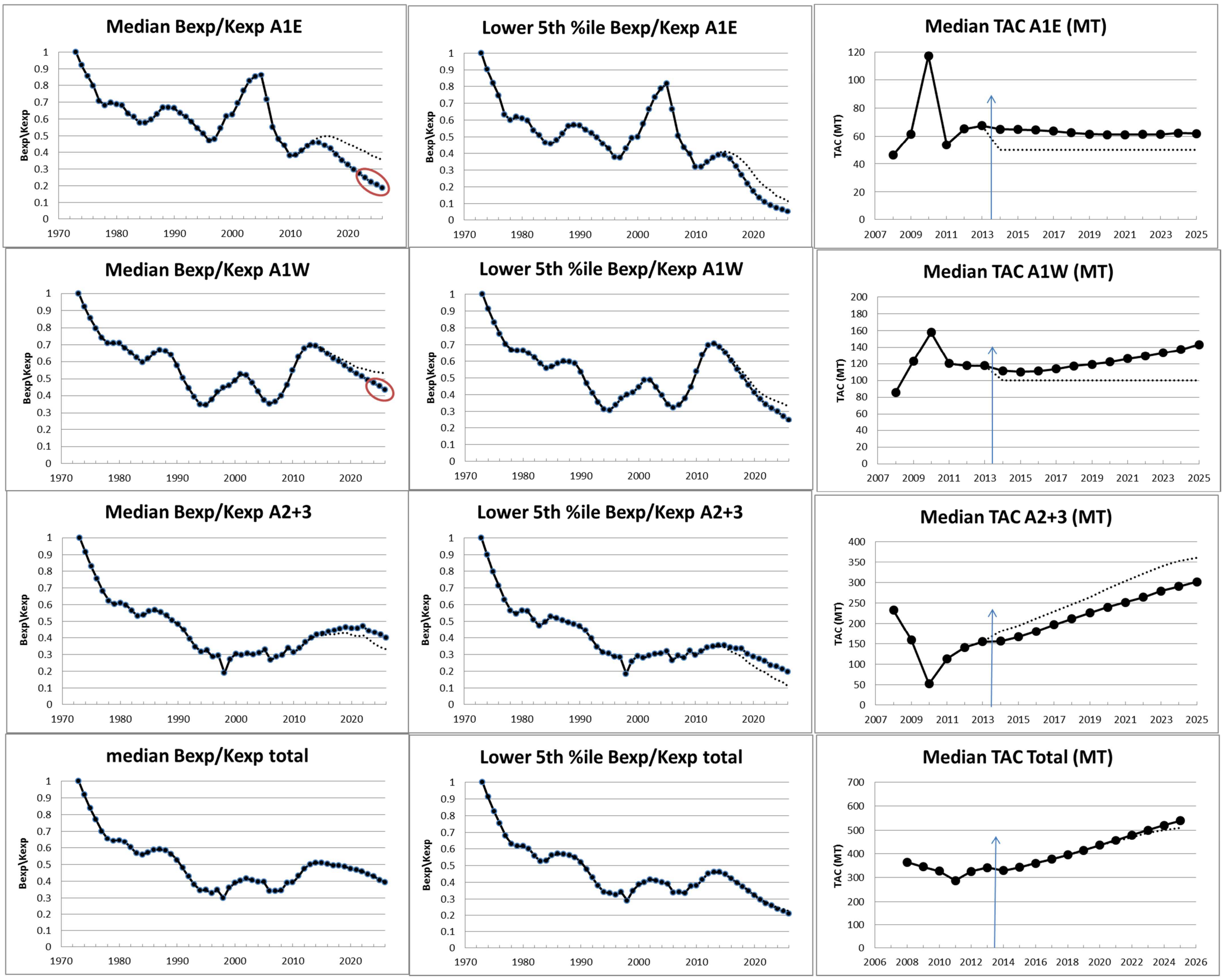


Figure 2: CMP3 ($CPUE_{targ}$ =1.00), CMP5 ($CPUE_{targ}$ =1.32) and CMP4 ($CPUE_{targ}$ =1.50) with the areal TAC split constraints of a 50 MT maximum for A1E, and a 100 MT maximum for A1W.

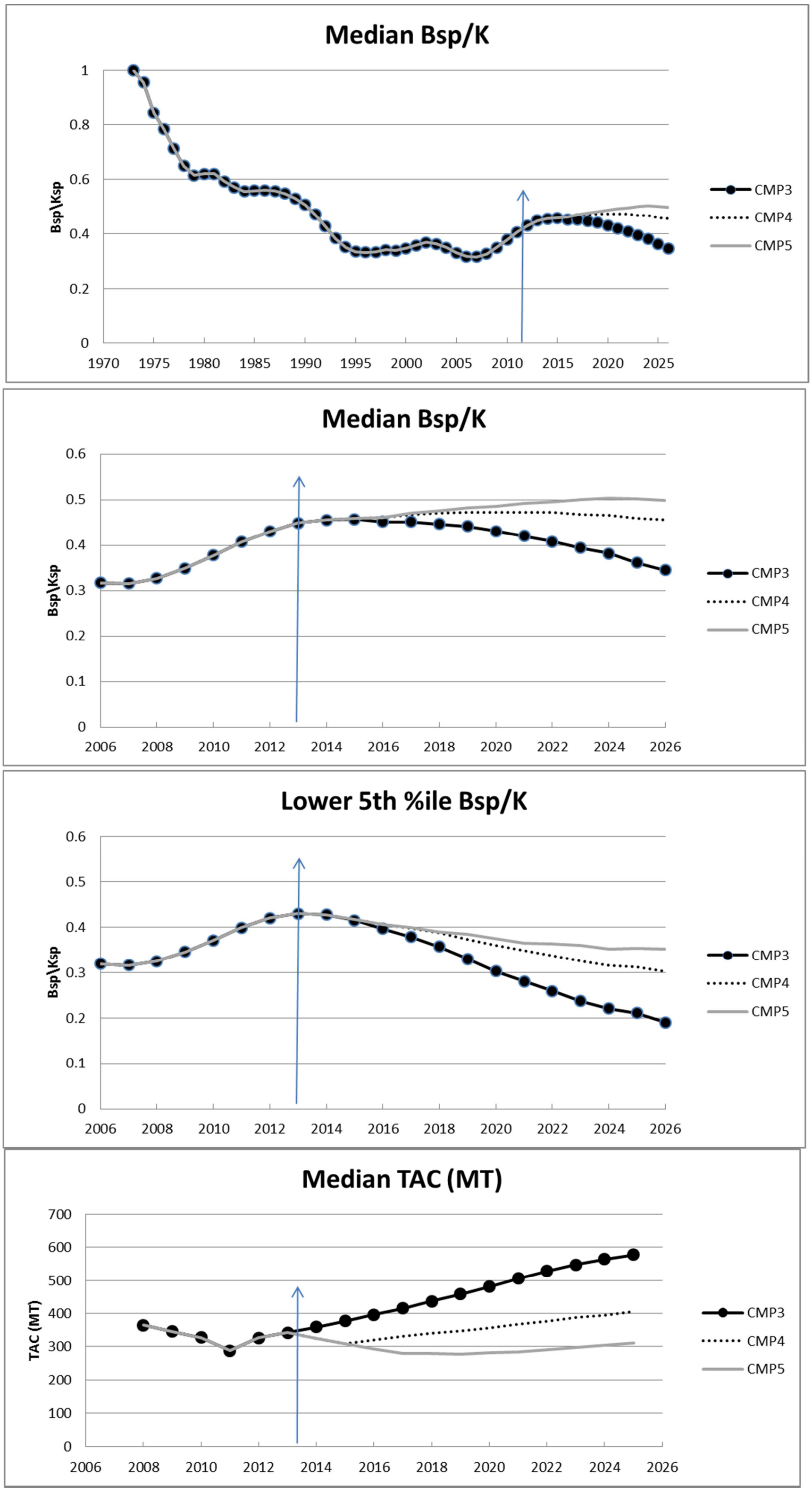


Figure 3a: CMP6 ($CPUE_{targ}$=1.32 with areal TAC split constraints of a 50 MT maximum for A1E and a 100 MT maximum for A1W, and with a further constraint of no TAC decrease for first year (2014)). Median and 5th and 95th percentiles are shown, except for plots showing individual realisations.

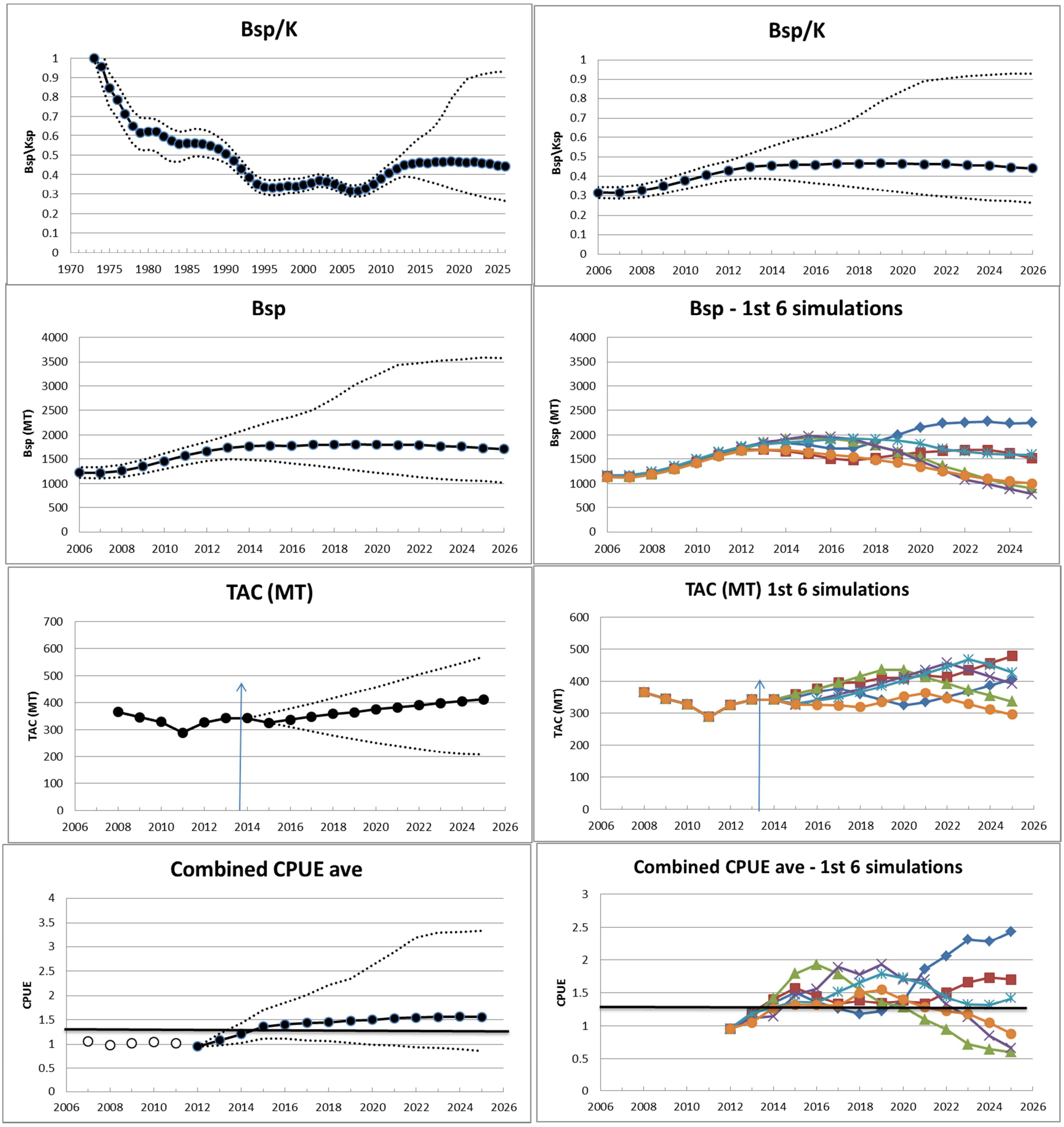


Figure 3b: CMP6 ($CPUE_{targ}$=1.32 with areal TAC split constraints of a 50 MT maximum for A1E and a 100 MT maximum for A1W, and with a further constraint of no TAC decrease for first year (2014)). Median and 5th and 95th percentiles are shown.

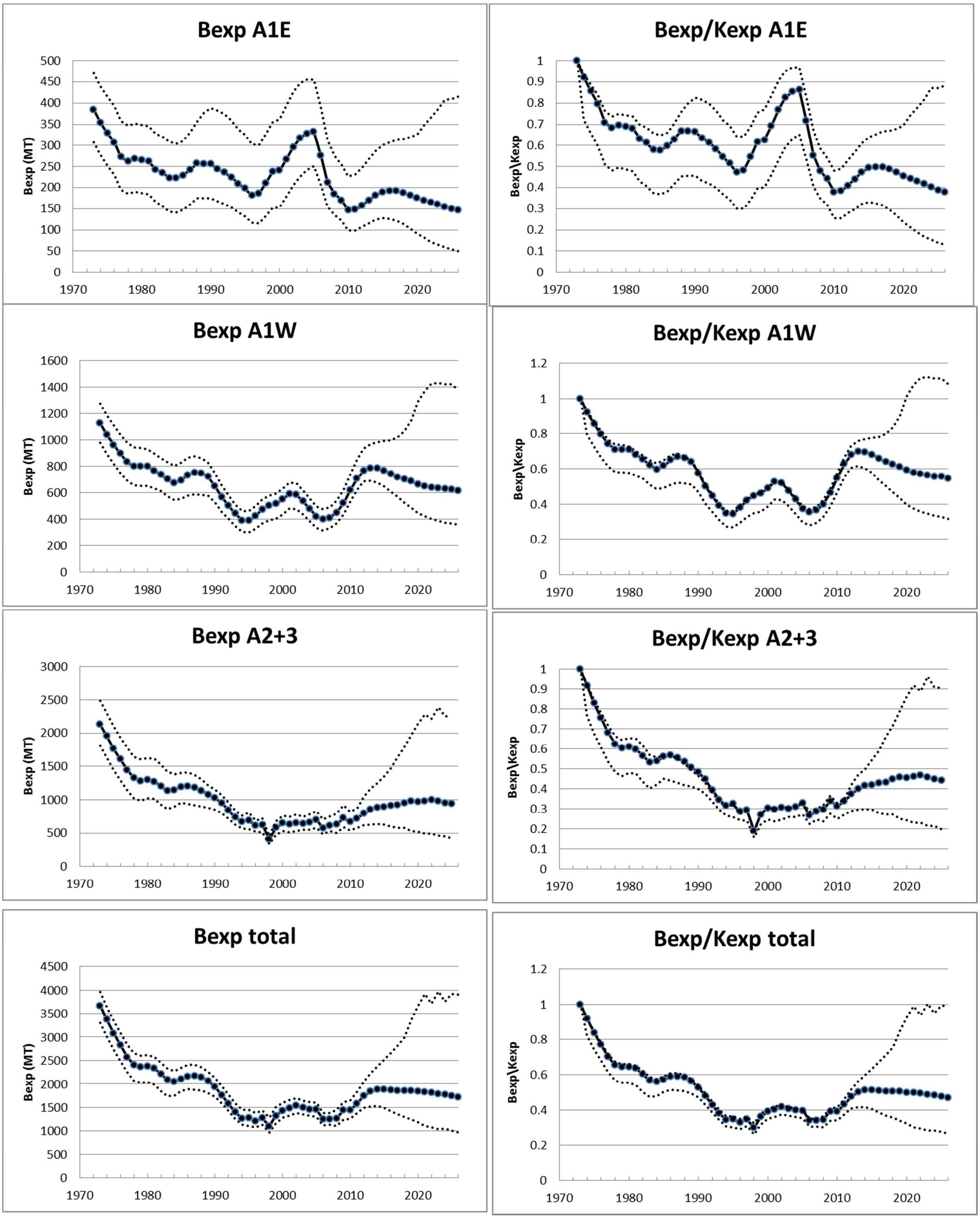


Figure 3c: CMP6 ($CPUE_{targ}$=1.32 with areal TAC split constraints of a 50 MT maximum for A1E and a 100 MT maximum for A1W, and with a further constraint of no TAC decrease for first year (2014)). Median and 5th and 95th percentiles are shown, except for plots showing individual realisations.

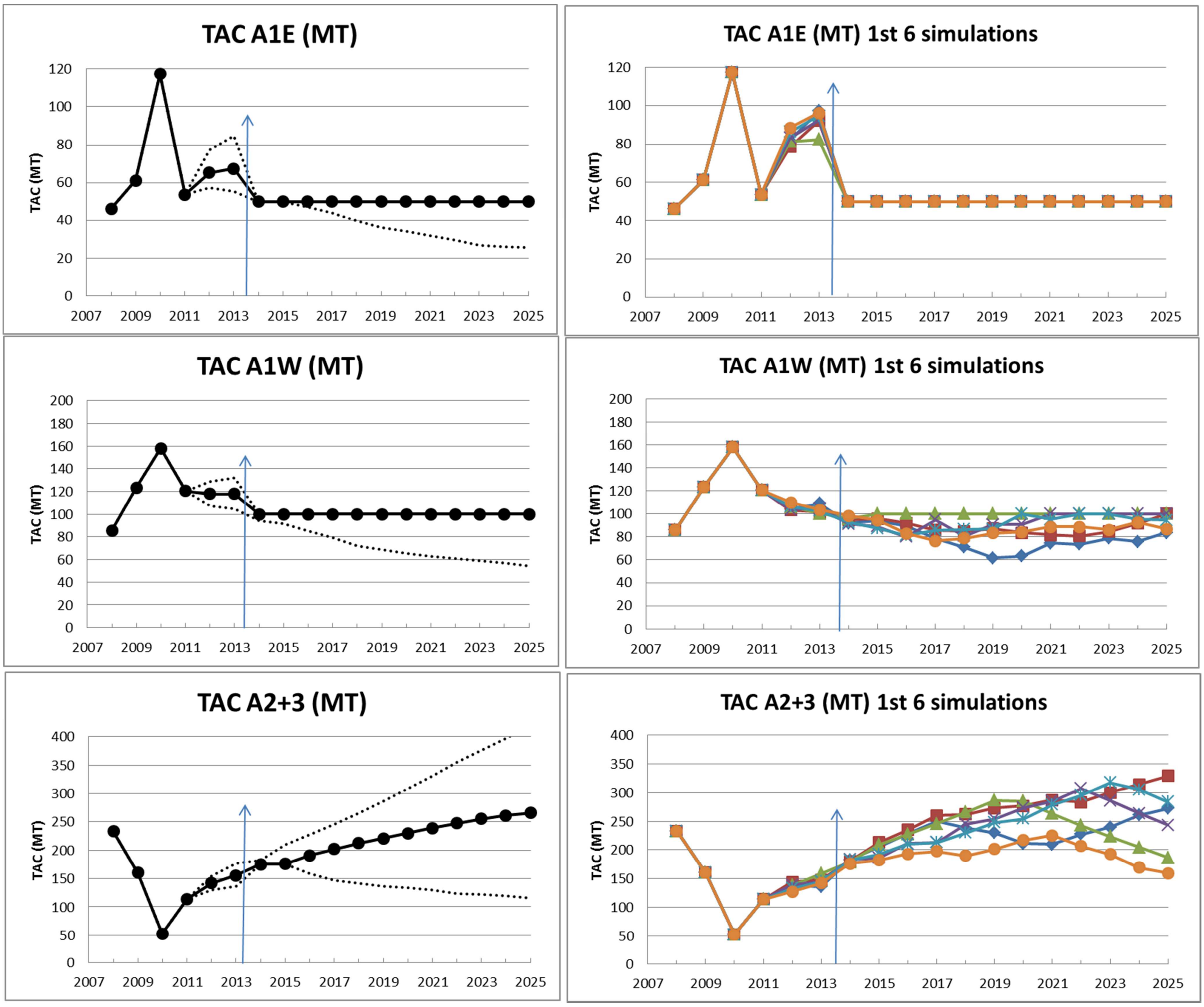


Figure 4: Median (top) and 5th %ile (bottom) comparative plots of TAC and Bsp for CMP5 ($CPUE_{targ}$=1.32), CMP6 ($CPUE_{targ}$=1.32a – the TAC may not decrease below the current level for the first year), and CMP7 ($CPUE_{targ}$=1.32b – the TAC may not decrease below the current level for the first 2 years).

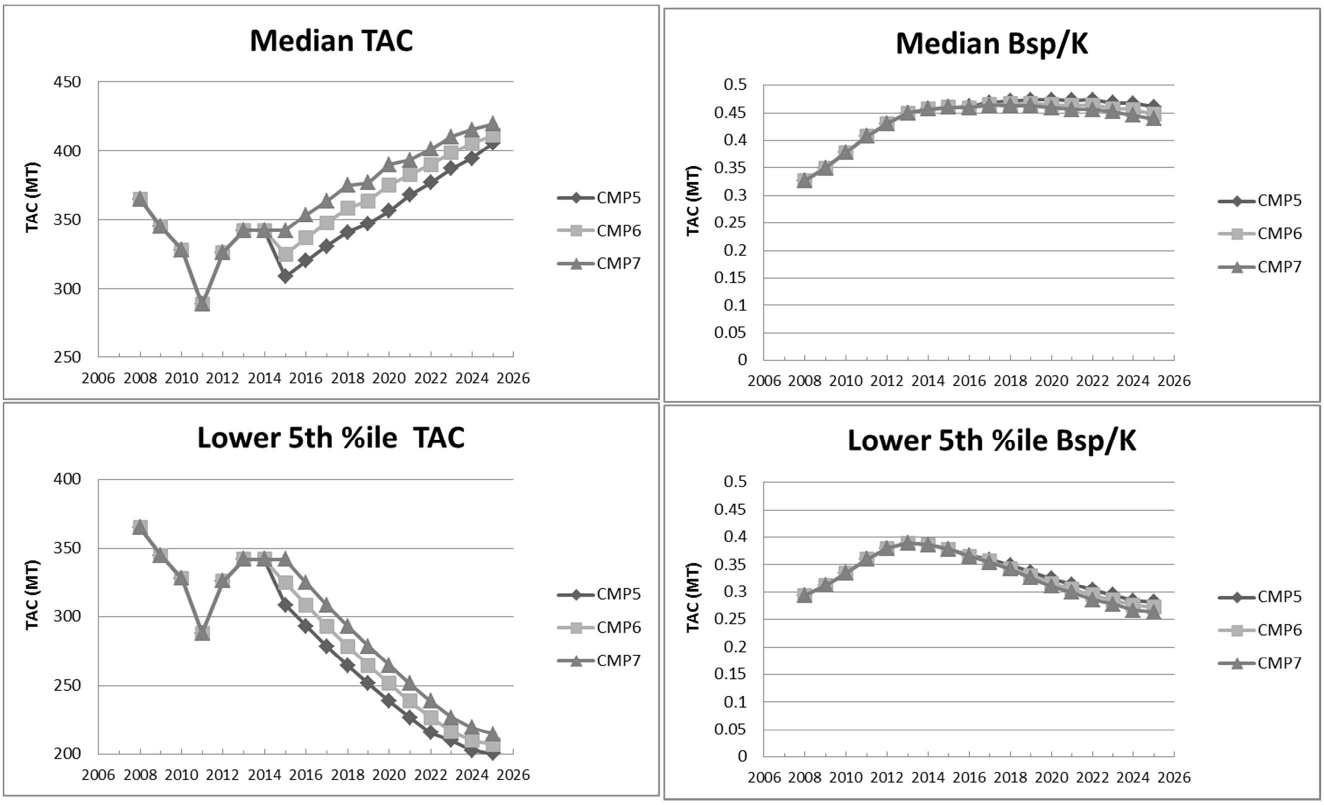
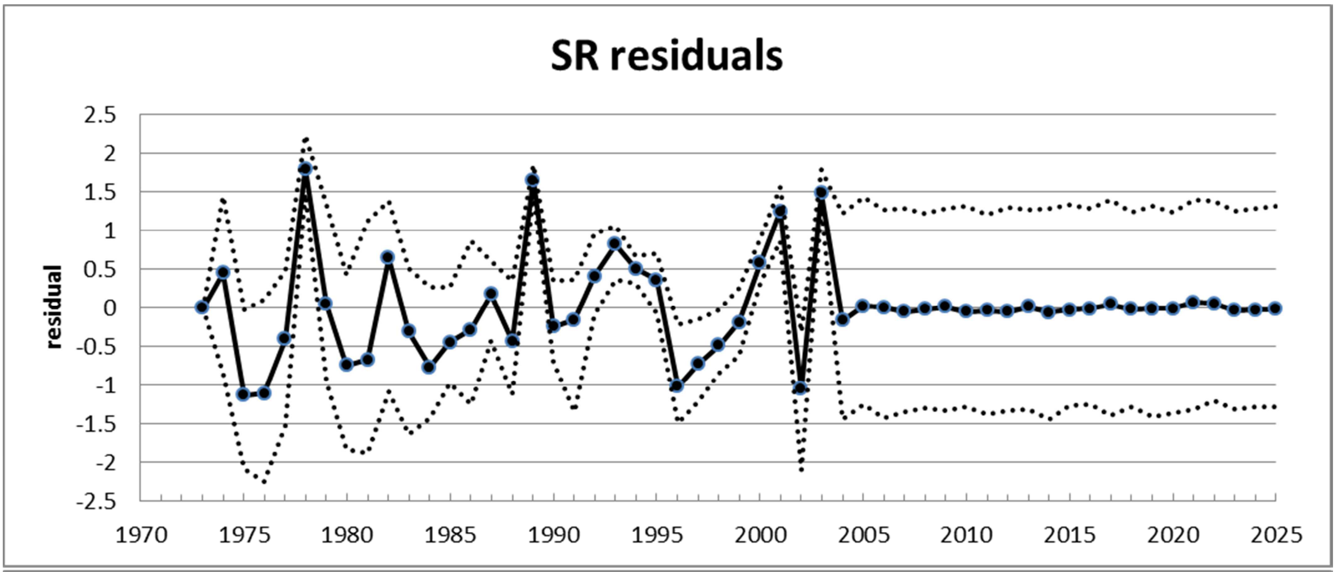
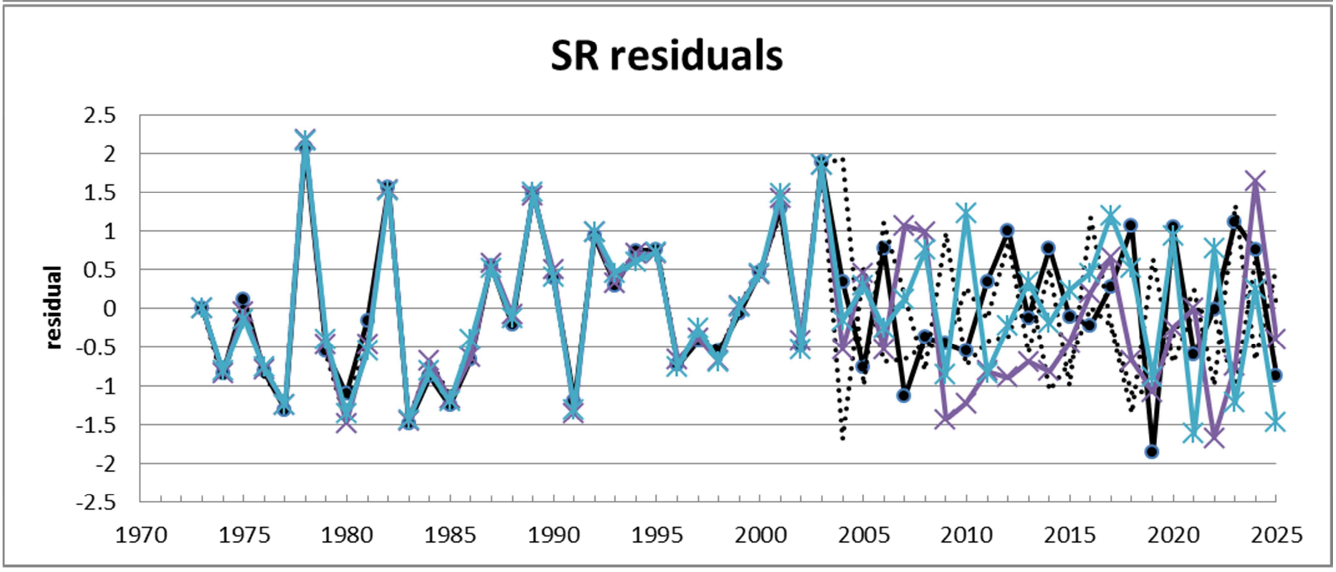


Figure 5: Stock recruit residuals: the top plot shows the median and 5th and 95th ile envelopes; the bottom plot shows the first 5 simulations considered.





Appendix: Current TAC rule

OMP 2010 consists of an algorithm that calculates the TAC for the resource using CPUE data collected from each of three areas (Areas 1, 2 and 3). OMP 2010 was updated slightly in 2013 to reflect the change to different areas A1E, A1W and A2+3.

Note that the TAC for season *y*+1 is based upon the CPUE series that ends in season *y*-1. Thus the TAC recommendation for 2013 was based on a CPUE series that ended with the most recent CPUE value available at the time a recommendation was requested, which would be for 2011.

TAC setting algorithm

The algorithm used to recommend the TAC for the South Coast Rock Lobster fishery for season *y*+1 is:

$$TAC_{y+1} = TAC_y[1+\alpha(s_y-\delta)]h(r_y) \qquad \text{(A1)}$$

where:

TAC_y is the TAC set (note NOT the catch taken) in season *y* ;

the value of α is set at 3.0; and δ is the tuning parameter (-0.2 for the current OMP).

s_y^A is the slope parameter from a regression of $\ln CPUE_y^A$ against *y* over the last five seasons' data (these will be for seasons *y*-5 to *y*-1 as data for season *y* will not be available at the time the recommendation is required) for each area *A*, and

$$s_y = \sum_{A=1}^{3} w^A s_y^A \qquad \text{(A2)}$$

where $$w^A = \frac{\frac{1}{\sigma_S^{A^2}}}{\sum_{A'=1}^{3}\left(\frac{1}{\sigma_S^{A'^2}}\right)} \qquad \text{(A3)}$$

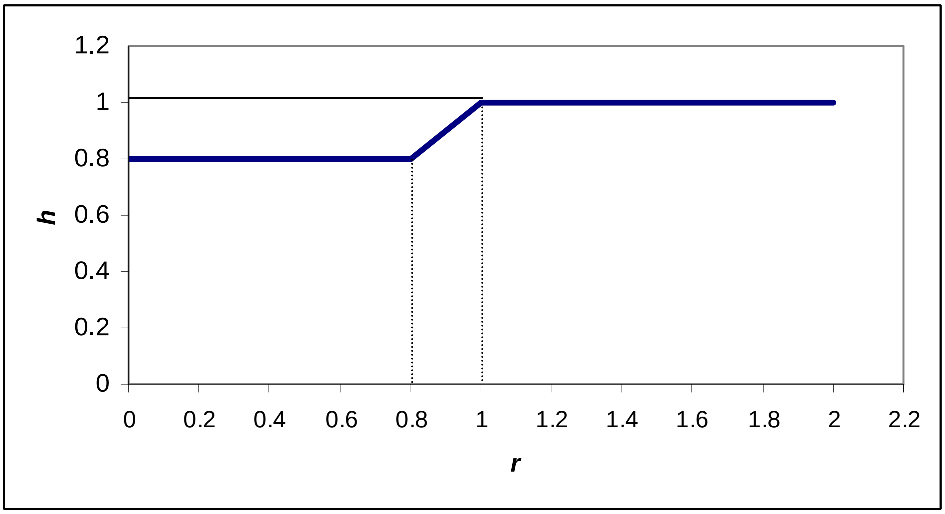
and σ_S^A is the standard error of the regression estimate of s_y^A subject to a lower bound of 0.15; and

δ is a control parameter value which is tuned for the RC to achieve the median recovery target of $B_{2025}^{sp}/B_{2006}^{sp}$ of 1.20 specified.

Further:

$$\begin{aligned} h(r) &= 0.8 && \text{for} \quad r \le 0.8 \\ &= r && \text{for} \quad 0.8 \le r \le 1.0 \\ &= 1.0 && \text{for} \quad r \ge 1.0 \end{aligned} \qquad \text{(A4)}$$

i.e.:



where *r* is the ratio of recent area-averaged CPUE to that at the time the OMP commenced:

$$\overline{CPUE}_{init} = \frac{1}{3}\sum_{y'=2003}^{2005}\sum_{A=1}^{3}\lambda_A CPUE_{y'}^{A} \qquad \text{(A5)}$$

$$\overline{CPUE}_{y} = \frac{1}{3}\sum_{y'=y-3}^{y-1}\sum_{A=1}^{3}\lambda_A CPUE_{y'}^{A} \qquad \text{(A6)}$$

$$r_y = \frac{\overline{CPUE}_y}{\overline{CPUE}_{init}} \qquad \text{(A7)}$$

and

$$\lambda_1 = 0.003$$
$$\lambda_2 = 0.128$$
$$\lambda_3 = 0.868\,.$$

The CPUE weighting factors, λ_1, λ_2 and λ_3 relate to relative biomass in each area, and were calculated as follows. Using the estimated values of *q* and B^{exp} for 2011 from the RC model:

	q	B^{exp} (MT)
Area A1E	0.01211	45
Area A1W	0.00357	505
Area 2+3	0.00101	959

The relative biomass weights are thus: Area A1E = 45/1508 = 0.03

Area A1W = 504/1508 = 0.33

Area 2+3 = 959/1508 = 0.64

In terms of CPUE what is therefore required is:

$$\begin{aligned} & 0.03\,B^1 + 0.33\,B^2 + 0.64\,B^3 \\ & = 0.03\frac{CPUE^1}{q_1} + 0.33\frac{CPUE^2}{q_2} + 0.64\frac{CPUE^3}{q_3} \\ & = 2.46 CPUE^1 + 93.61 CPUE^2 + 632.73 CPUE^3 \end{aligned} \tag{A8}$$

As the CPUE weights must sum to 1, it follows that the appropriate weighted average for CPUE is given by:

$$0.003\,CPUE^1 + 0.128\,CPUE^2 + 0.868\,CPUE^3$$

Inter-annual TAC constraint

A rule to restrict the inter-annual TAC variation to no more than 5% up or down from season to season is applied, i.e.:

if $TAC_{y+1} > 1.05 TAC_y$ $\quad TAC_{y+1} = 1.05 TAC_y$ (A9)

if $TAC_{y+1} < 0.95 TAC_y$ $\quad TAC_{y+1} = 0.95 TAC_y$