

# An Operational Management Procedure for the Tristan da Cunha rock lobster fishery

S.J. Johnston and D.S. Butterworth

MARAM

Department of Mathematics and Applied Mathematics

University of Cape Town

---

## Summary

This document provides full background on the OMP selected in May 2013 for providing recommendations for annual TACs for the rock lobster resource at the Tristan da Cunha island. The contents include the specifics of the OMP formula itself, and the results from the trials that were conducted to inform the process of selection of that OMP, as well as of further robustness tests to which the OMP selected was subjected.

## Introduction

In May 2013 an OMP selection process was conducted for the development and assessment of alternate OMPs to be used in setting the TAC at Tristan da Cunha island. In this original OMP selection process a slightly different version of the operating model was used to that considered here. Since then, the operating model has been updated to take account of some minor code corrections and revised assumptions to allow a better fit to the length distribution data at large lengths. The updated operating model results (Johnston and Butterworth 2013) are not greatly changed from those produced in earlier, except that the current spawning biomass depletion estimate has fallen from 1.00 to 0.75. Here we provide results of anticipated OMP performance for the final selected OMP and a range of alternate OMP candidates that were considered at the time.

## OMP development and management objectives

In preliminary discussion relating to the development of an OMP for Tristan da Cunha, it was decided that model predictions over a twenty year period under alternate candidate OMPs (CMPs) would be examined during the process of OMP selection. This period was considered to be sufficiently long to show trends in TAC, future CPUE and recruitment projections. It was noted that there would be a time lag in the reaction time of the OMP to any substantial changes in future recruitment, due the fact that very young recruiting lobsters take several years (6-7 years) before becoming large enough to impact the catch rate (due to the legal minimum carapace length of 70mm in place in this fishery).

It was also noted that the decline in CPUE since 2006 was most likely a result of exceptionally good recruitment in the late 1990s that had resulted in the exploitable biomass peaking around 2006. Johnston and Butterworth (2013) show that updated assessments of the resource estimate current spawning biomass to be around 0.75 of pristine. The current biomass level is thus estimated to be well above  $B_{msy}$  (which is usually considered to be  $\sim 0.50K$ ) – i.e. there is no biological need to rebuild this resource further at this time. After discussions with James Glass, it was decided that the management objective for this resource would be to aim to keep catch rates (CPUE) around recent levels, i.e. to aim for a target catch rate that is close to the average of the 2010, 2011, 2012 GLM standardized<sup>1</sup> catch rates ( $I^{tar}$ ) (where this value is calculated to be 1.163 kg/trap/hour). The main rationale behind the OMP is that if future observed CPUE values are above this level, then TACs should be increased, and if below this level, then TACs should be reduced.

It was also agreed that it would not be sensible to base the TAC rule on a single CPUE value, as there is likely to be considerable variability (noise) future CPUE estimates (as found in all fisheries), and thus an annual CPUE value is unlikely to be a true indication of the actual underlying status of the resource. As is the norm internationally, it is preferable to use a multi-year (often three-year) average of CPUE values to index of the resource status. Some fisheries use a five-year average. There is clearly a trade-off between more rapid reaction when the resource abundance changes up or down (i.e. using a three-year average) and reduced variability between the annual TAC values (i.e. using a five-year average). A three-year average was selected for this OMP.

As with many other fisheries, inter-annual TAC stability is a highly advantageous feature of an OMP. For this reason, the OMP formulation puts constraints on the amount the TAC can vary from one year to the next. Original analyses looked at both a +5/-5% inter-annual TAC change constraint, as well as a +5/-10% inter-annual TAC change constraint. The +5/-5% inter-annual TAC change constraint was selected for this OMP.

### Exceptional Circumstances

These provisions will be specified later, together with those for the OMPs for the other islands, to ensure inter-island consistency.

### Reference Case (RC) OMP

The OMP is a target-based rule based on the recent commercial CPUE, *viz.*

$$TAC_{y+1} = TAC_y + \alpha(I_y^{rec} - I^{tar}) \quad (1)$$

where

---

<sup>1</sup> Future GLMs will be renormalised to reflect an average abundance index for 2010 to 2012 of 1.163 as for the standardized CPUE series used for this analysis.

$I_y^{rec}$  is the average of the GLM standardized CPUE over the last three years ( $y-2, y-1, y$ ),

$I^{tar}$  is the CPUE target index of 1.163 (the average GLM standardised 2010-2012

CPUE), and

$$\alpha = 25$$

A rule to control the inter-annual TAC variation is also applied. The % TAC change relative to the previous year is restricted to a maximum of either up 5% down 5%, i.e.

If  $TAC_{y+1} < 0.95TAC_y$  then  $TAC_{y+1} = 0.95TAC_y$

If  $TAC_{y+1} > 1.05TAC_y$  then  $TAC_{y+1} = 1.05TAC_y$

Note that for the final selected OMP is was also decided to fix the TAC for the first year the OMP was applied (2013) to 165 MT.

#### Candidate management procedures (CMPs) explored

- The % TAC change relative to the previous year is restricted to a maximum of either up 5% down 5%, OR up 5% down 10%.
- Three different values of  $\alpha$  were initially examined:  $\alpha=25, 37.5$  or  $50$ . The larger the  $\alpha$  value, the more reactive the OMP is to changes in CPUE. The smaller  $\alpha$ , the less variability in TAC and thus more stability to the fishery.
- TAC(2013) is either fixed at 165 MT (indicated by \*) or is set by the OMP for this initial year.

The following candidate OMPs (CMPs) were explored:

**CMP1:**  $\alpha = 25$ ; +5%, -5% maximum inter-annual TAC change constraint

**CMP2:**  $\alpha = 25$ ; +5%, -10% maximum inter-annual TAC change constraint

**CMP3:**  $\alpha = 37.5$ ; +5%, -5% maximum inter-annual TAC change constraint

**CMP4:**  $\alpha = 37.5$ ; +5%, -10% maximum inter-annual TAC change constraint

**CMP5:**  $\alpha = 50$ ; +5%, -5% maximum inter-annual TAC change constraint

**CMP6:**  $\alpha = 50$ ; +5%, -10% maximum inter-annual TAC change constraint

<b>CMP1*:</b> $\alpha = 25$ ; +5%, -5% maximum inter-annual TAC change constraint, TAC(2013)=165 MT
---

**CMP2\*:**  $\alpha = 25$ ; +5%, -10% maximum inter-annual TAC change constraint, TAC(2013)=165 MT

**CMP3\*:**  $\alpha = 37.5$ ; +5%, -5% maximum inter-annual TAC change constraint, TAC(2013)=165 MT

**CMP4\***:  $\alpha = 37.5$ ; +5%, -10% maximum inter-annual TAC change constraint, TAC(2013)=165 MT

**CMP5\***:  $\alpha = 50$ ; +5%, -5% maximum inter-annual TAC change constraint, TAC(2013)=165 MT

**CMP6\***:  $\alpha = 50$ ; +5%, -10% maximum inter-annual TAC change constraint, TAC(2013)=165 MT

Note: CMP1\* was the final selected OMP.

### Alternate Operating models and Robustness trials

The performance of the final selected OMP was simulation tested for a range of alternate operating models and robustness tests. These were kept low in number due to time constraints, with the aim of testing the performance of the OMP under a range of particularly testing possible future scenarios. The trials considered were:

- **Rob1**: future recruitment is set equal to the average of the 2001-2010 recruitment (plus error).
- **Rob2**: At the start of 2013, 30% of all lobsters die (i.e. a once off event).
- **Rob3**: For 2011+, the carrying capacity is reduced by 30% (i.e. reduction continues into the future).
- **Rob4**: The underlying operating model forces spawning biomass in 2013 to be 0.5 of  $K$  (i.e. current spawning biomass is much lower relative to  $K$  than for the RC operating model).
- **SigR1**: Past and future recruitment variability is reduced to  $\sigma_R = 0.2$  (RC = 0.4).
- **SigR2**: Past and future recruitment variability if increased to  $\sigma_R = 0.8$  (RC = 0.4).

[Note Rob4, SigR1 and SigR2 involve changes to the underlying operating model.]

### Summary statistics

A number of summary statistics were defined in order to compare the trade-offs and performances of the alternate CMPs.

- CR(2032) = catch rate expected in 2032 (in kg/gear/hour)
- CR(2022) = catch rate expected in 2022 (in kg/gear/hour)
- $C_{ave\ 10}$  = average annual catch (in MT) over next 10 years (2013-2022)
- V10 = average TAC change from previous year over next 10 years (expressed as a %)
- The lower 5%ile of  $B_{sp}(2032)/K$  = the spawning biomass at the start of 2032 relative to pristine levels ( $K$ )

Each candidate CMP was run for 100 simulations. The medians, and the 5<sup>th</sup> and 95<sup>th</sup> percentiles of various management quantities of interest are reported.

## Results

Table 1 compares the expected performance results of the final selected OMP (CMP1\*) between the APR and OCT operating models. All statistics reported are median values unless otherwise stated. The main difference is that the updated OCT operating model estimates the lower 5<sup>th</sup> percentile Bsp(2032)/K to be lower at 0.57 compared with the APR result of 0.87, though still above the MSY level. The updated operating model also provides more optimistic estimates of future catch rates, although median TAC levels are largely unchanged with the updated operating model.

Table 2a reported the results of the 12 CMPs that were considered. There is very little difference in performance between them. Fixing the TAC(2013)=165 MT (the \* CMPs) results in slightly less average annual catch over the first 10 year period. The expected TAC change over the next 10 years is estimated to be small (less than 3% in median terms for all 12 CMPs). Catch rates are expected to increase over the first 10 years, and then come down somewhat by 2032. The median catch rates are expected to remain above the target value of 1.163 kg/trap/hour – although some reduction below this is seen at the lower 5%ile level.

Figure 1 illustrates the expected performance of the selected OMP, showing not only the median levels, but also the 5<sup>th</sup> and 95<sup>th</sup> percentile (i.e. showing the 90% probability interval) of each output statistic. Figure 1 also illustrates (in the right hand column of plots) what the expected outcomes of individual realisations could be. Note that the medians are calculated by averaging over a total of 100 possible realisations.

Table 3 and Figure 3 report comparative results of the six robustness tests when run with the final selected OMP (the RC). The only one of these that suggests possible cause for concern is Rob4 for which the lower 5% Bsp(2032)/K statistic in particular drops to the very low level of 0.12. This test considers the situation that the estimate of current spawning biomass relative to pristine is appreciably too high; continued updating of resource assessments as time progresses should be able to detect whether this is in fact the case.

## Final selection of OMP

CMP1\* was the final selected OMP for setting the TAC at Tristan da Cunha for a three year period, starting for the 2013/14 season, subject to review of the model by MRAG. Edwards and Rademeyer (2013) report that “[MRAG] repeated the simulation testing of this control rule and confirmed that the MARAM MP performed well. This amounted to a process of verifying MARAM’s proposed MP, and indicated that the use of [CMP1\*] would be justifiable. “

There were minimal differences between the +5/-5% and +5/-10% TAC constraint options, so it was agreed to apply the +5/-5% interannual TAC constraint.

An OMP which fixes the first TAC, TAC(2013), at 165 MT was preferred. All parties agreed to this decision after considerable debate. It was agreed that 165 MT would be more readily accepted by the Tristan

Council and community. Although this will result in an initial small decrease in TAC (from 170 MT in 2012) the situation will hopefully rectify itself in a few years if good conditions for the resource prevail at Tristan.

It is important to note that with this target-based OMP, as long as the three year average CPUE is below the target CPUE level, the TAC will be reduced. If the CPUE starts to increase but the average remains below the target level of 1.163, the TAC will still be reduced. Similarly, as long as the three-year average CPUE remains above the target level, the TAC will increase even if the recent trend in CPUE is downwards.

### **Future work**

Future OMP development will examine the potential from incorporating biomass survey data into the control rule. Edwards and Rademeyer (2013) suggest that inclusion of survey data could improve the performance of the OMP. They also report that the inclusion of trend information in potential OMPs did not yield any noticeable improvements in OMP performance.

This work will also include extending OMP development to Gough, Inaccessible and Nightingale islands. As with Tristan there will need to be close interactions with stakeholders as the final choice of these OMPs will probably involve a trade-off selection between higher catches and higher catch rates given that the resources are currently estimated to be above their MSY biomass levels.

### **References**

Edwards, C.E. and Rademeyer, R. 2013. Fisheries advice to the Tristan da Cunha Administration. Phase II: Development of a new management plan for rock lobster fisheries in the Tristan da Cunha archipelago. MRAG Ltd London, 23 pp.

Johnston, S.J. and Butterworth, D.S. 2013. Further updates to the 2013 Tristan da Cunha rock lobster assessment. MARAM/TRISTAN/2013/OCT/13.

Table 1: Comparison of final selected OMP (CMP1\*) expected performance results between the APR and OCT operating models. All statistics reported below are median values unless otherwise stated.

	$\alpha$	Inter-annual maximum TAC constraint	CR(2022) (kg/gear/hour)	CR(2032) (kg/gear/hour)	$C_{ave\ 10}$ (MT)	Lower 5%ile $C_{ave\ 10}$	V10 (%)	Lower 5%ile Bsp(2032/K)
<b>Apr CMP1*</b>	25	+5%,-5%	1.23	1.06	174	163	2.38	0.87
<b>Oct CMP1*</b>	25	+5%,-5%	1.38	1.24	171	163	1.90	0.57

Table 2: Reference case CMP results. All statistics reported below are median values unless otherwise stated.

	$\alpha$	Inter-annual maximum TAC constraint	CR(2022) (kg/gear/hour)	CR(2032) (kg/gear/hour)	Cave 10 (MT)	Lower 5%ile Cave 10	V10 (%)	Lower 5%ile Bsp(2032/K)
<b>CMP1</b>	25	+5%,-5%	1.37	1.23	175	167	1.43	0.57
<b>CMP2</b>	25	+5%,-10%	1.37	1.24	175	167	1.43	0.58
<b>CMP3</b>	37.5	+5%,-5%	1.35	1.22	176	166	1.98	0.57
<b>CMP4</b>	37.5	+5%,-10%	1.35	1.25	176	166	1.99	0.57
<b>CMP5</b>	50	+5%,-5%	1.34	1.21	177	165	2.42	0.57
<b>CMP6</b>	50	+5%,-10%	1.34	1.25	177	165	2.43	0.57
<b>CMP1*</b>	25	+5%,-5%	1.38	1.24	171	163	1.90	0.57
<b>CMP2*</b>	25	+5%,-10%	1.38	1.26	171	163	1.90	0.58
<b>CMP3*</b>	37.5	+5%,-5%	1.36	1.23	173	163	2.44	0.57
<b>CMP4*</b>	37.5	+5%,-10%	1.36	1.25	173	163	2.45	0.57
<b>CMP5*</b>	50	+5%,-5%	1.35	1.22	174	162	2.93	0.57
<b>CMP6*</b>	50	+5%,-10%	1.35	1.25	174	162	2.94	0.58

\*TAC(2013) fixed at 165MT

Table 3: CMP1\* ( $\alpha=25$ , +5%/-5%; TAC(2013)=165 MT) results for alternate robustness tests. All statistics reported below are median values.

	CR(2022) (kg/gear/hour)	CR(2032) (kg/gear/hour)	Cave 10 (MT)	V10 (%)	Lower 5%ile Bsp(2032/K)
<b>RC</b>	<b>1.23</b>	<b>1.06</b>	<b>174</b>	<b>2.38</b>	<b>0.87</b>
Rob1 (alternative recruitment)	<b>1.13</b>	<b>1.07</b>	<b>169</b>	<b>1.63</b>	<b>0.50</b>
Rob2 (30% die in 2013)	<b>1.45</b>	<b>1.48</b>	<b>137</b>	<b>4.15</b>	<b>0.62</b>
Rob3 (future K decreases 30%)	<b>0.87</b>	<b>0.88</b>	<b>167</b>	<b>1.60</b>	<b>0.42</b>
Rob4* (Bsp(2013)/K=0.5))	<b>1.91</b>	<b>0.92</b>	<b>205</b>	<b>4.57</b>	<b>0.12</b>
SigR1* ( $\sigma_R = 0.2$ )	<b>1.36</b>	<b>1.15</b>	<b>177</b>	<b>2.27</b>	<b>0.65</b>
SigR2* ( $\sigma_R = 0.8$ )	<b>1.76</b>	<b>1.61</b>	<b>167</b>	<b>1.87</b>	<b>0.49</b>

\*involve changes to the underlying operating model.



Figure 1: CMP1\* (final selected OMP) simulation results. The left column of plots show the expected medians, 5<sup>th</sup> and 95<sup>th</sup> percentiles, whilst the right column shows the output for the first 3 simulations. Vertical arrows show the start of the projection period. In the Catch rate plot, the horizontal red line shows the target catch rate (1.163), and in the Bsp plot the horizontal red line indicates the estimated K (unexploited spawning biomass level).

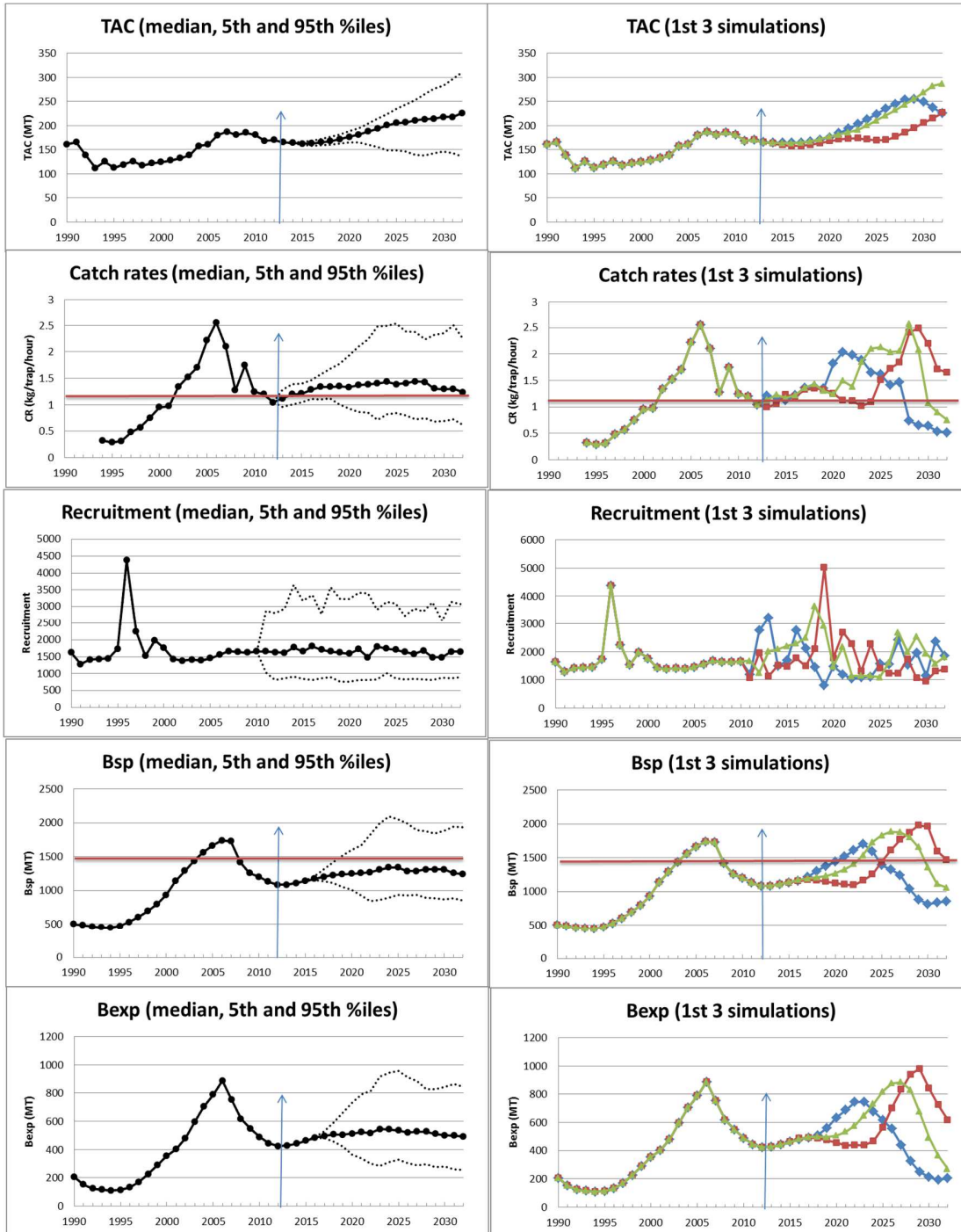


Figure 2: Comparative plots showing the medians and 5<sup>th</sup> and 95<sup>th</sup> percentiles for six CMPs for Reference case assumptions for the future. These CMPs assume TAC(2013) to be fixed at 165 MT. The red horizontal line in the two catch rate plots show the average of the three most recent CPUE values.

**CMP1\***:  $\alpha = 25$ ; +5%, -5% maximum inter-annual TAC change constraint; **CMP2\***:  $\alpha = 25$ ; +5%, -10% maximum inter-annual TAC change constraint

**CMP3\***:  $\alpha = 37.5$ ; +5%, -5% maximum inter-annual TAC change constraint; **CMP4\***:  $\alpha = 37.5$ ; +5%, -10% maximum inter-annual TAC change constraint

**CMP5\***:  $\alpha = 50$ ; +5%, -5% maximum inter-annual TAC change constraint; **CMP6\***:  $\alpha = 50$ ; +5%, -10% maximum inter-annual TAC change constraint

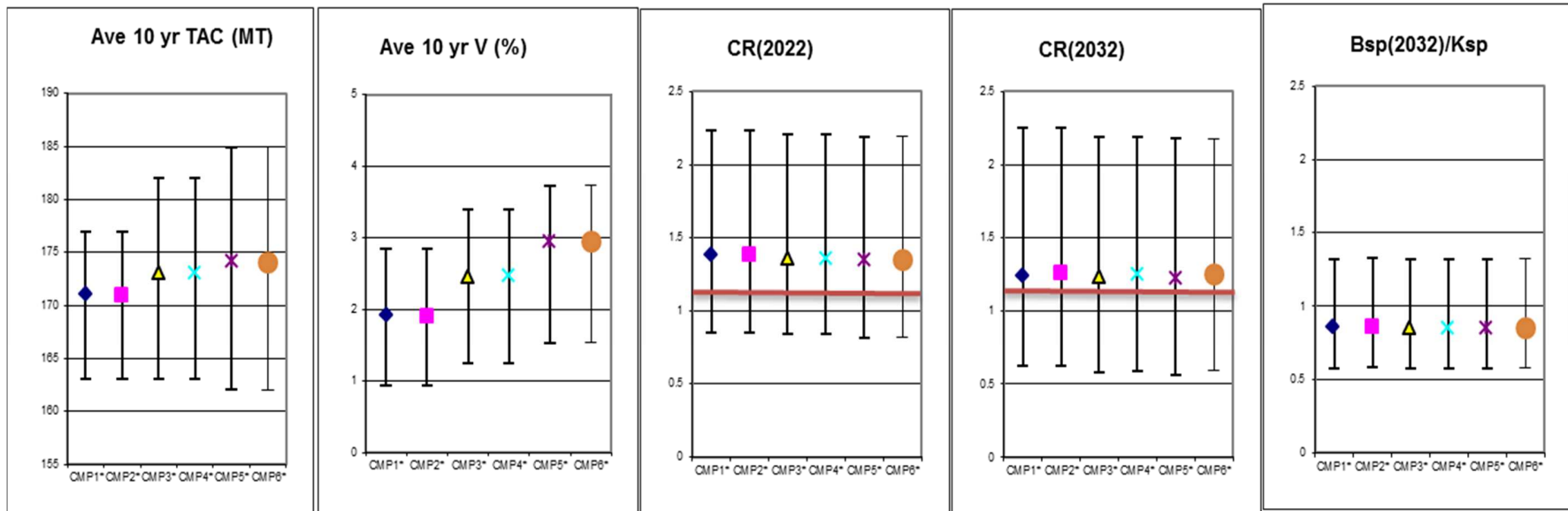


Figure 3: Comparative plots showing the medians and 5<sup>th</sup> and 95<sup>th</sup> percentiles for **CMP1\*** ( $\alpha = 25$ ; +5%, -5% maximum inter-annual TAC change constraint) for the RC and six robustness tests. The red horizontal line in the CR plots show the average of the three most recent CPUE values. Rob1: Future recruitment is set equal to the average of the 2001-2010 recruitment (plus error); Rob2: At the start of 2013, 30% of all lobsters die (i.e. a once off event); Rob3: For 2011+, the carrying capacity is reduced by 30% (i.e. reduction continues into the future); Rob4: The underlying operating model forces spawning biomass in 2013 to be 0.5 of K (i.e. current spawning biomass is lower relative to K than estimated for the RC operating model), sigR1 reduces recruitment variability  $\sigma_R$  to 0.2 and sigR2 increases this  $\sigma_R$  to 0.8.

