Initial results from the development of a new OMP 2020 for Tristan da Cunha island rock lobster resource

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Summary

Development of a revised OMP (OMP 2020) for the Tristan island rock lobster resource first leads to a recommendation to include the annual Edinburgh/GS CPUE and the biomass survey index as well as the Tristan powerboat CPUE index as inputs to the formula to provide an annual TAC recommendation. Following an extensive comparison exercise, two options are put forward as candidates for the revised OMP: CMP1 and CMP2. Both reflect slightly less risk of undue resource depletion than under the current OMP 2016. CMP1 is very similar to that current OMP, and is expected to maintain annual TACs close to 120 MT. In contrast, under CMP2 TACs would be expected to increase slightly over the next decade, accompanied by a slight decrease in the catch rate compared to that under CMP1.

Introduction

An OMP for setting the TAC for the rock lobster fishery at Tristan da Cunha island was first developed and implemented in 2013 (OMP 2013) (Johnston and Butterworth 2013). A new OMP (OMP 2016) was developed in 2016. The underlying OM (developed in 2016) used for testing this last OMP was fit to the powerboat GLM standardized CPUE data which had been rescaled to allow for changes in fishing efficiency over recent times. This OMP continued to be target-based, with the target (Itar) being the average of the 2010-2012 GLM standardized CPUE values (1.257 kg/trap/day). A new rule added at that time was that a TAC "floor" level of 120 tons was set, BUT there was a lower limit (Ilim) for the observed recent standardized CPUE 3-yr average below which this 120t floor rule was over-ruled on the basis of Exceptional Circumstances (ECs) having occurred. This updated OMP from 2016 is described in detail in Johnston and Butterworth (2016). Essentially the EC rule came into play once the recent 3-yr CPUE level dropped below 0.9 kg/trap/day.

Following an update of the Tristan assessment model (Johnston and Butterworth 2020), a new OMP 2020 is to be developed. The current OMP 2016 uses only the commercial CPUE data as input to the TAC-setting formula. The new OMP 2020 proposed continues to be target-based, but the analyses below examine the consequences of the inclusion of both the Edinburgh/GS CPUE and the biomass survey index as additional inputs.

OMP 2020 Candidates

OMP 2020 RC (equivalent to OMP 2016):

This OMP is again 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

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 the **Baseline** three-year (2010-2012) average GLM standardised CPUE = **1.287**

$\alpha = 25$

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 5% up or 5% down, i.e.:

If $TAC_{y+1} < 0.95TAC_y$ then $TAC_{y+1} = 0.95TAC_y$ (2)

If $TAC_{y+1} > 1.05TAC_y$ then $TAC_{y+1} = 1.05TAC_y$ (3)

A further NEW rule (added in 2016) is that:

If $TAC_{y+1} < 120t$ then $TAC_{y+1} = 120t$ (3)

Thus a "floor" TAC level of 120 tons is set, BUT this requires an associated lower limit in the observed recent CPUE 3-yr average below which this 120t floor level is over-ruled on the basis of Exceptional Circumstances occurring. The diagram below indicates how this further rule operates.

Alternative OMPs (ALT1, ALT2 and ALT3)

It is clearly desirable, now that further indices other than the standard CPUE index have been available for some time, to examine the effect of including not only the commercial CPUE as input into the TAC-setting equation, but also the possibility of including the Edinburgh/GS CPUE and/or the biomass survey index.

To do this, the following steps have been taken:

STEP 1: Normalise each series such that the 2010-2012 average equals 1.0 (for comparability purposes).

STEP 2: Calculate the I_y^{rec} value for each series ($I_y^{rec,comm}$, $I_y^{rec,Edin}$ and $I_y^{rec,survey}$) as the average of the normalized values over the last three years (*y*-2, *y*-1, *y*).

STEP 3: Calculate a combined J_y^{rec} from using some or all of the I_y^{rec} values.

OMP ALT1: $J_y^{rec} = \frac{w_1 I_y^{rec,comm} + w_2 I_y^{rec,Edin}}{w_1 + w_2}$, i.e. uses commercial CPUE and Edinburgh/Geo searcher CPUE

OMP ALT2: $J_y^{rec} = \frac{w_1 I_y^{rec,comm} + w_3 I_y^{rec,survey}}{w_1 + w_3}$, i.e. uses commercial CPUE and biomass survey index

OMP ALT3: $J_y^{rec} = \frac{w_1 I_y^{rec,comm} + w_2 I_y^{rec,Edin} + w_3 I_y^{rec,survey}}{w_1 + w_2 + w_3}$ i.e. used all three indices.

where the weights w_1, w_2 and w_3 are the inverse variances from the Base case model fits to these data in the underlying assessments (Johnston and Butterworth 2020), so that:

$$w_1 = \frac{1}{\sigma_{commn}^2} = \frac{1}{0.09^2} = 123$$

$$w_2 = \frac{1}{\sigma_{Edin}^2} = \frac{1}{0.32^2} = 10$$

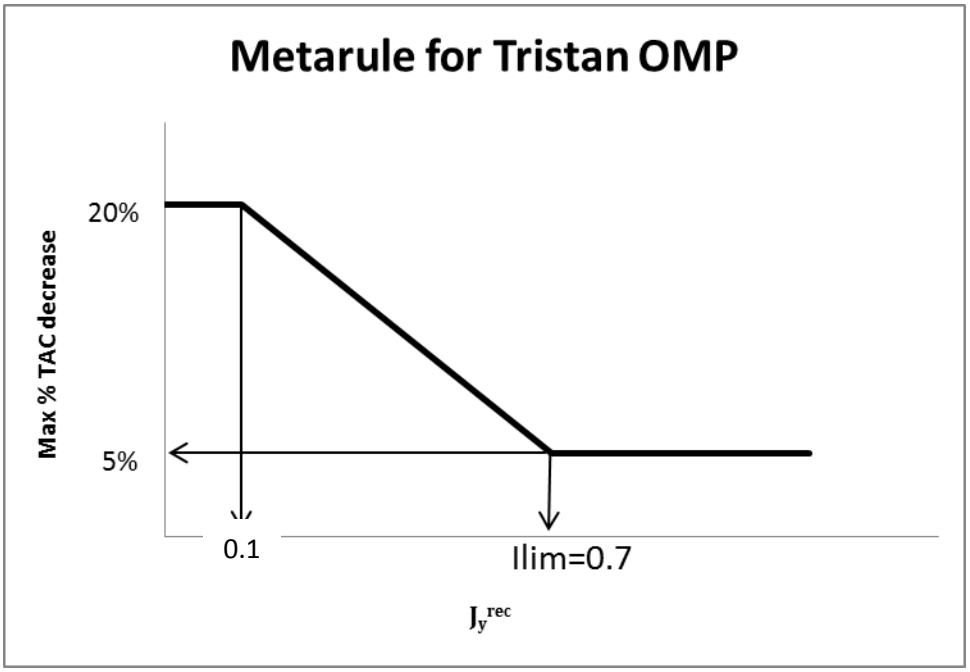
$$w_3 = \frac{1}{\sigma_{survey}^2} = \frac{1}{0.11^2} = 83 \qquad (4)$$

STEP4: Calculate the TAC.

$$TAC_{y+1} = TAC_y + \alpha(J_y^{rec} - J_{tar}) \qquad (5)$$

where J_{tar} and α are selected control parameters.

Exceptional Circumstances rule (for all OMP candidates)



If the recent catch rate J_y^{rec} value drops below a threshold level (**Ilim**), the TAC may decrease by more than the usual maximum 5% decrease. The Figure above shows how the maximum % the TAC may be reduced from year to year may change from the default of 5% (at Ilim) to a value of 20% at a value of J_y^{rec} of 0.1, depending on the value of J_y^{rec}. OMP 2020 RC sets Ilim=0.70 (equivalent to the value of 0.90 assumed for OMP 2016.

OMP variants

Results for a number of variants of OMP 2020 are reported here - see Table 1 for details. The RC OMP uses only the commercial CPUE index as input into the TAC-setting formula, whereas the other OMP variants examine using either or both the Edinburgh CPUE and Biomass survey index data as well. Results for varying the values of the control parameters J_{tar} and α are also reported. Detailed results are produced for two of the more promising OMP candidates, both for the ALT3 OMP variant where all three CPUE indices are used as input into the TAC-setting formula. These are:

CMP1: α=25; Jtar=1.0 (i.e. effectively the same parameters as the current OMP 2016).

CMP2: α=35; Jtar=0.8 (this CMP allows for a lower CPUE target and can lead to higher TACs).

Note that in this document the CPUE target is referred to as **Jtar**. OMP 2016 has an **Itar** value of 1.257 (the average of the 2010-2013 CPUE values), which is equivalent to a Jtar value of 1.0 where the CPUE index values are each re-normalised to their average 2010-2012 values.

Robustness trials

The idea is to develop "difficult" robustness trials in order to test how well the OMP is able to successfully adjust the TACs in response to a drop abundance and hence in CPUE values.

ROB1: At the start of 2020, 10% of all lobsters die (or are removed from the system).

ROB2: At the start of 2020, 30% of all lobsters die (or are removed from the system).

Summary statistics

CR(2022), CR(2025) and CR(2032)	powerboat catch rates (re-normalised)
Cave(5)	average TAC for the next 5 years (2020-2024)
Cave(10)	average TAC for the next 10 years (2020-2029)
AAV(10)	average inter annual TAC variation over 2020-2029 period (expressed as %)
Bsp(2025)/K, Bsp(2033/K)	spawning biomass relative to pristine (K)

Results

Table 2 reports key simulation results for a number of OMP variants (RC and three alternate OMPs). All statistics reported are median values unless otherwise stated. Figure 1a plots each CPUE series (before re-normalisation) along with their respective 2010-2012 average values. Figure 1b re-normalises these series to be able to compare their trends directly. The Appendix explains the reasons for differences between the current catch rate projections and those obtained three years ago for OMP2016.

Table 3 reports six key statistics for the **ALT3** OMP. Results are shown for a range of Jtar and α values.

Table 4 reports the median, lower 5th%ile and upper 5th%ile values of six key statistics for two more favoured OMP candidates (CMP1 and CMP2).

Table 5 reports six key statistics for two favoured CMPs (CMP1 α=25, J_{tar}=1.0; and CMP2 α=35, J_{tar}=0.8). Results are shown for the RC model as well as the two robustness tests. Results for a future TAC=0 scenario are also shown to reflect the highest abundance that the resource could achieve.

Figure 2 illustrates TACs, Bsp/K and CR trajectories for the favoured **CMP1** (J_{tar} =1.0, α= 25) and **CMP2** (J_{tar} =0.8, α= 35). In each plot the median with 5th and 95th percentiles are shown. For the bottom three plots, the J_{tar} values are shown as green horizontal lines.

Figure 3 compares the simulation results for the Bsp/K and TAC statistics for CMP1 and CMP2. The median results and the lower 5th %iles are illustrated. These show that even though there can be an appreciable short-term drop in abundance under the more severe robustness test ROB2, the resource recovers quite quickly from this – indeed almost as quickly under these CMPs as if no catch is taken. Figure 4 similarly compares the simulation results for the catch rate statistics for CMP1 and CMP2, as well as for a future zero TAC scenario. Only median results are presented there.

Discussion

The first aspect one needs to consider when examining future candidate OMPs for any resource is the current status of the stock. The updated 2020 assessment estimates current Bsp(2020/K) to be 0.75 (relative to pristine) – a very healthy level (Johnston and Butterworth 2020).

The current OMP (OMP 2016) when simulation tested in 2016 predicted a lower 5th%ile for Bsp(2033/K) of 0.55 (i.e. this was the accepted maximum risk level). The updated 2020 assessment is slightly more optimistic as regards Bsp projections – see Table 2 rows 1 and 2. OMP 2016 when simulation tested using the 2020 updated OM predicts a lower 5th%ile for Bsp(2033/K) of 0.58 (i.e. larger than thought three years previously).

When considering which CPUE data to incorporate into the OMP's TAC setting formula (see Table 2), there is not much difference amongst ALT1-ALT3 (i.e. including the Edinburgh and biomass survey index data does not make much difference). This is due to the fact that all three series have very similar trends (Figure 1b), as well as the powerboat CPUE data receiving by far the highest weighting (see equation 4), which is because they show the least variability about the biomass trend estimated by the assessment. It would seem that given that the three CPUE series are readily available, one should use all three data sources so as to take the most information possible into account – hence that ALT3 should be used as a basis for OMP development.

Using ALT3 (i.e. using all three indices) the next question is what J_{tar} value will give the equivalent level of risk accepted in 2016 (that is a lower 5th%ile on Bsp(2033/K) 0.55)? This would be J_{tar} =0.7 (Table 3) which would also allow for rather higher future TACs. Given that the current OMP has a J_{tar} =1.0, perhaps a J_{tar} =0.7 is too large a jump away from this original target in a single step. We thus suggest to focus onCMP1 which keeps the same J_{tar} value of 1.0, and CMP2 which lowers the J_{tar} value only to 0.8. Both these CMPs estimate a higher lower 5th%ile value for Bsp(2033/K) than the current OMP 2016, so are both "safe" (indeed "safer") contenders with regard to risk.

Before examining the tradeoffs between these two CMPs, note that discussion above has been in terms of lower 5th%ile for Bsp(2033/K) (as a measure of risk). The expected values for Bsp(2033/K), reflected below by their medians, are much higher and reflective of a resource in a healthy state.

	Median Bsp(2033/K)	Lower 5th%ile Bsp(2033/K)	Upper 5th%ile Bsp(2033/K)
CMP1	0.75	**0.58**	1.34
CMP2	0.74	**0.56**	1.34

The tradeoffs between these two CMPs can be viewed in Table 3 (compare the statistics within the two ellipses). CMP1 is expected to keep the TAC at around 120 for the next 5 and 10 year periods, with a lower 5th%ile for the risk statistic Bsp(2033/K) 0.58. CMP2 has a lower 5th%ile for the risk statistic Bsp(2033/K) which is only slightly lower at 0.56 (and still above that accepted for OMP 2016), but allows for increased median TAC of Cave(5)=129 MT when this is averaged over the next 5 years, and a Cave(10)=138 MT average over the next 10 years. In fact, considering a range of risk versus TAC tradeoffs, it is evident that a **5%** increase in the lower 5th%ile of Bsp(2033/K) results in a **10%** reduction in Cave(5) and a **17%** reduction in Cave(10). It should though also be noted that CMP2 does result in slightly lower catch rates after a few years (see Table 3 and Figure 2).

To summarise then, we suggest that the choice to be made is between CMP1 and CMP2 for which the risk of resource depletion is very similar, but the former secures slightly higher CPUEs, whereas the latter is expected to result in slightly higher future catches in due course.

References

Johnston, S.J and Butterworth, D.S. 2013. An operational management procedure for the Tristan da Cunha rock lobster fishery. MARAM document, MARAM/Tristan/2013/OCT/14.

Johnston, S.J. and Butterworth, D.S. 2016. Initial results in the development of a new OMP for Tristan da Cunha rock lobster. MARAM document, MARAM/Tristan/2016/APR/0.7

Johnston, S.J. and Butterworth, D.S. 2020. Updated 2020 Tristan rock lobster assessment. MARAM document, MARAM/Tristan/2020/FEB/04.

Table 1: Details of the 2016 OMP and the various 2020 OMP candidates presented in this paper.

OMP	α	Jtar	Indices used		
			Commercial CPUE	Edinburgh CPUE	Survey index
OMP 2016[#]	**25**	Jtar = 1.0	**YES**	NO	NO
RC	**25**	Jtar = 1.0	**YES**	NO	NO
ALT1	**25**	Jtar = 1.0	**YES**	**YES**	NO
ALT2	**25**	Jtar = 1.0	**YES**	NO	**YES**
ALT3	**25**	Jtar = 1.0	**YES**	**YES**	**YES**

[#] OMP 2016 as reported in 2016 (i.e. using the 2016 assessment model as the underlying OM).

Table 2: Simulation results for a number of candidate 2020 OMPs. All statistics reported below are median values unless otherwise indicated. The first row reports results for the current OMP 2016 as simulation tested in 2016.

OMP	α	Jtar	CR(2022) (kg/gear/hour) (re-normalised CR)	CR(2025) (kg/gear/hour) (re-normalised CR)	CR(2032) (kg/gear/hour) (re-normalised CR)	C_{ave} 5 (20-24) (MT)	C_{ave} 10 (20-29) (MT)	AAV(10) %	Lower 5%ile $B_{sp}(2033)/K$
OMP 2016[#]	25	Jtar = 1.0	1.08	1.11	0.99	122	130	2.82	0.55
RC	25	Jtar = 1.0	0.88	1.03	1.08	120	120	0.71	0.58
ALT1	25	Jtar = 1.0	0.86	1.03	1.04	120	121	1.24	0.58
ALT2	25	Jtar = 1.0	0.88	1.03	1.06	120	120	0.88	0.58
ALT3	25	Jtar = 1.0	0.88	1.03	1.05	120	121	0.97	0.58

[#] OMP 2016 as reported in 2016 (i.e. using the 2016 assessment model as the underlying OM).

Table 3: Six key statistics for the **ALT3** 2020 OMP, CR(2032) (**PURPLE**), C_{ave} 5 (**GREEN**), C_{ave} 10 (**ORANGE**), AAV(10)% (**MAUVE**), lower 5th % Bsp(2025/K) (**BLUE**), and lower 5%ile Bsp(2033/K) (**RED**). Results are shown for a range of Jtar and α values. The large dark blue ellipses correspond to the CMP1 and CMP2 OMP candidates explored in more detail.

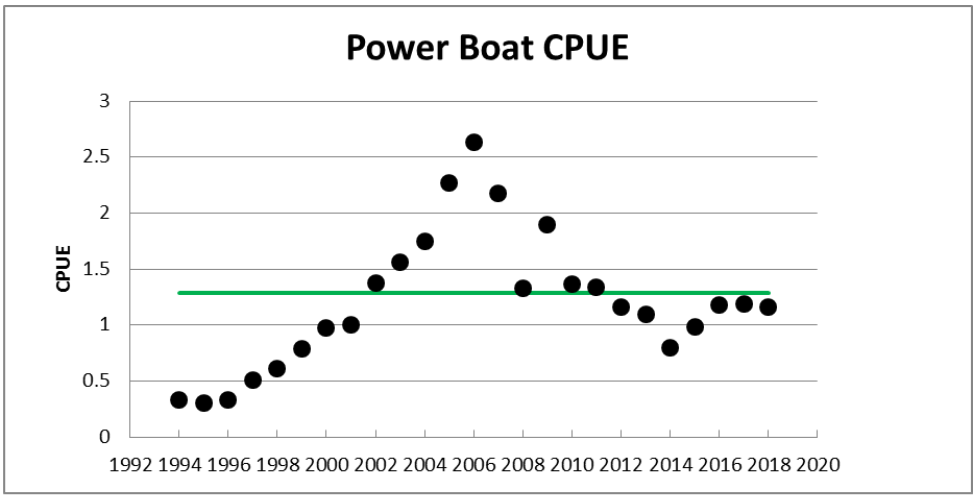
		Jtar=0.70	Jtar=0.80	Jtar=0.85	Jtar=0.90	Jtar=1.0
$\alpha = 15$	Median CR(2032)	0.96	1.01	1.04	1.06	1.07
	Median C_{ave}(5)	129	124	122	120	120
	Median C_{ave}(10)	136	129	125	123	120
	AAV(10)%	2.52	1.86	1.59	1.31	0.87
	Lower 5th%ile Bsp(2025)/K	0.74	0.74	0.74	0.74	0.74
	Lower 5th%ile Bsp(2033)/K	0.56	0.57	0.58	0.58	0.58
$\alpha = 25$	Median CR(2032)	0.90	0.98	1.01	1.04	1.07
	Median C_{ave}(5)	134	127	123	120	120
	Median C_{ave}(10)	146	134	128	123	121
	AAV(10)%	3.22	2.37	2.02	1.67	0.97
	Lower 5th%ile Bsp(2025)/K	0.74	0.74	0.74	0.74	0.75
	Lower 5th%ile Bsp(2033)/K	0.55	0.57	0.58	0.58	0.58
$\alpha = 35$	Median CR(2032)	0.86	0.95	0.99	1.03	1.06
	Median C_{ave}(5)	137	129	124	120	120
	Median C_{ave}(10)	153	138	130	124	121
	AAV(10)%	3.87	2.69	2.32	1.95	1.08
	Lower 5th%ile Bsp(2025)/K	0.73	0.74	0.74	0.74	0.75
	Lower 5th%ile Bsp(2033)/K	0.55	0.56	0.57	0.58	0.58
$\alpha = 50$	Median CR(2032)	0.83	0.92	0.98	1.03	1.05
	Median C_{ave}(5)	139	133	126	121	120
	Median C_{ave}(10)	157	143	133	125	121
	AAV(10)%	4.33	3.01	2.59	2.17	1.23
	Lower 5th%ile Bsp(2025)/K	0.73	0.74	0.74	0.74	0.75
	Lower 5th%ile Bsp(2033)/K	0.55	0.56	0.57	0.58	0.58

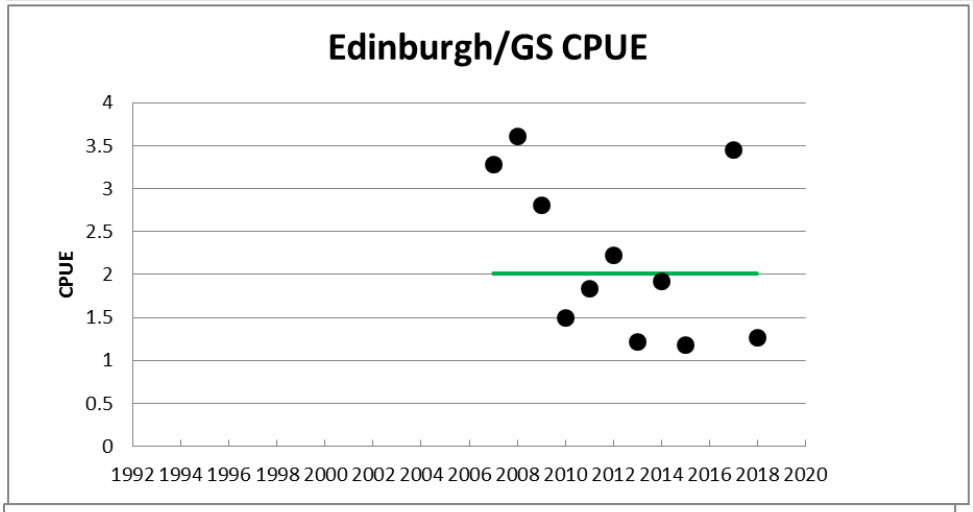
Table 4: The median, lower 5th%ile and upper 5th%ile values of six key statistics for two 2020 OMP candidates (CMP1 and CMP2).

		Median	Lower 5th %ile	Upper 5th %ile
CMP1	CR(2032)	**1.07**	0.59	1.92
	C_{ave}(5)	**120**	120	120
Jtar=1.0, $\alpha = 25$	C_{ave}(10)	**121**	120	123
	AAV(10)%	**0.97**	0.71	1.84
	Bsp(2025)/K	0.80	**0.75**	0.89
	Bsp(2033)/K	0.75	**0.58**	1.34
CMP2	CR(2032)	**0.95**	0.52	1.81
	C_{ave}(5)	**129**	126	134
Jtar=0.8, $\alpha = 35$	C_{ave}(10)	**138**	133	144
	AAV(10)%	**2.69**	1.93	3.35
	Bsp(2025)/K	0.79	**0.74**	0.88
	Bsp(2033)/K	0.84	**0.56**	1.36

Table 5: Six key statistics for two OMP CMPs (CMP1 α=25, Jtar=1.0; and CMP2 α=35, Jtar=0.8). CR(2032) (**PURPLE**), C_{ave} 5 (**GREEN**), C_{ave} 10 (**ORANGE**), AAV(10)(**PINK**) and lower 5th % Bsp(2025/K) (**BLUE**), and lower 5%ile Bsp(2033/K) (**RED**). Results are shown for the RC model as well as the two robustness tests. Results for a future TAC=0 scenario are also indicated.

		RC	ROB1	ROB2
CMP1	Median CR(2032)	**1.07**	**1.06**	**1.05**
	Median C_{ave}(5)	**120**	**120**	**115**
α=25	Median C_{ave}(10)	**121**	**120**	**115**
Jtar=1.0	AAV(10)%	**0.97**	**0.73**	**2.62**
	Lower 5th%ile Bsp(2025)/K	**0.74**	**0.72**	**0.52**
	Lower 5th%ile Bsp(2033)/K	**0.58**	**0.58**	**0.58**
CMP2	Median CR(2032)	**0.95**	**1.02**	**1.04**
	Median C_{ave}(5)	**129**	**125**	**116**
α=35	Median C_{ave}(10)	**138**	**126**	**116**
Jtar=0.8	AAV(10)%	**2.69**	**1.88**	**2.80**
	Lower 5th%ile Bsp(2025)/K	**0.74**	**0.67**	**0.52**
	Lower 5th%ile Bsp(2033)/K	**0.56**	**0.58**	**0.58**
TAC=0	Median CR(2032)	**1.47**	**1.47**	**1.47**
	Median C_{ave}(5)	**0**	**0**	**0**
	Median C_{ave}(10)	**0**	**0**	**0**
	AAV(10)%	**0**	**0**	**0**
	Lower 5th%ile Bsp(2025)/K	**0.81**	**0.73**	**0.74**
	Lower 5th%ile Bsp(2033)/K	**0.64**	**0.64**	**0.64**





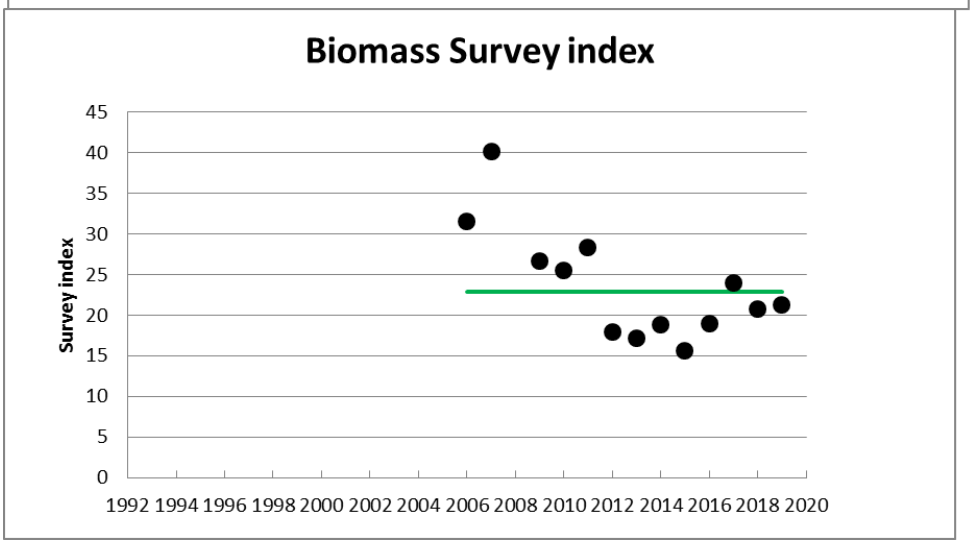


Figure 1a: The three different abundance series underlying the OM, reported in terms of the units usually used for each of those indices. In each case the Itar value, equivalent to the 2010-2012 average is shown as a green horizontal line.

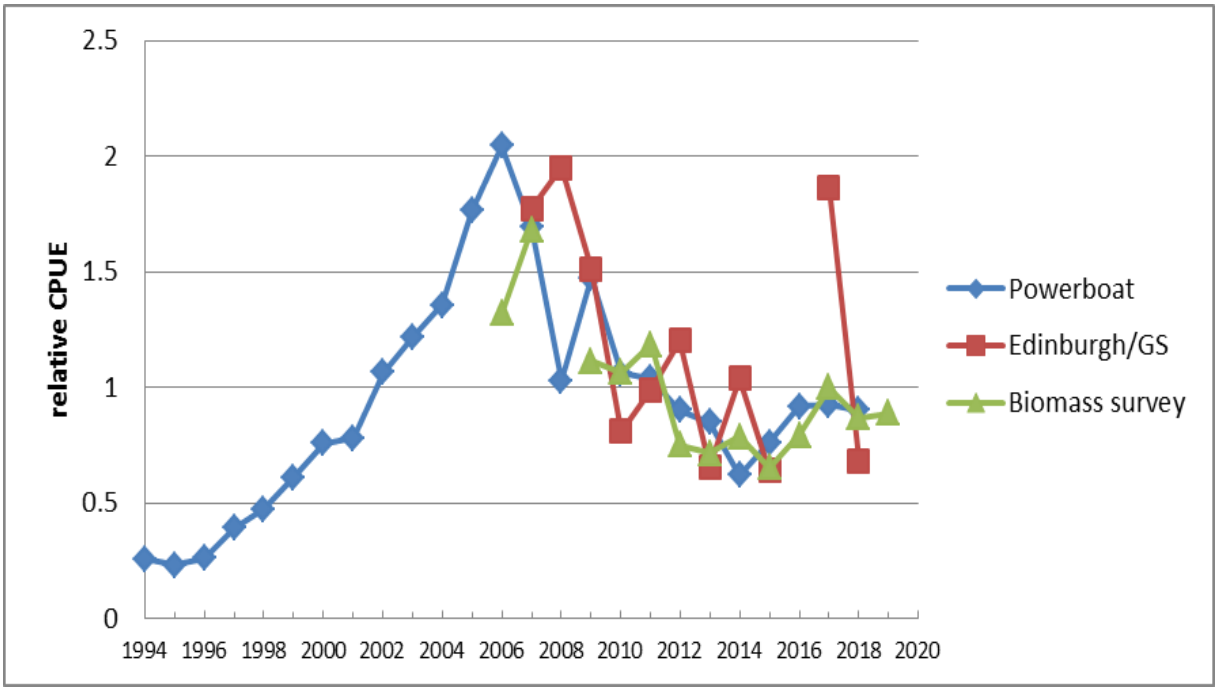


Figure 1b: Comparative plot of the three abundance indices which have each been normalized so that the 2010-2012 average values each equal 1.0.

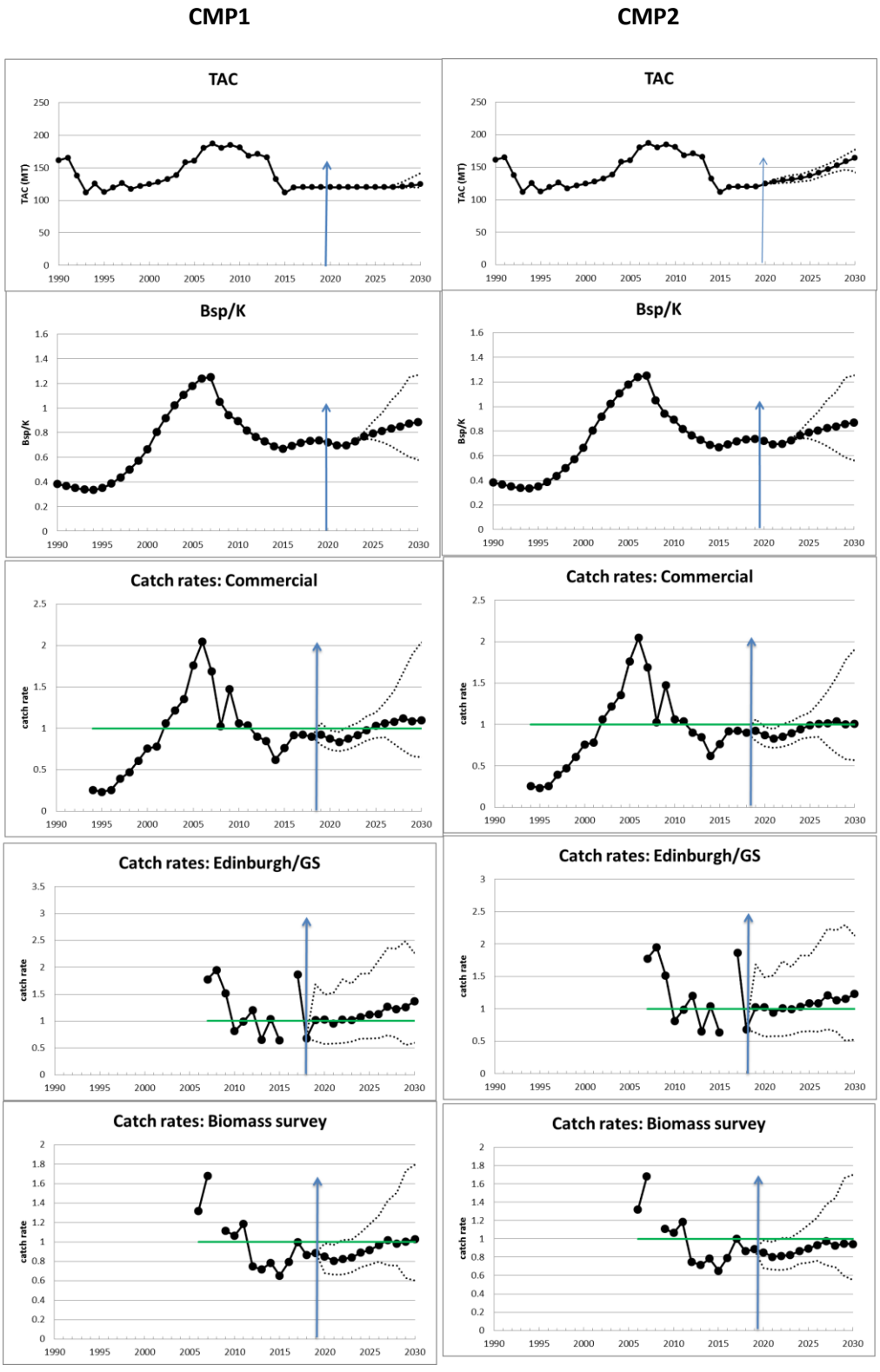


Figure 2: TACs, Bsp/K and CR trajectories for the **CMP1** (Jtar=1.0, α= 25) and **CMP2** (Jtar=0.8, α= 35). In each plot the median with 5th and 95th percentiles are plotted. For the bottom three plots, the Jtar values are shown as green horizontal lines.

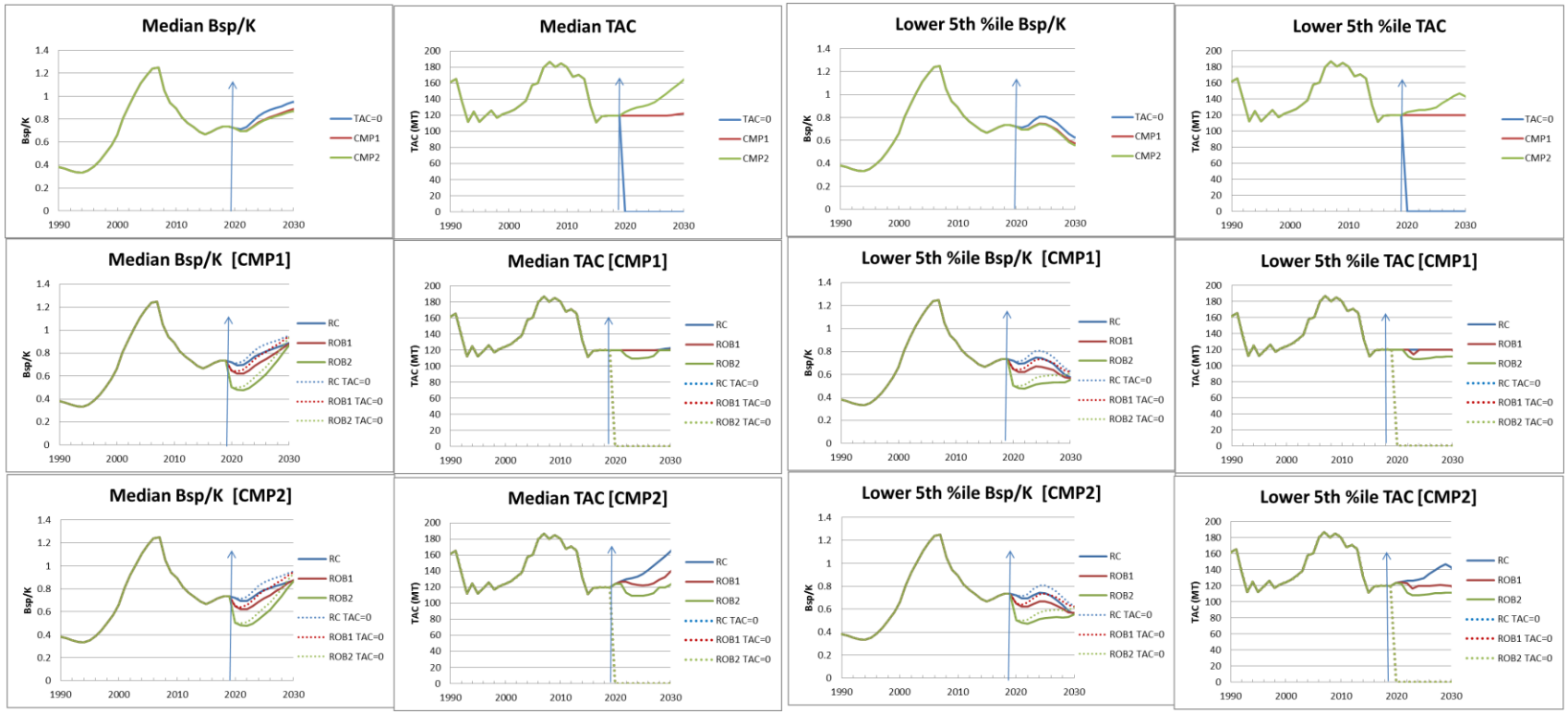


Figure 3: Simulation results for the Bsp/K and TAC statistics. The median results are shown in the first two columns, and the lower 5th %iles in the last two columns.

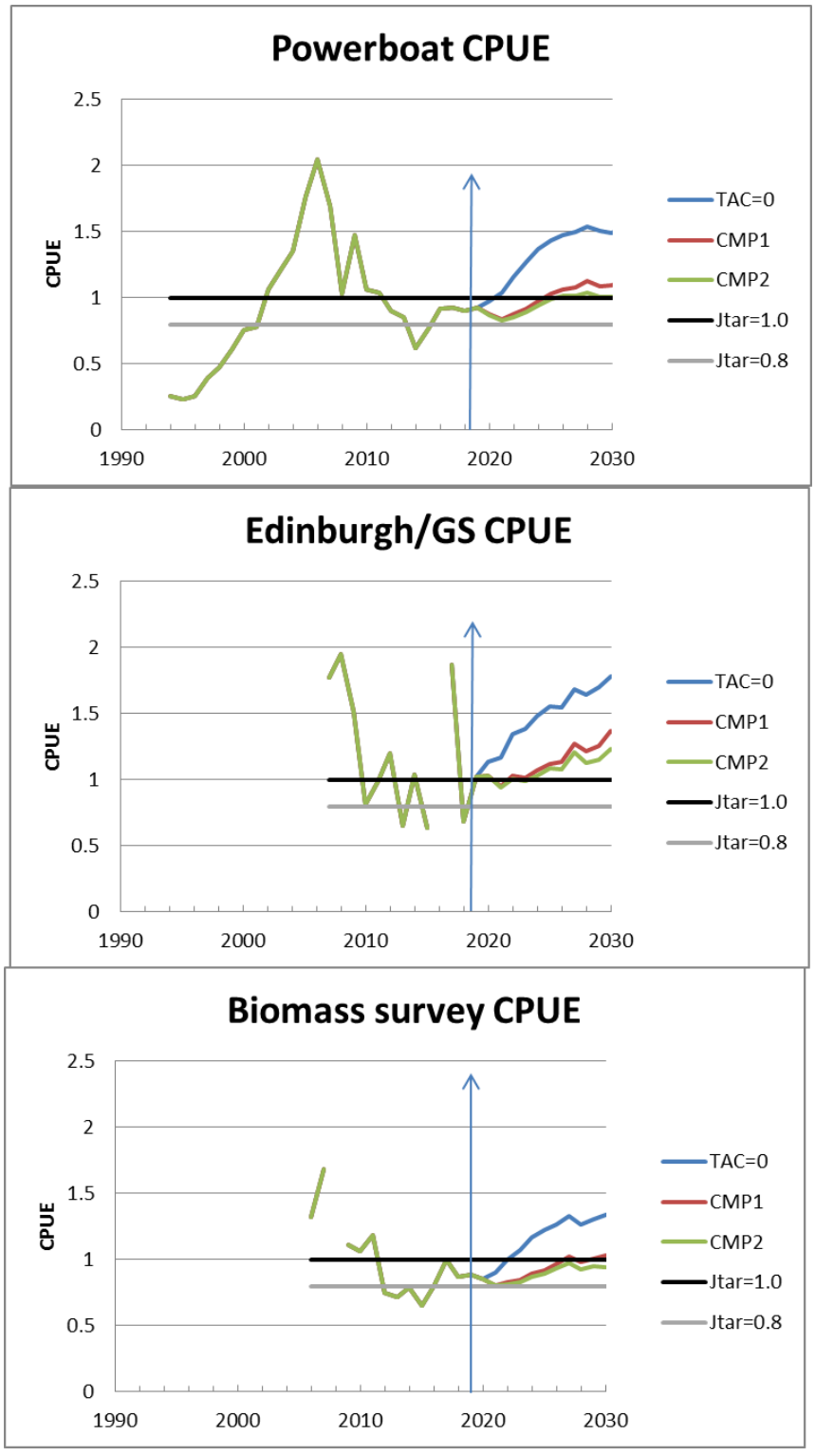


Figure 4: Simulation results for the catch rate statistics for CMP1 and CMP2, as well as for a zero future TAC scenario. Only median results are presented here.

Appendix: Comparison between the 2016 and 2020 assessments and projections with regards to catch rates and the recruitment residuals

In Table 2 it is notable that the catch rates (CR) projected in 2016 compared with those now projected with the 2020 assessment model (for the same OMP) are rather different. In 2016, the median CR(2022) was projected to be 1.08 by 2022 and 1.11 by 2025. The new 2020 assessment model however projects these median CRs to be lower at 0.88 and 1.03 respectively.

Figure A1 below shows this discrepancy in CRs clearly. The plot of the recruitment residuals show that the updated 2020 assessment estimate the SR residuals to be at a much lower level than was estimated or assumed in 2016 for the 2012-2016 period. Given the time lag between recruitment and the exploitable stock (and hence CRs), this results in lower CRs projected for the 2020's using the updated 2020 assessment model than was anticipated in 2016.

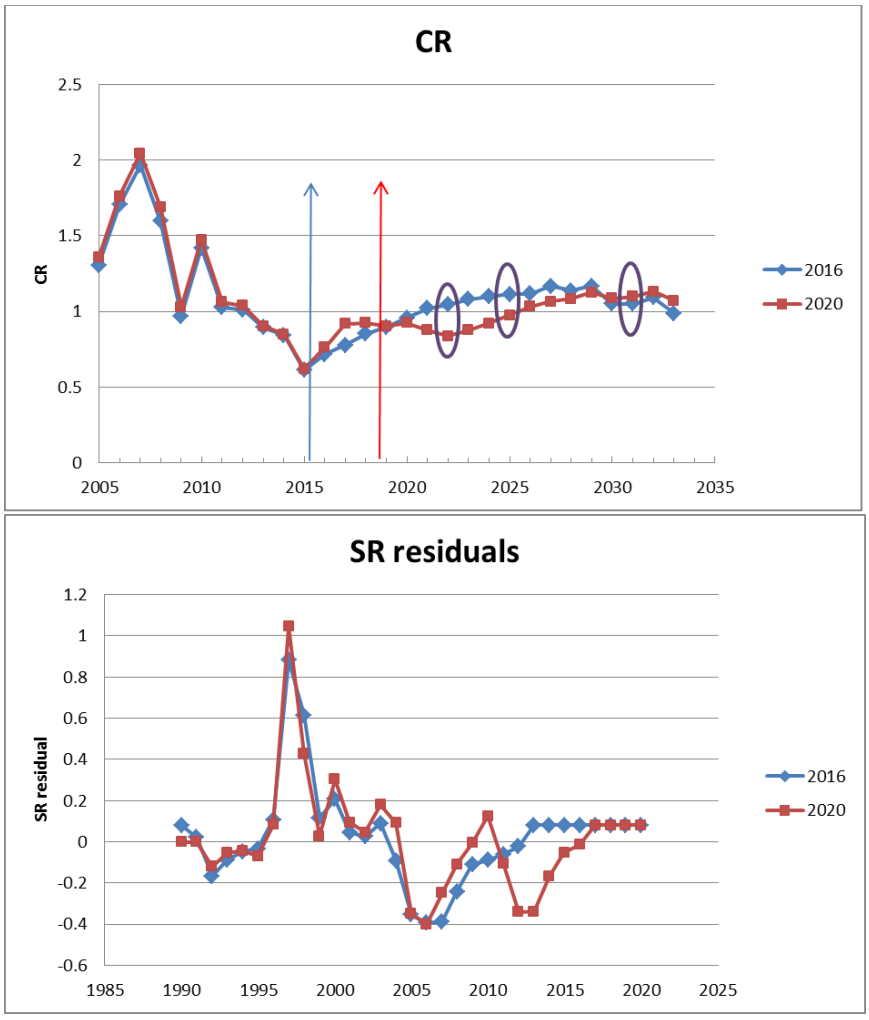


Figure A1: CR and recruitment residuals estimated/assumed for projections for either the 2016 assessment model or the updated 2020 assessment model.