OMP-2003 for the west coast rock lobster

S.J. Johnston, J. Glazer, A. Brandão

A formal description of the 2003 OMP in general terms was not produced at the time, but its specifications are evident from the document below entitled "West Coast Rock Lobster TAC for the 2003 season as calculated using the updated OMP", which was produced by the authors late in 2003.

The TAC for the 2003 (2003/04) season for West Coast Rock lobster is calculated to be **3206 MT** (commercial plus recreational). This value is calculated using the variant 5 OMP (the variant formally recommended) described fully in Johnston and Butterworth (2003), and the most recent CPUE, FIMS and somatic growth rate data.

Data

The data input to the updated OMP are reported in Table 1.

i) CPUE data

A full description of the CPUE GLM methodology is found is Glazer and Butterworth (2003). The CPUE data included in the GLM analysis cover the period 1993 – 2003 (over which the minimum size remained the same). The GLM model takes into account the following factors: season, Area, method, pull, month, season*Area and month*Area. The base case (BC) results reported in Glazer and Butterworth (2003) are the results used as input to the OMP, and are reported in Table 1.

ii) FIMS data

A full description of the GLM analysis applied to the FIMS data is found in Glazer (2003). The FIMS data are provided by L.Scott, UCT, pers commn. The FIMS of Dassen, Saldanha and Lamberts are area-weighted since it is assumed that the catchability coefficients in these areas are the same. The Cape is treated separately since catchability in this area differs from that for the other three areas. The resultant FIMS series input to the OMP is reported in Table 1.

iii) Somatic growth rate

A full description of the random effects GLM model used for standardising the male west coast rock lobster somatic growth rate data is found in Brandão and Butterworth (2003). A General Linear Mixed Model (GLMM) has been used to describe seasonal and spatial variation in somatic growth rate of the west coast rock lobster, in which the year-location interaction is treated as a random effect. The exclusion of records described by Glazer and Butterworth (2002) for removing the time-at-large effect was applied to the data for the analysis. The input data for the OMP corresponds to the "Less data" selection reported in Brandão and Butterworth (2003). The "less data" selection (6920 records at this time) has an expansion of 8 weeks on either side of the original moult cycle for sampling locations LM, DI, CP and KN. Port Nolloth is excluded from the analysis because it reflects a different temporal trend. Table 1 reports the annual estimates of the mean moult increment of a 70mm male lobster for this "less data" option. Note that for input into the OMP, we require the corresponding "Beta" values (somatic growth rate of a 1mm male lobster) which are computed by adding 5.8072 (70mm * slope where slope is the estimated coefficient of the length factor in the GLMM analysis) to the somatic growth values for a 70mm male lobster.

Variant 5 OMP

The six OMP variants considered as candidates for the updated OMP are described in Johnston and Butterworth (2003). Variant 5 was finally selected by the Working Group. Variant 5 allows for an intermediate level of resource rebuilding, greater variability in the TAC in the short term, and is indicated to result in a more likely increase than decrease in fishing effort (and hence employment). Variant 5 constrains the annual changes in TAC (Up and down) to a maximum 10%.

The Variant 5 TAC setting formula is as follows:

$$TAC_y = w_y TAC_{y-1} + (1-w_y)\alpha\left(1+\lambda(\beta_y^m - \overline{\beta}^m)\right)\frac{\hat{B}_y}{\hat{B}_{1992}}\left[\left(\frac{CPUE_{y-3,y-2,y-1}}{CPUE_{93,94,95}}\right)^{0.25}\left(\frac{FIMS_{y-3,y-2,y-1}}{FIMS_{92,93,94,95}}\right)^{0.75}\right]^p$$

where

w_y = 0.50 for all years,

10% maximum inter-annual TAC increase and decrease constraints apply,

λ = 1,

p = 2, and

α = 920.

Estimation of $\hat{B}_y$ and $\hat{B}_{1992}$

The underlying approach followed is to fit a simple population model to available CPUE, FIMS and somatic growth data to model the dynamics from 1992 to 2013, i.e.

$$B_{y+1}^{p} = B_{y}^{p} + G_y - (C_y + P_y) \quad (1)$$

where

B_y^p = population model biomass in season *y*,

G_y = annual "growth" of resource in season *y*,

C_y = annual commercial + recreational catch in season *y*, and

P_y = annual estimate of poaching for season *y*.

B_{1992}^p is a parameter estimated in fitting this model to data.

The annual somatic growth rate parameter β_y is the GLM estimated somatic growth of a male rock lobster of "zero" carapace length. For any season *Y* in the future ($Y \geq 2003$):

β_y is known for $1992 \leq y \leq Y-1$, and

β_y is set equal to the average of the values for the three preceding seasons for the

balance of the projection period (for which β_y would not be known in

practice in season *Y*) i.e. ($\sum_{y=Y-3}^{Y-1} \beta_y$)/3 for $Y \leq y \leq 2013$.

In the population model, the annual "growth" of the resource, G_y, is set to be:

$$G_y = a(\beta_y + b) \quad (2)$$

The value of *b* is set externally by regressing against β the equilibrium sustainable yield for the Reference Case assessment model's estimate of the biomass in 2002 for different values of β (this relationship is near linear). The intercept of this regression with the horizontal axis (β), averaged over RC1 and RC2 yields a value of b = -9.332.

Each season (from y = 2003), as new data become available, the population model (see equation (1)) is fitted by minimising the following negative log-likelihood:

$$-\ln L = \sum_{T=1993}^{y-1}\left\{\ln\sigma_{cpue} + \frac{1}{2\sigma_{cpue}^{2}}\left(\ln CPUE_T - \ln q_{cpue} - \ln B_T^P\right)^2\right\} + \sum_{T=1992}^{y-1}\left\{\ln\sigma_{FIMS} + \frac{1}{2\sigma_{FIMS}^{2}}\left(\ln FIMS_T - \ln q_{FIMS} - \ln B_T^P\right)^2\right\} \quad (3)$$

where

$CPUE_T$	is the trap CPUE generated by the operating model
$FIMS_T$	is the FIMS CPUE generated by the operating model
q_{CPUE}	is the trap catchability coefficient
q_{FIMS}	is the FIMS catchability coefficient

$$\ln q_{CPUE} = \frac{\sum_{T=1993}^{y-1}\left(\ln CPUE_T - \ln B_T^P\right)}{n_{CPUE}} \quad (4)$$

$$\ln q_{FIMS} = \frac{\sum_{T=1992}^{y-1}\left(\ln FIMS_T - \ln B_T^P\right)}{n_{FIMS}} \quad (5)$$

$$\sigma_{CPUE} = \sqrt{\frac{\sum_{T=1993}^{y-1}\left(\ln CPUE_T - \ln q_{cpue} - \ln B_T^P\right)^2}{n_{CPUE}}}\text{, and} \quad (6)$$

$$\sigma_{FIMS} = \sqrt{\frac{\sum_{T=1992}^{y-1}\left(\ln FIMS_T - \ln q_{FIMS} - \ln B_T^P\right)^2}{n_{FIMS}}} \quad (7)$$

The parameters of the likelihood L estimated in the fitting process are B_{1992}^P and a.

Observed data for the $CPUE_T$ and $FIMS_T$ values used in equation (3) for seasons already past in the simulation trials (i.e. for seasons 2001 and before) are used.

A penalty function is added to the negative log-likelihood function for the "a" parameter of the G_t relationship (equation 2) used. The penalty function is as follows:

$$P = \frac{(a - 4000)^2}{2\sigma_a^2}$$

where $\sigma_a = 1000$.

Thus, equation (3) becomes,

$$\begin{aligned} -\ln L = & \sum_{T=1993}^{y-1} \left\{ \ln \sigma_{cpue} + \frac{1}{2\sigma_{cpue}^2} \left(\ln CPUE_T - \ln q_{cpue} - \ln B_T^P \right)^2 \right\} \\ & + \sum_{T=1992}^{y-1} \left\{ \ln \sigma_{FIMS} + \frac{1}{2\sigma_{FIMS}^2} \left(\ln FIMS_T - \ln q_{FIMS} - \ln B_T^P \right)^2 \right\} + P \end{aligned} \qquad (8)$$

This penalty function was introduced to provide an appropriate trade-off between too little impact of the data upon *a* (leads to an inability to show adequate reaction to a changed somatic growth rate), and too much impact (causes TAC variability that is too large).

<u>Missing input indices to the OMP</u>

Two of the robustness trials (M1 and M2 of Johnston and Butterworth 2003) examined what the result would be if one of the OMP input indices is not available in a particular year. These trials assumed that if a particular index was missing, the previous season's value is used instead. As these trials showed very robust performance i.e. the performance predicted for the OMP was hardly effected, it is recommended that this procedure be adopted for the future in the event of missing data.

References

Brandão, A. and D.S. Butterworth. 2003. Standardised male west coast rock lobster somatic growth trends using a mixed linear ("random effects") model including data from the 2002/03 season. MC&M document, WG/07/03/WCRL19.

Glazer, J.P. 2003. GLM analysis applied to the FIMS data. MC&M document, WG/07/03/WCRL17.

Glazer, J.P. and D.S.Butterworth. 2002. The male West Coast rock lobster revised growth data. BENEFIT workshop document: BEN/DEC02/WCRL/2.

Glazer, J.P. and D.S.Butterworth. 2003. An index of abundance for the West Coast rock lobster resource derived from a GLM analysis of trap, bakkie and deckboat CPUE data for input to the OMP. MC&M document, WG/07/03/WCRL18.

Johnston, S.J. and Butterworth, D.S. 2003. FINAL results of alternate OMPs for the management of the West Coast rock lobster resource, MC&M document, WG/08/03/WCRL25.

Johnston, S.J. and Butterworth, D.S. 2004. Comparison between a 10% or 15% maximum TAC change constraint for the West Coast rock lobster OMP. MCM document, WG/01/04/WCRL1.

Post Script

The Working Group agreed that possible amendments of this OMP to allow instead for inter-annual TAC changes of up to 15% be considered based on further evaluations using existing models, data and tests. This work would be finalised by March 2004. Such a change to variant 5 would be recommended only if consensus amongst the Working Group was achieved.

Post-post script

These further results (Johnston and Butterworth 2004) were duly examined during 2004, and the Working Group decided that they did not justify changing the OMP specified above. Figure 1 (taken from Johnston and Butterworth 2004) reports a summary of these results.

Table 1: Input data for the OMP for the 2003 TAC calculation.

Year	**Commercial CPUE** (GLM standardised)	**FIMS** (GLM standardised)	**Somatic growth for 70mm male (mm) with corresponding "beta" value in brackets**
1990			4.10 (9.91)
1991			4.69 (10.50)
1992		1.124	4.18 (9.99)
1993	0.683	1.137	4.26 (10.07)
1994	0.556	0.646	4.15 (9.96)
1995	0.740	0.663	4.59 (10.40)
1996	0.902	0.933	4.98 (10.79)
1997	1.065	0.847	4.09 (9.90)
1998	1.081	1.239	3.69 (9.50)
1999	1.101	0.928	3.65 (9.46)
2000	1.155	0.554	4.56 (10.37)
2001	1.449	1.822	4.09 (9.90)
2002	1.267	1.107	4.52 (10.33)

Note: 2000 here, for example, refers to the 2000/2001 season.

Figure 1: Performance plots comparing the performance of 5 OMP variants for seven summary statistics. The 10% TAC change options are shown by solid symbols, whilst the 15% TAC change options are shown by open symbols.