South Coast Rock Lobster OMP 2014: Specifications and Results

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1. Introduction

An OMP for recommending the TAC for South Coast rock lobster resource was first developed and implemented for 20081 (Johnston and Butterworth 2008). A number of further OMPs have been developed for the management of this resource. These OMPs have all had similar underlying structures, with a median target spawning biomass $B_{2025}^{sp}/B_{2006}^{sp}$ of 1.20 when simulation tested, i.e. a spawning biomass increase in median terms of 20% over the 2006-2025 period. These OMPs were “slope-based” – that is the TAC-setting algorithm was based on the slope (gradient) of recent CPUE values to determine the TAC increase or decrease.

The operating model which was used to simulation test OMP-2014 is model RC1 reported in Johnston (2013). The parameters of RC1 were estimated in a Bayesian framework using MCMC. The resultant posterior distribution was used to generate 1000 vectors of parameters and current numbers at age to commence projections which were used to test candidate MPs. The median, 5th and 95th percentiles for all performance statistics were produced. This method was used for the first phase om OMP development.

Further simulation testing to provide a specific metarule governing the process under which the 5% maximum TAC inter-annual reduction constraint would be over-ruled if CPUE drops below a threshold level was conducted under a different simulation framework, where MCMC was not used, but rather the RC OM was used to project forwards with stochasticity for 1000 simulations – and again the median, 5th and 95th percentiles for all performance statistics were produced.

OMP-2014 as described below is to be used for setting the TACs for the South Coast rock lobster fishery for four seasons (2014-2017), and will be subject to review and possible revision in 2018.

2. OMP 2014

Previous OMPs for the South Coast rock lobster have all been “slope-based” OMPs, with targets of $B_{2025}(2006)/B_{2006}(2006)=1.20$, as described above.

With a “target-based” OMP such as OMP-2014, the decision whether to increase or decrease the TAC depends on whether recent CPUE values are above or below a pre-specified target CPUE value. OMP-2014 has as its target a median spawning biomass increase of 30% by 2025 relative to the 2006 value, i.e. $B_{2025}(2006)=1.30$.

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1 The convention used here is that 2008 refers to the 2008/2009 season
In 2014 a task group met to discuss further development of appropriate candidate OMPs for South Coast rock lobster. Information provided by OLRAC enabled progress to be made regarding the scaling of “model” (and GLM-standardised) CPUE values to units that are more meaningful to industry, viz. tails kg per day.

A CPUE measure more meaningful to industry
A multiplier is required to scale the model (and GLM standardised) CPUE values to a measure which industry finds more meaningful, viz. “tails kg per day”. The CPUE values for the period up to 2011 (Glazer 2013) were standardised (weighted over areas). Thus to calculate a scaling factor:

\[ F_{\text{industry scalar}} = \frac{\sum_{2008}^{2011} \text{industry nominal CPUE}}{\sum_{2008}^{2011} \text{GLM standardised CPUE}} = 259. \]

When reporting results of alternate OMP candidates, CPUE is thus reported as in units of “tails per kg day” - achieved by multiplying the “model” CPUE values by 259.

2.1 The TAC setting algorithm for OMP-2014
The algorithm used to recommend the TAC for the South Coast Rock Lobster fishery for season \( y+1 \) is:

\[ TAC_{y+1} = TAC_y \left[ 1 + \alpha \frac{\text{CPUE}_{y} - \text{CPUE}_{\text{target}}}{\text{CPUE}_{\text{target}}} \right] \quad (1) \]

where \( \text{CPUE}_{y} \) is a measure of recent CPUE and is calculated as follows:

\[ \text{CPUE}_{y} = \frac{1}{3} \sum_{y=3}^{y-3} \sum_{A=i}^{3} \lambda_{A} \text{CPUE}_{y}^{A} \quad (2) \]

where \( \text{CPUE}_{y}^{A} \) is the GLM standardised CPUE for area \( A \) in year \( y \) and the CPUE weighting factors, \( \lambda_{A1}, \lambda_{A2} \) and \( \lambda_{A3} \) relate to the proportion of the overall biomass in each the three fishing areas, and were calculated using estimated values of \( q \) and \( B^{exp} \) for 2011 from the RC1 model to be:

\[ \begin{align*}
\lambda_{A1} &= 0.003 \\
\lambda_{A2} &= 0.128 \\
\lambda_{A3} &= 0.868.
\end{align*} \]

\( \text{CPUE}_{\text{target}} = 1.22 \) – this value results in the median \( Bsp(2025/2006)=1.30 \), the selected biomass target for OMP-2014 under the RC1 operating model.

Note that \( TAC_{y} \) is the TAC set (not the catch taken) in season \( y \).

The tuning parameter \( \alpha \) controls how responsive the OMP is to CPUE deviations from the CPUE target, and for OMP-2014 is set to be 1.0.

Note that the TAC for season \( y+1 \) is to be based upon the CPUE series that ends in season
The TAC recommendation for the 2014/15 season would be based on a CPUE series that ended with the most recent CPUE value available at the time the TAC recommendation was required (August 2014) which would be here the 2012/13 season.

2.2 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 as in previous OMPs, i.e.:

\[
\begin{align*}
\text{if } TAC_{y+1} > 1.05TAC_y & \quad \text{\hspace{1cm} } TAC_{y+1} = 1.05TAC_y \\
\text{if } TAC_{y+1} < 0.95TAC_y & \quad \text{\hspace{1cm} } TAC_{y+1} = 0.95TAC_y
\end{align*}
\]

(3)

2.3 TAC for first season (2014)
The TAC for the first season that OMP-2014 is implemented (2014) is set at a 5% increase over the TAC for the previous 2013 season. Thus TAC(2014) is fixed at 359 MT. The inter-annual rules described in the section above will come into play from the 2015 season onwards.

2.4 Maximum CAP on TAC
A maximum cap on TAC in any year in the future is set at 450 MT.

3. The Generalized Linear Model applied to the South Cost rock lobster CPUE data to obtain area-specific indices of abundance

The nominal CPUE data for South Coast rock lobster are (re-)standardized each season by means of a Generalized Linear Model (GLM) to obtain area-specific standardized indices of abundance for input to the OMP.

Certain records are excluded from the analyses; these are as follows.
- Data from companies other than the four major companies for years prior to and including 1997.
- Data pertaining to Hout Bay Fishing vessels over the period 1997–2000, since they are considered to be unreliable.
- Sets with zero effort.
- Sets with zero catch.
- One record with a CPUE value of > 9kg/trap (this was considered an outlier).

The fishing grounds have historically been separated into four areas. However, based on analyses conducted by Gaylard and Bergh (2007), these four areas were revised to three. It is these revised “new areas” upon which the analyses are based.

The GLM

The base case GLM applied to obtain area-specific indices of abundance is:

\[
\begin{align*}
\ell n(CPUE) = I + \alpha_y + \beta_{\text{area}} + \gamma_{\text{depth}} + \eta_{\text{seas}} + \kappa_{\text{sec}} + \lambda_{\text{grid}} + \sigma_{\text{echo}} + \theta_{\text{gps}} + \zeta_{\text{video}} + \tau(\text{traps}) + (y \times \text{area}) + \varepsilon
\end{align*}
\]

(4)

where
- \(I\) is the intercept,
- \(\alpha_y\) is the split-year fishing season effect (1977 to the season prior to the year for which the CPUE value is being calculated),
\( \beta_{\text{seas}} \) is the season effect

- season 1 = October – December
- season 2 = January – March
- season 3 = April – June
- season 4 = July – September,

\( \gamma_{\text{depth}} \) is the depth effect

- \( d_{75} : \text{depth} < 100 \)
- \( d_{125} : 100 \leq \text{depth} < 150 \)
- \( d_{175} : 150 \leq \text{depth} < 200 \)
- \( d_{225} : 200 \leq \text{depth} < 250 \)
- \( d_{275} : \text{depth} \geq 250 \),

\( \eta_{\text{soak}} \) is the soak time effect

- \( \text{soak}_1 : \text{soak} \leq 24 \text{ hours} \)
- \( \text{soak}_2 : 24 < \text{soak} \leq 48 \)
- \( \text{soak}_3 : 48 < \text{soak} \leq 72 \)
- \( \text{soak}_4 : 72 < \text{soak} \leq 96 \)
- \( \text{soak}_5 : \text{soak} > 96 \text{ hours} \),

\( \kappa_{\text{vess}} \) is the vessel effect (42 vessels to 2006),

\( \lambda_{\text{grid}} \) is the grid effect (290 grid squares),

\( \omega_{\text{echo}} \) is the echo-sounder effect,

\( \theta_{\text{gps}} \) is the GPS effect,

\( \zeta_{\text{video}} \) is the video plotter effect,

traps is a measure of effort provided by the number of traps set

and is treated as a continuous variable,

\( (y \times \text{area}) \) is a fixed effect interaction term where area relates to one of the three areas, and

\( \varepsilon \) is assumed to be normally distributed.

Note that both grid and area cannot be included as main effects in the model because of confounding.

The standardized CPUE indices per area are calculated by applying the equation

\[ CPUE_{y,at} = e^{( \alpha_y + (y \times \text{area}) + \text{median}(\lambda_{\text{grid}}))} \]

where \( \text{median}(\lambda_{\text{grid}}) \) is the median value amongst those for the grids specific to each area.

4. Methodology for calculating the TAE (total allowable effort)

A procedure for control of effort in the South Coast rock lobster fishery, was agreed by the Rock Lobster Working Group at its meeting on 31 July 2008. This method is reported in OLRAC(2008) and reproduced below.

4.1. Fishing day allocations

4.1.1 Effort will be controlled by the allocation to each company in the fishery of a number of fishing days for each season.

4.1.2 The number of fishing days used for any single trip is calculated as the number of seadays used less 1.5. This definition applies, both in administration of effort control for the current season and in calculation of performance in previous seasons (see section 4.2 below).
4.1.3 A day is included as a *seaday* for a trip if any part of that day is spent at sea. Thus the sailing day and landing day are both counted as seadays. However if a vessel spends a full day in port, e.g. for repairs, and does not spend any part of that day at sea, that day will not be counted as a seaday.

4.1.4 A *trip* is deemed to end when fish are offloaded and a landing report is completed.

4.1.5 The *fishing day* allocation $E_{r,y}$ for rights holder $r$ in season $y$ will be calculated as:

$$E_{r,y} = Q_{r,y} / BCR_y$$

where $Q_{r,y}$ is the quota in kilograms for rights holder $r$ in season $y$, and $BCR_y$ is the *base catch rate* (in kg per fishing day) for season $y$ (see section 4.2 below).

4.1.6 A fishing day *pool* will be available from which companies may draw if needed, at the discretion of South Coast Rock Lobster Industry Association. The number of fishing days allocated to the pool will be:

$$E_{pool,y} = 0.1 \sum_r E_{r,y}$$

i.e. the pool is 10% of the total effort allocation to all rights holders.

4.2. Calculation of base catch rate

The base catch rate, $BCR_y$, for season $y$ is determined by:

$$BCR_y = \frac{1}{3}(CR_{y-4} + CR_{y-3} + CR_{y-2}) / D$$

where $CR_{y-n}$ is the recorded catch in kg per fishing day in season $y-n$,

calculated as $CR_{y-n} = C_{y-n} / E_{y-n}$,

$E_{y-n}$ is the total number of fishing days used by all participants in season $y-n$,

$C_{y-n}$ is the total catch in kg by all participants in season $y-n$, and

$D = 1.555369$ is a constant (see section 3.3 below).

4.3. Calculation of the divisor $D$ in equation (7)

$$D = e^{-2\sigma^2}$$

where $\sigma^2$ is the expected variance in: $[\ln(CR_y) - \ln(\frac{1}{3}(CR_{y-4} + CR_{y-3} + CR_{y-2}))]$ which is estimated as:

$$\sigma^2 = \frac{1}{17} \sum_{y=1990}^{2006} [\ln(CPUE_y) - \ln(\overline{CPUE_y})]^2$$

where
 CPUE\textsubscript{14} is the GLM standardised catch per trap in season 14, and

\[
\bar{\text{CPUE}}_{14} = \frac{1}{4}(\text{CPUE}_{13} + \text{CPUE}_{14} + \text{CPUE}_{15} + \text{CPUE}_{16}).
\] (10)

### 4.4. Base catch rate for the 2014 season.

Using equation (7) the base catch rate for 2014 is

\[
\text{BCR}_{2014} = \frac{1}{4}(\text{CR}_{2010} + \text{CR}_{2011} + \text{CR}_{2012}) / D
\]

\[
= \frac{1}{4}(258.523 + 170.923 + 187.70) / 1.555369
\]

\[
= 127.98 \text{ kg per fishing day}
\]

### 5. Results

At the SWG SCRL meeting on 24 July 2014, the request was made that further and final OMP results be presented for the following:

- A (maximum) cap on the annual TAC of 450 tons
- No constraint on the TAC for area A1E
- Projections for a 20 year period
- Bsp(2025/2006) median tunings: values of 1.20, 1.30 and 1.40 to be presented. The results for the three tunings above are reported for the following OMP variants:

**Variant 1**: The TAC is constrained to not decrease in first two seasons (2014 and 2015), thereafter the 5% maximum inter-annual TAC change constraint is imposed.

**Variant 2**: The TAC is increased by 5% in the first season (2014) and thereafter the OMP rules are used to set the annual TACs (and the 5% maximum inter-annual TAC change constraint is imposed).

**Results**

Table 1 reports results for the final OMP variant (for the three selected tunings for median B(2025/2006) of 1.20, 1.30 or 1.40). Table 2 reports the median, 5\textsuperscript{th} and 95\textsuperscript{th} percentiles of the TACs for the first three seasons (2014, 2015, and 2016).

Figure 1 compares results three different CPUE target tunings. Note the final OMP has a tuning of Bsp(2025/2006)=1.3. Figure 2 reports results the CPUE target of 1.3 where the left plots show the median trajectories along with the 5\textsuperscript{th} and 95\textsuperscript{th} percentiles. The right hand plots show the results of the first six (of 1000) simulations.

**References**

Gaylard, J.D. and M.O. Bergh. 2007. A clustering of South Coast rock lobster fishing grid blocks based on similarity of CPUE trend. 9pp. South Coast rock lobster task group document (May 2007).


\(^2\) The convention is that, e.g., 2014 refers to the 2014/15 season.

\(^3\) Given the (maximum) cap on the TAC, this value could not be achieved. The results reported correspond to a slightly larger value.

Table 1: Variant 2 OMP results presented for three tunings (TAC increased 5% in first season, thereafter OMP rules set TAC). Values reported are medians, with the 5th and 95th percentiles shown in parentheses for some statistics. The final selected OMP is bolded (target of 1.30 for Bsp(2025/06).

<table>
<thead>
<tr>
<th>CPUE_targ</th>
<th>CPUE_targ in industry units (tails kg per day)</th>
<th>CPUE (2025)</th>
<th>CPUE (2025) in industry units (tails kg per day)</th>
<th>Bsp(2025/06)</th>
<th>Bsp(2025/K)</th>
<th>Cave (2014-2025)</th>
<th>AAV (2014-2025)</th>
<th>A1E B_exp(2025)/K Lower 5%ile</th>
<th>A1W B_exp(2025)/K Lower 5%ile</th>
<th>A2+3 B_exp(2025)/K Lower 5%ile</th>
<th>Effort (2025/2014)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.95</td>
<td>246</td>
<td>180</td>
<td>1.35</td>
<td>350</td>
<td>1.22 (0.65; 2.75)</td>
<td>0.39 (0.21; 0.89)</td>
<td>427 (381; 428)</td>
<td>2.34</td>
<td>0.13</td>
<td>0.20</td>
<td>0.19</td>
</tr>
<tr>
<td>1.22</td>
<td>316</td>
<td>180</td>
<td>1.46</td>
<td>378</td>
<td>1.30 (0.75; 2.79)</td>
<td>0.41 (0.24; 0.91)</td>
<td>409 (300; 427)</td>
<td>3.20</td>
<td>0.16</td>
<td>0.25</td>
<td>0.22</td>
</tr>
<tr>
<td>1.35</td>
<td>350</td>
<td>180</td>
<td>1.55</td>
<td>401</td>
<td>1.40 (0.86; 2.89)</td>
<td>0.45 (0.27; 0.93)</td>
<td>373 (275; 426)</td>
<td>4.06</td>
<td>0.17</td>
<td>0.29</td>
<td>0.25</td>
</tr>
</tbody>
</table>

Table 2: Median and 5th and 95th percentile TACs for 2014, 2015 and 2016. Results shown for three tunings of median B(25/06) – 1.2, 1.3 and 1.4.

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>1.2</td>
<td>359 (359; 359)</td>
<td>377 (377; 377)</td>
<td>396 (396; 396)</td>
</tr>
<tr>
<td>1.3</td>
<td>359 (359; 359)</td>
<td>356 (341; 377)</td>
<td>373 (324; 396)</td>
</tr>
<tr>
<td>1.4</td>
<td>359 (359; 359)</td>
<td>341 (341; 377)</td>
<td>344 (324; 396)</td>
</tr>
</tbody>
</table>
Figure 1: Results for the three different recovery scenarios. The final selected OMP was Bsp(2025/2006)=1.3.
Figure 2: Median Bsp(2025/2006) = 1.3 tuning. The left hand plots show the medians (solid dots) with the 5th and 95th %iles as dashed lines. The right hand side plots show results for the first six (of 1000) simulations run (except for the top right plot which is identical to the top left plot but for a shorter time period).