The South Coast Rock Lobster Reference Case Operating Model

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SUMMARY

This document details the assessment method used to provide the Reference Case Operating Model used in 2013 for simulation testing of the current South Coast rock lobster OMP (OMP-2014). That model was fit to data to 2010; those data series are also reported, together with their subsequent extensions to 2015.

Data

Note the fishery is divided into three sub-areas: sub-area 1E, sub-area 1W and sub-area 2+3 (for the associated rationale see MARAM/IWS/2017/SCRL/BG1).

At the time of the 2013 Operating Model (OM) development (this was to be used for simulation testing of OMP-2014), data were available up to and including 2010 only. Subsequently, these data have been updated, and the data series extended to 2015. This extended data series is what is reported in Appendix A, but note only the data up to 2010 were used for the OM developed in 2013.

Catch

The historical annual catches for each sub-area are provided by Glazer 2017a, which reports the catches from 1977[1]-2015. The total catch for the resource is also known for the period 1973-1976. In order to split the total catch between the three sub-areas for this early period, the average sub-area catch-splits observed in the immediately following five-year period 1977-1981 were used. Table A1 (see Appendix A) reports the annual catches for each sub-area.

[1] The convention used here is that the split season is referenced by the first year, e.g. 1977 refers to the 1977/78 season, where the season commences in October and ends the following September.

CPUE

Standardised CPUE values for each sub-area are reported by Glazer 2017b. They are listed in Appendix A in Table A2.

Scientific Catch-at-length data

Glazer (2013, 2015 and 2016) provides the scientific catch-at-length data for each sub-area (in 5mm size-classes) for the period 1995-2015. The senior author subsequently manipulated some of these data to provide suitable plus- and minus-groups for input to fitting the population models. The rule applied was that an observed proportion less than 1% should be incorporated into a plus or minus group. Tables A3a-f provide the final CAL input data as used in the updated 2017 assessments – although note that only data up to and including 2010 were available for use in the 2013 OM. Note that for each year, the male+female proportions will sum to 1.0.

The Age-Structured Production Model for the South Coast rock lobster

Introduction

The south coast rock lobster resource is modelled using an age-structured-production-model (ASPM) which fits to catch-at-length data directly. The model is sex-disaggregated (*m*/*f*) and area-disaggregated. Population equations have been modified from Baranov form to Pope's approximation. This speeds the runtime of the program.

Note that the model estimates annual variability in the proportion of recruitment (age 0 lobsters) to each sub-area each year. Though formally there is no inter-sub-area movement allowed in the model after this recruitment, in effect this means that there is allowance for such movement, but only for ages less than those which the fishery exploits.

The model and fitting procedure described below take account of Panel recommendation made at the November 2012 IWS (see Appendix B).

1. The population model

The resource dynamics are modelled by the equations:

$$N_{y+1,0}^{m,A} = \lambda^A R_{y+1} \qquad (1)$$

$$N_{y+1,0}^{f,A} = \lambda^A R_{y+1} \qquad (2)$$

$$N_{y+1,a+1}^{m,A} = \sum_{l} [\vec{N}_{y,a,l}^{m,A} e^{-M^m/2} - \vec{C}_{y,a,l}^{m,A}] e^{-M^m/2} \qquad (3)$$

$$N_{y+1,a+1}^{f,A} = \sum_{l} [\vec{N}_{y,a,l}^{f,A} e^{-M^f/2} - \vec{C}_{y,a,l}^{f,A}] e^{-M^f/2} \qquad (4)$$

$$N_{y+1,p}^{m,A} = \sum_{l} [\vec{N}_{y,p-1,l}^{m,A} e^{-M^m/2} - \vec{C}_{y,p-1,l}^{m,A}] e^{-M^m/2} + \sum_{l} [\vec{N}_{y,p,l}^{m,A} e^{-M^m/2} - \vec{C}_{y,p,l}^{m,A}] e^{-M^m/2} \qquad (5)$$

$$N_{y+1,p}^{f,A} = \sum_{l} [\vec{N}_{y,p-1,l}^{f,A} e^{-M^f/2} - \vec{C}_{y,p-1,l}^{f,A}] e^{-M^f/2} + \sum_{l} [\vec{N}_{y,p,l}^{f,A} e^{-M^f/2} - \vec{C}_{y,p,l}^{f,A}] e^{-M^f/2} \qquad (6)$$

where

$N_{y,a}^{m/f,A}$ is the number of male or female (*m/f*) lobsters of age *a* at the start of year *y* in sub-area *A*,

$\vec{N}_{y,a,l}^{m/f,A}$ is the number of male or female (*m/f*) lobsters of age *a* of length *l* at the start of year *y* in sub-area *A* (see equation 15),

$M^{m/f}$ denotes the natural mortality rate for male or female (*m/f*) lobsters which is assumed to be constant for all *a* (and here identical for male and female lobsters). Note that this value is fixed at *0.10* in this model.

$\vec{C}_{y,a,l}^{m/f,A}$ is the catch of male or female (*m/f*) lobsters of age *a* of length *l* in year *y* in sub-area *A*, and

p is the maximum age considered (taken to be a plus-group).

Note: $\sum_{A} \lambda^A = 1$ and that $0 < \lambda^A < 1$. The model makes the assumption there is no cross-boundary movement after recruitment.

The number of recruits of age 0, of each sex, at the start of year *y* is related to the spawner stock size by a stock-recruitment relationship:

$$R_y = \frac{\alpha B_y^{sp}}{\beta + (B_y^{sp})^{\gamma}} e^{\varsigma_y} \tag{7}$$

where

α, β and γ are spawner biomass-recruitment parameters (γ =1 for a Beverton-Holt relationship),

ς_y reflects fluctuation about the expected (median) recruitment for year *y*, and

B_y^{sp} is the spawner biomass at the start of year *y*, given by:

$$B_y^{sp} = \sum_{a=1}^{p} f_a \sum_A \; [w_a^{f,A} N_{y,a}^{f,A}] \tag{8}$$

where $w_a^{f,A}$ is the begin-year mass of female lobsters at age *a* in sub-area *A*, and f_a is the proportion of lobster of age *a* that are mature.

In order to work with estimable parameters that are more meaningful biologically, the stock-recruit relationship is re-parameterised in terms of the pre-exploitation equilibrium female spawning biomass, K^{sp}, and the "steepness" of the stock-recruit relationship (recruitment at $B^{sp} = 0.2K^{sp}$ as a fraction of recruitment at $B^{sp} = K^{sp}$):

$$\alpha = \frac{4hR_1}{5h-1} \tag{9}$$

and

$$\beta = \frac{(K^{sp}(1-h))}{5h-1} \tag{10}$$

where

$$R_1 = K^{sp} / \{\sum_A \lambda^A \left[\sum_{a=1}^{p-1} f_a w_a^{f,A} e^{-\sum_{a'=0}^{a-1} M_{a'}^f} + f_p w_p^{f,A} \frac{e^{-\sum_{a'=0}^{p-1} M_{a'}^f}}{1-e^{-M_p^f}} \right] \} \tag{11}$$

The total catch by mass in year *y* for sub-area *A* is given by:

$$C_y^A = \sum_{m/f} \sum_a \sum_l \vec{C}_{y,a,l}^{m/f,A} \tag{12}$$

where

$$\vec{C}_{y,a,l}^{m,A} = w_{a+\frac{1}{2}}^{m,A} \vec{N}_{y,a,l}^{m,A} S_l^{m,A} F_y^A \tag{13}$$

$$\vec{C}_{y,a,l}^{f,A} = w_{a+\frac{1}{2}}^{f,A} \vec{N}_{y,a,l}^{f,A} S_l^{f,A} \mu^A F_y^A \tag{14}$$

where $w_l^{m/f,A}$ denotes the mass of a *m/f* lobster at length *l* in sub-area *A*, and where

$S_l^{m/f,A}$ is the length-specific selectivity for male/female lobsters in sub-area *A*,

F_y^A is the fully selected fishing mortality in year *y* for lobsters in sub-area *A*, and which is constrained to be $\leq$ 0.80,

μ^A is the relative female selectivity scaling parameter for sub-area *A*, and

$$\vec{N}_{y,a,l}^{m/f,A} = N_{y,a}^{m/f,A} Q_{a,l}^{m/f,A} \tag{15}$$

where $Q_{a,l}^{m/f,A}$ is the proportion of lobsters of age *a* that fall in the length group *l* for the sex and sub-area concerned (thus $\sum_l Q_{a,l}^{m/f,A} = 1$ for all ages *a*).

The matrix *Q* is calculated under the assumption that length-at-age is normally distributed about a mean given by the von Bertalanffy equation (Brandão *et al*., 2002), i.e.:

$$l_a \sim N^*\left[l_\infty^{m/f,A}\left(1 - e^{-\kappa(a-t_0)}\right); \theta_a^2\right] \tag{16}$$

where

N^* is the normal distribution truncated at ± 3 standard deviations, and

θ_a is the standard deviation of length-at-age *a*, which is modelled to be proportional to the expected length-at-age *a*, i.e.:

$$\theta_a = \beta^* l_\infty^{m/f,A}\left(1 - e^{-\kappa(a-t_0)}\right) \tag{17}$$

with β^* a parameter whose value is estimated in the model fitting process.

Somatic Growth rate model

Growth is assumed to be both sex and sub-area dependent. The κ (slope) parameter of the length increment versus length relationship is sub-area-independent, but the intercepts vary with sub-area. Thus the annual growth of a 75mm male lobster from each sub-area is given by

$$g75^{m,1E} = g75 + \Delta g1E + \Delta gm$$

$$g75^{m,1W} = g75 + \Delta g1W + \Delta gm$$

$$g75^{m,2+3} = g75 + \Delta gm$$

and, the annual growth rate of a 75mm female lobster from each sub-area is given by:

$$g75^{f,1E} = g75 + \Delta g1E$$

$$g75^{f,1W} = g75 + \Delta g1W$$

$$g75^{f,2+3} = g75.$$

[It follows that $l_\infty^{m/f,A} = 75.0 + (\frac{g75^{m/f,A}}{\kappa})$.]

Values from OLRAC (2012, Model 8) for the five somatic growth rate parameters which are based on data analysis and used in fitting the model (see equation (40 below)) are reported in Table 1 below:

Table 1: The somatic growth-rate parameters.

	Estimates
g75	3.280 mm
κ	0.099 yr^{-1}
Δgm	0.996 mm
Δg1E	-2.840 mm
Δg1W	-0.790 mm

To put these parameter values into perspective, the above values result in l_∞ (mm) and g75 (mm) values as reported in Table 2 below.

Table 2: The resultant l_∞ (mm) and g75 values.

	l_∞ (mm)	g75 (mm)
A1Em	89.51	1.44
A1Ef	79.44	0.44
A1Wm	110.15	3.48
A1Wf	100.09	2.48
A2+3m	118.19	4.28
A2+3f	108.13	3.28

[Note for A1Em there is a catch-at-length data plus group of 105+mm, and for A1Ef one of 95+mm.]

The model estimate of mid-year exploitable biomass is given by:

$$\hat{B}_y^A = \hat{B}_y^{m,A} + \hat{B}_y^{f,A} \tag{18}$$

where

$$\hat{B}_y^{f,A} = \sum_a \sum_l \mu^A S_l^{f,A} [w_{a+\frac{1}{2}}^{f,A} \vec{N}_{y,a,l}^{f,A} e^{-M^f/2}] \tag{19}$$

$$\hat{B}_y^{m,A} = \sum_a \sum_l S_l^{m,A} [w_{a+\frac{1}{2}}^{m,A} \vec{N}_{y,a,l}^{m,A} e^{-M^m/2}] \tag{20}$$

and where

μ^A is an sub-area-specific factor that scales female relative to male catchability; and

$\hat{B}_y^A$ is the total (male plus female) model estimate of mid-year exploitable biomass for year y in sub-area A.

The overall fishing proportion in sub-area A is:

$$\tilde{F}_y^A = \frac{C_y^{obs,A}}{B_y^A} \tag{21}$$

Catch-at-length proportions

$$\hat{p}_{y,l}^{m,A} = \frac{\sum_a \vec{C}_{y,a,l}^{m,A}}{\sum_l \sum_{m,f} \sum_a \vec{C}_{y,a,l}^{m/f,A}} \quad (22)$$

$$\hat{p}_{y,l}^{f,A} = \frac{\sum_a \vec{C}_{y,a,l}^{f,A}}{\sum_l \sum_{m,f} \sum_a \vec{C}_{y,a,l}^{m/f,A}} \quad (23)$$

where $\hat{p}_{y,l}^{m/f,A}$ is the estimated proportion of catch in sub-area *A* of *m/f* lobsters in length class *l* in year *y* (note that the total proportions of male plus female lobsters will thus equal 1.0 in any given year and sub-area).

Time varying selectivity-at-length function

The selectivity function (which depends on length) **may** be allowed to vary over the time period for which catch-at-age data are available (1995-2010). To effect this, the form of the selectivity function is generalised to:

$$S_{y,l}^{m/f,A} = \frac{1}{1+e^{-\ln 19(l-(l_{50}^{m/f,A}+\delta_y^{m/f,A})/\Delta^{m/f,A}}} \quad (24)$$

The estimable parameters are thus:

- $l_{50}^{m/f,A}$ (the expected length at 50% selectivity), and
- $\Delta^{m/f,A}$ and for *y* = 1995-2010

Note:

- the expected length at 95% selectivity ($l_{95}^{m/f,A}$) is given by $l_{50}^{m/f,A} + \Delta^{m/f,A}$,
- $\delta_y^{m/f,A}$ for pre-1995 and 2011+ = 0.

An extra term is added to the negative log likelihood to limit the extent to which the $\delta_y^{m/f,A}$ differ from zero – see equation 39.

An issue to be taken into account is that for equation (24), if $\delta_y^{m/f,A}$ decreases, this means that selectivity is increasing on younger lobsters; however given that the model fitting procedure assumes that:

$$\hat{CPUE}_y = q\sum_l w_l S_{l,a} N_{l,a} e^{-M/2} \quad (25)$$

this situation seems implausible, in that an enhanced CPUE would result even if there was not any increase in abundance.

Presumably enhanced catches of younger animals are achieved by spatially redistributing effort on a scale finer than captured by the GLM standardisation of the CPUE. A standard method to adjust for this, while maintaining a constant catchability coefficient *q*, is to renormalise the selectivity function in some way:

$$S_{y,l}^{m/f,A} \rightarrow S_{y,l}^{*,m/f,A} = S_{y,l}^{m/f,A} / X_y^{m/f,A} \quad (26)$$

where here as a simple initial approach we have chosen:

$$X_y^{m/f,A} = \sum_{l_1^{m/f,A}}^{l_2^{m/f,A}} \frac{S_{y,l}^{m/f,A}}{l_2^{m/f,A} - l_1^{m/f,A} + 1} \quad (27)$$

i.e., normalising selectivity by its average over a certain length range, so that now if $\delta_y^{m/f,A}$ decreases, the $S_{y,l}^{*,m/f,A}$ will decrease for large *l* to compensate for the effort spread to locations where younger animals are found associated with the increase for smaller *l*.

The values of $l_1^{m/f,A}$ and $l_2^{m/f,A}$ were fixed at the values in Table 3 below to ensure that the ranges associated with these *l* values cover the greater part of these distributions.

Table 3: The values of $l_1^{m/f,A}$ and $l_2^{m/f,A}$ used in the OM tuning.

	$l_1^{m/f,A}$	$l_2^{m/f,A}$
A1E male	65	90
A1E female	65	90
A1W male	65	90
A1W female	65	90
A2+3 male	55	90
A2+3 female	55	90

For sub-areas A1E and A1W – selectivity is assumed to remain constant over time (because data for these sub-areas are inadequate for changes over time to be estimated), so that the procedure above was applied only for sub-area A2+3 only and for only the years for which data are available at the time (1995-2010).

Thus for y=1995, 2010:

$$l_*^m \to l_*^m + \varepsilon_{l*,y}^m \qquad \varepsilon_{l*,y}^m \sim N(0, \sigma_{l*,m}^2)$$

$$l_*^f \to l_*^f + \varepsilon_{l*,y}^f \qquad \varepsilon_{l*,y}^f \sim N(0, \sigma_{l*,f}^2)$$

$$\mu^m \to \mu^m + \varepsilon_{\mu,y}^m \qquad \varepsilon_{\mu,y}^m \sim N(0, \sigma_{\mu,m}^2)$$

$$\mu^f \to \mu^f + \varepsilon_{\mu,y}^f \qquad \varepsilon_{\mu,y}^f \sim N(0, \sigma_{\mu,f}^2)$$

$$\delta^m \to \delta^m + \varepsilon_{\delta,y}^m \qquad \varepsilon_{\delta,y}^m \sim N(0, \sigma_{\delta,m}^2)$$

$$\delta^f \to \delta^f + \varepsilon_{\delta,y}^f \qquad \varepsilon_{\delta,y}^f \sim N(0, \sigma_{\delta,f}^2)$$

Extra terms are added to the negative log likelihood to limit the extent to which the ε estimates differ from zero:

$$-lnL \to -lnL + \frac{1}{2}\sum_{y,\frac{m}{f}} \left(\frac{\varepsilon_{l*,y}^m}{\sigma_{l*,m}}\right)^2 + \left(\frac{\varepsilon_{l*,y}^f}{\sigma_{l*,f}}\right)^2 + \left(\frac{\varepsilon_{\mu,y}^m}{\sigma_{\mu,m}}\right)^2 + \left(\frac{\varepsilon_{\mu,y}^f}{\sigma_{\mu,f}}\right)^2 + \left(\frac{\varepsilon_{\delta,y}^m}{\sigma_{\delta,m}}\right)^2 + \left(\frac{\varepsilon_{\delta,y}^f}{\sigma_{\delta,f}}\right)^2 \qquad (28)$$

Time varying recruitment distribution over sub-areas

The model is further expanded to allow for recruitment distributions which vary over time for each of the three sub-areas as follows:

Without time-varying recruitment:

$$R_y^A = \lambda^A R_y \qquad \text{see equation (1)}$$

With time variation this becomes:

$$R_y^A = \lambda_y^{*,A} R_y \qquad (29)$$

where

$$\lambda_y^{*,A} = \frac{\lambda^A e^{\varepsilon_{A,y}}}{\sum_A \lambda^A e^{\varepsilon_{A,y}}} \qquad (30)$$

The $\varepsilon_{A,y}$ are thus further estimable parameters. An additional term is also added to the –ln*L* function (see equation 38 below).

2. The likelihood function

The model is fitted to CPUE and catch-at-length (male and female separately) data from each of the three sub-areas to estimate the model parameters. Contributions by each of these to the negative log-likelihood (-ln*L*), and the various additional penalties added are as follows.

Relative abundance data (CPUE)

The likelihood is calculated assuming that the observed abundance index is log-normally distributed about its expected (median) value:

$$CPUE_y^A = q^A B_y^A e^{\varepsilon_y^A} \text{ or } \varepsilon_y^A = \ln(CPUE_y^A) - \ln(q^A B_y^A) \tag{31}$$

where

$CPUE_y^A$ is the CPUE abundance index for year *y* in sub-area *A*,

B_y^A is the model estimate of mid-year exploitable biomass for year *y* in sub-area *A* given by equation 18,

q^A is the constant of proportionality (catchability coefficient) for sub-area *A*, and

ε_y^A from $N(0,(\sigma^A)^2)$.

The contribution of the abundance data to the negative of the log-likelihood function (after removal of constants) is given by:

$$-\ln L = \sum_A \sum_y \left[\left(\varepsilon_y^A\right)^2 / 2(\sigma^A)^2 + \ln(\sigma^A) \right] \tag{32}$$

where

σ^A is the residual standard deviation estimated in the fitting procedure by its maximum likelihood value:

$$\hat{\sigma}^A = \sqrt{1/n \sum_y \left(\ln CPUE_y^A - \ln \hat{q}^A \hat{B}_y^A\right)^2} \tag{33}$$

where

n is the number of data points in the CPUE series, and

q^A is the catchability coefficient, estimated by its maximum likelihood value:

$$\ln \hat{q}^A = 1/n \sum_y \left(\ln CPUE_y^A - \ln \hat{B}_y^A\right) \tag{34}$$

Catches-at-length

The following term is added to the negative log-likelihood:

$$-\ell n\, L^{\text{length}} = w_{len} \sum_A \sum_y \sum_l \sum_{m/f} \left[\ln\left(\sigma_{len}^A / \sqrt{p_{y,l}^{m/f,A}}\right) + p_{y,l}^{m/f,A} \left(\ln p_{y,l}^{m/f,A} - \ln \hat{p}_{y,l}^{m/f,A}\right)^2 / 2\left(\sigma_{len}^A\right)^2 \right] \tag{35}$$

where

$p_{y,l}^{m/f,A}$ is the observed proportion of *m*/*f* lobsters (by number) in length group *l* in the catch in year *y* in sub-area *A*, and

σ_{len}^A is the standard deviation associated with the length-at-age data in sub-area *A*, which is estimated in the fitting procedure by:

$$\hat{\sigma}_{len}^A = \sqrt{\sum_{m/f} \sum_y \sum_l p_{y,l}^{m/f,A} \left(\ln p_{y,l}^{m/f,A} - \ln \hat{p}_{y,l}^{m/f,A}\right)^2 / \sum_{m/f} \sum_y \sum_l 1} \tag{36}$$

Equation (32) makes the assumption that proportion-at-length data are log-normally distributed about their model-predicted values. The associated variance is taken to be inversely proportional to $p_{y,l}^{m/f,A}$ to down-weight contributions from observed small proportions which will correspond to small predicted sample sizes.

The RC model fixes w_{len} = 1.0 (i.e. gives equal weight to the CAL data as to the CPUE data).

Stock-recruitment function residuals

The assumption that these residuals are log-normally distributed and could be serially correlated defines a corresponding joint prior distribution. This can be equivalently regarded as a penalty function added to the log-likelihood, which for fixed serial correlation ρ is given by:

$$-\ln L = -\ln L + \sum_{y=y1}^{y2}\left[\frac{\varsigma_y - \rho\varsigma_{y-1}}{\sqrt{1-\rho^2}}\right]^2 / 2\sigma_R^2 \tag{37}$$

where

$\varsigma_y = \rho\tau_{y-1} + \sqrt{1-\rho^2}\eta_y$ is the recruitment residual for year *y* (see equation 7), which is estimated for years *y1* to *y2* if $\rho = 0$, or *y1*+1 to *y2* if $\rho > 0$,

$\eta_y \sim N(0, \sigma_R^2)$,

σ_R is the standard deviation of the log-residuals, which is input, and

ρ is their serial correlation coefficient, which is input.

Note that here (as in previous assessments), ρ is set equal to zero, i.e. the recruitment residuals are assumed uncorrelated, and σ_R is set equal to 0.8. Because of the absence of informative age data for a longer period, recruitment residuals are estimated for years 1974 to 2003 only.

Time varying recruitment distribution parameters

The following term is added to the –ln*L* term to constrain the size of these terms in equation 29 (i.e. to fit to genuine difference rather than to noise):

$$-\ln L = -\ln L + \sum_A \sum_{y=1973}^{y=2004}\left(\frac{\varepsilon_{A,y}^2}{\sigma_\lambda^2}\right) \tag{38}$$

where σ_λ=1.0.

Time varying selectivity

An extra term is added to the likelihood function in order to smooth the extent of change in the selectivity in equation 24, as follows:

$$-\ln L \to -\ln L + \sum_{m/f}\sum_A \sum_{y=1995}^{y=2010}\left(\frac{\delta_y^{m/f,A}}{\sigma_{sel}}\right)^2 \tag{39}$$

where the σ_{sel} is input (a value of 7.5 is used, having provided reasonable performance in previous assessments).

Somatic growth parameters – within model estimation

The somatic growth rate parameter values in Table 1 are updated in the model fitting process.

The growth parameters constitute a vector **x.** The following contribution is then added to the penalised negative log-likelihood in the assessment:

$$-\ln L^{c} = \frac{1}{2}\ln|\mathbf{\Sigma}| + \frac{1}{2}(\mathbf{x}-\boldsymbol{\mu})^{T}\mathbf{\Sigma}^{-1}(\mathbf{x}-\boldsymbol{\mu}) \qquad (40)$$

where the parameters *g75*, $\kappa, \Delta gm, \Delta g1E$ *and* $\Delta g1w$ are components of the vector ***x***,

$\mathbf{\Sigma}$ is the variance covariance matrix (as provided by OLRAC, 2012), and

$\boldsymbol{\mu}$ is a vector which contains the estimates in Table 1 (as provided by OLRAC, 2012).

3. Model parameter values fixed in estimation

Natural mortality: Natural mortality $M^{m/f}$ for male and female lobsters is assumed to be the same (*M*) for all age classes and both sexes, and is fixed at 0.10 yr^{-1}.

Age-at-maturity: The proportion of lobsters of age *a* that are mature is approximated by $f_a = 1$ for *a* > 9 years (i.e. $f_a = 0$ for *a* = 0, …,9).

Minimum age: Age 0.

Maximum age: *p* = 20, and is taken as a plus-group.

Minimum length: length 1mm.

Maximum length: 180mm, what is taken as a plus-group.

Mass-at-age: The mass $w_a^{m/f,A}$ of a *m/f* lobster at age *a* in sub-area *A* is given by:

$$w_a^{m/f,A} = \alpha\left[\hat{L}_{\infty}^{m/f,A}\left(1-e^{-\hat{\kappa}(a-\hat{t}_0)}\right)\right]^{\beta} \qquad (41)$$

Mass-at-length:

$$w_l^{m/f,A} = \alpha l^{\beta} \qquad (42)$$

where the values of α and β are 0.0007 and 2.846 (units gm and mm) respectively (and are assumed constant for male and female lobsters and across sub-areas).

Stock-recruitment relationship: The shape parameter, γ, is fixed to 1, corresponding to a Beverton-Holt form.

Further Fixed inputs for the RC

Table 3: Fixed parameter inputs to the 2013 Reference Case assessment model

Parameter	Equation	RC Input value
σ_{sel}	39	7.5
σ_R	37	0.8
σ_λ	38	1.0
w_{len}	35	1.0

Table 4: Estimable parameters of the 2013 Reference Case assessment model.

Parameter	**What is it**	**Which equation**	**Number of parameters**
K^{sp}	Pristine female spawning biomass	9, 11	1
H	Steepness parameter of SR function	9,10	1
$l_{50}^{m/f,A}$	Selectivity function parameter	24	6
$\Delta_{95}^{m/f,A}$	Selectivity function parameter	24	6
μ^{A}	Relative female selectivity scaling parameters	14	3
β^{*}	Parameter of length-at-age distribution	17	1
λ^{A}	Sub-area specific recruitment proportion	1	2 ($\lambda^3 = 1 - \lambda^1 - \lambda^2$)
$\varepsilon_{A,y}$	Time varying recruitment distribution	30	62
ς_{y}	Stock recruit residuals	7	30
$\delta_{y}^{m/f,A}$	Time varying selectivity	24, 39	90
$5\ somatic\ growth\ parameters$		40	5
TOTAL			**207**

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Appendix A: List of data used in fitting the 2017 SCRL ASPM

Table A1: Historical annual catch (MT) from each of the three sub-areas (from Glazer 2017a). The average sub-area catch splits for the period 1977-1981 used to produce the catches for 1973-76. Note that data up to 2010 only were available at the time of the 2013 OM development.

Year	Area 1E	Area 1W	Area 2+3
1973	No data avaiable in the catch-effort database for these years		
1974			
1975			
1976			
1977	69.73	175.95	421.32
1978	4.21	97.82	358.97
1979	0.37	31.52	90.11
1980	25.41	86.06	64.54
1981	15.27	122.99	209.74
1982	57.84	88.45	260.71
1983	12.20	112.95	398.84
1984	45.23	155.77	248.99
1985	1.05	84.47	364.48
1986	6.84	103.82	339.34
1987	3.73	102.50	345.77
1988	11.44	88.38	352.19
1989	49.86	62.50	339.64
1990	38.18	191.94	246.87
1991	60.85	122.21	341.48
1992	38.65	108.02	383.29
1993	43.68	147.54	333.05
1994	42.76	176.44	288.69
1995	34.93	87.75	382.21
1996	68.27	63.91	310.50
1997	31.06	74.51	310.82
1998	31.94	161.26	322.83
1999	56.65	191.98	263.54
2000	123.26	86.96	213.18
2001	18.92	89.61	179.47
2002	11.56	199.01	129.43
2003	18.55	188.63	142.82
2004	23.61	143.41	214.99
2005	21.58	152.09	208.33
2006	145.85	52.18	182.98
2007	93.96	79.47	213.57
2008	46.33	85.75	232.92
2009	61.22	123.44	160.35
2010	117.39	157.96	52.65
2011	62.98	126.75	117.27
2012	29.78	88.13	177.10
2013	6.28	62.58	275.14
2014	1.94	90.24	237.82
2015	38.98	163.38	98.64

Table A2: Standardised CPUE indices (kg/trap) for each sub-area (from Glazer 2017b). Note that only data up to and including 2010 were available at the time of the 2013 OM development.

Year	Area 1E	Area 1W	Area 2+3
1977	2.51	1.86	2.21
1978	1.40	1.45	1.98
1979	1.06	1.55	1.76
1980	2.73	2.24	2.00
1981	2.44	1.77	1.89
1982	1.94	1.54	1.59
1983	1.61	1.76	1.82
1984	2.26	1.60	1.68
1985	0.44	1.45	1.59
1986	1.21	1.62	1.91
1987	1.01	2.18	1.72
1988	1.74	2.06	2.03
1989	3.26	1.88	2.03
1990	1.87	1.84	1.57
1991	1.42	1.34	1.40
1992	1.94	1.14	1.51
1993	1.38	1.03	1.36
1994	0.99	1.09	1.15
1995	1.22	0.90	1.14
1996	0.96	0.90	0.94
1997	0.89	0.88	0.83
1998	1.50	1.26	0.68
1999	1.22	1.00	0.67
2000	1.64	1.06	0.73
2001	1.46	1.32	0.87
2002	1.70	1.44	0.78
2003	1.66	1.36	0.98
2004	1.89	1.28	1.35
2005	1.37	1.20	1.03
2006	1.30	0.78	0.82
2007	1.07	1.09	1.10
2008	1.38	1.21	1.14
2009	1.15	1.17	0.85
2010	1.33	1.23	0.93
2011	0.94	1.09	0.93
2012	0.82	0.88	0.96
2013	1.36	1.26	1.39
2014	1.45	1.38	1.26
2015	1.99	1.46	1.04

Table 3a: Sub-area 1E male scientific catch-at-length proportions. Note “45” refers to the 45-49 mm carapace length range. Values bolded are those that were altered from the raw format to prevent proportions less than 0.01. Note that only data up to and including 2010 were available for the 2013 OM development.

	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
45	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
50	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006
55	0.000	0.000	0.030	0.000	0.017	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.013	0.000	0.000	0.000	0.037	0.053	0.000	0.009
60	0.000	0.026	0.106	0.000	0.081	0.015	0.044	0.000	0.000	0.000	0.000	0.000	0.035	0.072	0.014	0.052	0.107	0.026	0.036	0.000	0.008
65	0.000	0.072	0.178	0.000	0.134	0.103	0.127	0.035	0.000	0.040	0.000	0.000	0.082	0.121	0.078	0.245	0.191	0.128	0.141	0.000	0.006
70	0.000	0.105	0.173	0.000	0.105	0.176	0.166	0.189	0.000	0.242	0.000	0.000	0.108	0.135	0.182	0.171	0.108	0.179	0.180	0.000	0.022
75	0.000	0.056	0.086	0.000	0.053	0.104	0.084	0.247	0.000	0.294	0.000	0.000	0.088	0.102	0.144	0.064	0.087	0.154	0.121	0.000	0.107
80	0.000	0.015	0.000	0.000	0.023	0.034	0.036	0.156	0.000	0.125	0.000	0.000	0.085	0.065	0.063	0.028	0.066	0.096	0.081	0.000	0.127
85	0.000	0.000	0.000	0.000	0.011	0.000	0.014	0.050	0.000	0.026	0.000	0.000	0.046	0.033	0.022	0.015	0.034	0.025	0.027	0.000	0.075
90	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.013	0.000	0.000	0.000	0.000	0.018	0.023	0.011	0.000	0.027	0.017	0.019	0.000	0.015
95	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006
100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
105	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
110	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
115	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
120	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
125	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 3b: Sub-area 1E female scientific catch-at-length proportions. Note "45" refers to the 45-49 mm carapace length range. Values bolded are those that were altered from the raw format to prevent proportions less than 0.01. Note that only data up to and including 2010 were available for the 2013 OM development.

	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
45	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
50	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003
55	0.000	0.021	0.047	0.000	0.049	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.016	0.000	0.000	0.000	0.000	0.014	0.000	0.011
60	0.000	0.119	0.101	0.000	0.147	0.047	0.092	0.000	0.000	0.000	0.000	0.000	0.055	0.054	0.022	0.042	0.095	0.026	0.038	0.000	0.005
65	0.000	0.289	0.138	0.000	0.187	0.206	0.189	0.066	0.000	0.071	0.000	0.000	0.129	0.102	0.112	0.216	0.150	0.077	0.117	0.000	0.030
70	0.000	0.239	0.104	0.000	0.124	0.212	0.167	0.112	0.000	0.118	0.000	0.000	0.165	0.098	0.175	0.119	0.059	0.095	0.088	0.000	0.099
75	0.000	0.058	0.069	0.000	0.051	0.086	0.066	0.081	0.000	0.069	0.000	0.000	0.118	0.082	0.114	0.032	0.027	0.071	0.044	0.000	0.245
80	0.000	0.000	0.000	0.000	0.019	0.015	0.015	0.037	0.000	0.016	0.000	0.000	0.049	0.049	0.041	0.017	0.030	0.047	0.041	0.000	0.180
85	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.013	0.000	0.000	0.000	0.000	0.021	0.024	0.023	0.000	0.020	0.021	0.000	0.000	0.036
90	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.003
95	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003
100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
105	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
110	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
115	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
120	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
125	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 3c: Sub-area 1W male scientific catch-at-length proportions. Note “45” refers to the 45-49 mm carapace length range. Values bolded are those that were altered from the raw format to prevent proportions less than 0.01. Note that only data up to and including 2010 were available for the 2013 OM development.

	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
45	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
50	0.000	0.019	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
55	0.000	0.023	0.000	0.000	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
60	0.018	0.027	0.032	0.023	0.043	0.000	0.011	0.000	0.000	0.000	0.025	0.014	0.031	0.078	0.037	0.025	0.044	0.015	0.015	0.003	0.004
65	0.069	0.051	0.049	0.073	0.079	0.019	0.056	0.027	0.042	0.035	0.028	0.126	0.076	0.110	0.149	0.081	0.076	0.057	0.047	0.009	0.009
70	0.130	0.084	0.095	0.109	0.095	0.085	0.150	0.080	0.110	0.076	0.050	0.231	0.123	0.138	0.151	0.158	0.085	0.114	0.056	0.063	0.048
75	0.099	0.087	0.128	0.106	0.083	0.143	0.163	0.125	0.155	0.100	0.082	0.196	0.111	0.114	0.117	0.134	0.084	0.127	0.104	0.056	0.072
80	0.061	0.067	0.090	0.084	0.063	0.127	0.095	0.118	0.142	0.105	0.109	0.208	0.081	0.080	0.067	0.105	0.092	0.118	0.102	0.102	0.090
85	0.040	0.045	0.049	0.051	0.048	0.084	0.044	0.088	0.089	0.083	0.092	0.092	0.051	0.056	0.036	0.044	0.061	0.071	0.106	0.107	0.100
90	0.033	0.027	0.028	0.030	0.039	0.058	0.021	0.051	0.051	0.056	0.065	0.036	0.024	0.032	0.022	0.034	0.048	0.059	0.107	0.096	0.088
95	0.026	0.016	0.019	0.019	0.023	0.031	0.010	0.028	0.022	0.031	0.025	0.000	0.018	0.021	0.000	0.016	0.021	0.016	0.034	0.102	0.096
100	0.023	0.010	0.020	0.015	0.021	0.018	0.011	0.019	0.014	0.021	0.013	0.000	0.000	0.000	0.000	0.015	0.023	0.000	0.023	0.029	0.037
105	0.000	0.000	0.000	0.018	0.000	0.016	0.000	0.000	0.000	0.019	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.018	0.029
110	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.002
115	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001
120	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
125	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 3d: Sub-area 1W female scientific catch-at-length proportions. Note “45” refers to the 45-49 mm carapace length range. Values bolded are those that were altered from the raw format to prevent proportions less than 0.01. Note that only data up to and including 2010 were available for the 2013 OM development.

	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
45	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
50	0.000	0.024	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
55	0.000	0.024	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.001
60	0.033	0.034	0.035	0.040	0.050	0.000	0.018	0.000	0.000	0.000	0.028	0.000	0.047	0.055	0.034	0.017	0.039	0.012	0.011	0.001	0.001
65	0.102	0.085	0.068	0.097	0.096	0.031	0.074	0.038	0.033	0.039	0.048	0.000	0.087	0.081	0.113	0.068	0.080	0.064	0.043	0.006	0.006
70	0.133	0.130	0.127	0.118	0.112	0.090	0.153	0.093	0.086	0.091	0.085	0.000	0.118	0.075	0.116	0.098	0.090	0.107	0.057	0.062	0.043
75	0.086	0.111	0.121	0.096	0.102	0.115	0.116	0.129	0.109	0.106	0.119	0.000	0.098	0.060	0.089	0.069	0.076	0.095	0.080	0.065	0.068
80	0.060	0.069	0.070	0.062	0.081	0.092	0.045	0.093	0.081	0.097	0.107	0.000	0.068	0.041	0.045	0.067	0.072	0.075	0.080	0.094	0.072
85	0.044	0.038	0.033	0.035	0.032	0.051	0.021	0.057	0.037	0.062	0.069	0.000	0.041	0.027	0.027	0.026	0.036	0.036	0.053	0.073	0.069
90	0.023	0.026	0.016	0.025	0.008	0.025	0.013	0.033	0.025	0.040	0.033	0.022	0.025	0.020	0.000	0.023	0.035	0.035	0.053	0.050	0.057
95	0.011	0.000	0.011	0.000	0.015	0.016	0.000	0.020	0.000	0.021	0.022	0.043	0.000	0.000	0.000	0.020	0.014	0.000	0.018	0.040	0.060
100	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.018	0.000	0.022	0.000	0.000	0.000	0.000	0.024	0.000	0.011	0.013	0.028
105	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.015
110	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
115	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
120	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
125	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 3e: Sub-area 2+3 male scientific catch-at-length proportions. Note "45" refers to the 45-49 mm carapace length range. Values bolded are those that were altered from the raw format to prevent proportions less than 0.01. Note that only data up to and including 2010 were available for the 2013 OM development.

	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
45	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
50	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
55	0.016	0.000	0.000	0.028	0.020	0.010	0.000	0.016	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.027	0.004	0.001
60	0.095	0.059	0.067	0.063	0.116	0.054	0.014	0.046	0.030	0.040	0.024	0.000	0.075	0.069	0.046	0.000	0.033	0.034	0.037	0.012	0.009
65	0.138	0.082	0.132	0.090	0.186	0.103	0.047	0.063	0.045	0.049	0.060	0.074	0.128	0.109	0.098	0.055	0.062	0.051	0.052	0.025	0.022
70	0.083	0.068	0.089	0.078	0.111	0.095	0.099	0.078	0.081	0.071	0.107	0.152	0.124	0.087	0.119	0.133	0.147	0.071	0.088	0.048	0.039
75	0.046	0.055	0.051	0.044	0.031	0.065	0.102	0.082	0.107	0.077	0.097	0.166	0.066	0.050	0.101	0.103	0.095	0.066	0.083	0.084	0.064
80	0.042	0.056	0.043	0.042	0.015	0.049	0.088	0.066	0.092	0.077	0.076	0.165	0.052	0.037	0.064	0.145	0.107	0.072	0.094	0.081	0.071
85	0.034	0.049	0.033	0.039	0.015	0.041	0.061	0.049	0.055	0.053	0.057	0.083	0.039	0.033	0.036	0.030	0.036	0.047	0.057	0.073	0.071
90	0.023	0.035	0.026	0.037	0.012	0.034	0.039	0.034	0.035	0.041	0.036	0.037	0.026	0.036	0.022	0.036	0.032	0.056	0.052	0.059	0.054
95	0.017	0.025	0.020	0.026	0.011	0.022	0.023	0.021	0.019	0.023	0.023	0.019	0.022	0.032	0.012	0.032	0.014	0.033	0.024	0.051	0.054
100	0.011	0.020	0.017	0.018	0.000	0.015	0.012	0.014	0.012	0.023	0.014	0.017	0.019	0.027	0.011	0.015	0.015	0.039	0.017	0.030	0.035
105	0.016	0.017	0.022	0.018	0.000	0.021	0.013	0.015	0.014	0.000	0.015	0.000	0.012	0.025	0.000	0.000	0.000	0.019	0.014	0.028	0.029
110	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.011	0.000	0.000	0.000	0.000	0.017	0.000	0.012	0.014
115	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.004
120	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.002
125	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000

Table 3f: Sub-area 2+3 male scientific catch-at-length proportions. Note “45” refers to the 45-49 mm carapace length range. Values bolded are those that were altered from the raw format to prevent proportions less than 0.01. Note that only data up to and including 2010 were available for the 2013 OM development.

	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
45	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
50	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000
55	0.026	0.019	0.013	0.034	0.054	0.020	0.000	0.021	0.000	0.010	0.000	0.000	0.011	0.017	0.000	0.000	0.000	0.000	0.000	0.005	0.002
60	0.126	0.065	0.085	0.065	0.168	0.075	0.022	0.050	0.034	0.035	0.034	0.000	0.073	0.059	0.046	0.000	0.031	0.033	0.022	0.008	0.014
65	0.127	0.096	0.112	0.085	0.135	0.099	0.071	0.066	0.061	0.055	0.075	0.016	0.094	0.092	0.089	0.040	0.060	0.044	0.032	0.023	0.021
70	0.062	0.089	0.074	0.067	0.052	0.070	0.112	0.087	0.117	0.091	0.111	0.019	0.058	0.073	0.104	0.104	0.132	0.073	0.076	0.033	0.055
75	0.042	0.074	0.052	0.064	0.022	0.055	0.107	0.090	0.120	0.109	0.103	0.022	0.038	0.053	0.087	0.083	0.073	0.068	0.079	0.068	0.066
80	0.030	0.063	0.048	0.069	0.018	0.055	0.083	0.073	0.082	0.101	0.065	0.049	0.037	0.045	0.062	0.120	0.087	0.072	0.093	0.067	0.081
85	0.027	0.051	0.041	0.051	0.015	0.041	0.051	0.052	0.044	0.066	0.041	0.047	0.034	0.044	0.043	0.025	0.027	0.048	0.056	0.079	0.072
90	0.020	0.036	0.035	0.039	0.019	0.032	0.029	0.036	0.026	0.042	0.031	0.062	0.033	0.048	0.028	0.034	0.028	0.057	0.048	0.061	0.056
95	0.009	0.020	0.020	0.022	0.000	0.021	0.015	0.020	0.015	0.022	0.017	0.052	0.026	0.037	0.017	0.030	0.021	0.038	0.025	0.050	0.055
100	0.011	0.022	0.010	0.020	0.000	0.012	0.013	0.020	0.013	0.014	0.013	0.019	0.023	0.010	0.013	0.015	0.000	0.034	0.015	0.029	0.045
105	0.000	0.000	0.010	0.000	0.000	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.014	0.012	0.027	0.038
110	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.013	0.000	0.014	0.017
115	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.007
120	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.002
125	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000

Appendix B: Incorporation of previous panel recommendations

Following recommendations made during the NOV 2012 International Workshop held at UCT (see Appendix for Workshop Panel recommendations for South Coast rock lobster taken from MARAM IWS/NOV12/REP/1) the following apply to the RC assessment model presented in the main text.

RC model:

1) Model splits fishing sub-areas into A1E, A1W and A2+3.
2) CAL data and CPUE data received equal weighting in –lnL.
3) All five growth parameters are updated within the fitting procedure using the method described in MARAM IWS/NOV12/SCRL/P2 section 2.7.
4) Fits only to CAL data that either have a total annual sample size of >200, and two of the four quarters have been sampled. If either of these two constraints are not achieved, then the CAL data for that sub-area is NOT included in the likelihood.
5) Fits TVS for A2+3 only – only for the years for which CAL data are included in the –lnL. The δ values for other years (years for which CAL data are not available/utilised) are set equal to zero.
6) Re-parameterise the way in which the average recruitment proportions to sub-areas and the year-specific recruitment proportions to sub-areas are modelled (see equation A.29 in MARAM/IWS/NOV12/SCRL/P2).