SCRL OMP-2019 simulation testing and initial development proposals

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Summary

This document sets out the details of the process proposed to be used for projecting the 2018 assessment forwards and generating future pseudo-data in the simulation testing to be applied in the development of a new SCRL OMP-2019.

Introduction

The proposed simulation framework for the new OMP-2019 testing is described below. The Operating Model (OM) has recently been updated (Johnston and Butterworth 2019).

It is proposed that at least 100 simulations of the OM will be projected ahead under TACs calculated using the new OMP rules. Each simulation will have random noise added to certain future components of the model (e.g. the selectivity and the recruitment) and input data (CPUE) generated as described below. In projecting forwards, the simulations will assume that the split of the global TAC between the three fishing areas is proportional to the recent (now 2012-2016) average of the fishing mortalities in each area (as was assumed for the 2014 OMP development).

Summary of 2018 updated assessment (OM) to be used in OMP-2019 testing:

- Fit to CPUE and CAL data up to and including 2015
- The assessment includes the observed catch for 2016 and 2017 and assumes the catch for the 2018 season (321 MT) will be taken; thus the assessment ends in 2018, i.e. projections will start at the beginning of 2019 season.

Thus:

- The new OMP will need to set its first OMP TAC for 2019 (The current 2018 TAC set was 321 MT).
- The new OMP will use the observed CPUE for up to and including 2017, and then model-generated CPUE (with noise) for 2018+ [1]
- The OMP TAC for year *y* will use CPUE information from 2014 to year (*y*-2), and catches from 1973 to year (*y*-1), to incorporate only the information which would be available at the time the TAC has to be recommended.

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[1] These values may differ depending on the timing of the OMP development with relation to the final CPUE calculations done during 2019.

When projecting the population forwards for the simulation testing of various new OMP candidates, a number of assumptions will need to be made. The framework suggested for these is detailed below.

Stock-Recruit residuals

The model has already estimated residuals for 1974-2008[2].

For 2009+ $$R_y = \frac{\alpha B_y^{sp}}{\beta + B_y^{sp}} e^{\varepsilon_y - \sigma_R^2/2} \quad \varepsilon_y \sim N(0, \sigma_R^2) \qquad (1)$$

where σ_R =0.8

The assessment provides values for $\hat{N}_{2018,a}$ for $a \geq 1$, under the assumption that the ε_y are estimated for 1974-2008 (but constrained to average zero) and fixed at 0.0 for 2009+. To allow for random variation in recruitment from 2009-2017 when projecting, the following adjustments are made to the numbers at age to start the projections:

$$\hat{N}_{2018,a} \rightarrow \hat{N}_{2018,a} e^{\varepsilon_{2018-a}} \qquad \text{for } a = 1,2 \ldots 7 \qquad (2)$$

where the ϵ_{2018-a} are generated from $N(0, \sigma_R^2)$

This does not introduce any substantial bias into computations, as any catch prior to 2018 from the cohorts concerned is minimal.

However, given indications of some temporal auto-correlation in the stock recruit residuals an AR(1) process is assumed. The associated auto-correlation s_R is estimated by:

$$s_R = \sum_{y=1974}^{y=2007} \hat{\varepsilon}_{y+1} \, \hat{\varepsilon}_y / \sum_{y=1974}^{y=2007} \hat{\varepsilon}_y^2 \qquad (3)$$

Then instead of generating the ε_y from $N(0, \sigma_R^2)$, the following equation is used:

$$\varepsilon_{y+1}^s = s_R \varepsilon_y^s + \sqrt{1 - s_R^2} \eta_y^s \qquad \eta_y^s \sim N(0, \sigma_R^2). \qquad (4)$$

This equation is first applied for *y*=2009 to provide ε_{2009}^s with an input of $\varepsilon_{2008}^s = \hat{\varepsilon}_{2008}$, i.e. the value estimated in the assessment.

[2] Residuals cannot be estimated for further years because the signal of recruitment strength comes from the length structure of the catch, and lobsters are first taken by the fishery at about age 8-10 years only.

Proportional split of recruitment *R*$_y$ by area

Historically for each area *A*, the proportional split of recruitment, $\lambda_y^{*,A}$ is defined by:

$$R_y^A = \lambda_y^{*,A} R_y \tag{5}$$

where

$$\lambda_y^{*,A} = \frac{\lambda^A e^{\varepsilon_{A,y}}}{\sum_A \lambda^A e^{\varepsilon_{A,y}}} \tag{6}$$

and

$$\varepsilon_{A,y} \sim N(0,\sigma_\lambda^2); \qquad \sigma_\lambda = 1.0$$

The $\lambda_y^{*,A}$ values from **1973** to **2008** are as estimated in the assessment.

The historical random effects $\varepsilon_{A,y}$ are treated as estimable parameters in the assessment (in addition to the three λ^A parameters), but are constrained through the addition of a penalty function in the log likelihood related to the assumption that they are normally distributed.

From these $\varepsilon_{A,y}$, the σ_ε^A (the standard deviation) and s_λ^A (the auto-correlation) can be calculated:

$$s_\lambda^A = \sum_{y=1973}^{y=2007} \hat{\varepsilon}_{A,y+1}\, \hat{\varepsilon}_{A,y} \Big/ \sum_{y=1973}^{y=2007} \hat{\varepsilon}_{A,y}^2, \tag{7}$$

$$\sigma_\lambda^A = \sqrt{\left[\sum_{y=1973}^{y=2007} \hat{\varepsilon}_{A,y}^2\right] / (2007 - 1973 + 1)} \tag{8}$$

For 2009+, $\lambda_y^{*,A,s}$ need to be generated where for each year:

$$\lambda_y^{*,A,s} \rightarrow \frac{\lambda_y^{*,A,s}}{\sum_{A=1}^{3} \lambda_y^{*,A,s}} \qquad \text{so that proportions sum to 1} \tag{9}$$

where *s* is the simulation index.

The $\lambda_y^{*,A,s}$ are generated from $\hat{\lambda}^A e^{\varepsilon_y^{A,s}}$, where:

$$\varepsilon_{y+1}^{A,s} = s_\lambda^A \varepsilon_y^{A,s} + \sqrt{1 - {s_\lambda^A}^2}\, \eta_y^{A,s} \qquad \text{with } \eta_y^{A,s} \text{ from } N(0,(\sigma_\varepsilon^A)^2).$$

The values required to initiate the projections are obtained by updating equation (2) as follows:

$$\hat{N}_{2018,a} \rightarrow \hat{N}_{2018,a} e^{\varepsilon_{2018-a}} \lambda_{2018-a}^{*A,s} \qquad \text{for } a = 1,2,3,4 \text{ (i.e. } \lambda \text{ generated)} \tag{10}$$

$\rightarrow \hat{N}_{2018,a} e^{\varepsilon_{2018-a}} \hat{\lambda}^{A,s}_{2018-a}$ for *a* = 5,6,7 (i.e. λ as estimated in assessment)

Future split of catch between areas

For 2018+, the total TAC for each season is split between the three areas as follows:

$$C^A_y = C^T_y \frac{\bar{F}^A B^A_{exp,y}}{(\bar{F}^{A1E} B^{A1E}_{exp,y} + \bar{F}^{A1W} B^{A1W}_{exp,y} + \bar{F}^{A2+3} B^{A2+3}_{exp,y})} \tag{11}$$

where

$$\bar{F}^A = \frac{\sum_{y=2012}^{y=2016} F^A_y}{5} \tag{12}$$

Selectivity

The RC assessment model assumes constant selectivity for areas A1E and A1W, but time-varying selectivity for A2+3. The selectivity function is:

$$S^{m/f,A}_{y,l} = \frac{e^{-\mu^{m/f,A}.l}}{1 + e^{(-\delta^{m/f,A}(l - l^{m/f,A}_*)}} \tag{13}$$

Thus there are three estimable parameters for each sex and each area (μ, δ and l*).

For Area A1E and A1W – selectivity is assumed to remain constant over time.

For Area A2+3 selectivity is allowed to vary over time for the period for which there are catch-at-length data (1995-2015).

Thus for Area 2+3 and for y=1995-2015:

$$l^m_* \rightarrow l^m_* + \varepsilon^m_{l*,y} \qquad \varepsilon^m_{l*,y} \sim N(0, \sigma^2_{l*,m})$$

$$l^f_* \rightarrow l^f_* + \varepsilon^f_{l*,y} \qquad \varepsilon^f_{l*,y} \sim N(0, \sigma^2_{l*,f})$$

$$\mu^m \rightarrow \mu^m + \varepsilon^m_{\mu,y} \qquad \varepsilon^m_{\mu,y} \sim N(0, \sigma^2_{\mu,m})$$

$$\mu^f \rightarrow \mu^f + \varepsilon^f_{\mu,y} \qquad \varepsilon^f_{\mu,y} \sim N(0, \sigma^2_{\mu,f})$$

$$\delta^m \rightarrow \delta^m + \varepsilon^m_{\delta,y} \qquad \varepsilon^m_{\delta,y} \sim N(0, \sigma^2_{\delta,m})$$

$$\delta^f \rightarrow \delta^f + \varepsilon^f_{\delta,y} \qquad \varepsilon^f_{\delta,y} \sim N(0, \sigma^2_{\delta,f})$$

For future stochastic projections (2016+), the six parameters above are assumed to change from year to year as an AR1 process.

Thus for 2016+: $\delta_y^{m/f,A,s} = \bar{\delta}^{m/f,A} + \eta_y^{m/f,A,s}$ (14)

where $\eta_{y+1}^{m/f,A,s} = s_\delta^{m/f,A} \eta_y^{m/f,A,s} + \sqrt{1 - {s_\delta^{m/f,A}}^2}\, \chi_y^s$ (15)

with χ_y^s from $N(0, (\sigma_\delta^{m/f,A})^2)$

where the auto-correlation $s_\delta^{m/f.A} = \left[\sum_{y=1995}^{y=2014} \hat{\eta}_{y+1} \hat{\eta}_y\right] / \sum_{y=1995}^{2014} \hat{\eta}_y^2$ (16)

and where $\bar{\delta}^{m/f,A}$ and $\sigma_\delta^{m/f,A}$ are calculated as the mean and standard deviation of the estimates from 1995 to 2015.

The other parameters are treated in a similar manner.

Allowing for fleet movement if CPUE in an area is too small to be economically viable

Following a task group meeting, OLRAC (pers. commn) provided a plot showing the percentage of total SCRL effort from each area against the catch (kg tails) per day for that area. This plot suggested that industry would move out of an area if catch rates dropped below 180 kg tails per day. Rules reported in Table 1 were developed on this basis for use in splitting the total TAC between the three areas. **Note that these rules are for simulation purposes only, and that no regulation of TAC at a area level is implied here. A number of such scenarios were examined in initial simulation testing for OMP-2014.**

Taking account of the TAE restriction

The total TAC for the resource set using the OMP is TAC_y. An average of the "observed" CPUEs (weighted average of CPUE values for three areas) over y-2, y-3 and y-4 period) is denoted by $\overline{CPUE_y}$.

The threshold CPUE, $CPUE_{thresh} = \frac{\overline{CPUEy}}{D} = \frac{\overline{CPUEy}}{1.555} =$ where the value of *D* (1.555) is as used in the OLRAC TAE calculations (OLRAC cc 2011).

During the simulations, $CPUE_y$ is generated from operating model including error. Then:

IF $CPUE_y > CPUE_{thresh}$ $\quad TAC_y \rightarrow TAC_y$

IF $CPUE_y \leq CPUE_{thresh}$ $\quad TAC_y \rightarrow TAC_y * \frac{CPUE_y}{CPUE_{thresh}}$ (17)

so that the TAE limitation is respected.

Future data generation

Future CPUE values need to be generated. There are always model estimates for $CPUE_y^A$ for past years. Projected into the future, the model provides expected $CP\hat{U}E_y^A$ values for each year and area. Future (2016+) CPUE values for simulation *s* are generated for each area A from:

$$CPUE_y^{A,s} = CP\hat{U}E_y^{A,s} \exp(\varepsilon_y^{A,s}) \qquad \varepsilon_y^{A,s} \sim N(0, (\sigma_{CPUE}^A)^2)) \tag{18}$$

where the σ_{CPUE}^A values are as estimated in the corresponding assessment.

Robustness testing

A set of robustness will be developed against which candidate OMPs will be simulation tested.

Summary Statistics

Note that the units of the target CPUE are “GLM-standardised” units. A calibration coefficient of 259 is used to convert the CPUE target into tails kg per day, to provide results which are more meaningful to the industry. Output statistics that were reported in the previous OMP testing were:

- $CPUE_{targ}$: Catch per unit effort in GLM units (kgs per trap)
- $CPUE_{targ}$ in industry units: $CPUE_{targ}$ x 259 (units are kg tails per day)
- CPUE threshold: the CPUE level (in industry units) in a area below which it is assumed in the projections that catches are transferred out of that area to the other areas.
- CPUE(2025): the median estimated CPUE in 2015.
- Bsp(2025/2006): the spawning biomass in 2025 relative to 2006 (this values was used to tune the different OMP candidates).
- Bsp(2025/K): the spawning biomass in 2025 relative to the unfished (pristine) spawning biomass.
- Cav(2014-2025): the average catch over the 2014-2025 period.
- AAV: the average (over 2014-2015) inter-annual catch variation (expressed as %). Note that all OMPs considered assumed a maximum inter-annual TAC change constraint of 5%.
- B^{exp}(2025)/K: the exploitable biomass in 2025 relative to the unfished pristine exploitable biomass (reported for each area).
- Effort(2025/2014): the effort in 2025 relative to the effort in 2014.
- CPUE(2025): the median estimated CPUE in 2025.

- Effort(2025/2014): the effort in 2025 relative to the effort in 2014. Here effort is simply calculated as "Catch/CPUE".
- Size structure of the catch in 2014 and 2015 expressed as the proportion of catch in each size class. These statistics were reported to see if there is a change in the expected catch size composition over time. Size structures were reported for each area individually. The catch proportions for each size class were averaged over the 1000 simulations, and the male and female proportions were summed.

It is suggested that these statistics be considered for revision following possible modifications.

OMP-2019: initial rules to be tested

A target-based OMP similar to OMP-2014 is suggested. 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 had as its target a median spawning biomass increase of 30% by 2025 relative to the 2006 value, i.e. *Bsp*(2025/2006)=1.30.

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:

$$TAC_{y+1} = TAC_y[1 + \alpha \frac{\overline{CPUE}_y - CPUE_{targ}}{CPUE_{targ}}] \qquad (19)$$

where $\overline{CPUE}_y$ is a measure of recent CPUE and is calculated as follows:

$$\overline{CPUE}_y = \frac{1}{3}\sum_{y'=y-3}^{y-1}\sum_{A=1}^{3}\lambda_A CPUE_{y'}^{A} \qquad (20)$$

where

$CPUE_{y'}^{A}$ is the GLM standardised CPUE for area *A* in year y' , and

the CPUE weighting factors, $\lambda_{A1E}, \lambda_{A1W}$ and λ_{A2+3} 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 for OMP-2014) from the RC model to be:

$$\lambda_{A1E} = 0.003$$
$$\lambda_{A1W} = 0.128$$
$$\lambda_{A2+3} = 0.868$$

[Note: OMP-2019 would update these values which would now pertain to 2016]

$CPUE_{targ}$ = **1.22 –** this value resulted in the median *Bsp*(2025/2006)=1.30, the selected biomass target for OMP-2014 under the RC operating model.

Note that TAC_y is the TAC set (not necessarily the catch taken) in season *y*.

The tuning parameter α controls how responsive the OMP is to CPUE deviations from the CPUE target, and for OMP-2014 was set at 1.0.

Note that the TAC for season *y*+1 is to be based upon the CPUE series that ends in season *y*-1, i.e. the TAC recommendation for the 2018 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 2018) which would now be the 2016 season.

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 was applied in previous OMPs, i.e.:

$$\text{if } TAC_{y+1} > 1.05 TAC_y \qquad TAC_{y+1} = 1.05 TAC_y \tag{21}$$

$$\text{if } TAC_{y+1} < 0.95 TAC_y \qquad TAC_{y+1} = 0.95 TAC_y$$

Maximum CAP on TAC

A maximum cap on TAC in any year in the future was set at 450 MT for OMP-2014.

References

Johnston, S.J and Butterworth, D.S. 2019. The 2018 South Coast rock lobster Reference case operating Model. FISHERIES/2019/APR/SCRL/01.

Johnston, S.J and Butterworth, D.S. 2019. 2018 updated South Coast rock lobster assessment results. FISHERIES/2019/APR/SCRL/02.

OLRAC cc, 2011. Methodology for effort control in the South Coast rock lobster fishery. FISHEREIS/2011/AUG/SWG/SCRL/05.

Table 1. Rules used in OMP-2014 OMP simulation testing for shifting the TAC amongst areas for which catch rates are below 180 kg tails per day (for simulation purposes only).

Scenario	CPUE_ind (y-1) (kg tails per day)			Catch (y+1)		
	A1E	A1W	A23	A1E	A1W	A23
1	<=180	<=180	<=180	0	0	0
2	<=180	<=180	>180	0	0	A1E+A1W+A23
3	<=180	>180	<=180	0	A1E+A1W+A23	0
4	<=180	>180	>180	0	A1W+($A1E * \frac{A1W}{A1W+A23}$)	A2+3+($A1E * \frac{A23}{A1W+A23}$)
5	>180	<=180	<=180	A1E+A1W+A23	0	0
6	>180	>180	>180	A1E	A1W	A2+3
7	>180	<=180	>180	A1E+($A1W * \frac{A1E}{A1E+A23}$)	0	A2+3+($A1W * \frac{A23}{A1E+A23}$)
8	>180	>180	<=180	A1E+($A23 * \frac{A1E}{A1E+A1W}$)	A1W+($A23 * \frac{A1W}{A1E+A1W}$)	0