

## Comparison between methods of estimating future recruitment for west coast rock lobster projections for super-area A8+

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### Abstract

Initial applications of alternative approaches to forward projection of the rock lobster abundance in super-area A8+, based on suggestions made at the 2018 international workshop (IWS), are presented.

Following the IWS in December 2018 some new methods for estimating future recruitment for projections based on the west coast rock lobster stock assessment were suggested. The IWS report reads:

“The projections used to select WCRL TACs consistent with avoiding further decline were implemented by projecting poaching at current levels and the central tendency of recent recruitment (given by the geometric mean) forward through to 2025. These projections could be improved in several ways: (a) bias-correct the geometric mean assuming log-normality, (b) use an arithmetic mean recruitment, (c) use bootstrap samples of the empirical distribution of recruitment values in the projections, or (d) preferably by re-parameterizing the 1975-2017 recruitment parameters via an estimated mean level ( $\bar{R}$ ) multiplied by annual recruitment deviates. This last parameterization would enable projections via randomly selecting recruitment values from their estimated distribution. Even so, further potential declines are predicted without a substantial reduction in both catch and poaching.”

It is suggestion (d) that is pursued below for super-area A8+, after first summarising the approach used last year.

### The 2018 assessment method:

#### *Estimation and projection of recruitment*

Recruitment was modelled as for previous assessments and projections. Historically recruitment was assumed to change linearly between a set of estimated recruitment values over time. Thus, past recruitments were estimated for each super-area for the years indicated by the following list of parameters:

- R1910, R1920, R1950, R1970, R1975, R1980, R1985, R1990, R1995, R1998, R2001, R2004, R2007 and R2010, where furthermore
- the R2007 and 2010 values were constrained by a penalty added to the  $-\ln L$  based on the geometric mean as follows:

$$pen1 = \frac{1}{2} \frac{(\ln R_{2007} - \ln \bar{R})^2}{\sigma_R^2} \quad \text{and}$$

$$pen2 = \frac{1}{2} \frac{(\ln R_{2010} - \ln \bar{R})^2}{\sigma_R^2} \quad \text{where}$$

$$\sigma_R^2 = \frac{\sum_{y=1975}^{y=2010} (\ln R_y - \ln \bar{R})^2}{9}$$

and finally

- all recruitments were constrained to be less than R1910.

Then for the (deterministic) projections reported last year:

- R2013+ values were set equal to the **geometric mean ( $\bar{R}$ )** of the R1975, R1980, R1985, R1990, R1995, R1998, R2001, R2004, R2007 and R2010 estimated values for the super-area in question.

This projection approach had a number of problems (some as identified by the IWS).

- Being deterministic, rather than based on stochastic sampling from past recruitments as in earlier analyses for OMPs, it needed to have used the mean rather than the median of these past recruitments to better reflect average past resource productivity into the future.
- The R2007 and R2010 values were not dealt with appropriately in the estimation.
- In estimating a median (or average), account needed to be taken of the lesser precision of the more recent estimates of recruitment.

#### The new 2019 assessment method:

*Note initial results only are reported at this stage, pending the provision of new data from the last season*

The 2018 method estimated:

$R_{1910}, X_{1920}, X_{1950}, X_{1970}, X_{1975}, X_{1980}, X_{1985}, X_{1990}, X_{1995}, X_{1998}, X_{2001}, X_{2004}, X_{2007}$  and  $X_{2010}$ ,

where  $x_y = \frac{R_y}{R_{1910}}$ . [14 estimable parameters]

#### NOW

Estimate  $R_{1910}, x_{1920}, x_{1950}$  [3 estimable parameters]

Estimate  $\bar{x} = \sum_{y=1970}^{y=2010} (x_y) / 11$  [1 estimable parameter]

Estimate for  $y=1970\dots 2010$ :  $x_y = \bar{x} e^{\varepsilon_y - \sigma_R^2/2}$  [11 estimable  $\varepsilon_y$  parameters]

Add to the  $-\ln L$  a penalty which is

$$\frac{1}{2\sigma_R^2} \sum_{y=1970}^{y=2010} \varepsilon_y^2$$

Note this estimating  $\bar{x}$  directly in this way takes account of the different precisions with which the individual assessments are estimated.

For the new deterministic projections reported below, R2013+ values are set equal to  $\bar{x}$ . Furthermore (Johnston and Butterworth, 2018):

- Future poaching is assumed as per the BC (Scenario 5) poaching scenario
- Future commercial catches are 717 MT for the 2018 season and 161 MT for 2019+ seasons.

## RESULTS

The value the current A8+ 2018 model gives a value for  $\sigma_R$  (for 1970 ... 2010) of 0.24, thus  $\sigma_R^2 = 0.0577$ .

However, results fixing this parameter in this way were unsatisfactory, failing to adequately represent recent trends in abundance indices (and in particular the recent slight upturn in the trap and hoopnet indices). For the moment then, results are shown for  $\sigma_R$  set equal to **0.50** and **1.00**.

Past results for the 2018 and initial results for the new 2019 approach are given in Table 1 and Figure 1, where the latter compares recruitment estimates, fits to abundance indices and deterministic projections.

Work is in progress on extending the new approach to the other super-areas. Abundance indices for the 2018/9 season will also be taken into account as soon as available.

## REFERENCE

Johnston, S.J. and Butterworth, D.S. 2018. Projections of the west coast rock lobster resource under different poaching and future catch scenarios. MARAM/IWS/2018/WCRL/P4.

Table 1: A8+ results.

|                             | 2018 Assessment method<br>( $\sigma_R = 0.24$ ) | 2018 Assessment method<br>( $\sigma_R = 0.24$ ) | 2019 assessment method<br>$\sigma_R$ fixed = <b>0.50</b> | 2019 assessment method<br>$\sigma_R$ fixed = <b>1.00</b> |
|-----------------------------|-------------------------------------------------|-------------------------------------------------|----------------------------------------------------------|----------------------------------------------------------|
| # estimable parameters      | 31                                              | 31                                              | 32                                                       | 32                                                       |
| -lnL total (T=D+R)          | -68.471                                         | -68.471                                         | -58.85                                                   | -66.56                                                   |
| -lnL from data (D)          | -69.385                                         | -69.385                                         | -68.55                                                   | -69.65                                                   |
| R penalties (R)             | 0.914                                           | 0.914                                           | 6.70                                                     | 3.08                                                     |
| Trap CPUE -lnL ( $\sigma$ ) | -38.93 (0.180)                                  | -38.93 (0.180)                                  | -37.11 (0.190)                                           | -38.53 (0.182)                                           |
| Hoop CPUE -lnL ( $\sigma$ ) | -38.18 (0.177)                                  | -38.18 (0.177)                                  | -37.27 (0.182)                                           | -38.53 (0.175)                                           |
| FIMS CPUE -lnL ( $\sigma$ ) | -14.43 (0.341)                                  | -14.43 (0.341)                                  | -15.31 (0.329)                                           | -14.25 (0.343)                                           |
| R_2004                      | 0.703                                           | 0.703                                           | 0.594                                                    | 0.642                                                    |
| R_2007                      | 0.790                                           | 0.790                                           | 0.687                                                    | 0.851                                                    |
| R_2010                      | 0.382                                           | 0.382                                           | 0.371                                                    | 0.373                                                    |
| $\bar{x}$                   | (0.357)                                         | 0.357<br>Used for<br>projections                | 0.376 (used<br>for<br>projections)                       | 0.380 (used<br>for<br>projections)                       |
| Geometric mean 1975..2010   | 0.316 (used for<br>projections)                 | 0.316                                           | NA                                                       | NA                                                       |
| B75m(1996) (B75m(1996)/K)   | 10 590 (0.057)                                  | 10 590 (0.057)                                  | 11 459 (0.059)                                           | 10 681 (0.056)                                           |
| B75m(2006) (B75m(2006)/K)   | 8 201 (0.044)                                   | 8 201 (0.044)                                   | 8 776 (0.046)                                            | 8 168 (0.043)                                            |
| B75m(2018) (B75m(2018)/K)   | 5 589 (0.030)                                   | 5 589 (0.030)                                   | 5 266 (0.027)                                            | 5 651 (0.029)                                            |
| B75m(2025)/B75m(2006)       | 0.873                                           | 1.332                                           | 0.785                                                    | 1.012                                                    |
| B75m(2030)/B75m(2006)       | 0.757                                           | 1.952                                           | 0.870                                                    | 1.060                                                    |
|                             | Om18n.for tue.res                               | Om18n.for am8.res                               | Om19n.for t3.res                                         | T5.res                                                   |

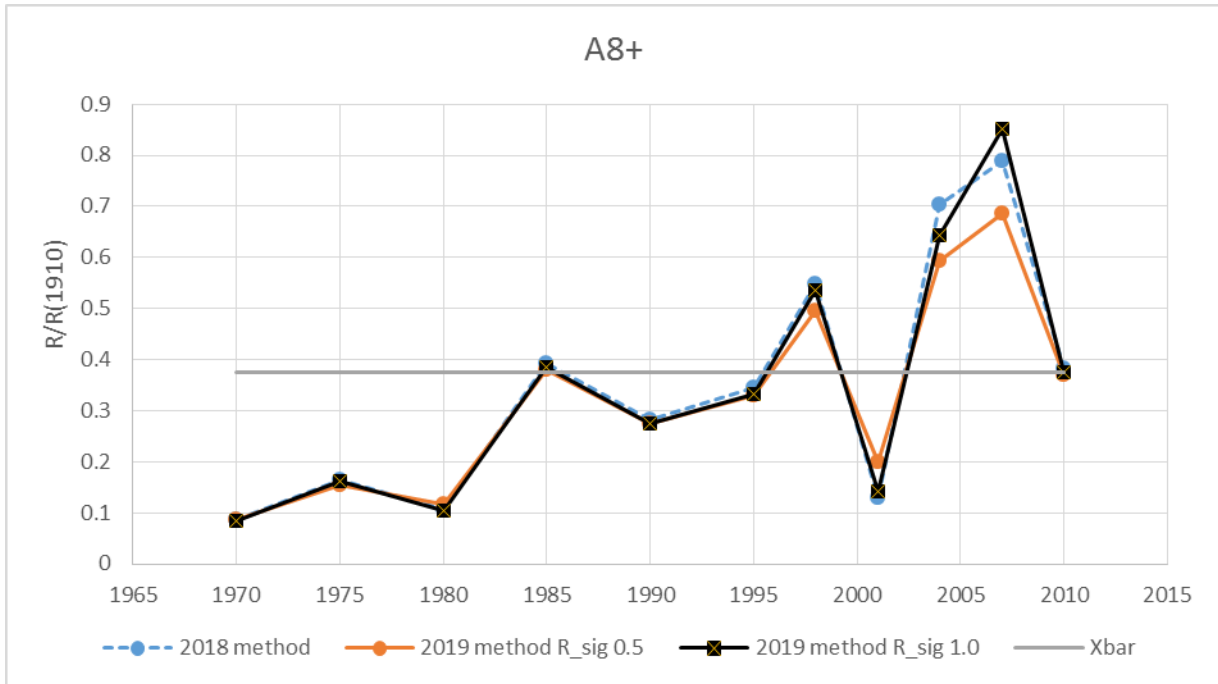


Figure 1a: R estimates from the A8+ 2018 assessment and the 2019 assessment with  $\sigma_R=0.50$  and **1.00**.

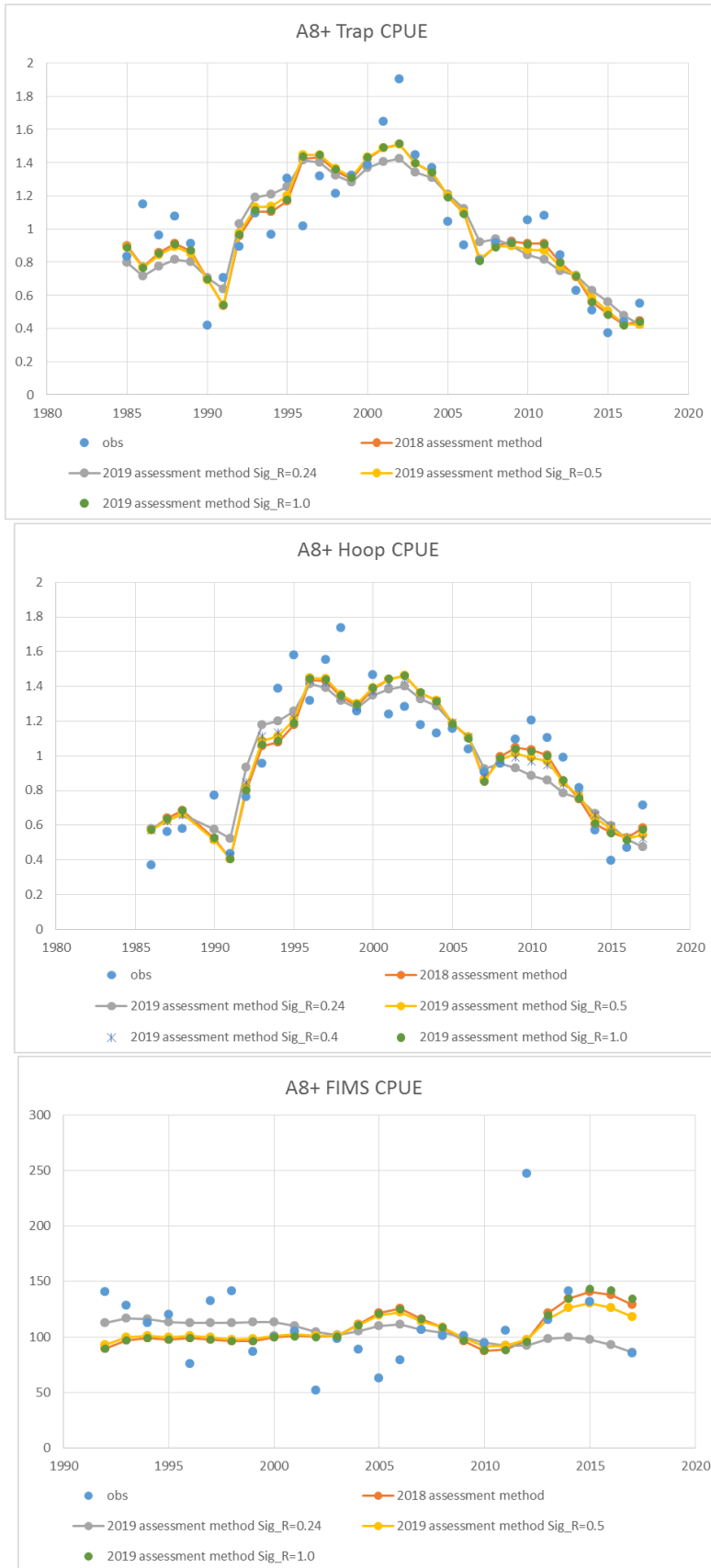


Figure 1b: Comparison of fits to A8+ CPUE for the four different assessment methods.

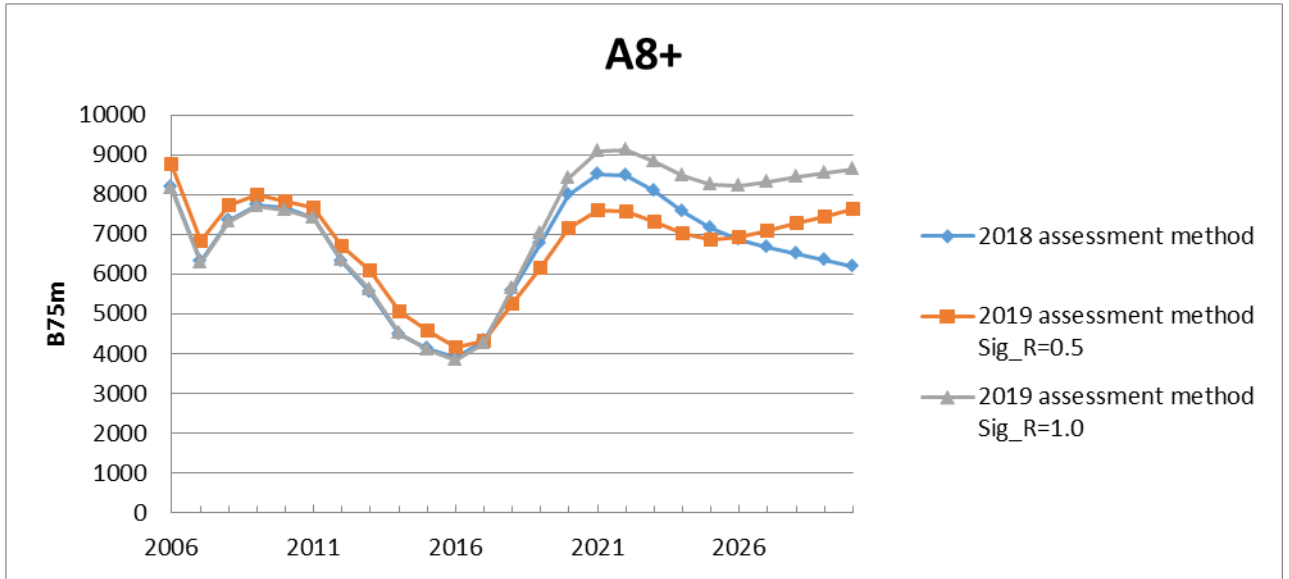


Figure 1c: Comparison between the A8+ B75m trajectories (for 2006-2030) of the different methodologies.