Underlying assumptions for the area-disaggregated stock assessment of west coast rock lobster

S.J. Johnston and D.S. Butterworth

MARAM
Department of Mathematics and Applied Mathematics
University of Cape Town
Rondebosch, Cape Town

Introduction

The West Coast resource is divided into the following "super" areas:
Area 1-2: The most Northern region – only a very small tonnage is currently caught in this area.
Area 3-4 (Areas 3 and 4 only)
Area 5-6 (Areas 5 and 6 only)
Area 7 (Dassen Island), and
Area 8+ (areas to the south and east of Dassen Island, which include Area 8 (Cape Point), Area 10 (Hout Bay), Area 11 (False Bay), and Areas 12-14 (East of Hangklip).

Figure 1 illustrates the West Coast rock lobster fishing zones and areas.

Various methods have been used to collate data from Areas 3, 4, 5 and 6 to produce values for the "super" Area 3-6.

Note that the convention used here for referring to split seasons is to quote only the first of the two years for each split season, i.e. the 1992/93 season is referred to here as "1992".

A size-structured modelling approach (as described in RLWS/DEC05/ASS/7/1/2) is used to model the dynamics of each super-areas independently.

The area-disaggregated modelling approach assumes that recruitment from each area remains in that area and that there is no immigration or emigration between areas (of larvae or adults).

General model features

A number of recommendations were made at the December 2005 Rock Lobster International Workshop relating to improving the current assessment model. Most of the suggestions were aimed at simplifying the population dynamics model in order to speed up the time it takes the model to fit to data.

The area-disaggregated models have thus been modified to include:

1) Sparse matrix multiplication

Programming efficiency can be improved when multiplying sparse matrices. The authors modified the code so that this was achieved.

2) Increasing the first year of the model from 1870 to 1910

The authors explored changing the existing 1870+ model into a 1910+ model, since very little catch occurred between 1870-1910. For each area, the 1870-1910 catches were summed, and then divided by 10. These catches were then added to each year from 1910-1919, thus the total catch over the 1910-1919 period is identical to the 1870-1919 period.

3) Placing lower bounds on the residual variances

The residual variances for several of the data sources for several of the areas in the spatially-disaggregated assessment are unrealistically low, indicating the possibility of over-fitting. The authors thus imposed a lower bound of 0.15 on all the σ values for all data sources in the model fitting procedure.

Note also that:
- The recruitment in 2000, R_{2000}, is now an estimable parameters
- R2005+ is calculated from the geometric mean of R_{75}, R_{80}, R_{85}, R_{90} and R_{95}.

Reference case and alternate models

After much discussion, a task group (consisting of Bergh, Butterworth, Jacobs and Johnston) decided that the most desirable method for producing two alternate models reflecting recent recruitment uncertainty for each super-area would be as follows:

To run the reference case model with the following penalty function added to the $-ln$L (this reflects "shrinkage to the mean". or in Bayesian terms using a prior that reflects the recent past distribution of recruitments):

$$pen = \frac{1}{2}\left(\ln R_{2000} - \ln \overline{R}\right)^2 / \sigma^2 \tag{1}$$

where

$$\ln \overline{R} = \frac{1}{5}\sum_{y=1975}^{1995}\ln R_y \tag{2}$$

$$\sigma^2 = \frac{1}{4}\sum_{y=1975}^{1995}\left(\ln \overline{R} - \ln R_y\right)^2 \tag{3}$$

The two alternate models (Alt1 and Alt2) are virtually identical to the RC model, except with regards to the R_{2000} value. For the RC model R_{2000} is an estimable parameter, although it was found to be estimated with very low precision (for Area 8 the 95% CI was 0.0001-1.65), and so is demonstrated in the estimation by the contribution from equation (1). For this reason, Alt1 and Alt2 models would correspond almost exactly to the RC best fit parameter values except for R_{2000} which would be fixed at the (approximate) upper and lower 25%iles of this distribution as follows:

$$\ln R_{2000}^{alt1} = \ln \hat{R}_{2000}^{RC} + \sigma\alpha \tag{4}$$

and

$$\ln R_{2000}^{alt2} = \ln \hat{R}_{2000}^{RC} - \sigma\alpha \qquad (5)$$

where σ is from equation (2) above, and the α value (0.741) corresponds to the 25%iles of a t-distribution with the appropriate number of degrees of freedom.

Area-disaggregated modelling assumptions

Historic Catch Record

For the area-disaggregated assessments, the Roy Melville-Smith catch record (i.e. pre-1968 period) is to be split for the different areas as follows:

$$C_{c,t}^{1-2} = 0.20 * C_{c,t}^{T}$$

$$C_{c,t}^{3-6} = 0.50 * C_{c,t}^{T}$$

$$C_{c,t}^{7} = 0.20 * C_{c,t}^{T}$$

$$C_{c,t}^{8} = 0.10 * C_{c,t}^{T}$$

where $C_{c,t}^{T}$ is the total commercial (Melville-Smith) catch for season t. When A3-6 is further divided into A3-4 and A5-6, a 40:60 split of the A3-6 catches is assumed for these two regions respectively. Figure 2 shows the MCM reported catches (expressed as % of the total west coast catch) for each "super-area" (1968+) upon which the above "historic" divisions were based upon, in conjunction with the knowledge that there has been a "fishing-down" of the resource from the North to the South over time.

The MCM database catch record is to be used for the period 1968-2005. This database provides commercial catches for each area.

Recreational catch data

Estimates, based upon telephone surveys, of the percentage breakdown for the "super" areas of the total annual recreational catches are as follows:

Area 1-2: 0 %
Area 3-6: 15% [this is further split equally into Area 3-4 and Area 5-6]
Area 7: 5%
Area 8: 80%

Poaching

The total poaching take from the resource is assumed to be divided into the super-areas as follows:
Area 1-2:   0%
Area 3-6:   5% [this is further split equally into Area 3-4 and Area 5-6]
Area 7:   15%
Area 8+:   80%

Somatic Growth rate

Somatic growth data used in these assessments are from a moult probability model which provides a somatic growth series for each of the "super" areas for the 1968-2004 period. For the historic period (1910-1967) the average of the available data (1968-2004) is assumed. Note that for super-area A1-2 future somatic growth, the 1985-2004 average is used (the somatic growth series for this region starts only in 1985).
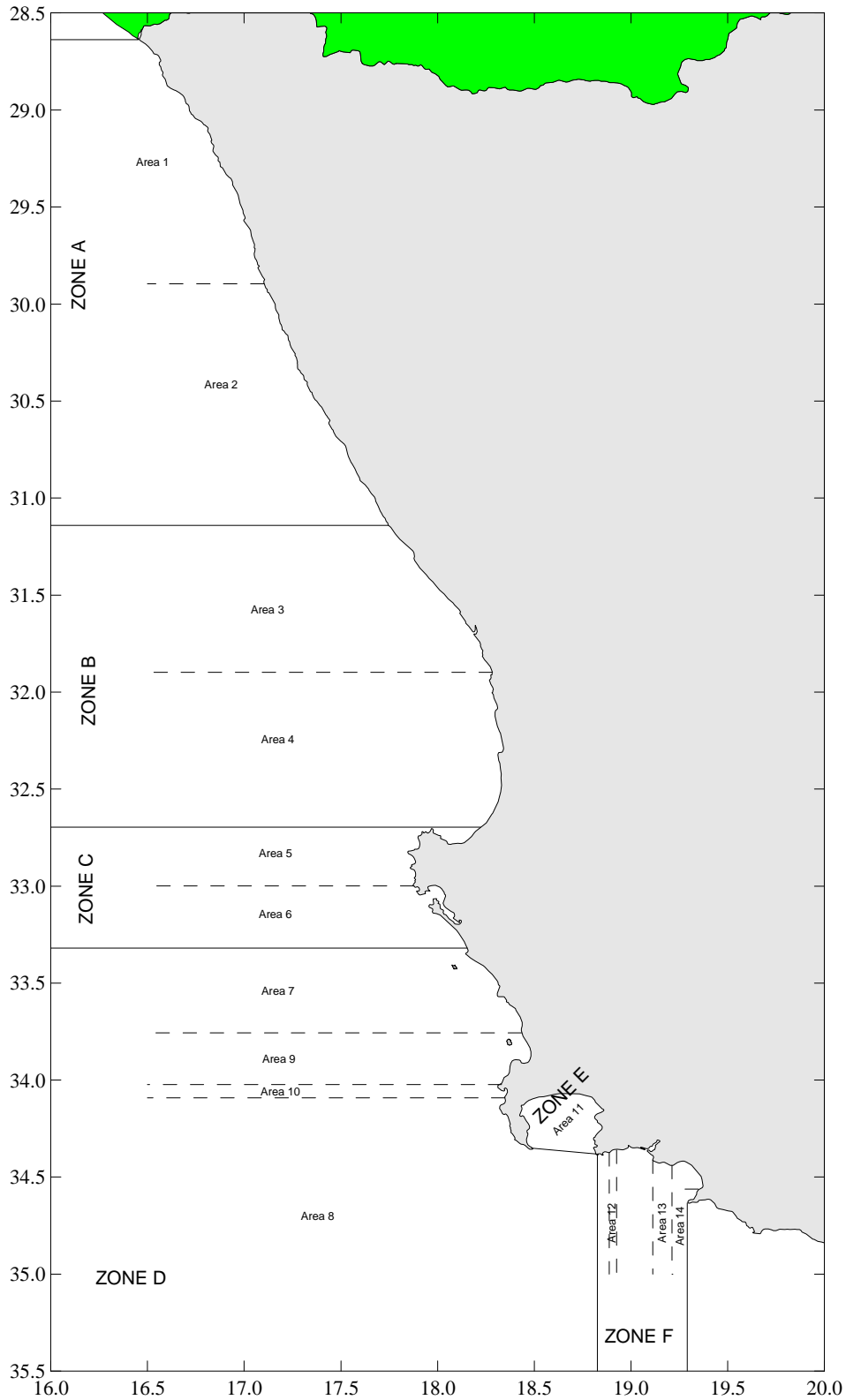
Figure 1: West coast rock lobster fishing zones and areas.

Figure 2: Super-area percentage breakdown of the total west coast catch.