Allowing for Time-varying Selectivity in South Coast Rock Lobster Assessments

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The Reference Case (RC) age-structured production model that has been used for past South Coast rock lobster assessments (ASWS/JUL07/SCRL/ASS/1) has assumed a time-invariant age-specific selectivity function. Previous work allowing the possibility of deviations from this assumption has used a model identical to the RC model, except that the age-specific selectivity function is allowed to vary over the time period for which catch-at-age data are available (1994 to y_{recent}). To effect this, the form of the selectivity function was generalised to:

$$S_{y,a} = \frac{1}{1+e^{-K(a-(a50+\delta_y))}} \quad \text{where } K = \frac{\ln 19}{\Delta} \tag{1}$$

The estimable parameters are thus: $a50$ (the expected age at 50% selectivity), Δ and δ_y for y = 1994 to y_{recent} (excluding 1999 as there are no catch-at-age data for 1999). Note that the expected age at 95% selectivity ($a95$) is given by $a50+\Delta$.

It is also assumed that for y<1994, 1999, and (y_{recent}+1)+ the δ_y = 0.

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

$$-\ln L \to -\ln L + \sum_{y=1994}^{y=yrecent} \left(\frac{\delta_y}{\sigma_{sel}}\right)^2 \text{ (sum excludes 1999)} \tag{2}$$

where the σ_{sel} is input (a value of 0.75 was found to provide reasonable performance). It may appear from the form of equation (1) that there is a confounding between $a50$ and δ_y as δ_y is estimated for every year for which there are catch-at-age data input to the model. This is however not the case (otherwise the term added in expression (2) would secure a mean at the estimated δ_y's of zero). The reason is that δ_y is set to zero for other years, to which $a50$ then applies, and this then influences the model estimated CPUE (equation (3) below) for those years, which in turn impacts the overall value of the likelihood.

Another issue is that for equation (1), if δ_y decreases, this means that selectivity is increasing on younger lobsters, while given that the model fitting procedure assumes that

$$C\hat{P}UE_y = q\sum_a w_a S_{y,a} N_{y,a} \quad (3)$$

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:

$$S_{y,a} \rightarrow S^*_{y,a} = S_{y,a} / X_y \quad (4)$$

where as a simple initial approach previous analyses used the form:

$$X_y = \sum_{a1}^{a2} \frac{S_{y,a}}{a2 - a1 + 1} \quad (5)$$

i.e., normalising selectivity by its average over a certain age range, so that now if δ_y decreases, the $S^*_{y,a}$ will decrease for large *a* to compensate for the effort spread to locations where younger animals are found associated with the increase for smaller *a*.

Equations (4) and (5) reflect a special case of a more general form used in southern bluefin tuna assessments (CCSBT, 2003):

$$S_{y,a} \rightarrow S^*_{y,a} = \left[S_{y,a} / \left\{ \sum_{j=a1}^{a2} S_{y,j} / (a2 - a1 + 1) \right\} \right]^{\psi} \quad (6)$$

Previous analyses experimented with choices for *a*1 and *a*2. A choice of *a*1=8 and *a*2=12 as a standard gave reasonable performance.

Reference

CCSBT. 2003. Report of the Second Meeting of the Management Procedure Workshop, 7-15 April, 2003., Queenstown, New Zealand. Commission for the Conservation of Southern Bluefin Tuna, Hobart, Australia.