SOME MODIFICATIONS TO THE CURRENT ADAPT-VPA MODEL FOR ANTARCTIC MINKE WHALES

MITSUYO MORI[1], DOUGLAS S. BUTTERWORTH[2]

1. The Institute of Cetacean Research, 4-5 Toyomi-cho, Chuo-ku, Tokyo, 104-0055, Japan

2. MARAM, Department of Mathematics and Applied Mathematics, University of Cape Town, Rondebosch 7701, South Africa

Contact e-mail: mori@cetacean.jp

ABSTRACT

The current ADAPT-VPA model of Mori *et al.* (2007) for Antarctic minke whales in Areas IIIE to VW is modified in two respects. One is the revision of the stock-recruitment relationship, and the other is the simplification of the functional form of the carrying capacity. AIC indicates that the model which includes the above two modifications is better compared to the “Reference case” scenario of Mori *et al.* (2007). Thus, future analyses will regard this modified version as a new “Reference case” scenario, which has the incidental advantage of corresponding more closely to the assumptions made in the SCAA (Statistical Catch at Age) approach of Punt and Polacheck (2006) to analysis of these data.

KEYWORDS ADAPT-VPA, CATCH-AT-AGE, NATURAL MORTALITY, ANTARCTIC MINKE WHALE

INTRODUCTION

This study is a continuation of the series of studies since Butterworth *et al*. (1999) (Butterworth *et al*. 2002, Mori and Butterworth 2005, Mori *et al*. 2006, Mori *et al*. 2007) and has modified the most recent analyses for Antarctic minke whales in Areas IIIE to VW (the I-stock) (Mori *et al*. 2007) in two respects:

1) Improvement of the stock-recruitment relationship; and
2) Simplification of the functional form of carrying capacity.

DATA

The data used are exactly the same as in Mori *et al*. (2007).

METHODOLOGY

The methodology used is exactly the same as in Mori *et al*. (2007) except in two respects. One is that equation (6) on Mori *et al*. (2007) which describes the assumed stock-recruitment relationship as follows:

$$N_{y+1,1} = \lambda \cdot N_y^f \left[1 + A\left\{ 1 - \left(\frac{N_y^f}{K_y^f} \right)^z \right\} \right] \qquad (1)$$

is modified as below:

$$N_{y+1,1} = \lambda \cdot N_y^f \left[1 + A \left\{ 1 - \left(\frac{N_y^{1+}}{K_y^{1+}} \right)^z \right\} \right] \quad (2).$$

The basis for this modification is that traditionally in the IWC Scientific Committee, it is usual to assume $\frac{N_y^{1+}}{K_y^{1+}}$ instead of $\frac{N_y^f}{K_y^f}$ for the density dependence on recruitment, i.e. that this dependence is on the 1+ rather than the mature female component of the population. Further, similar density dependence is assumed in the SCAA approach of Punt and Polacheck (2006), and this makes it easier to compare results between their method and this ADAPT-VPA approach.

The second modification concerns the functional form adopted for the change in carrying capacity over time. The functional form assumed in Mori *et al*. (2007) is as follows:

$$\tilde{K}_y^f = \begin{cases} K_1^f & y \le y_1 \\ K_1^f + \frac{\left(K_2^f - K_1^f\right)}{\left(y_2 - y_1\right)^\gamma}\left(y - y_1\right)^\gamma & y_1 + 1 \le y \le y_2 \\ K_2^f + \frac{\left(K_3^f - K_2^f\right)}{\left(y_3 - y_2\right)}\left(y - y_2\right) & y_2 + 1 \le y \le y_3 \\ K_3^f & y_3 + 1 \le y \end{cases} \quad (3)$$

with the following choices made for the "change" years: $y_1 = 1930$, $y_2 = 1960$ and $y_3 = 2000$. K_y^f is set to be

$$K_y^f \to \tilde{K}_y^f \cdot e^{\varepsilon_y} \quad (4)$$

where the ε_y are estimable parameters which are constrained to change somewhat smoothly over time under the assumption:

$$\varepsilon_y = \varepsilon_{y-1} + \eta_y \text{, where } \eta_y \sim N\left(0, \sigma^2\right). \quad (5)$$

The modified functional form is as follows:

$$K_y^{1+} = \begin{cases} K_1^{1+} & y \le y_1 \\ K_y^{1+} + \frac{\left(K_2^{1+} - K_1^{1+}\right)}{\left(y_2 - y_1\right)^\gamma}\left(y - y_1\right)^\gamma & y_1 + 1 \le y \le y_2 \\ K_2^{1+} + \frac{\left(K_3^{1+} - K_2^{1+}\right)}{\left(y_3 - y_2\right)}\left(y - y_2\right) & y_2 + 1 \le y \le y_3 \\ K_3^{1+} & y_3 + 1 \le y \end{cases} \quad (6)$$

with the following choices made for the "change" years: $y_1 = 1930$, $y_2 = 1960$ and $y_3 = 1980$. This choice of years was made because an initial exploration for different values of these change years indicated that the years listed were better in terms of improved maximum likelihood values. This functional form is much simpler than the previous functional form shown in equations (3)-(5).

RESULTS

Various output statistics for the I-stock are shown in Table 1, which includes the "Reference case" and the two sensitivity test results. The "Reference case" is the same as in Mori *et al*. (2007)[1]. For the two sensitivity test scenarios, the –*ln*L values shown are comparable with the "Reference case" since the same catch-at-age overdispersion parameter of the "Reference case" is used for these scenarios. Various plots for the "Reference case" and the two sensitivity test scenarios are shown in Figure 1.

AIC indicates that the model which includes the two modifications is better compared to the "Reference case". The AIC values here are not all exact because no account is taken of the penalty function used to limit K variation over time in two of the models, but the preference for the model with both modifications is nevertheless clear. Thus, future analyses will regard this modified version as a new "Reference case" scenario. This has the incidental advantage of corresponding more closely to the assumptions made in the SCAA approach of Punt and Polacheck (2006) to analysis of these data. Note that the best estimate (scenario "simplify K" in Figure 1) of the recent trend in abundance has changed with the modifications made from slightly down to slightly up.

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[1] The results for the "Reference case" differ slightly from Table 4 of Mori *et al*. (2007) since a coding error was found and has been corrected for this paper.

Table 1. Results of various statistics for the previous "Reference case" and sensitivity tests for the **I-stock**.

													Average proportions in each management area							
ID	**I-stock**	$b_{rec,1945\text{-}68}$	$b_{rec,1968\text{-}88}$	$b_{rec,1988\text{-}lastyr}$	$N_{tot,1945\text{-}68}$	$N_{tot,1968\text{-}88}$	$N_{tot,1988\text{-}lastyr}$	$N_{lstyr\text{-}5,1}/N_{1968,1}$	K_{1930}	K_{2000}/K_{1960}	K_{1960}/K_{1930}	M (CV)	IIIE	IV	VW	Survey q	MSYR (1+)	-lnL *	AIC *	No.Est.par
1	**Reference case (*m* =30)**	0.052	-0.032	-0.010	0.060	-0.020	-0.007	0.374	17047	0.626	9.187	0.056 (0.163)	0.205	0.425	0.371	0.71	0.06	319.56	1045.12	203
2	N1+/K1+	0.060	-0.025	-0.004	0.062	-0.012	-0.006	0.382	56183	0.643	4.468	0.050 (0.139)	0.225	0.417	0.358	0.62	0.07	319.87	1045.75	203
3	N1+/K1+ , simplify K	0.062	-0.024	0.005	0.062	-0.015	0.003	0.473	51783	0.576	5.007	0.046 (0.087)	0.204	0.428	0.368	0.71	0.06	318.07	894.137	129

* Excludes K variation penalty function contribution for ID1 and ID2.

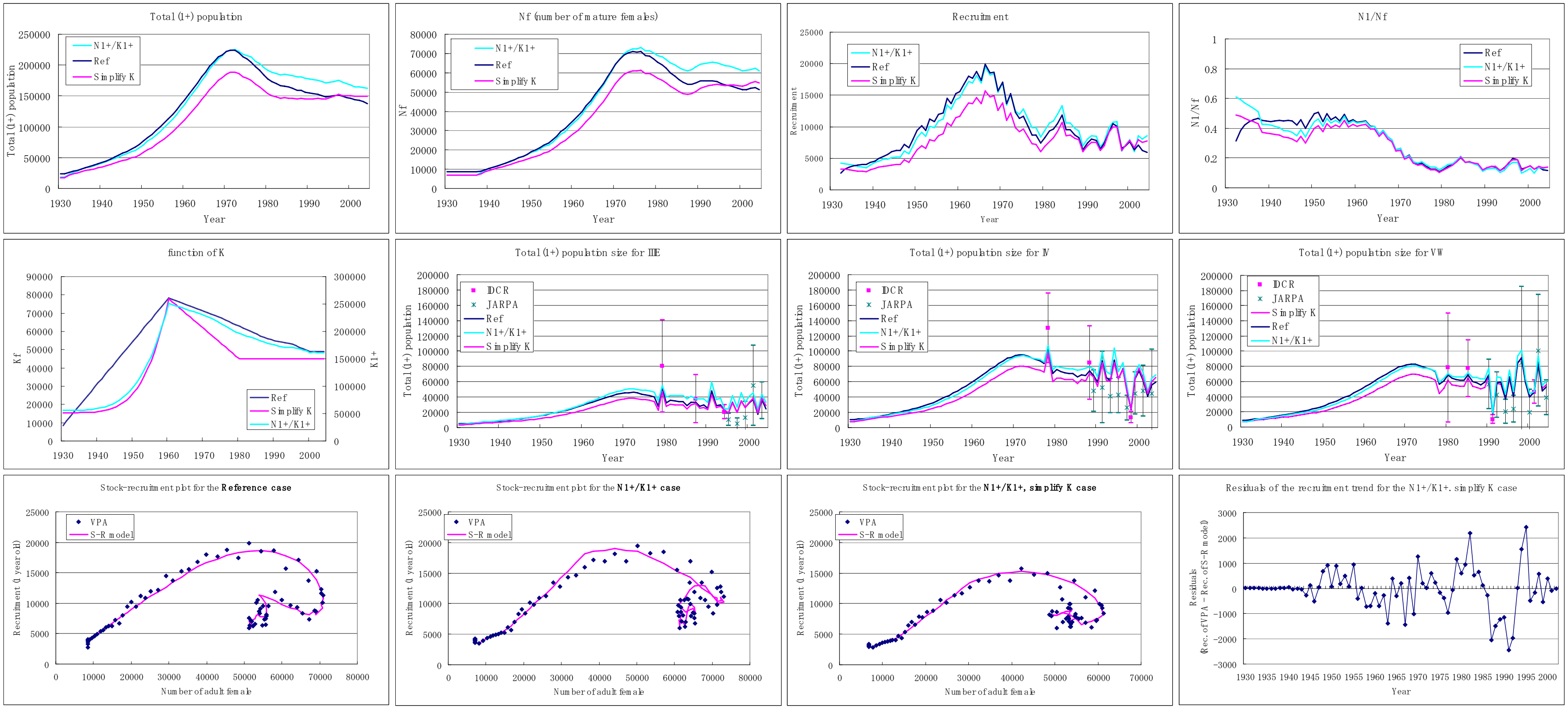

Figure 1. Plots of total population size by stock and by Area, number of mature females, recruitment, recruitment rate and carrying capacity for the I-stock for various sensitivity test runs, such as 1) replacing $\frac{N_y^{1+}}{K_y^{1+}}$ instead of $\frac{N_y^f}{K_y^f}$ for the following stock recruitment relationship and 2) together with simplifying the carrying capacity function as detailed in the text.