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A Note Related to Additional Sensitivity Tests for the Southern Hemisphere minke whale Statistical Catch-at-age Analysis

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ABSTRACT
Additional sensitivity tests are conducted to examine the impact of ignoring the data from JARPA on the outputs from the statistical catch-at-age analysis method of Punt and Polacheck (2008). The results suggest that the estimates of trends and natural mortality are most sensitive to ignoring the JARPA length-composition and age-at-length data while these estimates (and the associated measures of their uncertainty) are not very sensitive to ignoring the JARPA indices of relative abundance.

KEYWORDS: CATCH-AT-AGE, MINKE WHALE, SOUTHERN HEMISPSHERE

INTRODUCTION

Punt and Polacheck (2008) described the most recent version of the statistical catch-at-age method used to examine hypotheses related to trends in the abundance of Southern Hemisphere minke whales. They conducted example applications of the method using data for the I and P stocks of Southern Hemisphere minke whales, and explored several variants of a baseline set of specifications in order to examine sensitivity. One set of these sensitivity tests involved ignoring the JARPA indices of abundance (but not the associated age and length data). Unexpectedly, the results of this sensitivity test suggested that the outcomes from the statistical catch-at-age analysis are not sensitive to the inclusion or otherwise of ignoring these data.

IWC (2009) noted that the lack of sensitivity to ignoring the JARPA indices of abundance may be due to some structural constraints of the model (e.g. the stock recruitment relationship and / or the vulnerability functions) and recommended that it be investigated further. This note therefore explores the sensitivity of the results of the statistical catch-at-age method to ignoring the various aspects of the JARPA data.

RESULTS AND DISCUSSION

Fig. 1 plots the time-trajectories of total (1+) population size and recruitment for the reference case analysis and three sensitivity tests. These sensitivity tests explore the implications of ignoring (a) the JARPA indices of abundance, (b) the JARPA age-at-length data, and (c) the JARPA length-frequency data. The specifications of the analyses (e.g. choices for functional forms and which parameters are estimated) are those for the reference case analysis of Punt and Polacheck (2008). The analyses estimate separate values for natural mortality, growth and resilience for each stock. Table 1 lists the values for the agreed summary statistics (see table 5 of Punt and Polacheck (2008)).

The results from the statistical catch-at-age analysis are (as before) insensitive to whether or not the indices of abundance from JARPA are included in the analysis. However, the results are highly sensitive to the exclusion of either the JARPA age-at-length data or the JARPA length-frequency data (Fig. 1; Table 1).

Additional sensitivity tests were conducted to further explore the lack of sensitivity to ignoring the JARPA indices of abundance: (a) reducing the influence of the assumed stock-recruitment relationship by (substantially) increasing the assumed variation about that relationship, while simultaneously fixing carrying capacity to be constant, and (b) allowing vulnerability for the period of JARPA to vary over time rather than assume that vulnerability for the period of JARPA catches is time-invariant. Overall, the trends in both total (1+) abundance and recruitment for these two sensitivity tests are similar to those for the reference case analysis (Fig. 2; Table 1) although the estimates of $MSYR_{1+}$ from the analysis in which the extent of recruitment variation is substantially increased are markedly different from those for the reference case. This is not unexpected because allowing for considerable inter-annual variation in recruitment reduces the ability to detect the extent of compensation.

The estimates of natural mortality-at-age for ages 10+ are consistent among analyses, and none of the sensitivity tests lead to markedly less precise estimates of natural mortality-at-age.

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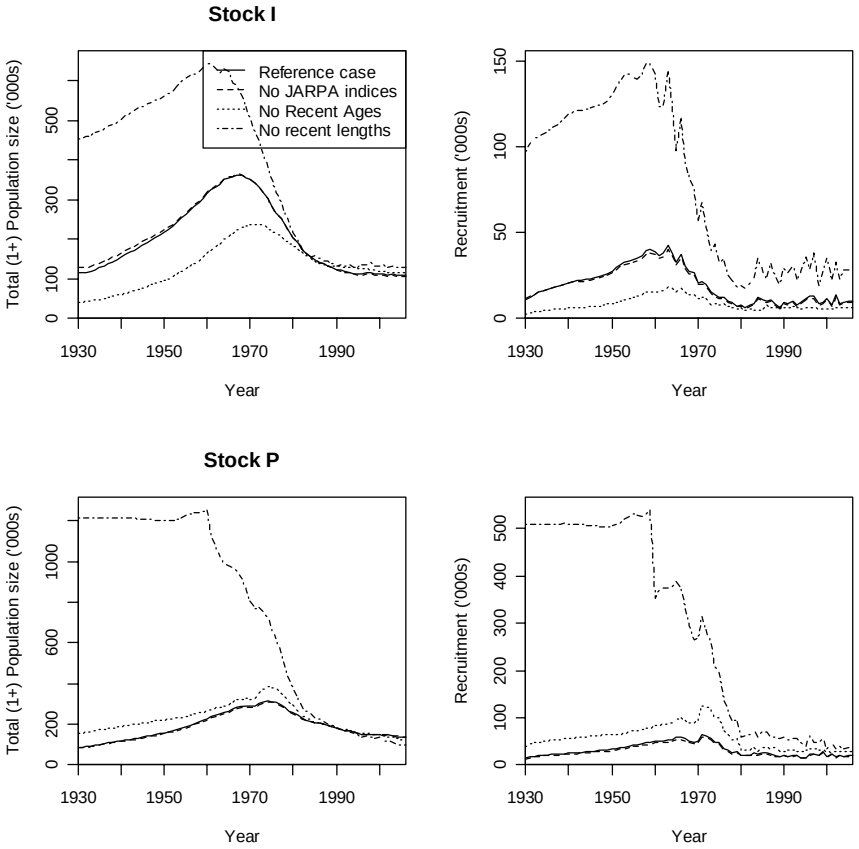

Figure 1. Time-trajectories of total (1+) population size and recruitment for the reference case analysis and the sensitivity tests in which (a) the JARPA indices of abundance are ignored, (b) the JARPA age-length keys are ignored, and (c) the JARPA length-frequency data are ignored.

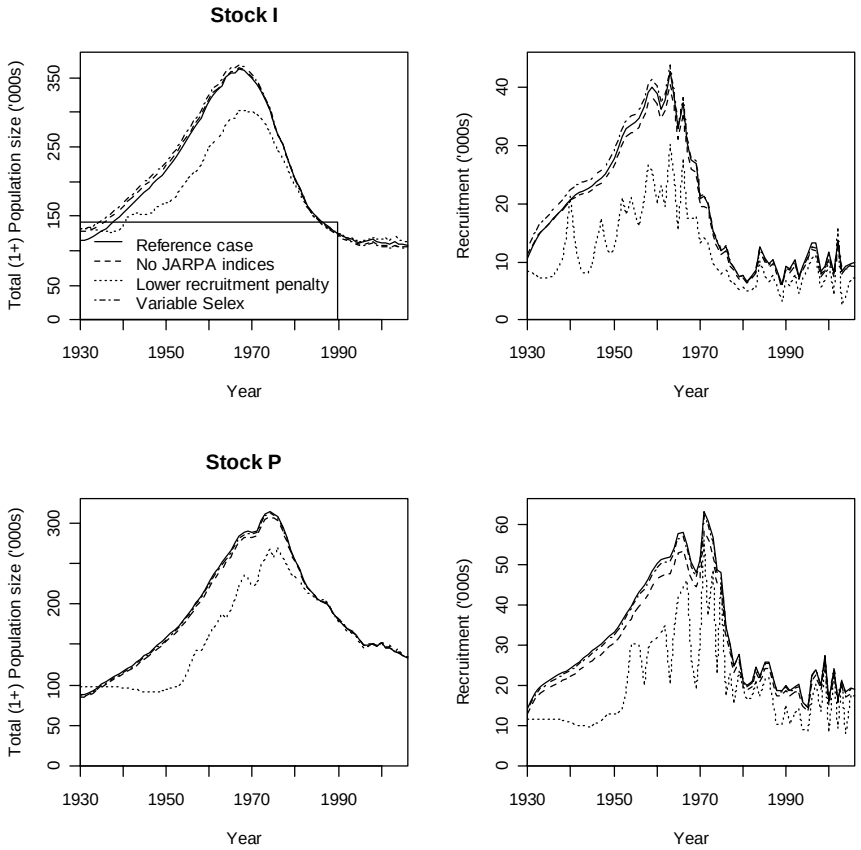

Figure 2. Time-trajectories of total (1+) population size and recruitment for the reference case analysis and the sensitivity tests in which (a) the JARPA indices of abundance are ignored, (b) the JARPA indices of abundance are ignored and the extent of inter-annual variation in recruitment is increased substantially, and (c) the JARPA indices of abundance are ignored and allowance is made to variation in vulnerability after 1986.

Table 1

Results of the reference case analysis and the analyses to examine the sensitivity of the results to modifying some of the assumptions of the analysis method. The asymptotic standard errors for the estimates for natural mortality are given in parenthesis. Analyses indicated by an asterisk are cases in which it proved impossible to find a positive definite Hessian matrix.

(a) Stock I

Case	b_{rec}			N_{tot}			$N_{End-5,1}/N_{1968,1}$	K_{1930}	K_{2000}/K_{1960} (%)	K_{1960}/K_{1930} (%)	Natural mortality (ages)			JARPA q / Mean proportion			MSYR
	1945-68	1968-88	1988-End	1945-68	1968-88	1988-End					0-3	10-30	35+	III-E	IV	V-W	
Reference	2.251	-6.191	0.935	3.210	-5.638	-0.880	0.389	115552	23.1	409.3	0.083 (0.014)	0.087 (0.005)	0.175 (0.009)	0.246	0.441	0.313	0.057
No JARPA indices	2.132	-6.252	0.893	3.019	-5.700	-1.034	0.366	128262	22.6	366.7	0.073 (0.014)	0.088 (0.005)	0.178 (0.010)	0.262	0.412	0.326	0.055
No JARPA age	4.589	-5.280	-0.440	4.965	-3.238	-0.939	0.369	41373	28.7	1000.0	0.016 (0.014)	0.059 (0.004)	0.184 (0.011)	0.234	0.457	0.309	0.043
No JARPA length*	-0.420	-6.747	0.210	0.573	-7.716	-0.313	0.388	454714	19.1	150.6	0.233	0.116	0.193	0.253	0.446	0.301	0.120
Lower Rec Penal **	3.494	-5.309	0.013	3.347	-4.748	-0.490	0.580	131329	N/A	N/A	0.026 (0.012)	0.078 (0.004)	0.178 (0.008)	0.264	0.419	0.317	0.005
Variable Selex **	2.083	-6.446	0.926	2.971	-5.850	-1.027	0.361	131489	21.906	361.913	0.086 (0.014)	0.088 (0.005)	0.178 (0.009)	0.262	0.411	0.327	0.056

(b) Stock P

Case	b_{rec}			N_{tot}			$N_{End-5,1}/N_{1968,1}$	K_{1930}	K_{2000}/K_{1960} (%)	K_{1960}/K_{1930} (%)	Natural mortality (ages)			JARPA q / Mean proportion		MSYR
	1945-68	1968-88	1988-End	1945-68	1968-88	1988-End					0-3	10-30	35+	V-E	VI-W	
Reference	3.401	-5.856	0.105	3.420	-2.417	-1.881	0.293	88006	11.8	1000.0	0.204 (0.030)	0.077 (0.004)	0.167 (0.013)	0.832	0.168	0.024
No JARPA indices	3.421	-5.746	0.217	3.435	-2.268	-1.842	0.303	85754	12.3	1000.0	0.191 (0.029)	0.077 (0.005)	0.166 (0.013)	0.834	0.166	0.024
No JARPA age	2.232	-7.579	-0.815	1.969	-3.221	-2.450	0.306	157719	4.2	1000.0	0.314 (0.032)	0.065 (0.004)	0.324 (0.018)	0.838	0.162	0.013
No JARPA length*	-1.770	-10.291	-2.979	-1.110	-8.482	-3.834	0.102	>99999	6.3	0.0	0.394	0.147	0.194	0.836	0.164	0.000
Lower rec penal **	6.801	-4.086	1.122	4.550	-1.000	-1.698	0.182	98152	N/A	N/A	0.155 (0.029)	0.068 (0.007)	0.152 (0.014)	0.832	0.168	0.001
Variable Selex **	3.416	-5.799	0.191	3.439	-2.371	-1.832	0.300	86683	12.1009	999.998	0.201 (0.030)	0.077 (0.004)	0.166 (0.013)	0.834	0.166	0.024

** Also ignores the JARPA indices of abundance.