Robben Island penguin survival rates from Bayesian analysis

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12 February 2010

Res Altwegg has criticized modeling results for the Robben Island penguin population in Robinson and Butterworth (2009) for what we understand to be the legitimate reason that the maximum likelihood estimator used there sets some estimates of survival rates on the upper bound of 0.98 imposed for that quantity (see Fig. 1 for results for model B from that earlier paper). Amongst other things, Hessian based estimates of confidence intervals are unreliable in these circumstances.

A more appropriate statistical approach is a Bayesian analysis, for which we have specified uniform priors (intended to be uninformative) for the model parameters (subject to any bounds imposed).

Markov Chain Monte Carlo simulations were performed for two variations of the Robben Island penguin population model. In one variation the data incorporated both moult counts and tagging information in computing posteriors for annual survival rates (Fig. 2). In the second variation only moult counts were used (Fig. 3). Fig. 4 shows corresponding Bayesian posterior results for the adult female moulter time series. The computations were effected using the ADMB package with a chain of 11 million samples. The first 1 million were excluded as burn-in, and then every 1000th vector in the chain extracted to provide a realization of the joint posterior. Inspection of traces for a number of the quantities of interest suggested that convergence to the posterior had been achieved in this process.

The plots in Fig. 2 to Fig. 4 demonstrate that the Bayesian approach of this paper provides a more reasonable representation of penguin survival rates and numbers over time, together with the associated statistical uncertainty, than did the earlier maximum likelihood estimate approach.

Reference

Robinson, W. and D. S. Butterworth. 2009. Fitting both moult counts and tagging data to a population model for Robben Island penguins. Document MCM/2009/SWG-PEL/33.

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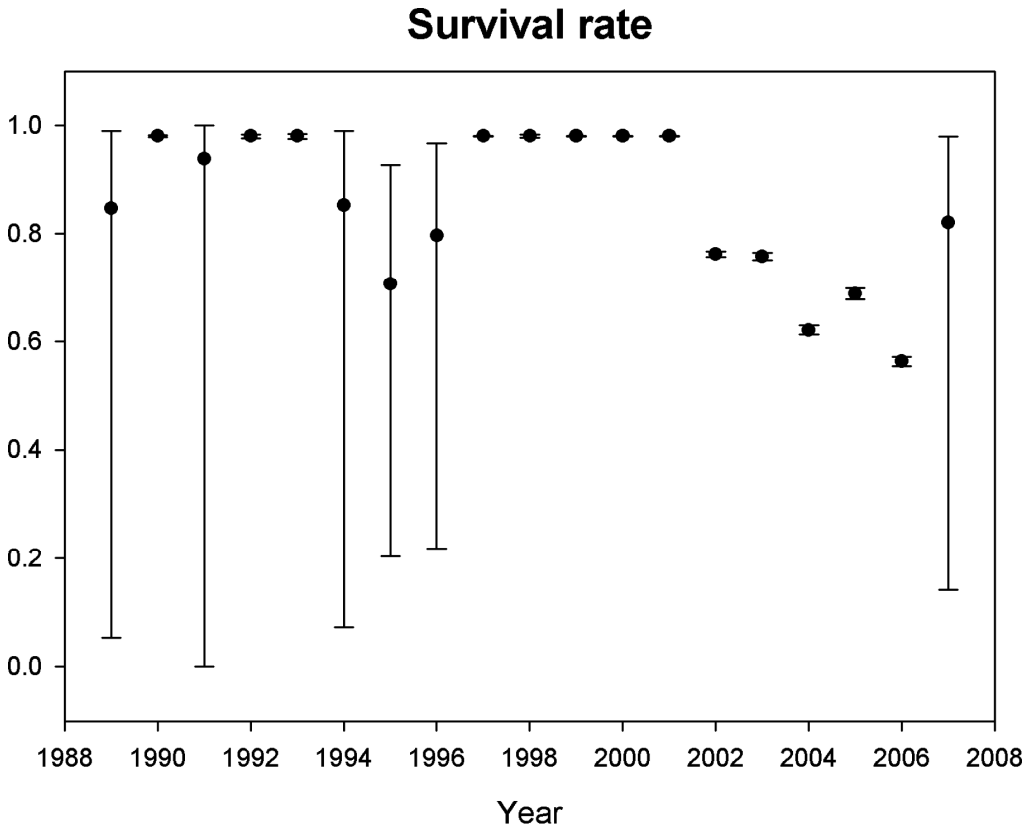

Fig. 1: Maximum likelihood estimates with standard deviations for tagging data (except for the 2001 resightings) as well as the moult count data included.

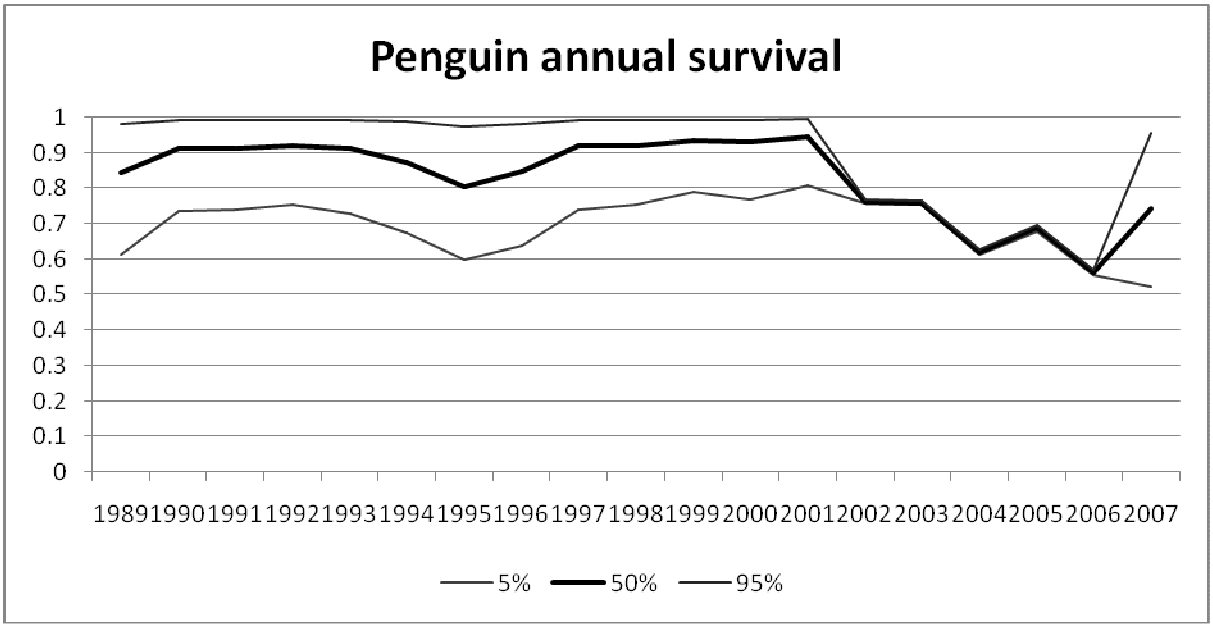

Fig. 2: Annual survival rates calculated when incorporating both moult counts and tagging data (2001 resightings excluded) using the Bayesian analysis. The posterior median is shown along with the 90% probability interval.

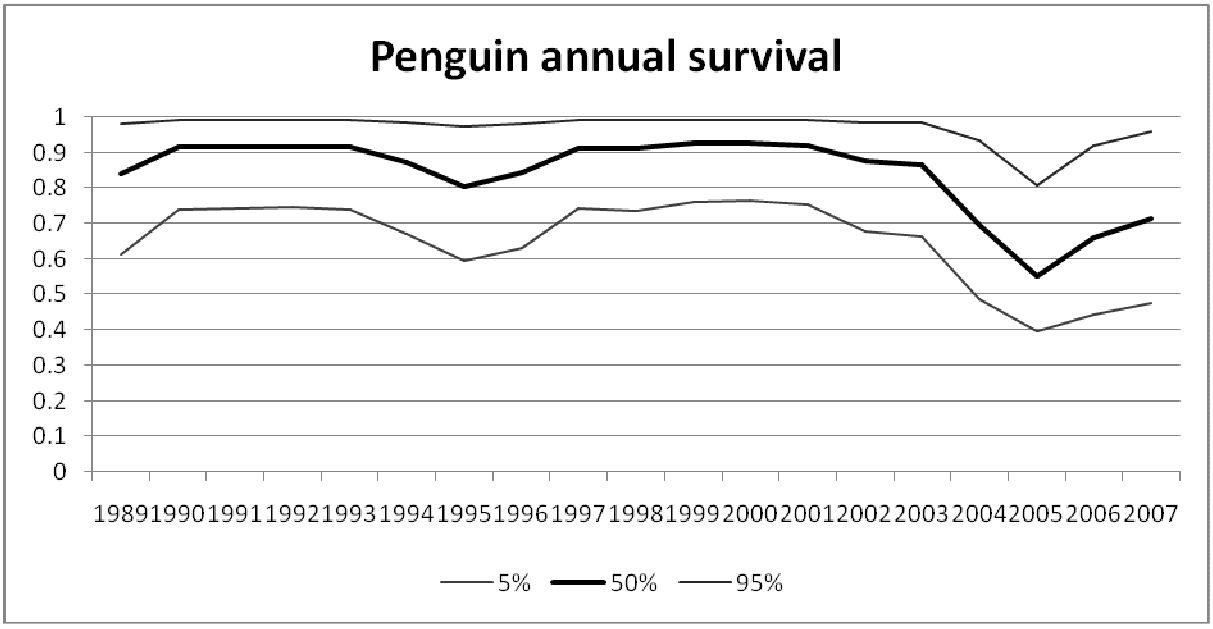

Fig. 3: Annual survival rates calculated when incorporating moult counts only. The posterior median is shown along with the 90% probability interval.

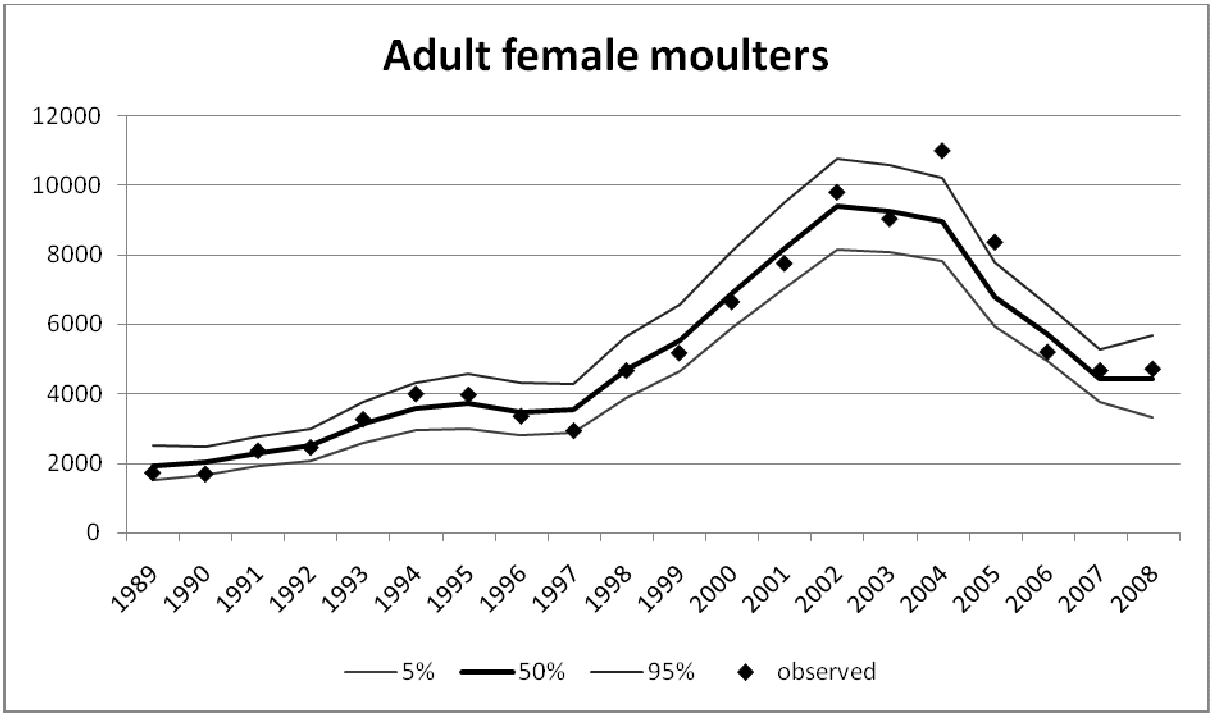

Fig. 4: Bayesian posterior median and 90% confidence intervals for the time series of adult female moulters. Moult counts and tagging data are used.