

Further responses to comments in Altwegg MCM/2010/SWG-PEL/23 regarding penguin analyses

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I. Analyses related to the effect of pelagic fishing in the vicinity of islands on penguin reproductive success

Altwegg argues that the “conclusion” (“suggestion” in the original document) in EAFWG/OCT/2007/STG/04 (the analysis in question is reproduced in MCM/2010/SWG-PEL/10) of positive correlations between fish catches and penguin reproduction is erroneous because “a much more likely explanation is that fisheries and penguins benefited in similar ways from variability in the environment: a good year for fisheries would have been a good year for penguins”.

Indeed an analysis that failed also to take account of this last possibility would be flawed, as Altwegg suggests. But the model in question *already* takes it into account. The GLM model concerned for relating the impact of pelagic fishing on penguin reproductive success was:

$$\ln(F_{y,i}^h) = \alpha_i + \beta_y + \lambda_i \frac{C_{y,i}}{\bar{C}_i} + \varepsilon_{y,i} \quad (1)$$

where:

$F_{y,i}^h$ is a measure of penguin reproductive success at island i in year y ,

$C_{y,i}$ is the total catch of sardine and anchovy taken within 20 km of island i in year y ,

\bar{C}_i is the mean annual catch over the period considered taken within 20 km of island i ,
and

λ_i is the parameter relating the effect of the extent of this catch around island i to the penguin response.

Two data sets quantifying the penguin response to fishing $F_{y,i}^h$ on each of Robben and Dassen Islands were considered: the annual fledging success of penguins and the ratio of breeders per adult moult each year.

Note that the right hand side of equation (1) includes not only the island-specific fishing impact term $\lambda_i C_{y,i}/\bar{C}_i$, but also an island-independent year factor β_y . This β_y factor reflects common influences that may be good or bad for penguin reproductive success in a particular

year independent of the impact of fishing, as Altwegg correctly indicates to be required. In regard to the impact of fishing parameter λ_i , what the model is estimating is any effect *on top of* Altwegg's "similar benefit" consideration. Altwegg's criticism would have been valid had equation (1) omitted the β_y term.

The general model of equation (1) has been applied to the updated data of fledging success and breeders per adult moult at the two islands, as listed in Table 1. Compared to the corresponding table in MCM/2010/SWG-PEL/10, Table 1 includes new data on fledging success at Robben Island and corrects earlier 2006 data for breeders per adult moult at both islands. In addition, Tables 1 and 2 correct a few typographical errors in their earlier counterparts.

The results for this model are given in Table 2 and are qualitatively unchanged from those in earlier analyses. The point estimate for one of the four λ parameters moves from being marginally positive to marginally negative, but the overall indication remains one of a positive effect of fishing on penguin reproductive success, though one not significant at the 5% level.

The approach of equation (1) has potentially weak power as it has to estimate a separate β_y parameter value for every year. This might be improved if one or more explanatory variables accounting for much of the variance in the β_y s could be found, though care needs to be taken here to select such variables on an *a priori* basis and avoid data dredging, so as not to require Bonferroni corrections when assessing statistical significance. To this end the annual November survey biomass estimate for sardine and anchovy combined in the Cape Columbine to Cape Point survey stratum was chosen. This stratum was selected because it includes both islands under consideration, and associated fish abundance estimates for that stratum had correlated with penguin dynamics in earlier analyses. The May recruit survey is closer in time to the penguin reproductive period, but the November survey was preferred because its estimates of abundance are much more precise (when the variance additional to that associated with survey sampling error is taken into account). Janet Coetzee and Carryn de Moor kindly provided the survey abundance estimates in question shown in Table 1.

An alternative GLM utilising these biomass estimates was then considered:

$$\ln(F_{y,i}^h) = \alpha_i + \mu_i B_y + \lambda_i \frac{C_{y,i}}{C_i} + \varepsilon_{y,i} \quad (2)$$

where:

B_y is the total sardine and anchovy November biomass estimate between Cape Columbine and Cape Point in year y , and

μ_i is the parameter relating the effect of the total biomass of sardine and anchovy to the penguin reproductive response at island i .

Results for this "Biomass" GLM applied to the same data are also given in Table 2. Of the estimated λ parameter values, two are weakly negative, one weakly positive and one more

strongly positive. However although estimation precision is improved a little through this alternative approach, none of the estimates of the λ (or indeed also of the μ) parameters is statistically significant at the 5% level; further the μ parameter point estimate for Dassen Island is negative for breeders per adult moult, contrary to what might be expected.

It would seem that the measure of fish abundance selected has too weak a correlation with the factor actually impacting penguin reproductive success each year (the β_y s) to be able to improve upon the results from equation (1).

On balance overall, the data continue to point towards a positive (rather than a negative) effect of fishing near colonies on penguin reproductive success, but only weakly so.

II. Implications of juveniles being less detectable than adults in penguin moult counts

The penguin population analyses to which Altwegg refers (MCM/2009/SWG-PEL/33 and following documents) assume that adult and juvenile penguins are equally detectable in moult counts.

Altwegg argues that “the model thus critically depends on the proportion of juveniles among the counts to separate survival from reproduction”, and “if juvenile penguins are undercounted more than adults, the proportion of juveniles would be biased low as a measure of reproduction and survival would be pushed to the limit as the model tries to compensate”.

To investigate whether this is indeed the case, previous Bayesian analyses were extended to incorporate a prior on a parameter p_j reflecting the detectability of juvenile penguins relative to adults in the moult counts. A uniform prior on the interval [0.5; 0.9] was assumed for p_j .

Figures 1, 2 and 3 respectively contrast Bayesian posterior results with and without this modification for the time series of penguin abundance (in terms of female moults), annual survival and reproductive success at Robben Island. Results for abundance hardly change. Posterior medians for survival rate are also hardly changed, though the upper and particularly the lower 5-percentiles are shifted upwards. Only for reproductive success is there an appreciable upward shift in the overall distribution.

Figure 4 shows that the analysis updates the prior for relative detectability p_j appreciably, and also that there is no indication of support for values of p_j outside the [0.5; 0.9] range considered for the prior (so that the bounds initially assumed for this prior are not problematic).

Altwegg’s suggested effect thus provides improved estimates of some model parameters, and includes the interesting result that there is likely a lower relative detectability of juveniles to adults in the moult counts in the 60%-80% range. This is associated with an increase in the estimated reproductive success compared to the model assuming $p_j = 1$, but in other respects little changes, and the model readily accommodates this further effect.

Table 1: Available data on the fledging success of penguins, the breeders (twice the number of nests) per adult moult ratio, the total sardine and anchovy catch in a 20 km neighbourhood of the Robben and Dassen Island penguin colonies, and the total sardine and anchovy November biomass from Cape Columbine to Cape Point.

Year	Fledging success		Breeders per adult moult ratio		Sardine and Anchovy Catch		November biomass (Cape Columbine to Cape Point)
	Robben	Dassen	Robben	Dassen	Robben	Dassen	
1995	0.380	0.650	0.573	1.584	8974	16879	13297
1996	0.650	0.805	0.944	1.555	8041	17119	25883
1997	0.970	0.929	1.190	1.349	14580	5509	208513
1998	0.750	1.057	0.797	1.340	9116	12122	342876
1999	0.600	1.083	0.810	1.414	20205	35407	253682
2000			0.919	1.359	11706	21676	649592
2001	0.840		0.935	1.641	12608	33084	1108733
2002	0.900		0.864	1.771	28817	37864	41306
2003	0.570		0.810	1.794	42812	34052	16876
2004	0.720		0.895	2.831	14931	18515	736
2005	0.900		1.111	2.480	8295	39860	17
2006	0.580		0.952	2.342	19961	31194	64473

Table 2: Parameter estimates and standard errors (in parenthesis) for the effect of the amount of catch taken around each island on fledging success of penguins and the ratio of breeders per adult moult. None of the estimates for λ or μ are statistically significant at the 5% level.

	Fledging success		Breeders per adult moult ratio	
	General	Biomass	General	Biomass
λ_{Robben}	+0.362 (0.379)	-0.008 (0.138)	-0.003 (0.163)	-0.023 (0.108)
λ_{Dassen}	+0.417 (0.179)	+0.069 (0.209)	+0.214 (0.225)	+0.232 (0.145)
μ_{Robben}		+0.046 (0.050)		+0.012 (0.045)
μ_{Dassen}		+0.223 (0.155)		-0.072 (0.044)
Year 1996	+0.382 (0.131)		+0.238 (0.209)	
Year 1997	+0.724 (0.142)		+0.333 (0.214)	
Year 1998	+0.639 (0.133)		+0.101 (0.210)	
Year 1999	+0.143 (0.236)		+0.039 (0.240)	
Year 2000			+0.139 (0.211)	
Year 2001	+0.640 (0.172)		+0.194 (0.225)	
Year 2002	+0.366 (0.438)		+0.173 (0.265)	
Year 2003	-0.387 (0.734)		+0.165 (0.298)	
Year 2004	+0.436 (0.193)		+0.506 (0.212)	
Year 2005	+0.800 (0.173)		+0.458 (0.232)	
Year 2006	+0.114 (0.267)		+0.389 (0.232)	

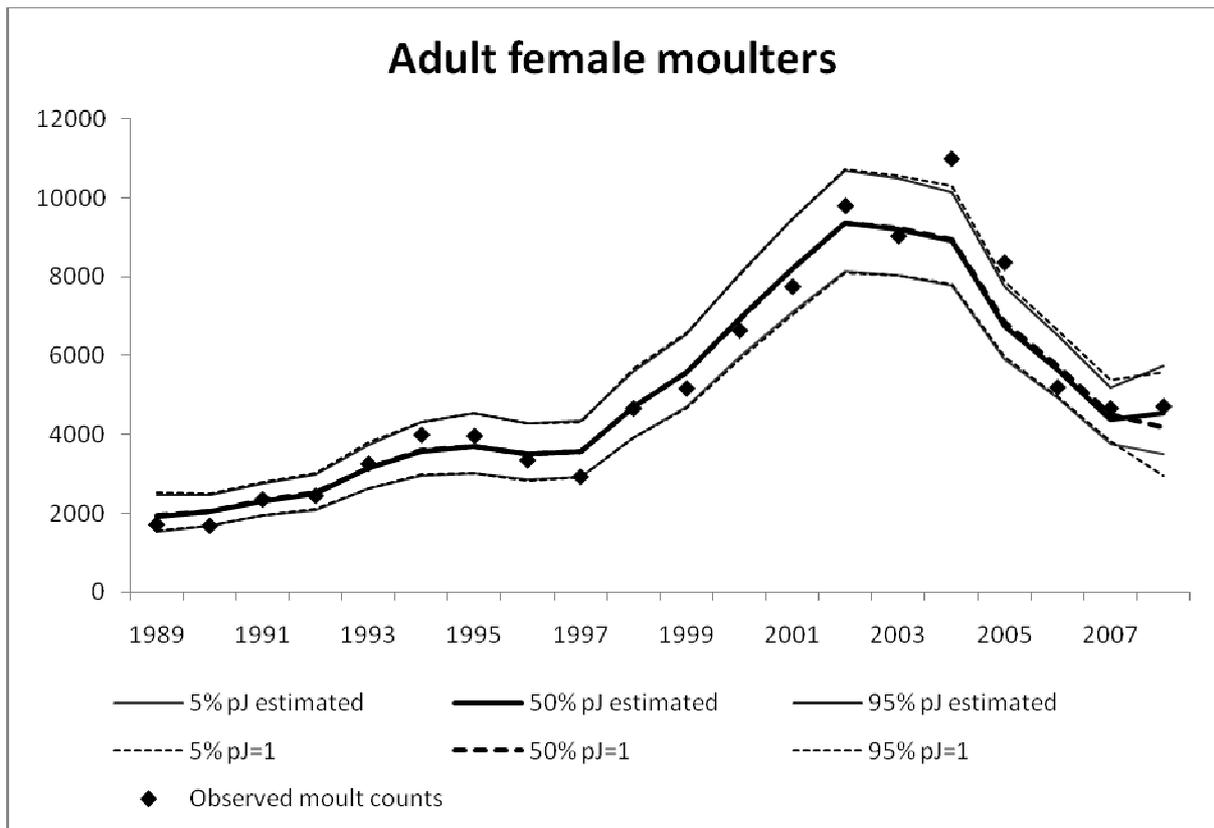


Figure 1: Adult female penguin abundance at Robben Island

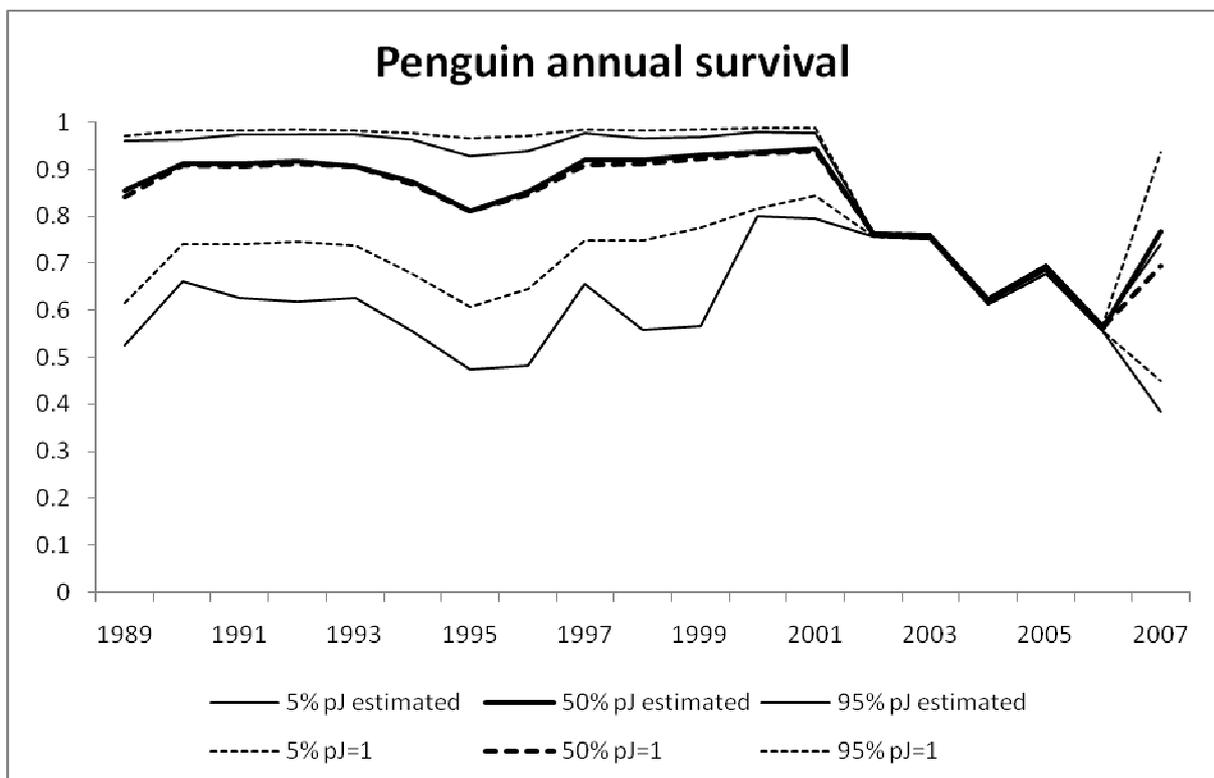


Figure 2: Penguin annual survival at Robben Island

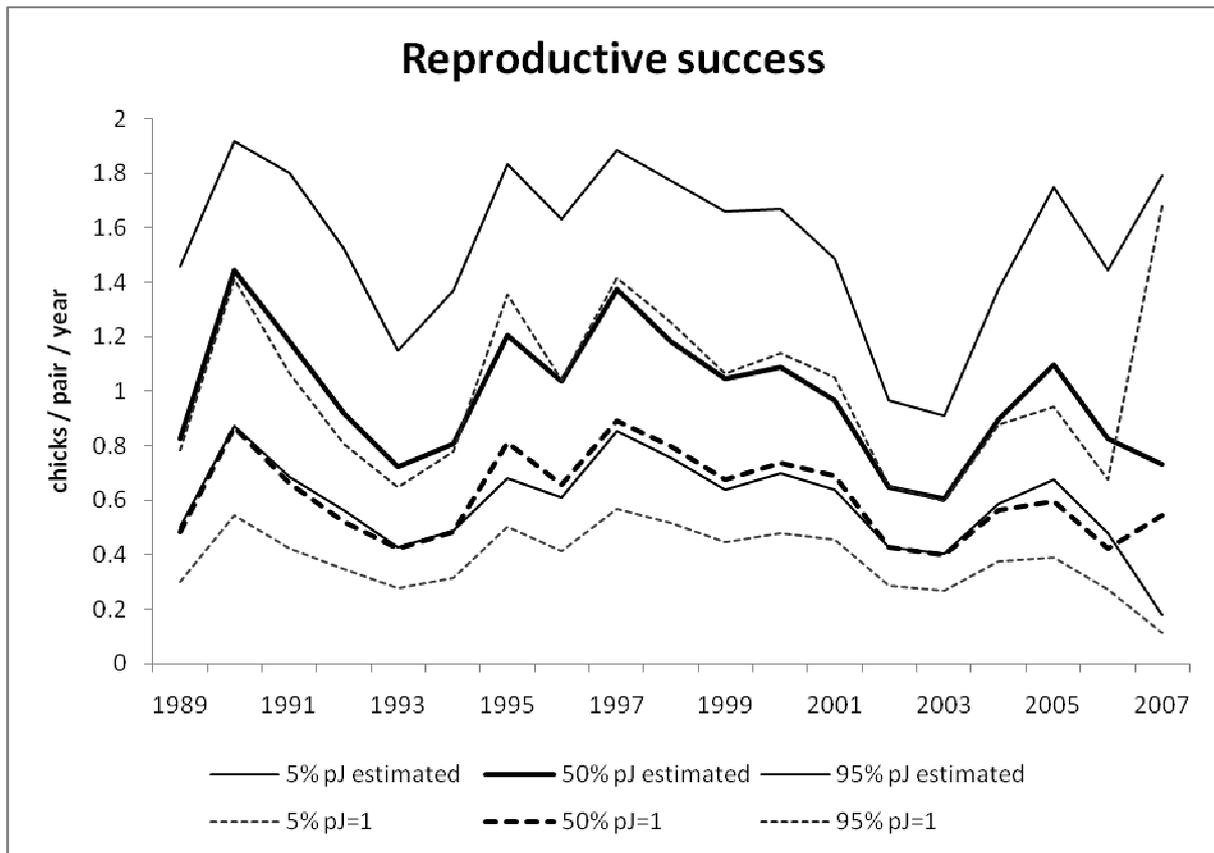


Figure 3: Annual penguin reproductive success at Robben Island

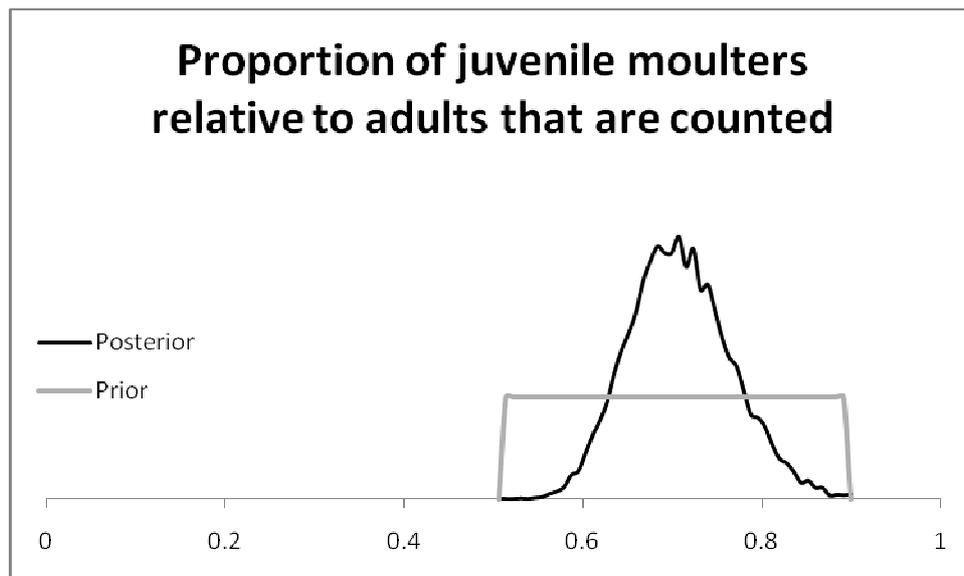


Figure 4: The prior distribution for the detectability at Robben Island of juvenile relative to adult moulters $U[0.5, 0.9]$ and the corresponding posterior which shows the extent to which the data available update this prior.