A Note on Likely Data Requirements for Analyses of the Possible Impact of Pelagic Fishing in the Vicinity of Breeding Colonies of Penguins

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INTRODUCTION

There are probably essentially three hypotheses concerning the effects of pelagic fishing on penguin populations (as it would affect reproductive success or survival rates through impacting prey availability):

i)   the fishery overall reduces pelagic fish populations below the levels that would otherwise occur, thus reducing the amount of prey available to predators such as penguins;

ii)   pelagic fishing in the neighbourhood of a penguin breeding colony reduces the local density of prey available to penguins, this being deleterious to breeding birds which have a limited foraging range; and

iii)   pelagic fishing in the neighbourhood of a penguin colony breaks up shoals (for these fish larger shoals offer effectively better protection against natural predators by reducing the per capita probability of a predator finding a forage fish), and thus increases prey detectability.

Under hypotheses i) and ii) penguin reproductive success and survival rates would decrease given (additional) fishing, whereas under hypothesis iii) the reverse would occur.

The Task Team which has been appointed to consider possible further closures or partial closures to purse-seine fishing around all penguin breeding colonies will need to evaluate what support existing evidence offers to hypothesis ii) and to hypothesis iii) [hypothesis i) relates to the different question of whether overall pelagic catches should be reduced to possibly benefit penguins, but it has been decided not to pursue that aspect further at this time].

Those evaluations will in turn need the relevant data to be consolidated for analysts, and this note intends to facilitate the initiation of that process.

DATA FOR POTENTIAL ANALYSES

The primary question to be addressed requires two types of data for analysis: measures of reproductive success or survival, and measures of explanatory variables such as catches or resource abundances in the vicinity of colonies. The following constitute initial lists of annual measures for embellishment.

Penguin demographics

1) Fledging success (Robben and Dassen)
2) Breeders per adult moulter (Robben and Dassen)
3) Annual survival rate (Robben)
4) Mean foraging path length (St Croix, Bird, ….)
5) Mean foraging trip duration(St Croix, Bird, …)
6) Moult counts (Robben, Dassen, …)

Fish-related

1) Catch by species in vicinity (within 20 km?) of colony
2) Abundance of pelagic fish by species in the survey stratum in which the colony occurs, for both the May recruit and the November spawning biomass series.

In addition, the consequences of possibly closing only part of the region around a colony need to be investigated. This requires data on feeding areas for birds resident at a colony, and also the locations in the colonies where these birds were originally tagged to check whether the data reflect a spatially representative sample of the penguins throughout the colony.

Responsibilities need to be allocated for the preparation of these data.

ANALYSES

Appendix A describes an earlier analysis of the type required (reproduced from Brandao and Butterworth, 2007). This sought to establish the impact of fishing on fledging success and breeders per adult moulter at the Robben and Dassen colonies. In all four cases penguin reproductive output was estimated to have **increased** for larger catches, but none of the results was statistically significant at the 5% level.

Such analyses need to be repeated and extended. Thus for the Appendix A analyses, for example, the data series considered need to be extended, and the analyses should be conducted for sardine and anchovy separately as well as combined. For these analyses, the multiplicative effect of catches was assumed to be proportional to the catch in tons; more complex models involving different functional forms and perhaps including fish abundance indices as further co-variates also need to be considered.

Care must be taken with the use of annual counts, as their analysis in this context would first require the finalisation of population models for which residuals of model fits could be taken as independent in checking for correlations with the effects of fishing.

Comments from the Working Group on potential forms of relationships for such analyses would be helpful.

REFERENCE

Brandao, A. and Butterworth, D.S. 2007. An initial analysis of the power of monitoring certain Indices to determine the effect of fishing on penguin reproductive success from an experiment where pelagic fishing is prohibited in the neighbourhood of Robben Island, but continues around Dassen Island. MCM document EAFWG/OCT2007/STG/04.

APPENDIX A

GLM TO CONSIDER THE IMPACT OF PELAGIC FISHING ON PENGUIN REPRODUCTIVE SUCCESS

The following GLM is applied to historical data of fledging success of penguins (or breeders per adult moulter ratio), which takes into consideration the total catch of sardine and anchovy around each island as a fraction of the average catch around the island over the time period considered:

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

where:

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

$\bar{C}_i$ is the mean annual catch over the period considered taken around island i, and

λ_i is a parameter relating the effect of the extent of catch around island i to the fledging success of penguins (or breeders per adult moulter ratio).

Table A.1. Available data on the fledging success of penguins, the breeders per adult moulter ratio and total sardine and anchovy catches in a 20 km neighbourhood of the penguin colonies considered in the analyses presented in this paper (see text for sources).

Year	Fledging success of penguins		Breeders per adult moulter ratio		Total sardine and anchovy catch (t)	
	Robben	**Dassen**	**Robben**	**Dassen**	**Robben**	**Dassen**
1995	0.380	0.650	0.287	0.792	8974	16879
1996	0.650	0.805	0.472	0.777	8041	17119
1997	0.970	0.929	0.595	0.668	14580	5509
1998	0.750	1.057	0.399	0.670	9116	12122
1999	0.600	1.083	0.468	0.707	20205	35407
2000	—	—	0.485	0.622	11706	21676
2001	—	—	0.503	0.820	12608	33084
2002	—	—	0.441	0.893	28817	37864
2003	—	—	0.437	0.903	42812	34052
2004	—	—	0.489	1.415	14931	18515
2006	—	—	0.556	1.240	8295	39860

Table A.2. Parameter estimates (and standard errors) for the effect of the amount of catch taken around each island on fledging success of penguins or the breeders per adult moulter ratio. None of these estimates is statistically significant at the 5% level.

Parameter	Fledging success of penguins	Breeders per adult moulter ratio
λ_{Robben}	+0.258 (0.270)	+0.009 (0.172)
λ_{Dassen}	+0.417 (0.179)	+0.417 (0.238)