The Penguin decline – where should most analysis effort *really* be focused?

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SUMMARY

The impact, if any, of pelagic fishing in the neighbourhood of penguin breeding colonies on penguin population trends is unclear. Broad indications are, however, that the likely magnitude of any such impact still leaves some 90% of the recent penguin decline to be explained, and a priority for further analyses is to seek to understand the reasons for this decline better. Two hypotheses to explain this decline are summarized: shortage of food, and loss of optimal breeding habitat coupled to the large increase in abundance of a competing seal population during the previous century. These two hypotheses suggest radically different management actions to mitigate the current penguin decline. Provision of related scientifically based advice to managers in line with an ecosystem approach requires the development of tactical multi-species models, likely of the "MICE" type. This would be to evaluate and to attempt to discriminate (on a broadly defensible basis statistically) amongst those two and possibly other hypotheses for the penguin decline, so as to be in line with best practice internationally in the provision of tactical scientific fisheries management advice.

Keywords: anchovy, decline hypothesis, MICE model, penguin, sardine, seal, tactical advice

Introduction

Most of the discussions in the Pelagic Working Group related to the serious decline in numbers of African penguins over recent decades have focused on the interpretation of the results from the island closure experiment. Discussion has then moved from there to the appropriateness or otherwise of (further) closures of the neighbourhoods around penguin breeding colonies to pelagic fishing.

Debate remains about whether a positive effect of such closures on penguin population growth rates has been demonstrated, and if so the exact magnitude of that effect. Broadly speaking though, indications from the experiment results are that if there is such an effect, its magnitude would be in the vicinity of 1% p.a. on the growth rate of the penguin population at the colony concerned. For example, Sherley et al. (2018) estimate that a reduction of a little more than 1% p.a. in a population decrease rate approaching 20% p.a. at Robben Island would result from closure, and the point estimates reflected in Figure 1 of Butterworth (2018) for Dassen and Robben Islands for response variables that can be linked directly to penguin population growth rates are broadly similar to that 1%. Since these Islands have already been closed for about 50% of the time over about the past decade, should closure apply every year in the future, the further reduction in present decrease rates which these results suggest would be some 0.5% p.a., or in relative terms an amelioration of ~3% of the present decline. The Sherley et al. (2018) estimate of a decline rate 20% p.a. in the Robben Island penguin population is perhaps rather high in comparison with the decline in overall penguin numbers over the last three decades, which is nearer to about 4% p.a. (Makhado et al. 2020) – even so, stopping fishing around such islands entirely would perhaps achieve a relative reduction of only some 12% of that 4% decline.

Hence in seeking to take appropriate action to reduce the penguin decline, the real burning question is: **what are the reasons accounting for the remaining near 90% of the penguin decline?**

Hypotheses to explain the decline

The hypothesis emphasized thus far in the debate on this question has been a shortage of (forage fish) food (e.g. DEA, 2020). But on consideration, the veracity of such an explanation is not immediately obvious. Certainly, the penguin population did show a brief upturn during the boom in sardine and anchovy abundances around the turn of the century, dropping again later co-incident with a subsequent decline in especially the sardine biomass. But the anchovy biomass has stayed relatively high since that peak some 20 years ago, and remains a good deal higher than is was last century over the period since surveys started in the mid-1980s. Overall, forage fish (sardine and anchovy) abundance has been better over the last decade than it was from the mid-80s to the early 90's, and fishery harvest rates on both species (even on the west coast where they tend to be higher than on the south) are generally low compared to most such fisheries internationally.

Are there alternative hypotheses which might explain the continued decline in penguin numbers over the last three to four decades, absent the brief upturn around the turn of the century? Viewed on a multi-decadal scale, the penguins' environment has deteriorated for two other reasons. First, loss of their optimal breeding habitat, provided by burrowing into guano deposits on islands, as these deposits have since been removed by harvesting. Secondly, the Cape fur seal population recovered steadily from near extirpation around the turn of the 19th century, and was increasing rapidly in absolute terms during the latter half of that period until levelling off in the 90's. Furthermore, current seal numbers may be "abnormally" high, as for various reasons large most large land-based seal breeding colonies developed for the first time during that period; this became possible in part because

of the anthropogenic reduction in large land-based carnivores, predation by which would otherwise likely have extirpated such colonies. This then removed some space-limitation effects which might previously have restricted the size of the seal population to lower numbers than at present. The penguin population decline may therefore be predominantly the result of competition with seals for food, given that sardine and anchovy constitute important components of seals' diets, and this competition might also be the primary reason hampering their recovery. "Competition" in this context is not referring to the "direct" competition sometimes observed in the form of rogue seals predating on penguins as they return to their islands from foraging trips, or interfering with penguins and their nests as they compete for space on islands where both species are present. Rather it pertains to the "indirect" (and not directly visible) competition that arises from the ceiling on the total production of forage fish species which to partition amongst a number of different predator species.

How to move from hypotheses to scientifically based management recommendations?

Hence there are (at least) two different hypotheses that could account for the penguin decline. Importantly in this context, they have completely different management implications when it comes to taking action to arrest the penguin decline: reduce the extent of pelagic fishing vs commence a major seal cull. How then are these hypotheses to be evaluated to provide associated relative plausibilities to inform sound scientifically based management recommendations?

What becomes important when moving towards the development of such recommendations for actual management is to appreciate that these need to be evaluated by the use of tactical models, and not in terms of opinions linked to results from more general strategic models which offer little assistance at this level. Importantly also, tactical models have to be fit to data, and it is comparative statistical measures of the qualities of the fits to those data that provide the basis to accord relative plausibility weightings to (or *in extremis* to dismiss some or select only one of) those models. Consideration of the fits (and whether they are satisfactory) of such tactical models to data is the primary principle implicitly accepted internationally in fisheries as a pre-requisite for the provision of sound scientifically justified tactical advice by scientists to managers.

Hence, the line of analysis that would now seem to be the priority to pursue is the initiation of an EAF approach that develops appropriate multi-species models based on each of these two (and possibly other) hypotheses. This would likely take a MICE (Models of Intermediate Complexity for Ecosystem assessment) approach so as to provide a basis for giving defensible scientific advice to managers on the matter of an appropriate response to the decline in penguin numbers, which would be in line with best practice internationally in the provision of such tactical advice.

This document has deliberately been written to provide a broad perspective only, aiming to get its main thrust across without over-burdening the reader with details. Clearly the next step required would be the development of these MICE (models), which in turn first requires the assembly of the key data inputs required. In line with their very name, such models will involve a fair amount of aggregation (if only because the data available dictate this) – thus, for example, they would not be at a colony level for penguins, but rather at a whole population level or perhaps disaggregated into three sections of the west, south and east coasts. In commencing such an exercise though, immediate encouragement is provided by the (unusual by world norms) availability of good series of abundance estimates (covering the past three decades at least) for all of sardine, anchovy, penguins and seals from surveys/counts which have been scientifically designed and conducted.

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