Peer review of Cormorant modelling research:

Modelling the consequences of the New Cormorant Licensing Policy

Central Science Laboratory December 2004

1. Reporting and methods

1.1 Objectives

This paper outlines the development and application of a stochastic modelling system for predicting the population dynamics of the UK cormorant population with growth rate and initial population estimate inputs derived from analyses of time series of field surveys of population size. The paper addresses all of the aspects and objectives of the project plan clearly. The context is clear and so are the aims and objectives.

1.2 Design of the model

The modelling was undertaken in Crystal Ball. Whilst I am familiar with the approach, , I believe that the researchers have not given an adequate description of the approach here to allow those unfamiliar with the previous work to assess the work.

The basic model uses a simple growth equation with growth rates derived from between years difference in populations sizes in these years. Thus, the population in a year is determined from the population size in the previous year and an estimate of the growth rate for the year. Two sorts of model are considered; density dependent, where the growth rate is assumed to be dependent on the population size in the preceding year and density independent, where the observed growth rates over the time series are used as samples from which the growth rate in any one year is selected. Culling is applied as a straightforward removal of birds from the population in each time step.

The population of an organism at any given point in space and time is determined by four basic population processes: reproduction and immigration, which increase the population, and mortality (which includes culling) and emigration which reduce it. Where data are available on each of these processes it is possible to predict future population trends in terms of these processes. There are many modelling approaches which can be used to predict population dynamics based on these fundamental processes. In the modelling undertaken here, the researchers have simplified the population dynamics of the cormorant population by assuming there is no net effect of migration (either in or out of the population) and they have also assumed that the increase in population size between years (the finite growth rate) is the net sum of reproduction minus mortality. By not modelling the underlying processes of mortality and reproduction (and also migration) the researchers make no assumptions about the role of the underlying ecological processes in determining population dynamics. The derived growth rates between years are used in two ways. When assuming that population growth rate in cormorants is not density dependent the observed differences in population size between years are assumed to represent a sample of the potential growth rates that can occur in the UK cormorant population. The authors have then assumed that the estimates represent samples from a range of statistical distributions and use the estimated distributions to provide inputs for the models. In the case of the density dependent models they have used the same empirically derived growth rate data as response variables in regressions against population size to quantify the effects of population size on growth rate. The assumption here is that the net growth between years is dependent on the population in the preceding year. The derived regression equation is then used to predict growth rates for use in the model. A further density dependent model based on a bootstrap fit is also developed but less fully described. The description of the derivation of the slope and constant inputs for this model were sketchy.

Whilst there appears to be little doubt that there is a density dependent relationship between population growth rate and population size, consideration of Figure 2 indicates that there is considerable noise. This indicates that there are other processes influencing the population – these are likely to be density independent processes, possible weather such as hard winters. As the model stands it is not possible to combine density independent and density dependent processes because the model operates at the level of net growth rate. I could envisage an analysis of WeBs counts in relation to winter climatic variables which might serve to explain some of the variation in apparent population growth. If trends in relation to weather, or some other explanatory variable, could be found then a conventional model that considered mortality and reproduction separately would be better able to include both density dependent and non-density dependent processes. It might have been useful to investigate whether or not such weather related trends or relationships with any other potential explanatory variables existed in the WeBs data.

1.3 Assumptions

I would have liked the researchers to have justified the ‘Crystal ball’ approach more fully, why was this approach used rather than a simple reproduction and mortality based approach. A key assumption in this modelling is that the observed population size differences between years represent a sample of the range of population growth rates that can occur in the UK cormorant population. This is perhaps an unfair criticism because this could be levelled at most modelling exercises (but see below). Nonetheless, I do believe that the researchers should have given a more thorough consideration of the relative impact and significance of any failures in model assumptions associated with the approach that they adopted.

2. Data and analysis

2.1 Uncertainties

There are a considerable number of uncertainties in the data used in the model. These uncertainties arise from the use of WeBs data in calculating population size in each year. These have obvious impacts on the calculation of growth rates and also the initial starting population for the model. The authors discuss these uncertainties at considerable length and also the implications for model outputs. Uncertainties in the model are more difficult to quantify. The model is essentially black box in that the growth rate estimates used are derived from empirical estimates of population size and no underlying ecological processes (reproduction and mortality) are modelled explicitly. In view of this, the models effectively operate within the known range of population changes (or statistics derived from it). Thus, if any of the underlying population processes, death, mortality, migration, reproduction change individually as a result of the culling or a change in any other externality, then the model would not be capable of predicting population size, as none of these processes are modelled explicitly.

The fact that the bootstrap model gave wider ranges in predictions (because it utilises two coefficients each with their own sample variation) does not mean that it is less precisely defined relative to the other models – on the contrary it is probably more conservative because it recognises more potential sources of variation.

2.2 Figures and Tables

The figures are much more readily interpreted than the Tables. Table 6 could have been presented as a series of Figures (but this is a minor criticism). The legend to Table 7 is not clear – specifically what is a percentage probability ?

3. Concluding

3.1 Relevant subject matter

The modelling as presented is clear and succinct. I would have liked a more thorough discussion of why this modelling approach was adopted and specifically why it was the best approach available for the cormorant in the UK. In a sense there is no ecological justification for the Crystal Ball approach. The report states that there is a problem with populations of cormorant increasing, but the background and ecological explanations for the change in the population are not articulated. This ecology might seem unimportant given that the population has increased, but it does have implications for the modelling. Are there, for instance, features of cormorant biology that make this approach more appropriate than a simple matrix based model or a spatially explicit model? Since practical cormorant control will involved culling at specific sites, are there likely to be a spatial features (movement between sites, immigration following culling) that may have impacts on the conclusions drawn from the modelling ? Are there data constraints that effectively preclude any of these other modelling approaches ? These issues should be aired as the treatment, whilst of interest, means that we are not presented with the 'whole story'.

3.2 Judgement and evidence

The conclusions as written and based on the modelling as presented are clear and succinct.

3.3 support of conclusions

The model and logical arguments support the conclusions and recommendations as presented. The analytical approach to deriving growth rates for both the density independent and density dependent models is exhaustive in relation to the available data. In effect the researchers have attempted to use the available growth data in as many ways as possible. So, if we can assume that: i) there are no other external driving variables that could 'kick in' as the culling is implemented and ii) that the growth rates observed from the WeBs data are typical of the range that can occur in the UK population, then we can conclude that the model outputs must contain (somewhere within them) the real response to culling.

4. Overall

The work represents sound and robust science and the conclusions are supported by the evidence and analyses presented. The authors usefully discuss the concept of Adaptive Resource Management (ARM), as practised in the management of wildfowl exploitation in the US. This discussion is valuable because it effectively argues for ongoing monitoring and modelling. This strategy is logical because it means that the policy maker can respond to changes in population numbers should the culling strategy generate population consequences that are at odds with those predicted by the model as it currently stands. Furthermore, an ARM approach will allow effective validation of the model, increasing not only the data base on which it is based but also allowing for further modification and extension of the model and the control strategy imposed in the field.

10/01/05