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Scientific analysis of the impact of killing cormorants

As you will know, the RSPB disagrees strongly with the decision to licence the killing of an increased number of cormorants that was announced by Mr Bradshaw last September. Following discussion with Defra officials that resulted in important changes and clarification of the policy, the RSPB did not seek a Judicial Review of the decision.

However, at that time, we expressed our concern about an analysis conducted by the Central Science Laboratory as published on the Defra website, which was used to inform the Minister's decision. We provided detailed comments on the CSL model, and hoped that these would be considered in a revision of the analysis conducted before Christmas.

We are grateful for the opportunity to see those revised analyses. In light of the fact that the previous paper was so fundamentally flawed, we are surprised that the revised analyses are not available for wider public and scientific scrutiny. We urge Defra to publish the revised documents on their website.

The RSPB still has severe reservations over the amended analyses, which we have explained in detail in the attached paper. We remain convinced that the method of modelling density dependence is unsound, a view endorsed by Professor Steve Buckland. This has resulted in a serious underestimate of the impact of the Minister's policy on the wintering cormorant population. Defra's failure to analyse the impact of this policy on the UK breeding population, and the lack of adequate monitoring systems for both populations make it impossible for the Minister to ensure his actions do not breach his obligations under the EU Birds Directive.

We remain deeply disturbed that the decision to kill such a large number of native waterbirds was taken without the benefit of high quality science, and that the attempt to revise the analysis has not tackled some of the key defects.

The RSPB asks you to undertake an urgent, thorough, independent, critically-assessed review of the science that has been used to support the increased level of culling permitted and to monitor the performance of the policy. We hope that you will respond positively to this request, in order to alleviate our concerns and demonstrate Defra's commitment to sound science. We shall make a public call on Defra to do this in a week's time, based on the attached.

I do hope that you will find the attached of interest, and I look forward to hearing whether Defra will review the scientific basis of its decision.

Yours sincerely

M. J. Avery

Dr Mark Avery
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RSPB Comments on CSL's revised cormorant cull analysis

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We have read the revised CSL modelling paper (December 2004 version) with interest and have the following comments to make. While it represents a significant improvement on the model used by the Minister to make the decision (September 2004), several important defects remain and these are important enough to render many of the key predictions of cull impact unreliable. These problems are all likely to underestimate the impact of the cull on cormorant numbers.

Especially weak is the treatment of density-dependence and, hence, the conclusions about whether or not the population would be expected to stabilise after an initial decline and, if so, at what level. There is a fundamental flaw in the method used to estimate the strength of density-dependence which renders the conclusions drawn about the impact of culling invalid. This problem is described in detail in Appendix 1. In addition, the presentation of the predictions of various starting populations and density-dependent relationships is laboured and confusing. We would advocate presenting the predictions from those parameters that are the most reliable and conducting a sensitivity analysis so that the relative effects of varying degrees of inaccuracy in the starting parameters can be presented graphically. We also question whether the power and reporting times of existing monitoring schemes are adequate to allow declines of concern to be detected in a timely manner for the purpose of adaptive resource management. We expand these points in detail in the following sections.

1. The modelling of density dependence is unsound

Problem 1

The model uses only a time series of population estimates to generate the modelled relationship between population multiplication rate and population size (the density-dependence function). This method has a fundamental disadvantage that is difficult to overcome and has not been addressed in the analyses carried out in CSL (2004). This can be explained in simple terms. Suppose that a resident population of cormorants was really exactly the same in each of a series of years, but that the counts fluctuate from year to year either because of (a) errors (missing some sites, missing some birds at some sites, double counting when the same bird moves between sites counted on different dates, observer counting or recording errors, data entry errors, etc) and/or (b) real changes in numbers of cormorants because of variations in the number of temporary immigrants from other populations, or in the proportion of the total population that winters in sites that are surveyed. If this is the case, and the fluctuations can be regarded as random, then a plot of population multiplication rate against population size will yield an apparent density-dependent relationship - the count will be more likely to fall after a high count and increase after a low count. Remember that the real number of resident cormorants is the same in every year in this thought experiment, so there is no real information whatsoever on density-dependence in the resident population in these counts. It can be seen intuitively that count errors lead to the strength of density dependence being estimated to be higher than it really is.

Are there likely to be counting errors and fluctuations caused by the two sources (a) and (b) described above in these data? The answer is certainly yes. We know that not all sites with cormorants were counted in every year, that counts were not simultaneous, so double counting is likely and that the counters and data managers are human. We also consider it likely that the number of cormorants moving temporarily to the UK in winter varies among years (there is evidence that the proportions of UK coastal breeders and of immigrants from continental Europe have changed over recent decades and vary from year to year). The likely magnitude of the errors introduced in this way is not clear. One potentially large source of error is the failure to adjust counts for missing years using either a log-linear model or Underhill's imputing method (the counts used in the analysis appear to unadjusted annual monthly maxima). Although adjusting for missing counts will reduce the effects of measurement error (and should therefore be done), this will not remove all such error. This means that the CSL estimates of the density-dependence relationship are likely to overestimate its strength. The statistical tests of whether density dependence exists or not are not proof against this problem. The precautions taken in CSL 2004 do not solve the problem. A consequence of this is that the population's ability to compensate for the extra mortality caused by culling is likely to be overestimated to an unknown degree by the CSL approach.

We present models in Appendix 1 that clearly demonstrate that count errors in the cormorant WeBS counts would lead to over-estimation of the strength of density-dependence, with further simulations showing that the predictions of the model are sensitive to small variations in this parameter.

Should we discount the modelling of density-dependence based on time series of counts altogether? Some authorities think so, and advocate instead that population ecologists should measure demographic rates (survival, breeding success) independently of population counts and then build population models based on density-dependence (if any) of these rates. Previous studies have identified evidence of density-dependent adult survival in a Danish cormorant colony (Frederiksen & Bregnballe 2000), and it would be possible to test for density-dependence in adult and first-year survival rates using UK ring-recovery data (Wernham & Peach 1999). It might be possible to get more reliable estimates of the strength of density dependence from the WeBS data alone if the measurement error could be quantified and allowed for in the calculations. However, this has not been done in the CSL 2004 document, and would not be easy to do.

Problem 2

A separate problem with the modelling of density dependence lies in the fact that the count data used for this include a period, 1987-1990, when the counts show a systematic trend to increase. It is generally advisable, if the objective is to assess what will happen if you perturb a more or less stable population, to base the measurement of density dependence on a period in which the population shows stability with fluctuations, rather than systematic trend. This is because external conditions might have been changing during the period of population change and therefore be different from those in the later period of stability. Of course, it is also possible that external conditions were broadly the same in the period of population change, but the possibility of a difference cannot be excluded. In this case, the effect of excluding data from the period of rapid increase can easily be judged by removing the three left-handmost points from Figure 2 of CSL 2004. It is obvious that the slope of the fitted regression remains similar when this is done, so the estimated strength of density dependence is not sensitive to this. However, the precision with which the density dependence can be estimated is markedly reduced, which will make the uncertainty in predictions much larger. For example, the spread of projections in Figures 3 and 4 of CSL 2004 should be much wider than is shown.

Another compelling reason for excluding the leftmost point in Fig. 2 (and from all other analyses) is that the WeBS counts for 1986/87 and 1987/88 are probably both gross underestimates of true numbers on WeBS sites during those winters. Cormorant counts were first introduced with the release of a new recording form during 1986/87, but many counters used the old forms during 1986/87 and 1987/88, and there are thought to be many instances of zero counts for cormorant in the WeBS database where no counts were actually undertaken.

Problem 3

There is an inconsistency in the manner in which variations in the starting population size and density-dependence are treated. The intercept of the density-dependent relationship used within sets of simulations is held constant irrespective of the randomly drawn starting population size. This results in the population sizes for any given simulation tending to converge on the equilibrium level determined by the intercept, which results in the uncertainty surrounding the model predictions being underestimated. We believe it would be preferable to adjust the intercept for each simulation so that the population is stable at the starting population size. This will increase the variability of the predictions, and is biologically sensible since the observed WeBS trend has been broadly stable over the previous three years.

2. A problem with the density independent models

There is a defect in the density independent models, for a related reason to that described above for the density dependent models. The population multiplication rate has been estimated from data for the whole period- including a period of rapid increase. Hence, the population is estimated to be growing at about 6% per year. However, it is clear from Figure 1 that this rate is not applicable to the recent situation, because the population has grown more slowly since about 1990. If the estimate was made with data from about 1990 onwards the population multiplication rate estimate would be considerably lower- about 2.5% per year. This makes a difference to the projected impact of the cull assuming density-independence. For example, with a population multiplication rate of 1.06 and a current wintering population of 17,000, the impact of an annual cull of 3000 birds would be a reduction in population by 66% after 5 years of culling. If the population multiplication rate is realistically estimated as 1.025 then the same culling regime would cause a population reduction of 80%.

3. Estimating the probability that the UK will violate the Birds Directive

The CSL 2004 paper estimates the risk that different culling policies would lead to the cormorant population falling below the 1979 level, which is the Government's understanding of its obligations under the Birds Directive (House of Commons Written Answers 25 January 2005: Column 209W).

The paper estimates the population in 1979 by a linear regression based upon the WeBS counts, which is questionable in itself. They then use the models and estimates of uncertainty to calculate the risk. This procedure is seriously flawed because of the defects in the models outlined above. In particular, the probable overestimation of the strength of density dependence will lead to their approach seriously underestimating the risk of a given cull procedure causing the population to fall below the 1979 level. Furthermore, inclusion of the unreliable (low) count for 1987/88 will cause the 1979 population to be underestimated, which will further affect assessment of UK obligations under the Birds Directive

CSL define the criterion population for violation in terms of wintering numbers on freshwaters. However, it is the total UK population, rather than inland wintering numbers, that are the basis for the UK's obligation under the Birds Directive.The inland wintering population is comprised largely of a variable geographic (and biologically arbitrary) subset of the total UK population, and the proportion of the total population wintering inland has increased since 1979. As such, the increases in the total UK population are far less than those estimated from WeBS counts. Comprehensive censuses of UK breeding colonies (excl. Isle of Man and Channel Isles) in 1969-70, 1985-87 and 1999-2001 counted 6,071, 6761 and 8,884 AONs respectively. By interpolation, we can estimate a population of 6,468 AON during 1979, and deduce that the population increased by 37% between then and 2000. This rate of increase is considerably slower than the 260% estimated from the WeBS counts. As such, the risk of the new policy violating the Birds Directive obligations as assessed by Defra is considerably higher than that presented in the CSL paper.

In order to address this, the models should assess the proportional change in the breeding population that would occur in response to the culling policy relative to the 1979 breeding population estimate. However, the current model cannot provide this information as it merely predicts changes in wintering numbers. A more sophisticated demographic model that includes data on the provenance of inland wintering birds and considers the impacts on numbers at breeding colonies should be developed in order to ensure that UK government understands the impact of its policy.

4. Problems with the Adaptive Resource Management approach
In view of the defects and uncertainties outlined above, we regard as a wise precaution Defra's decision not to rely solely on the predictions of the models to guide management of the cormorant population in the long-term. WeBS counts will be used to assess the effects on the population and the models and management will be adjusted accordingly. This will, theoretically, reduce the likelihood of a fall in numbers leading to a change in conservation status - we note that the Minister has told Parliament that the Government "has no intention of allowing the cormorant population to be reduced to anything approaching the 1979 level".

For this approach to be effective it is essential that the monitoring strategy in place has a short reporting time and accuracy and precision to give adequate power to detect trends that are more rapid than anticipated so that licensing can be adjusted. We would question whether WeBS is adequate in either respect in its current form. The data in the CSL report only run up to the winter of 2000/2001 suggesting subsequent counts have not yet been fully collated, analysed and published. A four-year lag in dissemination time means that population declines of conservation concern are not recognised in a timely manner, such that excessive culling continues. Examination of the diagrams in Appendix 1 indicates that large population changes can occur at proposed cull levels during a four year period. Furthermore, the power of the WeBS data to detect declines of varying magnitudes over different time periods has not been assessed. As such, it is plausible that sampling and count errors may result in declines of conservation concern not being recognised for several years. The consequences of reporting lag times and sampling error for the efficacy of the proposed adaptive management procedure should be assessed immediately using simulation models.

A further problem, alluded to previously, is that WeBS counts only relate to the inland wintering population, whereas we believe the UK breeding population should be the principal focus of concern. This is because of legal requirements outlined above and because density-dependent movements of coastal wintering birds inland in response to culling have the potential to obscure national declines. As such, responses of the cormorant population to the new policy would be best monitored at the breeding colonies through the JNCC's Annual Seabird Monitoring Programme. We would recommend that power and reporting analyses of the type recommended above for WeBS counts are conducted for SMP data as a matter of urgency following the methods of (Anker-Nillsen *et al*. 1996). A scheme capable of quantifying cormorant trends with sufficient precision should be designed and implemented in time for the forthcoming breeding season. If required, we believe that Defra must fund any additional survey effort required to achieve an effective monitoring strategy as a result of its change in licensing policy.

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