Chamberlain, D., S. Freeman, M. Rehfisch, T. Fox, and M. Desholm. 2005. Appraisal of Scottish Natural Heritage's Wind Farm Collision Risk Model and its Application. British Trust for Ornithology Research Report 401. http://www.iberica2000.org/documents/eolica/REPORTS/COLLISION_MODEL_BTO.pdf

Executive Summary:
1. There are concerns over the potential impacts of wind farms on bird mortality rates due to turbine collisions. Scottish Natural Heritage (SNH) has produced a model to predict collision risk within the sweep area of the turbine rotors, assuming no avoiding action, based on input parameters derived from bird survey data (number of birds per unit time flying through the sweep area) and structural and operational variables describing the wind turbines. Mortality rates are determined by combining predicted collision risk with the numbers of birds at risk and bird avoidance rates when turbines are encountered.
2. This report critically evaluates the SNH collision risk model and its use with avoidance rates to predict bird mortality. Specifically the aims were: (i) To assess the underlying mathematics and assumptions of the model; (ii) To identify those input parameters which vary or are estimated, and which can have a large effect on the model outputs; (iii) To identify any flaws or limitations in the calculation of avoidance rates; (iv) To provide an aid to interpretation of model outputs for non-specialists including a checklist of input parameters for particular scrutiny and any caveats attached to these; (v) To provide recommendations for improvements to the model, its application and interpretation, including data requirements and survey methodologies to adequately parameterize the model, and to provide caveats for the use and interpretation of the model.
3. The model was found to be generally statistically sound. There were two features that could be improved upon. First, it would be more accurate to use a more precise method of integration such as Simpson's rule or the trapezoidal method rather than the simpler rectangular method employed. However, use of these more accurate methods made very little difference to model predictions in the examples here. Second, greater consideration needs to be given of the effects of overlapping rotors on collision risk, although a formal analysis would require a considerable degree of model development.
4. Input parameters to the collision risk model were varied in turn (within a realistic range) in order to assess the sensitivity of predicted collision risk to possible measurement errors. Variations in bird length and wing span had only small effects on collision risk. Bird speed was non-linearly related to collision risk and its variation had a greater effect on predicted collision risk than bird size. Predicted mortality increased exponentially at very low speeds (< 5m/s), but it is doubtful whether many birds fly at this speed.
5. There were non-linear effects of rotor diameter, rotation period and rotor blade pitch angle. Predicted collision risk increased exponentially with decreases in the former two variables. As these are known variables (rather than estimated) it should be possible for very accurate measurements to be used in the model.
6. The outputs from the collision risk models were combined with bird data to predict the mortality rate (assuming no avoiding action). Estimates are made of the number of birds at risk in a given time period (usually from observational survey data of birds flying at risk height through the proposed wind farm). Errors in bird counts and especially of the numbers at risk height will translate into directly proportional errors in predicted mortality rate.
7. The final calculation of mortality incorporates avoidance rates simply by multiplying (1 –avoidance rate) by collision risk and bird numbers at risk. Avoidance rates used in the examples presented were high (>0.90) and therefore resulted in a large adjustment to predicted mortality. Equally, small errors in avoidance rate were shown to result in large percentage changes in predicted mortality rates.
8. Further case studies were used to illustrate the effects of varying different parameters on predicted mortality. In each case, change in avoidance rate had the greatest effect on predicted mortality. In one example, a 10% change in all input parameters to the collision risk model and in numbers of birds at risk resulted in a 52% increase in predicted mortality. A 10% decrease in avoidance rate alone resulted in an increase of over 2000% in predicted mortality.
9. Avoidance rates are poorly known. Estimates are usually derived from the ratio of mortality (estimated by corpse searches) to birds in the risk area, both of which are subject to (sometimes considerable) error. This error will therefore have a large effect on predicted mortality. Given the clear species and site-specific variations in mortality rates, it is deemed unacceptable to use avoidance rates derived from other studies without clear and rigorous justification.
10. It is imperative that further research is carried out on avoidance rates. It is suggested that remote survey methods using surveillance azimuth radar and thermal infrared imagery, for example, be used to assess the behaviour of birds encountering wind farms and any avoiding action taken. Ideally, this would be possible over a range of species and environmental conditions (seasonal, diurnal and weather variations).

11. Mortality is likely to be increased in poor visibility (e.g. at dusk or in poor weather), yet many surveys take place only when (human) visibility is good. Surveys are improved by use of remote technologies as outlined above, so movements under a range of conditions are known. Use of these techniques is not routine, but it is suggested that they should be part of any EIA.
12. Similarly, the relative sensitivity of collision risk to bird speed necessitates further research using remote technologies. In each case considered, bird speed was derived from a single source and was based on radar data for birds migrating. It is conceivable that there may be considerable variation in bird speed depending on species and prevailing conditions.
13. The collision risk model is a robust tool to predict collision risk in the absence of avoidance rates. However, the latter factor has a very large effect on predicted mortality. It is also very poorly studied. For these reasons, we are unable to recommend use of the collision risk model without further research into avoidance rates. The latter must be considered a very high priority.