Natural England Commissioned Report NECR196

# Pink-footed goose anthropogenic mortality review: Avoidance rate review

First published 6 October 2015

www.gov.uk/natural-england

# Foreword

Natural England commission a range of reports from external contractors to provide evidence and advice to assist us in delivering our duties. The views in this report are those of the authors and do not necessarily represent those of Natural England.

## Background

Natural England has been advising on the environmental impacts of onshore and offshore wind farms to both applicants and regulators for a number of years. Over that time the cumulative impacts to certain species has been a key issue. Recently one species in particular, the pink-footed goose *Anser brachyrhyncus*, was thought to be reaching levels of cumulative impact that may be unsustainable.

In order to better understand this Natural England commissioned the Wildfowl and Wetlands Trust to undertake a review on the impacts of wind farms to pink-footed geese.

The results provide the best evidence at the current time and they are published in three related reports:

- This report *Pink-footed Goose anthropogenic mortality review: Avoidance rate review* (NECR196);
- *Pink-footed goose anthropogenic mortality: collision risk modelling* (NECR197)
- *Pink-footed Goose anthropogenic mortality review: Population model* (NECR198).

This information will be used by Natural England, regulators, applicants and their consultants to make better informed decisions about new wind farms.

This report should be cited as WWT Consulting *Pink-footed Goose anthropogenic mortality review: Avoidance rate review*. Natural England Commissioned Report, NECR196 .

**Natural England Project Manager** – Helen Rowell, Block B Government Buildings, Whittington Road, Worcester, WR5 2LQ **helen.rowell@naturalengland.org.uk**

**Contractor** – WWT (Consulting) Limited, Slimbridge, Gloucestershire, GL2 7BT

**Keywords** – pink-footed geese, collision risk, mortality, flight height, wind farms, population viability analysis, migration routes, band model, foraging movements

**Further information**
This report can be downloaded from the Natural England website: **www.gov.uk/government/organisations/natural-england**. For information on Natural England publications contact the Natural England Enquiry Service on 0845 600 3078 or e-mail **enquiries@naturalengland.org.uk**



.

ISBN 978-1-78354-238-3

| | | |
|---|---|---|
| Client: Natural England | | |
| Project: Pink-footed Goose anthropogenic mortality review | | |
| Title: Avoidance rate review | | |
| Issue: 2 | Date: November 2014 | WWT Consulting<br>Wildfowl & Wetlands Trust<br>Slimbridge, Gloucestershire GL2 7BT, UK<br><br>T +44 (0)1453 891222 F +44 (0)1453 890827<br>E info@wwtconsulting.co.uk<br>W wwtconsulting.co.uk |
| Checked by: GB | | |
| Approved by: RW | | |

INVESTOR IN PEOPLE

THE BRITISH ASSESSMENT BUREAU ISO14001 Certification No.187180

THE BRITISH ASSESSMENT BUREAU ISO9001 Certification No.189776

UVDB empowered by Achilles Supplier no 060371

## Contents

Contents

Figures

**1. INTRODUCTION**

**2. METHODS**

**3. RESULTS**

Evidence used to set avoidance rate

**Additional studies**

**4. DISCUSSION**

**5. CONCLUSIONS**

**6. REFERENCES**

**APPENDIX I. FIGURES**

**APPENDIX II. TABLES**

## Figures

Figure 1 - Different possibilities when attempting to calculate the mean chord length in a circle. Each method gives a different mean chord length. Source - http://demonstrations.wolfram.com/RandomChordParadox/

## Tables

Table 1 - Summary table

# 1. INTRODUCTION

**1.1** Natural England (NE) has recently raised concern about the cumulative effect of mortalities from anthropogenic sources, chiefly off and onshore wind farms, on the UK overwintering population of Pink-footed Goose, *Anser brachyrhynchus* (PFG hereafter).

**1.2** In order to clarify thinking and arrive at an informed position, as well as to inform inter-agency discussion on any agreed stance to related issues, WWT Consulting has been instructed to undertake an evidence review.

**1.3** The review will undertake the following:

- review information available for PFG and other species of goose from onshore and offshore wind farms;
- appraise the evidence used to calculate avoidance rates;
- consider interpretations of the evidence used to calculate avoidance rates, and the consequences of these different interpretations; and
- a review of the SNH guidance document ‘Avoidance rates for wintering species of geese in Scotland at onshore wind farms’.

# 2. METHODS

**2.1** In order to complete the review, a number of studies were critically examined, the most relevant being the Scottish Natural Heritage (SNH) guidance document, ‘Avoidance rates for wintering species of geese in Scotland at onshore wind farms’ (SNH 2013), the ‘Review of goose collisions at operating wind farms and estimation of the goose avoidance rate’ by Fernley *et al.* 2006, the Pendlebury appraisal (2006) of the Fernley paper and the ‘Hellrigg wind farm: Goose refuge monitoring report’ (Ecology Consulting 2012).

# 3. RESULTS

**3.1** In May 2013 Scottish Natural Heritage (SNH) published a guidance document entitled ‘Avoidance rates for wintering species of geese in Scotland at onshore wind farms’ (SNH 2013). This document recommended a revised avoidance rate for wintering geese which may encounter onshore wind farms in Scotland. It also suggests that the rate is likely to be justifiably applied to offshore sites, given the current state of knowledge.

**3.2** SNH have recommended that an avoidance rate used in the Band collision risk model (Band 2007) for wintering geese at onshore wind farms is set at 99.8% with the stated aim of being able to provide more accurate mortality assessments, especially for informing cumulative impact assessments and to retain the confidence of developers, consultants and academics in collision risk modelling.

**3.3** The previous avoidance rate used since the last review in 2006 was 99.0%. This figure came from a SNH decision looking to better the precautionary default avoidance rate from 95.0%, after a review by the BTO (Pendlebury 2006) of the paper, 'A review of goose collisions at operating wind farms and estimation of the goose avoidance rate' (Fernley *et al.* 2006).

## Evidence used to set avoidance rate

**3.4** The main resources SNH used to set the revised avoidance rate (99.8%) for wintering geese were:

- Fernley *et al.* 2006 and the subsequent BTO review, Pendlebury 2006;
- information from the AES Geo Energy wind farm in Bulgaria; and
- a literature review including a summary of 'Impacts of wind farms on swans and geese: a review' (Rees 2012).

### Fernley *et al*. 2006 and Pendlebury 2006

**3.5** Fernley *et al.* (2006) reviewed data from five wind farms in the US: Stateline, Buffalo Ridge, Nine Canyons, Klondike and Top of Iowa; and one in the Netherlands, Kreekrak. Species involved in the analysis were Canada Goose *Branta canadiensis*, Snow Goose *Anser caerulescens* and Brent Goose *Branta bernicla*. These data were used in a collision risk model which was similar, but not identical to the Band model.

**3.6** Due to lack of bird use survey data at Top of Iowa wind farm in the US and Kreekrak wind farm in the Netherlands, these sites could not be used to calculate avoidance rates. The goose avoidance rate calculated in this paper is the mean avoidance rate, calculated by dividing observed mortality (corrected for detection and removal by scavengers) by the predicted number of collisions per year (based on bird use data) and subtracting from 1 at the four remaining study wind farm sites in the US.

**3.7** From this approach Fernley *et al.* calculated a goose avoidance rate of 99.93%.

**3.8** Using the same data as Fernley *et al.*, with some differences in methodology Pendlebury (2006) recalculated the avoidance rates for geese.

**3.9** The main methodological differences used by Pendlebury were:

- data for Snow Goose were not used, giving an avoidance rate for Canada Goose only;
- refined values of mean length of Canada Goose were used;
- a mean flight speed was calculated for Canada goose using additional data;
- average avoidance rate was calculated slightly differently, by dividing mean number of corpses (corrected for corpse search completeness - a measure of the effectiveness of corpse searches) by the mean number of collisions (predicted per year with no avoidance or displacement) and subtracting the quotient from 1, rather than taking a mean of avoidance rates. This gives greater weighting to sites with greater bird use; and
- two equations were used to calculate the mean distance a bird is expected to fly over a circle of known radius (used to calculate the probability that a bird which flies through the survey plot will encounter a turbine): one assuming the same flight direction of all birds (equation 1), and one assuming random flight directions of birds (equation 2). For an illustrated explanation of this see Figure 1, Appendix I.

3.10 Pendlebury calculated the mean avoidance estimate for Canada Goose to be 99.91% and 99.89% using the two different equations.

3.11 The analyses included corpses found incidentally outside the formal corpse searches, without these, avoidance would have been calculated at 100% for all sites.

3.12 To investigate the affects of corpses being missed during searches, given the low corpse search completeness at some sites, Pendlebury repeated the analyses assuming that 10 corpses were not detected at each site.

3.13 A total of ten unfound corpses at any site decreased overall avoidance rates from 99.91% to 99.81% using equation 1 and from 99.89% to 99.77% using equation 2. However, it did cause a drop from 100% to 96.76% (equation 1) or 96.26% (equation 2) at one site. This was due to a low number of predicted collisions at this location.

### AES Geo Energy wind farm, Bulgaria

3.14 The SNH guidance paper reviewed collision probabilities at the Saint Nikola wind farm in Bulgaria (Zehtindjiev & Whitfield 2011). Data such as flight heights, frequencies and numbers were collected over two years and corpse searches were undertaken.

3.15 Collision mortality was calculated for Red-breasted Goose *Branta ruficollis* and Greater White-fronted Goose *Anser albifrons.*

3.16 For Red-breasted Geese collision mortality estimates ranged from 0.13 birds per annum using a 99.9% avoidance rate (2010/11 data) to 8.9 birds per annum using a 99% avoidance rate (2009/10 data).

3.17 For Greater White-fronted Goose collision mortality ranged from 1.7 birds per annum using 99.9% avoidance rate (2010/11 data) to 86.1 birds per annum using a 99% avoidance rate (2009/10 data).

3.18 No carcasses were found during corpse searches.

3.19 SNH calculated, using the 2010/11 Greater White-fronted Goose data, that an avoidance rate of 99.7% was the minimum avoidance rate that could account for zero collisions, using a 5% quantile as a level of significance. Using 2009/10 data the minimum avoidance rate which could account for zero collisions was 99.9% at the 5% level.

3.20 SNH concluded that it's reasonable to suppose that the actual avoidance rate for Greater White-fronted Geese was likely to be 99.7%, assuming some corpses may have been missed.

### SNH review of other literature

3.21 The literature review in the SNH guidance uses data from Durr (2012), Rees (2012) and Rydell *et al* (2012), among others, and details the low levels of goose casualties at wind farms across Europe and Scandinavia, where post construction monitoring has taken place. Unfortunately inadequate data exists to be able to calculate avoidance rates, and dead birds were found incidentally at a number of sites. The review does suggest that in general geese do not collide with wind farms in large numbers, however the data cannot provide robust avoidance rates or be tested statistically.

## Additional studies

**3.22** An initiative in Germany called PROGRESS aims to characterise collision mortality and calculate avoidance rates from 54 wind farms across Germany. Unfortunately, at the time of writing these data were not available. The Scottish Wind Farm Bird Steering Group (SWBSG) is also making efforts to collate data which have and are being collected from onshore wind farms in Scotland, however this is still work in progress. Ecology Consulting undertook pre and post-construction monitoring at Hellrigg Wind Farm in Cumbria, UK.

## Hellrigg Wind Farm

**3.23** Post construction monitoring was undertaken at Hellrigg Wind Farm during the winter of 2011/2012. Surveys included weekly goose field counts, dropping counts, collision searching using SNH methodology (SNH 2009) and vantage point surveys with recording of flight heights (Ecology Consulting 2012).

**3.24** It is worth noting that mitigation, in the form of fields designated as goose refuge areas, was in place post-construction and that food availability had changed in 2011/12, compared to the pre-construction survey period due to crop rotation.

**3.25** No PFG were found during corpse searches. Entering the pre-construction data into the Band (2007) collision risk model using a 99% avoidance rate predicted that 20 PFGs would collide annually.

**3.26** Macro-avoidance, resulting in lower densities of birds flying across the wind farm, was noted during post-construction monitoring in the winter of 2011/12. Using the observed data from 2011/12, not taking into account displacement then 12.6 PFG corpses would have been expected, taking into account displacement then 5.2 PFG corpses would have been expected.

**3.27** In this case using the 99% avoidance rate has overestimated the actual collision risk assuming no corpses were missed and unaccounted for, however it must be remembered that this data has only been collected over one winter 2011/12.

## Offshore wind farm sites

**3.28** Owing to their inaccessibility for such studies, there are currently few data on avoidance rates from offshore wind farm sites.

**3.29** Using radar studies, Plonczkeir & Simms (2012) established a wind farm macro-avoidance rate for flocks of geese of 94.46% at Lynn and Inner Dowsing wind farm. This incorporated a vertical avoidance measure recorded by visual observations, as well as horizontal avoidance which was recorded by radar. Thus the ‘avoidance rate’ reported in this study was different from that used in the above terrestrial studies to inform avoidance rates for collision risk modelling as it related to flocks of geese and not individuals and considered avoidance at the scale of the wind-farm and not of the turbines. It is therefore likely the avoidance rate for individuals would be higher due to micro-avoidance of turbines. However, observations were mostly made in good weather conditions when avoidance may have been greater.

# 4. DISCUSSION

**Fernley et al. 2006 and Pendlebury 2006**

**4.1** The data used in this study was far from perfect, many assumptions and estimates were made, methodologies differed between sites and corpse searches in some cases were inadequate (see Pendlebury 2006). For details of equations and data needed in order to calculate avoidance rates also see Pendlebury (2006).

**4.2** The main shortfalls of the study are listed below:

- fraction of birds flying at rotor height was estimated at two sites, taking into account similar vegetation type and close proximity to each other (one of the sites used to estimate another was itself estimated from a third site);
- incidental records of corpses found were included in analysis at two sites, indicating inadequate corpse search methodologies;
- bird use surveys did not include all months of the year at one site;
- corpse search completeness estimates were very low at one site limiting confidence in the zero goose collisions recorded;
- a proportion of vantage points recording bird use were not on site at one wind farm (2-4 miles away);
- number of goose flight hours per day was estimated;
- proportions of geese within waterbird numbers was estimated at one site;
- an average length of Canada Goose was used, ignoring races of birds; and
- out of three ways to calculate mean chord length of a circle only one was considered.

**4.3** It is worth noting that some of these data problems would result in a precautionary underestimate of avoidance rate (overestimate of collision rates).

**4.4** There are three ways to calculate the mean chord length in a circle, a value which is used to calculate the probability that a bird flying through the survey plot will encounter a turbine (see Fig 1 Appendix II). As the figure illustrates, possibility a) birds are assumed to fly parallel across the circle; possibility b) birds are assumed to enter the circle in one place then cross it in a random direction and possibility c) birds are assumed to cross a random point in the circle (http://demonstrations.wolfram.com/RandomChordParadox/). Options a) and b) have been considered by Pendlebury (2006) but option c) has not. As Pendlebury mentions, discussions with a mathematician would be needed in order to investigate option c further and confirm the most appropriate method to use.

**4.5** Only four sites have been used in the Fernley *et al*. study and between site variation has not been adequately studied. This would be important if the findings of the study are used to inform other sites. Differences could arise from topography of the site, weather conditions especially those creating poor visibility, numbers of geese using the site and surrounding area, proximity to feeding and roosting areas, seasonality of use and habituation over time (Pendlebury 2006).

**4.6** It is also difficult to know how these data on Canada and Snow Goose can be applied to Pink-footed Goose.

**4.7** Having more thorough corpse searches, for example as increased survey period, increased survey plots and frequency of searches would increase the accuracy of collision rates, seeing as these are comparatively rare events.

**4.8** It should be noted that Pendlebury concludes by stating that studies reviewed by Fernley *et al.* cannot be used to produce reliable estimates of goose avoidance rates, due to the small numbers of sites and flaws in the protocols used to collect data.

**AES Geo Energy wind farm, Bulgaria**

**4.9** Concerns over quality of data collection, survey design and quality of reporting have been raised about this unpublished report, as well as it being a short term study, using only two years of data.

**4.10** In particular, carcass removal tests and searcher efficiency trials were not carried out in either year, an important detail as scavenger rates can vary between years due to differences in populations and behaviour of different species (Zehtindjiev 2011). In 2010/11 corpse searches were carried out responsively to the presence of geese in the area and surveyed turbines were deliberately selected (Zehtindjiev & Whitfield 2011). This methodology makes it impossible to estimate collision mortality across the whole site, especially as some turbines may present more risk than others within the wind farm.

**4.11** The value for avoidance rates for geese calculated in the SNH guidance document assumes that all data is collected in a scientifically reliable manner, and that methodologies are well designed and lead to unbiased results. There is doubt that this is the case, especially regarding corpse searches, the results of which play an essential role in deriving avoidance rates.

**Hellrigg Wind Farm**

**4.12** More robust studies of this kind are needed to be able to adjust the avoidance rate for geese with confidence. Studies such as this at different sites, in different weather conditions and over additional years would provide quality data on which to base a change to the avoidance rates.

**Offshore wind farm studies**

**4.13** Onshore and offshore wind farms are generally encountered by geese at different stages of their annual cycle, during the winter and breeding season for onshore developments and during migration for the offshore ones. It may be appropriate for there to be some variation in avoidance rates used in each situation, but as yet there are no studies which could be used to quantify this.

**4.14** As noted in the review above there were, at the time of writing, no data from offshore wind farm studies which could directly inform an avoidance rate for collision risk modelling. The study by Plonczkeir & Simms (2012) though useful for the study of macro-avoidance did not take account of micro-avoidance by individuals and thus their flock avoidance rate of 94.46% was not directly comparable.

**4.15** Recognising the importance of micro and macro-avoidance at offshore wind farms the Crown Estate has launched a joint industry programme to deploy surveillance devices on wind turbines at offshore wind farm sites to record collision/avoidance events (The Crown Estate 2013).

**Displacement and avoidance**

**4.16** To clarify the issue as to whether the avoidance rate calculated by SNH takes into account displacement, Pendlebury (2006) explained the avoidance rate used by SNH in the Band collision risk model is a combination of displacement and avoidance, as the model uses the avoidance rates in order to correct collision rates calculated using flight activity data collected before turbines are present, which therefore do not include avoidance or displacement behaviour.

**4.17** From a range of post construction monitoring, the displacement distances for feeding geese and swans at wintering sites ranged from 100-600m, but there may be large scale effects, with fewer swans and geese returning to wintering areas post construction of wind farms (Rees 2012).

**4.18** It is therefore necessary to monitor for more than one year pre- and post construction, in order to determine firstly the frequency of movement over the site in the absence of turbines, bearing in mind that birds may change their flight lines due to location of food supply and weather conditions, and secondly, annual variations in macro avoidance.

**4.19** SNH's recommendations of monitoring in years 1,2,3,5,10 and 15 post construction where major habitat change has not been part of the process (SNH 2009 cited in Rees 2012) should therefore be adhered to.

**4.20** A summary of studies reviewed, avoidance rates estimated and an assessment of the quality of the study can be found in Appendix 2, Table 1.

## 5. CONCLUSIONS

**5.1** Keeping the results of other studies and collected evidence in mind, SNH guidance turns to the Pendlebury (2006) review to set the avoidance rate for wintering geese (as it did to set the 99% avoidance rate previously), accepting the precautionary approach that 10 corpses at each site were missed, and uses the most precautionary equation to set the avoidance rate for geese at 99.8%.

**5.2** The main problems with this are as follows:

- Pendlebury states that the studies reviewed by Fernley *et al.* (2006) cannot be used to produce reliable estimates of avoidance rates; and
- the last avoidance rate set at 99%, was made after the Pendlebury review, and since then there has been no other good quality data over a suitable timescale on which to base a justifiable change.

**5.3** Although the average avoidance rate for geese is likely to be high, and may well be in the region of 99.8%, rates set for national use should be based on sound data, collected over an appropriate number of sites and timescales, using comparable methodologies and published following peer review.

**5.4** It is undoubtedly essential to retain the confidence of developers, consultants and academics in the discipline of collision risk modelling. However, basing decisions on poorly collected data, with inconsistent methodologies, focusing on different species in different countries is unlikely to do this. Where there is uncertainty, avoidance rates for birds should be precautionary and since the last review of Fernley *et al*. (2006) and Pendlebury (2006) there seems to be little new evidence on which to base an informed revision.

**5.5** Therefore the current avoidance rate of 99% should continue to be adhered to, pending results of more robust studies which may at the earliest come from outputs of the PROGRESS and SWBSG projects. Amending avoidance rates could then be revisited in the light of more reliable information.

## 6. REFERENCES


BAND W, MADDERS M & WHITFIELD DP. 2007. Developing field and analytical methods to assess avian collision risk at wind farms. In M de Lucas, GFE Janss & M Ferrer (eds.). 2007. Bird and Wind Farms: Risk Assessment and Mitigation, pp. 259–275. Quercus, Madrid, Spain.

DÜRR T. 2012. http://www.mugv.brandenburg.de/cms/detail.php/bb1.c.312579.de

ECOLOGY CONSULTING. 2012. Hellrigg Wind Farm: Goose Refuge Monitoring Report 2011-2012. Report to RWE Npower Renewables.

FERNLEY J, LOWTHER S & WHITFIELD P. 2006. A review of goose collisions at operating wind farms and estimation of the goose avoidance rate . Natural Research Ltd, West Coast Energy and Hyder Consulting report. West Coast Energy, Mold, UK.

http://demonstrations.wolfram.com/RandomChordParadox/. Viewed 22 Nov 2013

PENDLEBURY C. 2006. Review of 'Review of goose collisions at operating wind farms and estimation of the goose avoidance rate'. BTO report to SNH

PLONCZKEIR P & SIMMS IC. 2012. Radar monitoring of Pink-footed Geese: behavioural responses to offshore wind farm development. Journal of Applied Ecology 49, 1187-1194

REES E.C. 2012. Impact of wind farms on swans and geese: a review. *Wildfowl*. 62: 37-72.

RYDELL J, ENGSTRÖM H, HEDENSTRÖM A, LARSEN JK, PETTERSSON J & GREEN M. 2012. The effect of wind power on birds and bats – A synthesis. Swedish Environmental Protection Agency. http://www.naturvardsverket.se/Documents/publikationer6400/978-91-620-6511-9.pdf

SNH GUIDANCE. 2009. Guidance on methods for monitoring bird populations at onshore wind farms. SNH Guidance Note

SNH GUIDANCE. 2013. Avoidance rates for wintering species of geese in Scotland at onshore wind farms.

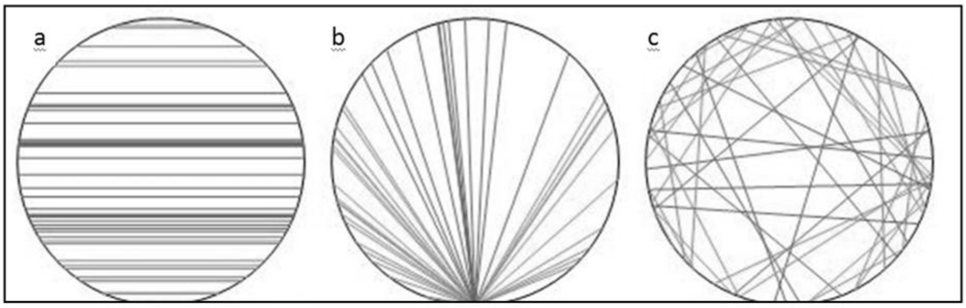
THE CROWN ESTATE. 2013. £3m joint industry programme to accelerate deployment of offshore wind programme. 6 November 2013. [Online]. Available: http://www.thecrownestate.co.uk/news-media/news/2013/-gbp-3m-joint-industry-programme-to-accelerate-deployment-of-offshore-wind-programme/. Accessed 21 January 2014.

ZEHTINDJIEV P. 2011. Summary of activities and the results of ornithological and bat monitoring in 2011. Report to AES Geo Energy OOD, Sofia, Bulgaria.

ZEHTINDJIEV P & WHITFIELD P. 2011. Monitoring of wintering geese in the AES Geo Energy Wind Farm "Sveti Nikola" territory and the Kaliakra region in winter 2010/11. Unpublished report to AES Geo Energy OOD, Sofia, Bulgaria.

# APPENDIX I. Figures

### Figure 1 - Different possibilities when attempting to calculate the mean chord length in a circle. Each method gives a different mean chord length. Source - http://demonstrations.wolfram.com/RandomChordParadox/




# APPENDIX II. Tables

### Table 1 - Summary table

| Study | Summary and key points | Avoidance | Study quality |
|---|---|---|---|
| Ecology Consulting. 2012. Hellrigg Wind Farm: Goose Refuge Monitoring Report 2011-2012. Report to RWE Npower Renewables. | This report describes post construction monitoring durin the winter of 2011/2012. Surveys included weekly goose field counts, dropping counts, collision searching using SNH methodology (SNH 2009) and vantage point surveys with recording of flight heights. | A 99% avoidance rate overestimated the collision risk, assuming no corpses were missed. | A robust study which used many different survey types.Timescales still short (2 years). |
| Fernley J, Lowther S & Whitfield P. 2006. A review of goose collisions at operating wind farms and estimation of the goose avoidance rate . Natural Research Ltd, West Coast Energy and Hyder Consulting report. West Coast Energy, Mold, UK. | A review of data from five windfarms in the US and one in the Netherlands, involving studies of Canada, Snow and Brent Geese. A mean goose avoidance rate of 99.93%, was calculated from data from four windfarms, by dividing observed mortality by the predicted number of collisions per year and subtracting from unity. | 99.93% | 9 main shortfalls. |
| Pendlebury C. 2006. Review of 'Review of goose collisions at operating wind farms and estimation of the goose avoidance rate'. BTO report to SNH. | This paper is a review of Fernley et al (2006). Pendlebury disregarded some data, used refined bird measurements in the calculation of predicted collision rates, and calculated the avoidance rate in adifferent way, giving greater weighting to sites with greater bird use. Analyses included incidentally found corpses, and assumed that 10 corpses were not found at each site. Two different ways were used to calculate predicted bird collisions. This gave overall avoidance rates of 99.81% and 99.77% using two different methods. | 99.77 - 99.81% | Shortfalls of above study taken into account when recalculating avoidance rates. |
| Plonczkeir P & Simms IC. 2012. Radar monitoring of Pink-footed Geese: behavioural responses to offshore wind farm development. Journal of Applied Ecology 49, 1187-1194 | This paper established a wind farm macro-avoidance rate for flocks of geese of 94.46% at Lynn and Inner Dowsing wind farm. This incorporated a vertical avoidance measure recorded by visual observations, as well as horizontal avoidance which was recorded by radar. | 94.46% | Micro avoidance of individuals not taken into account and avoidance rate at the scale of the wind farm and not individual turbines. |
| Rees E.C. 2012. Impact of wind farms on swans and geese: a review. Wildfowl. 62: 37-72. | This paper reviews data published on the effects of onshore and offshore windfarms on swans and geese. It discusses avoidance and displacement issues, and highlights gaps in data. | _ | _ |
| Zehtindjiev P & Whitfield P. 2011. Monitoring of wintering geese in the AES Geo Energy Wind Farm "Sveti Nikola" territory and the Kaliakra region in winter 2010/11. Unpublished report to AES Geo Energy OOD, Sofia, Bulgaria. | This report is a short term study covering two years. There are concerns over quality of data collection, survey design and quality of reporting. Corpse searches were of particular concern in this study, as search efficiency testing and carcass removal by predator tests were not carried out. Methodology of corpse searches was questionable. | _ | Concerns over quality of study and reporting. |