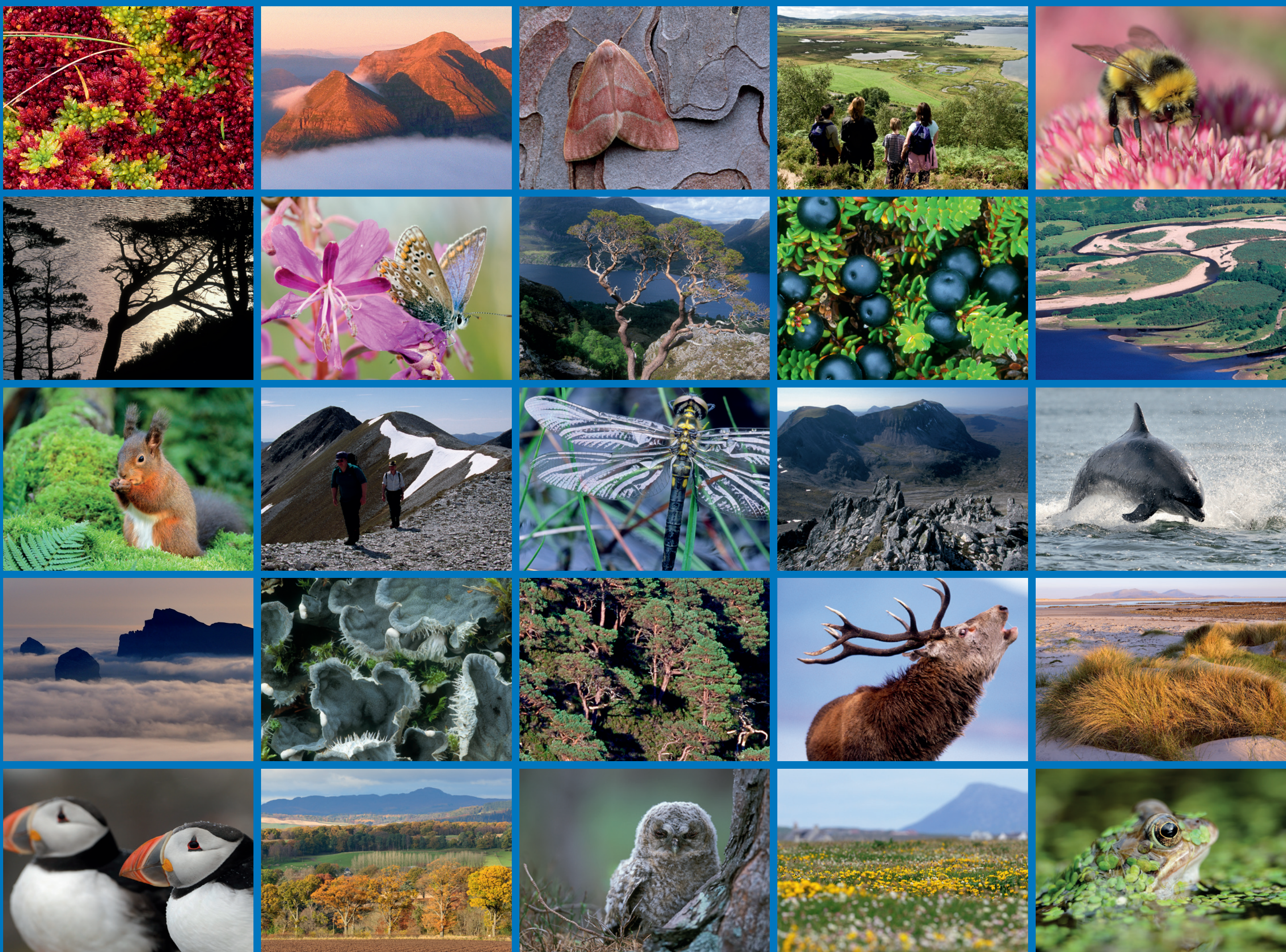
Scottish Natural Heritage
Research Report No. 1019

Avoidance rates of herring gull, great black-backed gull and common gull for use in the assessment of terrestrial wind farms in Scotland



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RESEARCH REPORT

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Avoidance rates of herring gull, great black-backed gull and common gull for use in the assessment of terrestrial wind farms in Scotland

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RESEARCH REPORT

Summary

Avoidance rates of herring gull, great black-backed gull and common gull for use in the assessment of terrestrial wind farms in Scotland

Research Report No. 1019
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Keywords

avoidance rate; herring gull; great black-backed gull; common gull; wind farm

Background

The aim of this report is to assess if the avoidance rates used in the basic Band model (Option 1) for herring gull *Larus argentatus*, great black-backed gull *L. marinus* and common gull *L. canus* in the marine environment are also applicable to collision risk modelling at terrestrial wind farms in Scotland.

Main findings

- At present, SNH recommend use of a precautionary 0.98 avoidance rate for all gull species at terrestrial wind farms;
- SNCBs recommend use of a 0.995 avoidance rate for large gulls at offshore wind farms;
- The 0.995 rate is based on evidence from terrestrial wind farms, reviewed and evaluated thoroughly by the BTO, making the assumption that avoidance in the marine environment would be the same as in the terrestrial environment;
- The BTO review suggested an evidence-based avoidance rate of 0.992 for small gulls, also based on terrestrial data;
- Since the evidence-based avoidance rates are based on detailed and robust data, it would be appropriate for SNH to recommend use of avoidance rates of 0.995 for large gulls and 0.992 for small gulls at terrestrial wind farms as well as for offshore wind farms;
- It is inconsistent to use a 0.98 avoidance rate for gulls at terrestrial wind farms when strong empirical evidence clearly indicates much higher avoidance;
- All the above rates apply in the case of the basic Band model (Option 1) and are not appropriate for the 'extended' Band model.

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Thanks to Aonghais Cook, British Trust for Ornithology, for a quick response to confirm that BTO are unaware of any new evidence on gull collision rates/avoidance rates published since the BTO report in 2014.

Thanks to Jared Wilson, Marine Scotland Science, for also confirming that he is unaware of any new evidence on gull collision rates/avoidance rates published since the BTO report in 2014.

1. INTRODUCTION

The aim of this report is to assess if the avoidance rates used in the basic Band model (Option 1) for herring gull *Larus argentatus*, great black-backed gull *L. marinus* and common gull *L. canus* for collision risk modelling (CRM) at wind farms in the marine environment are also applicable to CRM at terrestrial wind farms in Scotland.

Background

Estimating numbers of birds that might be killed by collision with wind turbines is routinely done in the UK using the Band model (Band, 2012). The Band model is a mechanistic model that calculates the chances of a bird being hit by rotating turbine blades if it flies through the area at a height where collision is possible and makes no attempt to avoid the spinning rotors. In reality, birds will tend to show some avoidance behaviour, either changing their flight path to avoid entering into the wind farm at all (often termed 'macro-avoidance'), or changing their flight path to fly between, above or below rows of turbines rather than through the rotor swept area (often termed 'meso-avoidance'), or changing their flight path at the last moment to avoid collision as they pass through the danger area (often termed 'micro-avoidance'). These behavioural responses of birds reduce collision risk. This can be accounted for in Band model calculations either by using a generic 'default' estimate of avoidance rate which is considered to be precautionary (e.g. a value of 98% avoidance is currently recommended by SNH for bird species where species-specific empirical evidence is lacking; Scottish Natural Heritage, 2010), or by measuring actual collision rates at a specific wind farm (by collecting carcasses of collision victims post-construction, corrected for carcass loss) and comparing this with that predicted by the Band model based on pre-construction surveys of bird flight activity in the area. It is important to note that for empirical measurement of avoidance, the correct comparison is between pre-construction predicted mortality and post-construction observed mortality, as this allows for macro-avoidance (where birds choose not to enter the wind farm). However, this comparison may be compromised by changes in bird abundance over time. An alternative is to compare numbers of collisions with predictions of the Band models based on bird flux rates measured at the same time. That approach provides an estimate of 'within-wind farm avoidance rate' rather than total avoidance rate, as it does not account for macro-avoidance. However, it is likely to be a more accurate estimate than one based on pre-construction flight activity levels, especially where bird numbers may change significantly from year to year.

For many bird species, there are not enough data available to estimate the actual avoidance rates (using the approach described above) that should be used in Band model calculations and so default values need to be used. However, where empirical evidence provides reliable measurement of actual avoidance rates, the use of species-specific or group-specific measured rates is appropriate.

SNH's approach to the use of avoidance rates in collision risk modelling at terrestrial wind farms is set out at https://www.nature.scot/wind-farm-impacts-birds-use-avoidance-rates-snh-wind-farm-collision-risk-model (Scottish Natural Heritage, 2010). SNH is committed to reviewing avoidance rates for individual species (or species groups) periodically, as new information becomes available.

As the offshore wind farm industry has developed, there has been considerable work undertaken to estimate avoidance rates appropriate to apply in the marine environment. For some species which may be found in both terrestrial and marine locations, including herring gull, great black-backed gull and common gull, the estimated avoidance rates on-shore and off-shore are different. SNH recommends the use with the basic Band model of a 'default' precautionary (rather than evidence-based) avoidance rate of 0.98 for herring gull, great black-backed gull and common gull at terrestrial wind farms (Scottish Natural Heritage, 2010). A review by the British Trust for Ornithology (Cook *et al*., 2014), estimated for the basic Band model for offshore wind farms, evidence-based within-windfarm avoidance rates of 0.9959 (S.D. 0.0006) for herring gull or 0.9956 (S.D. 0.0004) for large gulls in general, and 0.9921 (S.D. 0.0015) for small gulls (predominantly common gulls and black-headed gulls *Chroicocephalus ridibundus*). Consideration of the BTO review led the Statutory Nature Conservation Bodies (SNCBs) to recommend use of the basic Band model with an avoidance rate of 0.995 (+/- 0.001; 2 x S.D.) for herring gull, great black-backed gull and lesser black-backed gull *L. fuscus* for offshore windfarm case-work (JNCC *et al*., 2014). It should be noted that these estimates compare observed and predicted numbers of collisions post-construction, so do not include any measurement of macro-avoidance.

In offshore wind farm assessments, cumulative impacts are generally the most significant issues of concern in relation to protected bird populations (Brabant *et al*., 2015). In a limited number of cases, and for a limited range of species, the cumulative collision risk from on-shore and off-shore developments has to be calculated. For gulls, where the recommended avoidance rates are different between marine and terrestrial windfarms, current practice within SNH is that a correction factor is applied to the estimate of marine collisions to allow them to be combined with the terrestrial estimates. It has been suggested that a single avoidance rate should be applied in both the marine and terrestrial wind farm casework and a judgement has to be made as to whether there is a case for using the marine avoidance rates for herring gull, great black-backed gull and common gull in both environments.

2. AVOIDANCE RATES USED FOR GULLS IN TERRESTRIAL ASSESSMENTS

SNH's current guidance indicates use of a 'default value' of avoidance rate for herring gull, great black-backed gull and common gull of 0.98 for the basic Band model applied to terrestrial wind farm case work (Scottish Natural Heritage, 2010). This 0.98 value is considered to be suitably precautionary in the absence of substantial empirical data, taking account of uncertainties inherent in the data on avoidance rates (Scottish Natural Heritage, 2010). It is not based on empirical evidence for these particular species, but is based on general observations of many different bird species at many different terrestrial wind farms. The precautionary estimate of 0.98 was proposed by SNH before the BTO review (Cook *et al*., 2014) of empirical evidence regarding gull avoidance rates was available.

3. AVOIDANCE RATES USED FOR GULLS IN OFFSHORE ASSESSMENTS

Studies have been carried out at offshore wind farms to measure behavioural responses of birds to offshore wind turbines. These include use of radar to track flight lines of birds approaching offshore wind farms (Desholm & Kahlert, 2005; Fijn *et al*., 2015), use of thermal cameras to monitor behaviour of birds close to offshore turbines and to identify collisions (Desholm *et al*., 2006), and use of human observers on suitable platforms to observe and measure bird flight behaviour with tools such as laser rangefinders (Desholm *et al*., 2006). While considerable amounts of data have been gathered from such studies, it has proved impossible up until now to measure avoidance rates of birds at offshore wind farms (Cook *et al*., 2014; ORJIP, 2016).

In order to obtain empirical estimates of avoidance for key seabird species, Marine Scotland commissioned the British Trust for Ornithology (BTO) to review evidence for avoidance rates of gannet *Morus bassanus*, kittiwake *Rissa tridactyla*, large gulls and small gulls. Although radar studies indicated high levels of macro-avoidance of offshore wind farms by gannets, studies at offshore wind farms did not permit quantification of avoidance rates for use in Band model calculations.

Instead, for gulls, BTO reviewed measurements of actual collision numbers of gulls at terrestrial wind farms where these had been measured using appropriate methods and for suitable sample sizes, and compared these to numbers predicted on the basis of contemporary measurements of bird flux rates (i.e. estimating within-wind farm avoidance rates). The assumption was made that within-wind farm avoidance rates of gulls at offshore wind farms would be closely similar to those measured at terrestrial wind farms so data from terrestrial studies could be used for offshore case work. This assumption has not been tested thoroughly because within-wind farm avoidance rates have not yet been measured empirically at any offshore wind farm. However, SNCBs agreed to this procedure and now recommend avoidance rates for Band modelling at offshore wind farms based on these terrestrial data (JNCC *et al*., 2014).

The estimation of avoidance rates at terrestrial wind farms requires counting of corpses of birds killed by collision, so that actual numbers killed can be compared to predicted totals based on the Band model. This could lead to an overestimation of avoidance rates if some corpses are undetected. Correction factors can be used to allow for incomplete detection (Winkelmann, 1992: Bernardino *et al*., 2011), to avoid this potential bias. In their review, Cook *et al*. (2014) looked carefully and critically at the methodologies reported in each of the wind farm studies they reviewed, and excluded from analysis all studies that were found to fall below the highest standard of data quality assurance in relation to corpse collection. In addition, for those studies which Cook *et al*. (2014) considered to be of highest quality, Cook *et al*. (2014) plotted data derived from each individual study to assess the extent to which any one or more of the studies resulted in high leverage of the estimate obtained, or showed evidence of the data being an outlier relative to the distribution of parameter values across the sample of studies. That approach provides greater confidence in the estimates obtained being representative. For example, there were no clear differences in apparent corpse detection success between sites in industrial versus agricultural habitat. Cook *et al*. (2014) also carried out a sensitivity analysis on the data, finding that their conclusions regarding avoidance rates were relatively robust to the likely errors associated with estimation of corpse detection rates. They therefore concluded that estimates of avoidance rates were not biased by corpse detection issues in the studies they included in their review, and this conclusion was accepted by SNCBs.

3.1 Herring gull

For herring gull, BTO identified seven terrestrial wind farms where data of suitable quality were available to permit reliable quantification of within-wind farm avoidance rates for input into Band models. These were Avonmouth Docks, Boudwijn Kanaal, Bouin, Gneizdzewo, Hellrigg, Kessingland, and Zeebrugge. Avonmouth Docks and Zeebrugge are wind farms in industrial dockland areas so are coastal. The other sites are in agricultural habitat, though in all cases the wind farms are near to the coast. None of these sites is an offshore wind farm. Basic parameters for these sites are listed in Table 1.

Table 1. Features of wind farms for which avoidance rates of herring gulls (and other gull species) were quantified by BTO for application in offshore wind farm assessments

Wind farm	Parameters			
	Turbines	Hub height (m)	Rotor speed (rpm)	Landscape
Avonmouth Docks[1]	3	79	17.5	Industrial port
Boudwijn Kanaal[2]	14	55	43	Agriculture
Bouin[3]	8	60	18	Agriculture
Gneizdzewo[4]	19	80	18	Agriculture
Hellrigg[5]	4	80	18	Agriculture
Kessingland[6]	2	80	15	Agriculture
Zeebrugge[7]	25	34	43	Industrial port

[1] The Landmark Practice (2013)
[2] Everaert (2008), Everaert & Kuikjen (2007), Everaert *et al*. (2002)
[3] Dulac (2008)
[4] Zielinski et al. (2008, 2010, 2011, 2012)
[5] Percival (2012, 2013)
[6] Wild Frontier Ecology (2013)
[7] Everaert (2008), Everaert & Kuikjen (2007), Everaert & Stienen (2007), Everaert *et al*. (2002)

BTO concluded from their review that a total of 526,047 herring gulls were estimated to have passed through these seven sites over the course of their respective study periods. After adjustments were made to this total to account for the proportion of birds flying at rotor height, the size of the rotor swept area and the probability of birds passing through the rotor-swept area without collision, this was predicted to result in 2,157 collisions based on Band model option 1. However, in total only nine herring gull collisions were recorded across all sites during their respective study periods. This corresponds to a within-wind farm avoidance rate of 0.9959 (±0.0006 SD) using option 1 of the Band model (Cook *et al*., 2014). Careful analysis of the data indicated consistent results across sites, with no particular site having excessive leverage on the results.

3.2 Great black-backed gull

Cook *et al*. (2014) concluded that there were not enough data on great black-backed gull to allow a reliable empirical species-specific avoidance rate to be calculated. They proposed that an avoidance rate for great black-backed gull should be based on the species group ‘large gulls’, comprising lesser black-backed gull, herring gull, great black-backed gull, Caspian gull *L. cachinnans* and yellow-legged gull *L. michahellis*.

A total of 639,560 large gulls were estimated to have passed through the same seven sites used for estimating avoidance rate of herring gull (Table 1) over the course of their respective study periods. After adjustments were made to this total to account for the proportion of birds flying at rotor height, the size of the rotor swept area and the probability of birds passing through the rotor-swept area without collision, this was predicted to result in 3,368 collisions based on Band model option 1. However, in total only 42 large gull collisions were recorded across all sites during their respective study periods. This corresponds to a within-wind farm avoidance rate of 0.9956 (±0.0004 SD) using option 1 of the Band model (Cook *et al*., 2014). Note, however, that the majority of these gulls were herring gulls or lesser black-backed gulls, with great black-backed gulls representing only a small minority of the total, so these avoidance rate estimates are largely determined by herring gull behaviour and make the untested assumption that great black-backed gull avoidance is closely similar to that of herring gull.

3.3 Common gull

Only three of the sites reviewed by Cook *et al*. (2014) provided suitable data to estimate avoidance rates of common gulls. These were Gneizdzewo, Kessingland and Hellrigg, all three being terrestrial wind farms in agricultural habitat (Table 1). A total of 841,008 common gulls were estimated to have passed through these three sites over the course of their respective study periods. After adjustments were made to this total to account for the proportion of birds flying at rotor height, the size of the rotor swept area and the probability of birds passing through the rotor-swept area without collision, this was predicted to result in 3,405 collisions based on Band model option 1. However, in total only two common gull collisions were recorded across all sites during their respective study periods. This corresponds to a within-wind farm avoidance rate of 0.9995 (± 0.0003 SD) using option 1 of the Band model (Cook *et al*., 2014).

Cook *et al*. (2014) also presented data for ‘small gulls’, representing a combination of common gulls and black-headed gulls. A total of 1,589,953 small gulls were estimated to have passed through seven sites (all of those listed in Table 1) over the course of their respective study periods, with common gull forming just over half of this total. After adjustments were made to this total to account for the proportion of birds flying at rotor height, the size of the rotor swept area and the probability of birds passing through the rotor-swept area without collision, this was predicted to result in 5,263 collisions based on Band model option 1. However, in total only 42 small gull collisions were recorded across all sites during their respective study periods. This corresponds to a within-wind farm avoidance rate of 0.9921 (±0.0015 SD) using option 1 of the Band model (Cook *et al*., 2014).

3.4 A flaw in the BTO report methodology

The BTO report (Cook *et al*., 2014) presents avoidance rates calculated based on both Option 1 and Option 2 of the basic Band model. Option 1 is the version of the model using site-specific flight height data, which is the version generally preferred by SNCBs in offshore case work. Option 2 uses generic flight height data compiled across many studies rather than site-specific data. Use of generic data may be necessary where site-specific data are lacking or are inadequate in some respect. However, Cook *et al*. (2014) calculated avoidance rates for Option 2 based on at-sea flight height data summarised in Johnston *et al*. (2014a). The data modelling was inaccurate in that paper and has subsequently been recalculated (Johnston *et al*., 2014b). But more importantly, it is inappropriate to use flight height distributions for gulls observed at sea in relation to flight over land. Gulls tend to fly much lower over the sea than they do over land (Corman & Garthe, 2014; Ross-Smith *et al*., 2016). Using the at-sea flight height distributions seriously underestimates the proportion of gulls that are flying at collision risk height when over land, and so produces misleading predictions of numbers likely to be killed at terrestrial wind farms. This biases the estimated avoidance rate when using Option 2 (i.e. avoidance rates estimated using this approach will be too high). It is inappropriate to use at sea flight height distribution data in relation to collision risk at terrestrial wind farms therefore, the Option 2 estimates presented in Cook *et al*. (2014) should be disregarded. Although SNCBs noticed anomalous differences in avoidance rates between Option 1 and Option 2 analyses in Cook *et al*. (2014), they did not identify the reason for the anomalies (JNCC *et al*., 2014), but it seems clear that this arose from inappropriate use of at sea flight height distributions in relation to terrestrial wind farms. Scrutiny of the data presented in Cook *et al*. (2014) shows that observed flight heights of gulls at the terrestrial wind farms used in the analysis were consistently higher than the at sea flight height distributions reported in Johnston *et al*. (2014a, b), which is consistent with the findings from gull tracking of Corman & Garthe (2014), Ross-Smith *et al*. (2016), and with the general understanding of gull behaviour.

4. EVIDENCE SINCE PUBLICATION OF THE BTO REVIEW

SNCBs considered the BTO review (Cook *et al*. 2014) to be comprehensive and thorough, and were not aware of any additional data that could have been included to improve estimates of gull avoidance rates. JNCC *et al*. (2014) stated '*The SNCBs welcome this important piece of work and congratulate Marine Scotland Science (MSS) for taking the initiative to commission this report and the British Trust for Ornithology (BTO) for conducting such a thorough review*'. The review considered material available up until summer 2014 and a review carried out in 2016 (MacArthur Green, 2016) found no further evidence on avoidance rates of gulls additional to that included in the BTO review.

The Scottish Windfarm Bird Steering Group (SWBSG) were asked if they knew of any reports providing new data on collision rates or avoidance rates of herring gulls, great black-backed gulls or common gulls that have been produced since the review by the BTO. No new evidence was identified by SWBSG from this request. Aonghais Cook, British Trust for Ornithology also confirmed that he was unaware of any new evidence on gull collision rates/avoidance rates published since completion of the BTO report, as did Jared Wilson, Marine Scotland Science.

Dierschke *et al*. (2016) published a review of studies of avoidance and attraction of seabirds in relation to offshore wind farms (but did not quantify avoidance rates appropriate for Band model calculations). They concluded that herring gulls showed no macro-avoidance of offshore wind farms, and in four out of 13 studies they showed some attraction to offshore wind farms. Great black-backed gulls showed slight avoidance in one case, but attraction in six cases, and no response in five cases. Common gulls showed no macro-avoidance of offshore wind farms, but showed some attraction in three cases and no response in six cases.

These data suggest that for these gull species the within-wind farm avoidance rate will be essentially the same as the total avoidance rate, as there is no macro-avoidance to add in. However, the evidence of some attraction to offshore wind farms suggests that gull densities may be higher at offshore wind farms post-construction compared to pre-construction, which could increase collision risk at offshore wind farms (without altering the estimated avoidance rates).

In contrast to the situation offshore, there seems to be no evidence for attraction of gulls to terrestrial wind farms, presumably the weak and inconsistent attraction to offshore wind farms relating to enhanced foraging opportunities in some of these where prey densities increase around offshore wind turbines and scour protection (Stenberg *et al*., 2015), or in the absence of trawl fishing within offshore wind farms (Coates *et al*., 2016).

5. DISCUSSION

The question posed in this review was 'are avoidance rates used in the basic Band model (Option 1) for herring gull, great black-backed gull and common gull in the marine environment also applicable to collision risk modelling of terrestrial wind farms in Scotland?'. The answer to this must be yes. The avoidance rates used in offshore assessments are those recommended by SNCBs (JNCC *et al*., 2014) and since these are based entirely on evidence from terrestrial wind farms, it is clear that, if anything, these rates apply better to terrestrial case work than to offshore case work. There can be no justification in recommending the use of terrestrial wind farm evidence-based rates in offshore work but not applying these same rates in terrestrial case work.

It is important to recognise one flaw in the Cook *et al*. (2014) review. The application of at sea generic flight height distribution data to terrestrial wind farm collision modelling is inappropriate and misleading, and estimates for Option 2 calculations of the Band model in that report should be disregarded. However, that criticism does not apply to Option 1 calculations as those are based on site-specific flight height data for each of the assessed terrestrial wind farms and so can be considered robust.

A recommendation to increase the avoidance rate of gulls for Band Option 1 calculations for terrestrial wind farms in Scotland is consistent with the fact that the 0.98 avoidance rate was intended to be precautionary in the absence of empirical evidence and was intended to be subject to review and refinement when empirical evidence became available (Scottish Natural Heritage, 2010). That evidence is now clearly available, and has been accepted as appropriate for application to offshore wind farm collision modelling (JNCC *et al*., 2014). Avoidance of 0.995 for large gulls and 0.992 for small gulls is also consistent with the evidence-based recommendation of an avoidance rate of 0.995 for great skua *Stercorarius skua*, a species with similar ecology to large gulls, and for red-throated diver *Gavia stellata* (Furness, 2015).

Another important question to ask is: are avoidance rates determined at a variety of terrestrial wind farms in agricultural and industrial port habitats in a variety of countries around Europe applicable to sites in Scotland? There is no evidence to suggest that avoidance rates differ significantly between different terrestrial habitats, although flight heights of birds might be more likely to do so. There was no clear difference in avoidance rate between wind farms in industrial ports and those in agricultural land (Cook *et al*., 2014).

The data from the seven key wind farms included in the BTO study included data collected at all times of year, but predominantly from the nonbreeding season and most likely involving gulls that were not breeding. Since breeding gulls are central-place foragers and need to return quickly to the nest when provisioning chicks, it is possible that breeding gulls might take greater risks when breeding than they would during the nonbreeding period. However, life-history theory suggests that long-lived birds such as gulls should not increase risk of mortality much in order to try to increase reproductive output, as they will have potentially many future years in which to breed if they protect their own survival. So any trade-off between risk and reproduction should be very small and possibly negligible. Such increased risk might manifest itself in terms of breeding birds choosing to fly a more direct but risky route through a wind farm rather than around it. This may increase collision risk by increasing flight activity near to turbines, but would not necessarily alter within-wind farm avoidance rate, particularly since gulls show little or no macro-avoidance (Dierschke *et al*., 2016). These considerations suggest that the data reviewed by BTO are appropriate for application to Scottish terrestrial wind farms.

6. CONCLUSIONS

- At present, SNH recommends use of a 0.98 avoidance rate for all gull species at terrestrial wind farms with the Band collision model.

- At present, SNCBs recommend use of a 0.995 avoidance rate for large gulls at offshore wind farms with the Band Option 1 collision model (which is essentially the same as the onshore version of the model).

- The 0.995 rate is based on evidence from terrestrial wind farms, reviewed and evaluated thoroughly by the BTO.

- There is, at present, no assessment of the validity of applying avoidance rates derived from terrestrial wind farm data to the offshore environment, although there is also no evidence to suggest that avoidance rates differ between these environments.

- The BTO review suggested an evidence-based avoidance rate of 0.992 for small gulls for use with the Band Option 1 model, also based entirely on evidence from terrestrial wind farms.

- Since the evidence-based avoidance rates are based on detailed and robust data, it would be appropriate, and more consistent, for SNH to recommend use of avoidance rates of 0.995 for large gulls and 0.992 for small gulls at terrestrial wind farms as well as for offshore wind farms.

- All the above rates apply only in the case of the basic Band model (Option 1) and are not appropriate for the ‘extended’ Band model which is sometimes used in offshore case work.

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