APPENDIX A11.2

ESTIMATION OF FLIGHT ACTIVITY (NOT DIVERS)

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Appendix 11.2: Estimation of Flight Activity (not divers)

Introduction

Collision Risk Modelling (CRM) requires as an input the expected flight activity that will occur at rotor swept height in the areas where turbines are proposed. This is typically expressed as the flying time at rotor height per unit area per unit time, e.g. bird flying seconds per hectare per year.

This appendix explains the three-step process used to estimate flight activity levels in the vicinity of proposed turbines for all species except red-throated diver, e.g. waders and skua species and merlin. Red-throated diver was treated differently because far more information was available (from the 2000+ mapped flight lines) for this species (ref birds TR).

The three-step process attempts to make the best use possible of the data available. The estimates of flight activity that result from this process need to be interpreted bearing in mind the data and method limitations. However, there is no reason to believe they are affected by any serious bias. Even if more detailed information on flight activity by wader and skua species had been recorded during generic VP watches it is unlikely the final results and assessments would be materially different. In any case methods would still have been required to overcome inevitable spatial biases in survey data caused by distance-detection effects and differences in bird density between VP locations and proposed turbine locations.

Generic VP data and Moorland Bird Survey (MBS) data

The core data available on flight activity by wader and skua species comes from the programme of generic VP watches that was conducted across the site from numerous VPs at all seasons of the year, as described in Appendix A11.1 (Birds Technical Report). For these species the occurrence of any flight activity (seen or not seen) was recorded for each 5-minute period through each VP watch session. The data therefore describe the proportion of 5-minute intervals when flight activity by a species was recorded.

The 5-minute-period flight activity data provide high quality information on when (seasonally and time of day) flight activity occurred and an index of the relative amount of activity occurring within the viewing arc of each VP. However these data do not provide information on the number of birds involved, flying height, flight duration, the routes followed or whether some activity that occurred was likely to have not been detected. The 5-minute-period data essentially provide an index of flight activity and this requires to be calibrated before it can be used to provide absolute estimates of flight activity that can be used for CRM. A study was undertaken in 2007 and 2008 that measured various flight parameters and distance-detection effects required to make the necessary calibrations (see below and Birds TR).

The generic VP data provide a measure of flight activity at the locations where it was obtained. Provided there are numerous VP locations, and these are chosen at random with respect to bird distributions, then generic VP data are likely to provide approximately representative measures of flight activity across an area of interest – in this case the Viking Study Area. However, because of distance-detection effects the generic VP data is inevitably spatially biased in favour of the vicinity of VPs, as flight activity close to VPs is more likely to be seen that that further away. Whereas generic VP locations are likely to be representative of the initial area of interest they are unlikely to be representative of proposed turbine locations if the layout design has been influenced by ornithology sensitivities, as is strongly the case for the Viking windfarm. Indeed, if the layout tends to avoid bird sensitive areas it is to be expected that on average flight activity levels in the vicinity of proposed turbines will be lower than in the vicinity of the VPs. This raises the question of how best to take account of this in analyses. If the assumption is made that flight activity is directly proportional to breeding density (in all wader and skua species the concerns regarding collision risk are to breeding birds) then the data from Moorland Bird Survey can be used to do this. Differences in breeding density (measured from MBS results) between VP locations and proposed turbine locations provide an easy way to estimate flight activity at turbine locations, and thereby estimate collision risks.

In summary, a three-step process is required to estimate flight activity in the vicinity of the proposed turbines from the 5- minute-period generic VP flight activity data.

- **Step 1** – calibrate the index values into absolute estimates of flight activity using mean flight parameter values,
- **Step 2** – account for distance-detection effects.
- **Step 3 –** factor in breeding density differences between VP locations and proposed turbine locations using MBS data.

These are each explained in detail below.

Step 1 - Calibration

A study was undertaken in 2007 and 2008 that aimed to collect the information required to calibrate the 5-minute-period index and correct for bias caused by changes in detection with distance. This study aimed to quantify mean flight parameter values and obtain information on how detection changed with increasing distance from a VP for merlin, golden plover, dunlin, whimbrel, arctic skua, great skua and greylag goose (full details in Appendix Birds TR). Initially curlew were also included but were dropped so that observers could concentrate on species of greater interest. The study was conducted at seven selected VPs that looked across typical areas of the Viking site. They all had 180 degree viewing arcs with approaching 100% visibility up to 2 km. To aid accurate plotting of flight lines a series of distance markers were laid out in an arc 500 m from each VP.

The flight parameters quantified were:

- The mean number of birds per flight event.
- The mean duration of each flight event.

- The mean number of 5-minute periods straddled by each flight event.
- The mean proportion of flying time at rotor height (actually recorded as five height bands, see Appendix A11.1, Birds TR).

Provided these flight parameter data are obtained for a reasonably large sample of flights, and making the assumption that the flights witnessed are representative of flights by that species over the Viking site in general, then it is straightforward to convert the index values from 5-minute-period data into estimates of the actual amount of flight activity that occurred (and was likely to be detected). Put another way, the calibration provides a means to estimate the total amount of flight activity that would have been recorded had an observer recorded full details of the flight activity seen.

Step 1, worked example

Results from calibration study for whimbrel.

Total number of 5-minute periods watched = 2648

- No. of flight events observed = 94
- No. of positive 5-minute intervals = 114
- Mean no. 5-minute periods straddled per flight event = 1.21
- Mean flight event duration (seconds) = 93.4
- Mean number birds per flight event = 1.25
- Proportion of flight activity at rotor swept height (RSH) = 0.408

On average each positive 5-minute interval corresponds to:

(1/1.21) flight events x 1.25 birds x 93.4 seconds = 96.5 seconds of flight activity.

Of this activity, 40.8% was estimated to be at rotor swept height = 39.4 seconds.

Thus, it is estimated that had full flight data been recorded in the generic VP watches, then for each 5-minute period when flying whimbrel were noted on average there would have been 39.4 seconds of observable flight activity at RSH.

This value (39.4s per positive 5-min interval) can now be used to estimate the average flight activity per hour from 5-minute interval VP data. By way of example, for the data above, the number of positive 5-minute intervals was 114 and the number of hours of observation was 220.67 (2648/12). Therefore, the estimated average flight activity is 20.3 seconds at RSH per hour of observation ((39.4 x 114)/ 220.67).

Step 2 – Distance-detection effects

Step 2 involves correcting for distance-detection effects. The standard method described in the SNH guidance for estimating flight activity from VP watch data is to assume that all activity within the visible area of the viewing arc up to 2 km away is seen. For relatively small species this assumption is seriously violated because there is a moderate to high likelihood that flight activity away from the VP but well within 2 km goes undetected. In fairness the SNH guidance was developed with large species in mind such as raptors and geese, species for which the problem of reduced detection with distance is relatively minor. The consequence of overlooking a proportion of the flight activity within 2 km is to underestimate flight activity and unless this is corrected for, collision risk will also be underestimated. The magnitude of underestimation is potentially large, e.g. over an order of magnitude is typical for waders. Therefore, if CRM is to produce credible results distance-detection effects must be taken into consideration.

The 2007/08 calibration study had a second purpose: to collect data on how the detection of each species when flying reduces with increasing distance from a VP. Changes in the detection with distance of flying birds seen in the study were quantified by comparison of the recorded flight activity per unit of the visible area in each of a series of 250 m-wide concentric distance bands centred on the VP. Because VPs were chosen at random with respect to bird flight activity and the location of breeding territories, there was an expectation that the actual amount of flight activity per unit area should be on average constant across all distance bands. The results from all seven VPs were analysed together (see Appendix A11.1 Birds TR). Mapped merlin flight data collected from generic VP watches were also examined using the same method because insufficient merlin flights were seen in distance-detection study.

For all species the results showed a tendency for observed flight activity per unit area to reduce successively in the further away distance bands, in most species reducing to zero well before 2 km. The effect was most marked in the smallest species (dunlin) and least marked in the largest species (great skua). The proportional difference between the observed flight activity per unit area in the closest distance band(s) and those bands further away from the VP gives an estimate of the proportion of flight activity that was overlooked in each distance band and thereby provides a simple means to correct for distance-detection effects. The proportion of the visible area in each distance band that was effectively watched mirrors the bands' histogram heights relative to that for the closest band, which is assumed to have 100% detection (just as in conventional Distance Sampling).

Table 1. Example of distance-detection results for whimbrel.

Distance Band (m)	Observed whimbrel flight activity per unit area relative to 0-250 m band
0-250	100%
250-500	44%
500-750	24%
750-1000	8%
1000-1250	2%

1250-1500	1%
1500-1750	0%
1750-2000	0%

The distance detection results for whimbrel in the Table 1 indicate a fall off in observed flight activity with each successive distance band. It is assumed that all activity was seen in the 0-250 m band, and the others are expressed relative to this.

The 5-minute-interval generic VP data (the data that ultimately need to be corrected) contain no information on the distance that flight activity was from the VP, however the visible area for 250 m wide distance band can be calculated for each VP (using GIS software). Therefore, the simplest way to apply the distance–detection correction, and the way used here, is to calculate the effective area of each distance band, i.e. the area that would have been effectively watched if the observed flight activity was at the same level as in the closest distance band(s). For example, if the amount of activity observed in a distance band was estimated to be 50% and the visible area of this band was 100 ha (from GIS calculation), then the effective area is 50 ha.

The first part of Step 2 was to calculate for the calibration study VPs the effective area watched for each species as described above. GIS software was used to calculate the potentially visible area (at 20 m elevation above the ground) of each 250 m-distance band for each VP. Then the effective area observed of each distance band was calculated by multiplying the potentially visible area figure by the appropriate % detection figure for that species/distance band combination. The effective areas of all the distance bands for a species were then summed to give an effective total area watched. The second part of Step 2, was to repeat the exercise for the generic VPs and calculate the effective area watched for each species at each generic VP. Mean effective visible areas from VPs for each species are presented in Table 2. On average, the calibration VPs had slightly greater visible areas as they were less affected by the view being interrupted by hills and dead ground. Note, in estimating the average flight activity for the Viking windfarm, data were only included from those generic VPs that faced towards and were <1 km from the proposed turbine layout. This meant that data from 21 VPs were used in the analyses; data from 19 others were rejected. Note also that the calculation of flight activity at each generic VP used the effective visible area figure for that VP and not the mean value for all VPs.

Table 2. Mean effective visible areas (ha) for each species after correcting for distance-detection.

Species	**Calibration VPs**	**Generic VPs**
Merlin	126.2	109.3
Greylag goose	222.6	188.3

Golden plover	53.2	47.8
Dunlin	4.5	4.5
Whimbrel	41.3	38.0
Curlew	82.0	72.9
Arctic skua	122.2	107.4
Great skua	205.6	170.3

The corrected value for flight activity per unit area is thus the total estimated time birds were in seen flying (from Step 1) divided by the sum of the effective areas of the distance band. For example, using the results for whimbrel for the calibration VPs, an average of 20.3 seconds of flight activity per hour of watching was recorded (Step 1) and the mean effective visible area from the VPs was 41.3 ha (Table 2). Therefore, the mean flight activity was estimate at 20.3 sec/hr divided by 50 ha, which equals 0.406 seconds per hour per hectare. The corresponding estimate was made for the generic VP data using the proportion of positive 5-minute intervals for a species and the total time watched.

Flight activity estimates from generic VP data were actually calculated as an annual total. To do this the data were split into three seasonal periods: winter (September to February), core breeding season (May, June and July) and 'shoulder' season (March, April and August). The mean estimated flight activity (bird seconds/ha/season) was calculated for each season from the season duration (181, 92 and 92 days respectively) and average day length for the season (8.5, 18.1 and 14.5 hours respectively). The results for the three seasons were then summed to give the estimated flight activity per year. It was assumed that there was no flight activity during the hours of darkness. Although winter flight data were included in the analysis, in practice there was either no or very low flight activity levels recorded at this time of year (see Appendix A11.1 Figs 6 a-j).

Step 3 – Estimating spatial differences in flight activity

Steps 1 and 2 calibrate the 5-minute-period flight activity data from generic VPs and express this as the estimated flight activity per unit area per unit time. These values give the estimated flight activity in the vicinity of the generic VPs. These were chosen at random with respect to the distribution of birds and therefore, taken as a whole should be representative of flight activity across the wider area i.e. the Viking Study Area. However, the proposed turbines are not located at random with respect to bird distributions; indeed the layout was designed to avoid the most sensitive bird areas, especially those of priority species. Therefore, the estimates of flight activity in the vicinity of the generic VPs are not likely to be representative of flight activity in the vicinity of turbines; this has to be accounted for.

The next step, Step 3, is to estimate the mean level of flight activity in the vicinity of the proposed turbines (the input data required for CRM) by accounting for differences in breeding density between the locations of generic VPs and the locations of proposed turbines. Note this step is not required for merlin because they hunt over wide areas up to several kilometres from their nest. Step 3 uses results from Moorland Bird Survey (obtained in the same year as generic VP watches were undertaken) to calculate breeding density and assumes that flight activity at a location is directly proportional to breeding density. Essentially, breeding density measures for a location are used as a surrogate for relative flight activity at that location. The MBS results are the only spatially unbiased data available across the study area to inform variation in density. The MBS results are maps of the nominal territory centres (the average location where birds were seen over successive visits) of breeding birds in the year of survey (Maps 52-75 in Appendix A11.1). The MBS results show that the density of each species varies widely across the study area; indeed it is this variation that was used as a basis for identifying the differences in bird sensitivity that was taken into account in the windfarm design process.

Having established that MBS results can in principal give information on spatial variation in relative flight activity to use alongside absolute measures flight activity from generic VPs, the question arises of how the MBS information is best used and over what spatial scale it should be translated into a density value. This requires information on how far from a territory centre the regular flight activity of an average breeding pair extends. This is unknown but can be estimated approximately from median nearest neighbour distances (the distance between two territory centres) (Table 3). In theory, if territories were close packed across a landscape and the use of the airspace was exclusive to the territory holders, then flight activity by a pair would extend out from the territory centre to half the nearest neighbour distance and no further. In practice observations suggests there is some overlap in the airspace used by adjacent pairs, i.e. the air space of a territory is not entirely exclusive. Furthermore, the assessment needs to err on the side of caution and recognise the inherent approximation of the MBS derived nominal territory centre locations. Therefore, it is reasonable to assume that regular flight activity by a pair extends over a greater distance from its nominal territory centre. For the purposes of analyses it is assumed that it extends twice as far, i.e. to a distance from the nominal centre equal to the median nearest neighbour distance. This distance is to some extent arbitrary and therefore not ideal, however it does provide a reasonable basis for the analyses in the absence of better spatial data on flight activity and the estimate of density is relatively robust to the value chosen. Furthermore, it is important to realise that the choice of value for this distance has no influence on determining the amount of flight activity over the study area, all it affects is the calculation of breeding bird density (and therefore relative flight activity) in the areas occupied by turbines and, thus how the total risk is divided up between turbines.

Table 3. Median nearest neighbour distances of selected species breeding species based on measurement of Moorland Bird Survey results.

Species	Median nearest neighbour distance (m)
Dunlin	341
Golden plover	416

Lapwing	230
Whimbrel	508
Curlew	*359
Arctic skua	817
Great skua	537

* 400 m used in analysis

For the purposes of estimating relative flight activity in the vicinity of the proposed turbines, the density of breeding pairs of each species was calculated for a circle centred on the turbine with a radius equal to the median nearest neighbour distance for that species. The density for each turbine location was calculated from the sum of MBS nominal territory centres within the circle divided by the area of the circle, and the values were then averaged to give a mean density value for all 127 turbine locations (Table 4). If there were no nominal territory centres of a species within the circle the breeding density was taken to be zero and it follows that relative flight activity at that location also approximates to zero (in which case a turbine at that location would pose no collision risk). The breeding density in the vicinity of the generic VPs was also calculated (Table 4). The difference between the mean density of a species in the vicinity of generic VPs and at proposed turbines locations (expressed as a percentage of the VP value) indicates the assumed relative difference in flight activity.

The final part of Step 3 is to estimate the mean flight activity at the proposed turbine locations (Table 5). This is calculated from the mean estimated flight activity at the generic VP locations derived from Step 2 multiplied by the relative mean breeding density at turbine locations from Table 4).

Table 4. The estimated mean density of breeding birds in the vicinity of generic VPs and proposed turbines, the percentage difference between them andthe number of turbine locations where breeding density was greater than zero in the year of survey.

Species	**Mean breeding density in vicinity of generic VPs * (prs/km^2)**	**Mean breeding density in vicinity of proposed turbines ** (prs/km^2)**	**Mean density at turbine locations *cf* generic VPs** (for use in Table 5)	**No. of turbine locations where breeding density is >zero**
Dunlin	1.13	0.80	70.4%	26
Golden plover	1.20	0.99	81.8%	53
Whimbrel	0.46	0.25	54.5%	(38 ***) 29
Curlew	2.61	2.05	78.6%	92
Arctic skua	0.49	0.27	54.8%	58

Great skua	0.79	0.83	106.0%	68

*   Data used were from only the 21 generic VPs that overlooked the windfarm and were within 1 km of proposed turbines..

****** The mean of values from 127 turbine locations.

******* Corresponding figure for all years with survey data.

Table 5. The estimated mean flight activity in the vicinity of generic VPs and proposed turbine locations.

Species	**Estimated mean flight activity in vicinity of generic VPs at RSH (s/ha/yr)** (From Step 2)	**Estimated mean density at turbine locations *cf* generic VPs** (From Table 4)	**Estimated mean flight activity in vicinity of proposed turbines at RSH (s/yr/ha)**
Merlin	15.4	100%	15.4
Dunlin	257.9	70.4%	181.6
Golden plover	3021.6	81.8%	2472.2
Whimbrel	560.2	54.5%	305.2
Curlew	1287.9	78.6%	1012.1
Arctic skua	403.9	54.8%	221.4
Great skua	2841.1	106.0%	3012.0

The estimates of flight activity for each species in the vicinity of turbines (Table 5) is in a form that can be used in CRM. The figures in Table 5 are an estimate of the baseline flight activity in the vicinity of turbines and do not take in to consideration any reduction in flight activity that occurs due to displacement of breeding birds. This should be factored in to CRM as appropriate. For example, if displacement causes 50% reduction in breeding density in the vicinity of turbines, then the input figure for flight activity used in CRM should also be reduced by 50%.

Whimbrel landform correction factor

Typically whimbrels use the concave and lower parts of the landscape whereas typically wind turbines are placed on the convex and higher parts of the landscape. This raised the question of whether the predicted CRM collision rates for whimbrel were biased high as the assumption was initially made that their flight activity was random with respect to landform. If there was a tendency for whimbrel activity to be concentrated over parts where turbines were less likely to be placed then this should be corrected for.

This was analysed using the Calibration Study data where there were mapped flight lines from six VPs. The amount of flight activity seen in each of a 200 m x 200 m square array was calculated. Each 200 m square was classified as one of four landform types: 'steep slopes' (average gradient >0.2), 'gentle slopes' (gradient <0.2, valleys), 'hill top' (gradient <0.2, summits) and 'near stream' (stream marked within 200 m square on 1:25000 OS map). Analysis of these data showed that there was a weak tendency for whimbrel to fly more over the 'gentle slope' and 'stream' squares (i.e. the concave and lower landform elements) and to avoid steep slopes and hill tops compared to what would be expected if they showed no selection.

An analysis of the landform type where turbines are proposed within 500 m of whimbrel territories indicated that turbines were disproportionately more likely to be located in 200 m squares classed as 'hill top' and disproportionately less likely to be located in 200 m squares classed as 'stream'.

An examination of the mismatch between landform selection by flying whimbrel and turbine locations estimates that on average flight activity over areas selected for turbines is likely to be was on average 9% less than if flight activity and turbines were randomly located with respect to landform. This means that the estimated flight activity, and hence collision risk for whimbrel in the vicinity of turbines is likely to be too high by 9%.

The same landform analyses were undertaken for golden plover (but not for any other species). This showed the opposite effect to whimbrel, with the birds showing a slight tendency to use the convex and upper part of the landscape more than expected if flight activity was random with respect to landform. However, the effect was weak. When combined with the assessment of turbine locations the analyses suggested that golden plover flight activity predictions are likely to be biased low by a factor of approximately 1%. In light of this result it was decided that initial collision predictions for golden plover should not be adjusted because the correction value is very small and given it will be effected by sampling error (the data are inherently noisy and the analysis methods used quite course) the effect may be spurious anyway.