Appendix 8.2 Collision Risk Modelling Report: September 2020 – August 2022

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Introduction

Overview

ITPEnergised was appointed by the Applicant to undertake collision risk modelling using data taken from their ornithological surveys (as commissioned by the Applicant) in support of a proposed wind farm development at Nisthill in Orkney. In order to assess the likely impacts of the Proposed Development on the local bird population, analysis for the potential for collision risk has been undertaken on certain key species. The analysis has been undertaken using the design freeze layout and development boundary, as displayed in **Appendix 8.1: Figure 1**, and a provisional turbine specification as outlined in Table 1.

Table 1 Candidate Turbine – Siemens Gamesa SG-155

Parameter	Value
Viewshed Area (Within site)	120.33 Ha (VP1 – 95.4: VP2 – 79.6)
Overlap	54.9 Ha
No. turbines	4
Rotor Diameter	155 m
Hub Height	102.5 m
Max rotor depth	4.2 m
Max chord	4.5 m
Pitch	6°
Rotation period	5.17 secs
Turbine 'lifetime'	25 years

Collision Risk Modelling

Band *et al.* (2007) described a method by which field data on bird flight activity can be gathered and used to quantify crudely the likelihood of collisions with turbines: the 'Band' Collision Risk Model (CRM). This method is more suitable for some species than others (Madders & Whitfield 2006). For example, fast moving raptors like merlin and most songbirds are difficult to detect beyond a distance of a few hundred metres and nocturnal species are difficult to detect at all. As a result, it is rarely possible to generate reliable estimates of flight activity for these species and collision risk is best determined qualitatively.

The Band CRM involves two methods to predict estimated collision fatalities, depending on the pattern of flight of the species involved: 'predictable' and 'unpredictable' flight methods. The predictable flight method (PFM) is appropriate when birds tend to move through an area in a relatively consistent direction, such as during migration or when moving between localised feeding and roosting sites. The unpredictable flight method (UFM) is more appropriate when flights are not in any particular direction and assumes that they are random.

Data Collection and Species Selection

Surveys were undertaken from two VPs between September 2020 and August 2022 with 151 hours at VP1 and 144 hours at VP2, this time period constitutes two breeding seasons and two non-breeding seasons.

A total of 9 target species were recorded from the VP surveys and are summarised below in Table 2. All the survey flights were recorded onto ArcGIS and the data entered into an excel spreadsheet and further analysed in order to select all the flights which were recorded at potential collision height ('PCH') within the viewshed of the VP. PCH is the height between the low and high points of the rotor sweep of the turbine blades, namely between 25 and 180m, all flights and the total number of individuals recorded at PCH within the site boundary from each viewshed of the VP are displayed below in Table 2.

Records at specific height bands were only recorded within the site boundary meaning the Collision risk Zone (CRZ) is a volume which covers the site at PCH. A total of five species (merlin and white-fronted goose with no at-risk seconds, hen harrier with just 32 at-risk seconds across two full years of survey, Arctic skua with 180 at-risk seconds and a 99.5% avoidance rate and whooper swan with a single flight and a 99.5% avoidance rate) are not considered to be significantly affected by collision with the proposed turbines and are not taken forward for collision risk modelling (Table 2).

Of the four remaining species, three were considered to use the site in a random way (great skua, peregrine and short-eared owl) and one was considered to use the site in a predictable way and as such was assessed using the linear model (red-throated diver).

Table 2 Target Species Recorded September 2020 – August 2022

Species	Flights	Total no birds in flights	Duration	In site	In site @ PCH (25-180m)	Total No. Of At Risk Flight Sec. (No. seconds at PCH 25-180m*no birds in flights)	Collison Risk Modelling carried Out
Arctic skua	5	6	265	209	154	**180**	NO
Great skua	43	47	2,036	1,743	1,423	**1,559** (247 Sept 21, 928 Year 1, 384 Year 2)	**YES**
Hen harrier	67	67	8,373	6,790	32	**32**	NO
Merlin	1	1	10	10	0	**0**	NO
Peregrine	4	4	1,023	460	454	**454**	**YES**
Red throated diver	12	13	2,179	1,258	1,186	**1,216**	**YES**
Short-eared owl	20	20	2,887	2,778	317	**317**	**YES**
White-fronted goose	1	13	323	0	0	**0**	NO
Whooper swan	1	3	112	52	**52**	156	NO

Methods

Collision risk has been calculated based as an average figure for the area covered by the site **(Appendix 8.1: Figure 1)** and based on a layout of four wind turbines of the specifications outlined in Table 1. It should be noted that the resultant figures provide an average for the site as a whole and does not allow for the potential of configuring a layout in order to minimise the impacts of the proposed turbines.

The predicted level of collision mortality is based on results obtained from a collision risk model which uses flight activity data, species' parameters and turbine specifications to obtain a collision rate as outlined in SNH guidance (SNH, 2000). The collision risk modelling follows two models, firstly

the random flight model which is used for foraging or displaying birds and secondly the regular model used for commuting or migrating birds.

The guidance also outlines bird biometrics including bird length and wingspan as well as flight speeds and recommended avoidance rates which are inputs into the model and the figures for the species carried forward for collision risk in this assessment are outlined in Table 3 below.

Data on bird flight speed and biometrics were taken from Alerstam *et al.* (2007) and the published avoidance rates was used (SNH 2017).

Detailed data on survey dates, times and weather can be found in **Appendix 8.1: Annex A: Table A1.** For reference, all great skua flights at PCH are presented in Figure 1 and red-throated diver in Figure 2.

Table 3 Target Species Bird Biometrics

Species Name	Bird length (m)	Wingspan (m)	Flight speed (m/s)	Avoidance Rate (%)
Great skua	0.56	1.36	14.9	99.5
Peregrine	0.42	1.02	16.0	98
Short-eared owl	0.38	1.02	8.0	98
Red-throated diver	0.61	1.11	17.0	99.5

Results

Four species were taken forward for collision risk modelling, three using the random model (great skua, peregrine and short-eared owl) and the other using the linear model (red-throated diver).

Full working examples for Year 1 for each are outlined below and a summary of the results for Year 2 is also outlined (the only difference being a survey period of April – September in Year 1 as compared to a survey period of April to August in Year 2). A summary of all the results for clarity is shown in Table 4 below.

Table 4 Collision Risk Modelling Results

Species Name	Year 1 Collision Rate	Year 2 Collision Rate	Average Collison rate	Collisions - Scheme Lifetime (using notional 25 years for comparison)	Years per collision
Great skua (breeding - season only)	0.077	0.033	0.055	1.385	18.047
Peregrine (annual)	0.018	0.001	0.009	0.233	107.071
Red-throated diver (breeding - season only)	0.075	0.024	0.050	1.238	20.202
Short-eared owl	0.032	0.007	0.019	0.485	51.493

CRM Calculations

Stage 1: Number of Birds Flying Through the Rotors per Year

Calculate the number of hours of observation expressed in hectare hours.

Hectare hours = viewshed@PCH (in site) * survey duration (hrs)

vp1 =95.4Ha

vp2 =79.6Ha

Overlap = 54.9 Ha

Table 5 – Hectare Hours Calculation – April to September 2021 for Great Skua and red-throated diver only

Date	VP	Start Time	End Time	Hours	Ha hours
07-Apr-21	1	14:00	17:00	3	286.2
10-Apr-21	2	07:00	10:00	3	238.8
19-Apr-21	1	04:30	07:30	3	286.2
19-Apr-21	2	13:00	16:00	3	238.8
04-May-21	2	15:00	18:00	3	238.8
04-May-21	1	19:00	22:00	3	286.2
25-May-21	2	06:00	09:00	3	238.8
25-May-21	1	13:00	16:00	3	286.2
07-Jun-21	1	03:30	06:30	3	286.2
08-Jun-21	2	19:00	22:00	3	238.8
15-Jun-21	2	07:00	10:00	3	238.8
15-Jun-21	1	11:00	14:00	3	286.2
12-Jul-21	2	09:00	12:00	3	238.8
12-Jul-21	1	14:00	17:00	3	286.2
20-Jul-21	2	07:00	10:00	3	238.8
20-Jul-21	1	18:00	21:00	3	286.2
03-Aug-21	1	05:00	08:00	3	286.2
03-Aug-21	2	12:00	15:00	3	238.8
24-Aug-21	2	06:00	09:00	3	238.8
24-Aug-21	1	15:00	18:00	3	286.2
14-Sep-21	2	08:00	11:00	3	238.8
14-Sep-21	1	13:00	16:00	3	286.2
28-Sep-21	1	07:00	10:00	3	286.2
28-Sep-21	2	16:00	19:00	3	238.8
Total					6300

Calculate hectare seconds = hectare hours * 3600

= 6300 * 3600

= 22,680,000

Great skua – Year 1

Great skua were recorded in September 2020 but as this period was not part of a full continuous breeding season, calculations are based on the full 2021 breeding season recordings i.e. between April and September 2021 when great skua, which spend the winter out on the open ocean, are present in the UK.

A total of 24 great skua flights were recorded between April and September 2021 including a combined total of 26 great skua. Of the 24 flights, 18 were recorded 'at-risk', i.e at collision height over the site, and therefore are included in the collision risk modelling (See Figure 1).

Calculate the bird observation in all areas and percentage of time birds active in overall observed area.

Table 5 All Great Skua flights April – September 2021

Date	Number	VP	<PCH	PCH	>PCH	At-risk seconds
25-May-21	1	2	0	25	0	25
25-May-21	1	2	0	48	0	48
25-May-21	1	1	18	0	0	0
25-May-21	1	1	7	35	0	35
25-May-21	1	1	5	25	0	25
25-May-21	1	1	10	0	0	0
07-Jun-21	1	1	0	40	0	40
07-Jun-21	1	1	0	55	0	55
07-Jun-21	1	1	5	26	0	26
07-Jun-21	1	1	1	7	0	7
07-Jun-21	1	1	0	55	0	55
07-Jun-21	1	1	14	0	0	0
15-Jun-21	1	1	9	43	0	43
15-Jun-21	1	1	0	105	0	105
20-Jul-21	1	2	0	42	0	42
20-Jul-21	1	1	0	40	0	40
20-Jul-21	1	1	0	48	0	48
03-Aug-21	3	1	0	48	0	144
24-Aug-21	1	2	51	0	0	0

Date	Number	VP	<PCH	PCH	>PCH	At-risk seconds
24-Aug-21	1	2	53	0	0	0
24-Aug-21	1	1	8	41	0	41
24-Aug-21	1	1	0	68	0	68
14-Sep-21	1	2	0	41	0	41
28-Sep-21	1	1	0	40	0	40
Total						**928**

Table 6 - Day / Hours lengths Orkney

	Apr	May	Jun	Jul	Aug	Sept
Daylight hours - Orkney	14.5	16.9	18.3	17.7	15.5	12.8
Hours per day - 5% of night	0.475	0.355	0.285	0.315	0.425	0.56
Hours per day - 25% of night	2.375	1.775	1.425	1.575	2.125	2.8
Total flight hours per day 5%	14.975	17.255	18.585	18.015	15.925	13.36
Total flight hours per day 25%	16.875	18.675	19.725	19.275	17.625	15.6
Total days per month	30	31	30	31	31	30
Total flight hours per month - day	435	523.9	549	548.7	480.5	384
Total flight hours per day-5% night	449.25	534.905	557.55	558.465	493.675	400.8
Total flight hours per day - 25%	506.25	578.925	591.75	597.525	546.375	468

Table 7- Available flight hours - Totals

Species	April-August	April-September
Great skua (5% night)	2594	2995
Red-throated diver (25% night)	2821	3289

Bird Activity = Total bird flight time / hectare seconds

= 928 / 22,680,000

BA = 0.0000409171

Overall Area covered by VPs = 120.1Ha

Proportion of time potentially active = Area x BA = 0.004914145

Hours potentially active = 2995 (See Table 7)

Seconds potentially active (2995*3600) = 10780722

Number of seconds of bird occur in airspace = sec potentially active * bird activity

= 10780722* 0.004914145

= 52978.02702

Calculate flight risk volume (Vw)

Vw = 1201000 (m^2) * rotor diameter (m)

Vw = 186155000

Calculate combined rotor swept volume

Vr = number of turbines (n) * pi * r2 * (max chord + bird length)

Vr = 4 * pi * 6006.25 * (4.5 + 0.56)

Vr = 381718.81

Calculate bird occurrence in swept volume

Occurrence = no of sec of bird occ * combined rotor swept volume/flight risk volume

= 52978.02702* (Vr/Vw)

= 52978.02702* (381718.81/ 186155000)

= 108.6337162

Calculate bird transits time and potential number of transits per year

Transit time = (max chord + bird length) / bird speed (m^2)

= (4.5 + 0.56) / 14.9

= 0.339597315

No. of transits = occurrence / transit time

= 108.6337162 / 0.339597315

= 319.8897966

Stage 2 Collision Risk of Bird Passing through Rotor (Assuming No Avoidance)

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA											W Band	12/05/2022
Only enter input parameters in blue												
K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**									
NoBlades	3					Upwind:			Downwind:			
MaxChord	4.5	m	r/R	c/C	α	collide		contribution	collide		contribution	
Pitch (degrees)	6		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r	
BirdLength	0.56	m	0.025	0.575	6.33	22.03	0.86	0.00107	21.49	0.84	0.00105	
Wingspan	1.36	m	0.075	0.575	2.11	7.52	0.29	0.00220	6.98	0.27	0.00204	
F: Flapping (0) or gliding (+1)	1		0.125	0.702	1.27	5.40	0.21	0.00263	4.74	0.18	0.00231	
			0.175	0.860	0.90	4.67	0.18	0.00318	3.86	0.15	0.00263	
Bird speed	14.9	m/sec	0.225	0.994	0.70	4.21	0.16	0.00368	3.27	0.13	0.00287	
RotorDiam	155	m	0.275	0.947	0.58	3.38	0.13	0.00362	2.49	0.10	0.00267	
RotationPeriod	5.17	sec	0.325	0.899	0.49	2.80	0.11	0.00355	1.96	0.08	0.00248	
			0.375	0.851	0.42	2.37	0.09	0.00347	1.57	0.06	0.00230	
			0.425	0.804	0.37	2.28	0.09	0.00377	1.52	0.06	0.00252	
			0.475	0.756	0.33	2.04	0.08	0.00378	1.33	0.05	0.00246	
Bird aspect ratioo: β	0.41		0.525	0.708	0.30	1.85	0.07	0.00378	1.18	0.05	0.00242	
			0.575	0.660	0.28	1.68	0.07	0.00377	1.06	0.04	0.00238	
			0.625	0.613	0.25	1.54	0.06	0.00375	0.97	0.04	0.00235	
			0.675	0.565	0.23	1.42	0.06	0.00373	0.89	0.03	0.00233	
			0.725	0.517	0.22	1.31	0.05	0.00369	0.82	0.03	0.00232	
			0.775	0.470	0.20	1.21	0.05	0.00365	0.77	0.03	0.00232	
			0.825	0.422	0.19	1.12	0.04	0.00360	0.72	0.03	0.00232	
			0.875	0.374	0.18	1.04	0.04	0.00354	0.69	0.03	0.00234	
			0.925	0.327	0.17	0.96	0.04	0.00347	0.66	0.03	0.00236	
			0.975	0.279	0.16	0.89	0.03	0.00339	0.63	0.02	0.00240	
				Overall p(collision) =			**Upwind**	**6.7%**		**Downwind**	**4.7%**	
								Average	**5.7%**			

Annual Collision Rate assuming no avoidance

= No. of transits * Ave probability of collision

= (319.8897966 / 100) x 5.7

= 18.23371841

Corrected for avoidance

= 18.23371841– ((18.23371841/ 100) *99.5)

= 0.091168592

Corrected for downtime

= 0.091168592* 0.85

= 0.077493303

= **0.08** collisions per year (12.9 years per collision)

Over notional lifetime of the scheme

0.077493303 * 25 = **1.94**

Great skua – Year 2

		Year 2 April to august sweep 25-200m
hectare secs		18900000
total bird flight time		384
Bird Activity (ba)		0.0000203175
Overall Area covered by VPs (excluding overlap) =		120.1
		1201000
proportion of time active in area		0.002440127
hours potentially active		2593.845
seconds potentially active (hours*3600)		9337842
no of seconds of bird occ in airspace = sec potentially active * bird activity		22785.52024
Calculate flight risk volume (Vw)		Vw = Overall area (m^2) * rotor diameter (m)
		186155000
Calculate combined rotor swept volume (Vr)		Vr = number of turbines (n) * pi * r^2 * (max chord + bird length)
		381718.81
Calculate bird occurrence in swept volume		Occurrence
		46.72268631
Calculate bird transits time and potential number of transits per year		max chord+bird length / bird speed
		0.339597315
No. of transits occurrence / transit time		137.5826138
Annual Collision Rate assuming no avoidance		7.842208989
Corrected for avoidance		0.039211045
Corrected for downtime		0.033329388
		30.00355104
Over lifetime of the scheme		0.833234705
		0.83

Red Throated Diver – Year 1 (Linear)

A total of 9 red-throated diver registrations were recorded totalling 10 individuals from VP surveys, of which all flights were recorded through the risk window, crossing the window a total of 19 times. The flights included in the linear model and are shown in Figure 2.

Stage 1: Number of Birds Flying Through the Rotors per Year

Calculation of the 'risk window'; Cross section area equal to the width of the wind farm across the general direction of flight multiplied by the height of turbine to rotor tip. Width of wind farm was determined using GIS.

Width of transit flight (Ws)	= 1590m
Turbine height (th)	= 180m
Risk Window (W)	= Ws * th
	= 1590m * 180m
	= 286,200 m^2

Calculate the area occupied by rotor blades (A)

Number of turbine (n)	= 4
Rotor radius (r)	= 77.5
A	= n * π *r2
A	= 4 * 3.14* 6,006.25
A	= 75,438.5 m^2

Express the area occupied by rotor blades (A) as a proportion of the risk window (W)

Proportion (P)	= A/W
	= 75,438.5 / 286,200
	= 0.2636

Calculate the number of bird potentially flying through the site per year (N)

N	= number of red-throated diver transits at PCH per year
	= hourly rate of transit * available hours for flight

Hours surveyed between April 2021 and September 2021

	= hectare hours (correcting for overlap) / hectares visible in Study area
	= 6300 / 120.3
	= 52.369
No. of divers observed in same period	= 19 transits in 11 flights
Hourly rate of transit	= 19 / 52.369
	= 0.3628

Hours available for flight are equal to number of daylight hours in the same period plus 25% of night hours (see Table 7)

Hours available = 3289 1

N = hours available * rate of transit = 3289 1 * 0.3628

= 1193.3

Calculate the number of birds flights (Nf) to fly through the rotor (P)

Nf = N * P

= 1193.3* 0.2636

= 314.54

Stage 2: Collision Risk of Bird Passing Through Rotor (Assuming No Avoidance)

Stage 2 was calculated using the prepopulated spreadsheet provided by Scottish Natural Heritage (SNH) for calculating the probability of collision for any species (available at: http://www.snh.gov.uk/docs/C234672.xls)

Variable highlighted in blue where entered into the spreadsheet. Bird biometrics where determined using the British Trust for Ornithology website (http://www.bto.org/about-birds/birdfacts) bird flight speeds were assumed using the flight speeds characterised by Bruderer and Boldt (2001).

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA												
Only enter input parameters in blue											W Band	14/06/2022
K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**									
NoBlades	3					Upwind:			Downwind:			
MaxChord	4.5	m	r/R	c/C	α	collide		contribution	collide		contribution	
Pitch (degrees)	6		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r	
BirdLength	0.61	m	0.025	0.575	7.22	23.95	0.82	0.00102	23.41	0.80	0.00100	
Wingspan	1.11	m	0.075	0.575	2.41	8.16	0.28	0.00209	7.62	0.26	0.00195	
F: Flapping (0) or gliding (+1)	1		0.125	0.702	1.44	5.88	0.20	0.00251	5.22	0.18	0.00223	
			0.175	0.860	1.03	5.10	0.17	0.00305	4.29	0.15	0.00257	
Bird speed	17	m/sec	0.225	0.994	0.80	4.60	0.16	0.00354	3.67	0.13	0.00282	
RotorDiam	155	m	0.275	0.947	0.66	3.69	0.13	0.00346	2.80	0.10	0.00263	
RotationPeriod	5.17	sec	0.325	0.899	0.56	3.05	0.10	0.00338	2.20	0.08	0.00244	
			0.375	0.851	0.48	2.84	0.10	0.00364	2.04	0.07	0.00262	
			0.425	0.804	0.42	2.52	0.09	0.00365	1.76	0.06	0.00255	
			0.475	0.756	0.38	2.25	0.08	0.00365	1.54	0.05	0.00250	
Bird aspect ratioo: β	0.55		0.525	0.708	0.34	2.03	0.07	0.00364	1.37	0.05	0.00245	
			0.575	0.660	0.31	1.85	0.06	0.00363	1.23	0.04	0.00241	
			0.625	0.613	0.29	1.69	0.06	0.00361	1.11	0.04	0.00238	
			0.675	0.565	0.27	1.55	0.05	0.00358	1.02	0.03	0.00235	
			0.725	0.517	0.25	1.43	0.05	0.00354	0.94	0.03	0.00233	
			0.775	0.470	0.23	1.32	0.05	0.00349	0.88	0.03	0.00232	
			0.825	0.422	0.22	1.22	0.04	0.00344	0.82	0.03	0.00232	
			0.875	0.374	0.21	1.13	0.04	0.00338	0.78	0.03	0.00233	
			0.925	0.327	0.20	1.05	0.04	0.00331	0.74	0.03	0.00234	
			0.975	0.279	0.19	0.97	0.03	0.00324	0.71	0.02	0.00236	
				Overall p(collision) =			**Upwind**	**6.5%**		**Downwind**	**4.7%**	
								Average	**5.6%**			

Calculation of collision rate

Collision Rate = Nf * average probability of collision

= 314.54 * 0.056

= 17.61

Calculation of collision rate applying 99.5% avoidance rate

= 17.61 * 0.005

= 0.088

1. Correct collision rate for down time (assuming wind farm operates at 85%)

= (0.088 / 100) * 85

Annual Collision Risk = **0.075**

2. Calculate the number of year per collision

= 1 / 0.075

Year per collision = **13.4**

3. Calculate the number of collisions per lifetime of the scheme (given a 25 value for comparison)

= 0.075 * 25

Collision / 25 years = **1.87**

Red Throated Diver – Year 2 (Linear)

A total of 3 red-throated diver registrations were recorded totalling 3 individuals from VP surveys, of which all flights were recorded through the risk window, crossing the window a total of 6 times. The flights included in the linear model and are shown in Figure 2.

Stage 1: Number of Birds Flying Through the Rotors per Year

Calculation of the 'risk window'; Cross section area equal to the width of the wind farm across the general direction of flight multiplied by the height of turbine to rotor tip. Width of wind farm was determined using GIS.

Width of transit flight (Ws)	= 1590m
Turbine height (th)	= 180m
Risk Window (W)	= Ws * th
	= 1590m * 180m
	= 286,200 m^2

Calculate the area occupied by rotor blades (A)

Number of turbine (n)	= 4
Rotor radius (r)	= 77.5
A	= n * π *r2
A	= 4 * 3.14* 6,006.25
A	= 75,438.5 m^2

Express the area occupied by rotor blades (A) as a proportion of the risk window (W)

Proportion (P)	= A/W
	= 75,438.5 / 286,200
	= 0.2636

Calculate the number of bird potentially flying through the site per year (N)

N	= number of red-throated diver transits at PCH per year
	= hourly rate of transit * available hours for flight

Hours surveyed between April 2022 and August 2022

	= hectare hours (correcting for overlap) / hectares visible in Study area
	= 5250 / 120.3
	= 43.64
No. of divers observed in same period	= 6 transits in 3 flights
Hourly rate of transit	= 6 / 43.64
	= 0.137

Hours available for flight are equal to number of daylight hours in the same period plus 25% of night hours (Table 7)

Hours available = 2821

N = hours available * rate of transit = 2821 * 0.137

= 386.477

Calculate the number of birds flights (Nf) to fly through the rotor (P)

Nf = N * P

= 386.477 * 0.2636

= 101.88

Stage 2: Collision Risk of Bird Passing Through Rotor (Assuming No Avoidance)

Stage 2 was calculated using the prepopulated spreadsheet provided by Scottish Natural Heritage (SNH) for calculating the probability of collision for any species (available at: http://www.snh.gov.uk/docs/C234672.xls)

Variable highlighted in blue where entered into the spreadsheet. Bird biometrics where determined using the British Trust for Ornithology website (http://www.bto.org/about-birds/birdfacts) bird flight speeds were assumed using the flight speeds characterised by Bruderer and Boldt (2001).

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA												
Only enter input parameters in blue											W Band	14/06/2022
K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**									
NoBlades	3					Upwind:			Downwind:			
MaxChord	4.5	m	r/R	c/C	α	collide		contribution	collide		contribution	
Pitch (degrees)	6		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r	
BirdLength	0.61	m	0.025	0.575	7.22	23.95	0.82	0.00102	23.41	0.80	0.00100	
Wingspan	1.11	m	0.075	0.575	2.41	8.16	0.28	0.00209	7.62	0.26	0.00195	
F: Flapping (0) or gliding (+1)	1		0.125	0.702	1.44	5.88	0.20	0.00251	5.22	0.18	0.00223	
			0.175	0.860	1.03	5.10	0.17	0.00305	4.29	0.15	0.00257	
Bird speed	17	m/sec	0.225	0.994	0.80	4.60	0.16	0.00354	3.67	0.13	0.00282	
RotorDiam	155	m	0.275	0.947	0.66	3.69	0.13	0.00346	2.80	0.10	0.00263	
RotationPeriod	5.17	sec	0.325	0.899	0.56	3.05	0.10	0.00338	2.20	0.08	0.00244	
			0.375	0.851	0.48	2.84	0.10	0.00364	2.04	0.07	0.00262	
			0.425	0.804	0.42	2.52	0.09	0.00365	1.76	0.06	0.00255	
			0.475	0.756	0.38	2.25	0.08	0.00365	1.54	0.05	0.00250	
Bird aspect ratioo: β	0.55		0.525	0.708	0.34	2.03	0.07	0.00364	1.37	0.05	0.00245	
			0.575	0.660	0.31	1.85	0.06	0.00363	1.23	0.04	0.00241	
			0.625	0.613	0.29	1.69	0.06	0.00361	1.11	0.04	0.00238	
			0.675	0.565	0.27	1.55	0.05	0.00358	1.02	0.03	0.00235	
			0.725	0.517	0.25	1.43	0.05	0.00354	0.94	0.03	0.00233	
			0.775	0.470	0.23	1.32	0.05	0.00349	0.88	0.03	0.00232	
			0.825	0.422	0.22	1.22	0.04	0.00344	0.82	0.03	0.00232	
			0.875	0.374	0.21	1.13	0.04	0.00338	0.78	0.03	0.00233	
			0.925	0.327	0.20	1.05	0.04	0.00331	0.74	0.03	0.00234	
			0.975	0.279	0.19	0.97	0.03	0.00324	0.71	0.02	0.00236	
				Overall p(collision) =			**Upwind**	**6.5%**		**Downwind**	**4.7%**	
								Average	**5.6%**			

Calculation of collision rate

Collision Rate = Nf * average probability of collision

= 101.88 * 0.056

= 5.71

Calculation of collision rate applying 99.5% avoidance rate

= 5.71 * 0.005

= 0.028

1. Correct collision rate for down time (assuming wind farm operates at 85%)

= (0.029 / 100) * 85

Annual Collision Risk = **0.024**

2. Calculate the number of year per collision

= 1 / 0.0.24

Year per collision = **41.67**

3. Calculate the number of collisions per lifetime of the scheme (given a 25 value for comparison)

= 0.024 * 25

Collision / 25 years = **0.6**

Peregrine – Year 1 and Year 2

		Option A Year 1 sweep 45-200m		Year 1 April to august sweep 25-180m
hectare secs		45702360		45617580
total bird flight time		436		17
Bird Activity (ba)		0.0000095400		0.0000003727
Overall Area covered by VPs (excluding overlap) =		120.1	Ha	120.1
		1201000	m2	1201000
proportion of time active in area		0.001145753		4.47569E-05
hours potentially active		2994.645		2593.845
seconds potentially active (hours*3600)		10780722		9337842
no of seconds of bird occ in airspace = sec potentially active * bird activity		12352.04078		417.9325605
Calculate flight risk volume (Vw)		Vw = Overall area (m^2) * rotor diameter (m)		Vw = Overall area (m^2) * rotor diameter (m)
		186155000		186155000
Calculate combined rotor swept volume (Vr)		Vr = number of turbines (n) * pi * r^2 * (max chord + bird length)		Vr = number of turbines (n) * pi * r^2 * (max chord + bird length)
		381718.81		381718.81
Calculate bird occurrence in swept volume		Occurrence	no of sec of bird occ * combined rotor swept volume/flight risk volume	Occurrence
		25.32838929		0.856988637
Calculate bird transits time and potential number of transits per year		max chord+bird length / bird speed		max chord+bird length / bird speed
		0.339597315		0.339597315
No. of transits occurrence / transit time		74.58359692		2.523543614
Annual Collision Rate assuming no avoidance		4.251265024		0.143841986
Corrected for avoidance		0.021256325		0.00071921
Corrected for downtime		0.018067876		0.000611328
		55.34684766		1635.781904
Over lifetime of the scheme		0.451696909		0.015283211
		0.45		0.02
		55.34684766		1635.781904

Short-Eared Owl – Year 1 and Year 2

		Year 1 April to august sweep 25-180m	Year 2 April to august sweep 25-180m
hectare secs		45702360	45617580
total bird flight time		261	57
Bird Activity (ba)		0.0000057109	0.0000012495
Overall Area covered by VPs (excluding overlap) =		120.1	120.1
		1201000	1201000
proportion of time active in area		0.000685875	0.000150067
hours potentially active		4503.38	4503.38
seconds potentially active (hours*3600)		16212168	16212168
no of seconds of bird occ in airspace = sec potentially active * bird activity		11119.51854	2432.913769
Calculate flight risk volume (Vw)		Vw = Overall area (m^2) * rotor diameter (m)	
		186155000	186155000
Calculate combined rotor swept volume (Vr)		Vr = number of turbines (n) * pi * r^2 * (max chord + bird length)	
		368139.88	368139.88
Calculate bird occurrence in swept volume		Occurrence	Occurrence
		21.98994505	4.811327028
Calculate bird transits time and potential number of transits per year		max chord+bird length / bird speed	max chord+bird length / bird speed
		0.61	0.61
No. of transits occurrence / transit time		36.04909025	7.887421357
Annual Collision Rate assuming no avoidance		1.874552693	0.410145911
Corrected for avoidance		0.037491054	0.008202918
Corrected for downtime		0.031867396	0.00697248
		31.38003516	143.4209824
Over lifetime of the scheme		0.796684894	0.174312012
		0.80	0.17
		31.38003516	143.4209824

References

Alerstam T., Rosén M., Bäckman J., Ericson P.G.P., Hellgren O., (2007). Flight speeds among bird species: allometric and phylogenetic effects. PLoS Biol, 5, 1656-1662. DOI:10.1371/journal.pbio.0050197

Band, W., Madders, M. & Whitfield, D.P. (2007*).* Developing field and analytical methods to assess avian collision risk at wind farms. In de Lucas, M, Janss, G. and Ferrer, M. (eds) *Birds and Wind Power*. Lynx Edicions, Barcelona.

Cook, A.S.C.P., Humphreys, E.M., Masden, E.A. & Burton, N.H.K. 2014. *The avoidance rates of collision between birds and offshore turbines.* BTO Research Report No. 656.

SNH (2017). *Avoidance Rates for the onshore SNH Wind Farm Collision Risk Model*. SNH Information and Guidance Note. SNH, Battleby.

SNH (2017). Avoidance Rates for the onshore SNH Wind Farm Collision Risk Model. SNH Information and Guidance Note. SNH, Battleby.

Whitfield, D.P. and M. Madders. 2006. A review of the impacts of wind farms on hen harriers Circus cyaneus and an estimation of collision avoidance rates. Natural Research Information Note 1 (revised). Natural Research Ltd, Banchory, UK.

Appendix 1 Figures

Figure 1 Great Skua at risk flights

N

Tumulus

Lochside

Cott

28

Dale

Myres

of Swannay

Dale

aquoy

Ludenhill

Muckle

Holm

106

(107)

Hundland

Hill

27

Tumulus

Nisthouse

50

Loon

Hundland

Loch of

Hundland

26

Skesquoy

KEY:

Site Boundary

Species

Great skua - Year 1

Great skua - Year 2

0 0.25 0.5 km

Scale 1:10,000 @ A3

Nisthill Wind Farm

ITPENERGISED

Nisthill Wind Farm
Technical Appendix 8.2

Collision Risk Modelling Report - Figure 1

Great skua flightlines

Date:	Drawn by:	Checked by:	Version:
05/10/2022	AT	MF	V1

Project Number: 3586

Figure 2 Red Throated Diver at risk flights

N

Rantan Tumulus
Lochside Cott
Dale
Myres
Hunchaquoy
Ludenhill
Muckle Holm
Hundland Hill
106 (107)
Nisthouse
Tumulus
Hundland
Loch of Hundland
Skesquoy
Deasbreck
Kirbuster
Loonan
Newton
Sleet Moss
Burn o
28
27
26
50
70

KEY:

- Site Boundary
- Turbines
- Turbine buffers - 500m
- Risk window

Species

- Red-throated diver - Year 1
- Red-throated diver - Year 2

0 0.3 0.6 km

Scale 1:13,000 @ A3

Nisthill Wind Farm

ITPENERGISED

Nisthill Wind Farm
OrnithologyTechnical Appendix 8.2

Collision Risk Modelling - Figure 2

Red-throated diver

Date:	Drawn by:	Checked by:	Version:
05/10/2022	AT	MF	V1

Project Number: 3586