Appendix 7.3 Collision Risk Modelling

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Appendix 7.3 Collision Risk Modelling

Introduction

ITPEnergised was appointed by Orkney Islands Council to undertake a series of ornithological surveys in support of a proposed wind farm development at Quanterness in April 2018. 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 an indicative layout and development boundary, as displayed in Figure 7.1, and a provisional turbine specification as outlined in Table 1.

Table 1 - Candidate Turbine - Vestas V136 4.2MW

Parameter	Value
Collision Risk Area (turbines plus 500m)	328.778943
Viewshed Area	592.177845
No turbines	6
Rotor diameter	136m
Hub height	82m
Max rotor depth	4.2
Max chord	4.1
Pitch	Variable – use 15
Rotation period	(6-16 rpm, ave = 11 rpm) = 5.45 secs
Turbine operation time	25 years

Data Collection and Species Selection

Surveys were undertaken from a single VP between April 2018 and March 2019 with 78 hours undertaken, this time period constitutes one complete year. A total of ten 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 the VP. PCH is the height between the low and high points of the rotor sweep of the turbine blades, namely between 14 and 150m, all flights and the total number of individuals recorded at PCH within the viewshed of the VP are displayed below in Table 2. The area covered by the viewshed is larger than the area of the Proposed Development and the collision risk modelling process adjusts the figures to allow for this, calculating the results to give an average amount for the collision risk zone ('CRZ'). The CRZ is a volume which covers the proposed turbines and a 500m buffer at PCH.

Table 2 - Target Species Recorded April 2018 – March 2019

Species	Flights	Total no birds in flights	Flights in Viewshed	Flight in Viewshed @ PCH	Individuals in Viewshed @ PCH	Total No. Of At Risk Flight Sec.	Collison Risk Modelling carried Out
Curlew	65	2498	65	60	2136	92913	Yes
Golden plover	7	1595	7	6	1415	132725	Yes
Great skua	2	3	2	1	2	61	No
Greylag goose	30	3614	30	28	2994	222045	Yes
Hen harrier	5	6	4	1	1	30	No
Lapwing	53	1387	53	52	1383	76947	Yes
Oystercatcher	20	64	20	18	61	2823	Yes
Redshank	9	136	9	9	136	4785	Yes
Short-eared owl	2	2	2	2	2	230	No
Snipe	1	1	0	0	0	0	No

Methods

Collision risk has been calculated based as an average figure for the area covered by the viewshed (Figure 7.1) and based on a layout of six wind turbines of the specifications outlined in Table 1. It should be noted that the resultant figures provide an average for the survey area 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). A full working example for one of the six species (curlew) is detailed below and the results for the other five species are also shown.

Table 3 - Target Species Bird Biometrics

Species Name	Bird length (m)	Wingspan (m)	Flight speed (m/s)	Avoidance Rate (%)
Curlew	0.55	0.9	16.3	98
Golden Plover	0.28	0.72	13.7	98
Greylag Goose	0.82	1.64	19.3	99.8
Lapwing	0.30	0.84	12.8	98
Oystercatcher	0.45	0.86	13	95
Redshank	0.28	0.66	12	98

Results

Table 4 - Results

Species Name	Annual Collsion rate	Collisions - Scheme Lifetime	Years per collision
Curlew	0.05	1.25	20
Golden Plover	0.043	1.09	23
Greylag Goose (Sep-Mar)	0.1	2.07	12.1
Lapwing	0.025	0.54	47
Oystercatcher	0.002	0.05	469
Redshank	0.001	0.03	911

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 (to 2 km) * survey duration (hrs)

VP 1 viewshed = 592.177845 Ha

Date	VP	Start Time	End Time	Hours	Ha hours
17-Apr-18	1	14:00	17:00	3	1776.53
17-Apr-18	1	17:30	20:30	3	1776.53
02-May-18	1	09:45	12:45	3	1776.53
02-May-18	1	13:15	16:15	3	1776.53
06-Jun-18	1	04:05	07:05	3	1776.53
06-Jun-18	1	07:35	10:35	3	1776.53
06-Jul-18	1	15:54	18:54	3	1776.53

Date	VP	Start Time	End Time	Hours	Ha hours
06-Jul-18	1	19:24	22:24	3	1776.53
19-Aug-18	1	12:43	15:43	3	1776.53
19-Aug-18	1	16:13	19:13	3	1776.53
22-Aug-18	1	05:50	08:50	3	1776.53
22-Aug-18	1	09:20	12:20	3	1776.53
29-Sep-18	1	12:24	15:24	3	1776.53
29-Sep-18	1	15:54	18:54	3	1776.53
31-Oct-18	1	09:55	12:55	3	1776.53
31-Oct-18	1	13:25	16:25	3	1776.53
01-Nov-18	1	07:33	10:33	3	1776.53
01-Nov-18	1	11:03	14:03	3	1776.53
31-Dec-18	1	09:06	12:06	3	1776.53
31-Dec-18	1	12:36	15:36	3	1776.53
21-Jan-19	1	09:33	12:33	3	1776.53
21-Jan-19	1	13:03	16:03	3	1776.53
25-Feb-19	1	11:00	14:00	3	1776.53
25-Feb-19	1	14:30	17:30	3	1776.53
30-Mar-19	1	10:10	13:10	3	1776.53
30-Mar-19	1	13:40	16:40	3	1776.53
Total					46,189.78

Calculate hectare seconds = hectare hours * 3600

= 46189.78 * 3600

= 166283208

Calculations species full example - Curlew

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

All Curlew flights April 2018 – March 2019 (highlighted flights not recorded at PCH)

Date	Number	VP	HB1 <PCH (0-10m)	PCH (11-150m)	>PCH (150m+)	Total flight time at PCH in seconds
18-Apr-18	250	1	30	0	0	0
18-Apr-18	7	1	10	80	0	560
18-Apr-18	2	1	20	110	0	220
18-Apr-18	7	1	15	45	0	315
18-Apr-18	1	1	32	60	0	60
18-Apr-18	2	1	30	50	0	100
18-Apr-18	9	1	33	15	0	135
18-Apr-18	2	1	15	15	0	30
18-Apr-18	2	1	0	40	0	80
18-Apr-18	55	1	0	105	0	5775
18-Apr-18	2	1	0	80	0	160
18-Apr-18	75	1	45	0	0	0
18-Apr-18	2	1	0	155	0	230
18-Apr-18	2	1	0	50	0	100
01-May-18	1	1	9	20	0	20
01-May-18	2	1	6	30	0	60

Date	Number	VP	HB1 <PCH (0-10m)	PCH (11-150m)	>PCH (150m+)	Total flight time at PCH in seconds
01-May-18	2	1	6	15	0	30
01-May-18	1	1	4	30	0	30
01-May-18	1	1	8	45	0	45
01-May-18	2	1	15	16	0	32
01-May-18	1	1	0	23	0	23
01-May-18	1	1	0	33	0	33
01-May-18	1	1	0	47	0	47
01-May-18	1	1	0	24	0	24
01-May-18	1	1	0	26	0	26
01-May-18	1	1	7	35	0	35
01-May-18	1	1	0	27	0	27
01-May-18	1	1	0	38	0	38
01-May-18	1	1	0	23	0	23
01-May-18	1	1	4	30	0	30
01-May-18	1	1	0	16	0	16
01-May-18	2	1	2	40	0	80
01-May-18	1	1	0	57	0	57
01-May-18	1	1	0	15	0	15
01-May-18	1	1	13	10	0	10
01-May-18	1	1	0	33	0	33
02-Jun-18	1	1	0	160	0	160
02-Jun-18	1	1	8	8	0	8
02-Jun-18	1	1	6	40	0	40
02-Jun-18	2	1	7	120	0	240
02-Jun-18	1	1	1	30	0	30
02-Jun-18	2	1	5	33	0	66
02-Jun-18	1	1	0	133	0	133
02-Jun-18	1	1	15	49	0	49
02-Jun-18	1	1	4	98	0	98
02-Jun-18	1	1	8	8	0	8
02-Jun-18	1	1	10	35	0	35
02-Jun-18	1	1	0	52	0	52
07-Jul-18	2	1	8	45	0	90
07-Jul-18	1	1	19	0	0	0
07-Jul-18	2	1	19	0	0	0
07-Jul-18	12	1	6	15	0	180
07-Jul-18	7	1	7	30	0	210
20-Aug-18	1	1	0	45	17	15
20-Aug-18	38	1	0	19	0	722
20-Aug-18	35	1	15	8	0	280
21-Aug-18	28	1	4	40	0	1120
01-Nov-18	24	1	17	30	0	720
01-Nov-18	90	1	15	21	0	1890
01-Nov-18	34	1	29	0	0	0
01-Nov-18	455	1	0	52	0	23660
25-Feb-19	500	1	21	51	0	25500
30-Mar-19	400	1	6	50	0	20000
30-Mar-19	400	1	7	22	0	8800
30-Mar-19	11	1	0	28	0	308
Total						92913

Calculate Bird Activity

Bird Activity = Total bird flight time / hectare seconds

= 92913 / 166283208

BA = 0.0005587636

Overall Area covered by VPs = 592.177

Hours potentially active (12 daylight hours plus 25% night time hours) = 5337.86

Seconds potentially active (5337.86*3600) = 19216296

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

= 19216296 * 0.0005587636
= 10737.36628

Calculate flight risk volume (Vw)

Vw = 3287789.43 (m2) * rotor diameter (m)

Vw = 447139362.5

Calculate combined rotor swept volume

Vr = number of turbines (n) * pi * r2 * (max chord + bird length)
Vr = 6 * (pi * 4624) * (4.1 + 0.55)
Vr = 405090.144

Calculate bird occurrence in swept volume

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

= 10737.36628* (Vr/Vw)

= 10737.36628* (405090.144/ 447139362.5)

= 9.727618762

Calculate bird transits time and potential number of transits per year

Transit time = (max chord + bird length) / bird speed (m2)
= (4.1 + 0.55) / 16.3
= 0.28527

No. of transits = occurrence / transit time
= 9.727618762/ 0.29

= 34.09896469

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

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA												
Only enter input parameters in blue											W Band	03/05/2019
K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**									
NoBlades	3					Upwind:			Downwind:			
MaxChord	4.1	m	r/R	c/C	α	collide		contribution	collide			contribution
Pitch (degrees)	15		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)		from radius r
BirdLength	0.55	m	0.025	0.575	4.08	13.58	0.93	0.00117	12.36	0.85		0.00106
Wingspan	0.9	m	0.075	0.575	1.36	4.93	0.34	0.00255	3.71	0.26		0.00192
F: Flapping (0) or gliding (+1)	0		0.125	0.702	0.82	3.75	0.26	0.00322	2.26	0.16		0.00194
			0.175	0.860	0.58	3.45	0.24	0.00415	1.62	0.11		0.00195
Bird speed	8	m/sec	0.225	0.994	0.45	3.39	0.23	0.00525	1.28	0.09		0.00198
RotorDiam	136	m	0.275	0.947	0.37	2.95	0.20	0.00557	0.94	0.06		0.00177
RotationPeriod	5.45	sec	0.325	0.899	0.31	2.62	0.18	0.00586	0.71	0.05		0.00160
			0.375	0.851	0.27	2.37	0.16	0.00612	0.56	0.04		0.00146
			0.425	0.804	0.24	2.17	0.15	0.00634	0.64	0.04		0.00187
			0.475	0.756	0.21	2.00	0.14	0.00652	0.71	0.05		0.00232
Bird aspect ratioo: β	0.61		0.525	0.708	0.19	1.85	0.13	0.00667	0.76	0.05		0.00273
			0.575	0.660	0.18	1.72	0.12	0.00679	0.79	0.05		0.00311
			0.625	0.613	0.16	1.60	0.11	0.00687	0.80	0.06		0.00346
			0.675	0.565	0.15	1.49	0.10	0.00691	0.81	0.06		0.00377
			0.725	0.517	0.14	1.39	0.10	0.00692	0.81	0.06		0.00404
			0.775	0.470	0.13	1.29	0.09	0.00690	0.80	0.06		0.00428
			0.825	0.422	0.12	1.20	0.08	0.00684	0.79	0.05		0.00449
			0.875	0.374	0.12	1.12	0.08	0.00674	0.77	0.05		0.00466
			0.925	0.327	0.11	1.04	0.07	0.00661	0.75	0.05		0.00480
			0.975	0.279	0.10	0.96	0.07	0.00645	0.73	0.05		0.00490
				Overall p(collision) =			**Upwind**	**11.4%**		**Downwind**		**5.8%**
								Average	**8.6%**			

Annual Collision Rate assuming no avoidance

= No. of transits * Ave probability of collision
= 34.09896469 / 100 x 8.6

= 2.932510964

Corrected for avoidance

= 2.932510964– ((2.932510964/ 100) *98)

= 0.058650219

Corrected for downtime

= 0.058650219 * 0.85

= 0.049852686 collisions per year (40.87 years per collision)

Over lifetime of the scheme

0.049852686 * 25
= 1.24631716

Golden Plover Results

hectare secs		166283208	
total bird flight time		132725	
ba		0.0007981864	
Overall Area covered by VPs (excluding overlap) =		592.177	5921778
hrs potentially active (12 months daylight hours plus 25% night		5337.86	
seconds potentially active		5337.86*3600	
		19216296	
no of seconds of bird occ in airspace = sec potentially active * bird activity		15338.18668	
Calculate flight risk volume (Vw		Vw = 3287789.43 (m^2) * rotor diameter (m)	
		447139362.5	
Calculate combined rotor swept volume		Vr = number of turbines (n) * pi * r^2 * (max chord + bird length)	
		381568.7808	
Calculate bird occurrence in swept volume		Occurrence	no of sec of bird occ * combined rotor swept volume/flight risk volume
		13.08892413	
Calculate bird transits time and potential number of transits per year			
		0.319708029	
No. of transits occurrence / transit time		40.94024215	
Annual Collision Rate assuming no avoidance		2.579235256	2.5792
Corrected for avoidance		0.051584705	0.0516
Corrected for downtime		0.043846999	0.0438
		22.80657776	
Over lifetime of the scheme		1.096174984	1.0962

Lapwing Results

hectare secs		166283208	
total bird flight time		76947	
ba		0.0004627467	
Overall Area covered by VPs (excluding overlap) =		592.177	5921778
hrs potentially active (12 months daylight hours plus 25% night		5337.86	
seconds potentially active		5337.86*3600	
		19216296	
no of seconds of bird occ in airspace = sec potentially active * bird activity		8892.276894	
Calculate flight risk volume (Vw		Vw = 3287789.43 (m^2) * rotor diameter (m)	
		447139362.5	
Calculate combined rotor swept volume		Vr = number of turbines (n) * pi * r^2 * (max chord + bird length)	
		383311.104	
Calculate bird occurrence in swept volume		Occurrence	no of sec of bird occ * combined rotor swept volume/flight risk volume
		7.622921977	
Calculate bird transits time and potential number of transits per year			
		0.34375	
No. of transits occurrence / transit time		22.17577303	
Annual Collision Rate assuming no avoidance		1.264019062	1.2640
Corrected for avoidance		0.025280381	0.0253
Corrected for downtime		0.021488324	0.0215
		46.53690056	
Over lifetime of the scheme		0.537208102	0.5372

Oystercatcher Results

hectare secs		166283208	
total bird flight time		2823	
ba		0.0000169771	
Overall Area covered by VPs (excluding overlap) =		592.177	5921778
hrs potentially active (12 months daylight hours plus 25% night		5337.86	
seconds potentially active		5337.86*3600	
		19216296	
no of seconds of bird occ in airspace = sec potentially active * bird activity		326.2362103	
Calculate flight risk volume (Vw		Vw = 3287789.43 (m^2) * rotor diameter (m)	
		447139362.5	
Calculate combined rotor swept volume		Vr = number of turbines (n) * pi * r^2 * (max chord + bird length)	
		396378.528	
Calculate bird occurrence in swept volume		Occurrence	no of sec of bird occ * combined rotor swept volume/flight risk volume
		0.289200727	
Calculate bird transits time and potential number of transits per year			
		0.357692308	
No. of transits occurrence / transit time		0.808518162	
Annual Collision Rate assuming no avoidance		0.050128126	0.0501
Corrected for avoidance		0.002506406	0.0025
Corrected for downtime		0.002130445	0.0021
		469.3854253	
Over lifetime of the scheme		0.053261134	0.0533

Redshank Results

hectare secs		166283208	
total bird flight time		4785	
ba		0.0000287762	
Overall Area covered by VPs (excluding overlap) =		592.177	5921778
hrs potentially active (12 months daylight hours plus 25% night		5337.86	
seconds potentially active		5337.86*3600	
		19216296	
no of seconds of bird occ in airspace = sec potentially active * bird activity		552.9721098	
Calculate flight risk volume (Vw		Vw = 3135377 (m^2) * rotor diameter (m)	
		426411282.9	
Calculate combined rotor swept volume		Vr = number of turbines (n) * pi * r^2 * (max chord + bird length)	
		381568.7808	
Calculate bird occurrence in swept volume		Occurrence	no of sec of bird occ * combined rotor swept volume/flight risk volume
		0.494820147	
Calculate bird transits time and potential number of transits per year			
		0.3875	
No. of transits occurrence / transit time		1.276955219	
Annual Collision Rate assuming no avoidance		0.067678627	0.0677
Corrected for avoidance		0.001353573	0.0014
Corrected for downtime		0.001150537	0.0012
		869.1596207	
Over lifetime of the scheme		0.028763416	0.0288

Greylag Goose Results

Width of transit flight (Ws)	3217	
Turbine height (th)	150	
Risk Window (W) = Ws * th	482550	
1. Calculate the area occupied by rotor blades (A)	87116.16	
1. Express the area occupied by rotor blades (A) as a proportion of the risk window (W)		
Proportion (P)	0.180533	
1. Calculate the number of bird potentially flying through the site per year (N)	3595	
1. Calculate the number of birds flights (Nf) to fly through the rotor (P)	649.0158	
Collision rate	48.68	48.68
Calculation of collision rate applying 99.8% avoida	0.10	0.10
Correct collision rate for down time (assuming win	0.08275	0.08
Calculate the number of year per collision	12.08466	12.08
Calculate the number of collisions per lifetime of th	2.068738	2.07

Limitations to Findings

The survey data used for collision risk modelling was collected over a relatively short time period (12 months. The results are therefore open to an annual bias and may not give a true reflection of bird activity over a several year period. It is likely different levels of breeding success and/or extreme weather conditions between years will likely alter bird behaviour with for example adult birds required to make a higher number of trips to forage for food in successful years as compared to poor years.

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