APPENDIX A11.3

COLLISION RISK MODELLING

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Appendix A11.3: Collision Risk Modelling

The Band collision model (Band *et al* 2007) was used to estimate collision rates. The quantity of field data available for red-throated divers was much greater than for other species and for this reason collision estimates for red-throated diver were calculated individually for each turbine location. For all other species flight activity input data were the mean for all turbine locations, and so the collision rate was calculated for an average turbine and this was multiplied by the number of turbines to give the estimated collisions for the whole windfarm.

Red-throated Diver

Estimates of fight activity at each proposed turbine location are presented in Table A11.ap3.1. The method used to estimate diver flight activity is described in Technical Appendix A11.1. The calculation for Stage 2 of the Band Model for red-throated diver is presented in Table A11.3.2. An example Band Stage 1 calculation for a single turbine is presented in Table A11.3.3. The estimated collisions from each turbine for 98% and 99% assumed avoidance rates are presented in Table A11.3.4.

Table A11.3.1. Estimated annual flight activity at rotor swept height for 200 x 200 m cells centred on each proposed turbine. Data converted from kilometres flown per year to hours flown per year using a mean flight speed of 17.5 m/s. Activity by breeding birds is adjusted for breeding site occupancy rate.

Quadrant	Turbine	Activity at RSH in 200 x 200 m tiles (hrs/yr)	
		Breeders	Non-breeders
Delting	5	0.572	0.579
Delting	6	0.318	0.056
Delting	7	0.572	0.093
Delting	9	0.329	0.028
Delting	10	0.321	0.600
Delting	11	0.000	0.105
Delting	12	0.000	0.000
Delting	13	0.150	0.150
Delting	14	0.000	0.034
Delting	15	0.072	0.072
Delting	16	0.000	0.000
Delting	17	0.058	0.183
Delting	18	0.175	0.155
Delting	23	0.022	0.094
Delting	24	0.124	0.046
Delting	25	0.028	0.391
Delting	26	0.064	0.203
Delting	27	0.000	0.007
Delting	28	0.140	0.020
Delting	29	0.000	0.827
Delting	30	0.068	0.286

Delting	31	0.207	0.519
Delting	32	0.027	0.156
Delting	33	0.159	0.962
Kergord	42	0.000	0.000
Kergord	43	0.000	0.000
Kergord	44	0.000	0.000
Kergord	45	0.000	0.000
Kergord	46	0.000	0.482
Kergord	47	0.000	0.065
Kergord	48	0.000	0.152
Kergord	49	0.000	0.000
Kergord	50	0.000	0.000
Kergord	51	0.000	0.000
Kergord	52	0.000	0.000
Kergord	53	0.000	0.000
Kergord	54	0.000	0.000
Kergord	55	0.000	0.000
Kergord	56	0.000	0.016
Kergord	57	0.000	0.000
Kergord	58	0.000	0.000
Kergord	59	0.000	0.000
Kergord	60	0.000	0.000
Kergord	61	0.000	0.000
Kergord	62	0.000	0.127
Kergord	63	0.021	0.012
Kergord	64	0.048	0.062
Kergord	66	0.032	0.079
Kergord	67	0.158	0.058
Kergord	68	0.112	0.070
Kergord	69	0.033	0.023
Kergord	70	0.041	0.041
Kergord	71	0.017	0.024
Kergord	72	0.061	0.247
Kergord	73	0.004	0.005
Kergord	74	0.000	0.000
Kergord	75	0.155	0.042
Kergord	76	0.304	0.327
Kergord	77	0.195	0.141
Kergord	78	0.000	0.000
Kergord	79	0.000	0.000
Kergord	80	0.000	0.000
Kergord	81	0.000	0.000
Kergord	82	0.000	0.000
Kergord	83	0.000	0.000
Kergord	84	0.000	0.000
Kergord	85	0.000	0.000
Kergord	86	0.000	0.000
Kergord	87	0.000	0.000

Kergord	88	0.000	0.000
Nesting	89	0.000	0.000
Nesting	90	0.000	0.000
Nesting	91	0.000	0.000
Nesting	92	0.094	0.018
Nesting	93	0.012	0.020
Nesting	94	0.061	0.051
Nesting	95	0.000	0.000
Nesting	96	0.066	0.017
Nesting	97	0.083	0.015
Nesting	98	0.279	0.198
Nesting	99	0.100	0.065
Nesting	100	0.037	0.700
Nesting	101	0.052	0.775
Nesting	102	0.015	0.255
Nesting	103	0.036	0.202
Nesting	104	0.009	0.067
Nesting	105	0.151	0.337
Nesting	106	0.049	0.043
Nesting	107	0.032	0.280
Nesting	108	0.128	0.181
Nesting	109	0.029	0.465
Nesting	110	0.092	0.230
Nesting	111	0.030	0.094
Nesting	112	0.051	0.089
Nesting	113	0.068	0.487
Nesting	114	0.045	0.805
Nesting	115	0.192	0.113
Nesting	116	0.154	0.855
Nesting	117	0.105	0.636
Nesting	118	0.129	0.145
Nesting	119	0.102	0.089
Nesting	120	0.302	0.315
Nesting	121	0.186	0.184
Nesting	122	0.434	0.516
Nesting	123	0.031	0.056
Nesting	124	0.025	0.021
Nesting	125	0.129	0.553
Nesting	126	0.001	0.001
Nesting	127	0.123	0.234
Nesting	128	0.002	0.005
Nesting	129	0.187	0.157
Nesting	130	0.039	0.021
Nesting	131	0.178	0.114
Nesting	132	0.079	0.236
Nesting	137	0.120	0.041
Nesting	138	0.000	0.000
Nesting	139	0.066	0.186

Nesting	140	0.028	0.028
Nesting	141	0.000	0.000
Nesting	142	0.022	0.022
Nesting	143	0.005	0.005
Nesting	144	0.014	0.076
Nesting	145	0.018	0.101
Nesting	147	0.000	0.000
Nesting	148	0.023	0.062
Nesting	149	0.053	0.199
Nesting	150	0.085	0.058

Table A11.3.2. Band Model Stage 2 calculation for the probability of collision by red-throated divers.

			Calculation of alpha and p(collision) as a function of radius								
K: [1D or [3D] (0 or 1)	1					Upwind:			Downwind:		
NoBlades	3										
MaxChord	3.60	m	r/R	c/C	)	collide		contribution	collide		contribution
Pitch (degrees)	13.0		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	0.71	m	0.025	0.575	9.36	29.63	1.00	0.00125	28.70	1.00	0.00125
Wingspan	1.1	m	0.075	0.575	3.12	10.19	0.38	0.00284	9.26	0.34	0.00258
F: Flapping (0) or gliding (+1)	0		0.125	0.702	1.87	7.23	0.27	0.00335	6.10	0.23	0.00283
			0.175	0.860	1.34	6.20	0.23	0.00403	4.81	0.18	0.00312
Bird speed	18	m/sec	0.225	0.994	1.04	5.58	0.21	0.00466	3.97	0.15	0.00331
RotorDiam	110	m	0.275	0.947	0.85	4.53	0.17	0.00462	2.99	0.11	0.00306
RotationPeriod	4.62	sec	0.325	0.899	0.72	3.79	0.14	0.00457	2.33	0.09	0.00281
			0.375	0.851	0.62	3.26	0.12	0.00454	1.88	0.07	0.00262
			0.425	0.804	0.55	2.91	0.11	0.00459	1.61	0.06	0.00254
			0.475	0.756	0.49	2.63	0.10	0.00463	1.40	0.05	0.00247
Bird aspect ratioo:)	0.65		0.525	0.708	0.45	2.39	0.09	0.00466	1.24	0.05	0.00242
			0.575	0.660	0.41	2.19	0.08	0.00467	1.12	0.04	0.00238
			0.625	0.613	0.37	2.01	0.07	0.00466	1.02	0.04	0.00236
			0.675	0.565	0.35	1.85	0.07	0.00465	0.94	0.03	0.00235
			0.725	0.517	0.32	1.71	0.06	0.00461	0.88	0.03	0.00236
			0.775	0.470	0.30	1.59	0.06	0.00457	0.83	0.03	0.00238
			0.825	0.422	0.28	1.47	0.05	0.00450	0.79	0.03	0.00241
			0.875	0.374	0.27	1.36	0.05	0.00443	0.76	0.03	0.00246
			0.925	0.327	0.25	1.26	0.05	0.00434	0.74	0.03	0.00252
			0.975	0.279	0.24	1.17	0.04	0.00423	0.72	0.03	0.00260
			Overall p(collision) =			**Upwind**		**8.4%**	**Downwind**		**5.1%**
								Average	**6.8%**		

Table A11.3.3. Sample collision calculation for a single turbine, using flight activity data for the surrounding 200 x 200 m cell. Data shown are for breeding divers and Turbine #5 (Delting Quadrant).

Turbine parameters		
Size of activity envelope	4	ha
Rotor diameter	110	m
Hub height	90	m
Max. rotor depth in metres	4.2	m
Max. chord	3.60	m
Pitch	13.0	degrees
Rotation period	4.62	s
Turbine operation time	85	%

RH parameters		
Length	0.71	m
Wingspan	1.1	m
Assumed flight speed	17.5	ms^-1
Activity at RSH	67.1	%

Collision probability	6.8	%

Mortality estimate		
Flight risk volume (Vw)	4400000	m^3
Rotor swept area (Ar)	9503	m^2
Rotor swept volume (Vr) = Ar*(d+l)	46661	m^3
Bird occupancy (n)	0.572	hr/yr
Bird occupancy of rotor swept vol (b)	21.84	bird-secs
Bird transit time (t)	0.3	secs
No. of transits through rotors	77.83	per year
Estimated no. of collisions	4.47	per year

Table A11.3.4 Predicted annual mortality per turbine for breeding and non-breeding red-throated divers.

Quadrant	Turbine	Collisions after assumed avoidance						Combined
		Breeders			Non-breeders			
		0%	98%	99%	0%	98%	99%	98%
Delting	5	4.47	0.09	0.04	4.52	0.09	0.05	0.18
Delting	6	2.48	0.05	0.02	0.44	0.01	0.00	0.06
Delting	7	4.47	0.09	0.04	0.72	0.01	0.01	0.10
Delting	9	2.57	0.05	0.03	0.22	0.00	0.00	0.06
Delting	10	2.51	0.05	0.03	4.68	0.09	0.05	0.14
Delting	11	0.00	0.00	0.00	0.82	0.02	0.01	0.02
Delting	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Delting	13	1.17	0.02	0.01	1.17	0.02	0.01	0.05
Delting	14	0.00	0.00	0.00	0.27	0.01	0.00	0.01
Delting	15	0.57	0.01	0.01	0.57	0.01	0.01	0.02
Delting	16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Delting	17	0.45	0.01	0.00	1.43	0.03	0.01	0.04
Delting	18	1.36	0.03	0.01	1.21	0.02	0.01	0.05
Delting	23	0.18	0.00	0.00	0.73	0.01	0.01	0.02
Delting	24	0.97	0.02	0.01	0.36	0.01	0.00	0.03
Delting	25	0.22	0.00	0.00	3.05	0.06	0.03	0.07
Delting	26	0.50	0.01	0.00	1.59	0.03	0.02	0.04
Delting	27	0.00	0.00	0.00	0.05	0.00	0.00	0.00
Delting	28	1.09	0.02	0.01	0.15	0.00	0.00	0.02
Delting	29	0.00	0.00	0.00	6.46	0.13	0.06	0.13
Delting	30	0.53	0.01	0.01	2.23	0.04	0.02	0.06
Delting	31	1.62	0.03	0.02	4.05	0.08	0.04	0.11
Delting	32	0.21	0.00	0.00	1.21	0.02	0.01	0.03
Delting	33	1.24	0.02	0.01	7.51	0.15	0.08	0.17
Kergord	42	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kergord	43	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kergord	44	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kergord	45	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kergord	46	0.00	0.00	0.00	3.76	0.08	0.04	0.08
Kergord	47	0.00	0.00	0.00	0.51	0.01	0.01	0.01
Kergord	48	0.00	0.00	0.00	1.18	0.02	0.01	0.02
Kergord	49	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kergord	50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kergord	51	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kergord	52	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kergord	53	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kergord	54	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kergord	55	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kergord	56	0.00	0.00	0.00	0.12	0.00	0.00	0.00
Kergord	57	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kergord	58	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Kergord	59	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kergord	60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kergord	61	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kergord	62	0.00	0.00	0.00	0.99	0.02	0.01	0.02
Kergord	63	0.16	0.00	0.00	0.09	0.00	0.00	0.01
Kergord	64	0.38	0.01	0.00	0.48	0.01	0.00	0.02
Kergord	66	0.25	0.01	0.00	0.62	0.01	0.01	0.02
Kergord	67	1.23	0.02	0.01	0.45	0.01	0.00	0.03
Kergord	68	0.87	0.02	0.01	0.55	0.01	0.01	0.03
Kergord	69	0.26	0.01	0.00	0.18	0.00	0.00	0.01
Kergord	70	0.32	0.01	0.00	0.32	0.01	0.00	0.01
Kergord	71	0.13	0.00	0.00	0.19	0.00	0.00	0.01
Kergord	72	0.47	0.01	0.00	1.93	0.04	0.02	0.05
Kergord	73	0.03	0.00	0.00	0.04	0.00	0.00	0.00
Kergord	74	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kergord	75	1.21	0.02	0.01	0.33	0.01	0.00	0.03
Kergord	76	2.37	0.05	0.02	2.55	0.05	0.03	0.10
Kergord	77	1.52	0.03	0.02	1.10	0.02	0.01	0.05
Kergord	78	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kergord	79	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kergord	80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kergord	81	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kergord	82	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kergord	83	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kergord	84	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kergord	85	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kergord	86	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kergord	87	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kergord	88	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nesting	89	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nesting	90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nesting	91	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nesting	92	0.73	0.01	0.01	0.14	0.00	0.00	0.02
Nesting	93	0.09	0.00	0.00	0.16	0.00	0.00	0.00
Nesting	94	0.48	0.01	0.00	0.40	0.01	0.00	0.02
Nesting	95	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nesting	96	0.51	0.01	0.01	0.13	0.00	0.00	0.01
Nesting	97	0.65	0.01	0.01	0.12	0.00	0.00	0.02
Nesting	98	2.18	0.04	0.02	1.55	0.03	0.02	0.07
Nesting	99	0.78	0.02	0.01	0.51	0.01	0.01	0.03
Nesting	100	0.29	0.01	0.00	5.47	0.11	0.05	0.12
Nesting	101	0.41	0.01	0.00	6.05	0.12	0.06	0.13
Nesting	102	0.11	0.00	0.00	1.99	0.04	0.02	0.04
Nesting	103	0.28	0.01	0.00	1.58	0.03	0.02	0.04
Nesting	104	0.07	0.00	0.00	0.52	0.01	0.01	0.01
Nesting	105	1.18	0.02	0.01	2.63	0.05	0.03	0.08
Nesting	106	0.38	0.01	0.00	0.33	0.01	0.00	0.01
Nesting	107	0.25	0.01	0.00	2.18	0.04	0.02	0.05

Nesting	108	1.00	0.02	0.01	1.41	0.03	0.01	0.05
Nesting	109	0.22	0.00	0.00	3.63	0.07	0.04	0.08
Nesting	110	0.72	0.01	0.01	1.80	0.04	0.02	0.05
Nesting	111	0.23	0.00	0.00	0.74	0.01	0.01	0.02
Nesting	112	0.40	0.01	0.00	0.69	0.01	0.01	0.02
Nesting	113	0.53	0.01	0.01	3.80	0.08	0.04	0.09
Nesting	114	0.35	0.01	0.00	6.29	0.13	0.06	0.13
Nesting	115	1.50	0.03	0.02	0.88	0.02	0.01	0.05
Nesting	116	1.20	0.02	0.01	6.68	0.13	0.07	0.16
Nesting	117	0.82	0.02	0.01	4.96	0.10	0.05	0.12
Nesting	118	1.01	0.02	0.01	1.13	0.02	0.01	0.04
Nesting	119	0.80	0.02	0.01	0.70	0.01	0.01	0.03
Nesting	120	2.36	0.05	0.02	2.46	0.05	0.02	0.10
Nesting	121	1.46	0.03	0.01	1.44	0.03	0.01	0.06
Nesting	122	3.39	0.07	0.03	4.03	0.08	0.04	0.15
Nesting	123	0.24	0.00	0.00	0.44	0.01	0.00	0.01
Nesting	124	0.19	0.00	0.00	0.16	0.00	0.00	0.01
Nesting	125	1.00	0.02	0.01	4.32	0.09	0.04	0.11
Nesting	126	0.01	0.00	0.00	0.01	0.00	0.00	0.00
Nesting	127	0.96	0.02	0.01	1.83	0.04	0.02	0.06
Nesting	128	0.02	0.00	0.00	0.04	0.00	0.00	0.00
Nesting	129	1.46	0.03	0.01	1.23	0.02	0.01	0.05
Nesting	130	0.31	0.01	0.00	0.16	0.00	0.00	0.01
Nesting	131	1.39	0.03	0.01	0.89	0.02	0.01	0.05
Nesting	132	0.62	0.01	0.01	1.84	0.04	0.02	0.05
Nesting	137	0.93	0.02	0.01	0.32	0.01	0.00	0.03
Nesting	138	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nesting	139	0.52	0.01	0.01	1.46	0.03	0.01	0.04
Nesting	140	0.22	0.00	0.00	0.22	0.00	0.00	0.01
Nesting	141	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nesting	142	0.17	0.00	0.00	0.17	0.00	0.00	0.01
Nesting	143	0.04	0.00	0.00	0.04	0.00	0.00	0.00
Nesting	144	0.11	0.00	0.00	0.59	0.01	0.01	0.01
Nesting	145	0.14	0.00	0.00	0.79	0.02	0.01	0.02
Nesting	147	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nesting	148	0.18	0.00	0.00	0.48	0.01	0.00	0.01
Nesting	149	0.41	0.01	0.00	1.55	0.03	0.02	0.04
Nesting	150	0.67	0.01	0.01	0.45	0.01	0.00	0.02
Total		**69.8**	**1.4**	**0.7**	**140.2**	**2.8**	**1.4**	**4.2**

Other species

The turbine parameters used for other species are the same as for red-throated diver (Table A11.3.3), but the size of activity envelope considered is a single hectare. The calculations of collision probabilities using Stage 2 of the Band Model are not presented for other species but this follows the same method shown for red-throated diver (Table A11.3.2). The collision probabilities from Band Stage 2 together with other input parameters specific to each species are shown in Table A11.ap3.5. The method used to estimate mean baseline flight activity in the vicinity of turbines from the generic VP watch data is explained in Appendix A11.2. This included correcting the data for detection bias and accounting for difference in breeding density between the areas overlooked by VPs and the vicinity of turbines. Details of the calculations and results are shown below. The component calculations used to estimate the average number of collisions per turbine for each species is presented in Table A11.ap3.6. The estimated total number of collisions for each species under the proposed T127 layout is shown in Table A11.ap3.7.

The total number of collisions to occur each year estimated by CRM assumes that the same amount of flight activity occurs in the vicinity of turbines during operational conditions as during baseline pre-construction surveys, i.e. no displacement effects. However, displacement effects are likely. To illustrate this, the estimated number of annual collisions that would occur if there was 50% displacement of breeding birds in the vicinity of turbines is also shown (Table A11.ap3.7). The estimated numbers of collisions based on the same data but without correcting for detection bias is presented so that comparison can be made with estimates for other developments where no correction has been undertaken (Table A11.ap3.7).

Few distance-detection data were collected for curlew and as a result there is less confidence about the actual levels of flight activity for this species. For this reason two alternative CRM calculations were undertaken, using different corrections. Curlew Alternative 1 assumes that the change in detection with distance was intermediate between whimbrel (a similar species that is about 15% smaller) and arctic skua (a species that is about 15% larger and is similar in colour). This is considered the more realistic and therefore more likely alternative. Curlew Alternative 2 used the same distance-detection correction as whimbrel and, as this is a smaller species, is likely to over correct for detection bias (i.e. the estimated collision mortality likely to be too high). Nevertheless it is useful to present Alternative 2 as it indicates the magnitude of possible collision mortality for this species using a highly conservative basis for correcting detection bias.

Table A11.3.5. Input parameters for Band collision models for all species other than red-throated diver.

Input parameters	Unit	Greylag	Merlin	Golden plover	Dunlin	Curlew (Alt. 1)	Curlew (Alt. 2)	Whimbrel	Arctic skua	Great skua
Mean flight activity at RSH in vicinity of turbines (corrected for detection bias)	sec/ha/yr	413	15.4	2472	182	1012	1952	305	221	3012
Bird length	m	0.83	0.28	0.28	0.18	0.55	0.55	0.45	0.6	0.56
Bird wingspan	m	1.64	0.56	0.72	0.41	0.90	0.90	0.80	1.10	1.33
Assumed flight speed	m/sec	16	14	14	13	13	13	13	12	12
Collision probability (from Band Model Stage 2)		7.7%	5.3%	5.5%	4.9%	6.9%	6.9%	6.3%	7.5%	7.4%
Assumed avoidance rate		99%	98%	98%	98%	98%	98%	98%	98%	98%

Table A11.3.6. Band CRM Model Stage 1 calculations to estimate mean number of collisions per turbine for species other than red-throated diver.

Calculation	Unit	Greylag	Merlin	Golden plover	Dunlin	Curlew (Alt. 1)	Curlew (Alt. 2)	Whimbrel	Arctic skua	Great skua
Flight risk volume (Vw) (i.e. 1 ha x rotor diameter)	m^3	1100000	1100000	1100000	1100000	1100000	1100000	1100000	1100000	1100000
Rotor swept area (Ar)	m^2	9503.3	9503.3	9503.3	9503.3	9503.3	9503.3	9503.3	9503.3	9503.3
Rotor swept volume (Vr) = Ar*(d+l)	m^3	47801.7	42574.9	42574.9	41624.5	45140.8	45140.8	44190.4	45615.9	45235.8
Bird occupancy (n)	secs/yr	413	15	2472	182	1012	1952	305	221	3012
Bird occupancy of rotor swept vol (b)	bird-secs	17.1	0.6	95.7	6.9	41.5	80.1	12.3	9.2	123.9
Bird transit time (t)	secs	0.314	0.320	0.320	0.337	0.365	0.365	0.358	0.400	0.397
No. of transits through rotors	per year	57.1	1.9	299.0	20.4	113.7	219.2	34.3	22.9	312.3
No. of collisions per turbine	per year	3.7	0.08	14.0	0.9	6.7	12.9	1.8	1.5	19.6

Table A11.3.7. Estimates of total annual collision mortality for proposed windfarm layout with 127 turbines for species other than red-throated diver.

Scenario	Unit	Greylag	Merlin	Golden plover	Dunlin	Curlew (Alt. 1)	Curlew (Alt. 2)	Whimbrel	Arctic skua	Great skua
T127. No displacement.	birds/year	4.7	0.213	35.5	2.2	16.9	32.7	4.7	3.7	49.9
T127. 50% displacement.	birds/year	2.4	0.11	17.8	1.1	8.5	16.3	2.3	1.9	24.9
T127 50% displacement. No correction for detection bias.	birds/year	0.99	0.03	2.02	0.01	1.30	1.18	0.17	0.45	9.59