

Appendix 8G
Lewis Peatlands SPA: CRM and PVA

1. Collision Risk Modelling

1.1.1 This section presents the approach taken to providing a collision risk estimate for the red-throated diver population associated with the Lewis Peatlands SPA.

1.1.2 The 2018 surveys identified five active red-throated diver breeding locations, one of which was within the Proposed Development, and four that fell within the Lewis Peatlands SPA (**Appendix 8D: Confidential Appendix**). One of these four, however, fell outside the field survey area and focal watch surveys (FW) were not undertaken at this location. Of the remaining three sites within the SPA, two were located to the west of the Proposed Development, and one to the North. All five breeding attempts appeared to be successful.

1.1.3 As red-throated diver frequently change nesting locations between years, and given the proximity of the nest site located within the Proposed Development, it was deemed precautionary to assume that this pair would be associated with the SPA population in some years. Furthermore, it was also deemed precautionary to assume that the pair located to the north within the SPA would also in some years be located to the west of the Proposed Development. Therefore the regular collision risk model (CRM) selected for this work was based on flights recorded from focal watch surveys of four red-throated diver nests located within or close to the SPA.

1.1.4 In 111 hours of survey effort, the focal watches recorded 173 flights of divers during focal watch surveys; of these 117 were at collision risk height.

1.2 Methodology

The approach to regular CRM follows that described in **Appendix F: CRM.**

Selection of Flights

1.2.1 The regular modelling method for birds with predictable flight activity such as divers travelling from breeding lochans to feed at sea or on larger water bodies requires the calculation of the number of birds flying through the turbine rotor swept area each year.

1.2.2 The first step was to identify the risk window relevant for red-throated diver. This was defined as 'a window of width equal to the width of the wind farm perpendicular to the general flight direction of the birds' (SNH, 2000). The length of the risk window also includes for a 50 m micro-siting allowance plus an additional 75 m either side to allow for the radius of the rotor blade. **Table 8G.1.1** presents the risk window selected for red-throated diver and the number of turbines within that risk window whilst the relevant risk windows are illustrated in **Figure 8G.1, Annex A**.

1.2.3 Calculations of available active time were based on the appropriate season (**Appendix 8D**), and survey effort included FW locations associated with the four nest sites monitored. As a precautionary measure, the total number of birds recorded at PCH within a 500m buffer of the wind farm polygon was included for analysis, regardless of whether it actually crossed the risk window or not.

1.2.4 Full details of all flights included in the random CRM models are shown in **Annex B** and details of CRM calculations are presented in **Annex C**.

Table 8G.1.1 Number of Birds Observed Passing through Risk Window

	Season	Risk window (m)	Number of turbines	Total number flights	Total number birds	Total number birds at PCH
Red-throated diver	Breeding	6,052	35	142	173	117

Bird Parameters

1.2.5 The same bird parameters used in **Appendix F** were included in the CRM.

1.3 Results

1.3.1 A summary of the CRM results is shown in **Table 8G.3.1** below, whilst details of model calculations are presented in **Annex B**.

Table 8G.1.1 Predicted Collision Rates for Lewis Peatlands SPA: Red-throated Diver

Avoidance rate %	Season	Potential collisions	No avoidance	Avoidance
99.5	Breeding (April 2018 – August 2018)	Per year 1 bird every *X* years Over 25 years	85.53 0.012 2138.30	0.428 2.34 10.69

2. Population Viability Analysis

2.1 Background

2.1.1 The potential impacts on the golden and red-throated divers future population's trajectories, arising from collision mortality scenarios derived from CRM modelling are investigated using population modelling approaches.

2.1.2 The main approach was an adapted Population Projection Matrix (PPM) in which the matrix arithmetic is replaced by a sequence of year specific (cohort) values. This approach is used because it is easier to incorporate additional wind farm related mortality into this type of model.

2.2 Golden Eagle

2.2.1 The combined collision rate from the breeding and non-breeding golden eagle CRM was applied to a simple deterministic population model for the Lewis Peatlands SPA population over a 25 year period, with calculations presented in **Annex C**.

2.2.2 Population model parameters were taken from population modelling carried out for the NHZ golden eagle population by Natural Research (2019):

- Age classes were s0 (fledged-1), s1 (1-2), s2 (2-3) and s3 (3-4), and Adults 4+ years old);
- SPA breeding population size at the start of the model is assumed to be:
  - s4 - 5 breeding pairs;
  - s3 – 2 individuals;
  - s2 – 2 individuals;
  - s1 – 3 individuals;
  - s0 – 4 individuals.
- Background adult survival rate 0.951;
- Background survival rate for all other age classes 0.795;
- Fledging rate of 0.33 (0.165 females fledged);
- Only adults are assumed to fledge young at the rate of 0.165 females per pair per year.

2.2.3 Using these parameters, the golden eagle population of the Lewis Peatlands SPA is predicted to rise to 12 pairs over the next 25 years without any additional mortality.

2.2.4 With an assumed additional loss of 0.16 birds per year as a result of collisions with turbines (assumed to all be breeding adults as a worst-case scenario) the population is still predicted to rise, albeit at a slower rate, to 7 pairs over the course of a 25 year period.

2.3 Red-throated Diver

2.3.1 The collision rate from the Lewis Peatlands SPA red-throated diver CRM (**Section 1**) was applied to a simple deterministic population model over a 25 year period, with calculations presented in **Annex C**.

2.3.2 Population model parameters were as follows (the same parameters as those used in the Stornoway Wind Farm Variation 2016):

- Age classes were s0 (fledged-1), s1 (1-2), and adults are 2+ years old;
- SPA breeding population size at the start of the model is assumed to be:
  - Adults – 156 individuals;
  - s1 – 33 individuals;
  - s0 – 47 individuals.
- Background adult survival rate is 0.84 (figure from Hemmingsson & Eriksson 2002);
- Background survival rate for fledglings and non-breeding individuals is 0.75 (figure derived from Viking Wind Farm and from Hemmingsson & Eriksson 2002[1]); and
- Fledging rate is 0.6 young per pair per year.

2.3.3 Using these figures, the red-throated diver population of the Lewis Peatlands SPA is predicted to rise to 92 pairs and 41 non-breeding individuals over the next 25 years without any additional mortality.

2.3.4 With an assumed additional loss of 0.43 birds per year as a result of collisions with turbines (assumed to all be breeding adults as a worst-case scenario) the population is still predicted to rise; from 78 pairs to 87 pairs over the course of a 25 year period.

2.4 Cumulative Red-throated Diver

2.4.1 The cumulative collision rate for all wind farms in the Western Isles (**Table 2.1**) was applied to a simple deterministic population model over a 25 year period, with calculations presented in **Annex C**.

Table 2.1 Cumulative Assessment: Lewis Peatlands SPA Red throated Diver (deaths over 25 years)

Wind farm Site	Turbines	Adults	Sub-adults
Stornoway	35	10.7	0.0
Muaitheabhal*	33	0.0	0.0
Muaitheabhal East and South Extensions*	12	0.6	0.0
Pentland Road	6	0.0	0.0
Beinn Greidaig	3	2.3	0
Monan	3	0.0	0.0
Baile an Truseil	3	0.0	0.0

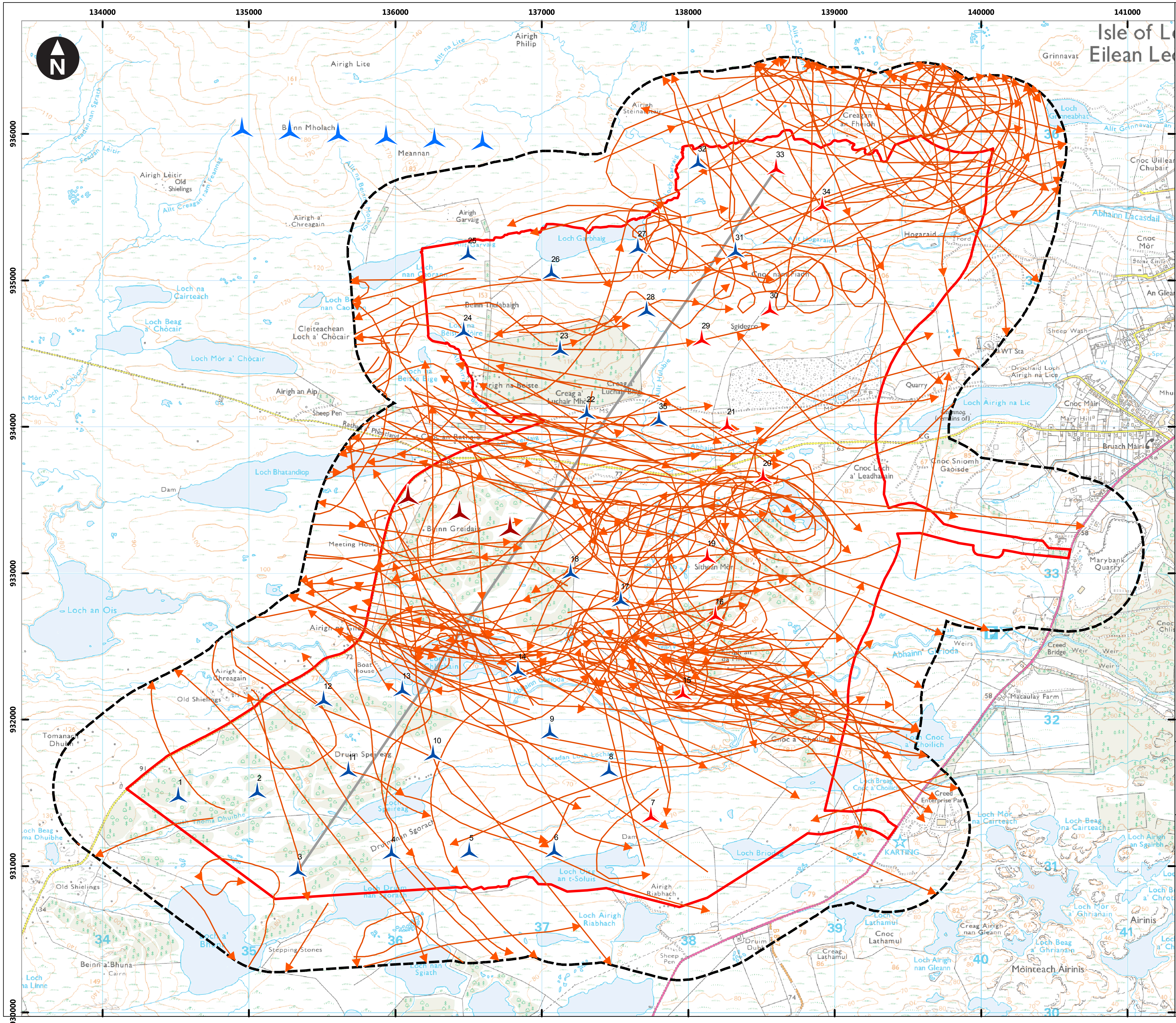
[1] The rate provided by Hemmingsson and Eriksson (2002) for survival of red-throated diver, 0.37 to age two, would result in the UK population declining rapidly. The rate used for the analysis here is less pessimistic than this, but more pessimistic than the figure presented within the Viking Wind Farm ES. The survival rate is that estimated by D. Okil for the Shetland red-throated diver population and provided by SNH (NB. This estimate is used for birds from 0.1 to two years old to be precautionary)

Wind farm Site	Turbines	Adults	Sub-adults
Arnish	3	0.0	0.0
Loch Carnan	3	2.0	0.0
Sandwick North	1	0.0	0.0
Druim Leathann	14	0.0	0.0
All	**120**	**15.6**	**0.0**

2.4.2 A total of 15.6 mortalities over a 25 year period equates to a loss of 0.63 birds per year. This figure was applied to the model (**Appendix C**).

2.4.3 With an assumed additional loss of 0.63 birds per year as a result of collisions with turbines (assumed to all be breeding adults as a worst-case scenario) the population is still predicted to rise; from 78 pairs to 85 pairs over the course of a 25 year period.

Annex A
Figures



Key

Development site boundary

500m buffer

Wind turbine 180m to blade tip

Wind turbine 156m to blade tip

Beinn Grideag wind turbine

Pentland road wind turbine

Flightline at PCH

RH

0 0.5 1 1.5 km

Scale at A3: 1:25,000

Client

Lewis Wind Power
Cumhachd Gaoithe

Stornoway Wind Farm
Environmental Impact Assessment Report

Figure 8G.1.1
Red-throated diver (breeding): regular model flights included in CRM April-August 2018

April 2019

wood.

F:\GWM\DATA\PROJECT\40001 Stornoway Optimisation Feasibility Study\D040 Design\GIS\mxd\40001-Gos435.mxd Originator: gwenda.pannu

Annex B
CRM Calculations

Band Model - Regular Flights (All FW effort and clipped flights at PCH)		
Species: Red-throated diver		
Season: Breeding season 2018 (April - August)		
Bird Parameters		
length (m)	0.69	
wingspan (m)	1.16	
flapping (0)or gliding (1)	0	
Assumed flight speed (m/s)	17.89	
Available hours active	2816.94	
Survey effort (hours)	111	
No birds observed in risk window	117	
Avoidance Rate 99.5%	0.005	
Wind Farm Parameters		
Max height of turbines (m)	180	
Number turbines	35	
Rotor diameter (m)	150	
Hub height (m)	105	
Max chord (m)	4.2	
Pitch (degrees)	12	
Rotation period (secs)	4.7	
Turbine operation time 85%	0.85	
Risk window width (m)	6052	
Calculations		
Risk window area (m2)	1089360	
Area occupied by rotors	618501	
Rotor area as a proportion of risk window area	0.568	
No of birds per hour of observation	1.054	
Potential number birds crossing windfarm area	2969	
Number birds through rotors	1685.81	
Stage 2 Probability of collision	0.060	
Calculation of number collisions	**No avoidance**	**Avoidance 99.5%**
Collisions per year	85.53	0.428
Years per collision	0.012	2.34
Over 25 years	2138.30	10.69

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA											
Only enter input parameters in green cells											08/03/2019
K: [1D or [3D] (0 or 1)	**1**		**Calculation of alpha and p(collision) as a function of radius**								
NoBlades	**3**						Upwind:			Downwind:	
MaxChord	**4.2**	m	r/R	c/C	α	collide		contribution	collide		contribution
Pitch (degrees)	**12**		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	**0.69**	m	0.025	0.575	7.14	25.64	0.91	0.00114	24.64	0.88	0.00110
Wingspan	**1.16**	m	0.075	0.575	2.38	8.88	0.32	0.00238	7.88	0.28	0.00211
F: Flapping (0) or gliding (+1)	**0**		0.125	0.702	1.43	6.38	0.23	0.00285	5.16	0.18	0.00230
			0.175	0.860	1.02	5.54	0.20	0.00346	4.03	0.14	0.00252
Bird speed	**17.89**	m/sec	0.225	0.994	0.79	5.03	0.18	0.00404	3.29	0.12	0.00264
RotorDiam	**150**	m	0.275	0.947	0.65	4.10	0.15	0.00403	2.45	0.09	0.00240
RotationPeriod	**4.70**	sec	0.325	0.899	0.55	3.50	0.12	0.00406	1.93	0.07	0.00224
			0.375	0.851	0.48	3.10	0.11	0.00414	1.61	0.06	0.00215
			0.425	0.804	0.42	2.78	0.10	0.00421	1.37	0.05	0.00208
			0.475	0.756	0.38	2.52	0.09	0.00426	1.20	0.04	0.00203
Bird aspect ratioo: β	0.59		0.525	0.708	0.34	2.30	0.08	0.00430	1.06	0.04	0.00199
			0.575	0.660	0.31	2.11	0.08	0.00433	0.96	0.03	0.00196
			0.625	0.613	0.29	1.94	0.07	0.00433	0.87	0.03	0.00195
			0.675	0.565	0.26	1.80	0.06	0.00433	0.81	0.03	0.00195
			0.725	0.517	0.25	1.66	0.06	0.00431	0.76	0.03	0.00197
			0.775	0.470	0.23	1.54	0.06	0.00427	0.72	0.03	0.00200
			0.825	0.422	0.22	1.43	0.05	0.00422	0.70	0.02	0.00205
			0.875	0.374	0.20	1.33	0.05	0.00415	0.70	0.03	0.00220
			0.925	0.327	0.19	1.23	0.04	0.00407	0.72	0.03	0.00236
			0.975	0.279	0.18	1.14	0.04	0.00398	0.72	0.03	0.00252
				Overall p(collision) =			**Upwind**	**7.7%**		**Downwind**	**4.3%**
								Average	**6.0%**		

Annex C
Population Viability Analysis

Lewis Peatlands SPA - Population Modelling: golden eagle

Fledging rate	Adult survival	Survival rate s0 to s3	Additional mortality - turbines
0.165	0.9512	0.795	0.16

Background Model - no additional mortality

	Adults	S3	S2	S1	S0
2016	5.0	2.0	2.0	3.0	4.0
2017	6.3	1.6	2.4	3.2	0.8
2018	7.3	1.9	2.5	0.6	1.0
2019	8.5	2.0	0.5	0.8	1.1
2020	9.6	0.4	0.6	0.9	1.3
2021	9.5	0.5	0.7	1.1	1.5
2022	9.4	0.6	0.8	1.2	1.5
2023	9.4	0.7	1.0	1.2	1.5
2024	9.5	0.8	0.9	1.2	1.5
2025	9.6	0.7	0.9	1.2	1.5
2026	9.7	0.7	0.9	1.2	1.5
2027	9.9	0.7	0.9	1.2	1.5
2028	10.0	0.7	1.0	1.2	1.5
2029	10.1	0.8	1.0	1.2	1.6
2030	10.2	0.8	1.0	1.2	1.6
2031	10.3	0.8	1.0	1.3	1.6
2032	10.4	0.8	1.0	1.3	1.6
2033	10.5	0.8	1.0	1.3	1.6
2034	10.7	0.8	1.0	1.3	1.7
2035	10.8	0.8	1.0	1.3	1.7
2036	10.9	0.8	1.0	1.3	1.7
2037	11.0	0.8	1.1	1.3	1.7
2038	11.1	0.8	1.1	1.4	1.7
2039	11.3	0.8	1.1	1.4	1.7
2040	11.4	0.9	1.1	1.4	1.8
2041	11.5	0.9	1.1	1.4	1.8

Additional mortality

	Adults	S3	S2	S1	S0
2018	5.0	1.0	2.0	2.0	2.0
2019	5.4	1.6	1.6	1.6	0.8
2020	6.2	1.3	1.3	0.6	0.8
2021	6.8	1.0	0.5	0.7	1.0
2022	7.1	0.4	0.5	0.8	1.1
2023	6.9	0.4	0.6	0.8	1.1
2024	6.7	0.5	0.7	0.9	1.1
2025	6.6	0.5	0.7	0.9	1.1
2026	6.6	0.6	0.7	0.8	1.0
2027	6.5	0.5	0.7	0.8	1.0
2028	6.5	0.5	0.7	0.8	1.0
2029	6.4	0.5	0.7	0.8	1.0
2030	6.4	0.5	0.6	0.8	1.0
2031	6.3	0.5	0.6	0.8	1.0
2032	6.3	0.5	0.6	0.8	1.0
2033	6.2	0.5	0.6	0.8	1.0
2034	6.1	0.5	0.6	0.8	1.0
2035	6.1	0.5	0.6	0.8	1.0
2036	6.0	0.5	0.6	0.8	1.0
2037	6.0	0.5	0.6	0.8	0.9
2038	5.9	0.5	0.6	0.8	0.9
2039	5.8	0.5	0.6	0.7	0.9
2040	5.8	0.5	0.6	0.7	0.9
2041	5.7	0.5	0.6	0.7	0.9
2042	5.6	0.5	0.6	0.7	0.9
2043	5.6	0.5	0.6	0.7	0.9

Lewis Peatlands SPA - Population Modelling: red throated diver

Fledging rate	Adult survival	Survival rate to year 2	Survival rate Fledglings	Additional mortality - turbines
0.6	0.84	0.75	0.75	0.43

Background Model - no additional mortality

	Adults	s1	s0
2018	156.0	33.0	47.0
2019	155.8	35.3	46.7
2020	157.3	35.1	47.2
2021	158.4	35.4	47.5
2022	159.6	35.6	47.9
2023	160.8	35.9	48.2
2024	162.0	36.2	48.6
2025	163.2	36.5	49.0
2026	164.5	36.7	49.3
2027	165.7	37.0	49.7
2028	166.9	37.3	50.1
2029	168.2	37.6	50.5
2030	169.4	37.8	50.8
2031	170.7	38.1	51.2
2032	172.0	38.4	51.6
2033	173.3	38.7	52.0
2034	174.6	39.0	52.4
2035	175.9	39.3	52.8
2036	177.2	39.6	53.2
2037	178.5	39.9	53.6
2038	179.9	40.2	54.0
2039	181.2	40.5	54.4
2040	182.6	40.8	54.8
2041	183.9	41.1	55.2
2042	185.3	41.4	55.6
2043	186.7	41.7	56.0

Additional mortality

	Adults	s1	s0
2018	156.0	33.0	47.0
2019	155.4	35.3	46.6
2020	156.5	35.0	47.0
2021	157.3	35.2	47.2
2022	158.1	35.4	47.4
2023	158.9	35.6	47.7
2024	159.7	35.8	47.9
2025	160.5	35.9	48.2
2026	161.4	36.1	48.4
2027	162.2	36.3	48.7
2028	163.1	36.5	48.9
2029	163.9	36.7	49.2
2030	164.8	36.9	49.4
2031	165.6	37.1	49.7
2032	166.5	37.3	50.0
2033	167.4	37.5	50.2
2034	168.3	37.7	50.5
2035	169.2	37.9	50.8
2036	170.1	38.1	51.0
2037	171.0	38.3	51.3
2038	171.9	38.5	51.6
2039	172.8	38.7	51.8
2040	173.7	38.9	52.1
2041	174.7	39.1	52.4
2042	175.6	39.3	52.7
2043	176.6	39.5	53.0

Lewis Peatlands SPA - Cumulative Population Modelling: red throated diver

Fledging rate	Adult survival	Survival rate to year 2	Survival rate Fledglings	Additional mortality - turbines
0.6	0.84	0.75	0.75	0.63

Background Model - no additional mortality

	Adults	s1	s0
2018	156.0	33.0	47.0
2019	155.8	35.3	46.7
2020	157.3	35.1	47.2
2021	158.4	35.4	47.5
2022	159.6	35.6	47.9
2023	160.8	35.9	48.2
2024	162.0	36.2	48.6
2025	163.2	36.5	49.0
2026	164.5	36.7	49.3
2027	165.7	37.0	49.7
2028	166.9	37.3	50.1
2029	168.2	37.6	50.5
2030	169.4	37.8	50.8
2031	170.7	38.1	51.2
2032	172.0	38.4	51.6
2033	173.3	38.7	52.0
2034	174.6	39.0	52.4
2035	175.9	39.3	52.8
2036	177.2	39.6	53.2
2037	178.5	39.9	53.6
2038	179.9	40.2	54.0
2039	181.2	40.5	54.4
2040	182.6	40.8	54.8
2041	183.9	41.1	55.2
2042	185.3	41.4	55.6
2043	186.7	41.7	56.0

Additional cumulative mortality

	Adults	s1	s0
2018	156.0	33.0	47.0
2019	155.2	35.3	46.5
2020	156.1	34.9	46.8
2021	156.7	35.1	47.0
2022	157.4	35.3	47.2
2023	158.0	35.4	47.4
2024	158.6	35.5	47.6
2025	159.3	35.7	47.8
2026	159.9	35.8	48.0
2027	160.6	36.0	48.2
2028	161.3	36.1	48.4
2029	161.9	36.3	48.6
2030	162.6	36.4	48.8
2031	163.3	36.6	49.0
2032	164.0	36.7	49.2
2033	164.7	36.9	49.4
2034	165.4	37.0	49.6
2035	166.1	37.2	49.8
2036	166.8	37.4	50.0
2037	167.5	37.5	50.2
2038	168.2	37.7	50.5
2039	168.9	37.8	50.7
2040	169.6	38.0	50.9
2041	170.4	38.2	51.1
2042	171.1	38.3	51.3
2043	171.8	38.5	51.6