moray offshore renewables ltd

Environmental Statement

Technical Appendix 4.5 A - Ornithology Baseline and Impact Assessment

**Telford, Stevenson, MacColl Wind Farms
and associated Transmission Infrastructure
Environmental Statement**

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1 Introduction

1.1 Moray Offshore Wind Farm

The Crown Estate has awarded EDP Renováveis (EDPR) and Repsol (previously SeaEnergy Renewables) the exclusive rights to develop wind farm sites within Zone 1 of the UK Round 3. EDPR and Repsol have formed Moray Offshore Renewables Limited (MORL) to develop the zone in the Moray Firth, Scotland.

The Moray Firth zone is located 22.2 km from the coast, on the Smith Bank in the Moray Firth, and covers an area of 522.15 km^2. The water depths vary between approximately 35-57 m. Peak spring tidal speeds can be up to 1.2 knots.

MORL intends to develop 1.5 GW of offshore wind by 2020 within the zone. The development will be split into two phases: a first phase of 1 – 1.5 GW) consisting of three wind farm sites; Telford, Stevenson and MacColl, and the second phase of up to 500 MW (Western Development Area). The focus of this Technical Report is the former three proposed wind farm sites and associated offshore transmission infrastructure (OfTI).

1.2 Ornithological Technical Report

Natural Power Consultants (NPC) undertook bird and marine mammal baseline surveys for the three proposed wind farm sites between April 2010 and March 2012. NPC have also been acting as lead ornithological consultants, advising MORL on additional survey requirements to support the Environmental Impact Assessment (EIA) and in light of Habitat Regulations Assessment (HRA). As part of the EIA process the Environmental Statement (ES) sections for birds have been produced by NPC. This Technical Report provides additional information on the baseline ornithological studies and the impact assessments to that provided in the ES (Chapters 4.5, 7.4, 10.4 and 14.4).

1.3 Designated sites – long list

The Moray Firth holds internationally important numbers of breeding seabirds and over-wintering waterbirds (e.g. ducks, divers, grebes and waders). In addition the Moray Firth is also important during the spring and autumn migration periods as a feeding area for birds moving between breeding grounds at high latitudes and wintering grounds further south within the UK and beyond. In recognition of these ornithological interests there are a number of designated sites situated around the Moray Firth. In addition to designated sites within the Moray Firth are several other sites with potential connectivity with the three proposed wind farm sites, due to the foraging distances of the qualifying species in question.

These sites designated for ornithological interests comprise of SPAs (Special Protection Areas), Ramsar sites, and SSSIs (Sites of Special Scientific Interest). A long list (Table 3) of designated sites has therefore been produced which will be looked at in detail within this Technical Report in order to ascertain whether connectivity is likely to occur, based on foraging distances of the designated species (Tables 1 & 2). The search distance that was deemed appropriate for most species was 100 km, based on mean maximum foraging distances (Tables 1 and 2) in a search area consisting of: the coastline from Strathy Point, north Caithness to Peterhead, Aberdeenshire; and Orkney (SPAs in this search area are shown in Table 3). SPAs included in the list in addition to those within this search area are Scottish SPAs designated for breeding gannet (based on this species foraging ranges) and Manx shearwater (due to individuals potentially migrating through the Moray Firth).

Short-listing of an SPA was based on whether a designated species was likely to show connectivity. For the breeding season, this was based on the highest 'mean maximum' foraging distance from one of two sources, either a review undertaken by Birdlife International (Table 1; http://seabird.wikispaces.com/), or a review by Thaxter *et al.* 2012 (Table 2). Additional sites were also short-listed for the following migratory seabird species: Manx shearwater, Arctic tern, great skua and Arctic skua.

The population estimates provided in Table 3 are those from the SPA citations and a more recent population estimate if one is available. In most cases, however, the most recent population estimate will be that from the Seabird 2000 census which took place in 1998-2002. In each of the species accounts in Section 4, information on UK population trend estimates for between 2000 and 2010, per JNCC (2011), is also provided for species for which this is available. These population trends have not been used to predict individual SPA population sizes for 2010, however, due to the problem of inter-site variation in trends. Also, for East Caithness Cliffs SPA the monitoring of plots within the SPA was undertaken in 1999 and 2005 (Swann 2012); however these have not been used to extrapolate for the whole SPA as the monitoring only included four small areas.

Table 1. Foraging ranges for detected species, taken from Birdlife International

SPECIES	Maximum, km	Mean maximum, km	Mean, km
Fulmar	664	311.4	69.3
Gannet	640	308.4	140.1
Shag	20	16.4	6.5
Cormorant	50	31.7	8.5
Common tern	37	33.8	8.7
Arctic tern	21	12.2	11.7
Kittiwake	200	65.8	25.4
Great skua	100	42.3	35.8
Arctic skua	100	40.0	28.0

Table 1. Foraging ranges for detected species, taken from Birdlife International

Guillemot	200	60.6	24.5
Razorbill	51	31.0	10.3
Puffin	200	62.2	30.3

Table 2. Foraging ranges for detected species, taken from Thaxter *et al.* 2012

SPECIES	**Maximum, km**	**Mean maximum, km (± sd)**	**Mean, km (± sd)**	**Confidence of Assessment**
Fulmar	580	400 ± 245.8	47.5 ± 1	Moderate
Gannet	590	229.4 ± 124.3	92.5 ± 59.9	Highest
Shag	17	14.5 ± 3.5	5.9 ± 4.7	Moderate
Cormorant	35	25 ± 10	5.2 ± 1.5	Moderate
Common tern	*30*	15.2 ± 11.2	4.5 ± 3.2	Moderate
Arctic tern	30	24.2 ± 6.3	7.1 ± 2.2	Moderate
Herring gull	92	61 ± 44	10.5	Moderate
Kittiwake	120	60 ± 23.3	24.8 ± 12.1	Highest
Great skua	219	86.4		Low
Arctic skua	75	62.5 ± 17.7	6.4 ± 5.9	Uncertain
Guillemot	*135*	84.2 ± 50.1	37.8 ± 32	Highest
Razorbill	95	48.5 ± 35.0	23.7 ± 7.5	Moderate
Puffin	200	105.4 ± 46.0	4	Low

Table 3. Long-list of sites designated for ornithological interests.

Site and Designation	Distance to wind farm sites	Interest feature	Citation population estimates			Revised population estimates			
			pop	Type	timescale	pop	Type	timescale	source
East Caithness Cliffs SPA, SSSI Short-listed (fulmar, herring gull, great black-backed gull, kittiwake, guillemot, razorbill, puffin)	20 km	Fulmar	15000	4ymbp	85 - 88	14202	bp	98 - 02	SNH 2008
		Shag	2300	4ymbp	85 - 88	1056	bp	98 - 02	SNH 2008
		Cormorant	230	4ymbp	85 - 88	94	bp	98 - 02	SNH 2008
		Peregrine	6	bp	mid 90s			1999	SMP
		Kittiwake	32500	4ymbp	85 - 88	40410	bp	98 - 02	SNH 2008
		Herring gull	9400	4ymbp	85 - 88	3393	bp	98 - 02	SNH 2008
		Great Black-backed gull	800	4ymbp	85 - 88	180	bp	98 - 02	SNH 2008
		Guillemot	106700	I	85 - 88	158985	I	98 - 02	SNH 2008
		Razorbill	15800	I	85 – 88	17830	I	98 - 02	SNH 2008
		Puffin	1750	4ymbp	85 - 88	274	bp	98 - 02	SNH 2008
		Seabird Assemblage							
North Caithness Cliffs SPA, SSSI Short-listed (razorbill, puffin, fulmar, kittiwake, guillemot)	33 km	Razorbill	4000	I	85 - 88	2463	I	98 - 02	SNH 2008
		Peregrine	6	bp	mid 90s				
		Puffin	1750	bp	85 - 88	7045	ob	98 - 02	SNH 2008
		Fulmar	14700	bp	85 - 88	14168	bp	98 - 02	SNH 2008
		Kittiwake	13100	bp	85 - 88	10147	bp	98 - 02	SNH 2008
		Guillemot	38300	I	85 - 88	70584	bp	98 - 02	SNH 2008
		Seabird Assemblage							
Pentland Firth Islands SPA, SSSI Short-listed (Arctic tern)	42 km	Arctic tern	1200	4ymbp	92 - 95	No data			

Table 3. Long-list of sites designated for ornithological interests.

Site and Designation	Distance to wind farm sites	Interest feature	Citation population estimates			Revised population estimates			
			pop	Type	timescale	pop	Type	timescale	source
Moray and Nairn Coast **SPA, SSSI, Ramsar** **Not short-listed**	46 km	Greylag goose	2679	5ym	91/92 - 95/96				
		Pink-footed goose	139	5ym	91/92 - 95/96				
		Redshank	862	5ym	91/92 - 95/96	No data			
		Osprey	7	bp	early 90s				
Troup, Pennan and Lion's Heads **SPA, SSSI** **Short-listed (fulmar, herring gull, kittiwake, guillemot)**	49 km	Razorbill	4800	I	1995	3001	I	2007	SNH 2008
		Fulmar	4400	bp	1995	1795	AOS	2007	SNH 2008
		Herring gull	4200	bp	1995	1687	AOS	2007	SNH 2008
		Kittiwake	31600	bp	1995	17171	AON	2007	SNH 2008
		Guillemot	44600	I	1995	17598	I	2007	SNH 2008
		Seabird Assemblage							
Switha **SPA, SSSI** **Not short-listed**	56 km	Barnacle goose	1120	5ym	93/94 - 97/98	No data			
Hoy **SPA, SSSI** **Short-listed (great skua, puffin, fulmar, great black-backed gull, kittiwake, Arctic skua, guillemot)**	58 km	Great skua	1900	bp		1770	AOT	98 - 02	SNH 2008
		Peregrine	6	bp					
		Puffin	3500	bp		417	I	98 - 02	SNH 2008
		Fulmar	35000	4ymbp	85 - 88	32600	AOS	98 - 02	SNH 2008
		Red-throated diver	58	bt	1994				
		Great black-backed gull	570	4ymbp		428	AON	98 - 02	SNH 2008
		Kittiwake	3000	4ymbp	85 - 88	781	AON	98 - 02	SNH 2008
		Arctic skua	59	4ymbp	85 - 88	50	AOT	98 - 02	SNH 2008
		Guillemot	13400	4ymbp	85 - 88	20514	I	98 - 02	SNH 2008
		Seabird Assemblage							

Table 3. Long-list of sites designated for ornithological interests.

Site and Designation	Distance to wind farm sites	Interest feature	Citation population estimates			Revised population estimates			
			pop	Type	timescale	pop	Type	timescale	source
Dornoch Firth and Loch Fleet: **SPA, SSSI, Ramsar** **Not short-listed**	58 km	Eurasian wigeon	15022	5ym	91/92 - 95/96	No data			
		Greylag goose	2079	5ym	91/92 - 95/96				
		Bar-tailed godwit	1300	5ym	91/92 - 95/96				
		Osprey	20	bp	early 90s				
Copinsay **SPA, SSSI** **Short-listed (fulmar, kittiwake)**	61 km	Fulmar	1615	4ymbp	85 - 88	No data			
		Great Black-backed gull	490	4ymbp	85 - 88				
		Kittiwake	9550	4ymbp	85 - 88				
		Guillemot	29450	4ym I	85 - 88				
		Seabird Assemblage							
Loch of Strathbeg **SPA, SSSI, Ramsar** **Short-listed (geese, whooper swan)**	68 km	Eurasian teal	1898	5ym	91/92 - 95/96				
		Greylag goose	3325	wpm					
		Pink-footed goose	33924	5ym	91/92 - 95/96	No data			
		Goldeneye	109	5ym	91/92 - 95/96				
		Whooper swan	183	5ym	91/92 - 95/96				
		Sandwich tern	530	5ymbp	93 - 97				
Auskerry **SPA, SSSI** **Short-listed (Arctic tern)**	79 km	European Storm petrel	3600	bp	1995	No data			
		Arctic tern	780	4ym	92 - 95				
Inner Moray Firth **SPA, SSSI, Ramsar** **Not short-listed**	83 km	Greylag goose	2651	5ym	92/93 - 96/97				
		Bar-tailed godwit	1090	5ym	92/93 - 96/97				
		Red-breasted merganser	1184	5ym	92/93 - 96/97	No data			
		Osprey	2	bp	early 90s				

Table 3. Long-list of sites designated for ornithological interests.

Site and Designation	Distance to wind farm sites	Interest feature	Citation population estimates			Revised population estimates			
			pop	Type	timescale	pop	Type	timescale	source
		Common tern	310	bp	SCR				
		Redshank	1621	5ym	92/93 - 96/97				
Cromarty Firth **SPA, SSSI, Ramsar** **Not short-listed**	87 km	Greylag goose	1782	5ym	92/93 - 96/97	No Data			
		Whooper swan	64	5ym	92/93 - 96/97				
		Bar-tailed godwit	1355	5ym	92/93 - 96/97				
		Osprey	2	bp	early 90s				
		Common tern	294	5ymbp	89 - 93				
Calf of Eday **SPA, SSSI** **Short-listed (fulmar)**	99 km	Fulmar	1955	4ymbp	85 - 88	No data			
		Great black-backed gull	983	4ymbp	85 - 88				
		Cormorant	233	4ymbp	85 - 88				
		Kittiwake	1717	4ymbp	85 - 88				
		Guillemot	12645	4ym I	85 - 88				
		Seabird Assemblage							
Marwick Head **SPA** **Not short-listed**	99 km	Kittiwake	7700	bp	1991	5410	bp	98 - 02	SNH 2008
								98 - 02	SNH 2008
		Guillemot	37700	bp	1991	33709	I		
Rousay **SPA, SSSI** **Short-listed (fulmar, Arctic skua, Arctic tern)**	99 km	Fulmar	1240	3ymbp	86 - 88	714	bp	98 - 02	SNH 2008
		Kittiwake	4900	3ymbp	86 - 88	2713	bp	98 - 02	SNH 2008
		Arctic skua	130	3ymbp	86 - 88	158	bp	98 - 02	SNH 2008
		Arctic tern	790	5ymbp	91 - 95	709	bp	98 - 02	SNH 2008
		Guillemot	10600	3ym I	86 - 88	6149	I	98 - 02	SNH 2008
		Seabird Assemblage							
East Sanday Coast	101 km	Turnstone	1400	3ym	91/92 - 93/94	No data			

Table 3. Long-list of sites designated for ornithological interests.

Site and Designation	Distance to wind farm sites	Interest feature	Citation population estimates			Revised population estimates			
			pop	Type	timescale	pop	Type	timescale	source
SPA, SSSI, Ramsar **Not short-listed**		Purple sandpiper	840						
West Westray **SPA, SSSI** **Short-listed (fulmar, Arctic skua, Arctic tern)**	108 km	Razorbill	1946	5ym I	85 - 88	2253	I	98 - 02	SNH 2008
		Fulmar	1400	5ymbp	93/94 - 97/98	4270	bp	98 - 02	SNH 2008
		Kittiwake	23900	4ymbp	85 - 88	33281	bp	98 - 02	SNH 2008
		Arctic skua	78	4ymbp	85 - 88	61	bp	98 - 02	SNH 2008
		Arctic tern	1140	4ymbp	85 - 88	1066	bp	98 - 02	SNH 2008
		Guillemot	42150	4ym I	85 - 88	52967	I	98 - 02	SNH 2008
		Seabird Assemblage							
Papa Westray **SPA, SSSI** **Short-listed**	129 km	Arctic tern	1950	bp	1997	No data			
Sule Skerry and Sule Stack **SPA, SSSI** **Short-listed (gannet)**	131 km	Gannet	5900			No data			
		Guillemot							
		Leach's petrel							
		Puffin							
		Shag							
		Storm petrel							
		Seabird Assemblage							

Table 3. Long-list of sites designated for ornithological interests.

			Citation population estimates			Revised population estimates			
Site and Designation	**Distance to wind farm sites**	**Interest feature**	**pop**	**Type**	**timescale**	**pop**	**Type**	**timescale**	**source**
Fair Isle	143 km	Gannet	1166	bp	85 - 88	4085	Bp	2011	4085
SPA, SSSI		Arctic skua	110	bp	85 - 88				
		Arctic tern	1100	bp	85 - 88				
Short-listed (gannet, Arctic skua, Arctic tern)		Fair Isle wren							
		Fulmar							
		Great skua							
		Guillemot							
		Kittiwake							
		Puffin							
		Razorbill							
		Shag							
		Seabird Assemblage							
North Rona and Sula Sgier	205 km	Gannet	10400	bp	85 - 88	9225	Bp	2004	SMP
		Fulmar							
Short-listed (gannet)		Great black backed gull							
		Guillemot							
		Kittiwake							
		Leach’s petrel							
		Puffin							
		Razorbill							
		Storm petrel							
		Seabird Assemblage							

Table 3. Long-list of sites designated for ornithological interests.

Site and Designation	Distance to wind farm sites	Interest feature	Citation population estimates			Revised population estimates			
			pop	Type	timescale	pop	Type	timescale	source
Noss	222 km	Gannet	6860	bp	85 - 88	9767	Bp	2008	SMP
SPA, SSSI		Great skua	410	bp	93 - 97				
		Fulmar							
Short-listed (gannet, great skua)		Guillemot							
		Kittiwake							
		Puffin							
		Seabird Assemblage							
Firth of Forth Islands	237 km	Gannet	21600	bp	85 - 88	No data			
SPA, SSSI		Arctic tern							
		Common tern							
Short-listed (gannet)		Cormorant							
		Fulmar							
		Guillemot							
		Herring gull							
		Kittiwake							
		Lesser black-backed gull							
		Puffin							
		Razorbill							
		Roseate tern							
		Sandwich tern							
		Shag							
		Seabird Assemblage							

Table 3. Long-list of sites designated for ornithological interests.

Site and Designation	Distance to wind farm sites	Interest feature	Citation population estimates			Revised population estimates			
			pop	Type	timescale	pop	Type	timescale	source
Hermaness, Saxa Vord and Vala Field **SPA, SSSI** **Short-listed (gannet, great skua)**	298 km	Gannet Great skua Fulmar Guillemot Kittiwake Puffin Red-throated diver Shag Seabird Assemblage	16400 630	bp bp	85 - 88 1997	No data			
Rum **SPA, SSSI** **Short-listed (Manx shearwater)**	366 km	Manx shearwater Golden Eagle Guillemot Kittiwake Red-throated diver Seabird Assemblage	61000	bp	85 - 88	120000	Bp	2001	SMP
St Kilda **SPA, SSSI** **Short-listed (Manx shearwater)**	376 km	Gannet Manx shearwater	50050	bp	85 - 88	59622 1299	Bp Bp	2004 1999	SMP SMP
Ailsa Craig **SPA, SSSI** **Not short-listed**	630 km	Gannet	23000	bp	85 - 88	27130	Bp	2004	SMP

Key: (5)ym – (5) year mean; (5)ymbp – 5 year mean breeding pairs; wpm – winter peak mean; bp – breeding pairs; bt – breeding territories; ; I – Individuals; AOS – Apparently Occupied Sites; AOT – Apparently Occupied Territories; AON – Apparently Occupied Nests; ob – occupied burrows; SCR Seabird Census Register; SMP – Seabird Monitoring Project; SNH – SNH SPA marine extension paper.

1.4 Species

Species on Annex I of the Birds Directive, and regularly occurring migratory species are protected through a network of SPAs. The species of prime interest with regards to impact assessment would be any Annex I birds that are linked to an SPA population. In addition, under the Wildlife and Countryside Act 1981 (as amended) it is an offence to intentionally or recklessly kill, injure or take any wild bird or their eggs or nest. Species listed on Schedule 1 are also protected from disturbance at their nests or to their dependent young. A long-list of species that were considered for inclusion in the impact assessment is provided in Table 4. This list is based on factors such as the conservation status of each species and its status within the three wind farm sites, providing the following details of each species:

- whether it is included on Annex 1, or in the list of regularly occurring migrants, in the Birds Directive;
- whether it is a feature of SPAs listed in Table 3;
- whether it is listed on the Birds of Conservation Concern Red or Amber lists (Eaton *et al*., 2009);
- whether the species was regularly recorded (i.e. present on the majority of surveys during the relevant seasons) on the NPC boat-based surveys; and
- whether the species breeding range or known passage routes would make it likely as a frequent migrant (based on NPC expert judgement: Dr Chris Pendlebury and Mark Lewis) over the Moray Firth.

Table 4. Long-list of species to be considered for risk assessment

Species	scientific name	Annex 1	SPA feature	Red/amber list	Presence onsite	Regular migrant	Frequent migrant
Great northern diver	*Gavia immer*	■		🟨			
Black-throated diver	*Gavia arctica*	■		🟨			
Red-throated diver	*Gavia stellata*	■	■	🟨			
Great crested grebe	*Podiceps cristatus*					■	
Slavonian grebe	*Podiceps auritus*	■		🟨			
Fulmar	*Fulmarus glacialis*		■	🟨	■	■	
Gannet	*Morus bassanus*		■	🟨	■	■	
Manx shearwater	*Puffinus puffinus*			🟨		■	
Sooty shearwater	*Puffinus griseus*			🟨		■	
Storm petrel	*Hydrobates pelagicus*	■	■	🟨			
Leach's petrel	*Oceanodroma leucohora*	■		🟨			
Cormorant	*Phalacrocorax carbo*		■			■	
Shag	*Phalacrocorax aristotelis*		■	🟨		■	
Mute swan	*Cygnus olor*						

Table 4. Long-list of species to be considered for risk assessment

Species	scientific name	Annex 1	SPA feature	Red/amber list	Presence onsite	Regular migrant	Frequent migrant
Whooper swan	*Cygnus cygnus*	■	■	🟧			■
Greylag goose	*Anser anser*		■	🟧			■
Pink-footed goose	*Anser brachyrhynchus*		■	🟧			■
Barnacle goose	*Branta bernicula*		■	🟧			
Shelduck	*Tadorna tadorna*			🟧			
Gadwall	*Anas strepera*			🟧			
Pintail	*Anas acuta*			🟧			
Wigeon	*Anas penelope*		■	🟧			■
Mallard	*Anas platyrhynchos*			🟧			■
Shoveler	*Anas clypeata*			🟧			
Teal	*Anas crecca*		■	🟧			■
Tufted duck	*Aythya fuligula*			🟧			
Greater scaup	*Aythya marila*			🟥		■	■
Pochard	*Aythya ferina*			🟧			
Eider	*Somateria mollissima*			🟧		■	■
Common scoter	*Melanitta nigra*			🟥		■	■
Velvet scoter	*Melanitta fusca*					■	■
Long-tailed duck	*Clangula hyemalis*					■	■
Common goldeneye	*Bucephula clangula*		■	🟧		■	■
Red-breasted merganser	*Mergus serrator*		■			■	■
Osprey	*Pandion haliaetus*	■	■	🟧			
Marsh harrier	*Circus aeruginosus*			🟧			
Sparrowhawk	*Accipiter nisus*						
Kestrel	*Falco tinnunculus*			🟧			
Peregrine	*Falco peregrinus*	■	■				
Merlin	*Falco columbiarus*			🟧			
Oystercatcher	*Haematopus ostralegus*			🟧			■
Ringed plover	*Charadrius hiaticula*			🟧			■
Dotterel	*Charadrius morinellus*	■		🟧			
Golden plover	*Pluvialis apricaria*	■		🟧			■
Grey plover	*Pluvialis squatarola*			🟧			■
Lapwing	*Vanellus vanellus*			🟥			■
Knot	*Calidris canutas*			🟧			■
Sanderling	*Calidris alba*						■
Purple sandpiper	*Calidris maritima*		■	🟧			■
Dunlin	*Calidris alpina*	■		🟥			■
Ruff	*Philomachus pugnax*	■		🟥			
Jack snipe	*Lymnocryptes minimus*			🟧			
Snipe	*Gallinago gallinago*			🟧			■
Woodcock	*Scolopax rusticola*			🟧			■

Table 4. Long-list of species to be considered for risk assessment

Species	scientific name	Annex 1	SPA feature	Red/amber list	Presence onsite	Regular migrant	Frequent migrant
Black-tailed godwit	*Limosa limosa*			🟥			■
Bar-tailed godwit	*Limosa lapponica*	■	■	🟧			■
Whimbrel	*Numenius phaeopus*			🟥			■
Curlew	*Numenius arquata*			🟧			■
Common sandpiper	*Actitis hypoleucos*			🟧			■
Redshank	*Tringa totanus*		■	🟧			■
Turnstone	*Arenaria interpres*		■	🟧			■
Red-necked phalarope	*Phalaropus lobatus*	■		🟥			
Grey phalarope	*Phalaropus fulicaruis*						
Pomarine skua	*Stercorarius pomarinus*					■	
Arctic skua	*Stercorarius parasiticus*		■	🟥		■	
Long-tailed skua	*Stercorarius longicaudus*					■	
Great skua	*Stercorarius skua*		■	🟧	■	■	
Kittiwake	*Rissa trydactyla*		■	🟧	■	■	
Black-headed gull	*Chroicocephalus ridibundus*			🟧		■	
Common gull	*Larus canus*			🟧		■	
Lesser-black backed gull	*Larus fuscus*			🟧		■	
Herring gull	*Larus argentatatus*		■	🟥	■	■	
Great black-backed gull	*Larus marinus*			🟧	■	■	
Sandwich tern	*sterna sandvicensis*	■	■	🟧			
Arctic tern	*Sterna paradisaea*	■	■	🟧			
Common tern	*Sterna hirundo*	■	■	🟧			
Guillemot	*Uria aalge*		■	🟧	■		
Razorbill	*Alca torda*		■	🟧	■		
Little auk	*Alle alle*						
Puffin	*Fratercula arctica*		■	🟧	■		
Woodpigeon	*Columba palumbus*						
Collared dove	*Streptopelia decaocto*						
Cuckoo	*Cuculus canorus*			🟥			
Short-eared owl	*Asia flammeus*	■		🟧			
Swift	*Apus apus*			🟧			
Skylark	*alauda arvensis*			🟥			■
Meadow pipit	*Anthus pratensis*			🟧			■
Tree pipit	*Anthus trivialis*			🟥			
Rock pipit	*Anthus petrosus*						
White wagtail	*Moticilla alba*						■
Sand martin	*Riparia riparia*			🟧			■
House martin	*Delichon urbicum*			🟧			■
Swallow	*Hirundo rustica*			🟧			■

Table 4. Long-list of species to be considered for risk assessment

Species	scientific name	Annex 1	SPA feature	Red/amber list	Presence onsite	Regular migrant	Frequent migrant
Robin	*Erithacus rubecula*						⬛
Redstart	*Phoenicurus phoenicurus*						
Whinchat	*Saxicola rubetra*			🟧			
Wheatear	*Openanthe oenanthe*			🟧			⬛
Blackbird	*Turdus merula*						⬛
Ring ouzel	*Turdus torquatus*			🟥			
Fieldfare	*Turdus piliaris*						⬛
Song thrush	*Turdus philomenus*			🟥			⬛
Redwing	*Turdus iliacus*			🟥			⬛
Mistle thrush	*Turdus viscivorus*			🟧			
Blackcap	*Sylvia atricapilla*						⬛
Whitethroat	*Sylvia communis*			🟧			
Sedge warbler	*Acrocephalus schoenobaenus*						
Grasshopper warbler	*locustella naevia*			🟥			
Willow warbler	*Phylloscopus trochilus*			🟧			⬛
Chiffchaff	*Phylloscopus colybitta*						⬛
Goldcrest	*Regulus regulus*						⬛
Spotted flycatcher	*Muscicapa striata*			🟥			
Pied flycatcher	*Fidecula hypoleuca*			🟧			
Starling	*Sturnus vulgaris*			🟥			⬛
Carrion crow	*Corvus corone*						
Jackdaw	*Corvus monedula*						
Chaffinch	*Fringilla coelebs*						⬛
Brambling	*Fringilla montifringilla*						⬛
Siskin	*Carduelis spinus*						⬛
Lesser redpoll	*Carduelis cabaret*			🟥			
Common crossbill	*Loxia curvirostra*						
Snow bunting	*Plectrophenax nivalis*			🟧			

1.5 Risks to address

Key risks that will be addressed during the EIA process are:

- Disturbance caused by increased vessel traffic, esp. during construction and decommissioning;
- Displacement caused by the presence of the turbines, including indirect effects due to changes in prey availability associated with presence of

turbines;

- Collision with turbines whilst in flight; and
- Barrier effects caused by turbines, resulting in changes to flight routes (e.g. to feeding areas or on migration).

1.6 Definition of breeding seasons

As recommended by JNCC / SNH during consultation, the seasonal definitions vary between species, and are defined in Table 5. Definitions for 4 other species considered in this assessment (not included in stakeholder response) are provided in Table 6.

Table 5. JNCC/SNH recommended species-specific seasonal definitions.

Species	**Breeding season**	**Non-breeding season**
Gannet	April – Sept	Oct – March
Guillemot	April – July	Aug - March
Razorbill	April – July	Aug - March
Puffin	April – Aug	Sept - March
Kittiwake	April – Aug	Sept - March
Herring gull	April – Aug	Sept - March
Great black-backed gull	April – Aug	Sept - March

Table 6. Species-specific seasonal definitions for additional species.

Species	**Breeding season**	**Non-breeding season**
Arctic tern	May - Aug	-
Fulmar	April – Sept	Oct - March
Little auk	-	Oct - April
Great skua	April - Aug	-
Arctic skua	April - Aug	-

2 Baseline Methodologies

2.1 Boat-based surveys, 2010-2012

NPC has undertaken boat-based bird and marine mammal surveys since April 2010. 28 surveys were carried out with the final survey taking place in March 2012. The data provided in this Technical Report and the ES are based on the data collected during these surveys.

The survey methodology utilised followed the technique for ship-based seabird surveys outlined by Camphuysen *et al*. (2004), and the recommendations to improve this methodology outlined by MacLean *et al*. (2009). The characteristic of this approach was the use of a line-transect survey method within a survey area that incorporated the proposed three sites as well as a buffer, extending to a distance of approximately 4 km from the position of the outer turbines. East-west transect routes were selected as this placed them generally perpendicular to the Caithness coast.

Based on experience gained from numerous surveys of existing offshore wind farm (OWF) projects, instead of the approach set out in Camphuysen *et al.* (2004) whereby snapshots are taken at 5-minute intervals, snapshots were instead undertaken at time intervals of 1 minute. This allowed a larger number of snapshots, and as such had a far greater prospect of accurate determination of the density of flying birds. As many of the target species were generally encountered in flight, accurate determination of the density and flight heights of flying birds was thus seen to be critical to the value of the survey programme.

2.1.1 Vessels

Four vessels were used, depending on their availability, for the boat-based bird and marine mammal surveys (Images 1-3; Table 7). Each of these vessels complies with COWRIE guidance (Camphuysen *et al*., 2004; MacLean *et al*., 2009) in that they have:

- A length of 20-100 m;
- A forward viewing platform at least 5 m above sea level; and
- The capability of travelling in the range of 5-15 knots (generally approximately 10 knots) whilst surveying.

Table 7. Specifications of the vessels used for the bird and marine mammal surveys of Round 3 Zone 1.

Vessel	Length	Observer eye height	Survey speed	Image
Kintore	32.50 m	6.0 m	10 knots	1
Keverne	32.50 m	6.0 m	10 knots	1
Gemini Explorer	22.00 m	6.0 m	8.5 knots	2
Smit Yare	28.95 m	5.8 m	11 knots	3

Image 1. Kintore and Keverne vessels.

Image 2. Gemini Explorer vessel.

Image 3. Smit Spey vessel. The Smit Yare vessel used is identical to the Smit Spey.

2.1.2 Methods

The boat-based survey followed a line-transect methodology with a strip width of 300 m. The method was designed to enable distance sampling of bird data and calculation of densities. Observers were assigned an identification code, to allow additional analysis of results (MacLean *et al.*, 2009).

One surveyor recorded birds within a 90° forward arc and a second surveyor acted as a scribe/recorder. A third person was present on the observation platform to aid the other two surveyors where necessary. The three people alternated roles to prevent fatigue. In addition a fourth surveyor acted as a dedicated marine mammal observer, and also noted down weather information, speed and recorded GIS route. A fifth surveyor was also present when the vessel was surveying during migratory periods (mid-September to mid-November 2010 and mid-March to mid-May 2011) to act as a dedicated migration observer.

2.1.3 Seabird recording

The following parameters were key components of the method:

- Bird detection was undertaken by naked eye.
- Divers and seaduck, which are known to flush from the sea surface at distance from the survey vessel, were not expected to be present in significant numbers so an observer scanning forward was not used.

- Observations were made along the line transect with a strip width of 300 m.
- Subdivision of survey bands at the following intervals: 0-50 m (A), 50-100 m (B), 100-200 m (C), 200-300 m (D), 300+ m (E) perpendicular to ship.
- Records were taken in one-minute sessions.
- Every one minute, ‘snapshots’ were undertaken in the zone that is a square block of air extending 300 m to the front and 300 m perpendicular from the boat. The number, height and behaviour of those birds in flight within the snapshot zone were recorded.
- Flight heights were recorded in the following bands: <5 m, 5-10 m, 10-20 m, 20-200 m, 200-300 m, and >300 m.
- No bird observations in sea state five or more (moderate waves, chance of some spray) were used.
- Each survey track was traversed at a constant speed (approximately 8.5-11.0 knots).
- The position of the vessel was fixed regularly using GPS.

All those undertaking observations were trained to ESAS (European Seabirds at Sea) standards. The surveyors were highly experienced with the survey and recording methods and bird identification, including familiarity with all relevant scarce and common marine species, some knowledge of rarities and a full understanding of plumages and moults.

For each observation made during each of the boat-based surveys, the following information was recorded:

- Species (using BTO two letter codes);
- Number (count);
- Distance from vessel (see above);
- Height of flight (see above);
- Direction (where applicable); and
- Additional information regarding, age, sex, plumage and behaviour wherever possible.

All bird data and a number of environmental variables affecting visibility and thus survey efficiency (e.g. rain, cloud cover, glare, wind speed and sea state) were recorded. Boat speed was recorded at each snapshot location. Sea state was recorded at the start of transects and when there were changes in sea state (MacLean *et al*., 2009).

2.1.4 Survey details

Twenty eight boat-based bird and marine mammal surveys were carried out between April 2010 and March 2012 (Table 8).

Table 8. Dates of bird and marine mammal surveys undertaken for the three proposed wind farm s

Survey	Dates	Observers	Vessel
1	27 - 29/04/2010	SD, SC, GG, AS	Keverne, Kintore
2	24 - 26/05/2010	SC, GG, DB, KS	Kintore
3	15 - 17/06/2010	SC, GG, TS, MM	Keverne
4	26 - 28/07/2010	SC, GG, GC, RS	Gemini explorer
5	07 - 09/08/2010	SC, DB, SR, RS	Keverne
6	18 -19, 31/08/2010	SC, GC, GR, RS	Keverne
7	22,29-30/09/2010, 13/10/2010	SC, GG, AS, GC, HC, AC, SK, DD, CW, RS	Keverne, Kintore
8	13, 16, 31/10/2010	SC, GG, GC, HC, DD, JT, CW, GR	Keverne, Kintore, Smit Yare
9	15, 22/11/2010, 04/12/2010	HC, GG, GC, SC. CW, GR	Keverne
10	14, 21 - 22/12/2010	HC, GG, GR, RS, SR, GR	Keverne
11	13, 19, 22/01/2011	HC, GC, RS, SR	Keverne
12	10/02/2011, 03 - 04/03/2011	GC, DD, DB, SR	Kintore
13	05, 22, 25/03/2011	SC, GG, GC, RFG	Gemini explorer
14	14 - 16/04/2011	GC, RS, AMN, DD	Kintore
15	24 - 26/04/2011	GG, GC, IS, RS, AMN	Keverne
16	03 - 04/05/2011	GG, GC, IS, RS, AMN	Gemini explorer
17	04 - 06/06/2011	MH ,RS, CW, IS	Keverne
18	19 - 21/06/2011	SC, RS, DD, AMN	Keverne
19	09 - 11/07/2011	GG, MH, RS, IS	Gemini explorer
20	6, 14/08/2011	GG, GC, RS, RFG	Smit Yare, Gemini Explorer
21	18 – 19, 26/08/2011	GG, GC, RS, JN, IS	Gemini Explorer
22	15/09/2011, 01-02/10/2011	IS, DD, HC, GC, GG, RS, RFG	Kintore, Gemini Explorer
23	12/10/2011, 05-06/11/2011	RS, IS, DD, CW, GG, ML, HC	Gemini Explorer
24	06-07. 20/11/2011, 14/01/2012	GC, IS, AMN, SM, GG, ML, HC,	Gemini Explorer
25	14-16/01/2012	AS, SC, HC, DD, GG, ML, SM, IS	Gemini Explorer, Smit Yare
26	16, 28/01/2012, 02-03/02/2012	IS, GG, ML, SM, DD, MH	Gemini Explorer
27	09, 11-12/02/2012	DD, AMN, GG, AA	Gemini Explorer
28	13 – 15/03/12	GG, MH, HC, AMN, IS	Gemini Explorer

Observers listed in the above table: AA=Alan Addison, DB=Dan Brown, SC=Sarah Canning, AC=Andy Carroll, HC=Helen Chance, GC=Graeme Cook, SD=Sarah Dalrypmle, DD=David Devenport, RFG=Ruth Fernadez-Garcia, GG=Graeme Garner, MH=Matt Harding. SK=Stephen Kane, ML=Mark Lewis, MM=Micky Maher, SM=Stuart Murray, AMN=Angus McNab, GR=Garry Riddoch, RS=Rab Shand, KS=Kathy Shaw, AS= Alein Shreeve, IS=Ian Sim, TS=Tim Sykes, JT=John Thompson, CW=Chris Waltho,

2.1.5 Collision risk analysis

Data collected on birds in flight were used to estimate the number of individuals per species predicted to collide with the turbine rotors. This was undertaken using the collision risk model of Band (2011). Bird flights considered to represent a potential collision risk are those recorded within the flight height band corresponding to the height at which the blades will pass during turbine operation (band 4; 20-200 m, referred to as potential collision height (PCH). Birds not recorded within the transect area were excluded from the analysis.

A density of flights observed at PCH was calculated, and this was extrapolated up in order to estimate the number of individuals that would be likely to pass through the risk area per year (as per Band 2011). For each species, the risk of collision for an individual bird is calculated based on the characteristics of the birds (see Table 9) and the worst-case scenario number and specification of the turbines in the Rochdale Envelope for each of the three wind farm sites (Tables 10 and 11). Since most birds will exhibit avoidance behaviour when faced with wind turbines, estimated annual collisions are calculated based on avoidance rates of 98%, 98.5%, 99% and 99.5%. Species for which collision risk modelling was carried out were kittiwake, gannet, great black-backed gull and herring gull due to these species having > 20 flights at PCH during the 28 boat-based surveys.

Table 9. Bird characteristics used for collision risk analysis.

Species	Bird length, m	Wingspan, m	Flight speed, ms^{-1}	Collision probability
Gannet	0.935[1]	1.73[1]	14.9[2]	8.5%
Kittiwake	0.39[1]	1.075[1]	13.1[3]	7.5%
Herring gull	0.595[1]	1.44[1]	12.8[3]	8.4%
Great black-backed gull	0.71[1]	1.575[1]	13.7[3]	8.4%

[1]Snow & Perrins, 1998; [2]Pennycuick, 1997; [3]Alerstam *et al.*, 2007

Table 10. Turbine specifications used in collision risk modelling for the three wind farm sites combined.

Site	**1**	**2**	**3**
Number of turbines	139	72	72
Blade diameter (m)	130	172	172
Blade width (m)	4.2	5.8	5.8
Operation rate	80%	80%	80%
Top speed (rpm)	13.36	12.8	12.8
Lowest speed (rpm)	6.3	4.2	4.2
First speed quartile	7.5	5.7	5.7
Second speed quartile	8.9	7.4	7.4
Third speed quartile	10.7	9.6	9.6

Table 10. Turbine specifications used in collision risk modelling for the three wind farm sites combined.

Site	**1**	**2**	**3**
Forth speed quartile	12.5	11.7	11.7
% time in first speed quartile	8%	8%	8%
% time in second speed quartile	6%	6%	6%
% time in third speed quartile	9%	9%	9%
% time in forth speed quartile	77%	77%	77%

Site numbers refer to the order of construction of the three wind farm sites.

Avoidance rates

Definition of avoidance

A key component of collision risk modelling is the inclusion of a parameter to describe avoidance behaviour. Different species are expected to avoid wind farms to differing degrees (Pendlebury 1996, Cook *et al.*, 2011), and this avoidance behaviour can be described as either:

- Avoidance of the wind farm completely (macro-avoidance); or
- Avoidance of an individual turbine (micro-avoidance).

Total avoidance behaviour is therefore made up of a combination of these two avoidance rates:

- Total Avoidance = 1 – [(1 – macro-avoidance) x (1 – micro-avoidance)]; e.g.
- 99.5 % = 1 – [(1-90 %) x (1-95 %)

An avoidance rate of 98% was recommended by JNCC/SNH as a precautionary starting point for seabirds and whooper swan; a rate of 99% was recommended for geese. Reviews of avoidance rates for seabirds have been undertaken by the British Trust for Ornithology (BTO) (Cook *et al.*, 2011 and Maclean *et al.*, 2009). MacLean *et al.*, 2009 recommended the use of the total avoidance rates presented in Table 11. Collating data from studies at other developments has allowed for species-specific or group-specific avoidance rates to be estimated.

Table 11. Total avoidance rates recommended by the British Trust for Ornithology (MacLean *et al.*, 2009).

Species	**Total avoidance rate**
Terns, divers, cormorants, ducks, geese, grebes and puffin	99.0%
Auks, gulls and gannet	99.5%
Fulmar and shearwater	99.9%

Lynn and Inner Dowsing Offshore Wind Farms

A radar study of pink-footed geese has been undertaken off the Lincolnshire coast for the Lynn and Inner Dowsing Offshore Wind Farms, between 2007 and 2010

(Plonczkier pers. comm.). During the study 979 skeins were detected, of which 43,249 in 630 skeins were identified as pink-footed geese. No geese were recorded colliding with turbines. The proportion of geese flying through the turbine arrays has changed through the study, with 48% recorded in 2007 (pre/during construction), 26% in 2008, 38% in 2009, and 19% in 2010 (latter 3 years were post-construction). This implies that there has been macro-avoidance of the turbine arrays by geese (note that the estimates do not include micro-avoidance so are a conservative estimate of overall avoidance).

Nysted Offshore Wind Farm, Denmark

A radar study in Denmark was used to record flight-lines of migrating geese/ducks through Nysted Offshore Wind Farm. No collisions were detected despite the site being within a major migration route (Kahlert *et al*., 2004), and over 99% of birds were found to make detours around the site (Desholm & Kahlert, 2005).

Offshore Wind Farms in Swedish waters

Studies carried out using radar in Swedish waters between 1999 and 2003 tracked over 1.5 million wildfowl flight tracks, noting only one collision. All other birds avoided the turbines, even in conditions of low light or poor visibility (Pettersen 2005).

Egmond aan Zee and Princess Amalia Offshore Wind Farms, Netherlands

Boat-based surveys have been undertaken at Egmond aan Zee and Princess Amalia Offshore Wind Farms (Leopold *et al*., 2011). Significant avoidance was recorded for gannet, little gulls, guillemot and razorbill. Post-construction, the majority of gannets flew around the Egmond aan Zee without entering, and none were seen to enter Princess Amalia.

Egmond aan Zee Offshore Wind Farm, Netherlands

An addition post-construction study at the Egmond aan Zee Offshore Wind Farm was undertaken in 2007-2009 using visual observations and radar to estimate macro and micro-avoidance rates (Krijgsveld *et al*., 2011). Comparing the observed proportion of flights within the wind farm with the expected proportion, reductions of birds recorded within the wind farm for gannet, small gulls and large gulls were 88%, 56% and 24%, respectively. A measure of macro-avoidance can be obtained by using the deflection rates (where a bird flying towards the wind farm changes direction away from it): 89% for gannet, and 40% for gulls. A combination of visual and radar studies were also used to estimate a generic micro-avoidance rate of 97.6%. Combining the macro and micro-avoidance rates this gives total avoidance rate estimates for gannet and gulls of 99.7% and 98.6%, respectively.

Bligh Bank and Thorntonbank Offshore Wind Farms, Belgium

Boat-based surveys have been undertaken at Bligh Bank and Thorntonbank Offshore Wind Farms (Vanermen *et al*., 2011). Significant avoidance was recorded for fulmar, great skus and guillemot. In addition, a reduction in numbers was recorded for gannet within the wind farm areas compared to a control area, suggesting avoidance behaviour.

Belgium wind farm studies

A calculation of gull micro-avoidance rates for six onshore wind farm sites in Belgium (Everaert & Kuijken 2007), following the process used by Pendlebury (2006) and using additional information given by Dewar (2011), gives mean rates of 97.7% and 98.5%, for large and small gulls respectively (Table 12).

For each study, macro-avoidance was calculated as follows:

1- [1 / [(flux) x (ratio of rotor-swept area) x (collision rate)]]

Where Flux is the number of birds recorded flying through the survey 'window'.

Ratio of ratio-swept area is the proportion of the survey 'window' that is made up by the turbine rotor-swept area.

Collision rate is the likelihood of a bird flying through the rotor-swept area actually colliding with the turbine blades.

For five sites (Niuewkapelle, Gent, Boudewijnkanaal, Kleine Pathoekewig and Zeebrugge) the study area was the height of the rotor swept area (lower tip to upper tip) for the study turbines. For Oostervierum, the study area was the ground to the upper tip of the rotor-swept area for the study turbines.

The mean avoidance rates presented in Table 12 are weighted with flux, i.e. a greater weighting is given to sites with a greater number of gulls present, as per the method used by Pendlebury (2006).

Table 12. Calculation of micro-avoidance rates for gulls for Belgium sites.

Site	Species	Flux per mortality	Turbines in study area	Risk window, m	Ratio of rotor-swept area	Collision rate	Micro avoidance rate
Small gulls							
Nieuwkapelle	small gulls	2950	2	48 x 400	0.19	0.097	98.15%
Gent	small gulls	2250	6	82 x 1500	0.26	0.07	97.54%
Boudewijnkanaal	small gulls	3682	7	48 x 1400	0.19	0.085	98.30%
Kleine Pathoekewig	small gulls	3015	5	66 x 1400	0.19	0.076	97.64%
Oostervierum	Black-headed gull	4800	18	59 x 1100	0.30	0.125	99.45%
Small gulls weighted mean							98.38%
Large gulls							
Zeebrugge	large gulls	2100	6	34 x 720	0.22	0.139	98.46%
Boudewijnkanaal	large gulls	750	7	48 x 1400	0.19	0.108	93.45%
Boudewijnkanaal	large gulls	839	7	48 x 1400	0.19	0.108	94.15%

Table 12. Calculation of micro-avoidance rates for gulls for Belgium sites.

Site	Species	Flux per mortality	Turbines in study area	Risk window, m	Ratio of rotor-swept area	Collision rate	Micro avoidance rate
Kleine Pathoekewig	large gulls	695	5	66 x 1400	0.19	0.093	91.64%
Oostervierum	Herring gull	4800	18	59 x 1100	0.30	0.166	99.58%
Large gulls weighted mean							97.73%

Blyth Habour wind farm

A calculation of large gull micro-avoidance rate, also following the process used by Pendlebury (2006), was undertaken for the Blyth Harbour wind farm by Dewar (2011). This study was based on a study undertaken 1991 and 2001. The macro-avoidance rate calculated for large gulls was 99.1%.

Summary

The above avoidance rates are summarised in Table 13. The total avoidance rate estimate of 99.7% for gannet is based on the Egmond aan Zee study. The mean micro-avoidance estimate given for large gulls from the Dutch studies (97.7%) is similar to the generic estimate from Egmond aan Zee (97.6%), meaning the total avoidance rate estimates are the same (98.6%). For small gulls, using the mean micro-avoidance rate from the Dutch studies (98.5%) and the macro-avoidance rate from Egmond aan Zee (40%), gives a total avoidance rate estimate of 99.0%.

Table 13. Summary of avoidance rates for gannet and gulls.

Species	JNCC/SNH current guidance	MacLean *et al.*, 2009 recommendation	Summary of mean avoidance rates		
			Macro	Micro	Combined
Gannet	98%	99.5%	89%	97.6%	99.7%
Large gulls	98%	99.5%	40%	97.7%	98.6%
Small gulls	98%	99.5%	40%	98.5%	99.0%

Based on these data, total appropriate rates to use would therefore be 99.5% for gannet, 98.5% for herring and great black-backed gull, and 99% for kittiwake.

2.1.6 Density analysis

Distance sampling software Version 6.1 (Thomas *et al*., 2010) was used to calculate monthly estimates of density (individuals per km^2) and abundance (overall numbers) of birds using the sea within the three wind farm sites and the buffer area using conventional 'design-based' distance analysis. For some species, density surface modelling was also carried out using the DSM (Rexstad 2011) and MRDS (Laake *et al*., 2011) libraries in R version 2.13.1 (R Core Development Team). This analysis was carried out by NPC staff who had attended the CREEM 'advanced distance' course. The approach used for Density Surface Modelling was previewed by CREEM (Centre for Research into Ecological and Environmental Modelling) to allow their recommendations to be incorporated into the methodology, particularly with respect to the inclusion of covariates.

This analysis was undertaken in order to assess the distribution and density of birds within the sites, in order for this to feed into the displacement analysis. The displacement only used data for birds using the sea, rather than also including birds in flight, since it is the former that are potentially at risk of displacement. The birds in flight are potentially at risk from collision and barrier effects, but these effects are analysed/discussed separately. During the surveys, individuals were classed as 'using the sea' if they were on the sea or feeding (including those feeding from the air, such as gannet and terns).

Distance sampling operates on the principle that randomly distributed targets become more difficult to detect with increasing distance from the observer (Buckland *et al*., 2001). As a result, an increasing proportion of targets that are present will go undetected with distance. In order to account for this decline in detectability, a detection function is fitted to the data. This function allows the estimation of the number of undetected individuals present within the area surveyed, which is then incorporated into the calculations of overall density and population for each species. Since at least 60-80 observations are recommended in order to ensure that a reliable detection function is fitted (Buckland *et al*., 2001), data for any bird species for which fewer than 80 observations were not analysed in this way. No density estimates were made for these species, since they were recorded in low numbers and therefore the likely effect on them was considered to be minor. Numbers of birds eligible for inclusion within distance (those recorded using the sea, in transect and within distance bands A-D; < 300 m) are presented in Table 14.

Table 14. Number of observations eligible for inclusion in distance analysis (observed in transect, on the sea and within 300 m of the survey vessel).

Species	Number	Species	Number
Red-throated diver	3	Great black-backed Gull	256
Fulmar	1693	Large gull species	3
Sooty shearwater	17	Common tern	2
Manx shearwater	12	Arctic tern	86
Storm petrel	5	Guillemot	6340
Gannet	689	Razorbill	2015
Shag	45	Guillemot/razorbill	904
Red-necked phalarope	1	Black guillemot	2
Pomarine skua	1	Little auk	144
Arctic skua	28	Puffin	4284
Great Skua	222	Little auk/puffin	3
Kittiwake	531	Unidentified auk species	53
Lesser black-backed Gull	5	Rock dove / feral pigeon	1
Herring gull	86		

Species highlighted in green are those for which Distance analyses were carried out

Birds recorded in the final distance band (distance band E; >300 m) were excluded from the analysis because the average distance of counts within an unbounded category cannot be calculated. This truncation is routinely utilised for accurate density estimation using the distance sampling technique. In addition all records of birds in flight and all observations of individuals outside the transect area were excluded from the analysis.

In order to allow separate analysis of the site and buffer areas, boat-based survey transects were divided into lengths falling within the site area and those falling within the buffer area (ES Chapter, Figure 4.5-1, Volume 6b). Thus if transects passed through the sites, they were divided into three separate transect segments, a site transect and two segments representing the length of the transect passing through the buffer either side of the site area. The result was 48 transect segments (15 falling within the sites and 33 falling within the buffer area). For each species, a global detection function was fitted based on all data combined across surveys and regions. The function used to model the drop in detectability with distance was selected based on maximising goodness of fit to the data and minimising Akaike's Information Criterion (AIC). Estimates of density and population size were then calculated for the wind farm sites and the buffer for every month during which surveying took place, using the global detection function to allow estimation of undetected individuals. For species for which greater than 60 observations were observed during a single month of surveying, individual detection functions were fitted for those months and these estimates are presented in place of those modelled using a global detection function.

For six bird species, (fulmar; gannet; kittiwake; guillemot; razorbill; puffin), sufficient data were available for density surface modelling to be used to refine estimates of abundance, and to produce density surface maps to show density and distribution of birds within the wind farm sites and buffer. For these species, transects were divided into 600 m segments (i.e. 2 x the transect width) and each bird observation was assigned to the appropriate segment. Information on environmental covariates for use in the analysis was also extracted for the midpoint of the segment using bathymetry data and sediment data. A detection function was selected as before, but with the additional possibility of selecting a model including sea state and/or cluster size (log transformed to reduce the effect of outliers) as covariates to help explain differences in detectability.

General Additive Models (GAMs) were then fitted with a series of possible covariates to try to explain patterns in the data. The response variable was adjusted numbers of observations per segment (based on the raw data and rates of detectability derived from the detection function step). Possible covariates for inclusion in each model were sea depth, distance to the nearest coastline, sediment type and x and y coordinates. Month (April 2010 – March 2012) was included as a covariate since seasonal changes are important for explaining numbers of birds observed. The inclusion of month as a variable also allows estimation of abundance per month. Prior to the analysis, all variables were checked for outliers, homogeneity of variance, even coverage of possible values and collinearity. Sea depth and distance to the coast were removed as possible covariates prior to the analysis due to collinearity with other variables. The most appropriate model was then selected using forwards model selection based on minimising the GCV (generalised cross-validation) score.

The survey area was then divided up into 600 m by 600 m grid cells and the selected model for each species was used to predict the density of birds present within each grid cell for each month. These predictions were then used to predict overall numbers of birds within the three wind farm sites and the buffer area for each month during which surveys were carried out.

For each species, density surface plots were constructed based on densities per 600 m by 600 m grid square for the month during which the highest numbers of birds were predicted to have been present within the survey area.

Density Surface Modelling was employed as it allows the inclusion of covariates, which refines the modelling process to allow more precise estimation of bird abundance. In addition, since it is used to generate predictions across a grid covering the site, it allows clear visualisation of predicted density and distribution of birds across the site and facilitates predictions for sub areas within the site. Spatial autocorrelation was not accounted for in this analysis because it was advised by CREEM that this should be carried out using General Estimating Equations, which cannot be implemented within a General Additive Modelling framework using any functions currently available in R. Since not accounting for autocorrelation can result in biased estimates, we present results both from the density surface models and from the conventional 'design-based' alongside one another.

Table 15 shows the detection function and model fitted for each species.

Table 15. The detection function and model fitted for each species.

DSM	**Detection function**		**General Additive Model**
Species	**Key function**	**Covariates included**	**Covariates included in final model**
Guillemot	Hazard rate	log(cluster size); sea state	X coordinate; Y coordinate; sediment; month
Razorbill	Hazard rate	sea state	X coordinate; Y coordinate; sediment; month
Puffin	Hazard rate	log(cluster size); sea state	X coordinate; Y coordinate; month
Gannet	None*	None	X coordinate; Y coordinate; sediment; month
Fulmar	Hazard rate	log(cluster size); sea state	X coordinate; Y coordinate; sediment; month
Kittiwake	Hazard rate	log(cluster size)	X coordinate; Y coordinate; sediment; month

*No detection function fitted as no decline in detectability with distance

2.1.7 Flight Direction Analysis

NPC boat-based data were analysed to provide details of flights to and from the adjacent SPAs. The sites were broken down into different zones (i.e. collections of transects) which were analysed separately. The division was transects 1 – 6 (north), transects 7 – 12 (central) and transects 13 – 18 (south) (ES Baseline Chapter 4.5, Figure 4.5-1, Volume 6b). Birds were separated into datasets defined by their core breeding season (as defined by JNCC; Kober *et al.*, 2010) (Table 16). The total number of flights in each of the eight compass directions was then plotted for each species in each zone, for the breeding season. The aim of this was to ascertain if there were differences in flight directions across the different zones, or simple modality in the data across all three of the zones, inferring links to SPAs. Data collected on flight directions for birds in flight were also analysed separately for birds carrying fish, as these can be assumed to be heading towards their colony for either chick feeding or courtship.

Table 16. Breeding species and survey datasets used for each species.

	Core breeding season	surveys used
Fulmar	March - July	1 - 4, 13 - 19
Gannet	May - September	2 - 7, 16 - 19
Kittiwake	May - September	2 - 7, 16 - 19
Guillemot	May - June	2 - 3, 16 - 17
Razorbill	May - June	2 - 3, 16 - 17
Puffin	April - July	1 - 3, 14 - 19

The proportions of birds travelling in each direction were calculated from the totals of the five key species from the whole breeding season. The directions of flights used to allocate birds to the three SPAs are defined in Table 17.

Table 17. Results of flight direction analysis.

	N	NE	E	SE	S	SW	W	NW
Flights with food (guillemot, razorbill)								
East Caithness Cliffs SPA						✓	✓	✓
North Caithness Cliffs SPA	✓	✓						
Troup, Pennan and Lion's Heads SPA				✓	✓			
All flights								
East Caithness Cliffs SPA		✓	✓	✓		✓	✓	✓
North Caithness Cliffs SPA	✓ zone 1,2				✓ zone 1,2			
Troup, Pennan and Lion's Heads SPA	✓ zone 3				✓ zone 3			

2.1.8 Displacement analysis methods

Displacement analysis has been undertaken using the following process:

- The mean breeding season population estimate of birds using the sea for the three proposed wind farm sites combined has been used. The breeding season estimate has been used since it is this period that birds are most spatially constrained. The breeding season for each species is that as defined by JNCC/SNH (Table 5).
- The proportions of the site populations that are predicted to be from the three SPAs (East Caithness Cliffs SPA, North Caithness Cliffs SPA, and Troup, Pennan and Lion's Heads SPA) are taken from the precautionary estimates resulting from the flight direction analysis (Table 43).
- The proportion of the site populations that are assumed to be breeding (50%) is taken from advice provided by JNCC/SNH.

- The proportion of birds displaced from the wind farm sites are taken from the higher values recommended by JNCC/SNH (Table 18) for the 'worst-case scenario' (WCS) analysis. For the 'realistic scenario' (RS) analysis (Table 45), these are taken from the lower value recommended by JNCC/SNH based on data from the only current offshore wind farm in Scotland, Robin Rigg (Shenton & Walls, pers. comm., 2011[1]) and wind farms elsewhere in Europe (Table 13). More details of the latter studies are provided below.
- The proportion of these breeding birds that are predicted to fail in the current breeding attempt is taken as 100% for the WCS analysis, and also for most species for the RS analysis. For the RS analysis for fulmar and gannet this parameter is taken as 50% due to the much greater foraging ranges of these species, which is predicted to provide them with greater spatial flexibility.

The displacement analysis that has been undertaken used data from the boat-based survey on the numbers of birds recorded using the sea. The rationale for this (i.e. the exclusion of birds recorded in flight) is as follows:

- The boat-based survey is a snapshot survey providing data as if it were collected at a single point of time.
- Our approach takes the view that birds recorded as using the sea (including aerial foragers) are at risk from displacement, and birds recorded as in-flight (also including aerial foragers) are at risk from collision.
- This approach takes the view that the definition of displacement is the reduction of birds using the sea, for activities such as foraging, resting, etc.
- For collision risk this is accepted approach as numbers of birds recorded on the sea are not included in the collision risk modelling.
- A similar approach to the collision risk modelling has therefore been adopted for the displacement analysis, i.e. by using the number of birds recorded at risk from displacement at the time of the survey.
- This can be put into perspective by considering which birds would be included in a displacement analysis for a wave & tidal development; using this approach would mean that only the birds recorded using the sea would be included, whereas the alternative approach would require that birds in flight would also need to be included.

These displacement estimates were used in the population viability analysis (PVA) for the three Moray Firth SPAs (East Caithness Cliffs SPA, North Caithness Cliffs SPA, and Troup, Pennan and Lion's Heads SPA). The effects on these three SPAs were estimated based on the precautionary flight direction analysis presented in Table 43. Due to the precautionary approach of the flight direction analysis (the proportion flying to the three SPAs combined is >100%), summing the estimates of numbers

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[1] Presentation by Sally Shenton (E.on Climate & Renewables) and Richard Walls (Natural Power Consultants) at a SNH Marine Sharing Good Practice event, 3 November 2011.

displaced from the three SPAs will be greater than the total displacement estimate for the three SPAs combined.

Table 18. Displacement estimates.

Species	**Worst-case scenario**	**Realistic Scenario**
Fulmar	100%	50%
Gannet	100%	50%
Kittiwake	50%	10%
Great black-backed gull	50%	10%
Guillemot	100%	50%
Razorbill	100%	50%
Puffin	100%	50%

Displacement rates

The displacement rates used in the RS displacement analysis are informed by a recent analysis of data from the Robin Rigg Offshore Wind Farm in the Solway Firth. This analysis compared five pre-construction years with the construction year and one post-construction year. The resulting estimates of displacement rates (50% for gannet, 0-10% for gulls, and 30% for auks; Shenton & Walls, 2011) are within the ranges proposed by the statutory nature conservation agencies (SNCAs [Table 18]), except for the auk species. For gulls, an estimate of 10% has been used as the 'RS' rate. These rates are considered to be precautionary estimates of displacement due to this being based on the first year after construction only, so therefore does not include any habituation over time.

In terms of the relevance of the Solway Firth to the Moray Firth, there is a similar suite of seabird species present in both areas. For gannet and gulls the seasonal variation in numbers is similar for the two areas, with a peak in gannet numbers in the Robin Rigg study area between April and September, and gulls being present throughout the year. For auks, the peak in numbers recorded in the Robin Rigg study area is later in the year than in the Moray Firth, in October/November. There is therefore a greater proportion of auks in the non-breeding season than the breeding season in the Robin Rigg study area compared to the Moray Firth. This is expected to mean that the use of the Robin Rigg displacement rates for MORL will be a conservative estimate since non-breeding birds are more likely to be open to displacement due to not being 'central-based foragers' at this time of the year.

Further backup of these rates came from sites elsewhere in Europe:

- A 50% reduction in gannet numbers has been recorded post-construction at Thorntonbank Offshore Wind Farm (Belgium), compared to pre-construction and a control area (Vanermen & Stienen, 2009);

- No impact on the distribution of gulls (common gull, lesser black-backed gull, great black-backed gull, herring gull, kittiwake) arising from the construction of the Egmond aan Zee Offshore Wind Farm (Leopold *et al*, 2011);
- No changes in guillemot or razorbill numbers were recorded post-construction at Thorntonbank Offshore Wind Farm compared to the control area (Vanermen & Stienen, 2009); and
- Total displacement was not shown by guillemot or razorbill at the Egmond aan Zee Offshore Wind Farm, but further analysis is required to determine a rate (Leopold *et al*, 2011; Lindeboom *et al*., 2011).

2.1.9 Population viability analysis methods

The aim of the population viability analysis was to predict whether there would be an increase in the likelihood of a population reduction of seabird populations at the three local SPAs (East Caithness Cliffs SPA, North Caithness Cliffs SPA, and Troup, Pennan and Lion's Heads SPA) due to the predicted impacts arising from displacement and collisions. PVA was therefore undertaken for gannet, fulmar, kittiwake, herring gull, great black-backed gull, guillemot, razorbill and puffin.

Population viability analysis was carried out using R version 2.13.1 (R core Development Team, 2011). The functions used were modified versions of the vitalsim function in the popbio library (Stubben *et al*., 2007), adapted to allow the incorporation of multiple quasi-extinction thresholds and collision and displacement effects.

For each species a simple stochastic population model was built, incorporating an age class for each year of pre-breeding and an adult (breeding) age class. Models were based on estimates of the entire breeding population (counts of breeding pairs/apparently occupied nests were multiplied by two).

The starting point of each model was an initial population vector consisting of the number of individuals expected to be within each age-class, and a population projection matrix defining the expected contribution of individuals within each age class in a given year to each age class in the subsequent year. These values are calculated as products of birth rates, death rates and growth rates (the so-called vital rates).

In our models, all individuals in a given age-class progress to the next class in each subsequent year with the exception of adults, for which no individuals changed age-class. Growth rates were therefore 1 or 0. All other rates were based on those provided in the published literature available for each species (see table 16). Selection of published rates for use in the models was based on the date of the study, the duration of the study, the proximity of the study site to the Moray Firth, and the inclusion of a measurement of error around the estimated rate. Where multiple rates were provided in the same study, these rates were used in preference to including several rates each from separate studies. Where possible, survival rates included were age-class specific; however, in many cases it was not possible to obtain information on the survival rate of each individual age-class so the rate for the closest/most comparable age-class with data was used. Number of fledglings per breeding pair was used in place of birth rate.

Since population structure is unknown for most seabirds due to time spent away from the colony prior to breeding age, initial population vectors were calculated based on the number of breeding pairs and the stable population structure as derived from the population projection matrix (the ratio of individuals expected to be within each age class in a stable population is provided by the right eigenvector associated with the largest eigenvalue of the population projection matrix; [Morris and Doak, 2002]).

Environmental stochasticity was modelled at the level of the vital rates. For each year simulated by the model, a value for each vital rate was selected at random from a distribution with a mean value equal to the mean of that vital rate and a standard deviation equal to the standard deviation of that rate. (The latter is calculated as the square root of the variance within the vitalsim function.) A beta distribution was used to model survival rates as this is appropriate for modelling the probability of binary events (Morris and Doak, 2002). A stretched beta distribution was used to model birth rate because it allows an upper limit of greater than 1 to be set for the number of fledglings produced per pair per year. The upper limit was selected based on the maximum number of eggs laid per pair per year for each species. Once a value has been selected to represent fledgling production for a given simulated year, this value is then divided by two since each breeding individual will only be associated with half of the productivity of the pair. When values have been selected for each rate, these are used to build a new population projection matrix. New population vectors are then calculated by multiplying the previous year's population vector by the new population projection matrix, beginning with the initial population vector for the first simulated year.

Models were run for 25 years, representing the likely lifespan of the wind farm developments. Each 25 year simulation was run 1000 times.

Models were run for each SPA separately based on population estimates and predicted impacts for that SPA. For each species, a baseline model was run for SPA populations designated for that species (from Table 2) to estimate the likelihood of the population dropping below 50%, 60%, 70%, 75%, 80%, 85%, 90%, 95% or 100% of its current size. The same models were then run again including collision, displacement and both. Displacement was included in the model by reducing the proportion of adult birds breeding each year by a predicted number of birds displaced expressed as a proportion of breeding adults present at that SPA. Collision risk was incorporated by dividing the predicted number of collisions per year by age-class using data on age-structure of birds in flight based on boat-based surveys and then reducing survival rates within each age-class by the calculated proportion of individuals predicted to collide with wind turbines. For each species and SPA, simulations were run using twenty different values for displacement and collision representing the range of values predicted in the different scenarios. This simulated dataset (consisting of 1000 'trials' at each of 20 values of x) was used to model change in probability of dropping below each population size threshold with increasing collision or displacement using a binomial generalised linear model with a logit link. The equation generated was then used to calculate the probability of dropping below each population size threshold for the predicted values of displacement and collision for each scenario.

Density dependence was not incorporated into these models. Demographic stochasticity was also not included; however, this does not have a big effect at large population sizes (>20 breeding individuals; [Morris and Doak, 2002]). Since no models estimated the likelihood of a population becoming as small as this, it is considered that this is not an issue. The model assumes a closed system meaning that immigration, emigration and movement among sites were not incorporated. This is due to the paucity of data available regarding these processes.

Ideally, models would be validated by running the model from a previous time point and assessing the relationship between the predicted change in population and the observed change in the population. However, detailed data on population change are not available for the species and sites included in this analysis. Baseline model predictions were therefore qualitatively checked against current and recent changes for Scotland and for the UK as a whole (see appendix A). If predicted population trends for a species did not reflect observed population changes and alternatively equally justifiable rates were available for that species in the literature, these were trialled to see if the new population prediction more closely resembled population changes. This was successful for all species except great black-backed gull and herring gull, for which no rates were found that allowed the PVA to model current population trends.

Sensitivity analysis was carried out in order to identify the impact of changing any of the vital rates used on the model predictions. A deterministic sensitivity analysis was carried out on the mean population matrix for each species, investigating the effect of changing each rate in steps of 0.1 on the deterministic growth rate (see appendix A). This approach provides a very good approximation of sensitivity for stochastic models in long-lived species (Caswell, 2001; Morris and Doak, 2002). In all cases, adult survival rate had the greatest affect on the growth rate, suggesting that use of survival rates that were not age-class specific for juveniles is unlikely to have a large effect on conclusions drawn.

PVA can provide a valuable tool for assessing potential impacts of human activities on natural populations; however, as with any model, these are based on several assumptions and are limited in their ability to perfectly represent reality. The value of these models lies in comparison among different scenarios. We present baseline population models representing the prediction of the model over a 25 year period, and then compare this with models incorporating estimates of possible displacement, collision and both processes combined.

The demographic data used in the PVAs is summarised in Table 19. Reasons for selection of each rate and where applicable, method of calculation of the mean and variance for each rate are also provided.

Table 19. Demographic parameters used for population viability analysis.

Species	Demographic parameter	Data used: Mean (Variance)	Reference	Method of rate calculation	Method of variance calculation
Fulmar	Adult survival	0.972 (0.0045)	Dunnet and Ollason, 1978	Female survival – as provided	Largest variance provided for annual survival
	Juvenile survival	0.972 (0.0045)	No data	Female survival as provided above	As above
	Breeding age	9 years	Maclean *et al.*, 2007	Rounded to nearest whole year.	None required
	Number of eggs per clutch	1	Snow and Perrins, 1998	As provided	None required
	Fledglings per nest	0.190 (0.0158)	Mavor *et al.*, 2008	Value provided for UK in 2006 (divided by two)	Variance calculated using standard error and N provided (divided by two)
Gannet	Adult survival	0.922 (0.0001)	Wanless *et al.*, 2006	As provided	Process variance provided
	First year survival	0.420 (0.0062)	Wanless *et al.*, 2006	As provided	Process variance provided
	Second year survival	0.852 (0.0010)	Wanless *et al.*, 2006	As provided	Process variance provided
	Third year survival	0.908 (0)	Wanless *et al.*, 2006	As provided	No process variance provided
	Fourth year survival	0.910 (0)	Wanless *et al.*, 2006	As provided	No process variance provided
	Breeding age	5 years	Nelson, 2002	As provided	None required
	Number of eggs per clutch	1	Nelson, 2002	As provided	None required
	Number of fledglings per nest	0.345 (0.001)	Mavor *et al.*, 2008	Value provided for 1986 – 2005 (divided by two)	Variance calculated using standard error and N provided (divided by two)

Table 19. Demographic parameters used for population viability analysis.

Species	Demographic parameter	Data used: Mean (Variance)	Reference	Method of rate calculation	Method of variance calculation
Kittiwake	Adult survival	0.876 (0.1090)	Coulson and White, 1959	As provided	Variance calculated across the four years of the study
	Juvenile survival	0.790 (0)	Coulson and White, 1959	As provided	No measure of variance provided
	Breeding age	5 years	Robinson, 2005	As provided	None required
	Number of eggs per clutch	2	Snow and Perrins, 1998	As provided	None required
	Number of fledglings per nest	0.400 (0.0096)	Mavor *et al.*, 2008	Value provided for North East Scotland 2006 (divided by two)	Variance calculated using standard error and N provided (divided by two)
Herring gull	Adult survival	0.898 (0.0003)	Wanless *et al.*, 2006	Estimate of female survival as provided	Variance calculated from model based standard error
	Juvenile survival	0.45 (0.0049)	Wanless *et al.*, 2006	Estimated survival to age 4 on Isle of May	Variance calculated from model based standard error
	Breeding age	4	Robinson, 2005	As provided	None required
	Number of eggs per clutch	3	Snow and Perrins, 1998	As provided	None required
	Number of fledglings per nest	0.42 (0.0784)	Mavor *et al.*, 2008	Value for Noss, Shetland between 1986 – 2005 (divided by two)	Variance calculated using standard error and N provided (divided by two)
Great black-backed gull	Adult survival	0.930 (0)	Garthe and Huppop, 2004	As provided	No measure of variance provided
	Juvenile survival	0.930 (0)	No data	Adult survival as provided above	As above
	Breeding age	4 years	Robinson 2005	As provided	None required
	Number of eggs per clutch	2	Snow and Perrins, 1998	Lowest of range provided (2-3)	None required

Table 19. Demographic parameters used for population viability analysis.

Species	Demographic parameter	Data used: Mean (Variance)	Reference	Method of rate calculation	Method of variance calculation
	Number of fledglings per nest	0.405 (0.0882)	Mavor *et al*., 2008	Value provided for North Hill, Orkney between 1986 ands 2005 (divided by two)	Variance calculated using standard error and N provided (divided by two)
Guillemot	Adult survival	0.965 (0.0001)	Harris *et al*., 2007c	As provided	Variance calculated from model based 95% confidence intervals
	First year survival	0.560 (0.0002)	Harris *et al*., 2007c	As provided	Variance calculated from model based 95% confidence intervals
	Second year survival	0.792 (0.0009)	Harris *et al*., 2007c	As provided	Variance calculated from model based 95% confidence intervals
	Third year survival	0.917 (0.0003)	Harris *et al*., 2007c	As provided	Variance calculated from model based 95% confidence intervals
	Fourth year survival	0.938 (0.0003)	Harris *et al*., 2007c	As provided	Variance calculated from model based 95% confidence intervals
	Breeding age	5 years	Birkhead & Hudson 1977	As provided	None required
	Number of eggs per clutch	1	Snow and Perrins, 1998	As provided	None required
	Number of fledglings per nest	0.335 (0.0128)	Mavor *et al*., 2008	Value provided for Mull Head, Orkney (divided by two)	Variance calculated using standard error and N provided (divided by two)
Razorbill	Adult survival	0.807 (0.0008)	Lloyd and Perrins, 1977	As provided	Variance calculated from standard deviation
	Juvenile survival	0.807 (0.0008)	No data	Adult survival as provided above	As above
	Breeding age	4 years	Robinson 2005	As provided	None required
	Number of eggs per clutch	1	Snow and Perrins, 1998	As provided	None required

Table 19. Demographic parameters used for population viability analysis.

Species	Demographic parameter	Data used: Mean (Variance)	Reference	Method of rate calculation	Method of variance calculation
	Number of fledglings per nest	0.380 (0.0072)	Mavor *et al.*, 2006	Colony average between 1986 – 2005 (divided by two)	Variance calculated using standard error and N provided (divided by two)
Puffin	Adult survival	0.924 (0.0001)	Harris *et al.*, 1997	As provided	Variance calculated from model based standard error
	Juvenile survival	0.924 (0.0001)	No data	Adult survival as provided above	Adult variance as provided above
	Breeding age	5 years	Robinson 2005	As provided	None required
	Number of eggs per clutch	1	Snow and Perrins, 1998	As provided	None required
	Number of fledglings per nest	0.345 (0.0123)	Mavor *et al.*, 2008	Total value provided for 2006 (divided by two)	Variance calculated using standard error and N provided (divided by two)

2.2 Migration surveys

Migration surveys, designed by NPC, were undertaken in autumn 2010, and spring 2011. These consisted of the use of dedicated migration observers carrying out observations during the boat-based surveys and from coastal vantage points. This work was carried out and coordinated by NPC, with RPS Group Ltd. on behalf of MORL and Beatrice Offshore Wind Farm Ltd. (BOWL). Advice from JNCC and SNH was that repeat surveys in autumn 2011 and spring 2012 would not be required.

2.2.1 Boat-based migration surveys

A dedicated migration observer was present on both the MORL and BOWL survey vessels whilst undertaking the boat-based ESAS surveys during the autumn and spring migration periods. In 2010, these surveys were carried out for MORL on 22nd and 29th September, and 13th, 16th and 31st October, and for BOWL on 12th and 13th October. In 2011 these surveys were undertaken on 22nd and 25th March, 14th, 15th 16th, 25th and 26th April, and 3rd, 4th and 12th May.

The protocol used was:

- systematic 360° scanning (including overhead) for birds in flight;
- target species were geese, swans and any raptors;
- secondary target species were seaduck, waders and passerines; and
- data collected were:
    - time of observation (which was used to identify vessel location with the use of the GPS log);
    - species;
    - flock size;
    - flight height (0-5 m, 5-10 m, 10-20 m, 20-200 m, 200-300 m, or 300+ m);
    - flight direction; and
    - distance from vessel (to the nearest 500 m).

2.2.2 Coastal migration surveys

Migration observations from four coastal vantage points were undertaken to collect additional flight route data. In 2010, observations were carried out over an 8-week period between mid-September and mid-November, on a total of 16 days per vantage point (i.e. an average of 2 days per week). In 2011, observations were undertaken during the 8-week period between mid-March and mid-May, again on a total of 16 days per vantage point (i.e. an average of 2 days per week).

The locations for the coastal vantage points were:

- Sarclet Head, 7 km south of Wick (ND350433), to record flights heading from Caithness across the Moray Firth;
- Duncansby Head (ND406733), to record flights around the coast into the Moray Firth;
- Rosehearty, 7 km west of Fraserburgh (NJ931678) to record flights arriving into north-east Aberdeenshire; and
- Whitehills, 4 km west of Banff (NJ658655) to record flights arriving into the eastern part of the Moray coast.

Locations further west on the Moray coast, or further south-west on the Caithness coast, were not felt necessary as flights were unlikely to occur over these parts of the coast which would have headed towards or have headed from the proposed MORL and BOWL wind farms.

The protocol used was:

- systematic 180° scanning (including overhead) for birds in flight, for 6 hours per day (an hour break was taken between each 3-hour stint) as per SNH onshore wind farm vantage point guidance (SNH 2005);
- target species were geese, swans and any raptors;
- secondary target species were seaduck, waders and passerines;
- these surveys were not undertaken in weather conditions which were likely to preclude migration; and
- data collected were:
  - vantage point location;
  - time of observation;
  - species;

- flock size;
- flight height (0-20 m, 20-200 m, 200-300 m, or 300+ m);
- flight direction;
- distance from observer (to the nearest 500 m); and
- the recording of flight-lines at the sites onto maps which could later be digitised.

The observations on the Caithness coast were organised by NPC, and the observations on the Moray coast were organised by RPS Group Ltd. Surveys were coordinated between the four locations to ensure that where observations were carried out concurrently there was communication between observers so that repeat sightings of the same flock could be identified. Days when a survey vessel was carrying out at-sea bird surveys for either site were prioritised for carrying out the coastal observations, as long as weather conditions were not likely to preclude migration.

2.2.3 Collision risk assessment methods

In order to calculate predictions of mortality arising from collision with turbines, the number of birds passing through the three proposed wind farm sites during migration (autumn and spring combined) was first estimated, and then the number likely to collide was estimated using a collision risk model (Band 2011).

In order to estimate the number of birds which were likely to have passed through or near the wind farm sites, during the autumn and spring eight-week survey periods, a multiplication factor was applied to observations. The multiplication factor was calculated by:

- Calculating the total number of daylight hours during the autumn and spring survey periods combined (autumn: 8 weeks x 7 days x 10 hours average daylight = 560 hours; spring: 8 weeks x 7 days x 14 hours average daylight = 784 hours; total = 1344 hours.
- Dividing this by the average total number of hours spent undertaking observations at each pair of vantage points combined, plus the time spent on additional days for boat-based surveys[2] of the wind farm sites (autumn: 218 hours; spring: 232 hours; total = 450 hours). The Caithness VPs were classed as one pair, and the Moray VPs were another pair. The full time spent at all 4 VPs combined was not used since the ‘at risk’ flights recorded from one VP of

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[2] Note that the inclusion of time spent on boat-based surveys (on days when VPs were not being undertaken) is a difference in the method used to calculate the correction value between this report and the Beatrice Spring Migration Report by RPS.

a pair were likely to be on a different migratory route than the 'at risk' flights recorded from the other VP, and vice versa.

- Then multiplying this by a factor to take account of nocturnal flights. For spring a factor of 1.18 was used to reflect that an estimated 85% of pink-footed goose flights occur during daylight hours (derived from radar observations at Lynn and Inner Dowsing offshore wind farms (Plonczkier *pers comm*[3].)). A higher factor of 1.33 was used for the autumn (based on 25% of flights at night) due to a greater number of nocturnal flights expected at this time as the birds migrate into the UK.

These values (spring: 3.53; autumn: 3.99) were used to generate estimates of the number of probable and possible flights through the wind farm sites during the spring/autumn migration periods combined. A flight was judged as 'probably' flying through the wind farm sites if extrapolation of the linear flight direction intersected with one of the sites; a flight was judged as 'possibly' flying through the wind farm sites if this extrapolated flight route was within 2 km of one of the sites.

An estimate of flights at potential collision height (PCH) was then calculated by multiplying these estimates by the proportion observed at PCH from the autumn and spring boat-based observations (2603/4009 = 64.9%). Note that this estimate is based on the proportion of geese in flight band 20-200 m, and the Rochdale envelope includes a model that would have a blade tip height of 204 m above LAT (lowest astronomical tide), but this estimate is believed to be a very suitable approximation.

The model was also based on a range of turbine options within the current Rochdale Envelope (using blade length, number of turbines and maximum rotation speed), to give a range of estimates. The SNH spreadsheet (SNH 2000) was used to calculate species-specific collision probabilities based on the Rochdale Envelope turbine parameters, and wingspan/flight speed parameters provided in Table 20. An estimate of 80% operation time was also used, which is a typical value used for collision risk modelling. The precautionary avoidance rates recommended by SNH in collision risk modelling are 99% for geese and 98% for swans.

Table 20. Biometric data used to inform the collision risk assessment

	Mean flight speed (ms^{-1})	Mean wingspan (m)	Median body length (m)	Collision probability
Whooper swan	17.3 [4]	2.305	1.525	9.1-12.4%
Pink-footed goose	18.0 [5]	1.525	0.675	6.2-8.5%
Greylag goose	18.0 5	1.635	0.825	6.6-9.1%
Barnacle goose	18.0 5	1.385	0.64	6.1-8.3%

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[3] Presentation by Pavel Plonczkier on behalf of FEPA for the SOSS steering group, 15 September 2011

[4] 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(8): e197.

[5] Patterson, I.J. 2006. Geese and wind farms in Scotland. Report to SNH.

Table 20. Biometric data used to inform the collision risk assessment

	Mean flight speed (ms^{-1})	Mean wingspan (m)	Median body length (m)	Collision probability
Unidentified goose[6]	18.0 5	1.525	0.675	6.2-8.5%

2.3 Aerial surveys

Additional aerial surveys, designed by NPC to put the site distributions into a wider context and to further address species' connectivity with SPAs, were undertaken by Apem Imaging in summer 2011. These involved the collection of digital still images over the proposed three sites and over a wider study area (ES Baseline Chapter 4.5, Figure 4.5-9, Volume 6b). A Vulcan Air P68 Observer twin engine survey aircraft was flown along transects 2 km apart from each other, aligned in a north-north-west to south-south-east direction, and images were captured every 250 m along each transect line, at a resolution of 2 cm ground sample distance (GSD). The images were then quality assured in two stages. First, a sample of the images not containing birds were re-examined, and then when all images containing birds had been isolated, a sample of these was taken and were quality assured for identification.

The data collected using these methods were then used in analyses of flight direction, allowing linkages to be made between birds using the surveyed area and the various adjacent SPAs using circular statistics. Population estimates and smoothed density surface distribution maps for the surveyed area were also derived from these data (ES Baseline Chapter 4.5, Table 4.5-9; Figures 4.5-16 - 4.5-21, Volume 6b). Flight direction data were collected each survey. An example for each species is shown in ES Baseline Chapter 4.5, Figures 4.5-10 - 4.5-15, Volume 6b.

A fuller account of the aerial survey methods can be found in Technical Appendix 4.5 B.

2.4 Seabird Tracking

A seabird tracking study was also designed by NPC as part of the Integrated Ornithological Monitoring Project (IOMP [Walls *et al.*, 2009]). GPS loggers were attached to four key species of seabirds (fulmar, kittiwake, guillemot and razorbill), by the Marine Biology and Ecology Research Centre, University of Plymouth, at the Berriedale Cliffs SSSI within the East Caithness Cliffs SPA. The species were selected based on abundance and access to colonies. The loggers were deployed for periods of over 36 hours, allowing for the completion of at least one full foraging trip. Only known breeding birds were targeted and devices were only deployed on those known to be on eggs or chicks, to reduce the risk of abandonment.

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[6] Based on pink-footed goose parameters since this was the most frequently recorded goose species.

The data from the GPS loggers was used to plot the exact routes taken by each bird on each foraging bout (defined by at least one fix being taken at least 1 km from the colony), giving data on the duration and range of foraging trips. A summary of the results are provided in ES Baseline Chapter 4.5, Table 4.5-11. Two methods were used to differentiate between foraging and transit behaviours. First Passage Time was used to identify the scale at which food was searched for, and identifying Area Restricted Search behaviours allowed data to be binned into cells of a systematic grid (7 km x 7 km for fulmar, and 3 km x 3 km for the others) which would then be used to indicate levels of use per grid cell at both individual and species levels (ES Baseline Chapter 4.5, Figures 4.5-23 - 4.5-26, Volume 6b).

Additional modelling was undertaken to predict the foraging distributions of breeding fulmar, kittiwake, guillemot and razorbill from three SPAs (East Caithness Cliffs SPA, North Caithness Cliffs SPA, and Troup, Pennan and Lion's Heads SPA) (ES Baseline Chapter 4.5, Figures 4.5-27-4.5-30, Volume 6b). These predictions were based on mean foraging distance estimated from the tracking data and environmental covariates (sea depth and slope, sediment type, sea surface temperature and chlorophyll as measures), initially tested for correlation with the tracking data using GLMMs (Generalised Linear Mixed Models).

A fuller account of the deployment and analysis methods can be found in Technical Appendix 4.5 C

2.5 Desk-based literature reviews

Desk-based literature reviews were carried out to collate the most up to date information, to help inform the impact assessments, on aspects of seabird and migratory species ecology and behaviour such as foraging ranges and prey selection.

Data collected in the greater Moray Firth was obtained from the JNCC's ESAS database, with a view to using it to gain insight into longer term populations and distributions of seabirds in the Moray Firth area. These data were not collected to modern day ESAS standards, giving rise to some compatibility issues and rendering the data unsuitable for analyses such as Distance sampling and collision risk assessment. The dataset received spanned several years (1980-1983) but with reasonable coverage achieved only in 1982 it was decided to use data from this year only. These data were then compared with data collected by NPC between April 2010 to March 2012. Due to the limitations of the 1980s data they were used only in the analysis of flight directions by birds carrying food.

For disturbance sensitivity within the species accounts, information was taken from

Garthe and Huppop, 2004 to create a sensitivity-index based on sensitivity to disturbance by ship and helicopter traffic, and habitat-use flexibility; see Table 20.

Table 20. Sensitivity index based on figures from Garthe and Huppop, 2004

Species	Disturbance by ship and helicopter traffic	Habitat use flexibility	Sensitivity index	Level of sensitivity
Fulmar	1	1	2	Low
Gannet	2	1	3	Low
Arctic skua	1	2	3	Low
Great skua	1	2	3	Low
Kittiwake	2	2	4	Medium
Black-headed gull	2	2	4	Medium
Lesser black-backed gull	2	1	3	Low
Herring gull	2	1	3	Low
Great black-backed gull	2	2	4	Medium
Sandwich tern	2	3	5	Medium
Common tern	2	3	5	Medium
Arctic tern	2	3	5	Medium
Guillemot	3	3	6	Medium
Razorbill	3	3	6	Medium
Puffin	2	3	5	Medium

In the summary of potential effects for each species, threat levels were determined as defined below, as per IEEM (2010) guidance:

- Negligible - Threat will have no effect on the species.
- Minor - Threat will have a small but acceptable effect on the species.
- Moderate - Threat will affect the species to the extent that some mitigation may be necessary.
- Major - Threat will have an unacceptable effect on the species.

3 Baseline Results

3.1 Boat-based surveys, 2010-2012

3.1.1 Count data

A large variety of species was recorded during the first year of monitoring. This suggests that the survey effort and standard of surveyors were sufficient to adequately describe both the resident and transient elements of the sites' avifauna.

Counts of birds per boat-based survey are provided for birds in flight and for birds using the sea, in Tables 21-23.

For birds in flight, Table 21 lists all birds recorded, whilst Table 22 provides data from snapshot counts only. The latter excludes any records of birds in flight greater than 300 m from the vessel, so will be more accurate for assessing flight height information. Only flight height data from birds recorded in transect were used to inform the collision risk assessment.

Flight height data from snapshot counts are provided in Table 24. These data were used to determine the species for which collision risk analysis (CRA) would be required, based on the number recorded in the 20–200 m height band. A threshold of 20 individuals recorded in this height band during the 28 boat-based surveys was used to trigger the use of CRA. These species were gannet, kittiwake, herring gull and great black-backed gull.

Table 21. Total numbers of birds recorded in flight per survey, from the NPC boat-based surveys

Species	2010										2011															2012			Total
	Apr	May	Jun	July	Aug (1)	Aug (2)	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr (1)	Apr (2)	May	Jun (1)	Jun (2)	July	Aug (1)	Aug (2)	Sep	Oct	Win (1)	Win (2)	Win (3)	Feb	Mar	
Whooper swan									6																				6
Pink-footed goose							6	306		10			120									124	37		50		70		723
Greylag goose																							5	1			2	26	34
Grey goose sp.							17	2		24			43																86
Goose sp.								9		23												120							152
Wigeon						1	2																						3
Wigeon / pintail					1																								1
Teal					4																								4
Mallard								4																					4
Tufted duck																					6								6
Long-tailed duck	7																						10						17
Common scoter									2				7	5		5								16			1		36
Velvet scoter													1									3							4
Duck sp.																								4					4
Red-throated diver							1	2					1									5							9
Black-throated diver																										1			1
Great northern diver								2														1							3
Diver sp.	1								1																				2
Fulmar	285	439	413	799	767	938	263	327	595	707	670	399	375	331	470	699	856	457	916	1037	900	184	523	382	704	827	444	206	15913
Sooty shearwater					5	4	7	2	1	1										82	59	8							169
Manx shearwater	2	2	8	3	4	13	3							8	2	6	6	4	1	6	26	6							100
Storm petrel				10	54	23	10										1	4	1	19	8	32	3						165
Leach's petrel							2	1									1	1											5

Table 21. Total numbers of birds recorded in flight per survey, from the NPC boat-based surveys

Species	2010										2011															2012			Total
	Apr	May	Jun	July	Aug (1)	Aug (2)	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr (1)	Apr (2)	May	Jun (1)	Jun (2)	July	Aug (1)	Aug (2)	Sep	Oct	Win (1)	Win (2)	Win (3)	Feb	Mar	
Leach's petrel / storm petrel							1	1																					2
Gannet	131	86	105	155	295	241	326	243	12	11	48	81	119	134	84	41	84	76	139	117	180	224	278	101	39	67	74	72	3563
Shag							1	1	8	6	8	2								5				2	1		5	2	41
Cormorant / shag										1																			1
Sparrowhawk																				1									1
Merlin																						1							1
Oystercatcher					18																4							1	23
Ringed plover					6		8														1								15
Golden plover	50					2															36								88
Sanderling		25																											25
Purple sandpiper		1		1																									2
Dunlin		10																											10
Ruff					2																								2
Bar-tailed godwit																											15		15
Whimbrel															5					13									18
Curlew										1		1																	2
Redshank														7															7
Turnstone					8	1																							9
Small wader sp.	2																			10									12
Pomarine skua							1									1	1						5						8
Arctic skua	3	5	12	15	3	12	1	2							6	23	31	13	6	1	8	1	2						144
Long-tailed skua		1																											1
Great skua	16	12	90	36	39	24	7	1						33	70	103	96	59	33	18	30	11	7	1					686
Great skua / pomarine skua																	1												1
Kittiwake	1224	2119	842	385	47	59	83	73	16	84	58	126	192	1053	949	1132	1048	445	398	133	229	52	133	97	26	70	66	213	11352
Black-headed gull										1																			1

Table 21. Total numbers of birds recorded in flight per survey, from the NPC boat-based surveys

Species	2010										2011															2012			Total
	Apr	May	Jun	July	Aug (1)	Aug (2)	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr (1)	Apr (2)	May	Jun (1)	Jun (2)	July	Aug (1)	Aug (2)	Sep	Oct	Win (1)	Win (2)	Win (3)	Feb	Mar	
Common gull					7		1		1	1		2			1			1					4	2				1	21
Lesser black-backed gull	7		34	1									2			1			2										47
Herring gull	7	1	42	87	8			25	38	88	82	191	28	4	1	29	1	1	22	7	27	3	64	48	106	77	136	20	1143
Herring gull / lesser black-backed gull																1			1										2
Iceland gull																									1				1
Great black-backed gull	1	1		117	20	15	24	35	24	40	31	49	19	63	43	14	5	1	15	11	56	80	159	38	25	49	59	23	1017
Large gull sp.		17	11	81		2	1	1	9	46	17	27	3								3	2		2	1				223
Gull sp.				1									6																7
Sandwich tern															1														1
Common tern		3		7	1														1	1									13
Arctic tern		592	56	149	91	12									1	12	322	98	107	224	90	1							1755
Common tern / Arctic tern	1		2	8		12														1									24
Tern sp.				64																									64
Guillemot	1104	2042	2158	19	3	1	31	17	15	73	183	344	349	1287	729	971	3456	2431	641	37	2	98	44	56	81	145	112	950	17379
Razorbill	17	464	624	27	9	3	14	11	11	11	17	67	221	678	267	122	418	239	175	1		87	20	19	19	40	27	79	3687
Guillemot / razorbill	105	148	3032	11	3	1	18	58	28	37	112	295	525	2540	1865	1052	2657	1333	175	7		48	22	26	51	57	34	739	14979
Black guillemot								1																1					2
Little auk								12	17	6	49	4	3		3								11	7	6	6	3	5	132
Puffin	22	357	164	92	203	27	4	18		4		3	1	275	170	66	277	166	232	121	81	13	10	2	5	2	10	1	2326
Little auk / puffin										2																			2
Auk sp.		20	358	3			7	4	7	2	27	3	47	482	148	12	208							4	1				1333
Feral pigeon																							1						1

Table 21. Total numbers of birds recorded in flight per survey, from the NPC boat-based surveys

Species	2010										2011															2012			Total
	Apr	May	Jun	July	Aug (1)	Aug (2)	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr (1)	Apr (2)	May	Jun (1)	Jun (2)	July	Aug (1)	Aug (2)	Sep	Oct	Win (1)	Win (2)	Win (3)	Feb	Mar	
Collared dove																		2											2
Long-eared owl																							1						1
Carrion crow	1																												1
Skylark																						12	2	1					15
Swallow																4													4
Small warbler sp.							1																						1
Starling													1									1	1	10			2		15
Redwing							1		1																				2
Redwing / song thrush																						1							1
Wheatear															1							1							2
Pied wagtail								1							1					1			1						4
Meadow pipit																						14						1	15
Rock pipit																						1							1
Finch sp.																						4							4
Small passerine sp.								2																					2
Passerine sp.	1														1							5							7
Total	2987	6345	7951	2071	1598	1391	841	1161	792	1179	1302	1594	2063	6900	4818	4294	9469	5331	2865	1853	1746	1143	1343	820	1116	1341	1060	2339	77713

Table 22. Total numbers of birds recorded in flight per survey – within transect only, from the NPC boat-based surveys

Species	2010										2011															2012			Total	Total at PCH	% at PCH
	Apr	May	Jun	July	Aug (1)	Aug (2)	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr (1)	Apr (2)	May	Jun (1)	Jun (2)	July	Aug (1)	Aug (2)	Sep	Oct	Win (1)	Win (2)	Win (3)	Feb	Mar			
Pink-footed goose																							19						19	19	100
Greylag goose																								1					1		0
Fulmar	56	66	106	179	129	243	66	114	161	238	171	104	115	102	119	184	210	106	217	288	255	52	112	83	134	207	103	58	3978		0
Sooty shearwater					1	2		1		1										30	11	2							48		0
Manx shearwater		1	1		1										1	1	2			3		1							11		0
Storm petrel				2	17	5	2											2		4		13							45		0
Leach's petrel																	1												1		0
Gannet	12	13	14	23	38	31	33	64	2	1	16	16	24	36	15	9	15	7	28	15	26	45	48	22	4	14	13	24	608	71	11.7
Shag									1		4	1													1		1		8		0
Purple sandpiper		1																											1		0
Dunlin		10																											10		0
Curlew										1																			1		0
Turnstone					8																								8		0
Arctic skua	1		1	3	1	5		2								5	6	2	1		1								28		0
Great skua			11	2	6	3	4							9	16	22	15	8	6	2	5	1							110	1	0.9
Kittiwake	109	379	118	80	5	4	15	15	3	13	15	24	48	227	284	264	110	87	111	24	47	8	20	13	3	25	15	57	2123	97	4.6
Black-headed gull										1																			1		0
Common gull					1																		1						2		0
Lesser black-backed gull	4		4										1			1			1										11	3	27.3
Herring gull	2		3	13	5			13	16	24	19	46	4	2		21	1		8		13	1	3	6	30	39	40	4	313	105	33.5
Iceland gull																									1				1		0
Great black-backed gull				14	1	2	2	10	6	6	5	8	3	13	10				3	5	26	22	30	5	2	14	14	6	207	62	30.0
Large gull sp.																								1					1		0
Common tern																			1										1		0
Arctic tern		103	10	37	40	2										3	112	44	31	106	32								520	18	3.5
Common tern/ Arctic tern				1																									1		0
Guillemot	68	147	359	4	1		1	3	4	9	12	49	125	365	171	227	734	494	87	8		22	5	10	27	20	21	125	3098		0
Razorbill	5	31	123	10	1		6	5	7	2	3	9	65	253	58	26	67	43	30	1		15	3	4	1	5	9	14	796		0
Guillemot / razorbill			180				2	1	2	9	13	16	88	375	94	118	89	27				4				4		121	1143		0
Little auk								6	5		6	3	1										1	2	3	2		4	33		0
Puffin		34	24	20	27	3		6				2		68	36	12	48	34	40	19	17	2			3	1	1		397		0
Auk sp.		20																											20		0
Long-eared owl																							1						1		0
Skylark																							2						2		0
Redwing									1																				1		0
Pied wagtail																							1						1		0
Rock pipit																						1							1		0
Small passerine sp.								1																					1		0

Table 22. Total numbers of birds recorded in flight per survey – within transect only, from the NPC boat-based surveys

Species	2010										2011															2012			Total	Total at PCH	% at PCH
	Apr	May	Jun	July	Aug (1)	Aug (2)	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr (1)	Apr (2)	May	Jun (1)	Jun (2)	July	Aug (1)	Aug (2)	Sep	Oct	Win (1)	Win (2)	Win (3)	Feb	Mar			
Total	257	805	954	388	282	300	131	241	208	305	264	278	474	1450	804	893	1410	854	564	505	433	189	246	147	209	331	217	413	13552	376	2.8

* PCH (potential collision height) refers to the birds recorded in the 20-200 m height band.

Table 23. Total numbers of birds recorded using the sea per survey, from the NPC boat-based surveys.

Species	2010										2011															2012			Total
	Apr	May	Jun	July	Aug (1)	Aug (2)	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr (1)	Apr (2)	May	Jun (1)	Jun (2)	July	Aug (1)	Aug (2)	Sep	Oct	Win (1)	Win (2)	Win (3)	Feb	Mar	
Red-throated diver		1									2											1							4
Fulmar	290	532	58	240	254	184	31	37	68	107	38	10	61	293	330	433	131	23	55	314	435	11	172	34	25	12	15	16	4209
Sooty shearwater																				18	52								70
Manx shearwater		1		1	1	2														2	6	3							16
Storm petrel					2														2			7							11
Gannet	77	66	40	35	98	42	91	44			4	3	15	127	58	30	38	26	19	91	90	37	46	12	3	2	6	5	1105
Shag								1	7	38	4	8	5	1										11		3	5	1	84
Red-necked phalarope						1																							1
Pomarine skua						1																							1
Arctic skua	1	2	5	1		2									2	18	1	4			1	1							38
Great skua	4	12	21	5	16	3								27	60	117	22	15	9	9	9								329
Kittiwake	473	1615	53	29	6	4	1	1		2	14	99	281	1869	833	1035		415	683	259	280	3	10	12	9	6	5	149	8146
Lesser black-backed gull			3												1	4													8
Herring gull			2	5	1				3	3	16	40	3			4			7	1			13	1	10	3	14		126
Great black-backed gull	30	1		10	252	7	2	10	7	12	14	27	23	145	81	98			10	3	50	4	51	7	7	16	17	5	889
Large gull sp.												1				42													43
Common tern						1													1										2
Arctic tern		256		28	23											8	47	2	43	88	44								539
Guillemot	1856	3808	1139	114	77	84	71	9	9	42	162	625	561	1501	1790	3143	431	335	341	518	896	661	71	116	76	79	142	290	18947
Razorbill	78	1060	53	16	12	13	66	2	8	5	42	42	192	241	762	389	78	143	202	727	2854	950	21	39	25	56	40	62	8178
Guillemot / razorbill	25	2301	69	47	15	2	32	9	3	8	92	83	432	525	850	2091	39	87	228	1204	4548	874	12	32	29	20	4	12	13673
Black guillemot			1		1																								2
Little auk								2	15	10	130	7	9		14								2	8	6	13	4	21	241
Puffin	82	644	54	118	259	337	151	18	17	8	9	2	10	455	950	565	161	135	280	1797	2396	525	27	10	23	8	30	22	9093
Little auk / puffin										3	3																		6
Auk sp.		150	3	1		1	13	4	1	6	2				2	1	1	1		102	396				6				690
Feral pigeon																		1											1
Total	2916	10449	1501	650	1017	684	458	137	138	244	532	947	1592	5184	5733	7978	949	1187	1880	5133	12057	3077	425	282	219	218	282	583	66452

Table 24. Numbers of birds recorded in each height band and percentages within the 'collision risk zone'

Species	Height band						Total	% at 20-200 m
	0-5 m	5–10 m	10-20 m	20-200 m	200-300 m	300+ m		
Pink-footed goose				19			19	100
Greylag goose			1				1	0
Fulmar	3834	137	7				3978	0
Sooty shearwater	48						48	0
Manx shearwater	11						11	0
Storm petrel	45						45	0
Leach's petrel	1						1	0
Gannet	362	72	103	71			608	11.7
Shag	8						8	0
Purple sandpiper	1						1	0
Dunlin	10						10	0
Curlew		1					1	0
Turnstone	8						8	0
Arctic skua	17	7	4				28	0
Great skua	84	16	9	1			110	0.9
Kittiwake	958	507	561	97			2123	4.6
Black-headed gull		1					1	0
Common gull		1	1				2	0
Lesser black-backed gull	3	4	1	3			11	27.3
Herring gull	74	32	101	105	1		313	33.5
Iceland gull	1						1	0
Great black-backed gull	64	33	48	62			207	30
Large gull sp.			1				1	0
Common tern		1					1	0
Arctic tern	198	201	103	18			520	3.5
Common tern / Arctic tern		1					1	0
Guillemot	3046	50	2				3098	0
Razorbill	779	15	2				796	0
Guillemot / Razorbill	1137	6					1143	0
Little auk	33						33	0
Puffin	394	3					397	0

Table 24. Numbers of birds recorded in each height band and percentages within the 'collision risk zone'

Species	Height band						Total	% at 20-200 m
	0-5 m	5–10 m	10-20 m	20-200 m	200-300 m	300+ m		
Auk sp.		20					20	0
Long-eared owl			1				1	0
Skylark	2						2	0
Redwing		1					1	0
Pied wagtail			1				1	0
Rock pipit	1						1	0
Small passerine sp.	1						1	0

3.1.2 Collision risk analysis

The collision risk analysis was undertaken for four species, as determined in section 3.1.1. The excel spreadsheet used to calculate the number of predicted collisions for these species (Tables 25 and 26) is available upon request.

Table 25. Annual collision rates predicted for species with sufficient data, at an avoidance rate of 98%

Species	**Breeding season**	**Non-breeding season**	**Total**
Gannet	123	104	227
Kittiwake	108	42	150
Herring gull	21	187	208
Great black-backed gull	37	102	139

Table 26. Annual collision rates predicted for each species at different avoidance rates

Species	**98.0%**	**98.5%**	**99.0%**	**99.5%**
Gannet	227	170	113	57
Kittiwake	150	113	75	38
Herring gull	208	156	104	52
Great black-backed gull	139	105	70	35

3.1.3 Density estimates

The results of the density analysis from the boat-based surveys are presented in Table 27.

Table 27. Density and abundance estimates for key species, taken from 2010-2012 NPC boat-based survey data (birds per km²).

Species	**Breeding season**				**Non-breeding season**				**Model basis**
	Density		**Abundance**		**Density**		**Abundance**		
	Site	**Buffer**	**Site**	**Buffer**	**Site**	**Buffer**	**Site**	**Buffer**	
Fulmar	2.77	1.91	782	750	0.25	0.20	197	189	Model
Gannet	0.66	0.46	100	86	0.04	0.05	23	20	Model
Great skua	0.34	0.17	101	62	na	na	na	na	Design
Kittiwake	7.90	4.69	1963	1532	0.79	0.29	261	204	Model
Herring gull	0.02	0.05	7	18	0.14	0.13	41	47	Design
Great black-backed gull	0.91	1.48	271	526	0.36	0.22	106	77	Design

Table 27. Density and abundance estimates for key species, taken from 2010-2012 NPC boat-based survey data (birds per km²).

Species	**Breeding season**				**Non-breeding season**				**Model basis**
	Density		**Abundance**		**Density**		**Abundance**		
	Site	**Buffer**	**Site**	**Buffer**	**Site**	**Buffer**	**Site**	**Buffer**	
Arctic tern	0.77	5.35	229	1903	na	na	na	na	Design
Guillemot	25.57	18.60	6732	6943	2.84	3.47	990	1021	Model
Razorbill	6.03	3.53	1661	1674	2.64	3.04	892	899	Model
Guillemot & razorbill combined	9.20	5.10	2732	1815	2.39	2.78	711	989	Design
Little auk	na	na	na	na	0.51	0.38	151	136	Design
Puffin	6.55	5.55	1916	1971	0.75	1.05	450	463	Model

Tables 28-39 show monthly density (birds per km²) and abundance estimates for the same species within the three proposed wind farm sites and buffer zone, with confidence intervals (UCL: upper confidence limit; LCL: lower confidence limit) and percentage covariates (%CV), using the methods outlined in 2.1.6. Abundance derived from density surface modelling is also given for some species. Density and abundance estimates based on the April 2010 – March 2012 boat-based surveys undertaken by NPC are provided for the breeding and non-breeding seasons in Table 25.

Table 28. Density and abundance estimates derived from Distance sampling for fulmar.

	Wind farm sites									Buffer								
Month	Density	UCL	LCL	Abundance	UCL	LCL	%CV	Abundance (DSM)	Std error	Density	UCL	LCL	Abundance	UCL	LCL	%CV	Abundance (DSM)	Std error
Apr-10	4.55	2.76	7.49	1350	819	2225	25.12	1279.73	48.00	1.68	1.05	2.68	596	373	953	23.59	1227.69	35.08
May-10	9.01	4.96	16.35	2674	1474	4854	28.91	1254.98	36.89	5.94	2.75	12.86	2115	978	4574	39.43	1203.95	30.13
Jun-10	0.45	0.26	0.79	134	76	235	27.32	1071.71	34.48	0.71	0.38	1.33	252	134	474	31.87	1028.13	28.51
Jul-10	3.33	1.53	7.22	988	455	2146	39.24	776.88	21.39	1.31	0.76	2.27	467	269	809	27.73	745.29	17.64
Aug-10	2.02	1.25	3.28	601	371	974	23.46	535.25	14.71	2.31	1.50	3.56	822	534	1268	21.91	513.48	12.59
Sep-10	0.27	0.13	0.58	80	37	172	37.37	386.84	12.12	0.15	0.06	0.38	55	23	134	46.07	371.11	10.85
Oct-10	0.45	0.16	1.21	133	49	360	50.46	281.72	8.27	2.70	0.02	322.05	959	8	114570	206.80	270.27	7.19
Nov-10	0.38	0.11	1.25	112	34	372	57.48	191.20	5.84	1.97	0.64	6.10	702	227	2170	58.79	183.42	4.98
Dec-10	1.98	0.63	6.22	587	186	1846	57.75	133.44	4.17	1.48	0.17	12.61	528	62	4485	114.57	128.01	3.61
Jan-11	0.23	0.12	0.45	69	36	133	31.93	128.70	3.67	0.39	0.22	0.66	137	80	236	27.31	123.47	3.42
Feb-11	0.17	0.08	0.38	51	23	113	39.67	211.35	6.07	0.04	0.01	0.15	16	4	54	67.28	202.76	5.40
Mar-11	0.28	0.16	0.51	84	47	152	29.49	489.80	14.85	0.81	0.30	2.16	288	108	767	51.56	469.88	13.06
Apr-11	3.99	2.56	6.22	1185	761	1846	21.68	944.91	28.83	2.38	1.36	4.17	847	484	1483	28.59	906.49	25.60
May-11	5.22	2.75	9.89	1549	817	2937	31.69	1001.39	27.26	3.19	1.95	5.22	1134	692	1859	25.15	960.67	22.70
Jun-11	0.80	0.55	1.17	238	164	347	17.98	648.75	21.04	0.83	0.47	1.48	296	166	527	29.13	622.37	17.63
Jul-11	0.60	0.37	0.98	178	110	290	23.37	437.19	12.80	0.63	0.39	1.00	223	139	357	23.55	419.42	12.36
Aug-11	1.58	0.91	2.77	470	269	822	28.12	453.82	13.91	3.75	2.06	6.80	1332	734	2418	30.67	435.37	12.65
Sep-11	1.46	0.00	1619600.00	433	0	480980000	225.06	592.16	17.29	0	0	0	0	0	0	0	568.08	15.24
Oct-11	2.48	1.10	5.61	737	326	1666	41.89	518.15	14.71	1.01	0.53	1.95	361	187	695	33.59	497.08	13.18
Wint (1)	0.42	0.21	0.81	124	64	242	32.45	209.31	6.31	0.38	0.18	0.78	134	65	277	36.93	200.80	5.21
Wint (2)	0.30	0.09	1.00	88	26	296	62.89	56.97	1.76	0.38	0.21	0.71	137	74	254	31.20	54.65	1.52
Wint (3)	0.15	0.06	0.36	44	18	108	45.09	25.16	1.10	0.11	0.04	0.29	39	15	103	50.39	24.14	0.91
Feb-12	0.67	0.13	3.45	198	38	1024	89.00	32.09	1.03	0.15	0.06	0.42	55	20	151	53.29	30.79	0.83
Mar-12	0.24	0.10	0.55	70	30	164	41.33	91.57	2.79	0.15	0.07	0.34	55	24	122	40.92	87.85	2.55

Table 29. Density and abundance estimates derived from Distance sampling for gannet.

	Wind farm sites									Buffer								
Month	Density	UCL	LCL	Abundance	UCL	LCL	%CV	Abundance (DSM)	Std error	Density	UCL	LCL	Abundance	UCL	LCL	%CV	Abundance (DSM)	Std error
Apr-10	1.36	0.62	2.97	404	185	883	39.96	161.69	5.55	0.26	0.11	0.63	93	39	224	45.25	138.40	6.02
May-10	0.91	0.48	1.75	271	142	520	32.97	76.00	3.28	0.47	0.28	0.79	166	98	281	26.60	65.05	2.74
Jun-10	0.27	0.12	0.62	79	34	184	41.25	59.12	2.59	0.52	0.27	1.01	186	97	358	33.37	50.61	2.33
Jul-10	0.47	0.23	0.95	139	69	281	33.96	85.10	4.50	0.26	0.14	0.49	93	49	175	31.90	72.84	3.11
Aug-10	0.82	0.47	1.46	245	139	432	28.53	141.05	9.17	0.61	0.33	1.11	216	118	394	30.58	120.73	6.06
Sep-10	0.89	0.62	1.29	265	183	383	17.92	133.12	5.80	0.84	0.50	1.41	299	179	500	25.92	113.95	4.96
Oct-10	0.71	0.19	2.62	212	58	778	68.12	52.19	2.10	0.22	0.12	0.40	80	44	143	29.56	44.67	1.66
Nov-10	0	0	0	0	0	0	0	12.79	0.50	0	0	0	0	0	0	0	10.95	0.50
Dec-10	0	0	0	0	0	0	0	4.70	0.21	0	0	0	0	0	0	0	4.02	0.18
Jan-11	0.02	0	0.13	7	1	38	97.14	5.07	0.23	0.06	0.01	0.32	20	4	113	102.33	4.34	0.20
Feb-11	0.04	0.01	0.16	13	4	47	64.44	14.99	0.73	0.02	0.00	0.10	7	1	37	100.74	12.83	0.62

Table 29. Density and abundance estimates derived from Distance sampling for gannet.

	Wind farm sites									Buffer								
Month	Density	UCL	LCL	Abundance	UCL	LCL	%CV	Abundance (DSM)	Std error	Density	UCL	LCL	Abundance	UCL	LCL	%CV	Abundance (DSM)	Std error
Mar-11	0.13	0.04	0.41	40	13	122	57.18	56.83	2.51	0.17	0.05	0.62	60	16	219	68.27	48.64	2.40
Apr-11	1.48	0.74	2.99	440	219	887	35.59	119.27	5.37	0.49	0.24	0.98	173	85	350	36.32	102.10	3.46
May-11	0.36	0.13	1.00	106	38	297	51.06	107.47	5.67	0.26	0.07	1.00	93	24	356	71.05	92.00	3.89
Jun-11	0.33	0.20	0.55	99	60	164	24.14	66.56	3.09	0.32	0.21	0.49	113	74	173	21.26	56.97	2.49
Jul-11	0.11	0.02	0.53	33	7	157	83.68	56.34	2.55	0.26	0.14	0.49	93	50	173	31.26	48.22	1.97
Aug-11	0.68	0.37	1.24	202	111	367	29.91	80.25	4.16	0.71	0.34	1.48	253	121	527	38.18	68.69	3.19
Sep-11	0.18	0.07	0.48	53	20	142	48.54	116.26	5.07	0.54	0.34	0.85	193	122	303	22.81	99.51	4.59
Oct-11	0.51	0.21	1.23	152	64	364	44.01	81.58	3.64	0.43	0.24	0.78	153	84	277	29.83	69.83	2.78
Wint (1)	0.09	0.03	0.26	26	9	77	53.21	22.39	1.03	0.15	0.07	0.33	53	24	119	41.29	19.16	0.82
Wint (2)	0.04	0.01	0.26	13	2	76	96.95	4.59	0.25	0.02	0.00	0.10	7	1	37	101.01	3.93	0.24
Wint (3)	0	0	0	0	0	0	0	2.02	0.11	0.04	0.01	0.21	13	2	73	101.12	1.73	0.09
Feb-12	0	0	0	0	0	0	0	3.36	0.16	0.11	0.04	0.32	40	14	114	55.11	2.88	0.14
Mar-12	0.04	0.01	0.26	13	2	76	97.14	14.57	0.63	0.06	0.02	0.16	20	7	59	56.83	12.47	0.54

Table 30. Density and abundance estimates derived from Distance sampling for great skua.

	Wind farm sites								Buffer					
Month	Density	UCL	LCL	Abundance	UCL	LCL	%CV	Density	UCL	LCL	Abundance	UCL	LCL	%CV
Apr-10	0.09	0.03	0.26	26	9	77	52.94	0	0	0	0	0	0	0
May-10	0.09	0.03	0.27	26	9	81	56.21	0.15	0.07	0.33	53	24	117	40.39
Jun-10	0.22	0.13	0.38	66	39	114	26.20	0.21	0.09	0.46	73	32	165	41.63
Jul-10	0.09	0.04	0.20	26	12	59	39.11	0.02	0.00	0.10	7	1	36	99.93
Aug-10	0.07	0.02	0.20	20	7	59	53.76	0.12	0.03	0.43	43	12	151	67.98
Sep-10	0	/	/	0	/	/	0	0	/	/	0	/	/	0
Oct-10	0	/	/	0	/	/	0	0	/	/	0	/	/	0
Nov-10	0	/	/	0	/	/	0	0	/	/	0	/	/	0
Dec-10	0	/	/	0	/	/	0	0	/	/	0	/	/	0
Jan-11	0	/	/	0	/	/	0	0	/	/	0	/	/	0
Feb-11	0	/	/	0	/	/	0	0	/	/	0	/	/	0
Mar-11	0	/	/	0	/	/	0	0	/	/	0	/	/	0
Apr-11	0.81	0.47	1.41	242	139	419	26.92	0.11	0.05	0.26	40	17	92	43.49
May-11	1.74	0.74	4.07	516	221	1208	42.31	0.73	0.28	1.89	259	100	672	49.84
Jun-11	0.10	0.04	0.23	30	13	68	40.75	0.26	0.15	0.45	93	54	159	26.94
Jul-11	0.11	0.03	0.37	33	10	111	61.32	0.07	0.03	0.18	27	11	64	45.54
Aug-11	0.07	0.03	0.17	20	8	51	47.43	0.06	0.02	0.17	20	7	61	57.53
Sep-11	0	/	/	0	/	/	0	0	/	/	0	/	/	0
Oct-11	0	/	/	0	/	/	0	0	/	/	0	/	/	0
Wint (1)	0	/	/	0	/	/	0	0	/	/	0	/	/	0
Wint (2)	0	/	/	0	/	/	0	0	/	/	0	/	/	0
Wint (3)	0	/	/	0	/	/	0	0	/	/	0	/	/	0
Feb-12	0	/	/	0	/	/	0	0	/	/	0	/	/	0

Table 30. Density and abundance estimates derived from Distance sampling for great skua.

	Wind farm sites							Buffer						
Month	Density	UCL	LCL	Abundance	UCL	LCL	%CV	Density	UCL	LCL	Abundance	UCL	LCL	%CV
Mar-12	0	/	/	0	/	/	0	0	/	/	0	/	/	0

Table 31. Density and abundance estimates derived from Distance sampling for kittiwake.

	Wind farm sites									Buffer									
Month	Density	UCL	LCL	Abundance	UCL	LCL	%CV	Abundance (DSM)	Std error	Density	UCL	LCL	Abundance	UCL	LCL	%CV	Abundance (DSM)	Std error
Apr-10	3.68	1.10	12.33	1094	327	3663	64.01	2221.30	1852.36	1.13	0.29	4.44	403	103	1579	70.36	1732.99	3016.35
May-10	37.61	15.81	89.45	11167	4695	26563	45.06	4690.41	2393.15	17.83	6.56	48.47	6342	2333	17244	52.94	3659.30	2513.66
Jun-10	1.00	0.13	7.97	297	37	2366	117.70	1190.64	774.34	0.33	0.06	1.80	118	22	642	100.12	928.90	573.10
Jul-10	0.13	0.05	0.35	39	15	104	48.42	14.79	26.38	0.62	0.26	1.50	222	92	534	45.68	11.54	29.11
Aug-10	0.05	0.02	0.16	16	5	48	56.60	0.03	1.01	0.03	0.01	0.12	11	3	43	74.32	0.03	1.52
Sep-10	0.03	0	0.16	8	1	48	103.07	0	0.05	0	0	0	0	0	0	0	0.0	0.09
Oct-10	0.03	0	0.15	8	1	45	97.30	0	0.29	0	0	0	0	0	0	0	0.0	0.20
Nov-10	0	0	0	0	0	0	0	0	1.01	0	0	0	0	0	0	0	0.0	0.51
Dec-10	0.03	0	0.15	8	1	44	95.67	0.04	3.41	0.02	0	0.12	8	1	43	100.83	0.03	5.94
Jan-11	0.24	0.07	0.84	72	21	249	64.22	5.43	17.16	0.02	0	0.12	8	1	43	100.81	4.24	21.52
Feb-11	1.59	0.76	3.32	473	227	986	36.81	255.76	155.84	0.52	0.24	1.15	186	85	409	40.77	199.54	439.55
Mar-11	6.90	2.96	16.08	2048	878	4774	43.86	2235.26	1039.46	1.26	0.53	2.95	447	190	1049	44.22	1743.87	969.41
Apr-11	12.49	4.74	32.88	3708	1408	9763	51.31	4449.05	2775.57	8.89	3.01	26.29	3163	1070	9353	58.68	3471.00	5795.00
May-11	19.55	2.48	154.00	5805	737	45734	120.48	3472.75	1633.52	6.42	1.15	35.85	2284	409	12753	90.84	2709.33	1297.13
Jun-11	0.89	0.16	4.85	264	49	1440	96.64	1887.36	1527.72	2.93	0.70	12.27	1041	248	4367	81.23	1472.46	1051.23
Jul-11	1.73	0.79	3.81	515	234	1132	40.36	1059.99	1011.61	5.74	1.96	16.76	2041	699	5963	57.60	826.97	902.58
Aug-11	1.85	0.70	4.90	550	208	1457	50.64	646.86	309.10	3.01	0.96	9.43	1069	341	3356	59.79	504.66	369.23
Sep-11	0.08	0.02	0.32	23	6	96	71.65	322.24	132.38	0	0	0	0	0	0	0	251.40	159.33
Oct-11	0.21	0.05	0.84	62	16	248	71.74	97.19	56.24	0.10	0.03	0.39	37	10	139	65.46	75.82	119.29
Wint (1)	0	0	0	0	0	0	0	20.68	6.08	0.39	0.09	1.64	138	32	584	70.94	16.13	6.92
Wint (2)	0.07	0.01	0.41	21	4	123	97.74	6.56	3.19	0.11	0.03	0.37	39	12	133	65.84	5.12	3.05
Wint (3)	0.03	0	0.15	8	1	45	96.60	7.57	7.30	0.11	0.05	0.26	39	17	91	43.07	5.90	3.47
Feb-12	0	0	0	0	0	0	0	42.86	25.46	0.10	0.03	0.38	36	10	134	69.13	33.44	31.03
Mar-12	1.81	0.79	4.11	537	236	1221	41.45	666.71	391.33	1.44	0.61	3.40	514	218	1208	44.24	520.14	339.67

Table 32. Density and abundance estimates derived from Distance sampling for herring gull.

	Wind farm sites							Buffer						
Month	Density	UCL	LCL	Abundance	UCL	LCL	%CV	Density	UCL	LCL	Abundance	UCL	LCL	%CV
Apr-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
May-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 32. Density and abundance estimates derived from Distance sampling for herring gull.

	Wind farm sites							Buffer						
Month	**Density**	**UCL**	**LCL**	**Abundance**	**UCL**	**LCL**	**%CV**	**Density**	**UCL**	**LCL**	**Abundance**	**UCL**	**LCL**	**%CV**
Jun-10	0.08	0.01	0.49	24	4	146	103.53	0	0	0	0	0	0	0
Jul-10	0.04	0.01	0.23	12	2	68	98.21	0.13	0.02	0.74	47	9	264	101.90
Aug-10	0	0	0	0	0	0	0	0.02	0.00	0.09	6	1	33	101.73
Sep-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oct-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov-10	0.04	0.01	0.23	12	2	68	97.71	0.07	0.02	0.25	24	6	88	71.58
Dec-10	0	0	0	0	0	0	0	0.10	0.03	0.30	36	12	108	58.84
Jan-11	0.48	0.12	1.97	142	34	585	75.88	0.13	0.05	0.35	47	18	123	49.83
Feb-11	0.73	0.31	1.75	218	91	521	43.58	0.83	0.31	2.23	296	110	792	52.11
Mar-11	0.12	0.03	0.46	35	9	136	69.96	0	0	0	0	0	0	0
Apr-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
May-11	0.08	0.01	0.51	24	4	153	106.81	0.07	0.01	0.37	24	4	132	101.90
Jun-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jul-11	0.04	0.01	0.23	12	2	68	98.21	0.28	0.03	2.85	101	10	1013	104.73
Aug-11	0	0	0	0	0	0	0	0.02	0.00	0.09	6	1	33	101.64
Sep-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oct-11	0.12	0.02	0.56	35	7	167	85.74	0.07	0.01	0.37	24	4	133	102.24
Wint (1)	0.04	0.01	0.23	12	2	69	98.40	0	0	0	0	0	0	0
Wint (2)	0.16	0.06	0.41	47	18	123	47.65	0.36	0.11	1.15	129	40	409	62.19
Wint (3)	0.08	0.02	0.29	24	7	85	66.48	0.03	0.01	0.19	12	2	66	101.90
Feb-12	0.16	0.01	2.95	46	2	876	92.45	0.26	0.09	0.81	93	30	287	57.23
Mar-12	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 33. Density and abundance estimates derived from Distance sampling for great black-backed gull.

	Wind farm sites							Buffer						
Month	**Density**	**UCL**	**LCL**	**Abundance**	**UCL**	**LCL**	**%CV**	**Density**	**UCL**	**LCL**	**Abundance**	**UCL**	**LCL**	**%CV**
Apr-10	0.96	0.11	8.22	284	33	2442	105.44	0	0	0	0	0	0	0
May-10	0	0	0	0	0	0	0	0.03	0	0.15	10	2	52	101.08
Jun-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jul-10	1.16	0.06	22.65	346	18	6725	121.34	0.03	0.00	0.15	10	2	53	101.68
Aug-10	0.19	0.05	0.69	55	15	205	68.51	11.63	1.54	88.00	4137	547	31309	123.81
Sep-10	0	0	0	0	0	0	0	0.05	0.01	0.20	19	5	70	71.57
Oct-10	0.03	0.01	0.19	9	2	56	100.26	0.35	0.10	1.24	124	35	442	68.76
Nov-10	0.18	0.05	0.72	55	14	215	72.21	0.05	0.01	0.20	19	5	70	71.08
Dec-10	0.22	0.07	0.68	66	22	201	55.78	0.13	0.06	0.30	48	21	108	42.25
Jan-11	0.31	0.10	0.89	91	31	265	54.49	0.13	0.04	0.42	48	15	149	60.82
Feb-11	0.26	0.15	0.47	78	43	140	29.12	0.53	0.26	1.08	188	92	383	36.54
Mar-11	1.51	0.40	5.64	447	120	1674	62.78	0.46	0.24	0.89	165	86	316	33.13
Apr-11	2.20	0.85	5.71	653	251	1694	49.45	1.31	0.49	3.46	464	175	1230	51.68
May-11	3.77	0.57	24.75	1120	171	7351	106.86	0.43	0.12	1.59	154	42	564	67.59

Table 33. Density and abundance estimates derived from Distance sampling for great black-backed gull.

	Wind farm sites							Buffer						
Month	**Density**	**UCL**	**LCL**	**Abundance**	**UCL**	**LCL**	**%CV**	**Density**	**UCL**	**LCL**	**Abundance**	**UCL**	**LCL**	**%CV**
Jun-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jul-11	0.06	0.01	0.36	19	3	108	97.03	0.42	0.09	1.96	148	31	699	78.12
Aug-11	0.79	0.11	5.60	234	33	1663	100.04	0.94	0.15	6.02	334	52	2142	111.93
Sep-11	0.10	0.02	0.59	28	5	174	103.07	0.03	0.00	0.15	10	2	52	100.69
Oct-11	1.69	0.73	3.88	501	218	1153	41.80	0.35	0.17	0.70	124	62	250	35.83
Wint (1)	0.03	0.01	0.18	9	2	54	97.03	0.23	0.05	1.07	82	18	379	86.00
Wint (2)	0.16	0.05	0.53	47	14	157	60.89	0.05	0.01	0.20	19	5	70	71.19
Wint (3)	0.21	0.09	0.46	62	28	136	39.14	0.22	0.06	0.81	80	22	287	69.89
Feb-12	0.13	0.05	0.32	38	15	95	45.22	0.40	0.14	1.10	141	51	391	53.34
Mar-12	0.17	0.03	1.14	51	8	338	69.68	0.03	0.00	0.15	10	2	52	100.87

Table 34. Density and abundance estimates derived from Distance sampling for Arctic tern.

	Wind farm sites							Buffer						
Month	**Density**	**UCL**	**LCL**	**Abundance**	**UCL**	**LCL**	**%CV**	**Density**	**UCL**	**LCL**	**Abundance**	**UCL**	**LCL**	**%CV**
Apr-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
May-10	2.62	1.11	6.19	779	330	1838	43.14	4.04	1.64	9.99	1439	582	3555	46.86
Jun-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jul-10	0	0	0	0	0	0	0	30.78	0.51	1865.90	10951	181	663820	258.37
Aug-10	0.17	0.06	0.53	51	16	156	58.05	0.17	0.03	0.94	60	11	334	75.83
Sep-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oct-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dec-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jan-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Feb-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mar-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Apr-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
May-11	0.27	0.05	1.61	80	14	478	100.76	0	0	0	0	0	0	0
Jun-11	0.56	0.01	44.54	166	2	13227	177.81	0.47	0.07	3.37	167	23	1201	91.89
Jul-11	1.59	0.40	6.35	471	118	1886	68.35	0.14	0.03	0.78	50	9	276	100.42
Aug-11	0.95	0.21	4.30	282	62	1277	79.51	7.18	0.05	1011.50	2554	18	359860	216.45
Sep-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oct-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wint (1)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wint (2)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wint (3)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Feb-12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mar-12	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 35. Density and abundance estimates derived from Distance sampling for guillemot.

	Wind farm sites									Buffer								
Month	**Density**	**UCL**	**LCL**	**Abundance**	**UCL**	**LCL**	**%CV**	**Abundance (DSM)**	**Std error**	**Density**	**UCL**	**LCL**	**Abundance**	**UCL**	**LCL**	**%CV**	**Abundance (DSM)**	**Std error**
Apr-10	27.45	20.08	37.53	8151	5962	11144	15.40	9911.03	306.57	21.06	15.87	27.96	7493	5644	9948	14.25	10220.85	344.56
May-10	88.67	55.83	140.82	26332	16580	41820	22.41	13399.53	365.41	44.71	28.48	70.17	15905	10134	24963	22.78	13818.40	399.28
Jun-10	24.58	16.56	36.49	7300	4918	10836	19.67	6988.32	202.76	22.27	13.16	37.70	7924	4682	13411	26.50	7206.77	208.16
Jul-10	0.16	0.06	0.48	49	17	143	53.62	1129.87	33.07	2.94	1.24	6.95	1046	442	2473	44.70	1165.19	36.82
Aug-10	0.51	0.21	1.26	151	61	374	44.40	133.26	5.08	1.50	0.51	4.42	533	181	1574	57.78	137.42	4.81
Sep-10	1.01	0.57	1.81	301	169	538	28.68	38.03	1.68	0.77	0.33	1.82	275	117	646	44.12	39.22	1.71
Oct-10	0.10	0.03	0.37	29	8	111	68.09	43.09	1.71	0.15	0.06	0.40	53	20	141	51.13	44.44	1.77
Nov-10	0.03	0.01	0.20	10	2	60	102.35	118.94	3.90	0.23	0.11	0.47	81	40	167	36.68	122.66	4.58
Dec-10	0.93	0.32	2.68	276	95	796	53.22	355.59	10.06	0.58	0.23	1.51	208	80	536	49.55	366.70	10.99
Jan-11	2.64	1.53	4.56	784	455	1353	26.61	814.35	21.98	2.21	1.32	3.69	785	470	1311	25.85	839.81	23.02
Feb-11	7.74	5.79	10.33	2297	1721	3067	14.14	1739.53	46.98	7.78	4.52	13.39	2767	1607	4764	27.64	1793.91	52.72
Mar-11	7.24	4.48	11.69	2149	1330	3472	23.58	4107.81	127.35	7.25	4.17	12.59	2579	1485	4479	27.91	4236.22	124.77
Apr-11	20.48	16.37	25.63	6082	4860	7611	11.02	8065.82	234.85	17.35	13.36	22.52	6172	4755	8012	12.98	8317.96	244.52
May-11	34.94	22.82	53.51	10377	6776	15892	20.54	8219.01	229.82	31.52	24.69	40.24	11214	8785	14315	12.24	8475.94	269.46
Jun-11	4.95	3.71	6.61	1471	1103	1963	14.12	4209.17	113.50	4.95	3.67	6.67	1761	1306	2374	14.94	4340.75	124.16
Jul-11	3.32	2.04	5.40	985	605	1603	23.83	1935.93	52.08	4.02	2.15	7.50	1429	765	2668	31.94	1996.45	55.71
Aug-11	7.40	5.09	10.76	2197	1511	3194	18.35	1487.11	40.26	11.50	8.17	16.19	4092	2908	5759	17.22	1533.60	42.31
Sep-11	7.28	4.14	12.79	2161	1229	3799	28.26	1832.47	45.29	9.60	5.20	17.72	3414	1850	6303	31.44	1889.76	53.50
Oct-11	0.80	0.29	2.20	238	87	654	51.16	1821.61	51.47	1.32	0.73	2.38	470	261	847	29.73	1878.56	55.42
Wint (1)	0.80	0.32	2.01	238	95	598	45.67	853.61	20.83	2.92	1.66	5.13	1039	592	1824	28.43	880.29	24.58
Wint (2)	0.98	0.57	1.66	290	171	494	25.88	264.63	7.88	1.11	0.69	1.79	396	245	638	23.89	272.90	8.35
Wint (3)	1.08	0.59	1.97	319	175	584	28.92	149.84	4.85	1.24	0.75	2.03	440	268	723	24.83	154.53	5.06
Feb-12	1.38	0.79	2.41	411	236	716	26.65	313.37	8.70	3.08	1.99	4.77	1095	707	1695	22.27	323.17	9.29
Mar-12	5.59	3.40	9.19	1660	1010	2729	23.78	1773.26	53.01	4.26	2.58	7.05	1517	918	2508	25.32	1828.70	55.03

Table 36. Density and abundance estimates derived from Distance sampling for razorbill.

	Wind farm sites									Buffer								
Month	**Density**	**UCL**	**LCL**	**Abundance**	**UCL**	**LCL**	**%CV**	**Abundance (DSM)**	**Std error**	**Density**	**UCL**	**LCL**	**Abundance**	**UCL**	**LCL**	**%CV**	**Abundance (DSM)**	**Std error**
Apr-10	1.30	0.66	2.59	387	195	770	33.55	1853.02	768.10	1.07	0.62	1.85	382	222	658	27.44	1867.53	887.10
May-10	29.91	19.22	46.55	8883	5708	13824	22.12	2432.87	868.25	10.71	6.91	16.60	3810	2458	5906	22.20	2451.92	751.90
Jun-10	1.14	0.54	2.39	338	161	710	36.49	1844.60	698.74	0.51	0.25	1.00	180	91	356	34.79	1859.05	600.75
Jul-10	0.13	0.05	0.32	38	15	95	44.90	511.91	200.03	0.36	0.16	0.83	130	57	295	41.35	515.92	196.82
Aug-10	0.08	0.02	0.26	24	7	77	59.76	52.73	22.95	0.33	0.14	0.79	116	48	282	46.06	53.14	27.92
Sep-10	1.40	0.78	2.50	414	232	741	28.45	4.00	4.05	0.71	0.27	1.83	252	97	652	49.77	4.03	5.42
Oct-10	0.06	0.02	0.25	19	5	74	70.21	0.68	5.65	0	0	0	0	0	0	0	0.69	3.32
Nov-10	0.06	0.01	0.38	19	3	113	99.73	0.65	3.39	0.16	0.05	0.58	57	16	205	69.20	0.65	3.49

Table 36. Density and abundance estimates derived from Distance sampling for razorbill.

	Wind farm sites									Buffer								
Month	**Density**	**UCL**	**LCL**	**Abundance**	**UCL**	**LCL**	**%CV**	**Abundance (DSM)**	**Std error**	**Density**	**UCL**	**LCL**	**Abundance**	**UCL**	**LCL**	**%CV**	**Abundance (DSM)**	**Std error**
Dec-10	0.13	0.02	0.74	38	7	220	80.06	3.77	5.99	0.03	0.00	0.15	10	2	53	100.96	3.80	7.20
Jan-11	0.71	0.24	2.12	210	70	629	55.61	55.56	27.78	0.46	0.22	0.96	163	77	343	37.98	55.99	26.46
Feb-11	0.56	0.24	1.33	167	70	395	43.48	570.75	171.23	0.65	0.25	1.69	233	90	601	48.87	575.22	219.64
Mar-11	1.63	0.98	2.71	485	292	805	25.10	1712.76	573.86	3.83	2.06	7.11	1361	733	2529	31.39	1726.17	660.90
Apr-11	7.44	5.46	10.14	2210	1621	3012	15.20	1629.57	554.01	5.39	3.85	7.54	1919	1371	2684	16.78	1642.33	507.00
May-11	4.59	2.28	9.24	1364	678	2745	33.66	1122.49	400.37	4.24	2.85	6.32	1510	1015	2247	20.20	1131.28	366.22
Jun-11	1.40	0.70	2.83	417	207	841	33.81	1264.48	425.64	2.91	1.73	4.88	1034	617	1735	26.37	1274.38	363.70
Jul-11	2.28	1.52	3.43	678	451	1020	20.41	2631.40	1100.95	3.04	1.60	5.75	1080	570	2046	32.60	2652.01	1021.30
Aug-11	26.97	19.08	38.12	8009	5666	11321	17.24	5330.41	3118.30	17.82	12.77	24.87	6340	4543	8847	16.95	5372.16	4372.12
Sep-11	6.70	3.58	12.53	1990	1065	3721	31.62	4551.52	1533.43	20.88	13.63	31.99	7430	4850	11382	21.81	4587.17	1642.17
Oct-11	0.12	0.02	0.63	36	7	188	81.50	1199.95	354.10	0.36	0.14	0.94	130	50	334	48.58	1209.35	345.81
Wint (1)	0.16	0.07	0.39	48	19	117	43.80	164.83	57.58	1.46	0.37	5.75	519	132	2046	67.13	166.12	55.67
Wint (2)	0.52	0.11	2.42	156	34	720	63.37	33.39	21.42	0.19	0.06	0.64	67	20	227	64.96	33.65	19.67
Wint (3)	1.00	0.40	2.50	298	119	743	45.69	23.88	12.68	0.69	0.29	1.61	244	104	573	44.05	24.07	12.13
Feb-12	0.59	0.29	1.20	176	87	356	35.12	70.82	39.74	0.61	0.34	1.11	218	120	396	30.36	71.37	35.96
Mar-12	1.50	0.78	2.89	445	231	858	32.28	491.30	246.87	0.54	0.28	1.01	191	101	360	32.16	495.15	216.09

Table 37. Density and abundance estimates derived from Distance sampling for unidentified guillemot/razorbill.

	Wind farm sites							Buffer						
Month	**Density**	**UCL**	**LCL**	**Abundance**	**UCL**	**LCL**	**%CV**	**Density**	**UCL**	**LCL**	**Abundance**	**UCL**	**LCL**	**%CV**
Apr-10	0.49	0.18	1.31	146	54	390	47.99	0.06	0.01	0.31	20	4	109	100.42
May-10	41.00	20.43	82.26	12175	6067	24430	34.58	8.26	3.05	22.34	2937	1086	7947	52.20
Jun-10	1.43	0.36	5.62	424	108	1670	66.91	0.09	0.03	0.27	33	11	97	56.24
Jul-10	0.04	0.01	0.15	13	4	45	62.48	0.84	0.03	27.26	299	9	9699	119.00
Aug-10	0	0	0	0	0	0	0	0.16	0.01	2.22	56	4	789	101.98
Sep-10	0.40	0.12	1.29	119	37	384	59.93	0.21	0.10	0.42	73	36	148	35.83
Oct-10	0.04	0.01	0.15	13	4	45	62.48	0.13	0.03	0.52	47	12	184	73.34
Nov-10	0.02	0	0.14	7	1	42	104.32	0.04	0.01	0.14	13	4	48	69.96
Dec-10	0.11	0.01	0.88	33	4	262	87.14	0.06	0.01	0.31	20	4	110	101.12
Jan-11	1.05	0.40	2.78	311	117	825	49.25	0.84	0.33	2.15	299	117	765	48.07
Feb-11	0.87	0.41	1.83	258	122	545	37.45	0.82	0.29	2.30	292	105	817	54.16
Mar-11	3.10	1.39	6.92	920	412	2056	41.04	5.47	2.33	12.85	1947	829	4572	44.64
Apr-11	11.15	7.13	17.42	3310	2118	5173	22.17	3.40	2.12	5.44	1210	755	1937	24.03
May-11	17.48	9.23	33.08	5190	2742	9824	31.76	24.42	16.10	37.01	8686	5729	13168	21.07
Jun-11	1.00	0.47	2.14	298	140	636	38.45	0.34	0.13	0.86	120	47	305	48.72
Jul-11	1.00	0.39	2.55	298	117	758	45.52	3.42	0.76	15.45	1216	269	5498	80.62
Aug-11	25.19	17.24	36.80	7481	5121	10930	18.79	25.26	17.49	36.47	8985	6223	12973	18.50
Sep-11	5.75	2.54	13.03	1708	754	3871	41.68	10.95	6.55	18.30	3894	2329	6512	26.21
Oct-11	0.18	0.03	1.08	53	9	322	79.24	0.07	0.02	0.29	27	7	104	75.36

Table 37. Density and abundance estimates derived from Distance sampling for unidentified guillemot/razorbill.

	Wind farm sites							Buffer						
Month	**Density**	**UCL**	**LCL**	**Abundance**	**UCL**	**LCL**	**%CV**	**Density**	**UCL**	**LCL**	**Abundance**	**UCL**	**LCL**	**%CV**
Wint (1)	0.27	0.04	1.87	79	11	555	109.25	0.37	0.07	1.87	133	27	665	77.27
Wint (2)	0.62	0.26	1.53	185	76	453	45.06	0.02	0.00	0.10	7	1	36	99.98
Wint (3)	0.36	0.03	5.07	106	7	1507	130.74	0.07	0.03	0.18	27	11	65	46.51
Feb-12	0.07	0.02	0.29	20	5	85	74.54	0.02	0	0.10	7	1	36	100.35
Mar-12	0.27	0.12	0.59	79	36	174	38.48	0	0	0	0	0	0	0

Table 38. Density and abundance estimates derived from Distance sampling for little auk.

	Wind farm sites							Buffer						
Month	**Density**	**UCL**	**LCL**	**Abundance**	**UCL**	**LCL**	**%CV**	**Density**	**UCL**	**LCL**	**Abundance**	**UCL**	**LCL**	**%CV**
Apr-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
May-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jun-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jul-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aug-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sep-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oct-10	0.06	0.01	0.36	18	3	107	98.11	0.05	0.01	0.29	18	3	102	101.15
Nov-10	0.25	0.10	0.60	74	30	179	43.46	0.60	0.27	1.35	214	95	481	41.62
Dec-10	0.25	0.08	0.80	74	23	236	58.79	0.32	0.12	0.84	112	42	300	51.35
Jan-11	4.55	1.76	11.73	1350	524	3483	46.90	2.15	1.06	4.38	766	376	1560	36.33
Feb-11	0.25	0.07	0.85	74	21	253	62.73	0.16	0.04	0.59	55	15	211	73.32
Mar-11	0.19	0.03	1.15	55	9	342	103.13	0.44	0.04	4.79	156	14	1703	99.62
Apr-11	0.28	0	66.55	84	0	19762	152.35	0.05	0.01	0.29	18	3	102	100.95
May-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jun-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jul-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aug-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sep-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oct-11	0	0	0	0	0	0	0	0.10	0.03	0.37	37	10	133	69.64
Wint (1)	0.22	0.09	0.53	66	28	158	42.19	0.10	0.02	0.55	37	7	194	96.93
Wint (2)	0.12	0.03	0.48	37	10	143	70.13	0.21	0.04	1.16	74	13	412	84.29
Wint (3)	0.25	0.09	0.72	74	25	214	53.22	0.46	0.17	1.27	165	60	452	53.09
Feb-12	0.12	0.03	0.47	37	10	139	68.43	0.10	0.03	0.36	37	11	129	67.49
Mar-12	0.57	0.21	1.59	171	62	471	50.93	0.60	0.21	1.72	213	74	613	55.92

Table 39. Density and abundance estimates derived from Distance sampling for puffin.

	Wind farm sites									Buffer								
Month	Density	CIs		Abundance	CIs		%CV	Abundance (DSM)	Std error	Density	CIs		Abundance	CIs		%CV	Abundance (DSM)	Std error
Apr-10	1.18	0.68	2.03	349	202	603	26.30	1467.26	483.01	1.20	0.65	2.22	428	232	789	30.91	1509.38	481.02
May-10	16.22	12.48	21.09	4817	3705	6262	13.05	1045.53	295.79	9.27	7.11	12.09	3297	2528	4300	13.37	1075.54	282.75
Jun-10	0.70	0.28	1.75	209	84	520	45.27	1040.88	290.00	0.73	0.43	1.25	261	153	446	26.76	1070.76	333.84
Jul-10	1.05	0.60	1.85	313	178	551	27.06	1330.99	14.71	2.82	1.94	4.11	1004	689	1463	19.09	1369.20	12.59
Aug-10	3.37	2.19	5.19	1002	652	1541	20.61	1252.45	360.91	4.26	3.28	5.55	1517	1165	1976	13.29	1288.40	368.49
Sep-10	2.18	1.60	2.98	649	475	885	15.03	505.26	163.91	1.64	1.19	2.27	584	423	808	16.11	519.77	165.25
Oct-10	0.34	0.10	1.13	100	30	337	61.57	94.10	34.06	0.21	0.10	0.47	75	34	166	40.63	96.80	35.06
Nov-10	0.22	0.10	0.50	65	29	149	39.74	18.30	9.32	0.28	0.12	0.68	100	42	241	45.42	18.83	10.30
Dec-10	0.18	0.06	0.54	52	17	159	55.99	10.39	5.46	0.08	0.03	0.23	28	10	82	56.33	10.69	6.75
Jan-11	0.09	0.02	0.36	28	7	108	69.61	26.78	10.71	0.15	0.05	0.48	53	16	171	62.80	27.55	10.71
Feb-11	0.03	0.01	0.19	9	2	58	102.95	181.78	53.64	0.03	0.00	0.14	9	2	50	98.98	187.00	52.28
Mar-11	0.16	0.06	0.38	47	19	113	43.17	1043.91	324.14	0.16	0.06	0.44	56	20	157	53.49	1073.87	328.76
Apr-11	8.58	5.90	12.49	2548	1751	3709	18.08	2207.22	600.42	8.77	5.67	13.57	3120	2016	4828	21.81	2270.58	637.58
May-11	5.79	2.95	11.35	1720	877	3372	32.90	1921.80	572.34	7.36	4.55	11.91	2618	1617	4239	24.26	1976.96	581.55
Jun-11	2.03	1.41	2.94	603	418	872	18.11	1600.72	432.14	1.83	1.25	2.67	651	446	951	19.15	1646.67	522.12
Jul-11	5.34	3.79	7.51	1585	1127	2230	16.83	2444.97	703.26	1.85	1.15	2.96	657	410	1052	23.73	2515.15	784.04
Aug-11	21.22	16.93	26.61	6303	5027	7902	10.92	4849.39	1545.51	17.44	14.68	20.73	6205	5222	7374	8.64	4988.60	1787.05
Sep-11	5.49	3.36	8.97	1630	998	2663	23.95	3726.39	1149.17	10.55	7.36	15.14	3755	2618	5386	18.33	3833.35	1134.71
Oct-11	0.37	0.20	0.67	109	60	198	28.65	415.48	120.52	0.38	0.23	0.61	134	82	218	24.45	427.40	145.15
Wint (1)	0.09	0.03	0.30	28	9	90	58.53	10.04	8.38	0.18	0.09	0.36	66	33	129	34.07	10.32	10.38
Wint (2)	0.31	0.13	0.75	93	39	223	42.40	0.35	3.34	0.34	0.17	0.66	120	61	234	34.10	0.36	2.62
Wint (3)	0.03	0.01	0.19	9	2	56	100.13	0.16	1.14	0.18	0.09	0.38	66	32	134	36.20	0.17	1.23
Feb-12	0.60	0.28	1.29	179	84	382	36.48	2.17	3.63	0.30	0.12	0.75	105	41	268	48.54	2.23	4.03
Mar-12	0.34	0.17	0.67	100	51	198	32.85	265.44	84.12	0.27	0.15	0.50	96	52	178	31.10	273.06	83.77

3.1.4 Literature Review of Moray Firth seabird densities

For assessment of the offshohre cable route, bird density data are taken from the literature to provide density information that includes offshore and near-shore areas of the Moray Firth. These data are taken from an analysis of 26 years of ESAS surveys undertaken by JNCC (Kober *et al*., 2010), and are summarised in Table 40.

Table 40. Summary of JNCC ESAS survey data analysis for the Moray Firth, Kober *et al*., 2010.

Species	Season	Density, km^2
Fulmar	breeding	5 - 16
	winter	3 - 7
Sooty shearwater	summer	0.14 - 1.48
Manx shearwater	breeding	0.1 - 3.7
European Storm petrel	breeding	0.1 - 0.9
Gannet	breeding	0.9 - 2.9
	winter	0.4 - 1
Cormorant	breeding	0.03 - 0.288
	winter	0 - 0.21
Shag	breeding	0 - 5.73
	winter	0 - 8
Pomarine skua	spring	0.01 - 0.089
	autumn	0.007 - 0.043
Arctic skua	breeding	0.019 - 0.21
	autumn	0.014 - 1.112
Great skua	breeding	0.1 - 0.15
	winter	0.01 - 0.31
Kittiwake	breeding	0.1 - 185.0
	winter	0.1 - 20.5
Black-headed gull	winter	0.01 - 0.3
Little gull	autumn	0.01 - 0.07
Great black-backed gull	breeding	0.01 - 0.81
	winter	0.01 - 1.21
Common gull	breeding	0.01 - 0.19
	winter	0.1 - 1.1
Lesser black-backed gull	breeding	0.1 - 4.0
	winter	0.1 - 4.0
Herring gull	breeding	0.1 - 44.8
	winter	0.1 - 9.2
Glaucous gull	winter	0.001 - 0.088
Sandwich tern	breeding	0.001 - 0.010
Common tern	breeding	0.001 - 0.307
Arctic tern	breeding	0.01 - 0.93
Guillemot	breeding	0.1 - 713.4

Table 40. Summary of JNCC ESAS survey data analysis for the Moray Firth, Kober *et al.*, 2010.

Species	Season	Density, km^2
	autumn	0.1 - 254.8
	winter	0.1 - 62.7
Razorbill	breeding	0.1 - 22.0
	autumn	0.1 - 30.5
	winter	0.1 - 15.8
Little auk	winter	0.1 - 0.6
Puffin	breeding	0.1 - 14.8
	winter	0.1 - 3.8

3.1.5 Flight direction analysis

Flight directions of five key species (fulmar, kittiwake, guillemot, razorbill and puffin) were analysed in order to assess levels of connectivity with the sites for birds breeding at the three adjacent SPAs designated for seabirds. The three proposed wind farm sites were divided into three zones, each comprising six transects. Zone 1 contained the northernmost six transects, zone 2 the central six transects, and zone 3 the southernmost six transects. The wind farm sites were divided up as such to help ascertain whether birds using different parts of the sites were associated with the different SPAs. Strong patterns of directional bi-modality would indicate bird traffic to and from an SPA, set against a background of random flights. These data are summarised in Table 41.

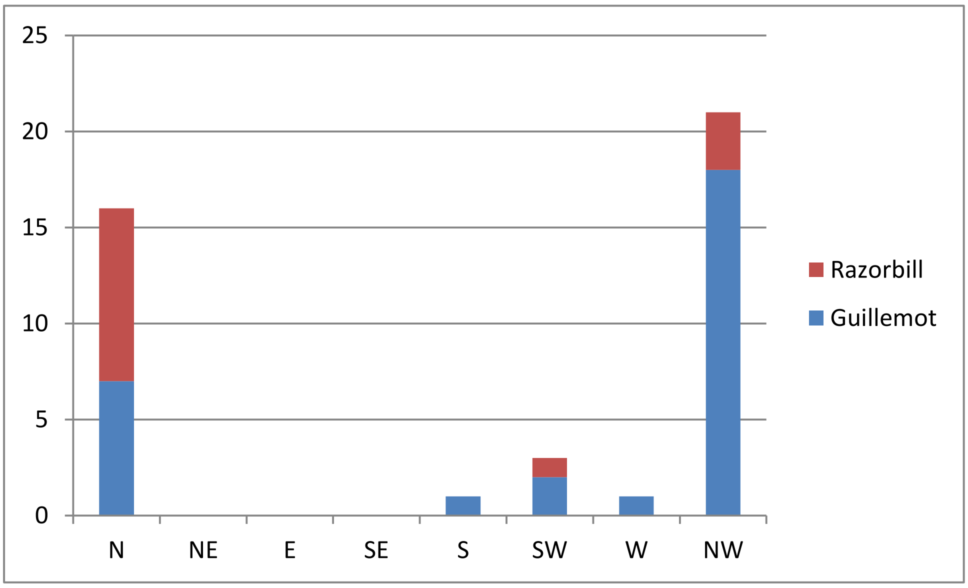
Table 41 Results of flight direction analysis.

		N	NE	E	SE	S	SW	W	NW
Fulmar	Zone 1 raw data	96.0	37.0	225.0	168.0	253.0	68.0	250.0	283.0
	Zone 2 raw data	178.0	90.0	437.0	432.0	236.0	138.0	657.0	504.0
	Zone 3 raw data	159.0	53.0	304.0	229.0	128.0	128.0	388.0	451.0
	Zone 1 %	7.0	2.7	16.3	12.2	18.3	4.9	18.1	20.5
	Zone 2 %	6.7	3.4	16.4	16.2	8.8	5.2	24.6	18.9
	Zone 3 %	8.6	2.9	16.5	12.4	7.0	7.0	21.1	24.5
Kittiwake	Zone 1 raw data	40.0	23.0	56.0	109.0	339.0	93.0	43.0	105.0
	Zone 2 raw data	359.0	153.0	182.0	348.0	399.0	140.0	307.0	498.0
	Zone 3 raw data	307.0	70.0	422.0	248.0	375.0	217.0	152.0	400.0
	Zone 1 %	5.0	2.8	6.9	13.5	42.0	11.5	5.3	13.0
	Zone 2 %	15.0	6.4	7.6	14.6	16.7	5.9	12.9	20.9
	Zone 3 %	14.0	3.2	19.3	11.3	17.1	9.9	6.9	18.3
Guillemot	Zone 1 raw data	265.0	13.0	34.0	219.0	738.0	225.0	52.0	683.0
	Zone 2 raw data	662.0	78.0	149.0	851.0	990.0	234.0	144.0	985.0
	Zone 3 raw data	343.0	26.0	57.0	445.0	749.0	155.0	105.0	386.0

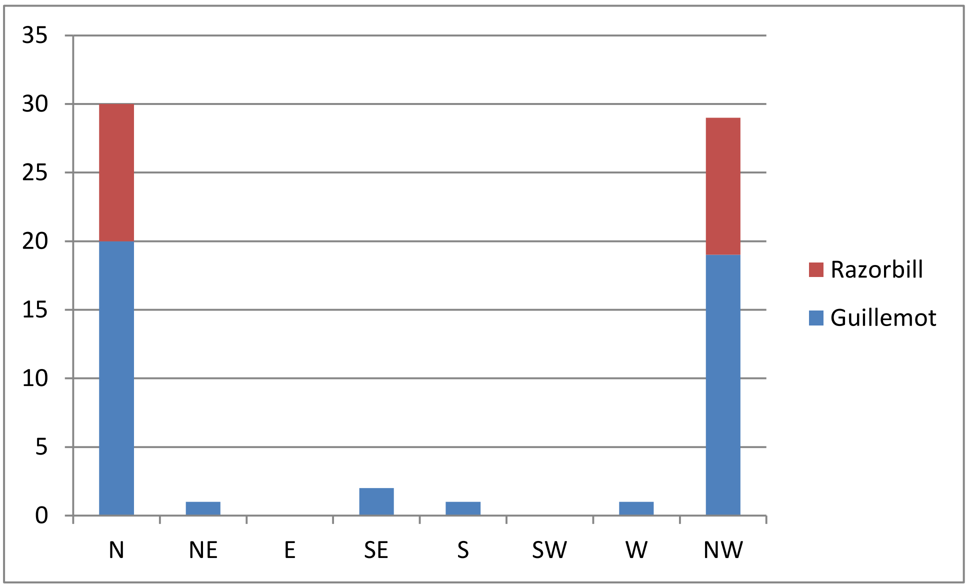
Table 41 Results of flight direction analysis.

		N	**NE**	**E**	**SE**	**S**	**SW**	**W**	**NW**
	Zone 1 %	11.9	0.6	1.5	9.8	33.1	10.1	2.3	30.6
	Zone 2 %	16.2	1.9	3.6	20.8	24.2	5.7	3.5	24.1
	Zone 3 %	15.1	1.1	2.5	19.6	33.1	6.8	4.6	17.0
Razorbill	Zone 1 raw data	64.0	5.0	2.0	29.0	143.0	66.0	3.0	72.0
	Zone 2 raw data	130.0	25.0	27.0	53.0	112.0	25.0	14.0	193.0
	Zone 3 raw data	120.0	15.0	15.0	93.0	245.0	31.0	31.0	89.0
	Zone 1 %	16.7	1.3	0.5	7.6	37.2	17.2	0.8	18.8
	Zone 2 %	22.5	4.3	4.7	9.2	19.3	4.3	2.4	33.3
	Zone 3 %	18.8	2.3	2.3	14.6	38.3	4.9	4.9	13.9
Puffin	Zone 1 raw data	83.0	10.0	16.0	52.0	164.0	71.0	15.0	146.0
	Zone 2 raw data	313.0	68.0	5.0	86.0	151.0	68.0	25.0	241.0
	Zone 3 raw data	111.0	27.0	3.0	10.0	55.0	24.0	32.0	54.0
	Zone 1 %	14.9	1.8	2.9	9.3	29.4	12.7	2.7	26.2
	Zone 2 %	32.7	7.1	0.5	9.0	15.8	7.1	2.6	25.2
	Zone 3 %	35.1	8.5	0.9	3.2	17.4	7.6	10.1	17.1

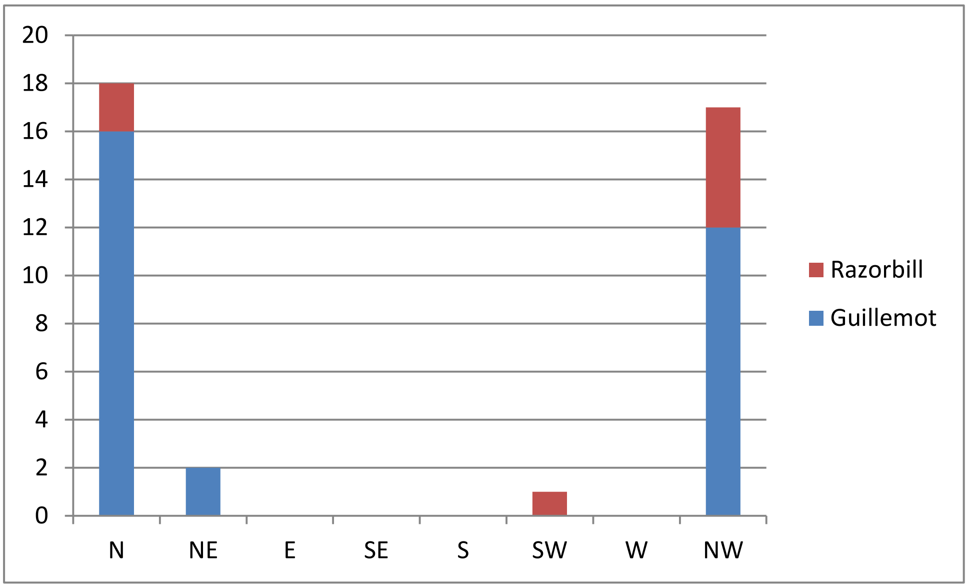
Seabirds are central-place foragers, and as such will make direct return flights towards the colony once a suitable prey item has been selected. Using the recorded flight directions of birds observed carrying food items gives a clearer indication of which colonies birds are associated with, as random flights are removed from the dataset. This approach however is only suitable for certain species such as auks, which carry food back to the colony in their bills, making it visible to boat-based observers (see Graphs 1-3).



Graph 1. Flight directions for all species from Zone 1 (Transects 1–6)



Graph 2. Flight directions for all species from Zone 2 (Transects 7–12)



Graph 3. Flight directions for all species from Zone 3 (Transects 13–18)

Discussion

Most of the five key species show some bimodality along a north or north-westerly – south or south-easterly axis, indicating that a large proportion of birds are travelling along this ‘route’ as opposed to making random flights. This is especially prominent among the auks. The species where this pattern is less obvious (fulmar and kittiwake) are those with larger foraging ranges and thus possibly less tied to feeding in areas directly adjacent to the colonies.

The assumption that this bimodality is linked to flights to and from breeding colonies for guillemot and razorbill is supported by the recorded flight directions of birds carrying food. Almost all of these birds were travelling in a north or north-westerly direction. This fits in with the pattern expected of birds returning towards the East Caithness Cliffs SPA or the North Caithness Cliffs SPA. The lack of records of birds with food travelling south or south-east suggests that birds flying in these directions are most likely to be leaving the colony and heading toward a preferred feeding ground. The analysis of birds carrying food was not undertaken for other species such as fulmar and kittiwake, as these carry food for the young in the crop.

Both datasets therefore suggest a link between the survey area and breeding grounds to the north or north-west, most likely the North Caithness Cliffs SPA or the northern section of the East Caithness cliffs SPA. The proportion of birds recorded in flight towards these SPAs can be used as a proxy for the proportion of the entire population of the survey area using the SPAs.

Table 42. Percentage of each species travelling to each SPA (weighted by abundance in each zone) for all records of flying birds in transect, and for birds with food.

	North Caithness Cliffs SPA		East Caithness Cliffs SPA		Troup, Pennan and Lions Heads SPA	
Species	**flying birds**	**Birds with food**	**flying birds**	**Birds with food**	**flying birds**	**Birds with food**
Fulmar	17.4		82.5		(17.4)	
Kittiwake	21.2		66.1		12.7	
Guillemot	41.2	44.7	58.8	51.5		3.9
Razorbill	50.3	51.2	49.7	48.8		
Puffin	80.4		19.6			

The above data were used to determine precautionary estimates of the proportion of birds of each species using the sites, from the three SPAs. The precautionary nature of these estimates means that their sum is greater than 100%. These estimates are provided in Table 43. Due to the proportion of birds flying to the three SPAs combined being >100%, summing the estimates of numbers displaced from the three SPAs will be greater than the total displacement estimate for the three SPAs combined.

Table 43. Precautionary estimates of the proportions of birds of each species using the sites, from three SPAs.

Species	North Caithness Cliffs SPA	East Caithness Cliffs SPA	Troup, Pennan and Lion's Heads SPA

Table 43. Precautionary estimates of the proportions of birds of each species using the sites, from three SPAs.

Species	North Caithness Cliffs SPA	East Caithness Cliffs SPA	Troup, Pennan and Lion's Heads SPA
Fulmar	25%	90%	25%
Kittiwake	30%	75%	25%
Guillemot	50%	60%	5%
Razorbill	40%	75%	5%
Puffin	85%	25%	0%

Great black-backed and herring gulls

For the purpose of analysis for great black-backed gull, 100% of SPA-nesters are assumed to be from the East Caithness Cliffs SPA. For herring gull, 75% of SPA-nesters are assumed to be from each of East Caithness Cliffs SPA and Troup, Pennan and Lion's Heads SPA.

For herring gull and great black-backed gull, the proportion of birds recorded within the three proposed wind farm sites that are likely to originate from these three SPAs was estimated. This was taken from Seabird 2000 data (Mitchell *et al*., 2004) since this is the most recent data source for colonies from the whole region being counted.

For herring gull, 5220 pairs bred within the three SPAs out of a total of 12255 pairs (43%) within the mean maximum foraging distance (61 km per Thaxter *et al*., 2012) of herring gull from the site (3505 in 'east coast Caithness', 33 in 'east coast Sutherland', 1345 in 'east coast Ross and Cromarty', 80 in 'Nairn', 581 in 'Moray', and 6711 in 'Banff and Buchan'; Mitchell 2004); a precautionary estimate of 50% of birds being SPA birds during the breeding season has therefore been made.

For great black-backed gull, 180 pairs bred within the three SPAs out of a total of 449 pairs (40%) within 61 km of the site (181 in 'east coast Caithness', 1 in 'east coast Sutherland', 220 in 'east coast Ross and Cromarty', 10 in 'Moray', and 37 in 'Banff and Buchan'; Mitchell 2004); a precautionary estimate of 50% of birds being SPA birds during the breeding season has therefore been made.

For the winter period immigration of birds into the Moray Firth is taken into account by estimating that 75% of herring gulls are immigrants, and 50% of great black-backed gulls (see species accounts for rationale).

3.1.6 Displacement analysis results

The results of the displacement analysis are provided in Tables 44 and 45. A description of the process is found in Section 2.1.8.

Table 44. Displacement analysis using 'worst-case scenario' (WCS) parameters.

	Fulmar	Gannet	Kittiwake	Herring gull	Great black-backed Gull	Guillemot	Razorbill	Puffin
Breeding season abundance	782	100	1963	7	271	6732	1661	1916
Proportion breeding	50%	50%	50%	50%	50%	50%	50%	50%
Displacement rate	100%	100%	50%	50%	50%	100%	100%	100%
Impact rate	100%	100%	100%	100%	100%	100%	100%	100%
East Caithness Cliffs SPA								
Population (individuals)	28404		80820	6786	360	158985	17830	548
% flying towards SPA	90%		75%	38%	50%	60%	75%	25%
Site population from SPA	704		1472	3	136	4039	1246	479
Number that are breeders	352		736	1	68	2020	623	240
Number displaced	352		368	1	34	2020	623	240
Number impacted	352		368	1	34	2020	623	240
North Caithness Cliffs SPA								
Population (individuals)	28336		20294			141168	2463	14090
% flying towards SPA	25%		30%			50%	40%	85%
Site population from SPA	195		589			3366	665	1629
Number that are breeders	98		294			1683	332	814
Number displaced	98		147			1683	332	814
Number impacted	98		147			1683	332	814

Table 44. Displacement analysis using 'worst-case scenario' (WCS) parameters.

	Fulmar	Gannet	Kittiwake	Herring gull	Great black-backed Gull	Guillemot	Razorbill	Puffin
Troup, Pennan and Lion's Heads SPA								
Population (individuals)	3590	3094	34342	3374		17598	3001	
% flying towards SPA	25%	100%	25%	38%		5%	5%	
Site population from SPA	195	100	491	3		337	83	
Number that are breeders	98	50	245	1		168	42	
Number displaced	98	50	123	1		168	42	
Number impacted	98	50	123	1		168	42	

Table 45. Displacement analysis using 'Realistic Scenario' (RS) parameters.

	Fulmar	Gannet	Kittiwake	Herring gull	Great Black-backed Gull	Guillemot	Razorbill	Puffin
Breeding season abundance	782	100	1963	7	271	6732	1661	1916
Proportion breeding	50%	50%	50%	50%	50%	50%	50%	50%
Displacement rate	50%	50%	10%	10%	10%	50%	50%	50%
Impact rate	50%	50%	100%	100%	100%	100%	100%	100%
East Caithness Cliffs SPA								
Population (individuals)	28404		80820	6786	360	158985	17830	548
% flying towards SPA	90%		75%	38%	50%	60%	75%	25%
Site population from SPA	704		1472	3	136	4039	1246	479
Number that are breeders	352		736	1	68	2020	623	240
Number displaced	176		74	0	7	1010	311	120

Table 45. Displacement analysis using 'Realistic Scenario' (RS) parameters.

	Fulmar	Gannet	Kittiwake	Herring gull	Great Black-backed Gull	Guillemot	Razorbill	Puffin
Number impacted	88		74	0	7	1010	311	120
North Caithness Cliffs SPA								
Population (individuals)	28336		20294			141168	2463	14090
% flying towards SPA	25%		30%			50%	40%	85%
Site population from SPA	195		589			3366	665	1629
Number that are breeders	98		294			1683	332	814
Number displaced	49		29			842	166	407
Number impacted	24		29			842	166	407
Troup, Pennan and Lion's Heads SPA								
Population (individuals)	3590	3094	34342	3374		17598	3001	
% flying towards SPA	25%	100%	25%	38%		5%	5%	
Site population from SPA	195	100	491	3		337	83	
Number that are breeders	98	50	245	1		168	42	
Number displaced	49	25	25	0		84	21	
Number impacted	24	13	25	0		84	21	

3.1.7 Population viability analysis results

The results of the PVAs are provided in Appendix A. The key bits of information used from these models are the changes from the baseline due to predicted impacts arising from the development of the three proposed wind farm sites. These changes are colour coded in the following way, according to the **increase in likelihood** of population reduction:

- 1-2%: pale orange;
- 2-5%: orange;
- 5-10%: dark orange; and
- >10%: brown.

3.2 Migration Surveys

The results of the migration surveys are provided in Table 46.

Table 46. Numbers of swans and geese recorded during the spring and autumn Moray Firth migration surveys.

	Observer location	**Whooper swan**	**Pink-footed goose**	**Greylag goose**	**Barnacle goose**	**Unidentified goose**
Autumn	Duncansby Head	7	1357	458	128	189
	Sarclet Head	36	1766	880	79	420
	Whitehills	16	2265	82	231	49
	Rosehearty	34	2990	20	463	120
	BOWL boat survey	0	1510	0	0	57
	MORL boat survey	0	14	0	0	1217
Spring	Duncansby Head	0	29	64	0	49
	Sarclet Head	0	47	2	0	0
	Whitehills	0	2396	37	0	0
	Rosehearty	0	1939	5	0	19
	BOWL boat survey	2	420	20	0	0
	MORL boat survey	0	>1000	0	0	430

The resulting annual collision estimates are also presented, in Table 47. Since 87.5% of the grey goose records were pink-footed goose, and 12.5% were greylag goose, the unidentified goose collision estimates can be attributed to pink-footed and greylag use using these proportions. A flight was judged as 'probably' flying through the wind farm sites if extrapolation of the linear flight direction intersected with one of the sites; a flight was judged as 'possibly' flying through the wind farm sites if this extrapolated flight route was within 2 km of one of the sites.

Table 47. Output of the autumn/spring swan and goose collision risk model for the wind farm sites.

Species	**Extrapolated number of flights**		**Estimated annual collision rate**	
	Possible	**Probable**	**Possible**	**Probable**
Whooper swan	0	36	0	0.1
Pink-footed goose	5202	18705	4.3	15.5
Greylag goose	206	3049	0.2	2.6
Barnacle goose	175	0	0.1	0

3.3 Aerial surveys

The purpose of the aerial survey work was to provide relative distribution information for the wider area, and information on flight directions. A summary of these results is provided in the ES (Chapter 4.5) and in the relevant species accounts, and a fuller account of the results of the aerial surveys can be found in Appendix 4.5 B.

3.4 Seabird Tracking Study

The data from the GPS loggers was used to plot the exact routes taken by each bird on each foraging bout (defined by at least one fix being taken at least one kilometre from the colony), giving data on the duration and range of foraging trips. A summary of these results is provided in the ES (Chapter 4.5) and in the relevant species accounts, and a fuller account of the results of the aerial surveys can be found in Appendix 4.5 C.

4 Species Accounts - Seabirds

4.1 Fulmar

4.1.1 Distribution

Fulmar breed and winter across the north Atlantic and north Pacific regions, from the UK and Japan in the south to high Arctic regions in the north. The UK and Irish breeding population constitutes approximately 3.6-7.2% of the global total, and 12.2-19.2% of the European breeding population (population estimates from Birdlife International: 2004) and the UK fulmar population increased by 1% between 2000 and 2010 (JNCC 2011). It has been estimated that immediately after the breeding season there are approximately 1.5 million fulmar in Scottish waters, and approximately 1 million during the winter months (Forrester *et al*., 2007).

The breeding population of fulmar in Great Britain and Ireland is approximately 537,800 pairs (as estimated from 'apparently occupied site' (AOS) data, 1998-2002), the majority of which (90%) are found in Scotland, particularly in the northern and western islands (Mitchell *et al*., 2004; Image 4). The population sizes of the surrounding regions of Highland, Grampian and Northern Islands are shown in Table 48. These areas contain 24% of the British and Irish fulmar population, with large numbers of fulmars breeding in SPAs close to the three proposed wind farm sites (Table 49).

JNCC analysis of ESAS data collected between 1980 and 2006, to provide at-sea distributions of fulmar during the breeding season and winter period are provided in Images 5a and 5b (Kober *et al*., 2010). These data do not show distributional hotspots for fulmar in proximity to the three proposed wind farm sites.

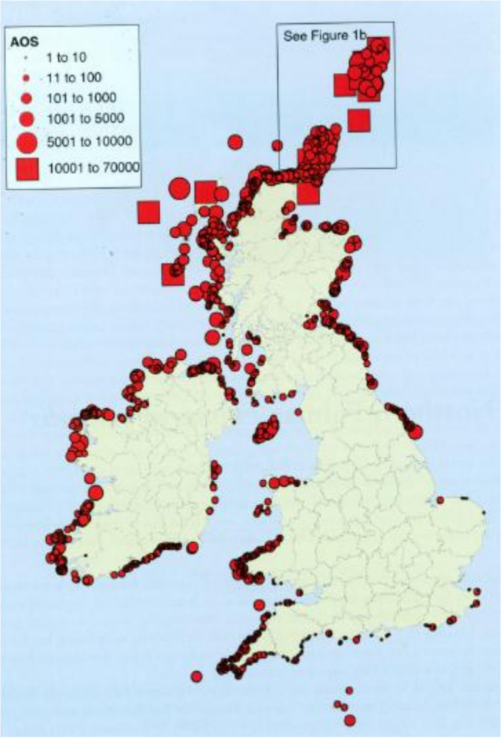


Image 4: Distribution of breeding fulmar, 1998-2002 (taken from Mitchell *et al.*, 2004).

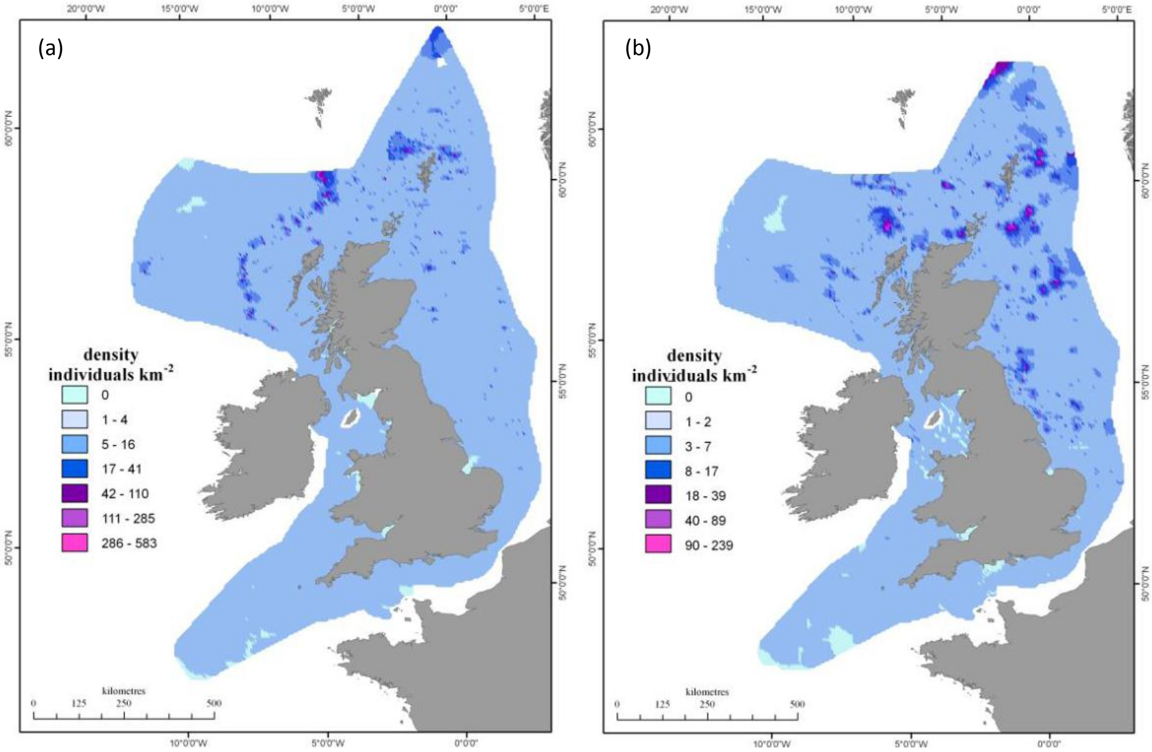


Image 5: JNCC predicted density surface maps produced from ESAS data collected between 1980 and 2006. Left (a): breeding. Right (b): winter. (Taken from Kober *et al*., 2010)

Table 48: Fulmar populations in districts around Moray Firth (Mitchell *et al.*, 2004)

Region	District	Population (AOS)
Northern Isles	Orkney	90,846
Highland	Caithness	29,957
	Ross & Cromarty (east)	1,638
Grampian	Moray	569
	Banff & Buchan	5,146
TOTAL		128,156

Table 49: SPAs designated for fulmar surrounding the wind farm sites

Colony	Location	Colony size (pairs)	Distance from wind farm sites	Count Date
East Caithness Cliffs	Caithness	15,000	20 km	1985-1988*1
North Caithness Cliffs	Caithness	14,700	33 km	1985-1988*1
Troup Head	Banff & Buchan	4,400	49 km	1995
Hoy	Orkney	35,000	58 km	1985-1988*1
Copinsay	Orkney	1,615	61 km	1985-1988*1
Calf of Eday	Orkney	1,955	99 km	1985-1988*1
Rousay	Orkney	1,240	99 km	1986-1988*2
West Westray	Orkney	1,400	108 km	1985-1988*1

*1 Seabird Colony Register Census, *2 three year mean

4.1.2 Annual cycle

Fulmar are present year-round in Scotland, dispersing somewhat during the non-breeding season, but with no pronounced migration. As such, varying numbers of birds are recorded at breeding colonies throughout the year with most nest sites being occupied regularly by January (Forrester *et al*., 2007). Egg laying in Scotland usually occurs in mid-May and the peak incubation period extends to mid-June (Snow and Perrins, 1998). During incubation parents swap the roles of incubation and foraging every 3-5 days (Hatch, 1990). Once the chick hatches it requires constant brooding for the first 15 days and during this period the adult birds alternate much more frequently (Ojowski *et al*., 2001). This usually takes place during the second half of June in Scottish breeding colonies. Chicks usually depart nest sites in August or September and typically range widely across the North Sea, north Atlantic and Arctic (Macdonald, 1977) for, on average, six to twelve years before settling to breed (Snow and Perrins, 1998).

4.1.3 Food preferences

The compositions of fulmar diets vary spatially (Furness and Todd, 1984) and appear to have changed through time. The main elements of fulmar diet are fish, squid, planktonic crustaceans (mainly copepods and amphipods) (Camphuysen and van Franeker, 1996; Phillips *et al.*, 1999a; Snow and Perrins, 1998) and trawler discards (Fisher, 1952; Hobson and Welch, 1992; Camphuysen and Garthe, 1997). Fulmar mostly forage on the sea surface, but are also capable of performing shallow splash and surface dives down to a maximum depth of 3-4 m (Hobson and Welch, 1992; Garthe and Furness, 2001; Snow and Perrins, 1998).

4.1.4 Foraging distances

Changes in feeding behaviour have been suggested as factors contributing to the growth of fulmar populations within recent historical times (Fisher, 1952), as such the foraging ecology of this species has been widely studied. Maximum foraging ranges have been observed to vary throughout the different stages of the breeding period, and differ from year to year and between colonies (Ojowski *et al.*, 2001; Furness and Todd 1984; Hamer *et al.*, 1997).

As part of the seabird tracking studies (Technical Appendix 4.5 B) GPS loggers were attached to fulmar in the East Caithness Cliffs SPA during the incubation and early chick rearing period of their breeding season. 48 tracking devices were deployed, of which 17 were retrieved, providing information about 28 complete foraging trips, and 4 incomplete foraging trips (Images 6 & 7). Based upon the complete foraging tracks the mean foraging range was 59.8 ± 73.9 km and maximum foraging range was 402.2 km. Most foraging birds travelled south-east and east to forage in the outer Moray Firth or further into the North Sea. Thirteen trips passed through the MORL zone, and during two of these birds spent a greater period within the MORL zone and appeared to forage.

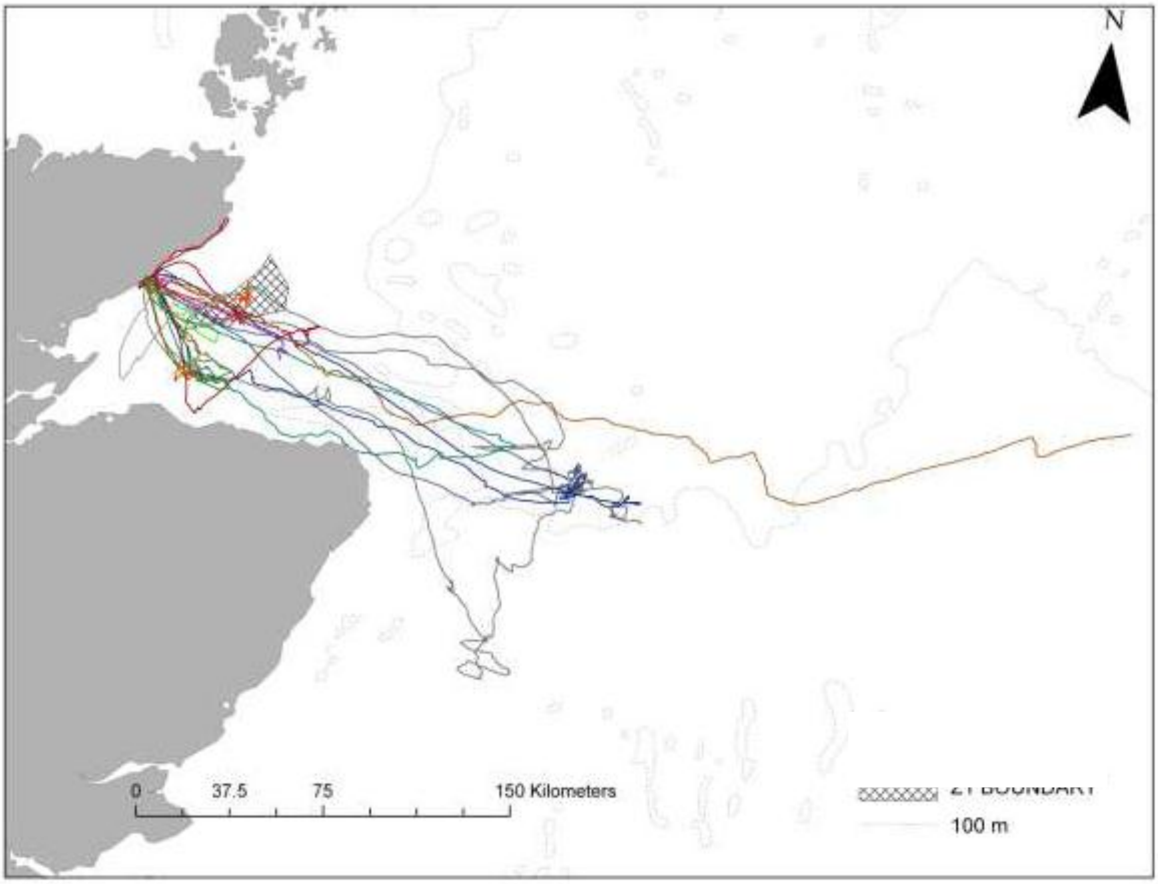


Image 6: GPS tracks of 17 fulmar breeding within the East Caithness Cliffs SPA (cross hatched area shows extent of MORL zone).

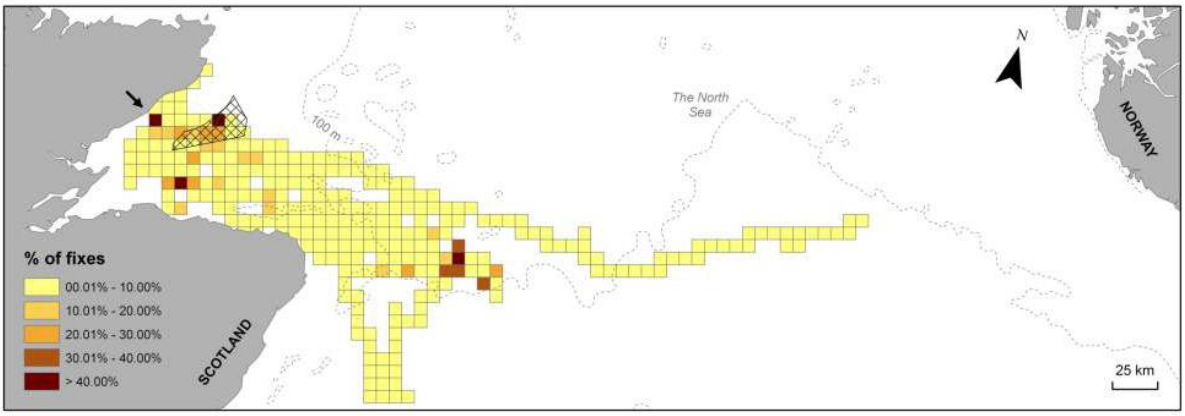


Image 7: Distribution and space use of all fulmar inferred from 2-minute resolution GPS positions (cross hatched area shows extent of MORL zone).

GPS-tracked fulmar from an Orkney colony in 2009 (9 birds) and 2010 (10 birds) foraged up to 2800 km from the colony during pre-breeding and incubation (trips of 2.4 to 15 days), and within 250 km during check-rearing (trips of 0.5-2.4 days) (*per.* Paul Thompson). The range of birds during the pre-laying and incubation periods included the North Sea and the Atlantic Ocean, whilst during chick-rearing their range was more limited but included areas off Aberdeenshire (*per.* Paul Thompson). Dunnet and Ollason (1982) reported a chick-rearing fulmar (the nestling later fledged) being trapped 460 km from its breeding colony in Scotland.

Other information available on foraging ranges of breeding fulmar is based on trip durations. Hamer *et al.* (1997) studied fulmars at two Scottish locations: St Kilda in the Western Isles and Foula in Shetland. They estimated the maximum foraging distances of fulmars from these breeding locations as 245 km and 122 km respectively. However these are likely to be over-estimates as they assumed constant flight speeds without including foraging time. A study in Norway showed foraging trips lasting an average of eight hours during brooding of young chicks; the distance travelled by fulmar at this time was estimated to be an average of 60 km (Weimerskirch *et al.*, 2001).

Where trawler discards constitute a large proportion of fulmar diet, the distribution of fishing boats surrounding colonies has been observed to influence foraging ranges (Garthe and Huppop, 1994).

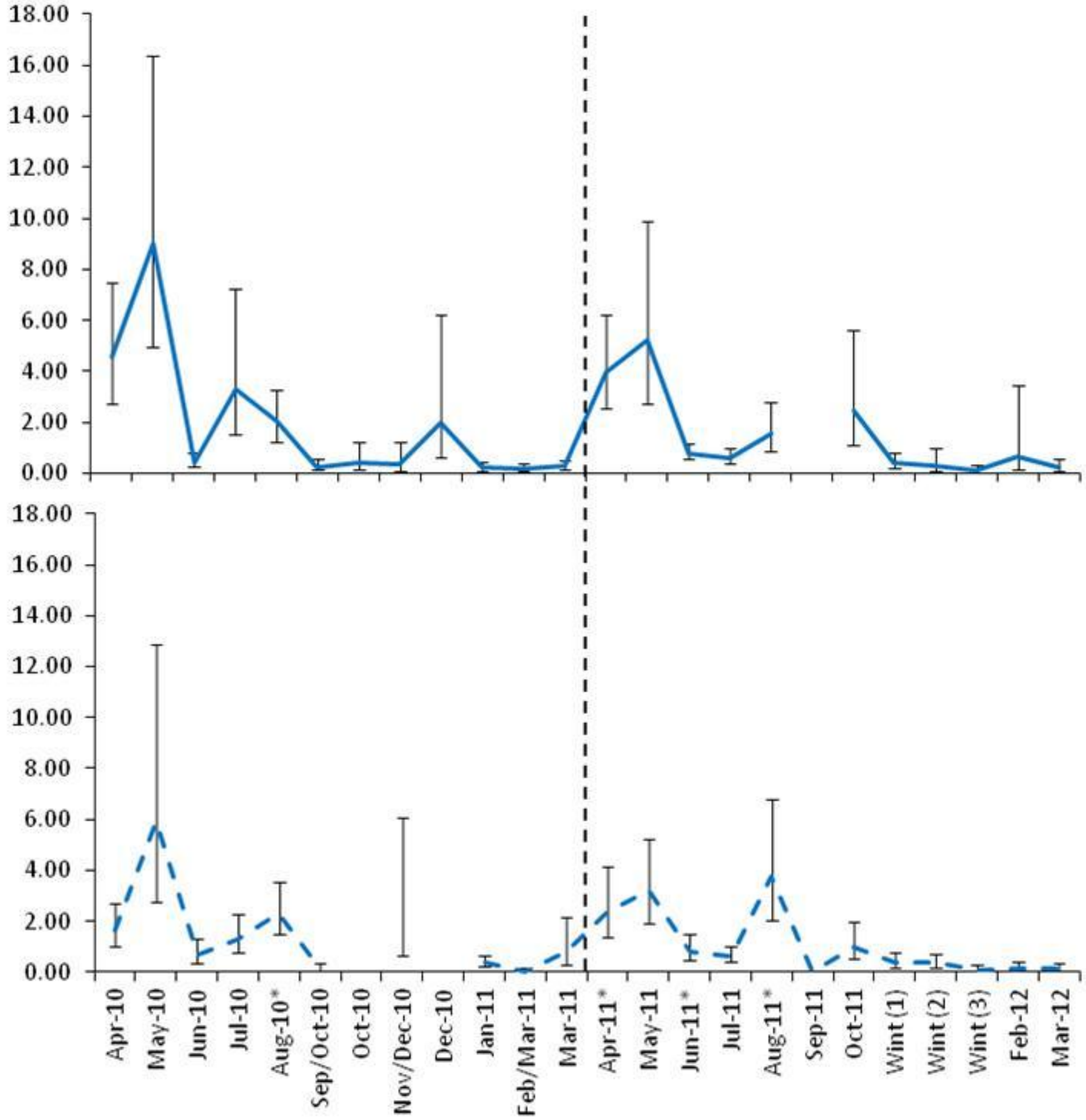
Birdlife International data on foraging distances for fulmar shows a maximum foraging distance of 664 km, a mean maximum of 311.43 km, and a mean foraging distance of 69.35 km.

4.1.5 Abundance and distribution within sites

Fulmar were recorded in all months of the survey. Densities were highest in spring, peaking in the three proposed wind farm sites in May 2010 (9.01 birds/km^2) and May 2011 (5.22 birds/km^2) (Table 28, Graph 4). The peak month for birds recorded using the sea was May 2010, with 532 birds recorded on boat-based surveys (Table 23). Annual variation in numbers recorded in flight is shown in Graph 5. Distribution maps for the species are shown in Figures 1 and 2.

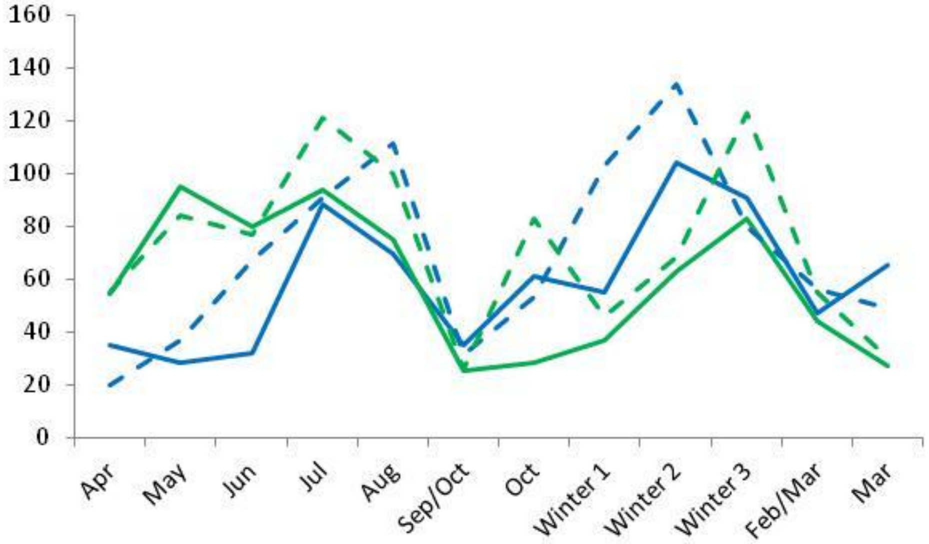
Table 50. Mean density and abundance of fulmar on the three wind farm sites and the buffer zone, in the breeding and non-breeding season, from boat-based surveys

Breeding Season				Non-breeding season			
Density		Abundance		Density		Abundance	
Site	Buffer	Site	Buffer	Site	Buffer	Site	Buffer
2.77	1.91	782	750	0.25	0.20	197	189



Graph 4. Temporal variation in fulmar density (birds/km^2) in the wind farm sites (solid line) and the buffer zone (dotted line) Excludes records with percentage CV greater than 100 (low confidence). In months where two surveys were conducted mean values are displayed. The winter surveys correspond to the three surveys undertaken between November and January.

* Two surveys were conducted during these months. The datasets from both were combined to derive density estimates through distance sampling.



Graph 5: Number of fulmar recorded in flight in transect during each of the MORL boat-based surveys between April 2010 and March 2012. Blue lines refer to surveys during first year. Green lines refer to surveys during second year. Solid lines refer to records within wind farm sites. Dashed lines refer to records within buffer area. In months where two surveys were conducted mean values are displayed. The winter surveys correspond to the three surveys undertaken between November and January.

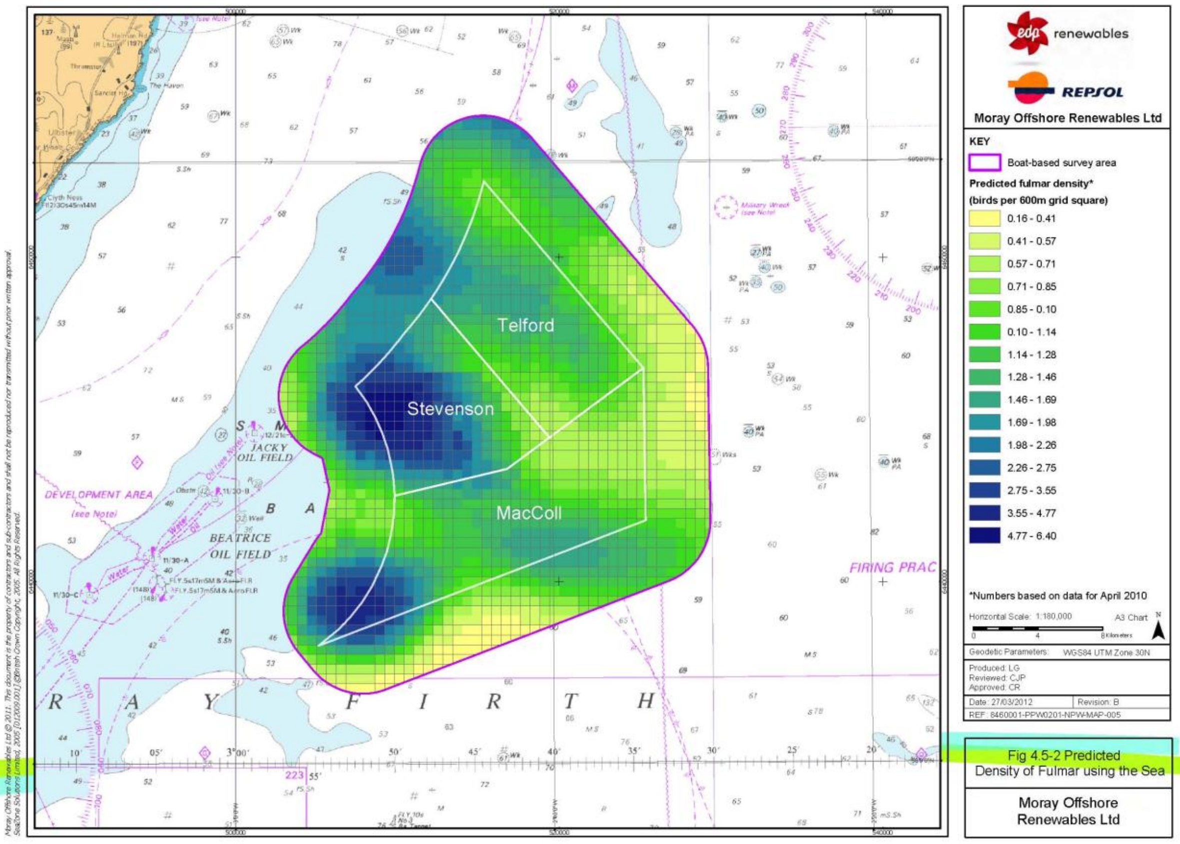


Figure 1. Modelled density surface map for fulmar from April 2010.

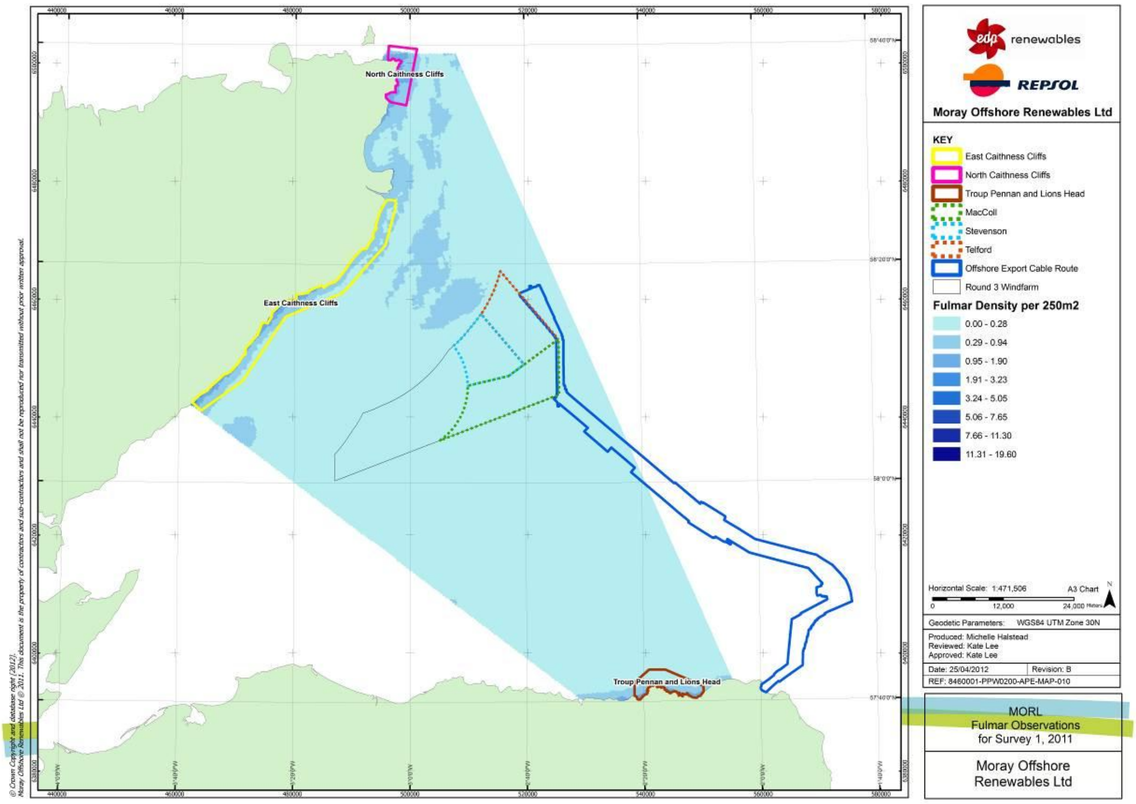


Figure 2a. Distribution of fulmar across the survey area, from digital aerial surveys - Survey 1.

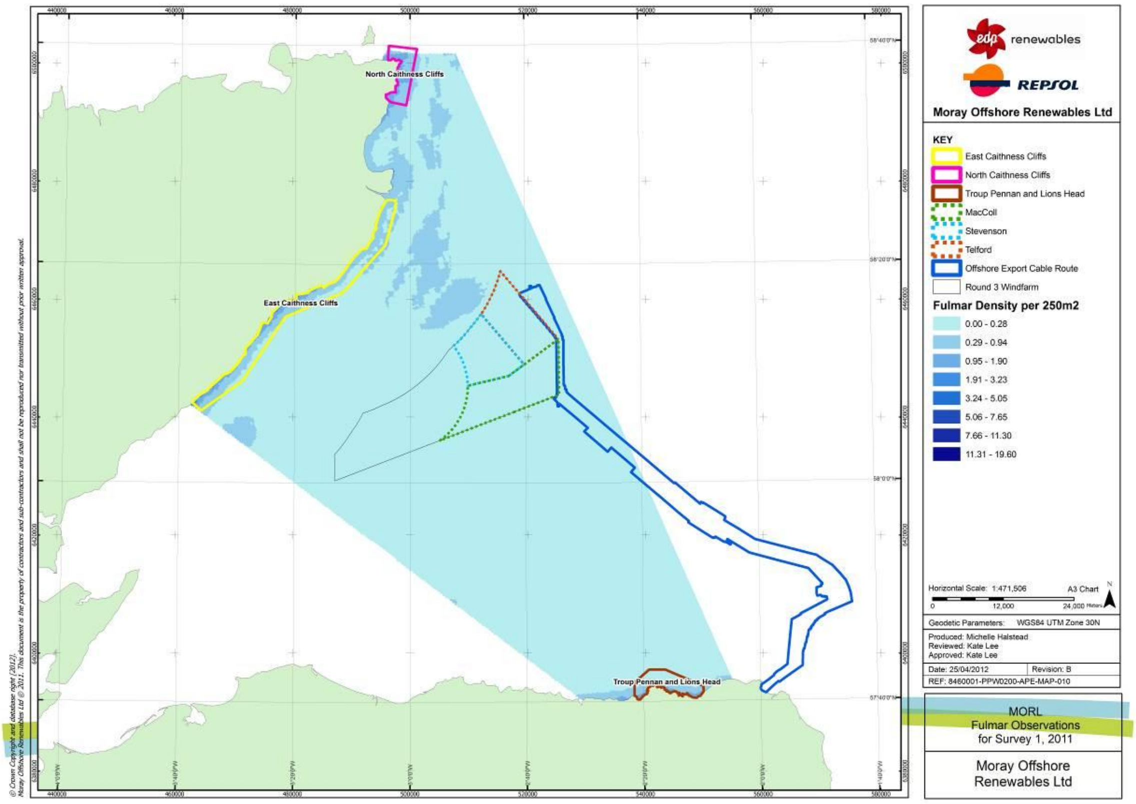


Figure 2b. Distribution of fulmar across the survey area, from digital aerial surveys - Survey 2.

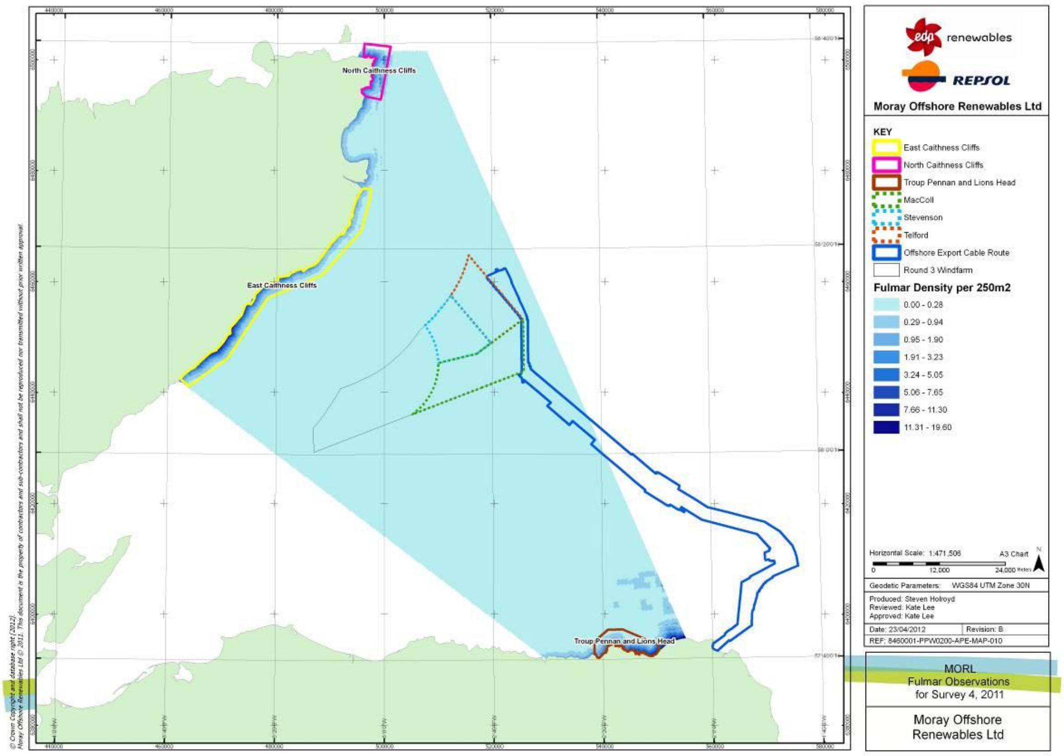


Figure 2c. Distribution of fulmar across the survey area, from digital aerial surveys - Survey 4.

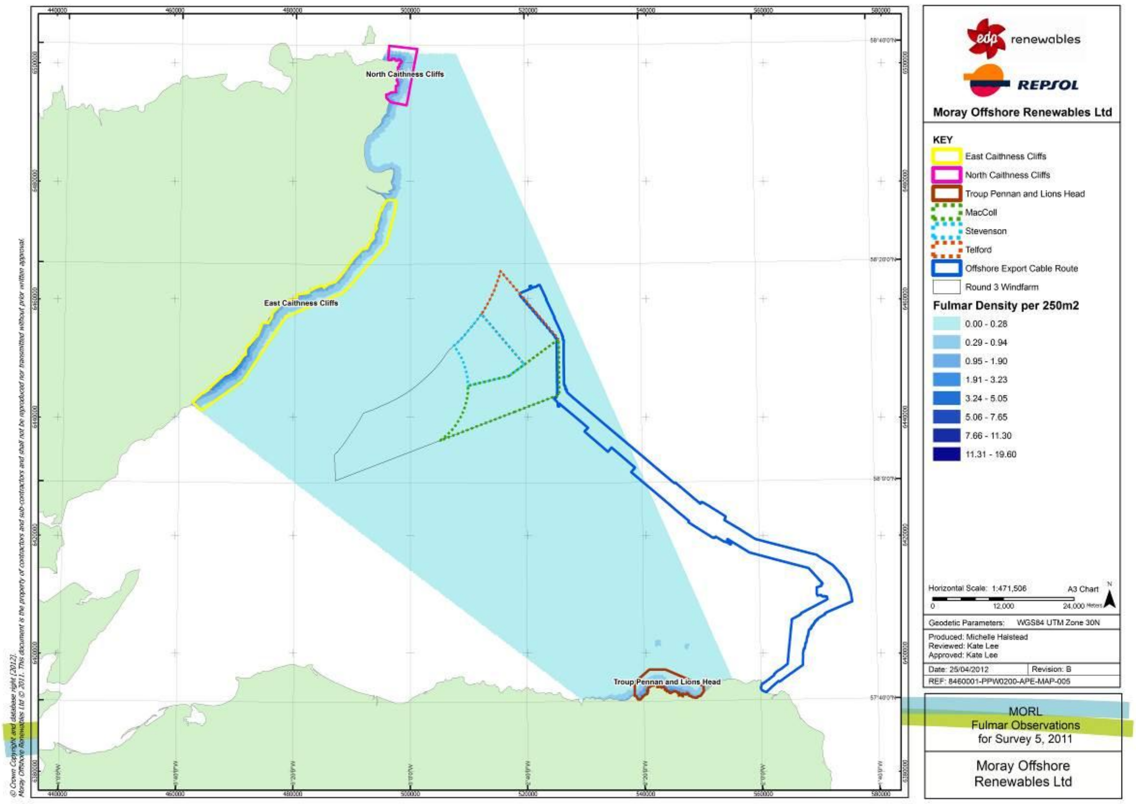


Figure 2d. Distribution of fulmar across the survey area, from digital aerial surveys - Survey 5.

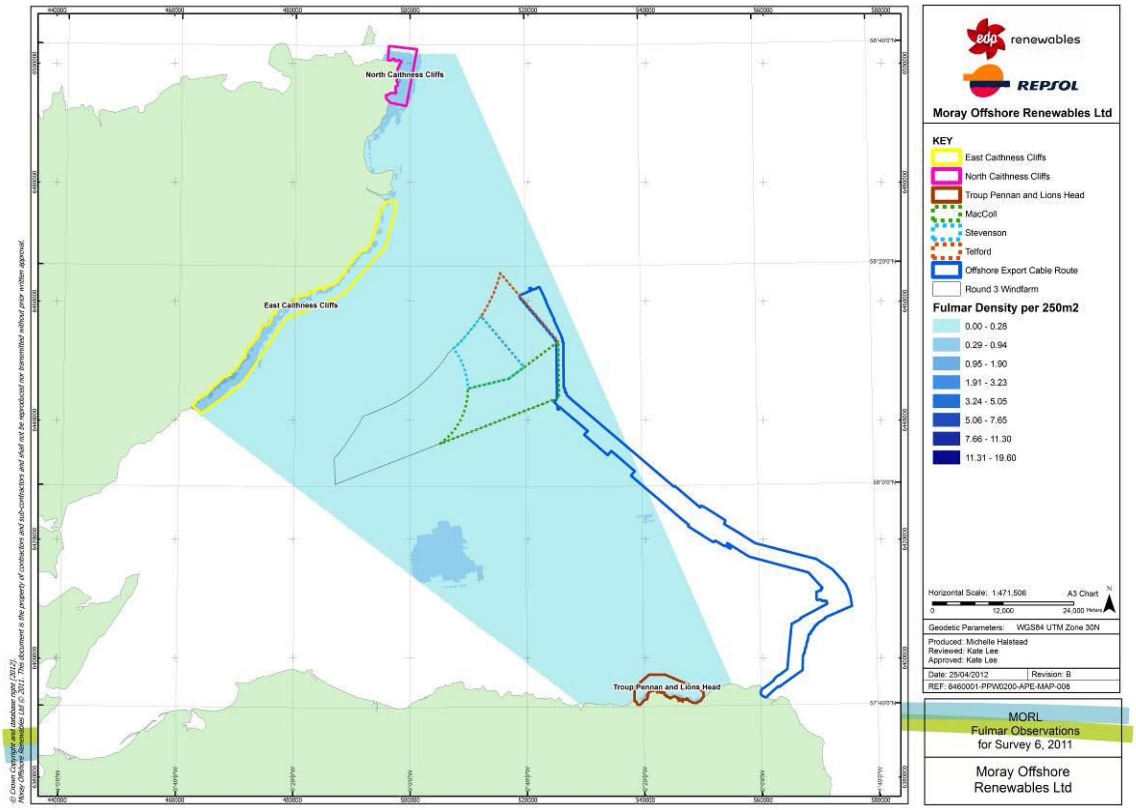
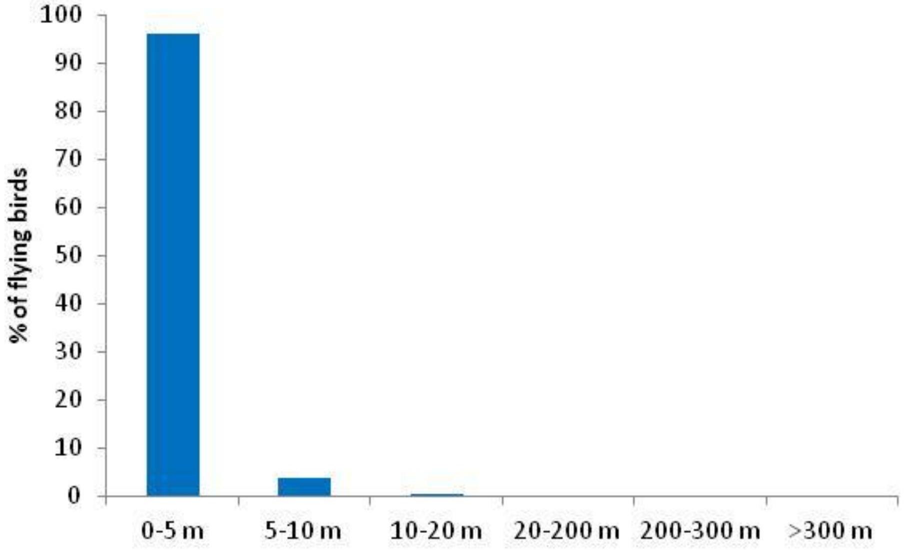


Figure 2e. Distribution of fulmar across the survey area area, from digital aerial surveys - Survey 6.

4.1.6 Potential for collision risk

The height distribution of the species, from the wind farm sites boat-based surveys, is provided in Table 22 and Graph 6; no fulmar were recorded within the potential collision risk height band of 20-200 m. A review of flight height data by the BTO estimated 0.01% of flights to be at a potential collision risk height (Cook *et al*., 2011). Due to the low flight height of fulmar, collision risk estimates for the species are negligible. Langston (2010) also assessed this species as being at low collision risk.



Graph 6: Proportions of fulmar flights recorded in each height band (for birds recorded in transect during April 2010 to March 2012 boat-based surveys).

4.1.7 Potential for disturbance / displacement / indirect effects

The mean densities of fulmar recorded within the three proposed wind farm sites were 2.77 birds/km^2 during the breeding season and 0.25 birds/km^2 during the non-breeding season, equating to abundances across the sites of 782 and 197 birds respectively (Table 50). Highest densities of fulmar were recorded on the western side of the wind farm sites, centred mainly on the 'Stevenson' wind farm.

The 'WCS' displacement analysis (100% displacement) predicted 391 individuals to be displaced from the three proposed wind farm sites (Table 44). The 'RS' analysis, using a 50% displacement rate, predicted 97 individuals to be displaced from the three sites (Table 45).

4.1.8 Potential for barrier effects

Fulmar undertake comparatively few, but long, foraging trips and are adapted to using efficient gliding flight, so the extra cost of additional distance is relatively small (Masden *et al.*, 2010). The threat posed by this potential effect is therefore considered to be minor.

4.1.9 Key risks

Table 51. Potential effects for fulmar.

Risk	Threat to species	Justification
Barrier effects	Minor	Relatively few foraging flights. Efficient flight and wing loading.
Collision	Negligible	Consistent low flight height. No flights at collision risk height. Assessed as low risk by Langston (2010).
Displacement and Disturbance	Minor	Large numbers on site. Macro-avoidance rates not known. Displacement of 97 individuals during the breeding season (RS).

4.2 Sooty shearwater

4.2.1 Distribution

Sooty shearwater breed in large numbers on oceanic islands throughout the southern hemisphere. Many disperse into the northern Atlantic during the austral winter. The global population is estimated to be approximately 20 million mature birds (Birdlife International: 2004), of which only a very small proportion (<1%) pass around the UK.

Almost all sooty shearwater recorded in Scottish waters occur between early August and early November (Forrester *et al.*, 2007). Estimates based on observations from land are unlikely to accurately reflect the size of the annual passage of this highly pelagic species, however it appears that numbers vary greatly between years with a maximum of 7500 in 2001 (Forrester *et al.*, 2007). The largest flock encountered within Scottish waters contained 2642 birds rafting at the north edge of the Smith Bank on/near the three proposed wind farms (Mudge and Crooke, 1986). The at-sea distribution during the summer (from JNCC analysis of ESAS data, collected between 1980 and 2006) is provided in Image 8, showing relatively high densities in the Moray Firth.

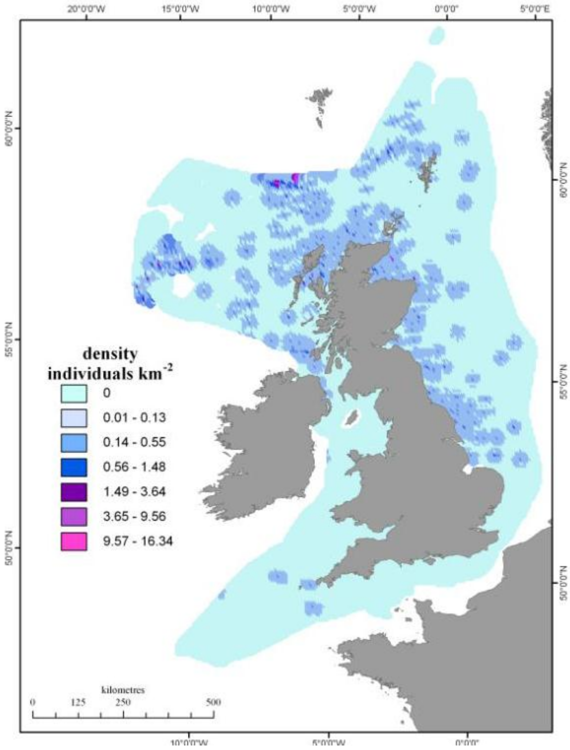


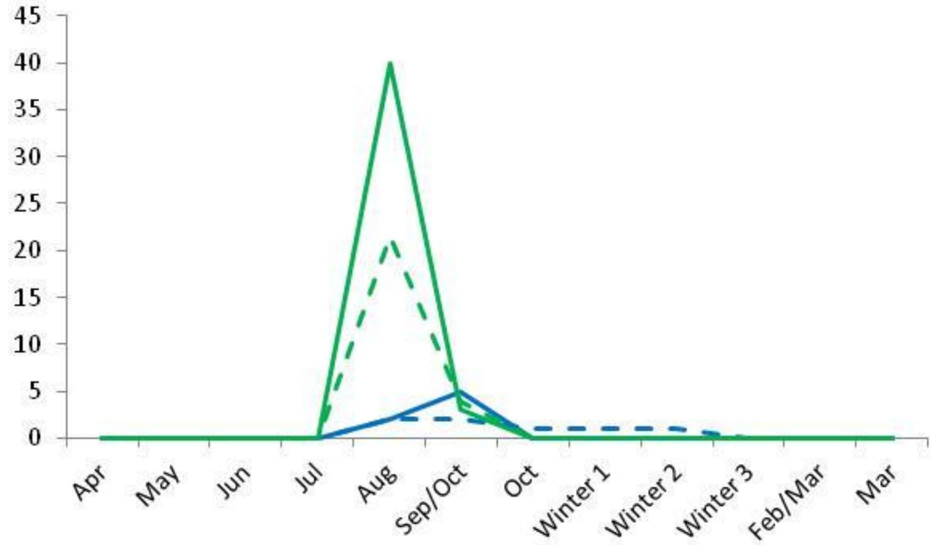
Image 8: JNCC predicted density surface maps for sooty shearwater during the summer period. Produced from ESAS data collected between 1980 and 2006 (taken from Kober *et al*., 2010).

4.2.2 Food preferences

Sooty shearwater have been observed to consume krill, small pelagic fish and squid (Brown *et al.*, 1981; Jackson, 1988), and have been recorded diving to depths of 67 m (Weimerskirch and Sagar, 1996).

4.2.3 Abundance and distribution within sites

Sooty shearwater were recorded in small numbers during the autumn and early winter months, between August and December. It was not possible to calculate densities due to small sample sizes, but numbers of birds recorded during boat-based surveys were highest in September 2010 and August 2011 (7 in 2010 and 111 in 2011, Tables 21 and 23, Graph 7). The peak month for birds recorded using the sea was August 2011, with 52 birds recorded on boat-based surveys (Table 23).



Graph 7: Total number of sooty shearwater recorded during each of the MORL boat-based surveys between April 2010 and March 2012 (including birds recorded in flight and using the sea). Blue lines refer to surveys during first year. Green lines refer to surveys during second year. Solid lines refer to records within the wind farm sites. Dashed lines refer to records within buffer area. In months where two surveys were conducted mean values are displayed. The winter surveys correspond to the three surveys undertaken between November and January.

4.2.4 Potential for collision risk

Due to the low numbers, and all flights being below potential collision height (Table 24), the potential effects on this species in terms of collision are likely to be negligible. A review of flight height information found no records of this species flying at potential collision height (Cook *et al*., 2011). Langston (2010) also assessed this species as being at negligible collision risk.

4.2.5 Potential for disturbance / displacement / indirect effects

Numbers of sooty shearwater were too low to allow any population estimates from distance sampling or density surface modelling. The largest number recorded within the three proposed wind farm sites was 100, in August 2011 (Tables 21 and 23). The threat posed by these potential effects is therefore believed to be negligible.

4.2.6 Potential for barrier effects

Sooty shearwaters encountered within the three proposed wind farm sites are non-breeding birds; therefore any barrier caused by the development will have a negligible effect on these long distance migrants.

4.2.7 Key Risks

Table 52. Potential effects for sooty shearwater.

Risk	Threat to species	Justification
Barrier effects	Negligible	Low numbers on site. Birds only present on migration. Efficient flight and wing loading.
Collision	Negligible	Low numbers on site. Consistently low flight height. Review of flight heights recorded none at collision risk height. Assessed as low risk by Langston (2010).
Displacement and Disturbance	Negligible	Low numbers on site. Birds only present on migration.

4.3 Manx shearwater

4.3.1 Distribution

Manx shearwater breed around the north Atlantic, with large colonies on the western coasts of Great Britain and Ireland and others in Iceland, the eastern coast of North America, Iberia and some of the Macronesian Islands. The species travels south of the equator in winter. The global population of Manx shearwater is estimated to be 340,000-410,000 pairs, of which 68-91% breed in Great Britain (Mitchell *et al*., 2004).

The breeding population of Manx shearwater in Great Britain and Ireland is approximately 332,300 pairs (1998-2002), breeding in 40 colonies in the west of the UK (Mitchell *et al*., 2004; Image 9). Approximately 38% of the British and Irish Manx shearwater population breeds in Scotland, 95% of these on Rum. UK SPAs designated for Manx shearwater, of which Rum and St Kilda are considered further in the impact assessment, are shown in Table 53. JNCC analysis of ESAS data collected between 1980 and 2006, to provide at-sea distributions of Manx shearwater during the breeding season and from October to November, are provided in Images 10a and 10b (Kober *et al*., 2010). These data do not show distributional hotspots for Manx shearwater within the three proposed wind farm sites.

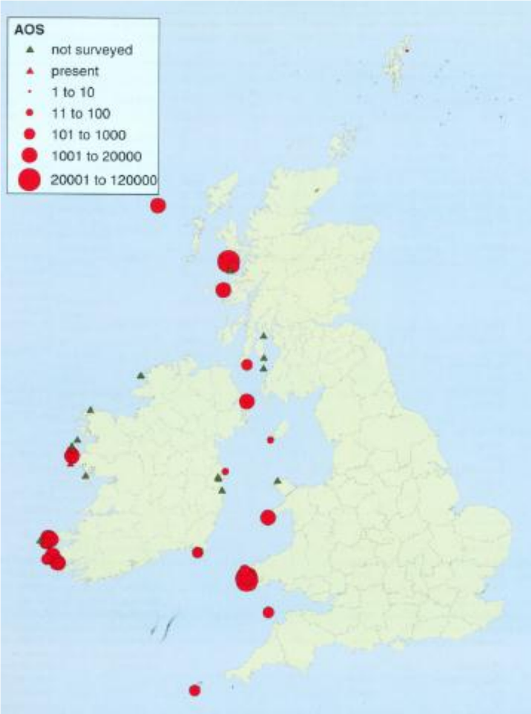


Image 9: Distribution of breeding Manx shearwater 1998-2002 (taken from Mitchell *et al*., 2004).

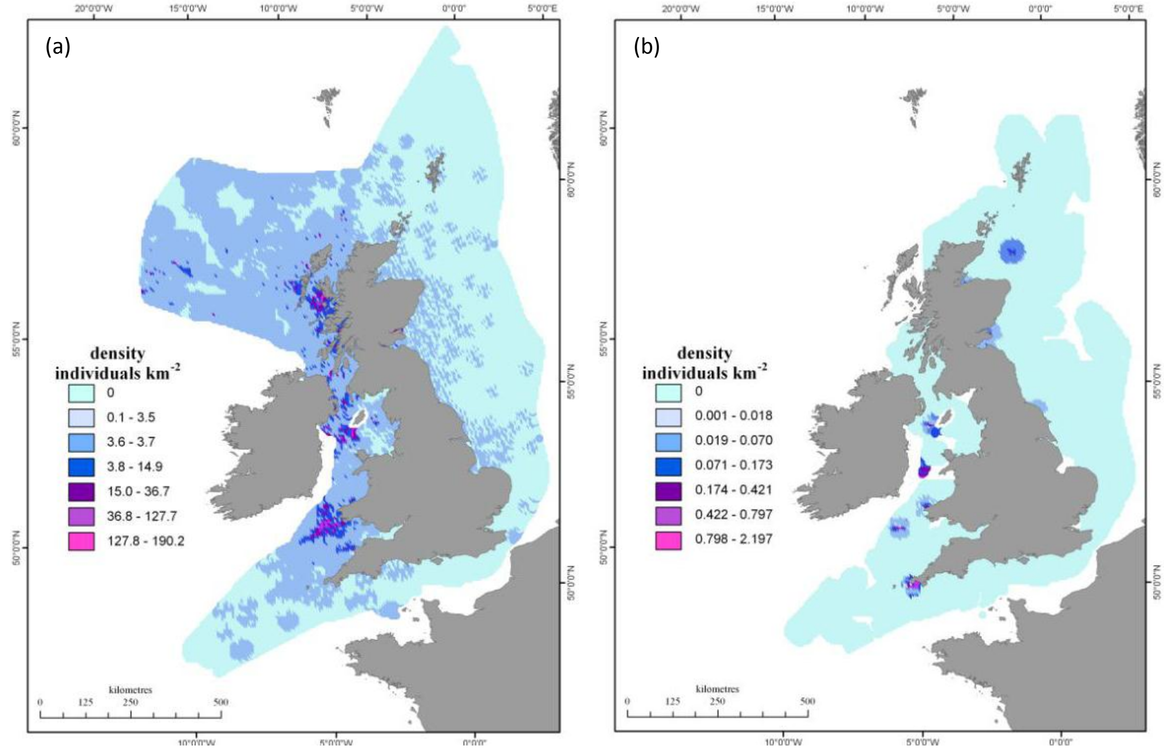


Image 10: JNCC predicted density surface maps produced from ESAS data collected between 1980 and 2006. Left (a): breeding. Right (b): October to November (taken from Kober *et al*., 2010).

Table 53: UK SPAs which are designated for Manx Shearwater

Site	Distance from wind farm sites*	AOS (date of census)
Rum	366 km	120,000 (in 2001)
St Kilda	376 km	4,803 (1999 & 2000)
Copeland Islands	652 km	4,633 (in 2000 & 2002-2003)
Aberdaron Coast & Bardsey Island	871 km	6,930 (in 1996)
Skokholm & Skomer	986 km	151,000 (in 1998)

* referring to the distance over sea only (i.e. not directly over land)

4.3.2 Annual cycle

Manx shearwater return to Scottish breeding sites in late March (Forrester *et al*., 2007). Eggs are laid from early May onwards and are incubated for approximately 50 days. Chicks fledge independently from their parents at the age of about 70 days (Snow and Perrins, 1998). Chicks usually fledge in September, after their parents have departed towards their wintering areas.

4.3.3 Food preferences

The diet of Manx shearwater includes small cephalopods, fish and floating carrion (Snow and Perrins, 1998). In addition to foraging on the sea surface Manx shearwater will make shallow plunge dives (from 1-2 m above the sea surface), and undertake in wing propelled pursuits of prey items.

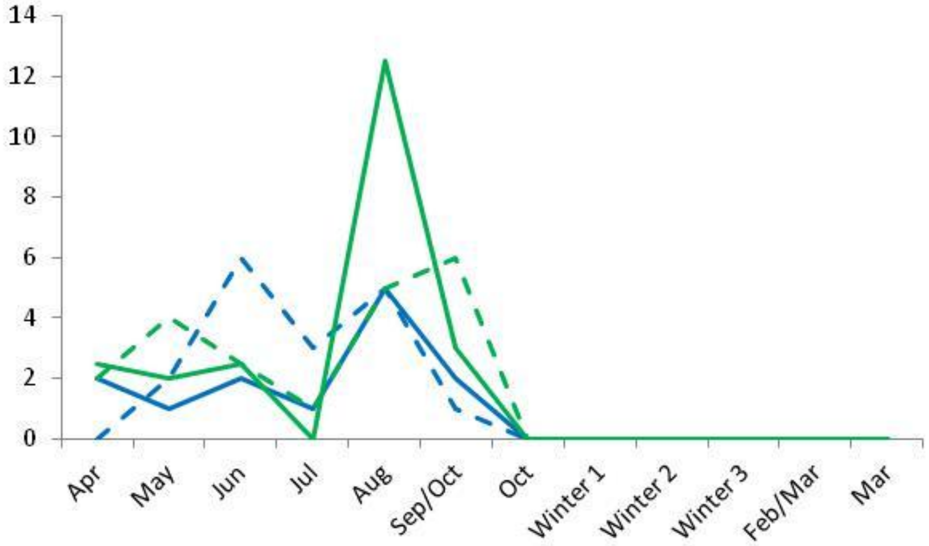
4.3.4 Foraging distances

Several studies suggest that breeding Manx shearwater frequently travel large distances from their colonies during foraging trips. GPS tracked birds from Skomer were observed to have foraging ranges of over 330 km, as they travelled to areas around the Mull of Galloway (Guilford *et al.*, 2008). Boat-based transect surveys conducted around the west of Scotland during the chick rearing period found that most Manx shearwaters were observed within a 50 km radius of Rum (Harrison *et al.*, 1994). Elsewhere, through analysing data from boat-based seabird surveys in relation to distances from colonies, maximum foraging ranges of between 160 and 260 km have been estimated (Birdlife International: http://seabird.wikispaces.com, Stone *et al*., 1994 & 1995; Lloyd *et al.*, 1991).

Based on the above information it is unlikely that breeding birds regularly forage within the three proposed wind farm sites, and if any do they are likely to do so in very small numbers. Potential connectivity with SPAs is therefore limited to birds migrating to or from the Rum SPA or St Kilda SPA during spring and autumn.

4.3.5 Abundance and distribution within sites

Manx shearwater were recorded in most months of the survey, with the exception of the winter months between October and February. It was not possible to calculate densities due to small sample sizes, but numbers of birds recorded during boat-based surveys were highest in August of each year (15 in 2010 and 32 in 2011, Tables 21 and 23, Graph 8). The peak month for birds recorded using the sea was August 2011, with 6 birds recorded on boat-based surveys (Table 23).



Graph 8: Total number of Manx shearwater recorded during each of the MORL boat-based surveys between April 2010 and March 2012 (including birds recorded in flight and using the sea). Blue lines refer to surveys during first year. Green lines refer to surveys during second year. Solid lines refer to records within the wind farm sites. Dashed lines refer to records within buffer area. In months where two surveys were conducted mean values are displayed. The winter surveys correspond to the three surveys undertaken between November and January.

4.3.6 Potential for collisions

Due to the low numbers, and all flights being below potential collision height (Table 24), the potential collision effects on this species are likely to be negligible. A review of flight height information also found a very low proportion (<1%) of records of this species flying at potential collision height (Cook *et al.*, 2011). Langston (2010) also assessed this species as being at low collision risk. Collision risk is therefore considered to be negligible for this species.

4.3.7 Potential for disturbance / displacement / indirect effects

Numbers of Manx shearwater were too low to allow any population estimates from distance sampling or density surface modelling. The largest number recorded within the wind farm sites was 32, in August 2011 (Tables 21 and 23). Due to these low numbers, disturbance and displacement risks are predicted to be negligible.

4.3.8 Potential for barrier effects

The closest SPA for Manx shearwaters is 366 km from the three proposed wind farm sites, exceeding all of the quoted maximum foraging ranges for this species. Therefore it is unlikely that any barrier caused by the development will have any impact on breeding birds, and any potential impact will be negligible during long distance migrations.

4.3.9 Key risks

Table 54. Potential effects for Manx shearwater.

Risk	Threat to species	Justification
Barrier effects	Negligible	Low numbers on site. Birds only present on migration. Efficient flight and wing loading.
Collision	Negligible	Low numbers on site. Consistently low flight height. Assessed as low risk by Langston (2010).
Displacement and Disturbance	Negligible	Low numbers on site. Birds only present on migration. SPA populations distant.

4.4 European storm petrel

European storm petrel breed on islands around the Atlantic coast of north-west Europe, and in much smaller numbers in the Mediterranean. Storm petrel are migratory, with those from UK colonies wintering off the coast of south and west Africa (Wernham *et al*., 2002). Estimates of global population size are difficult for this species and consequently vague. Mitchell *et al*. (2004) suggest a global population of between 300,000 and 680,000 pairs, of which 3.1 – 11.1% breed in Britain.

The breeding population of European storm petrel in Great Britain and Ireland is estimated to be approximately 82,800 pairs, in 95 colonies (1995-2002, Mitchell *et al*., 2004: Image 11). This population estimate is likely to be an underestimate due to difficulties associated with accessing some of the remote locations in which the species breeds, and its burrow nesting habits. The majority of colonies are concentrated on the west coast of Ireland though there are also several large colonies in Britain, particularly in Scotland, which is estimated to hold 26% of the British and Irish breeding population.

JNCC analysis of ESAS data collected between 1980 and 2006, to provide at-sea distributions of storm petrel during the summer, is shown in Image 12 (Kober *et al.*, 2010), with low to medium levels of density in the Moray Firth.

The nearest breeding locations for storm petrel to the three proposed wind farm sites are in Orkney, where there are estimated to be 1,870 Apparently Occupied Sites (95% confidence interval 1,110–4,255 AOS). Several colonies in the south and east of Orkney are relatively close to the wind farm sites (Table 55).

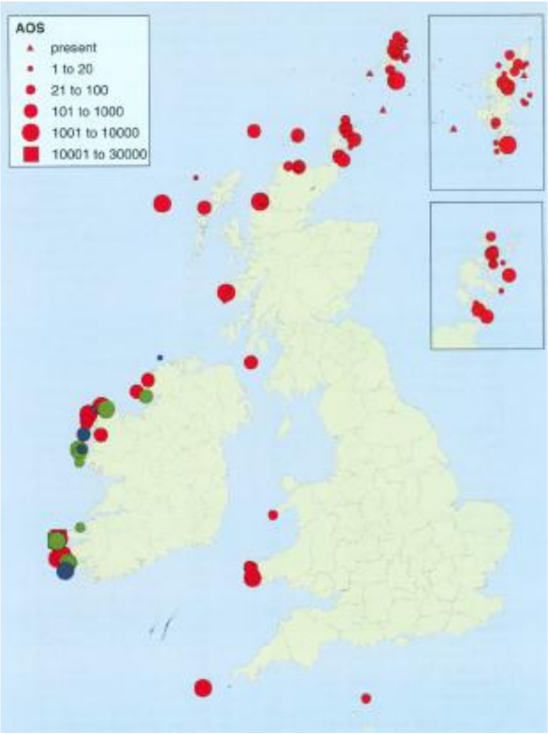


Image 11: Distribution of breeding storm petrel 1998-2002 (taken from Mitchell *et al.*, 2004)

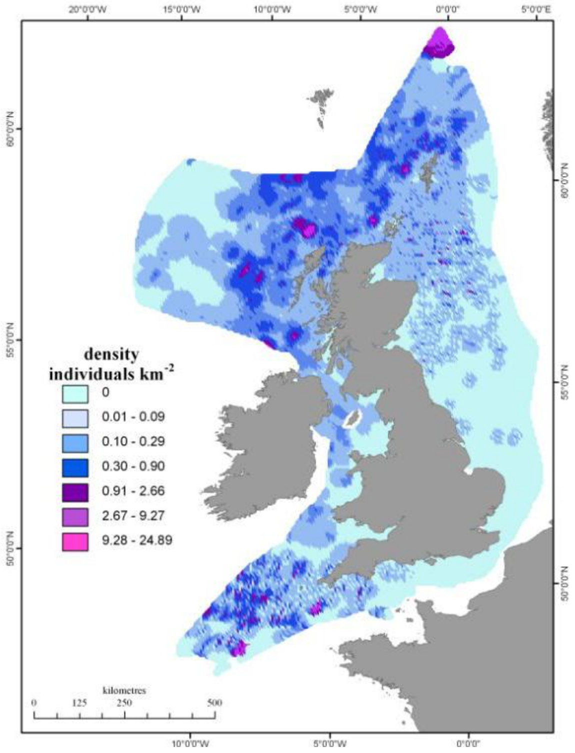


Image 12: JNCC predicted density surface maps for storm petrel during the summer period. Produced from ESAS data collected between 1980 and 2006 (taken from Kober *et al.*, 2010)

Table 55: Storm petrel colonies in the south and east of Orkney

Site	AOS	95% confidence intervals	Distance from wind farm sites	Date of survey
Pentland Skerries	102	77 – 134	40 km	2000
Swona	130	98 – 172	50 km	2000
Auskerry	994	372 – 3196	80 km	2001

4.4.1 Annual cycle

Much of the data about storm petrel breeding activity comes from the colony on Mousa in Shetland. At this colony birds typically return from their wintering areas in the second week of May, though dates vary from year to year (Forrester *et al*., 2007). The earliest egg laying usually occurs in early to mid-June, and the incubation period is approximately 38-50 days (Snow and Perrins, 1998). Chicks hatch from the third week of September onwards and fledge 56-86 days later (Snow and Perrins, 1998), from mid to late September through to mid-November. Ringing recoveries suggest that fledglings do not return to their natal areas during the first two to three years of their lives (Fowler *et al*., 1982).

4.4.2 Food preferences

Storm petrel forage primarily on planktonic fish, crustaceans and other zooplankton, as well as oil from fish (Cramp and Simmons, 1977). They also forage nocturnally in inshore areas, consuming intertidal benthic organisms (particularly *Eurydice* spp.) (D'Elbee and Hemery, 1997).

4.4.3 Foraging distances

Comparatively little is known about storm petrel foraging ranges. During daylight hours the species is pelagic, and generally found in offshore waters of over 50 m deep (Stone *et al.*, 1995). Ship-based surveys around the UK have found greatest storm petrel densities in waters over 1000 m deep (Stone *et al.*, 1995). Presumably this is a way of avoiding diurnal avian predators, as they have been observed to move into shallower inshore waters at night (D'Elbee and Hemery, 1997).

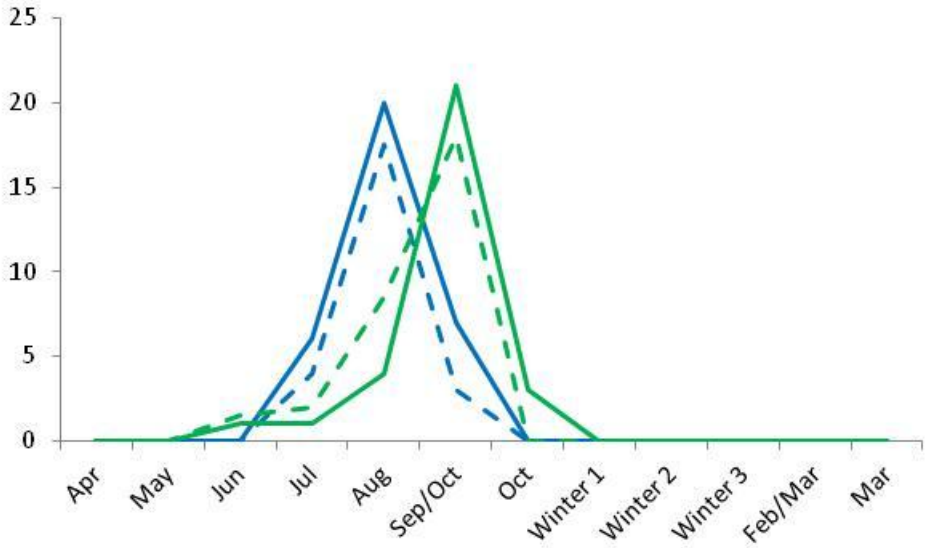
Given their small body size, attaching trackers to storm petrel is problematic, consequently most of the information about their foraging ranges is derived from ship-based transect methods or provisioning intervals. A study of storm petrel off St Kilda found that the highest densities were found near the edge of the continental shelf, more than 50 km from the breeding colonies (Leaper *et al.*, 1988). However

Bolton (1995) investigated food delivery to nestlings and found that the interval between visits by adults bringing food was short, suggesting that the adults had a small foraging range during this period. At the incubation stage of the breeding cycle (June to August), adult birds can forage for long periods without having to be at the nest site. For example, an egg on Mousa, Shetland was found to be left unbrooded for 11 days but still went on to hatch (Forrester *et al*., 2007). Given that they can spend such long durations away from the nest, adults could presumably disperse quite far from their breeding colonies.

Based on the above information it is possible that birds from the small colonies on Swona and the Pentland Skerries occasionally forage within the three proposed wind farm sites.

4.4.4 Abundance and distribution within sites

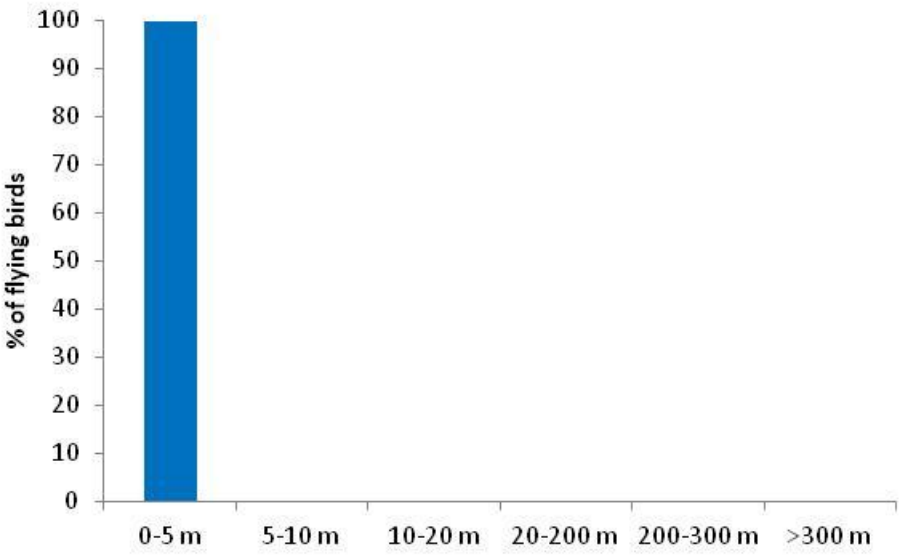
European storm petrel were recorded during the late summer and early autumn months. It was not possible to calculate densities due to small sample sizes, but numbers of birds recorded during boat-based surveys were highest in August/September of each year (56 in August 2010 and 39 in September 2011, Tables 21 and 23, Graph 9).



Graph 9: Total number of storm petrel recorded during each of the MORL boat-based surveys between April 2010 and March 2012 (including birds recorded in flight and using the sea). Blue lines refer to surveys during first year. Green lines refer to surveys during second year. Solid lines refer to records within the wind farm sites. Dashed lines refer to records within buffer area. In months where two surveys were conducted mean values are displayed. The winter surveys correspond to the three surveys undertaken between November and January.

4.4.5 Potential for collision risk

Due to the low numbers, and all flights being below potential collision height (Table 24, Graph 10), the potential collision effects on this species are likely to be negligible. A review of flight height information found a very low proportion (approximately 2%) of records of this species flying at potential collision height (Cook *et al.*, 2011). Langston (2010) also assessed this species as being at low collision risk, therefore collision risk for this species is considered to be negligible.



Graph 10: Proportions of storm petrel flights recorded in each height band (for birds recorded in transect during April 2010 to March 2012 boat-based surveys).

4.4.6 Potential for disturbance / displacement / indirect effects

Numbers of storm petrel were too low to allow any population estimates from distance sampling or density surface modelling. The largest number recorded within the three proposed wind farm sites was 32 (Tables 21 and 23), in August 2011. Due to these low numbers, disturbance and displacement risks are predicted to be low.

4.4.7 Potential for barrier effects

The sites are not likely to be within, or en route to, the main foraging areas of breeding storm petrel, and barrier effects are therefore predicted to be minor. During migration barrier effects are predicted to be negligible for this long distance migrant.

4.4.8 Key risks

Table 56. Potential effects for storm petrel.

Risk	Threat to species	Justification
Barrier effects	Negligible	Low numbers on site.
Collision	Negligible	Low numbers on site. Consistently low flight height. Assessed as low risk by Langston (2010).
Displacement and Disturbance	Minor	Low numbers on site. Most SPA populations distant.

4.5 Leach's petrel

Leach's petrel breeds on remote islands in the extreme north and west of Scotland, close to the deep oceanic waters beyond the continental shelf ever which they primarily forage. The estimated Scottish breeding population is approximately 48,000 AOS (Mitchell *et al*., 2004). Large numbers occur on St Kilda, and this is where over 90% of the Scottish breeding population is concentrated (Mitchell *et al*., 2004). Variable numbers also migrate past the coast in autumn.

Between April 2010 and March 2012, four Leach's petrel were identified within the boat-based survey area; records occurred in late September, mid-October and twice in June.

4.5.1 Potential for collision risk

Due to the low numbers, and all flights being below potential collision height, the potential collision effects on this species are likely to be negligible. Langston (2010) assessed this species as being at low collision risk. Collision risk is therefore considered to be negligible for this species.

4.5.2 Potential for disturbance / displacement / indirect effects

Numbers of Leach's petrel were too low to allow any population estimates from distance sampling or density surface modelling. The largest number recorded within the three proposed wind farm sites was two birds (Table 21). Due to these low numbers, disturbance and displacement risks are predicted to be negligible.

4.5.3 Potential for barrier effects

The sites are not likely to be within, or en route to, the main foraging areas of breeding Leach's petrel, and barrier effects are predicted to be negligible. During migration barrier effects are also predicted to be negligible for this long distance migrant.

4.5.4 Key Risks

Table 57. Potential effects for Leach's petrel.

Risk	Threat to species	Justification
Barrier effects	Negligible	Low numbers on site. Birds mainly present on migration.
Collision	Negligible	Low numbers on site. Consistently low flight height. Assessed as low risk by Langston (2010).
Displacement and Disturbance	Negligible	Low numbers on site. Birds mainly present on migration. Most SPA populations distant.

4.6 Gannet

Gannet breed on both sides of the Atlantic Ocean, at coastal sites in north-west Europe and easternmost Quebec. The UK and Irish population forms approximately 67% of the global population of 390,000 pairs, and 83% of the European population of approximately 312,300 pairs (Mitchell *et al*., 2004). The breeding season of gannets is prolonged (typically January to November in the UK), however outwith this period and throughout the year for sub-adult birds, most individuals travel to areas further south in the Atlantic.

The breeding population of gannet in Great Britain and Ireland is approximately 259,500 pairs breeding on 21 colonies (as estimated from AOS/AON 1998-2000 in Mitchell *et al*., 2004). The majority (72%) of the British and Irish population breeds around the Scottish coast. Information about SPAs around the UK designated for breeding gannet is shown in Table 58. The nearest colony to the three proposed wind farm sites is Troup Head, a recently established breeding area where the population has increased rapidly (2 AON in mid-1980s, 530 AON in mid-1990s, 1085 AON in 1998-2000, 1547 in 2004; 2787 in 2010; Mitchell *et al., 2004;* Wanless 2005; JNCC SMP).

JNCC analysis of ESAS data, collected between 1980 and 2006, to provide at-sea distributions of gannet during the summer and winter is shown in Images 13a and 13b

(Kober *et al*., 2010). These data do not show any distributional hotspots for gannet in proximity to the three proposed wind farm sites.

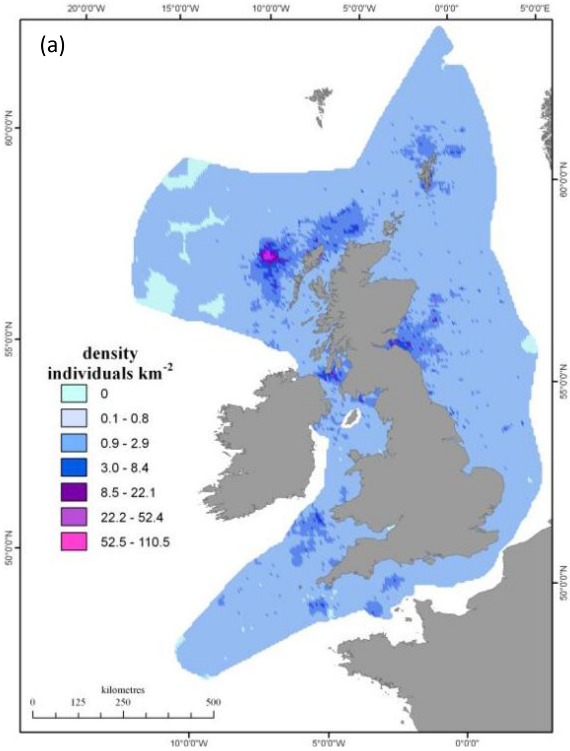


Image 13: JNCC predicted density surface maps produced from ESAS data collected between 1980 and 2006. Left (a): summer. Right (b): winter (taken from Kober *et al*., 2010).

Table 58: SPAs designated for gannet around the Scottish coast

Site Name	**AOS/AON**	**Distance to wind farm sites**
Ailsa Craig	32,456^{*1}	630 km
Fair Isle	1,123^{*2}	143 km
Forth Islands (*Bass Rock*)	34,397^{*1}	237 km
Grassholm, south Wales	30,688^{*2}	983 km
Hermaness, Saxa Vord and Valla Field	16,386^{*2}	298 km
North Rona & Sula Sgeir	10,440^{*1}	205 km
Noss	8,017^{*2}	222 km
St Kilda	60,428^{*1}	376 km
Sule Skerry & Sule Stack	4,888^{*1}	131 km

^{*1} 1994-1995, ^{*2} 1998-2000

4.6.1 Annual cycle

In the UK gannet start arriving back at colonies from January onwards, and immediately commence nest building. The earliest eggs are typically laid in the first week of April, the latest in early to mid-July (Forrester *et al*., 2007). Eggs are incubated for 42-46 days, with young birds fledging after another 84-97 days (Snow and Perrins, 1998). In Scotland the interval during which nestlings fledge is from August to November, with peak numbers doing so in mid to late September (Forrester *et al*., 2007). After a brief initial period during which they are largely incapable of flight, most fledglings move relatively quickly south towards waters off Iberia and west Africa (Wernham *et al*., 2002). Small numbers of fledglings from the Bass Rock colony have been recorded dispersing north and west around the Scottish coast before moving south (Wernham *et al*., 2002).

4.6.2 Food preferences

The gannet is a pelagic feeder, foraging primarily on lipid-rich fish up to 30 cm in length such as mackerel, herring and sandeel (Snow and Perrins, 1998; Hamer *et al*., 2007). They also feed upon fishery discards (Votier *et al.*, unpublished data). Studies during the breeding season on the Bass Rock colony have found variation between years in the proportion of different prey types (Hamer *et al*., 2007), with the main prey items being sandeels, mackerel, herring, sprats and Gadoids.

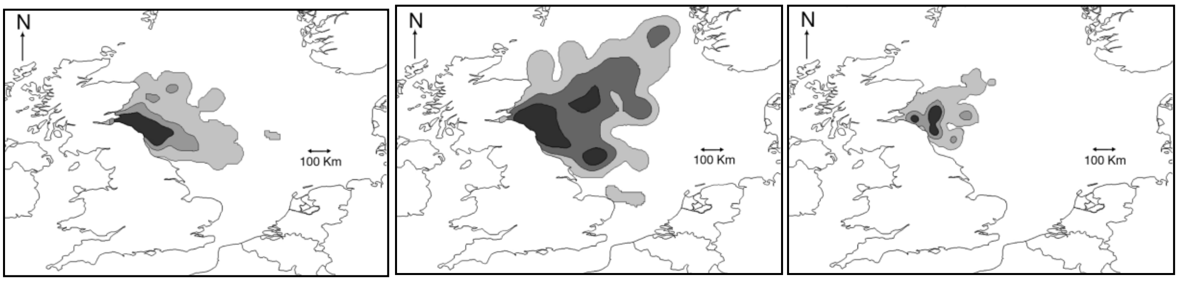
4.6.3 Foraging distances

Studies investigating the foraging distances of gannet from their breeding colonies suggest that ranges differ between colonies and from year to year.

Satellite telemetry studies of the Bass Rock colony found maximum foraging distances during the breeding season of up to 540 km (Hamer *et al*., 2007). This monitoring was carried out in 1998, 2002 and 2003, and between each of these years there was considerable variation in the foraging behaviour observed; summary data are shown in Table 59 and maps illustrating the areas in which foraging trips were recorded are shown in Image 14 (taken from Hamer *et al*., 2007) In 1998 and 2002 no birds were recorded foraging in the vicinity of the three proposed wind farms, and in 2003 there were three such records. These observations suggest that while gannet from the Bass Rock colony are capable of foraging within the three wind farm sites, they do so, at most, infrequently.

Table 59. Foraging trip data for gannets tracked from Bass Rock (Hamer *et al*., 2007).

	1998	**2002**	**2003**
Mean proportion of time spent foraging (%)	60.3	57.4	52.5
Mean duration of foraging trips (hours)	31.5	40.0	25.9
Mean max distance of foraging trips from colony (km)	224.3	319.7	170.5
Area in which 50% of foraging records were made (km^2)	10,822	30,555	4,202
Area in which 95% of foraging records were made (km^2)	96,290	211,120	45,890



1998 (17 birds tracked) **2002 (14 birds tracked)** **2003 (22 birds tracked)**

Image 14: Foraging ranges and destinations of gannet foraging trips from Bass Rock in 3 breeding seasons. Areas encompassing 50%, 75% and 95% of foraging locations are shown in black, dark grey and light grey respectively. (Taken from Hamer *et al*., 2007)

At the Hermaness colony in Shetland, Garthe *et al*. (1999) used temperature loggers to monitor the activity of three adults in the process of rearing young. From this they inferred foraging ranges of between 32 and 128 km, considerably less than the ranges observed at the Bass Rock colony (Hamer *et al*., 2007) (although the sample size was much smaller). Garthe *et al*. (1999) also noted that flying and foraging activity were only recorded during daylight hours.

Elsewhere, away from the North Sea, an even greater range of maximum foraging distances have been estimated. Voiter *et al*. (unpublished data) estimated that birds from Grassholm in Pembrokeshire travel up to 900 km from their breeding colony during foraging trips. However, satellite tracked birds breeding relatively nearby across the Irish Sea on Great Saltee (Co. Wexford, Ireland) had a mean foraging range of 90 km, and a maximum of 240 km (Hamer *et al.*, 2000).

Based on the above information, a summary is provided below of potential connectivity between gannet colonies and the development of the three proposed wind farm sites:

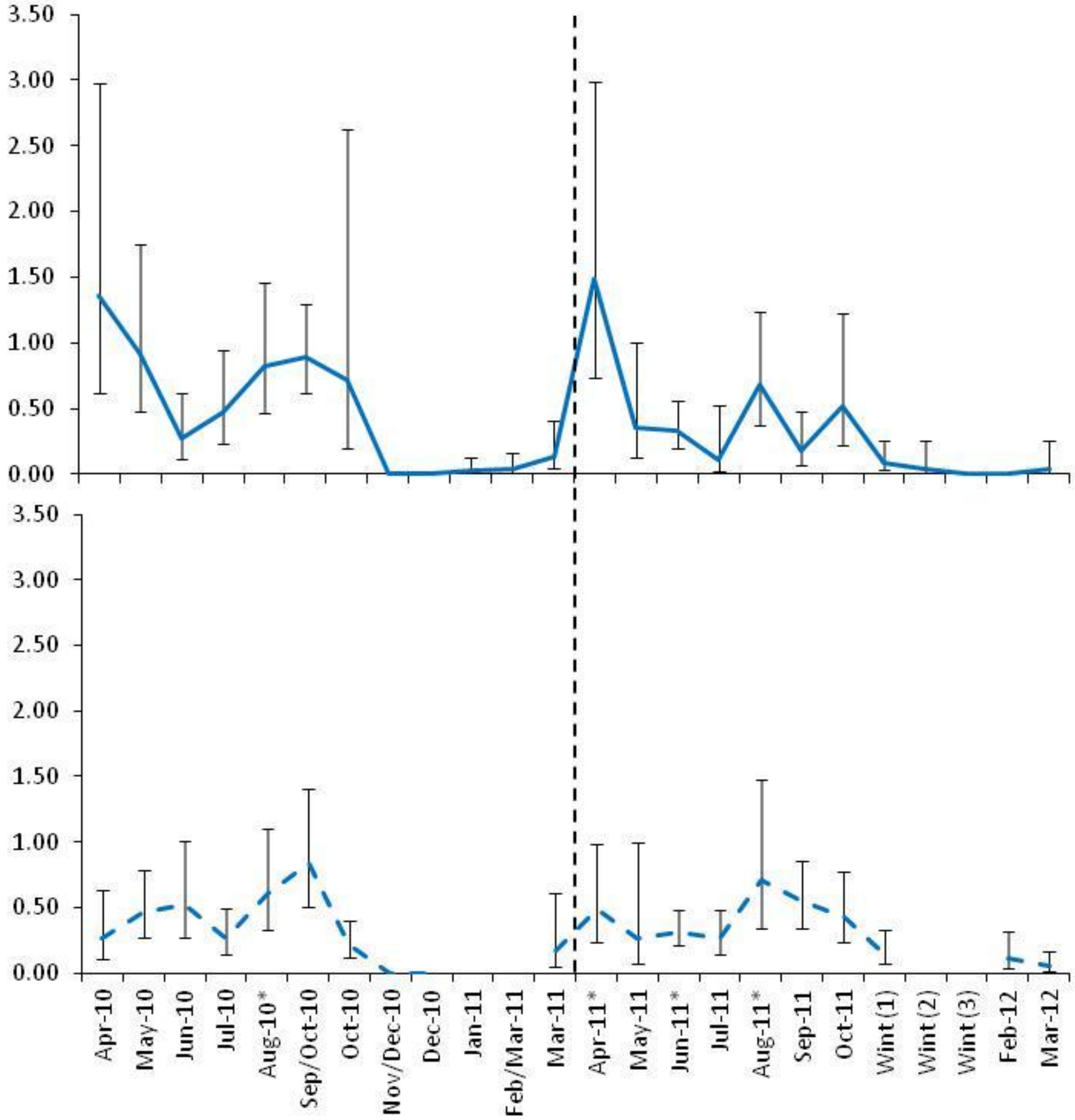
- The majority of gannet breeding recorded from the survey area are likely to be from the colony within the Troup, Pennan and Lion's Heads SPA, although this SPA is not designated for gannet.
- There are three colonies within approximately 200 km of the wind farm sites, within the maximum foraging ranges observed in most gannet tracking studies: Sule Skerry & Sule Stack SPA, Fair Isle SPA and North Rona & Sula Sgeir SPA (all bar the latter designated for gannet).
- The sites are also within the potential foraging range of birds from Noss SPA, Forth Island SPA, and Hermaness, Saxa Vord and Valla Field SPA (all designated for gannet).

4.6.4 Abundance and distribution within sites

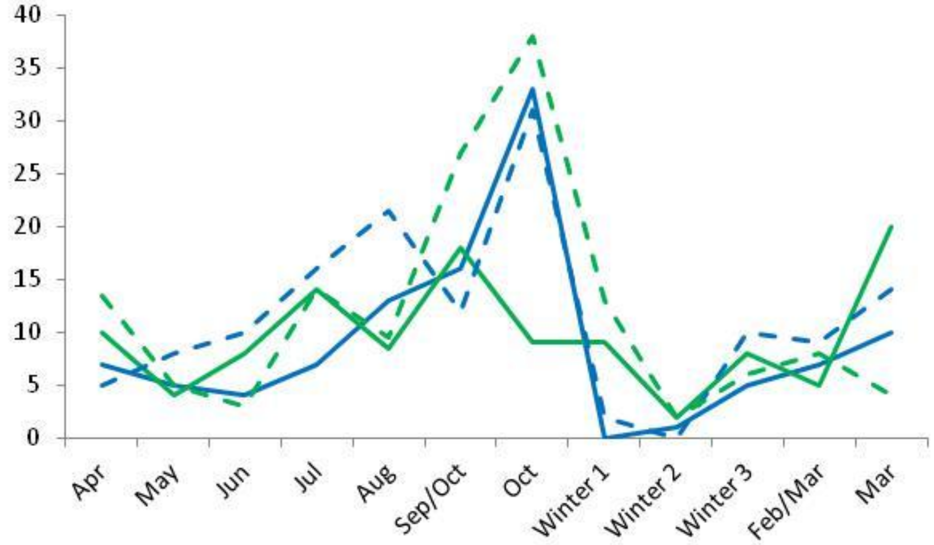
Gannet were recorded in all months of the survey. Densities were highest in spring, peaking in the three proposed wind farm sites in April 2011 (1.48 birds/km^2) and April 2010 (1.36 birds/km^2) (Table 29, Graph 11). The peak month for birds recorded using the sea was April 2011, with 127 birds recorded on boat-based surveys (Table 23). Annual variation in numbers recorded in flight is shown in Graph 12. A distribution map for the species is shown in Figure 3.

Table 60. Mean density and abundance of gannet on the three proposed wind farm sites and the buffer zone, in the breeding and non-breeding season from boat-based surveys

Breeding Season				Non-breeding season			
Density		Abundance		Density		Abundance	
Site	Buffer	Site	Buffer	Site	Buffer	Site	Buffer
0.66	0.46	100	86	0.04	0.05	23	20



Graph 11. Temporal variation in gannet density (birds/km²) in the wind farm sites (solid line) and the buffer zone (dotted line) Excludes records with percentage CV greater than 100 (low confidence). In months where two surveys were conducted mean values are displayed. The winter surveys correspond to the three surveys undertaken between November and January.



Graph 12: Number of gannet recorded in flight in transect during each of the MORL boat-based surveys between April 2010 and March 2012. Blue lines refer to surveys during first year. Green lines refer to surveys during second year. Solid lines refer to records within wind farm sites. Dashed lines refer to records within buffer area. In months where two surveys were conducted mean values are displayed. The winter surveys correspond to the three surveys undertaken between November and January.

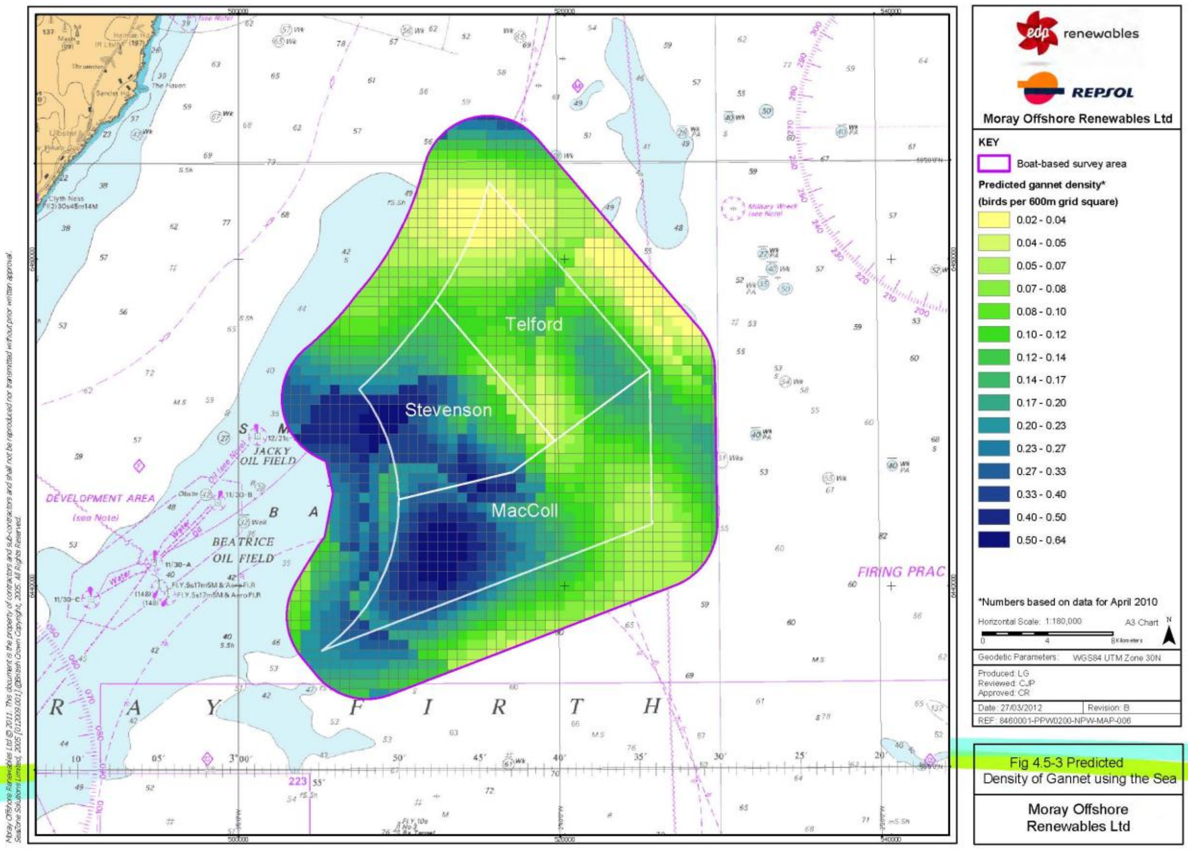
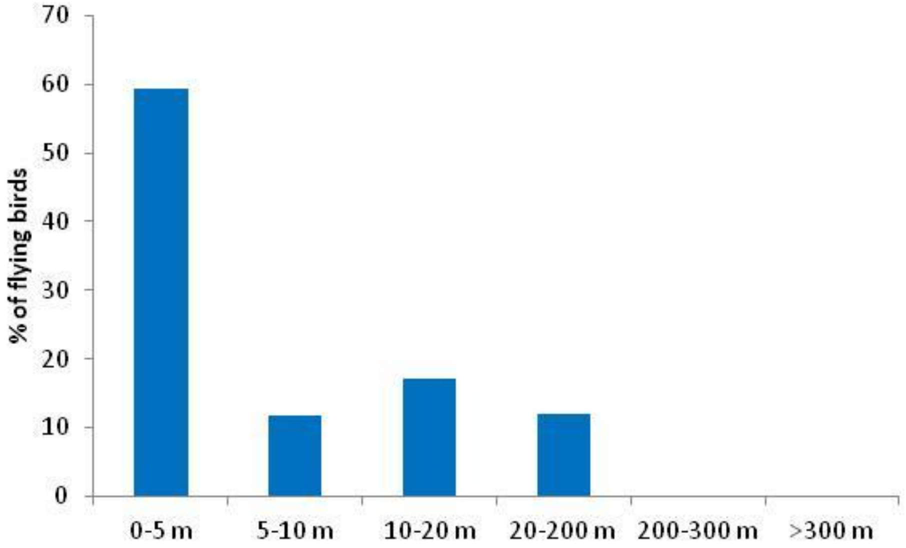


Figure 3. Modelled density surface map for gannet from April 2010.

4.6.5 Potential for collision risk

From the boat-based survey data, 11.7% of flights were in the 20-200 m height band (Table 24, Graph 13). A review of flight height information also found a similar proportion (approximately 14%) of records of this species flying at potential collision height (Cook *et al*., 2011). Langston (2010) assessed this species as being at medium collision risk. The collision risk analysis (assuming an avoidance rate of 98%) predicts that a total of 227 gannet will collide with the turbines, 123 in the breeding season and 104 in the non-breeding season (Table 25). Maclean *et al*. (2009) recommend the use of 99.5% avoidance for gannet, and further rationale for the use of this rate is provided in Section 2.1.5) which would mean an estimate of 57 collisions per year (Table 26).



Graph 13: Proportions of gannet flights recorded in each height band (for birds recorded in transect during April 2010 to March 2012 boat-based surveys).

4.6.6 Potential for disturbance / displacement / indirect effects

The mean densities of gannets recorded within the three proposed wind farm sites were 0.66 birds/km^2 during the breeding season and 0.04 birds/km^2 during the non-breeding season, equating to abundances across the sites of 100 and 23 birds respectively (Table 60). The highest densities of gannet within the survey area were recorded in the south-west of the three sites, most specifically the southern and western areas of Stevenson and MacColl (see Table 4.5-7 in Baseline Chapter; 4.5).

Gannet have a low sensitivity to ship and helicopter disturbance (Table 20; based on Garthe and Huppop, 2004), suggesting this will not be an issue for this species.

Analysis of data collected from Robin Rigg offshore wind farm in the Solway Firth, comparing the construction year with five pre-construction years, found a 50% reduction in gannet numbers using the site (Shenton & Walls, pers. comm.).

The 'WCS' displacement analysis (100% displacement) predicted 50 individuals to be displaced from the three proposed wind farm sites, equating to 1.6% of the Troup Head population (Table 44). The 'RS' analysis, using the 50% displacement rate, predicted 13 individuals to be displaced from the sites, equating to 0.4% of the Troup Head population (Table 45).

4.6.7 Potential for barrier effects

Breeding gannet have large foraging ranges (up to 540 km) and are therefore likely to use the three proposed wind farm sites. However, they undertake comparatively few but long foraging trips and are adapted to using efficient gliding flight, so the extra cost of additional distance are relatively small (Masden *et al*., 2010). Barrier effects are therefore predicted to be minor.

4.6.8 Key risks

Table 61. Potential effects for gannet.

Risk	**Threat to species**	**Justification**
Barrier effects	Minor	Efficient flight and wing loading. SPAs distant. Highest densities outwith breeding season.
Collision	Moderate	Collision risk of 57 per year at 99.5% avoidance. 11.7% of flights at collision risk height. Assessed as low risk by Langston (2010).
Displacement and Disturbance	Minor	Efficient flight and wing loading. SPAs distant. Highest densities outwith breeding season. Displacement of 13-50 individuals during breeding season.

4.7 Shag

Shag breed along the Atlantic coastline of Europe (from Morocco to Finland and Iceland), and occur throughout the Mediterranean. The world population is estimated to be 73,000-83,000 pairs, of which 35-40% breed in Britain (Mitchell *et al*., 2004) and the UK shag population declined by 15% between 2000 and 2010 (JNCC 2011). The breeding population of shag in Great Britain and Ireland is approximately 32,300 pairs (1998-2002), most of which are concentrated in the north and west (Mitchell *et al*., 2004; Image 15), with approximately 67% breeding in Scotland. The population sizes of the surrounding regions of Highland, Grampian and the Northern Islands are shown in Table 62. These areas contain 12% of the British and Irish shag population, and large numbers breed at the East Caithness Cliffs SPA (2300 pairs estimated for 1985-1988), 20 km from the three proposed wind farm sites.

JNCC analysis of ESAS data collected between 1980 and 2006, to provide at-sea distributions of shag during the breeding season and winter period, are shown in Images 16a and 16b (Kober *et al*., 2010). These data do not show any distributional hotspots for shag within the three proposed wind farm sites.

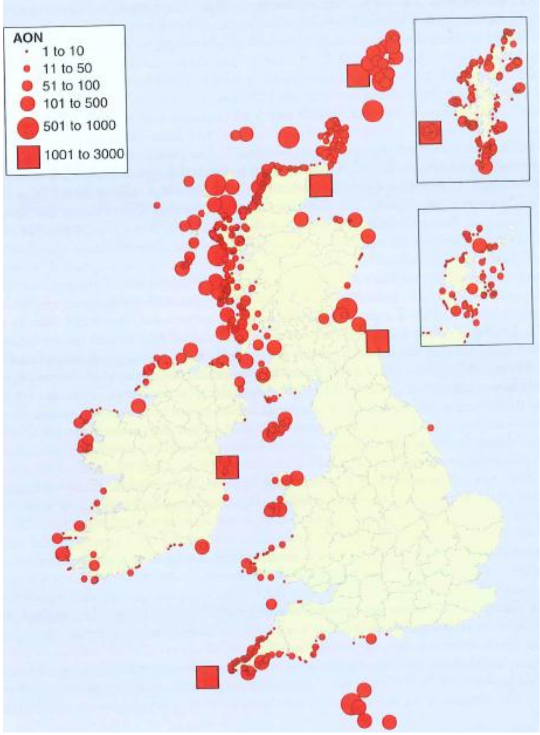


Image 15: Distribution of breeding shag, 1998-2002 (taken from Mitchell *et al*., 2004)

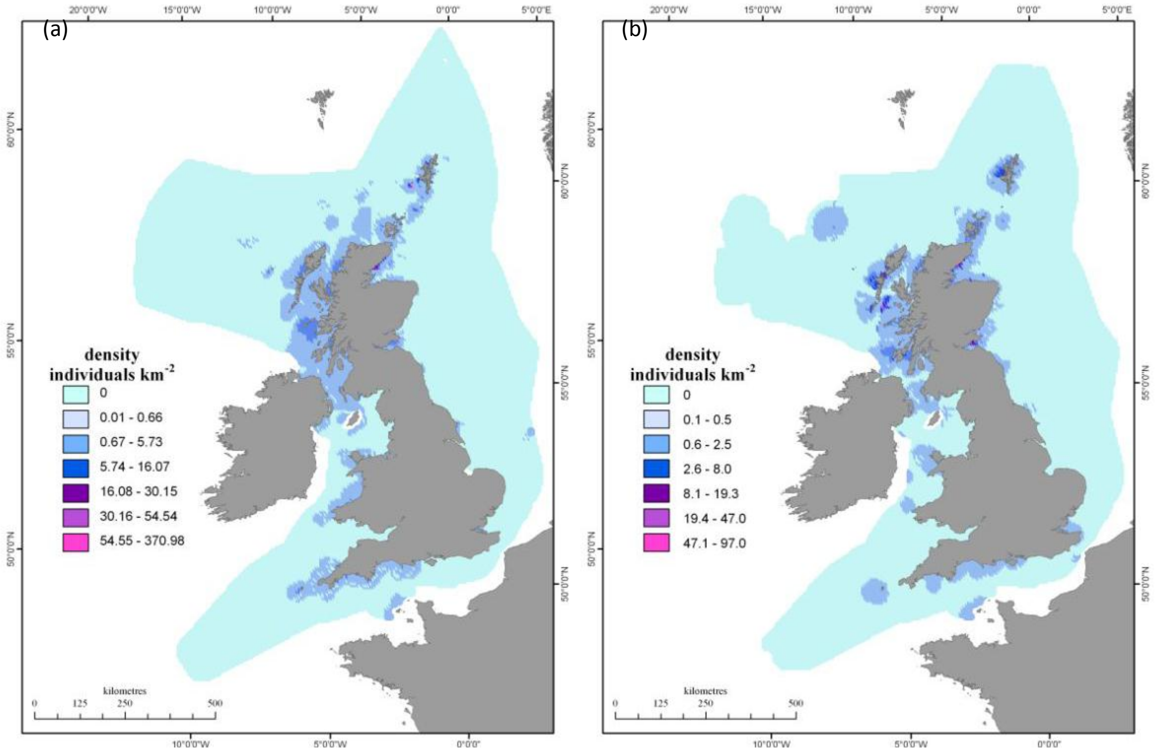


Image 16: JNCC predicted density surface maps produced from ESAS data collected between 1980 and 2006. Left (a): breeding. Right (b): winter (taken from Kober *et al*., 2010).

Table 62: Shag populations (Apparent Occupied Territories) in districts around the Moray Firth (Mitchell *et al*., 2004)

Region	District	Population (AOT)
Northern Isles	Orkney	1,872
Highland	Caithness	1,136
	Ross & Cromarty (east)	270
Grampian	Moray	33
	Banff & Buchan	656
TOTAL		3,967

4.7.1 Annual cycle

The breeding season of shag at Scottish colonies is highly variable and prolonged. On the Isle of May the dates on which females have laid their first egg has varied between the 1st of March and the 16th of May (Forrester *et al*., 2007). The incubation period lasts approximately 31 days, with young fledging 48-58 days after hatching (occasionally earlier) (Snow and Perrins, 2007). Chicks continue to be fed by parents after fledging, usually for several weeks. In some years large proportions (occasionally over 50%) of adults do not breed (Aebischer and Wanless, 1992). Shag from Scottish breeding colonies disperse widely around the UK and Ireland, and to a lesser extent around the North Sea coast of continental Europe, although many adults remain within 50-100 km of their breeding colonies throughout the year (Wernham *et al*., 2002).

4.7.2 Food preferences

Several studies suggest that the primary foraging method used by shags is benthic diving (Wanless *et al*., 1991a; Watanuki *et al*., 2008). At the Isle of May colony Harris and Wanless (1991) observed that breeding adults specialised of provisioning their nestlings with sandeels, but their own diet consisted of a wider range of prey species. Sandeels were estimated to constitute 98-100% of nestling diet, and most of the adult diet, in which gadoids were also present. Shag are diurnal foragers and, unlike the majority of diving seabirds, their plumage is partially water permeable. This requires them to return to land each day in order to dry their feathers, and as such they are constrained to foraging in relatively inshore areas (Daunt *et al*., 2006).

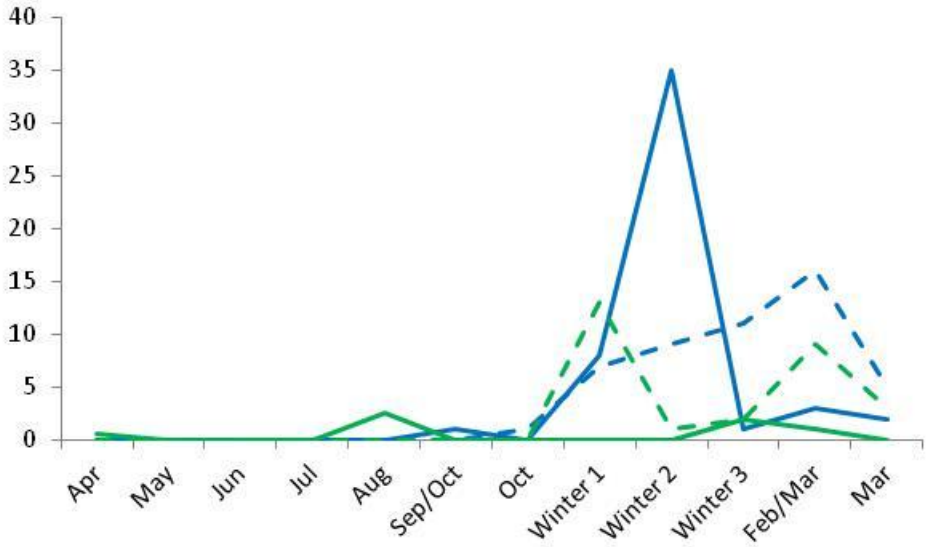
4.7.3 Foraging distances

The foraging ecology of shag has been extensively studied, particularly around the Isle of May. Using radio-tracking techniques Wanless *et al.* (1991b) found the mean foraging range of chick rearing adults to be 7.0 km, and the maximum to be 17 km. Over 90% of foraging trips were within a 13 km radius of the breeding colony. Other surveys using boat-based line transect methods have shown shorter foraging ranges around breeding colonies, for example around Sumburgh Head in Shetland, high densities of shag were recorded over two sandbanks out to a radius of 5 km from the breeding colony (Wright and Bailey, 1993). During this study the more distant of these sandbanks was utilised by shag only in years when sandeel availability was low, indicating that foraging range may increase somewhat when prey items are scarce. One Portuguese study recorded birds foraging up to 20 km from their breeding areas throughout the year, though generally within 4 km during the breeding season (Velando, 1997).

Birdlife International data on foraging distances for shag shows a maximum foraging distance of 20 km, a mean maximum of 16.42 km, and a mean foraging distance of 6.53 km. Based on the above information the three proposed wind farm sites are outwith the maximum foraging limit of birds from the East Caithness Cliffs SPA during the breeding season.

4.7.4 Abundance and distribution within sites

This species was recorded from the boat-based surveys between September 2010 and April 2011, and November 2011 and March 2012 (although 5 birds were also seen in August 2011) with a maximum count of 44 in the wind farm sites in December 2010 (Tables 21 and 23, Graph 14).



Graph 14: Total number of shag recorded during each of the MORL boat-based surveys between April 2010 and March 2012 (including birds recorded in flight and using the sea). Blue lines refer to surveys during first year. Green lines refer to surveys during second year. Solid lines refer to records within wind farm sites. Dashed lines refer to records within buffer area. In months where two surveys were conducted mean values are displayed. The winter surveys correspond to the three surveys undertaken between November and January.

4.7.5 Potential for collision risk

All records of birds in flight from boat-based surveys were below potential collision height. Data collected from other developments show that low numbers of this species fly at the potential collision risk height, with 12% from 230 records. Langston (2010) also assessed this species as being at low collision risk. Collision risk is therefore considered to be negligible for this species.

4.7.6 Potential for disturbance / displacement / indirect effects

Numbers of shag were too low to allow any population estimates from distance sampling or density surface modelling. The largest number recorded within the three proposed wind farm sites was 38 birds (Table 23). Due to these low numbers, disturbance and displacement risks are predicted to be negligible.

4.7.7 Potential for barrier effects

Despite the energetic costs of avoiding barriers being high for this species (Masden *et al.*, 2010), a mean foraging distance of 12 km suggests that birds breeding adjacent to the three proposed wind farm sites will not be impacted by their development. The impact is therefore predicted to be negligible.

4.7.8 Key risks

Table 63. Potential effects for shag.

Risk	**Threat to species**	**Justification**
Barrier effects	Negligible	Low numbers on site. Mainly recorded in non-breeding season. Wind farm sites distance from coast greater than maximum foraging range.
Collision	Negligible	Low numbers on site. None recorded at potential collision height. Assessed as low risk by Langston (2010).
Displacement and Disturbance	Negligible	Low numbers on site. Wind farm sites distance from coast greater than maximum foraging range. Not used for foraging in the breeding season.

4.8 Pomarine skua

Pomarine skua is a regular spring and autumn passage migrant to Scotland in small but variable numbers. Estimates of the sizes of these spring and autumn passages are 200-4,500 and 100-2,000 respectively (Forrester *et al*., 2007). Birds are recorded regularly in autumn on the east coast of Scotland, including in the Moray Firth, as they migrate towards their wintering grounds in the south Atlantic.

Very small numbers of pomarine skua were recorded, with a few records coming from spring and autumn months (August, September and October, and May and June - corresponding with the expected migration periods for adult birds).

4.8.1 Potential for collision risk

Very low numbers of pomarine skua were recorded within the three proposed wind farm sites, resulting in very low potential for collisions. All records of birds in flight were below the potential collision risk height. Studies of skua records from other developments suggest that fewer than 10% of skua records are from within the potential collision risk height. Langston (2010) assessed this species as being at medium collision risk. Collision risk is considered to be negligible for this species for the three proposed wind farm sites due to low numbers being present.

4.8.2 Potential for disturbance / displacement / indirect effects

With very low numbers of birds involved, and no birds from breeding colonies foraging in the area, it is assumed that effects from disturbance and displacement will be negligible.

4.8.3 Potential for barrier effects

Pomarine skua are long distance migrants, with no breeding birds foraging within or around the three proposed wind farm sites, so it is likely that any potential barrier effects on this species will be negligible.

4.8.4 Key Risks

Table 64. Potential effects for pomarine skua.

Risk	Threat to species	Justification
Barrier effects	Negligible	Low numbers on the site Wind farm sites not used for foraging in the breeding season. Efficient flight and wing loading.
Collision	Negligible	Low numbers on the site. None recorded at potential collision height. Assessed as medium risk by Langston (2010).
Displacement and Disturbance	Negligible	Low numbers on the site. Efficient flight and wing loading.

4.9 Arctic skua

Arctic skua breed around the northernmost coasts of Europe, Asia and North America and winter in the southern hemisphere around the southern coasts of Africa, South America and Australia and New Zealand. The Scottish population constitutes approximately 0.6-2.5% of an estimated global population of 85,400-335,000 pairs (Mitchell *et al*., 2004), however this global estimate may be a dramatic underestimation; Birdlife International suggest there may be between 500,000 and 10 million individuals. The UK Arctic skua population declined by 34% between 2000 and 2010 (JNCC 2011).

The breeding population of the Arctic skua in Great Britain and Ireland is approximately 2,100 pairs (1998-2002), all confined to northern and western Scotland (Mitchell *et al*., 2004). In addition variable numbers pass by Scottish coastlines each spring and autumn as they migrate to and from breeding grounds further north.

Spring passage is estimated to be between 1,000 and 5,000 birds mainly along western coasts, and autumn passage between 1,000 and 10,000 birds (Forrester *et al*., 2007) along both eastern and western coasts.

JNCC analysis of ESAS data collected between 1980 and 2006, to provide at-sea distributions of Arctic skua during the breeding season and autumn migration period (September to November), are shown in Images 17a and 17b (Kober *et al*., 2010). These data show low to medium densities recorded within the Moray Firth.

In the surrounding regions, breeding Arctic skua is limited to Caithness and Orkney (Table 65). These areas contain 38% of the British and Irish Arctic skua population. SPAs designated for Arctic Skua within these regions are listed in Table 66.

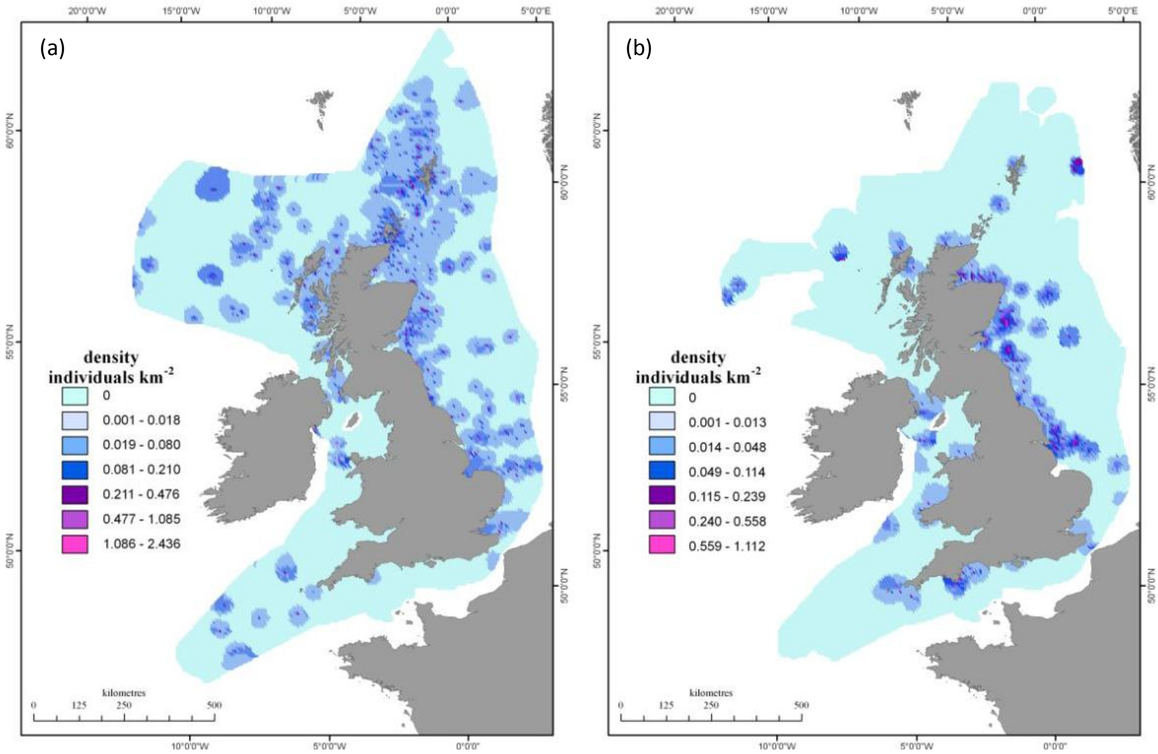


Image 17: JNCC predicted density surface maps produced from ESAS data collected between 1980 and 2006. Left (a): breeding. Right (b): September to November (taken from Kober *et al*., 2010).

Table 65 : Arctic skua populations in districts around the Moray Firth (Mitchell *et al*., 2004)

District	**Population (AOT)**
Orkney	720
Caithness	71
TOTAL	791

Table 66: SPAs surrounding the wind farm sites which are designated for Arctic skua.

Colony	Location	Colony size (pairs)	Distance from wind farm sites	Period
Hoy	Orkney	59	58 km	1985-1988*1
Rousay	Orkney	130	99 km	1986-1988*2
West Westray	Orkney	78	108 km	1985-1988*1

*1 Seabird Colony Register Census, *2 three year mean

4.9.1 Annual cycle

Adults return to Scottish breeding colonies from late April onwards, with egg laying occurring from mid-May (Forrester *et al*., 2007). Eggs are incubated for 25-28 days, and nestlings fledge 25-30 days after hatching (Snow and Perrins, 1998). Fledglings usually remain close to their natal site for approximately two more weeks, during which time they continue to be fed by their parents (Forrester *et al.*, 2007). Post-breeding dispersal typically occurs in late July or early August, however individuals that have failed in their breeding attempt may leave earlier (Forrester *et al.,* 2007). Birds move in a generally southward direction after breeding, with small numbers crossing overland but the bulk of the autumn passage moving along the coasts between August and October. Almost all winter in pelagic waters south of the equator, with most sub-adults remaining in pelagic areas for their first two years (Wernham *et al.,* 2002).

4.9.2 Food preferences

In the north-east Atlantic area Arctic skua obtain almost all of their food through kleptoparasitism (Furness, 1978 & 1987), particularly small fish carried by terns, small gulls and auks. As such, the main food item for Arctic skua in Scotland is generally sandeels (Furness, 1987). A small proportion of their diet is obtained through predation of other seabird species, mostly of eggs and chicks, and rodents, insects and berries are taken in some areas (Furness, 1987).

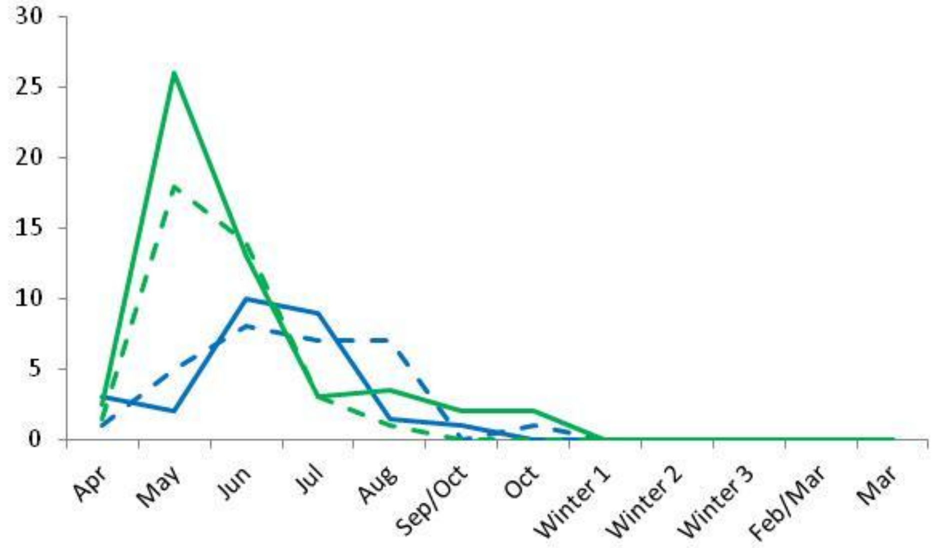
4.9.3 Foraging distances

Although a lot of research has taken place on Arctic skua on the Shetland Isles, foraging behaviour appears to be one of the lesser studied aspects of their ecology. Arctic skua spend relatively little time foraging compared to other seabirds, which is thought to be a result of their specialised kleptoparasitic behaviour. Studies of birds breeding on Foula have found very few patrolling (foraging) Arctic skua at distances greater than 2 km from the island (Furness, 1978), with hosts located within 1 km of two sites 2-3 km from breeding territories (Phillips, 1995).

Birdlife International data on foraging distances for Arctic skua shows a maximum foraging distance of 100 km, a mean maximum of 40 km, and a mean foraging distance of 28 km. Based on the above information it is unlikely that Arctic skuas breeding in SPAs in Orkney or from the small population in Caithness forage frequently, if at all, within the three proposed wind farm sites. Some of the birds recorded within the three proposed wind farm sites may be non-breeding individuals.

4.9.4 Abundance and distribution within sites

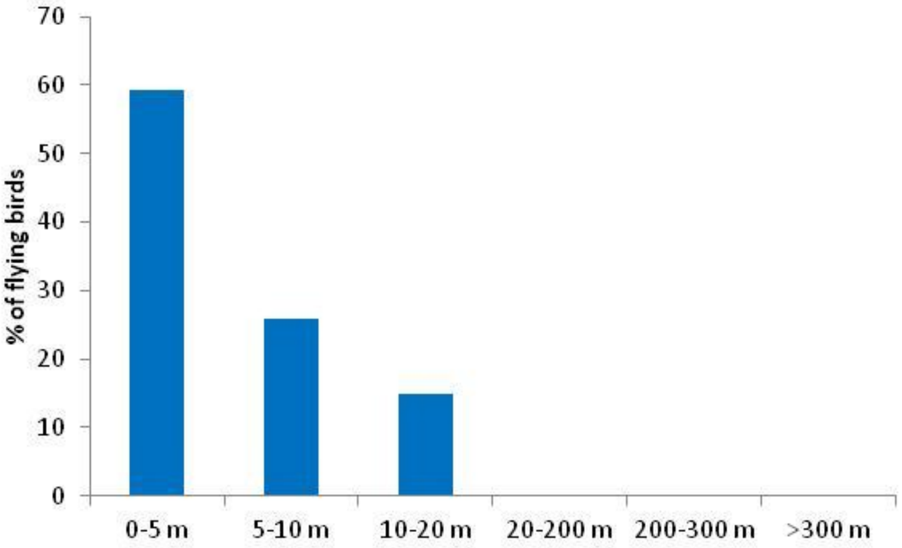
Arctic skua were recorded in most months, with birds only being absent during the winter, between November and March. Numbers of birds recorded during boat-based surveys were highest in the spring and summer periods. Maximum counts from boat-based surveys were 17 in June 2010 and 41 in May 2011 (Tables 21 and 23, Graph 15). No flights were recorded at potential collision height (Table 24, Graph 16).



Graph 15: Total number of Arctic skua recorded during each of the MORL boat-based surveys between April 2010 and March 2012 (including birds recorded in flight and using the sea). Blue lines refer to surveys during first year. Green lines refer to surveys during second year. Solid lines refer to records within wind farm sites. Dashed lines refer to records within buffer area. In months where two surveys were conducted mean values are displayed. The winter surveys correspond to the three surveys undertaken between November and January.

4.9.5 Potential for collision risk

Of 28 Arctic skua recorded in flight in transect, none were observed flying at potential collision risk height (Graph 16). Studies of flight height, collated from other offshore development areas show that 10% of Arctic skua were recorded flying at potential collision risk height. Langston (2010) assessed this species as being at medium collision risk. Collision risk is however considered to be negligible for this species for the three proposed wind farm sites due to low numbers being present.



Graph 16: Proportions of Arctic skua flights recorded in each height band (for birds recorded in transect during April 2010 to March 2012 boat-based surveys).

4.9.6 Potential for disturbance / displacement / indirect effects

Given the very small foraging ranges accessible to breeding Arctic skua, it is unlikely that birds within the three proposed wind farm sites during the breeding season are actually breeding birds. Due to these low numbers, disturbance and displacement risks are predicted to be negligible.

4.9.7 Potential for barrier effects

Overall barrier effects are likely to be minimal as the birds using the three wind farm sites are unlikely to be breeding birds. Most Arctic skua recorded on the sites will be non-breeding birds or in transit to or from breeding grounds. This effect is therefore predicted to be negligible.

4.9.8 Key risks

Table 67. Potential effects for Arctic skua.

Risk	Threat to species	Justification
Barrier effects	Negligible	Wind farm sites not used for foraging in the breeding season. Efficient flight and wing loading.
Collision	Negligible	None recorded at collision risk height. Assessed as medium risk by Langston (2010).
Displacement and Disturbance	Negligible	Wind farm sites not used for foraging in the breeding season.

4.10 Long-tailed skua

Long-tailed skua is a regular spring and autumn passage migrant in small but variable numbers. Estimates of the sizes of these spring and autumn passages are 100-1,600 and 100-1,000 respectively (Forrester *et al*., 2007). Birds are recorded regularly in autumn on the east coast of Scotland, including in the Moray Firth, as they migrate towards their wintering grounds in the south Atlantic.

Within the boat-based survey area only one long-tailed skua was recorded between April 2010 and March 2012; flying north in late May 2010 (Table 21).

4.10.1 Potential for collision risk

Very low numbers of long-tailed skua were recorded within the three proposed wind farm sites, resulting in very low potential for collisions. All records of birds in flight were below the potential collision risk height. Studies of skua records from other developments suggest that fewer than 10% of skua records are from within the potential collision risk height. Langston (2010) assessed this species as being at medium collision risk. Collision risk is considered to be negligible for this species for the wind farm sites due to low numbers being present.

4.10.2 Potential for displacement / disturbance / indirect effects

With very low numbers of birds involved, and no birds from breeding colonies foraging in the area, it is assumed that effects from disturbance and displacement will be negligible.

4.10.3 Potential for barrier effects

Long-tailed skua are long distance migrants, with no breeding birds foraging within or around the three proposed wind farm sites, so it is likely that any potential barrier effects on this species will be negligible.

4.10.4 Key Risks

Table 68. Potential effects for long-tailed skua.

Risk	Threat to species	Justification
Barrier effects	Negligible	Low numbers on the site. Wind farm sites not used for foraging in the breeding season. Efficient flight and wing loading.
Collision	Negligible	Low numbers on the site. None recorded at collision risk height. Assessed as medium risk by Langston (2010).
Displacement and Disturbance	Negligible	Low numbers on the site.

4.11 Great skua

A large majority of the global great skua population breeds in Scotland and Iceland, with smaller numbers occurring in the Faroe Islands, Svalbard and Norway. The species is migratory, with most birds wintering off the Atlantic coasts of France and Iberia, with juveniles often dispersing further south. The Scottish population constitutes approximately 60% of the global population of 16,000 pairs (Mitchell *et al*., 2004). Very few great skua are present in Scottish waters in winter (Forrester *et al*., 2007).

The breeding population of great skua in Great Britain and Ireland is approximately 9,600 pairs (1998-2002), with >99% breeding in Scotland; approximately 71% of these are in Shetland with the remainder in Orkney and western Scotland (Mitchell *et al*., 2004). Spring passage around the Scottish coast (mainly on the west) is estimated to be between 1,000 and 6,000 birds, and autumn passage between 2,000 and 10,000 birds (both eastern and western coasts) (Forrester *et al*., 2007).

JNCC analysis of ESAS data collected between 1980 and 2006, to provide at-sea distributions of great skua during the breeding season and autumn winter period are shown in Images 18a and 18b (Kober *et al*., 2010). These data show low to medium densities recorded within the Moray Firth.

The population sizes of the surrounding regions of Orkney and Caithness are shown in Table 69. These areas contain 23% of the British and Irish great skua population, and one SPA (Hoy: 1900 breeding pairs, 1996) 58 km from the wind farm sites.

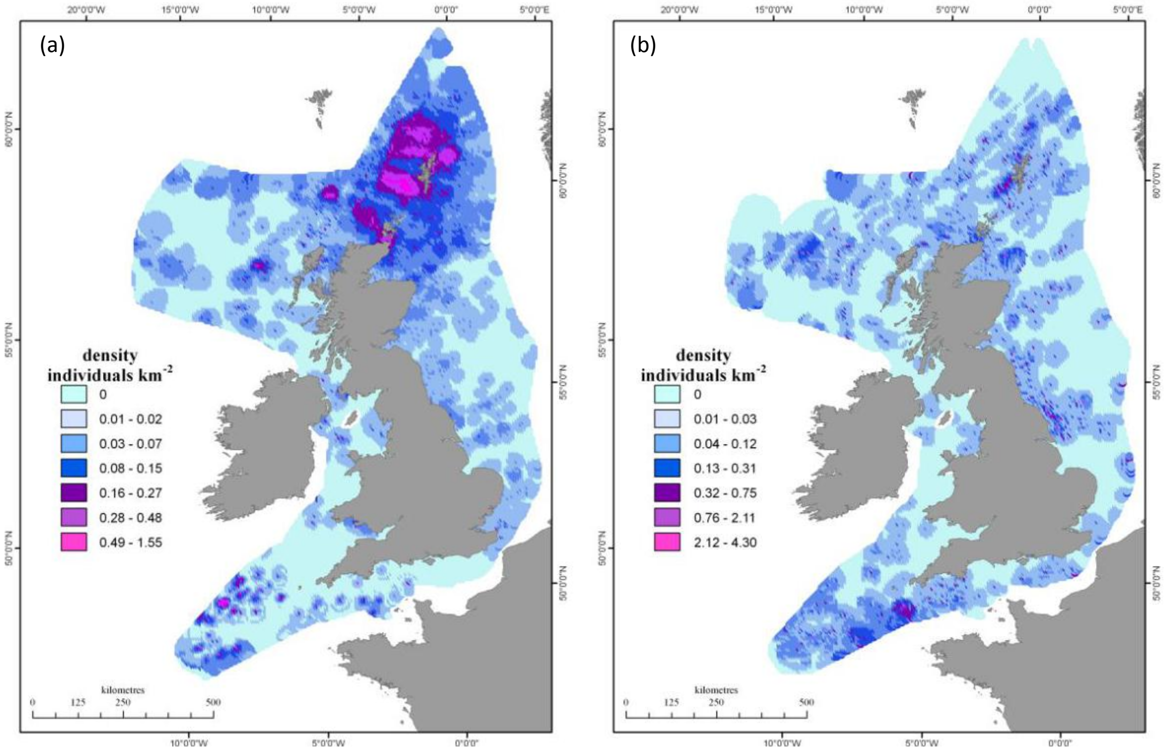


Image 18: JNCC predicted density surface maps produced from ESAS data collected between 1980 and 2006. Left (a): breeding. Right (b): winter (September to April)* (taken from Kober *et al*., 2010). *Almost all of the great skuas recorded in the northern areas shown in Image 18b were recorded in September to October and March to April

Table 69: Great skua populations in districts around the Moray Firth (Mitchell *et al*., 2004).	
District	**Population (AOT)**
Orkney	2,209
Caithness	5
TOTAL	2,214

4.11.1 Annual cycle

Adults return to Scottish breeding colonies from late March onwards, with eggs usually being laid in mid to late May (Forrester *et al*., 2007). Eggs are incubated for 26-32 days, and nestlings fledge 40-51 days after hatching (Snow and Perrins, 1998).

Birds start to move south, towards their wintering grounds, between mid-August and mid-September (Forrester *et al*., 2007). Great skuas do not start breeding until they are between five and twelve years of age (Klomp and Furness, 1992), before this many birds will return to areas near breeding colonies and form aggregations of non-breeding birds (Snow and Perrins, 1998).

4.11.2 Food preferences

Studies of great skua diet in Shetland suggest that, in general, fish obtained through either kleptoparasitism (mostly sandeels) of other seabird species, or trawler discards, form the bulk of food items consumed (Bearhop *et al*., 2001; Voiter *et al*., 2001 & 2003). Seabirds usually form only a small proportion of great skua diet, but are more frequently predated where fishery discards or sandeel-carrying host species are less available (Thompson *et al*., 1998; Phillips *et al.*, 1999b; Voiter *et al*., 2004a). Dietary composition may vary considerably between individuals, as some specialise on particular foraging methods (Voiter *et al*., 2004b,c).

4.11.3 Foraging distances

Great skua foraging ranges have been comparatively little studied, however it appears that there are dramatic differences between when individuals are predating seabirds and when they are obtaining fish. Voiter *et al*. (2004b) used radio-tracking methods to follow great skua with different dietary specialisations at Hermaness, in Shetland. Some individuals predated seabirds and usually stayed within 2 km of their nest site, while other individuals mainly foraged on fishery discards and travelled to areas when fishing boats were active, often over 10 km away. Foraging ranges may therefore reflect the distribution of fishing vessels around great skua breeding colonies.

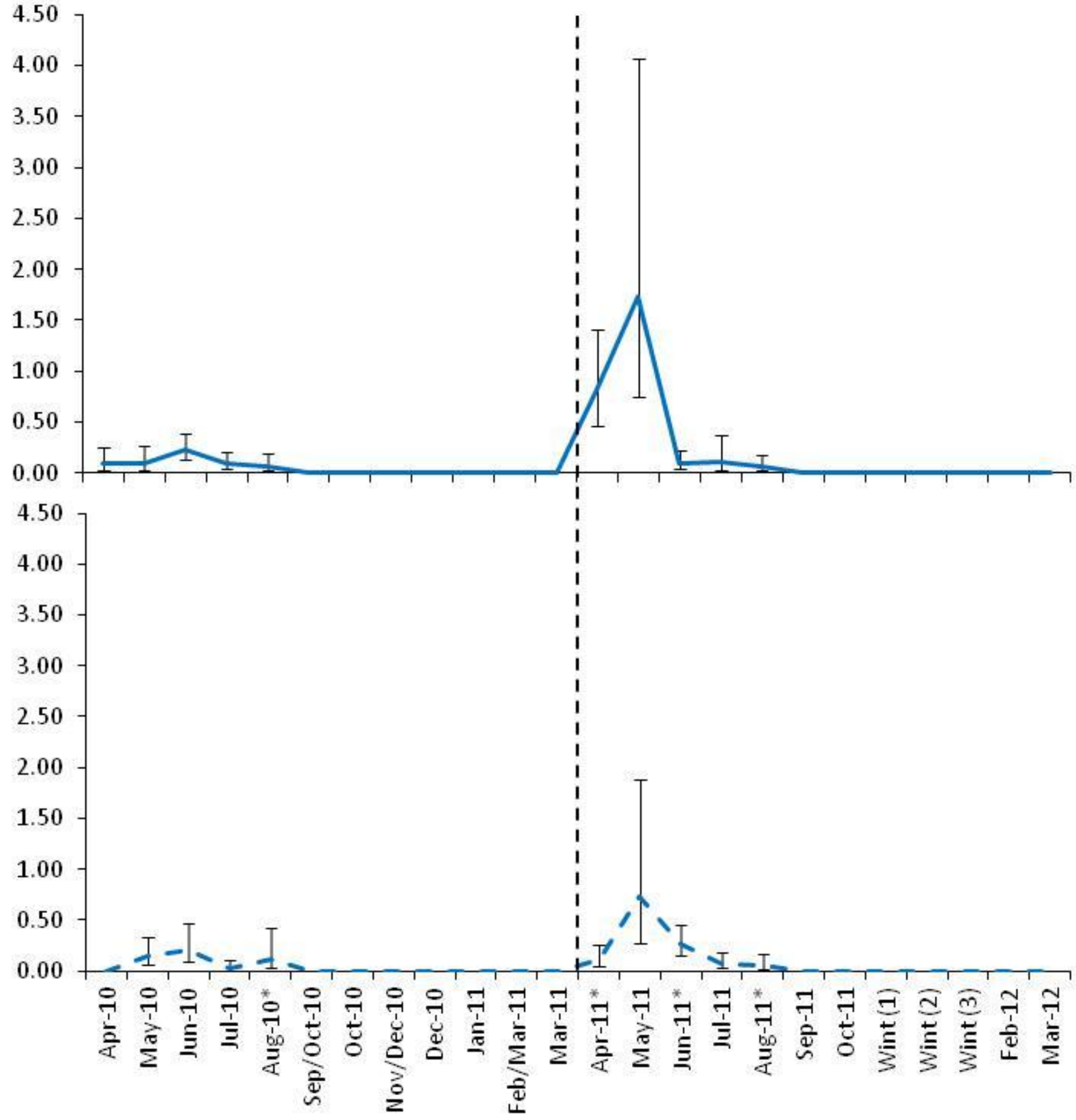
Birdlife International data on foraging distances for great skua shows a maximum foraging distance of 100 km, a mean maximum of 42.33 km, and a mean foraging distance of 35.8 km. Based on the above information it is unlikely the great skua breeding in SPAs in Orkney forage frequently, if at all, within the three proposed wind farm sites.

4.11.4 Abundance and distribution within sites

Great skua were recorded throughout the year apart from the winter months, with birds absent from November to March, other than one bird seen flying during the first winter 2011/2012 survey (Win 1, Table 21). Densities were highest in late spring, peaking in the three proposed wind farm sites in June 2010 (0.22 birds/km^2) and May 2011 (1.74 birds/km^2) (Table 30, Graph 17).

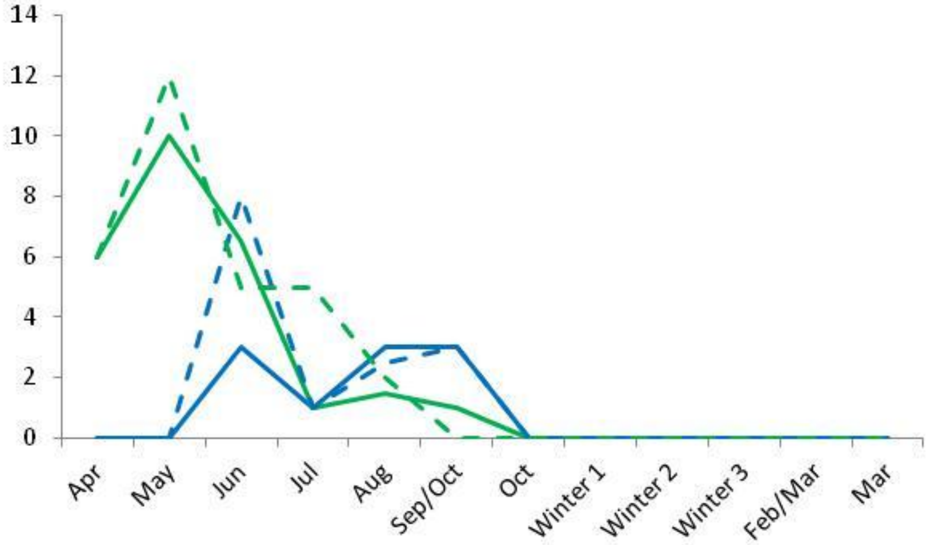
Table 70. Mean density and abundance of great skua on the three proposed wind sites and the buffer zone, in the breeding and non-breeding season from boat-based surveys

Breeding Season				Non-breeding season			
Density		**Abundance**		**Density**		**Abundance**	
Site	**Buffer**	**Site**	**Buffer**	**Site**	**Buffer**	**Site**	**Buffer**
0.34	0.17	101	62	n/a	n/a	n/a	n/a



Graph 17. Temporal variation in great skua density (birds/km²) in the wind farm sites (solid line) and the buffer zone (dotted line) Excludes records with percentage CV greater than 100 (low confidence).

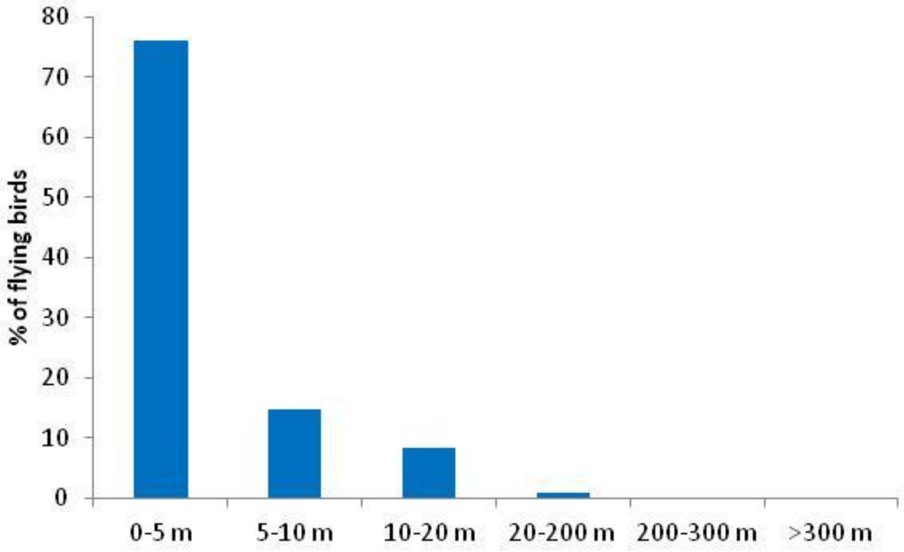
* two surveys were conducted during these months. The datasets from both were combined to derive density estimates through distance sampling.



Graph 18: Number of great skua recorded in flight in transect during each of the MORL boat-based surveys between April 2010 and March 2012. Blue lines refer to surveys during first year. Green lines refer to surveys during second year. Solid lines refer to records within wind farm sites. Dashed lines refer to records within buffer area. In months where two surveys were conducted mean values are displayed. The winter surveys correspond to the three surveys undertaken between November and January.

4.11.5 Potential for collision risk

Of 110 great skua recorded in flight in transect, only one was observed flying within the potential collision risk area (0.9%; Table 24, Graph 19). Of 195 birds recorded from other offshore development projects, 4% were observed flying at collision risk height (Cook *et al.*, 2011). Langston (2010) assessed this species as being at medium collision risk. Collision risk is considered to be low for this species for the three proposed wind farm sites, due to low numbers being recorded at potential collision height.



Graph 19: Proportions of great skua flights recorded in each height band (for birds recorded in transect during April 2010 to March 2012 boat-based surveys).

4.11.6 Potential for disturbance / displacement / indirect effects

The mean density of great skuas recorded within the three proposed wind farm sites was 0.34 birds/km^2 during the breeding season, equating to an abundance estimate across the three sites of 101 birds (Table 70).

Great skua have a low sensitivity to ship and helicopter disturbance (Table 20; based on Garthe and Huppop, 2004), suggesting this will not be an issue for this species.

Given the foraging ranges of breeding great skua, it is likely that the majority of individuals within the wind farm sites during the breeding season are non-breeding birds. Due to this, disturbance and displacement effects are predicted to be minor.

4.11.7 Potential for barrier effects

With measured foraging ranges between 2 and 10 km, it is unlikely that great skua observed within the three proposed wind farm sites are breeding birds. It is much more likely that they are non-breeding birds, or migrants transiting to or from the breeding grounds. This, combined with the relatively low energetic costs incurred to this species by avoidance, suggest that barrier effects would be negligible (Masden *et al*., 2010).

4.11.8 Key risks

Table 71. Potential effects for great skua.

Risk	Threat to species	Justification
Barrier effects	Negligible	Efficient wing loading and flight. Wind farm sites not used for foraging in the breeding season.
Collision	Minor	Proportion flying at collision risk height 0.04 in other studies. 0.9% recorded within collision risk height in wind farm sites. Assessed as medium risk by Langston (2010).
Displacement and Disturbance	Minor	Relatively low numbers during breeding season. Majority of individuals considered to be non-breeders.

4.12 Kittiwake

Kittiwake breed along the coastlines of the north Atlantic and Pacific oceans and parts of the north coast of Arctic Russia. They winter at sea over most of the northern parts of the northern hemisphere's oceans. The global population is estimated to be 4.3 million-5.2 million breeding pairs, with the UK and Irish population constituting 8-10% of this total (Mitchell *et al*., 2004). The UK kittiwake population declined by 30% between 2000 and 2010 (JNCC 2011).

It is unclear how many kittiwake winter in Scottish waters, although for such an oceanic species numbers are likely to be highly variable. Up to 10,000 have been estimated to be present in Scottish inshore waters in winter (Forrester *et al.*, 2007).

The breeding population of kittiwake in Great Britain and Ireland is approximately 416,000 pairs (estimated from AON data: 1998-2002 [Mitchell *et al*., 2004]). Breeding occurs around the UK coastline, with the largest populations being found in the north-east. The highest concentrations are found in Scotland, where 68% of AON were located (Mitchell *et al*., 2004; Image 19). The population sizes of the surrounding regions of Highland, Grampian and the Northern Isles are shown in Table 72. These areas contain 33% of the British and Irish population, and large numbers of kittiwake breed in SPAs short-listed for inclusion in the impact assessment (Table 73).

JNCC analysis of ESAS data collected between 1980 and 2006, to provide at-sea distributions of kittiwake during the breeding season and winter period, are shown in Images 20a and 20b (Kober *et al*., 2010). These data show medium densities of kittiwake occur in the Moray Firth during the breeding season.

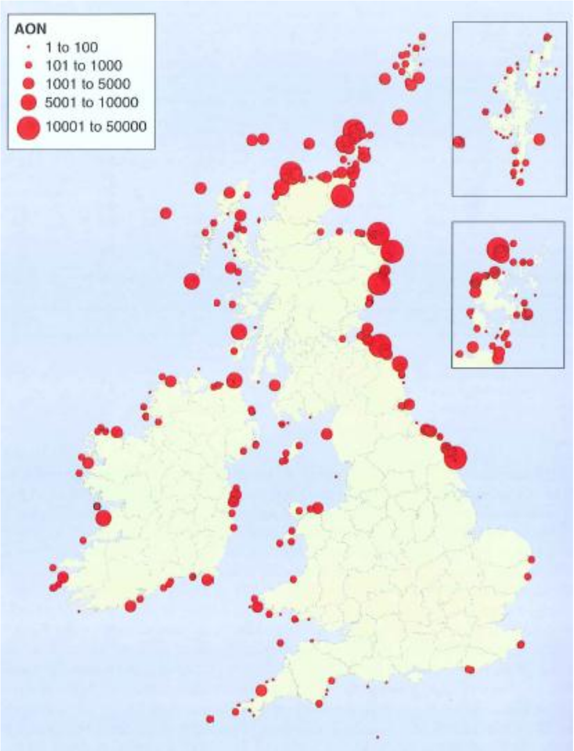


Image 19: Distribution of breeding kittiwake 1998-2002 (taken from Mitchell *et al.*, 2004).

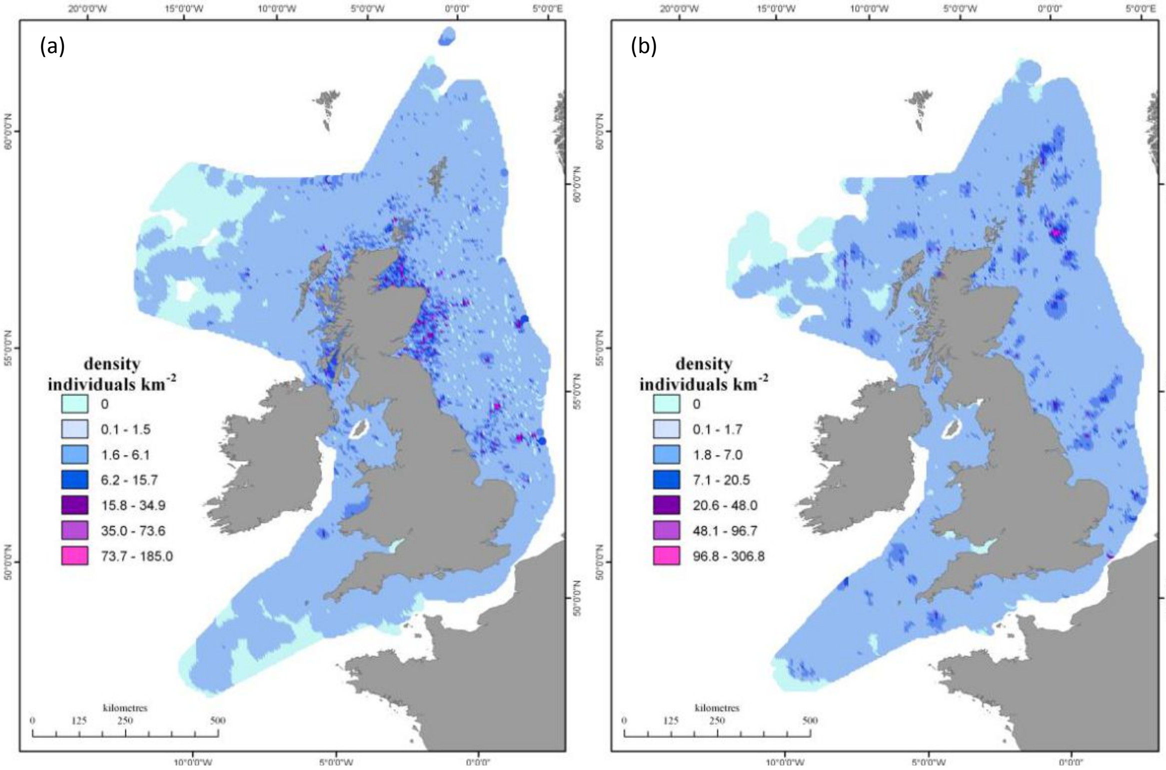


Image 20: JNCC predicted density surface maps produced from ESAS data collected between 1980 and 2006. Left (a): breeding. Right (b): winter (taken from Kober *et al.*, 2010).

Table 72: Kittiwake populations in districts around Moray Firth (Mitchell *et al.*, 2004)

Region	District	Population (pairs)
Northern Isles	Orkney	57,668
Highland	Caithness	49,533
	Ross & Cromarty (east)	944
Grampian	Moray	488
	Banff & Buchan	30,599
TOTAL		139,232

Table 73: SPAs designated for kittiwake surrounding the three proposed wind farm sites

Colony	Location	Colony size (pairs)	Distance from wind farm sites	Count Date
East Caithness Cliffs	Caithness	32,500	20 km	1985-1988*1
North Caithness Cliffs	Caithness	13,100	33 km	1985-1988*1
Troup Head	Banff & Buchan	31,600	49 km	1995
Hoy	Orkney	3,000	58 km	1985-1988*1
Copinsay	Orkney	9,550	61 km	1985-1988*1

*1 Seabird Colony Register Census, *2 three year mean

4.12.1 Annual cycle

Most Scottish kittiwake colonies are re-occupied in late February and March. Egg laying dates vary depending on local food availability (Hamer *et al.*, 1993), with the earliest typically being laid in early to mid-May, and median laying dates usually in mid to late May (Humphreys, 2002). Eggs usually hatch after a 25-32 day incubation period, with nestlings fledging after a further 33-54 days (average 43 days) (Snow and Perrins, 1998). Most fledglings rapidly head west after departing from their breeding colonies, towards wintering areas in the north Atlantic (Wernham *et al.*, 2002).

4.12.2 Food preferences

Small surface-dwelling fish (i.e. sandeel and sprat) form the majority of prey items taken by kittiwake; these are usually obtained through shallow splash diving. Other food items are picked from the sea surface, and trawler discards are taken where available (Cramp and Simmons, 1985; Ratcliffe *et al*., 2000).

4.12.3 Foraging distances

As part of the seabird tracking studies (Technical Appendix 4.5 C) GPS loggers were attached to kittiwakes in the East Caithness Cliffs SPA during the incubation and early chick-rearing period. 77 tracking devices were deployed, of which 25 were retrieved, providing information about 28 complete foraging trips and six incomplete foraging trips (Images 21 and 22). Based on data from fully recorded tracks the mean foraging range was 41.9 ± 36.9 km, and the maximum foraging range recorded was 119.6 km. Most birds travelled roughly south-west to forage off the southern part of the east Caithness coast, the mouth of the Dornoch Firth and the mouth of the inner Moray Firth. Smaller numbers travelled south-east to forage off the north Grampian coast. Several of the track birds passed through the western part of the R3Z1 area, but none appeared to forage and none came close to the three proposed wind farm sites.

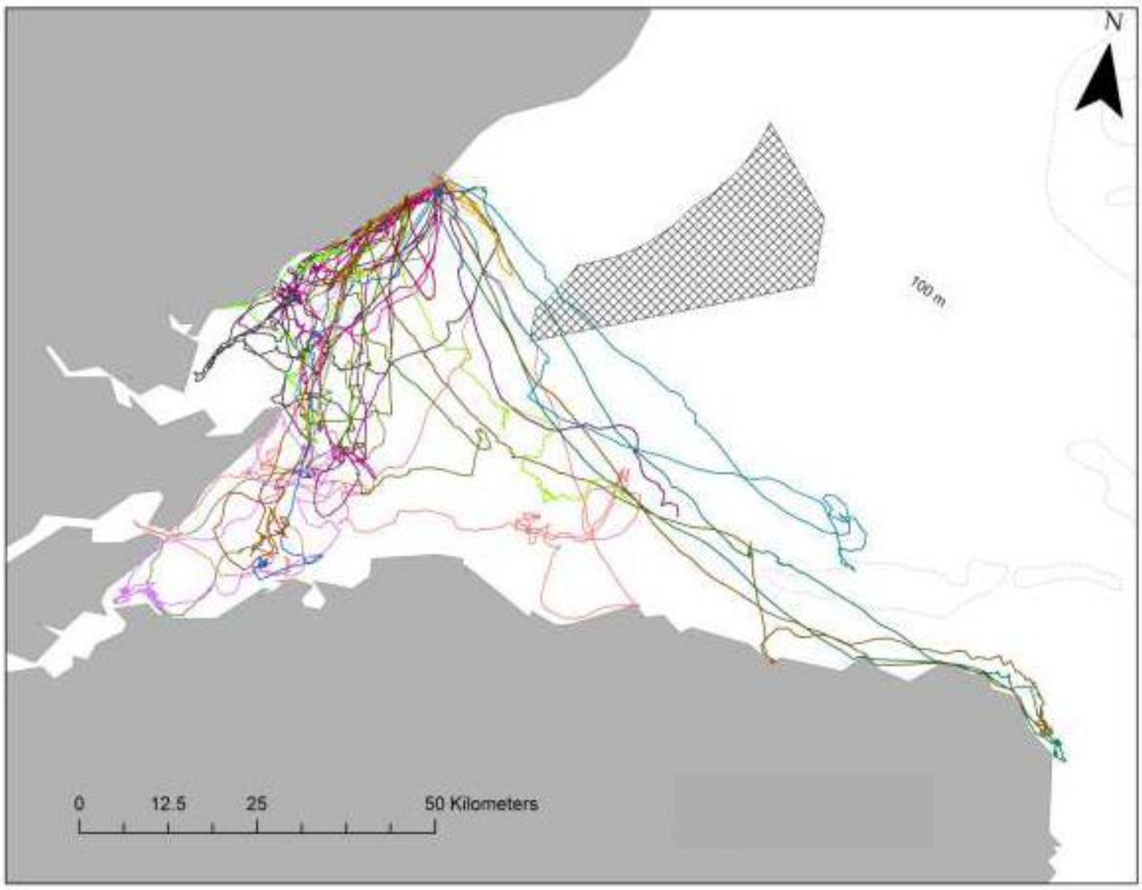


Image 21: GPS tracks of 25 kittiwake breeding within the East Caithness Cliffs SPA (cross hatched area shows extent of MORL zone).

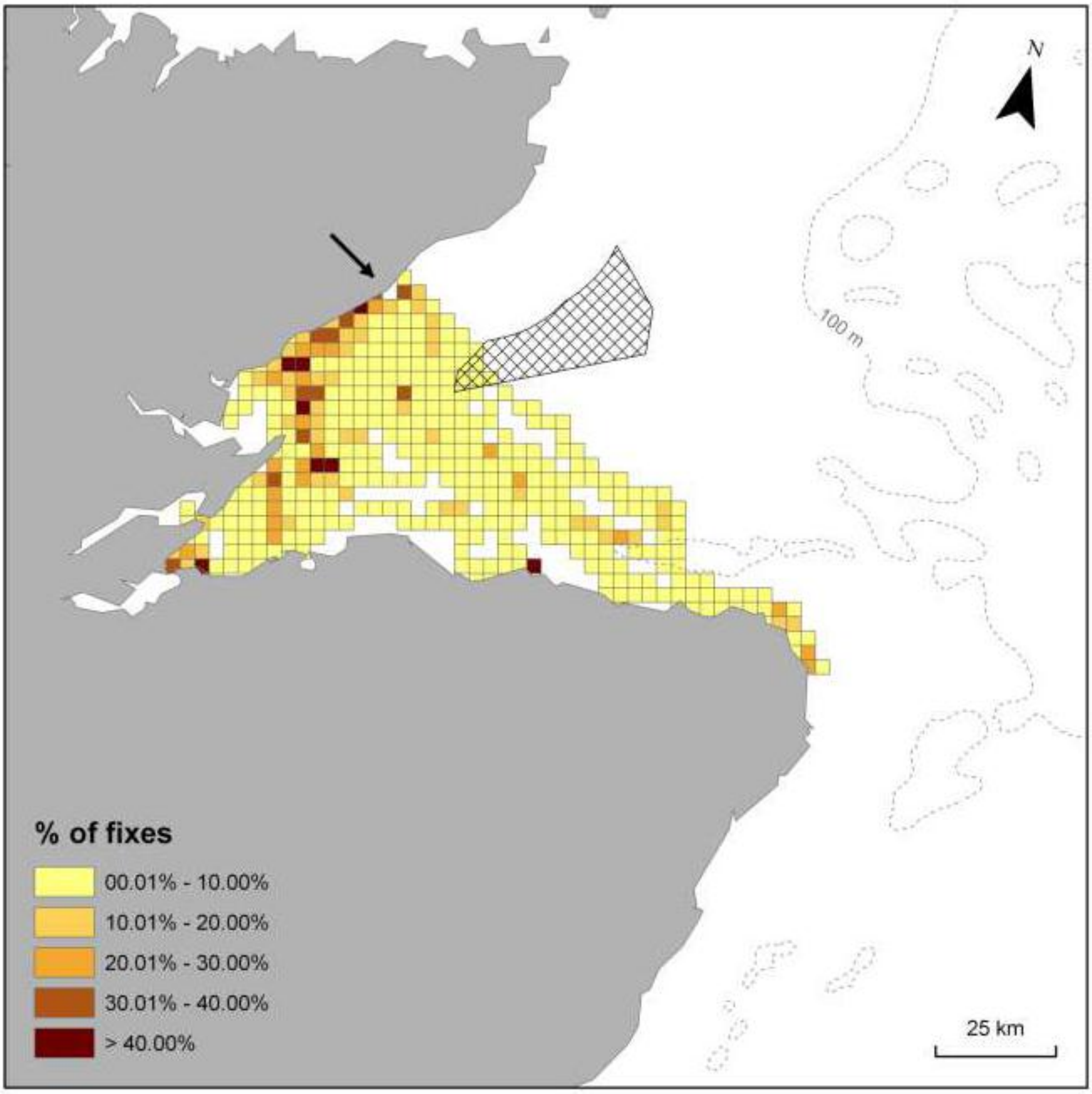


Image 22: Distribution and space use of all kittiwake inferred from 2-minute resolution GPS positions (cross hatched area shows extent of MORL zone).

The foraging ecology of kittiwake has been widely studied, so only the most relevant published data are referenced here. Many of these come from the well-studied population breeding on the Isle of May, in the Firth of Forth. Daunt *et al.* (2002) used data-loggers to investigate flight times and speeds as well as diving times and periods at rest. It was found that kittiwakes on the Isle of May had a maximum foraging distance of 73 ± 9 km. A further study on the Isle of May in 1999-2000 (Humphreys *et al.*, 2006) used radio-telemetry and concluded a similar maximum foraging distance of 83 km. Maximum trip duration was when chicks were between 10 and 15 days old (Humphreys, 2002).

Radio-tracked kittiwakes breeding at Sumburgh Head, Shetland were recorded foraging at distances greater than 40 km in 1990 when sandeel availability was poor, but mainly (97%) within 5 km in 1991 when food availability was better (Hamer *et al.*, 1993).

Kittiwake breeding at St Kilda have been recorded foraging at an offshore bank approximately 40 km from the colony, and also further afield at distances of 50-60 km (Leaper *et al.*, 1988).

Kittiwake at Welsh breeding colonies have also been studied. Stone *et al.* (1992) studied the densities of kittiwake in the seas around the islands of Skomer, Skokholm and Ramsey in Pembrokeshire. The highest densities of kittiwake were recorded at a distance of 20-30 km from the colonies. Some birds were also recorded at the edge of the surveyed area, which was 45 km from the colonies.

Birdlife International data on foraging distances for kittiwake shows a maximum foraging distance of 200 km, a mean maximum of 65.8 km, and a mean foraging distance of 25.45 km.

Based on the above information, a summary is provided below of potential connectivity between SPA kittiwake populations and the three proposed wind farm sites:

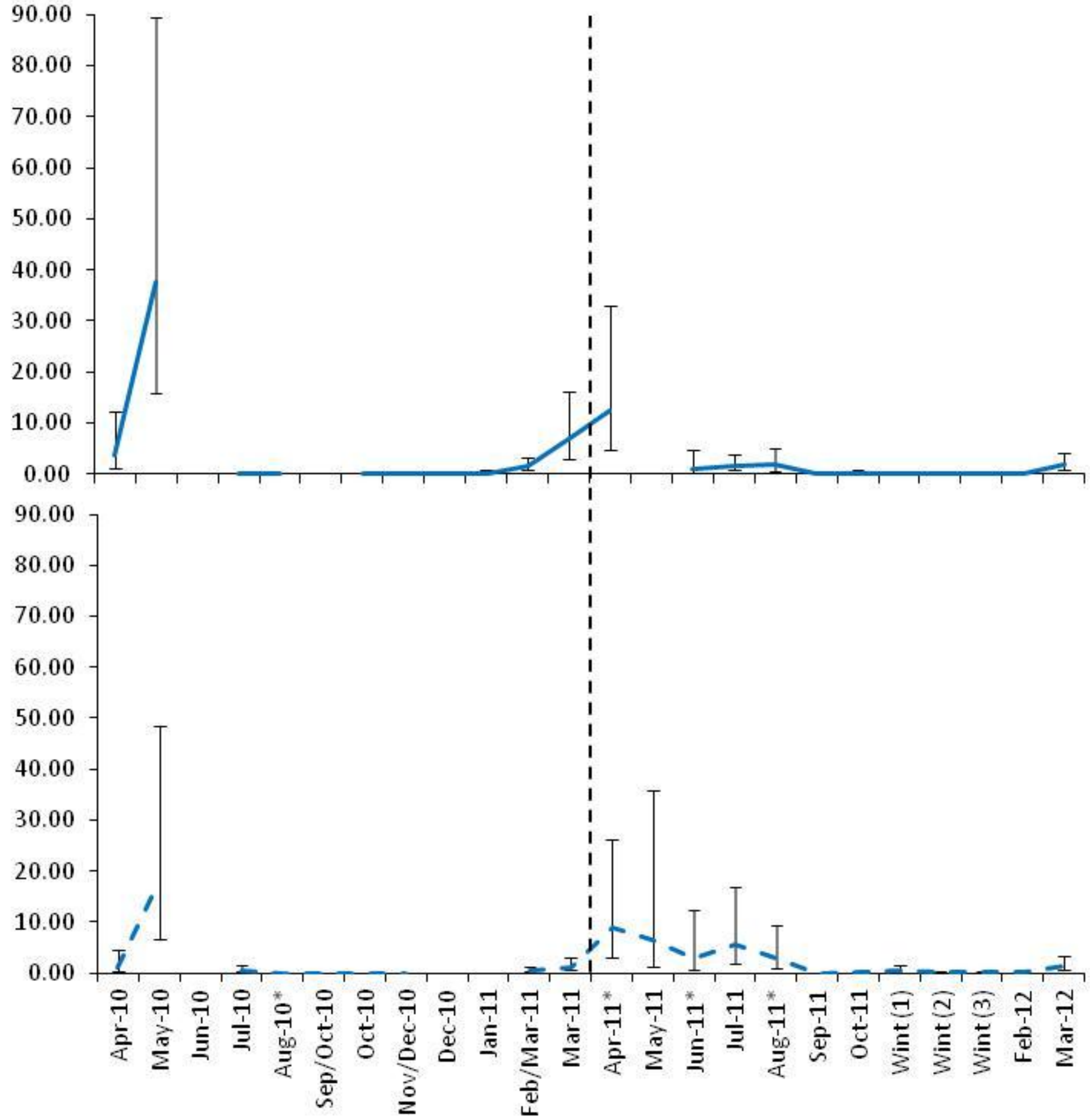
- The sites are within the foraging distance of East Caithness Cliffs SPA, North Caithness Cliffs SPA and Troup, Pennan and Lion's Heads SPA.
- The sites are also within the foraging distance of some of the Orkney SPAs (Hoy SPA and Copinsay SPA), though use of the sites is expected to be less frequent than for the SPAs listed above.

4.12.4 Abundance and distribution within sites

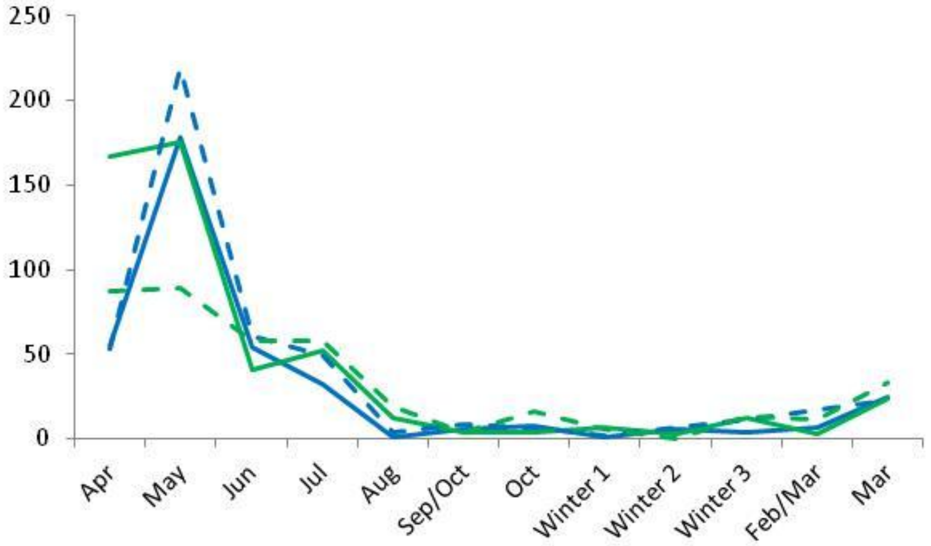
Kittiwake were recorded in all months of the survey. Densities were highest in spring, peaking in the three sites in May 2010 (37.61 birds/km^2) and May 2011(19.55 birds/km^2) (Table 33, Graph 20). The peak month for birds recorded using the sea was April 2011, with 1869 birds recorded on boat-based surveys (Table 23). Annual variation in numbers recorded in flight is shown in Graph 21. Distribution maps for the species are shown in Figures 4 and 5.

Table 74. Mean density and abundance of kittiwake on the three proposed wind farm sites and the buffer zone, in the breeding and non-breeding season from boat-based surveys

Breeding Season				**Non-breeding season**			
Density		**Abundance**		**Density**		**Abundance**	
Site	**Buffer**	**Site**	**Buffer**	**Site**	**Buffer**	**Site**	**Buffer**
7.90	4.69	1963	1532	0.79	0.29	261	204



Graph 20. Temporal variation in kittiwake density (birds/km²) in the wind farm sites (solid line) and the buffer zone (dotted line) Excludes records with percentage CV greater than 100 (low confidence). In months where two surveys were conducted mean values are displayed. The winter surveys correspond to the three surveys undertaken between November and January.



Graph 21: Number of kittiwake recorded in flight in transect during each of the MORL boat-based surveys between April 2010 and March 2012. Blue lines refer to surveys during first year. Green lines refer to surveys during second year. Solid lines refer to records within wind farm sites. Dashed lines refer to records within buffer area. In months where two surveys were conducted mean values are displayed. The winter surveys correspond to the three surveys undertaken between November and January.

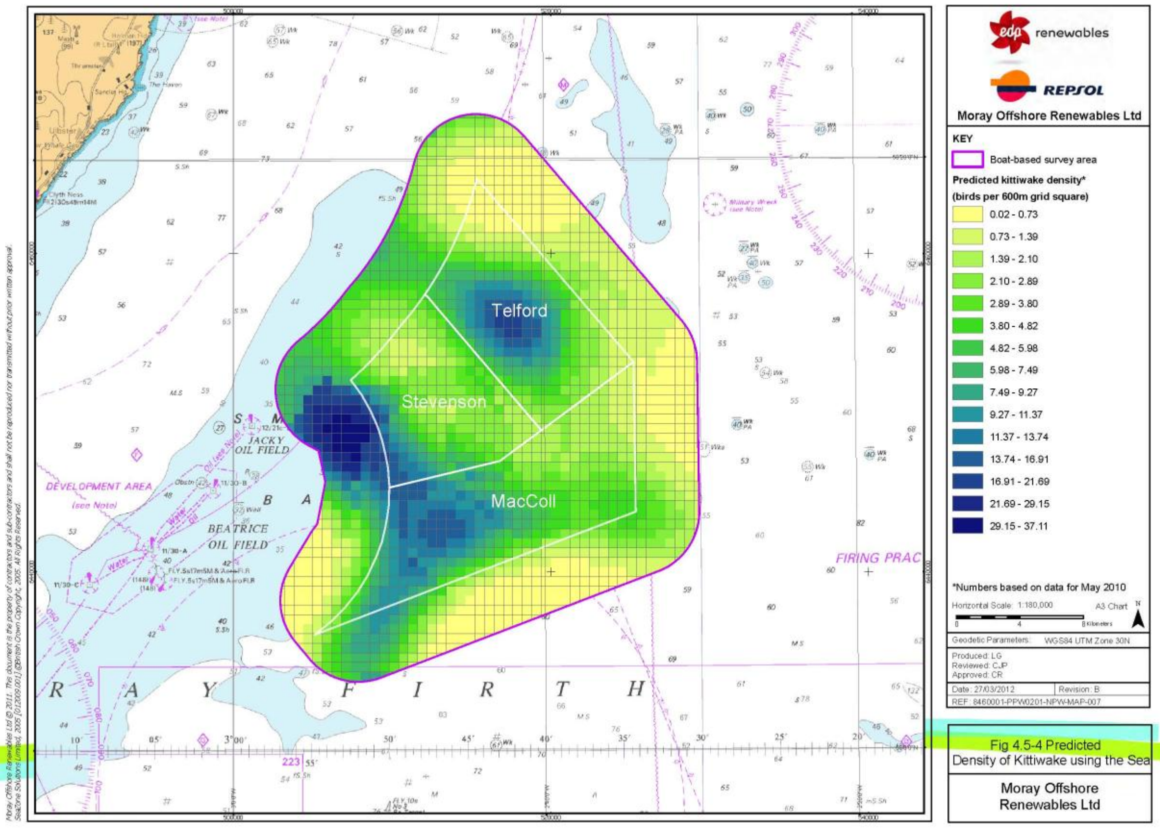


Figure 4. Modelled density surface map for kittiwake from May 2010.

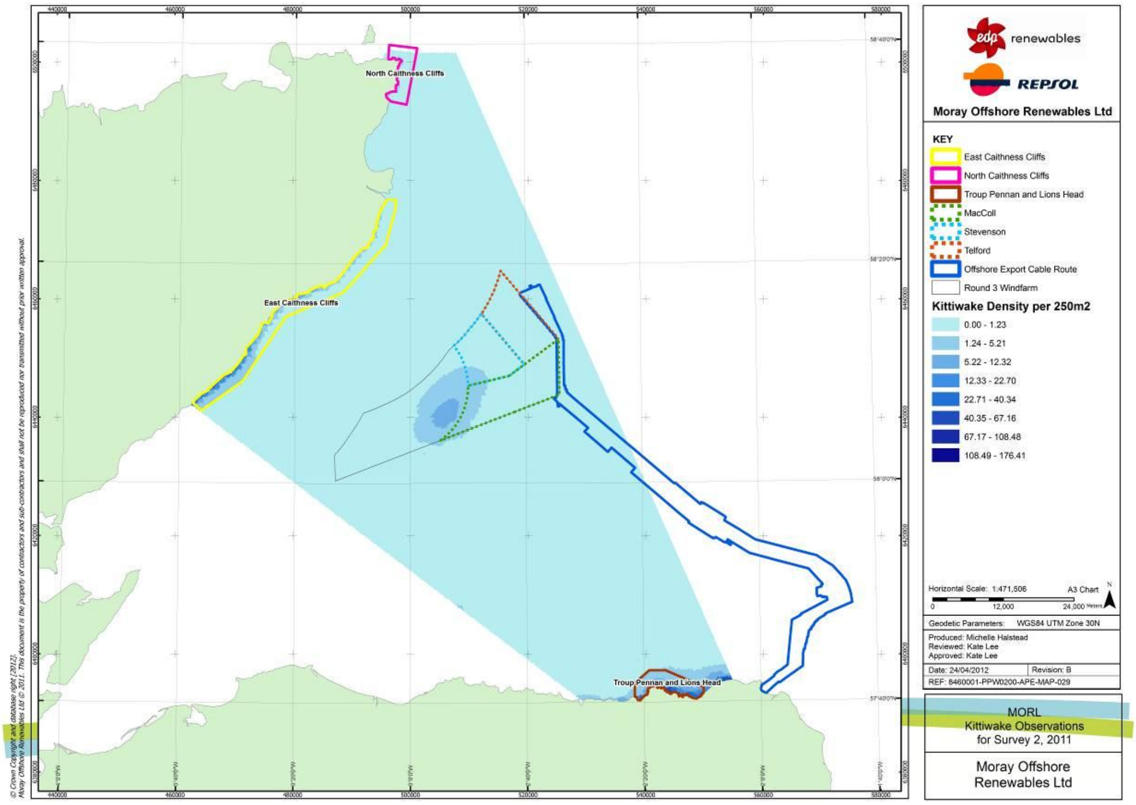


Figure 5a: Distribution of kittiwake across the survey area, from digital aerial surveys - Survey 2.

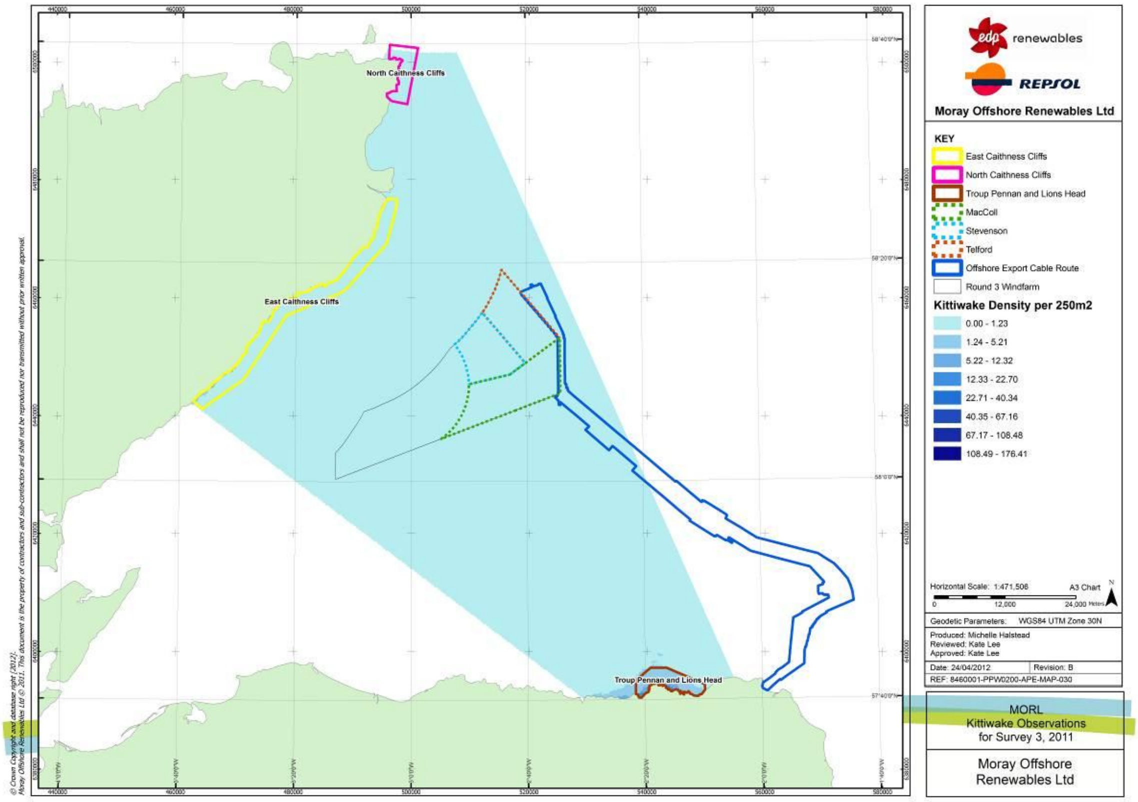


Figure 5b: Distribution of kittiwake across the survey area, from digital aerial surveys - Survey 3.

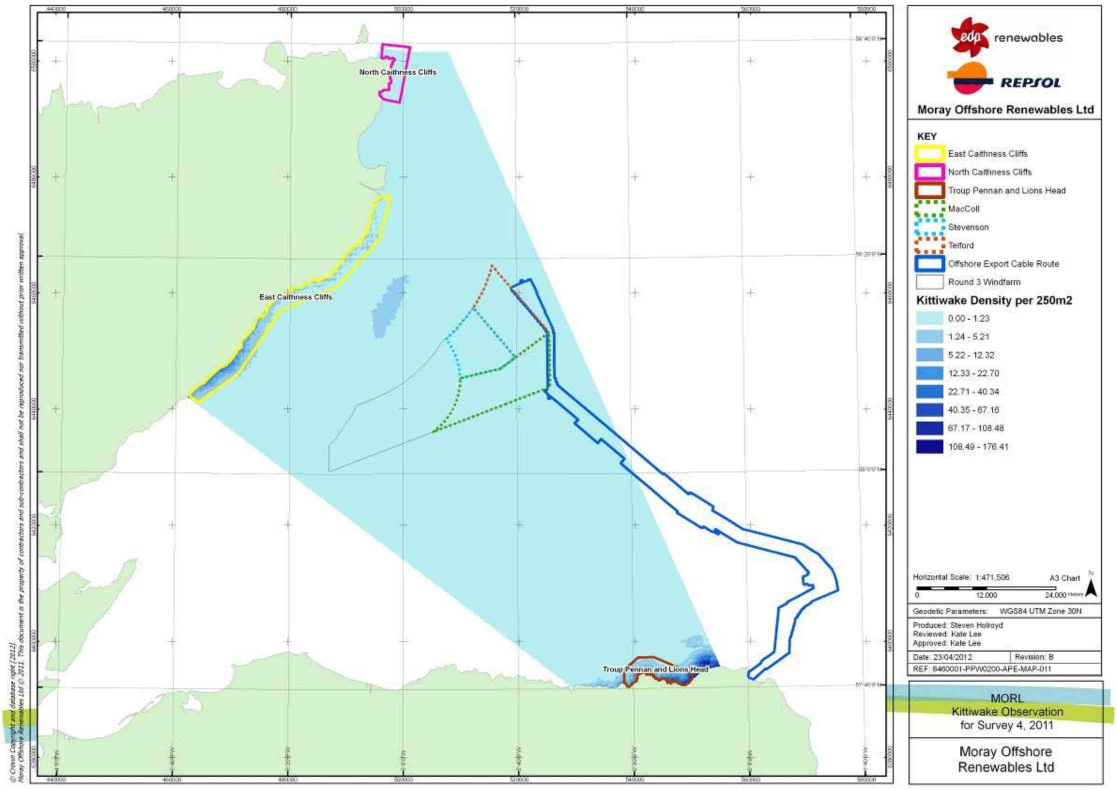


Figure 5c: Distribution of kittiwake across the survey area, from digital aerial surveys - Survey 4.

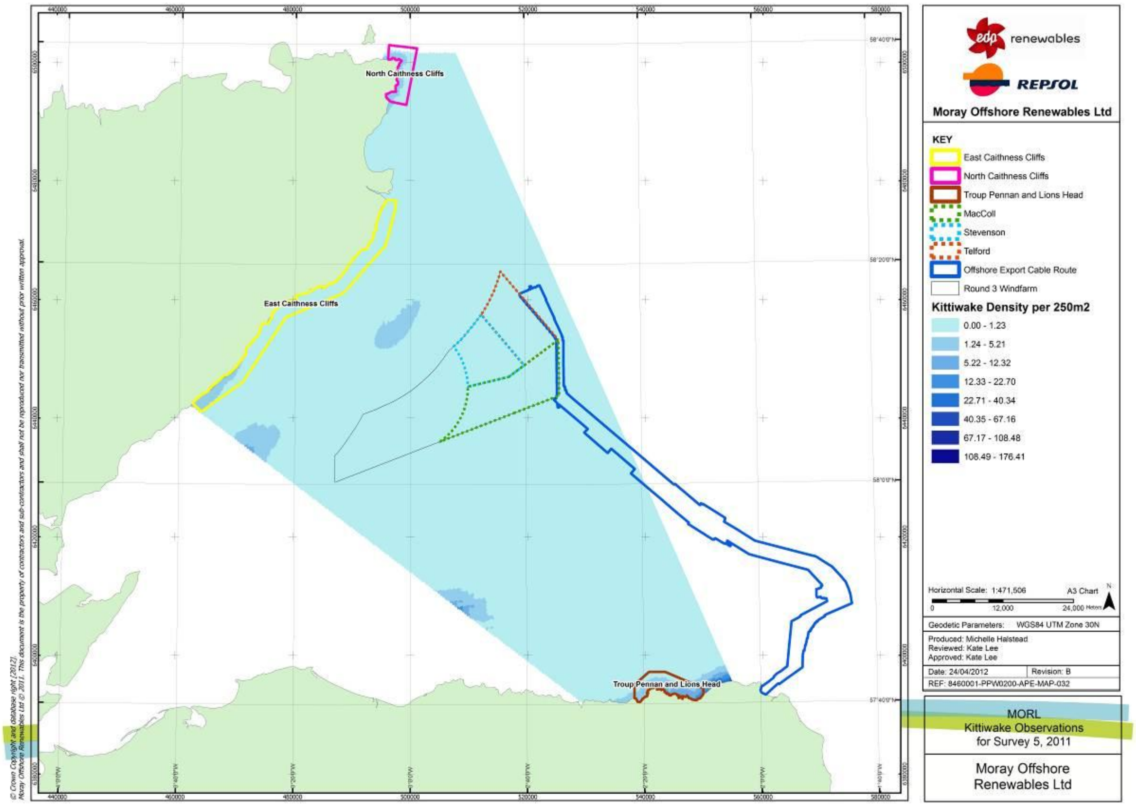


Figure 5d: Distribution of kittiwake across the survey area, from digital aerial surveys - Survey 5.

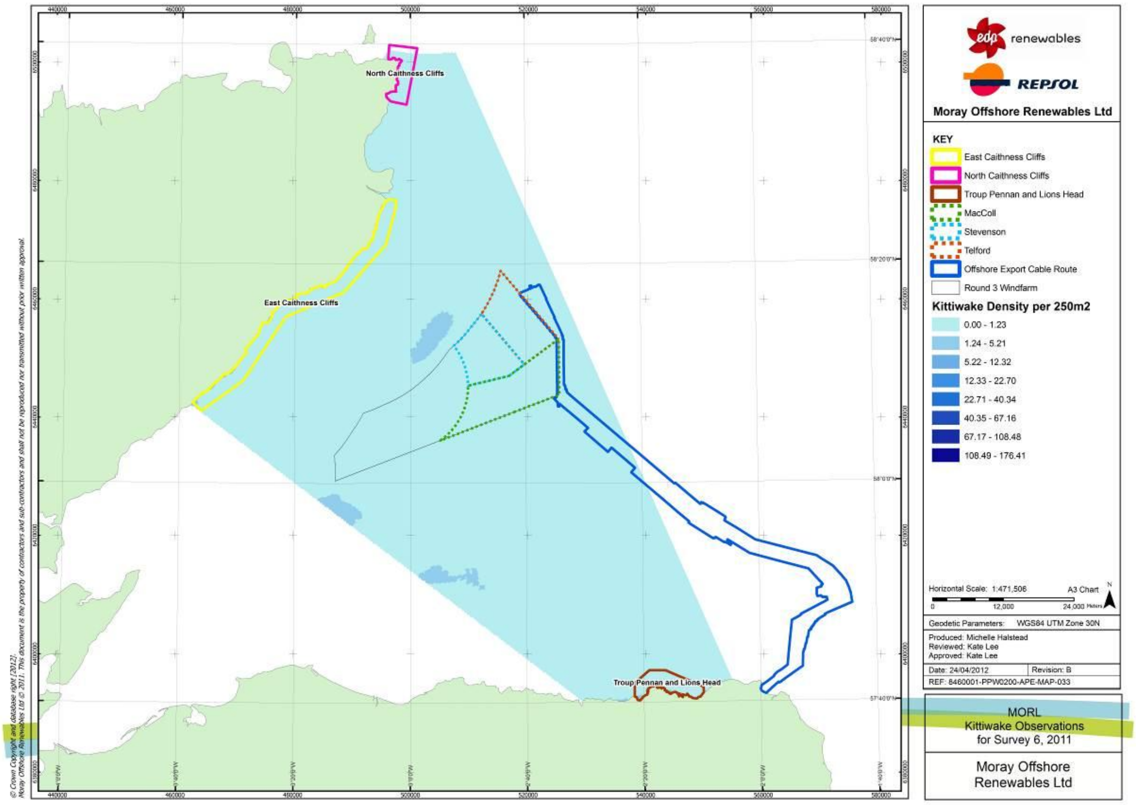
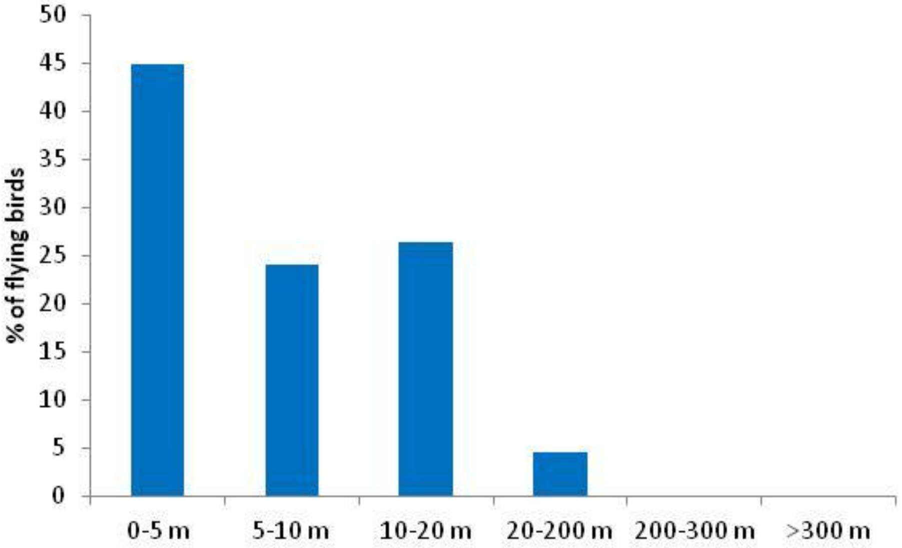


Figure 5e: Distribution of kittiwake across the survey area, from digital aerial surveys - Survey 6.

4.12.5 Potential for collision risk

Of 2123 kittiwake recorded flying in transect on boat-based surveys in the three proposed wind farm sites, 97 (4.6%) were recorded within the potential collision risk height (Table 24, Graph 22). Studies of data collated from other offshore developments found a proportion of 13% (from 14140 birds) flying at collision risk height, with the range varying between 1.5 and 30% (Cook *et al*., 2011). The proportion recorded within potential collision risk height for the three proposed wind farm sites was within this range; it should be noted that it is unclear from the Cook *et al*., 2011 report if flights outwith 300 m were included in this analysis (which would underestimate the proportion at low heights). Langston (2010) assessed this species as being at medium collision risk.

Collision risk assessment carried out for kittiwake in the Moray Firth show annual collision rates (at 98% avoidance) of 150 birds, with 108 collisions in the breeding season and 42 in the non-breeding season (Table 25). The rationale for the use of an avoidance rate of 99% is provided in Section 2.1.5; this gives an estimate of 38 collisions per year (Table 26).



Graph 22: Proportions of kittiwake flights recorded in each height band (for birds recorded in transect during April 2010 to March 2012 boat-based surveys).

4.12.6 Potential for disturbance / displacement / indirect effects

The mean densities of kittiwake recorded within the three proposed wind farm sites were 7.90 birds/km^2 during the breeding season and 0.79 birds/km^2 during the non-breeding season, equating to abundances across the three sites of 1963 and 261 birds respectively (Table 75).

The highest densities of kittiwake within the survey area were recorded in the south-west of the three proposed wind farm sites, with concentrations in the buffer zone west of Stevenson, in the western area of MacColl, and also with a smaller concentration in the centre of Telford (see Figure 4.5-4, Volume 6b, and Table 4.5-7 in Baseline Chapter 4.5).

Kittiwake have a medium sensitivity to ship and helicopter disturbance (Table 20; based on Garthe and Huppop, 2004), suggesting this will be a moderate issue for this species.

Analysis of data collected from Robin Rigg offshore wind farm in the Solway Firth, comparing the construction and post-construction years with five pre-construction years, found a 10% reduction in gull numbers using the site (Shenton & Walls, pers. comm.).

The 'WCS' displacement analysis (50% displacement) predicted 491 individuals to be displaced from the three proposed wind farm sites (Table 44). The 'RS' analysis, using a 10% displacement rate, predicted 98 individuals to be displaced from the three sites (Table 45).

4.12.7 Potential for barrier effects

With many kittiwake breeding at colonies adjacent to the SPA, and a mean foraging range of approximately 42 km, it is likely that the behaviour of some breeding kittiwakes will be influenced by the development. However, kittiwakes make relatively few, and long foraging trips, but despite this, the extra energetic costs incurred will be low as they employ efficient slow flapping and gliding flight, and have very energy efficient wing loading (Masden *et al*., 2010).

4.12.8 Key risks

Table 75. Potential effects for kittiwake.

Risk	Threat to species	Justification
Barrier effects	Minor	Infrequent (long) foraging trips. Efficient wing loading and flight.
Collision	Minor	4.6% flying within collision risk height in wind farm sites. 1.5-30% at collision risk height in other studies. Assessed as medium risk by Langston (2010). Collision risk estimates of: 38 collisions at 99% avoidance.
Displacement and Disturbance	Minor	Infrequent (long) foraging trips. Displacement of 98 individuals during the breeding season (RS). Moray Firth – scale aerial surveys show hotspots occur outwith the three proposed wind farm sites.

4.13 Black-headed gull

Black-headed gull is common and widespread as a breeding and wintering species in the UK. Approximately 142,000 pairs breed in the Britain and Ireland, of which 30% occur in Scotland, mostly at inland colonies (1998-2002; Mitchell *et al*., 2004) and the UK black-headed gull population increased by 29% between 2000 and 2010 (JNCC 2011). It has been estimated that 1.9 million black-headed gull winter in Britain, most of these coming from northern and eastern European breeding populations (Stone *et al*., 1997; Wernham *et al*., 2002). Black-headed gull utilise inland habitats and inshore tidal waters (Snow and Perrins, 1998), and as such are most likely to be encountered in offshore areas while undertaking local or migratory movements.

Between April 2010 and March 2012 only one black-headed gull was observed within the boat-based survey area; an individual flying east in mid-December (Tables 21 and 22).

4.13.1 Potential for collision risk

Only one black-headed gull was recorded in transect on boat-based surveys, a bird flying below the potential collision risk height. Studies of data collated from other offshore developments found of 16,358 birds recorded, 13% were recorded flying at potential collision risk height (Cook *et al*., 2011). Langston (2010) assessed this species as being at low collision risk. Given only one black-headed gull being recorded in the survey area in two years of surveying, this risk is predicted to be negligible.

4.13.2 Potential for disturbance / displacement / indirect effects

Taking into account the very low numbers of birds involved, and no birds from breeding colonies likely to be foraging in the area, it is assumed that impacts from disturbance and displacement will be negligible.

4.13.3 Potential for barrier effects

With such low numbers of birds using the sites, and any that do likely to be non-breeding birds, any barrier effects to this species with energy efficient flight and wing loading will be negligible.

4.13.4 Key Risks

Table 76. Potential effects for black-headed gull.

Risk	Threat to species	Justification
Barrier effects	Negligible	Low numbers on site. Birds on site likely to be non-breeders. Efficient wing loading and flight.
Collision	Negligible	Low numbers on site. Proportion of 0.13 recorded within collision risk height in other studies. Assessed as low risk by Langston (2010).
Displacement and Disturbance	Negligible	Low numbers on site. Birds on site unlikely to be breeding.

4.14 Common gull

Common gull is common and widespread as a breeding and wintering species in Scotland, with larger numbers passing through during the spring and autumn migration periods. Approximately 21,500 pairs breed in Britain and Ireland, 95% of these in Scotland (1998-2002; Mitchell *et al*., 2004). A wide variety of foraging habitats are utilised, particularly at inland and costal locations, with the species (along with black-headed) being less maritime in its habits than most other gulls.

Between April 2010 and March 2012, 21 common gull were recorded within the survey area, all in flight, and all below rotor height. 18 were observed outwith the breeding period (August – February). Given the small numbers recorded, and the low flight heights observed, it is unlikely that development of the three proposed wind farm sites would have any adverse affect upon this species.

4.14.1 Potential for collision risk

Seven common gulls were observed within the three proposed wind farm sites, and as discussed above all of these were recorded below collision risk height. Studies of data collated from other offshore developments have demonstrated that common gull have a mean flight height of 45.9 m, and of 5,074 birds recorded, a proportion of 0.21 were recorded flying at potential collision risk height. Langston (2010) assessed this species as being at low collision risk. Given the very low number of records, this risk is predicted to be negligible.

4.14.2 Potential for disturbance / displacement / indirect effects

With very low numbers of birds involved, and no birds from breeding colonies foraging in the area, it is predicted that effects from disturbance and displacement will be negligible.

4.14.3 Potential for barrier effects

With such low numbers of birds using the sites, and any that do likely to be non-breeding birds, and taking into account energy efficient flight and wing loading, any barrier effects to this species will be negligible.

4.14.4 Key Risks

Table 77. Potential effects for common gull.

Risk	Threat to species	Justification
Barrier effects	Negligible	Low numbers on site. Birds on site likely to be non-breeders. Efficient wing loading and flight.
Collision	Negligible	Low numbers on site. Proportion of 0.21 recorded within collision risk height in other studies. Assessed as medium risk by Langston (2010).
Displacement and Disturbance	Negligible	Low numbers on site. Birds on site unlikely to be breeding.

4.15 Lesser black-backed gull

Lesser black-backed gull breed around north-western Europe and the western part of northern Russia. Over most of their range they disperse in winter, extending their range to include coastal areas of North Africa, and parts of the Mediterranean and Arabia. The population of Great Britain and Ireland constitutes approximately 38-46% of the global population, which is estimated to be 267,000-316,000 pairs (Mitchell *et al.*, 2004). The UK lesser black-backed gull population declined by 36% between 2000 and 2010 (JNCC 2011).

Comparatively few lesser black-backed gull winter in Scotland, and most of those that do, do so in central and southern areas. Forrester *et al.* (2007) state a mid-winter population estimate of 200-600 individuals.

The breeding population of lesser black-backed gull in Great Britain and Ireland is approximately 116,700 pairs (1998-2002), widely spread across the region (Mitchell *et al.*, 2004; Image 23). Approximately 18% of the British and Irish population breeds in Scotland, mostly in the south and west.

The population sizes of the surrounding regions of Highland, Grampian and the Northern Isles are shown in Table 78. These areas contain <1% of the British and Irish lesser black-back gull population, and there are no SPAs designated for breeding lesser black-backed gull close to the three proposed wind farm sites.

JNCC analysis of ESAS data collected between 1980 and 2006, to provide at-sea distributions of lesser black-backed gull during the breeding season and winter period, are shown in Images 24a and 24b (Kober *et al.*, 2010). These data show low to medium densities of lesser black-backed gull recorded in the Moray Firth, particularly in inshore areas.

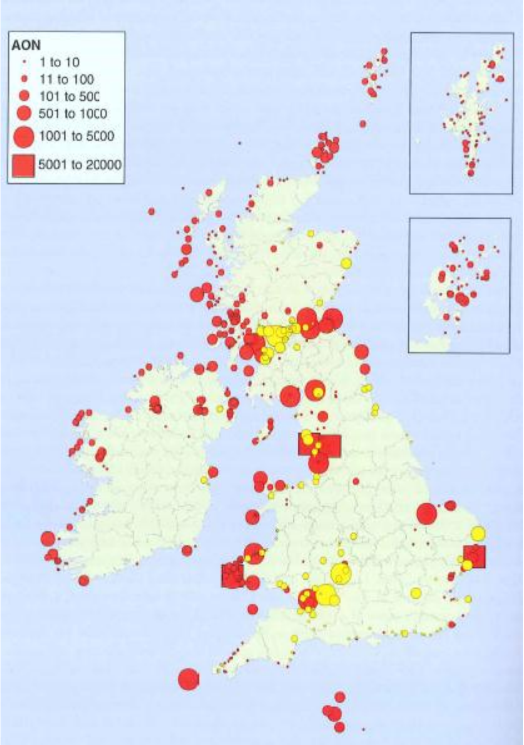


Image 23: Distribution of breeding lesser black-backed gull 1998-2002 (taken from Mitchell *et al.*, 2004). Red marked sites = natural colonies. Yellow marked sites = man-made colonies

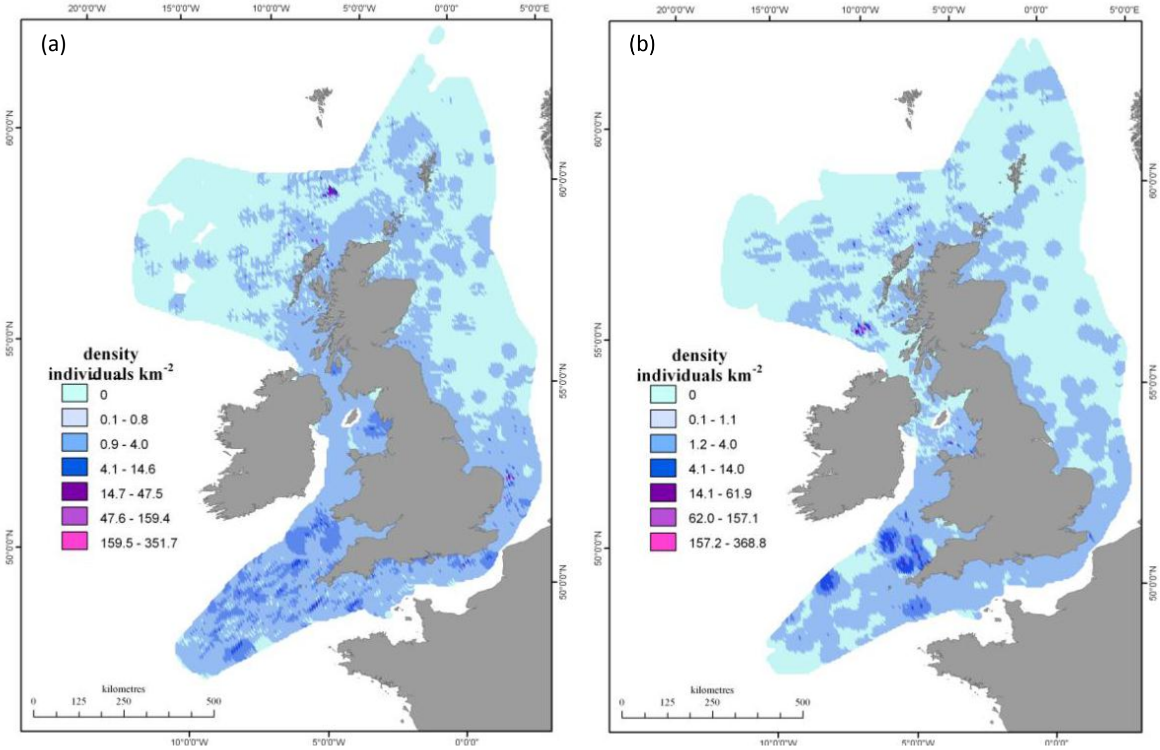


Image 24: JNCC predicted density surface maps produced from ESAS data collected between 1980 and 2006. Left (a): breeding. Right (b): winter (taken from Kober *et al.*, 2010).

Table 78: Lesser black-backed gull populations in districts around the Moray Firth (Mitchell *et al.*, 2004)

Region	District	Population (AON)
Northern Isles	Orkney	1,045
Highland	Caithness	2
	Ross & Cromarty (east)	7
	Inverness	6
Grampian	Banff & Buchan	10
TOTAL		1,070

4.15.1 Annual cycle

In Scotland birds return to their breeding areas from late February onwards, particularly in March, with egg laying typically occurring around the third week of May (Forrester *et al.*, 2007). Both parents are involved with the incubation of the clutch and subsequent provisioning of nestlings. Incubation lasts between 24 and 27 days, and chicks fledge approximately 30-40 days after hatching (Snow and Perrins, 1998). Adults disperse from breeding areas first, followed by juveniles, with the last usually remaining until late September or early October (Forrester *et al.*, 2007). In some of their wintering areas lesser black-backed gull show a greater use of freshwater habitats than other large gull species (Kilpi and Saurola, 1994), and in Scotland most winter around inland sites.

4.15.2 Food preferences

Lesser black-backed gulls consume a wide variety of food items including earthworms and other invertebrates, landfill waste, fish, and fishing boat discards (Stone *et al.*, 1992; Furness *et al.*, 1992; Bustnes *et al.*, 2010).

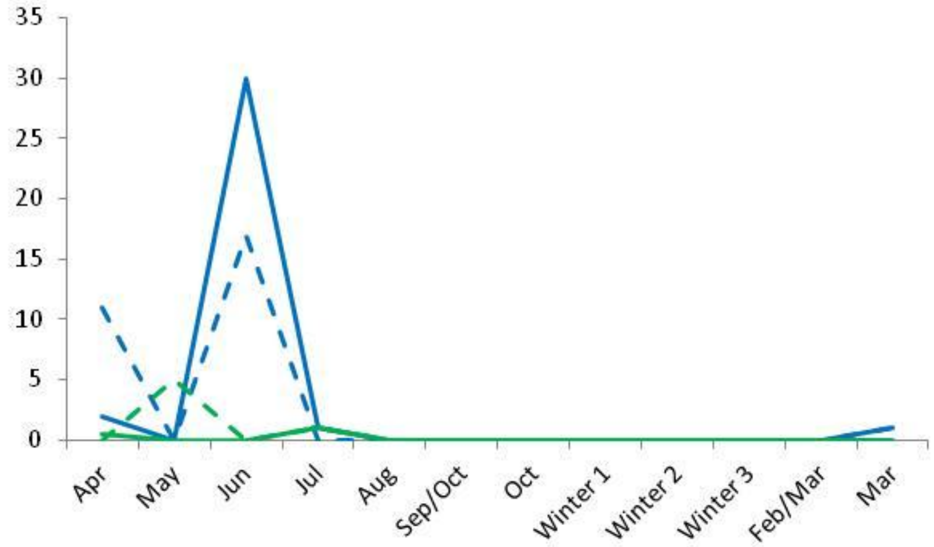
4.15.3 Foraging distances

The foraging ranges of lesser black-backed gull have been little studied, though given this species propensity to take fishery discards, marine feeding trip distances are likely to be influenced by the spatial distribution of fishing vessels in the proximity of breeding areas (Camphuysen, 1995; Garthe, 1997). In the southern North Sea 95% of lesser black-backed gulls associating with fishing vessels were within 135 km of breeding colonies, a considerably larger foraging range than herring gull (95% of which were within 54 km of breeding colonies) (Camphuysen, 1995).

Various studies have suggested foraging ranges of herring gull as between 35 and 100 km, therefore by assuming lesser black-backed gull foraging ranges are similar or slightly greater, the three proposed wind farm sites may be within the potential foraging range of the moderate population which breeds on Orkney (>60 km away).

4.15.4 Abundance and distribution within sites

Lesser black-backed gull were recorded in small numbers, with records restricted to the spring and summer months. It was not possible to calculate densities due to small sample sizes, but numbers of birds recorded during boat-based surveys were highest in June 2010 (37 birds recorded) and May 2011 (5 birds recorded) (Tables 21 and 23, Graph 23).



Graph 23: Total number of lesser black-backed gull recorded during each of the MORL boat-based surveys between April 2010 and March 2012 (including birds recorded in flight and using the sea). Blue lines refer to surveys during first year. Green lines refer to surveys during second year. Solid lines refer to records within wind farm sites. Dashed lines refer to records within buffer area. In months where two surveys were conducted mean values are displayed. The winter surveys correspond to the three surveys undertaken between November and January.

4.15.5 Potential for collision risk

Of 11 records of this species observed in flight in transect, three (27.3%) were within the potential collision risk height (Table 24). Studies of data collated from other offshore developments have found that of 24,481 birds recorded, a proportion of 0.22 were recorded flying at potential collision risk height. Given the very low number of records, this risk is predicted to be negligible.

4.15.6 Potential for disturbance / displacement / indirect effects

With low numbers of birds recorded on the three proposed wind farm sites, and low numbers of birds breeding on adjacent coastlines, it is predicted that the potential for displacement and disturbance for this species is negligible.

4.15.7 Potential for barrier effects

With such low numbers of birds using the site, and any that do likely to be non-breeding birds, and taking into account energy efficient flight and wing loading, any barrier effects to this species will be negligible.

4.15.8 Key Risks

Table 79. Potential effects for lesser black-backed gull.

Risk	Threat to species	Justification
Barrier effects	Negligible	Low numbers on site. Efficient flight and wing loading.
Collision	Negligible	Low numbers on site. Proportion of 0.22 birds flying at collision risk height in other studies. Assessed as medium risk by Langston (2010).
Displacement and Disturbance	Negligible	Low numbers on site.

4.16 Herring gull

The herring gull breeds in northern Eurasia and the north and east of North America. Some northern populations winter further south, with individuals reaching Central America, southern Europe and south-eastern China. The population of Great Britain and Ireland constitutes approximately 12-14% of the global population of 1.1 million-1.2 million pairs (Mitchell *et al*., 2004). The UK herring gull population declined by 38% between 2000 and 2010 (JNCC 2011).

An estimate of the minimum Scottish winter population was made during the winter of 1992/93 (Burton *et al*., 2003). 90,972 herring gull were recorded, however this is known to be an underestimate of the total wintering population as no records were returned from some areas, while others had very little coverage.

Up to 90% of herring gulls observed in Shetland in the winter are thought to be of the immigrant *argentatus* subspecies, and large numbers are also present offshore (Forrester *et al.* 2007)). In some winter flocks of herring gulls in north-east England, *argentatus* birds comprise 50% of all birds present (Gibbins 1991). A precautionary estimate of 75% of wintering birds within the boat-based study area being immigrants has therefore been made.

The breeding population of herring gull in Great Britain and Ireland is approximately 149,200 pairs (1998-2002), occurring around almost the entire British and Irish coastline and absent only from small stretches of the east coasts of England and Ireland (Mitchell *et al*., 2004; Image 25). Approximately 48% of the British and Irish herring gull population breed in Scotland.

The population sizes of the surrounding regions of Highland, Grampian and the Northern Isles are shown in Table 80. These areas contain 10% of the British and Irish herring gull population, and large numbers breed in two SPAs within the mean maximum foraging distance of 60 km from the three proposed wind farm sites (Table 81).

JNCC analysis of ESAS data, collected between 1980 and 2006, to provide at-sea distributions of herring gull during the breeding season and winter period are shown in Images 26a and 26b (Kober *et al*., 2010). These data show some distributional hotspots within the Moray Firth, particularly in inshore areas.

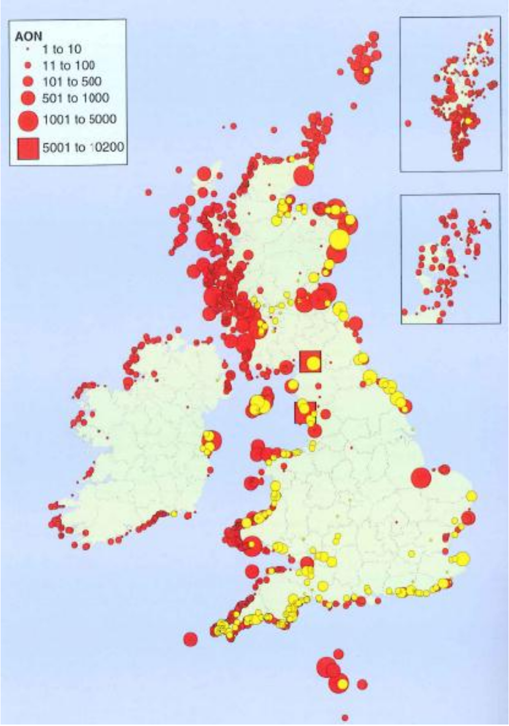


Image 25: Distribution of breeding herring gull 1998-2002 (taken from Mitchell *et al*., 2004). Red marked sites = natural colonies. Yellow marked sites = man-made colonies

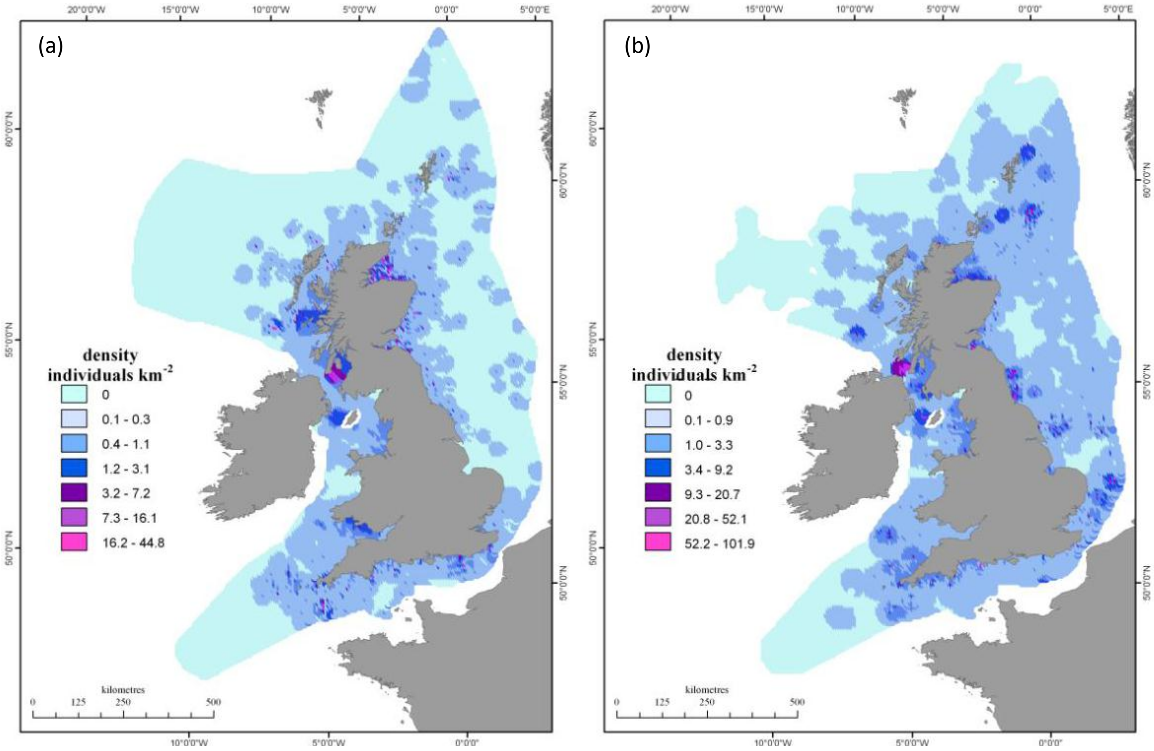


Image 26: JNCC predicted density surface maps produced from ESAS data collected between 1980 and 2006. Left (a): breeding. Right (b): winter (taken from Kober *et al*., 2010).

Table 80: Herring gull populations in districts around the Moray Firth (Mitchell *et al*., 2004)

Region	District	Population (AON)
Northern Isles	Orkney	1,933
Highland	Caithness	3,743
	Ross & Cromarty (east)	1,345
	Inverness	356
	Nairn	80
Grampian	Moray	581
	Banff & Buchan	6,671
TOTAL		14,709

Table 81: SPAs surrounding the wind farm sites which are designated for herring gull

Colony	Location	Colony size (pairs)	Distance from wind farm sites (km by sea)	Count date
East Caithness Cliffs	Highland	9,400	20	1985-1988[*1]

[*1] Seabird Colony Register Census (Note: This is the population estimate quoted in the SPA designation, however the population has declined dramatically since the CRC; Seabird 2000 surveys suggested 3503 AON along East Caithness Coastline)

4.16.1 Annual cycle

Although some birds remain within the vicinity of their breeding colonies throughout the year, most return in the spring. Egg laying commences in late April and peaks in mid-May (Forrester *et al*., 2007), with both parents sharing the incubation which lasts 28-30 days. Both parents feed the nestling, which fledges after 35-40 days (Snow and Perrins, 1998). After the breeding season a large proportion of birds from breeding colonies in the north of Scotland (particularly juveniles and females) move south (Monaghan *et al*., 1985), in particular to central Scotland, north-east England and, to a lesser extent, continental Europe.

4.16.2 Food preferences

Herring gulls are omnivorous and the diet of adults differs markedly from that of nestlings. Nestling diet largely compromises of fish and meat, while the adult diet is very variable and also contains large proportions of insects and plant material (Nogales *et al*., 1995). Herring gulls scavenge fishery discards, particularly in inshore waters (Camphuysen, 1995; Garthe, 1997), and studies near Glasgow observed a male bias (67%) among individuals foraging in this way (Forrester *et al*., 2007).

4.16.3 Foraging distances

Herring gull marine foraging ranges have been little studied for UK colonies, and are likely to be influenced by the spatial distribution of fishing vessels in the proximity of breeding areas (Camphuysen, 1995; Garthe, 1997). In the southern North Sea Camphuysen (1995) recorded 95% of herring gulls within 54 km of breeding colonies. Other studies have variously reported herring gull foraging ranges as 35 km (Netherlands: Spaans, 1971), 50 km (Morocco: Witt *et al*., 1981) and 70-100 km (Denmark; Klein: 1994). These estimates provide a mean maximum of 60 km.

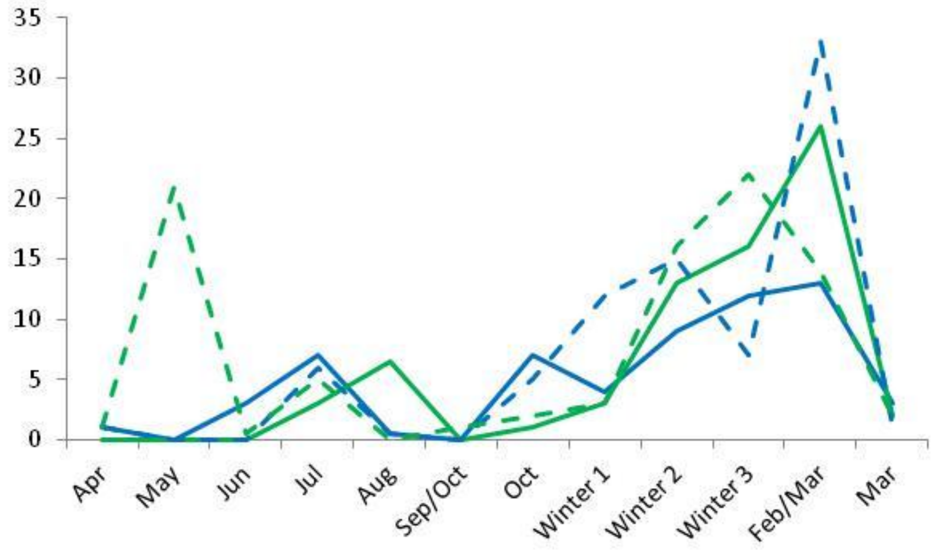
Based on the above information, the three proposed wind farm sites are within the potential foraging range of herring gull from the East Caithness Cliffs SPA. The three sites will also be within the potential foraging range of most of the herring gull which breed in non-SPA designated colonies surrounding the Moray Firth.

4.16.4 Abundance and distribution within sites

Herring gull were recorded in all months of the survey with the exception of September 2010. Peak numbers were recorded in the winter months, especially the mid-winter period, with a maximum of 231 birds recorded in February 2010 (Tables 21 and 23).

Table 82. Mean density and abundance of herring gull on the three proposed wind farm sites and the buffer zone, in the breeding and non-breeding season from boat-based surveys

Breeding Season				Non-breeding season			
Density		Abundance		Density		Abundance	
Site	Buffer	Site	Buffer	Site	Buffer	Site	Buffer
0.02	0.05	7	18	0.14	0.13	41	47

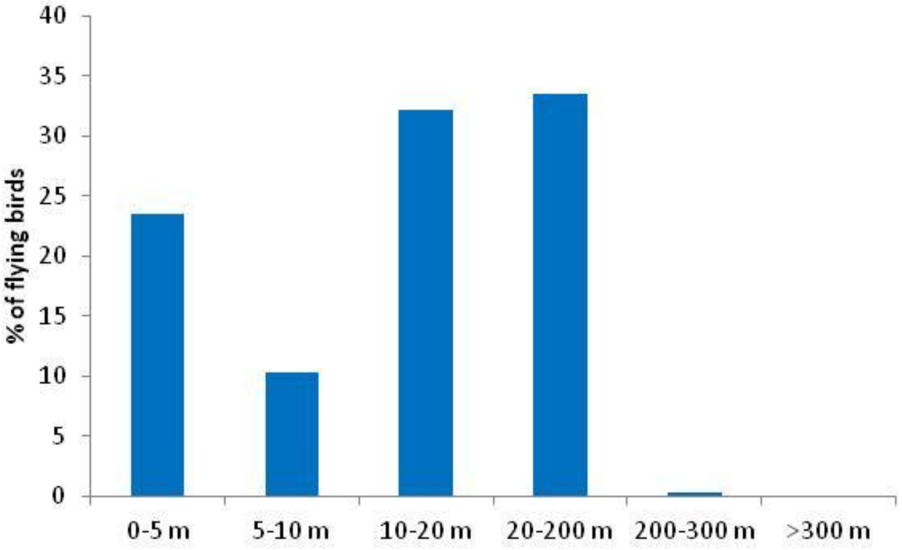


Graph 24: Number of herring gulls recorded in flight in transect during each of the MORL boat-based surveys between April 2010 and March 2012. Blue lines refer to surveys during first year. Green lines refer to surveys during second year. Solid lines refer to records within wind farm sites. Dashed lines refer to records within buffer area. In months where two surveys were conducted mean values are displayed. The winter surveys correspond to the three surveys undertaken between November and January.

4.16.5 Potential for collision risk

Of 313 herring gull observed in flight and in transect on boat-based surveys, 105 (33.5%) were within the potential collision risk height (Table 24, Graph 25). Studies of data collated from other offshore developments have demonstrated that of 15,108 birds recorded, a proportion of 0.24 were recorded flying at potential collision risk height (Cook *et al*., 2011). Other studies have shown 19 of 90 flights at 15-100 m altitude at Walney, 33 of 48 at potential collision risk height (15-50 m) at Humber Gateway, and at Teeside, 10% of 6051 at rotor height (>15 m). Langston (2010) assessed this species as being at medium collision risk.

Collision risk assessment carried out for herring gull in the Moray Firth show annual collision rates of 208 birds, with 21 collisions in the breeding season and 187 in the non-breeding season (using the 98% avoidance rate) (Table 25). The rationale for the use of an avoidance rate of 98.5% is provided in Section 2.1.5; this gives an estimate of 156 collisions per year (Table 26).



Graph 25: Proportions of herring gull flights recorded in each height band (for birds recorded in transect during April 2010 to March 2012 boat-based surveys).

4.16.6 Potential for disturbance / displacement / indirect effects

Numbers of herring gull were too low to allow any population estimates from distance sampling or density surface modelling. The largest number recorded within the three proposed wind farm sites was 231, in February 2011 (Tables 21 and 23). Other developments have recorded herring gull both avoiding and preferring developments, post-construction (Dierschke and Garthe 2005).

The 'WCS' displacement analysis (50% displacement) predicted 3 individuals to be displaced from the three proposed wind farm sites (Table 44). The 'RS' analysis, using a 10% displacement rate, predicted <1 individuals to be displaced from the three sites (Table 45).

Given the relatively small numbers involved, and the fact that the largest numbers were recorded on site outwith the breeding season, any potential effect is likely to be minor.

4.16.7 Potential for barrier effects

Herring gull have very energy efficient flight and wing loading (Masden *et al*., 2010), and their infrequency within the three proposed wind farm sites during the breeding season suggests that birds breeding at adjacent SPAs do not forage within the wind farm sites at this time of year. Therefore, any potential barrier created by the development will have a negligible effect on this species.

4.16.8 Key risks

Table 83. Potential effects for herring gull.

Risk	Threat to species	Justification
Barrier effects	Negligible	Largest numbers present in non-breeding season. Efficient flight and wing loading.
Collision	Moderate	Proportion of 0.22 flying at collision risk height in other studies. Assessed as medium risk by Langston (2010). Collision risk estimate of 156 collisions at 98.5%.
Displacement and Disturbance	Minor	Largest numbers present in non-breeding season. Displacement of <1 individuals during the breeding season (RS).

4.17 Iceland Gull

The Iceland gull is a rare winter visitor to Scottish waters, with between 50 -100 birds present in most winters. The species can be irruptive, with upwards of 250 birds present in Scottish waters during these winters (Forrester *et al*., 2007). The winter of 2011/2012 saw especially large numbers of Iceland gulls in British waters, with groups numbering over 50 recorded several times in the Northern and Western Isles. A relatively large proportion showed characteristics of the subspecies *Kumlieni,* suggesting a far north western origin.

Small numbers of Iceland gulls were recorded from the boat-based study area in January 2012.

4.18 Great black-backed gull

Great black-backed gull breed and winter around the coasts of north-west Europe and north-east North America. The Great Britain and Ireland populations of great black-backed gull form approximately 9-11% of the global population of 170,000-180,000 pairs, and 18-20% of the European population of 100,000-110,000 pairs (Mitchell *et al*., 2004). The UK great black-backed gull population declined by 14% between 2000 and 2010 (JNCC 2011)

The breeding population of great black-backed gull in Great Britain and Ireland is approximately 19,700 pairs, largely concentrated in the west of the region and in the Scottish Northern Isles (Mitchell *et al*., 2004; Image 27). Approximately 75% of the British and Irish population breeds in Scotland. Between 7,500 and 10,000 great black-backed gulls have been estimated to winter around the Scottish coast (Forrester & Andrews, 2007). No information is available on the proportion of wintering birds within the Moray Firth that are likely to be immigrants, so a precautionary estimate of 50% has been made.

The population sizes of the surrounding regions of Highland, Grampian and the Northern Isles are shown in Table 84. These areas contain 30% of the Great Britain and Irish great black-backed gull population, and large numbers breed in SPAs within the estimate of mean maximum foraging range of 60 km from the three proposed wind farm sites (Table 85).

JNCC analysis of ESAS data, collected between 1980 and 2006, to provide at-sea distributions of great black-backed gull during the breeding season and winter period are shown in Images 28a and 28b (Kober *et al*., 2010). These data show medium levels of great black-backed gull densities recorded within the Moray Firth, particularly in inshore areas.

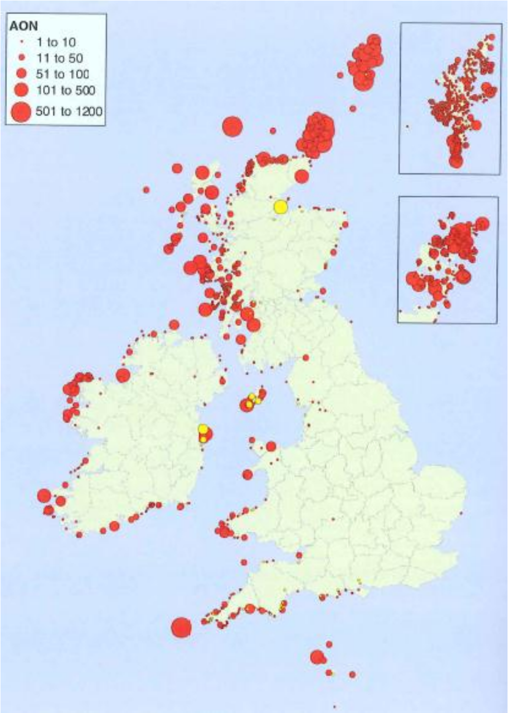


Image 27: Distribution of breeding great black-backed gulls 1998-2002 (taken from Mitchell *et al.*, 2004). Red marked sites = natural colonies. Yellow marked sites = man-made colonies

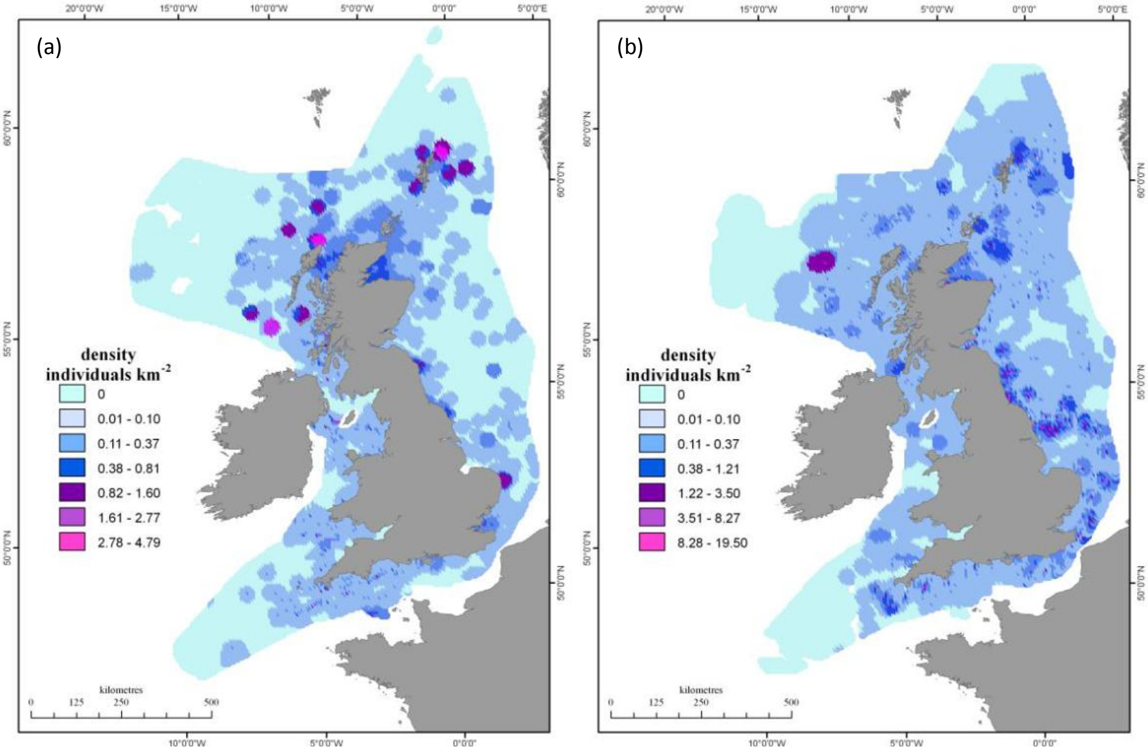


Image 28: JNCC predicted density surface maps produced from ESAS data collected between 1980 and 2006. Left (a): breeding. Right (b): winter (taken from Kober *et al.*, 2010).

Table 84: Great black-backed gull populations in districts around the Moray Firth (Mitchell *et al.*, 2004)

Region	District	Population (AOT)
Northern Isles	Orkney	5,505
Highland	Caithness	211
	Ross & Cromarty (east)	220
	Inverness	5
Grampian	Moray	10
	Banff & Buchan	37
TOTAL		5,988

Table 85: SPAs surrounding the three proposed wind farm sites which are designated for great black-backed gull

Colony	Location	Colony size (pairs)	Distance from wind farm sites	Count date
East Caithness Cliffs	Highland	842	20 km	1985-1988[*1]
Hoy	Orkney	1163	58 km	1985-1988[*1]

[*1] Seabird Colony Register Census (Note: These are the population estimates referred to in the SPA designations, however populations have declined dramatically since the CRC; Seabird 2000 surveys suggested 181 AON along East Caithness Coastline and 389 AON on Hoy).

4.18.1 Annual cycle

The breeding cycle of great black-backed gull on Ailsa Craig has been studied since the early 1990s (Zonfrillo, 1997). Territories are established and defended during February and March, with most eggs laid around the 20th of April. Eggs are incubated for ca. 26 days, hatching between mid May and early June. Chicks take 36-47 days to fledge (mean 43 days) (Snow and Perrins, 1998), and do so from early July onwards. Most Scottish great black-backed gulls are largely sedentary, not dispersing great distances from breeding areas (<50 km) outside the breeding season (Zonfrillo, 1997).

4.18.2 Food preferences

Great black-backed gull consume a very wide range of prey items and diet varies markedly in different areas. From pellet contents, Zonfrillo (1997) found that the diet of chick-rearing adults on Ailsa crag composed of 40% whitefish (probably mostly obtained from trawler discards), 30% rabbit and 30% bird species. In other areas (Orkney, Shetland, south-west Ireland) fish have been observed to make up a large majority of the diet (Beaman, 1978; Buckley, 1990). The seabird species predated by great black-backed gull include juvenile herring gull, kittiwake, shag, gannet and manx shearwater. Both adult and juvenile auks are predated (Harris, 1965; Beaman, 1978).

4.18.3 Foraging distances

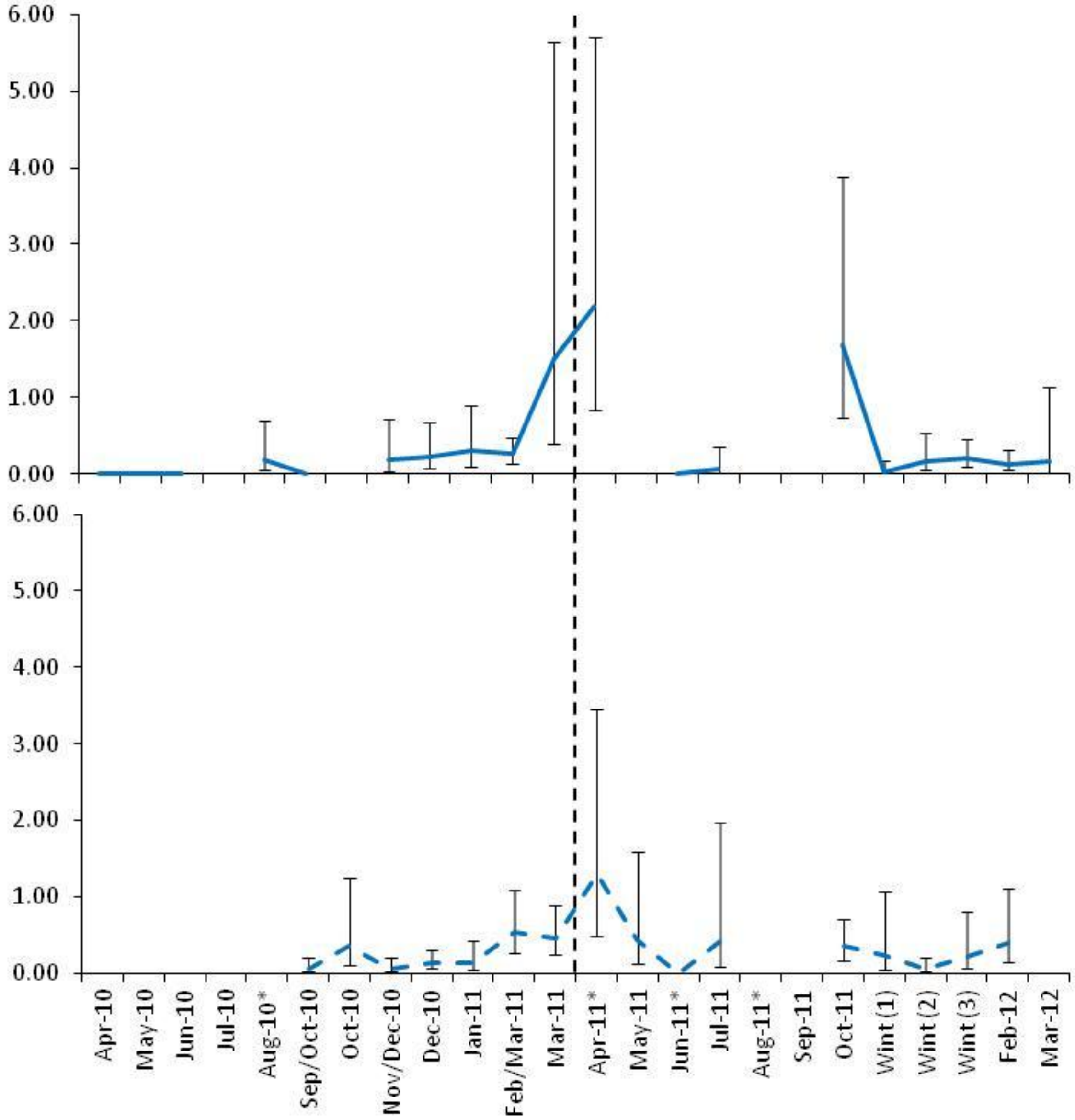
Little is known about great black-backed gull foraging behaviour. Within the survey area the species displays a similar foraging pattern to herring gulls, being generally scarce, though more frequently encountered in association with fishing boats or feeding aggregations of other seabirds. The mean maximum foraging range estimated for herring gull, of 60 km was used.

4.18.4 Abundance and distribution within sites

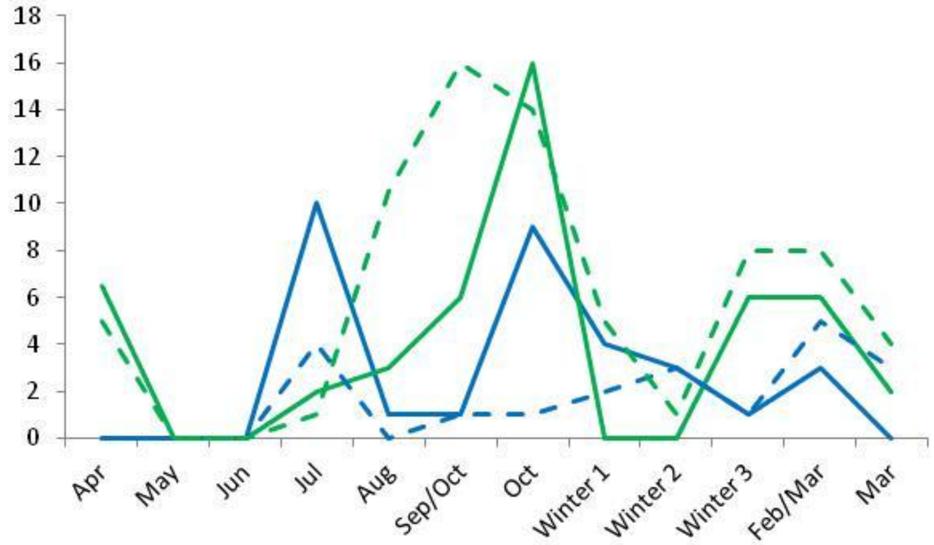
Great black-backed gull were recorded in all months of the survey with the exception of June 2010. Density and abundance data are shown in Table 86. Annual variation in numbers recorded in flight is shown in Graph 27. Distribution maps for the species are shown in Figure 6.

Table 86. Mean density and abundance of great black-backed gull on the three proposed wind farm sites and the buffer zone, in the breeding and non-breeding season from boat-based surveys

Breeding Season				**Non-breeding season**			
Density		**Abundance**		**Density**		**Abundance**	
Site	**Buffer**	**Site**	**Buffer**	**Site**	**Buffer**	**Site**	**Buffer**
0.91	1.48	271	526	0.36	0.22	106	77



Graph 26. Temporal variation in great black-backed gull density (birds/km^2) in the wind farm sites (solid line) and the buffer zone (dotted line) Excludes records with percentage CV greater than 100 (low confidence). In months where two surveys were conducted mean values are displayed. The winter surveys correspond to the three surveys undertaken between November and January.



Graph 27: Number of great black-backed gull recorded in flight in transect during each of the MORL boat-based surveys between April 2010 and March 2012. Blue lines refer to surveys during first year. Green lines refer to surveys during second year. Solid lines refer to records within wind farm sites. Dashed lines refer to records within buffer area. In months where two surveys were conducted mean values are displayed. The winter surveys correspond to the three surveys undertaken between November and January.

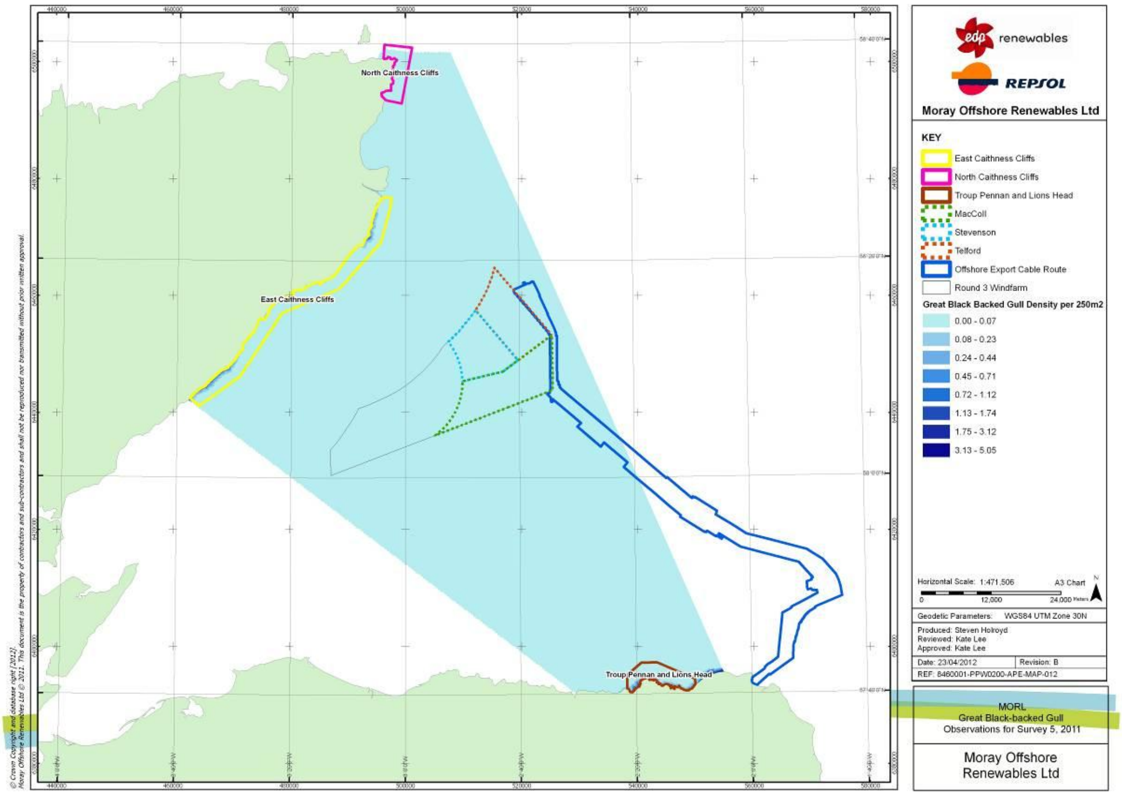


Figure 6a: Distribution of great black-backed gulls across the survey area, from digital aerial surveys - Survey 5.

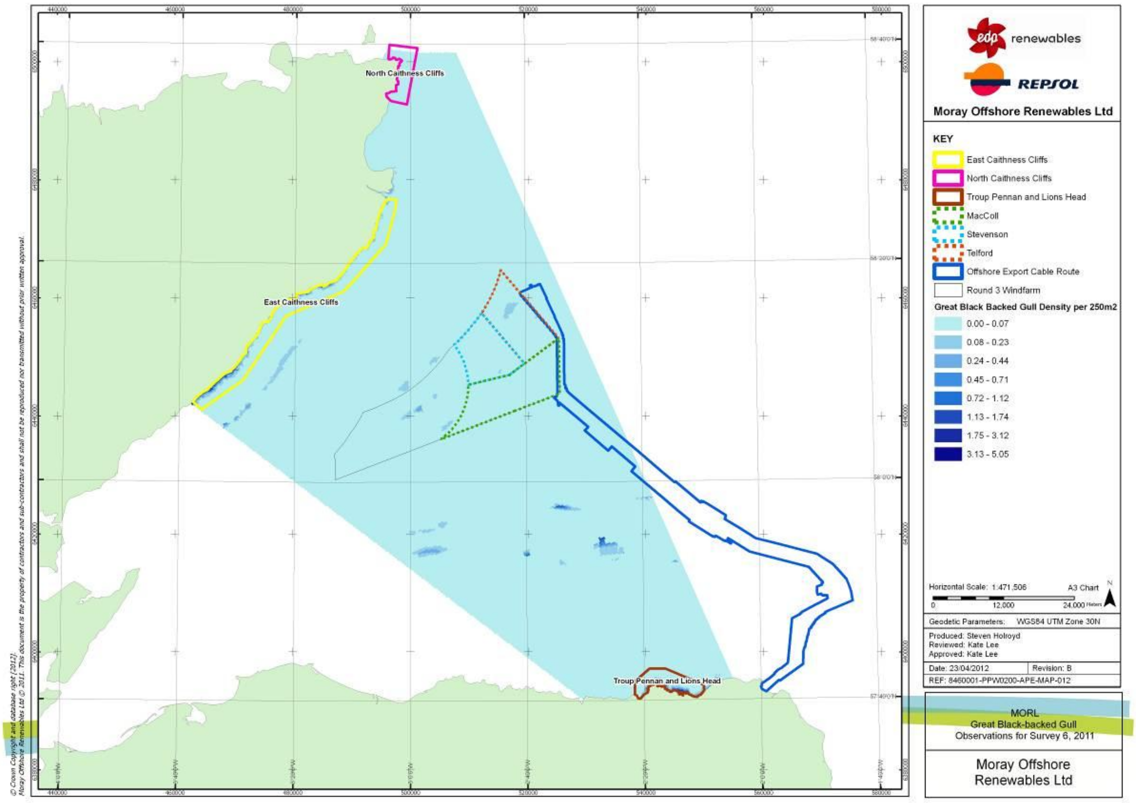
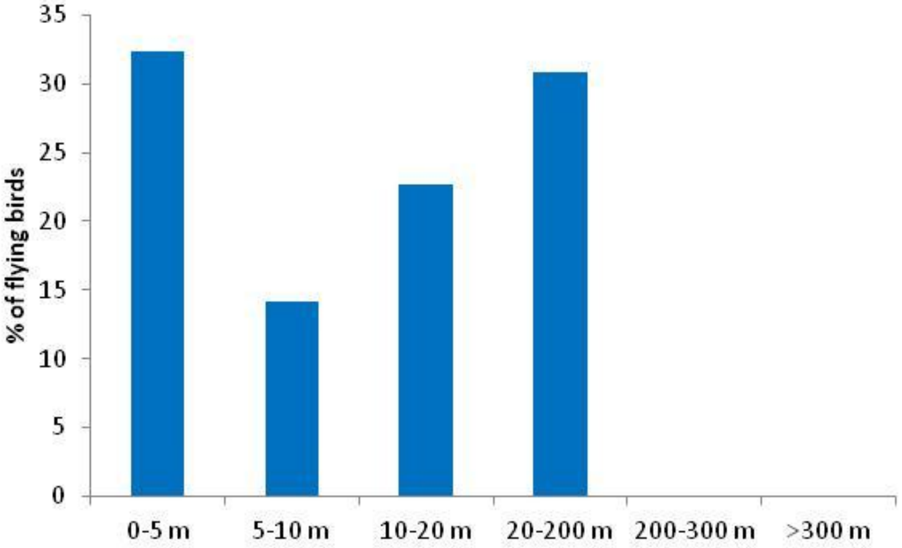


Figure 6b: Distribution of great black-backed gulls across the survey area, from digital aerial surveys - Survey 6.

4.18.5 Potential for collision risk

Of 207 great black backed gull recorded in flight and in transect on boat-based surveys, 62 (30%) were observed flying at potential collision risk height (Table 24 Graph 28). At other offshore developments, from a sample of 4325 observations, the proportion of birds recorded flying at potential collision risk height was 0.28 (Cook *et al*., 2011). Langston (2010) assessed this species as being at medium collision risk.

Collision risk assessment carried out for great black backed gull in the Moray Firth show annual collision rates of 139 birds, with 37 collisions in the breeding season and 102 in the non-breeding season (using 98% avoidance rate [Table 25]). The rationale for the use of an avoidance rate of 98.5% is provided in Section 2.1.5; this gives an estimate of 105 collisions per year (Table 26).



Graph 28: Proportions of great black-backed gull flights recorded in each height band (for birds recorded in transect during April 2010 to March 2012 boat-based surveys).

4.18.6 Potential for disturbance / displacement / indirect effects

The mean densities of great black-backed gull recorded within the three proposed wind farm sites were 0.91 birds/km^2 during the breeding season and 0.36 birds/km^2 during the non-breeding season, equating to abundances across the sites of 271 and 106 birds respectively (Table 86).

Great black-backed gull have a medium sensitivity to ship and helicopter disturbance (Table 20; based on Garthe and Huppop, 2004).

Analysis of data collected from Robin Rigg offshore wind farm in the Solway Firth, comparing the construction and post-construction years with five pre-construction years, found a 10% reduction in gull numbers using the site (Shenton & Walls, pers. comm.).

The ‘WCS’ displacement analysis (50% displacement) predicted 34 individuals to be displaced from the three proposed wind farm sites (Table 44). The ‘RS’ analysis, using the 10% displacement rate, predicted 14 individuals to be displaced from the three sites (Table 45).

4.18.7 Potential for barrier effects

Although the three proposed wind farm sites are likely to be well within the foraging range of this species, it is unlikely that any barrier created by the development will affect great black-backed gull. Generally numbers of this species recorded within the wind farm sites during the breeding season are low, suggesting that only small numbers forage on the sites during the breeding season. Also, with energy efficient flight and wing loading, any extra distance incurred by barriers will be of negligible energetic effect.

4.18.8 Key risks

Table 87. Potential effects for great black-backed gull.

Risk	**Threat to species**	**Justification**
Barrier effects	Negligible	Some macro-avoidance. Largest numbers present in non-breeding season. Efficient flight and wing loading.
Collision	Minor	Relatively high macro-avoidance. Very high micro-avoidance (>99%) Proportion of 0.28 flying at collision risk height in other studies. Assessed as medium risk by Langston (2010). Collision risk estimates of: 139 collisions at 98% avoidance; and 105 at 98.5%.
Displacement and Disturbance	Minor	Largest numbers present in non-breeding season. Displacement of 14 individuals during the breeding season (RS). Moray Firth – scale aerial surveys show hotspots occur outwith the three proposed wind farm sites.

4.19 Sandwich tern

Sandwich tern is a highly localised Scottish breeding species which winters along the west coast of Africa. Its breeding distribution is highly variable as colonies often move, with frequent site abandonments and colonisations. Sandwich terns formerly bred around the Moray Firth in large numbers (Operation Seafarer 1969-70: 1000 AON in Ross and Cromarty) but no longer do so, and the UK Sandwich tern population declined by 7% between 2000 and 2010 (JNCC 2011). During the most recent surveys (1998-2002) the nearest colonies to the three proposed wind farm sites were in Orkney (173 AON) and Gordon (524 AON) (Mitchell *et al*., 2004). During the surveys of the three sites only one sandwich tern has been recorded; in April 2011, an individual flying east at collision risk height. Given only a single observation, the threat of all potential effects on this species are considered negligible.

4.20 Common tern

Common tern is a widespread and locally common breeding species in Scotland, with most of the population nesting and foraging at coastal sites and estuaries. Large numbers of common tern breed around the Moray Firth (Table 88), and the UK common tern population increased by 3% between 2000 and 2010 (JNCC 2011). Only 15 were recorded during the boat-based surveys between April 2010 and March 2012. This low count is likely to be explained by this species predominantly foraging and breeding around inland and inshore waters (Mitchell *et al*., 2004).

Table 88: Common tern populations in districts around the Moray Firth (Mitchell *et al*., 2004)

Region	District	Population (AON)
Northern Isles	Orkney	125
Highland	Caithness	44
	Ross & Cromarty (east)	497
	Inverness	10
Grampian	Moray	24
	Banff & Buchan	202
TOTAL		902

Of the common tern observed, 13 were in flight and, of these, none were at collision risk height. 'Commic' tern records included 24 in flight, and of these 2 (8%) were at collision risk height. Given the small numbers recorded, and the low flight heights observed, it is unlikely that development of the three proposed wind farm sites would have any adverse effect upon this species.

4.21 Arctic tern

Arctic tern breed in the subarctic and Arctic latitudes of Europe, North America and Asia and winter south of the equator widely across the Southern Ocean. The populations of Great Britain and Ireland form approximately 2-7% of the global population of 800,000-2.7 million pairs, and 3-11% of the European and north Atlantic population of 493,000-1.8 million pairs (Mitchell *et al*., 2004). The UK Arctic tern population increased by 7% between 2000 and 2010 (JNCC 2011) and Birdlife international quotes a minimum current global population of 2 million mature individuals.

The breeding population of Arctic tern in Great Britain and Ireland is approximately 56,100 pairs (1998-2002). This species is more common in the north of the UK, with 84% breeding in Scotland, mostly in Shetland, Orkney and the Outer Hebrides (Mitchell *et al*., 2004; Image 29).

The population sizes of the surrounding regions of Highland, Grampian and the Northern Isles are shown in Table 89. These areas contain 26% of the British and Irish Arctic tern population. Moderately large numbers breed in SPAs in Orkney, all expected to be outwith the foraging distances of breeding birds.

JNCC analysis of ESAS data collected between 1980 and 2006, to provide at-sea distributions of Arctic terns during the breeding season, is shown in Image 30 (Kober *et al*., 2010). These data show low to medium densities of arctic tern recorded in the Moray Firth, particularly in inshore areas.

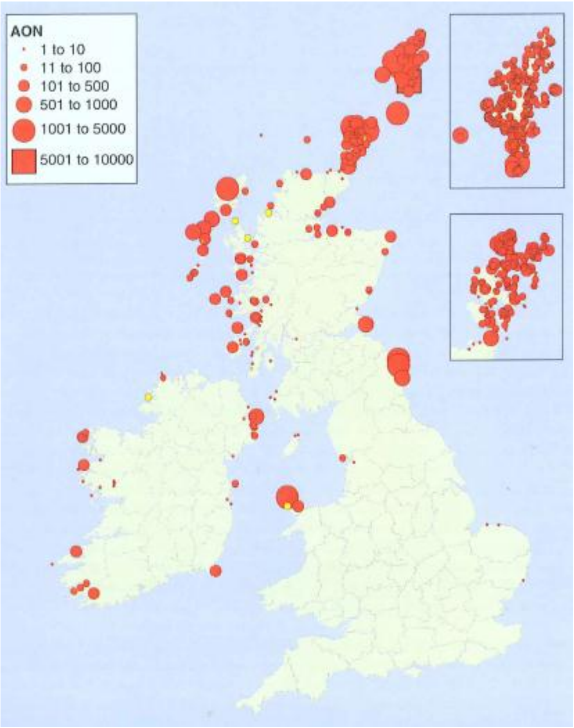


Image 29: Distribution of breeding Arctic tern 1998-2002 (taken from Mitchell *et al*., 2004)*

*Yellow marked sites = unidentified common or Arctic tern colony

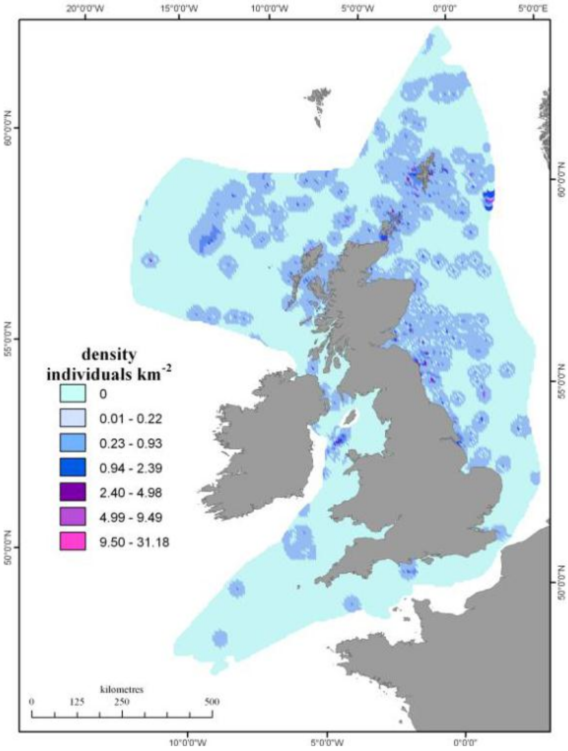


Image 30: JNCC predicted density surface maps for Arctic tern during the breeding period. Produced from ESAS data collected between 1980 and 2006 (taken from Kober *et al*., 2010).

Table 89: Arctic tern populations in districts around Moray Firth (Mitchell *et al*., 2004)

Region	**District**	**Population (AOT)**
Northern Isles	Orkney	13,476
Highland	Caithness	594
	Ross & Cromarty (east)	129
	Inverness	25
Grampian	Moray	244
	Banff & Buchan	184
TOTAL		14,652

4.21.1 Annual cycle

Breeding colony reoccupation typically occurs in late May, with eggs being laid in June (Forrester *et al*., 2007). Eggs are incubated for 20-24 days, and nestlings fledge 21-24 days after hatching (Snow and Perrins, 1998). Breeding sites are usually entirely vacated by mid-August (Forrester *et al*., 2007). After the breeding season birds rapidly migrate south towards their distant wintering grounds, with the latest Scottish records each year usually coming in October (Forrester *et al*., 2007). Many juveniles from British colonies winter off the coast of south and west Africa (Wernham *et al*., 2002).

4.21.2 Food preferences

Arctic terns depredate a wide range of marine fish and crustacean species (Ewins, 1985; Snow and Perrins, 1998), and in some areas diet has been observed to vary markedly between colonies and from year to year (Hall *et al*., 2000). Many studies from the around Britain (Orkney, Shetland, Anglesey, Coquet Island) have recorded sandeels as the major prey item taken by breeding Arctic tern (Langham, 1968; Furness, 1982; Ewins, 1985; Monaghan *et al*., 1989 & 1992; Newton and Crowe, 1999). Cleupeids may also constitute a large proportion of the prey items taken (Pearson, 1968; Newton and Crowe, 1999), and dietary composition may vary markedly throughout the breeding season (Langham, 1968).

4.21.3 Foraging distances

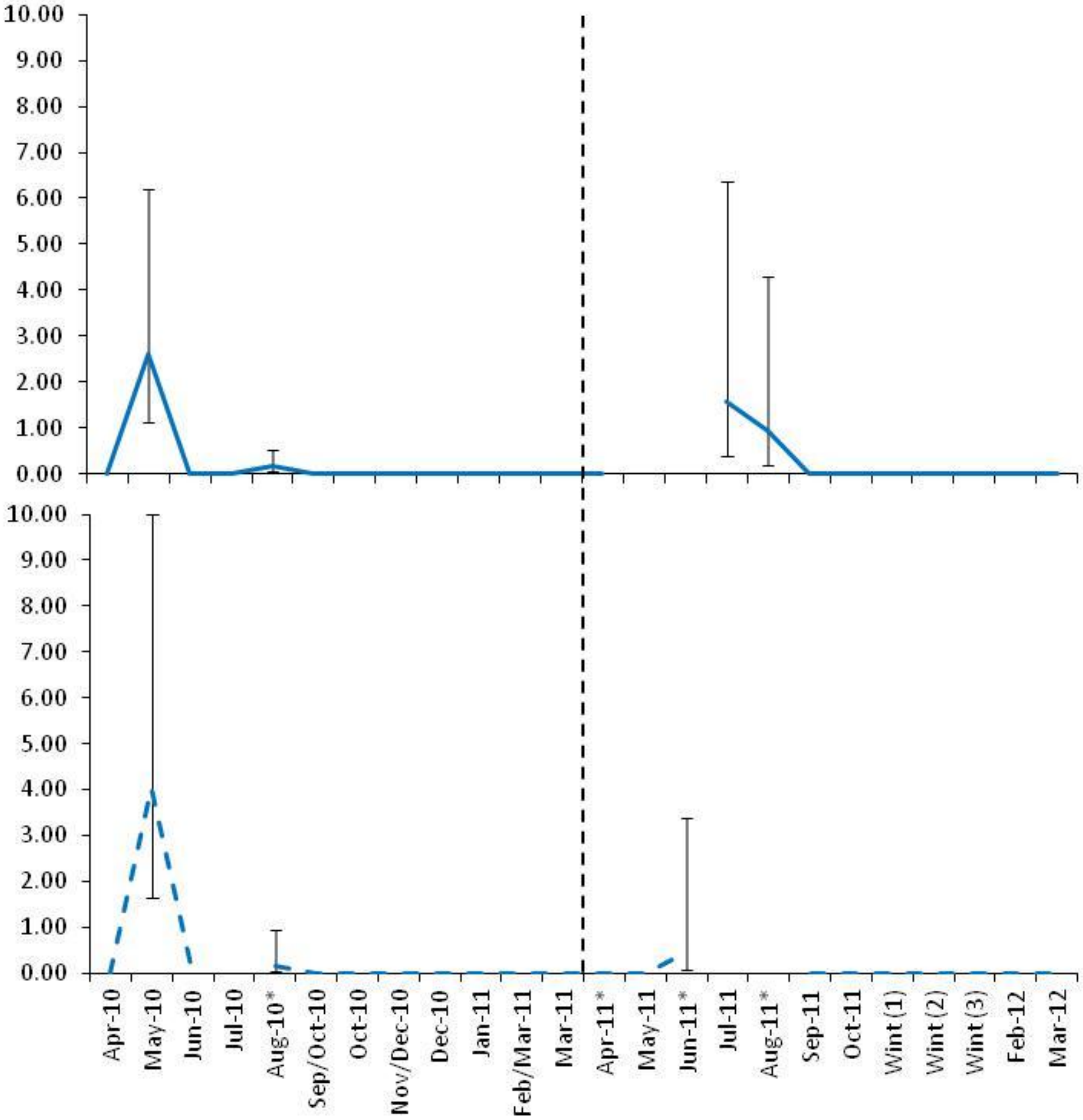
Several studies of North Sea Arctic tern colonies have observed that birds do not travel far to forage. Wanless *et al.* (1998) conducted boat-based surveys off the south-east coast of Scotland and found that Arctic terns were using near-shore waters for foraging and were not using offshore waters. Most terns were recorded within 10 km of breeding colonies. At colonies on Papa Westray and Mousa, on Orkney and Shetland respectively, flight trip durations during the chick rearing period were used to estimate maximum foraging ranges by assuming a constant flight speed (48 kmph) (Monaghan *et al*., 1992). Median trip lengths of 16 minutes and 19 minutes respectively suggest that birds were foraging within 15 km of their breeding colonies (Ratcliffe *et al.*, 2000). Similar foraging ranges inferred from trip durations suggest that Arctic tern breeding on the Farne Islands feed within 20 km of their breeding colony (Pearson, 1968). Garthe (1997) noted that common and Arctic terns off the North Sea coast of Germany were almost completely absent from sites more than 25 km from breeding colonies.

A radio-telemetry study based on Country Island, Nova Scotia, showed that Arctic Terns foraged, on average, less than 9 km from the breeding colony (range 2.4-20.6 km, mean 8.5 km) and within 5 km of land (range 0.3-17.2 km, mean 4.6 km) (Rock *et* *al*., 2007).

Birdlife International data on foraging distances for Arctic tern shows a maximum foraging distance of 20.60 km, a mean maximum of 12.24 km, and a mean foraging distance of 11.75 km. Based on the above information it is likely that the nearest SPAs in which Arctic tern breed (in Orkney) are too distant from the three proposed wind farm sites for the sites to be used by foraging breeding birds. The relatively small numbers of Arctic terns which breed in non-SPA designated colonies elsewhere around the Moray Firth are also probably unlikely to frequently use the three proposed wind farm sites for foraging.

4.21.4 Abundance and distribution within sites

Arctic tern were recorded during the spring and summer months. Densities were highest in spring 2010, peaking in May with 2.62 birds/km^2 and summer 2011, peaking in July with 1.59 birds/km^2 (Table 90, Graph 29). Annual variation in numbers recorded in flight is shown in Graph 30.

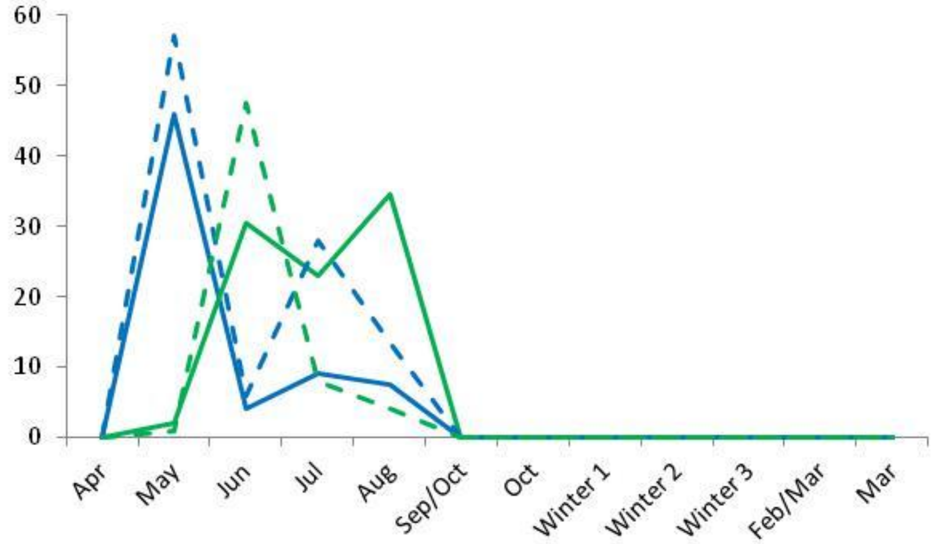


Graph 29 Temporal variation in Arctic tern density (birds/km^2) in the wind farm sites (solid line) and the buffer zone (dotted line) Excludes records with percentage CV greater than 100 (low confidence). In months where two surveys were conducted mean values are displayed. The winter surveys correspond to the three surveys undertaken between November and January.

* two surveys were conducted during these months. The datasets from both were combined to derive density estimates through distance sampling.

Table 90. Mean density and abundance of Arctic tern on the sites and the buffer zone, in the breeding and non-breeding season from boat-based surveys

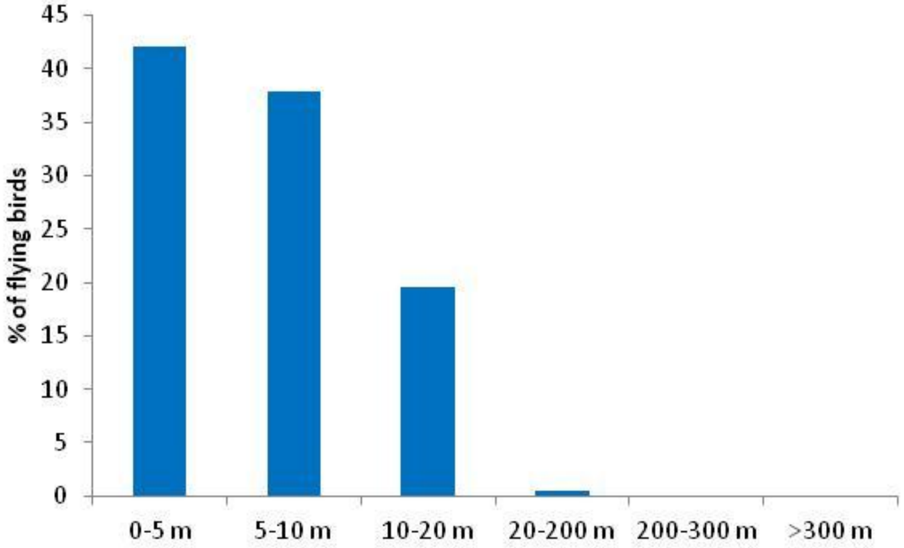
Breeding Season				**Non-breeding season**			
Density		**Abundance**		**Density**		**Abundance**	
Site	**Buffer**	**Site**	**Buffer**	**Site**	**Buffer**	**Site**	**Buffer**
0.77	5.35	229	1903	n/a	n/a	n/a	n/a



Graph 30: Number of Arctic tern recorded in flight and in transect during each of the MORL boat-based surveys between April 2010 and March 2012. Blue lines refer to surveys during first year. Green lines refer to surveys during second year. Solid lines refer to records within wind farm sites. Dashed lines refer to records within buffer area. In months where two surveys were conducted mean values are displayed. The winter surveys correspond to the three surveys undertaken between November and January.

4.21.5 Potential for collision risk

Of 520 Arctic terns recorded in flight and in transect within the sites, a total of 18 (3.5%) were observed flying at the collision risk height (Table 24 Graph 31). Of 122 Arctic terns recorded at other offshore developments, a proportion of 0.24 were observed flying within the collision risk height (Cook *et al*., 2011). Langston (2010) assessed this species as being at medium collision risk. Given the low number of records at potential collision height, the risk to this species is considered to be negligible.



Graph 31: Proportions of Arctic tern flights recorded in each height band (for birds recorded in transect during April 2010 to March 2012 boat-based surveys).

4.21.6 Potential for disturbance / displacement / indirect effects

The mean densities of Arctic tern recorded within the three proposed wind farm sites were 0.77 birds/km^2 during the breeding season. This equates to an abundance estimate across the sites of 229 birds.

Arctic tern have a medium sensitivity to ship and helicopter disturbance (Table 20; based on Garthe and Huppop, 2004).

4.21.7 Potential for barrier effects

Observed macro-avoidance rates among terns range between 51 and 69.5%. Terns are at risk of succumbing to the energetic costs of barrier effects during the breeding season as their foraging flights are mid-range, but frequent (with up to 12 foraging flights a day for common tern, for example). However, with the nearest SPA for breeding Arctic tern 42 km from the three proposed wind farm sites, and maximum and mean foraging ranges of 20.6 km and 11.75 km respectively, it would be unlikely that Arctic terns would suffer, and detrimental barrier effects as a result of the development are considered as being negligible.

4.21.8 Key risks

Table 91. Potential effects for Arctic tern.

Risk	Threat to species	Justification
Barrier effects	Negligible	Efficient flight and wing loading. Birds on site unlikely to be breeding.
Collision	Negligible	Mean flight height of 15 m. Proportion of 0.24 at collision risk height from other studies. Assessed as medium risk by Langston (2010).
Displacement and Disturbance	Minor	Birds on site unlikely to be breeding. SPAs distant.

4.22 Guillemot

Guillemot have a circumpolar distribution, breeding around the boreal and low-Arctic latitudes of the north Atlantic and Pacific oceans. The population of Great Britain and Ireland forms approximately 14% of the global population of an estimated 7.3 million pairs, and 35% of the approximately 2.8 million pairs which breed in Europe (Mitchell *et al*., 2004). The UK guillemot population increased by 17% between 2000 and 2010 (JNCC 2011).

The guillemot which breed in Scotland winter over a wide area of offshore waters from Iberia to the Norwegian coast (Wernham *et al*., 2002). Approximately 750,000 guillemots have been estimated to winter in Scottish waters (Stone *et al*., 1995; Forrester *et al*., 2007), with the majority in northern and eastern areas.

The breeding population of guillemots in Great Britain and Ireland is approximately 1.56 million individuals. The species occurs around the UK coastline (except the south-east), and is particularly numerous in the north and west. The breeding population is concentrated in Scotland, where 75% of individuals are found (Mitchell *et al*., 2004; Image 31).

The population sizes of the surrounding regions of Highland, Grampian and the Northern Isles are shown in Table 92. These areas contain 31% of the British and Irish guillemot population, and large numbers breed in SPAs close to the three proposed wind farm sites (Table 93).

JNCC analysis of ESAS data collected between 1980 and 2006, to provide at-sea distributions of guillemots during the breeding season, the post-breeding moult and the winter period, are shown in Images 32a, 32b and 32c (Kober *et al*., 2010). These data show some distributional hotspots within the Moray Firth, particularly during the autumn.

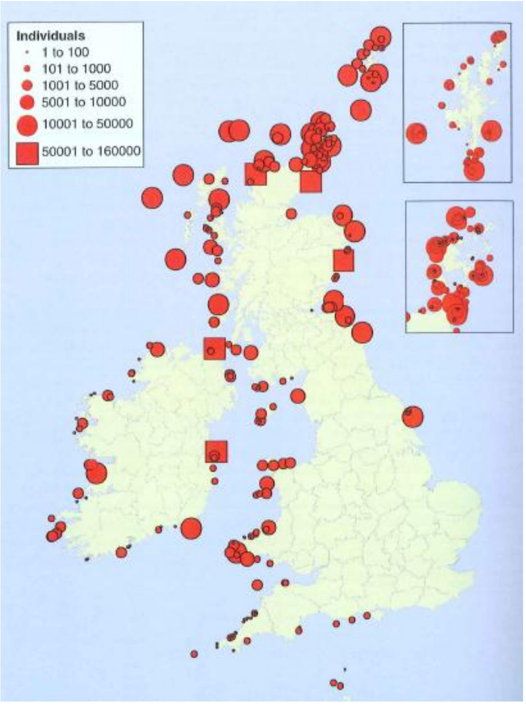


Image 31: Distribution of breeding guillemot 1998-2002 (taken from Mitchell *et al*., 2004)

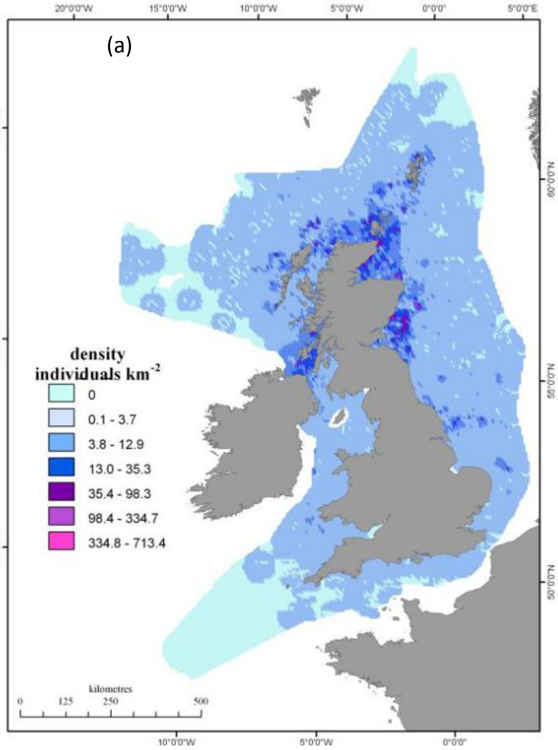


Image 32: JNCC predicted density surface maps for guillemot. Produced from ESAS data collected between 1980 and 2006. Above (a): breeding, Below left (b): August to September. Below right (c): winter (taken from Kober *et al*., 2010).

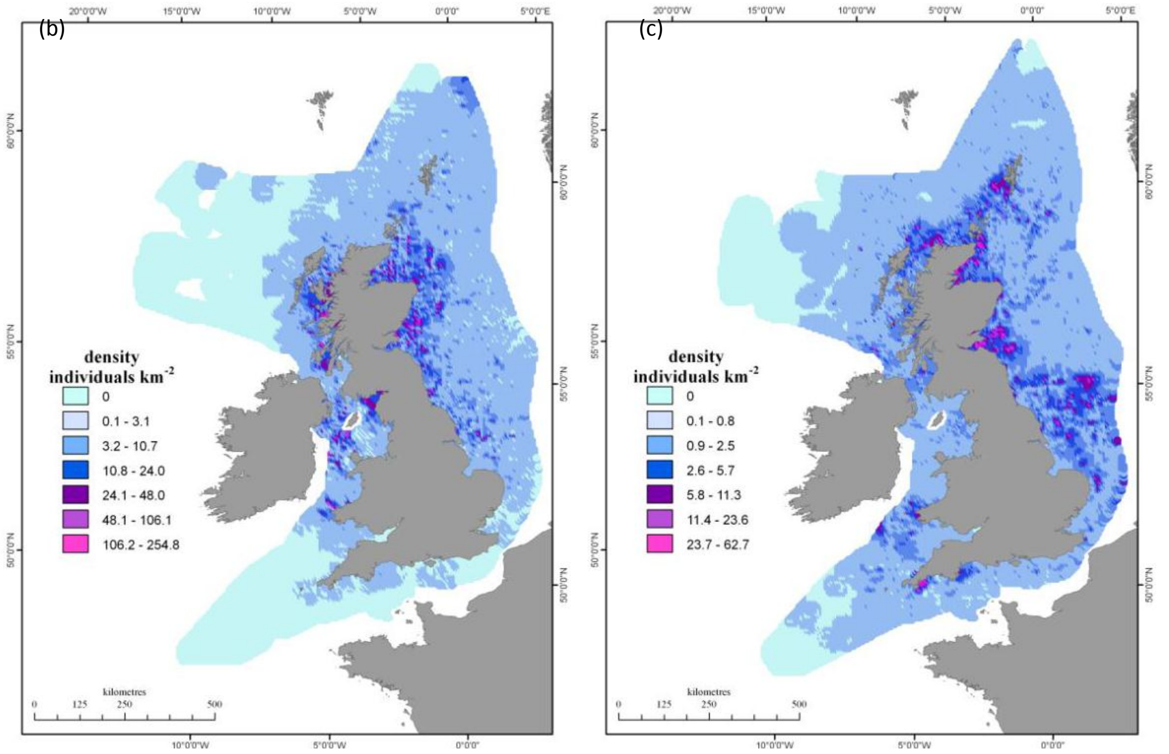


Table 92: Guillemot populations in districts around the Moray Firth (Mitchell *et al*., 2004)

Region	District	Population (ind.)
Northern Isles	Orkney	181,026
Highland	Caithness	226,254
	Ross & Cromarty (east)	1,944
Grampian	Banff & Buchan	73,970
TOTAL		483,194

Table 93: SPAs surrounding the three proposed wind farm sites which are designated for guillemot

Colony	Location	Colony size	Distance from wind farm sites	Count Date
East Caithness Cliffs	Caithness	106,700 ind.	20 km	1985-1988*1
North Caithness Cliffs	Caithness	38,300 ind.	33 km	1985-1988*1
Troup Head	Banff & Buchan	44,600 ind.	49 km	1995
Hoy	Orkney	13,400 ind.	58 km	1985-1988*1

*1 Seabird Colony Register Census.

4.22.1 Annual cycle

The return dates of adults to breeding sites is highly variable between colonies, with birds returning in some areas in late autumn and to others in spring (Forrester *et al*., 2007). This species lays a single egg, between mid-April and late May, with incubation typically lasting 28-37 days. Chicks fledge partly grown and incapable of flight, usually from 15 days after hatching (Snow and Perrins, 1998). The fledglings, accompanied by male parent birds, rapidly disperse away from breeding colonies and out to sea. Shortly after breeding adults undergo a full moult, during which time they are flightless and often aggregate in large groups in inshore waters (Blake *et al*., 1984). By October to November, with the moult complete, these flocks disperse as birds move further offshore (Pollock *et al*., 2000). Most guillemot do not breed until they are 5-6 years old and immature birds will move substantially further from their natal colonies than adults, sometimes visiting several colonies during a single summer (Halley and Harris 1993; Harris *et al.,* 1994). Many adults remain within a few hundred kilometres of their breeding colonies throughout the year (Wernham *et al*., 2002).

4.22.2 Food preferences

Guillemot are visual pursuit hunters able to perform both benthic and pelagic foraging dives. Many studies have described guillemot diet and, although there is considerable spatial and temporal variation in the composition of prey species (Blake *et al*., 1985), small lipid rich fish make up the majority of items consumed throughout the year. Several studies around Scotland in the 1980s found that during the breeding season guillemot diet consisted almost entirely of sandeels (Blake *et al*., 1985; Harris and Riddiford, 1989: Harris and Wanless, 1985). In contrast, between 1985 and 1987, birds from Skomer in Wales primarily provisioned their offspring with sprats (Hatchwell, 1991).

A wider range of prey species are consumed during the winter (Blake, 1983 & 1984; Blake *et al*., 1985). In addition to sandeels and sprat, herring and gadoids constitute considerable proportions of the prey items taken in some areas (Ouwehand *et al*., 2004).

4.22.3 Foraging distances

As part of the seabird tracking study (Technical Appendix 4.5 C), GPS loggers were attached to guillemots in the East Caithness Cliffs SPA during the incubation and early chick rearing period. 92 tracking devices were deployed, of which 26 were retrieved, providing information about 61 complete foraging trips and two incomplete foraging trips (Images 33 and 34). Based on data from fully recorded tracks the mean foraging range was 40.2 ± 32.1 km, and the maximum foraging range recorded was 156 km. Most birds travelled roughly south-west to forage at the mouth of the Dornoch Firth and in the inner Moray Firth. Smaller numbers travelled south-east to forage off the north Grampian coast. Several of the tracked birds passed through the western part of the MORL zone, but none appeared to forage and none came close to the three proposed wind farm sites.

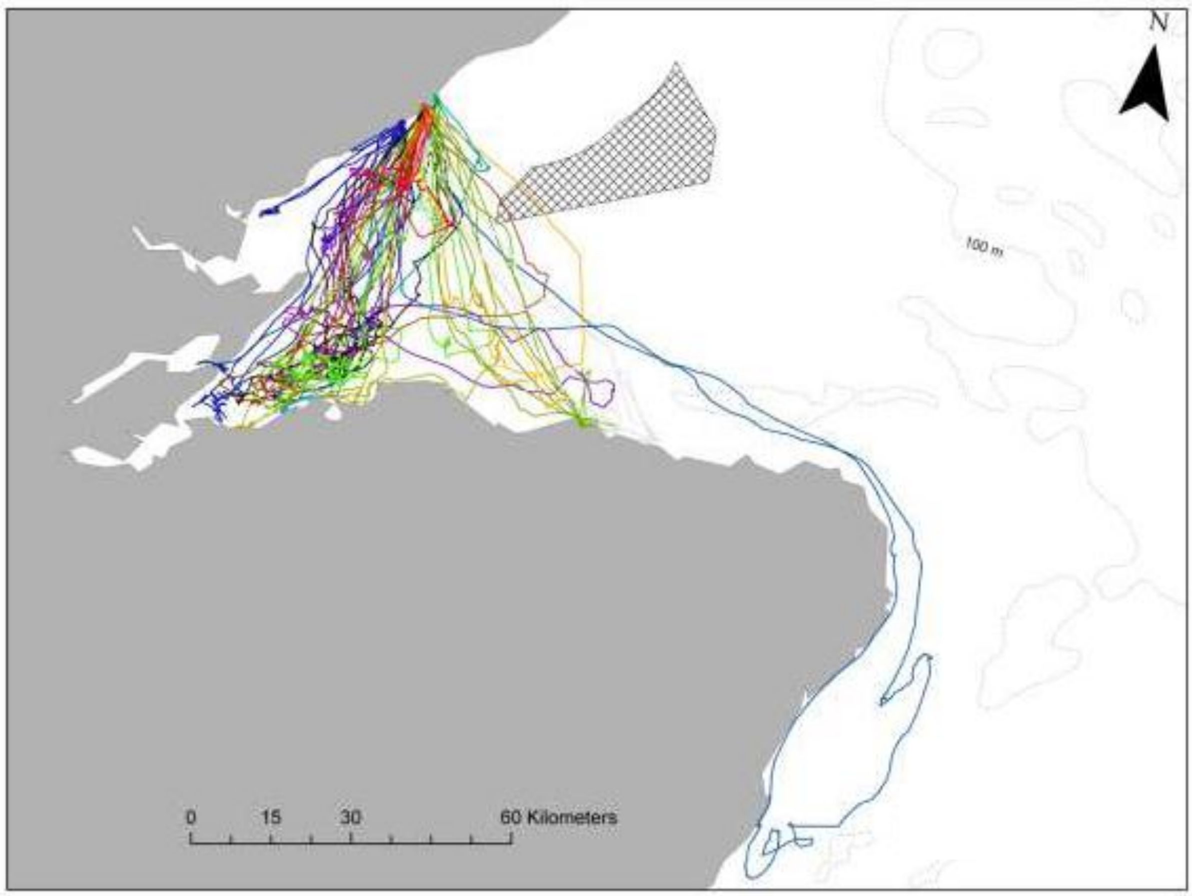


Image 33: GPS tracks of 26 guillemot breeding in the East Caithness Cliffs SPA (cross-hatched area shows extent of MORL zone)

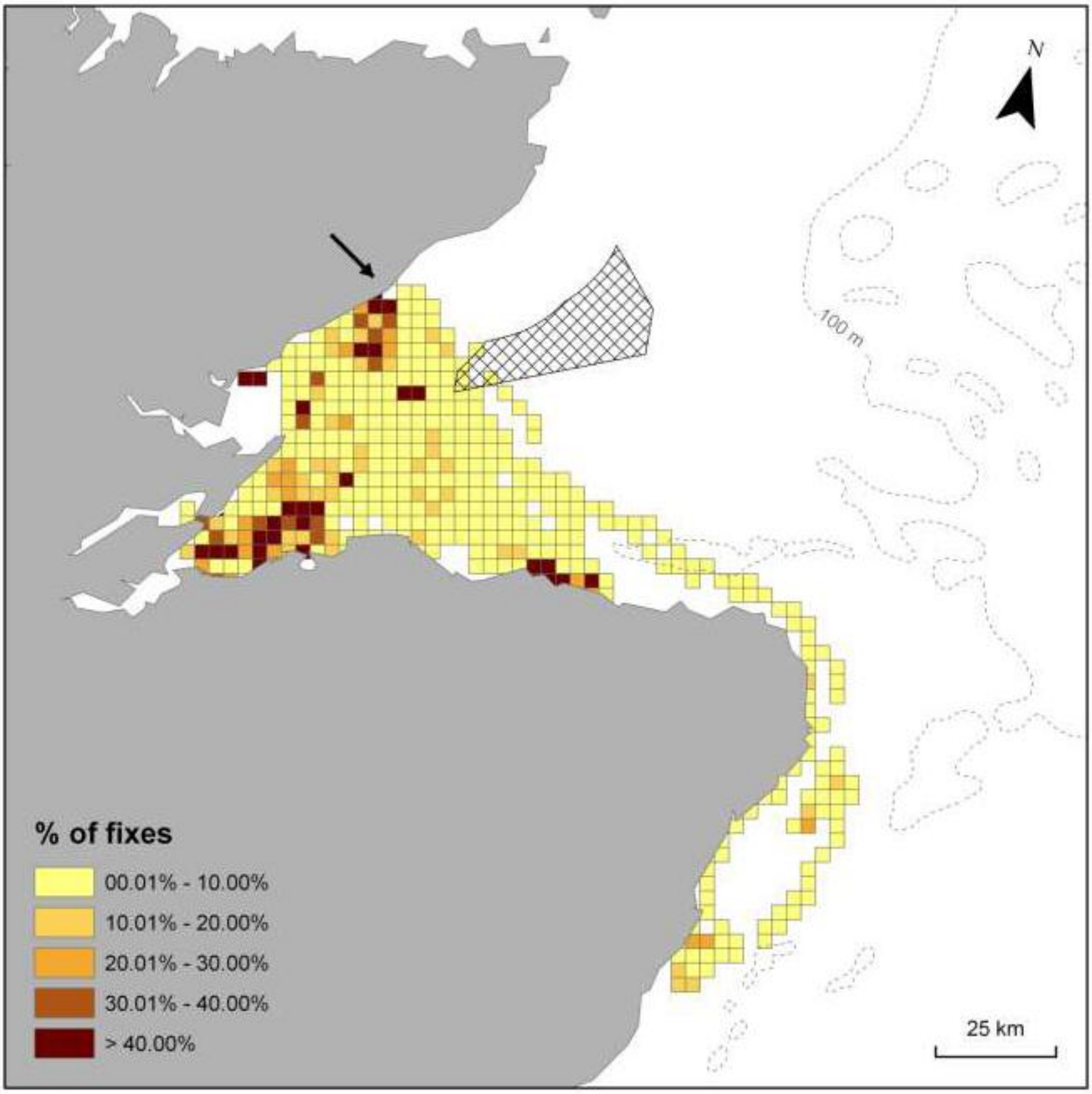


Image 34: Distribution and space use of all guillemot inferred from 2-minute resolution GPS positions (cross-hatched area shows extent of MORL zone)

A study by Thaxter *et al*. (2009) analysing data from GPS loggers used to track chick-rearing guillemot breeding on the Isle of May during 2002 and 2003, found that male and female parents differed significantly in their foraging ecology. The average maximum distance that foraging birds reached from their breeding site was 14.4 ± 6.6 km (11 trips) for males, but only 7.9 ± 5.3 km (8 trips) for females. Despite this there was a large degree of overlap in the foraging areas used by the different sexes.

Thaxter *et al*. (2010) used bird-borne data loggers to record information about the foraging behaviour of chick-rearing guillemots from the Isle of May colony. They observed a mean maximum foraging range from the colony of 14.4 km (± 12.2 km), and the overall foraging area (containing 95% of foraging trips recorded) was

1094 km^2. 60% of the foraging locations recorded were 10-20 km of the coast, and little use was made of areas closer to the coast or more than 25 km offshore.

An earlier study of the foraging ecology of guillemot from the Isle of May used radio-tracking equipment to establish that there was inter-annual variation in foraging ranges during each breeding season (Wanless *et al*., 1990). In 1986, during the chick-rearing period, 9% of foraging trips were within 2 km, 18% were between 2-7 km and 73% were further than 7 km. However, during the 1987 chick-rearing period, 34% of trips were within 2 km, 34% between 2-10 km, and only 31% were beyond 10 km.

Similar observations of foraging close to breeding colonies were made by Monaghan *et al*. (1994) while radio-tracking guillemot breeding at Sumburgh Head, Shetland. In 1990 birds travelled, on average, 7.1 km to forage (range 3.4–9.4 km), and in 1991 average foraging distances were only 1.2 km (range 0.1-4.8 km).

Dye-marked birds at Fair Isle were sighted feeding within 6-8 km of the colony (Bradstreet and Brown, 1985). Surveys around Fair Isle in June 1980 and 1981 also found most foraging occurring within 6 km of the colony (Langslow *et al.* cited in Webb *et al.*, 1985). Benn *et al.* (1987) found that most feeding took place within 5 km of North Rona and Sula Sgeir, with adults travelling a maximum of 15 km. Large numbers of guillemots from St Kilda were recorded feeding at a bank *c*. 40 km away (Leaper *et al.*, 1988). Almost all birds from Flamborough Head seen in June 1984 were feeding within 30 km of the colony, but with some recorded up to 40 km away (Webb *et al.*, 1985).

Birdlife International data on foraging distances for guillemot shows a maximum foraging distance of 200 km, a mean maximum of 60.61 km, and a mean foraging distance of 24.49 km. Based on the above information, a summary is provided below of potential connectivity between guillemot colonies and the development of the three proposed wind farm sites:

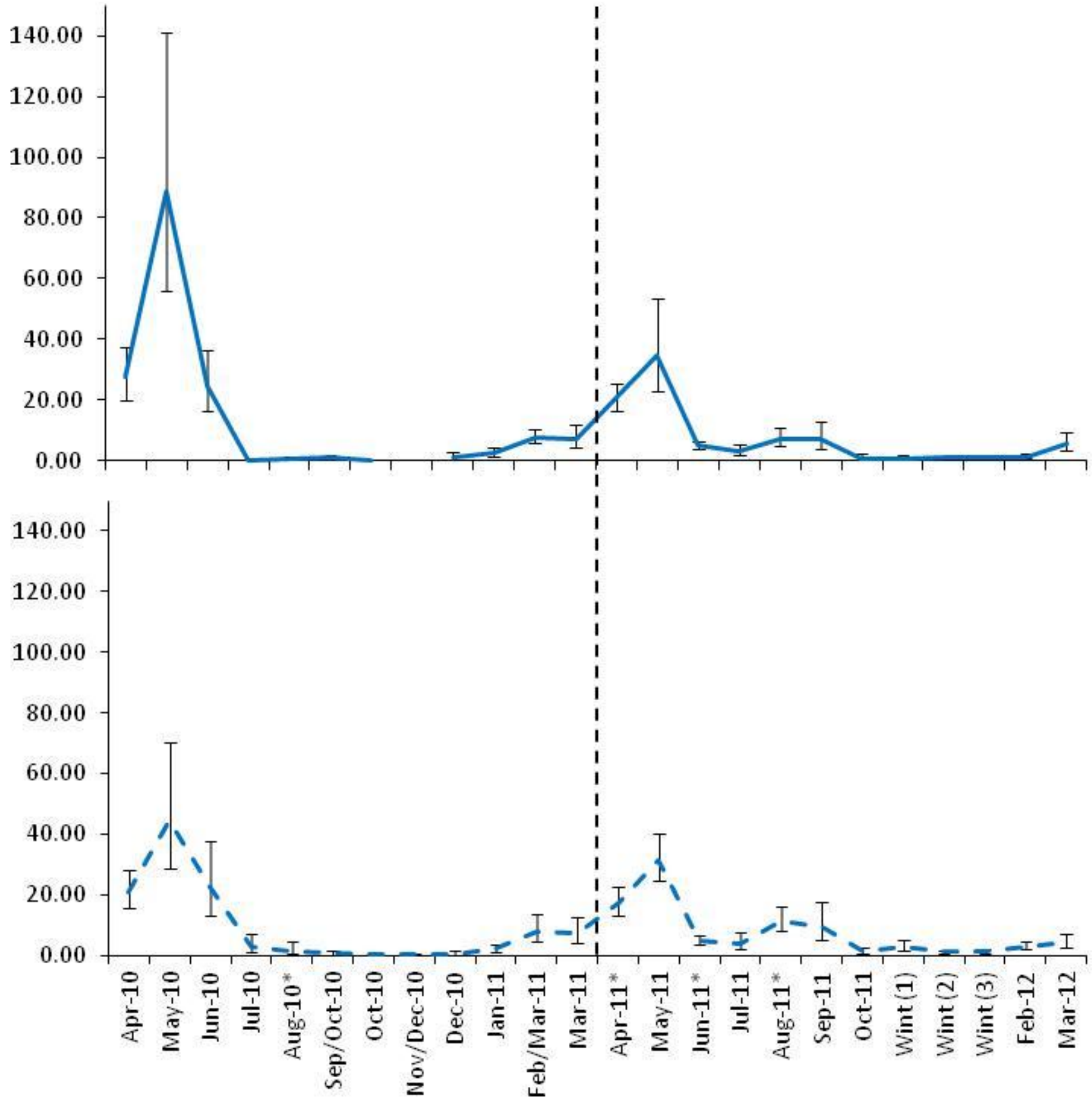
- The majority of guillemot recorded from the survey area are likely to be from the colonies within the North and East Caithness Cliffs SPAs, which are well within a 40 km range of the wind farm sites.
- Birds from the Troup, Pennan and Lion’s Heads SPA as well as those from the small non-SPA colonies in eastern Ross and Cromarty may also forage over the three wind farm sites (less than ca. 50 km away).
- Two other large SPA colonies in south Orkney (Hoy and Copinsay, both approximately 60 km from the wind farm sites) are also within the potential foraging range of this species.

4.22.4 Abundance and distribution within sites

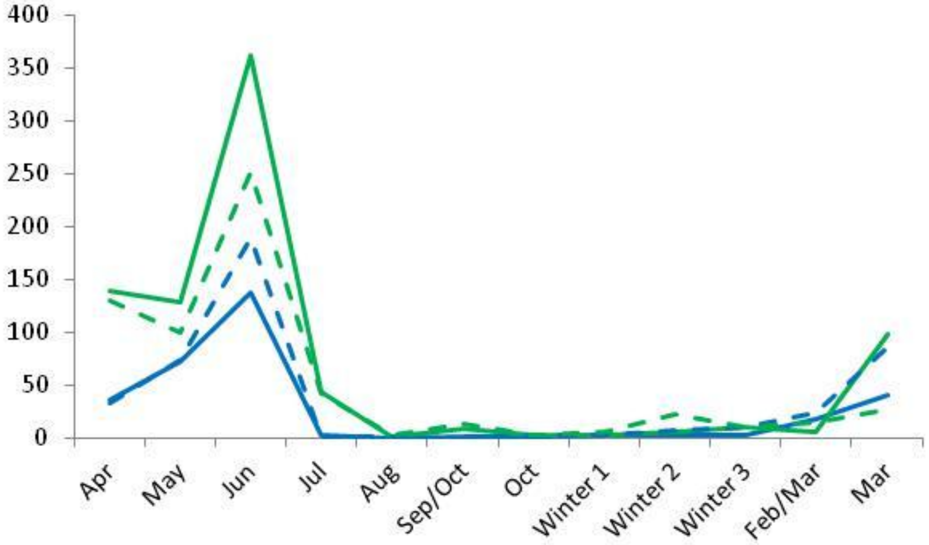
Guillemot were recorded in all months of the survey. Densities were highest in spring, peaking in May 2010 (88.67 birds/km^2) and May 2011 (34.94 birds/km^2) (Table 35, Graph 32). No flights were at potential collision height (Table 24). Annual variation in numbers recorded in flight is shown in Graph 33. Distribution maps for the species are shown in Figures 7 and 8.

Table 94. Mean density and abundance of guillemot on the three proposed wind farm sites and the buffer zone, in the breeding and non-breeding season from boat-based surveys

Breeding Season				**Non-breeding season**			
Density		**Abundance**		**Density**		**Abundance**	
Site	**Buffer**	**Site**	**Buffer**	**Site**	**Buffer**	**Site**	**Buffer**
25.57	18.60	6732	6943	2.84	3.47	990	1021



Graph 32. Temporal variation in guillemot density (birds/km^2) in the wind farm sites (solid line) and the buffer zone (dotted line) Excludes records with percentage CV greater than 100 (low confidence). In months where two surveys were conducted mean values are displayed. The winter surveys correspond to the three surveys undertaken between November and January.



Graph 33: Number of guillemot recorded in flight in transect during each of the MORL boat-based surveys between April 2010 and March 2012. Blue lines refer to surveys during first year. Green lines refer to surveys during second year. Solid lines refer to records within wind farm sites. Dashed lines refer to records within buffer area. In months where two surveys were conducted mean values are displayed. The winter surveys correspond to the three surveys undertaken between November and January.

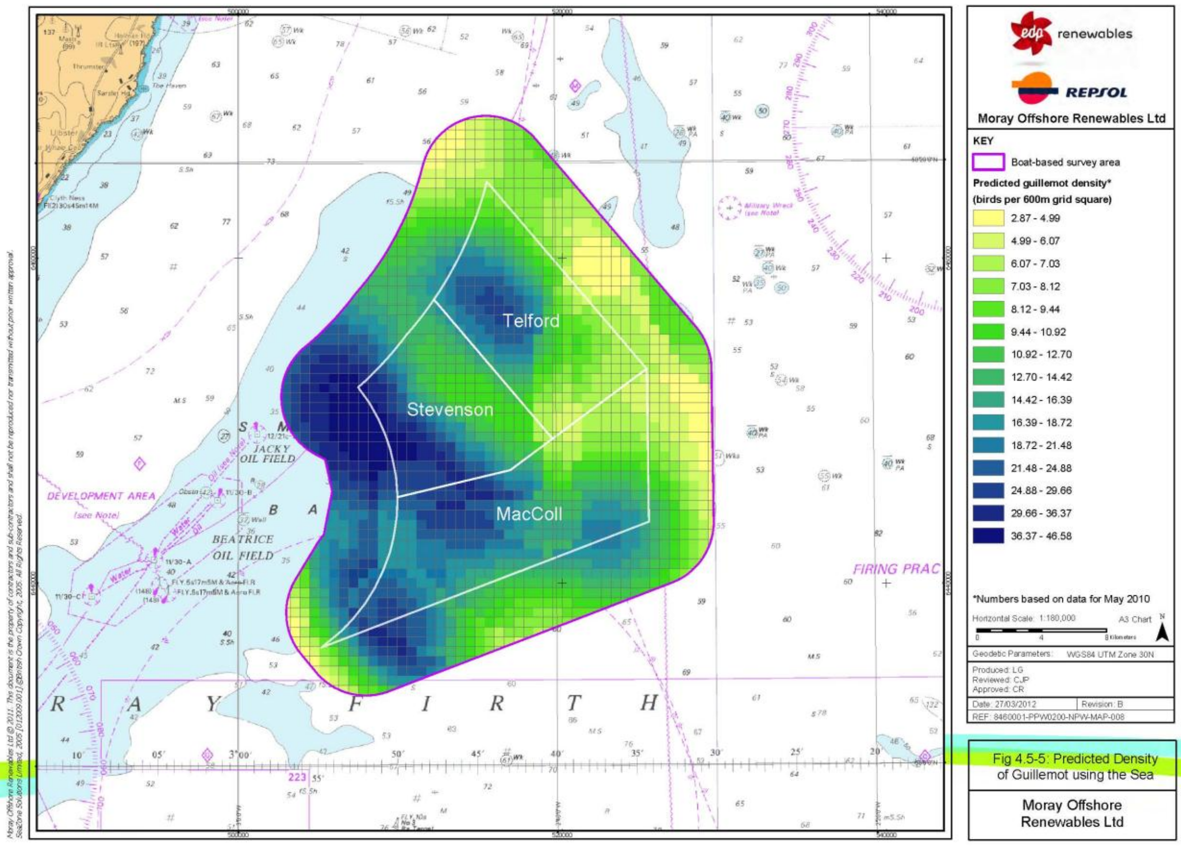


Figure 7: Modelled density surface map for guillemot from May 2010.

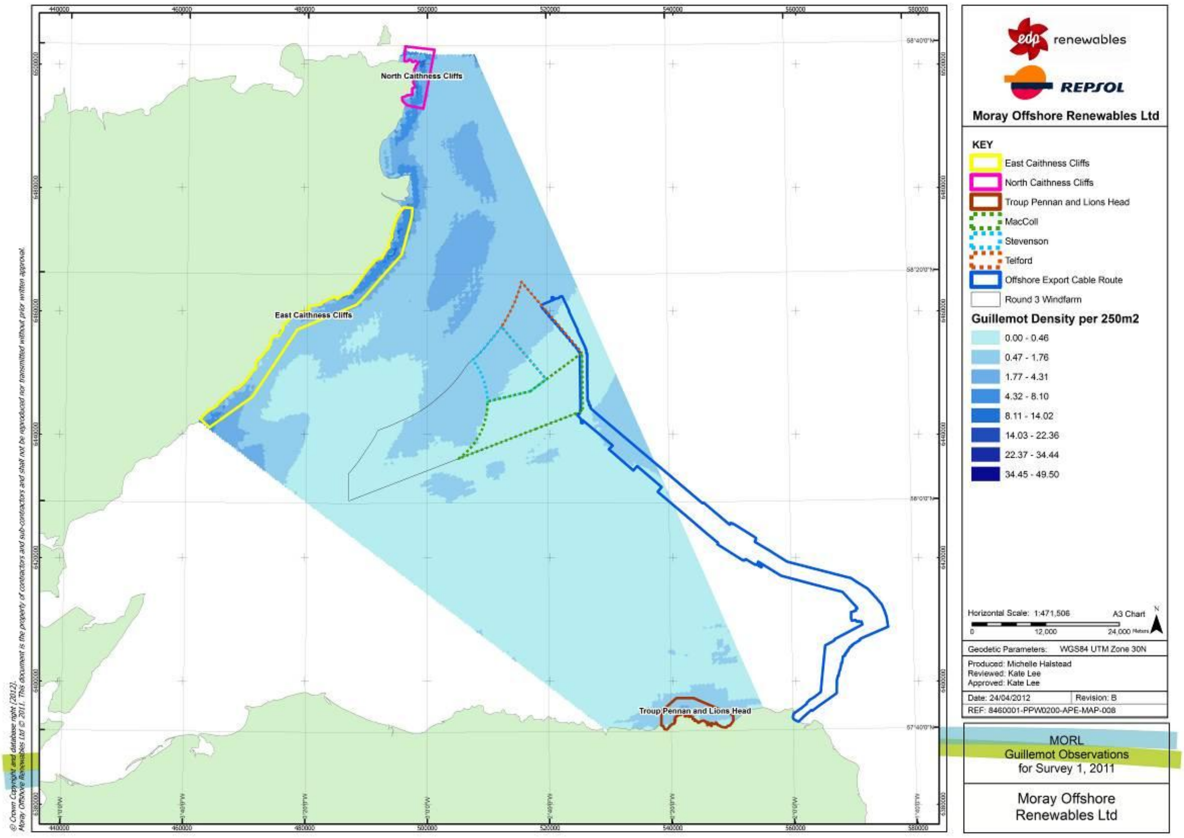


Figure 8a: Distribution of guillemots across the survey area, from digital aerial surveys - Survey 1.

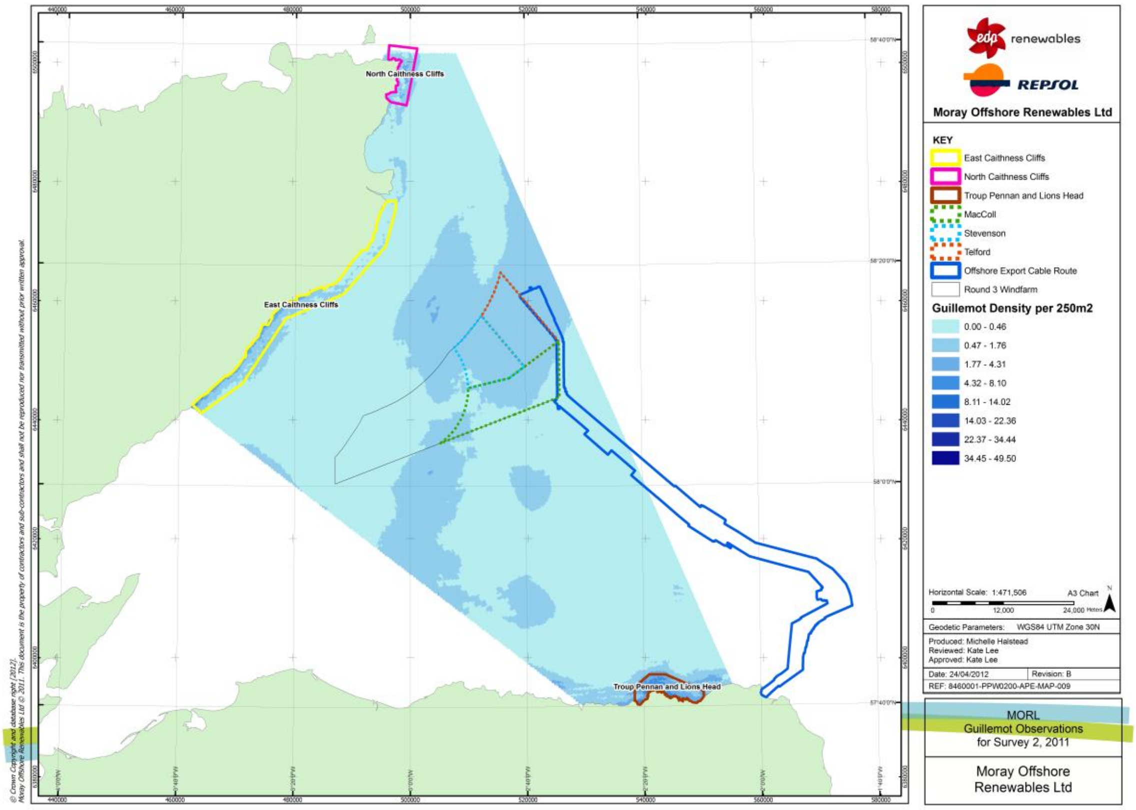


Figure 8b: Distribution of guillemots across the survey area, from digital aerial surveys - Survey 2.

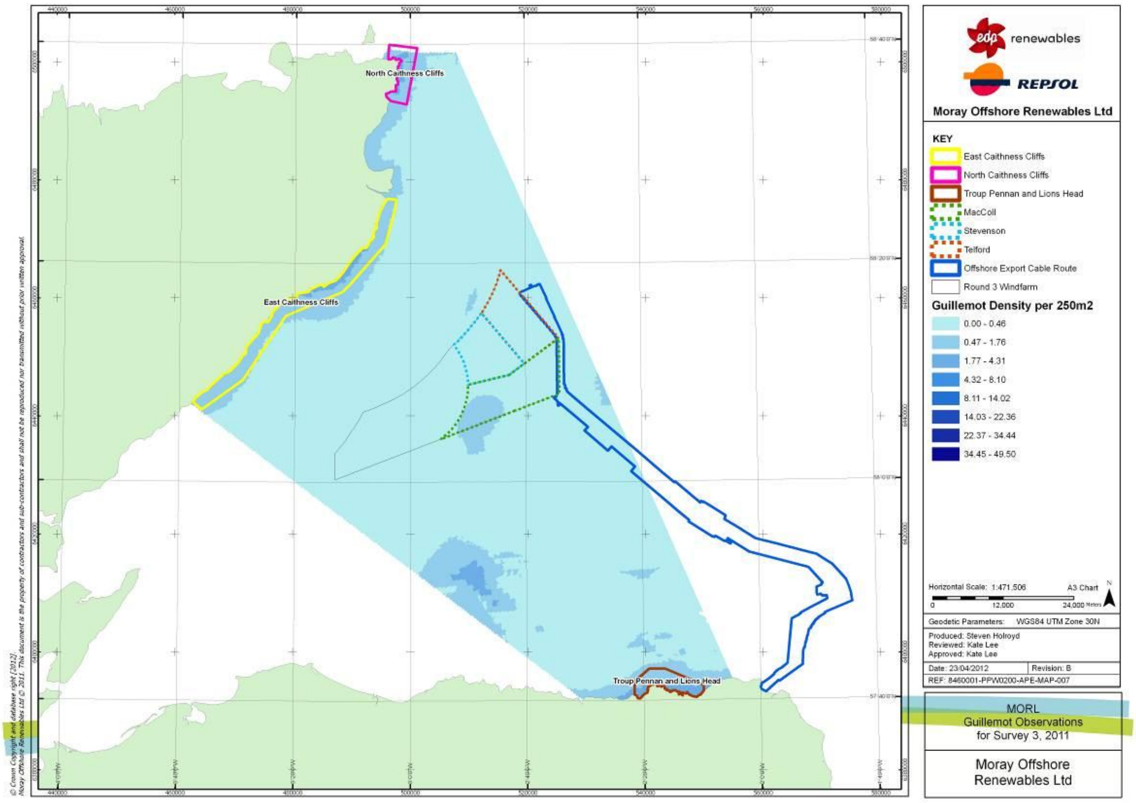


Figure 8c: Distribution of guillemots across the survey area, from digital aerial surveys - Survey 3.

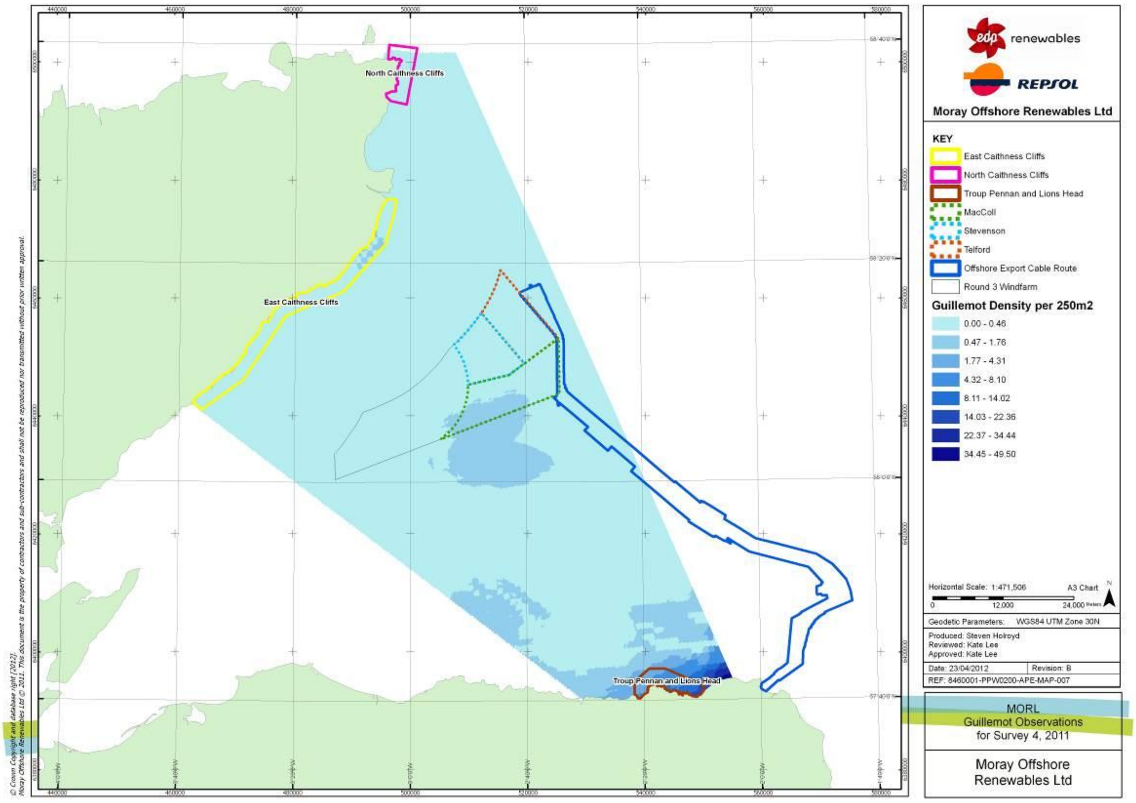


Figure 8d: Distribution of guillemots across the survey area, from digital aerial surveys - Survey 4.

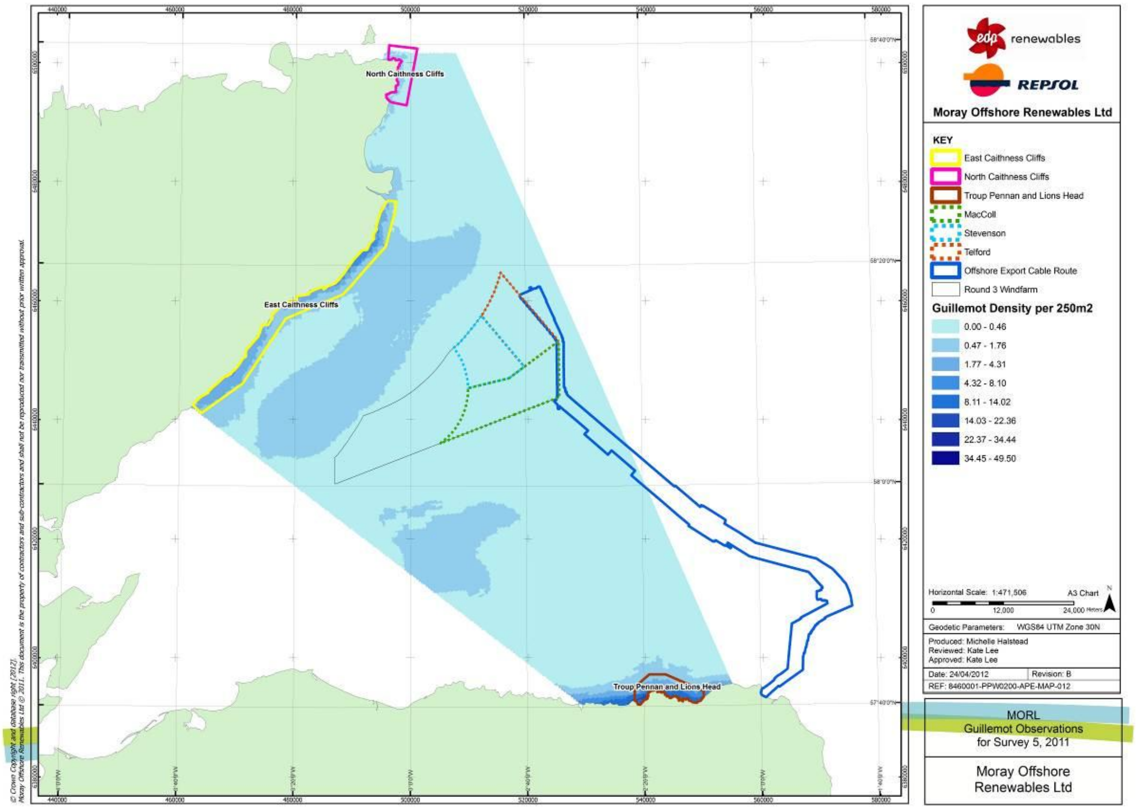


Figure 8e: Distribution of guillemots across the survey area, from digital aerial surveys - Survey 5.

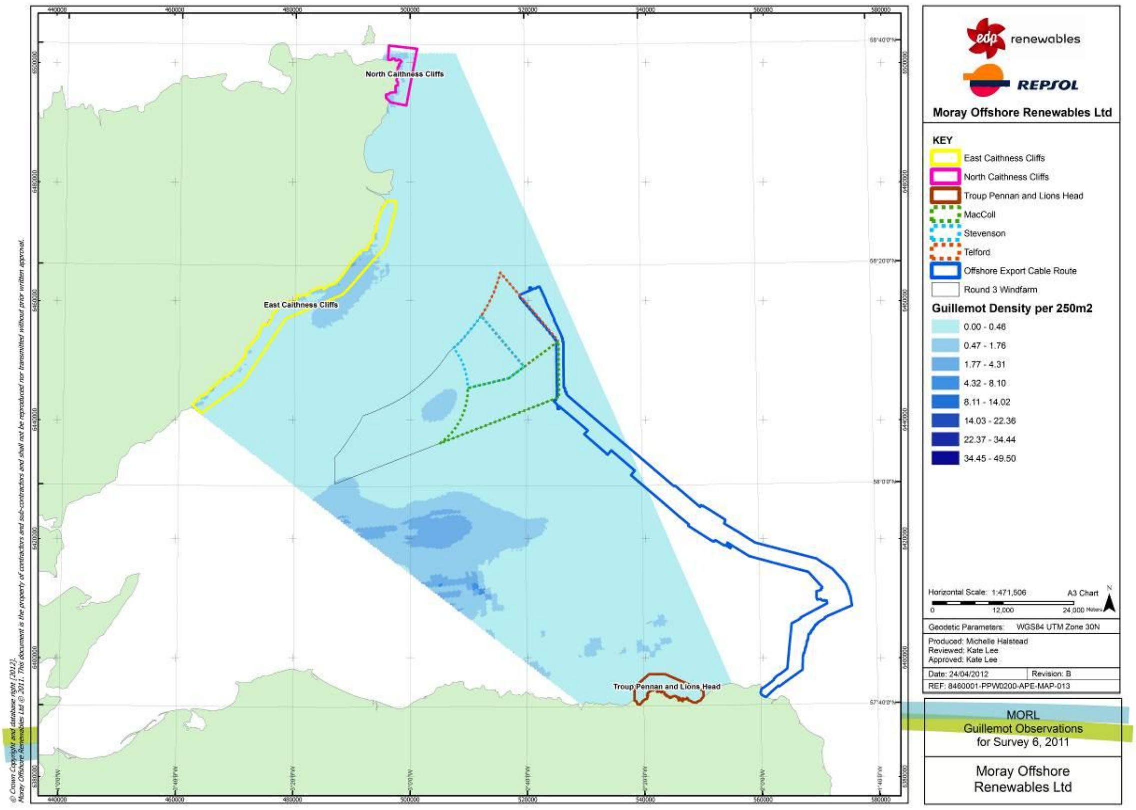
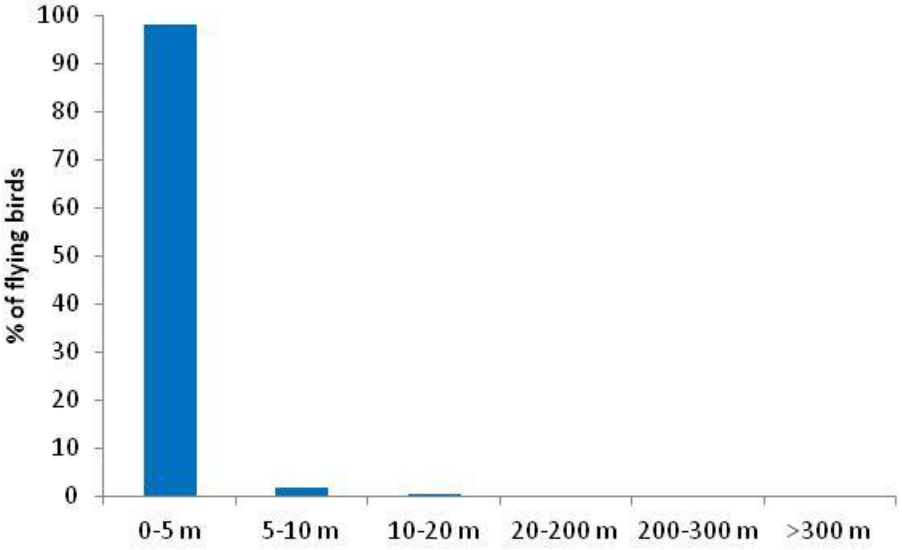


Figure 8f: Distribution of guillemots across the survey area, from digital aerial surveys - Survey 6.

4.22.5 Potential for collision risk

Of 3098 guillemots recorded in flight and in transect within the three proposed wind farm sites, no birds were observed flying within the collision risk height (Table 24 Graph 34). Data collated from other offshore developments show similar results, with a proportion of 0.01 guillemots recorded flying within the potential collision risk height, from a sample of 6507, with a range varying between 0 and 1.8% (Cook *et al*., 2011). Langston (2010) assessed this species as being at low collision risk. In summary it is concluded that collision risk is negligible.



Graph 34: Proportions of guillemot flights recorded in each height band (for birds recorded in transect during April 2010 to March 2012 boat-based surveys).

4.22.6 Potential for disturbance / displacement / indirect effects

The mean densities of guillemot recorded within the wind farm sites were 25.57 birds/km^2 during the breeding season and 2.84 birds/km^2 during the non-breeding season, equating to abundances across the sites of 6732 and 990 birds respectively (Table 94). The highest densities of guillemots were recorded within the western half of the sites, with particular concentrations in central MacColl, south-western Stevenson, western Telford and western parts of the buffer zone (see Figure 4.5-5, Volume 6b and Table 4.5-7 in Baseline Chapter 4.5).

Guillemots have a medium sensitivity to ship and helicopter disturbance (Table 20; based on Garthe and Huppop, 2004).

Various offshore developments have recorded evidence of avoidance (ranging from mild avoidance to strong avoidance), e.g. Garthe and Huppop, 2004) and Dierschke and Garthe (2005). Other studies however, such as Degraer and Brabant

(2009) have shown that densities have remained constant (relative to controls) during the first year of construction, inferring minimal levels of displacement.

Analysis of data collected from Robin Rigg offshore wind farm in the Solway Firth, comparing the construction and post-construction years with five pre-construction years, found a 30% reduction in auk numbers using the site (Shenton & Walls, pers. comm.).

The 'WCS' displacement analysis (100% displacement) predicted 3513 individuals to be displaced from the three proposed wind farm sites. The 'RS' analysis, using a 50% displacement rate, predicted 1,683 individuals to be displaced from the three sites (Tables 44 and 45).

4.22.7 Potential for barrier effects

This species has a maximum foraging range of 156 km, with a mean of 40.2 km was recorded for guillemot breeding on the East Caithness Cliffs SPA. However, given the location of hotspots for this species within the Moray Firth, barrier effects are expected to be minor.

4.22.8 Key risks

Table 95. Potential effects for guillemot.

Risk	Threat to species	Justification
Barrier effects	Minor	Moray Firth – scale aerial surveys show hotspots occur outwith the three proposed wind farm sites.
Collision	Negligible	Consistently low flight height. No flights at collision risk height. Mean flight height of 4 m. Assessed as low risk by Langston (2010).
Displacement and Disturbance	Minor	Displacement of 1,683 individuals during the breeding season (RS). Moray Firth – scale aerial surveys show hotspots occur outwith the three proposed wind farm sites.

4.23 Razorbill

Razorbills breed around the boreal and low-arctic latitudes of the Atlantic Ocean, with most in Iceland, Britain and Ireland, Norway and eastern Canada. The population of Great Britain and Ireland forms approximately 23.5% of the global population, with 15% of the global population estimated to breed in Scotland (Mitchell *et al*., 2004). The UK razorbill population increased by 1% between 2000 and 2010 (JNCC 2011).

The number of razorbills which winter around Scotland is unclear, but from the densities of birds observed during at-sea surveys (Webb *et al*., 1990; Skov *et al*., 1995) it has been estimated that up to 50,000 to 250,000 may be present (Forrester *et al*., 2007).

The breeding population of razorbills in Great Britain and Ireland is approximately 216,000 individuals. This species occurs around the UK, except the south and south-east coastline. It is most numerous in the north and west, with 64% of the breeding population in Scotland (Forrester *et al*., 2007; Image 35). JNCC analysis of ESAS data collected between 1980 and 2006, to provide at-sea distributions of razorbill during the breeding season, the post-breeding moult and the winter period area shown in Images 36a, 36b and 36c (Kober *et al*., 2010).

The districts which surround the Moray Firth contain a significant proportion (18%) of the British and Irish razorbill population (Table 96), with large numbers of razorbills breeding in SPAs close to the three proposed wind farm sites (Table 97).

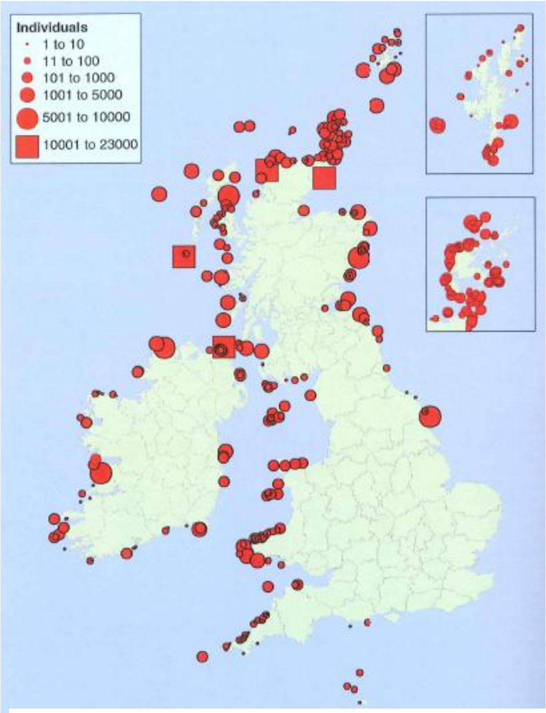


Image 35: Distribution of breeding razorbill 1998-2002 (taken from Mitchell *et al*., 2004)

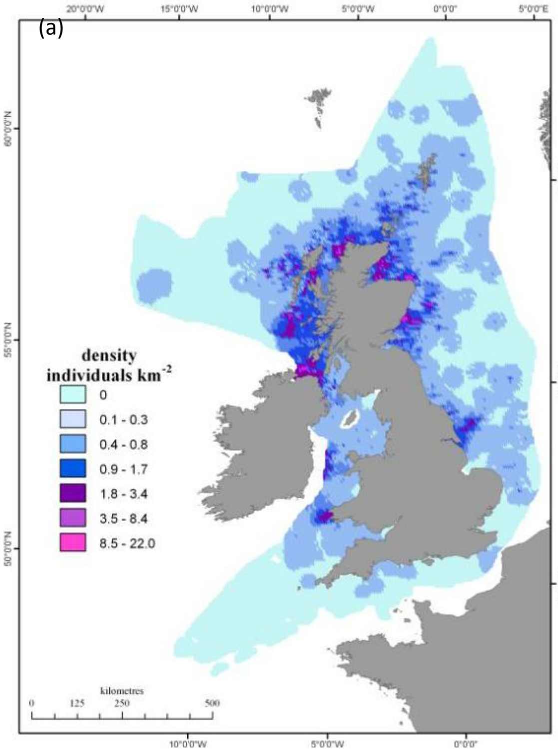


Image 36: JNCC predicted density surface maps for razorbill. Produced from ESAS data collected between 1980 and 2006. Above (a): breeding, below left (b): August to September. Below right (c): winter (taken from Kober *et al*., 2010).

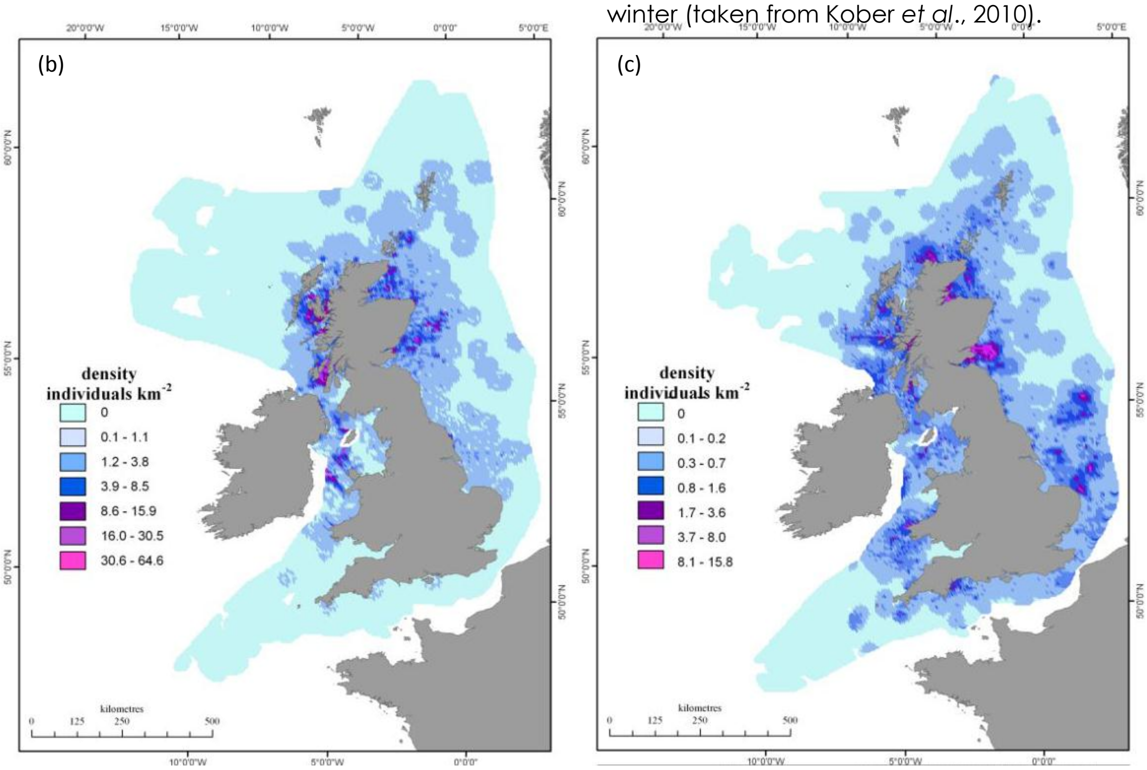


Table 96: Razorbill populations in districts around the Moray Firth (Mitchell *et al.*, 2004)

Region	District	Population (ind.)
Northern Isles	Orkney	10,194
Highland	Caithness	20,333
	Ross & Cromarty (east)	251
Grampian	Banff & Buchan	7,606
TOTAL		38,384

Table 97: SPAs surrounding the three proposed wind farm sites which are designated for razorbill

Colony	Location	Colony size	Distance from wind farm sites	Count Date
East Caithness Cliffs	Caithness	15,800 ind.	20 km	1985-1988*[1]
North Caithness Cliffs	Caithness	4,000 ind.	33 km	1985-1988*[1]
Troup Head	Banff & Buchan	4,400 ind.	49 km	1995
West Westray	Orkney	1,946 ind.	108 km	1985-1988*[1]

*[1] Seabird Colony Register Census

4.23.1 Annual cycle

In Scotland breeding colony reoccupation occurs from mid-March onwards, with egg laying typically between late April and late May (Forrester *et al*., 2007). Eggs are incubated for about 34 days, and young birds leave the nest 14 to 24 days after hatching (Snow and Perrins, 1998), usually before the end of July. Chicks fledge partly grown and incapable of flight and, accompanied by the male parent, rapidly disperse away from breeding colonies and out to sea. Shortly after breeding adults undergo a full moult, during which time they are also flightless. Following the post-breeding moult most razorbill gradually move south, with some birds travelling as far as the western Mediterranean and areas off north-west Africa (Wernham *et al.,* 2002).

4.23.2 Food preferences

Razorbill diet primarily consists of fish, although some invertebrates are also taken (Snow and Perrins, 1998). Studies on the Isle of May showed that sandeels are the main prey fed to razorbill chicks (Harris and Wanless, 1986).

By examining the stomach contents of birds killed in an oil spill in the south-east North Sea, Ouwehand *et al*. (2004) found the winter diet of razorbill to be more restricted than that of guillemot. 8-9 prey species were identified for razorbill, compared to 24-25 for guillemot, and the vast majority (91%) of razorbill prey items were less than 10 cm in length. Pilchards form a large proportion of the diet of birds wintering off western Iberia (Beja, 1989).

4.23.3 Foraging distances

In 2011 Votier *et al*. attached GPS loggers to razorbill in the East Caithness Cliffs SPA during the incubation and early chick rearing period (Technical Appendix 4.5 C). 31 tracking devices were deployed, of which 20 were retrieved, providing information about 58 complete foraging trips and two incomplete foraging trips (Images 37 and 38). Based on data from fully recorded tracks, the mean foraging range was 30.3 ± 11.2 km. The maximum foraging range recorded was, however, recorded as a partial track where the tracker signal ceased when a bird was 137 km from its breeding site and still travelling away. Most birds travelled roughly south-west to forage off the southern part of the east Caithness coast or at the mouth of the Dornoch Firth and, to a lesser extent, in the outer parts of the inner Moray Firth. None of the tracked birds passed through the MORL Zone (Votier pers comm.).

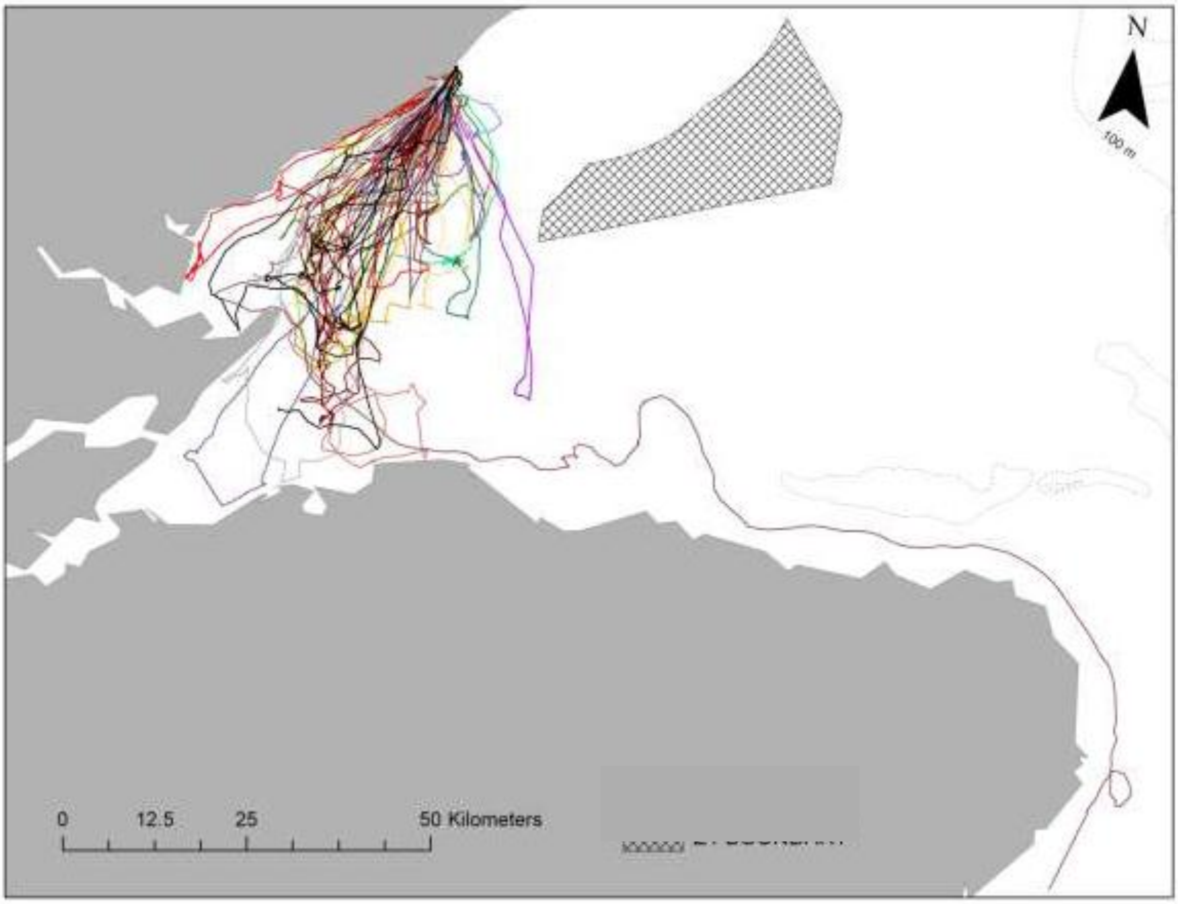


Image 37: GPS tracks of 18 razorbill breeding in the East Caithness Cliffs SPA (cross-hatched area shows extent of MORL zone)

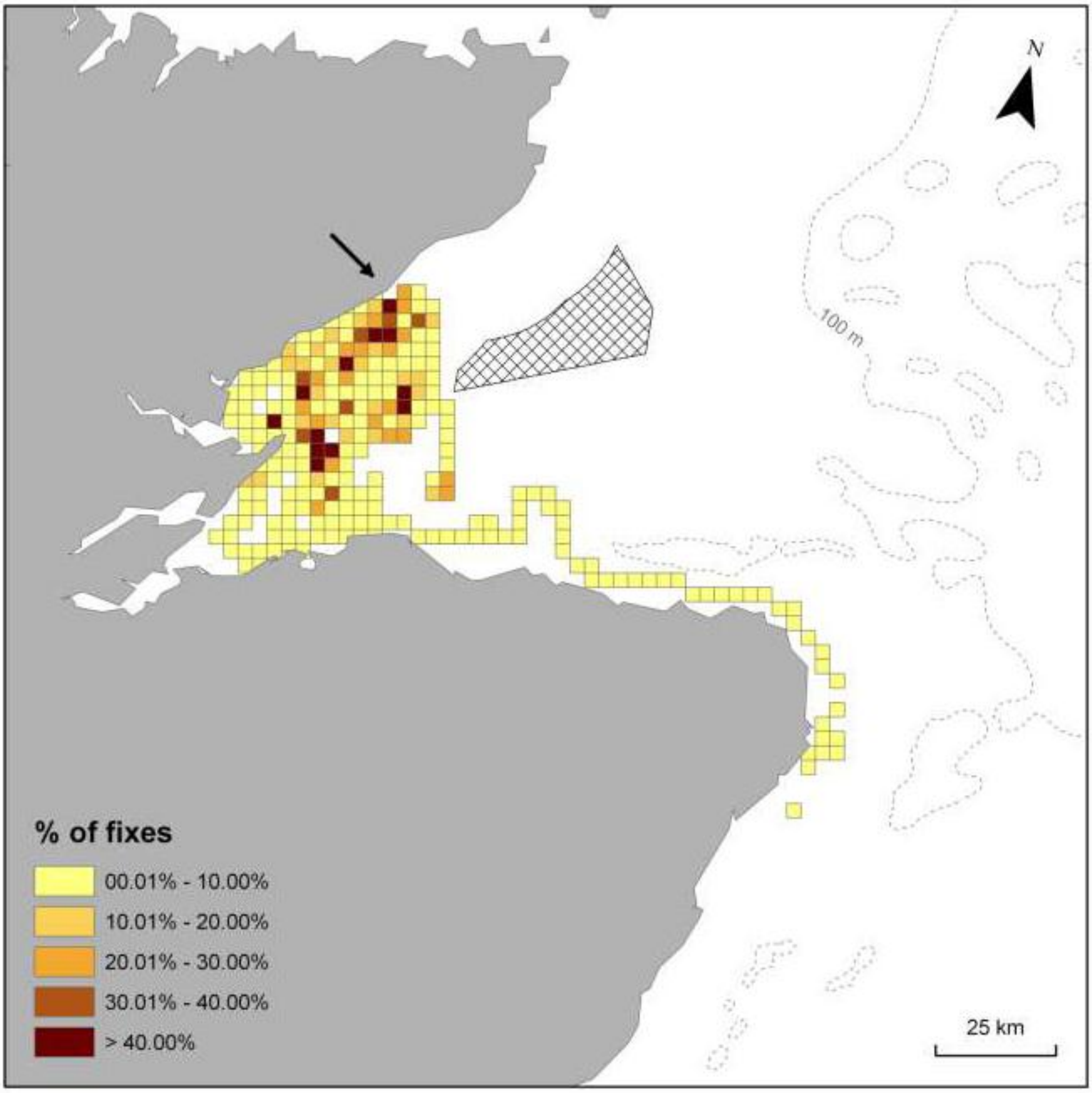


Image 38: Distribution and space use of all razorbill inferred from 2-minute resolution GPS positions (cross-hatched area shows extent of MORL zone).

Studies of razorbill foraging ecology have observed large differences in the distances that birds travel from colonies to feed. This is most probably explained by differences between colonies and suitable foraging areas.

Thaxter *et al*. (2010) used bird-borne data loggers to record information about the foraging behaviour of chick-rearing razorbill from the Isle of May colony. They observed a mean maximum foraging range from the colony of 18.4 km (± 14.8 km), and the overall foraging area (containing 95% of foraging trips recorded) was 2,201 km^2 (Image 39), approximately twice the area utilised by guillemot (1094 km^2). Almost half of the foraging locations recorded were within 10 km of the coast, with most of the remainder 30-40 km from the coast.

Image 39: Locations at sea recorded for GPS-tracked chick-rearing razorbill from the Isle of May. Areas encompassing 50%, 75% and 95% of foraging locations are shown in black, dark grey and light grey respectively (taken from Thaxter *et al*., 2010).

Similar observations of razorbill foraging range around the Isle of May were made by Wanless *et al*. (1990); they radio-tracked 3 chick-rearing adults from the Isle of May colony and found that in most foraging trips (32 of 35) birds travelled distances greater than 10 km.

Most other information on razorbill foraging distances comes from boat-based transect surveys. Such surveys around the Isle of May have found the highest concentrations of razorbill within 5 km of the colony, with aggregations also located 35 km away at the Wee Bankie (Tasker *et al*., 1987; Wanless *et al.*, 1998). Transect surveys around St Kilda have found similar distributions with the majority of razorbill foraging within 5 km of the islands, along with aggregations at the Whale Rock Bank 38 km away (Leaper *et al.,* 1988). Transect surveys near Flamborough Head in June 1984 found maximum densities of razorbill 26-28 km away from the colony, as well as large numbers within 1 km of the colony (Webb *et al.*, 1985). Similarly, during surveys around the Pembrokeshire Islands in 1990 the highest mean density of razorbill was within 5 km with birds also seen up to 25 km from the colonies, whereas in 1992 they were found in highest densities up to 10 km away with birds recorded up to 45 km away (although in low numbers beyond 25 km) (Stone *et al.,* 1992).

Birdlife International data on foraging distances for razorbill shows a maximum foraging distance of 51 km, a mean maximum of 31 km, and a mean foraging distance of 10.27 km.

A consensus from the above information is that the large majority of razorbills forage within 40-50 km of their breeding site. Based on this, a summary is provided below of potential connectivity between razorbill colonies and the development of the three proposed wind farm sites:

- Razorbills recorded from the survey area will include birds from the colonies within the North and East Caithness Cliffs SPAs, which are within a 40 km range of the three proposed wind farm sites.

Birds from the Troup, Pennan and Lion's Heads SPA may also forage over the three proposed wind farm sites (less than ca. 50 km away).

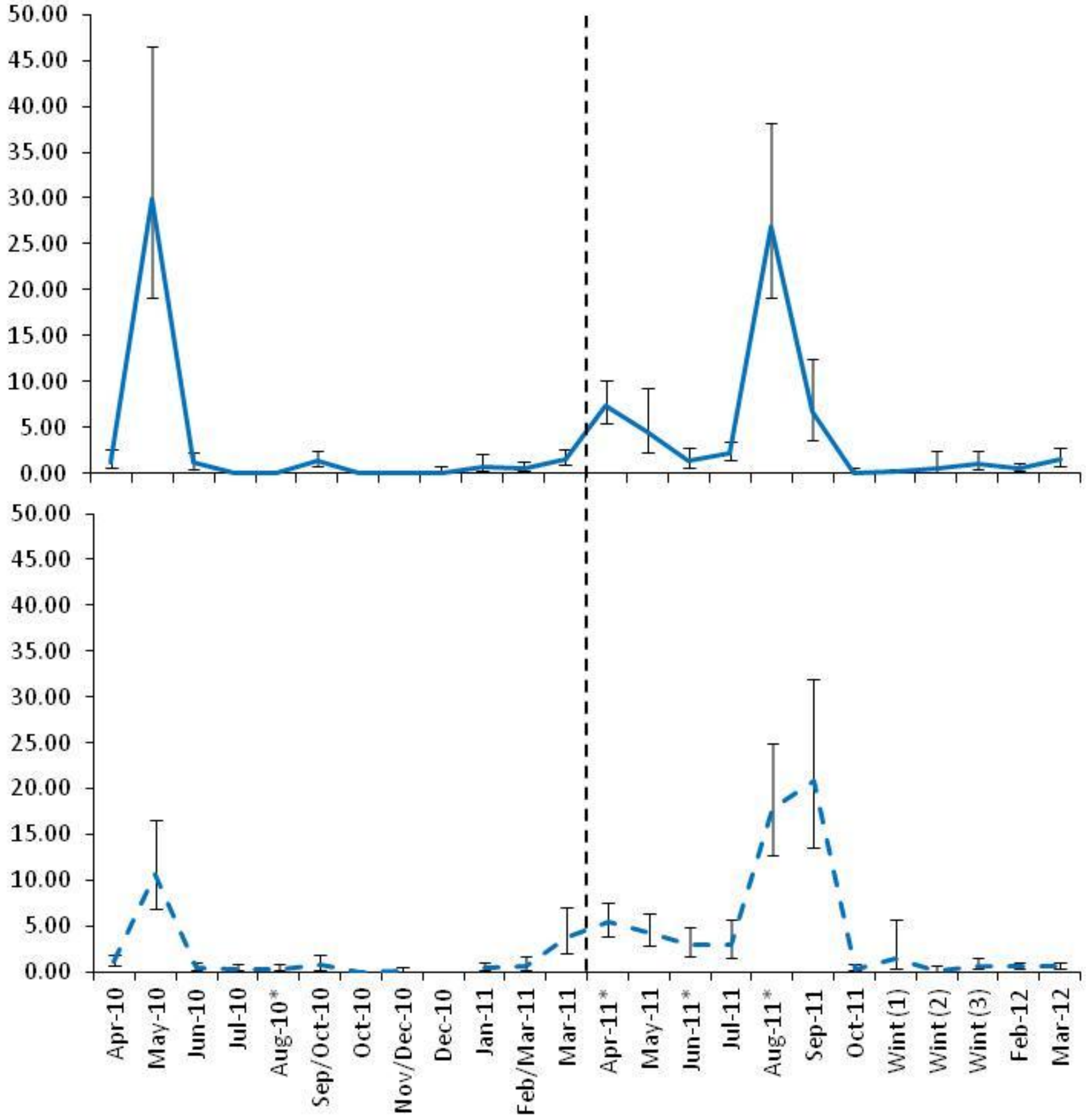
4.23.4 Abundance and distribution within sites

Razorbill were recorded in all months of the survey. Densities were highest in spring and summer, peaking in May 2010 (29.91 birds/km^2) and August 2011 (26.97 birds/km^2) (Table 36, Graph 35). The peak month for birds recorded using the sea was August 2011, with 2854 birds recorded on boat-based surveys (Table 21). Annual variation in numbers recorded in flight is shown in Graph 36. Distribution maps for the species are shown in Figures 9 and 10.

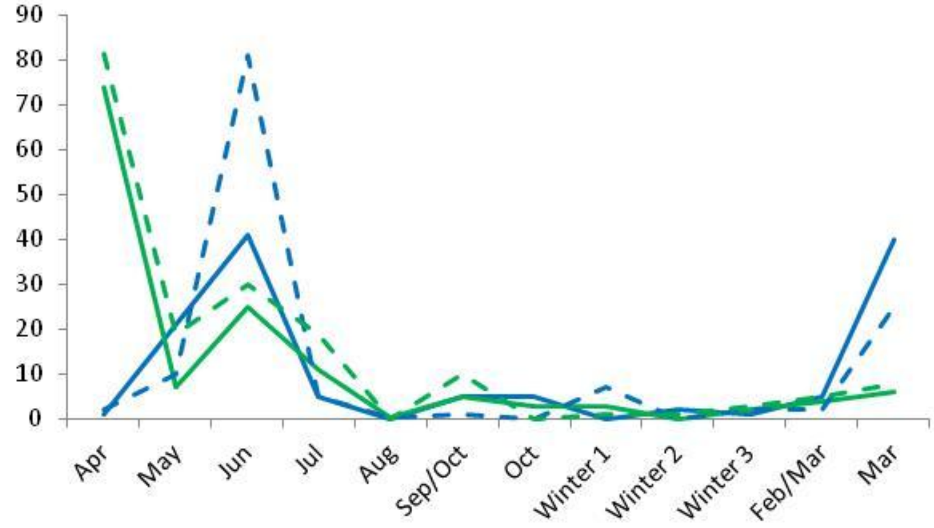
No flights were recorded at potential collision height.

Table 98. Mean density and abundance of razorbill on the three proposed wind site and the buffer zone, in the breeding and non-breeding season from boat-based surveys

Breeding Season				Non-breeding season			
Density		**Abundance**		**Density**		**Abundance**	
Site	**Buffer**	**Site**	**Buffer**	**Site**	**Buffer**	**Site**	**Buffer**
6.03	3.53	1661	1674	2.64	3.04	892	899



Graph 35. Temporal variation in razorbill density (birds/km^2) in the wind farm sites (solid line) and the buffer zone (dotted line) Excludes records with percentage CV greater than 100 (low confidence). In months where two surveys were conducted mean values are displayed. The winter surveys correspond to the three surveys undertaken between November and January.



Graph 36: Number of razorbill recorded in flight in transect during each of the MORL boat-based surveys between April 2010 and March 2012. Blue lines refer to surveys during first year. Green lines refer to surveys during second year. Solid lines refer to records within wind farm sites. Dashed lines refer to records within buffer area. In months where two surveys were conducted mean values are displayed. The winter surveys correspond to the three surveys undertaken between November and January.

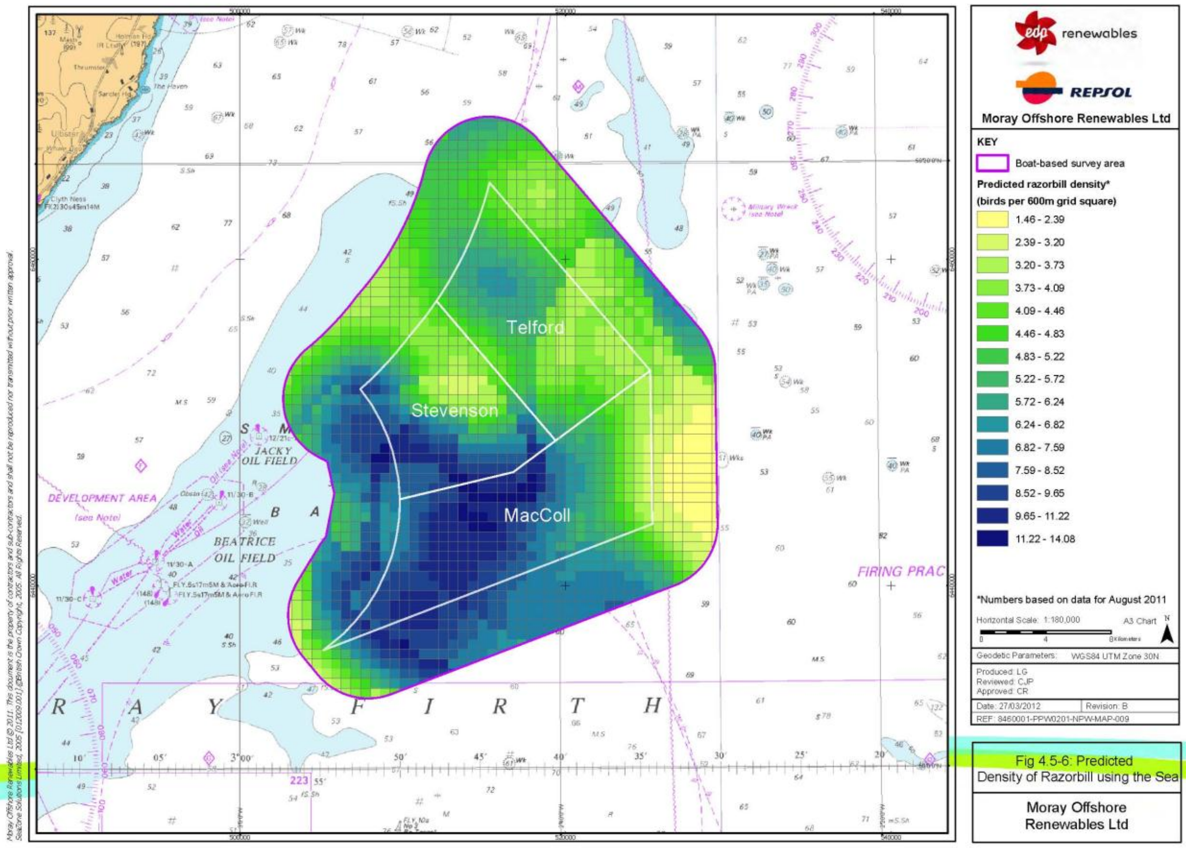


Figure 9: Modelled density surface map for razorbill from August 2011.

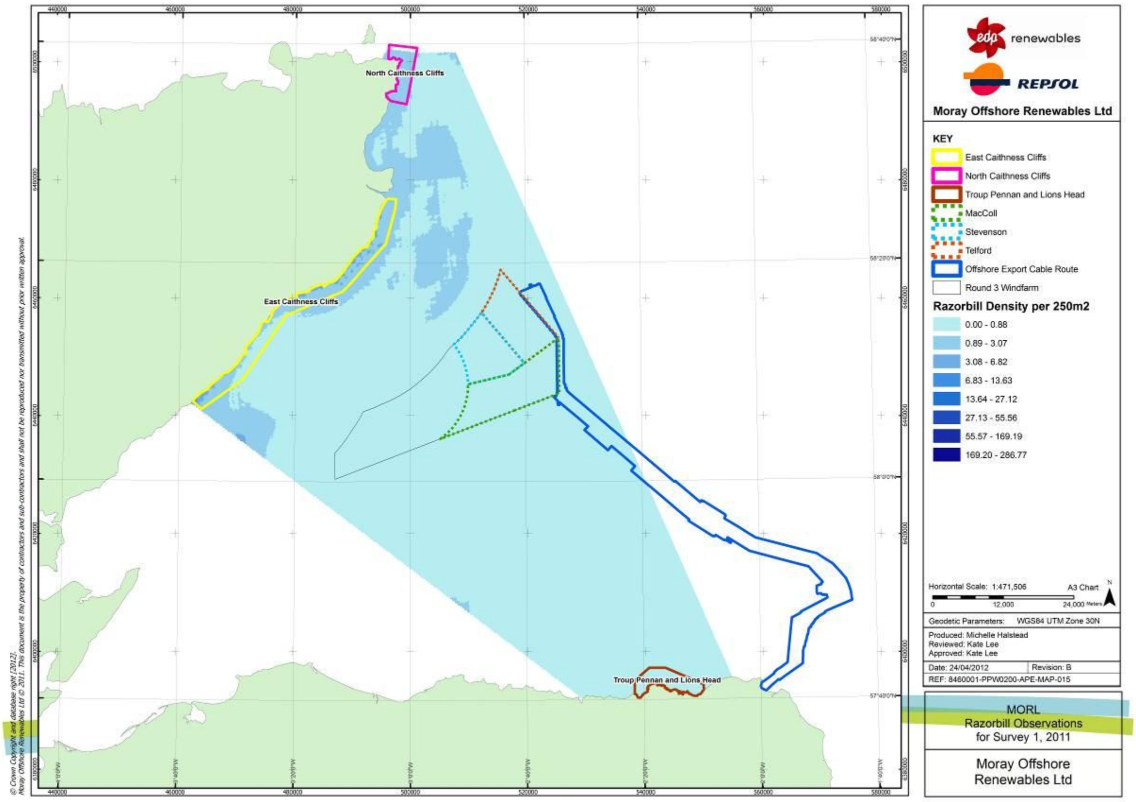


Figure 10a: Distribution of razorbill across the survey area, from digital aerial surveys - Survey 1.

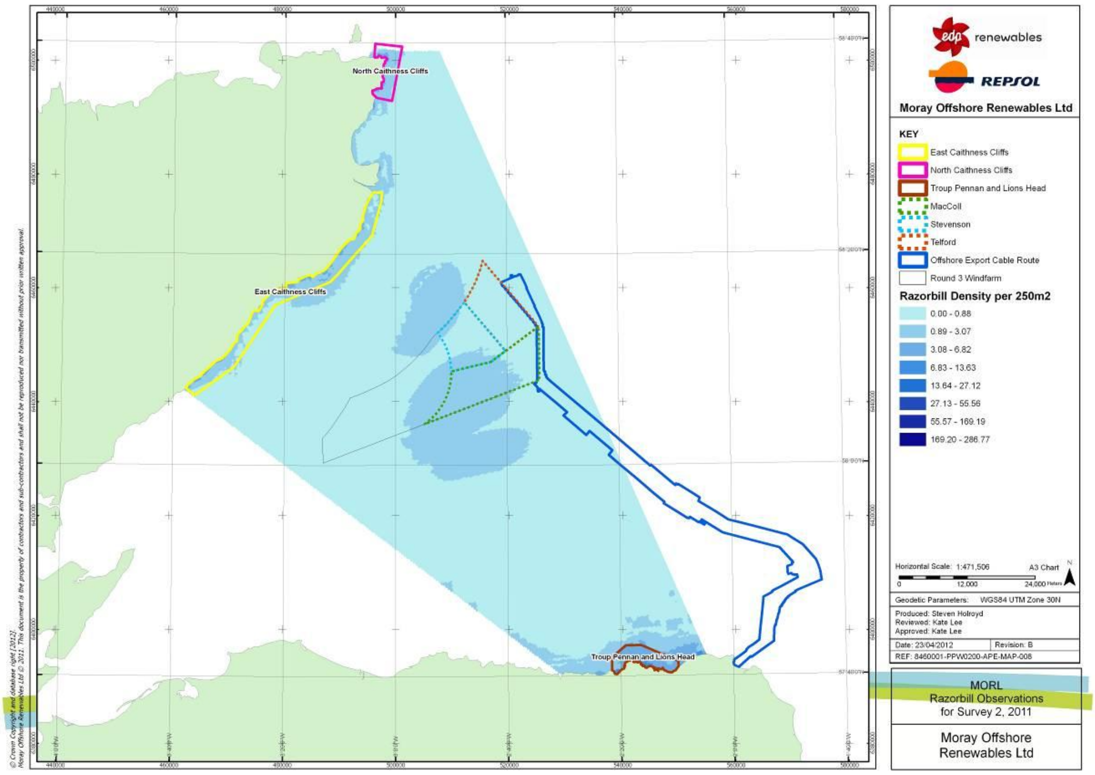


Figure 10b: Distribution of razorbill across the survey area, from digital aerial surveys - Survey 2.

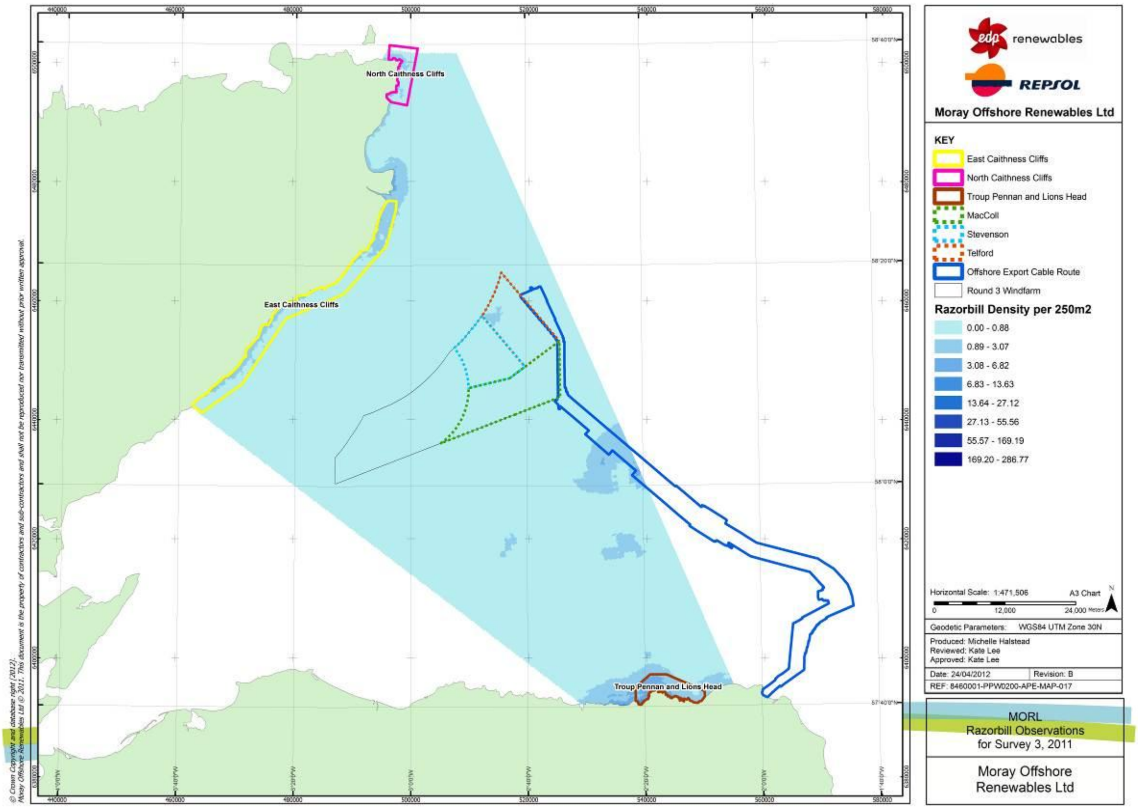


Figure 10c: Distribution of razorbill across the survey area, from digital aerial surveys - Survey 3.

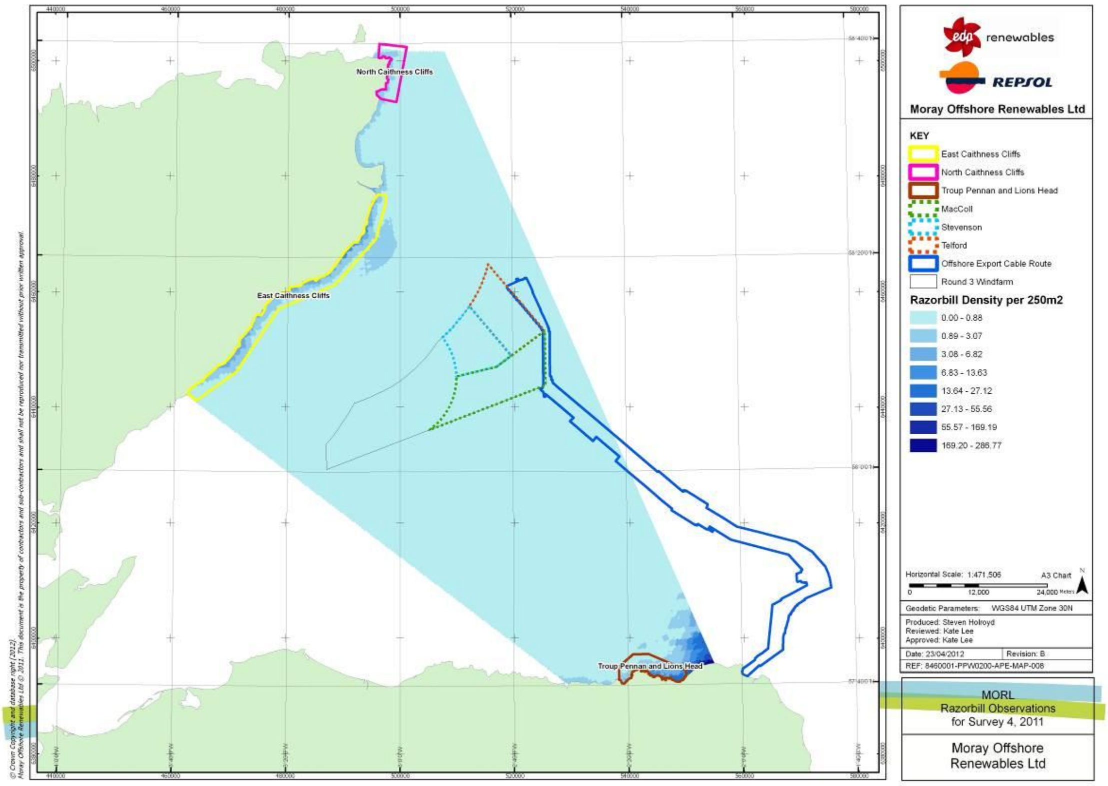


Figure 10d: Distribution of razorbill across the survey area, from digital aerial surveys - Survey 4.

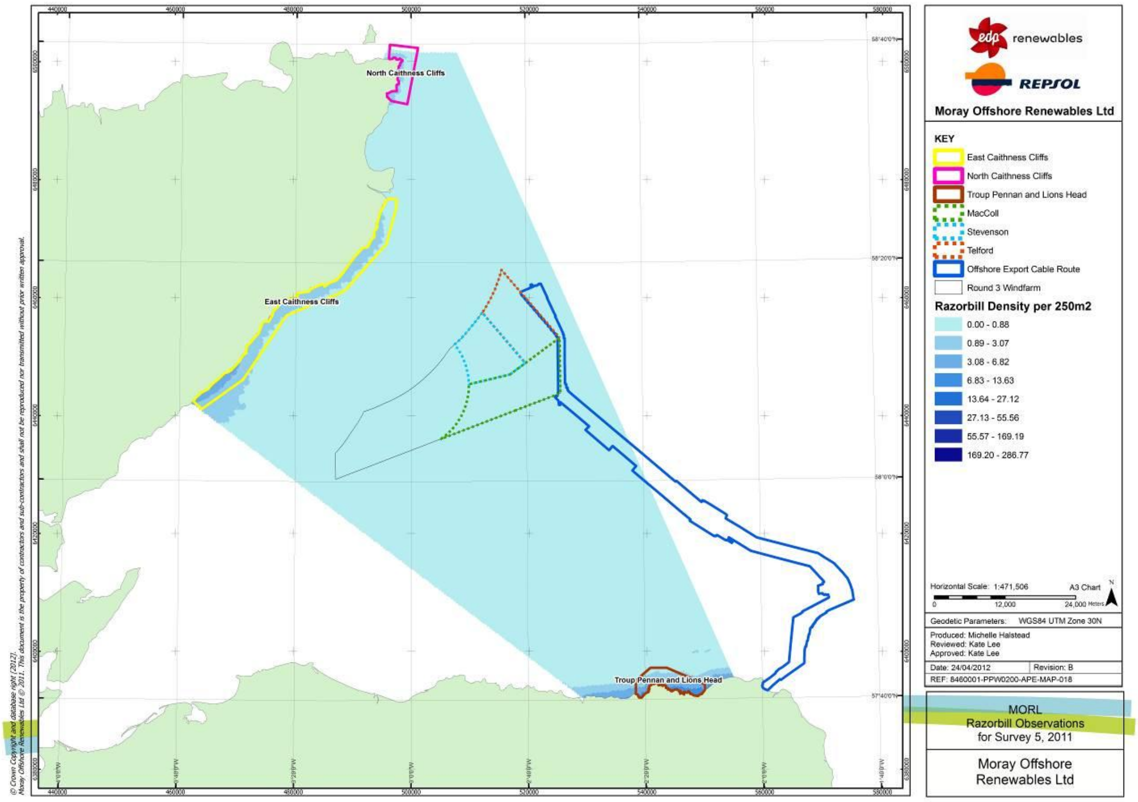


Figure 10e: Distribution of razorbill across the survey area, from digital aerial surveys - Survey 5.

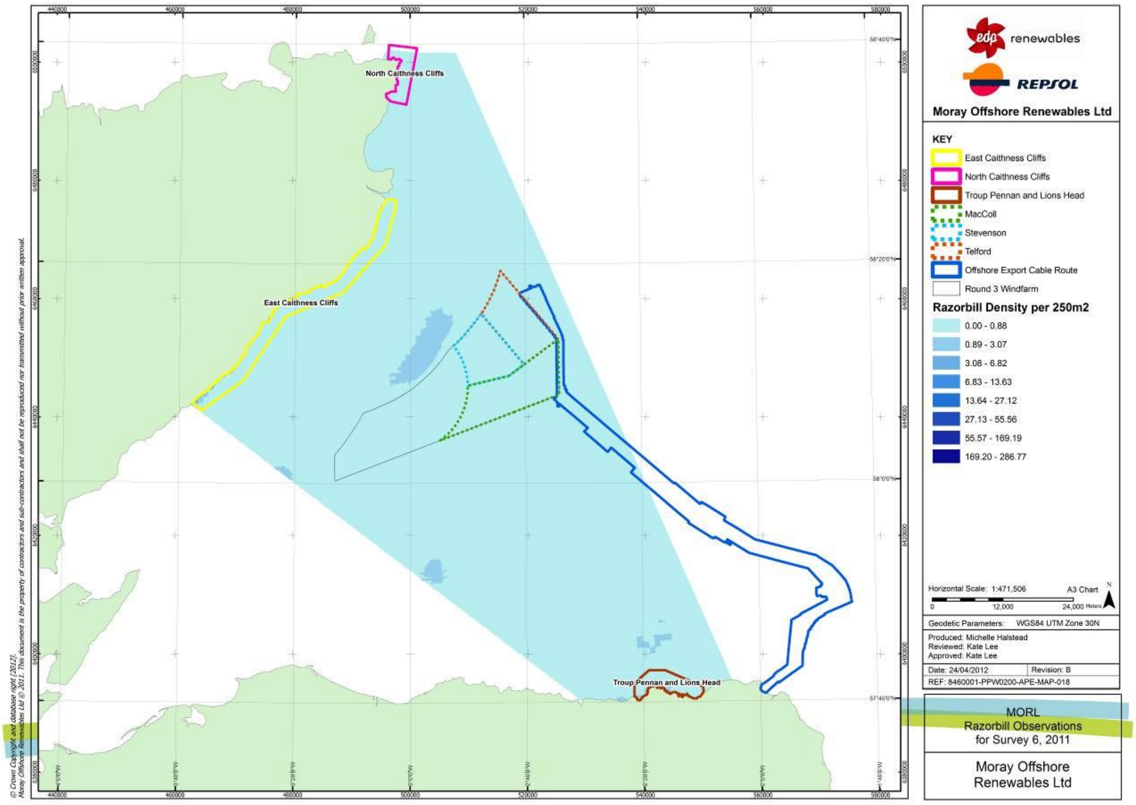
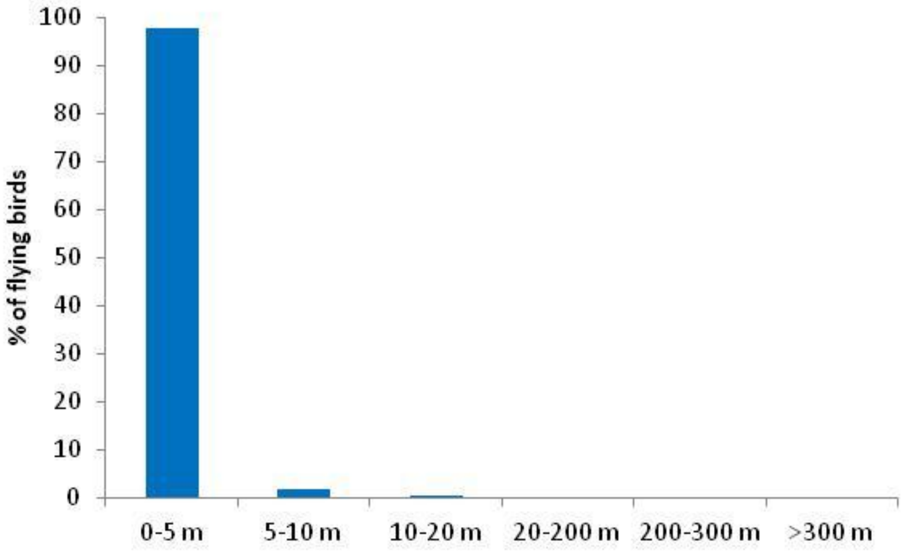


Figure 10f: Distribution of razorbill across the survey area, from digital aerial surveys - Survey 6.

4.23.5 Potential for collision risk

Of 796 razorbills recorded in flight and in transect on boat based surveys, none were observed within the collision risk height (Table 24, Graph 37). Of 3299 razorbills observed at other offshore developments, a proportion of 0.04 were recorded within the collision risk height, with the range varying between 0 and 4% (Cook *et al*., 2011). Langston (2010) assessed this species as being at low collision risk. In summary it is concluded that collision risk is negligible.



Graph 37: Proportions of razorbill flights recorded in each height band (for birds recorded in transect during April 2010 to March 2012 boat-based surveys).

4.23.6 Potential for disturbance / displacement / indirect effects

The mean densities of razorbill recorded within the three proposed wind farm sites were 6.03 birds/km^2 during the breeding season and 2.64 birds/km^2 during the non-breeding season, equating to abundances across the sites of 1661 and 892 birds respectively (Table 98).

The highest densities of razorbill were recorded within the southern half of the site, with particular concentrations in central and southern MacColl, central Stevenson, northern Telford, and western parts of the buffer zone.

Razorbill have a medium sensitivity to ship and helicopter disturbance (Table 20; based on Garthe and Huppop, 2004).

Various offshore developments have recorded evidence of strong avoidance, e.g.

Garthe and Huppop, (2004) and Dierschke and Garthe (2005). Other studies however, such as Degraer and Brabant (2009) have shown that densities have remained constant (relative to controls) during the first year of construction, inferring minimal levels of displacement.

Analysis of data collected from Robin Rigg offshore wind farm in the Solway Firth, comparing the construction and post-construction years with five pre-construction years, found a 30% reduction in auk numbers using the site (Shenton & Walls, pers. comm.).

The 'WCS' displacement analysis (100% displacement) predicted 899 individuals to be displaced from the three proposed wind farm sites. The 'RS' analysis, using a 50% displacement rate, predicted 415 individuals to be displaced from the three sites (Tables 44 and 45).

4.23.7 Potential for barrier effects

A maximum foraging range of 137 km (although from an incomplete track), with a mean of 30.3 km was recorded for razorbill breeding on the East Caithness Cliffs SPA. However, given the location of hotspots for this species within the Moray Firth, barrier effects are expected to be minor.

4.23.8 Key risks

Table 99. Potential effects for razorbill.

Risk	Threat to species	Justification
Barrier effects	Minor	Moray Firth – scale aerial surveys show hotspots occur outwith the three proposed wind farm sites.
Collision	Negligible	Consistently low flight height. Proportion flying at collision risk height of 0%. Assessed as low risk by Langston (2010).
Displacement and Disturbance	Minor	Displacement of 415 individuals during the breeding season (RS). Moray Firth – scale aerial surveys show hotspots occur outwith the three proposed wind farm sites.

4.24 Black guillemot

Black guillemot is a locally common breeding and wintering species around the Scottish coast, with a strong north and west distribution bias. The nearest major populations of this species to the three proposed wind farm sites are in East Caithness (1104 individuals), and Orkney (5820 individuals), with very small numbers elsewhere around the Moray Firth coast (total 40 individuals in East Ross and Cromarty, Moray, Banff and Buchan) (1998-2002; Mitchell *et al*., 2004).

Scottish black guillemot are comparatively sedentary, generally remaining close to their breeding sites in the winter, and recruiting into breeding populations near their natal site (Ewins, 1988). Black guillemot are benthic feeders, predominantly in inshore waters where they predate a wide variety of fish and invertebrate species (Ewins, 1990). For these reasons, within most of this species Scottish range, the number of birds making foraging and migratory movements over far offshore areas is likely to be small.

Only four black guillemot were recorded, singles in June and August 2010 (using the sea) and singles in October 2010 and November 2011 (in flight). Due to the low numbers records it is considered that risks of all potential impacts are negligible.

4.25 Little auk

Little auk breed in high Arctic regions, particularly on the Arctic islands of northern Canada and Russia, plus in Greenland, and in Norwegian Arctic territories (Spitsbergen etc.). The global population is estimated to be between 16 and 36 million mature individuals (Birdlife International), of which up to approximately 6% may winter in the North Sea.

Small but highly variable numbers of little auk are present around the UK each winter. There is a northerly and easterly bias to their distribution (Image 40: taken from Forrester *et al*., 2007), with the species generally remaining far from land unless driven into coastal waters by strong onshore winds. Up to one million little auks are estimated to winter in the North Sea (Stone *et al*., 1995), but what proportion of this population enters into UK waters is unclear. JNCC analysis of ESAS data collected between 1980 and 2006, to provide at-sea distributions of little auks during the winter period, is shown in Image 41 (Kober *et al*., 2010).

Image 40: Winter distribution of little Auk in Scotland. Dark shading = areas where larger numbers occur at higher frequency; pale shading = areas where smaller numbers occur irregularly. Inland records 1864-2004 are indicated. (Taken from Forrester *et al*., 2007)

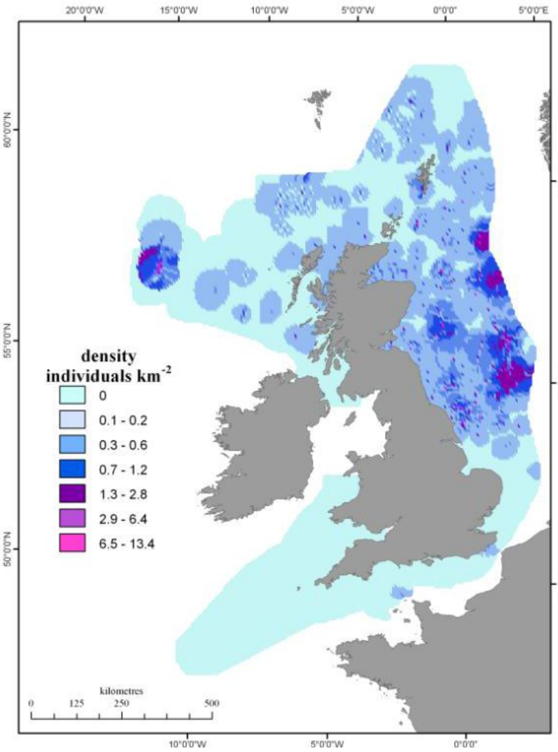


Image 41: JNCC predicted density surface maps for little auk in winter. Produced from ESAS data collected between 1980 and 2006. (taken from Kober *et al*., 2010).

Little auk disperse away from their breeding grounds before the end of August, and around this time undergo their post-breeding moult (Snow and Perrins, 1998). Each winter season the first birds are usually recorded in Britain in October, the last in late February or March (Forrester *et al*., 2007).

4.25.1 Food preferences

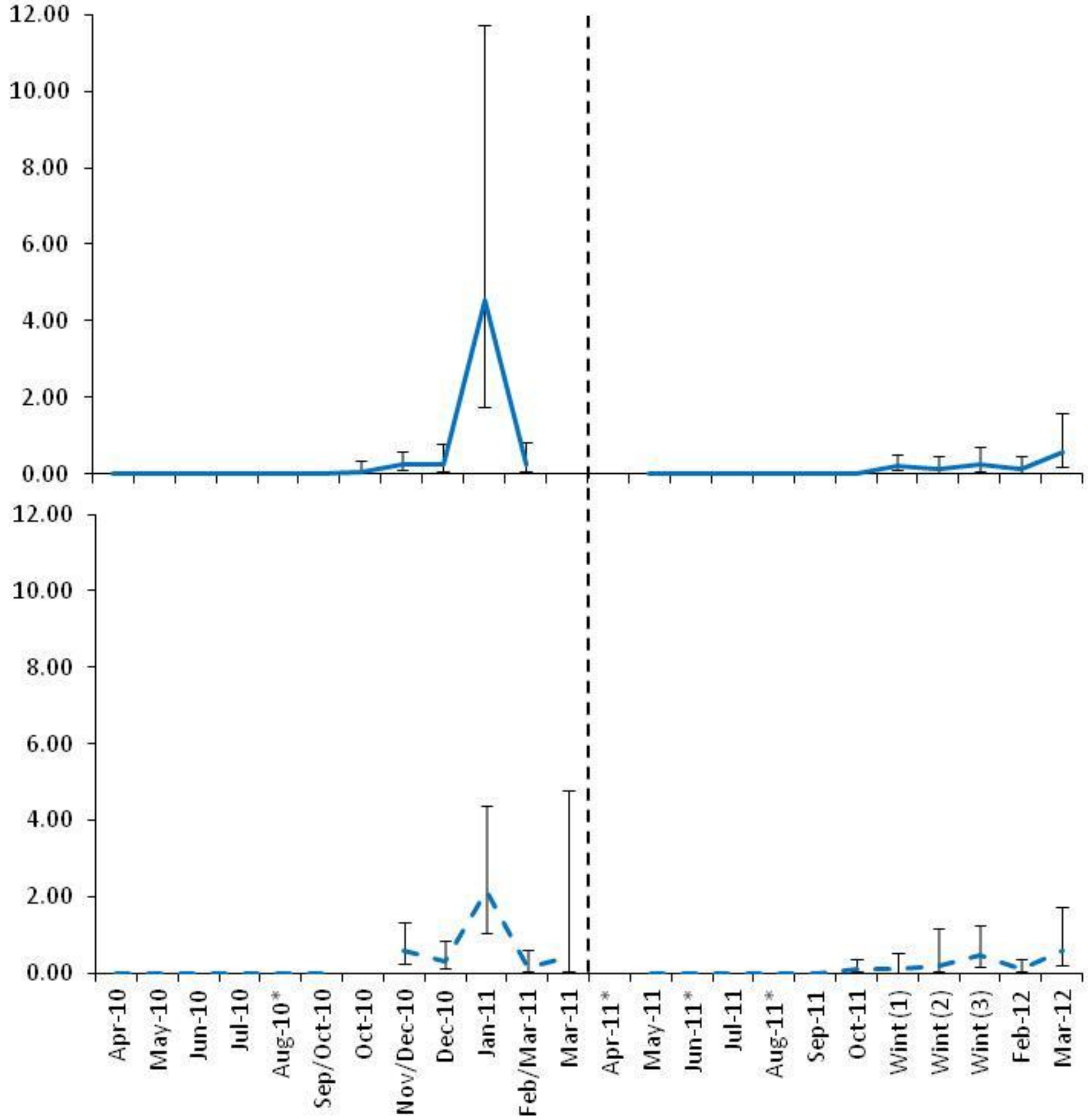
The diet of little auk consists largely of planktonic crustacea , particularly during the breeding season (Pedersen and Falk, 2001; Evans, 1981). Adults are also know to consume small quantities of annelids, molluscs and fish fry (Snow and Perrins, 1998). Prey items are captured by surface diving to mean maximum depths of 26-29 m (Falk *et al.*, 2000).

4.25.2 Abundance and distribution within sites

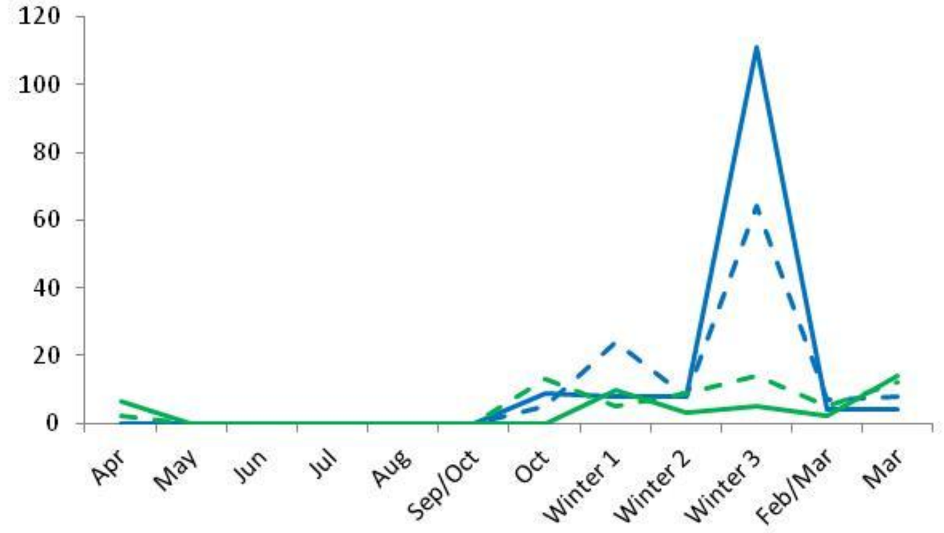
Little auk were recorded during the winter months, between October and April. Densities were highest during the mid-winter period, peaking in January 2011 (4.55 birds/km^2) (Table 39, Graph 38). The peak month for birds recorded using the sea was January 2010, with 130 birds recorded on boat-based surveys (Table 19).

Table 100. Mean density and abundance of little auk on the three proposed wind farm sites and the buffer zone, in the non-breeding season from boat based surveys.

Density		Abundance	
Site	**Buffer**	**Site**	**Buffer**
0.51	0.38	151	136



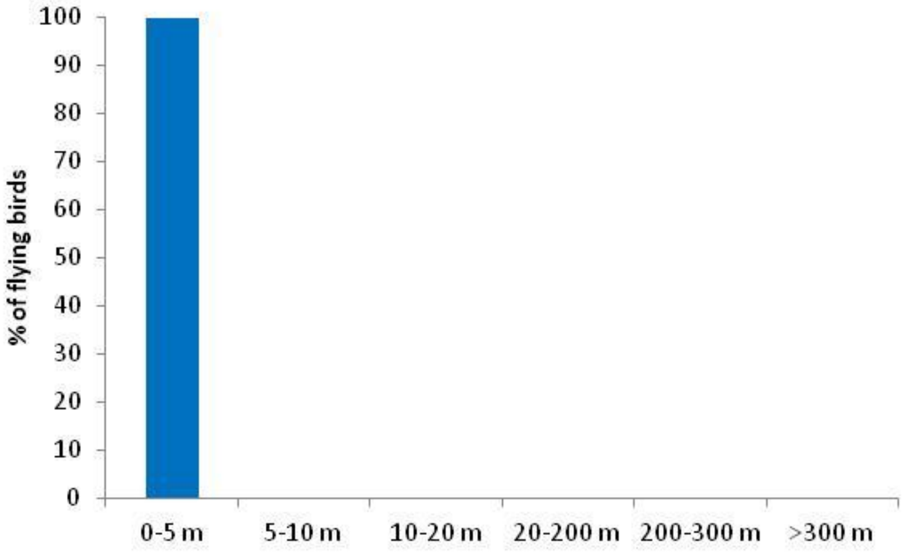
Graph 38. Temporal variation in little auk density (birds/km²) in the wind farm sites (solid line) and the buffer zone (dotted line) Excludes records with percentage CV greater than 100 (low confidence). In months where two surveys were conducted mean values are displayed. The winter surveys correspond to the three surveys undertaken between November and January.



Graph 39: Total number of little auks recorded during each of the MORL boat-based surveys between April 2010 and March 2012 (including birds recorded in flight and using the sea). Blue lines refer to surveys during first year. Green lines refer to surveys during second year. Solid lines refer to records within wind farm sites. Dashed lines refer to records within buffer area. In months where two surveys were conducted mean values are displayed. The winter surveys correspond to the three surveys undertaken between November and January.

4.25.3 Potential for collision risk

Of 33 little auk recorded in flight and in transect, none were observed flying within the collision risk height (Table 24 Graph 40). Little auks recorded at other offshore developments also flew below the collision risk height. Langston (2010) assessed this species as being at low collision risk. Collision risk is therefore considered to be negligible for this species.



Graph 40: Proportions of little auk flights recorded in each height band (for birds recorded in transect during April 2010 to March 2012 boat-based surveys)

4.25.4 Potential for disturbance / displacement / indirect effects

The mean densities of little auk recorded within the three proposed wind farm sites were 0.51 birds/km^2 during the non-breeding season, equating to an abundance estimate across the sites of 151 birds (Table 100).

4.25.5 Potential for barrier effects

Little auk are non-breeding visitors to the Moray Firth. They are adapted to life on the high seas and therefore, any barriers will have little effect on this species or its wintering grounds.

4.25.6 Key risks

Table 101. Potential effects for little auk.

Risk	**Threat to species**	**Justification**
Barrier effects	Negligible	Not present in breeding season.
Collision	Negligible	Assessed as low risk by Langston (2010). All records from wind farm sites below collision risk height. Presumed low flight height, as other auks.
Displacement and Disturbance	Negligible	Not present in breeding season.

4.26 Puffin

Puffin occur in the temperate, boreal and arctic regions across the north Atlantic Ocean. The population of Great Britain and Ireland comprises approximately 9-11% of the global population of between 5.5 million and 6.6 million pairs (Mitchell *et al.*, 2004).

British breeding populations disperse widely in winter, with birds from east coast colonies wintering mainly in the North Sea and birds from west coast colonies wintering mainly in the Atlantic and, to a lesser extent, the western Mediterranean. It is unclear how many puffin winter around the UK as the species is usually widely dispersed, mostly in far offshore waters. At-sea surveys around the Scottish coast have recorded wintering population densities of one individual every 20-50 km^2 (Stone *et al.*, 1995: Pollock *et al.*, 2000).

The breeding population of Atlantic puffin in Great Britain and Ireland is approximately 601,000 breeding pairs (estimated from AOB data, 1998-2002; Mitchell *et al.*, 2004). This species is more common in the north of the UK, and 82% of breeding birds are found in Scotland (Mitchell *et al.*, 2004; Image 42). JNCC analysis of ESAS data, collected between 1980 and 2006, to provide at-sea distributions of puffins during the breeding and winter periods are shown in Images 43a and 43b (Kober *et al.*, 2010).

The population sizes of the surrounding regions of Highland, Grampian and the Northern Isles are shown in Table 102. These areas contain 30% of the Great Britain and Irish puffin population, however most of these breed within the Sule Skerry and Sule Stack SPA to the west of Orkney and approximately 131 km from the three proposed wind farm sites. When this colony is excluded the counties surrounding the Moray Firth contain a very small proportion (<1%) of the British and Irish puffin population, with relatively few puffin breeding in SPAs close to the wind farm sites (Table 103).

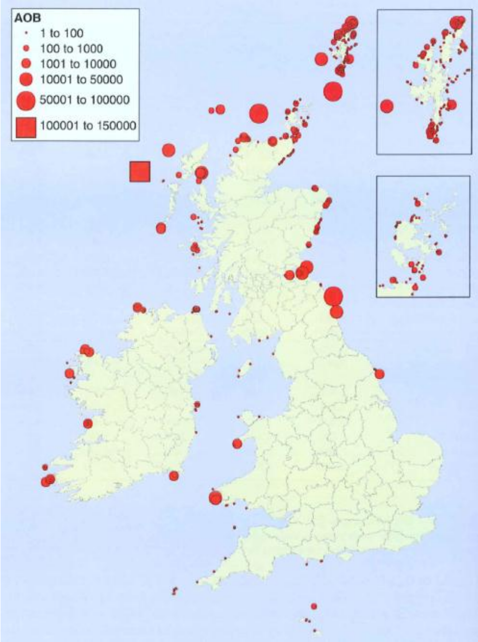


Image 42: Distribution of breeding puffin, 1998-2002 (taken from Mitchell *et al*., 2004).

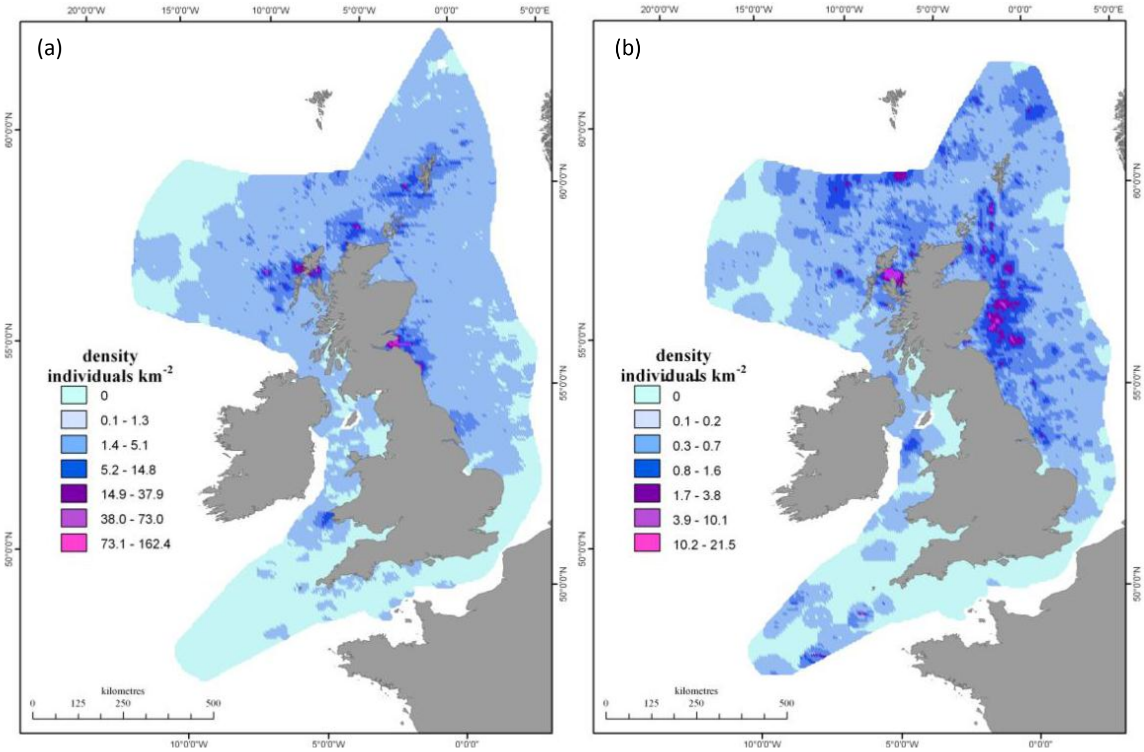


Image 43: JNCC predicted density surface maps produced from ESAS data collected between 1980 and 2006. Left (a): breeding. Right (b): winter (taken from Kober *et al*., 2010).

Table 102: Puffin populations in districts around the Moray Firth (Mitchell *et al*., 2004)

Region	District	Population (AOB[*1])
Northern Isles	Orkney	61,758[*2]
Highland	Caithness	1,278

Table 102: Puffin populations in districts around the Moray Firth (Mitchell *et al.*, 2004)

Region	District	Population (AOB*1)
Grampian	Banff & Buchan	1,026
TOTAL		64,062

*1AOB – Apparently Occupied Burrows, *2 59,471 AOB within Sule Skerry and Sule Stack SPA (131 km from the three wind farm sites).

Table 103: SPAs surrounding the three proposed wind farm sites which are designated for puffin

Colony	Location	Colony size	Distance from wind farm sites	Count Date
East Caithness Cliffs	Caithness	1,750 pair	20 km	1985-1988*1
North Caithness Cliffs	Caithness	1,750 pair	33 km	1985-1988*1
Hoy	Orkney	3,500 pair	58 km	1985-1988*1

*1 Seabird Colony Register Census

4.26.1 Annual cycle

On the east coast of Scotland puffin typically first return to their breeding colonies between late February and early March (Forrester *et al.*, 2007). Egg laying occurs from early April onwards, each female laying a single egg, which hatches after 36 to 45 days. Both parents feed the nestling, which usually fledges after 34 to 60 days, though fledging periods are occasionally lengthened, up to a maximum of about 55 days, in response to low prey availability (Snow and Perrins, 1998). Unlike guillemot and razorbill, puffin fledglings are able to fly when they leave their natal colonies, and are independent of their parents after doing so. Puffin from colonies in the east of Scotland therefore fledge from the end of June onwards, with parents usually remaining at the colony for several weeks after their nestling has departed (Forrester *et al.*, 2007). The breeding period at west coast colonies is usually 2-3 weeks later, with most young fledging in mid August (Harris, 1982 & 1985). Puffin undergo a complete moult in late winter before returning to their breeding colonies, during this time they are incapable of flying (Harris and Yule, 1977).

4.26.2 Food preferences

Puffin are visual pursuit hunters which predate a wide range of small fish species and the juveniles of some larger fish species. Puffin diet is well documented during the breeding season (Corkhill, 1973), with most data collected from a few widely separated breeding colonies. As diet varies from site to site, and given the small number of sites monitored, caution should be used in drawing wider geographical conclusions from these data. Dietary composition has also been observed to vary dramatically between years (Martin, 1989).

The most commonly taken prey species during the breeding season is lesser sandeel, with a large number of other fish species forming smaller proportions of the diet. For most of the Scottish colonies where puffin diet has been studied, sandeels make up the majority of prey items taken in most years, often the vast majority (Harris and Riddiford, 1989; Harris and Wanless, 1986; Hislop and Harris 1985; Martin, 1989). In seasons or areas where sandeels are less abundant, other prey species may make up considerable proportions of puffin diet; most notably sprat, capelin, rockling and herring. In recent years snake pipefish have become much more common in UK waters, and these too have been incorporated into puffin diet when key prey species are unavailable. Due to their low energy content compared to sandeels and other important seabird prey species, the increased consumption of snake pipefish has been linked with observed declines in the breeding productivity of several seabird species, including puffin (Harris *et al*., 2007 a & b).

One study of the winter diet of puffin near the Faroe Isles found differences between the diets of birds wintering far offshore and those wintering nearer inshore, though both consumed significant amounts of invertebrates (Falk *et al*., 1992). Offshore birds consumed squid and glacier lanternfish, while inshore birds predated krill and a wide range of small fish species.

Atlantic puffin are capable of diving to 60 m, although they usually forage at depths less than 30 m (Piatt and Nettleship, 1985; Burger and Simpson, 1986).

4.26.3 Foraging distances

There are relatively few studies of puffin foraging ranges during the breeding season, and at present, no information is available from studies using satellite trackers. The foraging ranges of three chick-rearing puffin from the Isle of May colony have been investigated by radio-tracking (Wanless *et al*., 1990) and for most foraging flights (9 of 14) the bird moved less than 2 km from the breeding colony. On one tracked flight a bird travelled between 2 and 10 km to forage, while on the other four flights birds went distances greater than 10 km.

The majority of information on puffin foraging distances comes from boat-based transect surveys. Such surveys around the Isle of May have found the highest concentrations of puffin close to the colony, with groups also occurring 35 km away at the Wee Bankie (Tasker *et al*., 1987; Wanless *et al*., 1998). Boat-based surveys around the colony at Flamborough Head suggest that foraging ranges may vary throughout the day (Webb *et al*., 1985), with peak puffin densities recorded 26-28 km from the colony in the morning and 6-8 km and 40 km later. Foraging ranges may also vary through the breeding season; a study from Coquet Island found that, while birds generally feed up to 20-25 km offshore, in July they forage closer inshore than in June (Breakwell *et al.*, 1996). Transect surveys around St Kilda recorded maximum foraging distances of 40 km away (Leaper *et al.*, 1988). Surveys around the Pembrokeshire Islands in 1990 and 1992 recorded birds within 35-40 km of the colonies (Stone *et al.*, 1992).

During a study in Norway when prey stocks were low near a breeding colony puffin were observed foraging at least 137 km away (Anker-Nilssen and Lorentsen, 1990).
Taking a conservative approach due to the inferential nature of much of the above information about the foraging range of this species, a summary is provided below of potential connectivity between puffin colonies and the development of the three proposed wind farm sites:
The majority of puffins recorded from the boat-based survey area are likely to be from the colonies within the North and East Caithness Cliffs SPAs, which are well within a 40 km range of the wind farm sites. During years in which stocks of fish prey species are low puffin may forage within the sites from colonies further afield, possibly from those in Orkney.

Birdlife International data on foraging distances for puffin shows a maximum foraging distance of 200 km, a mean maximum of 62.2 km, and a mean foraging distance of 30.35 km.

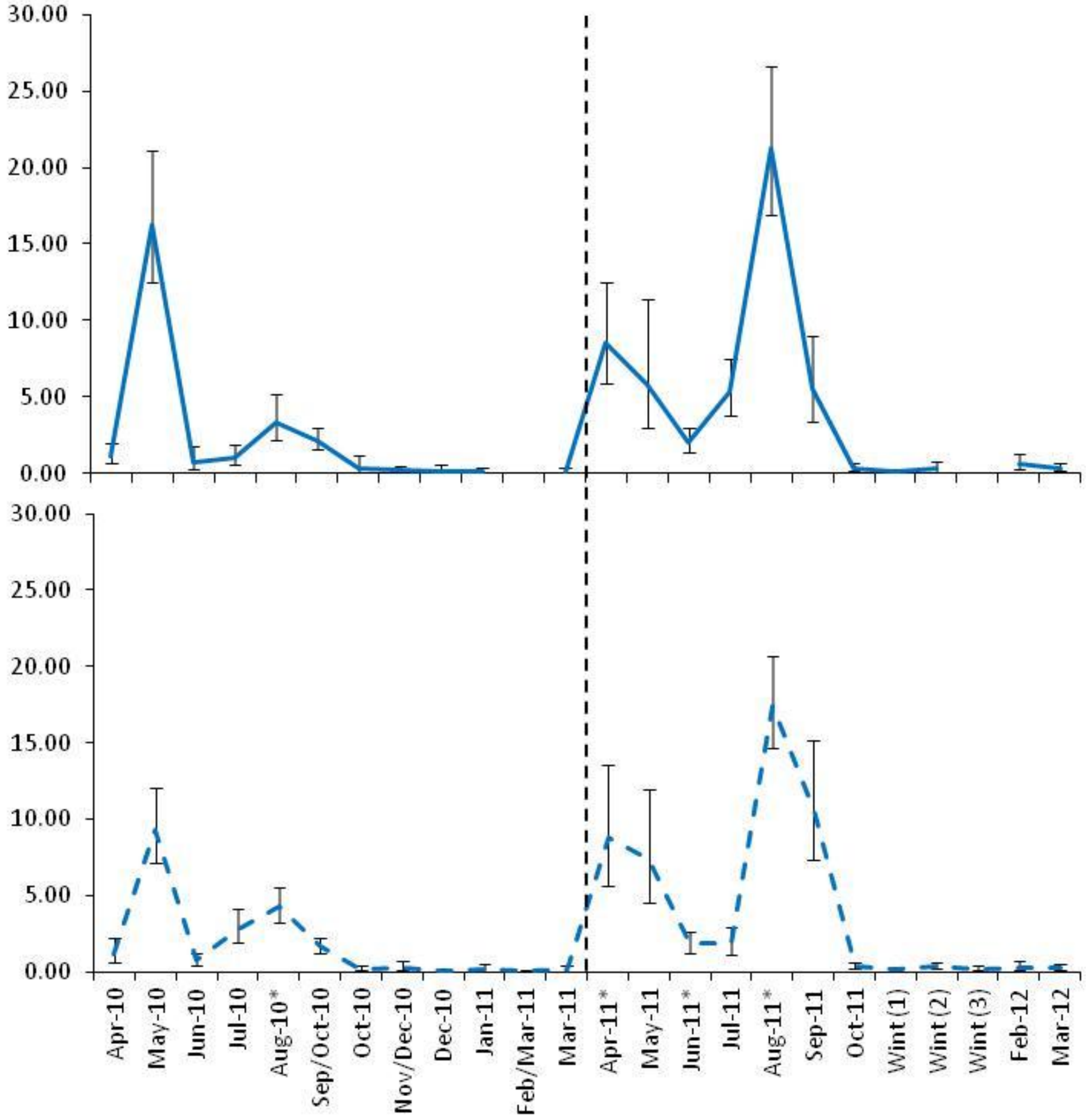
4.26.4 Abundance and distribution within sites

Puffin were recorded in all months of the survey. Densities were highest in spring and summer, peaking in May 2010 (16.22 birds/km^2) and August 2011 (21.22 birds/km^2) (Table 38, Graph 41). The peak month for birds recorded using the sea was August 2011, with 2396 birds recorded on boat-based surveys (Table 21). Annual variation in numbers recorded in flight is shown in Graph 42. Distribution maps for the species are shown in Figures 11 and 12.

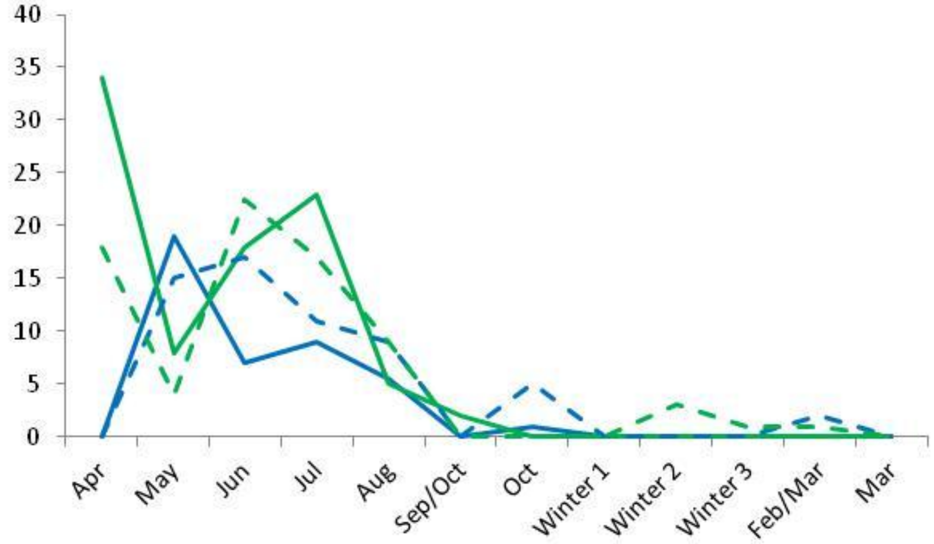
No flights were recorded at potential collision height.

Table 104. Mean density and abundance of puffin on the site and the buffer zone, in the breeding and non-breeding season from boat-based surveys

Breeding Season				Non-breeding season			
Density		Abundance		Density		Abundance	
Site	Buffer	Site	Buffer	Site	Buffer	Site	Buffer
6.55	5.55	1916	1971	0.75	1.05	450	463



Graph 41. Temporal variation in puffin density (birds/km²) in the wind farm sites (solid line) and the buffer zone (dotted line) Excludes records with percentage CV greater than 100 (low confidence). In months where two surveys were conducted mean values are displayed. The winter surveys correspond to the three surveys undertaken between November and January.



Graph 42: Number of puffin recorded in flight in transect during each of the MORL boat-based surveys between April 2010 and March 2012. Blue lines refer to surveys during first year. Green lines refer to surveys during second year. Solid lines refer to records within the three sites. Dashed lines refer to records within buffer area. In months where two surveys were conducted mean values are displayed. The winter surveys correspond to the three surveys undertaken between November and January.

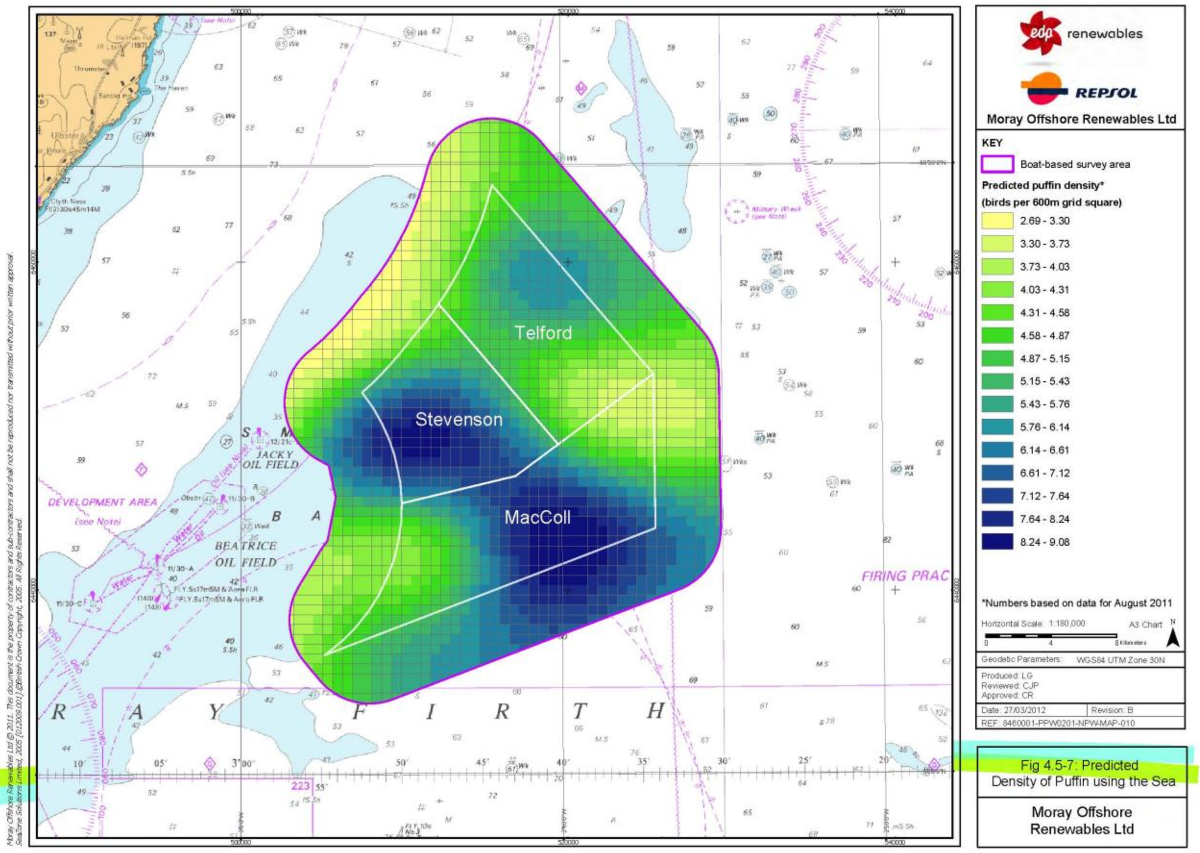


Figure 11: Modelled density surface map for puffin from August 2011.

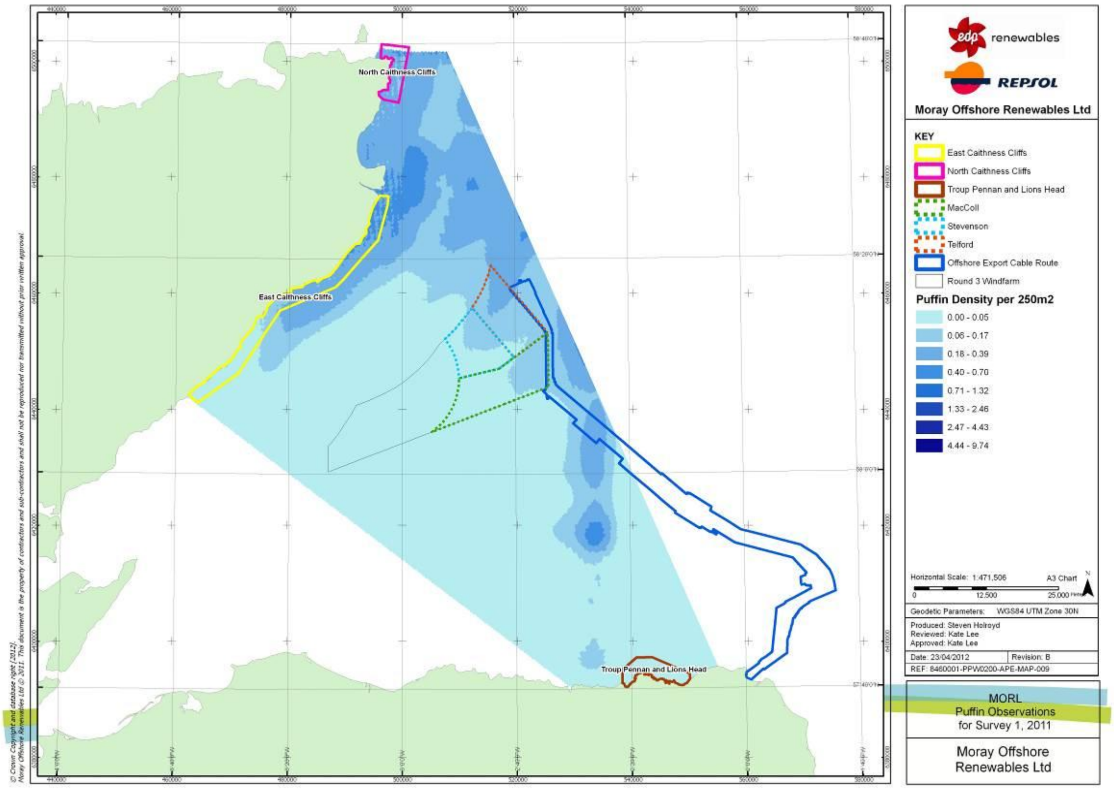


Figure 12a: Distribution of puffin across the survey area, from digital aerial surveys - Survey 1.

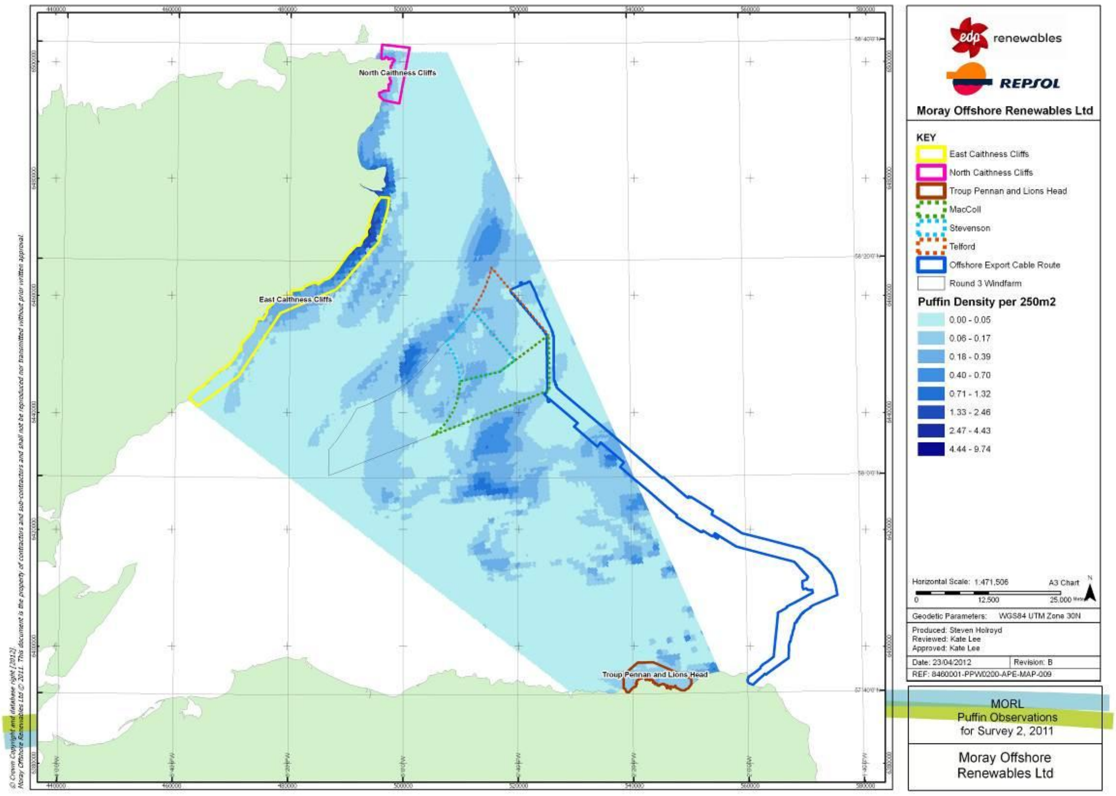


Figure 12b: Distribution of puffin across the survey area, from digital aerial surveys - Survey 2.

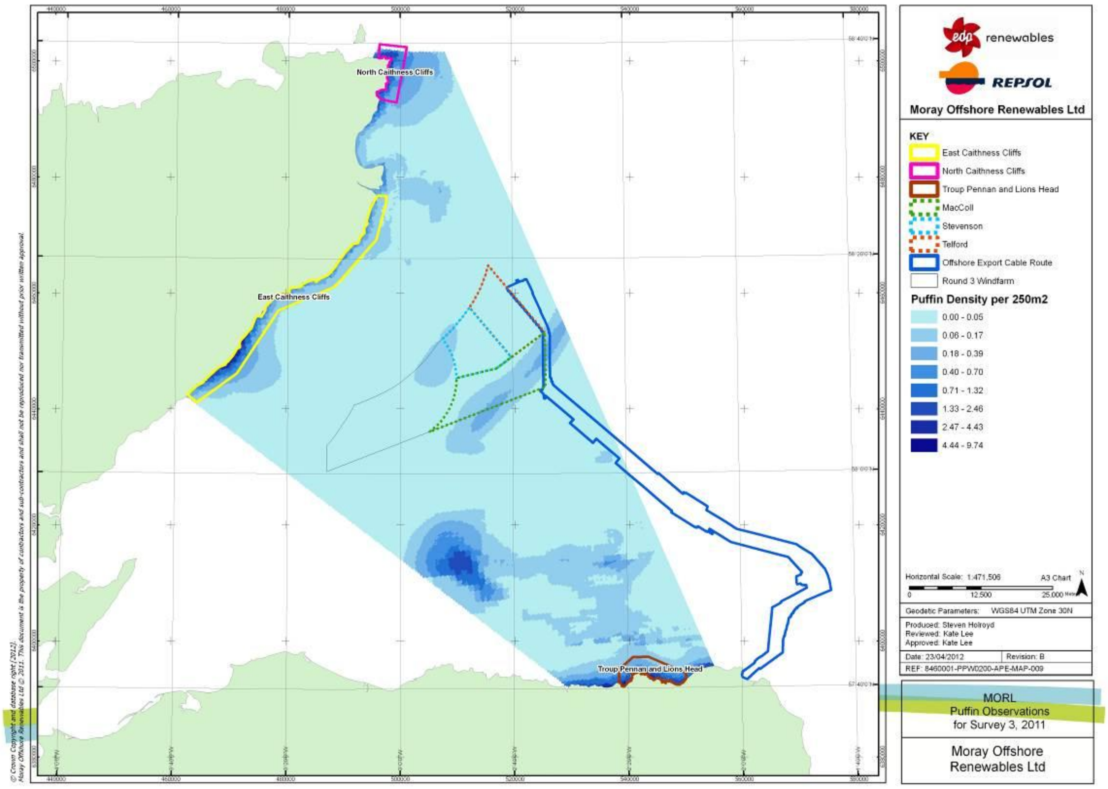


Figure 12c: Distribution of puffin across the survey area, from digital aerial surveys - Survey 3.

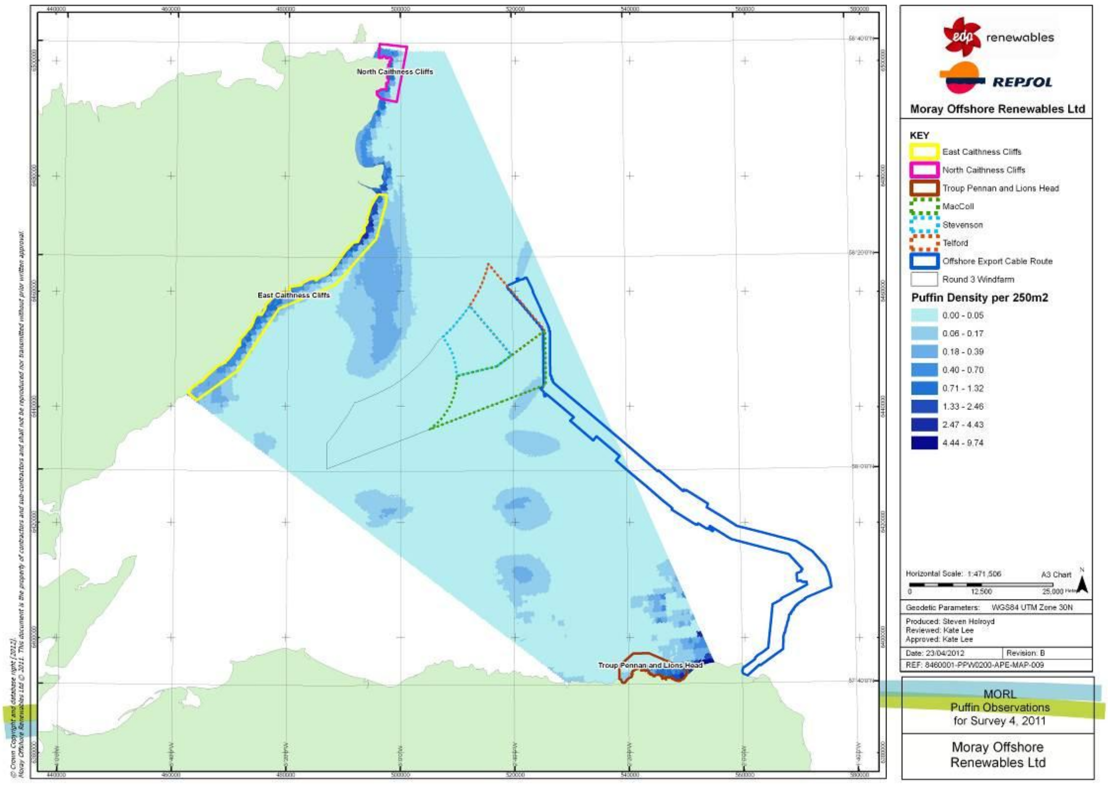


Figure 12d: Distribution of puffin across the survey area, from digital aerial surveys - Survey 4.

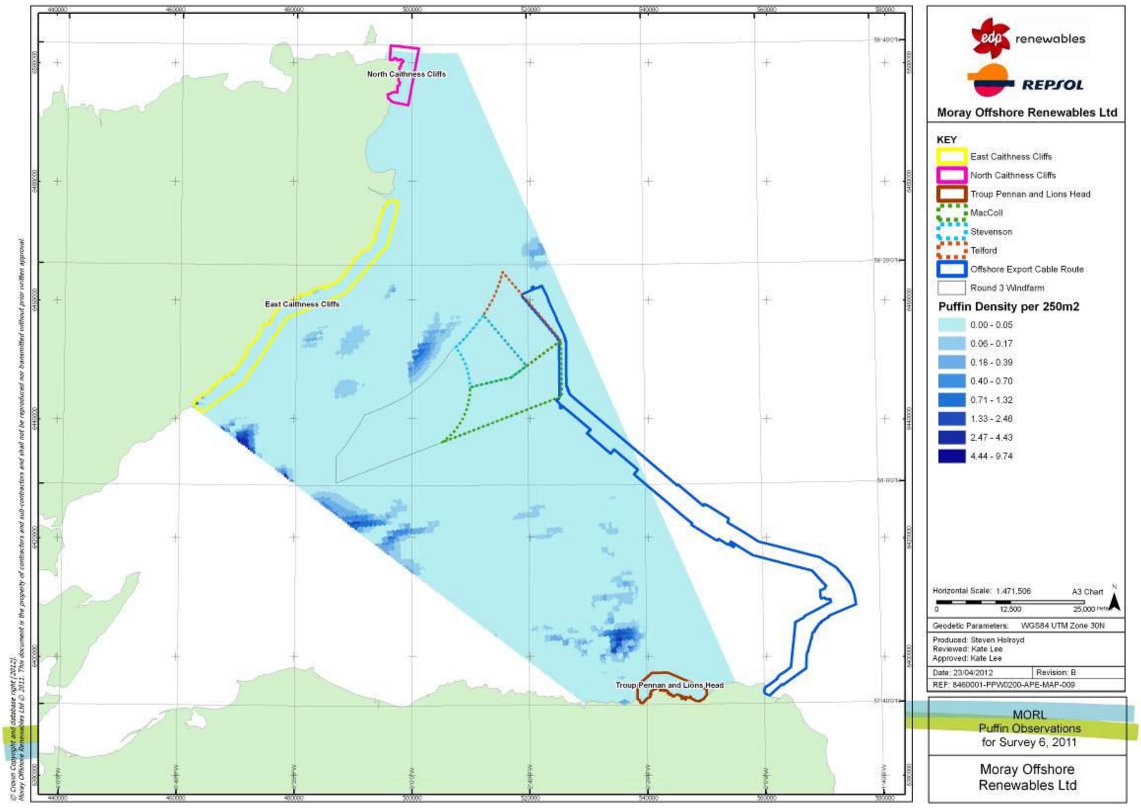
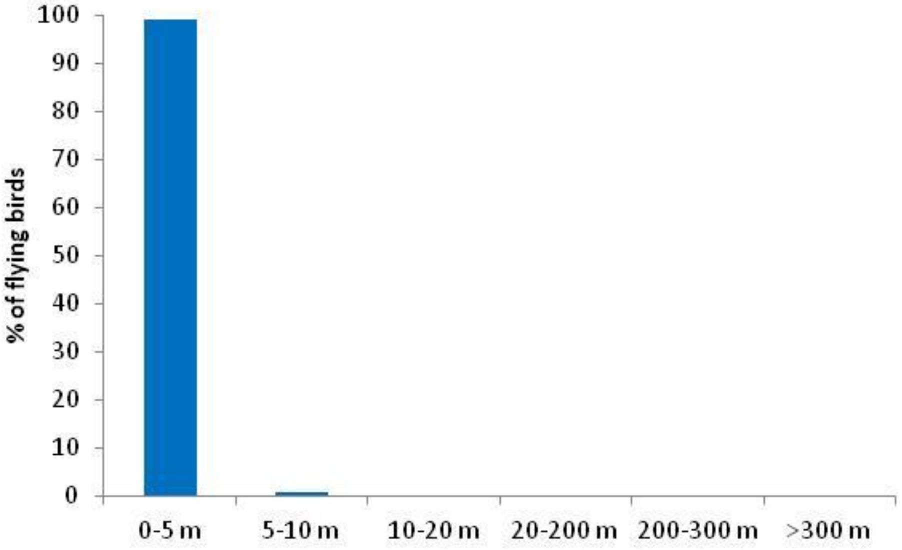


Figure 12e: Distribution of puffin across the survey area, from digital aerial surveys - Survey 6.

4.26.5 Potential for collision risk

Of 397 puffin recorded in flight and in transect, all were observed below the collision risk height (Table 24 Graph 43). Data from other offshore developments suggest that 0% of puffins were recorded within the collision risk height. Langston (2010) assessed this species as being at low collision risk. Collision risk is therefore considered to be negligible for this species.



Graph 43: Proportions of puffin flights recorded in each height band (for birds recorded in transect during April 2010 to March 2012 boat-based surveys).

4.26.6 Potential for disturbance / displacement / indirect effects

The mean densities of puffin recorded within the three proposed wind farm sites were 6.55 birds/km^2 during the breeding season and 0.75 birds/km^2 during the non-breeding season, equating to abundances across the sites of 1916 and 450 birds respectively (Table 104).

The highest densities of puffin within the survey area were recorded in the central and south-eastern parts of the site, with concentrations in the buffer zone in the south-east. There was also a smaller concentration in the centre of Telford (see Figure 4.5-7, Volume 6b and Table 4.5-7 in Baseline Chapter 4.5).

Puffin have a medium sensitivity to ship and helicopter disturbance (Table 20; based on Garthe and Huppop, 2004).

Analysis of data collected from Robin Rigg offshore wind farm in the Solway Firth, comparing the construction and post-construction years with five pre-construction years, found a 30% reduction in auk numbers using the site (Shenton & Walls, pers. comm.).

The ‘WCS’ displacement analysis (100% displacement) predicted 958 individuals to be displaced from the three proposed wind farm sites. The ‘RS’ analysis, using a 50% displacement rate, predicted 479 individuals to be displaced from the three sites (Tables 44 and 45).

4.26.7 Potential for barrier effects

A maximum foraging range of 137 km (although this was exceptional as it was recorded during a period of food shortage) has been observed for this species. Other studies have returned a range of foraging distances within 40 km. Foraging trips are relatively short and infrequent and as such, barrier effects may not have a substantial impact. Also, given the location of hotspots for this species within the Moray Firth, barrier effects are expected to be minor.

4.26.8 Key risks

Table 105. Potential effects for puffin.

Risk	Threat to species	Justification
Barrier effects	Minor	Moray Firth – scale aerial surveys show hotspots occur outwith the three proposed wind farm sites. Relatively infrequent foraging flights.
Collision	Negligible	All birds on site recorded below collision risk height. Assessed as low risk by Langston (2010). Proportion of 0 at collision risk height from other studies.
Displacement and Disturbance	Minor	Relatively infrequent foraging flights. Displacement of 287-958 individuals during the breeding season.

5 Species Accounts - Migrant Birds

The following migratory species accounts outline the population and conservation status of each of the species covered, the likelihood of their occurrence within the three proposed wind farm sites, and the potential risks of the development posed to each of them. All of the migratory species featured on the long list were considered originally, but only those deemed likely to pass through the wind farm sites more frequently are given full treatment. See Table 106 for a breakdown of which species were considered for fuller treatment and which ones were not. A table outlining the threats posed, along with the level of risk, is given for each group.

Information on flight heights and avoidance rates is taken from Cook *et al*. (2011). This is a review undertaken by the BTO (British Trust of Ornithology) for SOSS. Additional information on sensitivity to different wind farm-related impacts is provided by another review undertaken by the BTO (MacLean *et al*., 2009).

Table 106. Migrant birds regular in the vicinity of the three proposed wind farm sites.

Species group	**Larger movements**	**Smaller movements**
Geese and Swans	Whooper swan, pink-footed goose, greylag goose	Mute swan, barnacle goose
Ducks, Divers and Grebes	Mallard, teal, wigeon, tufted duck, eider, common scoter, velvet scoter, long-tailed duck, goldeneye, red-breasted merganser, great northern diver, red-throated diver	Pintail, gadwall, shoveler, pochard, scaup, black-throated diver, great crested grebe, Slavonian grebe
Waders	Oystercatcher, ringed plover, grey plover, golden plover, lapwing, knot, sanderling, purple sandpiper, turnstone, dunlin, common sandpiper, redshank, black-tailed godwit, bar-tailed godwit, curlew, whimbrel, snipe, woodcock	Dotterel, curlew sandpiper, little stint, wood sandpiper, green sandpiper, greenshank, spotted redshank, jack snipe, grey phalarope, red-necked phalarope, ruff
Raptors and Owls		Osprey, marsh harrier, sparrowhawk, kestrel, peregrine, merlin, long-eared owl, short-eared owl
Neopasserines		Woodpigeon, collared dove, cuckoo, swift

Table 106. Migrant birds regular in the vicinity of the three proposed wind farm sites.

Species group	Larger movements	Smaller movements
Passerines	Skylark, sand martin, house martin, swallow, meadow pipit, white wagtail, waxwing, robin, wheatear, song thrush, redwing, fieldfare, blackbird, blackcap, willow warbler, chiffchaff, goldcrest, starling, chaffinch, brambling, siskin	Rock pipit, tree pipit, redstart, whinchat, mistle thrush, ring ouzel, whitethroat, sedge warbler, grasshopper warbler, spotted flycatcher, pied flycatcher, redpoll, snow bunting, common crossbill, crow, jackdaw

5.1 Geese and Swans

Whooper swans and two species of geese were recorded in the three proposed wind farm sites. Pink-footed goose and greylag goose were recorded passing through in both spring and autumn, with peak numbers of each being recorded in April. Unidentified geese were also recorded in March, April, October and December, also peaking in April.

The following species of geese and swans are expected to pass through the wind farm sites.

5.1.1 Whooper swan

The majority of whooper swans arrive into the UK in autumn between mid-October to mid-November, whilst the majority of departures from the UK in the spring take place in March and April (Robinson *et al*., 2004).

Dedicated research has been undertaken in relation to whooper swan migration and wind farms in the UK by the Wildfowl & Wetlands Trust (WWT). Satellite tracking technology was used to track whooper swans from their UK wintering grounds back to their breeding grounds in Iceland (Griffin *et al.*, 2009) specifically to look at their migration routes in relation to proposed offshore wind farms in the UK.

Whooper swans wintering in western England and south-western Scotland followed the west coast and birds wintering in south-eastern England followed the east coast. As the birds got further from their wintering grounds the width of the migration front increased, but there was little overlap in the two migratory paths until the swans were less than 100 km from the north-west coast of Scotland (Image 44). It was shown that birds avoid passing over high ground, which may explain why birds follow coastal routes. Therefore, as might be expected, the tracked swans from Welney (Cambridgeshire) arrived into Moray & Nairn and Aberdeenshire as part of their migration north and from here continued either across or around the Moray Firth to progress north-west (Image 45).

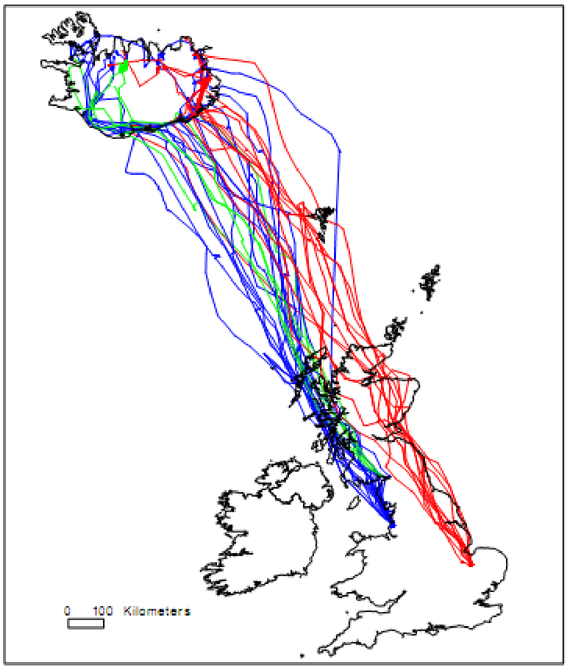


Image 44. Migration routes of 35 satellite-tagged whooper swans from the UK to Iceland in March-May 2009 from: Welney, Norfolk (red lines); Martin Mere, Lancashire (blue lines); and Caerlaverock, Dumfries & Galloway (green lines).Taken from Griffin *et al*., 2009.

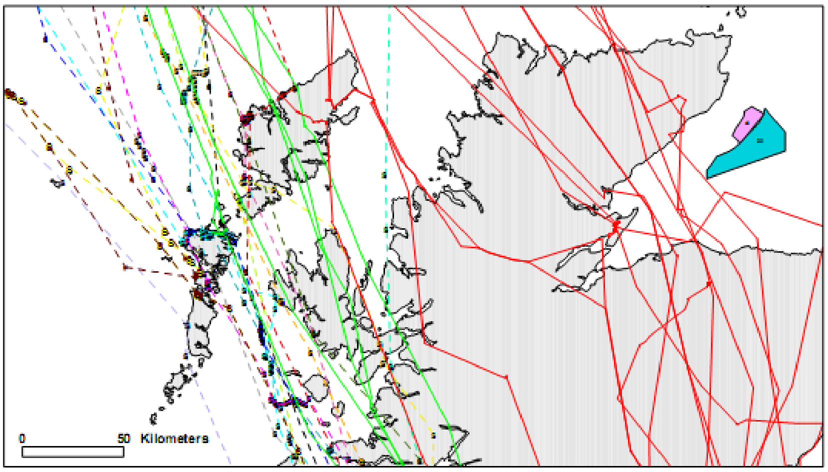


Image 45: Migration routes of 22 satellite-tagged whooper swans across northern Scotland in March-May 2009 from: Welney, Norfolk (red lines); Martin Mere, Lancashire (blue lines); and Caerlaverock, Dumfries & Galloway (green lines). Round 3 Zone 1 is shown in blue. Taken from Griffin *et al*., 2009.

Of the 12 tagged birds from Welney that reached the Moray Firth, three birds flew from Moray into Easter Ross, and six birds took a more easterly route, crossing from Moray into Sutherland. Two of the swans came within 10 km of the proposed MORL Zone, and one of these was within ca.1 km of it.

The whooper swans flew through offshore areas mostly during daylight hours, and generally when air pressure was high, with light winds. However this included weather of relatively poor visibility. The mean altitude of birds flying over water along the UK coast was 9 m (standard deviation: 16.2 m); below turbine rotor height. Flight height was not determined by weather conditions.

In total, 36 whooper swan flights are predicted to potentially pass through the three proposed wind farm sites each year on migration. Of these, a collision mortality rate of 1 per 10 years is predicted.

5.1.2 Pink-footed goose

Pink-footed geese breeding in Greenland and Iceland winter in England and Scotland. Autumn migration occurs between early/mid September and early/mid October (Mitchell & Hearn, 2004). A migration route across Caithness (via Strath Naver and the valley of Helmsdale) has been identified, but alternative routes will be used depending on where the birds make landfall. A major initial staging location is the Loch of Strathbeg in Aberdeenshire, along with several locations around the Inner Moray Firth. Migration across the Moray Firth may therefore occur, particularly between Caithness and Aberdeenshire. Reverse migration in the spring occurs in April and May (Mitchell & Hearn, 2004), following a similar route to that used in the autumn.

A radar study of pink-footed geese has been undertaken off the Lincolnshire coast for the Lynn and Inner Dowsing Offshore Wind Farms, between 2007 and 2010 by FERA (Food and Environment Research Agency). This study focussed on autumn migration (from mid-September into early November), with the radar operating for 24 hours per day, and concurrent visual observations occurring for 7 hours during daylight (Plonczkier pers. comm.[7]). During the study 979 skeins were detected, of which 43249 in 630 skeins were identified as pink-footed geese. No geese were recorded colliding with turbines. Flights of goose flocks were recorded over the sea at a variety of heights, with about a third of these at turbine blade height. 85% of the flights were recorded during daylight hours, with the remainder at night. The proportion of geese flying through the turbine arrays has changed through the study, with 48% recorded in 2007 (pre/during construction), 26% in 2008, 38% in 2009, and 19% in 2010 (latter 3 years were post-construction). This implies that there has been far-avoidance of the turbine arrays by geese, but the level of this far-avoidance has yet to be quantified.

In total, 24,017 pink-footed goose flights are predicted to potentially pass through the three proposed wind farm sites each year on migration. Of these, an annual collision mortality rate of 15.5-19.8 is predicted.

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[7] Presentation by Pawel Plonczkier on behalf of FERA for the SOSS steering group, 15 September 2011.

5.1.3 Greylag goose

Greylag geese migrating from Iceland to eastern Scotland during October and November (Hearn & Mitchell, 2004) may cross the Moray Firth. Historically the key arrival sites were in Aberdeenshire and around the Inner Moray, although the number spending the winter in Orkney is increasing each year (Holt *et al*., 2009). Within-winter movements of geese moving from Caithness to Easter Ross and from Easter Ross to Moray (Wernham *et al*., 2002) are likely to cross the inner Moray Firth, although it is possible that some flocks will cross further out. The majority of return migration into Caithness occurs in March, although movements may continue into April (Hearn & Mitchell, 2004).

In total, 2668 greylag goose flights are predicted to potentially pass through the three proposed wind farm sites each year on migration. Of these, an annual collision mortality rate of 2.6-2.8 is predicted.

5.1.4 Review of risk to geese and swans

Potential risks to geese and swans posed by the three proposed wind farm sites are summarised in Table 107.

Table 107. Review of risks to geese and swans

Risk	**Threat to species**	**Justification**
Barrier effects	Minor	Broad front migration. Additional distance to avoid wind farm negligible in relation to migratory distance.
Collision	Minor	Broad front migration. Low numbers recorded in the survey area. High avoidance rates. Low collision risk estimates. Flight height assumed to be very high for migrants
Displacement and disturbance	Negligible	3 wind farms not used for foraging or resting

5.2 Freshwater Ducks

Four species of freshwater ducks were recorded in the three proposed wind farm sites, all on autumn passage. The species involved were mallard, teal, wigeon and tufted duck, with most birds, and the largest variety of species being recorded in August.

The following species of freshwater ducks are expected to pass through the wind farm sites.

5.2.1 Mallard

The mallard is a sedentary species, with a non-breeding population numbering around 680,000 (Musgrove *et al*., 2011), and a breeding population of between 47,700 and 114,400 pairs (Baker *et al*., 2006). There are small scale movements of non-breeding birds into the UK, and some UK breeding birds winter elsewhere in northern Europe. The majority of Mallard movements into and out of the UK are thought to occur across the English Channel, or the central and southern North Sea (Wright *et al*., 2011).

The mallard is protected by 14 SPAs in Britain, all for non-breeding aggregations. The closest SPA to the three proposed wind farm sites for non-breeding mallard is the Firth of Forth SPA (Stroud *et al*., 2003). This species is listed on Annex 2 of the Birds Directive.

5.2.2 Wigeon

The wigeon is a scarce breeding bird in Britain, with between 300 and 500 pairs (Baker *et al*., 2006). Approximately 440,000 individuals winter in Great Britain (Musgrove *et al*., 2011), arriving from their breeding grounds in north-eastern Europe. They are distributed widely across Britain in winter, and although specific migration routes remain unknown, it is assumed that the largest concentrations of migrating birds would be in the North Sea (Wright *et al*., 2011). The winter influx occurs between August and November, with birds returning in March and April, although movements may occur away from these times due to hard weather, or smaller scale movements within the wintering range (Wright *et al*., 2011).

The wigeon is protected by 40 SPAs in Britain, two for breeding birds, and 38 for non-breeding aggregations. The Dornoch Firth and Loch Fleet SPA, Cromarty Firth SPA, the Inner Moray and Inverness Firths SPA, and the Moray and Nairn coast SPA have wigeon as a listed feature for non-breeding birds, and all lie on coastlines adjacent to the three proposed wind farm sites (Stroud *et al*., 2003). This species is listed on Annex 2 of the Birds Directive.

5.2.3 Teal

The teal is a scarce breeding bird in Britain, with between 1,500 and 2,600 pairs (Baker *et al*., 2006). Approximately 210,000 Eurasian teal winter in Great Britain (Musgrove *et al*., 2011). In addition, many birds use the British Isles en route to wintering sites in more southerly areas of Europe. Specific migration routes for Eurasian teal are not known. Ringing data suggests that movements occur over all parts of the UK, and as the wintering distribution is widespread, a pattern of movement is unlikely to be determined with current knowledge. Birds arrive from their breeding grounds between July and November, and leave again between February and May. During the winter, hard weather can induce more movement of birds into the UK from the north and east, as well as immigration from the UK to the continent (Wright *et al*., 2011).

The teal is protected by 30 SPAs in Britain, all for non-breeding aggregations. The Loch of Strathbeg SPA, the Dornoch Firth SPA and the Inner Moray and Inverness Firths SPA have teal as a listed feature, and lie on coastlines adjacent to the three proposed wind farm sites (Stroud *et al*., 2003). This species is listed on Annex 2 of the Birds Directive.

5.2.4 Tufted duck

The tufted duck has a breeding population of 7-8,000 territories (Baker *et al*., 2006) and a wintering population of 110,000 individuals (Musgrove *et al*., 2011). The influx of wintering birds originates in Iceland, Scandinavia and Russia, and arrival begins in the autumn with movements continuing through till January. Most of these birds then leave Britain in April and May to return to their breeding grounds. Movements are probably across the North Sea, with some birds moving over a stretch of the North Atlantic to Iceland (Wright *et al*., 2011).

The tufted duck is protected by seven SPAs in Britain, all for non-breeding aggregations of birds. The closest SPA to the three proposed wind farm sites for non-breeding tufted duck is Loch Leven SPA. This species is listed on Annex 2 of the Birds Directive.

5.2.5 Review of potential risks to freshwater ducks

Migrating ducks are believed to show medium sensitivity to barrier effects and a minimum of 99% avoidance rate of wind turbines (Maclean *et al*., 2009). Macro-avoidance rates of 45% have been demonstrated for freshwater duck species (Cook *et al*., 2011).

Potential risks to ‘freshwater’ ducks recorded in the survey area posed by the three proposed wind farm sites are summarised in Table 108.

Table 108. Review of risks to freshwater ducks

Risk	Threat to species	Justification
Barrier effects	Minor	Broad front migration Low numbers recorded in the survey area
Collision	Minor	Low flight height Low numbers recorded in the survey area Broad front migration Reasonable macro-avoidance rates High micro-avoidance rates
Displacement and disturbance	Negligible	3 wind farms not used for foraging or resting

5.3 Seaduck

Three species of seaduck were recorded in thethree proposed wind farm sites, common scoter, velvet scoter and long-tailed duck. All three were recorded in spring, with common scoter, the most numerous, also being recorded in November.

5.3.1 Common scoter

Common scoter are a very rare breeding bird in Britain, with fewer than 100 pairs (Baker *et al*., 2006) but have a wintering population of approximately 100,000 birds (Musgrove *et al*., 2011). Moulting flocks of this species occur in the summer and these birds may number as many as 30,000. These birds probably come from Scandinavia and Russia, so although the precise routes taken by migrating birds are not known, it can be assumed that these birds cross the North Sea. Moulting birds arrive in June and depart in September. Birds wintering in British waters arrive mainly from the Baltic, in September (Cabot, 2009).

Common scoter are protected by ten SPAs in Britain. Two of these are for breeding birds, and include the Caithness and Sutherland Peatlands SPA. Of the six sites designated for non-breeding aggregations, the Moray and Nairn coast SPA is situated on a coastline adjacent to the three proposed wind farm sites. There are also two offshore SPAs for this species, the closest being the Liverpool bay SPA (Stroud *et al*., 2003). This species is listed on Annex 2 of the Birds Directive, and is listed by the JNCC as a ‘regularly occurring migratory species’.

Large numbers of common scoter use inshore areas of the Moray Firth, with five year means from WeBS data of 3,238, and a maximum of 6,842 (Calbrade *et al*., 2010). Observer based aerial surveys have shown concentrations of these birds in Spey and

Burghead Bays, off Culbin Sands and in the greater Dornoch Firth. All records were within the 20 metre isobath (Dean *et al*., 2004, Lewis *et al*., 2008, 2009, Sohle *et al*., 2006, Wilson *et al*., 2006).

Common scoter are highly sensitive to disturbance, highly sensitive to habitat loss, show medium sensitivity barrier effects, and a minimum of 99% avoidance rate of wind turbines (Maclean *et al*., 2009) with micro-avoidance rates of 99.6% during daylight and 99.1% at night. Data collated from several proposed wind farm sites has shown that the mean flight height of the common scoter is 9.3 m, with 4% of all birds recorded flying in a generic 'collision risk zone' of 20–150 m above the sea (Cook *et al*., 2011).

5.3.2 Velvet scoter

The velvet scoter has a wintering population in Britain of approximately 2,500 birds (Musgrove *et al*., 2011), with the majority being found on the east coast of Scotland. Moulting birds also aggregate in small numbers during the summer months. Ringing recoveries suggest that some birds using British waters are from Scandinavia, but it is thought that Russian birds are involved as well. The timing of their movements is similar to that of common scoter (Cabot, 2009).

The velvet scoter occurs in the Moray Firth in relatively large numbers, with five year means derived from WeBS data of 798 birds, peaking at 1,261 (Calbrade *et al*., 2010). Observer based aerial surveys have shown concentrations can occur in Spey Bay. All records were from within the 20 m isobath (Dean *et al*., 2004, Lewis *et al*., 2008, 2009, Sohle *et al*., 2006, Wilson *et al*., 2006).

There are four SPAs protecting velvet scoter in Britain, all for non-breeding aggregations of birds. Of these, the Moray and Nairn coast SPA is situated on a coastline adjacent to the three proposed wind farm sites (Stroud *et al*., 2003). This species is listed on Annex 2 of the Birds Directive, and is listed by the JNCC as a 'regularly occurring migratory species'.

Velvet scoter are highly sensitive to disturbance, highly sensitive to habitat loss, and show medium sensitivity to barrier effects. Seaduck show a minimum of 99% avoidance rate of wind turbines (Maclean *et al*., 2009), with micro-avoidance rates of 99.6% during daylight and 99.1% at night. Data collated from several proposed wind farm sites has shown that the mean flight height of the velvet scoter is 1 m, with 0% of all birds recorded flying in a generic 'collision risk zone' of 20–150 m above the sea (Cook *et al*., 2011).

5.3.3 Long-tailed duck

The wintering population of long-tailed duck in Britain is currently estimated to be around 11,000 birds (Musgrove *et al*., 2011), with these birds coming from Russia, Scandinavia and Iceland. These birds arrive in autumn from October, and return to the breeding grounds by April or May. Little is known of the movements of long-tailed duck in British waters, but feeding flocks utilising coastal foraging areas are known to make flights of up to 12 km to roosting areas further offshore (Lack 1986).

Inshore areas of the Moray Firth are used by large numbers of long-tailed duck for feeding. WeBS data shows mean counts over the last five years of 6,288 birds, with a peak of 11,565 (Calbrade *et al*., 2010). Observer based aerial surveys have shown concentrations of long-tailed duck along the Morayshire coast and in the inner Moray Firth, particularly around Spey and Burghead Bays. Of 524 birds recorded on aerial surveys during January and February 2006, a minimum of 396 were in the Spey Bay area, with the majority of these within the 20 metre isobath (Dean *et al*., 2004, Lewis *et al*., 2008, 2009, Sohle *et al*., 2006, Wilson *et al*., 2006).

Long-tailed duck are protected by three SPAs in Britain, all for non-breeding aggregations of birds. Of these, the Moray and Nairn coast SPA has this species as a listed feature and is on a coastline adjacent to the three proposed wind farm sites (Stroud *et al*., 2003). This species is listed on Annex 2 of the Birds Directive, and is listed by the JNCC as a ‘regularly occurring migratory species’.

Long-tailed duck are highly sensitive to disturbance, show medium sensitivity to barrier effects, and a minimum of 99% avoidance rate of wind turbines (Maclean *et al*., 2009), with micro-avoidance rates of 99.6% during daylight and 99.1% at night. Data collated from several proposed wind farm sites has shown that the mean flight height of the long-tailed duck is 1.9 m (Cook *et al*., 2011).

5.3.4 Red-breasted merganser

The red-breasted merganser has a breeding population of 2,150 (Baker *et al*., 2006) and a wintering population of 8,400 in Britain (Musgrove *et al*., 2011), with birds arriving in winter from Europe. Those arriving from Iceland are distributed across northerly parts of Britain, while those coming from central Europe are mainly found on the east coast. Autumn migration of these birds occurs between October and December, with spring migration between February and May. During these times therefore, birds could be encountered in the North Sea, and sea areas to the north and east of the British Isles (Wright *et al*., 2011).

Red-breasted mergansers are protected by 15 SPAs in Britain, all for non-breeding aggregations of birds. Of these, the Cromarty Firth SPA, Inner Moray Firth SPA, and

Moray and Nairn coast SPA are situated on a coastline adjacent to the three proposed wind farm sites (Stroud *et al*., 2003). This species is listed on Annex 2 of the Birds Directive, and is listed by the JNCC as a 'regularly occurring migratory species'.

Migrating red-breasted mergansers show medium sensitivity to barrier effects and a minimum of 99% avoidance rate of wind turbines (Maclean *et al*., 2009), with micro-avoidance rates of 99.6% during daylight and 99.1% at night.

5.3.5 Review of potential risks to seaducks

Potential risks to seaducks recorded in the survey area (common scoter, velvet scoter and long-tailed duck) posed by the three proposed wind farm sites are summarised in Table 109.

Table 109. Review of risks to seaducks recorded within the boat-based survey area

Risk	Threat to species	Justification
Barrier effects	Minor	Broad front migration Low numbers recorded in the survey area
Collision	Minor	Low mean flight height Low numbers recorded in the survey area Broad front migration
Displacement and disturbance	Minor	3 wind farms not used for foraging or resting

Potential risks to seaducks not recorded in the survey area (eider, goldeneye and red-breasted merganser) posed by the three proposed wind farm sites are summarised in Table 110.

Table 110. Review of risks to seaducks not recorded within the boat-based survey area

Risk	Threat to species	Justification
Barrier effects	Negligible	Broad front migration Not recorded in the survey area
Collision	Negligible	Low mean flight height Low proportion of birds in generic collision risk zone Not recorded in the survey area Broad front migration High avoidance rates
Displacement	Negligible	Three sites not used for foraging or resting
Disturbance	Negligible	Three sites not used for foraging or resting

5.4 Divers

Great northern, red-throated and black-throated divers were recorded in the three proposed wind farm sites, with five unidentified divers also recorded. Most records came from the main spring and autumn passage periods.

The following species of divers are expected to pass through the three proposed wind farm sites.

5.4.1 Red-throated diver

The red-throated diver is a rare breeding bird in Britain, with fewer than 1,500 pairs (Baker *et al*., 2006). The winter population is around 17,000 birds (Musgrove *et al*., 2011), with the largest concentrations in the southern North Sea, and off the Welsh and north west English coasts. Little is known of the movements of this species.

The red-throated diver regularly occurs in inshore areas of the Moray Firth. WeBS data shows a five year mean of 63 birds, peaking at 117 (Calbrade *et al*., 2010). They are distributed widely through the area, with the majority of birds being within the 20 m isobath (Dean *et al*., 2004, Lewis *et al*., 2008, 2009, Sohle *et al*., 2006, Wilson *et al*., 2006).

Red-throated diver are protected by 11 SPAs in Britain, with ten for breeding birds (including the Caithness and Sutherland peatlands SPA, Hoy SPA, and the Orkney Mainland moors SPA) and one for non-breeding aggregations, the Firth of Forth SPA (Stroud *et al*., 2003). This species is listed on Annex 1 of the Birds Directive.

Red-throated divers show very high sensitivity to disturbance, high sensitivity to habitat loss, high sensitivity to barrier effects, and a minimum of 98% avoidance rate of wind turbines. Data collated from several proposed wind farm sites has shown that the mean flight height of the red-throated diver is 4.5 m, with 4% of all birds recorded flying in a generic ‘collision risk zone’ of 20–150 m above the sea (Cook *et al*., 2011).

5.4.2 Black-throated diver

The black-throated diver is an uncommon breeding species and winter resident, with respective populations of approximately 200 pairs and 700 – 800 birds (Forrester *et al*., 2007). This species is most common on western coasts, with the majority of eastern birds being recorded from the inner Moray Firth, the Firth of Forth, and Scapa Flow. Birds aggregate on their wintering grounds over November and move back towards breeding areas from March onwards.

There was only one record of black-throated diver in the study area, a single flying north-west over the buffer zone on 16th January 2012.

5.4.3 Great northern diver

The wintering population of great northern divers in British waters is currently believed to be approximately 2,500 birds (Musgrove *et al.*, 2011), with the largest concentrations off western and northern Scotland. British wintering birds come from Iceland, Greenland and possibly Canada as well. Most of these birds arrive during September and October, and return after moulting in April or May.

Relatively large numbers of great northern divers occur in the Moray Firth, with five year means from WeBS data of 14 birds, peaking at 37 (Calbrade *et al.*, 2010). Observer based aerial surveys have shown concentrations of these birds in Spey Bay, the outer Moray Firth and the Outer Dornoch Firths. This species is less restricted to areas within the 20 metre isobath but is generally restricted to areas within the 50 m isobath (Dean *et al.*, 2004, Lewis *et al.*, 2008, 2009, Sohle *et al.*, 2006, Wilson *et al.*, 2006).

There are no SPAs designated for the great northern diver in Britain (Stroud *et al.*, 2003). This species is listed on Annex 1 of the Birds Directive.

The risks specific to great northern divers are not documented, but are believed to be similar to other diver species. Data collated from several proposed wind farm sites has shown that 0% of all great northern diver recorded flying in a generic ‘collision risk zone’ of 20–150 m above the sea (Cook *et al.*, 2011).

5.4.4 Review of risks to divers

Potential risks to divers posed by the three proposed wind farm sites are summarised in Table 111.

Table 111. Review of risks to divers

Risk	Threat to species	Justification
Barrier effects	Minor	Broad front migration Not recorded in the survey area
Collision	Minor	Low mean flight height Low proportion of birds in generic collision risk zone Not recorded in the survey area Broad front migration High avoidance rates
Displacement and disturbance	Minor	Wind farms sites not used for foraging or resting

5.5 Raptors and owls

There was only one raptor and no owls recorded in the three proposed wind farm sites. The sole record was of a single sparrowhawk in August.

No species of raptors or owls are expected to pass through the wind farm sites in anything other than in very small numbers.

Potential risks to raptors and owls posed by the three proposed wind farm sites are summarised in Table 112.

Table 112. Review of risks to raptors and owls

Risk	Threat to species	Justification
Barrier effects	Negligible	Broad front migration Not recorded in the survey area
Collision	Negligible	Not recorded in the survey area Broad front and low density migration Some macro-avoidance
Displacement	Negligible	3 wind farms not used for foraging or resting
Disturbance	Negligible	3 wind farms not used for foraging or resting

5.6 Waders

The following species of wader were recorded in the three proposed wind farm sites: oystercatcher, ringed plover, golden plover, sanderling, purple sandpiper, turnstone, dunlin, redshank, curlew, whimbrel, ruff and red-necked phalarope. The vast majority of these were recorded during times of spring and autumn passage.

The following species are expected to pass through the three proposed wind farm sites.

5.6.1 Oystercatcher

Approximately 320,000 oystercatcher winter in the UK (Musgrove *et al*., 2011), with some 200,000 of these arriving from breeding grounds on the continent, to the north, and east. Those that winter in eastern areas arrive from Scandinavia or the near continent, and those from Iceland and the Faroes concentrate in Ireland and northern areas of the UK. Some UK breeders move southward (especially those from more northern areas), with some birds crossing the English Channel or Irish Sea. In spite of this knowledge of the provenance of wintering birds in different parts of the UK, exact migration routes are unknown. Birds arrive into the UK in late summer and return to their breeding grounds in spring, although immature birds remain on the wintering grounds (Wright *et al*., 2011).

The oystercatcher is protected by 33 SPAs in Britain, three for breeding birds, and 30 for non breeding aggregations. The breeding designations all lie on the west coast of Scotland. The Cromarty Firth SPA, Dornoch Firth and Loch Fleet SPA, Inner Moray Firth SPA and Moray and Nairn coast SPA all have oystercatcher as listed features, and all lie on coastlines adjacent to the three proposed wind farm sites (Stroud *et al*., 2003). This species is not listed on the Birds Directive.

5.6.2 Ringed plover

British breeding ringed plovers are fairly sedentary, or make small scale movements to wintering grounds over the Irish Sea and English Channel. Large numbers of birds breeding in more northern areas use the UK as a staging post en route to wintering areas in south-western Europe and west Africa, with the current non-breeding population estimate of 34,000 (Musgrove *et al*., 2011), thought to be conservative due to the difficulties in recording turnover of birds at individual sites. Scandinavian breeders tend to use the east coast of Britain while those breeding in more northern areas use western parts of the British Isles, so although specific migration routes are unknown, movements are likely to occur throughout British waters. Spring migration of birds toward northern breeding areas occurs through the UK during April and May (Wright *et al*., 2011).

Breeding ringed plover are protected by five SPAs in Britain, with the closest to the three proposed wind farm sites being in Shetland and on the west coast of Scotland. Of the 27 sites designated for non-breeding aggregations, the closest to the three proposed wind farm sites are on the west coast of Scotland, and the Firth of Forth SPA (Stroud *et al*., 2003). This species is not listed on the Birds Directive.

5.6.3 Golden plover

Approximately 22,500 pairs of golden plover breed in Britain (Baker *et al*., 2006), with numbers of up to 400,000 wintering birds (Musgrove *et al*., 2011). Some British breeding birds are known to undergo southerly migration towards wintering areas in southern Europe and northern Africa, while others remain within the UK. The numbers in winter are swollen by influx of birds from the north west (particularly into Ireland and western Britain) and from north eastern Europe (into eastern Britain, mainly via the Netherlands). These autumn movements occur between July and September, with wintering birds returning towards breeding grounds as early as February (Wright *et al*., 2011).

Golden plover are protected by 29 SPAs in Britain, with 7 designated for breeding birds, and 22 for non-breeding aggregations. There is one breeding designation, in northern and eastern Scotland, the Caithness and Sutherland Peatlands SPA. The closest non-breeding designation to the three proposed wind farm sites is the Firth of Forth SPA (Stroud *et al*., 2003). This species is listed on Annex 1 of the Birds Directive.

5.6.4 Grey plover

The grey plover does not breed in Britain, and has a passage and wintering population of 43,000 individuals. These birds originate in Russia and arrive between late summer and autumn, with most arriving in September, having staged on the coast of Denmark. Numbers in Britain then decline as many of these birds continue their movements south and west, over the English Channel. Spring passage occurs between March and May, as birds return to their breeding grounds over the North Sea (Wright *et al*., 2011).

This species is listed on Annex 2 of the Birds Directive. The grey plover is protected by 28 SPAs in Britain, all designated for non-breeding birds. The closest SPAs to the three proposed wind farm sites for non-breeding grey plover are the Firth of Tay and Eden Estuary SPA and Firth of Forth SPA.

5.6.5 Lapwing

The lapwing is a common bird in Britain, with between 137,000 and 174,000 breeding pairs (Baker *et al*., 2006), and a wintering population of 620,000 individuals (Musgrove *et al*., 2011). The British breeding population is partially migratory, with some birds moving westward towards wintering grounds in France and Iberia. Other birds arrive in Britain from continental breeding grounds to winter, mainly from late September to early November, making the return migration from March to May. Migration is thought to occur over the North Sea, Irish Sea and English Channel (Wright *et al*., 2011).

This species is listed on Annex 2 of the Birds Directive. The lapwing is protected by 38 SPAs in Britain, all designated for aggregations of non-breeding birds. The closest SPA to the three proposed wind farm sites for non-breeding lapwing is the Ythan Estuary, Sands of Forvie, and Meikle Loch SPA.

5.6.6 Knot

Around 320,000 red knot winter in Britain (Musgrove *et al*., 2011), arriving from breeding grounds in Canada and Greenland during July to September, after staging in Iceland or Norway. The return migration in spring occurs in May and birds use the same Norwegian or Icelandic staging posts, and there are movements of UK wintering birds across the North Sea towards the Wadden Sea in March.

There is considerable movement between wintering sites during the early winter, some birds crossing the North Sea or English Channel. These movements of red knot appear to be well known but precise knowledge of the routes taken is lacking. The variety of movements, and large numbers involved suggest that red knot could pass over any sea area of the UK during spring and autumn (Wright *et al*., 2011).
This species is listed on Annex 2 of the Birds Directive. Knot are protected by 25 SPAs in Britain, all designated for non-breeding birds. The Cromarty Firth SPA has knot as a listed feature and lies on a coastline adjacent to the three proposed wind farm sites (Stroud *et al*., 2003).

5.6.7 Sanderling

Britain hosts up to 16,000 sanderling in winter (Musgrove *et al*., 2011), or en route from northern breeding grounds to wintering areas in continental Europe and Africa. Precise routes are not known but it is assumed that migrating sanderling could occur anywhere in British waters during Spring or Autumn passage. Autumn passage is from July to August, with birds returning in spring from March to May (Wright *et al*., 2011).

This species is not listed on the Birds Directive. The sanderling is protected by 11 SPAs in Britain, all designated for non-breeding aggregations. The closest of these to the three proposed wind farm sites are the South Uist machair and lakes SPA, and the Firth of Tay and Eden estuary SPA (Stroud *et al*., 2003).

5.6.8 Purple sandpiper

This species is a very rare breeding bird in Britain, with up to five pairs (Baker *et al*., 2006), but up to 13,000 purple sandpiper winter in Britain (Musgrove *et al*., 2011), from breeding grounds as diverse as Canada, Greenland, Norway, Svalbard and Russia. Populations wintering in northern and western areas are dominated by birds from Canada and Greenland, while those wintering further south are more likely to be of Norwegian or Russian origin.

Birds arrive from their breeding grounds between July and October, with birds of eastern origin typically arriving earlier than those from Canada and Greenland. Precise migration routes are not known but birds wintering on northern North Sea coasts are known to migrate through Orkney during spring (Wright *et al*., 2011).

This species is listed on Annex 2 of the Birds Directive. The Purple sandpiper is protected by three SPAs, all designated for non-breeding aggregations. The East Sanday coast SPA has purple sandpiper listed as a feature which may be of relevance to the three proposed wind farm site (Stroud *et al*., 2003).

5.6.9 Dunlin

British breeding dunlin, numbering just under 10,000 pairs (Baker *et al*., 2006), winter in western Africa and migrate there via staging posts in France and Iberia. Also, large numbers of dunlin breeding in Iceland and the Baltic winter in similar areas, and those from further north pass through Britain in large numbers. The exact numbers of birds involved in these movements is difficult to ascertain due to high levels of turnover at key sites. These birds do not appear to have fixed migration routes and so could possibly occur anywhere in British waters during spring and autumn migration. These birds tend to migrate towards there wintering grounds between June and August, and return in spring during April and May. Birds breeding in Greenland also pass through the UK towards similar wintering areas at similar times of year.

In addition to the above, up to 350,000 dunlin winter in Britain (Musgrove *et al*., 2011), from breeding grounds in Russia and Scandinavia. The majority of these birds arrive in October and November having moulted on the Wadden Sea and return to their breeding grounds in April and May. Movements of these birds are thought to be concentrated around the southern North Sea and the eastern English Channel (Wright *et al*., 2011).

This species is listed on Annex 1 of the Birds Directive. The Dunlin is protected by 46 SPAs in Britain, with eight designated for breeding birds and 38 designated for non-breeding aggregations. There is one breeding designation in north eastern Scotland, the Caithness and Sutherland Peatlands SPA. Sites with non breeding aggregations of dunlin listed as features include the Cromarty Firth SPA, Dornoch Firth and Loch Fleet SPA, and Moray and Nairn coast SPA, all of which lie on coastlines adjacent to the three proposed wind farm sites (Stroud *et al*., 2003).

5.6.10 Common sandpiper

Approximately 12,000 pairs of common sandpiper breed in Britain. These birds migrate southward to spend the winter in sub-Saharan Africa, probably crossing the

English Channel. Spring migration occurs around April, with birds returning south in late summer and early autumn. Numbers passing through Britain are swollen by birds passing through from Scandinavia and north west Europe, these birds passing over the North Sea (Wright *et al*., 2011).

There are no SPAs designated for common sandpipers in Britain, and this species is not listed on the Birds Directive.

5.6.11 Redshank

British breeding redshank, numbering approximately 39,000 pairs (Baker *et al*., 2006), are largely sedentary and remain within the British Isles during the winter. Large numbers of Icelandic breeders arrive in autumn, between June and August, with non breeding estimates of around 120,000 in Britain (Musgrove *et al*., 2011). The distribution of these arrivals suggests that birds could occur anywhere within British waters (Wright *et al*., 2011).

This species is listed on Annex 2 of the Birds Directive. Redshank are protected by 40 SPAs in Britain, with four sites designated for breeding birds and 36 for non-breeding aggregations. Among the breeding designations, the closest to the three proposed wind farm sites are in western Scotland. The Cromarty Firth SPA, Inner Moray Firth SPA, and Moray and Nairn coast SPA all have non-breeding aggregations of redshank as listed features, and all lie on coastlines adjacent to the three proposed wind farm sites (Stroud *et al*., 2003).

5.6.12 Black-tailed godwit

The black-tailed godwit is a rare breeding bird in Britain, with between 44 and 52 pairs (Baker *et al*., 2006). It is much more numerous in winter and on passage, with 43,000 individuals wintering in Britain (Musgrove *et al*., 2011). British breeding birds migrate southward for the non-breeding season from July, and through to the autumn. The return spring migration occurs during March and April.

Icelandic breeding black-tailed godwits pass through, and winter in, Britain. Influx begins during July and August, with birds returning to Iceland during April and May. Precise routes for these movements are not known (Wright *et al*., 2011).

This species is listed on Annex 2 of the Birds Directive. The black-tailed godwit is protected by 29 SPAs in Britain, two for breeding birds, and 27 for non-breeding aggregations. The closest SPA for non-breeding birds to the three proposed wind farm sites is the Firth of Tay and Eden Estuary SPA.

5.6.13 Bar-tailed godwit

Bar-tailed godwits are common in Britain in winter, with a population of 38,000 individuals (Musgrove *et al*., 2011). These birds arrive from Scandinavia and Russia in late summer and early autumn, with some continuing on through Britain to winter in areas further south and west, and return in February and March. The exact routes taken by these birds are not known, but with many birds staging in the Wadden Sea, it is thought that routes may concentrate around this area (Wright *et al*., 2011).

This species is listed on Annex 2 of the Birds Directive. The bar-tailed godwit is protected by 23 SPAs in Britain, all designated for non-breeding aggregations of birds. Of these, the Cromarty Firth SPA, Dornoch Firth and Loch Fleet SPA, Inner Moray Firth SPA and the Moray and Nairn Coast SPA all lie on coastlines adjacent to the three proposed wind farm sites (Stroud *et al*., 2003).

5.6.14 Curlew

The Curlew has a breeding population of around 107,000 pairs in Britain (Baker *et al*., 2006), with approximately 140,000 individuals wintering (Musgrove *et al*., 2011). British breeding birds tend to remain within the British Isles during the winter, with general movement being in a south westerly direction. These movements occur between June and October after the breeding season, with birds making the return leg between January and March.

Influx of birds from breeding grounds in northern and eastern Europe coincides with post-breeding movements of British birds, but birds returning to the continent do so slightly later, between March and May. Ringing recoveries suggest that the bulk of curlews arriving into Britain do so across the southern North Sea (Wright *et al*., 2011).

This species is listed on Annex 2 of the Birds Directive. Curlew are protected by 26 SPAs in Britain, with one designated for breeding birds (the North Pennine moors SPA) and a further 25 for non-breeding aggregations. The Cromarty Firth SPA, Dornoch Firth and Loch Fleet SPA and Inner Moray Firth SPA all have curlew listed as listed features, and all lie on coastlines adjacent to the three proposed wind farm sites (Stroud *et al*., 2003).

5.6.15 Whimbrel

The whimbrel is a rare breeding bird in Britain with 530 breeding pairs (Baker *et al*., 2006). Larger numbers of birds occur on passage, en route from breeding grounds to the north and north-east towards wintering sites in western Africa. It is assumed that movements occur across a broad front, but large concentrations at selected sites suggest that specific migration routes may exist, at least in some areas. Current estimates suggest that just under 4,000 whimbrel pass through Britain in spring (Calbrade *et al*., 2010), but it is likely that this is an underestimate due to the difficulties in ascertaining levels of turnover at key sites (Wright *et al*., 2011).

This species is listed on Annex 2 of the Birds Directive. Whimbrels are protected by 12 SPAs in Britain, one for breeding birds in Shetland, and 11 for non-breeding aggregations. The closest of the non-breeding designations to the three proposed wind farm sites is the Morecambe Bay SPA (Stroud *et al*., 2003).

5.6.16 Snipe

The snipe is a common breeding bird in Britain, with between 52,600 and 69,000 breeding pairs, and approximately 100,000 wintering individuals. It is a chain migrant, with some British breeding birds moving south and west over the English Channel and Irish Sea to continental wintering grounds, and birds of the subspecies *faeroeensis* passing through mainland Britain having bred in Iceland, the Faeroes, Shetland and Orkney. The southerly movement commences in August and continues through to October, with the return spring movements taking place during March and April. It is possible that over 1 million snipe pass through or winter in Britain each year. Exact migration routes for snipe are not known, and although only one SPA is designated for common snipe it might be safest to assume that all UK waters are used my migratory snipe (Wright *et al*., 2011).

This species is listed on Annex 2 of the Birds Directive. The snipe is protected by one SPA in Britain. The Somerset Levels and Moors is designated for non-breeding aggregations of birds.

5.6.17 Woodcock

The woodcock is a common breeding bird in Britain, and has a wintering population of around 1.4 million birds. British breeding woodcock are largely sedentary, with only very small numbers moving south west towards France and Iberia. Influx of birds breeding in north-western Europe begins in October and carries on through to December, with birds thought to arrive in Britain on a broad front despite particularly large numbers passing through a few well covered sites. The return migration in spring occurs between February and April.

This species is listed on Annex 2 of the Birds Directive. There are no SPAs designated for woodcock in Britain, and this species is listed on Annex 2 of the Birds Directive.

5.6.18 Review of risks to waders

Macro-avoidance rates of 51% have been demonstrated for wading birds (Cook *et al*., 2011).

Potential risks to waders recorded in the survey area (oystercatcher, ringed plover, golden plover, sanderling, purple sandpiper, dunlin, ruff, curlew, whimbrel, redshank and turnstone) posed by the three proposed wind farm sites are summarised in Table 113.

Table 113. Review of risks to waders recorded within the survey area

Risk	Threat to species	Justification
Barrier effects	Minor	Broad front migration Low numbers recorded in the survey area
Collision	Minor	Low numbers recorded in the survey area Broad front migration Reasonable macro-avoidance rates
Displacement and disturbance	Minor	3 wind farms not used for foraging or resting

Potential risks to waders not recorded in the survey area (knot, grey plover, common sandpiper, black-tailed godwit, bar-tailed godwit, snipe and woodcock) posed by the three proposed wind farm sites are summarised in Table 114.

Table 114. Review of risks to waders not recorded within the survey area

Risk	Threat to species	Justification
Barrier effects	Negligible	Broad front migration Not recorded in the survey area
Collision	Negligible	Not recorded in the survey area Broad front migration Reasonable macro-avoidance rates
Displacement and disturbance	Negligible	3 wind farms not used for foraging or resting

5.7 Neopasserines

Only one species of neopasserine was recorded, a single collared dove observed in June.

No species of neopasserines (e.g. woodpigeon, collared dove, cuckoo, swift) are expected to pass through the three proposed wind farm sites in anything other than very small numbers. Potential risks posed to neopasserines by the wind farm sites are summarised in Table 115.

Table 115. Review of risks to neopasserines

Risk	Threat to species	Justification
Barrier effects	Minor	Broad front migration in small numbers Low numbers recorded in the survey area
Collision	Minor	Broad front migration in small numbers Low numbers recorded in the survey area Reasonable macro-avoidance rates Reasonable micro-avoidance rates Flight height assumed to be very high for migrants
Displacement and disturbance	Minor	3 wind farms not used for foraging or resting

5.8 Passerines

The following species of passerine were recorded in the three proposed wind farm sites; skylark, white wagtail, meadow pipit, swallow, wheatear, redwing, starling and carrion crow. The majority of records came during the spring passage period, in April, with much smaller numbers recorded during the autumn passage period.

The following species of passerines are expected to pass through the area.

5.8.1 Skylark

The population of skylark breeding in Britain, measured in territories, is 1.7 million (Baker *et al*., 2006). British skylarks may undertake altitudinal migration in large numbers, but for the most part remain within Britain for the winter. The winter population is augmented by influx from northern Europe, and some of these birds continue in a south-westerly direction, spending the winter in France or the Iberian Peninsula. The numbers of birds involved in these movements are not known, but in the context of British waters the largest concentrations of passage birds are in the North Sea and English Channel (Wright *et al*., 2011).

This species is listed on Annex 2 of the Birds Directive. There are no SPAs designated for skylark in Britain (Stroud *et al*., 2003).

5.8.2 Sand martin

The sand martin is a common summer visitor to Britain, with between with between 85,000 and 270,000 nests. Influx into Britain occurs between March and May, with birds arriving mainly in the south-east, and then spreading throughout the rest of the country along coastlines. In autumn, sand martins depart for wintering grounds in southern Europe and northern and western Africa between July and September (Wright *et al*., 2011).

There are no SPAs designated for sand martin in Britain (Stroud *et al*., 2003), and this species is not listed on the Birds Directive.

5.8.3 House martin

The house martin is a common breeding bird in Britain with between 253,000 and 505,000 pairs (Baker *et al*., 2006), which shows a similar migration strategy to the barn swallow. During spring and autumn migration, large numbers of birds cross the English Channel and Irish Sea, with those continuing further north doing so over land or following coastal routes. Spring migration into Britain mainly occurs in April, with autumn migration happening between August and October (Wright *et al*., 2011).

There are no SPAs designated for sand martin in Britain (Stroud *et al*., 2003), and this species is not listed on the Birds Directive.

5.8.4 Swallow

The barn swallow with approximately 680,000 pairs (Baker *et al*., 2006), is a common breeding bird in Britain with large numbers migrating between here and the species African wintering grounds. Spring migration occurs between March and May, with return passage between August and October. The majority of barn swallows make sea crossings over the English Channel or Irish Sea, with those breeding further north making their way towards their breeding grounds over land or following coastal routes. Autumn migration patterns are believed to be similar (Wright *et al*., 2011).

There are no SPAs designated for sand martin in Britain (Stroud *et al*., 2003), and this species is not listed on the Birds Directive.

5.8.5 Meadow pipit

The meadow pipit is a common breeding bird in Britain with a population, measured in territories, of 1.6 million (Baker *et al*., 2006). A large proportion of these British breeding birds migrate south-west to winter in the Iberian Peninsula. Those remaining in Britain for the winter are joined by migrants from northern Europe, with some of these birds also continuing further south. Meadow pipits are widespread in Britain during the whole year, so passage birds could occur anywhere in British waters, but the largest concentrations are likely to be in more southerly areas. Spring passage occurs in March and April, with autumn birds moving southward between July and October (Wright *et al*., 2011).

There are no SPAs designated for sand martin in Britain (Stroud *et al*., 2003), and this species is not listed on the Birds Directive.

5.8.6 White wagtail

The British race of the white wagtail, commonly known as the pied wagtail, is a common breeding bird in Britain, with between 255,000 and 330,000 territories (Baker *et al*., 2006). It makes southerly movements during the winter. Some birds remain within the British Isles but others cross the English Channel and Bay of Biscay to winter in France and the Iberian Peninsula. These movements occur alongside continental and Icelandic breeding birds that pass through Britain en route towards similar wintering locations. Some of these continental breeding birds also remain in Britain for the winter.

Precise migration routes are not known for this species, apart from the spring passage of continental breeding birds showing a westerly bias through the British Isles. It is therefore likely to occur anywhere within British waters on migration (Wright *et al*., 2011).

There are no SPAs designated for sand martin in Britain (Stroud *et al*., 2003), and this species is not listed on the Birds Directive.

5.8.7 Waxwing

The waxwing is a scarce winter visitor to Britain from Scandinavia and Russia, but in times of food shortage on their usual wintering grounds, can irrupt into Britain in relatively large numbers. Waxwings usually arrive in more northern areas, in late autumn and early winter, before spreading southward as the winter progresses. Exact migration routes for these irruptions are not known but should be assumed to be over the North Sea. The birds are thought to return to their breeding grounds via the Low Countries during the spring (Wright *et al*., 2011).

There are no SPAs designated for waxwing in Britain (Stroud *et al*., 2003), and this species is not listed on the Birds Directive.

5.8.8 Robin

The British population of robins, numbering just under 6 million territories (Baker *et al*., 2006), are largely sedentary. Scandinavian robins are migratory, and can occur in large numbers on passage in the British Isles, but these birds move on to spend the winter in southern Europe and Africa. Precise movements of migrating robins are not known, but migrating Scandinavian birds will cross the North Sea and the English Channel (Wright *et al*., 2011).

There are no SPAs designated for robin in Britain (Stroud *et al*., 2003), and this species is not listed on the Birds Directive.

5.8.9 Wheatear

The Northern wheatear is a common breeding bird in Britain, with a population of around 56,000 pairs (Baker *et al*., 2006). British breeding birds arrive from wintering areas in west Africa during March and early April, and depart southward in the autumn. Birds breeding to the north and west of Britain also pass through the British Isles on passage, generally a little later than their British counterparts. Precise migration routes are not known or this species and it may occur anywhere in British waters on migration. Concentrations of passage birds could occur in the English Channel, or to the north and west of the British Isles (Wright *et al*., 2011).

There are no SPAs designated for wheatear in Britain (Stroud *et al*., 2003), and this species is not listed on the Birds Directive.

5.8.10 Song thrush

The song thrush is a common bird in Britain, with over 1,144,000 territories, and these birds are largely sedentary. There are recorded south-westerly movements towards France and Iberia outwith the breeding season but these are uncommon. Some birds also pass through Britain on migration from Scandinavia but the scale of this movement is not known.

There are no SPAs designated for sand martin in Britain (Stroud *et al*., 2003), and this species is not listed on the Birds Directive.

5.8.11 Redwing

The redwing is a rare breeder with usually fewer than 17 pairs, but a common winter visitor with almost 700,000 birds wintering in Britain (Baker *et al*., 2006). Most redwing arrive across the North Sea, as the majority of British wintering birds have come from Russia and Scandinavia, but Icelandic and Faroese birds move to western Scotland.

Autumn influx of redwings occurs in greatest numbers during October, with spring movements happening between March and May. Redwing can occur anywhere in UK waters on passage, as many of those arriving from the north east may continue on towards wintering grounds further south in Europe. Specific migration routes are not known, but it is likely to occur in good numbers on passage in the North Sea and to the north-west of the British Isles (Wright *et al*., 2011).

There are no SPAs designated for sand martin in Britain (Stroud *et al*., 2003), and this species is not listed on the Birds Directive.

5.8.12 Fieldfare

The fieldfare is an irregular breeding bird in Britain, but is a much more numerous winter visitor, with a winter population of 680,000 individuals. Birds wintering in Britain arrive from Scandinavia from September, on a broad front. Spring migration occurs from March through to May.

There are no SPAs designated for sand martin in Britain (Stroud *et al*., 2003), and this species is not listed on the Birds Directive.

5.8.13 Blackbird

The British breeding population of blackbirds, numbering around 5 million territories (Baker *et al*., 2006), is largely sedentary, but large numbers of this species spend the winter in Britain or use it as a staging ground en route to southern Europe. No precise routes are known for these migratory populations, but ringing recoveries show their provenance to be to the east of Britain, so these birds probably cross the North Sea (Wright *et al*., 2011).

There are no SPAs designated for sand martin in Britain (Stroud *et al*., 2003), and this species is not listed on the Birds Directive.

5.8.14 Blackcap

Blackcaps are common breeding birds in Britain, with over 930,000 territories. Birds breeding in Britain are summer visitors, arriving from their wintering grounds in southern Europe and North Africa in April and May, and departing again during the autumn. Small numbers of blackcap also over-winter in Britain, arriving in the autumn from western and central Europe. Specific migration routes are not known for this species (Wright *et al*., 2011).

There are no SPAs designated for blackcap in Britain (Stroud *et al*., 2003), and this species is not listed on the Birds Directive.

5.8.15 Willow warbler

The willow warbler is a common breeding bird in Britain, with 2,125,000 territories. It winters in western Africa, arriving in Britain in spring during April, and departs towards its wintering grounds in late summer and early autumn. Specific migration routes are not known for this species (Wright *et al*., 2011).

There are no SPAs designated for willow warbler in Britain (Stroud *et al*., 2003), and this species is not listed on the Birds Directive.

5.8.16 Chiffchaff

The chiffchaff is a common breeding bird in Britain, with over 800,000 territories. It is also becoming a more frequent winter resident. Those undergoing autumn migration do so in September, and winter in western Africa, returning to Britain in early spring. Specific migration routes are not known for this species (Wright *et al*., 2011).

There are no SPAs designated for chiffchaff in Britain (Stroud *et al*., 2003), and this species is not listed on the Birds Directive.

5.8.17 Goldcrest

The goldcrest is a common breeding bird in Britain, with a population of 842,000 territories, with many more arriving during the autumn. These birds arrive across the North Sea from the Batlic and Scandinavia, most often in response to harsh weather. These autumnal influxes occur between September and November, with birds returning to their breeding grounds during March and April. Some birds also make movements across the English Channel and Irish Seas at similar times. Specific migration routes are not known for this species (Wright *et al*., 2011).

There are no SPAs designated for goldcrest in Britain (Stroud *et al*., 2003), and this species is not listed on the Birds Directive.

5.8.18 Starling

The starling is a common breeding bird in Britain, with this population of just over 800,000 pairs being mainly sedentary (Baker *et al*., 2006). In autumn and winter the British population is swollen by birds from all over continental Europe, so although specific migration routes are not known it is possible that large numbers of this species cross the North Sea (Wright *et al*., 2011).

There are no SPAs designated for starling in Britain (Stroud *et al*., 2003), and this species is not listed on the Birds Directive.

5.8.19 Chaffinch

The chaffinch is a very common breeding species in Britain, with a population of 5,974,000 territories. Most of these remain within Britain during the winter, and numbers are swollen at this time by influx of birds from Scandinavia and continental Europe. As many as 20 million chaffinches may cross the North Sea during the autumn, many wintering in Britain, but some continuing on to winter in Ireland.

Movements occur mainly between September and November, with the return journey between February and May. While some chaffinches make direct crossings of the North Sea, most make the shorter sea crossing between the Low Countries and south-eastern England. Broad front migration is more frequent during the spring. (Wright *et al*., 2011).

There are no SPAs designated for chaffinch in Britain (Stroud *et al*., 2003), and this species is not listed on the Birds Directive.

5.8.20 Brambling

The brambling is an irregular breeder but a common winter visitor to Britain, with a wintering population of between 45,000 and 1,800,000. These birds arrive from Scandinavia and Russia on a broad front across the North Sea. The influx occurs between September and November, with birds returning towards their breeding grounds during April and May (Wright *et al*., 2011).

There are no SPAs designated for brambling in Britain (Stroud *et al*., 2003), and this species is not listed on the Birds Directive.

5.8.21 Siskin

The siskin is a common breeding bird in Britain, with a population of 369,000 pairs. The breeding population is believed to be largely sedentary, with wintering populations swollen by influx from Scandinavia and the Baltic. These birds arrive in the autumn and return towards their breeding sites in April. Specific migration routes are not known for this species (Wright *et al*., 2011).

There are no SPAs designated for siskin in Britain (Stroud *et al*., 2003), and this species is not listed on the Birds Directive.

5.8.22 Review of risks to passerines

A macro-avoidance rate of 53% has been demonstrated for land birds responding to offshore wind farms, along with micro-avoidance rates of 99.86% for a mixture of resident and migrant species.

Potential risks posed to passerines migrating over land (sand martin, house martin and swallow) by the three proposed wind farm sites are summarised in Table 116.

Table 116. Review of risks to passerines mostly migrating over land		
Risk	**Threat to species**	**Justification**
Barrier effects	Minor	Migrates over land in this region Not recorded in the survey area
Collision	Minor	Migrates over land in this region Not recorded in the survey area Reasonable macro-avoidance rates Reasonable micro-avoidance rates Flight height assumed to be very high for migrants
Displacement and disturbance	Minor	3 wind farms not used for foraging or resting

Potential risks posed to passerines migrating over land and sea (skylark, meadow pipit, white wagtail, waxwing, robin, wheatear, song thrush, redwing, fieldfare, blackbird, blackcap, willow warbler, chiffchaff, goldcrest, starling, chaffinch, brambling, siskin) by the three proposed wind farm sites are summarised in Table 117.

Table 117. Review of risks to passerines migrating over land and sea.

Risk	Threat to species	Justification
Barrier effects	Minor	Broad front migration Low numbers recorded in the survey area
Collision	Minor	Broad front migration Low numbers recorded in the survey area Reasonable macro-avoidance rates Reasonable micro-avoidance rates Flight height assumed to be very high for migrants
Displacement and disturbance	Minor	3 wind farms not used for foraging or resting

6 Environmental Impact Assessment

6.1 EIA Methodology

The impact assessment process used for ornithology is that recommended by IEEM (Institute of Ecology and Environmental Management) for marine and coastal developments (IEEM 2010), whilst also using some further definitions provided by a review of potential biodiversity impacts of offshore wind farm developments (Wilhelmsson *et al*., 2010). The basis of this assessment process is the following steps (some relevant definitions are provided in Table 11.2.4.3):

- Identification of the activities associated with the development of the three sites that may result in effects on ornithological receptors;
- Identification of potential ornithological receptors / designated sites;
- Identification of likely significant effects on ornithological receptors / designated sites, during the construction, operation and decommissioning stages of the development;
- Description of development activity in terms of whether the effect is likely to be positive or negative, along with its magnitude, extent, duration, reversibility, timing and frequency;
- Characterisation of effect, including the risk / likelihood of its occurrence;
- Assessment of whether the likely (pre–mitigation) effects are ecologically significant and the geographical scale at which they are predicted to occur, including an indication of certainty in the predictions made;
- Provision of details of proposed mitigation (if applicable);
- Assessment of whether the residual (with mitigation) effects are ecologically significant and the geographical scale at which they are predicted to occur, including an indication of certainty in the predictions made; and
- Assessment of cumulative effects (with mitigation) (reported in ES Chapter 14.4).

Table 118. Definition of terms.

Term	Definition
Magnitude	The size of the effect, e.g. the number of individuals predicted to be affected.
Extent	The area over which the effect is predicted to occur.
Duration	The period of time over which the effect is predicted to occur: short–term for those which occur for up to 1 year (e.g. within the construction phase); medium–term lasting for up to 5 years (e.g. due to habituation); long term for those lasting for the whole operational phase, and permanent for those that are predicted to still be detectable after decommissioning (Wilhelmsson et al., 2010).
Reversibility	Whether the effect is predicted to be reversed, either through natural processes or mitigation.
Timing	The period of the year during which the activity would need to occur in order for the effect to occur.
Frequency	The frequency of the activity leading to the effect.
Risk	The likelihood that a particular effect will occur.

Ecological significance, in the context of the EIA Regulations, is used to describe the relative importance of a potential effect on a feature of importance. An ecologically significant effect is an effect that has an effect on the integrity of the site or ecosystem. Site integrity is defined (with particular reference to sites protected by the EC Habitats Directive,) in Scottish Government guidance (Scottish Executive, 2000), as "*the coherence of its ecological structure and function, across its whole area, that enables it to sustain the habitat, complex of habitats and / or the levels of populations of the species for which it was classified*".

Assessment of Natura sites is undertaken by determining whether there will be an adverse effect on the integrity of the site, by looking at the potential effects on each of the site's Conservation Objectives.

The geographic scale at which the ecological significance of an effect operates is defined as:

- **International** – ornithological receptors subject to the potential effect are features of European–designated sites, i.e. SPAs (Special Protection Areas) or RAMSAR sites.
- **National** – ornithological receptors subject to the potential effect are features of UK–designated sites, i.e. SSSIs (Sites of Special Scientific Interest), UK BAP (Biodiversity Action Plan) species.
- **Regional** – ornithological receptors subject to the potential effect are of regional (Moray Firth) importance.
- **Local** – ornithological receptors subject to the potential effect are of local

(site) importance.

Certainty in predictions will use the following criteria (based on IEEM Guidance probabilities, with further justification of definitions):

- **Certain** (probability estimated at >95 %) – interactions are well understood and documented, i.e. receptor sensitivity has been investigated in relation to the potential impact, data have a comprehensive spatial coverage / resolution, and predictions relating to effect magnitude have been modelled and / or quantified.
- **Probable** (probability estimated at 50–95 %) – interactions are understood using some documented evidence, i.e. receptor sensitivity is derived from sources that consider the likely effects, data have a relatively moderate spatial coverage / resolution, and predictions relating to effect magnitude have been modelled but not validated.
- **Uncertain** (probability estimated at <50 %) – interactions are poorly understood and not documented, i.e. predictions relating to effect magnitude have not been modelled and are based on expert interpretation using little or no quantitative data.

6.2 Species for impact assessment

The species to be considered for the impact assessment have been determined based on the likelihood of the potential risks occurring, plus HRA where appropriate. A summary of these risks, along with whether they have been short-listed for inclusion in the impact assessment is provided in Table 119.

Definitions for the threat levels listed below are as follows:

- **Negligible** – threat will have no effect on the species.
- **Minor** – threat will have a small but acceptable threat on the species.
- **Moderate** – threat will affect the species to the extent that some mitigation may be necessary.
- **Major** –threat will have an unacceptable effect on the species.

Table 119. Summary of risks and shortlist status of all long-list species

Species	Collision	Disturbance/ Displacement	Barrier effects	Short-list
Seabirds				
Fulmar	Negligible	Minor	Minor	YES
Sooty shearwater	Negligible	Negligible	Negligible	NO

Table 119. Summary of risks and shortlist status of all long-list species

Species	**Collision**	**Disturbance/ Displacement**	**Barrier effects**	**Short-list**
Manx shearwater	Negligible	Negligible	Negligible	NO
European storm petrel	Negligible	Negligible	Minor	NO
Leach's petrel	Negligible	Negligible	Negligible	NO
Gannet	Moderate	Minor	Minor	YES
Cormorant	Negligible	Negligible	Negligible	NO
Shag	Negligible	Negligible	Minor	NO
Pomarine skua	Negligible	Negligible	Negligible	NO
Arctic skua	Negligible	Negligible	Negligible	NO
Long-tailed skua	Negligible	Negligible	Negligible	NO
Great skua	Negligible	Minor	Minor	NO
Kittiwake	Minor	Minor	Minor	YES
Black-headed gull	Negligible	Negligible	Negligible	NO
Common gull	Negligible	Negligible	Negligible	NO
Lesser black-backed gull	Negligible	Negligible	Negligible	NO
Herring gull	Moderate	Minor	Negligible	YES
Iceland gull	Negligible	Negligible	Negligible	NO
Great black-backed gull	Minor	Minor	Negligible	YES
Sandwich tern	Negligible	Negligible	Negligible	NO
Common tern	Negligible	Negligible	Negligible	NO
Arctic tern	Negligible	Minor	Negligible	NO
Guillemot	Negligible	Minor	Minor	YES
Razorbill	Negligible	Minor	Minor	YES
Black guillemot	Negligible	Negligible	Negligible	NO
Little auk	Negligible	Negligible	Negligible	NO
Puffin	Negligible	Minor	Minor	YES
Migrants				
Whooper swan	Minor	Negligible	Negligible	NO
Mute swan	Negligible	Negligible	Negligible	NO
Pink-footed goose	Minor	Negligible	Minor	YES
Greylag goose	Minor	Negligible	Minor	YES
Barnacle goose	Negligible	Negligible	Negligible	NO
Shelduck	Minor	Negligible	Minor	NO
Mallard	Minor	Negligible	Minor	NO

Table 119. Summary of risks and shortlist status of all long-list species

Species	Collision	Disturbance/ Displacement	Barrier effects	Short-list
Gadwall	Negligible	Negligible	Negligible	NO
Shoveler	Negligible	Negligible	Negligible	NO
Pintail	Negligible	Negligible	Negligible	NO
Wigeon	Minor	Negligible	Minor	NO
Teal	Minor	Negligible	Minor	NO
Tufted duck	Minor	Negligible	Minor	NO
Scaup	Negligible	Negligible	Negligible	NO
Pochard	Negligible	Negligible	Negligible	NO
Eider	Negligible	Negligible	Negligible	NO
Common scoter	Minor	Minor	Minor	NO
Velvet scoter	Minor	Minor	Minor	NO
Long-tailed duck	Minor	Minor	Minor	NO
Goldeneye	Negligible	Negligible	Negligible	NO
Red-breasted merganser	Minor	Minor	Minor	NO
Red-throated diver	Minor	Minor	Minor	NO
Black-throated diver	Negligible	Negligible	Negligible	NO
Great northern diver	Minor	Minor	Minor	NO
Osprey	Negligible	Negligible	Negligible	NO
Marsh harrier	Negligible	Negligible	Negligible	NO
Sparrowhawk	Negligible	Negligible	Negligible	NO
Kestrel	Negligible	Negligible	Negligible	NO
Peregrine	Negligible	Negligible	Negligible	NO
Merlin	Negligible	Negligible	Negligible	NO
Oystercatcher	Minor	Minor	Minor	NO
Ringed plover	Minor	Minor	Minor	NO
Dotterel	Negligible	Negligible	Negligible	NO
Golden plover	Minor	Minor	Minor	NO
Grey plover	Negligible	Negligible	Negligible	NO
Lapwing	Minor	Minor	Minor	NO
Knot	Negligible	Negligible	Negligible	NO
Sanderling	Minor	Minor	Minor	NO
Purple sandpiper	Minor	Minor	Minor	NO
Dunlin	Minor	Minor	Minor	NO
Turnstone	Negligible	Negligible	Negligible	NO
Common sandpiper	Negligible	Negligible	Negligible	NO
Redshank	Minor	Minor	Minor	NO

Table 119. Summary of risks and shortlist status of all long-list species

Species	Collision	Disturbance/ Displacement	Barrier effects	Short-list
Black-tailed godwit	Negligible	Negligible	Negligible	NO
Bar-tailed godwit	Negligible	Negligible	Negligible	NO
Curlew	Minor	Minor	Minor	NO
Whimbrel	Minor	Minor	Minor	NO
Ruff	Negligible	Negligible	Negligible	NO
Snipe	Negligible	Negligible	Negligible	NO
Jack snipe	Negligible	Negligible	Negligible	NO
Red-necked phalarope	Negligible	Negligible	Negligible	NO
Woodcock	Negligible	Negligible	Negligible	NO
Woodpigeon	Negligible	Negligible	Negligible	NO
Collared dove	Negligible	Negligible	Negligible	NO
Cuckoo	Negligible	Negligible	Negligible	NO
Short-eared owl	Negligible	Negligible	Negligible	NO
Swift	Negligible	Negligible	Negligible	NO
Skylark	Minor	Minor	Minor	NO
Sand martin	Minor	Minor	Minor	NO
House martin	Minor	Minor	Minor	NO
Swallow	Minor	Minor	Minor	NO
Meadow pipit	Minor	Minor	Minor	NO
Tree pipit	Minor	Minor	Minor	NO
Rock pipit	Minor	Minor	Minor	NO
White wagtail	Minor	Minor	Minor	NO
Waxwing	Minor	Minor	Minor	NO
Robin	Minor	Minor	Minor	NO
Wheatear	Minor	Minor	Minor	NO
Redstart	Minor	Minor	Minor	NO
Whinchat	Minor	Minor	Minor	NO
Song thrush	Minor	Minor	Minor	NO
Redwing	Minor	Minor	Minor	NO
Fieldfare	Minor	Minor	Minor	NO
Ring ouzel	Minor	Minor	Minor	NO
Blackbird	Minor	Minor	Minor	NO
Blackcap	Minor	Minor	Minor	NO
Whitethroat	Minor	Minor	Minor	NO
Willow warbler	Minor	Minor	Minor	NO
Chiffchaff	Minor	Minor	Minor	NO
Sedge warbler	Minor	Minor	Minor	NO

Table 119. Summary of risks and shortlist status of all long-list species

Species	**Collision**	**Disturbance/ Displacement**	**Barrier effects**	**Short-list**
Grasshopper warbler	Minor	Minor	Minor	NO
Spotted flycatcher	Minor	Minor	Minor	NO
Pied flycatcher	Minor	Minor	Minor	NO
Starling	Minor	Minor	Minor	NO
Chaffinch	Minor	Minor	Minor	NO
Carrion crow	Minor	Minor	Minor	NO
Jackdaw	Minor	Minor	Minor	NO
Brambling	Minor	Minor	Minor	NO
Siskin	Minor	Minor	Minor	NO
Lesser redpoll	Minor	Minor	Minor	NO
Common crossbill	Minor	Minor	Minor	NO
Snow bunting	Minor	Minor	Minor	NO

Therefore, in summary, the species to be considered for the impact assessment for the three proposed wind farm sites are pink-footed goose, greylag goose, fulmar, gannet, kittiwake, herring gull, great black-backed gull, guillemot, razorbill, and puffin.

In addition, an impact assessment is undertaken for the offshore transmission infrastructure for fulmar, gannet, eider, long-tailed duck, common scoter, velvet scoter, red-throated diver, great northern diver, kittiwake, herring gull, great black-backed gull, guillemot, razorbill, and puffin. The additional species were selected due to the cable route including near-shore areas.

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TELFORD, STEVENSON, MACCOLL WIND FARMS AND ASSOCIATED TRANSMISSION INFRASTRUCTURE ENVIRONMENTAL STATEMENT

Ornithology Technical Report: Appendix A

Population Viability Analysis outputs for SPA species

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CONTENTS

KEY TO ACRONYMS USED IN GRAPHS

M-RA: number of birds predicted to be displaced per year based on data for MORL using the Realistic Approach displacement calculation and considering only birds observed on the sea to be at risk of displacement

M-WCS: number of birds predicted to be displaced per year based on data for MORL using the Worst Case Scenario displacement calculation and considering only birds observed on the sea to be at risk of displacement

M-RA-F: number of birds predicted to be displaced per year based on data for MORL using the Realistic Approach displacement calculation and including displacement of birds in flight

M-WCS-F: number of birds predicted to be displaced per year based on data for MORL using the Worst Case Scenario displacement calculation and including displacement of birds in flight

B-RA: number of birds predicted to be displaced per year based on data for BOWL and MORL combined using the Realistic Approach displacement calculation and considering only birds observed on the sea to be at risk of displacement

B-WCS: number of birds predicted to be displaced per year based on data for BOWL and MORL combined using the Worst Case Scenario displacement calculation and considering only birds observed on the sea to be at risk of displacement

B-RA-F: number of birds predicted to be displaced per year based on data for BOWL and MORL combined using the Realistic Approach displacement calculation and including displacement of birds in flight

B-WCS-F: number of birds predicted to be displaced per year based on data for BOWL and MORL combined using the Worst Case Scenario displacement calculation and including displacement of birds in flight

M-95: number of annual collisions predicted based on data for MORL, assuming a 95% avoidance rate

M-98: number of annual collisions predicted based on data for MORL, assuming a 98% avoidance rate

M-99: number of annual collisions predicted based on data for MORL, assuming a 99% avoidance rate

M-99.5: number of annual collisions predicted based on data for MORL, assuming a 99.5% avoidance rate

B-95: number of annual collisions predicted based on data for BOWL and MORL combined, assuming a 95% avoidance rate

B-98: number of annual collisions predicted based on data for BOWL and MORL combined, assuming a 98% avoidance rate

B-99: number of annual collisions predicted based on data for BOWL and MORL combined, assuming a 99% avoidance rate

B-99.5: number of annual collisions predicted based on data for BOWL and MORL combined, assuming a 99.5% avoidance rate

FULMAR

EAST CAITHNESS CLIFFS

DISPLACEMENT

Graph A1a

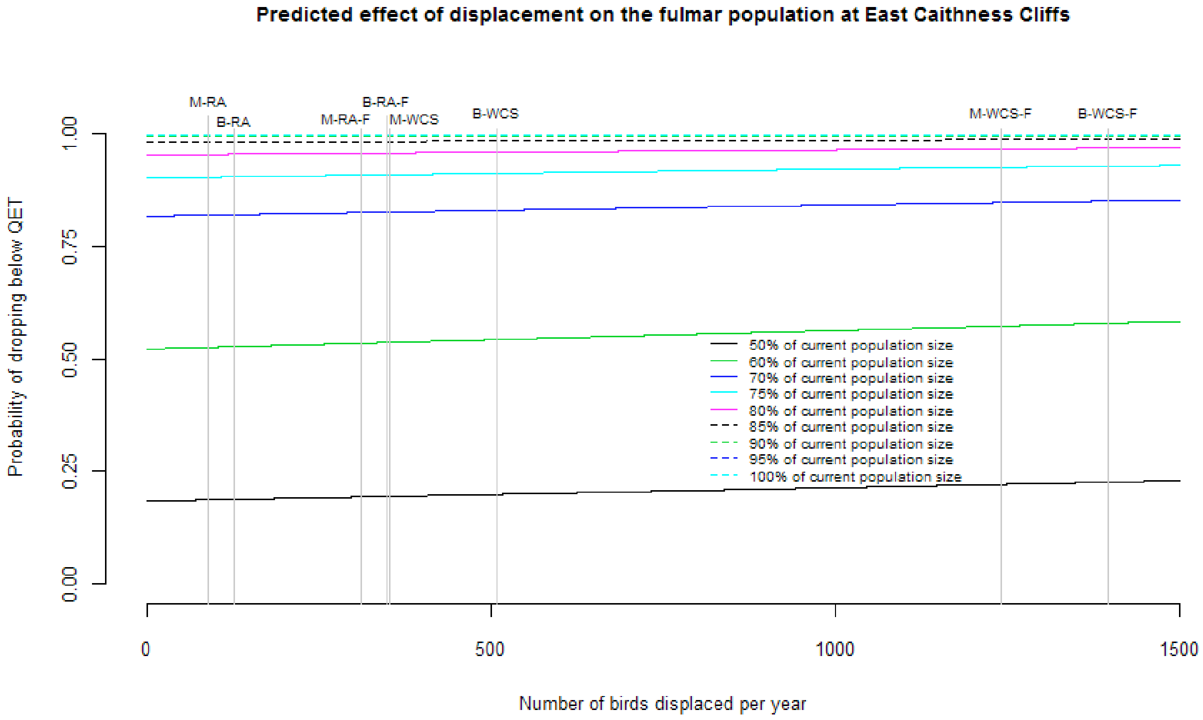
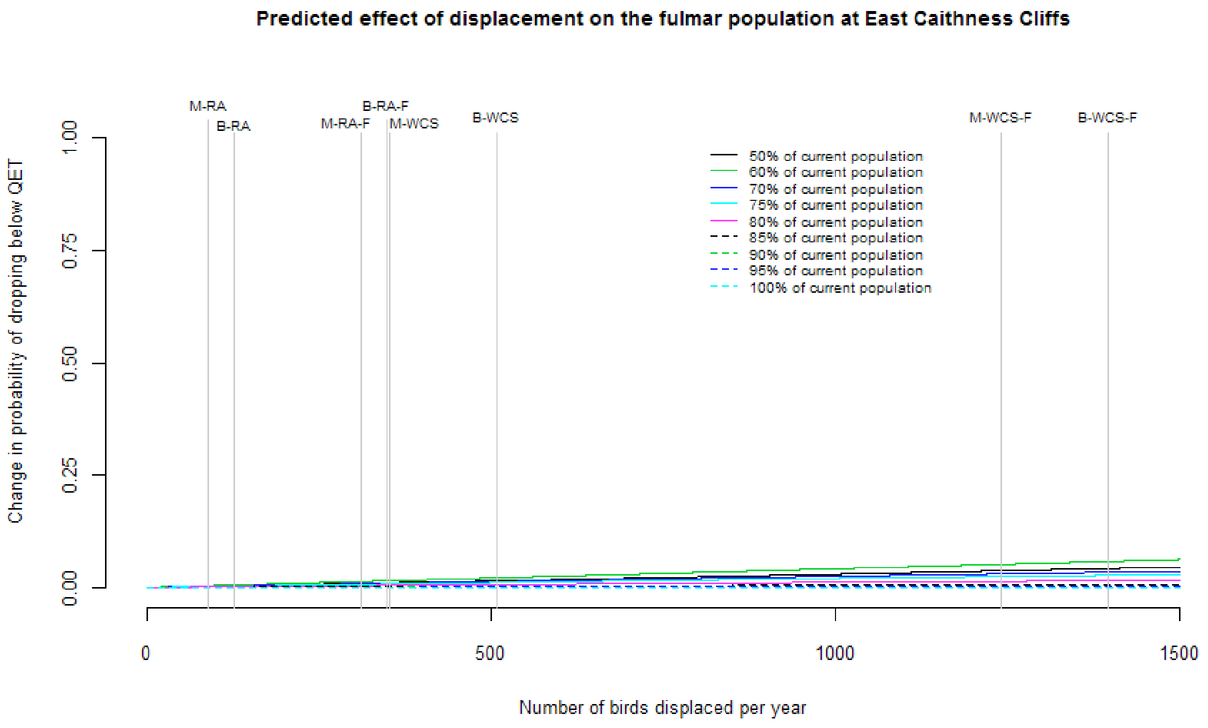


Table A1. Probability of population change from displacement of Fulmar at East Caithness Cliffs SPA.

Site	Displacement rate	Number displaced	Probability of dropping below percentage of current population size								
			50%	60%	70%	75%	80%	85%	90%	95%	100%
3 sites (primary assessment)	Baseline	0	0.183	0.522	0.818	0.902	0.954	0.982	0.994	0.998	1.000
3 sites (primary assessment)	WCS	352	0.193	0.536	0.826	0.910	0.958	0.984	0.995	0.998	1.000
3 sites (primary assessment)	RA	88	0.186	0.525	0.820	0.904	0.955	0.982	0.994	0.998	1.000
3 sites (primary assessment)	WCS flight	1240	0.220	0.572	0.847	0.926	0.967	0.987	0.996	0.999	1.000
3 sites (primary assessment)	RA flight	310	0.192	0.534	0.825	0.909	0.958	0.984	0.995	0.998	1.000
MacColl	WCS	122	0.187	0.527	0.821	0.905	0.955	0.983	0.994	0.998	1.000
MacColl	RA	31	0.184	0.523	0.818	0.903	0.954	0.982	0.994	0.998	1.000
MacColl	WCS flight	461	0.196	0.541	0.829	0.912	0.959	0.984	0.995	0.999	1.000
MacColl	RA flight	115	0.187	0.526	0.820	0.905	0.955	0.983	0.994	0.998	1.000
Telford	WCS	87	0.186	0.525	0.820	0.904	0.955	0.982	0.994	0.998	1.000
Telford	RA	22	0.184	0.522	0.818	0.903	0.954	0.982	0.994	0.998	1.000
Telford	WCS flight	432	0.196	0.539	0.828	0.911	0.959	0.984	0.995	0.999	1.000
Telford	RA flight	108	0.186	0.526	0.820	0.904	0.955	0.983	0.994	0.998	1.000
Stevenson	WCS	143	0.187	0.527	0.821	0.905	0.956	0.983	0.994	0.998	1.000
Stevenson	RA	36	0.184	0.523	0.818	0.903	0.954	0.982	0.994	0.998	1.000
Stevenson	WCS flight	348	0.193	0.536	0.826	0.909	0.958	0.984	0.995	0.998	1.000
Stevenson	RA flight	87	0.186	0.525	0.820	0.904	0.955	0.982	0.994	0.998	1.000

MacColl and Stevenson	WCS	265	0.191	0.533	0.824	0.908	0.957	0.983	0.994	0.998	1.000
MacColl and Stevenson	RA	66	0.185	0.524	0.819	0.904	0.955	0.982	0.994	0.998	1.000
MacColl and Stevenson	WCS flight	808	0.207	0.555	0.838	0.918	0.963	0.986	0.995	0.999	1.000
MacColl and Stevenson	RA flight	202	0.189	0.530	0.823	0.906	0.956	0.983	0.994	0.998	1.000
Stevenson and Telford	WCS	230	0.190	0.531	0.823	0.907	0.957	0.983	0.994	0.998	1.000
Stevenson and Telford	RA	57	0.185	0.524	0.819	0.903	0.955	0.982	0.994	0.998	1.000
Stevenson and Telford	WCS flight	780	0.206	0.554	0.837	0.918	0.963	0.986	0.995	0.999	1.000
Stevenson and Telford	RA flight	195	0.189	0.530	0.823	0.906	0.956	0.983	0.994	0.998	1.000
Telford and MacColl	WCS	209	0.189	0.530	0.823	0.907	0.956	0.983	0.994	0.998	1.000
Telford and MacColl	RA	52	0.185	0.524	0.819	0.903	0.955	0.982	0.994	0.998	1.000
Telford and MacColl	WCS flight	893	0.209	0.558	0.840	0.920	0.964	0.986	0.996	0.999	1.000
Telford and MacColl	RA flight	223	0.190	0.531	0.823	0.907	0.957	0.983	0.994	0.998	1.000
BOWL	WCS	155	0.188	0.528	0.822	0.905	0.956	0.983	0.994	0.998	1.000
BOWL	RA	39	0.184	0.523	0.819	0.903	0.954	0.982	0.994	0.998	1.000
BOWL	WCS flight	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BOWL	RA flight	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BOWL and MORL	WCS	507	0.198	0.542	0.830	0.913	0.960	0.984	0.995	0.999	1.000
BOWL and MORL	RA	127	0.187	0.527	0.821	0.905	0.955	0.983	0.994	0.998	1.000
BOWL and MORL	WCS flight	1396	0.225	0.579	0.851	0.929	0.969	0.988	0.996	0.999	1.000
BOWL and MORL	RA flight	349	0.193	0.536	0.826	0.910	0.958	0.984	0.995	0.998	1.000

Graph A1b



COLLISION

Graph A2a

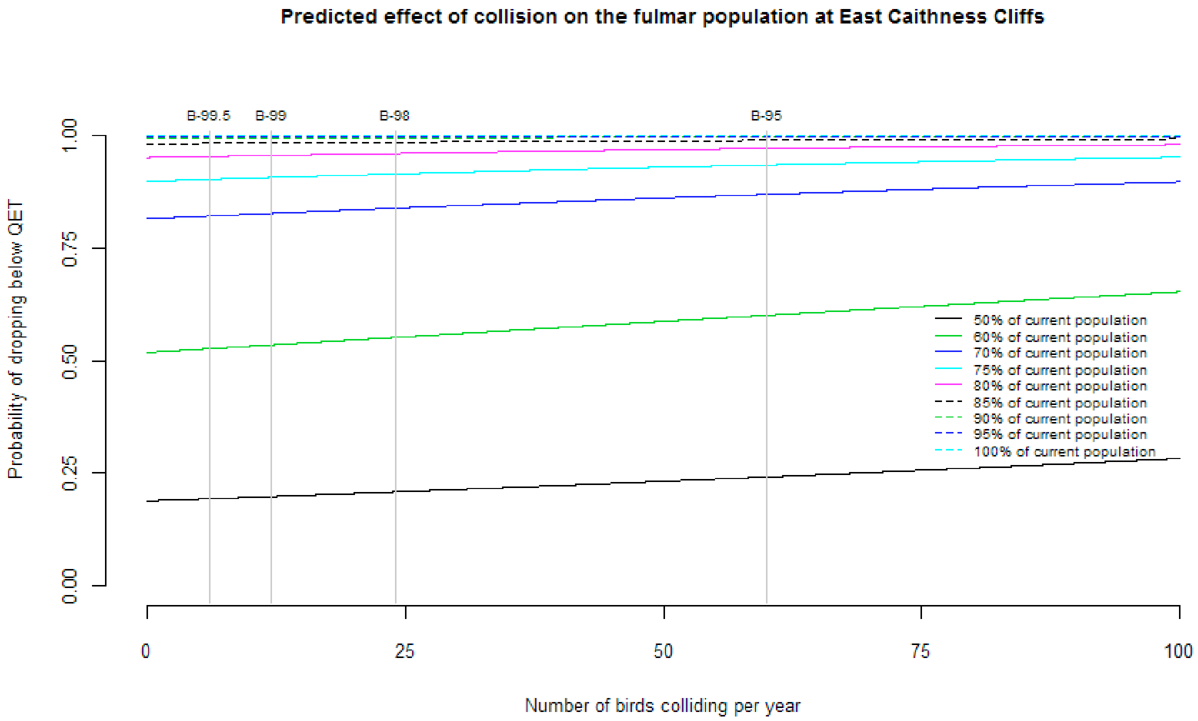
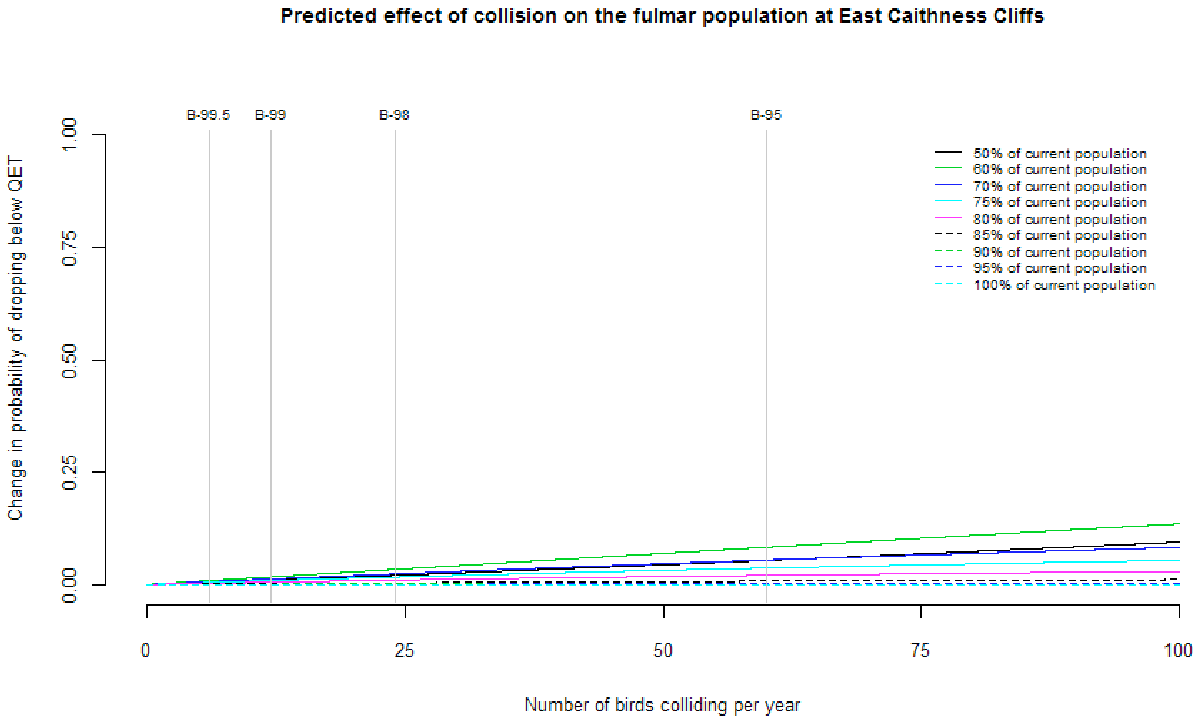


Table A2. Probability of population change from collision of Fulmar from East Caithness Cliffs SPA.

Site	Avoidance Rate	Number Colliding	Probability of dropping below percentage of current population size								
			50%	60%	70%	75%	80%	85%	90%	95%	100%
BOWL and MORL	Baseline	0	0.198	0.550	0.836	0.907	0.956	0.985	0.995	0.998	1.000
BOWL and MORL	95%	60	0.241	0.601	0.870	0.936	0.972	0.991	0.997	0.999	1.000
BOWL and MORL	98%	24	0.208	0.552	0.839	0.916	0.962	0.987	0.996	0.998	1.000
BOWL and MORL	99%	12	0.198	0.535	0.828	0.908	0.957	0.985	0.995	0.998	1.000
BOWL and MORL	99.50%	6	0.193	0.527	0.822	0.904	0.955	0.984	0.995	0.998	1.000

Graph A2b


Predicted effect of collision on the fulmar population at East Caithness Cliffs
B-99.5
B-99
B-98
B-95
50% of current population
60% of current population
70% of current population
75% of current population
80% of current population
85% of current population
90% of current population
95% of current population
100% of current population
Change in probability of dropping below QET
0.00
0.25
0.50
0.75
1.00
0
25
50
75
100
Number of birds colliding per year

COLLISION AND DISPLACEMENT – WORST CASE SCENARIO

Graph A3a

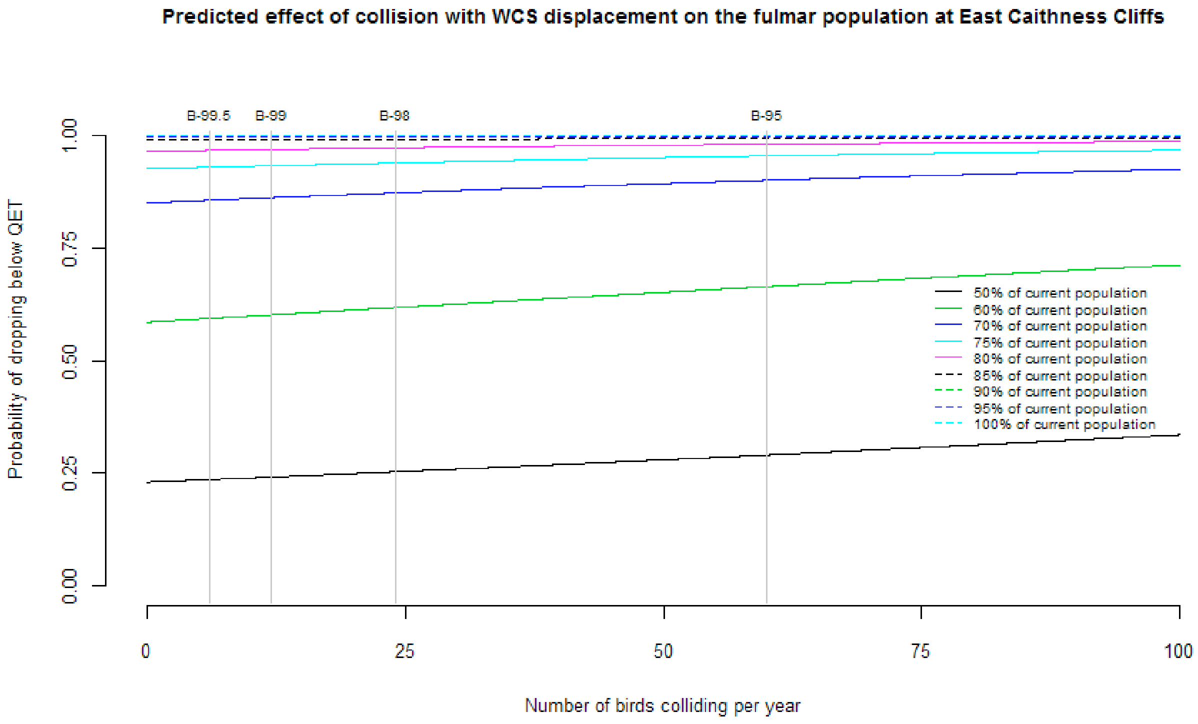
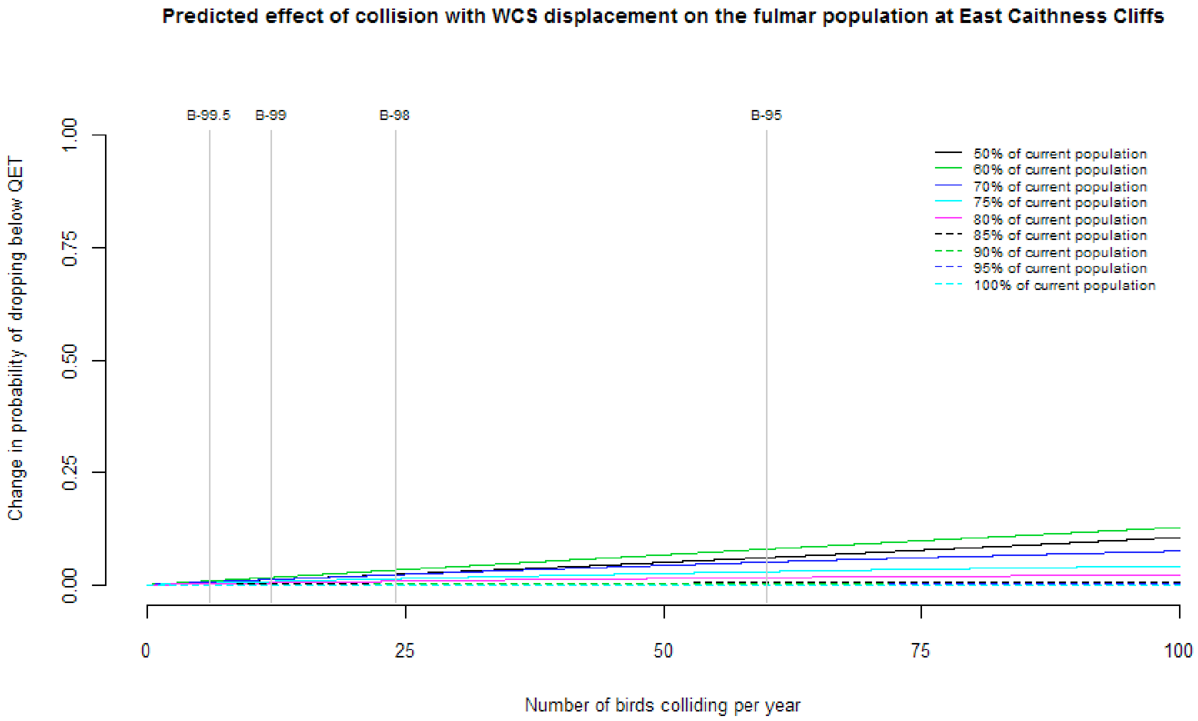


Table A3. Probability of population change from combined displacement and collision effects of fulmar from East Caithness Cliffs SPA using the Worst Case Scenario displacement rate including birds detected in flight.

Site	Number Displaced	Avoidance Rate	Number Colliding	Probability of dropping below percentage of current population size								
				50%	60%	70%	75%	80%	85%	90%	95%	100%
Baseline	0	N/A	0	0.230	0.586	0.851	0.927	0.966	0.990	0.997	0.999	1.000
BOWL and MORL	1396	95%	60	0.290	0.665	0.902	0.956	0.982	0.995	0.999	1.000	1.000
BOWL and MORL	1396	98%	24	0.253	0.618	0.874	0.940	0.974	0.993	0.998	0.999	1.000
BOWL and MORL	1396	99%	12	0.241	0.602	0.863	0.934	0.970	0.992	0.997	0.999	1.000
BOWL and MORL	1396	99.50%	6	0.235	0.594	0.857	0.931	0.968	0.991	0.997	0.999	1.000

Graph A3b


Predicted effect of collision with WCS displacement on the fulmar population at East Caithness Cliffs
B-99.5
B-99
B-98
B-95
50% of current population
60% of current population
70% of current population
75% of current population
80% of current population
85% of current population
90% of current population
95% of current population
100% of current population
Change in probability of dropping below QET
0.00
0.25
0.50
0.75
1.00
0
25
50
75
100
Number of birds colliding per year

Collision and Displacement – Realistic Approach

Graph A4a

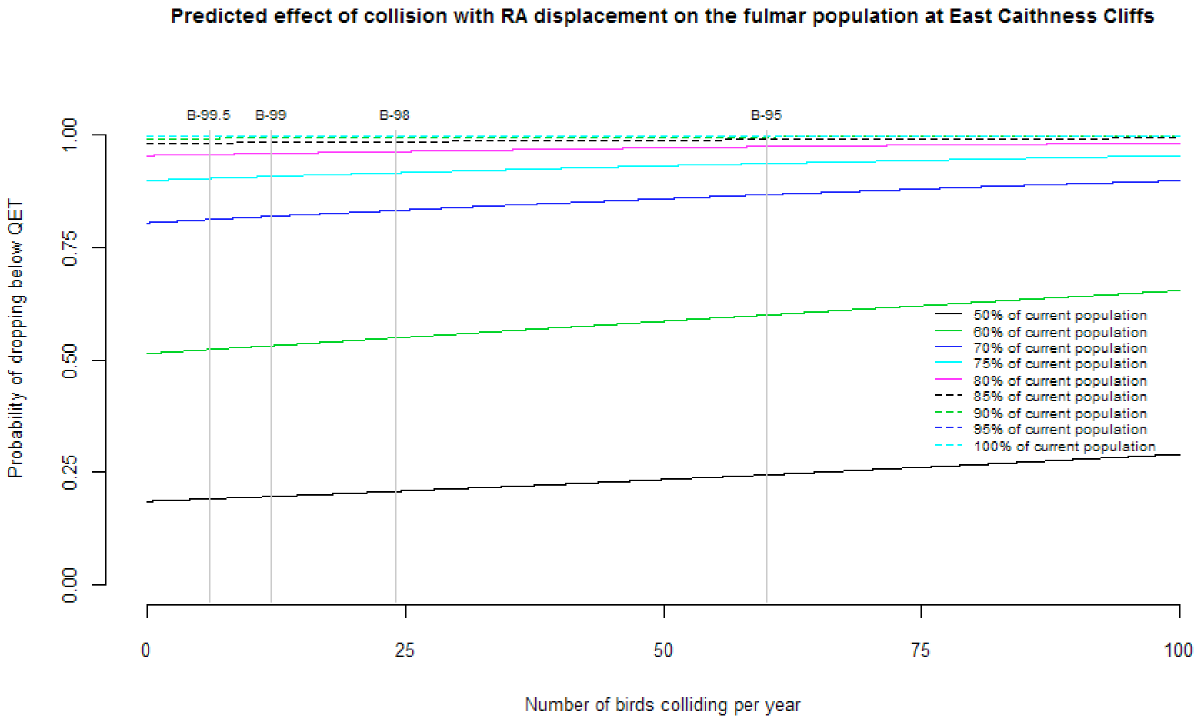
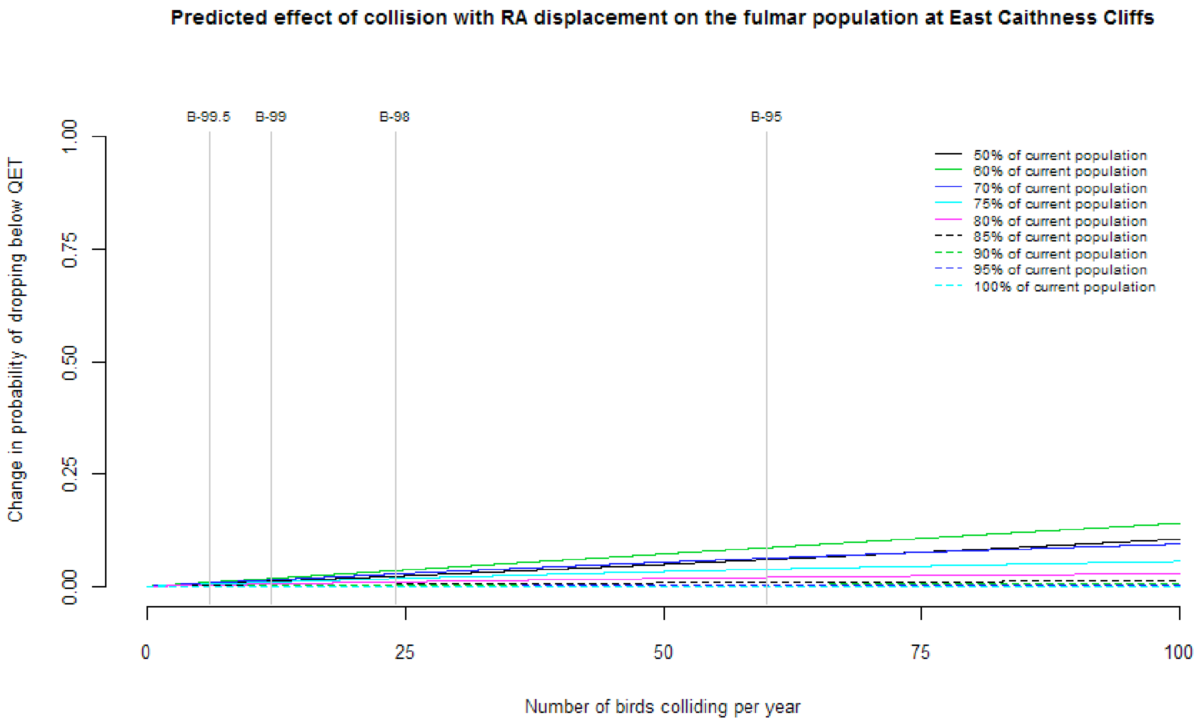


Table A4. Probability of population change from combined displacement and collision effects of fulmar from East Caithness Cliffs SPA using the Realistic Approach displacement rate including birds detected in flight.

Site	Number Displaced	Avoidance Rate	Number Colliding	Probability of dropping below percentage of current population size								
				50%	60%	70%	75%	80%	85%	90%	95%	100%
Baseline	0	N/A	0	0.185	0.514	0.806	0.900	0.955	0.982	0.993	0.998	1.000
BOWL and MORL	310	95%	60	0.244	0.600	0.868	0.938	0.975	0.991	0.997	0.999	1.000
BOWL and MORL	310	98%	24	0.207	0.549	0.833	0.917	0.964	0.986	0.995	0.998	1.000
BOWL and MORL	310	99%	12	0.196	0.532	0.820	0.909	0.960	0.985	0.994	0.998	1.000
BOWL and MORL	310	99.50%	6	0.190	0.523	0.813	0.904	0.958	0.984	0.993	0.998	1.000

Graph A4b


Predicted effect of collision with RA displacement on the fulmar population at East Caithness Cliffs
B-99.5
B-99
B-98
B-95
50% of current population
60% of current population
70% of current population
75% of current population
80% of current population
85% of current population
90% of current population
95% of current population
100% of current population
Change in probability of dropping below QET
0.00
0.25
0.50
0.75
1.00
0
25
50
75
100
Number of birds colliding per year

NORTH CAITHNESS CLIFFS

DISPLACEMENT

Graph A5a

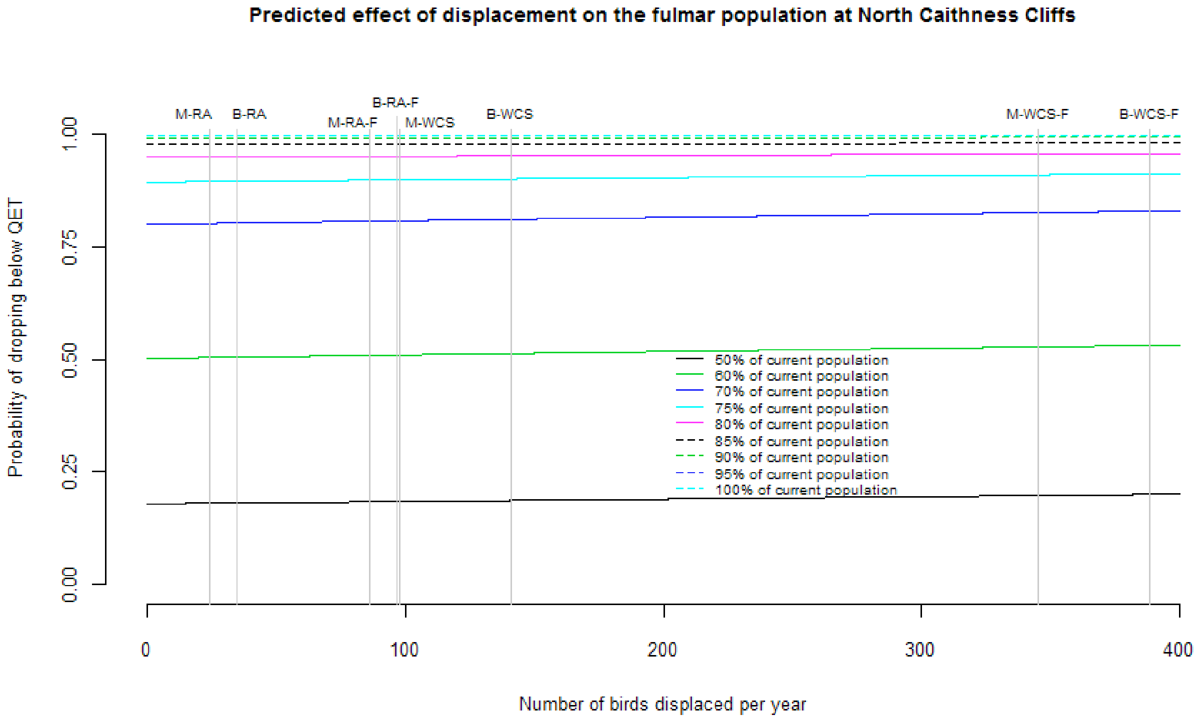
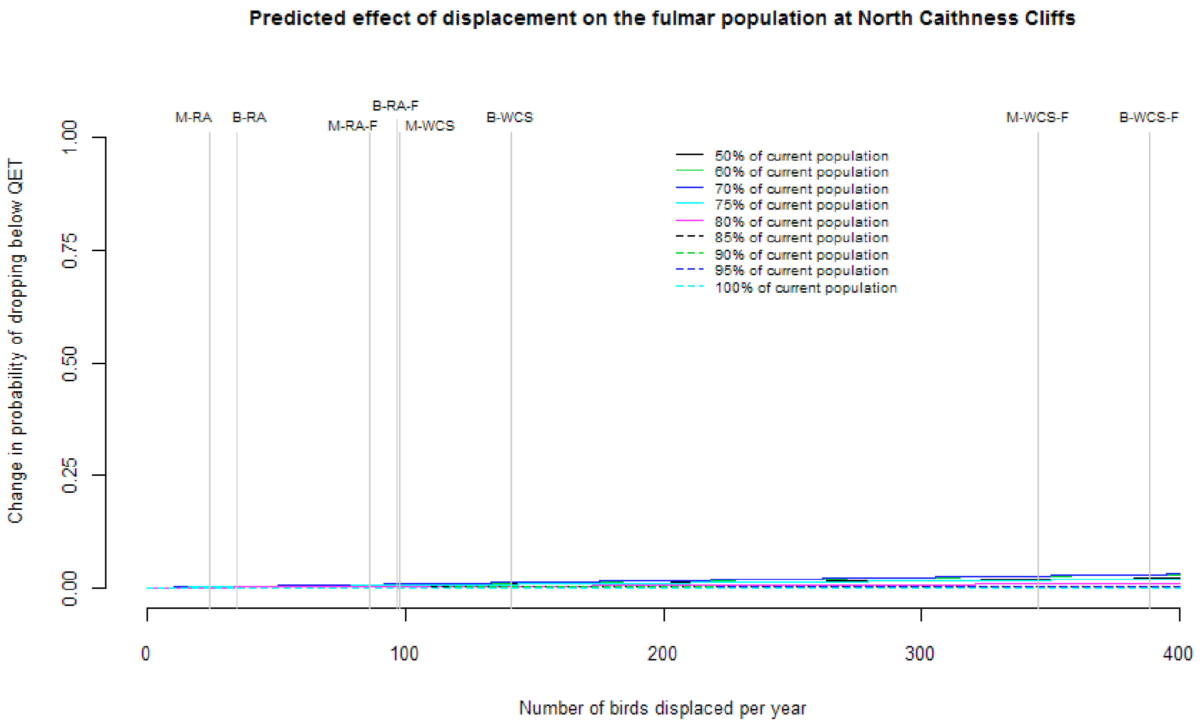


Table A5. Probability of population change from displacement of Fulmar at North Caithness Cliffs SPA

Site	Displacement rate	Number displaced	Probability of dropping below percentage of current population size								
			50%	60%	70%	75%	80%	85%	90%	95%	100%
3 sites (primary assessment)	Baseline	0	0.178	0.502	0.801	0.894	0.949	0.979	0.992	0.997	1.000
3 sites (primary assessment)	WCS	98	0.183	0.509	0.808	0.899	0.952	0.979	0.992	0.998	1.000
3 sites (primary assessment)	RA	24	0.179	0.504	0.802	0.895	0.950	0.979	0.992	0.997	1.000
3 sites (primary assessment)	WCS flight	345	0.196	0.527	0.826	0.911	0.957	0.981	0.994	0.998	1.000
3 sites (primary assessment)	RA flight	86	0.183	0.508	0.807	0.898	0.951	0.979	0.992	0.998	1.000
MacColl	WCS	34	0.180	0.505	0.803	0.896	0.950	0.979	0.992	0.997	1.000
MacColl	RA	9	0.179	0.503	0.801	0.895	0.950	0.979	0.992	0.997	1.000
MacColl	WCS flight	128	0.185	0.511	0.810	0.901	0.952	0.980	0.992	0.998	1.000
MacColl	RA flight	32	0.180	0.504	0.803	0.896	0.950	0.979	0.992	0.997	1.000
Telford	WCS	24	0.179	0.504	0.802	0.895	0.950	0.979	0.992	0.997	1.000
Telford	RA	6	0.179	0.503	0.801	0.894	0.950	0.979	0.992	0.997	1.000
Telford	WCS flight	120	0.184	0.511	0.810	0.900	0.952	0.980	0.992	0.998	1.000
Telford	RA flight	30	0.180	0.504	0.803	0.896	0.950	0.979	0.992	0.997	1.000
Stevenson	WCS	40	0.180	0.505	0.804	0.896	0.950	0.979	0.992	0.997	1.000

Stevenson	RA	10	0.179	0.503	0.801	0.895	0.950	0.979	0.992	0.997	1.000
Stevenson	WCS flight	97	0.183	0.509	0.808	0.899	0.952	0.979	0.992	0.998	1.000
Stevenson	RA flight	24	0.179	0.504	0.802	0.895	0.950	0.979	0.992	0.997	1.000
MacColl and Stevenson	WCS	74	0.182	0.508	0.806	0.898	0.951	0.979	0.992	0.998	1.000
MacColl and Stevenson	RA	18	0.179	0.503	0.802	0.895	0.950	0.979	0.992	0.997	1.000
MacColl and Stevenson	WCS flight	225	0.190	0.519	0.818	0.905	0.955	0.980	0.993	0.998	1.000
MacColl and Stevenson	RA flight	56	0.181	0.506	0.805	0.897	0.951	0.979	0.992	0.997	1.000
Stevenson and Telford	WCS	64	0.181	0.507	0.806	0.897	0.951	0.979	0.992	0.997	1.000
Stevenson and Telford	RA	16	0.179	0.503	0.802	0.895	0.950	0.979	0.992	0.997	1.000
Stevenson and Telford	WCS flight	217	0.189	0.518	0.817	0.905	0.954	0.980	0.993	0.998	1.000
Stevenson and Telford	RA flight	54	0.181	0.506	0.805	0.897	0.951	0.979	0.992	0.997	1.000
Telford and MacColl	WCS	58	0.181	0.506	0.805	0.897	0.951	0.979	0.992	0.997	1.000
Telford and MacColl	RA	15	0.179	0.503	0.802	0.895	0.950	0.979	0.992	0.997	1.000
Telford and MacColl	WCS flight	248	0.191	0.520	0.819	0.906	0.955	0.981	0.993	0.998	1.000
Telford and MacColl	RA flight	62	0.181	0.507	0.805	0.897	0.951	0.979	0.992	0.997	1.000
BOWL	WCS	43	0.180	0.505	0.804	0.896	0.950	0.979	0.992	0.997	1.000
BOWL	RA	11	0.179	0.503	0.801	0.895	0.950	0.979	0.992	0.997	1.000
BOWL	WCS flight	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BOWL	RA flight	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BOWL and MORL	WCS	141	0.185	0.512	0.811	0.901	0.953	0.980	0.992	0.998	1.000
BOWL and MORL	RA	35	0.180	0.505	0.803	0.896	0.950	0.979	0.992	0.997	1.000
BOWL and MORL	WCS flight	388	0.198	0.531	0.829	0.913	0.958	0.981	0.994	0.998	1.000
BOWL and MORL	RA flight	97	0.183	0.509	0.808	0.899	0.952	0.979	0.992	0.998	1.000

Graph A5b



COLLISION

Graph A6a

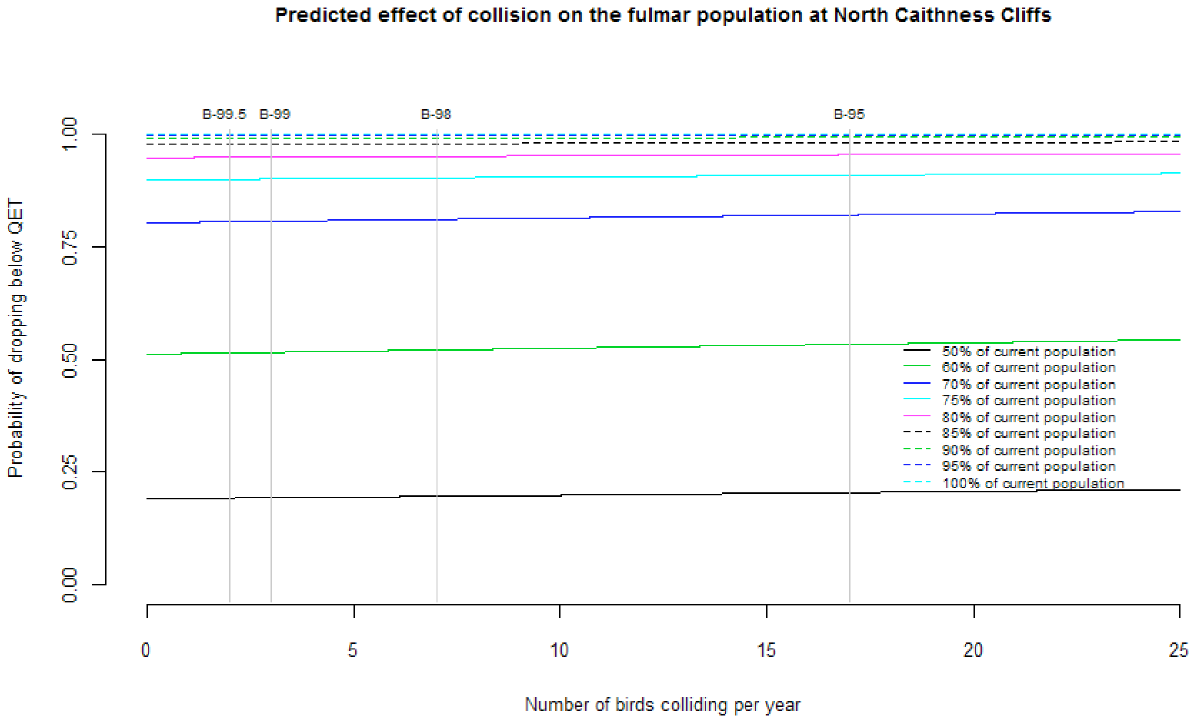
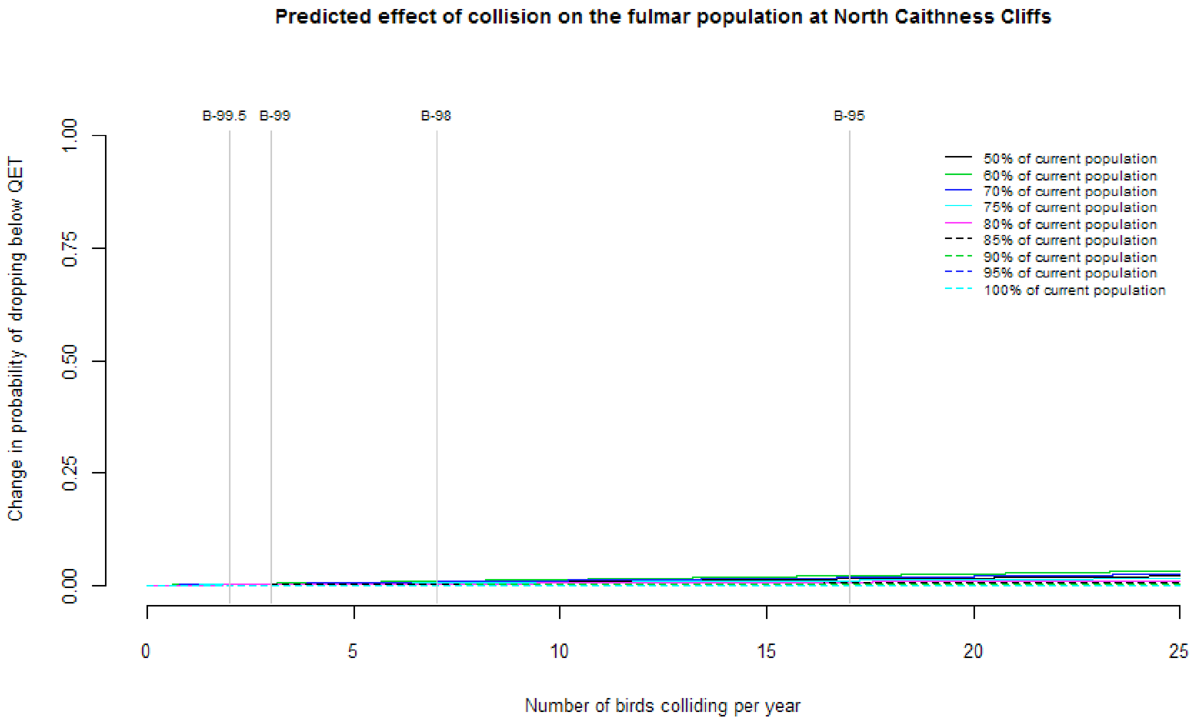


Table A6. Probability of population change from collision of Fulmar from North Caithness Cliffs SPA.

Site	Avoidance Rate	Number Colliding	Probability of dropping below percentage of current population size								
			50%	60%	70%	75%	80%	85%	90%	95%	100%
BOWL and MORL	Baseline	0	0.190	0.505	0.811	0.890	0.949	0.980	0.996	0.999	1.000
BOWL and MORL	95%	17	0.204	0.534	0.822	0.910	0.955	0.983	0.994	0.998	1.000
BOWL and MORL	98%	7	0.196	0.521	0.812	0.904	0.952	0.980	0.993	0.998	1.000
BOWL and MORL	99%	3	0.192	0.516	0.808	0.901	0.950	0.979	0.992	0.998	1.000
BOWL and MORL	99.50%	2	0.192	0.515	0.807	0.901	0.949	0.979	0.992	0.998	1.000

Graph A6b


Predicted effect of collision on the fulmar population at North Caithness Cliffs
B-99.5
B-99
B-98
B-95
50% of current population
60% of current population
70% of current population
75% of current population
80% of current population
85% of current population
90% of current population
95% of current population
100% of current population
Change in probability of dropping below QET
0.00
0.25
0.50
0.75
1.00
0
5
10
15
20
25
Number of birds colliding per year

COLLISION AND DISPLACEMENT – WORST CASE SCENARIO

Graph A7a

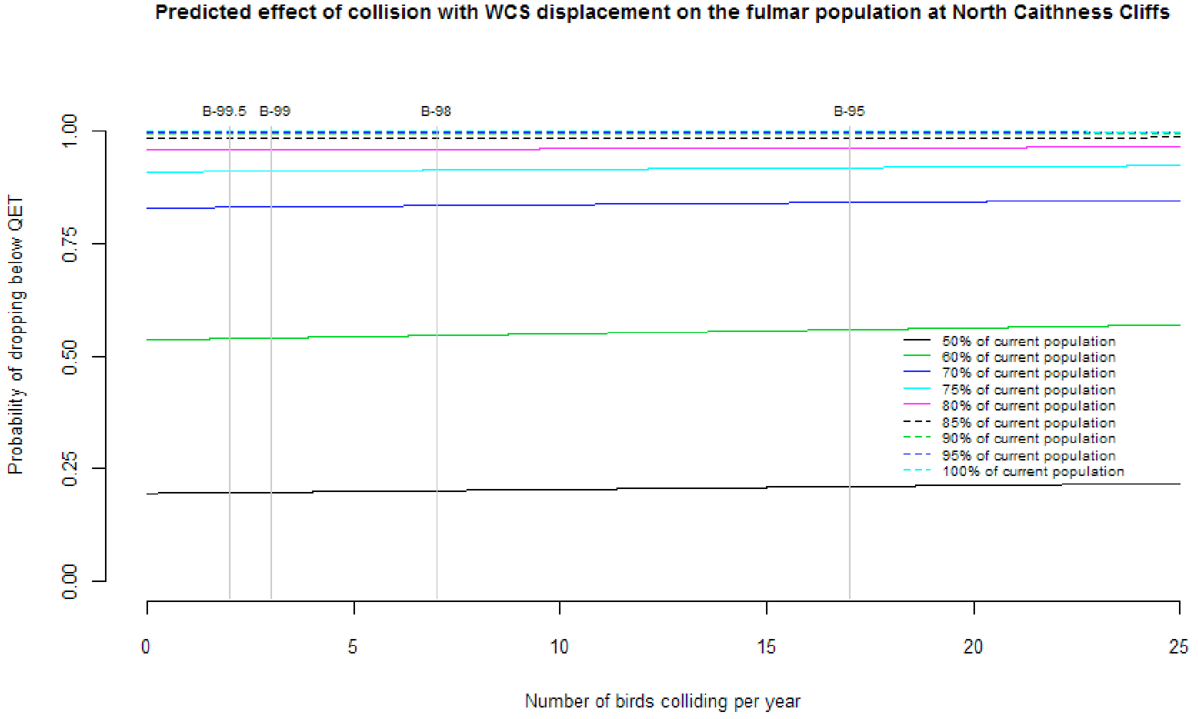
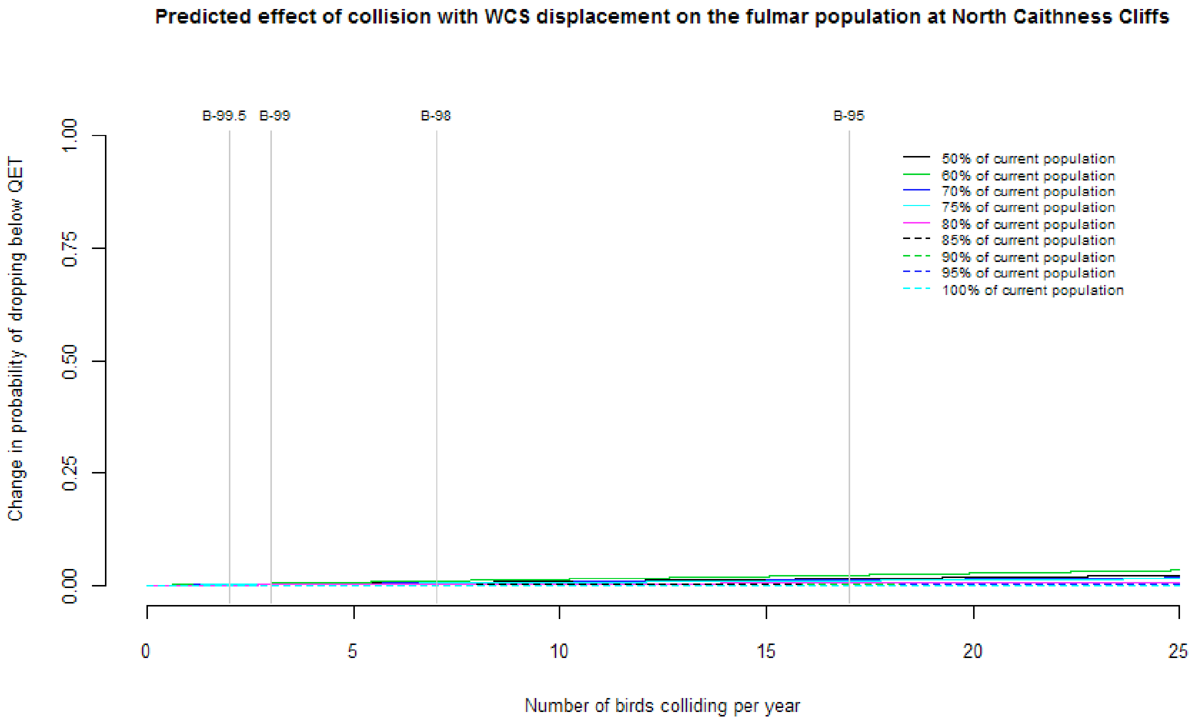


Table A7. Probability of population change from combined displacement and collision effects of fulmar from North Caithness Cliffs SPA using the Worst Case Scenario displacement not including birds detected in flight.

Site	Number Displaced	Avoidance Rate	Number Colliding	Probability of dropping below percentage of current population size								
				50%	60%	70%	75%	80%	85%	90%	95%	100%
BOWL and MORL	0	N/A	0	0.195	0.537	0.830	0.910	0.959	0.985	0.995	0.998	1.000
BOWL and MORL	388	95%	17	0.209	0.559	0.842	0.920	0.964	0.987	0.996	0.999	1.000
BOWL and MORL	388	98%	7	0.201	0.546	0.835	0.914	0.961	0.986	0.995	0.998	1.000
BOWL and MORL	388	99%	3	0.197	0.541	0.832	0.912	0.960	0.985	0.995	0.998	1.000
BOWL and MORL	388	99.50%	2	0.196	0.539	0.832	0.911	0.960	0.985	0.995	0.998	1.000

Graph A7b


Predicted effect of collision with WCS displacement on the fulmar population at North Caithness Cliffs
B-99.5
B-99
B-98
B-95
50% of current population
60% of current population
70% of current population
75% of current population
80% of current population
85% of current population
90% of current population
95% of current population
100% of current population
Change in probability of dropping below QET
0.00
0.25
0.50
0.75
1.00
0
5
10
15
20
25
Number of birds colliding per year

COLLISION AND DISPLACEMENT – REALISTIC APPROACH

Graph A8a

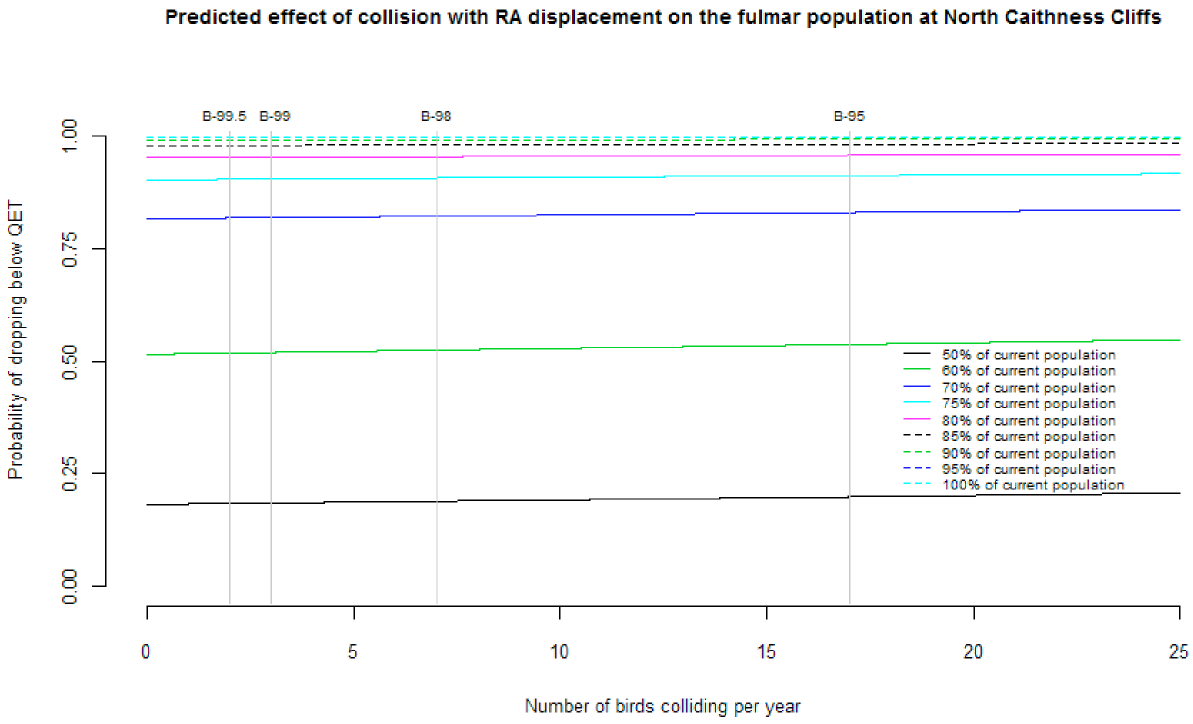
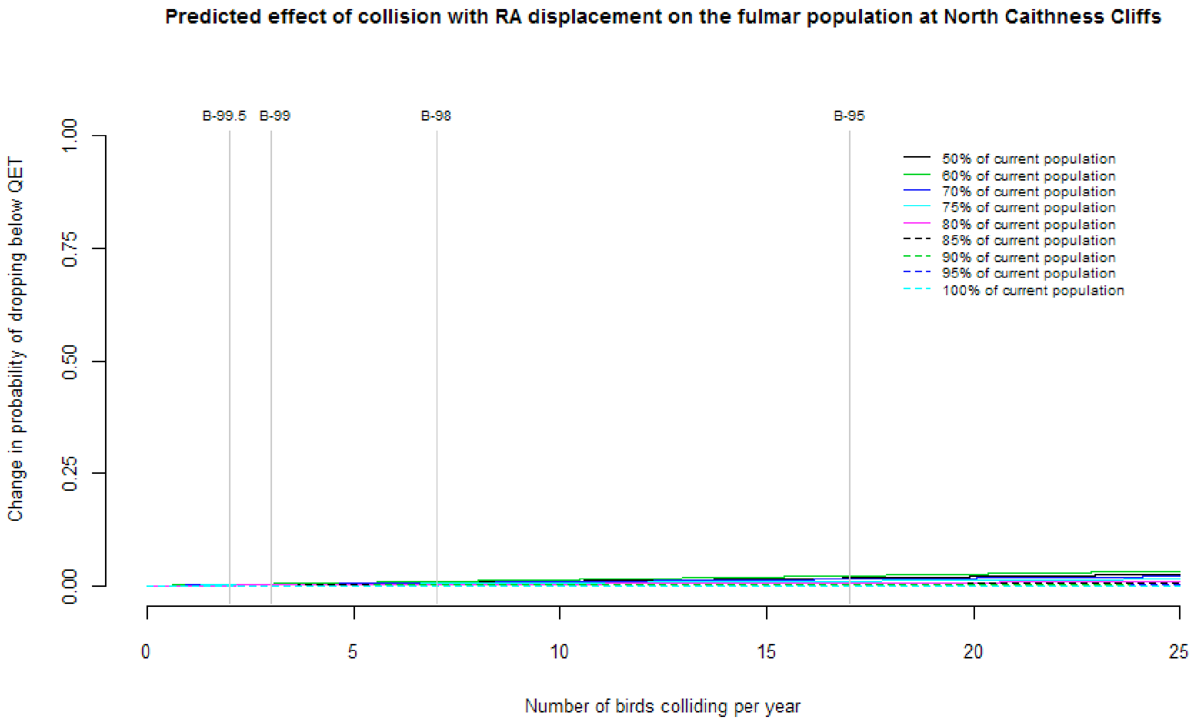


Table A8. Probability of population change from combined displacement and collision effects of fulmar from North Caithness Cliffs SPA using the Realistic Approach displacement rate not including birds detected in flight.

Site	Number Displaced	Avoidance Rate	Number Colliding	Probability of dropping below percentage of current population size								
				50%	60%	70%	75%	80%	85%	90%	95%	100%
Baseline	0	N/A	0	0.181	0.515	0.817	0.903	0.953	0.980	0.992	0.998	0.999
BOWL and MORL	86	95%	17	0.198	0.537	0.831	0.913	0.959	0.983	0.994	0.998	1.000
BOWL and MORL	86	98%	7	0.188	0.524	0.823	0.908	0.955	0.982	0.993	0.998	1.000
BOWL and MORL	86	99%	3	0.184	0.519	0.820	0.905	0.954	0.981	0.992	0.998	0.999
BOWL and MORL	86	99.50%	2	0.183	0.518	0.819	0.905	0.953	0.980	0.992	0.998	0.999

Graph A8b


Predicted effect of collision with RA displacement on the fulmar population at North Caithness Cliffs
B-99.5
B-99
B-98
B-95
50% of current population
60% of current population
70% of current population
75% of current population
80% of current population
85% of current population
90% of current population
95% of current population
100% of current population
Change in probability of dropping below QET
0.00
0.25
0.50
0.75
1.00
0
5
10
15
20
25
Number of birds colliding per year

TROUP HEAD

DISPLACEMENT

Graph A9a

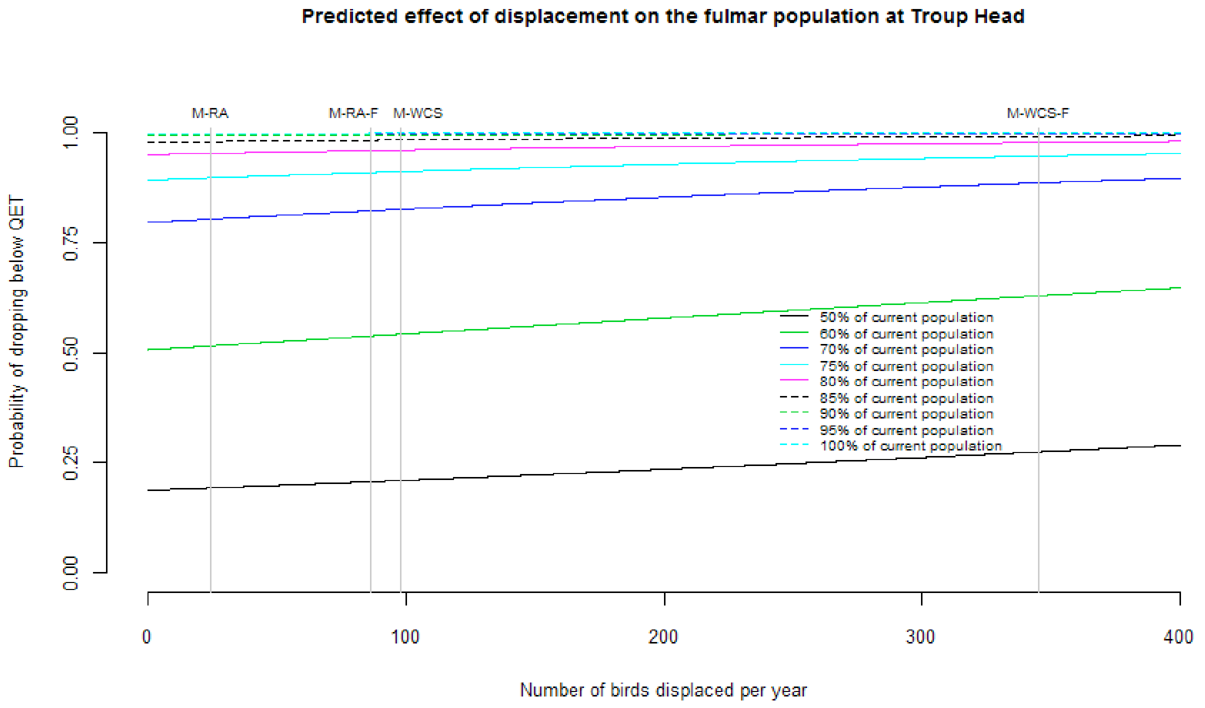
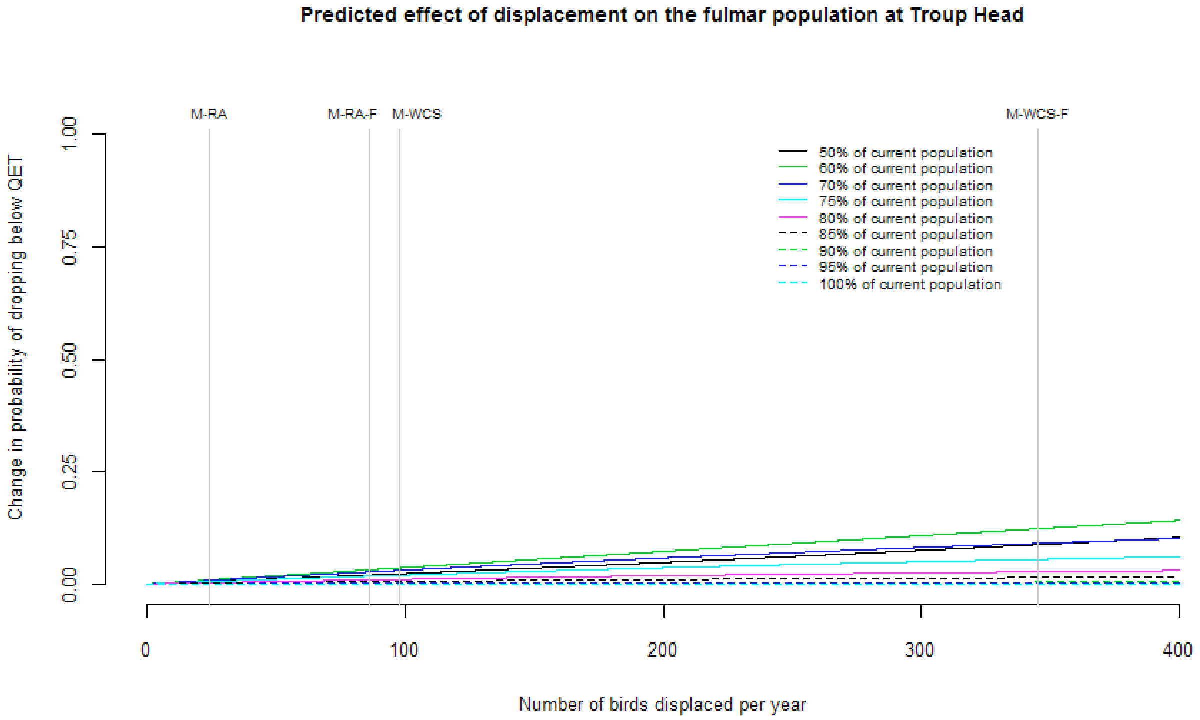


Table A9. Probability of population change from displacement of fulmar at Troup Head SPA.

Site	Displacement rate	Number displaced	Probability of dropping below percentage of current population size								
			50%	60%	70%	75%	80%	85%	90%	95%	100%
3 sites (primary assessment)	Baseline	0	0.187	0.507	0.797	0.893	0.951	0.979	0.994	0.997	1.000
3 sites (primary assessment)	WCS	98	0.209	0.542	0.827	0.913	0.961	0.984	0.995	0.999	1.000
3 sites (primary assessment)	RA	24	0.192	0.515	0.804	0.898	0.954	0.980	0.994	0.998	1.000
3 sites (primary assessment)	WCS flight	345	0.274	0.630	0.887	0.948	0.978	0.993	0.998	1.000	1.000
3 sites (primary assessment)	RA flight	86	0.206	0.538	0.823	0.910	0.960	0.984	0.995	0.999	1.000
MacColl	WCS	34	0.194	0.519	0.807	0.900	0.955	0.981	0.994	0.998	1.000
MacColl	RA	9	0.189	0.510	0.799	0.895	0.952	0.980	0.994	0.997	1.000
MacColl	WCS flight	128	0.216	0.553	0.835	0.918	0.964	0.986	0.996	0.999	1.000
MacColl	RA flight	32	0.194	0.518	0.807	0.900	0.955	0.981	0.994	0.998	1.000
Telford	WCS	24	0.192	0.515	0.804	0.898	0.954	0.980	0.994	0.998	1.000
Telford	RA	6	0.188	0.509	0.798	0.895	0.952	0.979	0.994	0.997	1.000
Telford	WCS flight	120	0.214	0.550	0.833	0.916	0.963	0.985	0.996	0.999	1.000
Telford	RA flight	30	0.193	0.518	0.806	0.900	0.955	0.981	0.994	0.998	1.000
Stevenson	WCS	40	0.196	0.521	0.809	0.902	0.956	0.981	0.994	0.998	1.000

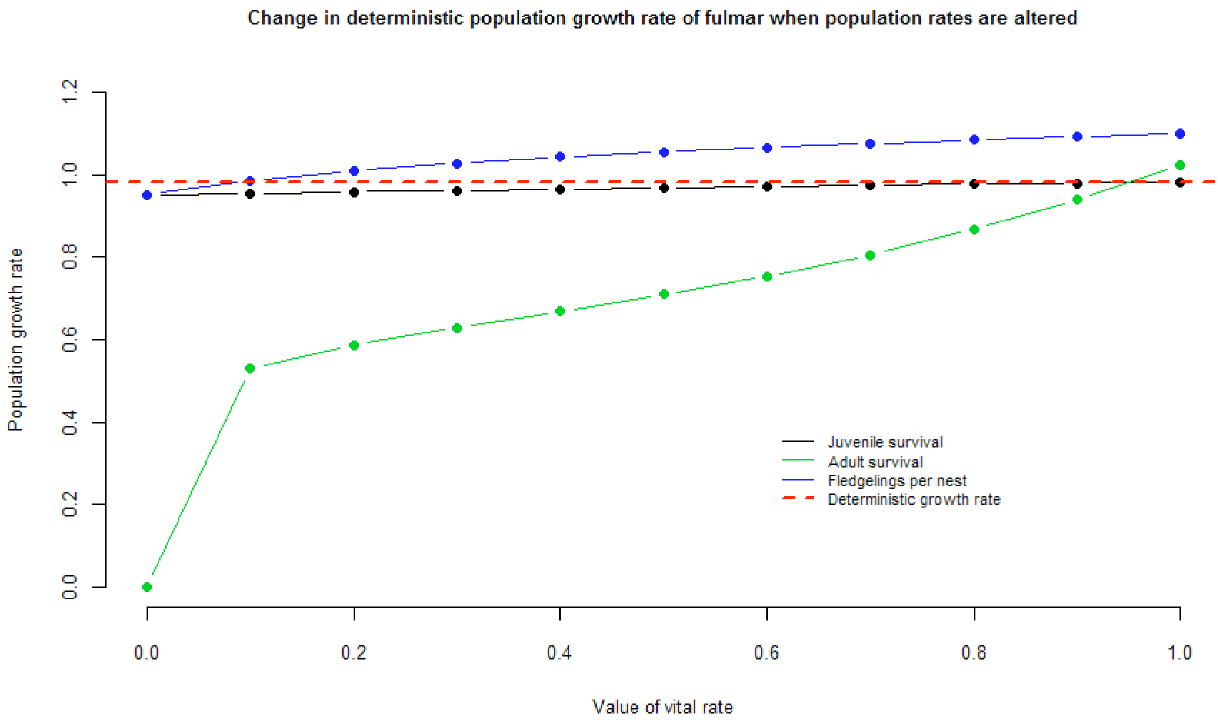
Stevenson	RA	10	0.189	0.510	0.800	0.895	0.952	0.980	0.994	0.997	1.000
Stevenson	WCS flight	97	0.209	0.542	0.826	0.912	0.961	0.984	0.995	0.999	1.000
Stevenson	RA flight	24	0.192	0.515	0.804	0.898	0.954	0.980	0.994	0.998	1.000
MacColl and Stevenson	WCS	74	0.203	0.534	0.820	0.908	0.959	0.983	0.995	0.999	1.000
MacColl and Stevenson	RA	18	0.191	0.513	0.802	0.897	0.953	0.980	0.994	0.998	1.000
MacColl and Stevenson	WCS flight	225	0.241	0.588	0.860	0.933	0.971	0.990	0.997	1.000	1.000
MacColl and Stevenson	RA flight	56	0.199	0.527	0.814	0.905	0.957	0.982	0.995	0.998	1.000
Stevenson and Telford	WCS	64	0.201	0.530	0.817	0.906	0.958	0.983	0.995	0.998	1.000
Stevenson and Telford	RA	16	0.190	0.513	0.802	0.897	0.953	0.980	0.994	0.998	1.000
Stevenson and Telford	WCS flight	217	0.239	0.585	0.858	0.932	0.971	0.989	0.997	1.000	1.000
Stevenson and Telford	RA flight	54	0.199	0.526	0.814	0.904	0.957	0.982	0.995	0.998	1.000
Telford and MacColl	WCS	58	0.200	0.528	0.815	0.905	0.957	0.982	0.995	0.998	1.000
Telford and MacColl	RA	15	0.190	0.512	0.801	0.896	0.953	0.980	0.994	0.998	1.000
Telford and MacColl	WCS flight	248	0.247	0.596	0.866	0.936	0.973	0.990	0.997	1.000	1.000
Telford and MacColl	RA flight	62	0.201	0.529	0.816	0.906	0.958	0.983	0.995	0.998	1.000
BOWL	WCS	0	0.187	0.507	0.797	0.893	0.951	0.979	0.994	0.997	1.000
BOWL	RA	0	0.187	0.507	0.797	0.893	0.951	0.979	0.994	0.997	1.000
BOWL	WCS flight	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BOWL	RA flight	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BOWL and MORL	WCS	98	0.209	0.542	0.827	0.913	0.961	0.984	0.995	0.999	1.000
BOWL and MORL	RA	24	0.192	0.515	0.804	0.898	0.954	0.980	0.994	0.998	1.000
BOWL and MORL	WCS flight	345	0.274	0.630	0.887	0.948	0.978	0.993	0.998	1.000	1.000
BOWL and MORL	RA flight	86	0.206	0.538	0.823	0.910	0.960	0.984	0.995	0.999	1.000

Graph A9b



SENSITIVITY

Graph A10



GANNET

TROUP HEAD

DISPLACEMENT

Graph A11a

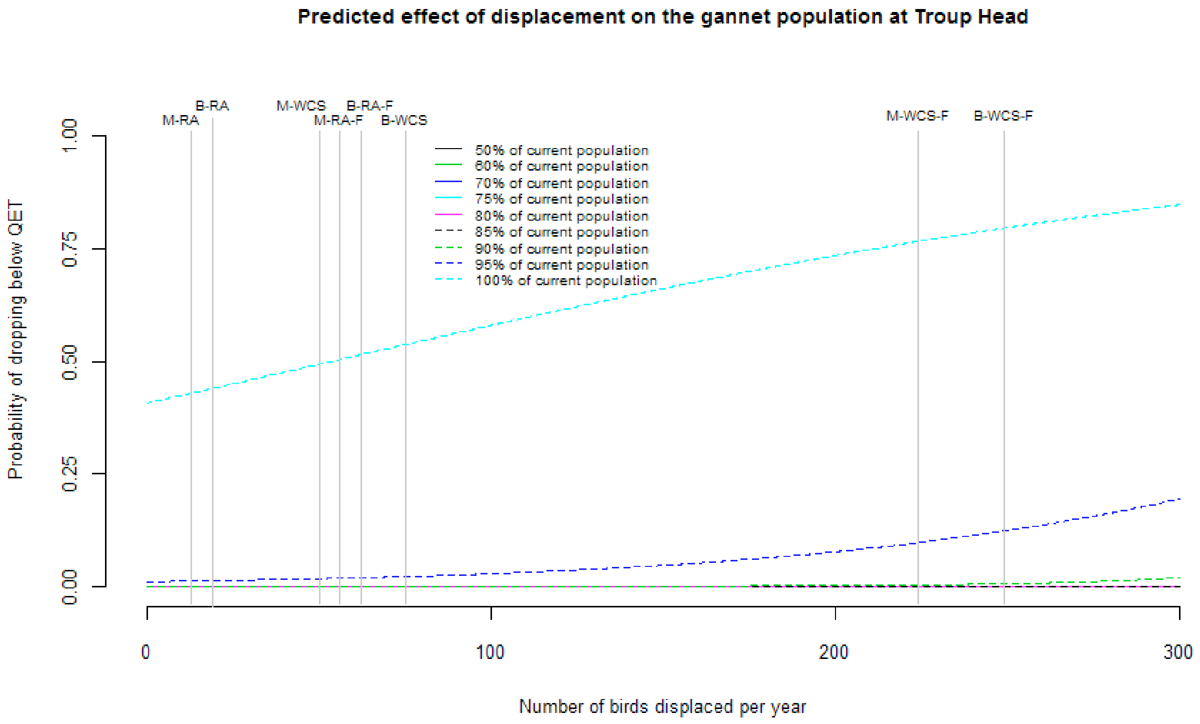
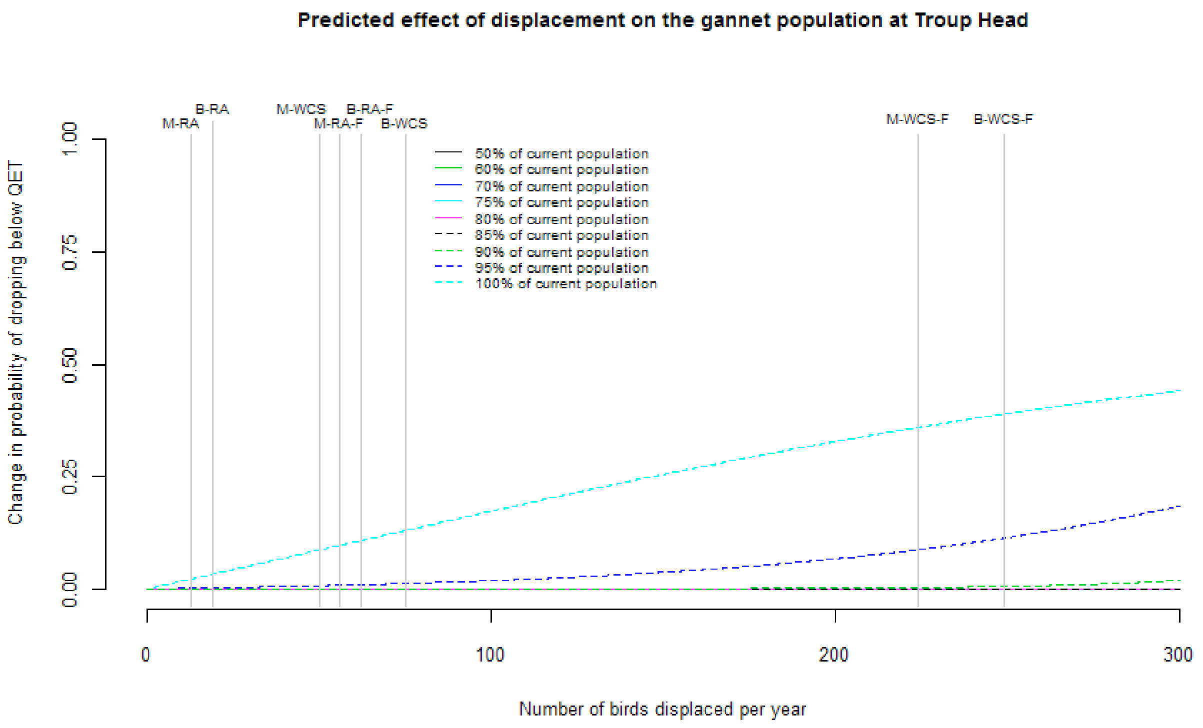


Table A11. Probability of population change from displacement of gannet at Troup Head SPA.

Site	Displacement rate	Number displaced	Probability of dropping below percentage of current population size								
			50%	60%	70%	75%	80%	85%	90%	95%	100%
3 sites (primary assessment)	Baseline	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.407
3 sites (primary assessment)	WCS	50	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.016	0.493
3 sites (primary assessment)	RA	13	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.011	0.429
3 sites (primary assessment)	WCS flight	224	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.096	0.766
3 sites (primary assessment)	RA flight	56	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.017	0.504
MacColl	WCS	27	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.013	0.453
MacColl	RA	7	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.010	0.420
MacColl	WCS flight	127	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.036	0.625
MacColl	RA flight	32	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.010	0.460
Telford	WCS	8	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.010	0.421
Telford	RA	2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.010	0.410
Telford	WCS flight	50	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.016	0.493

Telford	RA flight	13	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.010	0.430
Stevenson	WCS	16	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.011	0.434
Stevenson	RA	4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.010	0.410
Stevenson	WCS flight	47	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.016	0.488
Stevenson	RA flight	12	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.010	0.430
MacColl and Stevenson	WCS	43	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.015	0.481
MacColl and Stevenson	RA	11	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.010	0.430
MacColl and Stevenson	WCS flight	174	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.059	0.698
MacColl and Stevenson	RA flight	44	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.020	0.480
Stevenson and Telford	WCS	24	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.012	0.448
Stevenson and Telford	RA	6	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.010	0.420
Stevenson and Telford	WCS flight	97	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.027	0.575
Stevenson and Telford	RA flight	24	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.010	0.450
Telford and MacColl	WCS	35	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.014	0.467
Telford and MacColl	RA	9	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.010	0.420
Telford and MacColl	WCS flight	177	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.061	0.703
Telford and MacColl	RA flight	44	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.020	0.480
BOWL	WCS	25	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.013	0.450
BOWL	RA	6	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.010	0.417
BOWL	WCS flight	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BOWL	RA flight	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BOWL and MORL	WCS	75	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.021	0.537
BOWL and MORL	RA	19	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.012	0.440
BOWL and MORL	WCS flight	249	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	0.122	0.796
BOWL and MORL	RA flight	62	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.019	0.514

Graph A11b



COLLISION

Graph A12a

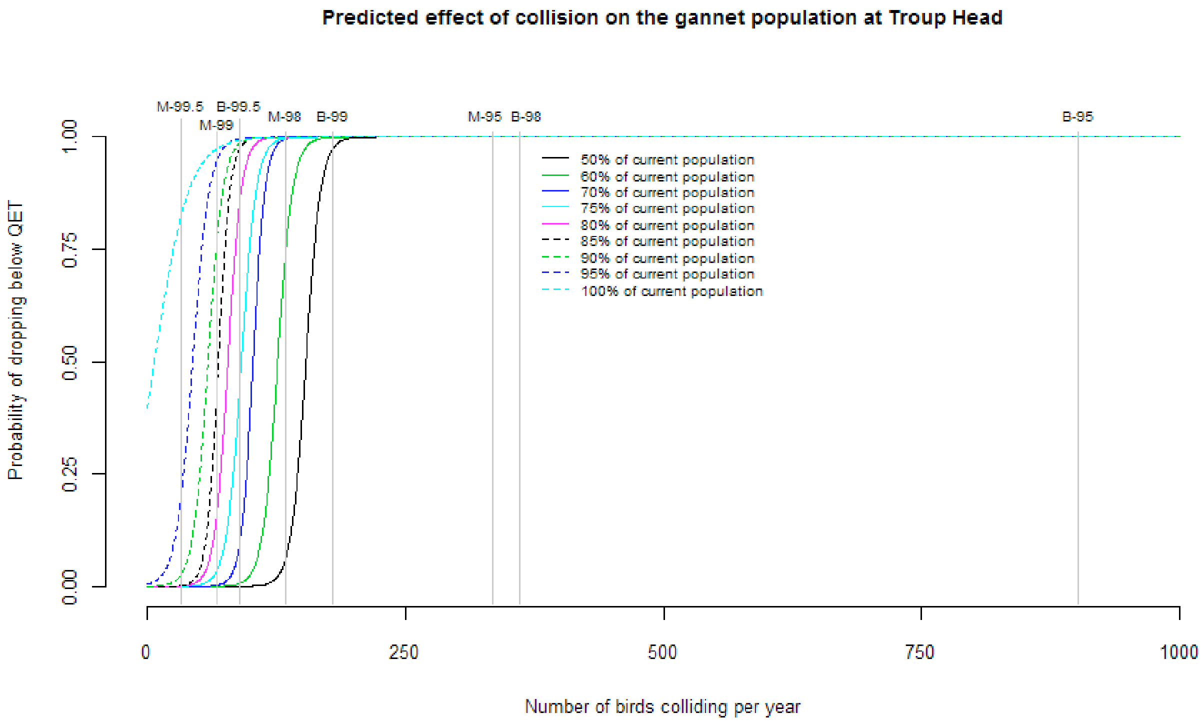
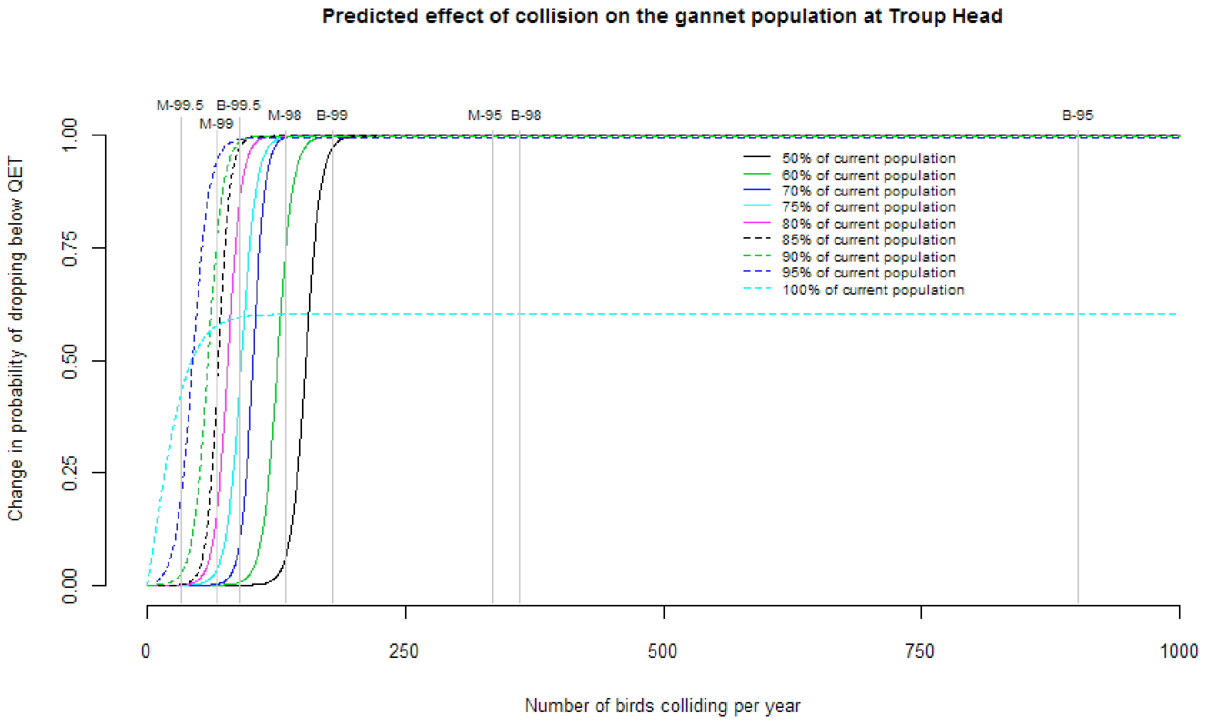


Table A12. Probability of population change from collision of gannet from Troup Head SPA.

Site	Avoidance Rate	Number Colliding	Probability of dropping below percentage of current population size								
			50%	60%	70%	75%	80%	85%	90%	95%	100%
3 sites (primary assessment)	Baseline	0	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	0.397
3 sites (primary assessment)	95%	567	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
3 sites (primary assessment)	98%	227	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
3 sites (primary assessment)	99%	113	0.003	0.139	0.860	0.954	0.995	1.000	0.999	1.000	0.998
3 sites (primary assessment)	99.50%	57	0.000	0.000	0.000	0.008	0.037	0.106	0.435	0.833	0.952
MacColl, Telford and Stevenson	95%	784	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl, Telford and Stevenson	98%	313	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl, Telford and Stevenson	99%	157	0.613	0.986	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl, Telford and Stevenson	99.50%	78	<0.001	0.001	0.014	0.136	0.493	0.833	0.935	0.985	0.986
MacColl	95%	443	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl	98%	177	0.962	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl	99%	89	0.000	0.006	0.087	0.423	0.842	0.972	0.985	0.996	0.993
MacColl	99.50%	44	0.000	0.000	0.000	0.001	0.005	0.012	0.112	0.499	0.902
Telford	95%	175	0.951	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Telford	98%	70	0.000	0.000	0.003	0.049	0.220	0.545	0.825	0.961	0.978
Telford	99%	35	0.000	0.000	0.000	0.000	0.001	0.002	0.035	0.246	0.843
Telford	99.50%	17	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.034	0.646
Stevenson	95%	166	0.847	0.996	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Stevenson	98%	66	0.000	0.000	0.002	0.029	0.132	0.370	0.729	0.938	0.972

Stevenson	99%	33	0.000	0.000	0.000	0.000	0.001	0.002	0.027	0.203	0.826
Stevenson	99.50%	17	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.034	0.646
MacColl and Stevenson	95%	609	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl and Stevenson	98%	244	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl and Stevenson	99%	122	0.012	0.357	0.967	0.987	0.999	1.000	1.000	1.000	0.999
MacColl and Stevenson	99.50%	61	0.000	0.000	0.001	0.014	0.066	0.194	0.573	0.891	0.962
Stevenson and Telford	95%	341	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Stevenson and Telford	98%	136	0.078	0.791	0.997	0.998	1.000	1.000	1.000	1.000	1.000
Stevenson and Telford	99%	68	0.000	0.000	0.002	0.038	0.172	0.456	0.781	0.951	0.975
Stevenson and Telford	99.50%	34	0.000	0.000	0.000	0.000	0.001	0.002	0.030	0.224	0.835
Telford and MacColl	95%	618	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Telford and MacColl	98%	247	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Telford and MacColl	99%	124	0.016	0.422	0.976	0.990	0.999	1.000	1.000	1.000	0.999
Telford and MacColl	99.50%	62	0.000	0.000	0.001	0.017	0.076	0.224	0.607	0.902	0.964
BOWL	95%	334	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BOWL	98%	134	0.061	0.742	0.996	0.997	1.000	1.000	1.000	1.000	1.000
BOWL	99%	67	0.000	0.000	0.002	0.033	0.151	0.413	0.756	0.945	0.973
BOWL	99.50%	33	0.000	0.000	0.000	0.000	0.001	0.002	0.027	0.203	0.826
BOWL and MORL	95%	901	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BOWL and MORL	98%	361	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BOWL and MORL	99%	180	0.975	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BOWL and MORL	99.50%	90	0.000	0.007	0.101	0.457	0.861	0.977	0.987	0.997	0.993

Graph A12b



COLLISION AND DISPLACEMENT – WORST CASE SCENARIO WITH FLIGHT

Graph A13a

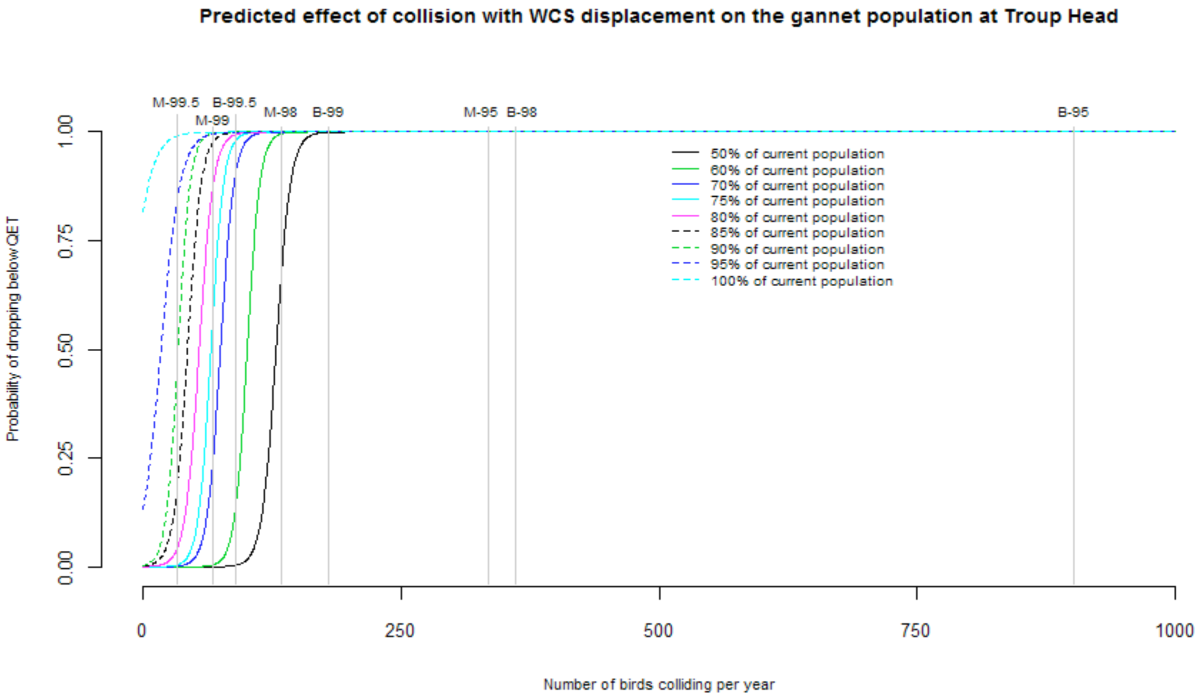
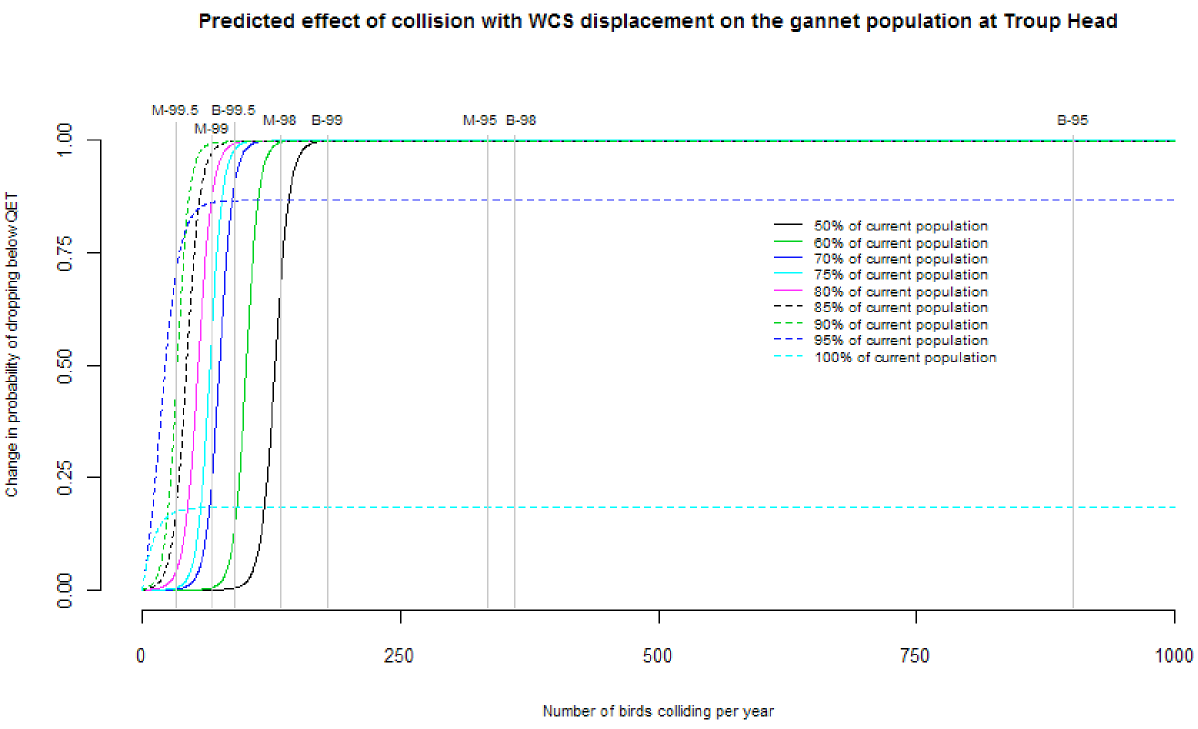


Table13. Probability of population change from combined displacement and collision effects of Gannet from Troup Head SPA using the Worst Case Scenario displacement rate including birds detected in flight.

Site	Number Displaced	Avoidance Rate	Number Colliding	Probability of dropping below percentage of current population size								
				50%	60%	70%	75%	80%	85%	90%	95%	100%
Baseline	0	N/A	0	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.003	0.133	0.817
3 sites (primary assessment)	249	95%	567	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
3 sites (primary assessment)	249	98%	227	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
3 sites (primary assessment)	249	99%	113	0.092	0.880	0.997	1.000	1.000	1.000	1.000	1.000	1.000
3 sites (primary assessment)	249	99.50%	57	0.000	0.001	0.059	0.192	0.597	0.891	0.981	0.986	0.999
MacColl, Telford and Stevenson	249	95%	784	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl, Telford and Stevenson	249	98%	313	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl, Telford and Stevenson	249	99%	157	0.983	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl, Telford and Stevenson	249	99.50%	78	0.001	0.023	0.614	0.882	0.970	0.995	0.999	0.999	1.000
MacColl	249	95%	443	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl	249	98%	177	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl	249	99%	89	0.003	0.125	0.896	0.978	0.994	0.999	1.000	1.000	1.000
MacColl	249	99.50%	44	0.000	0.000	0.008	0.027	0.181	0.539	0.850	0.946	0.997
Telford	249	95%	175	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Telford	249	98%	70	<0.001	0.006	0.318	0.667	0.909	0.983	0.998	0.997	1.000
Telford	249	99%	35	<0.001	0.000	0.002	0.006	0.056	0.234	0.548	0.870	0.993
Telford	249	99.50%	17	<0.001	<0.001	<0.001	<0.001	0.004	0.020	0.052	0.490	0.959
Stevenson	249	95%	166	0.995	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Stevenson	249	98%	66	0.000	0.003	0.201	0.510	0.847	0.969	0.996	0.995	1.000

Stevenson	249	99%	33	0.000	0.000	0.002	0.005	0.042	0.184	0.462	0.844	0.991
Stevenson	249	99.50%	17	0.000	0.000	0.000	0.000	0.004	0.020	0.052	0.490	0.959
MacColl and Stevenson	249	95%	609	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl and Stevenson	249	98%	244	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl and Stevenson	249	99%	122	0.271	0.970	0.999	1.000	1.000	1.000	1.000	1.000	1.000
MacColl and Stevenson	249	99.50%	61	0.000	0.001	0.104	0.314	0.727	0.937	0.991	0.991	0.999
Stevenson and Telford	249	95%	341	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Stevenson and Telford	249	98%	136	0.736	0.997	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Stevenson and Telford	249	99%	68	<0.001	0.005	0.255	0.591	0.881	0.977	0.997	0.996	1.000
Stevenson and Telford	249	99.50%	34	<0.001	<0.001	0.002	0.005	0.048	0.208	0.505	0.857	0.992
Telford and MacColl	249	95%	618	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Telford and MacColl	249	98%	247	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Telford and MacColl	249	99%	124	0.331	0.978	0.999	1.000	1.000	1.000	1.000	1.000	1.000
Telford and MacColl	249	99.50%	62	0.000	0.002	0.120	0.350	0.755	0.945	0.992	0.992	0.999
BOWL	249	95%	334	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BOWL	249	98%	134	0.676	0.996	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BOWL	249	99%	67	0.000	0.004	0.227	0.551	0.865	0.973	0.997	0.995	1.000
BOWL	249	99.50%	33	0.000	0.000	0.002	0.005	0.042	0.184	0.462	0.844	0.991
BOWL and MORL	249	95%	901	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BOWL and MORL	249	98%	361	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BOWL and MORL	249	99%	180	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BOWL and MORL	249	99.50%	90	0.004	0.144	0.910	0.982	0.995	0.999	1.000	1.000	1.000

Graph A13b



COLLISION AND DISPLACEMENT – REALISTIC APPROACH WITH FLIGHT

Graph A14a

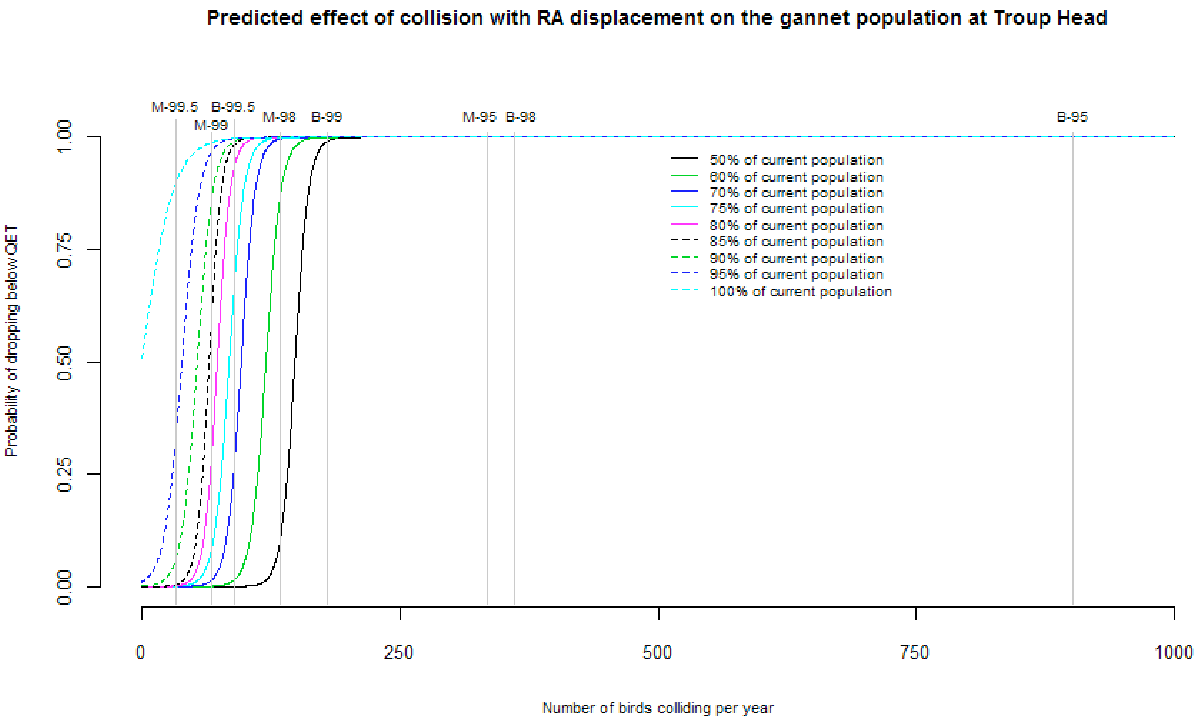
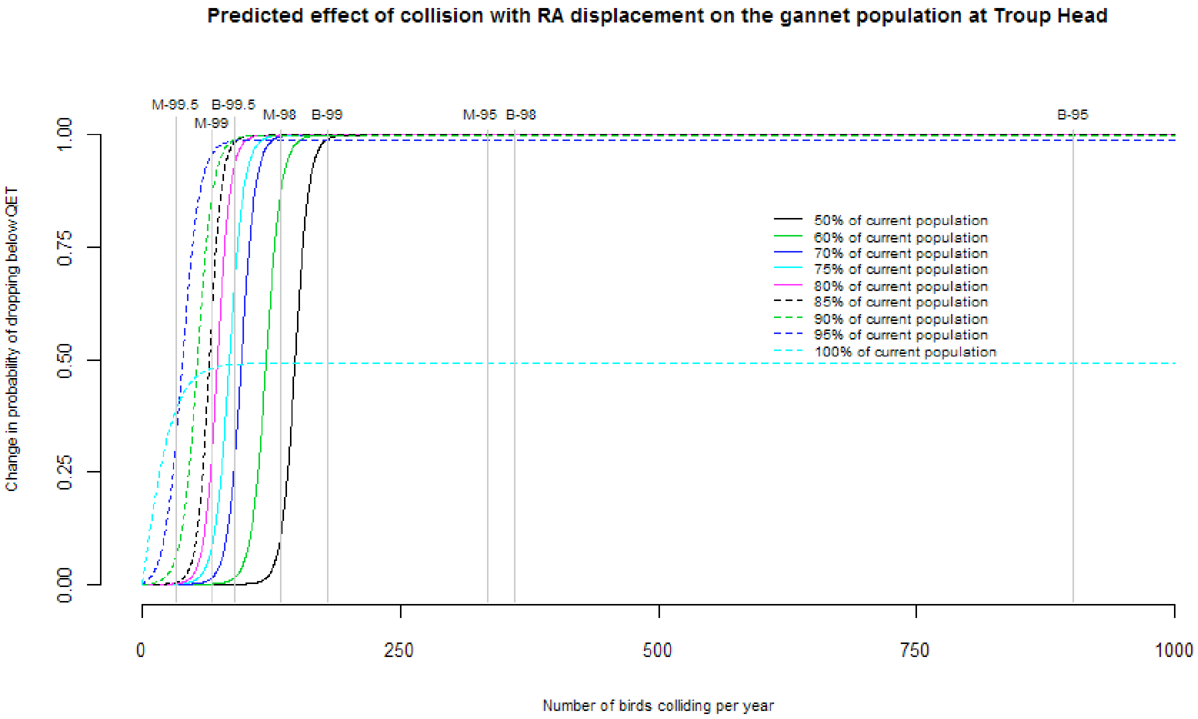


Table 14. Probability of population change from combined displacement and collision effects of Gannet from Troup Head SPA using the Realistic Approach displacement rate including birds detected in flight.

Site	Number Displaced	Avoidance Rate	Number Colliding	Probability of dropping below percentage of current population size								
				50%	60%	70%	75%	80%	85%	90%	95%	100%
Baseline	0	N/A	0	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.010	0.508
3 sites (primary assessment)	56	95%	567	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
3 sites (primary assessment)	56	98%	227	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
3 sites (primary assessment)	56	99%	113	0.005	0.270	0.923	0.983	0.998	1.000	1.000	1.000	0.999
3 sites (primary assessment)	56	99.50%	57	<0.001	<0.001	0.003	0.020	0.070	0.199	0.611	0.897	0.977
MacColl, Telford and Stevenson	56	95%	784	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl, Telford and Stevenson	56	98%	313	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl, Telford and Stevenson	56	99%	157	0.789	0.994	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl, Telford and Stevenson	56	99.50%	78	<0.001	0.003	0.063	0.285	0.689	0.899	0.961	0.991	0.994
MacColl	56	95%	443	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl	56	98%	177	0.987	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl	56	99%	89	<0.001	0.013	0.256	0.653	0.929	0.983	0.990	0.997	0.997
MacColl	56	99.50%	44	<0.001	<0.001	<0.001	0.003	0.009	0.026	0.223	0.652	0.948
Telford	56	95%	175	0.983	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Telford	56	98%	70	<0.001	0.001	0.020	0.114	0.379	0.694	0.896	0.976	0.990
Telford	56	99%	35	<0.001	<0.001	<0.001	0.001	0.002	0.006	0.081	0.392	0.910
Telford	56	99.50%	17	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.008	0.071	0.758
Stevenson	56	95%	166	0.936	0.998	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Stevenson	56	98%	66	<0.001	0.001	0.011	0.068	0.242	0.535	0.837	0.962	0.987

Stevenson	56	99%	33	<0.001	<0.001	<0.001	0.001	0.002	0.004	0.064	0.338	0.899
Stevenson	56	99.50%	17	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.008	0.071	0.758
MacColl and Stevenson	56	95%	609	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl and Stevenson	56	98%	244	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl and Stevenson	56	99%	122	0.019	0.560	0.979	0.995	1.000	1.000	1.000	1.000	1.000
MacColl and Stevenson	56	99.50%	61	<0.001	<0.001	0.005	0.035	0.125	0.329	0.727	0.933	0.982
Stevenson and Telford	56	95%	341	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Stevenson and Telford	56	98%	136	0.136	0.897	0.997	0.999	1.000	1.000	1.000	1.000	1.000
Stevenson and Telford	56	99%	68	<0.001	0.001	0.015	0.088	0.306	0.618	0.869	0.970	0.989
Stevenson and Telford	56	99.50%	34	<0.001	<0.001	<0.001	0.001	0.002	0.005	0.072	0.364	0.905
Telford and MacColl	56	95%	618	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Telford and MacColl	56	98%	247	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Telford and MacColl	56	99%	124	0.025	0.627	0.984	0.996	1.000	1.000	1.000	1.000	1.000
Telford and MacColl	56	99.50%	62	<0.001	<0.001	0.006	0.040	0.144	0.368	0.752	0.940	0.983
BOWL	56	95%	334	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BOWL	56	98%	134	0.105	0.869	0.996	0.999	1.000	1.000	1.000	1.000	1.000
BOWL	56	99%	67	0.000	0.001	0.013	0.077	0.273	0.577	0.854	0.966	0.988
BOWL	56	99.50%	33	0.000	0.000	0.000	0.001	0.002	0.004	0.064	0.338	0.899
BOWL and MORL	56	95%	901	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BOWL and MORL	56	98%	361	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BOWL and MORL	56	99%	180	0.992	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BOWL and MORL	56	99.50%	90	0.000	0.015	0.285	0.685	0.939	0.986	0.992	0.998	0.997

Graph A14b



COLLISION AND DISPLACEMENT – WORST CASE SCENARIO WITHOUT FLIGHT

Graph A15a

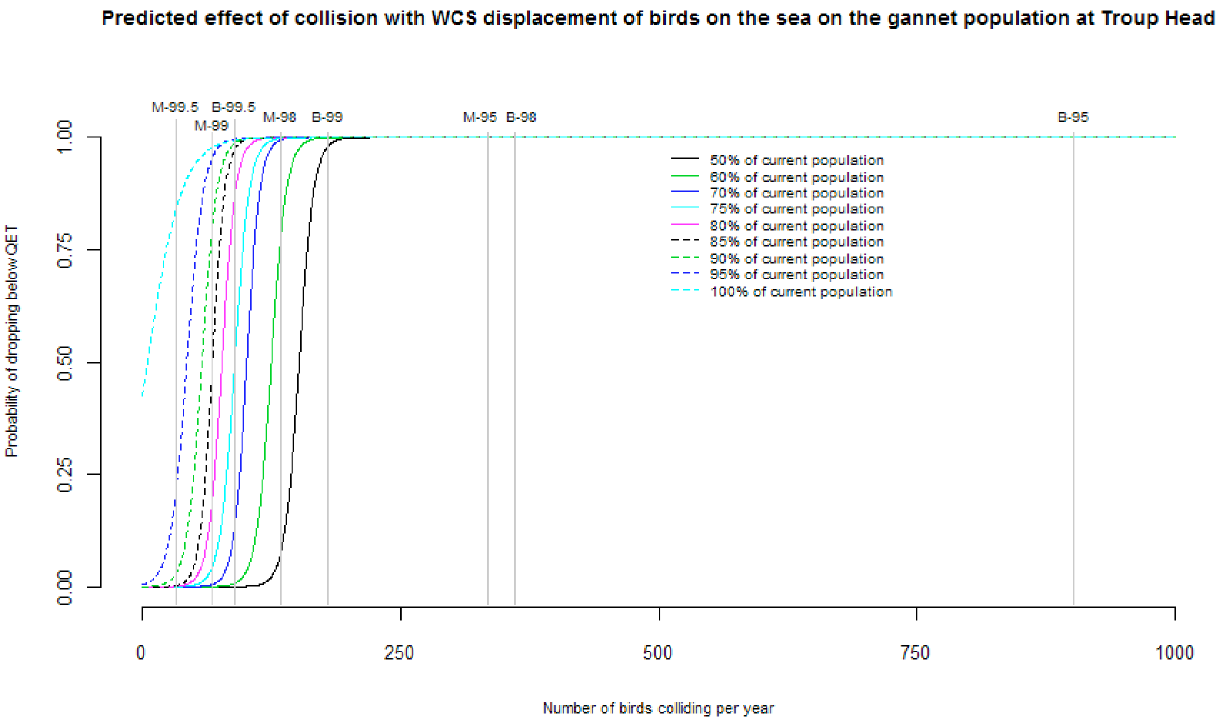
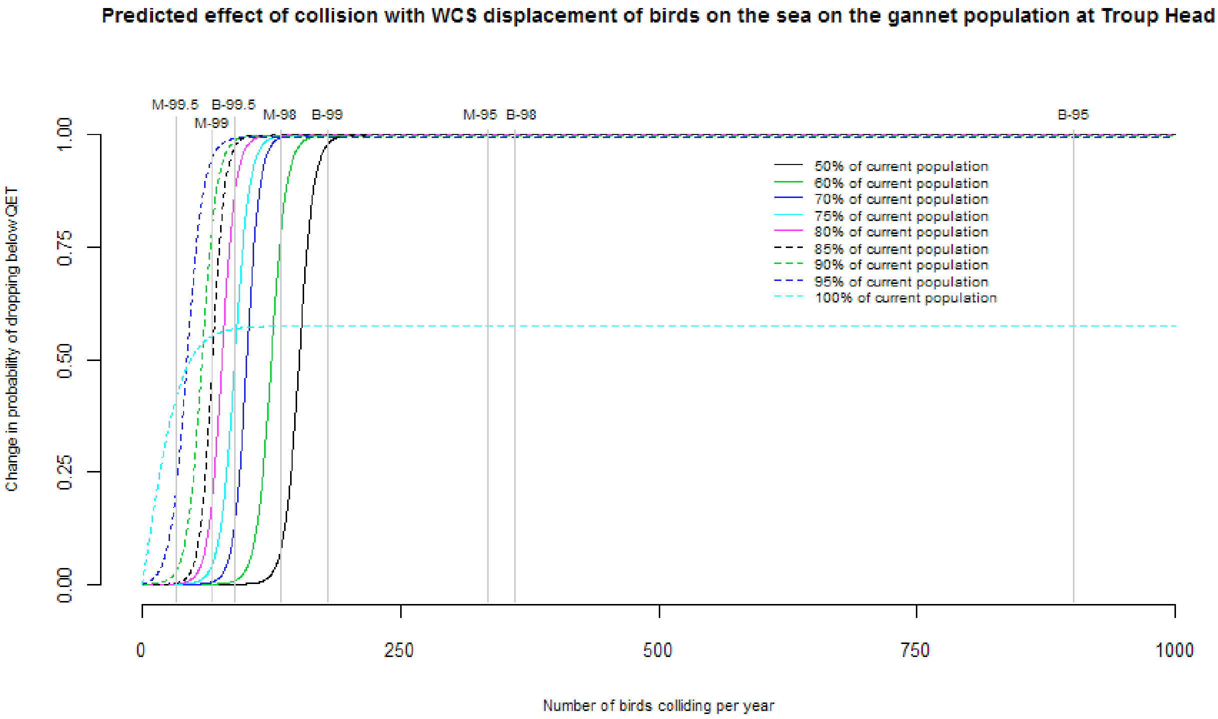


Table 15. Probability of population change from combined displacement and collision effects of Gannet from Troup Head SPA using the Worst Case Scenario displacement rate not including birds detected in flight.

Site	Number Displaced	Avoidance Rate	Number Colliding	Probability of dropping below percentage of current population size								
				50%	60%	70%	75%	80%	85%	90%	95%	100%
Baseline	0	N/A	0	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.013	0.545
3 sites (primary assessment)	75	95%	567	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
3 sites (primary assessment)	75	98%	227	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
3 sites (primary assessment)	75	99%	113	0.006	0.346	0.936	0.988	0.998	1.000	1.000	1.000	0.999
3 sites (primary assessment)	75	99.50%	57	<0.001	<0.001	0.003	0.029	0.102	0.306	0.727	0.905	0.975
MacColl, Telford and Stevenson	75	95%	784	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl, Telford and Stevenson	75	98%	313	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl, Telford and Stevenson	75	99%	157	0.865	0.995	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl, Telford and Stevenson	75	99.50%	78	<0.001	0.004	0.062	0.365	0.734	0.915	0.979	0.991	0.993
MacColl	75	95%	443	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl	75	98%	177	0.993	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl	75	99%	89	<0.001	0.019	0.265	0.731	0.936	0.983	0.995	0.997	0.996
MacColl	75	99.50%	44	<0.001	<0.001	<0.001	0.005	0.015	0.058	0.310	0.678	0.946
Telford	75	95%	175	0.991	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Telford	75	98%	70	<0.001	0.001	0.019	0.157	0.450	0.761	0.940	0.977	0.988
Telford	75	99%	35	<0.001	<0.001	<0.001	0.001	0.004	0.015	0.116	0.425	0.910
Telford	75	99.50%	17	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.011	0.084	0.772
Stevenson	75	95%	166	0.963	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Stevenson	75	98%	66	<0.001	0.001	0.010	0.096	0.308	0.634	0.901	0.964	0.985

Stevenson	75	99%	33	<0.001	<0.001	<0.001	0.001	0.003	0.011	0.091	0.370	0.900
Stevenson	75	99.50%	17	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.011	0.084	0.772
MacColl and Stevenson	75	95%	609	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl and Stevenson	75	98%	244	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl and Stevenson	75	99%	122	0.025	0.645	0.983	0.997	1.000	1.000	1.000	1.000	1.000
MacColl and Stevenson	75	99.50%	61	<0.001	<0.001	0.005	0.050	0.172	0.448	0.821	0.938	0.980
Stevenson and Telford	75	95%	341	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Stevenson and Telford	75	98%	136	0.190	0.925	0.998	1.000	1.000	1.000	1.000	1.000	1.000
Stevenson and Telford	75	99%	68	<0.001	0.001	0.014	0.123	0.376	0.702	0.923	0.972	0.987
Stevenson and Telford	75	99.50%	34	<0.001	<0.001	<0.001	0.001	0.003	0.013	0.103	0.397	0.905
Telford and MacColl	75	95%	618	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Telford and MacColl	75	98%	247	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Telford and MacColl	75	99%	124	0.034	0.705	0.988	0.997	1.000	1.000	1.000	1.000	1.000
Telford and MacColl	75	99.50%	62	<0.001	<0.001	0.006	0.057	0.195	0.486	0.840	0.945	0.981
BOWL	75	95%	334	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BOWL	75	98%	134	0.146	0.904	0.997	0.999	1.000	1.000	1.000	1.000	1.000
BOWL	75	99%	67	0.000	0.001	0.012	0.109	0.341	0.669	0.913	0.968	0.986
BOWL	75	99.50%	33	0.000	0.000	0.000	0.001	0.003	0.011	0.091	0.370	0.900
BOWL and MORL	75	95%	901	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BOWL and MORL	75	98%	361	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BOWL and MORL	75	99%	180	0.996	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BOWL and MORL	75	99.50%	90	0.000	0.022	0.296	0.758	0.945	0.985	0.996	0.998	0.997

Graph A15b


Predicted effect of collision with WCS displacement of birds on the sea on the gannet population at Troup Head

COLLISION AND DISPLACEMENT – REALISTIC APPROACH WITHOUT FLIGHT

Graph A16a

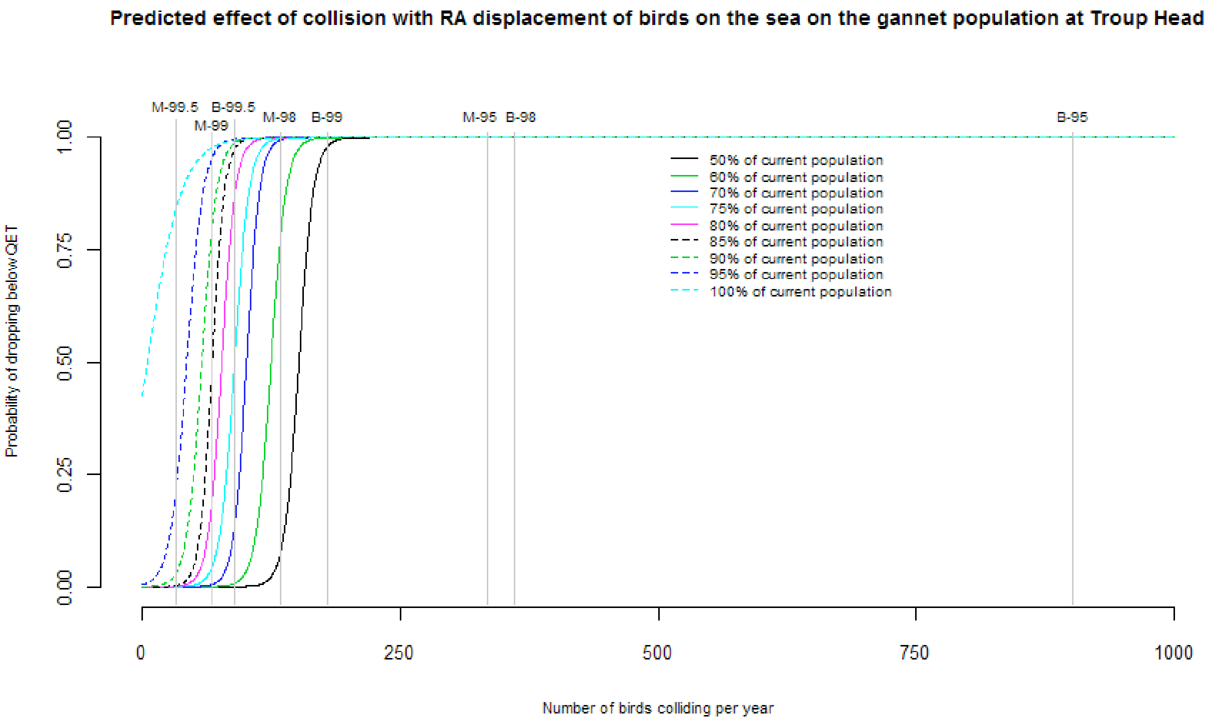
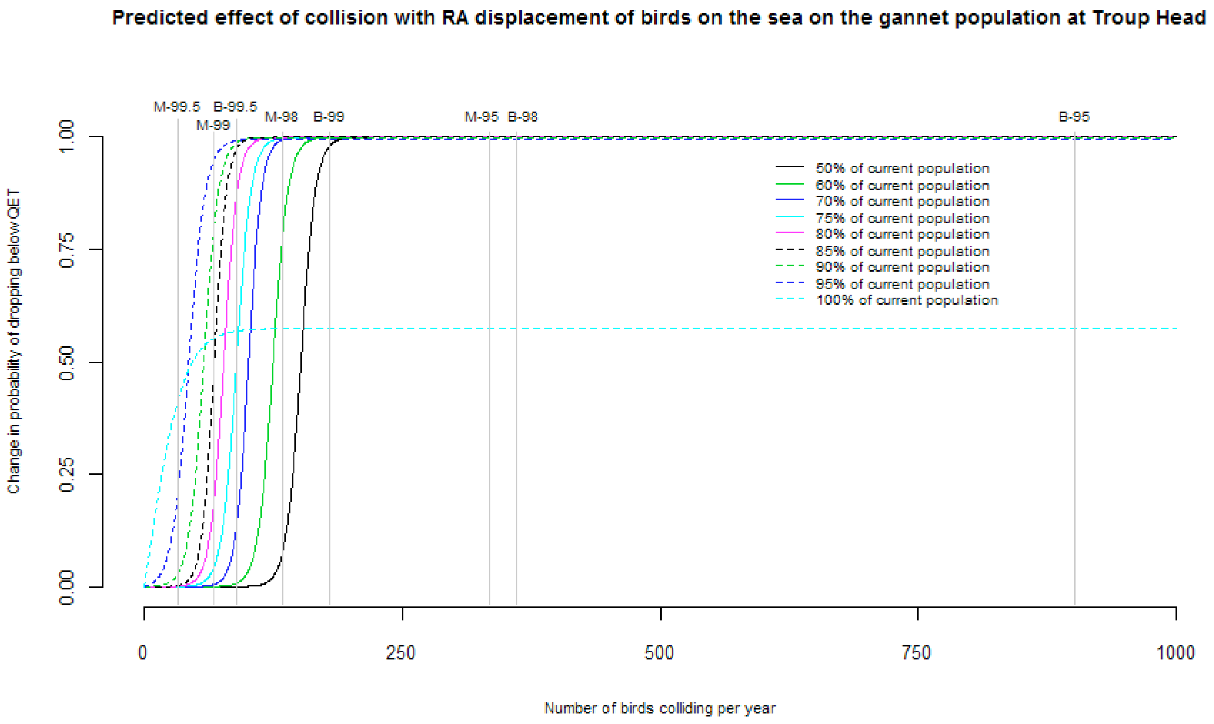


Table 16. Probability of population change from combined displacement and collision effects of gannet from Troup Head SPA using the Realistic Approach displacement rate not including birds detected in flight.

Site	Number Displaced	Avoidance Rate	Number Colliding	Probability of dropping below percentage of current population size								
				50%	60%	70%	75%	80%	85%	90%	95%	100%
Baseline	0	N/A	0	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	0.425
3 sites (primary assessment)	13	95%	567	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
3 sites (primary assessment)	13	98%	227	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
3 sites (primary assessment)	13	99%	113	0.004	0.161	0.866	0.965	0.996	0.999	1.000	1.000	0.998
3 sites (primary assessment)	13	99.50%	57	<0.001	<0.001	0.001	0.010	0.044	0.137	0.471	0.848	0.958
MacColl, Telford and Stevenson	13	95%	784	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl, Telford and Stevenson	13	98%	313	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl, Telford and Stevenson	13	99%	157	0.673	0.988	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl, Telford and Stevenson	13	99.50%	78	0.000	0.002	0.024	0.163	0.530	0.843	0.942	0.987	0.988
MacColl	13	95%	443	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl	13	98%	177	0.972	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl	13	99%	89	<0.001	0.007	0.124	0.481	0.858	0.971	0.987	0.997	0.994
MacColl	13	99.50%	44	<0.001	<0.001	<0.001	0.002	0.006	0.018	0.129	0.525	0.912
Telford	13	95%	175	0.963	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Telford	13	98%	70	<0.001	0.001	0.007	0.059	0.250	0.584	0.843	0.966	0.980
Telford	13	99%	35	<0.001	<0.001	<0.001	<0.001	0.002	0.004	0.041	0.265	0.858
Telford	13	99.50%	17	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	0.037	0.673
Stevenson	13	95%	166	0.880	0.997	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Stevenson	13	98%	66	<0.001	0.000	0.004	0.035	0.153	0.418	0.756	0.945	0.975

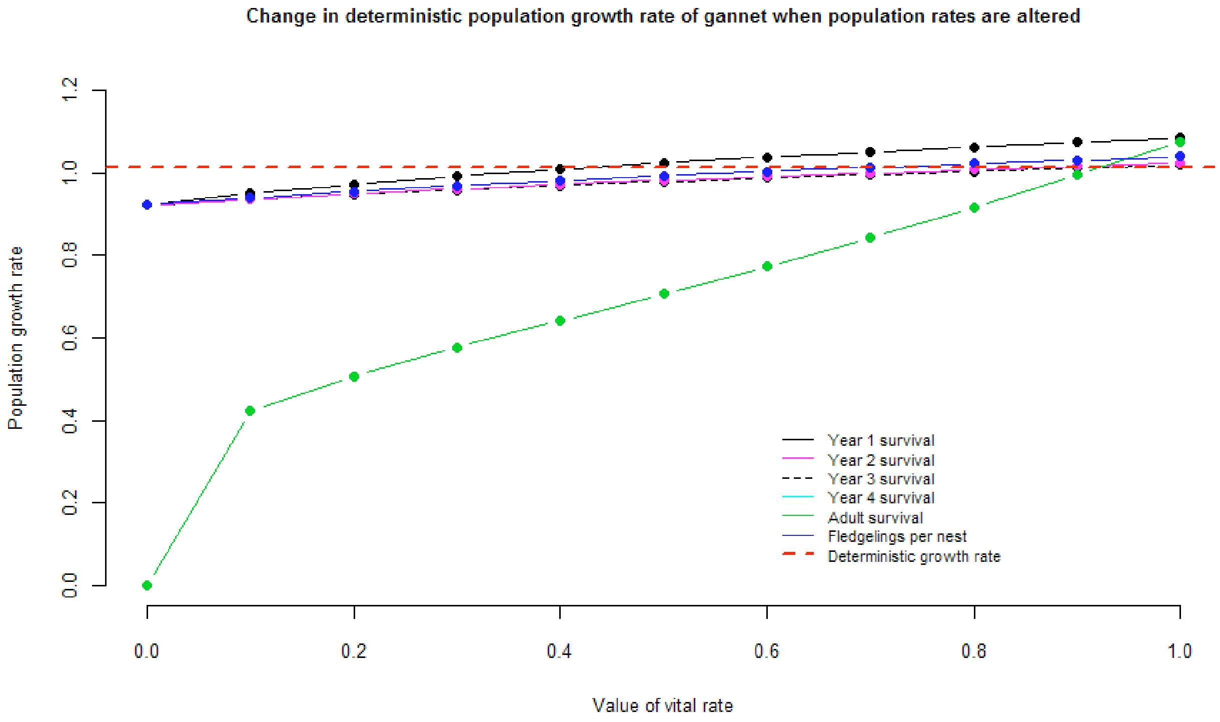
Stevenson	13	99%	33	<0.001	<0.001	<0.001	<0.001	0.001	0.003	0.031	0.220	0.843
Stevenson	13	99.50%	17	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	0.037	0.673
MacColl and Stevenson	13	95%	609	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl and Stevenson	13	98%	244	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl and Stevenson	13	99%	122	0.015	0.400	0.964	0.990	0.999	1.000	1.000	1.000	0.999
MacColl and Stevenson	13	99.50%	61	<0.001	<0.001	0.002	0.017	0.078	0.237	0.608	0.902	0.967
Stevenson and Telford	13	95%	341	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Stevenson and Telford	13	98%	136	0.096	0.821	0.996	0.999	1.000	1.000	1.000	1.000	1.000
Stevenson and Telford	13	99%	68	<0.001	<0.001	0.005	0.045	0.197	0.501	0.803	0.956	0.978
Stevenson and Telford	13	99.50%	34	<0.001	<0.001	<0.001	<0.001	0.001	0.003	0.036	0.242	0.851
Telford and MacColl	13	95%	618	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Telford and MacColl	13	98%	247	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Telford and MacColl	13	99%	124	0.019	0.467	0.974	0.992	0.999	1.000	1.000	1.000	0.999
Telford and MacColl	13	99.50%	62	<0.001	<0.001	0.002	0.020	0.089	0.269	0.640	0.912	0.968
BOWL	13	95%	334	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BOWL	13	98%	134	0.075	0.777	0.995	0.998	1.000	1.000	1.000	1.000	1.000
BOWL	13	99%	67	0.000	0.000	0.004	0.040	0.174	0.459	0.780	0.951	0.976
BOWL	13	99.50%	33	0.000	0.000	0.000	0.000	0.001	0.003	0.031	0.220	0.843
BOWL and MORL	13	95%	901	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BOWL and MORL	13	98%	361	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BOWL and MORL	13	99%	180	0.981	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BOWL and MORL	13	99.50%	90	0.000	0.008	0.143	0.516	0.875	0.976	0.988	0.997	0.994

Graph A16b



SENSITIVITY

Graph A17



KITTIWAKE

EAST CAITHNESS CLIFFS

DISPLACEMENT

Graph A18a

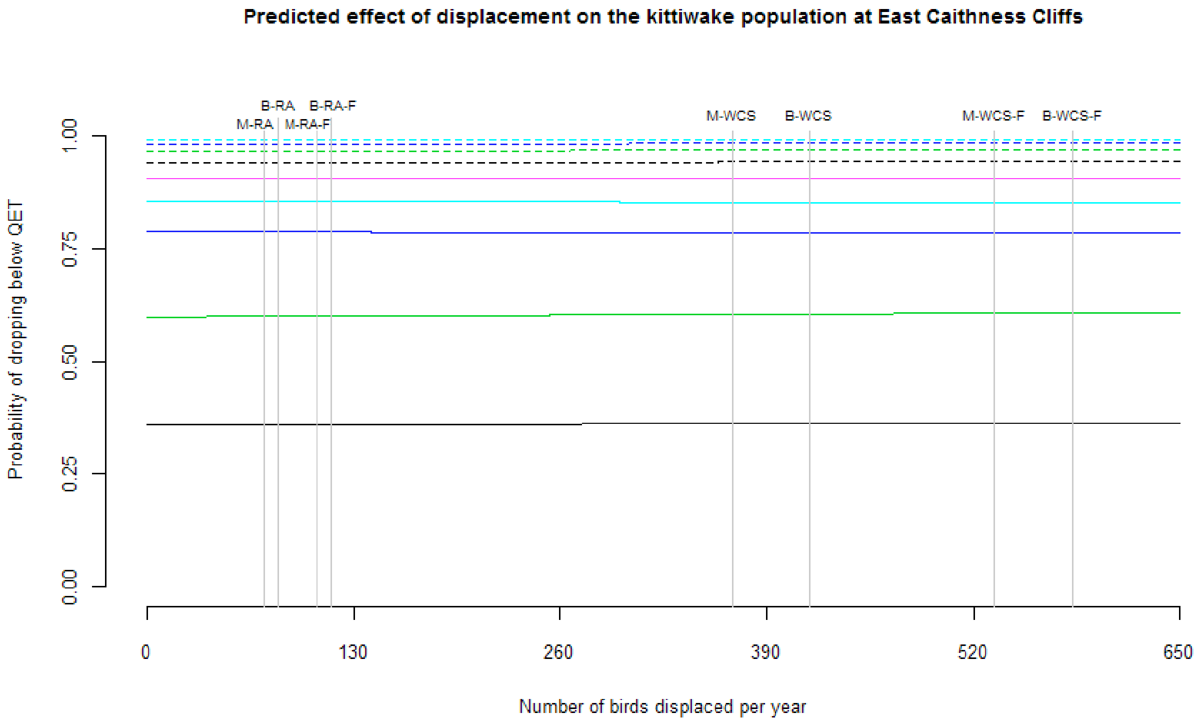
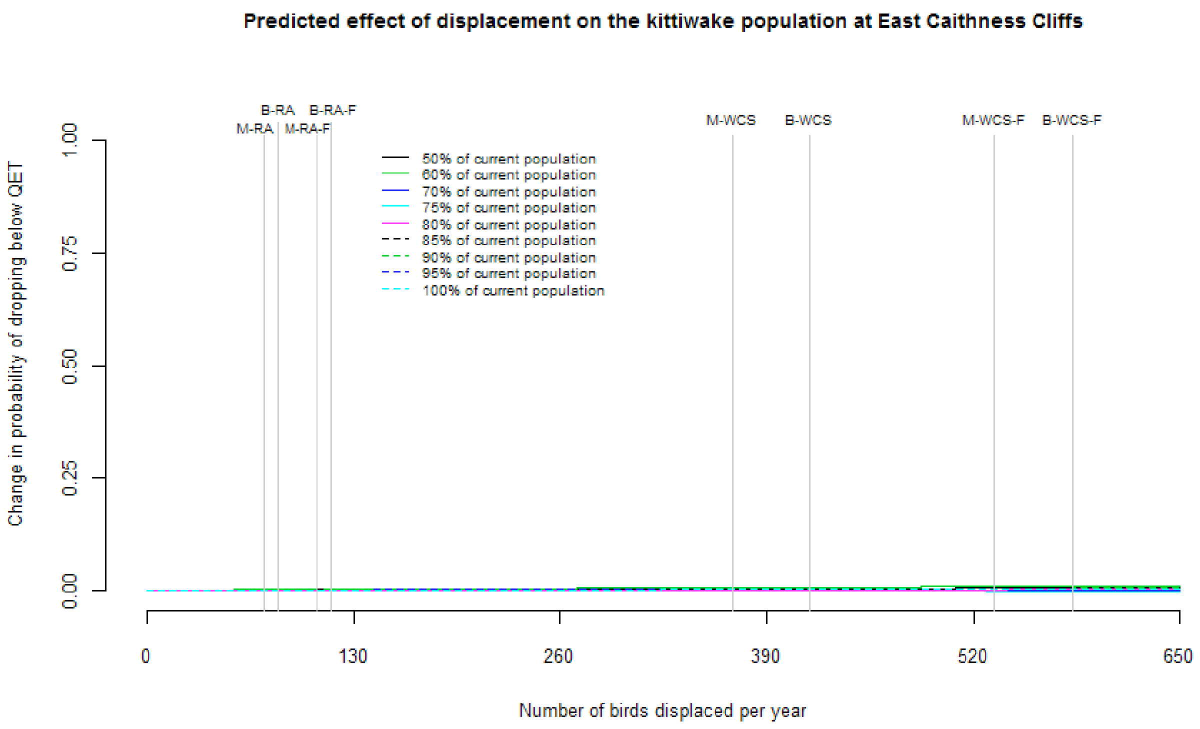


Table A18. Probability of population change from displacement of kittiwake at East Caithness Cliffs SPA.

Site	Displacement rate	Number displaced	Probability of dropping below percentage of current population size								
			50%	60%	70%	75%	80%	85%	90%	95%	100%
3 sites (primary assessment)	Baseline	0	0.358	0.598	0.787	0.855	0.905	0.940	0.966	0.982	0.992
3 sites (primary assessment)	WCS	368	0.361	0.604	0.786	0.853	0.906	0.943	0.969	0.984	0.993
3 sites (primary assessment)	RA	74	0.359	0.600	0.787	0.855	0.905	0.941	0.967	0.983	0.992
3 sites (primary assessment)	WCS flight	533	0.362	0.606	0.786	0.852	0.906	0.944	0.970	0.985	0.993
3 sites (primary assessment)	RA flight	107	0.359	0.600	0.787	0.854	0.905	0.941	0.967	0.983	0.992
MacColl	WCS	171	0.360	0.601	0.787	0.854	0.906	0.941	0.967	0.983	0.992
MacColl	RA	34	0.358	0.599	0.787	0.855	0.905	0.940	0.966	0.983	0.992
MacColl	WCS flight	268	0.360	0.602	0.786	0.854	0.906	0.942	0.968	0.984	0.992
MacColl	RA flight	54	0.359	0.599	0.787	0.855	0.905	0.940	0.967	0.983	0.992
Telford	WCS	125	0.359	0.600	0.787	0.854	0.905	0.941	0.967	0.983	0.992
Telford	RA	25	0.358	0.599	0.787	0.855	0.905	0.940	0.966	0.982	0.992
Telford	WCS flight	110	0.359	0.600	0.787	0.854	0.905	0.941	0.967	0.983	0.992
Telford	RA flight	22	0.358	0.599	0.787	0.855	0.905	0.940	0.966	0.982	0.992

Stevenson	WCS	75	0.359	0.600	0.787	0.855	0.905	0.941	0.967	0.983	0.992
Stevenson	RA	15	0.358	0.599	0.787	0.855	0.905	0.940	0.966	0.982	0.992
Stevenson	WCS flight	155	0.359	0.601	0.787	0.854	0.906	0.941	0.967	0.983	0.992
Stevenson	RA flight	31	0.358	0.599	0.787	0.855	0.905	0.940	0.966	0.983	0.992
MacColl and Stevenson	WCS	245	0.360	0.602	0.786	0.854	0.906	0.942	0.968	0.984	0.992
MacColl and Stevenson	RA	49	0.359	0.599	0.787	0.855	0.905	0.940	0.967	0.983	0.992
MacColl and Stevenson	WCS flight	423	0.362	0.605	0.786	0.853	0.906	0.943	0.969	0.985	0.993
MacColl and Stevenson	RA flight	85	0.359	0.600	0.787	0.855	0.905	0.941	0.967	0.983	0.992
Stevenson and Telford	WCS	199	0.360	0.601	0.787	0.854	0.906	0.941	0.968	0.983	0.992
Stevenson and Telford	RA	40	0.359	0.599	0.787	0.855	0.905	0.940	0.967	0.983	0.992
Stevenson and Telford	WCS flight	265	0.360	0.602	0.786	0.854	0.906	0.942	0.968	0.984	0.992
Stevenson and Telford	RA flight	53	0.359	0.599	0.787	0.855	0.905	0.940	0.967	0.983	0.992
Telford and MacColl	WCS	295	0.361	0.603	0.786	0.854	0.906	0.942	0.968	0.984	0.993
Telford and MacColl	RA	59	0.359	0.599	0.787	0.855	0.905	0.940	0.967	0.983	0.992
Telford and MacColl	WCS flight	378	0.361	0.604	0.786	0.853	0.906	0.943	0.969	0.984	0.993
Telford and MacColl	RA flight	76	0.359	0.600	0.787	0.855	0.905	0.941	0.967	0.983	0.992
BOWL	WCS	49	0.359	0.599	0.787	0.855	0.905	0.940	0.967	0.983	0.992
BOWL	RA	10	0.358	0.599	0.787	0.855	0.905	0.940	0.966	0.982	0.992
BOWL	WCS flight	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BOWL	RA flight	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BOWL and MORL	WCS	417	0.361	0.605	0.786	0.853	0.906	0.943	0.969	0.985	0.993
BOWL and MORL	RA	83	0.359	0.600	0.787	0.855	0.905	0.941	0.967	0.983	0.992
BOWL and MORL	WCS flight	582	0.363	0.607	0.785	0.852	0.906	0.944	0.970	0.985	0.993
BOWL and MORL	RA flight	116	0.359	0.600	0.787	0.854	0.905	0.941	0.967	0.983	0.992

Graph A18b



COLLISION

Graph A19a

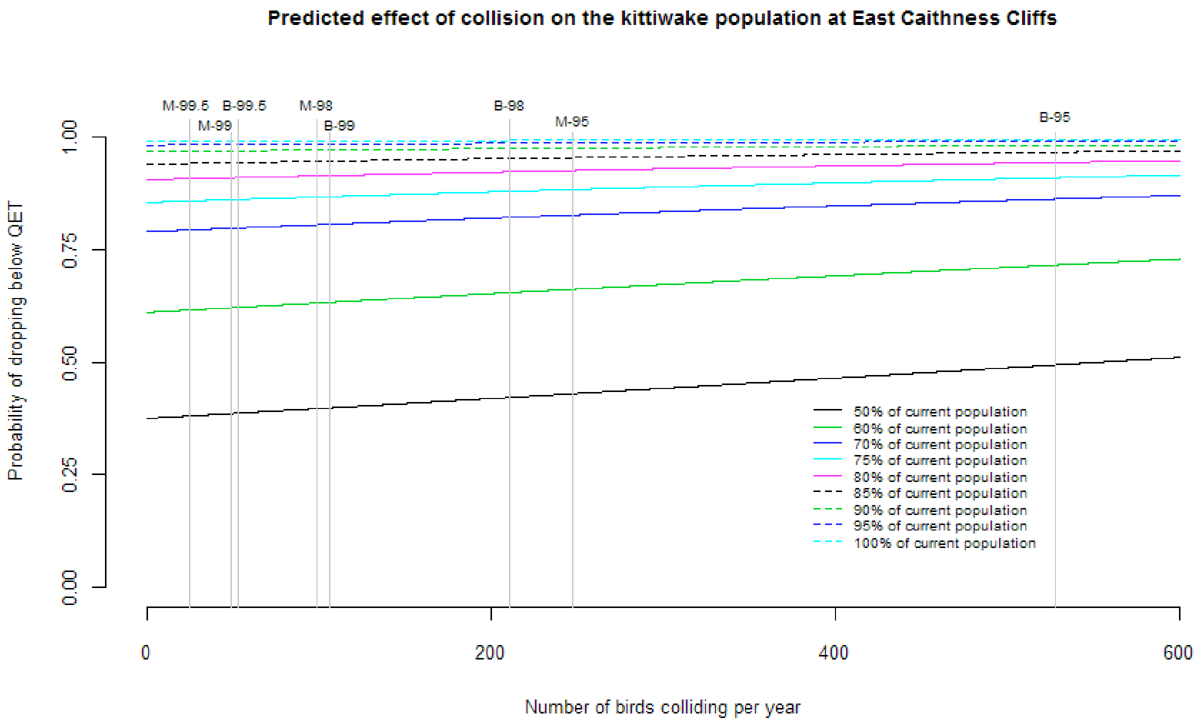
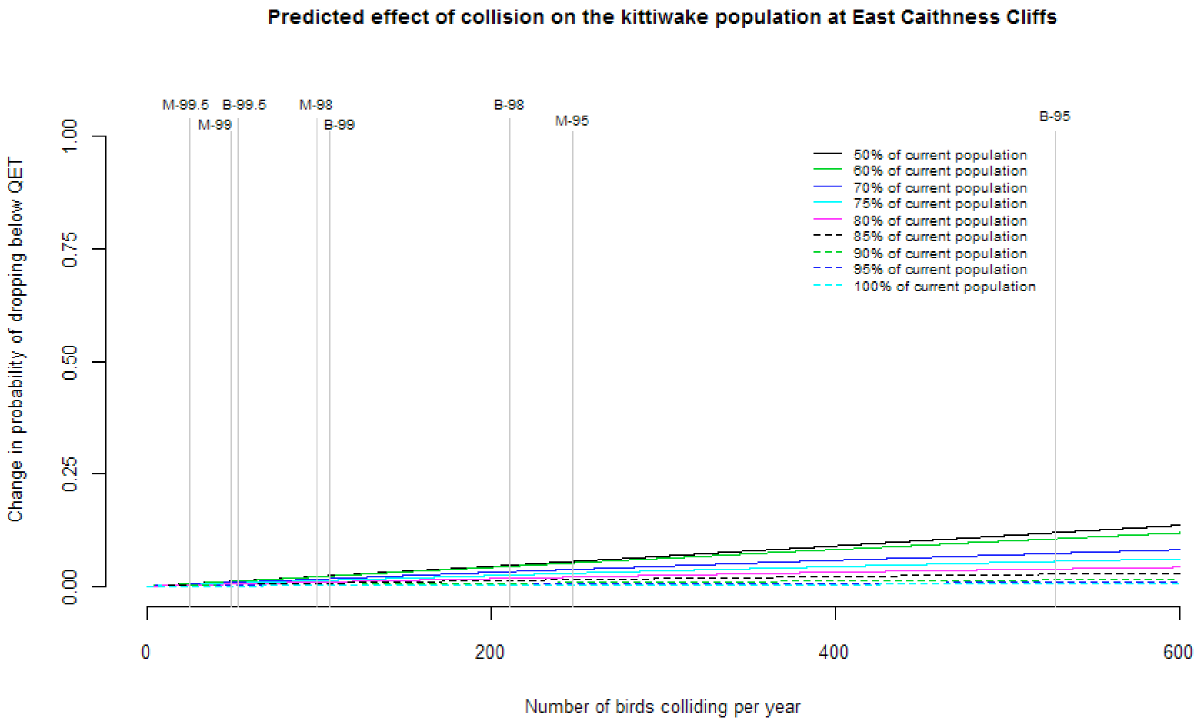


Table A19. Probability of population change from collision of kittiwake from East Caithness Cliffs SPA.

Site	Avoidance Rate	Number Colliding	Probability of dropping below percentage of current population size								
			50%	60%	70%	75%	80%	85%	90%	95%	100%
3 sites (primary assessment)	Baseline	0	0.368	0.578	0.779	0.848	0.900	0.938	0.965	0.984	0.992
3 sites (primary assessment)	95%	281	0.437	0.669	0.832	0.888	0.929	0.957	0.977	0.989	0.994
3 sites (primary assessment)	98%	113	0.400	0.635	0.808	0.869	0.916	0.948	0.973	0.986	0.993
3 sites (primary assessment)	99%	56	0.387	0.623	0.799	0.863	0.911	0.945	0.971	0.985	0.992
3 sites (primary assessment)	99.50%	28	0.381	0.617	0.795	0.859	0.909	0.943	0.970	0.984	0.992
MacColl, Telford and Stevenson	95%	396	0.464	0.692	0.847	0.899	0.937	0.962	0.980	0.990	0.995
MacColl, Telford and Stevenson	98%	159	0.410	0.644	0.815	0.875	0.920	0.951	0.974	0.987	0.993
MacColl, Telford and Stevenson	99%	79	0.392	0.628	0.803	0.865	0.913	0.946	0.972	0.985	0.992
MacColl, Telford and Stevenson	99.50%	40	0.384	0.619	0.797	0.861	0.910	0.944	0.970	0.985	0.992
MacColl	95%	199	0.419	0.653	0.821	0.879	0.923	0.953	0.975	0.987	0.993
MacColl	98%	80	0.392	0.628	0.803	0.865	0.913	0.946	0.972	0.985	0.992
MacColl	99%	40	0.384	0.619	0.797	0.861	0.910	0.944	0.970	0.985	0.992
MacColl	99.50%	20	0.379	0.615	0.794	0.858	0.908	0.942	0.970	0.984	0.992
Telford	95%	82	0.393	0.628	0.803	0.866	0.914	0.946	0.972	0.985	0.992
Telford	98%	33	0.382	0.618	0.796	0.860	0.909	0.943	0.970	0.984	0.992
Telford	99%	16	0.378	0.614	0.793	0.858	0.908	0.942	0.970	0.984	0.992
Telford	99.50%	8	0.377	0.613	0.792	0.857	0.907	0.942	0.969	0.984	0.991
Stevenson	95%	115	0.400	0.635	0.808	0.870	0.916	0.948	0.973	0.986	0.993
Stevenson	98%	46	0.385	0.621	0.798	0.861	0.910	0.944	0.971	0.985	0.992
Stevenson	99%	23	0.380	0.616	0.794	0.859	0.908	0.943	0.970	0.984	0.992

Stevenson	99.50%	12	0.377	0.613	0.792	0.857	0.907	0.942	0.969	0.984	0.991
MacColl and Stevenson	95%	314	0.445	0.676	0.837	0.891	0.931	0.959	0.978	0.989	0.994
MacColl and Stevenson	98%	126	0.402	0.637	0.810	0.871	0.917	0.949	0.973	0.986	0.993
MacColl and Stevenson	99%	63	0.389	0.624	0.800	0.863	0.912	0.945	0.971	0.985	0.992
MacColl and Stevenson	99.50%	31	0.382	0.618	0.795	0.860	0.909	0.943	0.970	0.984	0.992
Stevenson and Telford	95%	197	0.418	0.652	0.820	0.879	0.923	0.953	0.975	0.987	0.993
Stevenson and Telford	98%	79	0.392	0.628	0.803	0.865	0.913	0.946	0.972	0.985	0.992
Stevenson and Telford	99%	39	0.383	0.619	0.797	0.861	0.910	0.944	0.970	0.985	0.992
Stevenson and Telford	99.50%	20	0.379	0.615	0.793	0.858	0.908	0.942	0.970	0.984	0.992
Telford and MacColl	95%	281	0.437	0.669	0.832	0.888	0.929	0.957	0.977	0.989	0.994
Telford and MacColl	98%	112	0.400	0.635	0.808	0.869	0.916	0.948	0.973	0.986	0.993
Telford and MacColl	99%	56	0.387	0.623	0.799	0.863	0.911	0.945	0.971	0.985	0.992
Telford and MacColl	99.50%	28	0.381	0.617	0.795	0.859	0.909	0.943	0.970	0.984	0.992
BOWL	95%	247	0.430	0.662	0.828	0.884	0.927	0.955	0.976	0.988	0.994
BOWL	98%	99	0.397	0.632	0.806	0.868	0.915	0.947	0.972	0.986	0.992
BOWL	99%	49	0.386	0.621	0.798	0.862	0.911	0.944	0.971	0.985	0.992
BOWL	99.50%	25	0.380	0.616	0.794	0.859	0.909	0.943	0.970	0.984	0.992
BOWL and MORL	95%	528	0.494	0.716	0.863	0.911	0.945	0.968	0.983	0.992	0.996
BOWL and MORL	98%	211	0.422	0.655	0.822	0.880	0.924	0.954	0.975	0.988	0.994
BOWL and MORL	99%	106	0.398	0.633	0.807	0.869	0.916	0.948	0.972	0.986	0.993
BOWL and MORL	99.50%	53	0.386	0.622	0.799	0.862	0.911	0.944	0.971	0.985	0.992

Graph A19b



COLLISION AND DISPLACEMENT – WORST CASE SCENARIO

Graph A20a

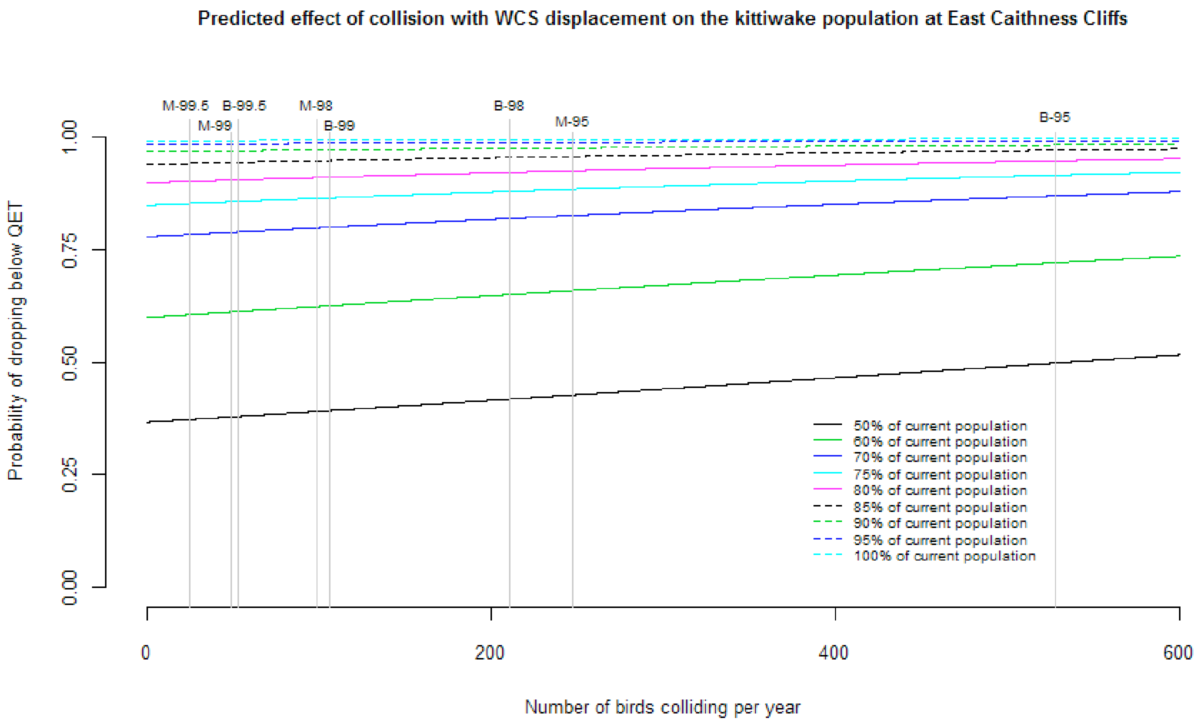
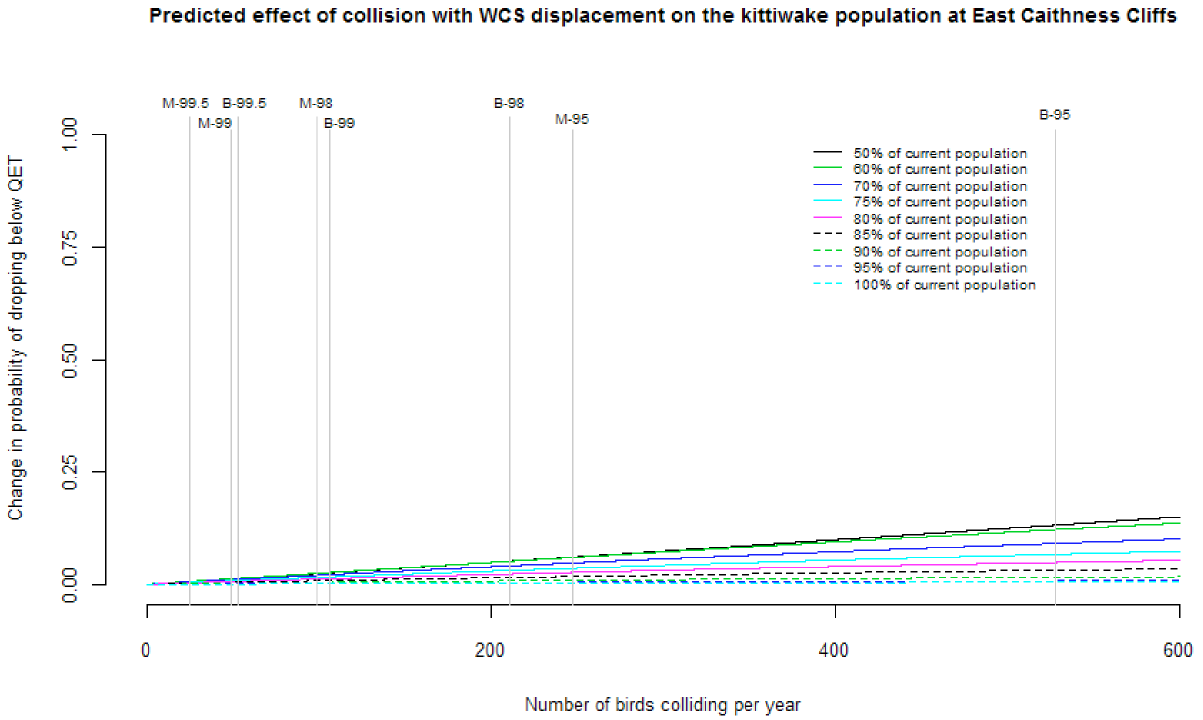


Table A20. Probability of population change from combined displacement and collision effects of kittiwake from East Caithness Cliffs SPA using the Worst Case Scenario displacement rate including birds detected in flight.

Site	Number Displaced	Avoidance Rate	Number Colliding	Probability of dropping below percentage of current population size								
				50%	60%	70%	75%	80%	85%	90%	95%	100%
Baseline	0	N/A	0	0.366	0.600	0.779	0.850	0.900	0.941	0.969	0.986	0.993
3 sites (primary assessment)	582	95%	281	0.435	0.667	0.832	0.889	0.929	0.960	0.978	0.990	0.996
3 sites (primary assessment)	582	98%	113	0.394	0.628	0.802	0.867	0.913	0.949	0.973	0.988	0.994
3 sites (primary assessment)	582	99%	56	0.380	0.614	0.791	0.858	0.906	0.945	0.971	0.987	0.993
3 sites (primary assessment)	582	99.50%	28	0.373	0.607	0.785	0.854	0.903	0.943	0.970	0.986	0.993
MacColl, Telford & Stevenson	582	95%	396	0.464	0.693	0.851	0.903	0.939	0.966	0.981	0.992	0.996
MacColl, Telford & Stevenson	582	98%	159	0.405	0.639	0.811	0.873	0.918	0.953	0.974	0.988	0.995
MacColl, Telford & Stevenson	582	99%	79	0.385	0.619	0.795	0.862	0.909	0.947	0.972	0.987	0.994
MacColl, Telford & Stevenson	582	99.50%	40	0.376	0.610	0.787	0.856	0.904	0.944	0.970	0.986	0.993
MacColl	582	95%	199	0.415	0.648	0.818	0.879	0.922	0.955	0.976	0.989	0.995
MacColl	582	98%	80	0.386	0.620	0.795	0.862	0.909	0.947	0.972	0.987	0.994
MacColl	582	99%	40	0.376	0.610	0.787	0.856	0.904	0.944	0.970	0.986	0.993
MacColl	582	99.50%	20	0.371	0.605	0.783	0.853	0.902	0.942	0.970	0.986	0.993
Telford	582	95%	82	0.386	0.620	0.796	0.862	0.909	0.947	0.972	0.987	0.994
Telford	582	98%	33	0.374	0.608	0.786	0.855	0.904	0.943	0.970	0.986	0.993
Telford	582	99%	16	0.370	0.604	0.782	0.852	0.902	0.942	0.969	0.986	0.993
Telford	582	99.50%	8	0.368	0.602	0.781	0.851	0.901	0.941	0.969	0.986	0.993
Stevenson	582	95%	115	0.394	0.628	0.802	0.867	0.913	0.950	0.973	0.988	0.994
Stevenson	582	98%	46	0.377	0.611	0.789	0.857	0.905	0.944	0.971	0.987	0.993

Stevenson	582	99%	23	0.372	0.605	0.784	0.853	0.902	0.943	0.970	0.986	0.993
Stevenson	582	99.50%	12	0.369	0.603	0.782	0.852	0.901	0.942	0.969	0.986	0.993
MacColl and Stevenson	582	95%	314	0.444	0.675	0.838	0.893	0.932	0.962	0.979	0.991	0.996
MacColl and Stevenson	582	98%	126	0.397	0.631	0.804	0.869	0.914	0.950	0.973	0.988	0.994
MacColl and Stevenson	582	99%	63	0.382	0.615	0.792	0.859	0.907	0.946	0.971	0.987	0.994
MacColl and Stevenson	582	99.50%	31	0.374	0.607	0.786	0.854	0.903	0.943	0.970	0.986	0.993
Stevenson and Telford	582	95%	197	0.414	0.648	0.818	0.879	0.921	0.955	0.976	0.989	0.995
Stevenson and Telford	582	98%	79	0.385	0.619	0.795	0.862	0.909	0.947	0.972	0.987	0.994
Stevenson and Telford	582	99%	39	0.376	0.609	0.787	0.856	0.904	0.944	0.970	0.986	0.993
Stevenson and Telford	582	99.50%	20	0.371	0.605	0.783	0.853	0.902	0.942	0.970	0.986	0.993
Telford and MacColl	582	95%	281	0.435	0.667	0.832	0.889	0.929	0.960	0.978	0.990	0.996
Telford and MacColl	582	98%	112	0.393	0.627	0.802	0.867	0.913	0.949	0.973	0.988	0.994
Telford and MacColl	582	99%	56	0.380	0.614	0.791	0.858	0.906	0.945	0.971	0.987	0.993
Telford and MacColl	582	99.50%	28	0.373	0.607	0.785	0.854	0.903	0.943	0.970	0.986	0.993
BOWL	582	95%	247	0.427	0.659	0.827	0.885	0.926	0.958	0.977	0.990	0.995
BOWL	582	98%	99	0.390	0.624	0.799	0.865	0.911	0.948	0.972	0.987	0.994
BOWL	582	99%	49	0.378	0.612	0.789	0.857	0.906	0.945	0.971	0.987	0.993
BOWL	582	99.50%	25	0.372	0.606	0.784	0.854	0.903	0.943	0.970	0.986	0.993
BOWL and MORL	582	95%	528	0.498	0.722	0.870	0.916	0.948	0.972	0.984	0.993	0.997
BOWL and MORL	582	98%	212	0.418	0.651	0.820	0.881	0.923	0.956	0.976	0.989	0.995
BOWL and MORL	582	99%	105	0.392	0.626	0.800	0.866	0.912	0.949	0.973	0.988	0.994
BOWL and MORL	582	99.50%	53	0.379	0.613	0.790	0.858	0.906	0.945	0.971	0.987	0.993

Graph A20b



COLLISION AND DISPLACEMENT – REALISTIC APPROACH

Graph A21a

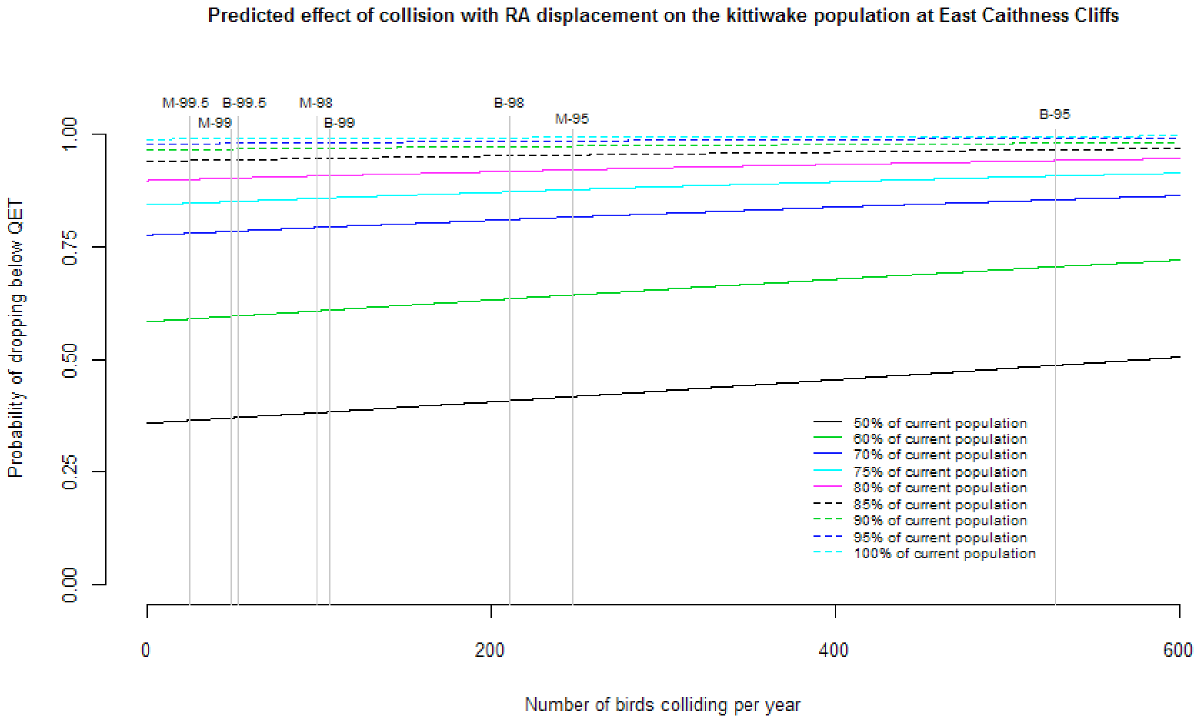
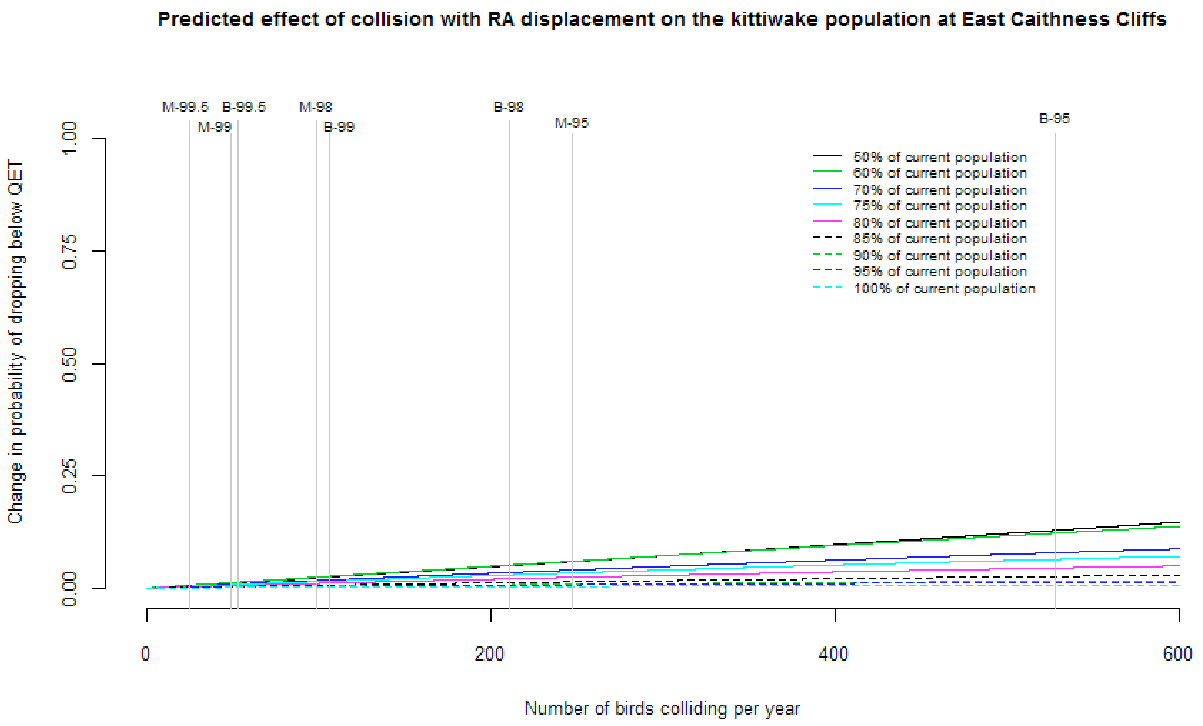


Table A21. Probability of population change from combined displacement and collision effects of kittiwake from East Caithness Cliffs SPA using the Worst Case Scenario displacement rate including birds detected in flight.

Site	Number Displaced	Avoidance Rate	Number Colliding	Probability of dropping below percentage of current population size								
				50%	60%	70%	75%	80%	85%	90%	95%	100%
Baseline	0	N/A	0	0.358	0.584	0.777	0.844	0.898	0.941	0.966	0.979	0.990
3 sites (primary assessment)	107	95%	281	0.425	0.651	0.822	0.882	0.925	0.957	0.975	0.987	0.994
3 sites (primary assessment)	107	98%	113	0.385	0.611	0.796	0.860	0.910	0.948	0.970	0.983	0.992
3 sites (primary assessment)	107	99%	56	0.371	0.598	0.786	0.852	0.904	0.945	0.968	0.981	0.991
3 sites (primary assessment)	107	99.50%	28	0.365	0.591	0.782	0.848	0.901	0.943	0.967	0.980	0.991
MacColl, Telford & Stevenson	107	95%	396	0.454	0.677	0.838	0.895	0.934	0.962	0.978	0.989	0.995
MacColl, Telford & Stevenson	107	98%	159	0.396	0.623	0.803	0.867	0.914	0.950	0.972	0.984	0.993
MacColl, Telford & Stevenson	107	99%	79	0.377	0.603	0.790	0.856	0.906	0.946	0.969	0.982	0.991
MacColl, Telford & Stevenson	107	99.50%	40	0.367	0.594	0.784	0.850	0.902	0.944	0.968	0.981	0.991
MacColl	107	95%	199	0.405	0.632	0.809	0.872	0.918	0.952	0.973	0.985	0.993
MacColl	107	98%	80	0.377	0.603	0.790	0.856	0.906	0.946	0.969	0.982	0.992
MacColl	107	99%	40	0.367	0.594	0.784	0.850	0.902	0.944	0.968	0.981	0.991
MacColl	107	99.50%	20	0.363	0.589	0.780	0.847	0.900	0.942	0.967	0.980	0.990
Telford	107	95%	82	0.377	0.604	0.791	0.856	0.907	0.946	0.969	0.982	0.992
Telford	107	98%	33	0.366	0.592	0.782	0.849	0.902	0.943	0.967	0.981	0.991
Telford	107	99%	16	0.362	0.588	0.779	0.846	0.900	0.942	0.967	0.980	0.990

Telford	107	99.50%	8	0.360	0.586	0.778	0.845	0.899	0.942	0.967	0.980	0.990
Stevenson	107	95%	115	0.385	0.612	0.796	0.861	0.910	0.948	0.970	0.983	0.992
Stevenson	107	98%	46	0.369	0.595	0.785	0.851	0.903	0.944	0.968	0.981	0.991
Stevenson	107	99%	23	0.363	0.589	0.781	0.848	0.901	0.943	0.967	0.980	0.991
Stevenson	107	99.50%	12	0.361	0.587	0.779	0.846	0.899	0.942	0.967	0.980	0.990
MacColl and Stevenson	107	95%	314	0.433	0.659	0.827	0.886	0.927	0.958	0.976	0.988	0.995
MacColl and Stevenson	107	98%	126	0.388	0.615	0.798	0.862	0.911	0.949	0.971	0.983	0.992
MacColl and Stevenson	107	99%	63	0.373	0.599	0.787	0.853	0.905	0.945	0.969	0.981	0.991
MacColl and Stevenson	107	99.50%	31	0.365	0.591	0.782	0.849	0.901	0.943	0.967	0.980	0.991
Stevenson and Telford	107	95%	197	0.405	0.632	0.809	0.871	0.918	0.952	0.973	0.985	0.993
Stevenson and Telford	107	98%	79	0.377	0.603	0.790	0.856	0.906	0.946	0.969	0.982	0.991
Stevenson and Telford	107	99%	39	0.367	0.593	0.783	0.850	0.902	0.944	0.968	0.981	0.991
Stevenson and Telford	107	99.50%	20	0.363	0.589	0.780	0.847	0.900	0.942	0.967	0.980	0.990
Telford and MacColl	107	95%	281	0.425	0.651	0.822	0.882	0.925	0.957	0.975	0.987	0.994
Telford and MacColl	107	98%	112	0.384	0.611	0.796	0.860	0.910	0.948	0.970	0.983	0.992
Telford and MacColl	107	99%	56	0.371	0.598	0.786	0.852	0.904	0.945	0.968	0.981	0.991
Telford and MacColl	107	99.50%	28	0.365	0.591	0.782	0.848	0.901	0.943	0.967	0.980	0.991
BOWL	107	95%	247	0.417	0.643	0.817	0.878	0.922	0.955	0.974	0.986	0.994
BOWL	107	98%	99	0.381	0.608	0.793	0.858	0.908	0.947	0.970	0.983	0.992
BOWL	107	99%	49	0.370	0.596	0.785	0.851	0.903	0.944	0.968	0.981	0.991
BOWL	107	99.50%	25	0.364	0.590	0.781	0.848	0.901	0.943	0.967	0.980	0.991
BOWL and MORL	107	95%	528	0.487	0.706	0.855	0.908	0.943	0.967	0.981	0.992	0.996
BOWL and MORL	107	98%	212	0.408	0.635	0.811	0.873	0.919	0.953	0.973	0.986	0.993
BOWL and MORL	107	99%	105	0.383	0.610	0.794	0.859	0.909	0.947	0.970	0.983	0.992
BOWL and MORL	107	99.50%	53	0.370	0.597	0.786	0.852	0.904	0.944	0.968	0.981	0.991

Graph A21b



NORTH CAITHNESS CLIFFS

DISPLACEMENT

Graph A22a

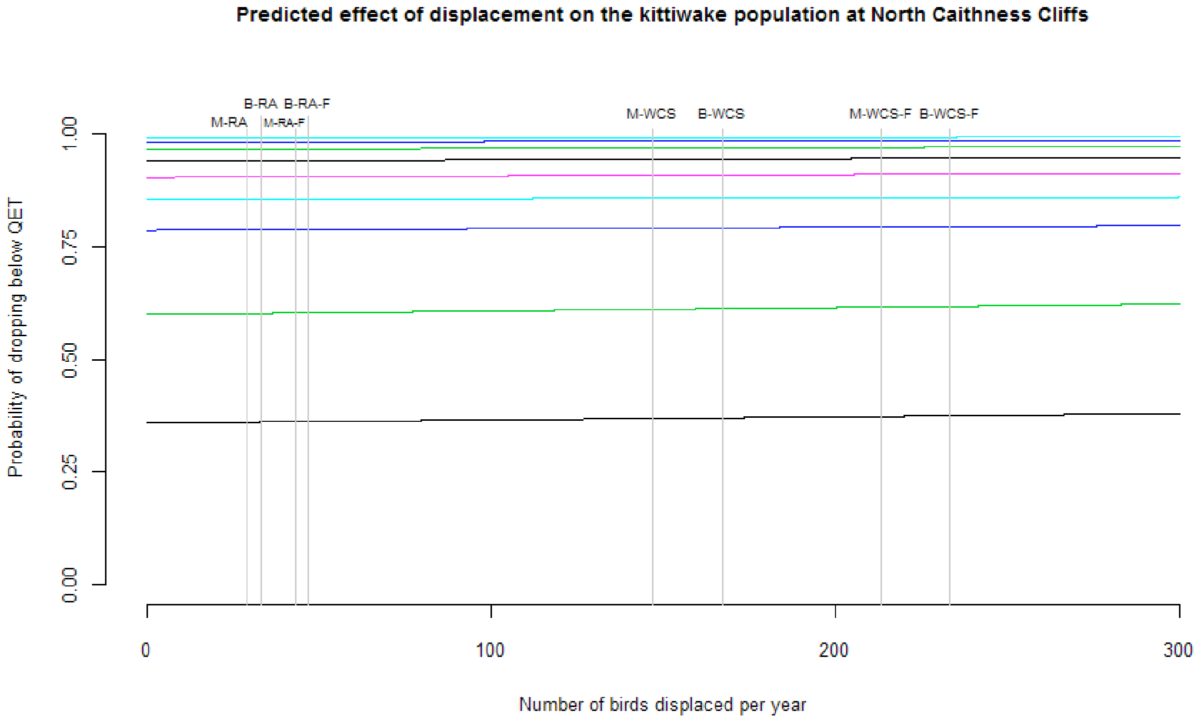
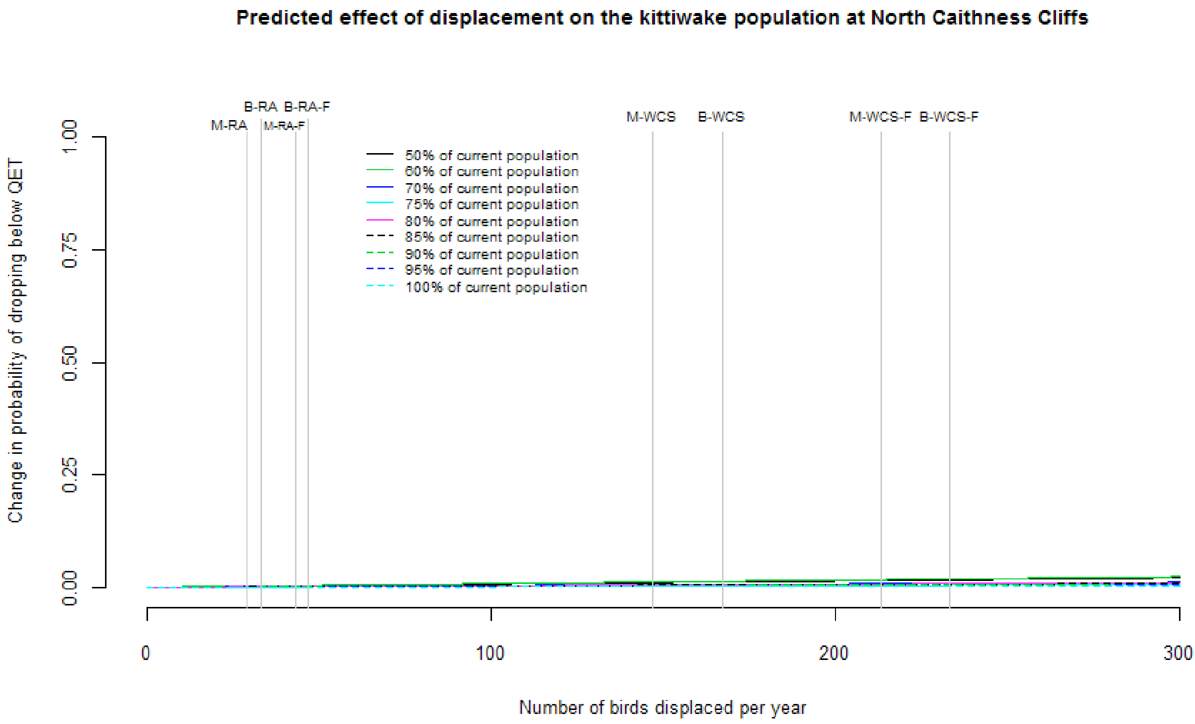


Table A22. Probability of population change from displacement of kittiwake at North Caithness Cliffs SPA.

Site	Displacement rate	Number displaced	Probability of dropping below percentage of current population size								
			50%	60%	70%	75%	80%	85%	90%	95%	100%
3 sites (primary assessment)	Baseline	0	0.358	0.599	0.787	0.855	0.904	0.940	0.966	0.983	0.992
3 sites (primary assessment)	WCS	147	0.368	0.611	0.792	0.857	0.909	0.944	0.970	0.985	0.993
3 sites (primary assessment)	RA	29	0.360	0.602	0.788	0.855	0.905	0.941	0.967	0.983	0.992
3 sites (primary assessment)	WCS flight	213	0.373	0.616	0.794	0.858	0.911	0.946	0.971	0.986	0.993
3 sites (primary assessment)	RA flight	43	0.361	0.603	0.788	0.856	0.906	0.941	0.967	0.983	0.992
MacColl	WCS	68	0.363	0.605	0.789	0.856	0.906	0.942	0.968	0.984	0.992
MacColl	RA	14	0.359	0.600	0.787	0.855	0.905	0.941	0.967	0.983	0.992
MacColl	WCS flight	107	0.365	0.608	0.790	0.857	0.908	0.943	0.969	0.984	0.993
MacColl	RA flight	21	0.360	0.601	0.787	0.855	0.905	0.941	0.967	0.983	0.992
Telford	WCS	50	0.362	0.603	0.788	0.856	0.906	0.942	0.967	0.983	0.992
Telford	RA	10	0.359	0.600	0.787	0.855	0.905	0.940	0.966	0.983	0.992
Telford	WCS flight	44	0.361	0.603	0.788	0.856	0.906	0.941	0.967	0.983	0.992
Telford	RA flight	9	0.359	0.600	0.787	0.855	0.904	0.940	0.966	0.983	0.992
Stevenson	WCS	30	0.360	0.602	0.788	0.855	0.905	0.941	0.967	0.983	0.992
Stevenson	RA	6	0.359	0.600	0.787	0.855	0.904	0.940	0.966	0.983	0.992
Stevenson	WCS flight	62	0.362	0.604	0.789	0.856	0.906	0.942	0.968	0.983	0.992

Stevenson	RA flight	12	0.359	0.600	0.787	0.855	0.905	0.941	0.967	0.983	0.992
MacColl and Stevenson	WCS	98	0.365	0.607	0.790	0.856	0.907	0.943	0.969	0.984	0.993
MacColl and Stevenson	RA	20	0.359	0.601	0.787	0.855	0.905	0.941	0.967	0.983	0.992
MacColl and Stevenson	WCS flight	169	0.370	0.612	0.793	0.858	0.910	0.945	0.970	0.985	0.993
MacColl and Stevenson	RA flight	34	0.360	0.602	0.788	0.855	0.905	0.941	0.967	0.983	0.992
Stevenson and Telford	WCS	80	0.364	0.606	0.789	0.856	0.907	0.942	0.968	0.984	0.992
Stevenson and Telford	RA	16	0.359	0.601	0.787	0.855	0.905	0.941	0.967	0.983	0.992
Stevenson and Telford	WCS flight	106	0.365	0.608	0.790	0.857	0.908	0.943	0.969	0.984	0.993
Stevenson and Telford	RA flight	21	0.360	0.601	0.787	0.855	0.905	0.941	0.967	0.983	0.992
Telford and MacColl	WCS	118	0.366	0.609	0.791	0.857	0.908	0.944	0.969	0.984	0.993
Telford and MacColl	RA	24	0.360	0.601	0.787	0.855	0.905	0.941	0.967	0.983	0.992
Telford and MacColl	WCS flight	151	0.368	0.611	0.792	0.857	0.909	0.944	0.970	0.985	0.993
Telford and MacColl	RA flight	30	0.360	0.602	0.788	0.855	0.905	0.941	0.967	0.983	0.992
BOWL	WCS	20	0.359	0.601	0.787	0.855	0.905	0.941	0.967	0.983	0.992
BOWL	RA	4	0.358	0.600	0.787	0.855	0.904	0.940	0.966	0.983	0.992
BOWL	WCS flight	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BOWL	RA flight	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BOWL and MORL	WCS	167	0.369	0.612	0.793	0.858	0.910	0.945	0.970	0.985	0.993
BOWL and MORL	RA	33	0.360	0.602	0.788	0.855	0.905	0.941	0.967	0.983	0.992
BOWL and MORL	WCS flight	233	0.374	0.617	0.795	0.859	0.912	0.947	0.971	0.986	0.994
BOWL and MORL	RA flight	47	0.361	0.603	0.788	0.856	0.906	0.942	0.967	0.983	0.992

Graph A22b



COLLISION

Graph A23a

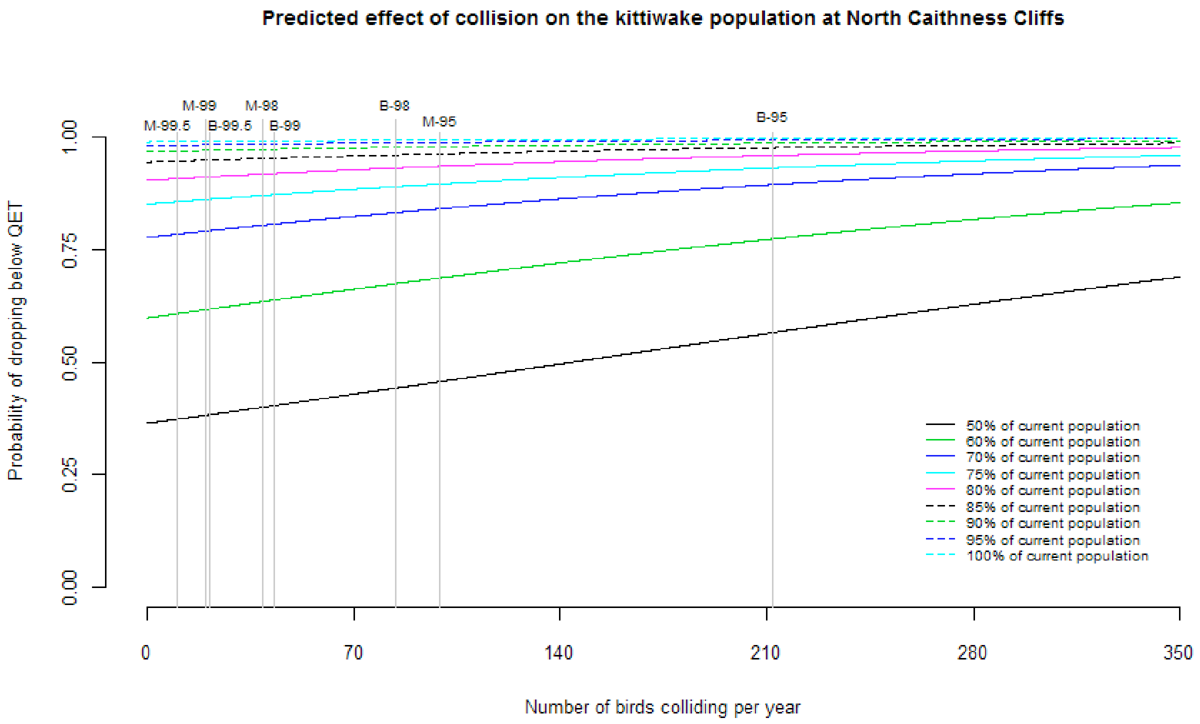
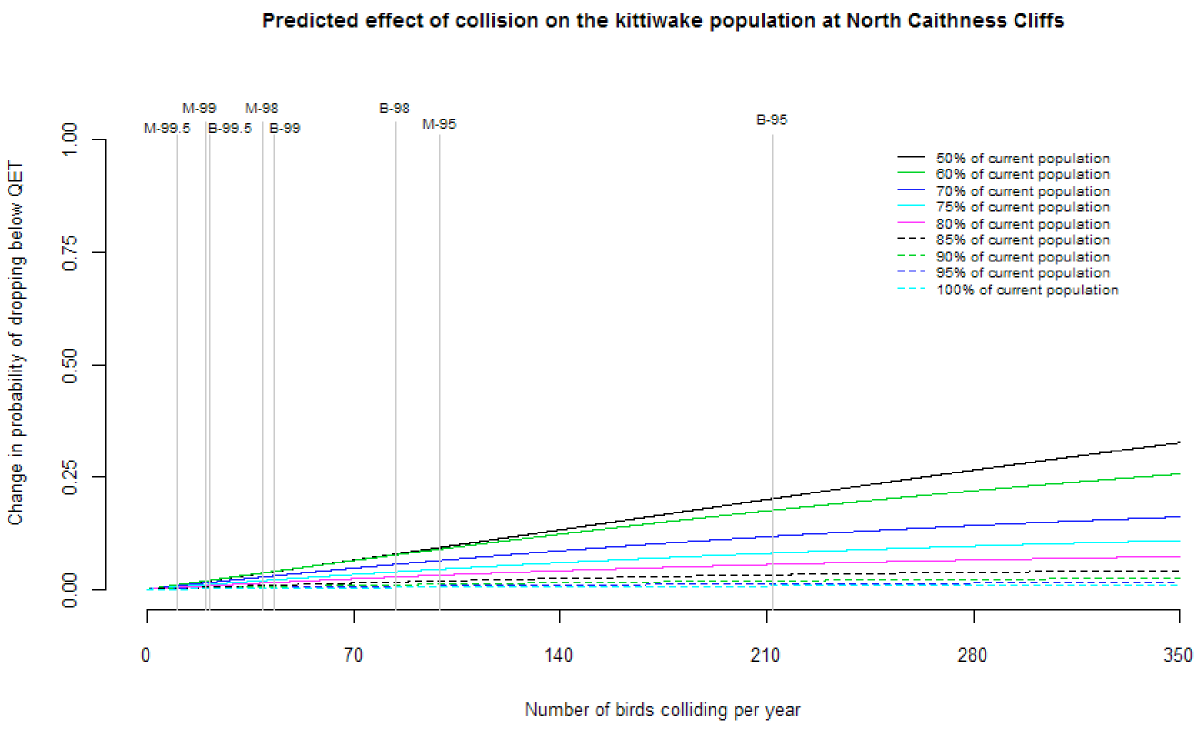


Table A23. Probability of population change from collision of kittiwake from North Caithness Cliffs SPA.

Site	Avoidance Rate	Number Colliding	Probability of dropping below percentage of current population size								
			50%	60%	70%	75%	80%	85%	90%	95%	100%
3 sites (primary assessment)	Baseline	0	0.364	0.598	0.778	0.852	0.905	0.946	0.969	0.982	0.990
3 sites (primary assessment)	95%	113	0.470	0.699	0.849	0.902	0.940	0.966	0.981	0.990	0.995
3 sites (primary assessment)	98%	45	0.405	0.640	0.809	0.874	0.921	0.955	0.974	0.986	0.993
3 sites (primary assessment)	99%	23	0.385	0.620	0.794	0.864	0.913	0.950	0.972	0.984	0.992
3 sites (primary assessment)	99.50%	11	0.374	0.609	0.786	0.858	0.909	0.948	0.970	0.983	0.991
MacColl, Telford and Stevenson	95%	159	0.515	0.736	0.873	0.917	0.950	0.972	0.985	0.992	0.996
MacColl, Telford and Stevenson	98%	63	0.422	0.656	0.820	0.882	0.926	0.958	0.976	0.987	0.994
MacColl, Telford and Stevenson	99%	32	0.393	0.628	0.800	0.868	0.916	0.952	0.973	0.985	0.992
MacColl, Telford and Stevenson	99.50%	16	0.378	0.613	0.789	0.860	0.911	0.949	0.971	0.984	0.991
MacColl	95%	80	0.438	0.671	0.831	0.889	0.931	0.961	0.978	0.989	0.994
MacColl	98%	32	0.393	0.628	0.800	0.868	0.916	0.952	0.973	0.985	0.992
MacColl	99%	16	0.378	0.613	0.789	0.860	0.911	0.949	0.971	0.984	0.991
MacColl	99.50%	8	0.371	0.606	0.783	0.856	0.908	0.947	0.970	0.983	0.991
Telford	95%	33	0.394	0.629	0.801	0.868	0.917	0.952	0.973	0.985	0.992
Telford	98%	13	0.376	0.611	0.787	0.859	0.910	0.948	0.971	0.984	0.991
Telford	99%	7	0.370	0.605	0.783	0.856	0.908	0.947	0.970	0.983	0.991
Telford	99.50%	3	0.367	0.601	0.780	0.854	0.906	0.946	0.969	0.983	0.990
Stevenson	95%	46	0.406	0.641	0.809	0.874	0.921	0.955	0.975	0.986	0.993
Stevenson	98%	18	0.380	0.615	0.791	0.861	0.912	0.949	0.971	0.984	0.991

Stevenson	99%	9	0.372	0.607	0.784	0.857	0.908	0.948	0.970	0.983	0.991
Stevenson	99.50%	5	0.368	0.603	0.781	0.855	0.907	0.947	0.970	0.983	0.991
MacColl and Stevenson	95%	126	0.483	0.710	0.856	0.906	0.943	0.968	0.982	0.991	0.996
MacColl and Stevenson	98%	50	0.410	0.645	0.812	0.876	0.922	0.956	0.975	0.987	0.993
MacColl and Stevenson	99%	25	0.387	0.622	0.795	0.865	0.914	0.951	0.972	0.985	0.992
MacColl and Stevenson	99.50%	13	0.376	0.611	0.787	0.859	0.910	0.948	0.971	0.984	0.991
Stevenson and Telford	95%	79	0.437	0.670	0.830	0.889	0.931	0.961	0.978	0.988	0.994
Stevenson and Telford	98%	32	0.393	0.628	0.800	0.868	0.916	0.952	0.973	0.985	0.992
Stevenson and Telford	99%	16	0.378	0.613	0.789	0.860	0.911	0.949	0.971	0.984	0.991
Stevenson and Telford	99.50%	8	0.371	0.606	0.783	0.856	0.908	0.947	0.970	0.983	0.991
Telford and MacColl	95%	112	0.469	0.698	0.849	0.901	0.940	0.966	0.981	0.990	0.995
Telford and MacColl	98%	45	0.405	0.640	0.809	0.874	0.921	0.955	0.974	0.986	0.993
Telford and MacColl	99%	22	0.384	0.619	0.793	0.863	0.913	0.950	0.972	0.984	0.992
Telford and MacColl	99.50%	11	0.374	0.609	0.786	0.858	0.909	0.948	0.970	0.983	0.991
BOWL	95%	99	0.456	0.688	0.842	0.897	0.936	0.964	0.980	0.990	0.995
BOWL	98%	39	0.400	0.635	0.805	0.871	0.919	0.954	0.974	0.986	0.992
BOWL	99%	20	0.382	0.617	0.792	0.862	0.912	0.950	0.971	0.984	0.991
BOWL	99.50%	10	0.373	0.608	0.785	0.857	0.909	0.948	0.970	0.983	0.991
BOWL and MORL	95%	212	0.566	0.774	0.895	0.933	0.960	0.978	0.988	0.994	0.997
BOWL and MORL	98%	84	0.442	0.675	0.833	0.891	0.932	0.962	0.978	0.989	0.994
BOWL and MORL	99%	43	0.403	0.638	0.807	0.873	0.920	0.954	0.974	0.986	0.993
BOWL and MORL	99.50%	21	0.383	0.618	0.793	0.863	0.913	0.950	0.972	0.984	0.992

Graph A23b



Collision and Displacement – Worst Case Scenario

Graph A24a

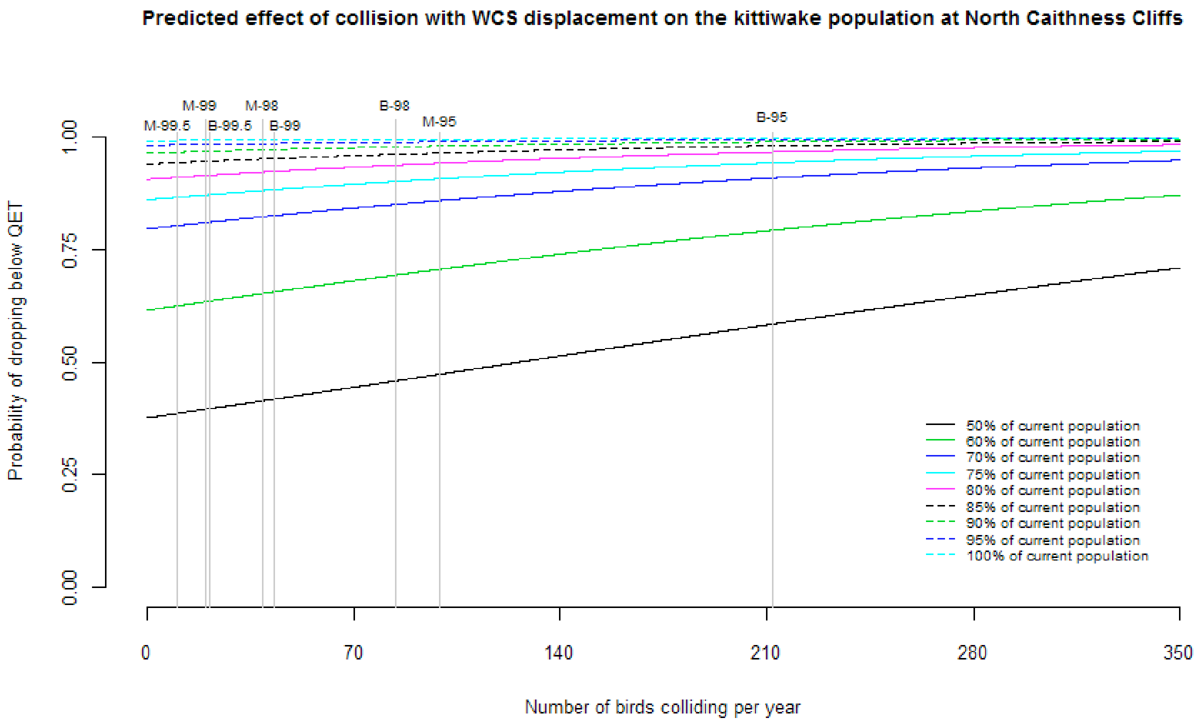
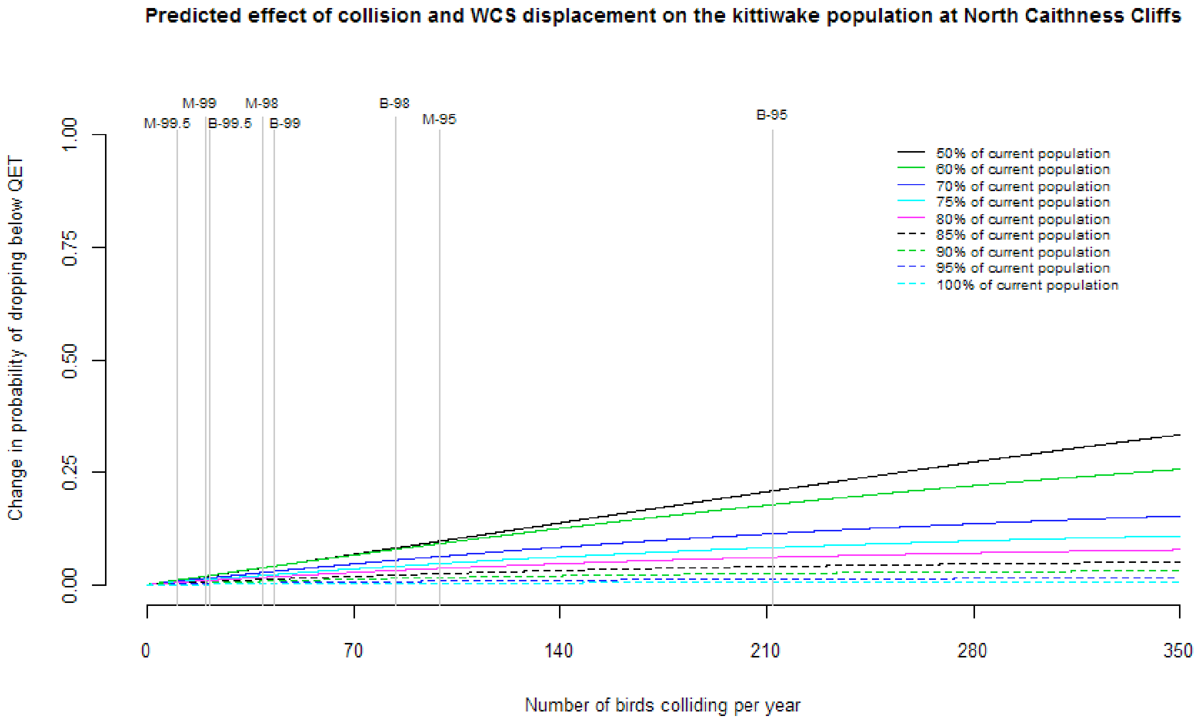


Table 24. Probability of population change from combined displacement and collision effects of kittiwake from North Caithness Cliffs SPA using the Worst Case Scenario displacement rate including birds detected in flight.

Site	Number Displaced	Avoidance Rate	Number Colliding	Probability of dropping below percentage of current population size								
				50%	60%	70%	75%	80%	85%	90%	95%	100%
Baseline	0	N/A	0	0.376	0.615	0.797	0.861	0.907	0.941	0.966	0.983	0.993
3 sites (primary assessment)	233	95%	113	0.487	0.719	0.867	0.914	0.947	0.968	0.983	0.992	0.996
3 sites (primary assessment)	233	98%	45	0.420	0.659	0.828	0.885	0.926	0.954	0.974	0.987	0.995
3 sites (primary assessment)	233	99%	23	0.398	0.638	0.813	0.874	0.917	0.948	0.970	0.985	0.994
3 sites (primary assessment)	233	99.50%	11	0.387	0.626	0.805	0.868	0.912	0.945	0.968	0.984	0.994
MacColl, Telford & Stevenson	233	95%	159	0.533	0.756	0.889	0.929	0.958	0.975	0.987	0.994	0.997
MacColl, Telford & Stevenson	233	98%	63	0.437	0.675	0.839	0.893	0.932	0.958	0.977	0.989	0.995
MacColl, Telford & Stevenson	233	99%	32	0.407	0.646	0.819	0.878	0.921	0.951	0.972	0.986	0.994
MacColl, Telford & Stevenson	233	99.50%	16	0.392	0.631	0.808	0.870	0.914	0.946	0.969	0.985	0.994
MacColl	233	95%	80	0.454	0.690	0.849	0.901	0.937	0.962	0.979	0.990	0.996
MacColl	233	98%	32	0.407	0.646	0.819	0.878	0.921	0.951	0.972	0.986	0.994
MacColl	233	99%	16	0.392	0.631	0.808	0.870	0.914	0.946	0.969	0.985	0.994
MacColl	233	99.50%	8	0.384	0.623	0.803	0.866	0.911	0.944	0.967	0.984	0.993
Telford	233	95%	33	0.408	0.647	0.820	0.879	0.921	0.951	0.972	0.986	0.994
Telford	233	98%	13	0.389	0.628	0.806	0.869	0.913	0.945	0.968	0.985	0.994
Telford	233	99%	7	0.383	0.622	0.802	0.865	0.910	0.943	0.967	0.984	0.993
Telford	233	99.50%	3	0.379	0.618	0.799	0.863	0.908	0.942	0.966	0.984	0.993
Stevenson	233	95%	46	0.421	0.659	0.828	0.885	0.926	0.954	0.974	0.987	0.995
Stevenson	233	98%	18	0.394	0.633	0.810	0.871	0.915	0.947	0.969	0.985	0.994

Stevenson	233	99%	9	0.385	0.624	0.803	0.866	0.911	0.944	0.967	0.984	0.993
Stevenson	233	99.50%	5	0.381	0.620	0.800	0.864	0.909	0.943	0.967	0.984	0.993
MacColl and Stevenson	233	95%	126	0.500	0.729	0.874	0.918	0.950	0.970	0.984	0.992	0.997
MacColl and Stevenson	233	98%	50	0.424	0.663	0.831	0.887	0.927	0.955	0.975	0.988	0.995
MacColl and Stevenson	233	99%	25	0.400	0.640	0.814	0.875	0.918	0.949	0.970	0.986	0.994
MacColl and Stevenson	233	99.50%	13	0.389	0.628	0.806	0.869	0.913	0.945	0.968	0.985	0.994
Stevenson and Telford	233	95%	79	0.453	0.689	0.848	0.900	0.937	0.962	0.979	0.990	0.996
Stevenson and Telford	233	98%	32	0.407	0.646	0.819	0.878	0.921	0.951	0.972	0.986	0.994
Stevenson and Telford	233	99%	16	0.392	0.631	0.808	0.870	0.914	0.946	0.969	0.985	0.994
Stevenson and Telford	233	99.50%	8	0.384	0.623	0.803	0.866	0.911	0.944	0.967	0.984	0.993
Telford and MacColl	233	95%	112	0.486	0.718	0.866	0.913	0.947	0.968	0.983	0.991	0.996
Telford and MacColl	233	98%	45	0.420	0.659	0.828	0.885	0.926	0.954	0.974	0.987	0.995
Telford and MacColl	233	99%	22	0.397	0.637	0.812	0.873	0.917	0.948	0.970	0.985	0.994
Telford and MacColl	233	99.50%	11	0.387	0.626	0.805	0.868	0.912	0.945	0.968	0.984	0.994
BOWL	233	95%	99	0.473	0.707	0.860	0.908	0.943	0.966	0.981	0.991	0.996
BOWL	233	98%	39	0.414	0.653	0.824	0.882	0.923	0.952	0.973	0.987	0.995
BOWL	233	99%	20	0.395	0.635	0.811	0.872	0.916	0.947	0.970	0.985	0.994
BOWL	233	99.50%	10	0.386	0.625	0.804	0.867	0.912	0.944	0.968	0.984	0.994
BOWL and MORL	233	95%	212	0.585	0.794	0.910	0.944	0.968	0.982	0.991	0.995	0.998
BOWL and MORL	233	98%	84	0.458	0.694	0.851	0.902	0.939	0.963	0.979	0.990	0.996
BOWL and MORL	233	99%	43	0.418	0.657	0.826	0.884	0.925	0.953	0.974	0.987	0.995
BOWL and MORL	233	99.50%	21	0.396	0.636	0.812	0.873	0.916	0.948	0.970	0.985	0.994

Graph A24b



COLLISION AND DISPLACEMENT – REALISTIC APPROACH

Graph A25a

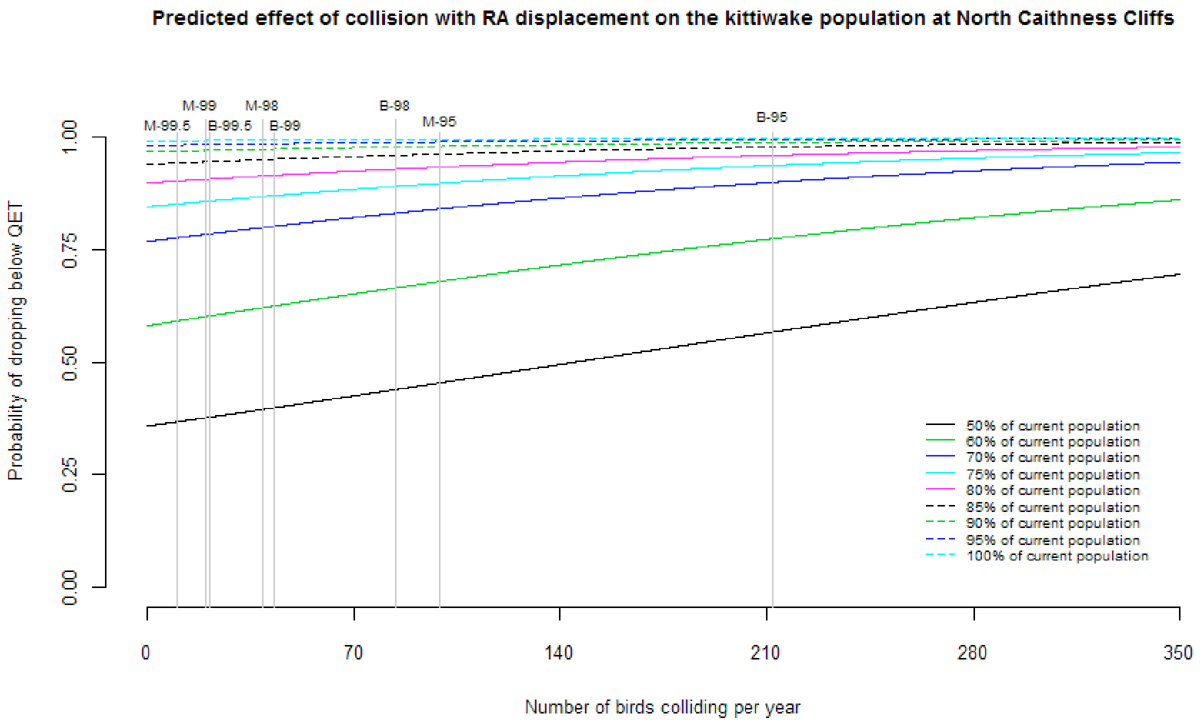
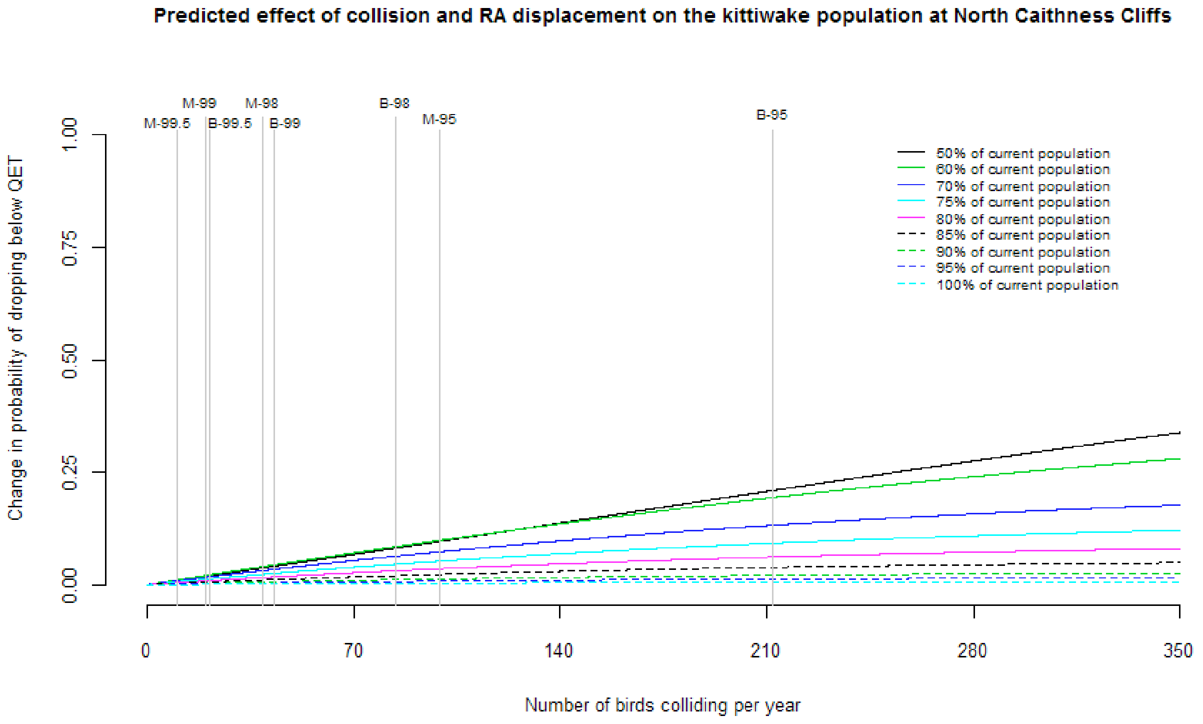


Table A25. Probability of population change from combined displacement and collision effects of kittiwake from North Caithness Cliffs SPA using the Realistic Approach displacement rate including birds detected in flight.

Site	Number Displaced	Avoidance Rate	Number Colliding	Probability of dropping below percentage of current population size								
				50%	60%	70%	75%	80%	85%	90%	95%	100%
3 sites (primary assessment)	0	N/A	0	0.358	0.581	0.768	0.846	0.899	0.941	0.968	0.983	0.993
3 sites (primary assessment)	43	95%	113	0.468	0.692	0.850	0.904	0.938	0.966	0.982	0.991	0.996
3 sites (primary assessment)	43	98%	45	0.400	0.627	0.804	0.872	0.917	0.952	0.975	0.987	0.994
3 sites (primary assessment)	43	99%	23	0.379	0.605	0.787	0.860	0.908	0.947	0.972	0.985	0.994
3 sites (primary assessment)	43	99.50%	11	0.368	0.593	0.777	0.853	0.904	0.944	0.970	0.984	0.993
MacColl, Telford & Stevenson	43	95%	159	0.514	0.733	0.876	0.922	0.950	0.973	0.986	0.993	0.997
MacColl, Telford & Stevenson	43	98%	63	0.418	0.645	0.817	0.881	0.923	0.956	0.977	0.988	0.995
MacColl, Telford & Stevenson	43	99%	32	0.388	0.614	0.794	0.865	0.912	0.949	0.973	0.986	0.994
MacColl, Telford & Stevenson	43	99.50%	16	0.373	0.598	0.782	0.856	0.906	0.945	0.971	0.984	0.993
MacColl	43	95%	80	0.435	0.662	0.829	0.890	0.929	0.960	0.979	0.989	0.996
MacColl	43	98%	32	0.388	0.614	0.794	0.865	0.912	0.949	0.973	0.986	0.994
MacColl	43	99%	16	0.373	0.598	0.782	0.856	0.906	0.945	0.971	0.984	0.993
MacColl	43	99.50%	8	0.365	0.589	0.775	0.851	0.902	0.943	0.970	0.984	0.993
Telford	43	95%	33	0.389	0.615	0.795	0.865	0.912	0.949	0.973	0.986	0.994
Telford	43	98%	13	0.370	0.595	0.779	0.854	0.904	0.944	0.970	0.984	0.993
Telford	43	99%	7	0.364	0.588	0.774	0.850	0.902	0.943	0.969	0.983	0.993
Telford	43	99.50%	3	0.360	0.584	0.771	0.848	0.900	0.942	0.969	0.983	0.993
Stevenson	43	95%	46	0.401	0.628	0.805	0.872	0.917	0.953	0.975	0.987	0.994
Stevenson	43	98%	18	0.375	0.600	0.783	0.857	0.906	0.946	0.971	0.985	0.993

Stevenson	43	99%	9	0.366	0.591	0.776	0.851	0.903	0.943	0.970	0.984	0.993
Stevenson	43	99.50%	5	0.362	0.586	0.773	0.849	0.901	0.942	0.969	0.983	0.993
MacColl and Stevenson	43	95%	126	0.481	0.704	0.858	0.909	0.942	0.968	0.983	0.992	0.997
MacColl and Stevenson	43	98%	50	0.405	0.632	0.808	0.875	0.919	0.953	0.975	0.987	0.995
MacColl and Stevenson	43	99%	25	0.381	0.607	0.789	0.861	0.909	0.947	0.972	0.985	0.994
MacColl and Stevenson	43	99.50%	13	0.370	0.595	0.779	0.854	0.904	0.944	0.970	0.984	0.993
Stevenson and Telford	43	95%	79	0.434	0.661	0.828	0.889	0.928	0.960	0.979	0.989	0.996
Stevenson and Telford	43	98%	32	0.388	0.614	0.794	0.865	0.912	0.949	0.973	0.986	0.994
Stevenson and Telford	43	99%	16	0.373	0.598	0.782	0.856	0.906	0.945	0.971	0.984	0.993
Stevenson and Telford	43	99.50%	8	0.365	0.589	0.775	0.851	0.902	0.943	0.970	0.984	0.993
Telford and MacColl	43	95%	112	0.467	0.692	0.849	0.904	0.938	0.966	0.982	0.991	0.996
Telford and MacColl	43	98%	45	0.400	0.627	0.804	0.872	0.917	0.952	0.975	0.987	0.994
Telford and MacColl	43	99%	22	0.378	0.604	0.786	0.859	0.908	0.947	0.972	0.985	0.994
Telford and MacColl	43	99.50%	11	0.368	0.593	0.777	0.853	0.904	0.944	0.970	0.984	0.993
BOWL	43	95%	99	0.454	0.680	0.841	0.898	0.934	0.963	0.981	0.990	0.996
BOWL	43	98%	39	0.395	0.621	0.800	0.869	0.915	0.951	0.974	0.986	0.994
BOWL	43	99%	20	0.376	0.602	0.785	0.858	0.907	0.946	0.971	0.985	0.994
BOWL	43	99.50%	10	0.367	0.592	0.777	0.852	0.903	0.943	0.970	0.984	0.993
BOWL and MORL	43	95%	212	0.567	0.775	0.900	0.938	0.961	0.979	0.989	0.995	0.998
BOWL and MORL	43	98%	84	0.439	0.665	0.832	0.891	0.930	0.961	0.979	0.990	0.996
BOWL and MORL	43	99%	43	0.398	0.625	0.803	0.871	0.916	0.952	0.974	0.987	0.994
BOWL and MORL	43	99.50%	21	0.377	0.603	0.786	0.859	0.908	0.946	0.972	0.985	0.994

Graph A25b



TROUP HEAD

DISPLACEMENT

Graph A26a

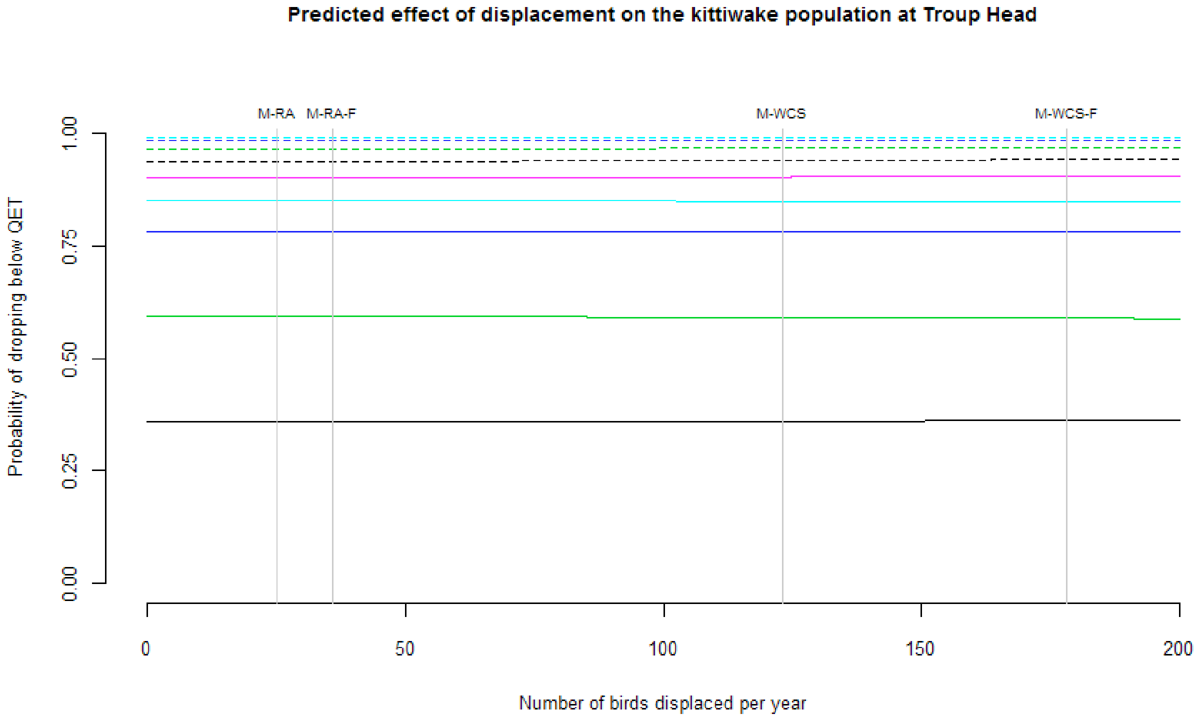
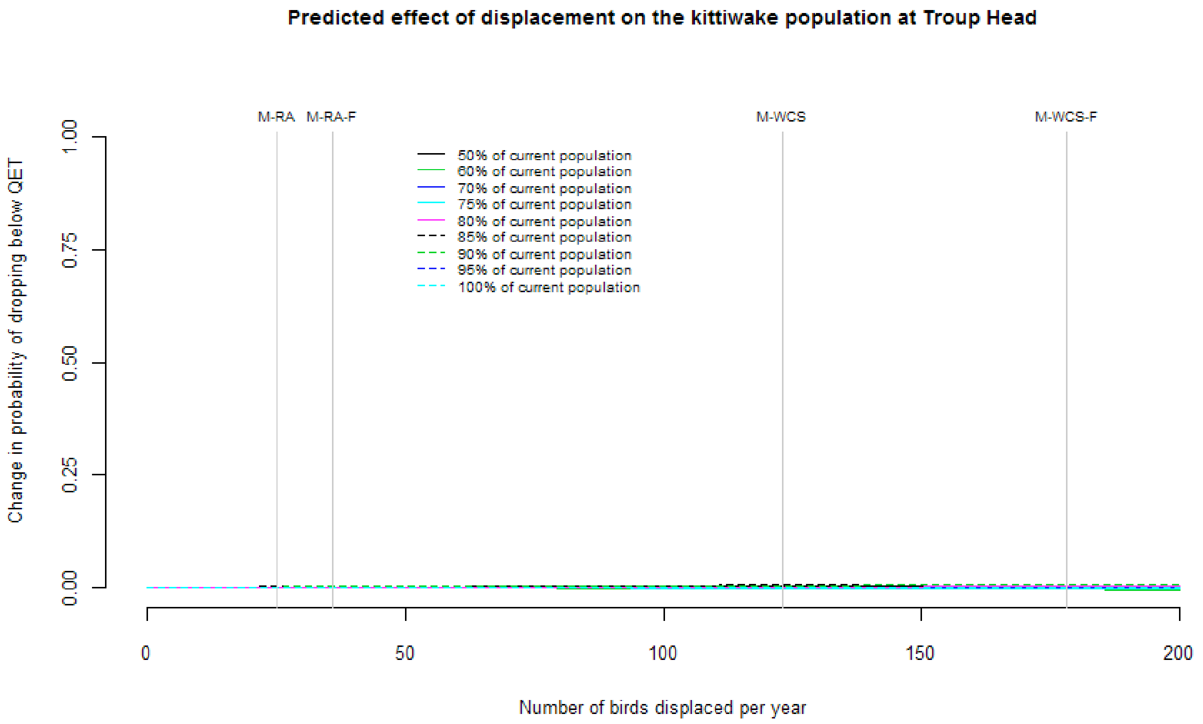


Table A26. Probability of population change from displacement of kittiwake at Troup Head SPA.

Site	Displacement rate	Number displaced	Probability of dropping below percentage of current population size								
			50%	60%	70%	75%	80%	85%	90%	95%	100%
3 sites (primary assessment)	Baseline	0	0.358	0.595	0.781	0.853	0.904	0.937	0.965	0.984	0.993
3 sites (primary assessment)	WCS	123	0.360	0.592	0.781	0.850	0.904	0.941	0.969	0.985	0.993
3 sites (primary assessment)	RA	25	0.359	0.594	0.781	0.852	0.904	0.938	0.966	0.984	0.993
3 sites (primary assessment)	WCS flight	178	0.361	0.590	0.781	0.848	0.905	0.943	0.970	0.985	0.993
3 sites (primary assessment)	RA flight	36	0.359	0.594	0.781	0.852	0.904	0.938	0.966	0.984	0.993
MacColl	WCS	57	0.359	0.593	0.781	0.852	0.904	0.939	0.967	0.984	0.993
MacColl	RA	11	0.359	0.595	0.781	0.853	0.904	0.937	0.966	0.984	0.993
MacColl	WCS flight	89	0.360	0.593	0.781	0.851	0.904	0.940	0.968	0.984	0.993
MacColl	RA flight	18	0.359	0.595	0.781	0.853	0.904	0.938	0.966	0.984	0.993
Telford	WCS	42	0.359	0.594	0.781	0.852	0.904	0.938	0.966	0.984	0.993
Telford	RA	8	0.359	0.595	0.781	0.853	0.904	0.937	0.965	0.984	0.993
Telford	WCS flight	37	0.359	0.594	0.781	0.852	0.904	0.938	0.966	0.984	0.993
Telford	RA flight	7	0.359	0.595	0.781	0.853	0.904	0.937	0.965	0.984	0.993
Stevenson	WCS	25	0.359	0.594	0.781	0.852	0.904	0.938	0.966	0.984	0.993
Stevenson	RA	5	0.359	0.595	0.781	0.853	0.904	0.937	0.965	0.984	0.993
Stevenson	WCS flight	52	0.359	0.594	0.781	0.852	0.904	0.939	0.967	0.984	0.993

Stevenson	RA flight	10	0.359	0.595	0.781	0.853	0.904	0.937	0.966	0.984	0.993
MacColl and Stevenson	WCS	82	0.359	0.593	0.781	0.851	0.904	0.940	0.968	0.984	0.993
MacColl and Stevenson	RA	16	0.359	0.595	0.781	0.853	0.904	0.937	0.966	0.984	0.993
MacColl and Stevenson	WCS flight	141	0.360	0.591	0.781	0.849	0.905	0.942	0.969	0.985	0.993
MacColl and Stevenson	RA flight	28	0.359	0.594	0.781	0.852	0.904	0.938	0.966	0.984	0.993
Stevenson and Telford	WCS	66	0.359	0.593	0.781	0.851	0.904	0.939	0.967	0.984	0.993
Stevenson and Telford	RA	13	0.359	0.595	0.781	0.853	0.904	0.937	0.966	0.984	0.993
Stevenson and Telford	WCS flight	88	0.360	0.593	0.781	0.851	0.904	0.940	0.968	0.984	0.993
Stevenson and Telford	RA flight	18	0.359	0.595	0.781	0.853	0.904	0.938	0.966	0.984	0.993
Telford and MacColl	WCS	98	0.360	0.592	0.781	0.850	0.904	0.940	0.968	0.985	0.993
Telford and MacColl	RA	20	0.359	0.595	0.781	0.852	0.904	0.938	0.966	0.984	0.993
Telford and MacColl	WCS flight	126	0.360	0.591	0.781	0.850	0.904	0.941	0.969	0.985	0.993
Telford and MacColl	RA flight	25	0.359	0.594	0.781	0.852	0.904	0.938	0.966	0.984	0.993
BOWL	WCS	0	0.358	0.595	0.781	0.853	0.904	0.937	0.965	0.984	0.993
BOWL	RA	0	0.358	0.595	0.781	0.853	0.904	0.937	0.965	0.984	0.993
BOWL	WCS flight	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BOWL	RA flight	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BOWL and MORL	WCS	123	0.360	0.592	0.781	0.850	0.904	0.941	0.969	0.985	0.993
BOWL and MORL	RA	25	0.359	0.594	0.781	0.852	0.904	0.938	0.966	0.984	0.993
BOWL and MORL	WCS flight	178	0.361	0.590	0.781	0.848	0.905	0.943	0.970	0.985	0.993
BOWL and MORL	RA flight	36	0.359	0.594	0.781	0.852	0.904	0.938	0.966	0.984	0.993

Graph A26b



COLLISION

Graph A27a

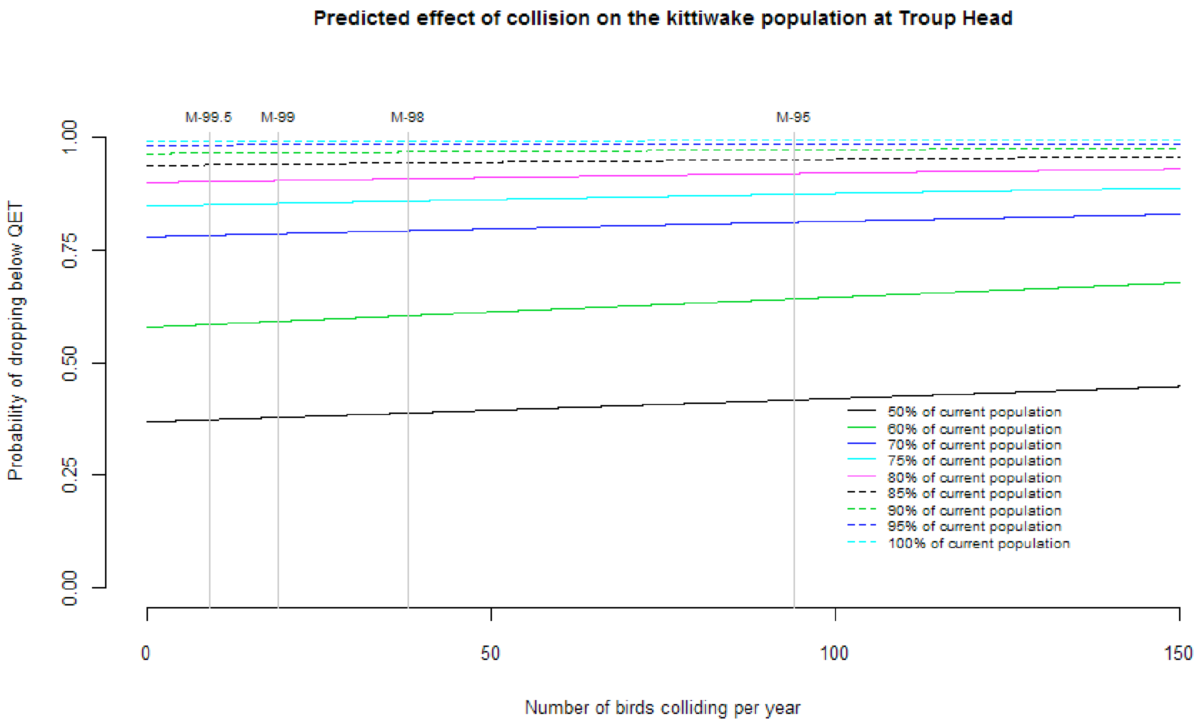
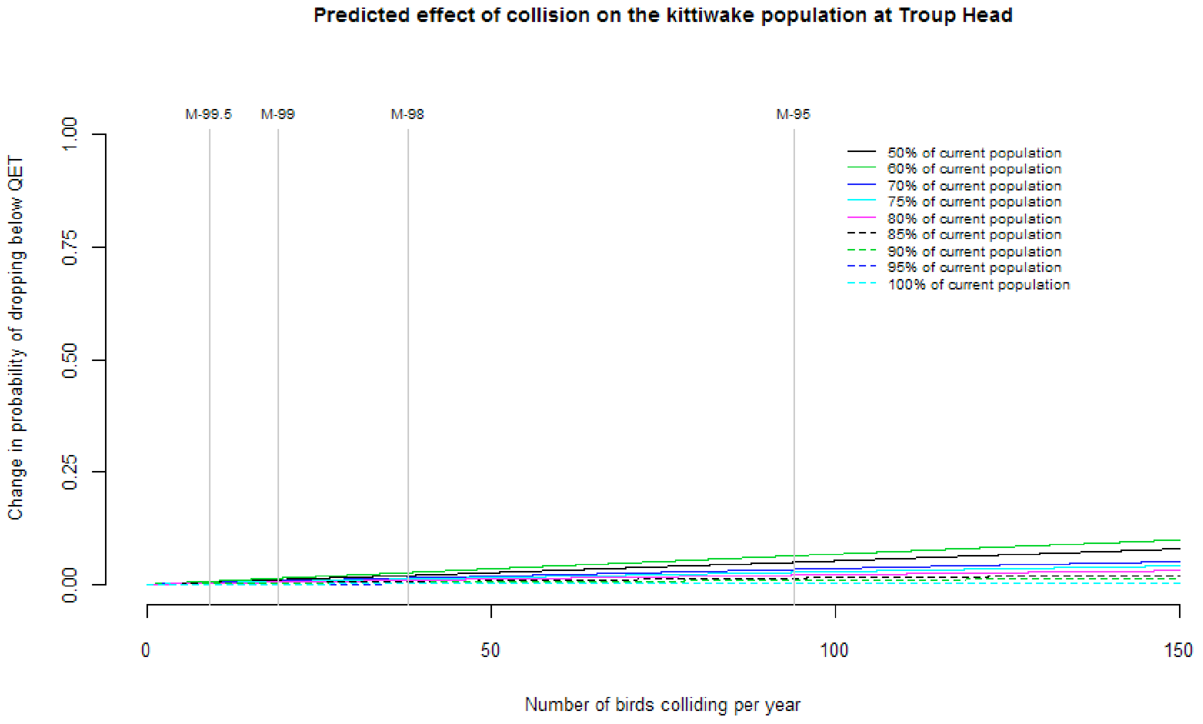


Table A27. Probability of population change from collision of kittiwake at Troup Head SPA.

Site	Avoidance Rate	Number Colliding	Probability of dropping below percentage of current population size								
			50%	60%	70%	75%	80%	85%	90%	95%	100%
3 sites (primary assessment)	Baseline	0	0.368	0.578	0.779	0.848	0.900	0.938	0.965	0.984	0.992
3 sites (primary assessment)	95%	94	0.417	0.641	0.812	0.874	0.920	0.951	0.973	0.986	0.994
3 sites (primary assessment)	98%	38	0.387	0.604	0.793	0.859	0.909	0.944	0.968	0.985	0.993
3 sites (primary assessment)	99%	19	0.377	0.591	0.786	0.854	0.905	0.941	0.966	0.984	0.992
3 sites (primary assessment)	99.50%	9	0.372	0.584	0.783	0.851	0.902	0.940	0.965	0.984	0.992
MacColl, Telford and Stevenson	95%	132	0.437	0.666	0.824	0.884	0.927	0.956	0.976	0.987	0.995
MacColl, Telford and Stevenson	98%	53	0.395	0.614	0.798	0.863	0.912	0.946	0.970	0.985	0.993
MacColl, Telford and Stevenson	99%	26	0.381	0.596	0.789	0.856	0.906	0.942	0.967	0.984	0.992
MacColl, Telford and Stevenson	99.50%	13	0.375	0.587	0.784	0.852	0.903	0.940	0.966	0.984	0.992
MacColl	95%	66	0.402	0.623	0.803	0.867	0.915	0.948	0.971	0.985	0.993
MacColl	98%	27	0.382	0.597	0.789	0.856	0.906	0.942	0.967	0.984	0.992
MacColl	99%	13	0.374	0.587	0.784	0.852	0.903	0.940	0.966	0.984	0.992
MacColl	99.50%	7	0.371	0.583	0.782	0.850	0.902	0.939	0.965	0.984	0.992
Telford	95%	27	0.382	0.597	0.789	0.856	0.906	0.942	0.967	0.984	0.992
Telford	98%	11	0.373	0.586	0.783	0.851	0.903	0.940	0.966	0.984	0.992
Telford	99%	5	0.370	0.582	0.781	0.849	0.901	0.939	0.965	0.984	0.992
Telford	99.50%	3	0.369	0.580	0.780	0.849	0.901	0.939	0.965	0.984	0.992
Stevenson	95%	38	0.387	0.604	0.793	0.859	0.909	0.944	0.968	0.985	0.993
Stevenson	98%	15	0.375	0.589	0.785	0.852	0.904	0.940	0.966	0.984	0.992
Stevenson	99%	8	0.372	0.584	0.782	0.850	0.902	0.939	0.965	0.984	0.992

Stevenson	99.50%	4	0.370	0.581	0.781	0.849	0.901	0.939	0.965	0.984	0.992
MacColl and Stevenson	95%	105	0.422	0.648	0.816	0.877	0.922	0.953	0.974	0.986	0.994
MacColl and Stevenson	98%	42	0.389	0.607	0.794	0.860	0.910	0.944	0.969	0.985	0.993
MacColl and Stevenson	99%	21	0.378	0.593	0.787	0.854	0.905	0.941	0.967	0.984	0.992
MacColl and Stevenson	99.50%	10	0.373	0.585	0.783	0.851	0.903	0.940	0.966	0.984	0.992
Stevenson and Telford	95%	66	0.402	0.623	0.803	0.867	0.915	0.948	0.971	0.985	0.993
Stevenson and Telford	98%	26	0.381	0.596	0.789	0.856	0.906	0.942	0.967	0.984	0.992
Stevenson and Telford	99%	13	0.374	0.587	0.784	0.852	0.903	0.940	0.966	0.984	0.992
Stevenson and Telford	99.50%	7	0.371	0.583	0.782	0.850	0.902	0.939	0.965	0.984	0.992
Telford and MacColl	95%	94	0.417	0.641	0.812	0.874	0.920	0.951	0.973	0.986	0.994
Telford and MacColl	98%	37	0.387	0.604	0.793	0.859	0.909	0.944	0.968	0.985	0.993
Telford and MacColl	99%	19	0.377	0.591	0.786	0.854	0.905	0.941	0.966	0.984	0.992
Telford and MacColl	99.50%	9	0.372	0.584	0.783	0.851	0.902	0.940	0.965	0.984	0.992
BOWL	95%	0	0.368	0.578	0.779	0.848	0.900	0.938	0.965	0.984	0.992
BOWL	98%	0	0.368	0.578	0.779	0.848	0.900	0.938	0.965	0.984	0.992
BOWL	99%	0	0.368	0.578	0.779	0.848	0.900	0.938	0.965	0.984	0.992
BOWL	99.50%	0	0.368	0.578	0.779	0.848	0.900	0.938	0.965	0.984	0.992
BOWL and MORL	95%	94	0.417	0.641	0.812	0.874	0.920	0.951	0.973	0.986	0.994
BOWL and MORL	98%	38	0.387	0.604	0.793	0.859	0.909	0.944	0.968	0.985	0.993
BOWL and MORL	99%	19	0.377	0.591	0.786	0.854	0.905	0.941	0.966	0.984	0.992
BOWL and MORL	99.50%	9	0.372	0.584	0.783	0.851	0.902	0.940	0.965	0.984	0.992

Graph A27b



COLLISION AND DISPLACEMENT – WORST CASE SCENARIO

Graph A28a

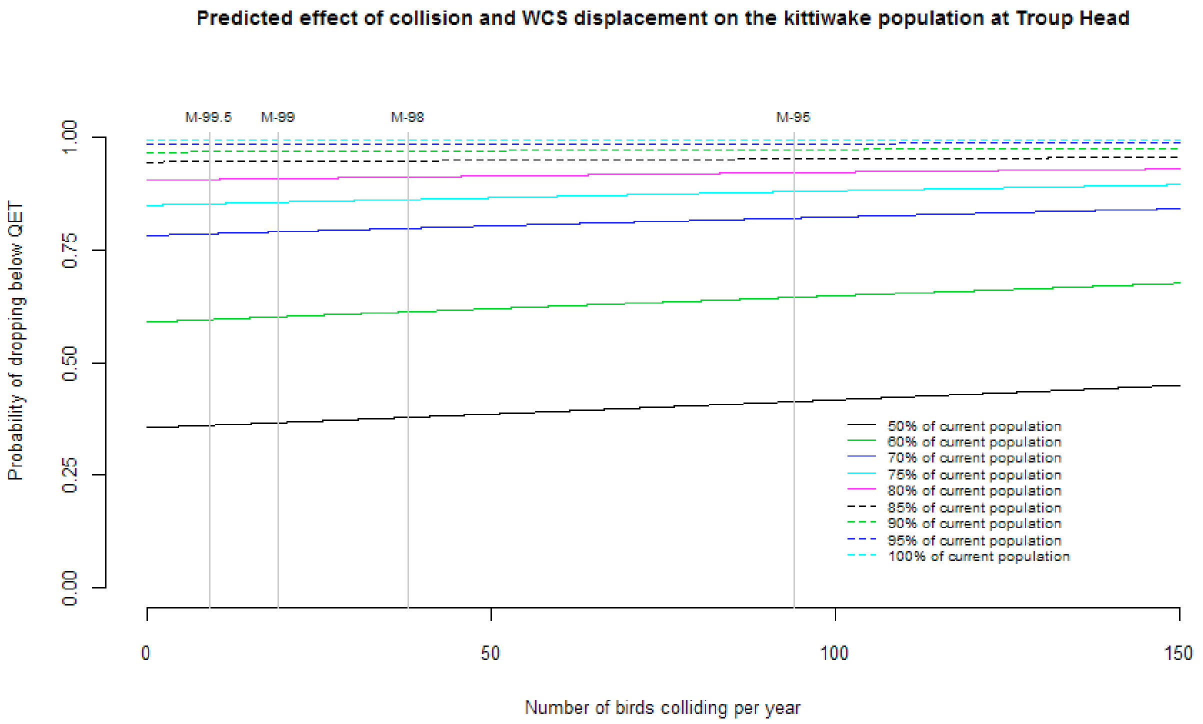
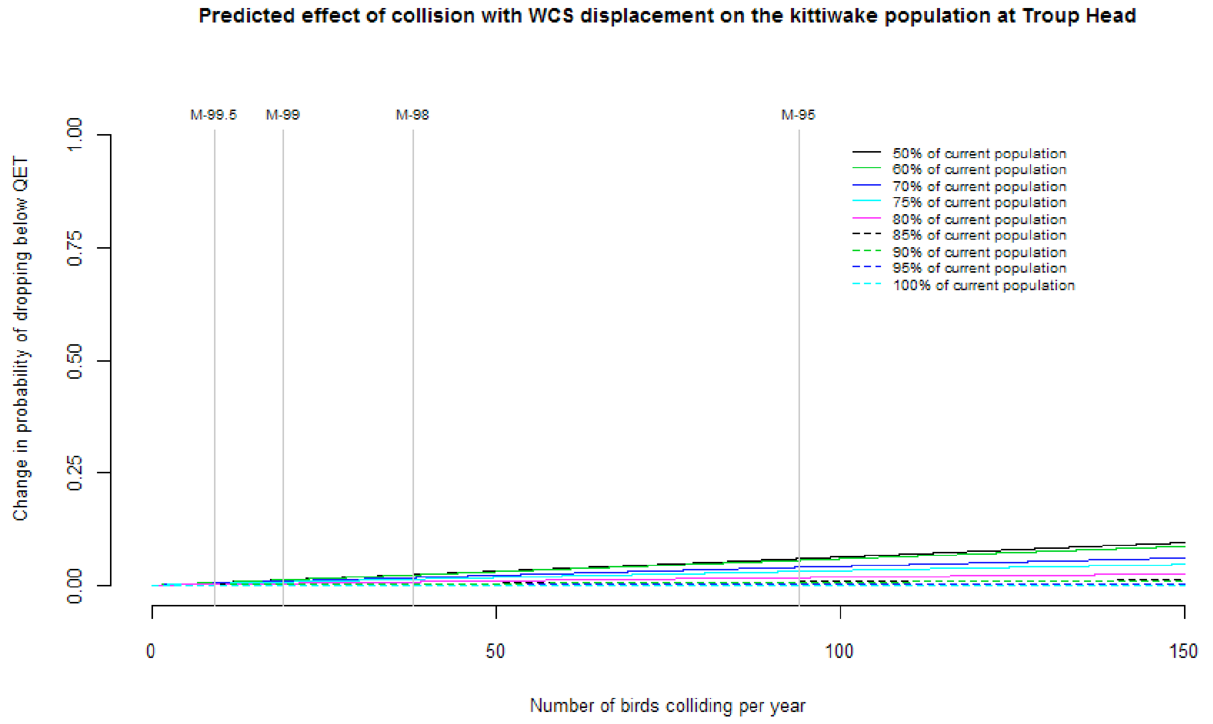


Table A28. Probability of population change from combined displacement and collision effects of kittiwake from Troup Head SPA using the Worst Case Scenario displacement rate including birds detected in flight.

Site	Number Displaced	Avoidance Rate	Number Colliding	Probability of dropping below percentage of current population size								
				50%	60%	70%	75%	80%	85%	90%	95%	100%
Baseline	0	N/A	0	0.354	0.590	0.782	0.850	0.906	0.946	0.968	0.986	0.994
3 sites (primary assessment)	178	95%	94	0.413	0.645	0.821	0.880	0.922	0.953	0.974	0.987	0.994
3 sites (primary assessment)	178	98%	38	0.378	0.613	0.799	0.863	0.913	0.949	0.970	0.986	0.994
3 sites (primary assessment)	178	99%	19	0.366	0.601	0.791	0.856	0.909	0.947	0.969	0.986	0.994
3 sites (primary assessment)	178	99.50%	9	0.360	0.595	0.786	0.853	0.907	0.946	0.968	0.986	0.994
MacColl, Telford & Stevenson	178	95%	132	0.437	0.666	0.836	0.891	0.928	0.955	0.976	0.988	0.994
MacColl, Telford & Stevenson	178	98%	53	0.387	0.621	0.805	0.867	0.915	0.950	0.971	0.986	0.994
MacColl, Telford & Stevenson	178	99%	26	0.370	0.606	0.794	0.859	0.911	0.948	0.969	0.986	0.994
MacColl, Telford & Stevenson	178	99.50%	13	0.362	0.598	0.788	0.854	0.908	0.947	0.969	0.986	0.994
MacColl	178	95%	66	0.395	0.629	0.810	0.872	0.918	0.951	0.972	0.987	0.994
MacColl	178	98%	27	0.371	0.606	0.794	0.859	0.911	0.948	0.970	0.986	0.994
MacColl	178	99%	13	0.362	0.598	0.788	0.854	0.908	0.947	0.969	0.986	0.994
MacColl	178	99.50%	7	0.359	0.594	0.785	0.852	0.907	0.946	0.968	0.986	0.994
Telford	178	95%	27	0.371	0.606	0.794	0.859	0.911	0.948	0.970	0.986	0.994
Telford	178	98%	11	0.361	0.597	0.787	0.853	0.908	0.947	0.968	0.986	0.994
Telford	178	99%	5	0.357	0.593	0.784	0.851	0.907	0.946	0.968	0.986	0.994
Telford	178	99.50%	3	0.356	0.592	0.783	0.851	0.906	0.946	0.968	0.986	0.994
Stevenson	178	95%	38	0.378	0.613	0.799	0.863	0.913	0.949	0.970	0.986	0.994
Stevenson	178	98%	15	0.364	0.599	0.789	0.855	0.908	0.947	0.969	0.986	0.994

Stevenson	178	99%	8	0.359	0.595	0.786	0.852	0.907	0.946	0.968	0.986	0.994
Stevenson	178	99.50%	4	0.357	0.592	0.784	0.851	0.906	0.946	0.968	0.986	0.994
MacColl and Stevenson	178	95%	105	0.420	0.651	0.826	0.883	0.924	0.954	0.975	0.987	0.994
MacColl and Stevenson	178	98%	42	0.380	0.615	0.800	0.864	0.913	0.949	0.971	0.986	0.994
MacColl and Stevenson	178	99%	21	0.367	0.603	0.791	0.857	0.910	0.947	0.969	0.986	0.994
MacColl and Stevenson	178	99.50%	10	0.360	0.596	0.787	0.853	0.908	0.946	0.968	0.986	0.994
Stevenson and Telford	178	95%	66	0.395	0.629	0.810	0.872	0.918	0.951	0.972	0.987	0.994
Stevenson and Telford	178	98%	26	0.370	0.606	0.794	0.859	0.911	0.948	0.969	0.986	0.994
Stevenson and Telford	178	99%	13	0.362	0.598	0.788	0.854	0.908	0.947	0.969	0.986	0.994
Stevenson and Telford	178	99.50%	7	0.359	0.594	0.785	0.852	0.907	0.946	0.968	0.986	0.994
Telford and MacColl	178	95%	94	0.413	0.645	0.821	0.880	0.922	0.953	0.974	0.987	0.994
Telford and MacColl	178	98%	37	0.377	0.612	0.798	0.862	0.912	0.949	0.970	0.986	0.994
Telford and MacColl	178	99%	19	0.366	0.601	0.791	0.856	0.909	0.947	0.969	0.986	0.994
Telford and MacColl	178	99.50%	9	0.360	0.595	0.786	0.853	0.907	0.946	0.968	0.986	0.994
BOWL	178	95%	0	0.354	0.590	0.782	0.850	0.906	0.946	0.968	0.986	0.994
BOWL	178	98%	0	0.354	0.590	0.782	0.850	0.906	0.946	0.968	0.986	0.994
BOWL	178	99%	0	0.354	0.590	0.782	0.850	0.906	0.946	0.968	0.986	0.994
BOWL	178	99.50%	0	0.354	0.590	0.782	0.850	0.906	0.946	0.968	0.986	0.994
BOWL and MORL	178	95%	94	0.413	0.645	0.821	0.880	0.922	0.953	0.974	0.987	0.994
BOWL and MORL	178	98%	38	0.378	0.613	0.799	0.863	0.913	0.949	0.970	0.986	0.994
BOWL and MORL	178	99%	19	0.366	0.601	0.791	0.856	0.909	0.947	0.969	0.986	0.994
BOWL and MORL	178	99.50%	9	0.360	0.595	0.786	0.853	0.907	0.946	0.968	0.986	0.994

Graph A28b.



COLLISION AND DISPLACEMENT – REALISTIC APPROACH

Graph A29a

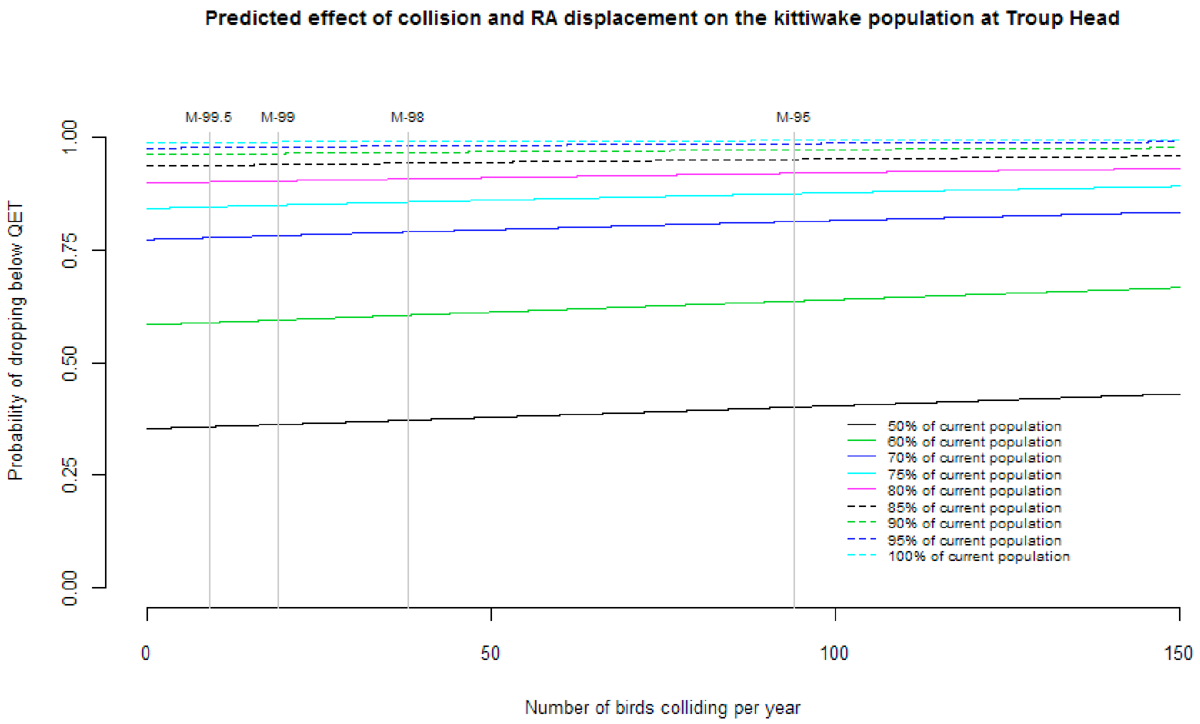
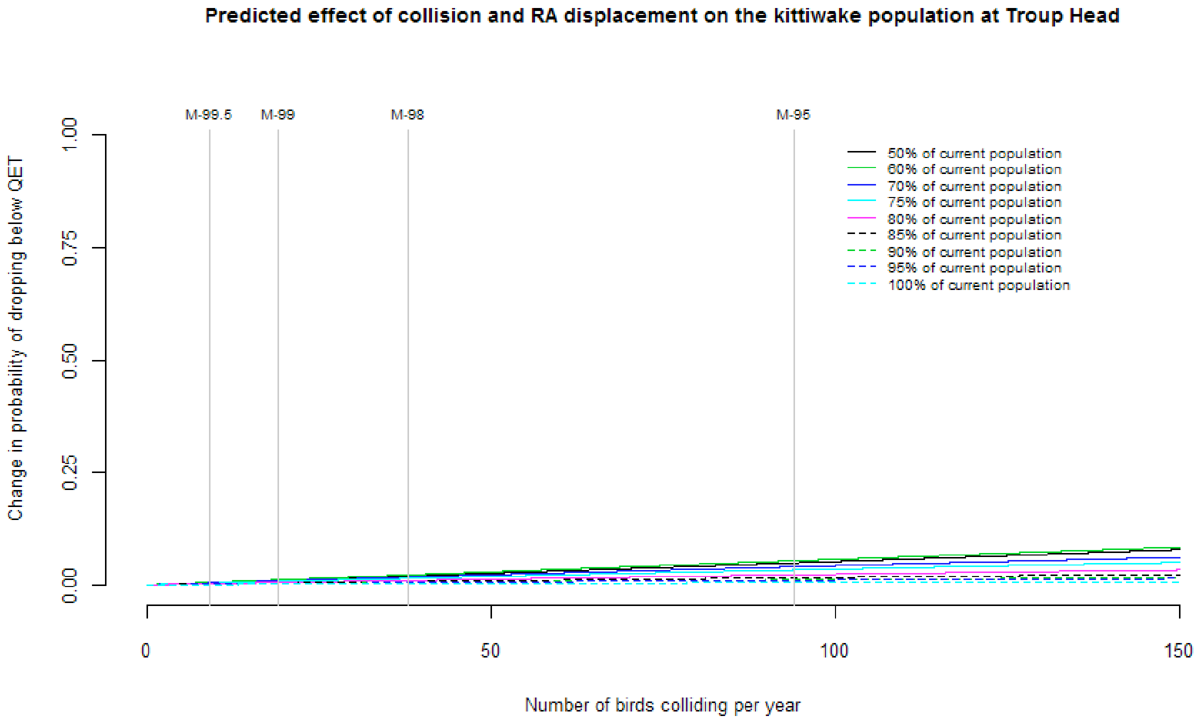


Table A29. Probability of population change from combined displacement and collision effects of kittiwake from Troup Head SPA using the Realistic Approach displacement rate including birds detected in flight.

Site	Number Displaced	Avoidance Rate	Number Colliding	Probability of dropping below percentage of current population size								
				50%	60%	70%	75%	80%	85%	90%	95%	100%
Baseline	0	N/A	0	0.352	0.583	0.774	0.843	0.899	0.937	0.962	0.977	0.989
3 sites (primary assessment)	36	95%	94	0.400	0.636	0.813	0.875	0.921	0.952	0.973	0.987	0.994
3 sites (primary assessment)	36	98%	38	0.371	0.605	0.790	0.857	0.908	0.943	0.967	0.982	0.991
3 sites (primary assessment)	36	99%	19	0.362	0.594	0.782	0.850	0.904	0.940	0.965	0.979	0.990
3 sites (primary assessment)	36	99.50%	9	0.357	0.589	0.778	0.846	0.901	0.938	0.964	0.978	0.990
MacColl, Telford & Stevenson	36	95%	132	0.420	0.657	0.828	0.887	0.928	0.957	0.977	0.990	0.995
MacColl, Telford & Stevenson	36	98%	53	0.379	0.614	0.797	0.862	0.912	0.946	0.969	0.983	0.992
MacColl, Telford & Stevenson	36	99%	26	0.365	0.598	0.785	0.852	0.905	0.941	0.966	0.980	0.991
MacColl, Telford & Stevenson	36	99.50%	13	0.359	0.591	0.779	0.848	0.902	0.939	0.964	0.979	0.990
MacColl	36	95%	66	0.386	0.621	0.802	0.866	0.915	0.948	0.970	0.984	0.993
MacColl	36	98%	27	0.366	0.599	0.786	0.853	0.906	0.941	0.966	0.980	0.991
MacColl	36	99%	13	0.359	0.591	0.779	0.848	0.902	0.939	0.964	0.979	0.990
MacColl	36	99.50%	7	0.356	0.587	0.777	0.845	0.901	0.938	0.963	0.978	0.990
Telford	36	95%	27	0.366	0.599	0.786	0.853	0.906	0.941	0.966	0.980	0.991
Telford	36	98%	11	0.358	0.590	0.778	0.847	0.902	0.939	0.964	0.978	0.990
Telford	36	99%	5	0.355	0.586	0.776	0.845	0.900	0.938	0.963	0.978	0.990
Telford	36	99.50%	3	0.354	0.585	0.775	0.844	0.900	0.937	0.963	0.977	0.989
Stevenson	36	95%	38	0.371	0.605	0.790	0.857	0.908	0.943	0.967	0.982	0.991
Stevenson	36	98%	15	0.360	0.592	0.780	0.848	0.903	0.939	0.964	0.979	0.990

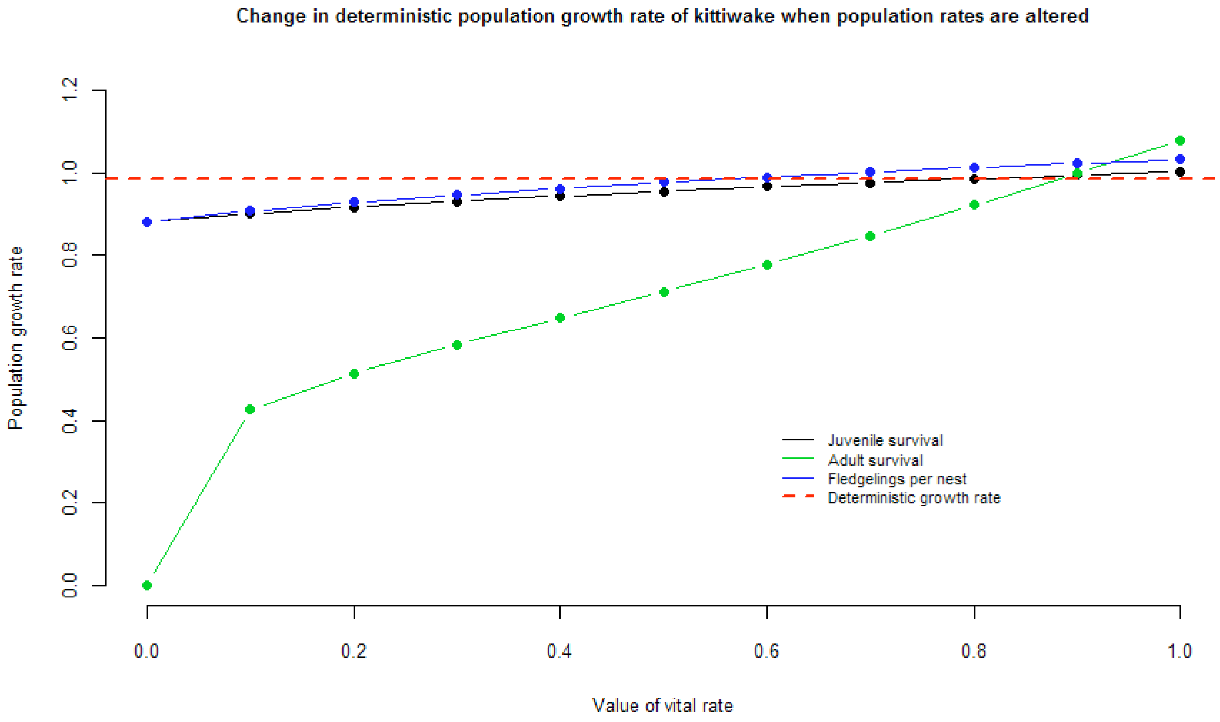
Stevenson	36	99%	8	0.356	0.588	0.777	0.846	0.901	0.938	0.963	0.978	0.990
Stevenson	36	99.50%	4	0.354	0.586	0.775	0.844	0.900	0.937	0.963	0.978	0.989
MacColl and Stevenson	36	95%	105	0.406	0.642	0.818	0.879	0.923	0.954	0.974	0.988	0.994
MacColl and Stevenson	36	98%	42	0.373	0.607	0.792	0.858	0.909	0.944	0.968	0.982	0.992
MacColl and Stevenson	36	99%	21	0.363	0.595	0.783	0.851	0.904	0.940	0.965	0.980	0.990
MacColl and Stevenson	36	99.50%	10	0.357	0.589	0.778	0.847	0.902	0.938	0.964	0.978	0.990
Stevenson and Telford	36	95%	66	0.386	0.621	0.802	0.866	0.915	0.948	0.970	0.984	0.993
Stevenson and Telford	36	98%	26	0.365	0.598	0.785	0.852	0.905	0.941	0.966	0.980	0.991
Stevenson and Telford	36	99%	13	0.359	0.591	0.779	0.848	0.902	0.939	0.964	0.979	0.990
Stevenson and Telford	36	99.50%	7	0.356	0.587	0.777	0.845	0.901	0.938	0.963	0.978	0.990
Telford and MacColl	36	95%	94	0.400	0.636	0.813	0.875	0.921	0.952	0.973	0.987	0.994
Telford and MacColl	36	98%	37	0.371	0.605	0.790	0.856	0.908	0.943	0.967	0.982	0.991
Telford and MacColl	36	99%	19	0.362	0.594	0.782	0.850	0.904	0.940	0.965	0.979	0.990
Telford and MacColl	36	99.50%	9	0.357	0.589	0.778	0.846	0.901	0.938	0.964	0.978	0.990
BOWL	36	95%	0	0.352	0.583	0.774	0.843	0.899	0.937	0.962	0.977	0.989
BOWL	36	98%	0	0.352	0.583	0.774	0.843	0.899	0.937	0.962	0.977	0.989
BOWL	36	99%	0	0.352	0.583	0.774	0.843	0.899	0.937	0.962	0.977	0.989
BOWL	36	99.50%	0	0.352	0.583	0.774	0.843	0.899	0.937	0.962	0.977	0.989
BOWL and MORL	36	95%	94	0.400	0.636	0.813	0.875	0.921	0.952	0.973	0.987	0.994
BOWL and MORL	36	98%	38	0.371	0.605	0.790	0.857	0.908	0.943	0.967	0.982	0.991
BOWL and MORL	36	99%	19	0.362	0.594	0.782	0.850	0.904	0.940	0.965	0.979	0.990
BOWL and MORL	36	99.50%	9	0.357	0.589	0.778	0.846	0.901	0.938	0.964	0.978	0.990

Graph A29b



SENSITIVITY

Graph 30



HERRING GULL

EAST CAITHNESS CLIFFS

DISPLACEMENT

Graph A31a

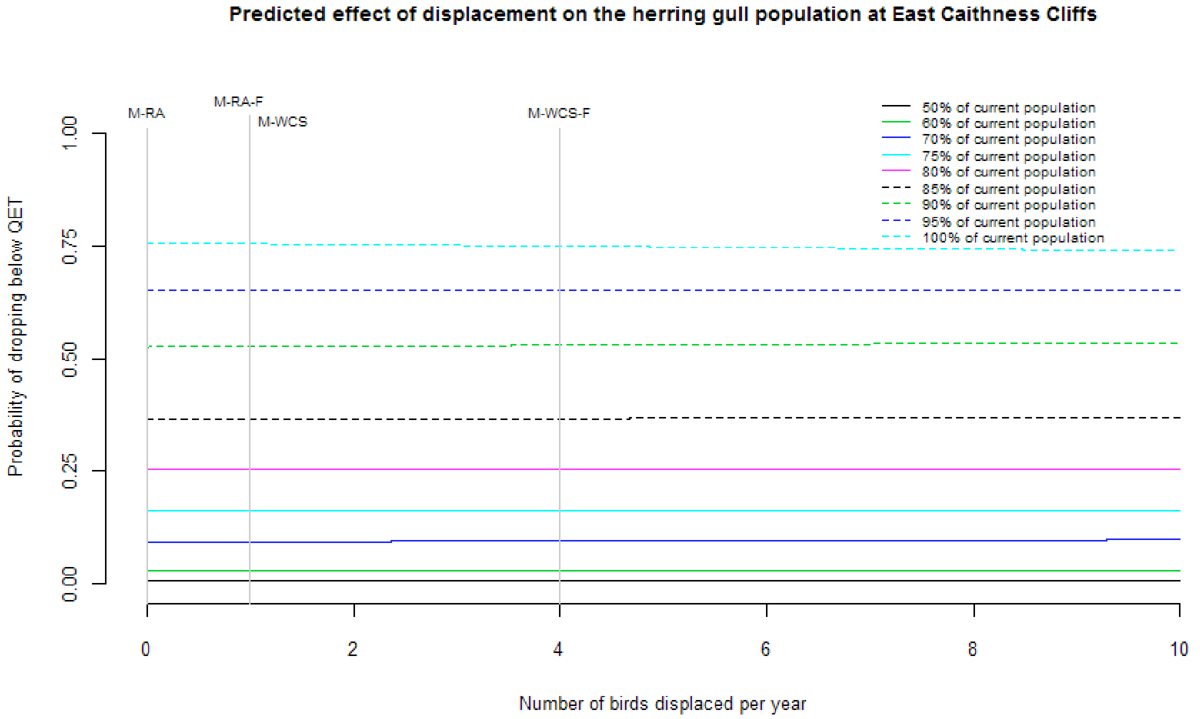
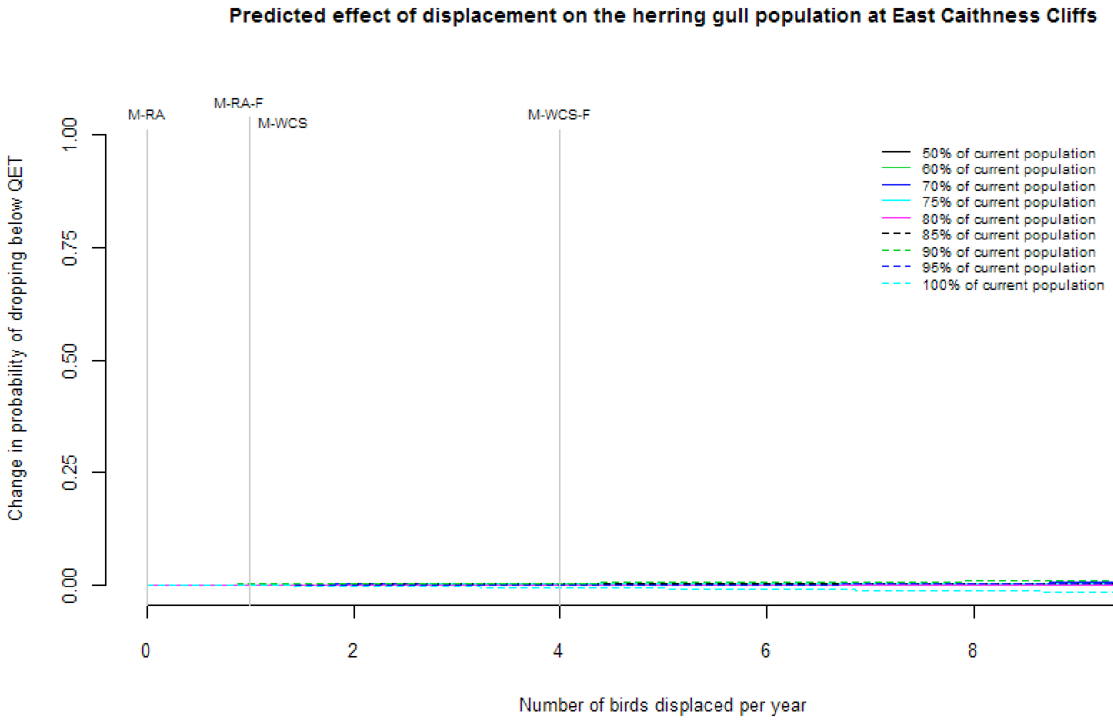


Table A31. Probability of population change from displacement of herring gull at East Caithness Cliffs SPA

Site	Displacement rate	Number displaced	Probability of dropping below percentage of current population size								
			50%	60%	70%	75%	80%	85%	90%	95%	100%
3 sites (primary assessment)	Baseline	0	0.007	0.028	0.092	0.160	0.255	0.365	0.526	0.651	0.757
3 sites (primary assessment)	WCS	1	0.007	0.028	0.092	0.160	0.255	0.365	0.527	0.651	0.755
3 sites (primary assessment)	RA	0	0.007	0.028	0.092	0.160	0.255	0.365	0.526	0.651	0.757
3 sites (primary assessment)	WCS flight	4	0.007	0.028	0.094	0.161	0.254	0.366	0.529	0.652	0.750
3 sites (primary assessment)	RA flight	1	0.007	0.028	0.092	0.160	0.255	0.365	0.527	0.651	0.755
MacColl	WCS	0	0.007	0.028	0.092	0.160	0.255	0.365	0.526	0.651	0.757
MacColl	RA	0	0.007	0.028	0.092	0.160	0.255	0.365	0.526	0.651	0.757
MacColl	WCS flight	1	0.007	0.028	0.092	0.160	0.255	0.365	0.527	0.651	0.755
MacColl	RA flight	0	0.007	0.028	0.092	0.160	0.255	0.365	0.526	0.651	0.757
Telford	WCS	0	0.007	0.028	0.092	0.160	0.255	0.365	0.526	0.651	0.757

Telford	RA	0	0.007	0.028	0.092	0.160	0.255	0.365	0.526	0.651	0.757
Telford	WCS flight	1	0.007	0.028	0.092	0.160	0.255	0.365	0.527	0.651	0.755
Telford	RA flight	0	0.007	0.028	0.092	0.160	0.255	0.365	0.526	0.651	0.757
Stevenson	WCS	0	0.007	0.028	0.092	0.160	0.255	0.365	0.526	0.651	0.757
Stevenson	RA	0	0.007	0.028	0.092	0.160	0.255	0.365	0.526	0.651	0.757
Stevenson	WCS flight	1	0.007	0.028	0.092	0.160	0.255	0.365	0.527	0.651	0.755
Stevenson	RA flight	0	0.007	0.028	0.092	0.160	0.255	0.365	0.526	0.651	0.757
MacColl and Stevenson	WCS	0	0.007	0.028	0.092	0.160	0.255	0.365	0.526	0.651	0.757
MacColl and Stevenson	RA	0	0.007	0.028	0.092	0.160	0.255	0.365	0.526	0.651	0.757
MacColl and Stevenson	WCS flight	3	0.007	0.028	0.093	0.161	0.254	0.366	0.529	0.651	0.752
MacColl and Stevenson	RA flight	1	0.007	0.028	0.092	0.160	0.255	0.365	0.527	0.651	0.755
Stevenson and Telford	WCS	0	0.007	0.028	0.092	0.160	0.255	0.365	0.526	0.651	0.757
Stevenson and Telford	RA	0	0.007	0.028	0.092	0.160	0.255	0.365	0.526	0.651	0.757
Stevenson and Telford	WCS flight	3	0.007	0.028	0.093	0.161	0.254	0.366	0.529	0.651	0.752
Stevenson and Telford	RA flight	1	0.007	0.028	0.092	0.160	0.255	0.365	0.527	0.651	0.755
Telford and MacColl	WCS	0	0.007	0.028	0.092	0.160	0.255	0.365	0.526	0.651	0.757
Telford and MacColl	RA	0	0.007	0.028	0.092	0.160	0.255	0.365	0.526	0.651	0.757
Telford and MacColl	WCS flight	2	0.007	0.028	0.093	0.161	0.254	0.366	0.528	0.651	0.754
Telford and MacColl	RA flight	0	0.007	0.028	0.092	0.160	0.255	0.365	0.526	0.651	0.757
BOWL	WCS	0	0.007	0.028	0.092	0.160	0.255	0.365	0.526	0.651	0.757
BOWL	RA	0	0.007	0.028	0.092	0.160	0.255	0.365	0.526	0.651	0.757
BOWL	WCS flight	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BOWL	RA flight	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BOWL and MORL	WCS	1	0.007	0.028	0.092	0.160	0.255	0.365	0.527	0.651	0.755
BOWL and MORL	RA	0	0.007	0.028	0.092	0.160	0.255	0.365	0.526	0.651	0.757
BOWL and MORL	WCS flight	4	0.007	0.028	0.094	0.161	0.254	0.366	0.529	0.652	0.750
BOWL and MORL	RA flight	1	0.007	0.028	0.092	0.160	0.255	0.365	0.527	0.651	0.755

Graph A31b


Predicted effect of displacement on the herring gull population at East Caithness Cliffs
M-RA
M-RA-F
M-WCS
M-WCS-F
Change in probability of dropping below QET
0.00
0.25
0.50
0.75
1.00
0
2
4
6
8
10
Number of birds displaced per year
50% of current population
60% of current population
70% of current population
75% of current population
80% of current population
85% of current population
90% of current population
95% of current population
100% of current population

COLLISION

Graph A32a

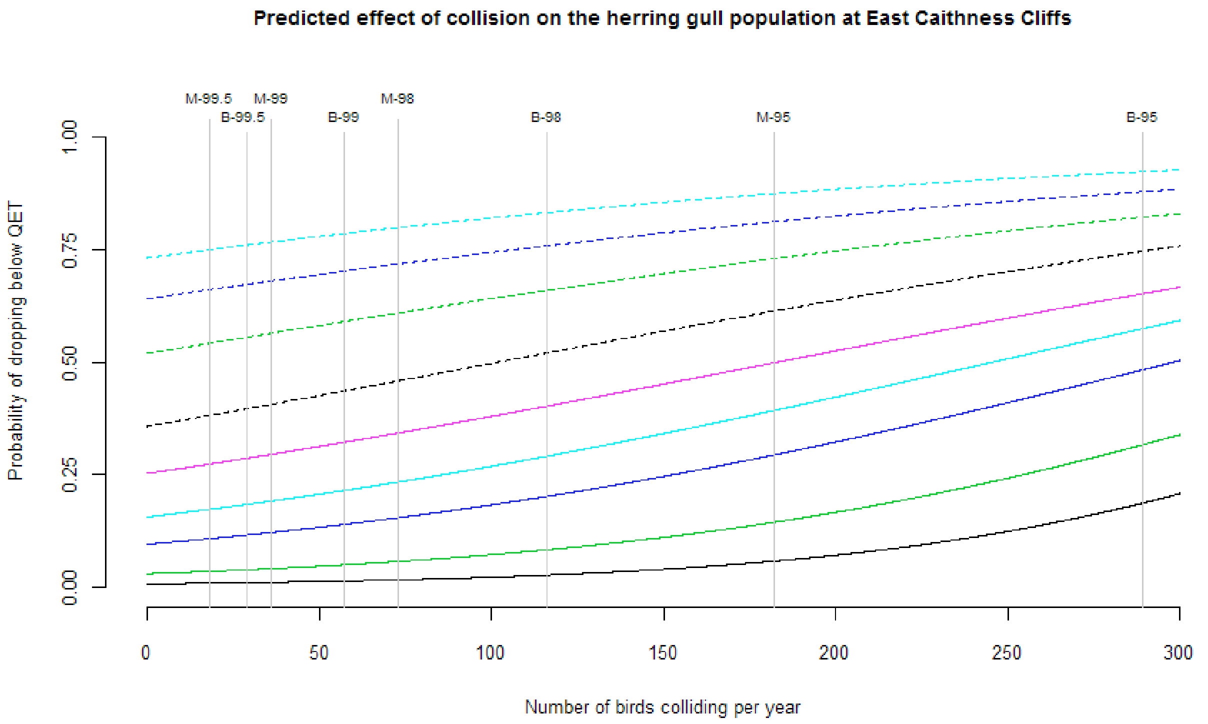
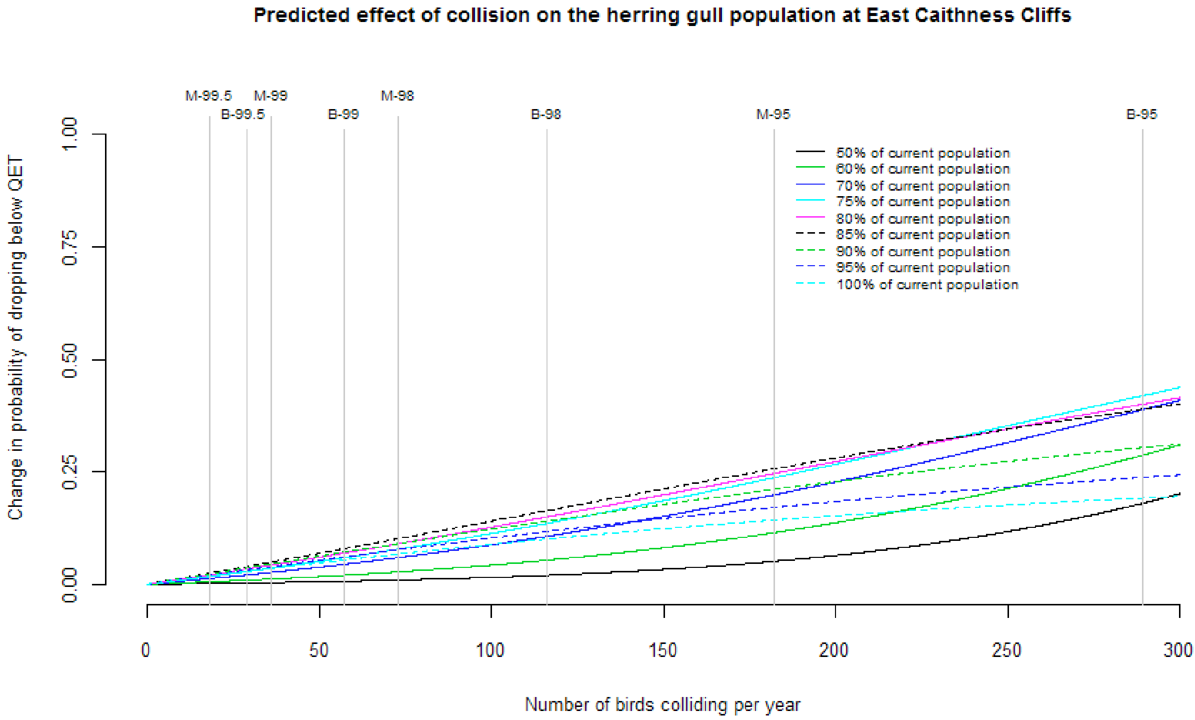


Table A32. Probability of population change from collision of herring gull from East Caithness Cliffs SPA.

Site	Avoidance Rate	Number Colliding	Probability of dropping below percentage of current population size								
			50%	60%	70%	75%	80%	85%	90%	95%	100%
3 sites (primary assessment)	Baseline	0	0.006	0.029	0.095	0.155	0.252	0.357	0.519	0.642	0.733
3 sites (primary assessment)	95%	107	0.023	0.076	0.190	0.278	0.389	0.507	0.650	0.751	0.826
3 sites (primary assessment)	98%	43	0.011	0.043	0.126	0.198	0.303	0.416	0.573	0.688	0.774
3 sites (primary assessment)	99%	21	0.008	0.035	0.109	0.175	0.277	0.385	0.546	0.665	0.753
3 sites (primary assessment)	99.50%	11	0.007	0.032	0.102	0.166	0.265	0.372	0.533	0.654	0.744
MacColl, Telford & Stevenson	95%	82	0.017	0.061	0.163	0.245	0.355	0.471	0.621	0.727	0.807
MacColl, Telford & Stevenson	98%	33	0.009	0.039	0.118	0.188	0.291	0.402	0.561	0.678	0.765
MacColl, Telford & Stevenson	99%	16	0.008	0.034	0.106	0.170	0.271	0.379	0.540	0.660	0.748
MacColl, Telford & Stevenson	99.50%	8	0.007	0.031	0.100	0.163	0.261	0.368	0.530	0.651	0.741
MacColl	95%	39	0.010	0.041	0.123	0.194	0.298	0.410	0.568	0.684	0.770
MacColl	98%	16	0.008	0.034	0.106	0.170	0.271	0.379	0.540	0.660	0.748
MacColl	99%	8	0.007	0.031	0.100	0.163	0.261	0.368	0.530	0.651	0.741
MacColl	99.50%	4	0.007	0.030	0.097	0.159	0.257	0.362	0.524	0.646	0.737
Telford	95%	14	0.007	0.033	0.104	0.168	0.268	0.376	0.537	0.657	0.746
Telford	98%	5	0.007	0.030	0.098	0.160	0.258	0.364	0.526	0.647	0.738
Telford	99%	3	0.006	0.030	0.097	0.158	0.256	0.361	0.523	0.645	0.736
Telford	99.50%	1	0.006	0.029	0.095	0.156	0.253	0.358	0.521	0.643	0.734
Stevenson	95%	29	0.009	0.038	0.115	0.183	0.286	0.396	0.556	0.674	0.761
Stevenson	98%	12	0.007	0.032	0.103	0.167	0.266	0.373	0.535	0.655	0.745
Stevenson	99%	6	0.007	0.031	0.099	0.161	0.259	0.365	0.527	0.649	0.739

Stevenson	99.50%	3	0.006	0.030	0.097	0.158	0.256	0.361	0.523	0.645	0.736
MacColl and Stevenson	95%	68	0.014	0.054	0.149	0.227	0.336	0.451	0.604	0.714	0.796
MacColl and Stevenson	98%	27	0.009	0.037	0.114	0.181	0.284	0.394	0.553	0.671	0.759
MacColl and Stevenson	99%	14	0.007	0.033	0.104	0.168	0.268	0.376	0.537	0.657	0.746
MacColl and Stevenson	99.50%	7	0.007	0.031	0.099	0.162	0.260	0.366	0.528	0.650	0.740
Stevenson and Telford	95%	43	0.011	0.043	0.126	0.198	0.303	0.416	0.573	0.688	0.774
Stevenson and Telford	98%	17	0.008	0.034	0.106	0.171	0.272	0.380	0.541	0.661	0.749
Stevenson and Telford	99%	9	0.007	0.032	0.101	0.164	0.263	0.369	0.531	0.652	0.742
Stevenson and Telford	99.50%	4	0.007	0.030	0.097	0.159	0.257	0.362	0.524	0.646	0.737
Telford and MacColl	95%	53	0.012	0.047	0.135	0.210	0.316	0.430	0.586	0.699	0.783
Telford and MacColl	98%	21	0.008	0.035	0.109	0.175	0.277	0.385	0.546	0.665	0.753
Telford and MacColl	99%	11	0.007	0.032	0.102	0.166	0.265	0.372	0.533	0.654	0.744
Telford and MacColl	99.50%	5	0.007	0.030	0.098	0.160	0.258	0.364	0.526	0.647	0.738
BOWL	95%	182	0.057	0.143	0.293	0.392	0.499	0.614	0.730	0.813	0.875
BOWL	98%	73	0.015	0.056	0.154	0.233	0.342	0.458	0.610	0.719	0.800
BOWL	99%	36	0.010	0.040	0.121	0.191	0.295	0.406	0.565	0.681	0.767
BOWL	99.50%	18	0.008	0.034	0.107	0.172	0.273	0.381	0.542	0.662	0.750
BOWL and MORL	95%	289	0.186	0.316	0.483	0.574	0.652	0.747	0.823	0.879	0.924
BOWL and MORL	98%	116	0.026	0.082	0.201	0.290	0.402	0.520	0.660	0.759	0.833
BOWL and MORL	99%	57	0.013	0.049	0.139	0.214	0.321	0.436	0.590	0.703	0.786
BOWL and MORL	99.50%	29	0.009	0.038	0.115	0.183	0.286	0.396	0.556	0.674	0.761

Graph A32b



COLLISION AND DISPLACEMENT – WORST CASE SCENARIO

Graph A33a

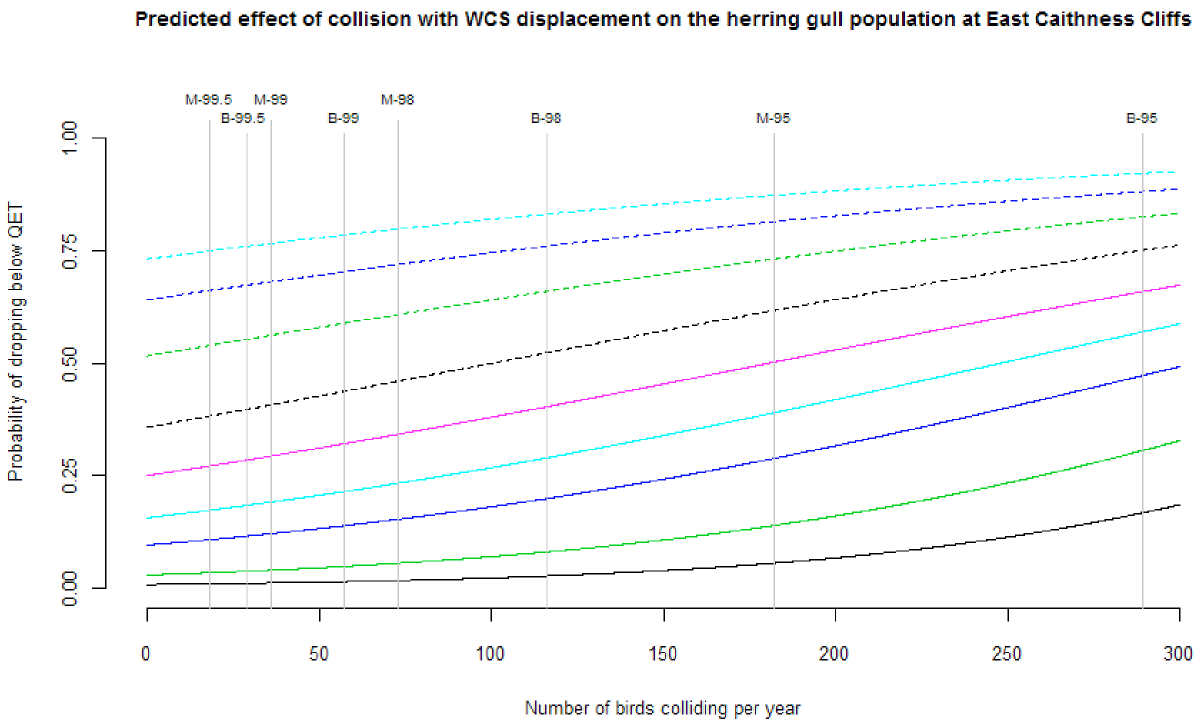
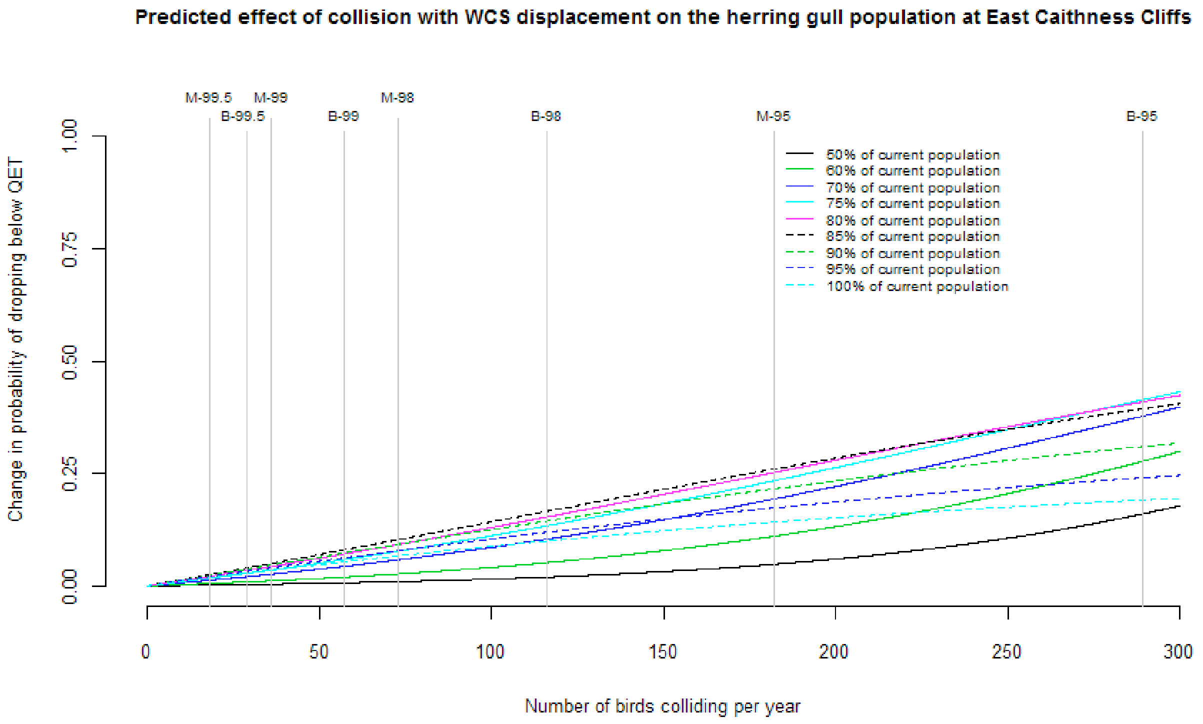


Table A33. Probability of population change from combined displacement and collision effects of herring gull from East Caithness Cliffs SPA using the Worst Case Scenario displacement rate including birds detected in flight.

Site	Number Displaced	Avoidance Rate	Number Colliding	Probability of dropping below percentage of current population size								
				50%	60%	70%	75%	80%	85%	90%	95%	100%
Baseline	0	N/A	0	0.007	0.028	0.095	0.156	0.250	0.357	0.516	0.642	0.732
3 sites (primary assessment)	4	95%	107	0.024	0.074	0.188	0.277	0.390	0.510	0.649	0.753	0.825
3 sites (primary assessment)	4	98%	43	0.011	0.042	0.126	0.198	0.302	0.417	0.571	0.689	0.773
3 sites (primary assessment)	4	99%	21	0.009	0.034	0.109	0.176	0.275	0.386	0.543	0.665	0.753
3 sites (primary assessment)	4	99.50%	11	0.008	0.031	0.102	0.166	0.263	0.372	0.530	0.654	0.743
MacColl, Telford & Stevenson	4	95%	82	0.018	0.059	0.161	0.244	0.354	0.473	0.620	0.729	0.806
MacColl, Telford & Stevenson	4	98%	33	0.010	0.038	0.118	0.188	0.289	0.403	0.558	0.678	0.764
MacColl, Telford & Stevenson	4	99%	16	0.008	0.033	0.106	0.171	0.269	0.379	0.537	0.660	0.748
MacColl, Telford & Stevenson	4	99.50%	8	0.008	0.030	0.100	0.163	0.259	0.368	0.526	0.651	0.740
MacColl	4	95%	39	0.011	0.040	0.123	0.194	0.297	0.411	0.566	0.685	0.769
MacColl	4	98%	16	0.008	0.033	0.106	0.171	0.269	0.379	0.537	0.660	0.748
MacColl	4	99%	8	0.008	0.030	0.100	0.163	0.259	0.368	0.526	0.651	0.740
MacColl	4	99.50%	4	0.007	0.029	0.097	0.159	0.255	0.363	0.521	0.646	0.736
Telford	4	95%	14	0.008	0.032	0.104	0.169	0.266	0.376	0.534	0.657	0.746
Telford	4	98%	5	0.007	0.030	0.098	0.160	0.256	0.364	0.523	0.647	0.737
Telford	4	99%	3	0.007	0.029	0.097	0.159	0.253	0.362	0.520	0.645	0.735
Telford	4	99.50%	1	0.007	0.029	0.096	0.157	0.251	0.359	0.517	0.643	0.733

Stevenson	4	95%	29	0.010	0.037	0.115	0.184	0.284	0.397	0.553	0.674	0.760
Stevenson	4	98%	12	0.008	0.032	0.103	0.167	0.264	0.374	0.532	0.655	0.744
Stevenson	4	99%	6	0.007	0.030	0.099	0.161	0.257	0.366	0.524	0.648	0.738
Stevenson	4	99.50%	3	0.007	0.029	0.097	0.159	0.253	0.362	0.520	0.645	0.735
MacColl and Stevenson	4	95%	68	0.015	0.052	0.148	0.227	0.335	0.453	0.602	0.715	0.795
MacColl and Stevenson	4	98%	27	0.009	0.036	0.114	0.182	0.282	0.394	0.551	0.672	0.758
MacColl and Stevenson	4	99%	14	0.008	0.032	0.104	0.169	0.266	0.376	0.534	0.657	0.746
MacColl and Stevenson	4	99.50%	7	0.008	0.030	0.099	0.162	0.258	0.367	0.525	0.650	0.739
Stevenson and Telford	4	95%	43	0.011	0.042	0.126	0.198	0.302	0.417	0.571	0.689	0.773
Stevenson and Telford	4	98%	17	0.008	0.033	0.106	0.172	0.270	0.381	0.538	0.661	0.749
Stevenson and Telford	4	99%	9	0.008	0.031	0.101	0.164	0.260	0.370	0.528	0.652	0.741
Stevenson and Telford	4	99.50%	4	0.007	0.029	0.097	0.159	0.255	0.363	0.521	0.646	0.736
Telford and MacColl	4	95%	53	0.013	0.046	0.134	0.209	0.315	0.431	0.584	0.699	0.782
Telford and MacColl	4	98%	21	0.009	0.034	0.109	0.176	0.275	0.386	0.543	0.665	0.753
Telford and MacColl	4	99%	11	0.008	0.031	0.102	0.166	0.263	0.372	0.530	0.654	0.743
Telford and MacColl	4	99.50%	5	0.007	0.030	0.098	0.160	0.256	0.364	0.523	0.647	0.737
BOWL	4	95%	182	0.055	0.139	0.288	0.389	0.502	0.617	0.732	0.815	0.874
BOWL	4	98%	73	0.016	0.055	0.153	0.233	0.342	0.460	0.609	0.720	0.799
BOWL	4	99%	36	0.011	0.039	0.120	0.191	0.293	0.407	0.562	0.682	0.767
BOWL	4	99.50%	18	0.009	0.033	0.107	0.173	0.271	0.382	0.539	0.662	0.750
BOWL and MORL	4	95%	289	0.167	0.305	0.472	0.569	0.659	0.751	0.826	0.882	0.923
BOWL and MORL	4	98%	116	0.026	0.080	0.199	0.289	0.403	0.523	0.660	0.761	0.832
BOWL and MORL	4	99%	57	0.013	0.047	0.138	0.214	0.320	0.437	0.589	0.704	0.785
BOWL and MORL	4	99.50%	29	0.010	0.037	0.115	0.184	0.284	0.397	0.553	0.674	0.760

Graph A33b



COLLISION AND DISPLACEMENT – REALISTIC APPROACH

Graph A34a

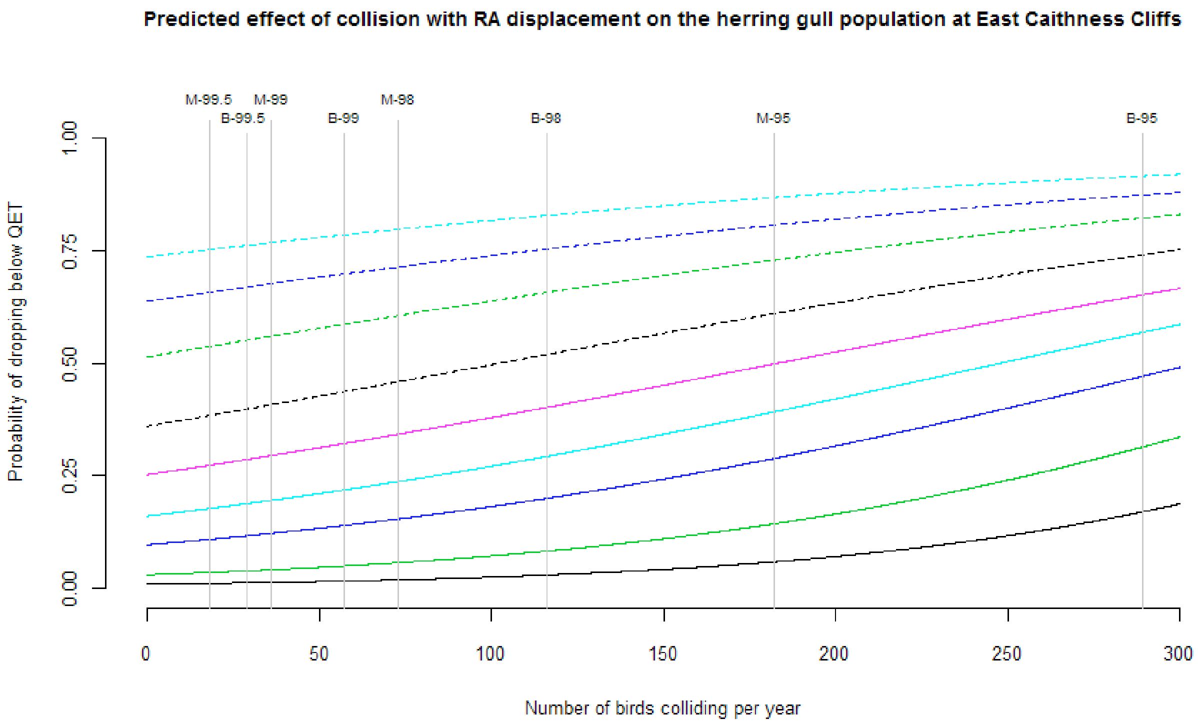
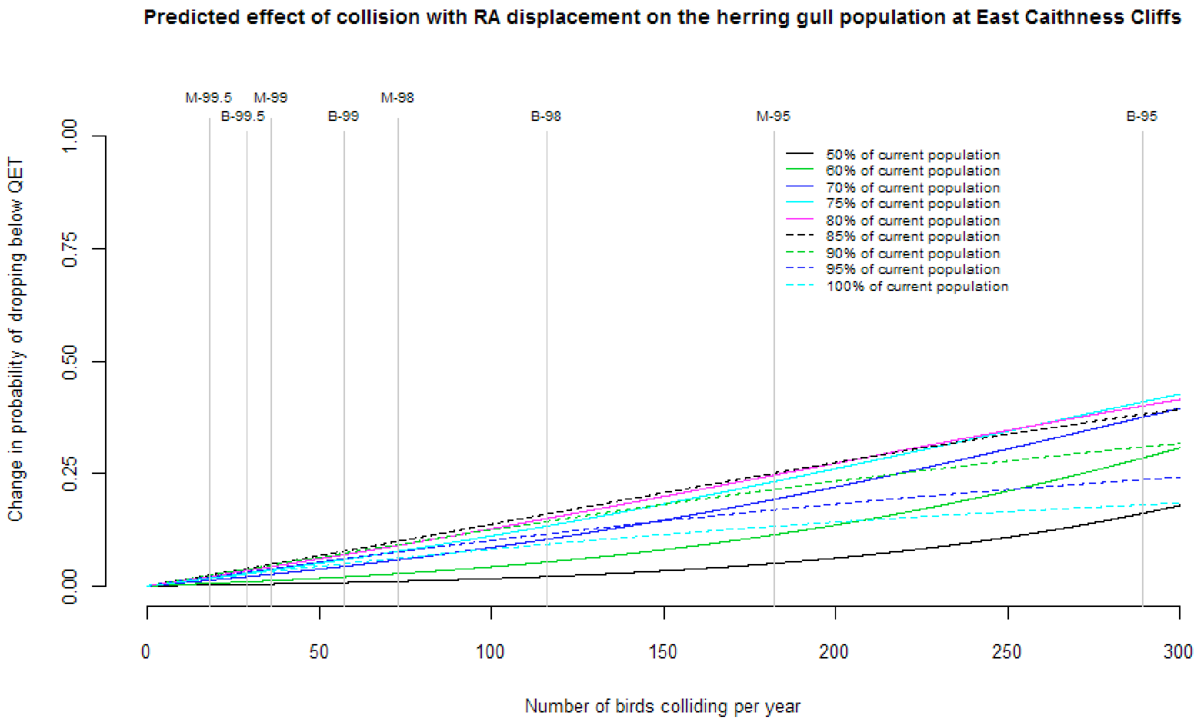


Table A34. Probability of population change from combined displacement and collision effects of herring gull from East Caithness Cliffs SPA using the Realistic Approach displacement rate including birds detected in flight.

Site	Number Displaced	Avoidance Rate	Number Colliding	Probability of dropping below percentage of current population size								
				50%	60%	70%	75%	80%	85%	90%	95%	100%
Baseline	0	N/A	0	0.006	0.029	0.094	0.156	0.243	0.362	0.518	0.645	0.743
3 sites (primary assessment)	1	95%	107	0.026	0.075	0.189	0.280	0.389	0.507	0.647	0.746	0.823
3 sites (primary assessment)	1	98%	43	0.013	0.043	0.127	0.202	0.303	0.417	0.569	0.684	0.774
3 sites (primary assessment)	1	99%	21	0.010	0.035	0.110	0.179	0.276	0.387	0.541	0.661	0.755
3 sites (primary assessment)	1	99.50%	11	0.009	0.032	0.103	0.170	0.264	0.374	0.528	0.651	0.747
MacColl, Telford & Stevenson	1	95%	82	0.020	0.061	0.162	0.248	0.354	0.471	0.617	0.723	0.805
MacColl, Telford & Stevenson	1	98%	33	0.011	0.039	0.119	0.191	0.291	0.403	0.556	0.674	0.766
MacColl, Telford & Stevenson	1	99%	16	0.009	0.033	0.106	0.174	0.270	0.381	0.535	0.656	0.751
MacColl, Telford & Stevenson	1	99.50%	8	0.009	0.031	0.101	0.167	0.261	0.370	0.525	0.647	0.744
MacColl	1	95%	39	0.012	0.041	0.124	0.198	0.298	0.412	0.564	0.680	0.771
MacColl	1	98%	16	0.009	0.033	0.106	0.174	0.270	0.381	0.535	0.656	0.751
MacColl	1	99%	8	0.009	0.031	0.101	0.167	0.261	0.370	0.525	0.647	0.744
MacColl	1	99.50%	4	0.008	0.030	0.098	0.163	0.256	0.365	0.519	0.643	0.740
Telford	1	95%	14	0.009	0.033	0.105	0.173	0.268	0.378	0.532	0.654	0.749
Telford	1	98%	5	0.008	0.030	0.099	0.164	0.258	0.366	0.521	0.644	0.741
Telford	1	99%	3	0.008	0.030	0.098	0.162	0.255	0.364	0.518	0.642	0.739
Telford	1	99.50%	1	0.008	0.029	0.096	0.160	0.253	0.361	0.516	0.640	0.738

Stevenson	1	95%	29	0.011	0.038	0.116	0.187	0.286	0.398	0.551	0.670	0.762
Stevenson	1	98%	12	0.009	0.032	0.104	0.171	0.266	0.375	0.530	0.652	0.748
Stevenson	1	99%	6	0.008	0.030	0.100	0.165	0.259	0.367	0.522	0.645	0.742
Stevenson	1	99.50%	3	0.008	0.030	0.098	0.162	0.255	0.364	0.518	0.642	0.739
MacColl and Stevenson	1	95%	68	0.017	0.053	0.149	0.230	0.335	0.452	0.600	0.709	0.794
MacColl and Stevenson	1	98%	27	0.011	0.037	0.114	0.185	0.283	0.395	0.549	0.668	0.761
MacColl and Stevenson	1	99%	14	0.009	0.033	0.105	0.173	0.268	0.378	0.532	0.654	0.749
MacColl and Stevenson	1	99.50%	7	0.009	0.031	0.100	0.166	0.260	0.369	0.523	0.646	0.743
Stevenson and Telford	1	95%	43	0.013	0.043	0.127	0.202	0.303	0.417	0.569	0.684	0.774
Stevenson and Telford	1	98%	17	0.010	0.034	0.107	0.175	0.271	0.382	0.536	0.657	0.752
Stevenson and Telford	1	99%	9	0.009	0.031	0.102	0.168	0.262	0.371	0.526	0.648	0.745
Stevenson and Telford	1	99.50%	4	0.008	0.030	0.098	0.163	0.256	0.365	0.519	0.643	0.740
Telford and MacColl	1	95%	53	0.014	0.047	0.135	0.213	0.316	0.431	0.581	0.695	0.782
Telford and MacColl	1	98%	21	0.010	0.035	0.110	0.179	0.276	0.387	0.541	0.661	0.755
Telford and MacColl	1	99%	11	0.009	0.032	0.103	0.170	0.264	0.374	0.528	0.651	0.747
Telford and MacColl	1	99.50%	5	0.008	0.030	0.099	0.164	0.258	0.366	0.521	0.644	0.741
BOWL	1	95%	182	0.058	0.142	0.288	0.391	0.498	0.610	0.729	0.808	0.869
BOWL	1	98%	73	0.018	0.056	0.153	0.236	0.342	0.459	0.606	0.714	0.798
BOWL	1	99%	36	0.012	0.040	0.121	0.195	0.294	0.408	0.560	0.677	0.768
BOWL	1	99.50%	18	0.010	0.034	0.108	0.176	0.273	0.383	0.537	0.658	0.753
BOWL and MORL	1	95%	289	0.169	0.313	0.471	0.569	0.652	0.741	0.823	0.875	0.917
BOWL and MORL	1	98%	116	0.028	0.082	0.199	0.292	0.401	0.519	0.657	0.754	0.829
BOWL and MORL	1	99%	57	0.015	0.048	0.139	0.218	0.321	0.436	0.586	0.699	0.786
BOWL and MORL	1	99.50%	29	0.011	0.038	0.116	0.187	0.286	0.398	0.551	0.670	0.762

Graph A34b



TROUP HEAD

DISPLACEMENT

Graph A35a

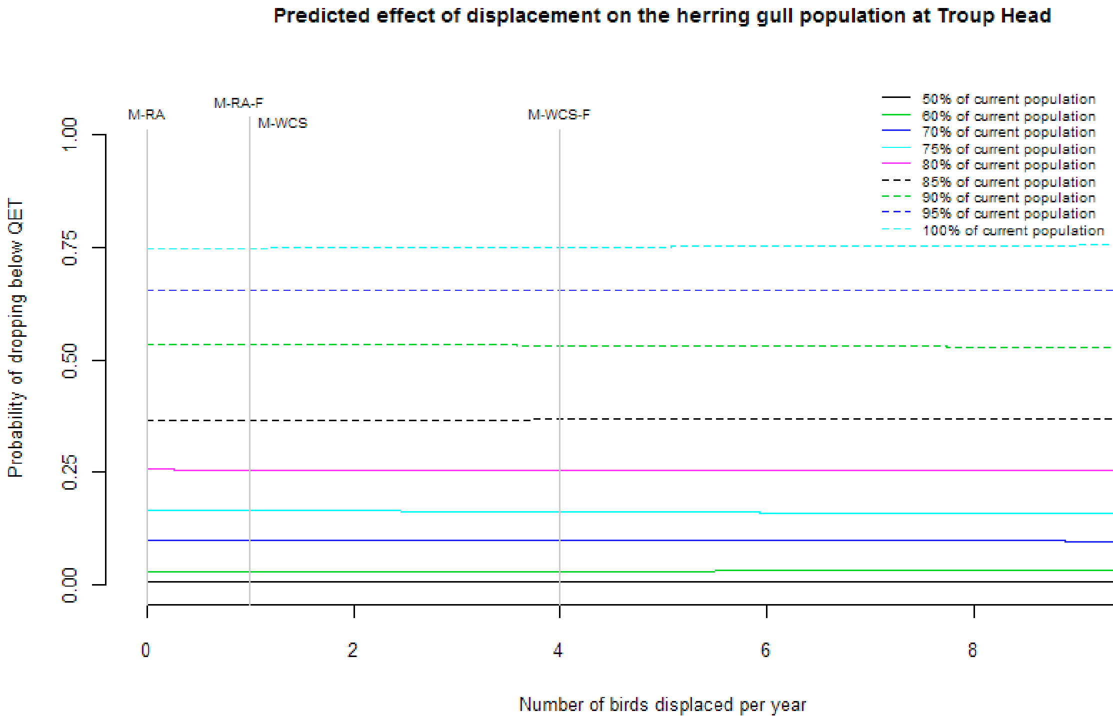
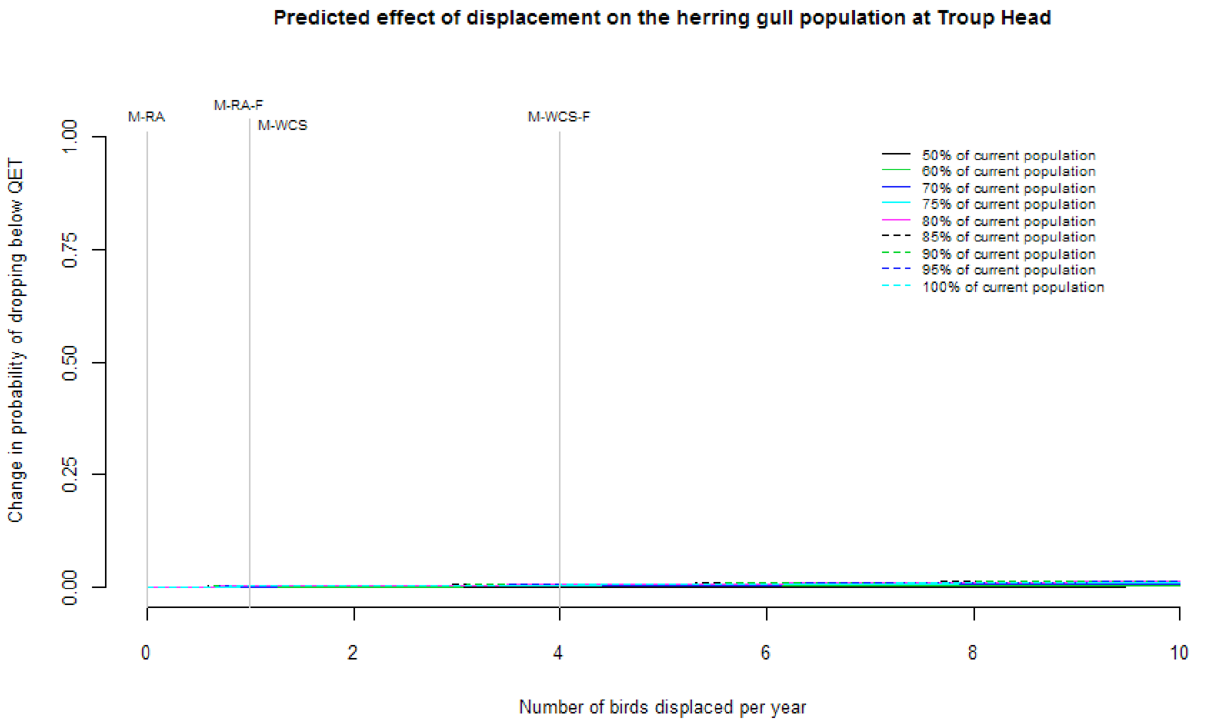


Table A35. Probability of population change from displacement of herring gull at Troup Head SPA.

Site	Displacement rate	Number displaced	Probability of dropping below percentage of current population size								
			50%	60%	70%	75%	80%	85%	90%	95%	100%
3 sites (primary assessment)	Baseline	0	0.007	0.028	0.092	0.160	0.255	0.365	0.526	0.651	0.757
3 sites (primary assessment)	WCS	1	0.006	0.027	0.099	0.164	0.255	0.365	0.534	0.654	0.748
3 sites (primary assessment)	RA	0	0.006	0.027	0.099	0.165	0.255	0.365	0.535	0.654	0.748
3 sites (primary assessment)	WCS flight	4	0.007	0.029	0.098	0.162	0.255	0.367	0.532	0.655	0.751
3 sites (primary assessment)	RA flight	1	0.006	0.027	0.099	0.164	0.255	0.365	0.534	0.654	0.748
MacColl	WCS	0	0.006	0.027	0.099	0.165	0.255	0.365	0.535	0.654	0.748
MacColl	RA	0	0.006	0.027	0.099	0.165	0.255	0.365	0.535	0.654	0.748
MacColl	WCS flight	1	0.006	0.027	0.099	0.164	0.255	0.365	0.534	0.654	0.748
MacColl	RA flight	0	0.006	0.027	0.099	0.165	0.255	0.365	0.535	0.654	0.748
Telford	WCS	0	0.006	0.027	0.099	0.165	0.255	0.365	0.535	0.654	0.748
Telford	RA	0	0.006	0.027	0.099	0.165	0.255	0.365	0.535	0.654	0.748
Telford	WCS flight	1	0.006	0.027	0.099	0.164	0.255	0.365	0.534	0.654	0.748
Telford	RA flight	0	0.006	0.027	0.099	0.165	0.255	0.365	0.535	0.654	0.748

Stevenson	WCS	0	0.006	0.027	0.099	0.165	0.255	0.365	0.535	0.654	0.748
Stevenson	RA	0	0.006	0.027	0.099	0.165	0.255	0.365	0.535	0.654	0.748
Stevenson	WCS flight	1	0.006	0.027	0.099	0.164	0.255	0.365	0.534	0.654	0.748
Stevenson	RA flight	0	0.006	0.027	0.099	0.165	0.255	0.365	0.535	0.654	0.748
MacColl and Stevenson	WCS	0	0.006	0.027	0.099	0.165	0.255	0.365	0.535	0.654	0.748
MacColl and Stevenson	RA	0	0.006	0.027	0.099	0.165	0.255	0.365	0.535	0.654	0.748
MacColl and Stevenson	WCS flight	3	0.007	0.028	0.098	0.163	0.255	0.366	0.533	0.655	0.750
MacColl and Stevenson	RA flight	1	0.006	0.027	0.099	0.164	0.255	0.365	0.534	0.654	0.748
Stevenson and Telford	WCS	0	0.006	0.027	0.099	0.165	0.255	0.365	0.535	0.654	0.748
Stevenson and Telford	RA	0	0.006	0.027	0.099	0.165	0.255	0.365	0.535	0.654	0.748
Stevenson and Telford	WCS flight	3	0.007	0.028	0.098	0.163	0.255	0.366	0.533	0.655	0.750
Stevenson and Telford	RA flight	1	0.006	0.027	0.099	0.164	0.255	0.365	0.534	0.654	0.748
Telford and MacColl	WCS	0	0.006	0.027	0.099	0.165	0.255	0.365	0.535	0.654	0.748
Telford and MacColl	RA	0	0.006	0.027	0.099	0.165	0.255	0.365	0.535	0.654	0.748
Telford and MacColl	WCS flight	2	0.007	0.028	0.098	0.163	0.255	0.366	0.533	0.654	0.749
Telford and MacColl	RA flight	0	0.006	0.027	0.099	0.165	0.255	0.365	0.535	0.654	0.748
BOWL	WCS	0	0.006	0.027	0.099	0.165	0.255	0.365	0.535	0.654	0.748
BOWL	RA	0	0.006	0.027	0.099	0.165	0.255	0.365	0.535	0.654	0.748
BOWL	WCS flight	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BOWL	RA flight	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BOWL and MORL	WCS	1	0.006	0.027	0.099	0.164	0.255	0.365	0.534	0.654	0.748
BOWL and MORL	RA	0	0.006	0.027	0.099	0.165	0.255	0.365	0.535	0.654	0.748
BOWL and MORL	WCS flight	4	0.007	0.029	0.098	0.162	0.255	0.367	0.532	0.655	0.751
BOWL and MORL	RA flight	1	0.006	0.027	0.099	0.164	0.255	0.365	0.534	0.654	0.748

Graph A35b



COLLISION

Graph A36a

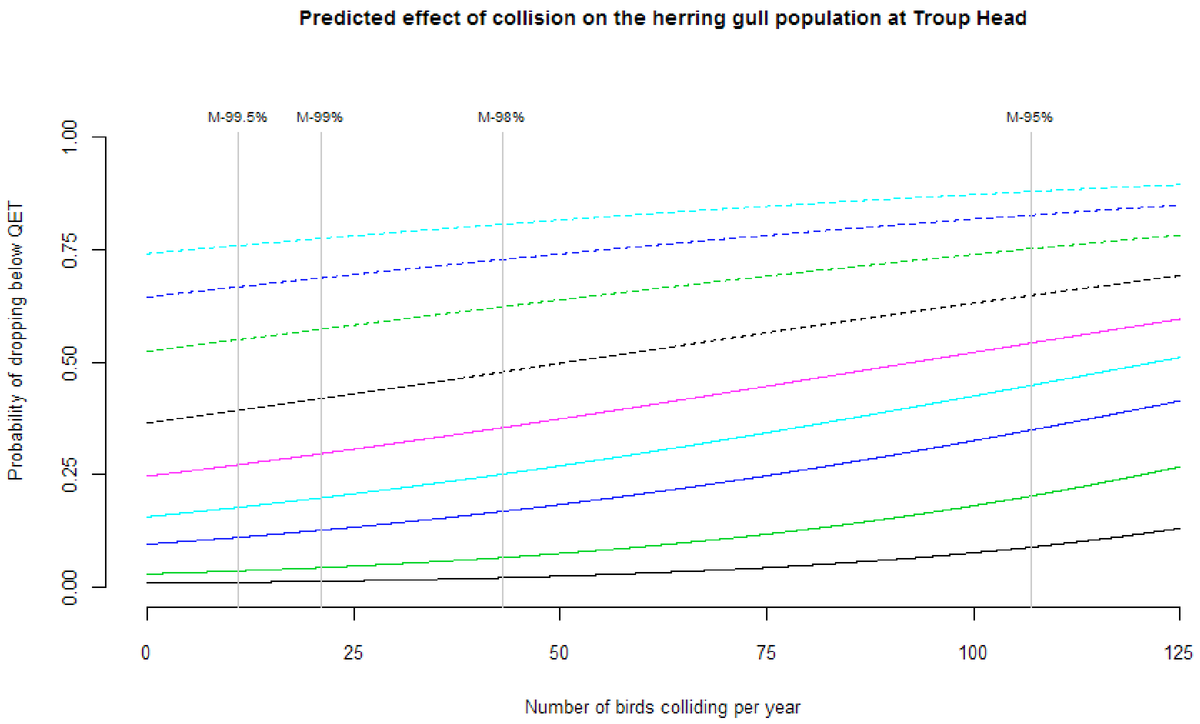
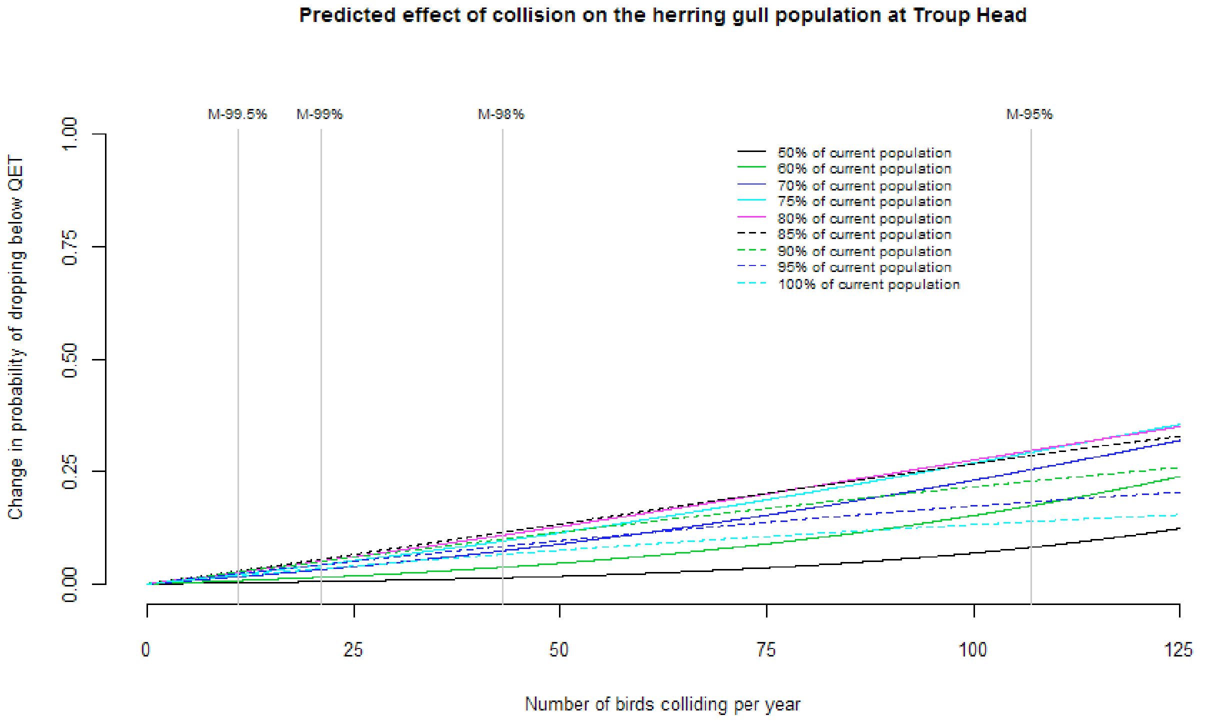


Table A36. Probability of population change from collision of herring gull at Troup Head SPA.

Site	Avoidance Rate	Number Colliding	Probability of dropping below percentage of current population size								
			50%	60%	70%	75%	80%	85%	90%	95%	100%
3 sites (primary assessment)	Baseline	0	0.007	0.028	0.095	0.156	0.246	0.364	0.524	0.645	0.742
3 sites (primary assessment)	95%	107	0.088	0.202	0.349	0.448	0.543	0.649	0.753	0.828	0.880
3 sites (primary assessment)	98%	43	0.020	0.065	0.168	0.251	0.354	0.478	0.624	0.729	0.807
3 sites (primary assessment)	99%	21	0.012	0.043	0.126	0.198	0.296	0.419	0.573	0.688	0.775
3 sites (primary assessment)	99.50%	11	0.009	0.035	0.110	0.177	0.272	0.392	0.550	0.668	0.760
MacColl, Telford & Stevenson	95%	82	0.050	0.133	0.268	0.365	0.467	0.584	0.706	0.793	0.855
MacColl, Telford & Stevenson	98%	33	0.016	0.054	0.147	0.226	0.327	0.451	0.601	0.710	0.793
MacColl, Telford & Stevenson	99%	16	0.011	0.039	0.118	0.187	0.284	0.405	0.562	0.678	0.768
MacColl, Telford & Stevenson	99.50%	8	0.009	0.033	0.106	0.171	0.265	0.384	0.543	0.662	0.755
MacColl	95%	39	0.018	0.060	0.159	0.241	0.343	0.467	0.615	0.722	0.802
MacColl	98%	16	0.011	0.039	0.118	0.187	0.284	0.405	0.562	0.678	0.768
MacColl	99%	8	0.009	0.033	0.106	0.171	0.265	0.384	0.543	0.662	0.755
MacColl	99.50%	4	0.008	0.031	0.100	0.163	0.255	0.374	0.534	0.654	0.748
Telford	95%	14	0.010	0.037	0.115	0.183	0.279	0.400	0.557	0.674	0.764
Telford	98%	5	0.008	0.031	0.101	0.165	0.258	0.377	0.536	0.656	0.750
Telford	99%	3	0.008	0.030	0.099	0.161	0.253	0.372	0.531	0.652	0.747
Telford	99.50%	1	0.007	0.029	0.096	0.158	0.248	0.367	0.526	0.647	0.743
Stevenson	95%	29	0.014	0.050	0.140	0.216	0.317	0.440	0.592	0.703	0.787
Stevenson	98%	12	0.010	0.036	0.111	0.179	0.274	0.395	0.552	0.670	0.761
Stevenson	99%	6	0.008	0.032	0.103	0.167	0.260	0.379	0.538	0.658	0.752

Stevenson	99.50%	3	0.008	0.030	0.099	0.161	0.253	0.372	0.531	0.652	0.747
MacColl and Stevenson	95%	68	0.036	0.103	0.228	0.321	0.426	0.547	0.677	0.771	0.839
MacColl and Stevenson	98%	27	0.014	0.048	0.136	0.212	0.311	0.435	0.587	0.699	0.784
MacColl and Stevenson	99%	14	0.010	0.037	0.115	0.183	0.279	0.400	0.557	0.674	0.764
MacColl and Stevenson	99.50%	7	0.009	0.033	0.104	0.169	0.262	0.382	0.541	0.660	0.753
Stevenson and Telford	95%	43	0.020	0.065	0.168	0.251	0.354	0.478	0.624	0.729	0.807
Stevenson and Telford	98%	17	0.011	0.039	0.119	0.189	0.286	0.408	0.564	0.680	0.769
Stevenson and Telford	99%	9	0.009	0.034	0.107	0.173	0.267	0.387	0.545	0.664	0.757
Stevenson and Telford	99.50%	4	0.008	0.031	0.100	0.163	0.255	0.374	0.534	0.654	0.748
Telford and MacColl	95%	53	0.026	0.078	0.190	0.278	0.382	0.506	0.646	0.746	0.820
Telford and MacColl	98%	21	0.012	0.043	0.126	0.198	0.296	0.419	0.573	0.688	0.775
Telford and MacColl	99%	11	0.009	0.035	0.110	0.177	0.272	0.392	0.550	0.668	0.760
Telford and MacColl	99.50%	5	0.008	0.031	0.101	0.165	0.258	0.377	0.536	0.656	0.750
BOWL	95%	0	0.007	0.028	0.095	0.156	0.246	0.364	0.524	0.645	0.742
BOWL	98%	0	0.007	0.028	0.095	0.156	0.246	0.364	0.524	0.645	0.742
BOWL	99%	0	0.007	0.028	0.095	0.156	0.246	0.364	0.524	0.645	0.742
BOWL	99.50%	0	0.007	0.028	0.095	0.156	0.246	0.364	0.524	0.645	0.742
BOWL and MORL	95%	107	0.088	0.202	0.349	0.448	0.543	0.649	0.753	0.828	0.880
BOWL and MORL	98%	43	0.020	0.065	0.168	0.251	0.354	0.478	0.624	0.729	0.807
BOWL and MORL	99%	21	0.012	0.043	0.126	0.198	0.296	0.419	0.573	0.688	0.775
BOWL and MORL	99.50%	11	0.009	0.035	0.110	0.177	0.272	0.392	0.550	0.668	0.760

Graph A36b



COLLISION AND DISPLACEMENT – WORST CASE SCENARIO

Graph A37a

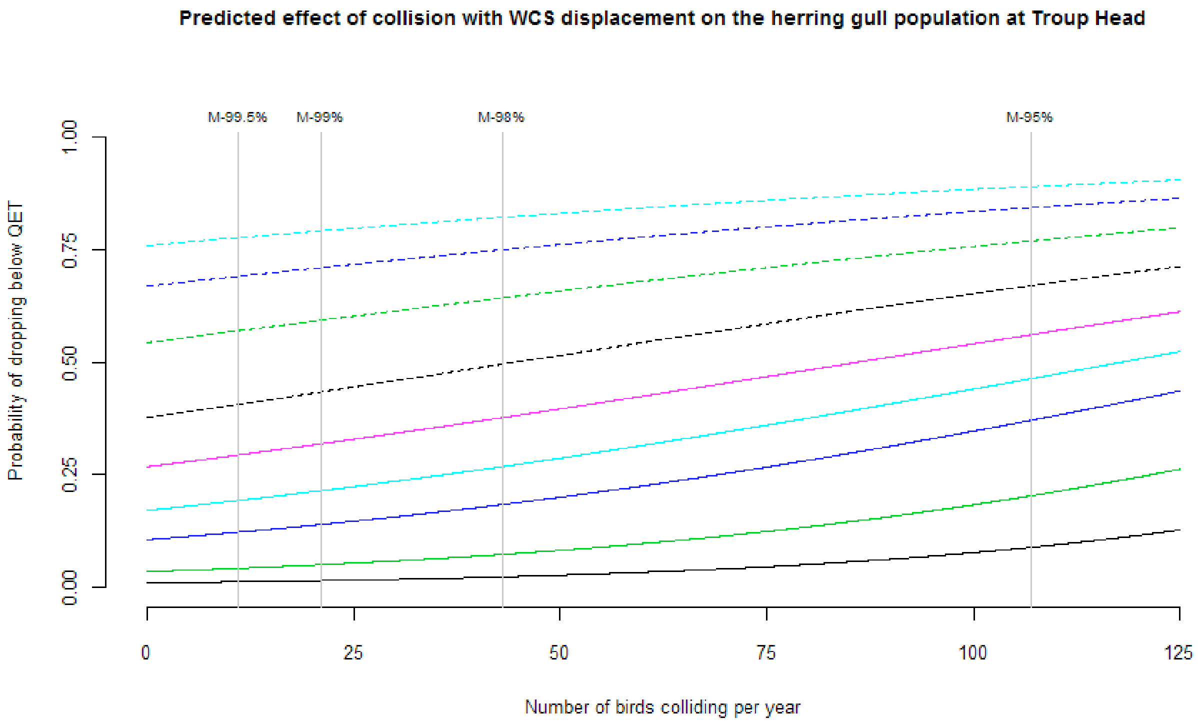
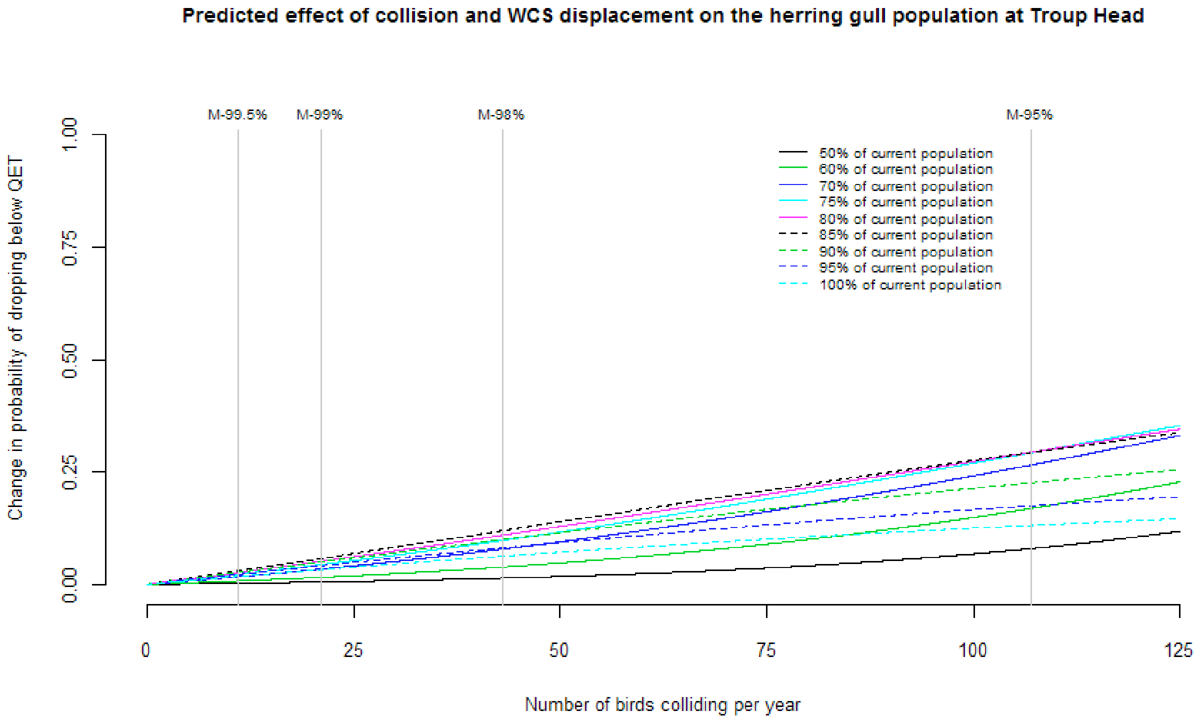


Table A37. Probability of population change from combined displacement and collision effects of herring gull from Troup Head SPA using the Worst Case Scenario displacement rate including birds detected in flight.

Site	Number Displaced	Avoidance Rate	Number Colliding	Probability of dropping below percentage of current population size								
				50%	60%	70%	75%	80%	85%	90%	95%	100%
Baseline	0	N/A	0	0.008	0.034	0.105	0.17	0.267	0.376	0.544	0.669	0.76
3 sites (primary assessment)	4	95%	107	0.088	0.203	0.371	0.463	0.561	0.670	0.770	0.844	0.891
3 sites (primary assessment)	4	98%	43	0.022	0.072	0.183	0.268	0.377	0.496	0.643	0.750	0.823
3 sites (primary assessment)	4	99%	21	0.014	0.049	0.139	0.214	0.318	0.434	0.593	0.711	0.792
3 sites (primary assessment)	4	99.50%	11	0.011	0.041	0.122	0.192	0.293	0.406	0.570	0.691	0.777
MacColl, Telford & Stevenson	4	95%	82	0.052	0.138	0.288	0.382	0.488	0.605	0.724	0.811	0.868
MacColl, Telford & Stevenson	4	98%	33	0.018	0.061	0.162	0.242	0.349	0.467	0.621	0.733	0.809
MacColl, Telford & Stevenson	4	99%	16	0.012	0.045	0.130	0.203	0.306	0.420	0.582	0.701	0.785
MacColl, Telford & Stevenson	4	99.50%	8	0.010	0.039	0.117	0.186	0.286	0.398	0.563	0.685	0.773
MacColl	4	95%	39	0.020	0.067	0.174	0.257	0.366	0.484	0.634	0.743	0.817
MacColl	4	98%	16	0.012	0.045	0.130	0.203	0.306	0.420	0.582	0.701	0.785
MacColl	4	99%	8	0.010	0.039	0.117	0.186	0.286	0.398	0.563	0.685	0.773
MacColl	4	99.50%	4	0.009	0.036	0.111	0.178	0.277	0.387	0.553	0.677	0.766
Telford	4	95%	14	0.012	0.043	0.126	0.199	0.301	0.414	0.577	0.697	0.782
Telford	4	98%	5	0.009	0.037	0.112	0.180	0.279	0.390	0.556	0.679	0.768
Telford	4	99%	3	0.009	0.036	0.109	0.176	0.274	0.384	0.551	0.675	0.765
Telford	4	99.50%	1	0.009	0.034	0.106	0.172	0.270	0.379	0.546	0.671	0.762
Stevenson	4	95%	29	0.016	0.057	0.154	0.233	0.339	0.456	0.612	0.725	0.804
Stevenson	4	98%	12	0.011	0.042	0.123	0.194	0.296	0.409	0.572	0.693	0.779

Stevenson	4	99%	6	0.010	0.038	0.114	0.182	0.281	0.392	0.558	0.681	0.770
Stevenson	4	99.50%	3	0.009	0.036	0.109	0.176	0.274	0.384	0.551	0.675	0.765
MacColl and Stevenson	4	95%	68	0.038	0.110	0.246	0.338	0.447	0.566	0.697	0.791	0.853
MacColl and Stevenson	4	98%	27	0.015	0.055	0.150	0.228	0.334	0.450	0.607	0.722	0.801
MacColl and Stevenson	4	99%	14	0.012	0.043	0.126	0.199	0.301	0.414	0.577	0.697	0.782
MacColl and Stevenson	4	99.50%	7	0.010	0.038	0.115	0.184	0.284	0.395	0.560	0.683	0.771
Stevenson and Telford	4	95%	43	0.022	0.072	0.183	0.268	0.377	0.496	0.643	0.750	0.823
Stevenson and Telford	4	98%	17	0.012	0.046	0.132	0.205	0.308	0.423	0.584	0.703	0.786
Stevenson and Telford	4	99%	9	0.010	0.040	0.118	0.188	0.288	0.401	0.565	0.687	0.774
Stevenson and Telford	4	99.50%	4	0.009	0.036	0.111	0.178	0.277	0.387	0.553	0.677	0.766
Telford and MacColl	4	95%	53	0.028	0.086	0.207	0.295	0.404	0.524	0.665	0.767	0.835
Telford and MacColl	4	98%	21	0.014	0.049	0.139	0.214	0.318	0.434	0.593	0.711	0.792
Telford and MacColl	4	99%	11	0.011	0.041	0.122	0.192	0.293	0.406	0.570	0.691	0.777
Telford and MacColl	4	99.50%	5	0.009	0.037	0.112	0.180	0.279	0.390	0.556	0.679	0.768
BOWL	4	95%	0	0.008	0.034	0.105	0.170	0.267	0.376	0.544	0.669	0.760
BOWL	4	98%	0	0.008	0.034	0.105	0.170	0.267	0.376	0.544	0.669	0.760
BOWL	4	99%	0	0.008	0.034	0.105	0.170	0.267	0.376	0.544	0.669	0.760
BOWL	4	99.50%	0	0.008	0.034	0.105	0.170	0.267	0.376	0.544	0.669	0.760
BOWL and MORL	4	95%	107	0.088	0.203	0.371	0.463	0.561	0.670	0.770	0.844	0.891
BOWL and MORL	4	98%	43	0.022	0.072	0.183	0.268	0.377	0.496	0.643	0.750	0.823
BOWL and MORL	4	99%	21	0.014	0.049	0.139	0.214	0.318	0.434	0.593	0.711	0.792
BOWL and MORL	4	99.50%	11	0.011	0.041	0.122	0.192	0.293	0.406	0.570	0.691	0.777

Graph A37b



COLLISION AND DISPLACEMENT – REALISTIC APPROACH

Graph A38a

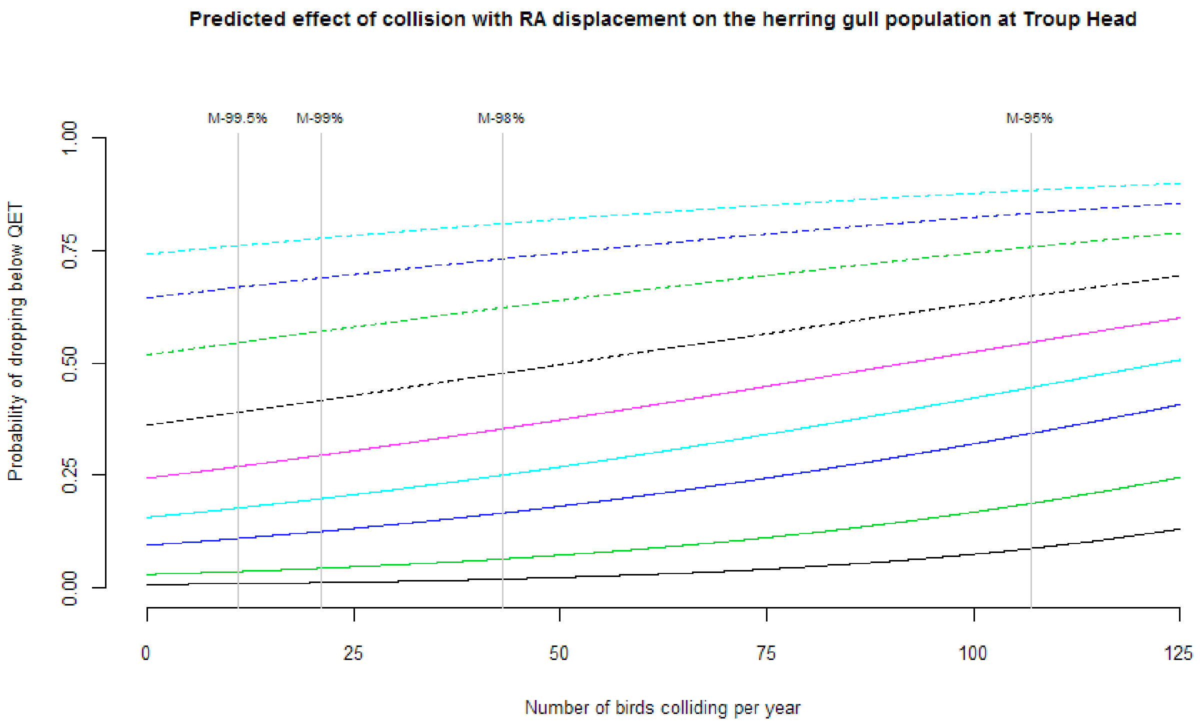
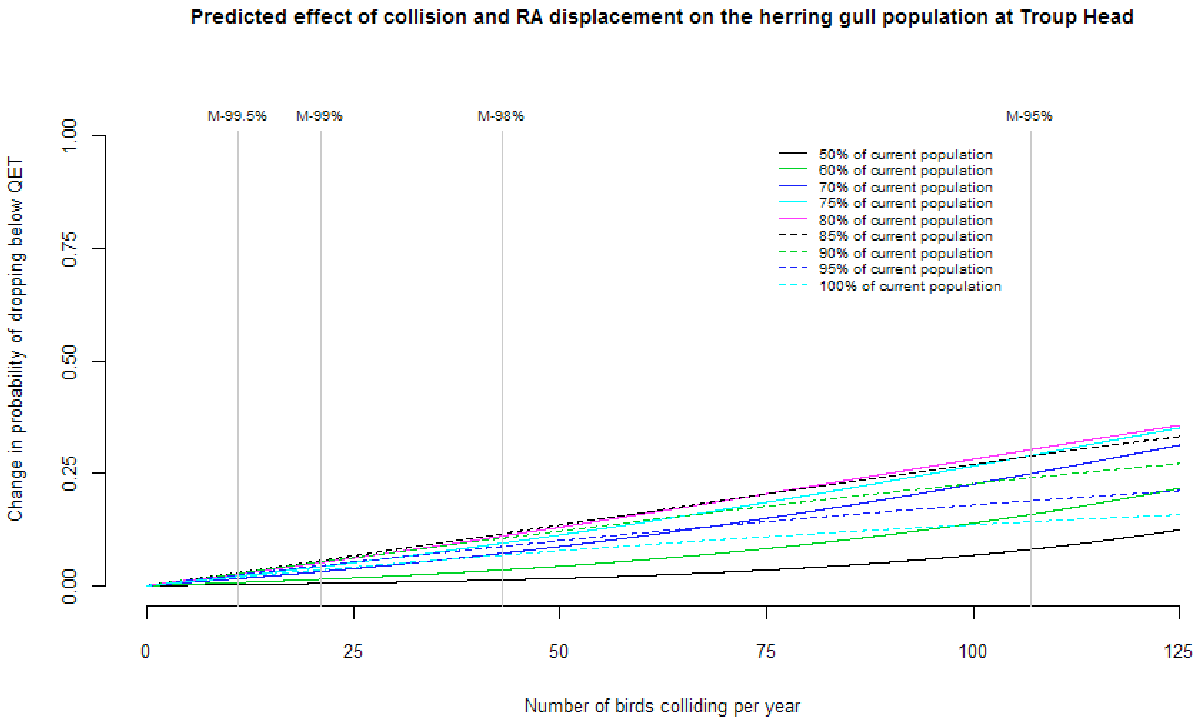


Table A38. Table A33. Probability of population change from combined displacement and collision effects of herring gull from Troup Head SPA using the Realistic Approach displacement rate including birds detected in flight.

Site	Number Displaced	Avoidance Rate	Number Colliding	Probability of dropping below percentage of current population size								
				50%	60%	70%	75%	80%	85%	90%	95%	100%
Baseline	0	N/A	0	0.006	0.029	0.094	0.156	0.243	0.362	0.518	0.645	0.743
3 sites (primary assessment)	1	95%	107	0.087	0.187	0.343	0.445	0.546	0.650	0.758	0.834	0.885
3 sites (primary assessment)	1	98%	43	0.019	0.063	0.166	0.250	0.353	0.477	0.623	0.732	0.811
3 sites (primary assessment)	1	99%	21	0.011	0.043	0.125	0.198	0.294	0.417	0.570	0.689	0.778
3 sites (primary assessment)	1	99.50%	11	0.008	0.035	0.109	0.177	0.269	0.390	0.546	0.669	0.762
MacColl, Telford & Stevenson	1	95%	82	0.048	0.125	0.264	0.363	0.469	0.584	0.710	0.798	0.859
MacColl, Telford & Stevenson	1	98%	33	0.014	0.053	0.146	0.225	0.326	0.449	0.599	0.713	0.796
MacColl, Telford & Stevenson	1	99%	16	0.009	0.039	0.117	0.187	0.281	0.403	0.558	0.679	0.770
MacColl, Telford & Stevenson	1	99.50%	8	0.008	0.033	0.105	0.171	0.262	0.382	0.538	0.662	0.756
MacColl	1	95%	39	0.017	0.059	0.157	0.240	0.342	0.466	0.614	0.725	0.805
MacColl	1	98%	16	0.009	0.039	0.117	0.187	0.281	0.403	0.558	0.679	0.770
MacColl	1	99%	8	0.008	0.033	0.105	0.171	0.262	0.382	0.538	0.662	0.756
MacColl	1	99.50%	4	0.007	0.031	0.099	0.163	0.252	0.372	0.528	0.654	0.750
Telford	1	95%	14	0.009	0.037	0.113	0.183	0.276	0.398	0.553	0.675	0.766
Telford	1	98%	5	0.007	0.032	0.100	0.165	0.255	0.374	0.531	0.656	0.751
Telford	1	99%	3	0.007	0.031	0.098	0.161	0.250	0.369	0.526	0.652	0.748
Telford	1	99.50%	1	0.006	0.029	0.095	0.158	0.246	0.364	0.521	0.647	0.745

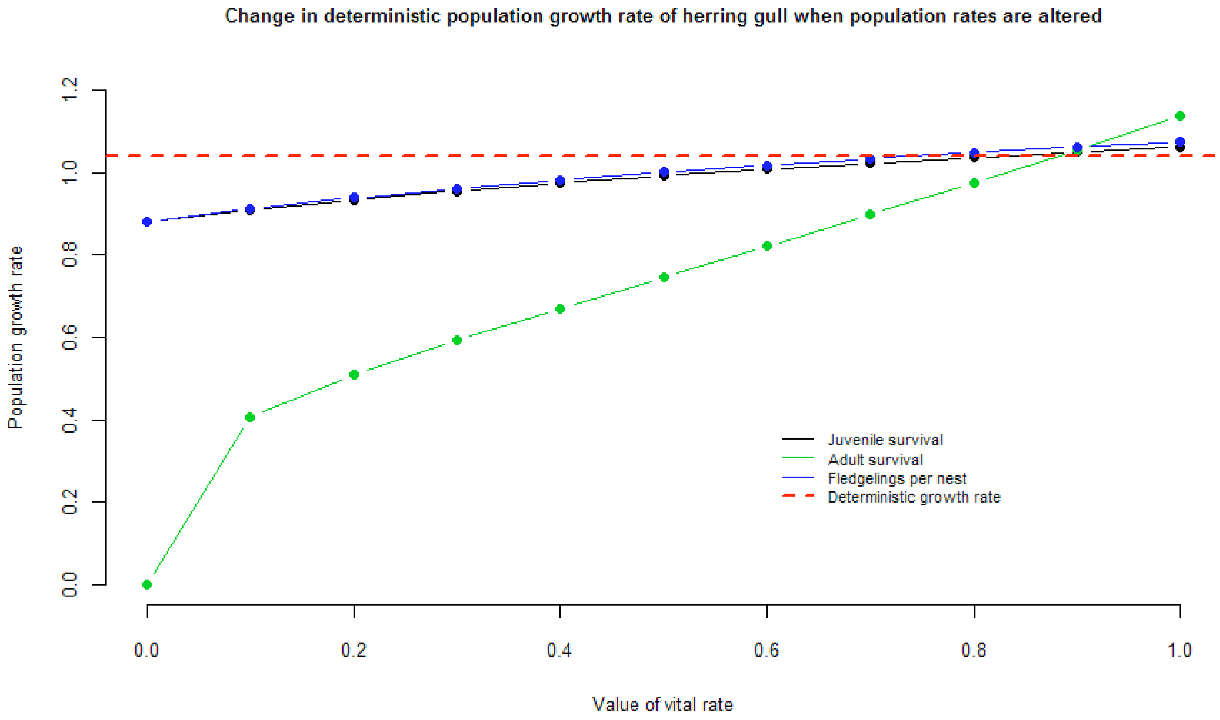
Stevenson	1	95%	29	0.013	0.049	0.138	0.216	0.315	0.439	0.590	0.705	0.790
Stevenson	1	98%	12	0.009	0.036	0.110	0.179	0.272	0.393	0.548	0.671	0.763
Stevenson	1	99%	6	0.007	0.032	0.102	0.167	0.257	0.377	0.533	0.658	0.753
Stevenson	1	99.50%	3	0.007	0.031	0.098	0.161	0.250	0.369	0.526	0.652	0.748
MacColl and Stevenson	1	95%	68	0.034	0.098	0.225	0.320	0.426	0.546	0.680	0.776	0.843
MacColl and Stevenson	1	98%	27	0.012	0.047	0.135	0.211	0.310	0.433	0.585	0.701	0.787
MacColl and Stevenson	1	99%	14	0.009	0.037	0.113	0.183	0.276	0.398	0.553	0.675	0.766
MacColl and Stevenson	1	99.50%	7	0.008	0.033	0.103	0.169	0.260	0.380	0.536	0.660	0.755
Stevenson and Telford	1	95%	43	0.019	0.063	0.166	0.250	0.353	0.477	0.623	0.732	0.811
Stevenson and Telford	1	98%	17	0.010	0.040	0.118	0.189	0.284	0.406	0.560	0.681	0.771
Stevenson and Telford	1	99%	9	0.008	0.034	0.106	0.173	0.264	0.385	0.541	0.664	0.758
Stevenson and Telford	1	99.50%	4	0.007	0.031	0.099	0.163	0.252	0.372	0.528	0.654	0.750
Telford and MacColl	1	95%	53	0.024	0.076	0.188	0.277	0.382	0.505	0.646	0.750	0.824
Telford and MacColl	1	98%	21	0.011	0.043	0.125	0.198	0.294	0.417	0.570	0.689	0.778
Telford and MacColl	1	99%	11	0.008	0.035	0.109	0.177	0.269	0.390	0.546	0.669	0.762
Telford and MacColl	1	99.50%	5	0.007	0.032	0.100	0.165	0.255	0.374	0.531	0.656	0.751
BOWL	1	95%	0	0.006	0.029	0.094	0.156	0.243	0.362	0.518	0.645	0.743
BOWL	1	98%	0	0.006	0.029	0.094	0.156	0.243	0.362	0.518	0.645	0.743
BOWL	1	99%	0	0.006	0.029	0.094	0.156	0.243	0.362	0.518	0.645	0.743
BOWL	1	99.50%	0	0.006	0.029	0.094	0.156	0.243	0.362	0.518	0.645	0.743
BOWL and MORL	1	95%	107	0.087	0.187	0.343	0.445	0.546	0.65	0.758	0.834	0.885
BOWL and MORL	1	98%	43	0.019	0.063	0.166	0.25	0.353	0.477	0.623	0.732	0.811
BOWL and MORL	1	99%	21	0.011	0.043	0.125	0.198	0.294	0.417	0.57	0.689	0.778
BOWL and MORL	1	99.50%	11	0.008	0.035	0.109	0.177	0.269	0.39	0.546	0.669	0.762

Graph A38b



SENSITIVITY

Graph A39



GREAT BLACK-BACKED GULL

EAST CAITHNESS CLIFFS

DISPLACEMENT

Graph A40a

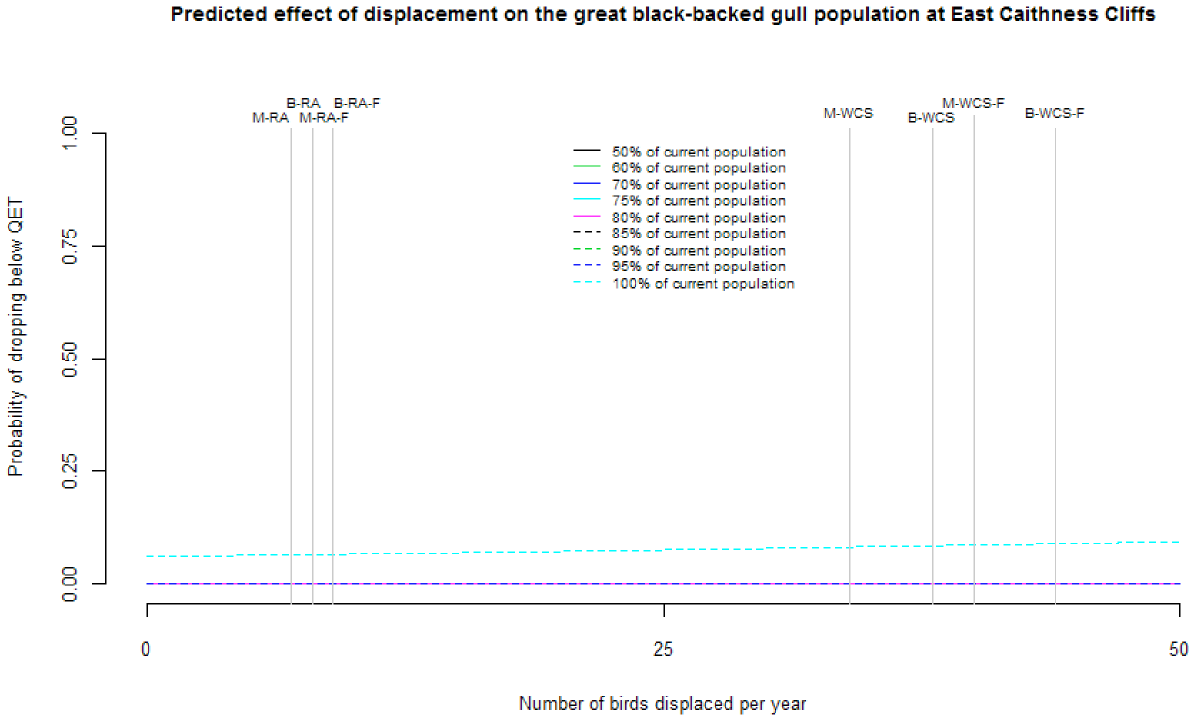
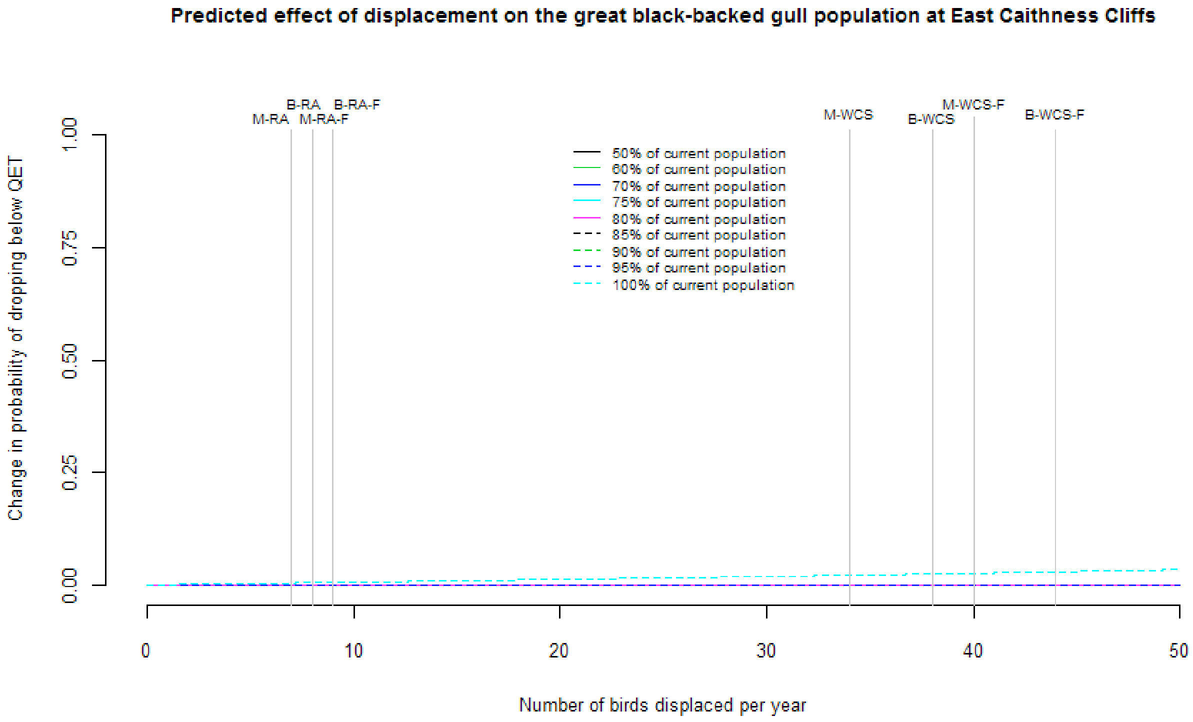


Table A40. Probability of population change from displacement of great black backed gull at East Caithness Cliffs SPA.

Site	Displacement rate	Number displaced	Probability of dropping below percentage of current population size								
			50%	60%	70%	75%	80%	85%	90%	95%	100%
3 sites (primary assessment)	Baseline	0	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.059
3 sites (primary assessment)	WCS	34	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.080
3 sites (primary assessment)	RA	7	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.063
3 sites (primary assessment)	WCS flight	40	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.085
3 sites (primary assessment)	RA flight	8	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.063
MacColl	WCS	15	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.068
MacColl	RA	3	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.061
MacColl	WCS flight	19	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.070
MacColl	RA flight	4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.061
Telford	WCS	11	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.065

Telford	RA	2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.060
Telford	WCS flight	7	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.063
Telford	RA flight	1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.060
Stevenson	WCS	8	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.063
Stevenson	RA	2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.060
Stevenson	WCS flight	14	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.067
Stevenson	RA flight	3	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.061
MacColl and Stevenson	WCS	23	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.073
MacColl and Stevenson	RA	5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.062
MacColl and Stevenson	WCS flight	34	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.080
MacColl and Stevenson	RA flight	7	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.063
Stevenson and Telford	WCS	19	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.070
Stevenson and Telford	RA	4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.061
Stevenson and Telford	WCS flight	21	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.071
Stevenson and Telford	RA flight	4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.061
Telford and MacColl	WCS	26	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.075
Telford and MacColl	RA	5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.062
Telford and MacColl	WCS flight	26	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.075
Telford and MacColl	RA flight	5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.062
BOWL	WCS	4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.061
BOWL	RA	1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.060
BOWL	WCS flight	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BOWL	RA flight	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BOWL and MORL	WCS	38	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.083
BOWL and MORL	RA	8	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.063
BOWL and MORL	WCS flight	44	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.088
BOWL and MORL	RA flight	9	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.064

Graph A40b


Predicted effect of displacement on the great black-backed gull population at East Caithness Cliffs
B-RA
B-RA-F
M-RA
M-RA-F
M-WCS
B-WCS
M-WCS-F
B-WCS-F
50% of current population
60% of current population
70% of current population
75% of current population
80% of current population
85% of current population
90% of current population
95% of current population
100% of current population
Change in probability of dropping below QET
0.00
0.25
0.50
0.75
1.00
0
10
20
30
40
50
Number of birds displaced per year

COLLISION

Graph A41a

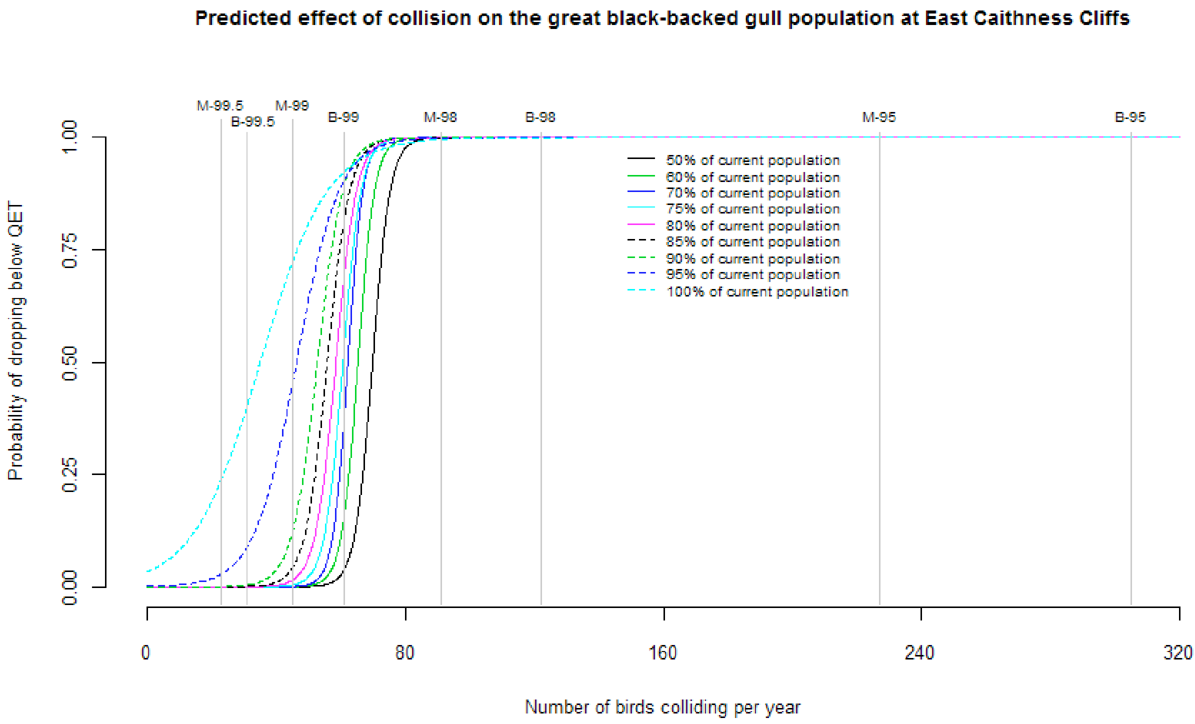
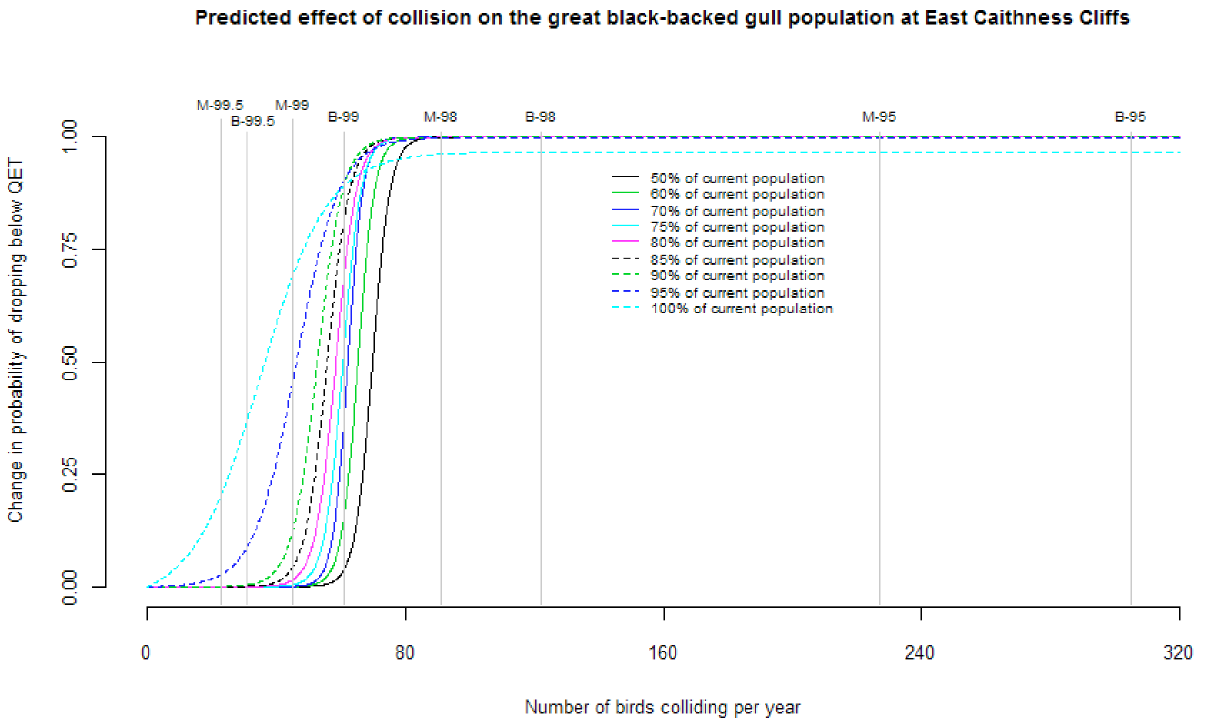


Table A41. Probability of population change from collision of great black-backed gull at East Caithness Cliffs SPA.

Site	Avoidance Rate	Number Colliding	Probability of dropping below percentage of current population size								
			50%	60%	70%	75%	80%	85%	90%	95%	100%
3 sites (primary assessment)	Baseline	0	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.033
3 sites (primary assessment)	95%	78	0.952	0.993	0.999	0.998	0.998	0.998	0.998	0.992	0.984
3 sites (primary assessment)	98%	31	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.004	0.089	0.404
3 sites (primary assessment)	99%	16	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.010	0.138
3 sites (primary assessment)	99.50%	8	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.069
MacColl, Telford & Stevenson	95%	109	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.999
MacColl, Telford & Stevenson	98%	43	<0.001	<0.001	<0.001	0.002	0.008	0.024	0.077	0.378	0.683
MacColl, Telford & Stevenson	99%	22	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.024	0.222
MacColl, Telford & Stevenson	99.50%	11	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	0.090
MacColl	95%	52	0.001	0.005	0.012	0.044	0.116	0.249	0.452	0.706	0.837
MacColl	98%	21	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.021	0.205
MacColl	99%	10	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	0.082
MacColl	99.50%	5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.052
Telford	95%	18	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.013	0.162
Telford	98%	7	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.063
Telford	99%	4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.048
Telford	99.50%	2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.040
Stevenson	95%	39	<0.001	<0.001	<0.001	<0.001	0.002	0.008	0.029	0.248	0.594
Stevenson	98%	15	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.008	0.127
Stevenson	99%	8	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.069
Stevenson	99.50%	4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.048

MacColl and Stevenson	95%	91	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.999	0.995
MacColl and Stevenson	98%	36	<0.001	<0.001	<0.001	<0.001	0.001	0.003	0.014	0.173	0.523
MacColl and Stevenson	99%	18	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.013	0.162
MacColl and Stevenson	99.50%	9	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.075
Stevenson and Telford	95%	57	0.009	0.037	0.094	0.214	0.387	0.584	0.746	0.837	0.892
Stevenson and Telford	98%	23	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.028	0.239
Stevenson and Telford	99%	11	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	0.090
Stevenson and Telford	99.50%	6	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.057
Telford and MacColl	95%	70	0.515	0.862	0.967	0.965	0.974	0.984	0.988	0.974	0.967
Telford and MacColl	98%	28	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.058	0.337
Telford and MacColl	99%	14	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.007	0.116
Telford and MacColl	99.50%	7	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.063
BOWL	95%	227	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BOWL	98%	91	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.999	0.995
BOWL	99%	45	0.000	0.000	0.001	0.004	0.014	0.042	0.122	0.452	0.723
BOWL	99.50%	23	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.028	0.239
BOWL and MORL	95%	305	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BOWL and MORL	98%	122	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BOWL and MORL	99%	61	0.038	0.155	0.371	0.530	0.689	0.817	0.890	0.904	0.924
BOWL and MORL	99.50%	31	0.000	0.000	0.000	0.000	0.000	0.001	0.004	0.089	0.404

Graph A41b



COLLISION AND DISPLACEMENT – WORST CASE SCENARIO

Graph A42a

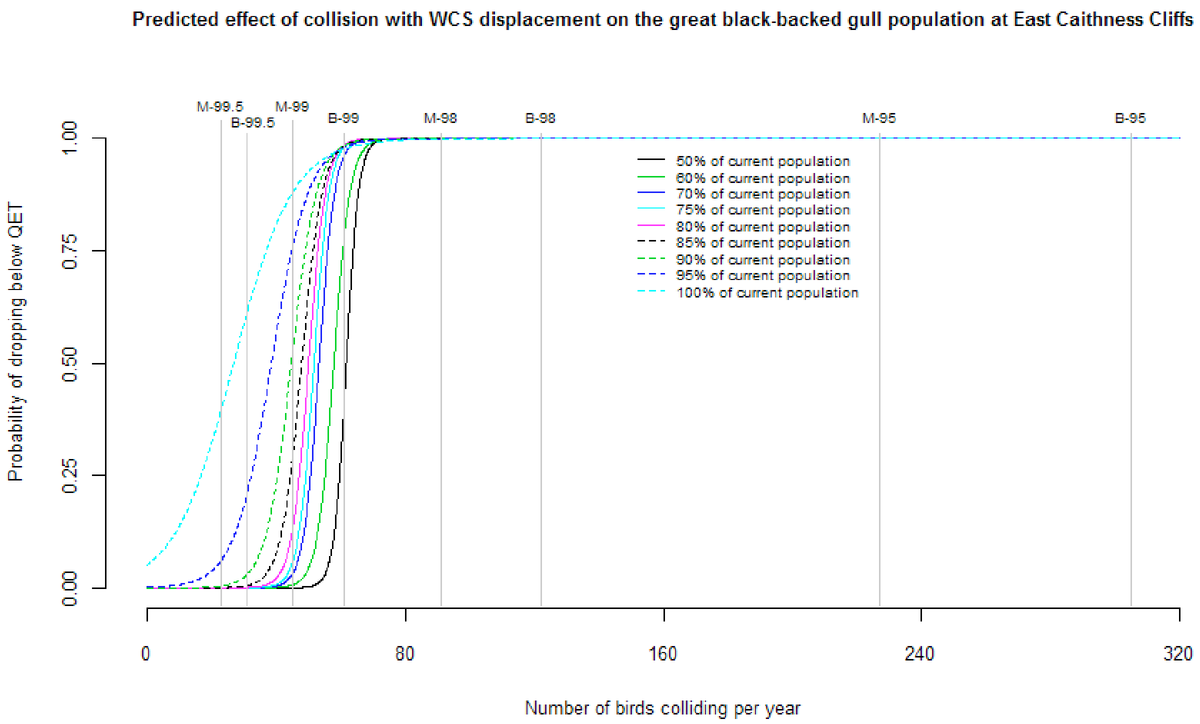
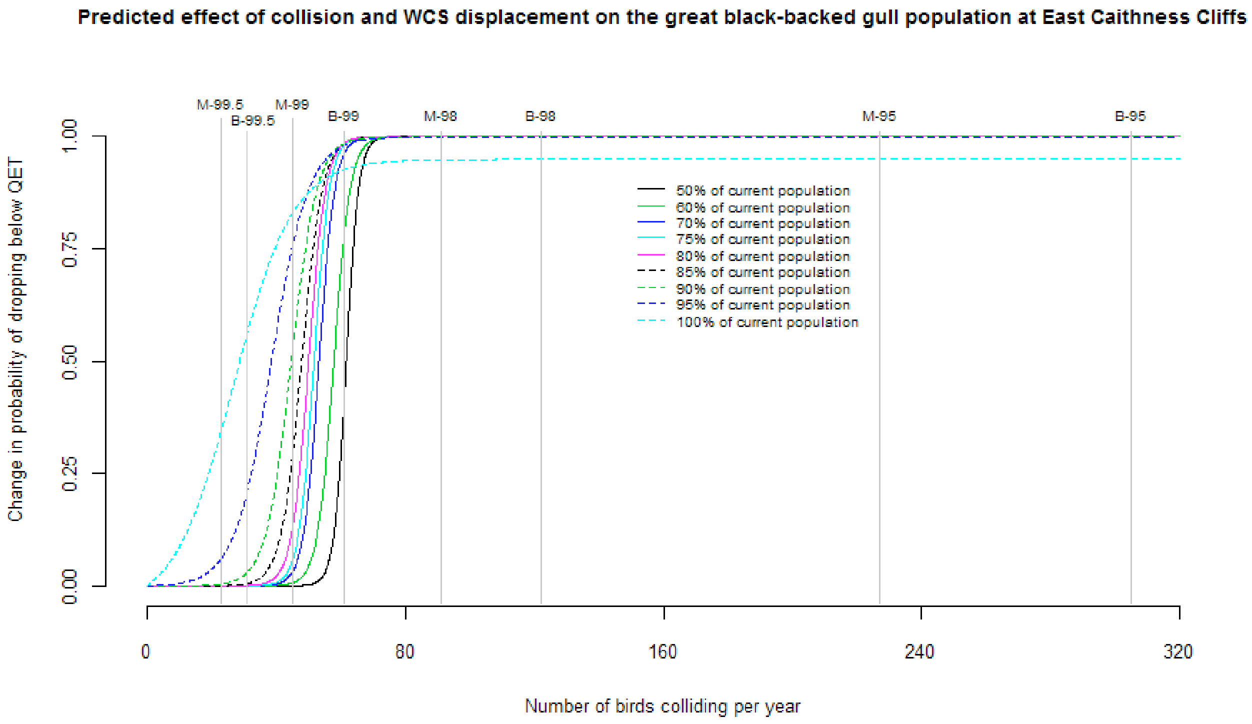


Table A42. Probability of population change from combined displacement and collision effects of great black backed gull from East Caithness Cliffs SPA using the Worst Case Scenario displacement rate including birds detected in flight.

Site	Number Displaced	Avoidance Rate	Number Colliding	Probability of dropping below percentage of current population size								
				50%	60%	70%	75%	80%	85%	90%	95%	100%
Baseline	0	N/A	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.092
3 sites (primary assessment)	44	95%	78	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.999	0.996
3 sites (primary assessment)	44	98%	31	<0.001	<0.001	<0.001	<0.001	0.001	0.005	0.030	0.211	0.614
3 sites (primary assessment)	44	99%	16	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.019	0.235
3 sites (primary assessment)	44	99.50%	8	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	0.114
MacColl, Telford & Stevenson	44	95%	109	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MacColl, Telford & Stevenson	44	98%	43	<0.001	0.003	0.014	0.025	0.064	0.177	0.395	0.687	0.855
MacColl, Telford & Stevenson	44	99%	22	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.052	0.372
MacColl, Telford & Stevenson	44	99.50%	11	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.008	0.151
MacColl	44	95%	52	0.006	0.091	0.369	0.534	0.680	0.784	0.866	0.914	0.940
MacColl	44	98%	21	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.044	0.347
MacColl	44	99%	10	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.007	0.138
MacColl	44	99.50%	5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.085
Telford	44	95%	18	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.027	0.277
Telford	44	98%	7	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	0.103
Telford	44	99%	4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.077
Telford	44	99.50%	2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.062

Stevenson	44	95%	39	<0.001	0.001	0.003	0.005	0.015	0.058	0.191	0.521	0.792
Stevenson	44	98%	15	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.016	0.216
Stevenson	44	99%	8	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	0.114
Stevenson	44	99.50%	4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.077
MacColl and Stevenson	44	95%	91	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.999
MacColl and Stevenson	44	98%	36	<0.001	<0.001	0.001	0.001	0.005	0.023	0.099	0.391	0.733
MacColl and Stevenson	44	99%	18	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.027	0.277
MacColl and Stevenson	44	99.50%	9	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.006	0.125
Stevenson and Telford	44	95%	57	0.077	0.420	0.824	0.904	0.935	0.946	0.959	0.962	0.965
Stevenson and Telford	44	98%	23	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	0.062	0.398
Stevenson and Telford	44	99%	11	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.008	0.151
Stevenson and Telford	44	99.50%	6	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.094
Telford and MacColl	44	95%	70	0.987	0.992	0.999	1.000	1.000	0.999	0.998	0.996	0.991
Telford and MacColl	44	98%	28	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.014	0.136	0.533
Telford and MacColl	44	99%	14	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.013	0.198
Telford and MacColl	44	99.50%	7	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	0.103
BOWL	44	95%	227	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BOWL	44	98%	91	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.999
BOWL	44	99%	45	0.000	0.006	0.031	0.056	0.128	0.287	0.521	0.757	0.880
BOWL	44	99.50%	23	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.062	0.398
BOWL and MORL	44	95%	305	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BOWL and MORL	44	98%	122	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BOWL and MORL	44	99%	61	0.407	0.779	0.961	0.981	0.985	0.984	0.985	0.981	0.977
BOWL and MORL	44	99.50%	31	0.000	0.000	0.000	0.000	0.001	0.005	0.030	0.211	0.614

Graph A42b



COLLISION AND DISPLACEMENT – REALISTIC APPROACH

Graph A43a

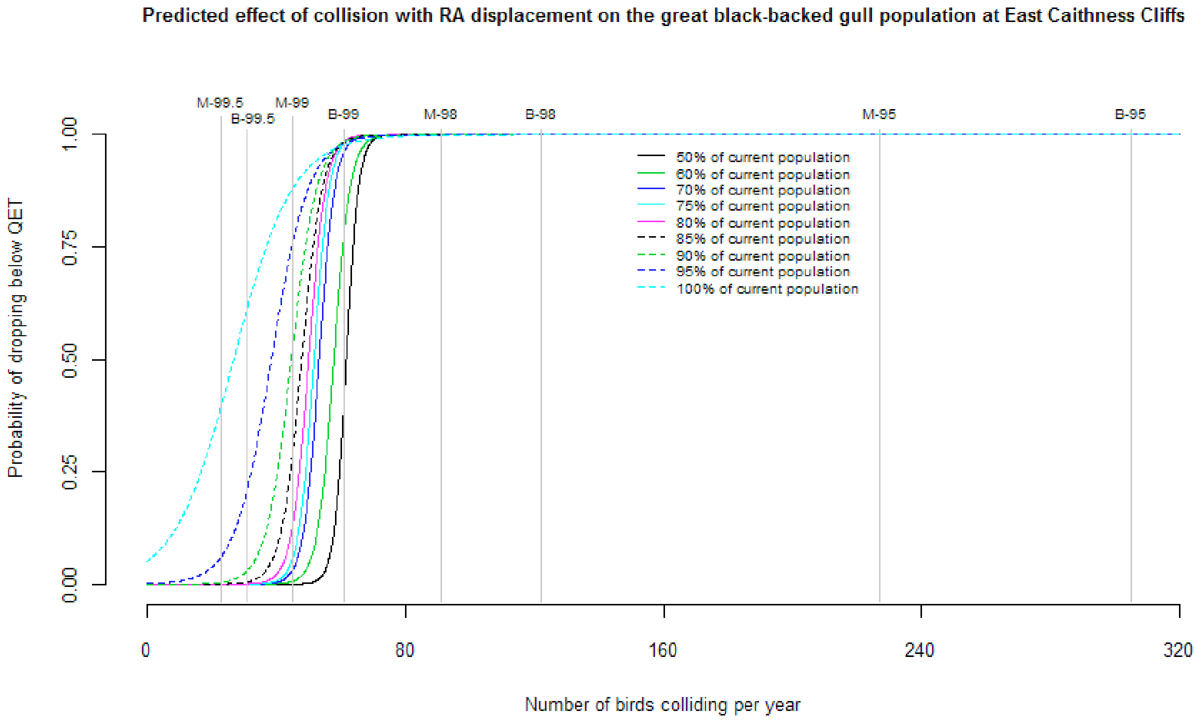
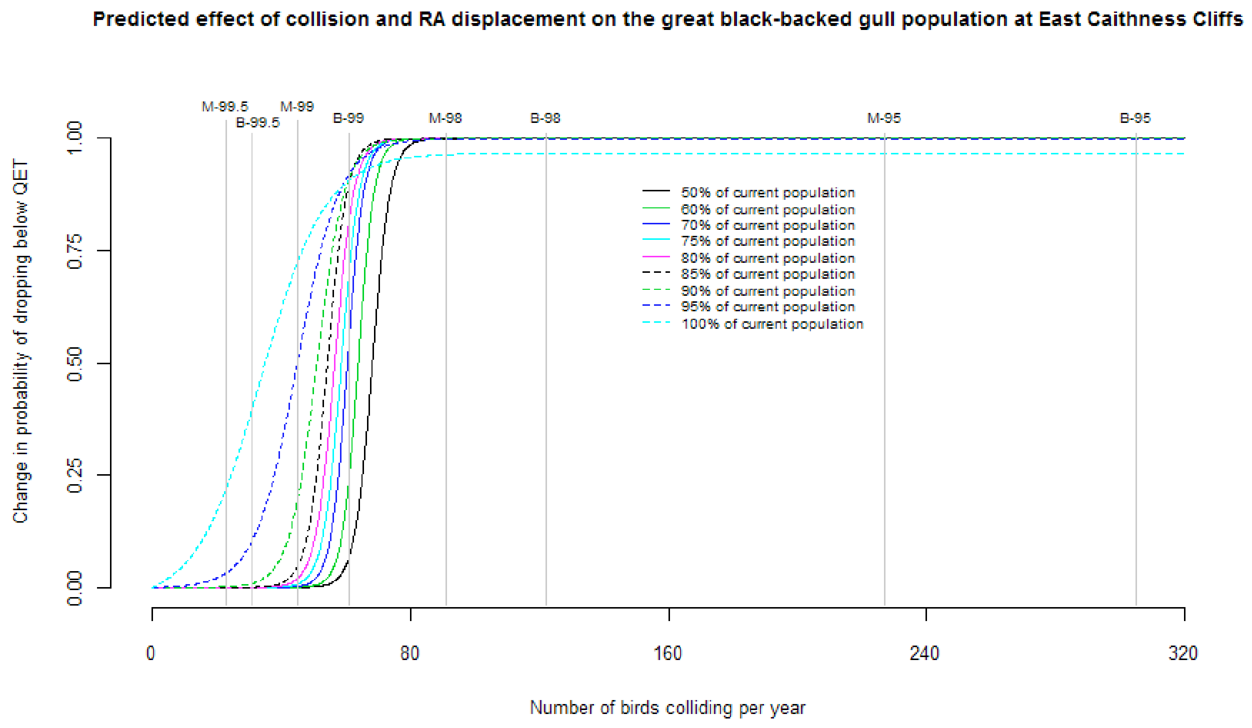


Table A43. Probability of population change from combined displacement and collision effects of great black backed gull from East Caithness Cliffs SPA using the Realistic Approach displacement rate including birds detected in flight.

Site	Number Displaced	Avoidance Rate	Number Colliding	Probability of dropping below percentage of current population size								
				50%	60%	70%	75%	80%	85%	90%	95%	100%
Baseline	0	N/A	0	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.033
3 sites (primary assessment)	8	95%	78	0.972	0.997	0.999	0.999	0.999	1.000	0.998	0.994	0.988
3 sites (primary assessment)	8	98%	31	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.009	0.105	0.432
3 sites (primary assessment)	8	99%	16	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.012	0.144
3 sites (primary assessment)	8	99.50%	8	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.070
MacColl, Telford & Stevenson	8	95%	109	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.999
MacColl, Telford & Stevenson	8	98%	43	<0.001	<0.001	0.001	0.004	0.010	0.025	0.130	0.425	0.718
MacColl, Telford & Stevenson	8	99%	22	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.029	0.236
MacColl, Telford & Stevenson	8	99.50%	11	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	0.093
MacColl	8	95%	52	0.003	0.008	0.034	0.086	0.174	0.322	0.553	0.746	0.863
MacColl	8	98%	21	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.025	0.218
MacColl	8	99%	10	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	0.084
MacColl	8	99.50%	5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.053
Telford	8	95%	18	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.016	0.171
Telford	8	98%	7	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.064
Telford	8	99%	4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.048

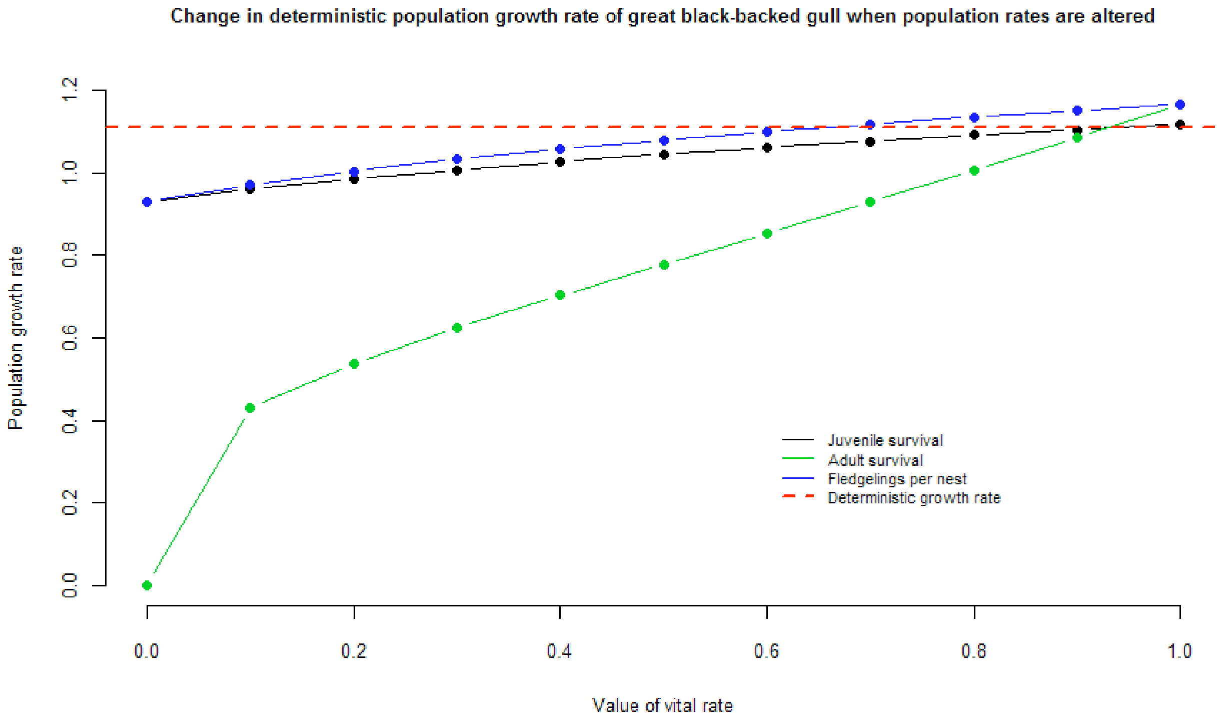
Telford	8	99.50%	2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.040
Stevenson	8	95%	39	<0.001	<0.001	<0.001	0.001	0.003	0.007	0.055	0.286	0.630
Stevenson	8	98%	15	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.010	0.132
Stevenson	8	99%	8	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.070
Stevenson	8	99.50%	4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.048
MacColl and Stevenson	8	95%	91	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.999	0.997
MacColl and Stevenson	8	98%	36	<0.001	<0.001	<0.001	<0.001	0.001	0.003	0.028	0.202	0.557
MacColl and Stevenson	8	99%	18	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.016	0.171
MacColl and Stevenson	8	99.50%	9	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	0.077
Stevenson and Telford	8	95%	57	0.017	0.060	0.200	0.360	0.535	0.708	0.800	0.864	0.912
Stevenson and Telford	8	98%	23	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.033	0.254
Stevenson and Telford	8	99%	11	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	0.093
Stevenson and Telford	8	99.50%	6	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.058
Telford and MacColl	8	95%	70	0.654	0.923	0.977	0.983	0.990	0.994	0.988	0.979	0.975
Telford and MacColl	8	98%	28	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	0.069	0.360
Telford and MacColl	8	99%	14	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.009	0.121
Telford and MacColl	8	99.50%	7	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.064
BOWL	8	95%	227	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BOWL	8	98%	91	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.999	0.997
BOWL	8	99%	45	0.000	0.001	0.002	0.008	0.019	0.046	0.193	0.501	0.757
BOWL	8	99.50%	23	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.033	0.254
BOWL and MORL	8	95%	305	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BOWL and MORL	8	98%	122	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BOWL and MORL	8	99%	61	0.068	0.242	0.549	0.701	0.817	0.899	0.911	0.921	0.940
BOWL and MORL	8	99.50%	31	0.000	0.000	0.000	0.000	0.000	0.001	0.009	0.105	0.432

Graph A43b



SENSITIVITY

Graph A44



GUILLEMOT

EAST CAITHNESS CLIFFS

DISPLACEMENT

Graph A45a

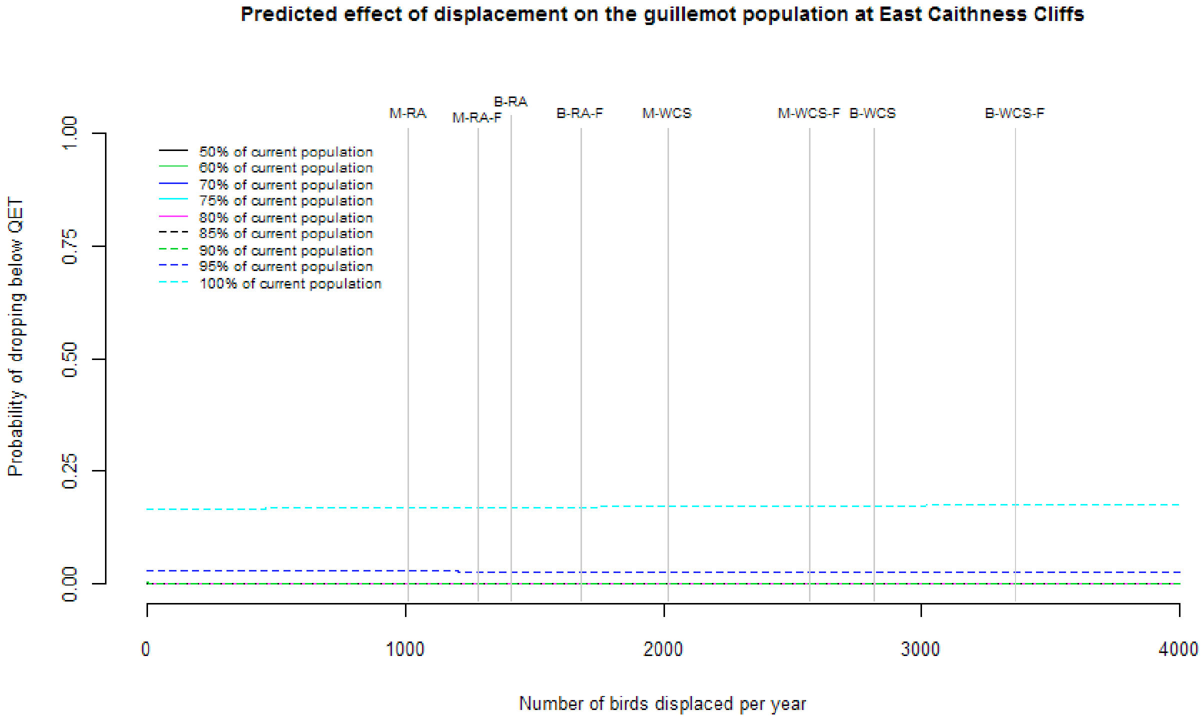
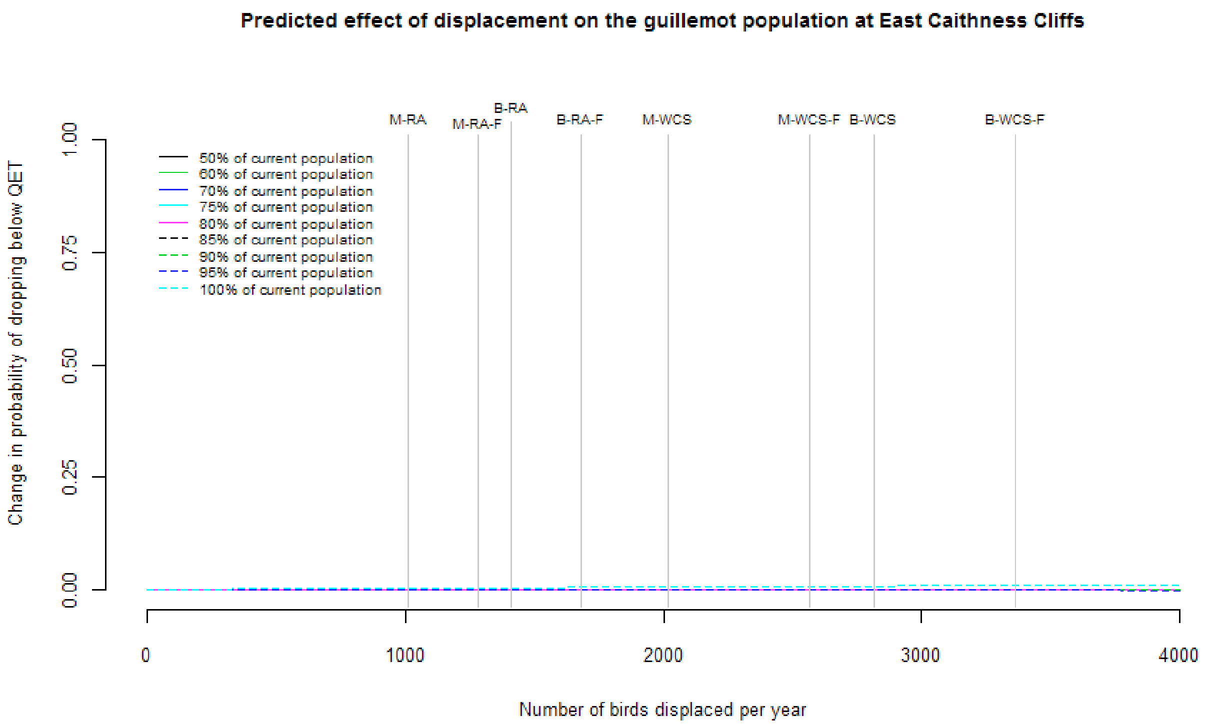


Table A45. Probability of population change from displacement of guillemot at East Caithness Cliffs SPA.

Site	Displacement rate	Number displaced	Probability of dropping below percentage of current population size								
			50%	60%	70%	75%	80%	85%	90%	95%	100%
3 sites (primary assessment)	Baseline	0	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.027	0.165
3 sites (primary assessment)	WCS	2020	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.170
3 sites (primary assessment)	RA	1010	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.168
3 sites (primary assessment)	WCS flight	2566	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.025	0.171
3 sites (primary assessment)	RA flight	1283	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.168
MacColl	WCS	878	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.167
MacColl	RA	439	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.027	0.166
MacColl	WCS flight	1114	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.168
MacColl	RA flight	557	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.027	0.167
Telford	WCS	518	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.027	0.166

Telford	RA	259	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.027	0.166
Telford	WCS flight	823	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.027	0.167
Telford	RA flight	412	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.027	0.166
Stevenson	WCS	624	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.027	0.167
Stevenson	RA	312	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.027	0.166
Stevenson	WCS flight	629	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.027	0.167
Stevenson	RA flight	314	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.027	0.166
MacColl and Stevenson	WCS	1502	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.169
MacColl and Stevenson	RA	751	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.027	0.167
MacColl and Stevenson	WCS flight	1743	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.169
MacColl and Stevenson	RA flight	871	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.167
Stevenson and Telford	WCS	1142	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.168
Stevenson and Telford	RA	571	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.027	0.167
Stevenson and Telford	WCS flight	1452	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.169
Stevenson and Telford	RA flight	726	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.027	0.167
Telford and MacColl	WCS	1395	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.169
Telford and MacColl	RA	698	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.027	0.167
Telford and MacColl	WCS flight	1937	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.170
Telford and MacColl	RA flight	969	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.168
BOWL	WCS	797	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.027	0.167
BOWL	RA	398	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.027	0.166
BOWL	WCS flight	797	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.027	0.167
BOWL	RA flight	398	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.027	0.166
BOWL and MORL	WCS	2816	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.025	0.172
BOWL and MORL	RA	1408	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.169
BOWL and MORL	WCS flight	3363	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.025	0.173
BOWL and MORL	RA flight	1681	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.169

Graph A45b


Predicted effect of displacement on the guillemot population at East Caithness Cliffs
Change in probability of dropping below QET
0.00
0.25
0.50
0.75
1.00
Number of birds displaced per year
0
1000
2000
3000
4000
M-RA
M-RA-F
B-RA
B-RA-F
M-WCS
M-WCS-F
B-WCS
B-WCS-F
50% of current population
60% of current population
70% of current population
75% of current population
80% of current population
85% of current population
90% of current population
95% of current population
100% of current population

NORTH CAITHNESS CLIFFS

DISPLACEMENT

Graph A46a

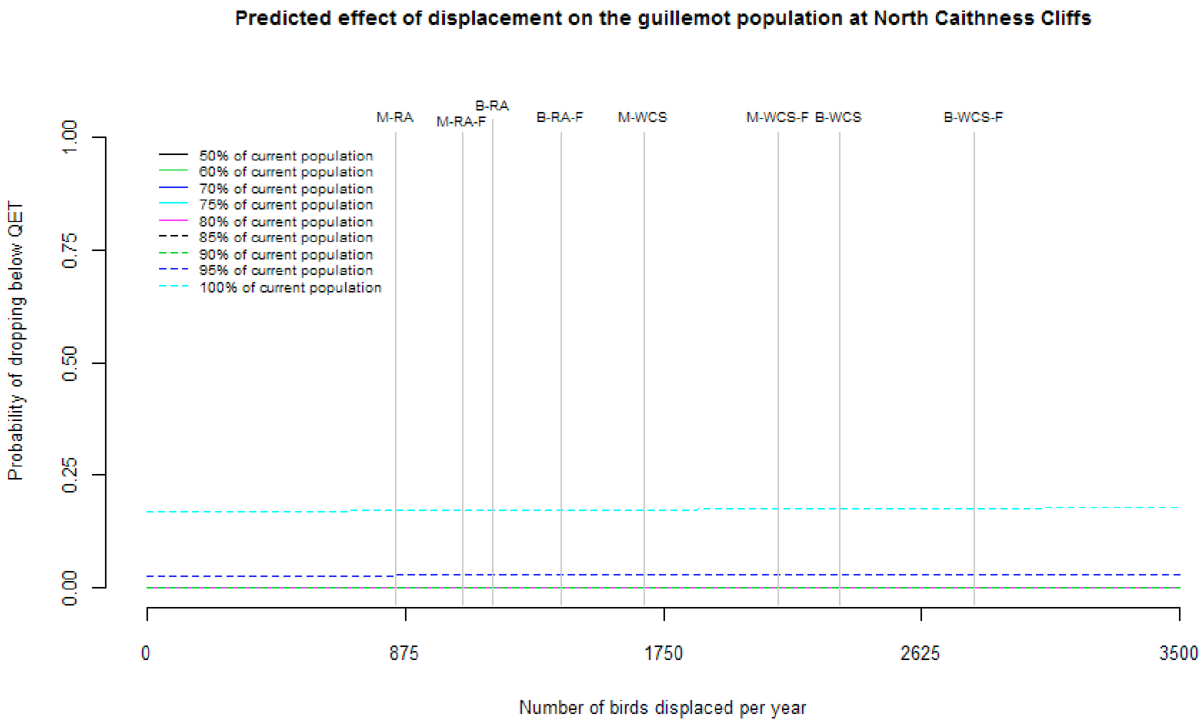
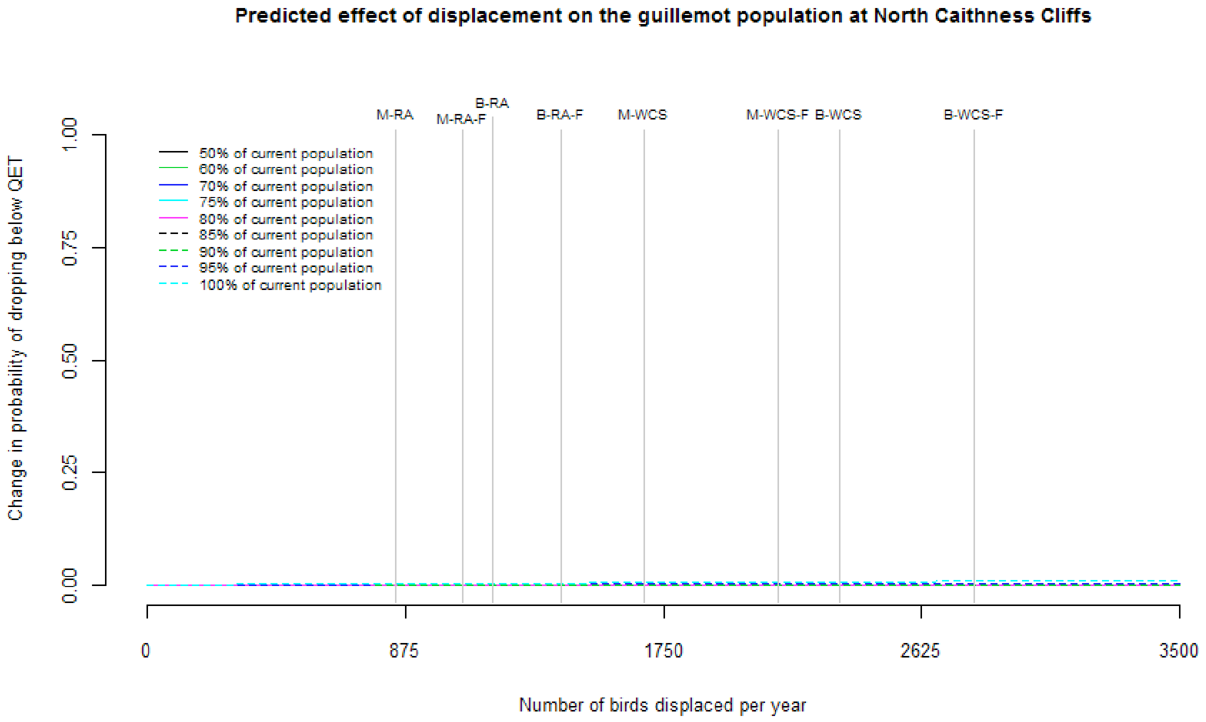


Table A46. Probability of population change from displacement of guillemot at North Caithness Cliffs SPA

Site	Displacement rate	Number displaced	Probability of dropping below percentage of current population size								
			50%	60%	70%	75%	80%	85%	90%	95%	100%
3 sites (primary assessment)	Baseline	0	0.000	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.025	0.168
3 sites (primary assessment)	WCS	1683	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.027	0.172
3 sites (primary assessment)	RA	842	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.170
3 sites (primary assessment)	WCS flight	2138	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.028	0.173
3 sites (primary assessment)	RA flight	1069	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.027	0.170
MacColl	WCS	732	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.170
MacColl	RA	366	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.169
MacColl	WCS flight	928	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.170
MacColl	RA flight	464	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.169
Telford	WCS	431	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.169
Telford	RA	216	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.168
Telford	WCS flight	686	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.169
Telford	RA flight	343	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.169
Stevenson	WCS	520	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.169
Stevenson	RA	260	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.168
Stevenson	WCS flight	524	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.169
Stevenson	RA flight	262	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.168

MacColl and Stevenson	WCS	1252	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.027	0.171
MacColl and Stevenson	RA	626	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.169
MacColl and Stevenson	WCS flight	1452	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.027	0.172
MacColl and Stevenson	RA flight	726	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.170
Stevenson and Telford	WCS	952	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.170
Stevenson and Telford	RA	476	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.169
Stevenson and Telford	WCS flight	1210	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.027	0.171
Stevenson and Telford	RA flight	605	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.169
Telford and MacColl	WCS	1163	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.027	0.171
Telford and MacColl	RA	581	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.169
Telford and MacColl	WCS flight	1614	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.027	0.172
Telford and MacColl	RA flight	807	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.170
BOWL	WCS	664	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.169
BOWL	RA	332	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.169
BOWL	WCS flight	664	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.169
BOWL	RA flight	332	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.169
BOWL and MORL	WCS	2347	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.028	0.174
BOWL and MORL	RA	1173	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.027	0.171
BOWL and MORL	WCS flight	2802	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.028	0.175
BOWL and MORL	RA flight	1401	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.027	0.171

Graph A46b



TROUP HEAD

DISPLACEMENT

Graph A47a

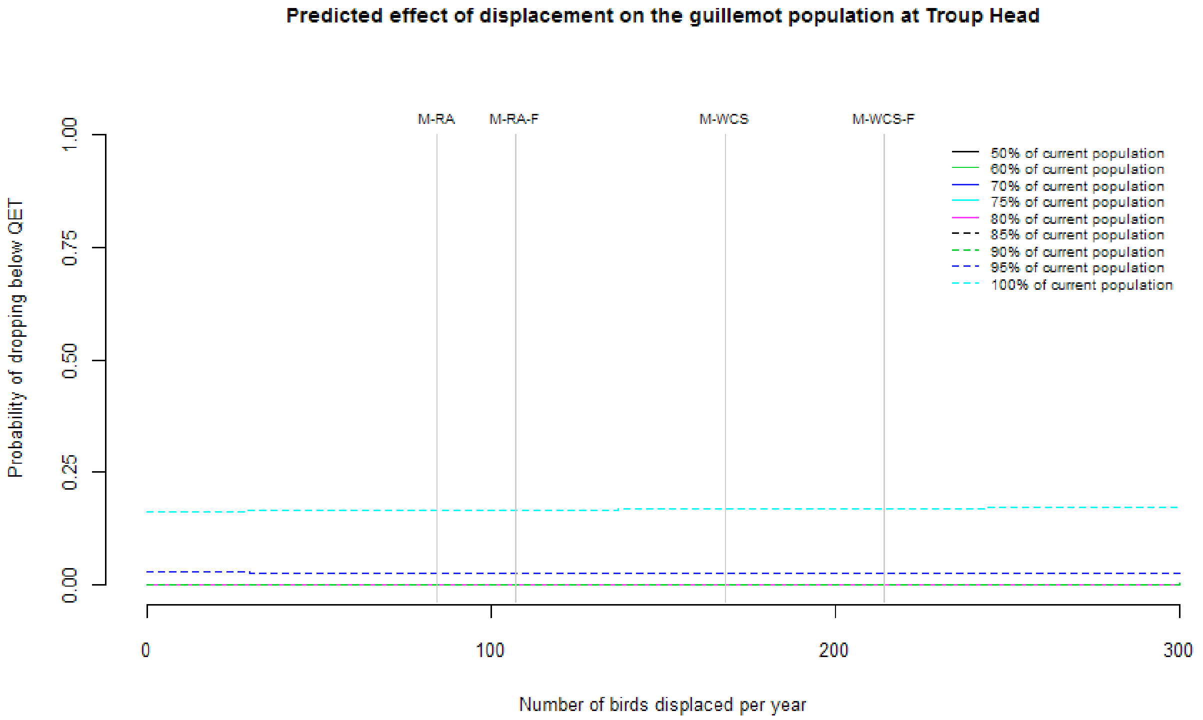
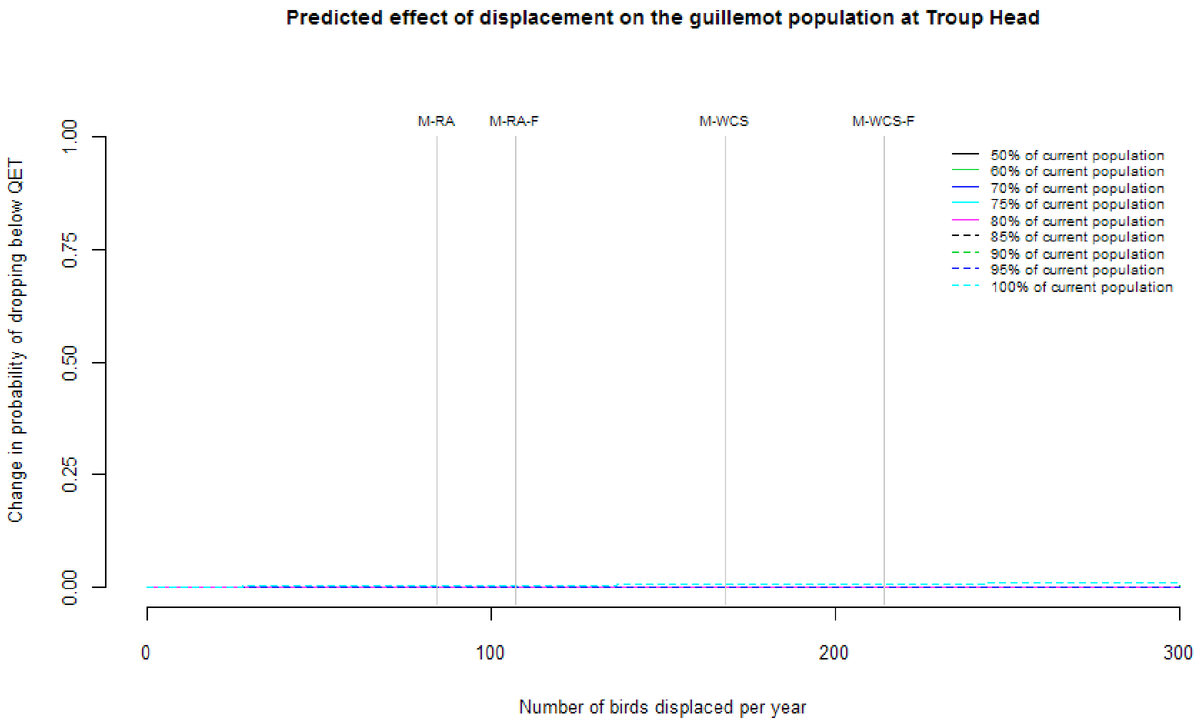


Table A47. Probability of population change from displacement of guillemot at Troup Head SPA.

Site	Displacement rate	Number displaced	Probability of dropping below percentage of current population size								
			50%	60%	70%	75%	80%	85%	90%	95%	100%
3 sites (primary assessment)	Baseline	0	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.162
3 sites (primary assessment)	WCS	168	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.167
3 sites (primary assessment)	RA	84	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.165
3 sites (primary assessment)	WCS flight	214	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.025	0.169
3 sites (primary assessment)	RA flight	107	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.165
MacColl	WCS	73	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.164
MacColl	RA	37	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.163
MacColl	WCS flight	93	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.165
MacColl	RA flight	46	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.164
Telford	WCS	43	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.164
Telford	RA	22	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.163
Telford	WCS flight	69	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.164
Telford	RA flight	34	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.163

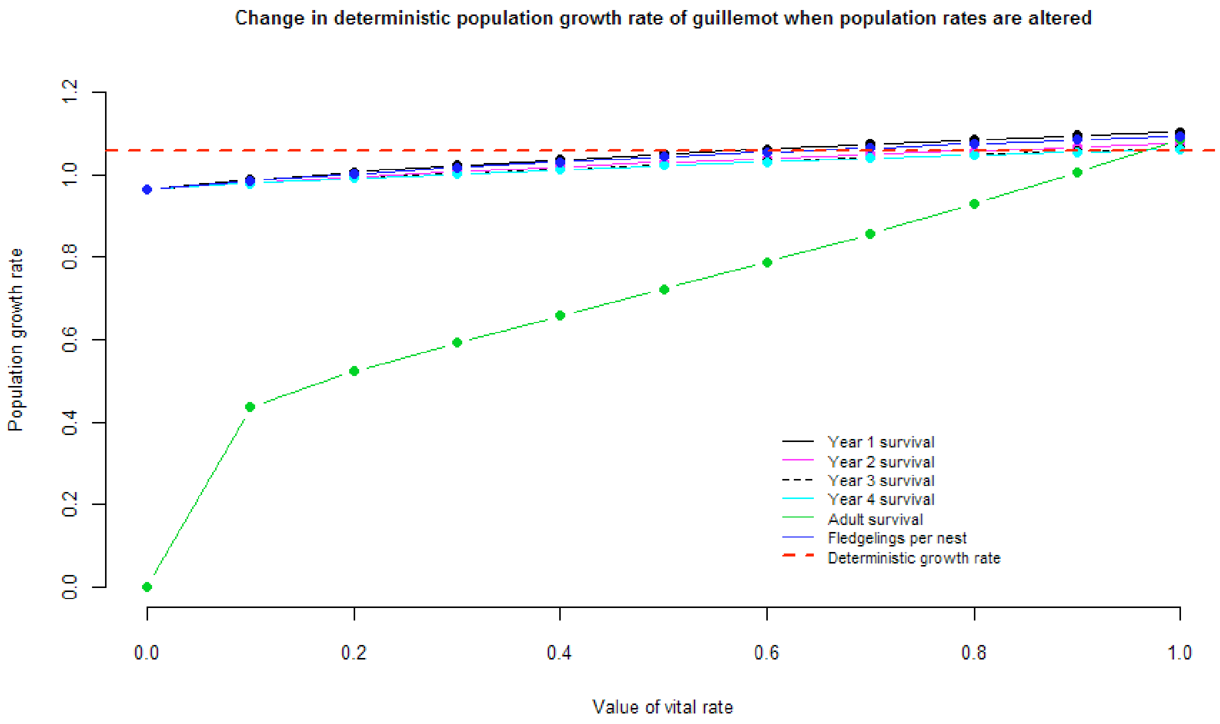
Stevenson	WCS	52	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.164
Stevenson	RA	26	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.163
Stevenson	WCS flight	52	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.164
Stevenson	RA flight	26	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.163
MacColl and Stevenson	WCS	125	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.166
MacColl and Stevenson	RA	63	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.164
MacColl and Stevenson	WCS flight	145	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.167
MacColl and Stevenson	RA flight	73	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.164
Stevenson and Telford	WCS	95	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.165
Stevenson and Telford	RA	48	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.164
Stevenson and Telford	WCS flight	121	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.166
Stevenson and Telford	RA flight	60	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.164
Telford and MacColl	WCS	116	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.166
Telford and MacColl	RA	58	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.164
Telford and MacColl	WCS flight	161	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.167
Telford and MacColl	RA flight	81	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.165
BOWL	WCS	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.162
BOWL	RA	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.162
BOWL	WCS flight	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.162
BOWL	RA flight	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.162
BOWL and MORL	WCS	168	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.167
BOWL and MORL	RA	84	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.165
BOWL and MORL	WCS flight	214	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.025	0.169
BOWL and MORL	RA flight	107	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.165

Graph A47b



SENSITIVITY

Graph A48



RAZORBILL

EAST CAITHNESS CLIFFS

DISPLACEMENT

Graph A49a

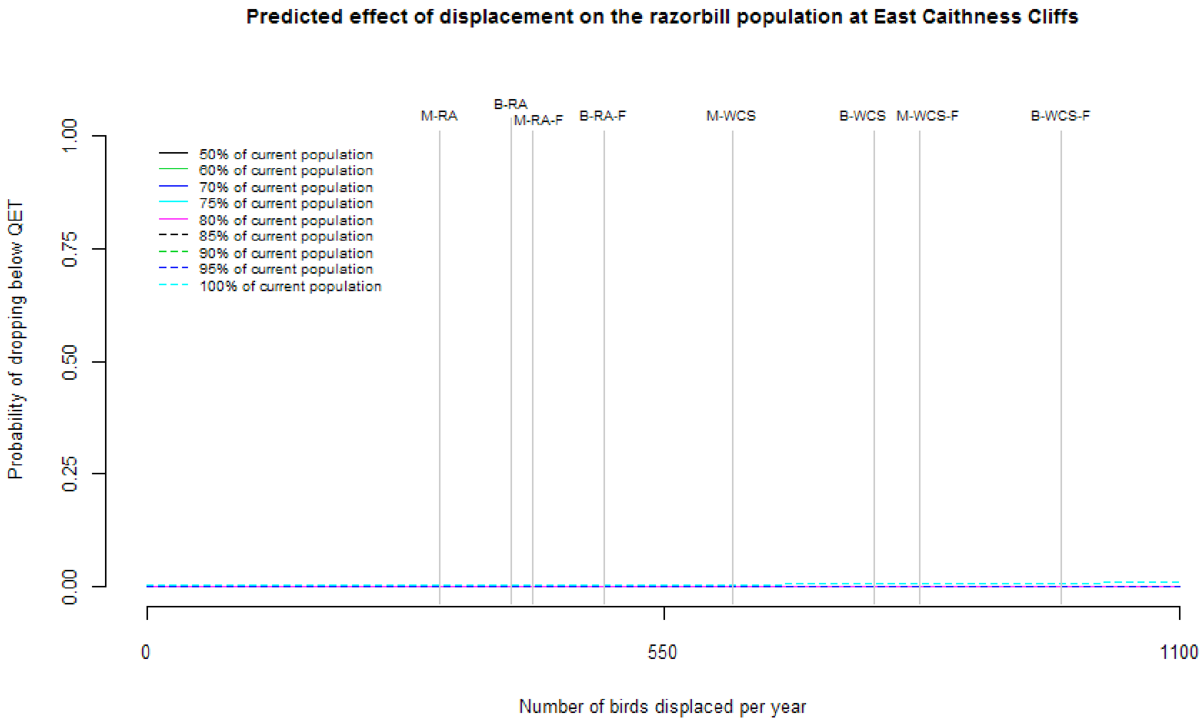
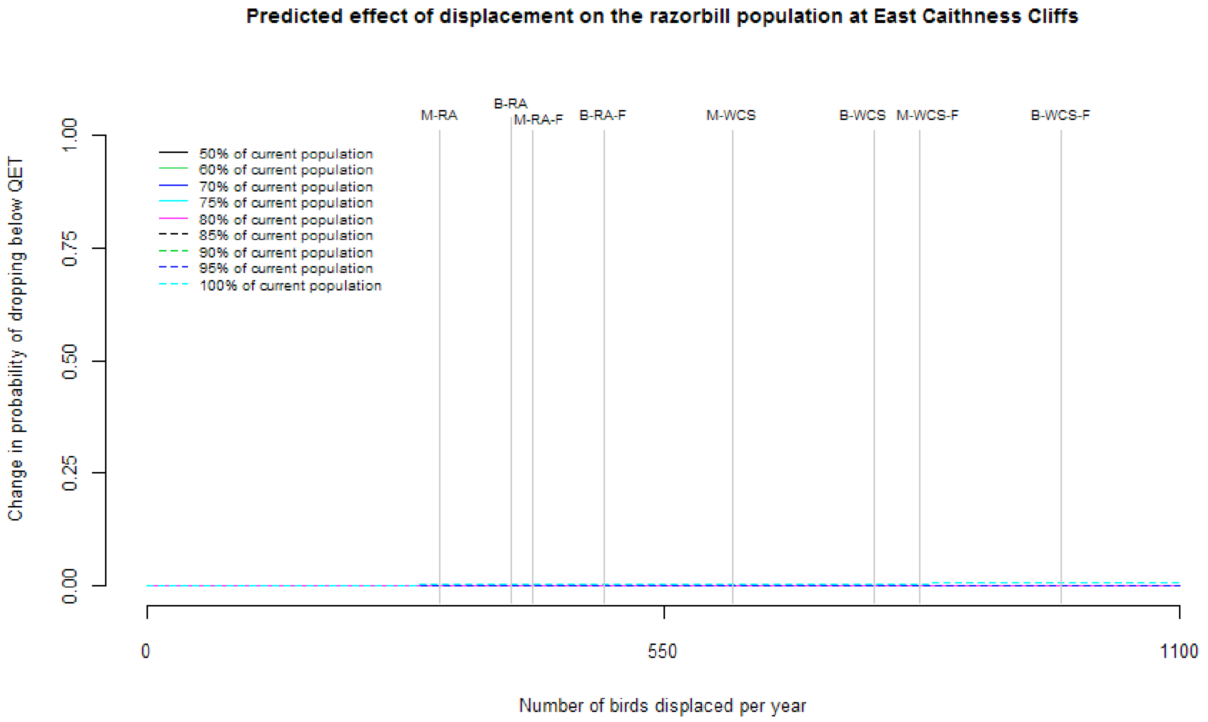


Table A49. Probability of population change from displacement of razorbill at East Caithness Cliffs SPA.

Site	Displacement rate	Number displaced	Probability of dropping below percentage of current population size								
			50%	60%	70%	75%	80%	85%	90%	95%	100%
3 sites (primary assessment)	Baseline	0	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
3 sites (primary assessment)	WCS	623	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004
3 sites (primary assessment)	RA	311	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
3 sites (primary assessment)	WCS flight	822	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005
3 sites (primary assessment)	RA flight	411	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003
MacColl	WCS	316	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
MacColl	RA	158	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
MacColl	WCS flight	383	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
MacColl	RA flight	191	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
Telford	WCS	146	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
Telford	RA	73	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
Telford	WCS flight	221	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
Telford	RA flight	110	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002

Stevenson	WCS	161	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
Stevenson	RA	80	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
Stevenson	WCS flight	219	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
Stevenson	RA flight	109	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
MacColl and Stevenson	WCS	477	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003
MacColl and Stevenson	RA	238	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
MacColl and Stevenson	WCS flight	601	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004
MacColl and Stevenson	RA flight	301	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
Stevenson and Telford	WCS	307	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
Stevenson and Telford	RA	154	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
Stevenson and Telford	WCS flight	439	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003
Stevenson and Telford	RA flight	220	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
Telford and MacColl	WCS	462	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003
Telford and MacColl	RA	231	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
Telford and MacColl	WCS flight	604	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004
Telford and MacColl	RA flight	302	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
BOWL	WCS	152	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
BOWL	RA	76	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
BOWL	WCS flight	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BOWL	RA flight	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BOWL and MORL	WCS	774	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005
BOWL and MORL	RA	387	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
BOWL and MORL	WCS flight	974	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.007
BOWL and MORL	RA flight	487	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003

Graph A49b



NORTH CAITHNESS CLIFFS

DISPLACEMENT

Graph A50a

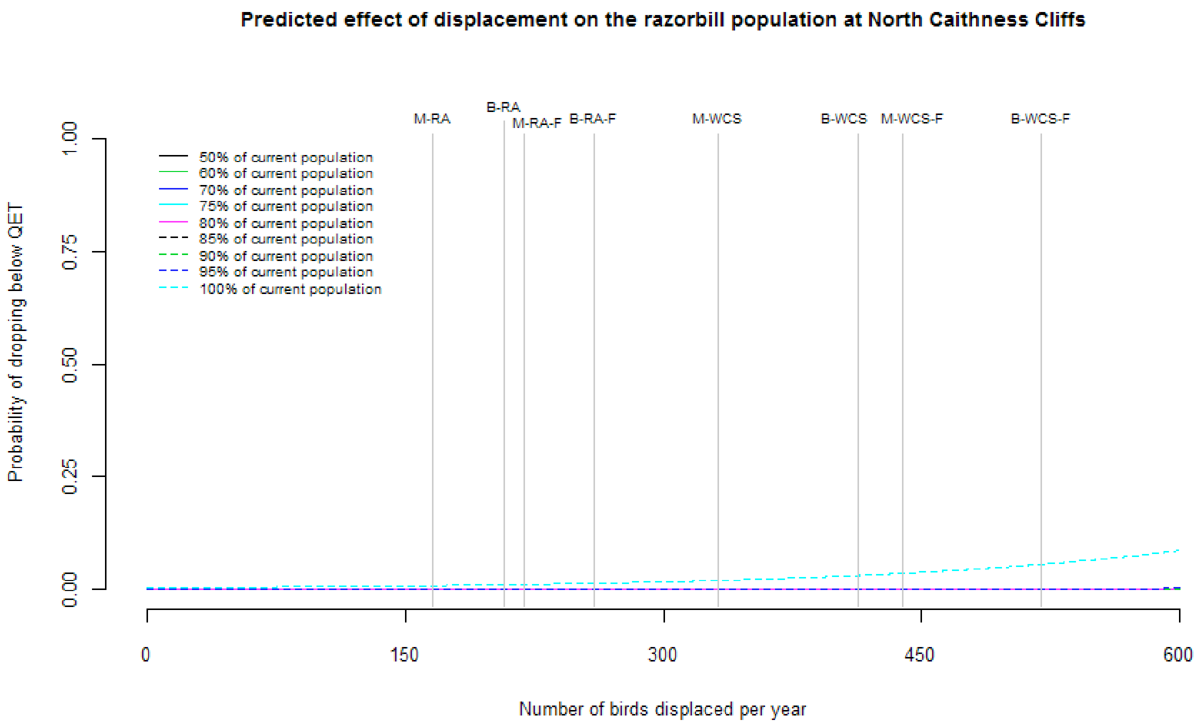
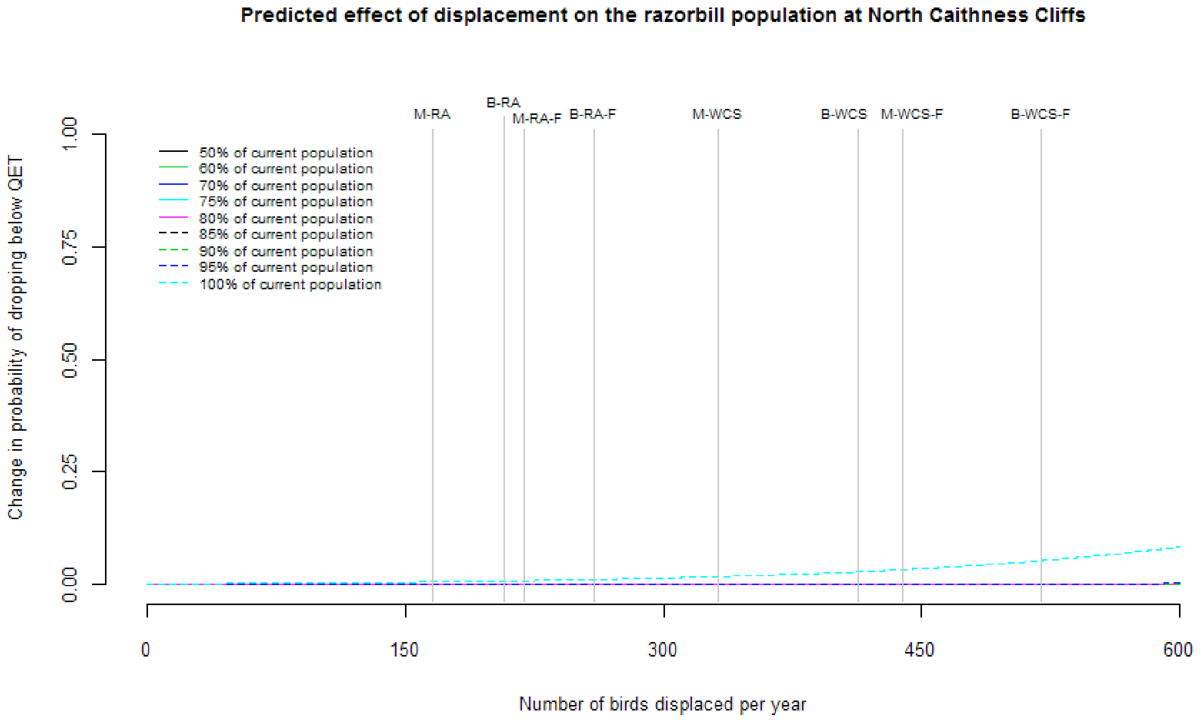


Table A50. Probability of population change from displacement of razorbill at North Caithness Cliffs SPA.

Site	Displacement rate	Number displaced	Probability of dropping below percentage of current population size								
			50%	60%	70%	75%	80%	85%	90%	95%	100%
3 sites (primary assessment)	Baseline	0	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003
3 sites (primary assessment)	WCS	332	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.018
3 sites (primary assessment)	RA	166	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007
3 sites (primary assessment)	WCS flight	439	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.034
3 sites (primary assessment)	RA flight	219	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.009
MacColl	WCS	168	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007
MacColl	RA	84	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004
MacColl	WCS flight	204	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.009
MacColl	RA flight	102	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005
Telford	WCS	78	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004
Telford	RA	39	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003
Telford	WCS flight	118	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005
Telford	RA flight	59	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004
Stevenson	WCS	86	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004

Stevenson	RA	43	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003
Stevenson	WCS flight	117	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005
Stevenson	RA flight	58	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004
MacColl and Stevenson	WCS	254	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.012
MacColl and Stevenson	RA	127	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005
MacColl and Stevenson	WCS flight	321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.017
MacColl and Stevenson	RA flight	160	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007
Stevenson and Telford	WCS	164	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007
Stevenson and Telford	RA	82	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004
Stevenson and Telford	WCS flight	234	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010
Stevenson and Telford	RA flight	117	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005
Telford and MacColl	WCS	246	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.011
Telford and MacColl	RA	123	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005
Telford and MacColl	WCS flight	322	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.017
Telford and MacColl	RA flight	161	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007
BOWL	WCS	81	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004
BOWL	RA	40	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003
BOWL	WCS flight	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BOWL	RA flight	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BOWL and MORL	WCS	413	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.029
BOWL and MORL	RA	207	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.009
BOWL and MORL	WCS flight	519	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.054
BOWL and MORL	RA flight	260	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.012

Graph A50b



TROUP HEAD

DISPLACEMENT

Graph A51a

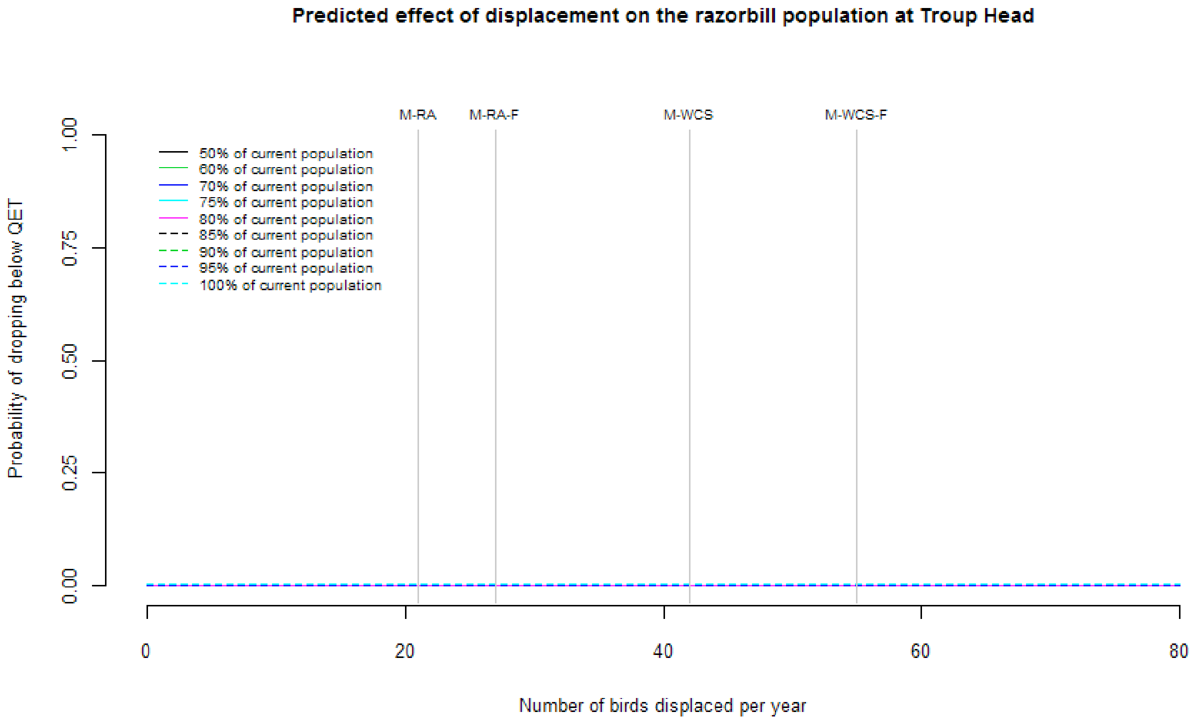
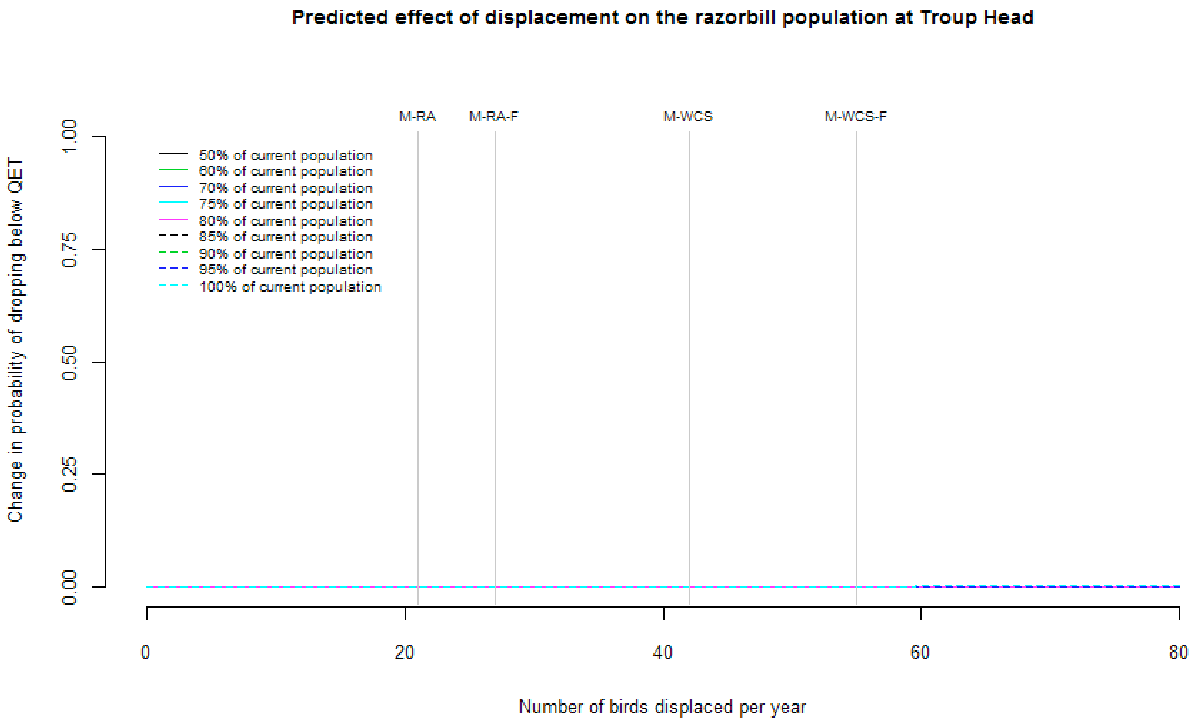


Table A51. Probability of population change from displacement of razorbill at Troup Head SPA.

Site	Displacement rate	Number displaced	Probability of dropping below percentage of current population size								
			50%	60%	70%	75%	80%	85%	90%	95%	100%
3 sites (primary assessment)	Baseline	0	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
3 sites (primary assessment)	WCS	42	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003
3 sites (primary assessment)	RA	21	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
3 sites (primary assessment)	WCS flight	55	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003
3 sites (primary assessment)	RA flight	27	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
MacColl	WCS	21	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
MacColl	RA	11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
MacColl	WCS flight	26	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
MacColl	RA flight	13	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
Telford	WCS	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
Telford	RA	5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
Telford	WCS flight	15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
Telford	RA flight	7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002

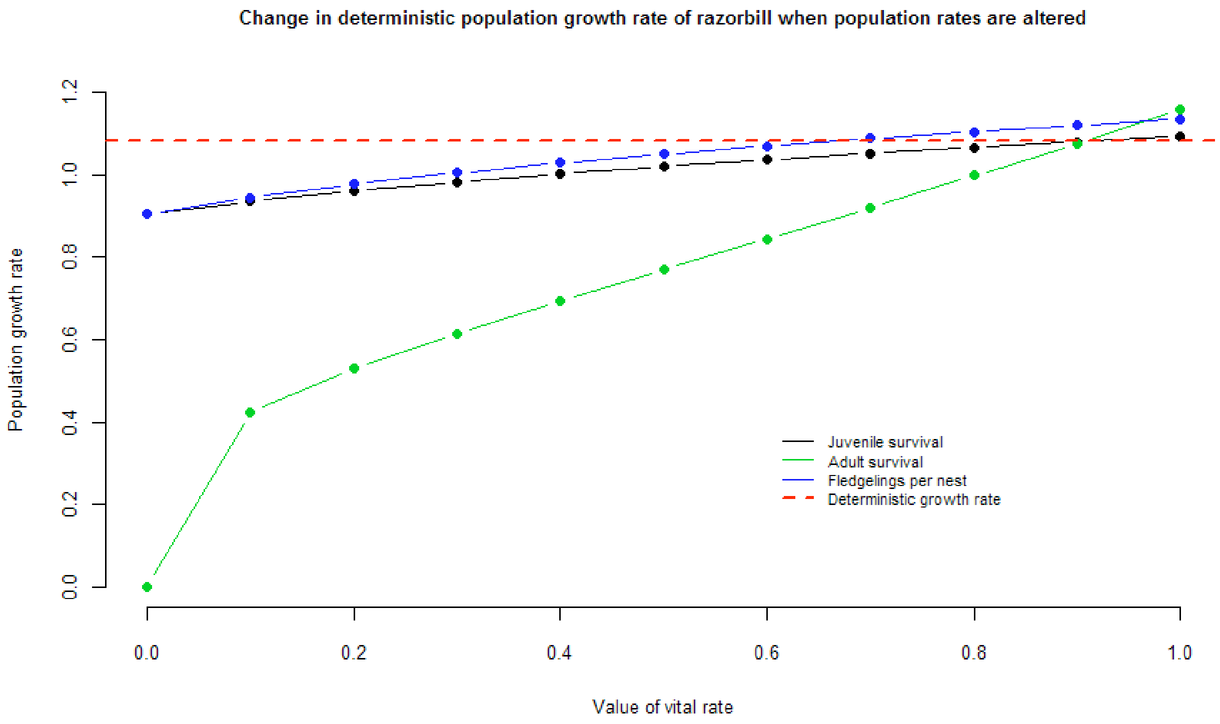
Stevenson	WCS	11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
Stevenson	RA	5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
Stevenson	WCS flight	15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
Stevenson	RA flight	7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
MacColl and Stevenson	WCS	32	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
MacColl and Stevenson	RA	16	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
MacColl and Stevenson	WCS flight	40	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003
MacColl and Stevenson	RA flight	20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
Stevenson and Telford	WCS	20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
Stevenson and Telford	RA	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
Stevenson and Telford	WCS flight	29	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
Stevenson and Telford	RA flight	15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
Telford and MacColl	WCS	31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
Telford and MacColl	RA	15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
Telford and MacColl	WCS flight	40	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003
Telford and MacColl	RA flight	20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
BOWL	WCS	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
BOWL	RA	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
BOWL	WCS flight	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BOWL	RA flight	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BOWL and MORL	WCS	42	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003
BOWL and MORL	RA	21	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
BOWL and MORL	WCS flight	55	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003
BOWL and MORL	RA flight	27	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002

Graph A51b



SENSITIVITY

Graph A52



PUFFIN

EAST CAITHNESS CLIFFS

DISPLACEMENT

Graph A53a

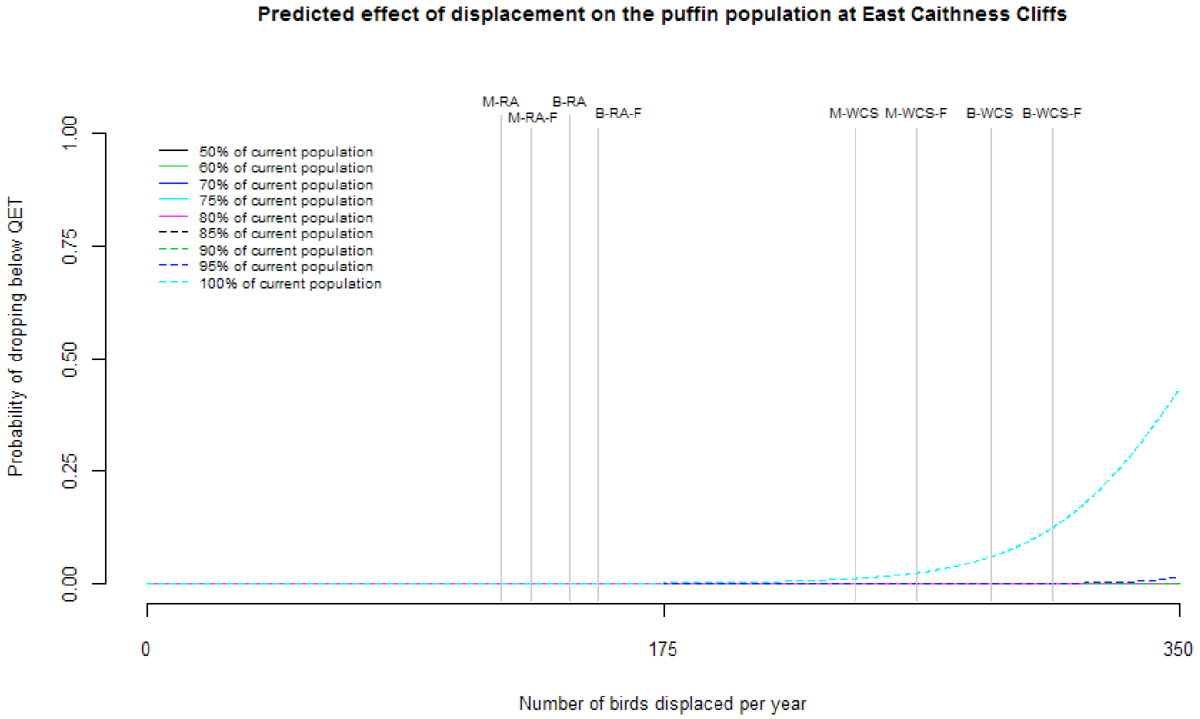
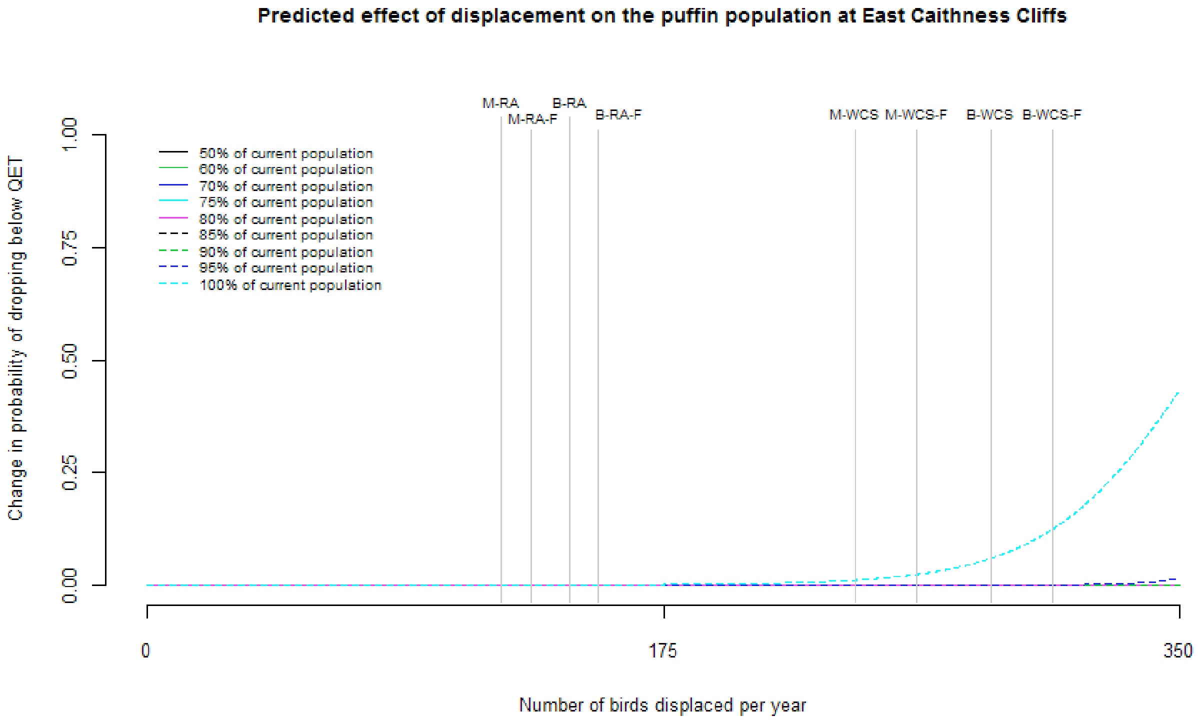


Table A53. Probability of population change from displacement of puffin at East Caithness Cliffs SPA.

Site	Displacement rate	Number displaced	Probability of dropping below percentage of current population size								
			50%	60%	70%	75%	80%	85%	90%	95%	100%
3 sites (primary assessment)	Baseline	0	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
3 sites (primary assessment)	WCS	240	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010
3 sites (primary assessment)	RA	120	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3 sites (primary assessment)	WCS flight	261	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.023
3 sites (primary assessment)	RA flight	130	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MacColl	WCS	105	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MacColl	RA	52	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MacColl	WCS flight	90	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MacColl	RA flight	45	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Telford	WCS	64	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Telford	RA	32	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Telford	WCS flight	108	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Telford	RA flight	54	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Stevenson	WCS	71	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Stevenson	RA	36	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Stevenson	WCS flight	62	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Stevenson	RA flight	31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MacColl and Stevenson	WCS	176	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
MacColl and Stevenson	RA	88	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MacColl and Stevenson	WCS flight	153	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MacColl and Stevenson	RA flight	76	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Stevenson and Telford	WCS	135	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Stevenson and Telford	RA	67	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Stevenson and Telford	WCS flight	170	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
Stevenson and Telford	RA flight	85	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Telford and MacColl	WCS	168	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
Telford and MacColl	RA	84	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Telford and MacColl	WCS flight	198	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
Telford and MacColl	RA flight	99	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BOWL	WCS	46	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BOWL	RA	23	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BOWL	WCS flight	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BOWL	RA flight	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BOWL and MORL	WCS	286	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.059
BOWL and MORL	RA	143	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BOWL and MORL	WCS flight	307	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.124
BOWL and MORL	RA flight	153	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Graph A53b


Predicted effect of displacement on the puffin population at East Caithness Cliffs
Change in probability of dropping below QET
0.00
0.25
0.50
0.75
1.00
Number of birds displaced per year
0
175
350
M-RA
M-RA-F
B-RA
B-RA-F
M-WCS
M-WCS-F
B-WCS
B-WCS-F
50% of current population
60% of current population
70% of current population
75% of current population
80% of current population
85% of current population
90% of current population
95% of current population
100% of current population

NORTH CAITHNESS CLIFFS

DISPLACEMENT

Graph A54a

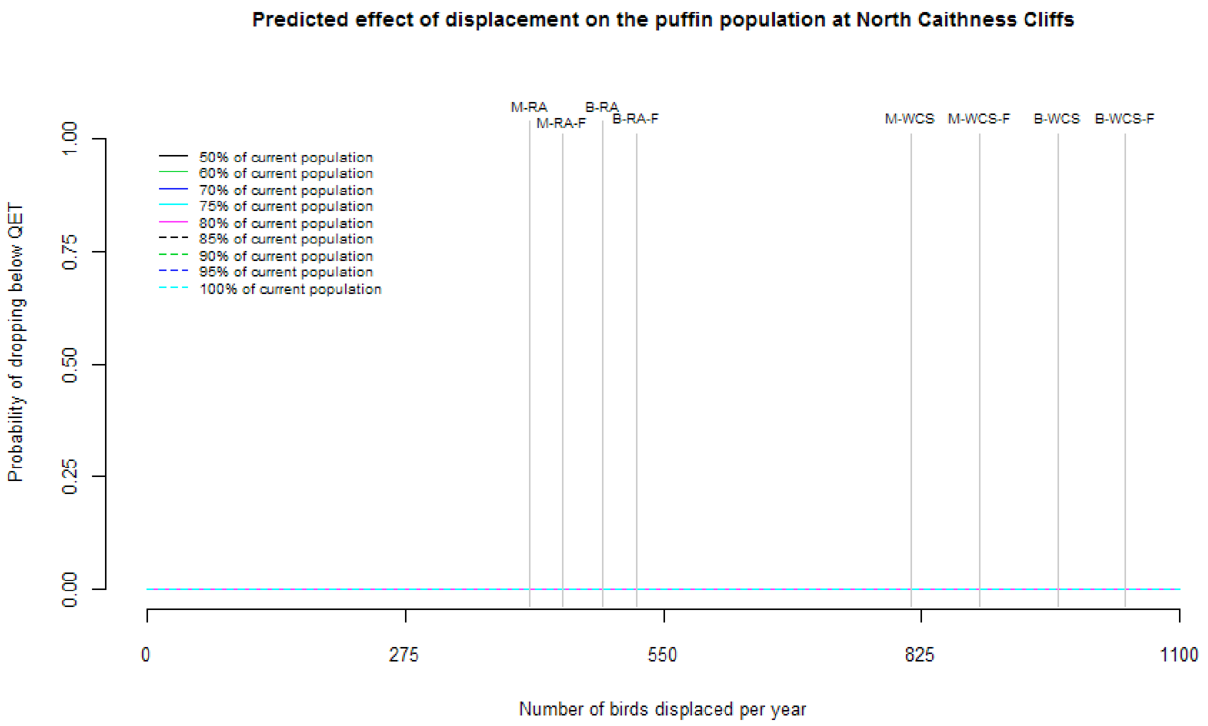
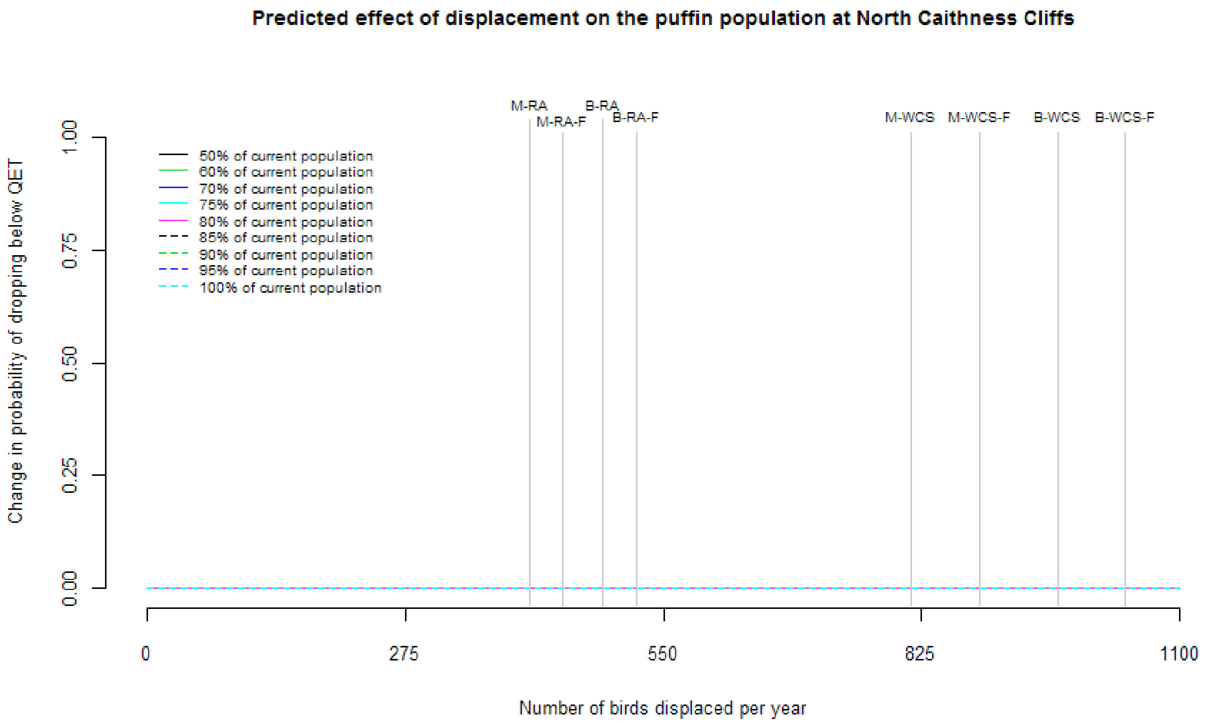


Table A54. Probability of population change from displacement of puffin at North Caithness Cliffs SPA.

Site	Displacement rate	Number displaced	Probability of dropping below percentage of current population size								
			50%	60%	70%	75%	80%	85%	90%	95%	100%
3 sites (primary assessment)	Baseline	0	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
3 sites (primary assessment)	WCS	814	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3 sites (primary assessment)	RA	407	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3 sites (primary assessment)	WCS flight	886	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3 sites (primary assessment)	RA flight	443	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MacColl	WCS	357	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MacColl	RA	178	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MacColl	WCS flight	308	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MacColl	RA flight	154	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Telford	WCS	216	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Telford	RA	108	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Telford	WCS flight	367	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Telford	RA flight	184	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Stevenson	WCS	242	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

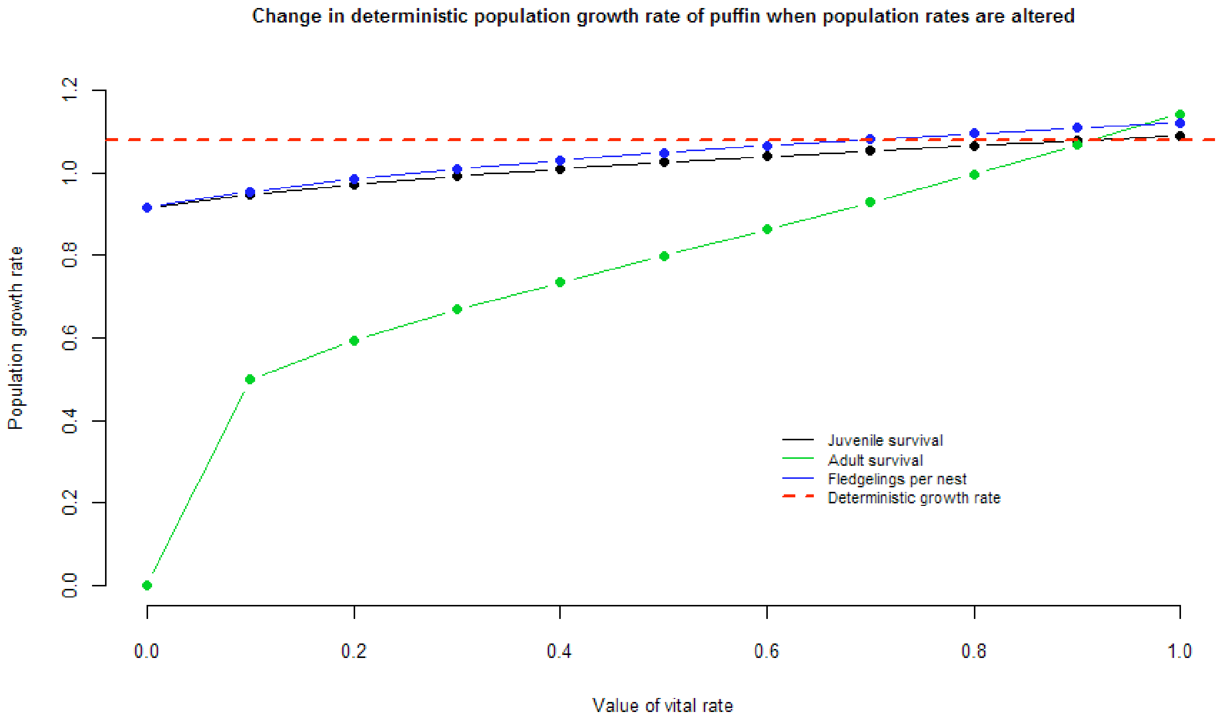
Stevenson	RA	121	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Stevenson	WCS flight	211	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Stevenson	RA flight	106	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MacColl and Stevenson	WCS	598	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MacColl and Stevenson	RA	299	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MacColl and Stevenson	WCS flight	519	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MacColl and Stevenson	RA flight	259	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Stevenson and Telford	WCS	458	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Stevenson and Telford	RA	229	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Stevenson and Telford	WCS flight	578	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Stevenson and Telford	RA flight	289	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Telford and MacColl	WCS	572	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Telford and MacColl	RA	286	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Telford and MacColl	WCS flight	675	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Telford and MacColl	RA flight	337	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BOWL	WCS	156	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BOWL	RA	78	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BOWL	WCS flight	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BOWL	RA flight	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BOWL and MORL	WCS	971	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BOWL and MORL	RA	485	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BOWL and MORL	WCS flight	1042	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BOWL and MORL	RA flight	521	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Graph A54b



SENSITIVITY

Graph A55



MODEL VALIDATION

Table A56. Deterministic and stochastic population growth rates predicted by baseline population models and qualitative changes in population size observed in the UK and Scotland.

Species	Site	Deterministic growth rate	Stochastic growth rate	Change in Scottish counts between Seabird Colony Register and Seabird 2000	Change in SPA-specific counts between Seabird Colony Register and Seabird 2000	Change in UK wide counts between Seabird 2000 and 2010
Fulmar	North Caithness Cliffs	0.981	0.980	Decrease	Decrease	Increase
Fulmar	East Caithness Cliffs	0.981	0.979	Decrease	Decrease	Increase
Fulmar	Troup Head	0.981	0.980	Decrease	Decrease	Increase
Gannet	Troup Head	1.012	1.011	Increase	n/a	n/a
Great black-backed gull	East Caithness Cliffs	1.108	1.107	Decrease	Decrease	Decrease
Guillemot	Troup Head	1.058	1.057	Increase	Increase	Increase
Guillemot	North Caithness Cliffs	1.058	1.057	Increase	Increase	Increase
Guillemot	East Caithness Cliffs	1.058	1.057	Increase	Increase	Increase
Herring gull	Troup Head	1.039	1.035	Decrease	Decrease	Decrease
Herring gull	East Caithness Cliffs	1.039	1.034	Decrease	Decrease	Decrease
Kittiwake	Troup Head	0.984	0.981	Decrease	Decrease	Decrease
Kittiwake	North Caithness Cliffs	0.984	0.982	Decrease	Decrease	Decrease
Kittiwake	East Caithness Cliffs	0.984	0.981	Decrease	Increase	Decrease
Puffin	North Caithness Cliffs	1.080	1.079	Increase	Increase	n/a
Puffin	East Caithness Cliffs	1.080	1.079	Increase	Decrease	n/a
Razorbill	Troup Head	1.080	1.080	Increase	Increase	Increase
Razorbill	North Caithness Cliffs	1.080	1.080	Increase	Decrease	Increase
Razorbill	East Caithness Cliffs	1.080	1.080	Increase	Increase	Increase

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