



N O R T H F A L L S

Offshore Wind Farm

PRELIMINARY ENVIRONMENTAL INFORMATION REPORT

Appendix 13.3 Supplementary Information for
Cumulative Assessment

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HASKONINGDHV UK LTD.

74/2 Commercial Quay
Leith
Commercial Street
Edinburgh
EH6 6LX
Industry & Buildings
VAT registration number: 792428892

+44 131 5550506 **T**
info.edinburgh@uk.rhdhv.com **E**
royalhaskoningdhv.com **W**

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Author(s): Helen Riley

Drafted by: Helen Riley, Lowell Mills-Frater, Rob Iredale

Checked by: Gemma Keenan

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Approved by: Thomas Crawford

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Glossary of Acronyms

BDMPS	Biologically Defined Minimum Population Scales
CEA	Cumulative Effects Assessment
CRM	Collision Risk Modelling
DCO	Development Consent Order
EIA	Environmental Impact Assessment
ES	Environmental Statement
HRA	Habitats Regulations Assessment
OWF	Offshore Wind Farm
PEIR	Preliminary Environmental Information Report
SeaMAST	The Seabird Mapping and Sensitivity Tool
SNCB	Statutory Nature Conservation Body
SPA	Special Protection Area
WTG	Wind Turbine Generator

Glossary of Terminology

Array areas	The two distinct offshore wind farm areas (including the 'northern array area' and 'southern array area') which together comprise the North Falls offshore wind farm.
As-built	A term used for offshore wind farm developments that are operational and where the turbine array 'as built' is different to the worst case scenario in the Environmental Impact Assessment for the development (for example where a wind farm is built out with fewer turbines than the consented design envelope).
Intertidal	Area on a shore that lies between Lowest Astronomical Tide (LAT) and Highest Astronomical Tide (HAT)
Landfall	The location where the offshore cables come ashore.
Migration free breeding season	The breeding season for migratory seabird species is defined as a wider breeding season and a narrower window known as the migration free breeding season. In a given species, the timing of breeding will vary depending on the location of the breeding area; with the start of breeding usually later in more northerly locations. Thus, while birds at some colonies are beginning to nest, others may still be migrating to breeding sites. A core or migration free breeding season is defined as the period when all or the majority of breeding adults of a given species are present at breeding colonies.
The Applicant	North Falls Offshore Wind Farm Limited (NFOW)
The Project or 'North Falls'	North Falls Offshore Wind Farm, including all onshore and offshore infrastructure.
Wind turbine generator	Power generating device that is driven by the kinetic energy of the wind

1 Introduction

This Appendix presents the information that underpins the quantitative element of the cumulative effects assessment (CEA) for Chapter 13 Offshore Ornithology (Volume I). A large number of offshore wind farm (OWF) projects require consideration in the CEA of offshore ornithology receptors. This is largely due to the wide-ranging nature of many of the receptors included in the assessment.

There is considerable complexity associated with the evolution of OWF project envelopes and changes to collision risk and displacement estimates over time (for example as a project progresses through Development Consent Order (DCO) Examination). In general, this assessment uses the consented designs for OWFs unless otherwise stated. It should be noted that because a number of OWFs have been built out with a design with lower predicted collision risk than the worst case at consent, this approach results in a substantial degree of precaution being included in the predicted impacts of collision risk, which should be accounted for during the interpretation of the CEA. It has been estimated that the use of consented rather than as-built OWF parameters may lead to the overestimation of collision rates by up to 40% (MacArthur Green, 2017; The Crown Estate and Womble Bond Dickinson, 2021).

For each species included in the CEA, tabulated estimates of collision risk mortality and the number of birds at risk of displacement are provided in Section 2 and Section 3 respectively. These numbers are provided as seasonal and annual totals, as appropriate. An explanation of the biologically relevant seasons used for each offshore ornithology receptor is provided in Chapter 13 (Volume I).

For red-throated diver, the outputs from an alternative approach (Section 0) to CEA for displacement are presented alongside the “standard” approach (Section 3.4.1). This uses modelled at-sea density estimates from the Seabird Mapping and Sensitivity Tool (SeaMAST) project (Bradbury et al., 2014). The reason for this is that the “standard” approach was not considered comprehensive due to a lack of data from many OWF assessments and the differing time periods over which baseline data for individual OWFs was collected.

The source of information for the majority of the OWFs included in this CEA was the assessment carried out for the Sheringham Shoal and Dudgeon Extension Projects (Royal HaskoningDHV, 2022). That assessment was in turn principally informed by the post-Examination update of the cumulative and in-combination collision risk and displacement assessment produced for the East Anglia ONE North and East Anglia TWO OWFs (MacArthur Green and Royal HaskoningDHV, 2021).

Key updates that have been made to this CEA when compared with the Sheringham Shoal and Dudgeon Extension Projects assessment are changes to the Hornsea Project Four OWF impacts to include the predicted impacts from the DCO Examination, and the addition of impacts from the Rampion 2 OWF. The predicted collision impacts for Hornsea Project Four were taken from the relevant Environmental Statement (ES) chapter (APEM, 2021) for lesser black-backed gull and herring gull, and from an updated version of the assessment presented at Deadline 6 of the Development Consent Order (DCO) Examination (APEM and GoBe Consultants, 2022) for all other species for which cumulative collision risk has been examined by this assessment. The latter document was also the source of information for displacement of gannet, guillemot and razorbill. Predicted impacts for the Rampion 2 OWF have been taken from relevant technical appendices which support the Preliminary Environmental Information Report (PEIR) (GoBe Consultants and Wood Group UK, 2021).

The cut off for inclusion of other OWFs into the CEA was October 2022. This means that for projects submitted for DCO Examination beyond this point, updates to the assessment will be required during the preparation of the North Falls Environmental Statement (ES).

In the species tables, OWFs are assigned to tiers as suggested by Natural England (2022a). These are shown in Table 1. Quantitative information is available for OWFs in tiers 1 to 5, which have been included in the assessment. OWFs in tiers 6 and 7 cannot be quantitatively considered with respect to the offshore ornithology assessment since no information at the required level of detail is publicly available (i.e. baseline seabird densities, CRM and displacement assessment results).

Table 1: Tiers for OWFs included in CEA

Tier	Status
1	Built and operational projects
2	Projects under construction
3	Consented but not yet under construction
4	Application submitted and not yet determined
5	PEIR produced and available
6	In planning and submission of assessment expected (e.g. identified in Planning Inspectorate list of projects)
7	Identified in relevant strategic plans or programmes

2 Cumulative Collision Risk

2.1 Gannet

Predicted seasonal and annual numbers of gannet collisions for OWFs included in the cumulative assessment are given in Table 2.

A review of bird species avoidance rates for use in CRM for OWFs is ongoing and interim guidance has been issued (Natural England 2022b). This states that there is clear evidence to show that gannets display behavioural responses beyond the perimeter of an OWF, resulting in the avoidance of the OWF area ('macro-avoidance'). The interim advice from Natural England (2022b) recommends that densities from baseline surveys within OWF array areas should be reduced by 65-85% to account for this macro-avoidance; and that the avoidance rate used in the CRM is increased from 98.9% (98.7–99.1) to 99.2% (± 0.03); and that the nocturnal activity factor is reduced from 0.1-0.2 to 0.08. These adjustments, which would substantially reduce collision risk estimates, have not been applied to the estimates in Table 2 below. Post-PEIR, the North Falls assessment will be updated to reflect the new guidance on CRM.

Table 2: Predicted gannet collisions at OWFs included in the cumulative assessment

Tier	OWF	Predicted gannet collisions ¹			
		Breeding	Autumn	Spring	Annual
1	Beatrice	37.4	48.8	9.5	95.7
1	Beatrice (demonstrator)	0.6	0.9	0.7	2.2
1	Blyth Demonstration	3.5	2.1	2.8	8.4
1	Dudgeon	22.3	38.9	19.1	80.3
1	East Anglia ONE	3.4	131.0	6.3	141.0
1	EOWDC (Aberdeen OWF)	4.2	5.1	0.1	9.3
1	Galloper	18.1	30.9	12.6	61.6
1	Greater Gabbard	14.0	8.8	4.8	27.5
1	Gunfleet Sands	-	-	-	-
1	Hornsea Project One	11.5	32.0	22.5	66.0
1	Humber Gateway	1.9	1.1	1.5	4.5
1	Hywind	5.6	0.8	0.8	7.2
1	Kentish Flats	1.4	0.8	1.1	3.3
1	Kentish Flats Extension	-	-	-	-
1	Kincardine	3.0	0.0	0.0	3.0
1	Lincs	2.1	1.3	1.7	5.0
1	London Array	2.3	1.4	1.8	5.5
1	Lynn and Inner Dowsing	0.2	0.1	0.2	0.5
1	Methil	6.0	0.0	0.0	6.0

Tier	OWF	Predicted gannet collisions ¹			
		Breeding	Autumn	Spring	Annual
1	Moray Firth (EDA)	80.6	35.4	8.9	124.9
1	Race Bank	33.7	11.7	4.1	49.5
1	Rampion	36.2	63.5	2.1	101.8
1	Scroby Sands	-	-	-	-
1	Sheringham Shoal	14.1	3.5	0.0	17.6
1	Teesside	4.9	1.7	0.0	6.7
1	Thanet	1.1	0.0	0.0	1.1
1	Triton Knoll	26.8	64.1	30.1	121.0
1	Westermost Rough	0.1	0.2	0.1	0.5
2	Dogger Bank A and B	81.1	83.5	54.4	219.0
2	Dogger Bank C and Sofia	14.8	10.1	10.8	35.7
2	Forth (Seagreen) Alpha and Bravo	800.8	49.3	65.8	915.9
2	Hornsea Project Two	7.0	14.0	6.0	27.0
2	Moray West	10.0	2.0	1.0	13.0
2	Near na Gaoithe	143.0	47.0	23.0	213.0
3	East Anglia ONE North	12.4	11.0	1.1	24.5
3	East Anglia THREE	6.1	33.3	9.6	49.0
3	East Anglia TWO	12.5	23.1	4.0	39.6
3	Hornsea Project Three	10.0	5.0	4.0	19.0
3	Inch Cape	336.9	29.2	5.2	371.3

Tier	OWF	Predicted gannet collisions ¹			
		Breeding	Autumn	Spring	Annual
3	Norfolk Boreas	14.1	12.7	3.9	30.7
3	Norfolk Vanguard	8.2	18.6	5.3	32.1
4	Hornsea Project Four	15.6	5.2	1.3	22.1
4	Sheringham and Dudgeon Extension Projects	2.1	3.5	0.2	5.8
5	North Falls	6.5	8.1	4.7	19.4
5	Rampion 2	11.9	2.6	0.7	15.1
TOTALS		1828.0	842.2	331.9	3002.3
- = No estimate available, either because the collision risk was zero or an estimate was not provided in the ES for a given OWF					

2.2 Kittiwake

Predicted seasonal and annual numbers of kittiwake collisions for OWFs included in the cumulative assessment are given in Table 3.

A review of bird species avoidance rates for use in CRM for OWFs is ongoing and interim guidance has been issued (Natural England 2022b). For kittiwake this recommends that the avoidance rate is increased from 98.9% (98.7-99.1) to 99.2 (± 0.03). These adjustments, which would reduce collision risk estimates by approximately 27%, have not been applied to the estimates in Table 3 below. Post-PEIR, the North Falls assessment will be updated to reflect the new guidance on CRM.

Table 3: Predicted kittiwake collisions at OWFs included in the cumulative assessment

Tier	OWF	Predicted kittiwake collisions			
		Breeding	Autumn	Spring	Annual
1	Beatrice	94.7	10.7	39.8	145.2
1	Beatrice (demonstrator)	0.0	2.1	1.7	3.8
1	Blyth Demonstration	1.7	2.3	1.4	5.4
1	Dudgeon	-	-	-	-
1	East Anglia ONE	1.8	160.4	46.8	209.0
1	EOWDC (Aberdeen OWF)	11.8	5.8	1.1	18.7
1	Galloper	6.3	27.8	31.8	65.9
1	Greater Gabbard	1.1	15.0	11.4	27.5
1	Gunfleet Sands	-	-	-	-
1	Hornsea Project One	44.0	55.9	20.9	120.8
2	Hornsea Project Two	16.0	9.0	3.0	28.0
1	Humber Gateway	1.9	3.2	1.9	7.0
1	Hywind	16.6	0.9	0.9	18.3
1	Kentish Flats	0.0	0.9	0.7	1.6
1	Kentish Flats Extension	0.0	0.0	2.7	2.7
1	Kincardine	22.0	9.0	1.0	32.0
1	Lincs	0.7	1.2	0.7	2.6
1	London Array	1.4	2.3	1.8	5.5
1	Lynn and Inner Dowsing	-	-	-	-

Tier	OWF	Predicted kittiwake collisions			
		Breeding	Autumn	Spring	Annual
1	Methil	0.4	0.0	0.0	0.4
1	Moray East	43.6	2.0	19.3	64.9
1	Race Bank	1.9	23.9	5.6	31.4
1	Rampion	54.4	37.4	29.7	121.5
1	Scroby Sands	-	-	-	-
1	Sheringham Shoal	-	-	-	-
1	Teesside	38.4	24.0	2.5	64.9
1	Thanet	0.2	0.5	0.4	1.1
1	Triton Knoll	24.6	139.0	45.4	209.0
1	Westermost Rough	0.1	0.2	0.1	0.5
2	Dogger Bank A and B	288.6	135.0	295.4	719.0
2	Dogger Bank C and Sofia	136.9	90.7	216.9	444.5
2	Forth (Seagreen) Alpha and Bravo	153.1	313.1	247.6	713.8
2	Moray West	79.0	24.0	7.0	110.0
2	Neart na Gaoithe	32.9	56.1	4.4	93.4
3	East Anglia ONE North	40.4	8.1	3.5	52.0
3	East Anglia THREE	4.9	56.6	30.7	92.3
3	East Anglia TWO	29.5	5.4	7.4	42.3
3	Hornsea Project Three	77.0	38.0	8.0	123.0
3	Inch Cape	13.1	224.8	63.5	301.4

Tier	OWF	Predicted kittiwake collisions			
		Breeding	Autumn	Spring	Annual
3	Norfolk Boreas	13.3	32.2	11.9	57.5
3	Norfolk Vanguard	21.8	16.4	19.3	57.5
4	Hornsea Project Four	74.5	13.9	4.6	93.0
4	Sheringham and Dudgeon Extension Projects	9.9	5.8	1.3	17.0
5	North Falls	21.0	19.1	19.1	52.3
TOTALS		1379	1566	1211	4157

- = No estimate available, either because the collision risk was zero or an estimate was not provided in the ES for a given OWF

2.3 Lesser black-backed gull

Predicted seasonal and annual numbers of lesser black-backed gull collisions for OWFs included in the cumulative assessment are given in Table 4.

A review of bird species avoidance rates for use in CRM for OWFs is ongoing and interim guidance has been issued (Natural England 2022b). For lesser black-backed gull this recommends that the avoidance rate is reduced from 99.5% (99.4-99.6) to 99.4 (± 0.04). These adjustments, which would increase collision risk estimates by about 20%, have not been applied to the estimates in Table 4 below. Post-PEIR, the North Falls assessment will be updated to reflect the new guidance on CRM.

Table 4: Predicted lesser black-backed gull collisions at OWFs included in the cumulative assessment

Tier	OWF	Predicted lesser black-backed gull collisions		
		Breeding	Non-breeding	Annual
1	Beatrice	0.0	0.0	0.0
1	Beatrice (demonstrator)	-	-	-
1	Blyth Demonstration	0.0	0.0	0.0
1	Dudgeon	7.7	30.6	38.3
1	East Anglia ONE	5.9	33.8	39.7
1	EOWDC (Aberdeen OWF)	0.0	0.0	0.0
1	Galloper	27.8	111.0	138.8
1	Greater Gabbard	12.4	49.6	62.0
1	Gunfleet Sands	1.0	0.0	1.0
1	Hornsea Project One	4.4	17.4	21.8
1	Humber Gateway	0.3	1.1	1.4
1	Hywind	0.0	0.0	0.0
1	Kentish Flats	-	-	-
1	Kentish Flats Extension	0.3	1.3	1.6
1	Kincardine	0.0	0.0	0.0
1	Lincs	1.7	6.8	8.5
1	London Array	-	-	-
1	Lynn and Inner Dowsing	-	-	-
1	Methil	0.5	0.0	0.5

Tier	OWF	Predicted lesser black-backed gull collisions		
		Breeding	Non-breeding	Annual
1	Moray East	0.0	0.0	0.0
1	Race Bank	43.2	10.8	54.0
1	Rampion	1.6	6.3	7.9
1	Scroby Sands	-	-	-
1	Sheringham Shoal	1.7	6.6	8.3
1	Teesside	0.0	0.0	0.0
1	Thanet	3.2	12.8	16.0
1	Triton Knoll	7.4	29.6	37.0
1	Westermost Rough	0.1	0.3	0.4
2	Dogger Bank A and B	2.6	10.4	13.0
2	Dogger Bank C and Sofia	2.4	9.6	12.0
2	Forth (Seagreen) Alpha and Bravo	2.1	8.4	10.5
2	Hornsea Project Two	2.0	2.0	4.0
2	Moray West	0.0	0.0	0.0
2	Neart na Gaoithe	0.3	1.2	1.5
3	East Anglia ONE North	0.9	0.6	1.5
3	East Anglia THREE	1.8	8.2	10.0
3	East Anglia TWO	4.2	0.5	4.7
3	Hornsea Project Three	8.0	1.0	9.0
3	Inch Cape	0.0	0.0	0.0

Tier	OWF	Predicted lesser black-backed gull collisions		
		Breeding	Non-breeding	Annual
3	Norfolk Boreas	6.2	8.1	14.3
3	Norfolk Vanguard	8.4	3.6	12.0
4	Hornsea Project Four	0.8	0.0	0.8
4	Sheringham and Dudgeon Extension Projects	1.6	0.3	1.8
5	North Falls	12.3	6.5	18.8
5	Rampion 2	0.6	1.2	1.8
TOTALS		173	380	553
- = No estimate available, either because the collision risk was zero or an estimate was not provided in the ES for a given OWF				

2.4 Great black-backed gull

Predicted seasonal and annual numbers of great black-backed gull collisions for OWFs included in the cumulative assessment are given in Table 5.

A review of bird species avoidance rates for use in CRM for OWFs is ongoing and interim guidance has been issued (Natural England 2022b). For great black-backed gull this recommends that the avoidance rate is reduced from 99.5% (99.4-99.6) to 99.4 (± 0.04). These adjustments, which would increase collision risk estimates by about 20%, have not been applied to the estimates in Table 5 below. Post-PEIR, the North Falls assessment will be updated to reflect the new guidance on CRM.

Table 5: Predicted great black-backed gull collisions at OWFs included in the cumulative assessment

Tier	OWF	Predicted great black-backed gull collisions		
		Breeding	Non-breeding	Annual
1	Beatrice	30.2	120.8	151.0
1	Beatrice (demonstrator)	0.0	0.0	0.0
1	Blyth Demonstration	1.3	5.1	6.3
1	Dudgeon	0.0	0.0	0.0
1	East Anglia ONE	0.0	46.0	46.0
1	EOWDC (Aberdeen OWF)	0.6	2.4	3.0
1	Galloper	4.5	18.0	22.5
1	Greater Gabbard	15.0	60.0	75.0
1	Gunfleet Sands	-	-	-
1	Hornsea Project One	17.2	68.6	85.8
1	Humber Gateway	1.3	5.1	6.3
1	Hywind	0.3	4.5	4.8
1	Kentish Flats	-	-	-
1	Kentish Flats Extension	0.1	0.2	0.3
1	Kincardine	0.0	0.0	0.0
1	Lincs	0.0	0.0	0.0
1	London Array	-	-	-
1	Lynn and Inner Dowsing	0.0	0.0	0.0
1	Methil	0.8	0.8	1.6

Tier	OWF	Predicted great black-backed gull collisions		
		Breeding	Non-breeding	Annual
1	Moray Firth (EDA)	9.5	25.5	35.0
1	Race Bank	0.0	0.0	0.0
1	Rampion	5.2	20.8	26.0
1	Scroby Sands	-	-	-
1	Sheringham Shoal	0.0	0.0	0.0
1	Teesside	8.7	34.8	43.6
1	Thanet	0.1	0.4	0.5
1	Triton Knoll	24.4	97.6	122.0
1	Westermest Rough	0.0	0.0	0.1
2	Dogger Bank A and B	5.8	23.3	29.1
2	Dogger Bank C and Sofia	6.4	25.5	31.9
2	Forth (Seagreen) Alpha and Bravo	13.4	53.4	66.8
2	Hornsea Project Two	3.0	20.0	23.0
2	Moray West	4.0	5.0	9.0
2	Neart na Gaoithe	0.9	3.6	4.5
3	East Anglia ONE North	3.7	1.2	5.0
3	East Anglia THREE	4.6	34.4	39.0
3	East Anglia TWO	3.5	3.4	6.9
3	Hornsea Project Three	8.0	28.0	36.0
3	Inch Cape	0.0	36.8	36.8

Tier	OWF	Predicted great black-backed gull collisions		
		Breeding	Non-breeding	Annual
3	Norfolk Boreas	6.9	28.7	35.6
3	Norfolk Vanguard	4.5	21.5	26.0
4	Hornsea Project Four	1.4	5.7	7.2
4	Sheringham and Dudgeon Extension Projects	4.8	0.2	5.0
5	North Falls	0.0	6.0	6.0
5	Rampion 2	0.9	3.1	4.0
TOTALS		191.0	810.4	1001.6
- = No estimate available, either because the collision risk was zero or an estimate was not provided in the ES for a given OWF				

3 Cumulative Displacement

3.1 Gannet

The predicted seasonal and annual numbers of gannet at risk of displacement from OWFs included in the cumulative assessment are given in Table 6. These are seasonal peak mean populations taken from OWF ES's. The standard area for assessment of gannet displacement is the OWF array area plus a 2km buffer (SNCBs 2017), although the buffer area for which data was presented is different for some OWFs included in the table.

Table 6: Predicted numbers of gannet at risk of displacement from OWFs included in the cumulative assessment

Tier	OWF	Number of gannets at risk of displacement			
		Spring	Breeding	Autumn	Annual
1	Beatrice	0	151	0	151
1	Beatrice (demonstrator)	-	-	-	-
1	Blyth Demonstration	-	-	-	-
1	Dudgeon	11	53	25	89
1	East Anglia ONE	76	161	3638	3875
1	EOWDC (Aberdeen OWF)	0	35	5	40
1	Galloper	276	360	907	1543
1	Greater Gabbard	105	252	69	426
1	Gunfleet Sands	9	0	12	21
1	Hornsea Project One	250	671	694	1615
1	Humber Gateway	-	-	-	-
1	Hywind	4	10	0	14
1	Kentish Flats	-	-	-	-
1	Kentish Flats Extension	0	0	13	13
1	Kincardine	0	120	0	120
1	Lincs	-	-	-	-
1	London Array	-	-	-	-
1	Lynn and Inner Dowsing	-	-	-	-

Tier	OWF	Number of gannets at risk of displacement			
		Spring	Breeding	Autumn	Annual
1	Methil	0	23	0	23
1	Moray Firth (EDA)	27	564	292	883
1	Race Bank	29	92	32	153
1	Rampion	0	0	590	590
1	Scroby Sands	-	-	-	-
1	Sheringham Shoal	2	47	31	80
1	Teesside	0	1	0	1
1	Thanet	-	-	-	-
1	Triton Knoll	24	211	15	250
1	Westermost Rough	-	-	-	-
2	Dogger Bank A and B	394	1155	2048	3597
2	Dogger Bank C and Sofia	464	2250	887	3601
2	Firth of Forth Alpha and Bravo	332	2956	664	3952
2	Hornsea Project Two	124	457	1140	1721
2	Moray West	144	2827	439	3410
2	Near na Gaoithe	281	1987	552	2820
3	East Anglia ONE North	44	149	468	661
3	East Anglia THREE	524	412	1269	2205
3	East Anglia TWO	192	192	891	1275

Tier	OWF	Number of gannets at risk of displacement			
		Spring	Breeding	Autumn	Annual
3	Hornsea Project Three	524	1333	984	2841
3	Inch Cape	212	2398	703	3313
3	Norfolk Boreas	526	1229	1723	3478
3	Norfolk Vanguard	437	271	2453	3161
4	Hornsea Project Four	401	976	790	2167
4	Sheringham and Dudgeon Extension Projects	57	440	638	1135
5	North Falls	245	68	453	766
5	Rampion 2	45	98	78	221
TOTALS		5759	21949	22503	50211
- = No estimate available, either because the collision risk was zero or an estimate was not provided in the ES for a given OWF					

3.2 Guillemot

The predicted seasonal and annual numbers of guillemots at risk of displacement from OWFs included in the cumulative assessment are given in Table 7. These are seasonal peak mean populations taken from OWF ES's. The standard area for assessment of guillemot displacement is the OWF array area plus a 2km buffer (SNCB 2017), although the buffer area for which data was presented is different for some OWFs included in the table.

Table 7: Predicted numbers of guillemots at risk of displacement from OWFs included in the cumulative assessment

Tier	OWF	Number of guillemots at risk of displacement		
		Breeding	Non-breeding	Annual
1	Beatrice	13610	2755	16365
1	Beatrice (demonstrator)	No estimate available	-	-
1	Blyth Demonstration	1220	1321	2541
1	Dudgeon	334	542	876
1	East Anglia ONE	274	640	914
1	EOWDC (Aberdeen OWF)	547	225	772
1	Galloper	305	593	898
1	Greater Gabbard	345	548	893
1	Gunfleet Sands	0	363	363
1	Hornsea Project One	9836	8097	17933
1	Hornsea Project Two	7735	13164	20899
1	Humber Gateway	99	138	237
1	Hywind	249	2136	2385
1	Kentish Flats	0	3	3
1	Kentish Flats Extension	0	4	4
1	Kincardine	632	0	632
1	Lincs, Lynn and Inner Dowsing	582	814	1396
1	London Array	192	377	569
1	Moray Firth East	9820	547	10367

Tier	OWF	Number of guillemots at risk of displacement		
		Breeding	Non-breeding	Annual
1	Race Bank	361	708	1069
1	Rampion	10887	15536	26423
1	Scroby Sands	No estimate available		
1	Sheringham Shoal	390	715	1105
1	Teesside	267	901	1168
1	Thanet	18	124	142
1	Triton Knoll	425	746	1171
1	Westermost Rough	347	486	833
2	Dogger Bank A (formerly Creyke Beck A)	5407	6142	11549
2	Dogger Bank B (formerly Creyke Beck B)	9479	10621	20100
2	Dogger Bank C (formerly Teesside A)	3283	2268	5551
2	Firth of Forth Alpha	13606	4688	18294
2	Firth of Forth Bravo	11118	4112	15230
2	Moray West	24426	38174	62600
2	Near na Gaoithe	1755	3761	5516
2	Sofia (formerly Teesside B)	5211	3701	8912
3	East Anglia ONE North	4183	1888	6071
3	East Anglia THREE	1744	2859	4603
3	East Anglia TWO	2077	1675	3752
3	Hornsea Project Three	13374	19174	32548

Project related

Tier	OWF	Number of guillemots at risk of displacement		
		Breeding	Non-breeding	Annual
3	Inch Cape	4371	3177	7548
3	Methil	25	0	25
3	Norfolk Boreas	7767	13777	21544
3	Norfolk Vanguard	4320	4776	9096
4	Hornsea Project Four	9382	36965	46347
4	Sheringham and Dudgeon Extension Projects	4934	15972	20906
5	North Falls	1103	4497	5,600
5	Rampion 2	185	13020	13205
TOTALS		186225	242730	428955

3.3 Razorbill

The predicted seasonal and annual numbers of guillemots at risk of displacement from OWFs included in the cumulative assessment are given in Table 8. These are seasonal peak mean populations taken from OWF ES's. The standard area for assessment of razorbill displacement is the OWF array area plus a 2km buffer (SNCBs 2017), although the buffer area for which data was presented is different for some OWFs included in the table.

Table 8: Predicted numbers of razorbills at risk of displacement from OWFs included in the cumulative assessment

Tier	OWF	Number of razorbills at risk of displacement				
		Spring	Breeding	Autumn	Winter	Annual
1	Beatrice	833	873	833	555	3094
1	Beatrice (demonstrator)	No estimate available				
1	Blyth Demonstration	91	121	91	61	364
1	Dudgeon	346	256	346	745	1693
1	East Anglia ONE	336	16	26	155	533
1	EOWDC (Aberdeen OWF)	26	161	64	7	258
1	Galloper	394	44	43	106	587
1	Greater Gabbard	84	0	0	387	471
1	Gunfleet Sands	0	0	0	30	30
1	Hornsea Project One	1803	1109	4812	1518	9242
1	Hornsea Project Two	1668	2511	4221	720	9119
1	Humber Gateway	20	27	20	13	80
1	Hywind	0	30	719	10	759
1	Kentish Flats	No estimate available				
1	Kentish Flats Extension	No estimate available				
1	Kincardine	0	22	0	0	22
1	Lincs and LID	34	45	34	22	134
1	London Array	20	14	20	14	68

Tier	OWF	Number of razorbills at risk of displacement				
		Spring	Breeding	Autumn	Winter	Annual
1	Moray Firth East	168	2423	1103	30	3724
1	Race Bank	42	28	42	28	140
1	Rampion	3327	630	66	1244	5267
1	Scroby Sands	No estimate available				
1	Sheringham Shoal	30	106	1343	211	1690
1	Teesside	20	16	61	2	99
1	Thanet	21	3	0	14	37
1	Triton Knoll	117	40	254	855	1265
1	Westermost Rough	91	91	121	152	455
2	Dogger Bank A (formerly Creyke Beck A)	4149	1250	1576	1728	8703
2	Dogger Bank B (formerly Creyke Beck B)	5119	1538	2097	2143	10897
2	Dogger Bank C (formerly DB Teesside A)	1919	834	310	959	4022
2	Forth (Seagreen) Alpha and Bravo	891	9574	891	594	11950
2	Moray West	3585	2808	3544	184	10121
2	Near na Gaoithe	0	331	5492	508	6331
2	Sofia (formerly Dogger Bank Teesside B)	2953	1153	592	1426	6125
3	East Anglia ONE North	207	403	85	54	749
3	East Anglia THREE	1524	1807	1122	1499	5952
3	East Anglia TWO	230	281	44	136	692

Tier	OWF	Number of razorbills at risk of displacement				
		Spring	Breeding	Autumn	Winter	Annual
3	Hornsea Project Three	2105	630	2020	3649	8404
3	Inch Cape	0	1436	2870	651	4957
3	Methil	0	4	0	0	4
3	Norfolk Boreas	345	630	263	1065	2303
3	Norfolk Vanguard	924	879	866	839	3508
4	Hornsea Project Four	449	386	4311	455	5601
4	Sheringham and Dudgeon Extension Projects	464	4500	1239	1531	7734
5	North Falls	1860	168	266	2565	4859
5	Rampion 2	2164	44	19	22	2164
TOTALS		38358	37222	41827	26886	144293

3.4 Red-throated diver

3.4.1 Standard assessment

The standard approach to CEA for displacement from OWFs is to sum the seasonal/annual numbers of birds of a given species at risk of displacement, or the predicted seasonal/annual mortality as a result of displacement, for each OWF project within the area of search which has been screened into the assessment. If the number of birds at risk of displacement is summed then a displacement matrix (% of birds estimated to be displaced and % of displaced birds predicted to die as a result of displacement, SNCBs 2017) can be applied to the cumulative total to predict the cumulative predicted mortality from displacement.

For North Falls, red-throated divers were only present during the non-breeding season and the area of search for cumulative displacement of red-throated diver is the UK North Sea BDMPS (the largest non-breeding season BDMPS, Furness 2015). This is consistent with advice from Natural England on the scope of the cumulative assessment for red-throated divers at North Falls.

Within the UK North Sea, information on the number of red-throated divers at risk of displacement and/or the number of individuals predicted to die from displacement is not available for all OWFs. This is because assessments for some projects have not considered red-throated diver displacement at all, or have assessed effects in a qualitative manner. This includes projects where few or no red-throated divers were recorded during baseline surveys, for example projects which are distant from the coast (as red-throated divers overwintering in the UK generally occur in nearshore waters, Dierschke et al. 2017). The latter applies to all OWFs in Scottish North Sea waters.

The red-throated diver assessments that have been carried out for OWFs in the English North Sea are summarised in Table 9 and Table 10 below. Table 9 includes sites where no assessment, a qualitative assessment or a basic quantitative assessment was presented; Table 10 includes OWFs where a seasonal assessment was provided and gives predicted displacement mortality at 90-100% displacement and 1-10% mortality within the OWF and a buffer (which varied between 0-4km depending on the available data). For the purposes of Environmental Impact Assessment (EIA), Natural England recommended that red-throated diver displacement at North Falls should be considered as 100% within the OWF and a 4km buffer, and 1-10% mortality of displacement birds (which accords with the SNCBs (2017) guidance note on displacement). These displacement mortality predictions from North Falls have been summed with those for other OWFs. Thus, the displacement mortality predictions for OWFs presented in Table 10 do not strictly compare like with like, as there are variations in the buffer area considered and the percentage of birds predicted to be displaced (90-100%). However, these are considered to be the best available data at the time of writing for the standard approach to CEA for red-throated diver, given the variability in approach and information presented in Environmental Statements for OWFs in the southern North Sea (which in turn reflects the development of data collection and assessment methodology over time, and the increasing amount of empirical information that has become available on the responses of red-throated divers to OWFs).

Table 9 Red-throated diver assessments for OWFs in the southern North Sea – sites with no or basic assessment (source: MacArthur Green 2019)

Wind farm	Tier	Assessment method	Estimated mortalities from displacement
Blyth Demonstrator	1	Not assessed	No number presented
Dudgeon	1	Not assessed	No number presented
Galloper	1	Quantitative	1-14
Greater Gabbard	1	Quantitative	4-40
Gunfleet Sands	1	Qualitative	'very small'
Hornsea Project One	1	Not assessed	No number presented
Humber Gateway	1	Not assessed	No number presented
Kentish Flats	1	Qualitative	No number presented
Kentish Flats Extension	1	Qualitative	No number presented
Lincs	1	Qualitative	No number presented
London Array	1	Qualitative	No number presented
Lynn & Inner Dowsing	1	Qualitative	No number presented
Race Bank	1	Not assessed	No number presented
Scroby Sands	1	None	No number presented
Sheringham Shoal	1	None	No number presented
Teeside	1	Not assessed	No number presented
Thanet	1	Quantitative	<1-2
Triton Knoll	1	Not assessed	No number presented
Westernmost Rough	1	Not assessed	No number presented
Dogger Bank A and B (formerly Creyke Beck A and B)	2	Not assessed	No number presented
Dogger Bank C and Sofia (formerly Teeside A and B)	2	Not assessed	No number presented
Hornsea Project Two	2	Not assessed	No number presented
Hornsea Project Three	3	Not assessed	No number presented

Table 10 Estimated cumulative displacement mortality at OWFs in the southern North Sea, at 90-100% displacement within the Wind farm site and a 4km buffer, and 1-10% mortality of displaced birds.

Wind farm	Number of birds predicted to die from displacement (90-100% displacement, 1-10% mortality of displaced birds)				Source
	Autumn migration	Winter	Spring Migration	Annual	
Projects listed in Table 9	N/A	N/A	N/A	6 – 56	MacArthur Green 2019
Dudgeon and Sheringham Extension Projects	2 - 14	0 – 2	2 - 17	4 – 34	Royal HaskoningDHV 2022
East Anglia ONE	0.4 - 5	1 – 10	1.4 - 15	2.8 – 30	MacArthur Green 2019
East Anglia ONE North*	-	-	-	0.1 - 1	MacArthur Green & Royal HaskoningDHV 2022)
East Anglia THREE	0.4 - 5	0.2 – 2	2 - 20	2.6 – 27	MacArthur Green 2019
East Anglia TWO	0	0 – 2	2 - 25	3 – 28	Royal HaskoningDHV 2019
Hornsea Project Four	0	0	0	0	APEM 2022
Norfolk Vanguard	0.4 - 8	3.2 – 39	3 - 32	6.6 – 79	MacArthur Green 2019
Norfolk Boreas	0 - 1	1 - 15	5 - 62	6 – 78	MacArthur Green 2019
North Falls	0 - 1	1 - 6	5 – 49	6 - 56	Chapter 13, Table 13.50 (means, 100% displacement, 1-10% mortality)
Totals	3.2 - 35	7.4 - 83	23.4 - 254	41 - 430	

* Based on the effective size of the consented boundary for East Anglia ONE North. The western extent of the boundary presented for DCO examination was 2km away from the Outer Thames Estuary SPA at the nearest point. The Project was consented with an exclusion zone such that turbines could not be installed within 8km of the SPA boundary. Thus the number of red-throated divers predicted to die from displacement will have been reduced compared with estimates presented in the ES. Revised seasonal or annual abundance estimates of red-throated divers for East Anglia ONE North appear taking account of the exclusion zone appear not to be publicly available, so the seasonal numbers cannot be presented. Revision 5 of offshore ornithology without prejudice compensation measures for the Project (MacArthur Green and Royal HaskoningDHV 2022) provides estimates of the number of individuals displaced for the consented project of between 0 – 10.3, based respectively on a model of red-throated diver displacement developed by the applicant, and a straight-line approach recommended by Natural England, assuming a linear gradient in red-throated diver displacement from 100% at the OWF, to 0% at 10km. It is assumed this range estimates the number of individuals to be displaced annually, so that at 10% mortality of displaced individuals 0 – 1.3 red-throated divers would be predicted to die, and at 1% mortality 0.1 - 1 individuals.

3.4.2 SeaMAST

The Seabird Mapping and Sensitivity Tool (SeaMAST) (Bradbury et al., 2014) provides a common dataset covering the majority of English offshore waters, describing seabird densities in 3x3km squares based on both boat-based and visual aerial surveys. Both of these survey methods may under-estimate the number of red-throated divers present compared with Digital Aerial Surveys, thus this dataset was used to assess the potential relative contribution of UK OWFs in the southern North Sea to displacement of red-throated divers during the non-breeding season, rather than provide robust estimates of the numbers of birds present in individual OWFs and 4km buffers.

Whilst recent evidence indicates that displacement effects of operational OWFs exceed 4km (SNCBs 2022), Natural England advice for the North Falls EIA was to assess displacement for the OWF and a 4km buffer; to incorporate larger buffers with the SeaMAST data would cause complications due to extensive overlap of buffers at one OWF with buffers from other OWFs.

The “BDMPS_Non_Breeding_Boat_Plus_Aerial_D” SeaMAST dataset was selected to describe red-throated diver densities during the non-breeding season (henceforth referred to as “the SeaMAST dataset”). This dataset provides estimated seabird non-breeding season densities (sitting and flying birds summed) from a density surface model (DSM) of Wildfowl and Wetlands Trust (WWT) visual aerial survey data collected between 2001 - 2011, and JNCC European Seabirds At Sea (ESAS) boat-based survey data collected between 1979 - 2011.

The non-breeding season as defined for the SeaMAST data set covers the months September to February. September to February corresponds to the red-throated diver non-breeding season based on the full breeding season of March to August as defined by Furness (2015). The red-throated diver non-breeding season is further subdivided by Furness (2015) into post-breeding or autumn migration (September to November), migration-free winter season (December to January) and return or spring migration (February to April). During the two migration seasons, the north-western and south-western North Sea areas are considered to hold a single population of red-throated divers. During the migration-free winter season, it is considered that the north-western and south-western North Sea area populations are separate (Furness, 2015).

Thus, the SeaMAST data provided a single estimate of red-throated diver numbers during the non-breeding season (i.e. it was not possible to obtain separate estimates for the autumn migration, winter and spring migration periods). In addition, given the geographical coverage, no estimates were available for OWFs in the Scottish North Sea, although as stated previously, few or no red-throated divers were recorded at all of these sites, so they not contribute to a cumulative displacement effect during the spring and autumn migration periods of the non-breeding season.

The SeaMAST dataset is a collation of available data, which at the time was not collected for the purpose of a wider regional analysis. Thus, across some areas, survey effort may have occurred disproportionately over particular months or seasons depending on the original purpose of the surveys.

OWF boundaries were obtained from the Crown Estate, with any known changes accounted for prior to data processing. All 3x3 km grid squares that had been allocated the value “-99”, indicating a low confidence in the density generated by the DSM for that square, were excluded from the analysis. This led to a number of OWFs in English waters being excluded from the analysis as no abundance data were available. These were Dudgeon Extension Project, Dudgeon, Hornsea Projects One, Two and Three, Dogger Bank A, B, C and Sofia, Teesside A and Triton Knoll.

Estimates of red-throated diver abundance in OWFs and 4km buffers based on SeaMAST data are given in Table 11. To calculate the number of red-throated divers occurring within a given area, the red-throated diver density for each grid square was converted to an abundance by multiplying density by area. Where a

given polygon overlapped with more than one 3x3 square (which was usually the case) the estimated abundances for each square or part-square were summed. For areas inside OWFs, the SeaMAST dataset encompassing the area of interest was clipped to the boundary of each OWF. When repeating the exercise for the 4km OWF buffers, where there were instances of overlap between the buffers, and sometimes other OWFs, a system was devised to allocate red-throated divers to a particular OWF based on the tiered system for CEA based on advice from UK SNCBs. For overlapping OWFs and buffers occurring within tiers 1 and/or 2, buffers were amalgamated into a single polygon. Where a similar situation occurred for OWFs in tier 3 or above, OWF red line boundaries were prioritised over buffers. For overlapping buffers within the same tier, the abundance of red-throated divers within the overlapping area was calculated and split equally between the two buffers (site-specific details in Table 11). The reference population size used here for the non-breeding season was 19,978 based on the SeaMAST dataset (calculated as the sum of abundances from each grid square, excluding squares with a low confidence in the density).

Table 11 Estimated abundance of red-throated divers in OWFs in the English North Sea from SeaMAST data

Tier	OWF	Wind farm site		4km buffer		Wind farm + 4km buffer		Notes
		No. birds	% of ref population	No. birds	% of ref population	No. birds	% of ref population	
1	Blyth Demonstration	0.0	0.0	0.5	0.0	0.6	0.0	Site consists of three polygons; 4km buffers amalgamated
1	Dudgeon	-	-	-	-	-	-	Beyond extent of viable SeaMAST data - not included
1	East Anglia ONE	5.8	0.0	16.1	0.1	21.9	0.1	4km buffer overlap with East Anglia ONE North; East Anglia ONE buffer prioritised
1	Greater Gabbard and Galloper	35.4	0.2	77.9	0.4	113.3	0.6	4km buffer overlap with East Anglia TWO; Greater Gabbard/Galloper prioritised
1	Gunfleet Sands	54.0	0.3	487.2	2.4	541.2	2.7	
1	Hornsea Project One	-	-	-	-	-	-	Beyond extent of viable SeaMAST data - not included
1	Humber Gateway	0.1	0.0	0.7	0.0	0.8	0.0	
1	Kentish Flats	48.6	0.2	343.7	1.7	392.3	2.0	
1	Lincs, Lynn and Inner Dowsing	3.1	0.0	18.4	0.1	21.5	0.1	
1	London Array	337.4	1.7	1165.1	5.8	1502.6	7.5	
1	Race Bank	0.7	0.0	2.7	0.0	3.4	0.0	North-eastern edge of buffer not covered by SeaMAST data
1	Scroby Sands	9.7	0.0	80.0	0.4	89.6	0.4	
1	Sheringham Shoal	0.1	0.0	0.6	0.0	0.7	0.0	Northern section of OWF and buffer not covered by SeaMAST data

Tier	OWF	Wind farm site		4km buffer		Wind farm + 4km buffer		Notes
		No. birds	% of ref population	No. birds	% of ref population	No. birds	% of ref population	
1	Teesside	0.0	0.0	0.8	0.0	0.9	0.0	
1	Thanet	5.7	0.0	34.8	0.2	40.5	0.2	
1	Triton Knoll	-	-	-	-	-	-	Beyond extent of viable SeaMAST data - not included
1	Westermost Rough	0.1	0.0	0.8	0.0	0.9	0.0	North-eastern edge of buffer not covered by SeaMAST data
2	Dogger Bank A and B (formerly Creyke Beck A and B)	-	-	-	-	-	-	Beyond extent of viable SeaMAST data - not included
2	Dogger bank C and Sofia (formerly Dogger bank Teesside A and B)	-	-	-	-	-	-	Beyond extent of viable SeaMAST data - not included
2	Hornsea Project Two	-	-	-	-	-	-	Beyond extent of viable SeaMAST data - not included
3	East Anglia ONE North	31.7	0.2	89.1	0.4	120.8	0.6	Consented boundary, 4km buffer overlap with East Anglia ONE; East Anglia ONE buffer prioritised
3.	East Anglia THREE	5.9	0.0	13.2	0.1	19.1	0.1	4km buffer overlap with Norfolk Vanguard East; East Anglia THREE buffer prioritised
3	East Anglia TWO	19.0	0.1	71.4	0.4	90.4	0.5	4km buffer overlap with Greater Gabbard/Galloper; Greater Gabbard/Galloper prioritised

Tier	OWF	Wind farm site		4km buffer		Wind farm + 4km buffer		Notes
		No. birds	% of ref population	No. birds	% of ref population	No. birds	% of ref population	
3	Hornsea Project Three	-	-	-	-	-	-	Beyond extent of viable SeaMAST data - not included
3	Norfolk Boreas	2.9	0.0	3.5	0.0	4.6	0.0	Northern and eastern sections of OWF and 4km buffer beyond extent of viable SeaMAST data; 4km buffer overlap with Norfolk Vanguard East (4km buffers amalgamated)
3	Norfolk Vanguard	9.4	0	13.5	0.1	24.6	0.1	Eastern section of OWF and 4km buffer beyond extent of viable SeaMAST data; 4km buffer overlap with Norfolk Boreas and East Anglia THREE (East Anglia THREE prioritised, Norfolk Vanguard East and Boreas 4km buffer amalgamated)
4	Dudgeon Extension Project	-	-	-	-	-	-	Beyond extent of viable SeaMAST data - not included
4	Hornsea Project Four	-	-	-	-	-	-	Beyond extent of viable SeaMAST data - not included
4	Sheringham Shoal Extension Project	0.0	0.0	0.6	0.0	0.6	0.0	OWF and 4km overlap with Sheringham Shoal OWF. Sheringham Shoal prioritised.
5.	Five Estuaries	1.9	0.0	3.1	0.0	5.0	0.0	4km buffer overlap with 4km buffers of EA2, Greater Gabbard and Galloper

Project related

Tier	OWF	Wind farm site		4km buffer		Wind farm + 4km buffer		Notes
		No. birds	% of ref population	No. birds	% of ref population	No. birds	% of ref population	
5.	North Falls	14.7	0.1	84.4	0.4	99.1	0.5	4km buffer overlap with 4km buffers of Greater Gabbard and Galloper
	TOTALS	586.2	2.9	2508.3	12.6	3094.5	15.5	

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