Sheringham Shoal and Dudgeon Offshore Wind Farm Extension Projects

Apportioning and Habitats Regulations Assessment Updates Technical Note (Revision B) (Clean)

Revision B
March 2023
Document Reference: 13.3

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Prepared by:	
Royal HaskoningDHV	
Approved by:	Date:
Sarah Chandler, Equinor	**March 2023**

Table of Contents

Table of Tables

Table of Figures

Glossary of Acronyms

AEoI	Adverse Effect on Integrity
BDMPS	Biologically defined minimum population scale
CI	Confidence Interval
CIA	Cumulative Impact Assessment
CGR	Counterfactuals of Annual Population Growth Rate and Population Size
CPS	Counterfactuals of Annual Population Size
DAS	Discretionary Advice Service
DCO	Development Consent Order
DEL	Dudgeon Extension Limited
DEP	Dudgeon Offshore Wind Farm Extension Project
DOW	Dudgeon Offshore Wind Farm
EC	European Commission
EIA	Environmental Impact Assessment
ES	Environmental Statement
FFC	Flamborough and Filey Coast
GW	Greater Wash
HP4	Hornsea Project Four
HRA	Habitats Regulations Assessment
JNCC	Joint Nature Conservation Committee
LCI	Lower Confidence Interval
NNC	North Norfolk Coast
OWF	Offshore Wind Farm
RB	Race Bank
RIAA	Report to Inform Appropriate Assessment
SEL	Scira Extension Limited
SEP	Sheringham Offshore Wind Farm Extension Project
SOW	Sheringham Shoal Offshore Wind Farm
SPA	Special Protection Area
UCI	Upper Confidence Interval

Glossary of Terms

Biologically defined minimum population scale (BDMPS)	The estimated population size of a species within a defined biogeographic area during a biologically relevant season, as defined by Furness (2015).
Dudgeon Offshore Wind Farm Extension Project (DEP)	The Dudgeon Offshore Wind Farm Extension onshore and offshore sites including all onshore and offshore infrastructure.
Sheringham Shoal Offshore Wind Farm Extension Project (SEP)	The Sheringham Shoal Offshore Wind Farm Extension onshore and offshore sites including all onshore and offshore infrastructure.
The Applicant	Equinor New Energy Limited. As the owners of SEP and DEP, Scira Extension Limited (SEL) and Dudgeon Extension Limited (DEL) are the named undertakers that have the benefit of the DCO. References in this document to obligations on, or commitments by, 'the Applicant' are given on behalf of SEL and DEL as the undertakers of SEP and DEP.

1 Revision B Updates at Deadline 2

1. This document has been updated at Deadline 2 to include an updated Greater Wash SPA red-throated diver construction phase displacement / barrier effects assessment (**Section 11.2.1**).
2. In addition, the in-combination assessment for Sandwich tern has been updated to include an additional scenario (Scenario F – consented Offshore Wind Farm (OWF) designs, except for Dudgeon Offshore Wind Farm (DOW), which is assumed as-built and legally secured through a mechanism within the **Draft DCO (Revision D)** [document reference 3.1] (**Section 12.2.2**). The in-combination assessment has also been updated to correct an error in **Table 12-5**, which included incorrect values for existing OWFs.

2 Introduction

3. This document presents an update to the information used to produce the **Report to Inform Appropriate Assessment (RIAA)** [APP-059] submitted as part of the assessment of the Sheringham Shoal Offshore Wind Farm Extension Project (SEP) and Dudgeon Offshore Wind Farm Extension Project (DEP) on offshore ornithology receptors.
4. This has been undertaken at the request of Natural England, who in a Discretionary Advice Service (DAS) letter dated 16/09/2022 and subsequently in Appendix B of their Relevant Representation [RR-063], indicated that potential impacts should be re-estimated for the following populations:
   - Alde-Ore Estuary Special Protection Area (SPA) lesser black-backed gull (collision)
   - Flamborough and Filey Coast (FFC) SPA gannet (operational phase displacement and collision)
   - FFC SPA guillemot (operational phase displacement)
   - FFC SPA kittiwake (collision)
   - FFC SPA puffin (operational phase displacement)
   - FFC SPA razorbill (operational phase displacement)
   - Greater Wash (GW) SPA red-throated diver (construction phase displacement / barrier effects and operational phase displacement)
   - GW SPA Sandwich tern (collision)
   - North Norfolk Coast (NNC) SPA Sandwich tern (collision)
   - GW SPA little gull (collision)
5. In addition to these updates, an error in the processing of razorbill data for the FFC SPA was identified in the original assessment. This resulted in the mean peak counts for the breeding season and autumn migration season being mistakenly reversed during the production of displacement matrices. This has no effect on the

overall annual mortality estimates that are used to make conclusions in Environmental Statement (ES) **Chapter 11 Offshore Ornithology** [APP-097]. The updated assessment presented here with respect to Habitats Regulations Assessment (HRA) incorporates the correction of this error.

6. In response to the re-estimation of impacts set out above, Population Viability Analysis (PVA) has been updated where required. Revised PVA results have been presented for gannet, guillemot, kittiwake and razorbill in respect of FFC SPA.

7. This document also provides an assessment of the potential effects of SEP and DEP on the seabird assemblage feature of FFC SPA. This is in accordance with Natural England's Relevant Representation [RR-063], and, as advised during Natural England consultation, follows the approach recommended in Natural England's advice to the Hornsea Project Four (HP4) offshore windfarm (OWF), set out in its End of Examination Position Statement (Natural England, 2022).

2.1 Consultation on this Document

8. Natural England was consulted on a draft of this technical note in December 2022. **Table 2-1** provides a summary of comments received from Natural England in February 2023, and how these have been addressed in this version of the note.

Table 2-1: Natural England consultation summary

Comment number	Section of draft document	Paragraph	Natural England comment	Applicant response
1	2.2	Table 2-1 Note 1	This reference is: Natural England, 2022. Natural England interim advice on updated Collision Risk Modelling parameters (July 2022). Please clarify where these population sizes are obtained from.	Error corrected, **Table 3-1** now references JNCC (2022).
2	3.1	6. bullet point 2	There has been further tracking work of Lesser Black Backed Gull at Alde-Ore SPA carried out by Galloper OWF as part of their post consent monitoring. This more recent work supports these conclusions and Natural England recommend the inclusion of this additional evidence source. The relevant report is attached to this advice note.	Noted. Additional text added as bullet 3 of **Paragraph 12** to reference this study.
3	3.1	6. bullet point 3	The list of breeding locations excludes a number of larger colonies such as Great Yarmouth and Lowestoft which would be within 80km of SEP and DEP.	This information has been rechecked. The colonies at Great Yarmouth are addressed in this list – Berney Marshes is included, but Breydon Water is not listed as there is a zero count for this colony (based on most recent counts from JNCC (2022)). Lowestoft is beyond 80km from both SEP and DEP. A full list of included colonies is now provided in **Table 4-1**.
4	3.1	8.	Please could the data used to inform the estimate of 11.3% and 13.4% be provided: the colonies included, populations sizes and distance from both SEP and DEP. As an example a similar exercise was carried out by Boreas OWF and is presented in table 7.3 in EN010087- 001420-Offshore Ornithology Assessment Update.pdf (planninginspectorate.gov.uk).	A full list of included colonies is now provided in **Table 4-1**, as requested. Natural England's response regarding use of this apportioning approach is noted and welcomed. The limitations to this approach have been added to **Paragraph 14** and referenced in the updated assessment conclusion in **Paragraph 17**. It should be noted that the assessment concludes that there would be no adverse effect

Comment number	Section of draft document	Paragraph	Natural England comment	Applicant response
			Furthermore, while we welcome the use of this apportioning approach, we acknowledge that for projects that are distant from the focal colony (such as SEP and DEP) the method can result in a precautionary output. This is due to a lack of data to adequately parameterise realistic decay curves defining the relationship between colony and foraging distance. This tends to over-estimate the number of birds likely to be present at the further extent of the foraging ranges.	on integrity (AEoI) in respect of Lesser Black Backed Gull at Alde-Ore SPA.
5	3.2	Table 3-1	Predicted collision rates for Lesser Black Backed Gull (LBBG) of SEP and DEP combined scenario – Natural England observes that when considering the East Anglia One North OWF, the Secretary of State sought compensatory measures when considering a predicted impact of 0.3 adult LBBG collisions per annum for the Alde-Ore Estuary SPA. The circumstances were different to those of SEP and DEP, because at the time EA2, Norfolk Vanguard and Norfolk Boreas were under consideration for in-combination impacts, the combined contribution of which to the in-combination total was 6.6 adult LBBGs. Nevertheless, it may be prudent to reappraise the apportioning approach taken, to ensure that it has not over-estimated the likely degree of connectivity and therefore the predicted impact.	Noted – see above response. The conclusion of the assessment in respect of Lesser Black Backed Gull at Alde-Ore Estuary SPA, set out in **Section 4.2.2**, is that there would be no AEoI for SEP and DEP, and that there would be no measurable contribution to in-combination effects.

Comment number	Section of draft document	Paragraph	Natural England comment	Applicant response
6	3.2	Table 3-1 Note 1	Please reference where the breeding adult background population figure for the Alde-Ore Estuary SPA comes from.	Reference (JNCC 2022) now added (now **Table 4-2**)
7	5.1	17.	Natural England agrees with the conclusion that there is no connectivity between breeding adult guillemot population of the FFCFFC SPA and the Projects. Therefore no update to the assessment for the qualifying feature is required. Natural England apologies for this error.	Noted. The guillemot assessment in **Section 6** reflects this assumption.
8	8.1	32.	Natural England accepts the approach adopted in para.32 in this instance, due to the SEP and DEP projects being at the further extent of the foraging range.	Noted.

3 Methods

3.1 Apportioning

9. Apportioning rates specific to each qualifying feature used in the revised assessments are set out in the relevant sections. Apportioning has been updated for the following species:

- Lesser black-backed gull (Alde-Ore Estuary SPA) – breeding season apportioning undertaken using NatureScot interim guidance (SNH 2018). (It should be noted that the Applicant's position is that it is not necessary to apportion impacts to the Alde-Ore Estuary lesser black-backed gull population during the breeding season).
- Gannet (FFC SPA) – non-breeding seasons apportioning updated to remove adjustment to biologically defined minimum population scale (BDMPS) population based on the proportion of adults observed during baseline surveys.
- Kittiwake (FFC SPA) – non-breeding seasons apportioning updated to remove adjustment to BDMPS population based on the proportion of adults observed during baseline surveys.
- Razorbill (FFC SPA) – apportioning of birds during the breeding season added to the population assessment.
- Puffin (FFC SPA) – this assemblage species has been added to the assessment, and birds apportioned for the breeding and non-breeding seasons accordingly.

10. For all other species, the apportioning approach is unchanged from that presented in the **RIAA** [APP-059].

3.2 Background Populations for Habitats Regulations Assessment

11. The size of the qualifying feature populations and published adult annual mortality rates used in the HRA are presented in **Table 3-1**.

Table 3-1: Background populations and mortality rates used for HRA

SPA	Qualifying feature	Population (breeding adults/individuals)[1]	Published annual adult mortality rate[2]
Alde-Ore Estuary	Lesser black-backed gull	3,534	0.115
FFC	Gannet	26,784	0.081
FFC	Guillemot	121,754	0.061
FFC	Kittiwake	103,070	0.146
FFC	Puffin	2,879	0.094
FFC	Razorbill	40,506	0.105
GW	Red-throated diver	1,511	0.228[3]
GW	Sandwich tern	9,443	0.102

SPA	Qualifying feature	Population (breeding adults/individuals)[1]	Published annual adult mortality rate[2]
NNC	Sandwich tern		
GW	Little gull	1,255	0.200

Notes
1 From JNCC (2022), except puffin, from Aitken et al. (2017).
2 From Horswill and Robinson (2015).
3 Red-throated diver mortality rate is average all age class rate.

4 Alde-Ore Estuary SPA Lesser Black-backed Gull

4.1 Apportioning

12. The **RIAA** [APP-059] set out that during the breeding season, it did not seem likely that there would be connectivity between SEP and DEP, and the breeding adult lesser black-backed gull population of the Alde-Ore Estuary SPA. This was based on the following:

- Whilst SEP (114km) and DEP (120km) are just within the mean maximum foraging range (Woodward et al., 2019) of lesser black-backed gull from the Alde-Ore Estuary SPA (127km (±109km)), large parts of both Offshore Wind Farms (OWF) are beyond the mean maximum foraging range. Based on these distances it would be expected that few birds or foraging trips will occur at this distance from the colony, and even fewer with any regularity.
- Modelled at-sea distributions derived from tracking data during the breeding season (April to August) from breeding adult birds (Thaxter et al., 2015) indicate that SEP and DEP are outside the home foraging range (i.e. beyond the 95% utilisation distribution) of lesser black-backed gulls from the Alde-Ore Estuary SPA.
- Tracking studies undertaken during the 2019 and 2020 breeding seasons, as part of monitoring of the Galloper OWF (Green *et al.*, 2021) also indicate that lesser black-backed gulls from Alde-Ore Estuary SPA are unlikely to occur at SEP and DEP during the breeding season. Tracked birds had an average offshore foraging range of 31.5km ± 27.0km during 2019, and 21.3km ± 19.1km during 2020 (i.e. significantly less than the distance to SEP and DEP), and no tracked birds were recorded in the vicinity of SEP and DEP during the studies. These results were similar to pre-construction tracking at Galloper OWF undertaken between 2010 and 2015.

- This does not mean that breeding adult lesser black-backed gulls from the Alde-Ore Estuary SPA will not be present at SEP and DEP during the breeding season. However, it does suggest that the majority of birds recorded on site during the breeding season are unlikely to be breeding adults from the SPA, and that any breeding adults at SEP and DEP from this SPA will be present in small numbers only.
- There are several breeding locations for this species located on the north Norfolk coast, including Blakeney Point (latest count 10 nests in 2020), Holkham (latest count 5 nests in 2020), Berney Marshes (latest count 20 nests in 2019), Outer Trial Bank (latest count 1,294 nests in 2018) and Hunstanton town (latest count one nest in 2019) (Joint Nature Conservation Committee (JNCC), 2022). These breeding locations are all within 80km of SEP and DEP, which is a much shorter distance than birds breeding at the Alde-Ore Estuary SPA. It therefore seems likely that the majority of birds recorded at SEP and DEP during the breeding season are birds from these breeding colonies.

13. Natural England's Relevant Representation [RR-063] requested that in addition to the non-breeding seasons for this species (autumn migration, spring migration, and winter), apportioning is carried out for breeding season impacts. In accordance with Paragraphs 1394 to 1397 of the **RIAA** [APP-059], it remains the Applicant's view that, on the basis of available evidence, it is not necessary to apportion impacts to the Alde-Ore Estuary lesser black-backed gull population during the breeding season. Nonetheless, updated collision risk model (CRM) values are presented below including apportioned breeding season values.

14. Apportioning has been undertaken using the approach outlined in the NatureScot interim guidance (SNH 2018) which is based on relative population sizes of colonies within mean maximum plus one standard deviation of SEP and DEP, and colony distance (**Table 4-1**), combined with age class ratios of a stable modelled population, as per Furness (2015). For SEP and DEP respectively, this method calculated 11.3% and 13.4% of birds present during the breeding season to be breeding adults belonging to the Alde-Ore Estuary SPA. This approach is considered to be precautionary, as a lack of data to adequately parameterise realistic decay curves defining the relationship between colony and foraging distance will result in an over-estimate of the number of birds likely to be present at the further extent of the foraging range, i.e. at SEP and DEP.

15. In addition, outside of the breeding season, the proportions of breeding adult Alde-Ore Estuary SPA birds present at SEP and DEP was estimated from Furness (2015) to be 0.6% (i.e. 1,280 / 209,007) during the spring and autumn migration seasons, and 1.6% (i.e. (1,280 * 0.5) / 39,314) during the winter season.

Table 4-1: Lesser black backed gull colonies used to inform breeding season apportioning estimation for Alde-Ore Estuary SPA to SEP and DEP

Colony [1]	Latest count [2]	Distance to SEP (km)	Distance to DEP (km)
Blakeney Point	14	25.5	43.9
Stiffkey	14	27.0	45.6
Holkham NNR	5	31.9	50.7
Titchwell Marsh RSPB	0	43.1	61.6
Holme Dunes NNR	0	48.4	66.8
Hunstanton Town	1	50.9	69.3
Breydon Water	0	71.1	76.8
Outer Trial Bank	1294	71.3	89.8
Berney Marshes	20	72.2	79.2
Lowestoft	750	86.2	92.7
Minsmere RSPB (Scrape & Beach)	2	107.7	116.7
Orfordness Beach (Orford Ness 1)	**97**	**122.3**	**132.1**
Reavels (Industrial Site)	14	123.2	136.6
Ransomes and Rapiar (Industrial Site)	15	124.5	137.6
Havergate Island	**1670**	**124.7**	**135.2**
Hollesley Marsh	19	125.7	136.6
Fox's Marina / Ipswich Docks	9	125.9	139.1
Ransomes Euro Park (urban)	50	126.5	139.3
Read's Island RSPB	4	128.1	136.0
Felixstowe Docks	1401	135.6	147.5
Flamborough 8 (incl. harbour but not buildings)	14	135.7	136.6

Notes
1. Alde-Ore Estuary SPA colonies in **Bold**
2. Apparently Occupied Nests (AON) from JNCC (2022)

4.2 Revised Predicted Impacts

4.2.1 Collision

16. Annual impacts of SEP, DEP, and SEP and DEP on the Alde-Ore Estuary SPA lesser black-backed gull qualifying feature, based on the apportioning rates presented above, and the updated CRMs presented in **CRM Updates (Environmental Impact Assessment (EIA) Context) Technical Note** [document reference 13.2] are presented in **Table 4-2**.

Table 4-2: Estimated Annual Collision Risk for Breeding Adult Alde-Ore Estuary SPA Lesser Black-backed Gull at SEP, DEP, and SEP and DEP Combined, along with Associated Increases in Adult Mortality Within the Population

OWF	Output	Annual Alde-Ore Estuary SPA lesser black-backed gull collision rate	% increase to annual mortality of Alde-Ore Estuary SPA lesser black-backed gull population[1]
DEP	95% UCI	0.85	0.22
	Mean	0.17	0.04
	95% LCI	0.00	0.00
SEP	95% UCI	0.33	0.10
	Mean	0.07	0.02
	95% LCI	0.00	0.00
SEP and DEP	95% UCI	1.18	0.31
	Mean	0.24	0.06
	95% LCI	0.00	0.00

Notes
1. Background population is Alde-Ore Estuary SPA breeding adults (3,534 individuals; JNCC (2022)), adult age class annual mortality rate of 0.115 (Horswill and Robinson, 2015)

4.2.2 Potential Effects of SEP and DEP Alone and In-Combination with Other Projects

17. The conclusions of the in-combination assessment are unchanged from those presented in the **RIAA** [APP-059]. The mean mortality for lesser black-backed gull from Alde-Ore Estuary SPA as a result of SEP and DEP is significantly below one bird per annum, which means on average one bird from this population would die every four years. This would result in a mortality change of 0.06%, which would not be detectable against natural variation. Given the small magnitude of the predicted impact, and the fact that this value is considered precautionary (refer to **Paragraph 14**) it is considered that collision impacts at SEP and DEP would not contribute substantially to the in-combination impacts on this qualifying feature, and would not delay, or prevent the achievement of the conservation objectives.

18. It is concluded that predicted lesser black-backed gull mortality due to collision at SEP, DEP, and SEP and DEP, would not adversely affect the integrity of the Alde-Ore Estuary SPA. There would be no measurable contribution from SEP and DEP to in-combination effects.

5 FFC SPA Gannet

5.1 Apportioning

19. Natural England were largely in agreement with the apportioning approach set out in the **RIAA** [APP-059], but advised that it is not appropriate to correct the BDMPS apportioning in the non-breeding season for the proportion of adults observed in the

baseline survey data. This is because the proportion of adults is already corrected for with the BDMPS figures, and applying this correction 'double corrects', reducing the level of impact apportioned.

20. This change to the apportioning methodology has been made. For SEP and DEP, 76.6% of birds present during the breeding season were calculated to be breeding adults belonging to the FFC SPA (based on 100% FFC SPA breeding adult apportioning and the fact that 76.6% of birds recorded during the breeding season for which a plumage was assigned were adults), in addition to 6.2% (i.e. (22,122 * 0.7) / 248,385) and 4.8% (i.e. 22,122 / 456,299) of birds present at SEP and DEP during the spring and autumn migration seasons respectively.

5.2 Revised Predicted Impacts

5.2.1 Operational Phase Displacement

21. The annual estimated displacement impacts of SEP, DEP, and SEP and DEP on the FFC SPA gannet qualifying feature, based on the apportioning rates presented in **Section 5.1**, using the same methods used in the **RIAA** [APP-59], are presented in **Table 5-1**, **Table 5-2** and **Table 5-3** respectively.

Table 5-1: Predicted Operational Phase Displacement and Mortality of FFC SPA Breeding Adult Gannets at DEP

Mean peak abundance estimate type	Mean peak abundance estimate by season	Number of SPA breeding adults present by season[1]	Year round mortality range[2]	Year round% background mortality annual increase range[3]
Upper 95% Confidence Interval (CI)	554 (autumn) 103 (spring) 692 (breeding) 1,349 (year round)	27 (autumn) 6 (spring) 530 (breeding) 563 (year round)	3 - 5 (3.94)	0.16 - 0.21
Mean	343 (autumn) 47 (spring) 417 (breeding) 807 (year round)	17 (autumn) 3 (spring) 319 (breeding) 339 (year round)	2 - 3 (2.37)	0.09 - 0.12
Lower 95% CI	186 (autumn) 10 (spring) 180 (breeding) 376 (year round)	9 (autumn) 1 (spring) 138 (breeding) 147 (year round)	1 - 1 (1.03)	0.04 - 0.05

Notes

1. For autumn migration season (Oct-Nov), assumes 4.8% of adult birds are FFC SPA breeders (Furness 2015). For spring migration season (Dec-Feb), assumes 6.2% of adult birds are FFC SPA breeders. For breeding season (Mar-Sept), assumes 100% of adult birds are FFC SPA breeders, combined with 76.7% of gannets allocated an age class during breeding season baseline surveys as being adults

2. Assumes displacement rates of 0.600 to 0.800 and mortality rate of 1% of displaced birds, value in parentheses is mortality rate at 0.700 displacement and 1% mortality

3. Background population is FFC SPA breeding adults (26,784 individuals), adult age class annual mortality rate of 0.081 (Horswill and Robinson, 2015)

Table 5-2: Predicted Operational Phase Displacement and Mortality of FFC SPA Breeding Adult Gannets at SEP

Mean peak abundance estimate type	Mean peak abundance estimate by season	Number of SPA breeding adults present by season[1]	Year round mortality range[2]	Year round% background mortality annual increase range[3]
Upper 95% CI	426 (autumn) 31 (spring) 47 (breeding) 504 (year round)	21 (autumn) 2 (spring) 36 (breeding) 59 (year round)	0 - 0 (0.41)	0.02 - 0.02
Mean	295 (autumn) 11 (spring) 23 (breeding) 329 (year round)	14 (autumn) 1 (spring) 18 (breeding) 33 (year round)	0 - 0 (0.23)	0.01 - 0.01
Lower 95% CI	193 (autumn) 0 (spring) 3 (breeding) 196 (year round)	9 (autumn) 0 (spring) 2 (breeding) 11 (year round)	0 - 0 (0.08)	0.00 - 0.00

Notes

1. For autumn migration season (Oct-Nov), assumes 4.8% of adult birds are FFC SPA breeders (Furness 2015). For spring migration season (Dec-Feb), assumes 6.2% of adult birds are FFC SPA breeders. For breeding season (Mar-Sept), assumes 100% of adult birds are FFC SPA breeders, combined with 76.7% of gannets allocated an age class during breeding season baseline surveys as being adults

2. Assumes displacement rates of 0.600 to 0.800 and mortality rate of 1% of displaced birds, value in parentheses is mortality rate at 0.700 displacement and 1% mortality

3. Background population is FFC SPA breeding adults (26,784 individuals), adult age class annual mortality rate of 0.081 (Horswill and Robinson, 2015)

Table 5-3: Predicted Operational Phase Displacement and Mortality of FFC SPA Breeding Adult Gannets at SEP and DEP

Mean peak abundance estimate type	Mean peak abundance estimate by season	Number of SPA breeding adults present by season[1]	Year round mortality range[2]	Year round% background mortality annual increase range[3]
Upper 95% CI	980 (autumn) 133 (spring) 739 (breeding) 1,852 (year round)	48 (autumn) 8 (spring) 566 (breeding) 622 (year round)	4 - 5 (4.35)	0.17 - 0.23
Mean	638 (autumn) 57 (spring) 440 (breeding) 1,135 (year round)	31 (autumn) 4 (spring) 337 (breeding) 371 (year round)	2 - 3 (2.60)	0.10 - 0.14
Lower 95% CI	378 (autumn) 10 (spring) 183 (breeding) 571 (year round)	18 (autumn) 1 (spring) 140 (breeding) 159 (year round)	1- 1 (1.11)	0.04 - 0.06

Notes

1. For autumn migration season (Oct-Nov), assumes 4.8% of adult birds are FFC SPA breeders (Furness 2015). For spring migration season (Dec-Feb), assumes 6.2% of adult birds are FFC SPA breeders. For breeding season (Mar-Sept), assumes 100% of adult birds are FFC SPA breeders, combined with 76.7% of gannets allocated an age class during breeding season baseline surveys as being adults

Mean peak abundance estimate type	Mean peak abundance estimate by season	Number of SPA breeding adults present by season[1]	Year round mortality range[2]	Year round% background mortality annual increase range[3]
2. Assumes displacement rates of 0.600 to 0.800 and mortality rate of 1% of displaced birds, value in parentheses is mortality rate at 0.700 displacement and 1% mortality 3. Background population is FFC SPA breeding adults (26,784 individuals), adult age class annual mortality rate of 0.081 (Horswill and Robinson, 2015)				

5.2.2 Collision

5.2.2.1 SEP and DEP

22. The annual estimated collision impacts of SEP, DEP, and SEP and DEP on the FFC SPA gannet qualifying feature, which assume a macro-avoidance rate of 0.7, based on the apportioning rates presented in **Section 5.1**, and the updated CRMs presented in **CRM Updates (EIA Context) Technical Note** [document reference 13.2], are presented in **Table 5-4**.

Table 5-4: Estimated annual collision risk for breeding adult FFC SPA gannet at SEP, DEP, and SEP and DEP, along with associated increases in mortality within the population

OWF	Output	Annual FFCSPA gannet collision rate	% increase to annual mortality of FFC SPA gannet population[1]
DEP	95% Upper CI (UCI)	0.95	0.04
	Mean	0.30	0.01
	95% Lower CI (LCI)	0.02	0.00
SEP	95% UCI	0.23	0.01
	Mean	0.04	0.00
	95% LCI	0.00	0.00
SEP and DEP	95% UCI	1.17	0.05
	Mean	0.34	0.02
	95% LCI	0.02	0.00
Notes 1. Background population is FFC SPA breeding adults (26,784 individuals), adult age class annual mortality rate of 0.081 (Horswill and Robinson, 2015)			

5.2.3 Combined Operational Phase Displacement and Collision

5.2.3.1 SEP and DEP

23. The combined impacts of operational phase displacement and collision of SEP, DEP, and SEP and DEP on the FFC SPA gannet qualifying feature, based on the

impacts described in **Section 5.2.1** and **Section 5.2.2.1**, which assumed a macro-avoidance rate of 0.7, are presented in **Table 5-5**.

Table 5-5: Estimated annual combined operational phase displacement and collision risk for breeding adult FFC SPA gannet at SEP, DEP, and SEP and DEP, along with associated increases in mortality within the population

OWF	Output	Annual FFCSPA gannet displacement mortality[1]	Annual FFCSPA gannet collision rate	Combined annual FFCSPA gannet mortality	% increase to annual mortality of FFC SPA gannet population[1]
DEP	95% UCI	3.94	0.95	4.89	0.23
	Mean	2.37	0.30	2.67	0.12
	95% LCI	1.03	0.02	1.05	0.05
SEP	95% UCI	0.41	0.23	0.64	0.03
	Mean	0.23	0.04	0.27	0.01
	95% LCI	0.08	0.00	0.08	0.00
SEP and DEP	95% UCI	4.35	1.17	5.53	0.25
	Mean	2.60	0.34	2.94	0.14
	95% LCI	1.11	0.02	1.13	0.05

Notes

1. Assumes gannet displacement rate of 0.700, aligned with recommended 70% macro-avoidance for the CRM proposed by Natural England [RR-063]

2. Background population is FFC SPA breeding adults (26,784 individuals), adult age class annual mortality rate of 0.081 (Horswill and Robinson, 2015)

5.2.4 Potential Effects of SEP and DEP In-Combination with Other Projects

5.2.4.1 Operational Phase Displacement/Barrier Effects

24. Seasonal and annual population estimates of breeding adult gannets of the FFCFFC SPA at all OWFs included in the in-combination assessment are presented in **Table 5-6**. The values for all OWFs are unchanged from those presented in the **RIAA** [APP-59], with the exception of the inclusion of data from the Rampion 2 PEIR (GoBe Consultants, Wood Group UK, 2021a & 2021b) and updated values from HP4 (Ørsted, 2022).

25. The estimated annual total of breeding adult gannets from FFC SPA at risk of displacement from all OWFs within the UK North Sea BDMPS combined is 9,113 (**Table 5-6**). Of this total, SEP and DEP contribute 0.4% and 3.7% respectively. Using displacement rates of 0.600 to 0.800 and a maximum mortality rate of 1% of displaced birds (UK SNCBs, 2017), the number of FFC SPA birds predicted to die each year would be between 55 and 73 (**Table 5-7**).

26. The estimated increase in mortality of FFC SPA breeding adult gannets due to in-combination displacement is between 2.54% and 3.36%. Increases in the existing mortality rate of greater than 1% could be detectable against natural variation.

Table 5-6: Seasonal and annual population estimates of all gannets at SEP, DEP and other OWFs included in the in-combination assessment, and breeding adult birds apportioned to FFC SPA

Tier	OWF	Seasonal population at risk of displacement[1]							
		Breeding		Autumn migration		Spring migration		Annual	
		Total	FFC	Total	FFC	Total	FFC	Total	FFC
1	Beatrice	151	0	0	0	0	0	151	0
1	Beatrice Demonstrator	-	-	-	-	-	-	-	-
1	Blyth Demonstration Project	-	-	-	-	-	-	-	-
1	Dudgeon	53	53	25	1.2	11	0.7	89	54.9
1	East Anglia ONE	161	161	3638	174.6	76	4.7	3875	340.3
1	European Offshore Wind Deployment Centre	35	0	5	0.2	0	0	40	0.2
1	Galloper	360	0	907	43.5	276	17.1	1543	60.6
1	Greater Gabbard	252	0	69	3.3	105	6.5	426	9.8
1	Gunfleet Sands	0	0	12	0.6	9	0.6	21	1.2
1	Hornsea Project One	671	671	694	33.3	250	15.5	1615	719.8
1	Humber Gateway	-	-	-	-	-	-	-	-
1	Hywind	10	0	0	0	4	0.2	14	0.2
1	Kentish Flats	-	-	-	-	-	-	-	-
1	Kentish Flats Extension	0	0	13	0.6	0	0	13	0.6
1	Kincardine	120	0	0	0	0	0	120	0

Tier	OWF	Seasonal population at risk of displacement[1]							
		Breeding		Autumn migration		Spring migration		Annual	
		Total	FFC	Total	FFC	Total	FFC	Total	FFC
1	Lincs	-	-	-	-	-	-	-	-
1	London Array	-	-	-	-	-	-	-	-
1	Race Bank	92	92	32	1.5	29	1.8	153	95.3
1	Rampion	0	0	590	28.3	0	0	590	28.3
1	Scroby Sands	-	-	-	-	-	-	-	-
1	Sheringham Shoal	47	47	31	1.5	2	0.1	80	48.6
1	Teesside	1	0.5	0	0	0	0	1	0.5
1	Thanet	-	-	-	-	-	-	-	-
1	Westermost Rough	-	-	-	-	-	-	-	-
2	Triton Knoll	211	211	15	0.7	24	1.5	250	213.2
3	Dogger Bank Creyke Beck Projects A and B	1155	577.5	2048	98.3	394	24.4	3597	700.2
3	Dogger Bank Teesside Projects A and B	2250	1125	887	42.6	464	28.8	3601	1196.4
3	East Anglia ONE North	149	149	468	22.5	44	2.7	661	174.2
3	East Anglia THREE	412	412	1269	60.9	524	32.5	2205	505.4
3	East Anglia TWO	192	192	891	42.8	192	11.9	1275	246.7
3	Firth of Forth Alpha and Bravo	2956	0	664	31.9	332	20.6	3952	52.5
3	Hornsea Project Three	1333	844	984	47	524	32.5	2841	924

Tier	OWF	Seasonal population at risk of displacement[1]							
		Breeding		Autumn migration		Spring migration		Annual	
		Total	FFC	Total	FFC	Total	FFC	Total	FFC
3	Hornsea Project Two	457	457	1140	54.7	124	7.7	1721	519.4
3	Inch Cape	2398	0	703	33.7	212	13.1	3313	46.8
3	Methil	23	0	0	0	0	0	23	0
3	Moray Firth (EDA)	564	0	292	14	27	1.7	883	15.7
3	Moray West	2827	0	439	21.1	144	8.9	3410	30
3	Neart na Gaoithe	1987	0	552	26.5	281	17.4	2820	43.9
3	Norfolk Boreas	1229	1229	1723	82.7	526	32.6	3478	1344.3
3	Norfolk Vanguard	271	271	2453	117.7	437	27.1	3161	415.8
Total (all projects above)		20367	6492	20544	986	5011	311	45922	7789
5	*Hornsea Project Four*	976	883.1	790	38.3	401	25.0	2167	946.4
5	*Rampion 2 (PEIR)*	98	0	78	3.7	45	2.8	221	6.5
5	*DEP*	*417*	*319.8*	*343*	*16.5*	*47*	*2.9*	*807*	*339.2*
5	*SEP*	*23*	*17.6*	*295*	*14.1*	*11*	*0.7*	*328*	*32.4*
Total (all projects)		21881	7713	22050	1058	5514	342	49224	9113

Notes

1. The preferred standard area over which to assess gannet displacement is the OWF plus a 2km buffer, however the buffer zones included in this assessment varied between 0-4km depending on the data available, see **Appendix 11.2 Supplementary Information to Inform the Offshore Ornithology Cumulative Impact Assessment** [APP-196] for further details and sources of seasonal populations for other OWFs besides SEP and DEP. Dashes indicate no data available for a given OWF.

Table 5-7: In-Combination displacement matrix for gannet from FFC SPA from OWFs in the UK North Sea, with the ranges of displacement and mortality considered by the assessment shown in red

		Mortality (%)										
		1	2	3	4	5	10	20	30	50	80	100
Displacement (%)	10	9	18	27	36	46	91	182	273	456	729	911
	20	18	36	55	73	91	182	365	547	911	1458	1823
	30	27	55	82	109	137	273	547	820	1367	2187	2734
	40	36	73	109	146	182	365	729	1094	1823	2916	3645
	50	46	91	137	182	228	456	911	1367	2278	3645	4556
	60	55	109	164	219	273	547	1094	1640	2734	4374	5468
	70	64	128	191	255	319	638	1276	1914	3189	5103	6379
	80	73	146	219	292	365	729	1458	2187	3645	5832	7290
	90	82	164	246	328	410	820	1640	2460	4101	6561	8202
	100	91	182	273	365	456	911	1823	2734	4556	7290	9113

5.2.4.2 Collision Risk

27. Seasonal and annual in-combination totals of estimated collision mortality of breeding adult gannets of the FFC SPA at all OWFs included in the in-combination assessment are presented in **Table 5-8**. These values include data from the proposed Rampion 2 PEIR (GoBe Consultants, Wood Group UK, 2021a & 2021b) and final published values from Hornsea Project 4, using the 'preferred Natural England approach'. All values have been updated to reflect the 99.2% avoidance rate and 70% macro-avoidance used for the SEP and DEP project-alone assessment presented in the **CRM Updates (EIA Context) Technical Note** [document reference 13.2], and in accordance with Natural England's advice provided in their Relevant Representation [RR-063]. The updated values have been calculated by a simple transformation from the previous 98.9% avoidance rate (i.e. by dividing existing CRM values by (1-0.989) and multiplying by (1-0.992) to update to the 99.2% avoidance rate, then multiplying by (1-0.7) to apply the 70% macro-avoidance).

28. The total predicted annual in-combination collision mortality for breeding adult gannets from the FFC SPA is 67 individuals (**Table 5-8**). Between them, SEP and DEP contribute 0.3 birds to this total, or 0.50%. The predicted in-combination mortality would increase the baseline adult mortality rate of the FFC SPA breeding adult gannet population by 3.1%. This magnitude of increase could result in detectable population level effects.

Table 5-8: Estimated Collision Mortality at UK North Sea OWFs for Gannet by Season, Including those Apportioned to FFC SPA Breeding Adult Population

Tier	OWF	Seasonal population at risk of collision[1]							
		Breeding		Autumn migration		Spring migration		Annual	
		Total	FFC	Total	FFC	Total	FFC	Total	FFC
1	Beatrice	8.16	0.00	10.65	0.51	2.07	0.13	20.88	0.63
1	Beatrice Demonstrator	0.13	0.00	0.20	0.01	0.15	0.01	0.48	0.02
1	Blyth Demonstration Project	0.76	0.00	0.46	0.02	0.61	0.04	1.83	0.07
1	Dudgeon	4.87	4.87	8.49	0.41	4.17	0.26	17.52	5.52
1	East Anglia ONE	0.74	0.74	28.58	1.37	1.37	0.09	30.76	2.20
1	European Offshore Wind Deployment Centre	0.92	0.00	1.11	0.05	0.02	0.00	2.03	0.07
1	Galloper	3.95	0.00	6.74	0.32	2.75	0.17	13.44	0.50
1	Greater Gabbard	3.05	0.00	1.92	0.09	1.05	0.07	6.00	0.15
1	Gunfleet Sands	-	-	-	-	-	-	-	-
1	Hornsea Project One	2.51	2.51	6.98	0.34	4.91	0.31	14.40	3.14
1	Humber Gateway	0.41	0.41	0.24	0.01	0.33	0.02	0.98	0.44
1	Hywind	1.22	0.00	0.17	0.01	0.17	0.01	1.57	0.02
1	Kentish Flats	0.31	0.00	0.17	0.01	0.24	0.02	0.72	0.02
1	Kentish Flats Extension	-	-	-	-	-	-	-	-
1	Kincardine	0.65	0.00	0.00	0.00	0.00	0.00	0.65	0.00

Tier	OWF	Seasonal population at risk of collision[1]							
		Breeding		Autumn migration		Spring migration		Annual	
		Total	FFC	Total	FFC	Total	FFC	Total	FFC
1	Lincs	0.46	0.46	0.28	0.01	0.37	0.02	1.09	0.50
1	London Array	0.50	0.00	0.31	0.02	0.39	0.02	1.20	0.04
1	Lynn and Inner Dowsing	0.04	0.04	0.02	0.00	0.04	0.00	0.11	0.04
1	Race Bank	7.35	7.35	2.55	0.12	0.89	0.05	10.80	7.53
1	Rampion	7.90	0.00	13.85	0.67	0.46	0.03	22.21	0.70
1	Scroby Sands	-	-	-	-	-	-	-	-
1	Sheringham Shoal	3.08	3.08	0.76	0.04	0.00	0.00	3.84	3.12
1	Teesside	1.07	0.52	0.37	0.02	0.00	0.00	1.46	0.55
1	Thanet	0.24	0.00	0.00	0.00	0.00	0.00	0.24	0.00
1	Westermost Rough	0.04	0.04	0.02	0.00	0.04	0.00	0.11	0.04
2	Triton Knoll	5.85	5.85	13.99	0.67	6.57	0.41	26.40	6.92
3	Dogger Bank Creyke Beck Projects A and B	17.69	8.86	18.22	0.87	11.87	0.74	47.78	10.45
3	Dogger Bank Teesside Projects A and B	3.23	1.61	2.20	0.11	2.36	0.15	7.79	1.85
3	East Anglia ONE North	2.71	2.71	2.40	0.11	0.24	0.02	5.35	2.84
3	East Anglia THREE	1.33	1.33	7.27	0.35	2.09	0.13	10.69	1.81
3	East Anglia TWO	2.73	2.73	5.04	0.24	0.87	0.04	8.64	3.01

Tier	OWF	Seasonal population at risk of collision[1]							
		Breeding		Autumn migration		Spring migration		Annual	
		Total	FFC	Total	FFC	Total	FFC	Total	FFC
3	Firth of Forth Alpha and Bravo	174.72	0.00	10.76	0.52	14.36	0.89	199.83	1.40
3	Hornsea Project Three	2.18	1.31	1.09	0.00	0.87	0.00	4.15	1.53
3	Hornsea Project Two	1.53	1.53	3.05	0.15	1.31	0.08	5.89	1.75
3	Inch Cape	73.51	0.00	6.37	0.31	1.13	0.07	81.01	0.37
3	Methil	1.31	0.00	0.00	0.00	0.00	0.00	1.31	0.00
3	Moray Firth (EDA)	17.59	0.00	7.72	0.37	1.94	0.12	27.25	0.50
3	Moray West	2.18	0.00	0.44	0.02	0.22	0.01	2.84	0.04
3	Neart na Gaoithe	31.20	0.00	10.25	0.49	5.02	0.31	46.47	0.81
3	Norfolk Boreas	3.08	3.10	2.77	0.13	0.85	0.05	6.70	3.29
3	Norfolk Vanguard	1.79	1.79	4.06	0.19	1.16	0.07	7.00	2.05
Total (all projects above)		390.98	50.84	179.52	8.57	70.91	4.34	641.43	63.93
5	*Hornsea Project Four*	*3.40*	*3.08*	*1.13*	*0.06*	*0.28*	*0.02*	*4.82*	*3.15*
5	*Rampion 2 (PEIR)*	*2.12*	*0.00*	*0.88*	*0.04*	*0.30*	*0.02*	*3.30*	*0.06*
5	*DEP*	*0.36*	*0.27*	*0.50*	*0.02*	*0.03*	*0.00*	*0.90*	*0.30*
5	*SEP*	*0.05*	*0.04*	*0.11*	*0.01*	*0.00*	*0.00*	*0.16*	*0.04*
Total (all projects)		396.91	54.23	182.15	8.70	71.53	4.38	650.62	67.48
Notes									

Tier	OWF	Seasonal population at risk of collision[1]							
		Breeding		Autumn migration		Spring migration		Annual	
		Total	FFC	Total	FFC	Total	FFC	Total	FFC

1. Values have been updated to reflect 99.2% avoidance rate and 70% macro-avoidance. See also **Appendix 11.2 Supplementary Information to Inform the Offshore Ornithology Cumulative Impact Assessment** [APP-196] for further details and sources of seasonal populations for other OWFs besides SEP and DEP. Dashes indicate no data available for a given OWF.

5.2.4.3 Combined Displacement/Barrier Effects and Collision Risk

29. The predicted annual in-combination breeding adult FFC SPA gannet mortality from collision and displacement of OWFs screened into the Appropriate Assessment (**Table 5-7** and **Table 5-8**) is shown in **Table 5-9**. SEP and DEP contributed approximately 2.1-2.4% of the total predicted impact of these scenarios. The predicted mortality would increase the baseline adult mortality rate of the FFC SPA breeding adult gannet population by greater than 1% (up to 6.5% in the worst case). This magnitude of increase could result in detectable population level effects.

Table 5-9: Predicted in-combination annual collision and displacement mortality for breeding adult gannet of the FFC SPA under different displacement scenarios

	Displacement			Collision (70% macro-avoidance)	Displacement and Collision		
	0.600 disp., 1% mort.	0.700 disp., 1% mort.	0.800 disp., 1% mort.		0.600 disp., 1% mort.	0.700 disp., 1% mort.	0.800 disp., 1% mort.
In-combination Annual mortality	55	64	73	67.5	122.5	131.5	140.5
Increase to FFC SPA background adult mortality	2.5%	2.9%	3.4%	3.1%	5.6%	6.1%	6.5%

30. As for the **RIAA** [APP-59], PVA was undertaken to assess the population-level impacts from these effects. The same population model was used as for the FFC SPA gannet population in the **RIAA** [APP-59], for which details and the underpinning demographic parameters are outlined in ES **Appendix 11.1 - Offshore Ornithology Technical Report** [APP-195]. The levels of additional mortality considered in the PVA were as specified in **Table 5-9**, with the PVA projections extending over an assumed 40-year operational period.

31. The levels of mortality resulting from SEP and DEP in-combination with other projects are lower, overall, than those that were predicted in the **RIAA** [APP-59]. Thus, the upper range for the predicted additional annual mortality is 140.5 adult birds (**Table 5-9**) which compares with 419 adult birds based on the predictions in the **RIAA** [APP-59]. As would be expected, the resultant counterfactuals of annual population growth rate (CGR) and population size (CPS) indicate substantially smaller population level impacts than those predicted in the **RIAA** [APP-59], with the upper values being 0.993 for CGR and 0.775 for CPS (**Table 5-10** - which compares with upper values of 0.981 for the CGR and 0.465 for CPS for the different displacement and collision effect scenarios presented in the **RIAA** [APP-59]).

32. On this basis, the conclusions of the **RIAA** [APP-59] in relation to the FFC SPA gannet population remain unchanged and the predicted gannet mortality due to the combined effects of operational phase displacement and collision at SEP, DEP and SEP and DEP combined, in-combination with other projects would not result in an AEoI of the FFC SPA.

Table 5-10: PVA Outputs for the FFC SPA breeding gannet population in relation to the predicted collision and displacement effects resulting from SEP and DEP in-combination with other projects

Effect (with rates of displacement and mortality)		Annual mortality (number of breeding adults)	Increase in annual mortality rate[1]	Median CGR[2]	Median CPS[3]
Displacement only	0.60 disp., 1% mort.	55.0	0.0020534648	0.998	0.905
	0.70 disp., 1% mort.	64.0	0.0023894863	0.997	0.890
	0.80 disp., 1% mort.	73.0	0.0027255078	0.997	0.876
Collisions only	N/A	67.5	0.0025201613	0.997	0.885
Displacement plus collisions	0.60 disp., 1% mort.	122.5	0.0045736260	0.994	0.801
	0.70 disp., 1% mort.	131.5	0.0049096476	0.994	0.787
	0.80 disp., 1% mort.	140.5	0.0052456691	0.993	0.775

Notes

1. Calculated as the absolute difference between the mortality rates for the unimpacted (i.e. baseline) and impacted populations, expressed as a proportion, for a starting population size of 26,784 breeding adults and a baseline annual mortality rate of 0.081.
2. CGR is the counterfactual of annual population growth rate, calculated as the median of the ratio of the annual growth rate of the impacted to un-impacted (or baseline) population, expressed as a proportion.
3. CPS is the counterfactual of population size, calculated as the median of the ratio of the end-point size of the impacted to un-impacted population size, expressed as a proportion. In this case, the end-point population size is predicted on the basis of a 40-year operational period.

6 FFC SPA Guillemot

6.1 Apportioning

33. The **RIAA** [APP-59] sets out that during the breeding season, it is unlikely there is connectivity between SEP and DEP, and the breeding adult guillemot population of the FFC SPA.

34. SEP and DEP are situated 112km and 116km respectively from the FFC SPA boundary at the nearest point. Excluding data from breeding guillemots at Fair Isle, where reduced prey availability was considered to be causing substantially increased foraging ranges during the breeding season, the mean maximum foraging range of guillemot is 55.7km (±39.7km) (Woodward et al., 2019).

35. With the Fair Isle data excluded, the mean maximum foraging range plus one standard deviation (95.4km) is less than the distance between FFC SPA and SEP and DEP, so the position that there is no connectivity between this population and SEP and DEP during the breeding season is maintained from the **RIAA** [APP-59]. This position is agreed by Natural England in their Relevant Representations [RR-063]. Therefore, no updates to the project-alone assessment for this qualifying feature have been made.

36. Updated in-combination values for operational phase displacement have been calculated, including values from Rampion 2 PEIR (GoBe Consultants, Wood Group UK, 2021a & 2021b) and updated values from HP4 (Orsted, 2022). The apportioning approach for birds within SEP and DEP is unchanged from the **RIAA** [APP-59]; 4.4% of birds present at SEP and DEP during the non-breeding season are considered to be breeding adults from the FFC SPA.

6.1.1 Potential Effects of SEP and DEP In-Combination with Other Projects

6.1.1.1 Operational Phase Displacement/Barrier Effects

37. Seasonal and annual population estimates of breeding adult guillemots of the FFC SPA at all OWFs included in the in-combination assessment are presented in **Table 6-1**. The values for all OWFs are unchanged from those presented in the **RIAA** [APP-59], with the exception of the inclusion of data from the Rampion 2 PEIR (GoBe Consultants, Wood Group UK, 2021a & 2021b) and updated values from HP4 (Ørsted, 2022).

38. The estimated annual total of breeding adult guillemots from FFC SPA at risk of displacement from all OWFs within the UK North Sea BDMPS combined is 36,336 (**Table 6-2**). Of this total, SEP and DEP contribute 0.1% and 1.8% respectively. It should also be noted that HP4 contributes approximately 28% of this total. Using displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% of displaced birds (UK SNCBs, 2017), the number of FFC SPA birds predicted to die each year would be between 109 to 2,543 (**Table 6-2**).

39. The estimated increase in mortality of FFC SPA breeding adult guillemot due to in-combination displacement impacts is between 1.47% and 34.24%. Increases in the existing mortality rate of greater than 1% could be detectable against natural variation.

Table 6-1: Seasonal and Annual Population Estimates of All Guillemots at SEP, DEP and Other OWFs Included in the In-Combination Assessment, and Breeding Adult Birds Apportioned to FFC SPA

Tier	OWF	Seasonal population at risk of displacement[1]					
		Breeding		Non-breeding		Total	
		Total	FFC	Total	FFC	Total	FFC
1	Beatrice	13610.0	0.0	2755.0	121.2	16365.0	121.2
1	Beatrice Demonstrator	No estimate available					
1	Blyth Demonstration Project	1220.0	0.0	1321.0	58.1	2541.0	58.1
1	Dudgeon	334.0	0.0	542.0	23.8	876.0	23.8
1	East Anglia ONE	274.0	0.0	640.0	28.2	914.0	28.2
1	European Offshore Wind Deployment Centre	547.0	0.0	225.0	9.9	772.0	9.9
1	Galloper	305.0	0.0	593.0	26.1	898.0	26.1
1	Greater Gabbard	345.0	0.0	548.0	24.1	893.0	24.1
1	Gunfleet Sands	0.0	0.0	363.0	16.0	363.0	16.0
1	Hornsea Project One	9836.0	4554.1	8097.0	356.3	17933.0	4910.4
1	Humber Gateway	99.0	99.0	138.0	6.1	237.0	105.1
1	Hywind	249.0	0.0	2136.0	94.0	2385.0	94.0
1	Kentish Flats	0.0	0.0	3.0	0.1	3.0	0.1
1	Kentish Flats Extension	0.0	0.0	4.0	0.2	4.0	
1	Kincardine	632.0	0.0	0.0	0.0	632.0	0.0
1	Lincs & LID	582.0	0.0	814.0	35.8	1396.0	35.8
1	London Array	192.0	0.0	377.0	16.6	569.0	16.6
1	Race Bank	361.0	0.0	708.0	31.2	1069.0	31.2

Tier	OWF	Seasonal population at risk of displacement[1]					
		Breeding		Non-breeding		Total	
		Total	FFC	Total	FFC	Total	FFC
1	Rampion	10887.0	0.0	15536.0	683.6	26423.0	683.6
1	Scroby Sands	No estimate available					
1	Sheringham Shoal	390.0	0.0	715.0	31.5	1105.0	31.5
1	Teesside	267.0	267.0	901.0	39.6	1168.0	306.6
1	Thanet	18.0	0.0	124.0	5.5	142.0	5.5
1	Westermost Rough	347.0	347.0	486.0	21.4	833.0	368.4
2	Triton Knoll	425.0	425.0	746.0	32.8	1171.0	457.8
3	Dogger Bank Creyke Beck A	5407.0	1892.5	6142.0	270.2	11549.0	2162.7
3	Dogger Bank Creyke Beck B	9479.0	3317.7	10621.0	467.3	20100.0	3785.0
3	Dogger Bank Teesside A	3283.0	1149.1	2268.0	99.8	5551.0	1248.9
3	Dogger Bank Teesside B	5211.0	1823.9	3701.0	162.8	8912.0	1986.7
3	East Anglia ONE North	4183.0	0.0	1888.0	83.1	6071.0	83.1
3	East Anglia THREE	1744.0	0.0	2859.0	125.8	4603.0	125.8
3	East Anglia TWO	2077.0	0.0	1675.0	73.7	3752.0	73.7
3	Firth of Forth Alpha	13606.0	0.0	4688.0	206.3	18294.0	206.3
3	Firth of Forth Bravo	11118.0	0.0	4112.0	180.9	15230.0	180.9
3	Hornsea Project Three[2]	13374.0	0.0	17772.0	782.0	31146.0	782.0
3	Hornsea Project Two	7735.0	3581.3	13164.0	579.2	20899.0	4160.5
3	Inch Cape	4371.0	0.0	3177.0	139.8	7548.0	139.8
3	Methil	25.0	0.0	0.0	0.0	25.0	0.0

Tier	OWF	Seasonal population at risk of displacement[1]					
		Breeding		Non-breeding		Total	
		Total	FFC	Total	FFC	Total	FFC
3	Moray Firth (EDA)	9820.0	0.0	547.0	24.1	10367.0	24.1
3	Moray West	24426.0	0.0	38174.0	1679.7	62600.0	1679.7
3	Neart na Gaoithe	1755.0	0.0	3761.0	165.5	5516.0	165.5
3	Norfolk Boreas	7767.0	0.0	13777.0	606.2	21544.0	606.2
3	Norfolk Vanguard	4320.0	0.0	4776.0	210.2	9096.0	210.2
Total (all projects above)		170621	17457	170874	7519	341495	24975
5	*Hornsea Project Four*	*9382.0*	*5235.2*	*36965.0*	*4849.8*	*46347.0*	*10085.0*
5	*Rampion 2 (PEIR)*	*185.0*	*0.0*	*13020.0*	*572.9*	*13205.0*	*572.9*
5	*DEP*	*3839.0*	*0.0*	*14887.0*	*655.0*	*18726.0*	*655.0*
5	*SEP*	*1094.5*	*0.0*	*1085.0*	*47.7*	*2179*	*47.7*
Total (all projects)		185122	22692	236831	13644	421952	36336

Notes

1. The preferred standard area over which to assess guillemot displacement is the OWF plus a 2km buffer, however the buffer zones included in this assessment varied between 0-4km depending on the data available, see **Appendix 11.2 Supplementary Information to Inform the Offshore Ornithology Cumulative Impact Assessment** [APP-196] for further details and sources of seasonal populations for other OWFs besides SEP and DEP.
2. For Hornsea Project Three, values for the breeding season align with those presented for East Anglia One North (SPR, 2019). Values presented for HP4 assessment have not been used, as these relate to immature (rather than adult) birds, and are not considered relevant to the in-combination assessment for SEP and DEP.

Table 6-2: In-Combination displacement matrix for guillemot from FFC SPA from OWFs in the UK North Sea, with the ranges of displacement and mortality considered by the assessment shown in red

		Mortality (%)										
Displacement (%)		1	2	3	4	5	10	20	30	50	80	100
	10	36	73	109	145	182	363	727	1090	1817	2907	3634
	20	73	145	218	291	363	727	1453	2180	3634	5814	7267
	30	109	218	327	436	545	1090	2180	3270	5450	8721	10901
	40	145	291	436	581	727	1453	2907	4360	7267	11627	14534
	50	182	363	545	727	908	1817	3634	5450	9084	14534	18168
	60	218	436	654	872	1090	2180	4360	6540	10901	17441	21801
	70	254	509	763	1017	1272	2543	5087	7630	12717	20348	25435
	80	291	581	872	1163	1453	2907	5814	8721	14534	23255	29069
	90	327	654	981	1308	1635	3270	6540	9811	16351	26162	32702
	100	363	727	1090	1453	1817	3634	7267	10901	18168	29069	36336

40. As for the **RIAA** [APP-59], PVA was undertaken to assess the population-level impacts from the displacement effects. The same population model was used as for FFC SPA guillemot population in the **RIAA** [APP-59], for which details and the underpinning demographic parameters are outlined in ES **Appendix 11.1 - Offshore Ornithology Technical Report** [APP-195]. The levels of potential additional mortality considered in the PVA were for the same combinations of displacement rates and mortality rates as in the **RIAA** [APP-59] – i.e. 1%, 2%, 5% and 10% mortality for displacement rates of 30%,40%, 50%, 60% and 70% (**Table 6-2** and **Table 6-3**). The PVA projections extended over an assumed 40-year operational period.

41. The levels of mortality resulting from SEP and DEP in-combination with other projects are lower, overall, than those that were predicted in the **RIAA** [APP-59]. Thus, for the evidence-based displacement and mortality rates of 50% and 1%, respectively, the estimated in-combination mortality is 182 adult birds (**Table 6-2**) which compares with 220 adult birds as estimated in the **RIAA** [APP-59]. As would be expected, the resultant CPS value indicates a smaller impact on the population than as predicted in the **RIAA** [APP-59], with the CPS for the evidence-based displacement and mortality rates of 50% and 1%, respectively, being 0.934 (**Table 6-3** - which compares with a value of 0.920 for this combination of displacement and mortality rates as estimated in the **RIAA** [APP-59]). The CGR value estimated for this combination of displacement and mortality rates does not differ to that estimated in the **RIAA** [APP-59], at least when it is expressed to three decimal places. The lower levels of impact predicted on the population when compared with those predicted in the **RIAA** [APP-59] are reflected in the respective CGR and CPS values derived for the full range of displacement and mortality rates that are considered within the PVAs.

42. On this basis, the conclusions of the **RIAA** [APP-59] in relation to the FFC SPA guillemot population remain unchanged and the predicted guillemot mortality due to the effects of operational phase displacement at SEP, DEP and SEP and DEP combined, in-combination with other projects would not result in an AEoI of the FFC SPA.

Table 6-3: PVA Outputs for the FFC SPA Breeding Guillemot Population in Relation to the Predicted Displacement Effects Resulting from SEP and DEP In-Combination with Other Projects

Displacement rate	Mortality rate	Annual mortality (number of breeding adults)	Increase in annual mortality rate[1]	Median CGR[2]	Median CPS[3]
30%	1%	109	0.0008952478	0.999	0.960
	2%	218	0.0017904956	0.998	0.921
	5%	545	0.0044762390	0.995	0.814
	10%	1090	0.0089524779	0.990	0.662
40%	1%	145	0.0011909260	0.999	0.947
	2%	291	0.0023900652	0.997	0.896
	5%	727	0.0059710564	0.993	0.759
	10%	1453	0.0119338995	0.987	0.576
50%	1%	182	0.0014948174	0.998	0.934
	2%	363	0.0029814216	0.997	0.872
	5%	908	0.0074576605	0.992	0.709
	10%	1817	0.0149235343	0.983	0.501
60%	1%	218	0.0017904956	0.998	0.921
	2%	436	0.0035809912	0.996	0.848
	5%	1090	0.0089524779	0.990	0.662
	10%	2180	0.0179049559	0.980	0.436
70%	1%	254	0.0020861738	0.998	0.909
	2%	509	0.0041805608	0.995	0.825
	5%	1272	0.0104472954	0.988	0.617
	10%	2543	0.0208863774	0.977	0.379

Notes

1. Calculated as the absolute difference between the mortality rates for the unimpacted (i.e. baseline) and impacted populations, expressed as a proportion, for a starting population size of 121,754 breeding adults and a baseline annual mortality rate of 0.061.
2. CGR is the counterfactual of annual population growth rate, calculated as the median of the ratio of the annual growth rate of the impacted to un-impacted (or baseline) population, expressed as a proportion.

Displacement rate	Mortality rate	Annual mortality (number of breeding adults)	Increase in annual mortality rate[1]	Median CGR[2]	Median CPS[3]
3. CPS is the counterfactual of population size, calculated as the median of the ratio of the end-point size of the impacted to un-impacted population size, expressed as a proportion. In this case, the end-point population size is predicted on the basis of a 40-year operational period.					

7 FFC SPA Kittiwake

7.1 Apportioning

43. Natural England were largely in agreement with the apportioning approach set out in the **RIAA** [APP-59], but advised that it is not appropriate to correct the BDMPS apportioning in the non-breeding season for the proportion of adults observed in the baseline survey data. This is because the proportion of adults is already corrected for with the BDMPS figures, and applying this correction 'double corrects', reducing the level of impact apportioned.

44. This change to the apportioning methodology has been made. For SEP and DEP, 83.9% of birds present during the breeding season were calculated to be breeding adults belonging to the FFC SPA (based on 100% FFC SPA breeding adult apportioning and the fact that 83.9% of birds recorded during the breeding season for which a plumage was assigned were adults), in addition to 7.2% (i.e. (75,234 * 0.6) / 627,816) and 5.4% (i.e. (75,234 * 0.6) / 829,937) of birds present at SEP and DEP during the spring and autumn migration seasons respectively.

45. Updated in-combination values for operational phase collision risk have been calculated, using the updated CRM avoidance rate for kittiwake provided by Natural England in Appendix B1 of their Relevant Representation [RR-063], and including values from Rampion 2 PEIR (GoBe Consultants, Wood Group UK, 2021a) and updated values from the HP4 (Ørsted, 2022).

7.2 Revised Predicted Impacts

7.2.1 Collision

46. The annual estimated collision impacts of SEP, DEP, and SEP and DEP on the FFC SPA kittiwake qualifying feature, based on the apportioning rates presented in **Section 7.1**, and the updated CRMs presented in **CRM Updates (EIA Context) Technical Note** [document reference 13.2], are presented in **Table 7-1**.

Table 7-1: Estimated annual collision risk for breeding adult FFC SPA kittiwake at SEP, DEP, and SEP and DEP, along with associated increases in mortality within the population.

OWF	Output	Annual FFCSPA kittiwake collision rate	% increase to annual mortality of FFC SPA kittiwake population[1]
DEP	95% UCI	14.34	0.10
	Mean	5.80	0.04

OWF	Output	Annual FFCSPA kittiwake collision rate	% increase to annual mortality of FFC SPA kittiwake population[1]
	95% LCI	0.91	0.01
SEP	95% UCI	2.67	0.02
	Mean	0.55	0.00
	95% LCI	0.00	0.00
SEP and DEP	95% UCI	17.01	0.11
	Mean	6.36	0.04
	95% LCI	0.91	0.01

Notes

1. Background population is FFC SPA breeding adults (103,070 individuals), adult age class annual mortality rate of 0.146 (Horswill and Robinson, 2015)

7.2.2 Potential Effects of SEP and DEP In-Combination with Other Projects

47. Seasonal and annual in-combination totals of estimated collision mortality of breeding adult kittiwakes of the FFC SPA at all OWFs included in the in-combination assessment are presented in **Table 7-2**.

48. The total predicted annual collision mortality for breeding adult kittiwakes from the FFC SPA is 292.7 individuals (**Table 7-2**). Between them, SEP and DEP contribute 6.4 birds to this total, or 2.2%. The predicted in-combination mortality would increase the baseline adult mortality rate of the FFC SPA breeding adult kittiwake population by 1.9%. This magnitude of increase could result in detectable population level effects.

Table 7-2: Estimated Collision Mortality at UK North Sea OWFs for Kittiwake by Season, Including those Apportioned to FFC SPA Breeding Adult Population

Tier	OWF	Seasonal population at risk of collision[1]							
		Breeding		Autumn migration		Spring migration		Annual	
		Total	FFC	Total	FFC	Total	FFC	Total	FFC
1	Beatrice	68.9	0.0	7.8	0.4	28.9	2.1	105.6	2.5
1	Beatrice Demonstrator	0.0	0.0	1.5	0.1	1.2	0.1	2.8	0.1
1	Blyth Demonstration Project	1.2	0.0	1.7	0.1	1.0	0.1	3.9	0.1
1	Dudgeon	-	-	-	-	-	-	-	-
1	East Anglia ONE	1.3	0.0	116.7	6.3	34.0	2.5	152.0	8.7
1	European Offshore Wind Deployment Centre	8.6	0.0	4.2	0.2	0.8	0.1	13.6	0.3
1	Galloper	4.6	0.0	20.2	1.1	23.1	1.7	47.9	2.8
1	Greater Gabbard	0.8	0.0	10.9	0.6	8.3	0.6	20.0	1.2
1	Gunfleet Sands	-	-	-	-	-	-	-	-
1	Hornsea Project One	32.0	26.5	40.7	2.2	15.2	1.1	87.9	29.8
1	Humber Gateway	1.4	1.4	2.3	0.1	1.4	0.1	5.1	1.6
1	Hywind	12.1	0.0	0.7	0.1	0.7	0.1	13.3	0.1
1	Kentish Flats	0.0	0.0	0.7	0.1	0.5	0.1	1.2	0.1
1	Kentish Flats Extension	0.0	0.0	0.0	0.0	2.0	0.1	2.0	0.1
1	Kincardine	16.0	0.0	6.5	0.4	0.7	0.1	23.3	0.4

Tier	OWF	Seasonal population at risk of collision[1]							
		Breeding		Autumn migration		Spring migration		Annual	
		Total	FFC	Total	FFC	Total	FFC	Total	FFC
1	Lincs	0.5	0.5	0.9	0.1	0.5	0.1	1.9	0.6
1	London Array	1.0	0.0	1.7	0.1	1.3	0.1	4.0	0.2
1	Lynn and Inner Dowsing	-	-	-	-	-	-	-	-
1	Race Bank	1.4	1.4	17.4	0.9	4.1	0.3	22.8	2.6
1	Rampion	39.6	0.0	27.2	1.5	21.6	1.5	88.4	3.1
1	Scroby Sands	-	-	-	-	-	-	-	-
1	Sheringham Shoal	-	-	-	-	-	-	-	-
1	Teesside	27.9	0.0	17.5	0.9	1.8	0.1	47.2	1.1
1	Thanet	0.1	0.0	0.4	0.0	0.3	0.0	0.8	0.1
1	Westermost Rough	0.1	0.1	0.1	0.0	0.1	0.0	0.4	0.1
2	Triton Knoll	17.9	17.9	101.1	5.5	33.0	2.4	152.0	25.7
3	Dogger Bank Creyke Beck Projects A and B	209.9	40.6	98.2	5.3	214.8	15.5	522.9	61.3
3	Dogger Bank Teesside Projects A and B	99.6	19.2	66.0	3.6	157.7	11.3	323.3	34.1
3	East Anglia THREE	4.4	0.0	50.2	2.7	27.3	2.0	82.0	4.7
3	Firth of Forth Alpha and Bravo	111.3	0.0	227.7	12.3	180.1	12.9	519.1	25.2
3	Hornsea Project Three[2]	56.0	0.0	27.6	0.0	5.8	0.0	89.5	0.0

Tier	OWF	Seasonal population at risk of collision[1]							
		Breeding		Autumn migration		Spring migration		Annual	
		Total	FFC	Total	FFC	Total	FFC	Total	FFC
3	Hornsea Project Two	11.6	9.7	6.5	0.4	2.2	0.1	20.4	10.2
3	Inch Cape	9.5	0.0	163.5	8.8	46.2	3.3	219.2	12.1
3	Methil	0.3	0.0	0.0	0.0	0.0	0.0	0.3	0.0
3	Moray Firth (EDA)	31.7	0.0	1.5	0.1	14.0	1.0	47.2	1.1
3	Moray West	57.5	0.0	17.5	0.9	5.1	0.4	80.0	1.3
3	Neart na Gaoithe	23.9	0.0	40.8	2.2	3.2	0.2	67.9	2.5
3	Norfolk Boreas[2]	9.7	0.0	23.4	0.0	8.7	0.0	41.8	0.0
3	Norfolk Vanguard[2]	15.9	0.0	11.9	0.0	14.0	0.0	41.8	0.0
3	East Anglia ONE North	29.4	0.0	5.9	0.0	2.5	0.0	37.8	0.0
3	East Anglia TWO	21.5	0.0	3.9	0.0	5.4	0.0	30.8	0.0
Total (all projects above)		927.5	117.2	1124.6	56.8	867.7	59.9	2919.9	233.9
5	*Hornsea Project Four*	54.2	51.2	10.1	0.5	3.3	0.2	67.6	52.0
5	*Rampion 2 (PEIR)*	1.3	0.0	1.2	0.1	5.3	0.4	7.7	0.4
5	*DEP*	6.6	5.6	3.4	0.2	0.9	0.1	10.9	5.80
5	*SEP*	0.6	0.5	0.9	0.0	0.0	0.0	1.5	0.55
Total (all projects)		990.2	174.5	1140.1	57.6	877.3	60.6	3007.6	292.7

Notes

1. See **Appendix 11.2 Supplementary Information to Inform the Offshore Ornithology Cumulative Impact Assessment** [APP-196] for further details and sources of seasonal populations for other OWFs besides SEP and DEP. Dashes indicate no data available for a given OWF.

Tier	OWF	Seasonal population at risk of collision[1]							
		Breeding		Autumn migration		Spring migration		Annual	
		Total	FFC	Total	FFC	Total	FFC	Total	FFC

2. Hornsea Project THREE, Norfolk Vanguard, Norfolk Boreas, East Anglia ONE North and East Anglia TWO have been consented on the condition that impacts on FFC SPA kittiwakes are compensated. Therefore, the number of birds from this population lost due to impacts at these OWFs are assumed to be zero, which is reflected in the totals.

49. As for the **RIAA** [APP-59], PVA was undertaken to assess the population-level impacts associated with the in-combination collision mortality. The same population model was used as for the FFC SPA kittiwake population in the **RIAA** [APP-59], for which details and the underpinning demographic parameters are outlined in **ES Appendix 11.1 - Offshore Ornithology Technical Report** [APP-195]. The levels of additional mortality considered in the PVA were as specified in **Table 7-3** (with these in-turn derived from the totals in **Table 7-2**), with the PVA projections extending over an assumed 40-year operational period.

50. The levels of mortality resulting from the in-combination scenarios are lower, overall, than those that were predicted in the **RIAA** [APP-59]. Thus, the predicted additional annual mortality for SEP and DEP in-combination with the other OWFs is 293 adult birds (**Table 7-2**) which is 40% lower than the total for SEP and DEP in-combination with the other OWFs as estimated in the **RIAA** [APP-59] (i.e. 488 adult birds). As would be expected, the resultant counterfactuals of annual population growth rate (CGR) and population size (CPS) indicate substantially smaller population level impacts than those predicted in the **RIAA** [APP-59], with the values for SEP and DEP in-combination with the other OWFs being 0.997 for CGR and 0.871 for CPS (**Table 6-3** - which compares with values of 0.994 for the CGR and 0.794 for CPS in the **RIAA** [APP-59]).

51. However, despite the lower predicted collision mortality (when compared with that predicted in the **RIAA** [APP-59]), it is considered that the level of mortality from SEP and DEP in-combination with the other OWFs may still be sufficient to affect the potential for the “restore” conservation objective for the SPA kittiwake population to be achieved. Whilst noting the concerns over the basis for the “restore” objective (as outlined in the **RIAA** [APP-59]) and the very small contribution of SEP (particularly) and DEP to the in-combination collision mortality, it is concluded that the potential for an AEoI of the FFC SPA cannot be ruled out.

Table 7-3: PVA outputs for the FFC SPA kittiwake population in relation to the predicted collision mortality resulting from SEP and DEP in-combination with other projects.

In-combination scenario	Annual mortality (number of breeding adults)	Increase in annual mortality rate[1]	Median CGR[2]	Median CPS[3]
Tier 1-3 OWFs	233.9	0.0022693315	0.997	0.896
Tier 1-4 OWFs	286.4	0.0027782090	0.997	0.874
Tier 1-4 OWFs plus SEP and DEP	292.7	0.0028398176	0.997	0.871

Notes

1. Calculated as the absolute difference between the mortality rates for the unimpacted (i.e. baseline) and impacted populations, expressed as a proportion, for a starting population size of 26,784 breeding adults and a baseline annual mortality rate of 0.081.
2. CGR is the counterfactual of annual population growth rate, calculated as the median of the ratio of the annual growth rate of the impacted to un-impacted (or baseline) population, expressed as a proportion.

In-combination scenario	Annual mortality (number of breeding adults)	Increase in annual mortality rate[1]	Median CGR[2]	Median CPS[3]
3. CPS is the counterfactual of population size, calculated as the median of the ratio of the end-point size of the impacted to un-impacted population size, expressed as a proportion. In this case, the end-point population size is predicted on the basis of a 40-year operational period.				

8 FFC SPA Razorbill

8.1 Apportioning

52. The **RIAA** [APP-59] set out that during the breeding season, it did not seem likely that there was connectivity between SEP and DEP, and the breeding adult razorbill population of the FFC SPA.

53. Natural England's Relevant Representation [RR-063] recommended that some level of apportioning is presented for FFC SPA razorbill.

54. SEP and DEP are situated 112km and 116km respectively from the FFC SPA boundary at the nearest point. Excluding data from breeding razorbills at Fair Isle, where reduced prey availability was considered to be causing substantially increased foraging ranges during the breeding season, the mean maximum foraging range of razorbill is 73.8km (±48.4km) (Woodward et al., 2019).

55. The mean maximum foraging range plus one standard deviation (122.2km) is greater than the distance between FFC SPA and SEP and DEP. However, this measurement is considered to be a poor indicator of typical foraging behaviour. It would be expected that few breeding adult birds or foraging trips will occur at this distance from the colony, and even fewer with any regularity.

56. To estimate the proportion of FFC SPA breeding adults present at SEP and DEP, the number of SPA breeding adults presented in Furness (2015) (20,002) is divided by the number of UK North Sea and Channel BDMPS immature birds (289,560). Such an approach is considered reasonable given the fact that a high proportion of razorbills occurring in offshore waters are likely to be immature birds (based upon the stable age structures estimated from population models (e.g. Furness 2015)), whilst SEP and DEP are at the extremity of the breeding season foraging range of razorbill from the FFC SPA. Therefore, it is not credible to assume that a high proportion of the birds occurring at SEP and DEP during the breeding season are adults from the FFC SPA. This results in an estimated proportion of FFC SPA breeding adult birds present at SEP and DEP during the breeding season of 6.9%.

57. During autumn and spring migration, it is assumed that 3.4% of razorbills present at SEP and DEP (i.e. (20,002 * 0.9) / 591,874) are FFC SPA breeding adults. During the winter season, the corresponding percentage is 2.7% (i.e. (20,002 * 0.3) / 218,622).

8.2 Revised Predicted Impacts

8.2.1 Operational Phase Displacement

58. The annual estimated displacement impacts of SEP, DEP, and SEP and DEP on the FFC SPA razorbill qualifying feature, based on the apportioning rates presented in **Section 8.1**, using the same methods used in the **RIAA** [APP-59], are presented in **Table 8-1**, **Table 8-2** and **Table 8-3** respectively. These numbers also incorporate the correction of mean peak counts for the breeding season and autumn migration season being mistakenly reversed during the production of displacement matrices, as explained in **Section 1**.

Table 8-1: Predicted operational phase displacement and mortality of FFC SPA breeding adult razorbills at DEP

Mean peak abundance estimate type	Mean peak abundance estimate by season[1]	Number of SPA breeding adults present by season[2]	Year round mortality range[3]	Year round annual baseline mortality increase range (%)[3,4]
Upper 95% CI	1,469 (b) 6,857 (aut) 1,348 (win) 652 (spr) 10,326 (year round)	101 (b) 233 (aut) 36 (win) 22 (spr) 393 (year round)	1 - 28 (2)	0.03 - 0.65 (0.05)
Mean	923 (b) 3,741 (aut) 845 (win) 320 (spr) 5,829 (year round)	64 (b) 127 (aut) 23 (win) 11 (spr) 225 (year round)	0 - 16 (1)	0.02 - 0.37 (0.03)
Lower 95% CI	518 (b) 1,266 (aut) 450 (win) 85 (spr) 2,319 (year round)	36 (b) 43 (aut) 12 (win) 3 (spr) 94 (year round)	0 - 7 (0)	0.01 - 0.15 (0.01)

Notes

1. Breeding season = b, autumn migration season = aut, winter season = win, spring migration season = spr

2. For breeding season (Apr-Jul), assumes 6.9% of birds are FFC SPA breeding adults. For autumn migration and spring migration seasons, assumes 3.4% of birds are FFC SPA breeding adults. For winter season, assumes 2.7% of birds are FFC SPA breeding adults.

3. Assumes displacement rates of 0.300 to 0.700 and mortality rate of 1% to 10% of displaced birds. Evidence-based estimates assuming a 0.500 displacement rate and 1% mortality of displaced birds are presented in parentheses.

4. Background population is FFC SPA breeding adults (40,506 individuals), adult age class annual mortality rate of 10.5% (Horswill and Robinson, 2015)

Table 8-2: Predicted operational phase displacement and mortality of FFC SPA breeding adult razorbills at SEP

Mean peak abundance estimate type	Mean peak abundance estimate by season[1]	Number of SPA breeding adults present by season[2]	Year round mortality range[3]	Year round annual baseline mortality increase range (%)[3,4]
Upper 95% CI	421 (b) 1,245 (aut) 1,112 (win) 300 (spr) 3,078 (year round)	29 (b) 42 (aut) 30 (win) 10 (spr) 112 (year round)	0 - 8 (1)	0.01 - 0.18 (0.01)
Mean	316 (b) 759 (aut) 686 (win) 144 (spr) 1,905 (year round)	22 (b) 26 (aut) 19 (win) 5 (spr) 71 (year round)	0 - 5 (0)	0.01 - 0.12 (0.01)
Lower 95% CI	206 (b) 326 (aut) 339 (win) 26 (spr) 897 (year round)	14 (b) 11 (aut) 9 (win) 1 (spr) 35 (year round)	0 - 2 (0)	0.00 - 0.06 (0.00)

Notes

1. Breeding season = b, autumn migration season = aut, winter season = win, spring migration season = spr

2. For breeding season (Apr-Jul), assumes 6.9% of birds are FFC SPA breeding adults. For autumn migration and spring migration seasons, assumes 3.4% of birds are FFC SPA breeding adults. For winter season, assumes 2.7% of birds are FFC SPA breeding adults.

3. Assumes displacement rates of 0.300 to 0.700 and mortality rate of 1% to 10% of displaced birds. Evidence-based estimates assuming a 0.500 displacement rate and 1% mortality of displaced birds are presented in parentheses.

4. Background population is FFC SPA breeding adults (40,506 individuals), adult age class annual mortality rate of 10.5% (Horswill and Robinson, 2015)

Table 8-3: Predicted operational phase displacement and mortality of FFC SPA breeding adult razorbills at SEP and DEP

Mean peak abundance estimate type	Mean peak abundance estimate by season[1]	Number of SPA breeding adults present by season[2]	Year round mortality range[3]	Year round annual baseline mortality increase range (%)[3,4]
Upper 95% CI	1,890 (b) 8,101 (aut) 2,460 (win) 951 (spr) 13,402 (year round)	131 (b) 275 (aut) 66 (win) 32 (spr) 505 (year round)	2 - 35 (3)	0.04 - 0.83 (0.06)
Mean	1,239 (b) 4,500 (aut) 1,531 (win)	86 (b) 153 (aut) 41 (win)	1 - 21 (1)	0.02 - 0.49 (0.03)

Mean peak abundance estimate type	Mean peak abundance estimate by season[1]	Number of SPA breeding adults present by season[2]	Year round mortality range[3]	Year round annual baseline mortality increase range (%)[3,4]
	464 (spr) 7,734 (year round)	16 (spr) 296 (year round)		
Lower 95% CI	724 (b) 1,591 (aut) 789 (win) 111 (spr) 3,214 (year round)	50 (b) 54 (aut) 21 (win) 4 (spr) 129 (year round)	0 - 9 (1)	0.01 - 0.21 (0.02)

Notes

1. Breeding season = b, autumn migration season = aut, winter season = win, spring migration season = spr

2. For breeding season (Apr-Jul), assumes 6.9% of birds are FFC SPA breeding adults. For autumn migration and spring migration seasons, assumes 3.4% of birds are FFC SPA breeding adults. For winter season, assumes 2.7% of birds are FFC SPA breeding adults.

3. Assumes displacement rates of 0.300 to 0.700 and mortality rate of 1% to 10% of displaced birds. Evidence-based estimates assuming a 0.500 displacement rate and 1% mortality of displaced birds are presented in parentheses.

4. Background population is FFC SPA breeding adults (40,506 individuals), adult age class annual mortality rate of 10.5% (Horswill and Robinson, 2015)

8.2.2 Potential Effects of SEP and DEP In-Combination with Other Projects

8.2.2.1 Operational Phase Displacement/Barrier Effects

59. Seasonal and annual population estimates of breeding adult razorbill of the FFC SPA at all OWFs included in the in-combination assessment are presented in **Table 8-4**. The values used are unchanged from those provided in the **RIAA** [APP-59], except for updated values for HP4 (Ørsted, 2022) and the addition of values from the Rampion 2 PEIR (GoBe Consultants, Wood Group UK, 2021a & 2021b).

60. The estimated annual total of breeding adult razorbills from FFC SPA at risk of displacement from all OWFs within the UK North Sea BDMPS combined is 6,978 (**Table 8-4**). Of this total, SEP and DEP contribute 1.0% and 3.2% respectively. Using displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% of displaced birds (UK SNCBs, 2017), the number of FFC SPA birds predicted to die each year would be between 21 to 488 (**Table 8-5**).

61. The estimated increase in mortality of FFC SPA breeding adult razorbill due to in-combination displacement impacts is between 0.49% and 11.48%. Increases in the existing mortality rate of greater than 1% could be detectable against natural variation.

Table 8-4: Seasonal and Annual Population Estimates of All Razorbills at SEP, DEP and Other OWFs Included in the In-Combination Assessment, and Breeding Adult Birds Apportioned to FFC SPA

Tier	OWF	Seasonal population at risk of displacement[1]									
		Breeding		Autumn migration		Winter		Spring migration		Total	
		Total	FFC	Total	FFC	Total	FFC	Total	FFC	Total	FFC
1	Beatrice	873.0	0.0	833.0	28.3	555.0	15.0	833.0	28.3	3094.0	72.0
1	Beatrice Demonstrator	No estimate available									
1	Blyth Demonstration Project	121.0	0.0	91.0	3.1	61.0	1.6	91.0	3.1	364.0	8.0
1	Dudgeon	256.0	0.0	346.0	11.8	745.0	20.1	346.0	11.8	1693.0	44.0
1	East Anglia ONE	16.0	0.0	26.0	0.9	155.0	4.2	336.0	11.4	533.0	17.0
1	European Offshore Wind Deployment Centre	161.0	0.0	64.0	2.2	7.0	0.2	26.0	0.9	258.0	3.0
1	Galloper	44.0	0.0	43.0	1.5	106.0	2.8	394.0	13.4	587.0	18.0
1	Greater Gabbard	0.0	0.0	0.0	0.0	387.0	10.5	84.0	2.8	471.0	13.0
1	Gunfleet Sands	0.0	0.0	0.0	0.0	30.0	0.8	0.0	0.0	30.0	1.0
1	Hornsea Project One	1109.0	534.5	4812.0	163.6	1518.0	41.0	1803.0	61.3	9242.0	800.0
1	Humber Gateway	27.0	0.0	20.0	0.7	13.0	0.4	20.0	0.7	80.0	2.0
1	Hywind	30.0	0.0	719.0	24.4	10.0	0.3			759.0	25.0
1	Kentish Flats	No estimate available									

Tier	OWF	Seasonal population at risk of displacement[1]									
		Breeding		Autumn migration		Winter		Spring migration		Total	
		Total	FFC	Total	FFC	Total	FFC	Total	FFC	Total	FFC
1	Kentish Flats Extension	No estimate available									
1	Kincardine	22.0	0.0		0.0		0.0			22.0	0.0
1	Lincs & LID	45.0	0.0	34.0	1.1	22.0	0.6	34.0	1.1	134.0	3.0
1	London Array	14.0	0.0	20.0	0.7	14.0	0.4	20.0	0.7	68.0	2.0
1	Race Bank	28.0	0.0	42.0	1.4	28.0	0.8	42.0	1.4	140.0	4.0
1	Rampion	630.0	0.0	66.0	2.2	1244.0	33.6	3327.0	113.1	5267.0	149.0
1	Scroby Sands	No estimate available									
1	Sheringham Shoal	106.0	0.0	1343.0	45.7	211.0	5.7	30.0	1.0	1690.0	52.0
1	Teesside	16.0	0.0	61.0	2.1	2.0	0.1	20.0	0.7	99.0	3.0
1	Thanet	3.0	0.0	0.0	0.0	14.0	0.4	21.0	0.7	37.0	1.0
1	Westermost Rough	91.0	91.0	121.0	4.1	152.0	4.1	91.0	3.1	455.0	102.0
2	Triton Knoll	40.0	0.0	254.0	8.6	855.0	23.1	117.0	4.0	1265.0	36.0
3	Dogger Bank Creyke Beck A	1250.0	375.0	1576.0	53.6	1728.0	46.7	4149.0	141.1	8703.0	616.0
3	Dogger Bank Creyke Beck B	1538.0	461.4	2097.0	71.3	2143.0	57.9	5119.0	174.0	10897.0	765.0
3	Dogger Bank Teesside A	834.0	250.2	310.0	10.6	959.0	25.9	1919.0	65.2	4022.0	352.0

Tier	OWF	Seasonal population at risk of displacement[1]									
		Breeding		Autumn migration		Winter		Spring migration		Total	
		Total	FFC	Total	FFC	Total	FFC	Total	FFC	Total	FFC
3	Dogger Bank Teesside B	1153.0	345.9	592.0	20.1	1426.0	38.5	2953.0	100.4	6125.0	505.0
3	East Anglia ONE North	403.0	0.0	85.0	2.9	54.0	1.5	207.0	7.0	749.0	11.0
3	East Anglia THREE	1807.0	0.0	1122.0	38.1	1499.0	40.5	1524.0	51.8	5952.0	130.0
3	East Anglia TWO	281.0	0.0	44.1	1.5	136.4	3.7	230.0	7.8	692.0	13.0
3	Firth of Forth Alpha	5876.0	0.0			1103.0	29.8			6979.0	30.0
3	Firth of Forth Bravo	3698.0	0.0			1272.0	34.3			4970.0	34.0
3	Hornsea Project Three[2]	630.0	0.0	2020.0	69.0	3649.0	99.0	2105.0	72.0	8404.0	240.0
3	Hornsea Project Two	2511.0	1210.3	4221.0	143.5	720.0	19.4	1668.0	56.7	9119.0	1430.0
3	Inch Cape	1436.0	0.0	2870.0	97.6	651.0	17.6			4957.0	115.0
3	Methil	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0
3	Moray Firth (EDA)	2423.0	0.0	1103.0	37.5	30.0	0.8	168.0	5.7	3724.0	44.0
3	Moray West	2808.0	0.0	3544.0	120.5	184.0	5.0	3585.0	121.9	10121.0	247.0
3	Neart na Gaoithe	331.0	0.0	5492.0	186.7	508.0	13.7			6331.0	200.0
3	Norfolk Boreas	630.0	0.0	263.0	8.9	1065.0	28.8	345.0	11.7	2303.0	49.0
3	Norfolk Vanguard	879.0	0.0	866.0	29.5	839.0	22.7	924.0	31.4	3508.0	84.0
Total (all projects above)		32124	3268	35100	1194	24095	652	32531	1106	123848	6220

Tier	OWF	Seasonal population at risk of displacement[1]									
		Breeding		Autumn migration		Winter		Spring migration		Total	
		Total	FFC	Total	FFC	Total	FFC	Total	FFC	Total	FFC
5	*Hornsea Project Four*	*386.0*	*215.4*	*4311.0*	*145.7*	*455.0*	*12.5*	*449.0*	*15.2*	*8586.0*	*388.7*
5	*Rampion 2*	*44.0*	*0.0*	*18.0*	*0.6*	*22.0*	*0.6*	*2130.0*	*72.0*	*2214.0*	*73.2*
5	*SEP and DEP*	1238.5	85.5	4500.0	153.0	1530.5	41.3	464.0	15.8	7733.0	295.6
Total (all projects)		33793	3569	43929	1493	26103	706	35574	1209	142381	6978

Notes

1. The preferred standard area over which to assess razorbill displacement is the OWF plus a 2km buffer, however the buffer zones included in this assessment varied between 0-4km depending on the data available, see **Appendix 11.2 Supplementary Information to Inform the Offshore Ornithology Cumulative Impact Assessment** [APP-196] for further details and sources of seasonal populations for other OWFs besides SEP and DEP. Dashes indicate no data available for a given OWF.
2. For Hornsea Project Three, values for the breeding season align with those presented for East Anglia One North (SPR, 2019). Values presented for in the Hornsea Project Four assessment have not been used, as these relate to immature (rather than adult) birds, and are not considered relevant to the in-combination assessment for SEP and DEP.

Table 8-5: In-Combination Displacement Matrix for Razorbill from FFC SPA from OWFs in the UK North Sea, with the Ranges of Displacement and Mortality Considered by the Assessment Shown in Red

	Mortality (%)										
Displacement (%)	**1**	**2**	**3**	**4**	**5**	**10**	**20**	**30**	**50**	**80**	**100**
10	7	14	21	28	35	70	140	209	349	558	698
20	14	28	42	56	70	140	279	419	698	1116	1396
30	21	42	63	84	105	209	419	628	1047	1675	2093
40	28	56	84	112	140	279	558	837	1396	2233	2791
50	35	70	105	140	174	349	698	1047	1744	2791	3489
60	42	84	126	167	209	419	837	1256	2093	3349	4187
70	49	98	147	195	244	488	977	1465	2442	3907	4884
80	56	112	167	223	279	558	1116	1675	2791	4466	5582
90	63	126	188	251	314	628	1256	1884	3140	5024	6280
100	70	140	209	279	349	698	1396	2093	3489	5582	6978

62. As for the **RIAA** [APP-59], PVA was undertaken to assess the population-level impacts from the displacement effects. The same population model was used as for FFC SPA razorbill population in the **RIAA** [APP-59], for which details and the underpinning demographic parameters are outlined in **ES Appendix 11.1 - Offshore Ornithology Technical Report** [APP-195]. The levels of potential additional mortality considered in the PVA were for the same combinations of displacement rates and mortality rates as in the **RIAA** [APP-59] – i.e. 1%, 2%, 5% and 10% mortality for displacement rates of 30%,40%, 50%, 60% and 70% (**Table 8-5** and **Table 8-6**). The PVA projections extended over an assumed 40-year operational period.

63. The levels of mortality resulting from SEP and DEP in-combination with other projects are lower, overall, than those that were predicted in the **RIAA** [APP-59], although the differences are small. Thus, for the evidence-based displacement and mortality rates of 50% and 1%, respectively, the estimated mortality is 35 adult birds (**Table 8-5**), which compares with 36 adult birds as estimated in the **RIAA** [APP-59]. For this combination of displacement and mortality rates, the resultant CPS and CGR values are equivalent to those calculated in the **RIAA** [APP-59] (i.e. CGR = 0.999, CPS = 0.959 – **Table 8-6**), indicating that the predicted level of impact on the population remains the same as in the **RIAA** [APP-59]. At higher displacement and mortality rate combinations, the resultant CGR and CPS values are slightly greater than as calculated in the **RIAA** [APP-59] for the equivalent combination, indicating slightly lower levels of population-level impact.

64. On this basis, the conclusions of the **RIAA** [APP-59] in relation to the FFC SPA razorbill population remain unchanged and the predicted razorbill mortality due to the effects of operational phase displacement at SEP, DEP and SEP and DEP, in-

combination with other projects would not result in an adverse effect on integrity of the FFC SPA.

Table *8-6*: *PVA Outputs for the FFC SPA Breeding Razorbill Population in Relation to the Predicted Displacement Effects Resulting from SEP and DEP In-Combination with Other Projects*

Displacement rate	Mortality rate	Annual mortality (number of breeding adults)	Increase in annual mortality rate[1]	Median CGR[2]	Median CPS[3]
30%	1%	21	0.0005184417	0.999	0.975
	2%	42	0.0010368834	0.999	0.951
	5%	105	0.0025922086	0.997	0.881
	10%	209	0.0051597294	0.994	0.778
40%	1%	28	0.0006912556	0.999	0.967
	2%	56	0.0013825112	0.998	0.935
	5%	140	0.0034562781	0.996	0.846
	10%	279	0.0068878685	0.992	0.715
50%	1%	35	0.0008640695	0.999	0.959
	2%	70	0.0017281390	0.998	0.920
	5%	174	0.0042956599	0.995	0.812
	10%	349	0.0086160075	0.990	0.658
60%	1%	42	0.0010368834	0.999	0.951
	2%	84	0.0020737668	0.998	0.904
	5%	209	0.0051597294	0.994	0.778
	10%	419	0.0103441465	0.988	0.605
70%	1%	49	0.0012096973	0.999	0.943
	2%	98	0.0024193947	0.997	0.889
	5%	244	0.0060237989	0.993	0.746
	10%	488	0.0120475979	0.986	0.556

Notes

1. Calculated as the absolute difference between the mortality rates for the unimpacted (i.e. baseline) and impacted populations, expressed as a proportion, for a starting population size of 121,754 breeding adults and a baseline annual mortality rate of 0.061.
2. CGR is the counterfactual of annual population growth rate, calculated as the median of the ratio of the annual growth rate of the impacted to un-impacted (or baseline) population, expressed as a proportion.
3. CPS is the counterfactual of population size, calculated as the median of the ratio of the end-point size of the impacted to un-impacted population size, expressed as a proportion. In this case, the end-point population size is predicted on the basis of a 40-year operational period.

9 FFC SPA Puffin

9.1 Apportioning

65. Puffin is a named component of the breeding seabird assemblage qualifying feature of FFC SPA only, as opposed to a qualifying feature in its own right (Natural England, 2020). It was screened out of the **RIAA** [APP-59]. The **HRA Screening Report** [APP-060] concluded that puffin could be present at SEP and DEP, and therefore could be susceptible to a range of impact pathways, including operational phase displacement. However, it is not considered likely that sufficient numbers would be present at SEP and DEP for Likely Significant Effect to occur.

66. Natural England's Relevant Representation [RR-063] recommended that apportioning is presented for FFC SPA puffin and advised that, as a component of the breeding seabird assemblage, it will need to be considered as part of the assessment of impacts on the assemblage.

67. SEP and DEP are situated 112km and 116km respectively from the FFC SPA boundary at the nearest point. Excluding data from breeding puffins at Fair Isle, where reduced prey availability was considered to be causing substantially increased foraging ranges during the breeding season, the mean maximum foraging range of puffin is 119.6km (±131.2km) (Woodward et al., 2019).

68. The mean maximum foraging range of FFC SPA puffin means that SEP and DEP are within the foraging range of this species. However, given the distance between SEP and DEP and FFC SPA, it would be expected that the significant majority of FFC SPA breeding adult puffin foraging activity will occur closer to the colony than SEP and DEP. In addition, it would also be expected that an unknown proportion of birds at SEP and DEP during this season will not be breeding adult FFC SPA birds.

69. To estimate the proportion of FFC SPA breeding adults present at SEP and DEP, the number of SPA breeding adults presented in Furness (2015) (1,916) is divided by the number of UK North Sea and Channel BDMPS immature birds (31,984). Such an approach is considered reasonable given that a high proportion of puffins occurring in offshore waters are likely to be immature birds (based upon the stable age structures estimated from population models (e.g. Furness 2015)), and that SEP and DEP are at the extremity of the breeding season foraging range of puffin from the FFC SPA. Therefore, it is not credible to assume that a high proportion of the birds occurring at SEP and DEP during the breeding season are adults from the FFC SPA. This results in an estimated proportion of FFC SPA breeding adult birds present at SEP and DEP during the breeding season of 6.0%.

70. During the non-breeding season, it is assumed that 0.4% of puffins present at SEP and DEP are FFC SPA breeding adults, based on dividing the number of FFC SPA breeding adults present in UK waters during this season (i.e. 1,916 * 0.5) by the total number of puffins present in UK waters during this season (231,957) (Furness 2015).

9.2 Predicted Impacts

9.2.1 Operational Phase Displacement/Barrier Effects

71. The annual estimated displacement impacts of SEP, DEP, and SEP and DEP on the FFC SPA puffin qualifying feature, based on the apportioning rates presented in **Section 9.1** and using the same methods as used in the **RIAA** [APP-59] to estimate displacement of other species (UK SNCBs, 2017), are presented in **Table 9-1, Table 9-2,** and **Table 9-3** respectively. Thus, displacement rates of 0.30 to 0.70, combined with mortality rates of 1% to 10% amongst the birds estimated to be displaced, were applied to the each seasonally specific mean peak abundance estimate as apportioned to the FFC SPA puffin population.

Table 9-1: Predicted Operational Phase Displacement and Mortality of FFC SPA Breeding Adult Puffins at DEP

Mean peak abundance estimate type	Mean peak abundance estimate by season[1]	Number of SPA breeding adults present by season[2]	Year round mortality range[3]	Year round annual baseline mortality increase range (%)[3,4]
Upper 95% CI	52 (b) 93 (nb) 145 (year round)	3 (b) 0 (nb) 3 (year round)	0 - 0 (0)	0.00 - 0.09 (0.01)
Mean	24 (b) 46 (nb) 69 (year round)	1 (b) 0 (nb) 1 (year round)	0 - 0 (0)	0.00 - 0.04 (0.00)
Lower 95% CI	6 (b) 14 (nb) 20 (year round)	0 (b) 0 (nb) 0 (year round)	0 - 0 (0)	0.00 - 0.01 (0.00)

Notes
1. Breeding season = b, non-breeding season = nb

2. For breeding season (Apr - early Aug), assumes 6.0% of birds are FFC SPA breeding adults. For non-breeding season, assumes 0.4% of birds are FFC SPA breeding adults.

3. Assumes displacement rates of 0.300 to 0.700 and mortality rate of 1% to 10% of displaced birds. Evidence-based estimates assuming a 0.500 displacement rate and 1% mortality of displaced birds are presented in parentheses.

4. Background population is FFC SPA breeding adults (2,879 individuals on sea (Aitken et al., 2017), likely an underestimate of total population), adult age class annual mortality rate of 0.094 (Horswill and Robinson, 2015)

Table 9-2: Predicted Operational Phase Displacement and Mortality of FFC SPA Breeding Adult Puffins at SEP

Mean peak abundance estimate type	Mean peak abundance estimate by season[1]	Number of SPA breeding adults present by season[2]	Year round mortality range[3]	Year round annual baseline mortality increase range (%)[3,4]
Upper 95% CI	26 (b) 34 (nb)	2 (b) 0 (nb)	0 - 0 (0)	0.00 - 0.04 (0.00)

Mean peak abundance estimate type	Mean peak abundance estimate by season[1]	Number of SPA breeding adults present by season[2]	Year round mortality range[3]	Year round annual baseline mortality increase range (%)[3,4]
	60 (year round)	2 (year round)		
Mean	10 (b) 18 (nb) 28 (year round)	1 (b) 0 (nb) 1 (year round)	0 - 0 (0)	0.00 - 0.02 (0.00)
Lower 95% CI	0 (b) 2 (nb) 2 (year round)	0 (b) 0 (nb) 0 (year round)	0 - 0 (0)	0.00 - 0.00 (0.00)

Notes
1. Breeding season = b, non-breeding season = nb

2. For breeding season (Apr - early Aug), assumes 6.0% of birds are FFC SPA breeding adults. For non-breeding season, assumes 0.4% of birds are FFC SPA breeding adults.

3. Assumes displacement rates of 0.300 to 0.700 and mortality rate of 1% to 10% of displaced birds. Evidence-based estimates assuming a 0.500 displacement rate and 1% mortality of displaced birds are presented in parentheses.

4. Background population is FFC SPA breeding adults (2,879 individuals on sea (Aitken et al., 2017), likely an underestimate of total population), adult age class annual mortality rate of 0.094 (Horswill and Robinson, 2015)

Table 9-3: Predicted Operational Phase Displacement and Mortality of FFC SPA Breeding Adult Puffins at SEP and DEP

Mean peak abundance estimate type	Mean peak abundance estimate by season[1]	Number of SPA breeding adults present by season[2]	Year round mortality range[3]	Year round annual baseline mortality increase range (%)[3,4]
Upper 95% CI	78 (b) 127 (nb) 205 (year round)	5 (b) 1 (nb) 5 (year round)	0 - 0 (0)	0.01 – 0.13 (0.01)
Mean	34 (b) 63 (nb) 97 (year round)	2 (b) 0 (nb) 2 (year round)	0 - 0 (0)	0.00 - 0.06 (0.00)
Lower 95% CI	6 (b) 16 (nb) 21 (year round)	0 (b) 0 (nb) 0 (year round)	0 - 0 (0)	0.00 - 0.01 (0.00)

Notes
1. Breeding season = b, non-breeding season = nb

2. For breeding season (Apr - early Aug), assumes 6.0% of birds are FFC SPA breeding adults. For non-breeding season, assumes 0.4% of birds are FFC SPA breeding adults.

3. Assumes displacement rates of 0.300 to 0.700 and mortality rate of 1% to 10% of displaced birds. Evidence-based estimates assuming a 0.500 displacement rate and 1% mortality of displaced birds are presented in parentheses.

Mean peak abundance estimate type	Mean peak abundance estimate by season[1]	Number of SPA breeding adults present by season[2]	Year round mortality range[3]	Year round annual baseline mortality increase range (%)[3,4]
4. Background population is FFC SPA breeding adults (2,879 individuals on sea (Aitken et al., 2017), likely an underestimate of total population), adult age class annual mortality rate of 0.094 (Horswill and Robinson, 2015)				

72. The assessment of displacement effects on puffin from FFC SPA predicts that there would be no measurable increase in mortality as a result of SEP and/or DEP, either alone or cumulatively. Even taking the upper 95% abundance estimate and maximum (and highly unrealistic) level of displacement mortality, mortality of FFC SPA puffins is predicted to increase by only 0.36 birds, representing a 0.13% increase to the baseline mortality rate. This is well below the threshold that would be detectable against natural variation. Using mean abundance values and a realistic 50% displacement and 1% mortality, the number of birds predicted to die would be 0.001, which would produce no measurable increase in mortality within the FFC SPA population.

73. Accordingly, it can be concluded that predicted puffin mortality due to operational phase displacement at SEP, DEP, and SEP and DEP would not adversely affect the integrity of the FFC SPA.

9.2.2 Potential Effects of SEP and DEP In-Combination with Other Projects

9.2.2.1 Operational Phase Displacement/Barrier Effects

74. Given that no measurable increase in FFC SPA puffin mortality is predicted as a result of SEP and DEP, it is concluded that there would be no contribution to in-combination effects on this feature. Therefore, it is concluded that predicted puffin mortality due to displacement and barrier effects at SEP, DEP, and SEP and DEP, in-combination with other projects, would not adversely affect the integrity of the FFC SPA.

10 FFC SPA Seabird Assemblage

10.1 Qualifying feature

75. The breeding seabird assemblage qualifying feature for FFC SPA comprised 216,730 individual seabirds at classification, and 298,544 individuals in 2017 (Natural England, 2020). The Supplementary Advice on Conservation Objectives (SACOs; Natural England, 2020) for the seabird assemblage feature of the FFC SPA includes the following attributes and associated targets:

- Abundance: Maintain the overall abundance of the assemblage at a level which is above 216,730 individuals whilst avoiding deterioration from its current level as indicated by the latest mean peak count or equivalent.
- Diversity: Maintain the species diversity of the assemblage.

- Supporting habitats – extent and distribution of supporting habitat for the breeding season: Maintain the extent, distribution and availability of suitable breeding habitat which supports the feature for all necessary stages of its breeding cycle.
- Supporting habitats – quality of supporting breeding habitat: Maintain the structure, function and availability of the following habitats which support the assemblage feature for all stages.

76. There is potential for SEP and DEP (in relation to both project alone and in-combination effects) to have effects on the overall abundance and species diversity of the seabird assemblage qualifying feature, as well as on supporting habitats. This is considered in the sections below.

77. The assemblage comprises nine species:
- Gannet
- Kittiwake
- Guillemot
- Razorbill
- Fulmar
- Puffin
- Herring gull
- Cormorant
- Shag

78. Of these, the first four (gannet, kittiwake, guillemot and razorbill) are qualifying species of FFC SPA in their own right, and effects on these species have therefore been considered separately. In accordance with Natural England advice, further assessment of effects on puffin, which is an assemblage species only, has also been undertaken (**Section 9**).

79. Further consideration of the effects on the remaining species and the full assemblage is provided in the following sections.

10.1.1 Fulmar

80. The **HRA Screening Report** [APP-060] screened out potential effects on fulmar from FFC SPA, both during and outside the breeding season, due to the low sensitivity of this species to collision and disturbance/displacement effects.

10.1.2 Herring gull

81. The **HRA Screening Report** [APP-060] screened out potential effects on herring gull from FFC SPA, both during and outside the breeding season. SEP and DEP are beyond the mean maximum foraging range (and mean maximum +1SD) for this species during the breeding season. The screening report estimated that approximately 0.4% of birds present at SEP and DEP outside of the breeding season would be from this SPA. Updated CRM for this species estimates mean annual mortality of less than one bird (0.4); therefore, the number of mortalities for birds apportioned to FFC SPA (0.0016 birds) would be undetectable against natural variation, and would not contribute to any in-combination effect.

10.1.3 Cormorant and shag

82. The **HRA Screening Report** [APP-060] screened out potential effects on cormorant and shag from FFC SPA, both during and outside the breeding season. For both species, SEP and DEP are beyond the mean maximum foraging range (and mean maximum +1SD) for these species during the breeding season, and these species do not occur at SEP and DEP outside of the breeding season.

10.2 Assessment of Effect on Integrity (Alone and In-Combination)

10.2.1 Assemblage of Species: Abundance

83. As set out above, no significant changes to the abundance of fulmar, herring gull, cormorant and shag are predicted as a result of SEP and DEP. For the other assemblage species, the conclusions of the **RIAA** [APP-59] and relevant updates presented in this document are as follows:

- Gannet: The combined operational phase collision and displacement annual mortality for SEP and DEP (project alone, assuming displacement rate of 0.70) apportioned to FFC SPA is 2.94 birds, representing a 0.14% increase in FFC SPA mortality (**Table 5-5**). In-combination with other projects (and applying 70% macro-avoidance for collision risk and displacement rate of 0.70), the annual mortality is 131.5 birds, representing a 6.1% increase in the baseline mortality rate of the FFC SPA population (**Table 5-9**). The PVA outputs for gannet suggest that there is potential for small impacts on the annual population growth rate as a result of these in-combination effects but (as detailed in the **RIAA** [APP-59]) such levels of impact are highly unlikely to prevent further increases in the size of this population (**Table 5-10**).
- Kittiwake: Operational phase mean collision mortality for SEP and DEP (project alone) is 6.36 birds, representing a 0.04% increase in FFC SPA mortality (**Table 7-1**). In-combination with other projects, the annual mortality is 292.7 birds (**Table 7-2**), representing a 1.9% increase in FFC SPA mortality (**Paragraph 48**). The PVA outputs for kittiwake suggest that the predicted in-combination mortality may be sufficient to affect the potential for the “restore” objective for this SPA population to be achieved (**Table 7-3**), leading to the conclusion that the potential for an AEoI cannot be excluded. However, the scale of the potential impact is not considered sufficient to have the potential to affect the SACO target concerning the overall abundance of the seabird assemblage feature from being achieved.

- Guillemot: Operational phase displacement mean annual mortality for SEP and DEP (project alone, as presented in Table 9-109 of the **RIAA** [APP-59]) is between two and 49 birds, representing a 0.03-0.66% increase in FFC SPA mortality. In-combination with other projects, the annual mortality is between 109 and 2,543 birds (**Table 6-2**), representing a 1.47-34.24% increase in FFC SPA mortality (**Paragraph 39**), but noting that the effects based on the higher rates of displacement and mortality are considered overly precautionary. The PVA outputs for guillemot suggest small population-level impacts only over the range of displacement and mortality rates that are considered more reasonable on the basis of available evidence (**Table 6-3**), with no potential for an adverse effect to result. Consequently, it is considered that the effects on the SPA guillemot population would not prevent achievement of the SACO target relating to the overall abundance of the seabird assemblage feature.
- Razorbill: Operational phase displacement annual mortality for SEP and DEP (project alone) is between one and 21 birds, representing a 0.02-0.49% increase in FFC SPA mortality (**Table 8-3**). In-combination with other projects, the annual mortality is between 21 and 488 birds (**Table 8-5**), representing a 0.49-11.48% increase in FFC SPA mortality (**Paragraph 61**), but noting that the effects based on the higher rates of displacement and mortality are considered overly precautionary. The PVA outputs for razorbill suggest small population-level impacts only over the range of displacement and mortality rates that are considered more reasonable on the basis of available evidence (**Table 8-6**), with no potential for an adverse effect to result. Consequently, it is considered that effects on the SPA razorbill population would not prevent achievement of the SACO target relating to the overall abundance of the seabird assemblage feature.
- Puffin: No measurable increase in baseline annual mortality rate as a result of the additional mortality from operational phase displacement due to SEP and DEP (project alone) is predicted (**Table 9-3**). The levels of potential displacement mortality for the project alone scenario are so low that no contribution to the in-combination FFC SPA puffin mortality (**Paragraph 74**) is predicted. Consequently, it is considered that effects on the SPA puffin population would not prevent achievement of the SACO target relating to the overall abundance of the seabird assemblage feature.

10.2.2 Assemblage of Species: Diversity

84. Based on the information set out above and the assessments of the individual FFC SPA species populations which have been undertaken (both in the **RIAA** [APP-59] and, where relevant, as updated in this document), it is considered that there is no potential for any of the nine species to be lost from the FFC SPA breeding population as a result of effects from SEP, DEP or SEP and DEP, either for the project alone

or in-combination with other projects. The potential for an AEoI is identified only in relation to the FFC SPA kittiwake population in relation to SEP and DEP in-combination with other OWFs. This potential effect is not considered likely to lead to a risk of this population being lost from the breeding seabird assemblage at the FFC SPA, on the basis of the large size of this population, the limited scale of the predicted impact (relative to the population size) and the (slightly) increasing trend in population size over the last 15 – 20 years (at least). Therefore, the diversity of the assemblage would be maintained.

10.2.3 Supporting Habitat: Extent and Distribution of Supporting Habitat for the Breeding Season; and Supporting habitat: Quality of Supporting Breeding Habitat

85. FFC SPA is located 112km and 116km from SEP and DEP respectively, at its closest point. For assemblage species that are within the breeding season foraging range (i.e. gannet, kittiwake, razorbill, fulmar and puffin), it will be the case that areas closer to individual breeding sites within the SPA are likely to be of greater importance to foraging adult birds from the colony; i.e. that SEP and DEP will be located outside the core foraging range for these species. This is supported by evidence from tracking studies, which are discussed in the **RIAA** [APP-59]. For example, modelled at-sea utilisation distributions of breeding adult gannets, based on GPS tracking data (Langston *et al.*, 2013; Wakefield *et al.*, 2013) suggest that SEP and DEP are outside the core foraging range for this species.

86. Furthermore, at a distance of 112km from the breeding colony (i.e. the distance from SEP), and assuming 50% of the area around the colony is sea, the available foraging area would be approximately 19,704km^2. SEP and DEP occupy a total area of approximately 212km^2, which represents approximately 1% of the available sea area at this distance from the colony. Even if this was within a core foraging area for birds from the FFC SPA colony during the breeding season, it is very unlikely that this would represent a significant effect on the extent of available habitat for qualifying species. Therefore, taking into account the distance from the SPA and the fact that SEP and DEP are considered to be outside of core foraging areas for all assemblage species, it can be concluded that there would be no AEoI from SEP and/or DEP on the extent, distribution or quality of supporting habitat for assemblage species during the breeding season, and that any such effects are so minor (and unlikely to manifest) that they would not contribute in a meaningful way to any in-combination effect with other projects.

10.2.4 Conclusion

87. Given the above, it is concluded that the effects from SEP, DEP, and SEP and DEP, both alone and in-combination with other projects, would not result in an adverse effect on the breeding seabird assemblage qualifying feature of the FFC SPA.

11 GW SPA Red-throated Diver

11.1 Methods

11.1.1 Construction Phase Displacement / Barrier Effects

88. Section 9.3.3.4.4.1 of the **RIAA** [APP-59] addresses predicted construction-phase red-throated diver mortality as a result of cable-laying operations through the GW SPA, and no changes to this element of the assessment are proposed. However, in Natural England's Relevant Representation [RR-063], additional information was requested to assess the reduction in available habitat as a result of cable installation vessels.

89. The assessment of the effective area within the SPA over which displacement could occur has been calculated using the same approach as the mortality assessment from cable-laying operations, as presented in section 9.3.3.4.4.1 of the **RIAA** [APP-59]. It has been assumed that there would be 100% displacement effect within 2km of the cable laying vessel; this aligns with the approach used for the mortality assessment in the **RIAA** [APP-59]. This has been assessed in the context of the total GW SPA area (3,535.78km^2). A qualitative assessment of the likely temporal effects and other relevant considerations has also been undertaken.

11.1.2 Operation and Maintenance Phase Displacement Estimates

90. Updated operational phase displacement estimates for red-throated diver have been calculated using the same approach as the **RIAA** [APP-59] but using updated displacement rates which are provided in Table 3 of Appendix B of the Natural England Relevant Representation [RR-063] and which are replicated in **Table 11-1**. Displacement has been calculated within the SEP wind farm site and in 1km bands out to 10km from the boundary. However, as SEP is located approximately 6km from the boundary of GW SPA, there would be no overlap with the SPA 10km buffer until 6km from SEP, and therefore only bands from 6-10km are required for the project-alone assessment.

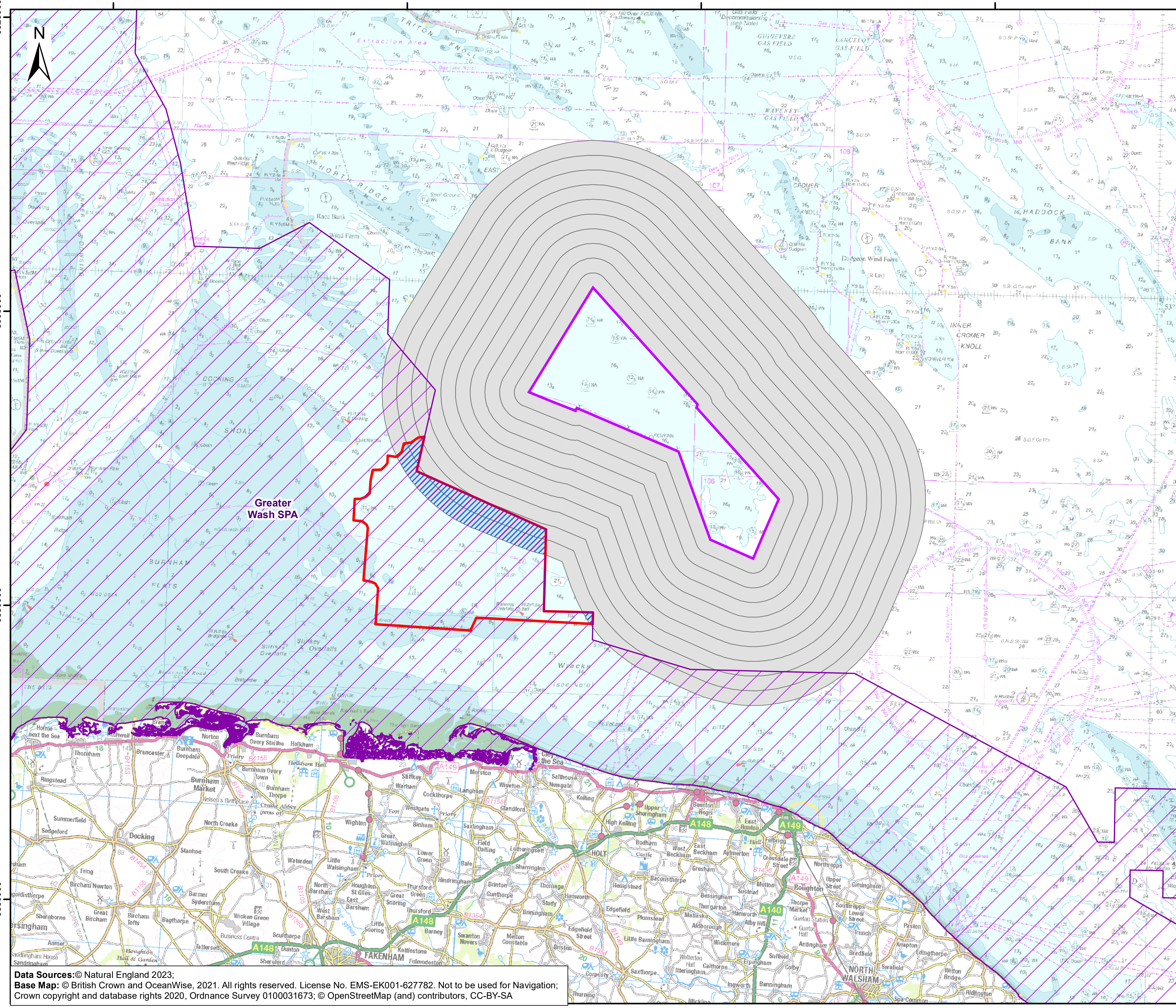
91. Updated estimates have also been calculated for the area within the SPA within which displacement could occur, based on Natural England's new displacement rates. Minor changes to the areas used for this calculation have all been used in the updated estimates, based on revised GIS analysis (**Appendix 3**). Two estimates have been presented; the first uses the same approach as the **RIAA** [APP-59]. The second uses information presented within the Departmental Brief for GW SPA (Natural England and JNCC, 2016) and which at a meeting on 15 November 2022 the Applicant was recommended by Natural England to investigate further. This method excludes an area of the SPA that is outside of the Maximum Curvature Analysis (MCA) for red-throated diver. The MCA is presented in the Departmental Brief (Natural England and JNCC, 2016) and identifies the areas where significant densities of red-throated diver are likely to be present, based on data presented in Lawson *et al.* (2016). This information contributed to determining the SPA boundary. A section of the GW SPA, which is also within 10km of SEP, lies outside the MCA for red-throated diver (**Figure 1**), i.e. the section of the SPA which was designated

on the basis of a different qualifying species (little gull) and not on the basis of the distribution of red-throated diver. As this area lies outside the zone designated for red-throated diver within the GW SPA, it is considered reasonable to exclude it from the estimate of the displacement area for this species (see **Figure 1**).

Table 11-1: Displacement gradient for red-throated diver (Appendix B of Natural England Relevant Representation [RR-063]) (greyed-out values are not required for the project alone assessment)

Buffer region (km)	Displacement rate (%)
Within OWF	100
0-1	80
1-2	74
2-3	68
3-4	63
4-5	57
5-6	51
6-7	46
7-8	40
8-9	34
9-10	29

92. All other parameters used in the updated red-throated diver displacement estimates are unchanged from the **RIAA** [APP-59]. However, it should be noted that within the RIAA, estimates were calculated up to 12km from the SEP boundary, whereas the updated Natural England advice requires estimates to 10km only; this approach (i.e. displacement calculated to 10km, using the updated displacement values provided by Natural England) has therefore been used.



Data Sources: © Natural England 2023;

Sheringham Shoal and Dudgeon Extension Projects

Title: Figure 1: Overlap of SEP 10km buffer (in 1km increments) with Greater Wash SPA and Red-throated Diver MCA (from Lawson et al., 2016)

Document: Apportioning and Habitats Regulations Assessment Updates Technical Note

Legend:

- Sheringham Shoal Offshore Wind Farm Extension Project Wind Farm Site
- Special Protection Area (SPA)
- Red-throated Diver MCA boundary
- Overlap with Greater Wash SPA and Red-throated Diver MCA
- 1km bands (1 to 10km)

Coordinate Reference System: WGS 1984 UTM Zone 31N
Transformation WGS84: OSGB_1936_To_WGS_1984_7

0 4 8 12 16 km
0 2 4 6 8 Nautical Miles

Scale: 1:250,000 Scale at size: A3

Equinor Doc. no.: C282-RH-Z-GA-000XX
RHDHV Doc. no.: PB8164-RHD-ZZ-OF-DR-Z-0261

REV	DATE	STATUS	DRW	CHK	APR
A	18/01/2023	First Issue	GC	RB	PM

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11.1.3 Background Population for Habitats Regulations Assessment

93. The relevant reference population for the HRA is the cited GW SPA population, which was 1,511 non-breeding individuals (Natural England, 2018). The annual baseline mortality of this population, assuming that the published mortality rate for all age classes of 22.8% applies (Horswill and Robinson, 2015), is 345 birds.

11.1.4 In-combination Assessment

94. The in-combination assessment has been updated using the same approach as the **RIAA** [APP-59], but with updated displacement values for 1-10km from the relevant OWFs (Westermost Rough, Humber Gateway, Triton Knoll, Race Bank, Lincs, Inner Dowsing, Sheringham Shoal, Lynn and Scroby Sands) calculated using density estimates from Lawson *et al.* (2016) and displacement rates from Appendix B of the Natural England Relevant Representation [RR-063]; **Table 11-1**). No relevant additional projects were identified for the updated assessment. The in-combination assessment for mortality (both project alone and in-combination) is based on the full SPA boundary; areas outside the red-throated diver MCA have not been excluded, as these areas are accounted for by the low red-throated diver densities in these areas from Lawson *et al.* (2016).

11.2 Results

95. It should be noted that the conclusions of the updated assessments in **Sections 10.2.1** and **10.2.2** below have not changed from those stated in the **RIAA** [APP-59] i.e. there would be no adverse effect on the red-throated diver feature of the GW SPA from operational phase displacement from SEP alone, or from SEP in-combination with other projects.

11.2.1 Potential Construction Phase Displacement / Barrier Effects on Greater Wash SPA Red-Throated Diver of SEP and DEP

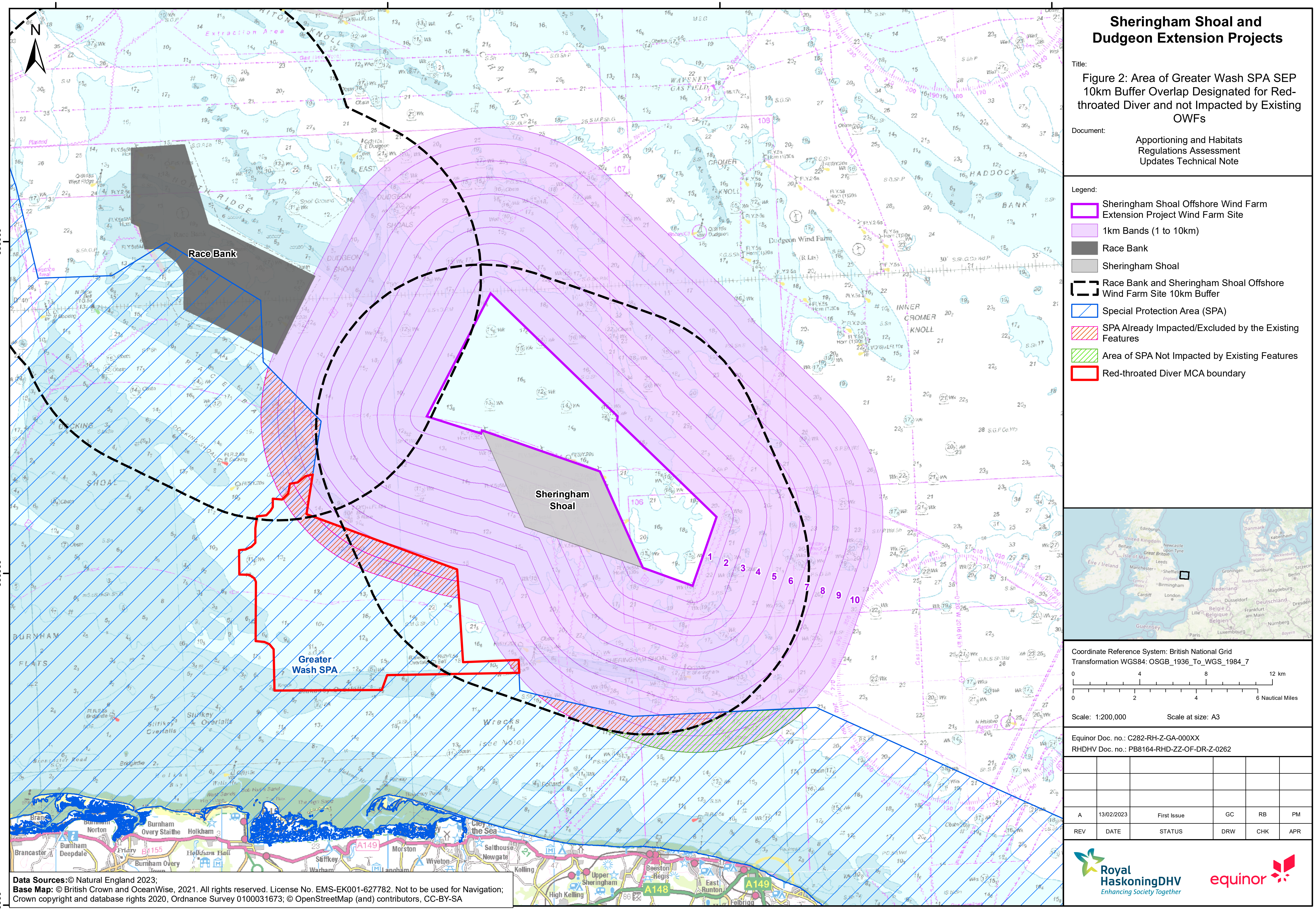
96. ES **Chapter 4 – Project Description** [APP-090] provides information on the expected cable-laying approach for SEP, DEP and SEP and DEP combined. One export cable would be required for each Project (i.e. two cables for SEP and DEP combined), with a cable length of 40km (SEP) and 62km (DEP); a total of 102km. The total duration of cable installation would be approximately 50 days for SEP and 60 days for DEP, or 100 days for SEP and DEP if these were installed as part of a concurrent construction scenario. However, the majority of cable laying activity would be undertaken outside the GW SPA; only approximately 9.6km of the total length of each of the two cable routes would be within the SPA. Assuming that displacement effects on red-throated diver could occur up to 2km from cable laying vessels, up to 11.6km of the cable laying activity (so for two cables; a total of 23.2km) could theoretically affect red-throated divers within the SPA. In total, therefore, this would represent approximately 23% of the total cable laying activity. Assuming that levels of activity are equal across the length of the cables, the total duration of activity affecting the SPA (assuming a worst case of 110 days, where SEP and DEP cables were installed separately) would be approximately 25 days.

97. The total affected area of the GW SPA at any one point in time (assuming one cable-laying vessel would be active at any one time, and that displacement effects would occur up to 2km from the vessel) would be 12.57km^2. This represents approximately 0.36% of the total GW SPA (3,535.78km^2). In accordance with evidence presented for East Anglia One North (SPR, 2019), the low speed of cable laying vessels is likely to be significantly less than typical tidal flows. Therefore, cable laying vessels can be considered effectively stationary (as far as the birds are concerned), and any impact would therefore occur around a single static point.

98. In accordance with the evidence presented in the **RIAA** [APP-59], this value is considered precautionary, as it would be expected that the level of effect would decline as distance from the vessel increased, but the calculation assumes 100% effect across all of the 2km impact area. It would also be expected that red-throated divers would return to the affected area after vessel departure; Burger *et al.* (2019) found that divers disturbed by vessels 'travelling at high speed' showed slow resettlement, while vessels sailing at 'medium speed' showed more rapid resettlement over an observed time period of seven hours. It is therefore reasonable to assume that resettlement would be more rapid again for very slow (i.e. effectively stationary) vessels during cable laying operations. Therefore, given the predicted short duration of the effects, it is considered very unlikely that there would be any detectable effects once cable laying was completed. Overall, no changes to the assessment presented in the **RIAA** [APP-59] are required; it is concluded that there would be no adverse effect on the integrity of the Greater Wash SPA red-throated diver population as a result of construction activity within the export cable corridor for SEP, DEP and SEP and DEP combined.

11.2.2 Potential Operation and Maintenance Phase Displacement / Barrier Effects on Greater Wash SPA Red-Throated Diver of SEP

99. **Table 11-2** presents the updated results of the SEP alone operational phase displacement/barrier effects calculation. **Table 11-3** presents updated values for the effective areas over which displacement of red-throated diver could occur within the GW SPA due to operational phase displacement effects from SEP. Separate estimates are presented that include and exclude areas within 10km of existing OWFs (Sheringham Shoal Offshore Wind Farm (SOW) and Race Bank); i.e. the latter accounts for the displacement effects which are already expected to occur; these areas (together with the area outside of the red-throated diver MCA) are shown hatched red ('SPA already Impacted/Excluded by the Existing Features') on **Figure 2**. **Table 11-4** presents values for the effective areas over which displacement of red-throated diver could occur within the GW SPA due to operational phase displacement effects from SEP, but excluding areas outside of the MCA for red-throated diver. The effective net area potentially impacted by SEP, i.e. within the red-throated diver MCA and outside areas within 10km of existing windfarms, is 4.39km^2 or 0.12% of GW SPA; the net impacted area is shown hatched green on **Figure 2**. As DEP is more than 10km from the Greater Wash SPA, no effects are predicted for this OWF.



Data Sources: © Natural England 2023;
Base Map: © British Crown and OceanWise, 2021. All rights reserved. License No. EMS-EK001-627782. Not to be used for Navigation; Crown copyright and database rights 2020, Ordnance Survey 0100031673; © OpenStreetMap (and) contributors, CC-BY-SA

Sheringham Shoal and Dudgeon Extension Projects

Title:

Figure 2: Area of Greater Wash SPA SEP 10km Buffer Overlap Designated for Red-throated Diver and not Impacted by Existing OWFs

Document:

Apportioning and Habitats Regulations Assessment Updates Technical Note

Legend:

- Sheringham Shoal Offshore Wind Farm Extension Project Wind Farm Site
- 1km Bands (1 to 10km)
- Race Bank
- Sheringham Shoal
- Race Bank and Sheringham Shoal Offshore Wind Farm Site 10km Buffer
- Special Protection Area (SPA)
- SPA Already Impacted/Excluded by the Existing Features
- Area of SPA Not Impacted by Existing Features
- Red-throated Diver MCA boundary

Coordinate Reference System: British National Grid
Transformation WGS84: OSGB_1936_To_WGS_1984_7

0 4 8 12 km
0 2 4 6 Nautical Miles

Scale: 1:200,000 Scale at size: A3

Equinor Doc. no.: C282-RH-Z-GA-000XX
RHDHV Doc. no.: PB8164-RHD-ZZ-OF-DR-Z-0262

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Table 11-2: Potential Operational Phase Displacement / Barrier Effects of Red-Throated Divers within the GW SPA due to SEP

Buffer area	**Displacement[1]**	**Red-throated diver abundance[2]**	**Red-throated diver displacement**	**Predicted mortality[4]**	
				1%	10%
6-7km	46%	0.00[3]	0.00	0.00	0.00
7-8km	40%	0.60	0.24	0.00	0.02
8-9km	34%	2.10	0.71	0.01	0.07
9-10km	29%	4.40	1.28	0.01	0.13
Total		7.10	2.23	0.02	0.22
% increase to mortality[5]				0.01%	0.07%

Notes

[1] Appropriate displacement distances and rates were set on basis of advice given by Natural England (November 2022)

[2] Calculated from mean modelled density estimates from Lawson *et al.* (2016)

[3] No density estimates occurred within this region due to its extremely small size. A mean of the two adjacent density estimates was therefore used as a surrogate.

[4] Mortality rates of displaced birds as previously advised by Natural England (SNCBs, 2017)

[5] Background population of 1,511 individuals, adult age class annual mortality rate of 22.8% (Horswill and Robinson, 2015)

Table 11-3: Effective Area Over which displacement of red-throated diver could occur within the GW SPA due to SEP buffer zones

OWF or buffer area	**% displacement**	**SEP overlap with SPA, including areas overlapping other OWF buffers**		**SEP overlap with SPA, excluding areas overlapping other OWF buffers**	
		Area of buffer overlapping SPA (km^2)	Effective area over which displacement could occur (km^2)[1]	Area of buffer overlapping SPA (km^2)	Effective area over which displacement could occur (km^2)[1]
6-7km	46%	0.85	0.39	0.00	0.00
7-8km	40%	5.08	2.03	0.11	0.04
8-9km	34%	21.65	7.36	5.15	1.75
9-10km	29%	34.94	10.13	13.86	4.02
Total		62.53	19.92	19.12	5.81
As % of Greater Wash SPA (3,535.78km^2)		1.77%	0.56%	0.54%	0.16%

[1] Effective area over which displacement could occur is calculated by multiplying the area of SPA within each buffer band by the % displacement within that band.

Table 11-4: Effective area over which displacement of red-throated diver could occur within the GW SPA due to SEP buffer zones, excluding zone outside of MCA for red-throated diver within the SPA

OWF or buffer area	% displacement	SEP overlap with SPA, including areas overlapping other OWF buffers		SEP overlap with SPA, excluding areas overlapping other OWF buffers	
		Area of buffer overlapping SPA (km^2)	Effective area over which displacement could occur (km^2)[1]	Area of buffer overlapping SPA (km^2)	Effective area over which displacement could occur (km^2)[1]
6-7km	46%	0.85	0.39	0.00	0.00
7-8km	40%	5.02	2.01	0.11	0.04
8-9km	34%	13.66	4.64	4.30	1.46
9-10km	29%	22.48	6.52	9.96	2.89
Total		42.02	13.57	14.37	4.39
As % of Greater Wash SPA (3,535.78km^2)		1.19%	0.38%	0.41%	0.12%
[1] Effective area over which displacement could occur is calculated by multiplying the area of SPA within each buffer band by the % displacement within that band.					

11.2.3 Potential Operational Phase Displacement / Barrier Effects on GW SPA Red-Throated Diver of SEP In-Combination with Other Projects

100. **Table 11-5** presents the updated results of the in-combination operational phase displacement/barrier effects. **Table 11-6** presents updated values for the effective areas over which displacement of red-throated diver could occur within the GW SPA due to operational phase displacement impacts from SEP.

101. All values in the project alone and in-combination assessments are lower than those presented in the **RIAA** [APP-59]. The conclusions of the assessment set out in the RIAA are therefore unchanged; predicted red-throated diver mortality and changes to distribution due to operational phase displacement of SEP, DEP and SEP and DEP combined, in-combination with other projects, would not adversely affect the integrity of the GW SPA.

Table 11-5: Potential in-combination operational phase displacement of red-throated divers within the GW SPA

Buffer area	Displacement rate[1]	Red-throated diver abundance within area of overlap with buffer (number individuals)[2]	Number of red-throated diver predicted to be displaced	Predicted mortality[3]	
				1%	10%
OWF	100%	7.2	7.2	0.1	0.7
0-1km	80%	29.6	23.7	0.2	2.4
1-2km	74%	39.5	29.2	0.3	2.9

Buffer area	Displacement rate[1]	Red-throated diver abundance within area of overlap with buffer (number individuals)[2]	Number of red-throated diver predicted to be displaced	Predicted mortality[3]	
				1%	10%
2-3km	68%	45.7	31.1	0.3	3.1
3-4km	63%	49.6	31.2	0.3	3.1
4-5km	57%	53.9	30.7	0.3	3.1
5-6km	51%	55.9	28.5	0.3	2.9
6-7km	46%	61.6	28.3	0.3	2.8
7-8km	40%	72.0	28.8	0.3	2.9
8-9km	34%	64.9	22.1	0.2	2.2
9-10km	29%	67.2	19.5	0.2	1.9
Total		547.1	280.4	2.8	28.0
% increase to mortality[4]				0.81%	8.14%

Notes

[1] Appropriate displacement distances and rates were set on basis of advice given by Natural England (November 2022)

[2] Calculated from mean modelled density estimates from Lawson *et al.* (2016)

[3] Mortality rates of displaced birds as previously advised by Natural England

[4] Background population of 1,511 individuals, adult age class annual mortality rate of 22.8% (Horswill and Robinson, 2015)

Table 11-6: Effective area over which red-throated diver displacement could occur within the GW SPA due to existing OWFs and SEP buffer zones

OWF or buffer area	% displacement	Existing OWF overlap with SPA		Existing OWF plus SEP overlap with SPA	
		Area of buffer overlapping SPA (km^2)	Effective area over which displacement could occur (km^2)[1]	Area of buffer overlapping SPA (km^2)	Effective area over which displacement could occur (km^2)[1]
OWF	100%	28.11	28.11	28.11	28.11
0-1km	80%	65.07	52.06	65.07	52.06
1-2km	74%	88.13	65.22	88.13	65.22
2-3km	68%	108.73	73.94	108.73	73.94
3-4km	63%	129.35	81.49	129.35	81.49
4-5km	57%	147.79	84.24	147.79	84.24
5-6km	51%	159.74	81.47	159.74	81.47
6-7km	46%	183.16	84.25	183.16	84.25

OWF or buffer area	% displacement	Existing OWF overlap with SPA		Existing OWF plus SEP overlap with SPA	
		Area of buffer overlapping SPA (km^2)	Effective area over which displacement could occur (km^2)[1]	Area of buffer overlapping SPA (km^2)	Effective area over which displacement could occur (km^2)[1]
7-8km	40%	197.77	79.11	198.53	79.41
8-9km	34%	192.85	65.57	201.25	68.43
9-10km	29%	195.35	56.65	203.56	59.03
Total		1467.94	723.99	1485.31	729.53
As % of Greater Wash SPA (3,535.78km^2)		41.52%	20.48%	42.01%	20.63%
[1] Effective area over which displacement could occur is calculated by multiplying the area of SPA within each buffer band by the % displacement within that band.					

12 GW SPA and NNC SPA Sandwich Tern

12.1 Apportioning

102. Natural England were in agreement with the apportioning approach set out in the **RIAA** [APP-59]. It is therefore unchanged in this revised assessment, as summarised in **Paragraphs 103** and **104** below. These values have been used for the updated CRM in **Section 12.2**.

103. For both SEP and DEP, 100% of birds present during the breeding season are considered to be breeding adults belonging to the GW SPA and NNC SPA. Whilst this assumption is reasonable for purposes of assessment, it is likely that this is a precautionary assumption. At around 50km, DEP is considerably beyond the mean maximum foraging range (34.3km (±23.2km)) (Woodward et al., 2019), of birds from the Scolt Head colony (which supports breeding birds belonging to both SPAs). Whilst DEP is within the mean maximum foraging range plus one standard deviation, this measurement is considered to be a poor indicator of typical foraging behaviour. It is therefore probable that a proportion of the birds using DEP will actually be non-breeding birds.

104. In addition, for the NNC SPA only, 21.8% of birds (i.e. (8,270 / 38,051)) present at SEP and DEP during the spring and autumn migration seasons are estimated to be breeding adult birds belonging to this population. This is unchanged from the **RIAA** [APP-59].

12.2 Revised Predicted Impacts

12.2.1 Collision

105. The annual estimated collision impacts of SEP, DEP, and SEP and DEP on the GW SPA and NNC SPA Sandwich tern qualifying feature, based on the apportioning rates presented in **Section 12.1**, and the updated CRMs presented in the **CRM**

Updates (EIA Context) Technical Note [document reference 13.2], are presented in:

- **Table 12-1** – using model-based density estimates and the flight speed of Fijn and Collier (2020) as input parameters
- **Table 12-2** – using model-based density estimates and the flight speed of Fijn and Gyimesi (2018) as input parameters
- **Table 12-3** – using design-based density estimates and the flight speed of Fijn and Collier (2020) as input parameters
- **Table 12-4** – using design-based density estimates and the flight speed of Fijn and Gyimesi (2018) as input parameters

106. The updated CRM uses a revised avoidance rate of 0.990, in accordance with advice provided by Natural England in its Relevant Representation [RR-063]. Other parameters are unchanged from those used in the **RIAA** [APP-59].

Table 12-1: Estimated annual collision risk for GW SPA and NNC SPA Sandwich tern at SEP, DEP, and SEP and DEP, along with associated increases in mortality within largest population size, using model-based density estimates and the flight speed of Fijn and Collier (2020) as a model input

OWF	Output	Annual GW SPA Sandwich tern collision rate	% increase to annual mortality of GW SPA Sandwich tern population[1]	Annual NNC SPA Sandwich tern collision rate	% increase to annual mortality of NNCSPA Sandwich tern population[1]
DEP	95% UCI	7.02	0.73	7.19	0.75
	Mean	4.15	0.43	4.22	0.44
	95% LCI	2.34	0.24	2.37	0.25
SEP	95% UCI	2.49	0.26	2.52	0.26
	Mean	1.36	0.14	1.37	0.14
	95% LCI	0.76	0.08	0.77	0.08
SEP and DEP	95% UCI	9.51	0.99	9.71	1.01
	Mean	5.50	0.57	5.58	0.58
	95% LCI	3.11	0.32	3.13	0.33

Notes

1. Background population is GW / NNC SPA breeding adults (9,443 individuals), adult age class annual mortality rate of 0.102 (Horswill and Robinson, 2015)

Table 12-2 Estimated annual collision risk for GW SPA and NNC SPA Sandwich tern at SEP, DEP, and SEP and DEP, along with associated increases in mortality within largest population size, using model-based density estimates and the flight speed of Fijn and Gyimesi (2018) as a model input

OWF	Output	Annual GW SPA Sandwich tern collision rate	% increase to annual mortality of GW SPA Sandwich tern population[1]	Annual NNC SPA Sandwich tern collision rate	% increase to annual mortality of NNCSPA Sandwich tern population[1]
DEP	95% UCI	8.33	0.86	8.52	0.88
	Mean	4.97	0.52	5.06	0.52
	95% LCI	2.81	0.29	2.84	0.29
SEP	95% UCI	2.99	0.31	3.02	0.31
	Mean	1.63	0.17	1.64	0.17
	95% LCI	0.92	0.10	0.92	0.10
SEP and DEP	95% UCI	11.32	1.17	11.55	1.20
	Mean	6.60	0.69	6.70	0.70
	95% LCI	3.73	0.39	3.76	0.39
1. Background population is GW / NNC SPA breeding adults (9,443 individuals), adult age class annual mortality rate of 0.102 (Horswill and Robinson, 2015)					

Table 12-3: Estimated annual collision risk for GW SPA and NNC SPA Sandwich tern at SEP, DEP, and SEP and DEP, along with associated increases in mortality within largest population size, using design-based density estimates and the flight speed of Fijn and Collier (2020) as a model input

OWF	Output	Annual GW SPA Sandwich tern collision rate	% increase to annual mortality of GW SPA Sandwich tern population[1]	Annual NNC SPA Sandwich tern collision rate	% increase to annual mortality of NNCSPA Sandwich tern population[1]
DEP	95% UCI	10.71	1.11	10.84	1.13
	Mean	3.66	0.38	3.69	0.38
	95% LCI	0.45	0.05	0.45	0.05
SEP	95% UCI	3.02	0.31	3.04	0.32
	Mean	0.92	0.10	0.93	0.10
	95% LCI	0.05	0.01	0.05	0.01
SEP and DEP	95% UCI	13.73	1.43	13.89	1.44
	Mean	4.59	0.48	4.62	0.48
	95% LCI	0.50	0.05	0.50	0.05
Notes					

OWF	Output	Annual GW SPA Sandwich tern collision rate	% increase to annual mortality of GW SPA Sandwich tern population[1]	Annual NNC SPA Sandwich tern collision rate	% increase to annual mortality of NNCSPA Sandwich tern population[1]
1. Background population is GW / NNC SPA breeding adults (9,443 individuals), adult age class annual mortality rate of 0.102 (Horswill and Robinson, 2015)					

Table 12-4 Estimated annual collision risk for GW SPA and NNC SPA Sandwich tern at SEP, DEP, and SEP and DEP, along with associated increases in mortality within largest population size, using design-based density estimates and the flight speed of Fijn and Gyimesi (2018) as a model input

OWF	Output	Annual GW SPA Sandwich tern collision rate	% increase to annual mortality of GW SPA Sandwich tern population[1]	Annual NNC SPA Sandwich tern collision rate	% increase to annual mortality of NNCSPA Sandwich tern population[1]
DEP	95% UCI	12.84	1.33	13.01	1.35
	Mean	4.39	0.46	4.43	0.46
	95% LCI	0.54	0.06	0.54	0.06
SEP	95% UCI	3.62	0.38	3.65	0.38
	Mean	1.11	0.11	1.11	0.12
	95% LCI	0.06	0.01	0.06	0.01
SEP and DEP	95% UCI	16.47	1.71	16.66	1.73
	Mean	5.50	0.57	5.54	0.57
	95% LCI	0.60	0.06	0.60	0.06
1. Background population is GW / NNC SPA breeding adults (9,443 individuals), adult age class annual mortality rate of 0.102 (Horswill and Robinson, 2015)					

12.2.2 Potential effects of SEP and DEP in-combination with other projects

107. Annual in-combination totals of estimated collision mortality of breeding adult Sandwich tern from GW SPA and NNC SPA are presented in **Table 12-5** and **Table 12-6**. These have been calculated based on the apportioning rates presented in **Section 12.1**, and the updated CRMs presented in the **CRM Updates (EIA Context) Technical Note** [document reference 13.2]. Estimates are presented for five different scenarios:

- Scenario A: Consented OWF designs;
- Scenario B: As-built OWF designs;
- Scenario C: As-built OWF designs, with unbuilt capacity built out using turbines of the same specification as the consented design;

- Scenario D: As-built OWF designs, with unbuilt capacity built out using turbines of the same specification as the as-built design; and
- Scenario E: As per scenario D, but with the assumption that the as-built layout of DOW is legally secured through a mechanism within the DCO[1].
- Scenario F: As per Scenario A (consented OWF designs) but with the as-built layout of DOW legally secured through a mechanism within the DCO.

108. The results are presented using the flight speed of Fijn and Collier (2020) as an input parameter (which is considered to be the most realistic value) and both model-based (**Table 12-5**) and design-based (**Table 12-6**) density estimates.

109. Since submission of Revision A of this document at Deadline 1 [REP1-057], a transcription error was identified whereby **Table 12-5** presented incorrect values. This error has now been corrected at Deadline 2 in this Revision B version.

110. The updated CRM uses a revised avoidance rate of 0.990, in accordance with advice provided by Natural England in its Relevant Representation [RR-063]. Other parameters are unchanged from those used in the **RIAA** [APP-59], other than the omission of macro-avoidance values which were used in some scenarios considered for the assessment in the RIAA however it should be noted that the assessments incorporating macro-avoidance did not form the basis of the assessment conclusions in the RIAA.

111. The outputs from the updated CRM are unchanged from those presented in the **RIAA** [APP-59] (where 0.980 avoidance rate and 50% macro-avoidance were used). Accordingly, no update to the PVA has been undertaken, and the conclusions to the RIAA are unchanged, i.e. that an AEoI of the GW SPA and NNC SPA cannot be ruled out as a result of predicted Sandwich tern mortality due to collision at SEP, DEP, and SEP and DEP, in-combination with other OWFs.

Table 12-5: In-combination collision risk for breeding adult Sandwich terns of the GW SPA and NNC SPA, using model-based density estimates and the flight speed of Fijn and Collier (2020) as a model input

OWF	Scenario A	Scenario B	Scenario C	Scenario D	Scenario E	Scenario F
DOW	20.0	16.6	22.3	21.3	16.6	16.6
Race Bank	45.7	15.5	15.9	15.6	15.6	45.7
SOW	8.7	8.7	8.7	8.7	8.7	8.7
Triton Knoll	8.9	3.0	5.6	3.9	3.9	8.9
DEP	4.5	4.5	4.5	4.5	4.5	4.5
SEP	1.4	1.4	1.4	1.4	1.4	1.4
Total (unapportioned)	89.2	49.7	58.4	55.4	50.7	85.8

[1] See Article 45 (Modification of DOW section 36 consent) of the **Draft DCO (Revision D)** [document reference 3.1]

OWF		Scenario A	Scenario B	Scenario C	Scenario D	Scenario E	Scenario F
GW SPA	Total collisions[1]	87.4	48.6	57.3	54.3	49.6	84.6
	% mortality change[3]	9.1%	5.0%	5.9%	5.6%	5.2%	8.8%
NNC SPA	Total collisions[2]	87.8	48.9	57.5	54.5	49.9	85.0
	% mortality change[3]	9.1%	5.1%	6.0%	5.7%	5.2%	8.8%

1. 100% of birds present during the breeding season are considered to be breeding adults belonging to the SPA
2. 100% of birds present during the breeding season and 21.8% of birds during the spring and autumn migration seasons are considered to be breeding adults belonging to the SPA
3. Background population is GW / NNC SPA breeding adults (9,443 individuals), adult age class annual mortality rate of 0.102 (Horswill and Robinson, 2015)

Table 12-6: In-combination collision risk for breeding adult Sandwich terns of the GW SPA and NNC SPA, using design-based density estimates and the flight speed of Fijn and Collier (2020) as a model input

OWF		Scenario A	Scenario B	Scenario C	Scenario D	Scenario E	Scenario F
DOW		20.0	16.6	22.3	21.3	16.6	16.6
RB		45.7	15.5	15.9	15.6	15.6	45.7
SOW		8.7	8.7	8.7	8.7	8.7	8.7
TK		8.9	3.0	5.6	3.9	3.9	8.9
DEP		3.8	3.8	3.8	3.8	3.8	3.8
SEP		0.9	0.9	0.9	0.9	0.9	0.9
Total (unapportioned)		88.0	48.5	57.2	54.2	49.5	84.7
GW SPA	Total collisions[1]	86.5	47.7	56.3	53.4	48.7	83.7
	% mortality change[3]	9.0%	5.0%	5.8%	5.5%	5.1%	8.7%
NNC SPA	Total collisions[2]	86.8	47.9	56.5	53.6	48.9	84.0
	% mortality change[3]	9.0%	5.0%	5.9%	5.6%	5.1%	8.7%

1. 100% of birds present during the breeding season are considered to be breeding adults belonging to the SPA
2. 100% of birds present during the breeding season and 21.8% of birds during the spring and autumn migration seasons are considered to be breeding adults belonging to the SPA

OWF	Scenario A	Scenario B	Scenario C	Scenario D	Scenario E	Scenario F
3. Background population is GW / NNC SPA breeding adults (9,443 individuals), adult age class annual mortality rate of 0.102 (Horswill and Robinson, 2015)						

13 GW SPA Little gull

13.1 Apportioning

112. Natural England were in agreement with the apportioning approach set out in the **RIAA** [APP-59]. It is therefore unchanged in this revised assessment; for both SEP and DEP, 100% of birds present are assumed to belong to the GW SPA population.

13.2 Revised Predicted Impacts

13.2.1 Collision

113. The annual estimated collision impacts of SEP, DEP, and SEP and DEP on the GW SPA little gull qualifying feature, based on the apportioning rate presented in **Section 13.1**, and the updated CRMs presented in the **CRM Updates (EIA Context) Technical Note** [document reference 13.2], are presented in **Table 13-1.**

Table 13-1: Predicted annual collision mortality for little gull at SEP and DEP relevant background populations with corresponding increases to baseline mortality of the population

Site	Annual collisions (mean and 95% CIs)	% annual mortality increase		
		Birds passing through GW area of search, lower estimate[1]	Birds passing through GW area of search, upper estimate[2]	North Sea flyway[3]
DEP	2.36 (0.00-8.08)	0.12 (0.00-0.40)	0.06 (0.00-0.20)	0.02 (0.00-0.05)
SEP	0.53 (0.00-1.80)	0.03 (0.00-0.09)	0.01 (0.00-0.05)	0.00 (0.00-0.01)
SEP and DEP	2.89 (0.00-9.88)	0.14 (0.00-0.49)	0.07 (0.00-0.25)	0.02 (0.00-0.07)
1. Background population of 10,000 individuals, adult age class annual mortality rate of 20.0% (Horswill and Robinson, 2015). Note that no age-class specific survival rates for little gull are available. 2. Background population of 20,000 individuals, adult age class annual mortality rate of 20.0% (Horswill and Robinson, 2015) 3. Background population of 75,000 individuals, adult age class annual mortality rate of 20.0% (Horswill and Robinson, 2015)				

13.2.2 Potential Effects of SEP and DEP In-Combination with Other Projects

114. The total predicted annual in-combination collision mortality for little gull from the GW SPA is 70.2 individuals (**Table 13-2**). Between them, SEP and DEP contribute 2.9 birds to this total, or 4.1%. The predicted in-combination mortality would increase the baseline adult mortality rate of the Greater Wash area of search population of

little gull (i.e. 10,000 to 20,000 birds) by 1.8% to 3.5%, and that of the North Sea flyway population by 0.5%.

115. These estimates do not materially change from those presented in the **RIAA** [APP-59], where in-combination collision mortality was estimated to be 69.6 individuals. Therefore, the conclusions of the **RIAA** [APP-59] are unchanged; i.e. that an AeoI of the GW SPA can be ruled out as a result of predicted little gull mortality due to collision at SEP, DEP, and SEP and DEP, in-combination with other OWFs.

Table 13-2: In-Combination Collision Risk for Little Gull Passing Through the Greater Wash Area of Search using Consented OWF Parameters

Tier	OWF	Predicted collisions
1	Hornsea Project One	4
1	Race Bank	21
1	SOW	3
2	Triton Knoll	26
3	Hornsea Project Three	0.5
3	Hornsea Project Two	0.5
3	Norfolk Boreas	3.9
3	Norfolk Vanguard	8.3
4	Hornsea Project Four	0.1
TOTAL (excluding SEP and DEP)		67.3
5	DEP	2.4
5	SEP	0.5
TOTAL (including SEP and DEP)		70.2

Appendix 1: SEP and DEP Updated CRM Outputs by Month

Alde-Ore Estuary SPA Lesser Black-backed Gull

Estimated monthly collision risk for Alde-Ore Estuary breeding adult lesser black-backed gull at DEP

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.00	0.07	0.00	0.35	0.39	0.02	0.00	0.00	0.00	0.02	0.85
Mean	0.00	0.00	0.00	0.01	0.00	0.07	0.08	0.01	0.00	0.00	0.00	0.00	0.17
95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Estimated monthly collision risk for Alde-Ore Estuary breeding adult lesser black-backed gull at SEP

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.00	0.00	0.00	0.07	0.17	0.09	0.00	0.00	0.00	0.00	0.33
Mean	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.03	0.00	0.00	0.00	0.00	0.07
95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Estimated monthly collision risk for Alde-Ore Estuary breeding adult lesser black-backed gull at SEP and DEP

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.00	0.07	0.00	0.41	0.56	0.12	0.00	0.00	0.00	0.02	1.18
Mean	0.00	0.00	0.00	0.01	0.00	0.07	0.12	0.03	0.00	0.00	0.00	0.00	0.24
95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FFC SPA Gannet

Estimated monthly collision risk for FFC SPA breeding adult gannet at DEP

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.16	0.29	0.07	0.09	0.07	0.06	0.14	0.04	0.03	0.01	0.95
Mean	0.00	0.00	0.03	0.12	0.02	0.01	0.02	0.01	0.05	0.01	0.01	0.00	0.30
95% LCI	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02

Estimated monthly collision risk for FFC SPA breeding adult gannet at SEP

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.00	0.08	0.00	0.00	0.04	0.04	0.05	0.00	0.02	0.00	0.23
Mean	0.00	0.00	0.00	0.02	0.00	0.00	0.01	0.01	0.01	0.00	0.01	0.00	0.04
95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Estimated monthly collision risk for FFC SPA breeding adult gannet at SEP and DEP

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.16	0.37	0.07	0.09	0.11	0.10	0.19	0.04	0.04	0.01	1.17

	J	F	M	A	M	J	J	A	S	O	N	D	Total
Mean	0.00	0.00	0.03	0.14	0.02	0.01	0.02	0.02	0.06	0.01	0.02	0.00	0.34
95% LCI	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02

FFC SPA Kittiwake

Estimated monthly collision risk for FFC SPA breeding adult kittiwake at DEP

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.10	0.07	0.68	6.02	3.18	0.49	0.79	2.51	0.31	0.11	0.03	0.05	14.34
Mean	0.04	0.03	0.18	3.31	0.96	0.09	0.30	0.71	0.11	0.05	0.01	0.03	5.80
95% LCI	0.00	0.00	0.00	0.90	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.91

Estimated monthly collision risk for FFC SPA breeding adult kittiwake at SEP

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.00	2.17	0.00	0.30	0.00	0.00	0.09	0.00	0.04	0.07	2.67
Mean	0.00	0.00	0.00	0.45	0.00	0.05	0.00	0.00	0.02	0.00	0.01	0.01	0.55
95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Estimated monthly collision risk for FFC SPA breeding adult kittiwake at SEP and DEP

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.10	0.07	0.68	8.19	3.18	0.79	0.79	2.51	0.40	0.11	0.07	0.13	17.01
Mean	0.04	0.03	0.18	3.76	0.96	0.14	0.30	0.71	0.13	0.05	0.02	0.04	6.36
95% LCI	0.00	0.00	0.00	0.90	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.91

GW SPA Sandwich tern (model-based density estimates)

Estimated monthly collision risk for GW SPA Sandwich tern at DEP, using model-based density estimates and the flight speed of Fijn and Collier (2020)

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.00	2.01	2.01	1.08	1.62	0.30	0.00	0.00	0.00	0.00	7.02
Mean	0.00	0.00	0.00	1.02	1.31	0.59	1.10	0.13	0.00	0.00	0.00	0.00	4.15
95% LCI	0.00	0.00	0.00	0.45	0.81	0.29	0.74	0.05	0.00	0.00	0.00	0.00	2.34

Estimated monthly collision risk for GW SPA Sandwich tern at SEP, using model-based density estimates and the flight speed of Fijn and Collier (2020)

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.00	0.09	0.58	0.80	0.86	0.16	0.00	0.00	0.00	0.00	2.49
Mean	0.00	0.00	0.00	0.02	0.33	0.36	0.59	0.05	0.00	0.00	0.00	0.00	1.36
95% LCI	0.00	0.00	0.00	0.00	0.19	0.14	0.42	0.01	0.00	0.00	0.00	0.00	0.76

Estimated monthly collision risk for GW SPA Sandwich tern at SEP and DEP, using model-based density estimates and the flight speed of Fijn and Collier (2020)

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.00	2.10	2.59	1.88	2.49	0.46	0.00	0.00	0.00	0.00	9.51
Mean	0.00	0.00	0.00	1.04	1.64	0.95	1.69	0.18	0.00	0.00	0.00	0.00	5.50
95% LCI	0.00	0.00	0.00	0.45	1.00	0.43	1.16	0.06	0.00	0.00	0.00	0.00	3.11

Estimated monthly collision risk for GW SPA Sandwich tern at DEP, using model-based density estimates and the flight speed of Fijn and Gyimesi (2018)

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.00	2.37	2.39	1.29	1.93	0.36	0.00	0.00	0.00	0.00	8.33
Mean	0.00	0.00	0.00	1.22	1.57	0.71	1.32	0.16	0.00	0.00	0.00	0.00	4.97
95% LCI	0.00	0.00	0.00	0.54	0.98	0.35	0.88	0.06	0.00	0.00	0.00	0.00	2.81

Estimated monthly collision risk for GW SPA Sandwich tern at SEP, using model-based density estimates and the flight speed of Fijn and Gyimesi (2018)

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.00	0.11	0.69	0.96	1.04	0.19	0.00	0.00	0.00	0.00	2.99
Mean	0.00	0.00	0.00	0.03	0.40	0.43	0.71	0.06	0.00	0.00	0.00	0.00	1.63
95% LCI	0.00	0.00	0.00	0.00	0.22	0.17	0.50	0.02	0.00	0.00	0.00	0.00	0.92

Estimated monthly collision risk for GW SPA Sandwich tern at SEP and DEP, using model-based density estimates and the flight speed of Fijn and Gyimesi (2018)

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.00	2.48	3.08	2.25	2.96	0.55	0.00	0.00	0.00	0.00	11.32
Mean	0.00	0.00	0.00	1.25	1.97	1.14	2.02	0.22	0.00	0.00	0.00	0.00	6.60
95% LCI	0.00	0.00	0.00	0.54	1.20	0.52	1.39	0.08	0.00	0.00	0.00	0.00	3.73

NNC SPA Sandwich tern (model-based density estimates)

Estimated monthly collision risk for NNC SPA Sandwich tern at DEP, using model-based density estimates and the flight speed of Fijn and Collier (2020)

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.00	2.01	2.01	1.08	1.62	0.30	0.16	0.00	0.00	0.00	7.19
Mean	0.00	0.00	0.00	1.02	1.31	0.59	1.10	0.13	0.07	0.00	0.00	0.00	4.22
95% LCI	0.00	0.00	0.00	0.45	0.81	0.29	0.74	0.05	0.02	0.00	0.00	0.00	2.37

Estimated monthly collision risk for NNC SPA Sandwich tern at SEP, using model-based density estimates and the flight speed of Fijn and Collier (2020)

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.00	0.09	0.58	0.80	0.86	0.16	0.03	0.00	0.00	0.00	2.52
Mean	0.00	0.00	0.00	0.02	0.33	0.36	0.59	0.05	0.01	0.00	0.00	0.00	1.37
95% LCI	0.00	0.00	0.00	0.00	0.19	0.14	0.42	0.01	0.00	0.00	0.00	0.00	0.77

Estimated monthly collision risk for NNC SPA Sandwich tern at SEP and DEP, using model-based density estimates and the flight speed of Fijn and Collier (2020)

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.00	2.10	2.59	1.88	2.49	0.46	0.20	0.00	0.00	0.00	9.71
Mean	0.00	0.00	0.00	1.04	1.64	0.95	1.69	0.18	0.08	0.00	0.00	0.00	5.58
95% LCI	0.00	0.00	0.00	0.45	1.00	0.43	1.16	0.06	0.03	0.00	0.00	0.00	3.13

Estimated monthly collision risk for NNC SPA Sandwich tern at DEP, using model-based density estimates and the flight speed of Fijn and Gyimesi (2018)

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.00	2.37	2.39	1.29	1.93	0.36	0.19	0.00	0.00	0.00	8.52
Mean	0.00	0.00	0.00	1.22	1.57	0.71	1.32	0.16	0.08	0.00	0.00	0.00	5.06
95% LCI	0.00	0.00	0.00	0.54	0.98	0.35	0.88	0.06	0.03	0.00	0.00	0.00	2.84

Estimated monthly collision risk for NNC SPA Sandwich tern at SEP, using model-based density estimates and the flight speed of Fijn and Gyimesi (2018)

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.00	0.11	0.69	0.96	1.04	0.19	0.04	0.00	0.00	0.00	3.02
Mean	0.00	0.00	0.00	0.03	0.40	0.43	0.71	0.06	0.01	0.00	0.00	0.00	1.64
95% LCI	0.00	0.00	0.00	0.00	0.22	0.17	0.50	0.02	0.00	0.00	0.00	0.00	0.92

Estimated monthly collision risk for NNC SPA Sandwich tern at SEP and DEP, using model-based density estimates and the flight speed of Fijn and Gyimesi (2018)

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.00	2.48	3.08	2.25	2.96	0.55	0.23	0.00	0.00	0.00	11.55
Mean	0.00	0.00	0.00	1.25	1.97	1.14	2.02	0.22	0.10	0.00	0.00	0.00	6.70
95% LCI	0.00	0.00	0.00	0.54	1.20	0.52	1.39	0.08	0.03	0.00	0.00	0.00	3.76

GW SPA Sandwich tern (design-based density estimates)

Estimated monthly collision risk for GW SPA Sandwich tern at DEP, using design-based density estimates and the flight speed of Fijn and Collier (2020)

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.00	3.76	3.19	0.94	2.18	0.64	0.00	0.00	0.00	0.00	10.71
Mean	0.00	0.00	0.00	0.89	1.49	0.35	0.73	0.20	0.00	0.00	0.00	0.00	3.66
95% LCI	0.00	0.00	0.00	0.00	0.40	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.45

Estimated monthly collision risk for GW SPA Sandwich tern at SEP, using design-based density estimates and the flight speed of Fijn and Collier (2020)

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.00	0.08	0.67	0.46	1.65	0.16	0.00	0.00	0.00	0.00	3.02
Mean	0.00	0.00	0.00	0.01	0.31	0.19	0.36	0.05	0.00	0.00	0.00	0.00	0.92

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% LCI	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05

Estimated monthly collision risk for GW SPA Sandwich tern at SEP and DEP, using design-based density estimates and the flight speed of Fijn and Collier (2020)

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.00	3.84	3.86	1.41	3.82	0.80	0.00	0.00	0.00	0.00	13.73
Mean	0.00	0.00	0.00	0.91	1.80	0.55	1.09	0.25	0.00	0.00	0.00	0.00	4.59
95% LCI	0.00	0.00	0.00	0.00	0.45	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.50

Estimated monthly collision risk for GW SPA Sandwich tern at DEP, using design-based density estimates and the flight speed of Fijn and Gyimesi (2018)

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.00	4.51	3.83	1.13	2.61	0.77	0.00	0.00	0.00	0.00	12.84
Mean	0.00	0.00	0.00	1.07	1.78	0.42	0.87	0.24	0.00	0.00	0.00	0.00	4.39
95% LCI	0.00	0.00	0.00	0.00	0.48	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.54

Estimated monthly collision risk for GW SPA Sandwich tern at SEP, using design-based density estimates and the flight speed of Fijn and Gyimesi (2018)

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.00	0.09	0.80	0.56	1.98	0.20	0.00	0.00	0.00	0.00	3.62
Mean	0.00	0.00	0.00	0.01	0.37	0.23	0.43	0.06	0.00	0.00	0.00	0.00	1.11
95% LCI	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06

Estimated monthly collision risk for GW SPA Sandwich tern at SEP and DEP, using design-based density estimates and the flight speed of Fijn and Gyimesi (2018)

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.00	4.60	4.63	1.69	4.58	0.96	0.00	0.00	0.00	0.00	16.47
Mean	0.00	0.00	0.00	1.09	2.15	0.66	1.31	0.29	0.00	0.00	0.00	0.00	5.50
95% LCI	0.00	0.00	0.00	0.00	0.54	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.60

NNC SPA Sandwich tern (design-based density estimates)

Estimated monthly collision risk for NNC SPA Sandwich tern at DEP, using design-based density estimates and the flight speed of Fijn and Collier (2020)

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.00	3.76	3.19	0.94	2.18	0.64	0.14	0.00	0.00	0.00	10.84
Mean	0.00	0.00	0.00	0.89	1.49	0.35	0.73	0.20	0.03	0.00	0.00	0.00	3.69
95% LCI	0.00	0.00	0.00	0.00	0.40	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.45

Estimated monthly collision risk for NNC SPA Sandwich tern at SEP, using design-based density estimates and the flight speed of Fijn and Collier (2020)

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.00	0.08	0.67	0.46	1.65	0.16	0.02	0.00	0.00	0.00	3.04
Mean	0.00	0.00	0.00	0.01	0.31	0.19	0.36	0.05	0.00	0.00	0.00	0.00	0.93
95% LCI	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05

Estimated monthly collision risk for NNC SPA Sandwich tern at SEP and DEP, using design-based density estimates and the flight speed of Fijn and Collier (2020)

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.00	3.84	3.86	1.41	3.82	0.80	0.16	0.00	0.00	0.00	13.89
Mean	0.00	0.00	0.00	0.91	1.80	0.55	1.09	0.25	0.03	0.00	0.00	0.00	4.62
95% LCI	0.00	0.00	0.00	0.00	0.45	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.50

Estimated monthly collision risk for NNC SPA Sandwich tern at DEP, using design-based density estimates and the flight speed of Fijn and Gyimesi (2018)

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.00	4.51	3.83	1.13	2.61	0.77	0.16	0.00	0.00	0.00	13.01
Mean	0.00	0.00	0.00	1.07	1.78	0.42	0.87	0.24	0.03	0.00	0.00	0.00	4.43
95% LCI	0.00	0.00	0.00	0.00	0.48	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.54

Estimated monthly collision risk for NNC SPA Sandwich tern at SEP, using design-based density estimates and the flight speed of Fijn and Gyimesi (2018)

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.00	0.09	0.80	0.56	1.98	0.20	0.03	0.00	0.00	0.00	3.65
Mean	0.00	0.00	0.00	0.01	0.37	0.23	0.43	0.06	0.00	0.00	0.00	0.00	1.11
95% LCI	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06

Estimated monthly collision risk for NNC SPA Sandwich tern at SEP and DEP, using design-based density estimates and the flight speed of Fijn and Gyimesi (2018)

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.00	4.60	4.63	1.69	4.58	0.96	0.19	0.00	0.00	0.00	16.66
Mean	0.00	0.00	0.00	1.09	2.15	0.66	1.31	0.29	0.04	0.00	0.00	0.00	5.54
95% LCI	0.00	0.00	0.00	0.00	0.54	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.60

GW SPA Little gull

Estimated monthly collision risk for GW SPA little gull at DEP

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.08	0.00	0.00	8.08
Mean	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.36	0.00	0.00	2.36
95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Estimated monthly collision risk for GW SPA little gull at SEP

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.42	1.19	0.00	1.80
Mean	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.08	0.41	0.00	0.53
95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Estimated monthly collision risk for GW SPA little gull at SEP and DEP

	J	F	M	A	M	J	J	A	S	O	N	D	Total
95% UCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	8.50	1.19	0.00	9.88
Mean	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	2.44	0.41	0.00	2.89
95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix 2: SEP and DEP Updated Operational Phase Displacement Matrices

FFC SPA Gannet, DEP

Potential displacement (down) and mortality (across) of FFC SPA gannet in DEP+2km (year round, upper 95% CI of mean peak density), with the ranges of displacement and mortality considered by the assessment shown in red

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	1	1	2	2	3	6	11	17	28	45	56
20%	1	2	3	5	6	11	23	34	56	90	113
30%	2	3	5	7	8	17	34	51	84	135	169
40%	2	5	7	9	11	23	45	68	113	180	225
50%	3	6	8	11	14	28	56	84	141	225	282
60%	3	7	10	14	17	34	68	101	169	270	338
70%	4	8	12	16	20	39	79	118	197	315	394
80%	5	9	14	18	23	45	90	135	225	360	450
90%	5	10	15	20	25	51	101	152	253	405	507
100%	6	11	17	23	28	56	113	169	282	450	563

Potential displacement (down) and mortality (across) of FFC SPA gannet in DEP+2km (year round, mean peak density)), with the ranges of displacement and mortality considered by the assessment shown in red

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	0	1	1	1	2	3	7	10	17	27	34
20%	1	1	2	3	3	7	14	20	34	54	68
30%	1	2	3	4	5	10	20	30	51	81	102
40%	1	3	4	5	7	14	27	41	68	108	136
50%	2	3	5	7	8	17	34	51	85	136	169
60%	2	4	6	8	10	20	41	61	102	163	203
70%	2	5	7	9	12	24	47	71	119	190	237
80%	3	5	8	11	14	27	54	81	136	217	271
90%	3	6	9	12	15	30	61	91	152	244	305
100%	3	7	10	14	17	34	68	102	169	271	339

Potential displacement (down) and mortality (across) of FFC SPA gannet in DEP+2km (year round, lower 95% CI of mean peak density)), with the ranges of displacement and mortality considered by the assessment shown in red

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	0	0	0	1	1	1	3	4	7	12	15
20%	0	1	1	1	1	3	6	9	15	24	29
30%	0	1	1	2	2	4	9	13	22	35	44
40%	1	1	2	2	3	6	12	18	29	47	59

50%	1	1	2	3	4	7	15	22	37	59	74
60%	1	2	3	4	4	9	18	27	44	71	88
70%	1	2	3	4	5	10	21	31	52	83	103
80%	1	2	4	5	6	12	24	35	59	94	118
90%	1	3	4	5	7	13	27	40	66	106	133
100%	1	3	4	6	7	15	29	44	74	118	147

FFC SPA Gannet, SEP

Potential displacement (down) and mortality (across) of FFC SPA gannet in SEP+2km (year round, upper 95% CI of mean peak density), with the ranges of displacement and mortality considered by the assessment shown in red

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	0	0	0	0	0	1	1	2	3	5	6
20%	0	0	0	0	1	1	2	4	6	9	12
30%	0	0	1	1	1	2	4	5	9	14	18
40%	0	0	1	1	1	2	5	7	12	19	23
50%	0	1	1	1	1	3	6	9	15	23	29
60%	0	1	1	1	2	4	7	11	18	28	35
70%	0	1	1	2	2	4	8	12	20	33	41
80%	0	1	1	2	2	5	9	14	23	37	47
90%	1	1	2	2	3	5	11	16	26	42	53
100%	1	1	2	2	3	6	12	18	29	47	59

Potential displacement (down) and mortality (across) of FFC SPA gannet in SEP+2km (year round, mean peak density), with the ranges of displacement and mortality considered by the assessment shown in red

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	0	0	0	0	0	0	1	1	2	3	3
20%	0	0	0	0	0	1	1	2	3	5	7
30%	0	0	0	0	0	1	2	3	5	8	10
40%	0	0	0	1	1	1	3	4	7	10	13
50%	0	0	0	1	1	2	3	5	8	13	16
60%	0	0	1	1	1	2	4	6	10	16	20
70%	0	0	1	1	1	2	5	7	11	18	23
80%	0	1	1	1	1	3	5	8	13	21	26
90%	0	1	1	1	1	3	6	9	15	23	29
100%	0	1	1	1	2	3	7	10	16	26	33

Potential displacement (down) and mortality (across) of FFC SPA gannet in SEP+2km (year round, lower 95% CI of mean peak density), with the ranges of displacement and mortality considered by the assessment shown in red

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	0	0	0	0	0	0	0	0	1	1	1

20%	0	0	0	0	0	0	0	1	1	2	2
30%	0	0	0	0	0	0	1	1	2	3	3
40%	0	0	0	0	0	0	1	1	2	4	4
50%	0	0	0	0	0	1	1	2	3	4	6
60%	0	0	0	0	0	1	1	2	3	5	7
70%	0	0	0	0	0	1	2	2	4	6	8
80%	0	0	0	0	0	1	2	3	4	7	9
90%	0	0	0	0	1	1	2	3	5	8	10
100%	0	0	0	0	1	1	2	3	6	9	11

FFC SPA Gannet, SEP and DEP

Potential displacement (down) and mortality (across) of FFC SPA gannet in DEP+2km and SEP+2km (year round, upper 95% CI of mean peak density), with the ranges of displacement and mortality considered by the assessment shown in red

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	1	1	2	2	3	6	12	19	31	50	62
20%	1	2	4	5	6	12	25	37	62	99	124
30%	2	4	6	7	9	19	37	56	93	149	186
40%	2	5	7	10	12	25	50	75	124	199	249
50%	3	6	9	12	16	31	62	93	155	249	311
60%	4	7	11	15	19	37	75	112	186	298	373
70%	4	9	13	17	22	44	87	131	218	348	435
80%	5	10	15	20	25	50	99	149	249	398	497
90%	6	11	17	22	28	56	112	168	280	448	559
100%	6	12	19	25	31	62	124	186	311	497	622

Potential displacement (down) and mortality (across) of FFC SPA gannet in DEP+2km and SEP+2km (year round, mean peak density), with the ranges of displacement and mortality considered by the assessment shown in red

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	0	1	1	1	2	4	7	11	19	30	37
20%	1	1	2	3	4	7	15	22	37	59	74
30%	1	2	3	4	6	11	22	33	56	89	111
40%	1	3	4	6	7	15	30	45	74	119	149
50%	2	4	6	7	9	19	37	56	93	149	186
60%	2	4	7	9	11	22	45	67	111	178	223
70%	3	5	8	10	13	26	52	78	130	208	260
80%	3	6	9	12	15	30	59	89	149	238	297
90%	3	7	10	13	17	33	67	100	167	267	334
100%	4	7	11	15	19	37	74	111	186	297	371

Potential displacement (down) and mortality (across) of FFC SPA gannet in DEP+2km and SEP+2km (year round, lower 95% CI of mean peak density), with the ranges of displacement and mortality considered by the assessment shown in red

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	0	0	0	1	1	2	3	5	8	13	16
20%	0	1	1	1	2	3	6	10	16	25	32
30%	0	1	1	2	2	5	10	14	24	38	48
40%	1	1	2	3	3	6	13	19	32	51	63
50%	1	2	2	3	4	8	16	24	40	63	79
60%	1	2	3	4	5	10	19	29	48	76	95
70%	1	2	3	4	6	11	22	33	56	89	111
80%	1	3	4	5	6	13	25	38	63	102	127
90%	1	3	4	6	7	14	29	43	71	114	143
100%	2	3	5	6	8	16	32	48	79	127	159

FFC SPA Puffin, DEP

Potential displacement (down) and mortality (across) of FFC SPA puffin in DEP+2km (year round, upper 95% CI of mean peak density), with the ranges of displacement and mortality considered by the assessment shown in red

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	0	0	0	0	0	0	0	0	0	0	0
20%	0	0	0	0	0	0	0	0	0	1	1
30%	0	0	0	0	0	0	0	0	1	1	1
40%	0	0	0	0	0	0	0	0	1	1	1
50%	0	0	0	0	0	0	0	1	1	1	2
60%	0	0	0	0	0	0	0	1	1	2	2
70%	0	0	0	0	0	0	0	1	1	2	2
80%	0	0	0	0	0	0	1	1	1	2	3
90%	0	0	0	0	0	0	1	1	2	3	3
100%	0	0	0	0	0	0	1	1	2	3	3

Potential displacement (down) and mortality (across) of FFC SPA puffin in DEP+2km (year round, mean peak density), with the ranges of displacement and mortality considered by the assessment shown in red

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	0	0	0	0	0	0	0	0	0	0	0
20%	0	0	0	0	0	0	0	0	0	0	0
30%	0	0	0	0	0	0	0	0	0	0	0
40%	0	0	0	0	0	0	0	0	0	1	1
50%	0	0	0	0	0	0	0	0	0	1	1

60%	0	0	0	0	0	0	0	0	0	1	1
70%	0	0	0	0	0	0	0	0	1	1	1
80%	0	0	0	0	0	0	0	0	1	1	1
90%	0	0	0	0	0	0	0	0	1	1	1
100%	0	0	0	0	0	0	0	0	1	1	2

Potential displacement (down) and mortality (across) of FFC SPA puffin in DEP+2km (year round, lower 95% CI of mean peak density), with the ranges of displacement and mortality considered by the assessment shown in red

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	0	0	0	0	0	0	0	0	0	0	0
20%	0	0	0	0	0	0	0	0	0	0	0
30%	0	0	0	0	0	0	0	0	0	0	0
40%	0	0	0	0	0	0	0	0	0	0	0
50%	0	0	0	0	0	0	0	0	0	0	0
60%	0	0	0	0	0	0	0	0	0	0	0
70%	0	0	0	0	0	0	0	0	0	0	0
80%	0	0	0	0	0	0	0	0	0	0	0
90%	0	0	0	0	0	0	0	0	0	0	0
100%	0	0	0	0	0	0	0	0	0	0	0

FFC SPA Puffin, SEP

Potential displacement (down) and mortality (across) of FFC SPA puffin in SEP+2km (year round, upper 95% CI of mean peak density), with the ranges of displacement and mortality considered by the assessment shown in red

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	0	0	0	0	0	0	0	0	0	0	0
20%	0	0	0	0	0	0	0	0	0	0	0
30%	0	0	0	0	0	0	0	0	0	0	1
40%	0	0	0	0	0	0	0	0	0	1	1
50%	0	0	0	0	0	0	0	0	0	1	1
60%	0	0	0	0	0	0	0	0	1	1	1
70%	0	0	0	0	0	0	0	0	1	1	1
80%	0	0	0	0	0	0	0	0	1	1	1
90%	0	0	0	0	0	0	0	0	1	1	2
100%	0	0	0	0	0	0	0	1	1	1	2

Potential displacement (down) and mortality (across) of FFC SPA puffin in SEP+2km (year round, mean peak density), with the ranges of displacement and mortality considered by the assessment shown in red

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	0	0	0	0	0	0	0	0	0	0	0

20%	0	0	0	0	0	0	0	0	0	0	0
30%	0	0	0	0	0	0	0	0	0	0	0
40%	0	0	0	0	0	0	0	0	0	0	0
50%	0	0	0	0	0	0	0	0	0	0	0
60%	0	0	0	0	0	0	0	0	0	0	0
70%	0	0	0	0	0	0	0	0	0	0	0
80%	0	0	0	0	0	0	0	0	0	0	1
90%	0	0	0	0	0	0	0	0	0	0	1
100%	0	0	0	0	0	0	0	0	0	1	1

Potential displacement (down) and mortality (across) of FFC SPA puffin in SEP+2km (year round, lower 95% CI of mean peak density), with the ranges of displacement and mortality considered by the assessment shown in red

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	0	0	0	0	0	0	0	0	0	0	0
20%	0	0	0	0	0	0	0	0	0	0	0
30%	0	0	0	0	0	0	0	0	0	0	0
40%	0	0	0	0	0	0	0	0	0	0	0
50%	0	0	0	0	0	0	0	0	0	0	0
60%	0	0	0	0	0	0	0	0	0	0	0
70%	0	0	0	0	0	0	0	0	0	0	0
80%	0	0	0	0	0	0	0	0	0	0	0
90%	0	0	0	0	0	0	0	0	0	0	0
100%	0	0	0	0	0	0	0	0	0	0	0

FFC SPA Puffin, SEP and DEP

Potential displacement (down) and mortality (across) of FFC SPA puffin in DEP+2km and SEP+2km (year round, upper 95% CI of mean peak density), with the ranges of displacement and mortality considered by the assessment shown in red

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	0	0	0	0	0	0	0	0	0	0	1
20%	0	0	0	0	0	0	0	0	1	1	1
30%	0	0	0	0	0	0	0	0	1	1	2
40%	0	0	0	0	0	0	0	1	1	2	2
50%	0	0	0	0	0	0	1	1	1	2	3
60%	0	0	0	0	0	0	1	1	2	2	3
70%	0	0	0	0	0	0	1	1	2	3	4
80%	0	0	0	0	0	0	1	1	2	3	4
90%	0	0	0	0	0	0	1	1	2	4	5
100%	0	0	0	0	0	1	1	2	3	4	5

Potential displacement (down) and mortality (across) of FFC SPA puffin in DEP+2km and SEP+2km (year round, mean peak density), with the ranges of displacement and mortality considered by the assessment shown in red

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	0	0	0	0	0	0	0	0	0	0	0
20%	0	0	0	0	0	0	0	0	0	0	0
30%	0	0	0	0	0	0	0	0	0	1	1
40%	0	0	0	0	0	0	0	0	0	1	1
50%	0	0	0	0	0	0	0	0	1	1	1
60%	0	0	0	0	0	0	0	0	1	1	1
70%	0	0	0	0	0	0	0	0	1	1	2
80%	0	0	0	0	0	0	0	1	1	1	2
90%	0	0	0	0	0	0	0	1	1	2	2
100%	0	0	0	0	0	0	0	1	1	2	2

Potential displacement (down) and mortality (across) of FFC SPA puffin in DEP+2km and SEP+2km (year round, lower 95% CI of mean peak density), with the ranges of displacement and mortality considered by the assessment shown in red

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	0	0	0	0	0	0	0	0	0	0	0
20%	0	0	0	0	0	0	0	0	0	0	0
30%	0	0	0	0	0	0	0	0	0	0	0
40%	0	0	0	0	0	0	0	0	0	0	0
50%	0	0	0	0	0	0	0	0	0	0	0
60%	0	0	0	0	0	0	0	0	0	0	0
70%	0	0	0	0	0	0	0	0	0	0	0
80%	0	0	0	0	0	0	0	0	0	0	0
90%	0	0	0	0	0	0	0	0	0	0	0
100%	0	0	0	0	0	0	0	0	0	0	0

FFC SPA Razorbill, DEP

Potential displacement (down) and mortality (across) of FFC SPA razorbill in DEP+2km (year round, upper 95% CI of mean peak density), with the ranges of displacement and mortality considered by the assessment shown in red

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	0	1	1	2	2	4	8	12	20	31	39
20%	1	2	2	3	4	8	16	24	39	63	79
30%	1	2	4	5	6	12	24	35	59	94	118
40%	2	3	5	6	8	16	31	47	79	126	157
50%	2	4	6	8	10	20	39	59	98	157	197
60%	2	5	7	9	12	24	47	71	118	189	236

70%	3	6	8	11	14	28	55	83	138	220	275
80%	3	6	9	13	16	31	63	94	157	252	314
90%	4	7	11	14	18	35	71	106	177	283	354
100%	4	8	12	16	20	39	79	118	197	314	393

Potential displacement (down) and mortality (across) of FFC SPA razorbill in DEP+2km (year round, mean peak density), with the ranges of displacement and mortality considered by the assessment shown in red

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	0	0	1	1	1	2	4	7	11	18	22
20%	0	1	1	2	2	4	9	13	22	36	45
30%	1	1	2	3	3	7	13	20	34	54	67
40%	1	2	3	4	4	9	18	27	45	72	90
50%	1	2	3	4	6	11	22	34	56	90	112
60%	1	3	4	5	7	13	27	40	67	108	135
70%	2	3	5	6	8	16	31	47	79	126	157
80%	2	4	5	7	9	18	36	54	90	144	180
90%	2	4	6	8	10	20	40	61	101	162	202
100%	2	4	7	9	11	22	45	67	112	180	225

Potential displacement (down) and mortality (across) of FFC SPA razorbill in DEP+2km (year round, lower 95% CI of mean peak density), with the ranges of displacement and mortality considered by the assessment shown in red

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	0	0	0	0	0	1	2	3	5	8	9
20%	0	0	1	1	1	2	4	6	9	15	19
30%	0	1	1	1	1	3	6	8	14	23	28
40%	0	1	1	2	2	4	8	11	19	30	38
50%	0	1	1	2	2	5	9	14	23	38	47
60%	1	1	2	2	3	6	11	17	28	45	56
70%	1	1	2	3	3	7	13	20	33	53	66
80%	1	2	2	3	4	8	15	23	38	60	75
90%	1	2	3	3	4	8	17	25	42	68	84
100%	1	2	3	4	5	9	19	28	47	75	94

FFC SPA Razorbill, SEP

Potential displacement (down) and mortality (across) of FFC SPA razorbill in SEP+2km (year round, upper 95% CI of mean peak density), with the ranges of displacement and mortality considered by the assessment shown in red

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	0	0	0	0	1	1	2	3	6	9	11
20%	0	0	1	1	1	2	4	7	11	18	22

30%	0	1	1	1	2	3	7	10	17	27	33
40%	0	1	1	2	2	4	9	13	22	36	45
50%	1	1	2	2	3	6	11	17	28	45	56
60%	1	1	2	3	3	7	13	20	33	54	67
70%	1	2	2	3	4	8	16	23	39	63	78
80%	1	2	3	4	4	9	18	27	45	71	89
90%	1	2	3	4	5	10	20	30	50	80	100
100%	1	2	3	4	6	11	22	33	56	89	112

Potential displacement (down) and mortality (across) of FFC SPA razorbill in SEP+2km (year round, mean peak density), with the ranges of displacement and mortality considered by the assessment shown in red

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	0	0	0	0	0	1	1	2	4	6	7
20%	0	0	0	1	1	1	3	4	7	11	14
30%	0	0	1	1	1	2	4	6	11	17	21
40%	0	1	1	1	1	3	6	9	14	23	28
50%	0	1	1	1	2	4	7	11	18	28	36
60%	0	1	1	2	2	4	9	13	21	34	43
70%	0	1	1	2	2	5	10	15	25	40	50
80%	1	1	2	2	3	6	11	17	28	45	57
90%	1	1	2	3	3	6	13	19	32	51	64
100%	1	1	2	3	4	7	14	21	36	57	71

Potential displacement (down) and mortality (across) of FFC SPA razorbill in SEP+2km (year round, lower 95% CI of mean peak density), with the ranges of displacement and mortality considered by the assessment shown in red

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	0	0	0	0	0	0	1	1	2	3	4
20%	0	0	0	0	0	1	1	2	4	6	7
30%	0	0	0	0	1	1	2	3	5	8	11
40%	0	0	0	1	1	1	3	4	7	11	14
50%	0	0	1	1	1	2	4	5	9	14	18
60%	0	0	1	1	1	2	4	6	11	17	21
70%	0	0	1	1	1	2	5	7	12	20	25
80%	0	1	1	1	1	3	6	8	14	23	28
90%	0	1	1	1	2	3	6	10	16	25	32
100%	0	1	1	1	2	4	7	11	18	28	35

FFC SPA Razorbill, SEP and DEP

Potential displacement (down) and mortality (across) of FFC SPA razorbill in DEP+2km and SEP+2km (year round, upper 95% CI of mean peak density), with the ranges of displacement and mortality considered by the assessment shown in red

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	1	1	2	2	3	5	10	15	25	40	50
20%	1	2	3	4	5	10	20	30	50	81	101
30%	2	3	5	6	8	15	30	45	76	121	151
40%	2	4	6	8	10	20	40	61	101	162	202
50%	3	5	8	10	13	25	50	76	126	202	252
60%	3	6	9	12	15	30	61	91	151	242	303
70%	4	7	11	14	18	35	71	106	177	283	353
80%	4	8	12	16	20	40	81	121	202	323	404
90%	5	9	14	18	23	45	91	136	227	363	454
100%	5	10	15	20	25	50	101	151	252	404	505

Potential displacement (down) and mortality (across) of FFC SPA razorbill in DEP+2km and SEP+2km (year round, mean peak density), with the ranges of displacement and mortality considered by the assessment shown in red

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	0	1	1	1	1	3	6	9	15	24	30
20%	1	1	2	2	3	6	12	18	30	47	59
30%	1	2	3	4	4	9	18	27	44	71	89
40%	1	2	4	5	6	12	24	35	59	95	118
50%	1	3	4	6	7	15	30	44	74	118	148
60%	2	4	5	7	9	18	35	53	89	142	177
70%	2	4	6	8	10	21	41	62	103	166	207
80%	2	5	7	9	12	24	47	71	118	189	237
90%	3	5	8	11	13	27	53	80	133	213	266
100%	3	6	9	12	15	30	59	89	148	237	296

Potential displacement (down) and mortality (across) of FFC SPA razorbill in DEP+2km and SEP+2km (year round, lower 95% CI of mean peak density), with the ranges of displacement and mortality considered by the assessment shown in red

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	0	0	0	1	1	1	3	4	6	10	13
20%	0	1	1	1	1	3	5	8	13	21	26
30%	0	1	1	2	2	4	8	12	19	31	39
40%	1	1	2	2	3	5	10	16	26	41	52
50%	1	1	2	3	3	6	13	19	32	52	65
60%	1	2	2	3	4	8	16	23	39	62	78
70%	1	2	3	4	5	9	18	27	45	72	90
80%	1	2	3	4	5	10	21	31	52	83	103

90%	1	2	3	5	6	12	23	35	58	93	116
100%	1	3	4	5	6	13	26	39	65	103	129

Appendix 3: Area calculations used for red-throated diver displacement assessment

MCA Zone only

Buffer	individual areas	total areas
8km	0.062	0.062
9km	6.959	7.992
9km	1.033	
10km	0.358	12.456
10km	12.098	
		20.51

SPA overlap

Buffer	individual areas	total areas
7km	0.854	0.854
8km	1.067	5.083
8km	4.016	
9km	7.981	21.653
9km	6.959	
9km	6.713	
10km	15.186	34.936
10km	0.381	
10km	19.369	
		62.526

Net areas exc MCA

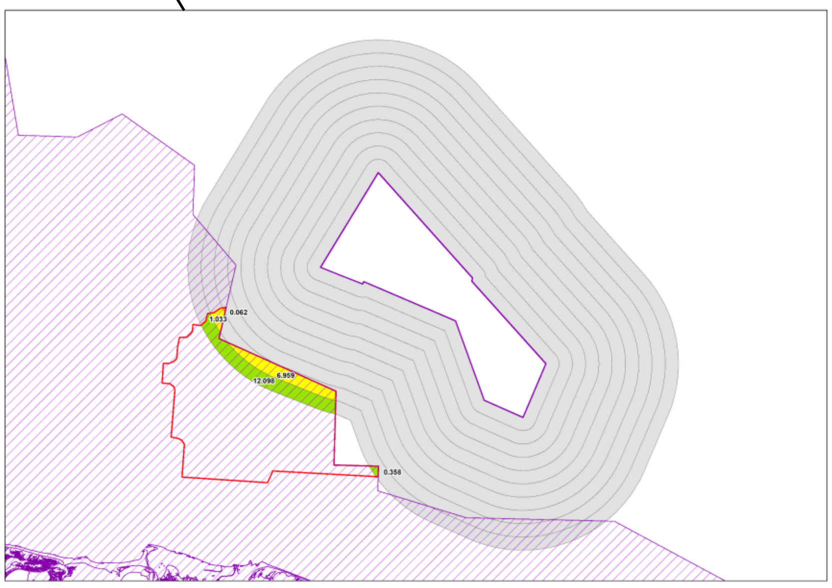
Buffer	individual areas	total areas
7km	0.854	0.854
8km	1.067	5.021
8km	3.954	
9km	7.981	13.661
9km	0	
9km	5.68	
10km	15.186	22.48
10km	0.023	
10km	7.271	
		42.016

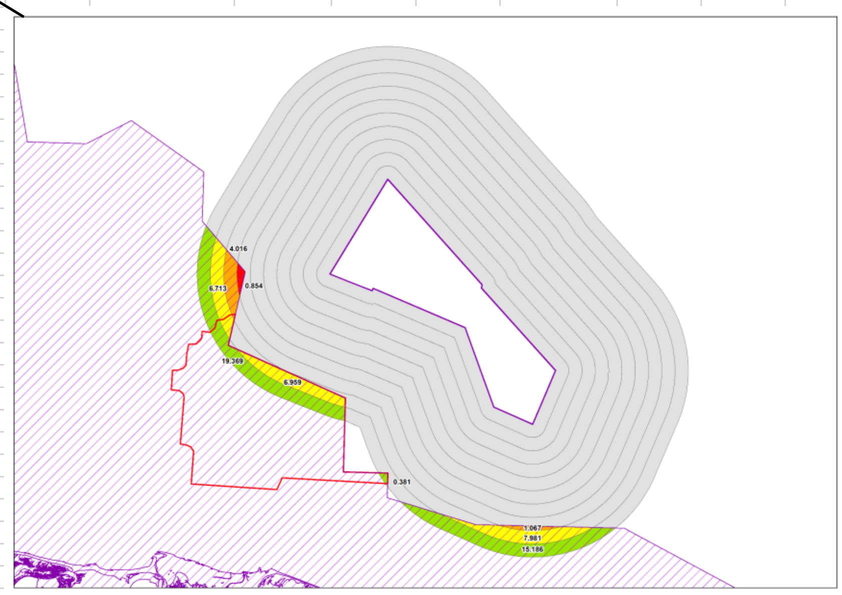
Net areas exc OWF overlap inc MCA

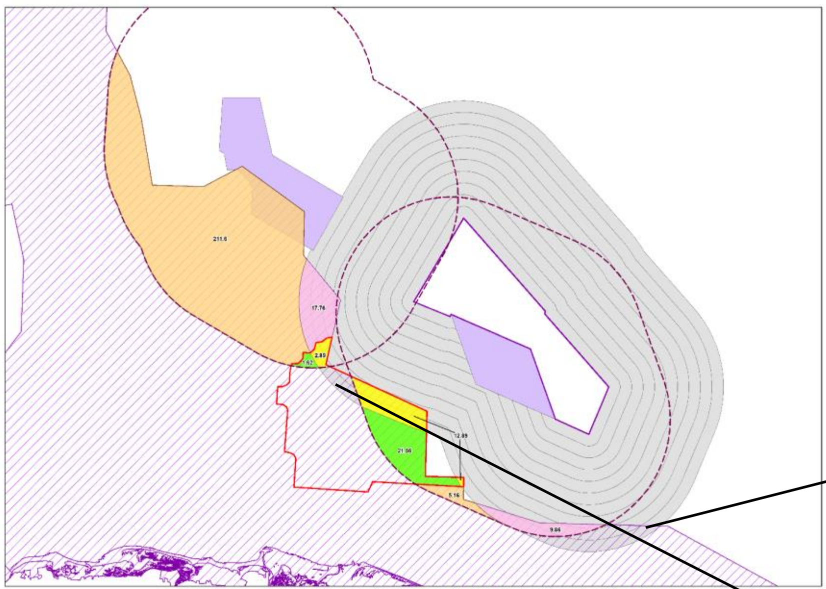
Buffer	individual areas	total areas
8km	0.11	0.11
9km	0.85	5.15
9km	4.3	
9km		
10km	9.96	13.86
10km	3.9	
10km		
		19.12

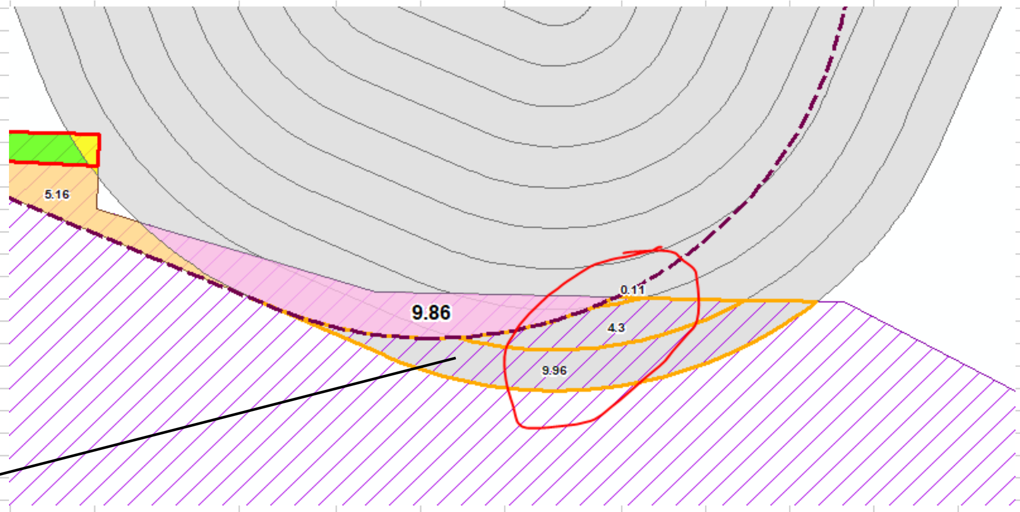
Net areas exc OWF overlap exc MCA

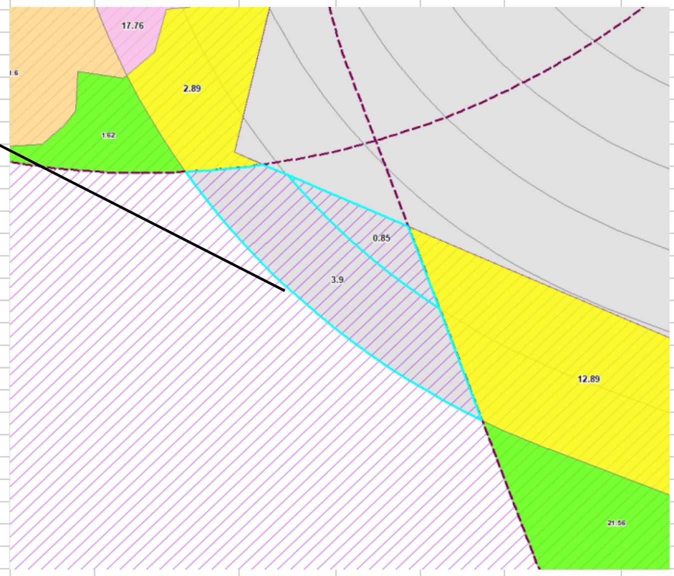
Buffer	dividual are	total areas
8km	0.11	0.11
9km		4.3
9km	4.3	
9km		
10km	9.96	9.96
10km		
10km		
		14.37











References

Aitken, D., Babcock, M., Barratt, A., Clarkson, C., and Prettyman, S., 2017. FFC pSPA Seabird Monitoring Programme – 2017 Report. RSPB.

Band, W., 2012. SOSS-02: Using a Collision Risk Model to Assess Bird Collision Risks For Offshore Wind Farms (No. SOSS-02).

Burger, C., Schubert, A., Heinänen, S., Dorsch, M., Kleinschmidt, B., Žydelis, R., Morkūnas, J., Quillfeldt, P., Nehls, G., 2019. A novel approach for assessing effects of ship traffic on distributions and movements of seabirds. Journal of Environmental Management 251, 109511. [redacted]

Fijn, R.C., Collier, M.P., 2020. Flight speeds of Sandwich terns off the Norfolk Coast (Internal document for Equinor). Bureau Waardenburg bv.

Fijn, R.C., Gyimesi, A., 2018. Behaviour related flight speeds of Sandwich Terns and their implications for wind farm collision rate modelling and impact assessment. Environmental Impact Assessment Review 71, 12–16. [redacted]

Furness, R. (2015). Non-breeding season populations of seabirds in UK waters: Population sizes for Biologically Defined Minimum Population Scales (BDMPS). Nat. Engl. Comm. Rep. 164.

GoBe Consultants, Wood Group UK, 2021a. Rampion 2 Wind Farm Preliminary Environmental Information Report: Volume 2, Chapter 12, Offshore & intertidal ornithology.

GoBe Consultants, Wood Group UK, 2021b. Rampion 2 Wind Farm Preliminary Environmental Information Report: Volume 4, Chapter 12, Offshore Ornithology Appendices.

Green, R.M., Thaxter C.B., Johnston, D.T., Boersch-Supan, P.H., Bouten, W., and Burton, N.H.K, 2021. Assessing Movements of Lesser Black-backed Gulls using GPS Tracking Devices in Relation to the Galloper Wind Farm. Report by BTO on behalf of Galloper Wind Farm Ltd.

Harwood, A., 2021. Preliminary investigation into Sandwich tern flight height distributions: Technical note for Natural England (draft). ECON Ecological Consultancy Ltd.

Horswill, C., Robinson, R.A., 2015. Review of seabird demographic rates and density dependence (JNCC Report No. 552). JNCC, Peterborough.

Johnston, A., Cook, A.S.C.P., Wright, L.J., Humphreys, E.M., Burton, N.H.K., 2014a. Modelling flight heights of marine birds to more accurately assess collision risk with offshore wind turbines. Journal of Applied Ecology 51, 31–41. [redacted]

Johnston, A., Cook, A.S.C.P., Wright, L.J., Humphreys, E.M. and Burton, N.H.K., 2014b Corrigendum. Journal of Applied Ecology, 51, doi: 10.1111/1365-2664.12260.
JNCC, 2022. Seabird Population Programme Online Database (Online Database). JNCC.
Langston, R.H.W., Teuten, E. & Butler, A., 2013. Foraging ranges of northern gannets Morus bassanus in relation to proposed offshore wind farms in the UK: 2010-2012. RSPB Report to DECC.
Lawson, J., Kober, K., Win, I., Allcock, Z., Black, J., Reid, J.B., Way, L., and O'Brien, S.H., (2016). An assessment of the numbers and distributions of wintering red-throated diver, little gull and common scoter in the Greater Wash. JNCC Report No. 574. JNCC, Peterborough.
Natural England and JNCC 2016. Departmental Brief: Greater Wash potential Special Protection Area.
Natural England, 2020. Conservation Advice for Marine Protected Areas - FFC SPA. https://designatedsites.naturalengland.org.uk/Marine/MarineSiteDetail.aspx?SiteCode=UK9006101&SiteName=flamborough+and+filey+coast&SiteNameDisplay=Flamborough+and+Filey+Coast+SPA&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=&NumMarineSeasonality=4&HasCA=1 [accessed 26/01/2023]
Natural England, 2022. Natural England interim advice on updated Collision Risk Modelling parameters (July 2022).
Ørsted, 2022. Hornsea Project Four Ornithology EIA & HRA Annex. Document reference: G5.24. Revision: 03.
Scottish Power Renewables, 2019. East Anglia One North – Habitat Regulations Assessment (HRA): Information to Support Appropriate Assessment.
SNH, 2018. Interim Guidance on apportioning impacts from marine renewable developments to breeding seabird populations in SPAs.
SNCBs, 2014. Joint Response from the Statutory Nature Conservation Bodies to the Marine Scotland Science Avoidance Rate Review.
Thaxter, C.B., Ross-Smith, V.H., Bouten, W., Clark, N.A., Conway, G.J., Rehfisch, M.M., and Burton, N.H.K. 2015. Seabird–wind farm interactions during the breeding season vary within and between years: A case study of lesser black-backed gull Larus fuscus in the UK. Biol. Conserv. 186, 347–358.
UK SNCBs, 2017. Joint SNCB Interim Displacement Advice Note: Advice on how to present assessment information on the extent and potential consequences of seabird displacement from Offshore Wind Farm (OWF) developments.
Wakefield, E. D., Bodey, T. W., Bearhop, S., Blackburn, J., Colhoun, K., Davies, R., Dwyer, R. G., Green, J., Grémillet, D., Jackson, A. L., Jessopp, M. J., Kane, A., Langston, R. H. W., Lescroël, A., Murray, S., Le Nuz, M., Patrick, S. C., Péron, C.,

Soanes, L., Wanless, S., Votier, S. C., Hamer K. C. 2013. Space Partitioning Without Territoriality in Gannets. Science 341: 68-70.
Woodward, I., Thaxter, C.B., Owen, E., Cook, A.S.C.P. 2019. Desk-based revision of seabird foraging ranges used for HRA screening. BTO Research Report No. 274.